EU-Project MoNit: Prognosis of future nitrate input into the Upper Rhine Valley aquifer

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[4]BRGM, Montpellier/France

MoNit: project partners from CH, D, F

project leader LUBW
Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg

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(European Regional Development Fund, ERRF)
Financial volume 2,93 Mio. €

project run 10/2002-06/2006

PAMINA

EU-Project MoNit: Prognosis of future nitrate input into the Upper Rhine Valley aquifer

29.-31.1.2007
MMM-Graz

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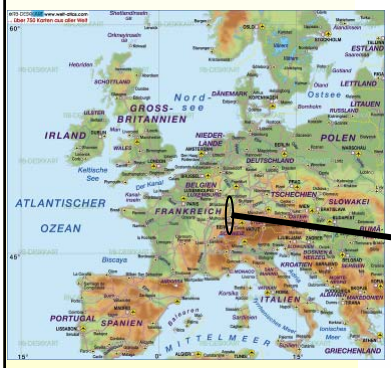
2. Modelling system in detail
3. Selected results + sources of error/uncertainty
4. Conclusion

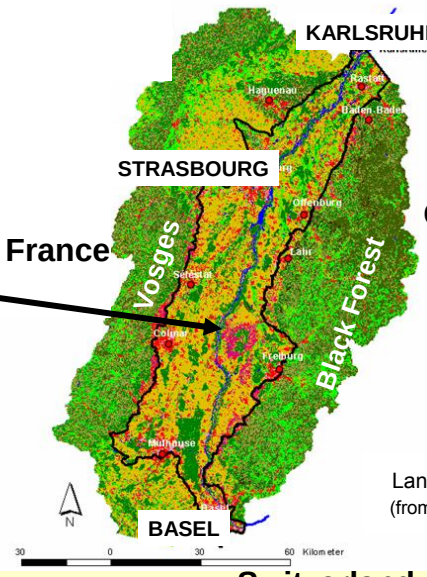
„**Mo**delling the **Nit**rate load of the Upper Rhine Valley aquifer system“

project leader LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg

The Upper Rhine Valley



Central Europe



Landuse (2000)
(from Landsat-TM)

The Upper Rhine Valley

The Upper Rhine Valley – one of the most important groundwater reservoirs in Central Europe (approx. 80 km³ water storage), has a high population density and intensive agriculture

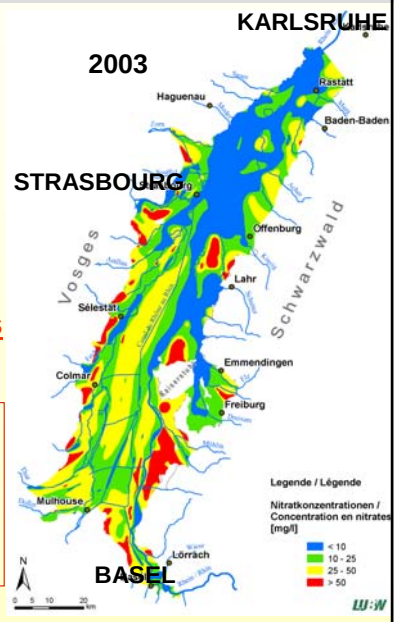
→

groundwater contamination by Nitrates in the entire Upper Rhine Valley

There was a urgent need for a

transnational

planning & prognosis instrument



MoNit

The **answer:**

Within MoNit a **transnational prognosis** instrument has been developed.

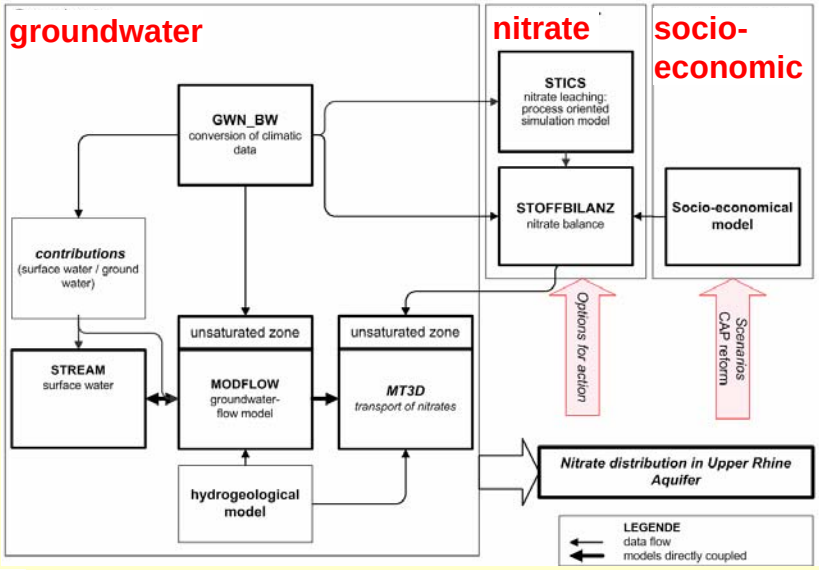
It allows to assess the effects of a changing

