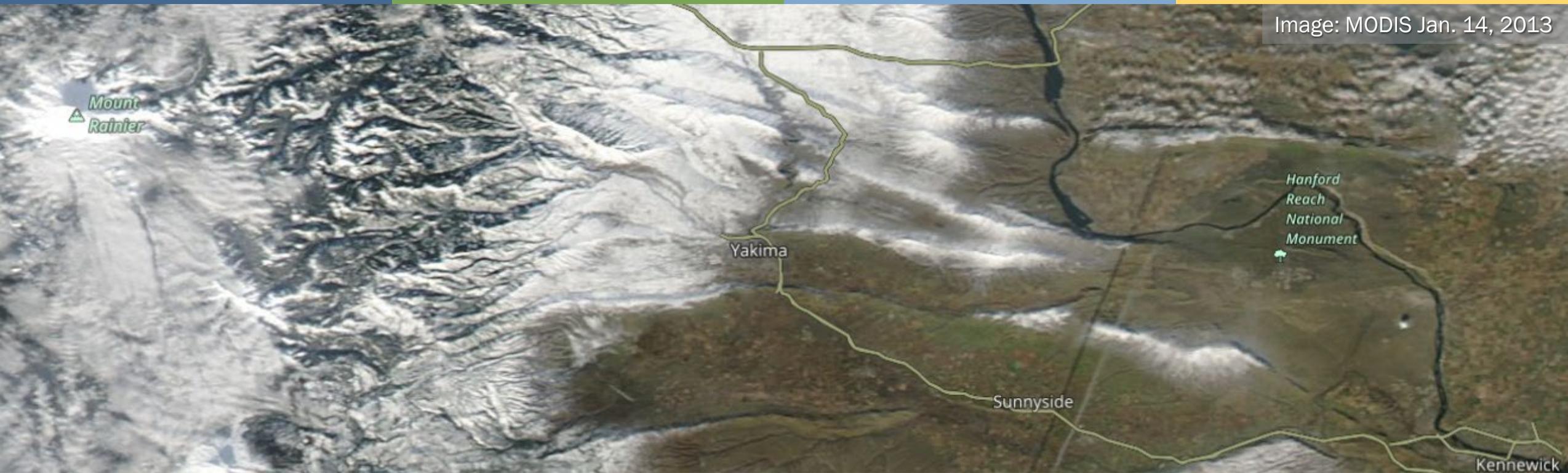# Yakima wintertime modeling preliminary results – 4/3 km EMAQ

Looking back at the Jan. 2013 YAWNS period

Ranil Dhammapala, Tes Ghidey, Farren Thorpe
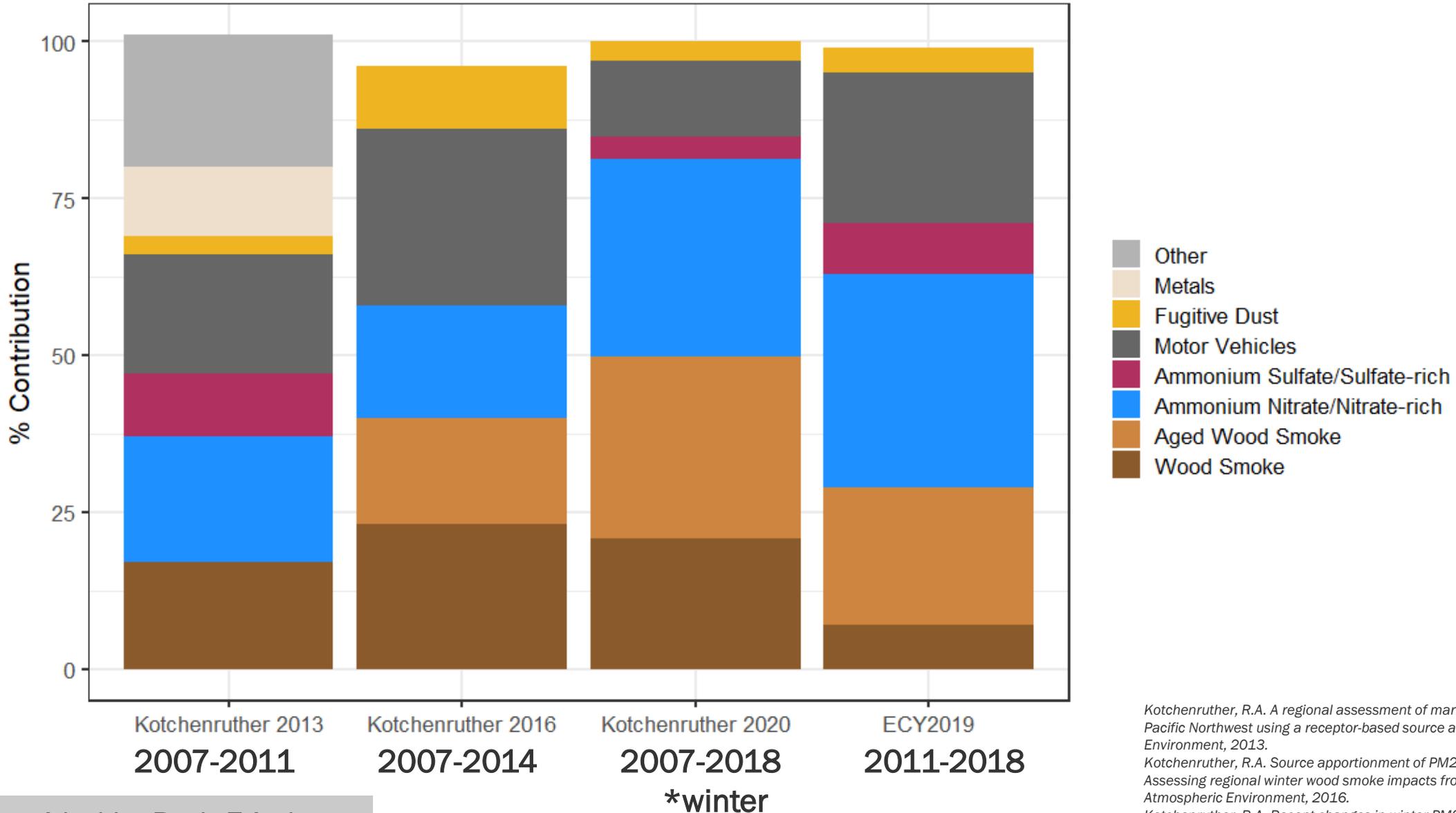
NW-AIRQUEST Mtg.

Oct 14, 2021

DEPARTMENT OF
ECOLOGY
State of Washington

Source apportionment of PM2.5 in Yakima

DEPARTMENT OF
ECOLOGY
State of Washington

Legend:
- Other
- Metals
- Fugitive Dust
- Motor Vehicles
- Ammonium Sulfate/Sulfate-rich
- Ammonium Nitrate/Nitrate-rich
- Aged Wood Smoke
- Wood Smoke

Kotchenruther 2013 — 2007-2011
Kotchenruther 2016 — 2007-2014
Kotchenruther 2020 — 2007-2018 *winter
ECY2019 — 2011-2018

Provided by Beth Friedman

Kotchenruther, R.A. A regional assessment of marine vessel PM2.5 impacts in the U.S. Pacific Northwest using a receptor-based source apportionment method. Atmospheric Environment, 2013.

Kotchenruther, R.A. Source apportionment of PM2.5 at multiple Northwest U.S. sites: Assessing regional winter wood smoke impacts from residential wood combustion. Atmospheric Environment, 2016.

Kotchenruther, R.A. Recent changes in winter PM2.5 contributions from wood smoke, motor vehicles, and other sources in the Northwest U.S. Atmospheric Environment, 2020.

