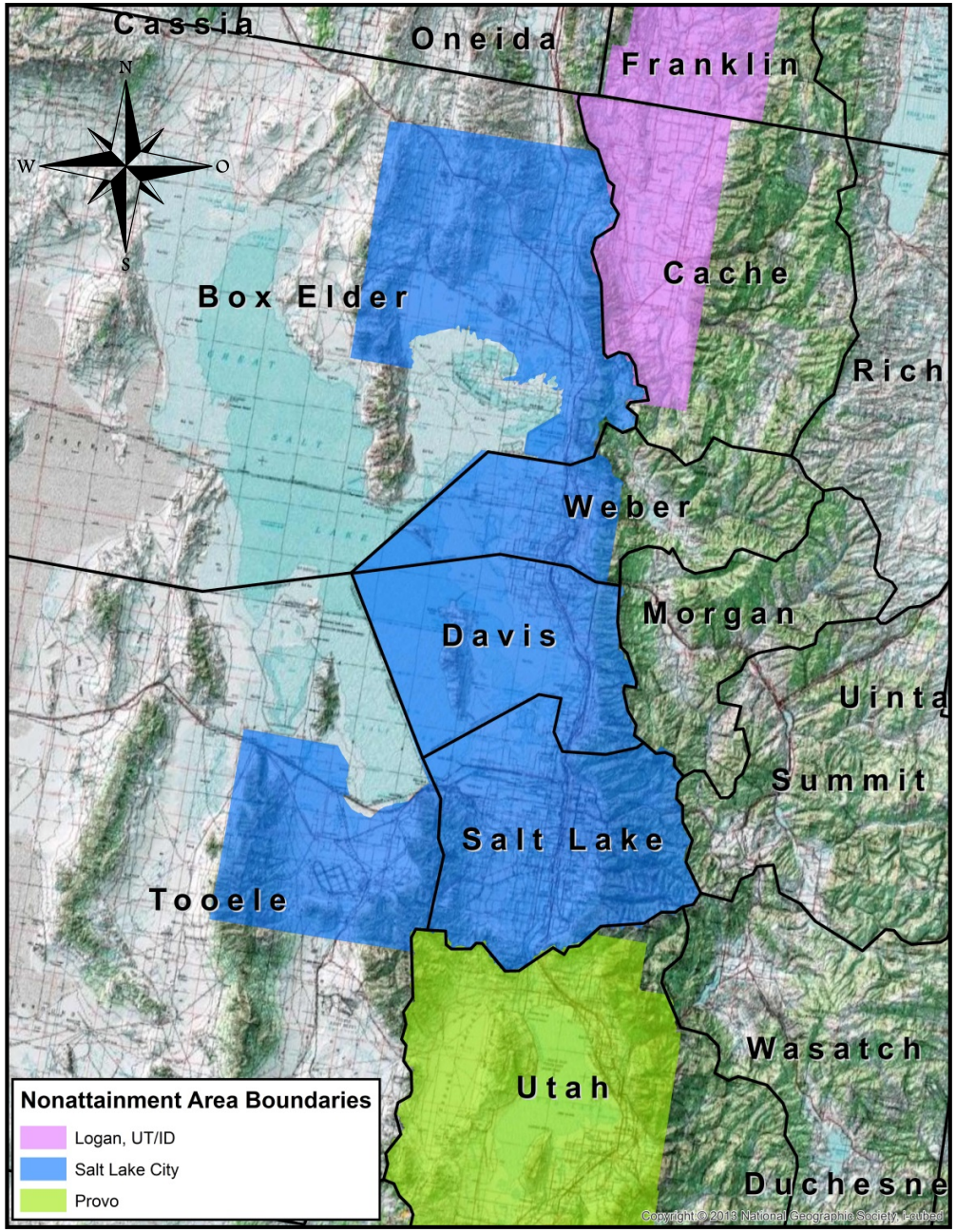
AIR QUALITY MODELING OF A TYPICAL WINTERTIME PM2.5 POLLUTION EVENT IN CACHE VALLEY, UTAH: IMPLICATIONS FOR EMISSION CONTROL STRATEGIES

NANCY DAHER, PH.D. & CHRISTOPHER PENNELL
AIR QUALITY MODELER

OVERVIEW

- Confined Topography
- Complex Terrain
- Strong Winter-time Inversions
- Exceedances of 24-hr PM2.5 NAAQS during Winter Inversions



OVERVIEW

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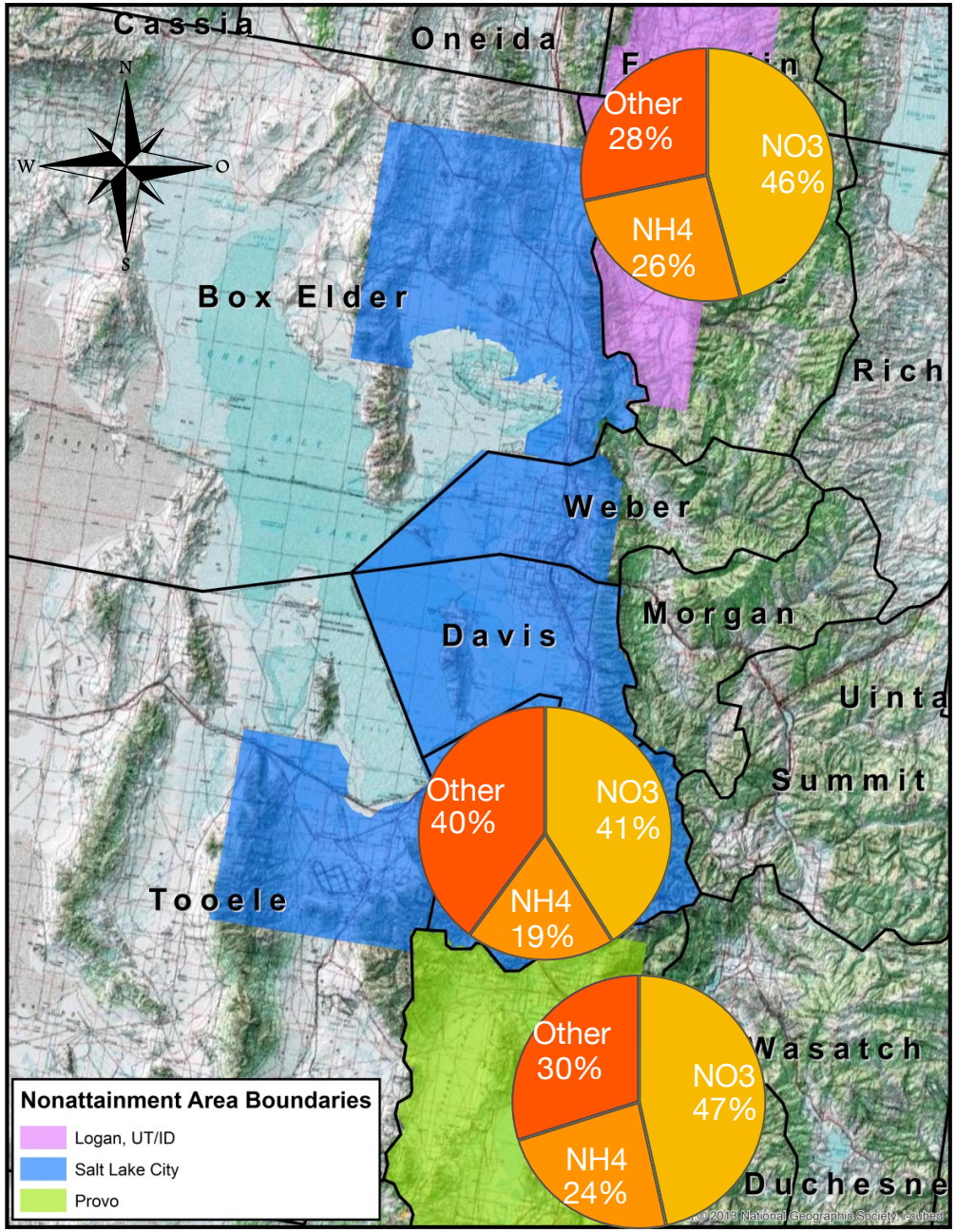
- Complex Terrain
- Strong Winter-time Inversions
- Exceedances of 24-hr PM2.5 NAAQS during Winter Inversions

