Water Quality Status – perspectives on surface waters in the past

Arthur Beusen

PBL/Utrecht university

Water Quality

› Water Quality contains different aspects:

   – Ecosystem: which animals, which plants?

   – Chemical components

   – Different quality for different purpose: bathing water, drinking water, irrigation water,…
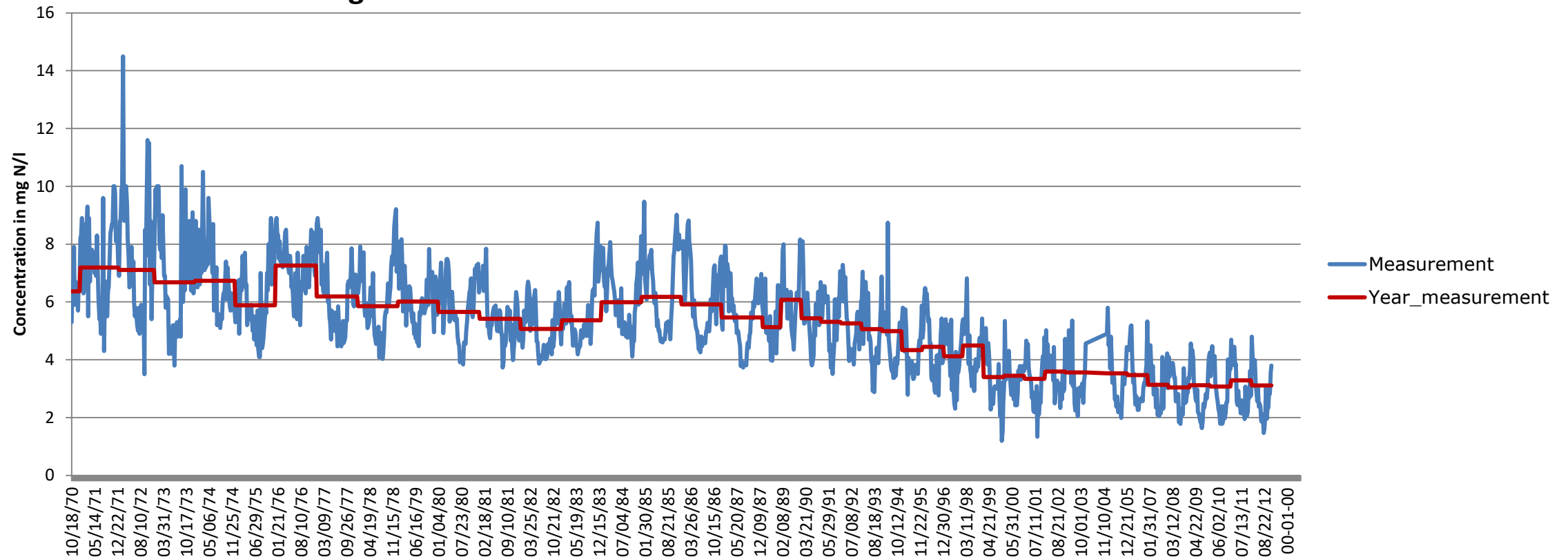
This presentation

› Only chemical component Nitrogen (N) and Phosphorus (P)

