Sensitivity of Spacebased Microwave Radiometer Observations to Ocean Surface Evaporation

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ABSTRACT

The methodology of spacebased estimation of evaporation (E) and latent heat flux from the ocean is described. Preliminary results of a simulation study with atmospheric radiation transfer model demonstrate that the observed radiances at the frequencies of the Tropical Rain Measuring Mission (TRMM) Microwave Imager (TMI) are sensitive the change of E. An algorithm to retrieve E directly from the radiances observed by TMI is being constructed.

INTRODUCTION

Ocean surface evaporation (E) and the latent heat (LH) it carries are the major components of the hydrologic and thermal forcing on the global oceans. However, there is practically no direct in situ measurements. Evaporation estimated from bulk parameterization methods depends on the quality and distribution of volunteer-ship reports which are far less than satisfactory. The only way to monitor E with sufficient temporal and spatial resolutions and coverage to study global environment changes is by spaceborne sensors.

The recently launched Tropical Rain Measuring Mission (TRMM) provides the opportunity to improve the estimation of E. The radiance at the frequencies observed by TRMM Microwave Imager (TMI) were simulated through a radiative transfer model using ocean surface parameters and atmospheric temperature and humidity profiles produced by the reanalysis of the European Center for Medium Range Weather Forecast (ECMWF). From the same ECMWF data set, coincident LH is computed using a surface layer turbulent transfer model [1]. The sensitivity of the radiance to LH over various environmental conditions are examined.

BULK PARAMETERIZATION

The computation of E by the bulk parameterization method requires the measurements of sea surface temperature (SST), surface-level wind speed (u) and humidity (q)[1]. Traditionally these measurements come from routine ship reports. Over ocean, u and SST have been directly retrieved from spacebased observations with sufficient accuracies, but not q. In earlier studies, a global statistical relation between q, needed for E computation, and the integrated water vapor (W), observable from space, was derived [2, 3]; the rationale and limitation for this relation were discussed [4]. Over the past decade, many attempts on improvement and validation were performed [5], without significant change in the basic approach and the overall accuracy.

DIRECT RETRIEVAL

Because all the three geophysical parameters;u, W, and SST, can be retrieved from the radiance at the frequencies measured by the Scanning Multichannel Microwave Radiometer (SMMR) on Nimbus-7, the feasibility of retrieving E directly from the measured radiance was demonstrated, using coincident brightness temperatures (equivalen radiance) observed by SMMR and E computed from ship data, in the monthly time scale [6]. While SMMR measures at ten channels, only six channels were identified as significantly useful in estimating E.

SMMR was followed by a series of operational microwave radiometers, the Special Sensor Microwave / Imager (SSM/I), the first of which was launched in 1987. SSM/I lacks the low frequency channels which are sensitive to SST. Some of the low frequency channels are again included in TMI launched in 1997 [7]. The frequencies of TMI are slightly different from those on SMMR. TMI has nine channels: 10, 19, 37, and 85 GHz at both vertical and horizontal polarizations and 21 GHz at only vertical polarization. The sensitivity of these channel measurements to E is examined through a radiation transfer model.

RADIATION TRANSFER MODEL

The brightness temperatures at frequencies measured by TMI are simulated by a general set of radiation transfer equations [8]. Liebe's unified millimeter-wave propagation model [9] is used to compute the gaseous absorption by oxygen and

