11.6 COUPLED MESOSCALE-MICROSCALE MODEL TO COMPUTE NEIGHBORHOOD SCALE WIND FIELDS

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1. INTRODUCTION

The coupling of a mesoscale model to a microscale airflow model with the inclusion of surface morphology features permits further analyses at the neighborhood scale. The Army Research Laboratory (ARL) has long used a microscale wind model (HRW) to perform diagnostic studies of the effects of terrain and vegetation on local winds. ARL has also used a hydrostatic mesoscale forecast model, BFM, to produce tailored forecast products. In studies of the effectiveness of the BFM to produce low level forecast products for local areas in complex terrain, the lack of response of low level forecast winds to the true high resolution terrain became evident. Earlier research resulted in the integration of the HRW code with the BFM to attain higher resolution meteorological analyses for very local, high resolution areas on open terrain. The objective of this study is to extend this existing coupled set of meso-microscale models to further analyze airflow variations on the neighborhood scale of motions.

2. THE MODELS

In addition to ARL's coupled set of meso-microscale models, the US Navy's larger scale Navy Oceanographic Global Atmospheric Prediction System, NOGAPS, was used to initialize the BFM. Other codes are used also to further analyze BFM output before the HRW input file was prepared. ARL's Atmospheric Sounding Program, ASP, was used to establish mandatory levels as a vertical sounding profile. A slope flow enhancement algorithm was used to derive slope winds to enhance the analysis of BFM output used to initialize HRW.

3. EXAMPLE SIMULATIONS

A simulation domain common to both models was selected. Within the confines of the San Francisco Bay, the San Pablo Bay-Western Contra Costa County, CA local area centered on Rodeo was identified for BFM (200km x 200km) and HRW (10km x 10km). The computational grid size for the BFM is 2.5km and 100m for HRW. Meteorologically, Jan 18 1998 was selected as one of the simulation cases. Digitized terrain elevation data were extracted from NIMA's DTED CD-ROM, whereas surface feature morphology data were constructed manually.

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BFM was initialized with the 0000Z, 1^0 NOGAPS analysis centered on San Francisco Bay. Solutions for 0000Z to 06000Z were generated in this simulation study. BFM's output was further analyzed by ASP, Barnes, and the slope flow to customize meteorological inputs to HRW in terms of upper air soundings and a set of 16 adjacent 'surface station' grid points. Initially, HRW simulated cases for terrain-only lower boundary conditions.

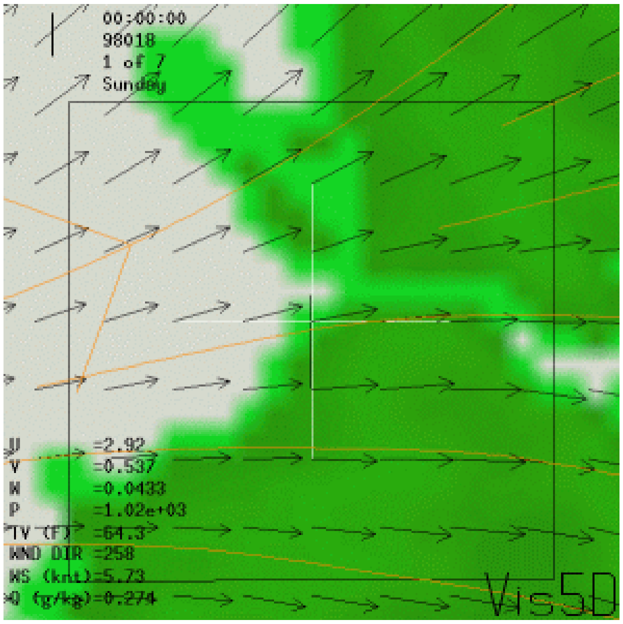
Figure 1 shows part of the BFM analysis for 0000Z with wind vectors every 2.5km and streamline analyses over plotted onto the San Pablo Bay area. The analysis shows slow changing speed and directional fields traversing water to land surfaces. Figure 2 depicts the resultant HRW horizontal mean wind vector and streamline fields with 100m grid size for 3km x3km area of the 10km x 10km simulation domain. The high resolution analysis reveals more deformation of the flow field especially where over water westerly flow is channeled into Franklin Canyon in a southeasterly direction.

Solutions were run again with the inclusion of surface feature morphology also with 100m resolution. Figure 3 shows an HRW wind field simulation for combined terrain and morphology effects. The flow field exhibits even more detailed variations in and about the non-uniformed array of urban and rural structures.

Figure 4 permits a closer inspection of neighborhood scale airflow. The resultant vector field is magnified to view a 1km x 1km area located just east of the center of Figure 3 domain. It is clear that the urban structures and their spacing further influence the over all flow channeled in and about the canyon.