› Only in rivers

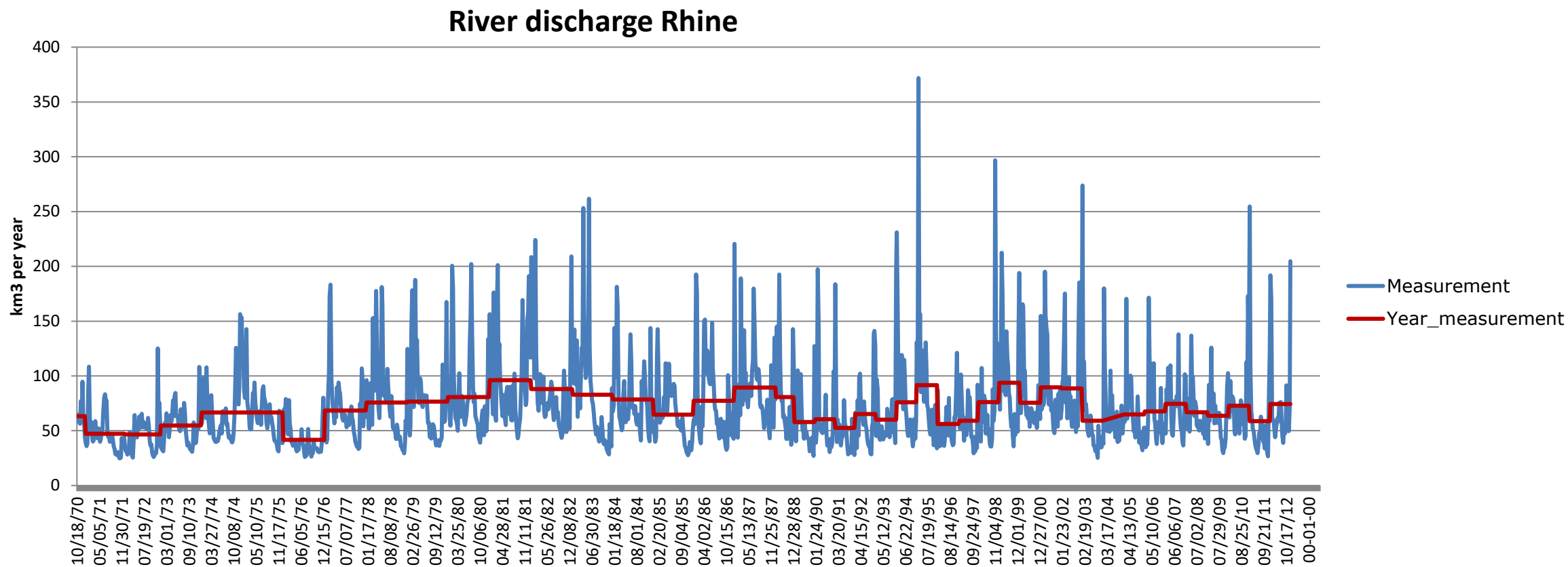# Water Quality

Nitrogen concentration Rhine

Source: Rijkswaterstaat

Discharge of Rhine

Source: Rijkswaterstaat

Observations

Observations (concentrations)

Long time series can show a trend

But

Often no long time series available

Representativeness: space and time? Location, discharge, depth, frequency of sampling,…

No explanation why this trend is occurring?

What is the source of N or P in water?

No future projection possible, but could be available up to last month

To answer these questions:

Modelling

A model represents real-world processes in a simplified way. So a proxy!

Concentration: mass N/mass water. Both must be correct (100/20 = 5 and 110/18=6.1!)

