Component 5: Assessing European Nitrogen and GHG fluxes, including scenarios

Wim de Vries

Activity leaders: Adrian Leip, Martha Bakker, Hans Kros, Pete Smith and Michael Obersteiner

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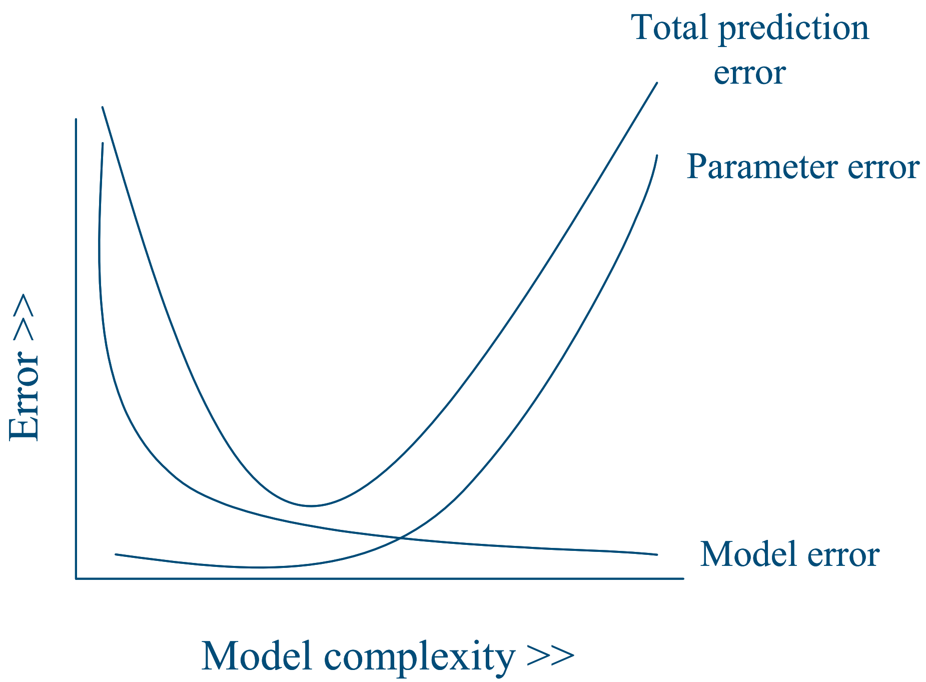
Contents

Objectives

- Develop and apply GIS-based integrated agro-ecological assessment **tools!** for the European scale to:
  - Assess **present** nitrogen (NH_3, NO_x) and greenhouse gas (GHG: CO_2, N_2O, CH_4) emissions and sinks and their interactions from terrestrial systems.
  - Assess **interactions** between C and N and between **agricultural and non-agricultural systems**.
  - Predict **past and future** N and GHG emissions/sinks in response to various scenarios on changes in: (i) land use and land management changes and (ii) climate and N deposition in response to different policies and strategies.

Modeling approach: scaling issues

- Trade-off between model complexity and data availability in large scale environmental applications.
- Choose level of complexity that minimizes total prediction error



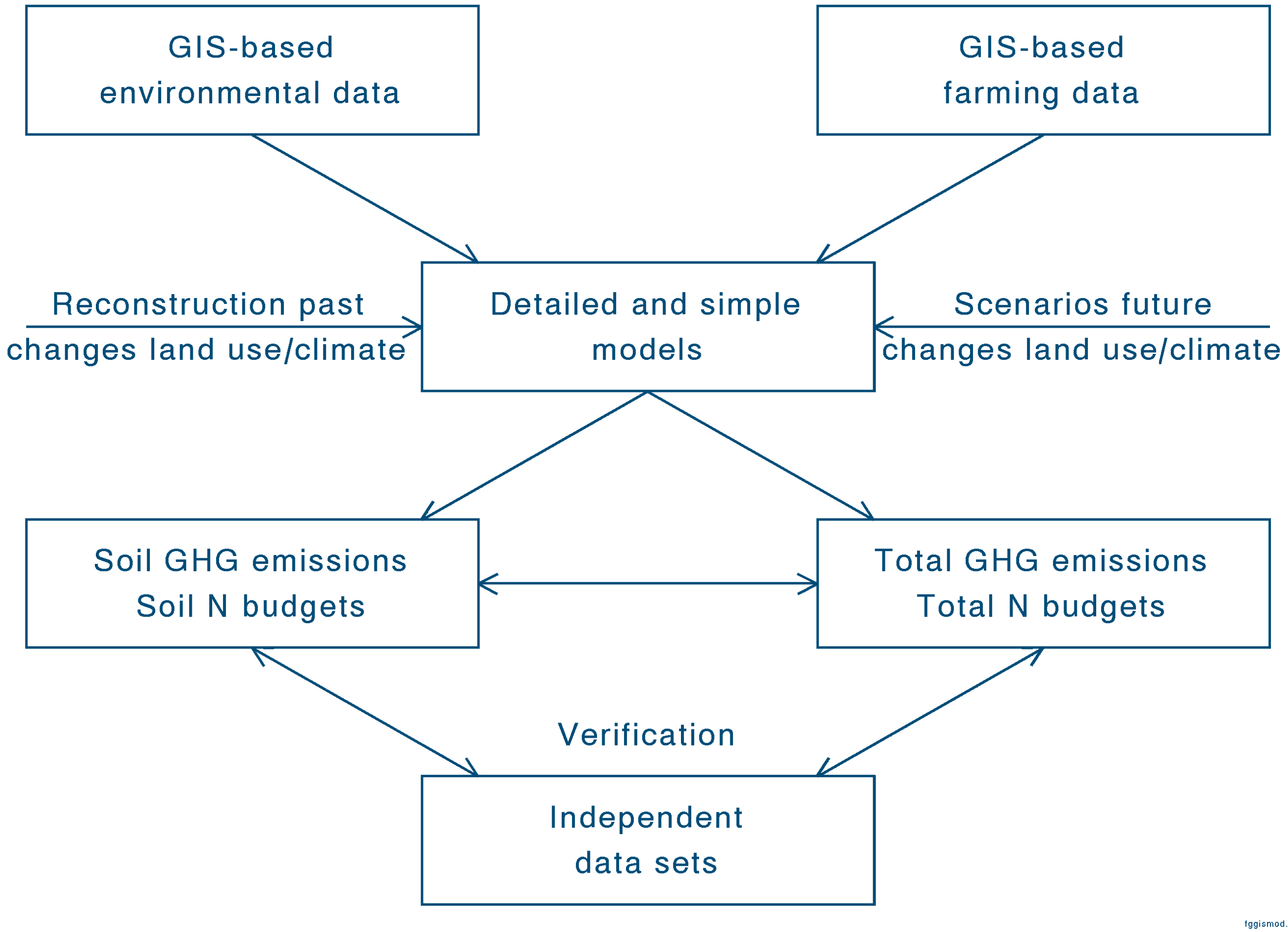
Modelling approach in NEU

- Use simple multi-sector and multi-component model to:
  - improve estimates of total N and GHG budgets and understanding of their **overall interactions** at a European scale.
  - Analyze environmental impacts of various scenarios/ policies (retrospective analysis and future prospects) on **total emissions** of N and GHG: Fast evaluation of a large number of alternative scenarios.

Modelling approach in NEU

- Use detailed ecosystem models to:
  - Analyze environmental impacts of various scenarios (retrospective analysis and future prospects) to **improve the understanding** of land use and climate change on N and GHG **soil emissions** at a European scale
  - Compare results of GHG soil emissions with those from the multi-sector model to gain insight in differences in model outcome by using different model approaches (part of the **uncertainty assessment**).

Organization of component 5 European integration



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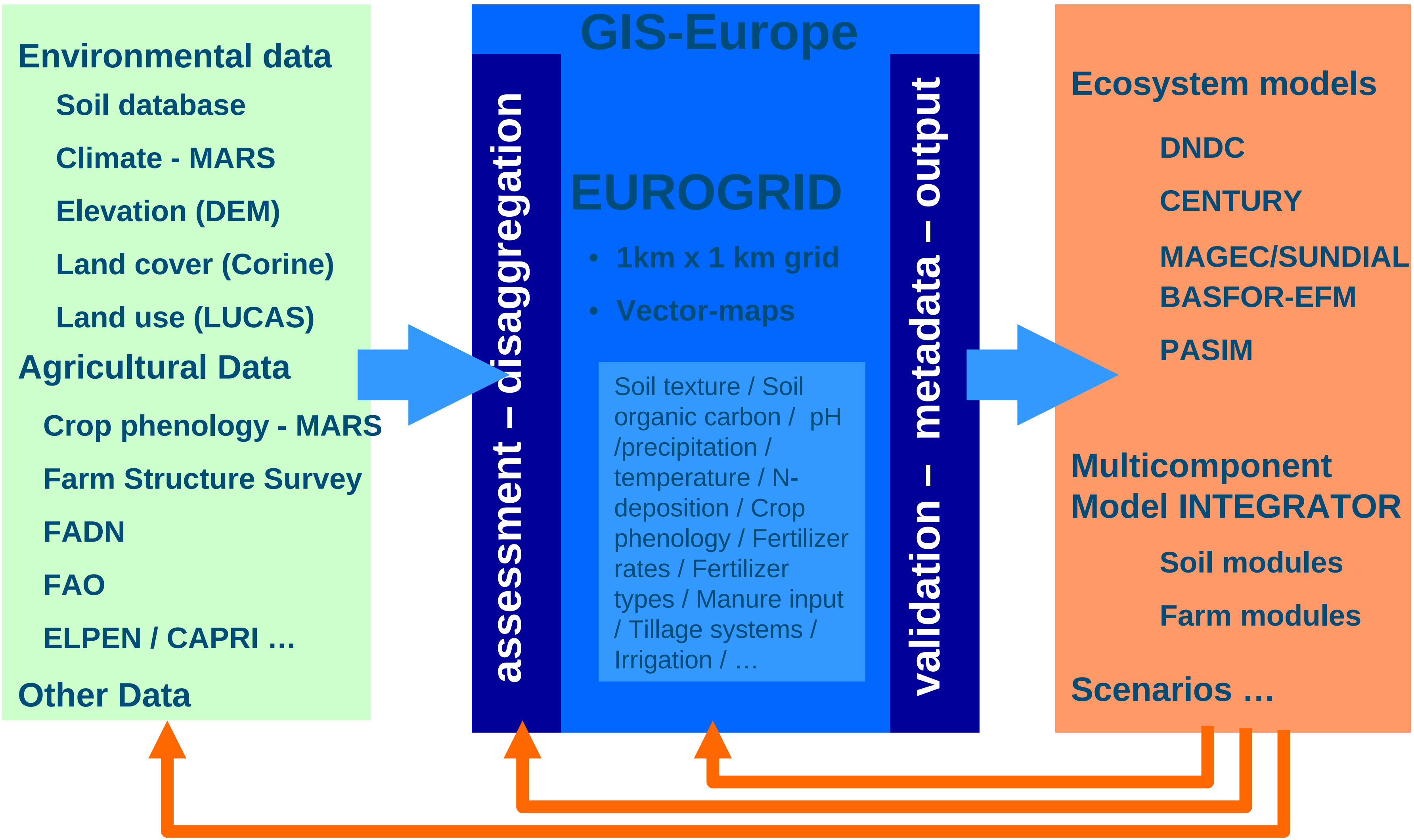
A 5.1 Derivation of harmonized GIS-based datasets

Activity 5.1 Harmonized GIS-based data

- Assess, analyze and collect GIS–based spatially explicit data for EU-25+5 (pan-European for land use) on:
  - *environmental data* (e.g. climate, soil, land cover/use, relief).
  - *farming systems and farming management* (e.g. rate and timing of manure application/fertilization, crop rotations etc).
- Develop a suitable data base for model application by:
  - Developing/standardizing disaggregation procedures to match modelling tools with respect to scale and content of data.
  - Constructing a data base infrastructure allowing a smooth data update to feed flexibly all modules.

