# Oceanic Influence on Global Hydrologic Cycle Observed from Space

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**Abstract**

The divergence of moisture transport integrated over the depth of the atmosphere over global oceans show similar geographic distribution as the surface fresh water flux (evaporation-precipitation). The temporal variations of the two terms also agree, from intraseasonal to interannual time scales, at selected locations. These two forcing terms were found to lead ocean surface salinity changes by 90° as expected. The interannual anomalies of the hydrologic parameters in the high latitude regions of North American and Eurasia are found the be opposite in phase, and their differences are found to have significant correlation with the moisture transport in the North Atlantic, suggesting N. Atlantic moisture transport is a bridge to the opposing hydrologic phases of the two continents.

## 1 Introduction

Past studies of oceanic influence on terrestrial hydrological cycles were consisted largely of showing the relation between precipitation over landmasses and the surface temperature of surrounding oceans, based on numerical model simulation and analysis of model products. The long-term acceleration of the hydrologic cycle was mainly demonstrated through its manifestation in the radiation budget. We have derived hydrologic parameters over global oceans using newly available and high-resolution space-based data, particularly those from the Tropical Rain Measuring Mission and QuikSCAT, making use of our pioneering effort and unique expertise in space-based observations of surface evaporation and moisture transport. The closure of the hydrologic balance in the atmosphere using spacebased data and ocean's response to the hydrologic forcing are demonstrated in Section 2. An example of application, showing the bridging of North American and Eurasia hydrologic balance through the moisture transport in North Atlantic, is discussed in Section 3.

## 2 Hydrologic Balance Over Ocean

The natural law on the conservation of mass governs the hydrologic balance in the atmosphere. The temporal change in water storage and the divergence of the moisture transport integrated over the depth of the atmosphere $\Theta$ has to balance the fresh water flux at the surface. The fresh water flux at the surface is the difference between evaporation (E) and precipitation (P). The temporal change of water storage can only be transient, and, when averaged over time, the balance is between $\nabla\cdot\Theta$ and E-P. Monitoring these two terms is critical to the characterization of the hydrological cycle and climate change. Direct in situ measurements of $\Theta$, E, and P are extremely sparse over ocean. While microwave radiometers can be used to estimate E and P, the estimation of $\Theta$ requires additional dynamic parameters, which must comes from the scatterometer.

