



Environmental stress and relative sea level rise in river delta systems

Zachary Tessler
Charles Vörösmarty
CUNY Environmental
CrossRoads Initiative

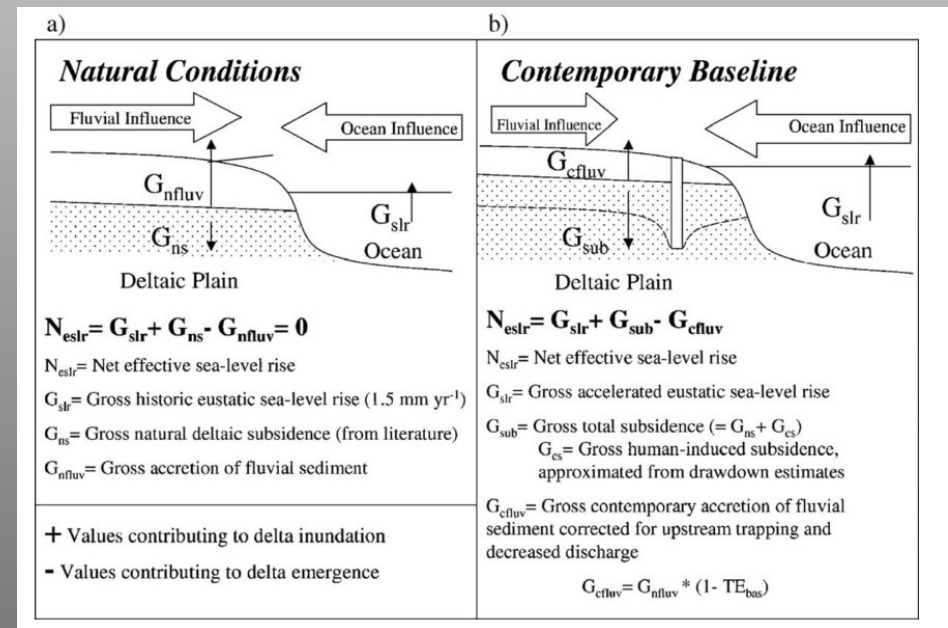
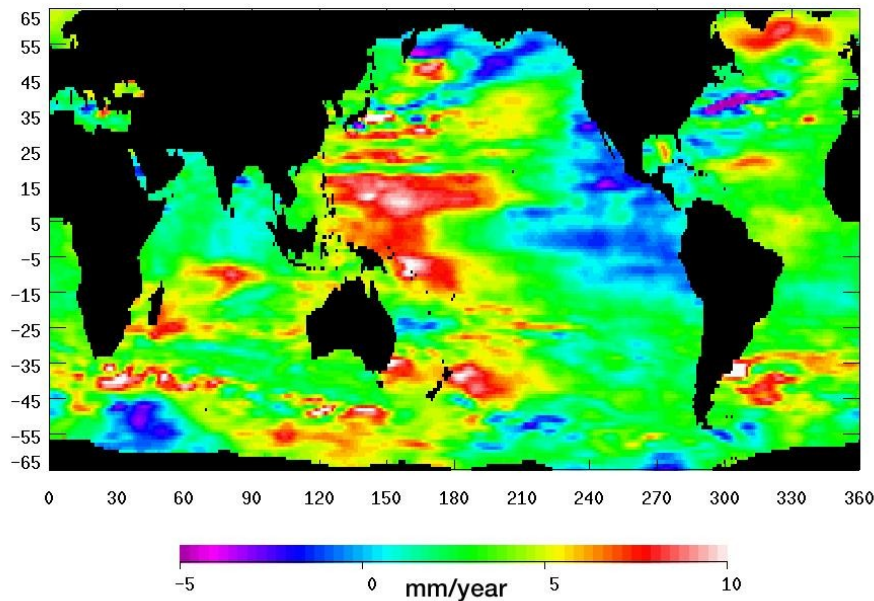
with several collaborators:
Kyle McDonald, Ronny
Schroeder, Michael
Grossberg, Irina Gladkova,
Hannah Aizenman, Balazs
Fekete, Hansong Tang

(Relative) Sea level rise

With a changing climate:

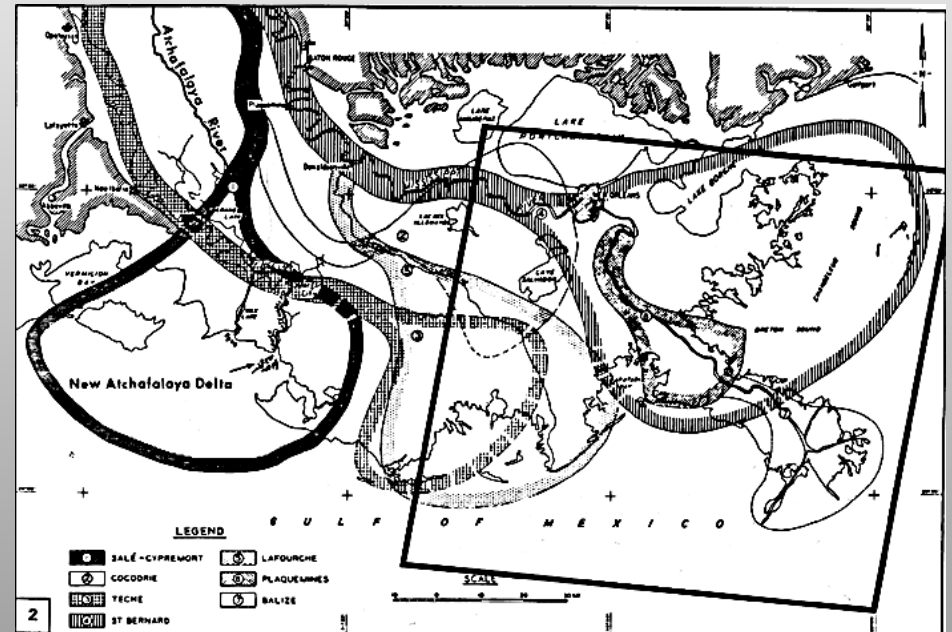
- Higher sea level (though spatially variable)
- An accelerated hydrological cycle
- On deltas, this is not all coastal communities must grapple with

Trend of Sea Level Change (1993-2008)



Deltas as a “natural” system

Deltas exist at the balance between sediment deposition, erosion, and sea level change

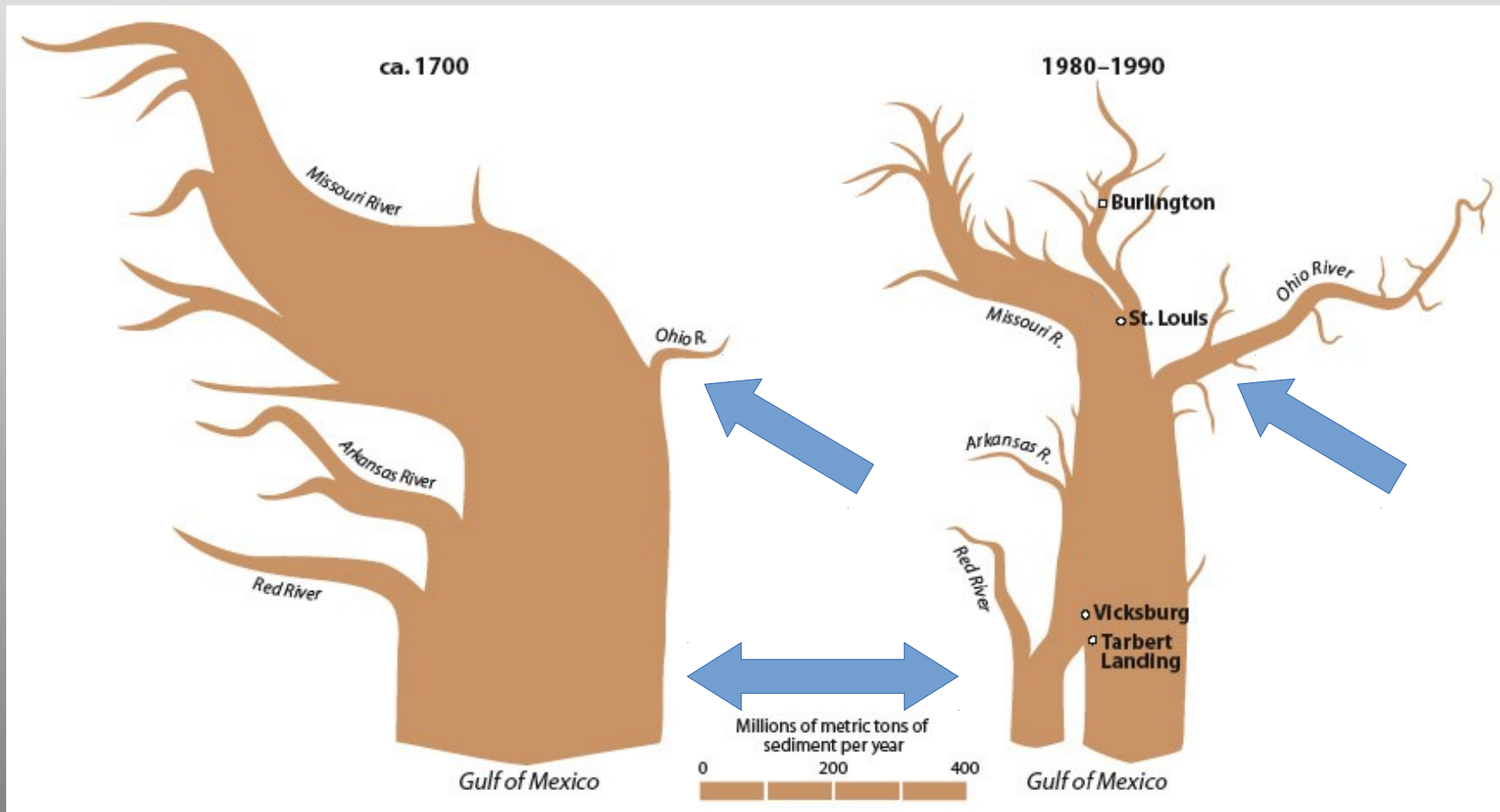


But are home to nearly half a billion people globally

- Cairo, Alexandria (Nile)
- Hong Kong, Guangzhou, Shenzhen (Pearl)
- Shanghai (Yangtze)
- Dhaka (Ganges)
- Bangkok (Chao Phraya)
- New Orleans (Mississippi)