Structure of C5 from the view of A 5.1



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Task 5.1.1 Assessment of environmental data at EU 25+ 5 level

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Task 5.1.1: Analysis of environmental data

- Definition and set-up of a consistent and comprehensive database structure incl. meta-data
- Set-up of data bases with relevant environmental information (soil, climate, land cover, …)
- Disaggregation of agricultural data and forestry statistics / land cover data into calculation units used by the models (combination of soil, elevation, land use etc or an INSPIRE compliant grid).

synergies with

Carbo-Europe

IP

build upon

CAPRI-D.S.

INSEA

ELPEN

…

Datasets at EU-level (EUROGRID)

Environmental data

- Land Cover (Corine)
- Land use biased to agricultural crops (LUCAS)
- Soil (ESDB v2; WISE)
- Climate data (MARS, EMEP)
- Elevation (GTOPO30)

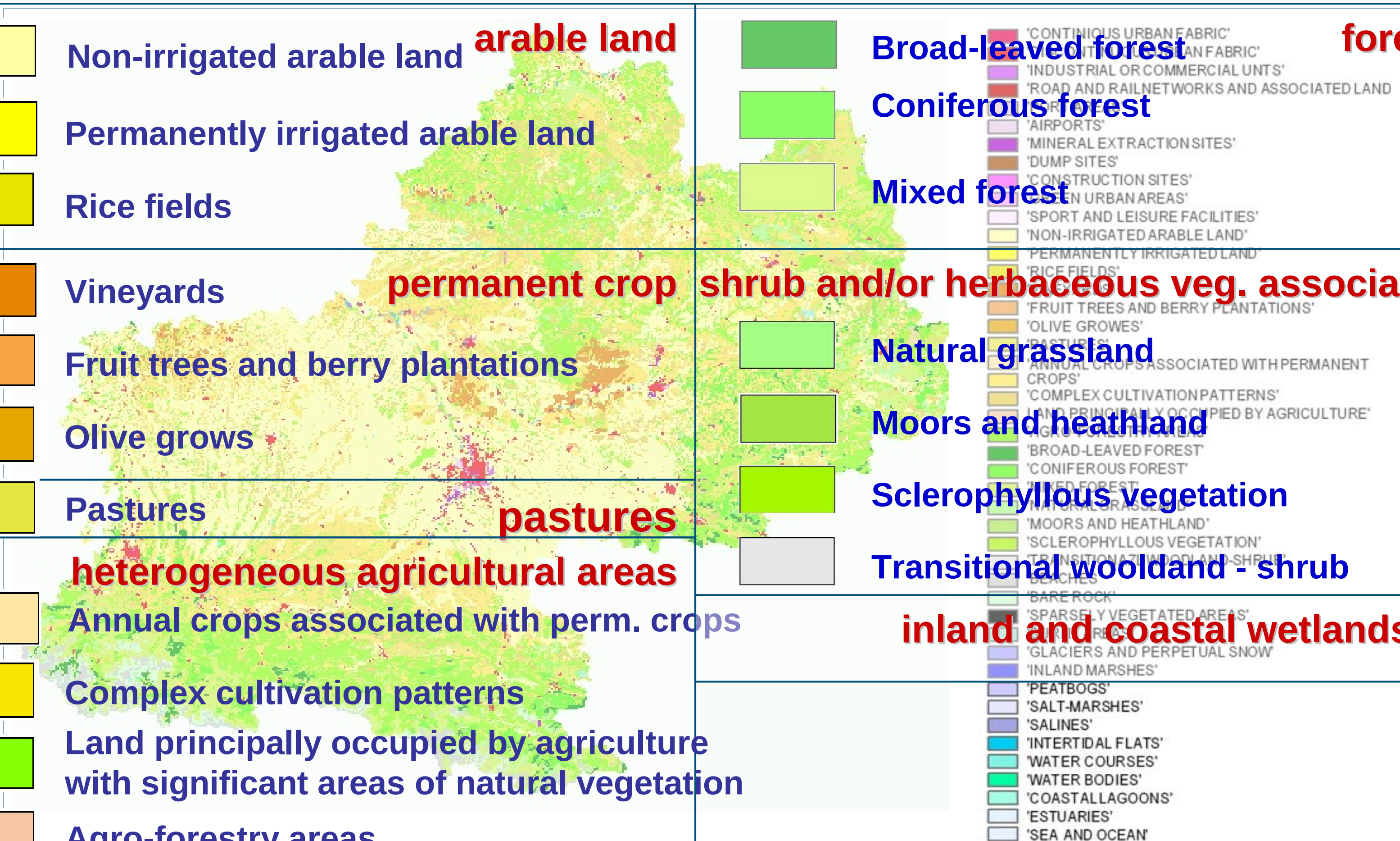
Agricultural data

- Farm Structure Survey
- Farm Accountancy Data Network (FADN)
- CoCo Database (CAPRI)
- etc….

Corine Landcover classes

44 land cover classes

High spatial resolution (100 by 100m)
Low detail of agricultural (11) and Forests & semi-natural land use classes (12)



arable land
- Non-irrigated arable land
- Permanently irrigated arable land
- Rice fields

permanent crop
- Vineyards
- Fruit trees and berry plantations
- Olive grows

pastures
- Pastures

heterogeneous agricultural areas
- Annual crops associated with perm. crops
- Complex cultivation patterns
- Land principally occupied by agriculture with significant areas of natural vegetation
- Agro-forestry areas

forests
- Broad-leaved forest
- Coniferous forest
- Mixed forest

shrub and/or herbaceous veg. association
- Natural grassland
- Moors and heathland
- Sclerophyllous vegetation
- Transitional woodland - shrub

inland and coastal wetlands (5)

European Topic Centre on Terrestrial Environment (2000)
Corine land cover database (Version 12/2000). Series

