Modeling for $PM_{2.5}$ Attainment Demonstrations in EPA Region 10 (WA, ID, OR, & AK)

An Assortment of Proposed Models from CMAQ to Linear Rollback

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Motivation for this presentation

- In the recent past, Region 10 has had relatively few NAAs.
- But now, with the strengthening of the $PM_{2.5}$ standard in 2006, we currently we have five $PM_{2.5}$ nonattainment areas.
  - All are based on violations of the daily 24-hr 35 ug/m3 standard (no violations of the 2006 annual standard).
  - Excluding summertime exceptional events (wildfire, dust), all exceedances are in the wintertime and related to air stagnation events.
  - Many have significant contributions from primary $PM_{2.5}$ emissions
- For attainment demonstration models, our states and locals have proposed using a wide range of tools from modified forms of WRF/CMAQ to more simplified models (e.g., linear rollback).
- One goal of this presentation is to inform other Feds, states, and locals about the various modeling approaches being attempted in Region 10 by our states and locals.
- A second goal is to explain EPA R10's approach and how we're working with our states to developing attainment demonstration models in each nonattainment area.

What does EPA Guidance and Regulations say about attainment demonstration models for the $PM_{2.5}$ NAAQS?

Both the OAQPS 2007 modeling guidance and the $PM_{2.5}$ modeling sections of Appendix W say similar things:

- **If you need to control the formation of secondary $PM_{2.5}$ for your attainment demonstration, states should use a photochemical grid model (CMAQ/CAMx).**
- **However, if the $PM_{2.5}$ problem can be addressed solely by controlling primary $PM_{2.5}$, a more simplified modeling approach or mix of modeling approaches could be appropriate.**
  (caveat: state needs to show that any potential increases in secondary PM are not likely to cause a failure to reach attainment)

So, both offer at least the *possibility* that models simpler than regional scale CMAQ/CAMx could be appropriate for $PM_{2.5}$ attainment demonstrations.

What is EPA Region 10's approach to the question of what form of attainment demonstration model is appropriate?

For areas with significant secondary $PM_{2.5}$ impacts or complexity:

the state should attempt photochemical modeling (CMAQ) as a *starting point* for the attainment demonstration.

But there are caveats:

- **All our NAA's are dominated by wintertime, air stagnation based exceedances, which are very difficult for photochemical models to accurately simulate.**
- **So, while CMAQ may be the starting point, states need to have fallback options if the photochemical model performance proves inadequate to demonstrate attainment with confidence.**

EPA Region 10's approach (cont.)

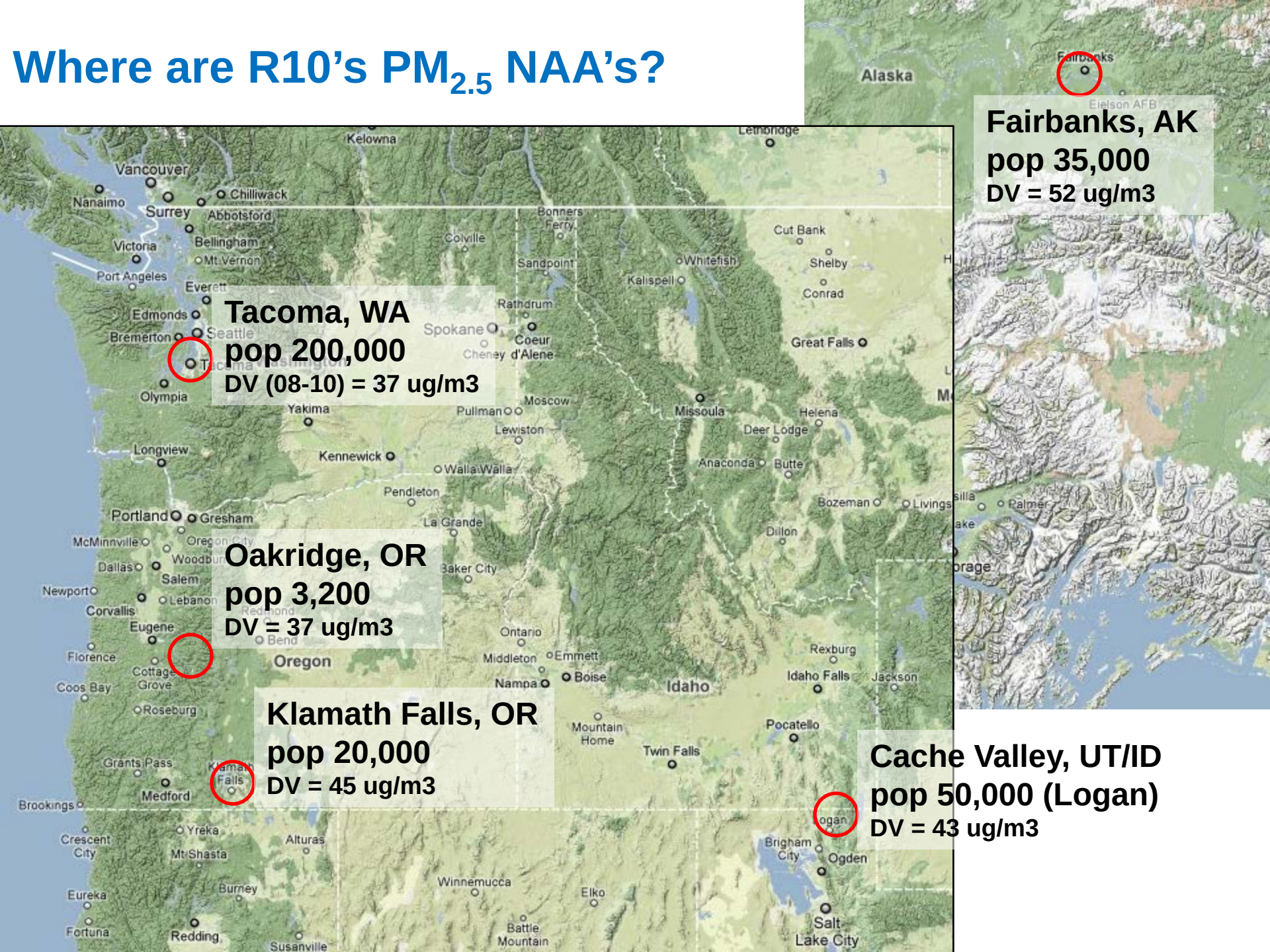
For areas with significant primary $PM_{2.5}$ impacts:

states and locals may attempt the attainment demonstration with a more simplified modeling approach (i.e., simpler than CMAQ/CAMx)

And there are caveats here too:

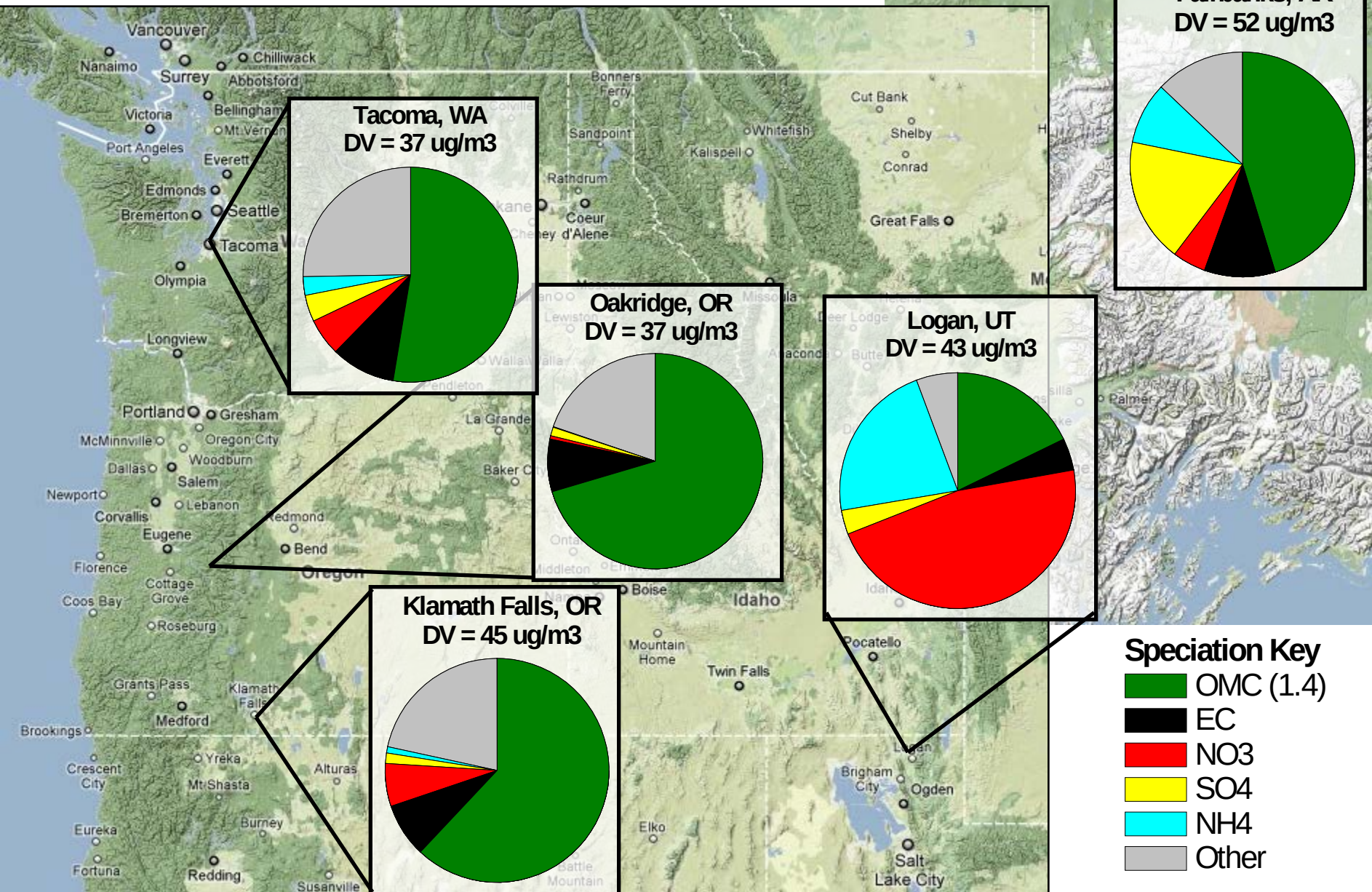
- **If using a simplified approach, the state will need to make conservative assumptions regarding the impacts of such things as:**
  - **background $PM_{2.5}$**
  - **secondary $PM_{2.5}$**
  - **inhomogeneity of sources in the NAA (point, area, & mobile)**
- **and these conservative assumptions may cause the state to be unable to make a successful attainment demonstration. If so, then the state may need to layering in added complexity using more sophisticated modeling tools to better constrain uncertainties. (e.g., chemical box modeling, point source modeling, etc.).**
- **Also, *this may mean that the final form of the attainment demonstration model is not the same as initially proposed ... it may evolve during the SIP development process.***

