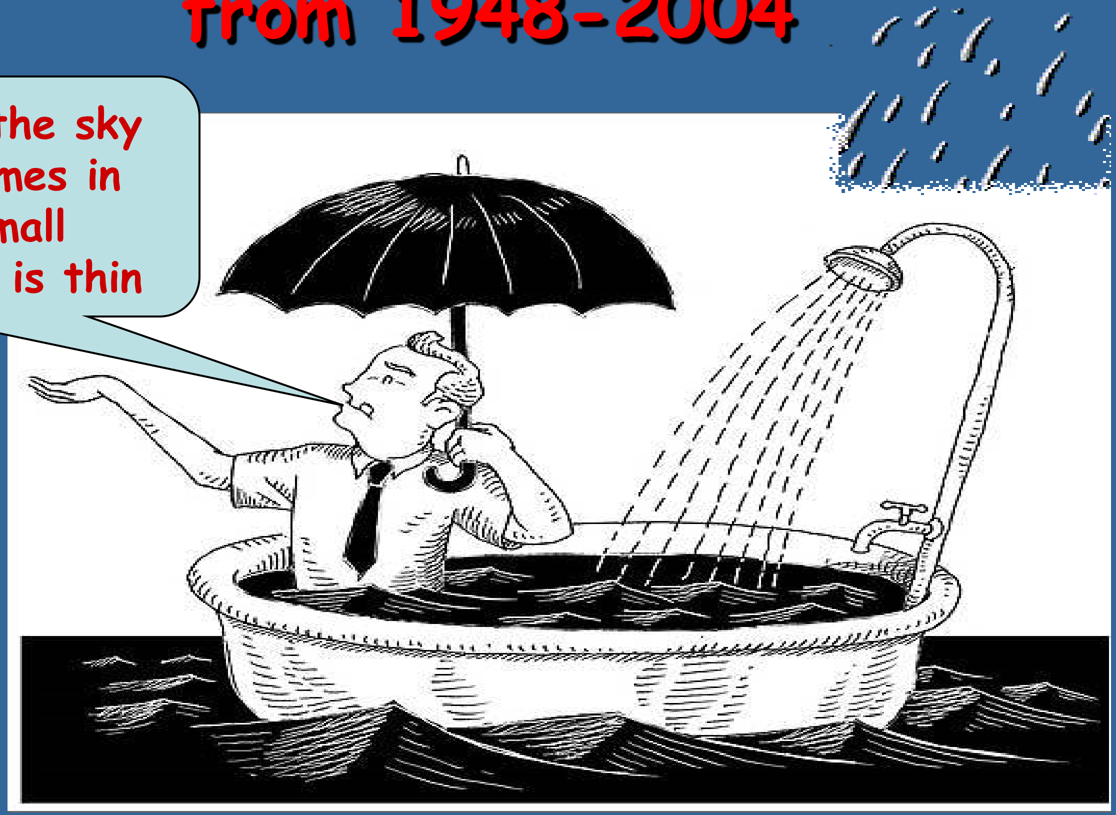
Changes in Continental Freshwater Discharge from 1948-2004

There are holes in the sky
Where the rain comes in
The holes are small
That's why the rain is thin

Spike Milligan



Aiguo Dai, Kevin Trenberth, Taotao Qian
John Milliman

J Climate May 2009

NCAR

Observations:

Monthly means

Streamflow 925 largest rivers

80% of drainage area covered

73% of total runoff

Gaps in data a major issue

Temperatures: CRU, NCDC; DTR: NCDC

Precipitation (CPC (Chen et al), **GPCP)**

Surface cloud

High frequency (within-month): from NRA, ERA-40

Relative humidity from NRA

Used to force land surface model

Verification:

Solar radiation

Soil moisture

Tools: Community Land Model 3 CLM3

Global, T42 and 0.5° grid

Forced by observations

Gaps in stream flow filled with linear regression using streamflow simulated CLM3 forced with observed precipitation and other atmospheric forcings that is significantly (and often strongly) correlated with the observed streamflow for most rivers.

Missing regions also filled using CLM3 simulated values via scaling

Use water year from October to September (best for NH)

Result: an observationally constrained, physically consistent view of changes over time.

Here we deal with actual river discharge

Includes climate variations and human interference

Dams, reservoirs

(alter seasonal flows but less effect on annual mean)

Withdrawal from rivers

Aquifer withdrawal (ground water mining)