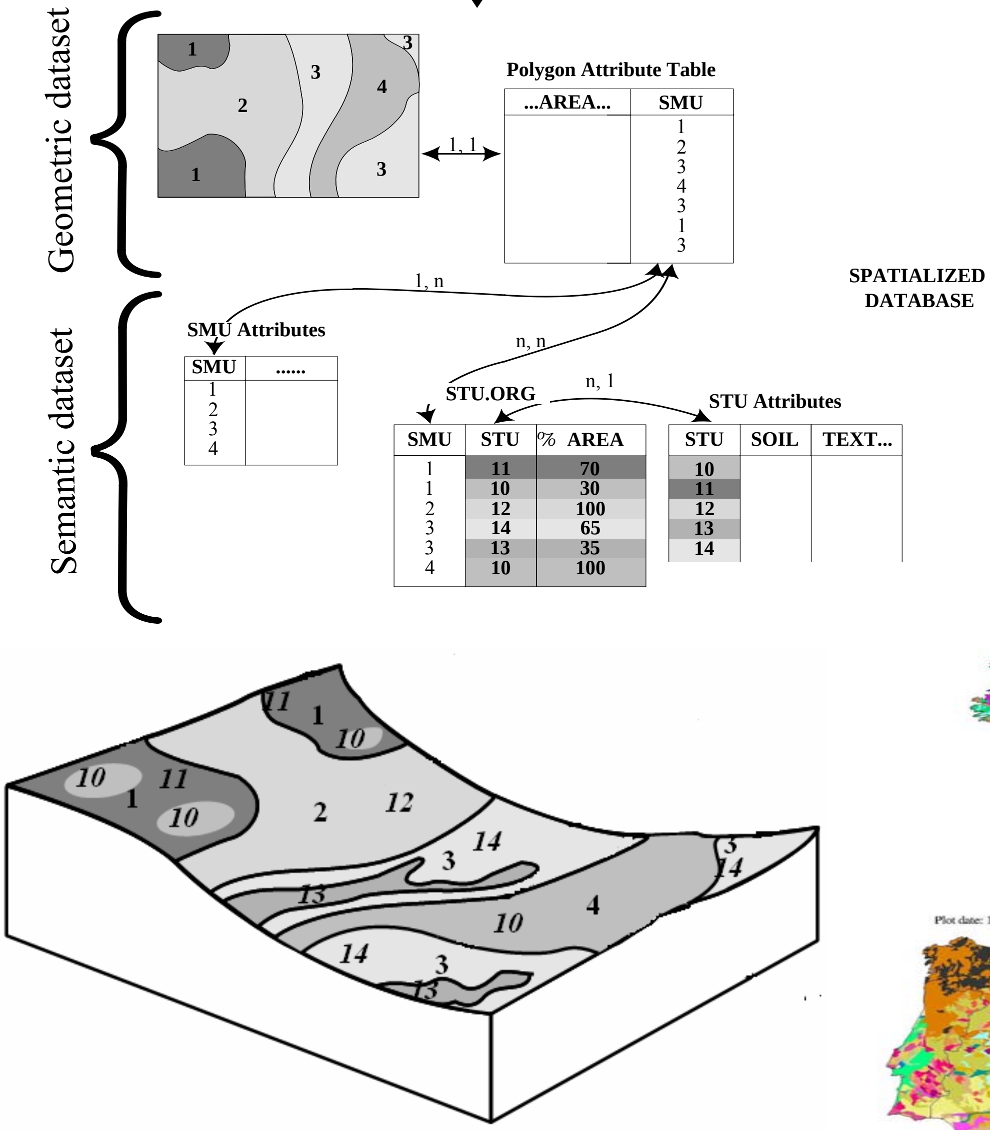
ESB Project
The European Soil Bureau

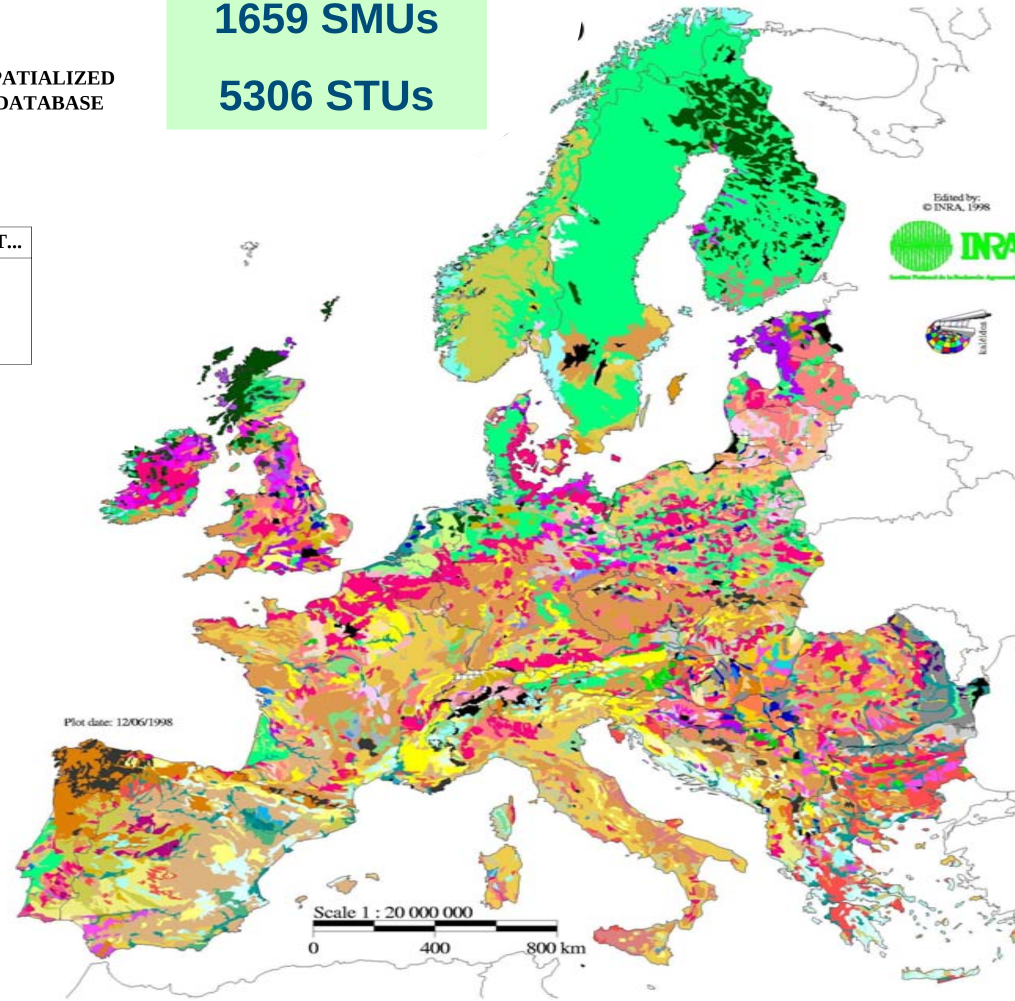
Soil and Waste Unit

Soil Geographical Data Base of Europe at Scale 1:1,000,000

1659 SMUs

5306 STUs





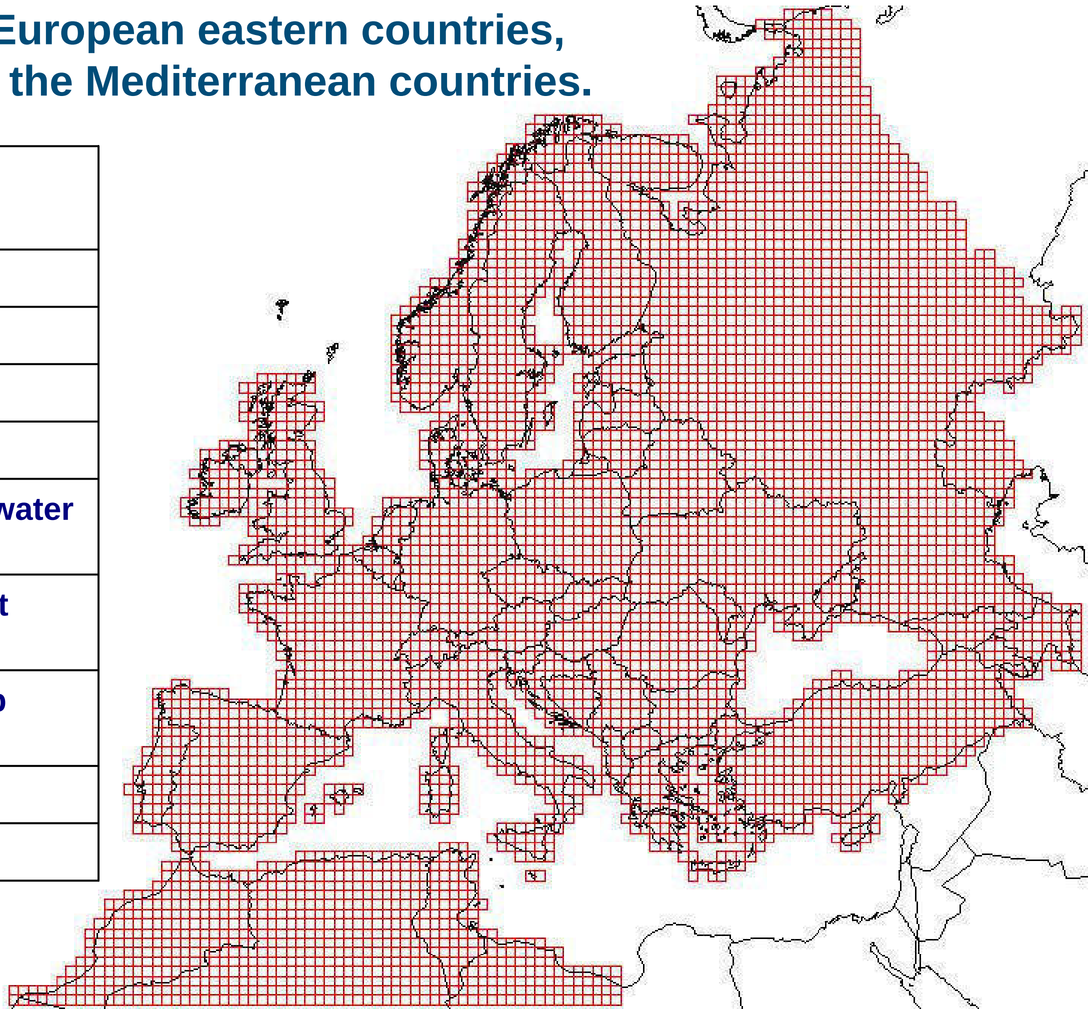
http://mars.jrc.it/marsstat

MARS-STAT Data Base:

daily meteorological interpolated data

- **50x50 km GRIDs**
- **meteo interpolated data from 1975**
- **EU member states, the central European eastern countries, the new Independent states and the Mediterranean countries.**

maximum temperature (°C)
minimum temperature (°C)
mean daily vapour pressure (hPa)
mean daily windspeed at 10m (m/s)
mean daily rainfall (mm)
Penman potential evaporation from a free water surface (mm/day)
Penman potential evaporation from a moist bare soil surface (mm/day)
Penman potential transpiration from a crop canopy (mm/day)
daily global radiation in KJ/m^2/day
snow depth (cm) *



CAPRI-DynaSpat

Disaggregation of agricultural statistics

<u>Motivation</u>: provide models with adequate input data.

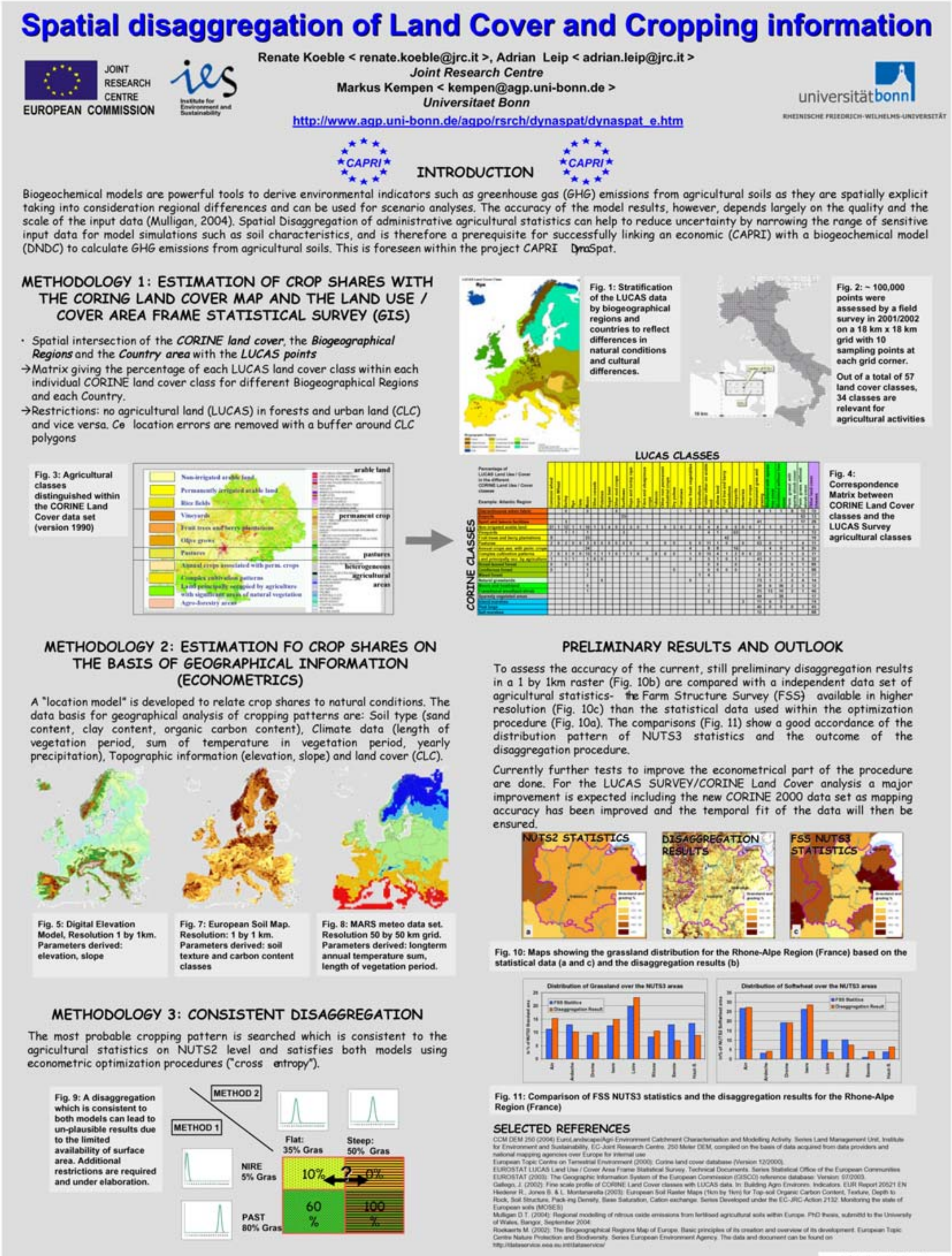
<u>Methodology</u>:

a) calibration of the Corine Land Cover map with LUCAS data (GIS)

b) estimate crop shares from environmental data (econometry)

c) consistent disaggregation of land use choices

<u>Timing</u>: … first product should be ready in April 2004 …



Task 5.1.2 Collection and analysis of agricultural data at EU 25+ 5 level

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Data needed – simple models

- Animal numbers and excretion rates.
- Amount of fertiliser applied and type of fertilizer.
- Amount of manure applied and type of manure (e.g. slurry, solid).
- Manure management (e.g. housing/storage types, field application methods).
- Start/stop dates for grazing.
- Crop rotation(s).

Data needed – complex models

As for simple models, plus:

- Ploughing, sowing, harvesting dates.
- Timing of fertiliser applications.
- Timing of manure applications.
- Irrigation and its timing..etc

Actions needed

- Harmonisation of collected farming data (agricultural statistics, cropping calendars, …) and assessment of data quality.
- Reconstruction of agricultural data to the past.
- Definition of rules/routines for deriving management and cropping information.
- Disaggregation procedures to assess model input at the level of model calculation units.
- Confront top down approach with bottom up approach based on synthesized expert knowledge (questionnaires).
- Validation of disaggregated maps in selected countries.

Harmonisation of collected statistical data

Statistical data: sources

- Regional EU-databank REGIO
- Farm Structure Survey (FSS/ Eurofarm)
- Farm Accountancy Data Network (FADN)

Different regional divisions between data sources

Information level of data sources varies between countries

Regional divisions of EU-15

REGIO			FSS		FADN	HARM	
NUTS1	NUTS2	NUTS3	Region	Sub-region		Region	Sub-region
77	206	1031	129	502	104	100	482

Assessment of data quality

- Estimates of sampling errors are relevant in view of uncertainty analyses.
- For example, most data published in the statistical tables of FSS are produced from sample surveys, varying between ca 3-40 % of the total population of agricultural holdings.
- A further error is introduced during the rounding treatment to guarantee confidentiality during the production of statistical tables from survey data.

Routines for management and cropping information

Example of a routine could be:

- Use temperature sum to estimate growing season start/end for arable crops and grass.
- Arable crops
  - Manure application at start and end of growing season.
  - Mineral fertiliser in first half of growing season.
- Grassland: mineral fertiliser and manure application throughout the growing season.

A5.2 – Deriving past, present and future land use scenario’s

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Activity 5.2 Derivation of “scenarios”

- Derivation of appropriate “scenario” types (historical reconstruction and future prospects) regarding land cover/land use, climate, N deposition for application by ecosystem models and multi-component model by
  - Inventory of past and current land use changes and land management.
  - Inventory of relevant EU and national policies to be used in deriving future scenarios (specifically on climate and N deposition)
  - Future scenarios on changes in land cover, land management, climate and N deposition

Activity 5.2 Derivation of “scenarios”

- Target period for the past: 1970 (1960) – 2000: acceptable data quality in view of reconstruction land cover and land management.
- Target period for the future: 2000 – 2030 (2040) (possible exploratory outlook to 2100).
- Specific geographic areas (countries) included for validation on past changes.

