The role of SWOT in water cycle science

Dennis P. Lettenmaier
Department of Civil and Environmental Engineering
University of Washington

Ocean and Hydrology Applications Workshop

Lisbon

October 21, 2010

Outline of this talk

I. What are the science questions
II. Lakes, reservoirs, and other surface storage change
III. Rivers and river discharge
IV. Applications opportunities

I. What are the science questions?

River basin (or continental) water balance:

$$dS/dt = P - E - Q$$

where P = precipitation

E = evapotranspiration

Q = river discharge

S = total basin storage $= S_{sm} + S_{gw} + S_{si} + S_{sw}$

sm = soil moisture

gw = groundwater

si = snow and ice

sw = surface water

Arguably, the relevant science question is: *where is the water, how much of it is moving, and what controls that movement?*

SWOT hydrology objective (per draft Mission Science Document):

The primary science rationales for the development of SWOT are … to make high resolution, wide-swath altimetric measurements of the … elevation of water on land for making fundamental advances in the understanding of … the spatial and temporal distribution of the storage and discharge of water on land.

II. Storage change (lakes, wetlands, reservoirs, river channels)

Inferred global size distribution of lakes (from Downing et al., 2006)

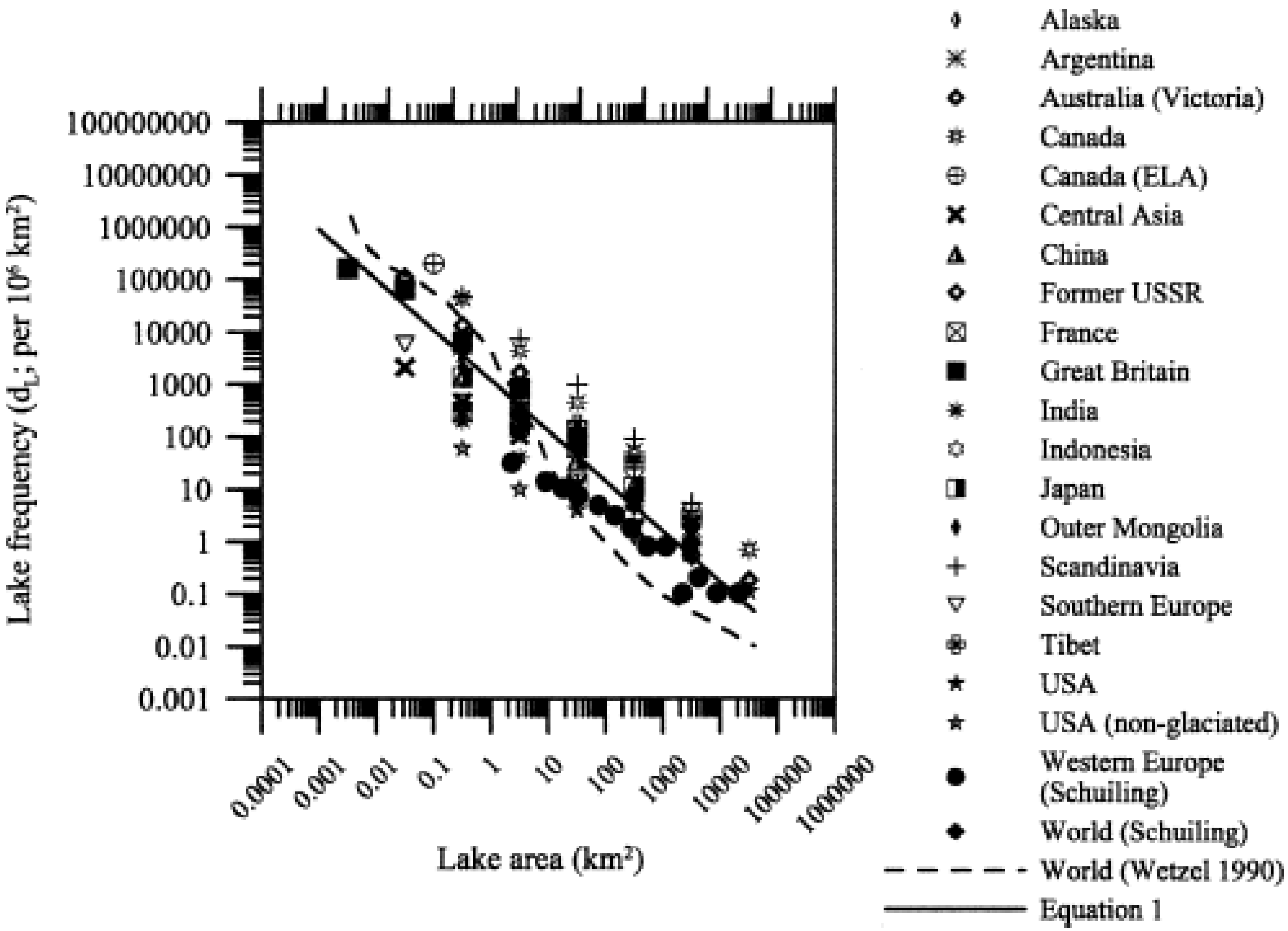


Fig. 1. Relationship between lake surface area and areal frequencies of different sized lakes. The filled circles and open squares indicate the frequencies of lake sizes digitized from Schuiling (1976). The dashed line represents the hypothesis advanced by Wetzel (1990), digitized from his fig. 5. All other data are from Meybeck (1995).

Predicted density of lakes from 1 – 10 km^2 surface area (from Downing et al, 2006)

