Modeling global river export: N, P, C, Si

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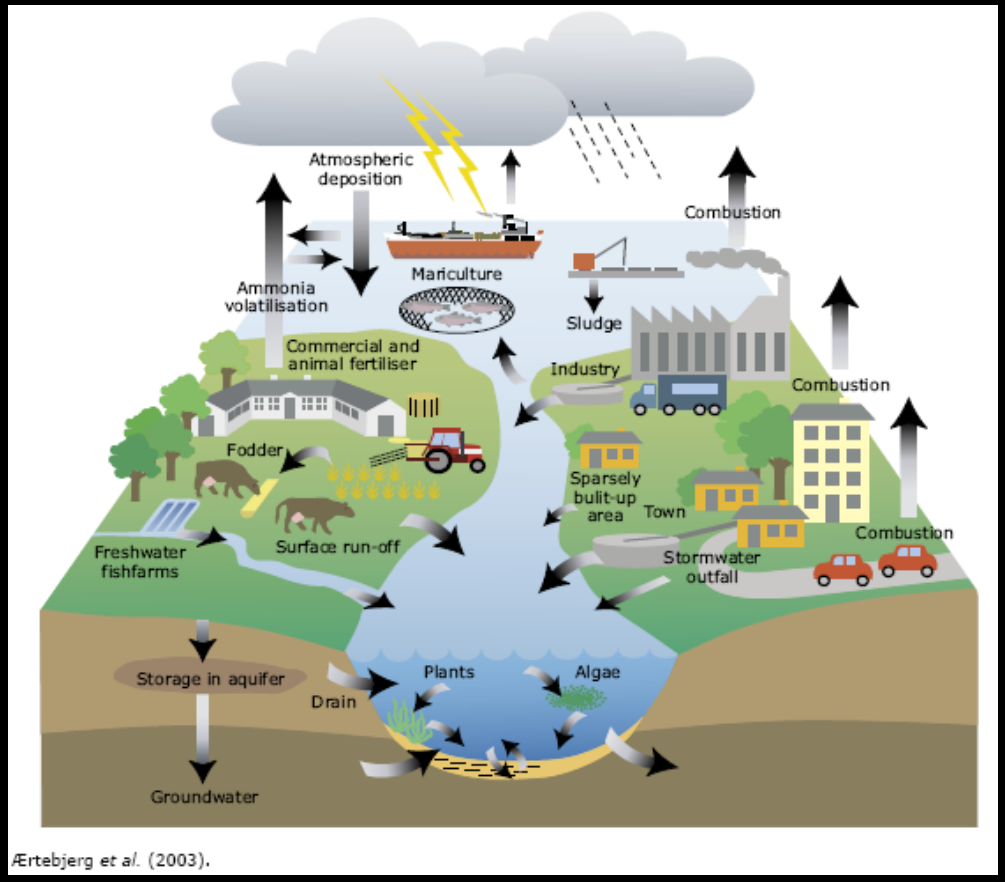
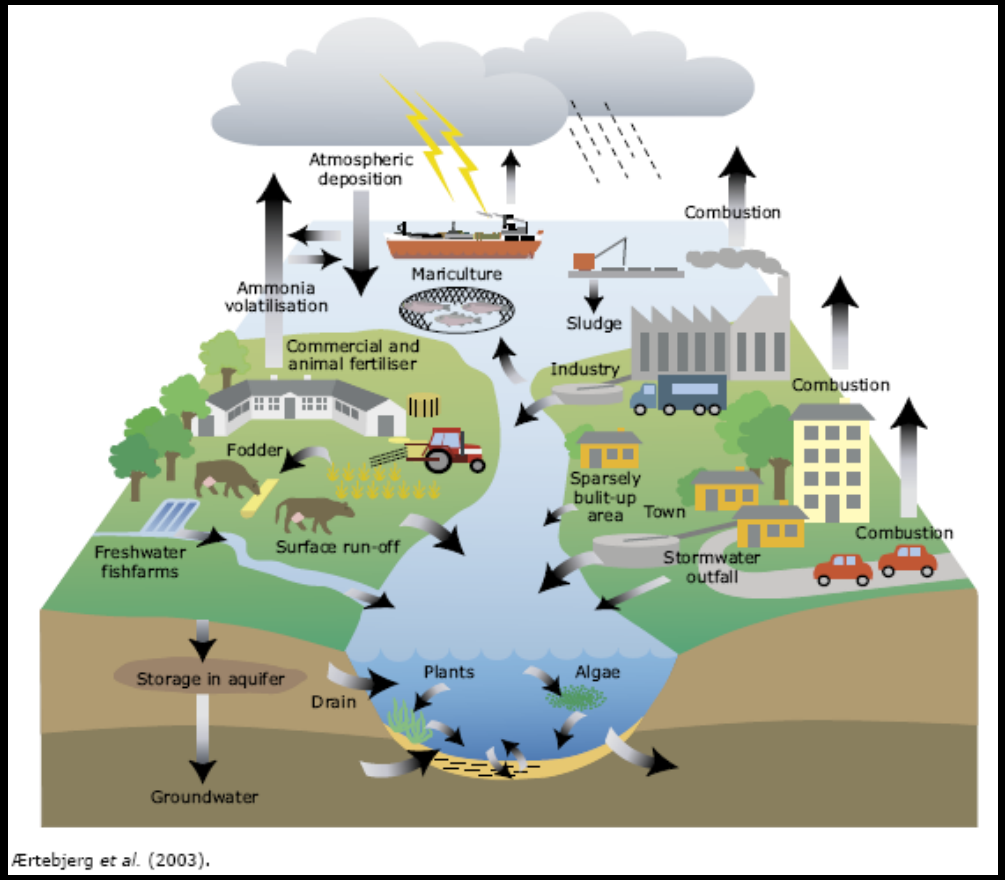
Rivers transport nutrients (N, P, Si, C) from watersheds to coastal waters



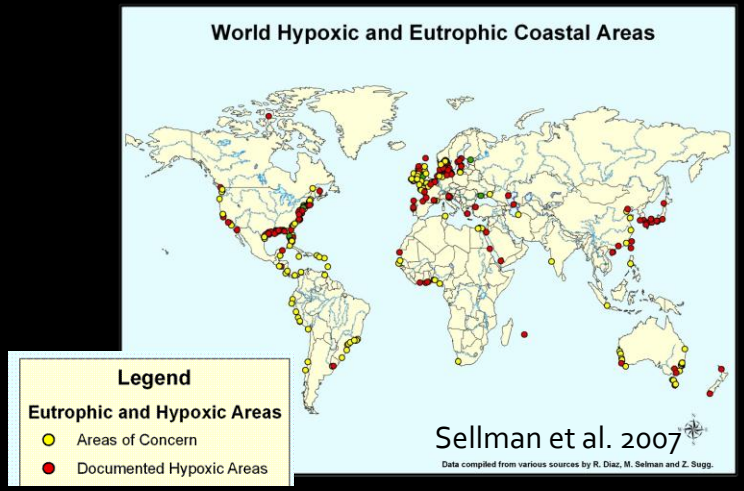
Ærtebjerg *et al.* (2003).

Rivers transport nutrients (N, P, Si, C) from watersheds to coastal waters



Ærtebjerg *et al.* (2003).