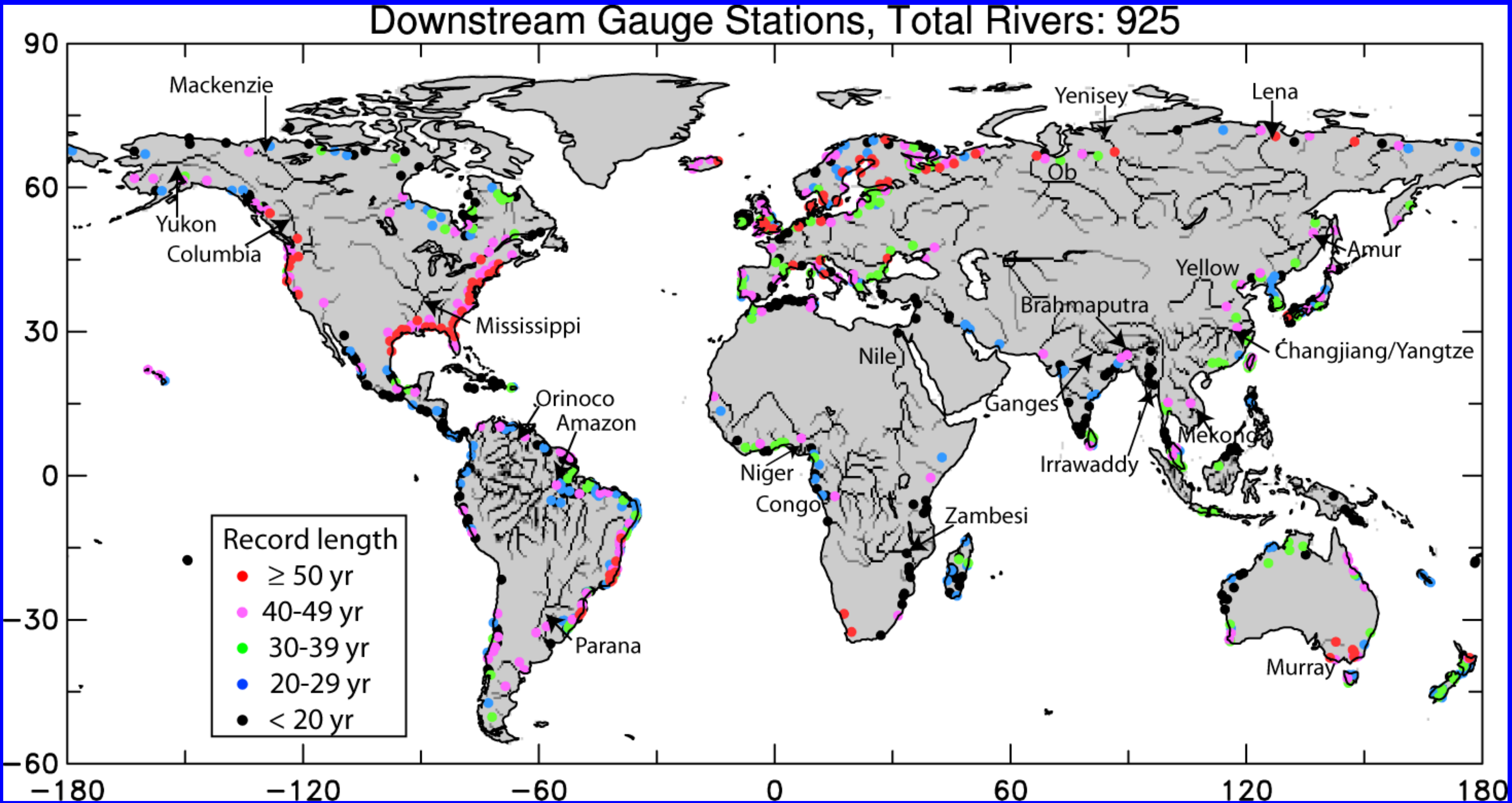
Irrigation

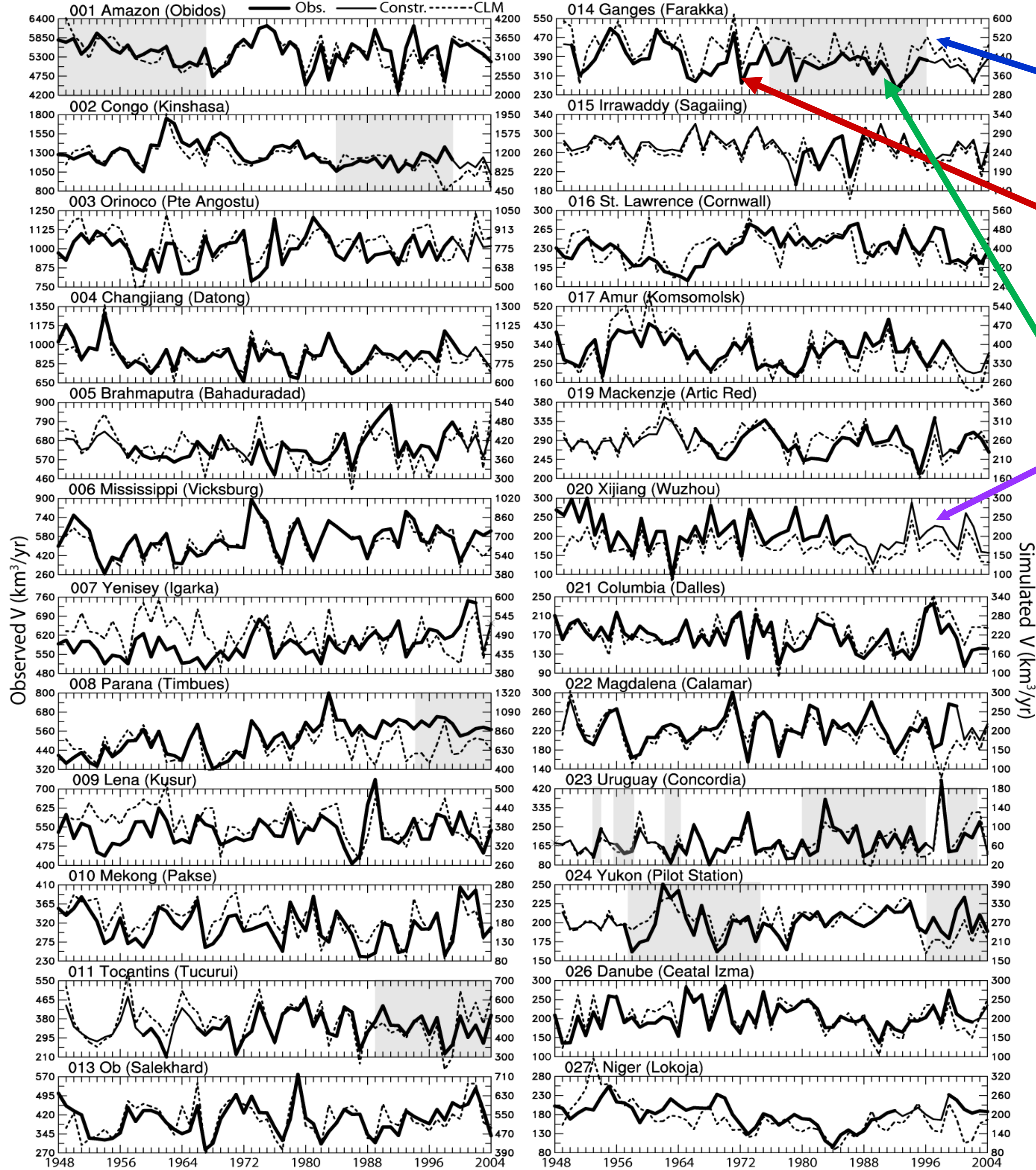
Urbanization, deforestation (affect runoff)

