Continental River Discharge and Reservoir Storage Trends and Variability from 1950 on

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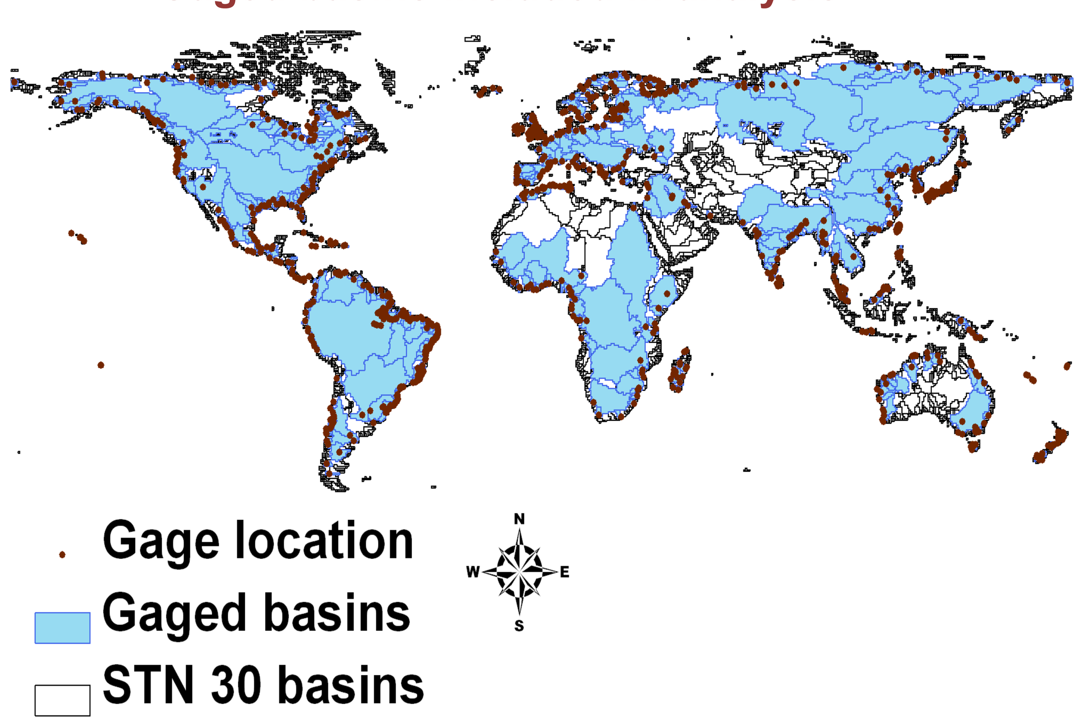
Annual River Discharge Estimates

The goal of this work is to estimate continental river fluxes to the ocean from observations. Dai et al. 2009 performed a thorough analysis of global streamflow using data from 925 river gages. These data were extrapolated by Dai et al. 2009 using CLM 3.0 to estimate monthly flow at the river mouth and in ungaged basins that drain within the same 10° latitudinal band.

We are in the process of updating these estimates using the VIC model, which arguably better represents runoff and streamflow than CLM. We routed the 1°x1° gridded global VIC runoff estimates of Sheffield et al. (2006) through the 0.5°x0.5° latitude by longitude STN-30p flow direction grid to 925 gaging stations and all river mouths.

Gaged basins included in analysis



Steps used by Dai et al. 2009 to fill in time series gaps and estimate ungaged values, and status for this analysis:

1) $Q(station,t) = a*Q_{obs}(nearby\ station, t) + b$
Completed by Dai et al. 2009, who compared estimates with basin integrated precipitation.

2) $Q(station, t) = c*Q_{model}(station, t) + d$
Completed.

