Potential Scientific Applications of SeaWinds and Its Follow-on

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Abstract
An example of combined use of spacebased scatterometer, microwave radiometer, and ocean color sensor in the study of extratropical ocean-atmosphere coupling is demonstrated. A new concept that combines both active and passive microwave measurements into a single sensor sharing a large antenna to provide high resolution measurements that will close the hydrologic balances is proposed.

1 Introduction

Spacebased microwave scatterometers give us measurements of ocean surface wind vectors under clear and cloudy conditions, day and night. They provide not only a near-synoptic global view, but also details that cannot be achieved with operational numerical weather prediction models. Such coverage and resolution are crucial to understand and predict changes in weather and climate. The past decade has seen continuous improvement to the coverage and resolution of ocean surface winds measured by spacebased scatterometers. Liu [2002] gave a review of the spacebased scatterometers and their scientific impacts. The SeaWinds scatterometer was launched with the Advanced Microwave Imager Scanning Radiometer (AMSR) and the Global Imager (GLI) on the Advanced Earth Observing Satellite (ADEOS)-II. Despite the early demise of ADEOS-II, the potential of strong sensor and science synergisms among the three sensors are still valid. An example on combined use of the three types of sensors is given in Section 2, and a concept of future mission is discussed in Section 3.

2 Extra-tropical Ocean Atmosphere Interactions

The ocean has long memory and its feedback to the atmosphere governs climate changes. Ocean processes are of much smaller scales and longer time scales than the atmospheric processes, and ocean-atmosphere coupling or the equivalent climate-weather interaction mechanisms, particularly over extra-tropical oceans, have been controversial. The five years time series of QuikSCAT high-resolution winds has begun to define the mean state and seasonal cycle with sufficient reality, and the removal of which has just revealed small scales and persistent wind features associated with oceanic fronts, which have never been observed when long time series of high-resolution winds were not available.

Fig.1 and Fig. 2 clearly demonstrated the relation between mesoscale ocean eddies, as manifested in sea surface temperature (SST) observed by microwave radiometer and surface wind divergence in the southern ocean along the Antarctic Circumpolar Current (ACC) and the western boundary current extensions. Similar patterns exist in the Agulhas current and Kuroshio extension. Zonal means have been removed from these data. Westerly wind anomalies are collocated with warm SST anomalies, and easterlies are collocated with cold SSTs, so that surface wind convergence is in quadrature with SST. The in-phase relationship between SST and surface wind speed indicates the ocean forcing through boundary layer mixing mechanism [Liu et al., 2000]. Evaporative cooling is enhanced over areas of collocated warmer water and higher wind speed and reduced over areas of the lower SST. Positive water vapor (in Fig. 1) and cloud liquid water (in Fig. 2) anomalies are located slightly to the east of the warm SSTs, possibly attributed to both the surface convergence to the east and enhanced evaporation over the warm SSTs. For 1° warming in SST, increase of latent heat from the ocean is 30-50 W/m^2, wind speed 0.6 m/s, and cloud liquid water 0.015 mm.

The similar and persistent patterns of atmospheric cloud liquid water and chlorophyll (biological production caused by upwelling of nutrients) suggest that coupling may not be confined to the atmospheric boundary layer and ocean mixed layer. Further studies are underway.

3 A New Mission Concept

The Japan Aereospace Exploration Agency (JAXA) is proposing a new mission called Global Change Observation Mission –W (GCOM-W). The first mission will carry a microwave scatterometer and radiometer. The sensor and science synergisms are discussed by Ebuchi and Liu [2005]. GCOM is not a single mission but consists of three consecutive satellites. It will preserve and extend time series of the critical parameters, such as ocean surface vector winds, sea surface temperature, atmospheric water vapor, and precipitation measured by SeaWinds and AMSR, while allowing the infusion of new technology for improved and expanded applications in the later missions. It may achieve both the goals of encouraging new and exciting technology while keeping the coherent policy relevant objective of long-term climate and environment changes.

