Oceanic Influence on the precipitation in India and China as observed by TRMM and QuikSCAT

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1 Introduction

Monsoon, by its Chinese definition, is the seasonal change of winds. The change is caused by the reversal of land-ocean temperature gradient. The change of oceanic influence is manifested through continental rain. The Tropical Rain Measuring Mission (TRMM) is designed primarily to measure rain and the microwave scatterometer, QuikSCAT, is the proven method to measure ocean surface wind vector.

Liu and Tang [2004] have developed and validated a method to estimate the moisture transport integrated over the depth of atmosphere over oceans ( ), using the precipitable water measured by the microwave radiometer on TRMM and the vector winds measured by QuikSCAT. To study oceanic influence on the precipitation in India and China, is interpolated to the coastline of East Asian and the Indian subcontinent and the component normal to the coastline is computed and related to the precipitation over land.

2 Indian Monsoons

Figure 1 shows that, during the summer monsoon, from May to November, moisture is transported into India from the Arabian Sea (red curve) and transported out to the Bay of Bengal (blue curve). The transport is reversed for the rest of the year, with low activity in all segments between February and May, as expected. The total moisture advected from oceans in the vicinity is in phase with the total rainfall integrated over land. During the peaks of summer monsoon, the moisture from the ocean exceeds the precipitation, suggesting that moisture may move north of India over land.

The transport out of the eastern coastline, however, occurs earlier than the transport in from the western

