P1.35 RELATIONSHIPS BETWEEN WINDSPEED AND PRECIPITATION IN THE PACIFIC ITCZ

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1. INTRODUCTION

Higher windspeeds are associated with more evaporation and latent heat flux from the ocean to the atmosphere. In regions of persistent deep tropical convection, it has been suggested that surface heat fluxes driven by wind may be an important forcing on convection (e.g. Raymond et. al. 2003), however this idea has never been tested using a large observational dataset. In this paper, we find that area-averaged, satellite-derived windspeed is directly related to precipitation throughout the Pacific Intertropical Convergence Zone (ITCZ).

Evaporation alone introduces little water when compared to the daily precipitation amounts typically observed in mesoscale convective complexes. Instead, the main immediate moisture source for the precipitation is moisture convergence. This does not point to a causal mechanism however; the moisture convergence can be regarded as a response to the latent heating due to deep convection. A different framework is required to understand where and when within large-scale regions of mean convergence (like the ITCZ) convection occurs.

Two layer and idealized models of the tropical circulation (e.g. Neelin and Held 1985, Zebiak 1986 Neelin and Zeng 2000, Sobel and Bretherton 2000) have suggested that evaporation and precipitation may be related through a ``convergence feedback'' causing anomalies in evaporation (or more generally, local sources of troposphere-integrated moist static energy) to drive much larger anomalies in precipitation (associated with the export of moist static energy). However, Sobel and Bretherton noted that this relationship between evaporation and precipitation is not convincingly borne out in observations and suggested that moisture advection might also be playing a role in determining the distribution of precipitation over the warm sea surface temperature regions.

2. METHODOLOGY

In this study, we use four years (1998-2001) of SSM/I and TMI satellite retrievals to look at the relationship between windspeed and precipitation within the Pacific ITCZ. The methodology is similar to that used by Bretherton, Peters and Back (Bretherton et al. 2004), hereafter BPB04.

To test the robustness of the microwave-derived windspeed-precipitation correlation, we also use several months of ground-based radar-derived area-averaged precipitation measurements from Kwajalein Island in the central Pacific ITCZ, as well as vector wind retrievals from QuikSCAT.

3. SSM/I and TMI-derived relationships

We examined the relationship between 2.5x2.5-degree daily averaged windspeed and precipitation (from the SSM/I and TMI) at 10N at several locations which are in the Pacific ITCZ for much of the year. At each gridpoint, all four years of windspeed and precipitation data were sorted by windspeed and subdivided into bins containing 60 gridpoint-days. Within each such bin, the mean, 25th, 50th and 75th percentiles of the 60 precipitation estimates are calculated. Fig. 1 illustrates this analysis in the Eastern Pacific ITCZ (at 95W, 10N) and at 160E, 10N in the western Pacific warm pool. In the western warm pool (Fig. 1b) no relationship is visible. In the Eastern Pacific however (Fig. 1a), there tends to be more rainfall on days with stronger winds, as found by Raymond et al. (2003) from limited in situ data from EPIC2001.

A complicating factor in this analysis is that the precipitation belts vary with the seasonal cycle. Only when convection is easily and frequently initiated do we expect to see a correlation between windspeed and precipitation. Outside deep convective regions, high windspeeds still enhance surface moisture fluxes, but this moisture is stored and advected downstream rather than being rained out locally. BPB04 found a strong correlation between precipitation and column relative humidity (***r***), defined as the ratio of the water vapor path to the saturation water vapor path. When ***r*** is low, it generally does not rain (BPB04) even when windspeeds are high.

To address these seasonal variations at each location, we repeated the analysis of Fig. 1, isolating only those days in the four-year record with column integrated relative humidity greater than 0.75 to focus only those times when it is likely to rain. Fig. 2 shows that with this ***r*** threshold, at all ITCZ locations examined, there is a remarkable linear correlation between windspeed and precipitation. On days with stronger winds there tends to be more rainfall.

The estimated increase in evaporation that occurs as windspeed rises from 4 to 8 m/s is less than 3 mm/day, small compared with the observed increases in precipitation (Fig. 2). This is consistent with a "convergence feedback" (Zebiak 1986, Sobel and Bretherton 2000). Small increases in evaporation add moist static energy to the atmospheric column and deep convection compensates for the added energy through the divergence of air with high moist static energy in the upper troposphere and convergence of air with slightly lower moist static energy in the lower and mid-troposphere. The associated moisture convergence adds to the increased evaporation to produce a much larger increase in precipitation.

Windspeed explains only a moderate, but highly statistically significant amount of the variability in precipitation, as is visible in the quartiles plotted in Fig. 2. The amount of correlation and the regression slope varies. The highest correlation and the steepest slope

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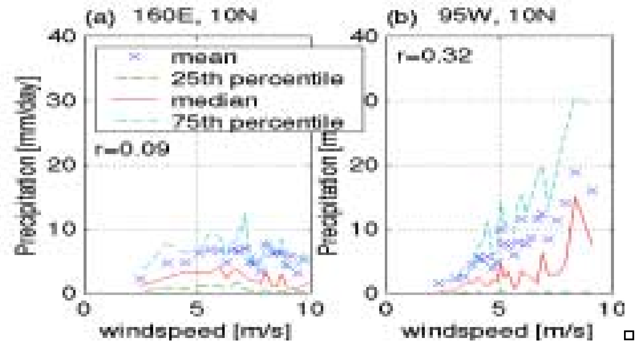

Figure 1: Distribution of daily precipitation binned against windspeed. X's show bin-mean precipitation, and lines show 25th, 50th and 75th percentiles of 60 2.5◦ gridpoint-day bins.