Coastal effects



Sellman et al. 2007

Global **NEWS** Model

Nutrient **E**xport from **W**ater**S**heds

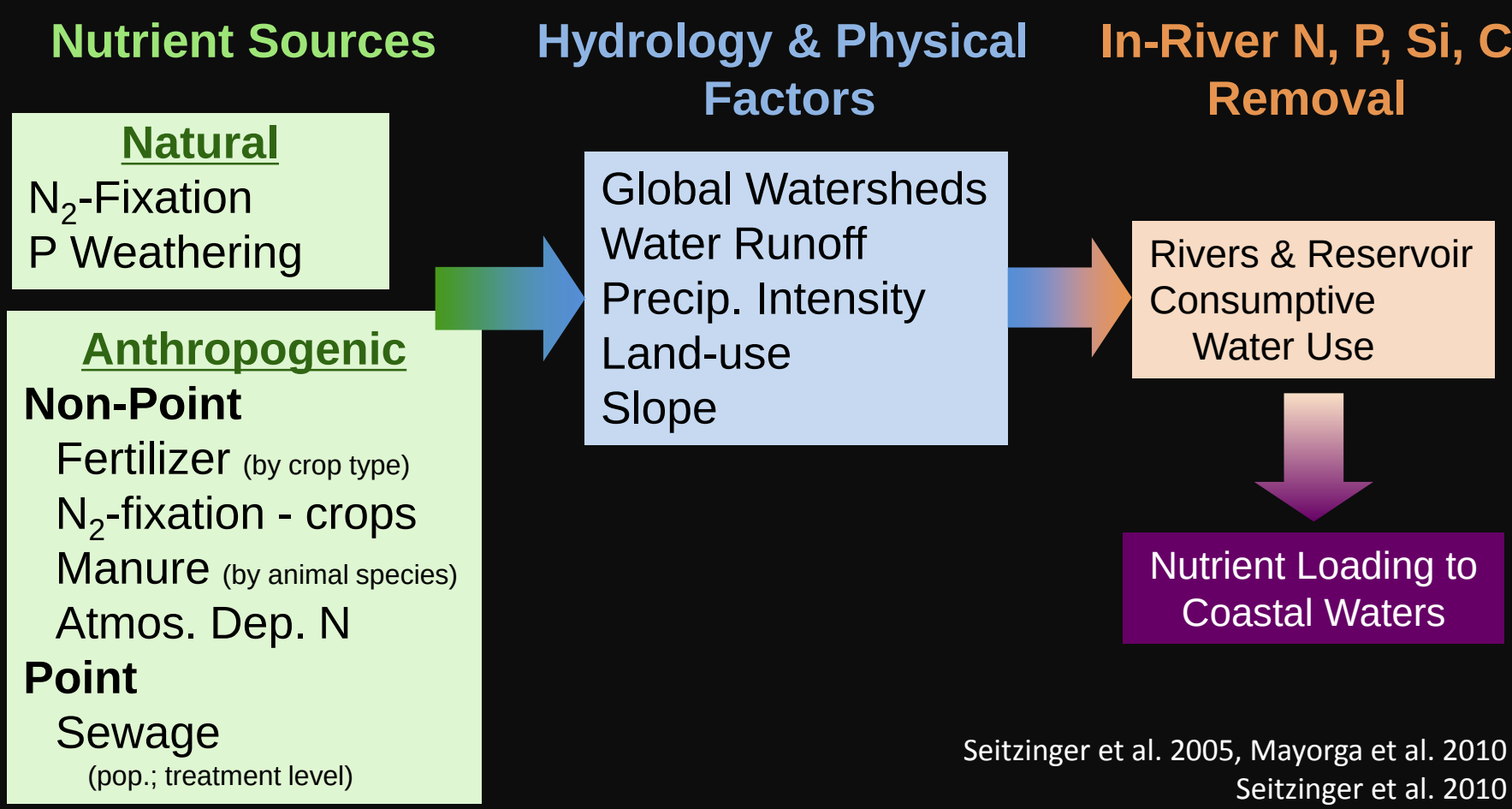
Nutrient Sources

Hydrology & Physical Factors

In-River N, P, Si, C Removal

Input databases 0.5^{o} x 0.5^{o}
>5000 watersheds globally
STN-30

Global **NEWS** Model



Seitzinger et al. 2005, Mayorga et al. 2010
Seitzinger et al. 2010

Global **NEWS** Model

Nutrient **E**xport from **W**ater**S**heds

At river mouths, predict export of:

	Dissolved		Particulate
	Inorganic	Organic	
N	DIN	DON	PN
P	DIP	DOP	PP
C	DIC*	DOC	POC
Si	DSi		

* DIC in prep.

Seitzinger et al. 2005, Mayorga et al. 2010
Seitzinger et al. 2010

Equation for DIN as example

$$Yld_F = Fe_{riv,F} * [(RSpnt_F + Rsdif_{ant,F}) + Rsdif_{nat,F}$$

$$Rsdif_{ant,DIN} = Fe_{ws,DIN} * WSdif_{ant,N} + Ag_{fr} * (f_{DIN}(R_{nat}) * EC_{DIN}), \text{ where:}$$

$$Fe_{ws,DIN} = e_{DIN} * f_{DIN}(R_{nat})$$

$$WSdif_{ant,N} = WSdif_{fe,N} + WSdif_{ma,N} + WSdif_{fix,ant,N} = WSdif_{dep,ant,N} – WSdif_{ex,N}]$$

Outline

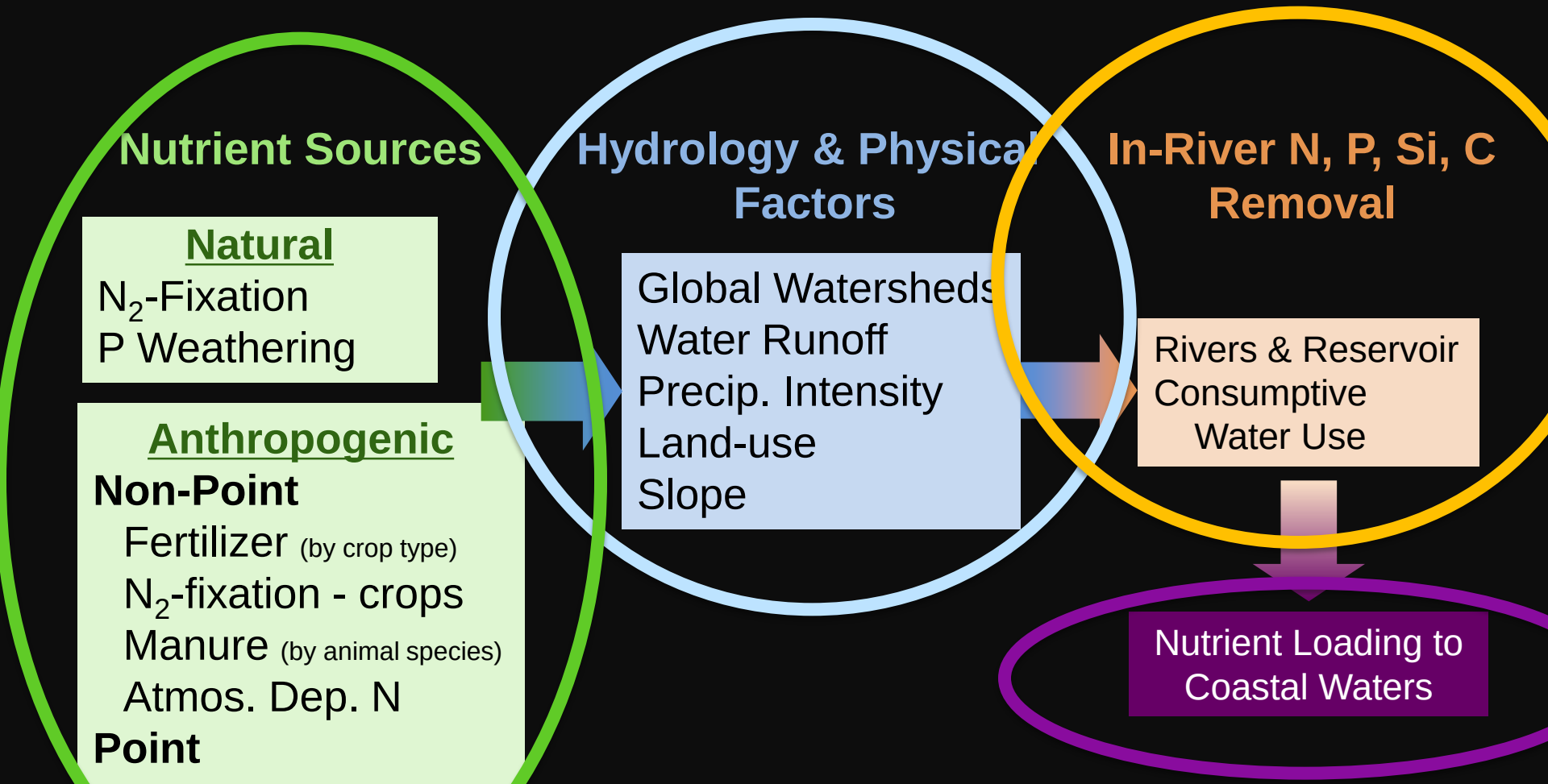
Applications	Spatial		Time step
	Input	Output	Annual
Global watersheds			
Yangtze watershed			
Sub-basins global DIP			
Sub-basins California			
Scenarios – global			

Outline

Applications	Spatial		Time step
	Input	Output	Annual
Global watersheds > 5000 watersheds	0.5^{o} x0.5^{o}	watershed	~2005
Yangtze watershed			
Sub-basins global DIP			
Sub-basins California			
Scenarios – global			

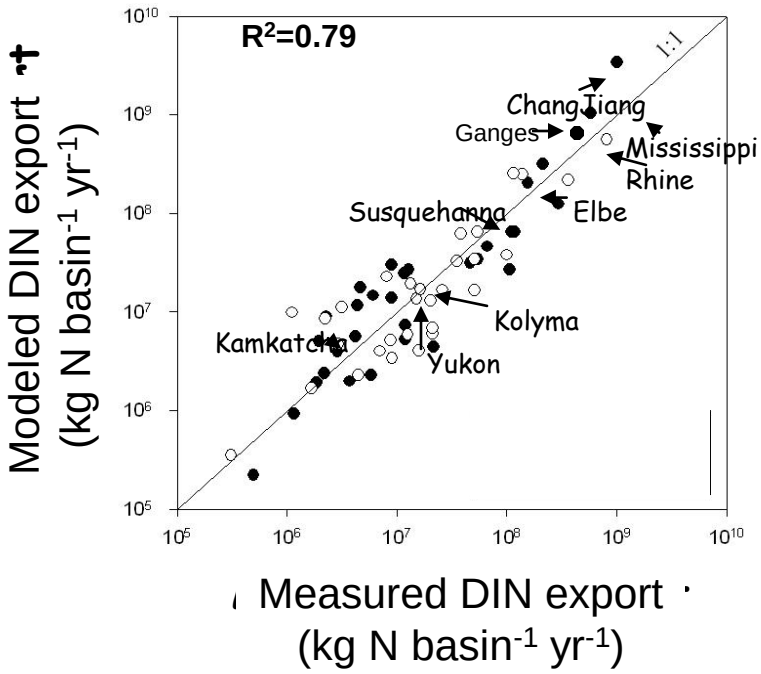
Why annual average for global application?