2

# Ammonium Nitrate contribution to total PM2.5

Produced by Ranil in 2012
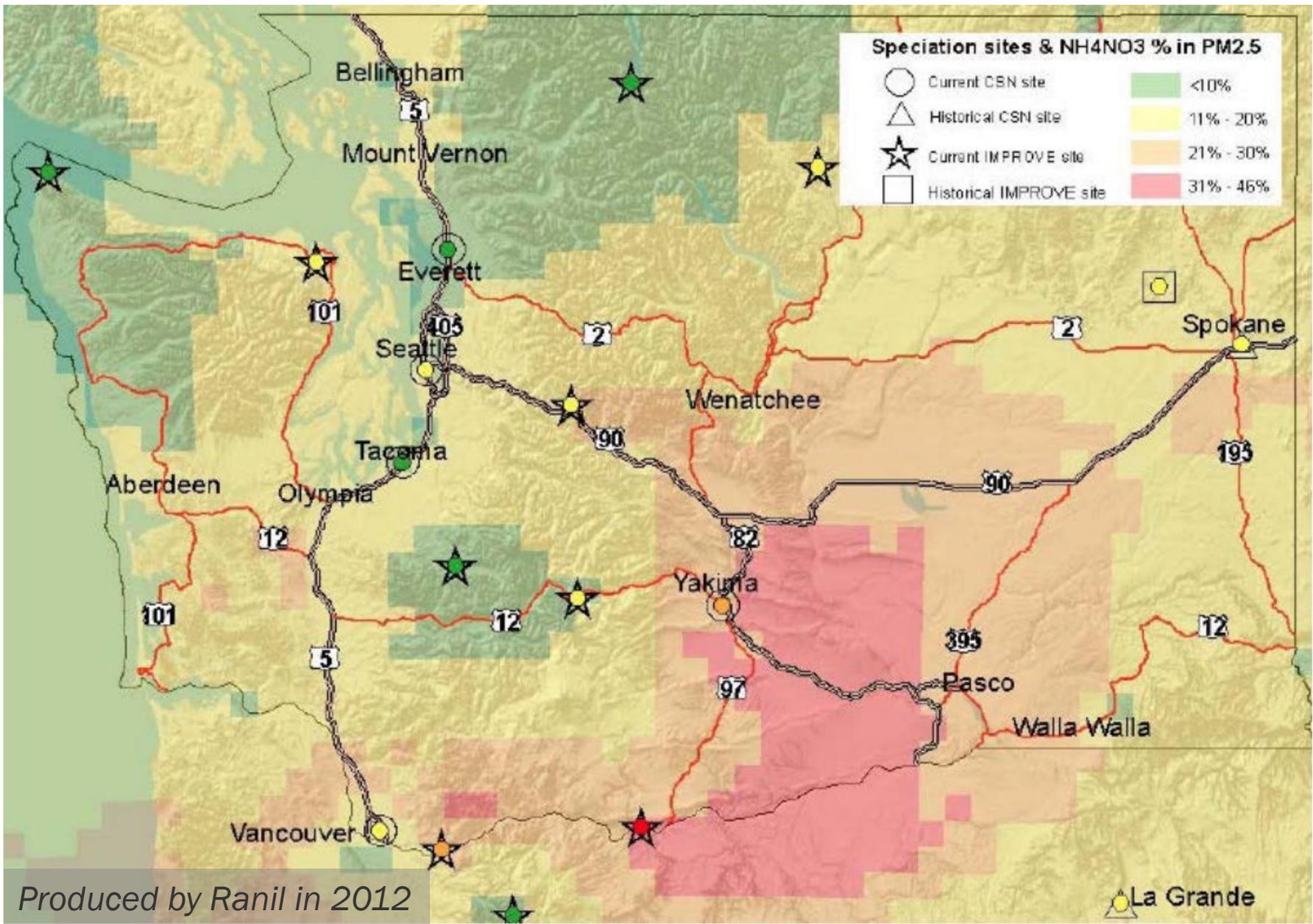
Yakima often has PM2.5 issues during the winter, but not just due to wood-smoke.

WSU and CWU were contracted by Ecology to perform a Yakima Air Wintertime Nitrate Study (YAWNS) to understand why particulate nitrate is a problem in the area.

Multi-pollutant monitoring campaign conducted in January of 2013.

YAWNS Conclusions

- High nitrate levels are likely caused by ammonia from agricultural activities interacting with NOx from motor vehicles during the right weather conditions.

- Air from both upper and lower Yakima valleys gradually mix together in typical conditions. However, mixing is restricted during cold, stagnant periods

