Atmospheric Reactive Nitrogen Modeling and Observations in the Columbia River Gorge

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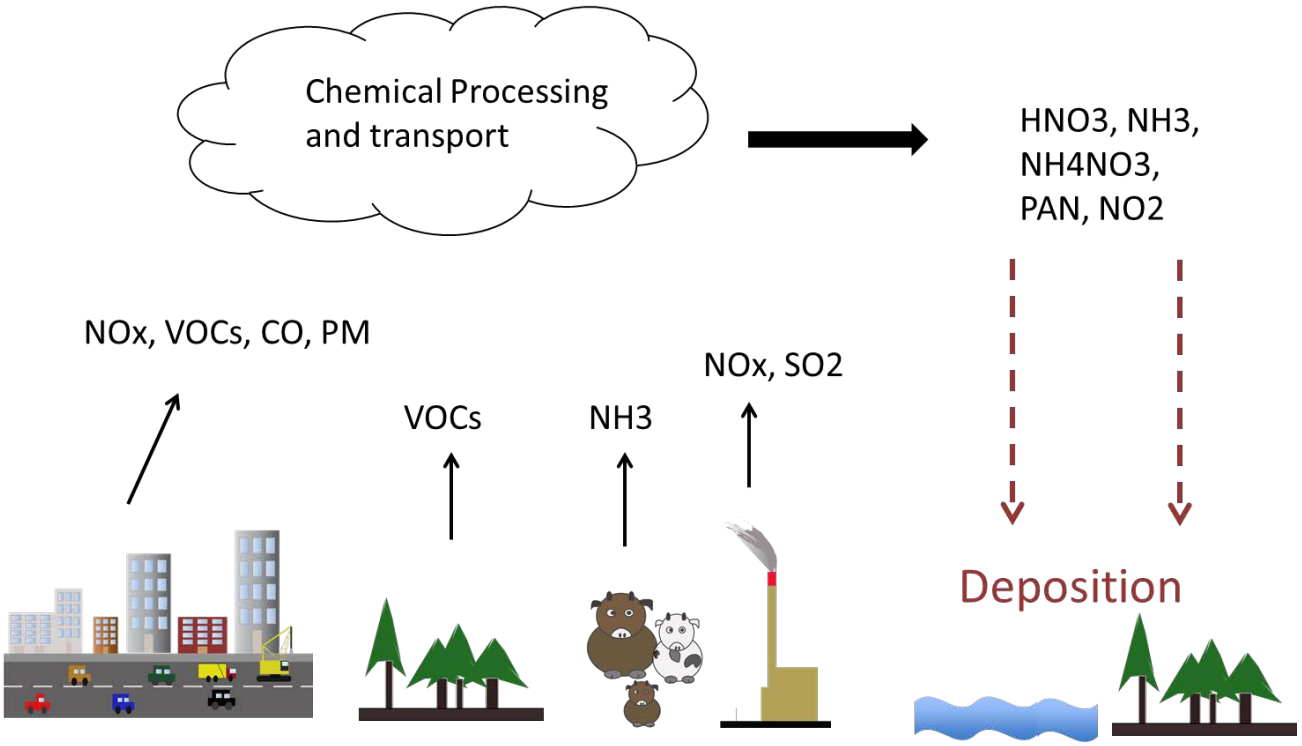
AMERICAN INDIAN SCIENCE & ENGINEERING SOCIETY

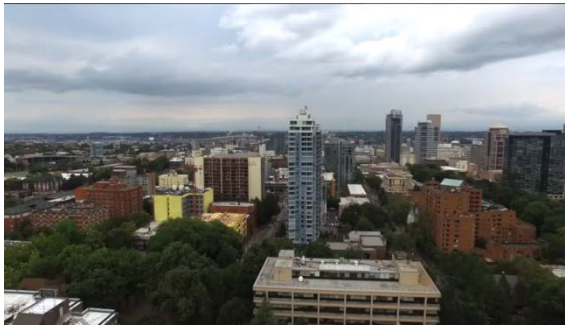
FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Research Interests



How do large sources affect the chemistry through the gradient in the CRG?

How do secondary pollutants affect the landscape (N Dep)?



Portland

DEQ Reference Station and Chemical Speciation Network (CSN)

Mt Zion

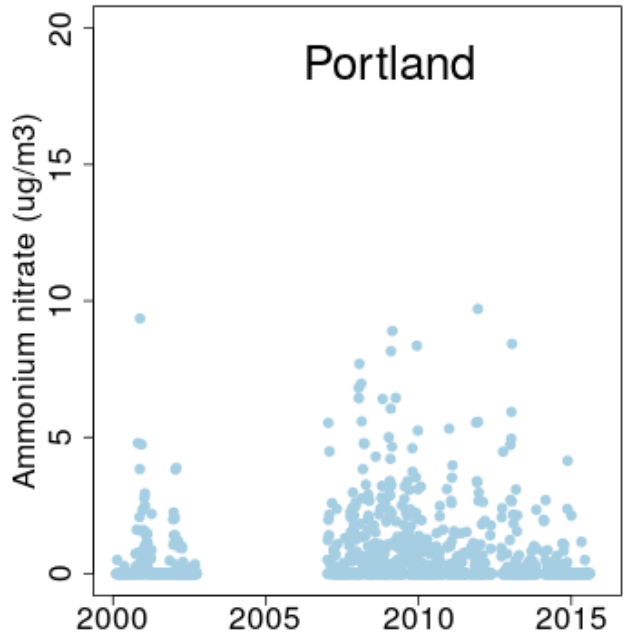
National Trends Network and
Interagency Monitoring of Protected Visual Environments (IMPROVE)

