MONERIS
–
MOdeling of Nutrient Emissions in RIver Systems: Oder

M. Venohr, J. Hürdler, D. Opitz

Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

AMBER annual meeting, March 2011

1. Modelling nutrient fluxes

2. Nutrient emissions during the last 50 years

3. Spatial and temporal variation of emissions

4. Measures to reduce emissions and loads

5. Paper and perspectives

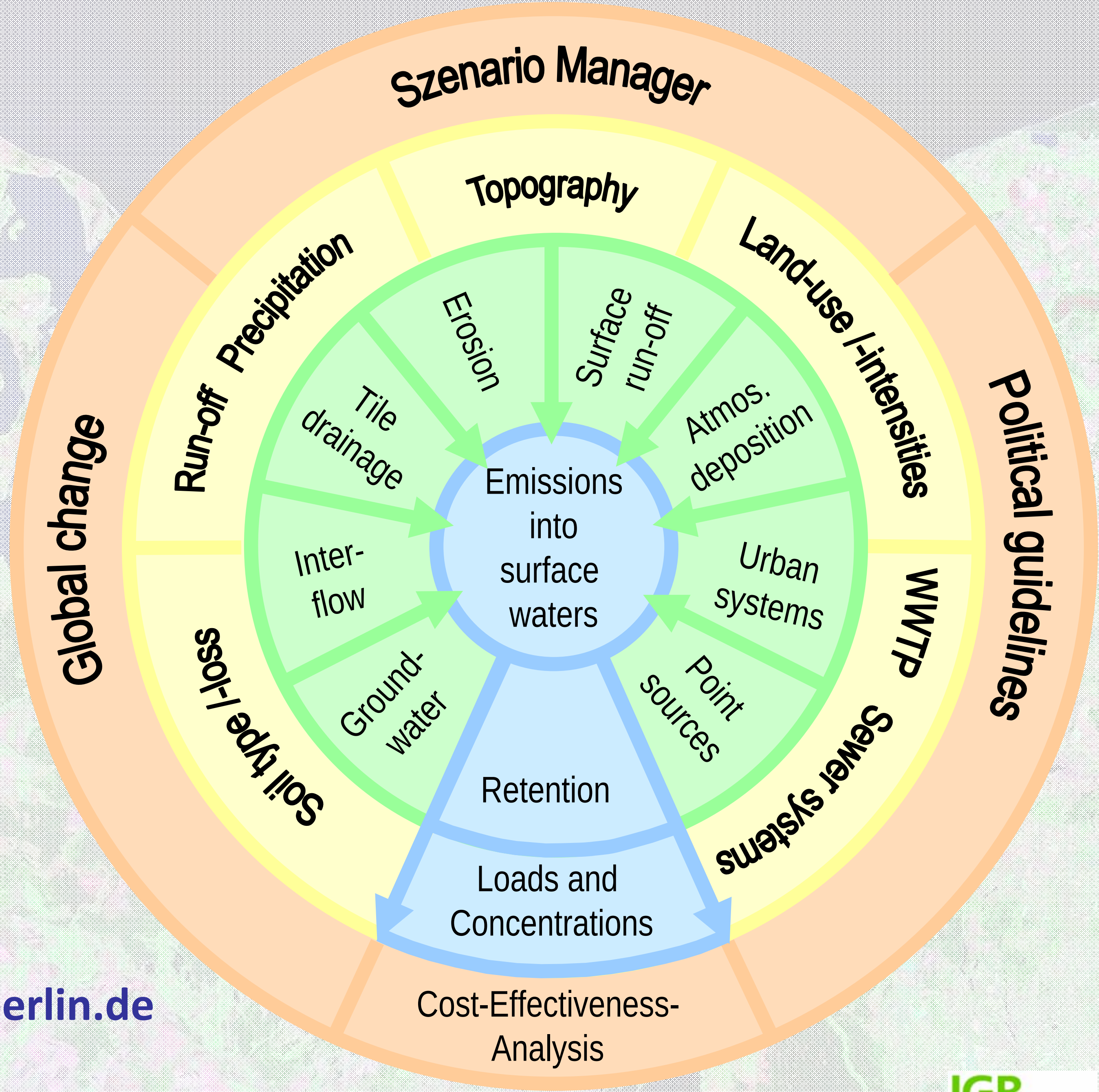
MONERIS

External framework

Catchment characteristics

Pathways

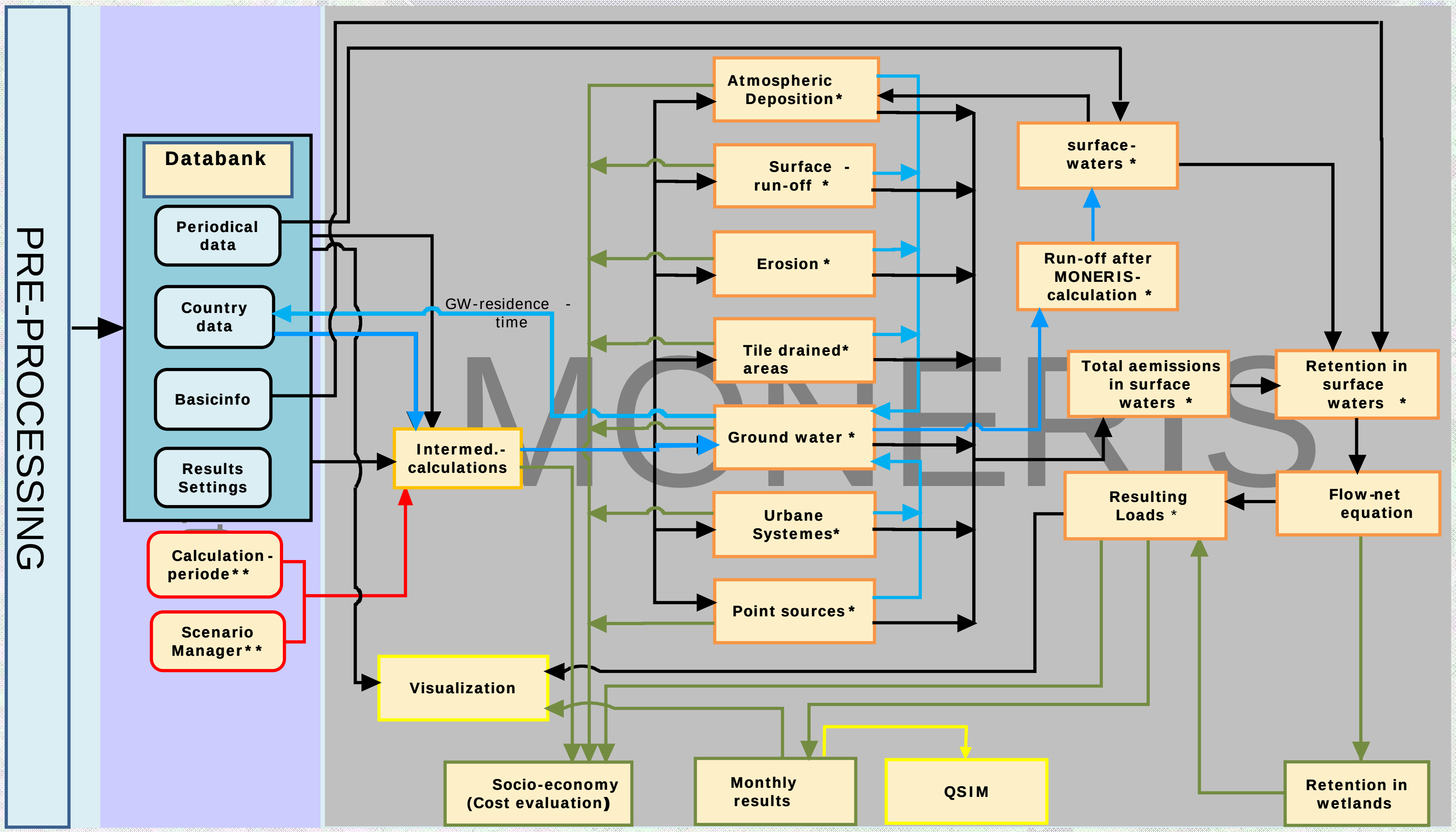
Surface waters



Details: moneris.igb-berlin.de

AMBER annual meeting, March 2011

