Contribution of point emissions on the $PM_{2.5}$ concentrations at breathing level

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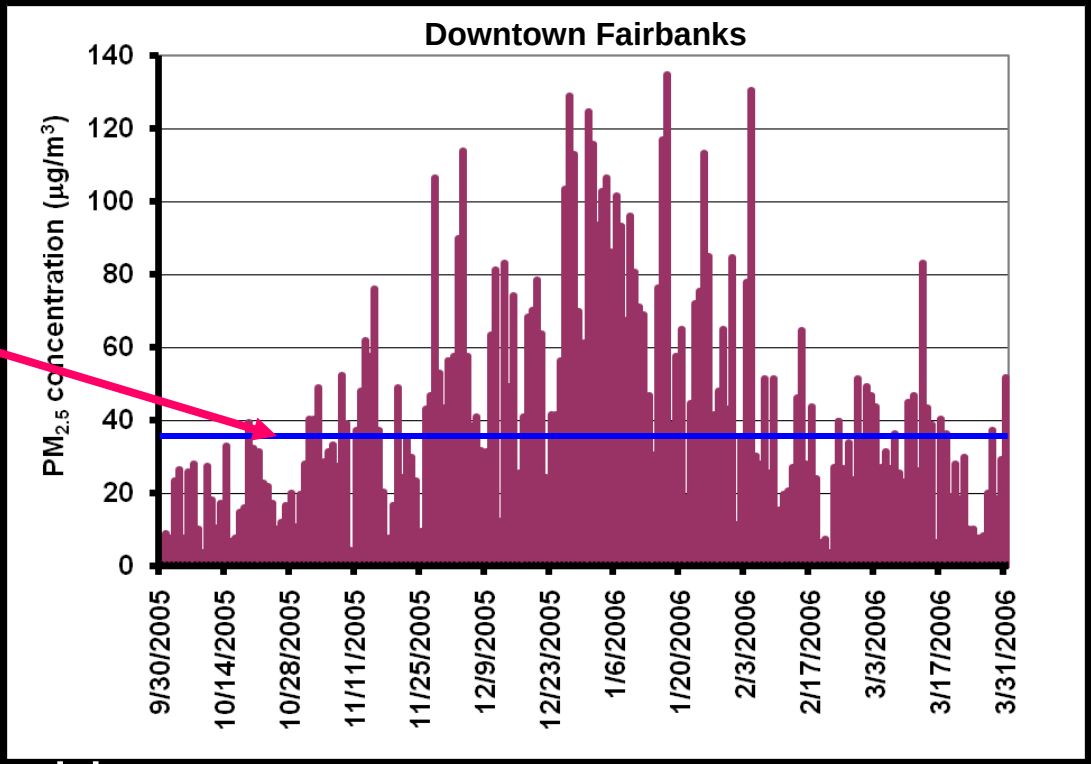
Fairbanks: violated new EPA regulations on consequent days

New EPA standards for $PM_{2.5}$

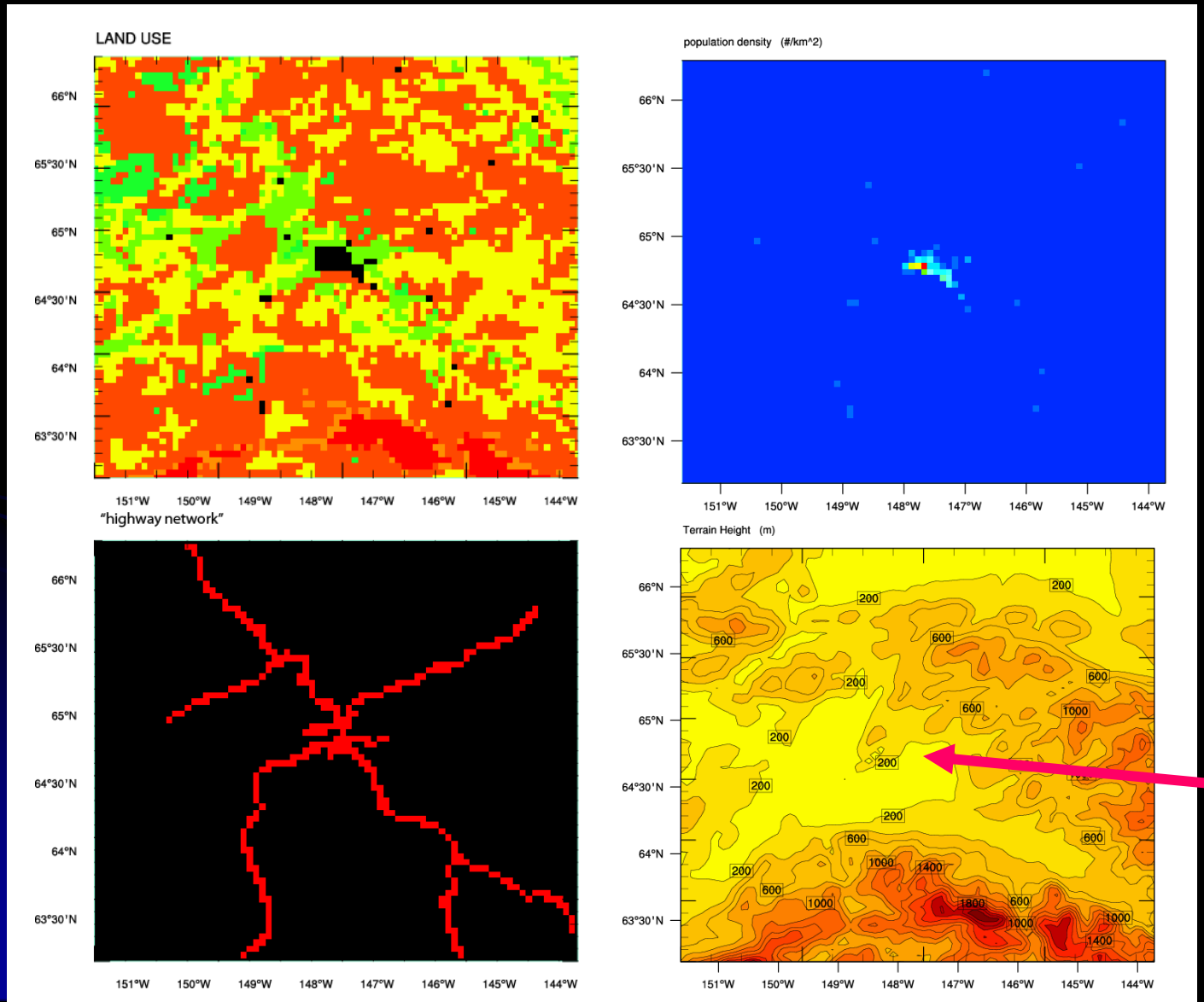
- previous 24h-standard of 65 µg/m³ lowered to 35 µg/m³
- annual standard of 15 µg/m³ remains