political (e.g. Common Agricultural Policy – CAP - of the European Union),

technical and

climatic framework on the **nitrate load**

Integrated modelling concept



Introduction – **Modelling system** – Results & sources of error - Conclusion

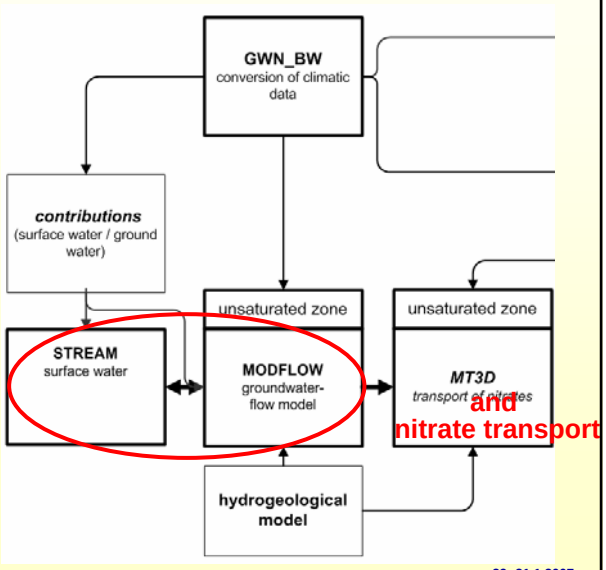
Groundwater model

accounts for:

groundwater recharge

surface water

groundwater flow



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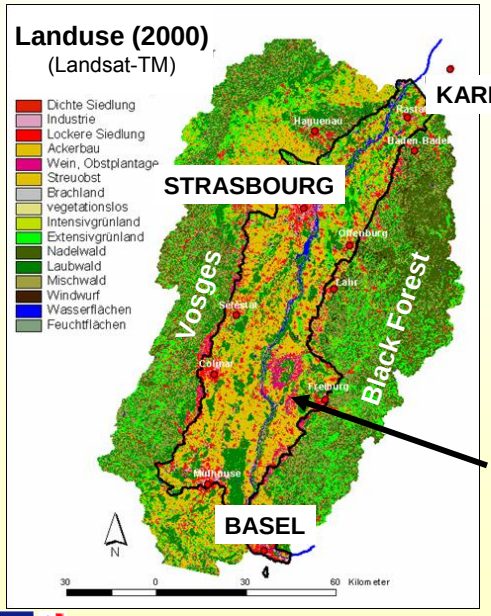
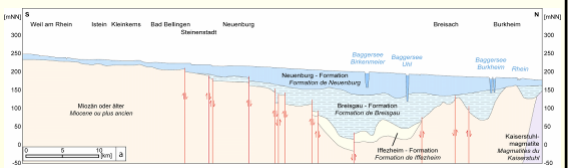


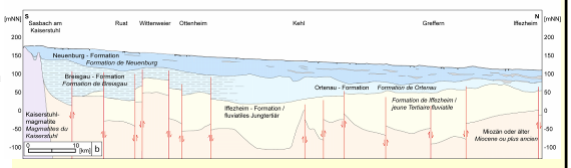
Upper Rhine aquifer
= <u>groundwater model</u>
(→ 4300 km²)

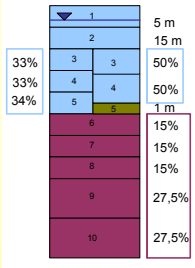
Introduction – **Modelling system** – Results & sources of error - Conclusion

Groundwater model: spatial discretisation

- 2 Aquifers
- partially 1 Aquiclude
- **10 model layers**
- **100 m grid size**







GOK

Neuenburg - Formation

Feinklastischer Horizont 4

Breisgau - Formation

MODFLOW + STREAM + MT3D
2000 (mod.) (+LAKE)

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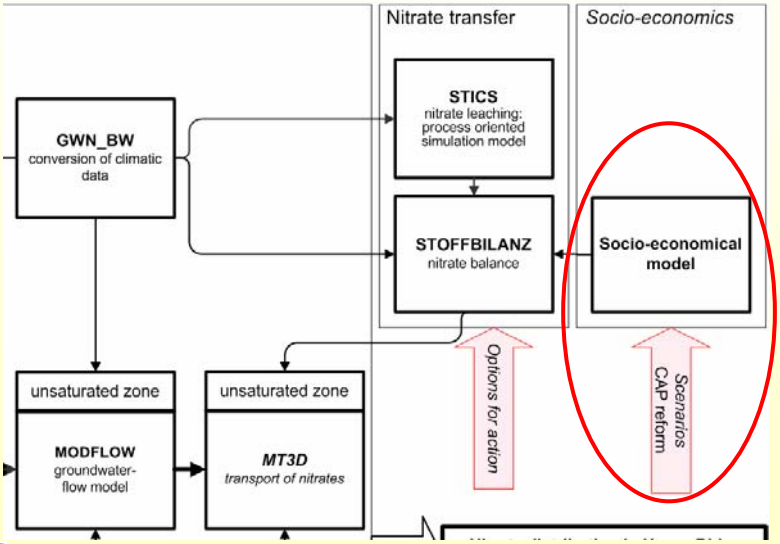
Socio-economic model