- Need to determine what kind of actions will help reduce aerosol nitrate in Yakima.
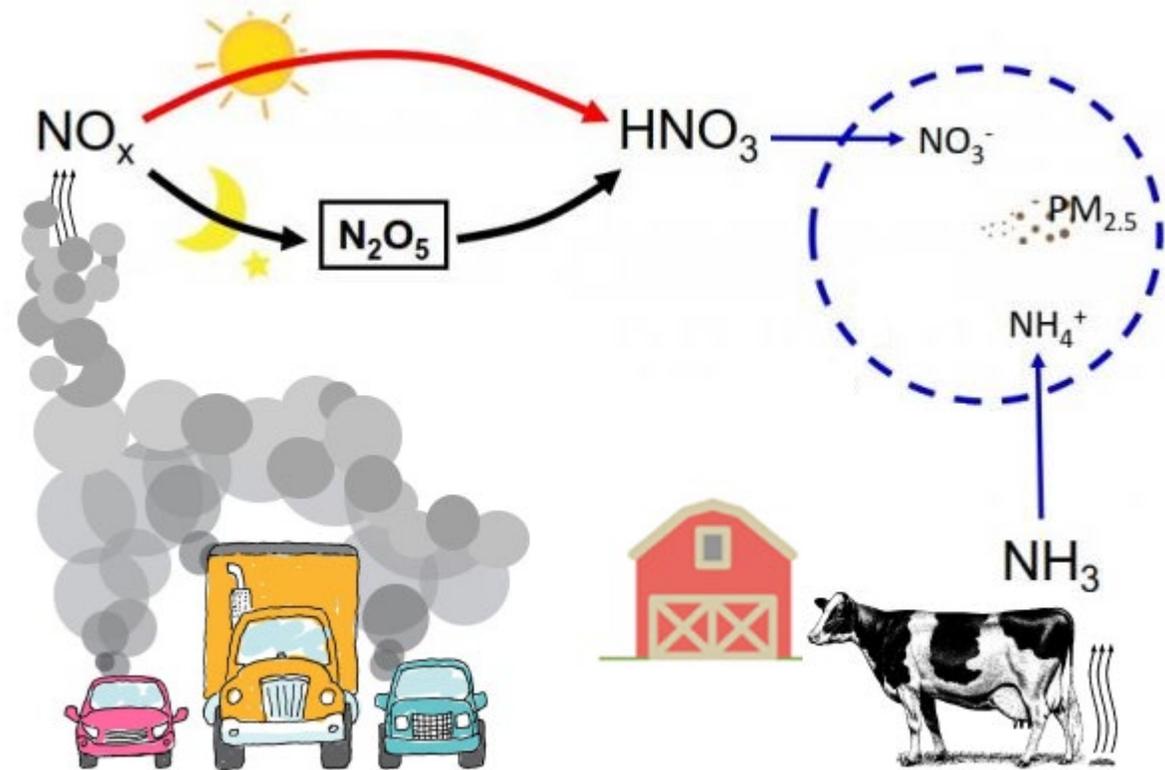
Yakima EMAQ 4/3km Modeling Domain UGAs (left) and terrain (right)
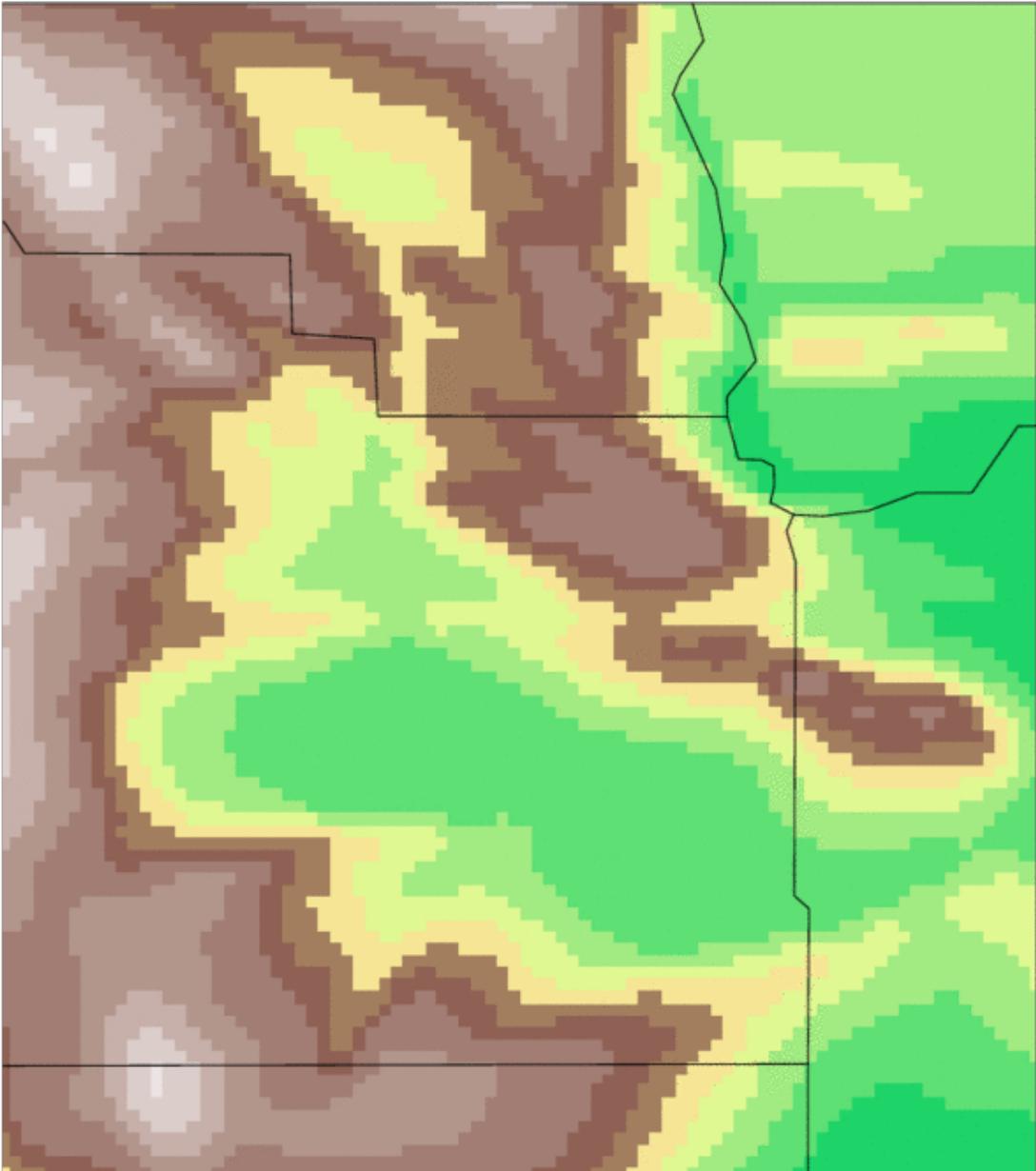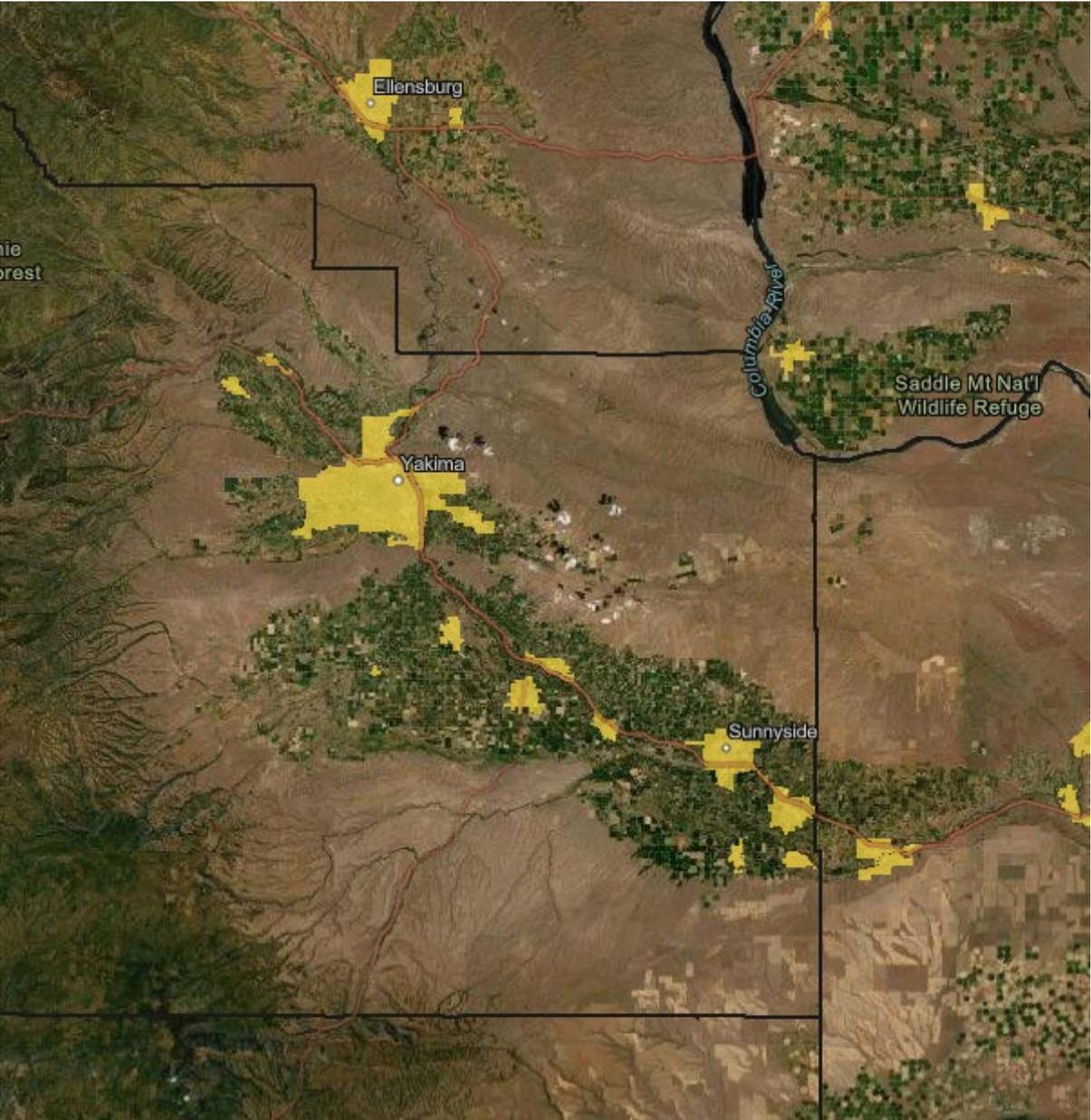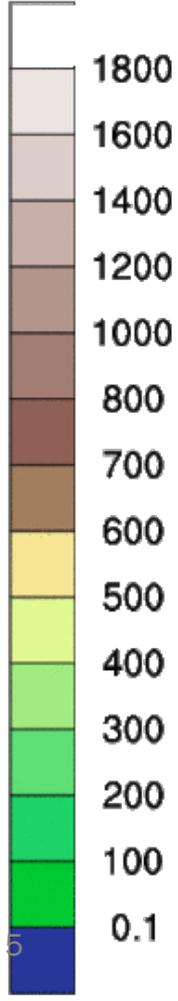
EMAQ Setup

Met — WRF ARW v3.7.1; MCIP v4.4

Emis — SMOKE v4.5

EI — biogenic (BEIS 3.61/BELD 4.1); area (2014, no road dust); onroad/nonroad (2014 adjusted to "2019"); point (2016);