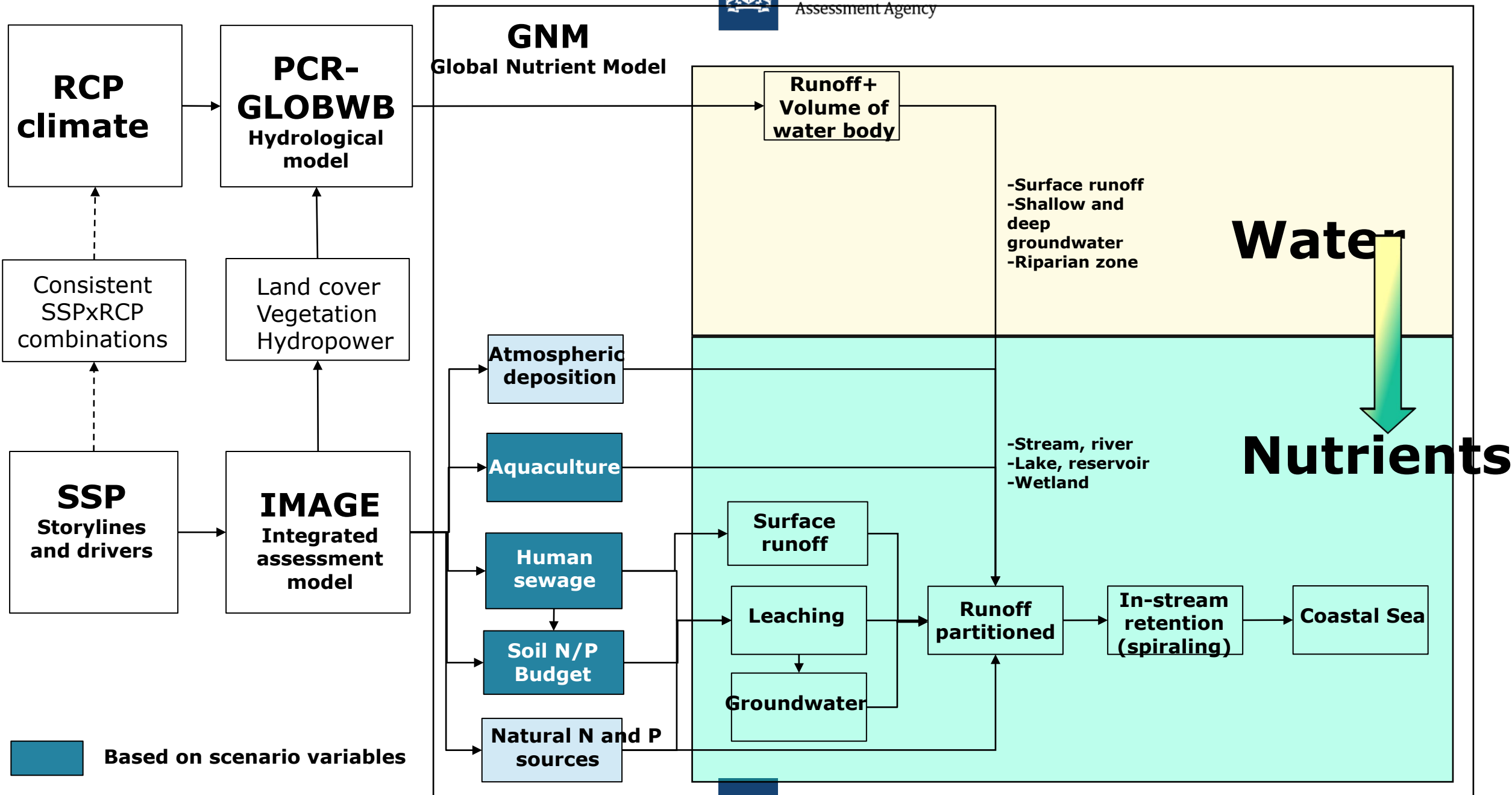Mass modelling of N and P: IMAGE-GNM model of PBL/Utrecht University

