EUROPEAN COMMISSION
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Modelling nutrient fate from agriculture: an integrated framework

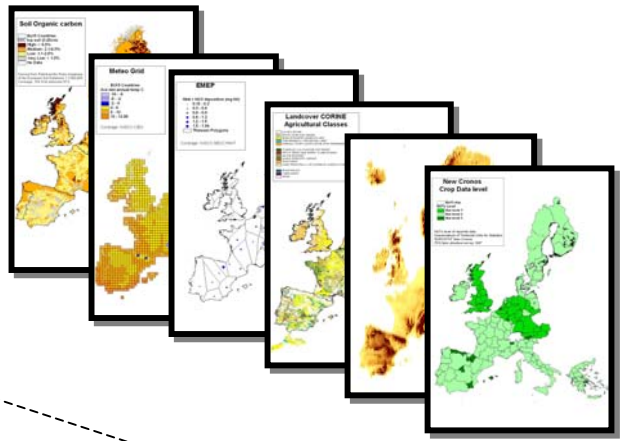
Bouraoui F., Grizzetti B., Mulligan D, Galbiati L.

Zurich July 13-15 2005
International Swat Conference

ies Institute for Environment and Sustainability
Soil and Waste Unit

Framework of FATE

Europe-wide Harmonized Geographical Database



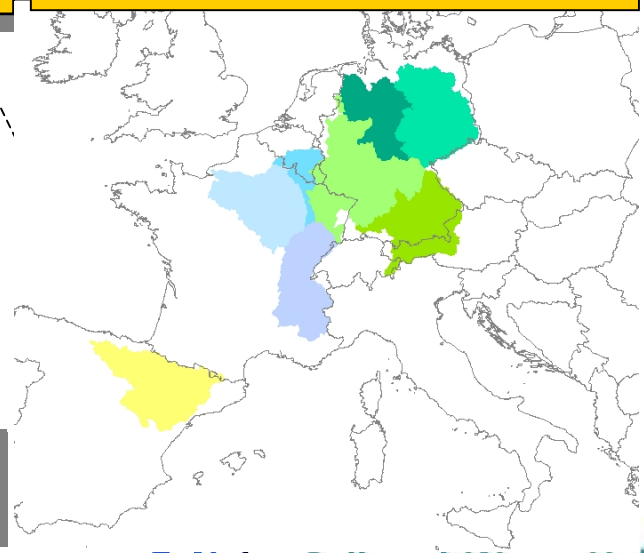
Policy Questions:

- Nitrate Directive
- Water framework directive
- Environmental indicators - IRENA
- The Soil Thematic Strategy

Policy Support

Assessment procedures
(nested approach)

STAT > SWAT > EPIC



Scenario analysis

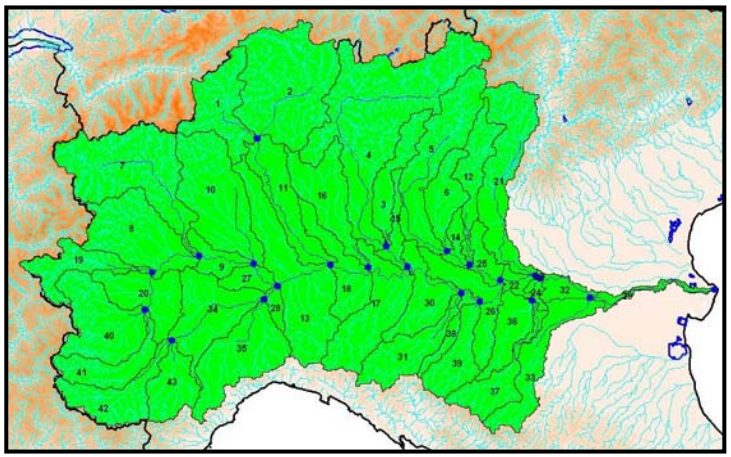
(agricultural practices)

