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# HERMES 2 Go

– Documentation and guidelines –
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## Contents

# HERMES Structure und Function

Typical folder structure

- parameter
- project
- RESULT
- weather

The folders **project**, **RESULTS** and **weather** have a subfolder with a short name (preferably in low case) identifying the simulation project. For example, if the project is called “her” there will be a sub-folder “her” inside each of the three last folders above.

The Hermes Batch mode allows multiple project setups to run concurrently.
-batch file xxx_batch.txt - defines the batch file to be executed (see below).
Example of batch file:

```
project=MAR21 fcode=109_120 plotNr=00001 poligonID=Scen11Fert0- resultfolder=RESULT/MAR21
project=MAR21 fcode=109_120 plotNr=00005 poligonID=Scen11Fert1- resultfolder=RESULT/MAR21
project=MAR21 fcode=109_120 plotNr=00009 poligonID=Scen11Fert2- resultfolder=RESULT/MAR21
project=MAR21 fcode=109_120 plotNr=00013 poligonID=Scen11Fert3- resultfolder=RESULT/MAR21
```

- **project** name is a folder within the **project** folder.
- **fcode** is the first part of the **weather** file.
- **plotNr** equals the **Polyg** and **PlotID** variables from other files (see table below)
- **poligonID** is just a name that will be copied to the output files (see table below)
- **resultfolder** is where the outputs will be copied

The resulting output file will have both the **poligonID** and the **plotNr**

**To run:**

> **hermestogo.exe -module** batch **-logoutput -batch** *batchfile.txt (in folder HERMES2GO)*

Examples:
> hermes2go.exe -module batch -logoutput -batch all_n2o_os_batch.txt

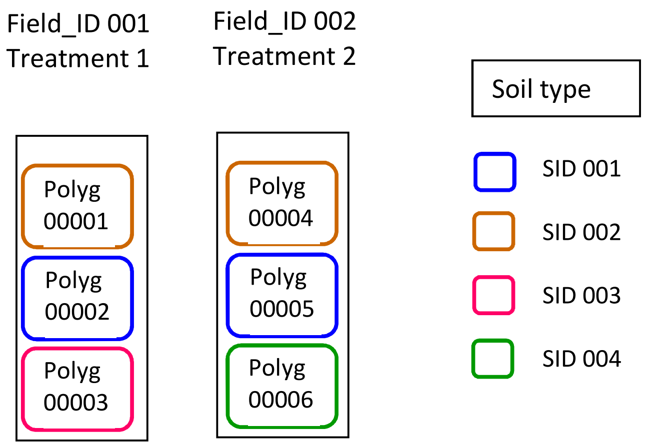
Note: Check the **.exe** version before running!

Additional Hermes resources: https://github.com/zalf-rpm/Hermes2Go
https://github.com/zalf-rpm/Hermes2Go/tree/fbab5f1bd53365f6c029bcde6d4367ddf77d0a2f/hermes

## Field and plot identifiers

Field, plot and soil identifiers are used to assign treatments, crop and soil types to each simulation unit or "polygon".

In the graphical depiction below, each "Polyg" will be associated to a Field ID that corresponds to a given treatment, and a soil ID (SID) that corresponds to a soil type.



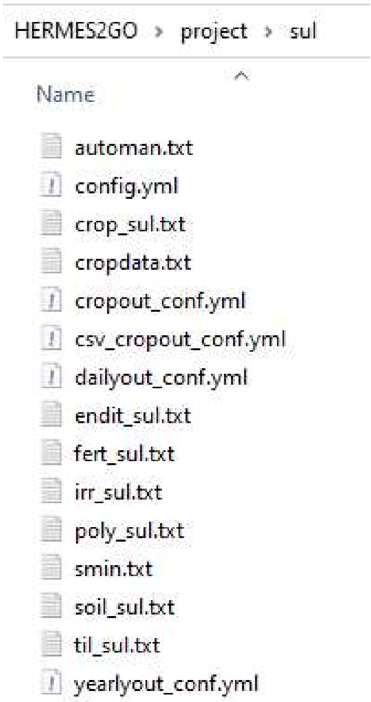

In the table below, each cell shows the identifying variable and the file containing it.
Variables in the same row are synonyms, and therefore, contain the same information.

| | | | | |
|---|---|---|---|---|
| POLY_XXX.txt<br>Variable: Polyg | Batch file<br>Variable: PlotNr | Endit_XXX.txt<br>Variable: Plot_ID | | |
| POLY_XXX.txt<br>Variable: SID | SOIL_XXX.txt<br>Variable: SID | | | |
| POLY_XXX.txt<br>Variable: Field_ID | CROP_XXX.txt<br>Variable: Field_ID | FERT_XXX.txt<br>Variable: Field_ID | IRR_XXX.txt<br>Variable: Field_ID | TIL_XXX.txt<br>Variable: Field_ID |
| Batch file<br>Variable: PoligonID (experiment number) | Output file .csv<br>Variable: poligonID | | | |

In the end, each combination of soil, crop and management should have a single polygon ID.
Each polygon will have a single output file.

## The folder “project”

Here is where all the model run settings are established.




„automan“ stands for automatic management (see below).
CROP is for crop settings, FERT for fertilization, IRR for irrigation, TIL is tillage.
Documents in the folder also include a “config” file and three output setting files, “cropout_conf”, “dailyout_conf” and “yearly_out”. All explained below.

**Automatic management file** (project/*projectname* / automan.txt)

This file is used in the modeling if the “Auto” variables in configuration file (project/projectname/config.yml) are set to 1.

Depiction

automan.txt

```
1  crp Sow1 Sow2 har2 TSmin Smomin Smomax Hmomin Hmomax Rainav Rainact TACCU Tbase Irrdv1 Irrdv2
2  SM  1503 1505 3110 9.1   0.0    97.0   0.0    99.0   5.0    0.5     380   0     2      6
3  WR  1503 1505 3110 9.1   0.0    97.0   0.0    99.0   5.0    0.5     380   0     2      6
4  end
```

```
Ndem1 Ndem2 Ndem3 stage1 stage 2 stage 3 Twindow orgF  amount appdat Irrlow irrdep irrmax
120   120   0     S0     S3      0       5       RM    200    H1     60     60     50
120   120   0     S0     S3      0       5       RM    200    H1     60     60     50
```

Definitions

| | | |
|---|---|---|
| Crp | Crop name | |
| Sow1, Sow2 | begin and end sowing window (ddmm) | |
| har2 | latest harvest date (ddmm). This is used in case the automatic harvest is delayed for too long | |
| TSmin | Minimum temperature for sowing (Maximum with “x” at the beginning) | |
| Smomin | Minimum soil moisture for sowing | |
| Smomax | Maximum soil moisture for sowing | |
| Hmomin | Minimum soil moisture for harvest | |
| Hmomax | Maximum soil moisture for harvest | |
| Rainav | maximum average rainfall (mm) during the last 3 days for harvest | |
| Rainact | maximum rainfall at actual day for harvest | |
| TACCU | Temperature sum above tbase from 1.January | |
| Tbase | Base temperature sum for TACCU | |
| Irrdv1, Irrdv2 | First and last development stage for automatic irrigation | |
| Ndem1, 2, 3 | N demand 1st application (Nmin 0-30 cm will be substracted); N demand 2nd application (Nmin 0-90 cm or lower rooting depth will be subtracted); N demand 3rd application (Nmin 0-90 cm or lower rooting depth will be subtracted). | |
| stage1, 2, 3 | Time of 1st, 2nd and 3rd application (first possible or fixed DOY or beginning of development stage if “S” is written before ) | |
| Twindow | Anz. Tage für gleitendes Tempmittel | |
| orgF | Organ. Düngerart | |
| amount | Menge org. Dünger | |

| | | |
|---|---|---|
| appdat | Anwendungszeitpunkt (H1 = harvest+1 Tag, S3 = Sowing minus 3 days) | |
| Irrlow | % nutzbares Feld Kapazität für Beregnungsinitialisierung, | |
| irrdep | Tiefe zur Berechnung der NFK% in cm | |
| irrmax | maximale tägliche Beregnungsmenge | |

Each of the automatic management aspects can be activated or deactivated in the Configuration file (see next section)

**Configuration file** (project/*projectname*/config.yml)

Definitions

| **Name** | **Description/Values** | **Notes/Examples** |
|---|---|---|
| *FORMATS* | | |
| Dateformat | DateDEshort: ddmmyy (default format, old)<br>DateDElong: ddmmyyyy<br>DateENshort: mmddyy<br>DateENlong: mmddyyyy<br>- short format "ddmmyy", e.g. 24.01.95 -> "ddmmyy" requires input as 240195 the century division year "DivideCentury" (see below) needs to be specified.<br>- long format "ddmmyyyy" (e.g. 24.01.2066 requires input as 24012066) | |
| DivideCentury | used only on short date format - Year to divide 20. and 21. Century (YY) | |
| GroundWaterFrom | *soilfile*= the model uses the values of GW for each soil ID (SID) in SOIL_XXX.txt.<br>*polygonfile*=the model uses the GH/GL values por each polygon (Polyg) in POLY_XXX.txt<br>*gwTimeSeries*= the model uses a true GW curve, stored in a csv file that contains a column for SID, Date and water level | |
| ResultFileFormat | 0=original Hermes .RES files, 1=.CSV | |
| ResultFileExt | result file extensions (default RES, csv) | |
| OutputIntervall | 0=no time series, 1=daily output | |
| ManagementEvents: | generate output for management events. 0=none (default) | |
| InitSelection | From POLY_XXX.txt, Uses: 1= all (if the word ALLE is written in the file), 2= Field_ID, 3= Polyg, 4=SoilID | See “initial conditions file” |

| | | |
|---|---|---|
| SoilFile | soil= uses the soil profile file name | |
| SoilFileExtension | txt = hermes soil, csv = csv table format | |
| CropFileFormat | txt = hermes crop, csv = csv table format | |
| MeasurementFileFormat | Measurement file (endit_*.) format (txt = old Hermes, csv = csv table format) | MeasurementFileFormat |
| PolygonGridFileName | Name of polygon grid file | poly |
| CropParameterFormat | Crop parameter file format (txt = original hermes crop, yml = yaml format) | |
| | | |
| *WEATHER* | | |
| WeatherFile | '%s**_mar-2021d2**.csv' . The part in bold corresponds to the second part of the weather file name (the first part, %s, is defined as **fcode** in the batch file) | In the file: **109_120_mar-2021d2.csv,** “109_120_” is provided in the batch file |
| WeatherFileFormat | 0=separator (, or ; or \t), 1 year per file ) (1=separator(, or ; or \t), multiple years per file | |
| WeatherFolder | Use quotation marks | "mar" |
| WeatherRootFolder | Use quotation marks | "./weather/" |
| WeatherNoneValue | Do not use quotation marks | 999.9 |
| WeatherNumHeader | Number of header rows | Minimum 1 |
| CorrectionPrecipitation | 0= no, 1 = yes (requires file /weather/preco.txt).<br>It raises the average annual rainfall by 10% as compared to standard measurements with Hellmann’s collector. | See below for more details |
| AnnualAverageTemperature | In Degree Celsius | |
| | | |
| *ATMOSPHERE* | | |
| ETpot | 1=Haude, 2=Turc-Wendling, 3=Penman-Monteith, 4=ET Gras Priestley Taylor, 5=from file | See below for more details |
| CO2method | 1=Nonhebel, 2=Hoffmann, 3=Mitchell | See below for more details |
| CO2concentration | (ppm) | 360 |
| CO2StomataInfluence | 1=on/0= off. Only used when ETpot = 3 | |
| NDeposition | annual kg/ha. Atmospheric N input via dry and wet deposition [kg N*ha-1]. | 20-50 |