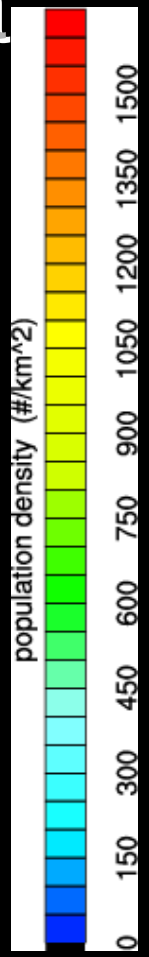


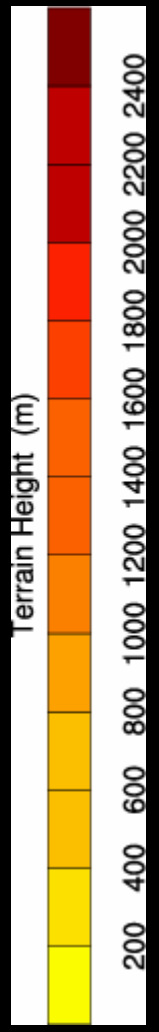
Reasons for violation

- Surrounded by hills on 3 sides
- Located at edge to air mass source region
- Wintertime radiative cooling leads to inversions
- High emissions

Model domain encompassing Fairbanks, adjacent area







Fairbanks located in a "bowl"