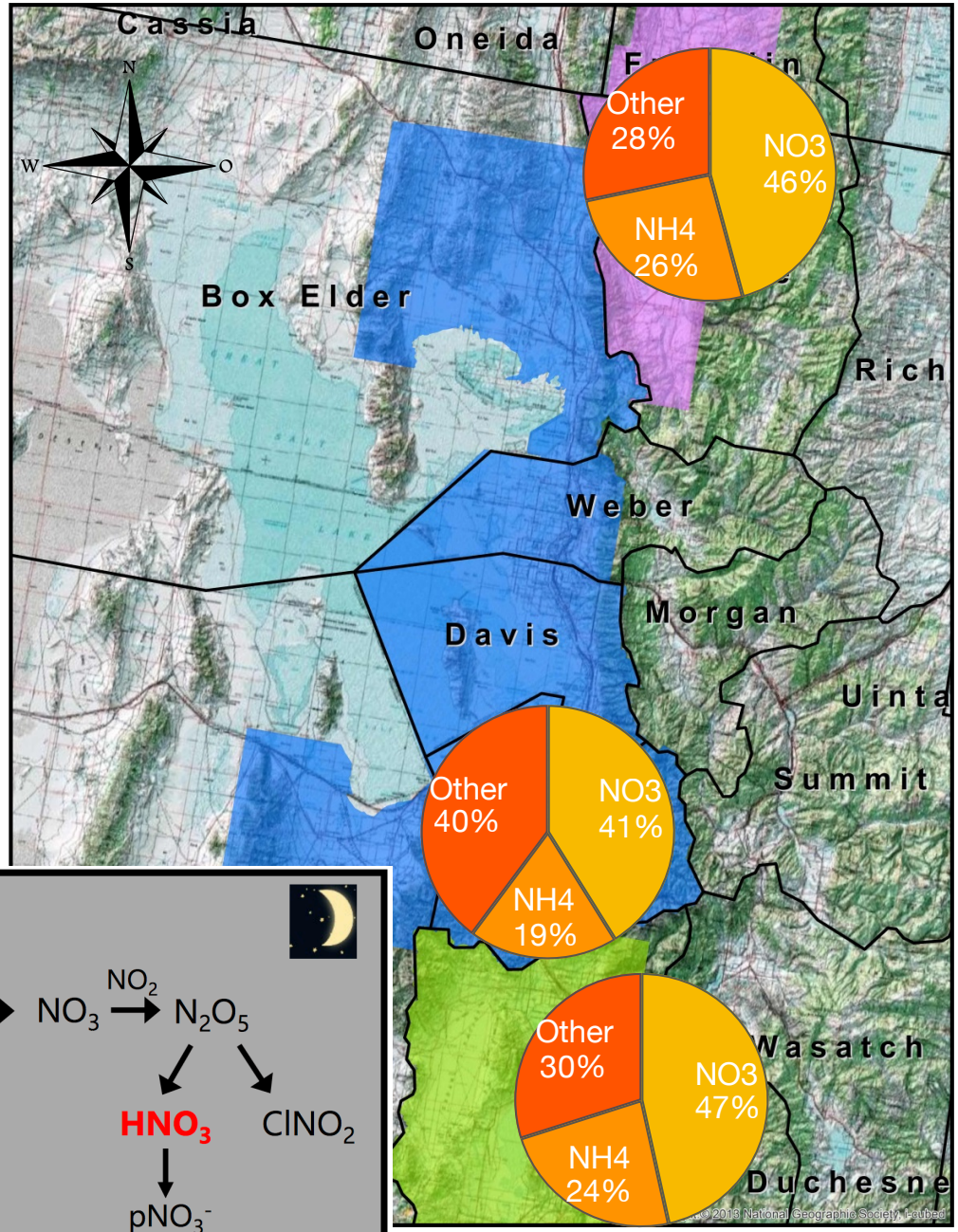
PM2.5 dominated by NH4NO3

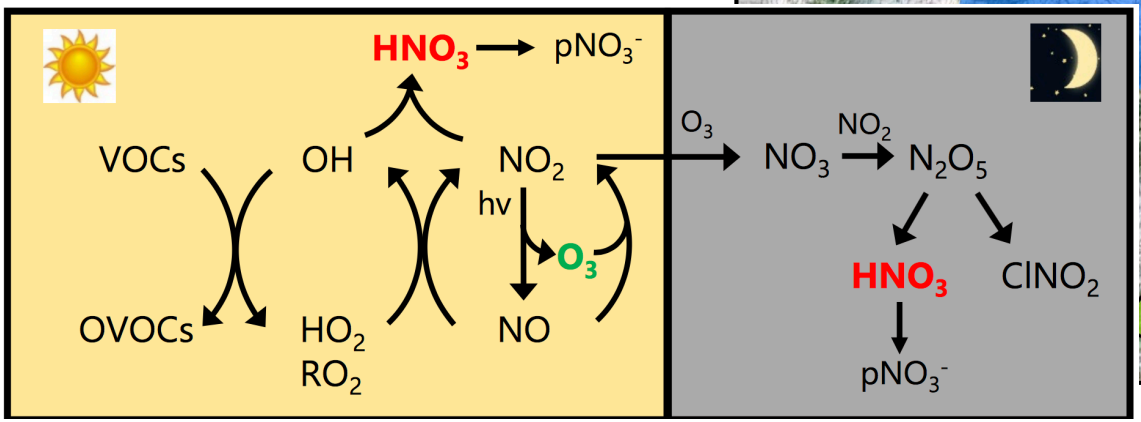


OVERVIEW

Complex Chemistry

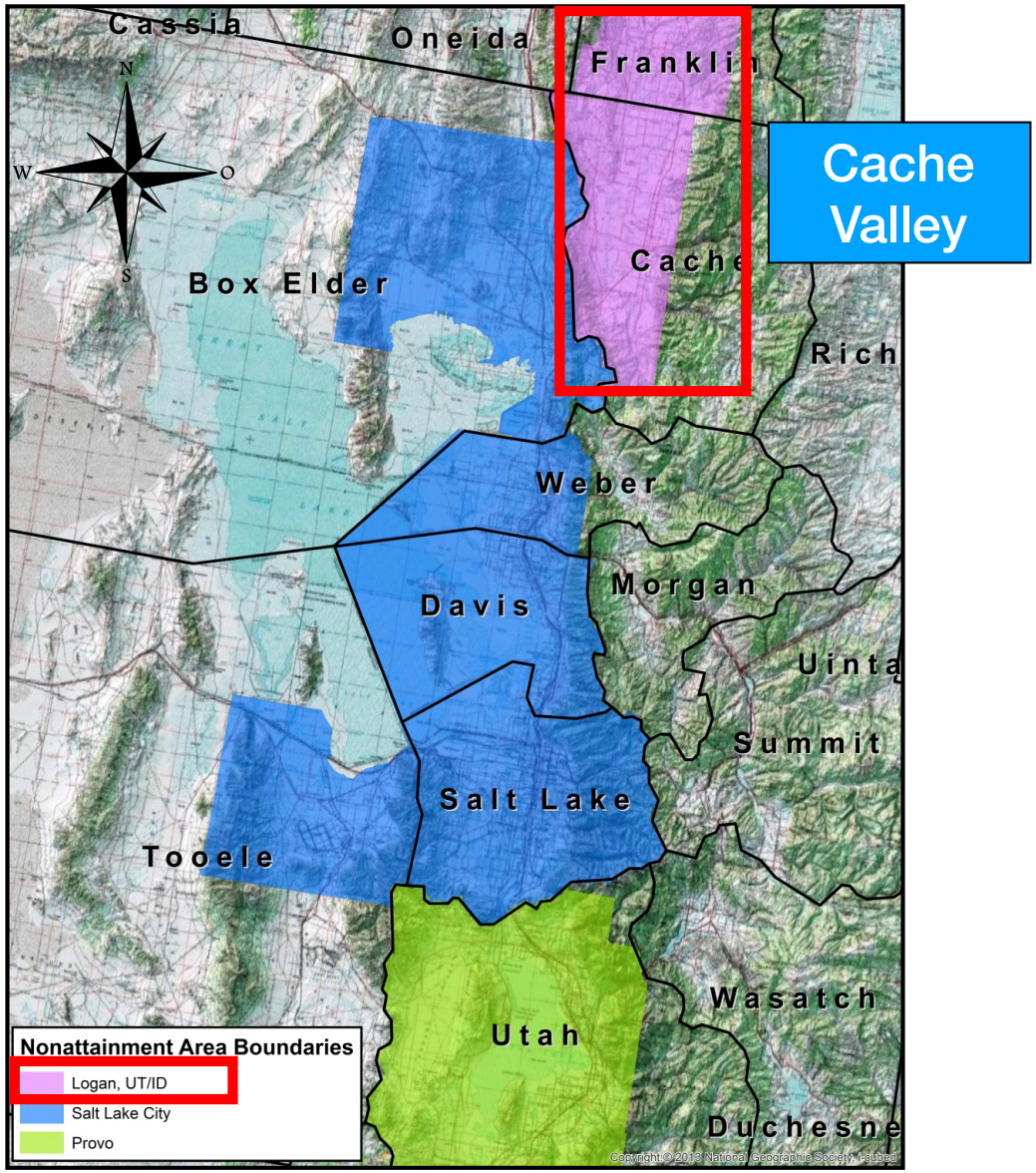
- Ammonia
- HNO3
- Ozone
- NOx
- Radical Sources (VOCs, ClNO2)





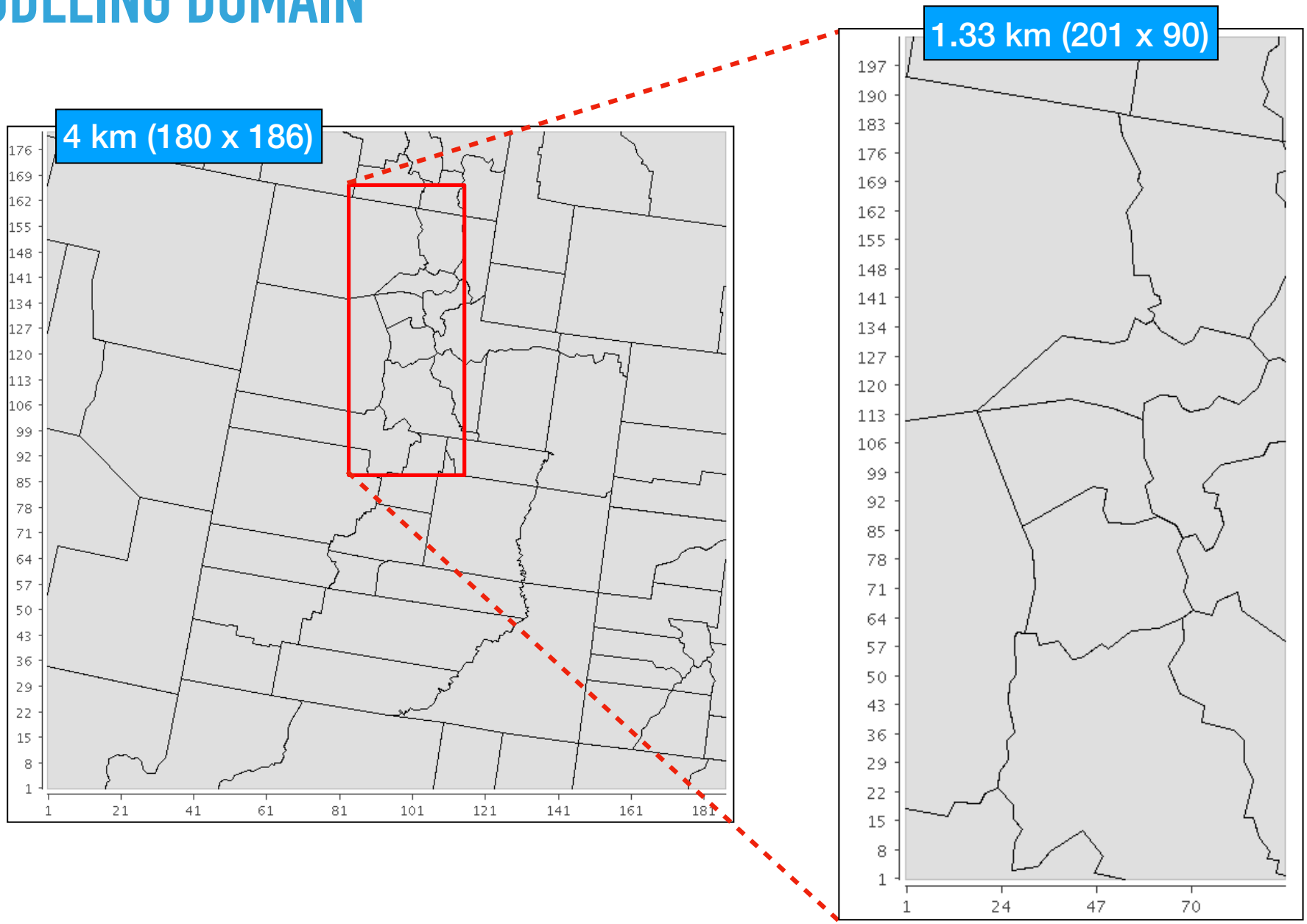
Womack et al. , AQUARIUS 2019 workshop.

OBJECTIVE

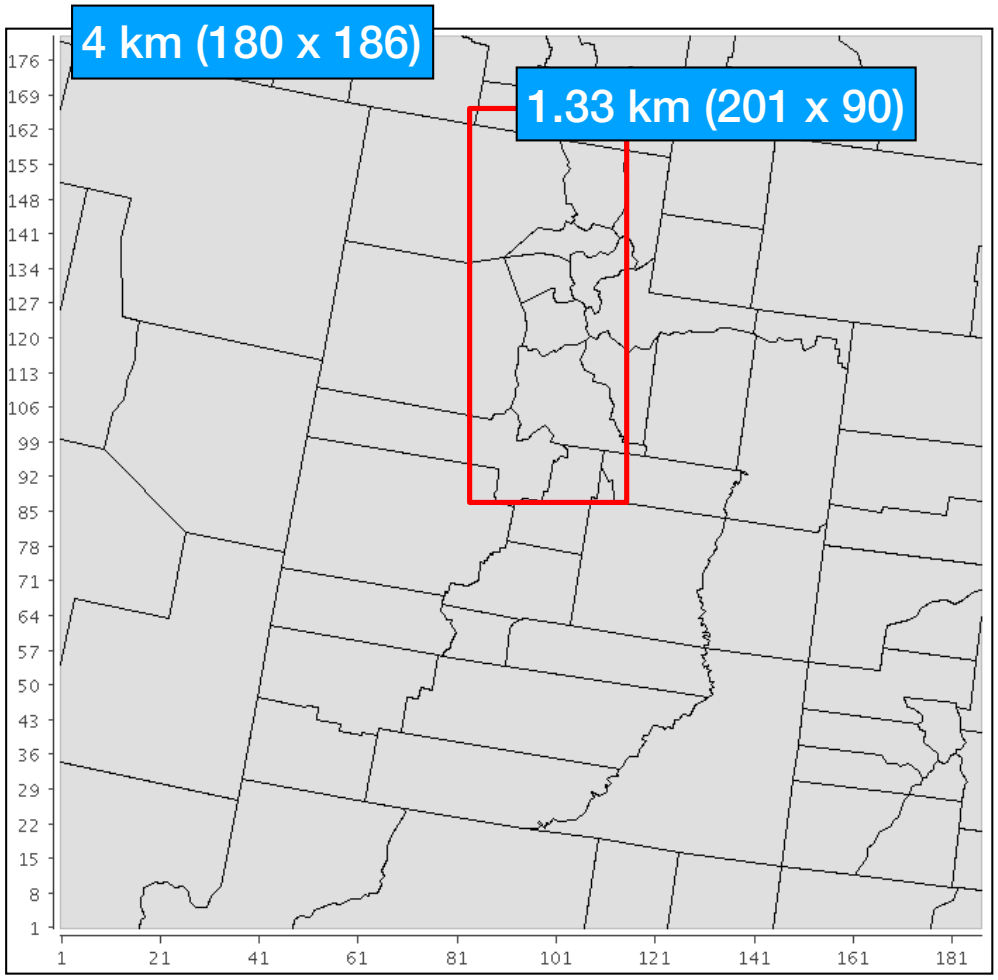


- Model a Typical Wintertime PM2.5 Inversion Event
- Implications for Control Strategies

