

IRD Research Unit 131

Freshwater Fish Diversity & Macroecology

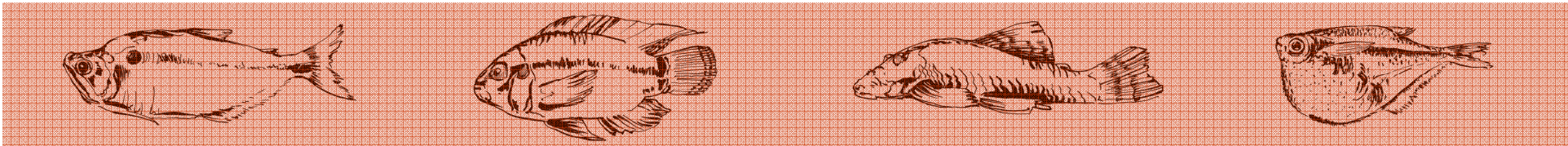


FRESHWATER ANIMAL DIVERSITY ASSESSMENT

## Global diversity of fish (Pisces) in freshwater

C. Lévêque · T. Oberdorff · D. Paugy ·  
M. L. J. Stiassny · P. A. Tedesco

Data we have... Analyses we do...  
Towards the next FADA step

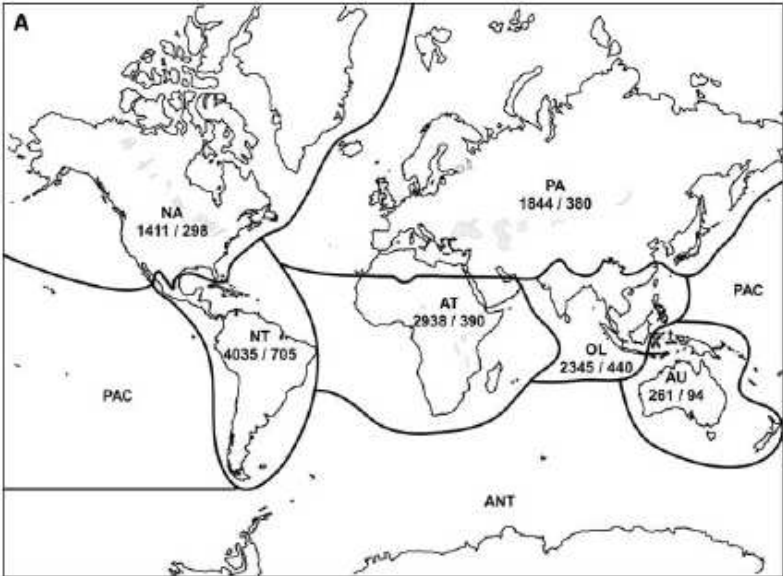


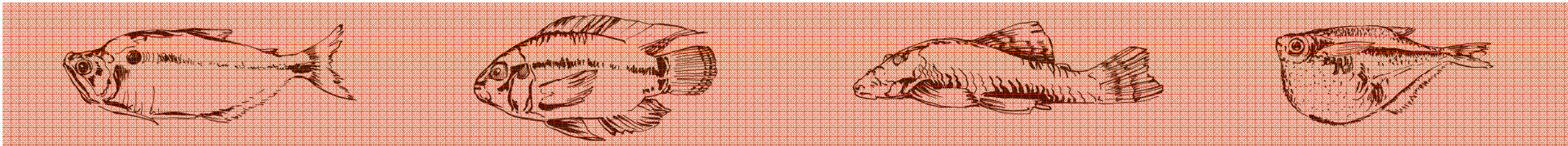
FRESHWATER ANIMAL DIVERSITY ASSESSMENT

# Global diversity of fish (Pisces) in freshwater

C. Lévêque · T. Oberdorff · D. Paugy ·  
 M. L. J. Stiassny · P. A. Tedesco

Species distribution data at the **basin scale** to identify biogeographical units



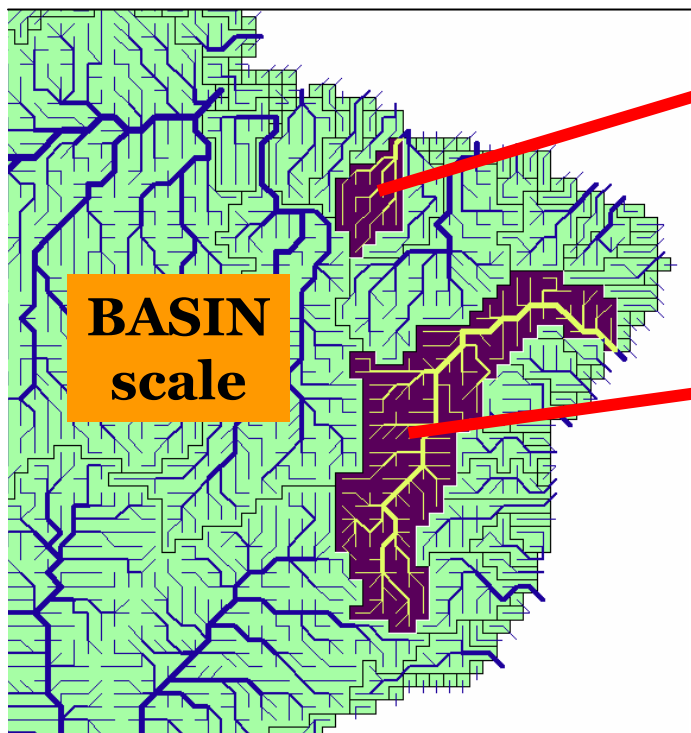
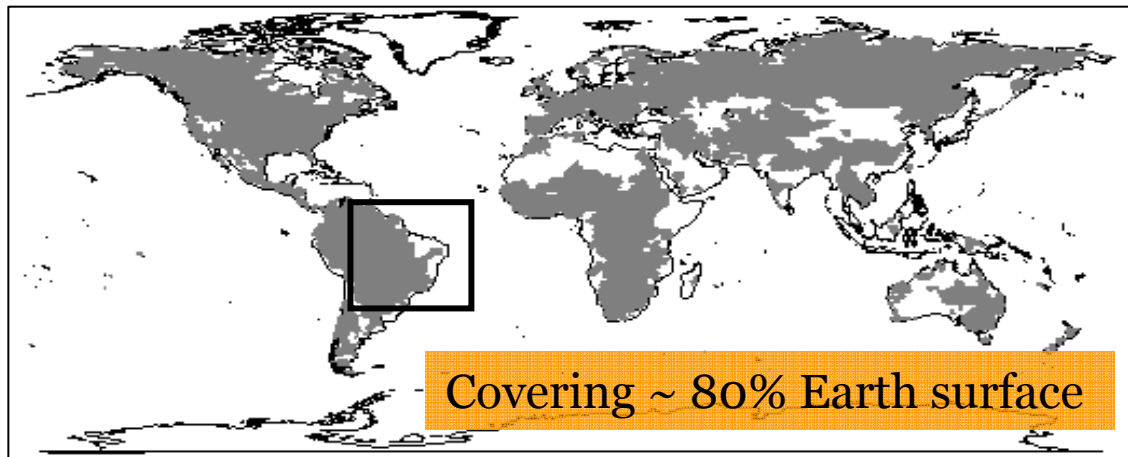


Data we have...

## Species distribution

~ 1000 drainage basins

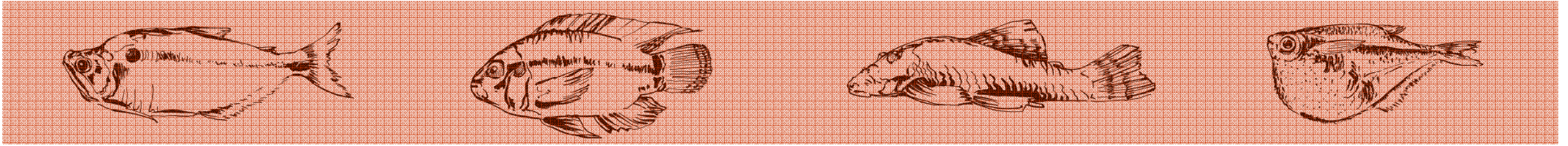
~ 10000 fish species



Genus - species
<i>Eigenmannia.virescens</i>
<i>Cetopsorhamdia.boquillae</i>
<i>Gephyrocharax.caucanus</i>
<i>Creagrutus.caucanus</i>

Genus - species
<i>Astyanax.fasciatus</i>
<i>Cetopsis.gobioides</i>
<i>Astyanax.scabripinnis</i>
<i>Cephalosilurus.fowleri</i>
<i>Australoheros.facetus</i>
<i>Bagropsis.reinhardti</i>

Status & Traits
Fresh - Brackish - Salt water
Native - Non Native
Endemic
IUCN threatened status
Maximum Body size