Where are R10's $PM_{2.5}$ NAA's?

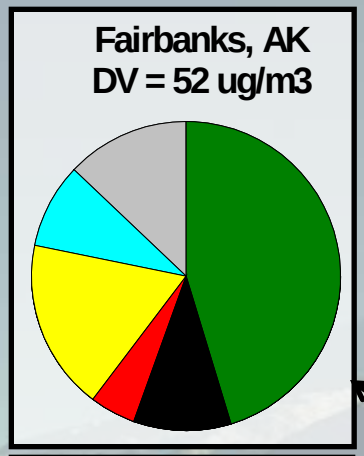


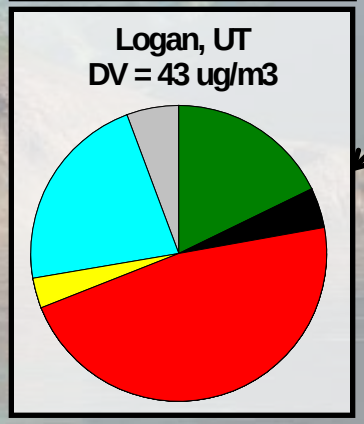
R10's $PM_{2.5}$ Chemical Speciation

- 2008-2010 Design Values (24hr 35ug standard)
- Speciation pies (06-10 winter data >25 ug/m3)



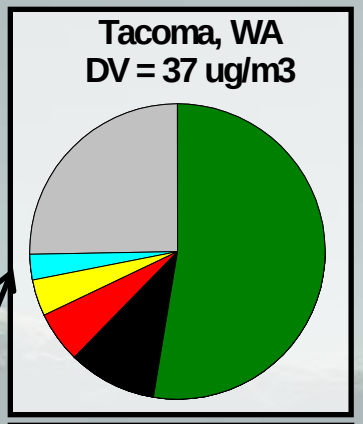
Which Approach for Attainment Demonstration Modeling?