MODELING DOMAIN



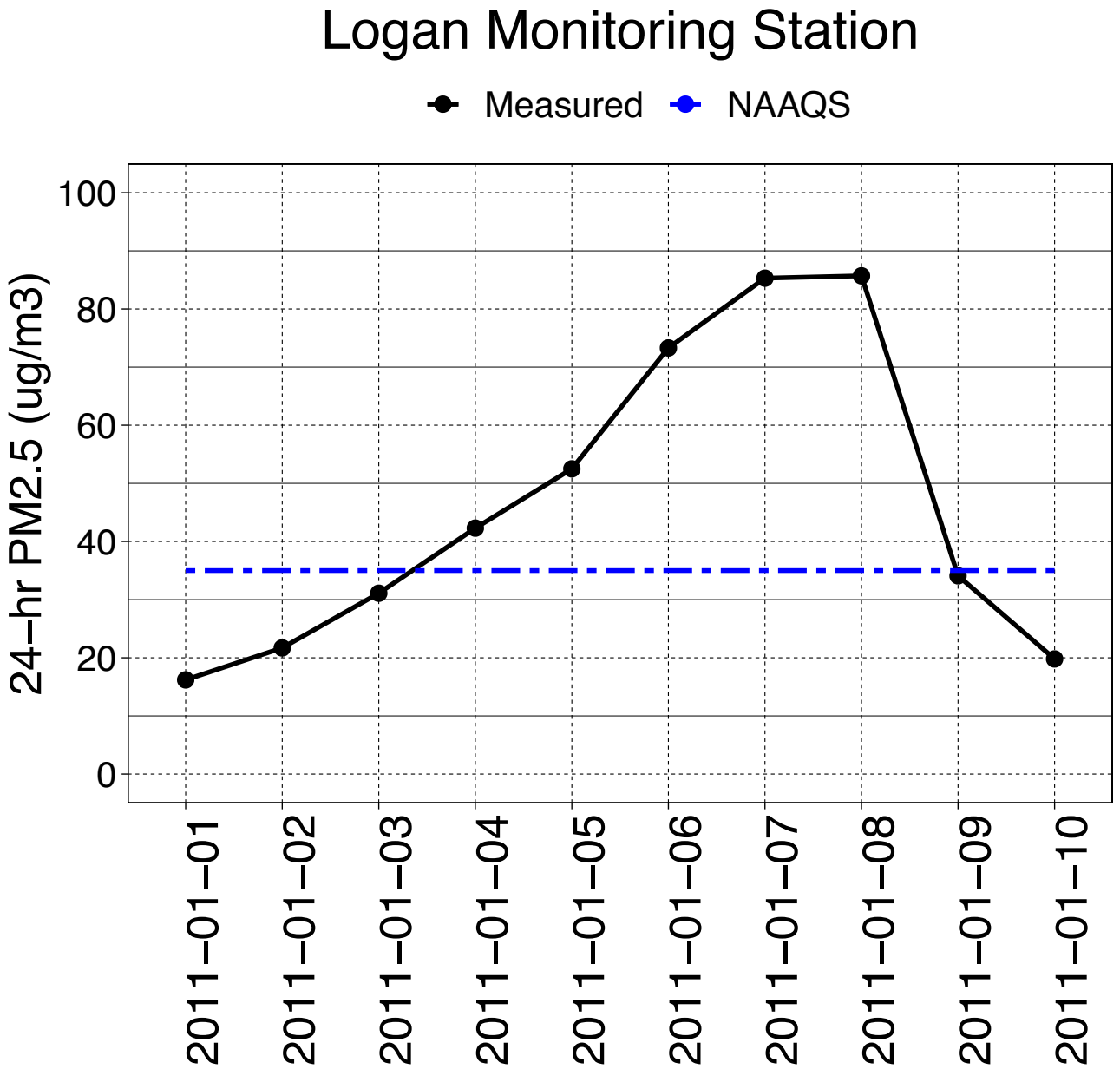
MODEL CONFIGURATION



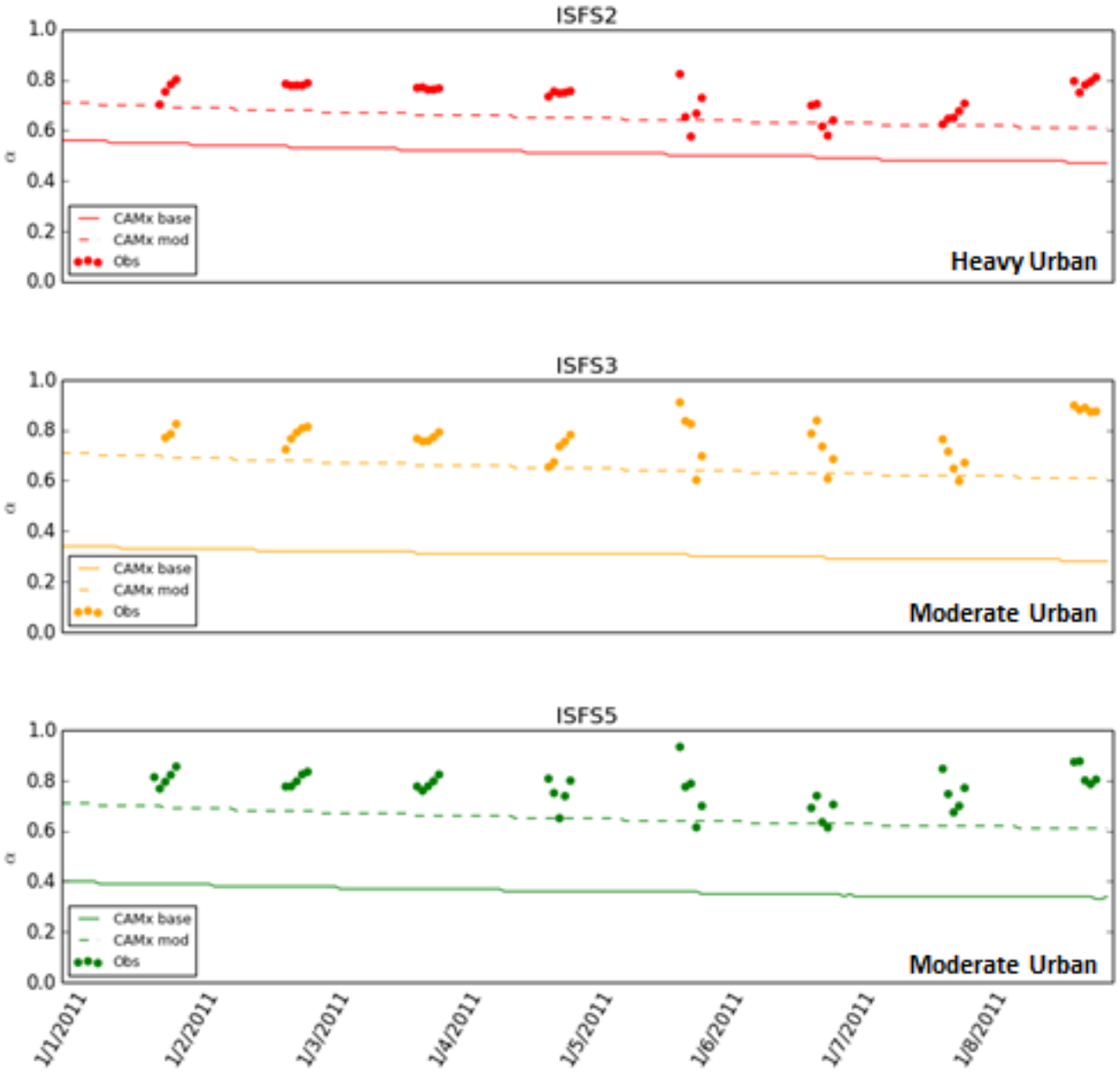
- CAMxv6.3
- 41 Vertical Layers
- Cb6r2h Chemistry Mechanism
- ZHANG03 Dry Deposition Scheme
- SMOKE3.6.5 Emissions Processor
- WRF Meteorological Processor

