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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A regional real-time forecast of marine boundary layers during VOCALS-Rex" *by* S. Wang et al.

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Response to Anonymous Referee #1

We would like to thank the reviewer for his constructive comments and many helpful suggestions, and believe that they have improved the presentation of the manuscript.

General comments

Because COAMPS real-time forecasts had some difficulties and missed quite a few days before October 20, 2008, and because the C130 and RHB observations started around that date, our analysis is focused on the time period of October 20 to November 29, 2008. Therefore, using R/V Jose Olaya measurement in the analysis does not appear to be appropriate for the current analysis. We plan to use those data to evaluate our new atmosphere-ocean coupled simulations.

We agree with the reviewer that there are some important differences between the model and observations along the coast of Peru. We address the reviewer's concern by discussing the specific issues raised by the reviewer in a newly added paragraph near the end of section 3. This paragraph addresses reviewer's three specific comments (18426, line 2-15; 18428, line 15-25; and 18428, line 28-29) made by the reviewer. We want to stress following three points regarding the wind comparison:

First, the larger mean forecast wind speed on the 45-km grid than the Quick SCAT along Peruvian coast is noticed. The forecast wind on the 15-km grid compares better with the combined satellite data from AMSR-E, SSMI and TMI satellites than the Quick Scat data. This may be partly due to the fact that QuikSCAT only has two passes over a location, while the combined dataset has 4 – 8 passes. Second, the diurnal phase difference between the forecast and the satellite is about 12 hours over the 100-km width coastal area (Fig. 5e and f). It is noticed that the model diurnal amplitude is very small, only 0.1-0.5 m s-1, along with the low correlation coefficient 0.2, which tends to introduce uncertainties in the statistics, as suggested by the reviewer. In addition, some model and satellite data studies indeed indicate meridional variations of the diurnal phase (Munoz, 2005, and Gille et al., 2005). More studies are clearly needed. Third, we pointed out that there are some differences in the amplitude comparison. Given the model-data difference shown in this study and importance of the diurnal characteristics of the surface winds in the area, we stress the need for more detailed analyses to fully understand the exact nature of the wind diurnal variation. Following paragraph will be included in the revised manuscript:

"There are some apparent differences between the forecast and satellite wind fields along west coast of Peru. The 45-km grid nest wind speed reaches a local maximum (ïĄ¿ 9 m s-1) compared to only 7 m s-1 from the QuickSCAT data (Fig. 2), although the 15-km grid nest forecast compares better with the combined satellite data from AMSR-E, SSM/I and TMI satellites. This may be partly due to the fact that QuikSCAT

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only has 1-2 passes over a location each day, while the combined dataset has 4 – 8 passes. The forecast diurnal amplitude over the area off Chile between 76° W and 72° W is $\sim$ 1.25 – 1.75 m s-1, significantly larger than that from the satellite data, $\sim$ 0.5 m s-1. Previous multi-year satellite data analyses, however, also show that the morning-to-afternoon wind speed increase can be as large as 1.5 m s-1 in the same area (Muñoz, 2005). The diurnal phase difference between the forecast and the satellite is about 12 hours over the 100-km width coastal area off Peru (Fig. 5e and f). The diurnal amplitude along the Peruvian coast is only 0.2 – 0.5 ms-1, along with a small correlation coefficient about 0.2, which implies significant uncertainties in the model diurnal statistics. The meridional variation of wind speed phase in this area has been noticed in previous studies. For example, Muñoz (2008) used model simulations to show a decrease in meridional wind speed along the southern coast of Peru from 1200 to 1800 LST compared to the corresponding increase over areas off central coast of Chile. Analysis of satellite data also suggest that the timing of the maximum meridional winds off Peru and northern Chile is generally several hours earlier than off the central region of Chile (e.g., Gille et al. 2005). The characteristics of the diurnal variation of surface winds in the coastal area are important, as they reflect the interaction among the lower troposphere circulation, sea breeze and MBL turbulence. Given the high uncertainties regarding the forecast-satellite wind phase difference and the meridional variation of the wind phase shown in these studies, more detailed analyses are needed to produce robust diurnal statistics of both model and observations and investigate the exact nature of the wind diurnal variation."