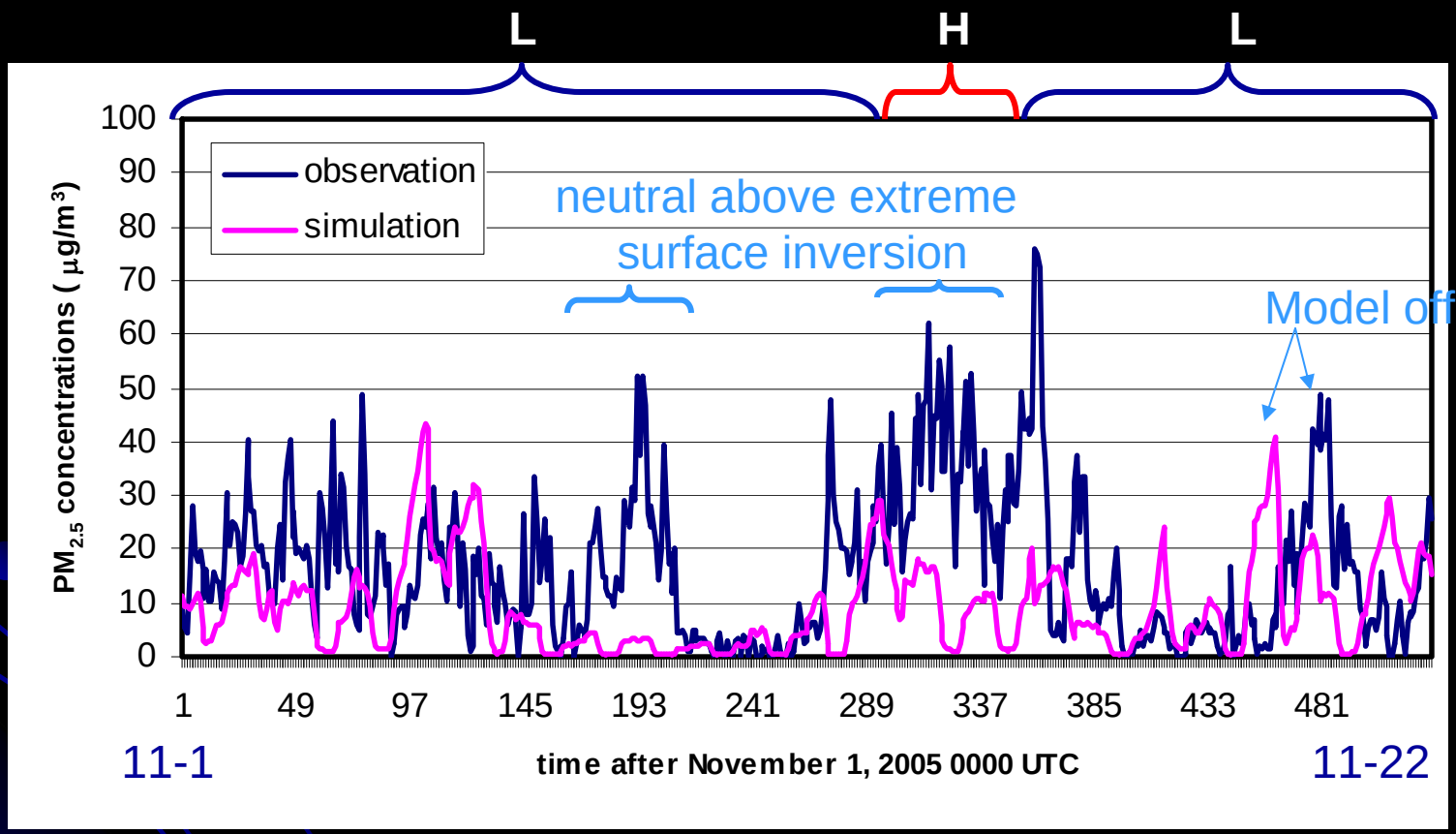
Population density data from T. Dunca

Method

Photo: Kramm 2007

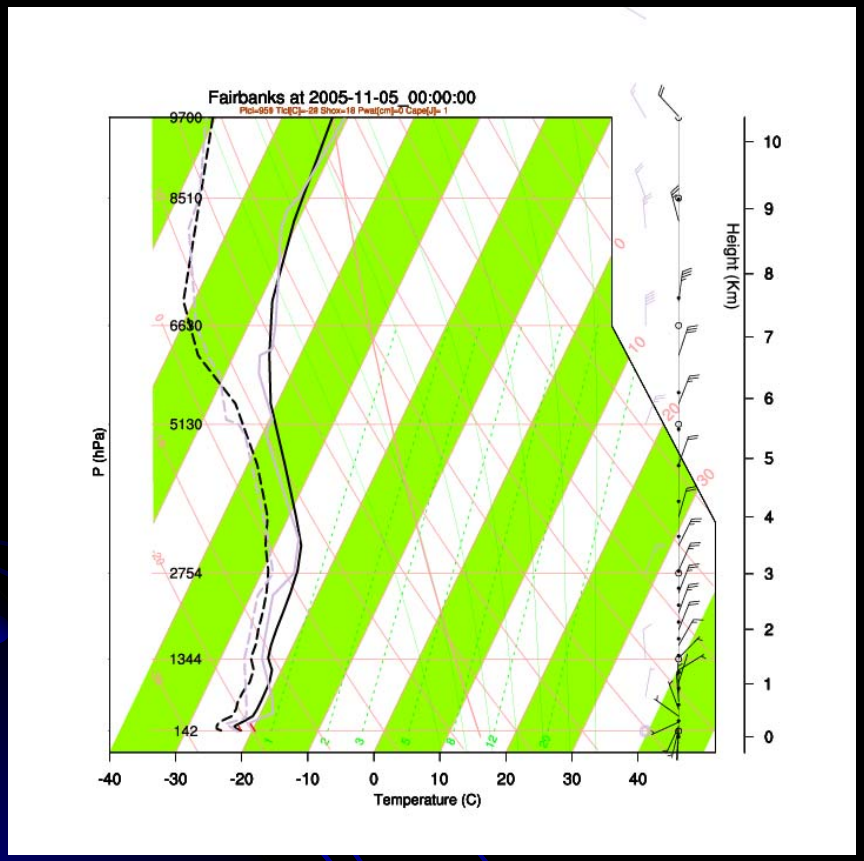
- Modified WRF/Chem V3.1 for Ak
  - background concentrations
  - cold region dry deposition
  - adapt for “winter” season
  - included cities/villages/settlements in land-use data using MODIS data
- Prepare emission data with Alaska Emission Model (AkEM)
- Run WRF/Chem V3.1 with different emission scenarios
- Investigate impact of $PM_{2.5}$ emissions on $PM_{2.5}$ concentrations at breathing level