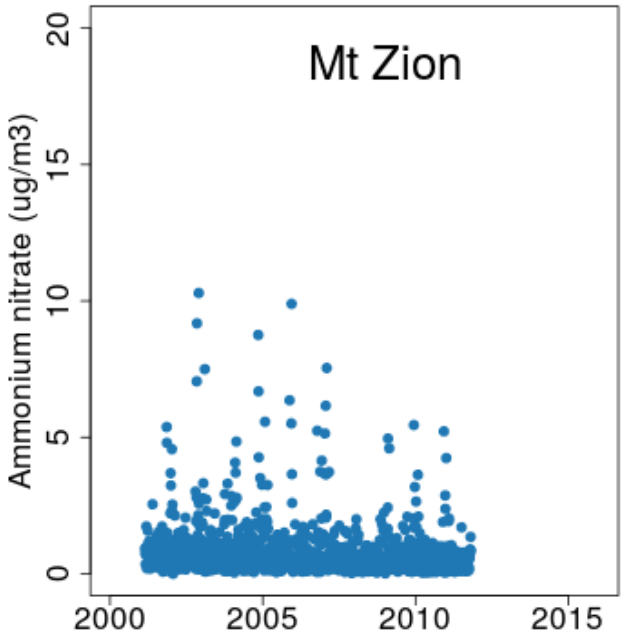
Wishram

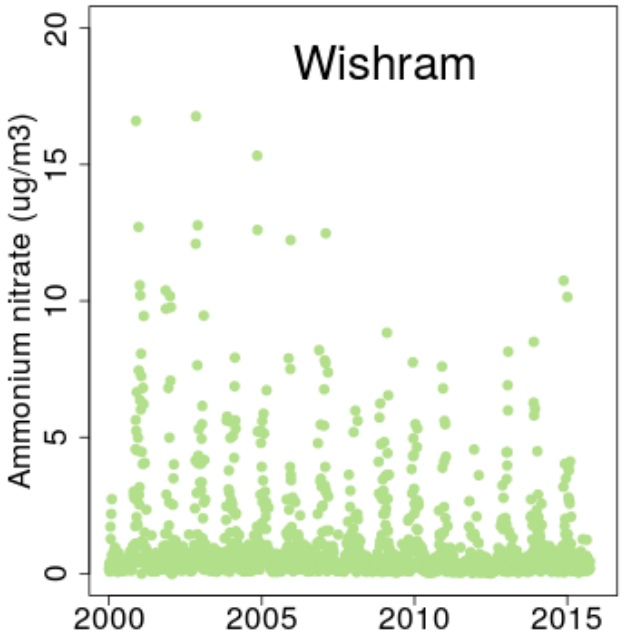
IMPROVE

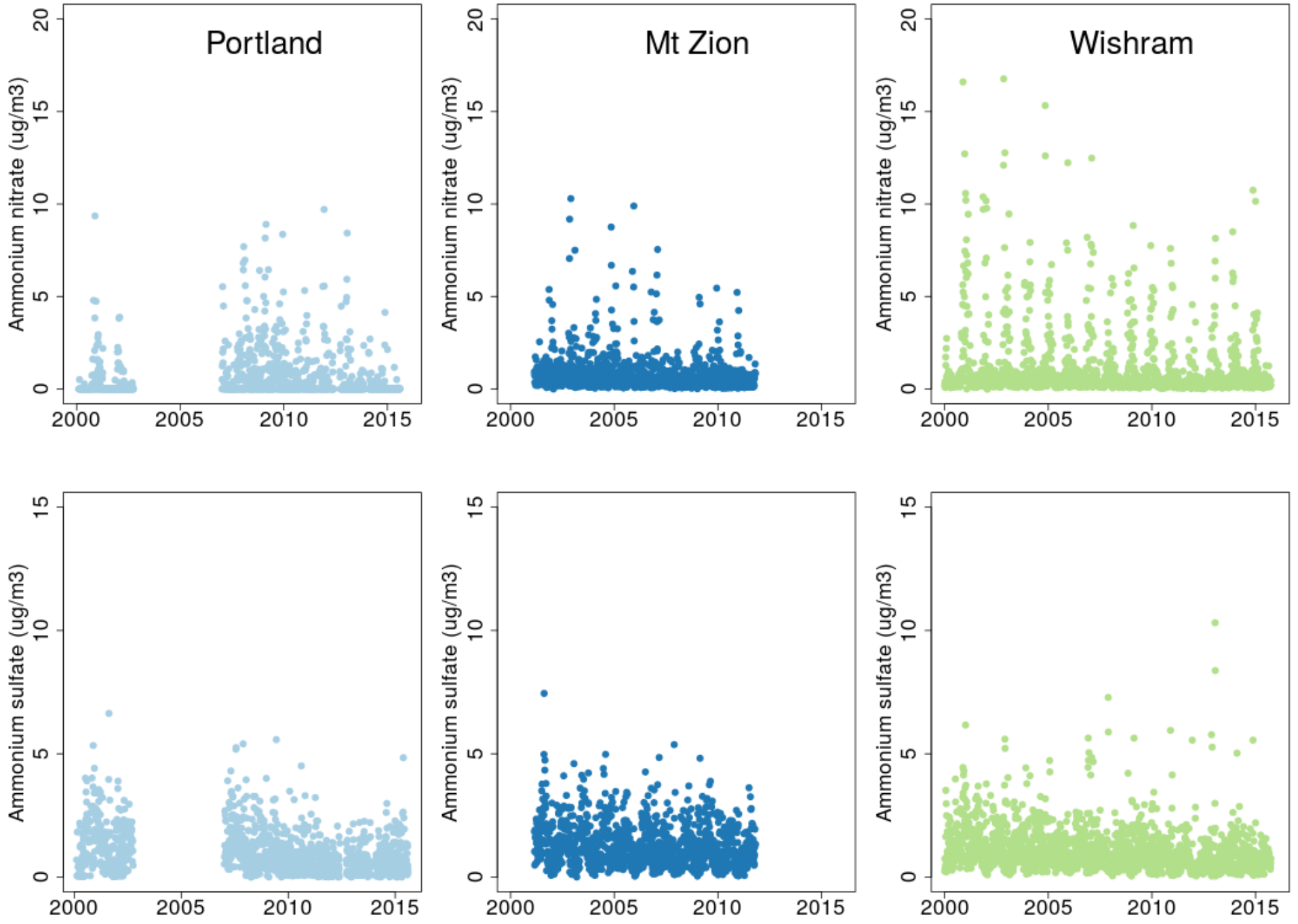
Outline

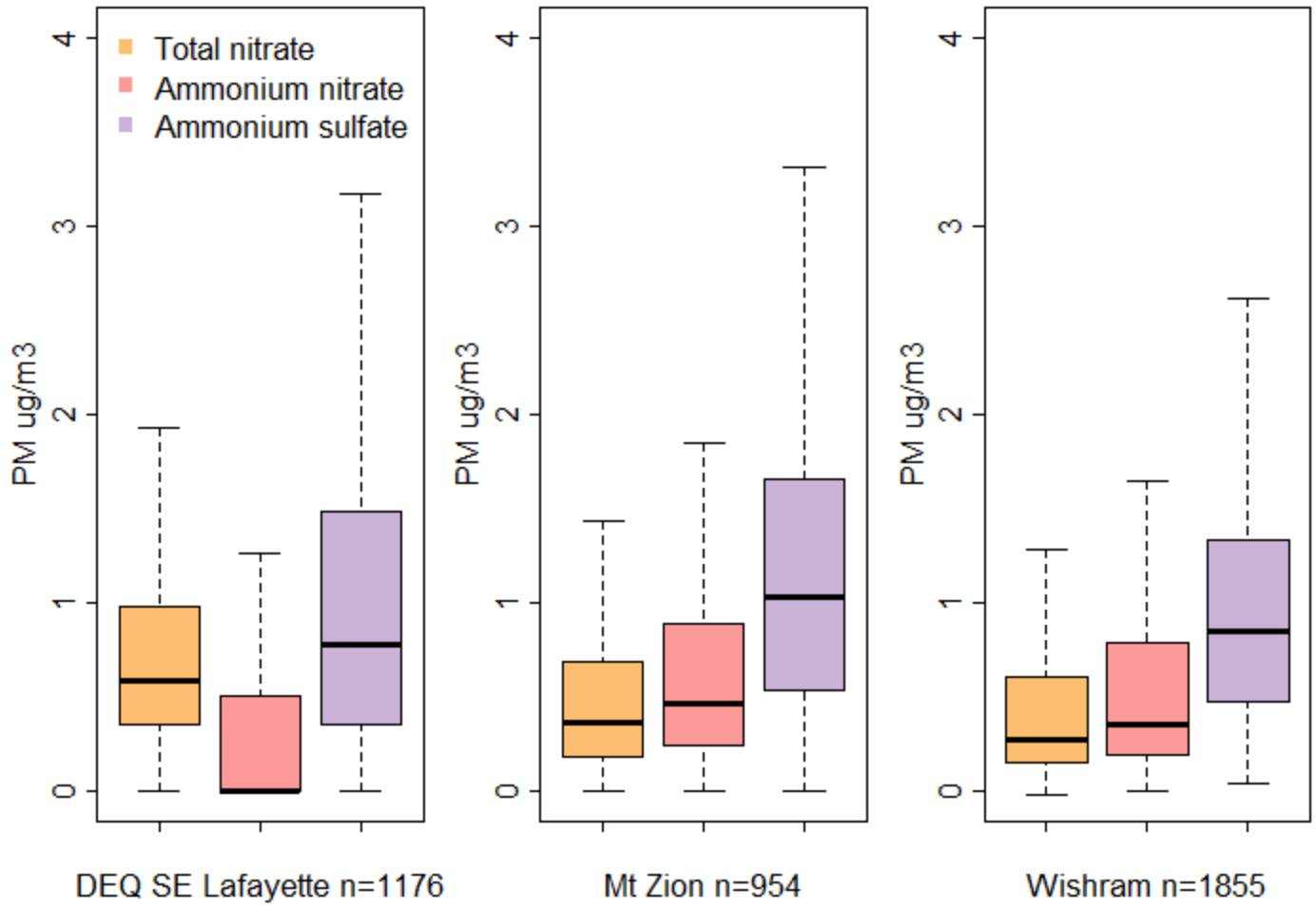
- Historical levels of secondary inorganic aerosol (SIA)
- Field observations
- Box model predictions


