Incorporating the Wind Erosion Prediction System (WEPS) into the AIRPACT Regional Air Quality Modeling System

Research Team

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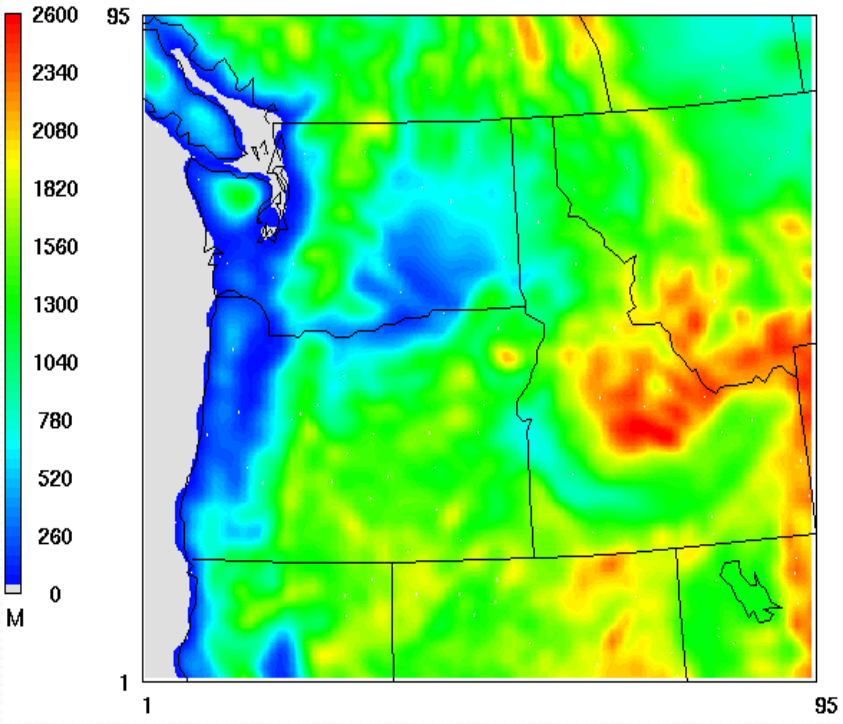
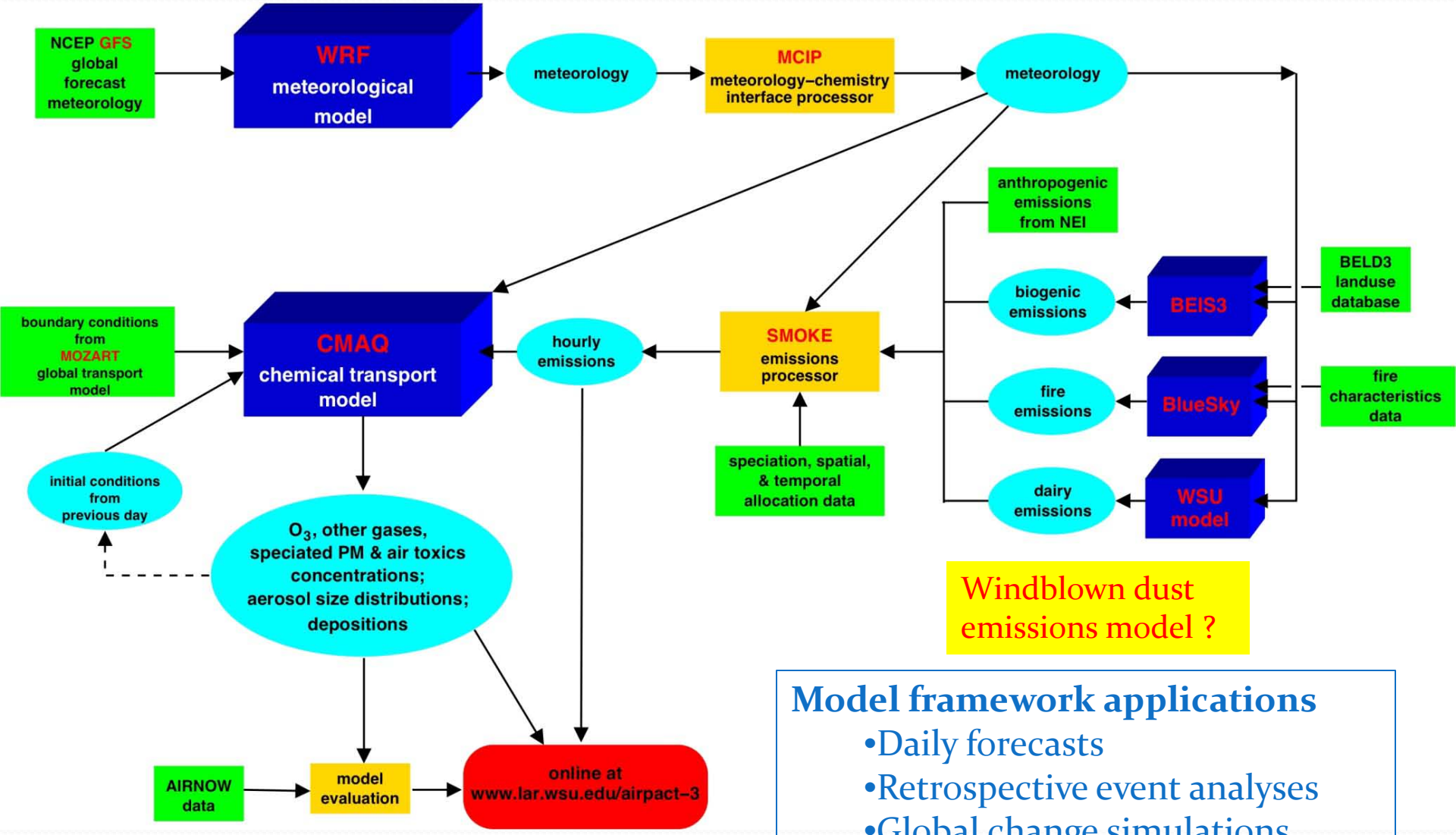
Tomorrow's Air Quality: AIRPACT-3 Daily Forecast System

