Manifestations of Climate Change in Annual-Mean Runoff and Streamflow, with a Focus on the United States

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Atmosphere-Land Column Water Balance

Atmospheric Inflow

Atmosphere
- Water vapor
- Condensed water

Atmospheric Outflow

Precipitation

Evapotranspiration

Land
- Snow pack
- Mountain glaciers
- Surface water
- Soil water
- Ground water

(Net) River Discharge

(Net) Ground-water Discharge
Robustness of Hydrospheric Response

Atmospheric water content anomaly, 30S-30N over ocean; GFDL GCM; SMMR,SMM/I observations (Held and Soden, 2006)

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Gaged Streamflow Trends, 1900s

- Red: Streamflow decreased
- Blue: Streamflow increased
It now appears likely that a substantial part of global streamflow variability during the 20th century was not a random internal fluctuation of the climate system, but rather was caused by externally forced changes in climate.
Model-Projected Changes in Annual Runoff, 2041-2060
Percentage change relative to 1900-1970 baseline. Any color indicates that >66% of models agree on sign of change; diagonal hatching indicates >90% agreement.

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Changes in Annual Runoff

Colorado River at Lee’s Ferry

USGS Fact Sheet 2004-3062, Version 2, August 2004
Model results are scaled to match adjusted flow record from Webb et al. (2005), which has linear slope of 16%/century.
Colorado River at Lee’s Ferry

[Graph showing discharge predictions from various models and historical observations.]

USGS
Colorado River at Lee’s Ferry
Combined SF Bay Inflows

Sacramento at Sacramento, San Joaquin at Vernalis

Discharge (10^6 acre-feet)

- 20c3m
- sresa1b: -12.94%
- sresb1: -9.44%
- sresa2: -10.98%

Concluding Comments

• Climate models have significant, though imperfect, skill in characterizing regional trends in mean annual streamflow.

• Climate models project substantial regional changes in mean annual streamflow for the 21st Century.