Structure of MONERIS



Run-off components

New developed modules

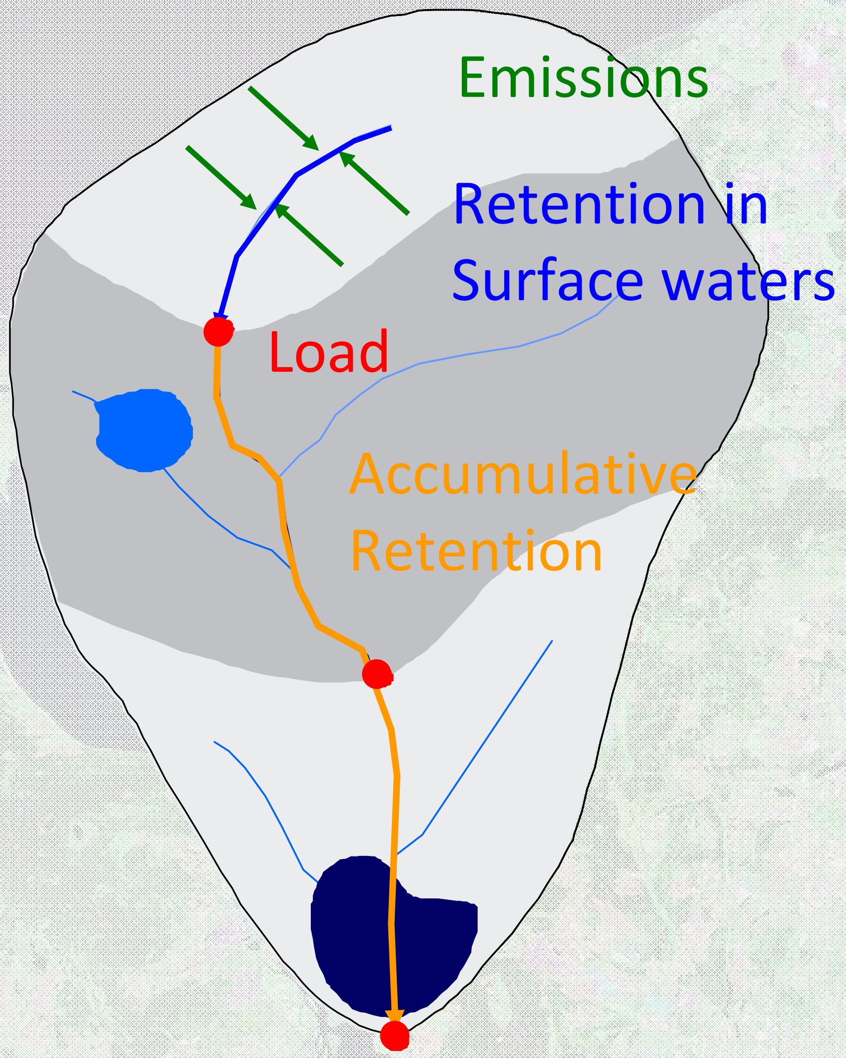
Link to external tools

* Saved as results in data bank

** Saved as settings in data bank

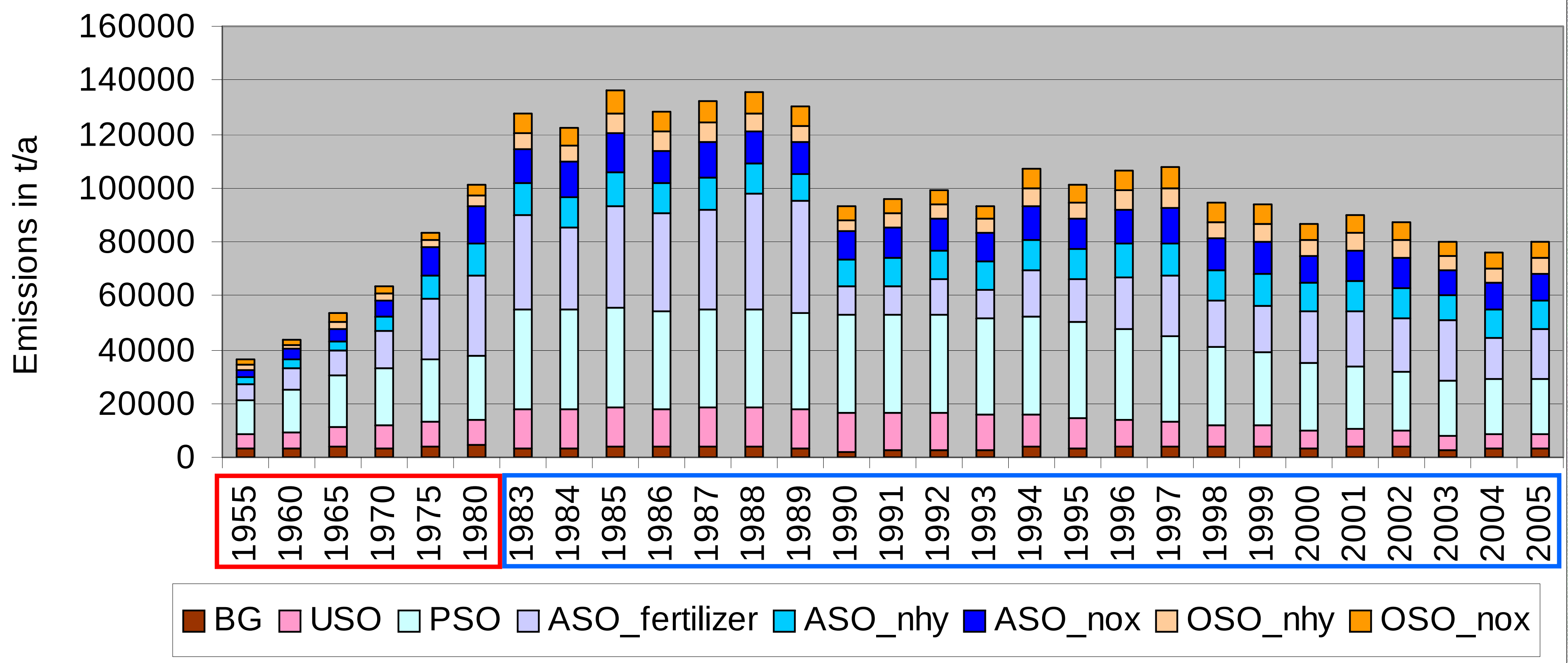
Nutrient balances in river systems

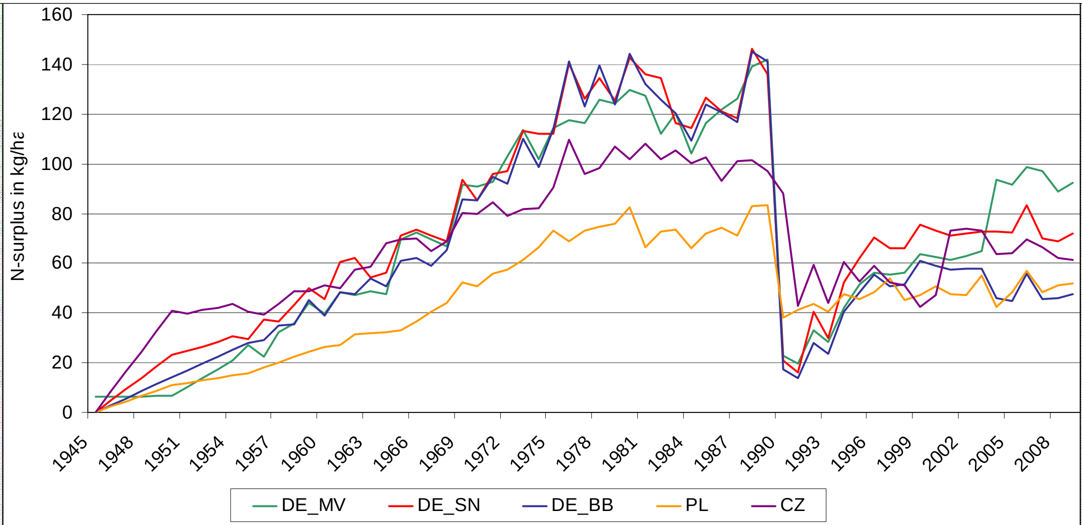
- Calculations for analytical units (semi-distributed)
- Emissions, instream retention and loads by semi-empirical/ conceptual approaches
- temporal resolution: annual (disaggregated to monthly)
- spatial resolution: 50 km²
- TN, DIN, DON, TP, Si



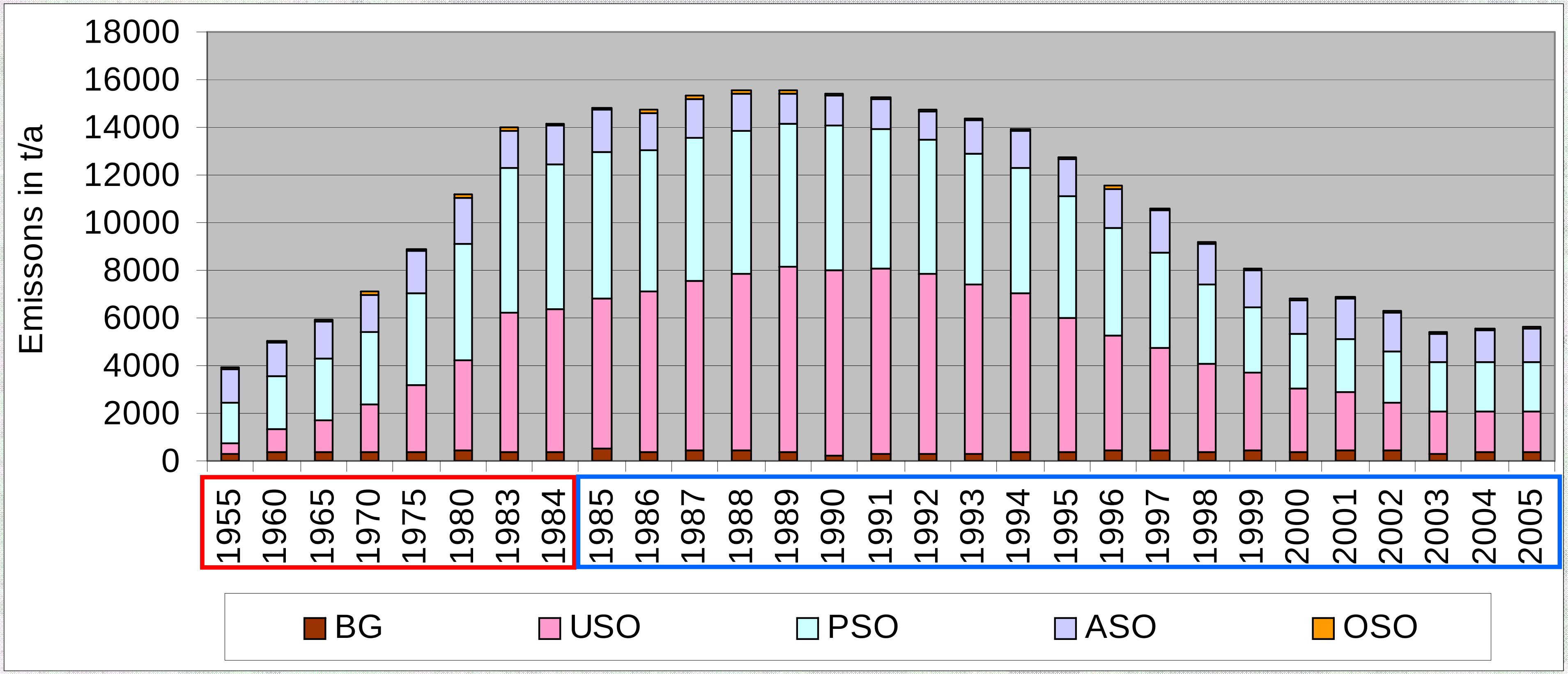
Impact ratio (IR = L%/E%)

