Carbon fluxes and sequestration opportunities in grassland ecosystems

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Overview

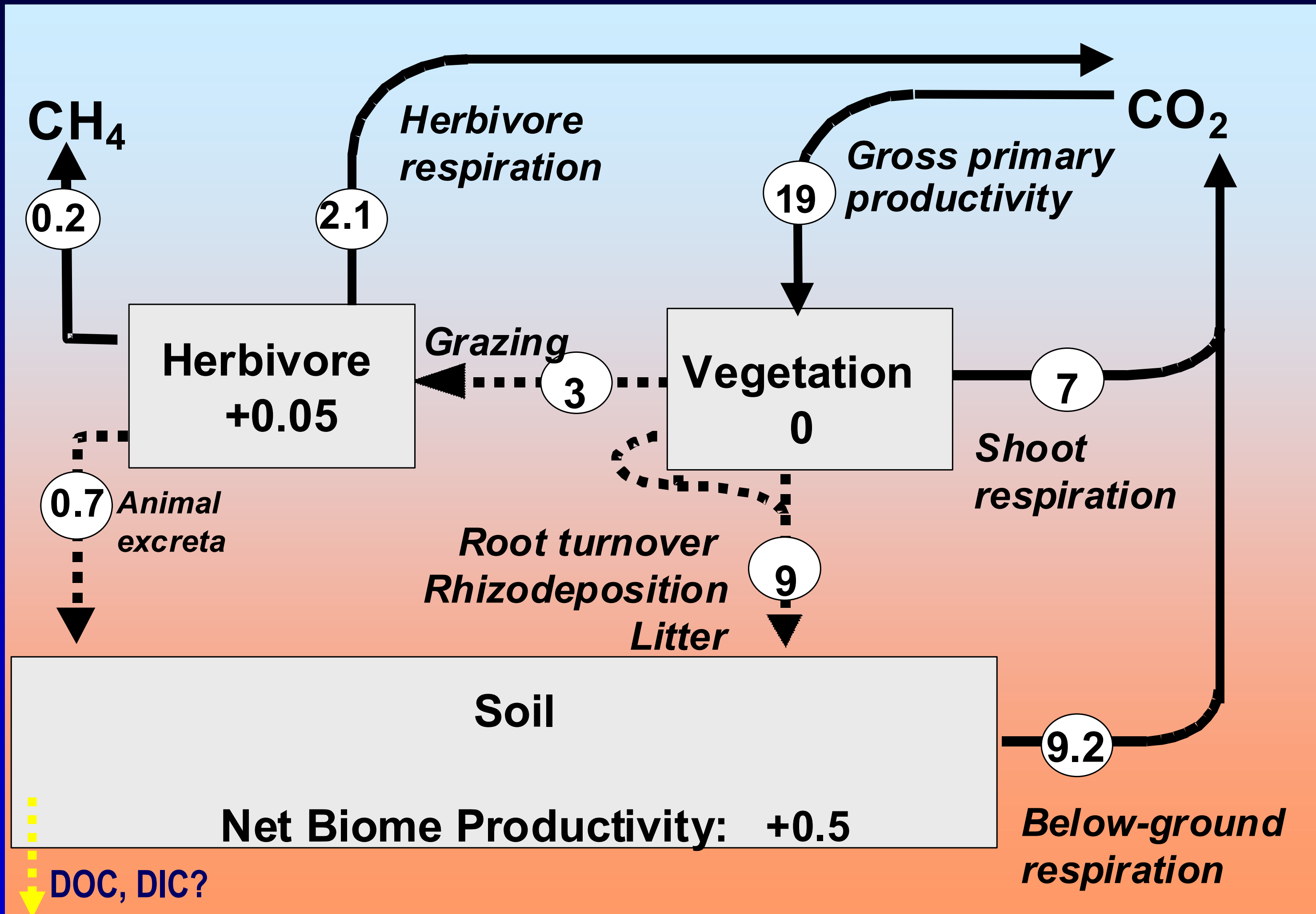
Introduction.

C cycling and Net Biome Productivity in grasslands

- Soil C and land management
- CO_2 fluxes
- Farm gate budget and mitigation options
- Upscaling to regional scale

Conclusions

Net Biome Productivity of a grazed grassland ($tC\ ha^{-1}\ yr^{-1}$)