Results, reports, maps, recommendations

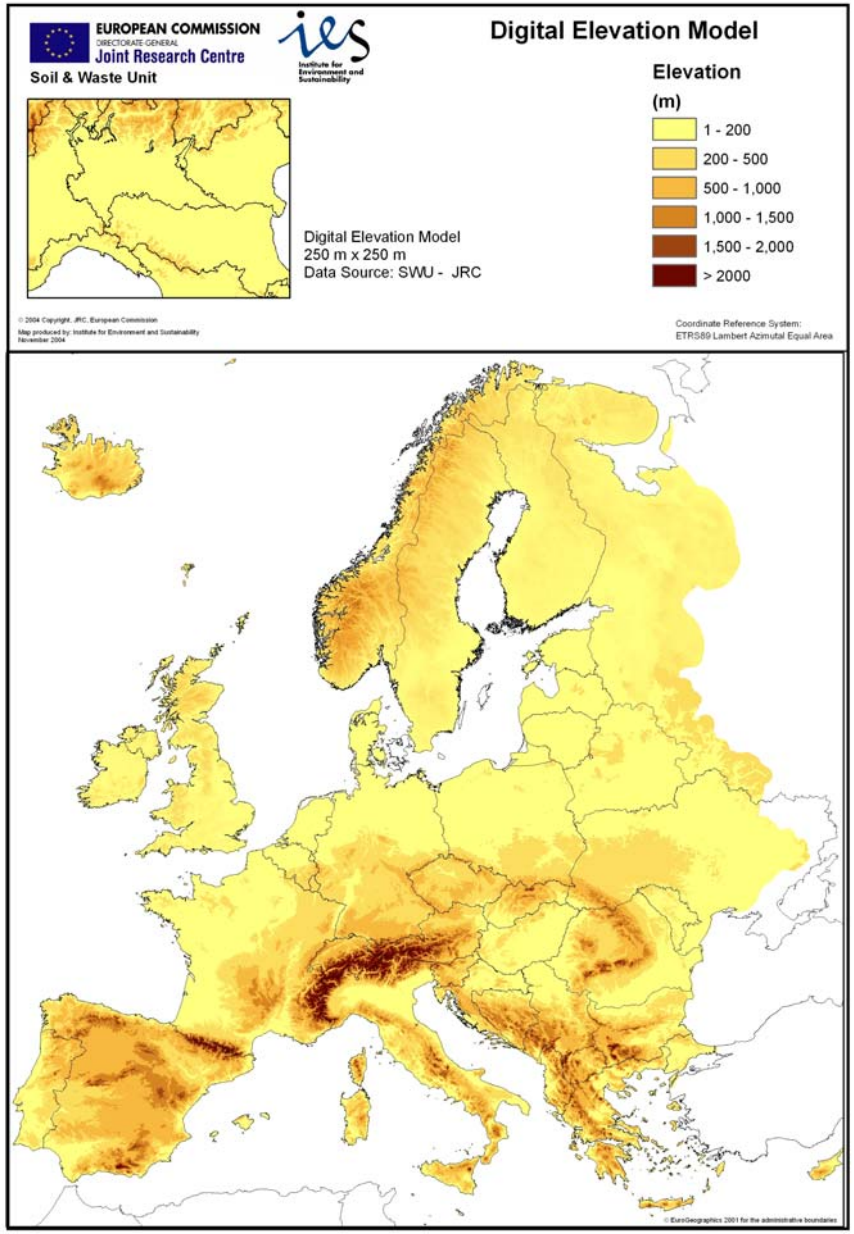
European DEM

•Source: **CCM SWU- JRC**
(Catchment characterisation and modelling

DEM 250 m x 250 m



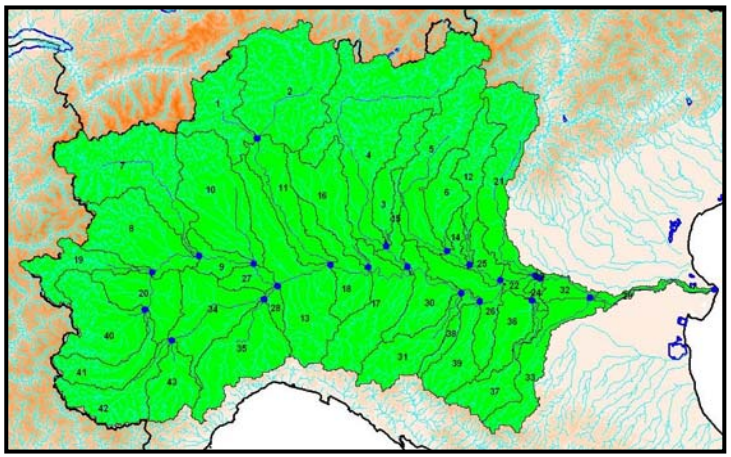
e.g. Po Valley – basin delineation



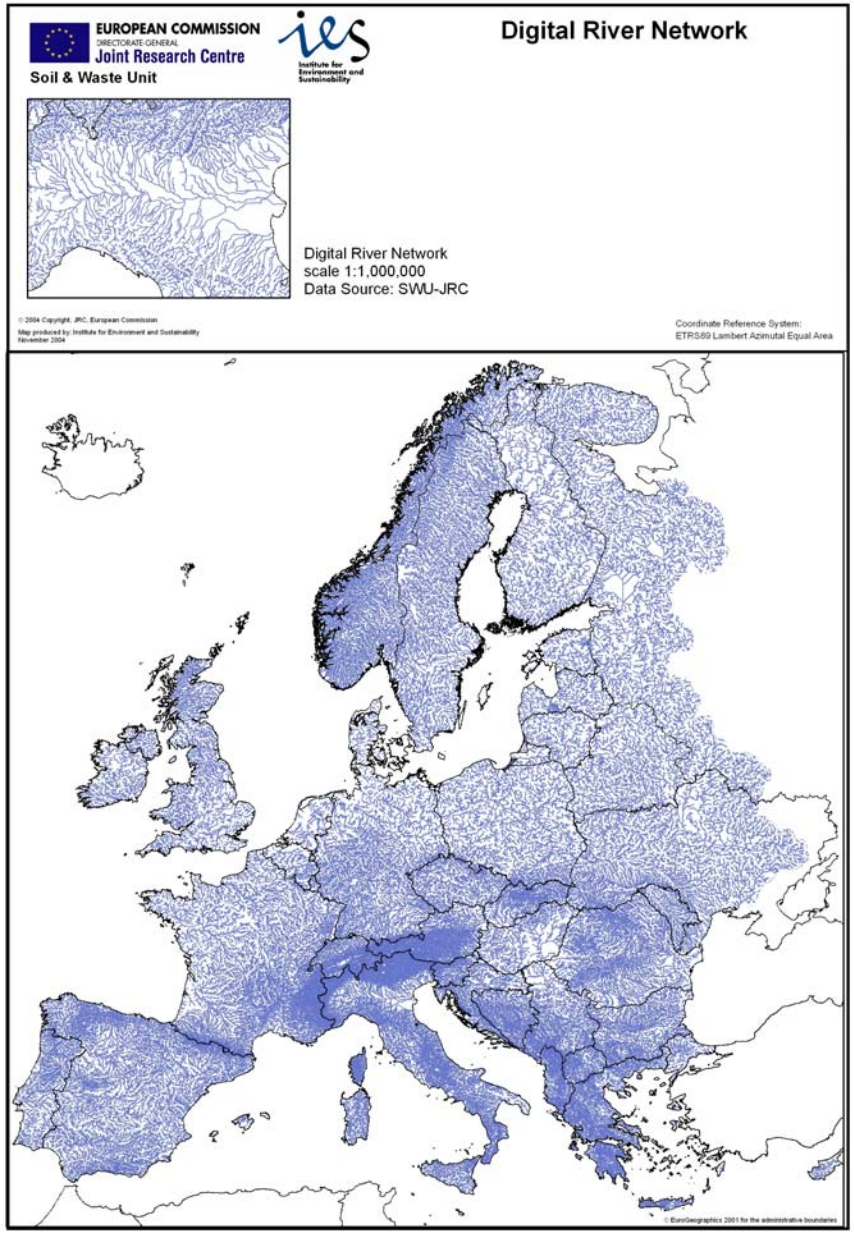
River and catchments Database

- Source: **CCM SWU- JRC**
  - Digital River Network
  - Catchments

- DEM and River network used to delineate basins



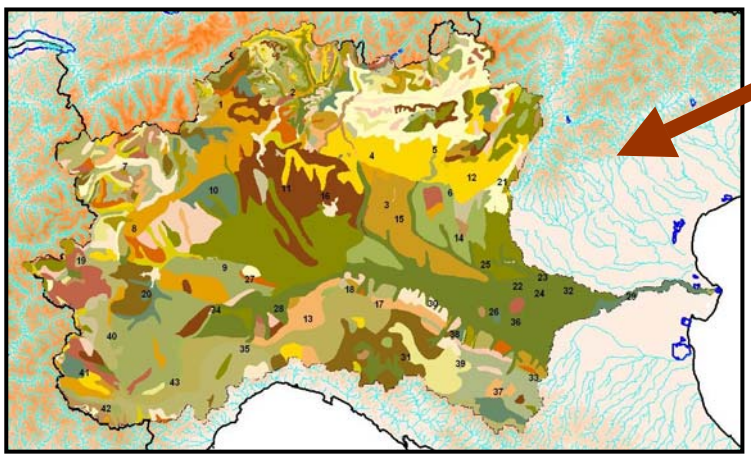
e.g. Po Valley – basin delineation



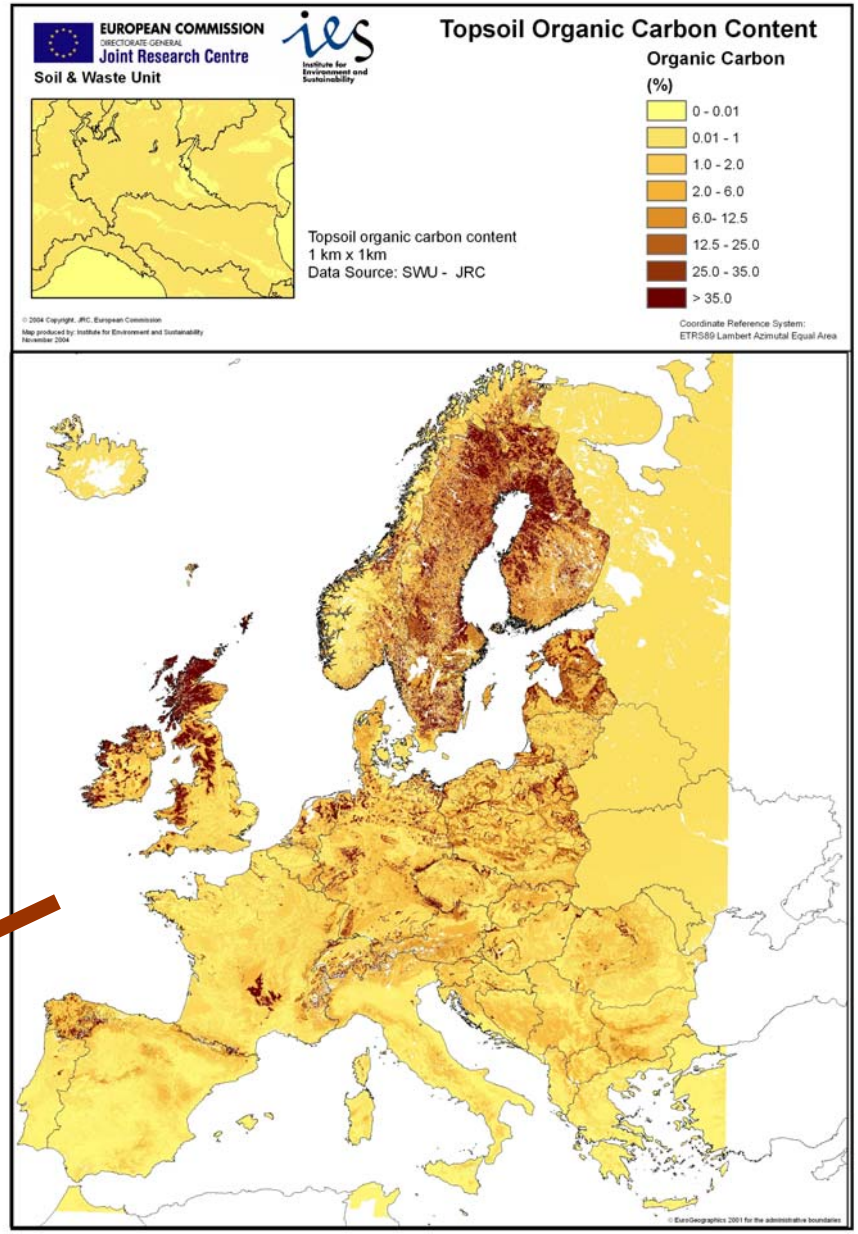
Soil parameters

- Source: **ESB (European Soil Bureau)**
- Soil Geographical Database of Europe
- Scale: 1:1,000,000

- **Topsoil / subsoil parameters**
  - Clay, sand and silt - content (%)
  - Depth to rock (cm)
  - Organic carbon (%)
  - Bulk density (g/cm^3) (packing density)
  - pH (base saturation)



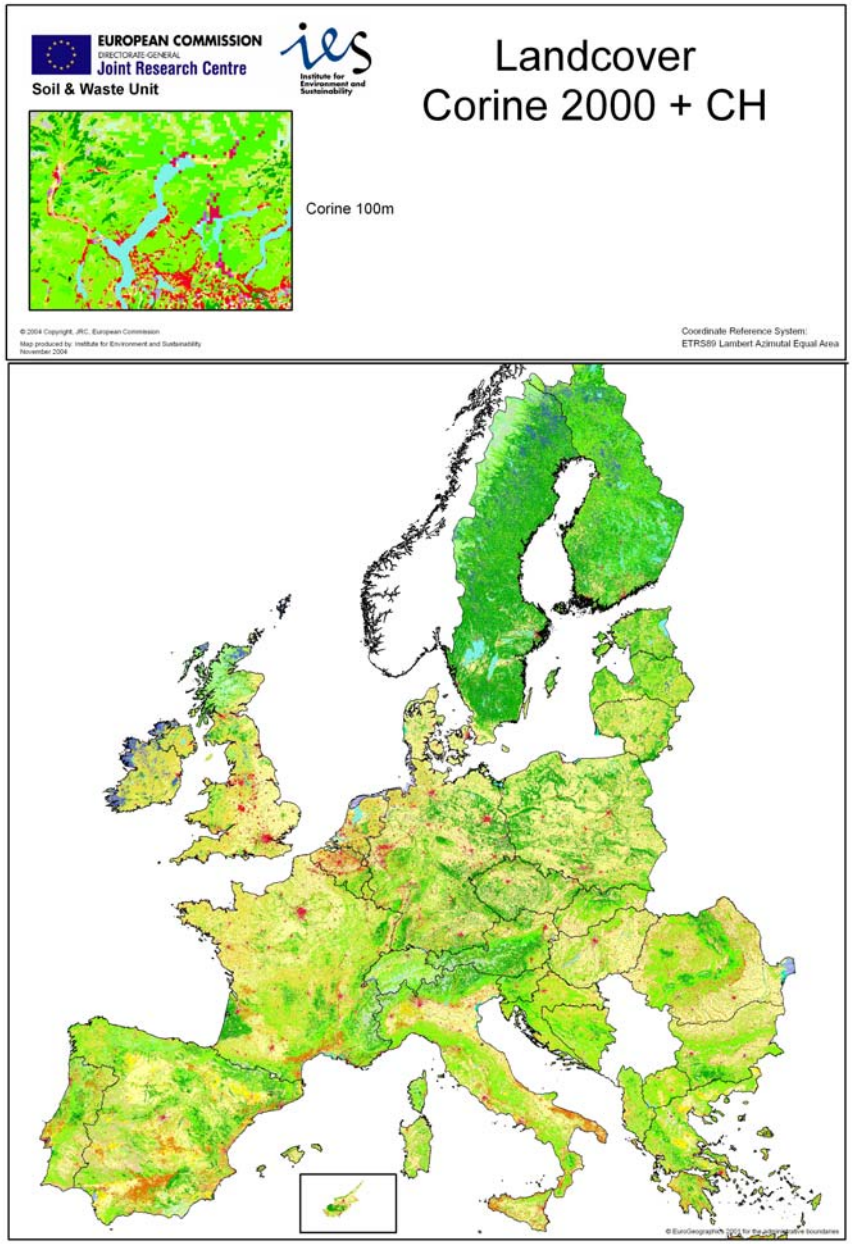
e.g Po Valley – Soils



From Landcover to Landuse

- CORINE landcover 100 m x 100 m grid

(COoRdinate INformation on the Environment)



- 44 landcover classes for 1990 and 2000
- Source: European Environment Agency (EEA) – ETC/TA

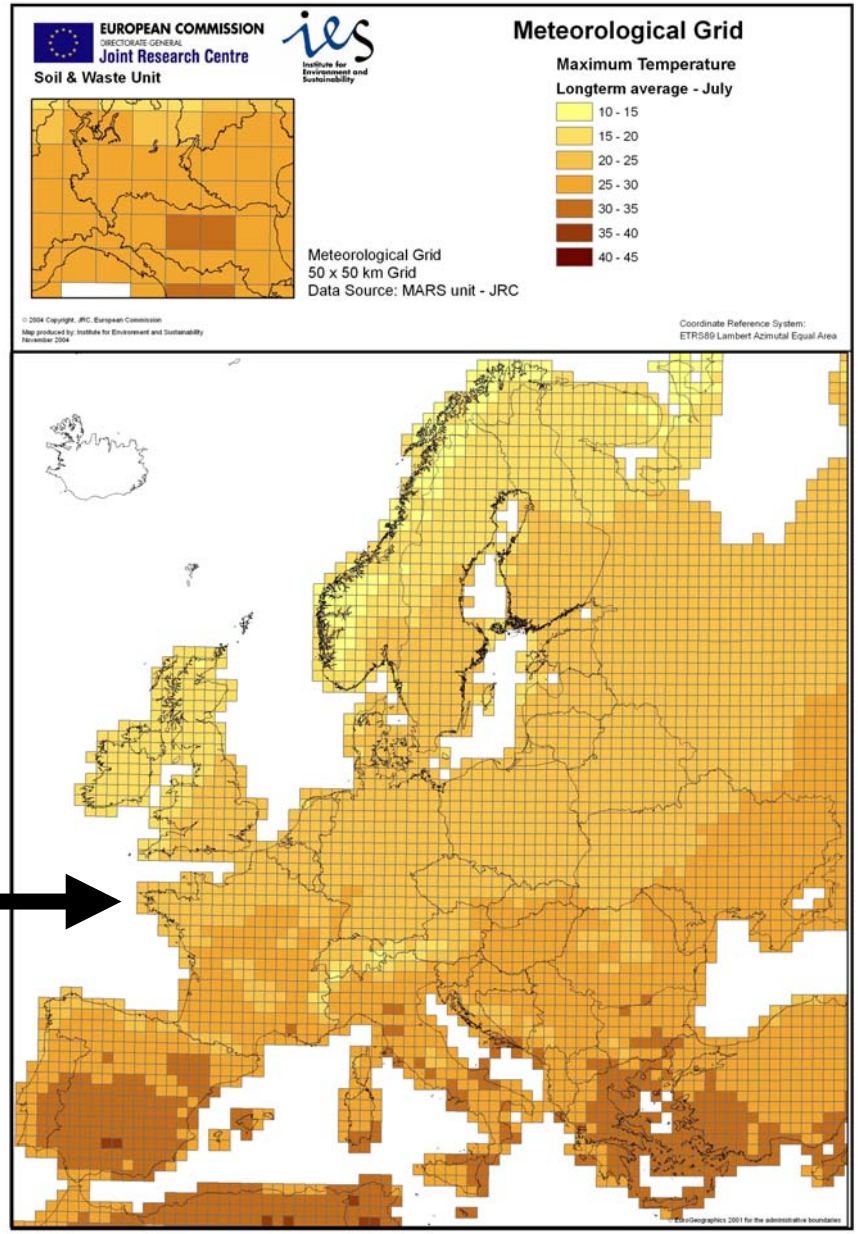
Meteorological data

- Source: **The Monitoring Agriculture and Regional Information Systems** (MARS) - JRC

- Derived from more than 1500 weather stations across Europe
- Interpolated onto a 50 km x 50 km grid

- MARS database daily meteorological data

Climate parameter	Unit
Minimum air temperature	^{o}C
Maximum air temperature	^{o}C
Precipitation	mm
Mean windspeed (at 10m height)	m/s
Mean vapour Pressure	hPa
Calculated potential evaporation	mm
Calculated global radiation	KJ/m^2

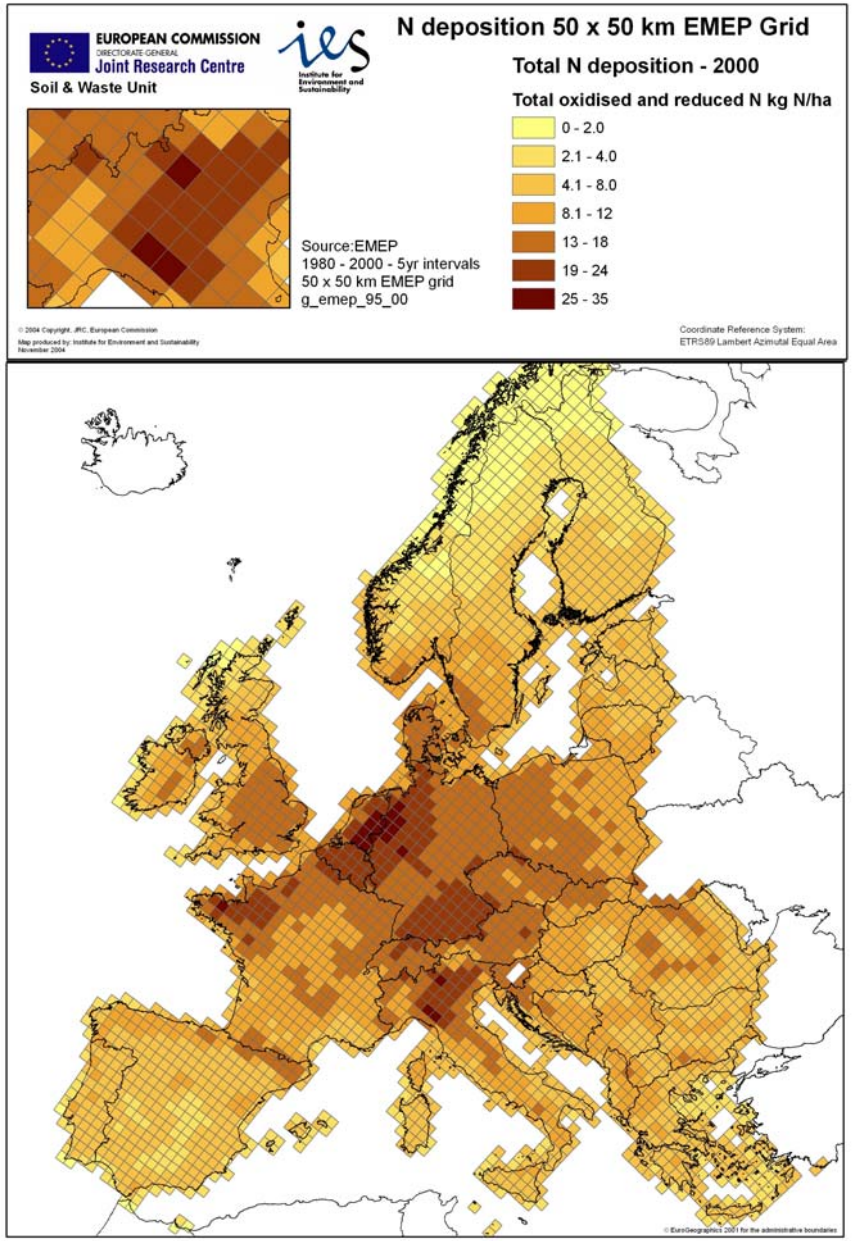


- Data extracted: 1990- 2003

- Weather generator used to fill data gaps in the MARS data.