Changes of TN emissions during last 50 years

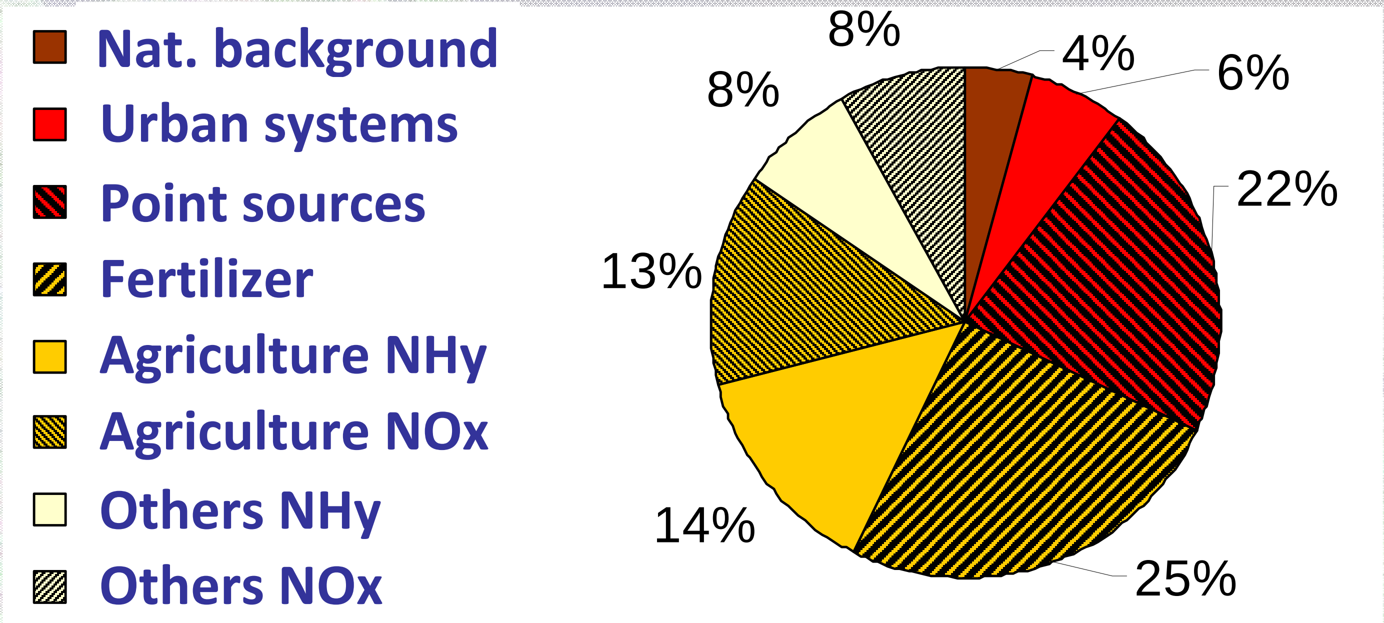




Changes of TP emissions during last 50 years

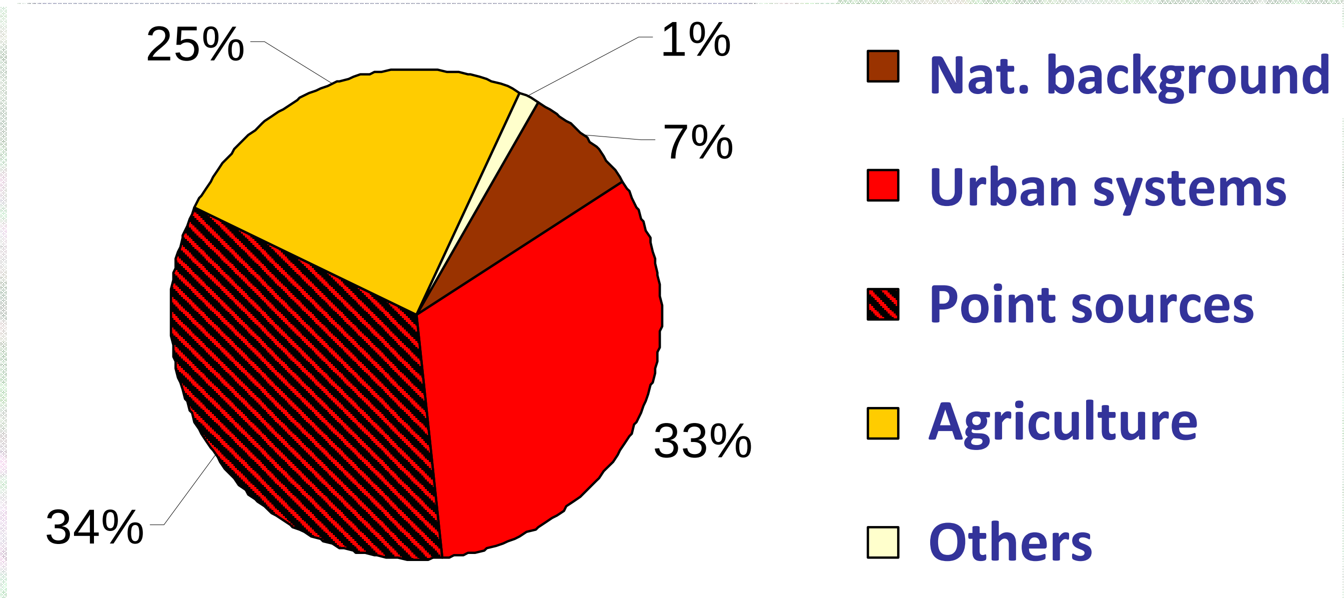


Source apportionment - 2005



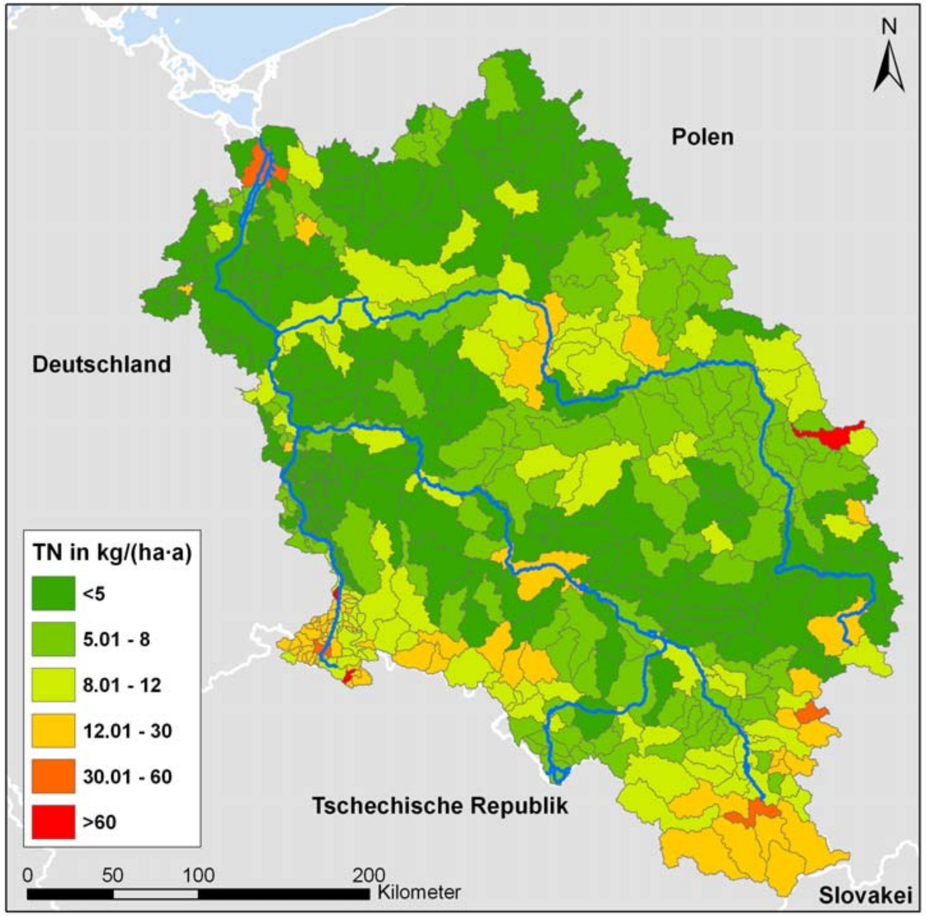