Some compensation esp in terms of changes in sea level

- Increases in flow are certainly dominated by climate
- Decreases in flow can have strong human interference component

World's 925 largest rivers





CLM3 (obs forcings) (dotted)

Observed gauge (solid bold)

Other station regression (shading)

Hindcast (CLM3) (thin line)

River discharge into oceans

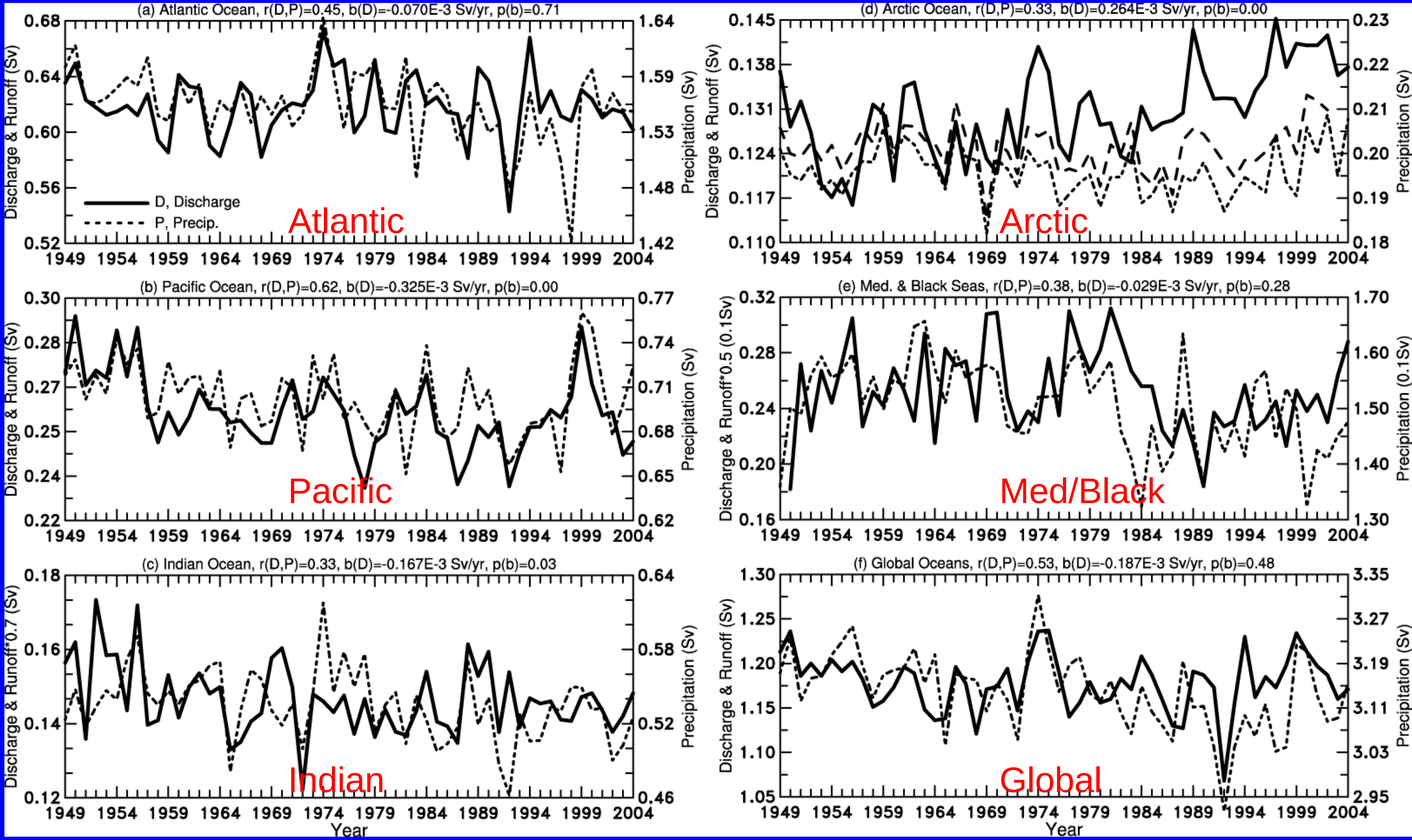
For water year (Oct-Sep)