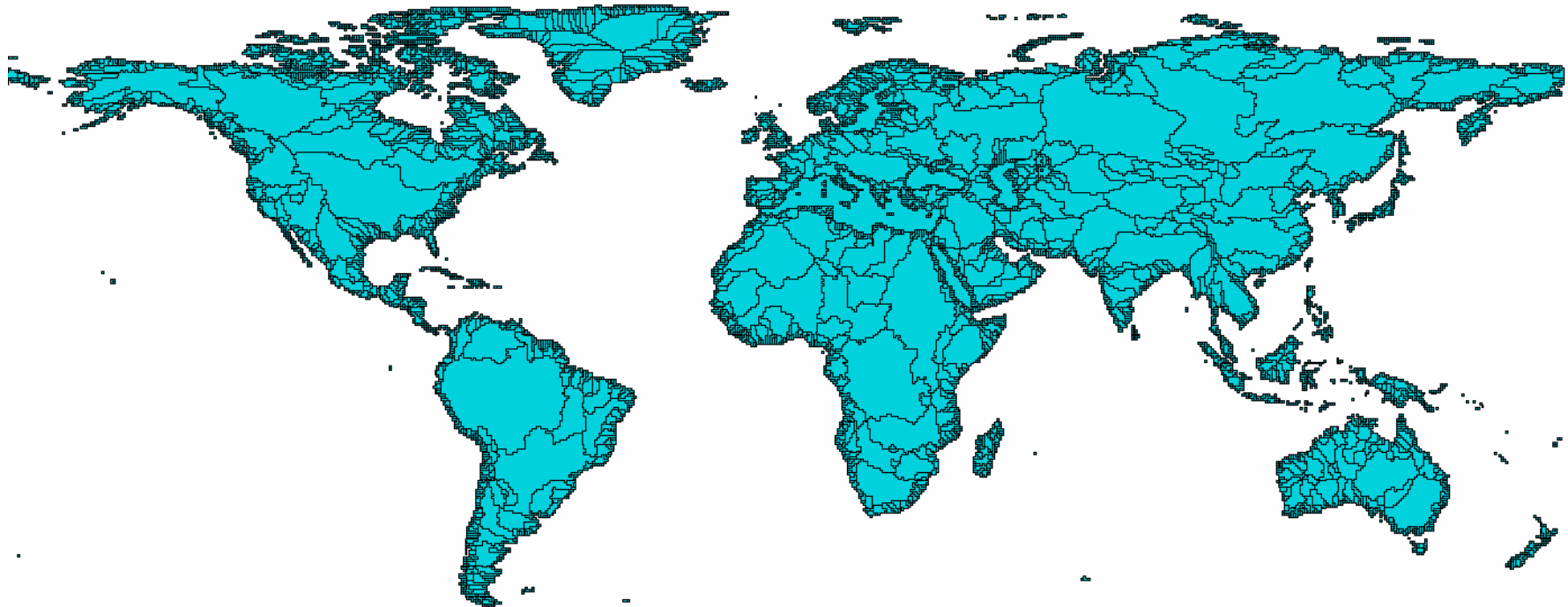


Data we have...

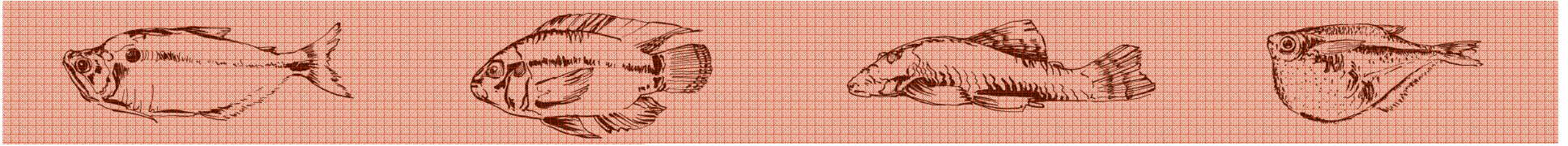
## **Geographical Information System (GIS) location of every basin**

~ 1000 drainage basins

0.5° x 0.5° grid



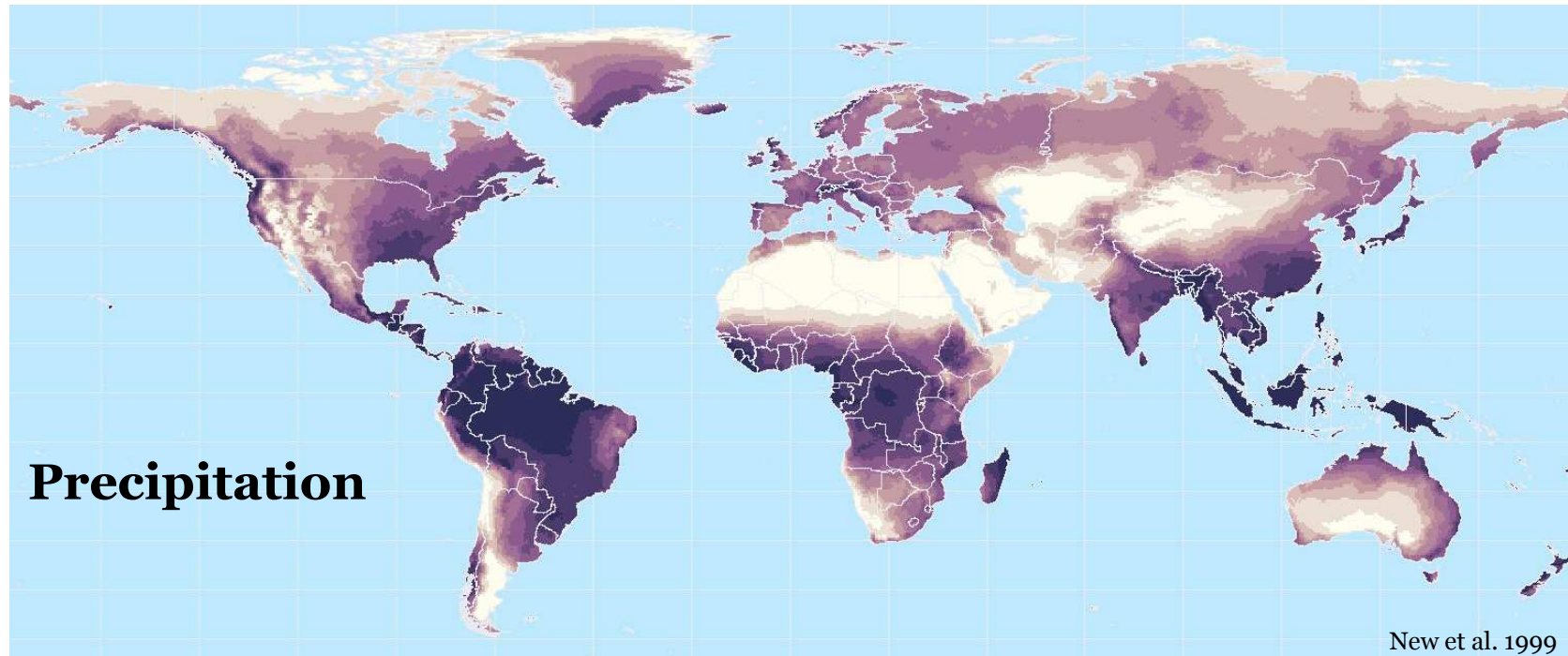
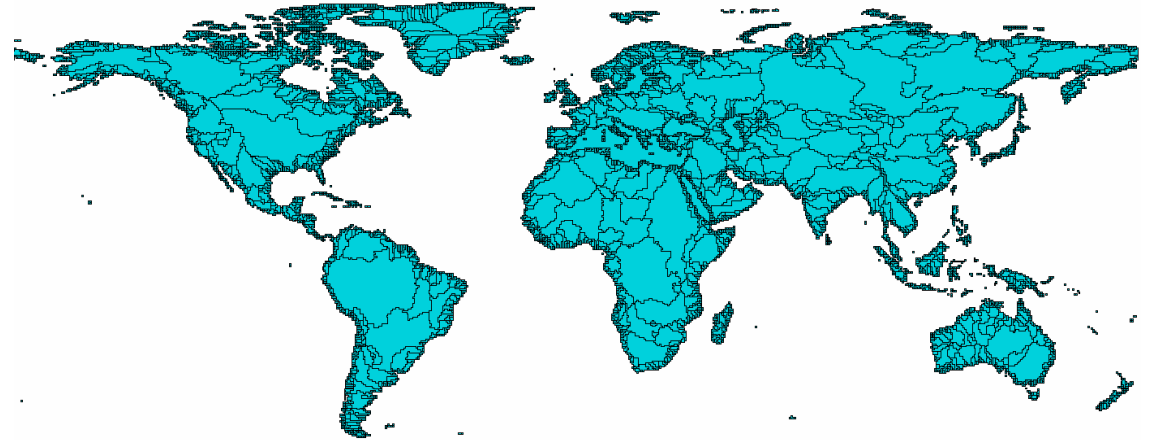


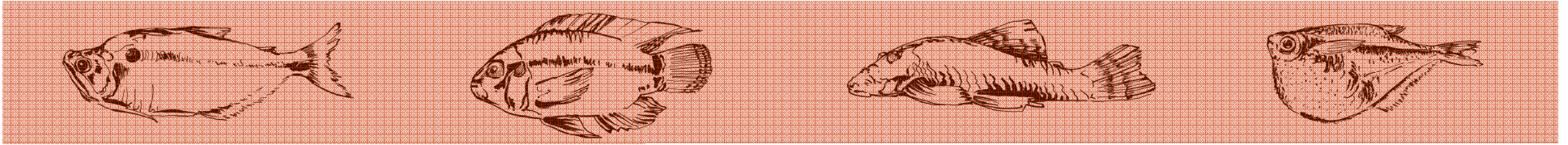


Data we have...

## GIS global scale data

- Climatic variables
- Land cover
- Historical events
- Human impacts





Data we have...