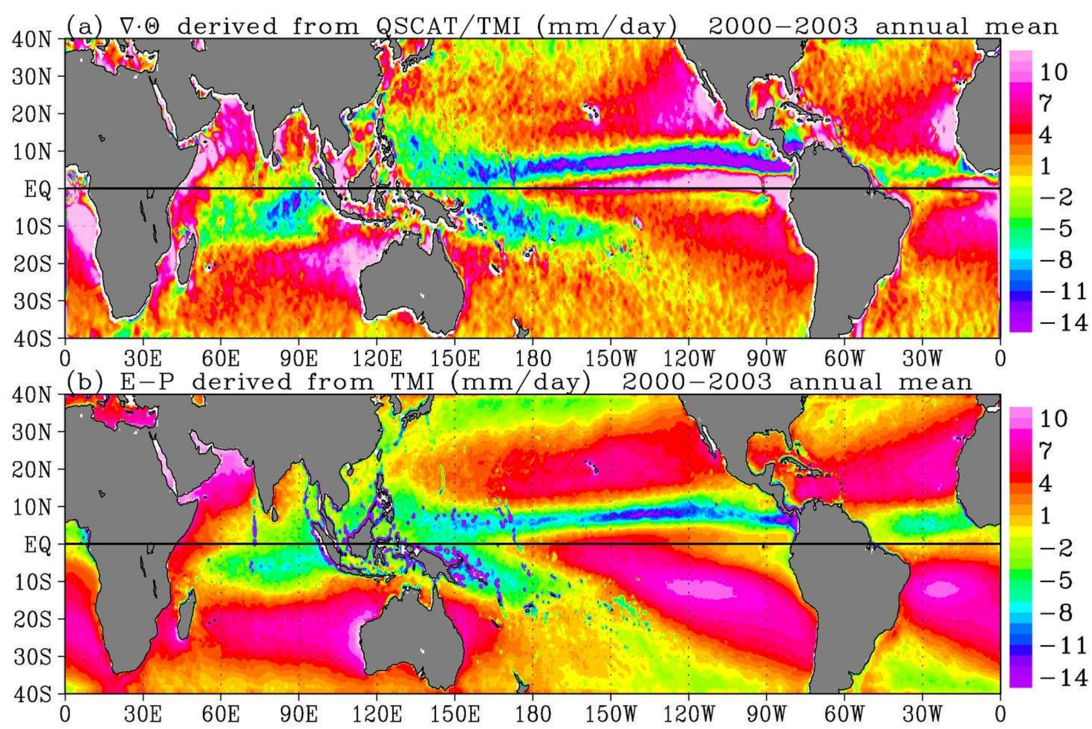



Fig. 1 Annual mean (from 2000 to 2003) distribution of (a) $\nabla\cdot\Theta$, and (b) E-P derived from QuikSCAT and TMI data.