bcon — Boundary conditions derived from MOZART monthly avg. (static daily, no diurnal profile)
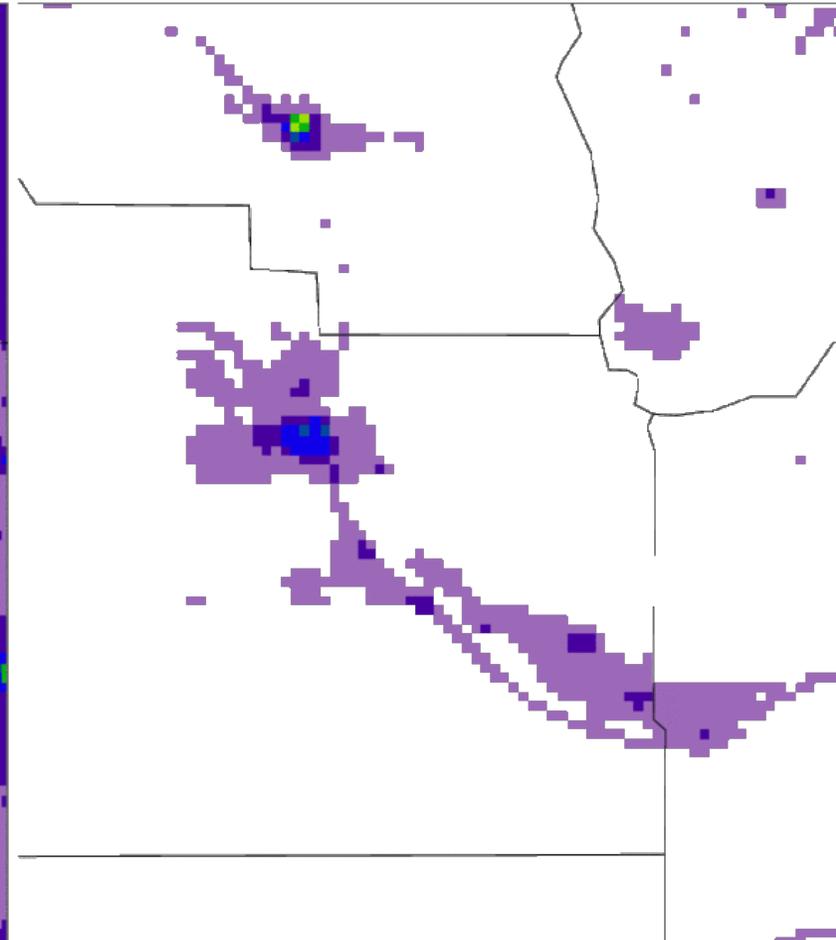
CTM — CMAQ v5.2; CB05; AERO6
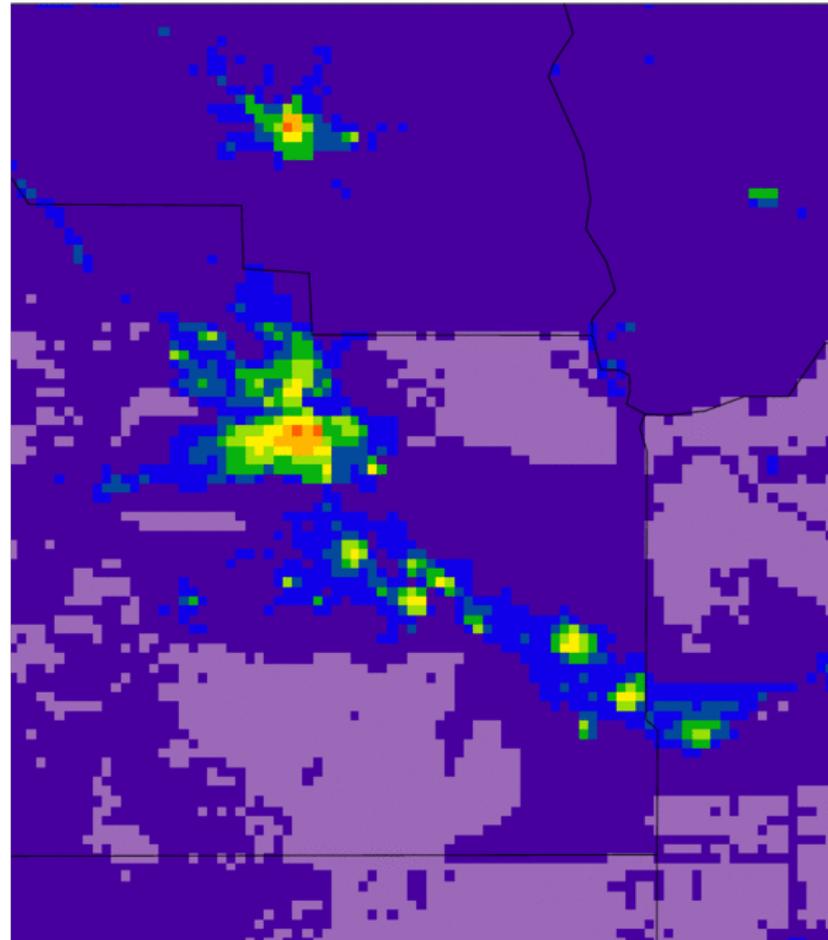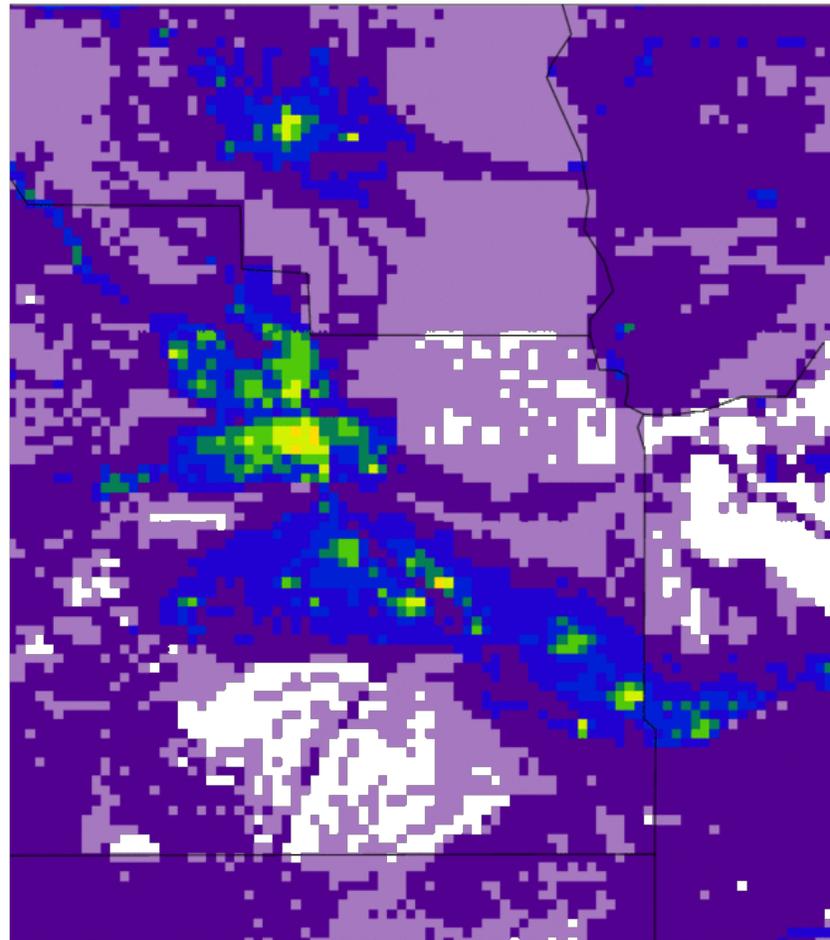