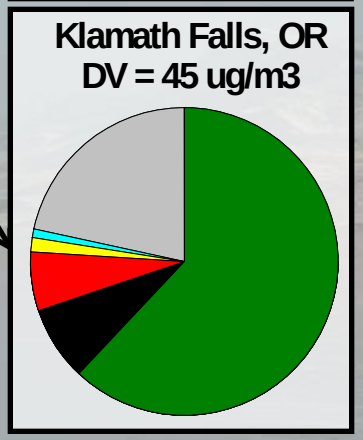


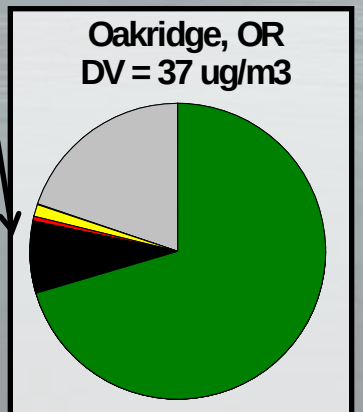


2 Areas starting with WRF/CMAQ

3 Areas starting with simplified approaches







Speciation Key

- OMC (1.4)
- EC
- NO3
- SO4
- NH4
- Other

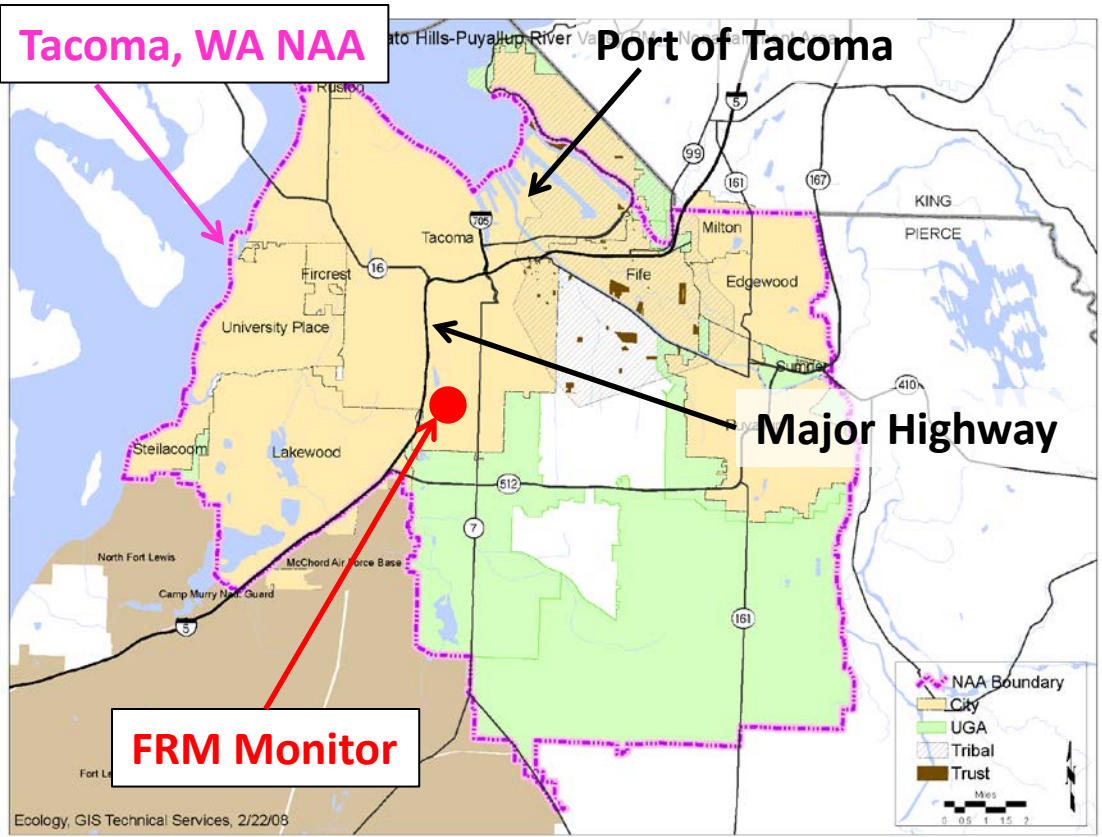
Areas attempting simpler models: Tacoma, WA

Airshed:

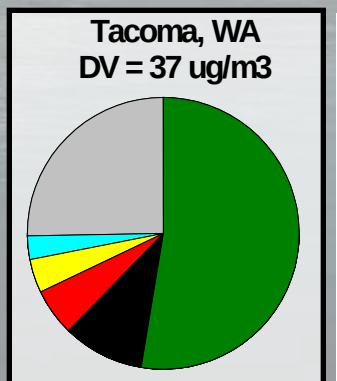
- A major urban area, population 200,000 [# wood burning devices = 65,000(!)]
- State and local believes wood burning devices are driving nonattainment
- Relatively minor contribution from inorganic secondary PM (SO_4, NO_3)
- All $PM_{2.5}$ exceedances are wintertime, air stagnation events

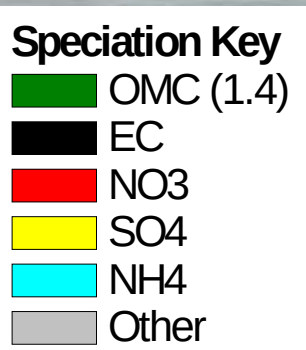
Potential complexities

- source mix – home heating, major highway, port of Tacoma, light industry.



