Joint Research Centre

The European Commission’s in-house science service

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Serving society
Stimulating innovation
Supporting legislation

Modelling greenhouse gas fluxes from European agriculture soils in support of decision making.

Lily Paniagua PhD. Student

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Education

Costa Rica
BS Biology

Wageningen, Netherlands

MSc Geo-Information Science

PhD student WIMEK Environment and Climate research

Work Experience

Costa Rica
Project Assistant
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Office

Virginia, US
Interniship
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Spatial Lab

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Project

Munich,
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MSc Thesis
Research
Assistant
Remote Sensing
Data Center

Ispra, Italy
Trainee
PhD Student
MARS unit
Institute of
Environment and
Sustainabiliy

Problem

Decision

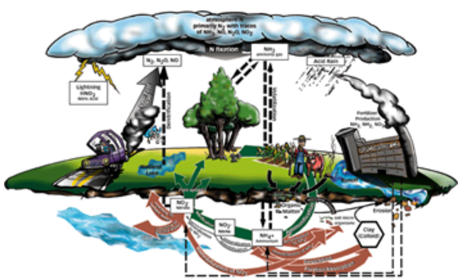
Modern Agriculture

Understand processes

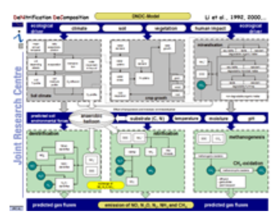
Simulations modelling

Meta Model

Contribution with my PhD



GHG emissions N_2O



Process base models DNDC-EUROPE

Climate is changing
Population is growing

Modern Agriculture

Food ?
Industry fiber ?

Intensification

Increase crop yield

Fertilizer
Reactive
Nitrogen

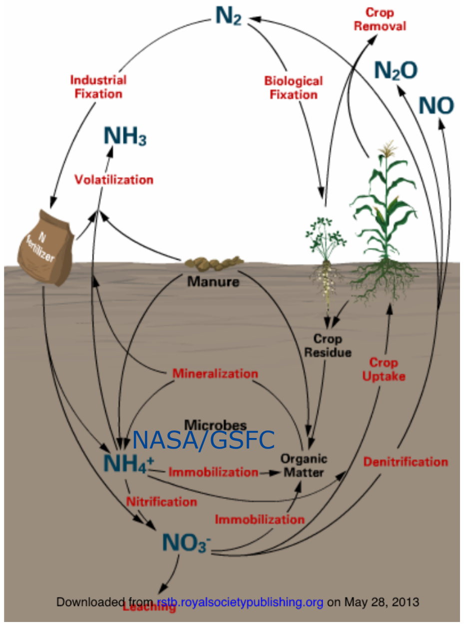
Without adequate Nitrogen management plan

N surplus in the environment

- Biodiversity loss
- soil acidification
- eutrophication of aquatic ecosystems health problems
- loss of drinking water sources
- Greenhouse gases
- N20,

N_2O

- GHG that contributes 300 times more to global warming than same mass emitted as CO_2
- Main anthropogenic source is agriculture
- Low cost opportunity sector for emission reduction
- Relevant in climate policies strategies



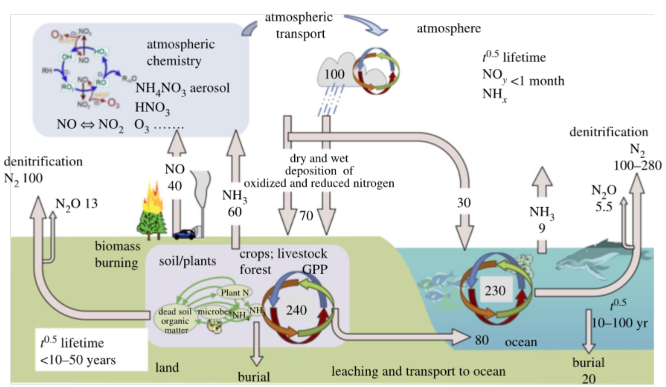


Figure 2. The processing and fluxes of reactive nitrogen in terrestrial and marine systems and in the atmosphere (Tg N yr^{-1}), showing the dominant forms of the N_r in the exchanges and the magnitude of the boundary fluxes, and approximate lifetimes, integrated over global scales.

TOP DOWN models

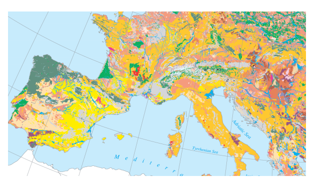
Atmosphere-monitoring stations

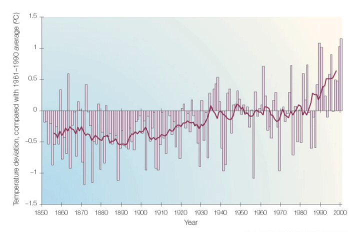
Inverse modelling technique

Global / continental scales

Nr Input → N_2O Output

Strong dependence on environmental factor with spatial and temporal variability





This variability is expensive and difficult to measure

DNDC
CENTURY

Larger regions

Extrapolate/ upscale

Large number of field samples

BOTTON-UP models

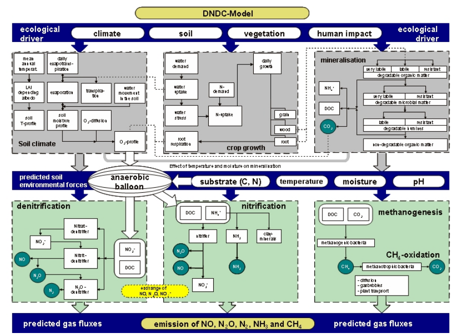
European Commission

Process based model	Components	Model flow	Data concerns

DNDC
DeNitrification-DeComposition

simulate carbon exchange,
nitrogen balances
trace gas emissions from agricultural

primary drivers
soil environmental
biogeochemical reactions.

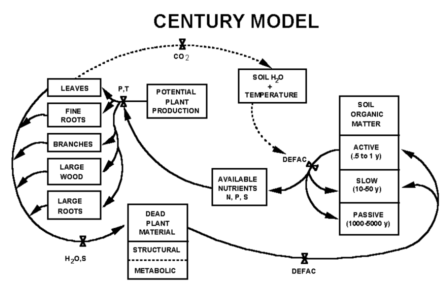


Limited real data available

CENTURY

simulates carbon and nutrient dynamics
for different ecosystems (agriculture)

SOC
water budget,
grassland, crop...
calculates the flow of carbon, nitrogen phosphorus and sulphur



Detailed national data sets but not consistent among member states

European Commission

The CAPRI modelling framework
“Common Agricultural Policy Regionalized Impact”

spatial assessment of agri-environmental indicators and linkages to bio-physical modelling

- Partial Equilibrium model for agriculture – “Bio-economic model” for policy impact assessment
- “multi-purpose”, allows to analyze
  - Market policies
  - Environmental policies
  - Changes in exogenous drivers
  - Environmental indicators
- Open source, maintained by European network including JRC institutes