linux — Computing Resources: 24 Virtual CPUs; 320 GB RAM; Scientific Linux 7.4 (Nitrogen)
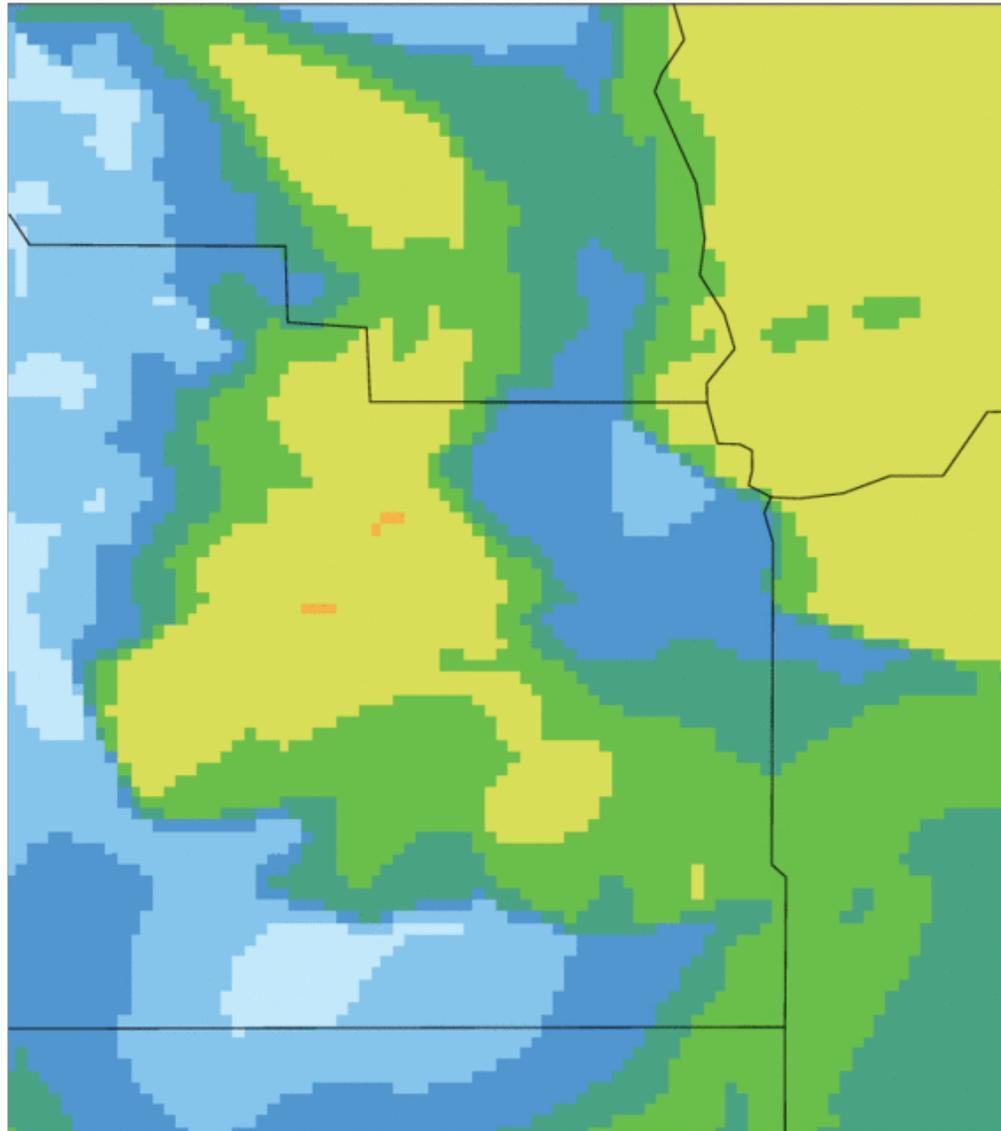
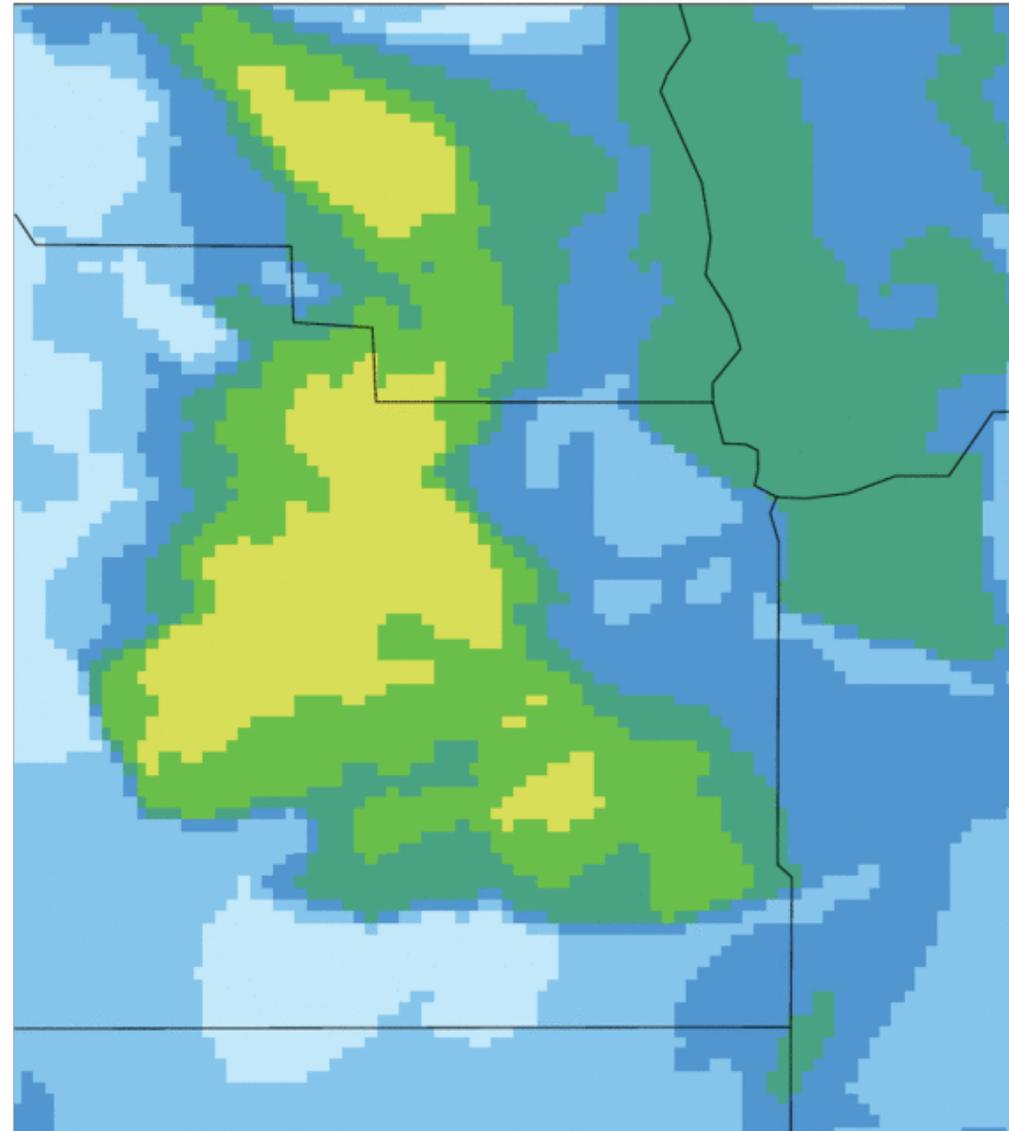# Emissions – Spatial Distribution
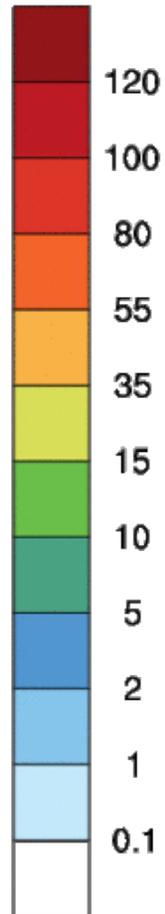