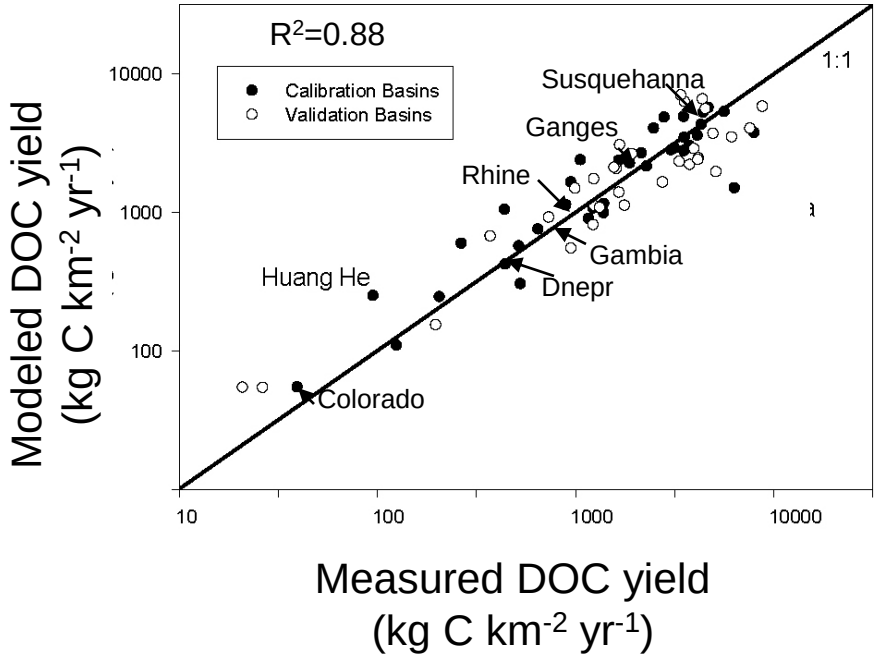
Global **NEWS** Model



Seitzinger et al. 2005, Mayorga et al. 2010
Seitzinger et al. 2010

Comparison of model predicted vs measured river transport



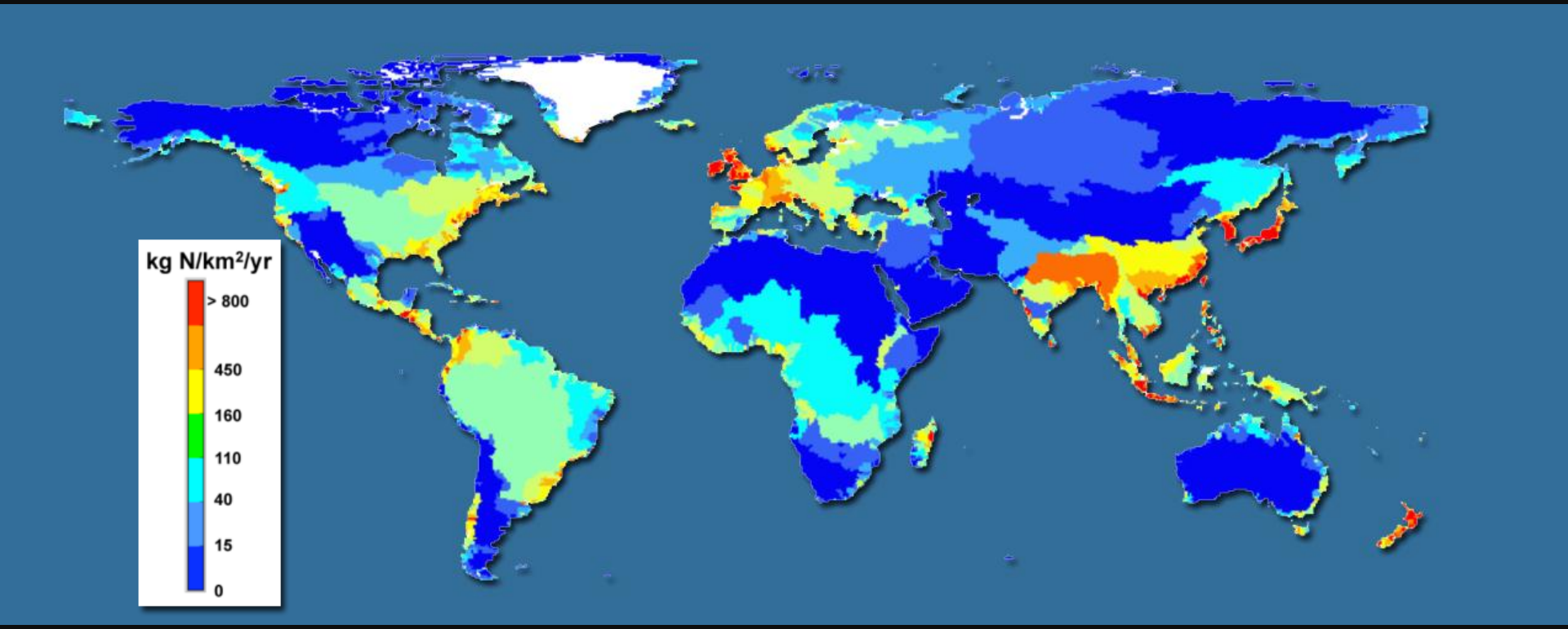


Dumont et al. Harrison et al.
Global Biogeochem Cycles 2005

River transport of DIN to coast

kg N/km2/yr

>5000 watersheds



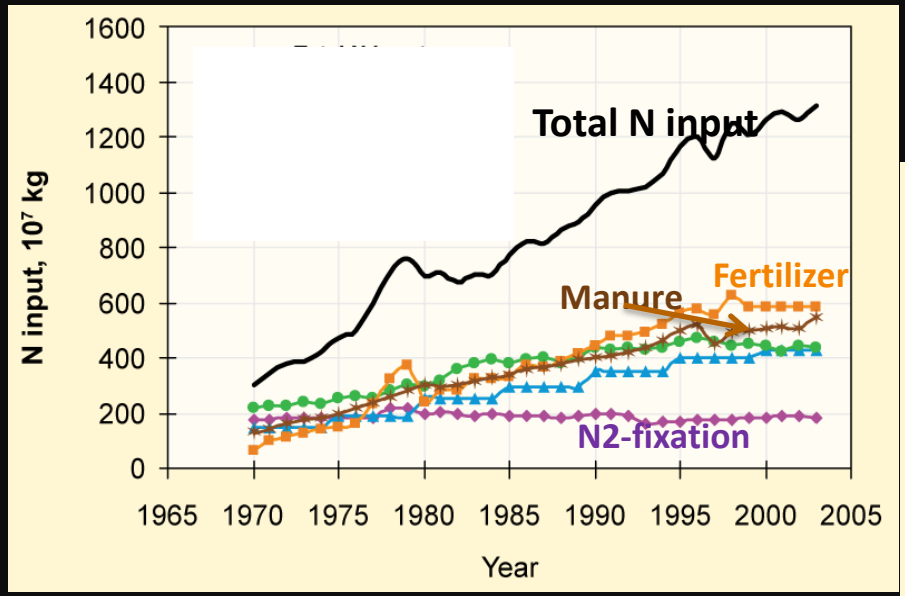
Seitzinger et al. 2005 Global Biogeochemical Cycles