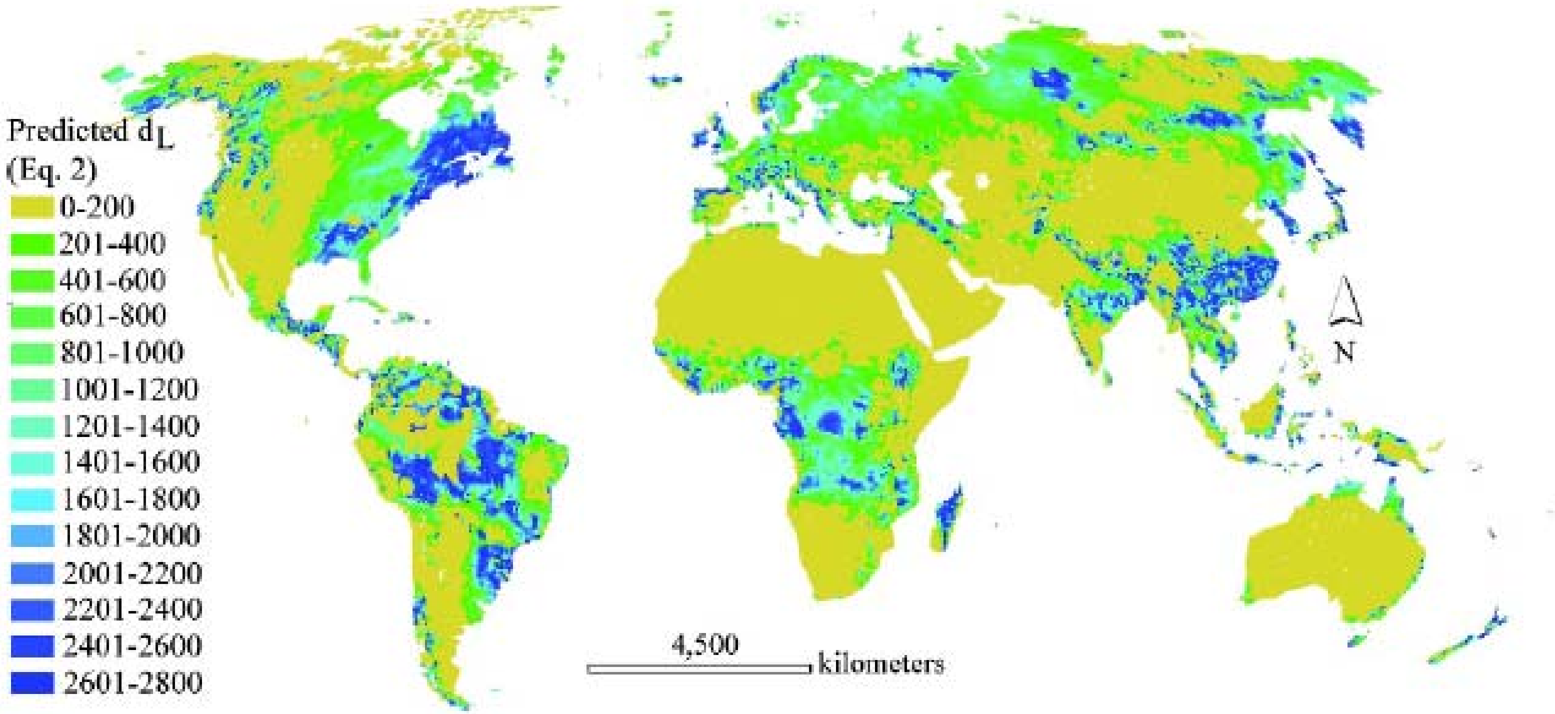
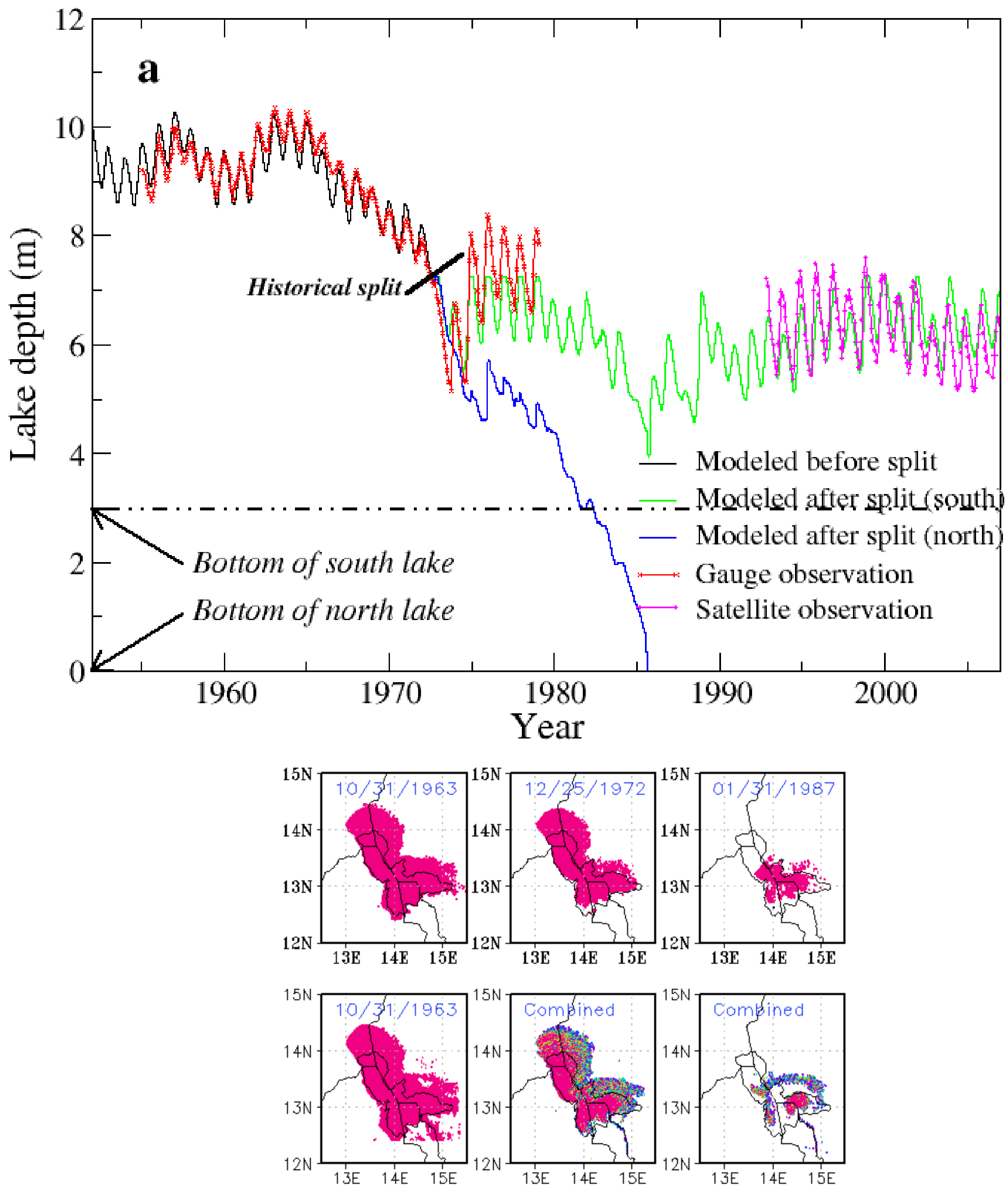
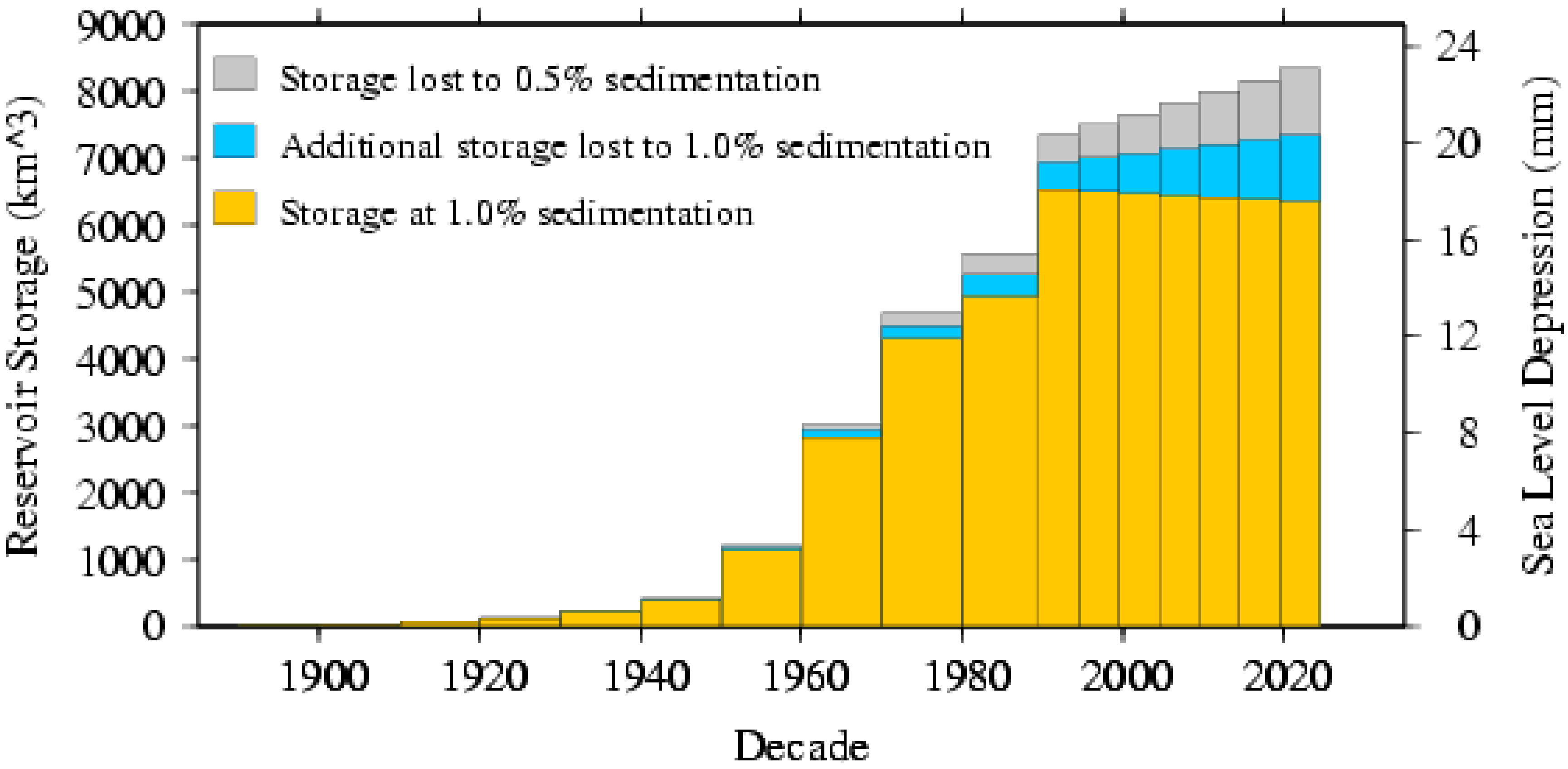


