A statistical meta model of DNDC to estimate nitrogen fate and irrigation water needs at 1x1 km grid at Pan-European scale

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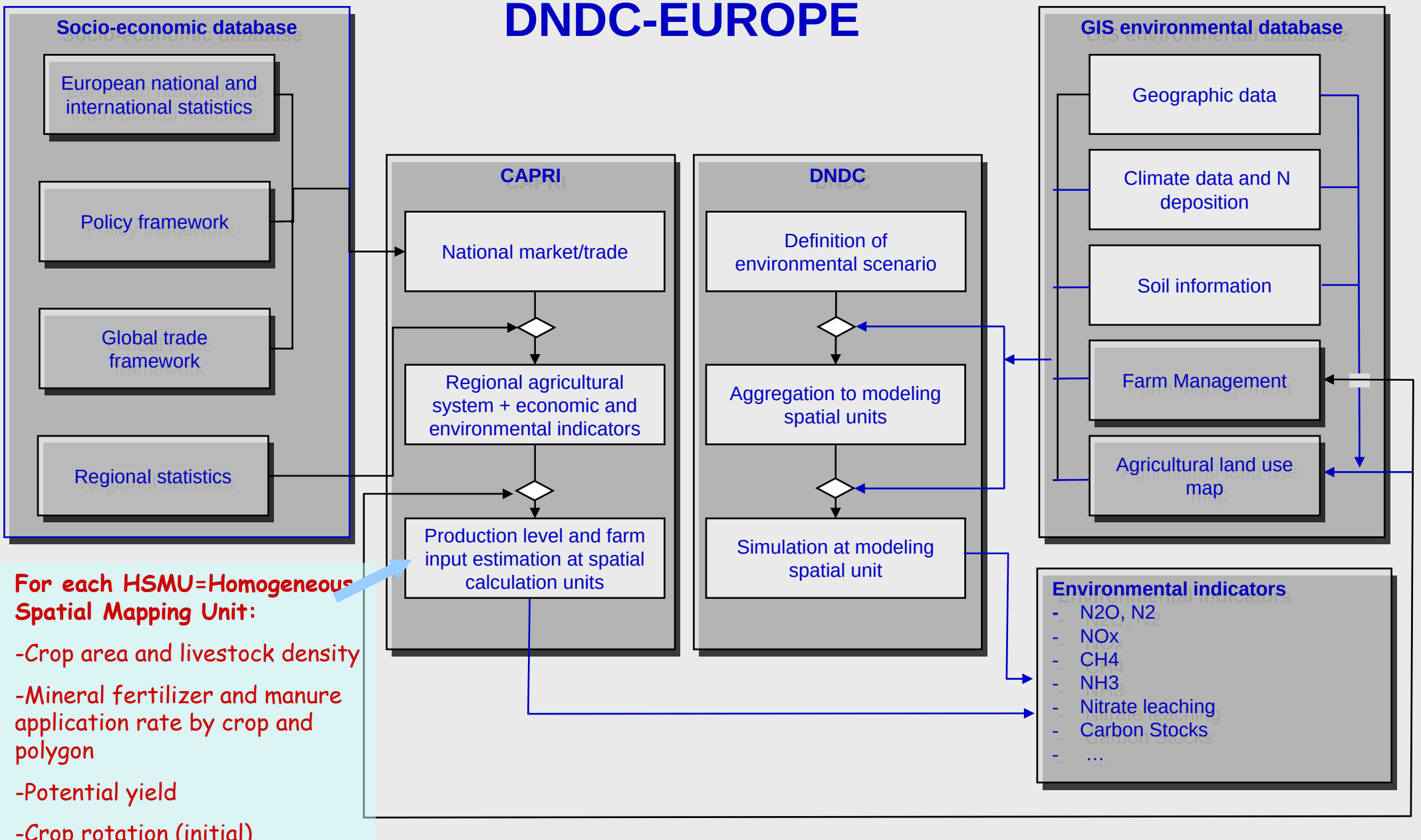


For each HSMU=Homogeneous Spatial Mapping Unit:

-Crop area and livestock density

-Mineral fertilizer and manure application rate by crop and polygon

-Potential yield

-Crop rotation (initial)

Developed in CAPRI-DynaSpat (2003-2007)

Leip et al, 2008, Biogeosciences

Why meta-model?

→ **The meta-model simulates (design-approach) the results of simulation results (model-approach) for the N budget in arable soils**

→ **Simulations with DNDC relatively time-consuming and must be interfaced to the economic model for ex-ante and policy-assessment scenarios**

→ **DNDC has an "own life" (crop yields) not necessarily matching observed regional averages, re-calibration time consuming and time**

