

Variations of land water storage over the last half century

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Using a land surface model (LSM), we can compute the hydrological balance over land and assess the continental water storage variations. These estimations can be carried out in 2 different modes; one is by using integrations of General Circulation Models where the LSM is included; the other is to integrate the LSM alone, which requires knowing atmospheric forcing data. To evaluate the realism of the simulated variations, we need to have some evaluations of the continental water budget from observations. Here, we will show that we can use alternatively the mean sea level measured by Topex-Poseidon for global storage, river discharge or recently Grace Mission for regional budgets.

The LSM used in these studies is the Orchidee LSM (Verant et al., 2004, Krinner et al., 2005). This model represents the water and energy cycle, the carbon cycle as well as the ecological processes. For this presentation, we have only used the water and energy components, which are derived from Sechiba. The water, which leaves the soil reservoir either through runoff or drainage, is stored in the three reservoirs of the routine scheme and cascades progressively towards the ocean (Fig. 1). Each reservoir is characterized by a different time constant with the fastest being considered as the stream flow. Generally, runoff routine schemes compute the river flows in an off-line mode, using output of runoff simulated in GCMs or LSMs. In this presentation, the river routing scheme was included in the LMD GCM.

AMIP integrations were carried out with the LMD GCM. They include El Nino 1997-1998 event. Over the period of T/P observations (from 1992 to present), we focus on the inter-annual variability of continental water between these two contrasted years. We infer the continental water budget, using T/P altimetry data and the recently released historical data of ocean subsurface temperature from Ishii et al. (2003). The drastic change between the 2 years, 1997 and 1998, is compared to the result simulated with the LMD GCM. (Ngo-duc et al., 2005a). We show that the AMIP Simulation reproduces accurately the seasonal variation of sea level due to land water mass and, also the contrast between the 2 years. The analysis of the model result shows that the inter-annual variation is caused mainly by the land tropical precipitation change. The study of the AMIP simulation shows that, over tropical latitudes, a substantial drying of soil is occurring during 1997 but soil moisture is hardly changing at these latitudes during 1998 (Fig. 2).

In order to study the inter annual variability of surface conditions over a larger number of years, we have built a forcing data set, NCC, based on reanalysis data, NCEP, corrected by CRU precipitation. We were able to define 53 years of data as forcing to Orchidee Model; and compute the evolution of land water storage over the last 53 years (Ngo-duc et al., 2005b). These results were validated by observed river discharges of the world's 10 largest rivers. One example is shown in Fig. 3.

The evolution of this continental water budget is used to analyse trends of this storage. (Ngo-duc et al., 2005c). Over the last 53 years, no significant trend is detected in this numerical experiment but there is a strong low frequency (10-20 years) variability in the land water storage. This low frequency variability originates in the tropics, mainly. The contribution of land water to sea level, simulated by Orchidee is highly anti-correlated with the thermal expansion of oceans, evaluated from global ocean temperature data set. This result indicates that a warming of the oceans, that induces the thermal expansion, accelerates the water cycle over land, which compensate partly the expansion by a reduction of sea level.

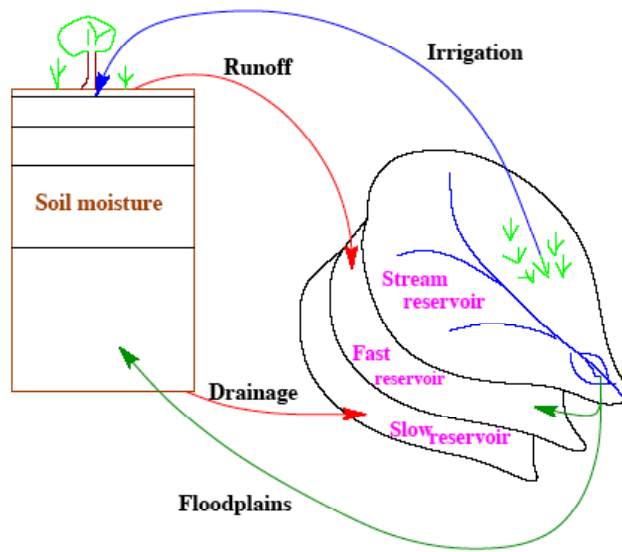


Figure 1. Principle of the river routing scheme.

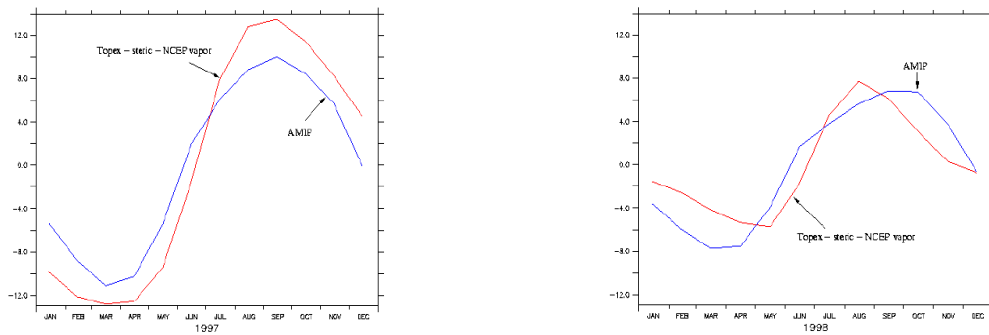


Figure 2: Contribution of continental water to sea level variations simulated by AMIP simulations and obtained from observations.