Portland
Ammonium nitrate (ug/m3)
0
5
10
15
20
2000
2005
2010
2015

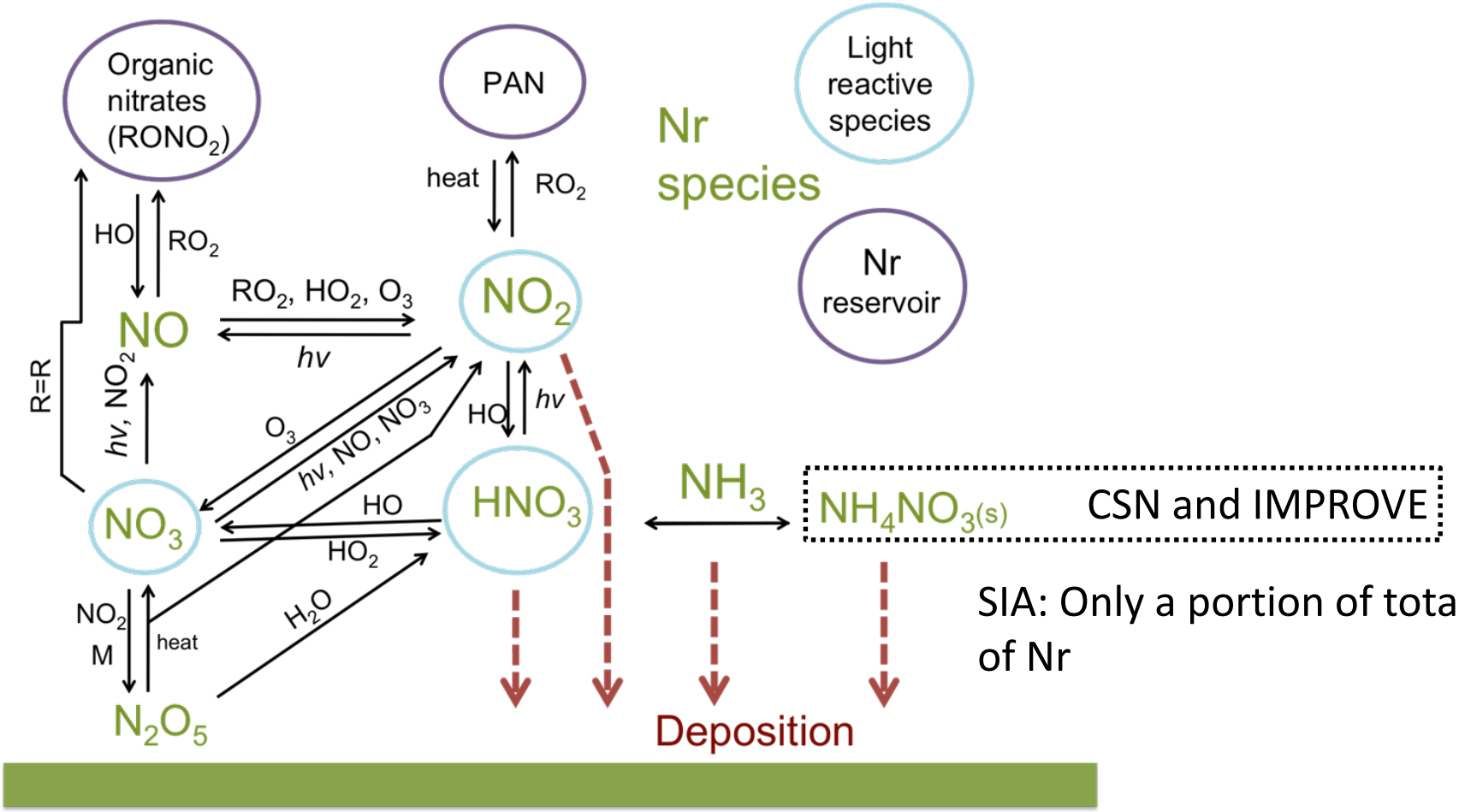

Mt Zion
Ammonium nitrate (ug/m3)
0
5
10
15
20
2000
2005
2010
2015

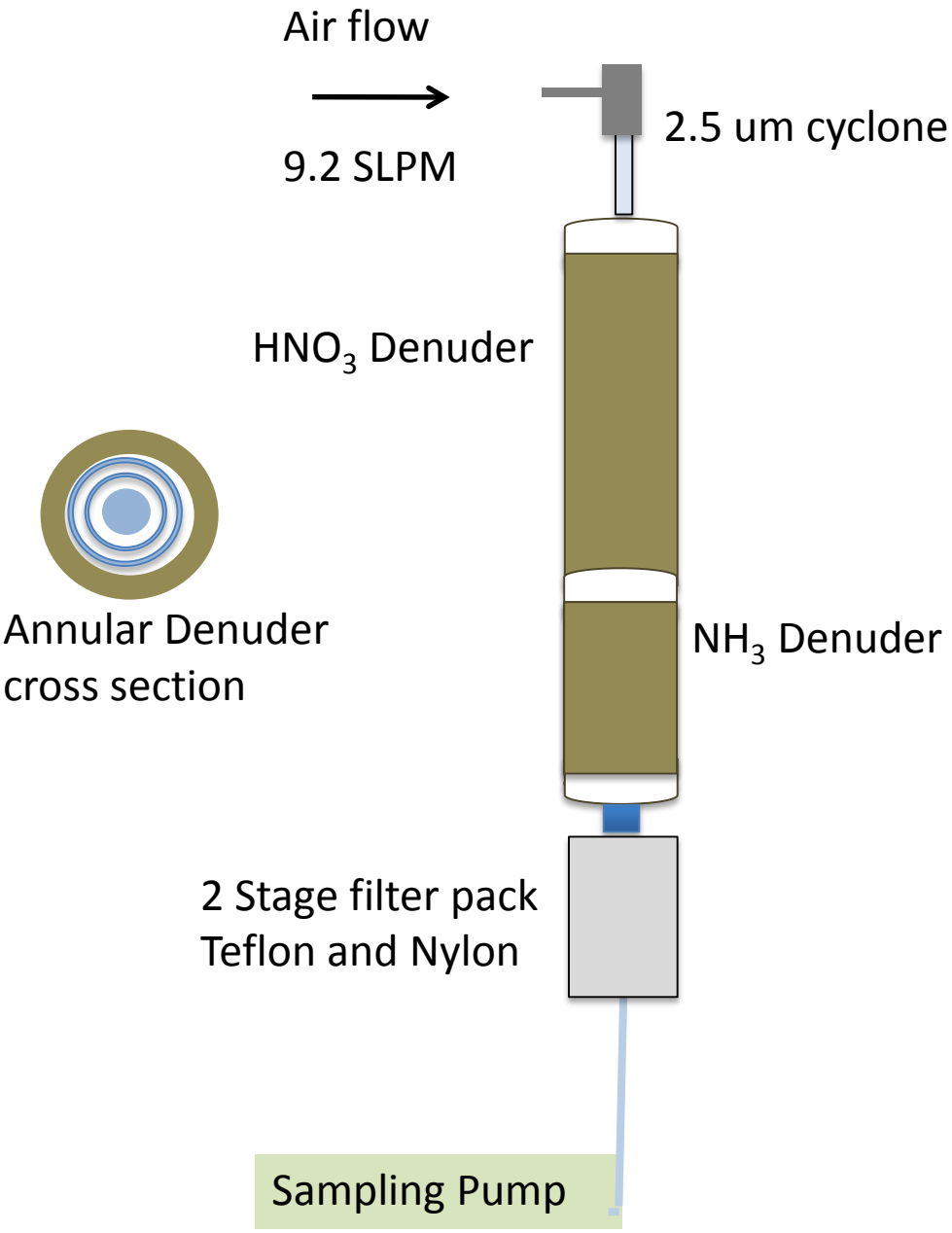

Wishram
Ammonium nitrate (ug/m3)
0
5
10
15
20
2000
2005
2010
2015


Portland
Mt Zion
Wishram
Ammonium nitrate (ug/m3)
Ammonium sulfate (ug/m3)
0
5
10
15
20
2000
2005
2010
2015


Total nitrate
Ammonium nitrate
Ammonium sulfate
PM ug/m3
0
1
2
3
4
DEQ SE Lafayette n=1176
Mt Zion n=954
Wishram n=1855

Can thermodynamic and kinetic box modeling to predict SIA partitioning, precursors and N deposition in the CRG?





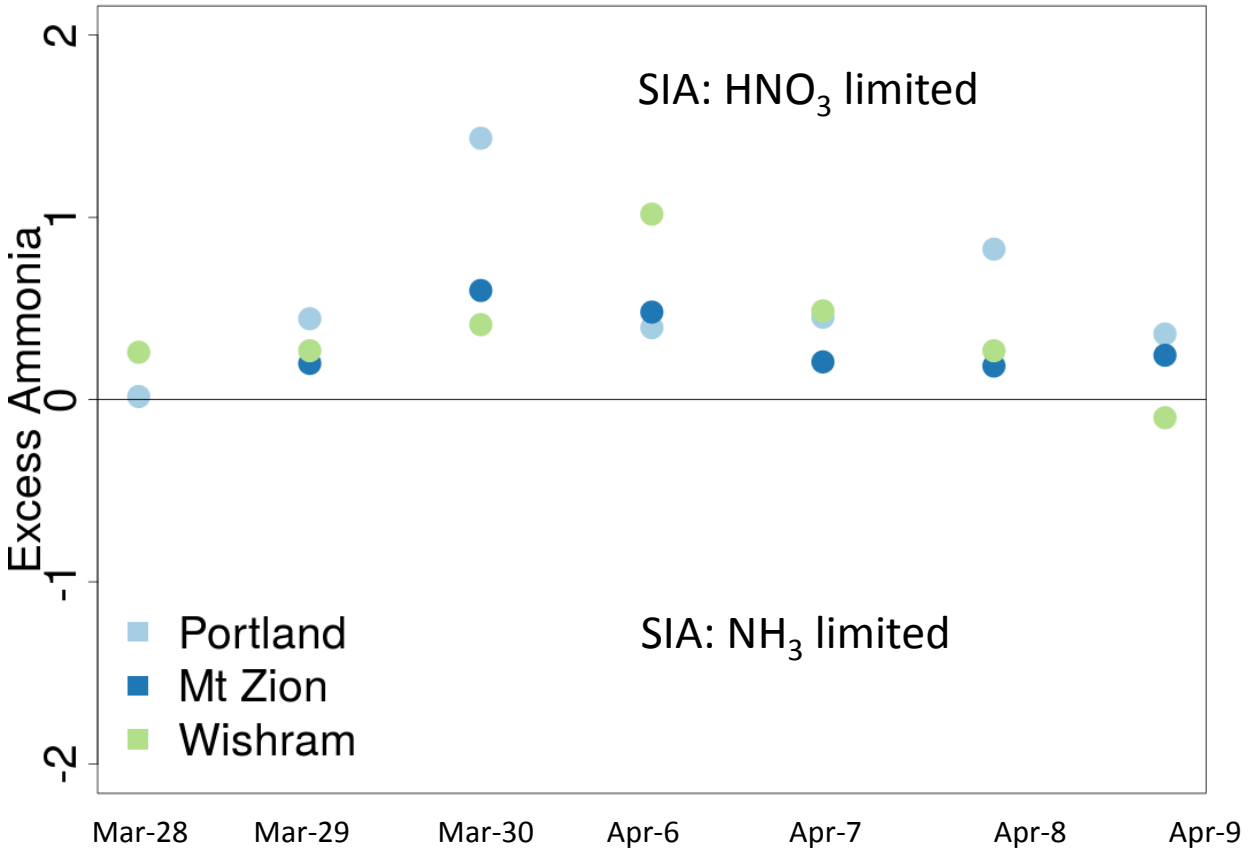
24 hours observations:

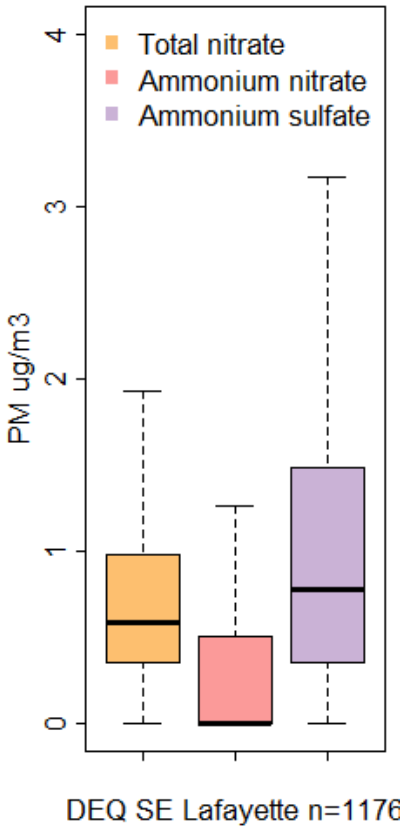
NH_3, HNO_3, PM nitrate, ammonium, and sulfate

Continuous observations:

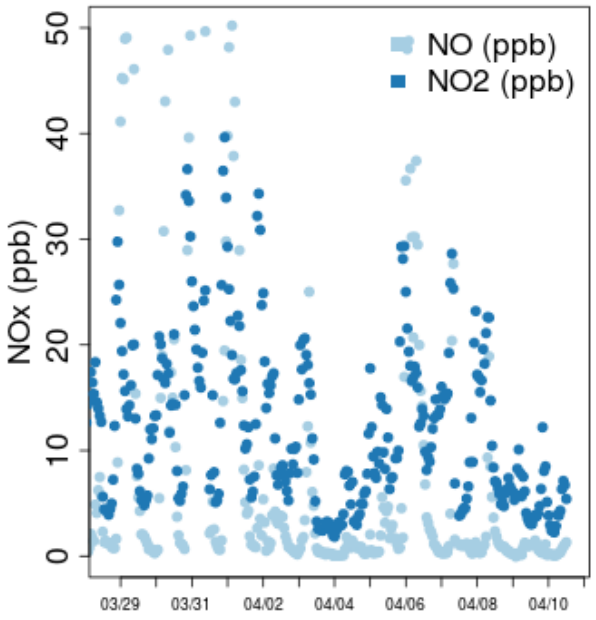
NOx, O_3, bscat, WS, WD, RH, Temp, NOy

NH_3 is playing a larger role in SIA production

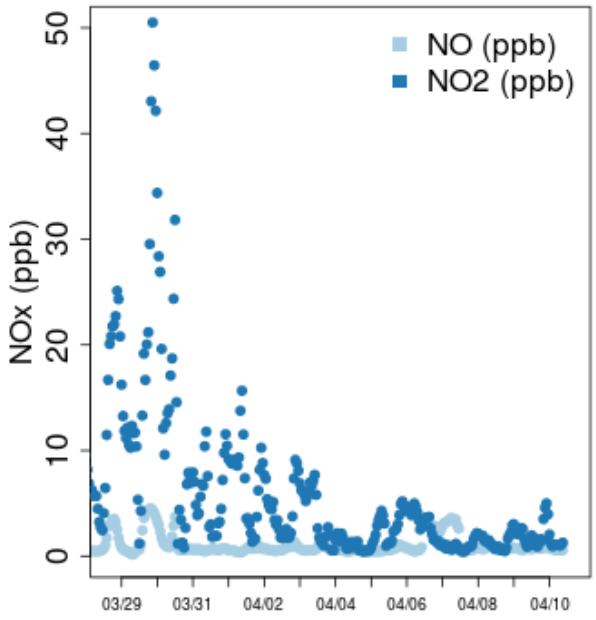




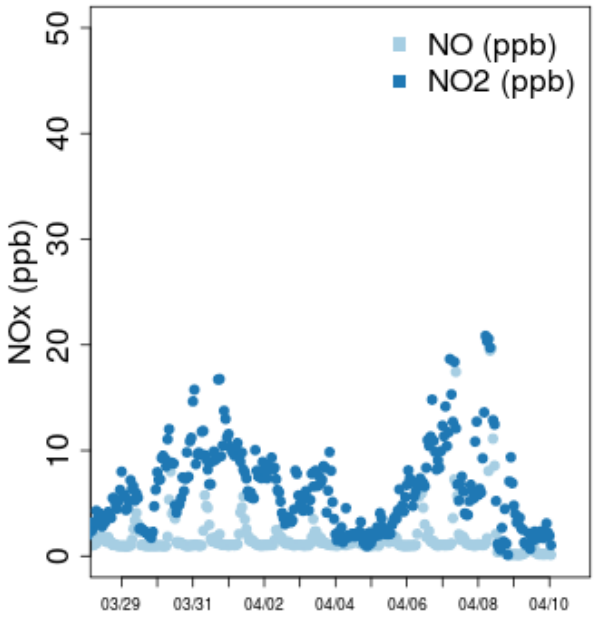
Excess NH_3 (EA) = NH_3 + NH_4^+ - $2SO_4^{2-}$ - NO_3^- - HNO_3