A5.2 – Deriving past, present and future changes

T 5.2.1 Historic land use reconstructions

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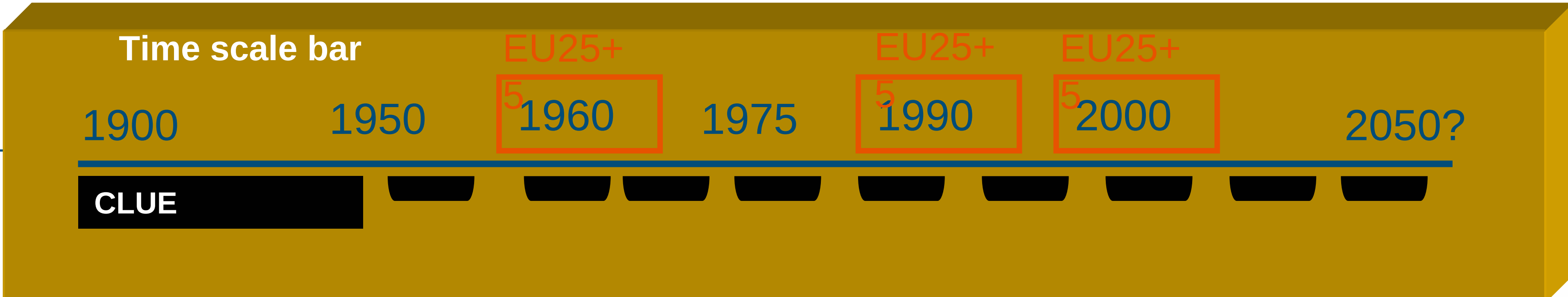
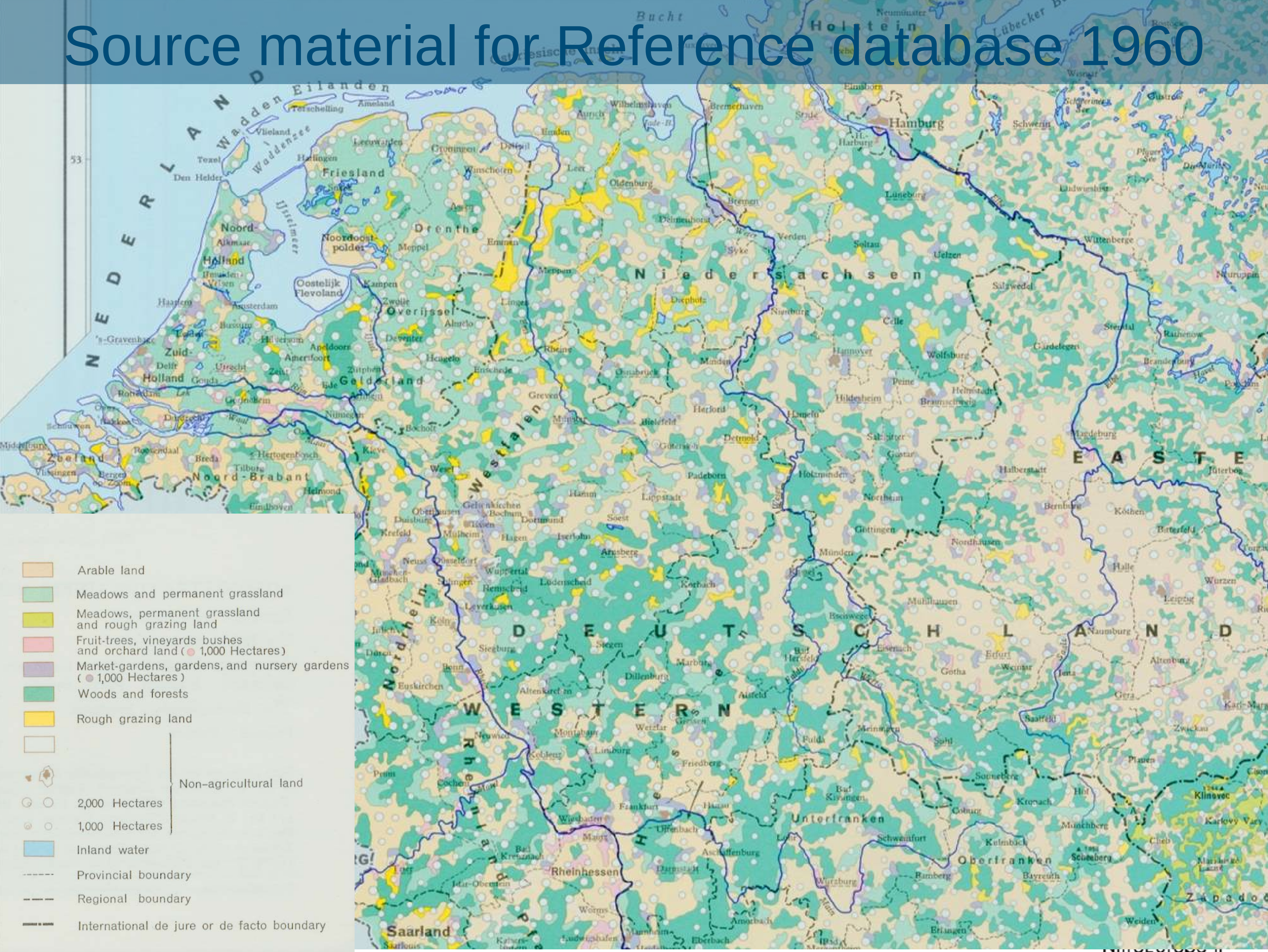
Historic land use reconstructions

- Historic land cover (maps from 1960) will be scanned and processed.
- Actual land cover information for EU 25 + 3 is available from e.g. CORINE (CLC90, CLC2000), PELCOM. Information for Switzerland and Norway (yet missing) will be included.
- CLUE model will be used to reconstruct past land use changes (retrospective analysis) at a 1km scale level.
- Historic validation for parts of Europe based on RS information in the BIOPRESS & VISTA project. Detailed validation on topographic maps (HGN) for the Netherlands.
- Land use statistics (FAO & EUROSTAT) will be collected especially for 1960 and 1975.

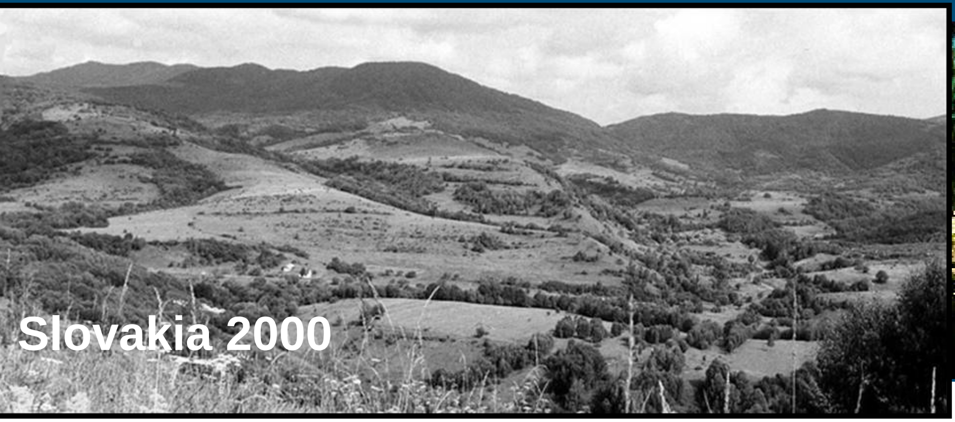


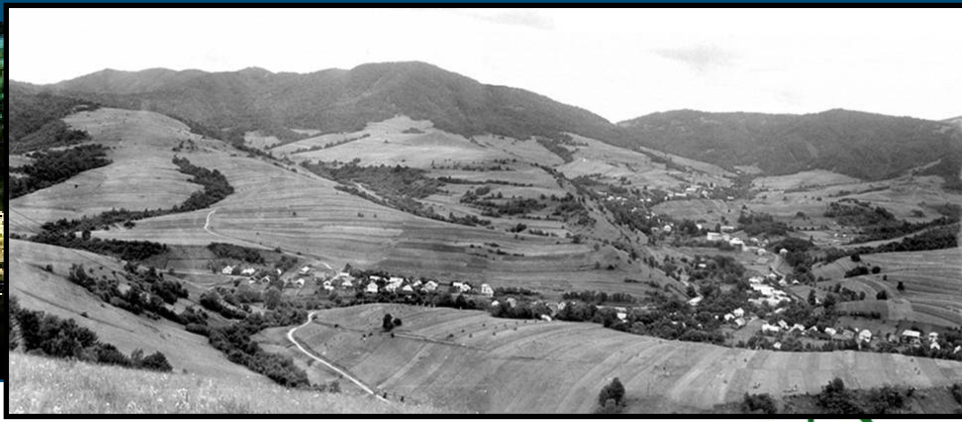
Source material for Reference database 1960



A 5.2 – Deriving scenario's on past, present and future changes

T 5.2.2 + 5.2.3. Assessing impacts of future scenarios/policies on land use





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NEU land use change models

Storylines → Following global SRES scenarios

> To what extent are changes
> In the storylines needed?

GTAP/IMAGE
Global economy and Integrated assessment models
→ Quant... a
at natio...

CLUE → High-resolution (1x1 km) land use changes

> Include new spatial data
> Include relevant policies

Models → Quant...