Trends modest, variability large

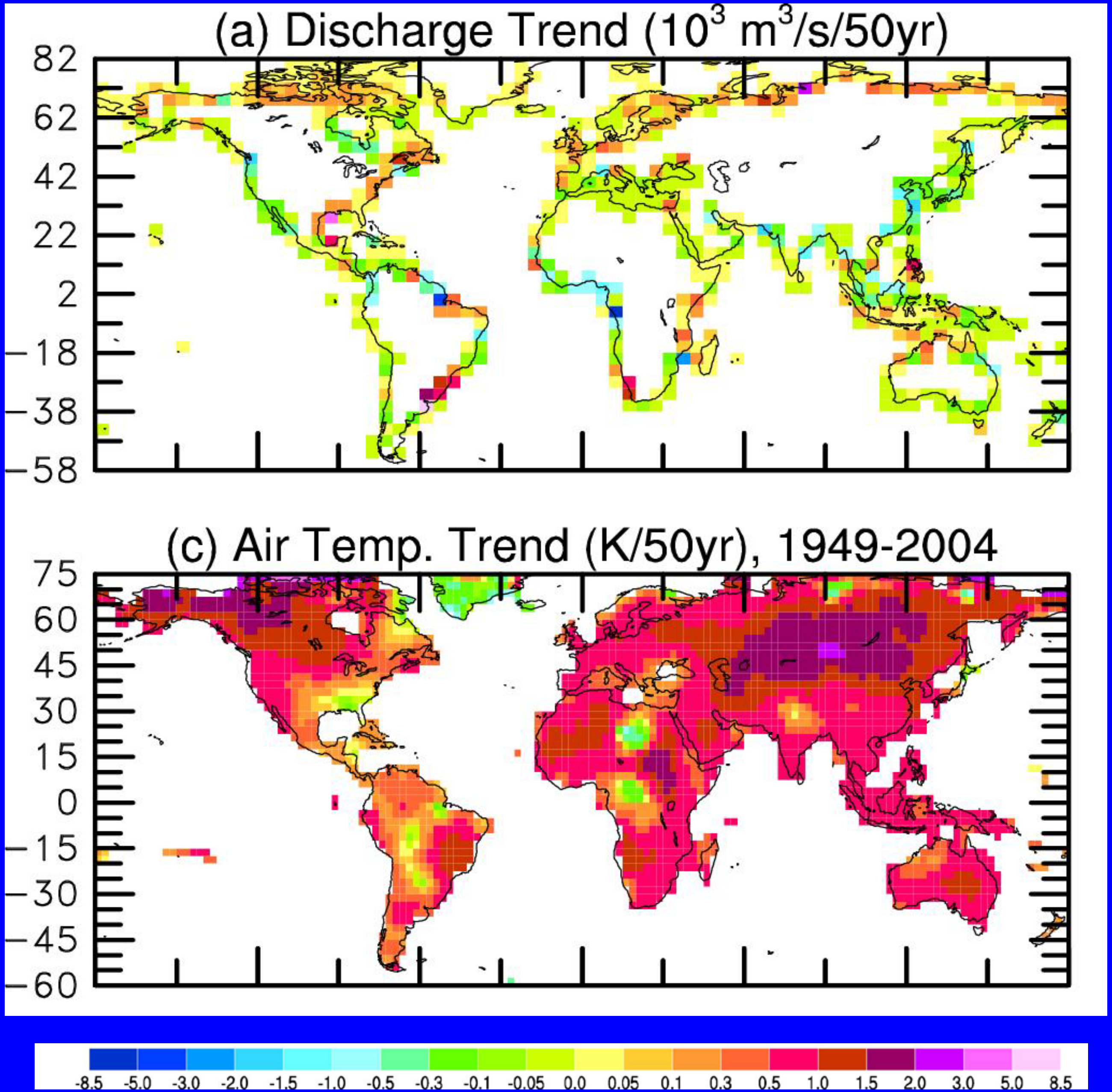
Large variations occur in yearly and decadal streamflow for most of world's large rivers and for continental discharge.