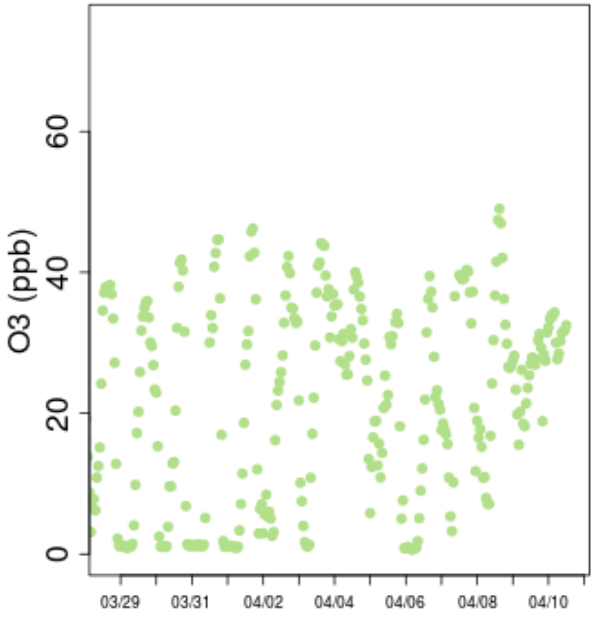
Portland

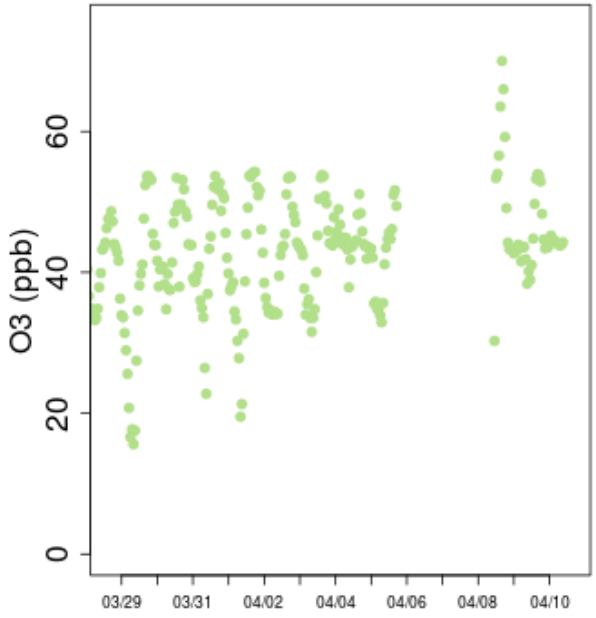


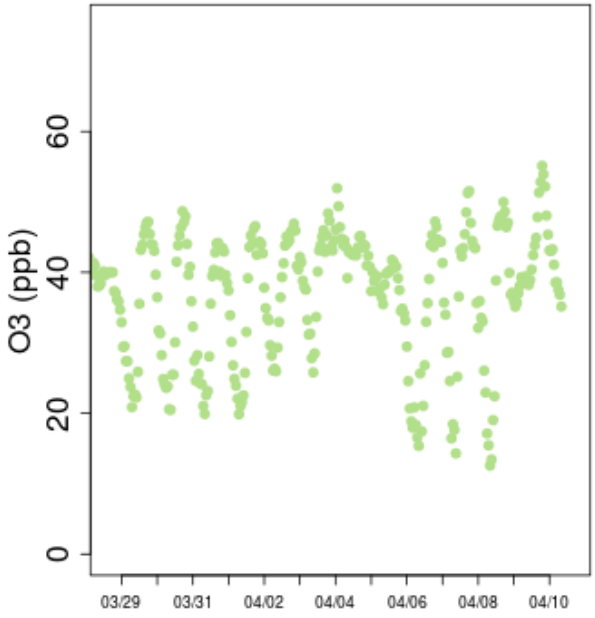
Mt Zion

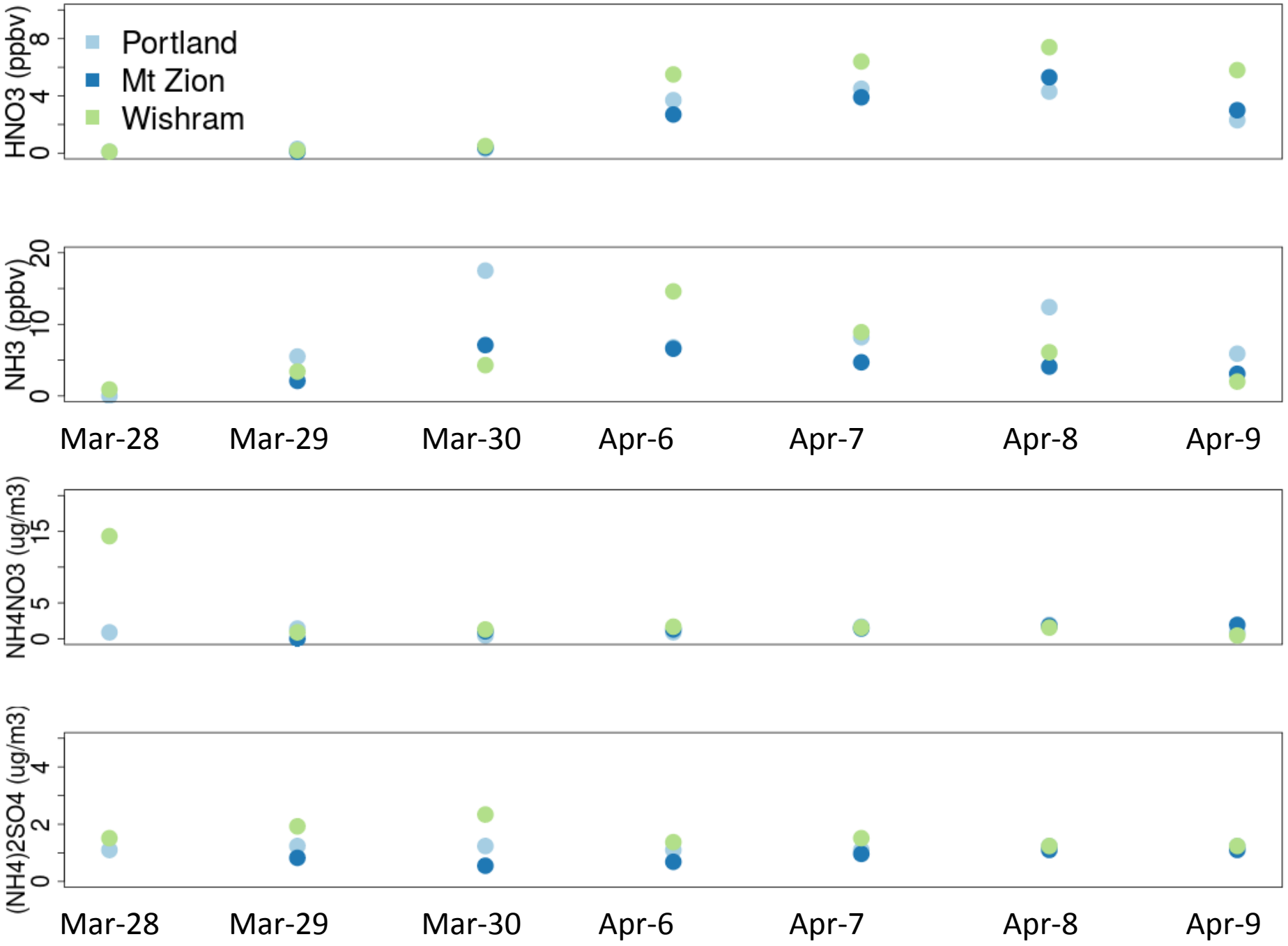


Wishram



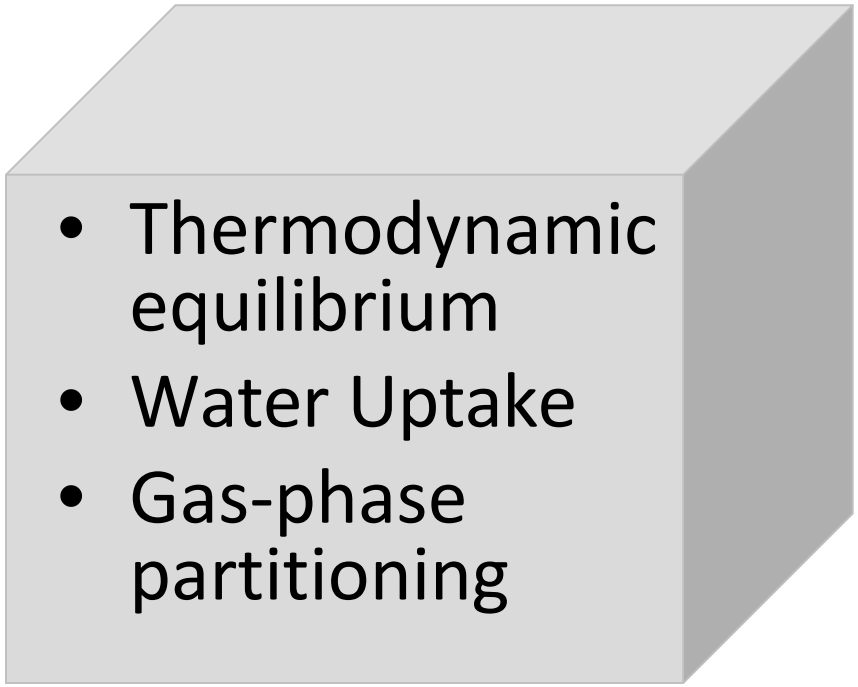




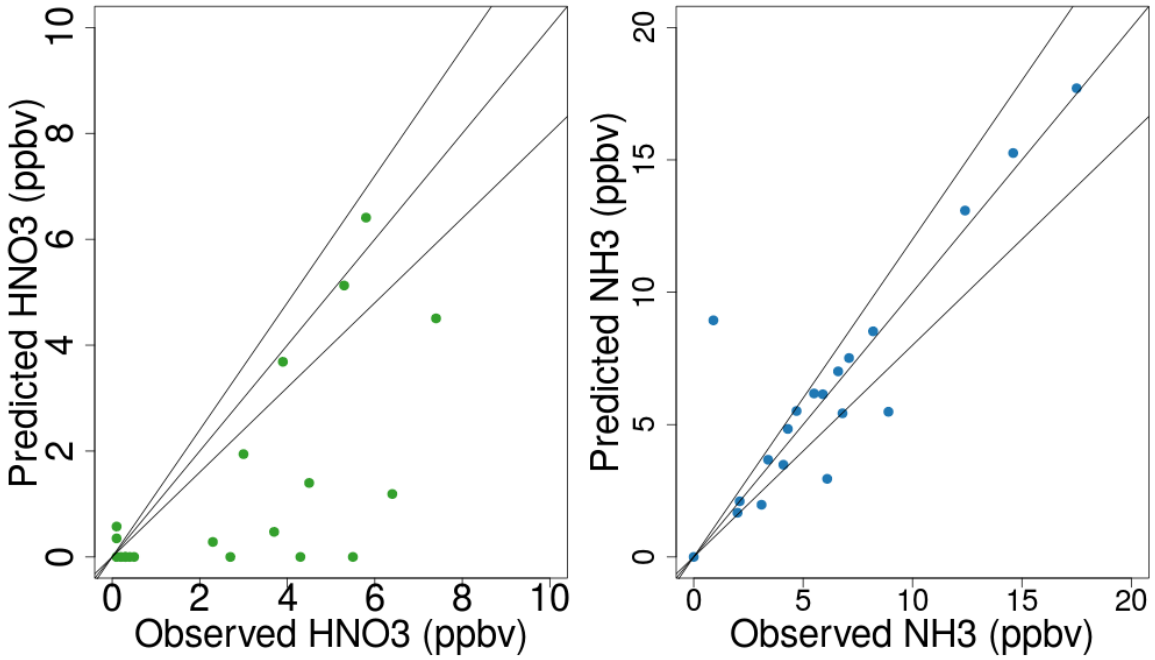

Portland
Mt Zion
Wishram
HNO3 (ppbv)
0
4
8
NH3 (ppbv)
0
10
20
Mar-28
Mar-29
Mar-30
Apr-6
Apr-7
Apr-8
Apr-9
NH4NO3 (ug/m3)
0
5
15
(NH4)2SO4 (ug/m3)
0
2
4
Mar-28
Mar-29
Mar-30
Apr-6
Apr-7
Apr-8
Apr-9

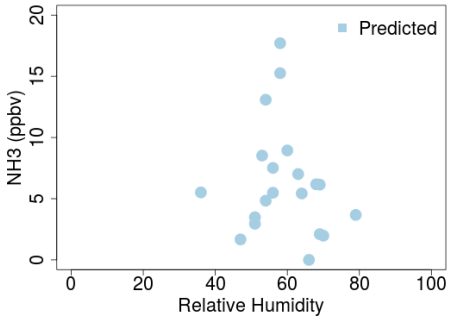
ISORROPIA Model

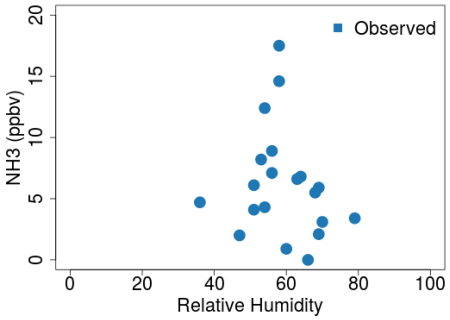
Total gas
+
aerosol,
Temp, RH

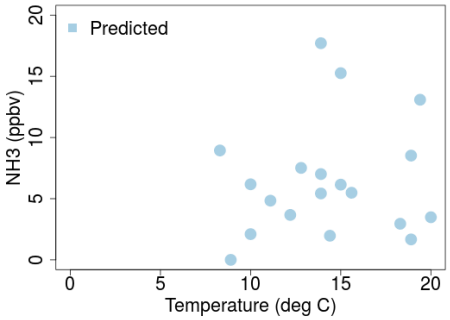


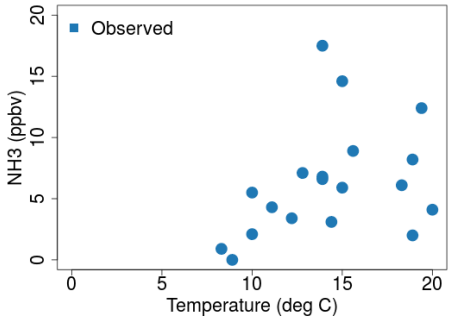
Inorganic Composition and phase state at equilibrium

