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## HERMES 2 Go

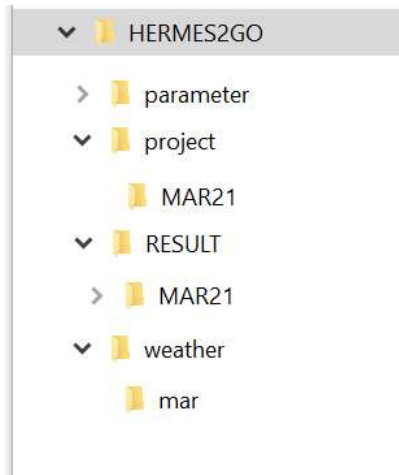
– Documentation and guidelines –  
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### Contents

HERMES Structure und Function .....	2
Field and plot identifiers .....	3
The folder “project” .....	4
Automatic management file .....	5
Configuration file .....	6
Crop file .....	11
Measurement file (a.k.a. Initial conditions file) .....	12
Fertilization file .....	14
Ground water file .....	14
Irrigation file .....	15
Polygon file .....	16
Soil file .....	17
Tillage file.....	20
Output files .....	20
Names of the output variables .....	22
The folder “parameter” .....	25
The folder “weather” .....	28
The folder “RESULT” .....	29
Sulfonie: Sulfur simulation .....	29
The folder “project” .....	29
The folder “parameter” .....	30
Turning knobs and interpreting results.....	30
Fertilizer recommendation.....	35
References.....	36
Annex .....	37
Glossary of variables .....	40

## HERMES Structure und Function

### Typical folder structure



The Hermes Batch mode allows to run multiple project setups concurrently.

-batch file xxx\_batch.txt - defines the batch file to be executed (see below).

Example of batch file:

```
1 project=MAR21·fcode=109_120·plotNr=00001·poligonID=Scen11Fert0- resultfolder=RESULT/MAR21
2 project=MAR21·fcode=109_120·plotNr=00005·poligonID=Scen11Fert1- resultfolder=RESULT/MAR21
3 project=MAR21·fcode=109_120·plotNr=00009·poligonID=Scen11Fert2- resultfolder=RESULT/MAR21
4 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:

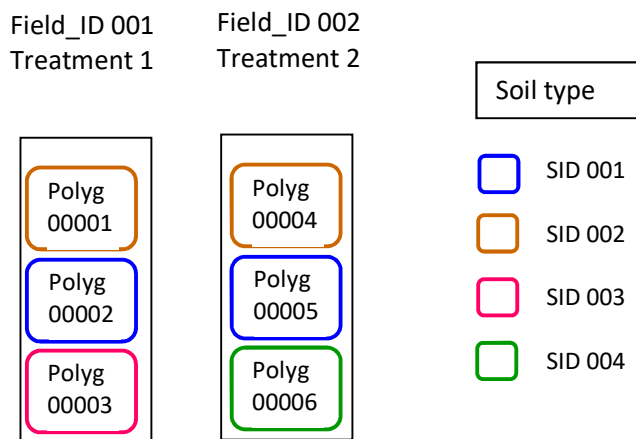
> **hermes2go.exe -module batch -logoutput -batch all\_DED\_batch.txt**

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

Additional Hermes resources: <https://github.com/zalf-rpm/Hermes2Go>

## Field and plot identifiers

A graphical depiction:



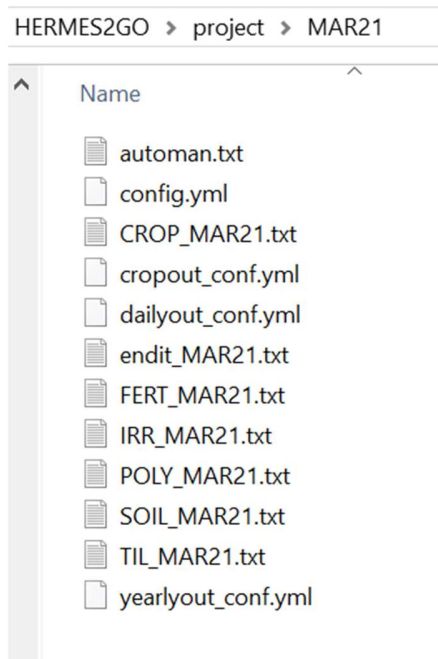
In the table below, each cell shows the variable and the file containing it. Variables in the same row are synonyms, and therefore contain the same information.

POLY_XXX.txt Variable: Polyg	Batch file Variable: PlotNr	Endit_XXX.txt Variable: Plot_ID		
POLY_XXX.txt Variable: SID	SOIL_XXX.txt Variable: SID			
POLY_XXX.txt Variable: Field_ID	CROP_XXX.txt Variable: Field_ID	FERT_XXX.txt Variable: Field_ID	IRR_XXX.txt Variable: Field_ID	TIL_XXX.txt Variable: Field_ID
Batch file Variable: PolygonID (experiment number)	Output file .csv Variable: polygonID			

At 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