Deltas as a human system

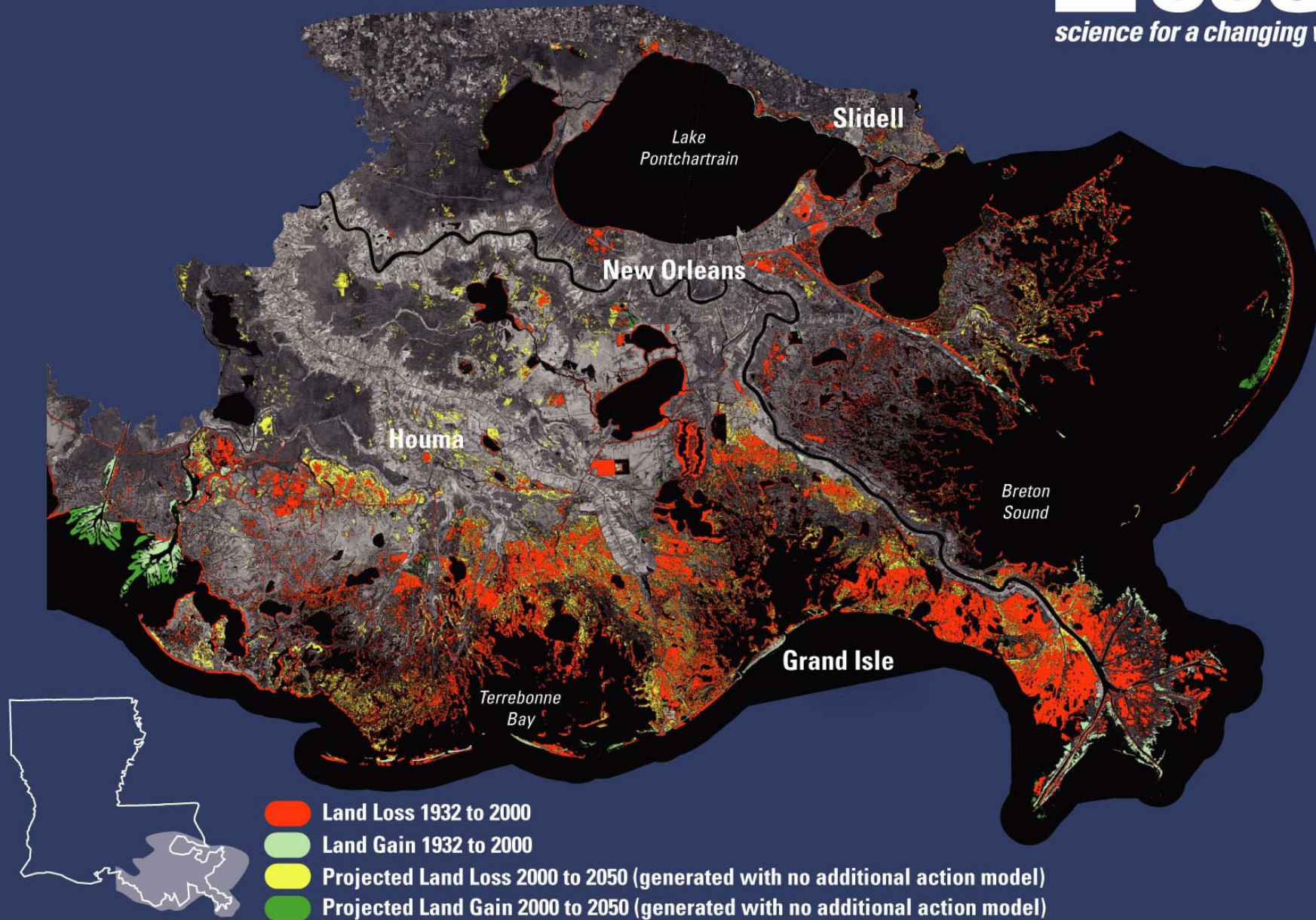
Current sediment input to Mississippi Delta is 50% of 1700 level



(Meade, 1995 USGS Circular 1133, fig 6A)

Deltas as a human system

Coastal Louisiana Land Loss



Delta Environmental Setting

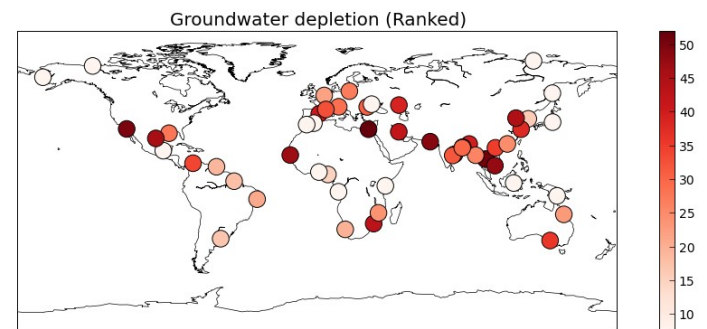
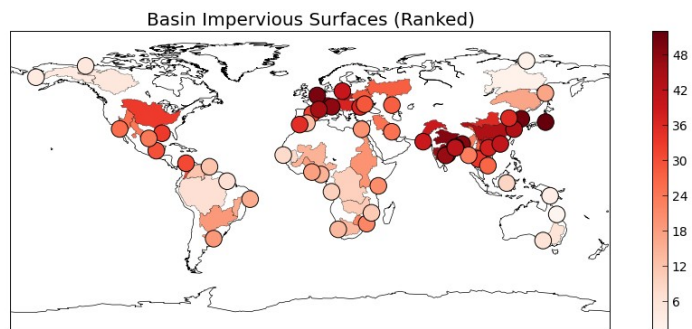
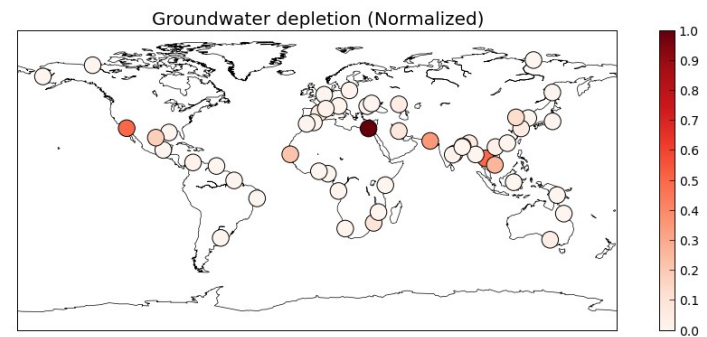
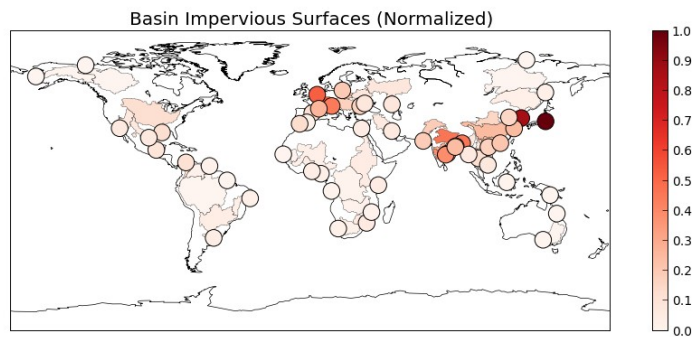
Characterize deltas by their “environmental setting”. Full risk analysis will also include “geophysical setting”: storm tracks, local sea level rise, tidal amplitude, ...

- Upstream Basin
 - Population Density (GRUMP)
 - Reservoir Volume Density (GrAND)
 - Impervious Surface (DMSP Nightlights)
- Local Delta
 - Population Density (GRUMP)
 - Impervious Surface (DMSP Nightlights)
 - Groundwater Depletion (WBM hydrological model)
 - Cropland Fraction (MODIS Landcover)
- GDP

