Indicators of Water Cycle Acceleration from GRACE and NASA NEWS Datasets


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Session H34D: Understanding and Predicting Water and Energy Cycle Changes December 15, 2010
Outline

• Definition of water cycle acceleration

• What we might expect to see vs. what we are seeing
  – Emphasis on study of storage variations or constraining water balance with storage

• How will the water cycle behave in the future?

• What should we be doing about it?
Water Cycle Acceleration

• In a warming climate, we can expect more evaporation, and thus more precipitation and more runoff, i.e. bigger exchanges or more cycling of water in the water cycle

• Models suggest and observations are beginning to indicate that the magnitude and frequency of hydrologic extremes of flooding and drought will also increase

• Furthermore, models suggest a redistribution of precipitation from the mid-latitudes, to high and low latitudes

• GRACE is beginning to contribute to studies of water cycle change by closing the water budget, and also by providing some new storage, rather than flux-based metrics.
What might we expect to see?

Global mean water fluxes (1,000 km$^3$/yr) at the start of the 21st century, based on satellite and ground-based observations and data integrating models. A comprehensive assessment of the global water cycle is being carried out by a multi-institutional team of investigators supported by NASA’s Energy and Water Cycle Study (NEWS) program.

**Characterizing the global water cycle requires data and expertise that can only be harnessed through an integrative team effort, as is fostered by NEWS**
What might we expect to see?

\[ E_O \quad P_O \quad E_L \quad P_L \]

\[ S_O \quad Q_A \quad Q_L \quad S_L \]
What do we see?

Global ocean evaporation from OAFlux, HOAPS, SSM/I

Mean of OAFlux, HOAPS, SSM/I, annual cycle removed

Syed et al., 2010
What do we see?

Global ocean precipitation from GPCP and CMAP

Mean of GPCP and CMAP, annual cycle removed

Syed et al., 2010
What do we see?

Global discharge time series, 1994-2006

\[ R = \Delta M + E - P \]

- **R**: Global freshwater discharge
- **\( \Delta M \)**: Global ocean mass change from T/P & Jason-1 mean sea level variations.
- We compared GRACE \( \Delta M \) with that computed using ARGO floats, and to Ishii (2006) and Ingleby and Huddleston (2007). Comparisons were favorable so we used both Ishii and IH to compute global discharge
- **E**: Global ocean evaporation (from OAFlux, HOAPS, SSM/I)
- **P**: Global ocean precipitation (from CMAP and GPCP)

Emerging trends show increase in discharge of 540 km\(^3\)/yr\(^2\) or 1.5%/yr for the 13-year time period

Syed et al., 2010
What might we expect to see?
What do we see?

Mass changes in global water reservoirs from GRACE, 2002-2010

Trends (mm/yr)
- Ocean = 1.2 ± 0.3
- Land = 0.3 ± 0.5
- Greenland = -0.60 ± 0.1
- Antarctica = -0.40 ± 0.2
What do we see?

- Amplitude of annual storage cycle provides a direct measure of water cycle strength

- Changes in amplitude provide a new, integrated and measurable metric of water cycle acceleration

- Amplitude of both land and ocean storage signal has increased by 0.3 mm/yr

- Ocean changes in this time period are primarily due to increasing evaporation, river discharge and ice melting
What might we expect to see?

IPCC AR4, Projected Patterns of Precipitation Change

Figure SPM.7. Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change.
How will the water cycle behave in the future?
Summary

• A largely storage driven assessment of water cycle change suggests that water cycle acceleration is the norm.

• NASA NEWS project is providing new metrics to quantify and understand these changes

• These and other metrics and datasets will be carefully monitored in the coming years as part of a comprehensive and ongoing assessment of the state of the water cycle

• The implications for increasing energetics, i.e. for changes in extremes, must be very carefully evaluated. It is not clear that our models can yet reproduce some of the metrics we discussed today, and therefore accurately predict future changes

• Data acquisition and model development should focus on better characterization and prediction of these changes. Dissemination of key advances and results should target informed decision making.