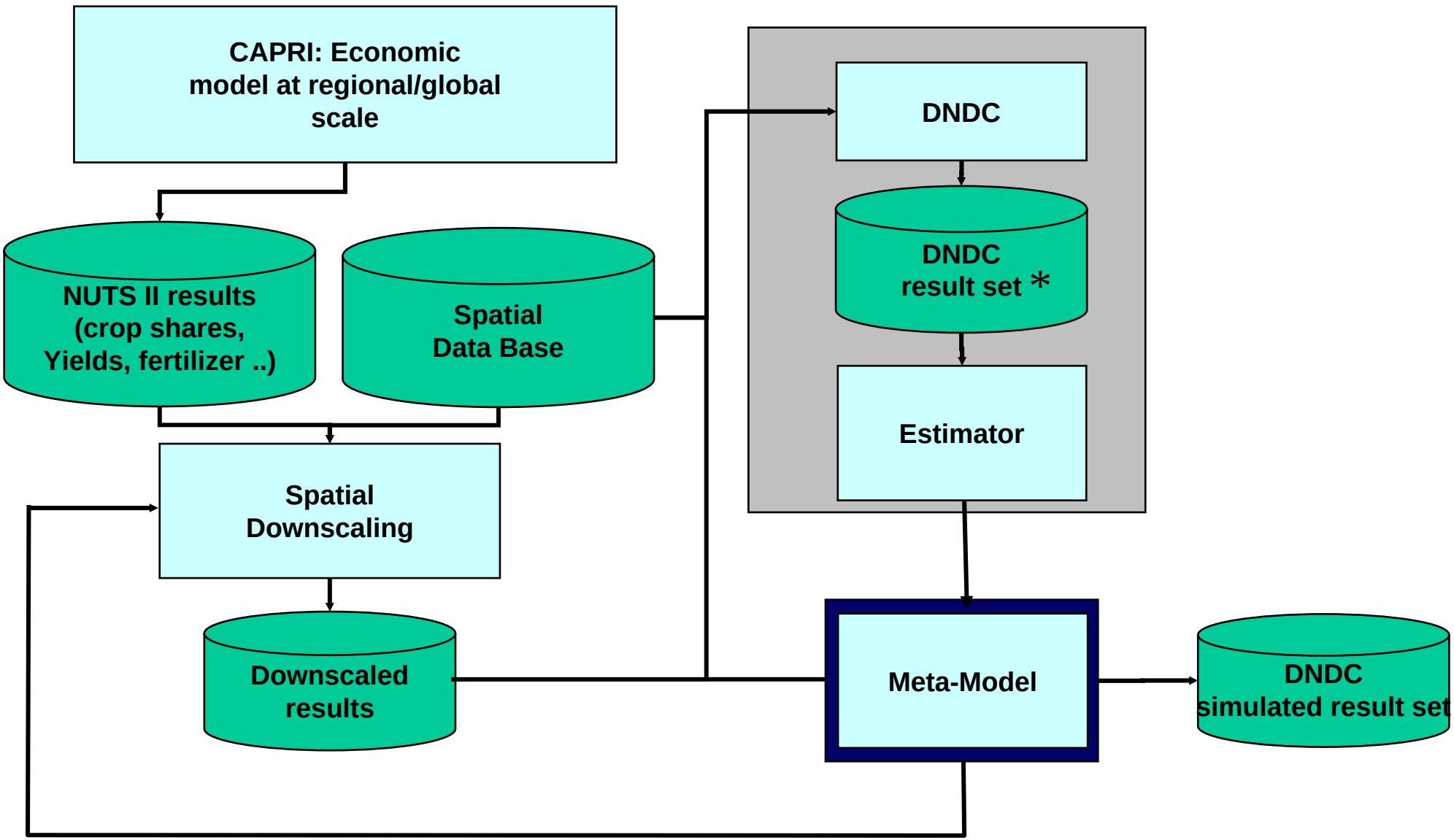
→ **Meta-model allows:**

- Faster result generation, without the need to apply the bio-physical model
- Immediate response on policy-scenario possible
- Improved consistency between economic & biophysical model