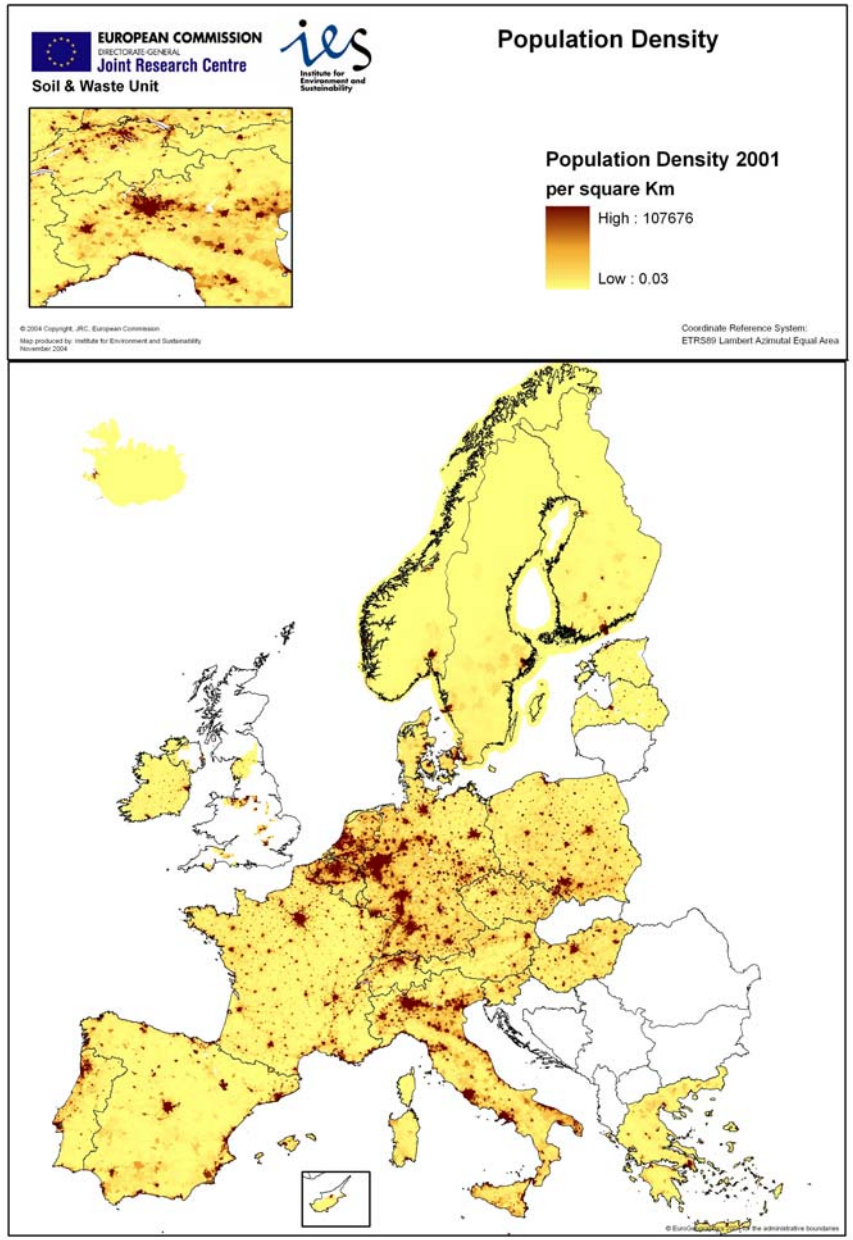
Atmospheric Deposition

- Source: **EMEP**
- Data derived from the Precipitation Chemistry Database of the Co-operative Programme for the Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
- The data are based on the Eulerian acid deposition model available on a 50 km x 50 km EMEP grid



Population Density

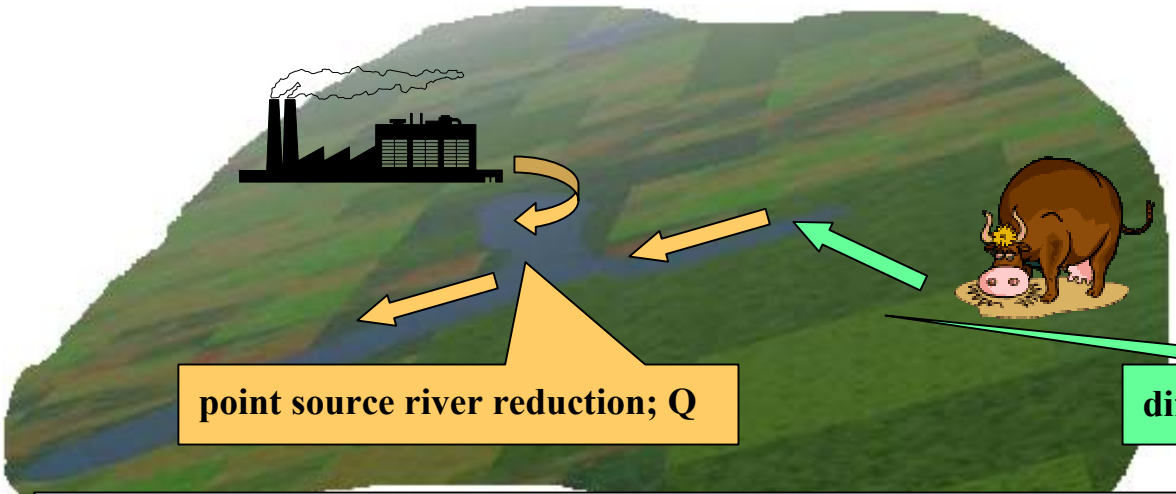
- Population density GISCO – cmec91/01
- 1991 and 2001 population density linked to comune (NUTS 5) polygons
- Eurostat data – population linked to treatment plants.



MODELLING TOOLS

	The STAT model	The process-based models
Model Type	Statistical model	Process-based model
Data requirement	• DEM & river network • Diffuse and point sources • Rainfall *Annual water flow and water quality*	• DEM & river network • Soil map + soil characteristics • Land use map + agricultural practices • Point sources • Daily precipitation, Max/min temperature, Weather generator *Daily water flow and water quality*
Model outputs	• N and P river export (annual) • N and P diffuse losses • Source apportionment • N and P retention	• N and P river export (daily) • N and P diffuse losses (pathways) • Source apportionment • N and P retention

The STAT model



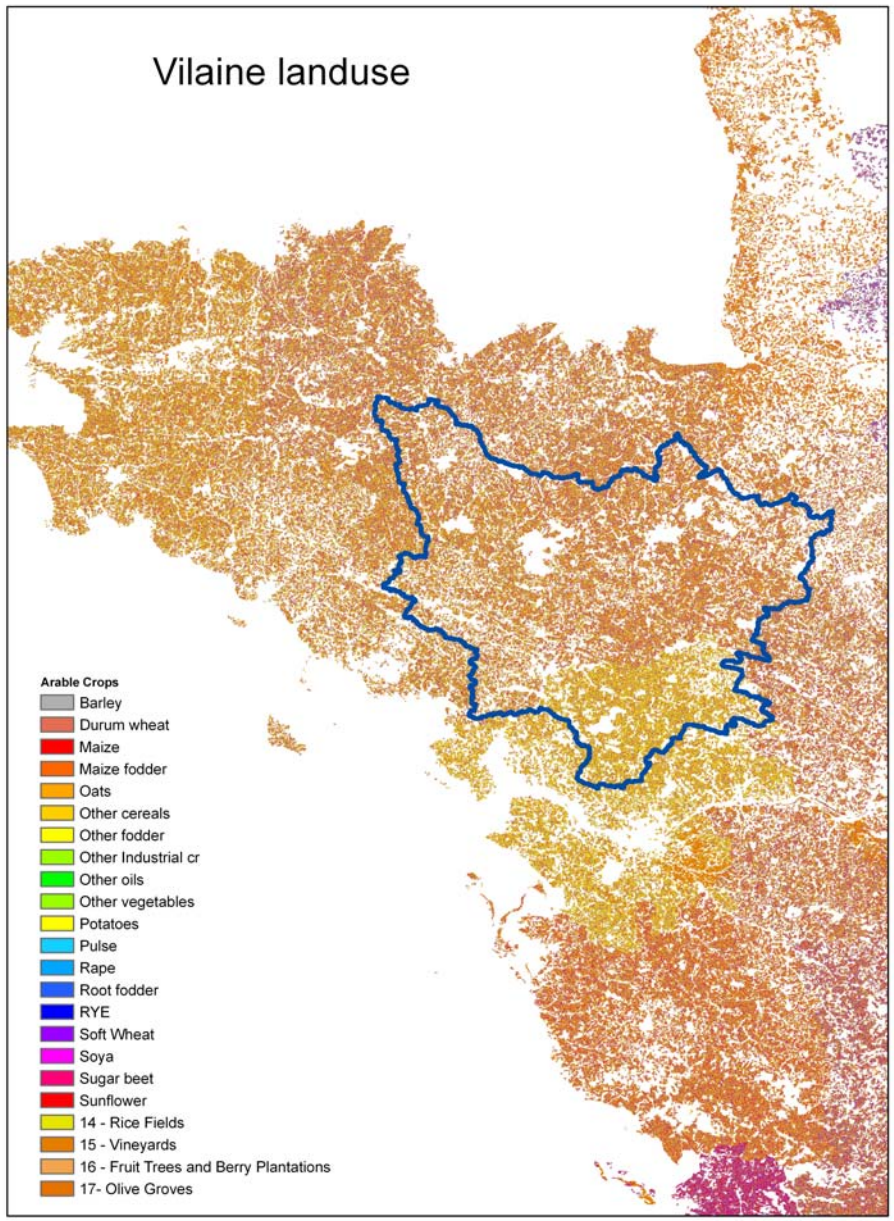
$$\text{Load} = (PS * \mathbf{Q} + DS * \mathbf{B} * \mathbf{Q})$$

