LandscapeDNDC v1.36.0

A process model for simulating biosphere-atmosphere-hydrosphere exchange processes

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Users Guide

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Chapter 1

Introduction

LandscapeDNDC (Haas et al., 2013) is a biogeochemical, process based simulation framework originally build around the site scale model MoBiLE (Grote et al., 2009) which is based on DNDC (Li, 1992; Li et al., 2000). It has since evolved into a modular and flexible simulation system for regional application allowing to plug in any choice of process descriptions for various parts of different natural ecosystems as well as switching between those descriptions at runtime.

Certainly, the main feature of LandscapeDNDC is its capability to handle more than one site, i.e. simulating many cells (e.g. regions) with a single program invocation. In contrast to other models in LandscapeDNDC all cells are synchronized with respect to time. This is highly significant for model coupling by means of a model-independent communication infrastructure. Each (loosely speaking) model can be set up to run in a batch mode which, however, is not suited for adding functionality from an external model in a regional setup. Also, note that input data is aggregated into a few input files as opposed to having one set of input data per cell. Furthermore, speed up can be achieved by deploying on multi-processor architectures where the simulation system can run parts of itself in parallel. No extra work is involved as it is intrinsically handled by the simulation system.

The challenge when running in regional mode is in coping with hitting resource limits. Having many cells or possibly high temporal resolution or long-time simulations results in high demands on memory and computation power. In general it is not possible to load all input data at once — something that is unlikely in a batch-mode approach. The fact that the input is condensed into one set of input data tremendously reduces file system overhead. The same is true for the outputs.

Another major incitement for this redesign was the desire to separate model and framework development such that contributors to the software are not required to have expertise on both parts while at the same time not conflicting with each others work.

This guide primarily addresses users and model (module) developers of LandscapeDNDC. It focuses on how to run the model, i.e. what input needs to be prepared and how it has to be formatted. Users who are implementing models from scratch will have to familiarize themselves with the framework to be able to integrate it into LandscapeDNDC.

The software is written in C/C++ conforming to the standard known as C++ 11. It compiles and runs on GNU/Linux (GCC, CLang, Intel, PGI, MinGW/GCC Cross-compiling for Microsoft Windows), MacOS X (GCC, CLang), Microsoft Windows platforms (MinGW/GCC, MSVC 8, MSVC 11) and the ARMv6 (e.g., GCC on Raspberry Pi).

Chapter 2

Getting Started

In this chapter we guide you through the process of obtaining, installing and configuring the simulation system LandscapeDNDC. Furthermore, we introduce the notion of simulation projects and propose a strategy of organizing and managing concurrently existing projects.

Preparing environmental inputs, e.g., boundary conditions, soil data and agricultural managements, is subject of later chapters.

We describe where and how to obtain the pre-compiled LandscapeDNDC program. Then we briefly describe the installation procedure and provide a short starting guide for the first LandscapeDNDC application.

2.1 Execute a computer script

The following sections will repeatedly use the term *execute* refering to the execution of the content of a computer script. The name of the computer script and its execution depend on your platform. On MS Windows, computer scripts have the file ending `.bat`, while on MacOS X and Linux, the filename typically ends on `.sh`. In order to execute a computer script, Windows users just need to double-click on the `.bat` file. On MacOS X and Linux systems, you execute a `.sh` file via command-line:

1. Open a Terminal application. On MacOS X, this would be, e.g., `Terminal.app`.
2. Navigate to the directory that includes your computer script. E.g., in case your computer script is located on your Desktop, type: `cd ~/Desktop/`
3. Execute the script by typing: `sh name-of-the-script.sh`

2.2 Obtain program

You will find up-to-date releases as well as a list of older versions of the simulation system at

`https://ldndc.imk-ifu.kit.edu/ldndc/downloads/`

that you may download. Select the archive according to your platform (e.g., MS Windows, MacOS X, Linux). Access is restricted and will be granted upon valid authentication. To get credentials, please contact `david.kraus@kit.edu`.

2.3 Installation of LandscapeDNDC

Extracting the downloaded archive of LandscapeDNDC for your system will result in a directory named `ldndc-version.system`. In order to install LandscapeDNDC, just execute the file `install.bat` (MS Windows) or `install.sh` (MacOS X, Linux) (see also section 2.1). After successful installation, you will find a directory named `.ldndc` in your user profile or home directory (note: you may need to change your directory options in order to display hidden files starting with a dot like `directory-namefilename`). The created directory `.ldndc` contains, e.g., a global database for model parametrization as well as some default model configuration (see also section 2.4). If you want to uninstall LandscapeDNDC, you simply delete '.ldndc'.

2.4 Configuration

In this section, we describe how to configure your simulation environment. To be able to successfully run LandscapeDNDC it needs a few information about where input is saved and output is to be written. In this step, we propose a structured directory for managing your simulations. Of course, feel free to diverge from this suggestion.

First of all, let's have a look at what LandscapeDNDC may access during a single simulation run:

- LandscapeDNDC program (`ldndc` or `ldndc.exe`)
- configuration file (`.conf`)
- resources database (`Lresources`)
- simulation inputs
- simulation outputs

- logging file (`.log`)

In the following we will explain what each of these are and where they should be located on your system. The LandscapeDNDC application program you can put where ever you feel is most convenient for you.

The **configuration file** for LandscapeDNDC is like it's address book, it helps to locate program, log file, simulation inputs and outputs. Additionally, this file holds options to change behavior of LandscapeDNDC (see section 2.4.2 for more details).

The **resources database** holds the default parameters for plant species and soils. LandscapeDNDC tries to find the file `Lresources`, which is by default expected to be in your local configuration directory. You may redefine the option `resources_path` in the configuration fileto instruct LandscapeDNDC to search this directory instead (2.4.2).

The simulation **input**defines a base directory where simulation project inputs are searched for. By default project inputs are searched for below the directory `input` in the current directory. The simulation **output** is analogous, it specifies where simulation results are written to and defaults to `output` inside the current directory. Both input and output base paths can be redefined in the configuration file.

The LandscapeDNDC *log* is used to store messages the simulation system emits during it's execution (see 2.6).

2.4.1 Proposed directory structure

Let's have a top-level directory where all LandscapeDNDC related data goes

In this directory we add a project folder, parameters folder, resources and programs folders. This directory structure already exists if you downloaded and extracted a LandscapeDNDC package.

Find your home directory On unixoid operating systems (e.g. MAC OS X, Linux, BSD, Solaris, HP UX) the path to your home directory is stored in the environment variable `HOME`. To display it's content type on the console:

```
$> echo $HOME
```

For MS Windows platforms the appropriate environment variable is called `userprofile` and can be printed using the command line program, typing

```
$> echo %userprofile%
```

or inspected in the system settings.

2.4.2 Configuration file and the command line

Options to control the simulation system are stored in a dedicated configuration file. By means of command line arguments and options, settings in the configuration file may be overwritten. You can ask LandscapeDNDC for a list of available command line options by running the command `ldndc --help`.

Configuration file The configuration file is a simple clear text file holding key/value pairs (key denotes an option name, value denotes an option's value). It is devided into sections that can be freely defined except the `[global]` section that is reserved. A section ends either at the line followed by another section definition or if end-of-file is encountered.

Most notable global configuration items
A list of configuration items most likely to be adjusted by a user:

- `input_path` path to input
- `output_path` path to output
- `resources_path` path to Lresources
- `log_file` output format of the logfile `.log` (see section 2.6)
- `log_level` setting a simulations logging verbosity level (see section 2.6)
- `progress_bar = "yes"` including a progress bar in the simulations

In order to tell LandscapeDNDC which `.conf` file you want to use, you can add this to the command line when running LandscapeDNDC. For this, see the next section (section 2.5)

2.5 Running simulations

In this section, we explain how to run LandscapeDNDC simulation projects. After successfully installing and configuring LandscapeDNDC it is time to learn how projects are structured and finally ran. Instead of using a Graphical User Interface (GUI) like most programs people know, LandscapeDNDC is executed from the command line. This allows for scripting and as such will likely be more powerful than most implementations of GUIs.

2.5.1 Console

Once a simulation project is set up, the user invokes the simulation run by issuing the command

```
$> ldndc [-c <configuration file>] <project-file>.
```

Providing an alternative configuration file is optional. If the `-c` option is omitted it is mandatory that the default (`~/.ldndc/ldndc.conf`) exists. The option `--help` lists all available options with a brief description of each.

2.5.2 First run of an example application

Within your downloaded `ldndc-version.system` directory you find various example applications under `projects`. In order to run the `gebesee` example, execute the file `DE_gebesee.bat` (MS Windows) or `DE_gebesee.sh` (MacOS X, Linux) under `ldndc-ldndc-version.syste` → `projects` → `arable` → `DE_gebesee`.

2.6 Logging File

A common part of a larger software project is a mechanism to consistently handle various status, informational, error and debugging messages.

LandscapeDNDC has a logging facility supporting a number of logging levels (Amount of information written into the `.log` file). The options are `silent`, `error`, `warn`, `info`, `verbose` which are increasingly noisy.

For asking questions related to a simulation project always include the logging file (`.log`). Also, it is best in this case to set the logging level as high as possible, e.g., `verbose`

Chapter 3

Inputs

This chapter goes over the input files available to run a simulation in LandscapeDNDC. These are the possible inputs:

- Project file
- Model setup file
- Site properties file
- Climate file
- Events / Management file
- Site parameter file
- Soil parameter file
- Species parameter file
- Airchemistry file
- Groundwater file

This chapter may get lengthy, so feel free to go to the Tutorials chapter 4, and come back here to get an in-depth explanation of a file.

3.1 Project file

The project file (`project_name.ldndc`) can be interpreted as the top-level input. It is written in the XML format:

```
<ldndcproject>
.
.
.
</ldndcproject>
```

The file contains:

1. meta data describing the content of the simulation project

   ```
   <description> ... </description>
   ```

2. simulation start time and duration

   ```
   <schedule ... />
   ```

3. input source definitions (input type + filenames)

   ```
   <inputs> ... </inputs>
   ```

4. output sink definition (output type + filenames)

   ```
   <outputs> ... </outputs>
   ```

Some things may be omitted, forcing LandscapeDNDC to use defaults unless unavailable in which case it will abort with an error message.

3.1.1 Target version

To enforce a *specific* LandscapeDNDC version or a *minimum* version to use for the simulation project, set either the attribute `PackageVersionRequired` (specific version) or `PackageMinimumVersionRequired` (minimum version) in the project file's root element (`<ldndcproject target version>`). The value of these attributes are version strings with the format `a.b.c` where `c` or `b` and `c` can be omitted, e.g., the following are equivalent (same for `PackageVersionRequired`):

- `PackageMinimumVersionRequired="1"`
- `PackageMinimumVersionRequired="1.0"`
- `PackageMinimumVersionRequired="1.0.0"`

To check what version you are currently using, see the package that you downloaded (e.g., version file) or run `bin/ldndc -V` on the command line.

3.1.2 Description

This section allows to set meta information about the project, like *project name* and *author*. Following the same pattern, any number of additional meta information may be set. The listed items (name,author,etc.) are read and may be used in the future (e.g., summary sheets).

```
<description>
    <name>PROJECT NAME</name>
    <author>AUTHOR</author>
    <email>EMAIL ADDRESS</email>
    <date>CREATION DATE</date>
</description>
```

3.1.3 Schedule

A block holding the simulation schedule. Time specification adheres to the rules described in Sec. 5. Examples:

- Simulation schedule with daily time resolution between two defined datetimes:

  ```
  <schedule time="2006-01-01/1 -> 2008-12-31" />
  ```

- Simulation schedule with hourly time resolution between two defined datetimes:

  ```
  <schedule time="2006-01-01/24 -> 2008-12-31" />
  ```

- Simulation schedule with two-hourly time resolution, defined starting datetime and simulation lenght of 7 years, 6 months and 2 days:

  ```
  <schedule time="2006-01-01/12 -> +7-6-2" />
  ```

No default available. Even though the schedule can be omitted and specified on the command line (i.e., `--schedule="2006-01-01/1->2008-12-31"`) it is not recommended to do so. Note, that when both are given the schedule read from the command line has precedence.

3.1.4 Input source definition

Within the `input` section the user must provide for each known input class zero or more input source definitions along with source attributes (e.g., default ID). The XML element name (example `<name />`) inside the `sources` block is forming the *source identifier*. This identifier must be unique within the scope of the list of sources and may be any valid element name not exceeding a size of 47 characters. Usually, the source identifier is chosen to be the name of the corresponding input class: the *default source*. If a non-default source identifier is used it is required to provide the corresponding input class via the `class` attribute. Where the source format is different from the class' default format (e.g., site input assumes an XML file by default) it must be explicitly specified via the `format` attribute (e.g., `txt`). For class name specifiers (e.g., `site`) and source format specifiers see the corresponding sections in Chapter 3.2.

A source definition example:

```
<input>
    <sources sourceprefix="exampleprefix/" >
        <setup source="setup.xml" format="xml" />
        <arablesite class="site" source="site.xml" format="xml" />
        <warmclimate class="climate" source="climate.txt" format="txt" />
        <event sourceprefix="eventpool/" source="arable-events.xml" />
    </sources>
</input>
```

The `source` attribute of each source definition is prefixed with the value given for the attribute `sourceprefix`. This attribute may be set globally for all source definitions (defaults to empty string) or locally for each source definition overwriting the global value (Note, that the prefix is not necessarily representing a directory path. I.e., a path separator (e.g., `"/"`) between the source prefix and the source is neither implied nor automatically inserted).

Also, take into account, that inputs are generally not read until they are requested by some client object (e.g., model requiring climate input). Failure, to open a requested input source will generally cause LandscapeDNDC to terminate (optionally, input synthesizers may kick in).

Source definitions and source prefixes are subject to string expansion, see section 8.1.

See section 2.4.2 for information on the input base path.

Additionally, a single set of attributes for each input class may be provided. For example, the default ID (`use`) which is used whenever a site does not provide an explicit link to an input (see section 3.2). Again global defaults may be given, which can be overwritten on a per input class basis. Find more details on input linking in section **??**.

A source attributes example:

```
<input>
    <!-- here go the sources -->
    <sources>
      ...
    </sources>

    <attributes use="0" endless="no" >
```

```
        <airchemistry endless="yes" />
        <siteparameters use="1" />
    </attributes>
</input>
```

3.1.5 Outputs

Within the *output* section the user may define custom sinks or reconfigure Landscape-DNDC internal *standard sinks* (e.g., species physiological outputs). See section ?? for a detailed description of (standard) sinks. In a similar way the input sources are uniquely identified by their source identifier each sink is uniquely identified by its *sink identifier/index* pair. The identifier is given by the XML element name. By default the sink's index is 0 but may be set to any positive integer. For indices greater zero the sinkname (if applicable) will be suffixed with the index value. A sink definition accepts a sink descriptor (e.g., filename) and a format (e.g., txt). In addition, attributes may be provided which are used depending on the format selected, e.g., `delimiter`.

A sink definition example:

```
<output>
    <sinks sinkprefix="example/output-" >
        <soilchemistrydaily sink="stdout" format="txt" delimiter=";" />
        <myspecialsink sink="bar.txt" format="txt" />
        <myspecialsink sink="foo.sqlite3" index="2" format="sqlite3" />
        <myspecialsink sink="!one.sqlite3" index="1" format="sqlite3" />
    </sinks>
</output>
```

The example above would cause the standard output for daily soilchemistry entities to write data columns separated by semicolons to the screen. Further, two non-standard sinks are linked to files named `output-bar.txt` writing tab-separated data columns into a text file and `output-foo-2.sqlite3` writing columns to a table of a SQLite3 database. The third version of the `myspecialsink` sink forces the name to be `output-one.sqlite3` omitting the index insertion (Be aware of name conflicts!). Note that, especially files are only created if they are internally requested. For example, if no model wishes to write soilchemistry data, this sink will not be attached. In the event, that directories along the path of an output sink do not exists, they will be created. Failure, e.g., due to missing write permissions, will cause LandscapeDNDC to terminate.

Sink prefixes are analogous to source prefixes and are also subject to string expansion, see section 8.1.

See section 2.4.2 for information on the output base path.

Standard streams The names `stdout`, `stderr` and `stdlog` are reserved and refer to the process' standard output channels. For sinks whose sink attribute was set to `*` (asterisk) all data is discarded (standard stream *nullsink* is such a sink).

3.2 Input sources

In this chapter we define each input entity that is used by LandscapeDNDC during a simulation. Depending on your actual simulation setup, i.e., selection of submodels, input entities may be used or not. Missing data is synthesized by LandscapeDNDC based on available data unless it is unreasonable to imply uninformed defaults. However, we strongly recommend to provide as much information as you can to drive the models to ensure meaningful results.

Definition of entities is first done in an input format independent way, that is, no details about how it has to appear in some specific source (e.g. file) is given. The purpose of the following sections is to give the user an overview of the entities LandscapeDNDC reads, their meaning, units and data types.

Input entity description Each input entity is described by a datatype and unit. Additionally, a range and default value may be given if applicable. We use the notation {*datatype* [*range*], [*default*], *unit*} where *range* and *default* may be omitted. Datatypes may be tuple, which are written as $(\mathrm{T}_1, \mathrm{T}_2, \ldots, \mathrm{T}_N)$ for arbitrary N-tuple. See explanation of datatypes below (U_T denotes undefined value (i.e., nodata value) of type T):

data type, set	meaning (example)	nodata value
bool, $\mathbb{B}$	truth values (true, false)	*none exists*
string	arbitrary sized character sequences ("spruce")	"NONE"
string<N>	character sequence with maximum size N, $N \geq 4$	"NONE"
integer, $\mathbb{Z}$	integer number $(-1, 0, 3)$	-9999
unsigned integer, $\mathbb{N}_0$	positive integer number $(1, 0, 3)$	-1
real, $\mathbb{R}$	floating point number (3.141)	-99.99
$(\mathrm{T}_1, \ldots, \mathrm{T}_N)$	N-tuple of values of datatypes $\mathrm{T}_1, \ldots, \mathrm{T}_N$ ((integer,real))	$(U_{\mathrm{T}_1}, \ldots, U_{\mathrm{T}_N})$
T list	list of values of datatype T	$U_\mathrm{T}, U_\mathrm{T}, U_\mathrm{T}, \ldots$

The notation for units is based on common symbols (e.g., m for meter) used to qualify the magnitude of a physical quantity. Units for entities which are void of unit will be written [-].

Throughout all inputs percentage quantities are scaled between 0 and 1.

Throughout all inputs boolean quantities may be written as *0*, *no*, *off* or *false* to express the respective switch to be off. The opposite may be written as one of *1*, *yes*, *on* or *true*. These boolean quantity values are case-insensitive.

Example Consider the water table depth whose value is a real number, has unit meter and defaults to 99 meters below soil surface. The expression {real, default 99, unit [m]} will reflect these properties. Further, assume the input entity average temperature T_{avg} which is given for each timestep as a real number without meaningful internal defaults. Properties of such entity will be expressed as {real list, default U_{real}, unit [°C]}.

3.2.1 Setup [`setup`]

In this section, we describe all input entities for the input class setup. Information given in this input class describe geographic location, model configuration and input selection. The sum of all setup input can be interpreted as the domain decomposition, i.e., the discretization of the region.

List of entities

1. *id* integer, default 0, unit [-]

   Unique id for a site simulation or one grid cell in a regional simulation (see 3.4.1)

2. *name* string, default <empty>, unit [-]

   A human readable name for a site

3. *model* string, default mobile, unit [-]

   The model to apply for the site

4. *active* bool, default yes, unit [-]

   Switch specifying if site is participating in simulation

5. *source links* (string47,integer) list, default (<class>,<default ID>), unit [-]

   Input linking: list source identifier and numerical ID of input block to use for input class (e.g., climate: (warmclimate, 0)) unless defaults yield correct linking

6. *elevation* real, default 100, unit [m]

   The site's elevation; use values greater 0.

7. *longitude* real, default 10, unit [degree]

   The site's longitude; the allowed range for longitudes is $[-180, 180]$. Note that this entity's nodata value is within this range. For this reason, unfortunately longitude -99.99 cannot be used. We kindly ask the user to use a slightly "disturbed" value, e.g., -99.990001.

8. *latitude* real, default 45, unit [degree]

   The site's latitude; the allowed range for latitudes is $[-90, 90]$.

9. *centroid* (real,real,real), default (0,0,0), unit [m]

   The site's centroid, i.e., the $x, y, z \in \mathbb{R}$ coordinates with respect to some coordinate system.

10. *bounding box* (real,real,real), default (0,0,0), unit [m]

    The site's bounding box in $\mathbb{R}^3 = (w, h, d)$ coordinates.

11. *area* real, default 1, unit $[\mathrm{m}^2]$

    The site's area. The volume must not be larger than the product wh, i.e., width and height of the bounding box.

12. *volume* real, default 1, unit $[\mathrm{m}^3]$

    The site's volume. The volume must not be larger than the volume of the bounding box.

13. *slope* real, default 0, unit [degree]

    The site's slope

14. *timezone* integer, default 1, unit [-]

    The site's timezone given as the offset in hours from Coordinated Universal Time (UTC) ranging from -11 to 12

15. *model/kernel specific options*

    Model specific options

    - MoBiLE

      (a) *module list* (string47,string47) list, unit [-]
      List of submodels to run during the simulation. The submodels name as well as a timemode (see 5.2) must be given.

      (b) *module options* (string,string) list, unit [-]
      Submodels, that is MoBiLE *modules*, can be globally configured via the configuration file or individually by options (key/value pairs) provided in the setup input. These options are passed to the module at instantiation time. For supported options consult the respective module documentation.

3.2.1.1 Formats

XML Example of setup input given as XML input:

```xml
<?xml version="1.0"?>
<ldndcsetup>
  <setup id="0" name="example name" model="mobile" active="on" >
    <use>
      <climate source="warmclimate" id="0" />
    </use>
    <location elevation="161.5" latitude="51.06" longitude="10.54"
     slope="0" timezone="" />
    <topology x="100" y="50" z="161.5" area="100.0"
     dx="10.0" dy="10.0" dz="1.5" volume="95.75" />
    <mobile>
      <modulelist>
        <module id="microclimate:canopyecm" timemode="daily" />
        <module id="watercycle:watercyclendndc" timemode="daily" >
          <!-- set model options -->
          <options potentialevaporationmodel="thornthwaite" />
        </module>
        <module id="physiology:arabledndc" />
        <module id="soilchemistry:metrx" />
        <module id="output:watercycle:daily" />
        <module id="output:soilchemistry:daily" >
          <!-- write additional columns -->
          <options writexyz="true" writearea="true" />
        </module>
        <module id="output:physiology:daily" />
      </modulelist>
    </mobile>
  </setup>

  <setup id="1" name="garmischer acker" model="arabledndc" >
    <use>
      <climate source="coldclimate" id="1" />
    </use>
    ...
  </setup>
</ldndcsetup>
```

And an example for using the grassland farmer:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<ldndcsetup>
    <setup id="0" name="example name" > <location elevation="860.0" latitude="47.5" longi
   <models>
```

```
      <model id="Farmer" />
      <model id="_MoBiLE" />
   </models>
    <Farmer file="some path/DE_graswang_general.farmer" id="1" >
    <mobile>
        <modulelist>
    </mobile>
    </setup>
</ldndcsetup>
```

3.2.2 Site [site]

In this section, we describe all input entities for the input class site. Primarily, site input defines soil properties such as pH value and wilting point for a variable number of soil strata. Soil strata can be further discretized by one or more soil layer that all have these properties. If properties are not supplied (indicated by the appropriate nodata value) they are estimated from available information such as humus or soil type classification. For the purpose of aiding heuristics in the initialization of soil properties in the models ecosystem state, LandscapeDNDC requires the user to specify the land use history of the site and may specify a few additional characteristics (e.g., soil type).

Soil characterization may include or exclude stones/rocks depending on different measurement approaches and/or points of view. While smaller stones are most likely included in soil samples of, e.g., bulk density, greater rocks are commonly removed. Within the context of LandscapeDNDC, all soil input information, with the exception of stone content, has to be provided for the bulk soil excluding any kind of stones/rocks.

Ecosystem names Known ecosystem names are *arable*, *grassland* and *forest*.

Humus type names Known humus type names are *humus*, *raw humus*, *moder* (with variants for beech, birch, eucalyptus, oak, pine and spruce) and *mull* (with variants for beech, birch, eucalyptus, oak, pine, spruce).

Soil type names Known soil type names are *bedrock*, *clay*, *clay loam*, *loam*, *loamy sand*, *organic material*, *sandy clay*, *sandy loam*, *sand*, *silty clay*, *silty loam*, *silt*, *silty clay loam* and *sandy clay loam*.

List of entities The following list provides the name and the description of soil entities. The most common input format for the soil is XML. See 3.2.2.1 for the respective XML specification.

1. *watertable* real, default 99, unit [m]

   Annual average water table depth (distance between soil surface and ground water table) is set equal to daily water table depth. In soil layers below the groundwater table, the porosity is assumed water filled. Soil layers above this value may or may not be influenced depending on the model assumption.

   xml attribute: **watertable**

2. *land use history* string, unit [-]

   Land use history, drives heuristics during initialization of the model. Accepts any valid ecosystem name.

   xml attribute: **usehistory**

3. *organic carbon content (5cm)* real, default U_{real}, unit $\left[\frac{kg}{kg}\right]$

   Organic carbon content in 5 cm depth is used to estimate the fraction of organic carbon content throughout the soil profile if this is not given explicitly as a soil strata property. If both the parameter and the specific strata information are missing, the carbon distribution is empirically estimated by a default function.

   xml attribute: **corg5**

4. *organic carbon content (30cm)* real, default U_{real}, unit $\left[\frac{kg}{kg}\right]$

   Same as 3 for 30cm depth.

   xml attribute: **corg30**

5. *humus type* string, unit [-]

   Humus type characterizes the basic features of the litter layer when not given explicitly in the soil strata description (otherwise they are not used). Accepts any valid humus type name.

   xml attribute: **humus**

6. *soil type* string, unit [-]

   Soil type characterizes the basic properties of the soil layers when these are not provided explicitly in the soil strata description. If all values for each soil layers are provided (see soil layer section), they are not used. The available choices are referring to the relative content of sand, loam, and silt in the soil texture. Accepts any valid soil type name (see your input format to find soil type names).

   xml attribute: **soil**

7. *litter height* real, default h_H, unit [mm]

   For all soil layers within the litter dimension, a number of soil properties, which are not provided (no data value) are set considering humus type specific properties.

NOTE: It is advisable to set a litter layer for all ecosystems where leaves are at least temporally covering the ground.

If no value is specified it is assumed to be 0 which effectively eliminates the litter.

xml attribute: **litterheight**

8. *soil stratum depth* real list, default 1, unit [mm]

   Vertical dimension/thickness of the strata. The depth does not define the position in the soil horizon.

   xml attribute: **depth**

9. *discretization* integer list, default 1, unit [-]

   Specifies the number of soil layers λ_k ($k = 1, \ldots, s$, s is number of stratum) that stratum k is internally split into.

   Each stratum is split into layers of equal height. The stratum depth H_k is given in the input for each stratum and used to calculate the individual layer height h_k within stratum k. This means the equations,

$$\Lambda = \sum_{k=1}^{s} \lambda_k, \quad h_k := \frac{H_k}{\lambda_k}$$

   yield the number of resulting soil layers Λ for the simulation and layer heights h_k within stratum k. Obviously, the depth D of the total soil column is given by

$$D = \sum_{k=1}^{s} \lambda_k h_k.$$

   xml attribute: **split**

10. *bulk density* real list, unit $\left[\frac{\mathrm{kg}}{\mathrm{dm}^3}\right]$

    The bulk density relative to the soil matrix.

    xml attribute: **bd**

11. *field capacity* real list, unit $\left[\frac{\mathrm{dm}^3}{\mathrm{m}^3}\right]$

    The field capacity relative to the soil matrix.

    xml attribute: **wcmax**

12. *wilting point* real list, unit $\left[\frac{\mathrm{dm}^3}{\mathrm{m}^3}\right]$

    The wilting point relative to the soil matrix.

    xml attribute: **wcmin**

13. *organic carbon content* real list, unit $\left[\frac{kg}{kg}\right]$

    The organic carbon content relative to the soil matrix.

    xml attribute: **corg**

14. *total nitrogen content* real list, unit $\left[\frac{kg}{kg}\right]$

    The organic nitrogen content relative to the soil matrix.

    xml attribute: **norg**

15. *clay content* real list, unit $\left[\frac{kg}{kg}\right]$

    The clay content relative to the soil matrix.

    xml attribute: **clay**

16. *sand content* real list, unit $\left[\frac{kg}{kg}\right]$

    The sand content relative to the soil matrix.

    xml attribute: **sand**

17. *silt content* real list, unit $\left[\frac{kg}{kg}\right]$

    The silt content relative to the soil matrix.

    xml attribute: **silt**

18. *stone fraction* real list, unit $\left[\frac{kg}{kg}\right]$

    Volumetric stone fraction.

    xml attribute: **scel**

19. *pH value* real list, unit [-]

    xml attribute: **pH**

20. *saturated hydraulic conductivity* real list, unit $\left[\frac{\text{cm}}{\text{min}}\right]$

    Saturated hydraulic conductivity.

    xml attribute: **sks**

21. *iron content* real list, unit $\left[\frac{kg}{kg}\right]$

    Soil iron content.

    xml attribute: **fe**

22. *VanGenuchten parameter n* real list, unit [-]

    xml attribute: **vangenuchten_n**

23. *VanGenuchten parameter α* real list, unit [1/m]

    xml attribute: **vangenuchten_alpha**

24. *Initial soil temperature* real list, unit [°C]
    xml attribute: **temp_init**
25. *Initial soil water content* real list, unit $\left[\frac{m^3}{m^3}\right]$
    xml attribute: **wc_init**
26. *Initial NH4 content* real list, unit $\left[\frac{mg}{dm^3}\right]$
    xml attribute: **nh4_init**
27. *Initial NO3 content* real list, unit $\left[\frac{mg}{dm^3}\right]$
    xml attribute: **no3_init**
28. *Initial DON content* real list, unit $\left[\frac{mg}{dm^3}\right]$
    xml attribute: **don_init**
29. *Initial DOC content* real list, unit $\left[\frac{mg}{dm^3}\right]$
    xml attribute: **doc_init**
30. *Initial POM content* real list, unit $\left[\frac{mg}{dm^3}\right]$
    xml attribute: **pom_init**
31. *Initial AORG content* real list, unit $\left[\frac{mg}{dm^3}\right]$
    xml attribute: **aorg_init**

Remark on discretization Many physical processes in the soil and their adjacent numerical treatment, like vertical transport of diffusion, struggle when differences in layer thickness are large. Therefore it is advisable to use approximately 20 mm layer thickness (not strata depth) for the top soil (soil parts of large carbon contents, generally the upper 300 mm). Furthermore, the layer heights should not get smaller with depth.

3.2.2.1 Formats

XML Example of site input given as XML input:

```
<?xml version="1.0"?>
<ldndcsite>
  <site id="..." >
    <general>
      <misc watertable="..." />
    </general>
    <soil>
```

```
      <general usehistory="..." corg30="..." corg5="..."
       humus="..." soil="..." litterheight="..." />
      <layers>
        <layer depth="..." split="..." bd="..." clay="..." ph="..."
          scel="..." sks="..." corg="..." norg="..." clay="..."
          sand="..." wcmin="..." wcmax="..." iron="..."
          wfps_max="..." wfps_min="..." porosity="..."
          macropores="..." vangenuchten_n="..." vangenuchten_alpha="..."
          wc_init="..." temp_init="..." nh4_init="..." no3_init="..."
          don_init="..." doc_init="..." pom_init="..." aorg_init="..."
        />

        <layer depth="..." split="..." bd="..." clay="..." ph="..."
          scel="..." sks="..." corg="..." norg="..." clay="..."
          sand="..." wcmin="..." wcmax="..." iron="..."
          wfps_max="..." wfps_min="..." porosity="..."
          macropores="..." vangenuchten_n="..." vangenuchten_alpha="..."
          wc_init="..." temp_init="..." nh4_init="..." no3_init="..."
          don_init="..." doc_init="..." pom_init="..." aorg_init="..."
        />
        <!-- any number of more strata -->
      </layers>
  </site>
</ldndcsite>
```

3.2.3 Event

In this section, we describe all input entities for the input class event. Events provide a mechanism to notify models about time triggered actions that may or may not be handled during simulation. For example, a planting event with *time* attribute value April 1st informs the models on the 1st of April in the first simulation year that a new species entered the simulation. To perform appropriate actions is now up to the model developer. For grassland simulation a dynamic management kernel (farmer) exists. If this is applied only a planting event needs to be scheduled in the event file. Planting and manuring are then handled in accordance with the chosen farmer parameters.

All events have in common a *type* and *time* attribute. While the later specifies when the event is to be fired the former specifies what type of event is to be fired. For time specifications see section 5. Furthermore, each event is equipped with a set of type-specific attributes. Hence, the type additionally hints the event reader what attributes to expect in the input source.

List of entities

1. *Read-ahead size* int, default U_{int}, unit [-]

   (*Not relevant to most users*) This integral value specifies the number of events to read during a single data reload : events are likely to be read sequentially in the order they appear in the input stream (e.g., xml file). However, the order of appearance may not match the chronological order of their execution. For this reason, reading only a subset of the full event input may miss an event further down the stream which trigger time will be in the past (relative to the simulation clock) at the time of the next reload. In effect, this event will be dropped and never dispatched. If events are dropped due to a too small read-ahead value, a warning is emitted. You may then increase the given value or reorder your input.

   If no value is given the complete input is read at once.

2. *Events*

   Event types The complete list of known events *cut*, *fertilize*, *flood*, *graze*, *harvest*, *irrigate*, *manure*, *plant*, *regrow*, *thin*, *throw*, and *till*.

   Find the list of known events and their attributes below.

3.2.3.1 Cut

Specifies that biomass is cut. This event applies to all living species equally.

1. *remains_absolute* real, default $\mathcal{P}$, unit $\left[\frac{\text{kg C}}{\text{ha}}\right]$

   The amount of plant biomass remaining on the field after cutting.

   See also *cut belowground biomass fraction* (see 1) for controlling removal of plant biomass.

2. *remains_relative* real, default $\mathcal{P}$, unit [-]

   The amount of plant biomass remaining on the field after cutting as relative fraction between [0-1].

3. *height* real, unit [m]

   the stubble height after cutting event

Formats - XML

```
<!-- Left 200 kg C ha-1 on the field -->
<event type="cut" time="2006-03-20" >
  <cut remains_absolute="200.0" />
</event>

<!-- Left 200 kg C ha-1 on the field -->
<event type="cut" time="2006-03-20" >
  <cut remains_relative="0.1" />
</event>

<!-- Cut until 5cm stubble height -->
<event type="cut" time="2006-03-20" >
  <cut height="0.05" />
</event>

<!-- Mulching and leave all biomass on the field -->
<event type="cut" time="2006-03-20" >
  <cut height="0.05" export_fruit="0" export_foliage="0" export_living_structural_tissue=
</event>
```

3.2.3.2 Fertilize

Specifies that fertilizer is applied to the field. Different fertilizer types are defined in LandscapeDNDC.

1. *type* string47, unit [-]

   The type of fertilizer that is applied. Available fertilizer types are *ammonium bicarbonate*, *anhydrous ammonia*, *nitrate*, *diammonium hydrogen phosphate*, *ammonium nitrate*, *ammonium sulphate*, *sulphate* and *urea*.

2. *amount* real, unit $\left[\frac{\text{kg N}}{\text{ha}}\right]$

   The amount of fertilizer to apply.

3. *depth* real, unit [m]

   The depth the fertilizer is brought into the soil.

Formats - XML

```
<!-- fertilizer type names used to select one of the previously
documented types:
```

```
ammonium bicarbonate: "nh4hco3"
anhydrous ammonia: "nh3"
nitrate: "no3"
diammonium hydrogen phosphate: "nh4hpo4"
ammonium nitrate: "nh4no3"
ammonium sulphate: "nh4so4"
sulphate: "so4"
urea: "urea"
-->

<!-- surface fertilizer application -->
<event type="fertilize" time="2006-04-10" >
  <fertilize type="nh4no3" amount="31.5" />
</event>

<!-- fertilizer injected in 5cm soil depth -->
<event type="fertilize" time="2006-04-10" >
  <fertilize type="nh4no3" amount="31.5" depth="0.05" />
</event>

<!-- sequence of fertilizer application for one month in each timestep -->
<event type="fertilize" time="2006-04-10 -> +1-0" >
  <fertilize type="nh4no3" amount="1.5" depth="0.01" />
</event>
```

3.2.3.3 Flood

1. *watertable* real, unit [mm]

   Water table height above soil surface

2. *bundheight* real, unit [mm]

   Height of a surrounding wall of a bund preventing runoff

3. *percolationrate* real, unit [mm]

   Maximum allowed percolation rate from deepest soil layer

4. *irrigationheight* real, unit [mm]

   Target height of watertable for a single irrigation event as soon as watertable drops below threshold (above defined watertable).

Formats - XML

```xml
<!-- flood event with constant water table of 10cm -->
<event type="flood" time="2006-10-30->2006-09-30" >
  <flood watertable="100.0" bundheight="200.0" />
</event>

<!-- irrigation triggered when watertable drops 15cm below soil surface -->
<event type="flood" time="2006-10-30->2006-09-30" >
  <flood watertable="-150.0" irrigationheight="50.0" bundheight="200.0" />
</event>

<!-- preventing runoff no water added -->
<event type="flood" time="2006-10-30->2006-09-30" >
  <flood bundheight="200.0" />
</event>
```

3.2.3.4 Graze

1. *livestock name* string47, unit [NONE]

   Name of a predefined livestock. Predefined livestock names are *cattle*, *horse*, *sheep* and *generic*. If a livestock name is given type-specific defaults are used. Such defaults are hardwired in the simulation system but may be overwritten (see the table below for those parameters).

2. *head count* real, unit [-]

   Number of livestock entities per hectar on the field.

   xml attribute: **headcount**

3. *grazinghours* real, unit [h]

   Number of hours the livestock is on the field grazing.

   xml attribute: **grazinghours**

4. *remains (relative)* real, unit [-]

   Relative amount of standing biomass remaining after grazing period.

   xml attribute: **remains_relative**

5. *carbon demand* real, unit $\left[\frac{\text{kg C}}{\text{d head}}\right]$

   Demand of carbon: the potential amount of carbon consumed by one entity livestock.

   xml attribute: **demandcarbon**

6. *carbon excreta (dung)* real, unit [-]

   Relative amount of grazed carbon, which is released to the field in form of dung.

   xml attribute: **excretacarbon**

7. *nitrogen excreta (dung)* real, unit [-]

   Relative amount of grazed nitrogen, which is released to the field in form of dung and urine.

   xml attribute: **excretanitrogen**

8. *urine fraction* real, unit [-]

   Fraction of urine of total nitrogen excreta.

   xml attribute: **urinefraction**

Parameterization of predefined livestock types

livestock name	C demand	C excreta	N excreta	urine fraction
cattle	4.6	0.3	0.8	0.64
horse	3.0	0.45	0.8	0.66
sheep	0.88	0.3	0.8	0.45
generic	2.8	0.3	0.8	0.55

Formats - XML