- WRF Weather Research and Forecasting model
- SMOKE: Sparse Matrix Operating Kernal for Emissions processing.
- CMAQ: Community Multi-scale Air Quality model:
  - O3, PM, and air toxics chemistry
  - PM in Aitken, accumulation, & coarse modes
  - Wet and dry deposition of N, S, O3, & Hg species



PM species
Nitrates
Sulfates
Organic aerosols
PM coarse (wind-blown dust)
PM2.5 total mass

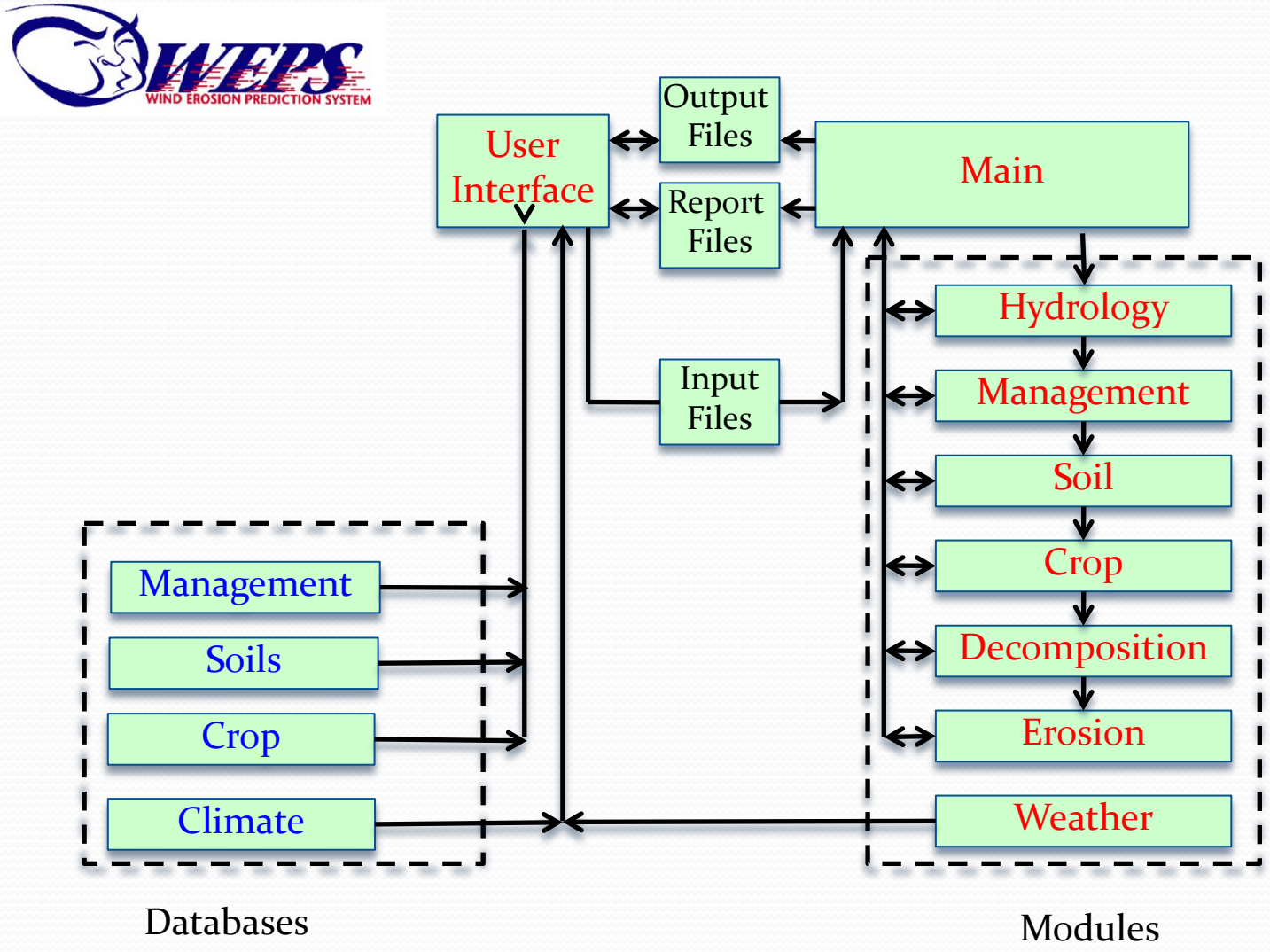
AIRPACT Modeling Framework



Windblown dust emissions model ?

