13B.2 EFFECTS OF THE SEA SURFACE TEMPERATURE ON MERIDIONAL PRESSURE GRADIENTS IN THE EASTERN PACIFIC

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1 INTRODUCTION

The Eastern Pacific region is important to the dynamics of several climate phenomena. One of the primary influences for all large-scale features in this region is the equatorial cold tongue and a large temperature gradient into the northern warm pool. It has been known that large meridional winds across the equator cause subsequent upwelling within this region but what is poorly understood is the exact mechanism for these cross-equatorial winds. It becomes a circular argument to pinpoint the effects of the Sea Surface Temperature (SST) on the meridional winds due to the fact both have positive feedbacks to one another. Although the SST is one factor determining the winds due to the influences on the Marine Atmospheric Boundary Layer (MABL) differential pressure, other influences have been documented including the differential heating between land and ocean and elevated diabatic heating (Gill 1980). Several studies have attempted to explain the effects of the SST on the large-scale pressure gradients, however most were analyzed using coarse models (Lindzen, et al. 1987),. It is the purpose of this paper to use the high-resolution in-situ data from the Eastern Pacific Investigation of Climate Processes (EPIC2001) to place a quantitative value on the effects of the meridional pressure gradients from the MABL and the atmosphere above it.

2 EXPERIMENTAL OBSERVATIONS

EPIC2001 (Weller, et al., 1999) provided an excellent opportunity to gather atmospheric profiles to an altitude of 6 km along the 95W meridian from 0 to 12˚N along with same day information on ocean parameters. The periods of analysis were from September 1 through October 15, 2001, a period known for a strong Intertropical Convergence Zone (ITCZ) in the region. Atmospheric profiles were taken using dropsondes while ocean data came from expendable ocean probes, both deployed from research aircraft. Although subsurface ocean data was obtained, the SST data was the only information needed for the current discussion. Although all data to date is only preliminary, the ocean SST was compared with both satellite SST and Tropical Atmospheric Ocean (TAO) mooring data to ensure accuracy.

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3 BOUNDARY LAYER HEIGHT

In order to define the height of the MABL, this discussion uses the definition suggested by Stull (1988). The boundary layer is that region of the troposphere that is directly influenced by the presence of the earth's surface and responds to surface forcing with a timescale of about an hour or less. This is also consistent with other definitions (Lindzen, et al 1987) in that the MABL is a region that is highly coupled to SST. In the latter case, it is highly likely that certain variables such as virtual temperature will show a large correlation to the SST.

In this study, SST from 5 flights were compared to the virtual temperature profiles. Correlation coefficients were calculated every 100 meters in the atmosphere and shown on Figure 1. Due to the fact that the SST data was limited, an averaged boundary layer height for all flights was calculated. This height of 1050 meters will then be used to determine the effects of the MABL on the surface pressure gradient in the subsequent section.

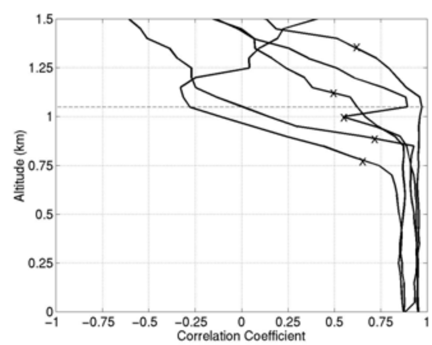

Figure 1: Correlation coefficients between SST and virtual temperature. A 95% significance level was chosen for each correlation profile and shown as an 'X'. The boundary layer height was chosen when correlation coefficient fell below this level.

4 PRESSURE GRADIENT CALCULATIONS

Although it is somewhat inappropriate to assume the MABL height is constant throughout the entire region of 0-12˚N, making this assumption can provide an initial assessment on how much effect the MABL contributes to the meridional pressure gradient.

