Global Water Cycle Variability and Change

Paul Houser (GMU)
Adam Schlosser (MIT)

CREW Center for Research on Environment and Water

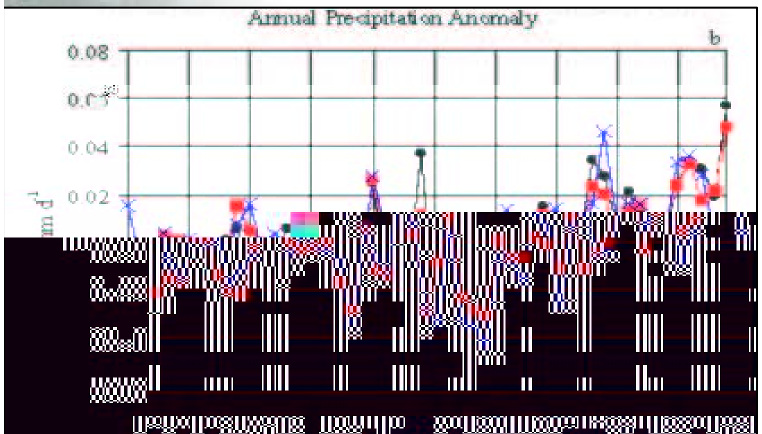
GEORGE MASON UNIVERSITY

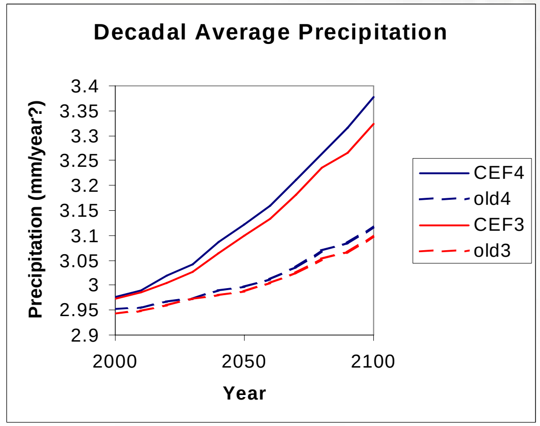
Water Cycle Research Making a Difference

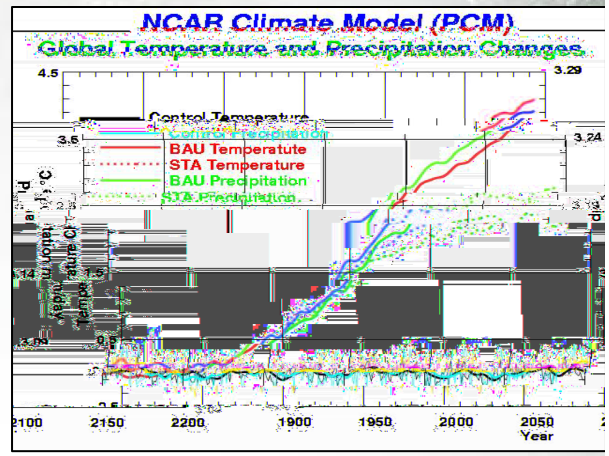
http://crew.iges.org

Motivation and Methodology

- Assess capability/consistency of “rate” changes in global water cycle detection.
- Assess our global-scale capabilities for providing an observed climatology and evaluation tool.







- Check for global balance/consistency:

$$\frac{dQ}{dt} = \langle E \rangle_{land+ocean} - \langle P \rangle_{land+ocean}$$

- Use optimal amount of satellite-based information from disparate data sets which comprise the major global water cycle components (i.e. atmos, ocean and land)

Global Water Budget Synthesis Products

Precipitation (1979-1999):

- Global Precipitation Climatology Project (GPCP): Adler et al., (2003)
- CPC Merged Analysis of Precipitation (CMAP): Xie and Arkin (1997)

Ocean Evaporation (1987-1999):

- Goddard Satellite-based Surface Turbulent Fluxes Version 2
  - GSSTF2: Chou et al., (2003)
- Hamburg Ocean Atmosphere Parameters and Fluxes from Satellites
  - HOAPS-G: Bentamy et al. (2003) and Fairall et al. (1996)