Model framework applications

- Daily forecasts
- Retrospective event analyses
- Global change simulations (current vs future (2050s)

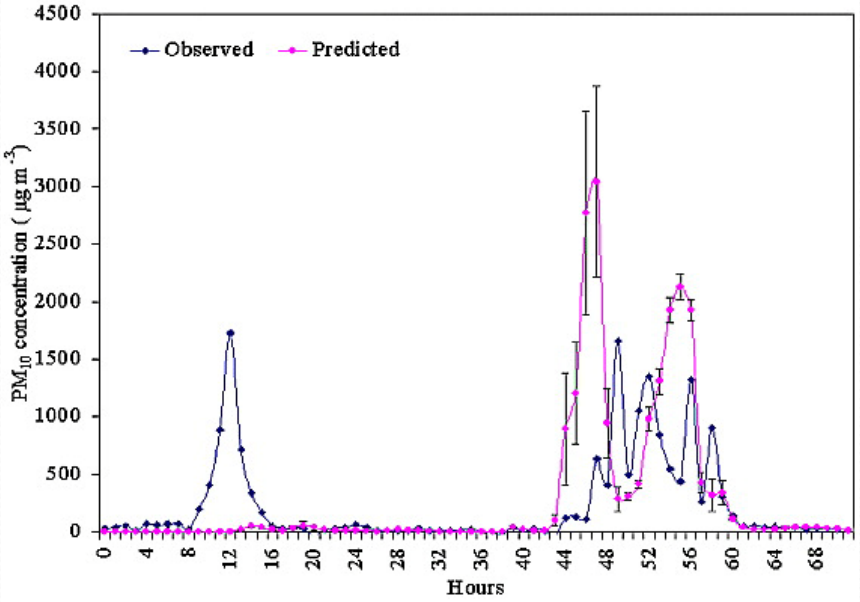

WEPS
WIND EROSION PREDICTION SYSTEM
User Interface
Output Files
Report Files
Input Files
Main
Hydrology
Management
Soil
Crop
Decomposition
Erosion
Weather
Management
Soils
Crop
Climate
Databases
Modules

WRF-EROSION-CMAQ Sensitivity Cases

- Use WRF/MCIP meteorology at 12-km resolution to drive WEPS EROSION module
- WEPS/EROSION simulation
  - Base case: Landuse and soil data at 12-km resolution
  - Sensitivity case: Landuse and soil data at 1-km resolution
  - Sensitivity case: range of soil moistures
- Three Test Cases:
  - September 23-25, 1999
  - October 4, 2009
  - August 26, 2010
- Simplifications:
  - no standing biomass
  - no residue
  - dry soil (base case)