About one-third of the top 200 rivers (including the Congo, Mississippi, Yenisey, Paraná, Ganges, Columbia, Uruguay, and Niger) show statistically significant trends during 1948-2004, with the rivers having downward trends (45) out-numbering those with upward trends (19)

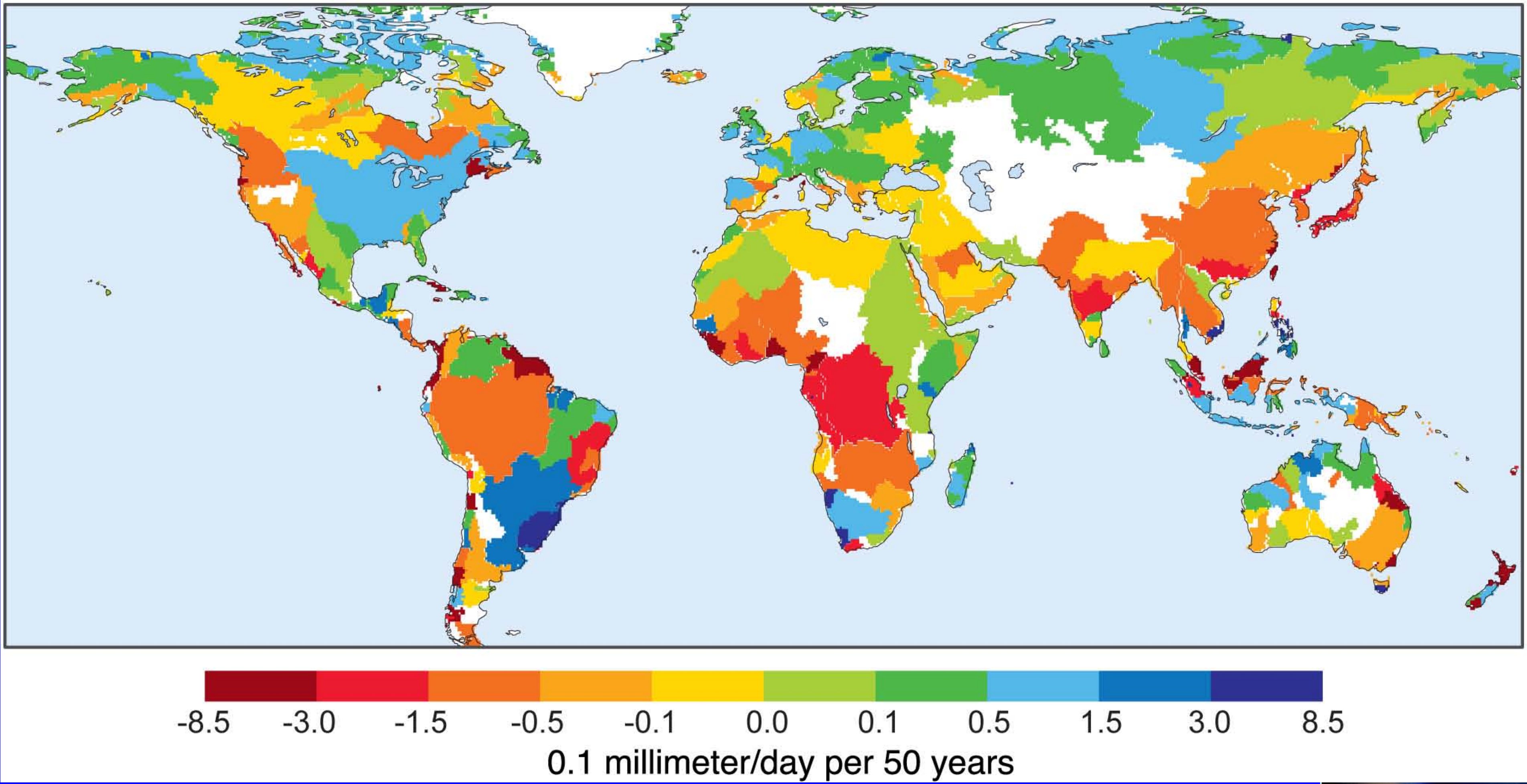
River discharge vs drainage area precipitation