| | | |
|---|---|---|
| | This value is added to the N balance with its 365th part every day. | |
| SDeposition | annual kg/ha | 7 |
| | | |
| *TIME* | | |
| | | |
| EndDate | "DDMMYYYY" | "30122021" |
| StartYear | YYYY. Model starts at the time of harvest of this year. Start year should match this year | See below |
| AnnualOutputDate | "DDMM" especially useful for year-end summaries | "1609"<br>See below |
| VirtualDateFertilizerPrediction | Write '--------' for no prediction | See "Fertilization recommendation" below |
| | | |
| *GEOGRAPHY* | | |
| Latitude | (degrees) | 52.52 |
| Altitude | (m.a.s.l) can be overwritten by weather file | |
| CoastDistance | (km) Required to calculate the coastal factor in option ETpot=2 | particularly relevant for distances less than 50 km |
| | | |
| *SOIL* | | |
| LeachingDepth | (dm) Percolation of water and the related leaching of N below the specified soil depth | 10 |
| OrganicMatterMineralProportion | Fraction of organic N not considered to be recalcitrant and thus available for daily N mineralisation. Default is 0.13. | 0.13 |
| PTF | Pedo transfer function: 0 = none (from HYPAR file), 1 = Toth 2015, 2 = Batjes for pF 2.5, 3 = Batjes for pF 1.7, 4 = Rawls et al. 2003 for pF 2.5.<br>If FC, WP and PS are to be manually provided, use PTF=0. | If PTF ≠ 0, pore volume (PoreSize) needs to be provided in the SOIL file (see more below) |
| KcFactorBareSoil | | 0.5 |
| GroundWaterPhase: | phase shift in days, if ground water is read from polygonfile (default is 80) | See below for more details |
| SulfurSatSolutionConcentration | Saturated Solution Concentration (SKSAT) in g S/l | |
| SulfurSolutionCoefficient | Sulfur Solution Coefficient (KLOS) | |

| | | |
|---|---|---|
| *MANAGEMENT* | | |
| Fertilization | (%) Mineral N percent of fertilizer. Mineral fertilizers have always 100 % | |
| AutoSowingHarvest | 0=Non-automatic, 1=automatic. If 1, will use file automan.txt, and needs a 1 under the variable autorg in CROP_XXX.txt file | |
| AutoFertilization | 0=Non-automatic, 1=automatic. If 1, will use file automan.txt, and needs a 1 under the variable autorg in CROP_XXX.txt file | |
| AutoIrrigation | 0=Non-automatic, 1=automatic. If 1, will use file automan.txt | To shut down individual plots go to POLY file |
| AutoHarvest | 0=Non-automatic, 1=automatic. If 1, will use file automan.txt | |
| Sulfonie | 0= Sulfur dynamics off; 1= on | |

The model starts the simulation in the specified **StartYear**, more precisely, at the date of harvest of that year. If measured initial values aren't available, start the model one year earlier to allow the model creating plausible initial conditions. In that case the year should correspond to the **harvest** date of the previous crop, and this will be the starting date on the outputs.

The model ends the simulation at the specified **EndDate**. If the date is before the specified **AnnualOutputDate**, the simulation runs until that date in (+1 day). Is the output date at the 31th December, the model requires a weather data file for the following days with data for at least the first days of that year.

**CorrectionPrecipitation**: Standard measurement of precipitation in 1 m above soil surface often differs from measurements at surface level. For this reason, it is possible to use Richter's (1995) monthly correction factors (for Germany conditions).

**ETpot**: Currently, the user can choose between 4 formulae to calculate evapotranspiration: HAUDE's formula calculates the potential evapotranspiration from the air saturation deficit at 14:00 and seasonal plant specific factors. It is the standard method of the German Weather Service and the original approach in HERMES. Alternatively, one can choose the TURC-WENDLING formula, which considers daily global radiation or sunshine hours, and PENMAN-MONTEITH, which requires additionally wind speed and humidity. Recently PRIESTLEY-TAYLOR has been included. Another option is to use pre-calculated ET0 values. (Some formulas in: https://www.climate-service-center.de/products_and_publications/publications/detail/063345/index.php.de#a9).

**CO2method**: see Long 1991 and Mitchel et al. 1995

**PTF** (Pedotransfer function):
0 = none (from file), 1 = Toth 2015, 2 = Batjes for pF 2.5, 3 = Batjes for pF 1.7, 4 = Rawls et al. 2003 for pF 2.5). The two pF options are based on two different definitions of FC. In Germany FC is considered to occur at 1.8 (=65 cm water column) matric potential, whereas in other regions 2.5 (=330 cm water column) is preferred.
Important: unlike PTF=0, PTF- > 0 does not tolerate layers with texture values 00. If FC and/or WP values are present, PTF>0 will ignore them.
To run PTFs >0 the PS value needs to be copied from the PTF=0 output into the SOIL file. Failing to do so, does not affect the resulting FC and WP calculations, but it will have an impact on the simulations when soil saturation is involved.
For more details see SOIL file.

**GroundWaterFrom:**
Option "soilfile": The Soil file can assign a constant value of ground water under the column GW for each soil ID (SID).
Option "polygonfile": The Polygon file can assign a minimum and maximum value of ground water under the columns GH and GL for each Polygon ID (Polyg). In this case, Hermes builds a sinusoidal function based on these two values starting the series with the maximum value. If a delay of this maximum is desired, there is a GroundWaterPhase parameter in the config file under the SOIL subtitle. Units are given in days.
Option "gwTimeSeries": this option uses a full time ground water data series that needs to be provided in a csv file with the name "gw_*ProjectName*.csv" (see Ground Water file section). If the time series has a missing date, the model will automatically fill out this date(s) with a straight line connecting the previous and the following value. If there is a ground water time series that does not correspond to any given soil ID, a new ground water ID can be created and listed in the Ground water file under a new SID denomination. The ground water SID will be assigned to the corresponding soil ID in the batch file.
For example, a new ground water ID (gwld) called "any" can be assigned to the corresponding soil ID (soilId) "075" as:

project=ABC WeatherFolder=wetter **soilId**=075 **gwId**=any fcode=109_121 plotNr=10002 resultfolder=RESULT/ABC

**Fertilization recommendation**
This function provides an amount and date of fertilization, and it is controlled by the item:
**- *virtual date for fertilizer prediction.***
The characters '------------' mean "no recommendation".
To produce a recommendation, a date (DDMMYYYY) is to be entered instead:
HERMES will calculate the N need from that date on and will do a recommendation of how much N to apply and provide the latest date for when to fertilize. The amount recommended will be input by the model and run a simulation until the date that appears in the reports.
HERMES creates two types of reports:
A console output:

```
SCHOSSEN
        ---------------------------------------------------------------
        |    N Bedarfsberechnung vom  30.03.2023 von Flaeche > 00031    |
        |            calculation of N demand  30.03.2023 of             |
        ---------------------------------------------------------------

                                             0 _ 30 cm: 028 kg N/ha
                                            30 _ 60 cm: 016 kg N/ha
                                            60 _ 90 cm: 010 kg N/ha
                                            -----------------------
                                             0 _ 90 cm: 055 kg N/ha

Es wurden bereits 045 kg N/ha durch die Pflanzen aufgenommen
*************************************************************************
|   Prognose des Stickstoffbedarfs bis zum Stadium <           SCHOSSEN  |
|   Voraussichtliches Eintrittsdatum  10.05.2023                          |
|   Empfohlene Duengung  051 kg N/ha   bis spaetestens 05.04.2023         |
*************************************************************************
Error Summary:
Number of errors: 0
Execution time:  125.3622ms
```

And a text report with a name starting with the letter d_ and the plot name

```
Fläche Nr 1
Datum      aktuelle Nmin - Werte  N-Düngung  düngen   Prognose   bis
           0-30 30-60 60-90 0-90cm  kg N/ha   bis      bis    Stadium
05.04.2023  027   023   012   062      038   10.05.2023 08.04.2023 < SCHOSSEN
```

In both cases, the calculation starting date, the N mineral uptake, the recommended amount of N, the date of recommendation, the date of application, the final date of simulation and the development phase are provided.

**Crop file** (project/*projectname* / CROP_XXX.txt)

Definitions

| Name | Description/Values | Notes/examples |
|---|---|---|
| Feld_ID | Field ID same as Field_ID in POLY_X, IRR_X, TIL_X, FERT_X. | See “Field and plots identifiers” |
| crp | Crop ID | WR, SM |
| Sowing | Sowing date in DDMMYYYY | |
| harvest | Harvest date in DDMMYYYY | dd/mm/yyyy |
| Rex | Percentage of residues exported from the field (i.e. 100 if straw is removed or 0 if all straw remains on the field). | |
| Yld | Residual from previous crop. Used when there is no previous crop. | |

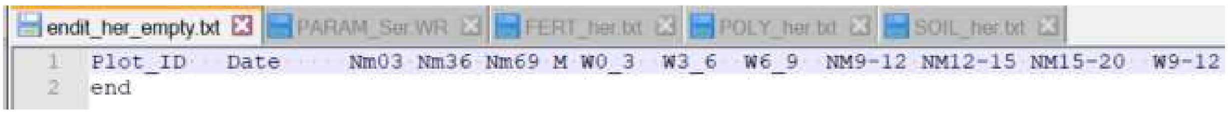
| | | |
|---|---|---|
| autorg | For each rotation: 0= do not read, 1=read fertilization values from **automan** file | |
| variety | The value on this column determines which crop parameter file will be used in the simulation. No value means that the parameter file chosen will be the default crop parameter (PARAM.XX, where XX is the crop acronym; see the folder “parameter”). Any other value (any string) needs to match the string after the “PARAM_” prefix in the “parameter” folder. | If Variety=no value, PARAM.XX is chosen.<br>If Variety= Danube, PARAM_Dan.XX is chosen |

Several crops can be entered in one file (crop rotation).,
For the first crop (Start year) only data of the harvest date will be used as starting date of the simulation. However, the input of a virtual sowing date is required. The dates should correspond to the initial year in the config file.
This means that an initial entry for each Field Id is required to indicate the start date of the simulation.
For example, if we have corn sown in April 2020 and harvested in September 2020, and we want to start the simulation in January 2020, we must add something like a fake previous crop:

| Field_ID | crp | Sowing | harvst | Rex | Yld | autorg | variety | comment |
|---|---|---|---|---|---|---|---|---|
| 001 | SM | 01012020 | 02012020 | 095 | 095 | | | |
| 001 | SM | 28042020 | 17092020 | 095 | 095 | 0 | Dan | |

**Measurement file (a.k.a. Initial conditions file)** (project/*projectname* / endit_XXX.txt)

Although these are commonly referred to as “Initial values” these, actually can be any measured/known values not necessarily at the beginning of the simulation.
The “endit” file has three possible configurations, to use:
1) the same initial values for all the experimental units, 2) a different value for each Field_ID (defined in the file CROP_xxx.txt and the POLY_xxx.txt), 3) a different value for each Polyg (POLY_xxx.txt), which is called Plot_ID in the endit_xxx.txt file, or 4) a different value for each SoilID.
Whatever the definition used, the IDs need to be also present on the first column of the endit_XXX file
The choice of any of these three spatial references needs to be set in the **config** file as 1, 2, 3 or 4, respectively (see section above).
An endit_xxx.txt file with no values:




Is used to avoid influence the model with measured values.

If for some reason the initial conditions file has the wrong referential information (IDs are wrong or the “endit” file is empty) HERMES will set the initial conditions automatically on the first date of the simulation. For example, in the first months, and if ground water is low, initial water content will be calculated as:
WC = FC – (FC-WP)*0.6. Where FC is field capacity and WP, wilting point at that layer.

If, for example, FC=0.23 and WP=0.08, the WC will be 0.14.

