Status and Attribution of Lake Water Quality

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Questions we can start to answer

1. What is the water quality of the world's largest lakes? [phytoplankton chl-a]

2. What environmental drivers control water quality?

3. What lake properties affect their sensitivity to these drivers?

4. How is status changing?

Data

Calimnos v1.04:

Phytoplankton chlorophyll-a (Chl-a)

- 0.0027 degree resolution (approx 300m sq)
- 998 lakes
- Monthly data from June 2003 to Jan 2012 (103 time points)

- 600m lake boundary excluded
- Chl-a values >700 µg/L excluded
- All remaining pixels averaged

GloboLakes Catchment Database v2.1

Lake Properties ("Sensitivity factors")

- Latitude, longitude, elevation, area, mean depth, residence time

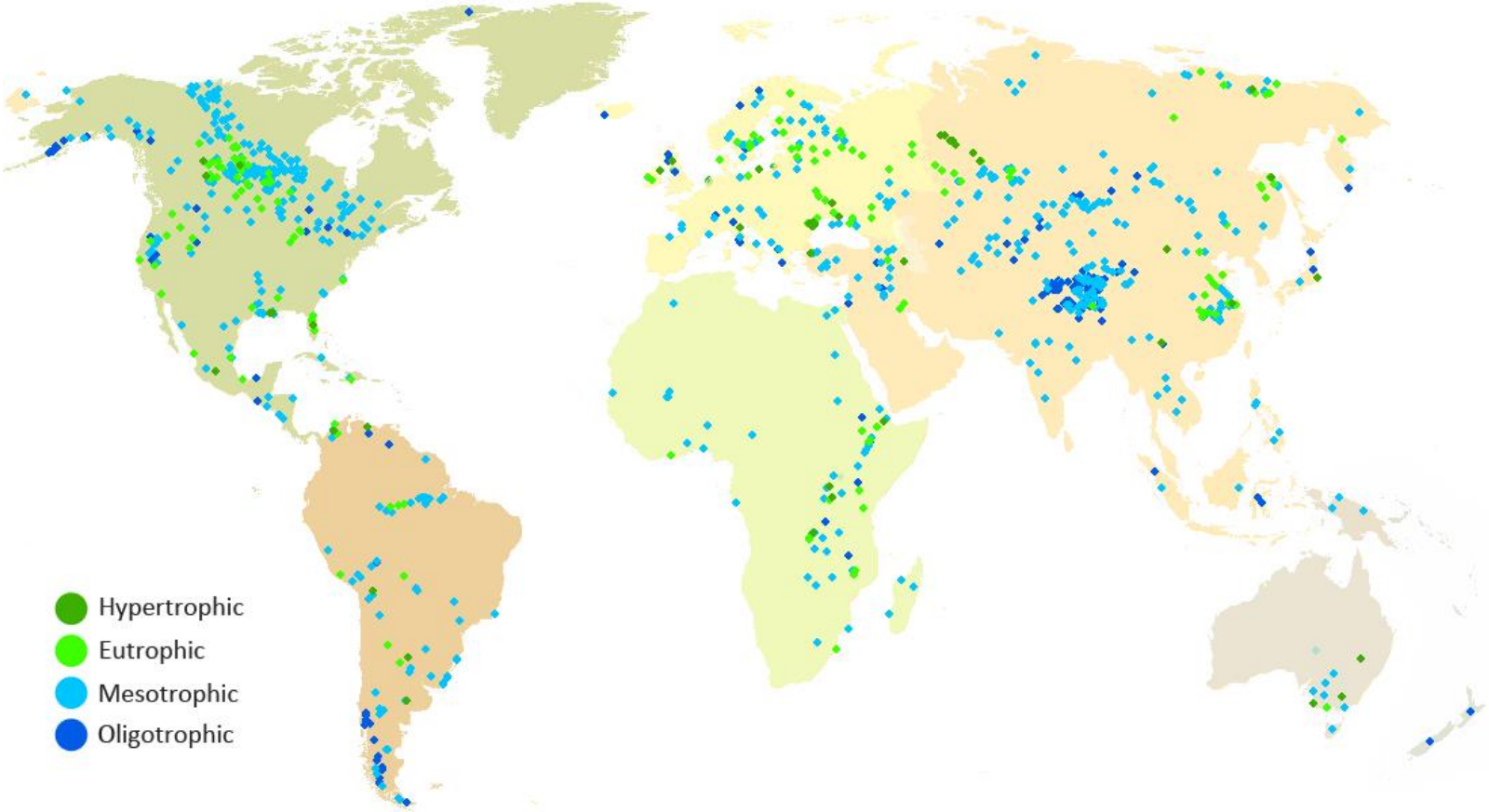
Catchment Drivers

- Population density (2000-2015)
- Land cover (2010)
- Vegetation Index (Net Primary Production)

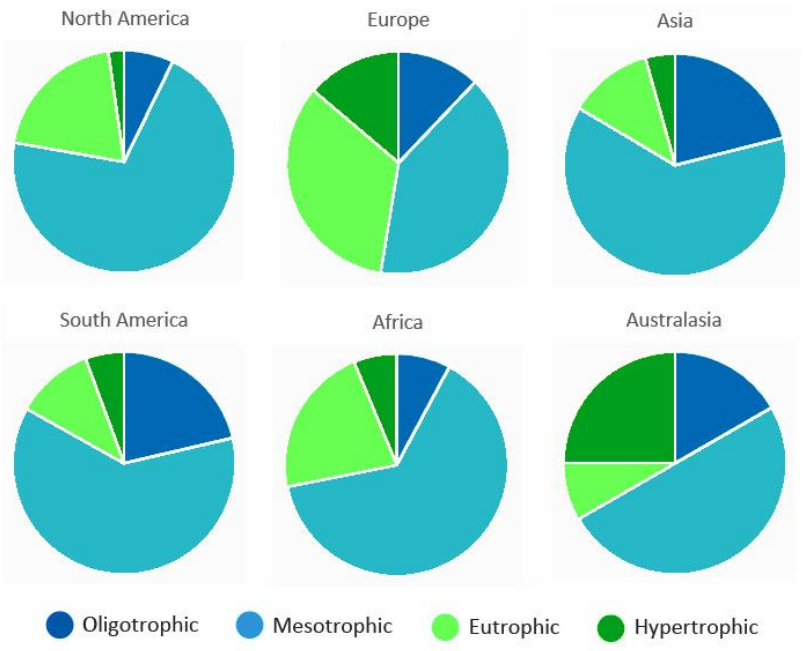
Climate Drivers

- Air temperature (over lake)
- Precipitation (over catchment)