PM2.5   CO   NOx

# EMAQ PM2.5 Concentrations

20130107
00 PST
ug/m3

Raw BCON

Augmented BCON

Two periods with a mesoscale stagnation episode:

- Clear Sky period, 10 – 16 January;
  - Night was characterized by elevated levels of both primary and secondary PM components
  - Diurnal cycle of the mixing layer followed a typical pattern

- Persistent Cloud period, 17 – 23 January;
  - Persistent low levels of all primary pollutants;
  - Meteorology driven; T & RH relatively flat
  - secondary PM remained high, especially particulate nitrate
  - Low-level cloud enhanced surface mixing and increased dilution of primary pollutants
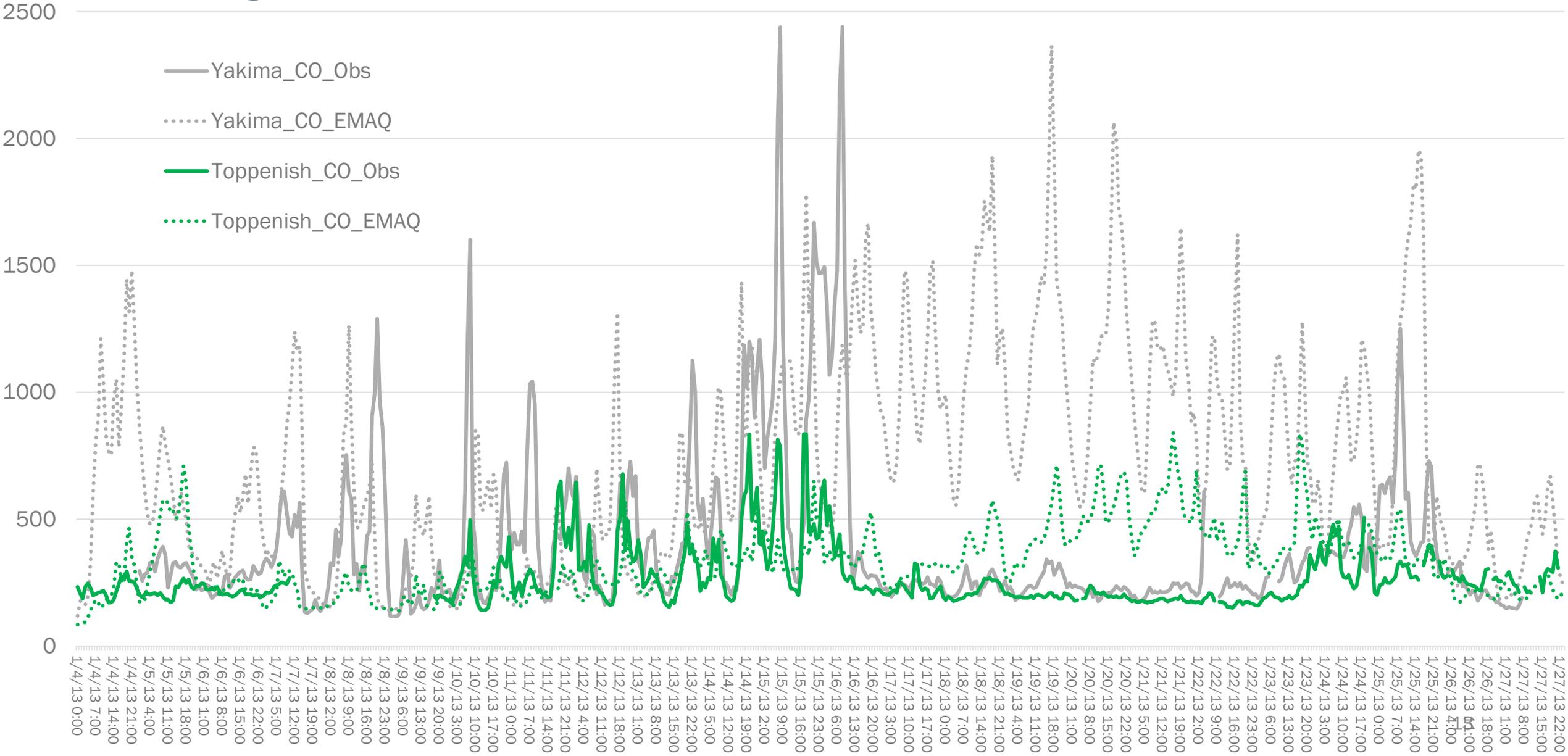
EMAQ PM2.5 Performance (µg/m³)