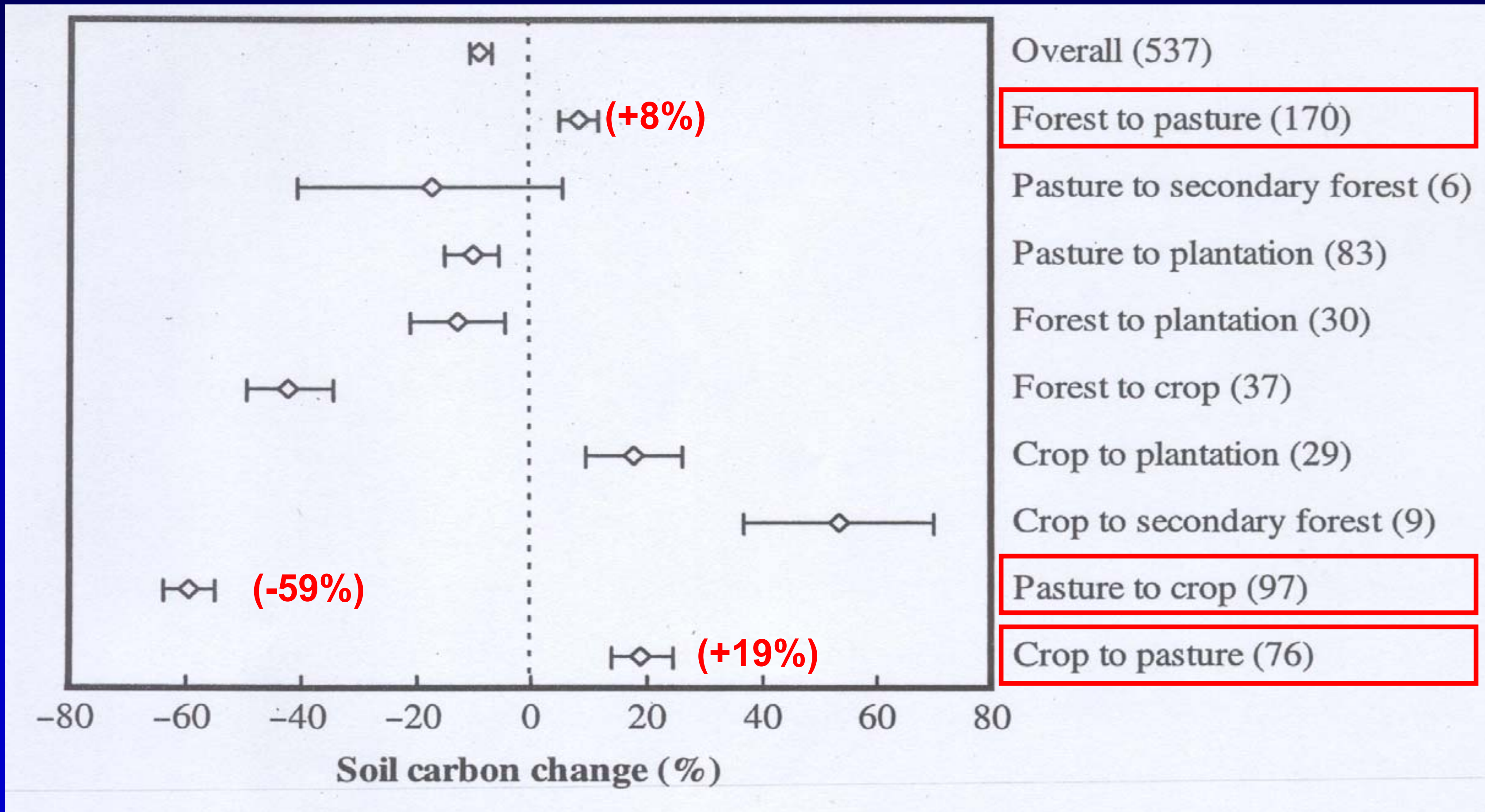


Sown grassland with intensive grazing (Soussana et al., Soil Use and Management, 2004)

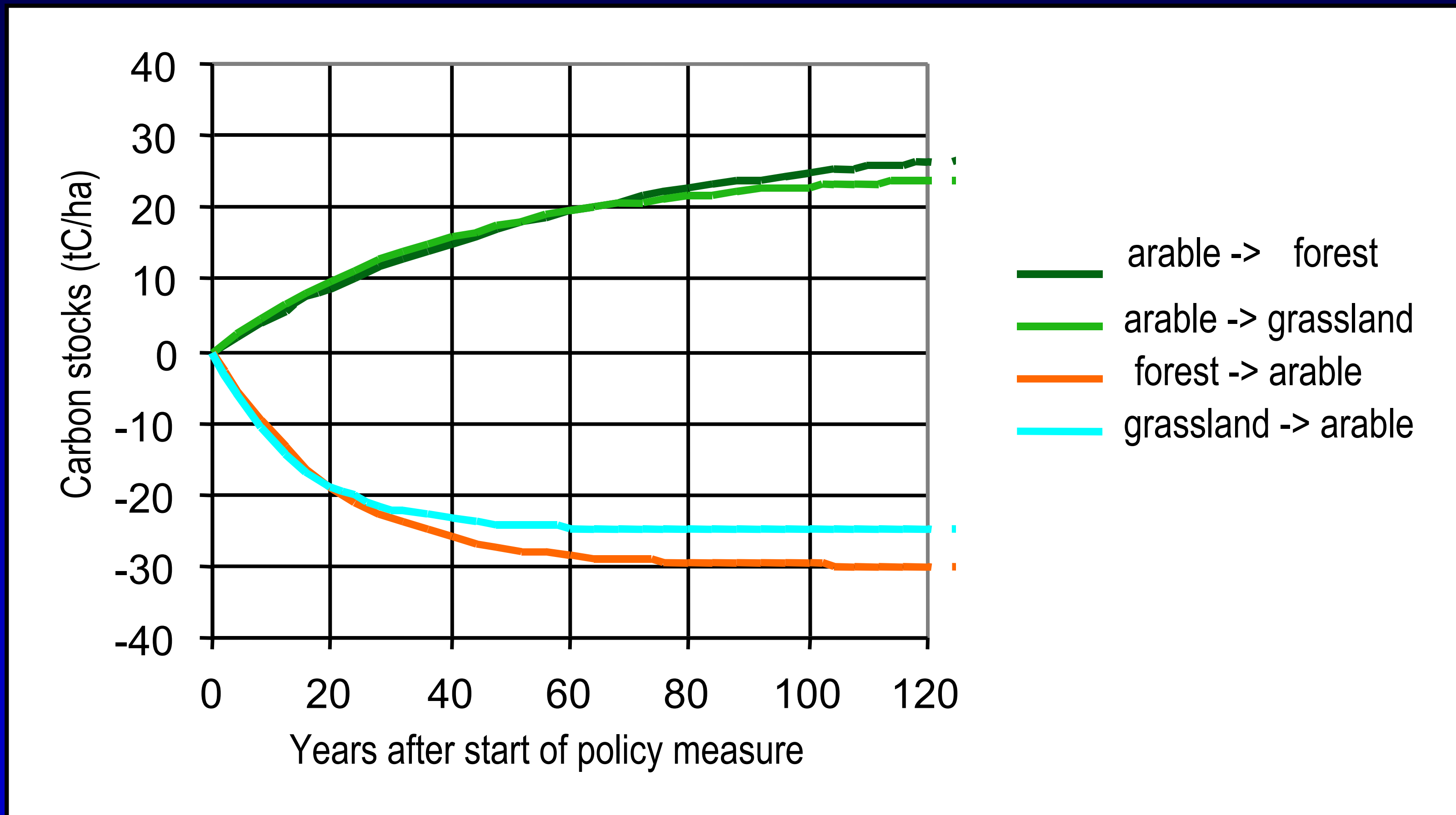
1. Grassland C stocks and land management