Trends 1948-2004

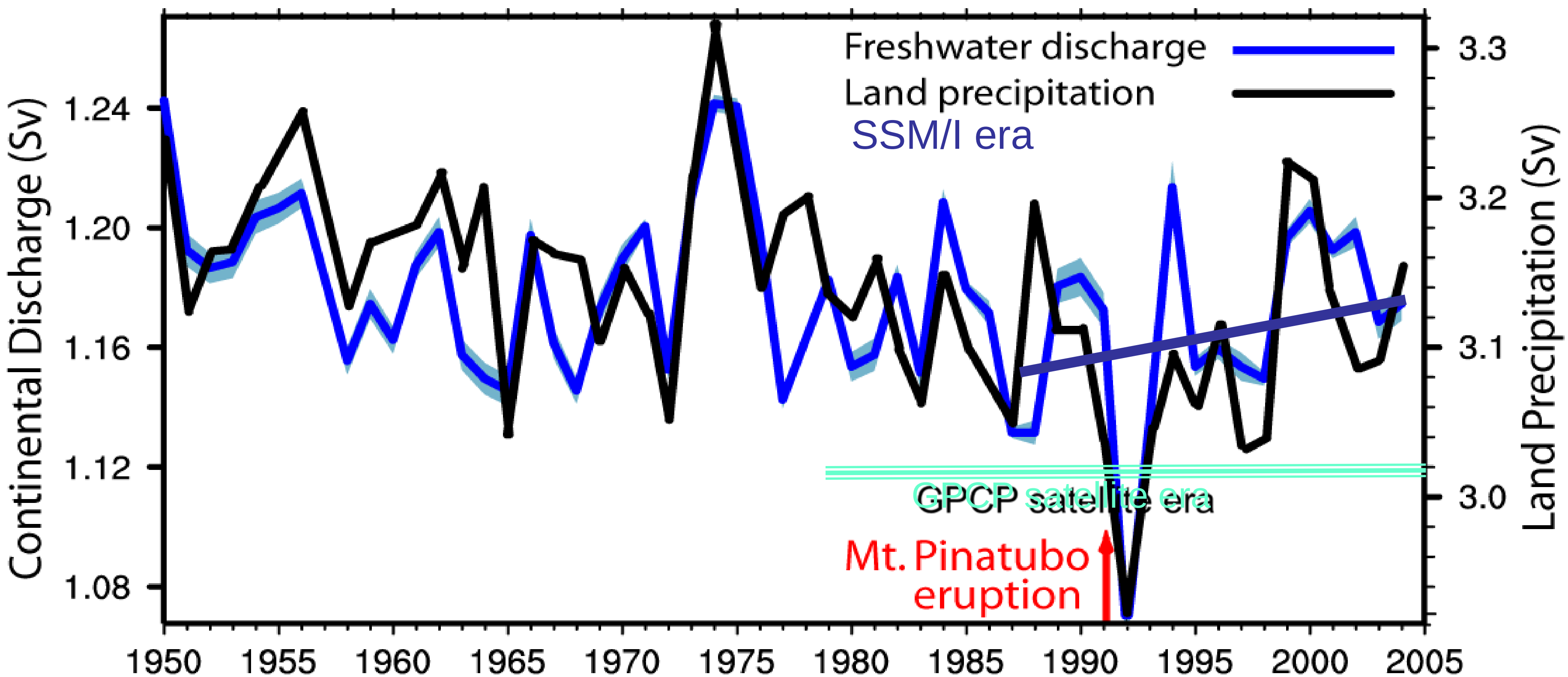


Inferred **runoff** trend 1948-2004
based on 925 rivers



Dai et al 2009

Pinatubo Effect on Hydrological Cycle

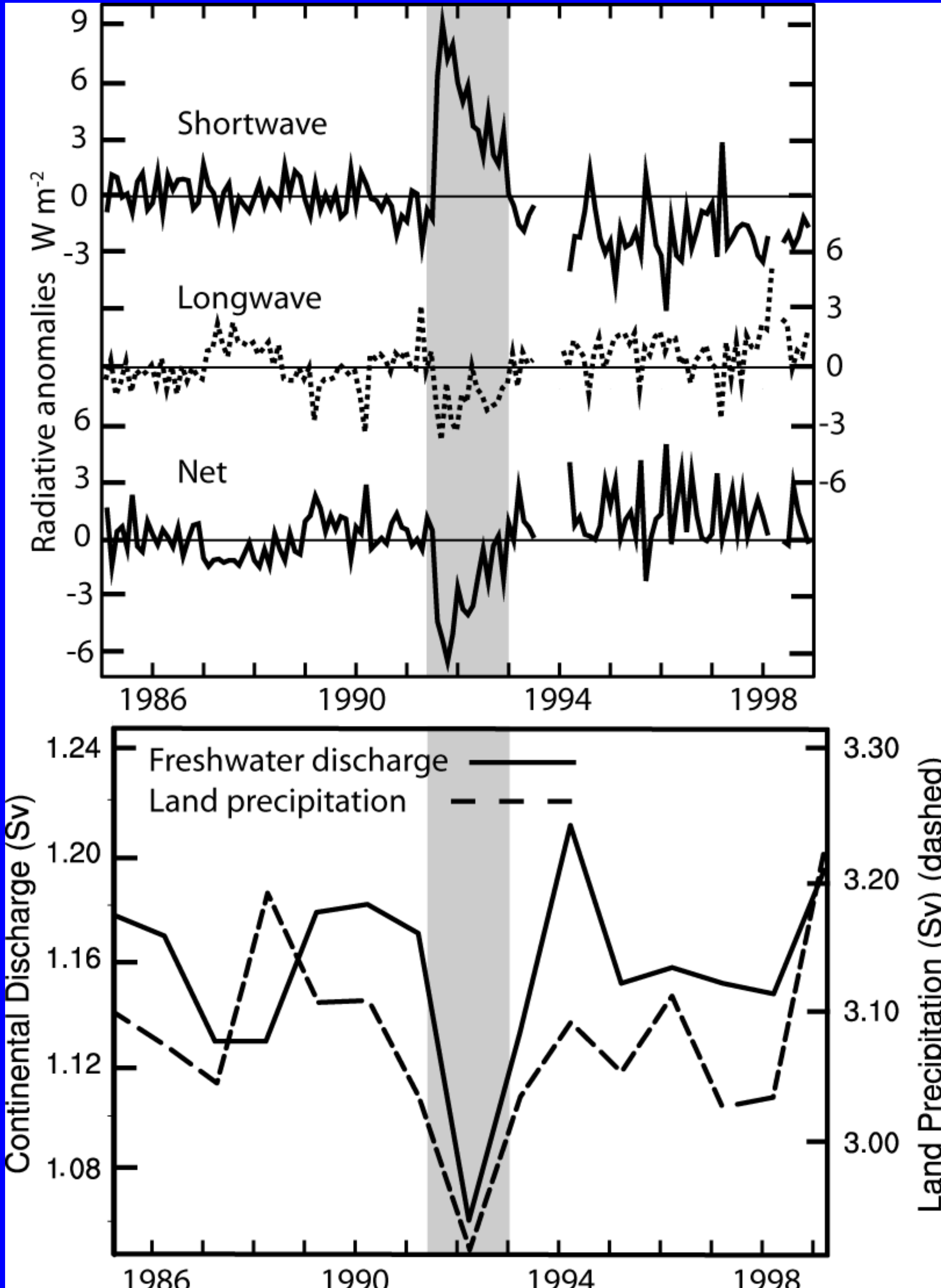


Estimated water year (1 Oct-30 Sep) **land precipitation** and river **discharge** into global oceans based on hindcast from output from CLM3 driven by observed forcings calibrated by observed discharge at 925 rivers.