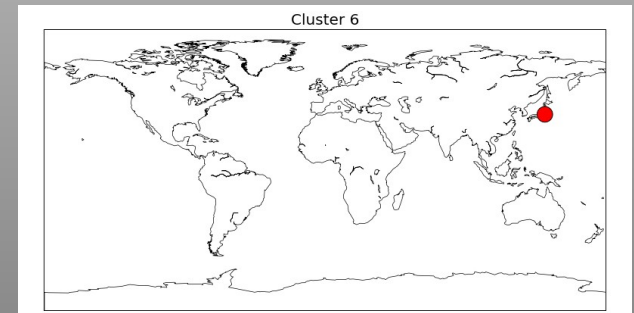
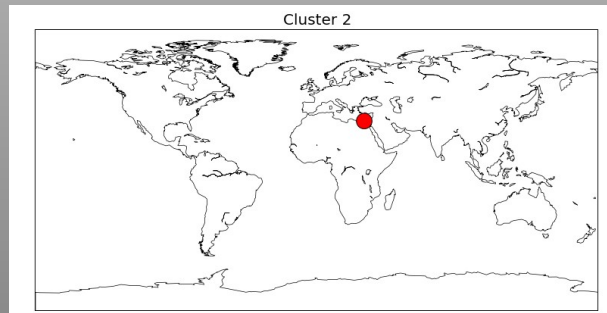
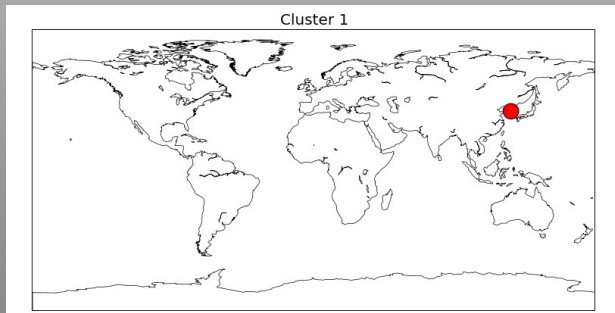
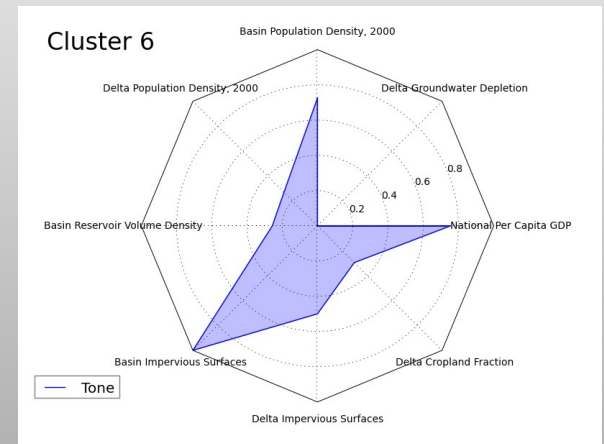
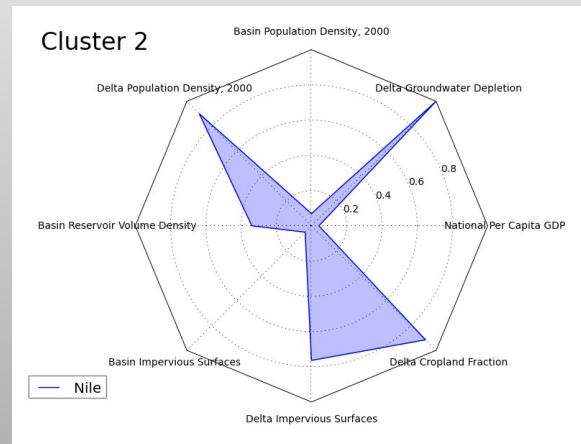
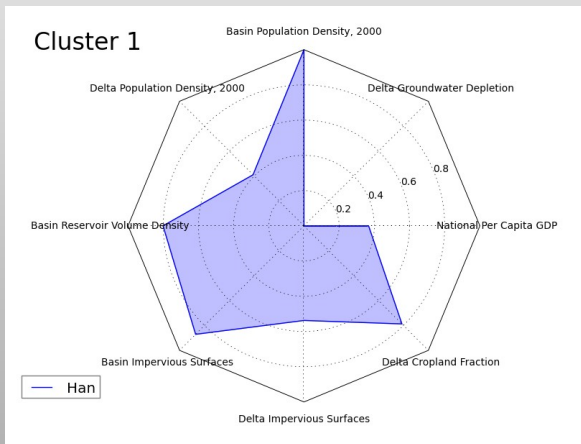
Sample stressor maps

Upstream basin – impervious surface fraction

Delta groundwater depletion



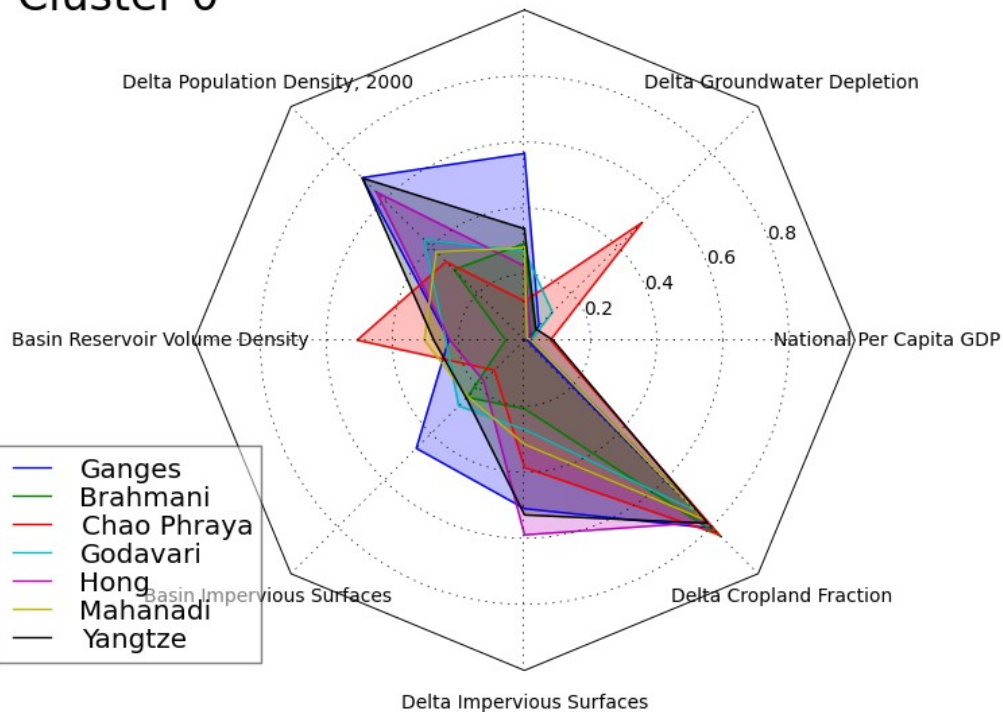
“Unique” deltas



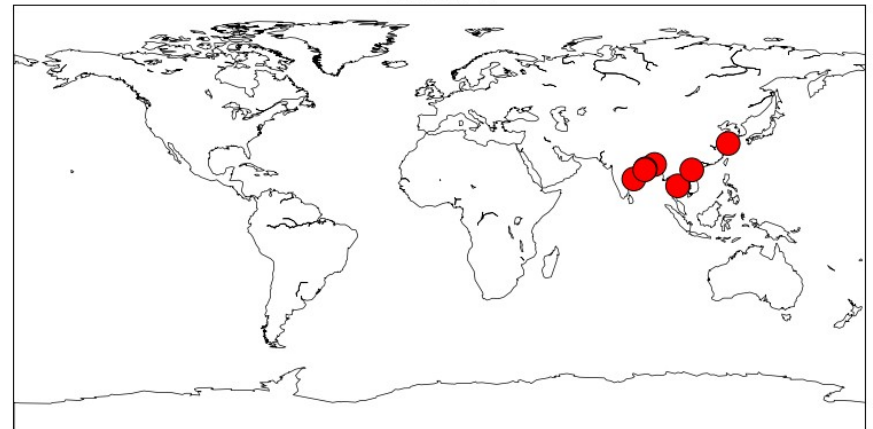
Populated, agricultural deltas, less-developed upstream