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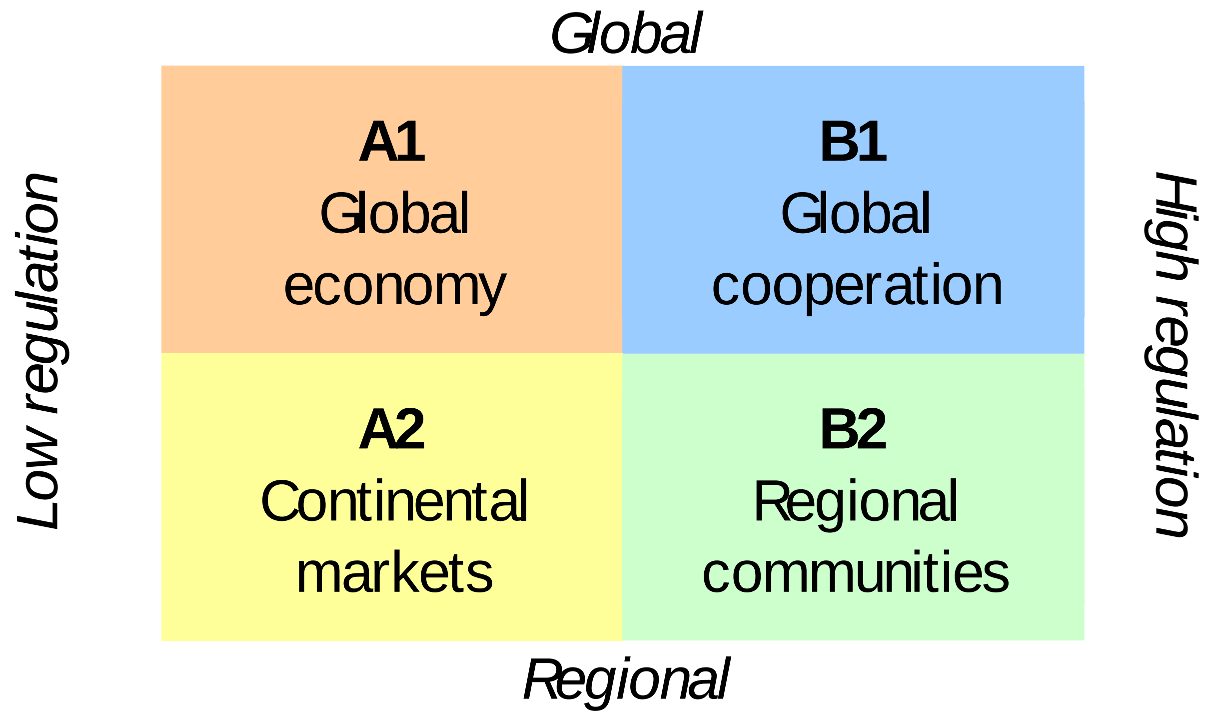
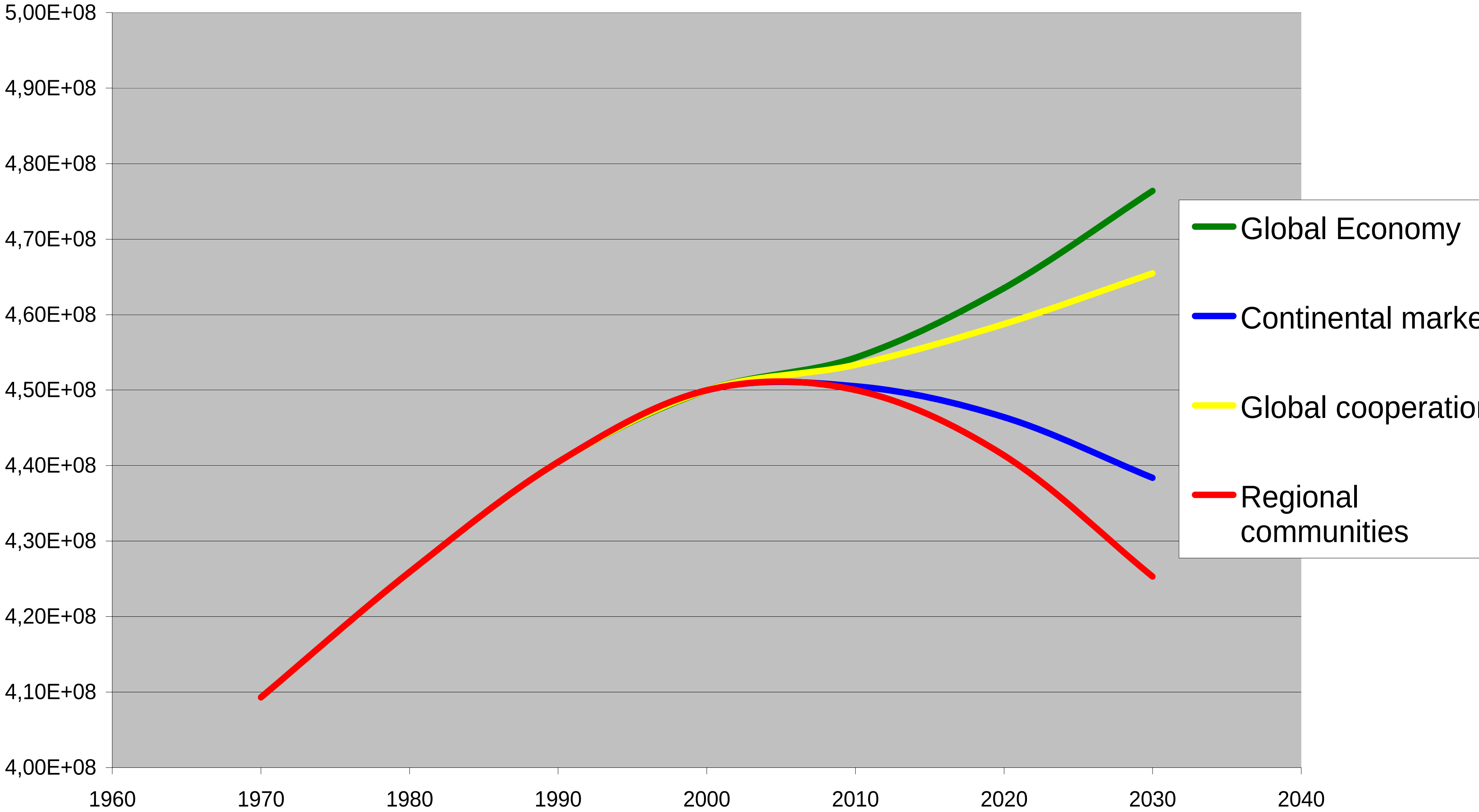
Scenario approach

Model parameters are specified, based on assumed scenario conditions



Drivers

Population EU-25



Urbanization

Residential
Industrial
Infrastructure
Recreation

Land abandonment

Regrowth of natural vegetation

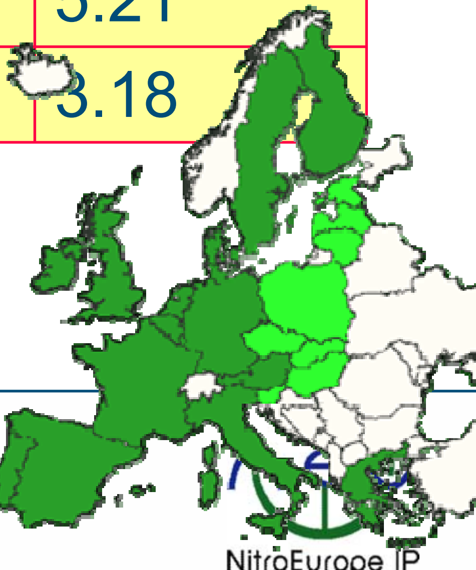
Degradation

Extensive land uses (hobby farming)

Major land use conversions

Percentage of total land area of the EU that faces urbanization, land abandonment or the development of new nature

	A1	A2	B1	B2
Urbanization	2.37	1.38	1.33	0.41
Land Abandonment	6.35	2.49	6.28	5.21
New nature	2.11	0.55	4.58	3.18



EURURALIS 2.0 prototype

1 Intro	2 past	3 scenario	4 drivers	5 general policy	**6 rural policy**	7 landuse change	8 indicators	9 integration	10 conclusions

Choose scenario

Adjust policy

Effect indicators

- Agro employment
- Rural employment
- Self-sufficiency

- CO2 storage
- N-use per ha
- Air pollution
- Water quality
- Biodiversity
- Landscape

- Farm Income
- Farm size
- Expenses

Means indicators

- Available land
- Inputs
- Water

Landuse change

Scenario A1 scenario A2 scenario B1 scenario B2 ……….

CAP

50 bill. Euro 1st pillar Continuation quota Continuation tariff	25 bill. Euro 1st pillar No quota Lower tariff walls	0 bill. Euro No quota No tariff wall

info

WFD

80% GEP	50% GEP	20% GEP

info

Energy

30% biofuels 10 % reduction CO2	20% biofuels 5 % reduction CO2	10% biofuels 0 % reduction CO2

info

RDP

50% LFA Services payments	25% LFA	0% LFA

info

EURURALIS 2.0 prototype

Choose scenario

Adjust policy

Effect indicators

- Agro employment
- Rural employment
- Self-sufficiency

- CO2 storage
- **N-use per ha**
- Water quality
- Biodiversity
- Landscape

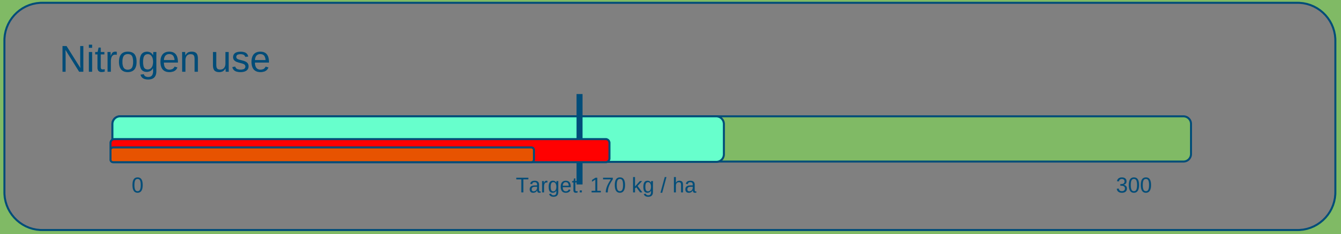
- Farm Income
- Farm size
- Expenses

Means indicators

- Available land
- Inputs
- Water

Landuse change

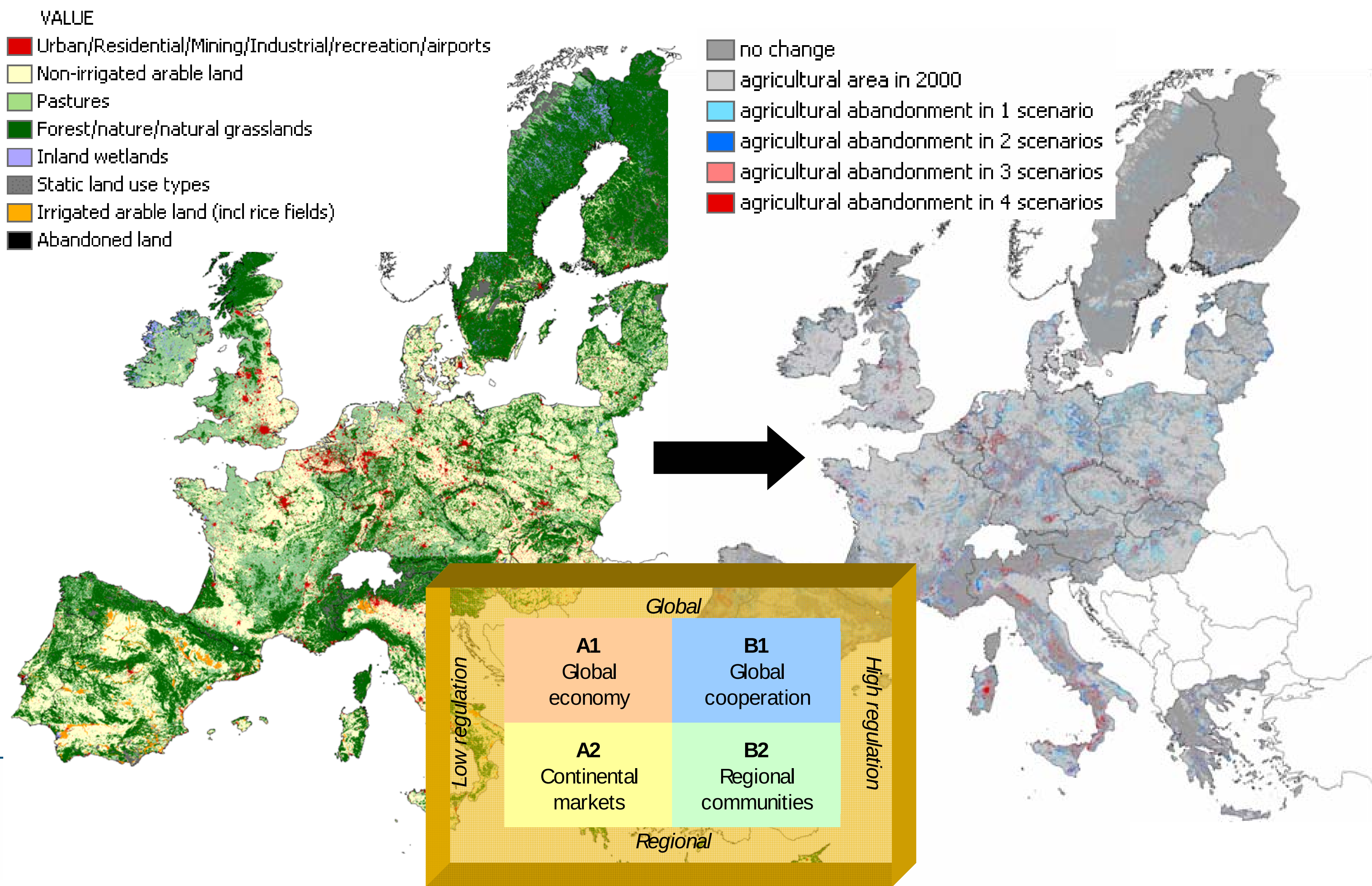
Scenario A1 scenario A2 scenario B1 scenario B2 ……….



Maps

Compare other scenarios

CLUE model input & output (Example)



Proposal Nitro Europe work scenarios

- Refine simulations of land use change for the period 2000-2030 based on updated SRES storylines, using the by EURURALIS approach:
- Refine land use classes and include nitrogen relevant spatial policies.
- Make extrapolations of land use change till 2080 based on ATEAM results for 2030-2080.