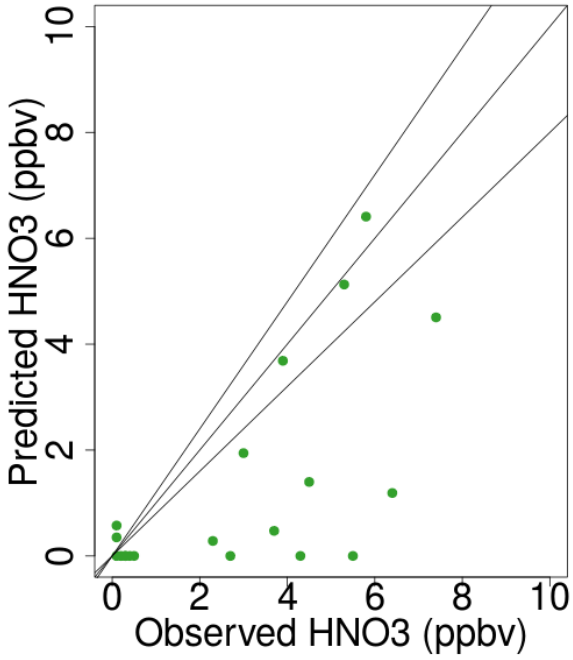

Predicted HNO3 (ppbv)
Observed HNO3 (ppbv)
0
2
4
6
8
10
Predicted NH3 (ppbv)
Observed NH3 (ppbv)
0
5
10
15
20

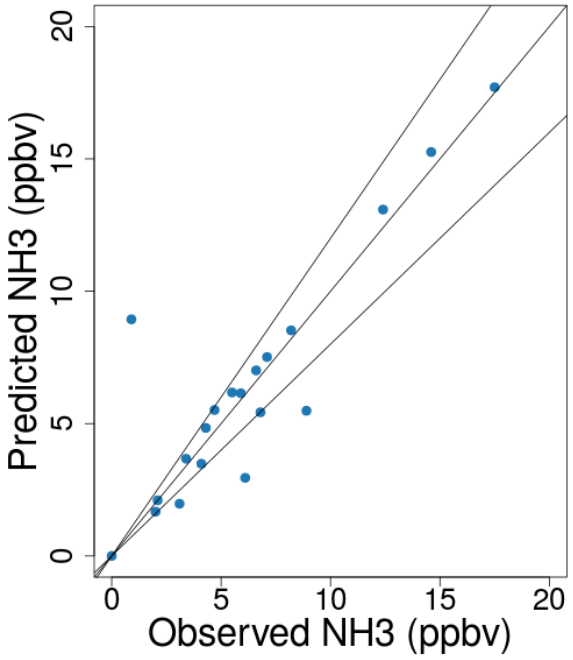

Predicted
NH3 (ppbv)
Relative Humidity

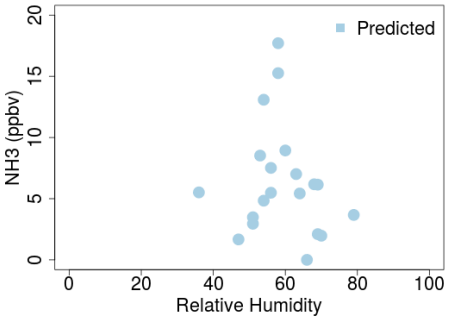

Observed
NH3 (ppbv)
Relative Humidity

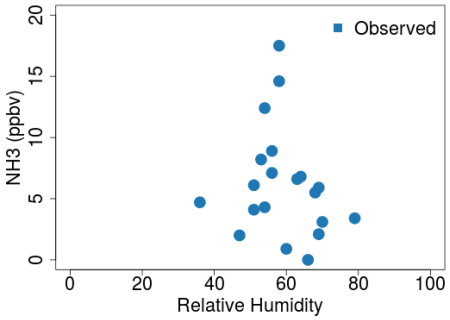

Predicted
NH3 (ppbv)
Temperature (deg C)

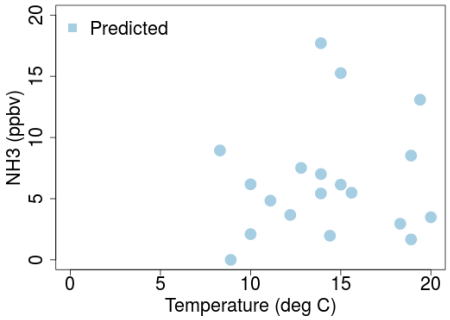

Observed
NH3 (ppbv)
Temperature (deg C)

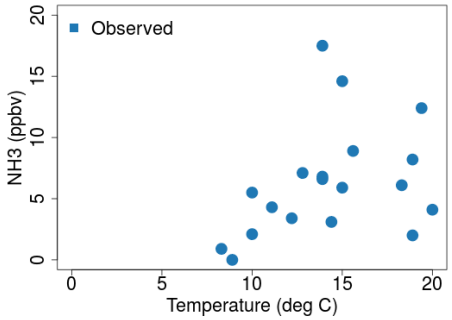

Predicted HNO3 (ppbv)
Observed HNO3 (ppbv)

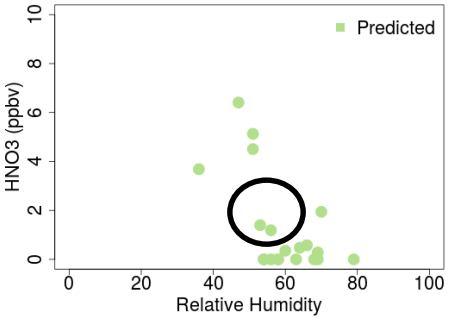

Predicted NH3 (ppbv)
Observed NH3 (ppbv)