```
crp Sow1 Sow2 har2 TSmin Smomin Smomax Hmomin Hmomax Rainav Rainact TACCU Tbase Irrdv1 Irrdv2
SM 0315 0515 1031 9.1 0.0 97.0 0.0 99.0 5.0 0.5 380 0 2 6
WR 0315 0515 1031 9.1 0.0 97.0 0.0 99.0 5.0 0.5 380 0 2 6
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)	
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 last 3 days for harvest	
Rainact	maximum rainfall 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 subtracted); 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
<i>FORMATS</i>		
Dateformat	DateDEshort: ddmmyy (default format, old) DateDElong: ddmmyyyy DateENshort: mmddyy DateENlong: mmddyyyy - short format "ddmmyy", e.g. 24.01.95 -> "ddmmyy" requires input as 240195 the century division year "DivideCentury" (see below) needs to be specified. - 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	<i>soilfile</i> = the model uses the values of GW for each soil ID (SID) in SOIL_XXX.txt. <i>polygonfile</i> =the model uses the GH/GL values por each polygon (Polyg) in POLY_XXX.txt <i>gwTimeSeries</i> = 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
<b>WEATHER</b>		
WeatherFile	'%s_ <b>mar-2021d2</b> .csv' . The part in bold corresponds to the second part of the weather file name (the first part, %s, is defined as <b>fcode</b> in the batch file)	In the file: <b>109_120_mar-2021d2.csv</b> , "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). 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	
<b>ATMOSPHERE</b>		
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
CO2StomatalInfluence	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]. This value is added to the N balance with its 365th part every day.	20-50
<b>TIME</b>		

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" See below
VirtualDateFertilizerPrediction	Write '-----' for no prediction	See "Fertilization recommendation" below
<i>GEOGRAPHY</i>		
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
<i>SOIL</i>		
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. 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
<i>MANAGEMENT</i>		
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	

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 ETO values. (confirm for HERMES2GO)

**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 gwld=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:

```
SCHOSEN
```

```
-----  
|      N Bedarfsberechnung vom 30.03.2023 von Flaechе > 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 <                SCHOSEN   |  
|   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	< SCHOSEN	

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 <b>automan</b> 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. 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:

	Plot ID	Date	Nm03	Nm36	Nm69	M	W0_3	W3_6	W6_9	NM9-12	NM12-15	NM15-20
1	00002	14042020	0089	0003	0004	3	0.104	0.079	0.111			
2	00002	02032021	0010	0003	0018	3	0.170	0.119	0.126			
3	00005	14042020	0012	0006	0002	3	0.089	0.095	0.114			
4	00005	02032021	0009	0002	0003	3	0.138	0.067	0.062			
5	00009	14042020	0018	0003	0003	3	0.117	0.140	0.139			
6	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_BOO21.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 <sup>-1</sup> ) 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 <b>parameter/FERTILIZ.TXT</b> )	KAS
date	DDMMYYYY	

**Ground water file** (project/projectname / GW\_XXX.txt)

1	SID, DATE, Level
2	023, 01082014, 39
3	023, 02082014, 40
4	023, 03082014, 36
5	023, 04082014, 29
6	023, 05082014, 29
7	023, 06082014, 28
8	023, 07082014, 26
9	023, 08082014, 25
10	023, 09082014, 25
11	023, 10082014, 25
12	023, 11082014, 25
13	023, 12082014, 25
14	023, 13082014, 25
15	023, 14082014, 25
16	023, 15082014, 25
17	023, 16082014, 25
18	023, 17082014, 25
19	023, 18082014, 25
20	023, 19082014, 25
21	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 (gwld) called “any” can be assigned to the corresponding soil ID (soilId) “075” as:

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

**Irrigation file** (project/projectname / IRR\_XXX.txt)