TN

TP

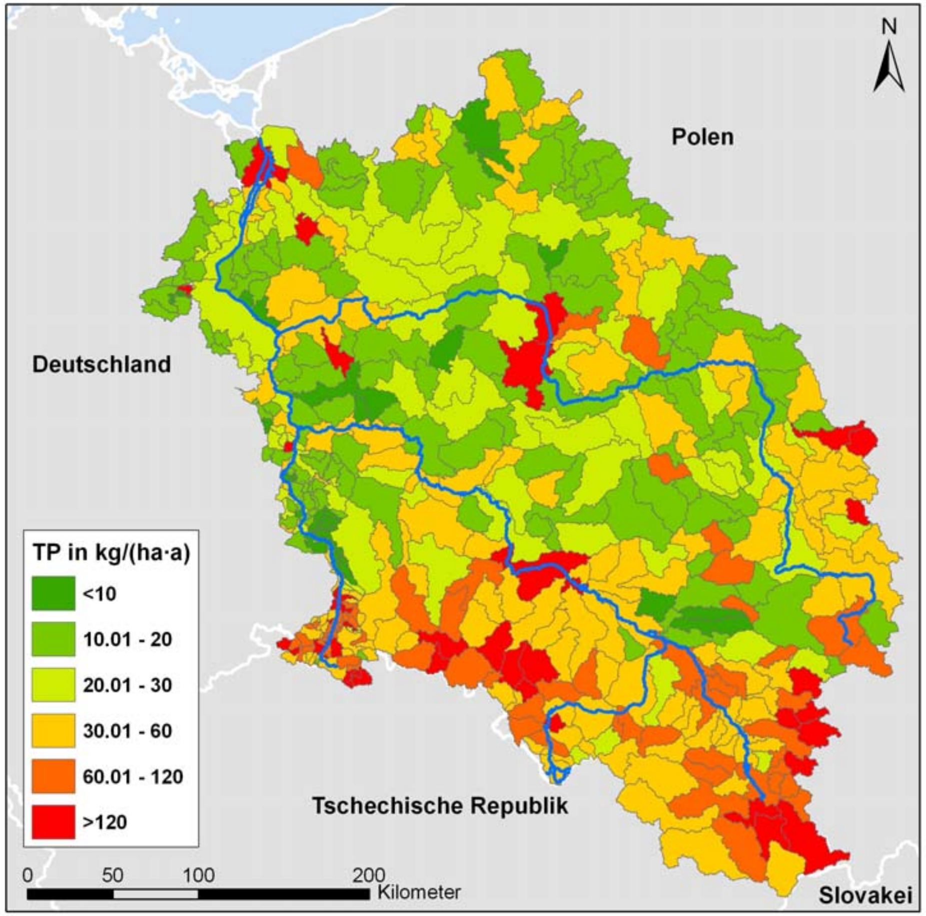


Spatial distribution of emissions - annual

TN



TP

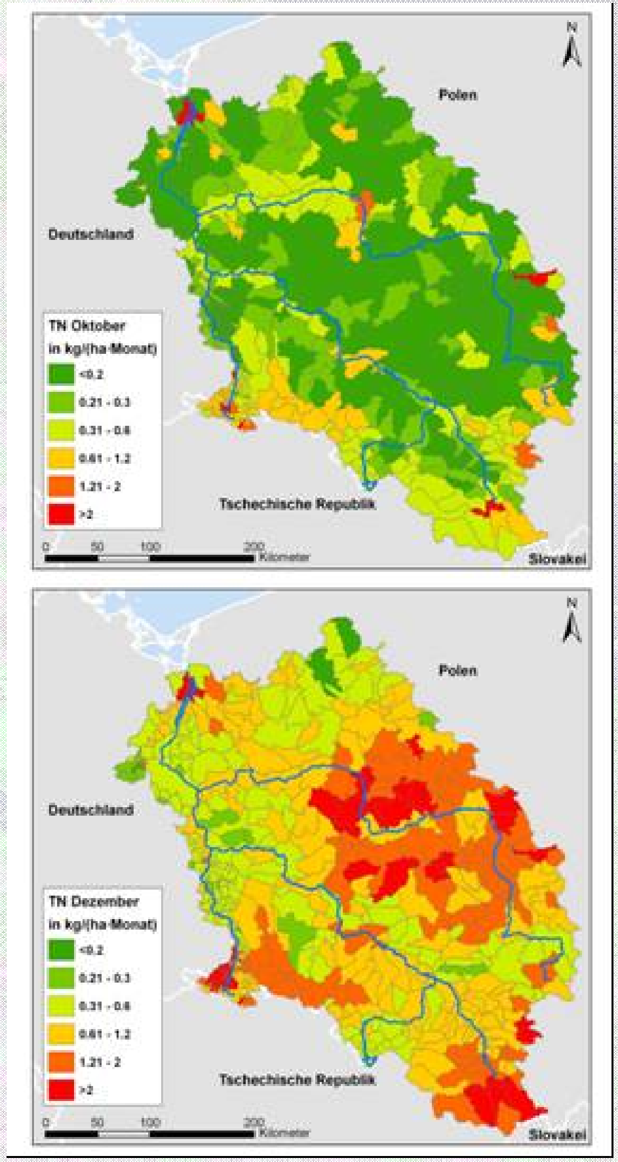


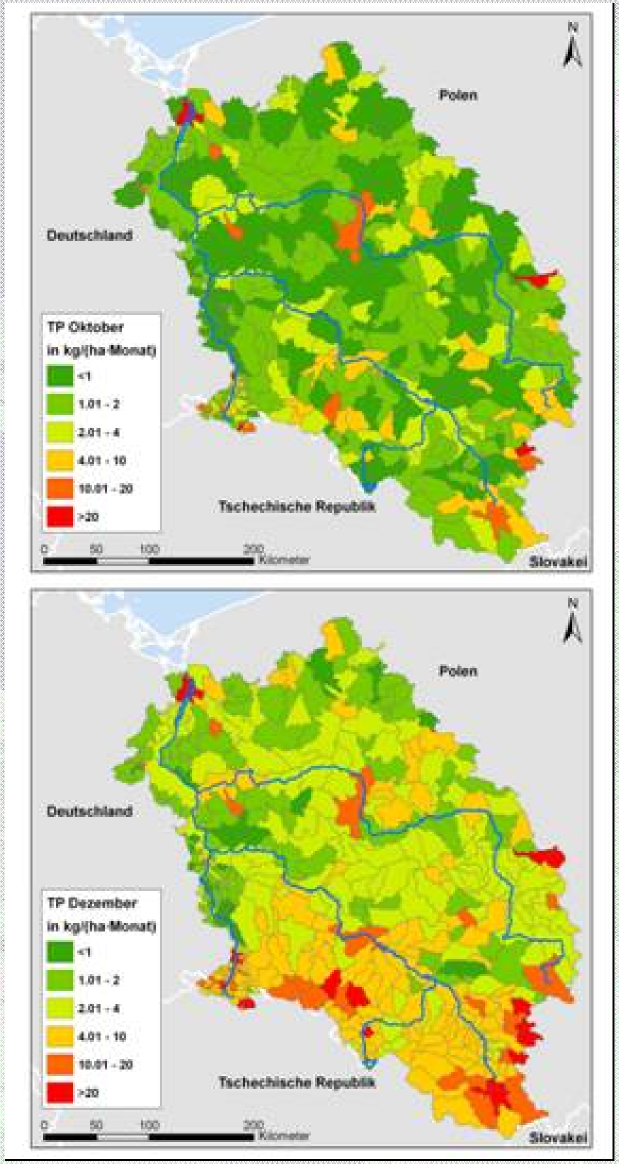
Spatial distribution of emissions - monthly

