7.5 EXPERIMENTAL DAILY NCEP ETA MODEL SMOKE MANAGEMENT FORECASTS

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1. INTRODUCTION

The availability of operational forecast guidance describing characteristics of atmospheric boundary layer behavior is extremely beneficial to decision-makers who monitor smoke dispersion resulting from wildland fire and prescribed burning. Currently, many National Weather Service Forecast Offices provide a 12-hour forecast of mixing height (the top level of a layer that begins just above the earth's surface and consists of strong vertical mixing) and mean transport wind flow (the mean horizontal wind speed and direction within the mixing layer). These forecasts are typically based upon sounding information or derived soundings from model output. However, prediction beyond 12 hours can also be of value to decision-makers requiring planning for one or more days ahead. Another advantage of model output is that it can account for temperature and moisture advection and synoptic scale lift or subsidence.

This paper describes a method utilizing 6-hourly National Centers for Environmental Prediction (NCEP) Eta model forecasts to produce gridded smoke management forecast products of mixing height and mean transport wind speed and direction. These products are being computed in an experimental mode at the Desert Research Institute Program for Climate, Ecosystem and Fire Applications (CEFA) in conjunction with the SCRIPPS Institution of Oceanography Experimental Climate Prediction Center's California Applications Project. Though the products are being generated for the entire U.S., results are currently being analyzed only for the West.

2. BACKGROUND

Mixing height represents the height or top of the atmospheric boundary layer, and can be thought of as a cap or lid to buoyant air (Stull, 1988). When buoyancy is minimal, the mixing height is low and particulants entrained in the boundary layer flow will remain near the surface. But higher mixing tops imply increased buoyancy and therefore, greater lift for particulants.

Wind plays an important role in the boundary layer in terms of particulant transport and dispersion. Mean transport wind represents a vertical average of zonal and meridional wind components (*u* and *v* components) from the surface up to the calculated mixing height.

The mixing level tends to be well defined in the afternoon hours (typically during times of maximum heating). However, the mixing layer can undergo significant diurnal and seasonal variability, and its location during night and early morning hours can be complex. For example, the mixing layer can decouple and become displaced above the ground during the nighttime hours due to localized radiational cooling and or low-level temperature advection.

The most commonly used method for calculating mixing height is based upon thermodynamic profiles (NWS, 1999). For example, the morning mixing height is defined as the level above ground at which the dry adiabatic ascent of the morning minimum surface temperature plus 5°C intersects the vertical temperature profile measured at 1200 UTC. The afternoon mixing height is based on the level above ground at which the adiabatic ascent of the afternoon maximum surface temperature intersects the 0000 UTC temperature profile. This latter method is applied to obtain a daily forecast of the afternoon mixing height utilizing the daily forecast maximum surface temperature and 1200 UTC sounding.

3. METHOD

In order to generate the experimental products on a daily basis, potential temperature (Θ), geopotential height (z) and zonal and meridional wind (u and v components) are extracted at each grid point (40 km) from the Eta model 00 UTC and 12 UTC runs. This is done for the initialization and each 6-hourly forecast out to 48 hours. Mixing height is then determined using a computer algorithm that checks for regions where Θ remains constant with increasing altitude. This signifies adiabatic conditions that in turn suggests the air is well mixed. The altitude at which Θ departs from constancy by one degree K signifies the top of the mixing layer.

Calculations are performed on sigma surfaces based on a non-dimensional coordinate system where the pressure at any particular level is normalized by the surface pressure. In the Eta model computations for mixing height, sigma levels range from .995 to .955 in increments of .005 and .950 to .450 in increments of .05. The .995 sigma represents the level closest to the surface.

Once the calculations of mixing height and mean transport wind for each model grid point are completed, graphical displays for the western U.S. are generated using the GrADS software package. For both mixing height and wind speed displays, the model grid points are interpolated to a .25 by .25 degree uniform grid using a Cressman analysis scheme incorporated into GrADS, and mean wind direction is simply shown by constant length vectors. However, for forecasters and users desiring actual numerical results, values can be provided for any of the original model grid points.

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4. EXAMPLES

Figure 1 provides an example graphic of mixing heights over the western U.S. using the 1 October 1999 00 UTC Eta initialization. In this example, the cooler colors represent higher mixing heights. The highest mixing heights are indicated in an area across Nevada, southern Utah, western Colorado and most of New Mexico. The lowest mixing heights, represented by warmer coolers, occur along all of the west coast and inland over the California central valley.