Outline

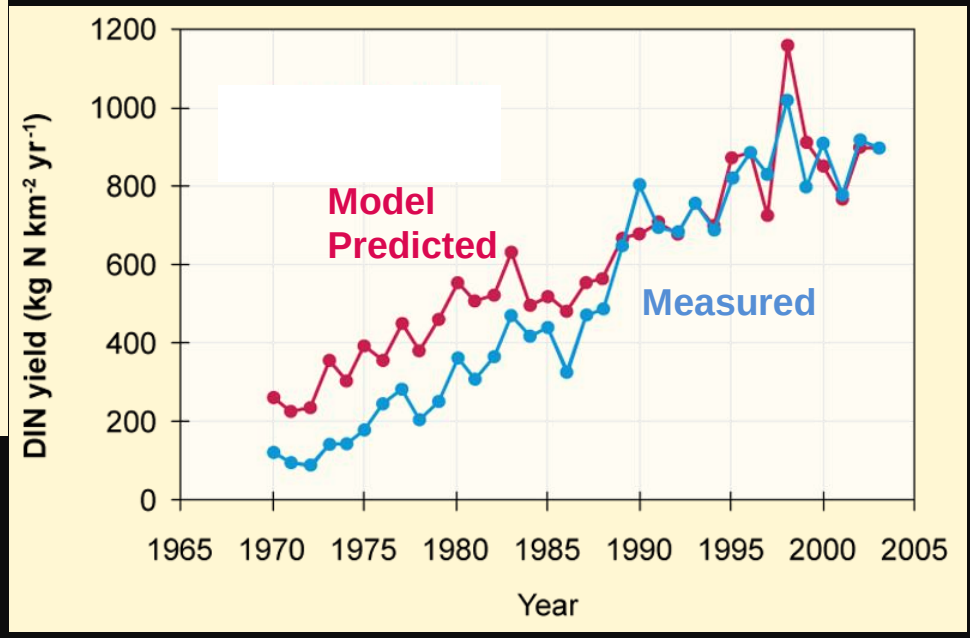
Applications	Spatial Input	Spatial Output	Time step Annual
Global watersheds	0.5^{o} x0.5^{o}	watershed	~2005
Yangtze watershed	province	watershed	yearly 30 yrs
Sub-basins global DIP			
Sub-basins California			
Scenarios – global			

Yangtze river watershed annual 1970 – 2003

Province level N input data



River DIN Export



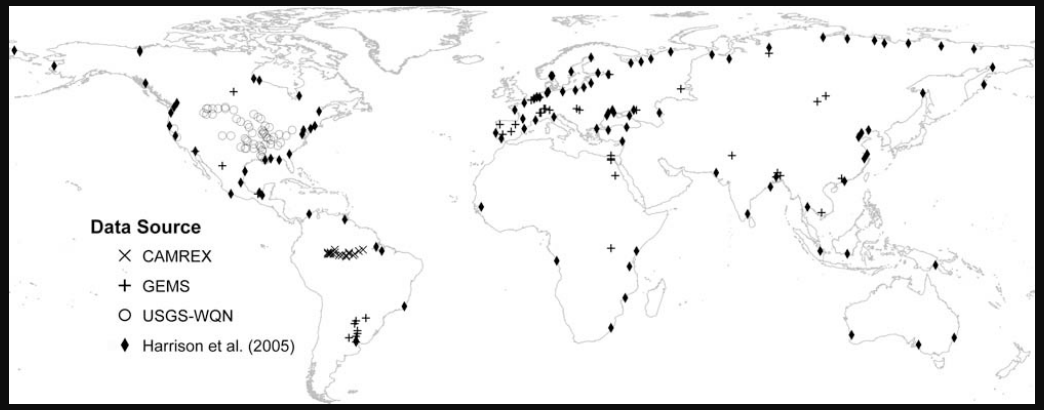
Yan et al. 2010 GBC

Outline

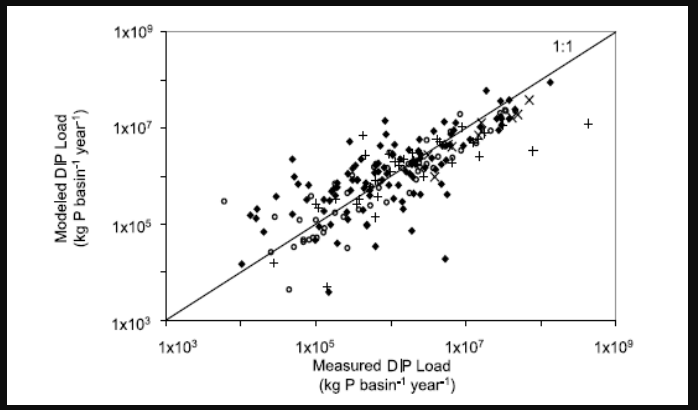
Applications	Spatial Input	Output	Time step Annual
Global watersheds	0.5^{o} x0.5^{o}	watershed	~2000
Yangtze watershed	province	watershed	yearly 30 yrs
Sub-basins global DIP	0.5^{o} x0.5^{o}	0.5^{o} x0.5^{o}	~2010
Sub-basins California			
Scenarios – global			

Hi resolution NEWS-DIP Sub-basin 0.5^{o} x 0.5^{o}

Measured data



Model vs Data



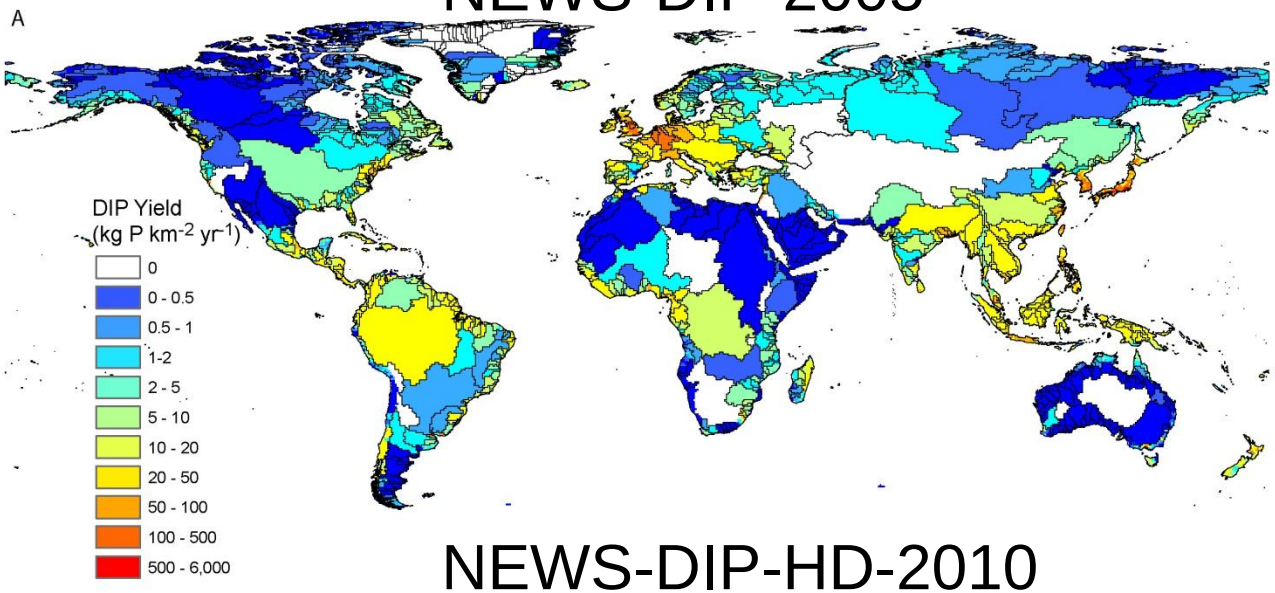
Harrison et al. 2010 GBC

NEWS-Predicted DIP Yield

(kg P / km^2 / yr)