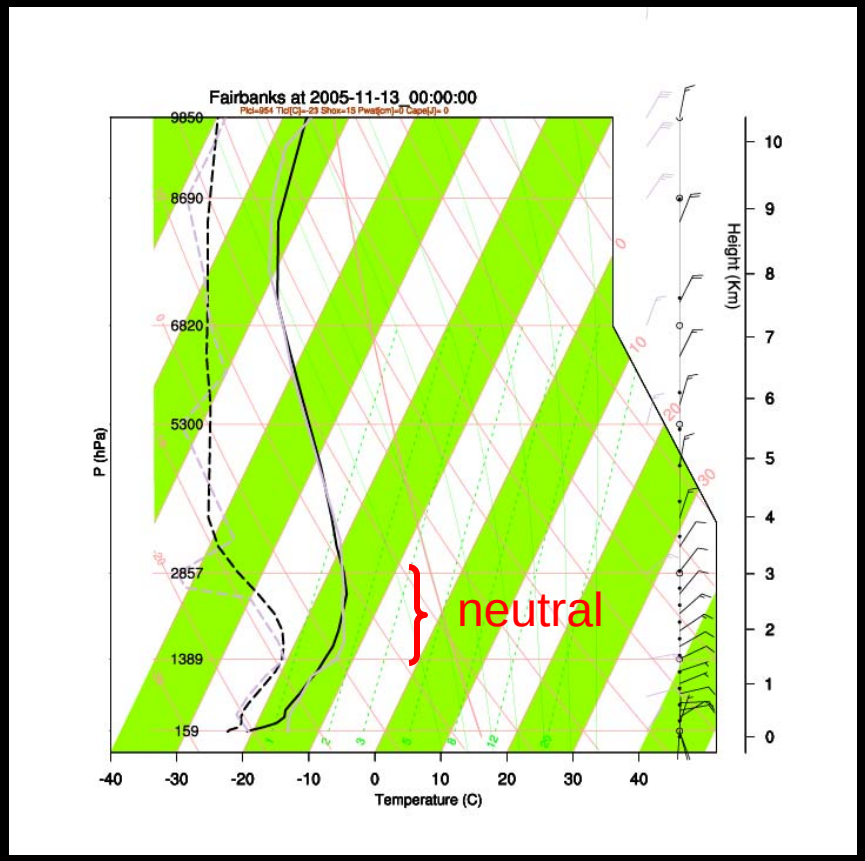
WRF/Chem acceptably predicts $PM_{2.5}$ concentrations



- WRF/Chem captures temporal evolution of response to synoptic situations and diurnal course of emissions

Neutral stratification over too strong surface inversion => simulated, observed $PM_{2.5}$ discrepancies





just inversions: $PM_{2.5}$ ok

neutral above too strong surface inversion: problem

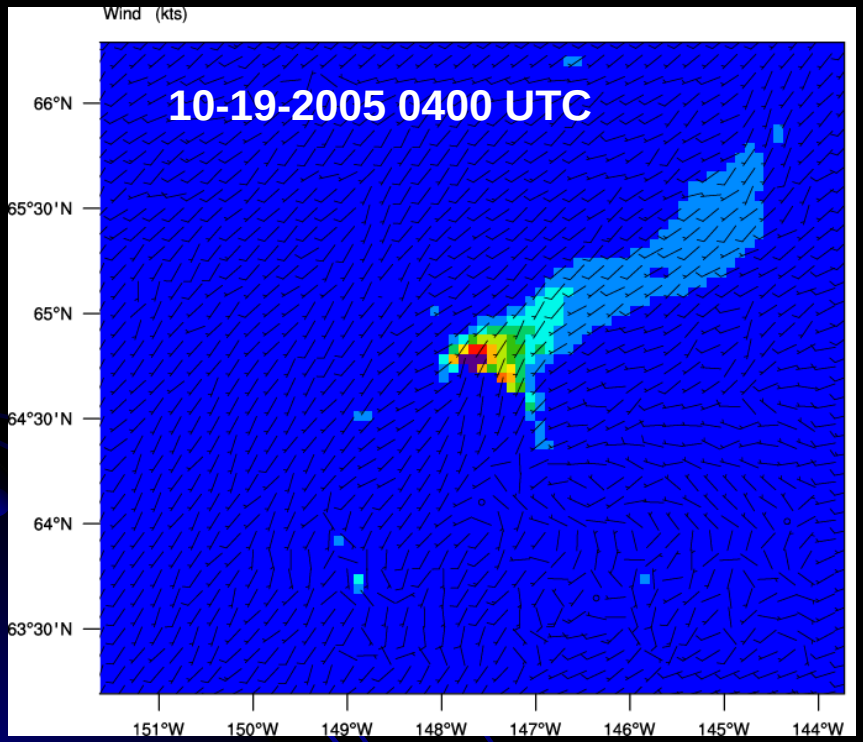
Black simulated, gray observed

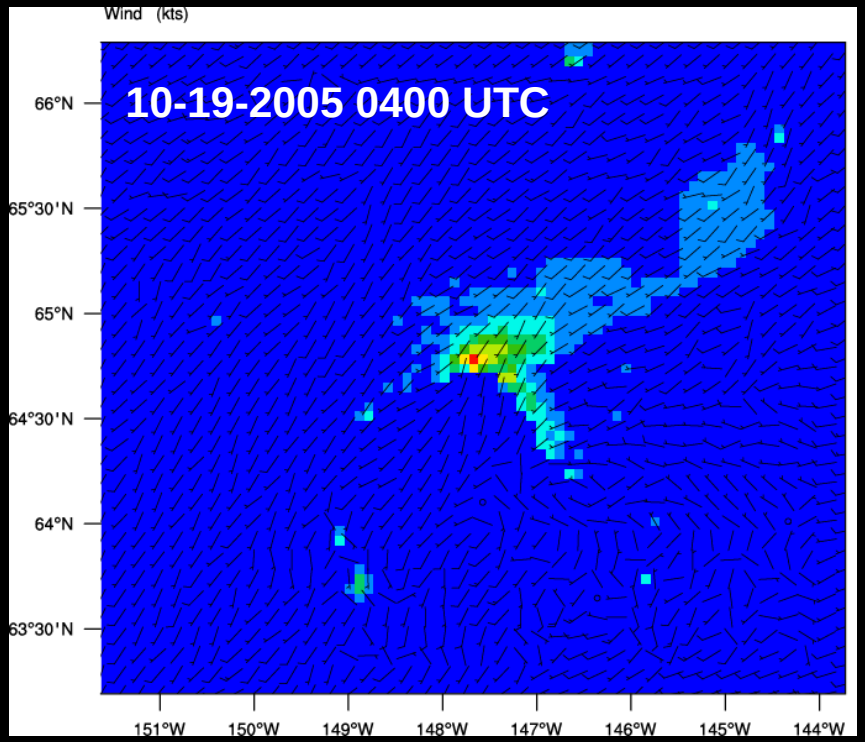
For details on WRF's ability to simulate inversions see Mölders and Kramm (2009)