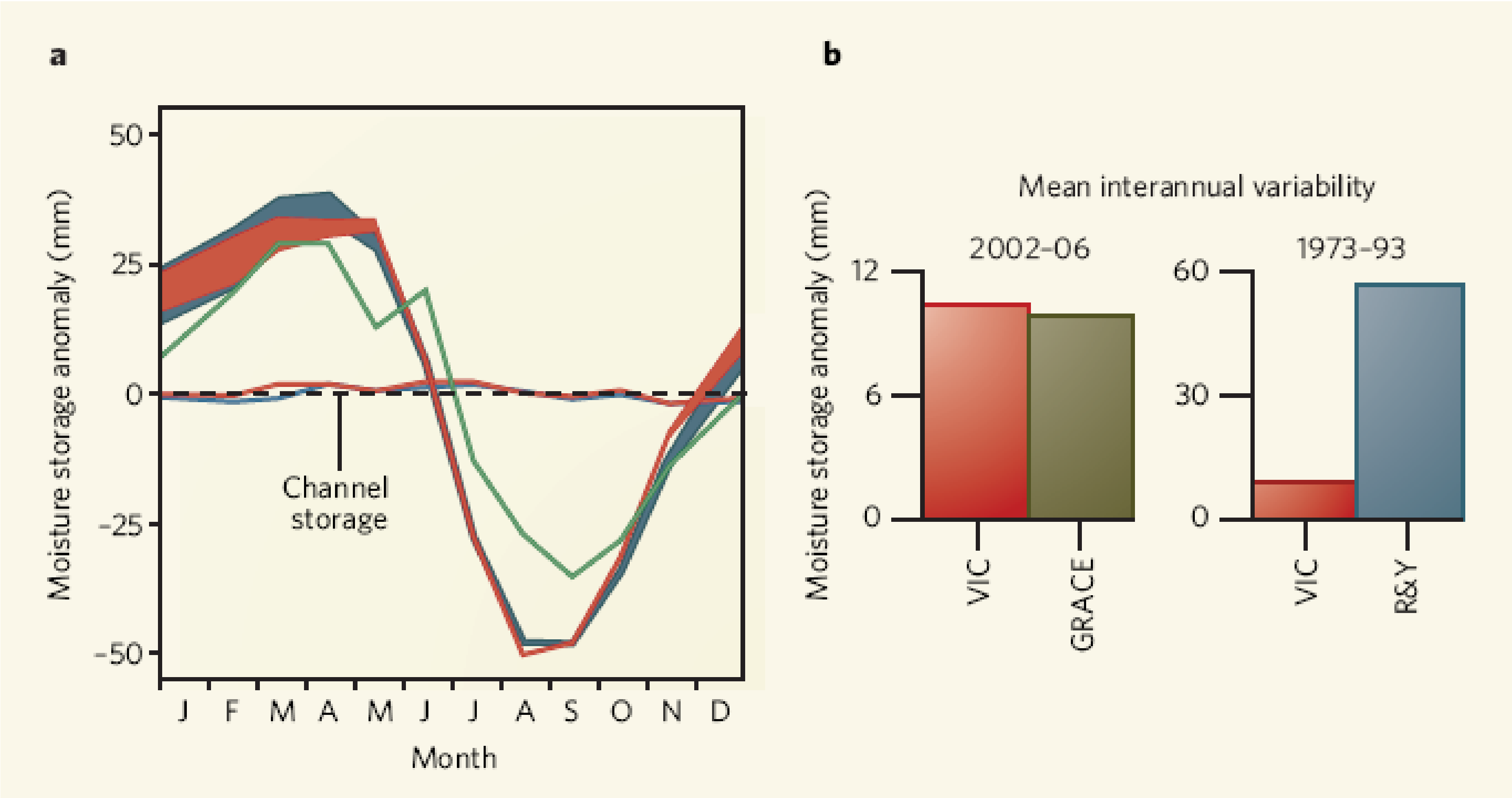
Fig. 3. Geographical analysis of the predicted world distribution of densities (d_L; Eq. 2) of lakes between 1 km^2 and 10 km^2 surface area. Predictions follow a world GIS model of annual run-off (Fekete et al. 2005) with a geographical resolution of 0.5° of latitude and longitude. Lake densities are shown in lakes per 10^6 km^2.


a
Lake depth (m)
Year
Historical split
Bottom of south lake
Bottom of north lake
Modeled before split
Modeled after split (south)
Modeled after split (north)
Gauge observation
Satellite observation
10/31/1963
12/25/1972
01/31/1987
10/31/1963
Combined
Combined

Estimated evolution of global reservoir storage, 1900 – (from Lettenmaier and Milly, 2009)



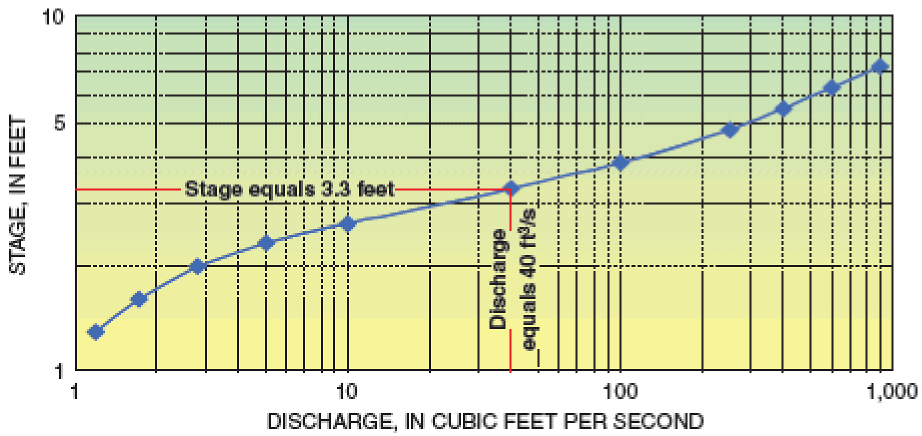
Inferred distribution of long term average Mississippi River seasonal storage variations (from Lettenmaier and Famiglietti, 2006)