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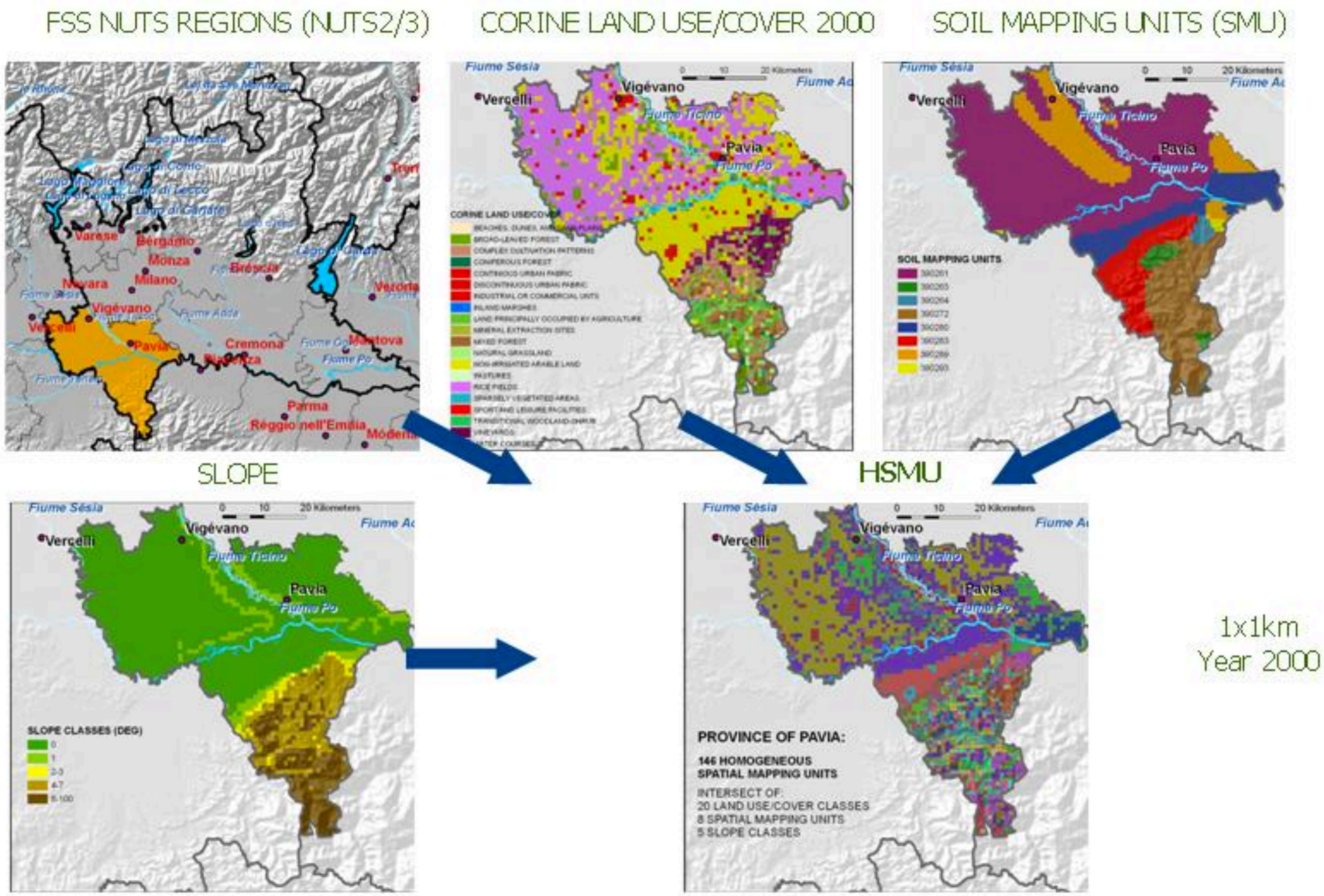

1x1km
Year 2000

HSMU

Homogeneous Spatial Mapping Units

- Land cover
- Administrative data
- Soil type
- Slope

Scale consistency with regional economic statistics

EUROPEAN COMMISSION
DIRECTORATE-GENERAL

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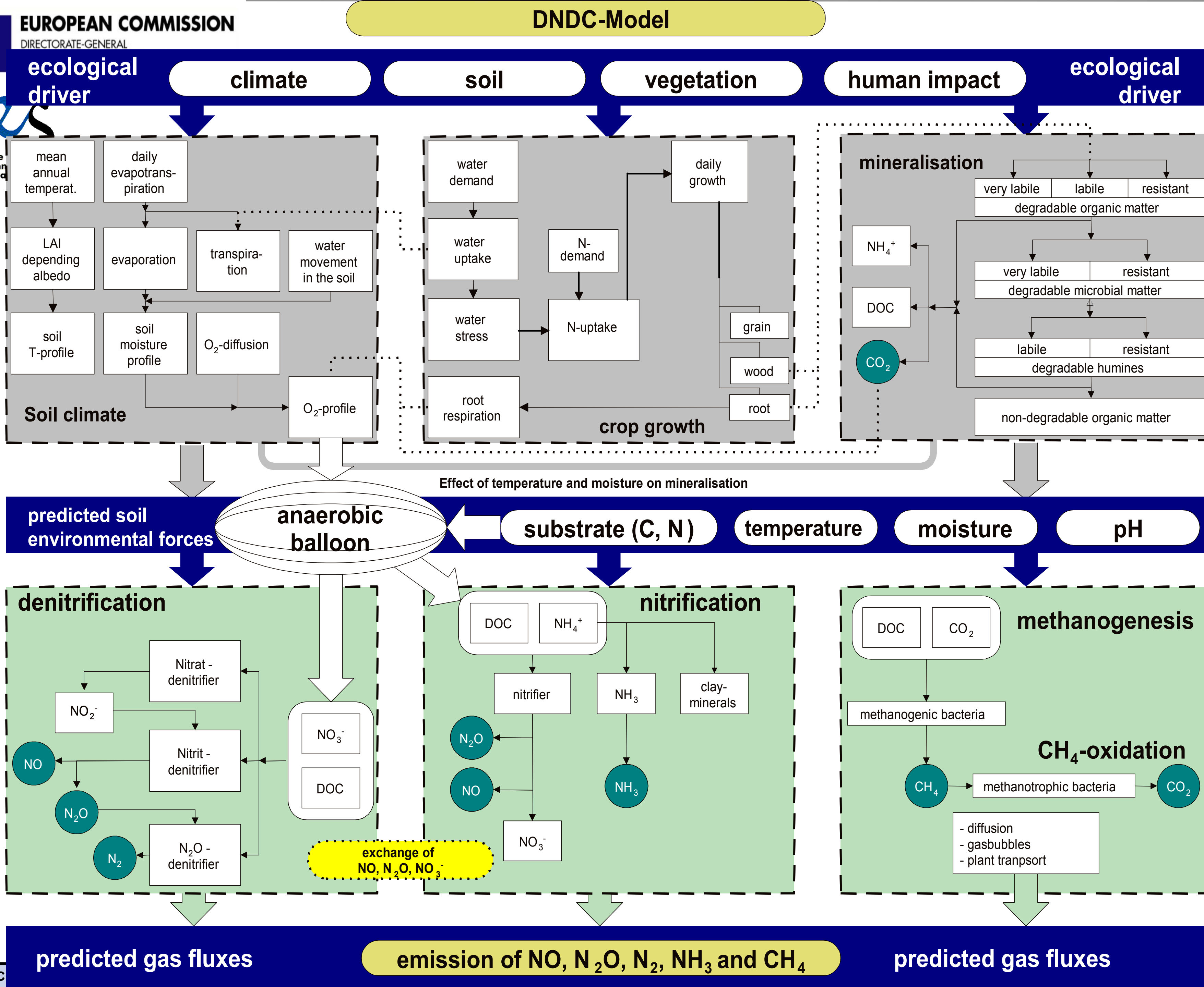
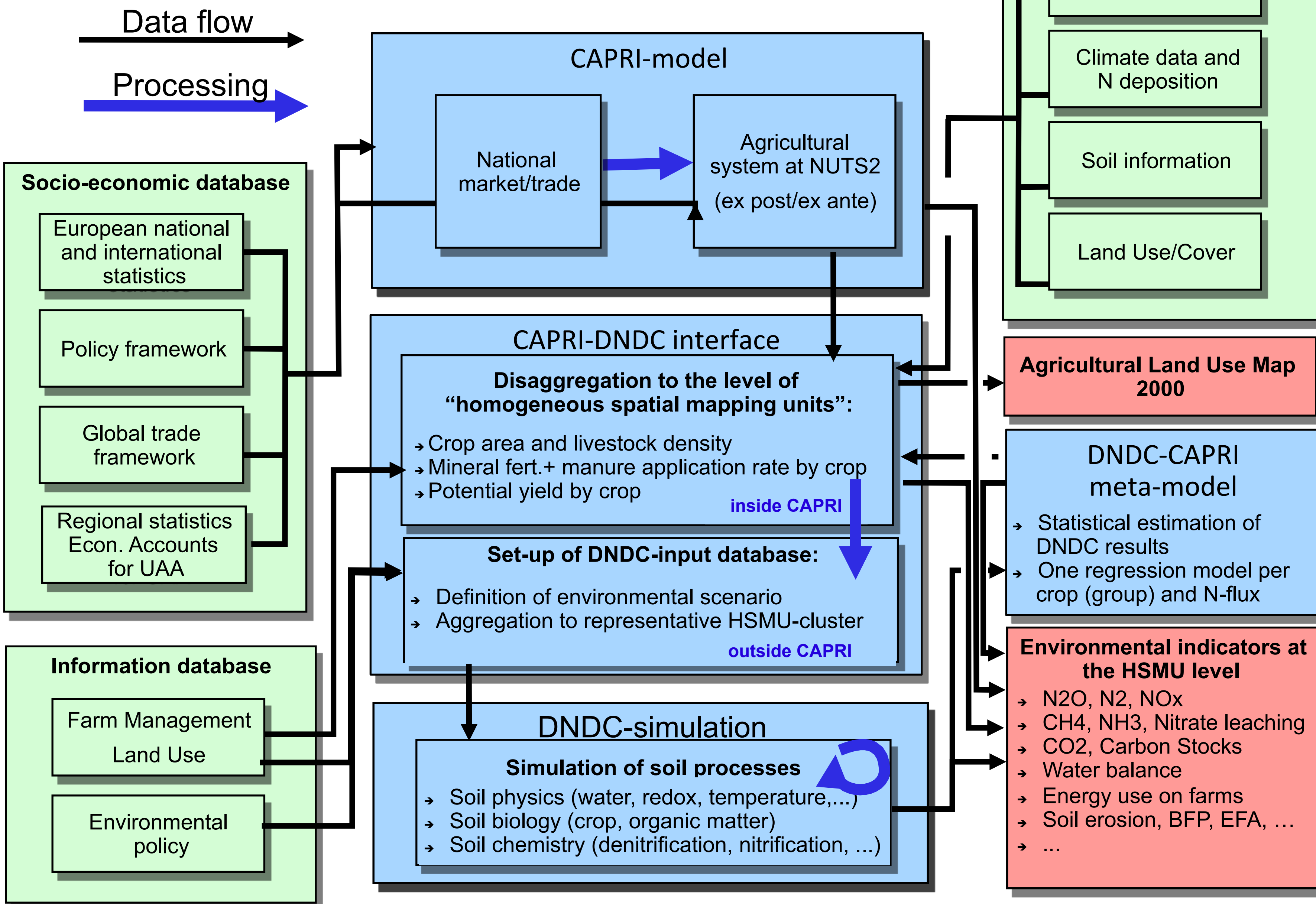