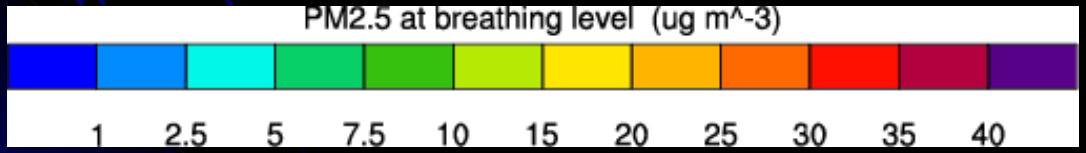
Geographical distribution of Tier 14 emission strongly affects $PM_{2.5}$

Misc. emission equally distributed over populated area

Same total emission, but lower where population density > 500, higher where <500 people/km^2



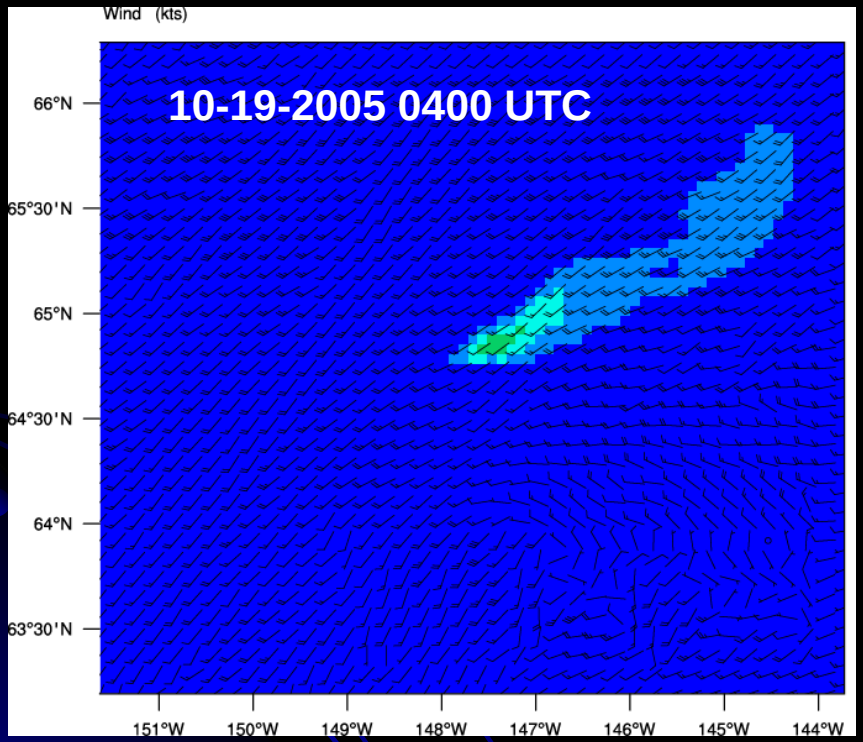


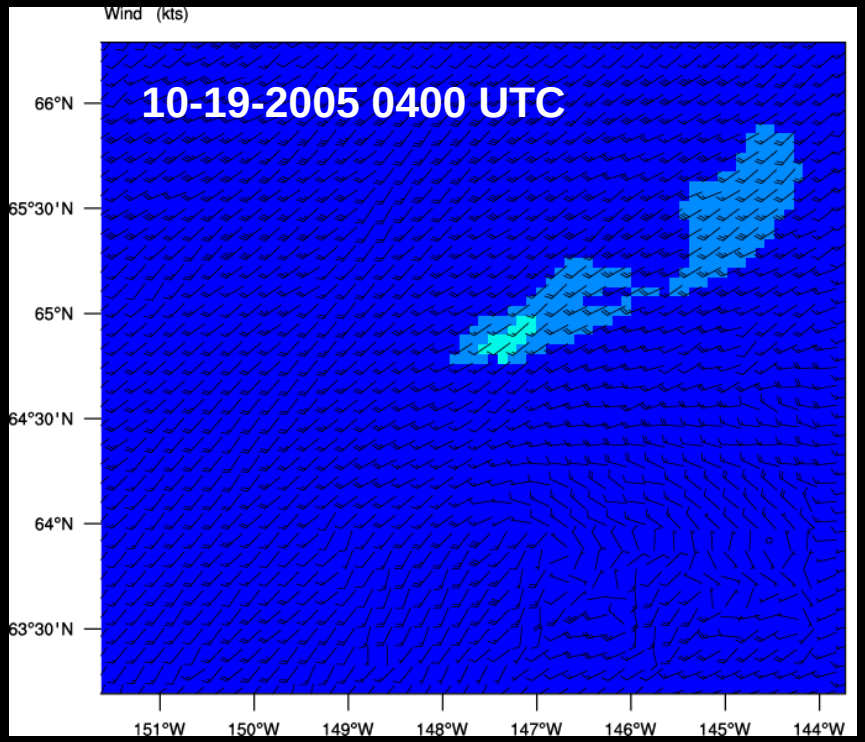


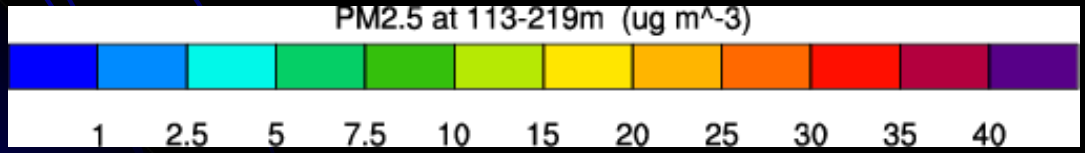