IMAGE: IAM model which contains climate change, land use changes,

agricultural production, lifestyle changes,

energy changes, etc on a consistent way

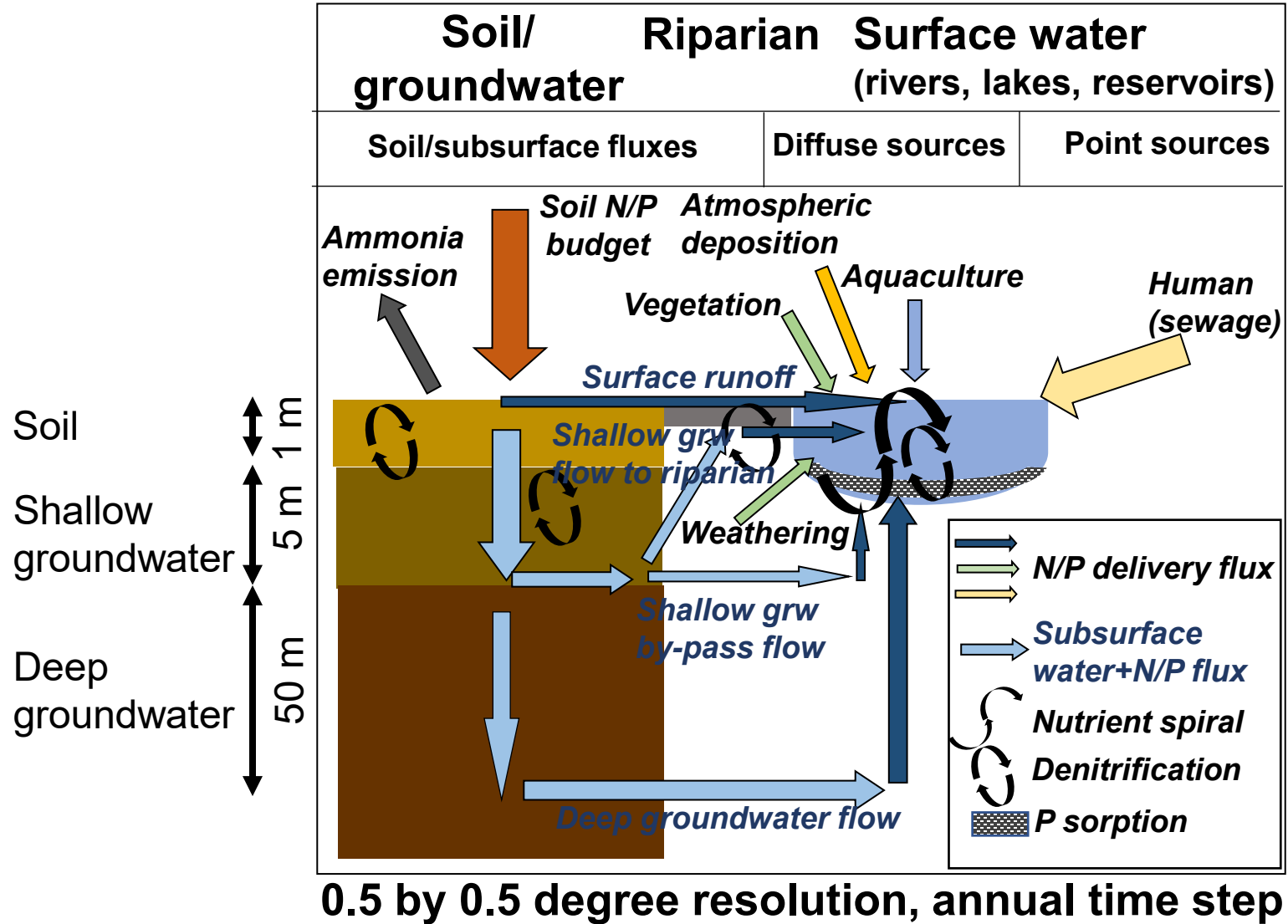Mass modelling of water: PCRGLOBWB of Utrecht University