Note: 1) effects of Pinatubo; 2) downward trend

(contrast to Labat et al (2004) and Gedney et al (2006) owing to more data and improved missing data infilling)

Trenberth and Dai 2007; Dai et al. 2009



Mount Pinatubo in June 1991 had a pronounced effect on land precipitation and runoff (3.6σ).

Ocean precipitation was also slightly below normal, and the global values are lowest on record.

Trenberth and Dai 2007

NCAR

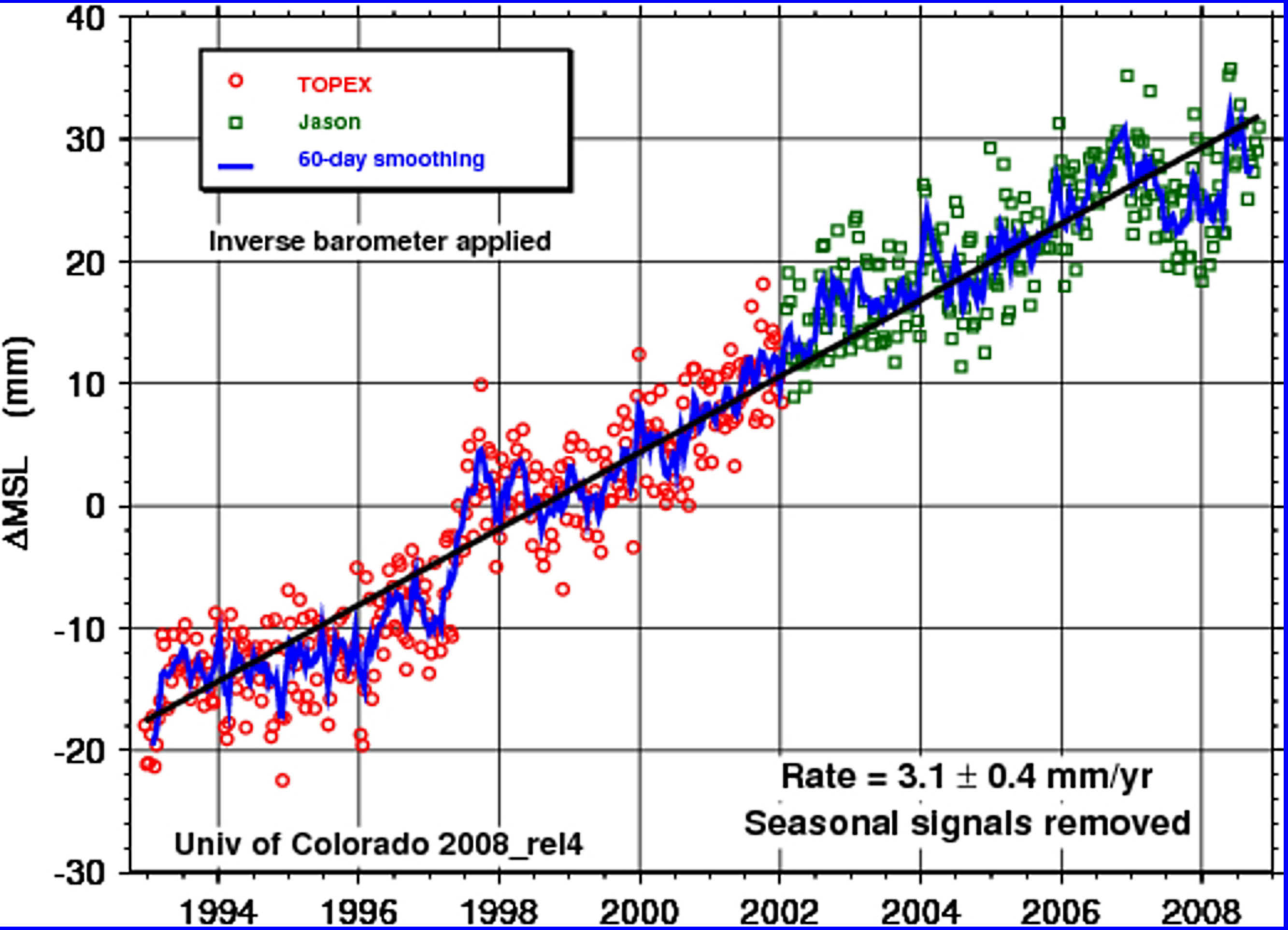
ENSO effects are large

From Gu et al (2007) regressions:

A 1.5°C drop in Niño 3.4 SSTs for 6 months, (as occurred from October 2007 to March 2008) increases rainfall over land in the tropics (±25°) to such an extent as to lower sea level by 6.0 mm.