```
<!-- graze -->
<!-- livestock type names used to select one of the previously
documented predefined types (give zero (i.e. customized animal) or
one type)
cattle: "cattle"
horse: "horse"
sheep: "sheep"
-->
<event type="graze" time="2006-05-05 -> 2006-05-11" >
  <graze livestock="cattle" headcount="28" grazinghours="9.5" />
</event>
<event type="graze" time="2006-05-05 -> +7" >
  <graze headcount="28" grazinghours="9.5" demandcarbon="4.6"
  excretacarbon="0.3" excretanitrogen="0.8" urinefraction="0.55" />
</event>
```

3.2.3.5 Harvest

Specifies that a previously planted species is going to be removed from the simulation. In the timestep immediately following the timestep a harvest event occured the species is finally evicted from the simulation, which means internal structures representing the species have vanished.

Note, that harvesting a species which was not planted causes the simulation to terminate prematurely.

1. *species name* string47, unit [-]

   Specifies the name (i.e., unique identification) of the species to be harvested. Species names are case-insensitive and leading and trailing whitespaces are removed

2. *remains* real, unit [%]

   The fraction of the aboveground biomass that is left on the field as residuals (*remains* and *stubbleheight* are mutually exclusive)

3. *stubbleheight* real, unit [m]

   Height of stubble left on the field as residuals. (*stubbleheight* and *remains* are mutually exclusive)

Formats - XML

```xml
<!-- harvest wheat -->
<event type="harvest" time="2006-10-27" >
  <harvest name="powerwheat" remains="0.7" />
</event>

<!-- harvest yummyrice -->
<event type="harvest" time="2006-09-01" >
  <harvest name="yummyrice" stubbleheight="0.3" />
</event>
```

3.2.3.6 Irrigate

1. *amount* real, unit [mm]

   amount of water

Formats - XML

```
<!-- irrigate event -->
<event type="irrigate" time="2006-04-30" >
  <irrigate amount="4" />
</event>
```

3.2.3.7 Manure

1. *manure type* string47, unit [-]

   The name of the type of manure to apply. Available choices of manure types are *beancake*, *compost*, *farmyard*, *green*, *straw* and *slurry*

2. *carbon* real, unit $\left[\frac{\text{kg C}}{\text{ha}}\right]$

   The amount of total carbon

3. *carbon/nitrogen ratio* real, unit [-]

   The carbon/nitrogen ratio

4. *available carbon* real, unit [-]

   The amount of dissolved organic carbon (does not apply to all manure types)

5. *available nitrogen* real, unit [-]

   The amount of dissolved organic and inorganic nitrogen (does not apply to all manure types)

Formats - XML

1. manure type: type
2. carbon: c
3. carbon/nitrogen ratio: cn
4. available carbon: availc
5. available nitrogen: availn

```
<!-- manure event -->
<event type="manure" time="2006-04-28" >
  <manure type="slurry" c="100" cn="12" availc="72" availn="6" />
</event>
```

3.2.3.8 Plant

Specifies that a species is to be added to the simulation.

1. *type* string47, unit [-]

   The type specifies the parameter block to use from the species parameter input (see 3.2.9). Type names are case-insensitive and leading and trailing whitespaces are removed.

2. *name* string47, default <type>, unit [-]

   The name assigns a unique identifier to the species which can further be used to relate to this species (e.g., see harvest event). If no name is given the type is used instead. Species names are case-insensitive and leading and trailing whitespaces are removed.

3. *species resource name* string47, default <type>, unit [-]

   The resource name is an optional property that may be used by some models to identify species-related resources (e.g., files). This string is not modified (e.g., no uppercasing) and read as-is.

4. *fractionalcover* real, unit [%]

   Specifies how much of the area is covered by the species.

5. *initialbiomass* real, unit $\left[\frac{kg}{ha}\right]$

   Total aboveground biomass

6. *group specific properties*

   For each species a list of group specific properties may be set (for a list of valid species groups see section 3).

   - CROP
     (a) *covercrop* bool, unit [false]
     specifies if this crop is a cover crop
     (b) *seedbedduration* int, unit [days]
     number of days in seedbed
     (c) *seedlingnumber* real, unit $\left[\frac{1}{ha}\right]$
     number of individuals per ha
   - GRASS
     (a) *covercrop* bool, unit [false]
     specifies if this grass is a cover crop
     (b) *maximum height* real, unit [m]
     average height of highest vegetation cohort

(c) *rooting depth* real, unit [m]
depth of roots

- WOOD

(a) *carbon reduction factor* real, unit [%]
reduction factor for initialization of the nitrogen and basic cation concentration relative to the maximum

(b) *breast height diameter* real, unit [m]
average individual diameter at 1.3 m height

(c) *minimum height* real, unit [m]
height of canopy start (from the ground)

(d) *maximum height* real, unit [m]
average height of highest vegetation cohort

(e) *rooting depth* real, unit [m]
depth of roots

(f) *number of individuals* integer, unit [-]
number of individuals per ha

(g) *volume* real, unit $\left[\frac{m^3}{ha}\right]$
stemwood (or stand) volume

Formats - XML

```
<!-- seeding a crop -->
<event type="plant" time="2006-05-20" >
  <plant name="powerwheat" type="wiwh" longname="WinterWheat" >
    <crop initialbiomass="10.0" fractionalcover="1.0" covercrop="no" />
    <params>
      <par name="tlimit" value="8.0" />
    </params>
  </plant>
</event>

<!-- seeding rice crop -->
<event type="plant" time="2006-01-10" >
  <plant name="yummyrice" type="sahodulan1" >
    <crop initialbiomass="10.0" fractionalcover="1.0" covercrop="no" />
  </plant>
</event>

<!-- seeding a grass -->
<event type="plant" time="2006-05-20" >
```

```
  <plant name="greencarpet" type="perg" >
    <grass initialbiomass="500.0" fractionalcover="1.0" />
  </plant>
</event>

<!-- putting trees -->
<event type="plant" time="2006-05-20" >
  <plant name="hayacomun" type="fasy" >
    <wood dbh="0.41" heightmax="35.0" treenumber="600" />
  </plant>
</event>
```

3.2.3.9 Regrow

Present trees are harvested and new trees are planted.

1. *species name* string47, unit [-]

   Name identifying species to regrow

2. *tree number* real, default 0, unit [-]

   Number of individuals to be newly set. The attributes *tree number resize factor* and *tree number* are mutually exclusive

3. *tree number resize factor* real, default 0, unit [-]

   New number of individuals is given by the current number of trees multiplied with this factor. The attributes *tree number resize factor* and *tree number* are mutually exclusive

4. *export biomass* real, default 1, unit [%]

   This factor determines the fraction of harvested aboveground biomass that is exported. The other fraction is allocated as plant litter to the corresponding soil pools. Default value set to 1.0, which means total removal (export) of harvested aboveground biomass. Roots always remain in the soil.

Formats - XML

```
<event type="regrow" time="2006-05-13" >
  <regrow name="hayacomun" treenumberresizefactor="1.3"
  heightmax="0.6" exportabovegroundbiomass="0.9"/>
</event>
```

3.2.3.10 Reparameterize species

1. *species name* string47, unit [-]

   Name identifying species to reparameterize

2. *species type* string47, unit [-]

   Type listed in species parameter input used to replace current parameter set (see 3.2.9 for details)

Formats - XML

```
<!-- reparameterization event -->
<event type="reparameterizespecies" time="2006-04-30" >
  <reparameterizespecies name="hayacomun" type="fagussylvatica-tortuosa" />
</event>
```

3.2.3.11 Thin

1. *species name* string47, unit [-]

   Name identifying species to thin

2. *reduction number* real, unit [%]

   Number of individuals to be removed

3. *reduction volume* real, unit [%]

   Stemwood (or stand) volume to be removed

4. *export foliage* bool, unit [false]

   Specifies whether foliage is exported or not

5. *export sapwood* bool, unit [false]

   Specifies whether sapwood is exported or not

6. *export corewood* bool, unit [false]

   Specifies whether corewood is exported or not

Formats - XML

```
<!-- thin event -->
<event type="thin" time="2007-02-01" >
  <thin name="poplar" reductionvolume="" reductionnumber=""
  exportfoliage="yes|no" exportsapwood="yes|no"
  exportcorewood="yes|no" />
</event>
```

3.2.3.12 Throw

1. *species name* string47, unit [-]

   Name identifying species subject to windthrow. If species name is ∗ (asterisk) affected species are selected based on some strategy (e.g., tallest trees first).

2. *reduction volume* real, unit [%, m^3]

   Specifies reduction factor or absolute amount of stand volume reduction.

XML Example of event input given as XML input:

Formats - XML

```
<!-- throw event -->
<event type="throw" time="2007-02-01" >
  <!-- relative reduction -->
  <throw name="poplar" reductionvolume="0.4" />
</event>

<!-- throw event -->
<event type="throw" time="2007-02-01" >
  <!-- absolute reduction -->
  <throw name="poplar" reductionvolume="!1000.0" />
</event>
```

3.2.3.13 Till

1. *depth* real, unit [m]

   Tilling depth (represents tilling method used)

Formats - XML

```
<event type="till" time="2006-11-01" >
  <till depth="0.15" />
</event>
```

3.2.4 Climate [climate]

In this section, we describe all input entities for the input class climate.

List of entities

1. *elevation* real, default 100, unit [m]

   Climate station's elevation

2. *latitude* real, default 45, unit [degree]

   Climate station's latitude

3. *longitude* real, default 10, unit [degree]

   Climate station's longitude

4. *annual average temperature* real, default 8, unit [°C]

   Averaged annual average temperature

5. *annual temperature amplitude* real, default 20, unit [°C]

   Averaged annual temperature amplitude

6. *annual precipitation* real, default 800, unit [mm]

   Averaged annual precipitation

7. *annual average cloudiness* real, default 0.55, unit [%]

   Averaged annual cloudiness

8. *rainfall intensity* real, default 5, unit [mm]

   Rainfall intensity

9. *annual average wind speed* real, default 1.5, unit $[\frac{m}{s}]$

   Averaged annual average wind speed

10. *precipitation* real list, unit [mm]

11. *average temperature* real list, unit [°C]

12. *minimum temperature* real list, unit [°C]
13. *maximum temperature* real list, unit [°C]
14. *global radiation* real list, unit $\left[\frac{W}{m^2}\right]$
15. *vapor pressure deficit* real list, unit [kPa]
16. *relative humidity* real list, unit [%]
17. *wind speed* real list, unit $\left[\frac{m}{s}\right]$
18. *long wave radiation* real list, unit $\left[\frac{W}{m^2}\right]$
19. *air pressure* real list, unit [mbar]

3.2.4.1 Formats

Plain text Example of climate input given as plain text input:

```
## time .. offset for first data record in data section

## id .. block id

## prec .. precipitation
## tavg .. temperature average
## tmax .. maximum temperature
## tmin .. minimum temperature
## grad .. global radiation
## vpd .. vapor pressure deficit
## wind .. windspeed
## lrad .. longwave radiation
## press .. air pressure

%global
       time = "2006-01-01/4"

%climate
       id = "0"
%attributes
       elevation = "161.5"
       latitude = "51.06"
       longitude = "10.54"
```

```
        wind speed = "3.0"

        annual precipitation = "492.0"
        temperature average = "9.6"
        temperature amplitude = "20.0"

%data
* * * prec tavg tmax tmin grad vpd wind lrad press
2006 1 1 0 2.05 4.87 0.53 256.0 0.073 2.11 252.87 993.805
2006 1 2 1.8 0.91 3.21 -3.5 184.06 0.196 1.27 90.93 993.805
2006 1 3 1.3 0.47 1.86 0.33 86.88 0.0064 1.38 -113.87 993.805
2006 1 4 0.3 0.40 1.26 0.33 186.88 0.0032 1.32 -63.87 993.805

## any number of more data records

%climate
        id = "1"
%attributes
        elevation = "161.5"
        latitude = "51.06"
        longitude = "12.0"

        cloudiness = "0.55"
        rainfall intensity = "5.0"
        wind speed = "1.2"

%data
* prec tavg tmin tmax
1 0 2.05 0.53 4.87
2 1.8 0.91 -3.5 3.21
3 1.3 0.47 0.33 1.86
4 0.4 0.43 0.23 0.86

## any number of more data records
```

3.2.5 Air chemistry [airchemistry]

In this section, we describe all input entities for the input class air chemistry.

List of entities

1. *Average methane concentration*, $\overline{CH_4}$ real, default 0, unit [ppm]
2. *Average carbon dioxide concentration*, $\overline{CO_2}$ real, default 370, unit [ppm]
3. *Average ammonia concentration*, $\overline{NH_3}$ real, default 0, unit [ppm]
4. *Average nitric oxide concentration*, $\overline{NO}$ real, default 0, unit [ppm]
5. *Average nitrogen dioxide concentration*, $\overline{NO_2}$ real, default 0, unit [ppm]
6. *Average ozone concentration*, $\overline{O_3}$ real, default 0, unit [ppm]
7. *Average ammonium wet deposition*, $\overline{NH_4}$ real, default 0.635, unit $\left[\frac{g}{m^3}\right]$
8. *Average daily ammonium dry deposition*, $\overline{NH_4{}^D}$ real, default 0, unit $\left[\frac{g}{m^2\,d}\right]$
9. *Average nitrate wet deposition*, $\overline{NO_3}$ real, default 0.365, unit $\left[\frac{g}{m^3}\right]$
10. *Average daily nitrate dry deposition*, $\overline{NO_3{}^D}$ real, default 0, unit $\left[\frac{g}{m^2\,d}\right]$

11. *Instantaneous methane concentration* real list, default $\overline{CH_4}$, unit [ppm]
12. *Instantaneous carbon dioxide concentration* real list, default $\overline{CO_2}$, unit [ppm]
13. *Instantaneous ammonia concentration* real list, default $\overline{NH_3}$, unit [ppm]
14. *Instantaneous nitric oxide concentration* real list, default $\overline{NO}$, unit [ppm]
15. *Instantaneous nitrogen dioxide concentration* real list, default $\overline{NO_2}$, unit [ppm]
16. *Instantaneous ozone concentration* real list, default $\overline{O_3}$, unit [ppm]
17. *Instantaneous ammonium wet deposition* real list, default $\overline{NH_4}$, unit $\left[\frac{g}{m^3}\right]$
18. *Daily ammonium dry deposition* real list, default $\overline{NH_4{}^D}$, unit $\left[\frac{g}{m^2\,d}\right]$
19. *Instantaneous nitrate wet deposition* real list, default $\overline{NO_3}$, unit $\left[\frac{g}{m^3}\right]$
20. *Daily nitrate dry deposition* real list, default $\overline{NO_3{}^D}$, unit $\left[\frac{g}{m^2\,d}\right]$

3.2.5.1 Formats

Plain text Example of airchemistry input given as plain text input:

```
## time .. offset for first data record in data section

## id .. block id

## ch4 .. methane
## co2 .. carbon dioxide
## nh3 .. ammonia
## nh4 .. ammonium (wet deposition)
## nh4dry .. ammonium (dry deposition)
## no .. nitric oxide
## no2 .. nitrogen dioxide
## no3 .. nitrate (wet deposition)
## no3dry .. nitrate (dry deposition)
## o3 .. ozone

%global
       time = "2006-01-01/3"

%airchemistry
       id = "0"
%attributes
       co2 = "365.0"
       ch4 = "0"

%data * * * nh4 no3 no3dry o3 nh3 no2 no
2006 1 1 0.74 0.42 0.17 0.0 0.0 0.0 0.0
2006 1 2 0.74 0.42 0.17 0.0 0.0 0.0 0.0
2006 1 3 0.74 0.42 0.17 0.0 0.0 0.0 0.0

## any number of more data records

%airchemistry
       id = "1"
%data
nh4 no3 co2
0.74 0.42 385.0
0.74 0.42 385.0
0.74 0.42 385.0

## any number of more data records
```

3.2.6 Groundwater [groundwater]

In this section, we describe all input entities for the input class groundwater.

List of entities

1. *watertable* real, default 99.0, unit [m]
   Depth of water table. Positive in downward direction, i.e., 1.0 means that the groundwatertable is 1.0 m below surface. Negative numbers are interpreted as surface watertable.

2. *no3* real, default 0.0, unit $[\frac{mg}{l}]$
   NO_3 concentration in groundwater.

3.2.6.1 Formats

Plain text Example of groundwater input given as plain text input:

```
## time .. offset for first data record in data section

## id .. block id

%global
       time = "2006-01-01/4"

%groundwater
       id = "0"
%attributes
       watertable = "99.0"
       no3 = "0.0"

%data
* * * watertable no3
1995 4 7 0.86 10.56
1995 4 8 0.84 10.28
1995 4 9 0.84 10.00

## any number of more data records

%groundwater
       id = "1"
```

```
%attributes
       watertable = "2.0"
       no3 = "3.24"

%data
* * * watertable no3
1995 4 7 0.86 10.56
1995 4 8 0.84 10.28
1995 4 9 0.84 10.00