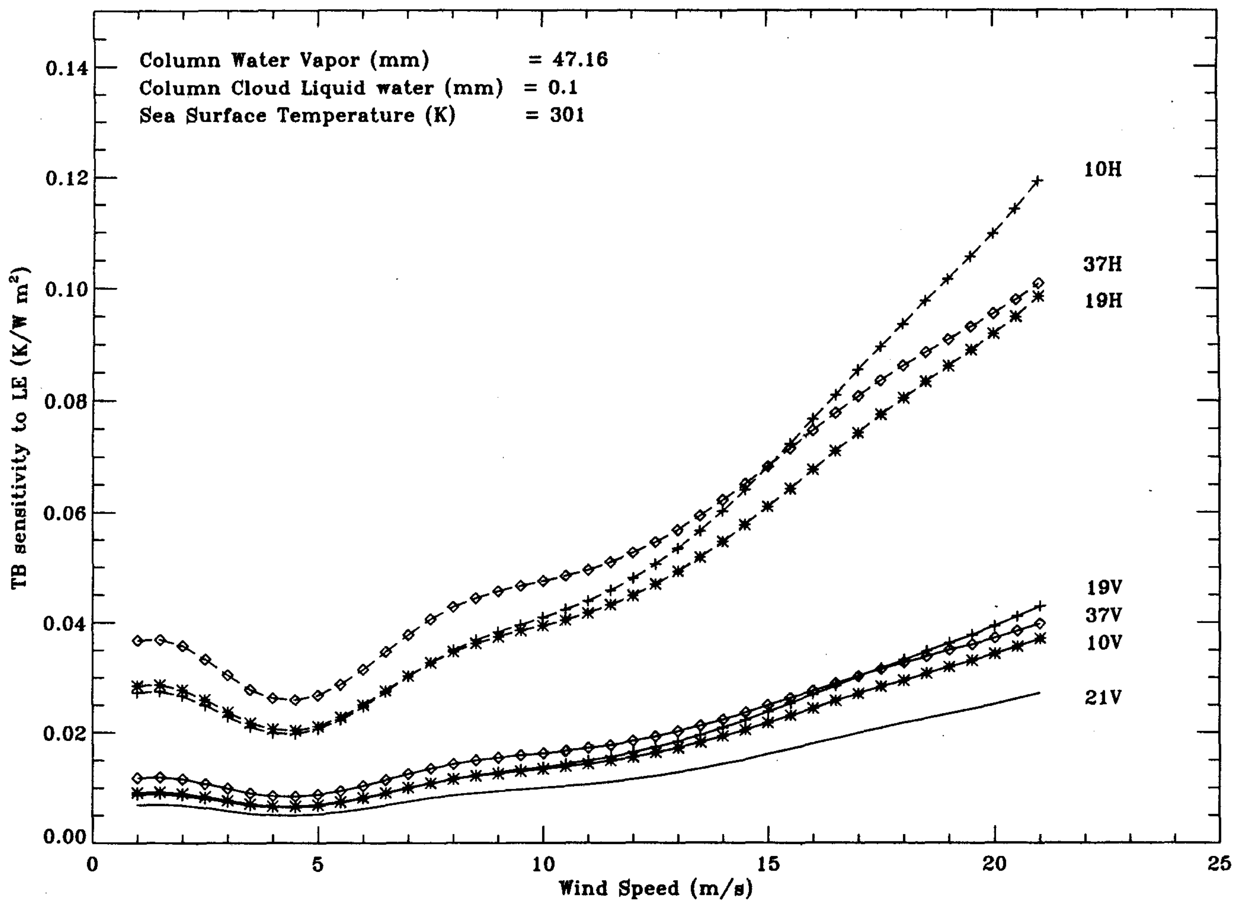

Fig. 1 The sensitivity of brightness temperature to change in latent heat flux as a function of surface wind speed for TMI channels.

water vapor. Recent models of surface emissivity from foam-free surface [10] and foam cover surface [11] are incorporated.

The input to this model is vertical profiles of temperature, specific humidity, cloud liquid and ice water density on 32 normalized pressure levels and surface conditions specified by SST, u, and salinity provided by the ECMWF reanalysis.

SENSITIVITY

As an example, Fig. 1 shows the sensitivity of the brightness temperature to the change of LH, for a typical set of atmospheric conditions, and for a range of u. The atmospheric conditions were selected from ECMWF reanalysis. While keeping all other parameters constant, u was varied within the range of 1-21 m/s. At each 0.5 m/s interval the change of brightness temperature and LE were computed for ± 0.5 m/s change of wind speed. The sensitivity is computed as the ratio of the change of brightness temperature to the change in LE. Results for the 85 GHz are not shown because they are known to be more sensitive to clouds than surface parameters.

The results show that the radiances are sensitive to change in E for all seven channels, but the horizontal polarized channels have higher sensitivity than vertically polarized channels. The sensitivity also increases with wind speed. The sensitivity dip at wind speed around 4 m/s is likely to be caused by the transition from smooth to rough flow at the surface. The 37H channel has the highest sensitivity for u below 15 m/s, but 10H channel is most sensitive for higher winds. The results also demonstrate the importance of the TRMM low frequency channels which are absent in SSM/I.

ACKNOWLEDGMENTS

This study was performed at the Jet Propulsion Laboratory, under contract with the National Aeronautics and Space Administration (NASA). It was supported by the Earth Observing System Interdisciplinary Science Program, the Tropical Rain Measurement Mission, and the Physical Oceanography Program of NASA. Eni Njoku kindly provided valuable suggestions.

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