Socio-economic model

- product prices
- input factors

agricultural activities

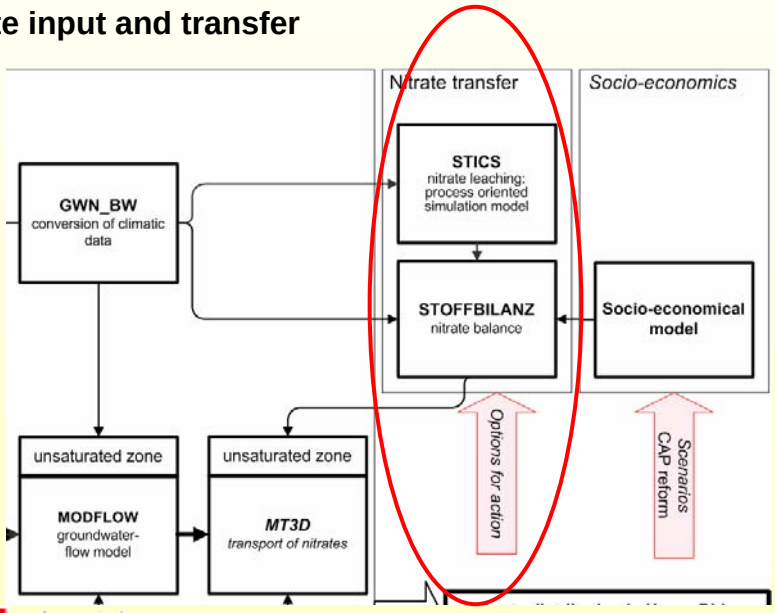
Common Agricultural Policy (CAP)

economical model (linear programming)

maximisation of income under constraints

cropping pattern (soil occupation)

Nitrate input and transfer

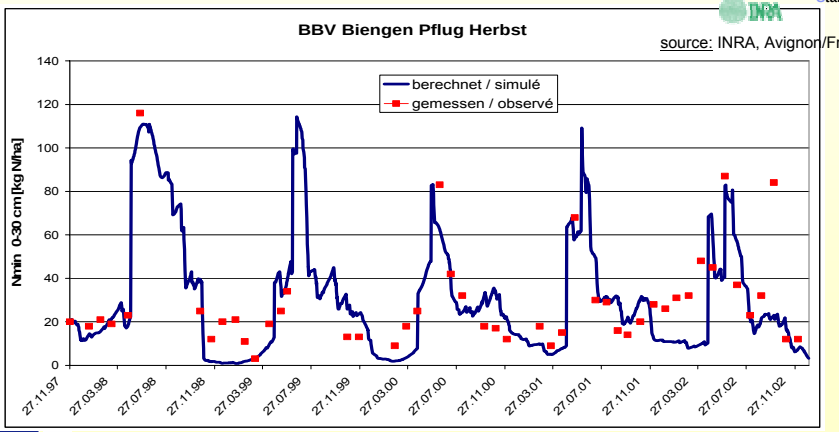


Introduction – **Modelling system** – Results & sources of error - Conclusion

Plant growth model (STICS) (plot/field scale)

<u>prognosis of</u>
crop harvest + nitrate leaching
– depending on soil type, climatic variations and cultivation methods

Simulateur multIdisciplinaire pour les Cultures Standard



source: INRA, Avignon/France

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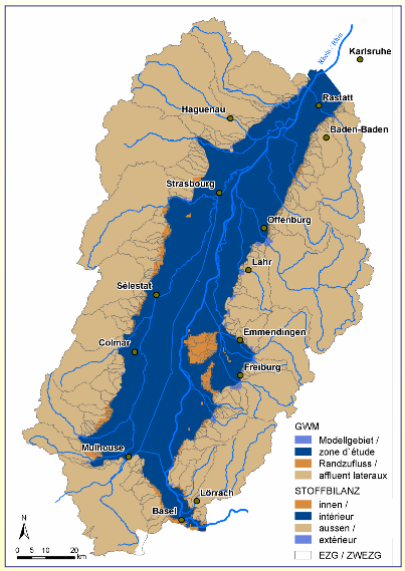
Interface to groundwater model

Nitrate balance model

STOFFBILANZ[1] covers

- area of the groundwater model (blue)
- Neighboring catchments

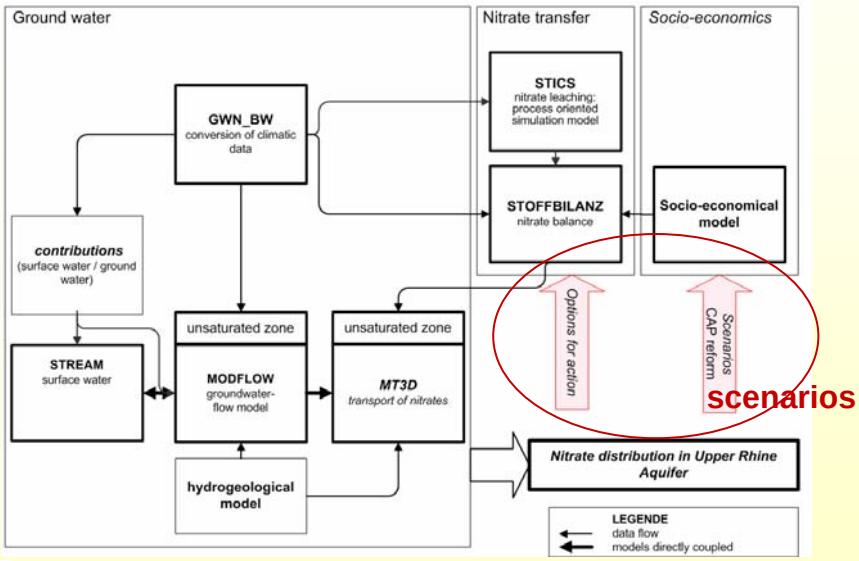
Its output is used as input to the groundwater model