Water Quality Status of the World's Largest Lakes



The first global Chl-a map tuned to optical water types

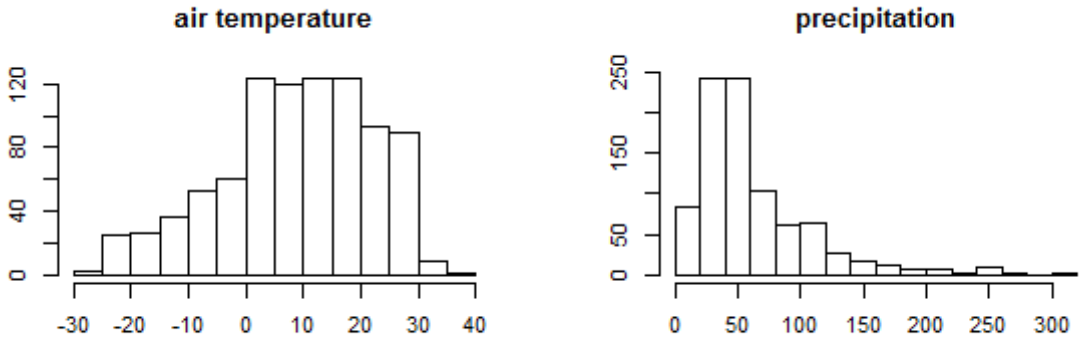


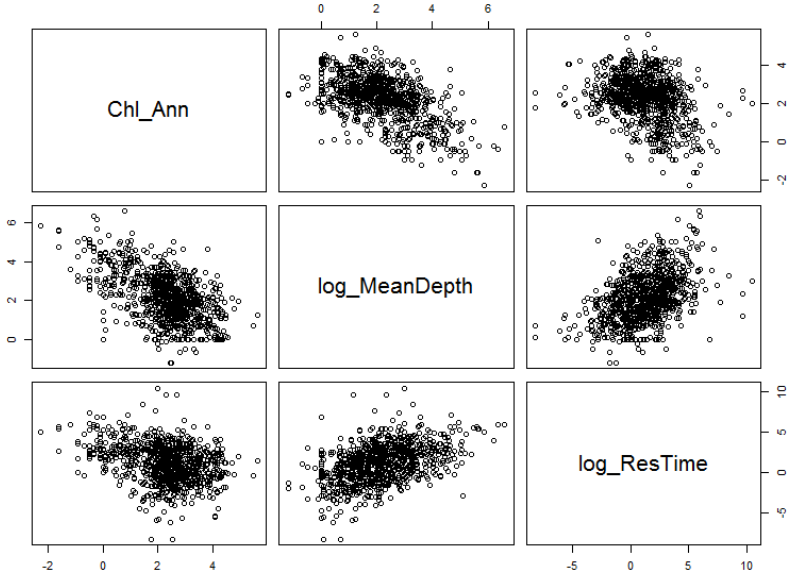
Europe has highest % of eutrophic or hypertrophic lakes

Statistical analysis: drivers of water quality

- Exploratory analysis and data transformations
- Linear models with stepwise selection of predictor variables

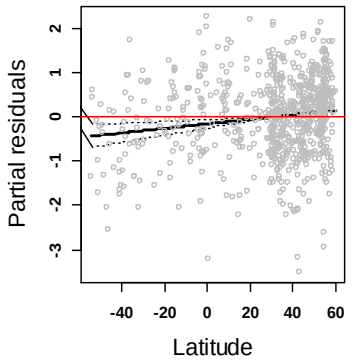
- Response: Annual mean chlorophyll-a
- Predictor variables split into three categories:
  - **Catchment**: % agriculture, % urban, annual NPP
  - **Climate**: air temperature, precipitation
  - **Lake properties**: lat/lon, elevation, area, depth

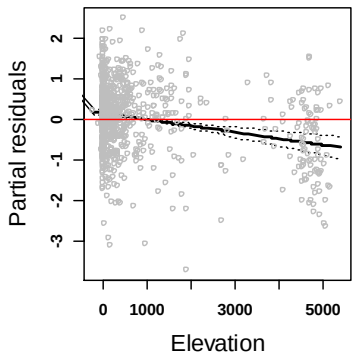




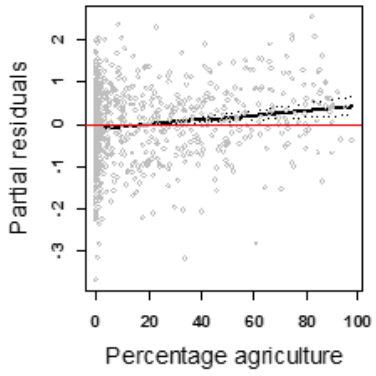
Results – Global Model

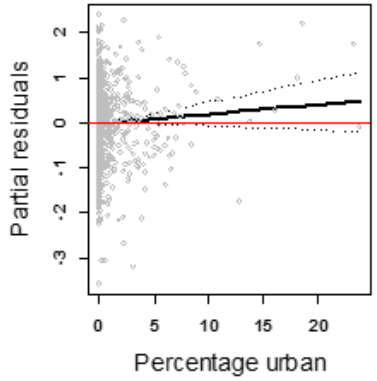
Model coefficients											
Longitude	Latitude	Elevation	Lake Area	Mean Depth	Temperature	Rainfall	Annual NPP	% Agriculture	%Urban	DF	Adj. R^5
	0.005	-0.0002	-0.115	-0.383	0.011	-0.006	0.328	0.005	0.021	781	0.49
	***	***	***	***	*	***	***	***			