```

1 Field_ID Ir NO3 date
2          mm mg/l
3 001      10 00 12062020
4 001      12 00 25062020
5 001      08 00 26042021
6 001      10 00 14052021
7 002      10 00 12062020
8 002      12 00 25062020
9 002      08 00 26042021
10 002      10 00 14052021
11 003      10 00 12062020
12 003      12 00 25062020
13 003      08 00 26042021
14 003      10 00 14052021
15 004      10 00 12062020
16 004      12 00 25062020
17 004      08 00 26042021
18 004      10 00 14052021
19 end
20

```

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		

**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 FC and have an impact on the final yield. Value of 99 will render ground water inactive.	Important: the GH and GL values 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 <b>config</b> 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  $GH \neq GL$  and the model uses only one GW value, an average of the two values provided is calculated. If  $GH \neq GL$  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 be 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												
1	SU	.055	.055	.055	.055	.055	.055	.055	.05	.03	.02	
2		.015	.01	.0075	.005	.004	.003	.002	.001	.0	.0	
3	SU2	.055	.055	.055	.055	.055	.055	.055	.05	.03	.02	
4		.015	.01	.0075	.005	.004	.003	.002	.001	.0	.0	
5	SU3	.055	.055	.055	.055	.055	.05	.035	.02	.015	.008	
6		.005	.003	.002	.001	.0008	.0005	.0002	.0	.0	.0	
7	SU4	.055	.055	.055	.055	.055	.055	.055	.05	.03	.02	
8		.015	.01	.0075	.005	.004	.003	.002	.001	.0	.0	
9	SL2	.055	.055	.055	.055	.055	.045	.025	.015	.007	.004	
10		.002	.001	.0007	.0005	.0	.0	.0	.0	.0	.0	
11	SL3	.055	.055	.055	.055	.055	.05	.035	.02	.015	.008	
12		.005	.003	.002	.001	.0008	.0005	.0002	.0	.0	.0	
13	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)

```

1 SID·Corg·Tex·lb·B·St·C/N·C/S·Hy·Rd·NuHo·FC·WP·PS·S%·SI%·C%·····DraiT·····Drai%·GW·LBG·CRLF
2 011·0.60·SU2·03·2·00·10·00·00·00·12·04·····00·00·00·82·14·04·····20····00·20····CRLF
3 011·0.26·SU2·06·3·00·10·00·00·00·····00·00·00·81·15·05·····20····00······CRLF
4 011·0.08·SL2·09·3·00·12·00·00·00·····00·00·00·78·15·06·····20····00······CRLF
5 011·0.00·SL2·20·3·00·00·00·00·00·····00·00·00·00·00·00·····20····00······CRLF
6 012·0.67·SU2·03·2·00·10·00·00·00·12·04·····00·00·00·84·13·04·····20····00·20····CRLF
7 012·0.40·SU2·06·3·00·10·00·00·00·····00·00·00·83·12·04·····20····00······CRLF
8 012·0.24·SL2·09·3·00·08·00·00·00·····00·00·00·78·17·05·····20····00······CRLF
9 012·0.00·SL2·20·3·00·00·00·00·00·····00·00·00·00·00·00·····20····00······CRLF

```

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 C_org	Organic carbon in [%]	
Tex 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 LayerDepth	Lower boundary of the soil horizon in [dm] below soil surface	03 for 30 cm
B 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 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 RootDepth	Max. effective rooting depth (dm). The Max Effective Root Depth in a PARAM.XXX crop file is limited by Rd.	
NuHo NumberHorizon	Number of Horizons	
FC 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 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 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% Sand, Silt, Clay	Percent sand, silt and clay	

DraiT DrainageDepth	(DRAIDEP). Drain depth of drainage system (dm)	See below
Drai% Drainage%	(DRAIFAK) Drain factor (fraction of water that drains). Fractions are indicated as ".X". "00" indicates no drainage.	See below
GW 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)

	Field_ID	Ti	Typ	date
2		cm		
3	002	00	0	03012020
4	005	00	0	03012020
5	009	00	0	03012020
6	013	00	0	03012020
7	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		

### 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
1 FillCharacter: '-' CR13
2 SeperatorCharacter: ',' CR13
3 NaValue: n.a. CR13
4 DataColumns: CR13
5   - Format: '%s' CR13
6     VariableName: Crop CR13
7   - Format: '%d' CR13
8     VariableName: HarvestYear CR13
9   - Format: '%05.f' CR13
10    VariableName: Biomass CR13
11   - Format: '%1.f' CR13
12    VariableName: Yield CR13
13   - Format: '%1.1f' CR13
14    VariableName: LAImax CR13
15   - Format: '%s' CR13
16    VariableName: SowDate CR13
17   - Format: '%d' CR13
18    VariableName: SowDOY CR13
19   - Format: '%d' CR13
20    VariableName: EmergDOY CR13
21   - Format: '%d' CR13
22    VariableName: AnthDOY CR13
23   - Format: '%d' CR13
24    VariableName: MatDOY CR13
25   - Format: '%d' CR13
26    VariableName: HarvestDOY CR13
27   - Format: '%05.2f' CR13
28    VariableName: Irrig CR13
29 Headlines: CR13
30   - 1: CR13
31     ColumnName: Crop CR13
32     ColumnName: Year CR13
33     ColumnName: AG_Biomass CR13
34     ColumnName: Yield CR13
35     ColumnName: MaxLAI CR13