Land use changes from or to grasslands

(Guo & Gifford, 2002)



Land use change effects on soil carbon stocks



Land use change: carbon storage is slower than carbon relase

(After INRA, 2002)

Soil C and grassland management





Degraded
Overgrazing
Less productive Vegetation
Degraded Sites

Nominally-Managed
Native Vegetation
Pasture/Rangeland with no grazing problems or inputs

Improved (medium/high input)
Fertilizers
More Productive Grasses
Irrigation
Liming
Seeding Legumes

IPCC Grassland Management Categories

Changes in grassland C stocks

- Rates of land use and grassland management changes
  - *Need to develop improved systems for the collection of statistics on types and timing of land use change and of agricultural management events (e.g. manuring, cutting, extent of grazing etc.)*
  - Need to know past history of land use and grassland management

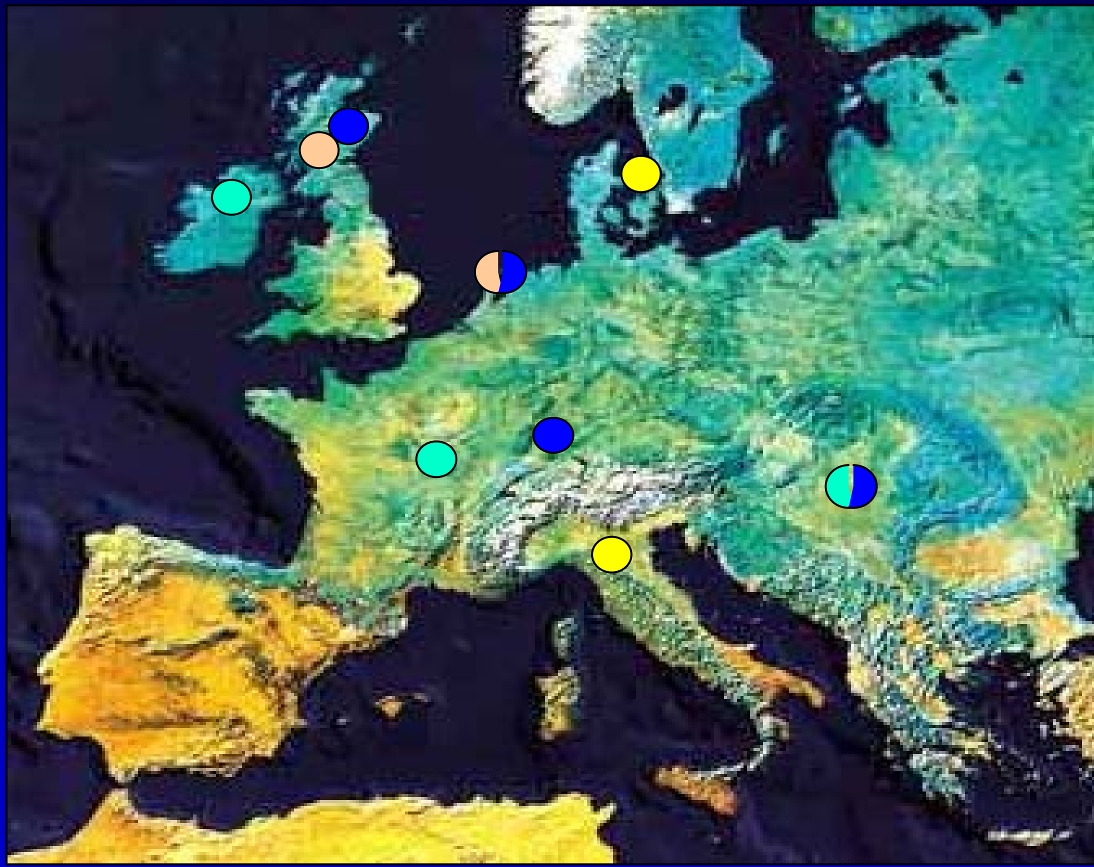
- Soil organic carbon change per unit area:
  - a) non-linear, more rapid during the early years after adopting a practice.
  - b) asymmetric: accumulation is slower than release
  - *Any estimate of soil C storage must refer to a given time period and both to the previous and current management.*
  - *Interrupting stock-enhancing practices usually results in a rapid release of carbon to the atmosphere.*

2. CO_2 fluxes

EC 'GreenGrass' project

FP5 - EESD (2002-2004)