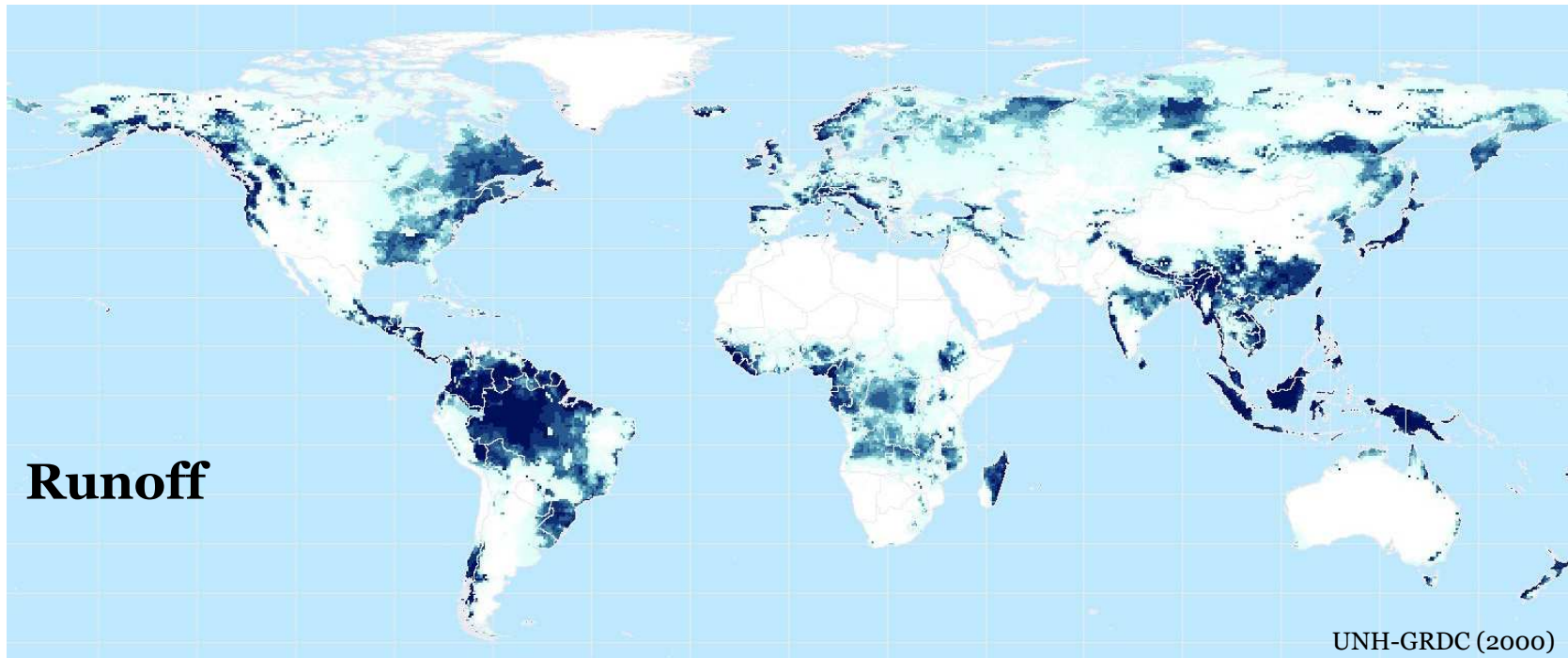
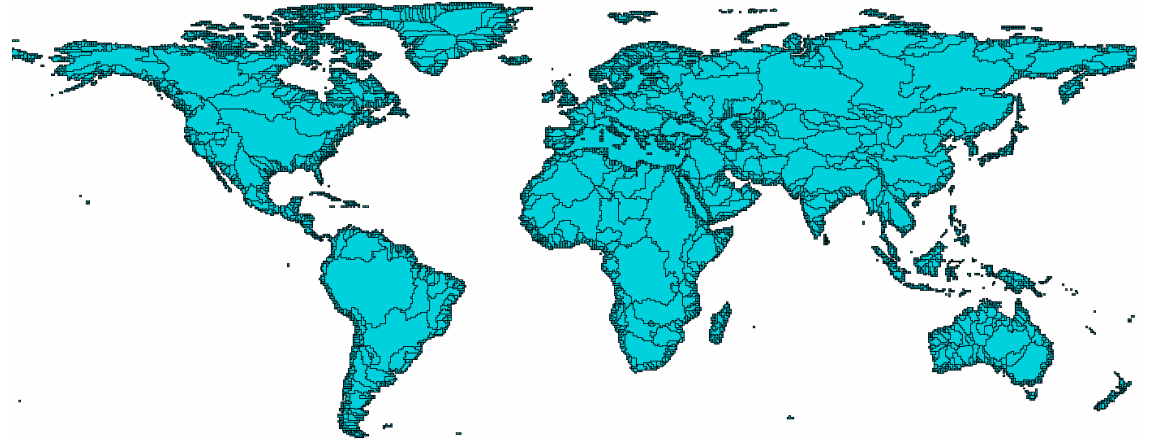
## GIS global scale data

Climatic variables

Land cover

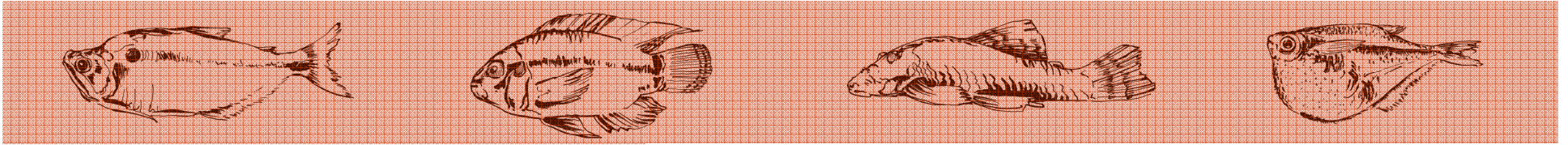
Historical events

Human impacts



**Runoff**

UNH-GRDC (2000)



Data we have...

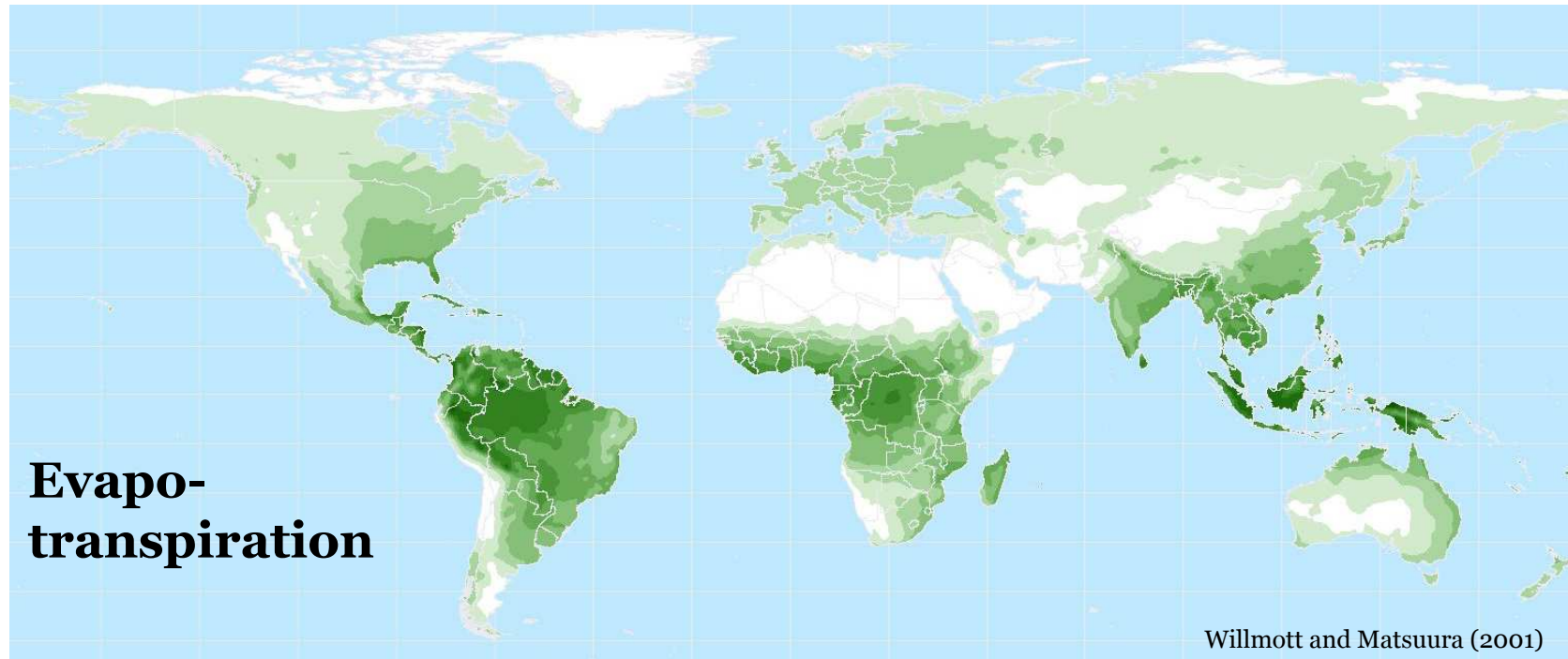
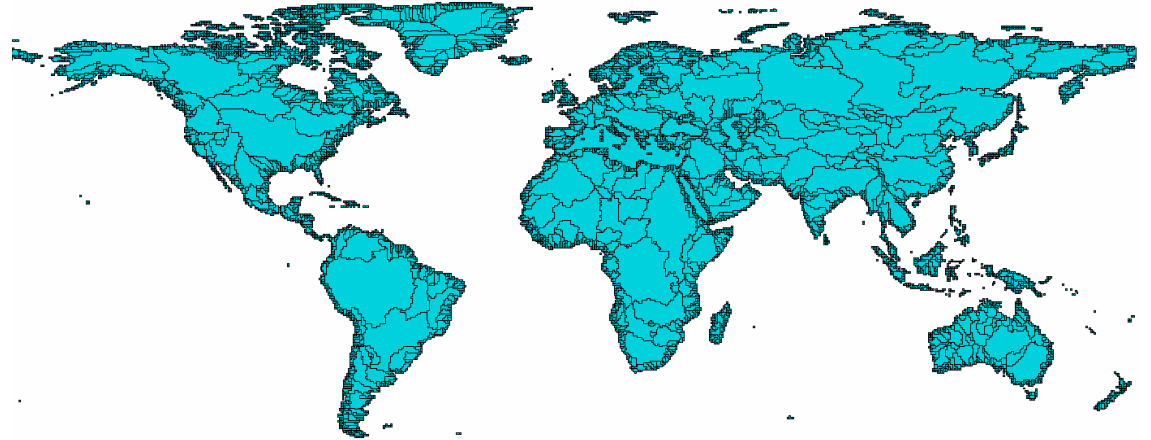
## GIS global scale data

Climatic variables

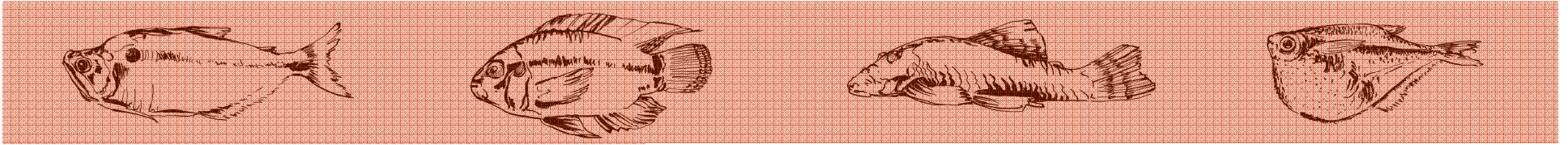
Land cover

Historical events

Human impacts







Data we have...

