P10.5 THE SUPPRESSION OF DEEP CONVECTION IN THE SOUTHWEST CARIBBEAN

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1 INTRODUCTION

The southwestern Caribbean is a region that has been characterized by high sea surface temperatures and strong winds but not much deep convection. The ECAC - 3 (Climate Experiment in the Warm Pools of the Americas) campaign was used to explore this region in more detail. The Mexican research ship *Justo Sierra* launched radiosondes to gather information which would be useful in explaining the development of convection (or the lack of it) in this area.

Almost all deep convection originates in the planetary boundary layer. Convection occurs when sufficient convective available potential energy exists and when the convective inhibition is locally reduced to the point at which a convective parcel can be lifted to the level of free convection by mechanical processes acting in the PBL. A key parameter in the development of deep convection is the PBL moist entropy. Entrainment of dry air from above the PBL tends to decrease the PBL moist entropy, while surface heat fluxes tend to increase it. Thus, strong surface winds and high sea surface tempartures which tend to increase PBL entropy ought to favor the development of deep convection. Our objective is to try to address the observed lack of deep convection in the Caribbean.

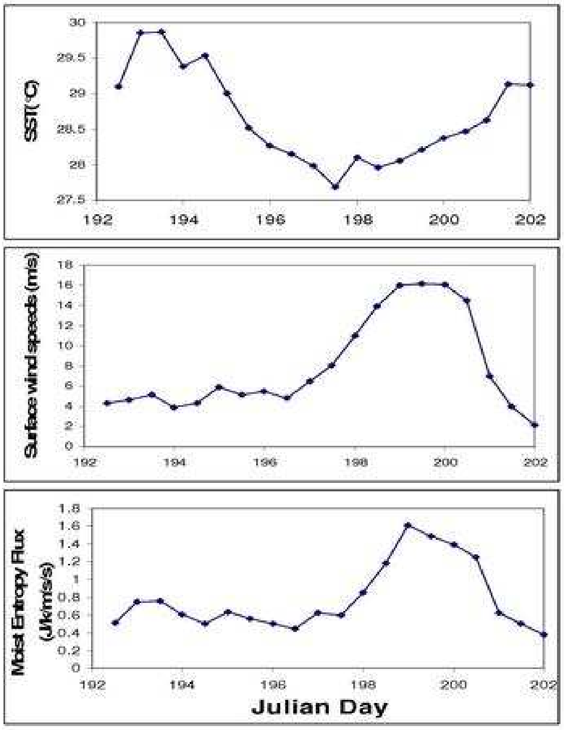

Figure 1: SST, surface winds and moist entropy flux as a function of Julian day.

2 DATA AND METHOD

Our analysis focuses on the data obtained from the radiosondes launched by the *Justo Sierra*. Deep convection is often correlated with strong surface winds and high sea surface temperatures. These conditions create strong entropy fluxes which in turn increase the boundary layer entropy and the CAPE, while reducing the CIN. The observations show a region just off the coast of Nicaragua which presents high sea surface temperatures and strong winds in the presence of a conditionally unstable atmosphere, but little deep convection. It's also relevant to mention the fact that the air above the PBL in this region is often very dry. Hence a possible explanation for the suppression of convection is the entrainment of dry air.

The PBL entrains air from the quiescent free troposphere overlying it, which tends to decrease the PBL

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moist entropy, and this in turn can suppress deep convection. We applied a bulk steady state balance model for the moist entropy in the boundary layer given by

$$w\frac{dS}{dz} + \frac{1}{\rho}\frac{F_{es}}{L} + S_R = 0 \qquad (1)$$

where we ignore horizontal advection. The first term represents the entrainment of moist entropy with w being the entrainment velocity, the second term is the surface flux of moist entropy, the third term corresponds to the radiation source term. The quantity L is the average depth of the PBL. The surface flux per unit area per unit time of the moist entropy is given by

$$F_{es} = \rho C_E (S_{SS} - S_B) U_{eff} \qquad (2)$$

where ρ is the air density at the sea surface, $C_E \approx 1 \times 10^{-3}$ is the surface exchange coefficient, S_{SS} is the value of the saturated moist entropy at the temperature and pressure of the sea surface, S_B is the PBL value of the moist entropy, and U_{eff} is given by

$$U_{eff} = \left(U_B^2 + W^2\right)^{1/2} \qquad (3)$$

where U_B is the mean PBL wind speed and W is a parameter which accounts for the averaged effect of PBL wind variability, which is important in low wind situations (typically $W \approx 3\,m/s$). We used this model to find the entrainment velocity (w) necessary to balance the surface flux and the radiation.