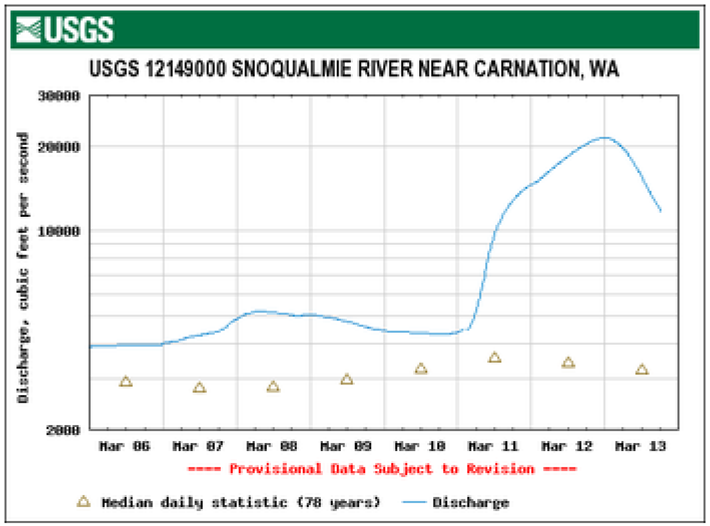


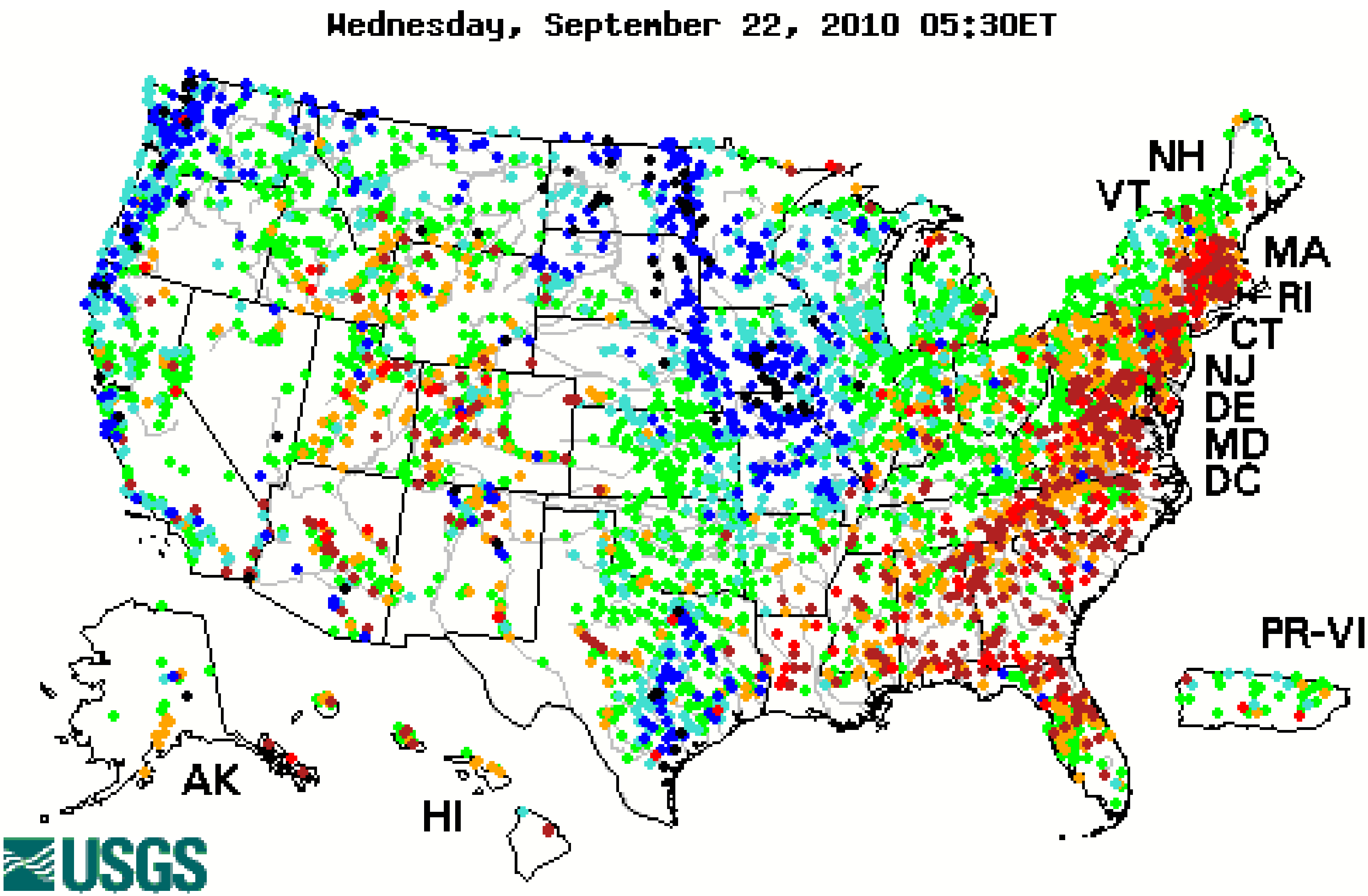
Surface water distribution, Arctic Coastal Plain, Alaska (photo courtesy Larry Smith)

Disappearing lakes: Arctic Coastal Plain, Alaska (visual courtesy Larry Smith)