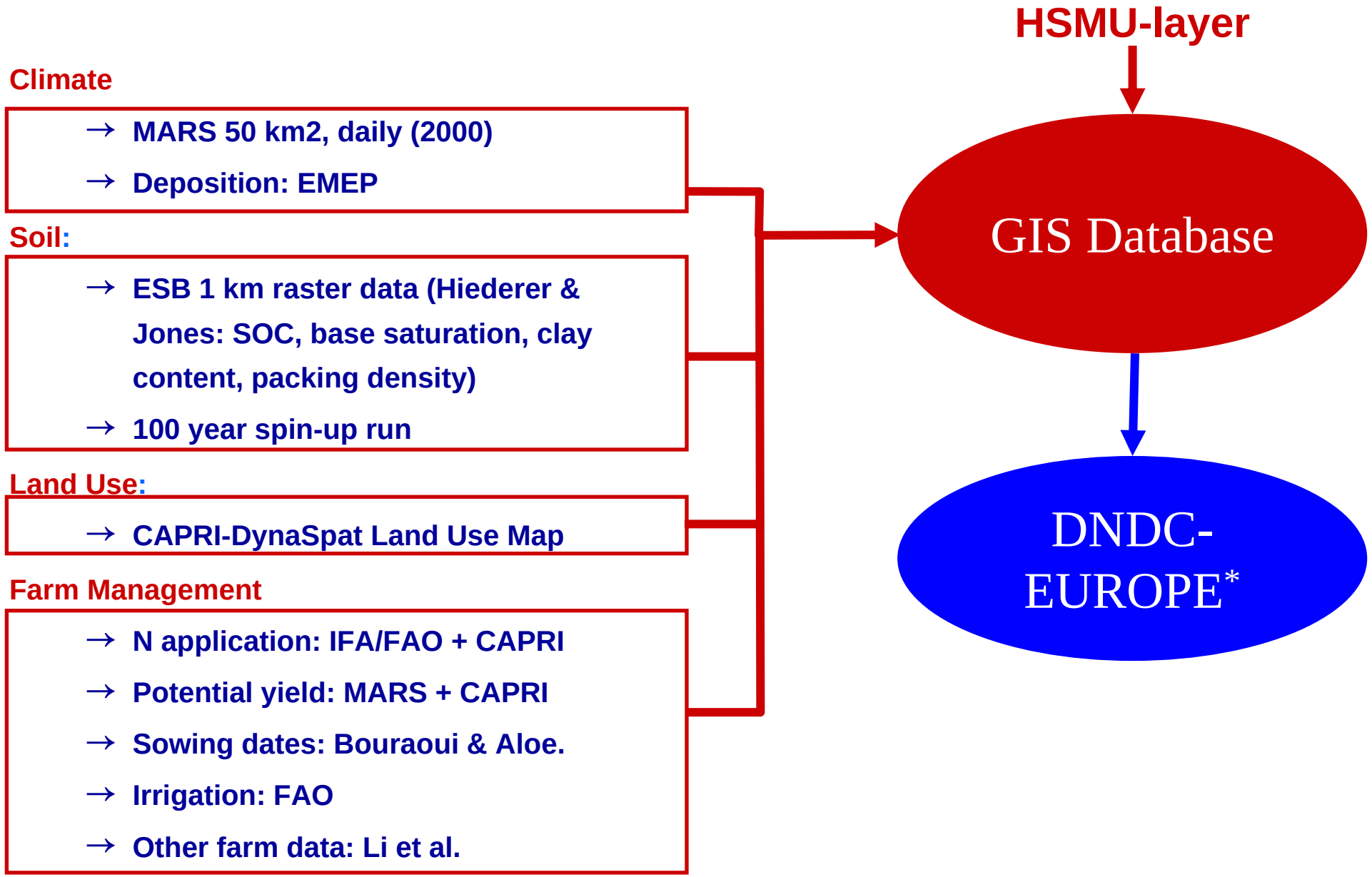
→ **But:**

- Is only a proxy for the bio-physical model, results only in average identical
- Valid only within the boundaries of the performed simulations
- Covers only a sub-set of the result variables

Overview on data flow



Set-up of DNDC



* modified DNDC V.89 to accommodate simulations of HSMU for in- and output handling

Data sources for meta-model

About 100.000 DNDC runs

→ **Based on Crop-HSMU combinations of**

- HSMUs (Homogenous Soil Mapping Units, clusters of 1x1 km grid cells) representative for NUTS II regions
- Satisfying criteria of ‘significance’ and ‘representativity’
- Crops (soft wheat, durum, barley, maize, rye, oats, paddy rice, potatoes, sugar beet, pulses, rape seed, sunflower seed, soya seed, vegetables)

→ **Combination, 8 runs were performed , covering all possible combinations of:**

- Mineral fertilization application: No-Yes
- Manure fertilization application: No-Yes
- Irrigation: No-Full

→ **in order to generate variance in major explanatory variables**

Overview on estimation and application of the meta-model

Four-step procedure:

- → **Estimation of linear regression models for each result variable of DNDC of interest**
- → **Adjust the potential yields (a key crop parameter of DNDC) in order to let the meta model reproduce the estimated yield at the estimated farming practice at 1x1 km grid**
- → **Forecast each result variable based on the meta-model for all the 1x1 km grid cell clusters (ca. 200.000 for EU27) for all crops present (up to 20, not just major ones)**
- → **Aggregate results from single crops to agricultural area per cluster of 1x1 km grid cells**

1. Regression analysis

Generation of regression models per rainfed and irrigated crop

- → **Different N losses (leaching, run-off, gaseous emissions)**
- → **Mineralization**
- → **Water balance elements (transpiration, evaporation, leaching)**
- → **Crop yields (measured in removed nitrogen)**

Explanatory variables:

- → **Soil parameters (clay content, packing density, soil organic carbon, PH)**
- → **Average climatic variables (rainfall per quarter, maximum and minimum temperature, E0, ET0)**
- → **Mineral and manure nitrogen applied, realized yield, potential yield**

2. Estimation procedure

All explanatory variables are possibly included:

→ **in linear and quadratic form, as square roots and logs, multiplied with each other variable, multiplied with the log of organic carbon, multiplied with the square of organic carbon**

→ **… which leads to possibly 140 explanatory variables**

Backwards elimination of insignificant variables based on OLS:

→ **Remove step-wise least insignificant variable, as long:**

- The adjusted R squared is still increasing
- The number of regressors exceeds 1/5 of the observations
- There are variables with Prob=0 > 0.1%

→ **R^2 are typically for 40% of the estimation >=95%, for 72% >=85% and only for 10% below 75% at Significance level 0.1%**