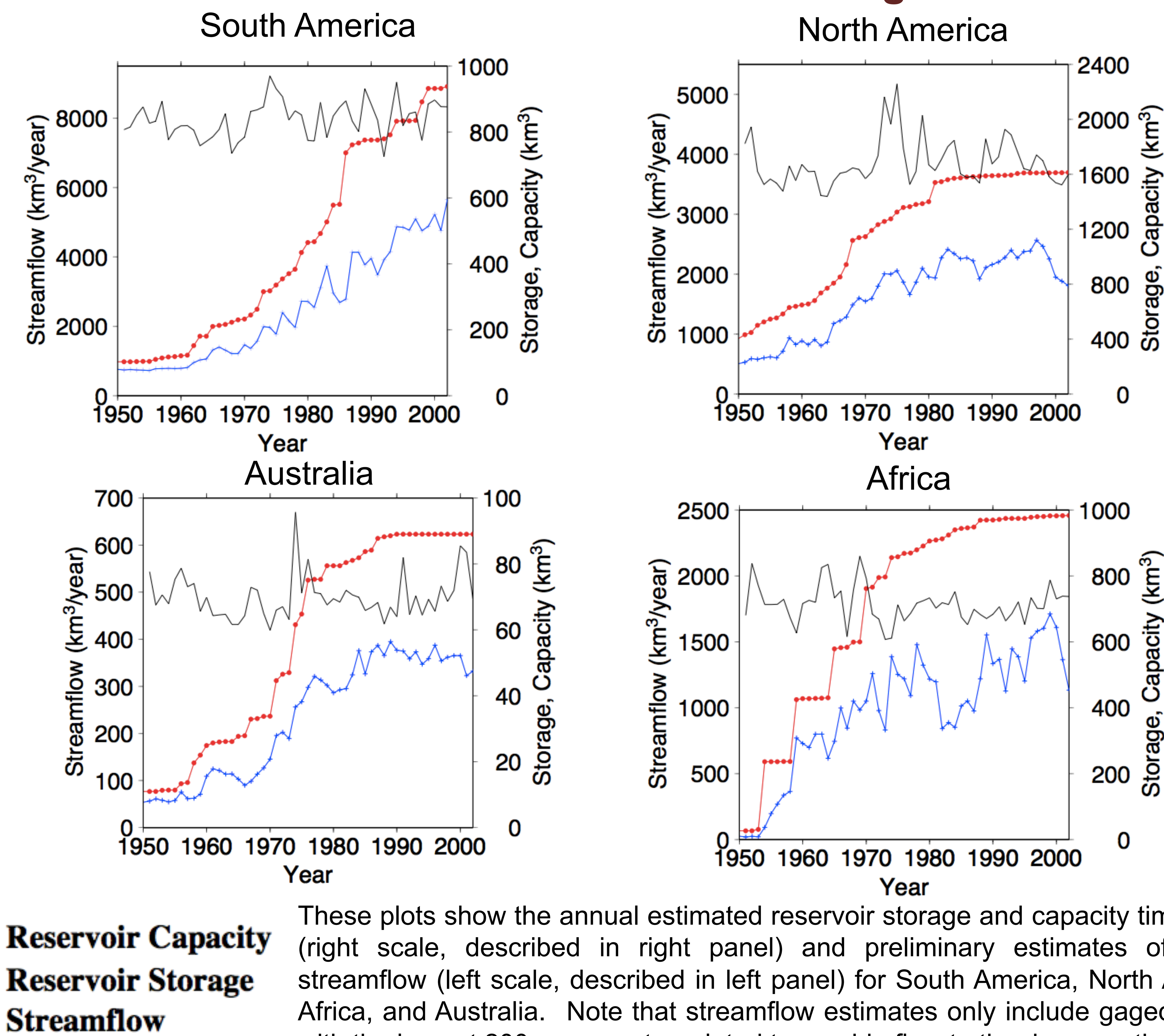
3) $Q(mouth,t) = Q_{obs}(station,t)*(Q_{model}(mouth,t)/Q_{model}(station,t)$
Initial results for Africa, Australia, South America, North America shown here.

4) $Q(unmonitored,t)=Q_{obs}(monitored,t)*(Q_{model}(unmonitored,t)/Q_{model}(monitored,t)$
In progess.