IMAGE-Global Nutrient Model
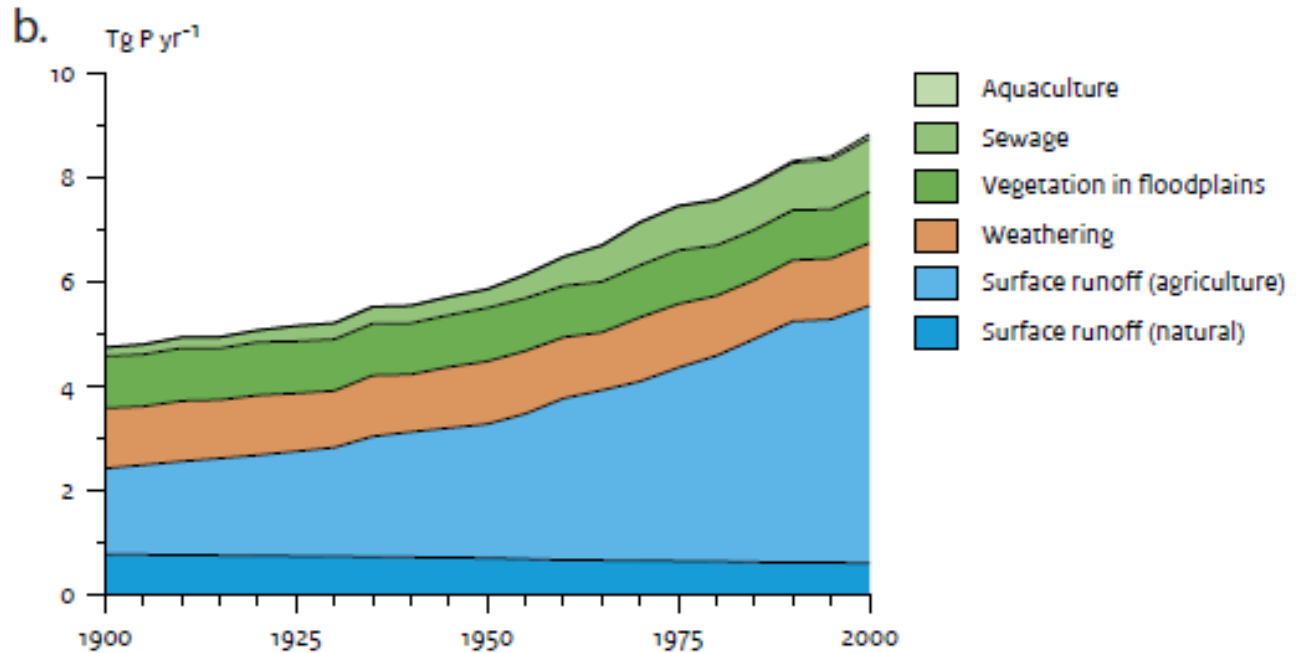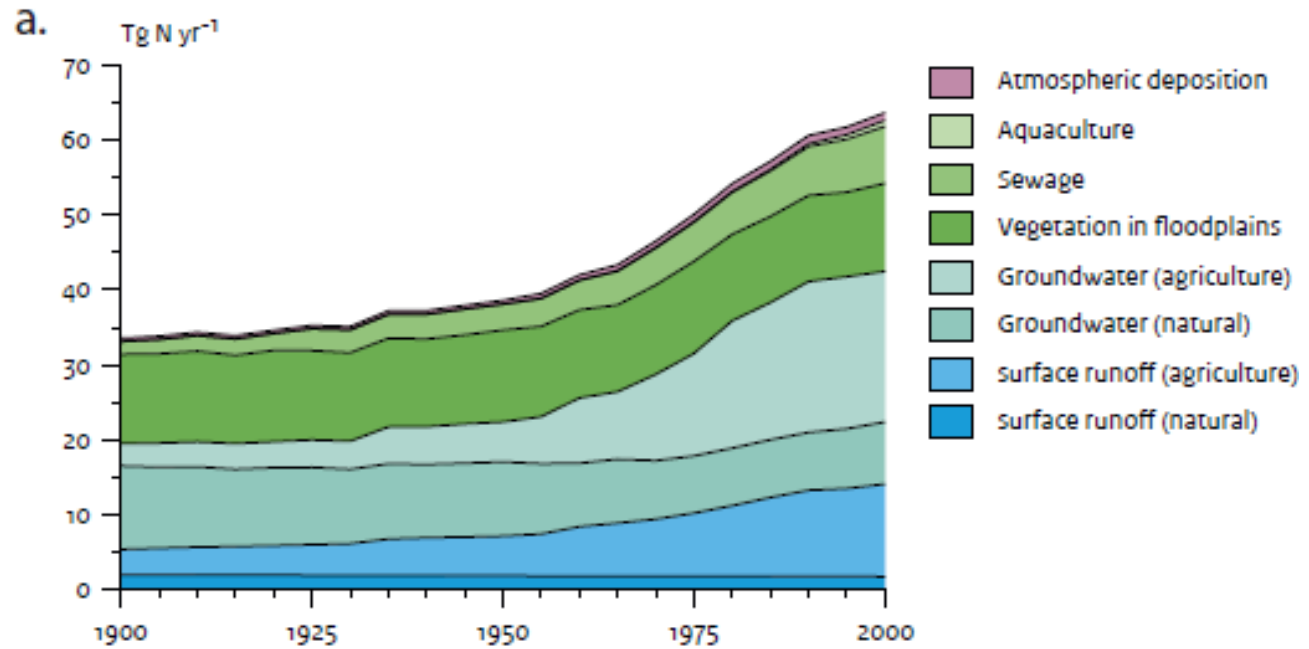
PBL Netherlands Environmental
Assessment Agency

GNM
Global Nutrient Model

RCP climate

PCR–GLOBWB
Hydrological model

Consistent SSPxRCP combinations

Land cover
Vegetation
Hydropower

SSP
Storylines and drivers

IMAGE
Integrated assessment model

Runoff+ Volume of water body

-Surface runoff
-Shallow and deep groundwater
-Riparian zone

Water

Atmospheric deposition

Aquaculture

-Stream, river
-Lake, reservoir
-Wetland

Nutrients

Human sewage

Soil N/P Budget

Natural N and P sources

Surface runoff

Leaching

Groundwater

Runoff partitioned

In-stream retention (spiraling)