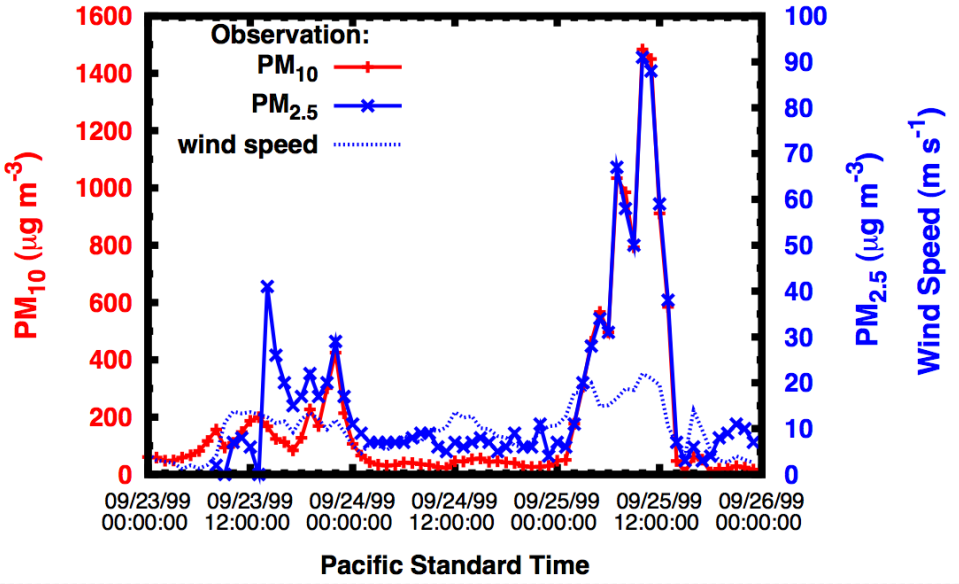
September 23-25, 1999 Event

PM_{10} Concentrations at Kennewick, WA



MM5/EMIT/CALGRID
Sundram et al., 2004

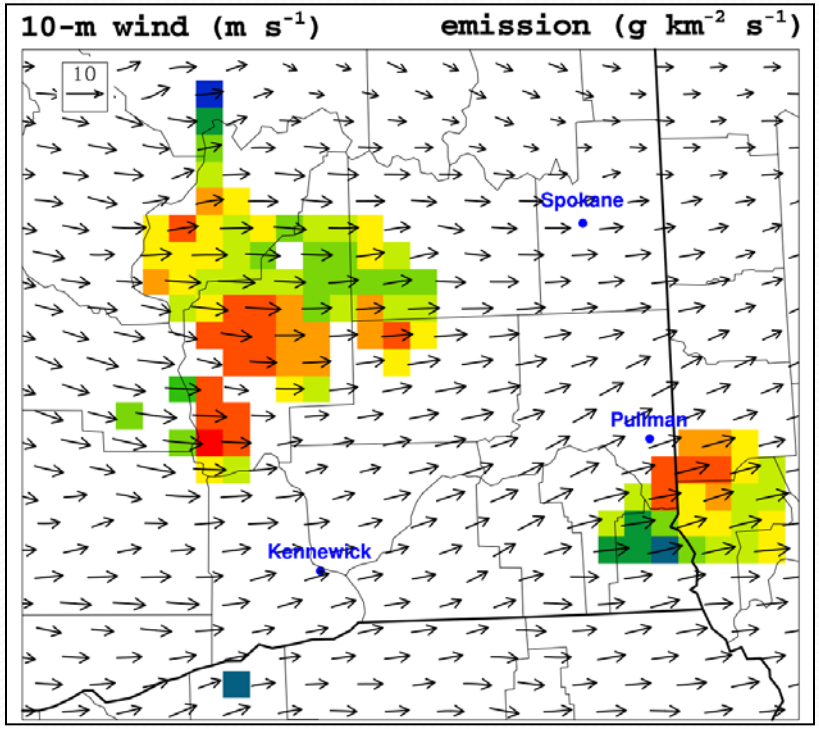
Observations at Spokane



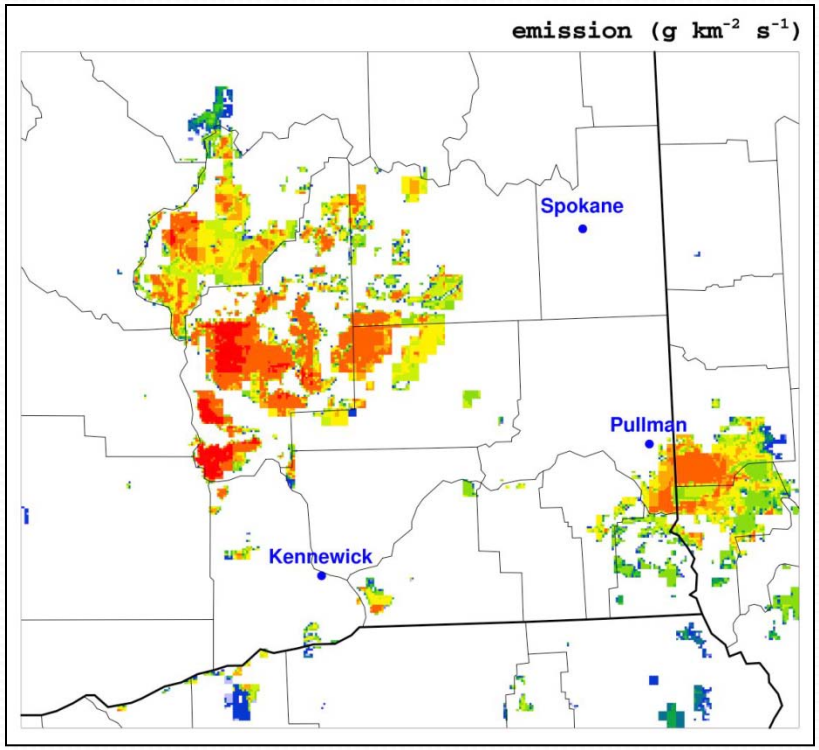