Results: Streamflow Summary Statistics

Streamflow, km³/yr	Mean Interannual Variability	Mean Annual	Mean Annual (Dai et al. 2009)
North America	279	3865	5200
South America	468	7978	10900
Australia	115	492	2200
Africa	41	1786	3600

Results: Streamflow and Reservoir Storage Time Series



These plots show the annual estimated reservoir storage and capacity time series (right scale, described in right panel) and preliminary estimates of annual streamflow (left scale, described in left panel) for South America, North America, Africa, and Australia. Note that streamflow estimates only include gaged basins, with the largest 200 gages extrapolated to provide flow to the river mouth.

Conclusions

Of the 4 continents examined, South America has the highest mean annual streamflow and mean interannual variability of streamfow; however North America has the largest mean annual reservoir storage and capacity, and the greatest mean interannual variability in storage. Storage capacity leveled off around 1990 for these continents (later for South America), and most are estimated to operate at around 40-60% of their capacity thereafter.

References

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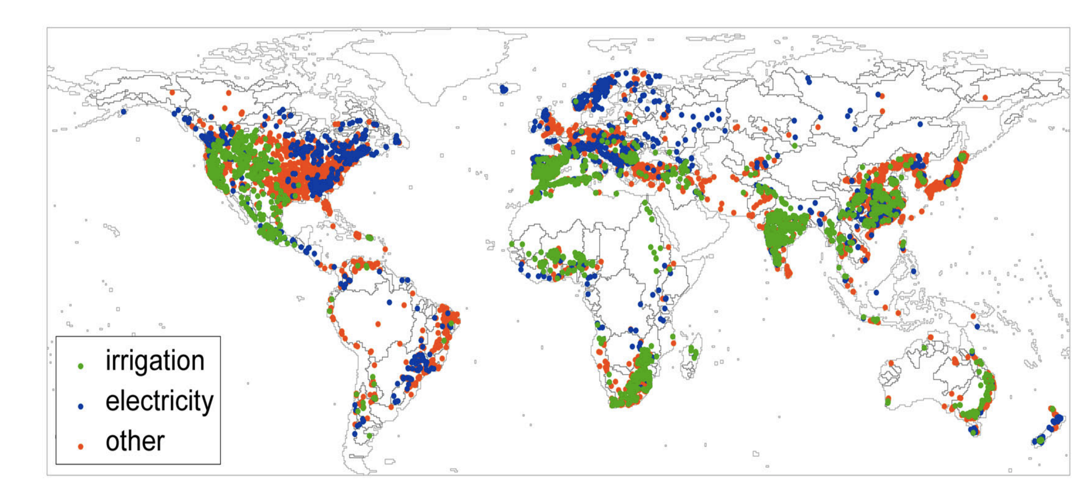
Annual Reservoir Storage Estimates

Human water use and reservoir storage can have a major impact on streamflow timing and quantity, but these effects are poorly known on a continental and global basis. Biemans et al. (2009), as part of the EU WATCH project, describe an approach, called LPJmL-water, to modeling monthly reservoir operations and irrigation withdrawals globally. Their approach draws from Haddeland et al. (2006) and Hanasaki et al. (2006). Irrigation demands are based on the amount of water needed to fill the soil to field capacity or to meet evaporative demand. Target releases for other uses are set constant. They represent reservoir storage in 7000 reservoirs globally with surface area larger than 0.1 km² (GRAND database). Here we examine the relationship between these estimates of storage and observation-based streamflow (see left panel).

Reservoirs included in analysis



Results: Reservoir Capacity Summary Statistics

Storage Capacity, km³	Mean Interannual Variability	Mean Annual Capacity
North America	23	1187
South America	16	442
Australia	1	57
Africa	18	702

Results: Reservoir Storage Summary Statistics

Storage, km³	Mean Interannual Variability	Mean Annual Storage
North America	49	714
South America	25	260
Australia	2	33
Africa	58	388