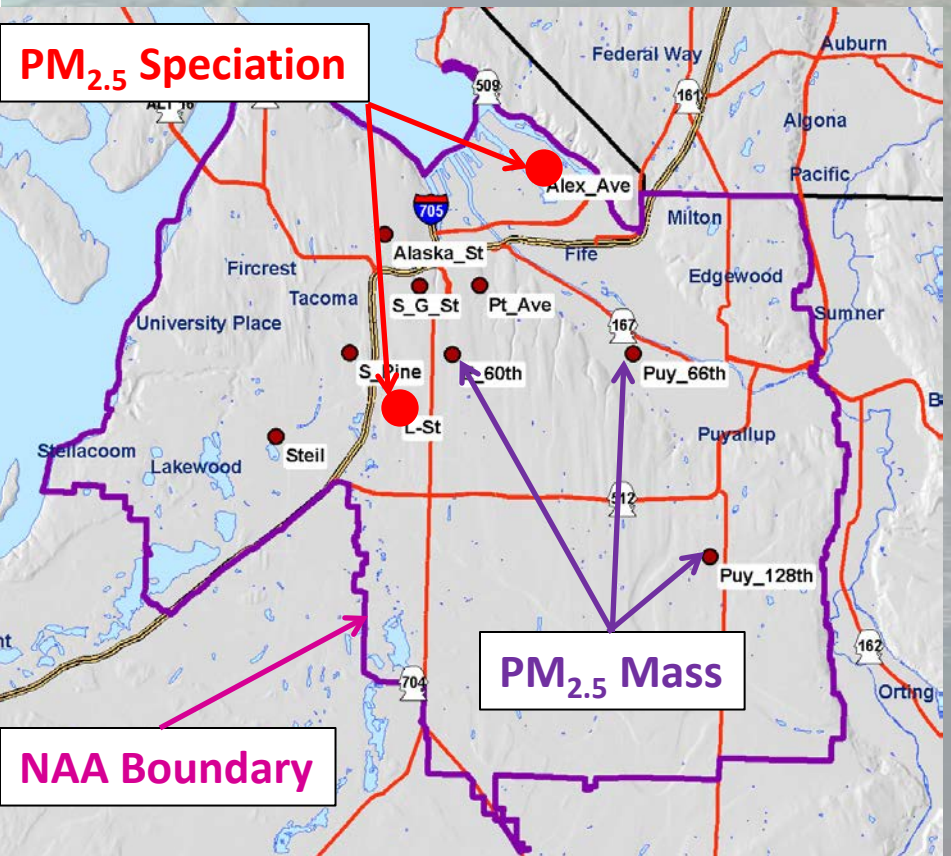
- possible airshed emissions inhomogeneities
- How to deal with 65,000 wood burning devices?
- are secondary organics important?





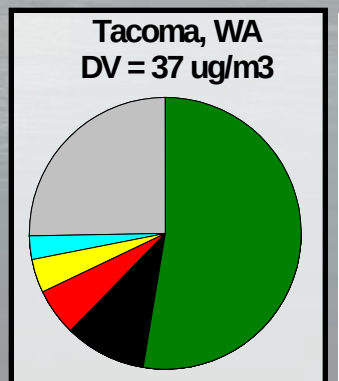
Proposed form of attainment model for Tacoma, WA

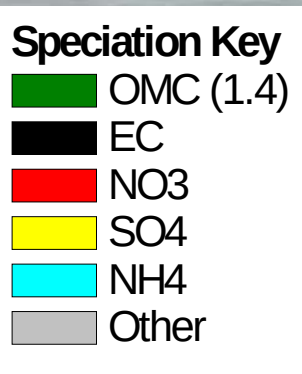
- WA is proposing linear rollback of primary $PM_{2.5}$ emissions
- Their rollback model will attempt to integrate 1 km gridded emissions, with emissions impacts distance weighted and tuned to the monitoring network.
- Monitoring network includes 2 speciation monitors and ~ 8 $PM_{2.5}$ monitors.
- Modeling will include conservative assumptions for background and secondary $PM_{2.5}$