PM2.5 ~ 6% of PM10

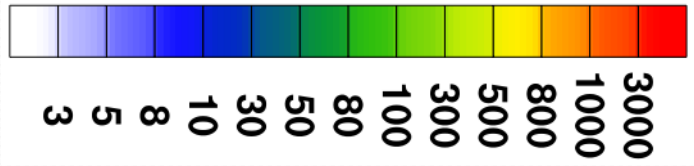
Sensitivity to Soil Data Resolution

12-km Resolution
with Area-Mean
Soil Properties



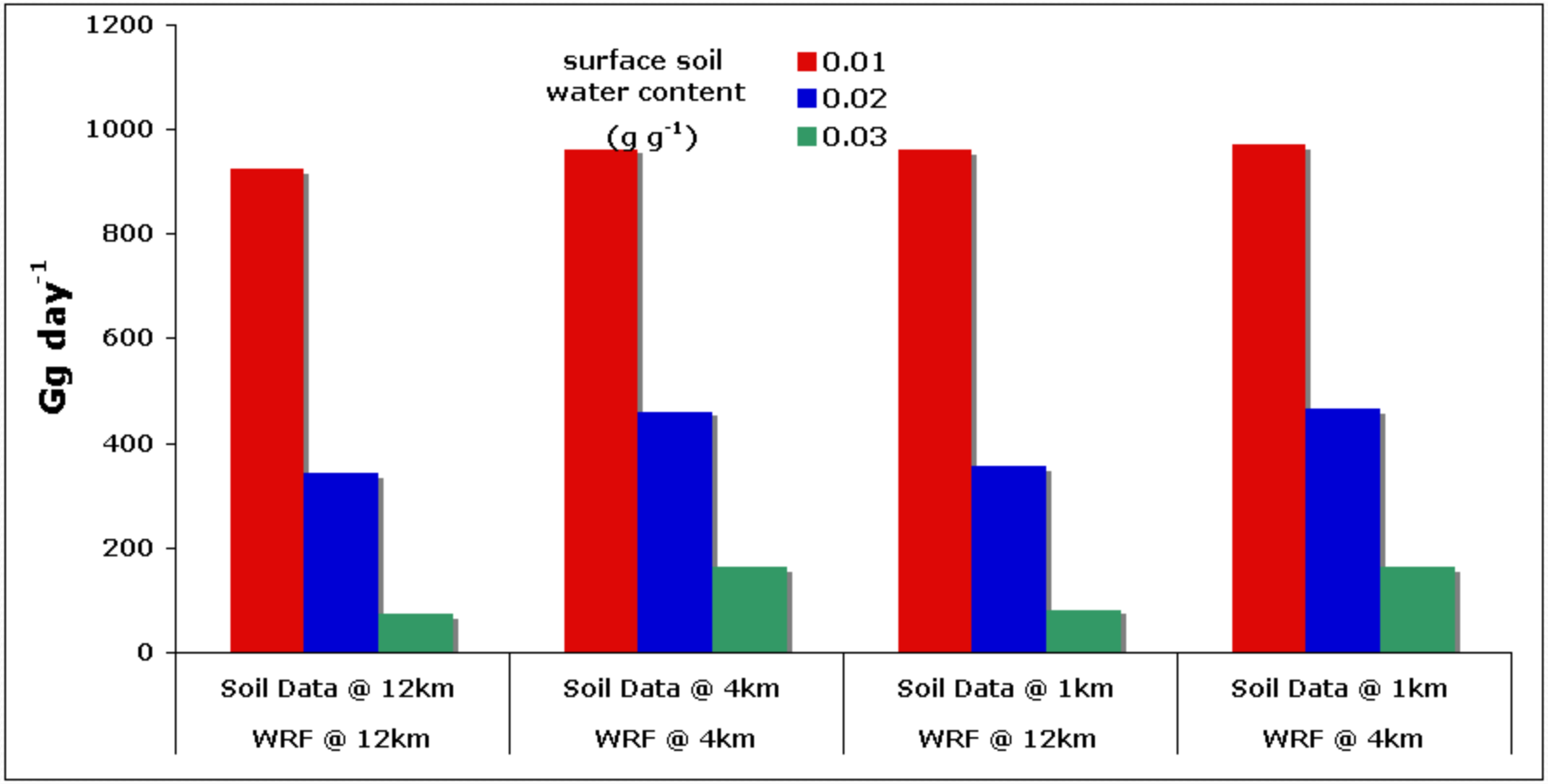
1-km Resolution
with 8 Soil Map Units
in each 1-km Cell