III. Rivers and river discharge



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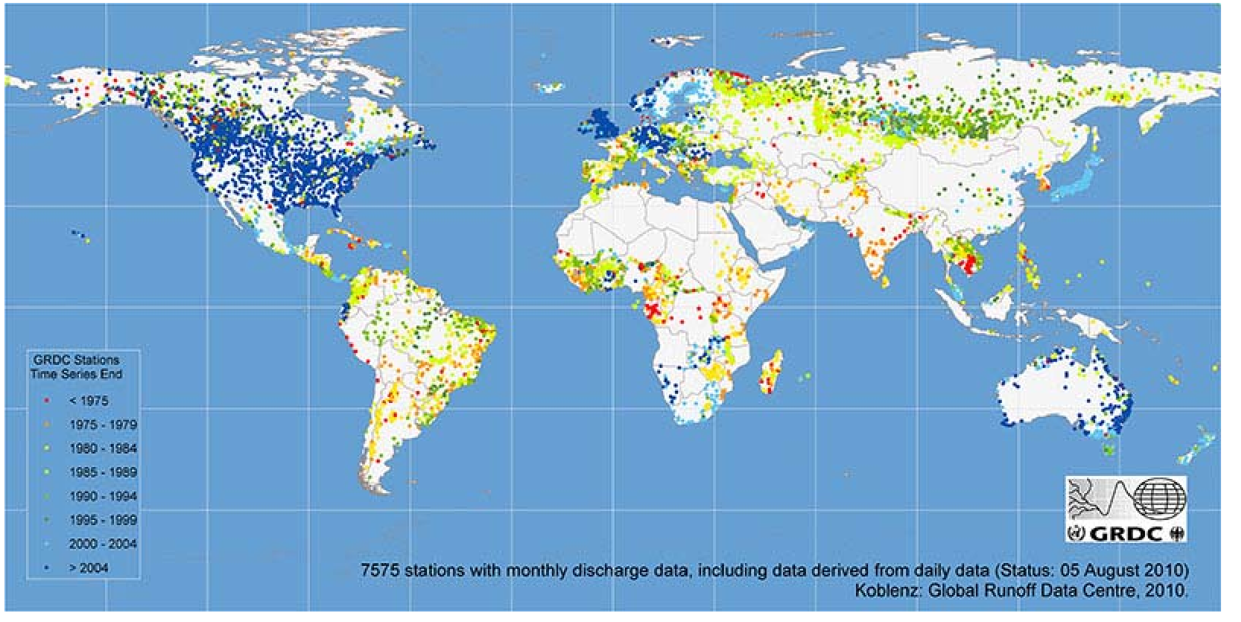
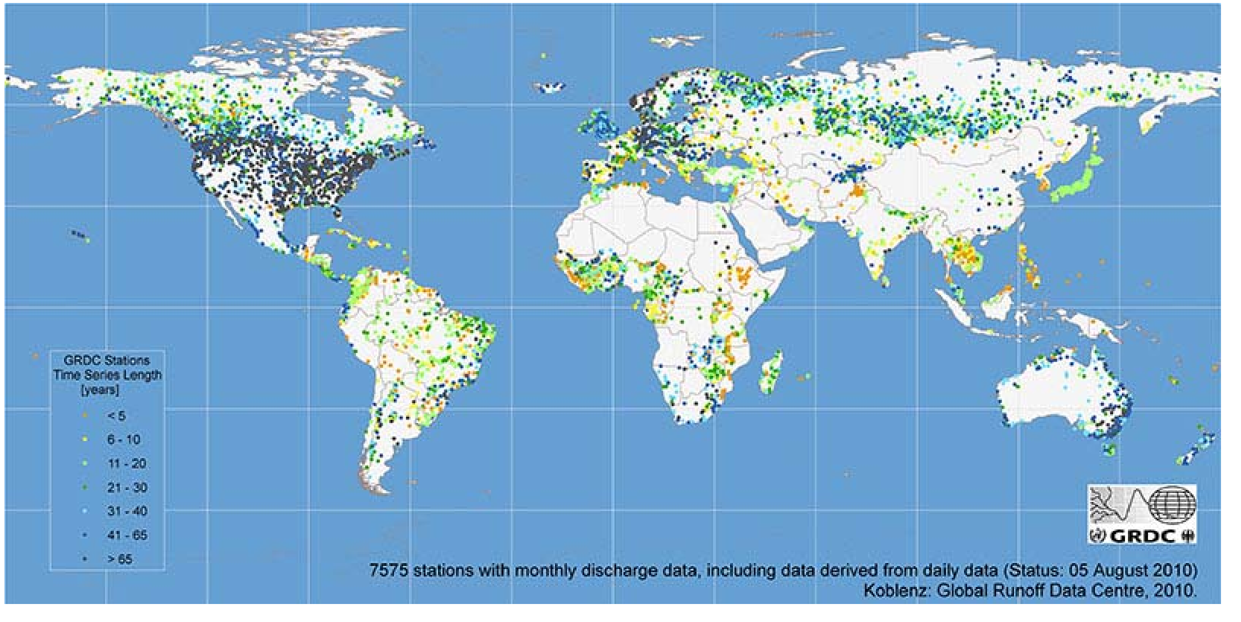
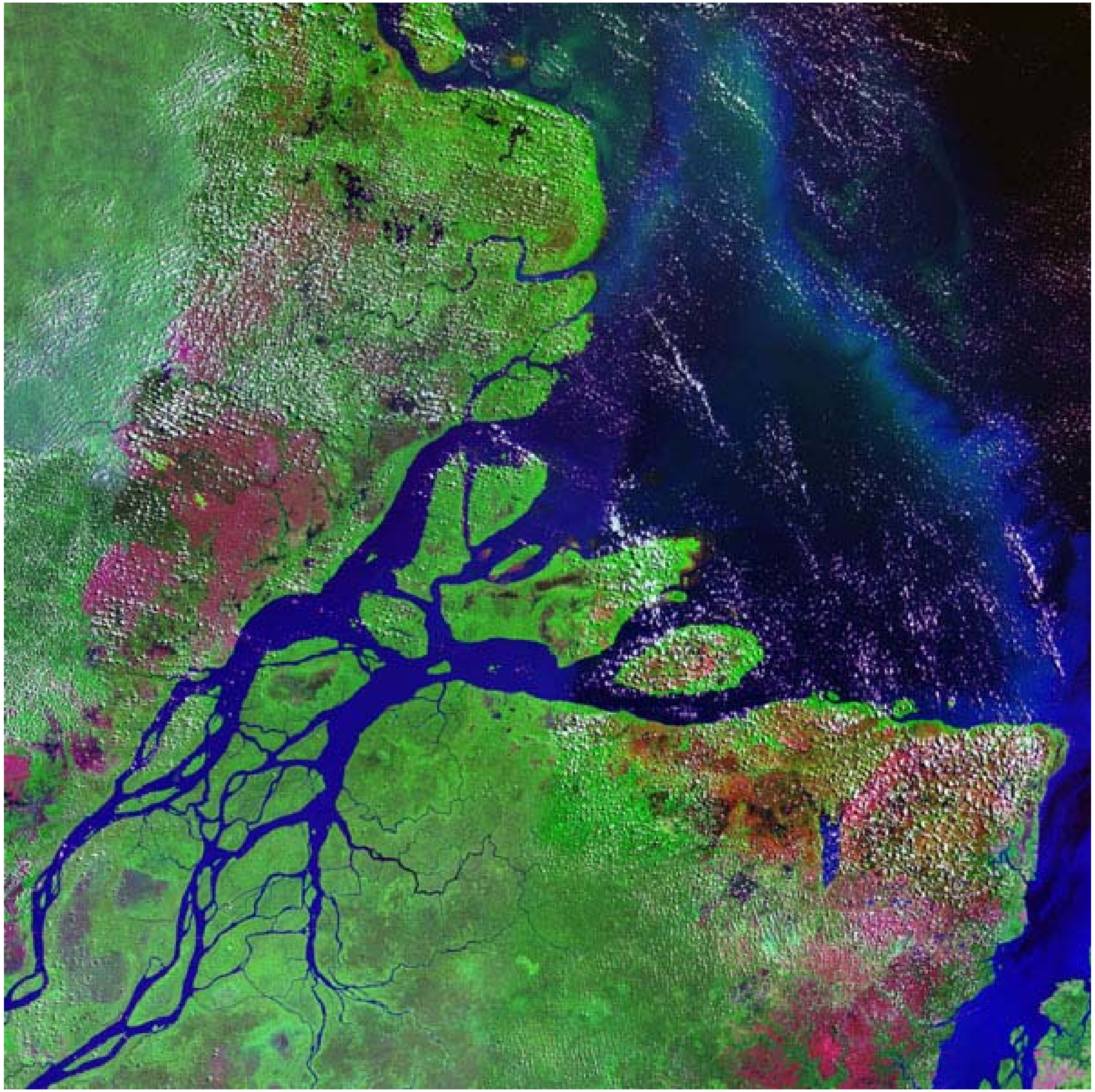
Global Runoff Data Centre distribution of archived station data by last observed year (upper) and total record length (lower)





High latitude braided river (courtesy Larry Smith)