Example of option 3 endit file:

endit_boo.txt

```
1  Plot_ID   Date     Nm03 Nm36 Nm69 M W0_3  W3_6  W6_9  NM9-12 NM12-15 NM15-20
2  00002     14042020 0089 0003 0004 3 0.104 0.079 0.111
3  00002     02032021 0010 0003 0018 3 0.170 0.119 0.126
4  00005     14042020 0012 0006 0002 3 0.089 0.095 0.114
5  00005     02032021 0009 0002 0003 3 0.138 0.067 0.062
6  00009     14042020 0018 0003 0003 3 0.117 0.140 0.139
7  00009     02032021 0034 0011 0009 3 0.168 0.143 0.150
```

```
W9-12 W12-15 W15-20 NAOS1  NAOS2  NAOS3  NFOS1 NFOS2 NFOS3
```

Example of option 1 endit file:

endit_BO021.txt

```
1  Plot_ID   Date     Nm03 Nm36 Nm69 M W0_3  W3_6  W6_9  NM9-12 NM12-15 NM15-20
2  ALLE      02032021 0010 0003 0018 3 0.170 0.119 0.126
3  end
```

Definitions:

| Name | Description/Values | Notes/examples |
|---|---|---|
| Plot_ID | Use the Field ID or Polyg ID if in the config file, InitSelection, was entered 2 or 3, respectively | See “Field and plots identifiers” |
| Date | The model starts at the start date of the simulation with a standard value and updates at the given date soil water and mineral N contents with the values specified here | |
| Nm03, Nm36, Nm69 | N mineral (kg N ha-1) at three 30-cm depths. | |
| W0_3, W3_6, W6_9 | Fraction (0-1) of soil water content for the three standard measurement depths | |
| M | Units of water content. 1= % available water, 2= % weight, 3= % volume. The first unit is recommended, since the choice of absolute water contents might lead | |

| | | |
|---|---|---|
| | to initial water contents exceeding field capacity and thus to the simulation of initial leaching and N loss | |
| NM9-12, NM12-15 NM15-20 | N mineral for further layers | |
| W9-12, W12-15, W15-20 | Water content for further layers | |
| NAOS1, NAOS2, NAOS3 | N-Pool slow mineralizable org. substance in layer (kg N/ha) | |
| NFOS1, NFOS2, NFOS3 | N-Pool fast mineralizable org. substance in layer (kg N/ha) | |

Notes:
Both nitrogen and water for the first three layer ranges need to be provided. If water is unknown, in some regions it is safe to put a value near field capacity during the winter months and use this year as a "pre-simulation year".

Although in the example above there are two dates (for the years 2020 and 2021), ONLY the first measured value of water will be applied to force the simulation.

**Fertilization file** (project/*projectname* / FERT_XXX.txt)

| Name | Description/Values | Notes/examples |
|---|---|---|
| Field_ID | | See "Field and plots identifiers" |
| N | N quantity | 030, 070, etc |
| Frt | Fertilizer name (fertilizer is defined in **parameter/FERTILIZ.TXT**) | KAS |
| date | DDMMYYYY | |

**Ground water file** (project/*projectname* / GW_XXX.txt)

GW_DED.txt

```
SID,DATE,Level
023,01082014,39
023,02082014,40
023,03082014,36
023,04082014,29
023,05082014,29
023,06082014,28
023,07082014,26
023,08082014,25
023,09082014,25
023,10082014,25
023,11082014,25
023,12082014,25
023,13082014,25
023,14082014,25
023,15082014,25
023,16082014,25
023,17082014,25
023,18082014,25
023,19082014,25
023,20082014,25
```

This file represents a ground water time series for modeling soil water dynamics.
This file is used only with the configuration option:
GroundWaterFrom: gwTimeSeries (file: config.yml).
When the option "soilfile" or "polygonfile" are used the ground water dynamics is given in the corresponding files (SOIL_XXX.txt and POLY_XXX.txt) respectively (see Configuration file section).
If the time series has a missing date, the model will automatically fill out this date(s) with a straight line connecting the previous and the following value.
In the example above the time series corresponds to a SID called 023. Other SIDs are listed below. Level is given in layer number (1-20, 99) or in dm in integer rounded up to 2 digits (no decimals).
If there is a ground water time series that does not correspond to any given soil ID, a new ground water ID can be created and listed in the Ground water file under a new SID denomination. The ground water SID will be assigned to the corresponding soil ID in the batch file.
For example, a new ground water ID (gwId) called "any" can be assigned to the corresponding soil ID (soilId) "075" as:

project=ABC WeatherFolder=wetter **soilId**=075 **gwId**=any fcode=109_121 plotNr=10002 resultfolder=RESULT/ABC

**Irrigation file** (project/*projectname* / IRR_XXX.txt)

```
Field_ID  Ir NO3 date
          mm mg/l
001       10  00 12062020
001       12  00 25062020
001       08  00 26042021
001       10  00 14052021
002       10  00 12062020
002       12  00 25062020
002       08  00 26042021
002       10  00 14052021
003       10  00 12062020
003       12  00 25062020
003       08  00 26042021
003       10  00 14052021
004       10  00 12062020
004       12  00 25062020
004       08  00 26042021
004       10  00 14052021
end
```

| Name | Description/Values | Notes/examples |
|---|---|---|
| Field_ID | | See "Field and plots identifiers" |
| Ir | amount of water applied at each event [mm] | |
| NO3 | N concentration of the irrigation water [mg N l-1] | |
| date | | |

**Management output configuration file** (project/*projectname* / managementout_conf.yml)

In "enable:" set it to true if an output is expected.

**Polygon file** (project/*projectname* / POLY_XXX.txt)

| Name | Description/Values | Notes/examples |
|---|---|---|
| Polyg | | See "Field and plots identifiers" |
| SID | | See "Field and plots identifiers" |
| Field_ID | | See "Field and plots identifiers" |
| GH | mean maximum groundwater level [dm]. Level commonly observed in spring. Values between 20 and 30 will change the | Important: the GH and GL values |

| | | |
|---|---|---|
| | FC and have an impact on the final yield. Value of 99 will render ground water inactive. | entered do NOT equal the final values (see below) |
| GL | mean minimum groundwater level [dm]. Value of 99 will render ground water inactive, because values higher than 35 (3.5 m) have no impact on soil water balance. | |
| Ir | 0=No irrigation, 1=Irrigation for individual polygons. 1 works only when AutoIrrigation=1 in **config** file. | |
| Comment | | |
| | | |

Polygons allow organizing sub-fields with different site properties (soil, groundwater level). In order to define polygons, soils and field crop management must be defined previously (SID, Field_ID, etc.).

GW defines the depth below which no water calculation is done. In the Polygon file a unique GW is defined when GH and GL have the same value.

If GH ≠ GL and the model uses only one GW value, an average of the two values provided is calculated. If GH ≠ GL and the model uses a changing GW value, the model assumes a linear change between end of high GW level and begin of low level, and so defines a GW at each time. If PTF=0 and Field Capacity isn't provided (= 00) a variable FC will be defined according to each GW value. If FC is provided it will stay constant.
Important: in the way the GW sinusoidal curve is calculated, the real oscillation will we more ample than the GH and GL provided. For example, a GH-GL of 1.7-2.0 will result in an amplitude of 1.55-2.15.
GW level is also used to calculate capillary rise. At any layer, when soil moisture falls below 70% of nFK (= nutzbare Feldkapazität, or Available Water Capacity) the distance of this layer to the GW level is used to search for the corresponding value in the PARCAP.TRU parameter file (table below).

PARCAP.TRU

```
SU   .055  .055  .055  .055  .055  .055  .055  .05   .03   .02
     .015  .01   .0075 .005  .004  .003  .002  .001  .0    .0
SU2  .055  .055  .055  .055  .055  .055  .055  .05   .03   .02
     .015  .01   .0075 .005  .004  .003  .002  .001  .0    .0
SU3  .055  .055  .055  .055  .055  .05   .035  .02   .015  .008
     .005  .003  .002  .001  .0008 .0005 .0002 .0    .0    .0
SU4  .055  .055  .055  .055  .055  .055  .055  .05   .03   .02
     .015  .01   .0075 .005  .004  .003  .002  .001  .0    .0
SL2  .055  .055  .055  .055  .055  .045  .025  .015  .007  .004
     .002  .001  .0007 .0005 .0    .0    .0    .0    .0    .0
SL3  .055  .055  .055  .055  .055  .05   .035  .02   .015  .008
     .005  .003  .002  .001  .0008 .0005 .0002 .0    .0    .0
SL4  .055  .055  .055  .055  .055  .05   .035  .02   .015  .008
```

In the PARCAP.TRU, for each soil type (SU, SU2, … etc.) there is a capillary rise factor corresponding to the number of layers to the GW. For example, if there is one layer distance, the capillarity factor is 0.055. If there are 11 layers, capillarity is 0.015.

## Soil file

(project/*projectname* / SOIL_XXX.txt, and SOIL_XXX.csv)

```
SID Corg Tex lb B St C/N C/S Hy Rd NuHo  FC WP PS S% SI% C%     DraiT   Drai% GW LBG
011 0.60 SU2 03 2 00 10  00  00 12 04   00 00 00 82 14 04     20   00 20   
011 0.26 SU2 06 3 00 10  00  00         00 00 00 81 15 05     20   00      
011 0.08 SL2 09 3 00 12  00  00         00 00 00 78 15 06     20   00      
011 0.00 SL2 20 3 00 00  00  00         00 00 00 00 00 00     20   00      
012 0.67 SU2 03 2 00 10  00  00 12 04   00 00 00 84 13 04     20   00 20   
012 0.40 SU2 06 3 00 10  00  00         00 00 00 83 12 04     20   00      
012 0.24 SL2 09 3 00 08  00  00         00 00 00 78 17 05     20   00      
012 0.00 SL2 20 3 00 00  00  00         00 00 00 00 00 00     20   00      
```

Note: the spaces between values in a row need to be reproduced exactly.

The second name corresponds to the CSV file

| Name | Description/Values | Notes/examples |
|---|---|---|
| SID | Soil ID | See “Field and plots identifiers” |
| Corg<br>C_org | Organic carbon in [%] | |
| Tex<br>Texture | Texture class (4th issue of the German soil survey manual; Bodenkundliche Kartieranleitung, KA5) File HYPAR.TRU in parameter folder or Table 1, Annex. | Values need to be provided when PTF=0 |
| Lb<br>LayerDepth | Lower boundary of the soil horizon in [dm] below soil surface | 03 for 30 cm |
| B<br>BulkDensityClass | Bulk density class (1-5): **1**:<1.4, **2**:1.4-1.6, **3:**1.6-1.8, **4:**1.8-2.0, and **5:** =>2.0) Values in g*cm-3 | Table 2, Annex |
| BulkDensity | Only in CSV files. A precise value. If present, it overwrites the BulkDensityClass | |
| St<br>Stone | Stone content [%, integers only] needs to be considered when calculating soil moisture | |
| C/N | Corg/Norg ratio. It is used to estimate Norg content in the soil. Enter 10, if the ratio is unknown. | |
| C/S | C/S ratio. | |
| Hy | Corr. factor for water logging for water holding capacity | |
| Rd<br>RootDepth | Max. effective rooting depth (dm). The Max Effective Root Depth in a PARAM.XXX crop file is limited by Rd. | |
| NuHo<br>NumberHorizon | Number of Horizons | |
| FC<br>FieldCapacity | water content at field capacity (Vol%). If 00 is given and PTF=0, the default values from HYPAR (KA5) are used according to Tex | |
| WP<br>WiltingPoint | water content at wilting point (Vol%). If 00 is given and PTF=0, the default values from HYPAR (KA5) are used according to Tex | |
| PS<br>PorVolume | total pore space (Vol%). If 00 is given and PTF=0, the default values from HYPAR (KA5) are used according to Tex. If PTF≠0, PS needs to be provided in this file. | |
| S%, SI%, C%<br>Sand, Silt, Clay | Percent sand, silt and clay | |

| | | |
|---|---|---|
| DraiT<br>DrainageDepth | (DRAIDEP). Drain depth of drainage system (dm) | See below |
| Drai%<br>Drainage% | (DRAIFAK) Drain factor (fraction of water that drains). Fractions are indicated as ".X". "00" indicates no drainage. | See below |
| GW<br>GroundWaterLevel | ground water level (dm). This is used as alternative to GH GL in POLY_XXX.txt, according to GroundWaterFrom in the config.yml file. When GW is deeper than 2 m it can be set to 99. | |
| LBG | obsolete | |
| lamda | obsolete | |

If soil organic matter (SOM) contents are at hand, you can approximate Corg contents by multiplying SOM by 0.58. If Corg contents of the subsoil are unknown, enter zero.

