Assessment of the Regional Impacts of the 1997-98 El Niño from Satellite-derived Rainfall and Sea Surface Temperature

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ABSTRACT

Using satellite-derived global rainfall and sea surface temperature, we assess the impacts of the 1997-98 El Niño on the Asian summer monsoon. Results show that a regional circulation pattern, partly forced by El Niño-related SST and partly from intraseasonal variability may be the main cause of the disastrous flood over the Yangtze River Basin during June-August, 1998.

1. Introduction

Using long-term (~ 20 years) precipitation and sea surface temperature (SST) estimates derived from satellite and blended with in-situ observations, we have carried out an assessment of the regional impacts of the 1997-99 El Niño /La Niña cycle on the regional climate fluctuations in the Asian-Australian monsoon region. Previous studies have shown that the Asian monsoon is generally weaker during an El Niño. However, during the giant El Niño of 1997-98, the Asian summer monsoon (ASM) was a mixed bag, affected by either normal, above or below normal rainfall in different regions. Paradoxically, the El Niño terminated abruptly, being replaced by a rapidly developing La Niña (the reverse of El Niño) in mid-1998. This raises the question of how much regional floods and droughts in the ASM region are due to El Niño /Southern Oscillation (ENSO) and how much are due to other factors. In this paper, we will present an analysis technique in using global rainfall and sea surface temperature data to separate the effects of ENSO and other factors in affecting regional floods and droughts. Using this techniques, we propose a new paradigm for monsoon-ENSO interactions, through the identification of intrinsic coupled ocean-atmosphere modes in the monsoon region.

2. Results

Three recurring ASM rainfall-SST coupled modes were identified. The first is a basin scale mode that captures SST and rainfall variability over the entire tropics (including the ASM region) with an east-west SST sea-saw and an anomalous Walker circulation across the Pacific, identified with those occur during El Niño or La Niña. This mode is further characterized by a pronounced biennial variation in ASM rainfall and SST fluctuation depicting the symmetric, or mirror-image component of El Niño /La Nina transition. The second mode comprises mixed regional and basin-scale rainfall and SST signals, with pronounced intraseasonal as well as interannual variabilities. This mode features a SST pattern associated with a developing La Niña, with a pronounced low level anticyclone in the northern

subtropics of the western Pacific. The third mode is interpreted as a coupled ocean-atmosphere mode in the ASM region. This mode possesses a decadal time scale and a linear trend, but is not a associated with El Niño /La Niña variability.

Possible causes of year-to-year rainfall variability over the ASM and sub-regions were evaluated from a reconstruction of the observed rainfall from singular eigenvectors of the coupled modes. It is found that while basin-scale SST can account for large of ASM rainfall variability in individual years fraction (up to 60% during the 1998 event), regional, non-ENSO related processes can accounts up to 15-20% of the rainfall variability in typical non-ENSO years. Stronger monsoon-ENSO relationship tends to occur in the summer immediately preceding a pronounced La Niña , i.e., 1998, 1988 and 1983. In addition, we find that the disastrous flood over the Yangtze River Basin during the summer of 1998 was due to excitation, partly by ENSO, of a low level subtropical West Pacific Anticyclone (WPA), which was responsible for the transport of abundant moisture from Indo-China and the South China Sea to central East Asia. Based on the aforementioned results, we propose a hypothesis that the WPA acting in concern with the eastward shift of the Walker circulation associated with the basin-scale SST forcing, may be instrumental in producing a biennial tendency in ENSO, i.e., rapid termination of El Niño and the subsequent development of La Niña during 1998-99.

3. Reference

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