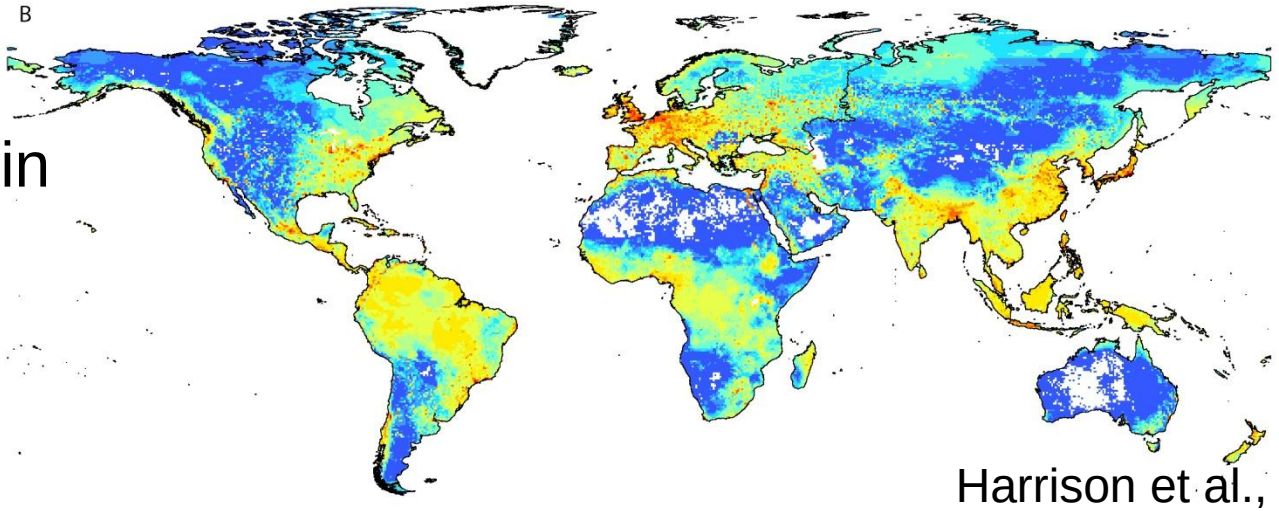
Basin

NEWS-DIP-2005



Sub-basin

NEWS-DIP-HD-2010



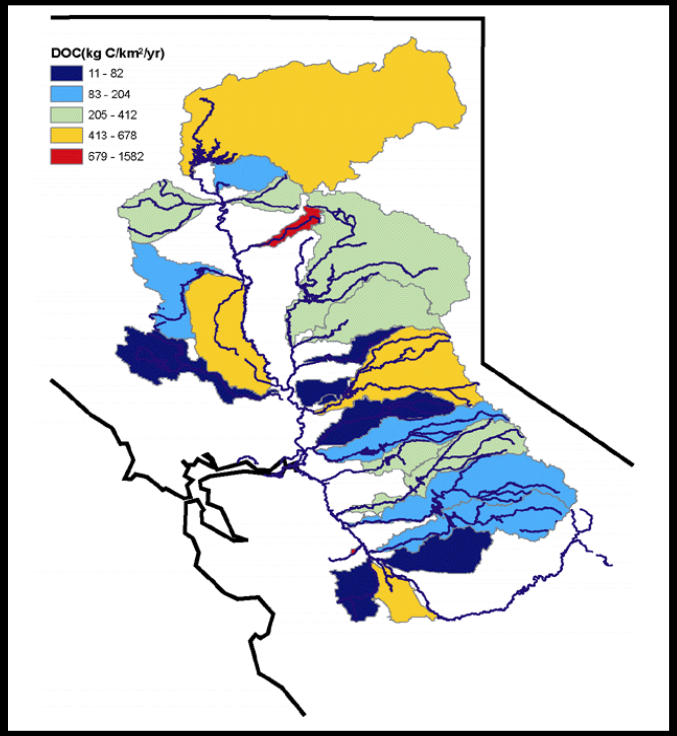
Harrison et al., GBC 2010

Outline

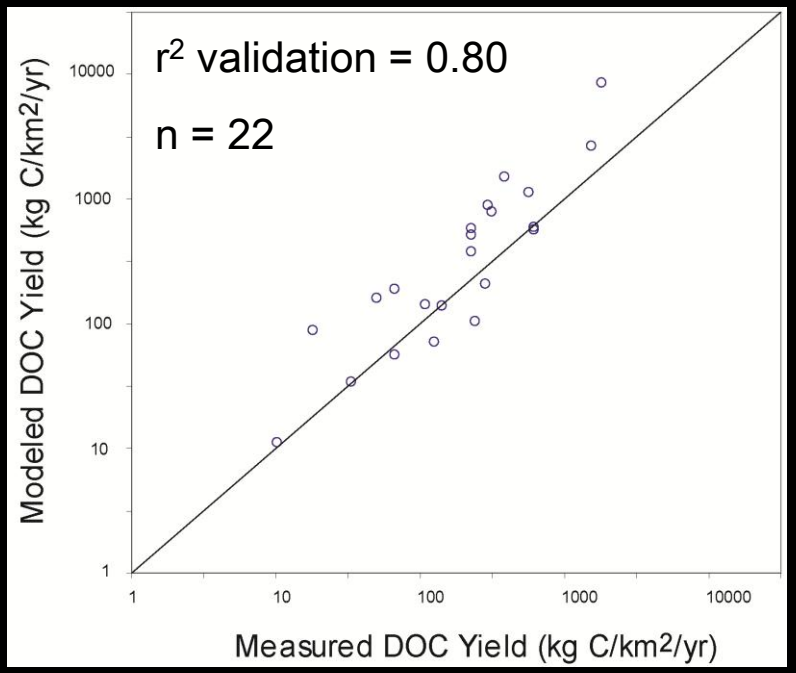
Applications	Spatial Input	Output	Time step Annual
Global watersheds	0.5º x0.5º	watershed	~2005
Yangtze watershed	province	watershed	yearly 30 yrs
Sub-basins global DIP	0.5º x0.5º	0.5º x0.5º	~2010
Sub-basins California	1 km	watershed	~2000
Scenarios – global			

DOC in Central Valley, CA watersheds

Measured DOC Yield
(kg C / km^2 / yr)



NEWS DOC Yield
(kg C / km^2 / yr)



Basin delineations: USGS
Runoff: USGS
Potential Runoff: DWR
Land Use: Fire and Resource Assessment Program (FRAP)
Concentration: Dahlgren (1999-2004)

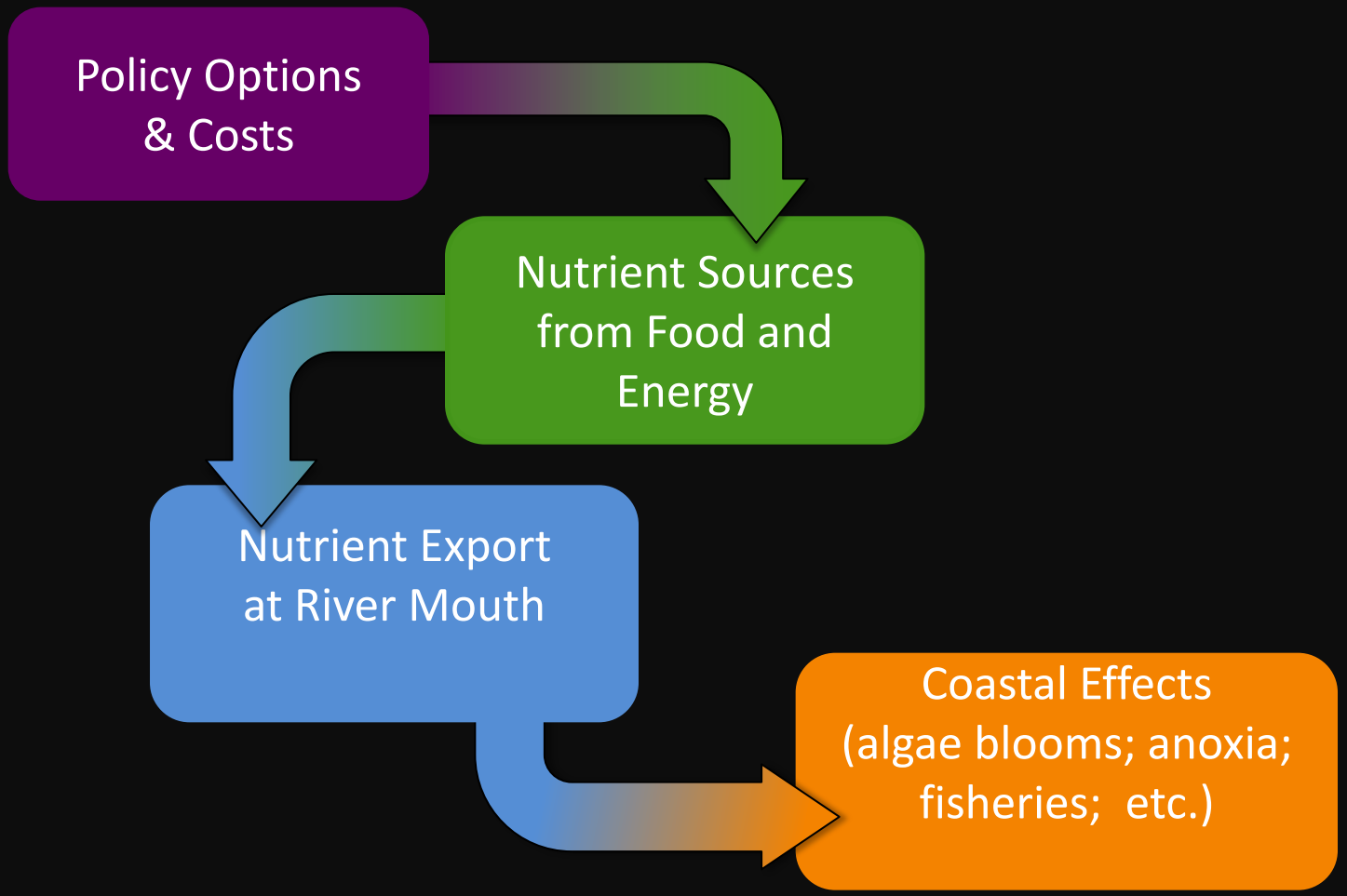
(Data courtesy of R. Dahlgren and USGS)

Harrison et al. In prep.