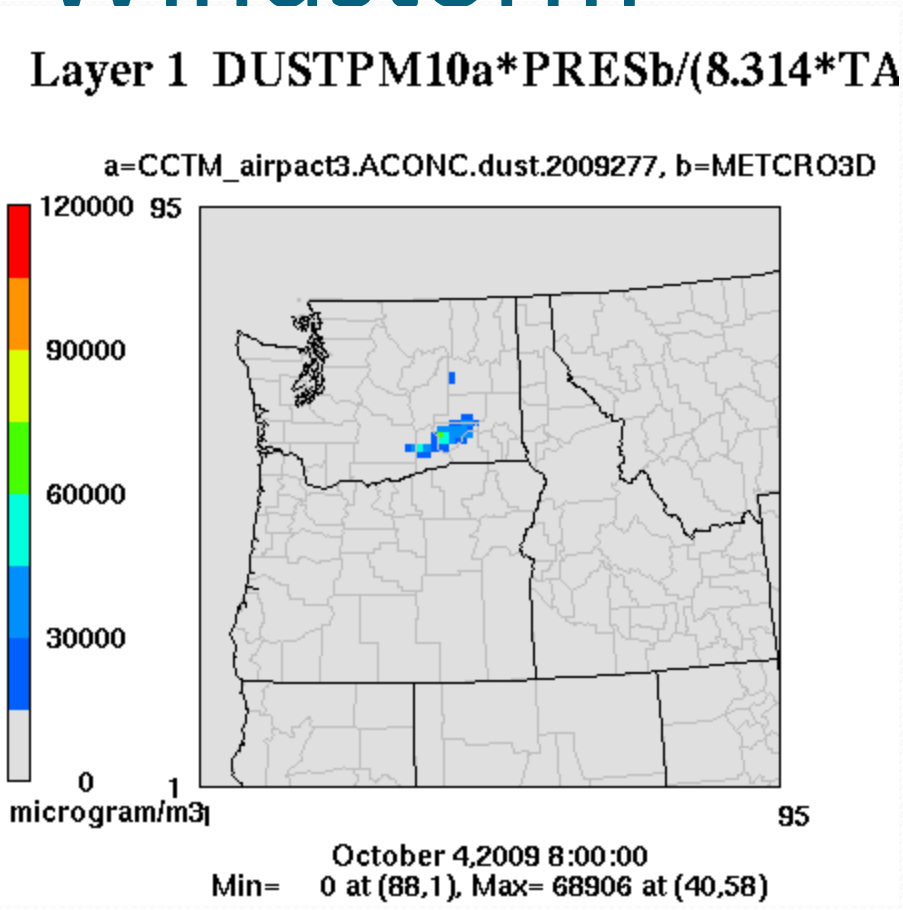
g km^{-2} s^{-1}

Sensitivity to Input Data Resolution and Surface Soil Moisture: PM_{10} Emissions



October 4, 2009 Windstorm

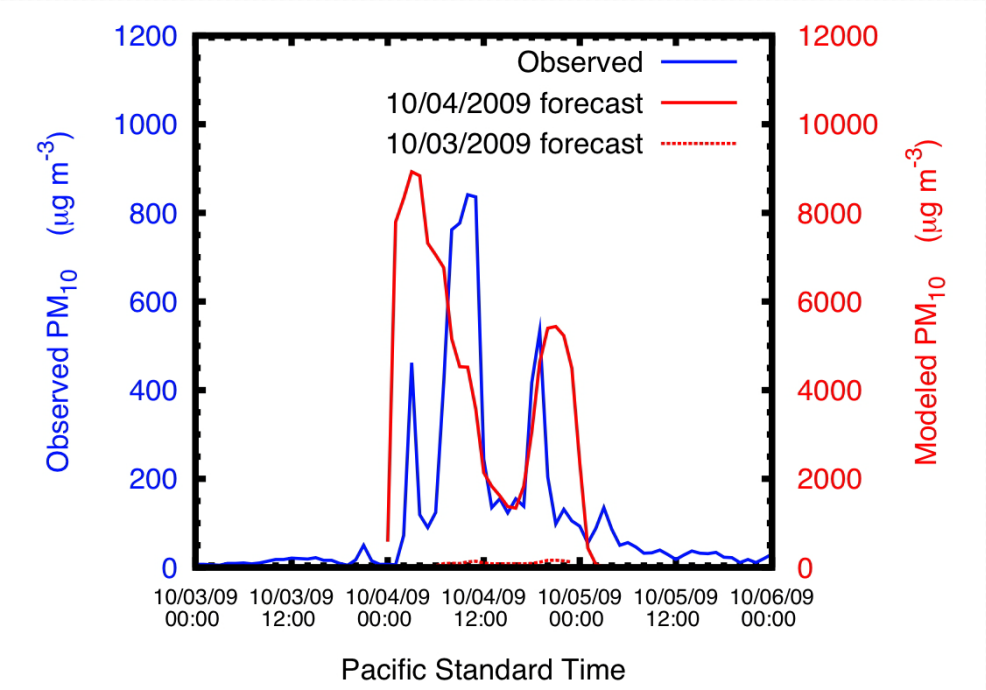
Courtesy Jeff Schmaltz, MODIS Rapid Response Team.
http://earthobservatory.nasa.gov/IOTD/view.php?id=40590



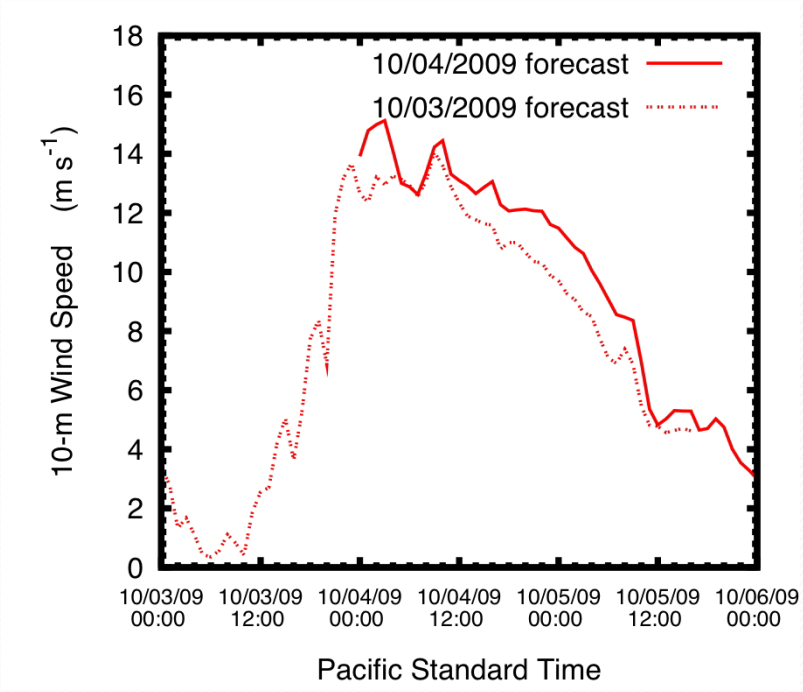
http://lar.wsu.edu/airpact-3/windblowndust.html