Cluster 0

Basin Population Density, 2000



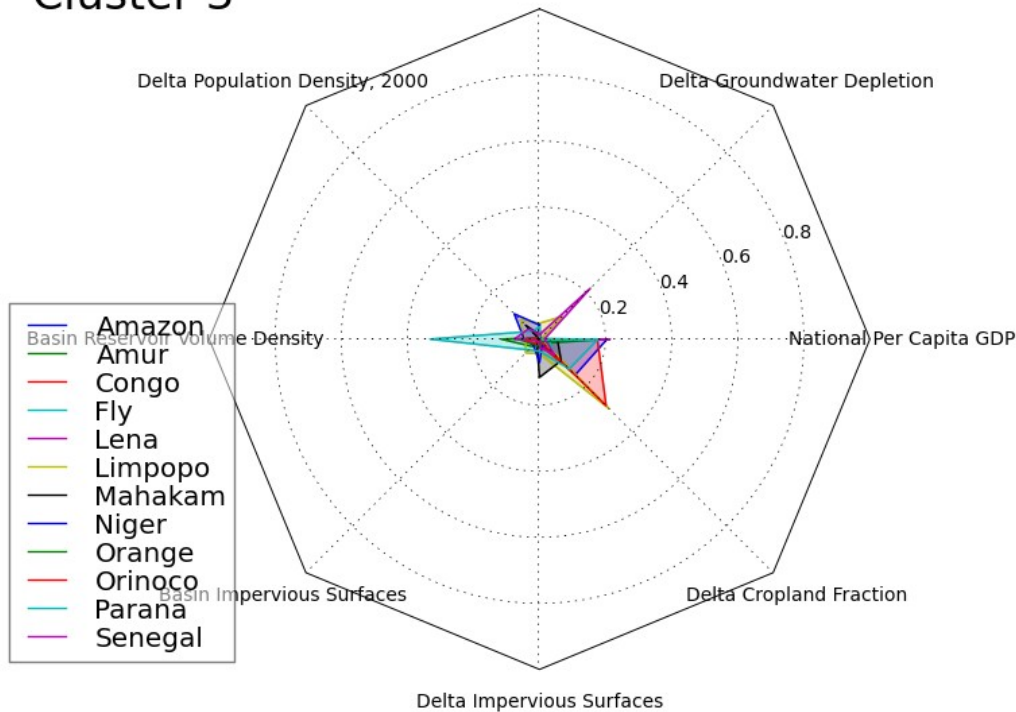
Cluster 0



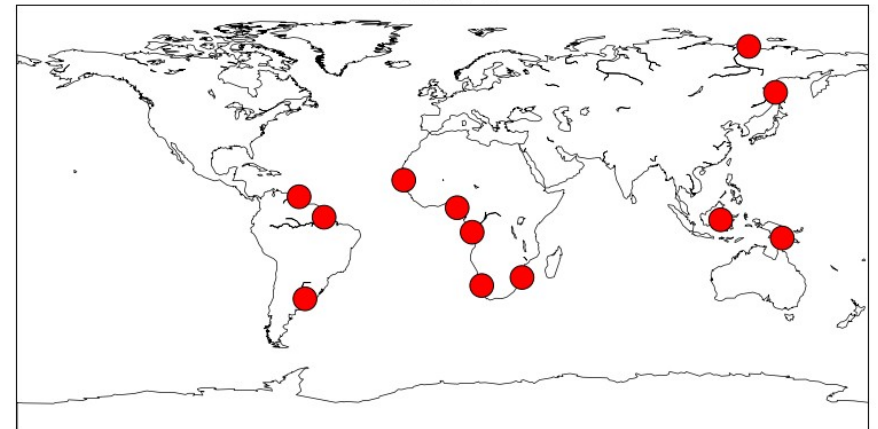
Low population, low development deltas

Cluster 3

Basin Population Density, 2000



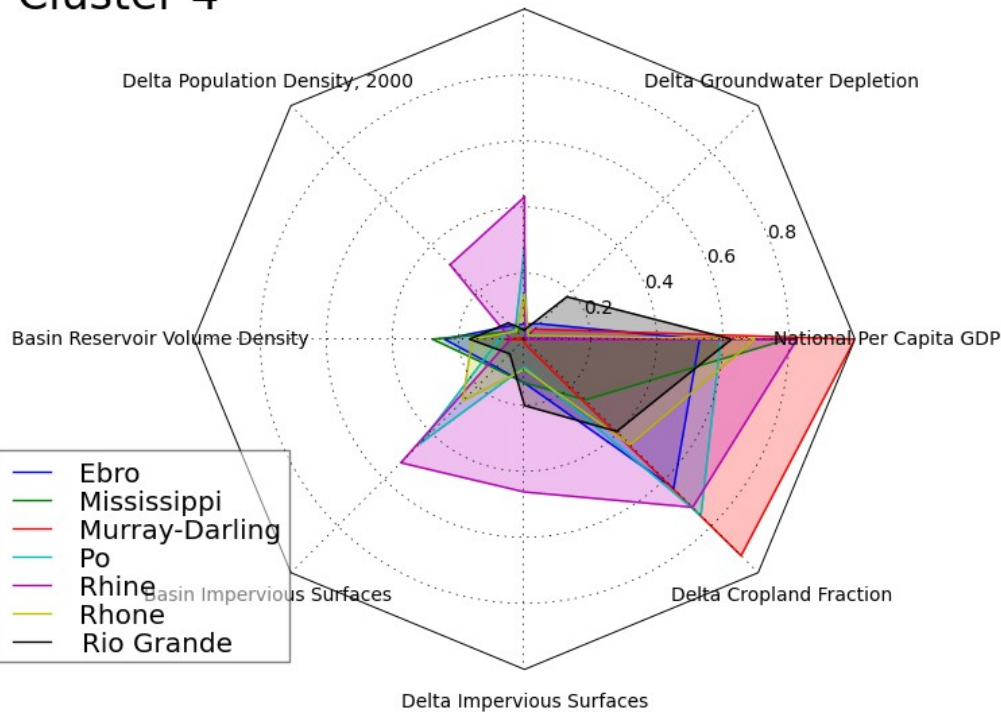
Cluster 3



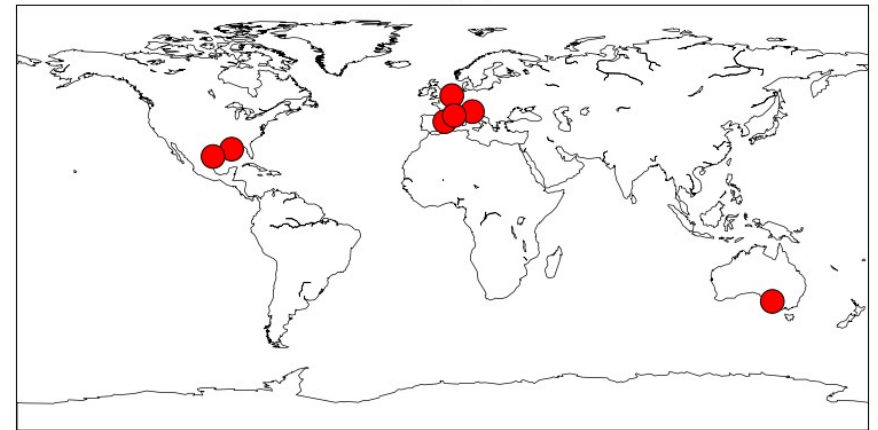
High GDP, agricultural deltas