TN **TP**

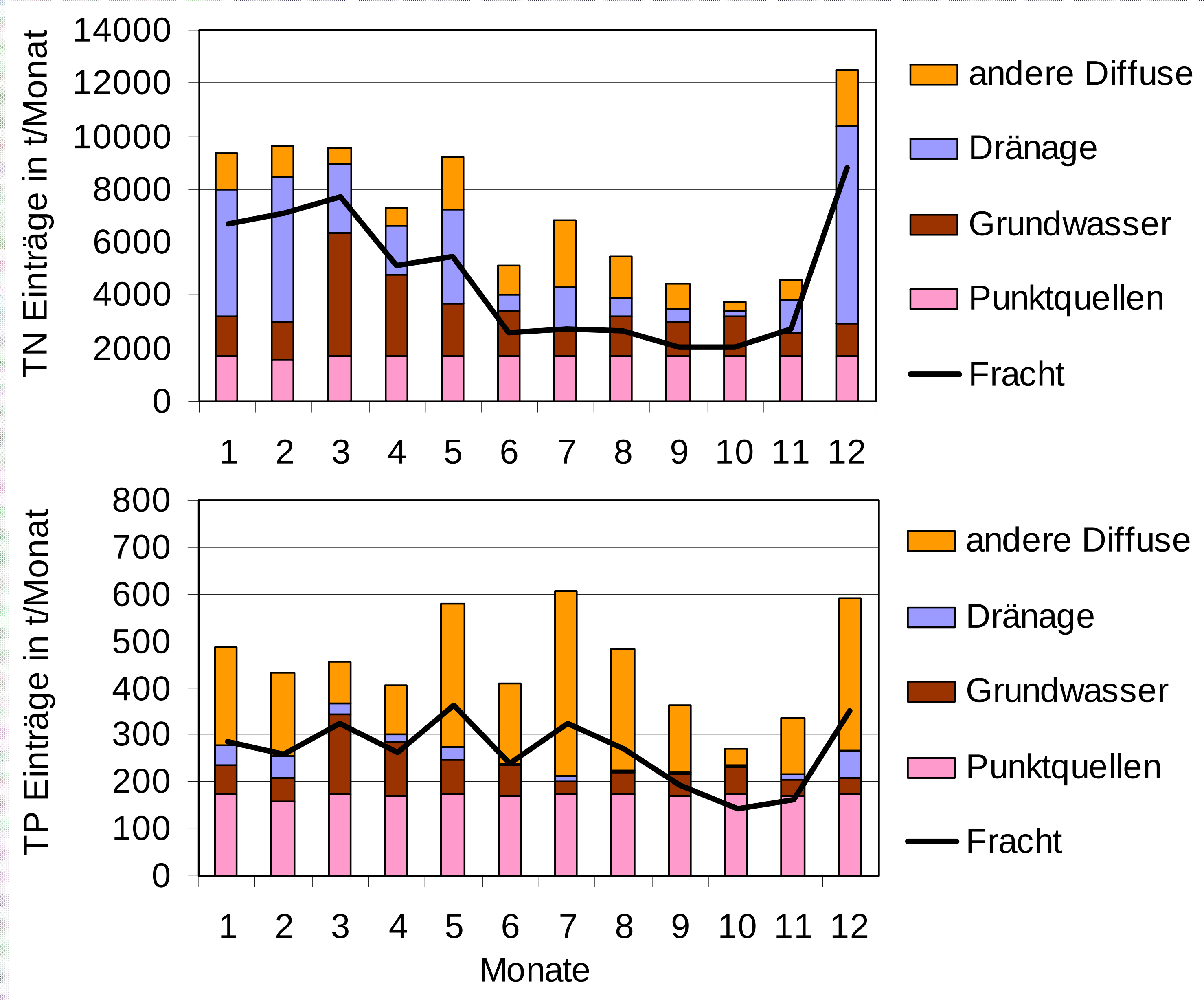
October

December

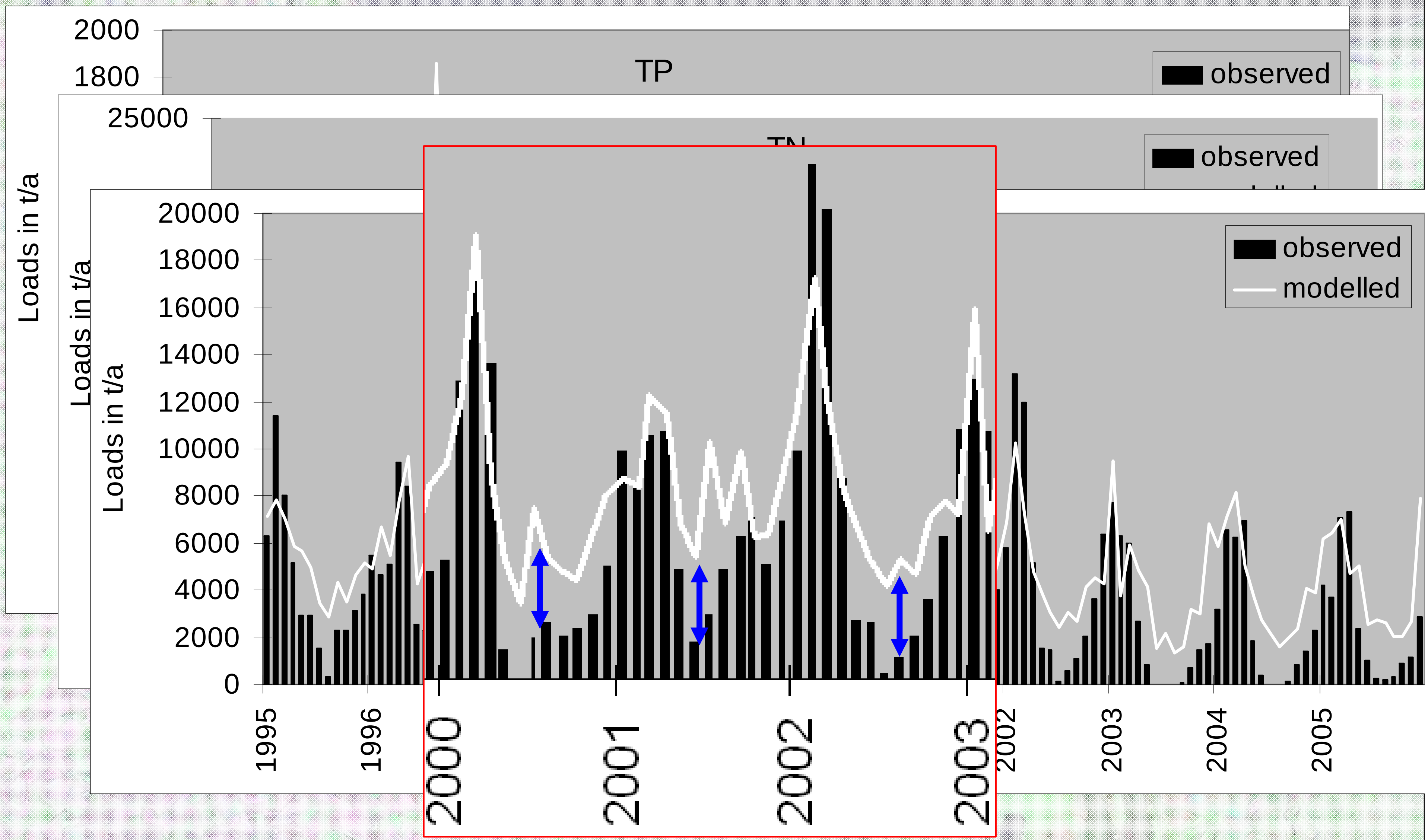




Monthly emissions in the year 2005



Monthly load comparison



Nutrient up-take by phytoplacton and phyto-benthos

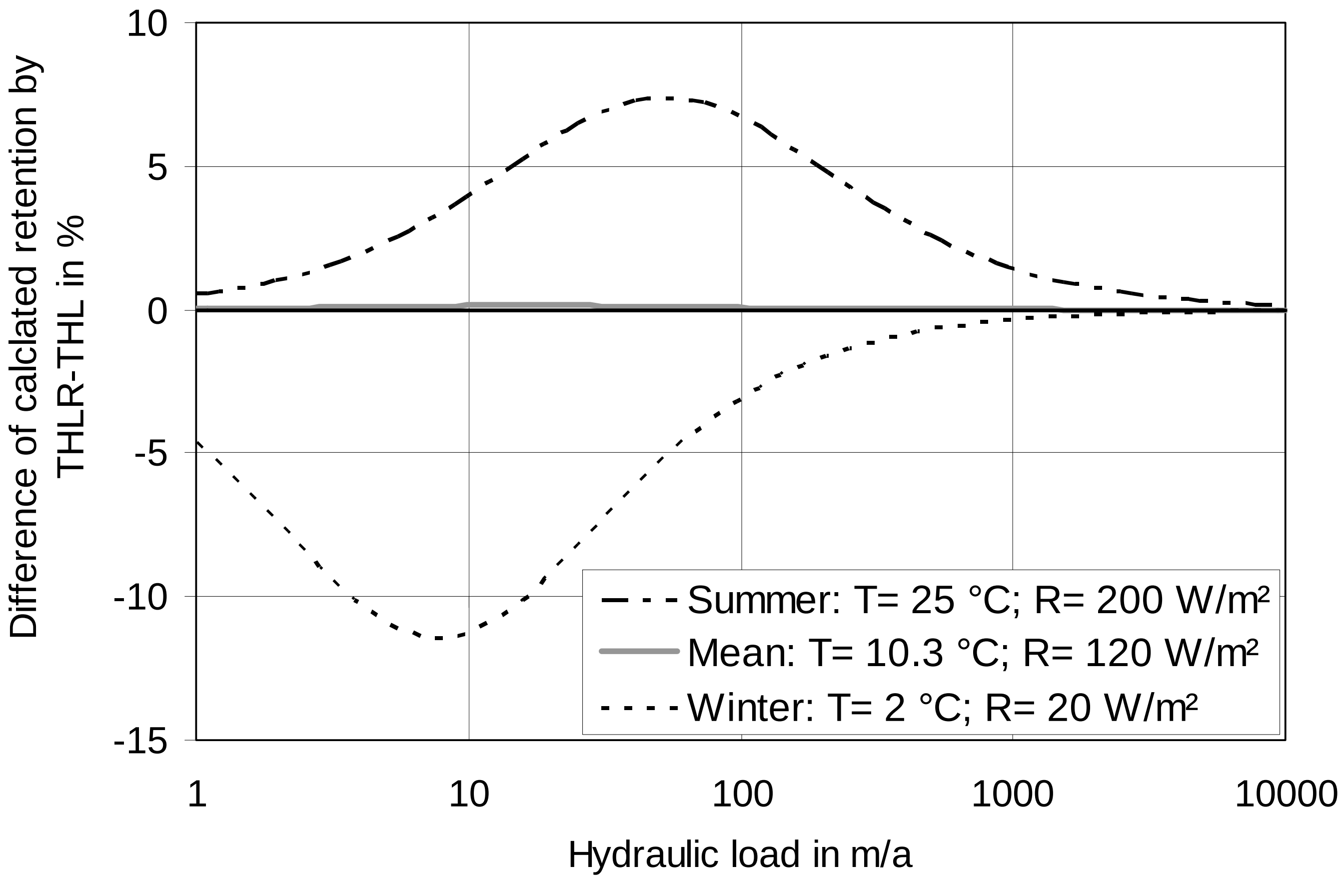
Monthly Retention - N-Uptake by aquatic organisms

$$RM_{THLR-DIN} = \frac{1}{1 + (4.74 + 0.031 \cdot R) \cdot e^{0.067 \cdot T} \cdot HL^{-1}} \cdot 100$$