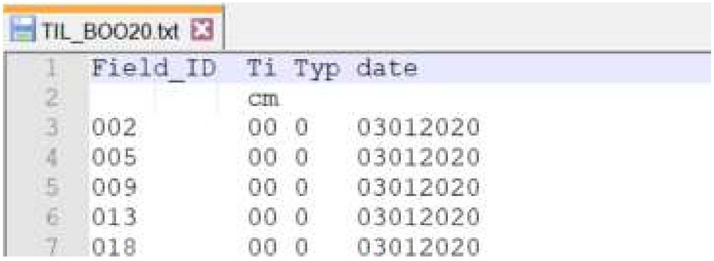
Important: unlike FTP=0, FTP > 0 does not tolerate layers with texture values 00. If FC and/or WP values are present, PTF>0 will ignore them.
To run FTPs >0 the PS value needs to be copied from the PTF=0 output into the SOIL file. Failing to do so, does not affect the resulting FC and WP calculations, but it will have an impact on the simulations when soil saturation is involved.
In summary:

| PTF | Tex (texture class) | FC, WP, PS | S%, SI%, C% |
|---|---|---|---|
| 0 based on provided texture | Must be provided | Must be 00 | Can be provided |
| 1-4 | Must be provided | FC and WP will be calculated, PS better be provided | Must be provided |
| 0 based on estimated FC, WP, PS by other means | Must be provided | Must be provided | |

When the default values from the HYPRAR file (KA5 taxonomy) are used (i.e. no Pedotransfer Function is given because PTF=0), FC values are modified by a correction factor, if GW is high (= > 60) or absent. Additionally, the FC is set to total pore space (FC=PS) in all layers below the GW level.
If fixed values for the capacities are provided in the soil file, no correction will be used, but FC = Pore space below GW will remain.

DraiT (drainage depth): when its value is less than 20 (the maximum depth at which drainage can occur), part of the water above FC drains away (carrying all nutrients with it) and part percolates down the soil (and stays). The fraction that drains is indicated by Drai%, which is typically around 80%.
Example: If DraiT=10 and Drai%=70, then all water exceeding FC between 0-1 m percolates down the soil leaving nutrients in the soil. Then 70% of all water exceeding FC below 1 m will be lost together with the nutrients. 30% will percolate down the soil.
When drainage values are used, GW would typically be set at least as deep as the DraiT, under the assumption that GW never sets itself above the DraiT level.

**Tillage file** (project/*projectname* / TIL_XXX.txt)



TIL_BOO20.txt

```
Field_ID  Ti Typ date
          cm
002       00 0   03012020
005       00 0   03012020
009       00 0   03012020
013       00 0   03012020
018       00 0   03012020
```

| Name | Description/Values | Notes/examples |
|---|---|---|
| Field_ID | | See “Field and plots identifiers” |
| Ti | Depth of tillage | |
| Typ | 0: the soil is not turned; 1: the soil is mixed to the depth entered in Ti | |
| date | | |

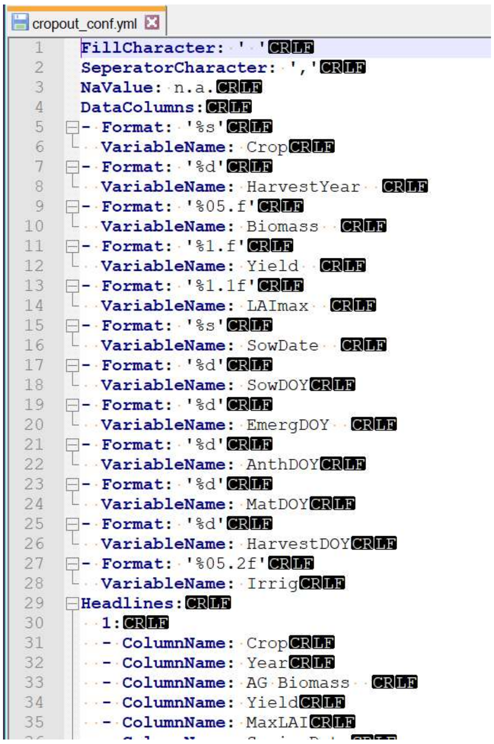
### Sulfonie module files

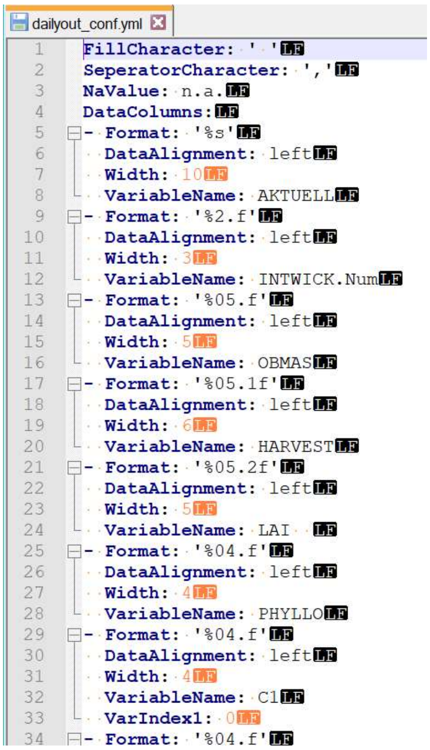
(project/*projectname* / cropdata.txt_and smin.txt)
The Sulfonie routine has two additional project files:
The *cropdata.txt* file has information on S content on different crops (for example, the mineral content in yield products, HEG; in above ground biomass, NEG; and in roots, Wura).
The *smin.txt* is used to input measures S mineral (SO4) values
(see Sulfonie: Sulfur simulation)

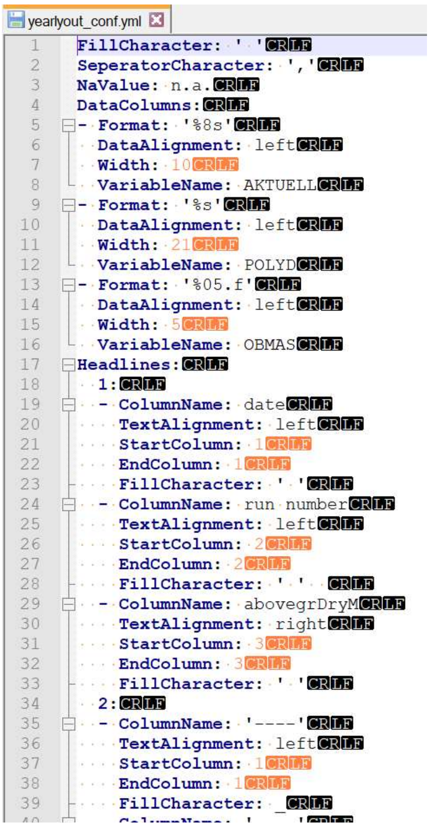
### Output files

(project/*projectname* /cropout_conf.yml, yearlyout_conf.yml, dailyout_conf.yml)

Cropout is output as starting with C
Yearlyout is output as starting with Y
Dailyout is output as starting with V


cropout_conf.yml
```yaml
FillCharacter: ' '
SeperatorCharacter: ','
NaValue: n.a.
DataColumns:
- Format: '%s'
  VariableName: Crop
- Format: '%d'
  VariableName: HarvestYear
- Format: '%05.f'
  VariableName: Biomass
- Format: '%1.f'
  VariableName: Yield
- Format: '%1.1f'
  VariableName: LAImax
- Format: '%s'
  VariableName: SowDate
- Format: '%d'
  VariableName: SowDOY
- Format: '%d'
  VariableName: EmergDOY
- Format: '%d'
  VariableName: AnthDOY
- Format: '%d'
  VariableName: MatDOY
- Format: '%d'
  VariableName: HarvestDOY
- Format: '%05.2f'
  VariableName: Irrig
Headlines:
  1:
  - ColumnName: Crop
  - ColumnName: Year
  - ColumnName: AG Biomass
  - ColumnName: Yield
  - ColumnName: MaxLAI
```


dailyout_conf.yml
```yaml
FillCharacter: ' '
SeperatorCharacter: ','
NaValue: n.a.
DataColumns:
- Format: '%s'
  DataAlignment: left
  Width: 10
  VariableName: AKTUELL
- Format: '%2.f'
  DataAlignment: left
  Width: 3
  VariableName: INTWICK.Num
- Format: '%05.f'
  DataAlignment: left
  Width: 5
  VariableName: OBMAS
- Format: '%05.1f'
  DataAlignment: left
  Width: 6
  VariableName: HARVEST
- Format: '%05.2f'
  DataAlignment: left
  Width: 5
  VariableName: LAI
- Format: '%04.f'
  DataAlignment: left
  Width: 4
  VariableName: PHYLLO
- Format: '%04.f'
  DataAlignment: left
  Width: 4
  VariableName: C1
  VarIndex1: 0
- Format: '%04.f'
```


yearlyout_conf.yml
```yaml
FillCharacter: ' '
SeperatorCharacter: ','
NaValue: n.a.
DataColumns:
- Format: '%8s'
  DataAlignment: left
  Width: 10
  VariableName: AKTUELL
- Format: '%s'
  DataAlignment: left
  Width: 21
  VariableName: POLYD
- Format: '%05.f'
  DataAlignment: left
  Width: 5
  VariableName: OBMAS
Headlines:
  1:
  - ColumnName: date
    TextAlignment: left
    StartColumn: 1
    EndColumn: 1
    FillCharacter: ' '
  - ColumnName: run number
    TextAlignment: left
    StartColumn: 2
    EndColumn: 2
    FillCharacter: ' '
  - ColumnName: abovegrDryM
    TextAlignment: right
    StartColumn: 3
    EndColumn: 3
    FillCharacter: ' '
  2:
  - ColumnName: '----'
    TextAlignment: left
    StartColumn: 1
    EndColumn: 1
    FillCharacter: _
```

General depiction of the output files

About string formatting in go:
[https://gobyexample.com/string-formatting](https://gobyexample.com/string-formatting)

Width is specified by an optional decimal number immediately preceding the verb. If absent, the width is whatever is necessary to represent the value. Precision is specified after the (optional) width by a period followed by a decimal number. If no period is present, a default precision is used. A period with no following number specifies a precision of zero. Examples:

```
%f     default width, default precision
%9f    width 9, default precision
%.2f   default width, precision 2
%9.2f  width 9, precision 2
%9.f   width 9, precision 0
```

```
%b      decimalless scientific notation with exponent a power of two,
        in the manner of strconv.FormatFloat with the 'b' format,
        e.g. -123456p-78
%e      scientific notation, e.g. -1.234456e+78
%E      scientific notation, e.g. -1.234456E+78
%f      decimal point but no exponent, e.g. 123.456
%F      synonym for %f
%g      %e for large exponents, %f otherwise. Precision is discussed below.
%G      %E for large exponents, %F otherwise
%x      hexadecimal notation (with decimal power of two exponent), e.g. -0x1.23abcp+20
%X      upper-case hexadecimal notation, e.g. -0X1.23ABCP+20
```

