2005 drought event in the Amazon River basin as measured by GRACE and estimated by climate models

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Satellite gravity measurements from the Gravity Recovery and Climate Experiment (GRACE) provide new quantitative measures of the 2005 extreme drought event in the Amazon river basin, regarded as the worst in over a century. GRACE measures a significant decrease in terrestrial water storage (TWS) in the central Amazon basin in the summer of 2005, relative to the average of the 5 other summer periods in the GRACE era. In contrast, data-assimilating climate and land surface models significantly underestimate the drought intensity. GRACE measurements are consistent with accumulated precipitation data from satellite remote sensing and are also supported by in situ water-level data from river gauge stations. This study demonstrates the unique potential of satellite gravity measurements in monitoring large-scale severe drought and flooding events and in evaluating advanced climate and land surface models.


1. Introduction

In the summer of 2005, the Amazon basin experienced an extreme drought. Many areas, especially in the west and south, suffered the worst drought in over a century, leading to official declarations of "public calamity", forest fires, crop losses, and economic havoc [Rohter, 2005]. The event appears connected both to the 2002-03 El Niño and to abnormal warming of the northern tropical Atlantic, which was up to two degrees warmer than average [Zeng et al., 2008a]. This paper compares measures of this event taken from satellite gravity observations and from data-assimilating hydrologic models.

Understanding and quantification of drought occurrence, extent, and intensity is limited by conventional data resources. Numerical climate models are valuable in analyzing and diagnosing climate variability, but quantifying and simulating abnormal events such as droughts remains a major modeling challenge. Prediction is an even greater challenge. Conventional observations, especially in situ meteorological and hydrological samples, are limited in both space and time. Furthermore, model representations of dynamical connections between boundary conditions and extreme climate events tend to be poor.

Terrestrial water storage (TWS) change, a major component of the global water cycle, includes changes in water stored in soil, as snow over land, and in ground water reservoirs. TWS change reflects accumulated precipitation, evapotranspiration, and surface and subsurface runoff with-