Tropical Instability Waves and ITCZ Breakdown in the Eastern Pacific

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Introduction

The purpose of this paper is to investigate the mechanisms of ITCZ modification by anomalies related to oceanic Tropical Instability Waves (TIW) and the possible influence TIW on Eastern Pacific cyclogenesis. We show that formation of the Eastern Pacific tropical storm Alvin, on 05/26/2007 at 250E, 12N, was preceded by o wind and precipitation anomalies related to instability wave that developed in the ocean. To explain how such anomalies could influence cyclogenesis, we examine the ITCZ breakdown in the presence of TIW using the modeling framework of Nieto and Schubert (1997).

Observations: genesis of Alvin

Fig. 1 shows SST, wind and precipitation fields averaged over the week preceding the development of Alvin (from May 20 to May 26). The wind pattern indicates an intensification of surface south-westerly flow over the areas of warm anomaly and a weakening of the wind over the colder water, in agreement with other observations of air-sea interaction in TIW (e.g. Hasizume, 2001, Small,2003). The impact of SST anomalies can also be observed in the precipitation field. South of the ITCZ, precipitation is fairly weak but follows the pattern of SST anomalies, with the maxima over the warm anomaly and no rainfall over the cold SST. In the ITCZ region, precipitation maxima develop downstream of SST warm anomalies in the areas of surface wind convergence.

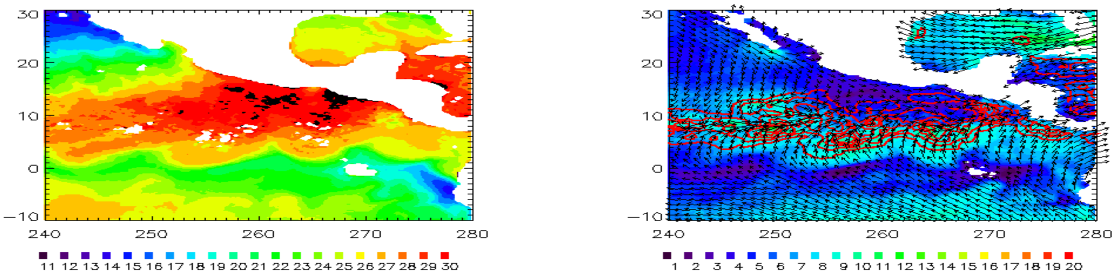

Fig.1 SST, surface wind and precipitation during the week preceding formation of Alvin

Shallow water experiments

To examine the mechanisms by which the SST anomalies related shown in Fig.1 could affect cyclogenesis, we conducted experiments using an idealized model of ITCZ breakdown. The experiment design was based on the work of Nieto and Schubert (1997). The zonally elongated, elliptical heat source (mass sink) used in their paper was modified to include the effect of TIW and to resemble the precipitation pattern shown in Fig 1.

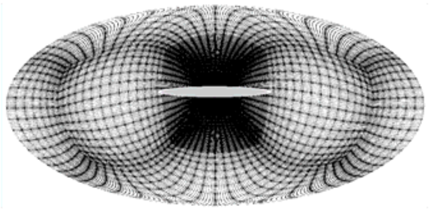

Fig.2 The hexahedral grid used in experiments. The resolution is increased in the region of the mass sink.

The model used in this study was a shallow water version of the Navy Spectral Element Model (NSEAM). (Giraldo and Rosmond 2004; Giraldo 2005). The grid configuration for the telescopic hexahedral grid used in the experiments is shown in Fig. 2

The development of potential vorticity perturbation for the elliptical and modified heat source is shown in Fig.3. The non-perturbed source case corresponds to experiments from Nieto and Schubert (1997). As in Nieto and Schubert (1997), the mass sink creates the potential vorticity anomaly in the northern part of the heating region. The PV anomaly is tilted by the cyclonic flow and breaks down into individual vortices around the 8th day of the integration. For TIW modified heating, local PV maxima develop in the first days of integration, north of the maximum heating. The size and position of the vortices is related to the zonal perturbations of the mass sink.

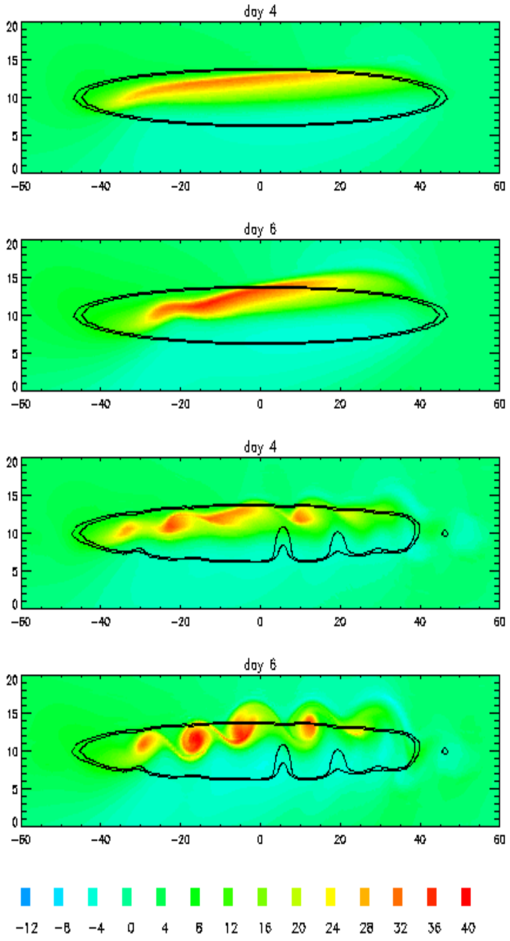

Figure 3. Potential vorticity perturbation (PV-PV(t=0)x 10^7) after 4 and 6 days of integration, with an elliptical and modified mass sink.

Discussion

We have shown that SST and heating anomalies associated with TIW can accelerate the barotropic breakdown of the ITCZ. Convective heat sources modified by air-sea interactions in TIW force local PV maxima north of the heating anomalies; these PV maxima can intensify, creating conditions favorable for cyclogenesis. Since we use a barotropic model with a specified heat source, the cyclogenesis process itself is beyond the scope of this paper. However, further intensification of vortices can occur through increased inertial stability and heating efficiency in the area of strong PV gradients (Hack and Schubert, 1986) and through thermodynamic feedbacks such as WISHE (Rotunno and Emanuel, 1986).

Acknowledgements

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