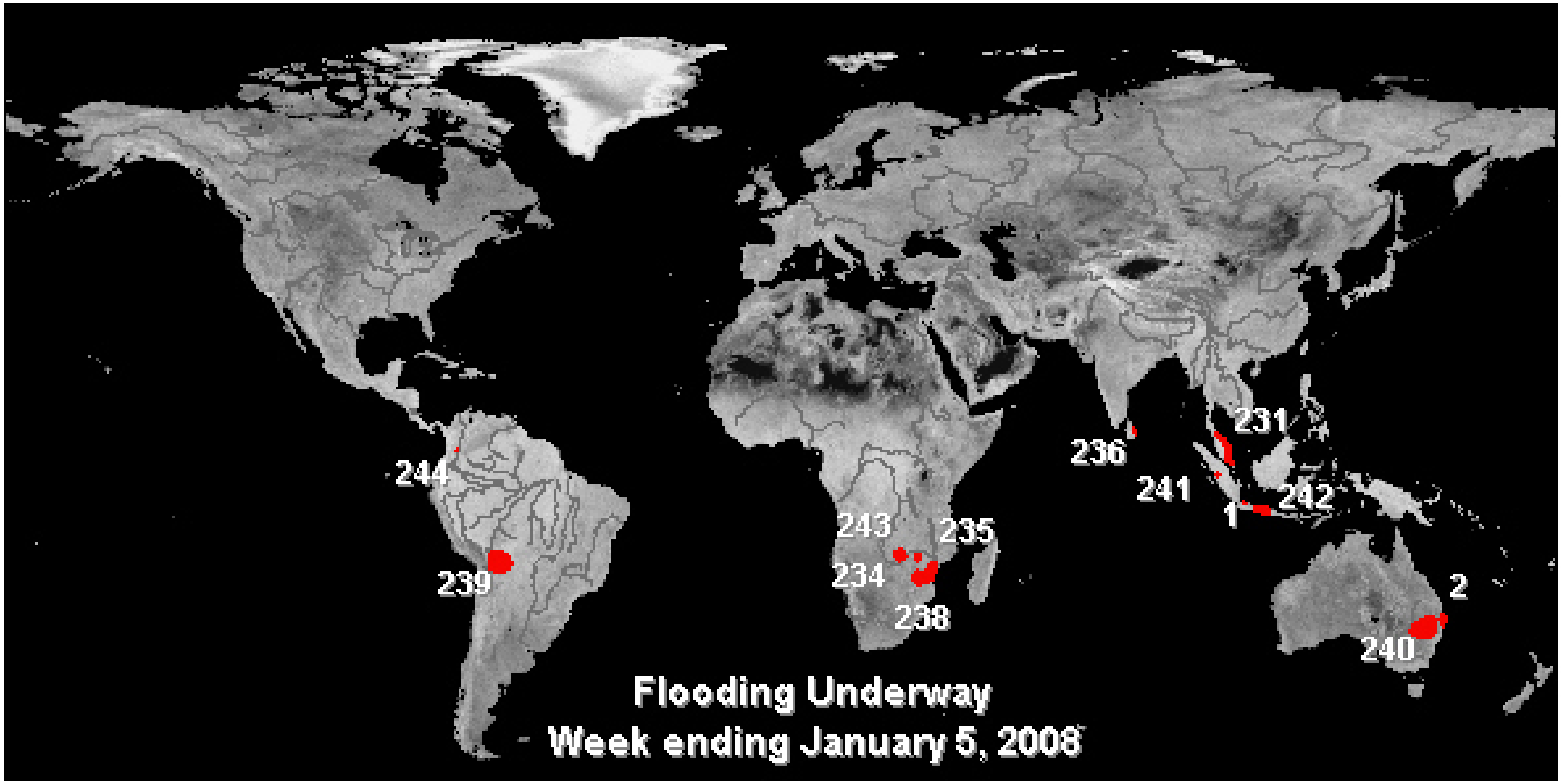
Amazon River near mouth (courtesy Doug Alsdorf)



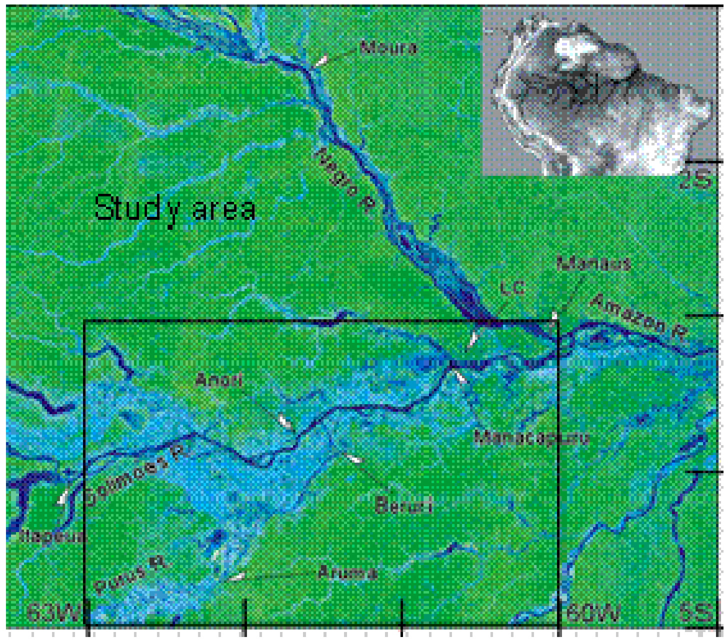
Amazon River, showing overbank flow from SWOT photo gallery)

Cedar Rapids, IA, June 2008 (photo by David Greedy)

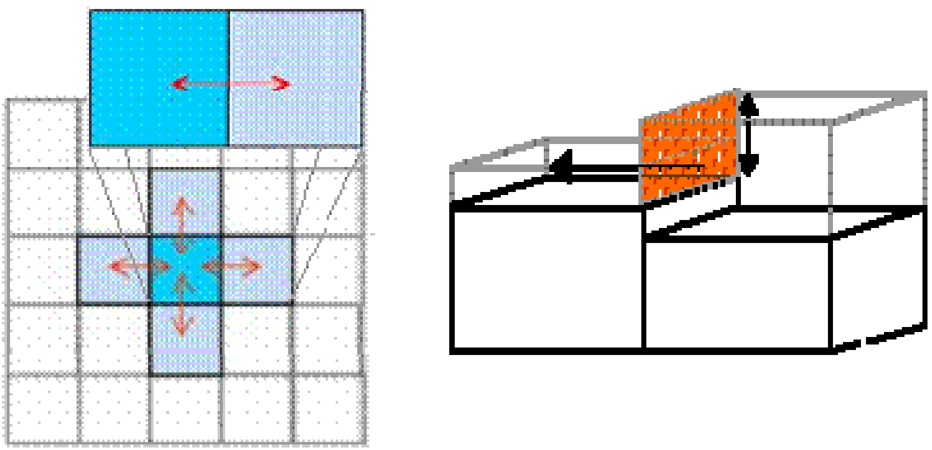
Global flood distribution, week of Jan 5, 2008 (courtesy Global Flood Observatory, Dartmouth University)

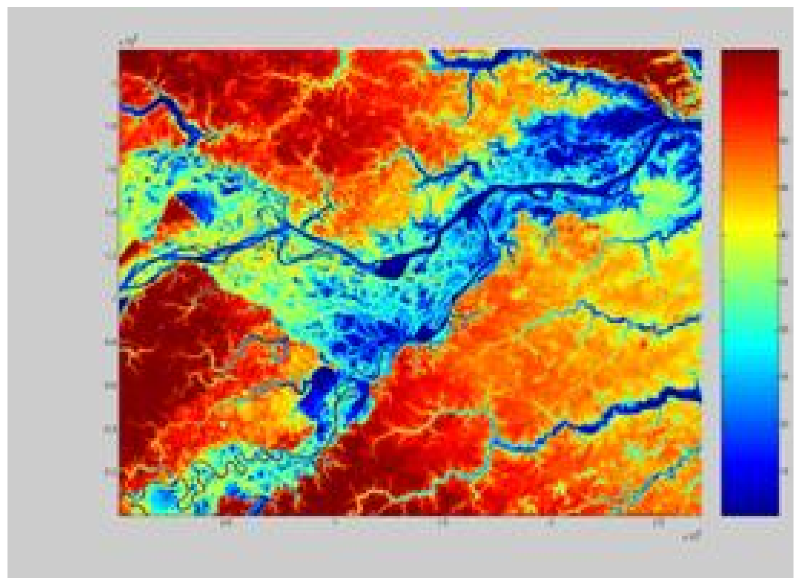


Seasonal inundation prediction, Amazon River (visuals courtesy Paul Bates)