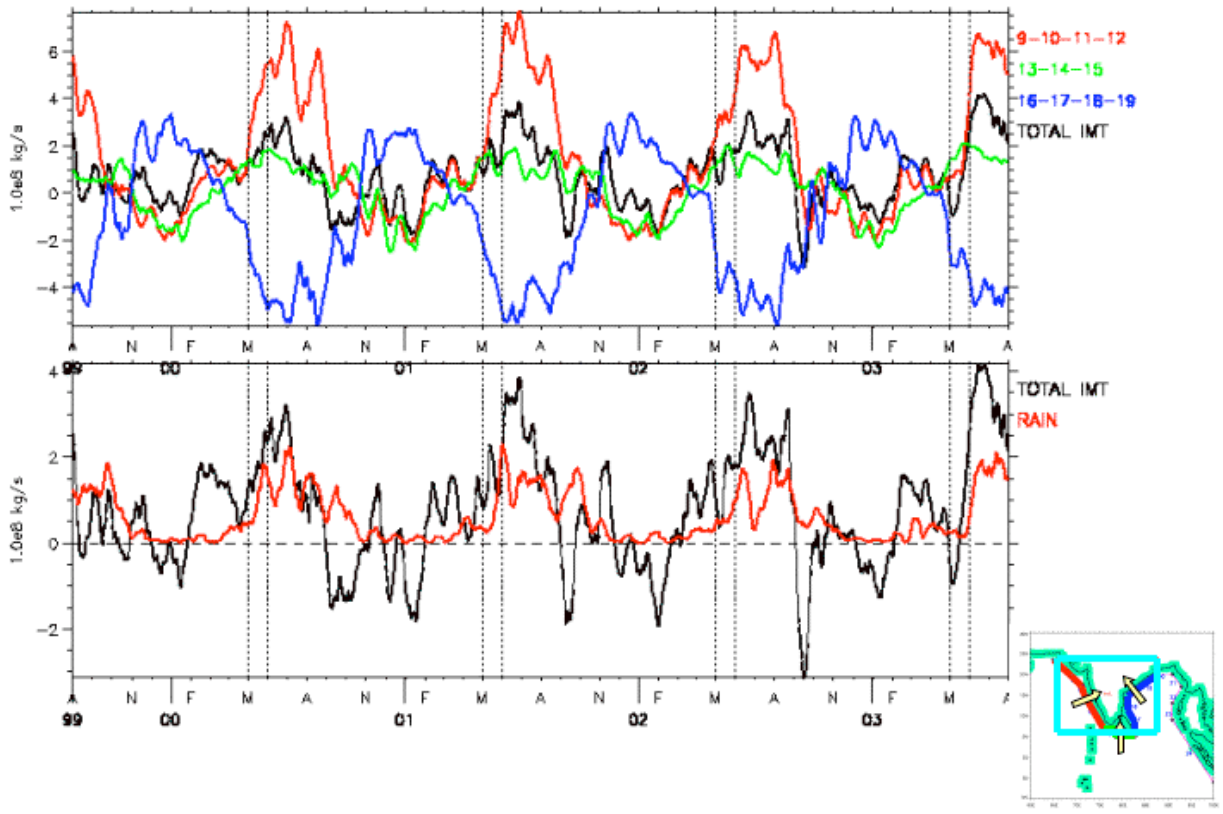

Figure 1. (top) Time series of into India continent from Arabian sea, integrated along line segment 9-10-11-12 (red), from Bay of Bangel, represented by line segments 16-17-18-19 (blue), and around southern tip of India (green), overlaid is the net total . (bottom) The net total oceanic (black) is compared with the precipitation (red) measured by TRMM integrated over India continent (40°E-100°E, 6°S-20°N) as indicated in the inserted map.

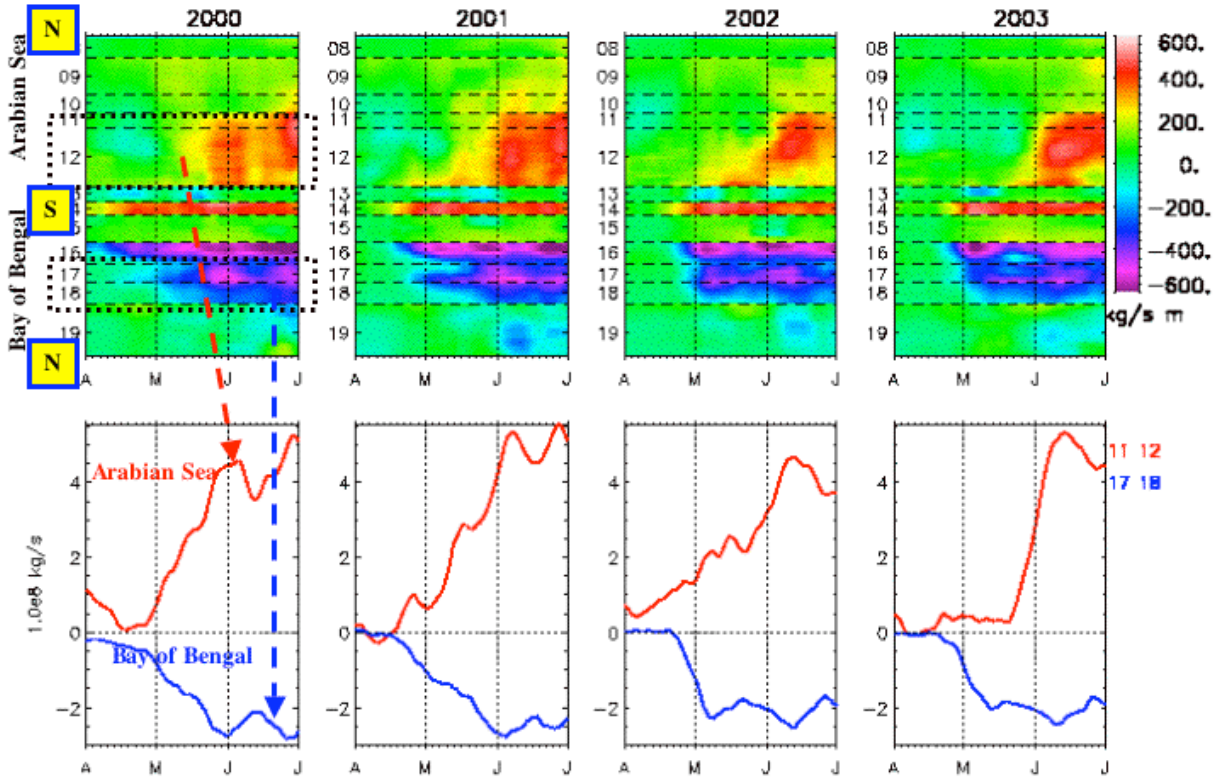

Figure 2. (top) Hovmolla diagram of into India continent from Arabian Sea and the Bay of Bangle, and (bottom) the time series of integrated in the indicated segment, for the summer monsoon seasons.