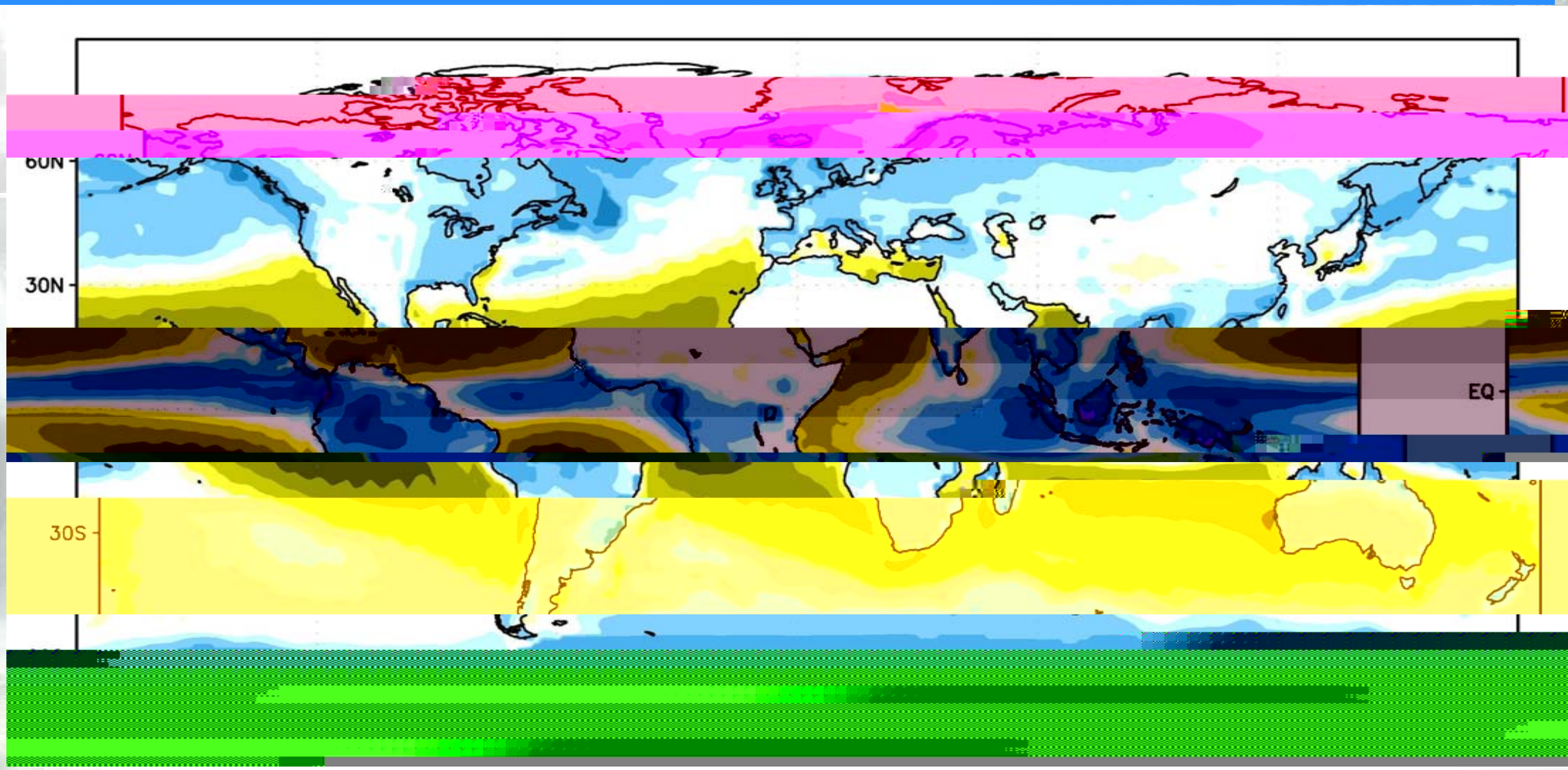
Land Evaporation:

- Global Offline Land Dataset (GOLD) Versions 1 (1979-1999) and Version 2 (1959-2002): Dirmeyer et al., (2005):
- ***Global Soil Wetness Project Phase 2 (GSWP2): 1986-1995***
  - ***13 Global land models forced with ISLSCP II data at 1° resolution***

Precipitable Water (1988-present): NASA Global Water Vapor Project (NVAP)