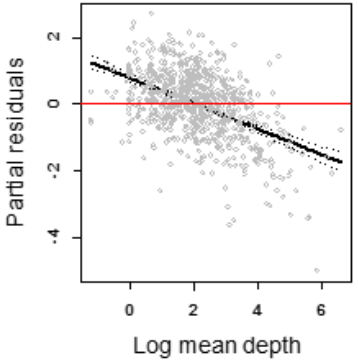


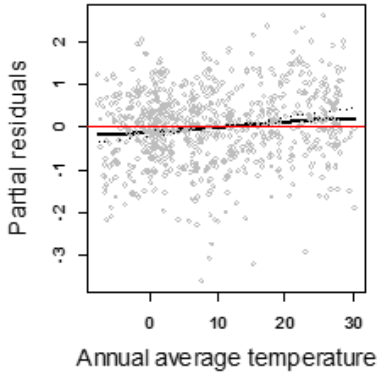


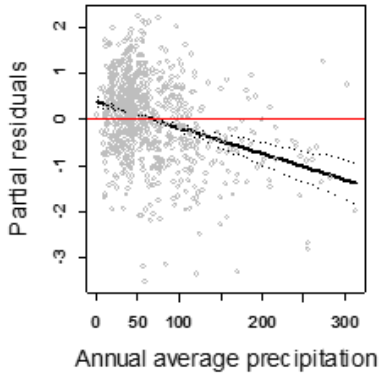
Climate factors

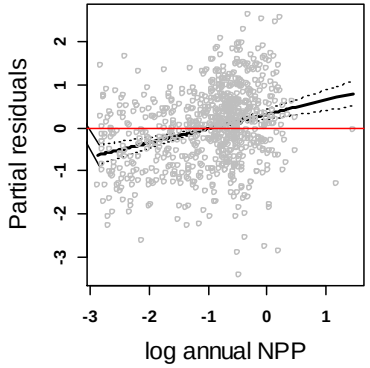








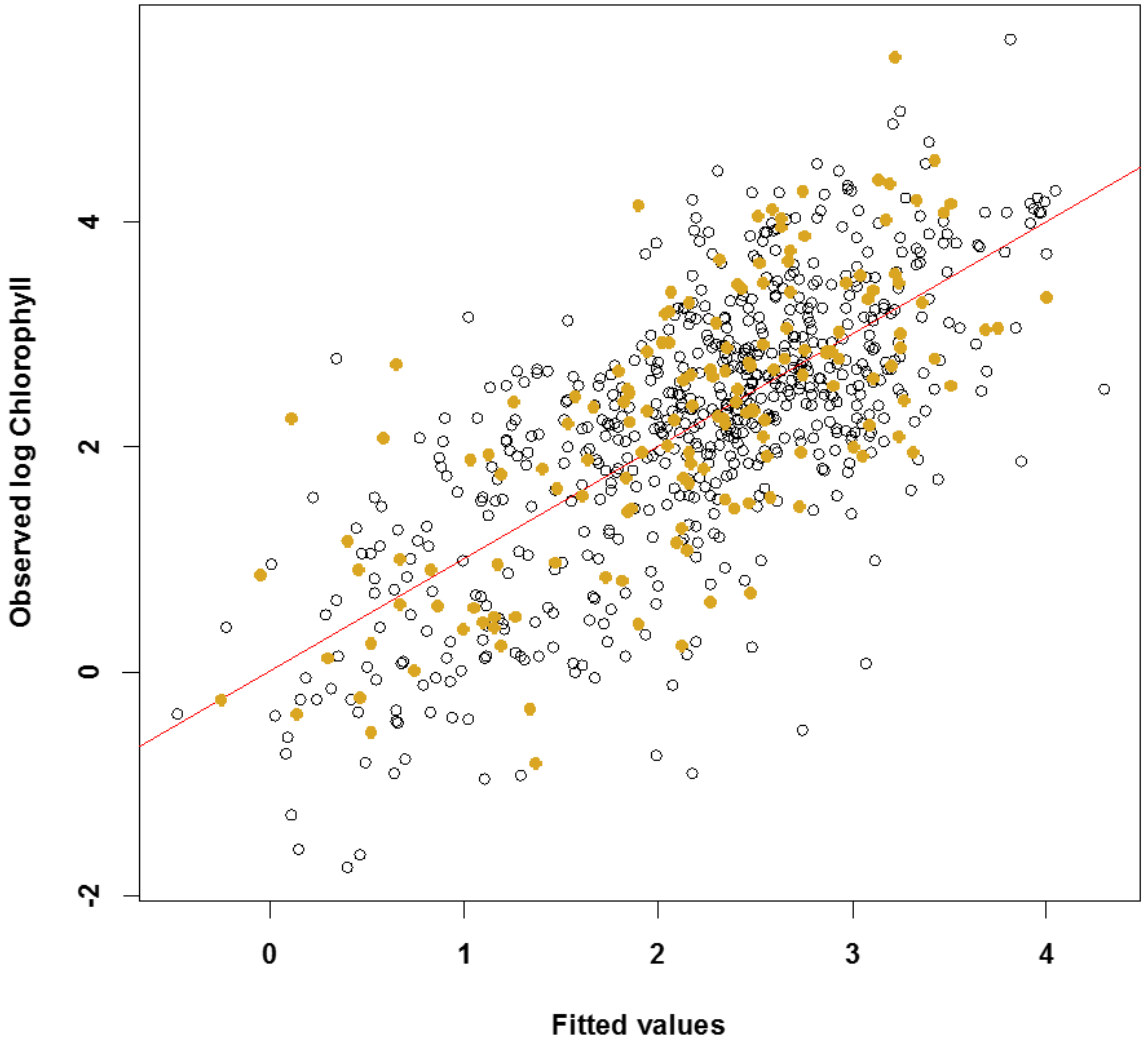




Lake sensitivity factors

Catchment factors

Global Model - Prediction



Dataset split into 80% training set and 20% test set to see how well the model (open circles) predicts 'new data' (yellow circles)

Results – Lake Types

Lake Types				Model coefficients											
Region	Elevation	Depth	Residence Time	Longitude	Latitude	Elevation	Lake Area	Mean Depth	Temperature	Rainfall	Annual NPP	% Agriculture	%Urban	DF	Adj. R^5
All Lakes					0.005	-0.0002	-0.115	-0.383	0.011	-0.006	0.328	0.005	0.021	781	0.49
					***	***	***	***	*	***	***	***			
All	<500 m			0.002	0.007		-0.118	-0.359	0.020	-0.006	0.431	0.004	0.038	506	0.42
				**	***		***	***	**	***	***	*	*		
All	<500 m	Shallow		0.002	0.005		-0.269			-0.004	0.323		0.038	201	0.31
				**	*		***			**	**		*		
All	<500 m	Deep		0.002	0.006		-0.053	-0.541	0.023	-0.008	0.468	0.004	0.049	297	0.42
				*	**			***	**	***	***		*		
All	<500 m		Short		0.003	-0.001	-0.089	-0.166		-0.006	0.344		0.070	199	0.28
						**	*	**		***	**		**		
All	<500 m		Long	0.002	0.006		-0.113	-0.417	0.023	-0.007	0.326	0.005	0.036	297	0.50
				**	**		**	***	*	***	**	*	.		