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A5.3 – Development of a multi-sector model

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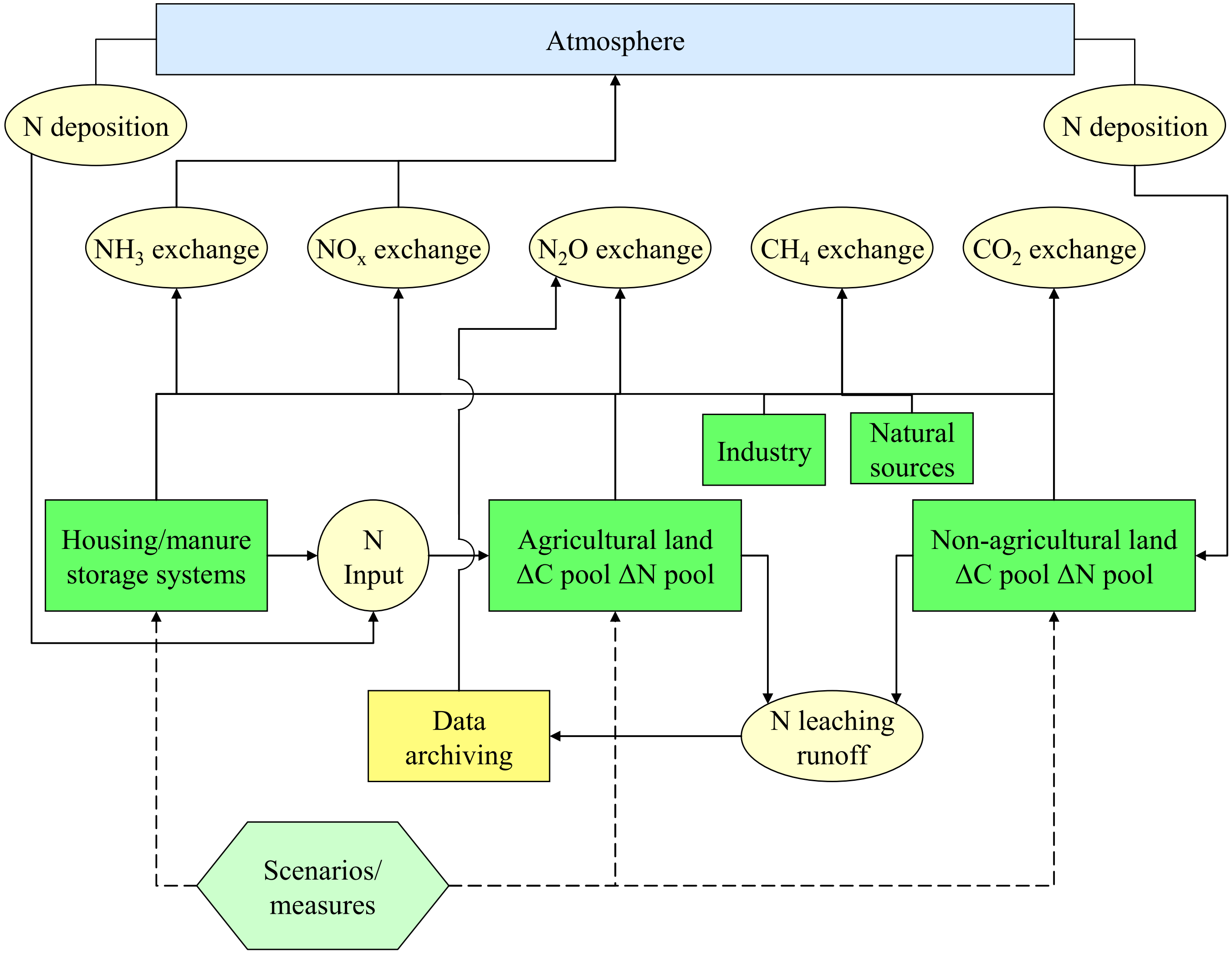
Activity 5.3 Development of multi-component model

Objective

- Develop an integrated European multi-sector and multi-component model (INTEGRATOR) to:
  - assess combined effects of past, present and future land use change and policy scenarios on European N (NH_3, NO_x) and GHG fluxes (CH_4, N_2O and CO_2).
  - assess effects of policy options to reduce the combined effects of acidification and climate change.
  - support work for the IPCC Guidelines update.

Approach:modules



Modules in INTEGRATOR

Type of emissions	*Updated IPCC approach*	*Empirical model*	*Process oriented model*
Natural sources	**CH_4 , N_2O**		
Industry	**CH_4, N_2O, NH_3, NO_x**	**-**	**-**
Animal husbandry	**CH_4, N_2O, NH_3, NO_x**	**CH_4, N_2O**	
Soils	**CH_4, N2O**	**CH_4, N_2O[1]**	***CH_4,N_2O, CO_2***
Surface waters	**N_2O (CH_4, NO_x, CO_2??)**	**N_2O??**	***N leaching***

1 Applied for model validation on upscaled independent data

A5.4 and A5.5 – Application of detailed ecosystem models and multi-sector model

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Activity 5.4 Application detailed ecosystem models

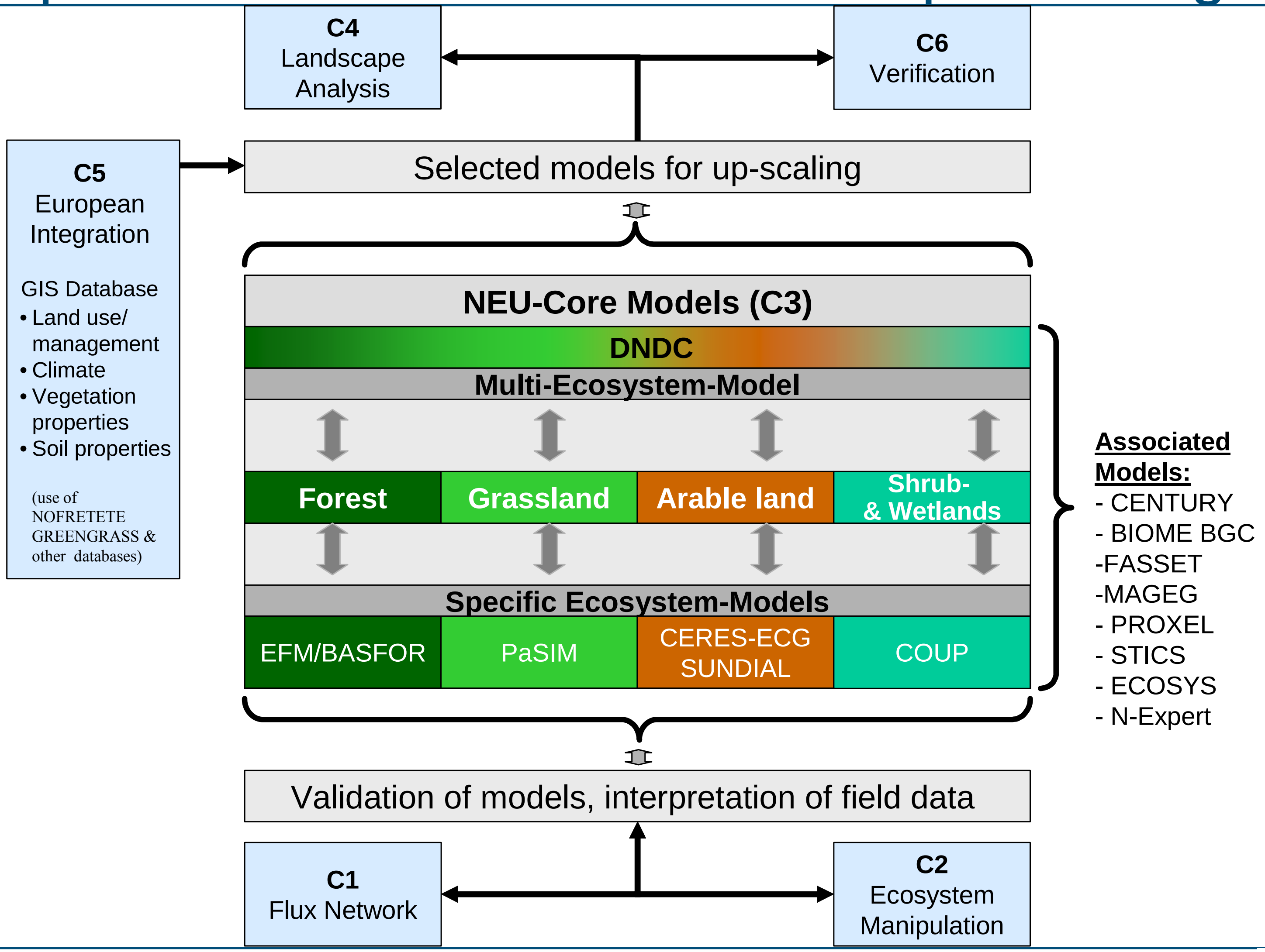
Link databases and scenarios to detailed ecosystem models to

- show the scenario effects on **soil emissions** of N, GHG and C and N sequestration in soils and living biomass.
- provide an input for the top down estimate of European N_2O and CH_4 budgets

Activity 5.5 Application of multi component model

- Link databases and scenarios to the multi-component assessment tool to:
  - show the scenario effects on **total emissions** of N, GHG and C and N sequestration in soils and living biomass.
  - provide an input for the update of the IPCC Guidelines.

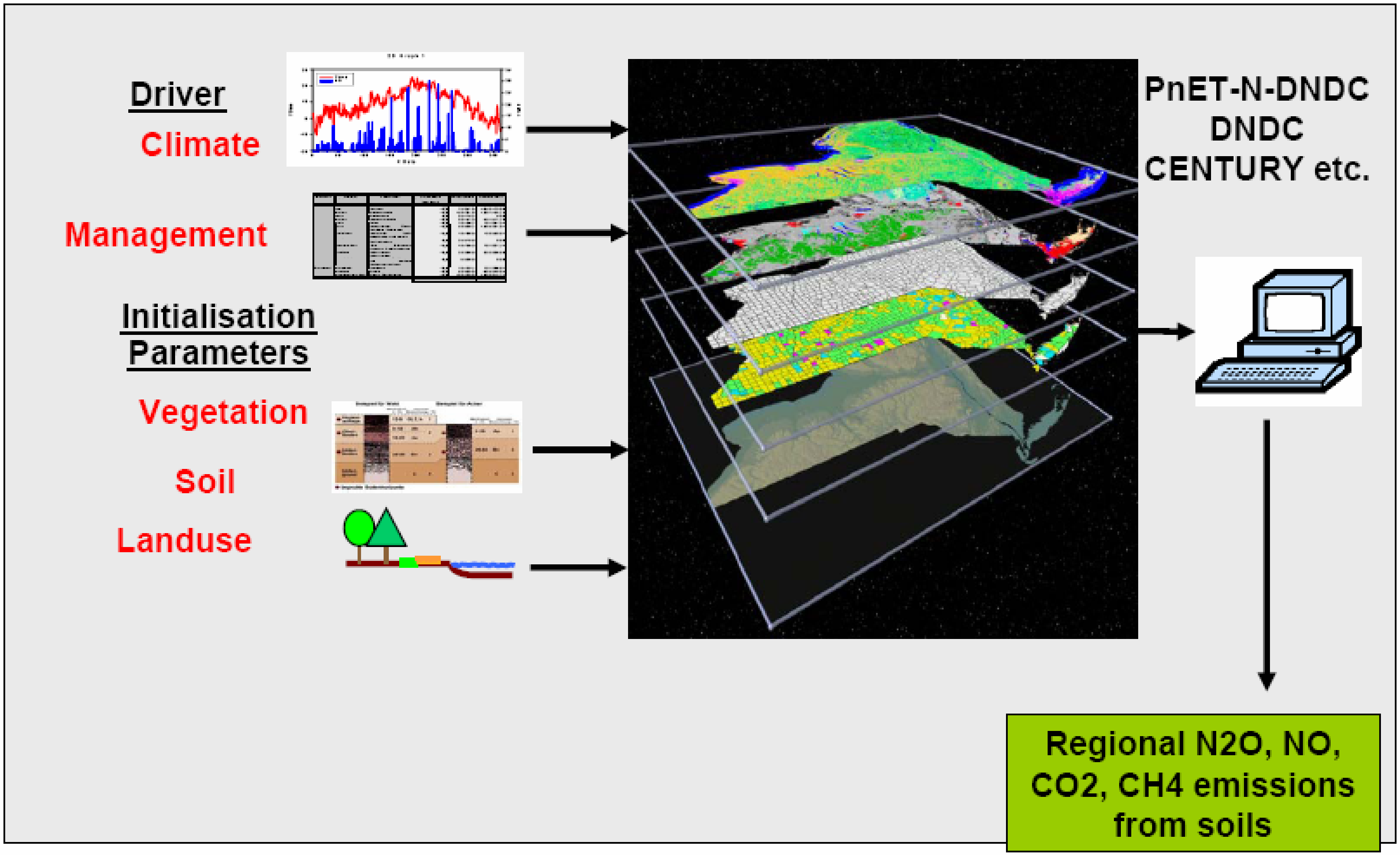
Role process-based models in European integration

