15B.3 THE EASTERN PACIFIC ITCZ DURING THE BOREAL SPRING

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1. INTRODUCTION

Of the global tropical oceans, the eastern Pacific has perhaps the strongest annual cycle. Intense air-sea interactions in this region result in a cold tongue-Intertropical Convergence Zone (ITCZ) complex during the boreal summer and fall. A narrow band of frequent deep convection (*i.e*., the ITCZ) appears between 5°N - 10°N, associated with warm sea surface temperature (SST), while a large area of cold SST (< 26°C) and infrequent deep convection occurs near and south of the equator. During the boreal spring, two ITCZs, as represented by monthly mean rainfall, are usually observed straddling the equator (Lietzke *et al.* 2001; Halpern and Hung 2001; Zhang 2001). This double ITCZ is coincident with the occurrence of relatively high SST (compared to immediately neighboring regions, or the same region at other times of year) along and south of the equator, and with seasonal weakening of southeasterly trade winds.

Using satellite-observed cloud data, Hubert *et al.* (1967) showed the presence of two convective zones in the eastern Pacific during March-May 1967. However, they concluded that the double ITCZ is not a characteristic feature of the tropical circulation. Recent satellite observations have improved our knowledge of this phenomenon. General agreement seems to have been reached that a double ITCZ normally occurs in the eastern Pacific during the boreal spring (Lietzke *et al*. 2001; Zhang 2001). Moreover, a recent study of high-resolution surface wind observations from the space-based scatterometer QuikScat found that the double ITCZ is discernible year-round in the Atlantic and eastern Pacific oceans, if it is defined using the surface convergence field rather than precipitation (Liu and Xie 2002). Liu and Xie (2002) used a short data record (only fully covering two episodes of the double ITCZs), and focused on surface wind; they did not include data for related fields such as rainfall and water vapor. Lietzke *et al.* (2001) described the temporal (weekly and monthly) and spatial patterns of several ITCZ-related variables during boreal spring in the eastern Pacific using the Special Sensor Microwave/Temperature-2 (SSM/T-2) derived cloud and water vapor, the Microwave Sounding Unit (MSU) derived rainfall, and the European Remote Sensing satellite (ERS-1 and ERS-2) scatterometer wind field. Their study was primarily concentrated on three years, *i.e*., 1995-1997.

With the availability of 6-season (1998-2003) high-quality satellite rainfall observations from the Tropical Rainfall Measuring Mission (TRMM), the first objective of this study is to characterize the spatial and temporal variation of convection and rainfall in the eastern Pacific during boreal spring with a specific interest in the occurrence of the double ITCZs. Compared to Lietzke et al. (2001) and Liu and Xie (2002), we use different and longer-record satellite observations including 6-season TRMM rainfall, and TRMM Microwave Imager (TMI) cloud, water vapor and SST. The year-to-year variation of the double ITCZs is emphasized, and shorter time scale evolution within each year is also examined.

Our second objective is to describe the observed relationships between the different variables studied here. Specifically, we wish to clarify what kind of SST meridional profiles are generally preferred by the double ITCZs (defined here by precipitation, rather than surface convergence), and to document the relative positions of maxima in the different variables. These issues are relevant for validating (or defining errors in) double ITCZs simulated in general circulation models, and perhaps also for testing theories for the mechanisms by which SST controls deep convection.

2. RESULTS

The eastern Pacific ITCZ during boreal spring is quantified by the 6-season TRMM rainfall data. Two individual convective bands are observed straddling across the equator during March and April in 1999, 2000, 2001 and 2002. The southern ITCZ becomes stronger than its northern counterpart in some cases. On the weekly time scale, convection can even shift entirely into the Southern Hemisphere. In the strong El Niño year 1998, only one broad convective zone appears, right across the equator. In 2003, one intense convective band is located around 5°N.

The ITCZs, as quantified by rainfall maxima, generally are closely associated in both space and time with SST maxima. At a given time, rainfall maxima are displaced meridionally from SST maxima by no more than a few degrees. To the extent the two are displaced, rainfall maxima tend to lie poleward of SST maxima. This result is different from what is found if the longitudinal averaging range is extended further west, across greater zonal inhomogeneities in the SST field. The

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surface pressure field in March and April has a broad maximum on the equator, with the rainfall maxima lying generally clearly poleward of the pressure minimum, different from what is found in other seasons.