Cluster 4

Basin Population Density, 2000



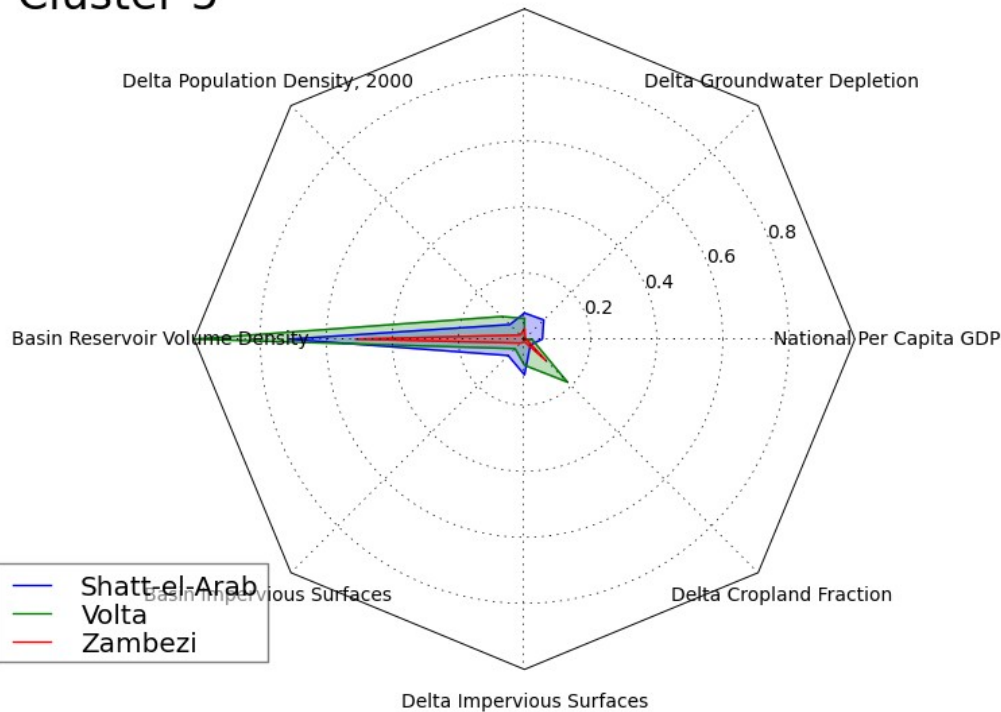
Cluster 4



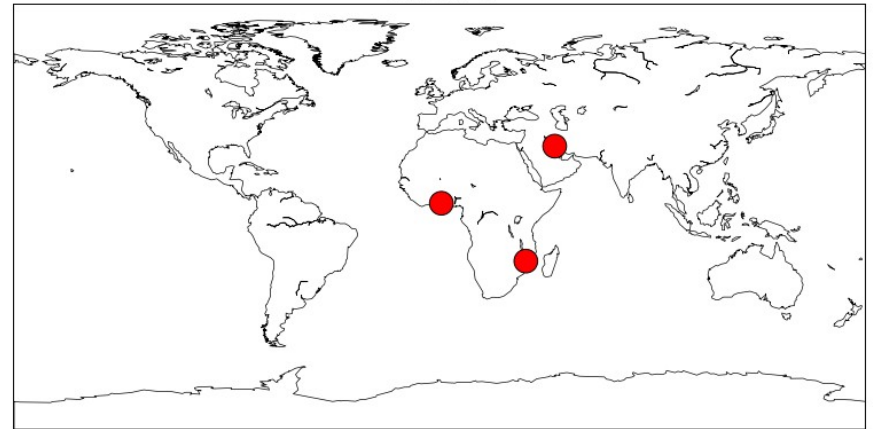
(Relatively) large dam impoundments

Cluster 5

Basin Population Density, 2000



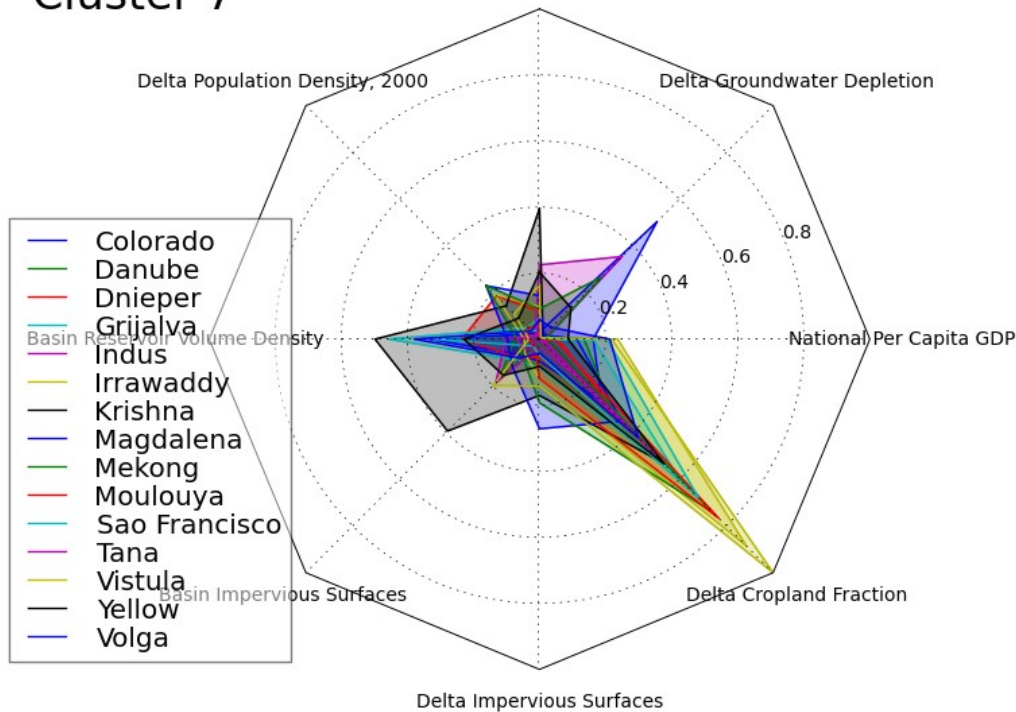
Cluster 5



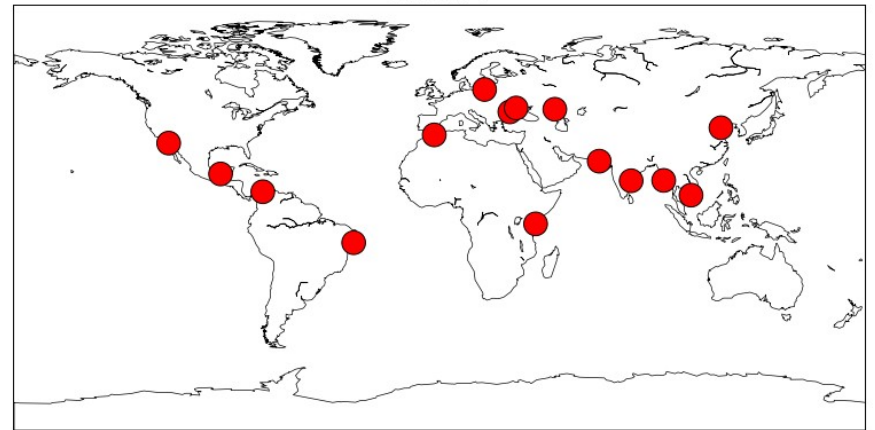
Less populous, low GDP, agricultural deltas