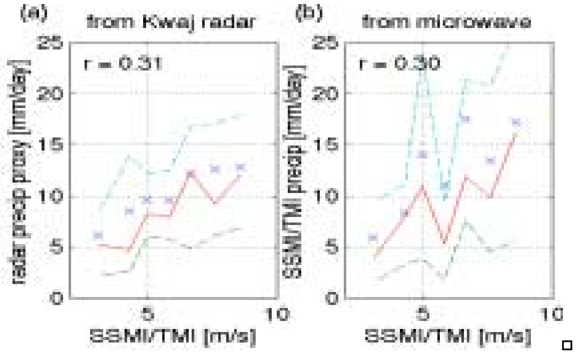

Figure 3: (a) Distribution of daily Kwajalein radar-derived precipitation proxy binned by SSM/I windspeeds (bin size: 30 gridpoint-days). (b) same, using SSM/I precipitation averaged over the two 2.5◦ gridpoints closest to Kwajalein.

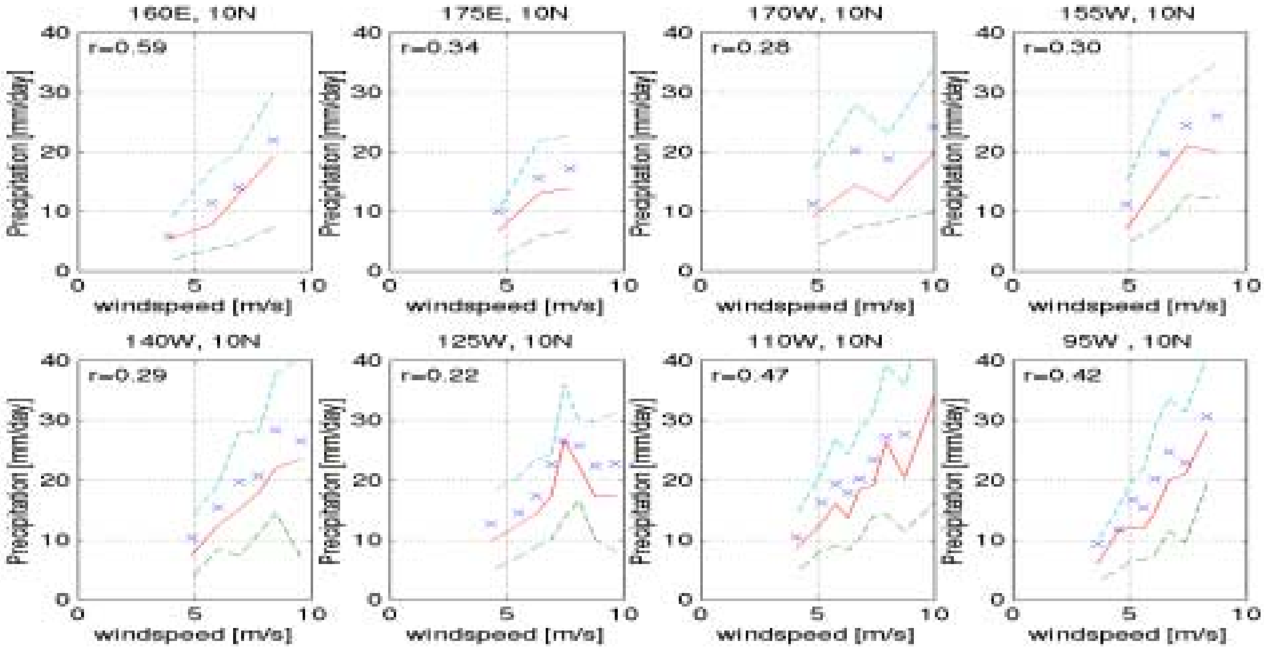

Figure 2: Daily precipitation distribution binned against windspeed for points throughout the Pacific ITCZ, when column relative humidity is greater than 0.75.

(greatest increase in rainfall for a given increase in windspeed) is east of 120W. There is also a strong correlation, but lesser slope in the western Pacific (160W). In the central Pacific, the correlations are not as strong, and the slopes are less steep.

One possible explanation for the spatial variations in the relationship is that moisture advection could be varying. Moisture advection is generally a drying effect in the ITCZ, so increased dry advection in higher wind conditions could counter-balance the increases in evaporation. Another possibility is that the amount of convergence feedback varies in association with the mean thermodynamic and vertical motion profiles.

3. VALIDATION USING KWAJEX DATA

There are a number of uncertainties involved in the retrieval of precipitation estimates from the SSM/I on a daily timescale. To address these uncertainties, we used the radar data to calculate the distribution of the Kwajalein radar-derived rainfall proxy, binned by windspeed, for days when column relative humidity is above 0.75 (shown in Fig. 3a). The results of this analysis are similar to those using the microwave-derived precipitation (Fig. 3b).

4. REFERENCES

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