Contributing to CarboEurope



CNR-IATAA

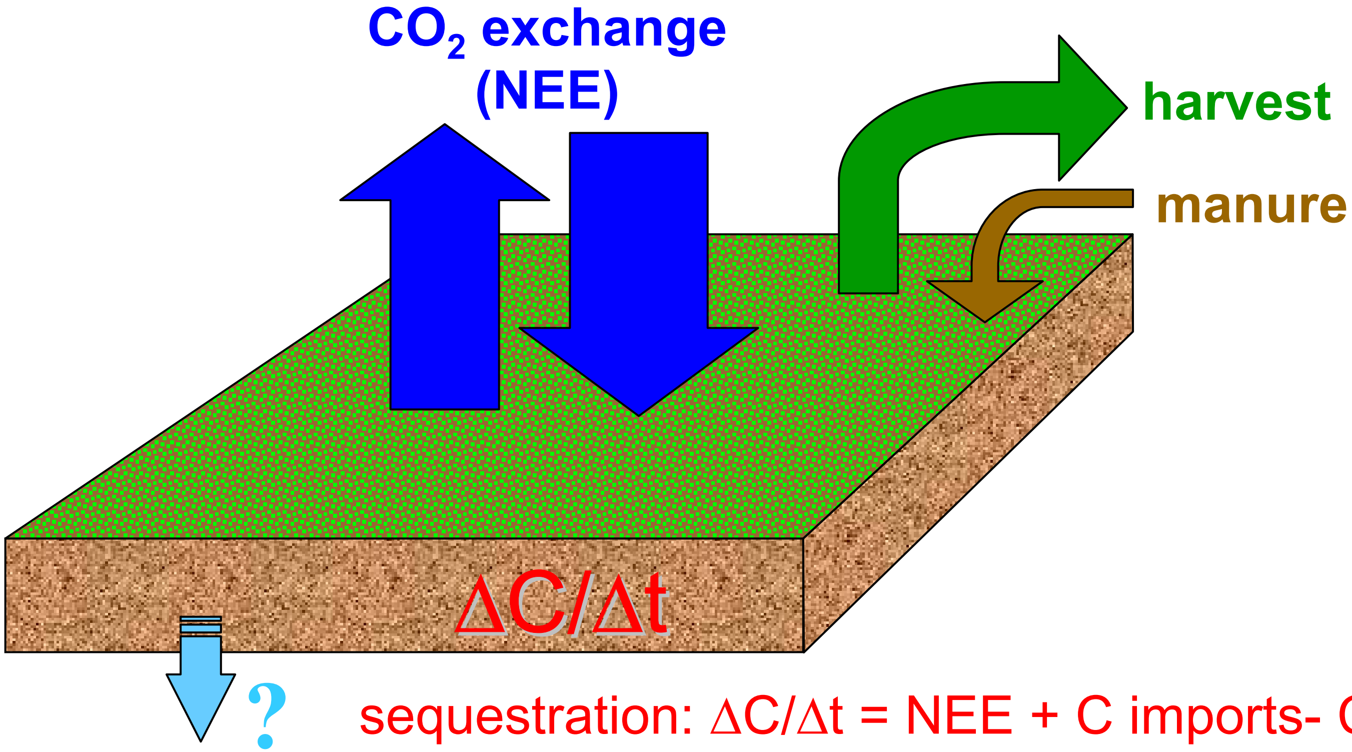
France ***(Co-ordination)*** Scotland Hungary Switzerland Ireland Italy The Netherlands Denmark

Activity 1.6. Grasslands & Wetlands

28 sites

- Main Grass.
- Main Wet.
- Anc. Grass.
- Anc. Wet.

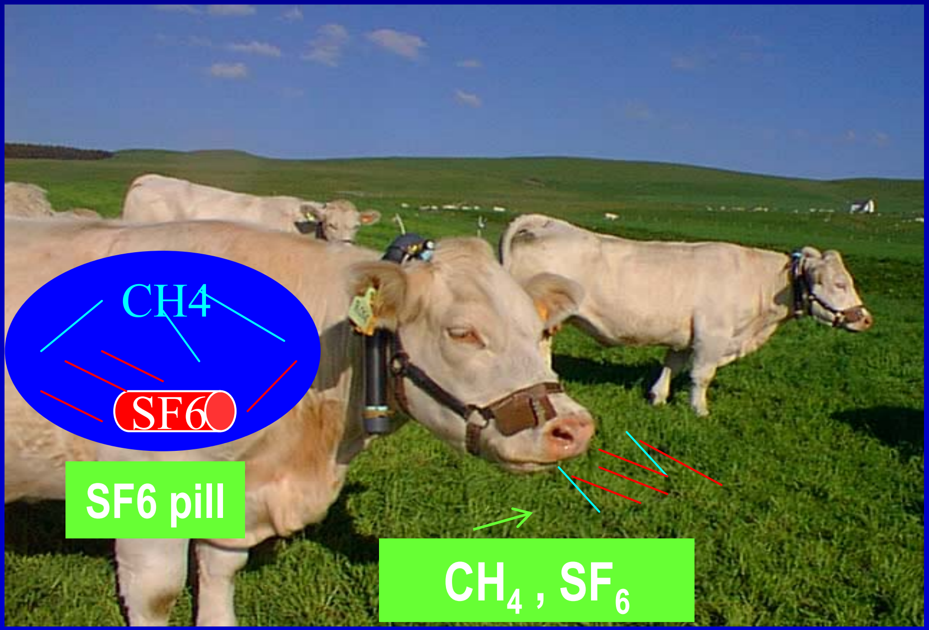
Components of the Grassland Carbon Budget