Problems

→ **DNDC not (yet) with varying weather**

- Decreases explanatory strength of climate parameter

→ **Due to low number of observation, some crops were grouped (durum and soft wheat; tomatoes and other vegetables; oats, rye and rice)**

→ **Yield in DNDC-results does not necessarily match "CAPRI"-consistent yield**

- → DNDC optimum yields estimated in order to recover the yield estimate for the cluster of 1x1 km grid cell:

$$Yield^{*}_{HSMU,c} = f(\overline{potYield}_{HSMU,}\mathbf{x}_{HSMU})$$

$$\Leftrightarrow$$

$$potYield^{*}_{HSMU,c} = f^{-1}(\overline{Yield}_{HSMU,}\mathbf{x}_{HSMU})$$

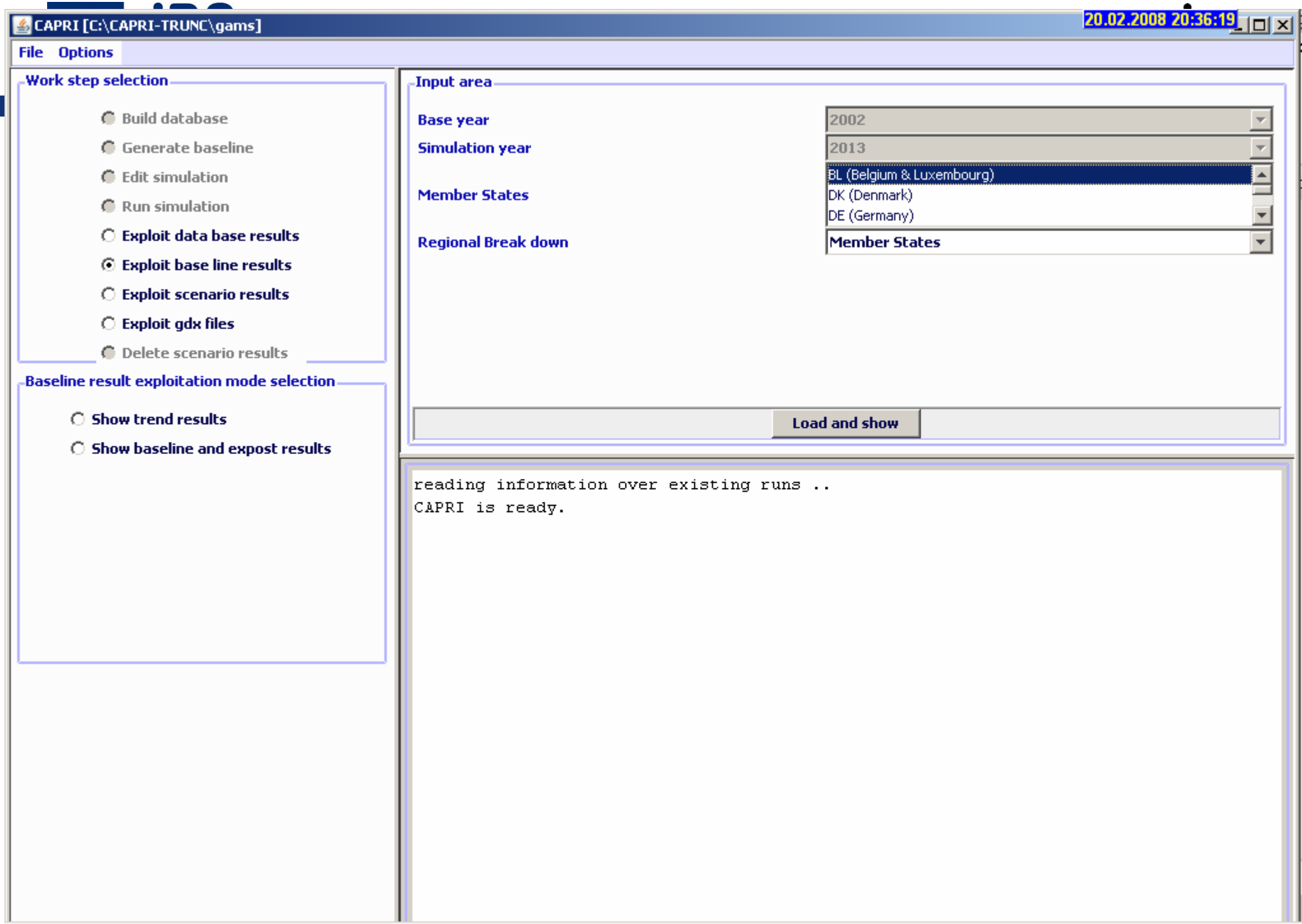
3. Forecasting at 1x1 km grid

→ **Meta-model estimates DNDC-results using the "calibrated" optimum yield (individual parameters)**

→ **Results were bounded to the min and max of the result variables in the observation sample (crude outlier control)**