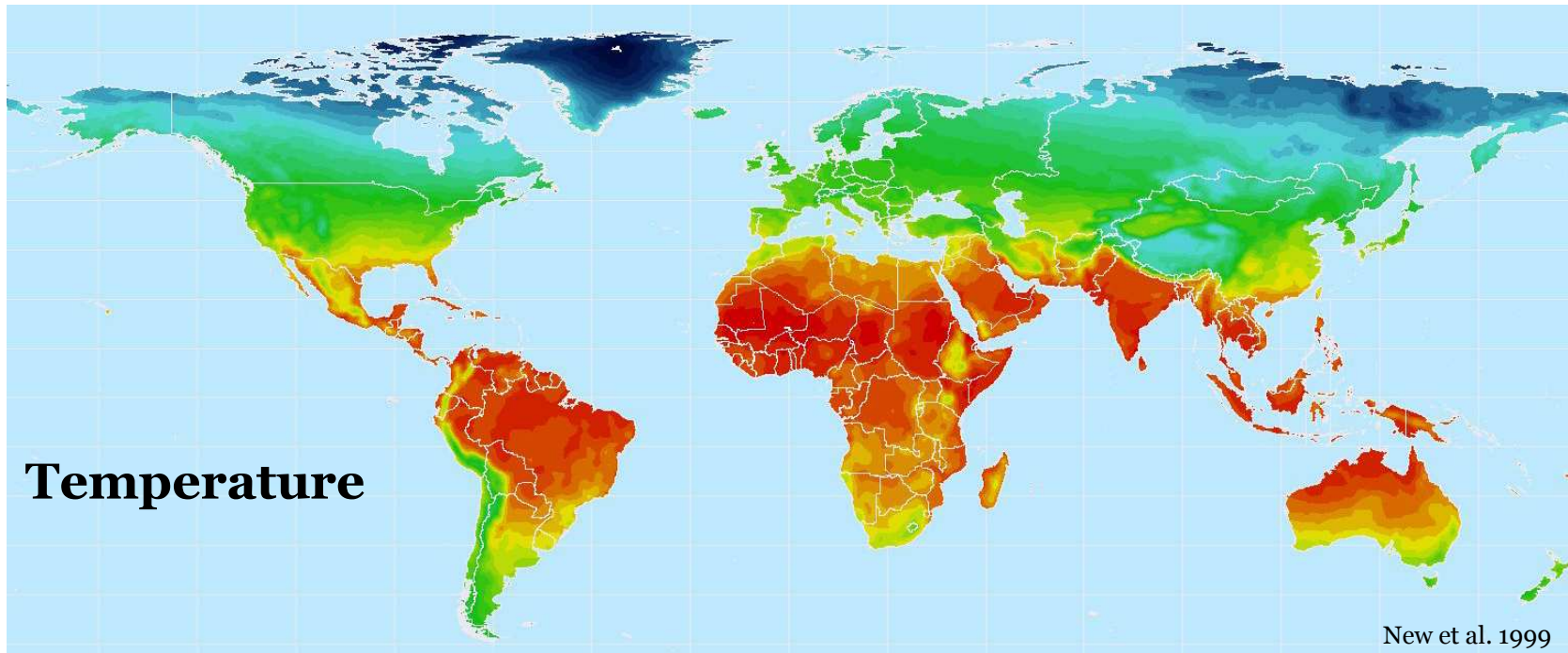
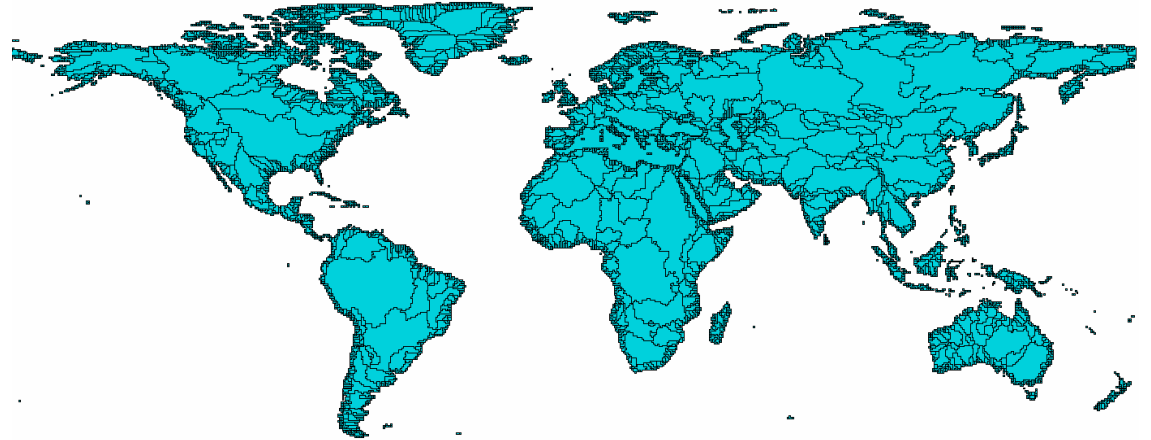
## GIS global scale data

Climatic variables

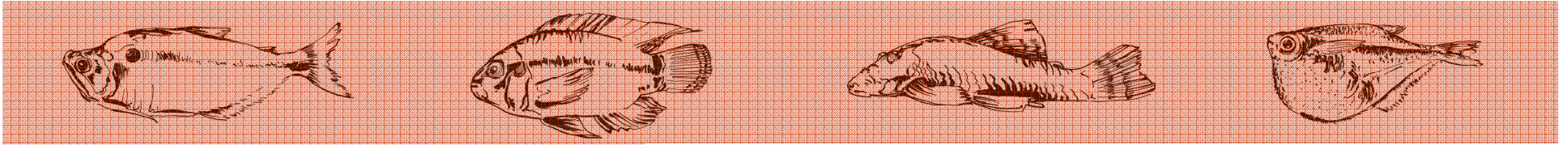
Land cover

Historical events

Human impacts



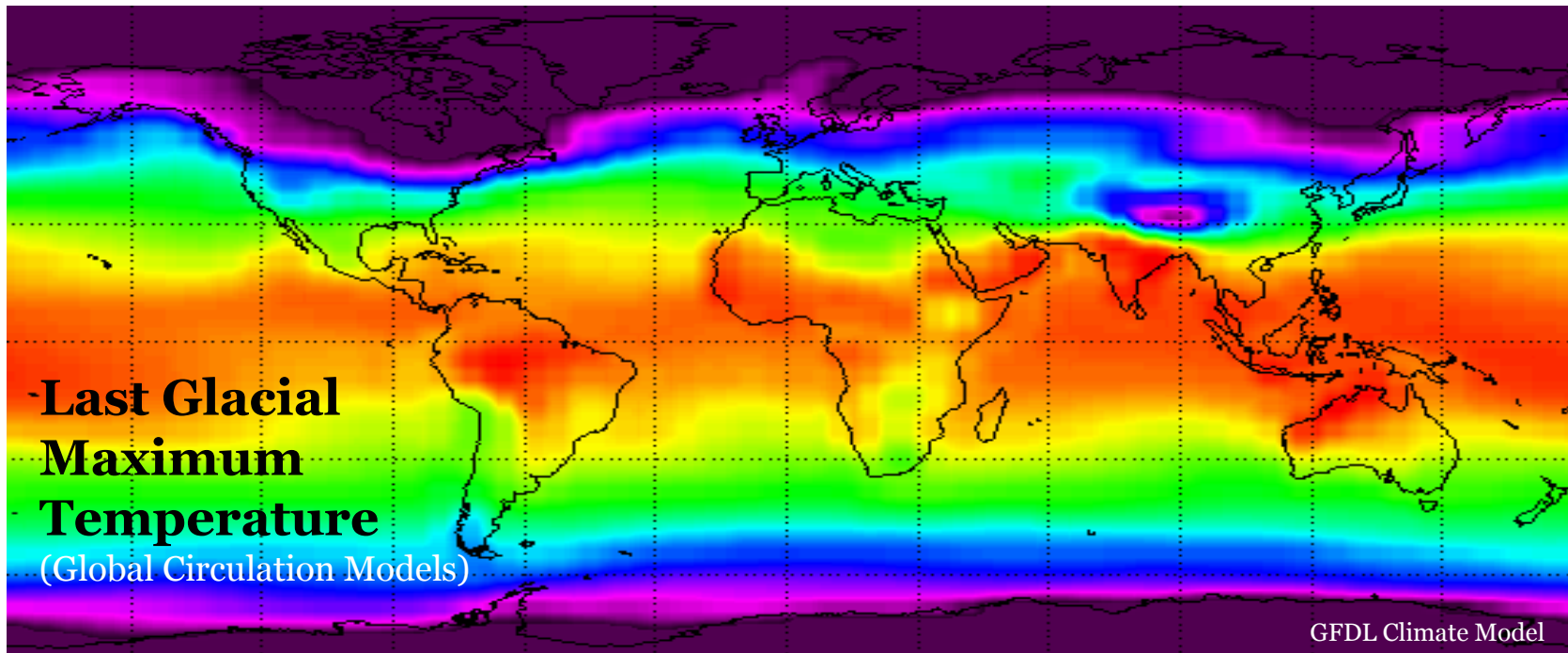
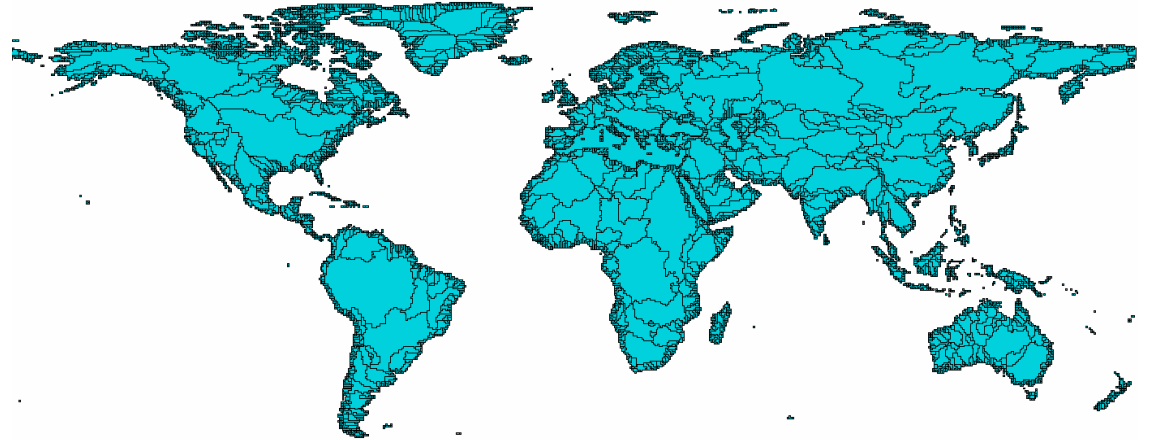