[1] cf. contribution of M. Gebel et al. at MMM

Selected results and sources of error

simulation of scenarios & options for action



definition of 3 scenarios

A1/B2 based on IPCC emission scenarios (2000):

Scenario A1: "high liberalization of markets"

and

Scenario B2: "growing energy costs" →strong extension of bio energy sector

plus

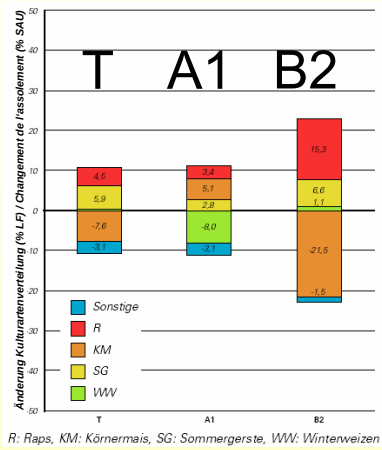
Tendency Scenario: most plausible scenario (by experts)

compared to base run (no changes 2000-2050)

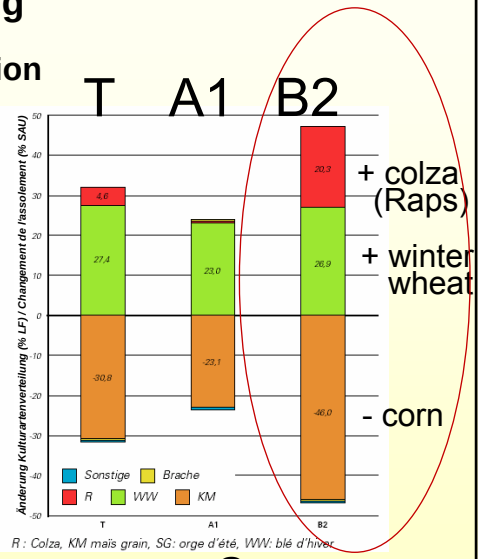
socio-economic modelling

→ **changes in soil occupation**

changes [% soil occupation]



R: Raps, KM: Körnermais, SG: Sommergerste, WW: Winterweizen



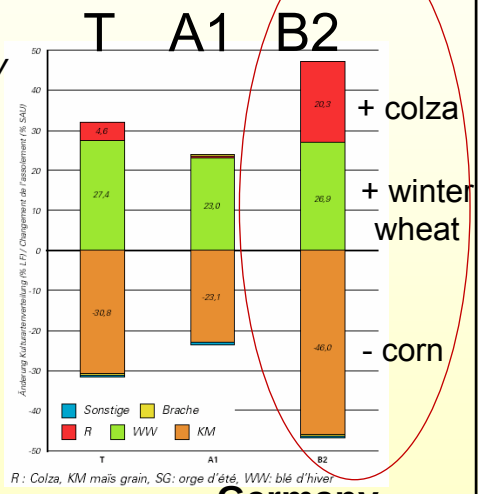
R : Colza, KM maïs grain, SG: orge d'été, WW: blé d'hiver

France **Germany**

Introduction – Modelling system – **Results & sources of error** - Conclusion

Source of error: socio-economic model type

Linear model / equilibrium:
small differences in income *may* cause large changes in soil occupation
→ not always realistic, farmers are "conservative"



R : Colza, KM maïs grain, SG: orge d'été, WW: blé d'hiver

Germany

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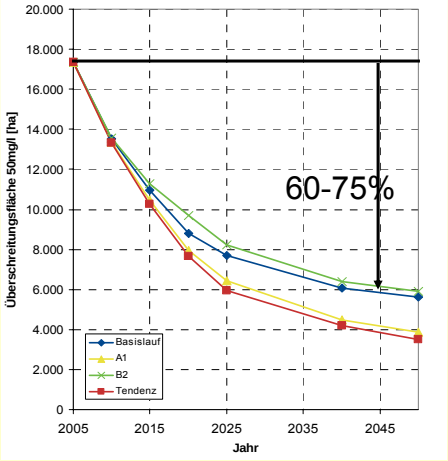
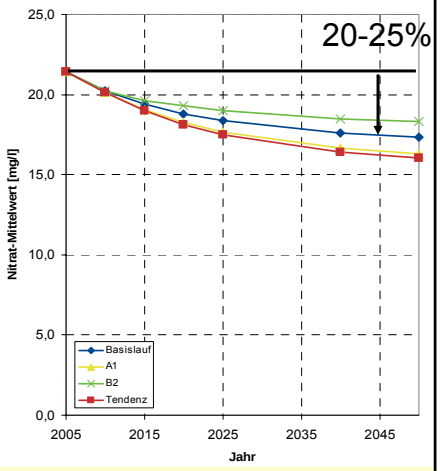
prognosis of nitrate concentration

area [ha] with **nitrate conc. > 50mg/l**



Mean value [mg/l]



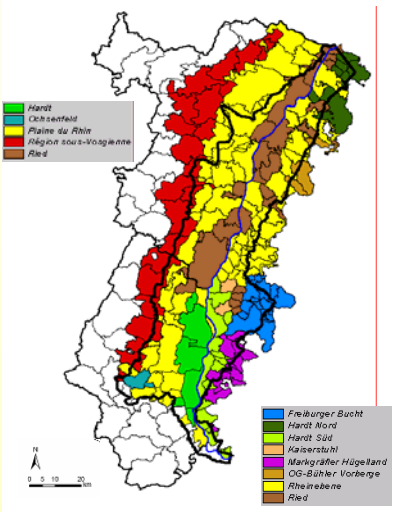
Source of error: spatial scale

Reason:

1980-2005
spatial resolution: community level

2005-2050: agricultural regions

→smoothing of input data
→elimination of hot spots



therefore: Change detection only on regional + country level

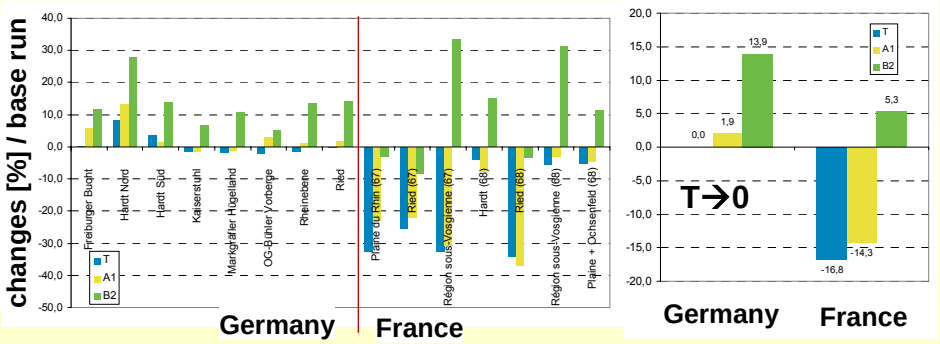
T – Tendency scenario

Scenario A1

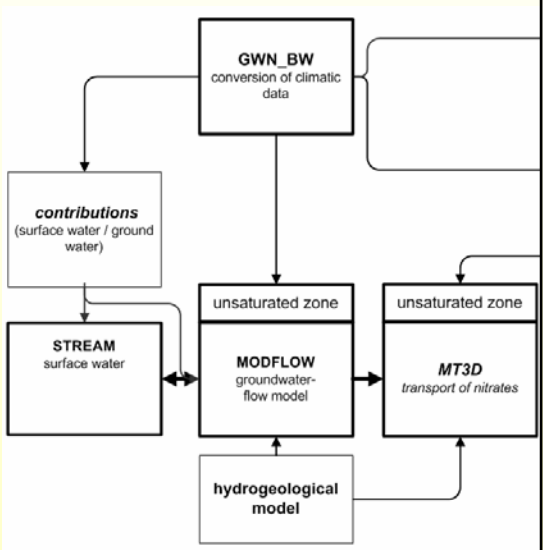
Scenario B2

each agricultural region reacts differently

13 agricultural regions → **mean (country)**

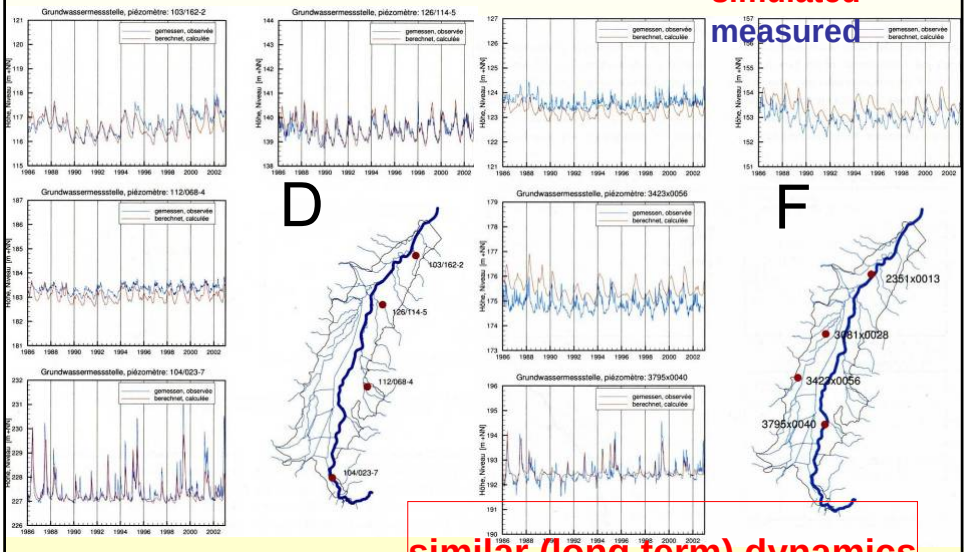


groundwater model



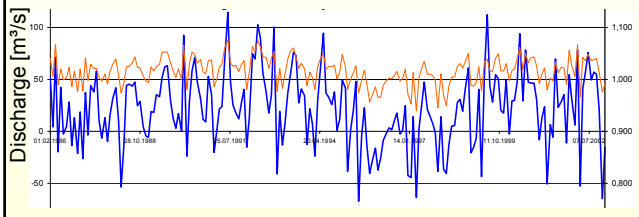
ground water table (1986-2003)