## Names of the output variables

| Variable | VariableName in Hermes | Suggested name | Index | Output type |
|---|---|---|---|---|
| | Crop | | | cropout |
| | HarvestYear | | | cropout |
| | Biomass | | | cropout |
| | Yield | | | cropout |
| | LAImax | | | cropout |
| | SowDate | | | cropout |
| | SowDOY | | | cropout |
| | EmergDOY | | | cropout |
| | AnthDOY | | | cropout |
| | MatDOY | | | cropout |
| | HarvestDOY | | | cropout |
| Automatic irrigation (mm) | Irrigation | | | cropout |
| | | | | |
| | AKTUELL | | | dailyout |
| Development stage | INTWICK.Num | Stage | | dailyout |

| | | | | |
|---|---|---|---|---|
| | OBMAS | AbovegroundDryMas | | dailyout |
| | fertili | Yield | | dailyout |
| | LAI | | | dailyout |
| | PHYLLO | BiolTime_Sum Deg | | dailyout |
| N min layers 1-8 | C1 | Nmin | | dailyout |
| N min layers 9-20 | Nmin9to20 | Nmin | | dailyout |
| N crop content (kg N ha-1) | PESUM | Ncrop | | dailyout |
| Field Capacity (cm3/cm3) | W (WNOR is FC uncorrected) | FC | | dailyout |
| Wilting Point (cm3/cm3) | WMIN | WP | | dailyout |
| Pore volume (cm3/cm3) | PORGES | PoreSize | | dailyout |
| Water content | WG | SoilW | VarIndex1: 0=day before, 1=current day. VarIndex2: depth | dailyout |
| Average Temperature (°C) | TEMPdaily | | | dailyout |
| Min and max temperature (°C) | TMINdaily, TMAXdaily | | | dailyout |
| Relative humidity | RHdaily | | | dailyout |
| photosynthetic active radiation, which is 50% of Global radiation (MJ $m^{-2}$) | RADdaily | | | dailyout |
| wind (with minimum at 0.5 m s-1) | WINDdaily | | | dailyout |
| Before irrigation is added (mm) | REGENdaily | | | dailyout |
| Portion of the irrigation (both active and automatic) that is added to daily precipitation (mm) | EffectiveIRRIG | | | dailyout |
| Cumulative automatic irrigation inputs (mm). Only automatic!!! | IRRISIM | | | dailyout |
| Deepest layer at which roots occur | WURZ | | Output values are in layer number | dailyout |
| Water stress factor (better: water sufficiency) (1 = no stress, 0 = full stress) | TRREL | W suffic | | dailyout |
| Nitrogen stress factor (1 = no stress, 0 = full stress) | REDUK | N suffic | | dailyout |
| Percolation | SICKER | PercSum | Cumulative, calculated for the entire profile | dailyout |

| | | | | |
|---|---|---|---|---|
| Capillary rise | CAPSUM | CapillSum | Cumulative, calculated for the entire profile | dailyout |
| Potential Evapotranspiration (cm) | VERDUNST | | Cumulative | dailyout |
| Actual Evapotranspiration | ETA | | | |
| Ground water | GW | GroundWater | | |
| | GRW | | | |
| Max N content (kg N/kgBiom) | GEHMIN | MinNconten | | |
| Min N content (kg N/kgBiom) | GEHMAX | MaxNcontent | | |
| N content above ground (kg N/kgBiom) | GEHOB | N-AGBiom | | |
| N content in root (kg N/kgBiom) | WUGEH | N-Root | | |
| Soil Organic Carbon (kg/ha) | SOC1 | Soil O C | | Yearly out |

EffectiveIRRIG is 10% of actual irrigation input.

Difference between field capacity (W) and uncorrected FC (WNOR):
When HERMES or HERMES2Go uses the values from the German Soil taxonomy (in the HYPAR file) the program may apply some correction (KRR) depending on high soil organic matter or shallow groundwater depth to calculate “W”. WNOR is the uncorrected value simply derived from texture. Since reduction of N mineralization is defined above field capacity (saturated soils) and below about 0.7 of plant available water, the program uses WNOR as field capacity to consider some reduction if real FC is higher due to the correction.

With the addition of the PTFs, and since some of the PTFs do use organic matter to calculate FC and WP, is this a problem?
I think WNOR = W when providing fixed values or derived by PTF. But for the latter we may have to check. However, there was a problem if you use varying GW levels since the model jumped into the module to re-estimate the parameters from HYPAR. Therefore, I have inactivated this re-calculation when fixed values are provided.
Important: unlike FTP=0, FTP > 0 does not tolerate layers with texture with values 00.

## The folder “parameter”

CROP_N.TXT
This file contains basic N and S parameters for each crop

CROP_N.TXT

```
KuA K_S TM_   N_HEG S_HEG N_NEG SNEG SWur Nfas Sfas
AB  2.0 0.86 04.10 00.20 00.80 0.05 0.10 0.67 1.00 Ackerbohne
CCM 1.3 0.60 01.00 00.06 01.00 0.09 0.10 0.20 0.30 Corn-Cob-Mix Kolben + K□rner
GR  0.0 0.17 00.45 00.04 00.00 0.00 0.10 0.00 0.00 Gr□nland Schnittnutzung
GR  0.0 0.20 00.50 00.03 00.00 0.00 0.10 0.60 0.90 Gras. Futter Gr□nmasse
H   1.2 0.86 01.50 00.12 00.50 0.09 0.10 0.00 0.00 Hafer
OA  1.2 0.86 01.50 00.12 00.50 0.09 0.10 0.00 0.00 Hafer
K   0.5 0.27 00.35 00.03 00.20 0.02 0.16 0.10 0.15 Kartoffeln
LUP 1.9 0.86 04.50 00.25 00.80 0.05 0.10 0.67 1.00 Lupinen
ORH 999 0.10 00.45 00.10 00.00 0.00 0.10 0.67 1.00 □lrettich
SE  999 0.10 00.45 00.05 00.00 0.00 0.10 0.60 0.90 Senf Zwischenfrucht
SG  0.7 0.86 01.40 00.12 00.50 0.09 0.10 0.00 0.00 Sommergerste
SM  .15 0.28 00.38 00.03 00.38 0.00 0.10 0.25 0.30 Silomais
```

| **Name** | **Description/Values** | **Notes/ examples** |
|---|---|---|
| KuA | crop (3 digits, left bound, capital letters) corresponds to the short form of the crop parameter files. | |
| K_S | Corn_straw (beet/leaf) relation (or grain-straw ratio) | |
| TM_ | dry matter content (%) | |
| N_HEG | N-content main product (kg/dt=%) | |
| S_HEG | S-content | |
| N_NEG | N- content by-product (straw, leaves) (kg/dt) | |
| SNEG | S-content | |
| NWur | N-percentage of total N in crops allocated to roots (kg/kg) | |
| SWur | S-allocated to roots | |
| Nfas | Percentage of fast mineralisable N of Ntotal of residues (kg/kg) | |
| Sfas | Percentage of fast mineralisable S of Ntotal of residues (kg/kg) | |

When a new crop type (crop species) is added to the list of crops to be modelled in HERMES, a new line should be created in this file. Otherwise, the model will result in an error.

FERTILIZ.TXT
This file contains the basic properties of the fertilizers to be used in the simulations.
Fertilizers are identified with a one-to-three character code.

FERTILIZ.TXT

```
Typ Ntot  Ndir Nfst Nslo NH4  Loss  Stot Sdir Sdir Unit    Name
KAS 01.00 1.00 0.00 0.00 0.50 0.00  0.00 0.00 0.00  kg     Calcium Ammonium Nitrate
AHL 01.00 1.00 0.00 0.00 1.00 0.00  0.00 0.00 0.00  kg     Ammonium Urea solution
H   01.00 1.00 0.00 0.00 1.00 0.00  0.00 0.00 0.00  kg     Urea
NPK 01.00 1.00 0.00 0.00 0.00 0.00  0.00 0.00 0.00  kg     NPK Fertiliser
ALZ 01.00 1.00 0.00 0.00 1.00 0.12  0.00 0.00 0.00  kg     Alzon
AZU 01.00 1.00 0.00 0.00 1.00 0.12  0.00 0.00 0.00  kg     Ansul
NIT 01.00 1.00 0.00 0.00 0.00 0.10  0.00 0.00 0.00  kg     Nitrophoska
RG  04.70 0.43 0.00 1.00 1.00 0.40  0.00 0.00 0.00  kg/m3  Cattle slurry
SM  00.60 0.15 0.20 0.80 1.00 0.40  0.00 0.00 0.00  kg/dt  Common manure
RM  00.60 0.15 0.20 0.80 1.00 0.40  0.00 0.00 0.00  kg/dt  Cattle manure
RSG 05.70 0.55 0.00 1.00 1.00 0.40  0.00 0.00 0.00  kg/m3  Cattle/pig slurry
SG  06.70 0.66 0.00 1.00 1.00 0.40  0.00 0.00 0.00  kg/m3  Pig slurry
SSM 00.76 0.15 0.20 0.80 1.00 0.40  0.00 0.00 0.00  kg/dt  Pig manure
HG  10.70 0.68 0.00 1.00 1.00 0.40  0.00 0.00 0.00  kg/m3  Poultry slurry
HFM 02.30 0.15 0.20 0.80 1.00 0.40  0.00 0.00 0.00  kg/dt  Poultry dry manure
HM  02.80 0.15 0.20 0.80 1.00 0.40  0.00 0.00 0.00  kg/dt  Poultry manure
CK  00.30 0.00 1.00 0.00 0.00 0.00  0.00 0.00 0.00  kg/dt  Calbokalk
```

Ntot: content of total Nitrogen in kg. Same for Stot.
Nfst: N fast fraction, Nslo: N slow fraction. The sum can be lower than 1 but not higher.
Unit: Expresses the amount in Ntot in kg per unit value of the fertilizer.
S corresponds to sulfur.

HYPAR.TRU
Soil type and hydraulic parameters

HYPAR.TRU | SOIL_MAR20.txt | config.yml | IRR_

```
BDA -- FK --   --nFK-- -- GPV-- -Wumax-
SS   19 17 16 12 10 10 41 36 32  5
SG   20 19 18 17 16 16 44 37 35  5
SM   14 11 11  9  8  7 42 36 31  6
SMG  15 11 11 11  8  7 41 35 31  6
SMF  19 16 14 15 13 11 42 36 31  6
SF   25 24 16 21 20 12 43 34 29  7
SU2  24 22 19 18 16 13 41 35 30  7
SU3  32 28 25 23 21 18 44 37 31  7
SU4  26 24 22 20 14 13 40 32 29  7
SL2  26 24 21 19 18 16 43 37 30  7
SLU  37 31 28 27 21 17 46 38 34  9
SL3  31 26 24 22 18 15 43 37 31  8
SL4  33 28 26 21 17 14 45 39 31  9
ST2  26 23 21 18 14 13 45 39 33  8
ST3  32 29 26 20 15 12 48 39 33  9
UU   40 37 34 28 26 22 46 39 37 11
US   39 33 29 27 25 19 46 38 36 10
UT2  39 36 32 27 25 21 48 40 34 11
```

| Name | Description/Values | Notes/examples |
|---|---|---|
| BDA | soil type/category | |
| FK | Field capacity. One of the three columns is chosen based on Bulk Density class 1-2, 3 or 4 | |
| nFK | “nutzbare Feldkapazität” is equivalent to “plant available water (FC-WP). One of the three columns is chosen based on Bulk Density class 1-2, 3 or 4. | For the whole profile (FC-WP) x We (=effective rooting depth). |

| | | |
|---|---|---|
| GPV | Pore volume. This value is used when PTF=0 in **config** file. When PTF≠0, GPV needs to be provided as PS in the **SOIL** file. One of the three columns is chosen based on Bulk Density class 1-2, 3 or 4 | |
| WUmax | maximum root depth. NOT USED ANYMORE | |

The relationship between BDA and the three soil capacity parameters is only established when PTF = 0 in the configuration file.

**Crop parameter files**
PARAM_*yyy.XX* and PARAM_*yyy.XX*.yml
(yyy= variety nick name, XX= crop acronym)

Crop parameter files have two formats. A text format (two- to three-letter extension) and a yml format (.yml). he format to be used can be assigned in the config.yml file ().There is a converter available to go from text to yml.