sequestration: $\Delta C/\Delta t$ = NEE + C imports- C exports

Global warming potential: N_2O and CH_4 trade-offs with CO_2

N_2O: automated static chambers and TDL



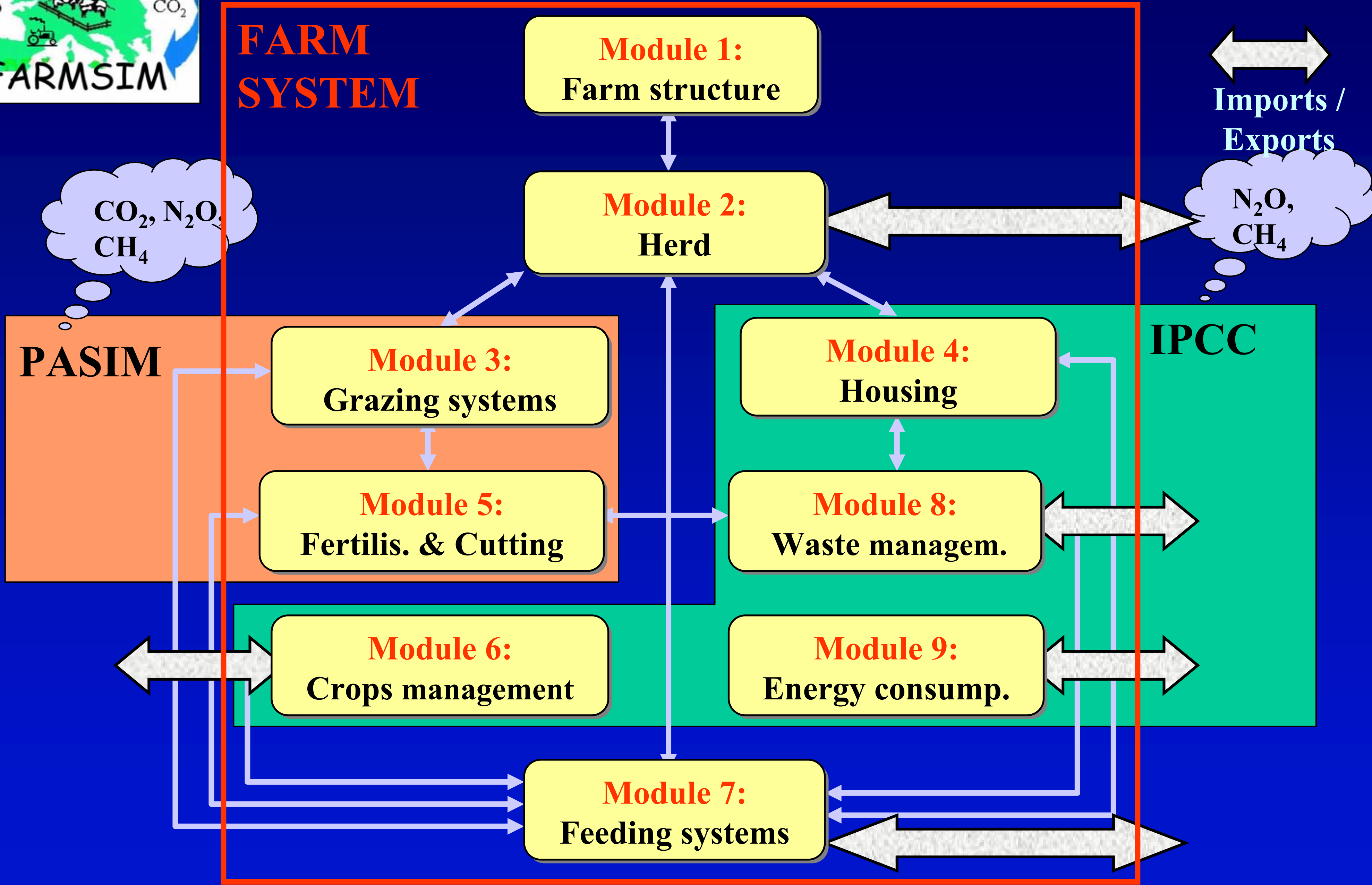
CH_4: *in-situ* SF_6 tracer method

Field scale flux measurements

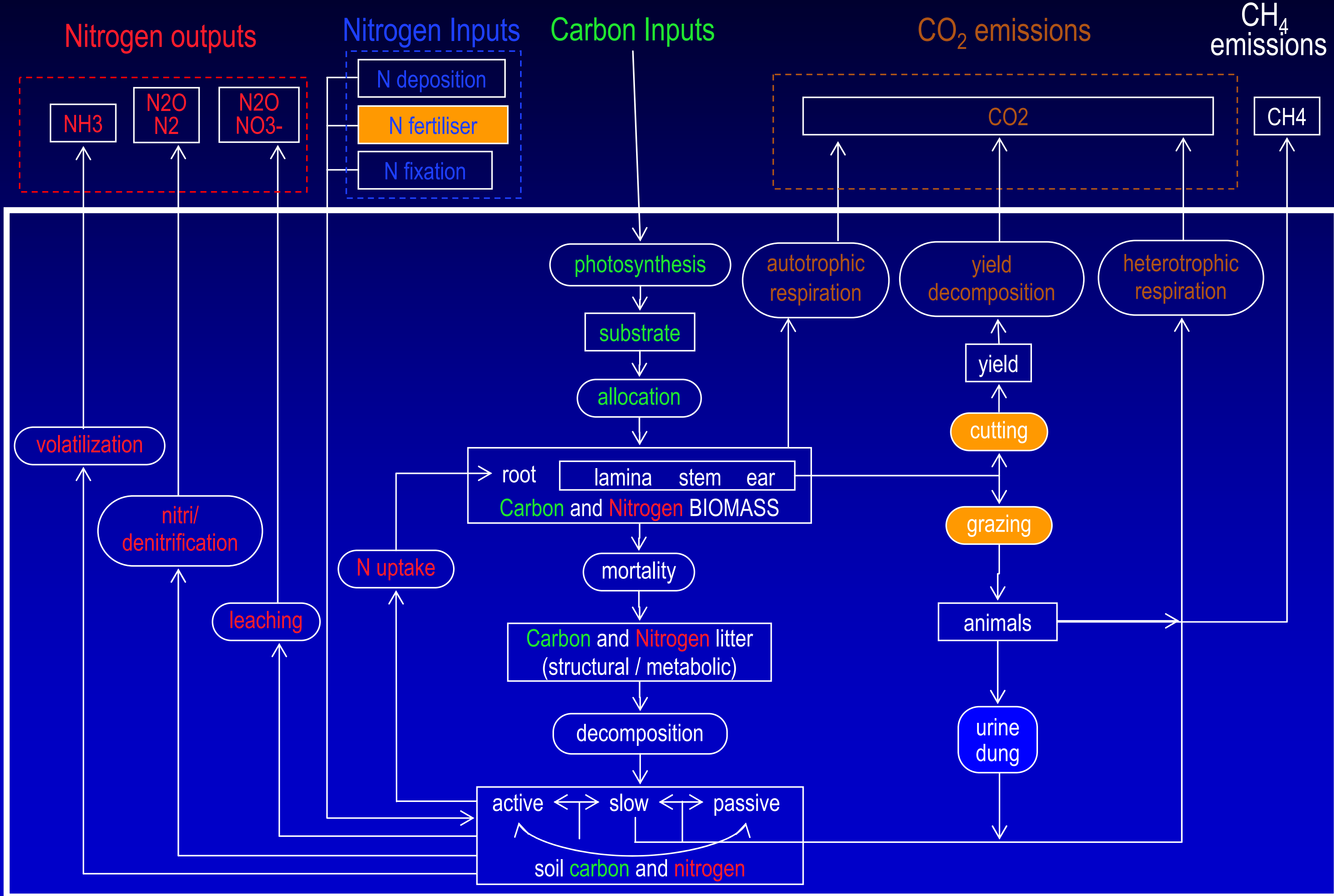
- In terms of NEE, managed grasslands are large apparent sinks of C
- C imports from manures and C exports from cuts should be taken into account to estimate NBP.
- Uncertainty associated to NBP is high
- The NBP was found to be a carbon sink, with approximately half of the sink activity resulting from imports of C from manures
- Emissions of N_2O and CH_4 resulted in a 40 % offset of the NEE
- The attributed emission balance, including indirect emissions of CO_2 and CH_4 from the cut herbage, was on average neutral.