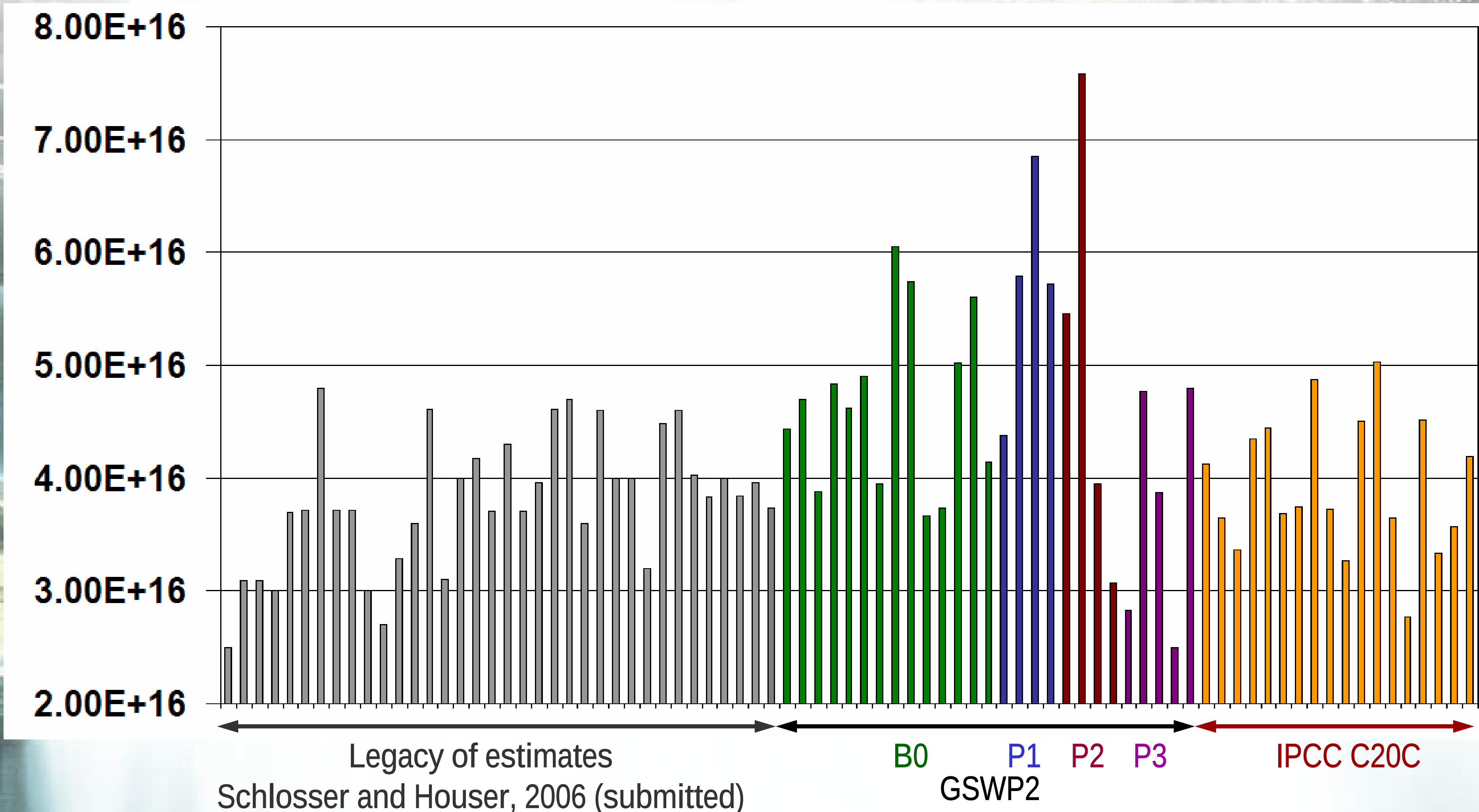
Model Output: IPCC Climate of 20th Century Runs

Geographic Distribution of Annual P-E (mm)



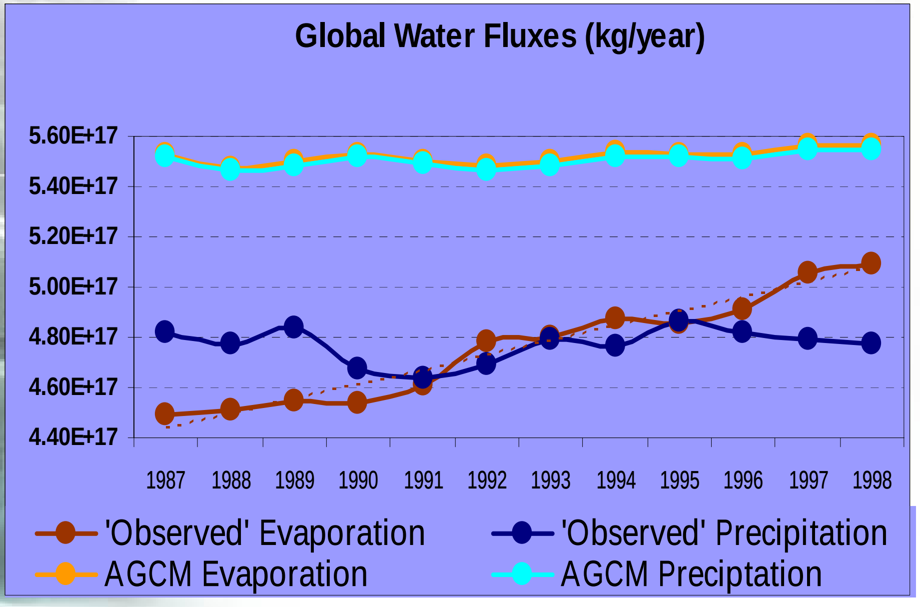
• Evaporation excess nearly ubiquitous over sub-tropical oceans, with a sharp contrast at coastal regions.
• Equatorial ocean evaporation minimum consistent with other findings (e.g. Seager et al., 2003).
• Tropical land areas show richest excess in precipitation.
• Major desert regions, tundra, and mountainous regions all indicate deficit to marginally-balanced conditions.
• Mid-latitude and boreal coastal/maritime environments exhibit adequate precipitation supply over evaporation.