+ Custom Modifications

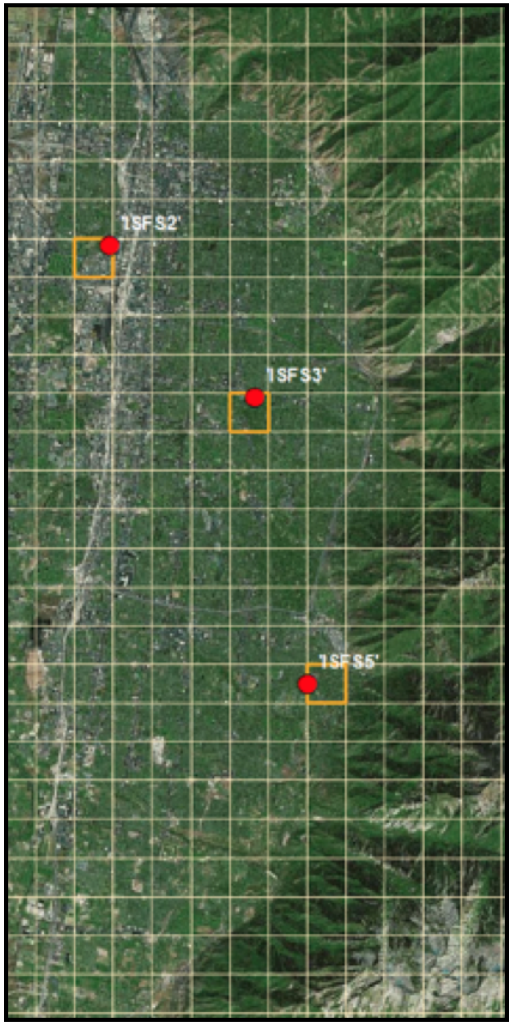
MODELING EPISODE: WINTERTIME INVERSION



MODEL MODIFICATIONS: SURFACE SNOW ALBEDO

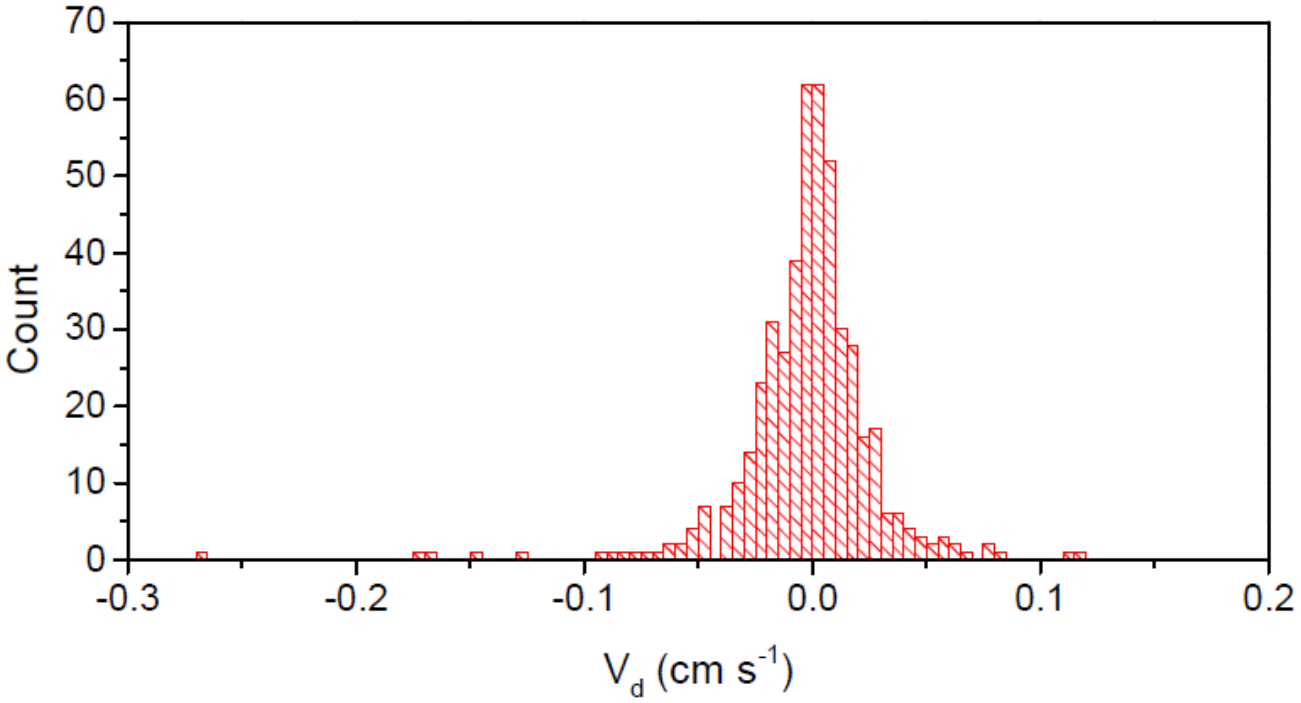


Set Snow Cover Fraction to 0.88 for Urban Land Use



MODEL MODIFICATIONS: OZONE DEPOSITION VELOCITY

Zeroed-out Ozone Deposition Velocity



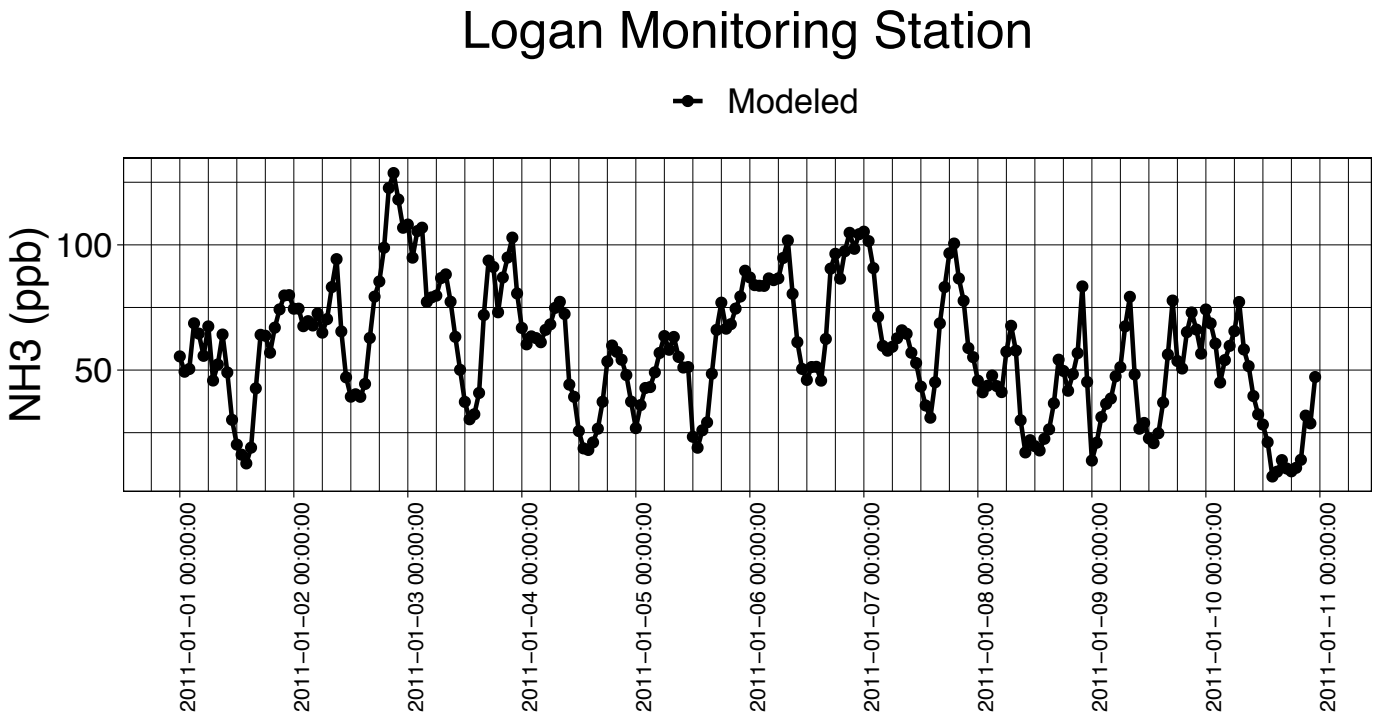
Histogram of ozone deposition velocity calculations for the snow-covered period (early February) inclusive of both nighttime and daytime data. Mean and median ozone deposition velocity were -0.002 and 0.0 cm s-1

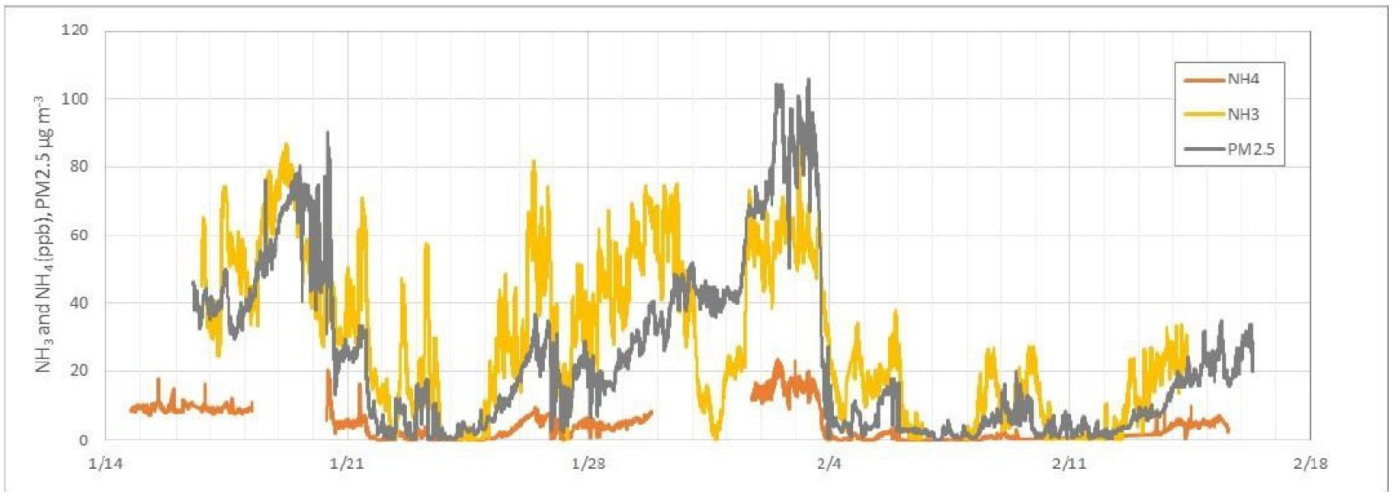
Helmig D. Et al. (2014). Final report: 2013 Uinta Basin Winter Ozone Study.

MODEL MODIFICATIONS: AMMONIA INJECTION & SURFACE DEPOSITION

Increased Surface Resistance to Ammonia ("RScale = 1")

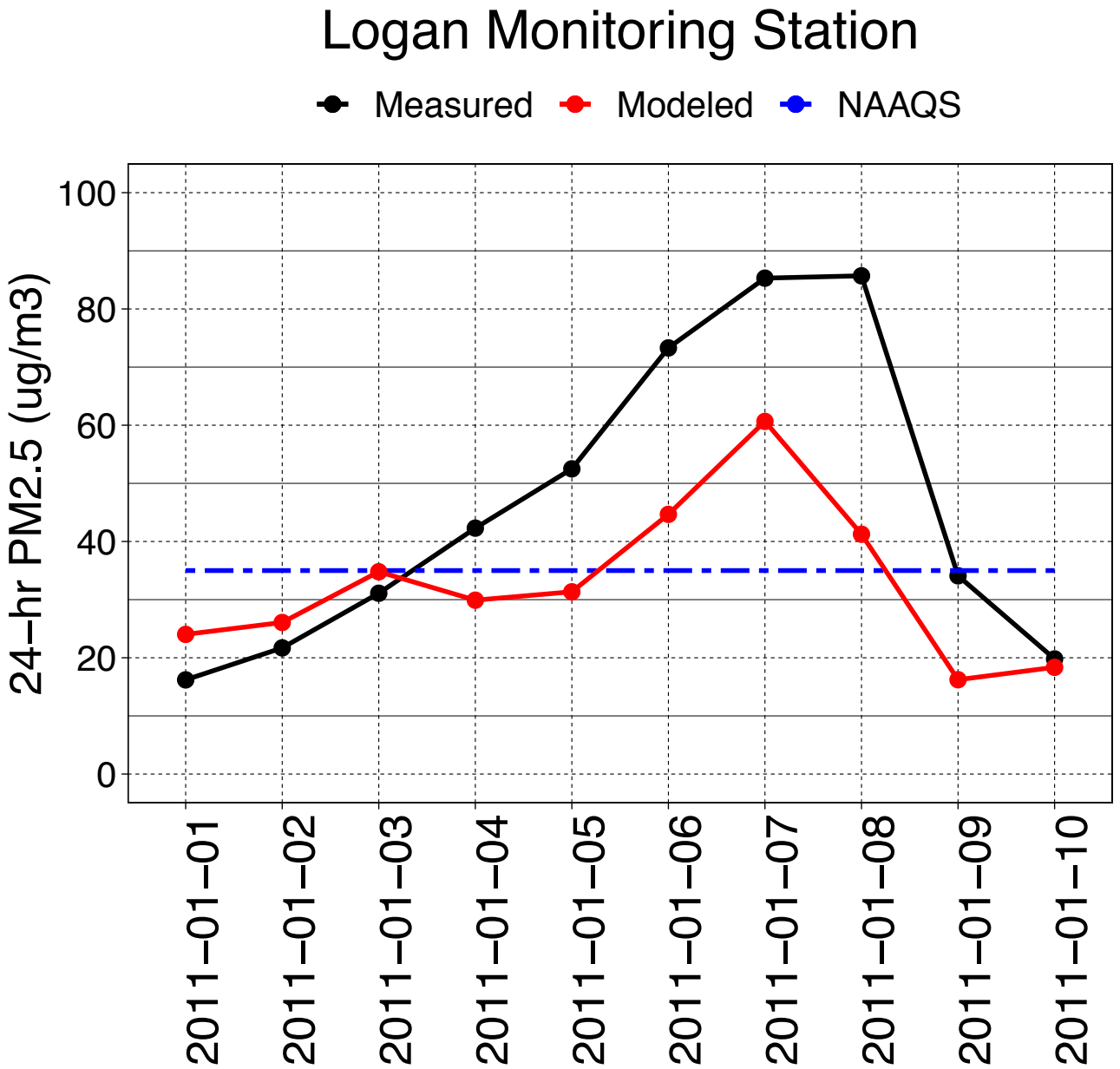
County	Saling Factor
Cache	80
Box Elder	6
Weber	6
Davis	4
Salt Lake	4
Tooele	6
Utah	4





2017 Utah Winter Fine Particulate Study.

RESULTS: 24-HR PM2.5



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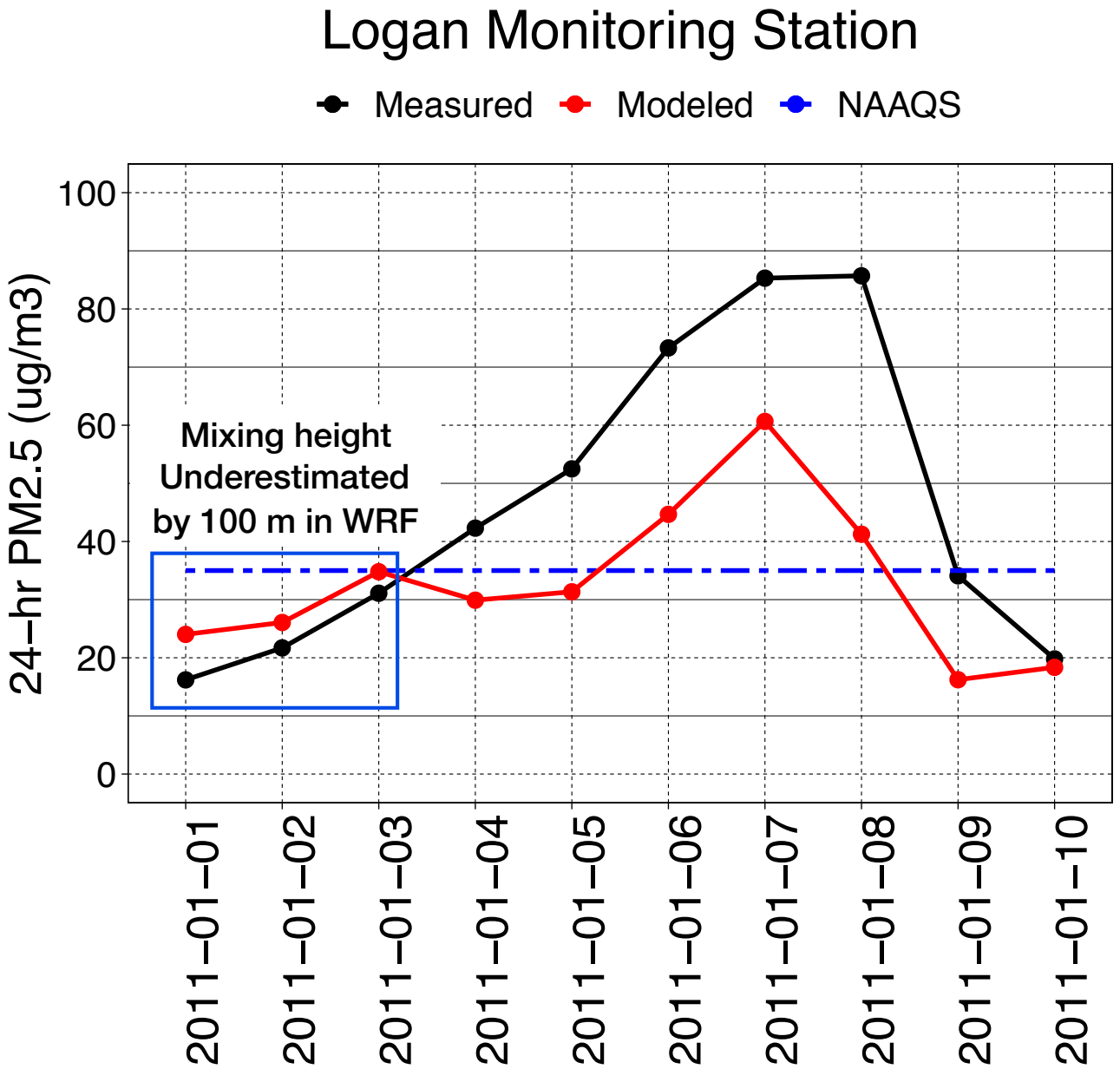

