Evaluation of COAMPS™ Real Time Forecast for CBLAST-Low Summer Experiments 2002/2003

Shouping Wang[1], Qing Wang[2], Zhiqiu Gao[2], James Edson[3], Robert Weller[3] and Costas Helmis[4]

[1]*Naval Research Laboratory, Monterey, CA*
[2]*Naval Postgraduate School, Monterey, CA*
[3]*Woods Hole Oceanographic Institute*
[4]*University of Athens, Athens, Greece*

1. INTRODUCTION

Air-sea interaction plays critical role in regulating the dynamic and thermodynamic structures in both oceanic and atmospheric boundary layers (BLs). These BL structures strongly feed back to impact the interaction, and thus affect the physical processes on the other side of the interface. Therefore, the issue of air-sea interaction involves not only those processes at the levels immediately next to the interface on both sides, but also the relevant structures in the BLs. The objectives of Coupled Boundary Layer Air/Sea Transfer project (CBLAST) are to understand this interaction in the context of coupled boundary layers and develop new modeling techniques based on this understanding. A particular emphasis is focused on the interaction at low-wind speeds in CBLAST-Low project.

A major component of the CBLAST-Low is the consecutive field experiments in each summer for 2001 - 2003 in the vicinity of Martha Vineyard Island. These experiments provide valuable measurements regarding the interaction at the interface and in both boundary layers on a number of observation platforms including air-sea interaction tower, buoys, aircraft, sodar and rawinde sonde. For three years, the Navy's COAMPS™ has been used to perform high-resolution real-time forecasts in the intensive observational period (IOP). The objectives of these forecasts are to provide

- weather information to the field scientists;
- surface forcing to ocean real-time forecast performed by the ocean group in Rutgers University;
- model data for evaluation of COAMPS™ physical parameterizations regarding the air-sea interaction;
- mesoscale meteorological conditions for interpreting and understanding the observation data.

This paper focuses on the evaluation of the COAMPS™ performance using both the mean and turbulence measurement collected during the 2002–2003 experiments.

2. SETUP OF REAL TIME FORECAST

The NRL COAMPS™ is a nonhydrostatic modeling system (Hodur, 1997) with a full suite of physical parameterizations. Particularly, the surface flux parameterization is modified to fit the COARE2.6 results as described in Wang *et al*. (2002). This improvement is important as our focus is on the air-sea interaction in low winds.

A 60-hour forecast was performed twice daily using nested grids with horizontal grid increments of 3 km, 9 km, and 27 km, respectively and 30 vertical levels. Fig. 1 shows part of the inner domain which covers the experiment area. This configuration were used in both the 2002 and 2003 summer field experiments.

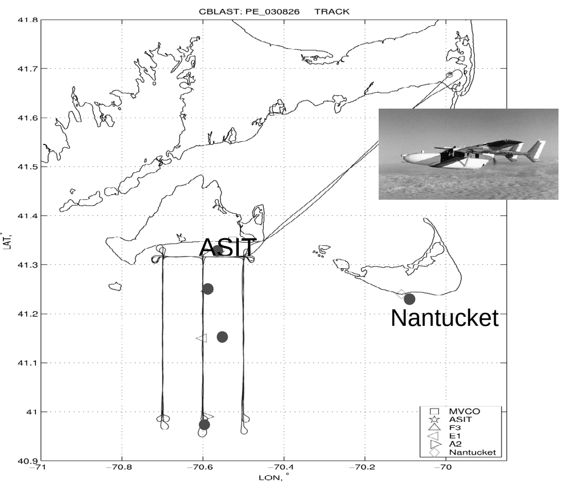

Fig. 1 CBLAST-Low field experiment area of 2002/2003. The dots are surface observation sites or buoys. The Nantucket site is on the island about 100 m from the southern coast line. The thin lines are samples of observation aircraft flight patterns.

3. SURFACE MEAN QUANTITIES

Comparison of COAMPS™ assimilated SST with the observed skin SST at ASIT (Air-Sea Interaction Tower) (Fig. 2a) shows the former is slightly higher than the latter which frequently shows the noticeable diurnal variation. The forecast 2 m air temperature closely follows the observed trend, although there is clear high bias in the first 12 days when the southwest flow was dominant. The forecast wind speed (Fig. 2c) tends to be underestimated when wind is weak, and overestimated when the wind is moderately high. The water vapor mixing ratio is the best performed variable as shown in Fig. 2d. These