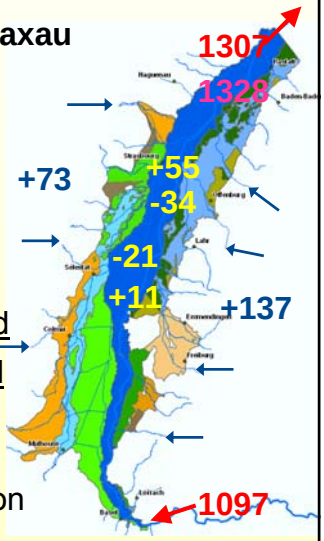
simulated
measured



Introduction – Modelling system – **Results & sources of error** - Conclusion

Independent model validation
Water balance of River Rhine: Basel - Maxau





- ΔQ (Maxau – Basel) = 210 m³/s <u>measured</u>
- ΔQ (Maxau – Basel) = 231 m³/s <u>simulated</u>
- **<u>Error</u>**: + 21 m³/s (10 %)
  → <u>Reasons</u>: (1) wrong rainfall distribution
  (2) undestimation of evapotranspiration
  (e.g. on irrigated land)

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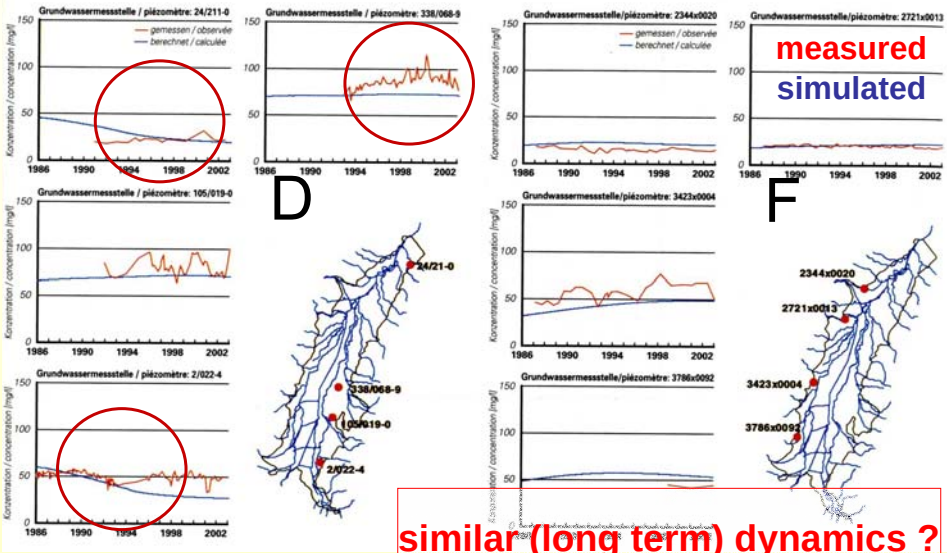
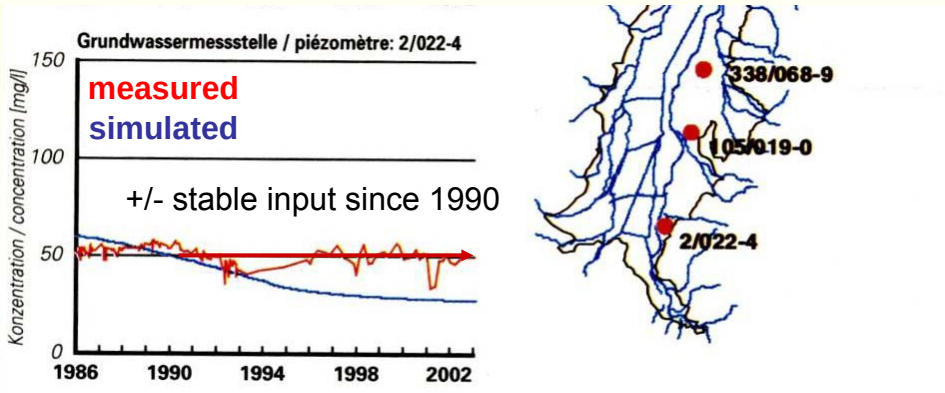
selected nitrate concentrations (1986-2003)