There appears to be a competition between the two ITCZs as measured by rainfall. When one is strong, there is a tendency for the other to be weak, with the total rainfall integrated over both varying less than the difference between the two. In the TMI data, a similar signal is found in the SST, suggesting that the rainfall competition is a manifestation of coupled ocean-atmosphere dynamics. In the longer-record Reynolds SST data, such a signal is much less apparent, as there is much more variability in the total SST integrated over both ITCZs. This would tend to suggest more of an independent role for atmospheric dynamics in creating the rainfall competition. Even in the TMI data there is evidence for independent atmospheric dynamics, as April of 1999 and 2003 have very similar SST structures but very different rainfall structures, with a strong southern ITCZ in 1999 and almost none in 2003.

Direct SST thermal forcing and related meridional gradients can effectively drive surface convergence in the tropics, specifically impacting the meridional wind component. Cold equatorial water which shapes two regional SST maxima across the equator is preferred by the double ITCZs, consistent with previous results (*e.g*., Zhang 2001; Lietzke *et al*. 2001).

As found previously (Liu and Xie 2002), the double convergence zone derived from the QuikScat wind field appears to be a much more frequently observed phenomenon than are the two rainfall peaks often used to quantify the ITCZs in the eastern Pacific. The double ITCZ defined by convection and rainfall is only observed during boreal spring, and even then monthly and weekly mean rainfall do not always follow surface convergence patterns exactly. Water vapor and cloud liquid water maxima appear when and where significant mean convective and rainfall bands are observed, quantitatively consistent with the results shown in Zhang (2001) and Lietzke *et al.* (2001). However, in several cases regional water vapor and cloud liquid water peaks are not associated with significant rainfall.

Many of the double ITCZ features found in the TRMM data are confirmed by the long-record data sets from the GPCP and NCEP/NCAR reanalysis project. Four types of the ITCZs are categorized based on the GPCP rainfall. The intense convective bands, particularly the southern ITCZ, seem to be determined not only by the local SST but also by the intensity of the equatorial cold tongue and surprisingly the SST north of the equator possibly through its impact on the regional atmospheric large-scale circulation.

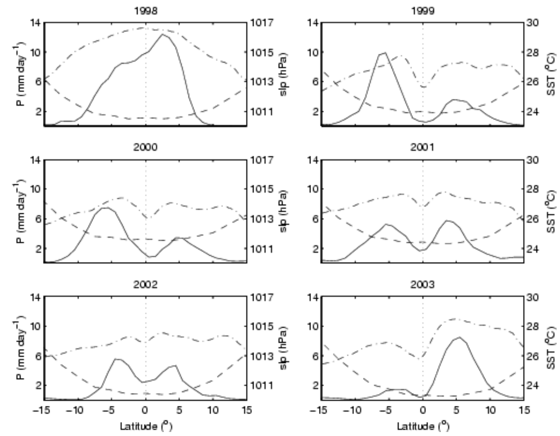

Figure 1 Meridional profiles of monthly TRMM rainfall (solid lines), surface pressure (dashed lines), and TMI SST (dashdot lines) between 90°W-130°W in March.

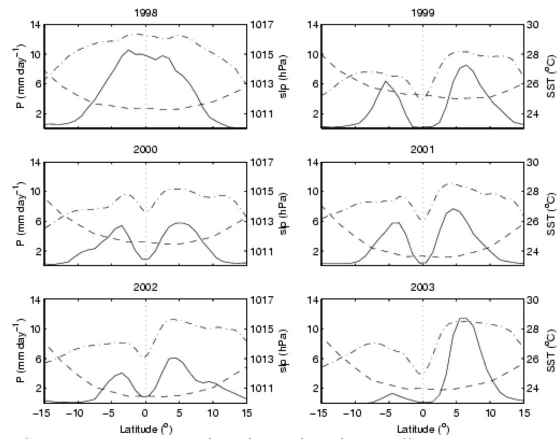

Figure 2 Same as in Fig. 1 but in April.

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