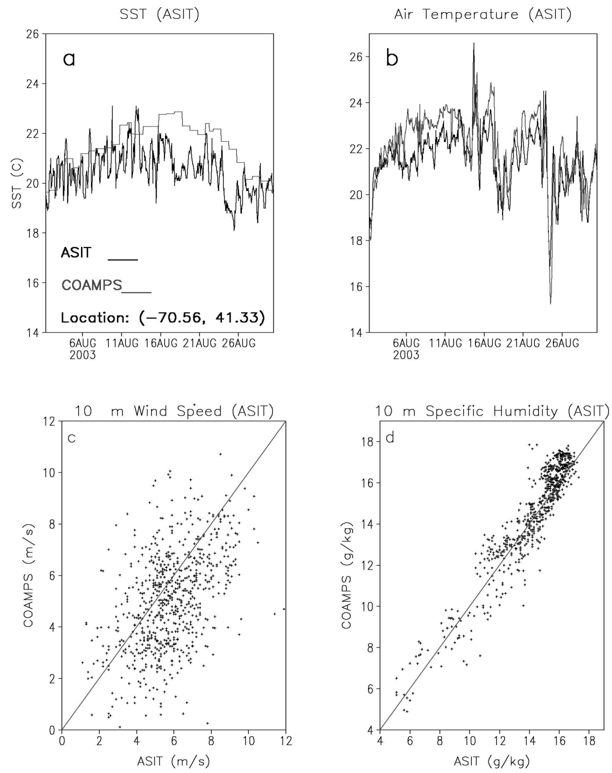

Fig. 2. Comparison between the COAMPS and observed mean variables. Time series of SST and air temperature (a and b); scatter plot of wind speed and specific humidity (c and d)

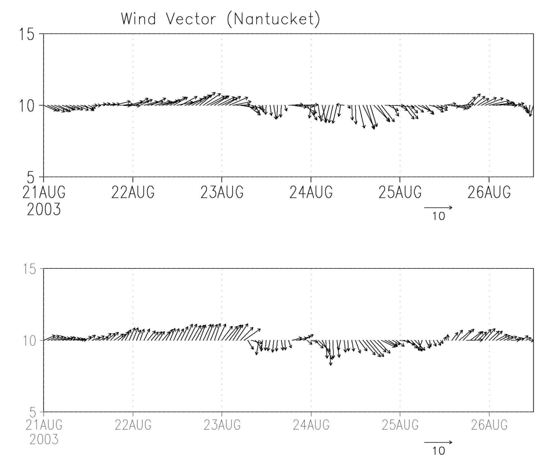

Fig. 3. Winter vectors at Nantucket site. Upper: obs; Lower: COAMPS

Mean quantities may significantly affect the forecast surface fluxes. Nantucket measurements are particularly useful as they provide strong competing influences of land and marine condition. COAMPS's wind direction is general good agreement with the observations as shown in Fig. 3, although the southerly component in the 22-23 of August seem too strong.

4. SURFACE FLUXES

Both predicted sensible and latent surface fluxes are clearly biased toward high values compared with those of the observation derived using

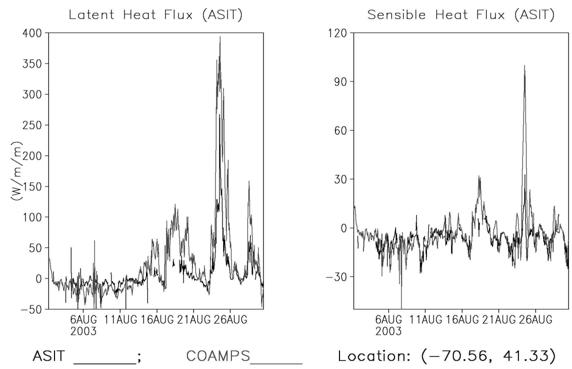

Fig. 4 Time series of the observed and COAMPS forecast latent (left) and sensible (right) heat fluxes.

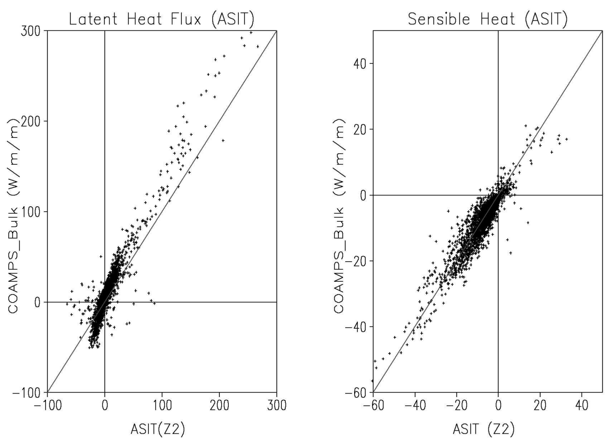

Fig. 5: Scatter plots of COAMPS surface flux using the observed mean variables vs. observation derived.

