P2.5 THE DIURNAL CYCLE OF THE CIRCULATION AND CLOUDINESS OVER THE SUBTROPICAL SOUTHEAST PACIFIC

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1. INTRODUCTION

Large-scale subsidence occurs year-round over the subtropical southeast Pacific (SSEP), resulting in a quasi-permanent surface anticyclone. This subtropical high drives south-southeasterly low-level winds along the west coast of South America, which in turn partially maintain a tongue of cold surface water due to coastal upwelling and equatorward alongshore advection. The cold SSTs and the adiabatically warmed air aloft lead to the formation of a cool marine boundary layer (MBL), often topped by an extensive deck of stratocumulus (Sc), and capped by a marked temperature inversion. A distinctive feature of this subtropical Sc deck is its particularly pronounced diurnal cycle in cloud amount, thickness and liquid water path, that is highly relevant to the quantification of the true impact of Sc on climate.

Motivated by the observational evidence of such a significant diurnal cycle, the mean regional circulation and cloudiness over the SSEP was investigated using the PSU-NCAR mesoscale model MM5, with a finest grid-spacing of 20 km. The simulation spans 15 days during November 2001 (austral spring) when the Sc deck reaches its largest extent over the SSEP.

2. RESULTS

The mean diurnal cycle in potential temperature (θ) and other variables,¿ is documented using the values averaged over the 15 days at each hour ([θ]). Vertical profiles of [θ] in three columns over the SSEP, generally representative of near-coastal and open ocean conditions, reveal a consistent cycle below 5 km ASL (Fig. 1). The maximum amplitude is found near 3 km ASL, with extremes occurring at ~1800 (max.) and ~0200 (min.) UTC. These extremes lead for about 5 hr those of a distinctive cycle observed below 1 km (within the MBL). The simulated diurnal cycles compare favorably with available observations. Compared with the observations, however, the modeled MBL is significatively shallower.

The diurnal cycle in mean vertical velocity [w] for the three columns is also included in Fig.1. Subsidence prevails during most of the day in the lower and middle troposphere, interrupted by a period of somewhat stronger ascending motion.
In all cases, the ascending motion (upsidence) is limited below 5 km and peaks at about 3 km ASL. Note the agreement in the timing of the ascent and cooling. Application of the thermodynamic-equation confirms that the local rate of change of [θ] is mostly due to the diurnally varying component in vertical advection.

Fig. 2 shows [w] at 800 hPa (qualitatively similar results are found between 850 hPa and 500 hPa). Subsidence prevails over most of the SSEP during morning and afternoon. Along the coast of southern Peru, subsidence maximizes at 1600 UTC (local noon) evolving into strong ascending motion within the next 2-3 hr. The upsidence region detaches from the continent by 2200 UTC forming a crescent-shaped band of about 400 km wide and 5 km deep that can be traced for at least 12 hr as it moves southwestward at ~1°/hr, resembling a free gravity wave.

Given the height scale of the upsidence wave (~5 km) and its somewhat similar structure and evolution in spring, summer and winter (similar simulations were performed in those months), we speculate that deep convection over the adjacent continent has little relevance in forcing the wave over the SSEP. Rather, we suggest a more prominent role of the mechanical blocking exerted by the steep, NW-SE oriented Peruvian Andes upon the SE low-level flow over the ocean.

A simulation using a 1-D version of the MM5 with finer vertical resolution reveals that the diurnal cycle in [w] does impact the modeled turbulence in the MBL. The significant deepening of the MBL during the upsidence period induces a more turbulent MBL and more entrainment. The warming and drying of the MBL result in a greater dissipation of the cloud layer in the afternoon, enhancing the amplitude of the diurnal cycle in cloud amount and LWP with respect to the cycle forced by absorption of solar radiation only.

REFERENCE

Garreaud, R., and R. Muñoz, 2003: The diurnal cycle in circulation and cloudiness over the subtropical Southeast Pacific: A modeling study. Accepted for publication in *J. of Climate*, October 2003.