## any number of more data records
```

3.2.7 Site parameters [siteparameters]

In this section, we describe all input entities for the input class site parameters.

1. *site parameters*

   Site parameters need readable short names and units.

   The following list contains all parameters that may be set.

   #1 *AMAXX*, θ_{A} — $\theta_{\text{A}} \in [0.6545, 1.9635] \subseteq \mathbb{R}$, unit [?]
   Microbial death rate.

   #2 *BY_PASSF*, θ_{BP} — $\theta_{\text{BP}} \in [0, 24] \subseteq \mathbb{R}$, unit [%]
   Fraction of water distributed directly across the root profile.

   #3 *CRACK_DEPTH*, θ_{CD} — $\theta_{\text{CD}} \in [0, 2] \subseteq \mathbb{R}$, unit [?]
   Maximum depth of cracks [m].

   #4 *CRACK_FRACTION*, θ_{CF} — $\theta_{\text{CF}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
   Fraction of water that infiltrates via cracks [-].

   #5 *DECONIT_ANVF1*, θ_{DA} — $\theta_{\text{DA}} \in [2, 8] \subseteq \mathbb{R}$, unit [?]
   Factor determining anaerobic volume fraction depending on water filled pore space.

   #6 *DECONIT_ANVF2*, θ^1_{DA} — $\theta^1_{\text{DA}} \in [4, 10] \subseteq \mathbb{R}$, unit [?]
   Factor determining anaerobic volume fraction depending on water filled pore space.

   #7 *DECONIT_CDECFAC*, θ_{DC} — $\theta_{\text{DC}} \in [0.1, 0.6] \subseteq \mathbb{R}$, unit [?]
   Decomposition reduction for coniferous litter.

#8 *DECONIT_DFDENI*, θ_{DD} $\theta_{\mathrm{DD}} \in [0.0005, 0.01] \subseteq \mathbb{R}$, unit [?]
Denitrifier fraction of total microbial biomass.

#9 *DECONIT_DFDENIFROST*, θ^1_{DD} $\theta^1_{\mathrm{DD}} \in [0.0005, 0.01] \subseteq \mathbb{R}$, unit [?]
Denitrifier fraction of total microbial biomass during freeze thaw.

#10 *DECONIT_D_HET*, θ_{DDH} $\theta_{\mathrm{DDH}} \in [0.001, 0.1] \subseteq \mathbb{R}$, unit [?]
Microbial death rate.

#11 *DECONIT_D_NGAS*, θ_{DDN} $\theta_{\mathrm{DDN}} \in [0.1, 2] \subseteq \mathbb{R}$, unit [?]
Diffusion coefficient.

#12 *DECONIT_DK_LIGNIN*, θ_{DDL} $\theta_{\mathrm{DDL}} \in [1, 5] \subseteq \mathbb{R}$, unit [?]
Exponential reduction factor of decomposition depending on lignin.

#13 *DECONIT_EFF_DOC*, θ_{DED} $\theta_{\mathrm{DED}} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency of carbon assimilation.

#14 *DECONIT_EFF_DON*, θ^1_{DED} $\theta^1_{\mathrm{DED}} \in [0.0005, 0.01] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency of organic nitrogen assimilation.

#15 *DECONIT_EFF_NH4*, θ_{DEN} $\theta_{\mathrm{DEN}} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency of ammonium assimilation.

#16 *DECONIT_EFF_NO2*, θ^1_{DEN} $\theta^1_{\mathrm{DEN}} \in [0.001, 0.1] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency of nitrite assimilation.

#17 *DECONIT_FNO*, θ_{DF} $\theta_{\mathrm{DF}} \in [0.005, 0.1] \subseteq \mathbb{R}$, unit [?]
Determines NO production during nitrification.

#18 *DECONIT_FNO2_DEN*, θ_{DFD} $\theta_{\mathrm{DFD}} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Determines NO2 production during denitrification.

#19 *DECONIT_FN2O*, θ^1_{DF} $\theta^1_{\mathrm{DF}} \in [0.00005, 0.001] \subseteq \mathbb{R}$, unit [?]
Determines N2O production during nitrification.

#20 *DECONIT_KCHEM*, θ_{DK} $\theta_{\mathrm{DK}} \in [0.000005, 0.0001] \subseteq \mathbb{R}$, unit [?]
Rate constant for NO production during chemodenitrifcation.

#21 *DECONIT_K_CELL*, θ_{DKC} $\theta_{\mathrm{DKC}} \in [0.001, 0.02] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for cellulose.

#22 *DECONIT_K_LIGNIN*, θ_{DKL} $\theta_{\mathrm{DKL}} \in [0.001, 0.02] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for lignin.

#23 *DECONIT_K_SOL*, θ_{DKS} $\theta_{\mathrm{DKS}} \in [0.005, 0.2] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for solutes.

#24 *DECONIT_K_H*, θ_{DKH} $\theta_{\mathrm{DKH}} \in [0.0001, 0.001] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for humus.

#25 *DECONIT_K_DOC*, θ_{DKD} $\theta_{\mathrm{DKD}} \in [100, 1000] \subseteq \mathbb{R}$, unit [?]
Rate constant for microbial carbon assimilation.

#26 *DECONIT_KM_N*, θ_{DKN} $\theta_{\mathrm{DKN}} \in [1, 100] \subseteq \mathbb{R}$, unit [?]
Rate constant for microbial nitrogen assimilation.

#27 *DECONIT_LEACHF*, θ_{DL} $\theta_{\mathrm{DL}} \in [0.01, 0.9] \subseteq \mathbb{R}$, unit [?]
Retention coefficient for leaching.

#28 *DECONIT_MUDEC*, θ_{DM} $\theta_{\mathrm{DM}} \in [10, 40] \subseteq \mathbb{R}$, unit [?]
Optimum temperature for decomposition.

#29 *DECONIT_PHMIN_CHEM*, θ_{DPC} $\theta_{\mathrm{DPC}} \in [3, 7] \subseteq \mathbb{R}$, unit [?]
Factor determining pH dependency of chemodenitrification.

#30 *DECONIT_PHOPT_CHEM*, θ^1_{DPC} $\theta^1_{\mathrm{DPC}} \in [0.4, 0.8] \subseteq \mathbb{R}$, unit [?]
Factor determining pH dependency of chemodenitrification.

#31 *DECONIT_PH_FACT_P5*, θ_{DPFP} $\theta_{\mathrm{DPFP}} \in [2, 5] \subseteq \mathbb{R}$, unit [?]
Factor determining pH dependency of chemodenitrification.

#32 *DECONIT_TF_CHEM1*, θ_{DTC} $\theta_{\mathrm{DTC}} \in [0.1, 0.4] \subseteq \mathbb{R}$, unit [?]
Factor determining temperature dependency of chemodenitrification.

#33 *DECONIT_TF_CHEM2*, θ^1_{DTC} $\theta^1_{\mathrm{DTC}} \in [0.01, 0.1] \subseteq \mathbb{R}$, unit [?]
Factor determining temperature dependency of chemodenitrification.

#34 *DECONIT_TNORM*, θ_{DT} $\theta_{\mathrm{DT}} \in [290, 300] \subseteq \mathbb{R}$, unit [?]
Normalization temperature for diffusion.

#35 *DECONIT_TSIGMA*, θ^1_{DT} $\theta^1_{\mathrm{DT}} \in [11, 15] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of decomposition on temperature.

#36 *DECONIT_WSHAPE*, θ_{DW} $\theta_{\mathrm{DW}} \in [1, 3] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of decomposition on water filled pore space.

#37 *DECONIT_WFPS_OPT*, θ_{DWO} $\theta_{\mathrm{DWO}} \in [0.1, 1] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of decomposition on water filled pore space.

#38 *DENIFRAC*, θ_{D} $\theta_{\mathrm{D}} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Microbial denitrifier fraction.

#39 *DIFF_C*, θ^1_{DC} $\theta^1_{\mathrm{DC}} \in [0.125, 0.375] \subseteq \mathbb{R}$, unit [?]
Diffusion constant for carbon compounds between aerobic an anaerobic microsites.

#40 *DIFF_N*, θ_{DN} $\theta_{\mathrm{DN}} \in [0.25, 0.75] \subseteq \mathbb{R}$, unit [?]
Diffusion constant for nitrogen compounds between aerobic an anaerobic microsites.

#41 *D_N2O*, θ^1_{DN} $\theta^1_{\mathrm{DN}} \in [0.031, 0.093] \subseteq \mathbb{R}$, unit [?]
Reduction constant for N2O diffusion.

#42 *D_NO*, θ^2_{DN} $\theta^2_{\mathrm{DN}} \in [0.0365, 0.1095] \subseteq \mathbb{R}$, unit [?]
Reduction constant for NO diffusion.

#43 *ECHY_KMM_ROOTS*, θ_{EKR} $\theta_{\mathrm{EKR}} \in [0.001, 1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten constant for the influence of fineroots abundance on water uptake.

#44 *ECHY_EVAPORATION_DEPTH_LIMIT_EXPONENT*, θ_{EEDLE} $\theta_{\mathrm{EEDLE}} \in [5, 20] \subseteq \mathbb{R}$, unit [?]
Exponent for depth dependency of soil-evaporation [-].

#45 *EEF_MAXIMUM_NITRIFICATION_INHIBITION*, θ_{EMNI} $\theta_{\mathrm{EMNI}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Maximum reduction due to nitrification inhibitors.

#46 *EEF_NITRIFICATION_INHIBITION_STABILITY_1*, θ_{ENIS_1} $\theta_{\mathrm{ENIS}_1} \in [-5, 0] \subseteq \mathbb{R}$, unit [?]
Parameter for decomposition of nitrification inhibitor [-].

#47 *EEF_NITRIFICATION_INHIBITION_STABILITY_2*, θ_{ENIS_2} $\theta_{\mathrm{ENIS}_2} \in [0, 0.01] \subseteq \mathbb{R}$, unit [?]
Parameter for decomposition of nitrification inhibitor [-].

#48 *EEF_NITRIFICATION_INHIBITION_DILUTION*, θ_{ENID} $\theta_{\mathrm{ENID}} \in [0.1, 10] \subseteq \mathbb{R}$, unit [?]
Parameter for dilution efficiency of nitrification inhibitor [-].

#49 *EEF_CONTROLLED_RELEASE_Q10*, θ_{ECRQ} $\theta_{\mathrm{ECRQ}} \in [1, 10] \subseteq \mathbb{R}$, unit [?]

Temperature coefficient for controlled release fertilizer.

#50 *EEF_CONTROLLED_RELEASE_LAG_PERIOD*, θ_{ECRLP} $\theta_{\mathrm{ECRLP}} \in [0, 30] \subseteq \mathbb{R}$, unit [?]
Lag period (days) for nitrogen release of applied controlled release fertilizer.

#51 *EEF_CONTROLLED_RELEASE_T80*, θ_{ECRT} $\theta_{\mathrm{ECRT}} \in [25, 100] \subseteq \mathbb{R}$, unit [?]
Duration (days) for 80

#52 *EEF_CONTROLLED_RELEASE_WFPS_FACTOR*, θ_{ECRWF} $\theta_{\mathrm{ECRWF}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Influence of water filled pore space on controlled release fertilizer [-].

#53 *EFFAC*, θ_{E} $\theta_{\mathrm{E}} \in [0.35, 0.95] \subseteq \mathbb{R}$, unit [?]
Fraction of decomposed carbon that goes to the dissolved organic carbon pool.

#54 *EFF_N2O*, θ_{EN} $\theta_{\mathrm{EN}} \in [0.0375, 0.1125] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency for N2O denitrification.

#55 *EFF_NO*, θ^1_{EN} $\theta^1_{\mathrm{EN}} \in [0.0755, 0.2265] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency for NO denitrification.

#56 *EFF_NO2*, θ^2_{EN} $\theta^2_{\mathrm{EN}} \in [0.214, 0.642] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency for NO2 denitrification.

#57 *EFF_NO3*, θ^3_{EN} $\theta^3_{\mathrm{EN}} \in [0.2005, 0.6015] \subseteq \mathbb{R}$, unit [?]
Microbial efficiency for NO3 denitrification.

#58 *EVALIM*, θ^1_{E} $\theta^1_{\mathrm{E}} \in [0.01, 2] \subseteq \mathbb{R}$, unit [?]
Maximum depth of soil-evaporation [m].

#59 *EXP1_NX*, θ^4_{EN} $\theta^4_{\mathrm{EN}} \in [1.5, 2] \subseteq \mathbb{R}$, unit [?]
Factor accounting for soil porosity effect on nitrogen effective diffusion coefficient.

#60 *EXP1_O2*, θ_{EO} $\theta_{\mathrm{EO}} \in [1.5, 2] \subseteq \mathbb{R}$, unit [?]
Factor accounting for soil porosity effect on O2 effective diffusion coefficient.

#61 *EXP2_NX*, θ^5_{EN} $\theta^5_{\mathrm{EN}} \in [1.5, 2] \subseteq \mathbb{R}$, unit [?]
Factor accounting for soil porosity effect on nitrogen effective diffusion coefficient.

#62 *EXP2_O2*, θ^1_{EO} $\theta^1_{\mathrm{EO}} \in [0.5, 2] \subseteq \mathbb{R}$, unit [?]
Factor accounting for soil porosity effect on O2 effective diffusion coefficient.

#63 *FIRE_FRAC_BLACKCARBON*, θ_{FFB} $\theta_{\mathrm{FFB}} \in [0.01, 0.04] \subseteq \mathbb{R}$, unit [?]
Fraction of black carbon of burned total carbon.

#64 *FIRE_FRAC_NH4*, θ_{FFN} $\theta_{\mathrm{FFN}} \in [0.1, 1] \subseteq \mathbb{R}$, unit [?]
Fraction of nh4 of burned total nitrogen.

#65 *FIRE_FRAC_NO3*, θ^1_{FFN} $\theta^1_{\mathrm{FFN}} \in [0.1, 1] \subseteq \mathbb{R}$, unit [?]
Fraction of no3 of burned total nitrogen.

#66 *FCLAY1*, θ_{F} $\theta_{\mathrm{F}} \in [0.07, 0.21] \subseteq \mathbb{R}$, unit [?]
Factor for clay dependency of humads decomposition process.

#67 *FCLAY2*, θ^1_{F} $\theta^1_{\mathrm{F}} \in [1.1513, 3.4539] \subseteq \mathbb{R}$, unit [?]
Factor for clay dependency of humads decomposition process.

#68 *FCO2_1*, θ_{F_1} $\theta_{\mathrm{F}_1} \in [0.605, 1.815] \subseteq \mathbb{R}$, unit [?]
Factor for CO2 production during humads decomposition process.

#69 *FCO2_2*, θ_{F_2} $\theta_{\mathrm{F}_2} \in [1.12, 3.36] \subseteq \mathbb{R}$, unit [?]
Factor for CO2 production during humads decomposition process.

#70 *FCO2_3*, θ_{F_3} $\theta_{\mathrm{F}_3} \in [1.15, 3.45] \subseteq \mathbb{R}$, unit [?]
Factor for CO2 production during humads decomposition process.

#71 *FCO2_4*, θ_{F_4} $\theta_{\mathrm{F}_4} \in [0.0425, 0.1275] \subseteq \mathbb{R}$, unit [?]
Factor for CO2 production during humads decomposition process.

#72 *FCO2_HU*, θ_{FH} $\theta_{\mathrm{FH}} \in [0.4, 1.2] \subseteq \mathbb{R}$, unit [?]
Factor for CO2 production during humads decomposition process.

#73 *FDL*, θ^2_{F} $\theta^2_{\mathrm{F}} \in [0.25, 0.75] \subseteq \mathbb{R}$, unit [?]
Fraction of decomposed labile litter that is assimilated by microbes instantaniously.

#74 *FDR*, θ^3_{F} $\theta^3_{\mathrm{F}} \in [0.175, 0.525] \subseteq \mathbb{R}$, unit [?]
Fraction of decomposed recalcitrant litter that is assimilated by microbes instantaniously.

#75 *FDVL*, θ^4_{F} $\theta^4_{\mathrm{F}} \in [0.325, 0.975] \subseteq \mathbb{R}$, unit [?]
Fraction of decomposed very labile litter that is assimilated by microbes instantaniously.

#76 *FNO3_U*, θ_{FU} $\theta_{\mathrm{FU}} \in [0.375, 0.9] \subseteq \mathbb{R}$, unit [?]
Factor steering NO3 availability for microbial assimilation.

#77 *FPERCOL*, θ_{F}^{5} $\theta_{\mathrm{F}}^{5} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Fraction of surface water that goes into runoff [day-1].

#78 *FRAC_LABILE_C_BEANCAKE*, θ_{FLCB} $\theta_{\mathrm{FLCB}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid carbon in beancake manure.

#79 *FRAC_LABILE_N_BEANCAKE*, θ_{FLNB} $\theta_{\mathrm{FLNB}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid nitrogen in beancake manure.

#80 *FRAC_LABILE_C_FARMYARD*, θ_{FLCF} $\theta_{\mathrm{FLCF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid carbon in farmyard manure.

#81 *FRAC_LABILE_N_FARMYARD*, θ_{FLNF} $\theta_{\mathrm{FLNF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid nitrogen in farmyard manure.

#82 *FRAC_LABILE_C_SLURRY*, θ_{FLCS} $\theta_{\mathrm{FLCS}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid carbon in slurry manure.

#83 *FRAC_LABILE_N_SLURRY*, θ_{FLNS} $\theta_{\mathrm{FLNS}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid nitrogen in slurry manure.

#84 *FRAC_LABILE_C_COMPOST*, θ_{FLCC} $\theta_{\mathrm{FLCC}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid carbon in compost manure.

#85 *FRAC_LABILE_N_COMPOST*, θ_{FLNC} $\theta_{\mathrm{FLNC}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fractions of liquid nitrogen in compost manure.

#86 *FRC*, θ_{F}^{6} $\theta_{\mathrm{F}}^{6} \in [0.025, 0.075] \subseteq \mathbb{R}$, unit [?]
Factor accounting for litter availability dependency on microbial death.

#87 *FRCUTR*, θ_{F}^{7} $\theta_{\mathrm{F}}^{7} \in [0, 0.4] \subseteq \mathbb{R}$, unit [?]
Fraction of fine root that dies after cutting event.

#88 *FRUNOFF*, θ_{F}^{8} $\theta_{\mathrm{F}}^{8} \in [0, 24] \subseteq \mathbb{R}$, unit [?]
Fraction of daily runoff from surface water [m day-1].

#89 *FTRANS*, θ_{F}^{9} $\theta_{\mathrm{F}}^{9} \in [0.0025, 0.0075] \subseteq \mathbb{R}$, unit [?]
Factor steering dissimilatory nitrate reduction to ammonium.

#90 *GROUNDWATER_NUTRIENT_RENEWAL*, θ_{GNR} $\theta_{\text{GNR}} \in [0, 24] \subseteq \mathbb{R}$, unit [?]
Time needed for complete replenishment of groundwater nutrients, e.g., no3 [hr].

#91 *GROUNDWATER_PERCOLATION*, θ_{GP} $\theta_{\text{GP}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Fraction of soil water flux in the saturated zone (directly above the groundwater) that flows into the groundwater and leaves the simulated soil domain [-].

#92 *GROUNDWATER_LATERAL_GRADIENT*, θ_{GLG} $\theta_{\text{GLG}} \in [0, 100000] \subseteq \mathbb{R}$, unit [?]
Lateral distance that has a groundwater level difference of 1 meter [m].

#93 *IMPEDANCE_PAR*, θ_{IP} $\theta_{\text{IP}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Reduction of hydraulic conductivity in presence of ice.

#94 *KCHEM*, θ_{K} $\theta_{\text{K}} \in [4, 12] \subseteq \mathbb{R}$, unit [?]
Reaction rate for chemo-denitrification [h-1].

#95 *KCRB_L*, θ_{KL} $\theta_{\text{KL}} \in [0.04625, 0.13875] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for labile inactive microbes.

#96 *KCRB_R*, θ_{KR} $\theta_{\text{KR}} \in [0.00111, 0.00333] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for recalcitrant inactive microbes.

#97 *KHDC_L*, θ^1_{KL} $\theta^1_{\text{KL}} \in [0.00037, 0.00111] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for labile humads.

#98 *KHDC_R*, θ^1_{KR} $\theta^1_{\text{KR}} \in [0.000185, 0.000555] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for recalcitrant humads.

#99 *KICE*, θ^1_{K} $\theta^1_{\text{K}} \in [0.375, 1.125] \subseteq \mathbb{R}$, unit [?]
Ice dependency on effective diffusion coefficient.

#100 *KLRAW*, θ^2_{K} $\theta^2_{\text{K}} \in [0.01, 0.1] \subseteq \mathbb{R}$, unit [?]
Decomposition constant for raw litter.

#101 *DNDC_KMM_C_DENIT*, θ_{DKCD} $\theta_{\text{DKCD}} \in [0.0085, 0.0255] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for carbon dependency of denitrification.

#102 *DNDC_KMM_N_DENIT*, θ_{DKND} $\theta_{\text{DKND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for nitrogen dependency of denitrification.

#103 *DNDC_KMM_C_MIC*, θ_{DKCM} $\theta_{\text{DKCM}} \in [0.001, 0.009] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for carbon dependency of microbial growth.

#104 *DNDC_KMM_N_MIC*, θ_{DKNM} $\theta_{\text{DKNM}} \in [0.0005, 0.003] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for nitrogen dependency of microbial growth.

#105 *DNDC_KMM_NO3_TRANSNH4*, θ_{DKNT} $\theta_{\text{DKNT}} \in [0.00001, 0.0002] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for nitrogen dependency of dissimilatory nitrate reduction to ammonium.

#106 *DNDC_KMM_NH4_NIT*, θ_{DKNN} $\theta_{\text{DKNN}} \in [0.0000442, 0.0001326] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for NH4 dependency of nitrification.

#107 *DNDC_KMM_NO2_NIT*, θ^1_{DKNN} $\theta^1_{\text{DKNN}} \in [0.00000125, 0.00000375] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for NO2 dependency of nitrification.

#108 *DNDC_KMM_O2_DECOMP*, θ_{DKOD} $\theta_{\text{DKOD}} \in [0.1, 0.5] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for O2 dependency of decomposition.

#109 *KN2O*, θ^3_{K} $\theta^3_{\text{K}} \in [0.0025, 0.0225] \subseteq \mathbb{R}$, unit [?]
Reaction rate for N2O reductase.

#110 *KNIT*, θ^4_{K} $\theta^4_{\text{K}} \in [0.5, 10] \subseteq \mathbb{R}$, unit [?]
Reaction rate for nitrification.

#111 *KNO*, θ^5_{K} $\theta^5_{\text{K}} \in [0.001, 0.003] \subseteq \mathbb{R}$, unit [?]
Reaction rate for NO reductase.

#112 *KRCH*, θ^6_{K} $\theta^6_{\text{K}} \in [0.000001, 0.00001] \subseteq \mathbb{R}$, unit [?]
Decomposition rate for humus pool.

#113 *KRCL*, θ^7_{K} $\theta^7_{\text{K}} \in [0.00925, 0.08325] \subseteq \mathbb{R}$, unit [?]
Decomposition rate for labile carbon pool [1 / day] (Stange 2001).

#114 *KRCR*, θ^8_{K} $\theta^8_{\text{K}} \in [0.0037, 0.0111] \subseteq \mathbb{R}$, unit [?]
Decomposition rate for recalcitrant carbon pool [1 / day] (Stange 2001).

#115 *KRCVL*, θ^9_{K} $\theta^9_{\text{K}} \in [0.0185, 0.185] \subseteq \mathbb{R}$, unit [?]
Decomposition rate for very labile carbon pool [1 / day] (Stange 2001).

#116 *LEFTGRASS*, θ_{L} — $\theta_{\mathrm{L}} \in [0, 1000] \subseteq \mathbb{R}$, unit [?]
Minimum amount of grass that needs to be remained after cutting event.

#117 *LIQDON_SLURRY*, θ_{LS} — $\theta_{\mathrm{LS}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of DON in organic fertilizer (slurry manure).

#118 *LIQNH4_SLURRY*, θ^1_{LS} — $\theta^1_{\mathrm{LS}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of NH4 in organic fertilizer (slurry manure).

#119 *LIQNO3_SLURRY*, θ^2_{LS} — $\theta^2_{\mathrm{LS}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of NO3 in organic fertilizer (slurry manure).

#120 *LIQUREA_SLURRY*, θ^3_{LS} — $\theta^3_{\mathrm{LS}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of UREA in organic fertilizer (slurry manure).

#121 *LIQDON_FARMYARD*, θ_{LF} — $\theta_{\mathrm{LF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of DON in organic fertilizer (farmyard manure).

#122 *LIQNH4_FARMYARD*, θ^1_{LF} — $\theta^1_{\mathrm{LF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of NH4 in organic fertilizer (farmyard manure).

#123 *LIQNO3_FARMYARD*, θ^2_{LF} — $\theta^2_{\mathrm{LF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of NO3 in organic fertilizer (farmyard manure).

#124 *LIQUREA_FARMYARD*, θ^3_{LF} — $\theta^3_{\mathrm{LF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of UREA in organic fertilizer (farmyard manure).

#125 *LIQDON_COMPOST*, θ_{LC} — $\theta_{\mathrm{LC}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of DON in organic fertilizer (compost manure).

#126 *LIQNH4_COMPOST*, θ^1_{LC} — $\theta^1_{\mathrm{LC}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of NH4 in organic fertilizer (compost manure).

#127 *LIQNO3_COMPOST*, θ^2_{LC} — $\theta^2_{\mathrm{LC}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of NO3 in organic fertilizer (compost manure).

#128 *LIQUREA_COMPOST*, θ^3_{LC} — $\theta^3_{\mathrm{LC}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of UREA in organic fertilizer (compost manure).

#129 *MCOEFF*, θ_{M} — $\theta_{\mathrm{M}} \in [0.0001, 0.003] \subseteq \mathbb{R}$, unit [?]
Maximum snow melting rate [m day-1 K-1].

#130 *METRX_AMAX*, θ_{MA} — $\theta_{\mathrm{MA}} \in [0.1, 3] \subseteq \mathbb{R}$, unit [?]
Maximum microbial death rate.

#131 *METRX_AMAX_ALGAE*, θ_{MAA} $\theta_{\mathrm{MAA}} \in [0.01, 0.1] \subseteq \mathbb{R}$, unit [?]
Maximum decay rate of algae.

#132 *METRX_BETA_LITTER_TYPE*, θ_{MBLT} $\theta_{\mathrm{MBLT}} \in [1, 3] \subseteq \mathbb{R}$, unit [?]
Exponential factor for litter decomposition reduction depending on lignin concentration.

#133 *METRX_BIOSYNTH_EFF*, θ_{MBE} $\theta_{\mathrm{MBE}} \in [0.3, 0.8] \subseteq \mathbb{R}$, unit [?]
Microbial nitrogen use efficiency.

#134 *METRX_CN_ALGAE*, θ_{MCA} $\theta_{\mathrm{MCA}} \in [10, 40] \subseteq \mathbb{R}$, unit [?]
C:N ratio of algae.

#135 *METRX_CN_FRAC_HUM3*, θ_{MCFH} $\theta_{\mathrm{MCFH}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
C:N ratio fraction of humus 3 pool in relation to soil C:N ratio.

#136 *METRX_CN_MIC_MAX*, θ_{MCMM} $\theta_{\mathrm{MCMM}} \in [10, 20] \subseteq \mathbb{R}$, unit [?]
Maximum allowed C:N ratio for microbes.

#137 *METRX_CN_MIC_MIN*, $\theta^{1}_{\mathrm{MCMM}}$ $\theta^{1}_{\mathrm{MCMM}} \in [2, 8] \subseteq \mathbb{R}$, unit [?]
Minimum allowed C:N ratio for microbes.

#138 *METRX_D_EFF_REDUCTION*, θ_{MDER} $\theta_{\mathrm{MDER}} \in [0.01, 10] \subseteq \mathbb{R}$, unit [?]
Reduction factor for gas diffusion.

#139 *METRX_F_PERTUBATION_MIX*, θ_{MFPM} $\theta_{\mathrm{MFPM}} \in [0.0000001, 0.001] \subseteq \mathbb{R}$, unit [?]
Diffusive mixing factor for soil organic matter due to, e.g., earthworm activity.

#140 *METRX_F_PERTUBATION_EXP*, θ_{MFPE} $\theta_{\mathrm{MFPE}} \in [0.01, 2] \subseteq \mathbb{R}$, unit [?]
Exponential factor for vertical decline of diffusive mixing of soil organic matter due to, e.g., earthworm activity.

#141 *METRX_F_RANVF_1*, θ_{MFR_1} $\theta_{\mathrm{MFR}_1} \in [0.5, 4] \subseteq \mathbb{R}$, unit [?]
Factor for calculation of relaxed anaerobic soil volume.

#142 *METRX_F_RANVF_2*, θ_{MFR_2} $\theta_{\mathrm{MFR}_2} \in [4, 20] \subseteq \mathbb{R}$, unit [?]
Factor for calculation of relaxed anaerobic soil volume.

#143 *METRX_F_SANVF_1*, θ_{MFS_1} $\theta_{\mathrm{MFS}_1} \in [0.5, 4] \subseteq \mathbb{R}$, unit [?]
Factor for calculation of strict anaerobic soil volume.

#144 *METRX_F_SANVF_2*, θ_{MFS_2} $\theta_{\mathrm{MFS}_2} \in [4, 20] \subseteq \mathbb{R}$, unit [?]
Factor for calculation of strict anaerobic soil volume.

#145 *METRX_F_CONNECTIVITY_1*, θ_{MFC_1} $\theta_{\mathrm{MFC}_1} \in [-1, 1] \subseteq \mathbb{R}$, unit [?]
Factor for calculation of pore connectivity.

#146 *METRX_F_CONNECTIVITY_2*, θ_{MFC_2} $\theta_{\mathrm{MFC}_2} \in [0, 30] \subseteq \mathbb{R}$, unit [?]
Factor for calculation of pore connectivity.

#147 *METRX_F_CHEMODENIT_PH_1*, θ_{MFCP_1} $\theta_{\mathrm{MFCP}_1} \in [1, 3] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of chemodenitrification.

#148 *METRX_F_CHEMODENIT_PH_2*, θ_{MFCP_2} $\theta_{\mathrm{MFCP}_2} \in [1, 4] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of chemodenitrification.

#149 *METRX_F_CHEMODENIT_T_1*, θ_{MFCT_1} $\theta_{\mathrm{MFCT}_1} \in [100, 10000000000] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of chemodenitrification.

#150 *METRX_F_CHEMODENIT_T_2*, θ_{MFCT_2} $\theta_{\mathrm{MFCT}_2} \in [1000, 10000000] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of chemodenitrification.

#151 *METRX_F_MIC_M_WEIBULL_1*, $\theta_{\mathrm{MFMMW}_1}$ $\theta_{\mathrm{MFMMW}_1} \in [0, 0.9] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of microbial activity.

#152 *METRX_F_MIC_M_WEIBULL_2*, $\theta_{\mathrm{MFMMW}_2}$ $\theta_{\mathrm{MFMMW}_2} \in [1, 30] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of microbial activity.

#153 *METRX_F_DECOMP_CN_1*, θ_{MFDC_1} $\theta_{\mathrm{MFDC}_1} \in [0, 2] \subseteq \mathbb{R}$, unit [?]
Factor for cn ratio dependency of decomposition.

#154 *METRX_F_DECOMP_CN_2*, θ_{MFDC_2} $\theta_{\mathrm{MFDC}_2} \in [10, 80] \subseteq \mathbb{R}$, unit [?]
Factor for cn ratio dependency of decomposition.

#155 *METRX_F_DECOMP_M_WEIBULL_1*, $\theta_{\mathrm{MFDMW}_1}$ $\theta_{\mathrm{MFDMW}_1} \in [0, 0.9] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of decomposition.

#156 *METRX_F_DECOMP_M_WEIBULL_2*, $\theta_{\mathrm{MFDMW}_2}$ $\theta_{\mathrm{MFDMW}_2} \in [5, 15] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of decomposition.

#157 *METRX_F_CH4_OXIDATION_T_EXP_1*, θ_{MFCOTE_1} $\theta_{\text{MFCOTE}_1} \in [0.5, 10] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of ch4 oxidation.

#158 *METRX_F_CH4_OXIDATION_T_EXP_2*, θ_{MFCOTE_2} $\theta_{\text{MFCOTE}_2} \in [25, 45] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of ch4 oxidation.

#159 *METRX_F_CH4_PRODUCTION_PH_1*, θ_{MFCPP_1} $\theta_{\text{MFCPP}_1} \in [0.5, 4] \subseteq \mathbb{R}$, unit [?]
Factor for ph dependency of ch4 production.

#160 *METRX_F_CH4_PRODUCTION_PH_2*, θ_{MFCPP_2} $\theta_{\text{MFCPP}_2} \in [0.5, 6] \subseteq \mathbb{R}$, unit [?]
Factor for ph dependency of ch4 production.

#161 *METRX_F_CH4_PRODUCTION_PH_3*, θ_{MFCPP_3} $\theta_{\text{MFCPP}_3} \in [4, 10] \subseteq \mathbb{R}$, unit [?]
Factor for ph dependency of ch4 production.

#162 *METRX_F_CH4_PRODUCTION_T_EXP_1*, θ_{MFCPTE_1} $\theta_{\text{MFCPTE}_1} \in [0.5, 10] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of ch4 production.

#163 *METRX_F_CH4_PRODUCTION_T_EXP_2*, θ_{MFCPTE_2} $\theta_{\text{MFCPTE}_2} \in [25, 45] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of ch4 production.

#164 *METRX_F_DECOMP_T_EXP_1*, θ_{MFDTE_1} $\theta_{\text{MFDTE}_1} \in [0.5, 5] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of decomposition.

#165 *METRX_F_DECOMP_T_EXP_2*, θ_{MFDTE_2} $\theta_{\text{MFDTE}_2} \in [25, 45] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of decomposition.

#166 *METRX_F_DECOMP_PH_1*, θ_{MFDP_1} $\theta_{\text{MFDP}_1} \in [0.5, 5] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of decomposition.

#167 *METRX_F_DECOMP_PH_2*, θ_{MFDP_2} $\theta_{\text{MFDP}_2} \in [0.1, 5] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of decomposition.

#168 *METRX_F_DECOMP_CLAY_1*, $\theta^1_{\text{MFDC}_1}$ $\theta^1_{\text{MFDC}_1} \in [0, 1] \subseteq \mathbb{R}$, unit [?]

(0.0: maximum clay effect,no more decomposition at all; 1.0: minimum clay effect, no more clay dependency at all).

#169 *METRX_F_DECOMP_CLAY_2*, $\theta^1_{\mathrm{MFDC}_2}$ $\theta^1_{\mathrm{MFDC}_2} \in [0, 10] \subseteq \mathbb{R}$, unit [?]
Factor for clay-dependent decomposition determining the shape of the response curve.

#170 *METRX_F_MIC_T_EXP_1*, $\theta_{\mathrm{MFMTE}_1}$ $\theta_{\mathrm{MFMTE}_1} \in [0.5, 5] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of microbial activity.

#171 *METRX_F_MIC_T_EXP_2*, $\theta_{\mathrm{MFMTE}_2}$ $\theta_{\mathrm{MFMTE}_2} \in [25, 45] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of microbial activity.

#172 *METRX_F_DENIT_N2_1*, θ_{MFDN_1} $\theta_{\mathrm{MFDN}_1} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Factor determining minimum fraction of denitrified nitrogen converted to N2 in relation to METRX_F_DENIT_N2_2.

#173 *METRX_F_DENIT_N2_2*, θ_{MFDN_2} $\theta_{\mathrm{MFDN}_2} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Factor determining maximum fraction of denitrified nitrogen converted to N2.

#174 *METRX_F_DENIT_PH_1*, $\theta^1_{\mathrm{MFDP}_1}$ $\theta^1_{\mathrm{MFDP}_1} \in [2, 7] \subseteq \mathbb{R}$, unit [?]
Factor determining ph dependency of denitrification; factor represents ph with 50

#175 *METRX_F_DENIT_PH_2*, $\theta^1_{\mathrm{MFDP}_2}$ $\theta^1_{\mathrm{MFDP}_2} \in [0.2, 1.5] \subseteq \mathbb{R}$, unit [?]
Factor determining ph dependency of denitrification.

#176 *METRX_F_DENIT_N2O_PH_1*, $\theta_{\mathrm{MFDNP}_1}$ $\theta_{\mathrm{MFDNP}_1} \in [2, 7] \subseteq \mathbb{R}$, unit [?]
Factor determining ph dependency of denitrification of N2O to N2; factor represents ph with 50

#177 *METRX_F_DENIT_N2O_PH_2*, $\theta_{\mathrm{MFDNP}_2}$ $\theta_{\mathrm{MFDNP}_2} \in [0.2, 1.5] \subseteq \mathbb{R}$, unit [?]
Factor determining ph dependency of denitrification.

#178 *METRX_F_DENIT_NO*, θ_{MFDN} $\theta_{\mathrm{MFDN}} \in [1, 20] \subseteq \mathbb{R}$, unit [?]
Exponential factor determining how much denitrified nitrogen goes to NO.

#179 *METRX_F_DENIT_M_WEIBULL_1*, $\theta^1_{\mathrm{MFDMW}_1}$ $\theta^1_{\mathrm{MFDMW}_1} \in [0, 0.99] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of denitrification.

#180 *METRX_F_DENIT_M_WEIBULL_2*, $\theta^1_{\mathrm{MFDMW}_2}$ $\theta^1_{\mathrm{MFDMW}_2} \in [5, 40] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of denitrification.

#181 *METRX_F_N_ALGAE*, θ_{MFNA} $\theta_{\mathrm{MFNA}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Factor determining algae growth depending on nitrogen availability.

#182 *METRX_F_N_CH4_OXIDATION*, θ_{MFNCO} $\theta_{\mathrm{MFNCO}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Factor determining CH4 oxidation depending on nitrogen availability.

#183 *METRX_F_NIT_FRAC_MIC*, θ_{MFNFM} $\theta_{\mathrm{MFNFM}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Ration of microbes able to nitrify.

#184 *METRX_F_NIT_MAX_MIC*, θ_{MFNMM} $\theta_{\mathrm{MFNMM}} \in [0.02, 1] \subseteq \mathbb{R}$, unit [?]
Ration of microbes able to nitrify.

#185 *METRX_F_NIT_NO_M_EXP_1*, $\theta_{\mathrm{MFNNME}_1}$ $\theta_{\mathrm{MFNNME}_1} \in [0, 20] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of no production during nitrification.

#186 *METRX_F_NIT_NO_M_EXP_2*, $\theta_{\mathrm{MFNNME}_2}$ $\theta_{\mathrm{MFNNME}_2} \in [-1.1, 1.1] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of no production during nitrification.

#187 *METRX_F_NIT_NO_N2O_T_EXP_1*, $\theta_{\mathrm{MFNNNTE}_1}$ $\theta_{\mathrm{MFNNNTE}_1} \in [0.01, 0.1] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of no production during nitrification.

#188 *METRX_F_NIT_NO_N2O_T_EXP_2*, $\theta_{\mathrm{MFNNNTE}_2}$ $\theta_{\mathrm{MFNNNTE}_2} \in [1, 20] \subseteq \mathbb{R}$, unit [?]
Factor for temperature dependency of no production during nitrification.

#189 *METRX_F_NIT_NO_N2O_M_WEIBULL_1*, $\theta_{\mathrm{MFNNNMW}_1}$ $\theta_{\mathrm{MFNNNMW}_1} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of n2o production during nitrification.

#190 *METRX_F_NIT_NO_N2O_M_WEIBULL_2*, $\theta_{\mathrm{MFNNNMW}_2}$ $\theta_{\mathrm{MFNNNMW}_2} \in [0, 30] \subseteq \mathbb{R}$, unit [?]
Factor for water filled pore space dependency of n2o production during nitrification.

#191 *METRX_FE_REDUCTION*, θ_{MFR} $\theta_{\mathrm{MFR}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Redox active fraction of total iron.

#192 *METRX_FRAC_FE_CH4_PROD*, θ_{MFFCP} $\theta_{\mathrm{MFFCP}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Fraction of iron that has to be reduced before CH4 is produced.

#193 *METRX_FRAC_MINERAL*, θ_{MFM} $\theta_{\mathrm{MFM}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Fraction of decomposed nitrogen being mineralized.

#194 *METRX_MIC_EFF_AEROBIC_RESPIRATION*, θ_{MMEAR} $\theta_{\mathrm{MMEAR}} \in [0.1, 1] \subseteq \mathbb{R}$, unit [?]
Microbial carbon use efficiency under aerobic conditions.

#195 *METRX_MIC_EFF_ANAEROBIC_RESPIRATION*, $\theta^1_{\mathrm{MMEAR}}$ $\theta^1_{\mathrm{MMEAR}} \in [0.1, 1] \subseteq \mathbb{R}$, unit [?]
Microbial carbon use efficiency under anaerobic conditions.

#196 *METRX_MIC_EFF_METHANE_OXIDATION*, θ_{MMEMO} $\theta_{\mathrm{MMEMO}} \in [0.1, 1] \subseteq \mathbb{R}$, unit [?]
Microbial use efficiency of methane oxidation.

#197 *METRX_MUEMAX_C_ALGAE*, θ_{MMCA} $\theta_{\mathrm{MMCA}} \in [0.0000001, 0.000002] \subseteq \mathbb{R}$, unit [?]
Growth rate constant for algae growth.

#198 *METRX_MUEMAX_C_CH4_OX_HA*, θ_{MMCCOH} $\theta_{\mathrm{MMCCOH}} \in [0.0001, 2] \subseteq \mathbb{R}$, unit [?]
Growth rate of high affinity methane oxidation microbes.

#199 *METRX_MUEMAX_C_CH4_OX_LA*, θ_{MMCCOL} $\theta_{\mathrm{MMCCOL}} \in [0.0001, 2] \subseteq \mathbb{R}$, unit [?]
Growth rate of high affinity methane oxidation microbes.

#200 *METRX_MUEMAX_C_CH4_PROD*, θ_{MMCCP} $\theta_{\mathrm{MMCCP}} \in [0.0005, 0.05] \subseteq \mathbb{R}$, unit [?]
Growth rate of methanogenic microbes.

#201 *METRX_MUEMAX_C_DENIT*, θ_{MMCD} $\theta_{\mathrm{MMCD}} \in [0.1, 10] \subseteq \mathbb{R}$, unit [?]
Growth rate of denitrifying microbes.

#202 *METRX_MUEMAX_C_FERM*, θ_{MMCF} $\theta_{\mathrm{MMCF}} \in [0.1, 10] \subseteq \mathbb{R}$, unit [?]
Growth rate of fermenting microbes.

#203 *METRX_MUEMAX_C_MIC*, θ_{MMCM} $\theta_{\text{MMCM}} \in [0.1, 10] \subseteq \mathbb{R}$, unit [?]
Growth rate of nitrifying microbes.

#204 *METRX_MUEMAX_C_FE_RED*, θ_{MMCFR} $\theta_{\text{MMCFR}} \in [0.01, 10] \subseteq \mathbb{R}$, unit [?]
Rate of iron reduction.

#205 *METRX_MUEMAX_H2_CH4_PROD*, θ_{MMHCP} $\theta_{\text{MMHCP}} \in [0.0005, 0.05] \subseteq \mathbb{R}$, unit [?]
Rate of methane production via H2.

#206 *METRX_MUEMAX_N_ASSI*, θ_{MMNA} $\theta_{\text{MMNA}} \in [1, 100] \subseteq \mathbb{R}$, unit [?]
Maximum rate of nitrogen assimilation.

#207 *METRX_KA_C_MIC*, θ_{MKCM} $\theta_{\text{MKCM}} \in [1, 100000] \subseteq \mathbb{R}$, unit [?]
Factor for carbon dependency of microbial death.

#208 *METRX_KF_NIT_NO_N2O*, θ_{MKNNN} $\theta_{\text{MKNNN}} \in [0.001, 0.12] \subseteq \mathbb{R}$, unit [?]
Maximum fraction of nitrified NH4 that goes to NO and N2O.

#209 *METRX_K_O2_CH4_PROD*, θ_{MKOCP} $\theta_{\text{MKOCP}} \in [10, 500] \subseteq \mathbb{R}$, unit [?]
Factor for O2 dependency of CH4 production.

#210 *METRX_K_O2_FE_RED*, θ_{MKOFR} $\theta_{\text{MKOFR}} \in [10, 5000] \subseteq \mathbb{R}$, unit [?]
Factor for O2 dependency of iron reduction.

#211 *METRX_K_FE_FE_RED*, θ_{MKFFR} $\theta_{\text{MKFFR}} \in [0, 50] \subseteq \mathbb{R}$, unit [?]
Factor for iron availability dependency of iron reduction.

#212 *METRX_KMM_AC_CH4_PROD*, θ_{MKACP} $\theta_{\text{MKACP}} \in [0.0001, 0.1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for acetate dependency of CH4 production.

#213 *METRX_KMM_AC_FE_RED*, θ_{MKAFR} $\theta_{\text{MKAFR}} \in [0.001, 0.1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for acetate dependency of iron reduction.

#214 *METRX_KMM_H2_FE_RED*, θ_{MKHFR} $\theta_{\text{MKHFR}} \in [0.0000001, 0.001] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for H2 dependency of iron reduction.

#215 *METRX_KMM_C_DENIT*, θ_{MKCD} $\theta_{\text{MKCD}} \in [0.00001, 0.01] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for carbon dependency of denitrification.

#216 *METRX_KMM_CH4_CH4_OX_HA*, θ_{MKCCOH} $\theta_{\mathrm{MKCCOH}} \in [0.000001, 0.1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for CH4 dependency of high affinity CH4 oxidation.

#217 *METRX_KMM_CH4_CH4_OX_LA*, θ_{MKCCOL} $\theta_{\mathrm{MKCCOL}} \in [0.00001, 1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for CH4 dependency of low affinity CH4 oxidation.

#218 *METRX_KMM_C_MIC*, θ^1_{MKCM} $\theta^1_{\mathrm{MKCM}} \in [0.0005, 0.05] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for carbon dependency of microbial growth.

#219 *METRX_KMM_O2_NIT*, θ_{MKON} $\theta_{\mathrm{MKON}} \in [0.0001, 0.1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for O2 dependency of nitrification.

#220 *METRX_KMM_H2_FERM*, θ_{MKHF} $\theta_{\mathrm{MKHF}} \in [0.0000005, 0.00005] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for H2 dependency of fermentation.

#221 *METRX_KMM_H2_CH4_PROD*, θ_{MKHCP} $\theta_{\mathrm{MKHCP}} \in [0.000001, 0.001] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for H2 dependency of CH4 production.

#222 *METRX_KMM_N_ALGAE*, θ_{MKNA} $\theta_{\mathrm{MKNA}} \in [0.01, 1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for nitrogen dependency algae growth.

#223 *METRX_KMM_N_CH4_OX*, θ_{MKNCO} $\theta_{\mathrm{MKNCO}} \in [0.0001, 0.1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for nitrogen dependency of CH4 oxidation.

#224 *METRX_KMM_N_DENIT*, θ_{MKND} $\theta_{\mathrm{MKND}} \in [0.0001, 0.01] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for nitrogen dependency of denitrification.

#225 *METRX_KMM_N_MIC*, θ_{MKNM} $\theta_{\mathrm{MKNM}} \in [0.0001, 0.01] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for nitrogen dependency of microbial growth.

#226 *METRX_KMM_NH4_NIT*, θ_{MKNN} $\theta_{\mathrm{MKNN}} \in [0.0001, 0.01] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for NH4 dependency of nitrification.

#227 *METRX_KMM_NO2_NIT*, θ^1_{MKNN} $\theta^1_{\mathrm{MKNN}} \in [0.000001, 0.001] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for NO2 dependency of nitrification.

#228 *METRX_KMM_O2_CH4_OX*, θ_{MKOCO} $\theta_{\text{MKOCO}} \in [0.00001, 0.01] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for O2 dependency of CH4 oxidation.

#229 *METRX_KMM_O2_FE_OX*, θ_{MKOFO} $\theta_{\text{MKOFO}} \in [0.001, 1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for O2 dependency of iron oxidation.

#230 *METRX_KMM_PH_INCREASE_FROM_UREA*, θ_{MKPIFU} $\theta_{\text{MKPIFU}} \in [0.00001, 1] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten factor for O2 dependency of iron oxidation.

#231 *METRX_KR_ANVF_DIFF*, θ_{MKAD} $\theta_{\text{MKAD}} \in [0, 10] \subseteq \mathbb{R}$, unit [?]
Modifier of diffusion between aerobic and anaerobic soil volumes.

#232 *METRX_KR_FRAG_ALGAE*, θ_{MKFA} $\theta_{\text{MKFA}} \in [0.01, 1] \subseteq \mathbb{R}$, unit [?]
Fragmentation constant of algae.

#233 *METRX_KR_FRAG_RAW_LITTER*, θ_{MKFRL} $\theta_{\text{MKFRL}} \in [0.005, 0.1] \subseteq \mathbb{R}$, unit [?]
Fragmentation constant of raw litter.

#234 *METRX_KR_FRAG_STUBBLE*, θ_{MKFS} $\theta_{\text{MKFS}} \in [0.0001, 0.01] \subseteq \mathbb{R}$, unit [?]
Fragmentation constant of stubble.

#235 *METRX_KR_FRAG_WOOD*, θ_{MKFW} $\theta_{\text{MKFW}} \in [0.00005, 0.001] \subseteq \mathbb{R}$, unit [?]
Fragmentation constant of wood.

#236 *METRX_KR_DC_AORG*, θ_{MKDA} $\theta_{\text{MKDA}} \in [0.0005, 0.05] \subseteq \mathbb{R}$, unit [?]
Decomposition constant of active organic soil.

#237 *METRX_KR_DC_CEL*, θ_{MKDC} $\theta_{\text{MKDC}} \in [0.05, 1] \subseteq \mathbb{R}$, unit [?]
Decomposition constant of cellulose.

#238 *METRX_KR_DC_HUM1*, θ_{MKDH} $\theta_{\text{MKDH}} \in [0.002, 0.03] \subseteq \mathbb{R}$, unit [?]
Decomposition constant of labile humus.

#239 *METRX_KR_DC_HUM2*, θ^1_{MKDH} $\theta^1_{\text{MKDH}} \in [0.00005, 0.003] \subseteq \mathbb{R}$, unit [?]
Decomposition constant of recalcitrant young humus.

#240 *METRX_KR_DC_HUM3*, θ^2_{MKDH} $\theta^2_{\text{MKDH}} \in [0.000001, 0.000125] \subseteq \mathbb{R}$, unit [?]
Decomposition constant of recalcitrant old humus.

#241 *METRX_KR_DC_LIG*, θ_{MKDL} $\theta_{\text{MKDL}} \in [0.005, 0.05] \subseteq \mathbb{R}$, unit [?]
Decomposition constant of lignin.

#242 *METRX_KR_DC_SOL*, θ_{MKDS} $\theta_{\text{MKDS}} \in [0.1, 0.8] \subseteq \mathbb{R}$, unit [?]
Decomposition constant of solutes.

#243 *METRX_KR_DENIT_CHEMO*, θ^1_{MKDC} $\theta^1_{\text{MKDC}} \in [1, 20] \subseteq \mathbb{R}$, unit [?]
Rate constant for chemodenitrification.

#244 *METRX_KR_OX_FE*, θ_{MKOF} $\theta_{\text{MKOF}} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Rate constant of iron oxidation.

#245 *METRX_KR_HU_AORG_HUM1*, θ_{MKHAH} $\theta_{\text{MKHAH}} \in [0.0005, 0.1] \subseteq \mathbb{R}$, unit [?]
Rate constant for humification of active organic material to labile humus.

#246 *METRX_KR_HU_AORG_HUM2*, θ^1_{MKHAH} $\theta^1_{\text{MKHAH}} \in [0.0001, 0.1] \subseteq \mathbb{R}$, unit [?]
Rate constant for humification of active organic material to recalcitrant young humus.

#247 *METRX_KR_HU_LIG*, θ_{MKHL} $\theta_{\text{MKHL}} \in [0.001, 0.1] \subseteq \mathbb{R}$, unit [?]
Rate constant for humification of lignin.

#248 *METRX_KR_HU_CEL*, θ_{MKHC} $\theta_{\text{MKHC}} \in [0.0001, 0.01] \subseteq \mathbb{R}$, unit [?]
Rate constant for humification of cellulose to labile humus.

#249 *METRX_KR_HU_SOL*, θ_{MKHS} $\theta_{\text{MKHS}} \in [0, 0.1] \subseteq \mathbb{R}$, unit [?]
Rate constant for humification of solutes to labile humus.

#250 *METRX_KR_HU_HUM1*, θ_{MKHH} $\theta_{\text{MKHH}} \in [0.000001, 0.005] \subseteq \mathbb{R}$, unit [?]
Rate constant for humification of labile humus to recalcitrant young humus.

#251 *METRX_KR_HU_HUM2*, θ^1_{MKHH} $\theta^1_{\text{MKHH}} \in [0.0000001, 0.0005] \subseteq \mathbb{R}$, unit [?]
Rate constant for humification of recalcitrant young humus to recalcitrant old humus.

#252 *METRX_KR_UREAHYDROLYSIS*, θ_{MKU} $\theta_{\text{MKU}} \in [0.001, 0.1] \subseteq \mathbb{R}$, unit [?]
Rate constant for urea hydrolysis.

#253 *METRX_KR_REDUCTION_CN*, θ_{MKRC} $\theta_{\mathrm{MKRC}} \in [0.001, 0.01] \subseteq \mathbb{R}$, unit [?]
Decomposition reduction due to C:N ratio.

#254 *METRX_KR_REDUCTION_ANVF*, θ_{MKRA} $\theta_{\mathrm{MKRA}} \in [0.01, 1.2] \subseteq \mathbb{R}$, unit [?]
Decomposition reduction due anaerobicity.

#255 *METRX_KR_REDUCTION_CONIFEROUS*, $\theta^{1}_{\mathrm{MKRC}}$ $\theta^{1}_{\mathrm{MKRC}} \in [0.05, 1] \subseteq \mathbb{R}$, unit [?]
Decomposition reduction for coniferous litter.

#256 *METRX_LIG_HUMIFICATION*, θ_{MLH} $\theta_{\mathrm{MLH}} \in [0.0001, 0.9] \subseteq \mathbb{R}$, unit [?]
Factor determining split of humified lignin between labile humus and recalcitrant young humus.

#257 *METRX_RET_HUMUS*, θ_{MRH} $\theta_{\mathrm{MRH}} \in [0, 0.005] \subseteq \mathbb{R}$, unit [?]
Retention factor for humus leaching.

#258 *METRX_RET_LITTER*, θ_{MRL} $\theta_{\mathrm{MRL}} \in [0, 0.05] \subseteq \mathbb{R}$, unit [?]
Retention factor for litter leaching.

#259 *METRX_RET_MICROBES*, θ_{MRM} $\theta_{\mathrm{MRM}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Retention factor for microbes leaching.

#260 *METRX_TILL_STIMULATION_1*, θ_{MTS_1} $\theta_{\mathrm{MTS}_1} \in [1, 30] \subseteq \mathbb{R}$, unit [?]
Stimulation factor of decomposition after tilling event.

#261 *METRX_TILL_STIMULATION_2*, θ_{MTS_2} $\theta_{\mathrm{MTS}_2} \in [0.01, 0.5] \subseteq \mathbb{R}$, unit [?]
Factor determining the time period of stimulation after tilling event ().

#262 *METRX_V_EBULLITION*, θ_{MVE} $\theta_{\mathrm{MVE}} \in [0, 20] \subseteq \mathbb{R}$, unit [?]
Speed constant for ebullition.

#263 *SOILDNDC_GROWTH_N2O_DENIT*, θ_{SGND} $\theta_{\mathrm{SGND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on N2O.

#264 *SOILDNDC_GROWTH_NO_DENIT*, $\theta^{1}_{\mathrm{SGND}}$ $\theta^{1}_{\mathrm{SGND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on NO.

#265 *SOILDNDC_GROWTH_NO2_DENIT*, $\theta^{2}_{\mathrm{SGND}}$ $\theta^{2}_{\mathrm{SGND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on NO2.

#266 *SOILDNDC_GROWTH_NO3_DENIT*, θ^{3}_{SGND} $\theta^{3}_{\text{SGND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on NO3.

#267 *SOILDNDC_MAINTENANCE_N2O_DENIT*, θ_{SMND} $\theta_{\text{SMND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of N2O.

#268 *SOILDNDC_MAINTENANCE_NO_DENIT*, θ^{1}_{SMND} $\theta^{1}_{\text{SMND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of NO.

#269 *SOILDNDC_MAINTENANCE_NO2_DENIT*, θ^{2}_{SMND} $\theta^{2}_{\text{SMND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of NO2.

#270 *SOILDNDC_MAINTENANCE_NO3_DENIT*, θ^{3}_{SMND} $\theta^{3}_{\text{SMND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of NO3.

#271 *SOILDNDC_KMM_N2O_DENIT*, θ_{SKND} $\theta_{\text{SKND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for nitrogen dependency of denitrification.

#272 *SOILDNDC_KMM_NO_DENIT*, θ^{1}_{SKND} $\theta^{1}_{\text{SKND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for nitrogen dependency of denitrification.

#273 *SOILDNDC_KMM_NO2_DENIT*, θ^{2}_{SKND} $\theta^{2}_{\text{SKND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for nitrogen dependency of denitrification.

#274 *SOILDNDC_KMM_NO3_DENIT*, θ^{3}_{SKND} $\theta^{3}_{\text{SKND}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-menten constant for nitrogen dependency of denitrification.

#275 *M_FACT_DEC1*, θ_{MFD} $\theta_{\text{MFD}} \in [0.2975, 0.8925] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of decomposition on water filled pore space.

#276 *M_FACT_DEC2*, θ^{1}_{MFD} $\theta^{1}_{\text{MFD}} \in [4, 12] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of decomposition on water filled pore space.

#277 *M_FACT_P1*, θ_{MFP} $\theta_{\text{MFP}} \in [0.225, 0.675] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of nitrification on water filled pore space.

#278 *M_FACT_P2*, θ^{1}_{MFP} $\theta^{1}_{\text{MFP}} \in [20, 60] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of nitrification on water filled pore space.

#279 *M_FACT_P3*, θ^2_{MFP} $\theta^2_{\mathrm{MFP}} \in [0.275, 0.825] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of N2O production during nitrification on water filled pore space.

#280 *M_FACT_P4*, θ^3_{MFP} $\theta^3_{\mathrm{MFP}} \in [2.5, 7.5] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of N2O production during nitrification on water filled pore space.

#281 *M_FACT_P5*, θ^4_{MFP} $\theta^4_{\mathrm{MFP}} \in [0.1125, 0.3375] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of microbial activity on water filled pore space.

#282 *M_FACT_P6*, θ^5_{MFP} $\theta^5_{\mathrm{MFP}} \in [5, 15] \subseteq \mathbb{R}$, unit [?]
Factor determining dependency of microbial activity on water filled pore space.

#283 *MICRRESP*, θ^1_{M} $\theta^1_{\mathrm{M}} \in [0.04, 0.12] \subseteq \mathbb{R}$, unit [?]
Factor determining microbial respiration.

#284 *MN2O*, θ^2_{M} $\theta^2_{\mathrm{M}} \in [0.001, 0.1185] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of N2O.

#285 *MNO*, θ^3_{M} $\theta^3_{\mathrm{M}} \in [0.001, 0.1185] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of NO.

#286 *MNO2*, θ^4_{M} $\theta^4_{\mathrm{M}} \in [0.001, 0.0525] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of NO2.

#287 *MNO3*, θ^5_{M} $\theta^5_{\mathrm{M}} \in [0.001, 0.135] \subseteq \mathbb{R}$, unit [?]
Microbial maintenance coefficient for denitrification of NO3.

#288 *MUEMAX*, θ^6_{M} $\theta^6_{\mathrm{M}} \in [2.4365, 7.3095] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate.

#289 *MUE_N2O*, θ_{MN} $\theta_{\mathrm{MN}} \in [0.05, 20] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on N2O.

#290 *MUE_NO*, θ^1_{MN} $\theta^1_{\mathrm{MN}} \in [0.05, 20] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on NO.

#291 *MUE_NO2*, θ^2_{MN} $\theta^2_{\mathrm{MN}} \in [0.05, 20] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on NO2.

#292 *MUE_NO3*, θ^3_{MN} $\theta^3_{\mathrm{MN}} \in [0.05, 20] \subseteq \mathbb{R}$, unit [?]
Microbial growth rate for denitrification on NO3.

#293 *NH4_DENIMAX*, θ_{ND} $\theta_{\mathrm{ND}} \in [0.4, 0.99] \subseteq \mathbb{R}$, unit [?]
Maximum nitrification fraction of NH4.

#294 *PERTL*, θ_{P} $\theta_{\mathrm{P}} \in [0.00025, 0.00075] \subseteq \mathbb{R}$, unit [?]
Downward transport of labile litter.

#295 *PERTMAX*, θ^1_{P} $\theta^1_{\mathrm{P}} \in [0.15, 0.45] \subseteq \mathbb{R}$, unit [?]
Limit depth for litter transport [m].

#296 *PERTR*, θ^2_{P} $\theta^2_{\mathrm{P}} \in [0.00005, 0.00015] \subseteq \mathbb{R}$, unit [?]
Downward transport of recalcitrant litter.

#297 *PERTVL*, θ^3_{P} $\theta^3_{\mathrm{P}} \in [0.005, 0.015] \subseteq \mathbb{R}$, unit [?]
Downward transport of very labile litter.

#298 *PHCRIT_N2O*, θ_{PN} $\theta_{\mathrm{PN}} \in [2.5, 7.5] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of N2O denitrification.

#299 *PHCRIT_NO2*, θ^1_{PN} $\theta^1_{\mathrm{PN}} \in [3.05, 9.15] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of NO2 denitrification.

#300 *PHCRIT_NO3*, θ^2_{PN} $\theta^2_{\mathrm{PN}} \in [3.15, 9.45] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of NO3 denitrification.

#301 *PHDELTA_N2O*, θ^3_{PN} $\theta^3_{\mathrm{PN}} \in [0.3075, 0.9225] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of N2O denitrification.

#302 *PHDELTA_NO2*, θ^4_{PN} $\theta^4_{\mathrm{PN}} \in [0.72, 2.16] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of NO2 denitrification.

#303 *PHDELTA_NO3*, θ^5_{PN} $\theta^5_{\mathrm{PN}} \in [0.76, 2.28] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of NO3 denitrification.

#304 *PH_FACT_P2*, θ_{PFP} $\theta_{\mathrm{PFP}} \in [0.65, 1.95] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of nitrification.

#305 *PH_FACT_P3*, θ^1_{PFP} $\theta^1_{\mathrm{PFP}} \in [0.04, 0.12] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of nitrification.

#306 *PH_FACT_P4*, θ^2_{PFP} $\theta^2_{\mathrm{PFP}} \in [0.5, 1.5] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of N2O production during nitrification.

#307 *PH_FACT_P5*, θ^3_{PFP} $\theta^3_{\mathrm{PFP}} \in [1.875, 5.625] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of chemodenitrification.

#308 *PHMAX*, θ_{P}^{4} $\theta_{\mathrm{P}}^{4} \in [5, 15] \subseteq \mathbb{R}$, unit [?]
Maximum allowed pH value.

#309 *PHMIN*, θ_{P}^{5} $\theta_{\mathrm{P}}^{5} \in [1.25, 3.75] \subseteq \mathbb{R}$, unit [?]
Minimum allowed pH value.

#310 *PHMIN_CHEM*, θ_{PC} $\theta_{\mathrm{PC}} \in [2.5, 7.5] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of chemodenitrification.

#311 *PHOPT_CHEM*, θ_{PC}^{1} $\theta_{\mathrm{PC}}^{1} \in [0.3, 0.9] \subseteq \mathbb{R}$, unit [?]
Factor for pH dependency of chemodenitrification.

#312 *PSL_SC*, θ_{PS} $\theta_{\mathrm{PS}} \in [0.01, 0.03] \subseteq \mathbb{R}$, unit [?]
Empirical decrease of hydraulic conductivity of coarse discretized soil layers.

#313 *PSL_WC*, θ_{PW} $\theta_{\mathrm{PW}} \in [0.01, 0.1] \subseteq \mathbb{R}$, unit [?]
Base layer depth for evaporation decrease with depth [m].

#314 *PT_ALPHA*, θ_{PA} $\theta_{\mathrm{PA}} \in [0.5, 1.5] \subseteq \mathbb{R}$, unit [?]
Priestley-Taylor coefficient of advection.

#315 *RBO*, θ_{R} $\theta_{\mathrm{R}} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Fraction of inactive microbes in active organic material pool.

#316 *RCEC*, θ_{R}^{1} $\theta_{\mathrm{R}}^{1} \in [23, 69] \subseteq \mathbb{R}$, unit [?]
Factor determining CO2 production during decomposition.

#317 *RCLAY*, θ_{R}^{2} $\theta_{\mathrm{R}}^{2} \in [0.1, 0.9] \subseteq \mathbb{R}$, unit [?]
Factor determining clay dependency of soil water evaporation.

#318 *RCNB*, θ_{R}^{3} $\theta_{\mathrm{R}}^{3} \in [4, 12] \subseteq \mathbb{R}$, unit [?]
C:N ratio of inactive microbes in active organic material pool.

#319 *RCNH*, θ_{R}^{4} $\theta_{\mathrm{R}}^{4} \in [6, 18] \subseteq \mathbb{R}$, unit [?]
C:N ratio of humads in active organic material pool.

#320 *RCNM*, θ_{R}^{5} $\theta_{\mathrm{R}}^{5} \in [4.9, 14.7] \subseteq \mathbb{R}$, unit [?]
C:N ratio of humus.

#321 *RCNRR*, θ_{R}^{6} $\theta_{\mathrm{R}}^{6} \in [120, 360] \subseteq \mathbb{R}$, unit [?]
C:N ratio of resistant residues.

#322 *RCNRVL*, θ_{R}^{7} $\theta_{\mathrm{R}}^{7} \in [12, 36] \subseteq \mathbb{R}$, unit [?]
C:N ratio of very labile residues.

#323 *RETDOC*, θ_{R}^{8} $\theta_{\mathrm{R}}^{8} \in [0,1] \subseteq \mathbb{R}$, unit [?]
Retention coefficient of DOC leaching.

#324 *RETNO3*, θ_{R}^{9} $\theta_{\mathrm{R}}^{9} \in [0,1] \subseteq \mathbb{R}$, unit [?]
Retention coefficient of NO3 leaching.

#325 *RETNH4*, θ_{R}^{10} $\theta_{\mathrm{R}}^{10} \in [0,1] \subseteq \mathbb{R}$, unit [?]
Retention coefficient of NH4 leaching.

#326 *RETSO4*, θ_{R}^{11} $\theta_{\mathrm{R}}^{11} \in [0,1] \subseteq \mathbb{R}$, unit [?]
Retention coefficient of SO4 leaching.

#327 *ROOT_DEPENDENT_TRANS*, θ_{RDT} $\theta_{\mathrm{RDT}} \in [-1,1] \subseteq \mathbb{R}$, unit [%]
Increases dependence of transpiration on roots.

#328 *ROOT_LENGTH_H2O_UP*, θ_{RLHU} $\theta_{\mathrm{RLHU}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
If root length instead of mass should be used for determining H2O uptake and drought stress.

#329 *ROOT_WATER_UPTAKE_COUVREUR*, θ_{RWUC} $\theta_{\mathrm{RWUC}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
On/off of Couvreur model.

#330 *SHR*, θ_{S} $\theta_{\mathrm{S}} \in [0.08, 0.24] \subseteq \mathbb{R}$, unit [?]
Fraction of labile humads.

#331 *SLOPE_CLAYF*, θ_{SC} $\theta_{\mathrm{SC}} \in [0.05, 0.08] \subseteq \mathbb{R}$, unit [?]
Factor determining clay dependency of soil water evaporation.

#332 *SLOPE_FF*, θ_{SF} $\theta_{\mathrm{SF}} \in [0.5, 2] \subseteq \mathbb{R}$, unit [?]
Specific slope factor for water flux from litter layers.

#333 *SLOPE_MS*, θ_{SM} $\theta_{\mathrm{SM}} \in [2, 3] \subseteq \mathbb{R}$, unit [?]
Specific slope factor for water flux from mineral soil.

#334 *SRB*, θ_{S}^{1} $\theta_{\mathrm{S}}^{1} \in [0.45, 0.99] \subseteq \mathbb{R}$, unit [?]
Fraction of labile inactive microbes.

#335 *SUCCESSION_N_TREE_INIT*, θ_{SNTI} $\theta_{\mathrm{SNTI}} \in [100, 20000] \subseteq \mathbb{R}$, unit [?]
New trees planted during succession.

#336 *SUCCESSION_HEIGHT_TREE_INIT*, θ_{SHTI} $\theta_{\mathrm{SHTI}} \in [0.1, 10] \subseteq \mathbb{R}$, unit [?]
Initial tree height during succession.

#337 *SUCCESSION_INTERVAL_S*, θ_{SIS} $\theta_{\mathrm{SIS}} \in [1, 100] \subseteq \mathbb{R}$, unit [?]
Years for regrowth of young tree during succession.

#338 *SUCCESSION_INTERVAL_L*, θ_{SIL} $\theta_{\mathrm{SIL}} \in [2, 1000] \subseteq \mathbb{R}$, unit [?]
Generation time in years for succession.

#339 *TEXP*, θ_{T} $\theta_{\mathrm{T}} \in [0.862, 2.586] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of diffusion between aerobic and anaerobic soil.

#340 *TF_CHEM1*, θ_{TC} $\theta_{\mathrm{TC}} \in [0.05, 0.15] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of chemodenitrification.

#341 *TF_CHEM2*, θ^1_{TC} $\theta^1_{\mathrm{TC}} \in [0.065, 0.195] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of chemodenitrification.

#342 *TFDAY*, θ^1_{T} $\theta^1_{\mathrm{T}} \in [1, 100] \subseteq \mathbb{R}$, unit [?]
Factor determining length of tilling effect on decomposition.

#343 *TF_DEC1*, θ_{TD} $\theta_{\mathrm{TD}} \in [1.77, 5.31] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of decomposition.

#344 *TF_DEC2*, θ^1_{TD} $\theta^1_{\mathrm{TD}} \in [18.5, 55.5] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of decomposition.

#345 *TF_DEN1*, θ^2_{TD} $\theta^2_{\mathrm{TD}} \in [2, 6] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of denitrification.

#346 *TF_DEN2*, θ^3_{TD} $\theta^3_{\mathrm{TD}} \in [20, 60] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of denitrification.

#347 *TFMAX*, θ^2_{T} $\theta^2_{\mathrm{T}} \in [1, 10] \subseteq \mathbb{R}$, unit [?]
Factor determining tilling intensity dependency on tilling depth.

#348 *TF_NUP_N2O1*, θ_{TNN} $\theta_{\mathrm{TNN}} \in [0.02755, 0.08265] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of N2O production during nitrification.

#349 *TF_NUP_N2O2*, θ^1_{TNN} $\theta^1_{\mathrm{TNN}} \in [4.705, 14.115] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of N2O production during nitrification.

#350 *TF_NUP_NO1*, θ^2_{TNN} $\theta^2_{\mathrm{TNN}} \in [0.011875, 0.035625] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of NO production during nitrification.

#351 *TF_NUP_NO2*, θ^3_{TNN} $\theta^3_{\mathrm{TNN}} \in [4.45, 13.35] \subseteq \mathbb{R}$, unit [?]
Temperature dependency of NO production during nitrification.

#352 *TICE*, θ_{T}^{3} $\theta_{\mathrm{T}}^{3} \in [0, 4] \subseteq \mathbb{R}$, unit [?]
Empirical coefficient to derive ice temperature.

#353 *TREF*, θ_{T}^{4} $\theta_{\mathrm{T}}^{4} \in [22.5, 67.5] \subseteq \mathbb{R}$, unit [?]
Reference temperature for NH3 volatilization.

#354 *SNOWDNDC_SNOWFALL_TEMPERATURE_LIMIT*, θ_{SSTL} $\theta_{\mathrm{SSTL}} \in [-1, 5] \subseteq \mathbb{R}$, unit [?]
Temperature limit for snowfall.

#355 *WCDNDC_EVALIM_FRAC_WCMIN*, θ_{WEFW} $\theta_{\mathrm{WEFW}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Fraction of wilting point which determines minimum water content of soil water evaporation.

#356 *WCDNDC_HAVE_CAPILLARY_ACTION*, θ_{WHCA} $\theta_{\mathrm{WHCA}} \in \{true, false\} \subseteq \mathbb{B}$, unit [?]
On/off of capillary action.

#357 *WCDNDC_INCREASE_POT_EVAPOTRANS*, θ_{WIPE} $\theta_{\mathrm{WIPE}} \in [0, 10] \subseteq \mathbb{R}$, unit [?]
Increases / decreases potential evapotranspiration.

Supported formats are

1. `xml`: see example **??** for XML formatted site parameters.
2. `resources`: can be locally overwritten to set an alternative global default.

3.2.7.1 Formats

XML Two short examples:

```
<?xml version="1.0"?>
<ldndcsiteparameters>
    <!--
      id .. block id
    -->

    <siteparameters id="0" >
        <!-- cut aboveground biomass remains -->
        <par name="leftgrass" value="100.0" />
```

```
        <!-- cut belowground biomass fraction -->
        <par name="frcutr" value="0.3" />
    </siteparameters>

    <siteparameters id="1" >
        <par name="leftgrass" value="100.0" />
        <par name="frcutr" value="0.9" />
    </siteparameters>

</ldndcsiteparameters>
```

A full reference example:

```
<?xml version="1.0"?>
<ldndcsiteparameters>
  <!--
    id .. block id
  -->

  <siteparameters id="0" >

    <!-- #1 Microbial death rate -->
    <par name="amaxx" value="0.6545 .. 1.9635" />
    <!-- #2 Fraction of water distributed directly across the r... -->
    <par name="by_passf" value="0 .. 24" />
    <!-- #3 Maximum depth of cracks [m] -->
    <par name="crack_depth" value="0 .. 2" />
    <!-- #4 Fraction of water that infiltrates via cracks [-] -->
    <par name="crack_fraction" value="0 .. 1" />
    <!-- #5 Factor determining anaerobic volume fraction depend... -->
    <par name="deconit_anvf1" value="2 .. 8" />
    <!-- #6 Factor determining anaerobic volume fraction depend... -->
    <par name="deconit_anvf2" value="4 .. 10" />
    <!-- #7 Decomposition reduction for coniferous litter -->
    <par name="deconit_cdecfac" value="0.1 .. 0.6" />
    <!-- #8 Denitrifier fraction of total microbial biomass -->
    <par name="deconit_dfdeni" value="0.0005 .. 0.01" />
    <!-- #9 Denitrifier fraction of total microbial biomass dur... -->
    <par name="deconit_dfdenifrost" value="0.0005 .. 0.01" />
    <!-- #10 Microbial death rate -->
    <par name="deconit_d_het" value="0.001 .. 0.1" />
    <!-- #11 Diffusion coefficient -->
    <par name="deconit_d_ngas" value="0.1 .. 2" />
    <!-- #12 Exponential reduction factor of decomposition depen... -->
    <par name="deconit_dk_lignin" value="1 .. 5" />
    <!-- #13 Microbial efficiency of carbon assimilation -->
    <par name="deconit_eff_doc" value="0.1 .. 0.9" />
    <!-- #14 Microbial efficiency of organic nitrogen assimilati... -->
    <par name="deconit_eff_don" value="0.0005 .. 0.01" />
    <!-- #15 Microbial efficiency of ammonium assimilation -->
    <par name="deconit_eff_nh4" value="0.1 .. 0.9" />
    <!-- #16 Microbial efficiency of nitrite assimilation -->
    <par name="deconit_eff_no2" value="0.001 .. 0.1" />
```

```
<!-- #17 Determines NO production during nitrification -->
<par name="deconit_fno" value="0.005 .. 0.1" />
<!-- #18 Determines NO2 production during denitrification -->
<par name="deconit_fno2_den" value="0.1 .. 0.9" />
<!-- #19 Determines N2O production during nitrification -->
<par name="deconit_fn2o" value="0.00005 .. 0.001" />
<!-- #20 Rate constant for NO production during chemodenitri... -->
<par name="deconit_kchem" value="0.000005 .. 0.0001" />
<!-- #21 Decomposition constant for cellulose -->
<par name="deconit_k_cell" value="0.001 .. 0.02" />
<!-- #22 Decomposition constant for lignin -->
<par name="deconit_k_lignin" value="0.001 .. 0.02" />
<!-- #23 Decomposition constant for solutes -->
<par name="deconit_k_sol" value="0.005 .. 0.2" />
<!-- #24 Decomposition constant for humus -->
<par name="deconit_k_h" value="0.0001 .. 0.001" />
<!-- #25 Rate constant for microbial carbon assimilation -->
<par name="deconit_k_doc" value="100 .. 1000" />
<!-- #26 Rate constant for microbial nitrogen assimilation -->
<par name="deconit_km_n" value="1 .. 100" />
<!-- #27 Retention coefficient for leaching -->
<par name="deconit_leachf" value="0.01 .. 0.9" />
<!-- #28 Optimum temperature for decomposition -->
<par name="deconit_mudec" value="10 .. 40" />
<!-- #29 Factor determining pH dependency of chemodenitrific... -->
<par name="deconit_phmin_chem" value="3 .. 7" />
<!-- #30 Factor determining pH dependency of chemodenitrific... -->
<par name="deconit_phopt_chem" value="0.4 .. 0.8" />
<!-- #31 Factor determining pH dependency of chemodenitrific... -->
<par name="deconit_ph_fact_p5" value="2 .. 5" />
<!-- #32 Factor determining temperature dependency of chemod... -->
<par name="deconit_tf_chem1" value="0.1 .. 0.4" />
<!-- #33 Factor determining temperature dependency of chemod... -->
<par name="deconit_tf_chem2" value="0.01 .. 0.1" />
<!-- #34 Normalization temperature for diffusion -->
<par name="deconit_tnorm" value="290 .. 300" />
<!-- #35 Factor determining dependency of decomposition on t... -->
<par name="deconit_tsigma" value="11 .. 15" />
<!-- #36 Factor determining dependency of decomposition on w... -->
<par name="deconit_wshape" value="1 .. 3" />
<!-- #37 Factor determining dependency of decomposition on w... -->
<par name="deconit_wfps_opt" value="0.1 .. 1" />
```

```
<!-- #38 Microbial denitrifier fraction -->
<par name="denifrac" value="0.1 .. 0.9" />
<!-- #39 Diffusion constant for carbon compounds between aer... -->
<par name="diff_c" value="0.125 .. 0.375" />
<!-- #40 Diffusion constant for nitrogen compounds between a... -->
<par name="diff_n" value="0.25 .. 0.75" />
<!-- #41 Reduction constant for N2O diffusion -->
<par name="d_n2o" value="0.031 .. 0.093" />
<!-- #42 Reduction constant for NO diffusion -->
<par name="d_no" value="0.0365 .. 0.1095" />
<!-- #43 Michaelis-Menten constant for the influence of fine... -->
<par name="echy_kmm_roots" value="0.001 .. 1" />
<!-- #44 Exponent for depth dependency of soil-evaporation [... -->
<par name="echy_evaporation_depth_limit_exponent" value="5 .. 20" />
<!-- #45 Maximum reduction due to nitrification inhibitors -->
<par name="eef_maximum_nitrification_inhibition" value="0 .. 1" />
<!-- #46 Parameter for decomposition of nitrification inhibi... -->
<par name="eef_nitrification_inhibition_stability_1" value="-5 .. 0" />
<!-- #47 Parameter for decomposition of nitrification inhibi... -->
<par name="eef_nitrification_inhibition_stability_2" value="0 .. 0.01" />
<!-- #48 Parameter for dilution efficiency of nitrification ... -->
<par name="eef_nitrification_inhibition_dilution" value="0.1 .. 10" />
<!-- #49 Temperature coefficient for controlled release fert... -->
<par name="eef_controlled_release_q10" value="1 .. 10" />
<!-- #50 Lag period (days) for nitrogen release of applied c... -->
<par name="eef_controlled_release_lag_period" value="0 .. 30" />
<!-- #51 Duration (days) for 80% release of applied controll... -->
<par name="eef_controlled_release_t80" value="25 .. 100" />
<!-- #52 Influence of water filled pore space on controlled ... -->
<par name="eef_controlled_release_wfps_factor" value="0 .. 1" />
<!-- #53 Fraction of decomposed carbon that goes to the diss... -->
<par name="effac" value="0.35 .. 0.95" />
<!-- #54 Microbial efficiency for N2O denitrification -->
<par name="eff_n2o" value="0.0375 .. 0.1125" />
<!-- #55 Microbial efficiency for NO denitrification -->
<par name="eff_no" value="0.0755 .. 0.2265" />
<!-- #56 Microbial efficiency for NO2 denitrification -->
<par name="eff_no2" value="0.214 .. 0.642" />
<!-- #57 Microbial efficiency for NO3 denitrification -->
<par name="eff_no3" value="0.2005 .. 0.6015" />
<!-- #58 Maximum depth of soil-evaporation [m] -->
<par name="evalim" value="0.01 .. 2" />
```

```
<!-- #59 Factor accounting for soil porosity effect on nitro... -->
<par name="exp1_nx" value="1.5 .. 2" />
<!-- #60 Factor accounting for soil porosity effect on O2 ef... -->
<par name="exp1_o2" value="1.5 .. 2" />
<!-- #61 Factor accounting for soil porosity effect on nitro... -->
<par name="exp2_nx" value="1.5 .. 2" />
<!-- #62 Factor accounting for soil porosity effect on O2 ef... -->
<par name="exp2_o2" value="0.5 .. 2" />
<!-- #63 Fraction of black carbon of burned total carbon -->
<par name="fire_frac_blackcarbon" value="0.01 .. 0.04" />
<!-- #64 Fraction of nh4 of burned total nitrogen -->
<par name="fire_frac_nh4" value="0.1 .. 1" />
<!-- #65 Fraction of no3 of burned total nitrogen -->
<par name="fire_frac_no3" value="0.1 .. 1" />
<!-- #66 Factor for clay dependency of humads decomposition ... -->
<par name="fclay1" value="0.07 .. 0.21" />
<!-- #67 Factor for clay dependency of humads decomposition ... -->
<par name="fclay2" value="1.1513 .. 3.4539" />
<!-- #68 Factor for CO2 production during humads decompositi... -->
<par name="fco2_1" value="0.605 .. 1.815" />
<!-- #69 Factor for CO2 production during humads decompositi... -->
<par name="fco2_2" value="1.12 .. 3.36" />
<!-- #70 Factor for CO2 production during humads decompositi... -->
<par name="fco2_3" value="1.15 .. 3.45" />
<!-- #71 Factor for CO2 production during humads decompositi... -->
<par name="fco2_4" value="0.0425 .. 0.1275" />
<!-- #72 Factor for CO2 production during humads decompositi... -->
<par name="fco2_hu" value="0.4 .. 1.2" />
<!-- #73 Fraction of decomposed labile litter that is assimi... -->
<par name="fdl" value="0.25 .. 0.75" />
<!-- #74 Fraction of decomposed recalcitrant litter that is ... -->
<par name="fdr" value="0.175 .. 0.525" />
<!-- #75 Fraction of decomposed very labile litter that is a... -->
<par name="fdvl" value="0.325 .. 0.975" />
<!-- #76 Factor steering NO3 availability for microbial assi... -->
<par name="fno3_u" value="0.375 .. 0.9" />
<!-- #77 Fraction of surface water that goes into runoff [d... -->
<par name="fpercol" value="0.1 .. 0.9" />
<!-- #78 Fractions of liquid carbon in beancake manure -->
<par name="frac_labile_c_beancake" value="0 .. 1" />
<!-- #79 Fractions of liquid nitrogen in beancake manure -->
<par name="frac_labile_n_beancake" value="0 .. 1" />
```

```
<!-- #80 Fractions of liquid carbon in farmyard manure -->
<par name="frac_labile_c_farmyard" value="0 .. 1" />
<!-- #81 Fractions of liquid nitrogen in farmyard manure -->
<par name="frac_labile_n_farmyard" value="0 .. 1" />
<!-- #82 Fractions of liquid carbon in slurry manure -->
<par name="frac_labile_c_slurry" value="0 .. 1" />
<!-- #83 Fractions of liquid nitrogen in slurry manure -->
<par name="frac_labile_n_slurry" value="0 .. 1" />
<!-- #84 Fractions of liquid carbon in compost manure -->
<par name="frac_labile_c_compost" value="0 .. 1" />
<!-- #85 Fractions of liquid nitrogen in compost manure -->
<par name="frac_labile_n_compost" value="0 .. 1" />
<!-- #86 Factor accounting for litter availability dependenc... -->
<par name="frc" value="0.025 .. 0.075" />
<!-- #87 Fraction of fine root that dies after cutting event -->
<par name="frcutr" value="0 .. 0.4" />
<!-- #88 Fraction of daily runoff from surface water [m day... -->
<par name="frunoff" value="0 .. 24" />
<!-- #89 Factor steering dissimilatory nitrate reduction to ... -->
<par name="ftrans" value="0.0025 .. 0.0075" />
<!-- #90 Time needed for complete replenishment of groundwat... -->
<par name="groundwater_nutrient_renewal" value="0 .. 24" />
<!-- #91 Fraction of soil water flux in the saturated zone (... -->
<par name="groundwater_percolation" value="0 .. 1" />
<!-- #92 Lateral distance that has a groundwater level diffe... -->
<par name="groundwater_lateral_gradient" value="0 .. 100000" />
<!-- #93 Reduction of hydraulic conductivity in presence of ... -->
<par name="impedance_par" value="0 .. 1" />
<!-- #94 Reaction rate for chemo-denitrification [h-1] -->
<par name="kchem" value="4 .. 12" />
<!-- #95 Decomposition constant for labile inactive microbes -->
<par name="kcrb_l" value="0.04625 .. 0.13875" />
<!-- #96 Decomposition constant for recalcitrant inactive mi... -->
<par name="kcrb_r" value="0.00111 .. 0.00333" />
<!-- #97 Decomposition constant for labile humads -->
<par name="khdc_l" value="0.00037 .. 0.00111" />
<!-- #98 Decomposition constant for recalcitrant humads -->
<par name="khdc_r" value="0.000185 .. 0.000555" />
<!-- #99 Ice dependency on effective diffusion coefficient -->
<par name="kice" value="0.375 .. 1.125" />
<!-- #100 Decomposition constant for raw litter -->
<par name="klraw" value="0.01 .. 0.1" />
```

```
<!-- #101 Michaelis-menten constant for carbon dependency of ... -->
<par name="dndc_kmm_c_denit" value="0.0085 .. 0.0255" />
<!-- #102 Michaelis-menten constant for nitrogen dependency o... -->
<par name="dndc_kmm_n_denit" value="? .. ?" />
<!-- #103 Michaelis-menten constant for carbon dependency of ... -->
<par name="dndc_kmm_c_mic" value="0.001 .. 0.009" />
<!-- #104 Michaelis-menten constant for nitrogen dependency o... -->
<par name="dndc_kmm_n_mic" value="0.0005 .. 0.003" />
<!-- #105 Michaelis-menten constant for nitrogen dependency o... -->
<par name="dndc_kmm_no3_transnh4" value="0.00001 .. 0.0002" />
<!-- #106 Michaelis-menten constant for NH4 dependency of nit... -->
<par name="dndc_kmm_nh4_nit" value="0.0000442 .. 0.0001326" />
<!-- #107 Michaelis-menten constant for NO2 dependency of nit... -->
<par name="dndc_kmm_no2_nit" value="0.00000125 .. 0.00000375" />
<!-- #108 Michaelis-menten constant for O2 dependency of deco... -->
<par name="dndc_kmm_o2_decomp" value="0.1 .. 0.5" />
<!-- #109 Reaction rate for N2O reductase -->
<par name="kn2o" value="0.0025 .. 0.0225" />
<!-- #110 Reaction rate for nitrification -->
<par name="knit" value="0.5 .. 10" />
<!-- #111 Reaction rate for NO reductase -->
<par name="kno" value="0.001 .. 0.003" />
<!-- #112 Decomposition rate for humus pool -->
<par name="krch" value="0.000001 .. 0.00001" />
<!-- #113 Decomposition rate for labile carbon pool [1 / day]... -->
<par name="krcl" value="0.00925 .. 0.08325" />
<!-- #114 Decomposition rate for recalcitrant carbon pool [1 ... -->
<par name="krcr" value="0.0037 .. 0.0111" />
<!-- #115 Decomposition rate for very labile carbon pool [1 /... -->
<par name="krcvl" value="0.0185 .. 0.185" />
<!-- #116 Minimum amount of grass that needs to be remained a... -->
<par name="leftgrass" value="0 .. 1000" />
<!-- #117 Fraction of DON in organic fertilizer (slurry manur... -->
<par name="liqdon_slurry" value="0 .. 1" />
<!-- #118 Fraction of NH4 in organic fertilizer (slurry manur... -->
<par name="liqnh4_slurry" value="0 .. 1" />
<!-- #119 Fraction of NO3 in organic fertilizer (slurry manur... -->
<par name="liqno3_slurry" value="0 .. 1" />
<!-- #120 Fraction of UREA in organic fertilizer (slurry manu... -->
<par name="liqurea_slurry" value="0 .. 1" />
<!-- #121 Fraction of DON in organic fertilizer (farmyard man... -->
<par name="liqdon_farmyard" value="0 .. 1" />
```

```
<!-- #122 Fraction of NH4 in organic fertilizer (farmyard man... -->
<par name="liqnh4_farmyard" value="0 .. 1" />
<!-- #123 Fraction of NO3 in organic fertilizer (farmyard man... -->
<par name="liqno3_farmyard" value="0 .. 1" />
<!-- #124 Fraction of UREA in organic fertilizer (farmyard ma... -->
<par name="liqurea_farmyard" value="0 .. 1" />
<!-- #125 Fraction of DON in organic fertilizer (compost manu... -->
<par name="liqdon_compost" value="0 .. 1" />
<!-- #126 Fraction of NH4 in organic fertilizer (compost manu... -->
<par name="liqnh4_compost" value="0 .. 1" />
<!-- #127 Fraction of NO3 in organic fertilizer (compost manu... -->
<par name="liqno3_compost" value="0 .. 1" />
<!-- #128 Fraction of UREA in organic fertilizer (compost man... -->
<par name="liqurea_compost" value="0 .. 1" />
<!-- #129 Maximum snow melting rate [m day-1 K-1] -->
<par name="mcoeff" value="0.0001 .. 0.003" />
<!-- #130 Maximum microbial death rate -->
<par name="metrx_amax" value="0.1 .. 3" />
<!-- #131 Maximum decay rate of algae -->
<par name="metrx_amax_algae" value="0.01 .. 0.1" />
<!-- #132 Exponential factor for litter decomposition reducti... -->
<par name="metrx_beta_litter_type" value="1 .. 3" />
<!-- #133 Microbial nitrogen use efficiency -->
<par name="metrx_biosynth_eff" value="0.3 .. 0.8" />
<!-- #134 C:N ratio of algae -->
<par name="metrx_cn_algae" value="10 .. 40" />
<!-- #135 C:N ratio fraction of humus 3 pool in relation to s... -->
<par name="metrx_cn_frac_hum3" value="0 .. 1" />
<!-- #136 Maximum allowed C:N ratio for microbes -->
<par name="metrx_cn_mic_max" value="10 .. 20" />
<!-- #137 Minimum allowed C:N ratio for microbes -->
<par name="metrx_cn_mic_min" value="2 .. 8" />
<!-- #138 Reduction factor for gas diffusion -->
<par name="metrx_d_eff_reduction" value="0.01 .. 10" />
<!-- #139 Diffusive mixing factor for soil organic matter due... -->
<par name="metrx_f_pertubation_mix" value="0.0000001 .. 0.001" />
<!-- #140 Exponential factor for vertical decline of diffusiv... -->
<par name="metrx_f_pertubation_exp" value="0.01 .. 2" />
<!-- #141 Factor for calculation of relaxed anaerobic soil vo... -->
<par name="metrx_f_ranvf_1" value="0.5 .. 4" />
<!-- #142 Factor for calculation of relaxed anaerobic soil vo... -->
<par name="metrx_f_ranvf_2" value="4 .. 20" />
```

```
<!-- #143 Factor for calculation of strict anaerobic soil vol... -->
<par name="metrx_f_sanvf_1" value="0.5 .. 4" />
<!-- #144 Factor for calculation of strict anaerobic soil vol... -->
<par name="metrx_f_sanvf_2" value="4 .. 20" />
<!-- #145 Factor for calculation of pore connectivity -->
<par name="metrx_f_connectivity_1" value="-1 .. 1" />
<!-- #146 Factor for calculation of pore connectivity -->
<par name="metrx_f_connectivity_2" value="0 .. 30" />
<!-- #147 Factor for pH dependency of chemodenitrification -->
<par name="metrx_f_chemodenit_ph_1" value="1 .. 3" />
<!-- #148 Factor for pH dependency of chemodenitrification -->
<par name="metrx_f_chemodenit_ph_2" value="1 .. 4" />
<!-- #149 Factor for temperature dependency of chemodenitrifi... -->
<par name="metrx_f_chemodenit_t_1" value="100 .. 10000000000" />
<!-- #150 Factor for temperature dependency of chemodenitrifi... -->
<par name="metrx_f_chemodenit_t_2" value="1000 .. 10000000" />
<!-- #151 Factor for water filled pore space dependency of mi... -->
<par name="metrx_f_mic_m_weibull_1" value="0 .. 0.9" />
<!-- #152 Factor for water filled pore space dependency of mi... -->
<par name="metrx_f_mic_m_weibull_2" value="1 .. 30" />
<!-- #153 Factor for cn ratio dependency of decomposition -->
<par name="metrx_f_decomp_cn_1" value="0 .. 2" />
<!-- #154 Factor for cn ratio dependency of decomposition -->
<par name="metrx_f_decomp_cn_2" value="10 .. 80" />
<!-- #155 Factor for water filled pore space dependency of de... -->
<par name="metrx_f_decomp_m_weibull_1" value="0 .. 0.9" />
<!-- #156 Factor for water filled pore space dependency of de... -->
<par name="metrx_f_decomp_m_weibull_2" value="5 .. 15" />
<!-- #157 Factor for temperature dependency of ch4 oxidation -->
<par name="metrx_f_ch4_oxidation_t_exp_1" value="0.5 .. 10" />
<!-- #158 Factor for temperature dependency of ch4 oxidation -->
<par name="metrx_f_ch4_oxidation_t_exp_2" value="25 .. 45" />
<!-- #159 Factor for ph dependency of ch4 production -->
<par name="metrx_f_ch4_production_ph_1" value="0.5 .. 4" />
<!-- #160 Factor for ph dependency of ch4 production -->
<par name="metrx_f_ch4_production_ph_2" value="0.5 .. 6" />
<!-- #161 Factor for ph dependency of ch4 production -->
<par name="metrx_f_ch4_production_ph_3" value="4 .. 10" />
<!-- #162 Factor for temperature dependency of ch4 production -->
<par name="metrx_f_ch4_production_t_exp_1" value="0.5 .. 10" />
<!-- #163 Factor for temperature dependency of ch4 production -->
<par name="metrx_f_ch4_production_t_exp_2" value="25 .. 45" />
```

```
<!-- #164 Factor for temperature dependency of decomposition -->
<par name="metrx_f_decomp_t_exp_1" value="0.5 .. 5" />
<!-- #165 Factor for temperature dependency of decomposition -->
<par name="metrx_f_decomp_t_exp_2" value="25 .. 45" />
<!-- #166 Factor for pH dependency of decomposition -->
<par name="metrx_f_decomp_ph_1" value="0.5 .. 5" />
<!-- #167 Factor for pH dependency of decomposition -->
<par name="metrx_f_decomp_ph_2" value="0.1 .. 5" />
<!-- #168 (0... -->
<par name="metrx_f_decomp_clay_1" value="0 .. 1" />
<!-- #169 Factor for clay-dependent decomposition determining... -->
<par name="metrx_f_decomp_clay_2" value="0 .. 10" />
<!-- #170 Factor for temperature dependency of microbial acti... -->
<par name="metrx_f_mic_t_exp_1" value="0.5 .. 5" />
<!-- #171 Factor for temperature dependency of microbial acti... -->
<par name="metrx_f_mic_t_exp_2" value="25 .. 45" />
<!-- #172 Factor determining minimum fraction of denitrified ... -->
<par name="metrx_f_denit_n2_1" value="0 .. 1" />
<!-- #173 Factor determining maximum fraction of denitrified ... -->
<par name="metrx_f_denit_n2_2" value="0 .. 1" />
<!-- #174 Factor determining ph dependency of denitrification... -->
<par name="metrx_f_denit_ph_1" value="2 .. 7" />
<!-- #175 Factor determining ph dependency of denitrification -->
<par name="metrx_f_denit_ph_2" value="0.2 .. 1.5" />
<!-- #176 Factor determining ph dependency of denitrification... -->
<par name="metrx_f_denit_n2o_ph_1" value="2 .. 7" />
<!-- #177 Factor determining ph dependency of denitrification -->
<par name="metrx_f_denit_n2o_ph_2" value="0.2 .. 1.5" />
<!-- #178 Exponential factor determining how much denitrified... -->
<par name="metrx_f_denit_no" value="1 .. 20" />
<!-- #179 Factor for water filled pore space dependency of de... -->
<par name="metrx_f_denit_m_weibull_1" value="0 .. 0.99" />
<!-- #180 Factor for water filled pore space dependency of de... -->
<par name="metrx_f_denit_m_weibull_2" value="5 .. 40" />
<!-- #181 Factor determining algae growth depending on nitrog... -->
<par name="metrx_f_n_algae" value="0 .. 1" />
<!-- #182 Factor determining CH4 oxidation depending on nitro... -->
<par name="metrx_f_n_ch4_oxidation" value="0 .. 1" />
<!-- #183 Ration of microbes able to nitrify -->
<par name="metrx_f_nit_frac_mic" value="0 .. 1" />
<!-- #184 Ration of microbes able to nitrify -->
<par name="metrx_f_nit_max_mic" value="0.02 .. 1" />
```

```
<!-- #185 Factor for water filled pore space dependency of no... -->
<par name="metrx_f_nit_no_m_exp_1" value="0 .. 20" />
<!-- #186 Factor for water filled pore space dependency of no... -->
<par name="metrx_f_nit_no_m_exp_2" value="-1.1 .. 1.1" />
<!-- #187 Factor for temperature dependency of no production ... -->
<par name="metrx_f_nit_no_n2o_t_exp_1" value="0.01 .. 0.1" />
<!-- #188 Factor for temperature dependency of no production ... -->
<par name="metrx_f_nit_no_n2o_t_exp_2" value="1 .. 20" />
<!-- #189 Factor for water filled pore space dependency of n2... -->
<par name="metrx_f_nit_no_n2o_m_weibull_1" value="0 .. 1" />
<!-- #190 Factor for water filled pore space dependency of n2... -->
<par name="metrx_f_nit_no_n2o_m_weibull_2" value="0 .. 30" />
<!-- #191 Redox active fraction of total iron -->
<par name="metrx_fe_reduction" value="0 .. 1" />
<!-- #192 Fraction of iron that has to be reduced before CH4 ... -->
<par name="metrx_frac_fe_ch4_prod" value="0 .. 1" />
<!-- #193 Fraction of decomposed nitrogen being mineralized -->
<par name="metrx_frac_mineral" value="0 .. 1" />
<!-- #194 Microbial carbon use efficiency under aerobic condi... -->
<par name="metrx_mic_eff_aerobic_respiration" value="0.1 .. 1" />
<!-- #195 Microbial carbon use efficiency under anaerobic con... -->
<par name="metrx_mic_eff_anaerobic_respiration" value="0.1 .. 1" />
<!-- #196 Microbial use efficiency of methane oxidation -->
<par name="metrx_mic_eff_methane_oxidation" value="0.1 .. 1" />
<!-- #197 Growth rate constant for algae growth -->
<par name="metrx_muemax_c_algae" value="0.0000001 .. 0.000002" />
<!-- #198 Growth rate of high affinity methane oxidation micr... -->
<par name="metrx_muemax_c_ch4_ox_ha" value="0.0001 .. 2" />
<!-- #199 Growth rate of high affinity methane oxidation micr... -->
<par name="metrx_muemax_c_ch4_ox_la" value="0.0001 .. 2" />
<!-- #200 Growth rate of methanogenic microbes -->
<par name="metrx_muemax_c_ch4_prod" value="0.0005 .. 0.05" />
<!-- #201 Growth rate of denitrifying microbes -->
<par name="metrx_muemax_c_denit" value="0.1 .. 10" />
<!-- #202 Growth rate of fermenting microbes -->
<par name="metrx_muemax_c_ferm" value="0.1 .. 10" />
<!-- #203 Growth rate of nitrifying microbes -->
<par name="metrx_muemax_c_mic" value="0.1 .. 10" />
<!-- #204 Rate of iron reduction -->
<par name="metrx_muemax_c_fe_red" value="0.01 .. 10" />
<!-- #205 Rate of methane production via H2 -->
<par name="metrx_muemax_h2_ch4_prod" value="0.0005 .. 0.05" />
```