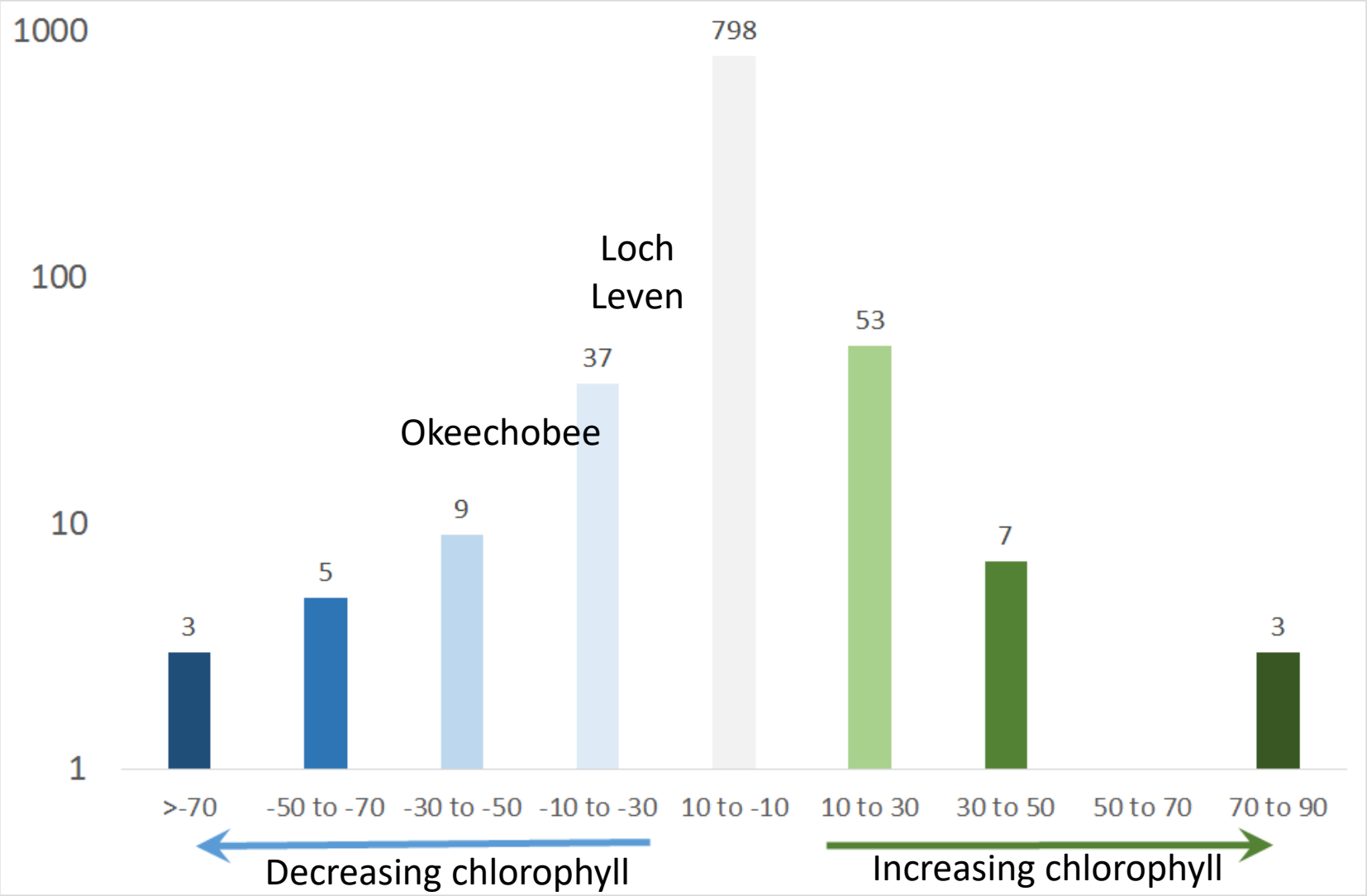
Consistency in effects

- Increase Chl-a: Longitude, Latitude, Temperature, **NPP**, % agricultural land, % Urban land
- Decrease Chl-a: Elevation, Area, Depth, **Rainfall**