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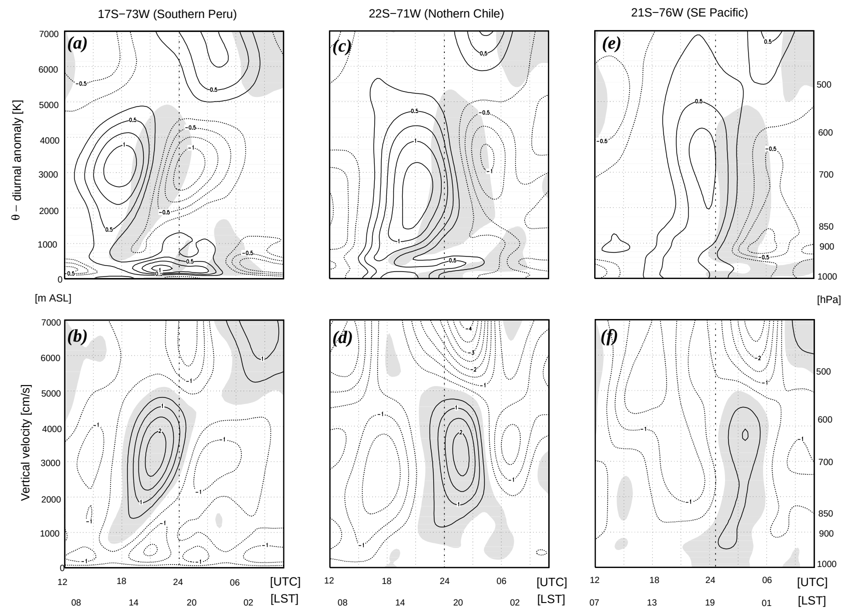

Figure 1. Potential temperature mean diurnal cycle anomaly (upper panels) and vertical wind mean diurnal cycle (lower panels) at three columns over the SSEP. θ anomalies (departure from the average at each hour over all hours and days) contoured every 0.25K, negative values in dashed line and the zero contour is omitted. Vertical velocity contoured every 0.5 cm/s.

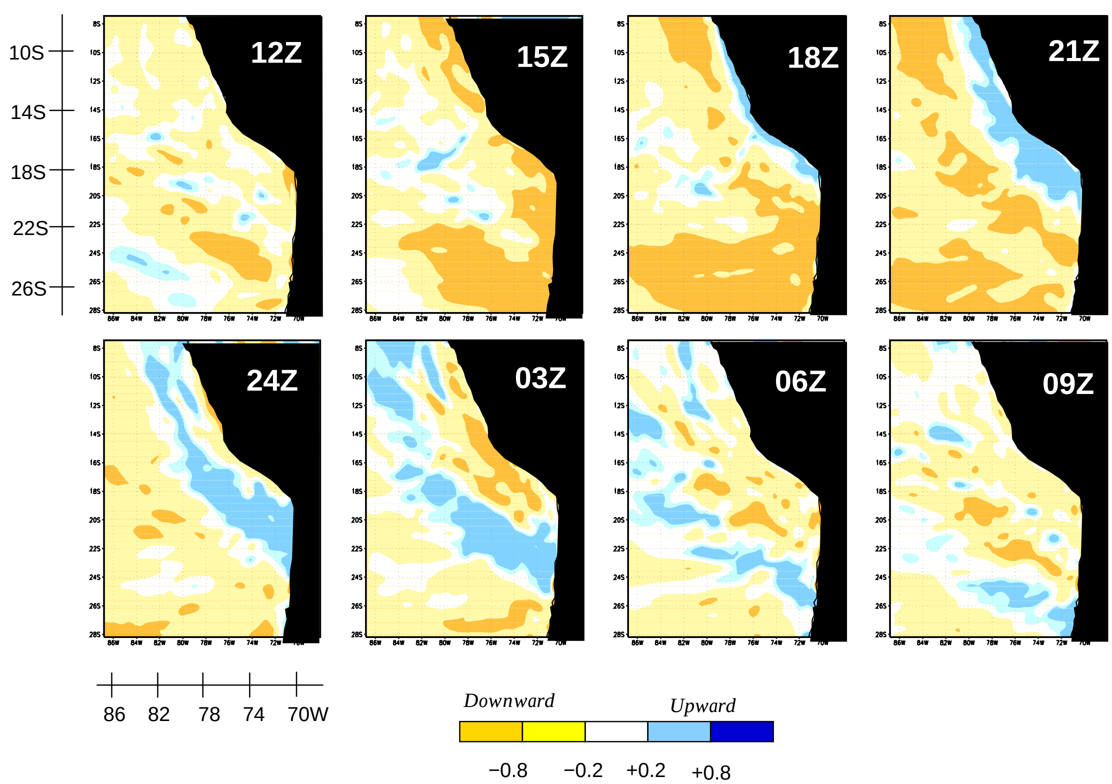

Figure 2. Mean vertical velocity at 800 hPa. Time is indicated at the top of each panel