```
<!-- #206 Maximum rate of nitrogen assimilation -->
<par name="metrx_muemax_n_assi" value="1 .. 100" />
<!-- #207 Factor for carbon dependency of microbial death -->
<par name="metrx_ka_c_mic" value="1 .. 100000" />
<!-- #208 Maximum fraction of nitrified NH4 that goes to NO a... -->
<par name="metrx_kf_nit_no_n2o" value="0.001 .. 0.12" />
<!-- #209 Factor for O2 dependency of CH4 production -->
<par name="metrx_k_o2_ch4_prod" value="10 .. 500" />
<!-- #210 Factor for O2 dependency of iron reduction -->
<par name="metrx_k_o2_fe_red" value="10 .. 5000" />
<!-- #211 Factor for iron availability dependency of iron red... -->
<par name="metrx_k_fe_fe_red" value="0 .. 50" />
<!-- #212 Michaelis-Menten factor for acetate dependency of C... -->
<par name="metrx_kmm_ac_ch4_prod" value="0.0001 .. 0.1" />
<!-- #213 Michaelis-Menten factor for acetate dependency of i... -->
<par name="metrx_kmm_ac_fe_red" value="0.001 .. 0.1" />
<!-- #214 Michaelis-Menten factor for H2 dependency of iron r... -->
<par name="metrx_kmm_h2_fe_red" value="0.0000001 .. 0.001" />
<!-- #215 Michaelis-Menten factor for carbon dependency of de... -->
<par name="metrx_kmm_c_denit" value="0.00001 .. 0.01" />
<!-- #216 Michaelis-Menten factor for CH4 dependency of high ... -->
<par name="metrx_kmm_ch4_ch4_ox_ha" value="0.000001 .. 0.1" />
<!-- #217 Michaelis-Menten factor for CH4 dependency of low a... -->
<par name="metrx_kmm_ch4_ch4_ox_la" value="0.00001 .. 1" />
<!-- #218 Michaelis-Menten factor for carbon dependency of mi... -->
<par name="metrx_kmm_c_mic" value="0.0005 .. 0.05" />
<!-- #219 Michaelis-Menten factor for O2 dependency of nitrif... -->
<par name="metrx_kmm_o2_nit" value="0.0001 .. 0.1" />
<!-- #220 Michaelis-Menten factor for H2 dependency of fermen... -->
<par name="metrx_kmm_h2_ferm" value="0.0000005 .. 0.00005" />
<!-- #221 Michaelis-Menten factor for H2 dependency of CH4 pr... -->
<par name="metrx_kmm_h2_ch4_prod" value="0.000001 .. 0.001" />
<!-- #222 Michaelis-Menten factor for nitrogen dependency alg... -->
<par name="metrx_kmm_n_algae" value="0.01 .. 1" />
<!-- #223 Michaelis-Menten factor for nitrogen dependency of ... -->
<par name="metrx_kmm_n_ch4_ox" value="0.0001 .. 0.1" />
<!-- #224 Michaelis-Menten factor for nitrogen dependency of ... -->
<par name="metrx_kmm_n_denit" value="0.0001 .. 0.01" />
<!-- #225 Michaelis-Menten factor for nitrogen dependency of ... -->
<par name="metrx_kmm_n_mic" value="0.0001 .. 0.01" />
<!-- #226 Michaelis-Menten factor for NH4 dependency of nitri... -->
<par name="metrx_kmm_nh4_nit" value="0.0001 .. 0.01" />
```

```
<!-- #227 Michaelis-Menten factor for NO2 dependency of nitri... -->
<par name="metrx_kmm_no2_nit" value="0.000001 .. 0.001" />
<!-- #228 Michaelis-Menten factor for O2 dependency of CH4 ox... -->
<par name="metrx_kmm_o2_ch4_ox" value="0.00001 .. 0.01" />
<!-- #229 Michaelis-Menten factor for O2 dependency of iron o... -->
<par name="metrx_kmm_o2_fe_ox" value="0.001 .. 1" />
<!-- #230 Michaelis-Menten factor for O2 dependency of iron o... -->
<par name="metrx_kmm_ph_increase_from_urea" value="0.00001 .. 1" />
<!-- #231 Modifier of diffusion between aerobic and anaerobic... -->
<par name="metrx_kr_anvf_diff" value="0 .. 10" />
<!-- #232 Fragmentation constant of algae -->
<par name="metrx_kr_frag_algae" value="0.01 .. 1" />
<!-- #233 Fragmentation constant of raw litter -->
<par name="metrx_kr_frag_raw_litter" value="0.005 .. 0.1" />
<!-- #234 Fragmentation constant of stubble -->
<par name="metrx_kr_frag_stubble" value="0.0001 .. 0.01" />
<!-- #235 Fragmentation constant of wood -->
<par name="metrx_kr_frag_wood" value="0.00005 .. 0.001" />
<!-- #236 Decomposition constant of active organic soil -->
<par name="metrx_kr_dc_aorg" value="0.0005 .. 0.05" />
<!-- #237 Decomposition constant of cellulose -->
<par name="metrx_kr_dc_cel" value="0.05 .. 1" />
<!-- #238 Decomposition constant of labile humus -->
<par name="metrx_kr_dc_hum1" value="0.002 .. 0.03" />
<!-- #239 Decomposition constant of recalcitrant young humus -->
<par name="metrx_kr_dc_hum2" value="0.00005 .. 0.003" />
<!-- #240 Decomposition constant of recalcitrant old humus -->
<par name="metrx_kr_dc_hum3" value="0.000001 .. 0.000125" />
<!-- #241 Decomposition constant of lignin -->
<par name="metrx_kr_dc_lig" value="0.005 .. 0.05" />
<!-- #242 Decomposition constant of solutes -->
<par name="metrx_kr_dc_sol" value="0.1 .. 0.8" />
<!-- #243 Rate constant for chemodenitrification -->
<par name="metrx_kr_denit_chemo" value="1 .. 20" />
<!-- #244 Rate constant of iron oxidation -->
<par name="metrx_kr_ox_fe" value="0.1 .. 0.9" />
<!-- #245 Rate constant for humification of active organic ma... -->
<par name="metrx_kr_hu_aorg_hum1" value="0.0005 .. 0.1" />
<!-- #246 Rate constant for humification of active organic ma... -->
<par name="metrx_kr_hu_aorg_hum2" value="0.0001 .. 0.1" />
<!-- #247 Rate constant for humification of lignin -->
<par name="metrx_kr_hu_lig" value="0.001 .. 0.1" />
```

```
<!-- #248 Rate constant for humification of cellulose to labi... -->
<par name="metrx_kr_hu_cel" value="0.0001 .. 0.01" />
<!-- #249 Rate constant for humification of solutes to labile... -->
<par name="metrx_kr_hu_sol" value="0 .. 0.1" />
<!-- #250 Rate constant for humification of labile humus to r... -->
<par name="metrx_kr_hu_hum1" value="0.000001 .. 0.005" />
<!-- #251 Rate constant for humification of recalcitrant youn... -->
<par name="metrx_kr_hu_hum2" value="0.0000001 .. 0.0005" />
<!-- #252 Rate constant for urea hydrolysis -->
<par name="metrx_kr_ureahydrolysis" value="0.001 .. 0.1" />
<!-- #253 Decomposition reduction due to C:N ratio -->
<par name="metrx_kr_reduction_cn" value="0.001 .. 0.01" />
<!-- #254 Decomposition reduction due anaerobicity -->
<par name="metrx_kr_reduction_anvf" value="0.01 .. 1.2" />
<!-- #255 Decomposition reduction for coniferous litter -->
<par name="metrx_kr_reduction_coniferous" value="0.05 .. 1" />
<!-- #256 Factor determining split of humified lignin between... -->
<par name="metrx_lig_humification" value="0.0001 .. 0.9" />
<!-- #257 Retention factor for humus leaching -->
<par name="metrx_ret_humus" value="0 .. 0.005" />
<!-- #258 Retention factor for litter leaching -->
<par name="metrx_ret_litter" value="0 .. 0.05" />
<!-- #259 Retention factor for microbes leaching -->
<par name="metrx_ret_microbes" value="0 .. 1" />
<!-- #260 Stimulation factor of decomposition after tilling e... -->
<par name="metrx_till_stimulation_1" value="1 .. 30" />
<!-- #261 Factor determining the time period of stimulation a... -->
<par name="metrx_till_stimulation_2" value="0.01 .. 0.5" />
<!-- #262 Speed constant for ebullition -->
<par name="metrx_v_ebullition" value="0 .. 20" />
<!-- #263 Microbial growth rate for denitrification on N2O -->
<par name="soildndc_growth_n2o_denit" value="? .. ?" />
<!-- #264 Microbial growth rate for denitrification on NO -->
<par name="soildndc_growth_no_denit" value="? .. ?" />
<!-- #265 Microbial growth rate for denitrification on NO2 -->
<par name="soildndc_growth_no2_denit" value="? .. ?" />
<!-- #266 Microbial growth rate for denitrification on NO3 -->
<par name="soildndc_growth_no3_denit" value="? .. ?" />
<!-- #267 Microbial maintenance coefficient for denitrificati... -->
<par name="soildndc_maintenance_n2o_denit" value="? .. ?" />
<!-- #268 Microbial maintenance coefficient for denitrificati... -->
<par name="soildndc_maintenance_no_denit" value="? .. ?" />
```

```
<!-- #269 Microbial maintenance coefficient for denitrificati... -->
<par name="soildndc_maintenance_no2_denit" value="? .. ?" />
<!-- #270 Microbial maintenance coefficient for denitrificati... -->
<par name="soildndc_maintenance_no3_denit" value="? .. ?" />
<!-- #271 Michaelis-menten constant for nitrogen dependency o... -->
<par name="soildndc_kmm_n2o_denit" value="? .. ?" />
<!-- #272 Michaelis-menten constant for nitrogen dependency o... -->
<par name="soildndc_kmm_no_denit" value="? .. ?" />
<!-- #273 Michaelis-menten constant for nitrogen dependency o... -->
<par name="soildndc_kmm_no2_denit" value="? .. ?" />
<!-- #274 Michaelis-menten constant for nitrogen dependency o... -->
<par name="soildndc_kmm_no3_denit" value="? .. ?" />
<!-- #275 Factor determining dependency of decomposition on w... -->
<par name="m_fact_dec1" value="0.2975 .. 0.8925" />
<!-- #276 Factor determining dependency of decomposition on w... -->
<par name="m_fact_dec2" value="4 .. 12" />
<!-- #277 Factor determining dependency of nitrification on w... -->
<par name="m_fact_p1" value="0.225 .. 0.675" />
<!-- #278 Factor determining dependency of nitrification on w... -->
<par name="m_fact_p2" value="20 .. 60" />
<!-- #279 Factor determining dependency of N2O production dur... -->
<par name="m_fact_p3" value="0.275 .. 0.825" />
<!-- #280 Factor determining dependency of N2O production dur... -->
<par name="m_fact_p4" value="2.5 .. 7.5" />
<!-- #281 Factor determining dependency of microbial activity... -->
<par name="m_fact_p5" value="0.1125 .. 0.3375" />
<!-- #282 Factor determining dependency of microbial activity... -->
<par name="m_fact_p6" value="5 .. 15" />
<!-- #283 Factor determining microbial respiration -->
<par name="micrresp" value="0.04 .. 0.12" />
<!-- #284 Microbial maintenance coefficient for denitrificati... -->
<par name="mn2o" value="0.001 .. 0.1185" />
<!-- #285 Microbial maintenance coefficient for denitrificati... -->
<par name="mno" value="0.001 .. 0.1185" />
<!-- #286 Microbial maintenance coefficient for denitrificati... -->
<par name="mno2" value="0.001 .. 0.0525" />
<!-- #287 Microbial maintenance coefficient for denitrificati... -->
<par name="mno3" value="0.001 .. 0.135" />
<!-- #288 Microbial growth rate -->
<par name="muemax" value="2.4365 .. 7.3095" />
<!-- #289 Microbial growth rate for denitrification on N2O -->
<par name="mue_n2o" value="0.05 .. 20" />
```

```
<!-- #290 Microbial growth rate for denitrification on NO -->
<par name="mue_no" value="0.05 .. 20" />
<!-- #291 Microbial growth rate for denitrification on NO2 -->
<par name="mue_no2" value="0.05 .. 20" />
<!-- #292 Microbial growth rate for denitrification on NO3 -->
<par name="mue_no3" value="0.05 .. 20" />
<!-- #293 Maximum nitrification fraction of NH4 -->
<par name="nh4_denimax" value="0.4 .. 0.99" />
<!-- #294 Downward transport of labile litter -->
<par name="pertl" value="0.00025 .. 0.00075" />
<!-- #295 Limit depth for litter transport [m] -->
<par name="pertmax" value="0.15 .. 0.45" />
<!-- #296 Downward transport of recalcitrant litter -->
<par name="pertr" value="0.00005 .. 0.00015" />
<!-- #297 Downward transport of very labile litter -->
<par name="pertvl" value="0.005 .. 0.015" />
<!-- #298 Factor for pH dependency of N2O denitrification -->
<par name="phcrit_n2o" value="2.5 .. 7.5" />
<!-- #299 Factor for pH dependency of NO2 denitrification -->
<par name="phcrit_no2" value="3.05 .. 9.15" />
<!-- #300 Factor for pH dependency of NO3 denitrification -->
<par name="phcrit_no3" value="3.15 .. 9.45" />
<!-- #301 Factor for pH dependency of N2O denitrification -->
<par name="phdelta_n2o" value="0.3075 .. 0.9225" />
<!-- #302 Factor for pH dependency of NO2 denitrification -->
<par name="phdelta_no2" value="0.72 .. 2.16" />
<!-- #303 Factor for pH dependency of NO3 denitrification -->
<par name="phdelta_no3" value="0.76 .. 2.28" />
<!-- #304 Factor for pH dependency of nitrification -->
<par name="ph_fact_p2" value="0.65 .. 1.95" />
<!-- #305 Factor for pH dependency of nitrification -->
<par name="ph_fact_p3" value="0.04 .. 0.12" />
<!-- #306 Factor for pH dependency of N2O production during n... -->
<par name="ph_fact_p4" value="0.5 .. 1.5" />
<!-- #307 Factor for pH dependency of chemodenitrification -->
<par name="ph_fact_p5" value="1.875 .. 5.625" />
<!-- #308 Maximum allowed pH value -->
<par name="phmax" value="5 .. 15" />
<!-- #309 Minimum allowed pH value -->
<par name="phmin" value="1.25 .. 3.75" />
<!-- #310 Factor for pH dependency of chemodenitrification -->
<par name="phmin_chem" value="2.5 .. 7.5" />
```

```
<!-- #311 Factor for pH dependency of chemodenitrification -->
<par name="phopt_chem" value="0.3 .. 0.9" />
<!-- #312 Empirical decrease of hydraulic conductivity of coa... -->
<par name="psl_sc" value="0.01 .. 0.03" />
<!-- #313 Base layer depth for evaporation decrease with dept... -->
<par name="psl_wc" value="0.01 .. 0.1" />
<!-- #314 Priestley-Taylor coefficient of advection -->
<par name="pt_alpha" value="0.5 .. 1.5" />
<!-- #315 Fraction of inactive microbes in active organic mat... -->
<par name="rbo" value="0.1 .. 0.9" />
<!-- #316 Factor determining CO2 production during decomposit... -->
<par name="rcec" value="23 .. 69" />
<!-- #317 Factor determining clay dependency of soil water ev... -->
<par name="rclay" value="0.1 .. 0.9" />
<!-- #318 C:N ratio of inactive microbes in active organic ma... -->
<par name="rcnb" value="4 .. 12" />
<!-- #319 C:N ratio of humads in active organic material pool -->
<par name="rcnh" value="6 .. 18" />
<!-- #320 C:N ratio of humus -->
<par name="rcnm" value="4.9 .. 14.7" />
<!-- #321 C:N ratio of resistant residues -->
<par name="rcnrr" value="120 .. 360" />
<!-- #322 C:N ratio of very labile residues -->
<par name="rcnrvl" value="12 .. 36" />
<!-- #323 Retention coefficient of DOC leaching -->
<par name="retdoc" value="0 .. 1" />
<!-- #324 Retention coefficient of NO3 leaching -->
<par name="retno3" value="0 .. 1" />
<!-- #325 Retention coefficient of NH4 leaching -->
<par name="retnh4" value="0 .. 1" />
<!-- #326 Retention coefficient of SO4 leaching -->
<par name="retso4" value="0 .. 1" />
<!-- #327 Increases dependence of transpiration on roots -->
<par name="root_dependent_trans" value="-1 .. 1" />
<!-- #328 If root length instead of mass should be used for d... -->
<par name="root_length_h2o_up" value="true .. false" />
<!-- #329 On/off of Couvreur model -->
<par name="root_water_uptake_couvreur" value="true .. false" />
<!-- #330 Fraction of labile humads -->
<par name="shr" value="0.08 .. 0.24" />
<!-- #331 Factor determining clay dependency of soil water ev... -->
<par name="slope_clayf" value="0.05 .. 0.08" />
```

```
<!-- #332 Specific slope factor for water flux from litter la... -->
<par name="slope_ff" value="0.5 .. 2" />
<!-- #333 Specific slope factor for water flux from mineral s... -->
<par name="slope_ms" value="2 .. 3" />
<!-- #334 Fraction of labile inactive microbes -->
<par name="srb" value="0.45 .. 0.99" />
<!-- #335 New trees planted during succession -->
<par name="succession_n_tree_init" value="100 .. 20000" />
<!-- #336 Initial tree height during succession -->
<par name="succession_height_tree_init" value="0.1 .. 10" />
<!-- #337 Years for regrowth of young tree during succession -->
<par name="succession_interval_s" value="1 .. 100" />
<!-- #338 Generation time in years for succession -->
<par name="succession_interval_l" value="2 .. 1000" />
<!-- #339 Temperature dependency of diffusion between aerobic... -->
<par name="texp" value="0.862 .. 2.586" />
<!-- #340 Temperature dependency of chemodenitrification -->
<par name="tf_chem1" value="0.05 .. 0.15" />
<!-- #341 Temperature dependency of chemodenitrification -->
<par name="tf_chem2" value="0.065 .. 0.195" />
<!-- #342 Factor determining length of tilling effect on deco... -->
<par name="tfday" value="1 .. 100" />
<!-- #343 Temperature dependency of decomposition -->
<par name="tf_dec1" value="1.77 .. 5.31" />
<!-- #344 Temperature dependency of decomposition -->
<par name="tf_dec2" value="18.5 .. 55.5" />
<!-- #345 Temperature dependency of denitrification -->
<par name="tf_den1" value="2 .. 6" />
<!-- #346 Temperature dependency of denitrification -->
<par name="tf_den2" value="20 .. 60" />
<!-- #347 Factor determining tilling intensity dependency on ... -->
<par name="tfmax" value="1 .. 10" />
<!-- #348 Temperature dependency of N2O production during nit... -->
<par name="tf_nup_n2o1" value="0.02755 .. 0.08265" />
<!-- #349 Temperature dependency of N2O production during nit... -->
<par name="tf_nup_n2o2" value="4.705 .. 14.115" />
<!-- #350 Temperature dependency of NO production during nitr... -->
<par name="tf_nup_no1" value="0.011875 .. 0.035625" />
<!-- #351 Temperature dependency of NO production during nitr... -->
<par name="tf_nup_no2" value="4.45 .. 13.35" />
<!-- #352 Empirical coefficient to derive ice temperature -->
<par name="tice" value="0 .. 4" />
```

```
    <!-- #353 Reference temperature for NH3 volatilization -->
    <par name="tref" value="22.5 .. 67.5" />
    <!-- #354 Temperature limit for snowfall -->
    <par name="snowdndc_snowfall_temperature_limit" value="-1 .. 5" />
    <!-- #355 Fraction of wilting point which determines minimum ... -->
    <par name="wcdndc_evalim_frac_wcmin" value="0 .. 1" />
    <!-- #356 On/off of capillary action -->
    <par name="wcdndc_have_capillary_action" value="true .. false" />
    <!-- #357 Increases / decreases potential evapotranspiration -->
    <par name="wcdndc_increase_pot_evapotrans" value="0 .. 10" />


  </siteparameters>

</ldndcsiteparameters>
```

3.2.8 Soil parameters [soilparameters]

In this section, we describe all input entities for the input class soil parameters.

A full reference example:

```
<?xml version="1.0"?>
<ldndcsoilparameters>
  <!--
    id .. block id
  -->

  <soilparameters id="0" >

    <!-- #1 Clay content -->
    <par name="clay" value="? .. ?" />
    <!-- #2 Bulk density -->
    <par name="density" value="? .. ?" />
    <!-- #3 Iron content -->
    <par name="iron" value="? .. ?" />
    <!-- #4 Ph value -->
    <par name="ph" value="? .. ?" />
    <!-- #5 Sand content -->
    <par name="sand" value="? .. ?" />
    <!-- #6 Sand content -->
    <par name="silt" value="? .. ?" />
```

```
    <!-- #7 Stone fraction -->
    <par name="stonefraction" value="? .. ?" />
    <!-- #8 Van Genuchten parameter alpha -->
    <par name="vangenuchten_alpha" value="? .. ?" />
    <!-- #9 Van Genuchten parameter n -->
    <par name="vangenuchten_n" value="? .. ?" />
    <!-- #10 Soil water content (maximum) -->
    <par name="wcmax" value="? .. ?" />
    <!-- #11 Water content at field capacity -->
    <par name="wc_fc" value="? .. ?" />
    <!-- #12 Soil water content (minimum, wilting point) -->
    <par name="wcmin" value="? .. ?" />
    <!-- #13 Water content at wilting point -->
    <par name="wc_wp" value="? .. ?" />
    <!-- #14 Saturated water content -->
    <par name="wc_sat" value="? .. ?" />
    <!-- #15 Residual water content -->
    <par name="wc_res" value="? .. ?" />
    <!-- #16 Macropores -->
    <par name="macropores" value="? .. ?" />