Using the hydrostatic equation, the pressure was calculated at each 100-meter level. The MABL weight was calculated assuming no pressure gradient at 1050 meters. The atmosphere above the MABL was calculated in the same manner, however the pressure gradients at the upper levels were present in the final calculations. The weights were also calculated for the entire atmosphere and compared to the measured pressure at the surface. Once the weights were calculated for each latitude, a best line linear fit was made. Figure 2 shows the best line fit for flight rf18. To ensure calculations were performed correctly, it is important to note the accuracy of the calculated pressure to the measured pressure. Table 1 shows the results for the remaining flights. It is apparent that the large-scale pressure gradient is primarily caused by the MABL.

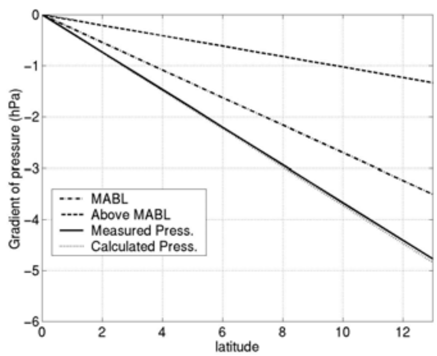

Figure 2: Best line linear fit for the pressures of flight rf18. MABL height = 1050 meters

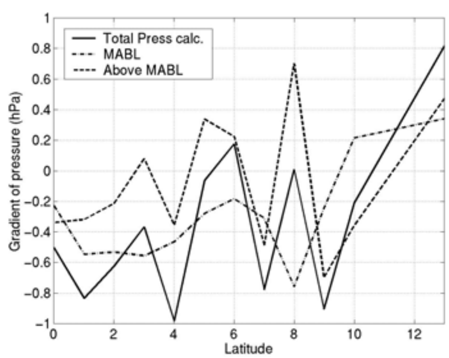

Figure 3: Individual latitude pressure gradients of flight rf18. MABL height=1050 meters.

In addition to calculating the best line fit, Figure 3 shows the pressure gradient calculated at each latitude within the same region. This figure is also from flight rf18 and is reflective of the other flights. It is apparent from this figure and Table 1 that although the large-scale pressure gradient is controlled by the MABL, the atmosphere above it controls the finer scale pressure perturbations.

Flight	ΔPc	ΔPm	%err	%M	%A	ccfM	ccfA	95%SL
rf03	-5.61	-5.50	1.84	64.7	35.3	0.72	0.88	0.55
rf06	-5.77	-5.82	0.93	67.8	32.2	**0.37**	0.88	0.58
rf08	-4.11	-4.04	1.62	87.7	12.3	0.66	0.87	0.58
rf10	-6.67	-6.72	0.74	55.0	45.0	**0.58**	0.97	0.67
rf11	-5.45	-5.49	0.80	65.6	34.4	**0.57**	0.91	0.73
rf18	-5.13	-5.20	1.34	72.6	27.4	**0.53**	0.81	0.55
rf19	-3.74	-3.92	4.64	93.1	6.9	0.73	0.90	0.58

Table 1: ΔPc & ΔPm = calculated and measured differential surface pressure (hPa) across the 95W meridian (typically 0-12EN), %err = percent error between ΔPc and ΔPm. %M & %A = percent contribution from MABL and above the MABL, respectively, to the total surface pressure gradient. ccfM & ccfA = correlation coefficients of SST to virtual temps for the MABL and above the MABL, respectively. 95% SL = Value of the correlation coefficients at the 95% significance level.

5 SUMMARY

From this preliminary analysis it is shown that the large-scale meridional pressure gradient of the eastern pacific is contributed by the MABL by 60 – 90%, where the vertical mixing coupled with the SST strongly influences the surface pressure field and hence the meridional winds. However, the contribution from the atmosphere above the MABL is by no means negligible (up to 45%). Especially, smaller scale pressure fluctuations in this region are primarily controlled by pressure fluctuations aloft. The mechanisms for this are unknown. It is the thought of this author that upper level pressure perturbations caused by diabatic heating may be affecting the small-scale pressure perturbations at the surface. Further research will use a more accurate 2nd order polynomial fit of the depth of the MABL.

6 REFERENCES

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