

# The Yakima Winter Air Nitrate Study (YAWNS): Project Update and Early Results

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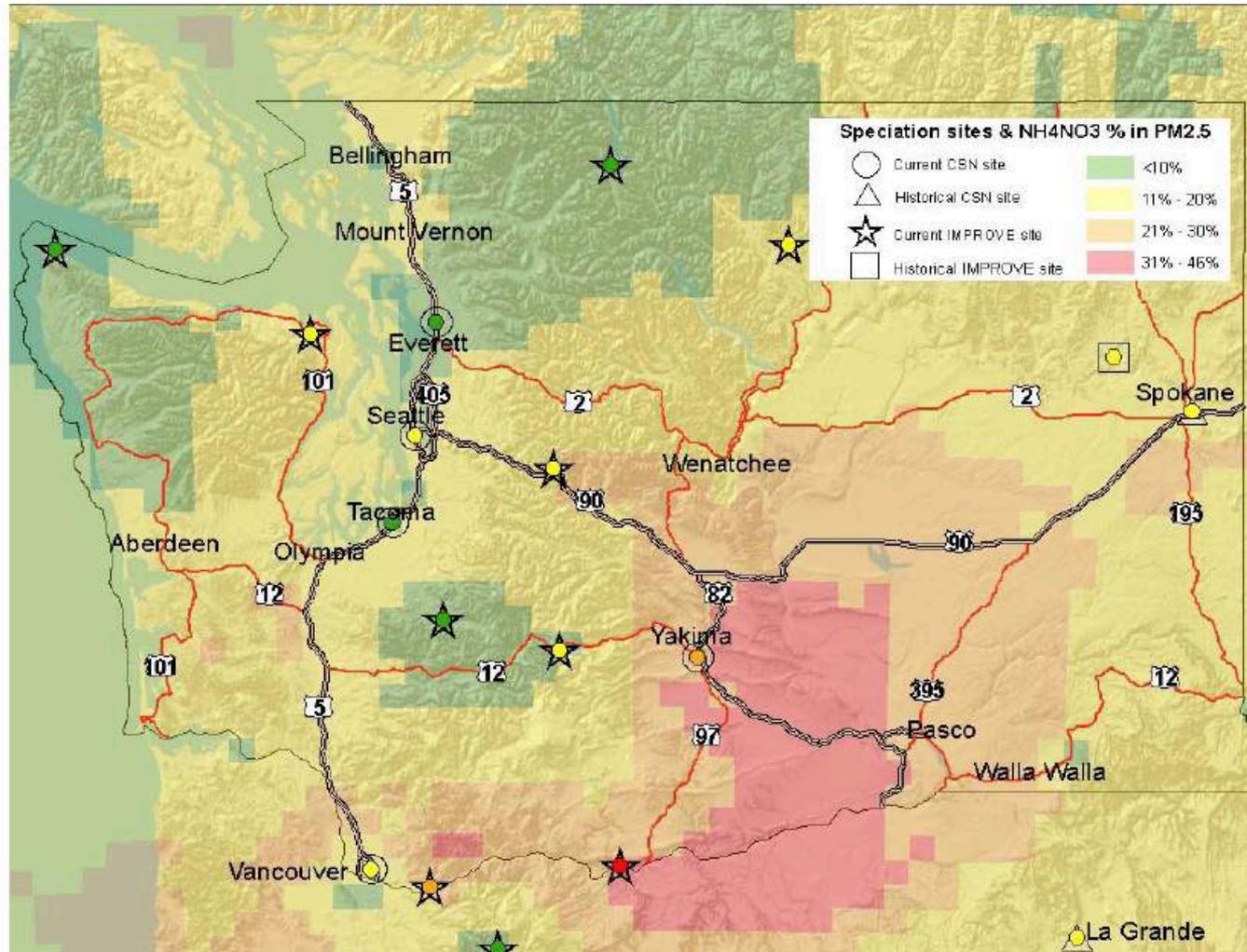
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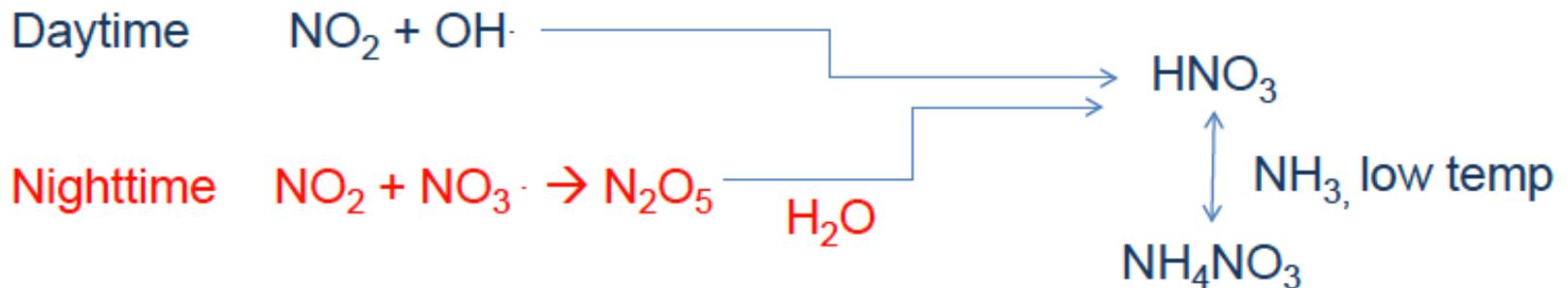
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# Large Contribution on Nitrate to Yakima PM<sub>2.5</sub>

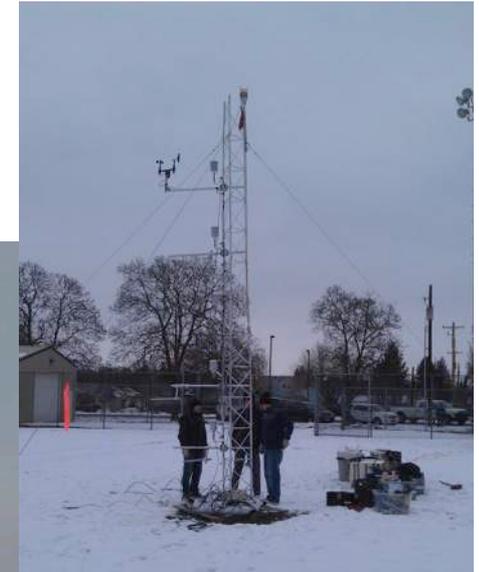


## Hypothesis

- Low temperature, high RH, and buildup of  $\text{PM}_{2.5}$ ,  $\text{NO}_2$ , and  $\text{NH}_3$  during stagnant winter evenings help to drive aerosol nitrate formation.
- $\text{NH}_3$  limitation unlikely, due to agricultural activities in the region.
- $\text{NO}_x$  (and possibly VOC) controls might be the most effective way of stemming aerosol nitrate formation.

