Progress Made Towards Including Wildfire in Real-Time Cloud Resolving Forecasts at NOAA/ESRL

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1. INTRODUCTION

NOAA recognizes that wildfires are a growing national issue threatening life, property, infrastructure and local economies.

Significant need for high-resolution forecasts containing fire weather information. These include local fire decision support, local and regional air quality, and aviation interests.

Forecasts need to be timely, quickly updated.

Forecast products need to be made available in real-time.
- Need to determine what information is important.

Forecasts need to be accurate and include:
- Local feedback between wildfire and environment,
- Large-scale effects from wildfire,
  - Focus on radiative and microphysical effects from smoke.

Forecasts need to be verified using field program data that can address the local and regional scale issues related to wildfires.

Wildfires impact weather and air quality in a variety of ways including:
- Poor air quality on local and regional scales
- Limited visibility near and downwind from fire,
- Reduced clouds along fire smoke plume
- Interaction between fire and meteorology.

Fig. 1 Satellite image showing smoke plume from the Station Fire near Los Angeles, CA on 31 Aug. 2009. Note that clouds are not observed where smoke is visible in the image (area between the red lines).

2. FORECAST MODEL

Examining the impact of wildfires on numerical forecasts.

Using the Weather Research and Forecast (WRF) model.
- Currently used for operational forecasts,
- Chemistry included to add additional fields beyond weather,
- Community model – research community improvements.

With WRF/Chem the aerosols are online.
- Completely embedded (no interpolation),
- Feedbacks between meteorology and smoke,
- Transport is consistent with meteorology,
- Uses same physical parameterization for subgrid,
- Run options range from very simple (single tracer) to very complex.

Forecast skill of model continually evaluated and improved using observational study data.

PM2.5 Emissions in WRF/Chem
- Anthopogenic: Global with seasonal variations, N.E.I. 2005 from EPA (CONUS).
- Biogenic: From vegetation as well as the ocean.
- Dust: Based upon wind speed and surface erosion.

3. CURRENT RESEARCH EFFORTS

Domain location:
- 3 km horizontal grid
- 711 x 647 grid points,
- 51 Stretched vertical levels
- Centered over western U.S.

Physics parameterizations:
- Thompson microphysics
- Goddard SW
- RRTM LW scheme
- RUC land surface
- MYJ TKE PBL scheme

Chemical parameterization:
- GOCART aerosol scheme.

Initial and boundary conditions:
- Derived from the Rapid Update Cycle (RUC) operational forecast.
- Bulk aerosol species cycled using previous forecast.

Initialization of PM2.5 from fires:
- Fire location obtain in real time using WF-ABBA and MODIS satellite products.
- Online computation of emissions amount and fire plume rise following (Fig. 3).

Examining methodologies to provide products to the user community.
- Web pages, FX-Net, other apps?
- What forecast products are needed?

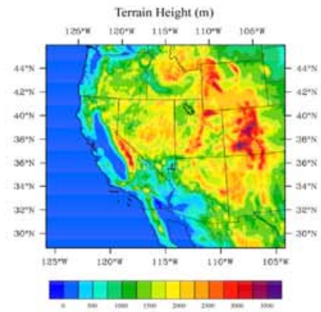

Fig. 2. Color filled countour plot showing the terrain elevation (m) in the forecast domain. Contour interval is 250 m and the elevationis shown in the color bar at the base of the image.

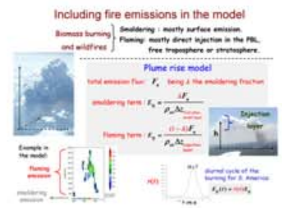

Fig. 3 The 1-D plume rise model used in the WRF-Chem model. Adapted from Freitas et al. 2007, (Atmos. Chem. Phys). The plume model computes the ejection height of emitted species based upon remotely sensed information and partitions the total flux of emitted mass between surface smoldering and the lofted flaming emissions.

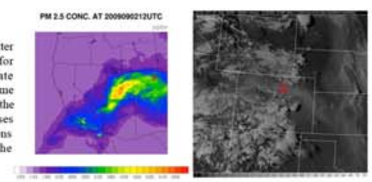

Fig. 4. Comparison between vertically integrated fine particulate matter in an real time WRF/Chem forecast compared to a satellite image for 2 Sept. 2009. The red circles on both images shows the approximate location of the Denver, CO metropolatin area. While the observation time and model forecast time are different, the model forecast shows that the transported smoke from the Station fire near Los Angeles, CA crosses Colorado near Denver. Besides reports of surface smoke observations for that day (not shown) the smoke appears to have suppressed the development of convective clouds.

Operational forecast models are using increasingly higher horizontal resolution.
- Need to adapt wildfire smoke parameterization to higher resolution models:
  - Thermodynamic effects (heating from wildfire)
  - Introduce radiative feedbacks from smoke

At ESRL, twice-daily real-time forecasts using chemical data assimilation and smoke (aerosol) prediction are being produced.
- Can examine chemical data assimilation impacts on wildfire and Air Quality forecasts.

The challenge: As computational resources increase, the horizontal resolution in operational forecast models is getting to convective resolving scales and domain sizes are increasing.

4. FUTURE WORK

Collaboration with other fire weather research groups (NIST, NCAR, Universities, other agencies).
- Provide feedback information to larger scale forecast models (e.g., aerosol concentration for data assimilation)
- Examine fire behavior models
- Interactions between wildfires and meteorology

Methodology: Close the gap between meteorology and fire behavior models

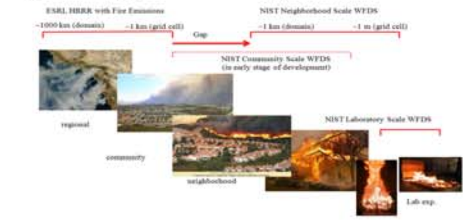

Fig. 4 Scales used in numerical models forecasting air quality and fire behavior.

- Large Eddy Simulations examining meteorological results:
  - Build "clean" initial and lateral boundary condition data,
  - Use LES to examine impact of wind data on fire behavior models,
  - Compare results between observations and high-resolution simulations.
- Improve fire parameterization and wildfire emissions
  - Include thermodynamic effects of wildfires
  - Couple fire behavior to meteorological model (e.g., WRF-FIRE)
  - Provide emission data from fire behavior model to meteorology

Fig. 5. Location of the Witch fire (21-22 Oct 2007) that will be used as subject for the LES study. The red lines show the location and movement of the fire front.

5. SUMMARY

NOAA/ESRL recognizes the need for high-resolution forecasts containing fire weather information

Forecasts and products need to be real-time and made available to a variety of users

Fire weather forecasts need to be as accurate as possible
- Numerical weather forecast models are increasing in resolution
- Feedbacks from wildfire to weather (& vice versa) needs to be included
- Online models like WRF/Chem are necessary
- Coupled fire behavior and weather forecast models being examined

Collaborative efforts at NOAA/ESRL:
- LES modeling with fire behavior model(s)
- Improve fire weather parameterization in large-scale models
- Examining products to disseminate forecast data
- Looking for additional collaborators