

# MEGAN and WRF-CHEM/

## Aerosol-Cloud interactions in WRF-CHEM

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# Emissions Modeling: MEGAN

- **MEGAN:** Model of Emissions of Gases and Aerosols from Nature
  - Guenther et. al., *Atmospheric Chemistry and Physics*, 2006
  - 134 emitted chemical species
  - 1 km<sup>2</sup> resolution
  - Input files available at: <http://cdp.ucar.edu>

actions Hierarchy: [MEGAN \(Model of Emissions of Gases and Aerosols from Nature\)](#) > [MEGAN Version 2.0](#) > [Input](#) > [ESRI\\_GRID\\_30sec](#) >



EF

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NCAR Community Data Portal, sponsored by NSF National Science Foundation

# MEGAN Framework: calculation of emissions

$$EM = \varepsilon \cdot \gamma_{CE} \cdot \gamma_{age} \cdot \gamma_{SM} \cdot \rho$$

$$\gamma_{CE} = \gamma_{LAI} \cdot \gamma_P \cdot \gamma_T$$

EM: Emission ( $\mu\text{g m}^{-2} \text{hr}^{-1}$ )

$\varepsilon$ : Emission Factor ( $\mu\text{g m}^{-2} \text{hr}^{-1}$ )

$\rho$ : Loss and Production within plant canopy

$\gamma_{CE}$ : Canopy Factor

$\gamma_{age}$ : Leaf Age Factor

$\gamma_{SM}$ : Soil Moisture Factor

$\gamma_{LAI}$ : Leaf Area Index Factor

$\gamma_P$ : PPFD Emission Activity Factor (light-dependence)

$\gamma_T$ : Temperature Response Factor

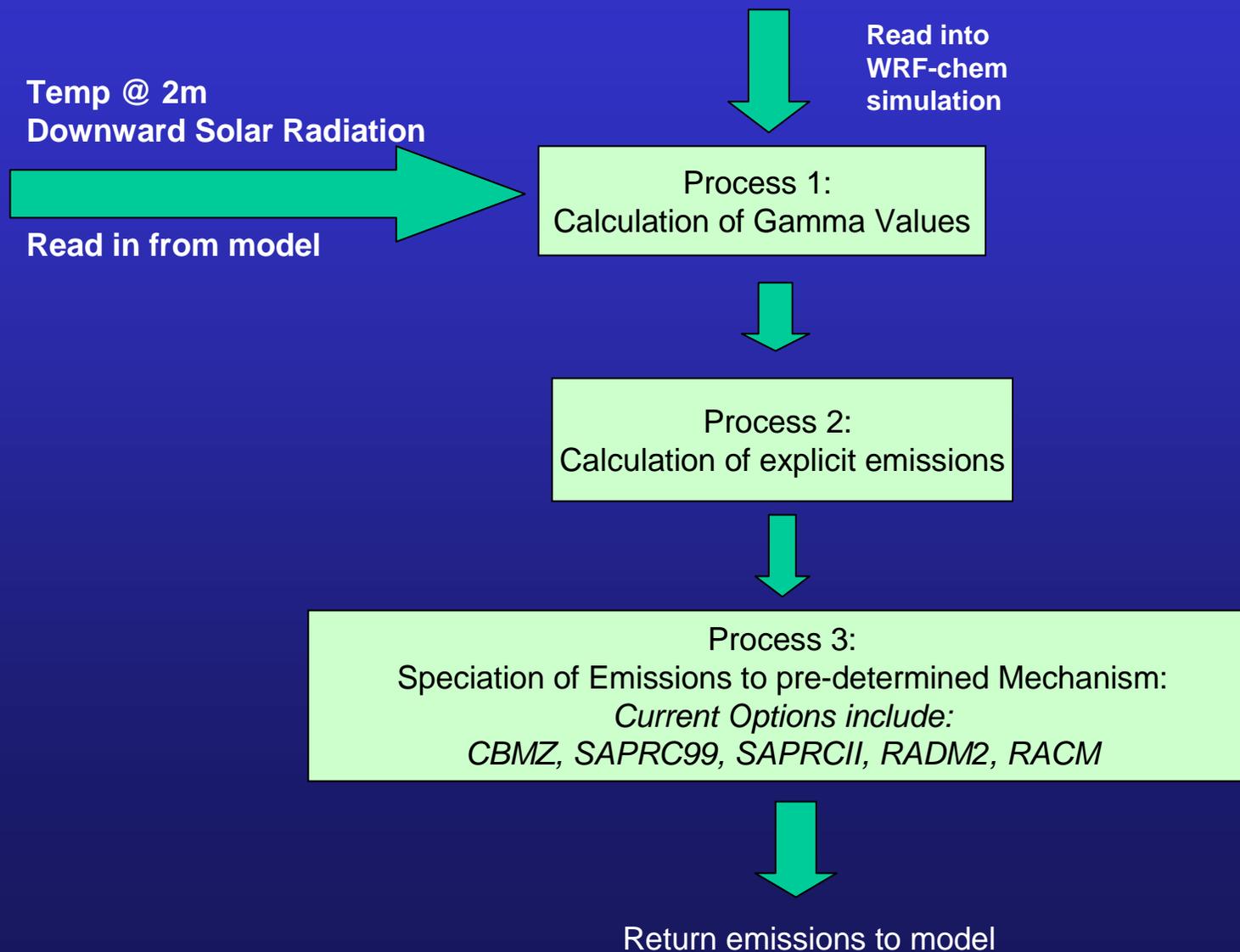
(Guenther et al., 2006)

# Current MEGAN Code in WRF-CHEM

- Online version of MEGAN in WRF-CHEM currently same as offline version 2.04
- The algorithm and data for  $\gamma_{SM}$  and  $\rho$  are not yet ready and they are assigned to 1.0.
- The light dependent factor is only applied to fractions of emission factors based on biological function of plants.
- Only maps of isoprene emission factors are used
  - All other species are assigned an emission factor by PFT
- No explicit canopy model
  - Xuemei Wang has implemented canopy model in one version

## MEGAN Input file

Includes emission factors, LAI, plant functional type fractions, and climatological temperature and solar radiation for each model grid cell  
Preprocessed prior to WRF-chem simulation\*



Read into  
WRF-chem  
simulation

Read in from model

Return emissions to model

# MEGAN INPUT FILE

- MEGAN input file needs to be preprocessed before model simulation
  - Documentation being developed
  - Currently requires geographic processing software
- File must include:
  - Grid information
  - Normalized Isoprene Emission factor\*
    - From NCAR Community Data Portal
    - Values from downloaded grid converted from g/km<sup>2</sup>/hr to mole/km<sup>2</sup>/hr
  - Monthly LAI
    - From NCAR Community Data Portal
  - Plant Functional Type (PFT)
    - From NCAR Community Data Portal
  - Average monthly temperature and downward solar radiation
- Currently only uses grid-specific isoprene emission factors
- User may edit variables in **module\_data\_megan2.F**

# Monthly Temperature and Solar Radiation

- NCEP NARR (NCEP North American Regional Reanalysis)