  </soilparameters>

</ldndcsoilparameters>
```

3.2.9 Species parameters [**speciesparameters**]

In this section, we describe all input entities for the input class species parameters. A species in LandscapeDNDC is uniquely identified by a *name*, i.e., a character string (with limited size). Each species is assigned a single parent which is also identified by its unique name. If no parent exist, i.e., the species has no ancestors, the *none* type acts as parent. Additionally, every species possesses a set of parameters which describe the properties of the species. To be able to use a species within a simulation with LandscapeDNDC, it needs to be defined in the species parameters input.

Defining a species is simply done by giving appropriate information of the species: *name*, *group* and a *parameter set*. The parent may be required depending on the input format.

List of entities

1. *mnemonic* string47, unit [-]

Species parameter set type name

2. *parent* string47, unit [-]

   Species parameter set this species inherits from (this may be optional and deduced from the input internally)

3. *species group* string47, default *none*, unit [-]

   A valid species group known to LandscapeDNDC. Currently known groups are *any* ("dummy"), *crop*, *grass* and *wood*. Amongst other things, the group helps models to decide which processes to trigger for a species or what properties it has.

4. *species parameters*

   The following list contains all parameters that may be set for a single species.

   #1 *C4_TYPE*, θ_{CT} $\theta_{\mathrm{CT}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   True for C4 photosynthesis type, false for C3 photosynthesis type.

   #2 *CONIFEROUS*, θ_{C} $\theta_{\mathrm{C}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   True for conifers, false for broad leaved species.

   #3 *DECIDUOUS*, θ_{D} $\theta_{\mathrm{D}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   True for deciduous, false for evergreen species.

   #4 *FREEGROWTH*, θ_{F} $\theta_{\mathrm{F}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   True for dimensional growth once a year (during a defined period) and false for continous growth.

   #5 *RATOON*, θ_{R} $\theta_{\mathrm{R}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   True for ratoon plants.

   #6 *ROOTS_ENVIRONMENTAL*, θ_{RE} $\theta_{\mathrm{RE}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   If true than a root development taking environmental circumstances into account is applied.

   #7 *SAVANNA*, θ_{S} $\theta_{\mathrm{S}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   True for savanna plants.

   #8 *TUBER*, θ_{T} $\theta_{\mathrm{T}} \in \{true, false\} \subseteq \mathbb{B}$, unit $[-]$
   True for plants with belowground storage organs.

   #9 *NDFLUSH*, θ_{N} $\theta_{\mathrm{N}} \in [?, ?] \subseteq \mathbb{Z}$, unit $[days]$
   Time interval necessary to complete growth of new foliage.

#10 *NDMORTA*, θ^1_{N} $\theta^1_{\mathrm{N}} \in [?, ?] \subseteq \mathbb{Z}$, unit $[days]$
Time interval necessary to complete litterfall of foliage.

#11 *DLEAFSHED*, θ^1_{D} $\theta^1_{\mathrm{D}} \in [?, ?] \subseteq \mathbb{Z}$, unit $[days]$
Total leaf longevity from the first day of the emergend year on.

#12 *A_REF*, θ_{AR} $\theta_{\mathrm{AR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Reference drought stress parameter for non-stomatal limitation (TUZET function).

#13 *A_EXP*, θ_{AE} $\theta_{\mathrm{AE}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Exponential parameter for non-stomatal limitation function (TUZET function).

#14 *AEIS*, θ_{A} $\theta_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for isoprenoid emission (J mol-1).

#15 *AEJM*, θ^1_{A} $\theta^1_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for electron transport (J mol-1).

#16 *AEKC*, θ^2_{A} $\theta^2_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for Michaelis-Menten constant for CO2 (J mol-1).

#17 *AEKO*, θ^3_{A} $\theta^3_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for Michaelis-Menten constant for O2 (J mol-1).

#18 *AERD*, θ^4_{A} $\theta^4_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for dark respiration (J mol-1).

#19 *AEVC*, θ^5_{A} $\theta^5_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for photosynthesis (J mol-1).

#20 *AEVO*, θ^6_{A} $\theta^6_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for RubP oxygenation (J mol-1).

#21 *ALB*, θ^7_{A} $\theta^7_{\mathrm{A}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Light reflection (albedo).

#22 *ALPHA0_IS*, θ_{AI} $\theta_{\mathrm{AI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Increase of isoprene emission activity per wheighted temperature unit (s-1).

#23 *ALPHA0_MT*, θ_{AM} $\theta_{\mathrm{AM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Increase of monoterpene emission activity per wheighted temperature unit (s-1).

#24 *AMAXA*, θ_{A}^{8} $\theta_{\mathrm{A}}^{8} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Intercept-coefficient for Amax calculation (nmolCO2 g-1 s-1 /

#25 *AMAXB*, θ_{A}^{9} $\theta_{\mathrm{A}}^{9} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximal net photosynthesis rate (nmolCO2 g-1 s-1 /

#26 *AMAXFRAC*, θ_{A}^{10} $\theta_{\mathrm{A}}^{10} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Daily Amax as fraction of instantaneous early-morning Amax.

#27 *BASEFOLRESPFRAC*, θ_{B} $\theta_{\mathrm{B}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Dark respiration as fraction of Amax.

#28 *CB*, θ_{C}^{1} $\theta_{\mathrm{C}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Crown base height - tree height ratio.

#29 *CDAMP*, θ_{C}^{2} $\theta_{\mathrm{C}}^{2} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Canopy temperature damping factor.

#30 *CL_P1*, θ_{CP} $\theta_{\mathrm{CP}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
First parameter for crown length calculation.

#31 *CL_P2*, θ_{CP}^{1} $\theta_{\mathrm{CP}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Second parameter for crown length calculation.

#32 *CDR_P1*, θ_{CP}^{2} $\theta_{\mathrm{CP}}^{2} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
First parameter for crown diameter calculation.

#33 *CDR_P2*, θ_{CP}^{3} $\theta_{\mathrm{CP}}^{3} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Second parameter for crown diameter calculation.

#34 *CDR_P3*, θ_{CP}^{4} $\theta_{\mathrm{CP}}^{4} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Third parameter for crown diameter calculation.

#35 *CELLULOSE*, θ_{C}^{3} $\theta_{\mathrm{C}}^{3} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Cellulose content in biomass.

#36 *CFCROPT*, θ_{C}^{4} $\theta_{\mathrm{C}}^{4} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Optimal ratio between fungi biomass and total mycorrhiza biomass.

#37 *CHILL_UNITS*, θ_{CU} $\theta_{\mathrm{CU}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Required chilling units vernalization.

#38 *CHILL_TEMP_MAX*, θ_{CTM} $\theta_{\mathrm{CTM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum temperature for chilling progress.

#39 *CSR_REF*, θ_{CR} $\theta_{\mathrm{CR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Reference water potential at which soil-root connection is lost (MPa).

#40 *CT_IS*, θ_{CI} $\theta_{\mathrm{CI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Scaling constant for temperature sensitivity of isoprene synthase.

#41 *CT_MT*, θ_{CM} $\theta_{\mathrm{CM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Scaling constant for temperature sensitivity.

#42 *CWP_REF*, θ^1_{CR} $\theta^1_{\mathrm{CR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Reference (=maximum) value for the (leaf area-normalized) specific xylem conductivity (mol MPa-1 m-2Leaf s-1).

#43 *DBRANCH*, θ^2_{D} $\theta^2_{\mathrm{D}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Branch dry weight mass per canopy volume (kg:m-̂3).

#44 *DF_EXP*, θ_{DE} $\theta_{\mathrm{DE}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Exponent for density effect on tree growth (-).

#45 *DF_LIMIT*, θ_{DL} $\theta_{\mathrm{DL}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Area cover at which trees start feeling density effects (m2:ha).

#46 *DFOL*, θ^3_{D} $\theta^3_{\mathrm{D}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Leaf density (kg DW:dm FW-3).

#47 *DFRTOPT*, θ^4_{D} $\theta^4_{\mathrm{D}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Optimum fine root density (kg:m-3).

#48 *DIAMMAX*, θ^5_{D} $\theta^5_{\mathrm{D}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Breast height diameter at maturity (m).

#49 *DOC_RESP_RATIO*, θ_{DRR} $\theta_{\mathrm{DRR}} \in [0, 1] \subseteq \mathbb{R}$, unit [?]
Ratio os root exudates related to root growth respiration.

#50 *DRAGC*, θ^6_{D} $\theta^6_{\mathrm{D}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Drag coefficient for wind speed approximation in canopy.

#51 *DSAP*, θ^7_{D} $\theta^7_{\mathrm{D}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Wood density (kg DW:dm FW-3).

#52 *DS_IS*, θ_{DI} $\theta_{\mathrm{DI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Entropy term for isoprene synthase sensitivity to temperature (J:mol-1:K-1).

#53 *DS_MT*, θ_{DM} $\theta_{\mathrm{DM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Entropy term for GDP synthase sensitivity to temperature (J:mol-1:K-1).

#54 *DVPD1*, θ_{D}^{8} $\theta_{\mathrm{D}}^{8} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
First parameter for vapor pressure deficit - impact on stomata conductance.

#55 *DVPD2*, θ_{D}^{9} $\theta_{\mathrm{D}}^{9} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Second parameter for vapor pressure deficit - impact on stomata conductance.

#56 *EF_ISO*, θ_{EI} $\theta_{\mathrm{EI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Isoprene emission rate under standard conditions (ug gDW-1 h-1).

#57 *EF_MONO*, θ_{EM} $\theta_{\mathrm{EM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Monoterpene emission rate under standard conditions (ug gDW-1 h-1).

#58 *EF_MONOS*, θ_{EM}^{1} $\theta_{\mathrm{EM}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Emission rate of stored terpenes under standard conditions (ug gDW-1 h-1).

#59 *EF_OVOC*, θ_{EO} $\theta_{\mathrm{EO}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Emission rate of other VOCs under standard conditions (ug gDW-1 h-1).

#60 *EXPL_NH4*, θ_{EN} $\theta_{\mathrm{EN}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Relative exploration rate of NH_4.

#61 *EXPL_NO3*, θ_{EN}^{1} $\theta_{\mathrm{EN}}^{1} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Relative exploration rate of NO_3.

#62 *EXP_ROOT_DISTRIBUTION*, θ_{ERD} $\theta_{\mathrm{ERD}} \in [-5, 15] \subseteq \mathbb{R}$, unit $[m - 1]$
Exponential factor for plant root distribution NO_3.

#63 *EXT*, θ_{E} $\theta_{\mathrm{E}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Light extinction (attenuation) coefficient for photosynthetic active radiation.

#64 *FAGE*, θ_{F}^{1} $\theta_{\mathrm{F}}^{1} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Relative decrease of emission synthesis per foliage age class.

#65 *FBRAF_M*, θ_{FM} $\theta_{\mathrm{FM}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Final branchwood fraction of mature trees (kg DW:kg DW-1).

#66 *FBRAF_Y*, θ_{FY} $\theta_{\mathrm{FY}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Final branchwood fraction of seedlings (kg DW:kg DW-1).

#67 *FFACMAX*, θ_{F}^{2} $\theta_{\mathrm{F}}^{2} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Maximum relativ amount of free available carbohydrates.

#68 *FIRE_RCK*, θ_{FR} $\theta_{\mathrm{FR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Crown damage parameter 1.

#69 *FIRE_P*, θ_{FP} $\theta_{\mathrm{FP}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Crown damage parameter 2.

#70 *FIRE_BARKA*, θ_{FB} $\theta_{\mathrm{FB}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Bark thickness parameter 1.

#71 *FIRE_BARKB*, θ^1_{FB} $\theta^1_{\mathrm{FB}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Bark thickness parameter 2.

#72 *FIRE_DENSFUEL*, θ_{FD} $\theta_{\mathrm{FD}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fuel bulk density [kg:m-3].

#73 *FIRE_FLAME*, θ_{FF} $\theta_{\mathrm{FF}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Scorch height parameter.

#74 *FIRE_FIRERESIST*, θ^1_{FF} $\theta^1_{\mathrm{FF}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire resistance parameter.

#75 *FIRE_EM_CO2*, θ_{FEC} $\theta_{\mathrm{FEC}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for CO_2 per biomass [kg:kg-1].

#76 *FIRE_EM_CO*, θ^1_{FEC} $\theta^1_{\mathrm{FEC}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for CO per biomass [kg:kg-1].

#77 *FIRE_EM_CH4*, θ^2_{FEC} $\theta^2_{\mathrm{FEC}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for CH_4 per biomass [kg:kg-1].

#78 *FIRE_EM_VOC*, θ_{FEV} $\theta_{\mathrm{FEV}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for VOC per biomass [kg:kg-1].

#79 *FIRE_EM_TPM*, θ_{FET} $\theta_{\mathrm{FET}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for TPM per biomass [kg:kg-1].

#80 *FIRE_EM_NOX*, θ_{FEN} $\theta_{\mathrm{FEN}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for nox per biomass [kg:kg-1].

#81 *FIRE_EM_N2O*, θ^1_{FEN} $\theta^1_{\mathrm{FEN}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for N_2O per biomass [kg:kg-1].

#82 *FIRE_EM_N2*, θ^2_{FEN} $\theta^2_{\mathrm{FEN}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fire emission factor for N_2 per biomass [kg:kg-1].

#83 *FOLRELGROMAX*, θ^3_{F} $\theta^3_{\mathrm{F}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum relative growth rate for foliage (

#84 *FRACTION_ROOT_START*, θ_{FRS} $\theta_{\mathrm{FRS}} \in [-1, 1] \subseteq \mathbb{R}$, unit [%]
Biomass fraction of roots at start of growing season [-].

#85 *FRACTION_ROOT*, θ^1_{FR} $\theta^1_{\mathrm{FR}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Biomass fraction of roots at maturity.

#86 *FRACTION_FRUIT*, θ^2_{FF} $\theta^2_{\mathrm{FF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Biomass fraction of fruit at maturity.

#87 *FRACTION_FOLIAGE*, θ^3_{FF} $\theta^3_{\mathrm{FF}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Biomass fraction of foliage at maturity.

#88 *FRET_N*, θ_{FN} $\theta_{\mathrm{FN}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum fraction of nitrogen retranslocated before tissue loss.

#89 *FROSTA*, θ^4_{F} $\theta^4_{\mathrm{F}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Frost effect on photosynthesis: species specific minimum temperature in stationary level equation (oC) for Eucalypt (King and Ball, 1998).

#90 *FROSTB*, θ^5_{F} $\theta^5_{\mathrm{F}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Frost effect on photosynthesis: species specific constant in stationary level equation for Eucalypt (King and Ball, 1998).

#91 *FRTALLOC_BASE*, θ^2_{FB} $\theta^2_{\mathrm{FB}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Relative share of foliage growth to root growth.

#92 *FRTALLOC_REL*, θ^2_{FR} $\theta^2_{\mathrm{FR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fixed amount of carbon allocated to root growth.

#93 *FRTLOSS_SCALE*, θ_{FS} $\theta_{\mathrm{FS}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Scaling factor for fine root loss.

#94 *FYIELD*, θ^6_{F} $\theta^6_{\mathrm{F}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fraction of growth respiration relative to gross assimilation.

#95 *GDD_BASE_TEMPERATURE*, θ_{GBT} $\theta_{\mathrm{GBT}} \in [-10, 20] \subseteq \mathbb{R}$, unit [ř$C$]
Base tempeature for growing degree days.

#96 *GDD_MAX_TEMPERATURE*, θ_{GMT} $\theta_{\mathrm{GMT}} \in [10, 40] \subseteq \mathbb{R}$, unit [ř$C$]
Maximum daily increase of growing degree days.

#97 *GDD_EMERGENCE*, θ_{GE} $\theta_{\mathrm{GE}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days until begin of emergence (dry seed -> emergence).

#98 *GDD_STEM_ELONGATION*, θ_{GSE} $\theta_{\mathrm{GSE}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days until begin of stem elongation.

#99 *GDD_FLOWERING*, θ_{GF} $\theta_{\mathrm{GF}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days until begin of flowering.

#100 *GDD_GRAIN_FILLING*, θ_{GGF} $\theta_{\mathrm{GGF}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days until begin of grain filling.

#101 *GDD_ROOTS_GROWN*, θ_{GRG} $\theta_{\mathrm{GRG}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days until downwards root growth ceases.

#102 *GDD_MATURITY*, θ_{GM} $\theta_{\mathrm{GM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days until maturity.

#103 *GDDFOLEND*, θ_{G} $\theta_{\mathrm{G}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days to complete foliar production.

#104 *GDDFOLSTART*, θ^1_{G} $\theta^1_{\mathrm{G}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Minimum temperature sum for foliage activity onset (oC).

#105 *GDDWODEND*, θ^2_{G} $\theta^2_{\mathrm{G}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days to complete wood production.

#106 *GDDWODSTART*, θ^3_{G} $\theta^3_{\mathrm{G}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Growing degree days to start wood production.

#107 *GGDPS_B*, θ_{GB} $\theta_{\mathrm{GB}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Base value for vmax for GGDP synthesis at 30 oC (umol L-1 s-1).

#108 *GSMAX*, θ^4_{G} $\theta^4_{\mathrm{G}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum stomata conductivity (mmolH2O m-2 s-1).

#109 *GSMIN*, θ^5_{G} $\theta^5_{\mathrm{G}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Minimum stomata conductivity (mmolH2O m-2 s-1).

#110 *GZRTZ*, θ^6_{G} $\theta^6_{\mathrm{G}} \in [0.001, 0.3] \subseteq \mathbb{R}$, unit $[md-1]$
Growth rate of fine root into deeper soil layers (m day-1).

#111 *H2OREF_A*, θ_{HA} $\theta_{\mathrm{HA}} \in [0, 1] \subseteq \mathbb{R}$, unit $[-]$

Relative available soil water content at which drought affects photosynthesis activity.

#112 *H2OREF_FLUSHING*, θ_{HF} $\theta_{\mathrm{HF}} \in [0, 1] \subseteq \mathbb{R}$, unit $[-]$
Relative available soil water content below which flushing is affected by water availability.

#113 *H2OREF_LEAF_GROWTH*, θ_{HLG} $\theta_{\mathrm{HLG}} \in [0, 1] \subseteq \mathbb{R}$, unit $[-]$
Relative available soil water content below which leaf growth is affected.

#114 *H2OREF_GS*, θ_{HG} $\theta_{\mathrm{HG}} \in [0, 1] \subseteq \mathbb{R}$, unit $[-]$
Relative available soil water content at which stomata are fully closed.

#115 *H2OREF_SENESCENCE*, θ_{HS} $\theta_{\mathrm{HS}} \in [0, 1] \subseteq \mathbb{R}$, unit $[-]$
Relative available soil water content below which restricted water availability triggers plant senescence.

#116 *HALFSAT*, θ_{H} $\theta_{\mathrm{H}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Half saturation light intensity (umoles m-2 s-1).

#117 *HA_IS*, θ_{HI} $\theta_{\mathrm{HI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for isoprene synthase (J mol-1).

#118 *HA_MT*, θ_{HM} $\theta_{\mathrm{HM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Activation energy for GDP synthase (J mol-1).

#119 *HD_IS*, θ^{1}_{HI} $\theta^{1}_{\mathrm{HI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Deactivation energy for isoprene synthase (J mol-1).

#120 *HDJ*, θ^{1}_{H} $\theta^{1}_{\mathrm{H}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Curvature parameter of jMax (J mol-1).

#121 *HD_EXP*, θ_{HE} $\theta_{\mathrm{HE}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Parameter for estimation of height:diameter ratio of stems.

#122 *HD_MAX*, θ^{1}_{HM} $\theta^{1}_{\mathrm{HM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum height to breast height diameter ratio (m m-1).

#123 *HD_MIN*, θ^{2}_{HM} $\theta^{2}_{\mathrm{HM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Minimum height to breast height diameter ratio (m m-1).

#124 *HD_MT*, θ^{3}_{HM} $\theta^{3}_{\mathrm{HM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Deactivation energy for monoterpene synthase (J mol-1).

#125 *HREF*, θ_{H}^2 $\theta_{\mathrm{H}}^2 \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Canopy depth where full foliage is developed.

#126 *HLEAFCRIT*, θ_{H}^3 $\theta_{\mathrm{H}}^3 \in [-50000, 0] \subseteq \mathbb{R}$, unit $[cm]$
Negative maximum leaf hydraulic head NO_3.

#127 *HYPOXIA*, θ_{H}^4 $\theta_{\mathrm{H}}^4 \in [0, 1] \subseteq \mathbb{R}$, unit $[-]$
Hypoxia effect on photosynthesis.

#128 *INI_N_FIX*, θ_{INF} $\theta_{\mathrm{INF}} \in [0, 10] \subseteq \mathbb{R}$, unit $[-]$
Factor determining nitrogen fixation.

#129 *KC25*, θ_{K} $\theta_{\mathrm{K}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten constant for CO2 at 25oC (umol mol-1 ubar-1).

#130 *KCOMPINIT*, θ_{K}^1 $\theta_{\mathrm{K}}^1 \in [-1.1, 1] \subseteq \mathbb{R}$, unit $[1/h]$
Compensatory hydraulic conductivity of the root system NO_3.

#131 *KM20*, θ_{K}^2 $\theta_{\mathrm{K}}^2 \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maintenance coefficient at reference temperature.

#132 *KM_GDPS_DMADP*, θ_{KGD} $\theta_{\mathrm{KGD}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
KM for GDP synthesis from DMADP (umol L-1).

#133 *KM_GDPS_IDP*, θ_{KGI} $\theta_{\mathrm{KGI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
KM for GDP synthesis from IDP (umol L-1).

#134 *KM_IS*, θ_{KI} $\theta_{\mathrm{KI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
KM for isoprene synthesis from DMADP (umol L-1).

#135 *KM_MT*, θ_{KM} $\theta_{\mathrm{KM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
KM for monoterpene synthesis from GDP(umol L-1).

#136 *K_MM_NITROGEN_UPTAKE*, θ_{KMNU} $\theta_{\mathrm{KMNU}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten constant for nitrogen uptake (kg:m-3).

#137 *KO25*, θ_{K}^3 $\theta_{\mathrm{K}}^3 \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Michaelis-Menten constant for O2 at 25oC (mmol mol-1 mbar-1).

#138 *KRC_WOOD*, θ_{KW} $\theta_{\mathrm{KW}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Decomposition rate of wood.

#139 *KRSCOMP*, θ_{K}^4 $\theta_{\mathrm{K}}^4 \in [0, 1] \subseteq \mathbb{R}$, unit $[1/h]$
Compensatory hydraulic conductivity of the root system.

#140 *KRSINIT*, θ_{K}^5 $\theta_{\mathrm{K}}^5 \in [0, 1] \subseteq \mathbb{R}$, unit $[1/h]$
Initial hydraulic conductivity of the root system.

#141 *LIGNIN*, θ_{L} $\theta_{\mathrm{L}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Lignin fraction of biomass.

#142 *MAINTENANCE_TEMP_REF*, θ_{MTR} $\theta_{\mathrm{MTR}} \in [5, 40] \subseteq \mathbb{R}$, unit [?]
Reference temperature for maintenance respiration.

#143 *MC_LEAF*, θ_{ML} $\theta_{\mathrm{ML}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maintenance respiration coefficient of leaves.

#144 *MC_STEM*, θ_{MS} $\theta_{\mathrm{MS}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maintenance respiration coefficient of stems.

#145 *MC_ROOT*, θ_{MR} $\theta_{\mathrm{MR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maintenance respiration coefficient of roots.

#146 *MC_STORAGE*, θ_{MS}^1 $\theta_{\mathrm{MS}}^1 \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maintenance respiration coefficient of storage organs.

#147 *MFOLOPT*, θ_{M} $\theta_{\mathrm{M}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Foliage biomass under optimal, closed canopy condition (kg m-2).

#148 *M_FRUIT_OPT*, θ_{MFO} $\theta_{\mathrm{MFO}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum achievable fruit dry weight biomass under optimal, closed canopy condition (kg m-2).

#149 *MORTCROWD*, θ_{M}^1 $\theta_{\mathrm{M}}^1 \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Crowding mortality (yr-1).

#150 *MORTNORM*, θ_{M}^2 $\theta_{\mathrm{M}}^2 \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Normal tree mortality (yr-1).

#151 *MUE_IS*, θ_{MI} $\theta_{\mathrm{MI}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Percentage decrease of isoprene emission activity per day (s-1).

#152 *MUE_MT*, θ_{MM} $\theta_{\mathrm{MM}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Percentage decrease of monoterpene emission activity per day (s-1).

#153 *MWFM*, θ_{M}^3 $\theta_{\mathrm{M}}^3 \in [0, 0.001] \subseteq \mathbb{R}$, unit [?]
Specific interception capacity of foliage (m m-2LAI).

#154 *MWWM*, θ^4_{M} $\theta^4_{\mathrm{M}} \in [0, 0.0001] \subseteq \mathbb{R}$, unit [?]
Specific interception capacity of wood mass (m kg-1DW).

#155 *NC_FOLIAGE_MIN*, θ_{NFM} $\theta_{\mathrm{NFM}} \in [-1, 0.2] \subseteq \mathbb{R}$, unit [?]
Minimum nitrogen concentration of foliage (kg kg-1).

#156 *NC_FOLIAGE_MAX*, θ^1_{NFM} $\theta^1_{\mathrm{NFM}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Optimum nitrogen concentration of foliage (kg kg-1).

#157 *NCFOLOPT*, θ^2_{N} $\theta^2_{\mathrm{N}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Optimum nitrogen concentration of foliage (kg kg-1).

#158 *NC_FINEROOTS_MAX*, θ^2_{NFM} $\theta^2_{\mathrm{NFM}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Maximum (optimum) nitrogen concentration of fine roots (kg kg-1).

#159 *NC_FINEROOTS_MIN*, θ^3_{NFM} $\theta^3_{\mathrm{NFM}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Minimum nitrogen concentration of fine roots (kg kg-1).

#160 *NC_FRUIT_MAX*, θ^4_{NFM} $\theta^4_{\mathrm{NFM}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Maximum (optimum) nitrogen concentration of fruit (kg kg-1).

#161 *NC_FRUIT_MIN*, θ^5_{NFM} $\theta^5_{\mathrm{NFM}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Minimum nitrogen concentration of fruit (kg kg-1).

#162 *NC_STRUCTURAL_TISSUE_MAX*, θ_{NSTM} $\theta_{\mathrm{NSTM}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Optimum nitrogen concentration of living structural tissue (kg kg-1).

#163 *NC_STRUCTURAL_TISSUE_MIN*, θ^1_{NSTM} $\theta^1_{\mathrm{NSTM}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Minimum nitrogen concentration of living structural tissue (kg kg-1).

#164 *NCSAPOPT*, θ^3_{N} $\theta^3_{\mathrm{N}} \in [0, 0.2] \subseteq \mathbb{R}$, unit [?]
Optimum nitrogen concentration of sapwood (kg kg-1).

#165 *N_DEF_FACTOR*, θ_{NDF} $\theta_{\mathrm{NDF}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Factor defines nitrogen deficiency.

#166 *N_DEMAND_VEG*, θ_{NDV} $\theta_{\mathrm{NDV}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Empirical vegetative nitrogen demand multiplier.

#167 *N_DEMAND_REPROD*, θ_{NDR} $\theta_{\mathrm{NDR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Empirical reproductive nitrogen demand multiplier.

#168 *NFIX_CEFF*, θ_{NC} $\theta_{\mathrm{NC}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Carbon use efficiency for nitrogen fixation.

#169 *NFIX_TMAX*, θ_{NT} $\theta_{\mathrm{NT}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum temperature for nitrogen fixation.

#170 *NFIX_TOPT*, θ^1_{NT} $\theta^1_{\mathrm{NT}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Optimum temperature for nitrogen fixation.

#171 *NFIX_TMIN*, θ^2_{NT} $\theta^2_{\mathrm{NT}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Minimum temperature for nitrogen fixation.

#172 *NFIX_W*, θ_{NW} $\theta_{\mathrm{NW}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Parameter m for water dependency of nitrogen fixation after Sinclair (1986).

#173 *NFIX_RATE*, θ_{NR} $\theta_{\mathrm{NR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Potential nitrogen fixation rate per plant dry matter tissue and day (kg N kg-1 DM-1 d-1).

#174 *PA*, θ_{P} $\theta_{\mathrm{P}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Factor to normalize arrhenius term to 1 for 30oC (-).

#175 *PEXS*, θ^1_{P} $\theta^1_{\mathrm{P}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fraction of root growth that goes into exsudation.

#176 *PFL*, θ^2_{P} $\theta^2_{\mathrm{P}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Distribution parameter for foliage biomass.

#177 *PHOTOPERIODISM*, θ^3_{P} $\theta^3_{\mathrm{P}} \in [0, 24] \subseteq \mathbb{R}$, unit [?]
Photosynthesis photoperiodism: threshold value (daylength in hour).

#178 *PSI_EXP*, θ_{PE} $\theta_{\mathrm{PE}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Exponent for conductivity loss function (unitless).

#179 *PSI_REF*, θ_{PR} $\theta_{\mathrm{PR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Reference xylem pressure for conductivity loss calculations (MPa).

#180 *PSL*, θ^4_{P} $\theta^4_{\mathrm{P}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Distribution parameter for fine root biomass.

#181 *PSNTFROST*, θ^5_{P} $\theta^5_{\mathrm{P}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Temperature at which photosynthesis enzymes start to decline (oC).

#182 *PSNTMAX*, θ^6_{P} $\theta^6_{\mathrm{P}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum daytime temperature for photosynthesis (oC).

#183 *PSNTMIN*, θ_{P}^{7} $\theta_{\mathrm{P}}^{7} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Minimum daytime temperature for photosynthesis (oC).

#184 *PSNTOPT*, θ_{P}^{8} $\theta_{\mathrm{P}}^{8} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Reference temperature for respiration (oC).

#185 *QHRD*, θ_{Q} $\theta_{\mathrm{Q}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum rooting depth relative to plant height.

#186 *QJVC*, θ_{Q}^{1} $\theta_{\mathrm{Q}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Relation between maximum electron transport rate and RubP saturated rate of carboxylation (–).

#187 *QRD25*, θ_{Q}^{2} $\theta_{\mathrm{Q}}^{2} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Relation between dark respiration rate and RubP saturated rate of carboxylation at 25 oC (umol m-2 s-1).

#188 *QRF*, θ_{Q}^{3} $\theta_{\mathrm{Q}}^{3} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Ratio between fine root- and foliage biomass under standard conditions.

#189 *QSF_P1*, θ_{QP} $\theta_{\mathrm{QP}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Independent fraction of sapwood area (cm2) to leaf area (m2) ratio.

#190 *QSF_P2*, θ_{QP}^{1} $\theta_{\mathrm{QP}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Height dependent fraction of sapwood area (cm2) to leaf area (m2) ratio.

#191 *QVOVC*, θ_{Q}^{4} $\theta_{\mathrm{Q}}^{4} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Relation between RubP saturated rate of oxygenation and carboxylation.

#192 *QWODFOLMIN*, θ_{Q}^{5} $\theta_{\mathrm{Q}}^{5} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Minimum ratio of carbon allocation to wood and foliage.

#193 *FRTMASSINIT*, θ_{F}^{7} $\theta_{\mathrm{F}}^{7} \in [0, 100] \subseteq \mathbb{R}$, unit $[kg/m^2]$
Fine root biomass for which KRSINIT and KRSCOMP are initialised.

#194 *RBUDDEM*, θ_{R}^{1} $\theta_{\mathrm{R}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Relative increase factor for allocation demand of buds.

#195 *REDISTRIBUTION_ROOT*, θ_{RR} $\theta_{\mathrm{RR}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Amount of root biomass that is redistributed within the rootsystem daily after germination in the dynamic root model.

#196 *RESP*, θ_{R}^{2} $\theta_{\mathrm{R}}^{2} \in [1, 200] \subseteq \mathbb{R}$, unit [?]
Factor determining plant respiration.

#197 *RESPQ10*, θ^3_{R} $\theta^3_{\mathrm{R}} \in [?,?] \subseteq \mathbb{R}$, unit [?]
Q10 for leaf respiration.

#198 *ROOTMRESPFRAC*, θ^4_{R} $\theta^4_{\mathrm{R}} \in [?,?] \subseteq \mathbb{R}$, unit [?]
Ratio of fine root maintenance respiration to biomass production.

#199 *ROOT_LENGTH_N_UP*, θ_{RLNU} $\theta_{\mathrm{RLNU}} \in \{true, false\} \subseteq \mathbb{B}$, unit [−]
If root length instead of mass should be used for determining N uptake.

#200 *RPMIN*, θ^5_{R} $\theta^5_{\mathrm{R}} \in [?,?] \subseteq \mathbb{R}$, unit [?]
(leaf area-normalized) specific whole plant minimum resistance (MPa m2 s mmol-1).

#201 *RS_CONDUCT*, θ_{RC} $\theta_{\mathrm{RC}} \in [?,?] \subseteq \mathbb{R}$, unit [?]
Aerenchyme conductivity.

#202 *SCALE_I*, θ_{SI} $\theta_{\mathrm{SI}} \in [?,?] \subseteq \mathbb{R}$, unit [?]
Scaling factor to convert isoprene activity into standard emission factor for isoprene.

#203 *SCALE_M*, θ_{SM} $\theta_{\mathrm{SM}} \in [?,?] \subseteq \mathbb{R}$, unit [?]
Scaling factor to convert monoterpene activity into standard emission factor for monoterpenes.

#204 *SDJ*, θ^1_{S} $\theta^1_{\mathrm{S}} \in [?,?] \subseteq \mathbb{R}$, unit [?]
Electron transport temperature response parameter.

#205 *SENESCENCE_AGE*, θ_{SA} $\theta_{\mathrm{SA}} \in [0,1] \subseteq \mathbb{R}$, unit [−]
Maximum percentage of living biomass being subject to senescence due to age (tissue turnover) (

#206 *SENESCENCE_DROUGHT*, θ_{SD} $\theta_{\mathrm{SD}} \in [0,1] \subseteq \mathbb{R}$, unit [−]
Maximum percentage of living biomass being subject to senescence due to drought stress (

#207 *SENESCENCE_FROST*, θ_{SF} $\theta_{\mathrm{SF}} \in [0,1] \subseteq \mathbb{R}$, unit [−]
Maximum percentage of living biomass being subject to senescence due to frost stress (

#208 *SENESCENCE_HEAT*, θ_{SH} $\theta_{\mathrm{SH}} \in [0,1] \subseteq \mathbb{R}$, unit [−]
Maximum percentage of living biomass being subject to senescence due to heat stress (

#209 *SENESCENCE_WATER*, θ_{SW} $\theta_{\mathrm{SW}} \in [0, 1] \subseteq \mathbb{R}$, unit $[-]$
Maximum percentage of living biomass being subject to senescence due to water stress (

#210 *SENESCSTART*, θ^2_{S} $\theta^2_{\mathrm{S}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Day of year when leaf senescence occurs (d).

#211 *SLAMAX*, θ^3_{S} $\theta^3_{\mathrm{S}} \in [2, 50] \subseteq \mathbb{R}$, unit $[m2kg - 1]$
Specific leaf area in the shade (m2 kg-1).

#212 *SLAMIN*, θ^4_{S} $\theta^4_{\mathrm{S}} \in [0, 50] \subseteq \mathbb{R}$, unit $[m2kg - 1]$
Specific leaf area under full light (m2 kg-1).

#213 *SLADECLINE*, θ^5_{S} $\theta^5_{\mathrm{S}} \in [0, 1] \subseteq \mathbb{R}$, unit [%]
Decline of specific leaf area with crop age (

#214 *SLOPE_GSA*, θ_{SG} $\theta_{\mathrm{SG}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Slope of foliage conductivity in response to assimilation in BERRY-BALL model.

#215 *SLOPE_GSCO2*, θ^1_{SG} $\theta^1_{\mathrm{SG}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Slope of stomata conductivity in response to CO_2.

#216 *SLOPE_GSH2O*, θ^2_{SG} $\theta^2_{\mathrm{SG}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Slope of foliage conductivity in response to relative available soil water content.

#217 *SLOPE_NC*, θ_{SN} $\theta_{\mathrm{SN}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Slope for rubisco activity depending foliage nitrogen concentration.

#218 *SRLMAX*, θ^6_{S} $\theta^6_{\mathrm{S}} \in [10000, 600000] \subseteq \mathbb{R}$, unit $[mkg - 1]$
Specific root length at the bottom of the root system (m kg-1).

#219 *SRLMIN*, θ^7_{S} $\theta^7_{\mathrm{S}} \in [2000, 100000] \subseteq \mathbb{R}$, unit $[mkg - 1]$
Specific root length at the bottom of the root system at maturity (m kg-1).

#220 *TAP_P1*, θ_{TP} $\theta_{\mathrm{TP}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
First parameter for stem taper function.

#221 *TAP_P2*, θ^1_{TP} $\theta^1_{\mathrm{TP}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Second parameter for stem taper function.

#222 *TAP_P3*, θ^2_{TP} $\theta^2_{\mathrm{TP}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Third parameter for stem taper function.

#223 *TAU*, θ_{T}^{1} $\theta_{\mathrm{T}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Leaf transmissivity.

#224 *TMINCRIT*, θ_{T}^{2} $\theta_{\mathrm{T}}^{2} \in [0, 100] \subseteq \mathbb{R}$, unit [°C]
Minimum critical temperature for identification of heat stress periods (°C).

#225 *THETA*, θ_{T}^{3} $\theta_{\mathrm{T}}^{3} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Curvature parameter.

#226 *TLIMIT*, θ_{T}^{4} $\theta_{\mathrm{T}}^{4} \in [-5, 25] \subseteq \mathbb{R}$, unit [°C]
Temperature limit for plant growth.

#227 *TOFRTBAS*, θ_{T}^{5} $\theta_{\mathrm{T}}^{5} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fraction of current fine root biomass that dies daily.

#228 *TOSAPMAX*, θ_{T}^{6} $\theta_{\mathrm{T}}^{6} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Fraction of current sapwood biomass that can die per day.

#229 *UCMAX*, θ_{U} $\theta_{\mathrm{U}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Max. spec. N-uptake rate (kgN m-2 leaf area).

#230 *UGWDF*, θ_{U}^{1} $\theta_{\mathrm{U}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Under-ground wood fraction (coarse root biomass in relation to total wood mass) [kgDW kgDW-1].

#231 *US_NH4*, θ_{UN} $\theta_{\mathrm{UN}} \in [0, 0.05] \subseteq \mathbb{R}$, unit $[kgNkg - 1]$
Max. spec. NH_4-N uptake rate (kgN kg-1 fine root dry weight day-1 or kgN km-1 fine root day -1).

#232 *US_NH4MYC*, θ_{UN}^{1} $\theta_{\mathrm{UN}}^{1} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Max. spec. NH_4-N uptake rate of mycorrhiza (kgN kg-1 fine root dry weight day-1).

#233 *US_DON*, θ_{UD} $\theta_{\mathrm{UD}} \in [0, 0.05] \subseteq \mathbb{R}$, unit $[kgNkg - 1]$
Max. spec. DON-N uptake rate (kgN kg-1 fine root dry weight day-1 or kgN km-1 fine root day -1).

#234 *US_NO3*, θ_{UN}^{2} $\theta_{\mathrm{UN}}^{2} \in [0, 0.05] \subseteq \mathbb{R}$, unit $[kgNkg - 1]$
Max. spec. NO_3-N uptake rate (kgN kg-1 fine root dry weight day-1 or kgN km-1 fine root day -1).

#235 *US_NO3MYC*, θ_{UN}^{3} $\theta_{\mathrm{UN}}^{3} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Max. spec. NO_3-N uptake rate of mycorrhiza (kgN kg-1 fine root dry weight day-1).

#236 *VCFACT*, θ_{V} $\theta_{\mathrm{V}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Scaling factor for enzyme activities in the MEP pathway other than isoprene and monoterpene synthases.

#237 *VCMAX25*, θ^1_{V} $\theta^1_{\mathrm{V}} \in [5, 200] \subseteq \mathbb{R}$, unit $[umolm - 2s - 1]$
Maximum RubP saturated rate of carboxylation at 25oC for sun leaves (umol m-2 s-1).

#238 *VPDREF*, θ^2_{V} $\theta^2_{\mathrm{V}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Vapor pressure at which stomata are fully closed (kPa).

#239 *WINTERLIMIT*, θ_{W} $\theta_{\mathrm{W}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Maximum allowed biomass before vernalization period.

#240 *WOODMRESPA*, θ^1_{W} $\theta^1_{\mathrm{W}} \in [?, ?] \subseteq \mathbb{R}$, unit [?]
Wood maintenance respiration as a fraction of gross photosynthesis.

#241 *WUECMAX*, θ^2_{W} $\theta^2_{\mathrm{W}} \in [1, 100] \subseteq \mathbb{R}$, unit $\left[\frac{\mathrm{mg\,CO_2}}{\mathrm{g\,H_2O}}\right]$
Maximum instantaneous water use efficiency.

#242 *WUECMIN*, θ^3_{W} $\theta^3_{\mathrm{W}} \in [1, 100] \subseteq \mathbb{R}$, unit $\left[\frac{\mathrm{mg\,CO_2}}{\mathrm{g\,H_2O}}\right]$
Minimum instantaneous water use efficiency constant.

#243 *ZRTMC*, θ_{Z} $\theta_{\mathrm{Z}} \in [0.01, 100] \subseteq \mathbb{R}$, unit $[m]$
Maximum depth of fine roots.

Supported formats are

1. `xml`: see example **??** for XML formatted species parameters
2. `resources`: can be locally overwritten to set an alternative global default.

3.2.9.1 Formats

XML Example of speciesparameters input given as XML input:

```
<?xml version="1.0"?>
<ldndcspeciesparameters>
   <!--
     id .. block id
     mnemonic .. type name of species
     group .. species group (may be omitted for children)
```

```
-->

<speciesparameters id="0" >

  <species mnemonic="__crops__" group="crop" >

      <par name="deciduous" value="true" />
      <par name="freegrowth" value="true" />

      <species mnemonic="__summercrops__" >

        <par name="winterlimit" value="0.0" />

      </species>

      <species mnemonic="__wintercrops__" >

        <par name="winterlimit" value="400.0" />

        <species mnemonic="winterwheat" name="winter wheat" >
            <par name="graincn" value="58.0" />
            <par name="grain" value="0.6" />
            <par name="root" value="0.05" />
            <par name="strawcn" value="50.0" />
            <par name="straw" value="0.35" />
            <par name="zrtmc" value="1.0" />
        </species>
      </species>
  </species>

  <species mnemonic="__grasses__" group="grass" >
      <species mnemonic="perennialgrass" >
        <par name="wuecmax" value="12.9" />
      </species>
  </species>

  <species mnemonic="__trees__" group="wood" >
      <species mnemonic="fagussylvatica" >
        <par name="amaxa" value="5.73" />
        <par name="amaxb" value="71.0" />

        <species mnemonic="fagussylvatica-tortuosa" >
```

```
                <par name="amaxa" value="1.3" />
              </species>
            </species>
        </species>

    </speciesparameters>
</ldndcspeciesparameters>
```

A full reference example:

```
<?xml version="1.0"?>
<ldndcspeciesparameters>
  <!--
    id .. block id
  -->

  <speciesparameters id="0" >
    <species mnemonic="loewenzahn" group="grass" >
      <!-- #1 True for C4 photosynthesis type, false for C3 phot... -->
      <par name="c4_type" value="true .. false" />
      <!-- #2 True for conifers, false for broad leaved species -->
      <par name="coniferous" value="true .. false" />
      <!-- #3 True for deciduous, false for evergreen species -->
      <par name="deciduous" value="true .. false" />
      <!-- #4 True for dimensional growth once a year (during a ... -->
      <par name="freegrowth" value="true .. false" />
      <!-- #5 True for ratoon plants -->
      <par name="ratoon" value="true .. false" />
      <!-- #6 If true than a root development taking environment... -->
      <par name="roots_environmental" value="true .. false" />
      <!-- #7 True for savanna plants -->
      <par name="savanna" value="true .. false" />
      <!-- #8 True for plants with belowground storage organs -->
      <par name="tuber" value="true .. false" />
      <!-- #9 Time interval necessary to complete growth of new ... -->
      <par name="ndflush" value="? .. ?" />
      <!-- #10 Time interval necessary to complete litterfall of ... -->
      <par name="ndmorta" value="? .. ?" />
      <!-- #11 Total leaf longevity from the first day of the eme... -->
      <par name="dleafshed" value="? .. ?" />
      <!-- #12 Reference drought stress parameter for non-stomata... -->
      <par name="a_ref" value="? .. ?" />
```

```
<!-- #13 Exponential parameter for non-stomatal limitation ... -->
<par name="a_exp" value="? .. ?" />
<!-- #14 Activation energy for isoprenoid emission (J mol-1... -->
<par name="aeis" value="? .. ?" />
<!-- #15 Activation energy for electron transport (J mol-1) -->
<par name="aejm" value="? .. ?" />
<!-- #16 Activation energy for Michaelis-Menten constant fo... -->
<par name="aekc" value="? .. ?" />
<!-- #17 Activation energy for Michaelis-Menten constant fo... -->
<par name="aeko" value="? .. ?" />
<!-- #18 Activation energy for dark respiration (J mol-1) -->
<par name="aerd" value="? .. ?" />
<!-- #19 Activation energy for photosynthesis (J mol-1) -->
<par name="aevc" value="? .. ?" />
<!-- #20 Activation energy for RubP oxygenation (J mol-1) -->
<par name="aevo" value="? .. ?" />
<!-- #21 Light reflection (albedo) -->
<par name="alb" value="? .. ?" />
<!-- #22 Increase of isoprene emission activity per wheight... -->
<par name="alpha0_is" value="? .. ?" />
<!-- #23 Increase of monoterpene emission activity per whei... -->
<par name="alpha0_mt" value="? .. ?" />
<!-- #24 Intercept-coefficient for Amax calculation (nmolCO... -->
<par name="amaxa" value="? .. ?" />
<!-- #25 Maximal net photosynthesis rate (nmolCO2 g-1 s-1 /... -->
<par name="amaxb" value="? .. ?" />
<!-- #26 Daily Amax as fraction of instantaneous early-morn... -->
<par name="amaxfrac" value="? .. ?" />
<!-- #27 Dark respiration as fraction of Amax -->
<par name="basefolrespfrac" value="? .. ?" />
<!-- #28 Crown base height - tree height ratio -->
<par name="cb" value="? .. ?" />
<!-- #29 Canopy temperature damping factor -->
<par name="cdamp" value="? .. ?" />
<!-- #30 First parameter for crown length calculation -->
<par name="cl_p1" value="? .. ?" />
<!-- #31 Second parameter for crown length calculation -->
<par name="cl_p2" value="? .. ?" />
<!-- #32 First parameter for crown diameter calculation -->
<par name="cdr_p1" value="? .. ?" />
<!-- #33 Second parameter for crown diameter calculation -->
<par name="cdr_p2" value="? .. ?" />
```

```
<!-- #34 Third parameter for crown diameter calculation -->
<par name="cdr_p3" value="? .. ?" />
<!-- #35 Cellulose content in biomass -->
<par name="cellulose" value="? .. ?" />
<!-- #36 Optimal ratio between fungi biomass and total myco... -->
<par name="cfcropt" value="? .. ?" />
<!-- #37 Required chilling units vernalization -->
<par name="chill_units" value="? .. ?" />
<!-- #38 Maximum temperature for chilling progress -->
<par name="chill_temp_max" value="? .. ?" />
<!-- #39 Reference water potential at which soil-root conne... -->
<par name="csr_ref" value="? .. ?" />
<!-- #40 Scaling constant for temperature sensitivity of is... -->
<par name="ct_is" value="? .. ?" />
<!-- #41 Scaling constant for temperature sensitivity -->
<par name="ct_mt" value="? .. ?" />
<!-- #42 Reference (=maximum) value for the (leaf area-norm... -->
<par name="cwp_ref" value="? .. ?" />
<!-- #43 Branch dry weight mass per canopy volume (kg:m\^-3... -->
<par name="dbranch" value="? .. ?" />
<!-- #44 Exponent for density effect on tree growth (-) -->
<par name="df_exp" value="? .. ?" />
<!-- #45 Area cover at which trees start feeling density ef... -->
<par name="df_limit" value="? .. ?" />
<!-- #46 Leaf density (kg DW:dm FW-3) -->
<par name="dfol" value="? .. ?" />
<!-- #47 Optimum fine root density (kg:m-3) -->
<par name="dfrtopt" value="? .. ?" />
<!-- #48 Breast height diameter at maturity (m) -->
<par name="diammax" value="? .. ?" />
<!-- #49 Ratio os root exudates related to root growth resp... -->
<par name="doc_resp_ratio" value="0 .. 1" />
<!-- #50 Drag coefficient for wind speed approximation in c... -->
<par name="dragc" value="? .. ?" />
<!-- #51 Wood density (kg DW:dm FW-3) -->
<par name="dsap" value="? .. ?" />
<!-- #52 Entropy term for isoprene synthase sensitivity to ... -->
<par name="ds_is" value="? .. ?" />
<!-- #53 Entropy term for GDP synthase sensitivity to tempe... -->
<par name="ds_mt" value="? .. ?" />
<!-- #54 First parameter for vapor pressure deficit - impac... -->
<par name="dvpd1" value="? .. ?" />
```

```
<!-- #55 Second parameter for vapor pressure deficit - impa... -->
<par name="dvpd2" value="? .. ?" />
<!-- #56 Isoprene emission rate under standard conditions (... -->
<par name="ef_iso" value="? .. ?" />
<!-- #57 Monoterpene emission rate under standard condition... -->
<par name="ef_mono" value="? .. ?" />
<!-- #58 Emission rate of stored terpenes under standard co... -->
<par name="ef_monos" value="? .. ?" />
<!-- #59 Emission rate of other VOCs under standard conditi... -->
<par name="ef_ovoc" value="? .. ?" />
<!-- #60 Relative exploration rate of \nhfour -->
<par name="expl_nh4" value="0 .. 1" />
<!-- #61 Relative exploration rate of \nothree -->
<par name="expl_no3" value="0 .. 1" />
<!-- #62 Exponential factor for plant root distribution \no... -->
<par name="exp_root_distribution" value="-5 .. 15" />
<!-- #63 Light extinction (attenuation) coefficient for pho... -->
<par name="ext" value="0 .. 1" />
<!-- #64 Relative decrease of emission synthesis per foliag... -->
<par name="fage" value="0 .. 1" />
<!-- #65 Final branchwood fraction of mature trees (kg DW:k... -->
<par name="fbraf_m" value="0 .. 1" />
<!-- #66 Final branchwood fraction of seedlings (kg DW:kg D... -->
<par name="fbraf_y" value="0 .. 1" />
<!-- #67 Maximum relativ amount of free available carbohydr... -->
<par name="ffacmax" value="0 .. 1" />
<!-- #68 Crown damage parameter 1 -->
<par name="fire_rck" value="? .. ?" />
<!-- #69 Crown damage parameter 2 -->
<par name="fire_p" value="? .. ?" />
<!-- #70 Bark thickness parameter 1 -->
<par name="fire_barka" value="? .. ?" />
<!-- #71 Bark thickness parameter 2 -->
<par name="fire_barkb" value="? .. ?" />
<!-- #72 Fuel bulk density [kg:m-3] -->
<par name="fire_densfuel" value="? .. ?" />
<!-- #73 Scorch height parameter -->
<par name="fire_flame" value="? .. ?" />
<!-- #74 Fire resistance parameter -->
<par name="fire_fireresist" value="? .. ?" />
<!-- #75 Fire emission factor for \cotwo\ per biomass [kg:k... -->
<par name="fire_em_co2" value="? .. ?" />
```

```
<!-- #76 Fire emission factor for CO per biomass [kg:kg-1] -->
<par name="fire_em_co" value="? .. ?" />
<!-- #77 Fire emission factor for \chfour\ per biomass [kg:... -->
<par name="fire_em_ch4" value="? .. ?" />
<!-- #78 Fire emission factor for VOC per biomass [kg:kg-1] -->
<par name="fire_em_voc" value="? .. ?" />
<!-- #79 Fire emission factor for TPM per biomass [kg:kg-1] -->
<par name="fire_em_tpm" value="? .. ?" />
<!-- #80 Fire emission factor for nox per biomass [kg:kg-1] -->
<par name="fire_em_nox" value="? .. ?" />
<!-- #81 Fire emission factor for \ntwoo\ per biomass [kg:k... -->
<par name="fire_em_n2o" value="? .. ?" />
<!-- #82 Fire emission factor for \ntwo\ per biomass [kg:kg... -->
<par name="fire_em_n2" value="? .. ?" />
<!-- #83 Maximum relative growth rate for foliage (% year-1... -->
<par name="folrelgromax" value="? .. ?" />
<!-- #84 Biomass fraction of roots at start of growing seas... -->
<par name="fraction_root_start" value="-1 .. 1" />
<!-- #85 Biomass fraction of roots at maturity -->
<par name="fraction_root" value="0 .. 1" />
<!-- #86 Biomass fraction of fruit at maturity -->
<par name="fraction_fruit" value="0 .. 1" />
<!-- #87 Biomass fraction of foliage at maturity -->
<par name="fraction_foliage" value="0 .. 1" />
<!-- #88 Maximum fraction of nitrogen retranslocated before... -->
<par name="fret_n" value="? .. ?" />
<!-- #89 Frost effect on photosynthesis: species specific m... -->
<par name="frosta" value="? .. ?" />
<!-- #90 Frost effect on photosynthesis: species specific c... -->
<par name="frostb" value="? .. ?" />
<!-- #91 Relative share of foliage growth to root growth -->
<par name="frtalloc_base" value="? .. ?" />
<!-- #92 Fixed amount of carbon allocated to root growth -->
<par name="frtalloc_rel" value="? .. ?" />
<!-- #93 Scaling factor for fine root loss -->
<par name="frtloss_scale" value="? .. ?" />
<!-- #94 Fraction of growth respiration relative to gross a... -->
<par name="fyield" value="? .. ?" />
<!-- #95 Base tempeature for growing degree days -->
<par name="gdd_base_temperature" value="-10 .. 20" />
<!-- #96 Maximum daily increase of growing degree days -->
<par name="gdd_max_temperature" value="10 .. 40" />
```

```
<!-- #97 Growing degree days until begin of emergence (dry ... -->
<par name="gdd_emergence" value="? .. ?" />
<!-- #98 Growing degree days until begin of stem elongation -->
<par name="gdd_stem_elongation" value="? .. ?" />
<!-- #99 Growing degree days until begin of flowering -->
<par name="gdd_flowering" value="? .. ?" />
<!-- #100 Growing degree days until begin of grain filling -->
<par name="gdd_grain_filling" value="? .. ?" />
<!-- #101 Growing degree days until downwards root growth ce... -->
<par name="gdd_roots_grown" value="? .. ?" />
<!-- #102 Growing degree days until maturity -->
<par name="gdd_maturity" value="? .. ?" />
<!-- #103 Growing degree days to complete foliar production -->
<par name="gddfolend" value="? .. ?" />
<!-- #104 Minimum temperature sum for foliage activity onset... -->
<par name="gddfolstart" value="? .. ?" />
<!-- #105 Growing degree days to complete wood production -->
<par name="gddwodend" value="? .. ?" />
<!-- #106 Growing degree days to start wood production -->
<par name="gddwodstart" value="? .. ?" />
<!-- #107 Base value for vmax for GGDP synthesis at 30 oC (u... -->
<par name="ggdps_b" value="? .. ?" />
<!-- #108 Maximum stomata conductivity (mmolH2O m-2 s-1) -->
<par name="gsmax" value="? .. ?" />
<!-- #109 Minimum stomata conductivity (mmolH2O m-2 s-1) -->
<par name="gsmin" value="? .. ?" />
<!-- #110 Growth rate of fine root into deeper soil layers (... -->
<par name="gzrtz" value="0.001 .. 0.3" />
<!-- #111 Relative available soil water content at which dro... -->
<par name="h2oref_a" value="0 .. 1" />
<!-- #112 Relative available soil water content below which ... -->
<par name="h2oref_flushing" value="0 .. 1" />
<!-- #113 Relative available soil water content below which ... -->
<par name="h2oref_leaf_growth" value="0 .. 1" />
<!-- #114 Relative available soil water content at which sto... -->
<par name="h2oref_gs" value="0 .. 1" />
<!-- #115 Relative available soil water content below which ... -->
<par name="h2oref_senescence" value="0 .. 1" />
<!-- #116 Half saturation light intensity (umoles m-2 s-1) -->
<par name="halfsat" value="? .. ?" />
<!-- #117 Activation energy for isoprene synthase (J mol-1) -->
<par name="ha_is" value="? .. ?" />
```

```
<!-- #118 Activation energy for GDP synthase (J mol-1) -->
<par name="ha_mt" value="? .. ?" />
<!-- #119 Deactivation energy for isoprene synthase (J mol-1... -->
<par name="hd_is" value="? .. ?" />
<!-- #120 Curvature parameter of jMax (J mol-1) -->
<par name="hdj" value="? .. ?" />
<!-- #121 Parameter for estimation of height:diameter ratio ... -->
<par name="hd_exp" value="? .. ?" />
<!-- #122 Maximum height to breast height diameter ratio (m ... -->
<par name="hd_max" value="? .. ?" />
<!-- #123 Minimum height to breast height diameter ratio (m ... -->
<par name="hd_min" value="? .. ?" />
<!-- #124 Deactivation energy for monoterpene synthase (J mo... -->
<par name="hd_mt" value="? .. ?" />
<!-- #125 Canopy depth where full foliage is developed -->
<par name="href" value="? .. ?" />
<!-- #126 Negative maximum leaf hydraulic head \nothree -->
<par name="hleafcrit" value="-50000 .. 0" />
<!-- #127 Hypoxia effect on photosynthesis -->
<par name="hypoxia" value="0 .. 1" />
<!-- #128 Factor determining nitrogen fixation -->
<par name="ini_n_fix" value="0 .. 10" />
<!-- #129 Michaelis-Menten constant for CO2 at 25oC (umol mo... -->
<par name="kc25" value="? .. ?" />
<!-- #130 Compensatory hydraulic conductivity of the root sy... -->
<par name="kcompinit" value="-1.1 .. 1" />
<!-- #131 Maintenance coefficient at reference temperature -->
<par name="km20" value="? .. ?" />
<!-- #132 KM for GDP synthesis from DMADP (umol L-1) -->
<par name="km_gdps_dmadp" value="? .. ?" />
<!-- #133 KM for GDP synthesis from IDP (umol L-1) -->
<par name="km_gdps_idp" value="? .. ?" />
<!-- #134 KM for isoprene synthesis from DMADP (umol L-1) -->
<par name="km_is" value="? .. ?" />
<!-- #135 KM for monoterpene synthesis from GDP(umol L-1) -->
<par name="km_mt" value="? .. ?" />
<!-- #136 Michaelis-Menten constant for nitrogen uptake (kg:... -->
<par name="k_mm_nitrogen_uptake" value="? .. ?" />
<!-- #137 Michaelis-Menten constant for O2 at 25oC (mmol mol... -->
<par name="ko25" value="? .. ?" />
<!-- #138 Decomposition rate of wood -->
<par name="krc_wood" value="? .. ?" />
```