$\mathbf{Q} = f(\text{river length})$

$\mathbf{B} = f(\text{Precipitation})$

2 model parameters

Presentation of the Vilaine Catchment



Area (Km^2): 10530

Rainfall (mm): 630-1000

Water Flow (m^3/s): 70

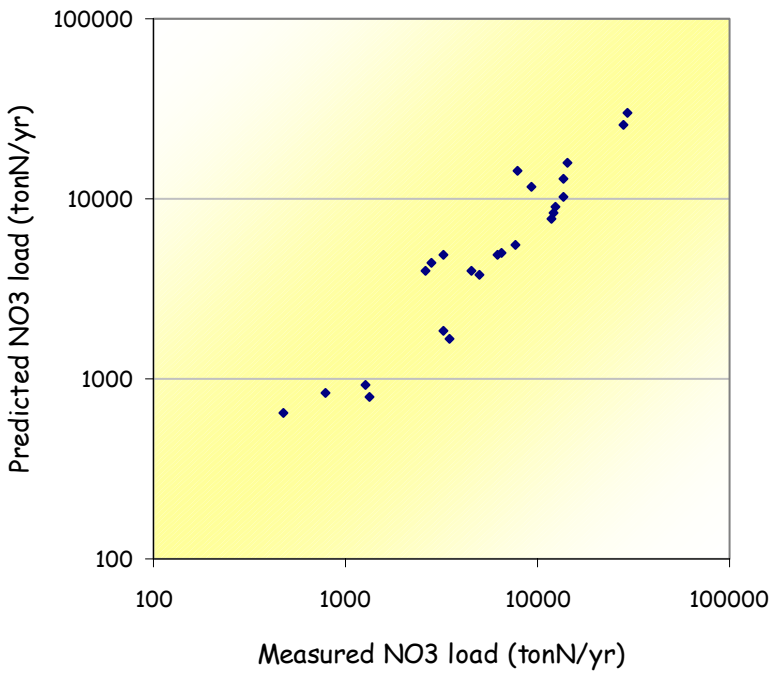
Arable land (%): 74

Fertiliser (kgN/ha):125

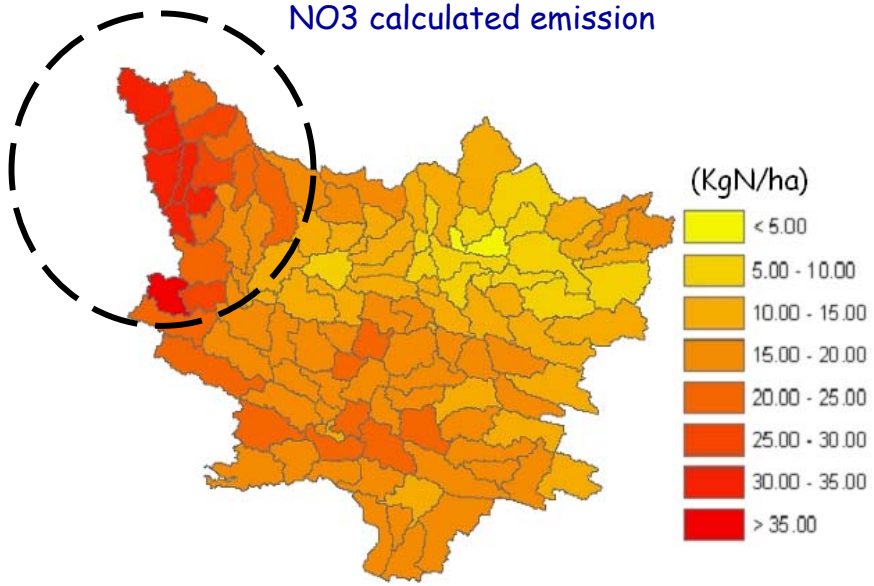
Application of the statistical model to the Vilaine catchment (10530 km²)

Calibration results:

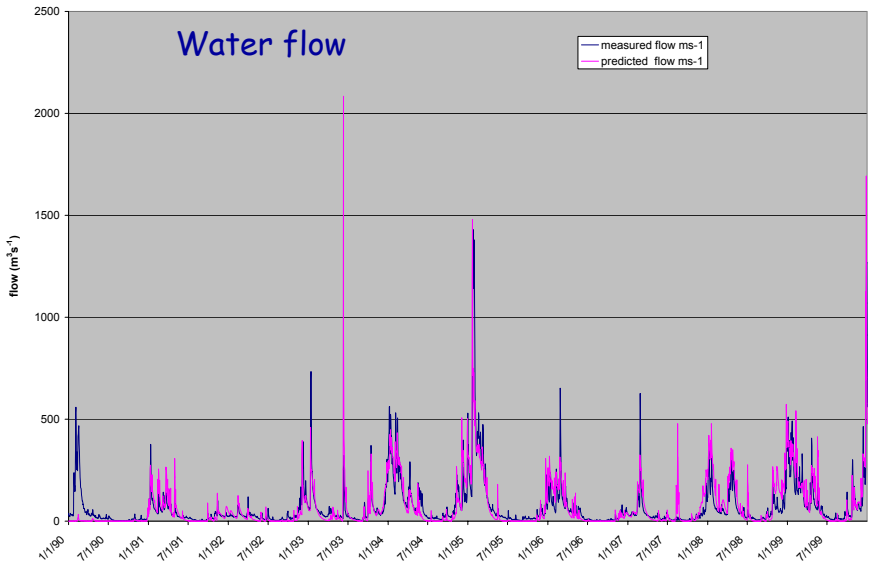
Nitrogen

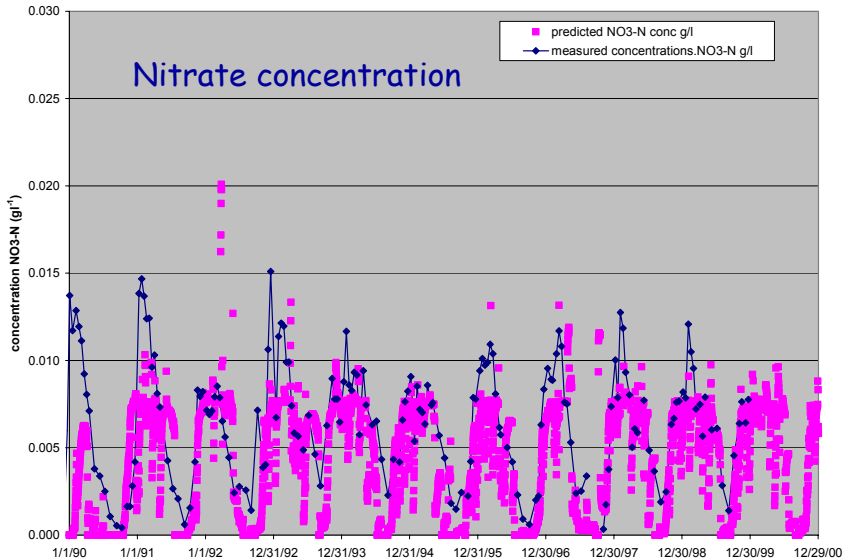


NO3 calculated emission



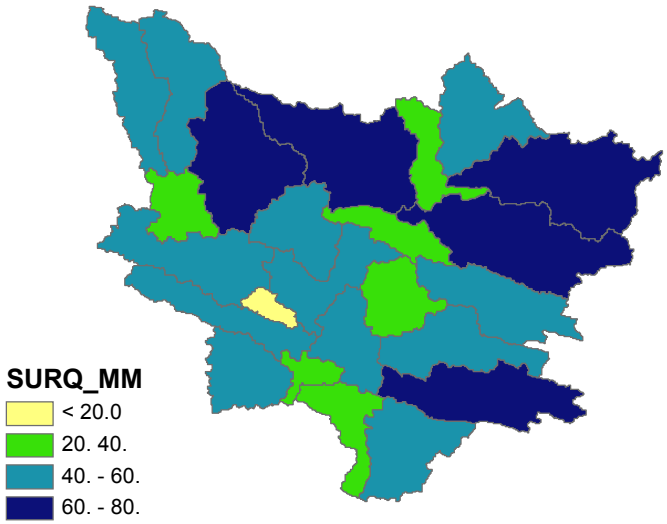
Application of the SWAT model to the Vilaine