<http://www.cdc.noaa.gov/cdc/data.narr.html>

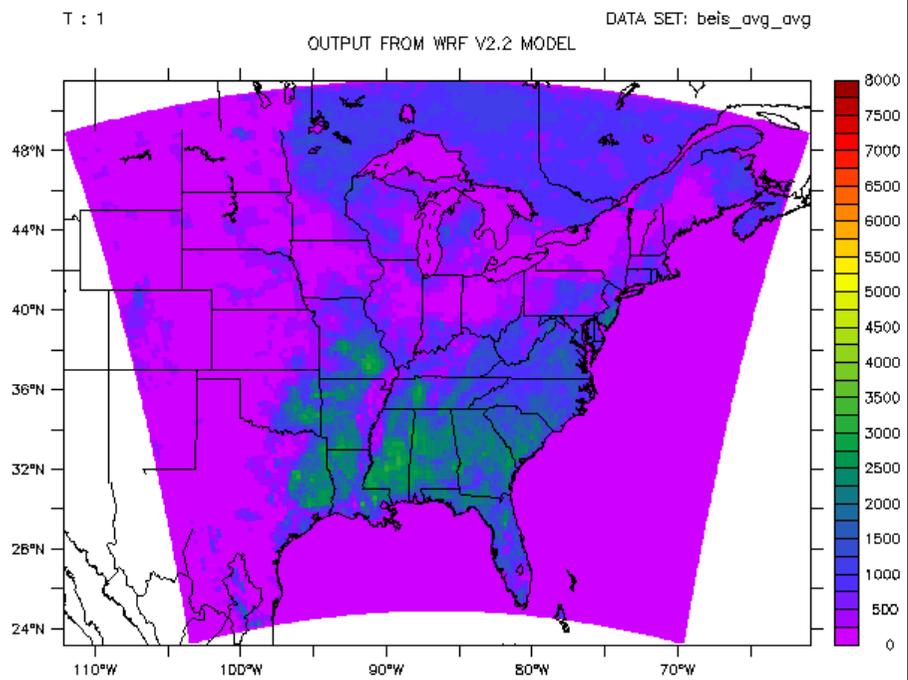
- Temperature and Solar Radiation data:

<http://www.cdc.noaa.gov/PublicData/tables/monthly.html>

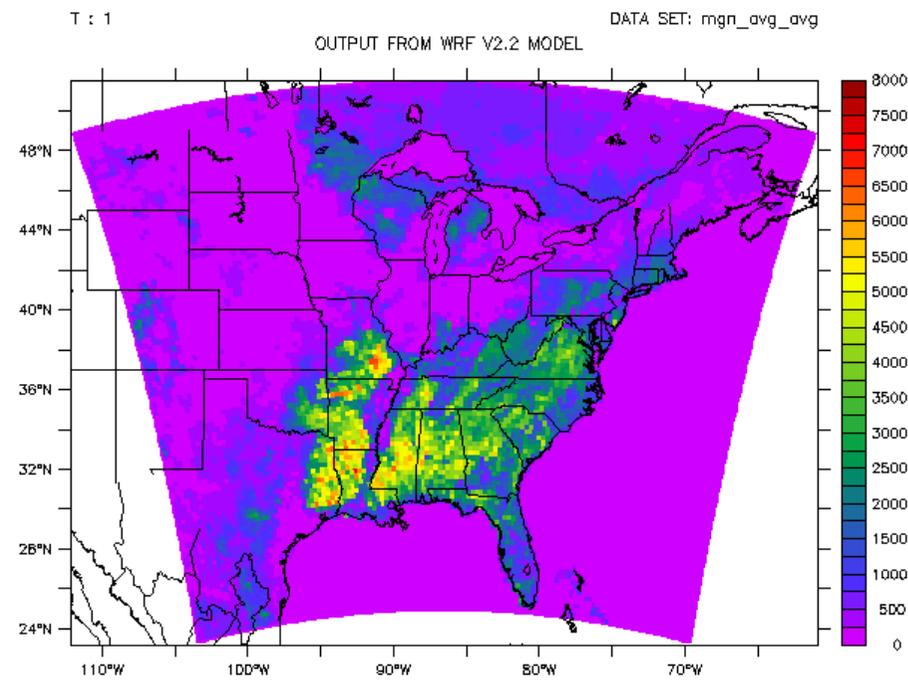
- For Downward Solar Radiation:

<http://gswp2.tkl.iis.u-tokyo.ac.jp/gswp2/free/ddc.html>

# MEGAN vs. BEIS3.11

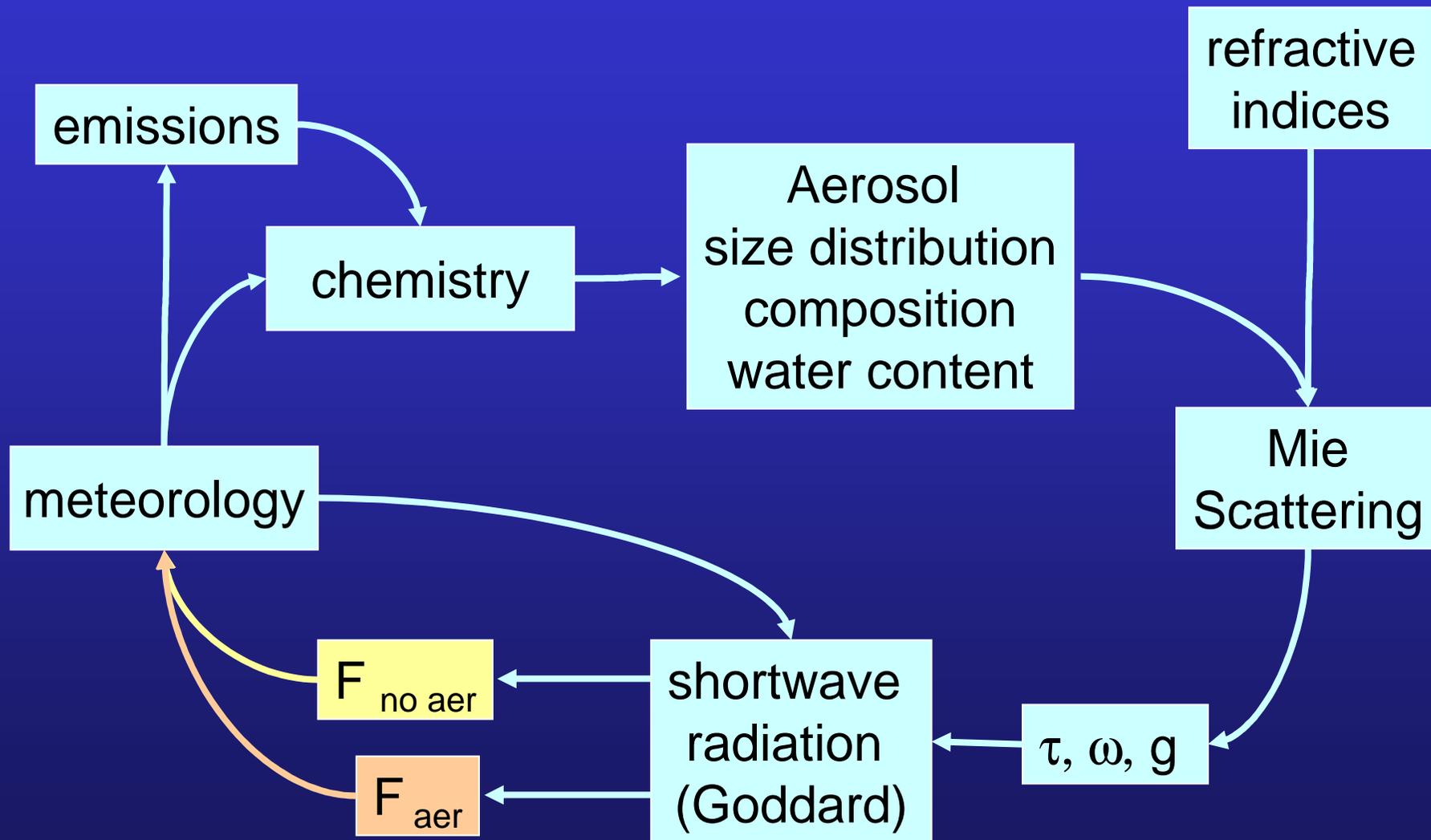


EBIO\_ISO\*68.11



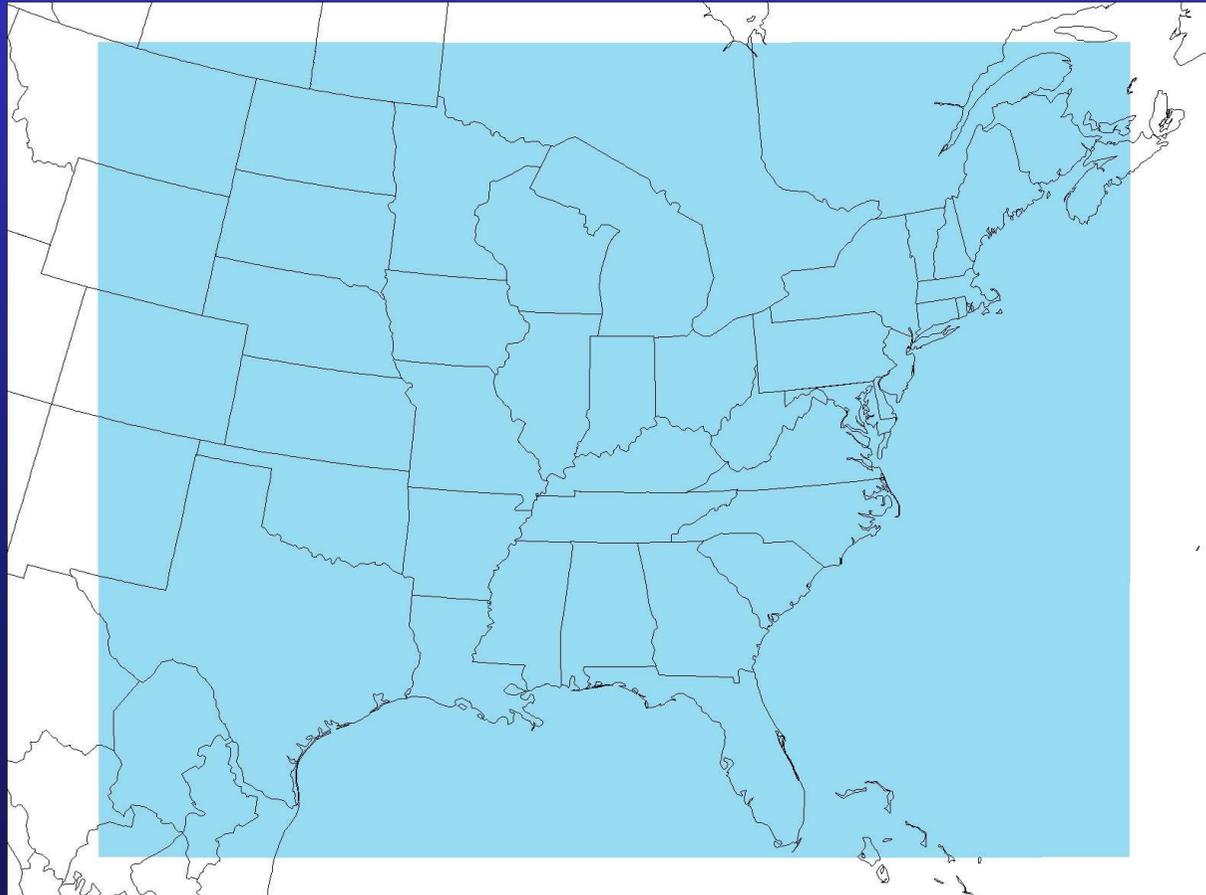
EBIO\_ISO\*68.11

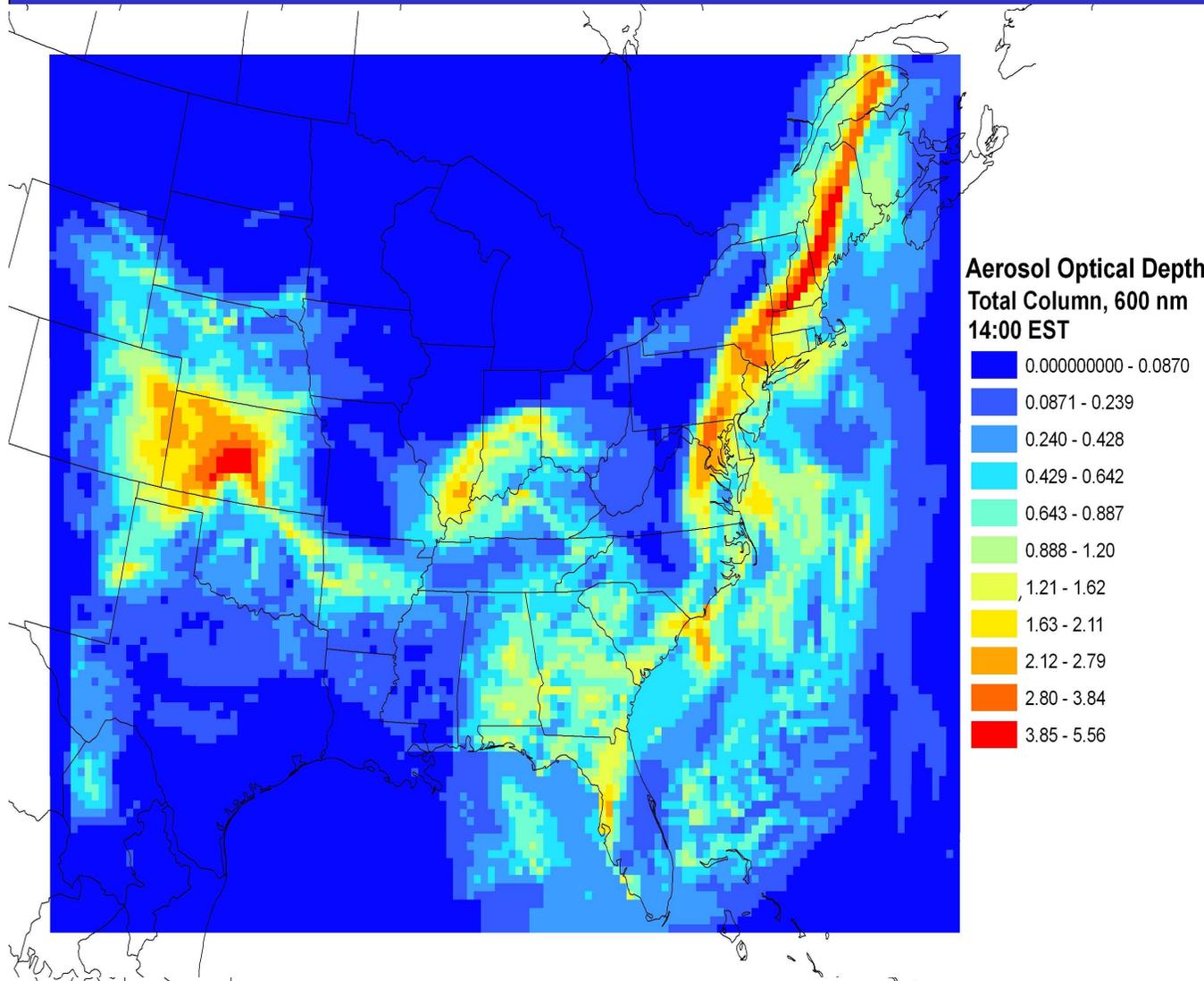
# Aerosol-Radiation Feedbacks within WRF-Chem