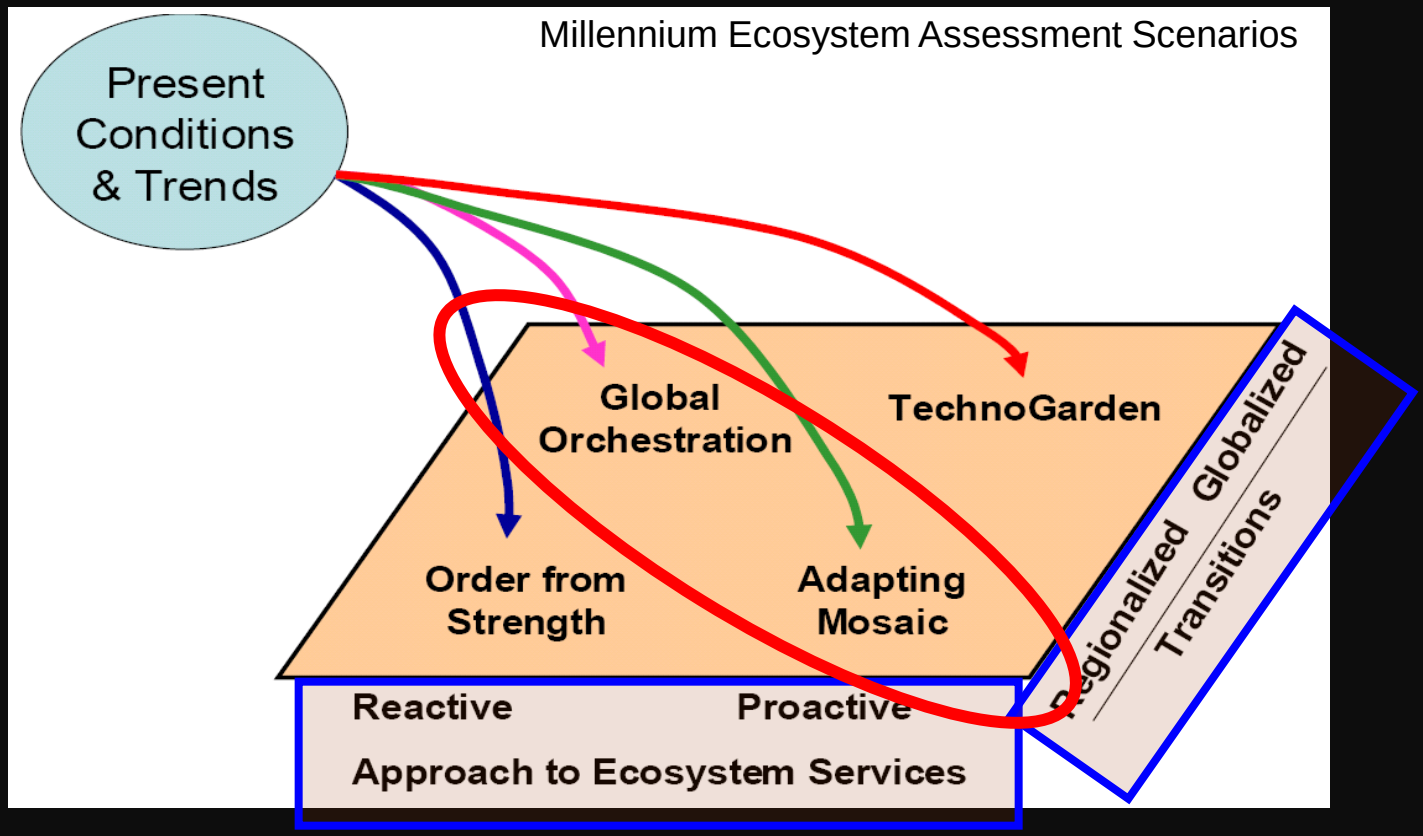
Outline

Applications	Spatial Input	Output	Time step Annual
Global watersheds	0.5° x0.5°	watershed	~2005
Yangtze watershed	province	watershed	yearly 30 yrs
Sub-basins global DIP	0.5° x0.5°	0.5° x0.5°	~2010
Sub-basins California	various	watershed	~2000
Scenarios – global	0.5° x0.5°	watershed	2000-2030-2050

Future scenarios



Nutrient export trajectories 2000-2030



Includes social, economic, policy, and ecological considerations

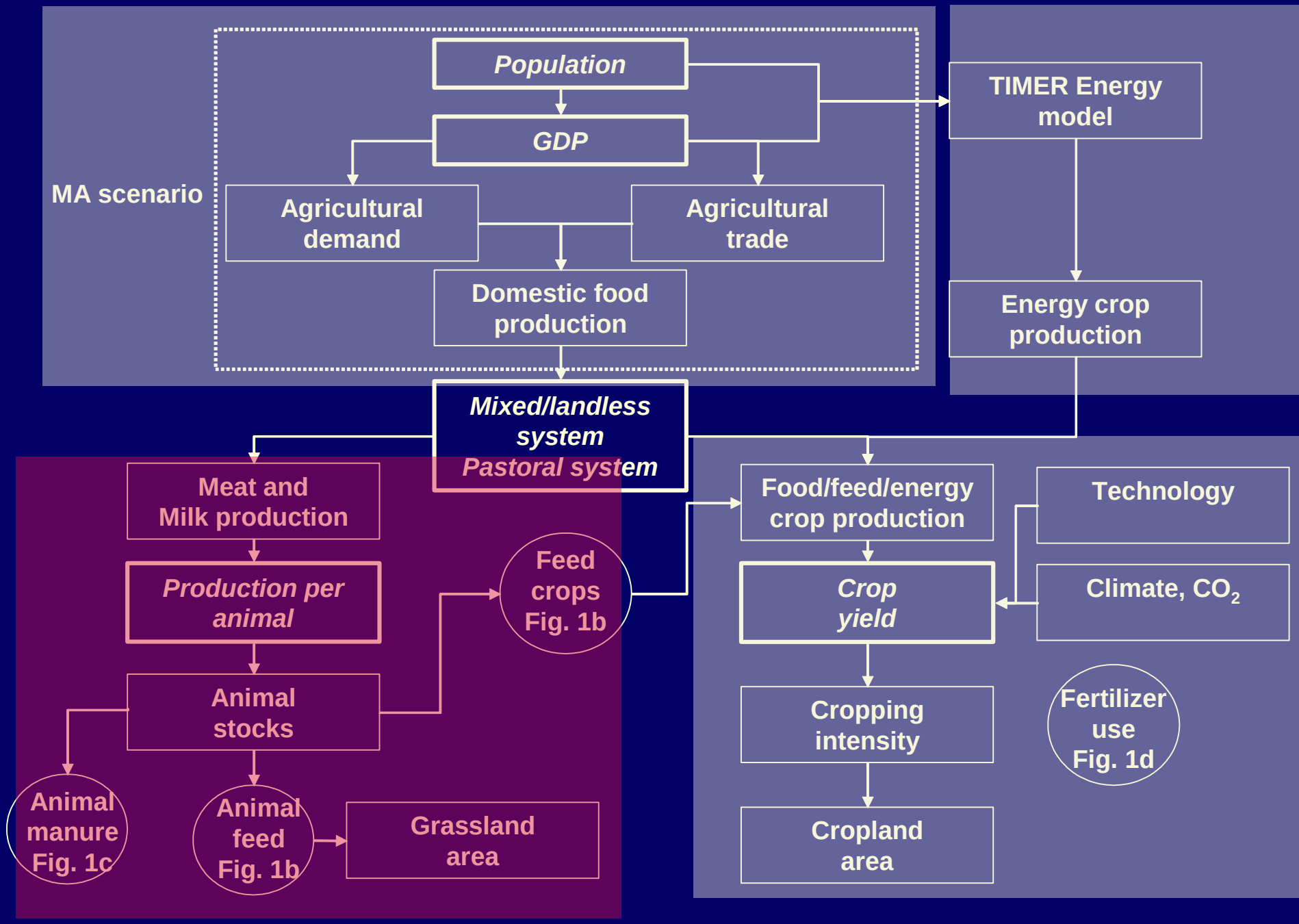
/www.millenniumassessment.org

Two scenarios

	Worst Case Global Orchestration	Better Case Adapting Mosaic
Envir. Approach	reactive	proactive
Income	high	medium
Population Increase	lower	higher
Fertilizer Use	high	moderate
Nutrient Management	not optimal	efficient
Meat Consumption	high	moderate
Sewage Treatment		
access	full	constant %
N removal	high	moderate

