ASSESSMENT OF TMI RETRIEVED SUB SKIN TEMPERATURE OVER THE NORTH INDIAN OCEAN

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Abstract:

Introduction: SST over the north Indian Ocean (NIO) behaves bimodal distribution over the year. SST over the north Indian Ocean varies very close to the threshold value of for the convection, which behaves as a regulator for the convective activity. Development of microwave remote sensing provides unprecedented sub skin temperature of ocean (Donlon et al., 2002, Parekh and Sarkar 2009) under the cloudy condition which provided platform to study variation of sub skin bulk temperature (ΔT) with environment parameters. Bulk temperature is an ocean temperature measure at the depth of 2.5m measure by the sensor installed on buoy. These buoys are deployed over the north Indian Ocean by the Ministry of Earth Sciences, India. Here we used satellite as well as in-situ observations as environmental parameters (i.e, wind speed, cloud liquid water, water vapor, bulk temperature, stability etc) and studied the variation of ΔT with this parameters during the different season of the year. Day and night behavior is also studied separately. The Tsubskin is representative of the water temperature at the bottom of the surface layer where the dominance of molecular and conductive processes gives way to turbulent heat transfer (Donlon et al. 2002, Saunders 1967). Tsubskin varies on a timescale of minutes and is influenced by solar warming in a manner strongly dependent on the turbulent energy density in the layer below. While at T2.5m turbulent heat transfer processes dominate, it may be significantly influenced by local solar heating and has a timescale of hours and typically varies with depth.

Data used

TMI data: For this study, daily gridded (version 3A) TMI data available online at Remote Sensing System site http://www.ssmi.com are used. These daily data are organized to a 0.25-degree grid divided into two maps based on ascending and descending passes. Version 3A is reprocessed data, which has taken care of rolls and pitch correction to the entire TMI dataset. This version 3A data set has been released in February 2003.

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In situ data: The in situ water temperature, air temperature, and wind speed data are obtained from the moored buoy program over the north Indian Ocean (NIO) (Premkumar et al. 2000). Five deep-sea buoys were operated during 1998–2002 and 11 during 2003. The bulk temperature (T2.5m) sensor is installed at, 2.5m below the sea surface and air temperature (Tair) and wind speed are measured by the sensors mounted at a height of 3m above the sea surface. The reported T2.5m, Tair, and wind speed are the average values of 600 samples (measurements acquired over 10 minutes with sampling speed of 1 sample per second) every 3 h. Detailed information about each sensor is available at http://www.niot.gov.in. Post calibration and error flagging of data are carried out before the buoy data are used.

Collocations strategy: Collocations of satellite data with small spatial and temporal windows around an in situ observer usually lead to an insufficient number of data pairs and can induce random error. The spatial window (temporal window)) for this study is 75 km (1 h), which has provided number of collocation greater than 3000. The total database was also analysed separately for the Arabian Sea (AS) and the Bay of Bengal (BoB) and for the characteristic seasons of this region (i.e. February to May is considered pre monsoon, June to September is considered monsoon, and October to January is considered as post-monsoon).

Result and Discussion: DT variation with water vapour (TWV) and cloud liquid water content (CLW): Variations in ΔT are analysed against variations in the TWV and CLW. No significant sensitivity to variations in these parameters could be observed. This could be due to frequencies below about 12 GHz; the surface radiance is proportional to subskin temperature, and microwaves penetrate clouds with little attenuation, giving a clear view of the sea surface under all weather conditions except rain. This further supports the fact that there is no apparent bias, reflecting the accuracy of the 21- GHz channel vapour retrieved and the algorithm's ability to account for absorption of the 10.65-GHz channel even at very high values of vapour (60 mm) (Gentemann et al. 2004). ΔT variation with bulk temperature: For T2.5m between 24°C and 28°C, the ΔTs decreasing with T2.5m. Data classification indicates that most of the cases of T2.5m belong to BoB during December to February (period known as winter monsoon). During this period latent heat losses in BoB are quite high, rendering forced free convective mixing, resulting in entrainment of cold water from the subsurface and decreasing the upper ocean temperature (Prasad 2004).

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No such significant trend was reported by Stammer et al. (2003), who carried out a global comparison (of TMI and Reynold's SST with in situ SST), while an opposite trend was reported (i.e. 0.08 to 0.14°C) by Gentemann et al. (2004) for the Pacific and the Atlantic for primarily Tbulk less than 25°C.

ΔT variation with T2.5m-Tair: The ΔT values are found to have significant variation with the surface boundary layer temperature difference (T2.5m-Tair) following an almost perfect line. Richardson number is an indicator to get information about whether boundary layer is stable or unstable. It depends mainly on the boundary layer vertical temperature gradient. For a negative Richardson number, the atmosphere is stable and for a positive one it is unstable. Under stable conditions, ΔT is found to be positive, and under unstable conditions ΔT is found to be negative. Thus, ΔT is a linear function of T2.5m-Tair with the opposite phase. This is perhaps possible due to damping of the roughness of the ocean surface under stable conditions (Castro et al. 2004) and enhancement of roughness during unstable conditions (Keller et al. 1985). Thus, this deviation in roughness may induce fluctuations in the ocean surface emissivity, which can potentially influence retrieval of Tsubskin. It is very noticeable that unstable conditions normally prevail during the night hours and may be contributing towards unusual warming under the higher wind conditions.

ΔT variation with surface wind speed: The response of ΔT temperatures to variations in wind speed is a subject of recent research (Donlon et al. 2002, Castro et al. 2004, Gentemann et al. 2004). It is found that ΔT is linearly decreasing with increasing wind. It becomes close to zero for wind speed 12m/s. ΔT vs wind speed variation in the daytime over the NIO (both AS and BoB) shows a decreasing trend. ΔT over the BoB reaches zero at wind speed magnitude of 12m/s. This value for the AS is in the range of 6–9m/s. In the BoB the upper ocean salinity structure is highly stratified due to freshwater flux through river runoff and high precipitation. This stratification in salinity substantiates the fact that a much larger magnitude of energy is required to break the stratification in the BoB (Shenoi et al. 2002), which inhibits mixing of cold water from below to upper Ocean. However, the trend of ΔT with wind speed during night-time is found to be insensitive up to a wind speed of 6m/s, and above it decreases with wind over the AS until it reaches zero at 12m/s, while for the BoB it remains insensitive to wind speed in the entire range. This trend contradicts the expected pattern of ΔT wind speed observed by earlier studies for night-time observations (Donlon et al. 2002, Gentemann et al. 2003, 2004). This unusual trend in night-time ΔT was found to occur mostly during non-monsoon seasons.

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