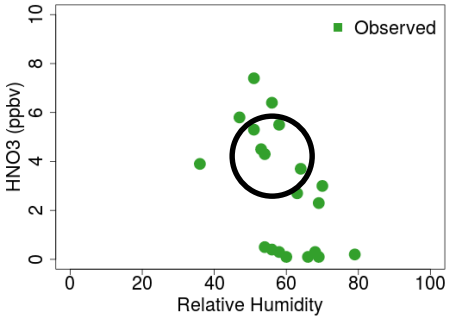


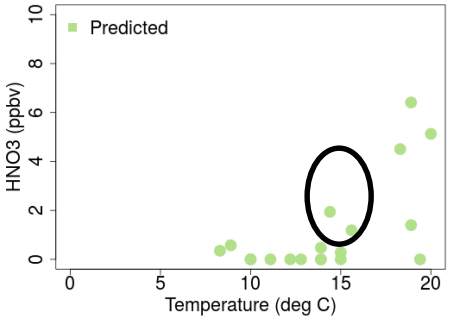


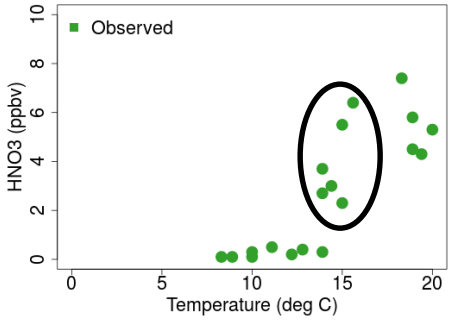


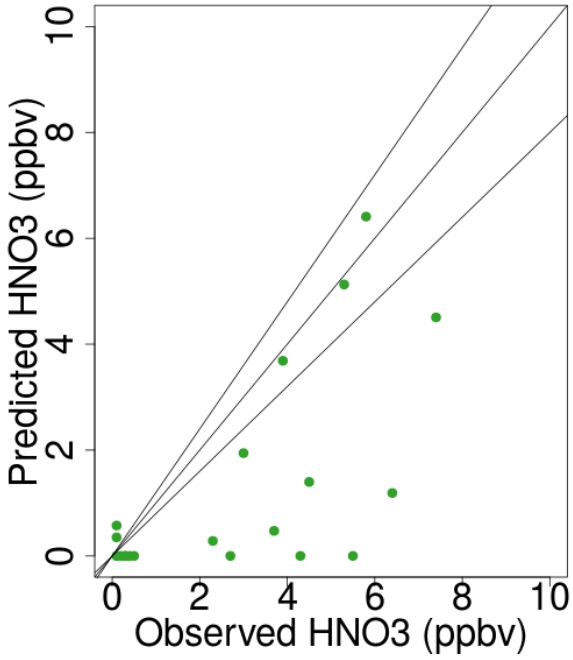


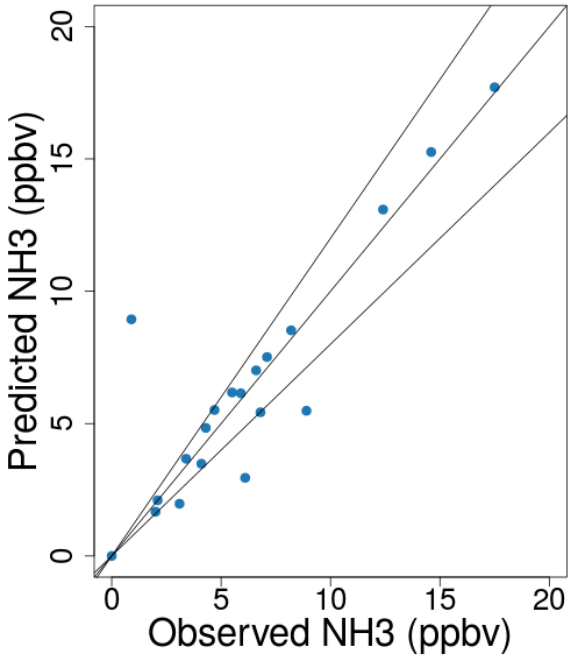




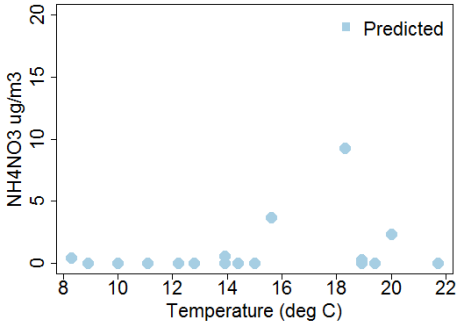


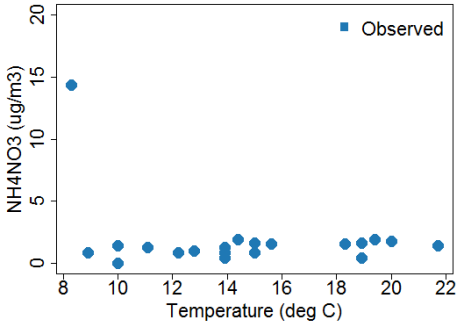


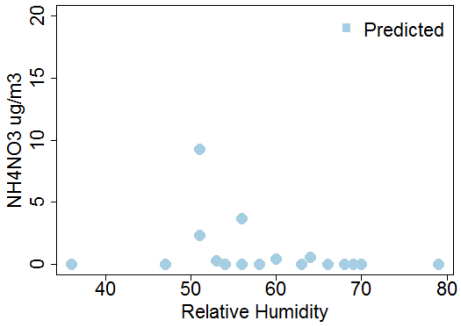


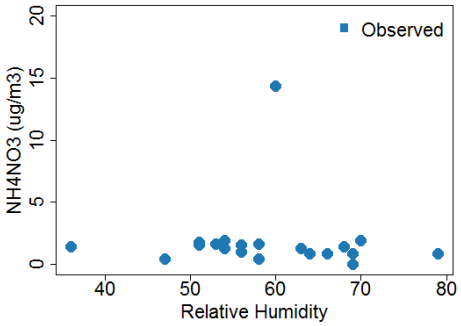


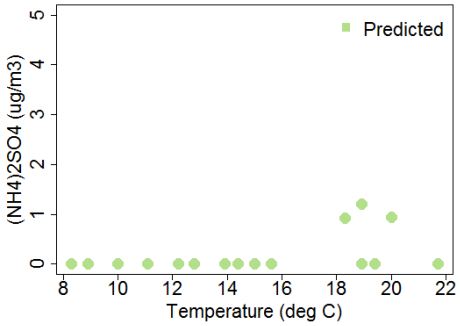
HNO_3 is under-predicted at ~15 deg C and ~ 50-60% RH

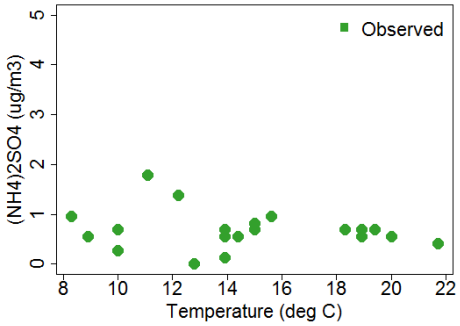


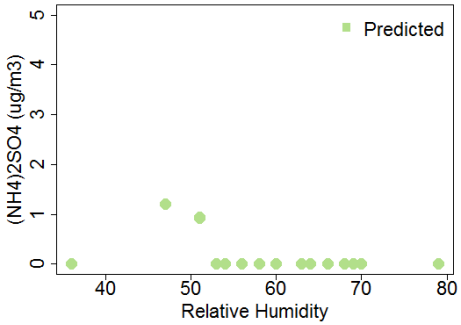


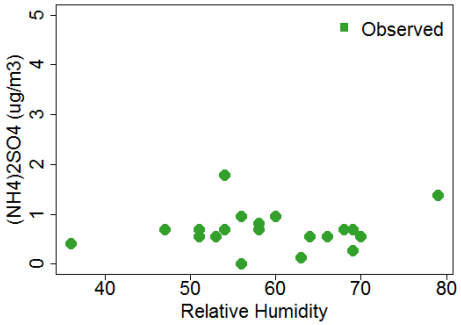


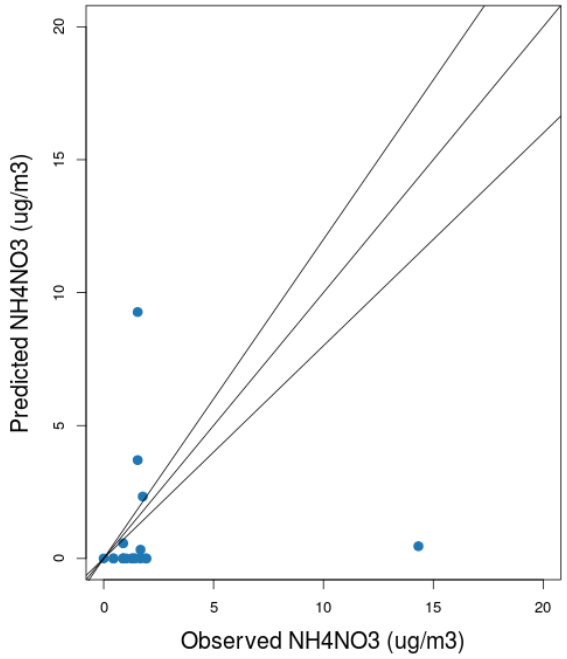


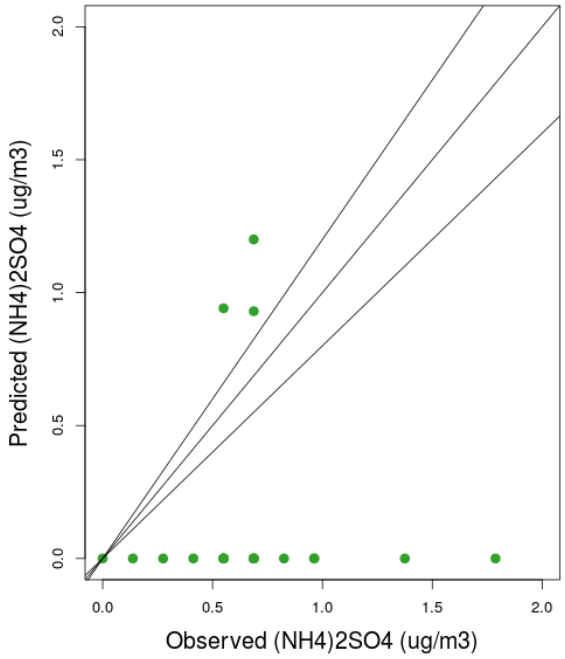












Without predicted HNO_3 well, SIA is not well represented either

Summary

- NH_3 and HNO_3 needs more measurements
- NH_3 is well predicted in thermodynamic models
- HNO_3 is not at 50-60% RH and ~15 deg C
- NH_4NO_3 important in total N deposition