Some definitions:
Crop N-content function no. (critical and max. N-contents).... 1
N-Gehaltsfunktion Nr. ....................................... 1
This is the function to calculate N max and N min, to determine the N stress and excess uptake during crop development. Functions (a total of nine) can be found in the crop.go code file (line 447).

Specific Leaf Area (German: Umrechnung Blattgewicht in Blattflaeche [m2/m2/kg TM] is actually expressed in ha, not $m^2$, that's why its value is in the order of 0.001 instead of 10.

Above ground organs (numbers of compartments increasing order)…. 234
organ no. for yield and fraction of organ (organ 4 80% =4.80)………….. 4.80
(In German: Oberirdische Organe (Nummern der Kompartimente aufsteigend))
In the HERMES code:
YORGAN is the organ number (4 the example below), 0 means the whole plant
YIFAK is the percentage value, eg. 95% (or 0.95 in code)
OBMAS above ground biomass
WORG list of biomass per organ

```
if g.YORGAN == 0 {g.HARVEST = g.OBMAS * g.YIFAK}
 else {g.HARVEST = g.WORG[g.YORGAN-1] * g.YIFAK}
```

Example: 4.95
WORG is of YORGAN index 3 (because it starts counting at 0) and multiply it by 0.95.

Trockenstress ab ETA/ETP-Quotient von: In the script is called DRYSWELL, and it is the threshold determining the effect of water stress on crop stage acceleration (WPROG). Higher values make the acceleration (WPROG) higher than 1, whereas lower values make WPROG = 1.

When a new crop type (crop species) is added to the list of crops to be modeled in HERMES, a new file with this species should be created. Additionally, a line in the CROP_N.txt file should be added. Some crops such as AA, GR, GRE, K, SG, SM, ZR, WG, WR and WW receive special treatment in de HERMES processes and are mentioned explicitly to the code. Therefore, if the new crop needs a special treatment such as a value of root mass (as in K) or a limited N uptake (as in ORH), the crop identifier should be added to the HERMES code as well.

## The folder “weather”

The weather file:

```
109_120_mar-2021d.csv
D: > ZALF > HERMES2GO > weather > mar > 109_120_mar-2021d.csv
iso-date,tmin,tavg,tmax,precip,globrad,wind,relhumid,vaporpress,dewpoint_temp,relhumid_tmin,relhumid_tmax
-,�C,�C,�C,mm ,MJ m-2,m s-1,%,kPa,°C,% 0-100,% 0-100
2020-01-01,-2.6,1.6,5.5,0,2.84256,4.3,72.4,999.9,999.9,999.9,999.9
2020-01-02,-4,0.3,7.1,0,3.24864,4,71.6,999.9,999.9,999.9,999.9
2020-01-03,-0.3,4.3,7,2.2,2.05632,9.7,75.9,999.9,999.9,999.9,999.9
2020-01-04,1.4,4,5.8,0.8,1.27008,16,85.3,999.9,999.9,999.9,999.9
2020-01-05,-1.5,1.3,3.9,0,1.6848,7,85.7,999.9,999.9,999.9,999.9
2020-01-06,1.4,4.6,6.7,0,2.28096,6.2,90.5,999.9,999.9,999.9,999.9
2020-01-07,-1.3,2.4,5.4,0,0.91584,5.2,70.4,999.9,999.9,999.9,999.9
2020-01-08,2.4,6.3,8.4,0.3,1.1664,8.9,84.1,999.9,999.9,999.9,999.9
2020-01-09,6.5,8.1,9.8,3.9,2.60064,6.7,40.3,999.9,999.9,999.9,999.9
2020-01-10,4.3,9.1,11.5,3.7,2.85984,11.2,64.6,999.9,999.9,999.9,999.9
```

**Make sure the CSV file is saved with the date format: YYYY-MM-DD!**

Minimum requirements
Mean daily temperature (tavg) measured in 2 m above ground [°C]
Water vapor saturation deficit at 14:00 o´clock [mm Hg] (not necessary when the TURC-WENDLING algorithm is used for evapotranspiration calculation)
Global radiation (globrad) in MJ m $^{-2}$. Values are in the order of 1-20. If units are in J cm $^{-2}$ divide the values into 100. To convert from W*day/m2, do: GloRad*24*60*60/1,000,000 or GloRad*0.0864
Precipitation (precip) in mm.
Wind speed should be in m/sec (typically between 0 and 15). If higher (km/h), divide data into 3.6.

Variable names should be:
iso-date, globrad, relhumid, tavg, precip, wind, tmin, tmax.

The water vapor saturation deficit at 14:00 o´clock can be calculated from air temperature in 2 m above ground [°C] and the relative air humidity [%] at 14:00 o´clock.
The requirement for these data is based on the use of the HAUDE algorithm for evapotranspiration calculation. As an alternative algorithm for more easily available weather data currently only, TURC-WENDLING is installed. The Penman-Monteith equation additionally requires minimum and maximum temperature and wind speed in 2 m. In the header line the height of the wind measurement in m is required to transform the wind speed to 2 m if another height is used.
Although Penman is the preferred method, it can overestimate ET when the wind is high.

In case of not having radiation information, sunshine hours can be used, and the model will translate it into radiation. This variable will be called “sun”. This function works only with evapotranspiration setting=3 (ETpot in configuration file).

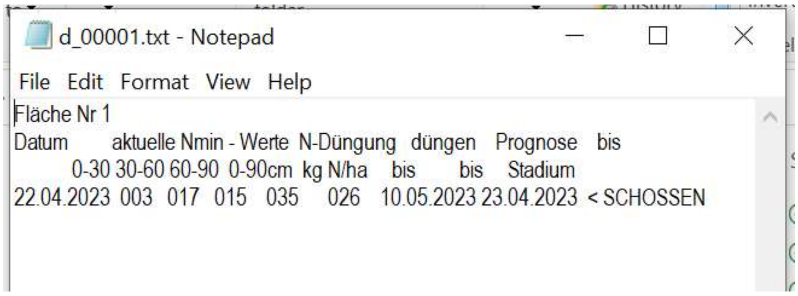
## The folder “RESULT”

Output file
The model creates three types of output files:
C : final output
V : daily output
Y : yearly output

One is a file which stores the annual sums at the selected annual output date. Please note that the first year of simulation might be incomplete. The other one usually stores the daily simulated values for each polygon separately using the name which is put together as „V“ + Site_ID + „.RES“.
The annual output file stores the annual sums polygon by polygon in a separate line. The structure of the annual output file is as follows:

```
POL_ID NOUT2000  SICK2000  NUpt2000 ETP2000 ETA2000 MIN2000 WGH2000 NMI2000  NOUT2001...
00001  0000.6    +004.7    000.0    017     017     0022.4  0240.5  0074.9   0069.5  ...
00002  0002.9    +015.3    000.0    017     017     0018.6  0204.5  0070.7   0102.1  ...
00003  0004.5    +022.2    000.0    017     017     0026.4  0223.0  0083.3   0088.4  ...
```

When generating recommendations, a „d” output file (txt) is produced for each polygon.




```
Fläche Nr 1
Datum      aktuelle Nmin - Werte  N-Düngung  düngen   Prognose   bis
        0-30 30-60 60-90 0-90cm kg N/ha    bis       bis     Stadium
22.04.2023 003  017  015   035    026   10.05.2023 23.04.2023 < SCHOSSEN
```

# Sulfonie: Sulfur simulation

## The folder “project”

Configuration file (“config”): this file has four new entries:

- Sulfonie (Section Management)(1 or 0) to activate the module,
- Saturated Solution Concentration (SKSAT) in Gramms S/Liter (Section Soil)
- Sulfur Solution Coefficient (KLOS) (Section Soil)
- S Deposition (Section Atmosphere)

And two new additional project files:

The *cropdata.txt* file has information on S content on different crops (for example, the mineral content in yield products, HEG; in above ground biomass, NEG; and in roots, Wura).
The *smin.txt* is used to input measures S mineral (SO4) values. Values here are mandatory (otherwise, it will be “0”).

## The folder “parameter”

The parameter file FERTILIZ.TXT has additional S columns: Stot, Sdir and Sfast
The crop parameter files (“PARAM_XX.XX”) have new S content parameters:
SGEFKT, SFunctExp, SCritContent, and WGSMAX (S content at end of phase)

# Turning knobs and interpreting results

**Atmosphere/global level**

CO2StomataInfluence (config.yml): 1 to 0 yield decreases

NDeposition (config.yml): increasing it decouples the effect of N fertilizer. It also increases yield.

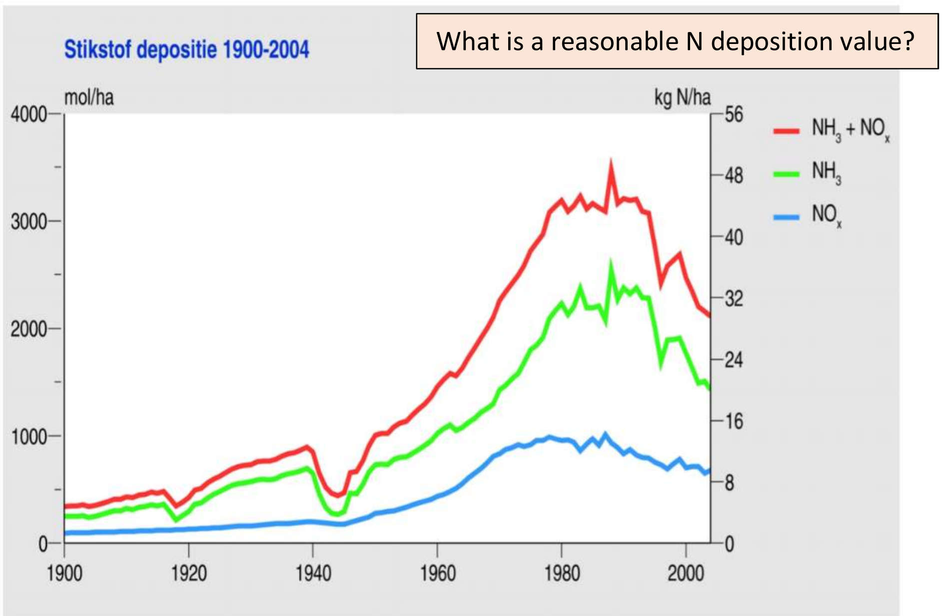
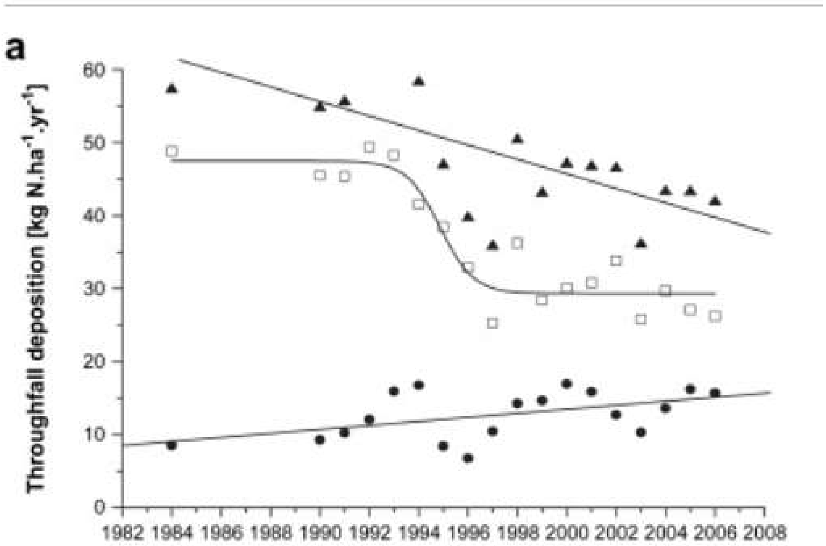



*Diagram 2.2 The average annual deposition of reduced and oxidized N in the Nederland in the period 1900–2004 reduced from historical emission sources (according to Noordijk 2007 from De Haan et al. 2008).*

Literature on N deposition values.
Triangles are total N (Boxman et al. 2008)

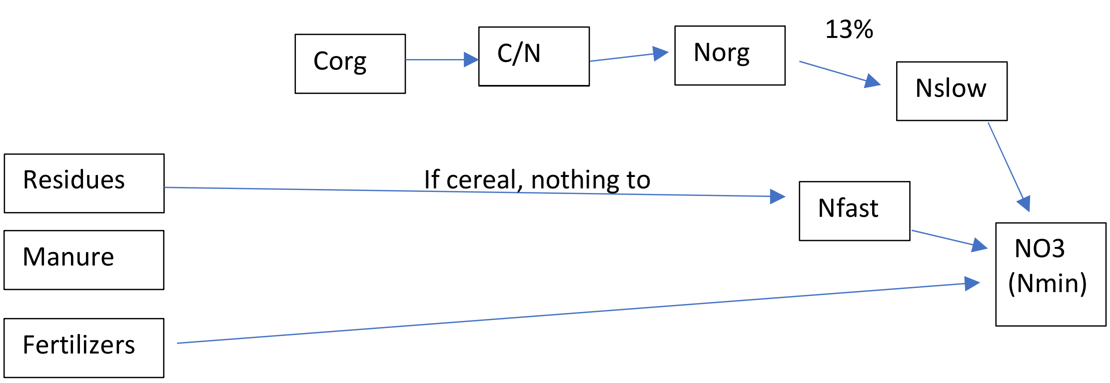



ETpot (config.yml) has a big impact on yield.

