4.5 A SIMULATION OF A REAL MCC EVENT OVER THE YELLOW SEA WITH COAMPS MODEL

Fanyou Kong * Brian Fiedler
CMRP, University of Oklahoma, Norman, OK 73019

1. INTRODUCTION

The mesoscale cellular convection (MCC) system is common in wintertime when continental cold air mass flows through a warmer ocean surface, resulting in a maritime mixed layer capped by cellular pattern cloud cells. The ability for mesoscale models to explicitly simulate this MCC cloud system is important since cloud cells from such systems affect the radiation budgets and precipitation in the marine boundary layer in a great manner. Fiedler (1999) simulated the MCC broadening process with the Naval Research Laboratory's mesoscale model COAMPS (Coupled Ocean/Atmosphere Mesoscale Prediction System) (Hodur 1997) under idealized condition and showed that the model "does an admirable job" at simulating MCC.

In this study, the MCC during a real cold-air outbreak over the Yellow Sea on January 25, 2000 has been simulated with the COAMPS model. During the outbreak, the cold northerly flow blow across the warm Yellow Sea, resulting a broad area of MCC occurrence (Figure 1)

2. MODEL CONFIGURATION

The numerical simulations are carried out in one single grid set with 2 km resolution in horizontal and 45 vertically stretched sigma levels ranging from 20 m near the surface to 790 m at the top at the height of about 14.8 km. Figure 2 shows the domain location. The domain has 175$\times$175 grids centered at 36.8N and 124.0E, covering a 350 km by 350 km region over the Yellow Sea. The model initial conditions are obtained directly from the Navy NOGAPS (Operational Global Atmospheric Prediction System) data (so called cold start), with a multivariate optimum interpolation (MVOI) analysis procedure. Since the MCC in such cold air outbreak events is the product of convective marine boundary layer with strong surface forcing, the cold start initialization is adequate for the quick setup of the convective boundary structure. The NOGAPS data also provide the lateral boundary conditions through the 24 h simulation process.

The large time step in integrating the advective mode is 5 s and the time-splitting ratio for the acoustic mode is 2.

3. RESULTS

Our first model running with full set of COAMPS operational settings turned out to fail to produce the desired MCC cloud structure during the entire 24 h simulation. Only solid stratiform cloud deck had been produced instead (Figure 3). Analysis to the model output revealed an extremely strong eddy mixing, with K_h and K_m as high as 700 m s^{-2}, within the convective boundary layer, resulted from the mesoscale model's Mellor-Yamada TKE package. When we reduced the K_h and K_m to one third of their original values, perfect MCC structure was developed (Figure 4). In this reduced K_h and K_m run, the thin stratiform cloud deck, initially formed 30 min into the simulation, begins to break up after 3 h. The mixing length of Bougeault and Lacarrère (1989) has also been tested in this case. It too requires certain reduction adjustment of its parameters to generate

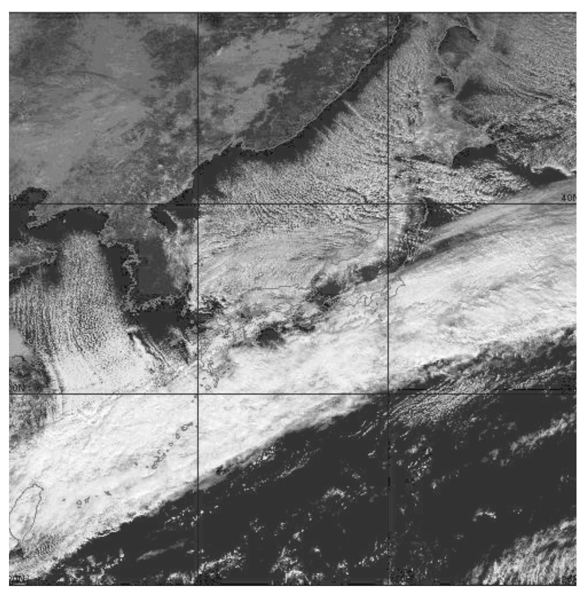

Figure 1: Visible satellite image at 0239 UTC on 25 January 2000.

*Corresponding author address: Dr. Fanyou Kong, CMRP, University of Oklahoma, Rm 1034 SEC, 100 E Boyd, Norman, OK 73019; e-mail: fkong@ou.edu.