→ **Nitrogen balance are closed by distributing the error in total N losses to individual losses (leaching, NH3, N2, N2O, NO) according to the coefficient of correlation**

$$\sqrt{1 - R^2_{ind\_loss}}$$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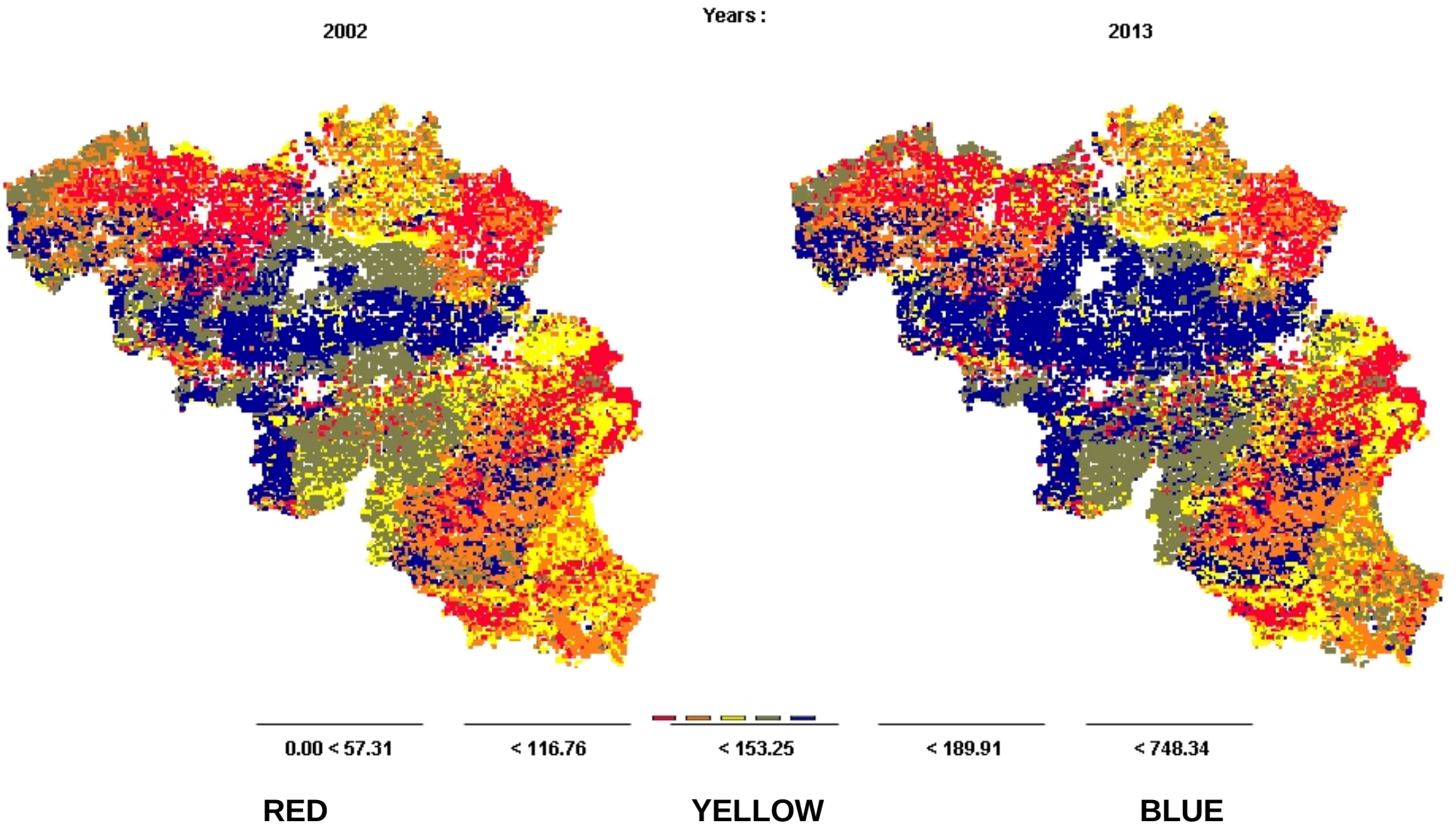
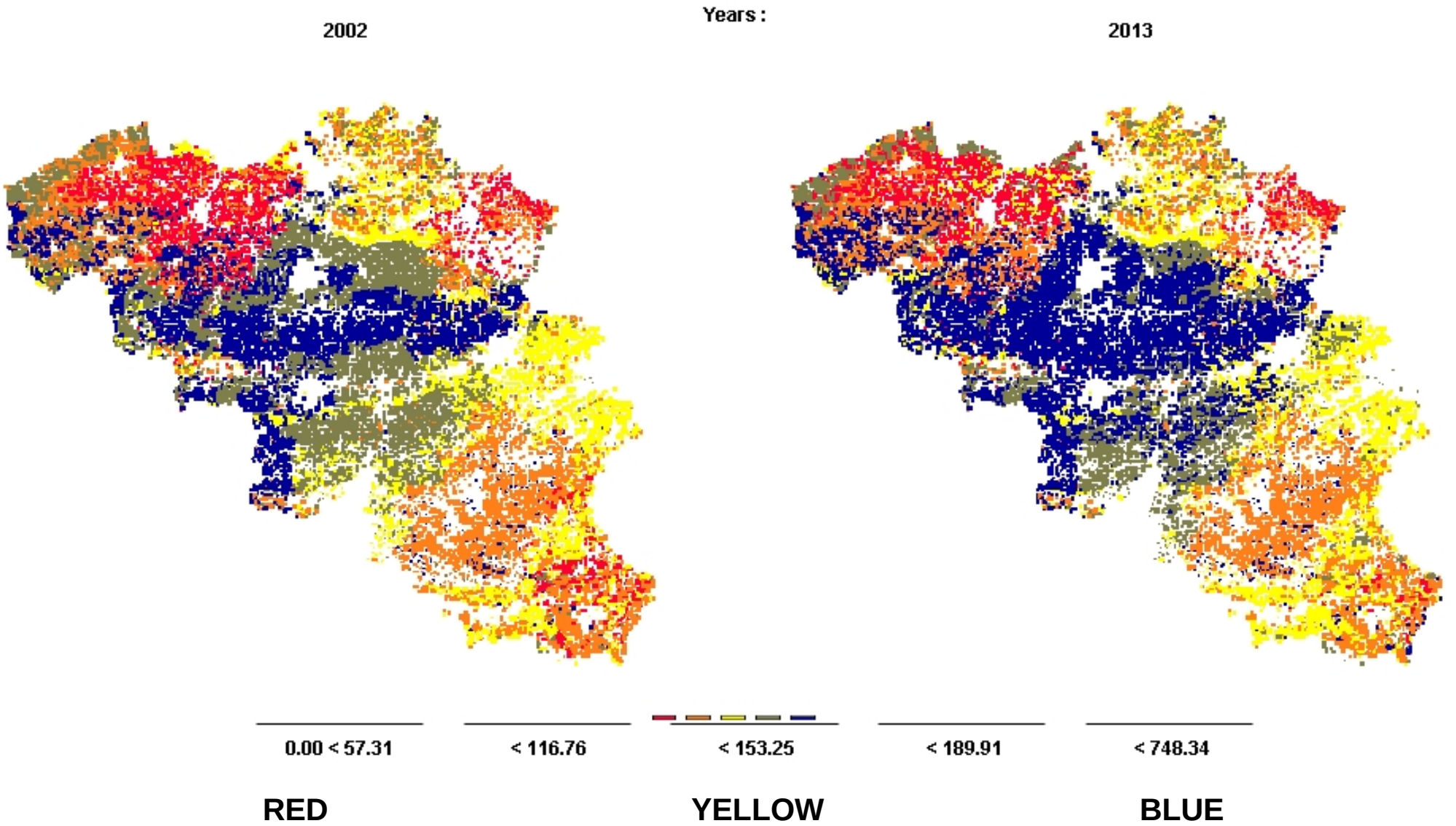
20.02.2008 20:36:19
File
Options
Work step selection
Build database
Generate baseline
Edit simulation
Run simulation
Exploit data base results
Exploit base line results
Exploit scenario results
Exploit gdx files
Delete scenario results
Baseline result exploitation mode selection
Show trend results
Show baseline and expost results
Input area
Base year
2002
Simulation year
2013
Member States
BL (Belgium & Luxembourg)
DK (Denmark)
DE (Germany)
Regional Break down
Member States
Load and show
reading information over existing runs ..
CAPRI is ready.