```

```

dailyout_conf.yml
1 FillCharacter: '-' CR13
2 SeperatorCharacter: ',' CR13
3 NaValue: n.a. CR13
4 DataColumns: CR13
5   - Format: '%s' CR13
6     DataAlignment: left CR13
7     Width: 10 CR13
8     VariableName: AKTUELL CR13
9   - Format: '%2.f' CR13
10    DataAlignment: left CR13
11    Width: 3 CR13
12    VariableName: INTWICK.Num CR13
13   - Format: '%05.f' CR13
14    DataAlignment: left CR13
15    Width: 5 CR13
16    VariableName: OBMAS CR13
17   - Format: '%05.1f' CR13
18    DataAlignment: left CR13
19    Width: 6 CR13
20    VariableName: HARVEST CR13
21   - Format: '%05.2f' CR13
22    DataAlignment: left CR13
23    Width: 5 CR13
24    VariableName: LAI CR13
25   - Format: '%04.f' CR13
26    DataAlignment: left CR13
27    Width: 4 CR13
28    VariableName: PHYLLO CR13
29   - Format: '%04.f' CR13
30    DataAlignment: left CR13
31    Width: 4 CR13
32    VariableName: C1 CR13
33    VarIndex1: 0 CR13
34   - Format: '%04.f' CR13

```

```

yearlyout_conf.yml
1 FillCharacter: '-' CR13
2 SeperatorCharacter: ',' CR13
3 NaValue: n.a. CR13
4 DataColumns: CR13
5   - Format: '%s' CR13
6     DataAlignment: left CR13
7     Width: 10 CR13
8     VariableName: AKTUELL CR13
9   - Format: '%s' CR13
10    DataAlignment: left CR13
11    Width: 21 CR13
12    VariableName: POLYD CR13
13   - Format: '%05.f' CR13
14    DataAlignment: left CR13
15    Width: 5 CR13
16    VariableName: OBMAS CR13
17 Headlines: CR13
18   - 1: CR13
19     ColumnName: date CR13
20     TextAlignment: left CR13
21     StartColumn: 1 CR13
22     EndColumn: 1 CR13
23     FillCharacter: '-' CR13
24     ColumnName: run_number CR13
25     TextAlignment: left CR13
26     StartColumn: 2 CR13
27     EndColumn: 2 CR13
28     FillCharacter: '-' CR13
29     ColumnName: abovegrDryM CR13
30     TextAlignment: right CR13
31     StartColumn: 3 CR13
32     EndColumn: 3 CR13
33     FillCharacter: '-' CR13
34     - 2: CR13
35     ColumnName: ---- CR13
36     TextAlignment: left CR13
37     StartColumn: 1 CR13
38     EndColumn: 1 CR13
39     FillCharacter: '-' CR13
40     ColumnName: 1 CR13

```

General depiction of the output files

About string formatting in go:

<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	My name	Index	Output type
	Crop			cropout
	HarvestYear			cropout
	Biomass			cropout
	Yield			cropout
	LAlmax			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 <sup>-2</sup> )	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	dailayout
Potential Evapotranspiration (cm)	VERDUNST		Cumulative	dailayout
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		

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”

### FERTILIZ.TXT

The three character short identifier.

Nfst: N fast fraction, Nslo: N slow fraction. The sum can be lower than 1 but not higher.