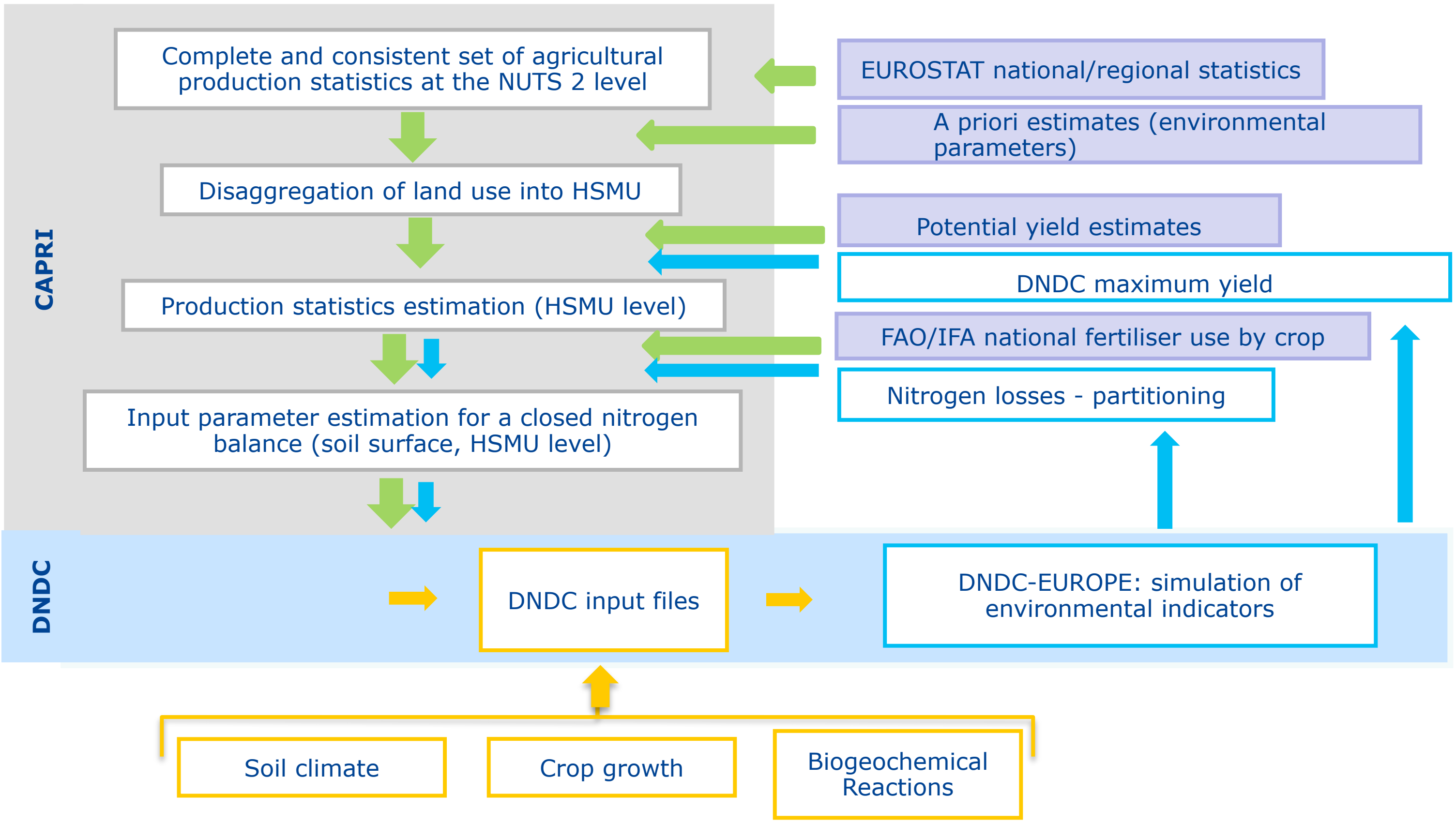
CAPRI / DNDC-EUROPE modelling framework



Leip et al, 2008, Biogeosciences

DNDC-EUROPE from plot to regional level by integrating

CAPRI database
environmental
land use
farm management



Process based model

- complex
- requires large ammounts of data,
- very high computation requirements
- limited flexibility for data exploration.
- no user-friendly