**N and Fertilization**

The effect of fertilization (difference between treatments) depends on the N supply from soil organic N mineralisation, which in turn depends on Corg, C/N (both at location/point level) and the size of the active pool (OrganicMatterMineralProportion, global level).

The input in the soil file should be Corg and the Norg is calculated by the C/N ratio, which should be obtained from dividing Corg/Norg from the soil measurements. Most of Norg (currently, 87%) is unavailable. The available portion (13%) goes completely into Nslow.



The default value for Nslow is 13% of Norg. The value can be adjusted in the Config.yml file in HERMES2Go (OrganicMatterMineralProportion: 0.13).

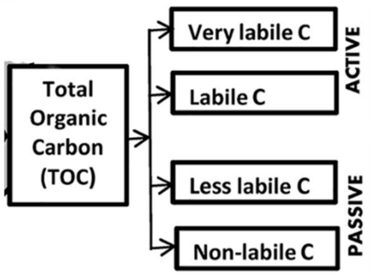
The other source of mineral N is $NH_4$.

OrganicMatterMineralProportion (config.yml) determines the availability of N, through defining the active C pool. This availability, indicated as Nmin, is the addition of Nslow and Nfast as decomposable fractions and kslow and kfast as reaction coefficients (day-1) depending on temperature (T) and soil moisture (Θ).

$$N_{\min}(t) = N_{slow} * (1 - e^{-k_{slow}(T,\Theta)*t}) + N_{fast} * (1 - e^{-k_{fast}(T,\Theta)*t})$$

The fast pool is completely calculated from the crop residues and would be zero in case of cereal straw. This pool, therefore, depends on the previous crop, its yield and the residue handling using the parameters defined in Crop_N.txt.

N pool sizes are derived from the percentage of "active" soil organic carbon (by default, 13%; Nuske 1983) and the composition of different crop residues and manure.




Typicaly OMMP is 0.13. Decreasing it reduces the N uptake and biomass. It also (at least in theory) makes the system more dependent on fertilization. OMMP can be as low as 0.04 or lower.

**Crop species/variety level**

Initial crop weight of roots and leaves (PARAM.CROP), an indirect way of reflecting plant (sowing) initial density, has also an impact on the final yield.

AMAX (PARAM.*CROP*): Max. CO2 assimilation rate: reducing it reduces N uptake and yield

Maximum effective rooting depth (PARAM.*CROP*) and Rd (SOIL_XXX.txt): decreasing it (by for example a dm) reduces the N uptake.

Specific Leaf Area in corn can be considered high if around 0.0020 and low if around 0.0010. Even in crop's development stage 1, SLA may have a big impact on yield.

To make a crop more tolerant to water stress in soil. Reduce the critical Eta/ETp (“drought stress below..” “Trockenstress ab ETA/ETP-Quotient von”), which can be defined for each stage separately.
In the model script is called DRYSWELL, and it is the threshold determining the effect of water stress on crop stage acceleration (WPROG). Higher values make the acceleration (WPROG) higher than 1, whereas lower values make WPROG = 1.

**Local/point level**

Ground water (SOIL.XXX or POLY.XXX files) has a big impact on yield.

Another way to make a crop more tolerant to water stress in soil, would be to increase rooting depth (maximum effective root depth in PARAM.CROP file).

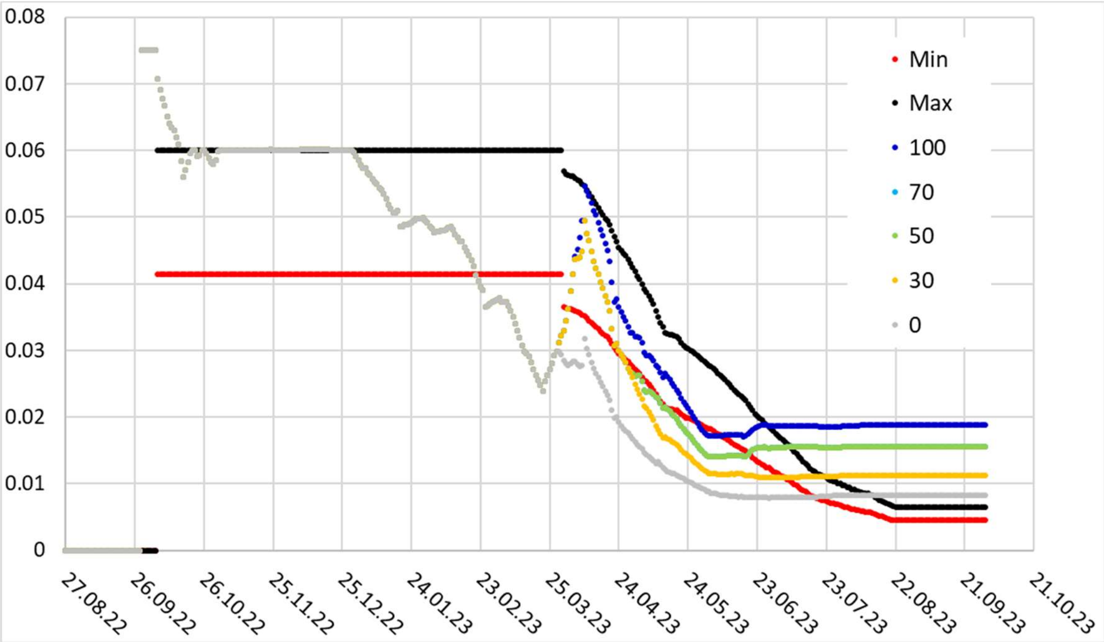
**Management level**

Irrlow has a big impact on the amount of automatic irrigation. The higher the percent, the less dry soil needs to be to trigger irrigation. As a result, the amount of irrigation can increase with increasing Irrlow without necessarily increasing the resulting yield.

Oxygen deficiency:
Water saturation in roots may cause biomass reduction due to oxygen deficiency. When the difference between Field Capacity and Pore Space is less than 8%, at times where the soil water content equals FC, the remaining air space can be too little to contain enough oxygen.

**Visualizing N deficit**

The amount of maximum and minimum N within which plants can optimally grow can be included in the daily output using the names GEHMAX and GEHMIN, respectively. GEHMAX and GEHMIN are calculated based on the formula chosen in the parameter “Crop N-content function no.” in the crop parameter (see The folder “parameter”). These quantities can be compared to amount of N uptake by the plants (see figure below), which corresponds with the model output called GEHOB.
For example, in the image below, maximum and minimum N curves are shown together with the N uptake by the crop when different fertilization amounts were applied (in kg/ha).




**Outputs**

In addition to above ground biomass N, about 10% is in roots (is this related to parameters/CROP_N.TXT?).

# Fertilizer recommendation

This function provides an amount and date of fertilization, and it is controlled by the item:
**- *virtual date for fertilizer prediction.***
in the configuration file.

The characters '------------' mean "no recommendation".
To produce a recommendation, a date (DDMMYYYY) is to be entered instead.
HERMES will calculate the N need from that date on and will make a recommendation of how much N to apply and provide the latest date for when to fertilize. The amount recommended will be input by the model and run a simulation until the date that appears in the reports.
HERMES creates two types of reports:
A console output:

```
SCHOSSEN
        ----------------------------------------------------------------
        |    N Bedarfsberechnung vom  30.03.2023 von Flaeche > 00031     |
        |            calculation of N demand  30.03.2023 of              |
        ----------------------------------------------------------------

                                              0 _ 30 cm: 028 kg N/ha
                                             30 _ 60 cm: 016 kg N/ha
                                             60 _ 90 cm: 010 kg N/ha
                                             -----------------------
                                              0 _ 90 cm: 055 kg N/ha

Es wurden bereits 045 kg N/ha durch die Pflanzen aufgenommen
*************************************************************************
|   Prognose des Stickstoffbedarfs bis zum Stadium <           SCHOSSEN  |
|   Voraussichtliches Eintrittsdatum  10.05.2023                          |
|   Empfohlene Duengung  051 kg N/ha   bis spaetestens 05.04.2023         |
*************************************************************************
Error Summary:
Number of errors: 0
Execution time:  125.3622ms
```

And a text report with a name starting with the characters "d_" and the plot name (RESULT folder).

```
d_00001.txt - Notepad
File  Edit  Format  View  Help
Fläche Nr 1
Datum       aktuelle Nmin - Werte  N-Düngung  düngen  Prognose  bis
            0-30 30-60 60-90 0-90cm  kg N/ha   bis     bis      Stadium
22.04.2023  003  017  015  035     026   10.05.2023 23.04.2023 < SCHOSSEN
```

In both cases, the calculation starting date, the N mineral uptake, the recommended amount of N, the date of recommendation, the date of application, the final date of simulation and the development phase are provided.

## Auto irrigation

To create an automatic harvest date, first check the parameters in the “automatic parameter” file (project/projectname / *automan.txt*), and if necessary, adjust for Irridv1, Irridv2, Irrlow, irrdep, irrmax (for more details see the “Automatic management file” in The folder “project” section). Also make sure that there is a row with the crop of interest.
To create an output of the irrigation applied, in the file *managementout_conf.yml* (The folder “project”) set the “irrigation: enabled:” to “true”. The Output will appear in the RESULT folder as a text file.
Check the batch file in case there is a setup for AutoIrrigation.
Then in the file config.yml (The folder “project”) set the AutoIrrigation to 1, and the ManagementEvents to 1.

## Auto harvest

Conditions for Auto Harvest is:

Use last date (“har2”) in automan.txt
**or** Temperature Sum > 60% of Temperature Sum of the last stage

> **and** Soil moisture in top layer is between Hmomin and Hmomax (soil should not be to wet for harvesting machines)
> **and** in the last 3 days it did not rain above a limit Rainav (crops should be relative dry)
> **and** at the day chosen for harvest it does not rain above the amount indicated in Rainact (it should not rain to much on the day of harvest)

To create an automatic harvest date, first check the parameters in the “automatic parameter” file (project/*projectname* / automan.txt), and if necessary, adjust for the second harvest time, minimum and maximum soil moisture, etc.
Then in the configuration file change “AutoHarvest” from 0 to 1.
Run HERMES.
The resulting date will appear in the “C-“ output files as “HarvDOY”.

## References


AG Bodenkunde (1994): Bodenkundliche Kartieranleitung. - 4. Auflage, Stuttgart. 392 S.

KERSEBAUM, K. C. (1995): Application of a simple management model to simulate water and nitrogen dynamics. Ecological Modelling 81, 145 - 156.