```
<!-- #139 Compensatory hydraulic conductivity of the root sy... -->
<par name="krscomp" value="0 .. 1" />
<!-- #140 Initial hydraulic conductivity of the root system -->
<par name="krsinit" value="0 .. 1" />
<!-- #141 Lignin fraction of biomass -->
<par name="lignin" value="? .. ?" />
<!-- #142 Reference temperature for maintenance respiration -->
<par name="maintenance_temp_ref" value="5 .. 40" />
<!-- #143 Maintenance respiration coefficient of leaves -->
<par name="mc_leaf" value="? .. ?" />
<!-- #144 Maintenance respiration coefficient of stems -->
<par name="mc_stem" value="? .. ?" />
<!-- #145 Maintenance respiration coefficient of roots -->
<par name="mc_root" value="? .. ?" />
<!-- #146 Maintenance respiration coefficient of storage org... -->
<par name="mc_storage" value="? .. ?" />
<!-- #147 Foliage biomass under optimal, closed canopy condi... -->
<par name="mfolopt" value="? .. ?" />
<!-- #148 Maximum achievable fruit dry weight biomass under ... -->
<par name="m_fruit_opt" value="? .. ?" />
<!-- #149 Crowding mortality (yr-1) -->
<par name="mortcrowd" value="? .. ?" />
<!-- #150 Normal tree mortality (yr-1) -->
<par name="mortnorm" value="? .. ?" />
<!-- #151 Percentage decrease of isoprene emission activity ... -->
<par name="mue_is" value="? .. ?" />
<!-- #152 Percentage decrease of monoterpene emission activi... -->
<par name="mue_mt" value="? .. ?" />
<!-- #153 Specific interception capacity of foliage (m m-2LA... -->
<par name="mwfm" value="0 .. 0.001" />
<!-- #154 Specific interception capacity of wood mass (m kg-... -->
<par name="mwwm" value="0 .. 0.0001" />
<!-- #155 Minimum nitrogen concentration of foliage (kg kg-1... -->
<par name="nc_foliage_min" value="-1 .. 0.2" />
<!-- #156 Optimum nitrogen concentration of foliage (kg kg-1... -->
<par name="nc_foliage_max" value="0 .. 0.2" />
<!-- #157 Optimum nitrogen concentration of foliage (kg kg-1... -->
<par name="ncfolopt" value="0 .. 0.2" />
<!-- #158 Maximum (optimum) nitrogen concentration of fine r... -->
<par name="nc_fineroots_max" value="0 .. 0.2" />
<!-- #159 Minimum nitrogen concentration of fine roots (kg k... -->
<par name="nc_fineroots_min" value="0 .. 0.2" />
```

```
<!-- #160 Maximum (optimum) nitrogen concentration of fruit ... -->
<par name="nc_fruit_max" value="0 .. 0.2" />
<!-- #161 Minimum nitrogen concentration of fruit (kg kg-1) -->
<par name="nc_fruit_min" value="0 .. 0.2" />
<!-- #162 Optimum nitrogen concentration of living structura... -->
<par name="nc_structural_tissue_max" value="0 .. 0.2" />
<!-- #163 Minimum nitrogen concentration of living structura... -->
<par name="nc_structural_tissue_min" value="0 .. 0.2" />
<!-- #164 Optimum nitrogen concentration of sapwood (kg kg-1... -->
<par name="ncsapopt" value="0 .. 0.2" />
<!-- #165 Factor defines nitrogen deficiency -->
<par name="n_def_factor" value="? .. ?" />
<!-- #166 Empirical vegetative nitrogen demand multiplier -->
<par name="n_demand_veg" value="? .. ?" />
<!-- #167 Empirical reproductive nitrogen demand multiplier -->
<par name="n_demand_reprod" value="? .. ?" />
<!-- #168 Carbon use efficiency for nitrogen fixation -->
<par name="nfix_ceff" value="? .. ?" />
<!-- #169 Maximum temperature for nitrogen fixation -->
<par name="nfix_tmax" value="? .. ?" />
<!-- #170 Optimum temperature for nitrogen fixation -->
<par name="nfix_topt" value="? .. ?" />
<!-- #171 Minimum temperature for nitrogen fixation -->
<par name="nfix_tmin" value="? .. ?" />
<!-- #172 Parameter m for water dependency of nitrogen fixat... -->
<par name="nfix_w" value="? .. ?" />
<!-- #173 Potential nitrogen fixation rate per plant dry mat... -->
<par name="nfix_rate" value="? .. ?" />
<!-- #174 Factor to normalize arrhenius term to 1 for 30oC (... -->
<par name="pa" value="? .. ?" />
<!-- #175 Fraction of root growth that goes into exsudation -->
<par name="pexs" value="? .. ?" />
<!-- #176 Distribution parameter for foliage biomass -->
<par name="pfl" value="? .. ?" />
<!-- #177 Photosynthesis photoperiodism: threshold value (da... -->
<par name="photoperiodism" value="0 .. 24" />
<!-- #178 Exponent for conductivity loss function (unitless) -->
<par name="psi_exp" value="? .. ?" />
<!-- #179 Reference xylem pressure for conductivity loss cal... -->
<par name="psi_ref" value="? .. ?" />
<!-- #180 Distribution parameter for fine root biomass -->
<par name="psl" value="? .. ?" />
```

```
<!-- #181 Temperature at which photosynthesis enzymes start ... -->
<par name="psntfrost" value="? .. ?" />
<!-- #182 Maximum daytime temperature for photosynthesis (oC... -->
<par name="psntmax" value="? .. ?" />
<!-- #183 Minimum daytime temperature for photosynthesis (oC... -->
<par name="psntmin" value="? .. ?" />
<!-- #184 Reference temperature for respiration (oC) -->
<par name="psntopt" value="? .. ?" />
<!-- #185 Maximum rooting depth relative to plant height -->
<par name="qhrd" value="? .. ?" />
<!-- #186 Relation between maximum electron transport rate a... -->
<par name="qjvc" value="? .. ?" />
<!-- #187 Relation between dark respiration rate and RubP sa... -->
<par name="qrd25" value="? .. ?" />
<!-- #188 Ratio between fine root- and foliage biomass under... -->
<par name="qrf" value="? .. ?" />
<!-- #189 Independent fraction of sapwood area (cm2) to leaf... -->
<par name="qsf_p1" value="? .. ?" />
<!-- #190 Height dependent fraction of sapwood area (cm2) to... -->
<par name="qsf_p2" value="? .. ?" />
<!-- #191 Relation between RubP saturated rate of oxygenatio... -->
<par name="qvovc" value="? .. ?" />
<!-- #192 Minimum ratio of carbon allocation to wood and fol... -->
<par name="qwodfolmin" value="? .. ?" />
<!-- #193 Fine root biomass for which KRSINIT and KRSCOMP ar... -->
<par name="frtmassinit" value="0 .. 100" />
<!-- #194 Relative increase factor for allocation demand of ... -->
<par name="rbuddem" value="? .. ?" />
<!-- #195 Amount of root biomass that is redistributed withi... -->
<par name="redistribution_root" value="? .. ?" />
<!-- #196 Factor determining plant respiration -->
<par name="resp" value="1 .. 200" />
<!-- #197 Q10 for leaf respiration -->
<par name="respq10" value="? .. ?" />
<!-- #198 Ratio of fine root maintenance respiration to biom... -->
<par name="rootmrespfrac" value="? .. ?" />
<!-- #199 If root length instead of mass should be used for ... -->
<par name="root_length_n_up" value="true .. false" />
<!-- #200 (leaf area-normalized ) specific whole plant minim... -->
<par name="rpmin" value="? .. ?" />
<!-- #201 Aerenchyme conductivity -->
<par name="rs_conduct" value="? .. ?" />
```

```
<!-- #202 Scaling factor to convert isoprene activity into s... -->
<par name="scale_i" value="? .. ?" />
<!-- #203 Scaling factor to convert monoterpene activity int... -->
<par name="scale_m" value="? .. ?" />
<!-- #204 Electron transport temperature response parameter -->
<par name="sdj" value="? .. ?" />
<!-- #205 Maximum percentage of living biomass being subject... -->
<par name="senescence_age" value="0 .. 1" />
<!-- #206 Maximum percentage of living biomass being subject... -->
<par name="senescence_drought" value="0 .. 1" />
<!-- #207 Maximum percentage of living biomass being subject... -->
<par name="senescence_frost" value="0 .. 1" />
<!-- #208 Maximum percentage of living biomass being subject... -->
<par name="senescence_heat" value="0 .. 1" />
<!-- #209 Maximum percentage of living biomass being subject... -->
<par name="senescence_water" value="0 .. 1" />
<!-- #210 Day of year when leaf senescence occurs (d) -->
<par name="senescstart" value="? .. ?" />
<!-- #211 Specific leaf area in the shade (m2 kg-1) -->
<par name="slamax" value="2 .. 50" />
<!-- #212 Specific leaf area under full light (m2 kg-1) -->
<par name="slamin" value="0 .. 50" />
<!-- #213 Decline of specific leaf area with crop age (%/100... -->
<par name="sladecline" value="0 .. 1" />
<!-- #214 Slope of foliage conductivity in response to assim... -->
<par name="slope_gsa" value="? .. ?" />
<!-- #215 Slope of stomata conductivity in response to \cotw... -->
<par name="slope_gsco2" value="? .. ?" />
<!-- #216 Slope of foliage conductivity in response to relat... -->
<par name="slope_gsh2o" value="? .. ?" />
<!-- #217 Slope for rubisco activity depending foliage nitro... -->
<par name="slope_nc" value="? .. ?" />
<!-- #218 Specific root length at the bottom of the root sys... -->
<par name="srlmax" value="10000 .. 600000" />
<!-- #219 Specific root length at the bottom of the root sys... -->
<par name="srlmin" value="2000 .. 100000" />
<!-- #220 First parameter for stem taper function -->
<par name="tap_p1" value="? .. ?" />
<!-- #221 Second parameter for stem taper function -->
<par name="tap_p2" value="? .. ?" />
<!-- #222 Third parameter for stem taper function -->
<par name="tap_p3" value="? .. ?" />
```

```
<!-- #223 Leaf transmissivity -->
<par name="tau" value="? .. ?" />
<!-- #224 Minimum critical temperature for identification of... -->
<par name="tmincrit" value="0 .. 100" />
<!-- #225 Curvature parameter -->
<par name="theta" value="? .. ?" />
<!-- #226 Temperature limit for plant growth -->
<par name="tlimit" value="-5 .. 25" />
<!-- #227 Fraction of current fine root biomass that dies da... -->
<par name="tofrtbas" value="? .. ?" />
<!-- #228 Fraction of current sapwood biomass that can die p... -->
<par name="tosapmax" value="? .. ?" />
<!-- #229 Max... -->
<par name="ucmax" value="? .. ?" />
<!-- #230 Under-ground wood fraction (coarse root biomass in... -->
<par name="ugwdf" value="? .. ?" />
<!-- #231 Max... -->
<par name="us_nh4" value="0 .. 0.05" />
<!-- #232 Max... -->
<par name="us_nh4myc" value="? .. ?" />
<!-- #233 Max... -->
<par name="us_don" value="0 .. 0.05" />
<!-- #234 Max... -->
<par name="us_no3" value="0 .. 0.05" />
<!-- #235 Max... -->
<par name="us_no3myc" value="? .. ?" />
<!-- #236 Scaling factor for enzyme activities in the MEP pa... -->
<par name="vcfact" value="? .. ?" />
<!-- #237 Maximum RubP saturated rate of carboxylation at 25... -->
<par name="vcmax25" value="5 .. 200" />
<!-- #238 Vapor pressure at which stomata are fully closed (... -->
<par name="vpdref" value="? .. ?" />
<!-- #239 Maximum allowed biomass before vernalization perio... -->
<par name="winterlimit" value="? .. ?" />
<!-- #240 Wood maintenance respiration as a fraction of gros... -->
<par name="woodmrespa" value="? .. ?" />
<!-- #241 Maximum instantaneous water use efficiency -->
<par name="wuecmax" value="1 .. 100" />
<!-- #242 Minimum instantaneous water use efficiency constan... -->
<par name="wuecmin" value="1 .. 100" />
<!-- #243 Maximum depth of fine roots -->
<par name="zrtmc" value="0.01 .. 100" />
```

```
    </species> <!-- close species loewenzahn -->
  </speciesparameters>

</ldndcspeciesparameters>
```

3.2.10 Farmer [farmer]

In this section, we describe all input entities for the input class farmer. Information given in this input class describe the base for the dynamic grassland management.

List of entities

1. *REG_COMMENT* text, default -, unit [-]

   Comment, which will be displayed in the LDNDC log

2. *REG_METHOD* int, default 1, unit [-]

   Define which regression method should be used between $FIRST\_REG\_DAY$ and $LAST\_REG\_DAY$.

   1 = site specific linear regression: Biomass = $REG1$ * doy + $REG2$

   2 = site specific power regression: Biomass = $REG1$ * pow(doy, $REG2$)

   3 = general regression approach: Biomass in % (of $YEARLY\_BIOMASS$) = -0.1228*doy + 48.9639

3. *REG1* real, default -15.251, unit [kg/ha/day or kg/ha]

   Defines linear or power regression coefficients.

4. *REG2* real, default 5873.6, unit [kg/ha or -]

   Defines linear or power regression coefficients.

5. *FIRST_REG_DAY* real, default 130, unit [doy]

   Defines before which day in spring the regression function runs with slope = 0.

6. *LAST_REG_DAY* real, default 316, unit [doy]

   Defines after which day in autumn the regression function runs with slope = 0.

7. *YEARLY_BIOMASS* real float, default 0.0, unit [kgha-1]

   Defines the value of the mean yearly biomass used for the general regression approach.

8. *DAYS_BETWEEN_CUTS* real, default 55, unit [days]

   Defines the maximum days between two cutting events after which a cut is forced ($DAYS\_BETWEEN\_CUTS + 1$).

9. *DAY_FIRST_CUT* real, default 150, unit [doy]

   Defines the latest day of the first cutting event after which a cut is forced ($DAY\_FIRST\_CUT + 1$).

10. *MIN_DAYS_BETWEEN_CUT_MANURE* real, default 4, unit [days]

    Defines the latest day of the first cutting event after which a cut is forced ($DAY\_FIRST\_CUT + 1$).

11. *RAIN_BOUNDARY* real, default 0.0, unit [mm]

    Defines the daily rain boundary for manure application (starting 7 days after a cutting event). If daily rain sum $> RAIN\_BOUNDARY$, the model loops as long as a day with daily rain sum $< RAIN\_BOUNDARY$ occurs.

12. *C_AMOUNT* real, default 437.45, unit [kgha-1]

    Defines the applied carbon amount per manure application. This is the only manure composition specific parameter which can be changed.

13. *FIRST_MANURE_METHOD* real, default 1, unit [-]

    Defines which method is used for the derivation of the doy of the first manure application (in a year). Recommended is method **1** which is very robust. Methods 2 and 3 were implemented without detailed testing:

    1 = depending on day of emergence, which is calculated by LDNDC plant sub-model plamox

    2 = based on a temperature target sum: temp_sum_target = 30.597 * $FIRST\_MANURE\_REGT$ - 150.98

    3 = if there were consecutive days ($FIRST\_MANURE\_DAYS$) with temperatures > threshold ($FIRST\_MANURE\_TEMP$) in the year (and no frost on that day/night or the following days)

14. *FIRST_MANURE_REGTEMP* real, default 7.0, unit [degC]

    Parameter used for not recommended $FIRST\_MANURE\_METHOD = 2$ or 3.

15. *FIRST_MANURE_TEMP* real, default 5.0, unit [degC]

    Parameter used for not recommended $FIRST\_MANURE\_METHOD = 2$ or 3.

16. *FIRST_MANURE_DAYS* real, default 5, unit [days]

    Parameter used for not recommended $FIRST\_MANURE\_METHOD = 2$ or 3.

17. *MANURE_METHOD* real, default 1, unit [-]

    This parameter was implemented for the restricted nitrogen scenario (see Petersen et al., 2021).

    1 = no restriction with manure applications after all cutting events (only exception is the second cutting event, see Petersen et al., 2021).

    2 = manure applications only after the 1st and 3rd cut to restrict yearly nitrogen fertilization rates by only allowing three manure events

3.2.10.1 Formats

farmer Example of farmer input:


```
{
   "1": {
       "parameter": [
           {
               "parameterlist": {
                  "reg_comment": "yearly_biomass = slightly adjusted mean biomass measurem
                  "reg_method": 3,
                  "yearly_biomass": 11000.00,
                  "rain_boundary": 0.5
               }
           }
       ]
   },
   "2": {
       "parameter": [
           {
               "parameterlist": {
                  "reg_comment": "chou chou",
                  "reg_method": 3,
                  "yearly_biomass": 9000,
                  "rain_boundary": 3
               }
           }
       ]
   }
}
```

3.2.11 FarmSystem [`farmsystem`]

In this section, we describe all input entities for the input class farmsystem. Information given in this input class describe the base for the dynamic crop management.

3.3 Species

In LandscapeDNDC species are described by their *name* , *group* and *type*. The group assigned to a plant species is, for example, used to determine which submodel is responsible for it. That is, a plant growth model may act only on species that belong to the group that the model is capable of describing. This enables multiple concurrently running plant models (e.g., a crop and a forest model) within an agroforestry simulation to interact without ambiguity. The type serves as a key for selecting a parameterization for the species. The name is used for the unique identification during the simulation and for model output.

List of species groups

1. Crops
2. Grasses
3. Trees

3.3.1 Parameterized vegetation types

LandscapeDNDC includes the following pre-parameterized vegetation types. For each vegetation type, the *mnemonic* (see 3.2.9) is placed in brackets on the right.

3.3.1.1 Crops

- brassica
  - * brassicanapus
    - \- springrape
      - \- Brassica Napus (spring) [SRAPE]
    - \- winterrape
      - \- Brassica Napus [RAPE]
  - * Brassica Oleracea [CABBAGE]
  - * Brussels Sprouts [BRUS]

- solanum
    * Solanum Lycopersicum [TOMO]
    * Ipomoea batatas [SWPO]
    * Solanum Tuberosum [POTA]
- legume
    * Pisum Sativum [PEAS]
    * Phaseolus vulgaris [BEAN]
    * Medicago Sativa [VETCH]
    * Vigna radiata [MUNGBEAN]
    * Medicago Sativa [ALFA]
    * Faba bean [FABA]
    * Cicer arietinum [CHIC]
    * Arachis Hypogaea [PEAN]
    * Pigeonpea [PIGE]
    * Cowpea [COWP]
    * Glycine max [SOYB]
- cucurbits
    * Zucchini, Cucurbita Pepo [CUPE]
- foeniculum
    * Foeniculum Vulgare [FOVU]
    * Foeniculum Vulgare [FENNEL]
- poaceae
    * wheat
        - springwheat
            - Triticum durum [DURUM]
            - Spring Wheat [SPWH]
        - winterwheat
            - Winter Wheat [WIWH]
            - Triticale [TRSE]
    * corn
        - foodcorn
            - Food Corn for the tropics [FOCOTROPICAL]

- Food Corn for temperate regions [FOCO]
- Silage Corn [SICO]

* rye
  - Winter Rye [WINTERRYE]
  - Spring Rye [SPRINGRYE]
* barley
  - winterbarley
    - Winter Barley [WBAR]
  - springbarley
    - Spring Barley [SBAR]
* millets
  - Sorghum bicolor [SORG]
  - Panicum miliaceum [MILT]
* rice
  - japonicas
    - Japonica [JAPONICA]
  - indica
    - Sahodulan 1 [SAHODULAN1]
    - IR 64 [IR64]
    - IR 72 [IR72]
    - Tubigan 18 [TUBIGAN18]
    - pau201 [PAU201]
    - IR 8 [IR8]
  - hybrid
    - Japonica-Indica [JAPONICA-INDICA]
  - Paddy Rice [PADR]
  - Upland Rice [UPLR]
* Avena Sativa [OATS]

• helianthus
  * Sunflower [SUNFLOWER]
• mustard
  * Sinapis Hirta [MUST]
• Linum Usitatissimum [FLAX]
• Carica Papaya [PAPA]

- Carthamus Tinctorius [SAFF]
- Cynara Cardunculus [ARTC]
- Allium Spp. [ONIO]
- Fragaria Spp. [STRB]
- Lactuca Sativa [LETC]
- Fruit Trees [FRUT]
- Apium Graveolens [CELY]
- Raphanus Sativus [RADI]
- Gossipium Hirsutum [COTT]
- Nicotiana tabacum [TOBA]
- Manihot Esculenta [CASSAVA]
- Herbaceous Vegetation [HERBS]
- Mentha piperita [MENT]
- Vitis Spp. [GRAP]
- Citrus X Limon [CITR]
- Beta vulgaris ssp vulgaris [BEET]
- Humulus Spp. [HOPS]

3.3.1.2 Grasses

- c4
  * Saccharum officinarum [SUCA]
  * Panicum Virgatum [PAVI]
  * Miscanthus Giganteus [MIGI]
  * Andropogon Gayanus [ANGA]
  * Pennisetum clandestinum [PECL]
  * Cenchrus biflorus [CEBI]
- c3
  * lolium

- Lolium Italicum [LOIT]
- Lolium Perenne [LOPE]

* Alpine meadows [MEAD]
* Annual Grass [GRASS]
* Perennial Grass [PERG]
* Mosses [MOSS]
* Deschampsia Flexuosa [DEFL]

- Default Parameters [NONE]

3.3.1.3 Trees

- woods
  * mixed
    - Temperate MixedForests [HARVARD]
    - Temperate MixedForests [VIELSALM]
    - Tropical Mixed Forests [TAPAJOS]
  * coniferous
    - pinus
      - Pinus Halepensis [PIHA]
      - Pinus Radiata [PIRA]
      - Pinus Resinosa [PIRE]
      - Pinus Ponderosa [PIPO]
      - Pinus Sylvestris [PISY]
      - Pinus Pinaster [PIPI]
    - picea
      - Picea Abies [PIAB]
      - Picea Sitchensis [PISI]
    - Abies Alba [ABAL]
    - Larix Decidua [LADE]
    - Pseudotsuga Menziesii [PSME]
  * broadleaved
    - acer
      - Acer Saccharum [ACSA]
      - Acer pseudoplatanus [ACPS]
      - Acer Rubrum [ACRU]
    - acacia

- Acacia Tortilis [ACTO]
- eucalyptus
  - Eucalyptus Tetrodonta [EUTE]
  - Eucalyptus Globulus [EUGL]
- salix
  - Salix Viminalis [SAVI]
- populus
  - Hybrid Poplar Typ Max4 [POMAX]
  - Hybrid Poplar Typ Monviso [POMON]
  - Populus alba [POAL]
- quercus
  - Quercus Cerris [QUCE]
  - Quercus Ilex [QUIL]
  - Quercus suber [QUSU]
  - Quercus Pubescens [QUPU]
  - Quercus Alba [QUAL]
  - Quercus Robur/Petraea [QURO]
  - Quercus Rubra [QURU]
- Eleagnus Angustifolia [ELAN]
- Betula Pendula/Pubescens [BEPE]
- Burkea Africana [BUAF]
- Robinia Pseudoacacia [ROPS]
- Tilia Cordata [TICO]
- Alnus glutinosa [ALGL]
- Fagus Sylvatica [FASY]
- Fraxinus excelsior [FREX]
- Liriodendron Tulipifera [LITU]
- Calluna Vulgaris [CAVU]
- Carpinus betulus [CABE]
- Elaeis guineensis [ELGU]

3.4 Miscellaneous

3.4.1 Regional input

Each input source by definition holds regional input, that means, input for an arbitrary number of sites can be listed. Setting up a regional simulation now means decomposing the domain under consideration into single sites. This is done via the *Setup* input. Each block in this input category reflects a single site in the entire domain. The characteristics of each site (e.g., soil properties, vegetation, climate) are defined by respective blocks in the remaining categories. Effectively, defining characteristics means picking a block from the “bucket” and linking to it from our site setup definition. How this can be accomplished is documented in the appropriate section (3.2.1).

If such linking is omitted, defaults will apply. First the category specific default will be checked in the project file. If none was set, the global default (the one in the *attribute* element, see 3.1.4) is examined. In case the global default is again invalid, the system falls back to the ID of the site, that is, the ID that was assigned to the block in the Setup. Does no such block of the requested category exist LandscapeDNDC gives up and complains about missing inputs. Note, that default IDs are lacking a source identifier. Consequently, default IDs apply to the default source unless a source was specified in the Setup information. For an example how to link to input blocks, see e.g., Section **??**.

3.4.2 Time-dependent input

For time-dependent input data, i.e., continuous input streams (e.g., climate data), a reload mechanism is employed. Every time a data item is requested (e.g., by time step) that is not yet in the internal data buffer, a buffer refresh is triggered.

In case an input stream contains no or no valid data for a requested time step, some input sources may provide a rewinding mechanism or a data synthesizer. Input sources supporting the *endless* attribute rewind the input to the beginning of the stream. Note that rewinding of input data may be sensitive to the boundaries of the provided data. For example climate data, which is usually subject to an annual pattern, should start/end at the same julian day in order to prevent inconsistencies. In this respect, for longer simulation times, leap years should be also considered in order to avoid a shift of the climate within the year. Data synthesizers inject input data that was not provided commonly using additional time-independent information that is given by the input source. For example, the climate input source may contain the time independent information *mean annual temperature*, which can be used to synthesize *daily mean temperature* depending on the day of the year.

Example for the rewinding mechanism of climate input. Assuming that climate data is available for: 2000-01-01->2000-12-31

- Simulation time: 2000-01-01->2000-12-31
  Neither rewinding nor synthesizing required

- Simulation time: 2000-01-01->2001-12-31
  If *endless* attribute is set to true, climate of the year 2000 will be reused for the year 2001. If *endless* attribute is set to false, climate for the year 2000 will be synthesized.

- Simulation time: 1999-01-01->2001-12-31
  Climate for the year 1999 will be synthesized. If *endless* attribute is set to true, climate of the year 2000 will be reused for the year 2001. If *endless* attribute is set to false, climate for the year 2000 will be synthesized.

- Simulation time: 2001-01-01->2001-12-31
  Climate for the year 2001 will be synthesized. Note, no rewinding of available climate data for time periods beyond the simulation time!

3.4.3 Input source readers

Input streams may contain a global section and a section with one or more blocks representing kernel-scale data. There is no restriction on applicable input formats (e.g., XML, JSON) and extending LandscapeDNDC to be able to process additional stream formats is straight forward. For the purpose of extracting information from input streams, a data reader must be available for the given format of the input stream. Such a data reader is split into two components: (i) the *regional reader* reading the global section and parsing the structure of the targeted input format and (2) the *data reader* that retrieves the data that is actually used by models. As such regional readers possess no knowledge about the content of the data sections and likewise, data readers have no knowledge of the structure of the full input. During simulation (initialization time) there exists one regional reader for each input stream and one data reader for each block in the input stream. Note that the latter only applies to blocks that were requested during simulation.

Chapter 4

Tutorials

This chapter provides several tutorials, which guide you from the basic model setup to more advanced LandscapeDNDC applications including parametrization of soil, vegetation and climate input.

4.1 Tutorial I: General model setup

The purpose of tutorial I is to make the user familiar with the general model setup, i.e., what kind of model inputs are needed and how they are created. The tutorial refers to an experimental site, which is located on the Central Swiss Plateau near the village of Oensingen in the north-western part of Switzerland (7°44'E, 47°17'N, 450 m a.s.l.). For the interested readership, further details regarding, e.g., site conditions, experimental design can be found in Ammann et al. (2007, 2009).

In order to run a valid LandscapeDNDC simulation, several model inputs need to be provided. As a first step, open the tutorials folder `CH_oensingen` and find the following model input files:

1. Project file (`CH_oensingen.ldndc`)
2. Model setup file (`CH_oensingen_setup.xml`)
3. Site properties file (`CH_oensingen_site.xml`)
4. Climate file (`CH_oensingen_climate.txt`)
5. Airchemistry file (`CH_oensingen_airchemistry.txt`)
6. Events file (`CH_oensingen_events.xml`)
7. Site parameter file (`CH_oensingen_siteparameters.xml`)

8. Species parameter file (`CH_oensingen_speciesparameters.xml`)

Each of the files listed is incomplete in some way and prevents LandscapeDNDC from running a successful simulation. The goal of this tutorial is to add the missing information, which is outlined in the following list, and finally run a successful simulation. Pay attention to the correct syntax, the use of a text editor will help. For MS Windows users we recommend Notepad++.

1. Project file
   The project file defines, e.g., the start and end of a simulation, the location of the required simulation input as well as the location of the model output. Note that the specification of input and output location within the project file are expanded by the particular configuration file (see Sec. 2.4 and 3.1). Open the project file `CH_oensingen.ldndc` and define:

   - Start of simulation to: 1 January 2001 (see Sec. 3.1.3)
   - Time resolution (1 hr) and duration of the simulation (5 years)

     ```
     <schedule time="2001-01-01/24 -> +5-0-0" />
     ```

   - Complete set of model inputs (i.e., setup, site, airchemistry, climate, events)

     ```
     <sources sourceprefix="tutorials/tutorial_1/CH_oensingen_" >
       <setup source="setup.xml" />
       <site source="site.xml" />
       <airchemistry source="airchemistry.txt" />
       <climate source="climate.txt" />
       <event source="events.xml" />
       <speciesparameters source="speciesparameters.xml" />
       <siteparameters source="siteparameters.xml" />
     </sources>
     ```

   - Location of the model output

     ```
     <sinks sinkprefix="tutorials/tutorial_1/CH_oensingen_output/CH_oensingen_" />
     ```

2. Setup file
   The setup file defines, e.g., the actual model selection for a particular simulation (see Sec. 3.2.1 and 7.1). Open the setup file `CH_oensingen_setup.xml` and define:

   - Simulation setup id of "0" and a meaningful name

     ```
     <setup id="0" name="oensingen intensive" >
     ```

   - Geographic location (7°44'E, 47°17'N, 450 m a.s.l.)

     ```
     <location elevation="450.0" latitude="47.17" longitude="7.44" />
     ```

- Suitable model selection for temperate grassland simulation

```
<modulelist>
    <module id="microclimate:canopyecm" timemode="subdaily" />
    <module id="watercycle:watercyclendnc" timemode="subdaily" />
    <module id="airchemistry:airchemistrydndc" timemode="subdaily"/>
    <module id="physiology:plamox" timemode="subdaily" />
    <module id="soilchemistry:metrx" timemode="subdaily" />

    <!-- outputs -->
    <module id="output:ecosystem:daily" />
    <module id="output:microclimate:daily" />
    <module id="output:watercycle:daily" />
    <module id="output:physiology:daily" />
    <module id="output:vegstructure:daily" />
    <module id="output:soilchemistry:daily" />
    <module id="output:soilchemistry:yearly" />
    <module id="output:report:arable" timemode="subdaily" />
</modulelist>
```

3. Site file
   Open the site file `CH_oensingen_site.txt` and define:

   - Soil type as silty clay (see Sec. 3.2.2) and soil organic carbon content in 5cm (3%) and 30 cm (0.5%).

   ```
   <general soil="SLCL" corg5="0.03" corg30="0.005" />
   ```

   - Define an explicit 2 cm soil layer discretization (see Sec. 3.2.2) for the upper soil stratum.

   ```
   <layer depth="100" split="5" corg="0.029" bd="1.2"
    wcmax="450.0" wcmin="220.0" clay="0.44"/>
   ```

   - Add an additional soil stratum at the bottom with an extension of 1m

   ```
   <layer depth="1000" corg="0.005" bd="1.2"
    wcmax="450.0" wcmin="220.0" clay="0.44"/>
   ```

4. Climate file
   Open the climate file `CH_oensingen_climate.txt` and define:

   - Time setting (start: '2001-01-01', daily time resolution)
   - Climate id

```
%global
    time = "2001-01-01/1"

%climate
    id = 0
```

5. Airchemistry file
   Open the airchemistry file `CH_oensingen_airchemistry.txt` and define:

   - CO_2 concentration: 380 [ppm] (see Sec. 3.2.5)
   - Nitrogen wet deposition (see Sec. 3.2.5):
     * Ammonium: 0.6 [mg l^{-1}]
     * Nitrate: 0.3 [mg l^{-1}]

   ```
   %data
   nh4 no3 co2
   0.6 0.3 380.0
   ```

6. Event file
   Open the event file `CH_oensingen_events.txt` and add a planting event for perennial grass (species = `perg`) at the first day of the simulation. Note that in case that your planting event is scheduled before the start of the simulation it will not be considered! The initial biomass should be 200 [kg DW ha^{-1}] (see Sec. 3.2.3).

```
<event type="plant" time="2001-01-01" >
    <plant name="perg" type="perg" >
        <grass initialbiomass="200.0" />
    </plant>
</event>
```

7. Site parameter file
   Open the site parameter file `CH_oensingen_siteparameters.xml` and assign a value of 0.5 to the locally changed site parameter *RETNO3*.

```
<siteparameters id="0" >
    <par name="retno3" value ="0.5" />
</siteparameters>
```

8. Species parameter file
   Open the species parameter file `CH_oensingen_speciesparameters.xml` and assign a value of 0.5 to the locally changed species parameter *INI_N_FIX* for the plant species *PERG* of the group *grass*.