the direct covariance method. This high bias is partly due to the errors in the SST and 10 m forecasted mean variables. To show this, we recomputed the fluxes using the observed mean variables and SST. Fig. 5 shows that both latent and sensible heat fluxes are significantly improved due to the use of the observed mean quantities. Particularly, the COAMPS sensible heat flux provides excellent estimate to the observation derived, even under stable conditions. Negative values of the latent heat flux are likely associated with the foggy and stable surface conditions because the temperature and moisture fluctuations are proportional to each under saturation situation. Efforts are currently being made to understand the turbulence characteristics and the COAMPS performance under stable and fog conditions

The comparison of latent heat flux at Nantucket site shows interesting features. When the onshore (southwestly) flow dominates on 22-23 of August (Fig. 3), the COAMPS flux at the neighbor *ocean* grid point is consistent with the observed even though the site is on the land, as shown in Fig. 6. When the northerly flow is present, the COAMPS flux at the land grid point is more representative of the observed. This result is clearly due to the fact that the surface flux parameterization only depends on the local roughness and skin surface temperature. Its inability to “see” the upstream turbulence characteristics is clearly a weakness for any mesoscale model. Its impact on the model forecasts depends on the grid resolution used in the model and is yet to be determined.

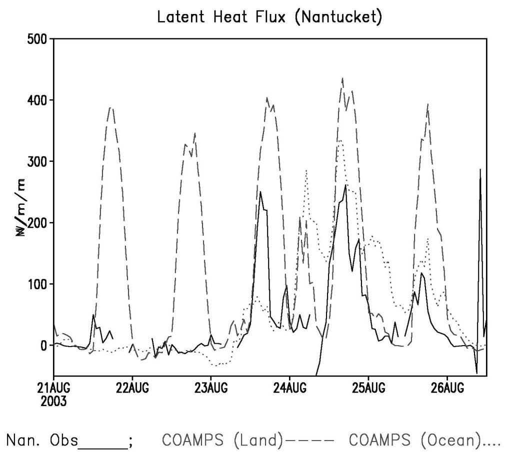

Fig. 6. Comparison between the observed and forecast latent heat fluxes. Dashed line represents the result from the closest neighbor land grid point; dotted the result from the ocean grid point.

5. LAND-SEA BREEZE

In the 2002 summer experiment, a well-defined land-sea breeze developed and maintained in the period of 7-8th of August. The event started with the unusually dominant but weak northerly flow in the early morning of 7th. The flow shifted to southerly around 1200 LST and became northerly again at 0200 LST 8th of August. The COAMPS forecast well captured this process, although the COAMPS wind direction shift on the 7th was 3 hours late as shown in Fig. 7. The change in the wind direction also affects the temperature and moisture in the marine boundary layer due to the transformation between the marine and continental air mass.

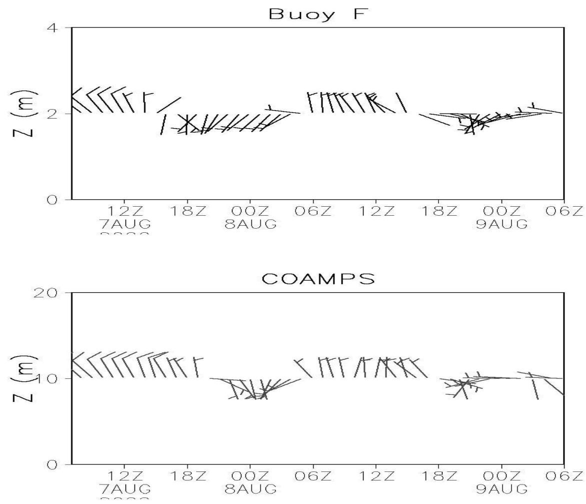

Fig. 7: Observed and forecast wind vectors at buoy F during the land-sea breeze episode.

The changes in the mean variables surely impact on the surface and the boundary layer turbulence characteristics and structure.

6. SUMMARY

CBLAST-Low provides comprehensive dataset for air-sea interaction at low-to-moderate wind speed and coastal marine boundary layer study. These data are used to evaluate the COAMPS real time forecast conducted in the field experiment period. Moisture appears to be the best forecasted variable. COAMPS assimilated SST is slightly higher than the observed. The forecasted land-sea breeze is very successful, probably in part due to the high-resolution used in the forecast.

7. ACKNOWLEDGMENTS

This work is supported by the Office of Naval Research through CBLAST project.

8. REFERENCE

Wang, S., Q., Wang, and J. Doyle: 2002; Some improvement of Louis surface flux parameterization. *15th Symposium on Boundary layers and Turbulence*, American Meteorological Society, 15-19, July 2002, Wageningen, the Nettherland. 547-550.