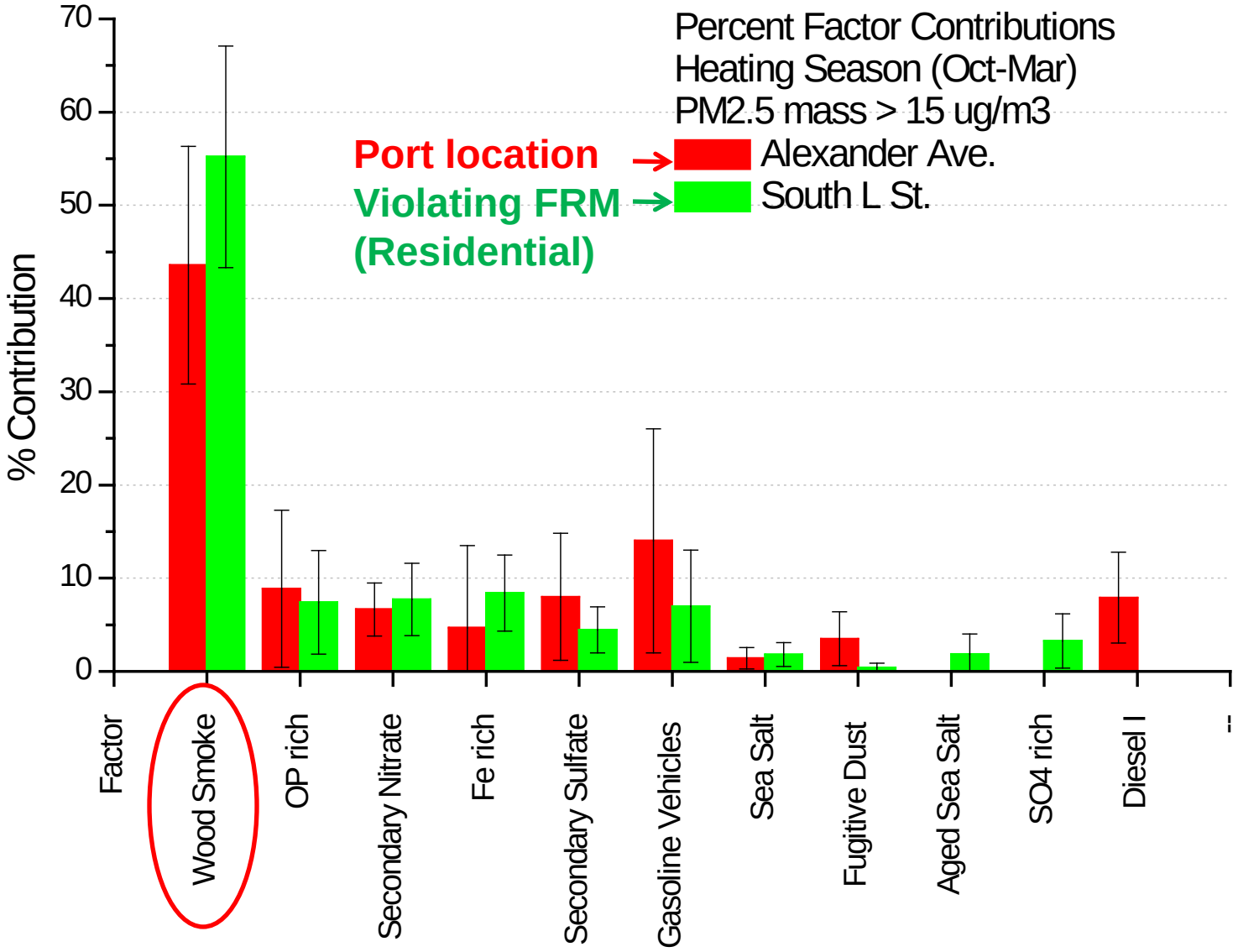
- No attainment modeling results yet (gridded emissions pending)

- Supplementary modeling includes PMF analysis on both speciation monitors.

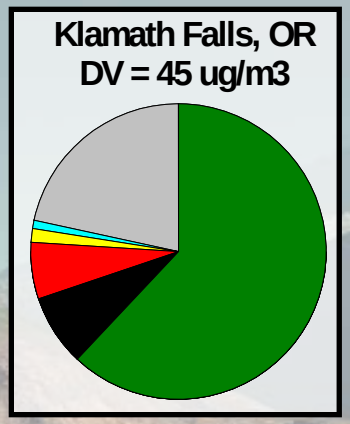


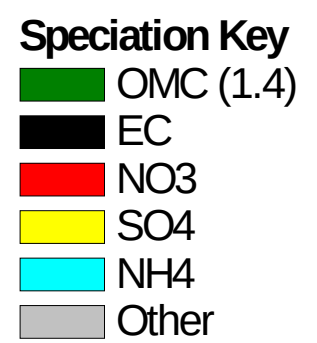


More Details – Tacoma, WA – PMF Results



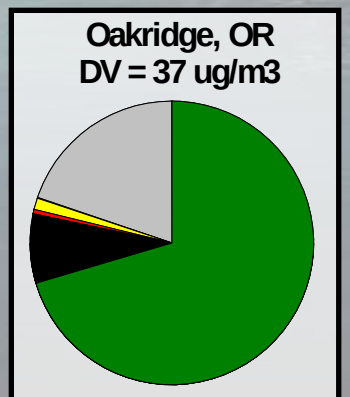
Other areas attempting simpler models: Klamath Falls, OR & Oakridge, OR





Klamath Falls airshed and potential complexities:

- Smaller town, eastern edge of Cascade range (pop 20,000)
- Some exceedance days have ~20% nitrate
- Source mix – home heating, mobile, a few small point sources
- PMF analyses indicates ~70% $PM_{2.5}$ from biomass burning.
- Current focus is on using rollback as the attainment demonstration model, making conservative assumptions about NO_3.
- State is working with Portland State University to conduct box modeling to evaluate SOA production to apportion primary vs. secondary OC. (box model uses latest GEOS Chem mechanism, which incorporates OC, SVOC, VOC volatility basis set concepts)