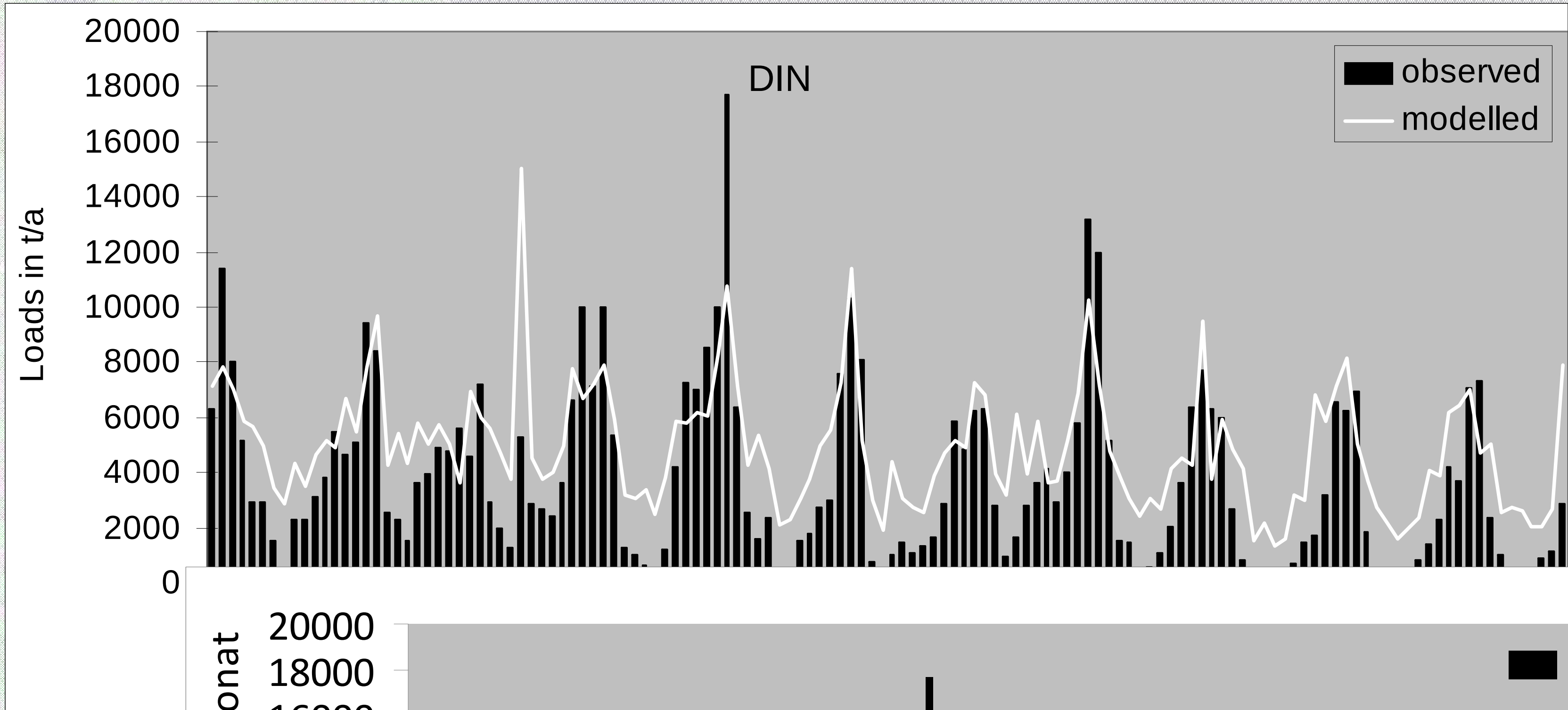
$RM_{THLR\text{-}DIN}$ = monthly modelled DIN retention, in %

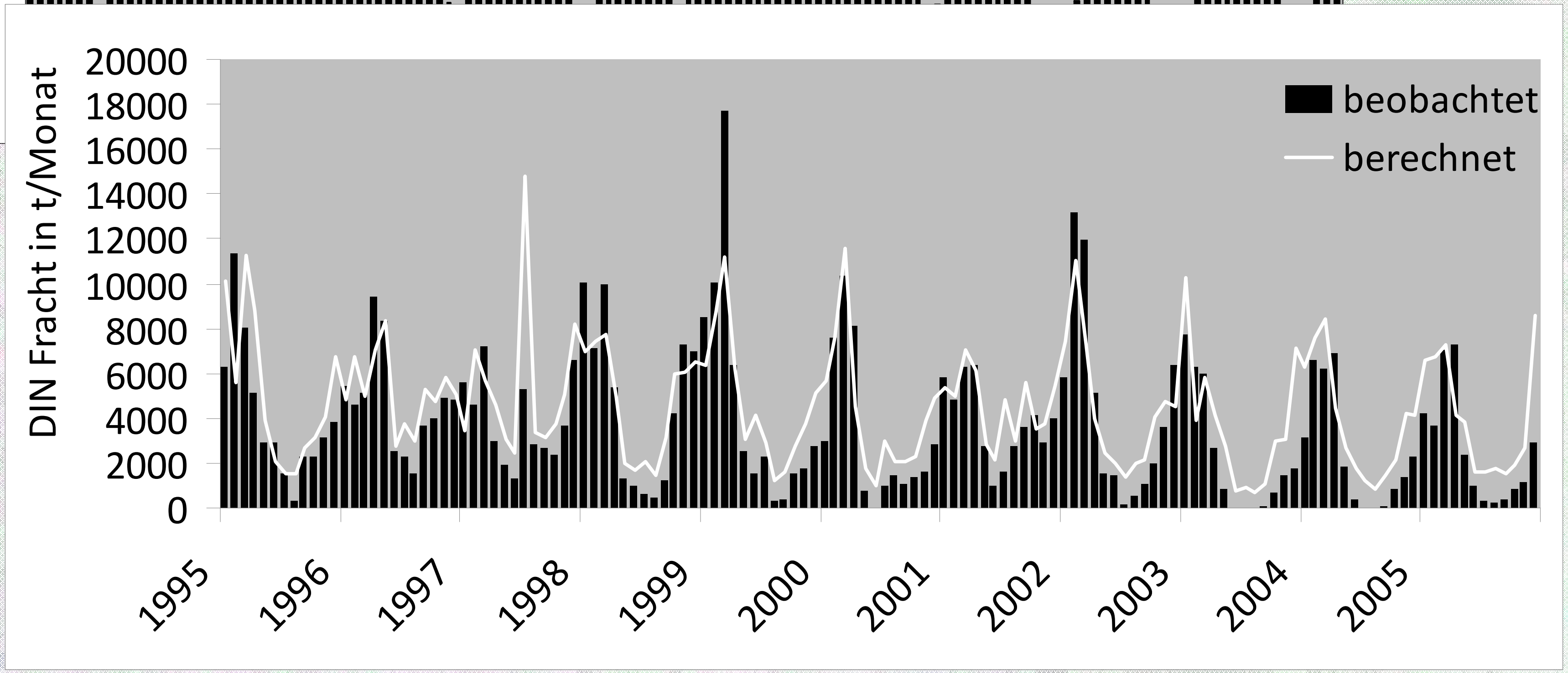
R = incoming short wave radiation at surface level, in W/m² (CM-SAF)

The approach was calibrated for a mean monthly radiation of 120 W/m².



Monthly DIN load comparison





Management options (measures)

Land-use changes

- Conversion of arable land to grassland
- Reduction of soil loss from arable land
- Reduction of tile drained areas
- Retention ponds for tile drainage discharges
- Reconstruction of wetlands / back shift of dikes
- Reduction of impervious urban areas

Land-use intensities

- Reduction of nitrogen surplus on agricultural land
- Reduction of atmospheric deposition
- Use of phosphate-free detergents

Wastewater treatment plants (WWTP)

- Reduction of discharge concentration for individual WWTPs

Decentralized waste water treatment plants (DCTP)

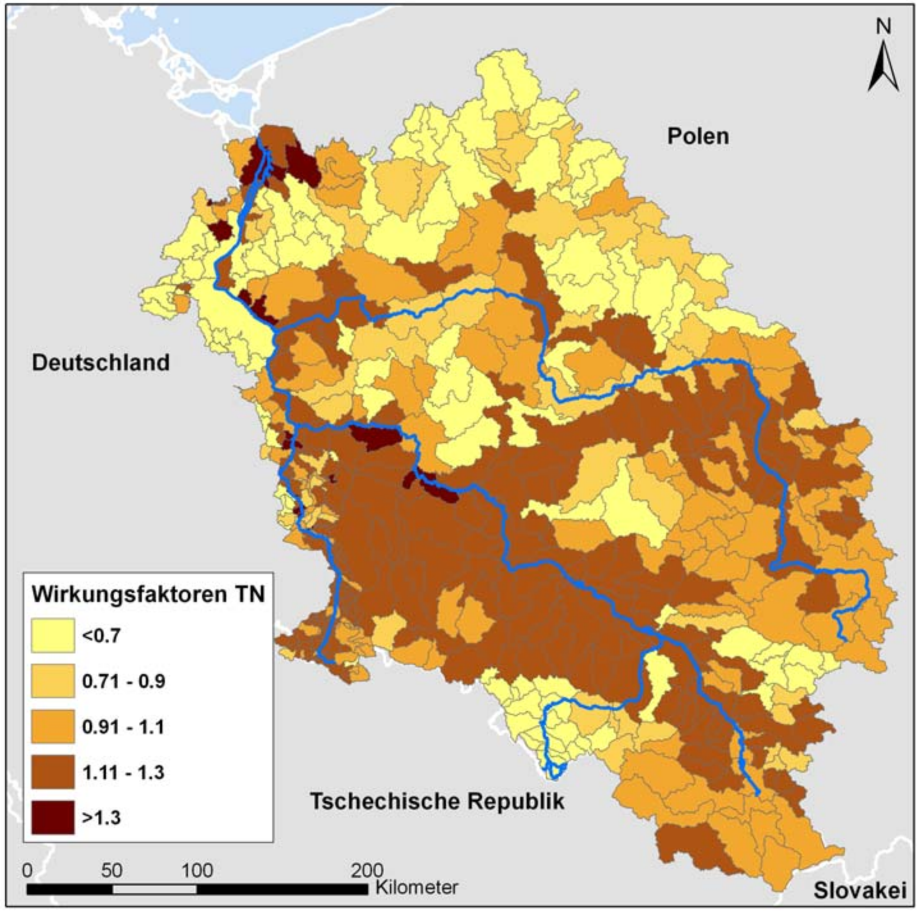
- Assume state of the art technique for DCTP
- Conversion of DCTP to (virtual) WWTP
- Assume P-removal for DCTP and WWTP