Decision making

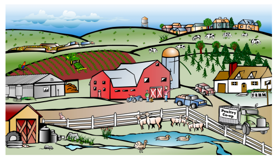
There is a need to create a flexible modelling framework:

- calculate GHG fluxes from European agricultural soils at
- different scales in a consistent way
- data variability is very high and expensive to measure
- should support data exploration,
- model integration and forecast emissions scenarios

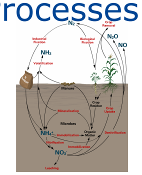
European Commission

REAL WORLD

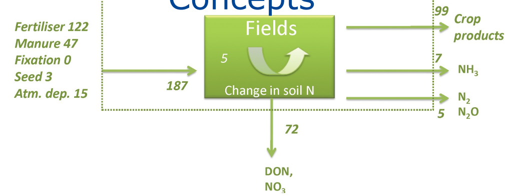
Drivers



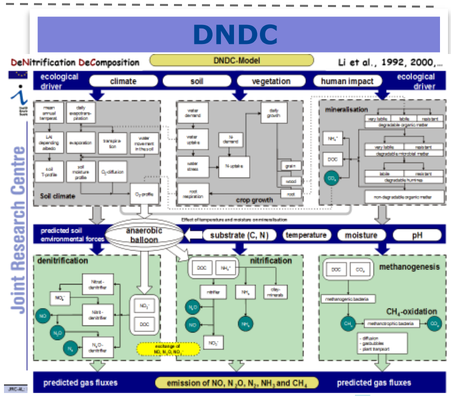
Processes



Concepts



COMPUTER SIMULATION



Parameterization

CAPRI database

Policy framework	Farm management
Global trade framework	Land Use/Cover
Geographic data	Statistics

CAPRI/ DNDC Interface

Detailed inputs outputs

Meta-model construction

META MODEL

CAPRI/ DNDC Meta-model

Only relevant input parameters defined by metamodel construction

Limits the system to significant statistical relationship reducing calculation time and parameter requirements

Joint Research Centre

Our aim is to model nutrient greenhouse gases fluxes at European scale in response to agriculture management practices for support of decision making by:

1. Constructing a **crop-generic meta-model**, improving input parameters by integrating different bio-physical models and validating it at different scales.

2. **Assessing input data** quality for upscaling local validated fluxes to European scale.

3. Exploring how to feed the meta-model through **N2O data assimilation**

4. **Forecasting N2O** emissions according to future climate scenarios and **crop and farm adaptations** to climate change.

DNDC-EUROPE

1-a. Meta-model construction

- Parameters ← Crop generic parameters
- Model integration ← BioMA framework: crop yield data

2. Assessing quality of input data

- For upscaling validated fluxes from local to regional scale

3. Data assimilation

- Integrate different N2O data sources through Data assimilation

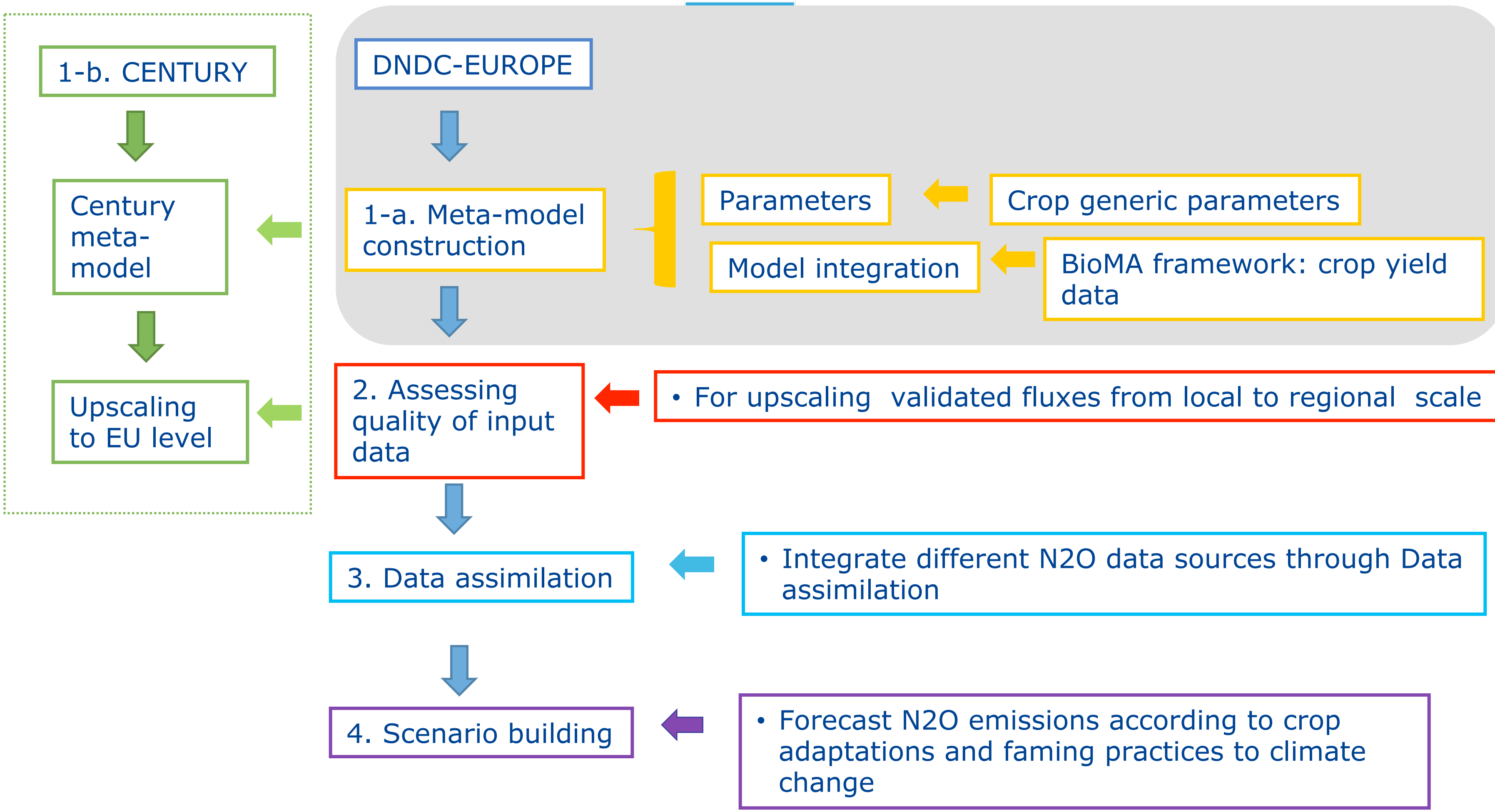
4. Scenario building

- Forecast N2O emissions according to crop adaptations and faming practices to climate change

1-b. CENTURY

Century meta-model

Upscaling to EU level


1-b. CENTURY
Century meta-model
Upscaling to EU level
DNDC-EUROPE
1-a. Meta-model construction
Parameters
Crop generic parameters
Model integration
BioMA framework: crop yield data
2. Assessing quality of input data
• For upscaling validated fluxes from local to regional scale
3. Data assimilation
• Integrate different N2O data sources through Data assimilation
4. Scenario building
• Forecast N2O emissions according to crop adaptations and faming practices to climate change