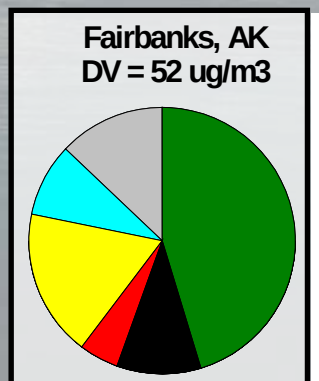
Oakridge airshed and potential complexities:

- Small mountain town (pop 3,200)
- Virtually no inorganic secondary PM on exceedance days
- Focus is solely on reducing home heating sources (wood stove changeouts)

Areas attempting WRF/CMAQ: Fairbanks, AK

Complexities:

- **Significant sulfate (how oxidized in winter, dark, 0 to -40C?)**
- **Ice fog – heterogeneous chemistry?**
- **Monster inversions (delta-T, >40C/100m, e.g. -50C -> -10C)**
- **Multiple sources – home heating, mobile, EGU's (coal) within city emitting at different altitudes in inversion**
- **Using a modified form of WRF/CMAQ (no CMAQ results yet).**



Speciation Key

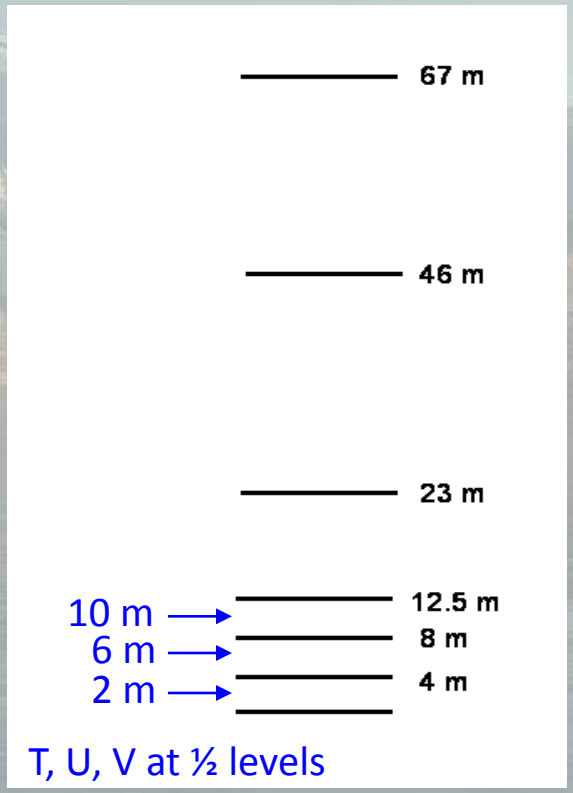
- OMC (1.4)
- EC
- NO3
- SO4
- NH4
- Other

More Details - Fairbanks, AK

WRF/CMAQ modifications

- expanded vertical resolution near surface
(EPA & Fairbanks worked with Penn State to modify WRF with lowest 5 levels at 4m, 8m, 12.5m, 23m, & 46m).
- Also required modification of nudging code and model/obs evaluation code.
- Significant improvement in met performance
- Also requires emissions model modification to put some 'surface' emissions above the first layer.
- high horizontal resolution (4 & 1.3 km)