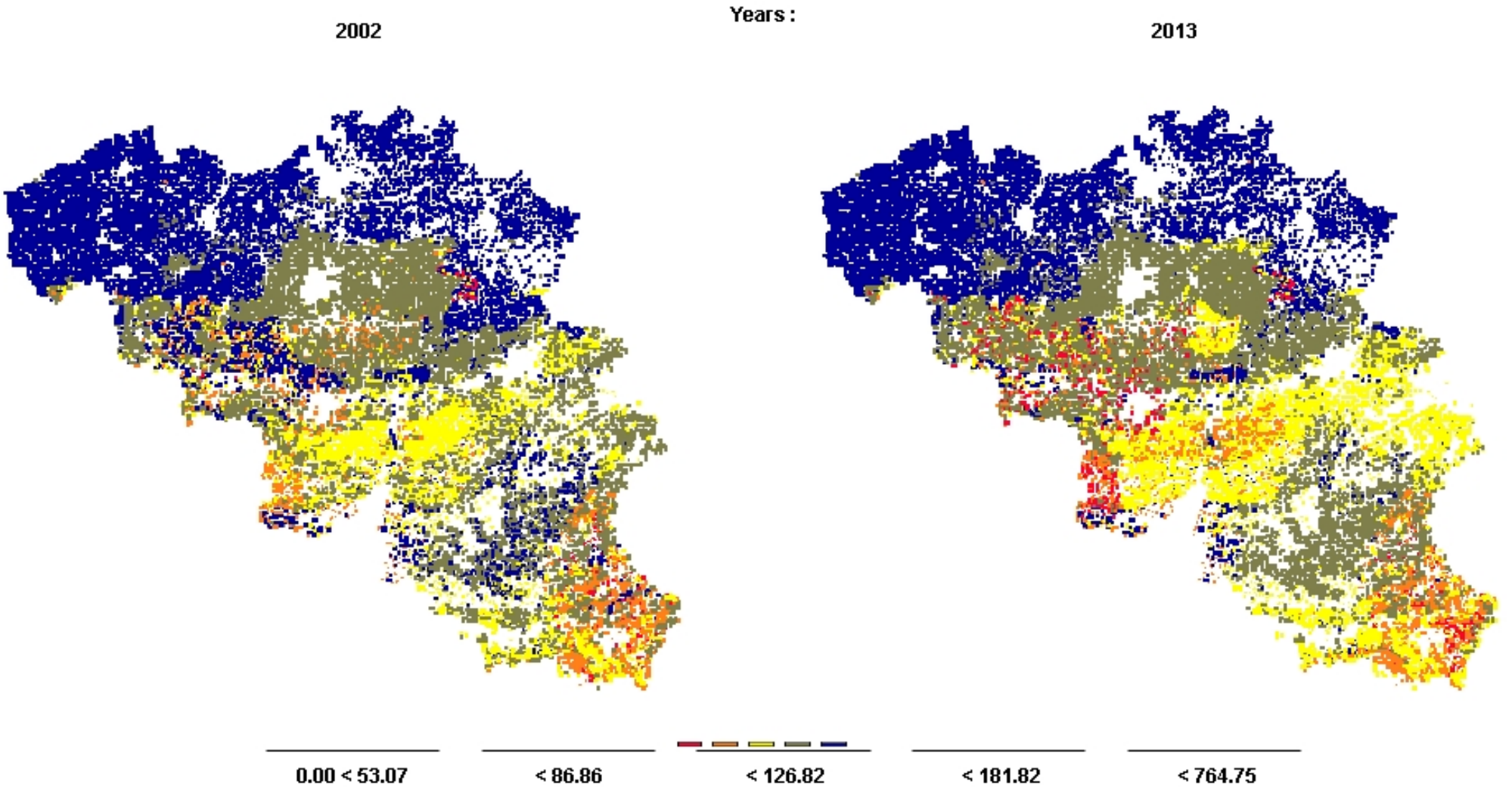
Belgium – Mineral fertilizer application 2002 vs. 2013