Tier 14 emission change also impacts $PM_{2.5}$ higher in ABL

Misc. emission equally distributed over populated area

Same total emission, but lower where population density > 500, higher where <500 people/km^2

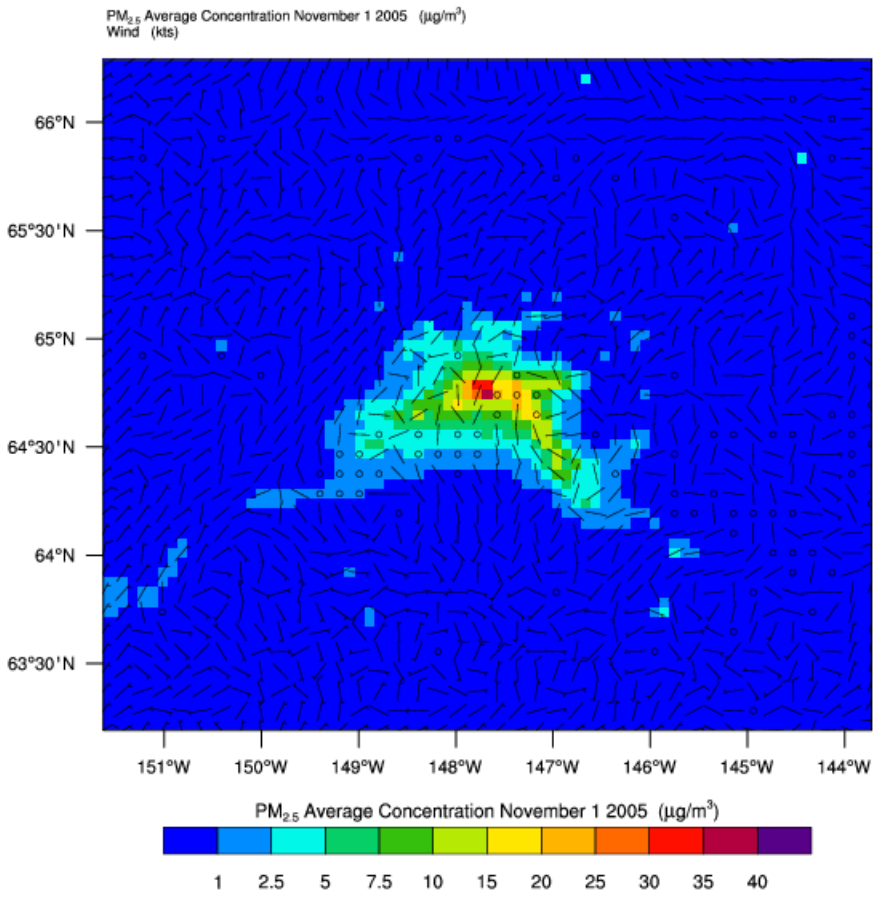






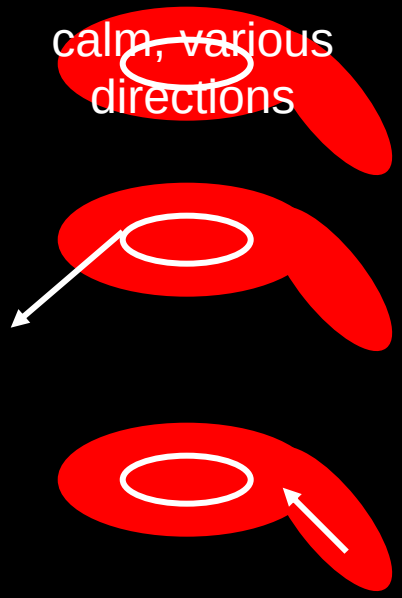
High spatial/temporal variability of $PM_{2.5}$ in non-attainment area

With point sources (REF)