WRF/CMAQ Vertical Levels



More Details - Fairbanks, AK

Additional modeling - ‘fallback’ option

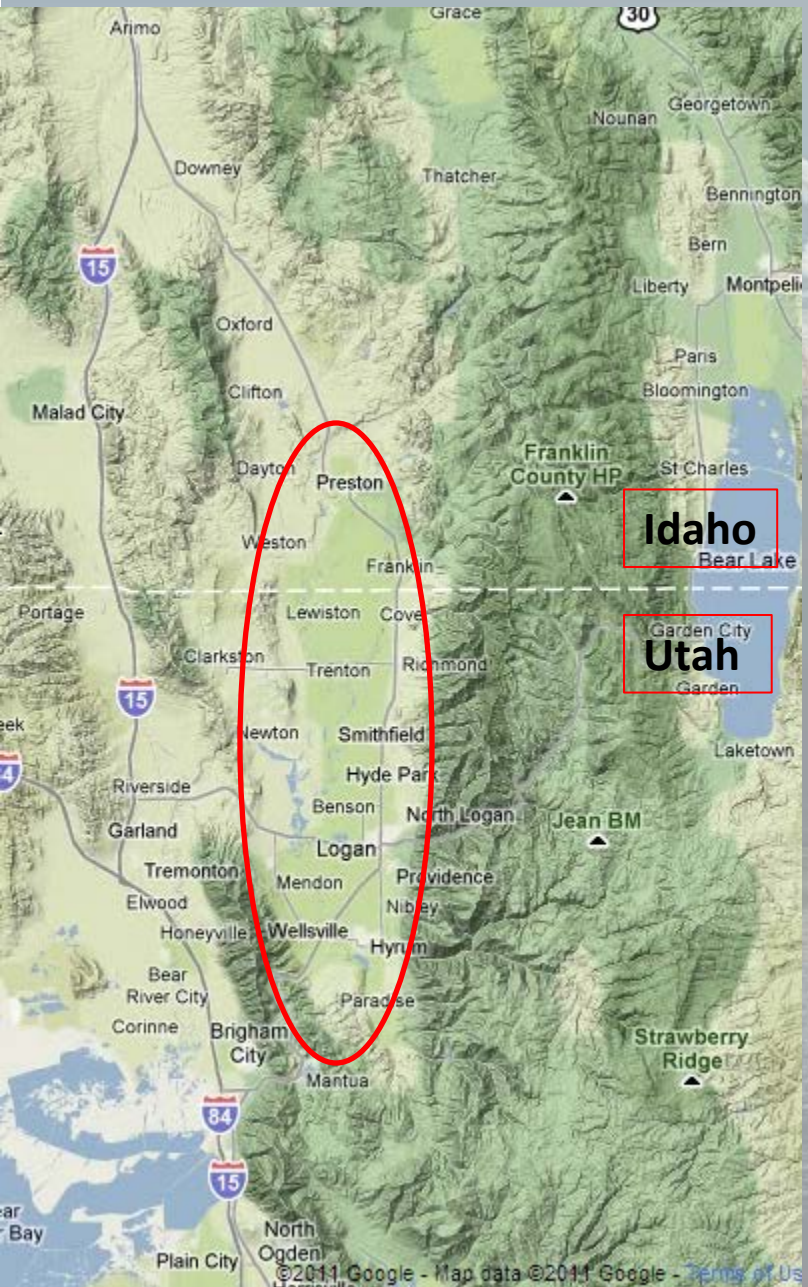
In addition to WRF/CMAQ (or as a fallback if performance is poor) Fairbanks is developing a Principal Component Analysis (PCA) based statistical model that could be used for attainment demonstrations.

This PCA model uses:

- **meteorology and emissions as independent variables**
- **24-hr PM2.5 as the dependant variable**
- **Thus, emissions can be modified with future year scenarios to predict 24-hr PM2.5, and develop an RRF**

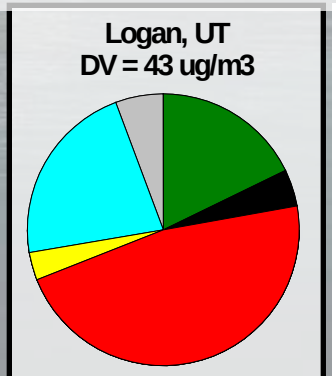
(the PCA model is essentially a sophisticated form of rollback)

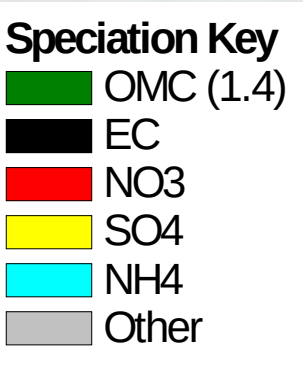
Areas attempting CMAQ: Cache Valley (UT/ID)



Complexities:

- NAA in 2 States, 2 EPA Regions
- Speciation dominated by sec. NH_4NO_3
- Sources dominated by mobile (NOx), agriculture (NH_3)
- In CMAQ - difficulty capturing winter stagnation, multi-day PM buildup (see earlier Utah modeling presentation)
- Likely will use modified WRF/CMAQ with no vertical advection and 90% reduction in eddy diffusivities to capture NH_4NO_3 buildup.





Thank you!
Questions?

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From the 2007 modeling guidance:

"States should use a photochemical grid model to simulate the effects of strategies to reduce ... the secondary components of particulate matter (i.e., mass associated with SO_4, NO_3 and secondary OC)."

"Based on its conceptual description of a PM2.5 nonattainment problem, a State could conclude that the PM2.5 problem can be addressed solely by reducing primary components of measured PM2.5."

"If this is the case, the State may not need to use a photochemical grid model in their attainment demonstration if it can present convincing qualitative arguments that an increase in the secondary components of PM will not cause [a failure to demonstrate attainment]."

From 40 CFR Part 51, Appendix W:

"Control agencies with jurisdiction over areas with secondary PM–2.5 problems are encouraged to use models which integrate chemical and physical processes (e.g., Models-3/CMAQ)."

"Primary components can be simulated using less resource-intensive techniques. Suitability of a modeling approach or mix of modeling approaches for a given application requires technical judgment."