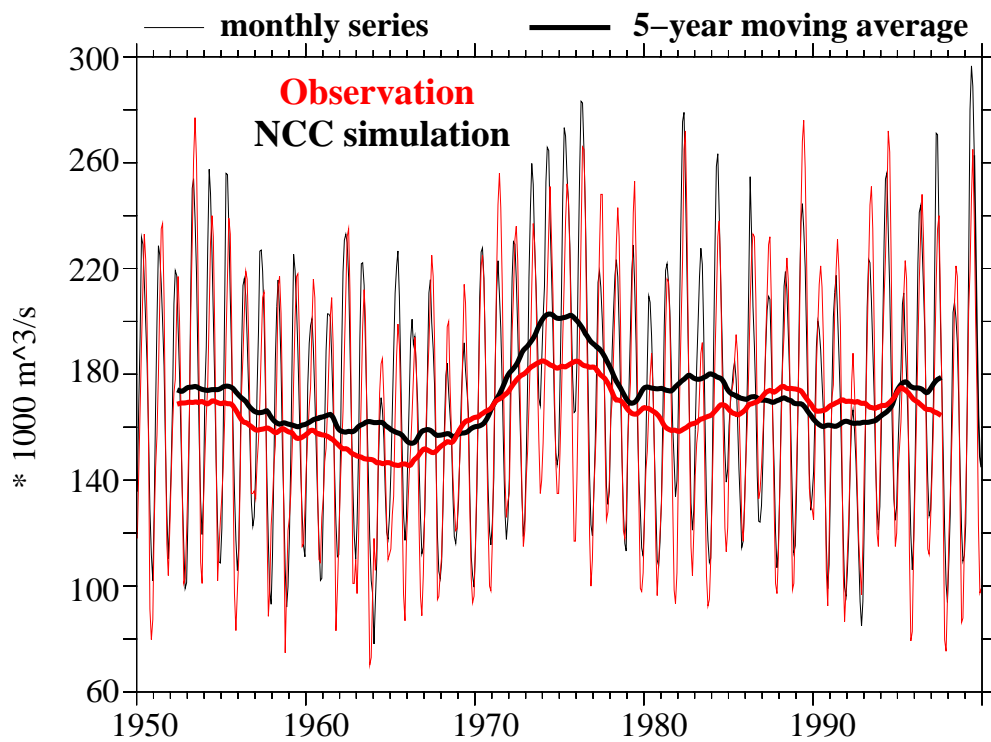


Figure 3: Discharge at Obidos, Amazon. Comparison between NCC simulation and observations of the HYBAM group (Callede et al., 2004).

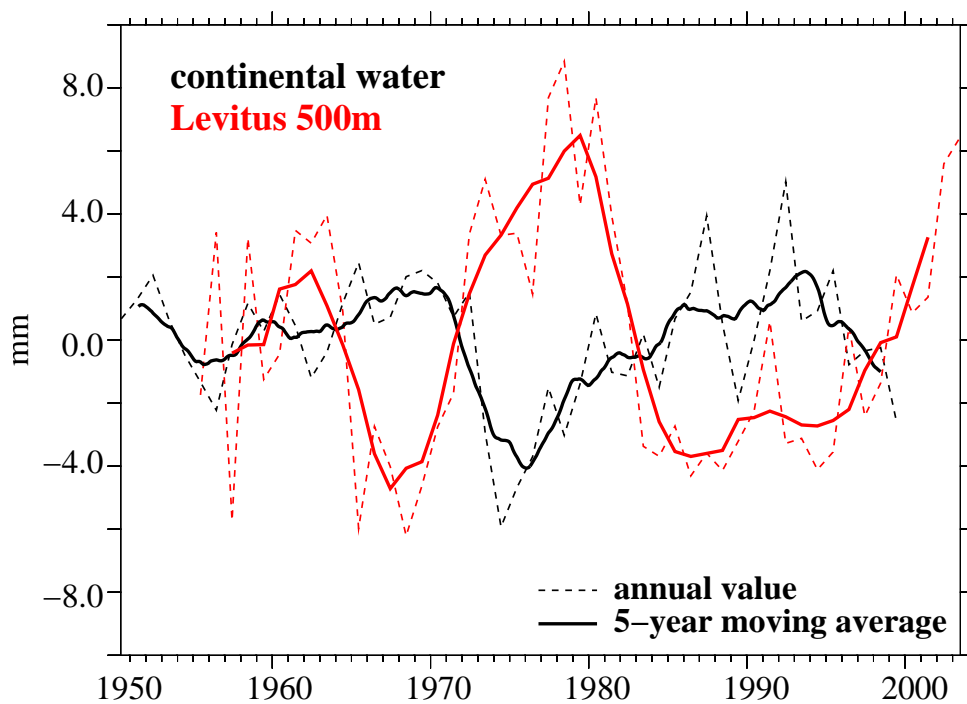


Figure 4: Time series of changes expressed as equivalent global sea level anomalies (mm) for the past 53 years. Land water storage simulated by Orchidee and Levitus thermosteric down to 500 m.

References

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