NEWS Progress Assessment 2010

Investigator

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Proposed

Study water and energy balances over ocean and the influence on terrestrial water cycle

Accomplishments

1 We have successfully derived water transport integrated over the depth of the atmosphere from spacebased observations, the divergence of which is the fresh water flux between the ocean and the atmosphere (evaporation-precipitation). We validated our classical method of estimating surface evaporation through dedicated field experiment. See publication 1, 6, and 8.

2 The mean value of ocean surface water flux is found to agree with those from MERRA model provided by NEWS. The historic value given in the textbook of Budyko published 36 years ago is found to be 20% too high. (see our presentation in 2009 Columbia meeting)

3 The annual variation of the flux with the climatological river discharge from continent subtracted agrees with ocean mass loss measured by GRACE both in amplitude and in phase. It also implies there is 20% uncertainty in the time variable river discharge.

4 Through Green's theorem, the continental water balance over South America was examined. The mean flux is 4% higher than Budyko's value. The atmospheric water influx minus river discharge agrees with the mass change in phase and amplitude of the annual cycle, with 13% uncertainties. (Publication 3)

5 The moisture transport we derived has been used in the study of MJO with Duane Waliser (Publication 9), in South Great Plain rainfall extremes with Xiquan Dong. We are applying the data to resolve the Sahel Precipitation Jump Paradox (Publication 10), and the oceanic source of East Asian rainfall at various time-scales. We have examined the anchoring effect of local mountains on monsoon rain (Publication 4).

6 Study how change of river discharges from Amazon and Yangtze Rivers affect the ocean (Publications 2 & 7).

7 We have revealed the penetrating effect of mid-latitude ocean fronts on the water and radiative balances near the Tropopause, way above the atmospheric boundary layer (Publication 5).

Significance

By successfully developed methodologies to estimate two major components of the water cycle; atmospheric moisture transport and surface water exchange over global oceans from spacebased observations (the latter through two separate approaches), we, for the first time, provide adequate temporal and spatial coverage for measurements of these two major parameters. The agreement with water conservation principles (closure), with GRACE data, in the long term mean and seasonal cycle lends credibility to the spacebased measurements and put quantitative uncertainty of continental and polar discharge of water to the ocean to within 20%.

Ocean closure could be translated to continental closure through the Green's theorem. South America, being almost entirely enclosed by open ocean and has the largest water change signal, gives the best result with only a few percents of uncertainty in the long term mean and slightly above 10% uncertainty in the monthly variation.

The unique utility of moisture transport integrated over the depth of the atmosphere is clearly demonstrated in studying the Sahel precipitation jump paradox and the Southern Great Plain extremes, where the surface moisture transport has significant seasonal difference from the transport aloft.

Although our major goal in NEWS study is to examine ocean's role in continental water balance, we also have worked with other investigators to reveal the effect of the change of two major rivers discharges on ocean current, salinity, and biological productivities.

The spacebased surface water and energy fluxes we produce also contribute to the computation of the ocean meridional heat and water flux, which is the major factors that governs Earth's moderate climate and is a major national and international research endeavor.

The coupling of the small and slow processes of the ocean to the transient and large-scale processes of the atmosphere, particularly in the extratropical latitudes, has been controversial. The atmospheric lapse rate is believed to be too weak to generate deep convection to transfer the effect of oceanic processes high enough in the atmosphere to be effective on the coupling. Past studies did not show the effect of local sea surface temperature changes beyond the boundary layer particularly in long time scales. Through satellite temperature and rain profiles, and cloud top radiative parameters, we revealed that the signatures of sea surface temperature and surface stress in mid-latitude ocean fronts penetrate way above the atmospheric boundary layer.

The results of our investigations contributes to and benefitted from other NASA Earth Science programs: Precipitation Measuring Mission (TRMM and GPM), Ocean Vector Wind Science Team (QuikSCAT), Ocean Surface Topography Science Team

(JASON), Ocean Surface Salinity Science Team (Aquarius), Sea Surface Temperature Science Team (AMSR-E and MODIS), Atlantic Meridional Overturning Current (AMOC) Science Team, and is at cross-cutting front of the international CLIVAR and GEWEX Programs. There are potential and plan to link with Carbon Cycle studies and the related space missions.

Publications

In the past five years, we have published 82 peer-reviewed papers. The following ten are most relevant to NEW objectives:

10 Liu, W. T., X. Xie, and K. B. Katsaros, 2010: Oceanic origin of the precipitation jump in the Sahel, J. Climate, submitted.

9 Waliser, D. E., B. Tian, X. Xie, W. T. Liu, M. J. Schwartz, and E. J. Fetzer, 2009: How well can satellite data characterize the water cycle of the Madden-Julian Oscillation? *Geophys. Res. Lett.,* **36**, L21803, doi:10.1029/2009GL040005.

8 Zeng, L., P. Shi, W. T. Liu, and D. Wang, 2009: Evaluation of a satellite-derived latent heat flux product in the South China Sea: A comparison with moored buoy data and various products. *Atmos. Res.,* **94**, 91-105.

7 Yan, X., Y. Jo, L. Jiang, Z. Wan, W. T. Liu, Y. Li, J. Zhan, and T. Du. 2008: Impact of the Three Gorges Dam water storage on the Yangtze River outflow into the East China Sea, *Geophys. Res. Lett.*, **35**, L05610, doi:10.1029/2007GL032908.

6 Xie, X., W.T. Liu and B. Tang, 2007: Spacebased estimation of moisture transport in marine atmosphere using support vector machine, *Remote Sens. Environ.*, **112**, 1845-1855.

5 Liu, W.T., X. Xie, and P.P. Niiler, 2007: Ocean-atmosphere interaction over Aqulhas Extension Meanders. *J. Climate*, **20**, 5784-5797.

4 Xie, S.-P., H. Xu, N.H. Saji, Y. Wang, and W.T. Liu, 2006: Role of narrow mountains in large-scale organization of Asian monsoon convection. *J. Climate,* **19**, 3420-3429.

3 Liu, W. T., X. Xie, W. Tang, and V. Zlotnicki, 2006: Spacebased observations of oceanic influence on the annual variation of South American water balance, *Geophys. Res. Lett.*, **33**, L08710, doi:10.1029/2006GL025683.

2 Jo, Y.-H., X.-H. Yan, B. Dzwonkowski, and W.T. Liu, 2005: A study of freshwater discharge from the Amazon River into the tropical Atlantic using multi-sensor data. *Geophys. Res. Lett.*, **32**. L02605, doi:10.1029/2004GL021840.

1 Liu, W.T. and W. Tang, 2005: Estimating moisture transport over ocean using spacebased observations from space. *J. Geophys. Res*. **110**, D10101, doi:10.1029/2004JD005300.