Forecast Sensitivity to Wind Speed

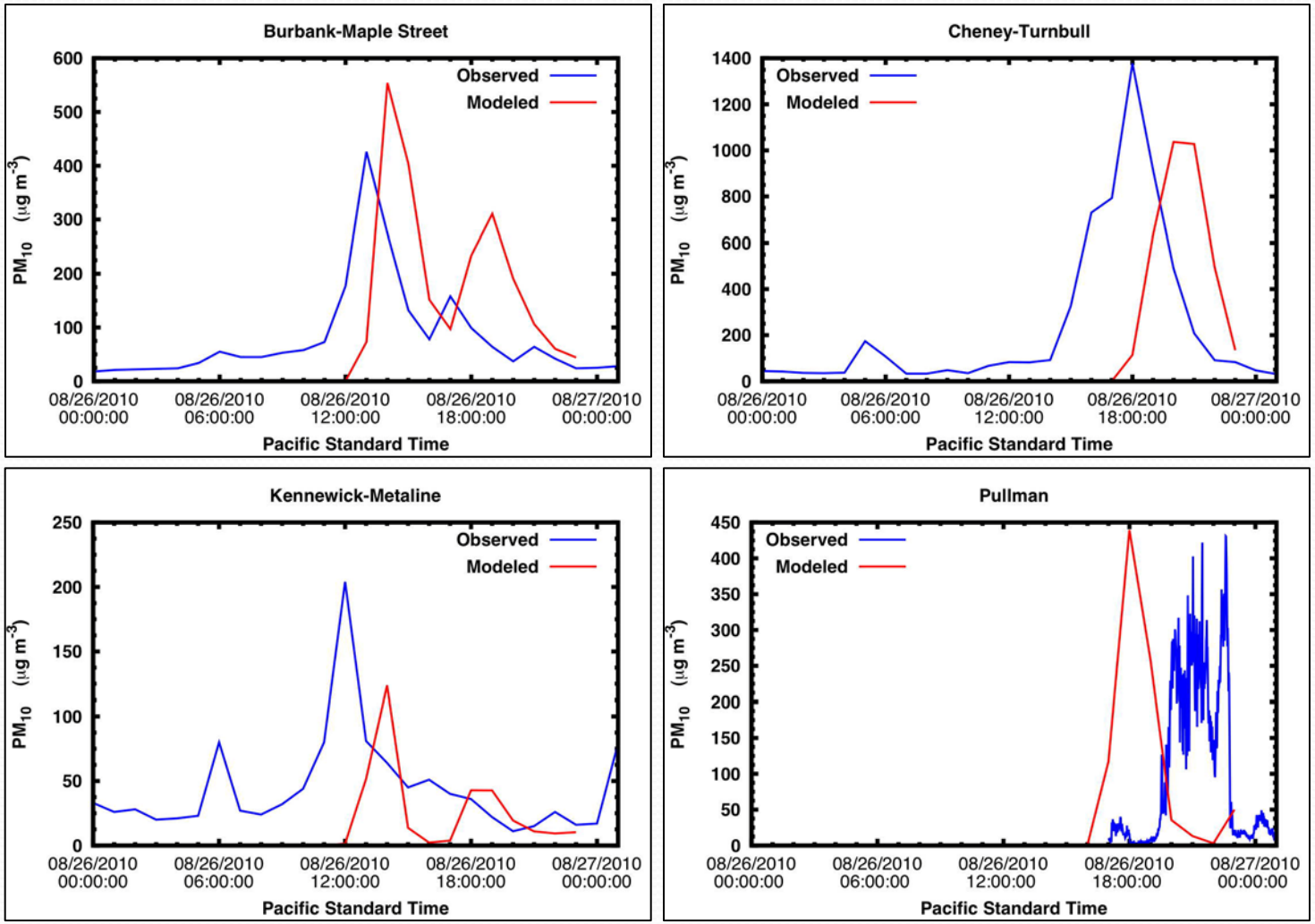
PM_{10} Concentration at Kennewick



Modeled 10-m Wind Speed at Emission Source



August 26, 2010 Event



Good model-observation agreement if surface aerodynamic roughness is changed from z_0=20 mm (WEPS default) to z_0=120 mm