3. Upscaling C budgets at the farm scale

Structure of the farm model FARMSIM



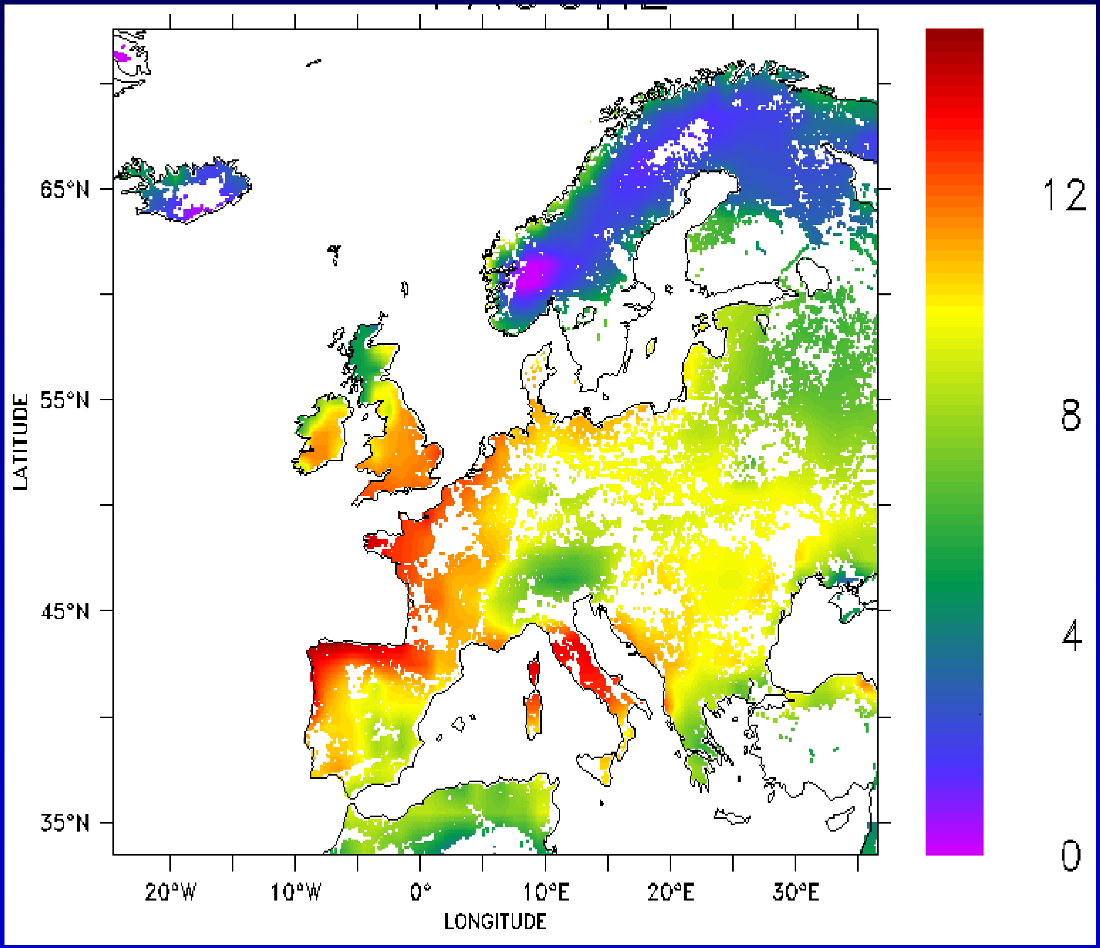
PaSim model (FAL, LSCE, CEH, INRA)