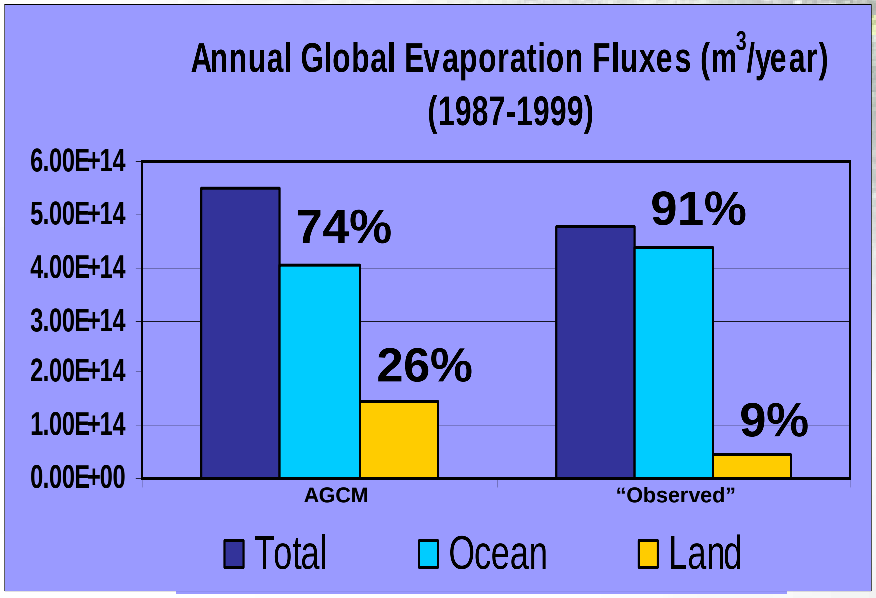
(Implied) Global Annual River Discharge



- Global fluxes comparable among the more recent estimates.
- Early 20th century fluxes highly variable and exhibit marginal trend.

AGCM Precipitation and Evaporation Evaluation





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- Observed averaged annual evaporation and precipitation mass flux balance to within 1%.
  - However, interannual global variations considerably uncorrelated.

- AGCM mean "rate" of annual global water cycle exceeds observed (~15%).
- AGCM interannual variability of annual global precip/evap ~50%/35% lower than observed.
- Relative contributions of land and ocean fluxes differ considerably.
  - What are the sources of these discrepancies (both in the models and "observations")?

- Trend in "observed" global evaporation (~1 %/year), but no trend in precipitation.
- Trend in AGCM global water-cycle rate during 1987-1999 and order of magnitude smaller.
  - Source of modeled trend from prescribed SSTs, is the response accurate?
  - Observations insufficient to detect AGCM trend (e.g. Ziegler et al., 2002).

Summary

- **Observationally-based estimates of global water fluxes balance, on an annual basis, to within 10% (~10^{16} kg/yr or ~50 teratons/yr) and fall within the range of previous estimates.**
  - Avg. U.S. yearly consumption ~10^{14} kg **(USDA)**
  - Total amount of water stored in atmosphere ~10^{16} kg
- **AGCM results imply more than a 0.1%/yr precision required for global trend detection, and consistency between precipitation and evaporation (e.g. Bosilovich *et al*., 2004).**
- **Ocean evaporation estimates require further attention, trend validation.**
- **For the forseeable future, global land evaporation estimates will primarily rely on model simulations/assimilation**
  - Veracity and quality of models and (forcing) data
  - Further analysis of GSWP 2 (1986-1995) land simulations
- **Extend/merge synthesis to current/pending satellites and complementary/blended data**
  - TRMM+constellation, GPM, EOS-Aqua/Terra and QuickScat
  - Clouds: e.g. ISCCP, CloudSat, CALIPSO
  - Other precipitation datasets – e.g. CMAP, GHCN, CRU
  - GRACE, IceSat, Aquarius, SMOS, etc…