The 1st meta-model:
Britz and Leip 2009

The 2nd meta-model:

Follador et al. 2011
Villa-Vialaneix et al. 2011

- Since 2011 the meta-model has not been used

  No follow-up of the work of Follador yet
- Not in CAPRI: results not sufficient robust
  - Based on insufficient number of DNDC simulation
  - No variance in wheather
  - Instransparent

Leip A, Busto M and Winiwarter W 2011

Developing spatially stratified N2O emission factors for Europe. *Environ. Pollut.* 159 3223–32

→ Update of the DNDC data pool

- DNDC-EUROPE simulation on ca. 200,000 spatial units (HSMUs)
- Up to 3 crops/HSMU (simulation entity)

- Each simulation entity
  - 10 simulations with different meteorological years (1991-2000)

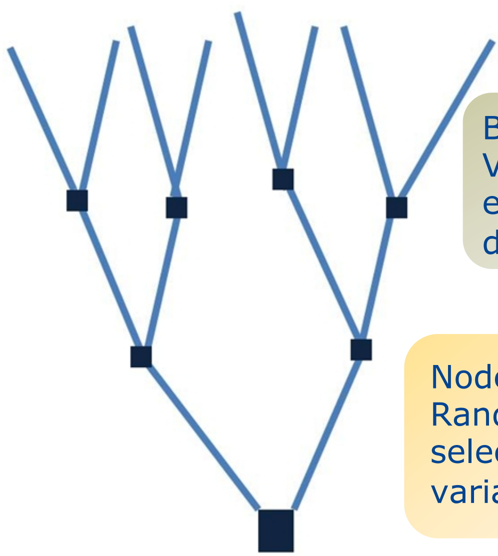
S00 Default: downscaled from CAPRI database

S01-S05 Response to mineral fertilizer application of Nmin set to 1.25, 1.1, 0.9, 0.75, 0.5 of default

S07-S12 Response to manure nitrogen application of Nman set to 1.25, 1.1, 0.9, 0.75, 0.5 of default

RANDOM Forest

Machine learning method
(Breiman, 2011)



Branches:
Variables split at each binary decision

Nodes:
Randomly selected variables

Builds trees from training set CART bagging
And then averages them.

Villa-Vilaneix et al. (2012)

Compared 8 metamodeling techniques, where RF:

Fast and easy to train

Large number of explanatory variables

Small available info

Handles missing data

Almost insensitive to hyper-parameters

Low computational time

European Commission

DNDC metamodels	Crop Generic Meta model
specific to one crop Wheat and rape seed (Britz & Leip, 2009) Corn (Villa-Vilaneix et al. 2012)	
One metamodel **One** crop	**One** metamodel ~**30** Crops (defined by CAPRI)
Input data: 11 Predictors	Input data: • All Predictors • 23 Crop Growth Parameters (defined by DNDC crop growth module)

- PLANT-TOTC total_potential_biomass_C (kg C/ha)
- GRAIN-FRAC portion_of_grain
- SHOOT-FRAC portion_of_shoot
- ROOTS-FRAC portion_of_root
- PLANT-CN plant_CN
- GRAIN-CN grain_CN_ratio
- ROOTS-CN root_CN_ratio
- SHOOT-CN shoot_CN_ratio
- PLANT-WATER water_requirement (cm water/g dry matter of grain)
- PLANT-L_MAX max_LAI
- PLANT-H_MAX max_height
- PLANT-TDD TDD_10
- PLANT-N_FIX N_fixation
- PLANT-L_EFF initial efficiency of use of absorbed light (kgCO2/ha/h)/(J/m2/s)
- PLANT-PHOTO maximum rate of leaf photosynthesis (kg CO2/ha/h)
- ROOTS-D_VEG rate constant of crop development in vegetative stage (1/d)
- ROOTS-D_REP rate constant of crop development in reproductive phase (1/d)
- PLANT-ECONO economic component/storage organic by weight
- SHOOT-LEAF specific leaf weight constant (kg dm/ha)
- SHOOT-STEM specific stem weight (kg dm/ha)
- PLANT-CO2 ratio of internal/external CO2 concentrations
- ROOTS-DEPTH maximum root depth for crop (m)
- ROOTS-INCRE increase rate of root depth (m/day)

DNDC crop codes

DNDC crop
0 Fallow
1 Corn
2 Winter_wheat
3 Soybean
4 Legume_hay
5 Non_legume_hay
6 Spring_wheat
7 Sugarcane
8 Barley
9 Oats
10 Alfalfa
11 Grassland
12 Perennial_grass

13 Sorghum
14 Cotton
15 Rye
16 Vegetables
17 New_crop
18 Potato
19 Beet
20 Paddy_rice
21 Banana
22 Celery
23 Peanut
24 Upland_rice
25 Rapeseed

26 Tobacco
27 Millet
28 Sunflower
29 Beans
30 DW_rice
31 Onion
32 New_crop
33 Strawberry
34 Lettuce
35 Artichoke
36 Nursery_flowers
37 Brussels_sprout
38 Berries
39 Truck_crops
40 Fruit_trees

41 Citrus
42 Grapes
43 Silage_corn
44 Hops
45 Tomato
46 Rainfed_rice
47 Mixed_cover_crop
48 Safflower
49 Flax

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DNDC_GIS_1.txt

Spatial and soil information

DNDC_GIS_1.txt

```
/*=========================================================================================

                                    EXAMPLE-FILE WITH HEADER --> THIS PART MUST BE REMOVE

Purpose: This file is the first of three GIS-files required to run DNDC-EUROPE.
         The name must be ${scenario}_${region}_1.txt
Content: In this file, all information at the level of the spatial unit on which DNDC-EUROPE is run is compiled
                                                 =========================
         - name of unit (HSMU), name of region (REGION), and name of country (COUNTRY) the unit belong to
         - the centre of the spatial unit is characterized by longitude (LON) and latitude (LAT)
         - index for the set of weather data (METEO). name of the meteo-dataset must be given in the setup.txt file
         - number of crop-rotations that are simulated in the spatial unit (NROT)
           and additional information on each rotation is given in the last columns of this file:
           - number of years in rotation (RY) and
           - code of the management in each year (CODE).
           Note that this part has a flexible number of columns. ${NROT} groups containing one value for RY and ${RY} number of CODE.
         - Soil characterization:
           - bulk density (BD, g/cm3),
           - soil organic carbon content (SOC, fraction),
           - clay fraction (CLAY)]
           - pH (PH)
         - Nitrogen concentration in precipitation (NPRE, mg/L)

                                                                                                                                            (example for first row wi
                                                                                                                                            0808 means that barley is
                                                                                                                                            However, also rotation
HSMU      METEO  NROT COUNTRY                 REGION                            LON    LAT    BD      SOC       CLAY      PH        NPRE  RY CODE RY CODE RY CODE
=======================================================================================================================================================*/
S00H47     47     3   Austria                 AT11_Burgenland                   16.4   47.1   1.33   0.04497    0.265     7.175     0.862 1 6 1 15 1 0808
S00H48     48     3   Austria                 AT11_Burgenland                   16.4   47.4   1.37   0.05695    0.248     6.824     0.877 1 6 1 15 1 0808
S00H49     49     2   Austria                 AT11_Burgenland                   16.6   47.8   1.27   0.04787    0.265     6.590     0.862 1 6 1 0808
S00H50     50     3   Austria                 AT11_Burgenland                   16.3   47.5   1.19   0.07851    0.221     6.601     1.013 1 6 1 0808 1 1
S00H51     51     3   Austria                 AT11_Burgenland                   16.3   47.3   1.28   0.01233    0.265     8.390     1.311 1 6 1 15 1 0808
S00H52     52     3   Austria                 AT11_Burgenland                   16.6   47.6   1.45   0.00970    0.265     8.390     1.311 1 6 1 15 1 0808
S00H53     53     3   Austria                 AT11_Burgenland                   16.6   47.5   1.45   0.01023    0.265     8.390     1.293 1 6 1 15 1 0808
S00H54     54     3   Austria                 AT11_Burgenland                   16.4   47.6   1.42   0.01041    0.265     8.390     1.311 1 6 1 15 1 0808
S00H55     55     3   Austria                 AT11_Burgenland                   16.3   47.7   1.40   0.01080    0.265     8.390     1.311 1 6 1 15 1 0808
```