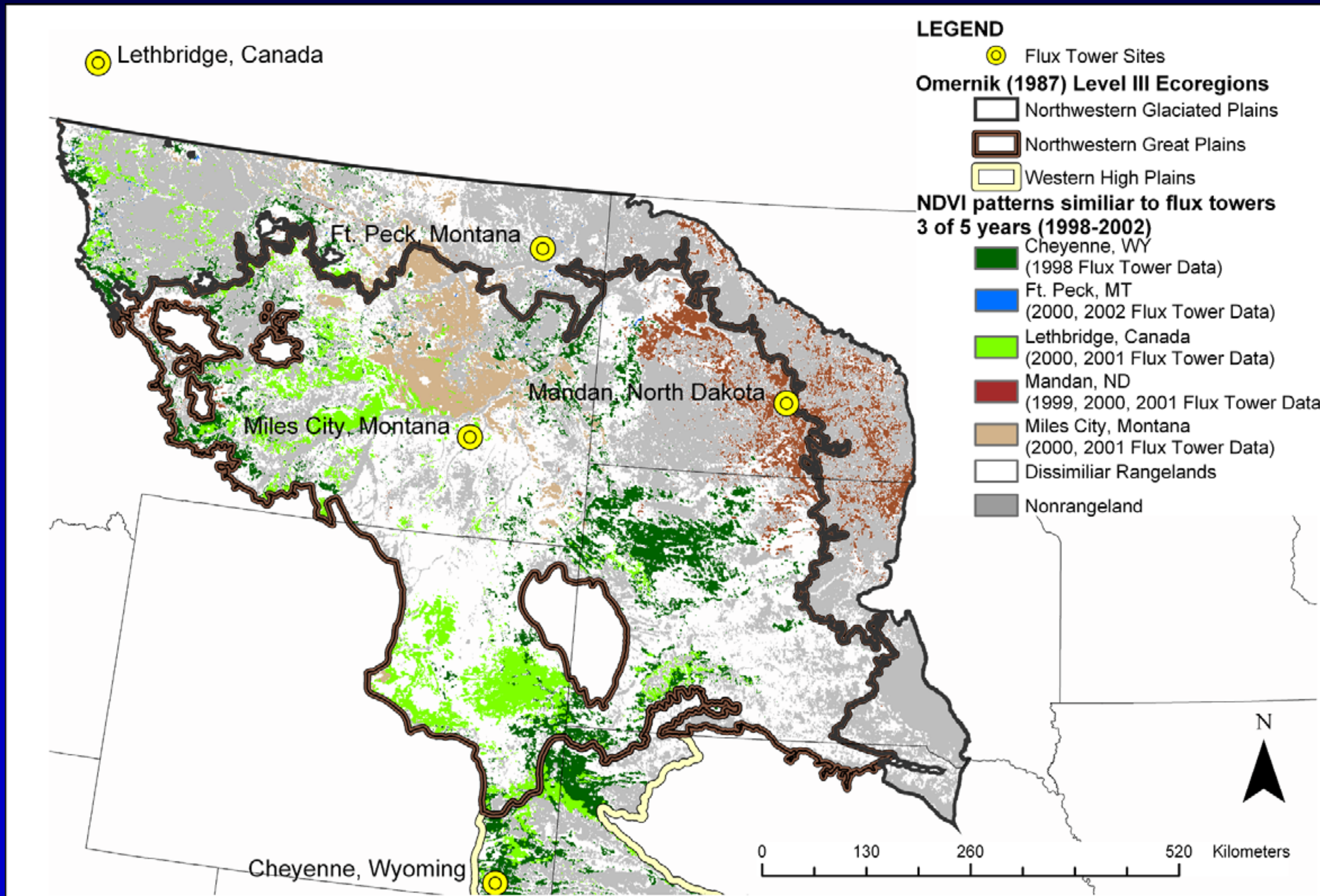
Farm scale C and GHG balance

- All simulated cattle farms were sources of GHG
- Indoors emissions are a major component of the farm budget
- Non CO_2 trace gases play a major role in the GHG budget
- Rate of emission per unit land area increased from extensive to intensive farming systems.
- Possibility to upscale budgets per region according to farm type. This allows to account for changes in farming practices.
- Pre-chain emissions may lead to much higher emission than farm gate budgets.