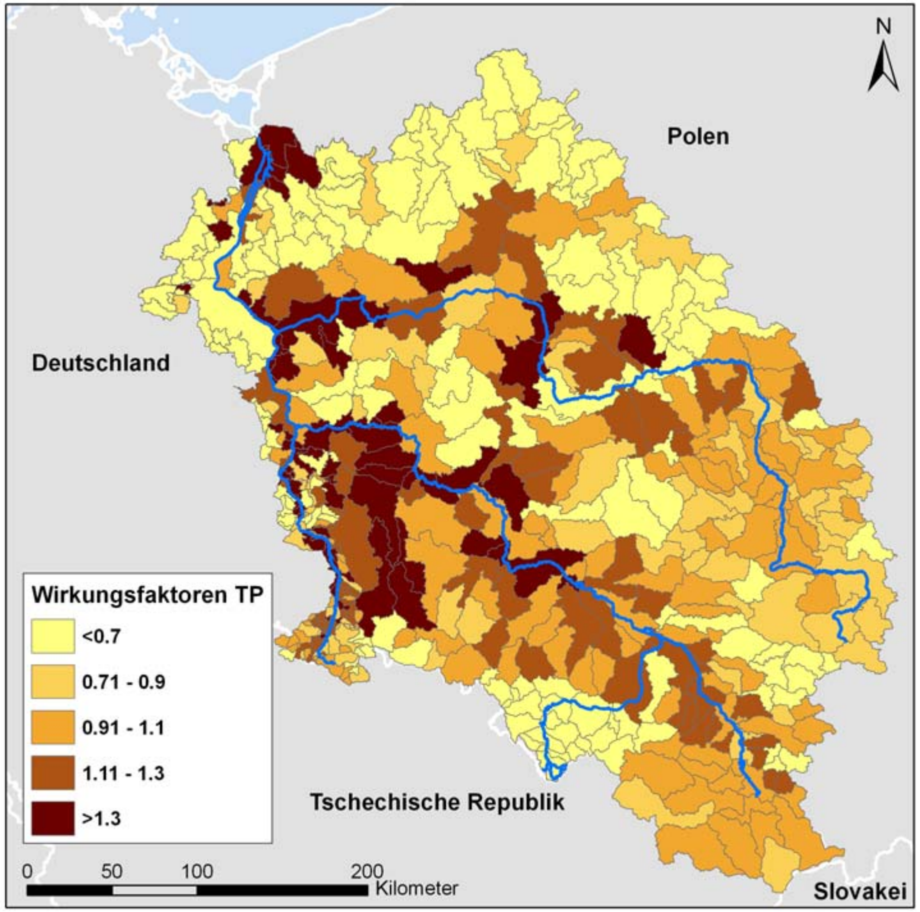
Sewer systems

- Increase of storage volume for combined sewers
- Soil filter for rainwater discharges of separate sewers
- increase share of inhabitants connected to sewers and WWTP

Contribution of single AUs on the load at the outlet

TN **Impact ratio (IR = L%/E%)** **TP**





Measures to reduce emissions to surface waters

<table>
<tr><th>Szenario</th><th>WWTP</th><th>Urban Systems</th><th>N-surplus</th><th>Erosion</th><th>Drainage Ponds</th><th>Atmosph. Deposition</th></tr>
<tr><td></td><td></td><td>%</td><td>kg/ha</td><td>%</td><td>ha/km2</td><td>%</td></tr>
<tr><td>COMP1</td><td></td><td>RBF: + 10
MKS: + 10</td><td>Max. 60</td><td>BA: -60
MG: >4
GR: 5</td><td>10</td><td></td></tr>
<tr><td>COMP2</td><td rowspan="2">waste water directive fulfilled</td><td>RBF: ± 20
MKS: ± 20</td><td>Max. 40</td><td>BA: -90
MG: >4
GR: 10</td><td>20</td><td rowspan="2">NOx -33
NHy ± 0</td></tr>
<tr><td>PARTLY1</td><td>RBF: ± 20 **
MKS: ± 20 **</td><td>Max. 40 *</td><td>BA: -90 **
MG: >2 **
GR: 20 **</td><td>20 *</td></tr>
<tr><td>PARTLY2</td><td></td><td>RBF: ± 50 **
MKS: ± 50 **</td><td>Max. 20 *</td><td>BA: -90 **
MG: >2 **
GR: 50 **</td><td>50 *</td><td></td></tr>
<tr><td>COMP3</td><td>extended</td><td>RBF: ± 50
MKS: ± 50</td><td>Max. 20</td><td>BA: -90
MG: >2
GR: 50</td><td>50</td><td>NOx -50
NHy -25</td></tr>
</table>

Only if IR for * Nitrogen & ** Phosphorus is > 1,1

Effect of measures to reduce emissions to surface waters

Scenario	WWTP	Urban Systems	N-surplus	Erosion	Tile Drainages	Atmosphär. Deposition	Total	Load
COMP1		N: -0,1 P: -0,3	N: -0,0 P: -0,0	N: -0,1 P: -1,5	N: -1,9 P: -0,6		N: -12,0 P: -12,6	N: -13,9 P: -18,6
COMP2	N: -4,4	N: -0,2 P: -0,8	N: -0,9 P: -0,0	N: -0,4 P: -4,7	N: -3,6 P: -1,0	N: -5,6	N: -14,2 P: -16,7	N: -15,9 P: -21,6
PARTLY1	P: -9,5	N: -0,1 P: -0,4	N: 0,0 P: 0,0	N: -0,3 P: -3,6	N: -1,6 P: -0,5	P: -0,8	N: -11,4 P: -14,4	N: -13,7 P: -21,0
PARTLY2		N: -0,1 P: -0,6	N: -2,2 P: 0,1	N: -0,4 P: -4,0	N: -2,3 P: -0,6		N: -13,6 P: -16,1	N: -16,0 P: -22,8
COMP3	N: -8,0 P: -16,3	N: -0,3 P: -1,2	N: -4,9 P: -0,1	N: -0,8 P: -9,0	N: -7,6 P: -1,8	N: -13,1 P: -1,1	N: -32,8 P: -30,1	N: -33,9 P: -37,1

Paper and perspectives

Paper:

- New retention approach
- joined paper on comparison of potential of measures and reduction goals in Elbe and Oder
- Climate + Nemunas → Jens Hürdler

Perspectives:

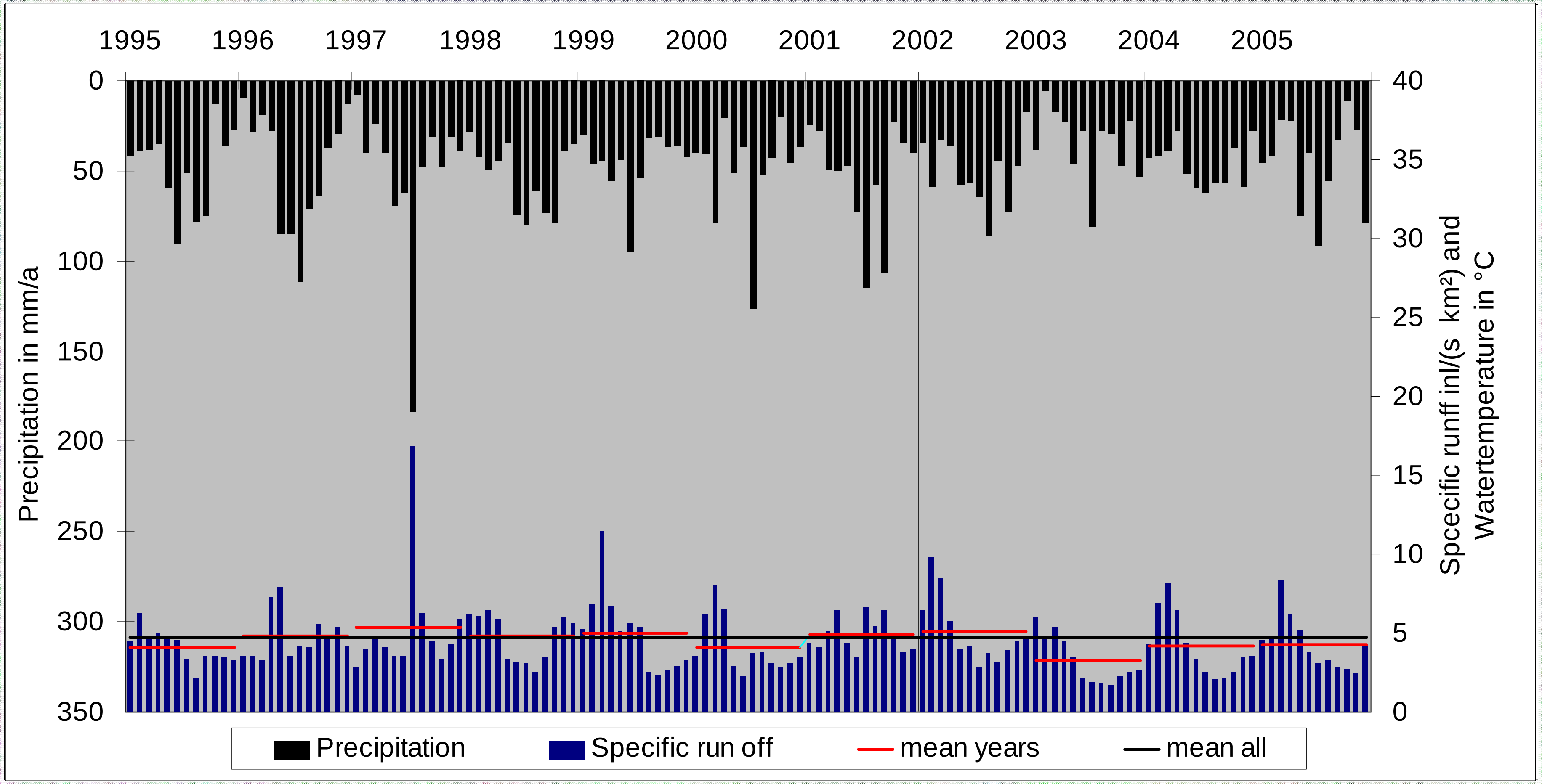
- Development of a catalogue of measures to transfer „real“ management options into MONERIS
- Results from GLOWA-Elbe-III, AMBER, RADOST, NITROLIMIT and AGRUM Weser +
- Option to consider this catalogue in next UFO-Plan of UBA (under discussion)
- Methods will be used by ICPDR
- Approach on monthly retention will be checked and further developed in NITROLIMIT

Thank you for your atention


Slides for discussion!