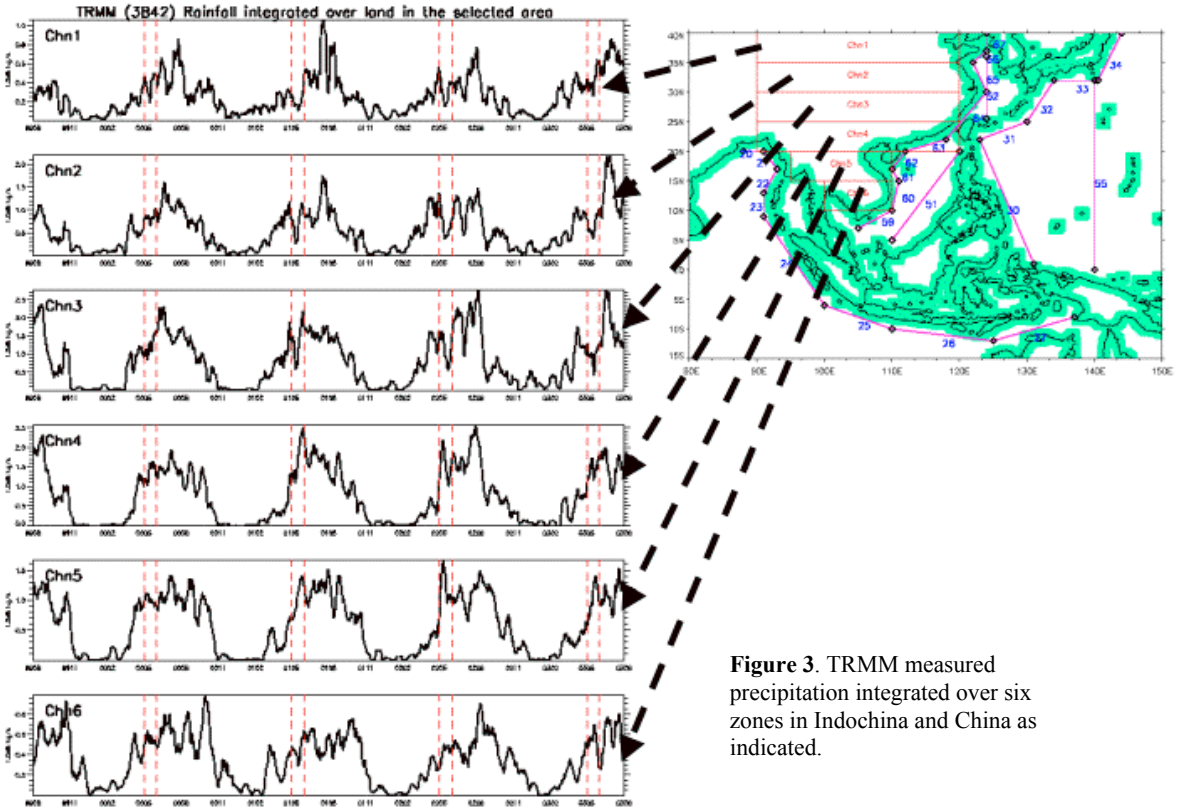

Figure 3. TRMM measured precipitation integrated over six zones in Indochina and China as indicated.