# Aerosol-Cloud Interactions: Direct Effect

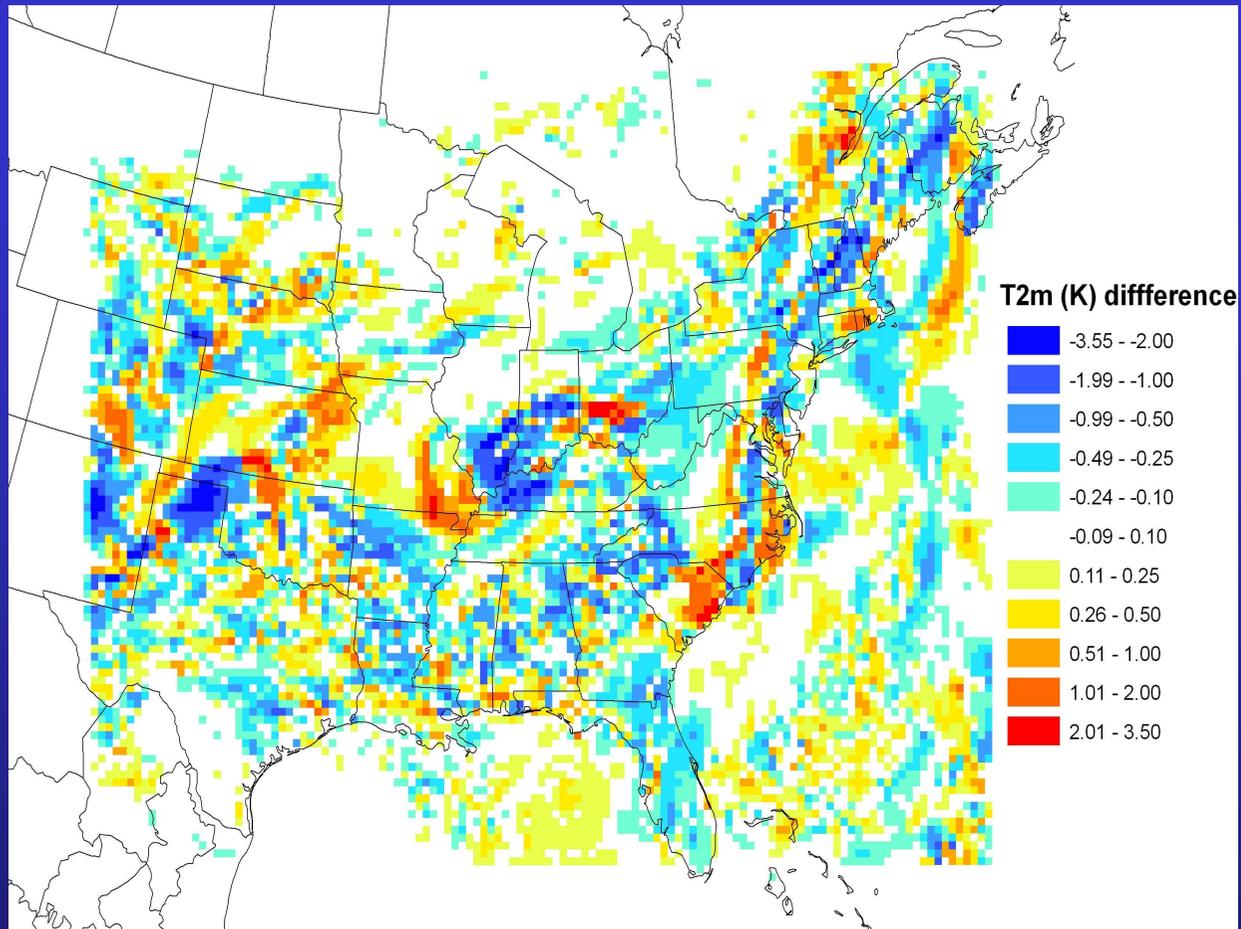
- MODEL Simulations
  - MOSAIC/CBMZ
  - 27km x 27km domain Eastern US
  - Episode during July 2004 as part of the ICARTT field campaign (<http://esrl.noaa.gov/csd/ICARTT/>)