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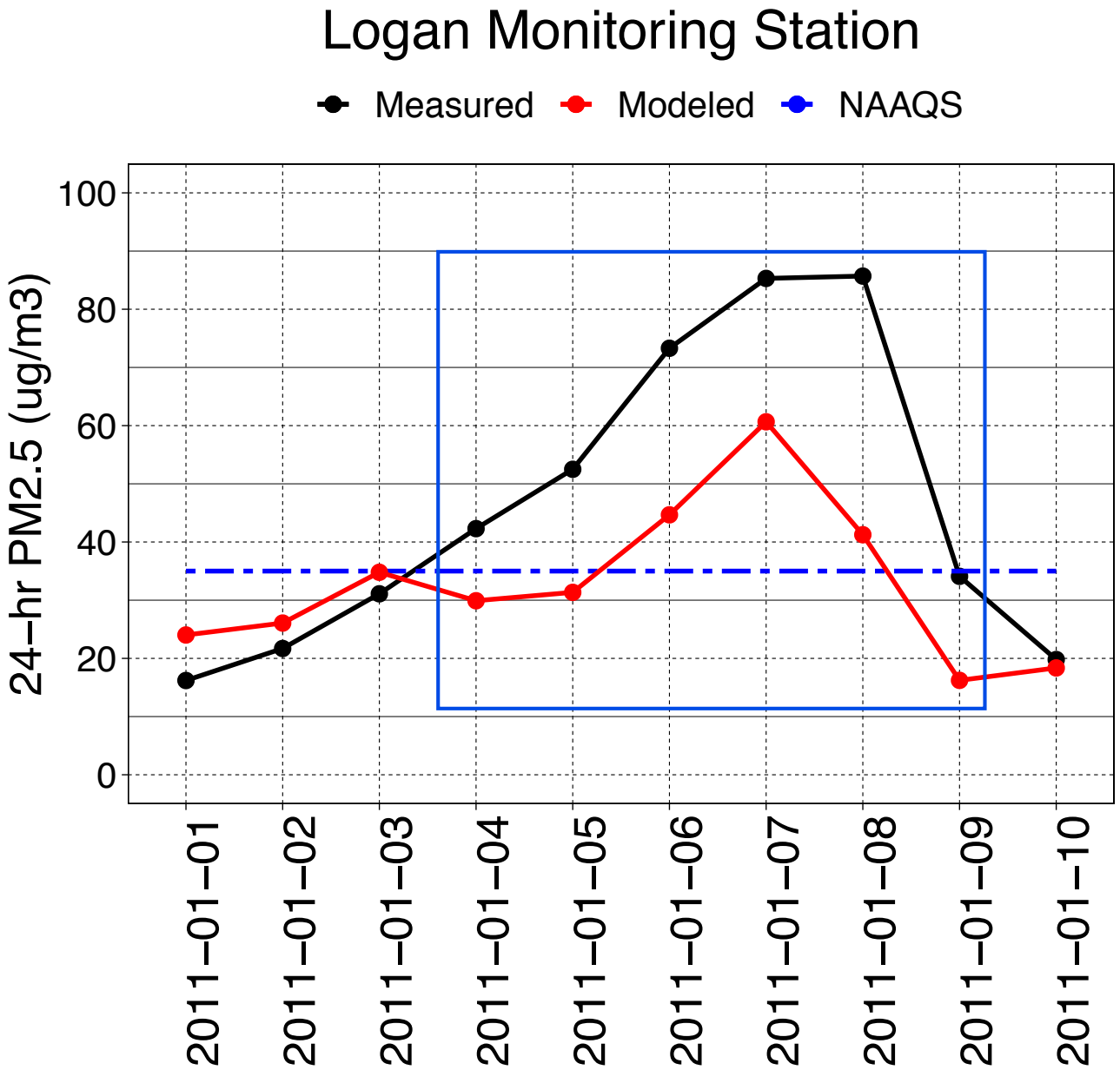
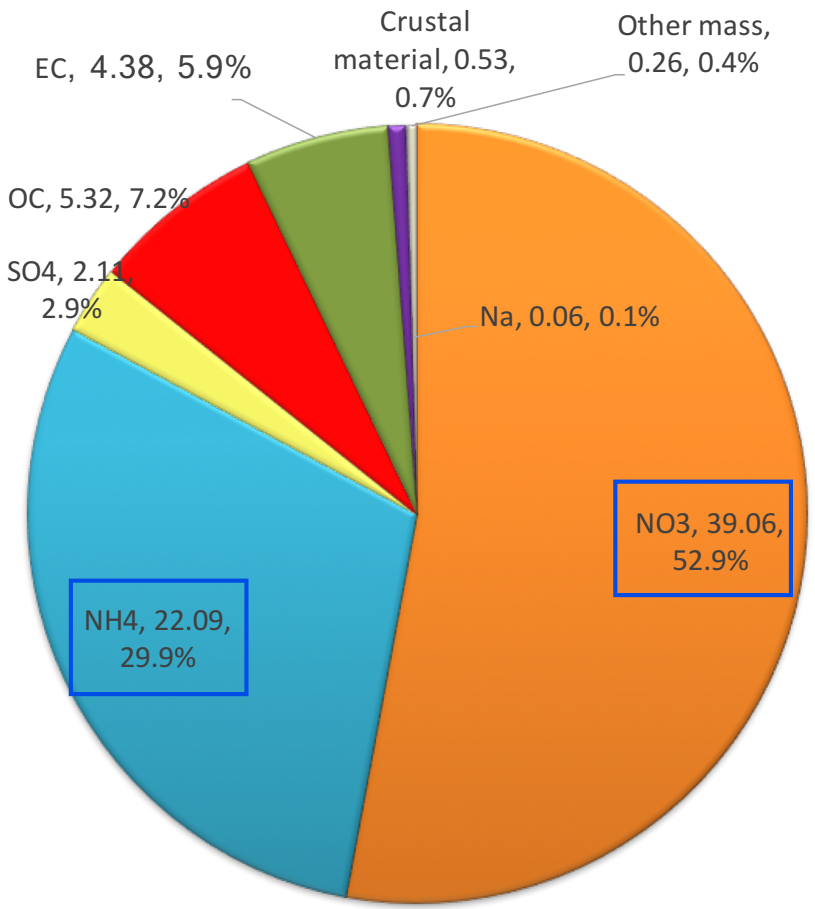
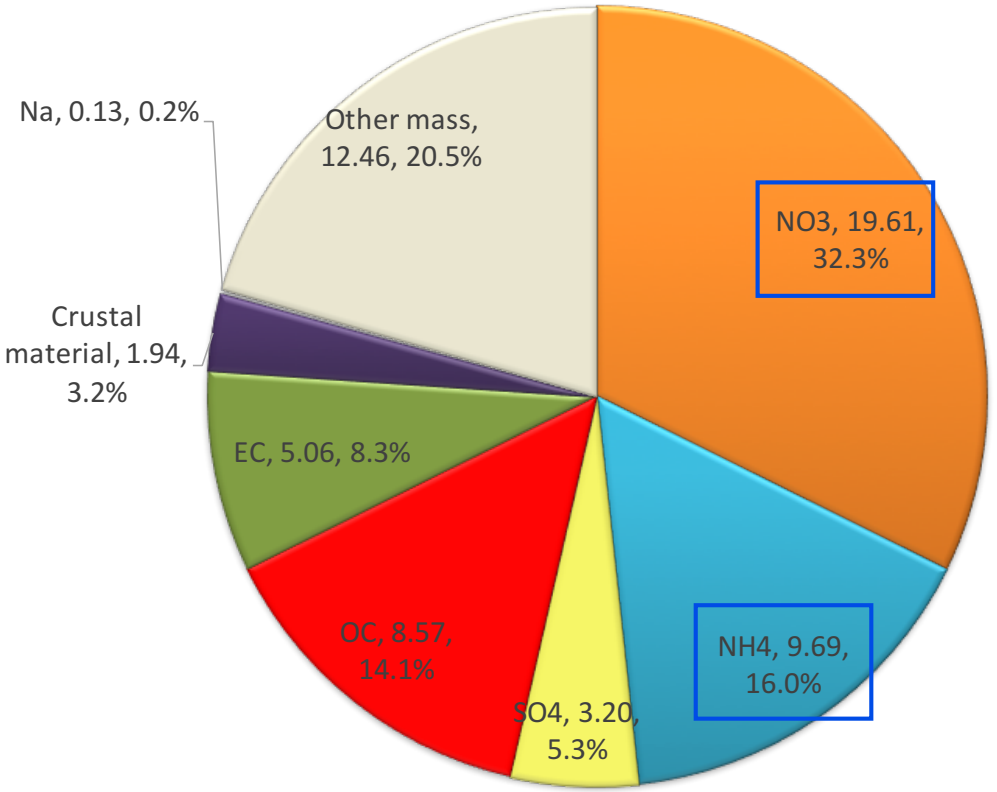