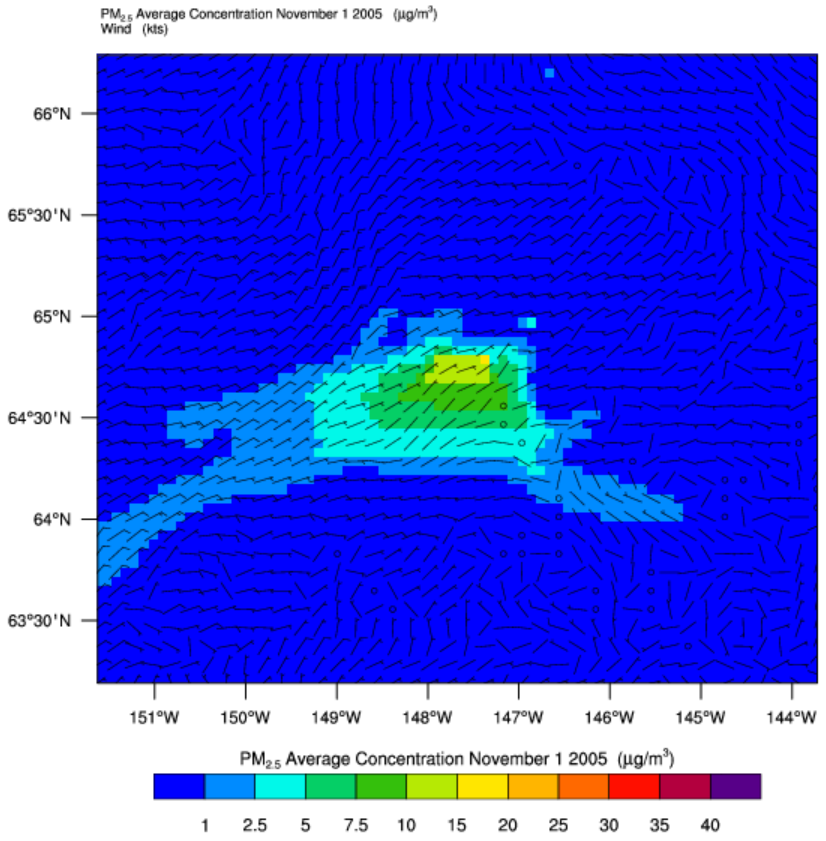
Daily average $PM_{2.5}$ concentration at breathing level November 1-16, 2005

Elevated concentration found in Fairbanks for the following wind patterns



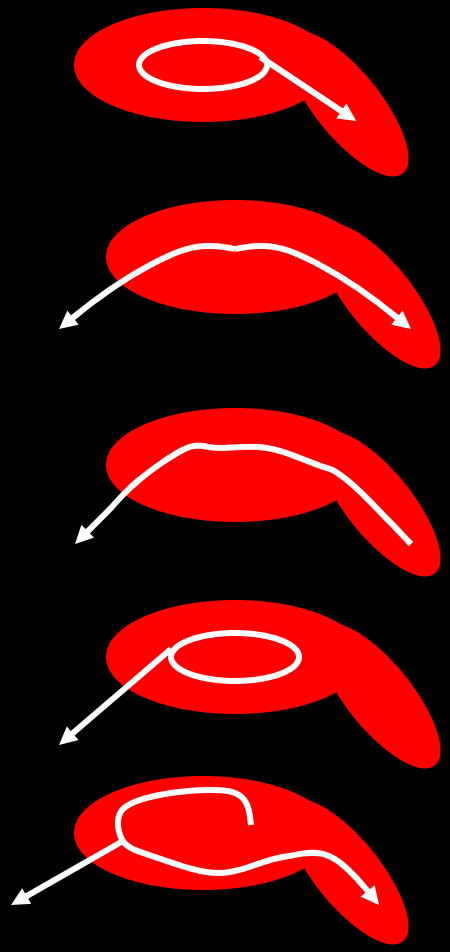
$PM_{2.5}$ plume thins with height, some point sources occasionally, visible

With point sources (REF)



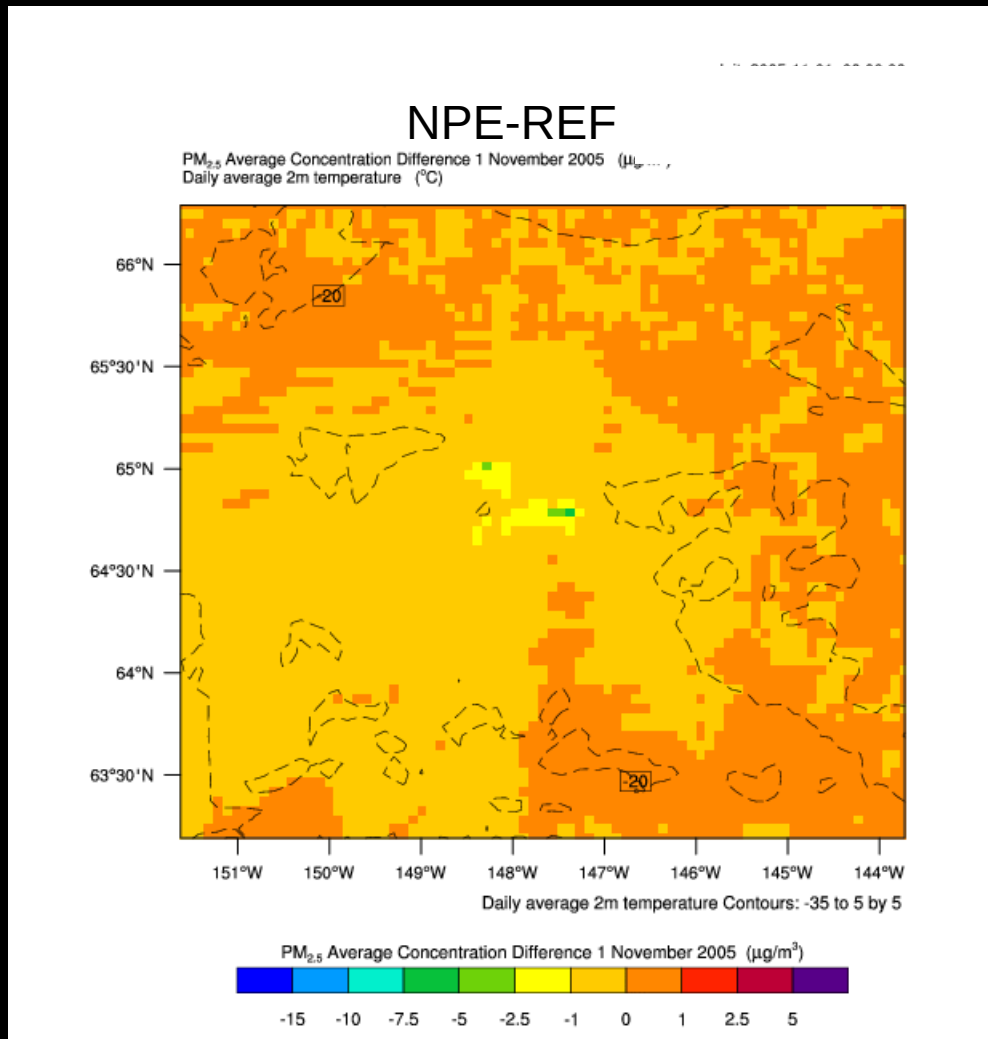
Daily average $PM_{2.5}$ concentration between 113 and 219m for November 1-16, 2005