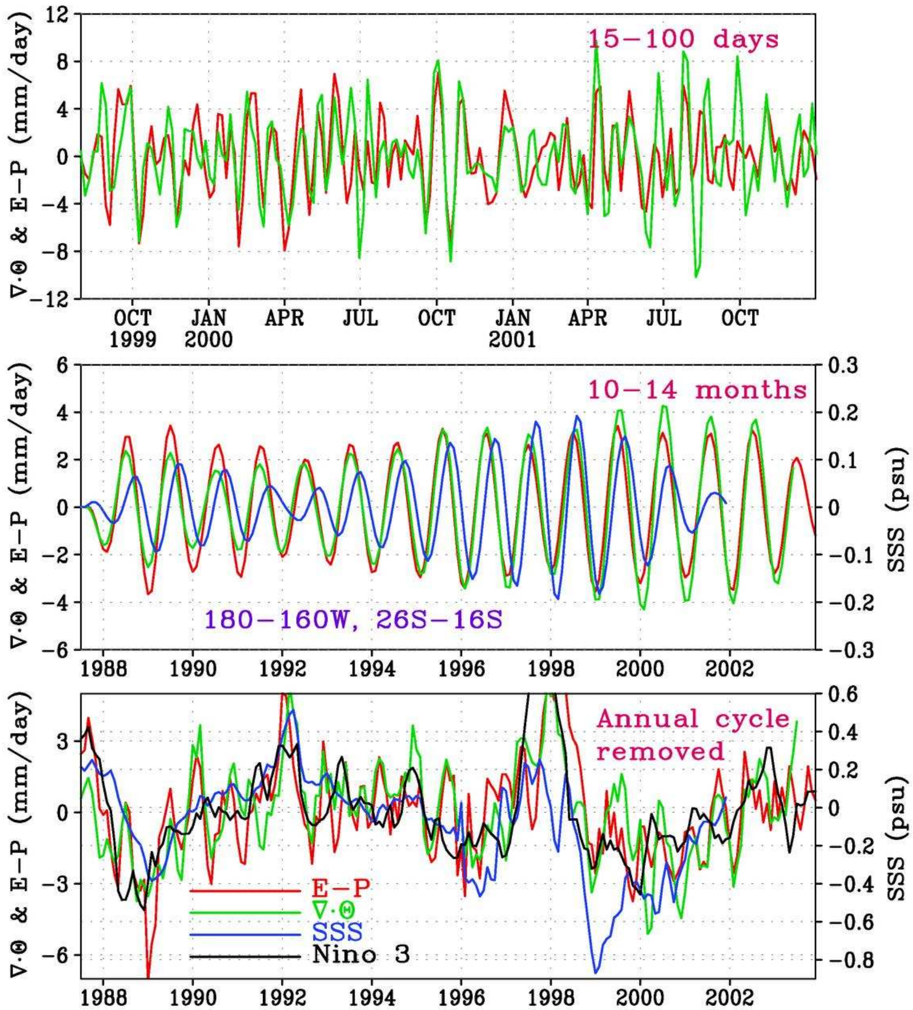


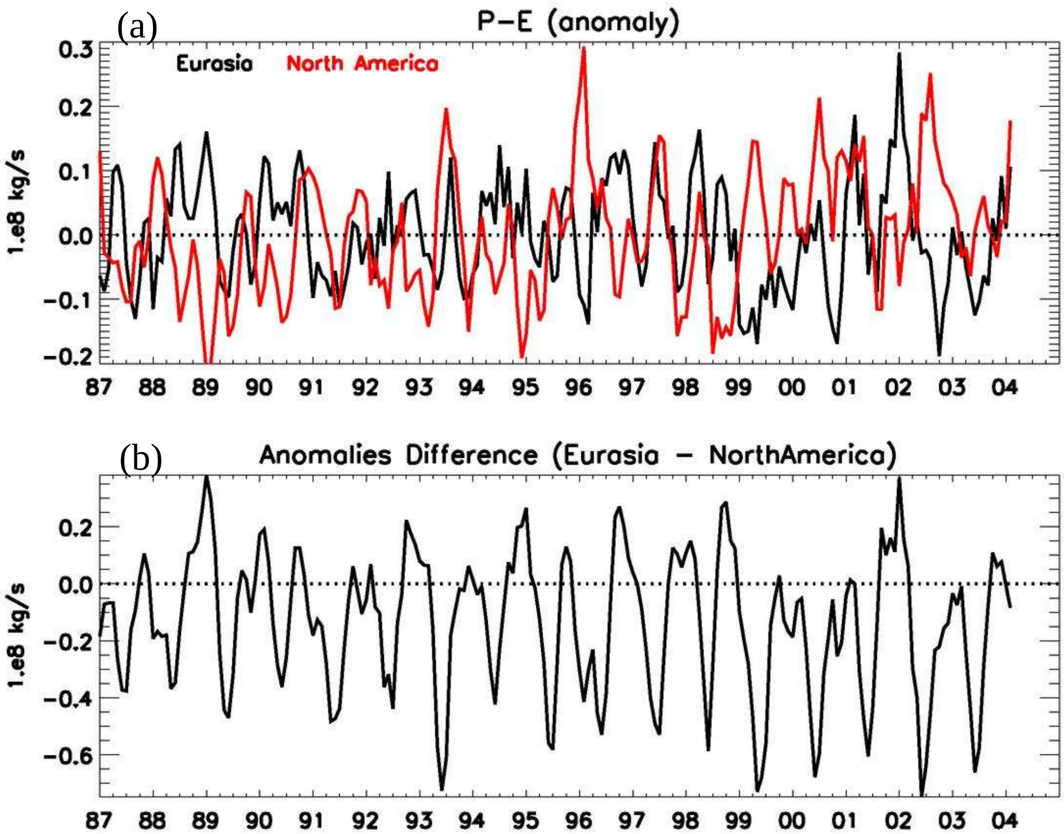

Fig. 2 Time series of $\nabla\cdot\Theta$ and E-P between $180^o$-$160^o$W and $16^o$S-$26^o$S for (a) 15-100 days, (b) 10-14 months, and (c) interannual anomalies. Sea surface salinity (SSS) and Nino3 index are superimposed.