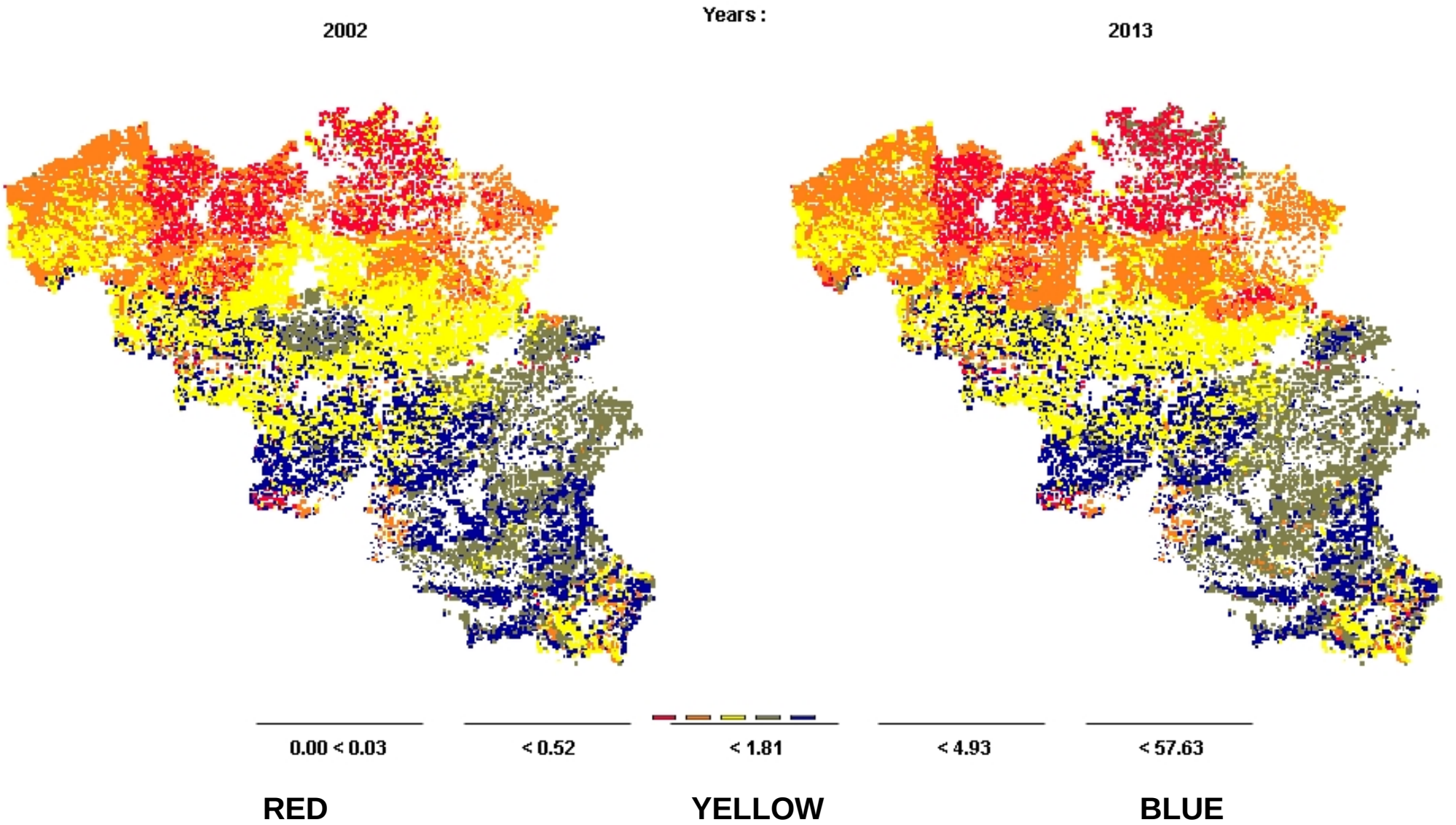
Belgium – Mineral fertilizer application 2002 vs. 2013