RESULTS: PM2.5 CHEMICAL SPECIATION

Measured
PM2.5 = 85.3 ug/m3

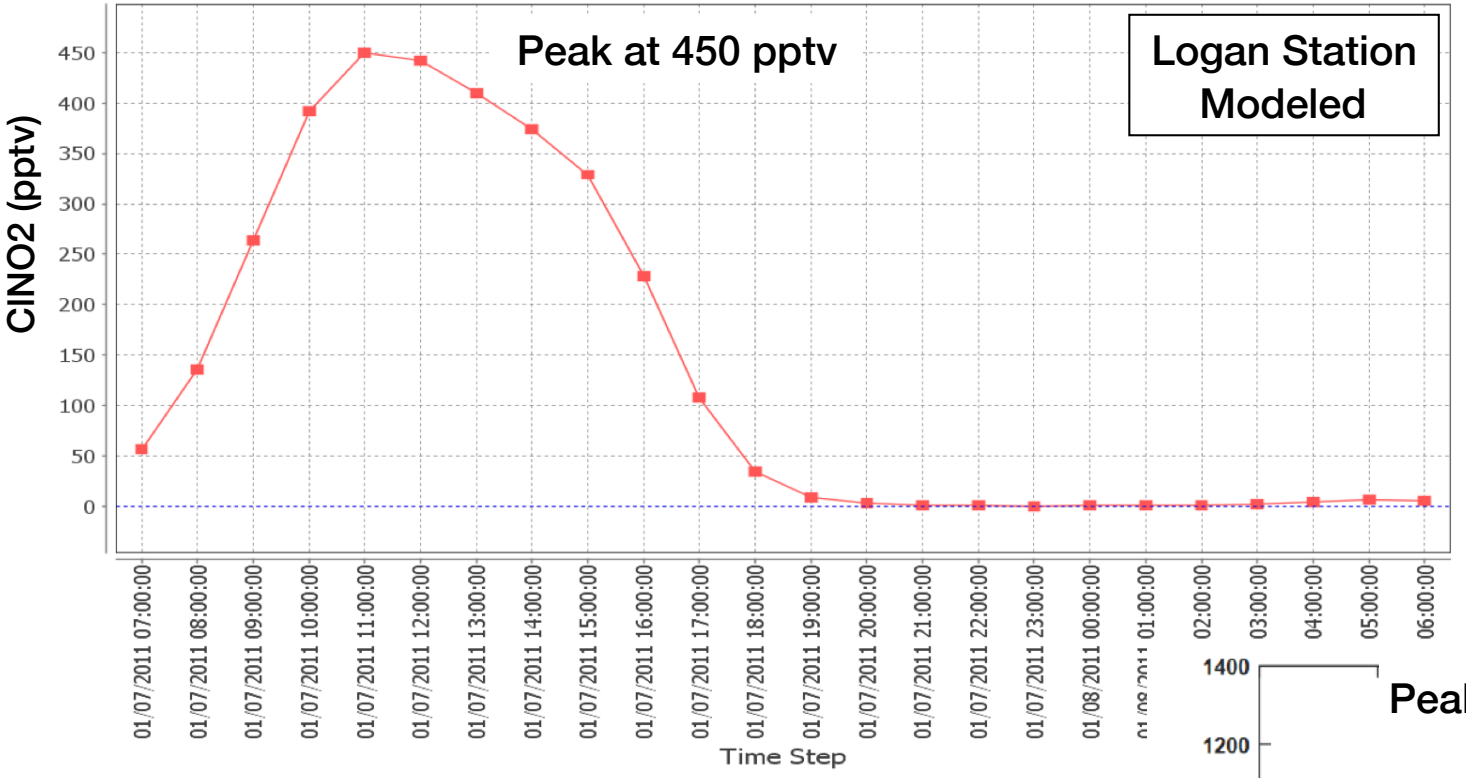


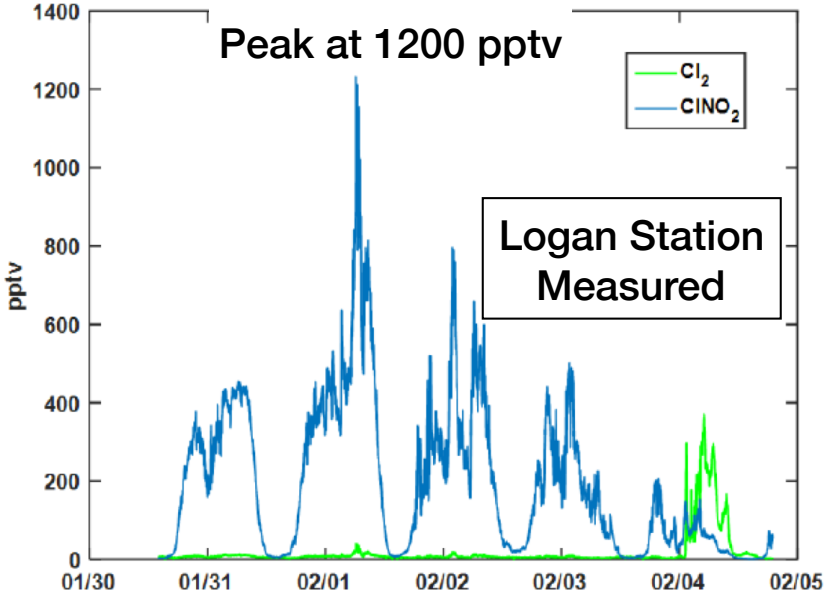
Modeled
PM2.5 = 60.7 ug/m3



Jan. 07, Peak PM2.5 Day

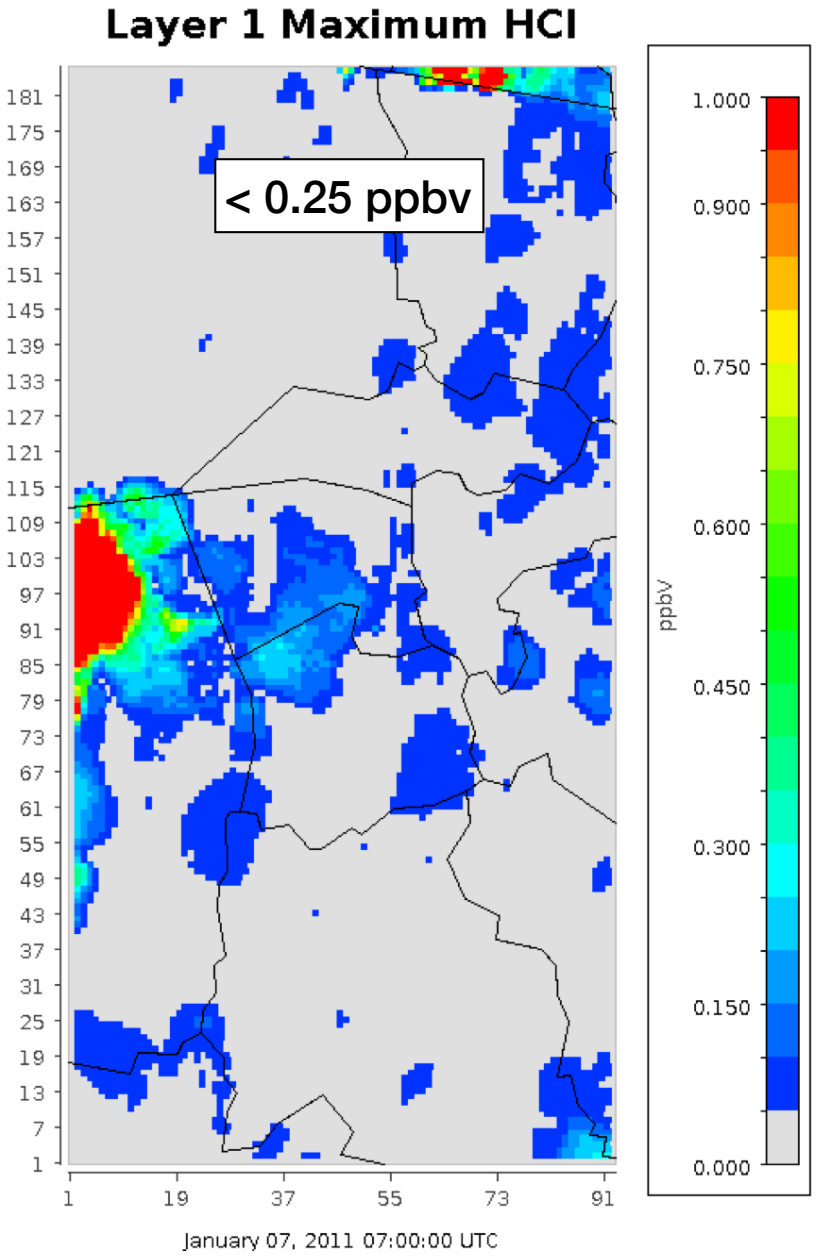
RESULTS: CLNO2 ON A TYPICAL EXCEEDANCE DAY

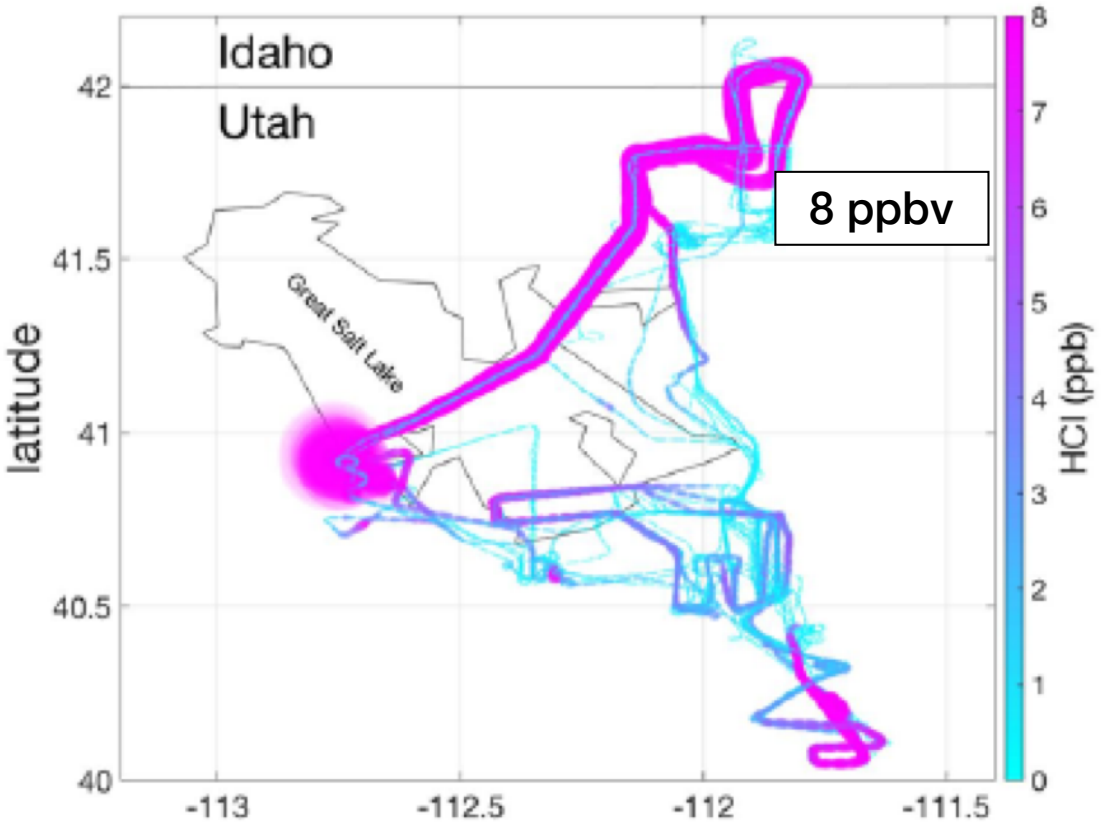




2017 Utah Winter Fine Particulate Study

RESULTS: HCL ON A TYPICAL EXCEEDANCE DAY





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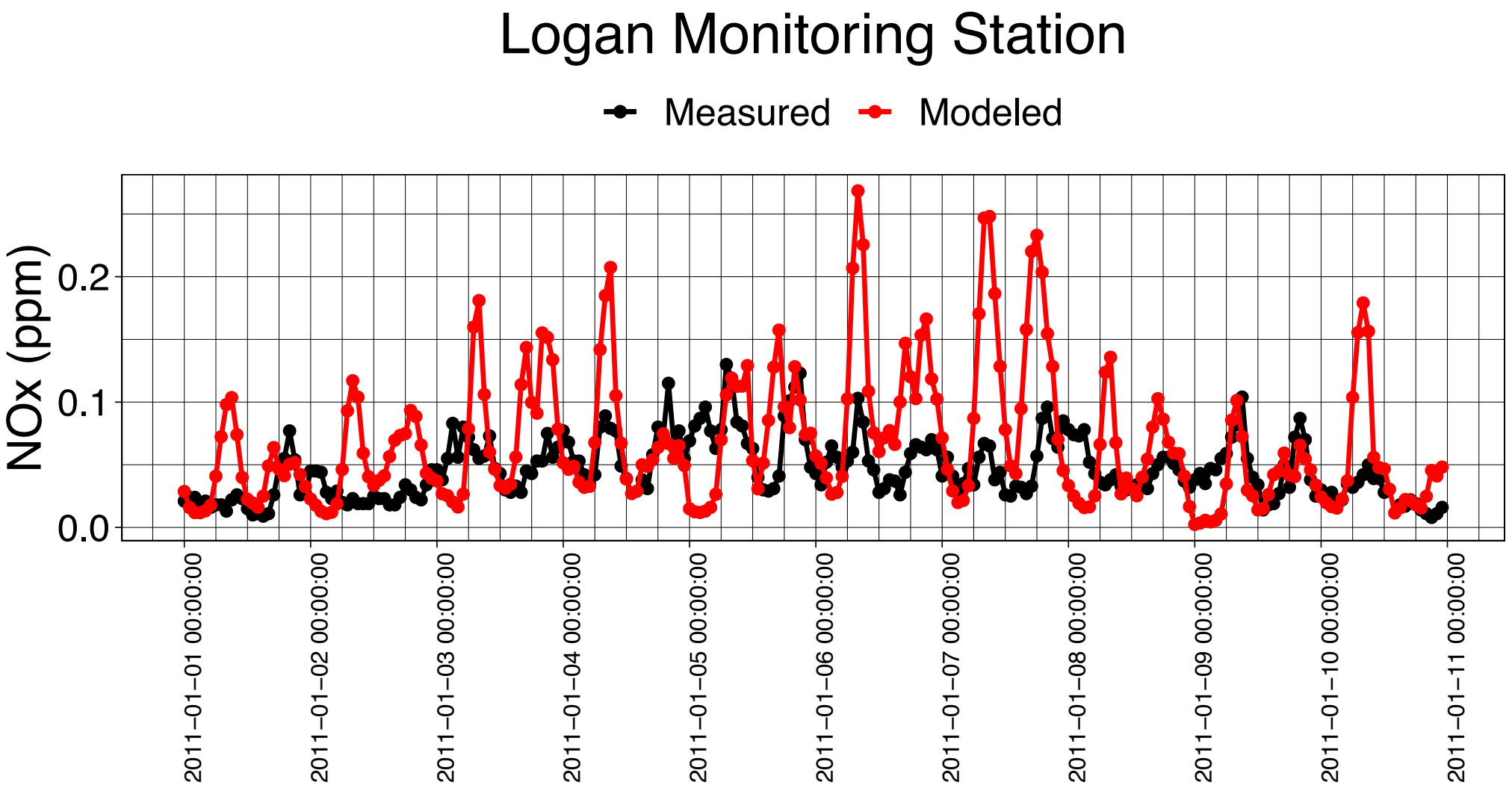
RESULTS: GASEOUS SPECIES – NOx