Farm management information

DNDC_GIS_1.txt | DNDC_GIS_2.txt | DNDC_GIS_3.txt

```
/*==========================================================================================

                                   EXAMPLE-FILE WITH HEADER --> THIS PART MUST BE REMOVED IF THIS FILE IS TO BE

Purpose: This file is the second of three GIS-files required to run DNDC-EUROPE.
         The name must be ${scenario}_${region}_2.txt
Content: In this file, all information at the level of a rotation-year (one year) in a spatial unit on which DN
                                              ====================================================
         One row in this file represents one farming year.

           !!! NOTE that for each spatial unit there are as many rows (= rotations-years) as
               the sum of ${RY} over all ${NROT} rotations in a spatial unit as indicated in the GIS-1 file !!!

         - name of unit (HSMU), number of crops in the current rotation-year (NCROP)
         - for each crop the following information is given: DNDC Crop-code (CODE), crop short name (CROP), a dummy number which is not used any longer in DNDC (used to be
         - number of tillage operations (NTILL). for each tillage operation the following information is required: date in julian days (TILLD), tillage method (tillage dept
         - number of events of mineral fertilizer application (NMIN): date in julian days (MIND), application rate in kg N/ha (MINRATE)
         - number of events of manure application (NMAN) NOTE!! - for some crops (e.g. beet) leaves left on the field are simulated as "manure input" with defined C/N ratio
           - date in julian days (MAND), application rate as carbon in kg C/ha (MANRATE), C/N ratio of manure (MANCN)
         - irrigation: fraction of water deficit compensated by irrigation [0-1] (IRRI)
         - number of flooding events (FLOOD) with julian date for each
         - number of cutting events  (CUTT)
         - number of grazing events (GRAZ) !!! NOTE DNDC-EUROPE has not yet been tested with cutting and grazing option and will probably NOT work.
Please contact adrian.leip@jrc.ec.europa.eu


HSMU          NCROP  CODE CROP   DUMMY SW   SD HD   CR   FLAG ------ repetition in case there ---  NTILL-TILLM  NMIN  MINRATE                     NMAN        MANRATE
                                                              ------    is a second crop)   -----     TILLD       MIND                              MAND          MANCN
=============================================================================================================================================================================
S00H47            1    6 S_SW    999999 0   72 221 0.2 999                                       1  70 3    1  72 121.3                      1  72       1.5 10.4
S00H47            2   15 RYE     999999 1 240 150 0.2 111  15 RYE     999999 2 240 150 0.2 999   1 238 3    1 240  25.5                      1 240       5.7 10.4
S00H47            2    8 BARL    999999 1 236  82 0.2 111   8 BARL    999999 2 236  82 0.2 999   1 234 3    1 266 102.7                      1 266       0.9 10.4
S00H48            1    6 S_SW    999999 0   72 221 0.2 999                                       1  70 3    1  72 115.8                      1  72       2.4 10.4
S00H48            2   15 RYE     999999 1 240 150 0.2 111  15 RYE     999999 2 240 150 0.2 999   1 238 3    1 240  22.4                      1 240      11.4 10.4
S00H48            2    8 BARL    999999 1 236  82 0.2 111   8 BARL    999999 2 236  82 0.2 999   1 234 3    1 266  98.7                      1 266       1.4 10.4
S00H49            1    6 S_SW    999999 0   72 221 0.2 999                                       1  70 3    1  72 106.0                      1  72       4.7 10.4
S00H49            2    8 BARL    999999 1 236  82 0.2 111   8 BARL    999999 2 236  82 0.2 999   1 234 3    1 266  81.6                      1 266       2.9 10.4
S00H50            1    6 S_SW    999999 0   72 221 0.2 999                                       1  70 3    1  72 109.5                      1  72       3.6 10.4
S00H50            2    8 BARL    999999 1 236  82 0.2 111   8 BARL    999999 2 236  82 0.2 999   1 234 3    1 266  91.8                      1 266       1.9 10.4
S00H50            1    1 CORN    999999 0 129 308 0.1 999                                       1 127 3    1 129 140.2                      2 129      27.5 10.4 309    5:
S00H51            1    6 S_SW    999999 0   72 221 0.2 999                                       1  70 3    1  72 107.2                      1  72       0.6 10.4
```

DNDC_GIS_1.txt | DNDC_GIS_2.txt | DNDC_GIS_3.txt

Crop parameter

```
/*=========================================================================================

                              EXAMPLE-FILE WITH HEADER --> THIS PART MUST BE REMOVED IF THIS FILE IS TO BE USE

Purpose: This file is the third of three GIS-files required to run DNDC-EUROPE.
         The name must be ${scenario}_${region}_3.txt
Content: In this file, all information at the level of individual crops in a crop rotation in a spatial unit on whic
                                              ==============================================================
         One row in this file represents one crop.

           !!! NOTE that for each spatial unit there are as many rows (= rotation-crops) as there are crops in a rot
               The file is read sequentially, so if a crop occurs twice at different places in the rotation, it must be described twice.

         - name of unit (HSMU)
         - flag whether there is more crop-information (111) or not (999) (FLAG)
         - crop-identification with DNDC Crop-code (CODE), short name (CROP) and long name (CROPL)
         - Parameterization of the crop in DNDC:
           (for a description of the parameters, please refer to the DNDC manual or papers).
             - PLANT-TOTC     total_potential_biomass_C (kg C/ha)
             - GRAIN-FRAC     portion_of_grain
             - SHOOT-FRAC     portion_of_shoot
             - ROOTS-FRAC     portion_of_root
             - PLANT-CN       plant_CN
             - GRAIN-CN       grain_CN_ratio
             - ROOTS-CN       root_CN_ratio
             - SHOOT-CN       shoot_CN_ratio
             - PLANT-WATER    water_requirement (cm water/g dry matter of grain)
             - PLANT-L_MAX    max_LAI
             - PLANT-H_MAX    max_height
             - PLANT-TDD      TDD_10
             - PLANT-N_FIX    N_fixation
             - PLANT-L_EFF    initial efficiency of use of absorbed light (kgCO2/ha/h)/(J/m2/s)
             - PLANT-PHOTO    maximum rate of leaf photosynthesis (kg CO2/ha/h)
             - ROOTS-D_VEG    rate constant of crop development in vegetative stage (1/d)
             - ROOTS-D_REP    rate constant of crop development in reproductive phase (1/d)
             - PLANT-ECONO    economic component/storage organic by weight
             - SHOOT-LEAF     specific leaf weight constant (kg dm/ha)
             - SHOOT-STEM     specific stem weight (kg dm/ha)
             - PLANT-CO2      ratio of internal/external CO2 concentrations
             - ROOTS-DEPTH    maximum root depth for crop (m)
             - ROOTS-INCRE    increase rate of root depth (m/day)

HSMU          SW CODE CROP CROPL        PLANT GRAIN  SHOOT  ROOTS PLANT GRAIN ROOTS SHOOT PLANT PLANT PLANT PLANT PLANT PLANT PLANT ROOTS ROOTS PLANT SHOOT SHOOT PLANT ROOT ROOT
                                        TOTC  FRAC   FRAC   FRAC  CN    CN    CN    CN    WATER L-MAX H_MAX TDD   N_FIX L_EFF PHOTO D_VEG D_REP ECONO LEAF  STEM  CO2   DEPTH INCRE
=========================================================================================================================================================================================
S00H47         0   6 SWHE S_SWHEAT      6232.7  0.34  0.41  0.25  40.6  25.0  60.0  60.0  474.0  3.0  0.5   800  1.00  0.50   40  0.030  0.030  0.7  450  2775  0.50  1.0  0.06
S00H47         1  15 RYEM RYE           3932.9  0.28  0.47  0.25  26.5  20.0  50.0  50.0  551.0  3.0  0.5  2000  1.00  0.40   35  0.035  0.020  0.8  450  1500  0.50  1.0  0.02
S00H47         1   8 BARL BARLEY        4718.2  0.26  0.47  0.27  41.0  26.0  44.0  57.0  508.0  3.0  0.5  1000  1.00  0.40   35  0.040  0.021  0.7  450  2775  0.50  1.0  0.06
[illegible]                             [illegible]0.34  0.41  0.25  40.6  25.0  60.0  60.0  474.0  3.0  0.5   800  1.00  0.50   40  0.030  0.030  0.7  450  2775  0.50  1.0  0.06
S00H48         1  15 RYEM RYE           3859.4  0.28  0.47  0.25  26.5  20.0  50.0  50.0  551.0  3.0  0.5  2000  1.00  0.40   35  0.035  0.020  0.8  450  1500  0.50  1.0  0.02
```