We are proposing a single instrument for launch on later GCOM missions that combines active and passive microwave concepts and provide co-incident and improved measurements of many key oceanic, atmospheric, land surface and sea ice parameters, now being measured and will be measured by separate on-going and planned space missions. By sharing a 6-m rotating parabolic deployable mesh antenna for active and passive microwave channels from 1.26 to 37 GHz, made feasible by recent advances in antenna technology, we will enhance the spatial resolutions of many parameters and

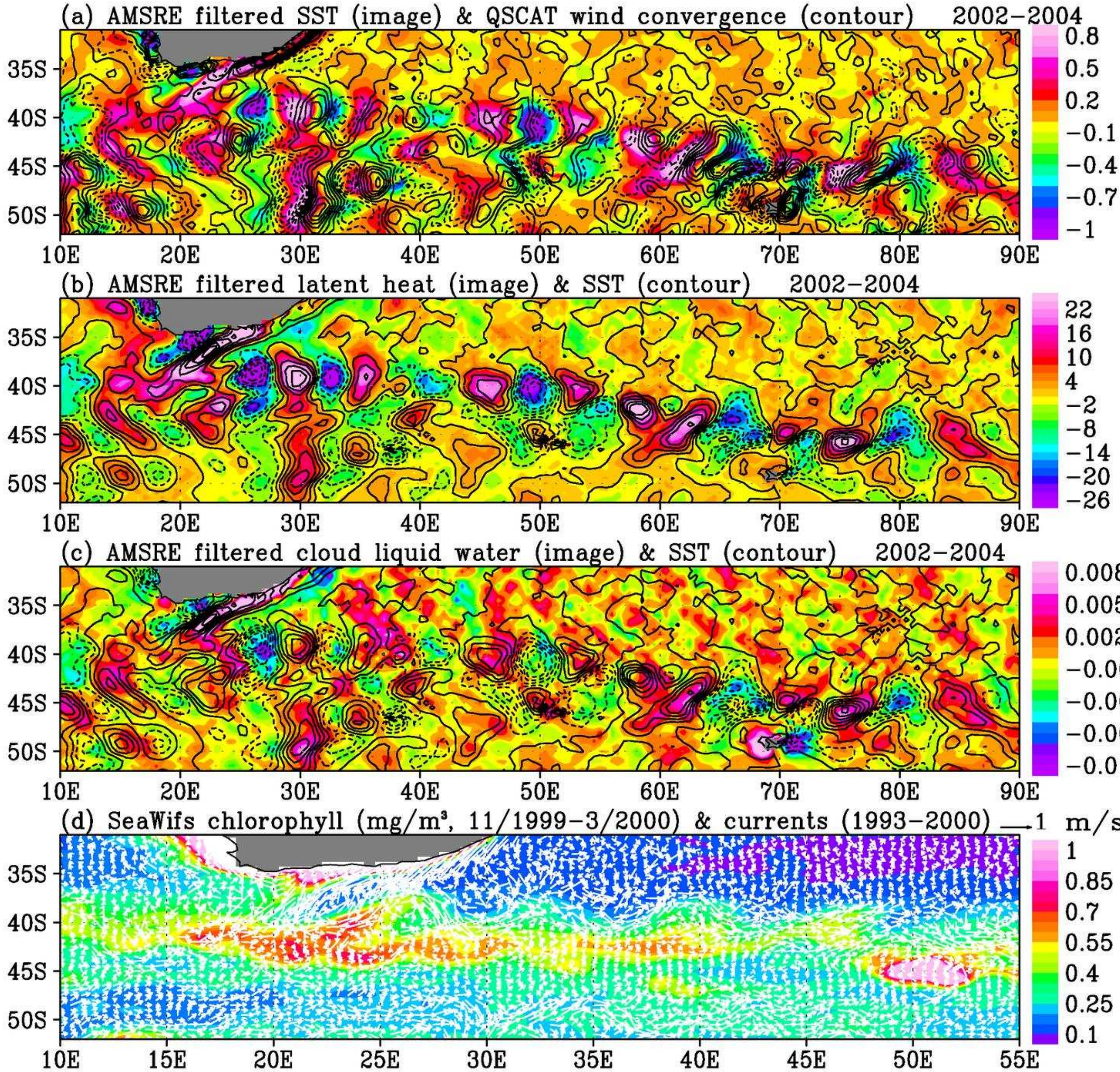

Fig. 1 (a) Filtered SST (color) and surface wind convergence (contour), (b) latent heat (color) and SST (contour), (c) cloud liquid water (color) and SST (contour) averaged from June, 2002 to December, 2004 derived from AMSR-E and QuikSCAT and (d) Chlorophyll averaged from November, 1999 to March 2000 using SeaWifs data, superposed by drifter currents averaged from 1993 to 2000. Contour interval is 0.1 x 10^{-5} /s for wind convergence and 0.2° for SST. A 10° zonal filter with a sine function weight was applied to remove large-scale variations.

provide the coincident measurements needed to optimize the retrieval of geophysical parameters, and to characterize the multiscale and non-linear interaction of the turbulent atmosphere and ocean. Besides parameters measured by SeaWinds and AMSR, ocean salinity and soil moisture can be retrieved and ocean surface evaporation and integrated moisture advection by the atmosphere can also be derived, thus closing the hydrologic balances. The coincident measurements will provide comprehensive characterization of all the essential terms in hydrologic balance over oceans and the oceanic influence of the cryospheric and terrestrial hydrologic cycles.