Cluster 7

Basin Population Density, 2000



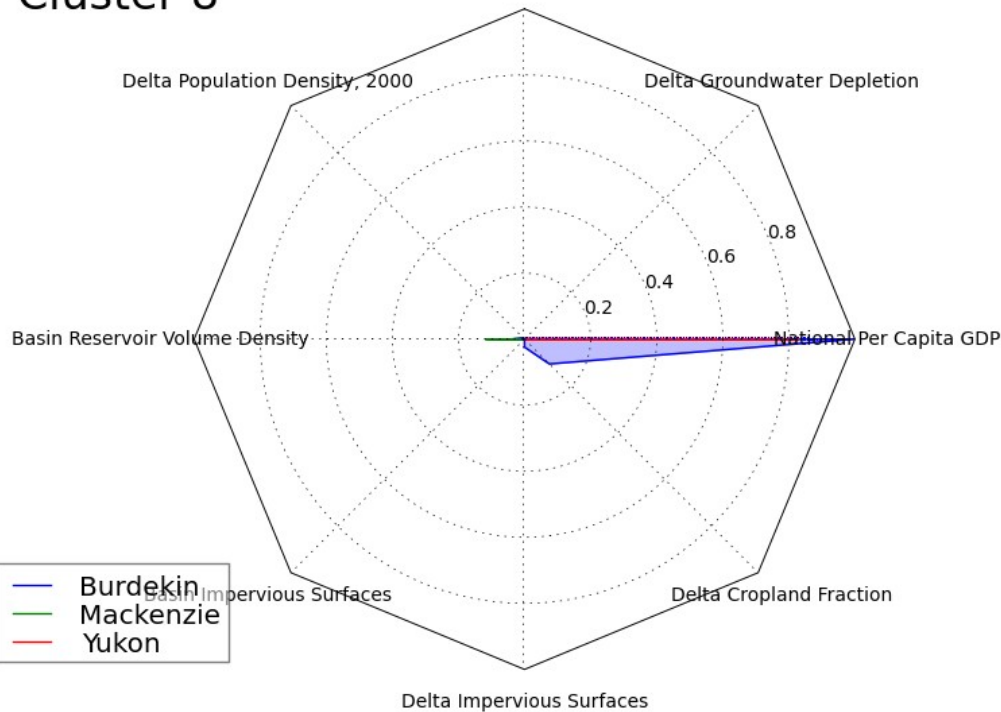
Cluster 7



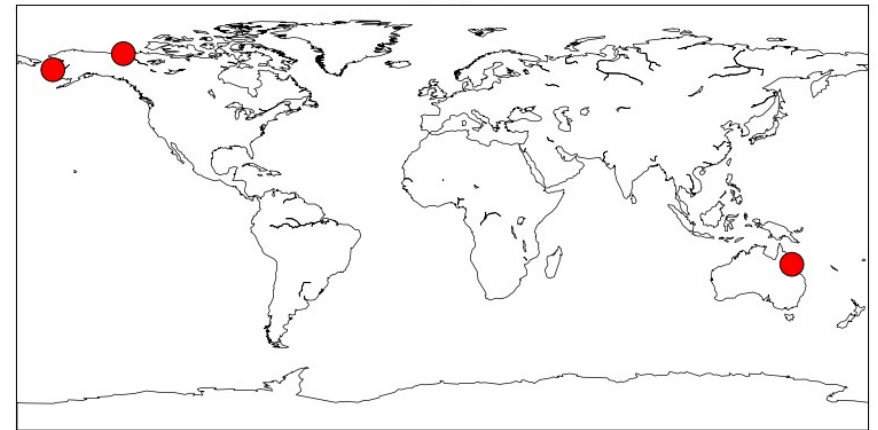
High GDP, low population deltas

Cluster 8

Basin Population Density, 2000



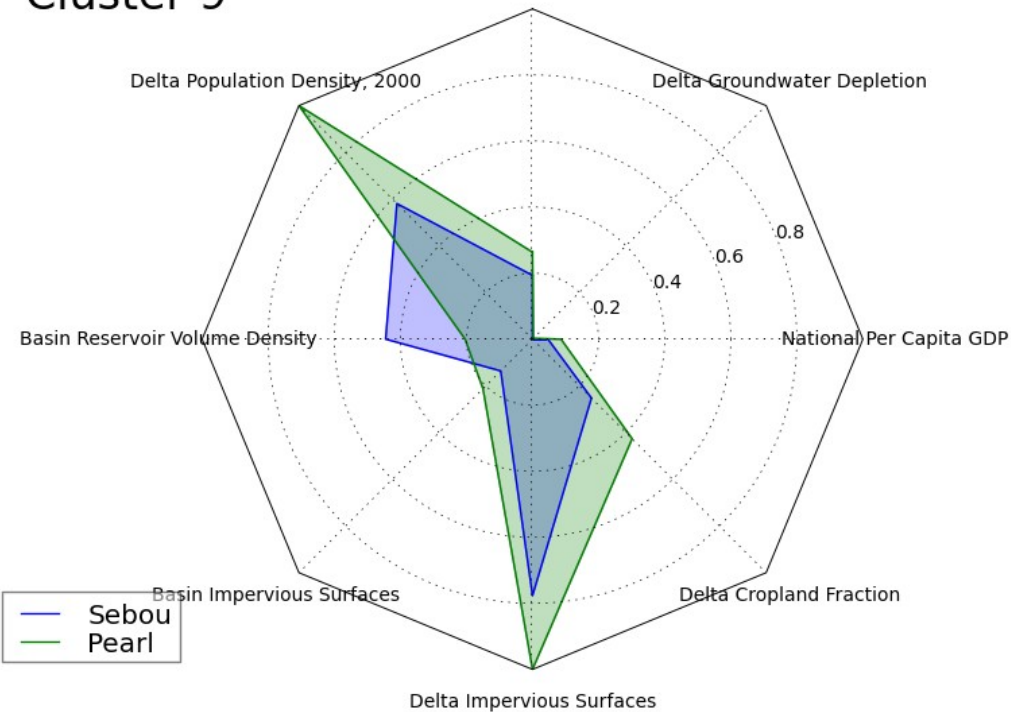
Cluster 8



Highly urbanized deltas

Cluster 9

Basin Population Density, 2000



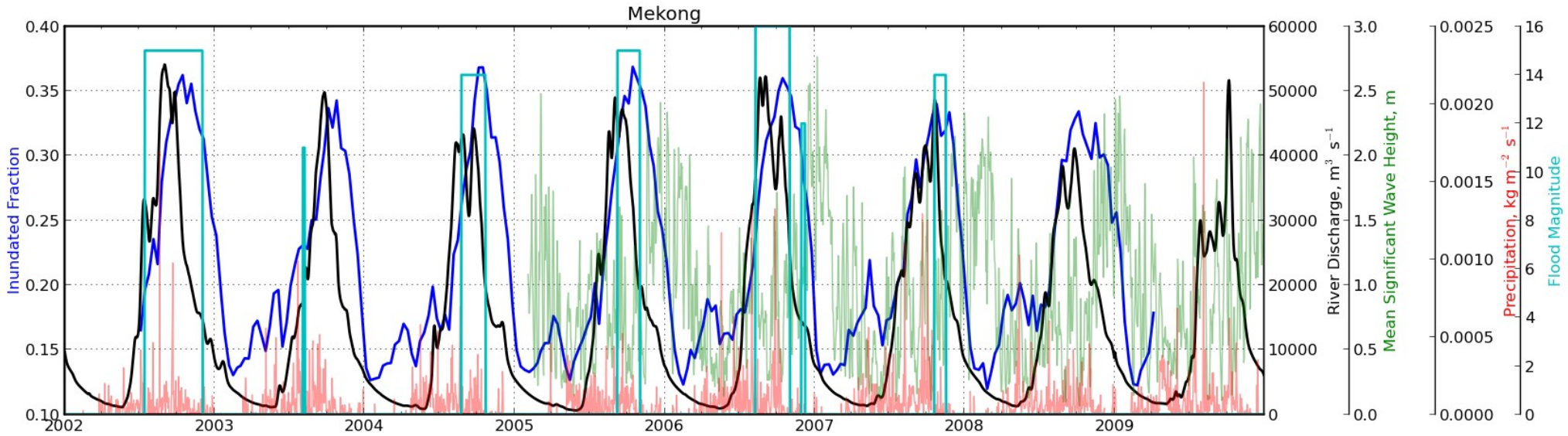
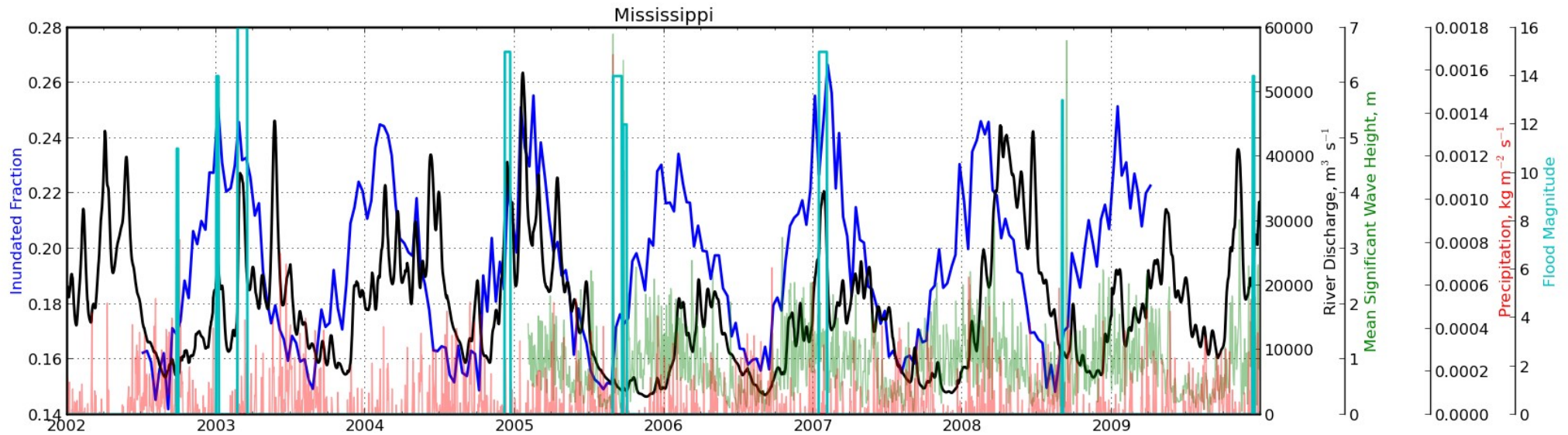
Cluster 9



Delta environmental typology

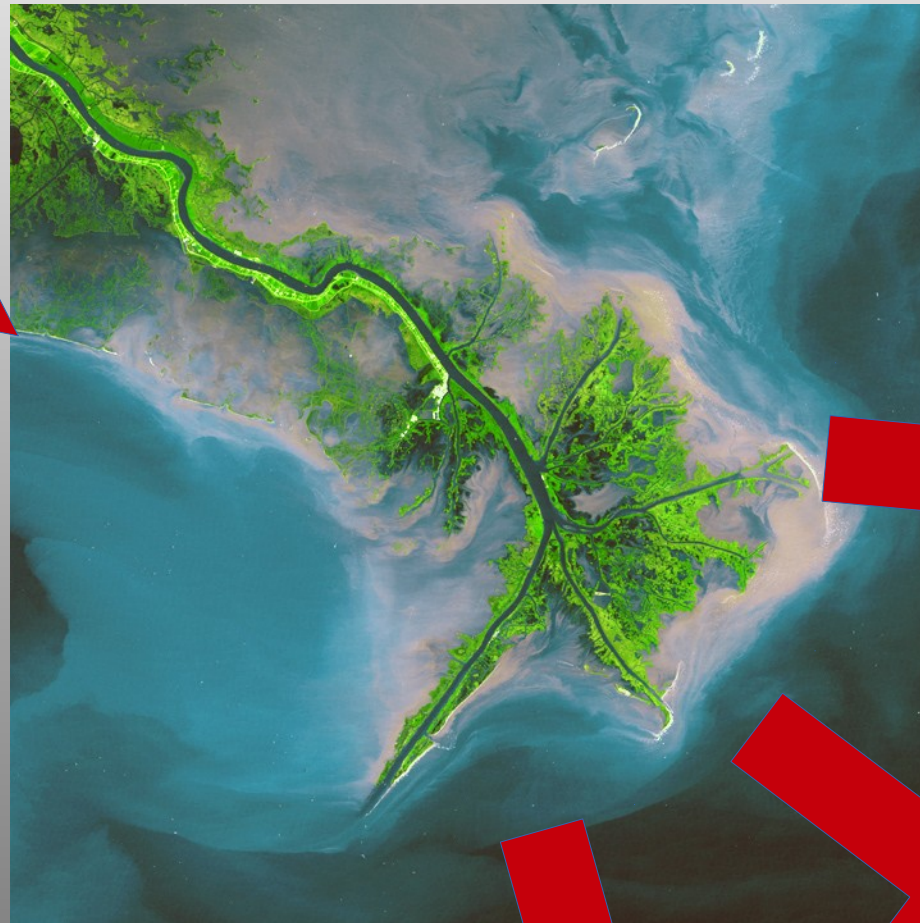
- Are these clusters experiencing similar relative sea level rise?
- Does surface inundation respond similarly to high discharge events, coastal storms?
- Are there differences in deltas' “functional health” within and between clusters? Can we observe these?