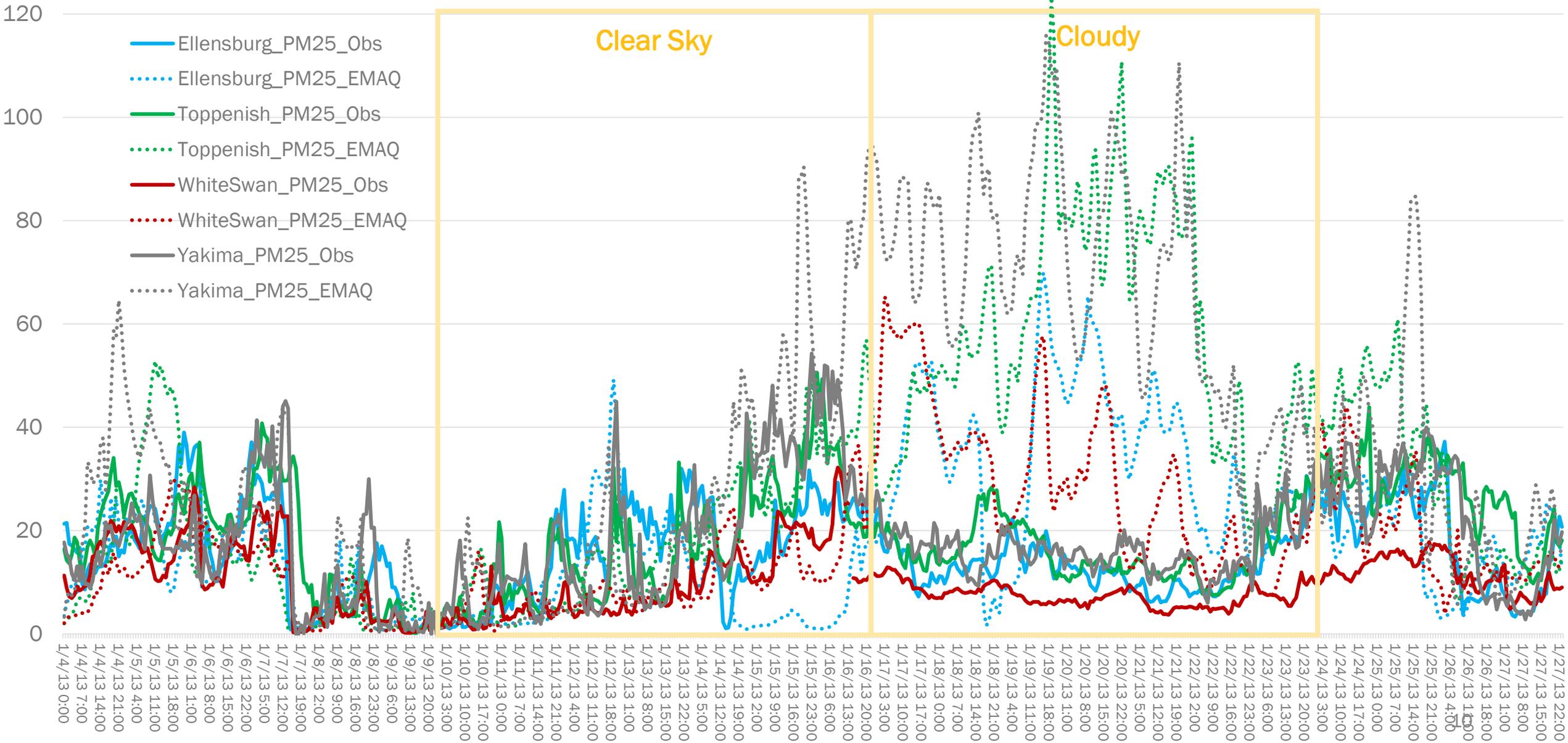
Observed / Modeled PM2.5 ratio (log scale)
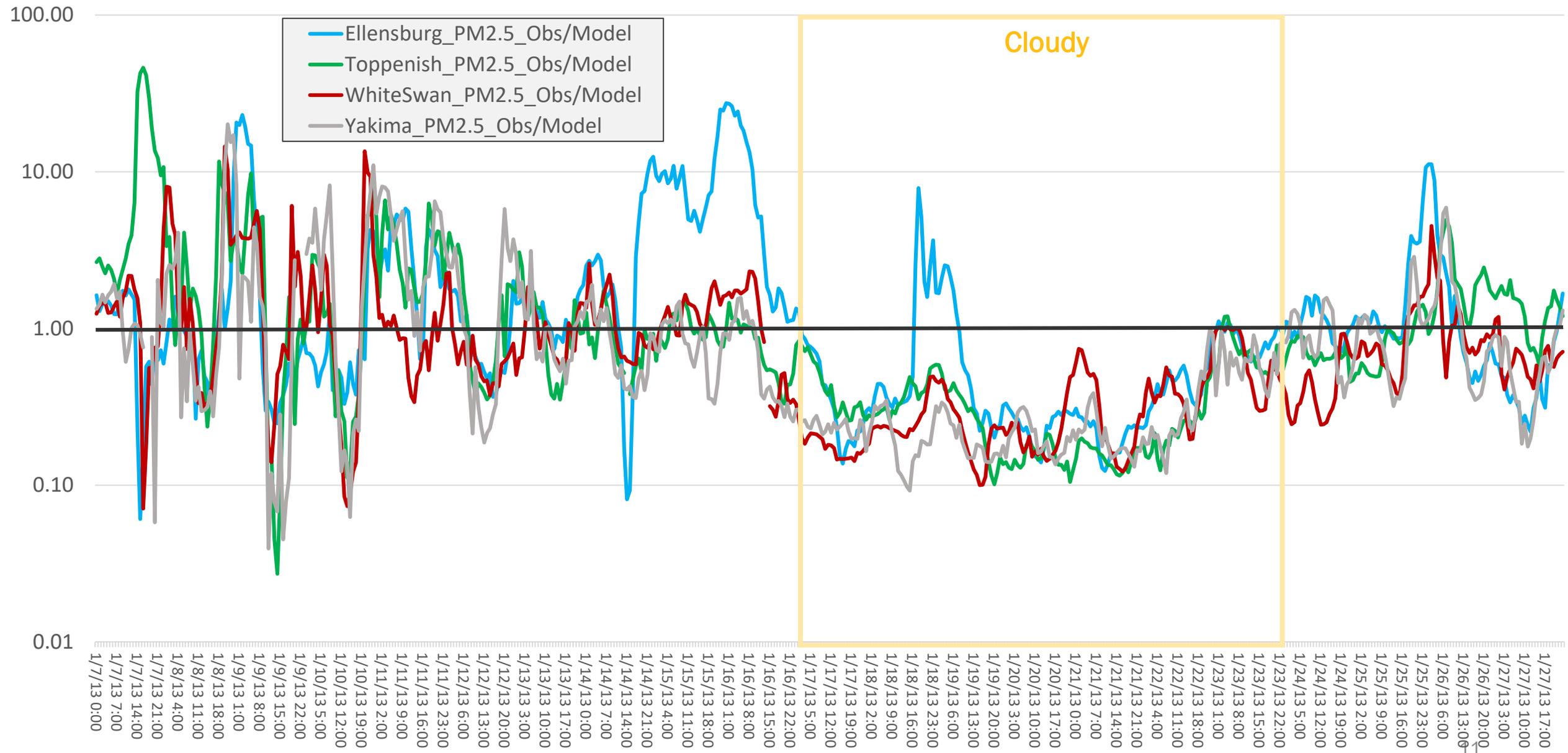
EMAQ PM2.5 Speciation
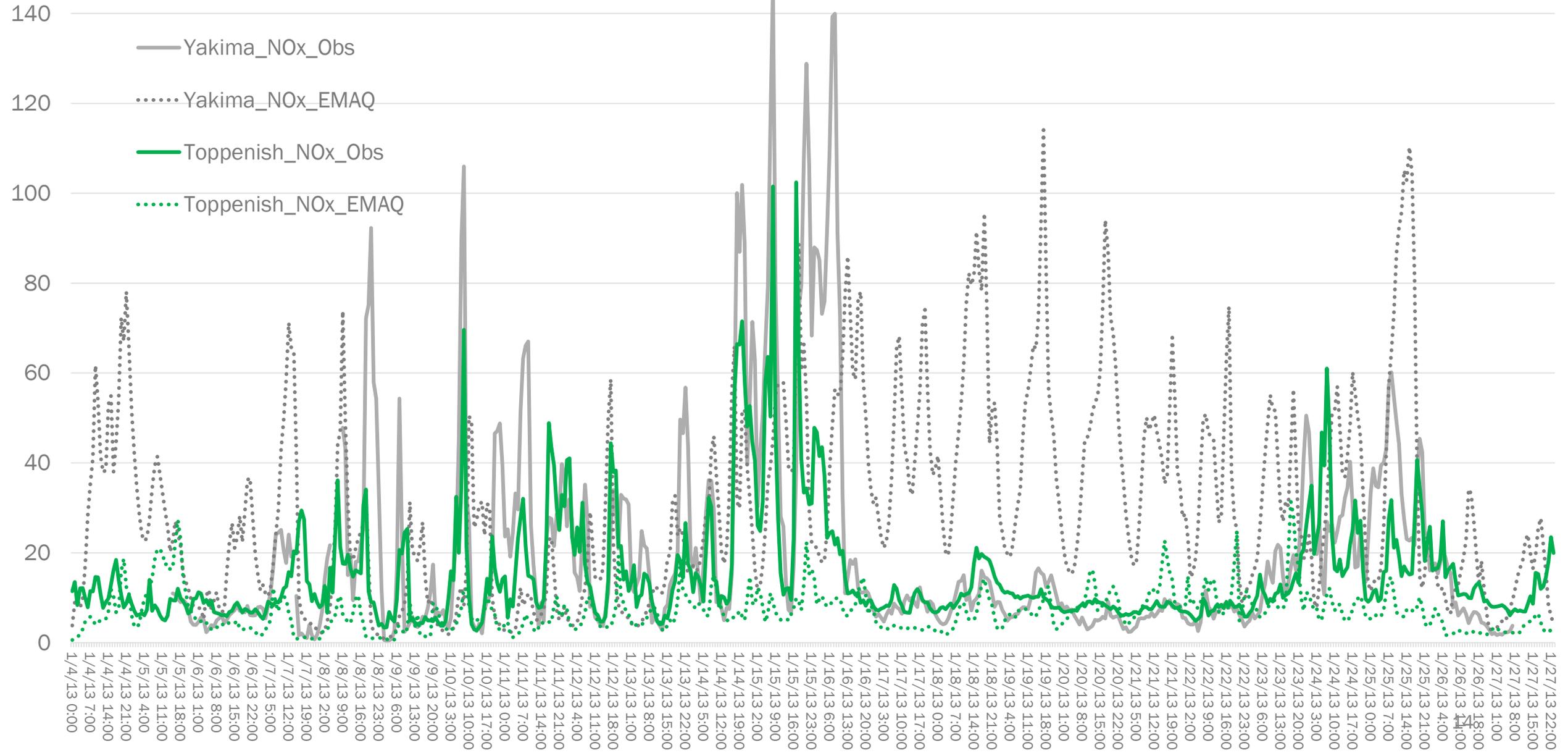
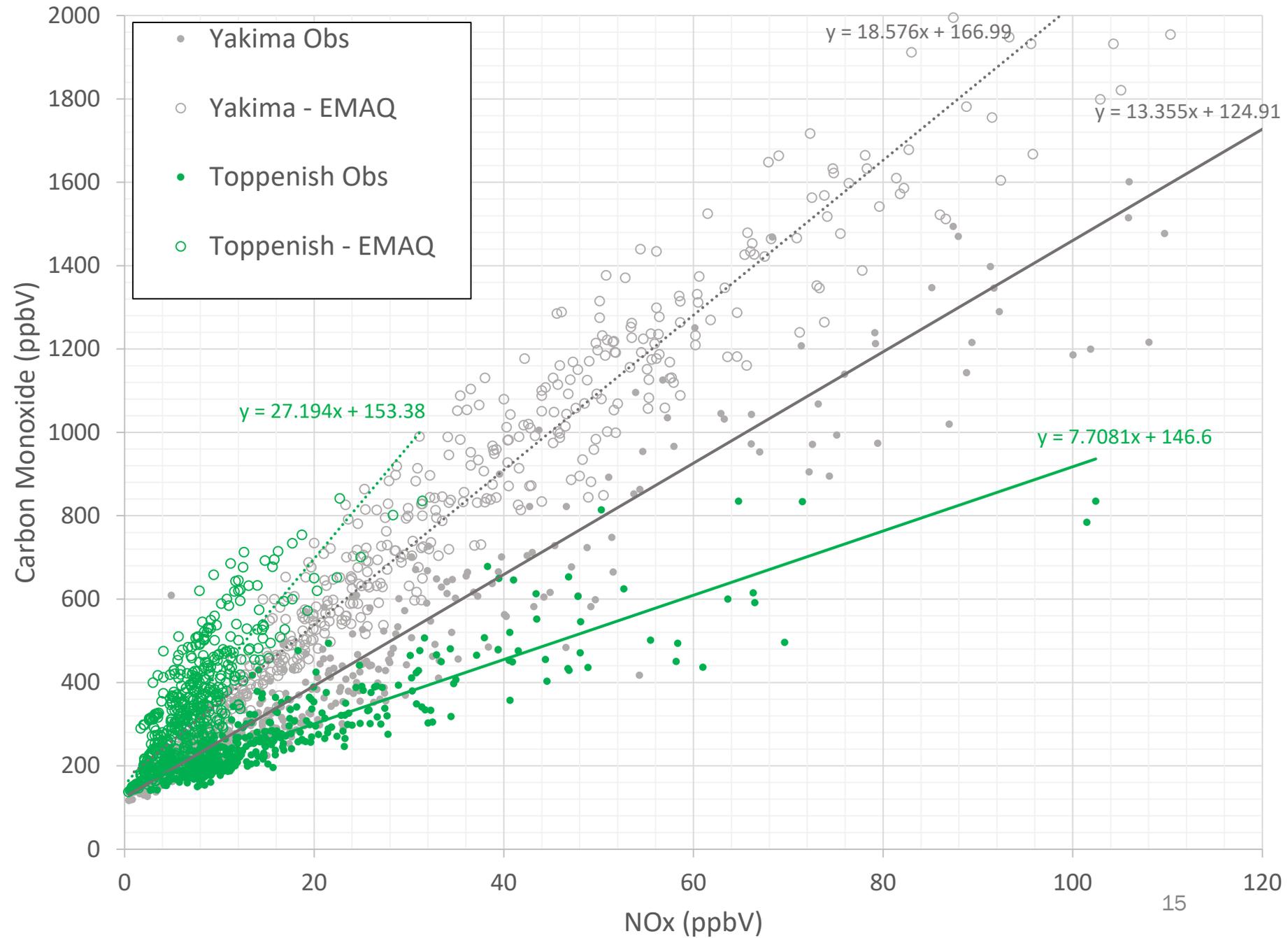| Aerosol	PM2.5 %	CMAQ Name
Nitrate	29%	ANO3
Potential Combustion SOA	21%	APCSO
Semivolatile Primary Organic Compound	15%	ASVPO# (1,2,3)
Ammonium	10%	ANH4
Elemental Carbon	7%	AEC
Sulfate	5%	ASO4
Low Volatility Primary Organic Compounds	4%	ALVPO1
Intermediate Volatility Primary Organic Compounds	3%	AIVPO1
High-Volatility SOA Product from Monoterpenes	1%	ATRP2
Oligomer products of biogenic SOA compounds	1%	AOLGB
Low Volatility Oxidized Combustion Organic Compounds	1%	ALVOO1
Everything Else	*3%*	*N/A*