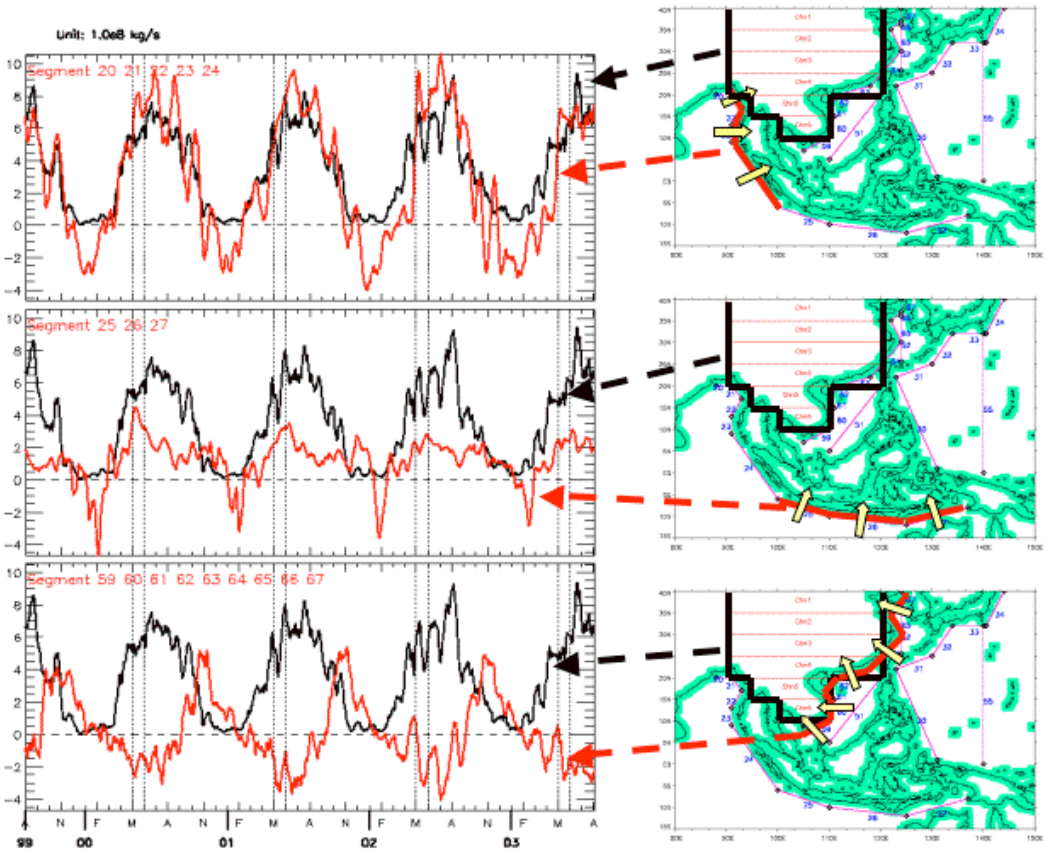

Figure 4. Time series of rainfall over China measured by TRMM (black) compared with integrated across east coast of Bay of Bengal (top), Southern Ocean (middle), and Western Pacific (bottom).

coastline, as shown in Figure 2. The delays are particular sharp and long in 2002 and 2003. There were suggestions that the onset of summer monsoon occurs earlier in the Bay of Bengal than in the Arabian Sea, but these are the clearest and most direct observations. This delay may cause droughts in India just before the onset of the summer monsoon.

3 China Monsoons

The temporal variation of the precipitation in 6 parallel zonal segments in Indochina and China measured by TRMM are clearly in phase, although the magnitude may be different, as shown in Figure 3. Continental rainfall integrated over the six areas and plotted as the black curve in Figure 4, agrees very well with the temporal variations of moisture advected from the Bay of Bengal. Precipitation increases sharply at the monsoon onset in May, and lasts until September. Part of the moisture passes over Indochina and moves back into land over the Chinese coast. However, over the major part of the Chinese coast, Figure 4 indicates that the sum of moisture influx from the Pacific Ocean occurs in fall, out of phase with the precipitation. During the rainy season in China (starting May), part of the moisture Bengal may go out from the east coast of Indochina, and there should still be some influx of moisture into southern China from the South and East China Sea.

4 Discussion

The method of estimating was developed with the awareness that such simple methods may not be sufficient for all purposes. The limited validation efforts showed that, except for low wind conditions, the derived transport field should be useful. Spacebased sensors provide better coverage and higher resolutions than rawinsondes and are not affected by any deficiency of the physics and parameterizations of operational numerical weather prediction models. This study clearly reveals the earlier start of the summer monsoon in the Bay of Bengal as compared with that in the Arabian Sea, and the dominant effects of moisture from the Indian Ocean in the precipitation of East Asia. The methodology of estimating , is also, in this sense, validated through application.

Acknowledgment

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References

Liu, W.T., and W. Tang, 2004: Moisture transport over oceans observed from space. J. Geophys. Res., submitted.