Monthly precipitation, temperature and run off

4. Monhtly emissions and loads from 1995 to 2005



Methods for monthly disaggregation of emissions and loads

Hypothesis: *The seasonal changes of the emissions are caused by the different portion of the pathways and their hydrological components.*

→ concentrations almost constant during year

Point sources: constant discharges during year (Load / 12)

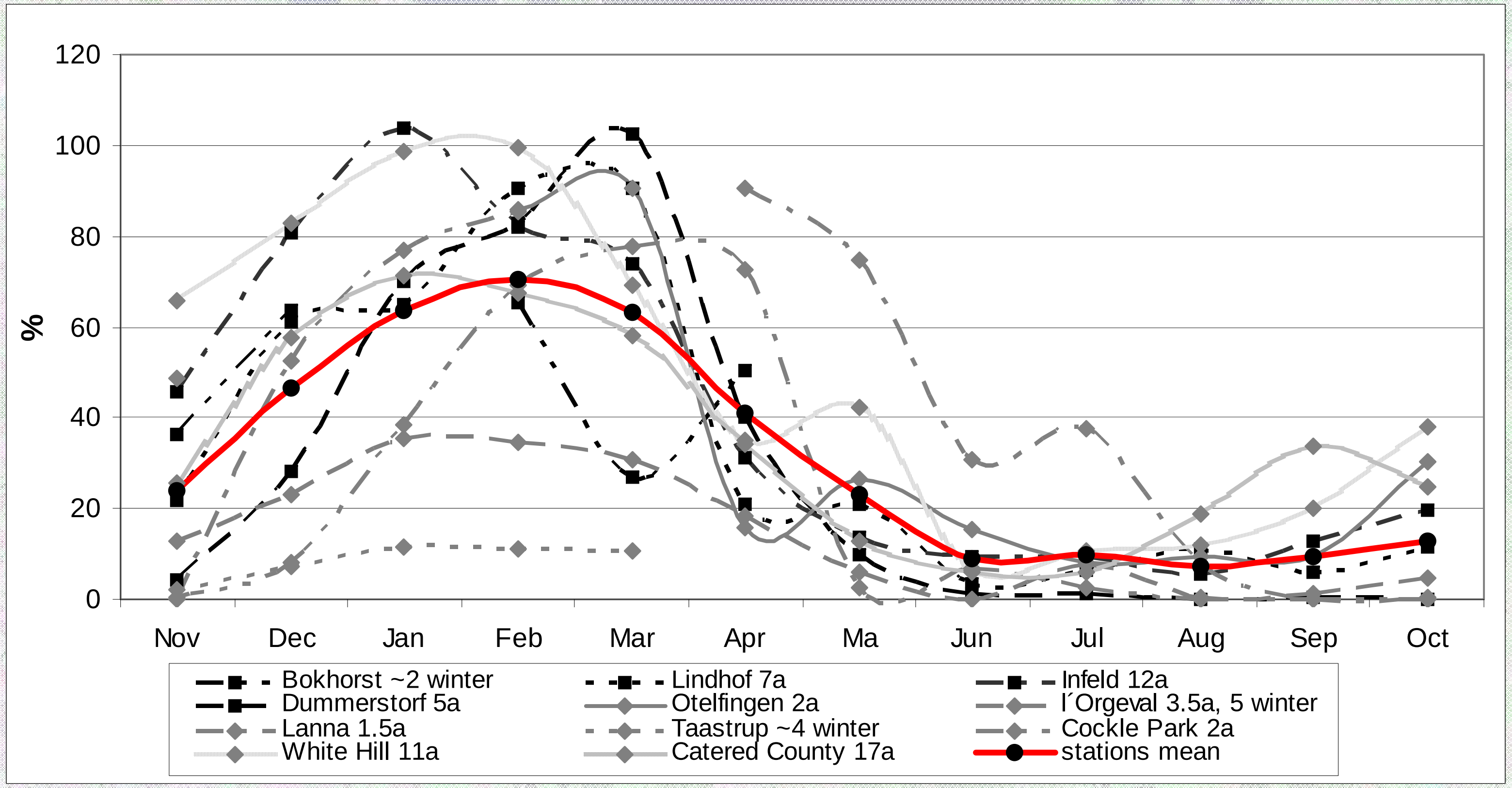
Tile Drainage, ground water,
other diffuse sources
(precipitation on surface waters, erosion, surface run off, urban areas)

$$C_a = E_a / Q_a \cdot C_u$$

C_a = mean annual concentration in mg/l
E_a = mean emissions from pathway(s) in t/a
Q_a = mean run off in m³/s
C_u = unit correction factor

Monthly discharges from tile drained areas

Measured discharges from tile drainages
as percentage of the monthly precipitation



(U. Hirt, IGB)

Monthly discharges from diffuse sources and from ground water

Monthly discharges from diffuse sources according to precipitation distribution

$$Q_{dif\_m} = Q_{dif\_yr} * P_m / P_{yr}$$

Q_{dif_m} = mean monthly discharge from diffuse sources in m³/s
Q_{dif_yr} = mean annual discharge from diffuse sources in m³/s
P_m = monthly precipitation in mm/a
P_{yr} = annual precipitation in mm/a

Ground water discharge as residual from total run off

$$Q_{gw\_m} = Q_{tot\_m} - Q_{dif\_m} - Q_{td\_m}$$

Qgw_m = mean monthly discharge from ground water in m³/s
Qtot_m = mean total run off from sub-catchment in m³/s
Qtd_m = mean monthly discharge from tile drainages in m³/s

Input data

PRE-PROCESSING

Input data on sub-catchment scale

Constant input data

- Land-use
- Soil type
- Hydro-geology
- Catchment topology

Annually changing input data

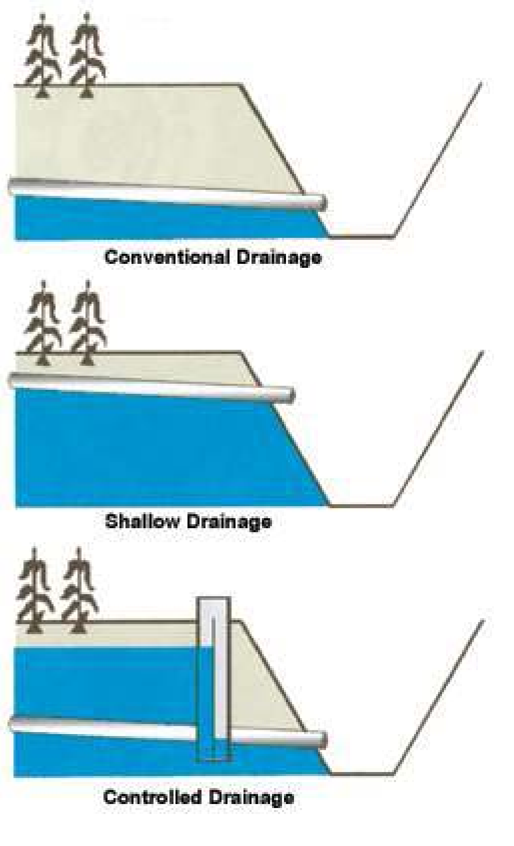
- Inhabitants / connection to sewer systems (time series)
- atmospheric deposition (time series)
- Inventory on waster water treatment plants
- Run off and concentrations (time series)

Input data for administrative units

Annually changing input data

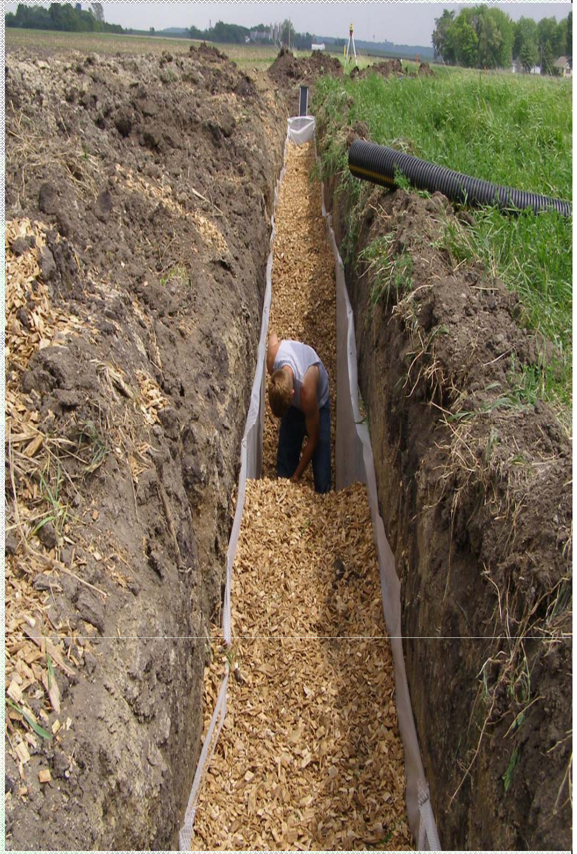
- Nitrogen balance (time series)
- Inhabitant specific P-emissions/ use of P in detergents (time series)

Wirkung von Dränmaßnahmen ?



Controlled drainage system

Retentionsteich



Bio-reactor

→ Implementierung ins Maßnahmentool in MONERIS

Hirt et al. (2011): Reduktion der Nährstoffeinträge entwässerter Gebiete. DWA-Themenheft.

Conclusions

- *The MONERIS approach has been further developed to calculate monthly emissions and loads on sub-catchment level.*
- *Present loads are 60% (TN) and 40% (TP) higher than loads in the 1960's.*
- *Loads from 2003 to 2005 shown an increasing trend.*
- *There a very limited potential for nutrient emissions reduction by agriculture or waste water treatment plants.*
- *For a higher reduction also atmospheric deposition has to be considered.*
- *In terms of water quality measures to reduce emissions should be evaluated considering monthly fluctuations in the emissions and the achieved reduction.*
- *Monthly variation of emissions and impact ratio could be a good basis to identify sub-catchment with a potential to reduce emissions to surface waters and loads to the lagoon.*