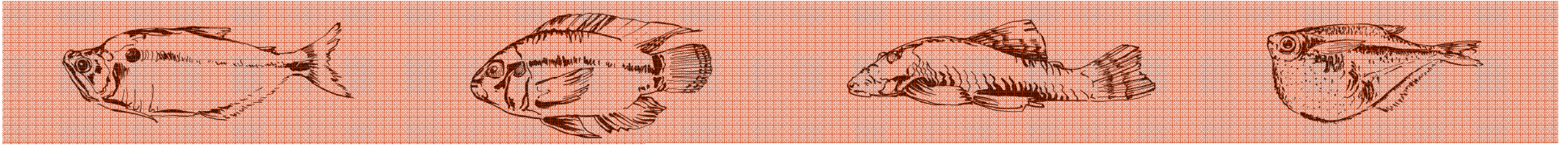


Data we have...

## GIS global scale data

- Climatic variables
- Land cover
- Historical events
- Human impacts

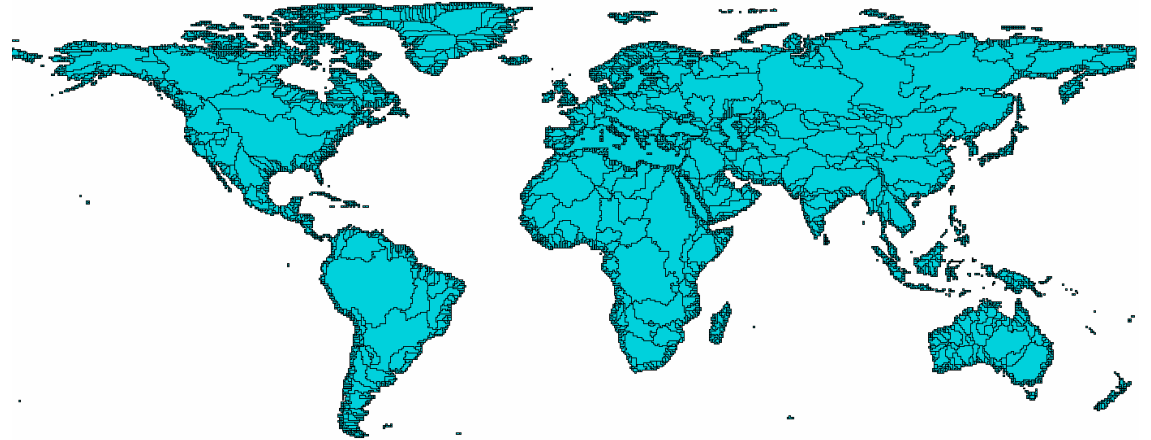




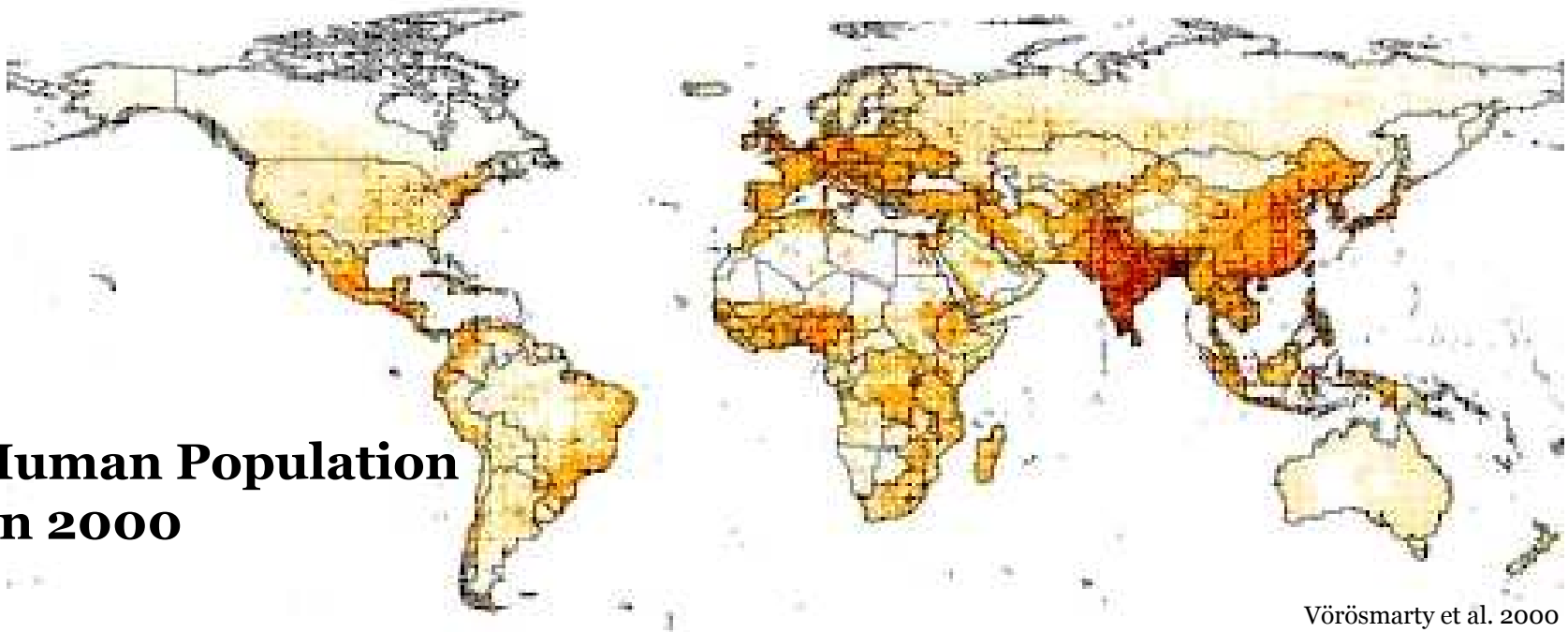
Data we have...

## GIS global scale data

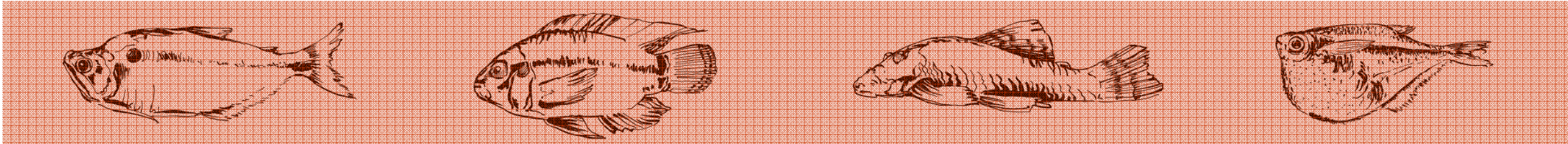
- Climatic variables
- Land cover
- Historical events
- Human impacts