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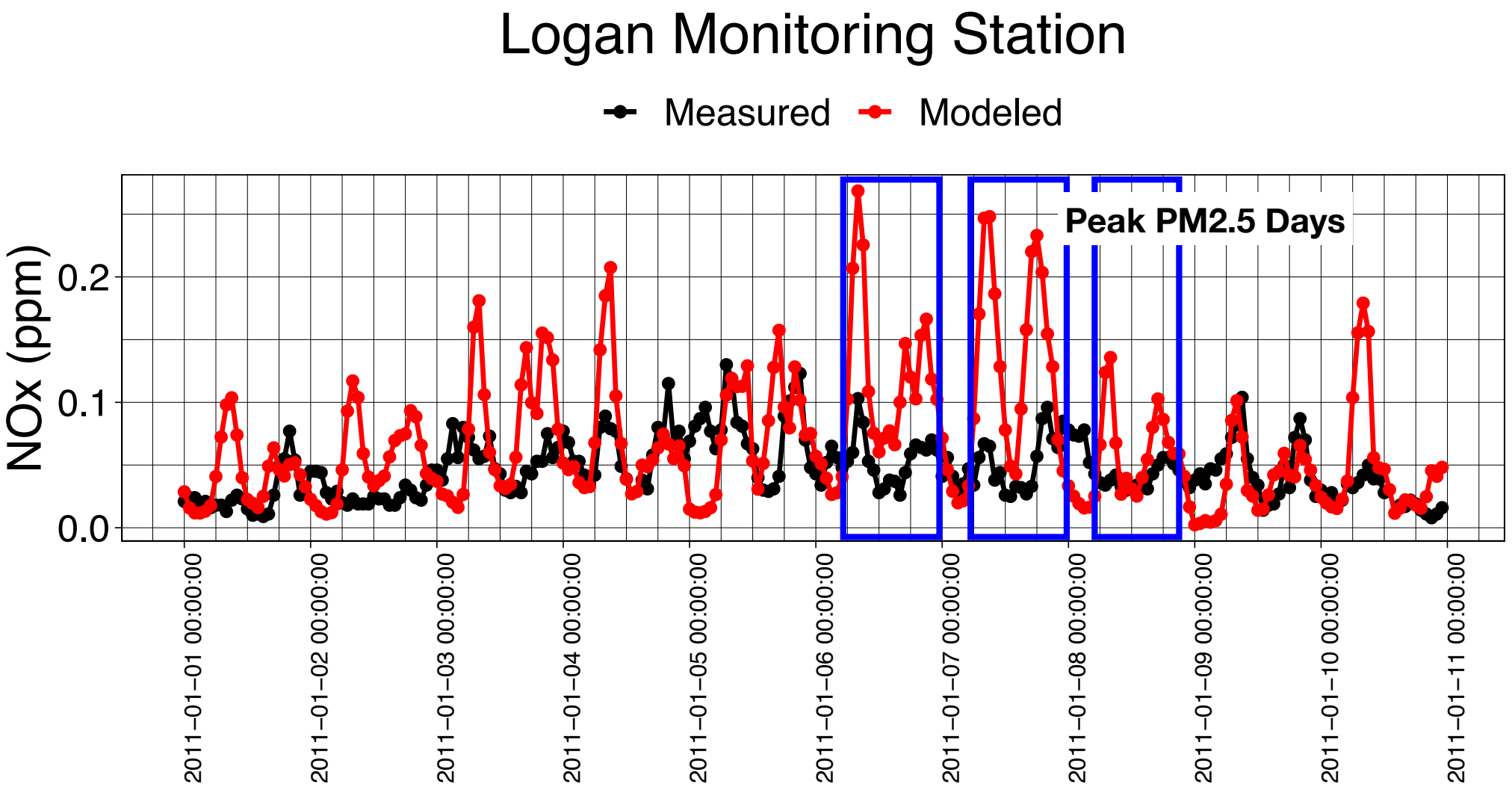
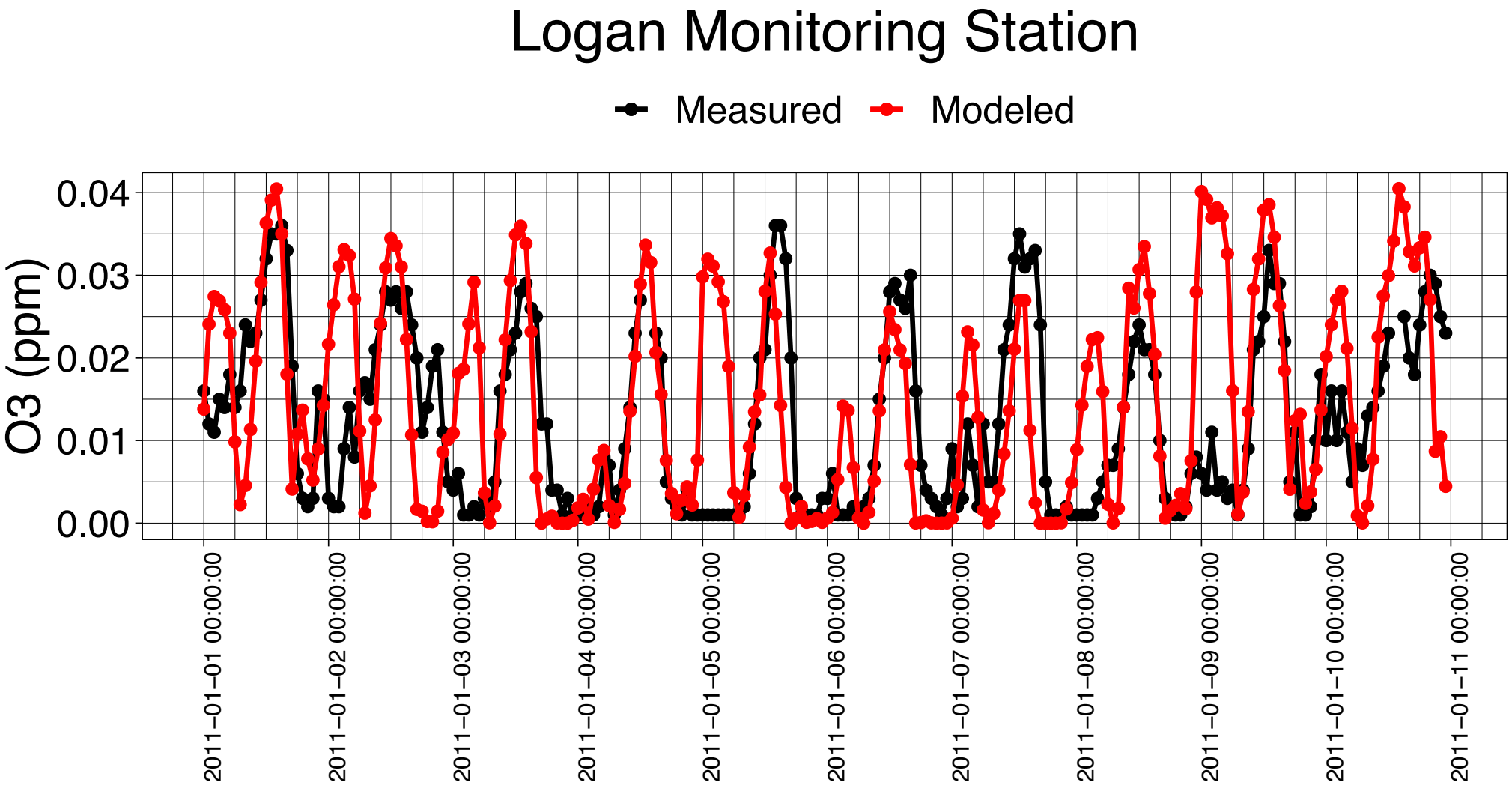


RESULTS: GASEOUS SPECIES – OZONE



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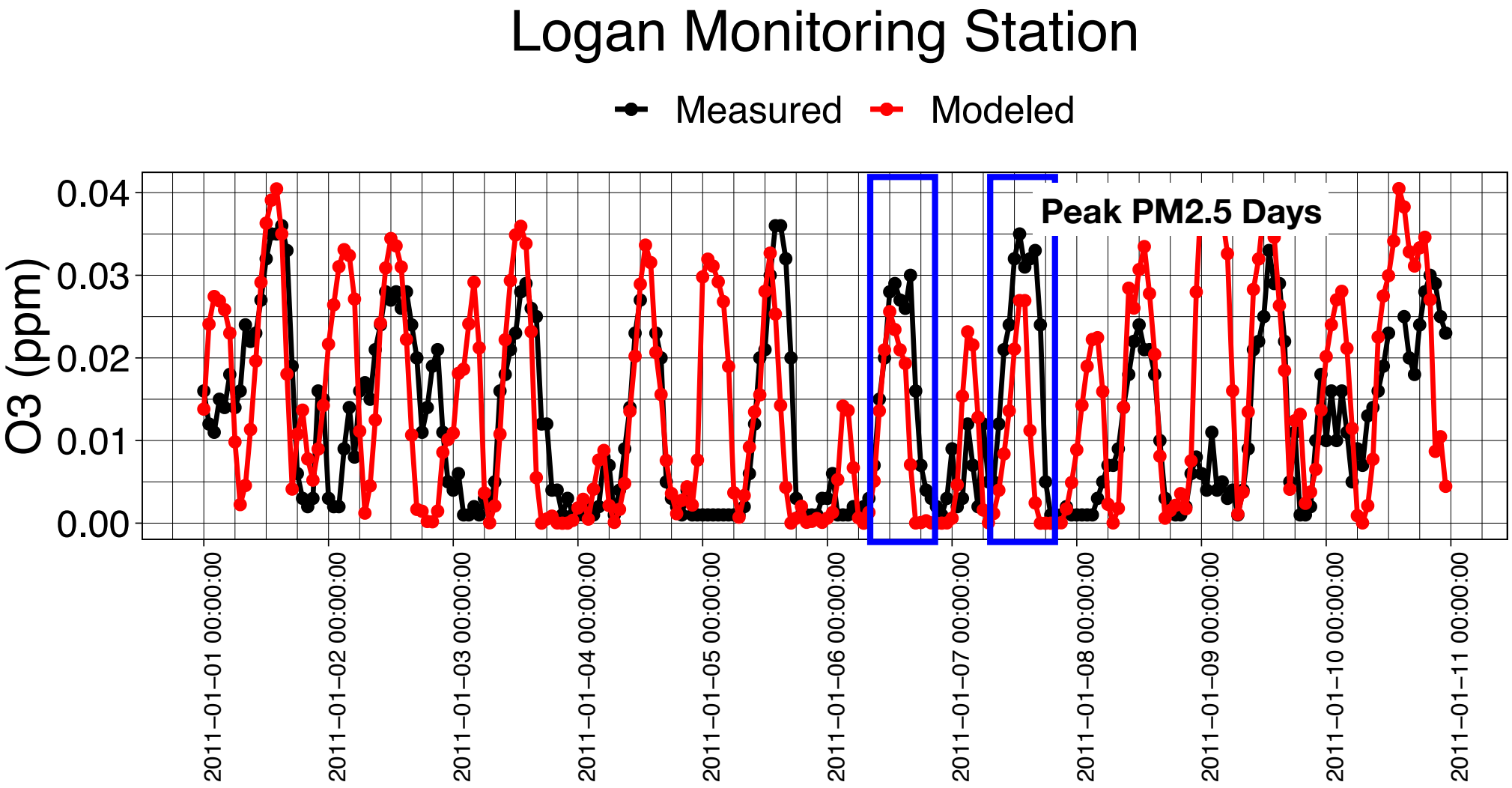