EMAQ Carbon Monoxide Performance (ppb)

Yakima_CO_Obs
Yakima_CO_EMAQ
Toppenish_CO_Obs
Toppenish_CO_EMAQ

EMAQ NOx Performance (ppb)

Legend: Yakima_NOx_Obs, Yakima_NOx_EMAQ, Toppenish_NOx_Obs, Toppenish_NOx_EMAQ

CO/NOx

y = 18.576x + 166.99

y = 13.355x + 124.91

y = 27.194x + 153.38

y = 7.7081x + 146.6

- Yakima Obs
- ○ Yakima - EMAQ
- Toppenish Obs
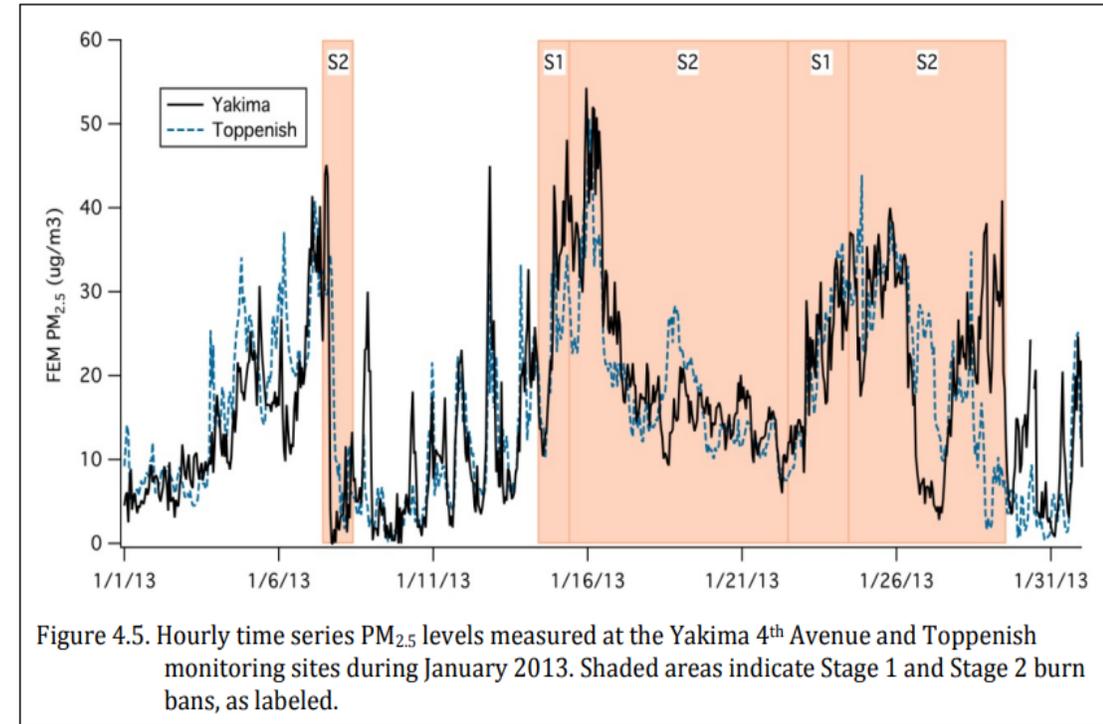- ○ Toppenish - EMAQ
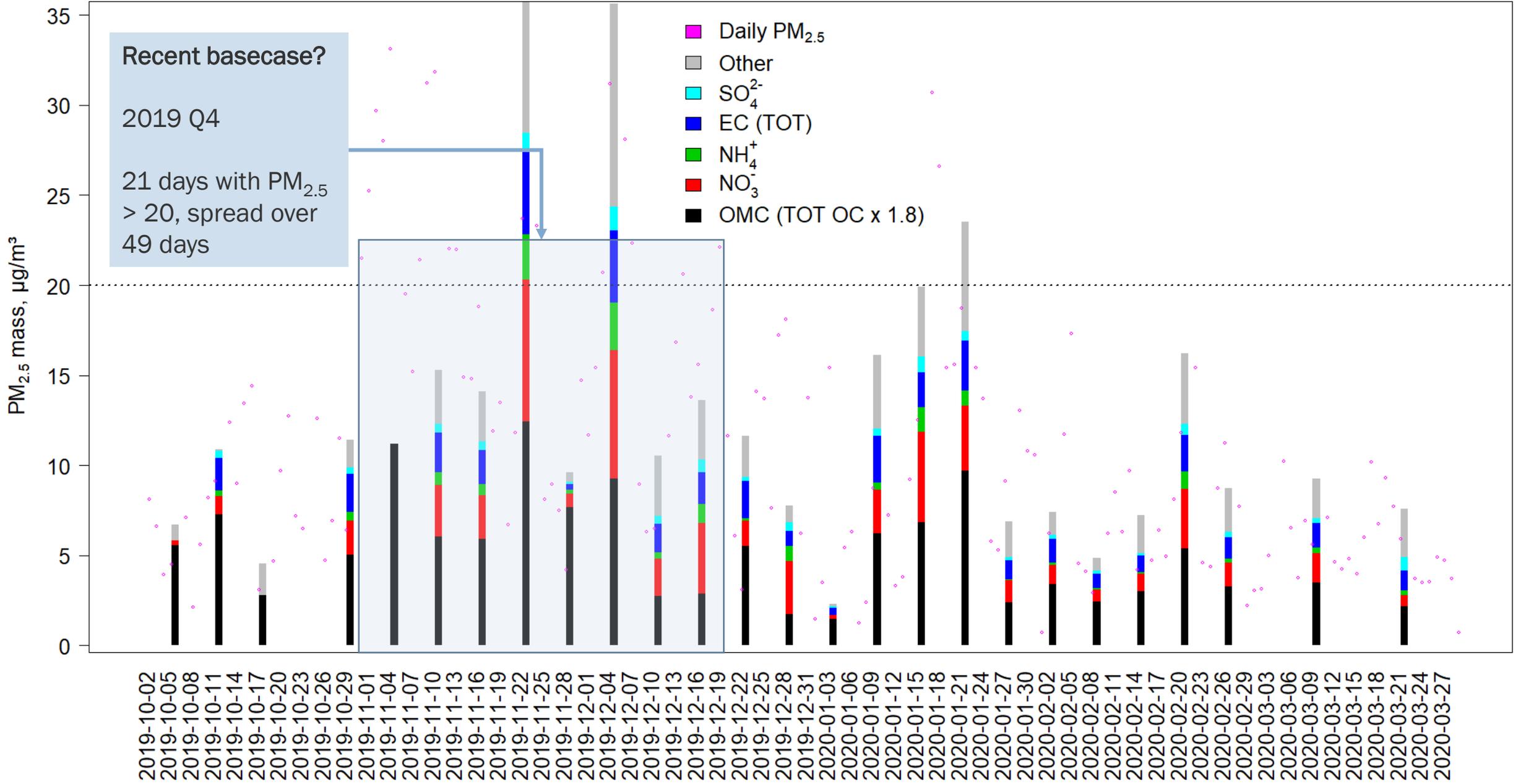
Carbon Monoxide (ppbV)

NOx (ppbV)

Next Steps

- Model emissions reductions
  - include burn ban adjustments
- Try observational nudging in WRF 1.33km
- Identify more recent base case
  - Implement constraints from YAWNS period
- Cloudy skies period
  - Use a different relative response factor?
- Emissions controls scenarios
  - Consult stakeholders to ID reasonable controls

Figure 4.5. Hourly time series $PM_{2.5}$ levels measured at the Yakima 4th Avenue and Toppenish monitoring sites during January 2013. Shaded areas indicate Stage 1 and Stage 2 burn bans, as labeled.

Yakima speciation data in recent winters

Thank you

Questions?

Image: Mt. Adams from Nob Hill;
Yakima Herald-Republic