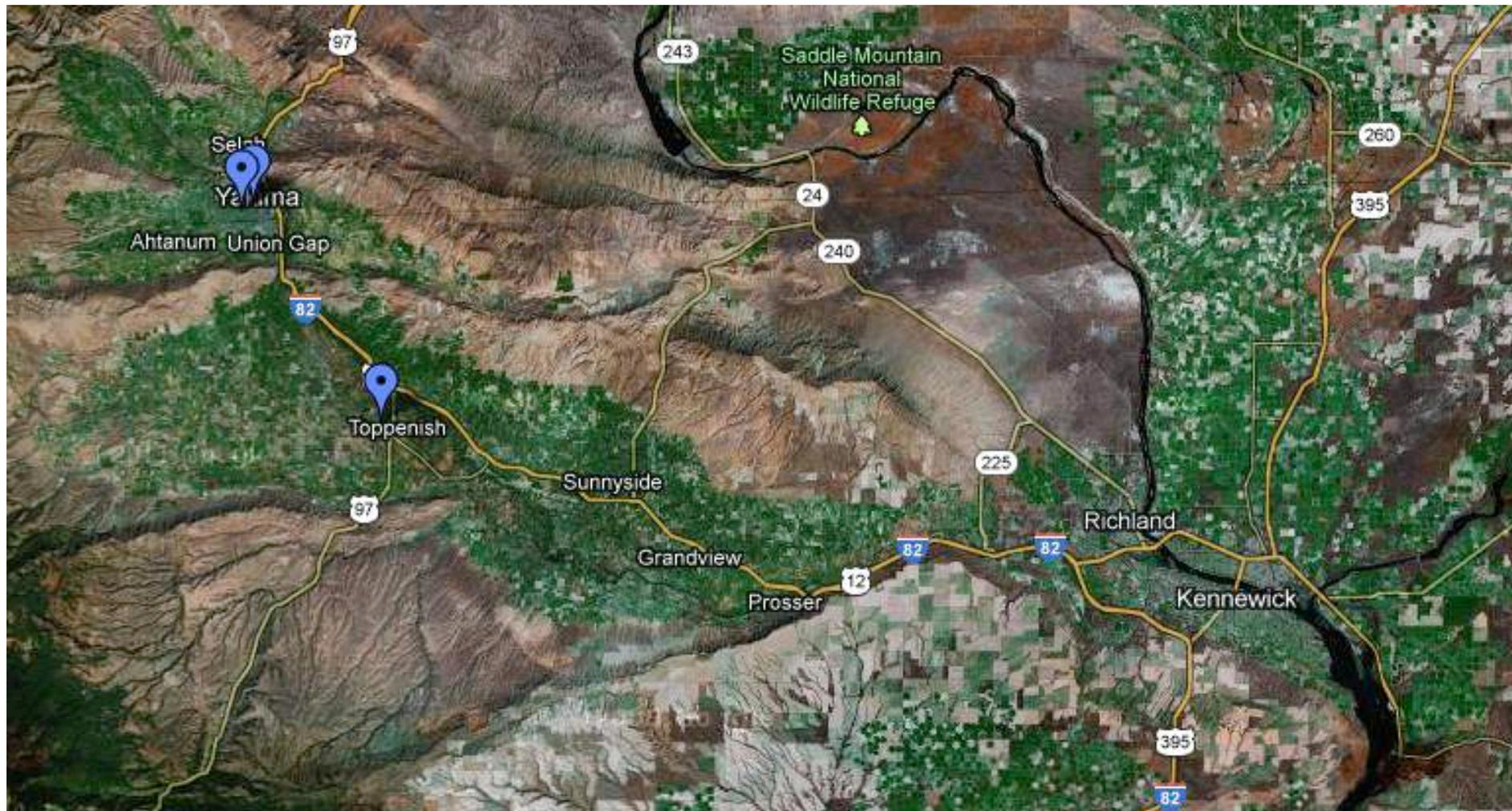


# YAWNS Site



Measurements from January 5-26, 2013

## Regional View of YAWNS Sites



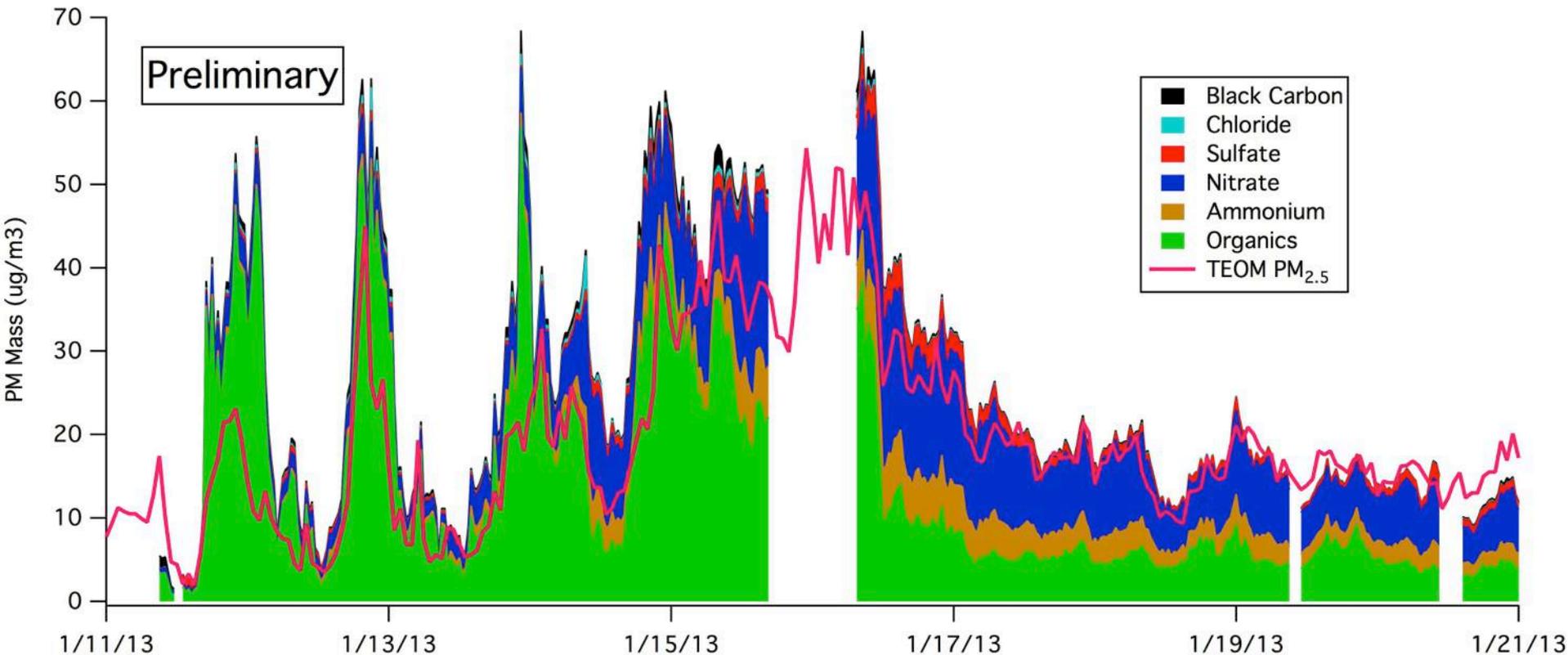
Measurement	Instrument	Sampling Period (minutes)
NO <sub>x</sub> & NO <sub>y</sub>	Air Quality Designs dual-channel instrument ( NO, NO <sub>2</sub> , and NO <sub>y</sub> )	1
NH <sub>3</sub>	Denuders w/ colorimetric analysis	8-hr daytime / 16-hr nighttime
CO	AeroLaser Vacuum UV instrument	1
O <sub>3</sub>	Dasibi ozone monitor	1
Trace organic gases (Continuous) <sup>(1)</sup>	Proton Transfer Reaction – Mass Spectrometer (PTR-MS)	1
Aerosol composition	High Resolution Aerosol Mass Spectrometer (HR-AMS)	5
Particle size distribution (0.020-0.700 μm)	Scanning Mobility Particle Sizer (SMPS)	5
Size-resolved black carbon mass	Single-Particle Soot Photometer (SP2) <i>Contributed by S. Kaspari at CWU</i>	5
Total particle number concentration	Condensation Particle Counter (CPC)	1
PBL Height	Vaisala Ceilometer	1
Radiative Flux	Actinic Flux Spectrograph	5
Baseline meteorological data	Vaisala WXT package	1
Surface energy, carbon, water exchange	5-m Instrumented Tower	30