## Human Population in 2000



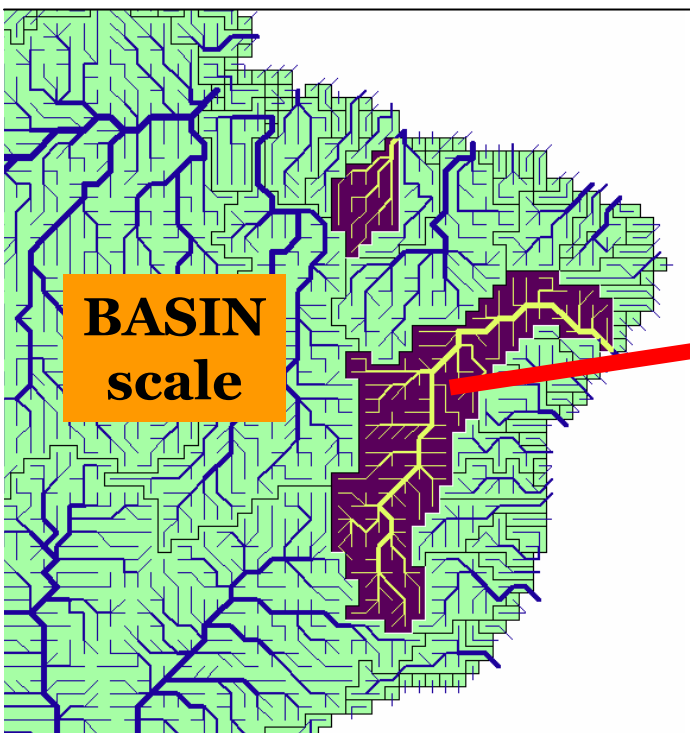
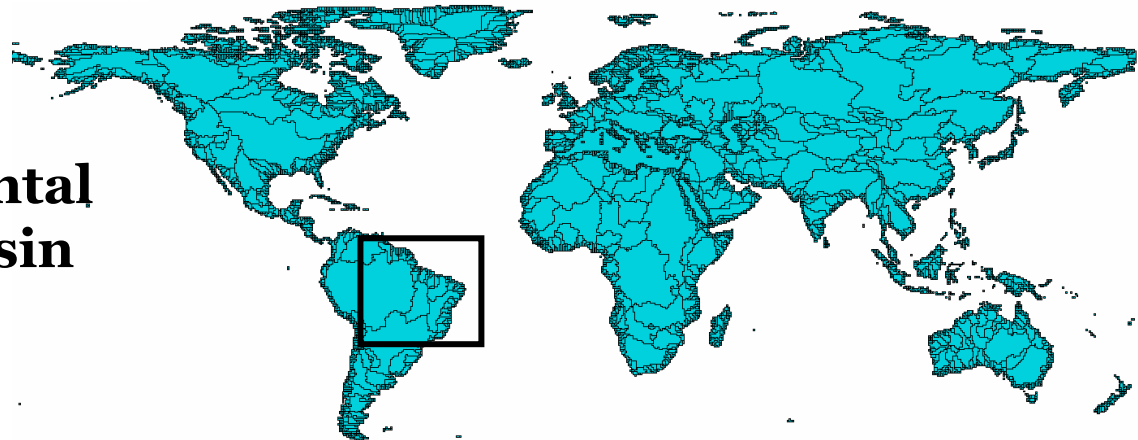
Vörösmarty et al. 2000



Data we have...

**Present & past environmental data for every drainage basin**

~ 1000 drainage basins



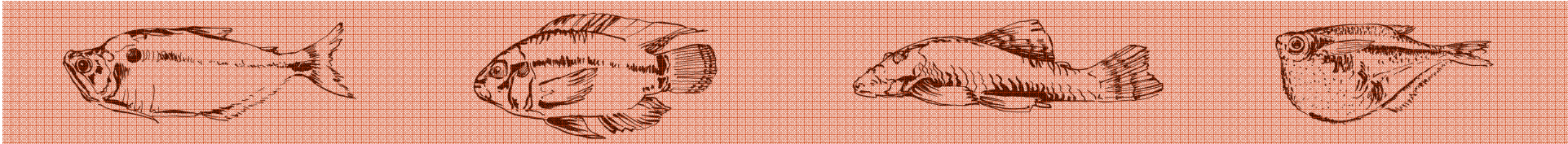
Estimates for Temporal & Spatial variability

- Area
- Elevation
- Vegetation cover (SAGE, IBGP, Ecoregions)
- Run-off
- Energy (AET, NPP)
- Climate (temperature, precipitation, PET)
- History (Ice cover & anomalies from the LGM)

- Habitat heterogeneity
- Seasonality & stability

- Anthropo-biomes (urban, cropland,...)
- Population density
- Dams location
- Simulated future climates (GCM)





Data we have...

## Distance estimates between drainage basins

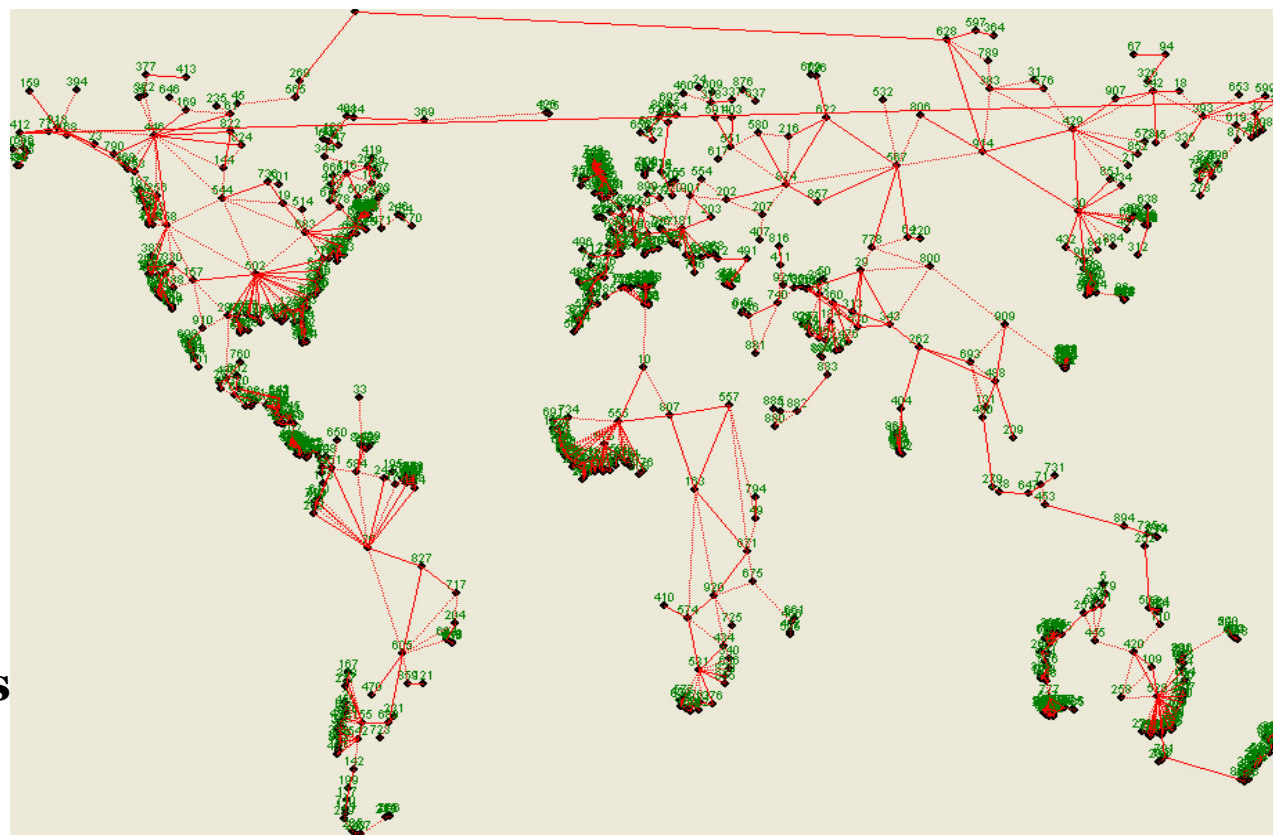
Geographic coordinates  
&  
Connectivity (neighbors)

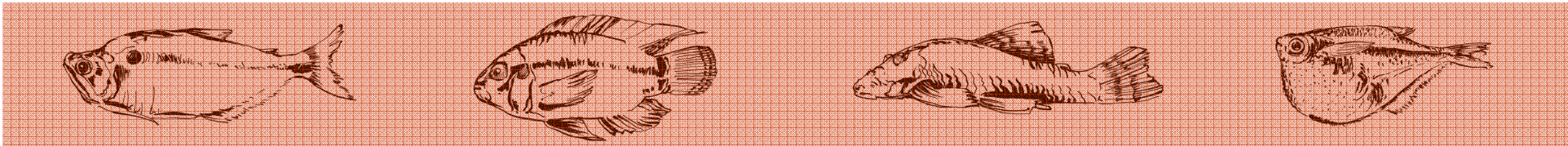
For every pair of basins:

Geographic distance matrix  
&  
Connectivity matrix



Spatial analysis methods  
(accounting for  
spatial autocorrelation)

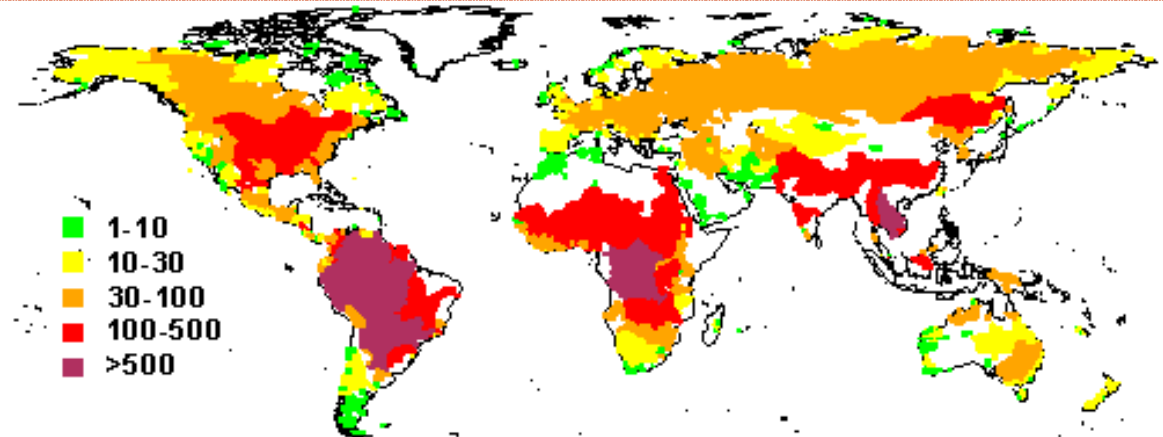




## Analyses we do...

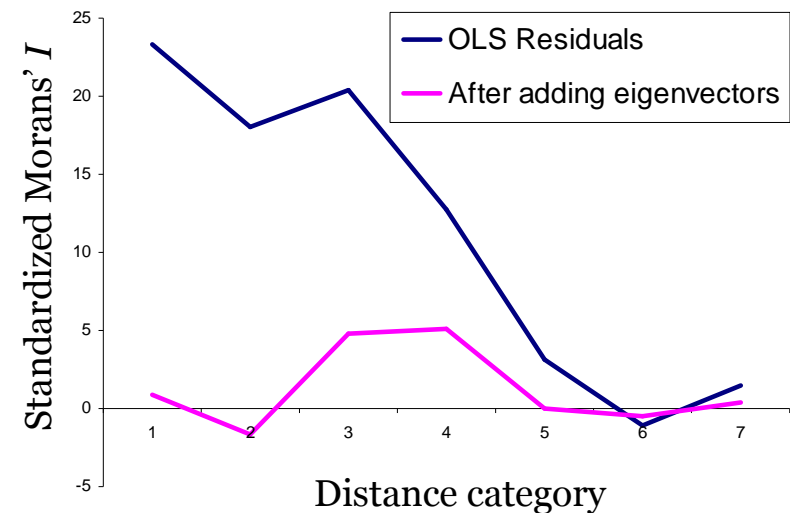
### Preliminary results on **Species richness patterns**