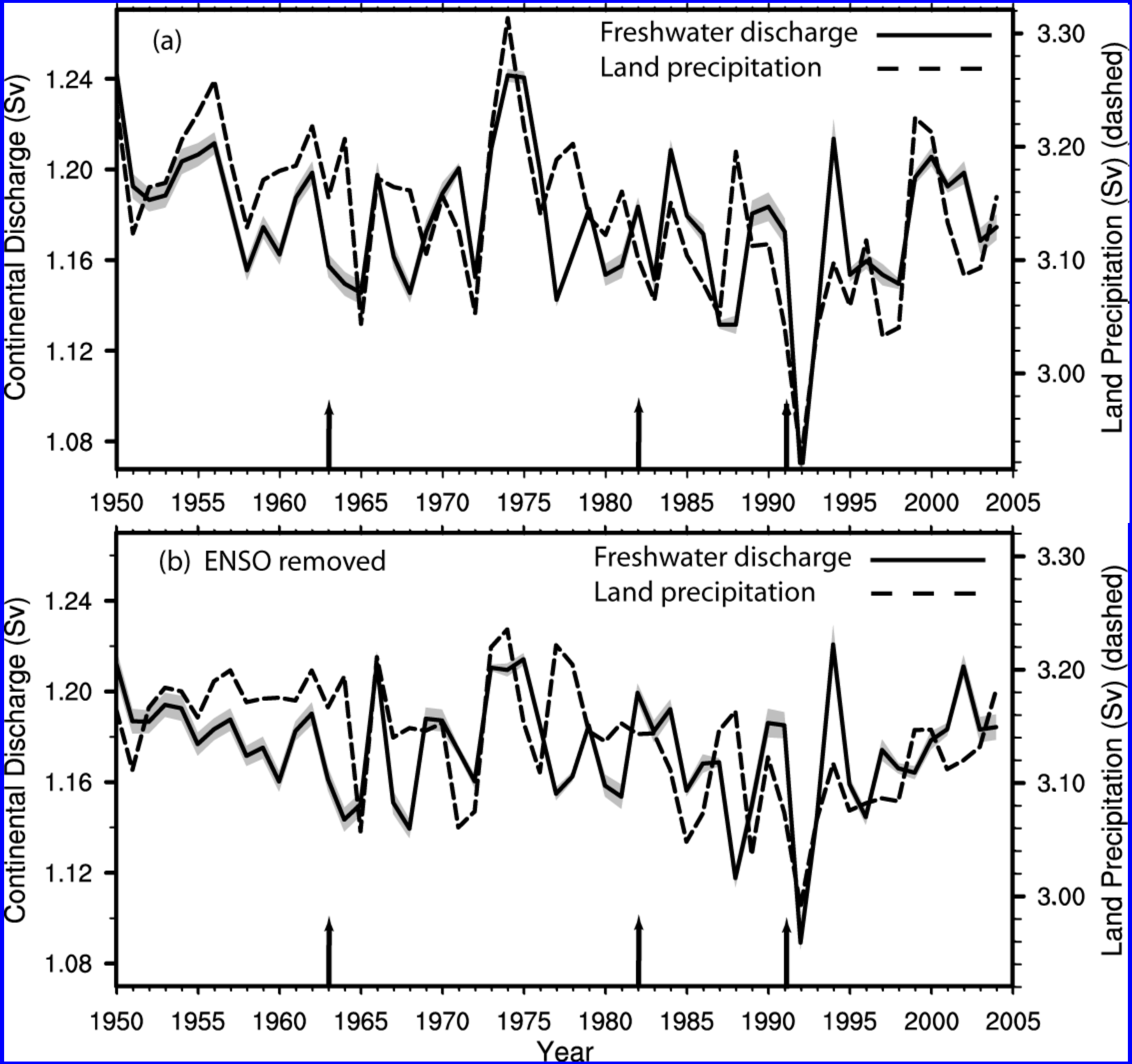
Sea level is rising:

from ocean expansion and melting glaciers



Main departures from linear trend are
1997-98 El Niño
and
2007-08 La Niña

Courtesy Steve Nerem



Annual (Oct-Sep) precipitation & land discharge based on observed streamflow plus missing data filled with CLM regression

R=0.62

ENSO removed using Nino 3.4 SSTs

Labat et al 2004 Adv Water Res

Used 221 rivers but focused on 10 reference rivers, 1880 to 1924, scaled with obsolete factors to give global values for period 1880 to 1994.

Our results show that the record prior to 1948 is not trustworthy as river data base is totally inadequate and analysis suffers from procedures used.

Trends are not reliable.

Gedney et al 2006 Nature (lots of hype)

Used the Labat et al trends, and applied a land surface model (like CLM3) forced with observed data and found they could not simulate the trends. But the trends were quite wrong and thus Gendey et al's conclusions that enhanced water efficiency in plants has no sound basis.

Neither our CLM3 simulation NOR the observed 925 streamflow discharge record analysis agree with the upward trends in Gedney et al.

Availability

The streamflow data set is freely available from http://www.cgd.ucar.edu/cas/catalog/

It is greatly superior to any other datasets available, with much more complete streamflow data, and vastly improved treatment of missing data in space and time.

Some data thru 2006