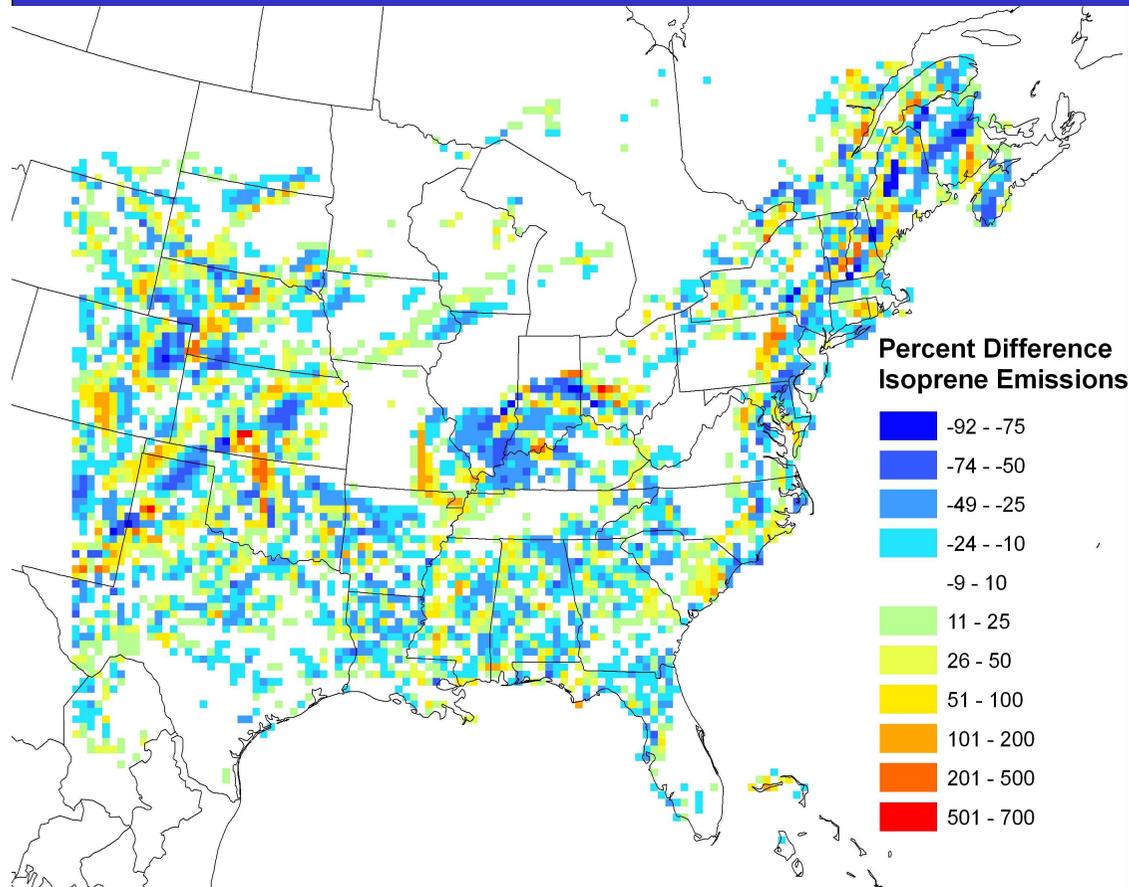
Dry PM<sub>2.5</sub> mass  
conc. (mg m<sup>-3</sup>)  
14:00 EST

Total Column  
AOD (600 nm)  
14:00 EST



Difference in T at  
2m (K) for 14:00  
EST (with –  
without aerosol  
interactions).

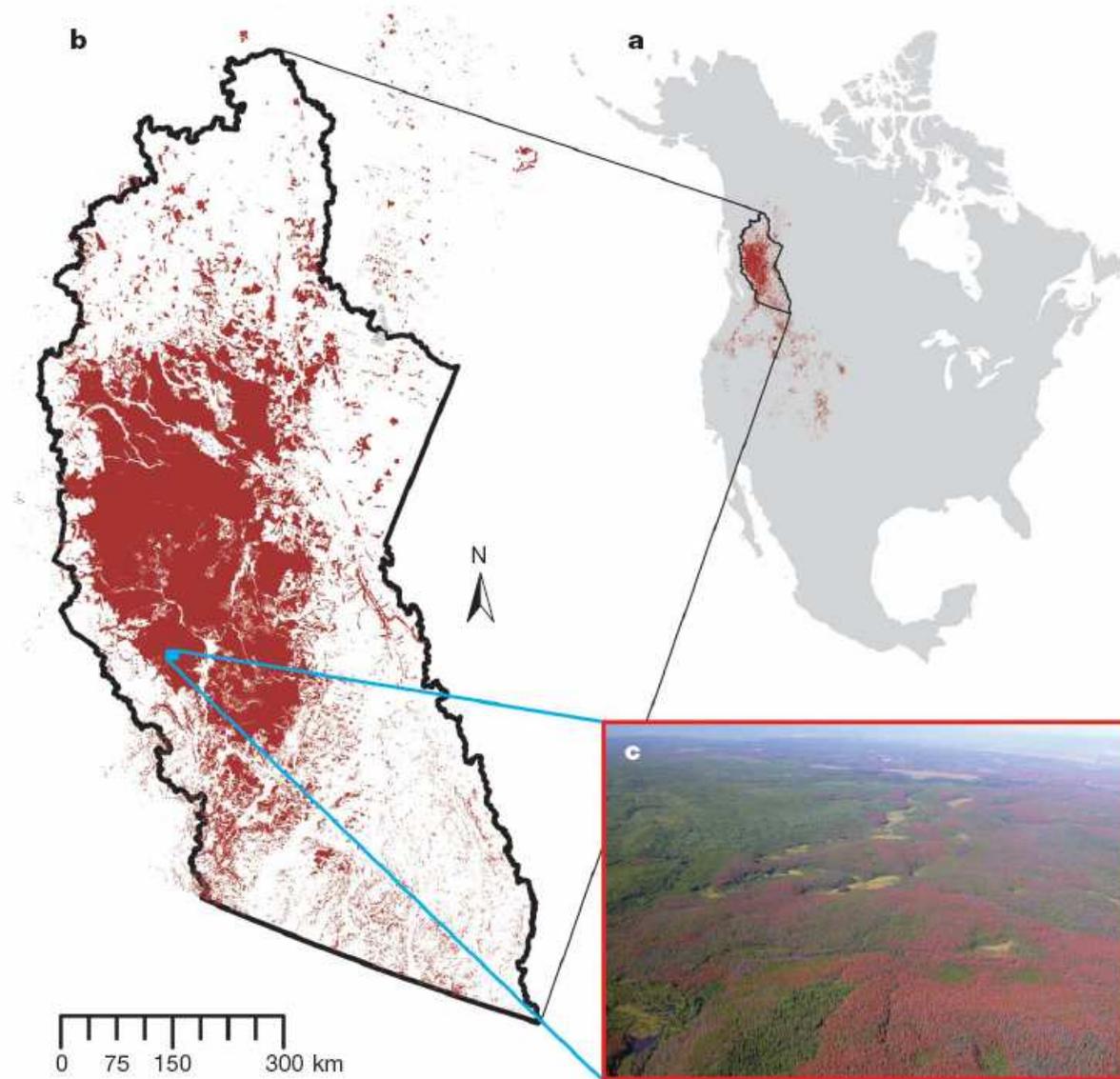
Percent difference in  
predicted isoprene  
emissions for  
14:00 EST July 23, 2004



- Inclusion of aerosol effects on radiation can change the simulated temperature at 2 m and the downward solar radiation significantly. The changes are very heterogeneous over the model domain.
- The changes in meteorology observed can impact the biogenic emissions. Changes seen in isoprene emissions domain wide for 14:00 EST were -2%; however, local changes in estimated isoprene emissions were as much as an order of magnitude.
- Future work includes performing simulations with MEGAN online within WRF-chem and exploring the impact on emissions and chemistry.