# NOW WHAT????

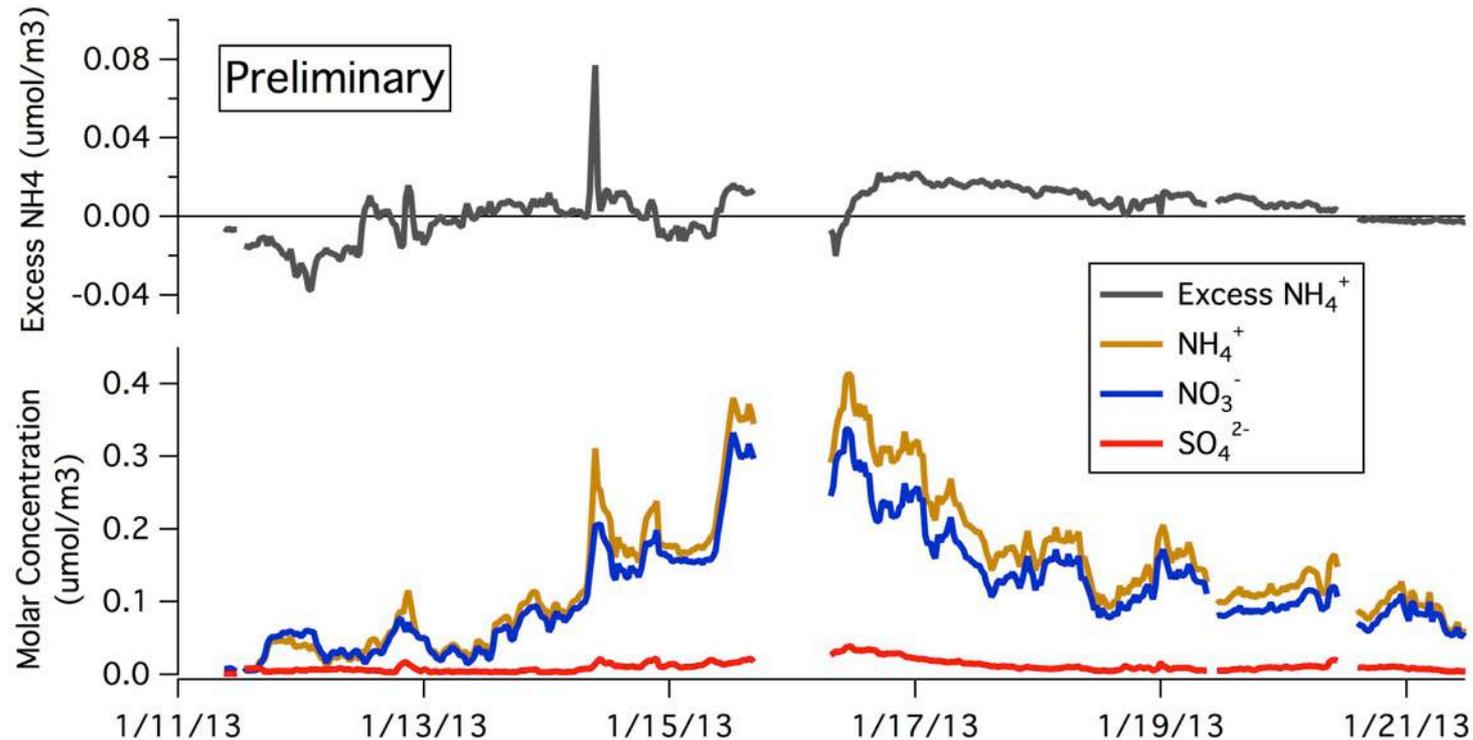


## Direction #1:

What are the chemical and meteorological drivers for the elevated nitrate observed during some (but not all) of the study?



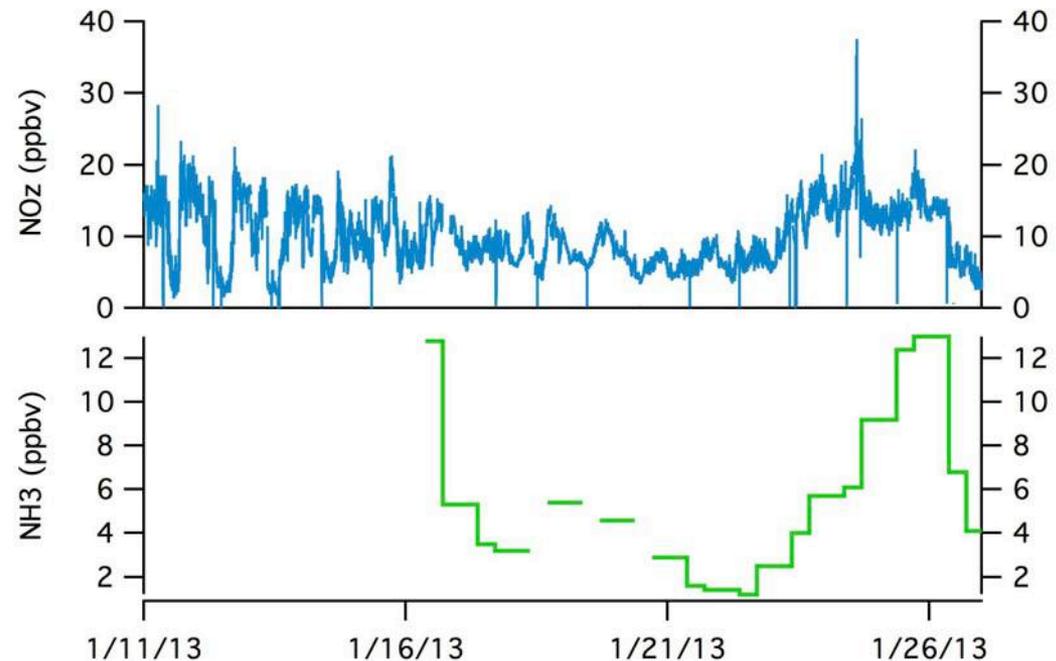
## Molar Balance of Inorganic Aerosol



- $\text{Excess NH}_4^+ = \text{NH}_4^+ - (2 * \text{SO}_4^{2-}) - \text{NO}_3^-$
- Data suggest that aerosol was neutralized to within measurement uncertainty in almost all cases during YAWNS.