DNDC output - Carbon

end_SOC; //Total Corg, kg C/ha
wrcvl; //Litter very labile, kg C/ha
wrcl; //Litter labile, kg C/ha
wrcr; //Litter resistant, kg C/ha
wcrb + wcrh; //Act Humus, kg C/ha
whumus; //Humus, kg C/ha

net_SOC; //kg C/ha
yr_C_mine; //kg C/ha
topc[2]; //kg C/kg soil
yr_soil_co2; //kg C/ha
yr_ch4; //kg C/ha

ProdC[1]+ProdC[2]+ProdC[3]; //count all crops, kg C/ha
prograin[1]+prograin[2]+prograin[3]; //count all crops, kg C/ha
prostraw[1]+prostraw[2]+prostraw[3]; //kg C/ha
proroot[1]+proroot[2]+proroot[3]; //kg C/ha
yr_addtc; //kg C/ha
yr_weedc; //kg C/ha
yr_leach_hu; //kg C/ha
yr_addmc; //Manure_amended (kgC/ha/yr)

DNDC output - Emissions

yr_dnn2o; //kg N/ha
yr_dnno; //kg N/ha
yr_dnn2; //kg N/ha
yr_soil_nh3; //kg N/ha
yr_plant_nh3; //kg N/ha
plantn[1]+plantn[2]+plantn[3]; //kg N/ha
yr_leach_NO3; //kg N/ha

Water balance

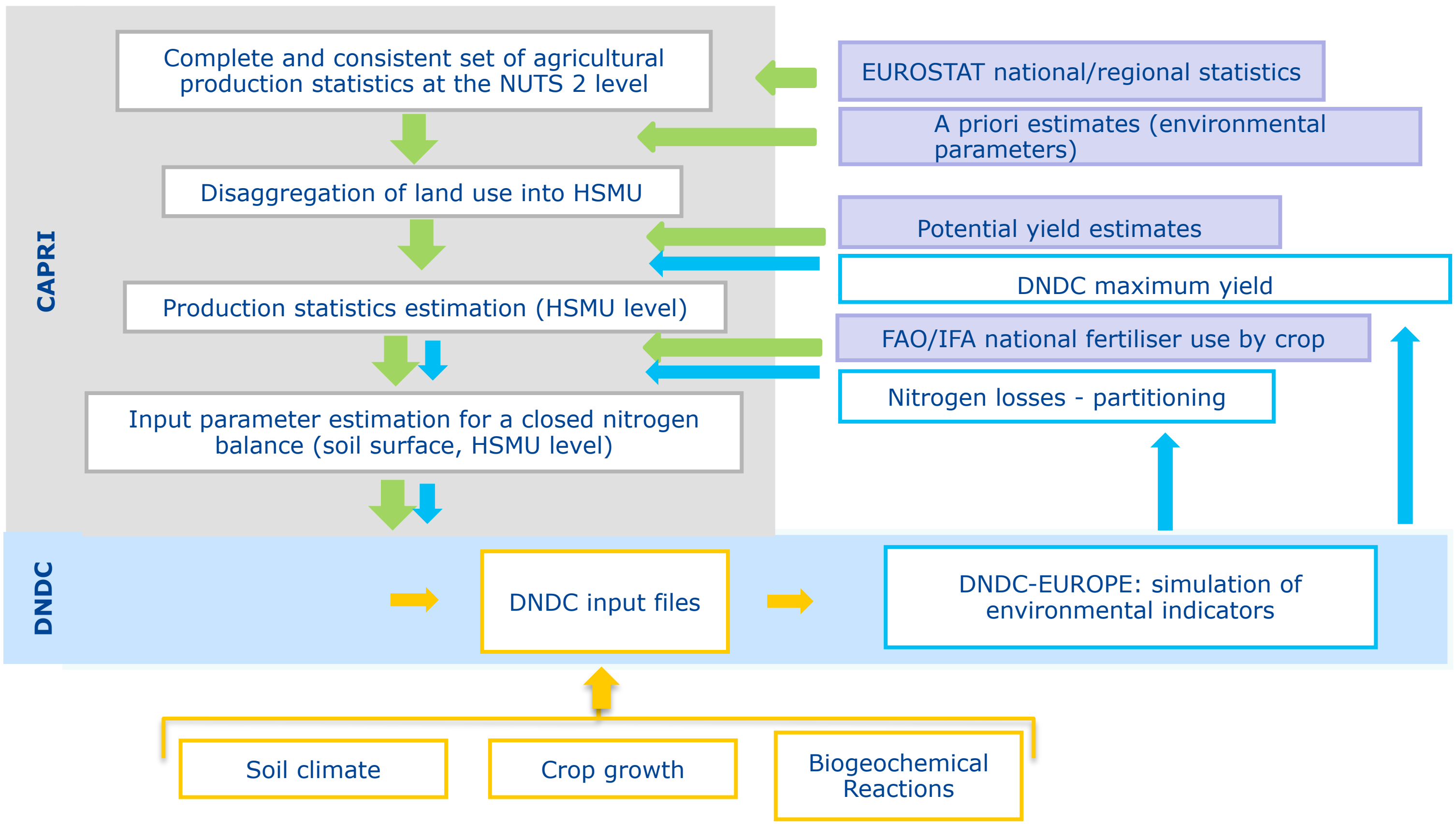
yr_TotalEvap; //mm water
yr_trans_WE; //mm water
yr_LeachWater;//parnum++;yr_PrecWater;//
yr_IrriWater;
yr_avet;
yr_rain*10.0; // mm
//