4. CONCLUSIONS

The results of this modeling study provide several conclusions. The 1^0 NOGAPS initialization field permitted more detail in BFM's mesoscale flow field for the 2.5km grid. With this higher resolution BFM output, HRW was then able to generate a very detailed airflow analysis in its localized area. For the Rodeo domain, the HRW output for 0000Z showed significant terrain influences during unstable conditions. With the inclusion of urban morphology, HRW's solutions exhibited even greater variations in the flow field. Further scrutiny of the solution for an area of a few blocks on a side ($1km^2$) reveals that the flow field is seen to be further influenced by the non-uniform urban structures.



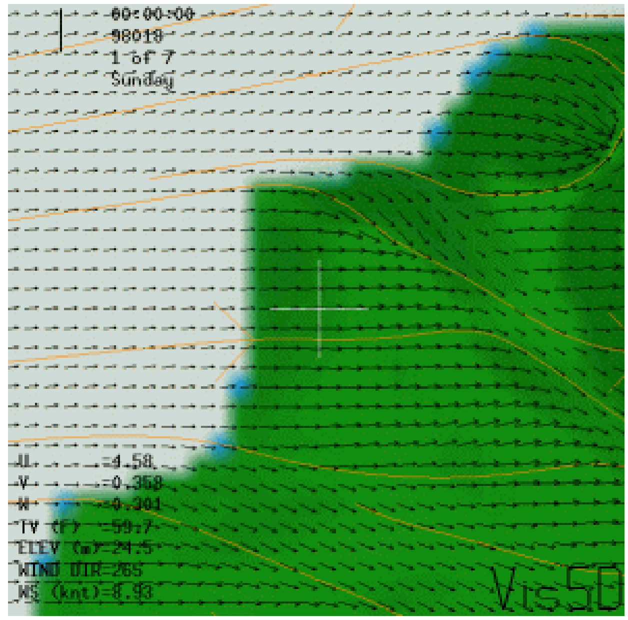
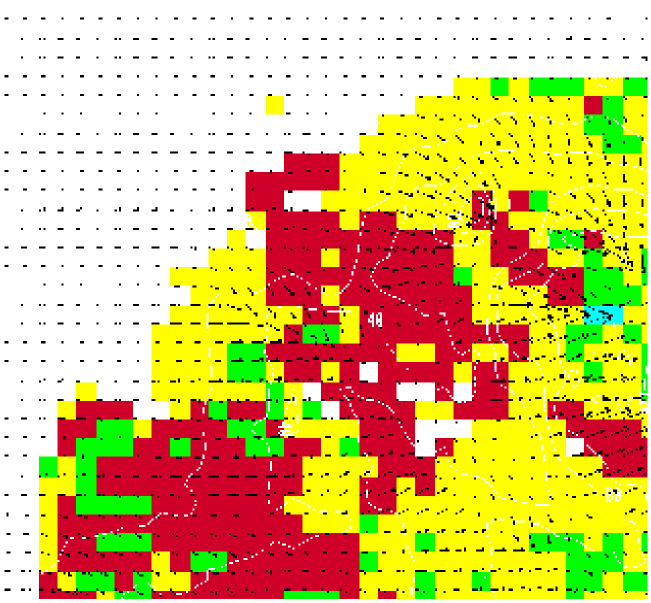


Figure 1. Partial view ($15km^2$) of full BFM domain with 2.5km grid for 0000Z with WSW flow at 2.9 knots under unstable conditions. The white cross locates the Rodeo site. Values given are at the white cross grid point.

Figure 2. Partial view ($3km^2$) of the HRW simulation with a 100m grid initialized with the BFM output of Figure 1, where only terrain is the lower boundary condition. The white cross is the Rodeo site. Every other vector is shown.



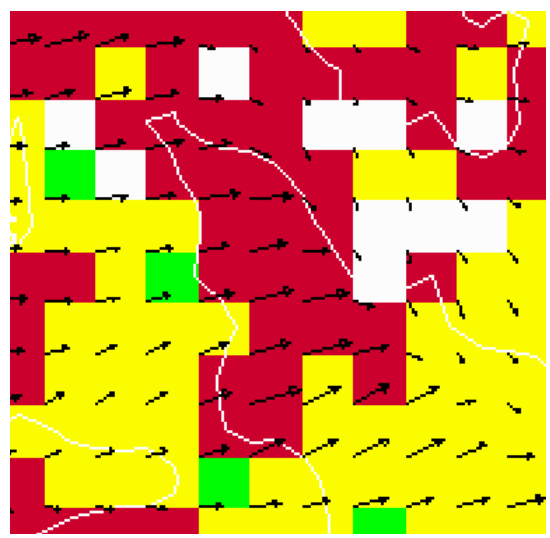


Figure 3. Partial view (same $3km^2$) of HRW simulation with 100 grid initialized by the Figure 1 output now with the surface morphology added to the HRW domain. Note: buildings are red, trees are green, grass is yellow, marsh is blue, white is impervious surface on terrain, but also denotes water surfaces as San Pablo Bay. All vectors are shown.

Figure 4. A close-up look of a 1km x 1km area located just east of the center of Figure 3 (match the white squares) depicting the neighborhood scale of motion computed by HRW. Strong channeling of flow by terrain shown in Figure 2 is modified by the interaction with urban structures in terms of both speed and direction.