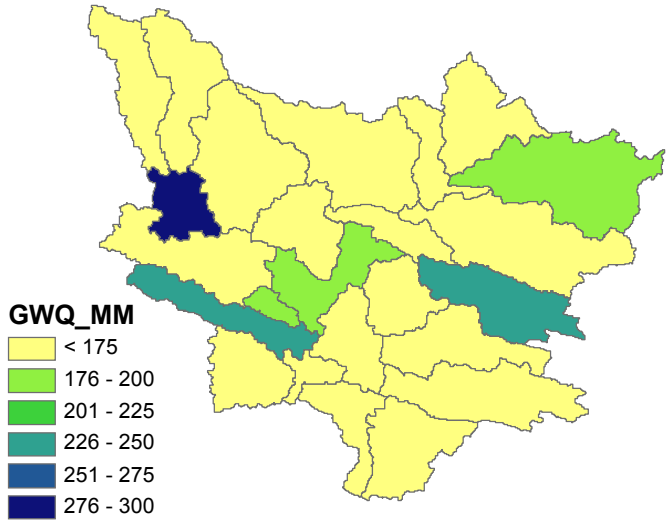


Pathways of water and sediment losses

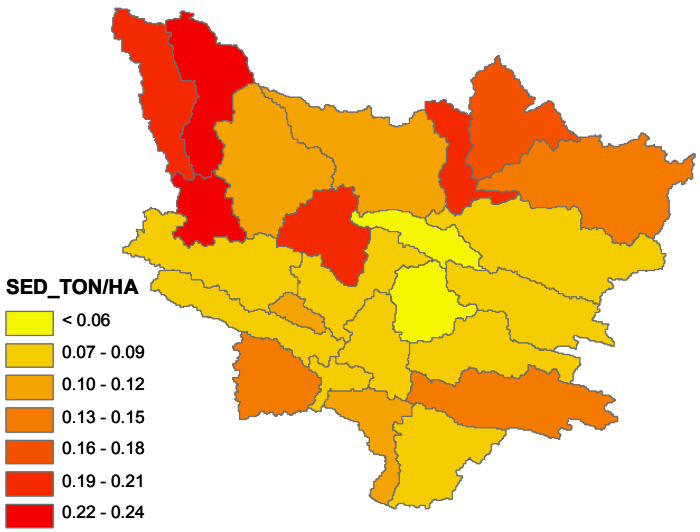
Surface runoff



Groundwater flow

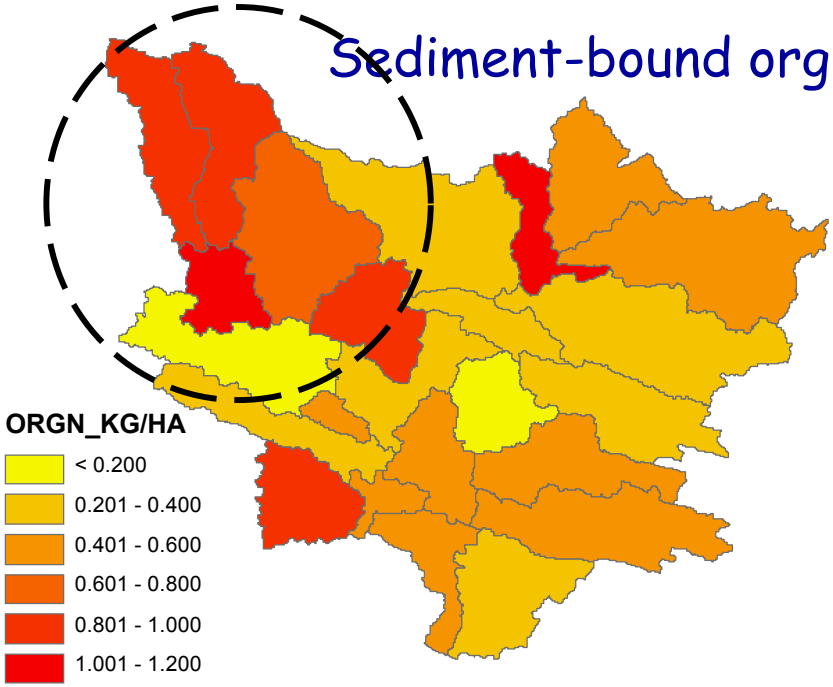


Sediment losses

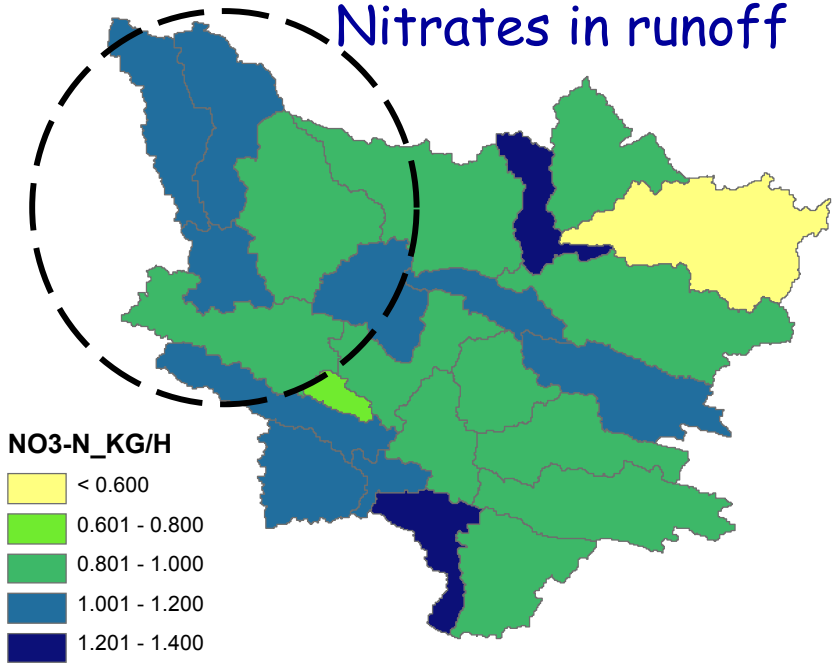


SWAT: Average N load in streams

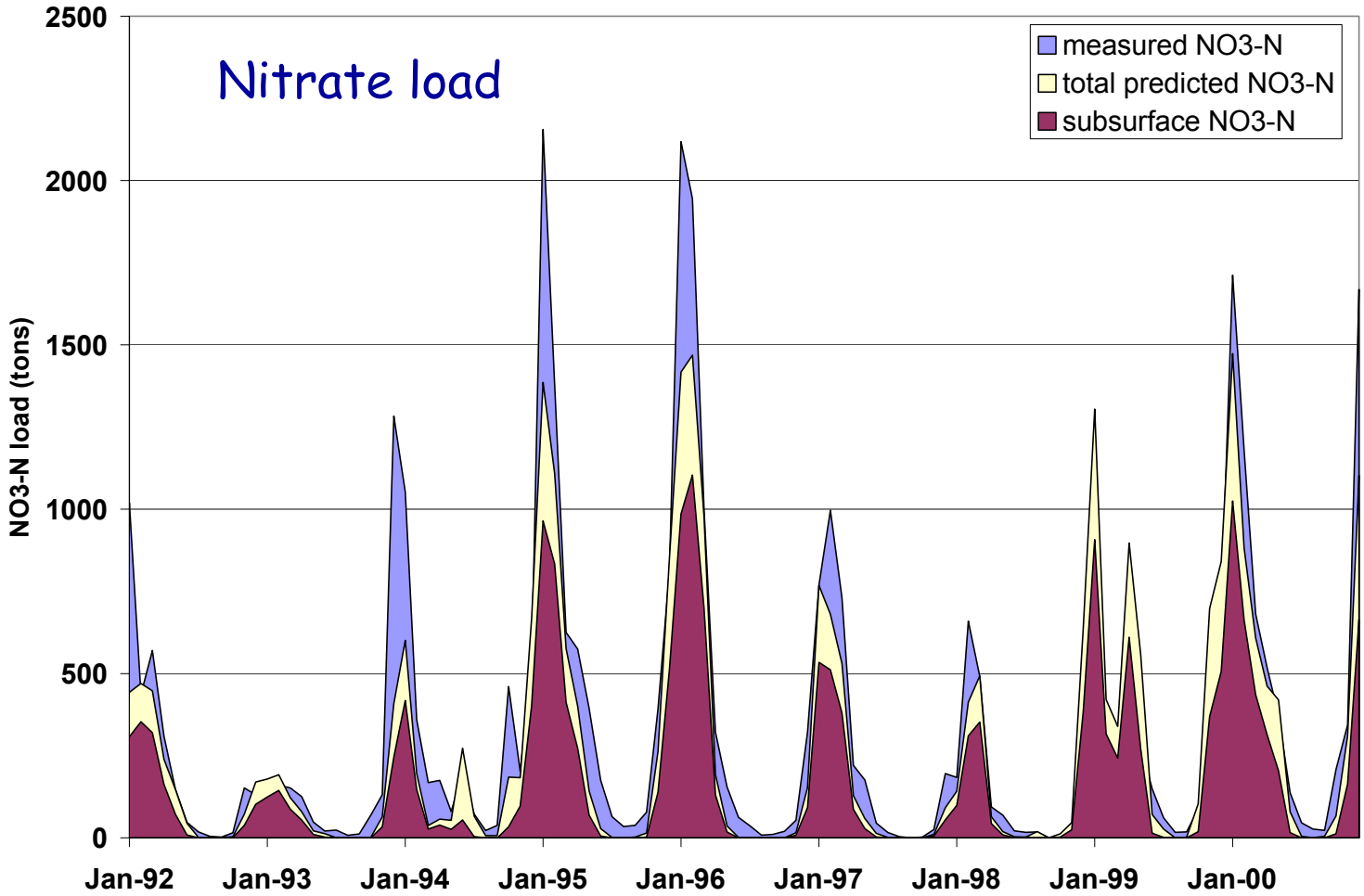
Sediment-bound org-N



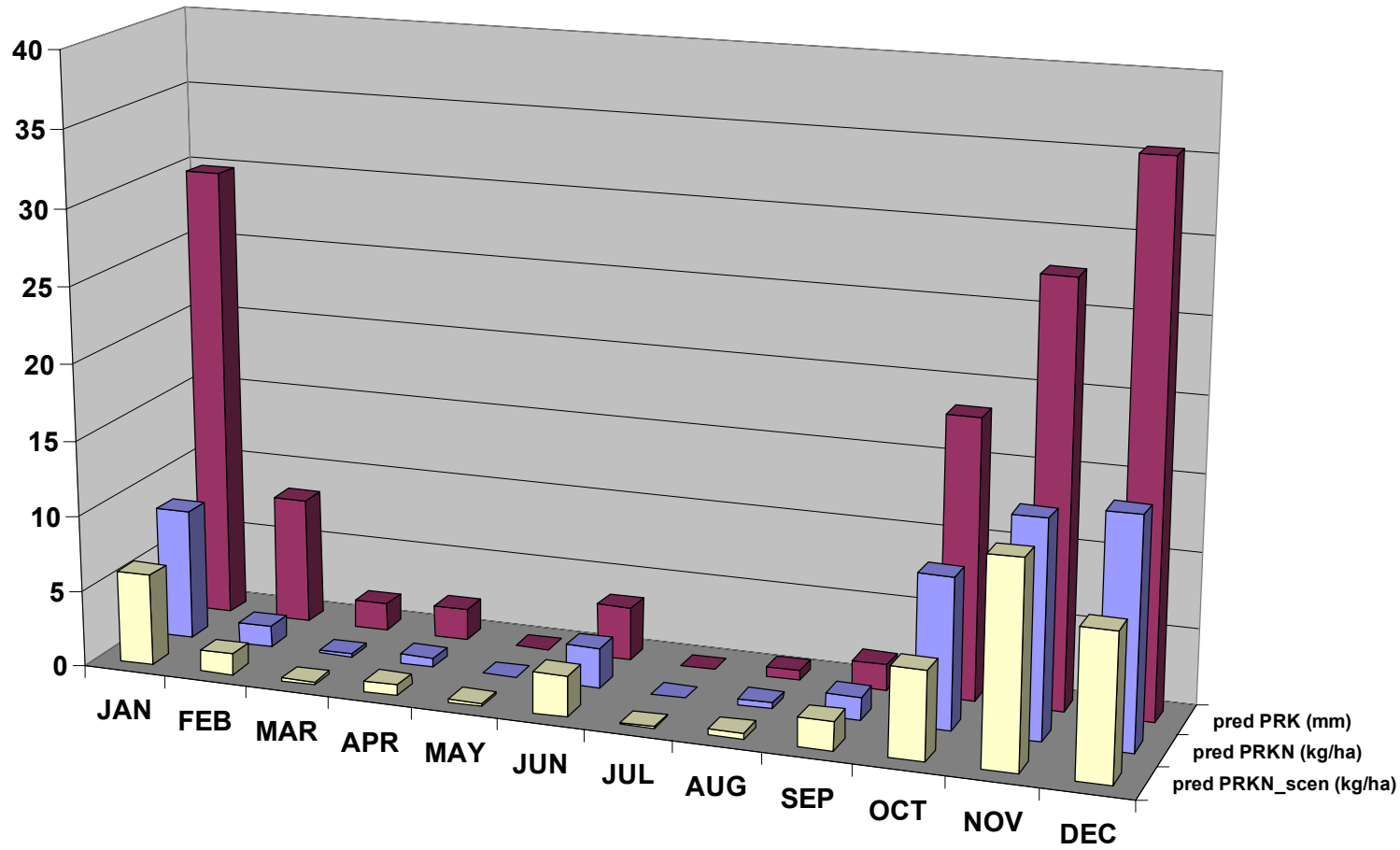
Nitrates in runoff



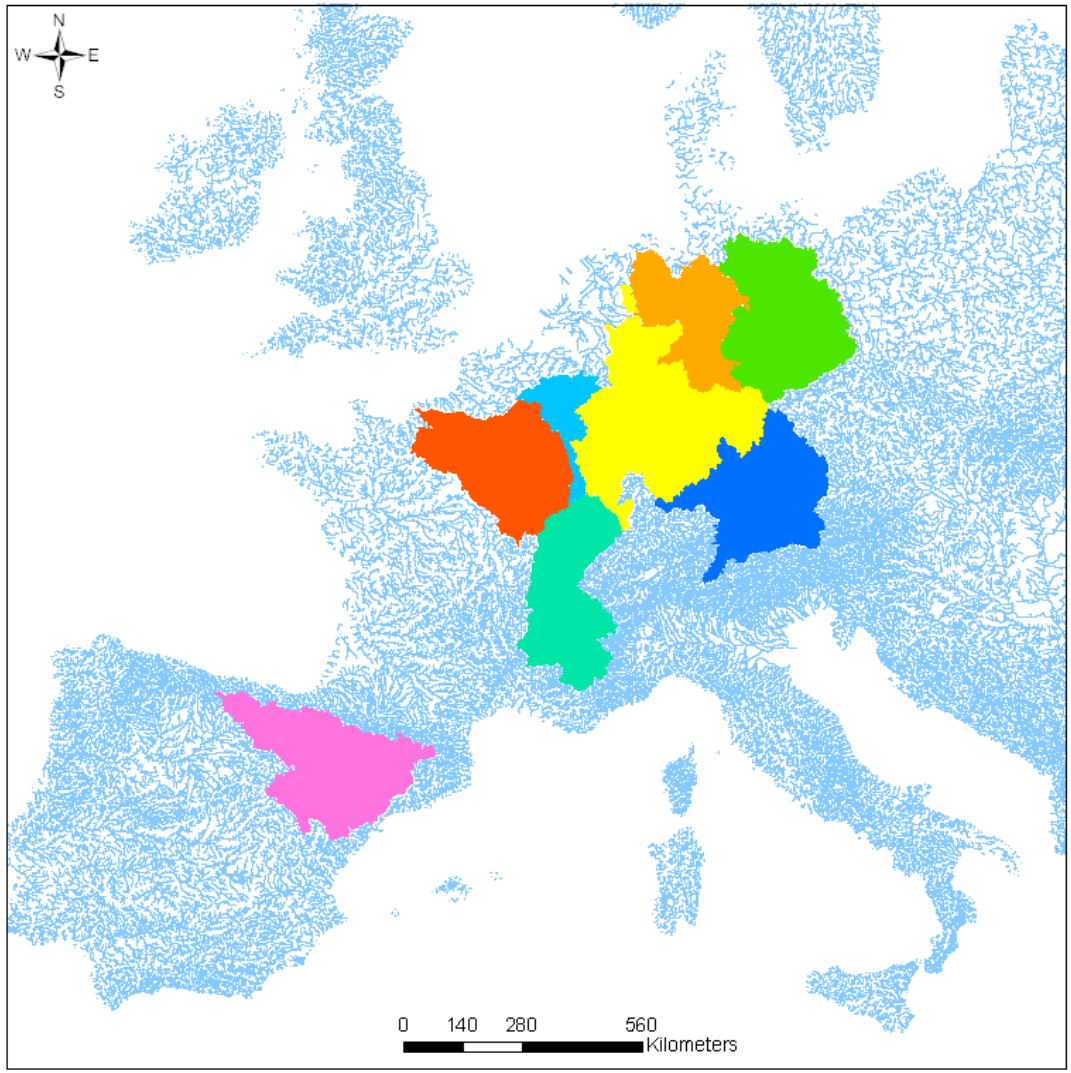
SWAT: NO3 loss pathway



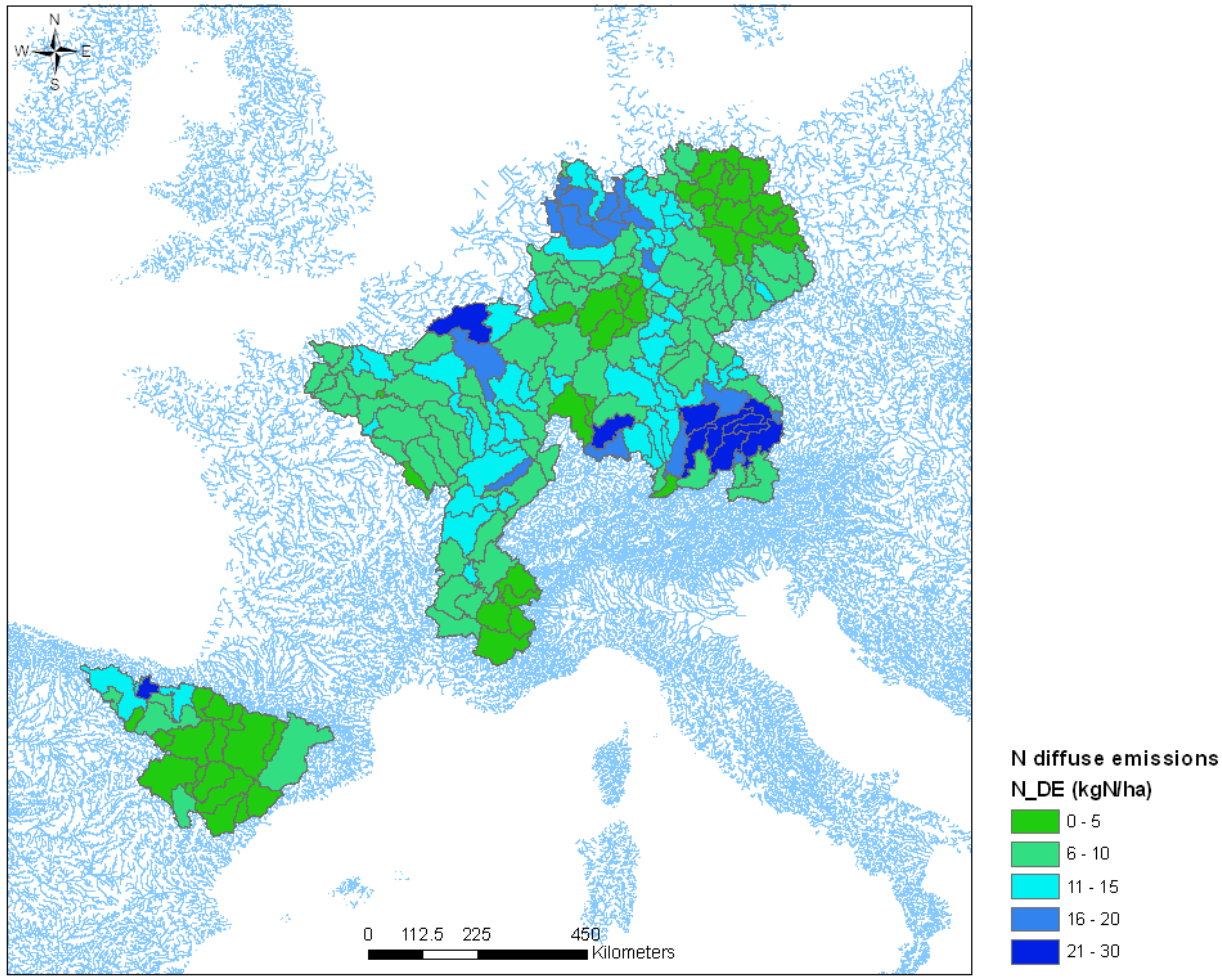
EPIC: simulation of a catch crop



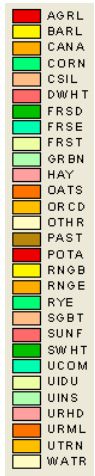