Instruments on the Tropical Rain Measuring Mission (TRMM) have provided estimation of P over oceans for many years. Liu and Niiler (1994) pioneered a method for estimation of E using microwave radiometer data. The method has been applied in many studies of ocean-atmopsheric interaction and climate changes [e.g. Liu et al., 1994] and subsequent improvements were reviewed by Liu and Katsaors (2001). The method to estimate $\Theta$, using a combination spacebased radiometer and scatterometer was recently demonstrated by Liu and Tang (2005). The three terms, $\Theta$, E and P, were estimated independently, using QuikSCAT and TRMM Microwave Radiometer (TMI) data, by Xie and Liu (2005). The similar geographical distributions of $\nabla\cdot\Theta$ and E-P as shown in Fig. 1, is one of the best validation of the estimation techniques and a clear demonstration of the science synergism of the two instruments.

Xie and Liu (2005) also selected two regions where long time series of salinity measurements are available provided by repeated ship tracks. In the South Pacific, as shown in Fig. 2, $\nabla\cdot\Theta$ and E-P agree from intraseasonal to interannual time scales. For the annual cycle, E-P and $\nabla\cdot\Theta$ agree well, but they lead salinity change by three months, as expected. If the annual cycle is sinusoidal, the change of forcing should be contemporary with the time rate of change of salinity but in quadrature with salinity.

### 3 Bridging North America and Eurasia

The differences between precipitation and evaporation/transpiration over North America and Eurasia, north of 50°N, derived from both in situ observations and operational numerical weather prediction products were made available through ArcticRIMS (Regional Integrated Hydrological Monitoring System for the Pan-Arctic Land Mass) [Lammers et al., 2002, Serreze et al., 2003]. The time series of interannual anomalies P-E integrated over N. Amereica (red) is almost opposite in phase with the time series integrated over Eurasia (black) in Fig. 3a. The difference



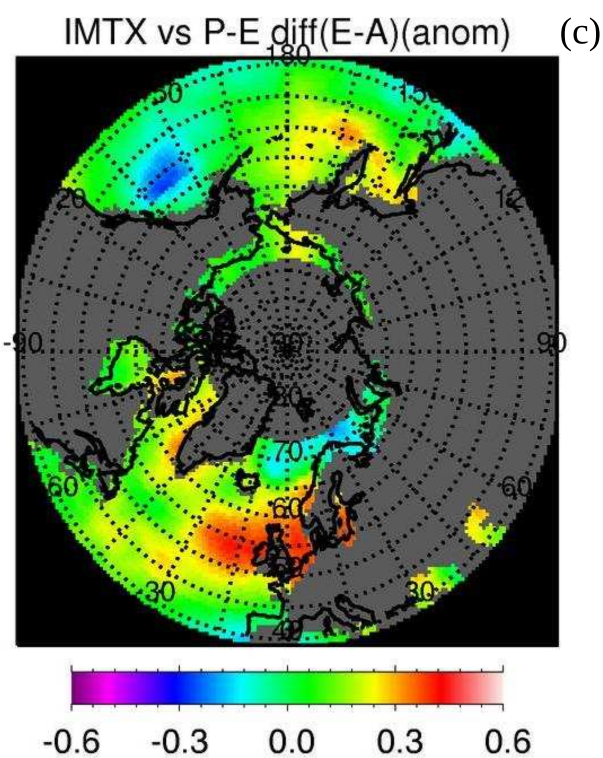




Fig. 3 (a) Time series of P-E anomalies integrated over Eurasia (black) and over North America (red) from 50°N to 80°N. (b) Difference between the two time series shown in (a). (c) Correlation coefficients between the difference time series shown in (b) and the zonal component of moisture transport derived from the Special Sensor Microwaver/Imager (SSM/I).

between the anomaly time series for the two continents, shown in Fig. 3b, has significant correlation coefficient with the time series of zonal component of Θ over major areas of the N. Atlantic, as shown in Fig. 3c. The opposite phases of the hydrologic balances over the arctic regions of the two continents are closely linked to the moisture transport over the N. Atlantic.

**Acknowledgment**

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