Inundation response



Delta-as-a-filter

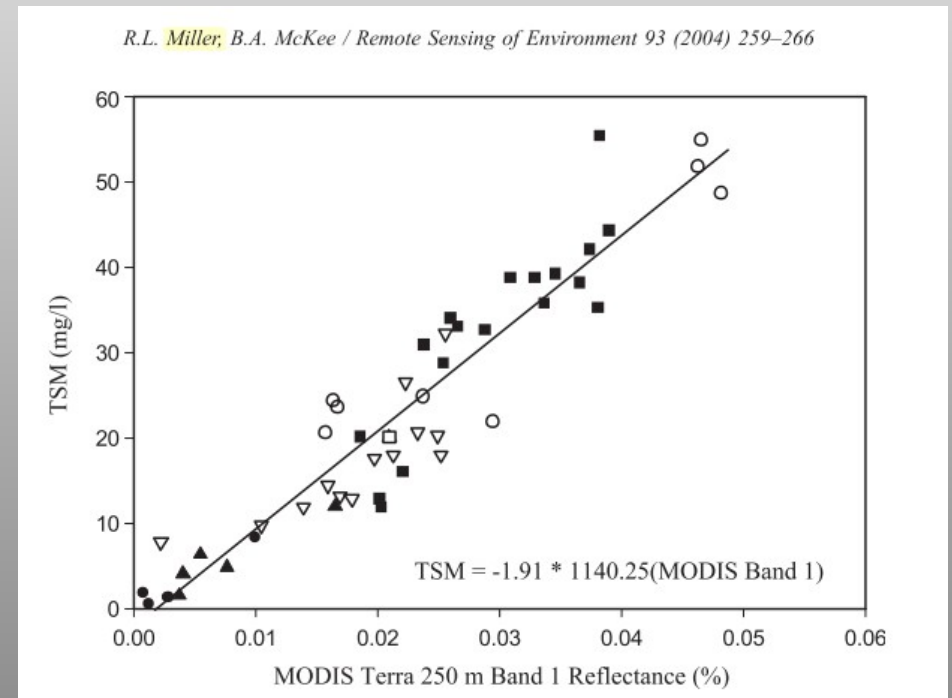
River inputs



Outputs to
coastal ocean

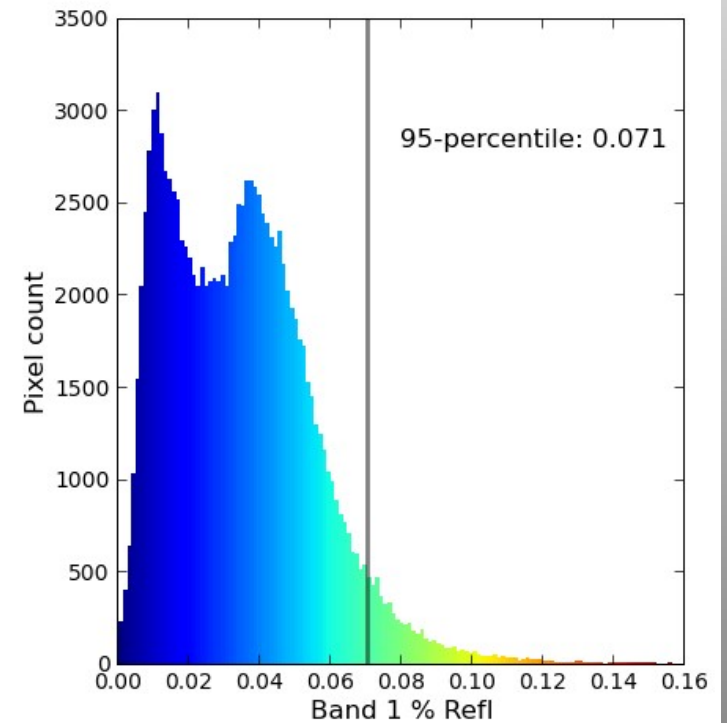
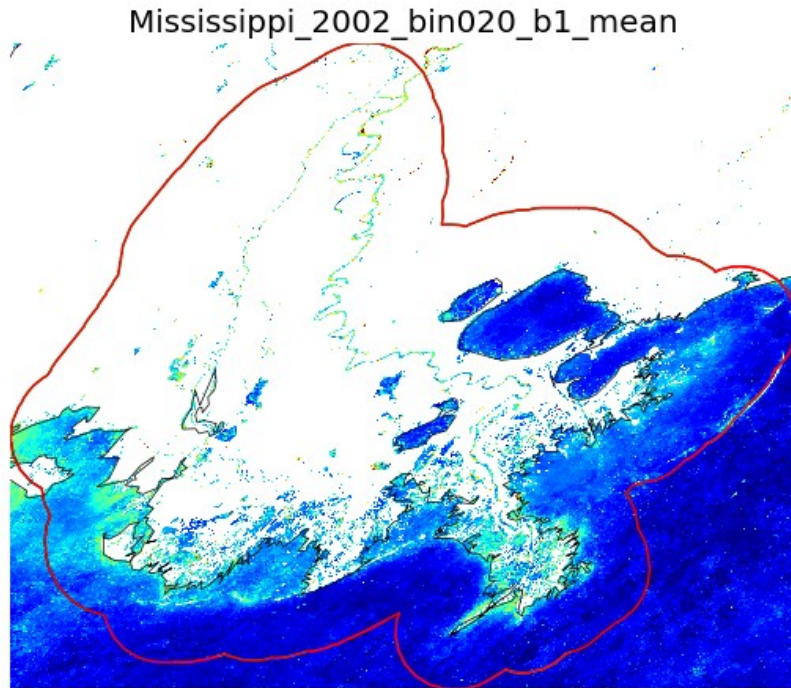
River Plume Sediment From MODIS

- Question: How does a (healthy, disturbed, developed...) delta filter the sediment flux between the river basin and the nearshore environment?
- We can model the fluvial discharge, sediment flux entering the delta
- Observe offshore sediment from remote sensing
- MODIS 250m Band 1 reflectance shows relationship with Total Suspended Matter



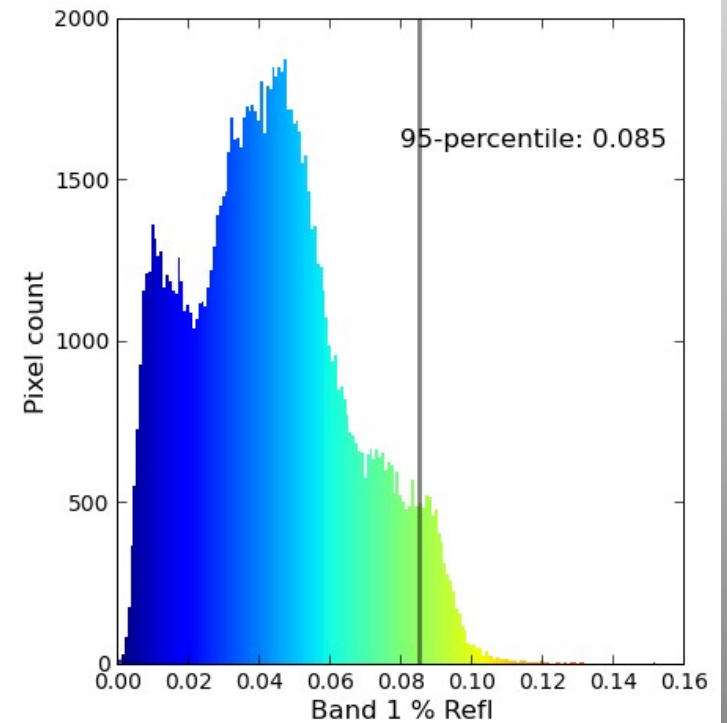
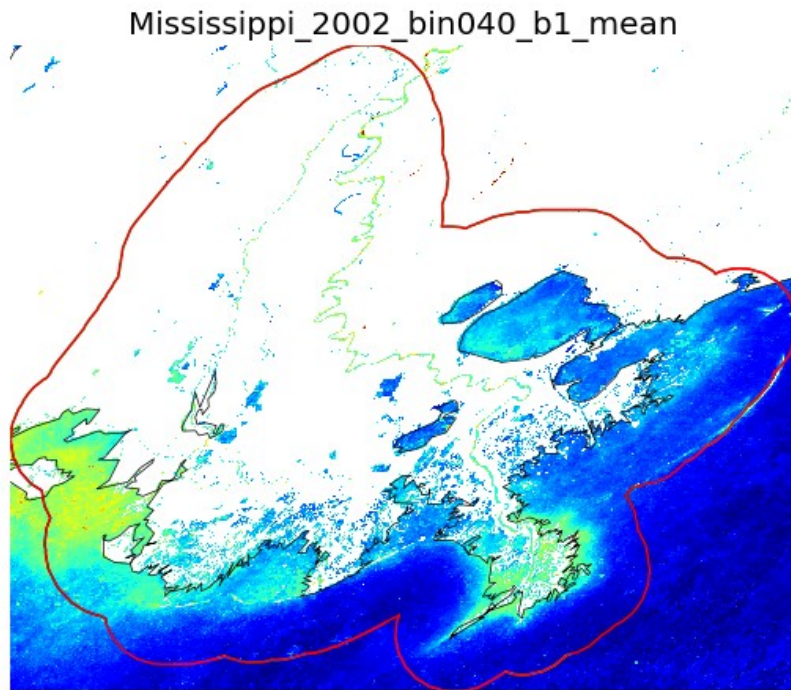
Mississippi, 2002

Low Discharge days (0-20 percentile)



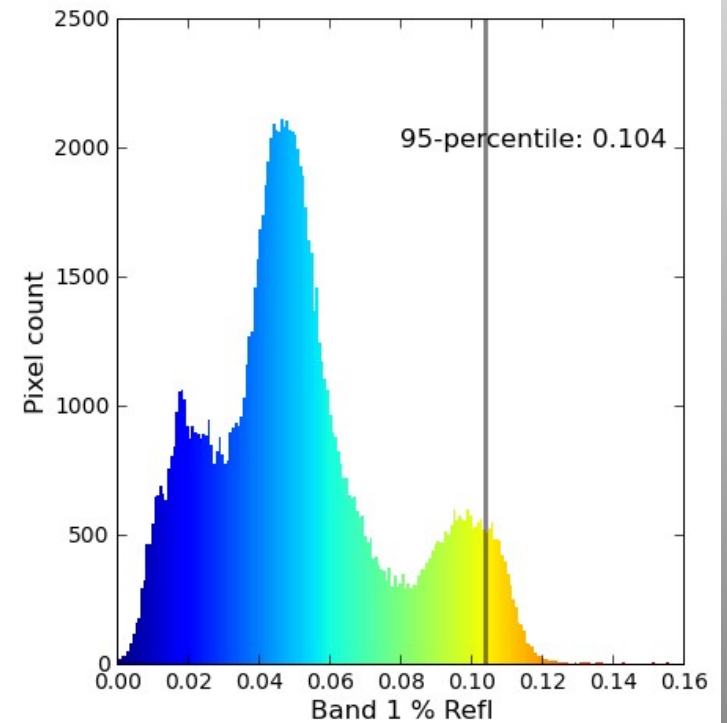
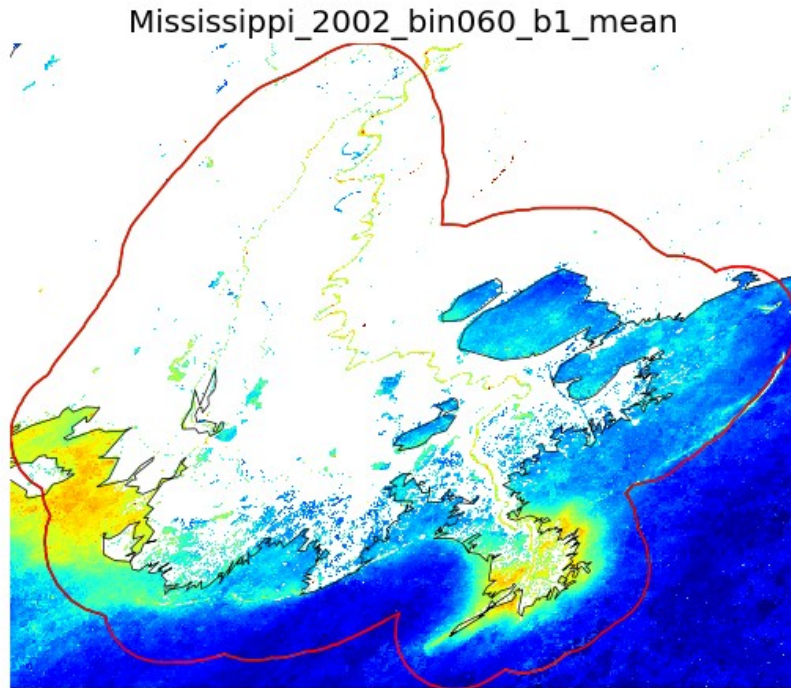
Mississippi, 2002

Low Discharge days (20-40 percentile)