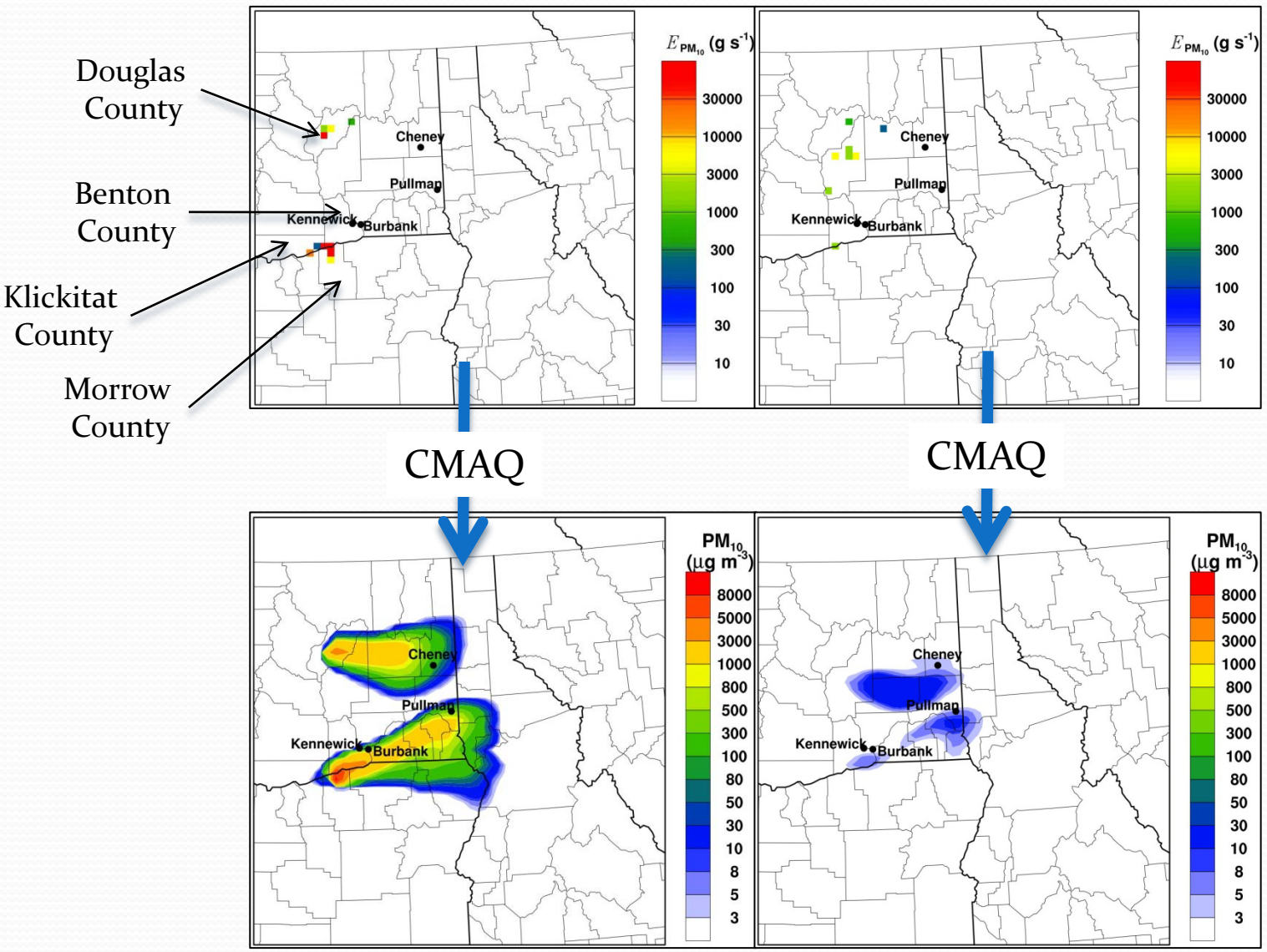
Summary for Sensitivity Study using only EROSION module

- Aggregating soil data to a more coarse spatial resolution decreases windblown PM_{10} emissions, but the difference is very small.
- Model results are very sensitive to surface soil moisture.
- Model results are very sensitive to wind speed, and small differences in the forecast winds can cause large differences in forecast dust events.
- With WRF-EROSION-CMAQ, the surface roughness length in EROSION had to be adjusted in order to achieve good model performance.

August 26, 2010 Event

WRF-MCIP-**EROSION**
(whole domain)

WRF-MCIP-**WEPS**
(Washington only)



Modeled PM_{10} Emissions ($g\ s^{-1}$) at 3 pm

Modeled PM_{10} Concentrations ($\mu g\ m^{-3}$) at 6 pm

Next Steps

- Investigate improvements to WRF-WEPS-CMAQ to address underestimation of PM_{10} concentrations
  - Modify fraction of PM10 related to horizontal soil erosion for eastern WA vs the midwest
  - Adjust threshold friction velocities
  - Use of MCIP Ustar vs EROSION Ustar.
- Extend the framework to regions outside the state of Washington.
- Incorporate PM2.5 component of windblown dust
- Improve the computational efficiency in order to implement AIRPACT-WEPS as a forecast tool.
- Investigate satellite products for near real-time landcover/soil status