Meso-scale Spectral Model Simulations over the San Jacinto Mountain Region

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1. Introduction

Accurate weather data input is critically important in simulating the advance of the surface fire front in the event of a wildland fire. In general, the fire perimeters advance in accordance to the prevailing wind direction but also complicated by the terrain and the availability of the fuel. Previously only meteorological models with coarse resolution, 5-km at best, or diagnostic models under heavy dynamical assumptions were applied in fire spread modeling studies (e.g. Weise et al. 2007). These previous efforts were hampered by the uncertainties of the weather data used in the fire-spread simulation. The uncertainties usually arise either from the coarse spatial scale of the meteorological model or from the over-simplified assumptions of the model.

In October 2006, the Esperanza wildfire consumed 16137 hectares of chaparral and desert scrub vegetation in mountain terrain roughly 50 km east of Riverside, CA over the area shown in Figure 1. Five US Forest Service fire fighters tragically perished in the fire suppression effort at the burned over location marked as “x”, primarily due to the unexpected intensified wind shift prior to the burn-over incident. This Santa Ana wind driven wildfire over complex terrain therefore provides a unique opportunity for model validation before an operational fire-spread predictive tool can be implemented. Weise et al. (2007) used two meteorological models, including RSM and MM5 with coarser resolution (5km) to drive a fire spread model in simulating the advancement of the fire lines. Their simulation showed a westward spread of fire that was a result of the simulated easterly parallel to the Banning Pass, which is with two high mountain peaks on either side. Their simulation clearly contradicted to the observed fire perimeter that showed an advancement of fire from northeast to southwest. We suspect that their inadequate wind simulation was likely caused by the insufficient horizontal resolution that failed to depict the mechanical as well as the thermo-dynamical processes over this complex terrain area.

In this study the Meso-scale Spectral Model (MSM; Juang 1992), a non-hydrostatic version of the Regional Spectral Model (RSM) is used to demonstrate the capability of the model in simulating near surface meteorological variables at 1-km grid intervals over the model domain shown in Fig. 1.

2. Numerical experiments

A pilot simulation over the two days period during the Esperanza fire was done by initializing and forcing the 5-km grid space MSM with National Centers for Environmental Prediction (NCEP) operational T385 analysis. A second nest of 1-km resolution simulation over the domain area in Figure 1 was subsequently run. Two experiments were carried out first to test the sensitivity of the domain size, one with a smaller domain with 82 by 88 grids, and the other with grids 136 by 136. Figure 2 shows the simulated 10-meter wind of the two experiments. It can clearly see that the northeasterly (circled in red) in the vicinity of the burned-over site is evident in the bigger domain model for both local time 1am (upper right) and 7am (lower right) simulations. Previous simulation with coarser resolution did not reveal this surface wind pattern at all. The simulation with smaller domain failed to show the northeasterly over the target area suggesting a possible strong influence from the lateral boundary when the domain is too smaller for such high-resolution simulation. Detail analysis is also underway to study the effect of diurnal radiation heating over the two mountain peaks. This diurnal variation is likely complicated by the imposing strong Santa Ana wind condition during the fire event.

3. Validations

Although observed fire perimeters does provide some indication of the near surface wind condition, validating high-resolution meteorological simulation such as the one in this study has been a difficult one for lacking obvious observational ground truth. To facilitate the validation effort, an array of 6 Remote Automatic Weather Stations (RAWSs) were deployed around the hills and valleys of the fire site covering a study area of 10 km by 10 km. The experimental hourly observation started in October 2008. Data have been automatically transmitted to the data collection center via satellite. Simulations of MSM during the Esperanza fire event and during October 2008 will be validated first against the nearby first order surface weather stations and the existing two RAWSs. Data compiled from the 6 experimental RAWSs will then be added to the available analysis to validate simulations during October 2008.