Elevated concentration found in Fairbanks for the following plume patterns



Local impact of point sources most the time

- Large impact of point sources on Nov 13, 14
  - Nov 13, 14, calm wind, various direction, $PM_{2.5}$ high
  - Real or not real?
- Difference has different meaning depending on total concentration
  - Significant contribution does not necessarily mean violation
  - Small impact may lead to violation

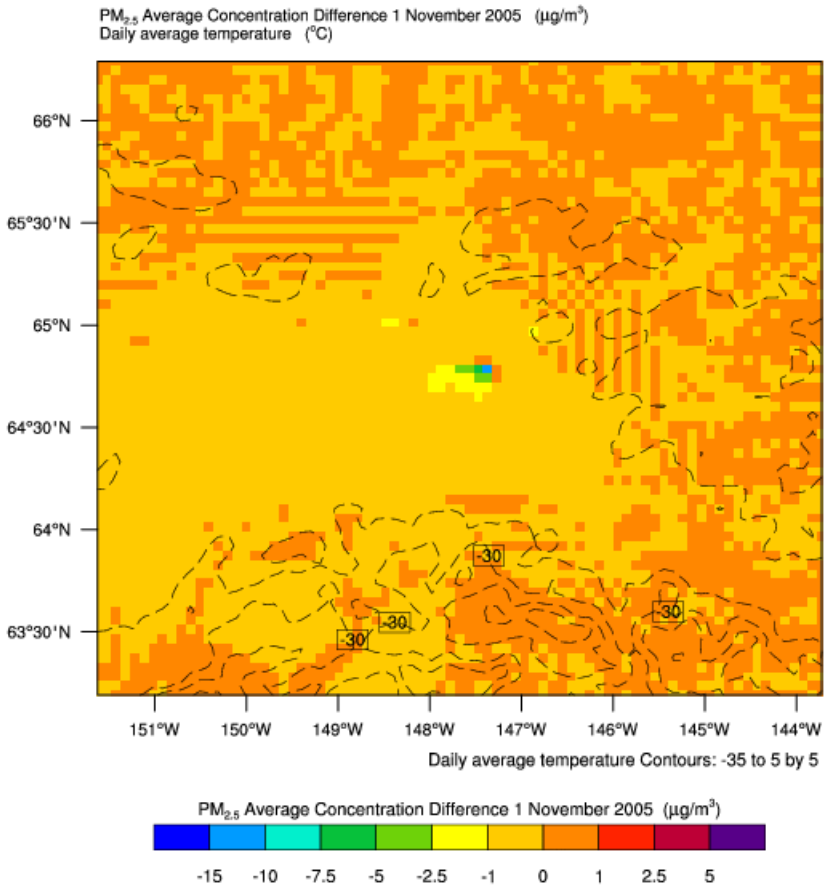


Daily average $PM_{2.5}$ concentration at breathing level November 1-16, 2005

Some $PM_{2.5}$ point sources occasionally clearly visible between 113-219m

- Large impact of point sources on Nov 13, 14
  - Surface inversion reaches to 1-1.5km
  - Plume travels along inversion
- Marginal spatial extend of differences in vicinity of point source at other times

NPE-REF



Daily average $PM_{2.5}$ concentration between 113 and 219m for November 1-16, 2005

Preliminary conclusion

- Fairbanks has “history” of non-compliance judged by new standards
- WRF/Chem has difficulties capturing $PM_{2.5}$ on days with neutral stratification and concurrent over-prediction of surface inversion strength
- Synoptic situation, local flow pattern important for violation
- $PM_{2.5}$ distribution heterogeneous over town, at upper levels long-range transport
- Area sources major contributor to $PM_{2.5}$ at breathing level most of the time
- Maximum $PM_{2.5}$ differences NPE-REF lower at breathing level than higher in the SL (e.g. 113-219m)