WRF-Chem evaluation over the Rocky Mountains forest during BEACHON-RoMBAS 2011

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1. Motivations

- Formation of secondary organic aerosols (SOA) from biogenic sources and their impacts on CCN and climate is poorly understood, in particular in areas influenced by anthropogenic pollutants, which have been suggested to greatly enhance the production of biogenic SOA.
- The BEACHON-RoMBAS field study took place in summer 2011 at the Manitou Forest Observatory (MFO) which is located in a complex mountain terrain at 2300m elevation, and at the forest / urban interface (Figs 1, 2).
- We use WRF-Chem to analyze the circulation patterns that influence the formation and transport of gaseous and aerosol pollutants at the site, and to investigate the sources of organic aerosol that were measured at the site.

2. Model Setup

- WRF-Chem simulation was performed for 25 July to Aug. 26, 2011 over the U.S. with the following configuration:
  - 2 domains: U.S at 36km, Colorado nested at 4km
  - coarse domain nudged to NARR 32km analysis
  - Monin double-moment scheme
  - Mellor-Yamada-Janjic PBL parameterization
  - Rapid Radiative Transfer Model for long wave radiation
  - Goddard scheme for short wave radiation
  - SAPRC99 chemistry and MOSAIC aerosols with updated SOA:
  - Emissions anthropogenic EPA NEI-05, biogenic MEGAN
  - Wet and dry deposition

3. Meteorological conditions during summer 2011

3.1 Influence of the North American Monsoon

- 3 active systems with mid-level southeasterly flow bringing moisture and favoring precipitations at MFO (25-28 July; 2-5 Aug.; 26-29 Aug.)
- Daytime winds influenced by the mountain upslope circulation;
- Nighttime southwesterly flow.

3.2 Complex near surface flow

- Model bias in predicted near surface RH, nighttime T and wind direction.

4. Transport of anthropogenic pollutants to the site

4.1 Flexpart backtrajectories

- Observations at MFO suggest (Fig. 9):
  - Higher fossil carbon levels 10-30% during 25 July to 1 Aug. (vs. < 10% after 12 Aug.)
  - Higher growth rate of newly formed aerosol nucleation clusters (Number Conc. in 4-40nm range).

4.2 WRF-Chem anthropogenic CO tracers

- Analysis of predicted CO tracer shows frequent transport of front-range pollutants to MFO (Fig. 10).

5. Near-surface concentrations of gaseous and aerosol pollutants at MFO

Reasonable daytime agreement; nighttime CO, ozone and anth. SOA frequently overpredicted:
- titration of O₃ by NO may be too weak, resulting in too low NO₂;
- bias in NOₓ coincides with bias in benzene -> not enough anthropogenic NO at the site
- nighttime PBL (min of 100m) may be too low

Biogenic SOA = 1µg/m³ from OH and ½ µg/m³ from nighttime chemistry