## Estimating Total Ammonia and Nitric Acid

- $\text{NH}_4\text{NO}_3$  is in thermodynamic equilibrium with gas-phase  $\text{NH}_3$  &  $\text{HNO}_3$ .
- The trace gases are hard to measure well.
- $\text{NH}_3$  measured using denuder system. Good sensitivity, but poor time resolution.
- No direct  $\text{HNO}_3$  measurement. Can use  $\text{NO}_z$  ( $= \text{NO}_y - \text{NO}_x$ ) as a proxy.



# Thermodynamic Modeling of Ammonium Nitrate Formation

- Plan is to generate time series of total  $\text{NH}_3$  and  $\text{HNO}_3$ , along with T, RH, etc., and then run thermo model to predict  $\text{NH}_4\text{NO}_3$  formation.
- Compare model partitioning with observations.
- Evaluate sensitivity of model results to reductions in  $\text{NH}_3$  and  $\text{HNO}_3$ .

## EXTENDED AIM AEROSOL THERMODYNAMICS MODEL

A community model for calculating gas/liquid/solid partitioning in aerosol systems containing inorganic and organic components and water, and solute and solvent activities in aqueous solutions and liquid mixtures.

**Simon L. Clegg** and **Peter Brimblecombe**, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK.

**Anthony S. Wexler**, Department of Mechanical and Aeronautical Engineering, University of California, Davis, CA 95616, USA.

Notice to Users: if you use results from the *E-AIM* models, please cite the [papers](#) describing the model and also this website giving the URL (<http://www.aim.env.uea.ac.uk/aim/aim.php>).

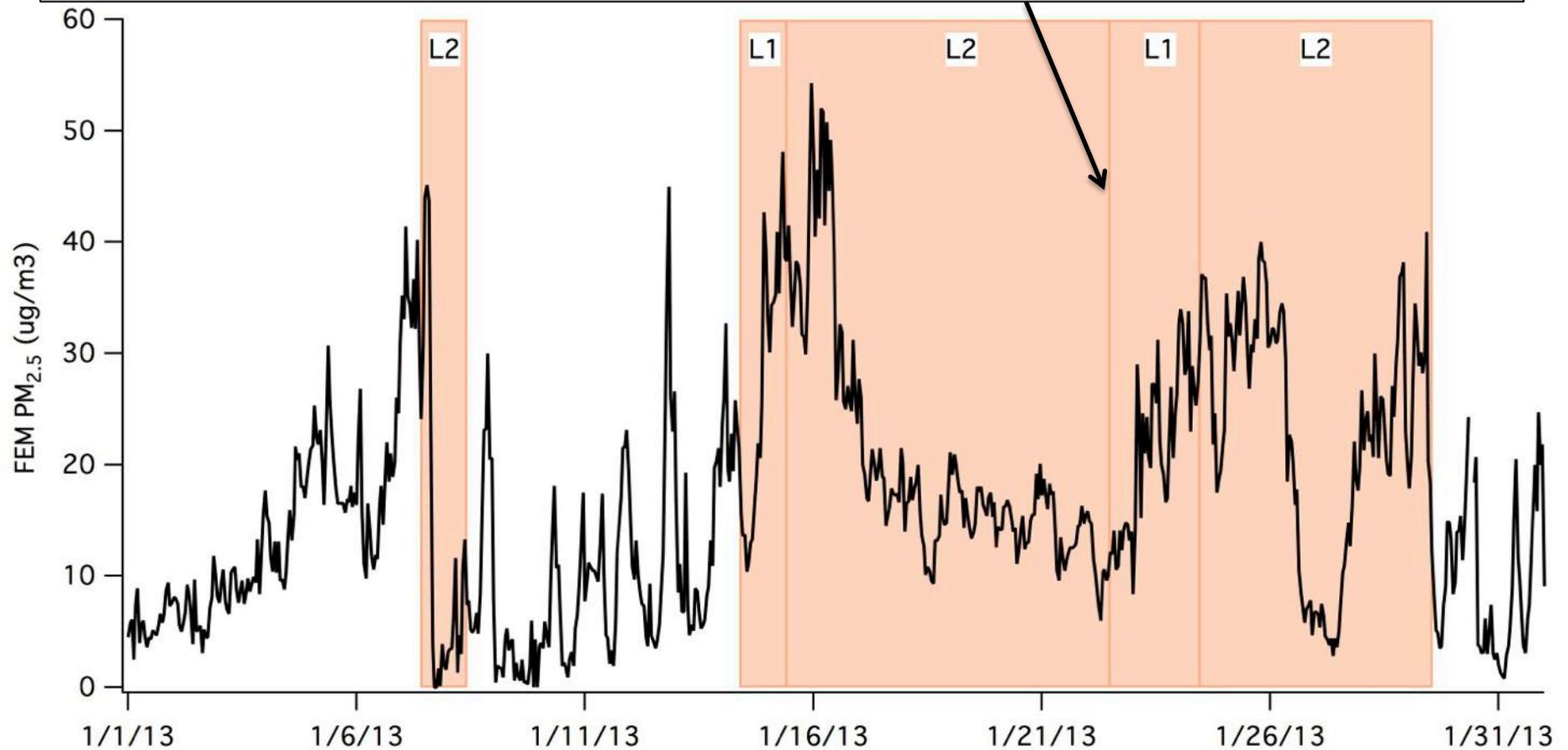
Welcome to the Extended AIM (*E-AIM*) site. Follow the links below to learn about the equilibrium thermodynamic models, and use them to solve a variety of different problems.

## Direction #2:

What is driving the ventilation observed at the transition from clear- to cloudy-sky 'stagnation' conditions?

Start Time	End Time	Ban Stage
1/7/2013 0930	1/8/2013 0900	2
1/14/2013 0900	Upgraded to S2 on 1/15/2013 0900	1
1/15/2013 0900	Downgraded to S1 on 1/22/2013 1100	2
1/22/2013 1100	Upgraded to S2 on 1/24/2013 1000	1
1/24/2013 1000	1/29/2013 1200	2