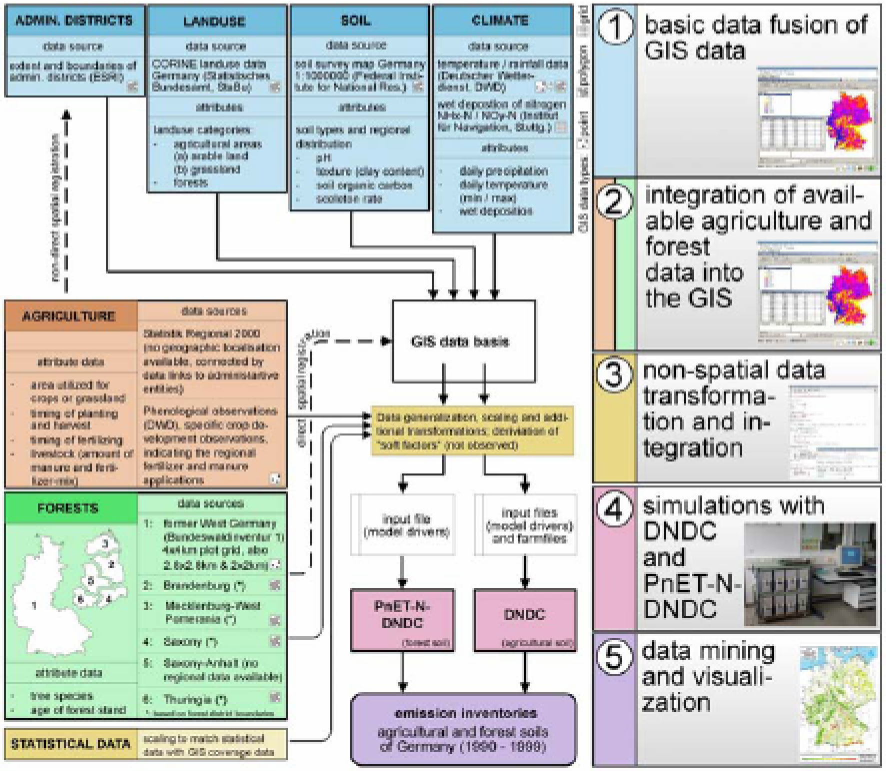


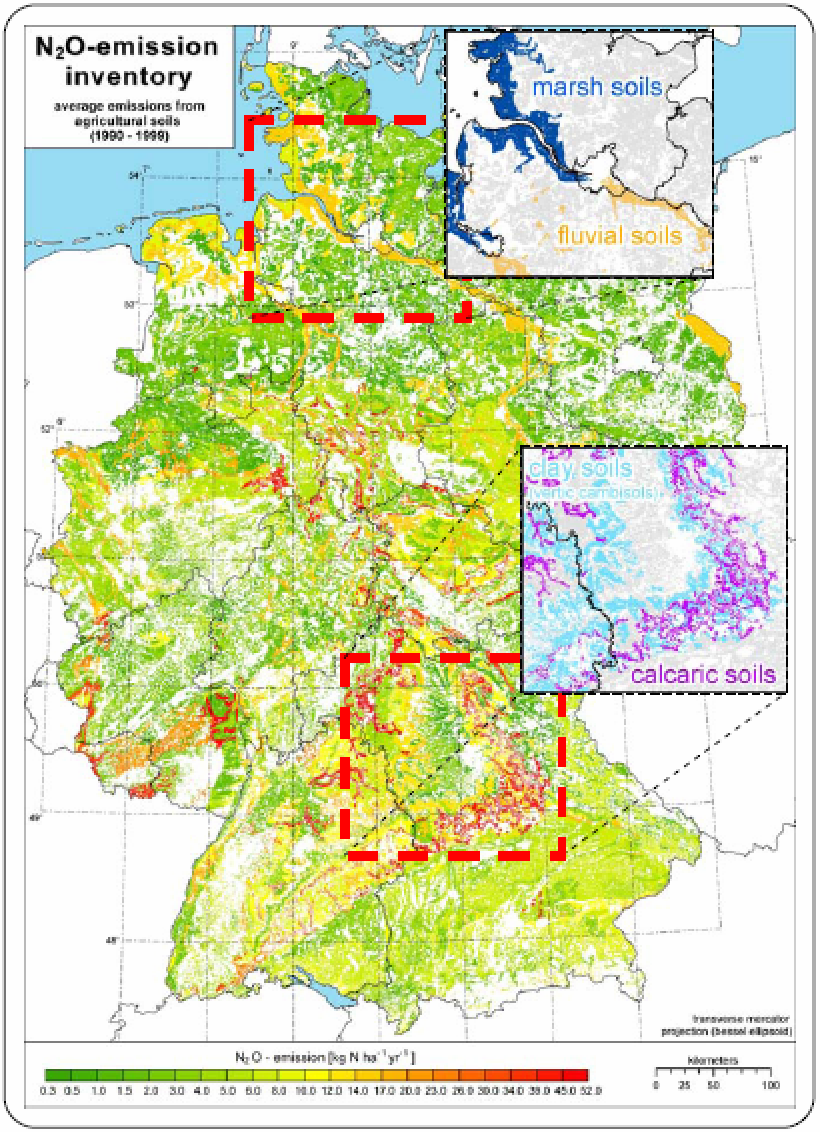
Selected detailed models for European integration

- Multi-ecosystem models:
  - DNDC
  - CENTURY
- Sectoral models
  - MAGEC/SUNDIAL/RothC
  - BASFOR-EFM
  - PaSim ??

How all the models work

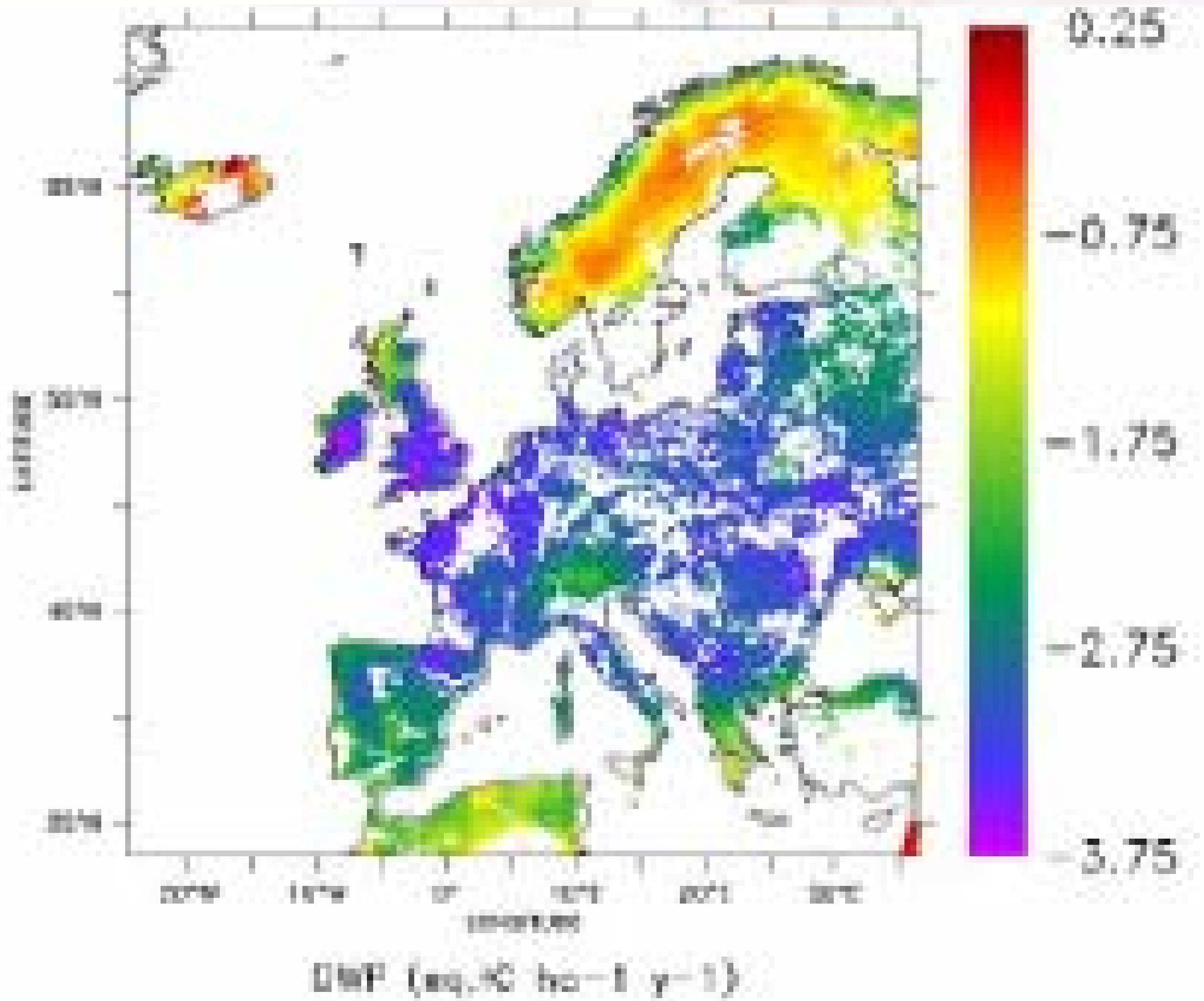






Multi-sectoral models: DNDC

Sectoral models - Grassland: PaSim



Total GHG balance (expressed as t C-eq. ha^{-1} y^{-1})

Approach to activity 5.4 and 5.5

- Use land-use and land-management reconstructions and future LUC projections to examine the impact of present and previous land-use on N and GHG emissions for Europe
- Run models for Europe for defined calculation units (combination of soil, elevation, land use etc). Examine impact of land-use and land-management. Quantify uncertainty due to
  - a) Uncertainty in land-use/management reconstruction,
  - b) Uncertainty in model parameters and variables (response to land-use and management).
- Examine potential mitigation scenarios.