### HYPAR.TRU

Soil type and hydraulic parameters

1	BDA	--	FK	--	--nFK--	--	GPV--	--	Wumax--		
2	SS	19	17	16	12	10	10	41	36	32	5
3	SG	20	19	18	17	16	16	44	37	35	5
4	SM	14	11	11	9	8	7	42	36	31	6
5	SMG	15	11	11	11	8	7	41	35	31	6
6	SMF	19	16	14	15	13	11	42	36	31	6
7	SF	25	24	16	21	20	12	43	34	29	7
8	SU2	24	22	19	18	16	13	41	35	30	7
9	SU3	32	28	25	23	21	18	44	37	31	7
10	SU4	26	24	22	20	14	13	40	32	29	7
11	SL2	26	24	21	19	18	16	43	37	30	7
12	SLU	37	31	28	27	21	17	46	38	34	9
13	SL3	31	26	24	22	18	15	43	37	31	8
14	SL4	33	28	26	21	17	14	45	39	31	9
15	ST2	26	23	21	18	14	13	45	39	33	8
16	ST3	32	29	26	20	15	12	48	39	33	9
17	UU	40	37	34	28	26	22	46	39	37	11
18	US	39	33	29	27	25	19	46	38	36	10
19	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 <b>config</b> file. When PTF≠0, GPV needs to be provided as PS in the <b>SOIL</b> 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\_N.TXT

	KuA	K_S	TM	N_HEG	S_HEG	N_NEG	SNEG	SWur	Nfas	Sfas	
1	AB	2.0	0.86	04.10	00.20	00.80	0.05	0.10	0.67	1.00	Ackerbohne
2	CCM	1.3	0.60	01.00	00.06	01.00	0.09	0.10	0.20	0.30	Corn-Cob-Mix · Kolben + Körner
3	GR	0.0	0.17	00.45	00.04	00.00	0.00	0.10	0.00	0.00	Grünland · Schnittnutzung
4	GR	0.0	0.20	00.50	00.03	00.00	0.00	0.10	0.60	0.90	Gras · Futter · Grünmasse
5	H	1.2	0.86	01.50	00.12	00.50	0.09	0.10	0.00	0.00	Hafer
6	OA	1.2	0.86	01.50	00.12	00.50	0.09	0.10	0.00	0.00	Hafer
7	K	0.5	0.27	00.35	00.03	00.20	0.02	0.16	0.10	0.15	Kartoffeln
8	LUP	1.9	0.86	04.50	00.25	00.80	0.05	0.10	0.67	1.00	Lupinen
9	ORH	999	0.10	00.45	00.10	00.00	0.00	0.10	0.67	1.00	Plrettich
10	SE	999	0.10	00.45	00.05	00.00	0.00	0.10	0.60	0.90	Senf · Zwischenfrucht
11	SG	0.7	0.86	01.40	00.12	00.50	0.09	0.10	0.00	0.00	Sommergerste
12	SM	.15	0.28	00.38	00.03	00.38	0.00	0.10	0.25	0.30	Silomais
13											

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		
N_NEG	N- content by-product (straw, leaves) (kg/dt)	
SNEG		
NWur	N-percentage of total N in crops allocated to roots (kg/kg)	
SWur		
Nfas	Percentage of fast mineralisable N of Ntotal of residues (kg/kg)	
Sfas		

PARAM\_yyy.XX (yyy= variety nick name, XX= crop acronym)

## Crop parameters

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 [m<sup>2</sup>/m<sup>2</sup>/kg TM] is actually expressed in ha, not m<sup>2</sup>, 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.