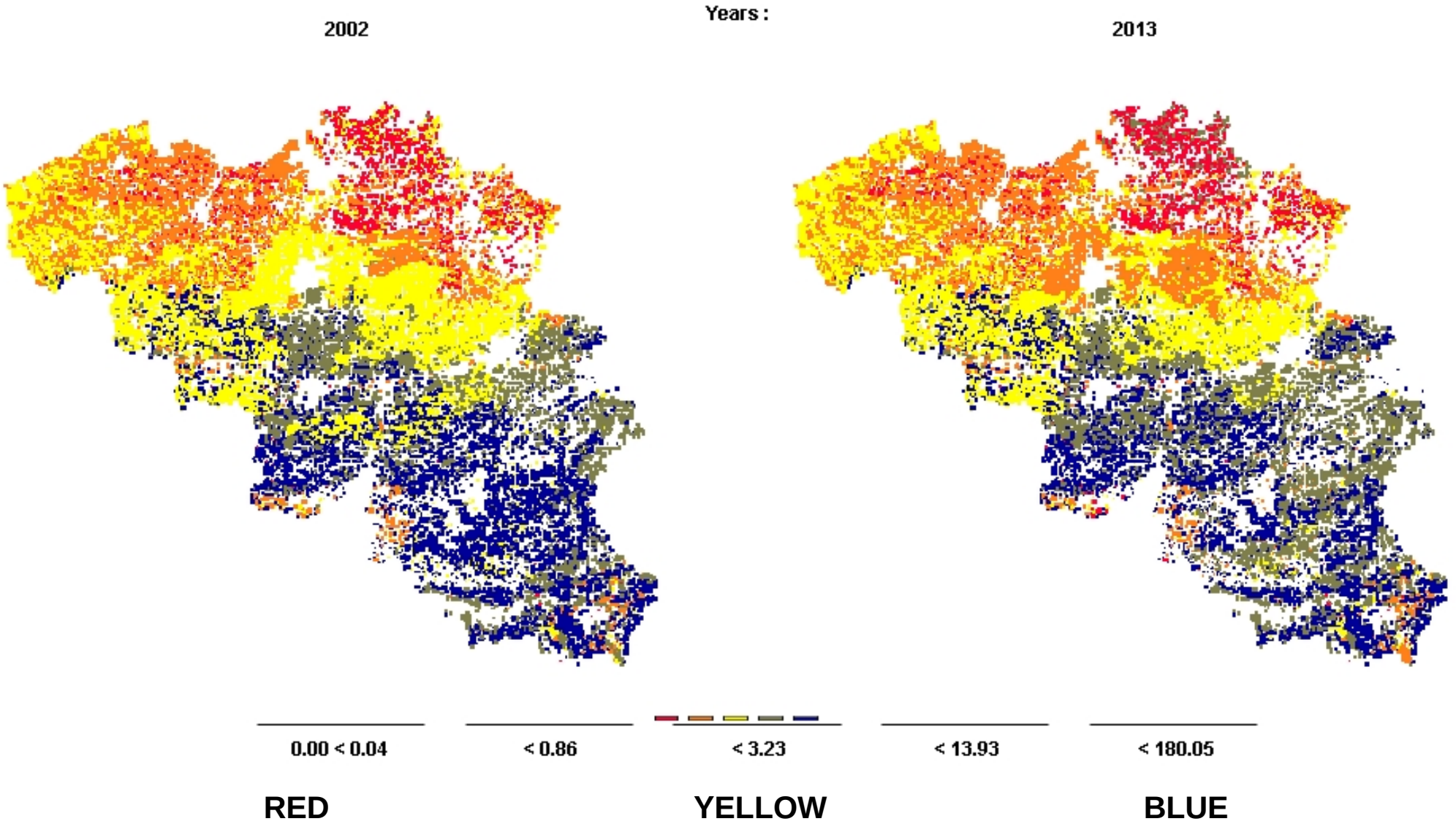
Belgium – Manure application 2002 vs. 2013



Belgium – N2O fluxes 2002 vs. 2013



Belgium – N2 fluxes 2002 vs. 2013



Summary

Methodology allows:

→ to estimate rather efficiently major result variables from DNDC for crops under climate-soil-farming practise combination

→ removes bias between simulated yields from crop growth model and down-scaled results by re-calibrating the potential yields in the meta model

Major remaining problems:

→ No observations for permanent grass land and tree cultures

→ Runs used same weather in every year

Thanks for your attention …

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