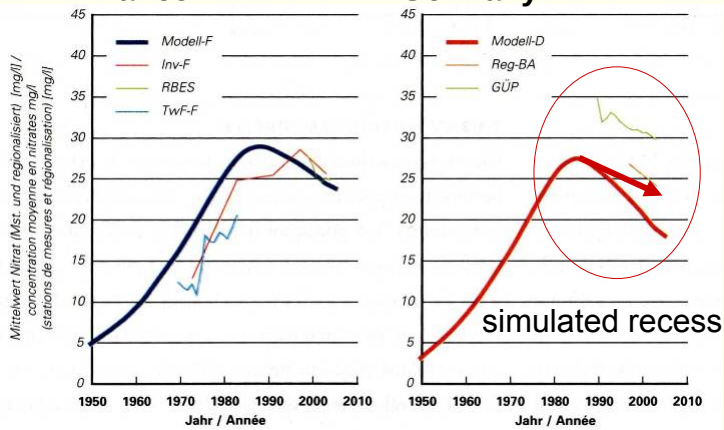


development of nitrate concentration 1950-2005
modelled vs. measured

→ partially wrong estimation of nitrate input for 1990-2000

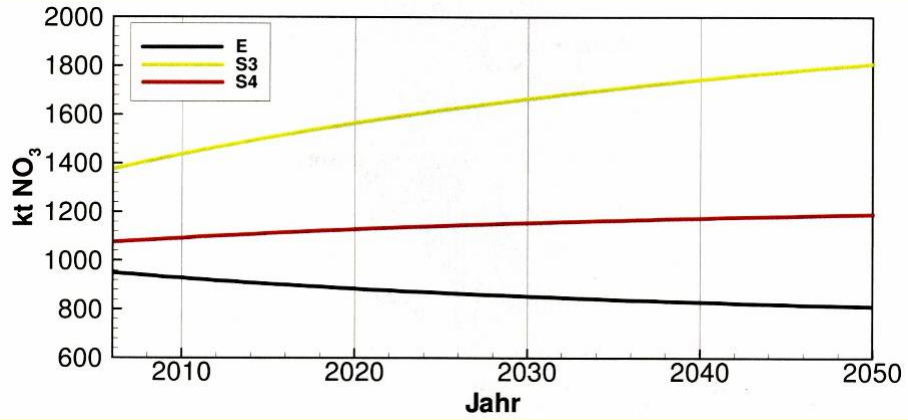
development of nitrate concentration 1950-2005
modelled vs. measured

France **Germany**

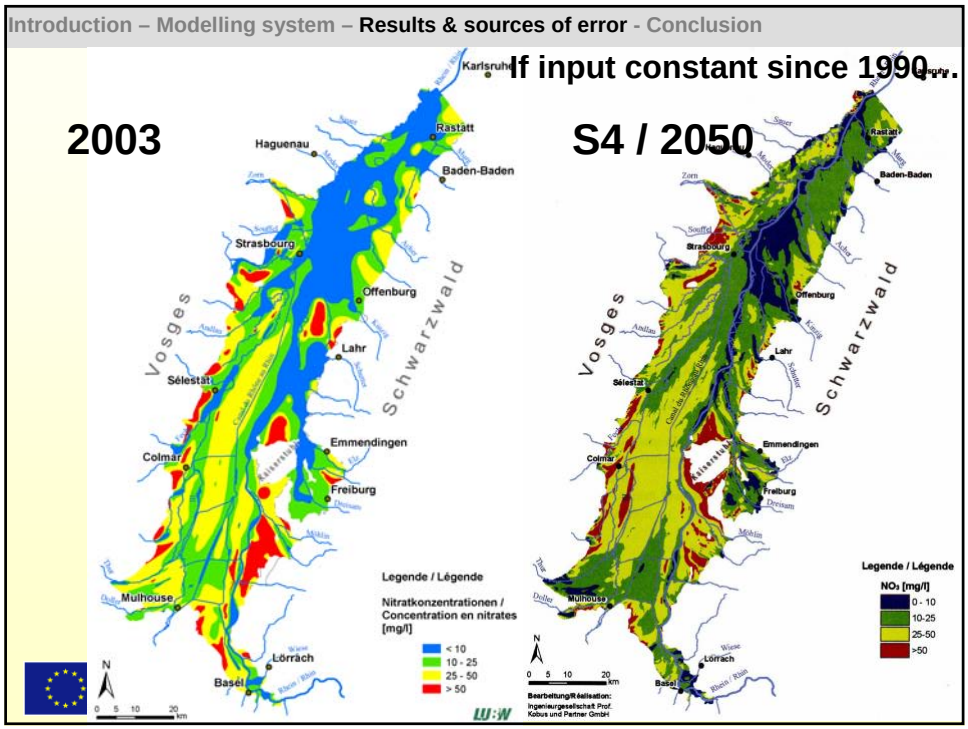


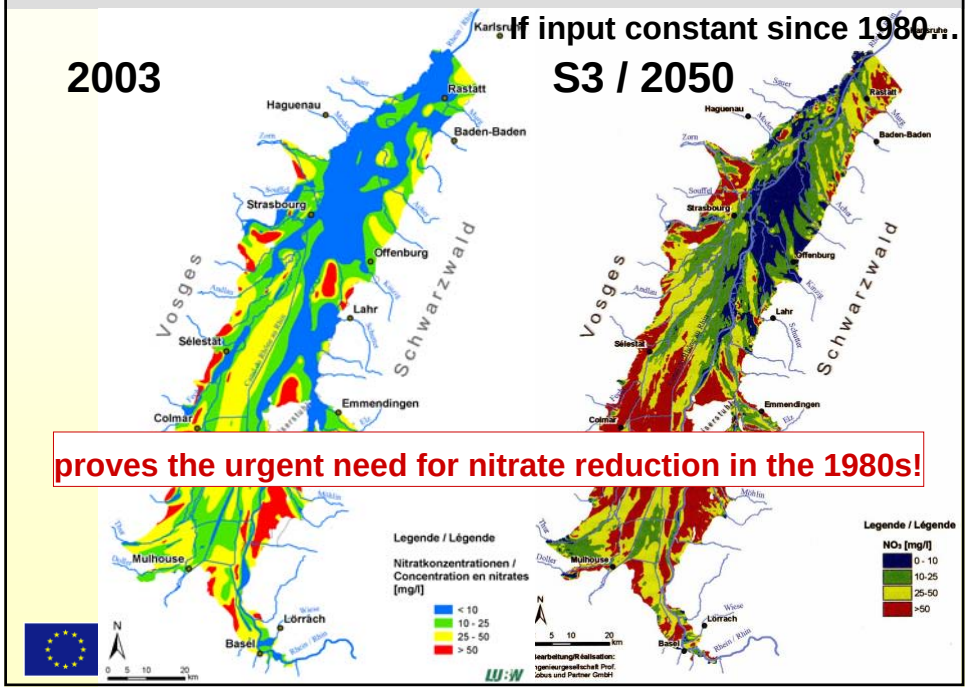
simulated recession too fast

Additional runs: development of nitrate storage 2005-2050



S3: no changes since 1980
S4: no changes since 1990 → +/- equilibrium
E: no changes since 2000 (“base run”)