Coastal Sea

Based on scenario variables

IMAGE-Global Nutrient Model

0.5 by 0.5 degree resolution, annual time step

Beusen et al, 2015, 2016, 2022

Delivery

1970 – 2015:
Cropland: + 2Mkm2
N fertilizer: 3X
Pfertilizer: 2X
Production: 3X
Pointsources: 2X

Beusen et al. 2015

Concentrations

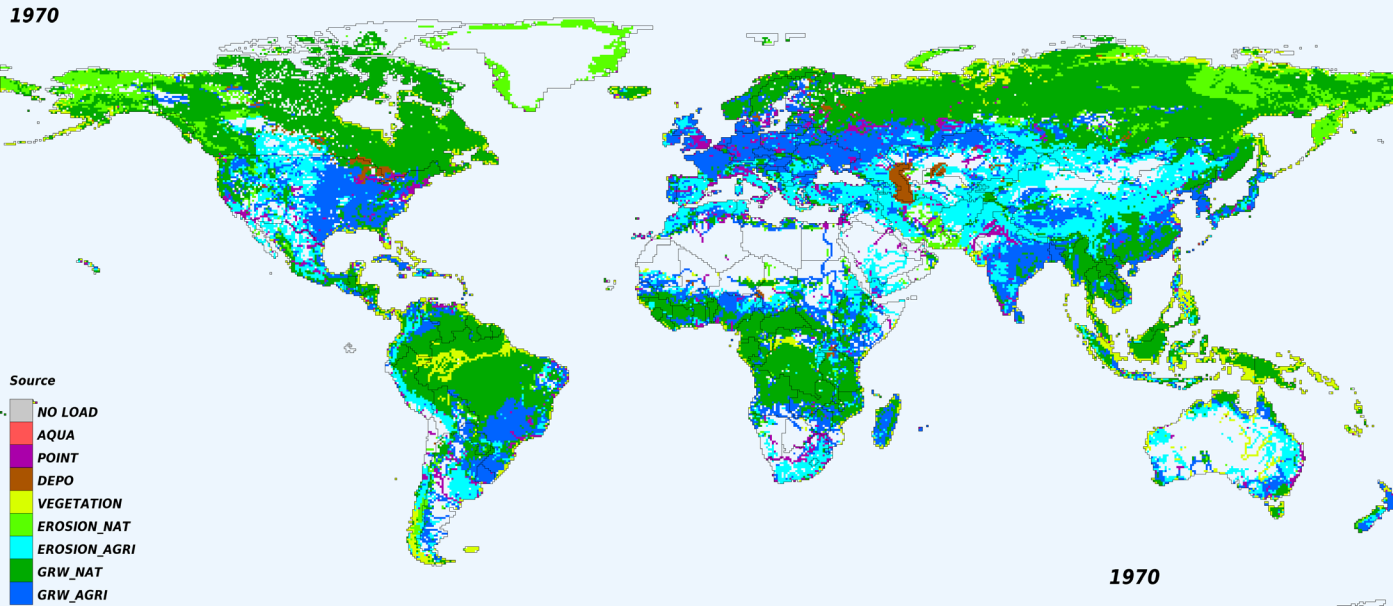*1970*

mg N per liter
< 0
0 - 0.1
0.1 - 1.0
1.0 - 2.5
2.5 - 5.0
5.0 - 10.0
> 10

Utrecht University & PBL

Nitrogen concentration

1970

mg P per liter
< 0
0 - 0.01
0.01 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 1.0
> 1.0

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Phosphorus concentration

Dominant source

1970

Source
- NO LOAD
- AQUA
- POINT
- DEPO
- VEGETATION
- EROSION_NAT
- EROSION_AGRI
- GRW_NAT
- GRW_AGRI

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Dominant source for N in streams