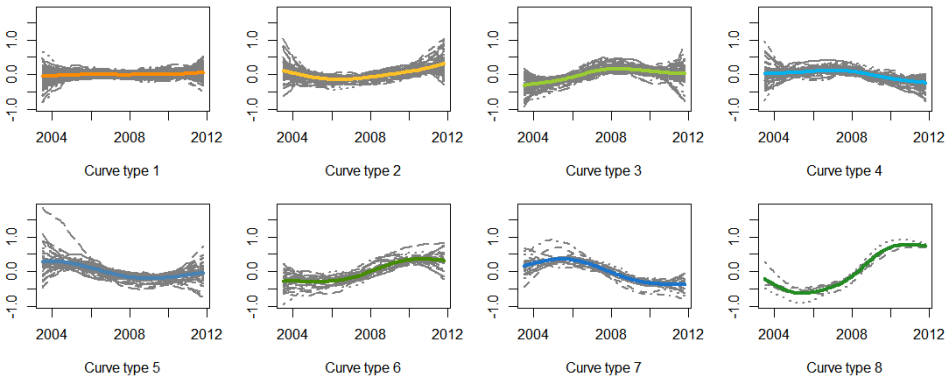
- **Temperature** has greater influence in deep and long residence time lakes
- **% Urban land** has greater influence in short residence time lakes

Chl-a trends

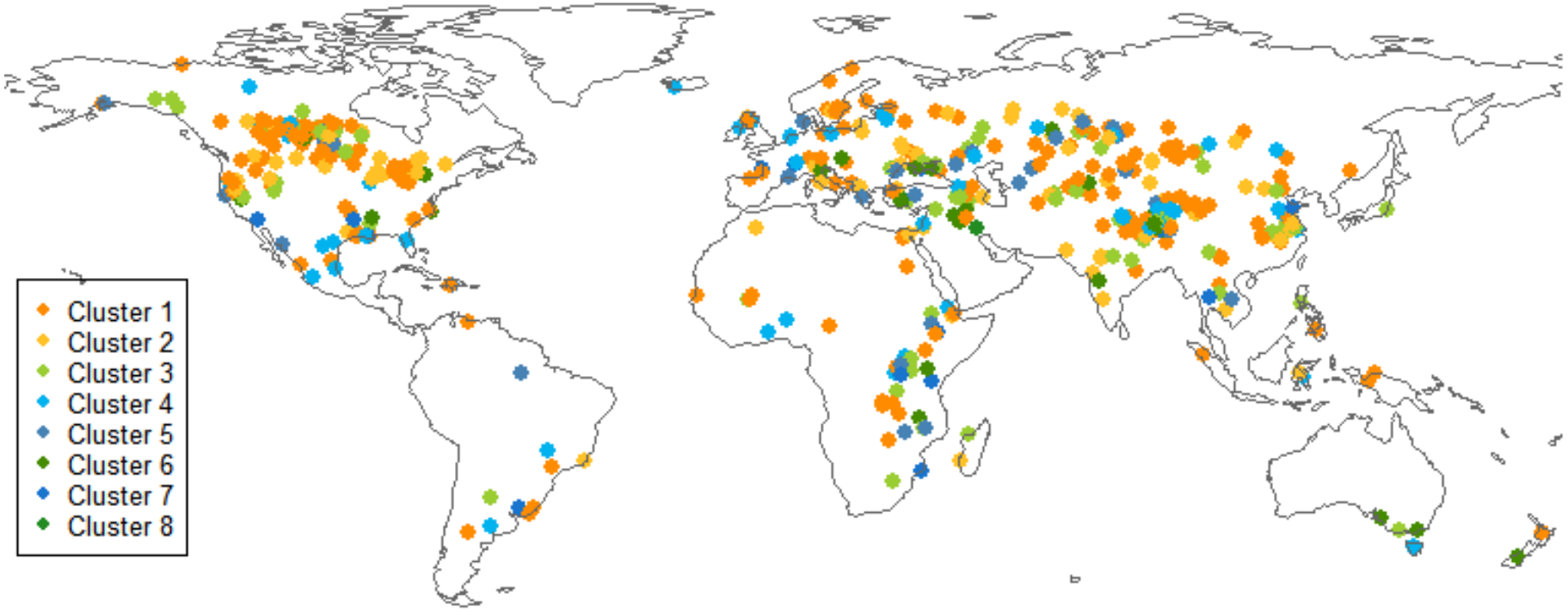
- Jul 2003-Apr 2006 vs Apr 2009-Jan 2012
- Lakes generally showing little change