If input constant since 1990…
2003
S4 / 2050
Karlsruhe
Rastatt
Haguenau
Baden-Baden
Strasbourg
Offenburg
Lahr
Sélestat
Colmar
Emmendingen
Freiburg
Mulhouse
Lörrach
Basel
Vosges
Schwarzwald
Legende / Légende
Nitratkonzentrationen / Concentration en nitrates [mg/l]
< 10
10 - 25
25 - 50
> 50
Legende / Légende
NO3 [mg/l]
0 - 10
10-25
25-50
>50
LU:W


If input constant since 1980…
2003
S3 / 2050
Karlsruhe
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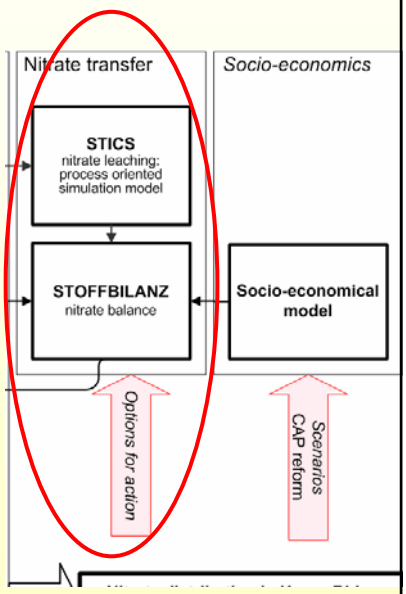
Haguenau
Baden-Baden
Strasbourg
Offenburg
Lahr
Sélestat
Colmar
Emmendingen
Mulhouse
Lörrach
Basel
Vosges
Schwarzwald
proves the urgent need for nitrate reduction in the 1980s!
Legende / Légende
Nitratkonzentrationen / Concentration en nitrates [mg/l]
< 10
10 - 25
25 - 50
> 50
Legende / Légende
NO3 [mg/l]
0 - 10
10-25
25-50
>50
LU:W

Plant growth model STICS

Source of error: Incomplete process representation

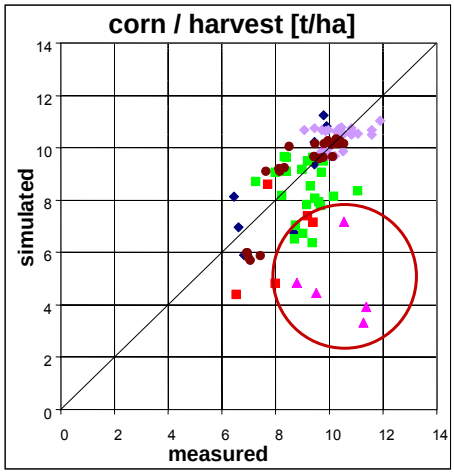


Introduction – Modelling system – **Results & sources of error** - Conclusion

Plant growth model STICS

Source of error: Incomplete process representation

On soils with high stone content, systematic underestimation of harvest[2]



[2]cf. Poster contribution of A. Heuer and M. Casper

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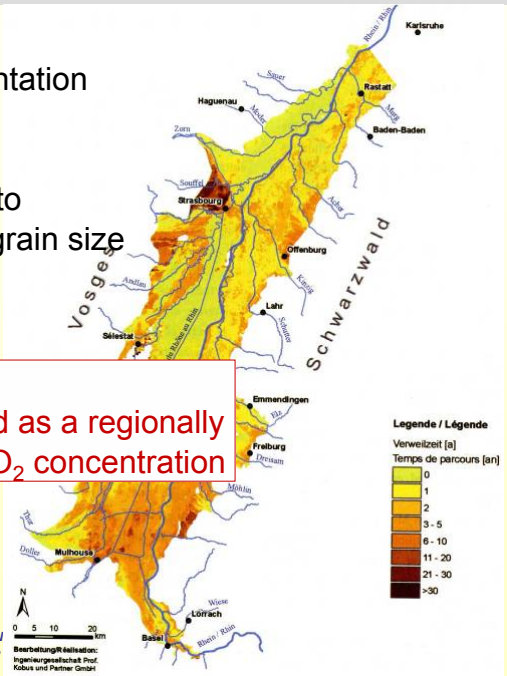
Source of error:
Incomplete process representation

Unsaturated zone
- delay: function of distance to groundwater table & grain size

- no decay of nitrates!

But:
decay of nitrates is simulated as a regionally calibrated linear function of O_2 concentration



Conclusion

- The modelling system is able to reproduce the long term behavior of the real system.
- The simulated fast recession of nitrate concentrations can not be validated for all measured locations (D/F).
- **Different sources of error/uncertainty could be detected**:
  - high sensitivity to small fluctuations in marked prices of the socio-economical model
  - differences in temporal and spatial scales of submodels
  - errors in input data (groundwater recharge + real amount of fertilizer application)
  - incomplete process representation

- Monitoring of Nitrates still necessary to prove reduction
- A permanent trans-national collaboration should be implemented

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Thank you for your kind attendance!