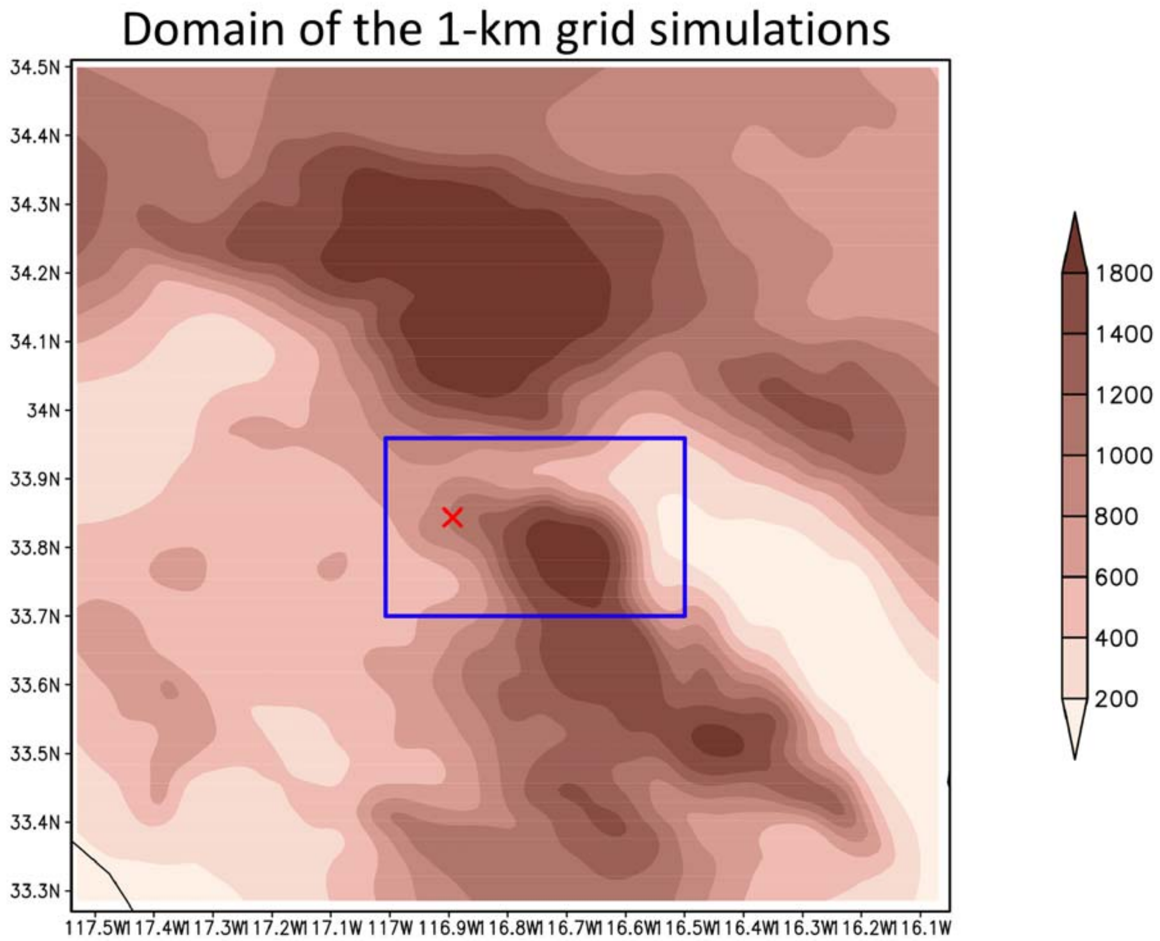

Figure 1. MSM 1-km resolution simulation domain with topograph shaded every 200 meters. San Gorgonio mountain peak is to the north and San Jacinto to the south. Both peaks exceed 3 km elevation. The entire domain has 136 by 136 grid points. The blue box indicates area for regional blow up. The "x" mark indicate the burned-over site during the Esperanza fire case.