Derived input data for the STAT model



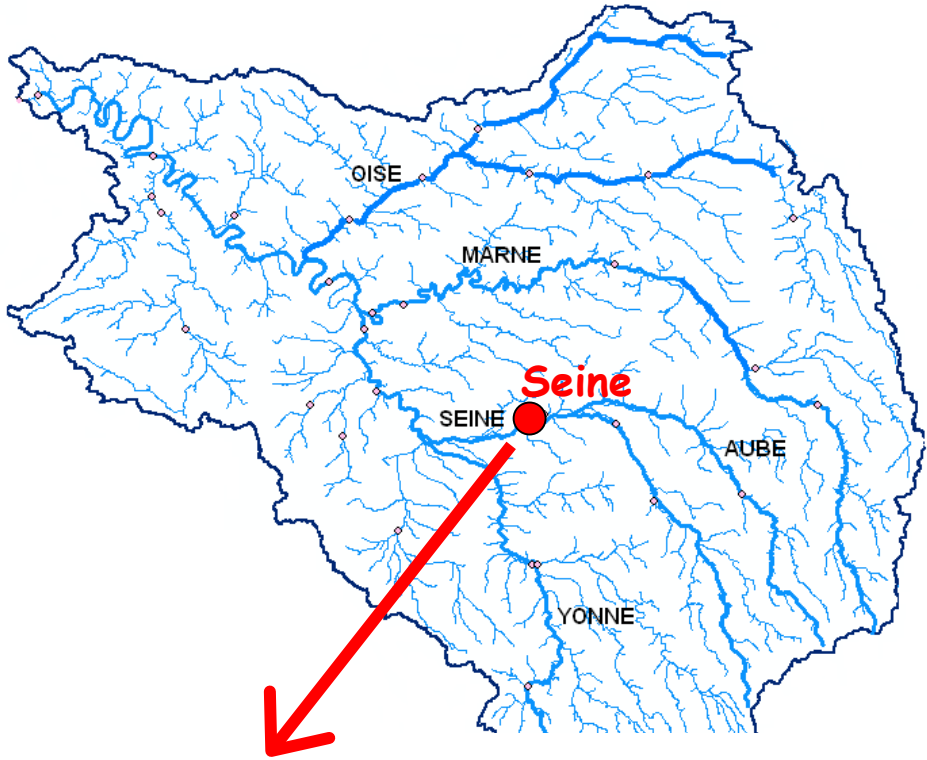
Nitrogen Diffuse Emissions



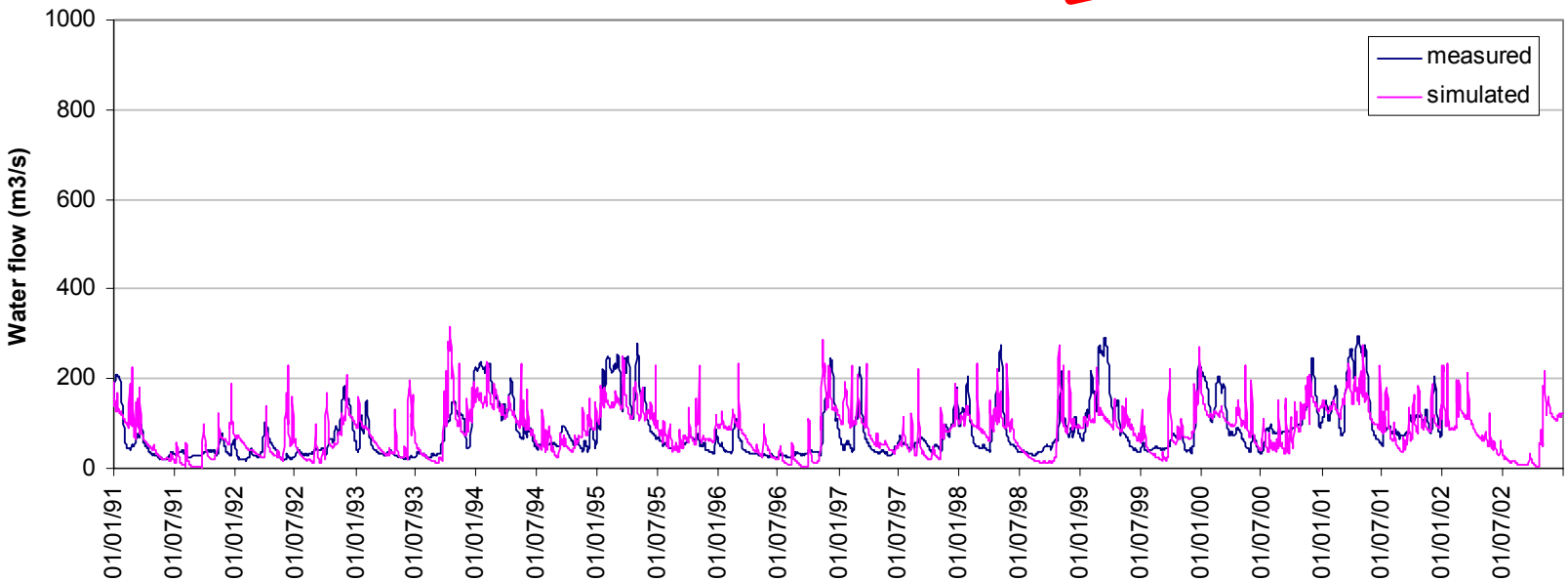
SWAT Application Seine basin



LandUse/Soil THRESHOLDS : 5 / 10 [%]
Number of HRUs: 1343
Number of Subbasins: 83


OISE
MARNE
Seine
SEINE
AUBE
YONNE

r^2=0.69 E=0.45


Water flow (m3/s)
1000
800
600
400
200
0
measured
simulated
01/01/91
01/07/91
01/01/92
01/07/92
01/01/93
01/07/93
01/01/94
01/07/94
01/01/95
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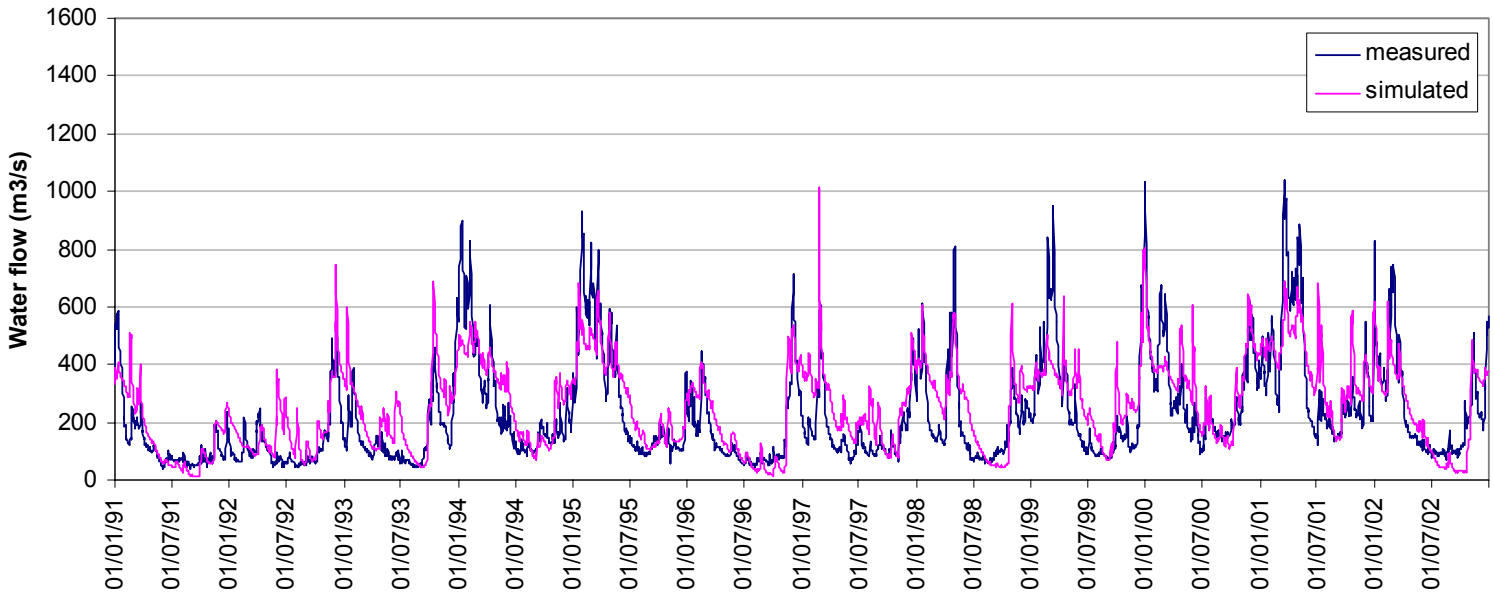
01/07/00
01/01/01
01/07/01
01/01/02
01/07/02