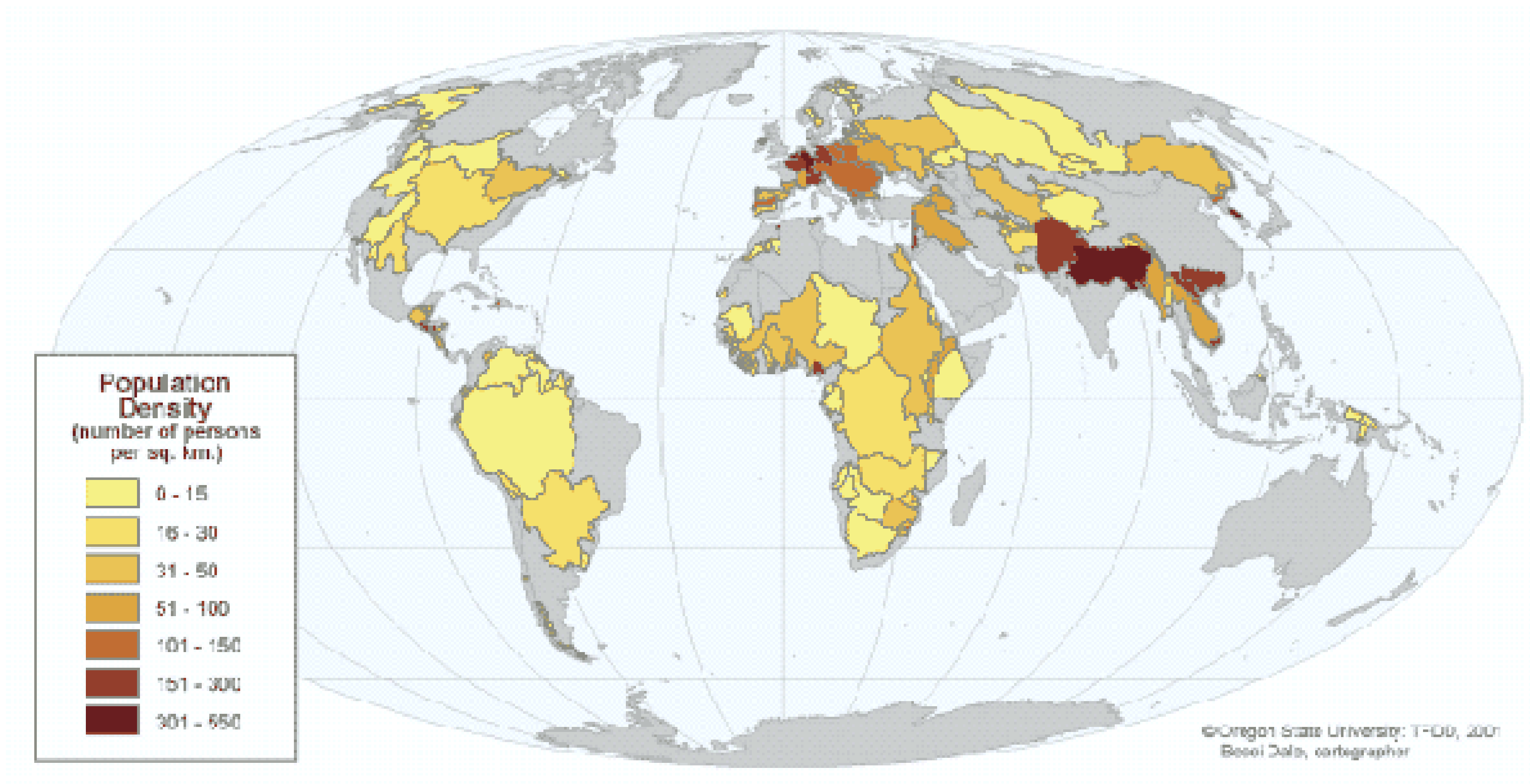
LISFLOOD-FP schematic





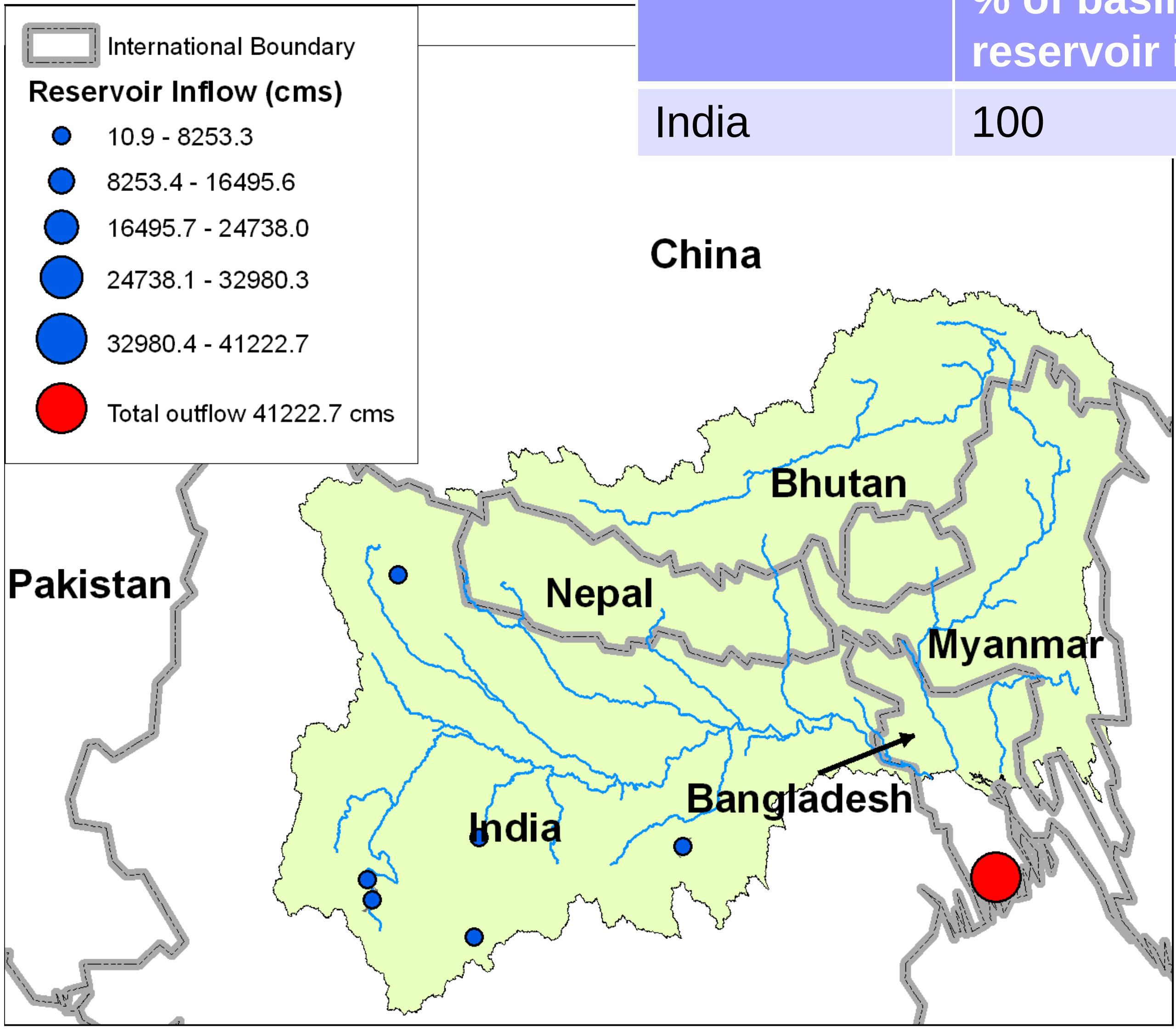
III. Applications opportunities

Transboundary river basins (courtesy Program in Water Conflict Management and Transformation, Oregon State University)



Ganges-Brahmaputra-Meghna

	% of basin-wide reservoir inflows	% of basin-wide reservoir volume
India	100	100



<u>Major Issues</u>

- Need to improve flood data communication across borders
- Problems of sharing dry season flow between India and Bangladesh
- Need to involve China in discussions before China builds large diversions and dams on the Tsangpo (Brahmaputra)
- General lack of knowledge about the GBM system