## The folder “weather”

The weather file:

```
109_120_mar-2021d.csv X
D: > ZALF > HERMES2GO > weather > mar > 109_120_mar-2021d.csv
1 |iso-date,tmin,tavg,tmax,precip,globrad,wind,relhumid,vaporpress,dewpoint_temp,relhumid_tmin,relhumid_tmax
2 |-,C,C,C,mm,MJ m-2,m s-1,%,kPa,°C,% 0-100,% 0-100
3 |2020-01-01,-2.6,1.6,5.5,0,2.84256,4.3,72.4,999.9,999.9,999.9,999.9
4 |2020-01-02,-4.0,3.7,1.0,3.24864,4.7,1.6,999.9,999.9,999.9,999.9
5 |2020-01-03,-0.3,4.3,7.2,2.2,2.05632,9.7,75.9,999.9,999.9,999.9,999.9
6 |2020-01-04,1.4,4.5,8.0,8.1,2.7008,16.8,5.3,999.9,999.9,999.9,999.9
7 |2020-01-05,-1.5,1.3,3.9,0,1.6848,7.8,5.7,999.9,999.9,999.9,999.9
8 |2020-01-06,1.4,4.6,6.7,0,2.28096,6.2,90.5,999.9,999.9,999.9,999.9
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
10|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
11|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
12|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<sup>-2</sup>. Values are in the order of 1-20. If units are in J cm<sup>-2</sup> 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.



## Sulfonie: Sulfur simulation

### The folder “project”

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

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

Measurement file (Initial conditions file, “endit”): Start values in S initial file 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. For example, content in roots for each phase.