4. Upscaling grassland C budgets at the regional scale

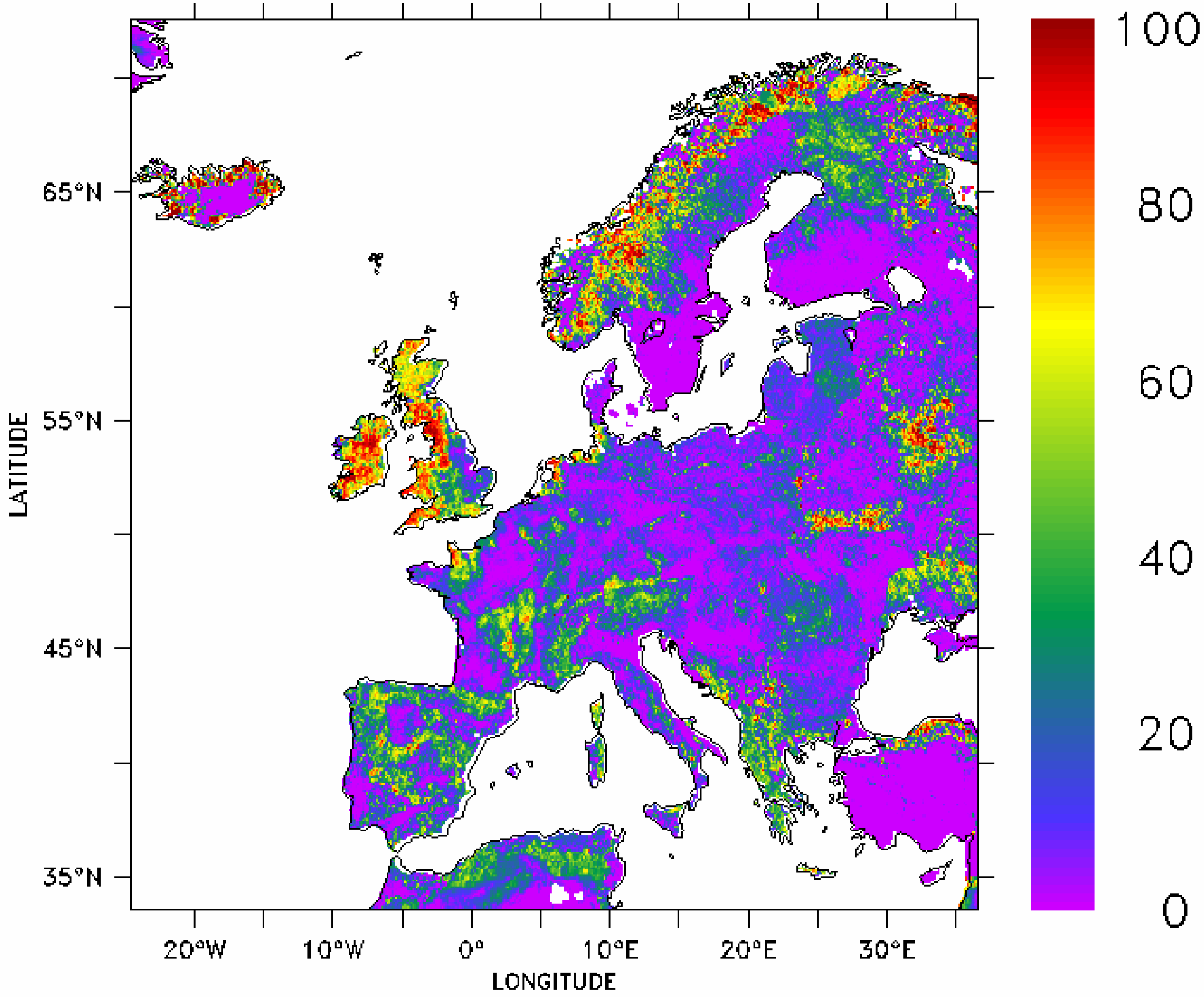


Ecosystem Similarity Concept



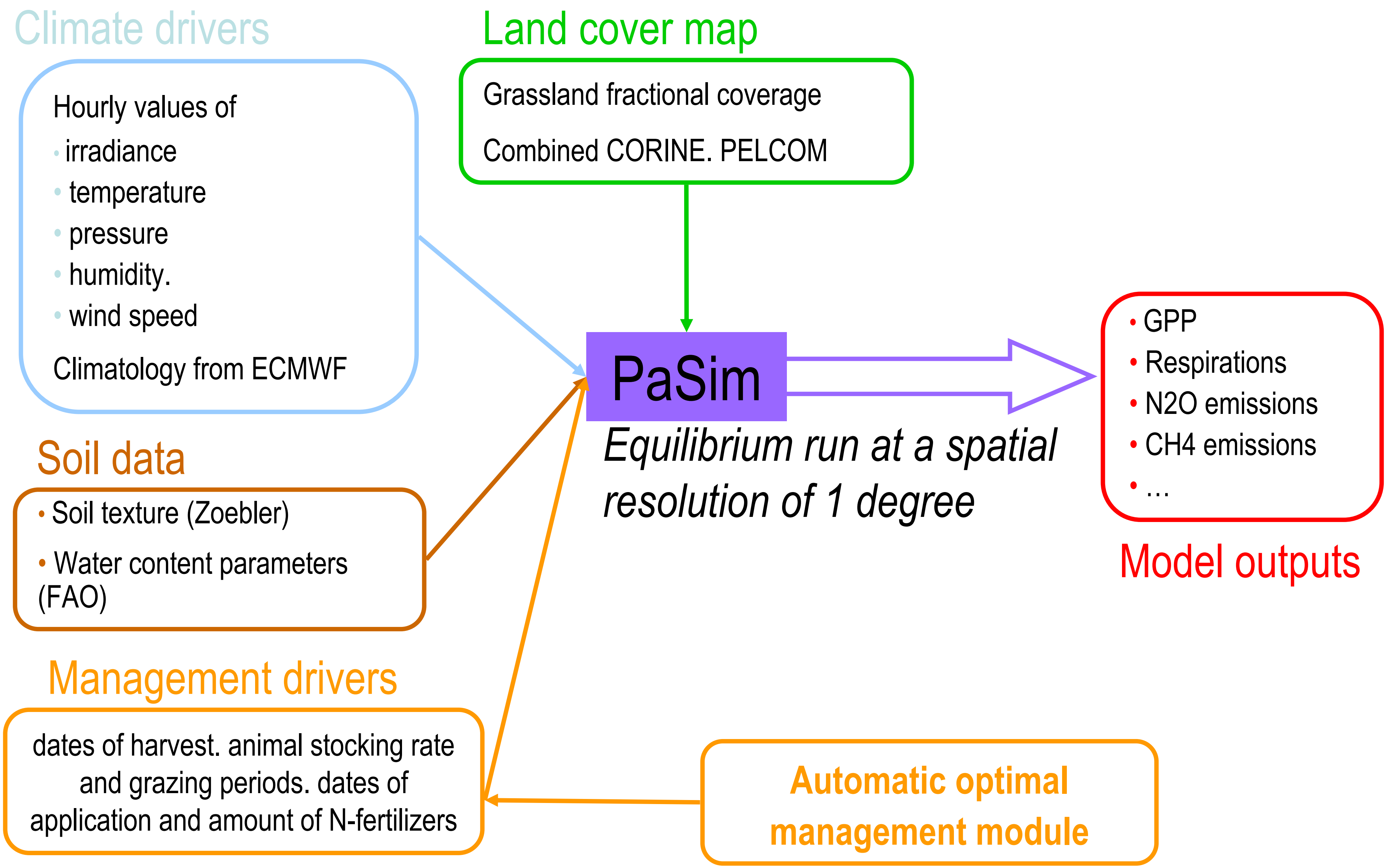
Gilmanov, Wylie, et al. 2004

Grasslands in Europe



% land cover (CORINE – PELCOM data)

Upscale Pasim at a regional scale



(Vuichard et al.)

Upscaling C budgets at regional scale

- Phenomenological models (with NDVI and GIS)
  - Light-response functions method works with grasslands
  - Provides estimates compatible with ecological theory and data
  - There are significant relationships between ecosystem scale characteristics and remotely sensed and on-site factors
- Process-based simulation models
  - CO_2, N_2O and CH_4 fluxes can be predicted by a process driven model at the European scale. It takes into account management
  - Optimal management scenario predicts
    - realistic values of yield
    - realistic dependencies with temperature and precipitation
  - Refine runs by using “real” management data
  - Develop “mitigation” runs