18430, line 11-13. COAMPS does show large changes in the MBL heights in the second half of October, which is clearly seen in Figure 6. The MBL height is ïĂă$\sim$1.5-2 km between 85 W and 80 W during this synoptically active period. COAMPS MBL heights, however, are more-or-less flat from Nov. 17 – Nov. 26, a synoptically weak period according to Rahn and Garreaud (2010), compared to the RHB MBL heights. A possible explanation is as follows. For synoptically active period, the MBL height tendency may be dominated by the large-scale forcing which can be resolved by the model. For the synoptically weak period turbulence mixing likely plays more prominent roles and it must be parameterized. The deficiencies in the turbulence parameterization may lead to more errors in zi in November, as shown in Fig. 6. One needs to analyze the budget of zi to evaluate this hypothesis. This issue is discussed in Section 4 in future revised manuscript.

18431, line 11-23. We estimated the jumps in meridional wind across the inversion for both the model forecast and RHB observation. The modeled jump is weaker than the observed due to a slightly weaker inversion and weaker MBL height slope.

18432, line 20. We looked at our 5-km grid results. The 41-day averaged results indeed show 7° reduction in the surface wind direction, a modest improvement. But it is not enough to fully correct the overprediction of the onshore component. Statements are added to address this issue.

18435, line 6-11. Because of the difference in the MBL heights between the observations and the forecast, the bias error shown in Fig, 11 very much reflect the bias in the MBL height. The figure does not contribute a lot to the evaluation. We decided to remove Fig. 11.

18441, line 29. The COAMPS with high vertical resolution was only run for 48 hours. For these 48 hours, we have not seen improvement in the decoupled MBL structure due to the solar warming.

Minor editing technical points:

18422, line 3. Wood et al. (2006) is changed to Wood et al (2010). 18422, line 16. “Wang et al., 1994” is changed to “Wang et al., 1993”. 18422, line 18. “McCaa and Bretherton, 2003” is changed to “McCaa and Bretherton, 2004”.

18435, line 8. Typos is corrected.

18439, line 20 and 25. “14:45” is changed to “14:50”.

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18443, line 20. Rahn and Garreaud (2010a and b) are included in reference

References: Bretherton et al. (2004), Hignett (1991) and Klein et al. (1995) are removed.

Fig. 5: the different scales are mentioned.

Bretherton et al. (2010) is included.

Muñoz (2008) is included.

Response to Anonymous Referee #2

We would like to thank the reviewer for his constructive comments, detailed editing and helpful suggestions. We believe that the comments have improved the presentation of the manuscript.

Is there any cloud fraction/partial cloudiness scheme used in COAMPS for the computation of radiative fluxes?

Cloud fraction scheme is not used in COAMPS for the computation of radiative fluxes. A statement is included in the modified manuscript to make this point clear.

How strongly is the diurnal cycle that you present influenced by the grid-cell convection events? Is the diurnal cycle during periods without grid-cell convection similar to the overall mean diurnal cycle?

The grid-scale convection may increase the diurnal amplitude if it occurs in the early morning when the cloud LWP is likely at the peak; it may also interrupt the natural diurnal cycle by producing additional thick clouds in the afternoon. Without the grid-scale convection, the diurnal amplitude appears to be closer to the satellite data, which can be seen for the area to the east of 75° W and between 19° S and 23° S from Fig. 10a-d and Fig. 4a. However, the overall diurnal signal from the model is weaker than that derived the satellite and RHB observations.

After Figure 5 are you still using results from the 15 km mesh for most of the rest of the paper? It's not clear from the text.

Yes, all the model results presented here are from the 15 km grid mesh except Fig. 2, Fig. 15, and Fig. 16, where the results on the 45 km and 5 km grid meshes are also included. This point is made clear toward the end of Section 2 (COAMPS real-time forecast setup and observation datasets) and at the beginning of Section 3 (Regional fields).

p. 18428: Line 12 – 14.

The reviewer is correct in that the time of the LWP maximum is indeed 2-4 hours earlier for the forecast than for the satellite. Statements regarding this difference are included in the paragraph.

p. 18428: Line 28.