Do we need S content partitioned by organs?

## Turning knobs and interpreting results

### Atmosphere/global level

CO2StomatalInfluence (config.yml): 1 to 0 yield decreases

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

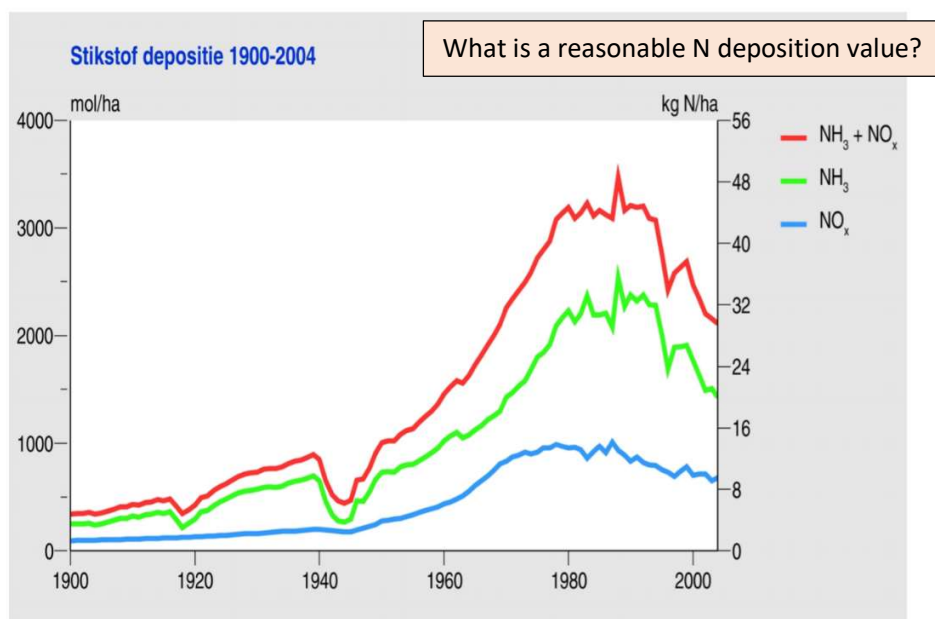
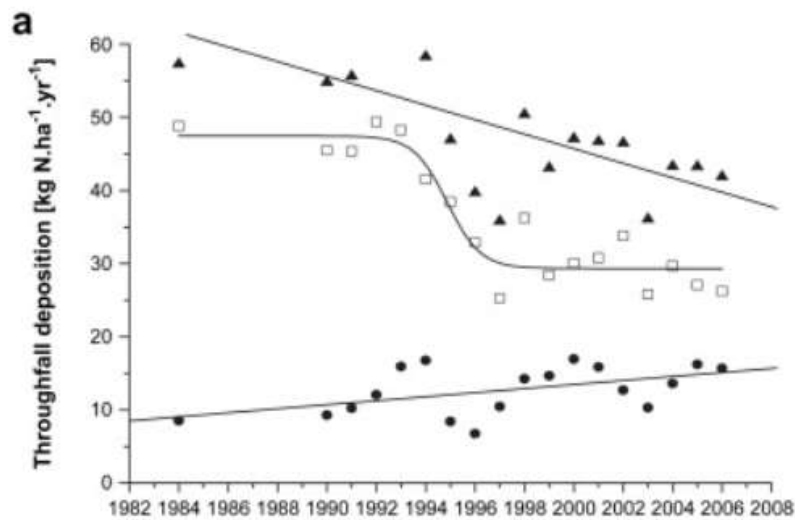


Diagram 2.2 The average annual deposition of reduced and oxidized N in the Nederland in the period 1900–2004 reduced from historical emission sources (according to Noordijk 2007 from De Haan et al. 2008).

Literature on N deposition values.

Triangles are total N (Boxman et al. 2008)

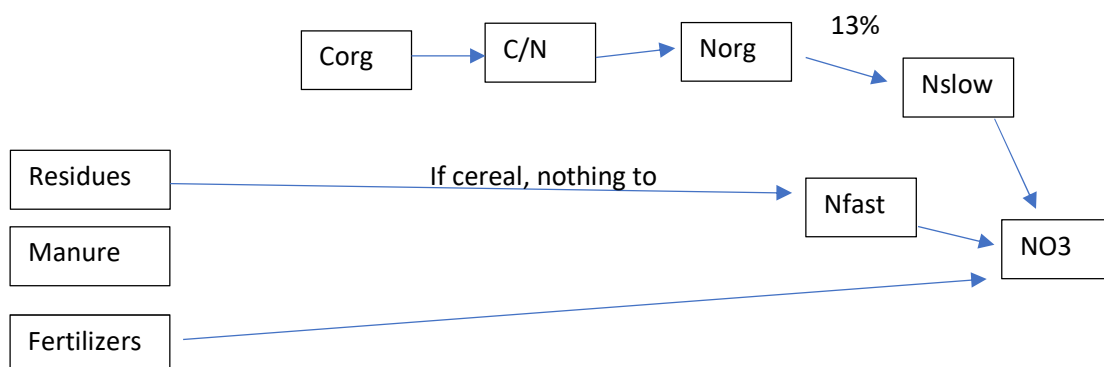


ETpot (config.yml) has a big impact on yield.

## 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.



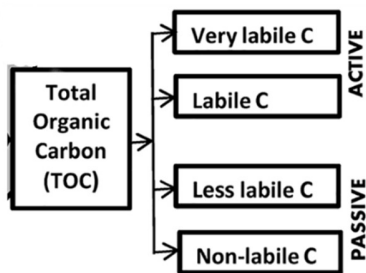
The default value for Nslow is 13% of Norg. The value can be adjusted in the Config.yml file in HERMES2Go (OrganicMatterMineralProportion: 0.13).

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<sup>-1</sup>) depending on temperature (T) and soil moisture (Θ).

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

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.



Typically 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. CO<sub>2</sub> 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.