# Pine Beetle Outbreak

Kurz et al., *Nature*, April 2008



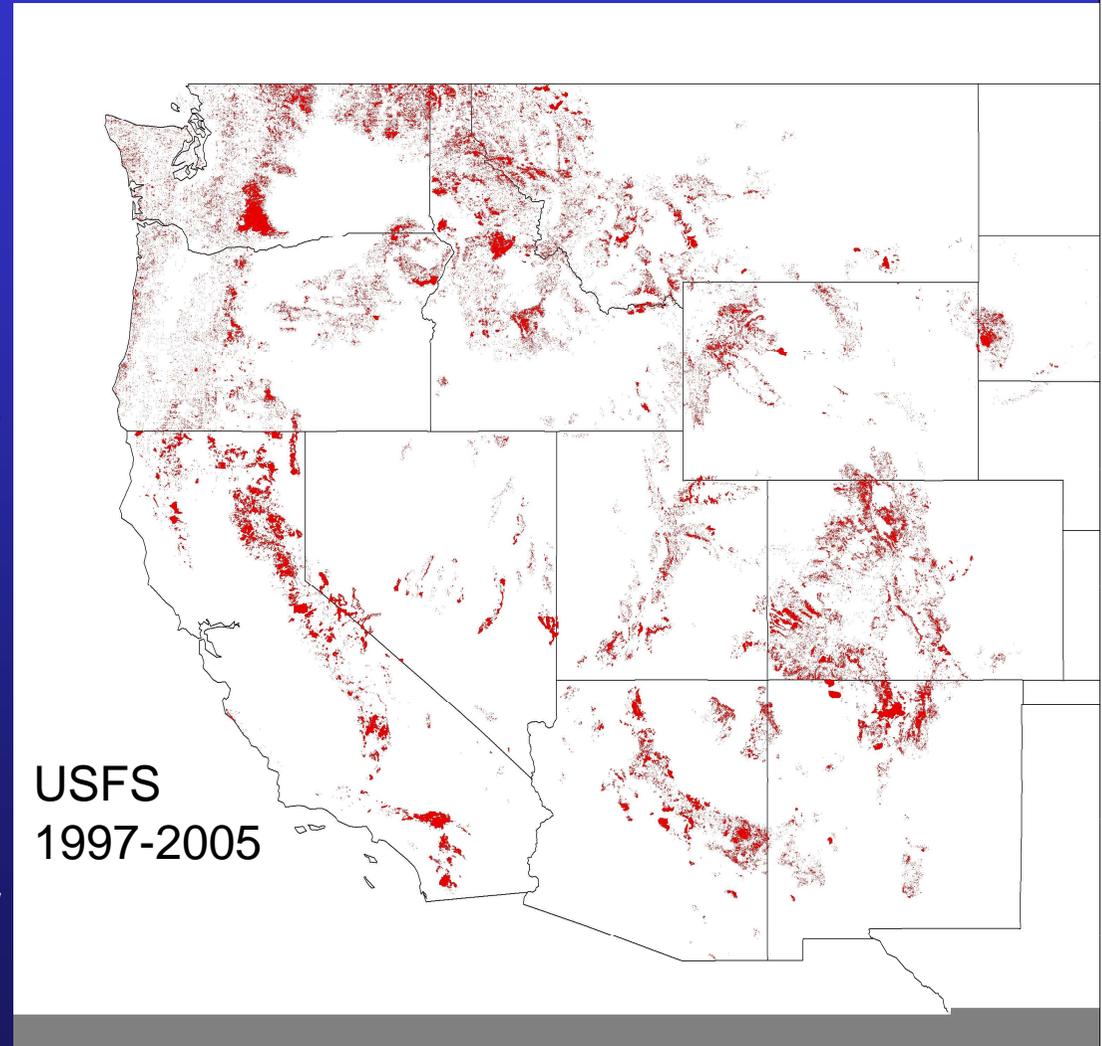
**Figure 1 | Geographic extent of mountain pine beetle outbreak in North America. a,** Extent (dark red) of mountain pine beetle. **b,** The study area includes 98% of the current outbreak area. **c,** A photograph taken in 2006

showing an example of recent mortality: pine trees turn red in the first year after beetle kill, and grey in subsequent years. Photo credit: Joan Westfall, Entopath Management Ltd.

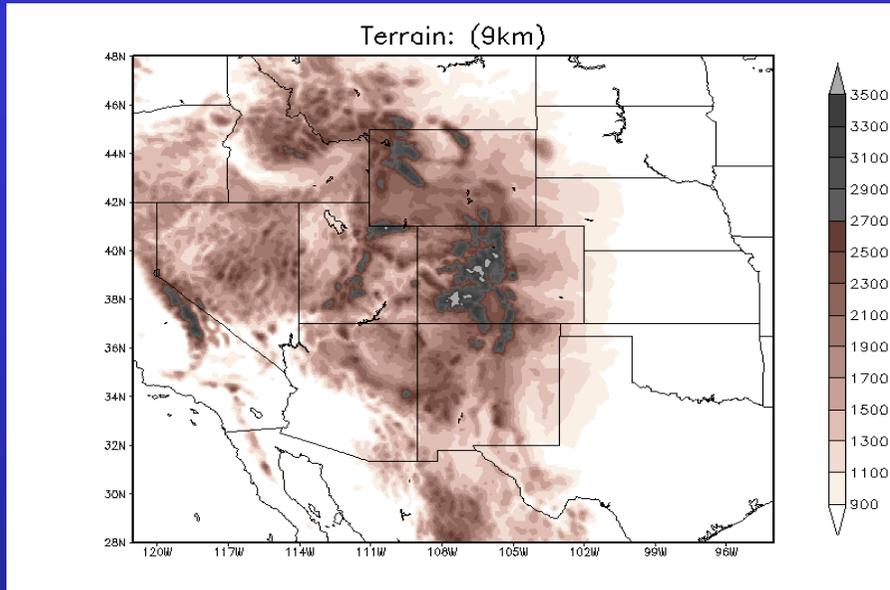
# Bark Beetle Infestations

Infestations are part of a natural cycle but consider:

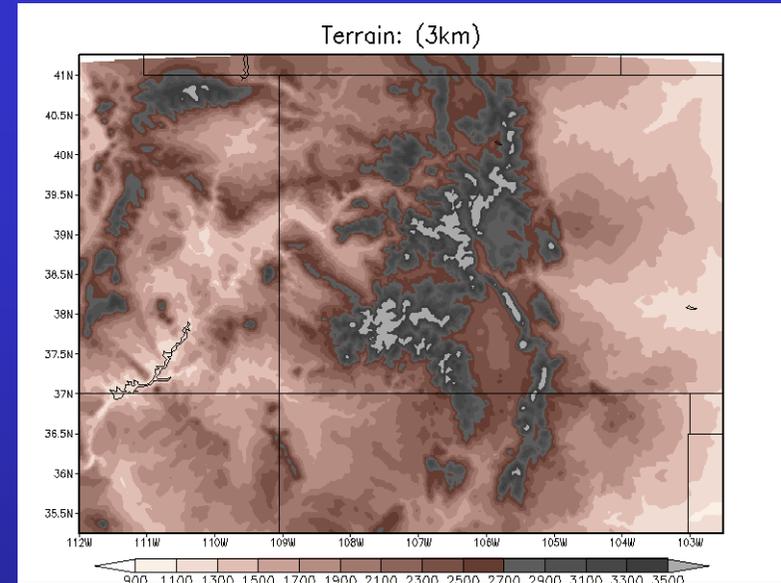
- 1000 Square miles infested in Summit and Grand Counties.
- Up to 90% loss of Lodgepole Pine in next 10 years
- Warmth allows pests to have 2 life cycles/year
- Absence of winter killing temperatures
- Combination of Fire Management and climate causes
- Debate over enhanced fire danger