The reviewer is correct in that the timing of the maximum wind speed is about 10-12 hours earlier than the satellite. It is not clear why it occurs. A paragraph regarding the wind comparison difference is included in Section 3. Also please see the reply to Referee #1.

p. 18432: Line 26-27.

The low qc is mainly due to the thinner cloud layers caused by lower zi. In COAMPS, there is no partial cloudiness scheme applied to the condensation calculation in the predictive qc equation, even though a cloudiness scheme is used to calculate the buoyancy flux for the turbulence kinetic energy prediction. This point is made clear in the modified manuscript.

p. 18433: Line 16.

We recalculated LW radiative fluxes using COAMPS radiation code and the forecast thermal structure. The results are presented in Fig. 9c and d (see the attached Fig.

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9 and note that we replaced the TKE plot in the old manuscript with the LW radiative fluxes.) They clearly show that the increase of moisture above clouds toward the coast indeed leads to the reduction in the LW radiative divergence in the cloud layer. This result is consistent with observations shown in Bretherton et al. (2010). For Section 7 (p. 18441 line 12), the main point is the impact of the mesoscale circulation on the height of the coastal MBL. Therefore, we remove the TKE plot, and replace it with liquid water profiles without mentioning the radiative cooling.

p. 18433: Line 25. The TKE plot is removed.

p. 18436: Lines 17-18. It is mentioned that qv at 10 m increases with SST.

p. 18437: Line 4: The wording regarding the “thick cloud” and the “cloud free” are defined following the reviewer’s suggestion.

p. 18440: Line 22.

The total advection near the surface shown in Fig. 15, to the most part, represents the horizontal advection, since the vertical motion is minimal near surface and the MBL structure is well mixed. More statements are included to explain why the total advection represents the horizontal advection near the surface.

p. 18442: Lines 25-29. Yes, the MBL deepens in part due to increasing SST because the lower troposphere stability becomes weaker to promote stronger entrainment. New statements are added in the new version.

p. 18442: Line 7. The sentence is changed to “..., including aircraft, ship, buoy and satellites”.

Table 1: Fixed.

Figure 3: Fixed.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 18419, 2010.

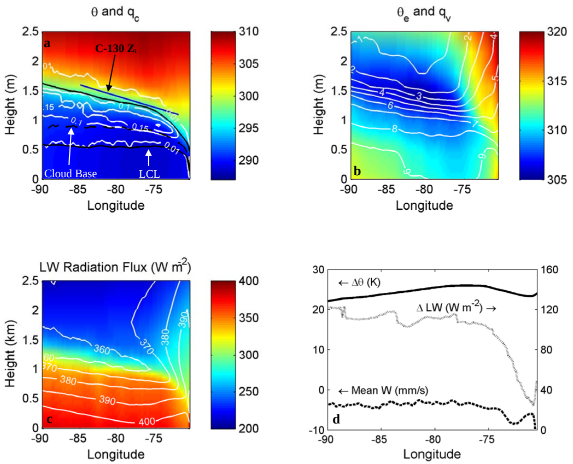

Fig. 9. COAMPS MBL variations along 20°S. (a) Longitude-height cross-section of q_c (white contours in g kg^{-1}) and θ (color shaded in K). The mean predicted MBL height is denoted by the upper branch of black curve, the mean LCL by the lower branch of the black curve, mean cloud base by the black dashed curve. The blue line is the MBL height fitted by C-130 data. (b) cross sections of q_v (white contours in g kg^{-1}) and θ_e (color shaded in K); (c) cross sections of downward LW flux (color shaded in W m^{-2}) and upward LW flux (white contours); and (d) predicted longitudinal variations of the lower troposphere stability ($\Delta\theta = \theta_{3km} - \theta_{SST}$, solid line in K), the time averaged vertical motion at the inversion height (dashed line in mm s^{-1}) and the total LW divergence across the cloud layer (ΔLW, dotted in Wm^{-2}). ΔLW is defined as the difference between the total LW radiative flux just above clouds and that just below the cloud base.

Fig. 1.