GRACE and Human Impacts on the Water Cycle

Matt Rodell, Ph.D.

Chief, Hydrological Sciences Laboratory
NASA Goddard Space Flight Center
Greenbelt, MD
Conventional radiation-based remote sensing technologies cannot sense water below the first few centimeters of the snow-canopy-soil column. GRACE is unique in its ability to monitor water at all levels, down to the deepest aquifer.
Terrestrial Water Storage Variations

TWS variations are dominated by:
- Soil moisture in temperate regions;
- Snow in polar and alpine regions;
- Surface water in the wet tropics.
Emerging Trends in Terrestrial Water Storage from GRACE

• Best fit linear rate of change of TWS (cm/yr).
• Based on JPL/Tellus GRACE mascon land hydrology product.
• Which apparent trends are real and likely to continue?
Exploitation of Water Resources

Percentage of Irrigated Area

Source: FAO and University of Frankfurt

Groundwater Depletion Rate (ca. 2000)

Wada et al. (2010)

Net Consumptive Use of Ground and Surface Waters, 1998-2002

Equivalent height of water (mm/yr)

Döll et al. (2011)

Terrestrial Water Storage “Trends” from GRACE

Equivalent height of water (mm/yr)

Equivalent height of water (cm/yr)
• Best fit linear rate of change of TWS (cm/yr).
• Based on JPL/Tellus GRACE mascon land hydrology product.
• Which apparent trends are real and likely to continue?
Annual irrigation water use ca. 2000 reported by the USGS at the county level in cubic kilometers, from Ozdogan et al., J. Hydrometeor., 2010.
Increase in evapotranspiration due to irrigation, from Ozdogan et al., *J. Hydrometeor.*, 2010. The increase in ET due to irrigation, averaged over the entire contiguous U.S., was 4% during the growing season, which is a huge impact on the water budget that also affects temperature and the energy budget.