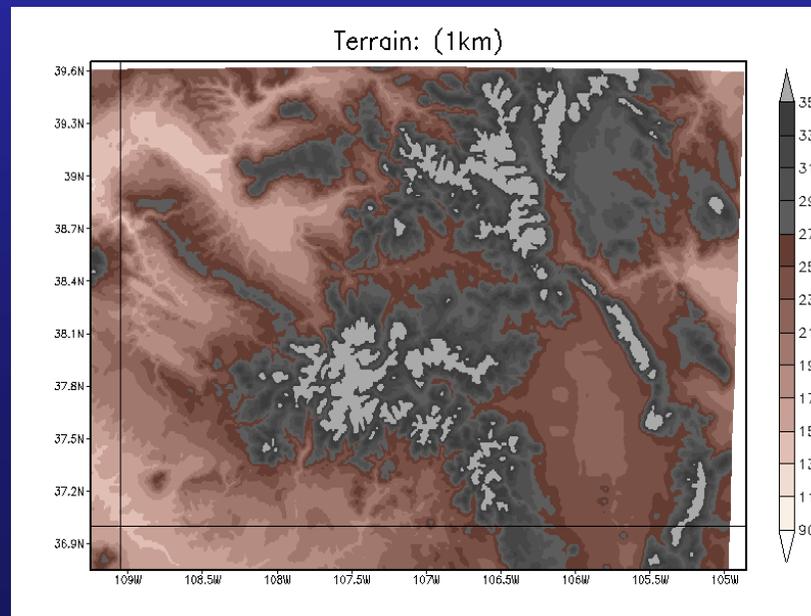
# WRF Domains and Terrain



303x262: Dom1



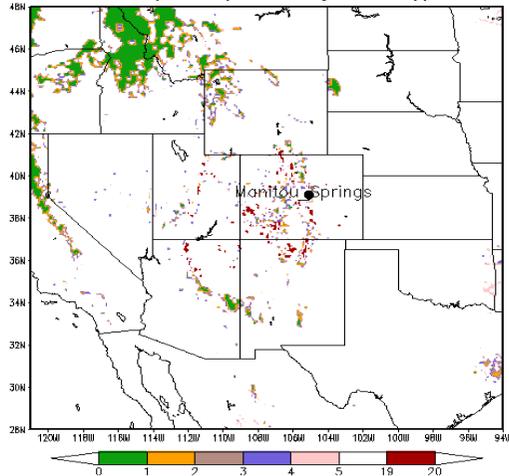
298x223: Dom2



391x323: Dom3

# Modis + Beetle\_killed\_forest Landuse Maps

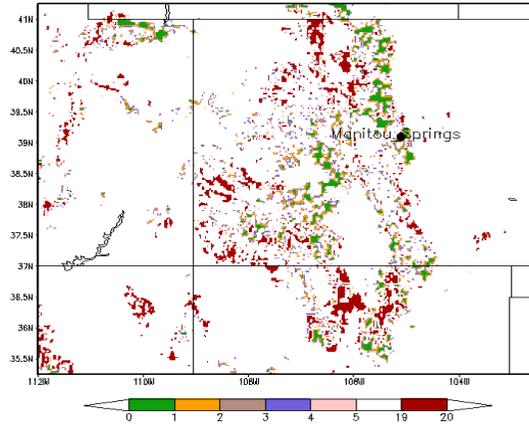
Modis (BEETLE) 9km Vegetation Type



- 1: Evergreen Needleleaf Forest 2: Evergreen Broadleaf Forest
- 3: Deciduous Needleleaf Forest 4: Deciduous Broadleaf Forest
- 5: Mixed Forests 6: Closed Shrublands
- 7: Open Shrublands 8: Woody Savannas 9: Savannas
- 10: Grasslands 11: Permanent wetlands 12: Croplands
- 13: Urban and Built-Up 14: cropland/natural vegetation mosaic
- 15: Snow and Ice 16: Barren or Sparsely Vegetated 17: Water
- 18: Wooded Tundra 19: Mixed Tundra 20: Beetle Killed Forest

9km

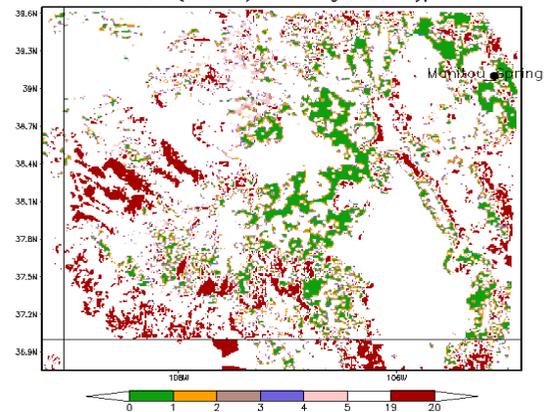
Modis (BEETLE) 3km Vegetation Type



- 1: Evergreen Needleleaf Forest 2: Evergreen Broadleaf Forest
- 3: Deciduous Needleleaf Forest 4: Deciduous Broadleaf Forest
- 5: Mixed Forests 6: Closed Shrublands
- 7: Open Shrublands 8: Woody Savannas 9: Savannas
- 10: Grasslands 11: Permanent wetlands 12: Croplands
- 13: Urban and Built-Up 14: cropland/natural vegetation mosaic
- 15: Snow and Ice 16: Barren or Sparsely Vegetated 17: Water
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3km

Modis (BEETLE) 1km Vegetation Type



- 1: Evergreen Needleleaf Forest 2: Evergreen Broadleaf Forest
- 3: Deciduous Needleleaf Forest 4: Deciduous Broadleaf Forest
- 5: Mixed Forests 6: Closed Shrublands
- 7: Open Shrublands 8: Woody Savannas 9: Savannas
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1km