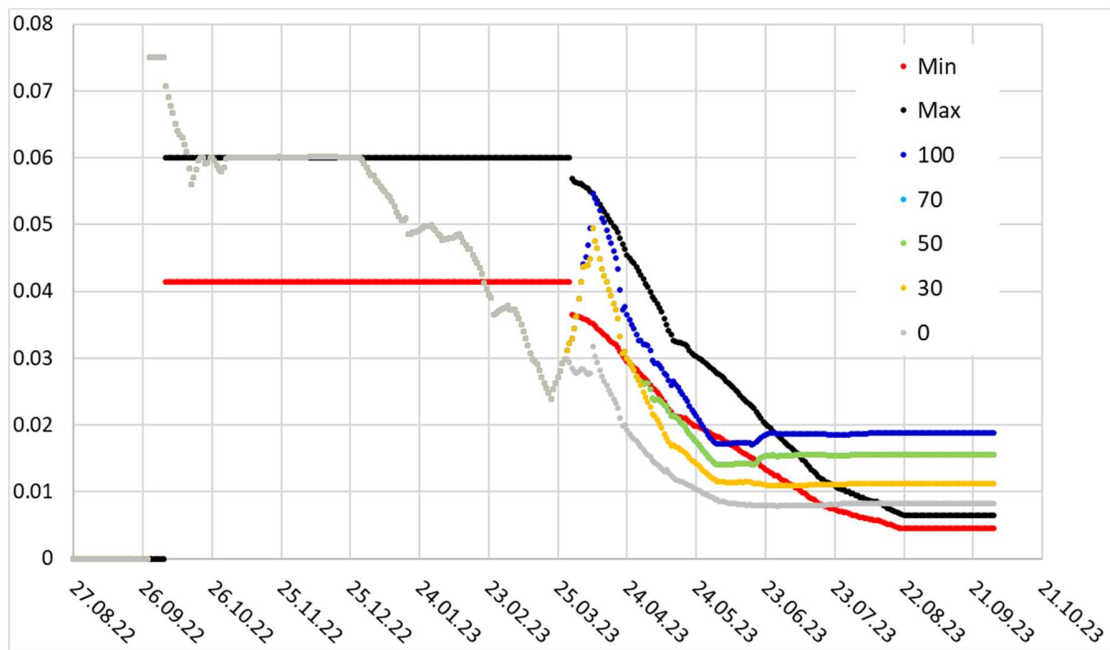
Oxygen deficiency:

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 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 characters "d\_" and the plot name (RESULT folder).



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.

## References

- AG Bodenkunde (1994): Bodenkundliche Kartieranleitung. - 4. Auflage, Stuttgart. 392 S.
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- KERSEBAUM, K.C, C. Nendel, W. Mirschel, R. Manderscheid, H.-J. Weigel and K. O. Wenkel (2009): Testing different CO<sub>2</sub> response algorithms against a FACE crop rotation experiment and application for climate change impact assessment on different sites in Germany. *Időjárás*, 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 <sup>-3</sup> ) (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

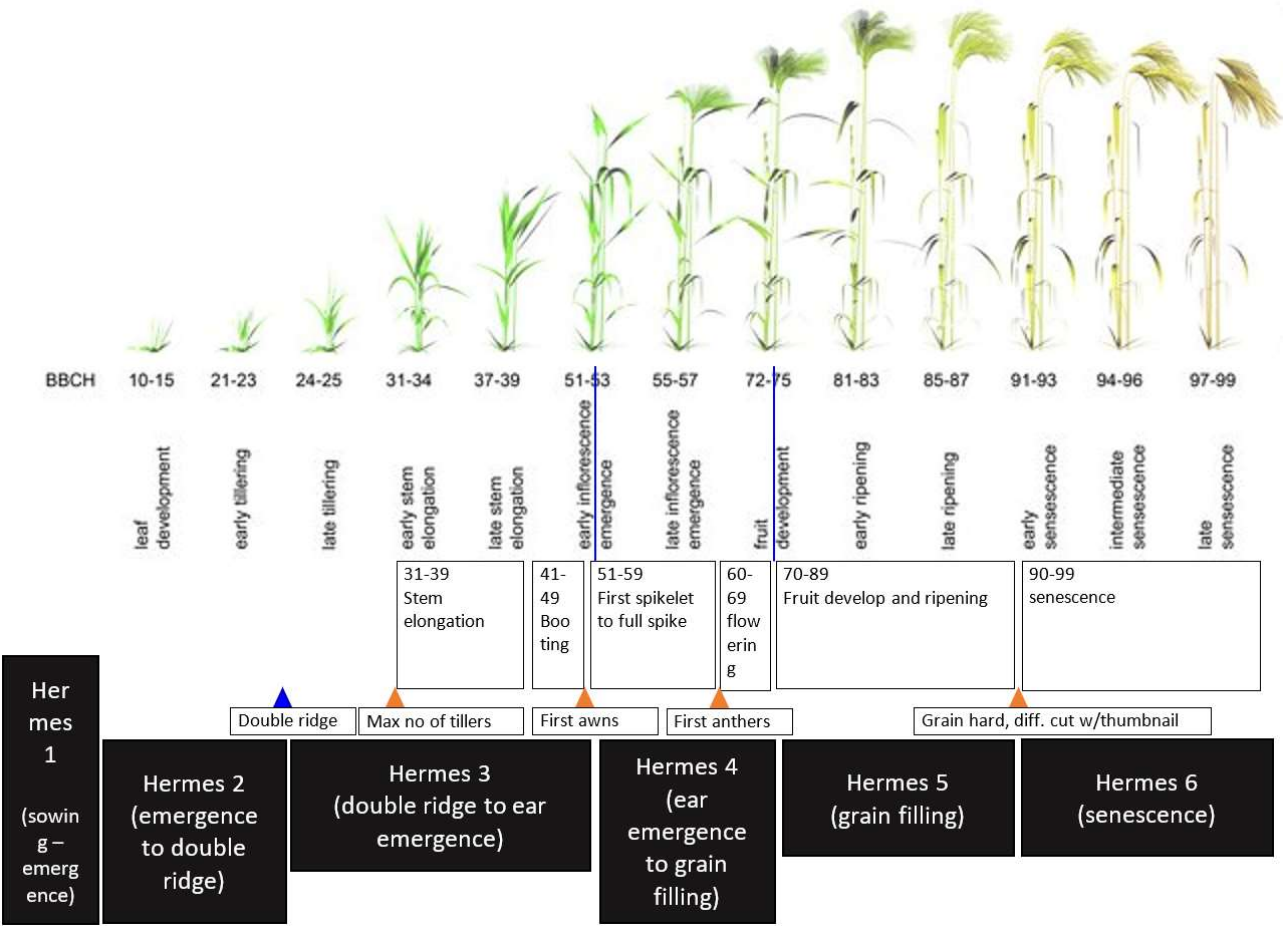
Table 3: crop list (needs to be updated)

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 “compartments”. 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

## 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
PESUM	N in crop		output	
TRREL	Water sufficiency (a.k.a. water stress factor)	0-1	output	

Field_ID	Polygon/Field ID
N	N amount
Frt	Fertilizer ID
date	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