N balance

// N input
IniSON ; //kg N/ha
IniSN ; //kg N/ha
yr_rainN ; //kg N/ha
yr_fixn[1]+yr_fixn[2]+yr_fixn[3]; //kg N/ha
yr_addfer; //kg N/ha
yr_addmn;
yr_addtn + yr_addrn + yr_sln;
yr_weedn; //kg N/ha
yr_minern; //kg N/ha
// // N output
EndSON ; //kg N/ha
EndSN ; //kg N/ha

DNDC-EUROPE from plot to regional level by integrating

CAPRI database
environmental
land use
farm management



1-b. CENTURY

Century meta-model

Upscaling to EU level

DNDC-EUROPE

1-a. Meta-model construction

Parameters

Crop generic parameters

Model integration

BioMA framework: crop yield data

2. Assessing quality of input data

- For upscaling validated fluxes from local to regional scale

3. Data assimilation

- Integrate different N2O data sources through Data assimilation

4. Scenario building

- Forecast N2O emissions according to crop adaptations and faming practices to climate change

Weather forecast oceanography

Different sources integrated to improve forecast skills

Data assimilation

Weights each measurements according to its source and uncertainty levels

Best possible atmospheric state

integrate different N2O emissions sources (field data and process-based models results)

Random forest

Missing input data for some points..
How RF deals with data gaps?

Dynamic assessment model updated with the latest state of N2O emissions

European Commission

1-b. CENTURY

Century meta-model

Upscaling to EU level

DNDC-EUROPE

1-a. Meta-model construction

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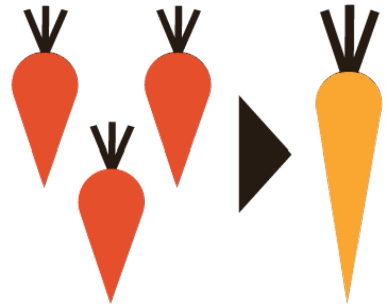
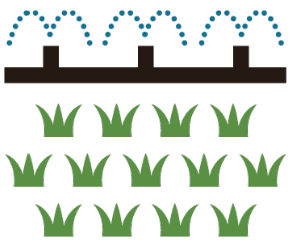
Scenario Building

Future scenarios N2O fluxes

- Crop yield during drought and inundation



New variations tolerant to heat, drought, salinity..



- planting times
- optimising irrigation
- migration of agricultural areas shifting traditional crops to others types

Crop Farming adaptations → ? → Future N2O fluxes

- PLANT-TOTC total_potenti
- GRAIN-FRAC portion_of_g
- SHOOT-FRAC portion_of_s
- ROOTS-FRAC portion_of_r
- PLANT-CN plant_CN
- GRAIN-CN grain_CN_ra
- ROOTS-CN root_CN_rati
- SHOOT-CN shoot_CN_ra
- PLANT-WATER water_requir
- PLANT-L_MAX max_LAI
- PLANT-H_MAX max_height
- PLANT-TDD TDD_10
- PLANT-N_FIX N_fixation
- PLANT-L_EFF initial efficie

s)

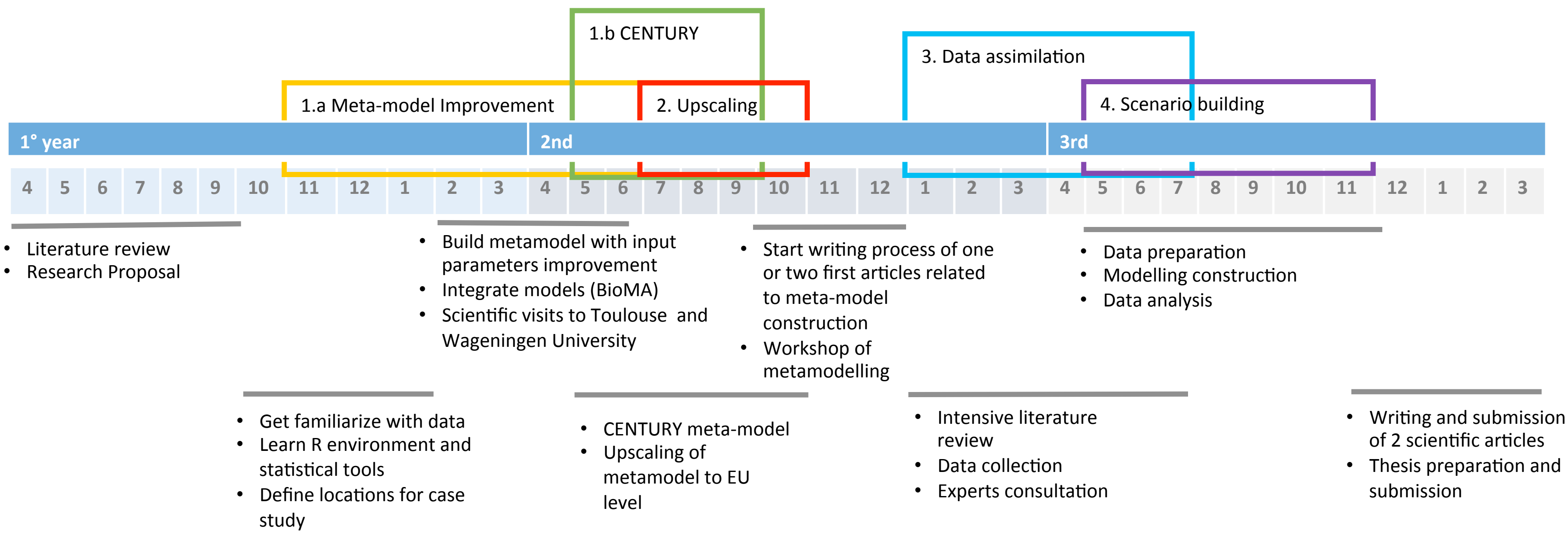
- PLANT-PHOTO maximum rate of leaf photosynthesis (kg CO2/ha/h)
- ROOTS-D_VEG rate constant of crop development in vegetative stage (1/d)
- ROOTS-D_REP rate constant of crop development in reproductive phase (1/

d)

- PLANT-ECONO economic component/storage organic by weight
- SHOOT-LEAF specific leaf weight constant (kg dm/ha)
- SHOOT-STEM specific stem weight (kg dm/ha)
- PLANT-CO2 ratio of internal/external CO2 concentrations
- ROOTS-DEPTH maximum root depth for crop (m)
- ROOTS-INCRE increase rate of root depth (m/day)

- Crop morphological parameters DNDC crop growth module
- Random forest to select most relevant to climate variations
- Intensive literature review
- Agronomic expert consultations

Thank you!


1.b CENTURY
3. Data assimilation
1.a Meta-model Improvement
2. Upscaling
4. Scenario building
1° year
2nd
3rd
4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3
• Literature review
• Research Proposal
• Build metamodel with input parameters improvement
• Integrate models (BioMA)
• Scientific visits to Toulouse and Wageningen University
• Start writing process of one or two first articles related to meta-model construction
• Workshop of metamodelling
• Data preparation
• Modelling construction
• Data analysis
• Get familiarize with data
• Learn R environment and statistical tools
• Define locations for case study
• CENTURY meta-model
• Upscaling of metamodel to EU level
• Intensive literature review
• Data collection
• Experts consultation
• Writing and submission of 2 scientific articles
• Thesis preparation and submission