Specifics vary by country

Bouwman et al. 2010 & Van Drecht et al. 2009 GBC


MA scenario
Population
GDP
Agricultural demand
Agricultural trade
Domestic food production
TIMER Energy model
Energy crop production
Mixed/landless system
Pastoral system
Meat and Milk production
Production per animal
Animal stocks
Feed crops Fig. 1b
Animal manure Fig. 1c
Animal feed Fig. 1b
Grassland area
Food/feed/energy crop production
Technology
Crop yield
Climate, CO2
Cropping intensity
Fertilizer use Fig. 1d
Cropland area

Two scenarios

	Worst Case Global Orchestration	Better Case Adapting Mosaic
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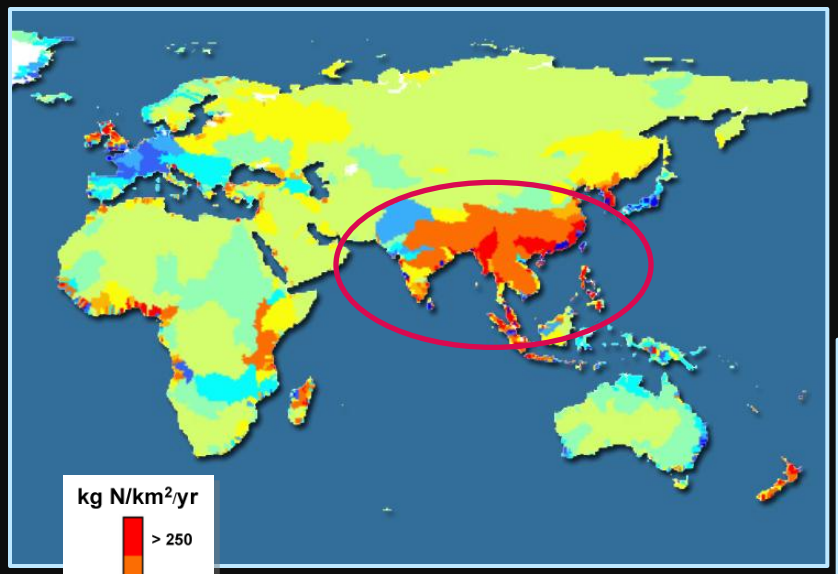
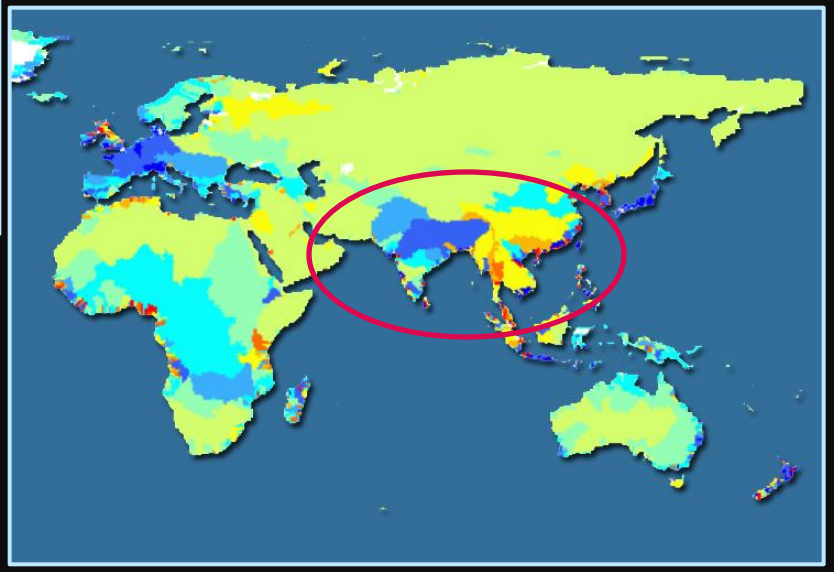
Change DIN river export 2000-2030



Global Orchestration

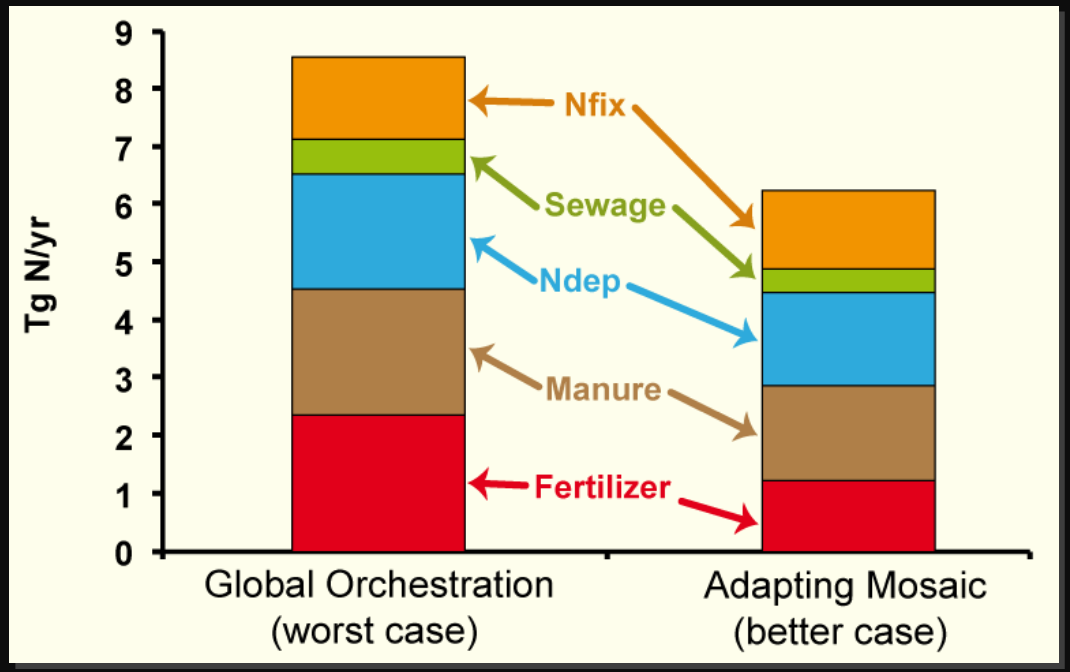


Adapting Mosaic

Seitzinger et al. 2010 GBC

Seitzinger et al. 2010 GBC

Contribution to river DIN export South Asia



How were improvements achieved?

- Sewage connectivity constant %
- Technological NOx controls
- Lower meat consumption
- Efficient management nitrogen in agriculture

Seitzinger et al. 2010, GBC

Summary

Applications	Spatial		Time step
	Input	Output	Annual
Global watersheds	0.5^{o} x0.5^{o}	watershed	~2005
Yangtze watershed	province	watershed	yearly 30 yrs
Sub-basins global DIP	0.5^{o} x0.5^{o}	0.5^{o} x0.5^{o}	~2010
Sub-basins California	1 km	watershed	~2000
Scenarios – global	0.5^{o} x0.5^{o}	watershed	2000-2030-2050

Acknowlegements and for more details

Mayorga et al. 2010	Model development, Envir. Modelling & Software

Global Biogeochemical Cycles 2010 - Special section

Seitzinger et al.	overview
Bouwman et al.	agriculture
Van Drecht et al.	urban wastewater
Feteke et al.	hydrology
Harrison et al.	hi resolution DIP
Yan et al.	Yangtze river