OISE
MARNE
Seine
SEINE
AUBE
YONNE

r^2=0.83 E=0.65


Water flow (m3/s)
1600
1400
1200
1000
800
600
400
200
0
measured
simulated
01/01/91
01/07/91
01/01/92
01/07/92
01/01/93
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01/01/94
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01/01/95
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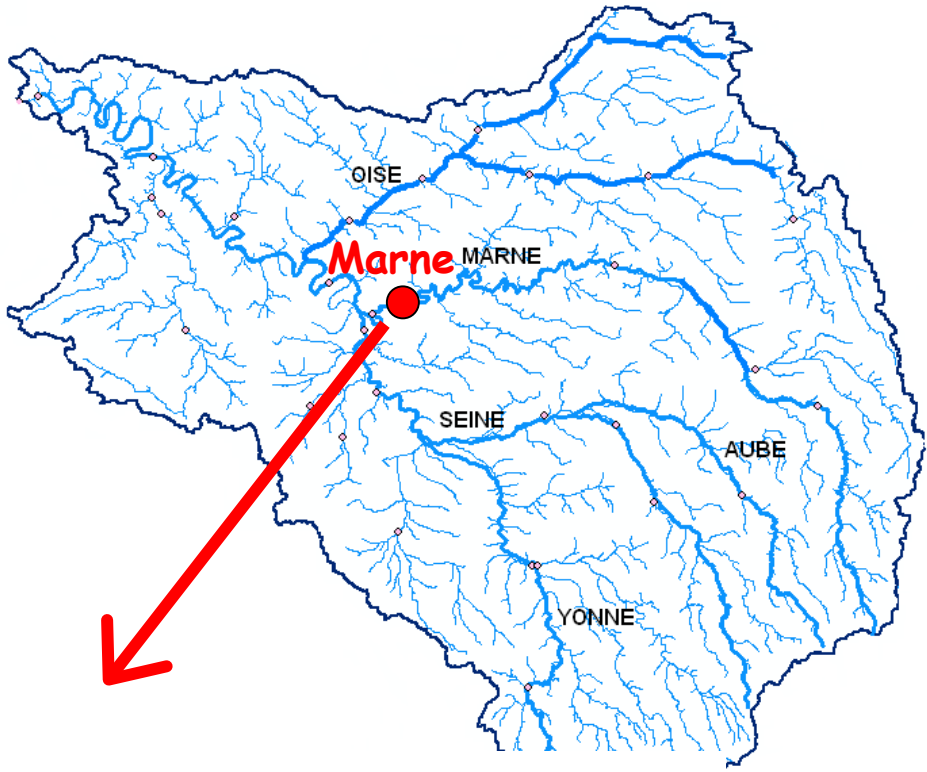
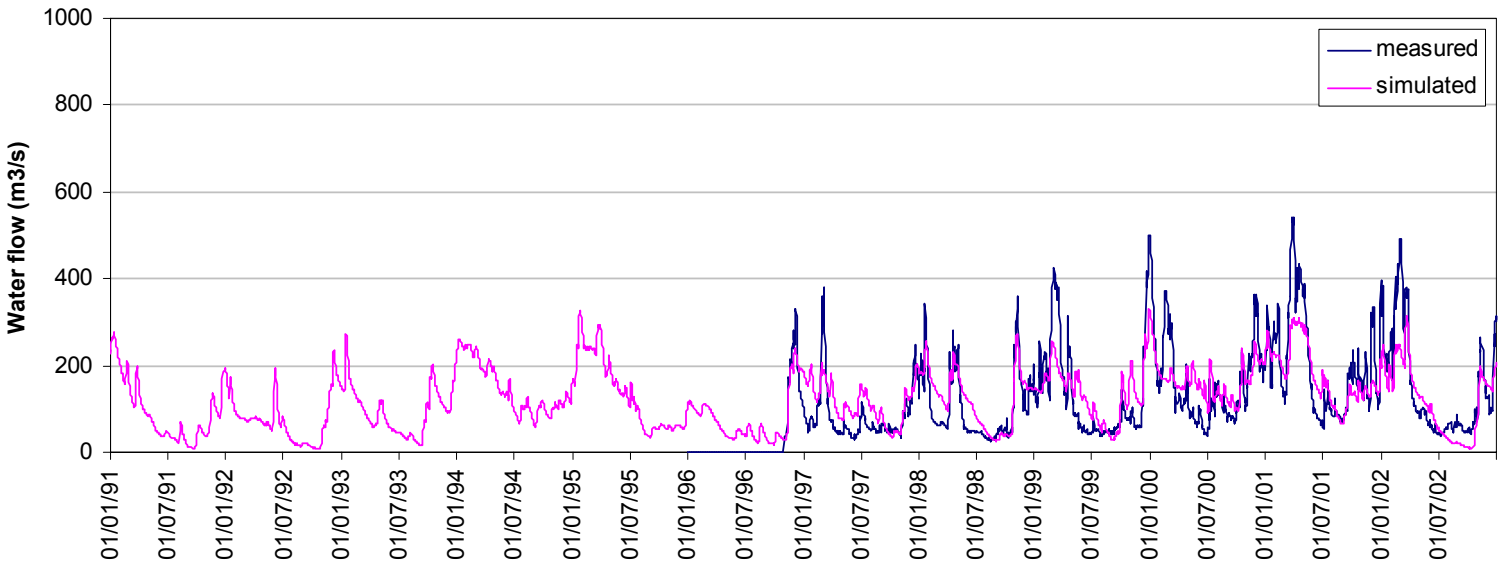
01/07/01
01/01/02
01/07/02


OISE
Marne
MARNE
SEINE
AUBE
YONNE

r^2=0.81 E=0.62


Water flow (m3/s)
1000
800
600
400
200
0
measured
simulated
01/01/91
01/07/91
01/01/92
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01/01/93
01/07/93
01/01/94
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01/01/95
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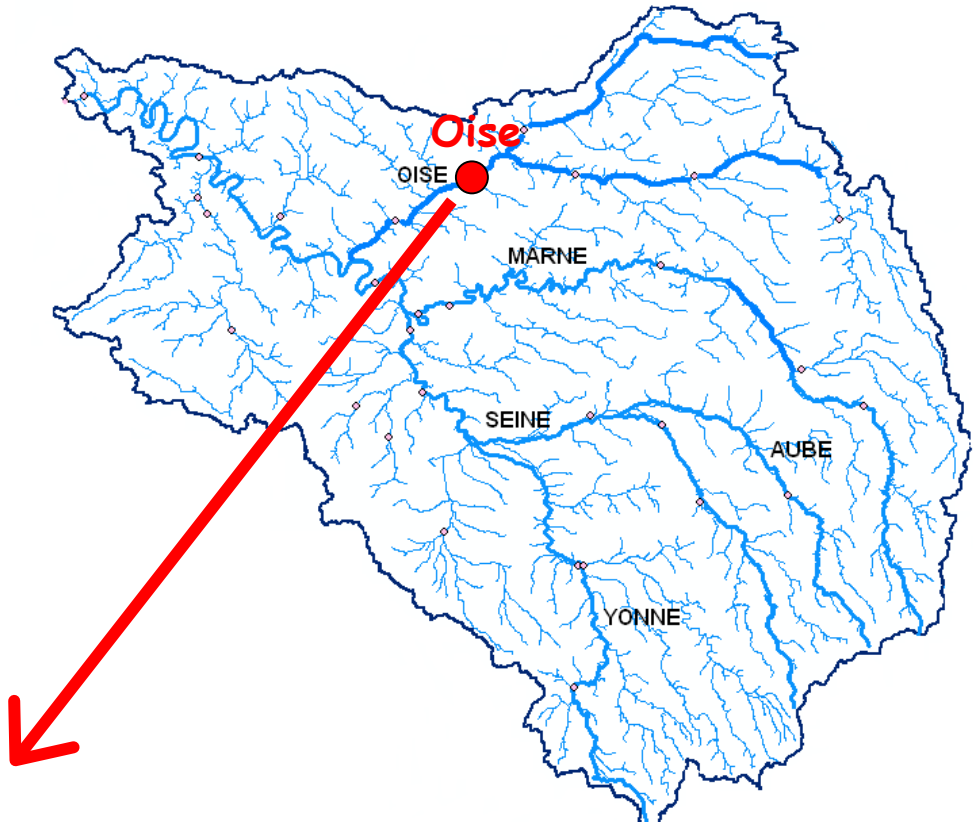
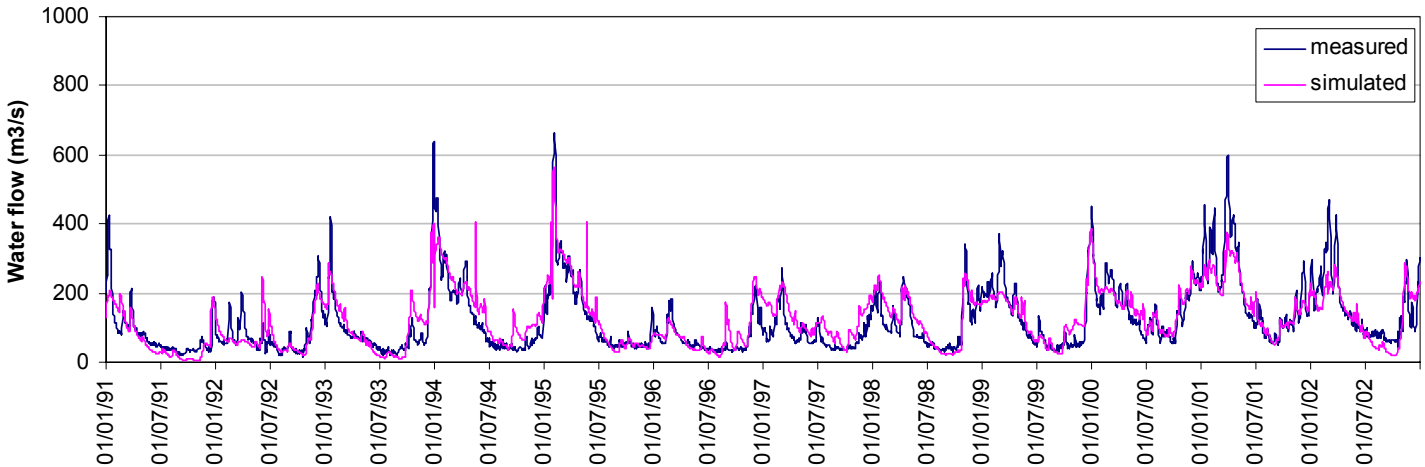
01/07/01
01/01/02
01/07/02


Oise
OISE
MARNE
SEINE
AUBE
YONNE

r^2=0.87 E=0.76


Water flow (m3/s)
1000
800
600
400
200
0
measured
simulated
01/01/91
01/07/91
01/01/92
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01/01/93
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01/01/94
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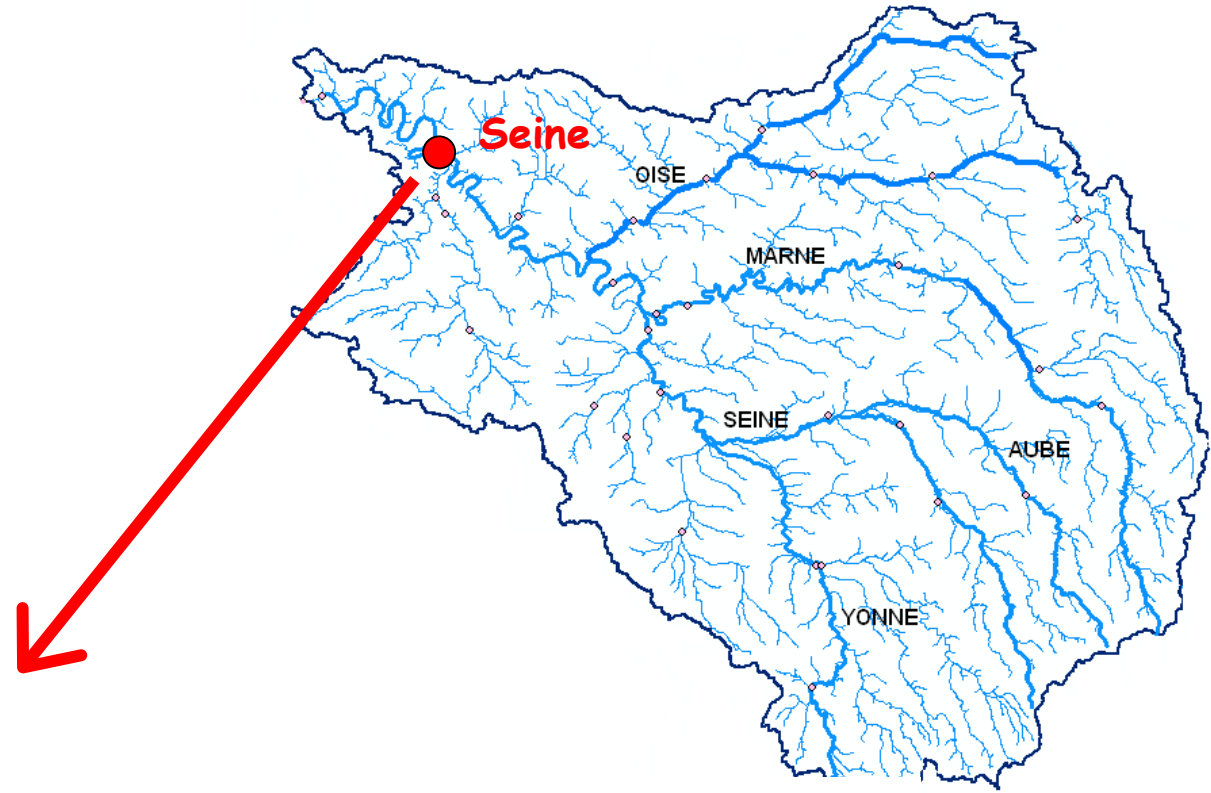
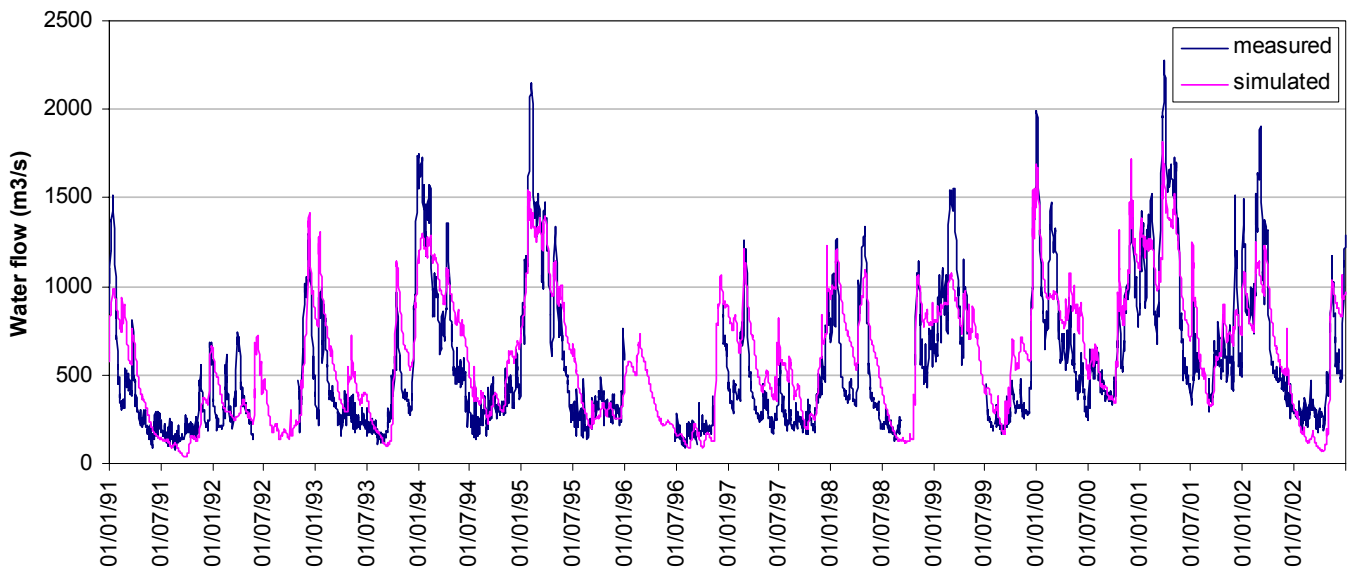
01/07/01
01/01/02
01/07/02