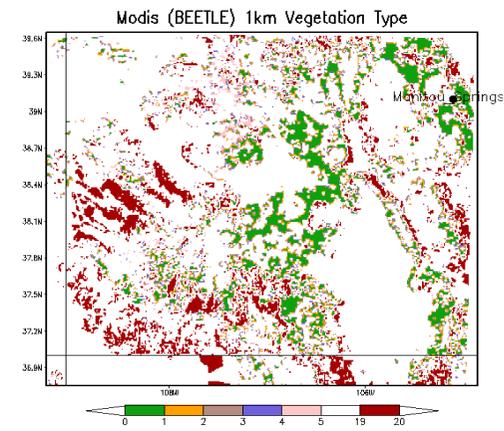
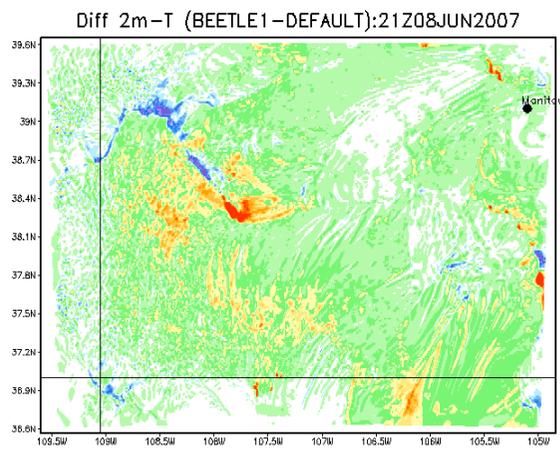
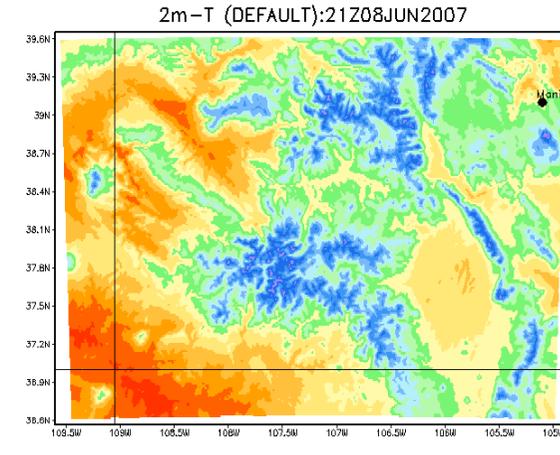
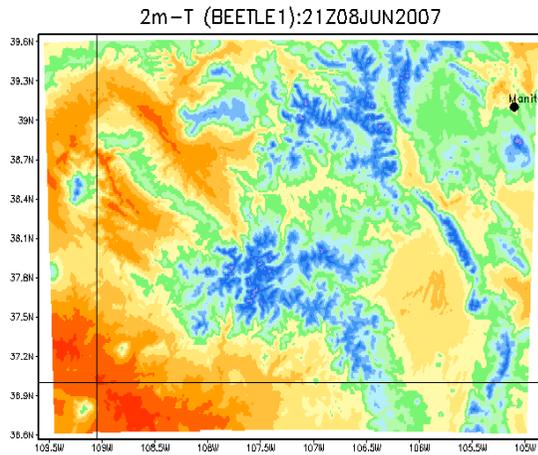
# WRF Model Physics Options

- Mp\_physics: WSM 3-class simple ice scheme
- LW: RRTM
- SW: Dudhia
- Sfc\_lay: Monin-Obukov scheme
- PBL: YSU

# Difference (Beetle-Default) 2m Temperature

Beetle

Default



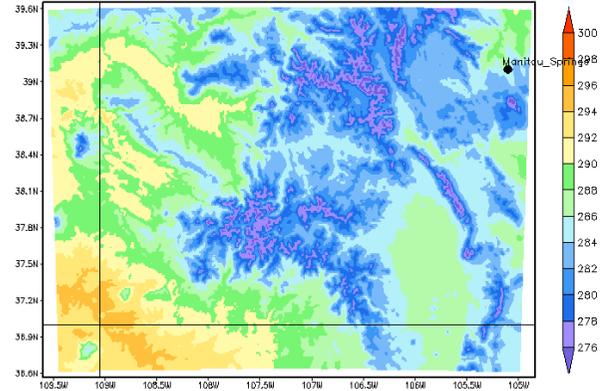
- 1: Evergreen Needleleaf Forest 2: Evergreen Broadleaf Forest
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Diff

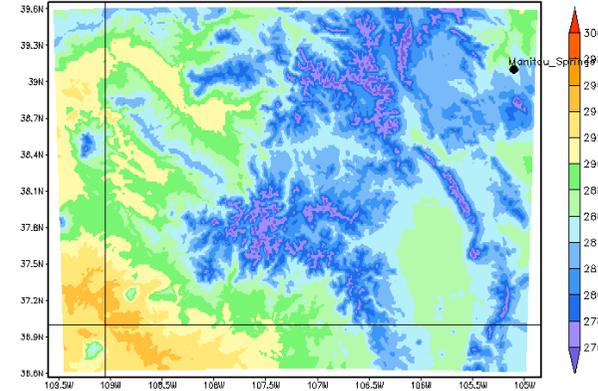
# Difference in Daytime Temporal Average (Beetle-Default)2m Temperature

Average  
6am to  
6pm LST  
Beetle

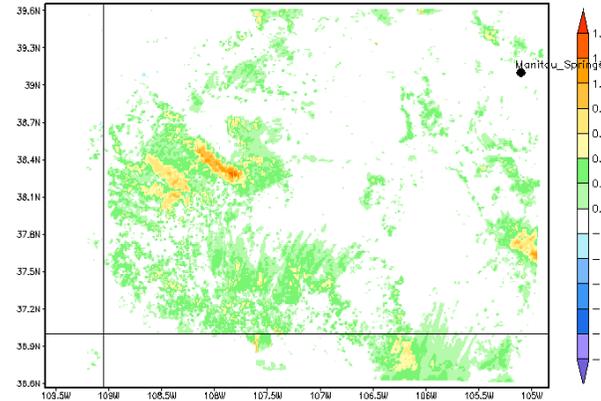
Average Day 2m-T (1200 to 0000 UTC) (BEETLE)



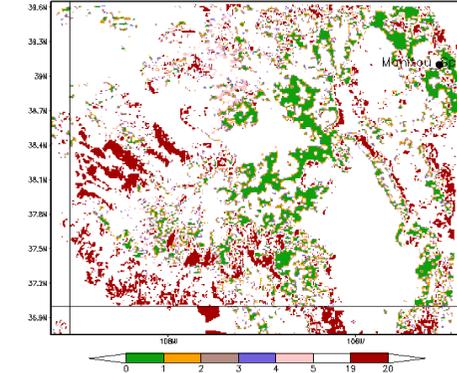
Average Day 2m-T (1200 to 0000 UTC) (DEFAULT)



Diff Average Day 2m-T (1200 to 0000 UTC) (BEETLE-DEF)



Modis (BEETLE) 1km Vegetation Type



- 1: Evergreen Needleleaf Forest 2: Evergreen Broadleaf Forest
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Difference

Average  
6am to  
6pm LST  
Default

- Still Working on MEGAN implementation
  - Input processing and documentation
  - Evaluation of code/output
  - WRF-Chem v3 has issues
- Looking at land surface interactions in WRF and WRF-chem
- Aerosol-cloud effects on emissions