FINDINGS & IMPLICATIONS

- Temporal Variation in PM2.5 Well Replicated
- Underestimation in Ammonium Nitrate
- Overestimation in NOx/Underestimation in O3 during Daytime Hours
- Potential Underestimation in Free Radical Sources
- Model Potentially Showing Disbenefits for Controlling NOx

ACKNOWLEDGMENTS

- Gail Tonnesen, EPA Region 8
- Chris Emery, Ramboll
- Erik Crosman, West Texas A&M University

THANK YOU

$NO + O_3 \rightarrow NO_2$ (R1)

$NO_2 + hv \rightarrow NO + O$ (R2)

$O + O_2 \rightarrow O_3$ (R3)

$NO_2 + OH \rightarrow HNO_3$ (R4)

$NO_2 + O_3 \rightarrow NO_3$ (R5)

$NO_2 + NO_3 \rightarrow N_2O_5$ (R6)

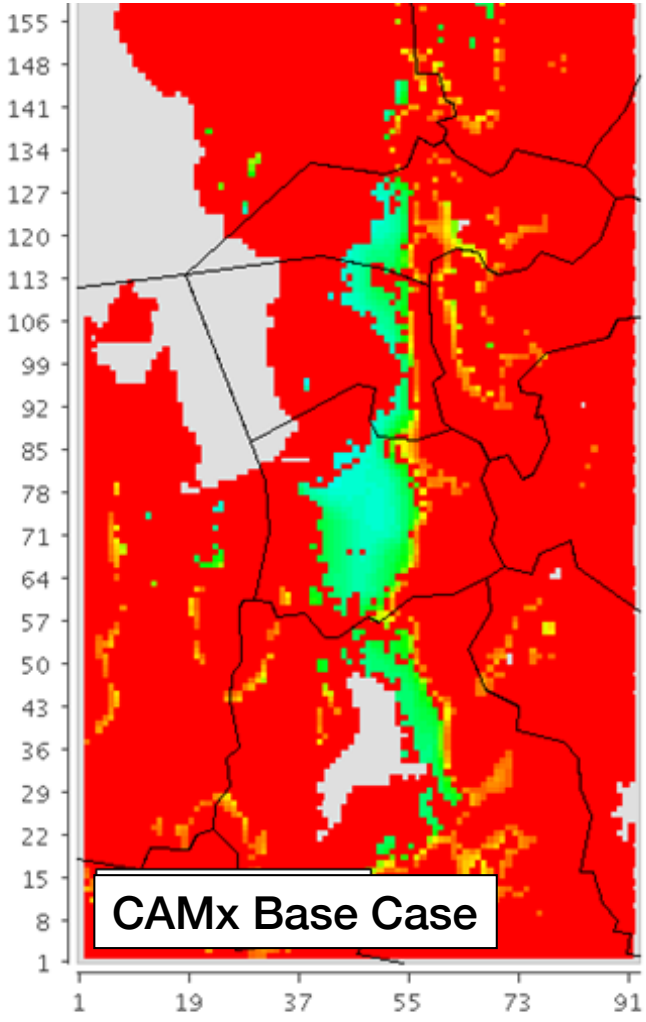
$N_2O_5 + \text{aerosol} \rightarrow 2\ HNO_3$ (R7)

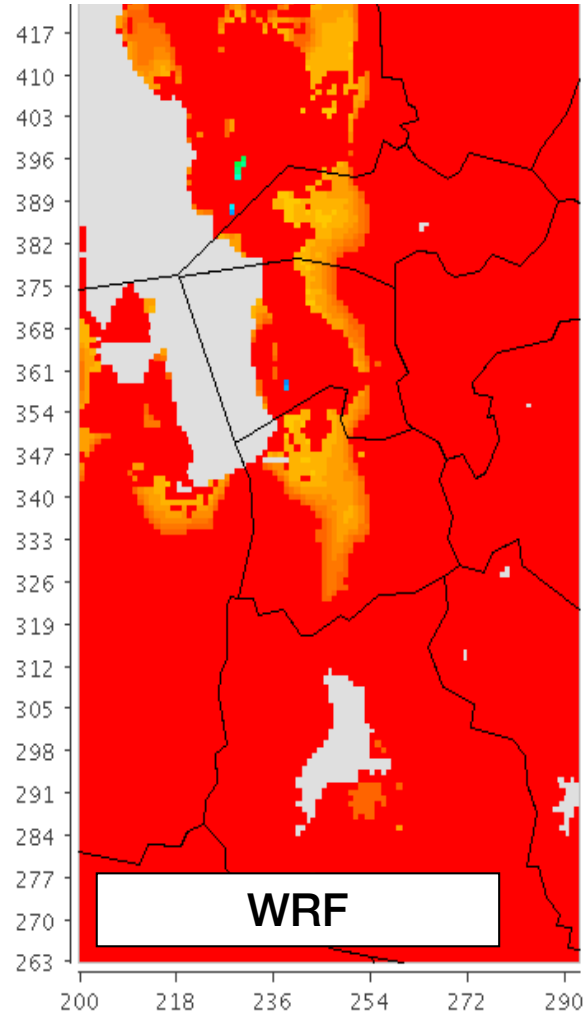
$N_2O_5 + \text{aerosol} \rightarrow HNO_3 + ClNO_2$ (R8)

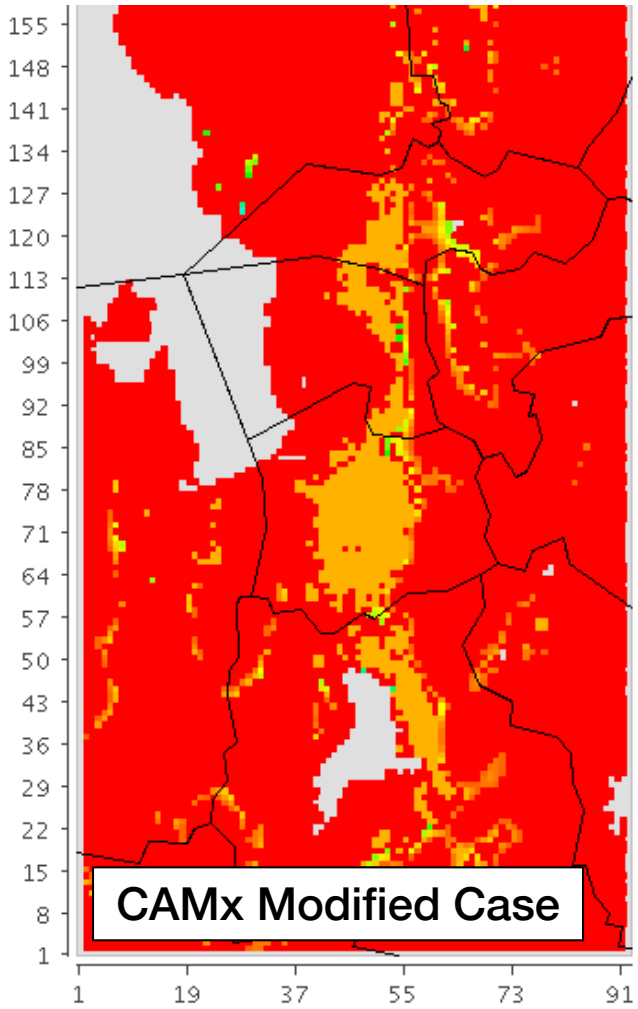
$NO + OH \rightarrow HONO$ (R9)

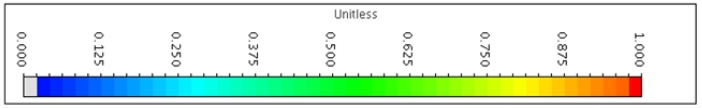
$HNO_3 + NH_3 \leftrightarrow \text{particulate } NH_4NO_3$ (R10)

MODEL MODIFICATIONS: SNOW FRACTION









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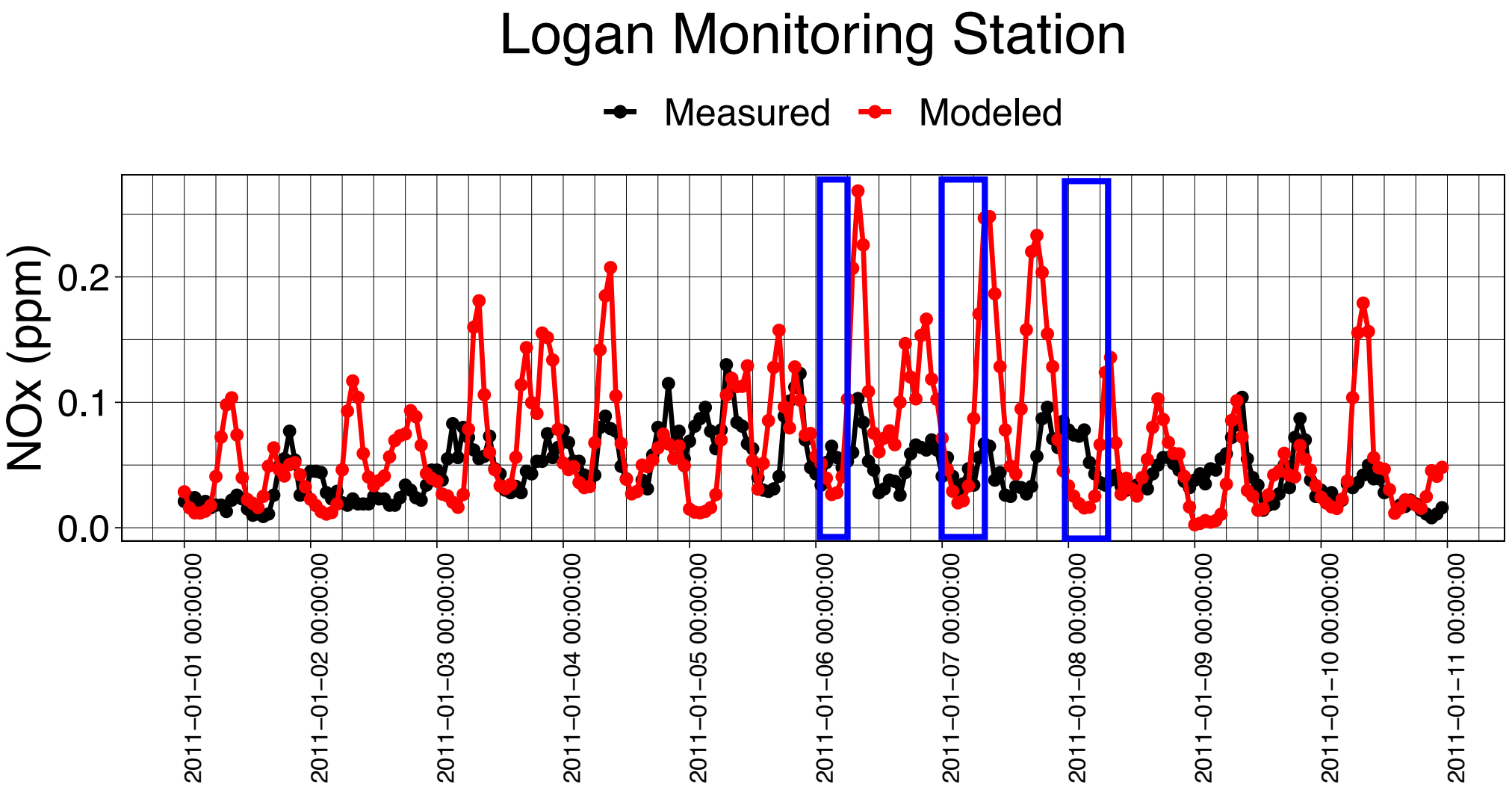

RESULTS: GASEOUS SPECIES – OZONE