Seine
OISE
MARNE
SEINE
AUBE
YONNE

r^2=0.87 E=0.61


Water flow (m3/s)
2500
2000
1500
1000
500
0
measured
simulated
01/01/91
01/07/91
01/01/92
01/07/92
01/01/93
01/07/93
01/01/94
01/07/94
01/01/95
01/07/95
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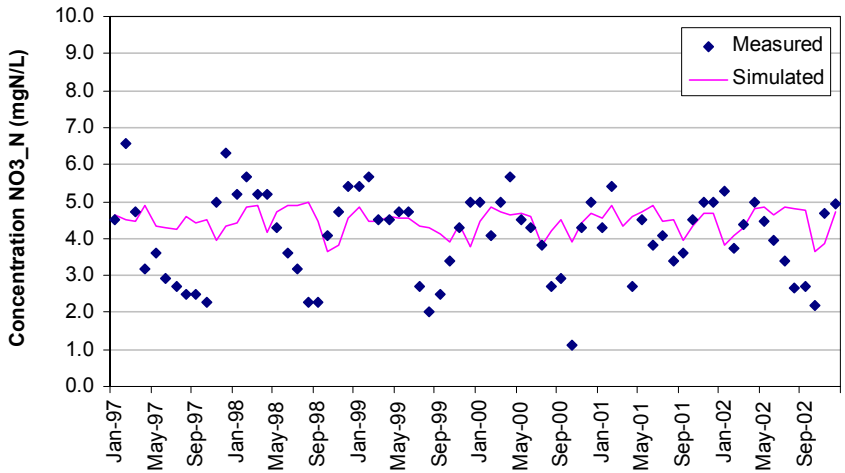
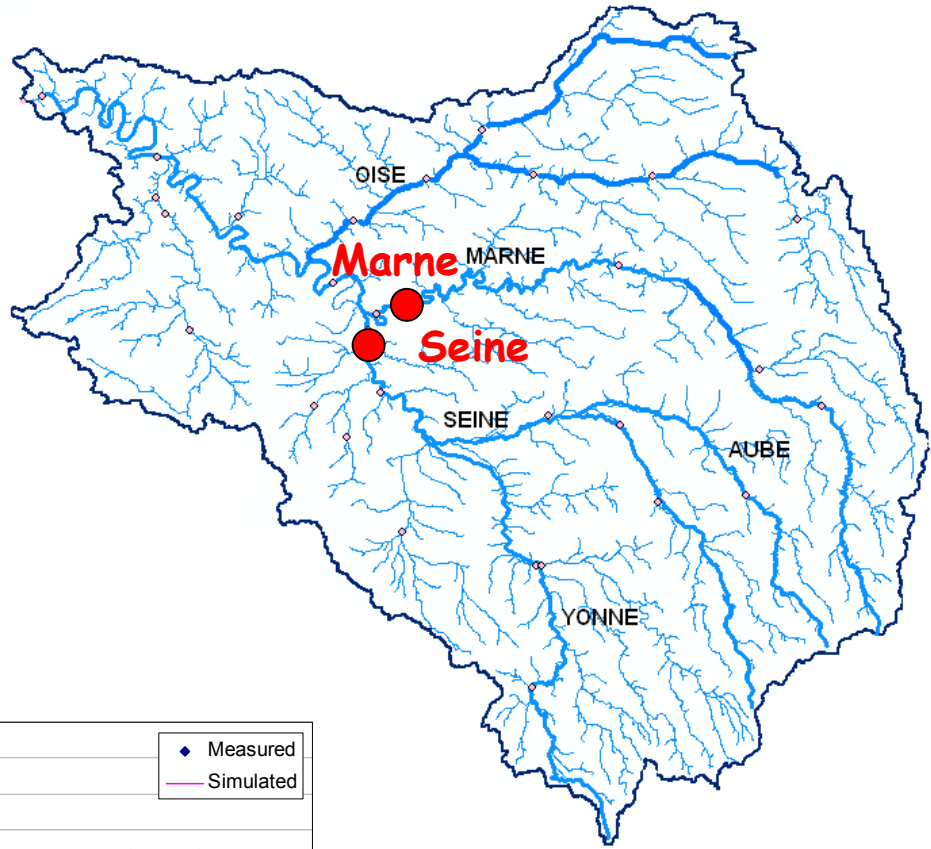
01/07/01
01/01/02
01/07/02

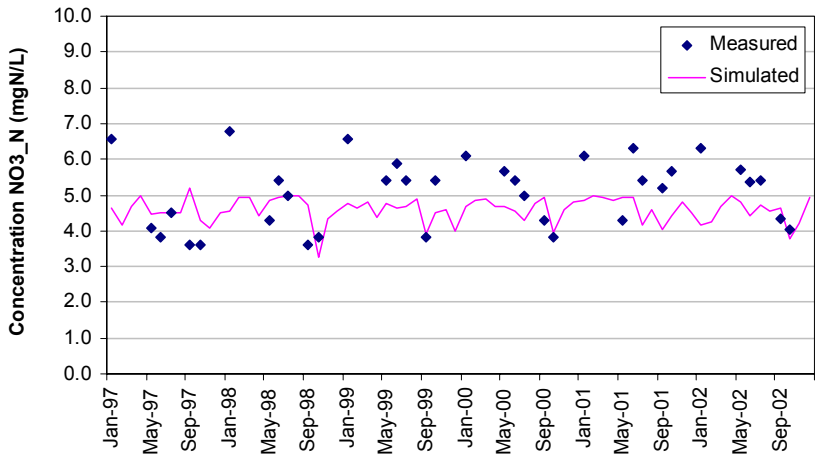
SWAT Application Seine Basin

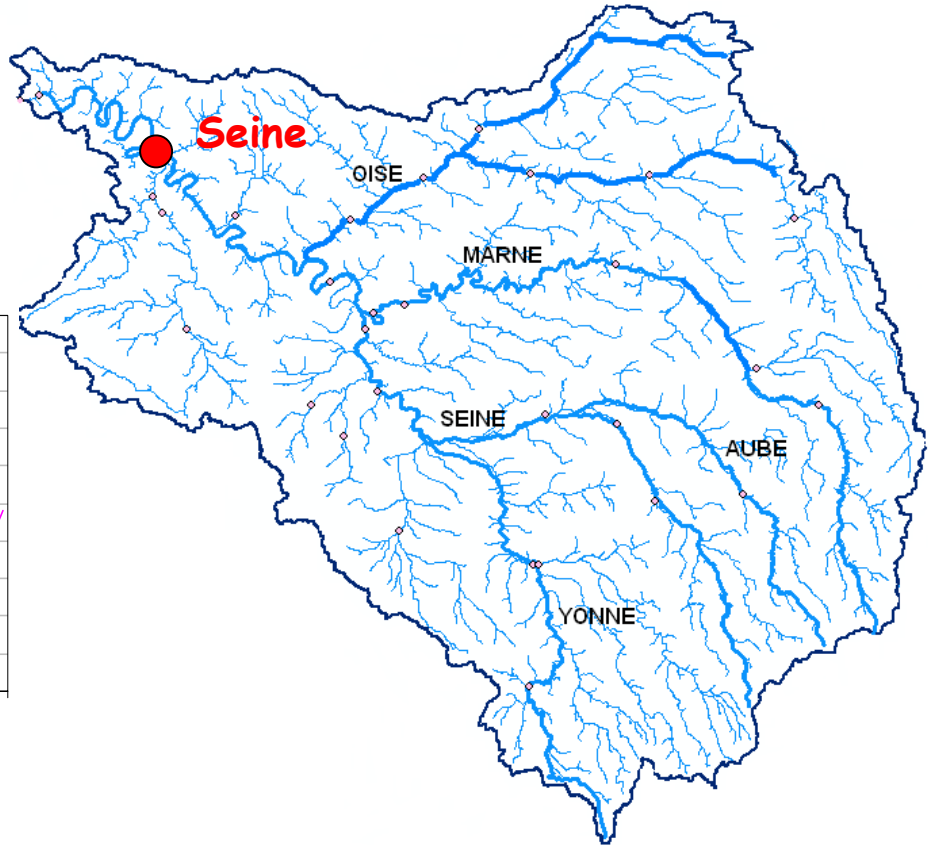
Marne- NOISIEL

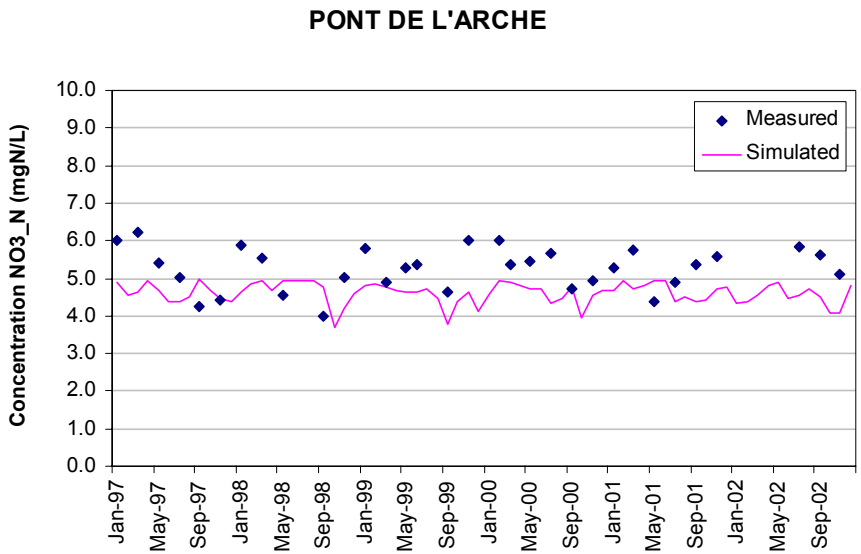


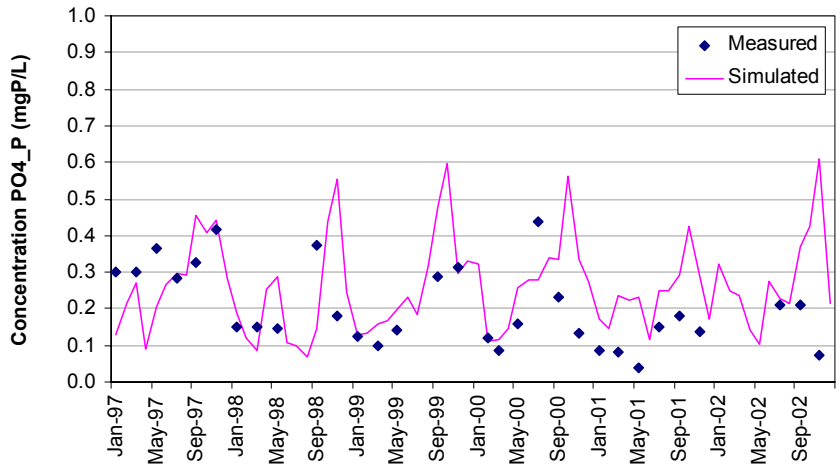


Seine- ORLY




Seine
OISE
MARNE
SEINE
AUBE
YONNE


PONT DE L'ARCHE
Concentration NO3_N (mgN/L)
Measured
Simulated
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jan-97
May-97
Sep-97
Jan-98
May-98
Sep-98
Jan-99
May-99
Sep-99
Jan-00
May-00
Sep-00
Jan-01
May-01
Sep-01
Jan-02
May-02
Sep-02


Concentration PO4_P (mgP/L)
Measured
Simulated
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan-97
May-97
Sep-97
Jan-98
May-98
Sep-98
Jan-99
May-99
Sep-99
Jan-00
May-00
Sep-00
Jan-01
May-01
Sep-01
Jan-02
May-02
Sep-02

Conclusions

FATE Framework: from regional to farm scale

- A **database** necessary to evaluate the fate of nutrient across a wide range of scale (continental to field scale) has been gathered.
- A set of **tools** to assess the fate of nutrients as affected by various management practices have been linked to the database to perform various analysis on nutrient sources and fate.

SWAT is being used to assess the impact of agriculture at sub-basin level taking into account major loss pathways. It will be used to evaluate the efficiency of various agri-environmental measures in the framework of CAP (cross-compliance)

Future plans include the sep-up of SWAT for the major European river basin