```
<ldndcspeciesparameters>
    <speciesparameters id="0" >
        <species mnemonic="perg" group="grass" >
            <par name="ini_n_fix" value="0.5" />
        </species>
    </speciesparameters>
</ldndcspeciesparameters>
```

4.2 Tutorial II: Accurate soil input description

The purpose of this tutorial is to familiarise the user with the creation of a site file from a realistic soil identification. The site considered here, Graswang, is an extensive grassland system located in the Ammer catchment in southern Germany (11°03'E, 47°57'N, 870 m a.s.l.). The soil profile including soil texture measurements are presented in Figure 4.1 and Table 4.1.

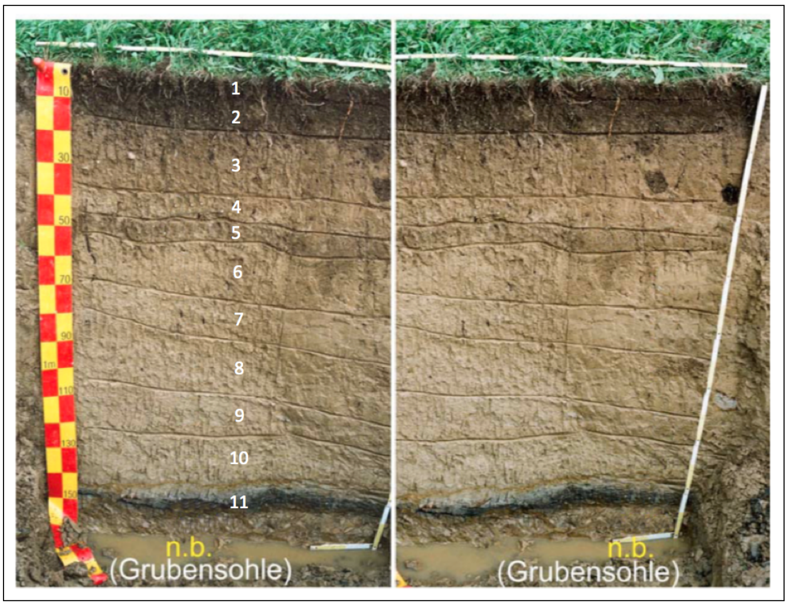

Figure 4.1: Soil profile of the Graswang site with carved identified soil horizons. Photo: J. Kuehn (2011), University of Hohenheim.

Table 4.1: Soil texture of the Graswang site. **lb**: Cumulative depth of lower boundary [cm]; **sc**: Stone content [%]; **clay**: Clay content [%]; **sand**: Sand content [%]; $\mathbf{c_{org.}}$: Organic carbon [%]; $\mathbf{n_{tot.}}$: Total nitrogen [%]; ρ: Bulk density [kg dm^{-3}]; **pH**: [-].

no.	lb	sc	clay	sand	$c_{org.}$	$n_{tot.}$	ρ	pH	name
1	21.0	1.5	58.5	6.4	5.81	0.67	0.82	7.1	aeAh
2	37.0	0.0	59.2	4.9	2.04	0.25	1.17	7.6	aeM
3	46.0	0.0	55.2	3.5	1.02	0.12	1.35	7.5	Sw-aeM1
4	53.0	0.0	60.5	1.0	1.60	0.18	1.19	7.4	Sw-aeM1
5	72.0	0.0	57.2	3.1	0.71	0.08	1.38	7.5	IIaelC1
6	86.0	0.0	55.6	7.0	0.49	0.06	1.44	7.6	aelC2
7	109.0	0.0	53.0	3.7	0.40	0.05	1.48	7.6	aelC3
8	124.0	0.0	54.0	4.0	0.37	0.03	1.50	7.6	aelC-Swd
9	143.0	0.0	54.3	2.5	0.39	0.04	1.54	7.7	aeSd
10	155.0	0.0	63.4	1.6	1.89	0.15	1.10	7.5	IIIaeolC-Sd1

4.2.1 Determination of saturated hydraulic conductivity

The saturated hydraulic conductivity determines a saturated soil's ability to transmit water along a hydraulic gradient and can be estimated by pedotransfer functions such as given by Cosby et al. (1984):

$$k_f = 60.96 \cdot 10^{-0.6+0.0126 \cdot \text{sand} - 0.0064 \cdot \text{clay}} \tag{4.1}$$

k_f: Saturated hydraulic conductivity $\left[\frac{\text{cm}}{\text{day}}\right]$
clay: Clay content (<2μm) [mass %]
sand: Sand content (50-2000μm) [mass %]

Use the above outlined approach and calculate the saturated hydraulic conductivity for each soil layer of the Graswang site. Make sure you use the right unit, e.g., in the above formula k_f is given $\left[\frac{\text{cm}}{\text{day}}\right]$, however, LandscapeDNDC expects $\left[\frac{\text{cm}}{\text{min}}\right]$.

4.2.2 Determination of field capacity and wilting point

Soil water content and movement depend on several forces. Besides gravity, soil adhesion and capillarity are important determining factors that are commonly summarized by effective macroscopic quantities. Within LandscapeDNDC the effective macroscopic quantities soil water content at wilting point and field capacity can be defined. Table 4.1 includes measured soil characteristics of the Graswang site. Based thereon, van Genuchten parameters can be derived, which can then be used to estimate field capacity and wilting point (Vereecken et al., 1990; AG-Boden, 1999).

The van Genuchten equation describes soil matrix potential at the macroscale Ψ depending on soil water content θ (van Genuchten, 1980):

$$\Psi(\theta_e) = \frac{1}{\alpha}\left[\theta_e^{-\frac{1}{m}} - 1\right]^{\frac{1}{n}}$$

with the effective soil water content

$$\theta_e = \frac{\theta - \theta_r}{\theta_s - \theta_r} \ .$$

θ_r: Residual soil water $[\frac{m^3}{m^3}]$
θ_s: Soil water content at saturation $[\frac{m^3}{m^3}]$
Ψ: Capillary pressure: [hPa]

Following Vereecken et al. (1990); AG-Boden (1999) the van Genuchten parameters can be derived by:

$$\theta_r = 0.015 + 0.005 \cdot \text{clay} + 0.014 \cdot \text{c}_{\text{org.}} \tag{4.2}$$
$$\theta_s = 0.81 - 0.283\,\rho + 0.001 \cdot \text{clay} \tag{4.3}$$
$$\alpha = \exp(-2.486 + 0.025 \cdot \text{sand} - 0.351 \cdot \text{c}_{\text{org.}} - 2.617\,\rho - 0.023 \cdot \text{clay}) \tag{4.4}$$
$$\text{n} = \exp(0.053 - 0.009 \cdot \text{sand} - 0.013 \cdot \text{clay} + 0.00015 \cdot \text{sand}^2) \tag{4.5}$$
$$\text{m} = 1 \tag{4.6}$$

clay: clay content (<2μm) [mass %]
sand: sand content (50-2000μm) [mass %]
$\text{c}_{\text{org.}}$: Soil organic carbon [mass %]
θ_s: Soil water content at saturation $[\frac{m^3}{m^3}]$
ρ: Bulk density [g cm^{-3}]

Field capacity and wilting point can now be estimated from the van Genuchten parameterized soil water retention curve assuming typical matrix potentials of 100 and 15000 [hPa], respectively:

$$\gamma_{\text{max}} = \theta_r + \frac{\theta_s - \theta_r}{(1.0 + (100 \cdot \alpha)^{\text{n}})^{\text{m}}} \tag{4.7}$$
$$\gamma_{\text{min}} = \theta_r + \frac{\theta_s - \theta_r}{(1.0 + (15000 \cdot \alpha)^{\text{n}})^{\text{m}}} \tag{4.8}$$

γ_{max}: Field capacity $[\frac{m^3}{m^3}]$
γ_{min}: Wilting point $[\frac{m^3}{m^3}]$

Note that the parameter m is set to 1, which means the relationship between the parameters n and m does not align with the parameterization of relative permeability as proposed by Mualem (1976). LandscapeDNDC allows for flexibility in defining n but employs the fixed n-m relationship according to Mualem. Therefore, the van Genuchten parameters from Vereecken et al. (1990); AG-Boden (1999) can only be used to derive field capacity and wilting point, but cannot be directly input into the model.

Follow the above outlined approaches and calculate only the field capacity and the wilting point for each soil layer of the Graswang site. Run two simulations, one without (leaving the corresponding attributes empty) and one with the calculated soil parameters. Compare the simulated soil water content at 10 and 30 cm soil depth of the two simulations with each other and with the experimental observations (see Fig. 4.2). Compare also simulated annual values of soil water percolation and NO_3^- leaching. Again, make sure you use the right unit, e.g., in the above formulas wilting point and field capacity are given in $[\frac{m3}{m3}]$, however, LandscapeDNDC expects $[\frac{mm}{m}]$.

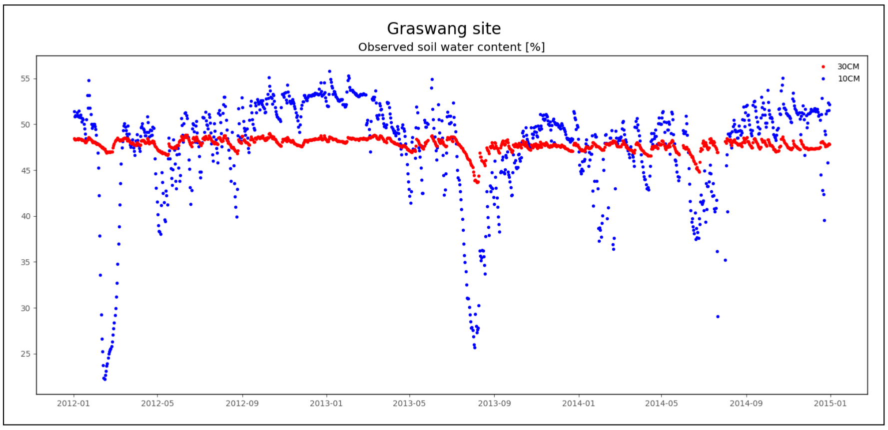

Figure 4.2: Observed soil water content of the Graswang site in 10cm and 30cm soil depth.

4.3 Tutorial III: Potential evapotranspiration

In this tutorial two different methods for the calculation of potential evapotranspiration are compared to each other, i.e., Thornthwaite (Thornthwaite, 1948) and Penman (Penman, 1948). In addition to both concepts, the user learns selecting different models options and manipulating the climate input. The model inputs of the tutorial refer to the Hoeglwlad experimental forest site in the southern part of Germany. Further details can be found in, e.g., Stange et al. (2000) and Luo et al. (2013).

4.3.1 Potential evapotranspiration after Thornthwaite

Daily potential evapotranspiration PET [m] after Thornthwaite (1948) with additions from Willmott et al. (1985) is calculated depending on temperature by

$$PET(T > 37.5) = -415.85 + 32.24 \cdot 37.5 - 0.43 \cdot 37.5^2 \tag{4.9}$$

$$PET(37.5 \geq T > 26) = -415.85 + 32.24 \cdot T - 0.43 \cdot T^2 \tag{4.10}$$

$$PET(T \leq 26) = 16 \cdot \left(10 \cdot \frac{T}{h_i}^{0.49239+0.0179h_i-0.0000771h_1^2+0.000000675h_i^3}\right) \tag{4.11}$$

These formulas give monthly values for an average of 12 hours daylight. They are corrected to the appropriate number of hours and devided to a daily value. Depending on the heat index h_i there can be a jump at 26 degreeC (maybe of 2mm per day). The method is purely empirical. The Thornthwaite heat index h_i is given by:

$$h_i = \sum_m (0.2 \cdot T_m)^{1.514} \tag{4.12}$$

The monthly temperature T_m is derived from the annual mean temperature T_a:

$$T_m = -0.5 \cdot T_a \cdot cos\left(2\pi \frac{d_m}{d_y}\right) \tag{4.13}$$

wherein d_m and d_y refer to the midmonth day of year and total number of days per year, respectively.

4.3.2 Potential evapotranspiration after Penman

The unterlying principle is that the energy between radiation, heat flux, and vaporizing water is balanced. It is set up for grass. For higher growing crops it should be adapted by a Penman crop factor in the original version. In the present implementation, the lai fullfils this role to some extend.

The albedo (reflection coefficient) a is determined by distinguishing

- dry soil (water table of less than 0.005mm): $rfs = 0.25 \cdot (1 - 0.5 watersaturation)$
- wet soil (water table of more than 0.005mm): $rfs = 0.05$

$$a = rfs \cdot e^{-0.5lai} + 0.25 \cdot \left(1 - e^{-0.5lai}\right) \tag{4.14}$$

This equation represents, that the background (soil or water) is shielded by the crop/grass. In Van Kraalingen and Stol (1997) the albedo is a fixed parameter. The size of the plant is taken into account by the crop coefficient curve.

Net radiation R_n is given by:

$$R_n = 81 - a)R_{shortwave} + R_{longwave,in} - R_{longwave,out} \tag{4.15}$$

Evapotranspiration is separated in a radiation and an aerodynamic term:

$$PET = PET_r + PET_d = \frac{1}{\lambda}\left(\frac{\frac{dp_s}{dT}R_n}{\frac{dp_s}{dT} + \gamma} + \frac{\gamma\lambda E_a}{\frac{dp_s}{dT} + \gamma}\right) \tag{4.16}$$

- λ: latent heat of vaporising water
- γ: the psychrometric constant
- E_a: isothermal evaporation, $E_a = f_w \cdot (p_s(T_2) - p_2)$
- $p_s(T_2)$: saturated vapour pressure at the temperature at 2m height
- p_2: vapour pressure at 2m height

Saturated vapour pressure p_s and respective derivative with respect to temperature are given by:

$$p_s = 0.61 \cdot e^{\frac{17.32T}{T+238.102}} \tag{4.17}$$

$$\frac{dp_S}{dT} = 238.102 \cdot 17.32 \cdot \frac{p_s}{(T + 238.102)^2} \tag{4.18}$$

The wind function is chosen depending on the surface type:

- $f_w = 2.63 \cdot (0.5 + 0.54v_w)$
- $f_w = 2.63 \cdot (1.0 + 0.54v_w)$

- v_w:wind speed

4.3.3 Tasks

1. Find the project directory of tutorial III

2. Run a simulation with the preset setup and define a meaningful prefix for the outputs such as: *DE_hoeglwald_default_*

3. Set the value of model option *potentialevapotranspiration* of the model *watercyclendc* to *penman*, adjust the prefix output (e.g., *DE_hoeglwald_penman_*) and run another simulation. Do not forget to adapt the output prefix otherwise old simulation runs will be overwritten.

4. Open the climate file and remove the column for windspeed. This can be done by replacing the entry for *wind* by ***. Run another simulation. Do not forget the output prefix!

5. Compare the outputs of potential evapotranspiration and percolation from the watercycle output and leaching of nutrients from the soilchemistry output of all simulations.

4.4 Tutorial IV: Simulations of rice-based cropping systems

In this tutorial the user learns step by step how to model rice cropping systems with LandscapeDNDC. Rice cropping is often subject to field flooding and therefore subject to fundamentally different ecosystem processes compared to upland cropping systems. This tutorial is divided into two main components, focusing first on the carbon cycle and second on the nitrogen cycle.

4.4.1 Carbon cycle

Contents

1. How to implement important management steps (e.g., field flooding, tilling, harvest residues) required for rice cropping.

2. How field flooding affects plant growth and the overall carbon cycling.

3. The effect of different water regimes on CH_4 emissions

Tasks

1. Find the project directory of tutorial IV.

2. The current management defines the planting and harvest of one rice crop:

```
<event type="plant" time="2007-02-01">
    <plant group="crop" type="ir72" name="ir72" >
        <crop initialbiomass="200.0" ></crop>
    </plant>
</event>
<event type="harvest" time="2007-05-10">
    <harvest remains="0.0" name="ir72" />
</event>
```

   Run a baseline simulation of *methane.ldndc* with the preset setup and plot the simulated aboveground biomass.

3. Rice crops display high sensitivity to drought, and as a result, they are commonly cultivated under flooded conditions. To maintain the required flooding, side bunds are built, and the soil is puddled. Puddling involves repeated ploughing under wet conditions over extended periods, leading to the formation of a compact soil layer at a depth of 10-30 cm, characterized by low saturated hydraulic conductivity. In order to establish a realistic water regime for rice cultivation, the following points are essential:

   - Define field bunds from the start of land preparation (approximately 3-4 weeks before planting) until harvest.

```
<event type="flood" time="2007-01-01->2007-05-10">
    <flood bundheight="100.0" />
</event>
```

   - Add a tilling event under flooded condtions at the onset of field preparation. Wet conditions can be established by defining a one-day flooding event. event.

```
<event type="till" time="2007-01-01">
    <till depth="0.1" />
</event>
<event type="flood" time="2007-01-01->2007-01-02">
    <flood watertable="50.0" />
</event>
```

- During the planting period, the field is maintained without flooding, and there is no presence of surface water. Instead, the field is kept adequately moist to support the germination and initial growth of the crops. Defining a negative watertable of, e.g., -10 mm yields water saturated conditions below 10 mm soil depth but prevents creation of a surface watertable.

```
<event type="flood" time="2007-01-24->2007-02-07">
    <flood watertable="-10.0" />
</event>
```

- Throughout the main cropping period, the field is flooded, maintaining a surface water table at a depth of 5 to 10 cm. The surface water table is maintained from one week after planting until maturity. This flooding practice ensures a continuous water supply, supporting the optimal growth and development of the crops until they are ready for harvest.

```
<event type="flood" time="2007-02-07->2007-05-04">
    <flood watertable="50.0" />
</event>
```

Run the simulation again and compare the simulated aboveground biomass with the previous run. Compare also the drought stress factor of both simulations.

The drought stress factor ϕ_d is defined for the interval [0,1] (0: maximum drought stress; 1: no drought stress). The factor depends on the actual soil water content (θ) in relation to the soil water content at wilting point (θ_{wp}), and field capacity (θ_{fc}). The factor scales linearly depending on the species-specific parameter $H2OREF\_A$ that describes the critical water content when drought stress starts:

$$\phi_d = \begin{cases} 1 & \theta \geq H2OREF\_A \cdot \theta_{fc} \\ \frac{\theta - \theta_{wp}}{H2OREF\_A \cdot \theta_{fc} - \theta_{wp}} & H2OREF\_A \cdot \theta_{fc} \geq \theta \geq \theta_{wp} \\ 0 & \theta \leq \theta_{wp} \end{cases}$$

4. Add a second rice crop with similar water management in the second half of the year. Check the phenological development of the second crop, which is given in the physiology output (dvs_flush). The crop should reach maturity before harvest, which is indicated by dvs_flush = 1.0. Change the *remains* attribute of the harvest event to *0.5* and *1.0* and compare the simulated methane emissions during the second cropping period of the year.

5. Add a drainage event of two weeks (i.e., a drainage event can be realized by two flooding events, with the second flooding event beginning two weeks after the end of the first flooding event. one month after planting and compare the results of plant biomass and CH_4 emissions to the previous simulations.

4.4.2 Nitrogen cycle

Contents

1. Add fertilization events (i.e., fertilizer type, amount and way of application)
2. Nitrogen input via atmospheric N-fixation
   - Introduce a nitrogen-fixing catch crop in the cropping rotation.
   - Evaluate the effect of photosynthetic active aquatic biomass.
3. Emissions of trace gases (e.g., NH_3, N_2O) and soil organic matter.

Tasks

1. Consider the baseline simulation from the previous paragraph with two continuously flooded unfertilized rice crops.
2. Add one or more uread-based fertilization event for each cropping period (e.g., 100 kg N-urea fertilizer). Compare the simulated plant biomass?

   ```
   <event type="fertilize" time="2007-02-01" >
       <fertilize type="urea" amount="100.0" depth="0.0" />
   </event>
   ```

   You can also change the depth of the applied fertilizer and evaluate the effect on trace gas emissions. By default, the fertilizer application depth is assumed to be 0.0 (surface application).
3. Change the fertilizer type to *NH4NO3* and compare not only the biomass but also the emissions of NH_3, N_2O and N_2 (see also 3.2.3.2).
4. Add a nitrogen-fixing catch crop (e.g., mungbean) between the two cropping seasons and plow the whole crop into the soil after harvest. How much can the amount of fertilizer be reduced without yield penalty? (see also 3.3)

   ```
   <event type="plant" time="2007-05-12">
   <plant name="mungbean" group="crop" type="mungbean" >
       <crop initialbiomass="50.0" covercrop="yes" ></crop>
   </plant>
   </event>
   <event type="harvest" time="2007-06-30">
       <harvest name="mungbean" />
   </event>
   ```

   If you set the planting event attribute *covercrop* = *true* the complete biomass including the fruit remains on the field.

5. Set the MeTr^{x}model option *algae* to *true* and run the simulation without catch crop (see also 3.2.1). Compare the simulated biomass of both simulations and discuss the effect on simulated CH_4 emissions.

```
<module id="soilchemistry:metrx" timemode="subdaily">
    <options algae="yes" wetland="yes" />
</module>
```

6. Run three 10-yr simulations and compare/discuss the nitrogen balances of those simulations on an annual basis. Set the MeTr^{x}model option *algae* to *true* for each simulation.

    - Two fertilized rice crops per year
    - Two non-fertilized rice crops per year
    - Two non-fertilized rice crops and one catch crop

Chapter 5

Model time and the simulation clock

At various places in LandscapeDNDC, execution paths depend on time. For example, a model might perform certain processes depending on season, day or night time or the beginning of a year. The framework uses time information to find the position from where to start to read records in time-dependent input data (e.g. climate). The most notable user for time is without doubt the event subsystem. Last but not least the simulation running time is given as a time period with a start and end date.

Within LandscapeDNDC we distinguish time objects representing fixed points in time, fixed time periods and clock objects that start from a fixed point in time and have the ability to advance forward in steps of one time unit (e.g. day). The later being used to keep track of the position in terms of time the simulation has reached. By design, a simulation is running strictly forward in time.

The most generic time object is the fixed period time object which contains two fixed time objects representing the beginning and end of the period. Note that minimum period-length is 1 timestep, which depends on time resolution.

LandscapeDNDC can be compiled to either honor leap years or treat all years as equal in length (i.e. 365 days). Be aware that all input data containing references specific to leap years will most likely not work with a leap year disabled version of LandscapeDNDC.

5.1 Time specification

Within LandscapeDNDC the smallest time unit is the *subday* t_{s} which is an integer $0 < t_{\mathrm{s}} \leq t_{\mathrm{res}}$ where $t_{\mathrm{res}} \in \mathbb{N}$ is the *time resolution* denoting the number of steps a single day is split into. For example, $t_{\mathrm{res}} = 24$ yields a time discretization of one hour. The four components of a fixed time are: *subday*, *day*, *month* and *year*.

By design, all time specifications are mapped to the most generic representation provided in the framework. That means any time specification read from some source is represented as a time period. There are two formats for valid time specifications

$$t_{\text{start}} \rightarrow t_{\text{end}} \qquad \text{and} \qquad t_{\text{start}} \rightarrow +t_{\text{diff}}$$

where $t_{\text{end}} \geq t_{\text{start}}$ and $t_{\text{diff}} \geq 0$. The second format internally maps to the first by adding the difference t_{diff} to the start time t_{start}. Valid expressions for time and periods are explained in detail in section 5.1.1.

5.1.1 Formal grammar

Formally, a valid time expression is given in extended backus-naur form (EBNF). Note that the earliest date T_0 is the first subday at the first of January 1901 (`1901-01-01-01`). For the sake of a simpler notation the grammar given does not consider the different month lengths and leap years. The implementation, however, rejects such invalid dates (e.g. 31st of June).

```
<TIME PERIOD> ::=  <DATE> "->" <DATE>|("+"<INTERVAL>)

<DATE>        ::= [<Y>"-"][<M>"-"]<D>["-"<S>]["/"<R>]
<INTERVAL>    ::= [<C>"-"][<C>"-"]<C>["-"<C>]

<Y> ::= "1901"|"1902"|"1903"|...
<M> ::= "1"|"2"|...|"12"
<D> ::= "1"|"2"|...|"31"
<S> ::= "1"|...|"<R>"

<R> ::= "1"|"2"|"3"|...

<C> ::= "0"|<R>
```

where the time components are year Y (1901 based), month M, day D and subday S. Only the day component is obligatory; components not given will be substituted if possible or require the user to provide them. Substituting only works if a *reference date* is available, e.g. the simulation's start date is used as reference date in case input data is lacking time settings in its global block.

The position of the component and the number of given components determines how the component is interpreted, e.g. `02-01` will be the first of February. Period time units are not limited, e.g. a period of 17 month is valid while in a date this would be invalid. Time resolution R is optional and defaults to 1. It may be added to the start date following a slash ("/"). Some symbolic equivalences

$$1SR \equiv 1D \qquad \{28, 29, 30, 31\}D \equiv 1M \qquad 12M \equiv \{365, 366\}D \equiv 1Y.$$

Some examples

time specification	result in words
`01-01`	first of January of reference year
`1950-02-13/6`	February 1950, time resolution of four hours
`1950-02-13-04/6`	same as above, but subday offset is 16 hours
`1950-02-13-07/6`	invalid because subday is out of range
`2012-02-29`	29th of February of 2012
`2011-02-29`	invalid, because 2011 is no leap year
`2012-01-01 -> 2013-03-01`	a period of fourteen months
`2012-01-01 -> +01-02-00`	a period of fourteen months
`2012-01-01 -> +14-00`	a period of fourteen months

5.1.2 Time difference vs time period

Let t be a valid LandscapeDNDC time. In addition to time difference t_{diff} the framework defines t_{period} as time difference increased by 1. The unit of 1 is determined from the time resolution of t. The reason for this is in interpreting durations given only a single time step.

example In effect, this means simulation time specifications like

`2001-01-02/2` and `2001-01-02/2 -> +0`

will cause the simulation to do one subday timestep.

5.2 Simulation clock

Within each project exists a single (official) clock object made available for read-only access to all kernels. It is initialized with the simulations start date read from the project file (value optionally overwritten by command line argument). After simulation start (i.e. models evolve in time) runtime control advances the clock by one subday unit.

LandscapeDNDC defines the following discrete *time positions*. Obviously, each timestep is at a subday position. The beginning of a day, i.e. $t_{\text{s}} = 1$, is refered to as the pre-day position while the post-day position is reached if $t_{\text{s}} = t_{\text{res}}$. In a similar way this can be applied to pre- and post-year.

timemode identifier	**meaning**
subdaily	each timestep
predaily	beginning of day
daily	end of day
premonthly	beginning of day at beginning of month
monthly	end of day at end of month
preyearly	beginning of day at beginning of year
yearly	end of day at end of year

Chapter 6

Compilation

6.1 Compilation and installation from source code

In this section, we describe how to obtain the source code for LandscapeDNDC and build an executable. It is recommended to install LandscapeDNDC to a folder where it can conveniently be executed from (i.e. the installation folder is specified in the PATH environment variable).

6.1.1 Obtain source code

If you received a source code archive file (e.g. `.zip`) you may unpack the file and safely skip the rest of this section. We use Subversion for versioning control and handling concurrent code developement. To retrieve the latest version of LandscapeDNDC checkout (or export) the HEAD revision using the URL:

`https://ldndc.imk-ifu.kit.edu/svn/ldndc/trunk`

You will need to provide a username and password. Consult a LandscapeDNDC project maintainer if you are missing appropriate credentials.

6.1.2 Configure sources and generate setup for build system

For this step, you need CMake (`http://www.cmake.org`) not older than version 2.8.11.

Start CMake (GUI recommended, check the box "Grouped") and set the source code directory. Selecting a build directory different from you source code directory (aka out-of-source build) is highly recommended because it does not clutter up the sources.

Press the *Configure* button. Note, that the first time you configure, CMake will ask you for a generator, i.e. the build environment that you use to compile the sources (e.g. Visual Studio 9 2008).

Check appropriate boxes: in grouped view mode options with the same prefix (the prefix is the part of the option name starting at the beginning up to the first underscore) are grouped under their prefix. Opening them, shows more options. After making changes run CMake again (i.e. click the *Configure* button). This might enable additional suboptions, which you can select (do not forget to configure again). Repeat this process until options are set according to your needs. Finally, press the *Generate* button. Usually, the defaults provide for a running simulation system with all the features enabled most users will find sufficient.

Additional packages are required for OpenMP, MPI, HDF5 (currently not working), NetCDF4 (work in progress), SQLite3, VTK, and jLDNDC (JDK, JNI).

Note, that during source code and build system configuration source code is being generated which is part of the LandscapeDNDC simulation system. As a consequence, bypassing this step will yield an incomplete source tree.

6.1.3 Compiling the source code

CMake generated configuration files for your selected build environment, e.g. for Visual Studio a solution file (`ldndc.sln`) was created. See your build environments manual for how to proceed from here. Depending on your source code configuration settings and platform the following programs and libraries may have been built:

- `ldndccommon` library providing basic functionality (memory allocators) and structures (e.g. numeric arrays)
- `ldndcserver` library providing I/O
- `ldndcclient` library providing server API for clients
- `ldndckernel-`<*kernel*> libraries holding models
- `ldndcc` C API

Be aware, that because some build targets depend on other targets, parallelized builds may cause trouble!

6.1.4 Installing the simulation system

Ideally, the user would copy the ldndc binary (e.g. ./bin/ldndc.exe) to a directory that is listed in the `PATH` environment variable. This way, LandscapeDNDC can be called from anywhere in the users directory tree.

Currently, there is no automatic installation procedure. Please, also consult section 2.4 on how to setup your LandscapeDNDC simulation environment.

6.1.5 Create packages

By running the appropriate shell script in the directory `packages` an archive will be created whose name reflects the date of creation. This will require a BASH compatible command shell.

6.1.6 Further comments

If you want to use the farmer (for grasslands) module, when compiling and building LDNDC, it must be switched on with: `KERNELS_ENABLE_FARMER_ldndc = on` in ldndc/build/CMakeCache.txt .

Chapter 7

Applications

7.1 Frequently used model selections

In this section most common model selections are presented. Available models are classified by ecosystem domain. For each model, supported time resolutions and model ID are given. For subdaily simulations, the recommended time step size is 1 hour.

1. Microclimate

   - CanopyECM
     * available time modes: `daily, subdaily`
     * xml-based module selection:

2. Watercycle

   - WatercycleDNDC (Kiese et al., 2011)
     * available time modes: `daily, subdaily`
     * xml-based module selection:

       ```
       <module id="watercycle:watercycledndc" timemode="daily" />
       ```

   - Echy (Dirnböck et al., 2020)
     * available time modes: `daily, subdaily`
     * xml-based module selection:

       ```
       <module id="watercycle:echy" timemode="daily" />
       ```

3. Airchemistry

- Airchemistry
  * available time modes: `daily, subdaily`
  * xml-based module selection:

```
<module id="airchemistry:airchemistrydndc" timemode="daily" />
```

4. Vegetation

- PlaMo^{x} (Kraus et al., 2016; Liebermann et al., 2020; Petersen et al., 2021)
  * available time modes: `subdaily`
  * xml-based module selection:

```
<module id="physiology:plamox" timemode="subdaily" />
```

- GrasslandDNDC (Molina-Herrera et al., 2016)
  * available time modes: `daily, subdaily`
  * xml-based module selection:

```
<module id="physiology:grasslanddndc" timemode="daily" />
```

- ArableDNDC (Molina-Herrera et al., 2016)
  * available time modes: `daily, subdaily`
  * xml-based module selection:

```
<module id="physiology:arabledndc" timemode="daily" />
```

- PSIM (Grote et al., 2009)
  * available time modes: `daily, subdaily`
  * xml-based module selection:

```
<module id="physiology:psim" timemode="daily" />
```

- PNET
  * available time modes: `daily`
  * xml-based module selection:

```
<module id="physiology:pnet" timemode="daily" />
```

5. Soilchemistry

- MeTr^{x} (Kraus et al., 2015, 2016)
  * available time modes: `daily, subdaily`
  * xml-based module selection:

```
<module id="soilchemistry:metrx" timemode="daily" />
```

- SoilchemistryDNDC
  * available time modes: `daily`
  * xml-based module selection:

```
<module id="soilchemistry:dndc" timemode="daily" />
```

7.1.0.1 Temperate grassland simulations

Temperate grasslands can be simulated with GrasslandDNDC or PlaMo^x. Both vegetation models run in combination with further partly required and partly optional models for:

- Microclimate (required)
  * CanopyECM
- Airchemistry (optional)
  * Airchemistry
- Watercycle (required)
  * WatercycleDNDC
  * Echy
- Soilchemistry (required)
  * SoilchemistryDNDC
  * MeTr^x

The farmer kernel schedules cutting and fertilizing events dynamically depending on the on-field biomass.

Recommended setup for PlaMo^x

```
<ldndcsetup>
    <setup id="0" name="plamox model setup" model="mobile" >
        <mobile>
            <modulelist>
                <module id="microclimate:canopyecm" timemode="subdaily" />
                <module id="watercycle:watercycledndc" timemode="subdaily" />
                <module id="airchemistry:airchemistrydndc" timemode="subdaily" />
                <module id="physiology:plamox" timemode="subdaily" />
                <module id="soilchemistry:metrx" timemode="subdaily" />
```

```
        </modulelist>
    </mobile>
  </setup>
</ldndcsetup>
```

Recommended setup for GrasslandDNDC

```
<ldndcsetup>
    <setup id="0" name="grasslanddndc model setup" model="mobile" >
        <mobile>
            <modulelist>
                <module id="microclimate:canopyecm" timemode="daily" />
                <module id="watercycle:watercyclendndc" timemode="daily" />
                <module id="airchemistry:airchemistrydndc" timemode="daily" />
                <module id="physiology:grasslanddndc" timemode="daily" />
                <module id="soilchemistry:metrx" timemode="daily" />
            </modulelist>
        </mobile>
    </setup>
</ldndcsetup>
```

7.1.0.2 Cropland simulations

Cropland can be simulated with ArableDNDC or PlaMo^x. Both vegetation models run in combination with further partly required and partly optional models for:

- Microclimate (required)
  * CanopyECM
- Airchemistry (optional)
  * Airchemistry
- Watercycle (required)
  * WatercycleDNDC
  * Echy
- Soilchemistry (required)
  * SoilchemistryDNDC
  * MeTr^x

Recommended setup for PlaMo^{x}

```
<ldndcsetup>
    <setup id="0" name="plamox model setup" model="mobile" >
        <mobile>
            <modulelist>
                <module id="microclimate:canopyecm" timemode="subdaily" />
                <module id="watercycle:watercycledndc" timemode="subdaily" />
                <module id="airchemistry:airchemistrydndc" timemode="subdaily" />
                <module id="physiology:plamox" timemode="subdaily" />
                <module id="soilchemistry:metrx" timemode="subdaily" />
            </modulelist>
        </mobile>
    </setup>
</ldndcsetup>
```

Recommended setup for ArableDNDC

```
<ldndcsetup>
    <setup id="0" name="arablendndc model setup" model="mobile" >
        <mobile>
            <modulelist>
                <module id="microclimate:canopyecm" timemode="subdaily" />
                <module id="watercycle:watercycledndc" timemode="subdaily" />
                <module id="airchemistry:airchemistrydndc" timemode="subdaily" />
                <module id="physiology:arabledndc" timemode="subdaily" />
                <module id="soilchemistry:metrx" timemode="subdaily" />
            </modulelist>
        </mobile>
    </setup>
</ldndcsetup>
```

7.1.0.3 Forest simulations

Forests can be simulated with PNET or PSIM. Both vegetation models run in combination with further partly required and partly optional models for:

- Microclimate (required)
    - CanopyECM

- Airchemistry (optional)
  * Airchemistry
- Watercycle (required)
  * WatercycleDNDC
  * Echy
- Soilchemistry (required)
  * SoilchemistryDNDC
  * MeTr^{x}

Recommended setup for PSIM

```
<ldndcsetup>
    <setup id="0" name="psim model setup" model="mobile" >
        <mobile>
            <modulelist>
                <module id="microclimate:canopyecm" timemode="subdaily" />
                <module id="watercycle:watercycledndc" timemode="subdaily" />
                <module id="airchemistry:airchemistrydndc" timemode="subdaily" />
                <module id="physiology:psim" timemode="subdaily">
                    <options timemode="subdaily" />
                </module>
                <module id="soilchemistry:metrx" timemode="subdaily" />
            </modulelist>
        </mobile>
    </setup>
</ldndcsetup>
```

7.2 Utilities

The software project includes auxiliary applications for various purposes. Currently, there are a few conversion programs to aid transition from the old framework implementation. In addition, the user finds a collection of programs that write the content of the configuration file and various input streams to standard output.

time – verify LandscapeDNDC time This little program reads a time string from the command line, parses it and writes it back to the screen including *time difference*, *time period* and *Julian day*.

geom-from-shapefile Extracts polygons and their bounding box from an ESRI shapefile.

catconffile – dump configuration file Writes the content of an LandscapeDNDC configuration file to the screen.

catclimate – dump climate input Writes the content of an LandscapeDNDC *climate* input source to the screen.

catsetup – dump setup input Writes the content of an LandscapeDNDC *setup* input source to the screen.

catsite – dump site input Writes the content of an LandscapeDNDC *site* input source to the screen.

catsiteparameters – dump siteparameters input Writes the content of an LandscapeDNDC *site parameter* input source to the screen.

cathumusparameters – dump humusparameters input Writes the content of an LandscapeDNDC *humus parameter* input source to the screen.

catsoilparameters – dump soilparameters input Writes the content of an LandscapeDNDC *soil parameter* input source to the screen.

catspeciesparameters – dump speciesparameters input Writes the content of an LandscapeDNDC *species parameter* input source to the screen.

projectinfo – query project file Tiny command line program that allows to query the project file, e.g., simulation schedule, author or sources. This may come in handy in shell scripts.

7.3 Tools

Tools as opposed to utilities are somewhat more heavy-weight in that they add own logic rather than just relaying framework functionality. These include input data generators some of which are also part of the framework (e.g., climate generator) but can also be run prior to simulation to improve performance, circumvent effects by the random number generator (e.g., for synthesizing precipitation) and increase transparency. Output converters can also be found here.

7.3.1 kkplot – create plots (from LandscapeDNDC output)

Creating plots for publications can be cumbersome and time-consuming. It is also very common that such plots have to be redone when data changes, i.e., simulations are rerun with modified inputs. In order to be able to at least partly automatize this work, the authors developed a plotting tool written in the Python programming language that reads a meta description for a set of plots. This plot description is a YAML (YAML) formatted text file listing graphs along with its data sources (e.g., table) and properties (e.g., labels and colors). Because it is unreasonable to expect such a tool to address any aspect and details of publishable figures, kkplot generates the code that finally creates the figure rather than creating the figure itself. This allows for fine-tuning by editing the generated code, which serves as a starting point and template.

By design, kkplot is capable of generating plotting code for various targets (called *engines*) that the user may select from. Currently, code can be generated for Python based on *matplotlib* (Hunter, 2007) and *pandas* (McKinney, 2011) or GnuPlot (Williams et al., 2010).

Different types of graphs (e.g., line, point, (stacked) area plots, histogram) can be created from data series read from files with temporal, spatial or spatiotemporal domains. Supported data formats are text tables and SQLite databases (SQLite). In addition, basic arithmetic on data columns can be performed (e.g., `PI * 2.0 * co2_auto * co2_hetero`, where `co2_auto`, `co2_hetero` are datacolumns (vectors) from possibly different datasources and `PI` the constant π). Arithmetic operators are applied elementwise for vectors. Figure 7.1 shows a few example plots created from a plot description comprising roughly 300 lines and collecting data from twelve different files.

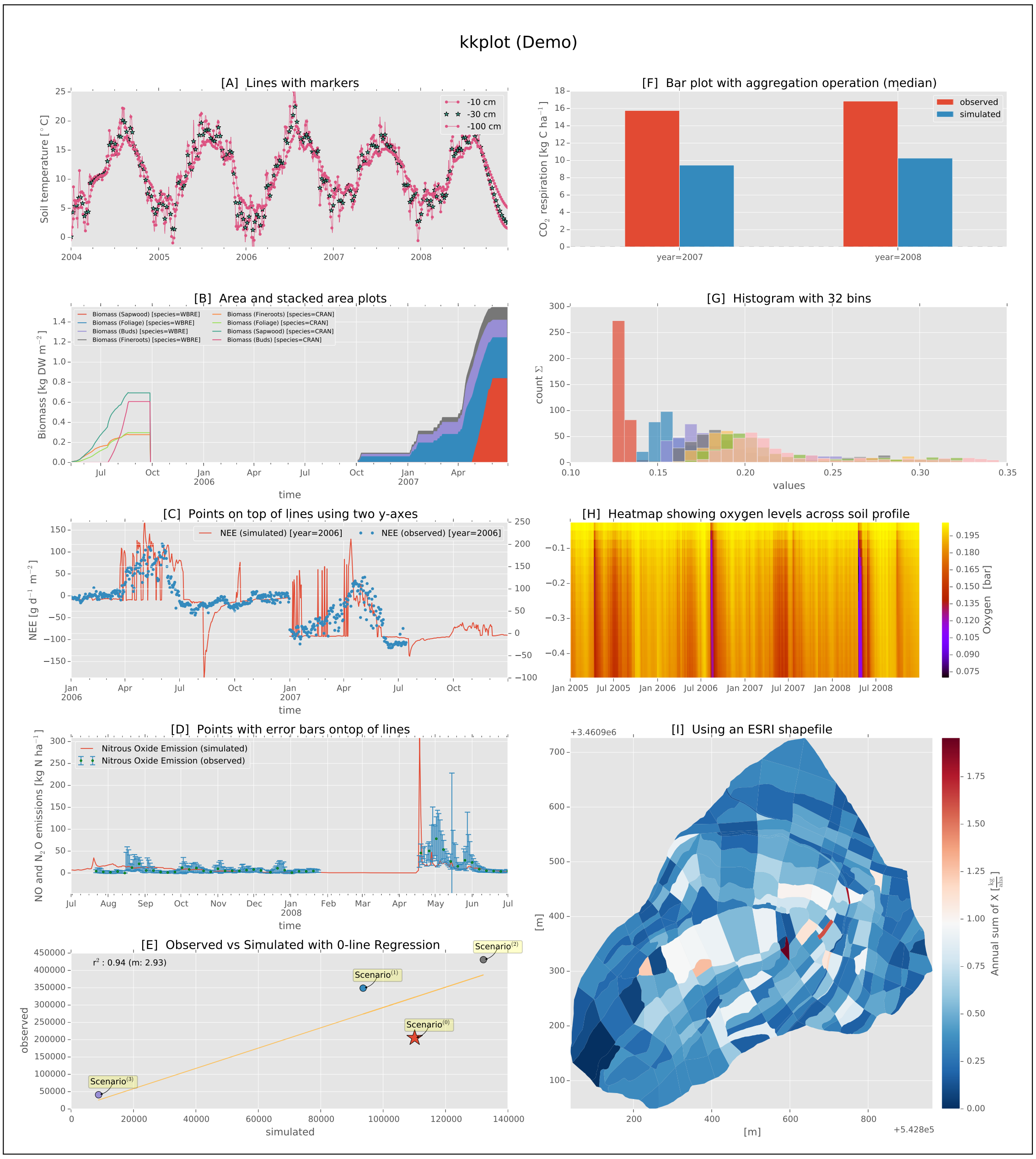

Figure 7.1: kkplot demo without postprocessing

For example, the configuration for plot [D] reads

```
N2O:
 title: '[D] Points with error bars ontop of lines'
  properties: { align: False,
      ylabel: 'NO and N$_2$O emissions [kg N ha$^{-1}$]'}
  time: '2007-07-01->2008-07-01'
  graphs:
   n2o_sim:
    name: [ 'dN_n2o_emis = 1000.0*dN_n2o_emis@soilchemistry']
    label: 'Nitrous Oxide Emission (simulated)'
   n2o_obs:
    name: [ 'n_n2o@observed_n2o', 'n_n2o_std@observed_n2o',
        '=.n2o_sim.result' ]
    style: { kind: 'points+errors', linestyle: 'point',
      marker: 'o', markersize: 2.0, markerstride: 6,
      markeredgecolor: 'green', markeredgewidth: 1.0 }
    label: 'Nitrous Oxide Emission (observed)'
```

7.3.2 generate-vtk – convert output to VTK

For visualization purposes, text file and SQLite3 output can be converted to VTK structured grid files. This tool can handle both *averaged* and *per layer* output data. It supports a number of *modes*, e.g., aggregating values annually or across the full simulation time.

7.3.3 simreq – simulation request client

This tool connects to a running LandscapeDNDC instance and allows to send requests to it. For example, querying simulation time, instantaneous values of internal variables or triggering a checkpoint. For this to work, LandscapeDNDC needs to be compiled with thread support.

Chapter 8

Miscellaneous

8.1 String expansion

A number of input quantities support (e.g., sink prefix in project file) the expansion of *format sequences* with a corresponding value. Supported format sequences are

- `%`s`Nr` expands to the process' MPI rank, where s is an optional padding character $s \in \{0, -, \_\}$ and $N \in \mathbb{N}$ specifies padding width. For example, `logfile-%04r.txt` on the first slave node would expand to `logfile-0001.txt`

  Note that in non-MPI builds `%r` always expands to `0`.

- `~` expands to the users home directory (this might not be available on all platforms)
- `%C` expands to the user's configuration directory.
- `%I` expands to the input basepath set in the configuration file.
- `%i` expands to the source prefix set in the project file.
- `%O` expands to the output basepath set in the configuration file.
- `%o` expands to the sink prefix set in the project file.
- `%R` expands to the resources basepath set in the configuration file.
- `%$` expands to the project name set in the project file
- `%V` expands to the LandscapeDNDC version string, e.g., *1.36.0*
- `%`s`Np` expands to the running ldndc process ID. See above for meaning of padding character.

Chapter 9

Acknowledgments and credits

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