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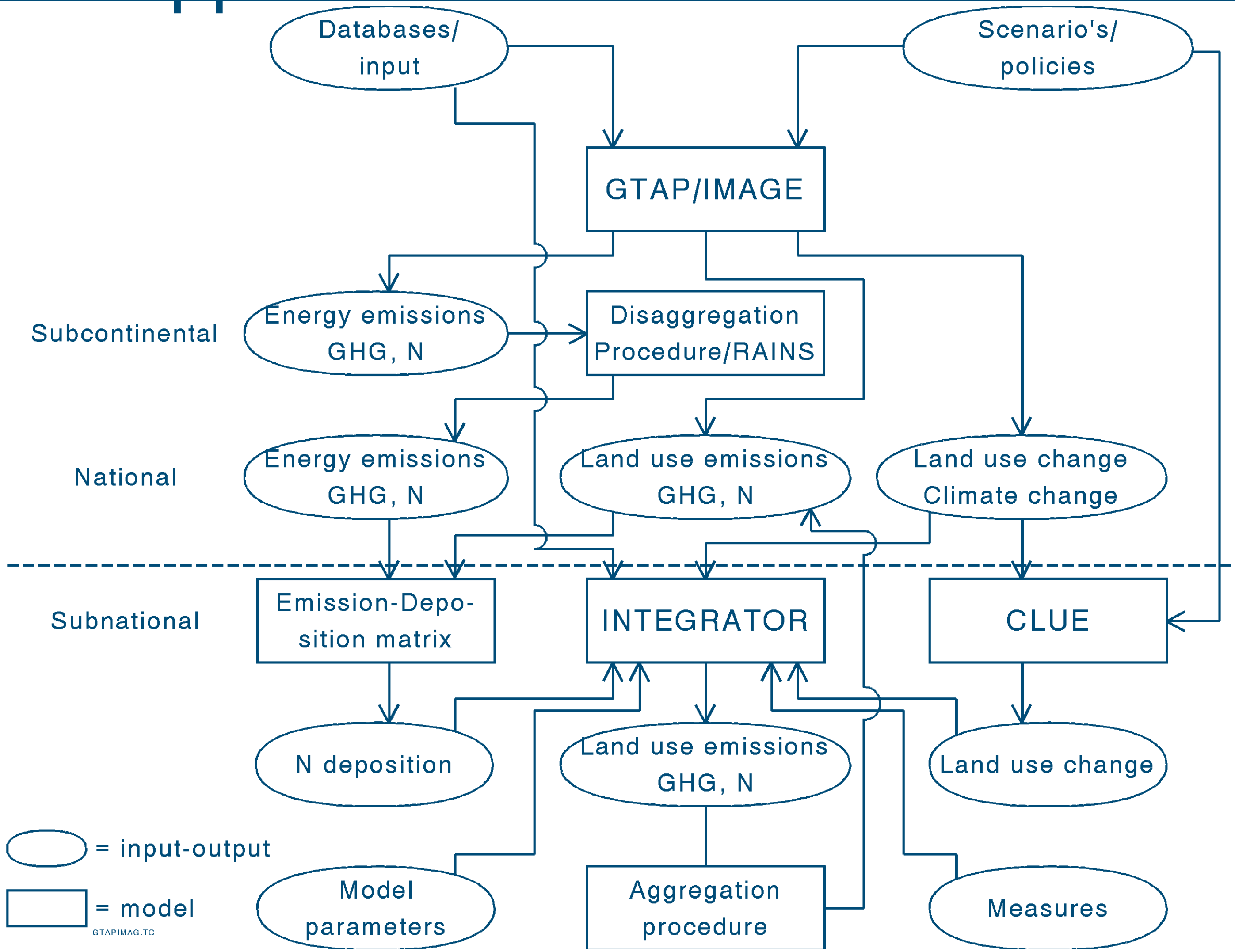
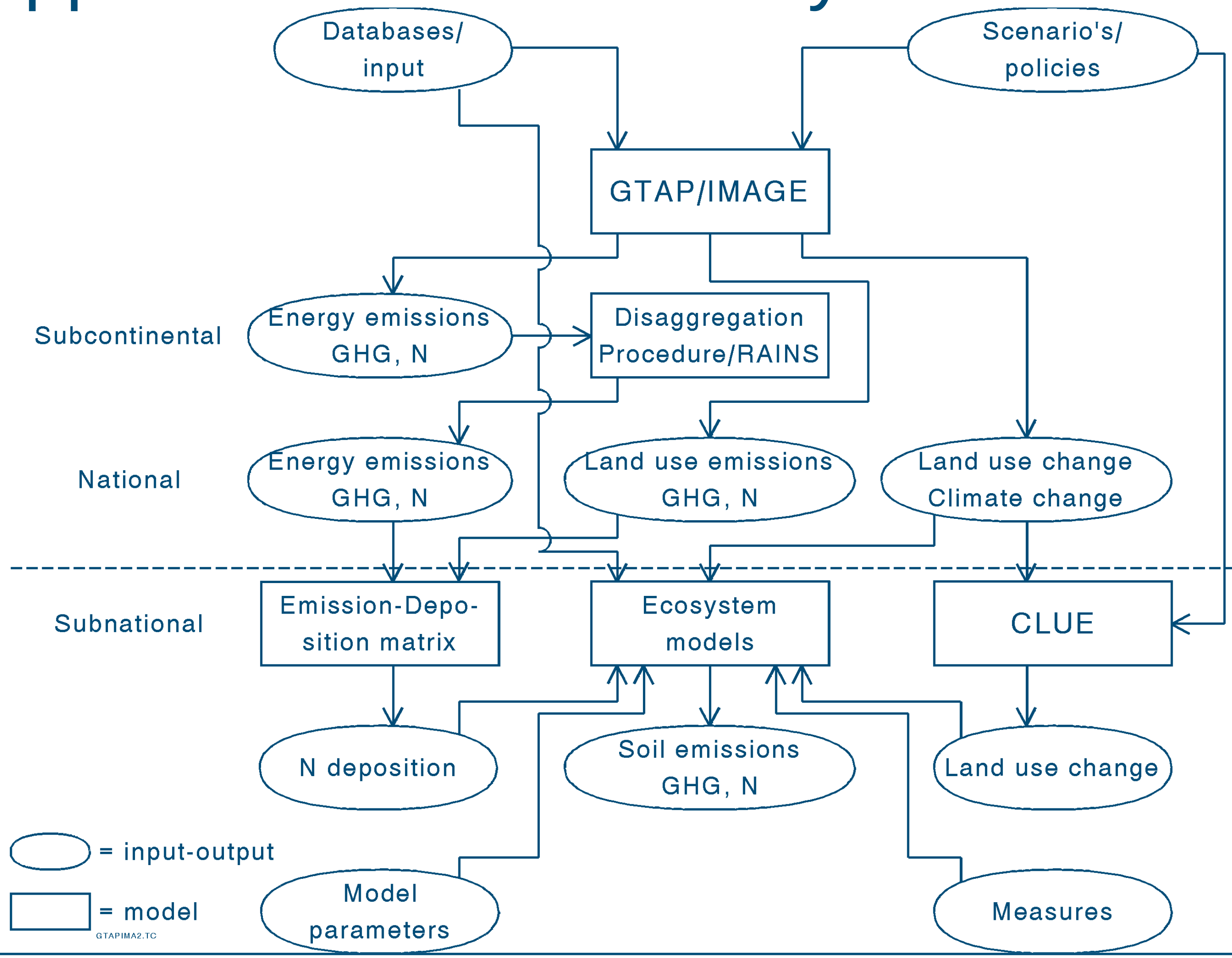
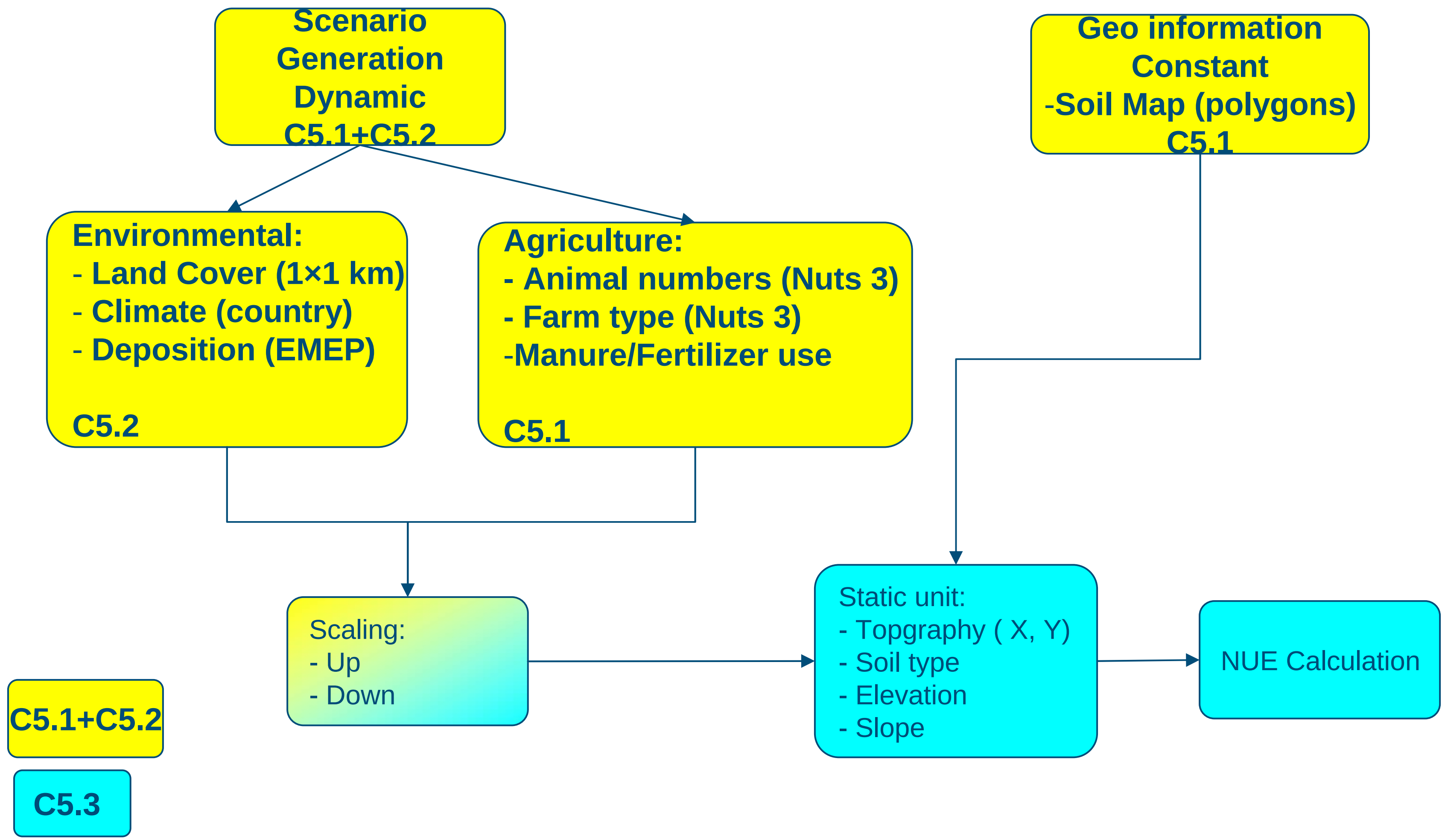
Application multi sector model



Application detailed ecosystem models



Application methodology



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Conclusions

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Previous work/Challenges

- In deriving **harmonized GIS-based data sets**, use will be made of experience in previous projects (ELPEN, CAPRI, GREENGRASS).
- NEU will put emphasis on high quality data assessment, using e.g. logic rules for deriving management information, disaggregation procedures, validation on detailed data and assigning data uncertainty.

- For the reconstruction of past changes and **scenarios** of future changes in land use/land management, climate and N deposition, use will be made of available model systems (IMAGE, CLUE) and ongoing projects (Eururalis).
- NEU will put emphasis on validation on detailed country data and on implications of including N relevant policies.

Previous work/Challenges

- In deriving a **multi-sector European-scale model** predicting **total** emissions of N and GHG use will be made of available model systems.
- NEU will integrate data derived in flux measurements and manipulation experiments in deriving modules for soil emissions, include interactions between emission from agricultural and non agricultural areas and validate results on independent upscaled empirical data

- In deriving **emissions of N and GHG in Europe**, use will be made of detailed ecosystem models that have already been applied at that scale
- NEU will estimate N and GHG emission in past, present and future in response to scenarios accounting for uncertainties, including comparing detailed models with a multi-sector model.

Parallel sessions

Tuesday 14 900-1200

- Room D. Development of harmonized datasets for European modeling (Chair: Adrian Leip) (A5.1, A6.1)

Wednesday 15 1000-1130

- Room F. European scale modeling of N and GHG fluxes (A5.3-5.5) (Chair: Wim de Vries)

Thursday 16 1045-1300

- Room C. European scale modeling: focus on scenarios (A5.2) with a link to modeling (A5.3-A5.5) (Chair: Wim de Vries, Martha Bakker)