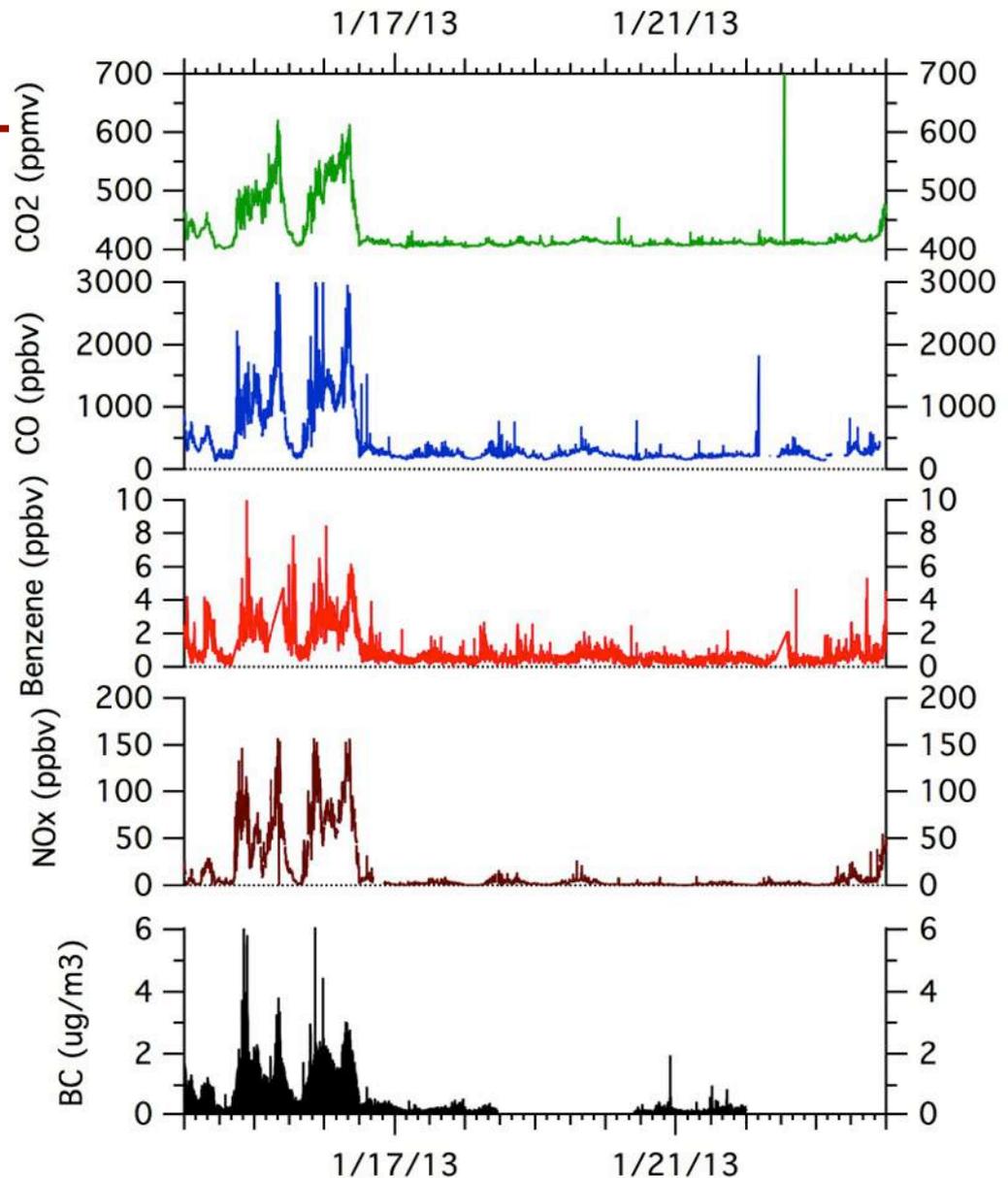
From press release: “YRCAA affirms that, based on air quality readings through this air stagnation episode, public compliance has been exceptional through this current Stage 2 Burn Ban, enabling YRCAA to now reduce the Burn Ban to a Stage 1 Burn Ban, for those that have a great need to use wood and pellet stoves to heat their homes.”



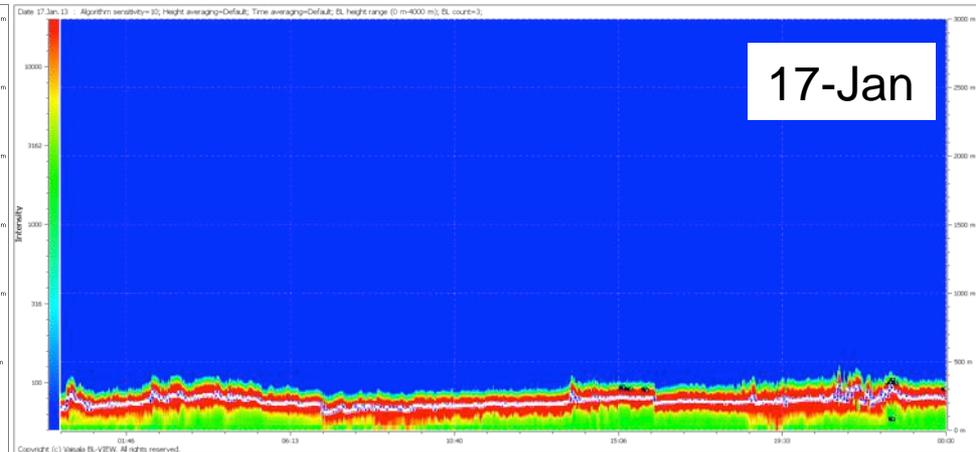
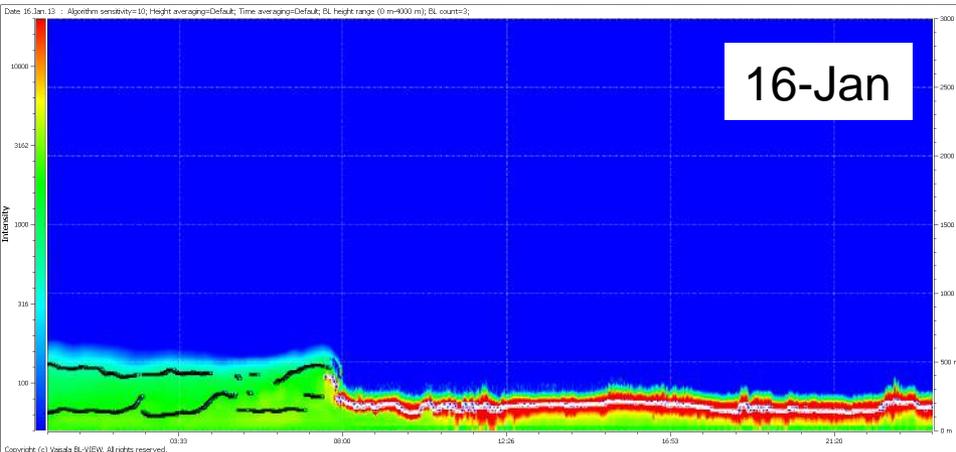
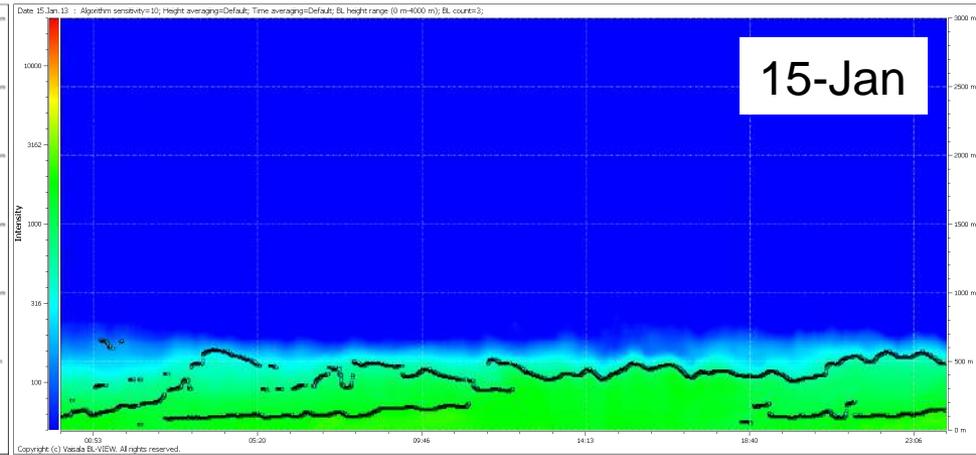
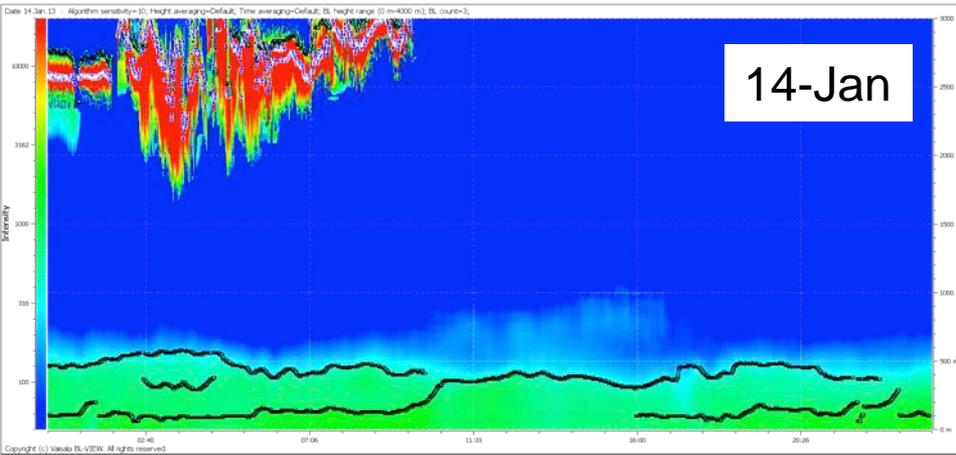
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## Our Observations