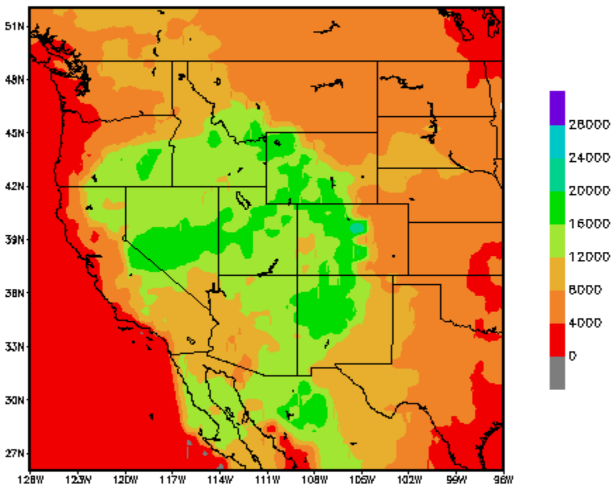

Figure 1. Example mixing height in feet above ground level for the 1 October 1999 00 UTC Eta initialization. Cooler colors indicate higher mixing heights.

Figure 2 shows the mean wind speed associated with the mixing heights in Figure 1. The strongest wind speeds are seen across eastern Oregon, southern Idaho and western Wyoming.

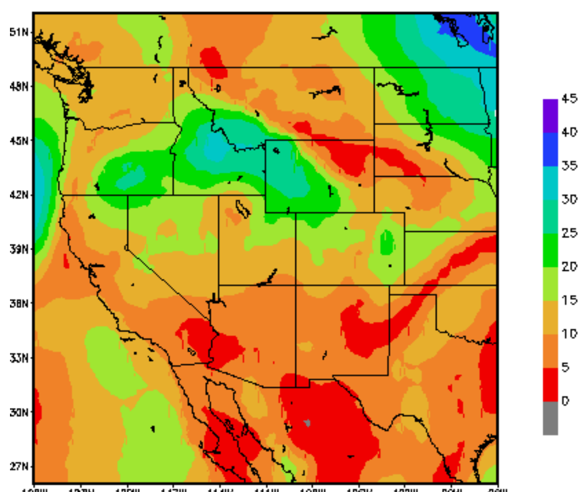

Figure 2. Example mixing height mean wind speed in mph for the 1 October 1999 00 UTC Eta initialization. Cooler colors indicate greater wind speeds.

Figure 3 shows the corresponding mean wind direction or mean transport flow. Except for the Pacific Northwest region, most of the West is generally under westerly flow in this example.

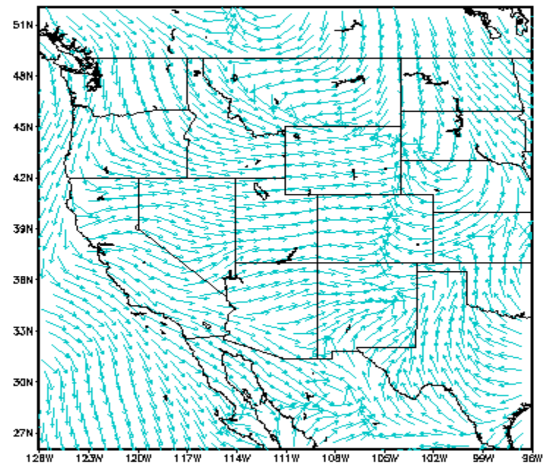

Figure 3. Example mixing height mean wind direction for the 1 October 1999 00 UTC Eta initialization.

5. SUMMARY

Even though the project is in the early stages of evaluation and verification, fire weather forecasters and smoke managers are finding immediate value and usefulness from these products. The primary advantages are that they provide an indication of boundary layer conditions in between sounding locations, and offer forecast guidance over large spatial scales and shorter time intervals. These operational products are not limited to 48 hour Eta forecasts; MRF forecasts could be used to produce mixing height guidance products out to 10 days. In this case, actual daily values may not be as important as mixing height trends.

Anticipated future work will focus on evaluation and verification. Though some basic verification has been undertaken, a more complete statistical analysis of mixing height and transport wind for the initialization and forecasts using sounding observations is needed to assess the quantitative skill of the forecasts. For longer term planning of smoke management, it would be desirable to determine seasonal and diurnal climatologies of mixing height and transport wind. This could be developed using the Eta initialization runs. Another relevant study would be relating mixing height behavior to synoptic scale patterns.

The products described in this paper are currently available in an experimental and semi-operational mode at http://www.dri.edu/Programs/CEFA.

6. REFERENCES

National Weather Service, 1999: Seattle Forecast Office Homepage, http://www.seawfo.noaa.gov.

Stull, R. B., 1988: *An Introduction to Boundary Layer Meteorology,* Kluwer Academic, 666 pp.