Aral Sea

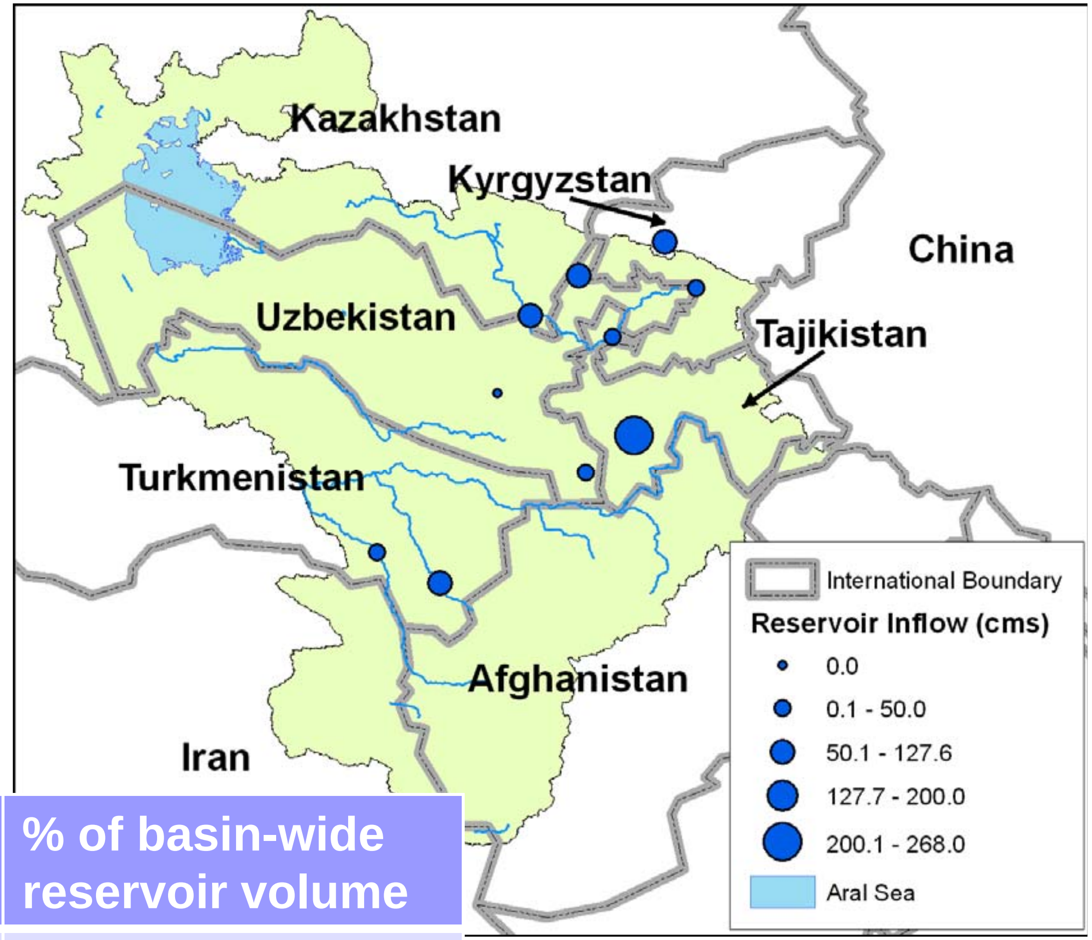
<u>Major Issues</u>

•No functioning basin management agreements

•Need to coordinate winter and summer water uses

•Monitoring of remote mountain lakes

•Large dams planned, so need for basin cooperation is urgent



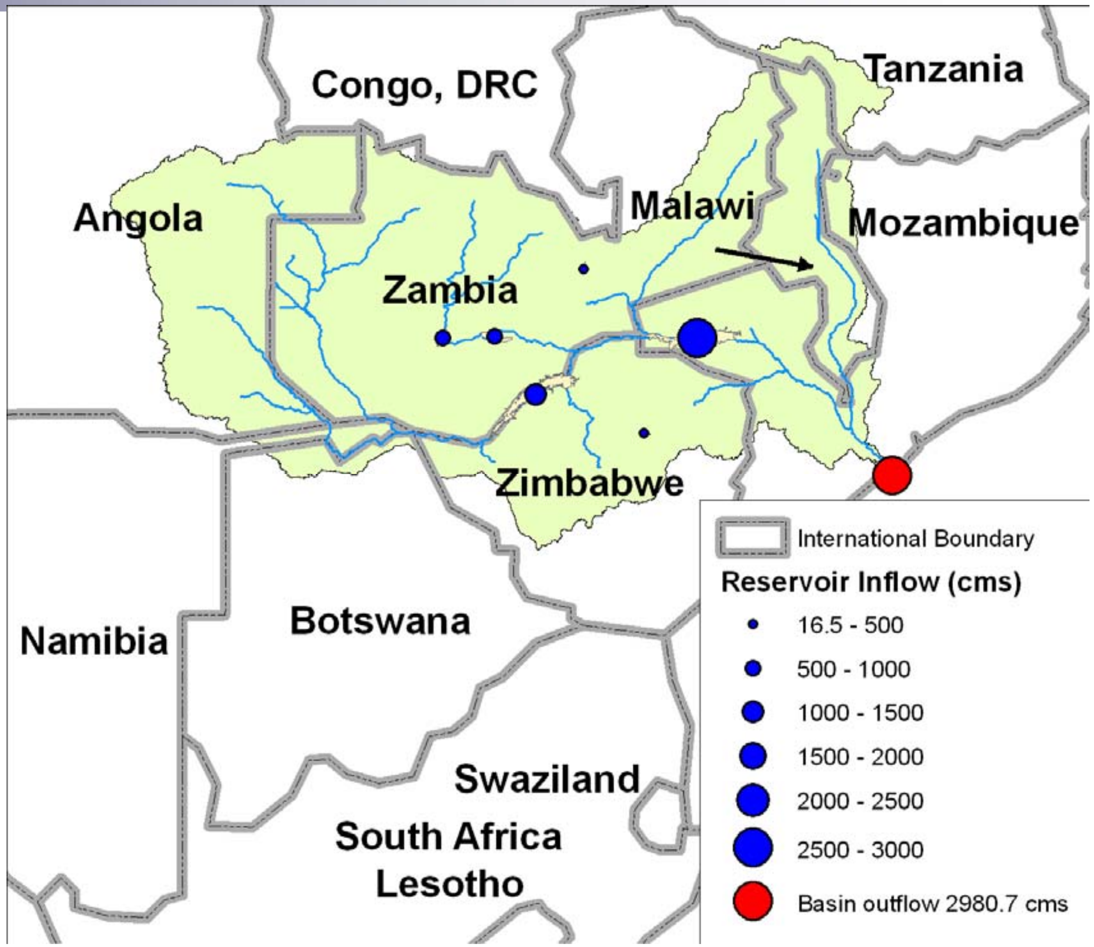
	% of basin-wide reservoir inflows	% of basin-wide reservoir volume
Turkmenistan	13	8
Kyrgyzstan	14	39
Kazakhstan	16	13
Uzbekistan	17	11
Tajikistan	40	29

Total basin outflow: 2980.72 cms

Zambezi

Major Issues

- •Political instability (esp, in Zimbabwe) prevents action on transboundary water issues
- •Flooding downstream in Mozambique due to poor data lead time
- •Large inter-basin water transfers envisioned – need proper data and strong water agreements for that to not to be contentious
- •But…SADC provides a good starting point



	% of basin-wide reservoir inflows	% of basin-wide reservoir volume
Zimbabwe	28	67
Mozambique	50	23
Zambia	21	10

Concluding thoughts

- SWOT will be transformational in terms of water cycle science – it will provide a quantum leap in the underpinnings of continental and global hydrology as visualized by Eagleson ~25 years ago
- We can only begin to scratch the surface of the types of investigations that SWOT will support – think for example of GRACE planning!
- We should acknowledge and embrace an obligation to the applications community – while SWOT is mostly about science, that is only part of the picture