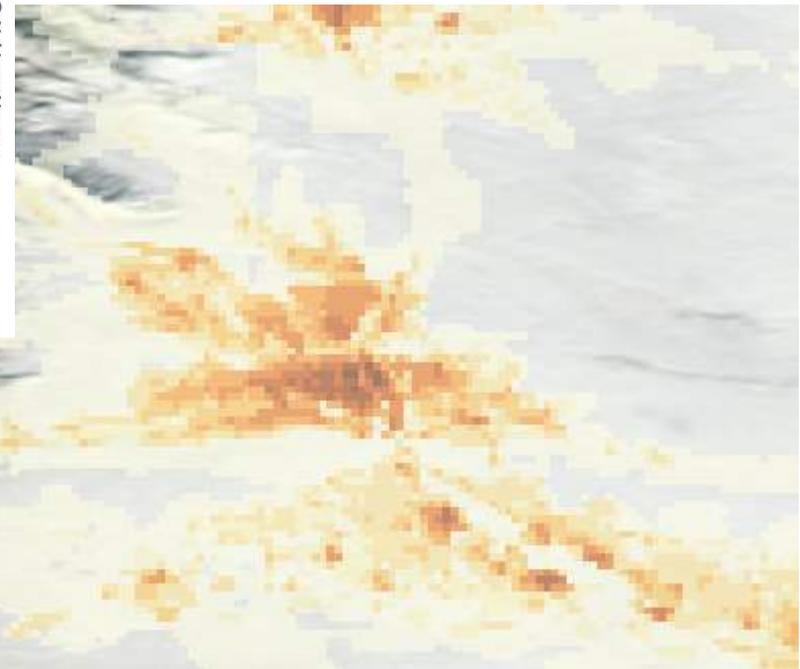
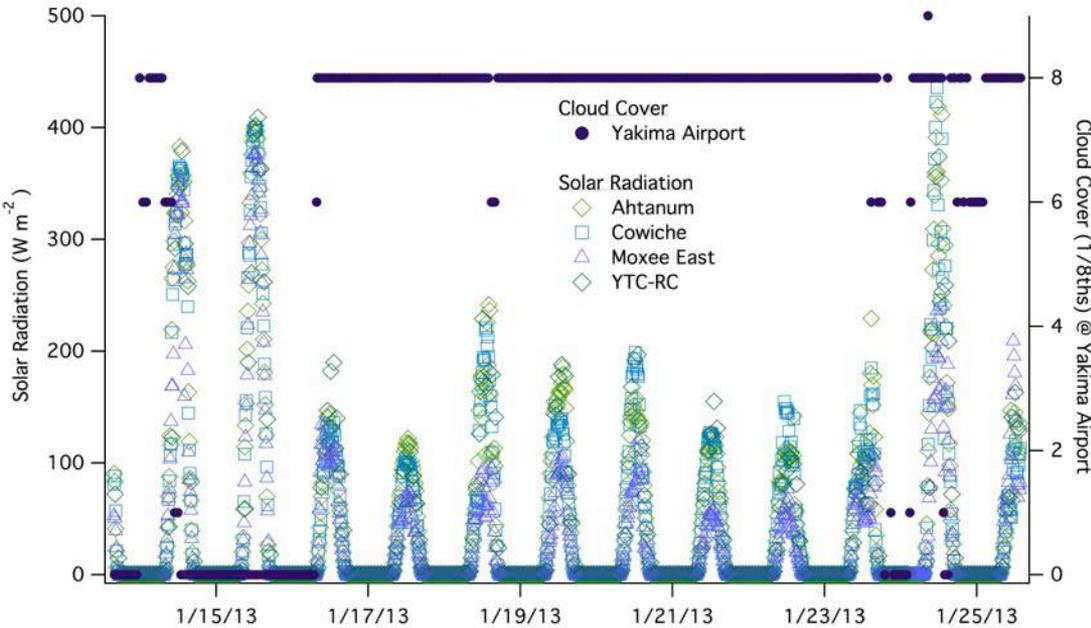
- Our measurements do not suggest a gradual decrease in pollution levels associated with a burn ban policy taking effect.
- Suggest instead a rapid change in condition on the morning of 1/16.
- All primary pollutants appear to have dropped to background levels.