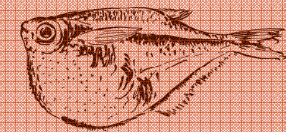
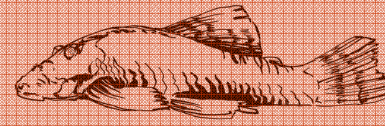
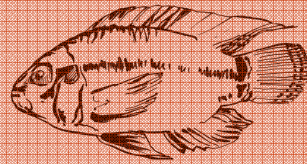
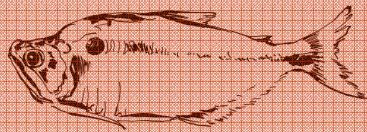
Selecting predictor variables:  
**AIC Model selection (& averaging)**  
 Spatial model:  
**Eigenvector-based filtering model**



**Total Species Richness at the basin scale  
(strictly native & freshwater species)**

Variables	Relative Variable Importance (delta<4)	Eigenvector Filtering Model $p$ values
AET_cv	1	0.020726 *
AET_mean	1	1.63E-08 ***
AREA	1	0.000127 ***
Isolation	1	1.17E-15 ***
LGM	1	2.91E-09 ***
OLSON Ecoregions	1	1.43E-06 ***
PET_cv	1	0.699459
PET_mean	1	1.16E-06 ***
Runoff_mean	1	0.000474 ***
SAGE Vegetation cover	1	2.00E-16 ***
Temperature_cv	1	2.00E-16 ***
Temperature_mean	1	2.00E-16 ***
Precipitation_cv	0.41	
Elevation range	0.27	
Precipitation_mean	0.25	

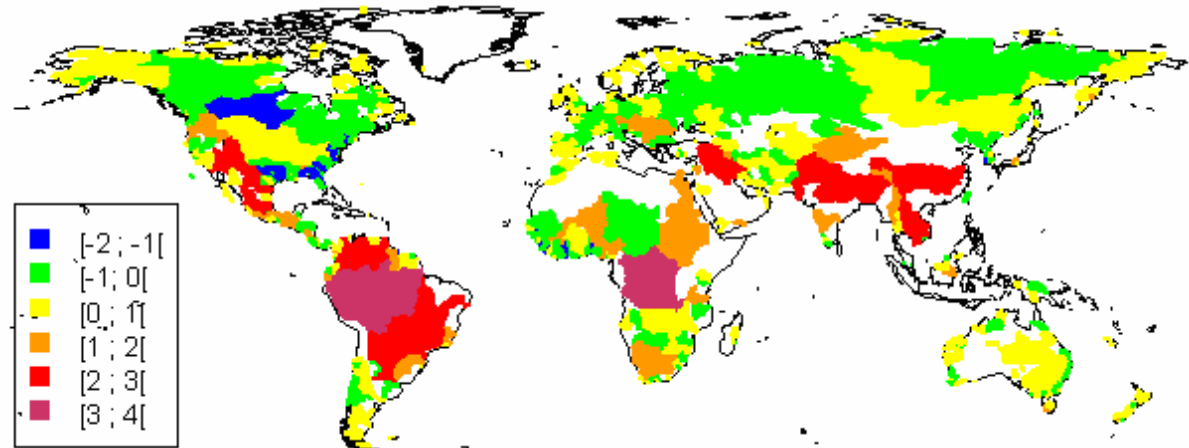




## Analyses we do...

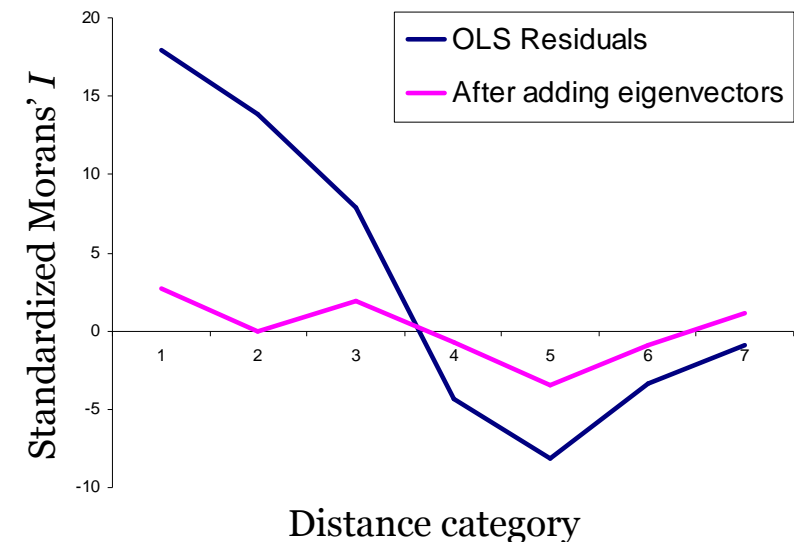
### Preliminary results on **Endemism patterns**

Selecting predictor variables:  
**AIC Model selection (& averaging)**  
Spatial model:  
**Eigenvector-based filtering model**

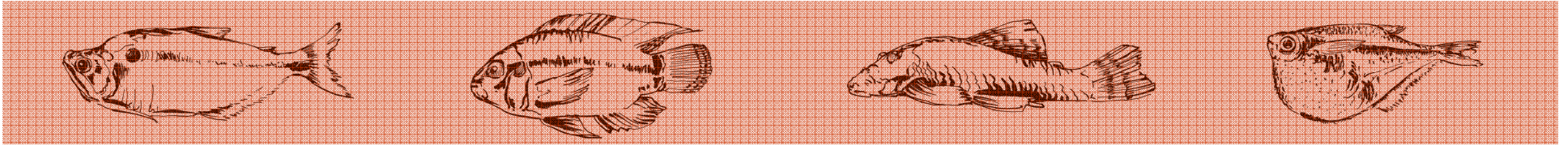


**Endemics (Null model residuals)**  
**(Species present in only one basin)**

Variables	Relative Variable Importance (delta<4)	Eigenvector Filtering Model $p$ values
AREA	1	2.00E-16 ***
Isolation	1	0.170257
LGM	1	0.571444
Temperature_cv	1	1.45E-09 ***
Temperature_mean	1	0.006506 **
Elevation range	1	1.45E-08 ***
Precipitation_mean	1	7.70E-05 ***
AET_cv	0.76	0.025421 *
PET_cv	0.52	0.60723
SAGE Vegetation cover	0.5	
AET_mean	0.45	1.43E-07 ***
OLSON Ecoregions	0.31	
PET_mean	0.28	
Precipitation_cv	0.27	
Runoff_mean	0.14	







## Towards the next step...

### Congruence analyses

- Congruent distribution patterns of freshwater organisms? Are these patterns linked to the same environmental and historical variables?
- Biodiversity Hotspots analyses: where do we find more richness, endemics and threatened species combined to increased human impact?

### Taxonomic and functional aspects

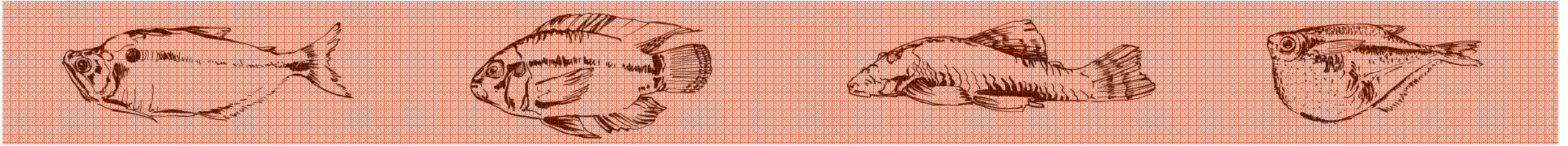
- Congruence in turn-over patterns to detect the main biogeographical barriers for freshwater organisms
- Detecting “species source basins”: do the most speciose families concentrate in the same places?
- Implications of functional traits as body size, dispersal capacities or strict freshwater habitat
- The lack of congruent patterns between groups can be much more informative about the mechanisms behind

### Potential problems

Scale of different datasets (drainage basins, ecoregions, localities,...)