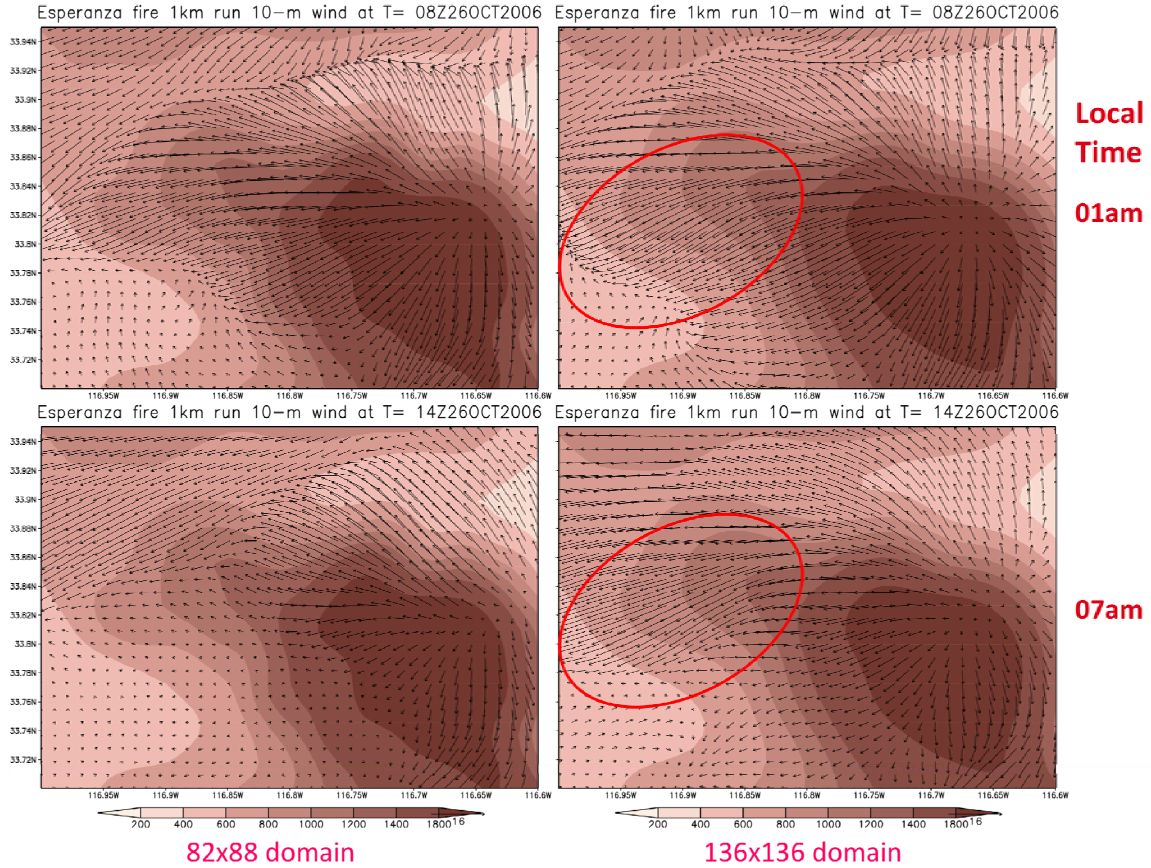

Figure 2. Regional blow-up of the 10-meter wind vector simulations over the San Jacinto Mountain area at 1-km grid space. Left panels show the simulation from a 82 by 88 grid model, and the right panes for 136 by 136 model. The 1am and 7am local time snapshots are shown in the upper and lower panels, respectively.

Reference:

Juang, H. H.-M, 2000: The NCEP mesoscale spectral model: The revised version of the nonhydrostatic regional spectral model. *Mon. Wea. Rev.*, 128, 2329-2362.

Weise, D., S. C. Chen, P. J. Riggan, C. Jones, B. W. Butler, and F. M. Fujioka, 2007: Using high-resolution weather data to predict fire spread using the FARSITE simulator—a case study in California chaparral. Seventh Symposium on Fire and Forest Meteorology 23 – 25 October 2007Bar Harbor, Maine.