KERSEBAUM, K.C, C. Nendel, W. Mirschel, R. Manderscheid, H.-J. Weigel and K. O. Wenkel (2009): Testing different CO2 response algorithms against a FACE crop rotation experiment and application for climate change impact assessment on different sites in Germany. Idöjárás, 113: 79-88.

Richter D. (1995): Ergebnisse methodischer Untersuchungen zur Korrektur des systematischen Messfehlers des Hellmann-Niederschlagsmessers. Ber. Dtsch. Wetterd. 159: pp. 93 .

# Annex

Table 1: Soil texture classification according to German soil mapping guide („Bodenkundlichen Kartieranleitung”) 4. edition.

| German name | English name | Code | clay % | silt % | sand % |
|---|---|---|---|---|---|
| reiner Sand | pure sand | SS | 0-5 | 0-10 | 85-100 |
| schwach schluffiger Sand | siltic sand | SU2 | 0-5 | 10-25 | 70-90 |
| schwach lehmiger Sand | loamic sand | SL2 | 5-8 | 10-25 | 67-85 |
| mittel lehmiger Sand | loamy sand | SL3 | 8-12 | 10-40 | 48-82 |
| schwach toniger Sand | clayic sand | ST2 | 5-17 | 0-10 | 73-95 |
| mittel schluffiger Sand | silty sand | SU3 | 0-8 | 25-40 | 52-75 |
| stark schluffiger Sand | silt-sand | SU4 | 0-8 | 40-50 | 42-60 |
| schluffig-lehmiger Sand | silty-loamy sand | SLU | 8-17 | 40-50 | 33-52 |
| stark lehmiger Sand | loam-sand | SL4 | 12-17 | 10-40 | 43-78 |
| mittel toniger Sand | clayey sand | ST3 | 17-25 | 0-15 | 60-83 |
| schwach sandiger Lehm | sandic loam | LS2 | 17-25 | 40-50 | 25-43 |
| mittel sandiger Lehm | sandy loam | LS3 | 17-25 | 30-40 | 35-53 |
| stark sandiger Lehm | sand-loam | LS4 | 17-25 | 15-30 | 45-68 |
| schwach toniger Lehm | clayic loam | LT2 | 25-35 | 30-50 | 15-45 |
| sandig-toniger Lehm | sandy-clayey loam | LTS | 25-45 | 15-30 | 25-60 |
| stark sandiger Ton | sand-clay | TS4 | 25-35 | 0-15 | 50-75 |
| mittel sandiger Ton | sandy clay | TS3 | 35-45 | 0-15 | 40-65 |
| reiner Schluff | pure silt | UU | 0-8 | 80-100 | 0-20 |
| sandiger Schluff | sandy silt | US | 0-8 | 50-80 | 12-50 |
| schwach toniger Schluff | clayic silt | UT2 | 8-12 | 65-92 | 0-27 |
| mittel toniger Schluff | clayey silt | UT3 | 12-17 | 65-88 | 0-23 |
| sandig-lehmiger Schluff | sandy-loamy silt | ULS | 8-17 | 50-65 | 18-42 |
| stark toniger Schluff | clay-silt | UT4 | 17-25 | 65-83 | 0-18 |
| schluffiger Lehm | silty loam | LU | 17-30 | 50-65 | 5-33 |
| mittel toniger Lehm | clayey loam | LT3 | 35-45 | 30-50 | 5-35 |
| mittel schluffiger Ton | silty clay | TU3 | 30-45 | 50-65 | 0-20 |
| stark schluffiger Ton | silt-clay | TU4 | 25-35 | 65-75 | 0-10 |
| schwach sandiger Ton | sandic clay | TS2 | 45-65 | 0-15 | 20-55 |
| lehmiger Ton | loamy clay | TL | 45-65 | 15-30 | 5-40 |
| schwach schluffiger Ton | siltic clay | TU2 | 45-65 | 30-55 | 0-25 |
| reiner Ton | pure clay | TT | 65-100 | 0-35 | 0-35 |

Table 2: effective bulk density class according to German soil mapping guide („Bodenkundlichen Kartieranleitung") 4. edition. Ld= Lagerungsdichte

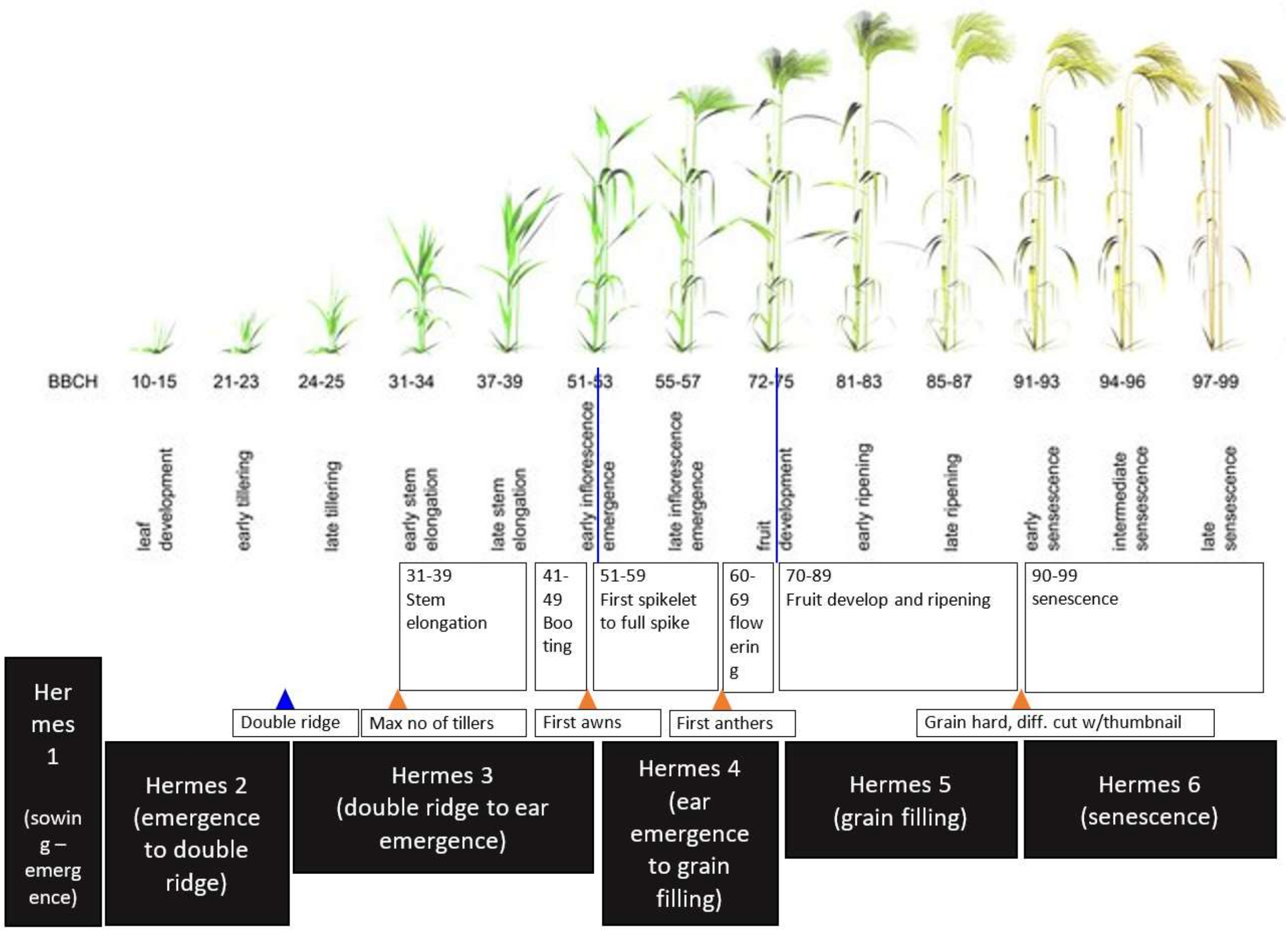
| Code | German name | English name | effective bulk density (g cm-3)<br>(dry bulk density + 0.009 · clay content [%]) |
|---|---|---|---|
| Ld1 | sehr gering | very low | < 1.4 |
| Ld2 | gering | low | 1.4 – 1.6 |
| Ld3 | mittel | medium | 1.6 – 1.8 |
| Ld4 | hoch | high | 1.8 – 2.0 |
| Ld5 | sehr hoch | very high | > 2.0 |

Table 3: crop list (needs to be updated)

| Code | German name | English name | Comment |
|---|---|---|---|
| K | Kartoffeln | Potatoes | Main crop |
| GR | Gras | Grass | |
| LUP | | Lupinus | |
| OA | Hafer | Oat | |
| OEL | Öllein | | |
| ORH | Ölrettich | Oilradish | Catch crop |
| PHA | Phacelia | Phacelia | |
| SE | Senf | Mustard | Catch crop |
| SG | Sommergerste | Spring barley | Main crop |
| SM | Silomais | Silage maize | Main crop |
| SO | Sorghum | | |
| S | | | |
| SOY | Soja | Soybean | |
| SW | Sommerweizen | Spring wheat | Main crop |
| WG | Wintergerste | Winter barley | Main crop |
| WR | Winterroggen | Winter rye | Main crop |
| WRA | Winterraps | Winter oil seed rape | |
| WW | Winterweizen | Winter wheat | Main crop |
| ZR | Zuckerrüben | Sugar beets | Main crop |

**Crop organs:**
A list of organs modeled in each species can be found in the corresponding PARAM.XX file (see: The folder "parameter") under the name of "compartiments". Organs are identified in the model algorithms by index numbers starting from 0 (which mostly corresponds to the root). In most cases there are four organs: root, leaves, stem and the fruit or storage organ.

Table 4:
Growth stages




31-39: Schossen 51-59: Ährenschieben 85-89: Reife

Table 5: PET

**Verfahren nach TURC-WENDLING (WENDLING ET AL. 1991)**

$$ET_{Pot-TuWe} = \frac{(R_{Gd} + 93 \cdot f_k) \cdot (T_m + 22)}{150 \cdot (T_m + 123)}$$

$R_{Gd}$: Tagessumme der Globalstrahlung [J/cm$^3$]
$f_k$: Küstenfaktor, im Küstenbereich von 50 km Breite als Mittelwert $f_k$=0,6, sonst $f_k$=1,0
$T_m$: Tagesmittel der Lufttemperatur [℃]

## Glossary of variables

| Name | Meaning | Units/Format | In file: | Notes |
|---|---|---|---|---|
| Feld_ID | Polygon/Field ID | | Crop | |
| crp | Crop ID | | Crop, automan | |
| Sowing | Sowing date | dd/mm/yyyy | Crop | |
| harvest | Harvest date | dd/mm/yyyy | Crop | |
| Rex | Residual management | | Crop | |
| Yld | Residual from previous crop | | Crop | |
| autorg | No Read/read values for automanagement file | 0/1 | Crop | Crop and config.yml/AutoIrrigation need to be in 1 or 0 together |
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| PESUM | N in crop | | output | |
| TRREL | Water sufficiency (a.k.a. water stress factor) | 0-1 | output | |

| | |
|---|---|
| Field_ID<br>N | Polygon/Field ID<br>N amount |
| Frt<br>date | Fertilizer ID<br>Date (dd/mm/yyyy) |

Init
Field_ID Polygon/Field ID
date Date (dd/mm/yyyy)
Nm03 Nmin. Layer 1
Nm36 Nmin. Layer 2
Nm69 Nmin. Layer 3
M 1 = % available water, 2 = % weight or 3 = % volume; unit water content
W0_3 Water Layer 1
W3_6 Water Layer 2
W6_9 Water Layer 3
Irr
Field_ID Polygon/Field ID
Ir mm Irrigation amount
N03 mg/l N concentration
date Irrigation date (dd/mm/yyyy)
Poly
Polyg Polygon ID
SID Soil ID
Field_ID Field ID
GH Groundwater high
GL Groundwater low
Ir Irrigation yes/no
comment