1970

Source
- NO LOAD
- AQUA
- POINT
- VEGETATION
- EROSION_NAT
- EROSION_AGRI
- WEATHERING

Utrecht University & PBL
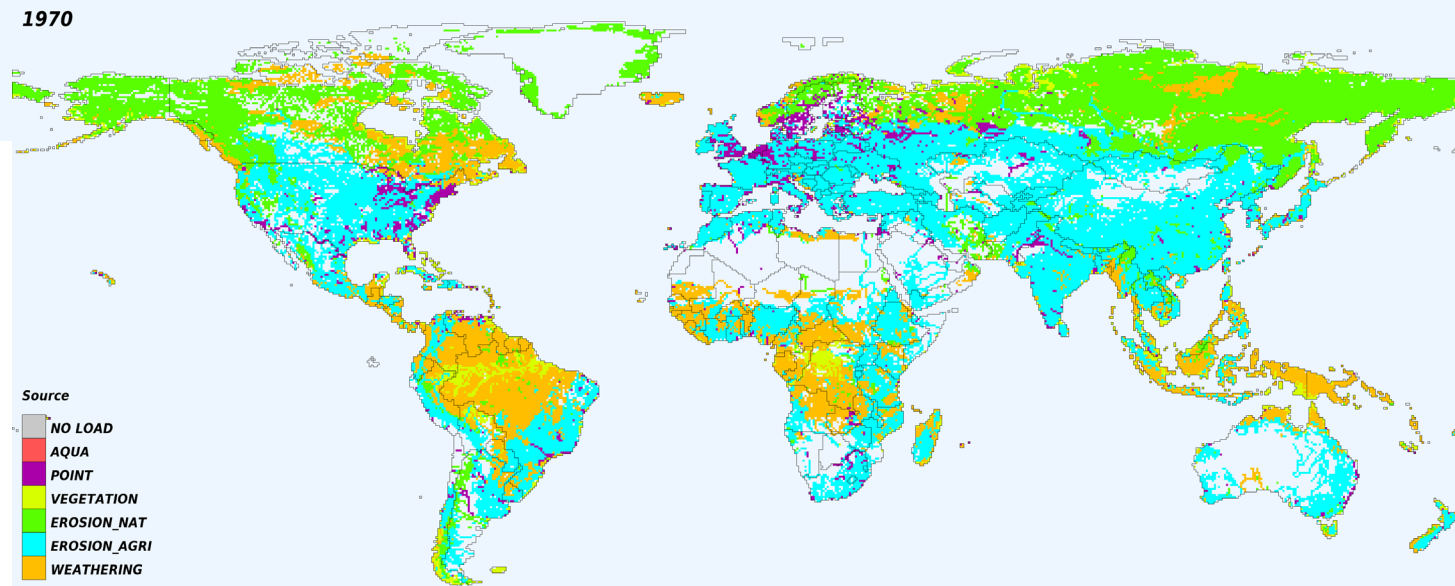
Dominant source for P in streams

Conclusions

N and P concentration is changing due to:

› Conversion from natural land to agricultural land

› Pointsources: First people are connected to a pipe, and treatment is following later

› Aquaculture is small, but is growing (China)

Sources

› **Model description**: Beusen A.H.W., van Beek L.P.H., Bouwman A.F., Mogollón J.M., Middelburg J.J. (2015) Coupling global models for hydrology and nutrient loading to simulate nitrogen and phosphorus retention in surface water – description of IMAGE–GNM and analysis of performance. Geosci. Model Dev. 8(12):4045-4067; doi:10.5194/gmd-8-4045-2015.

› **Model application 20th century**: Beusen A.H.W., Bouwman A.F., Van Beek L.P.H., Mogollón J.M., Middelburg J.J., 2016, Global riverine N and P transport to ocean increased during the 20th century despite increased retention along the aquatic continuum, Biogeosciences, 13, 2441-2451, doi:10.5194/bg-13-2441-2016.

› **SSP scenarios**: A.H.W. Beusen, J.C. Doelman, L.P.H. Van Beek, P.J.T.M. Van Puijenbroek, J.M. Mogollón, H.J.M. Van Grinsven, E. Stehfest, D.P. Van Vuuren, J.J. Middelburg, A.F. Bouwman (2022) Exploring river nitrogen and phosphorus loading and export to the global coastal ocean in the Shared Socio-economic Pathways Global Environmental Change, DOI: 10.1016/j.gloenvcha.2021.102426.

Discussion question

What are sources of water pollution in your own home country? And Why?

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