Chl-a trends – non-monotonic



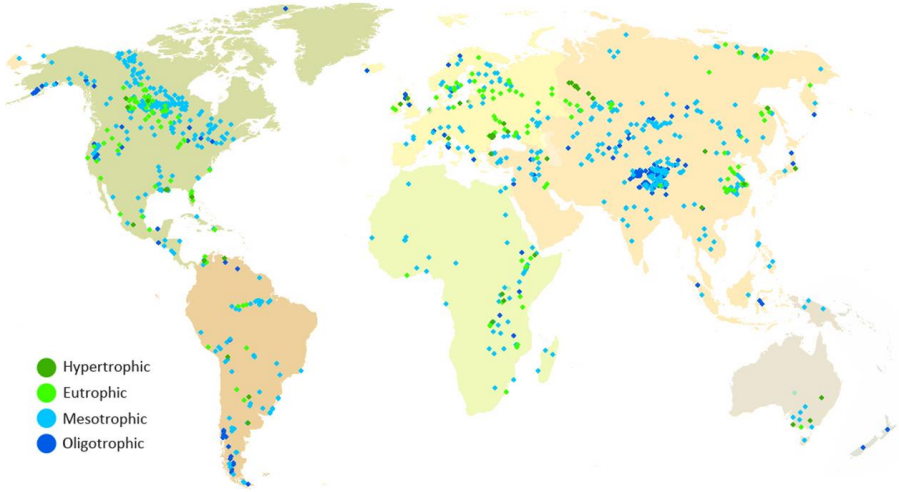
Smoothed Chl-a trend signals and cluster mean curves

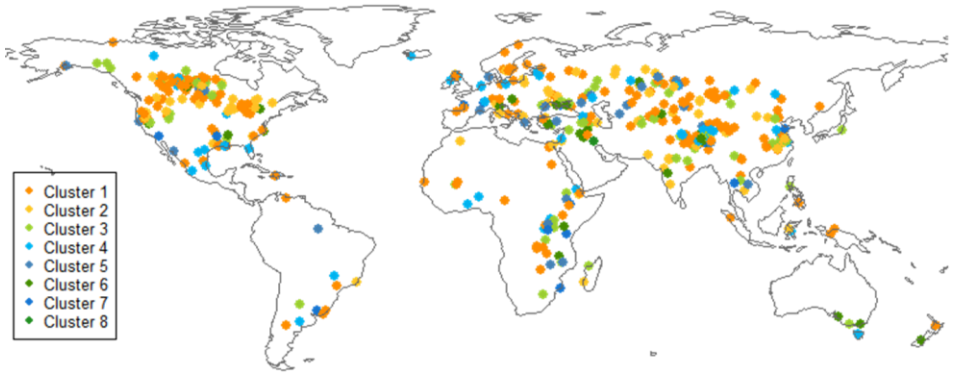


little change
generally decreasing
generally increasing

Key Messages

- Inter-disciplinary teamwork essential (EO, stats, GIS, ecology)
- EO is now delivering valuable optically-tuned data products that help us understand status and trends of global water quality
- Lakes differ in their sensitivity to drivers due to lake and catchment properties
- Consistent effects of climate drivers indicate global water quality will deteriorate with climate change





Thank you

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