# Ceilometer during Stagnation Period



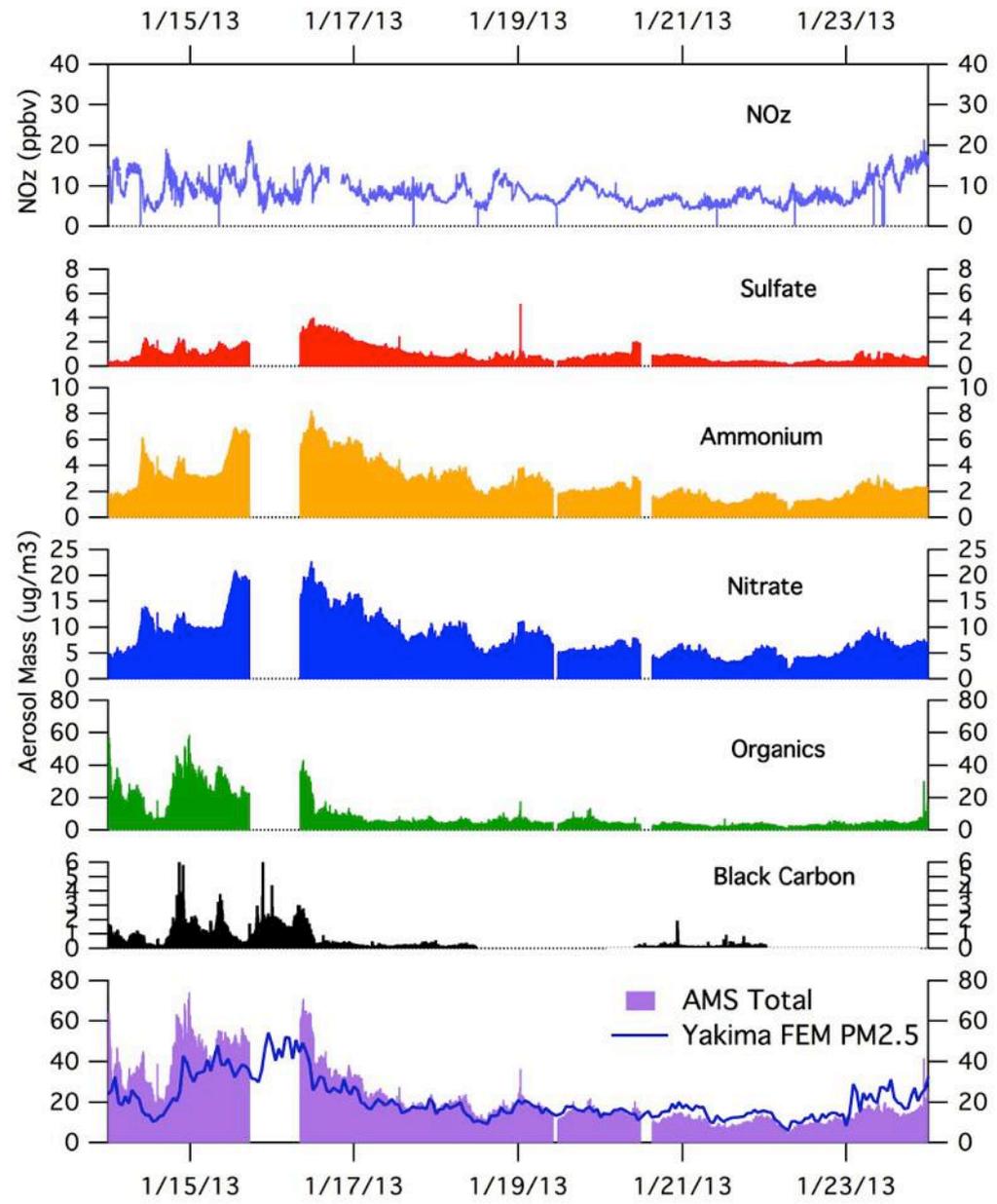
# Radiation and Cloud Cover



Cloud cover was consistent across Upper Yakima Valley & Wenas Valley.

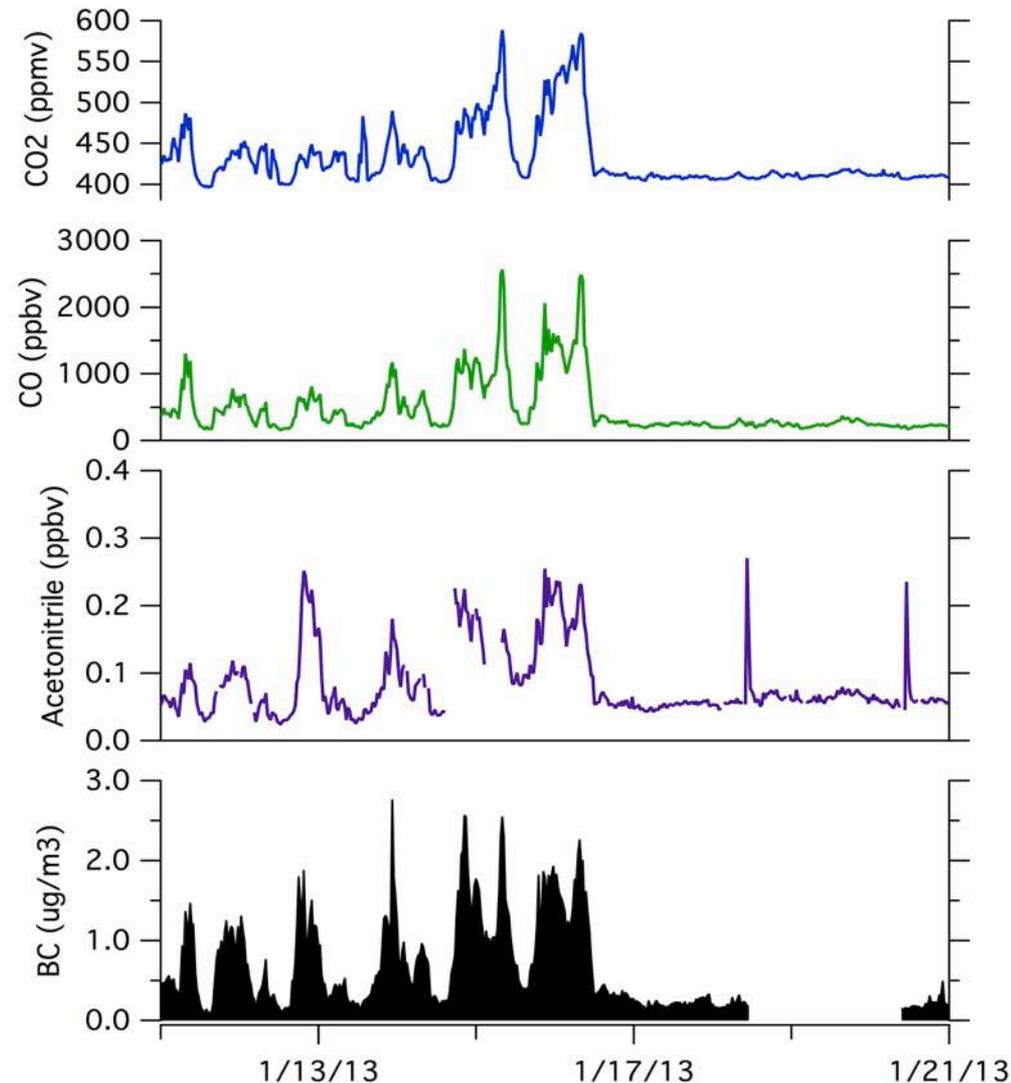
# Stagnation Period - Primary vs Secondary Species

- Unlike primary species, secondary species stay at same levels through cloudy stagnation period.
  - NOz & Ozone
- Organics decreased rapidly - presumably largely primary.
- Ammonium nitrate decreased more gradually.
- Elevated PM that led to burn ban decision was probably not result of wood smoke.
- Now focusing on the dynamic drivers that could lead to this result.