GLOBAL CHANGE IGBP International Geosphere-Biosphere Programme

ICSU International Council for Science

Global **NEWS** Model

Nutrient **E**xport from **W**ater**S**heds

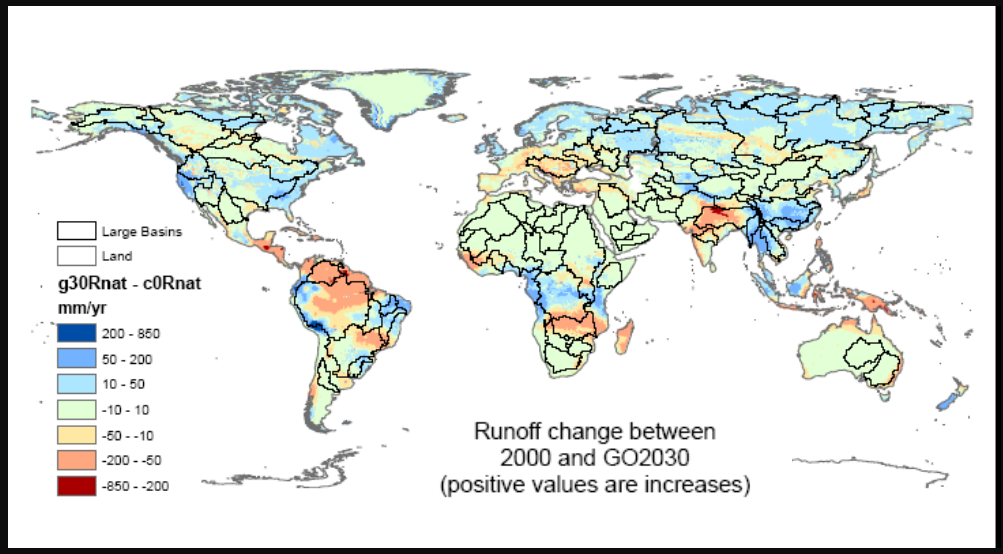
Nutrient Sources

Hydrology & Physical Factors

In-River N, P, Si Removal

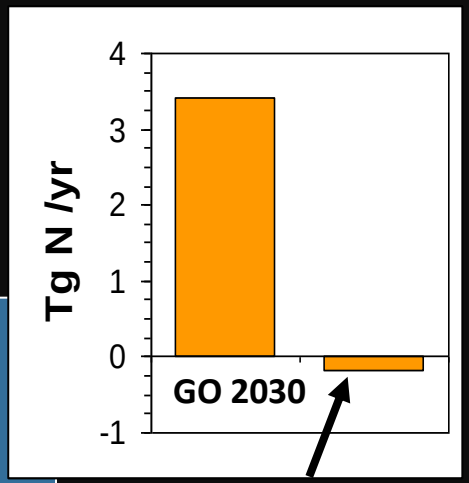
Input Databases 0.5^{o} x 0.5^{o}
> 5000 watersheds globally

DIN export change w/ 2030 climate

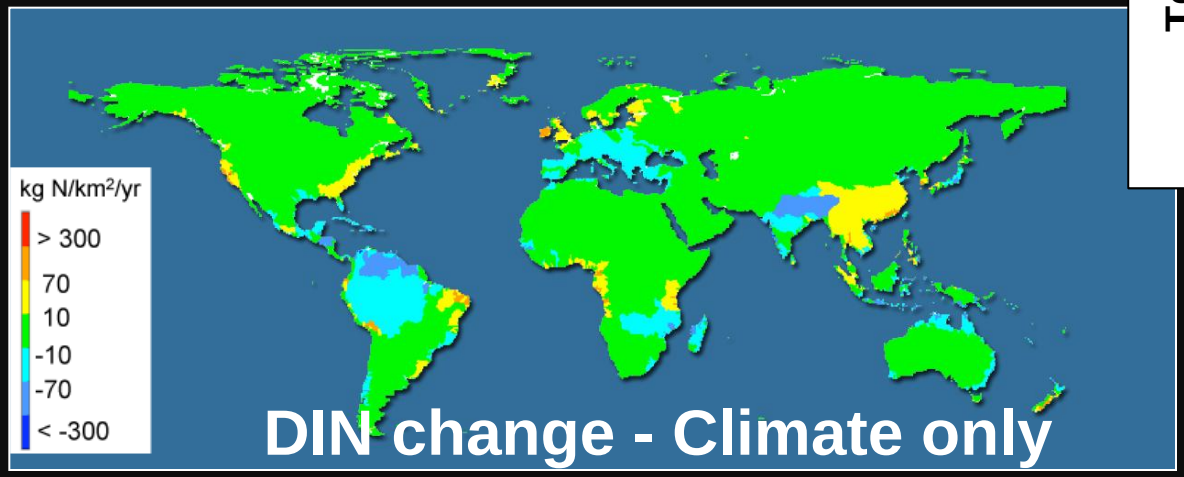


Water runoff change

Change DIN vs. 2000

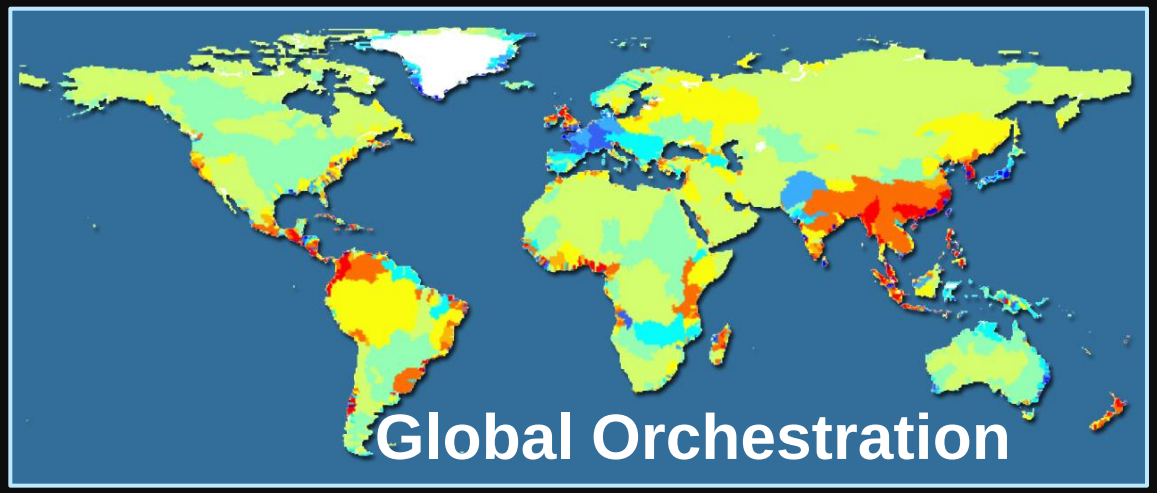


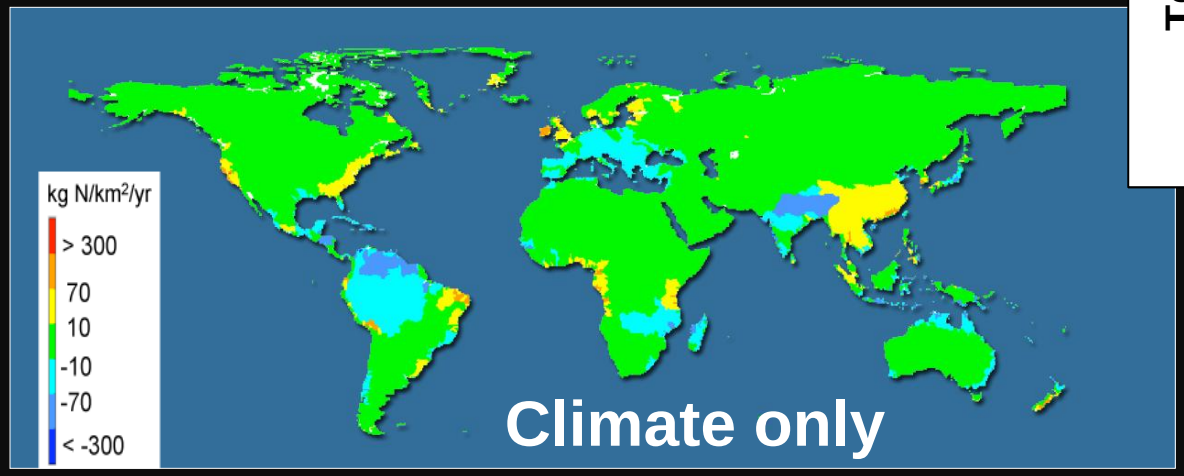
2000 N Inputs w/ GO 2030 Climate



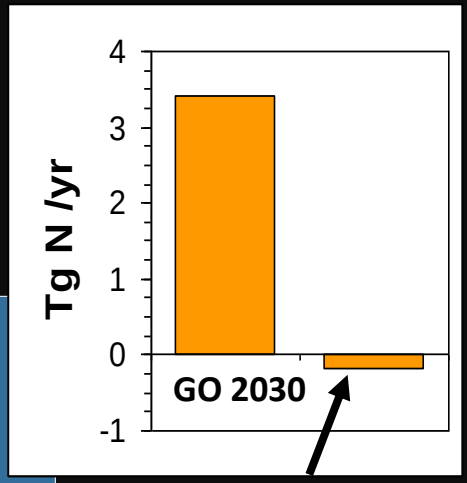
Mayorga, Seitzinger in prep.

DIN export change





Change vs. 2000



2000 N Inputs w/ GO 2030 Climate

Mayorga, Seitzinger in prep.

Effect of climate change only
on DIN river export?