3 RESULTS

Our results showed that for the period of strong winds, high entropy fluxes, and high sea surface temperatures (above $28\,C$) the entrainment velocities are considerably larger than the normal radiatively induced subsidence velocities. The typical values for these subsidence velocities lie around 0.5 cm/s to 1.0 cm/s. Nevertheless, for the period of interest for our study we found maximum values closer to $3.5\,cm/s$. which is indicative of a strong subsidence motion into the PBL from the free troposphere. The rest of the entrainment velocities fall into the normal values usually reported. We also notice that at the time that we find these high entrainment velocities the average moist entropy and the precipitable water in the PBL decrease, while the depth of the PBL increases.

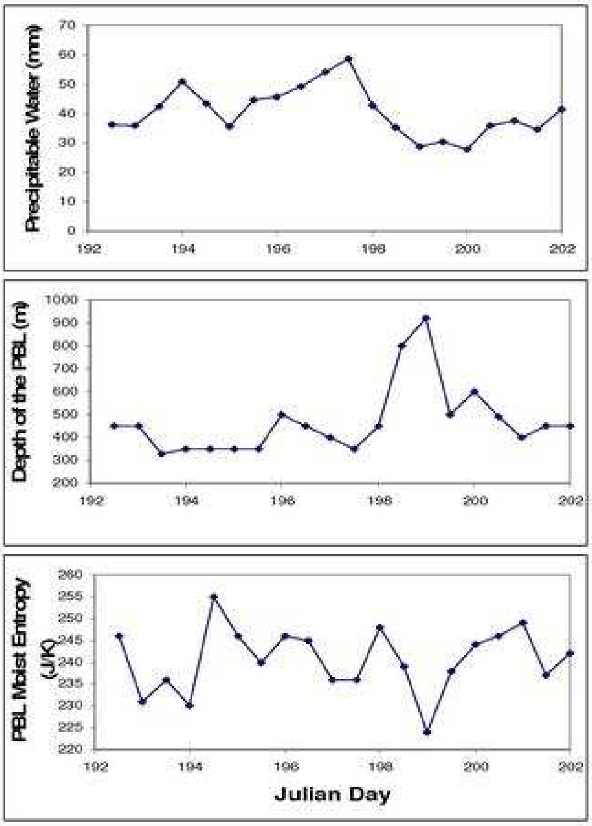

Figure 2: Precipitable water, depth of the PBL and PBL moist entropy as a function of Julian day.

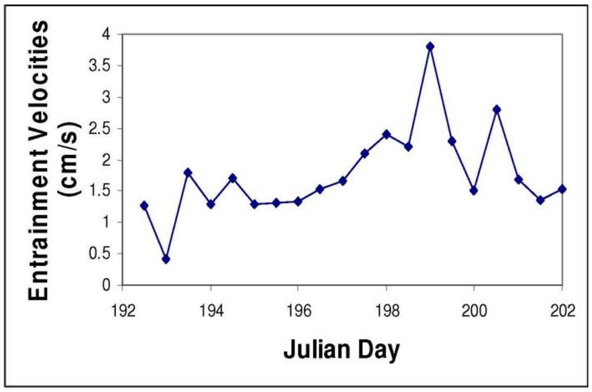

Figure 3: Entrainment velocities as a function of Julian day.

4 CONCLUSIONS

Entrainment velocities are highly variable, with strong winds correlated with high entrainment rates far exceeding typical radiatively induced subsidence rates. One would expect the growth of the PBL depth under these circumstances, and this is observed. However this growth is still less than expected in the presence of normal subsidence rates. Given the decrease in precipitable water during the period of high winds, free tropospheric subsidence was probably also well in excess of normal rates, which presumably acted to limit PBL growth. This subsidence was therefore most likely responsible for the suppression of deep convection in the face of strong winds and associated strong surface entropy fluxes. One caveat: Horizontal advection has been ignored in this analysis.

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