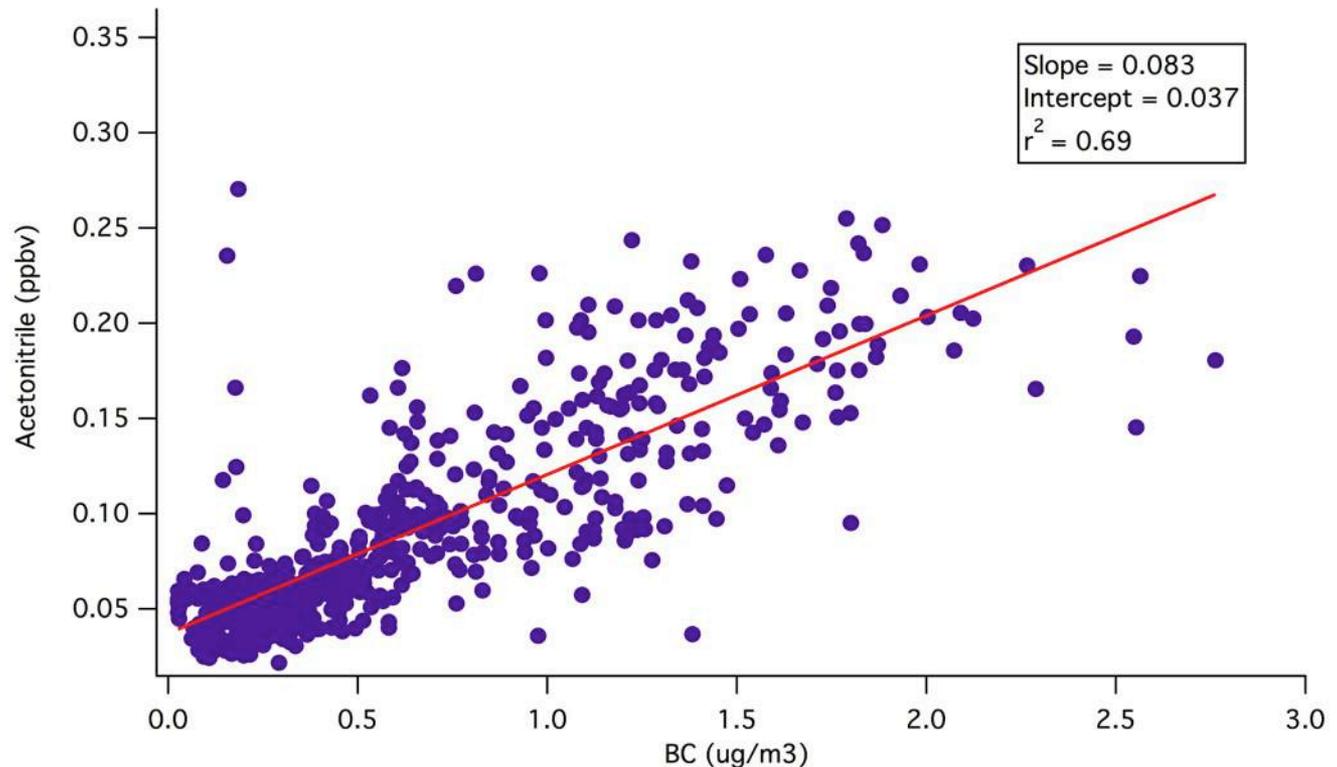
## Direction #3:

- Can we demonstrate clear links between proposed gas- and particle-phase proxies for wood smoke?
- Can these proxies be used effectively to assess the contributions of wood smoke to PM concentrations in Yakima?



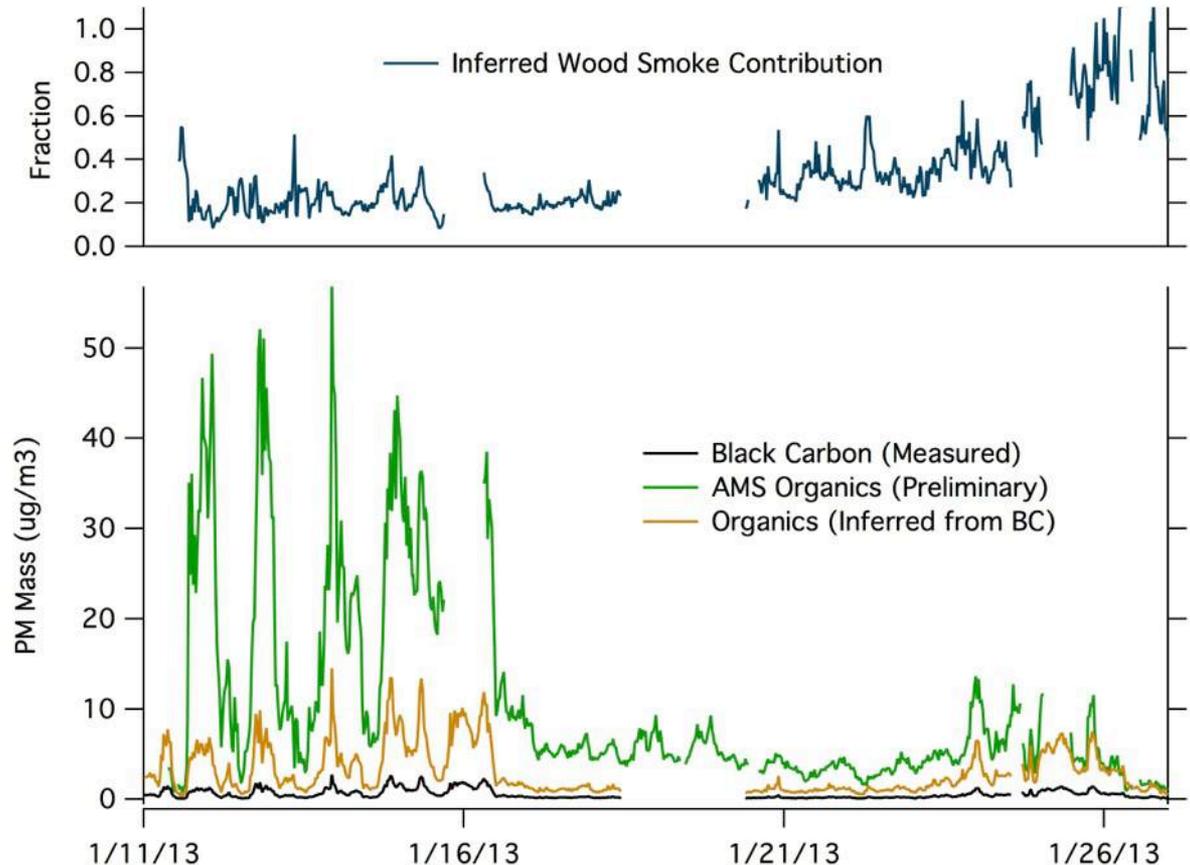
## Correlation Analysis

- In Yakima both BC and acetonitrile should be primarily from wood smoke.
- Strong correlation observed.
- CO and CO<sub>2</sub> have significant traffic sources, correlation w/ acetonitrile is less ( $r^2 = 0.55$  and  $0.52$ , respectively).
- Will also look at levoglucosan proxy in AMS and BBOA factor from PMF.



## Estimated Wood Smoke (Primary) OC from BC Observations

- From AIRPACT simulations, primary wood smoke BC/OM emissions ratio is ~5.25.
- Based on this and the preliminary AMS results, primary wood smoke contribution to OM ranges from 20% to 100%.
- Will also eventually be able to compare to AMS wood smoke factor.



## Still to Come...

- May-Nov: Analyses to address specific scientific and policy questions.
  - This will included Graham VanderSchelden working at Ecology for 3-4 months during the summer.
- Nov-Dec: Final reporting to Ecology.
- We'll also be preparing papers for peer-reviewed journals.
  - Current goal is a paper on each of these research directions.