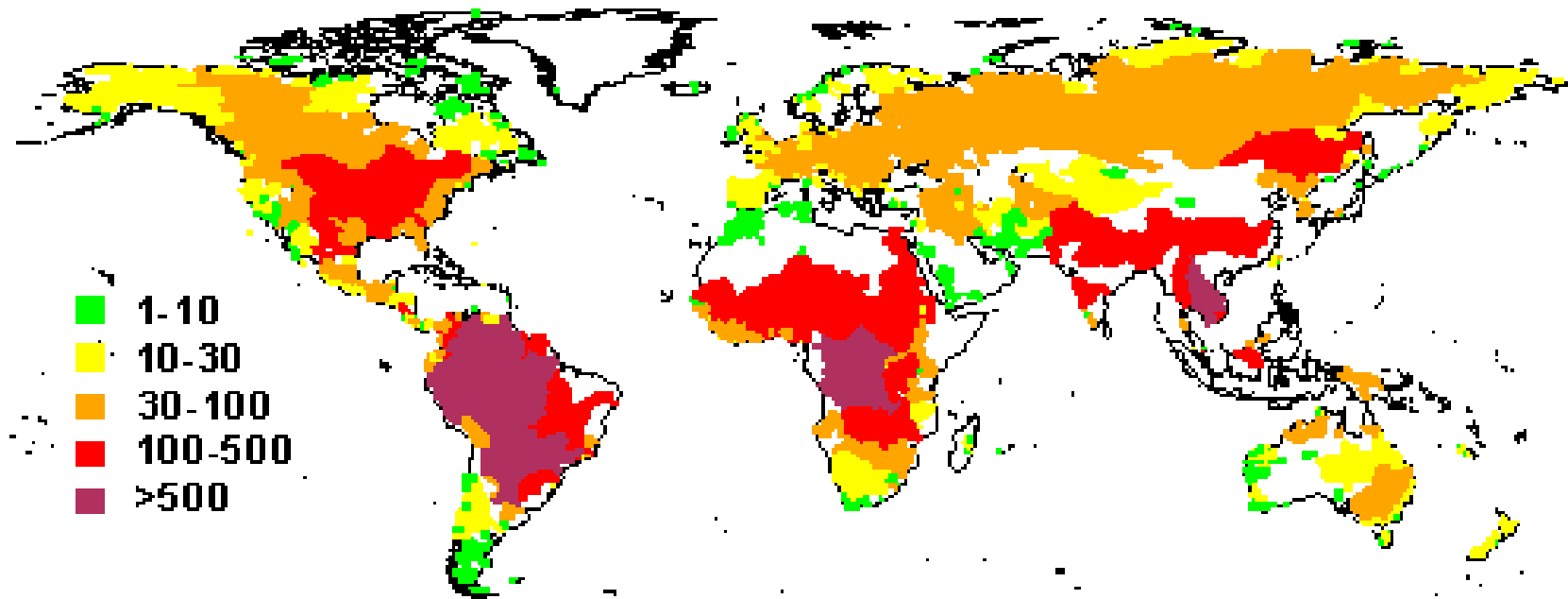
Taxonomic resolution of different organisms

Data gaps (mainly on tropical regions?)



Analyses we do...

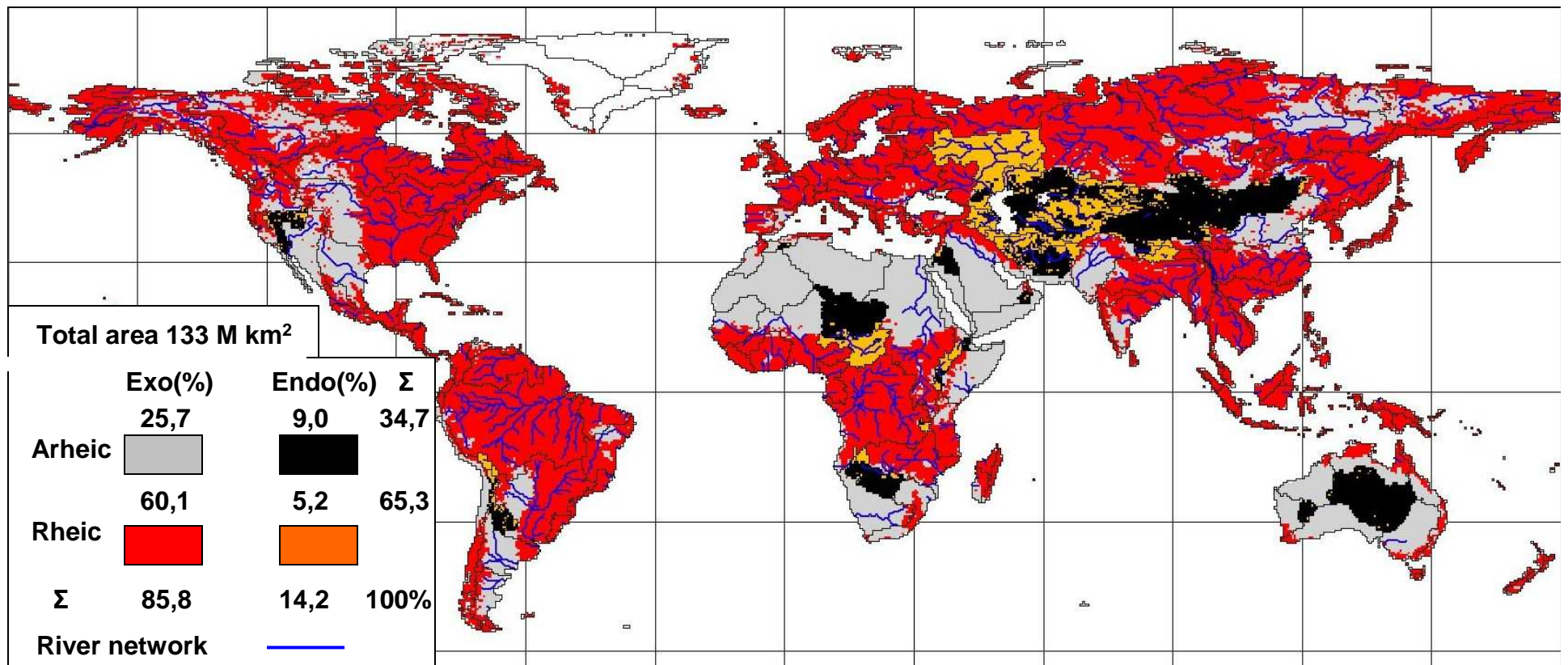
Preliminary results on  
**Species richness patterns**



**Total Species Richness at the basin scale  
(strictly native freshwater species)**

*We're still talking about  
catchment scale*

## Organisation of the continental surfaces by water into major units (activity scale)

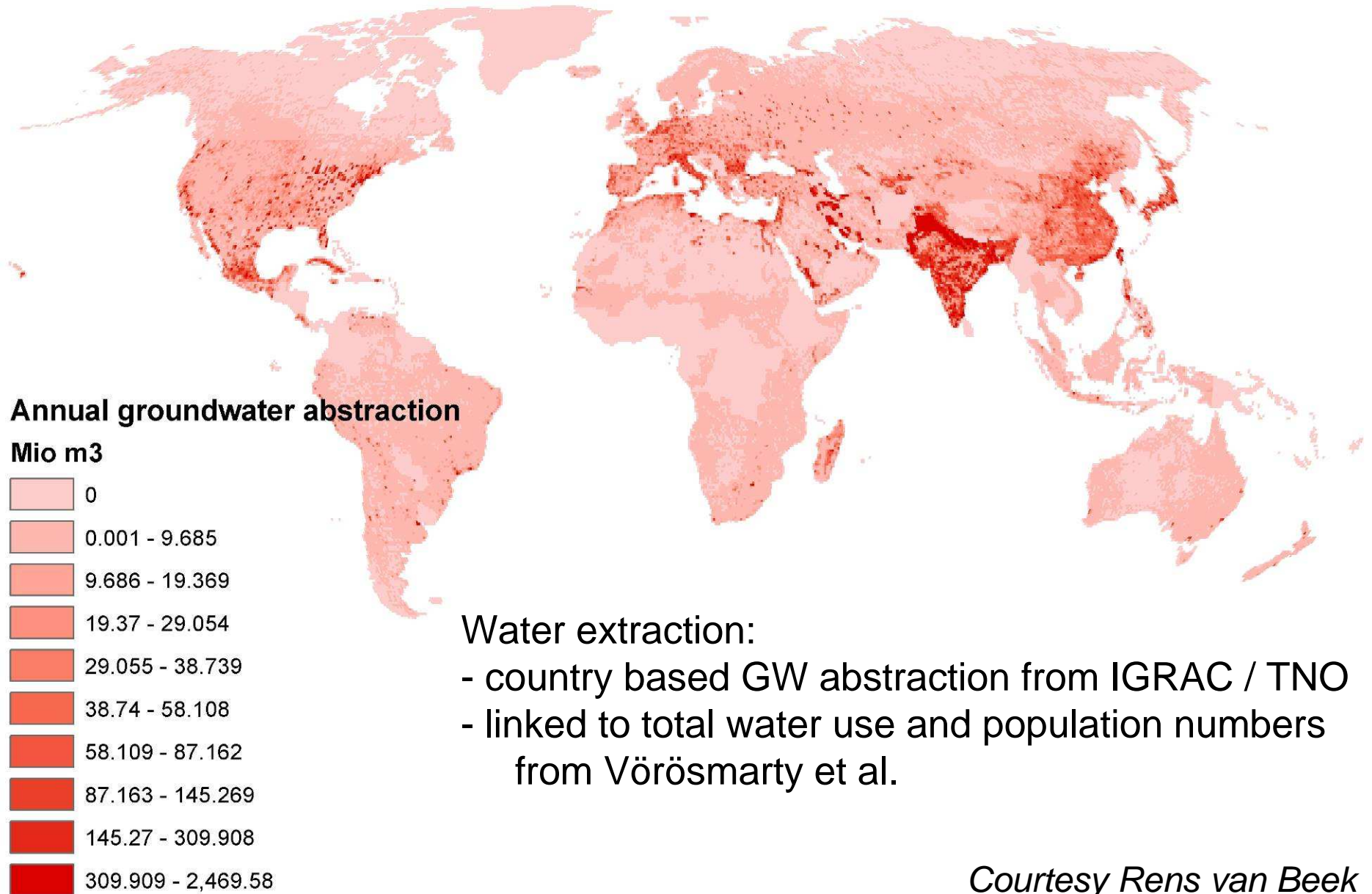


*River network : Vörösmarty et al. 2000 a & b, modified and adapted ; ~6200 individual river catchments*

*Runoff : Fekete et al. 2002*



# Groundwater abstraction



*Courtesy Rens van Beek*