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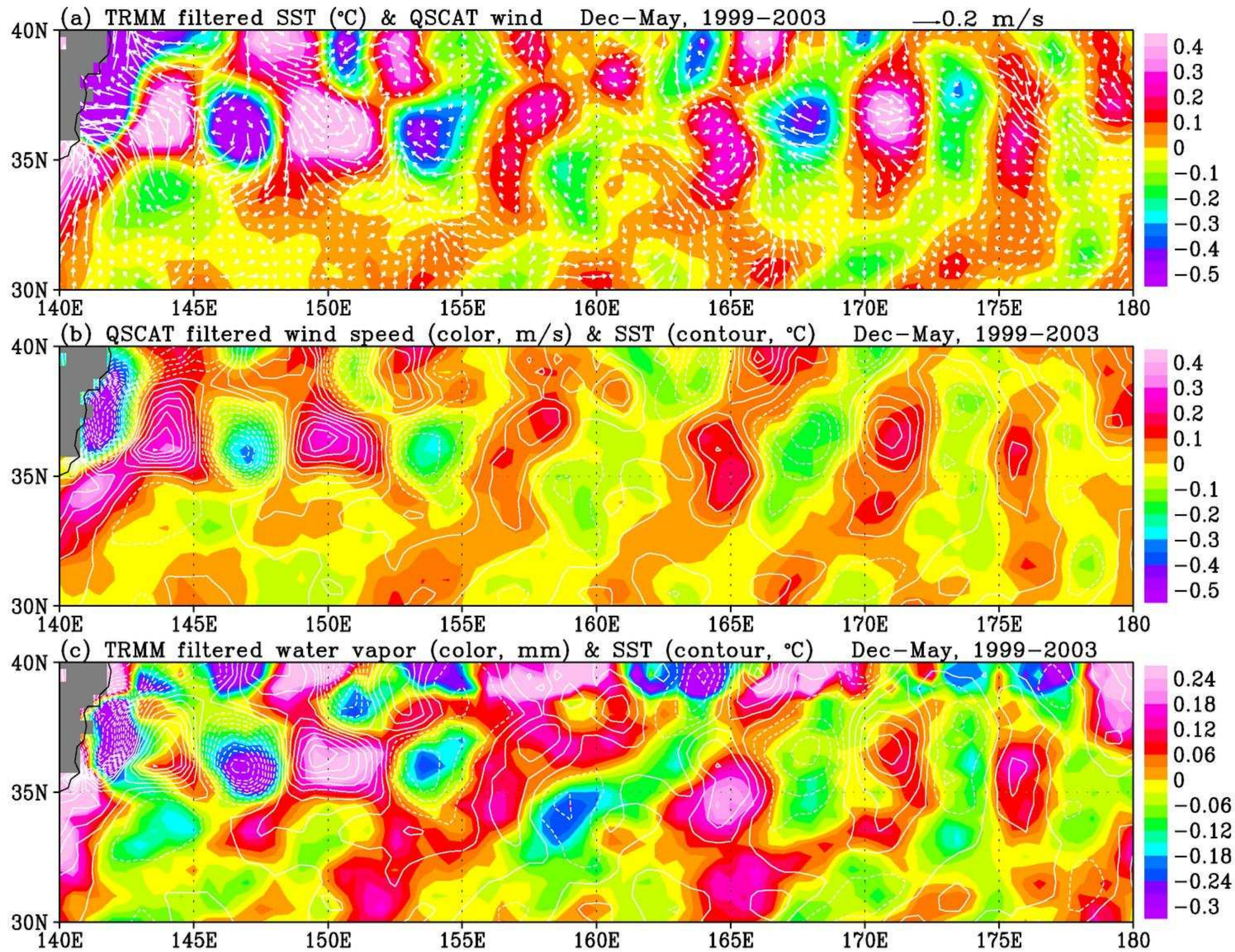

Fig. 2 (a) SST superposed by surface wind vectors, (b) wind speed (color) and SST (contour), and (c) water vapor (color) and SST (contour) averaged from December to May, 1999-2003 derived from the Tropical Rainfall Measuring Mission (TRMM) microwave imager (TMI) and QuikSCAT. Contour for SST is 0.1°C. The zonal filter was applied.

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