Mississippi, 2002

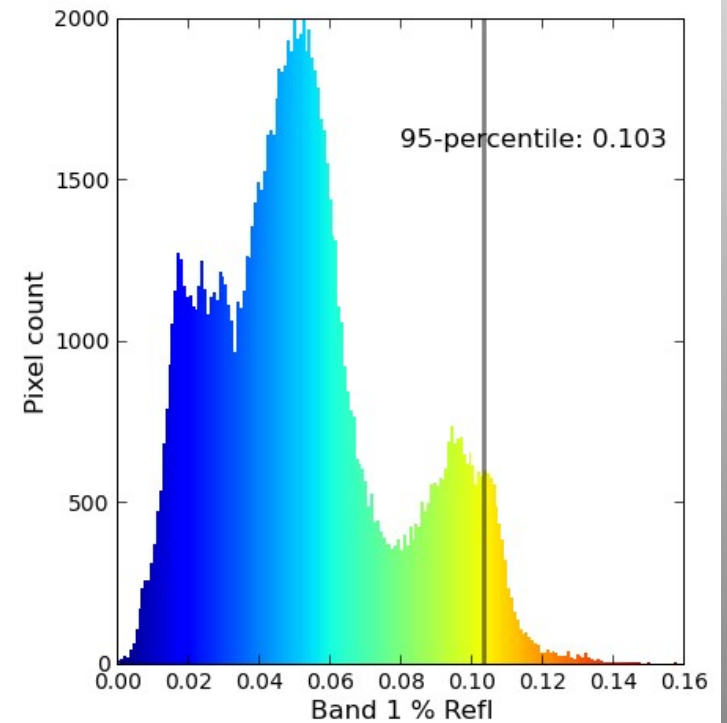
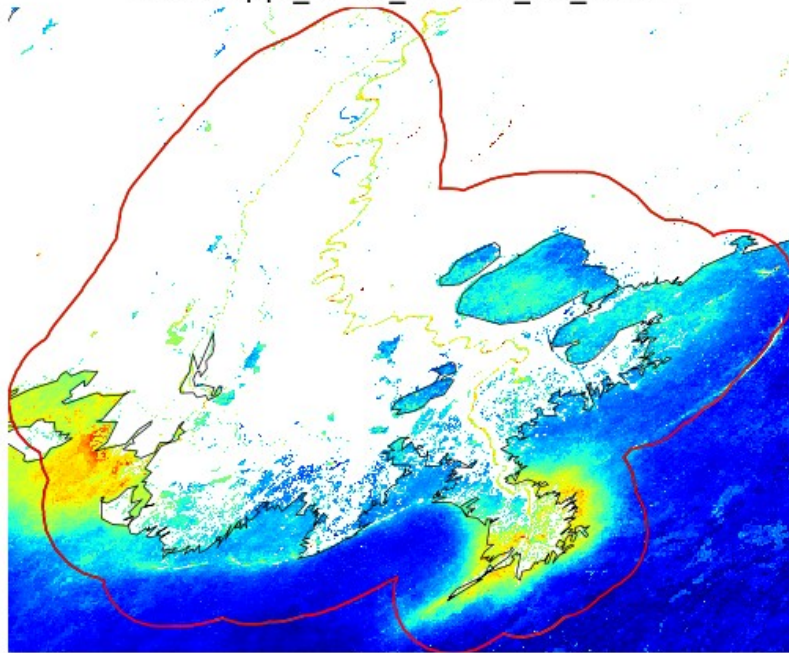
Mid Discharge days (40-60 percentile)



Mississippi, 2002

High Discharge days (60-80 percentile)

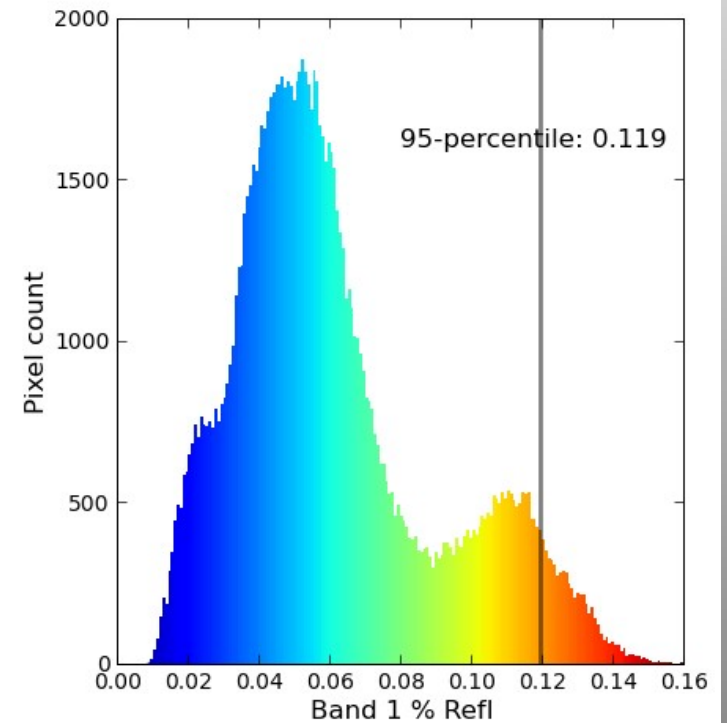
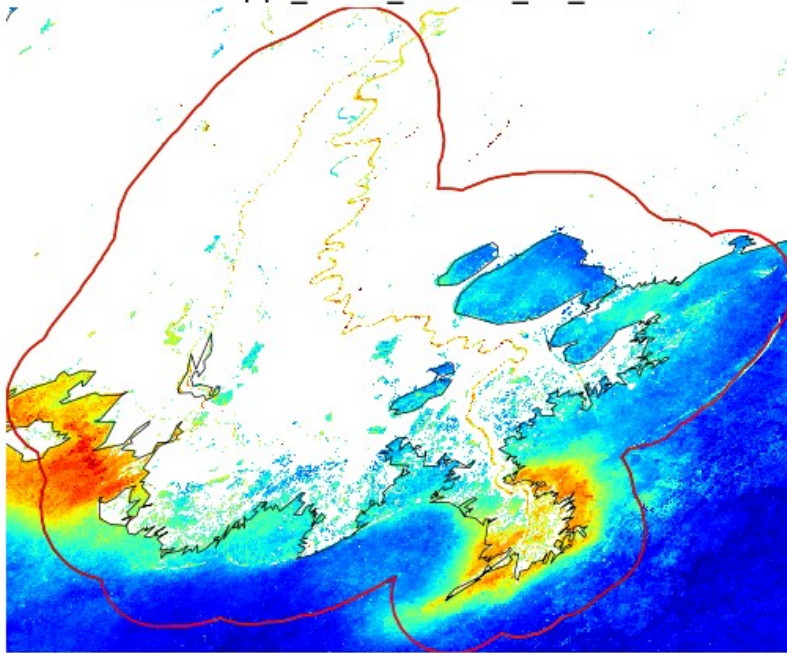
Mississippi_2002_bin080_b1_mean



Mississippi, 2002

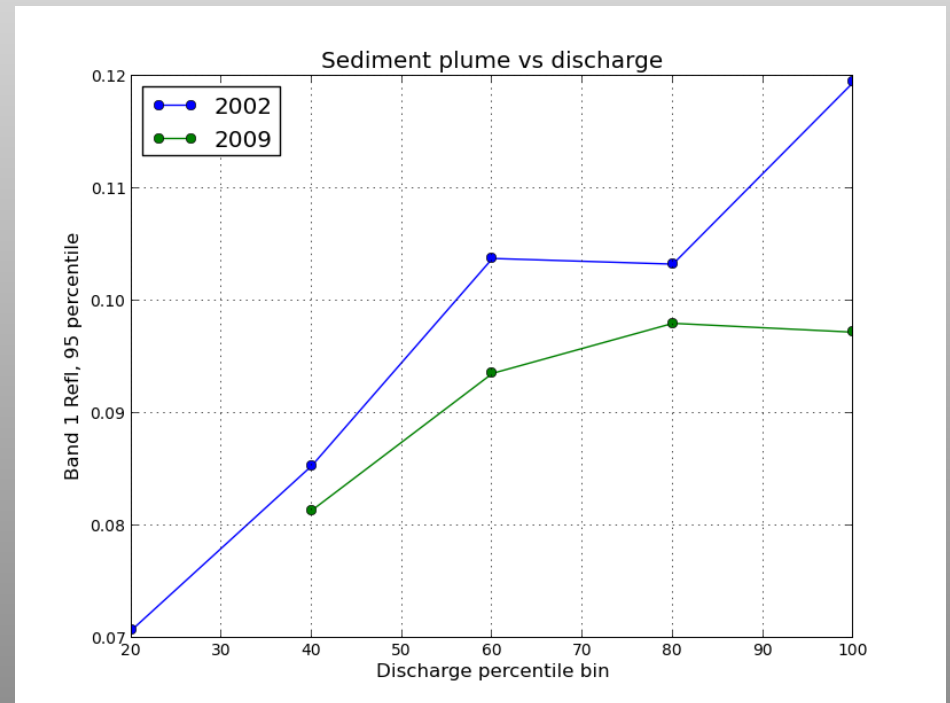
High Discharge days (80-100 percentile)

Mississippi_2002_bin100_b1_mean



Mississippi, 2002 vs 2009

- Early results, reduction in sediment plume
- Reduced sediment input? (Yes) Or increased sediment retention on the delta? (Possibly)
- Assumes sediment optical properties constant over this period, and that the surface plume is representative of the total sediment



Summary

- New global delta environmental typology
 - Working towards relationships with inundation, NDVI, other dynamic variables
- Developing methods for measuring change in delta filter function
 - Possible changes in Mississippi delta sediment export over past decade
 - Extending this to connect with the delta typology, sensing sediment export changes driven by environmental change