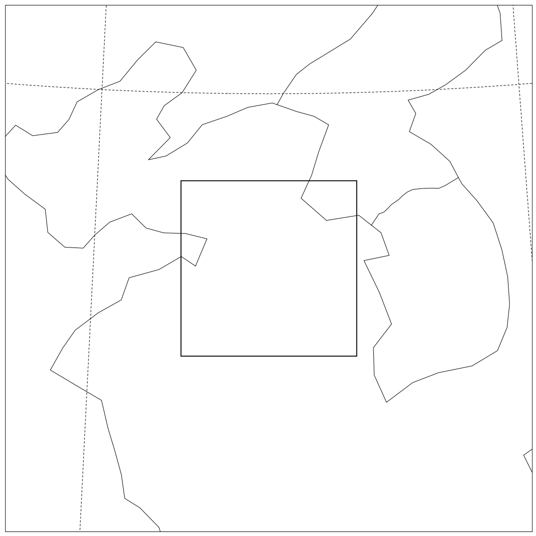

Figure 2: Diagram of model domain (the small square in the center).

proper level of eddy mixing in order for the model to produce well developed MCC.

The sensitivity of MCC to the surface heat fluxes has been tested. It is found that stronger latent heat flux results in more robust MCC development, while stronger sensible heat flux helps cells to penetrate higher.

4. CONCLUSIONS

The simulation results show that the COAMPS

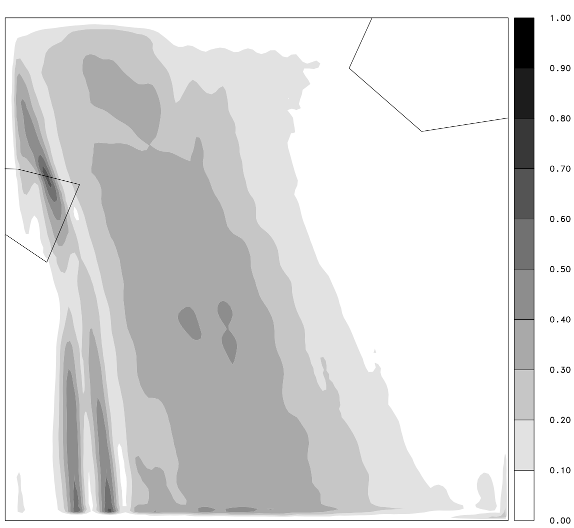

Figure 3: 9 h forecast column-density cloud water (kg m^{-2}) in the lowest 2 km valid 0900 UTC 25 January 2000, with original eddy mixing coefficients.

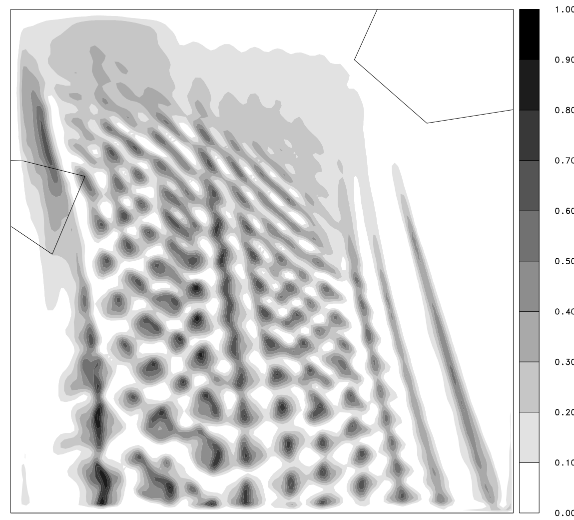

Figure 4: 9 h forecast column-density cloud water (kg m^{-2}) in the lowest 2 km valid 0900 UTC 25 January 2000, with reduced eddy mixing coefficients.

model is able to produce the well developed mesoscale cellular cloud cells for the real case situation. However, in order for the stratiform cloud deck to fully break up into cellular cloud pattern in a timely manner, the eddy mixing coefficients resulted from the model's Mellor-Yamada TKE computation need to be reduced significantly. The Bougeault-Lacarrère mixing length method is implanted into the COAMPS model and tested in the simulation. It too requires adjustment of its parameters to generate proper level of eddy mixing for the model to produce well developed MCC. Sensitivity tests are also conducted, which show the important impact of latent heat flux on the resulting MCC development and structures.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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