Investigation of Synoptic Disturbances and Their Effect on the Boundary Layer and SST in the East Pacific ITCZ on Seasonal and Interannual Time Scales

by

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Introduction

The east Pacific ITCZ appears as a band of persistent cloudiness between roughly 10ºS and 10ºN, depending on the season (Fig. 1a). The annual cycle in solar insolation tends to dominate the annual variability in the east Pacific convection, with a dominant amplitude in the northern hemisphere (Mitchell and Wallace 1992). The tropical ITCZs constitute the upward branch of the Hadley circulation, which transports heat, moisture and momentum out of the tropics, to the midlatitudes, making them a primary driver of global climate. The wind stress curl in the east Pacific ITCZ also forces upwelling in the ocean at this location, and establishes the transition between the westward moving north equatorial current (NEC) and the eastward moving north equatorial counter current (NECC). The upwelling is strongest in boreal fall when the zonal wind stress curl has a distinct maximum and the trades have a distinct minimum around 10˚ N (e.g. Wyrtki and Meyers 1976). This region is additionally distinguished as the most prolific producer of tropical cyclones per unit area in the world, with on average nine of these cyclones reaching hurricane strength each year.

The atmosphere in the east Pacific ITCZ is comprised largely of convectively coupled westward propagating synoptic waves (e.g. Chang 1970) (Fig. 1b). Waves of this type are also observed in the tropical Atlantic (Simpson et al. 1968; Reed et al. 1977), where their source is known to be barotropic instability over Africa (Burpee 1972). In the tropical western Pacific the source is less certain, but is likely tropical cyclones (e.g. Sobel and Bretherton 1999). The source of the east Pacific waves is also not well established, but is thought to be different from those in the west Pacific (Sobel and Bretherton 1999). It has been suggested that these waves play a role in determining the preferred latitude of the ITCZ (Holton et al. 1971). It has also been pointed out that their seasonality is similar to that of the ITCZ in the east Pacific (Gu and Zhang 2001). Additionally, these waves are a primary source of hurricanes in the Caribbean and east Pacific (Avila and Clark 1989), and typhoons in the west Pacific (Sobel and Bretherton 1999). Thus, these waves are significant for understanding both ITCZ dynamics, and the factors contributing to active or suppressed hurricane years, a present concern in the face of global climate warming.

Project Goals

Our primary objective is to investigate the role of synoptic variability in determining the location and seasonality of the east Pacific ITCZ, and any coupled or one-way interactions with the underlying SST. We will investigate the seasonal and interannual modulation of these waves in the atmospheric boundary layer, sea surface temperature, and upper ocean stability and mixing processes. As the SST has significant seasonal and interannual variability in this region, we will also investigate potential feedbacks between the SST and synoptic waves on these same time scales. Our overall intent is to investigate the consequences for air-sea coupling given the generally accepted view that the ITCZ is comprised of convectively coupled synoptic-scale disturbances.

Methodology

- In the first part of the study, the existence and strength of synoptic disturbances will be explored on annual and interannual time scales in the surface wind fields, surface fluxes, satellite data, and upper ocean currents, temperature and salinity fields. The primary data sets will be from the ATLAS buoys within the TAO-TRITON array, Eastern Pacific Investigation of Climate Processes (EPIC) enhanced 95° W TAO mooring data (Fig. 2), and NOAA International Satellite Cloud Climatology (ISCCP) level B radiance data (or other appropriate satellite products). Scatterometer winds and/or NCEP 1000 mb winds may also be used to fill gaps in the TAO surface wind data. NCEP or ECMWF 850 mb winds will be used to determine the presense of synoptic waves in the east Pacific, as these waves have their strongest signature at this level. A synoptic wave index will be produced from one or both of these model analyses and will be used to categorized the data with respect to the waves.

- The second part of the study will investigate the relationships among the measured and calculated variables within the context of the waves, in order to understand the forcing of the synoptic disturbances on the atmospheric boundary layer and upper ocean. These results will also be used to test existing theoretical models of such disturbances.

- Finally, case studies of synoptic activity during, preceding and following the EPIC2001 intensive observing period will be analyzed for wave-boundary layer-upper ocean interactions. A simple 1D model will also be used to more clearly identify the processes affecting the underlying upper ocean observed in the data.

Selected References

Avila, L, A., and G. B. Clark, 1989: Atlantic Tropical Systems of 1988. *Mon. Wea. Rev.*, **117**, 2260-2265.

Burpee, R. W., 1972: The origin and structure of easterly waves in the lower troposphere of North Africa. *J. Atmos. Sci.*, **29**, 77-90.

Chang, C.-P., 1970: Westward propagating cloud patterns in the tropical Pacific as seen from time-composite satellite photographs. *J. Atmos. Sci.*, **27**, 133-138.

Gu, G., and C. Zhang, 2001: A spectrum analysis of synoptic-scale disturbances in the ITCZ. *J. Clim.*, **14**, 2725-2739.

Holton, J. R., J. M. Wallace, and J. A. Young, 1971: On boundary layer dynamics and the ITCZ. *J. Atmos. Sci.*, **28**, 275-280.

Mitchell, T. P., and J. M. Wallace, 1992: The annual cycle in equatorial convection and sea surface temperature. *J. Clim.*, **5**, 1140-1156.

Reed, R. J., D. C. Norquist, and E. E. Recker, 1977: Structures and properties of African wave disturbances as observed during phase III of GATE. *Mon. Wea. Rev.*, **105**, 317-333.

Simpson, R. H., N. Frank, D. Shideler, and H. M. Johnson, 1968: Atlantic tropical disturbances, 1967. *Mon. Wea. Rev.*, **96**, 251-259.

Sobel, A., H., and C. S. Bretherton, 1999: Development of synoptic-scale disturbances over the summertime tropical northwest Pacific. *J. Atmos. Sci.*, **56**, 3106-3127.

Wyrtki, K., and G. Meyers, 1976: The trade wind field over the Pacific Ocean. *J. Appl. Meteorol.*, **15**, 698-704.

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