Next Steps

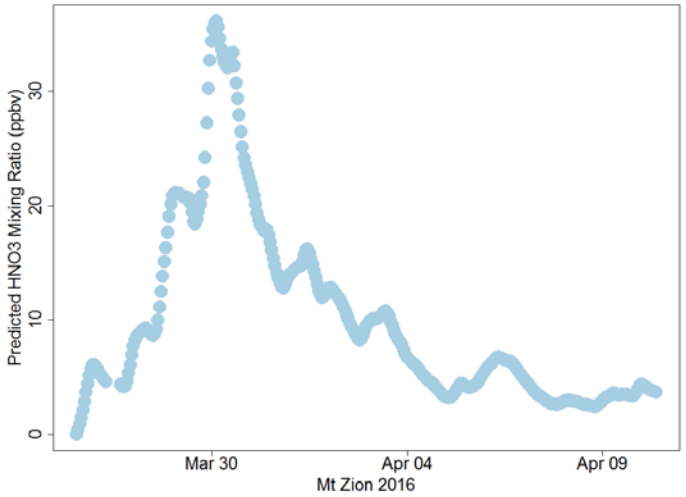
Mass in →

PAMOL Box Model

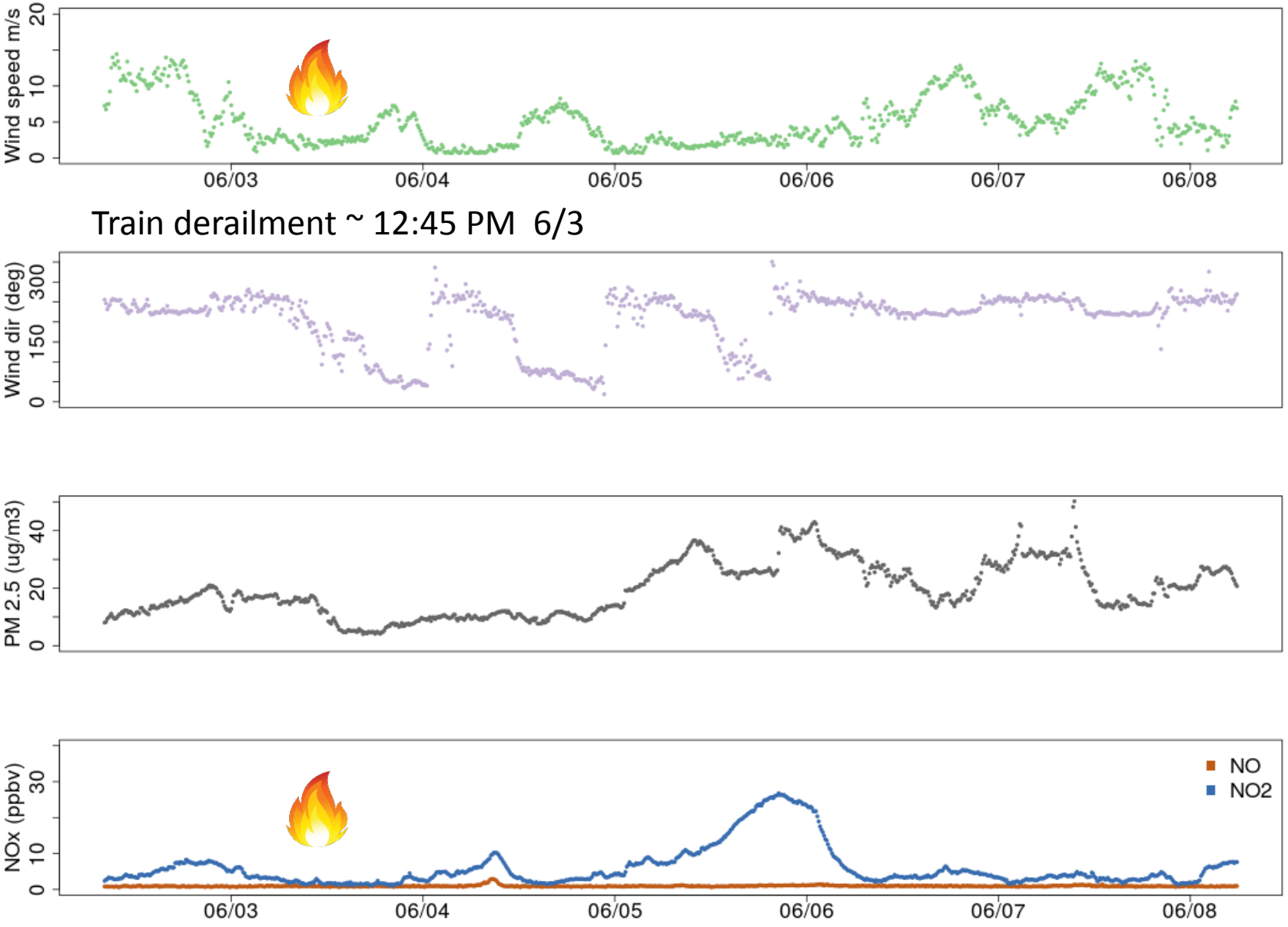
- Kinetics as a function of time
  - SAPRC99
  - TUV Photolysis rates

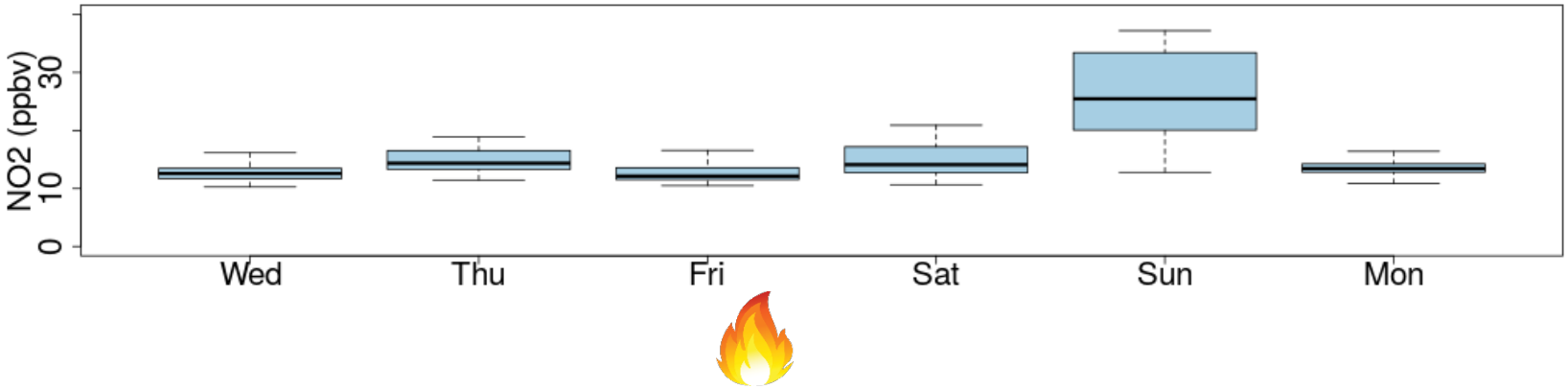
→ Secondary formation Mass out

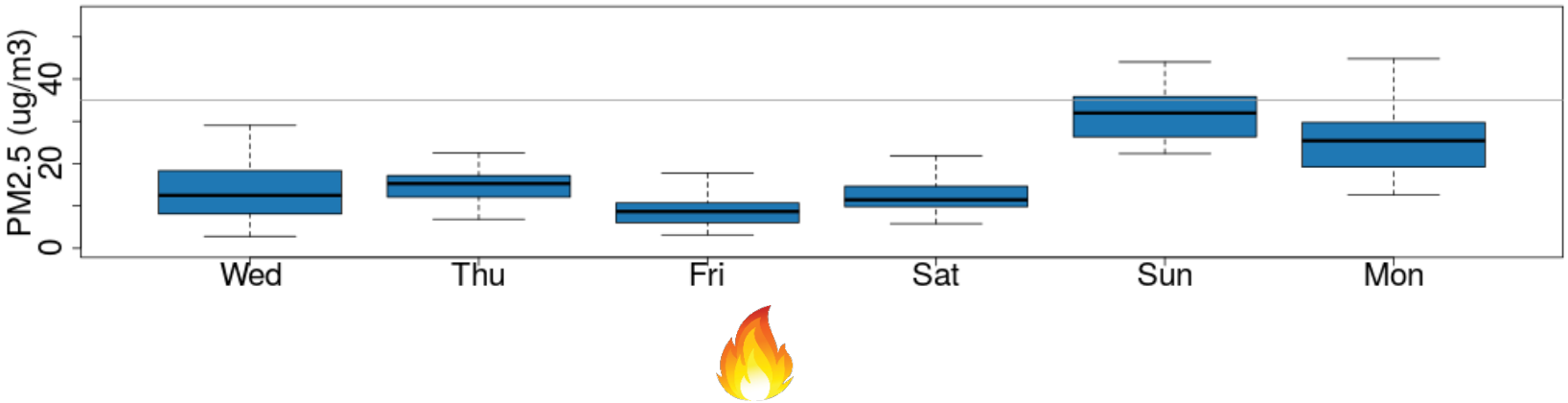
- Gas phase HNO3 predictions
- Estimated NH3 deposition
- Fraction of NHx in total N deposition

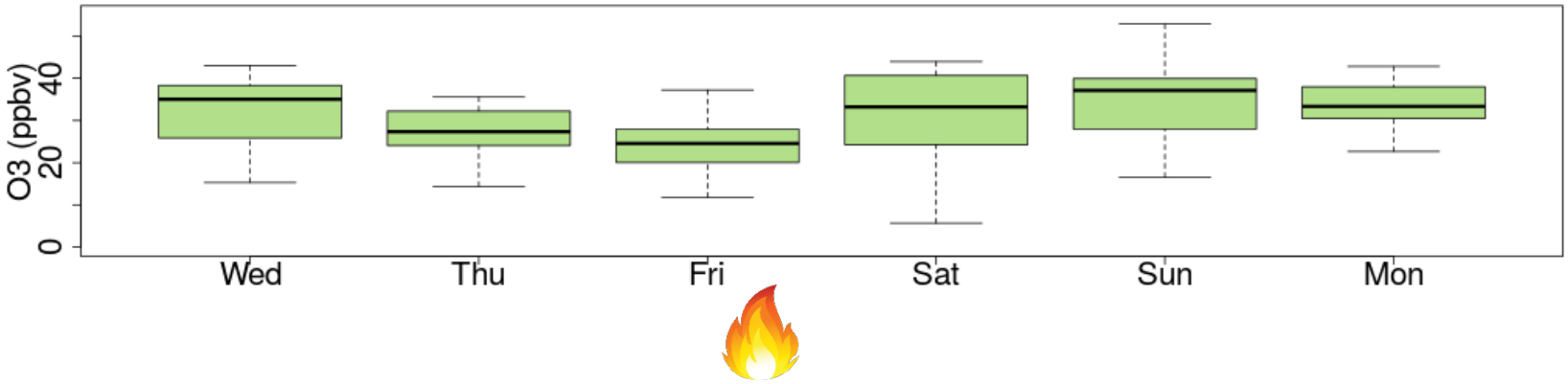


A little about the 6/3 train derailment…




NO2 (ppbv)
0
10
30
Wed
Thu
Fri
Sat
Sun
Mon

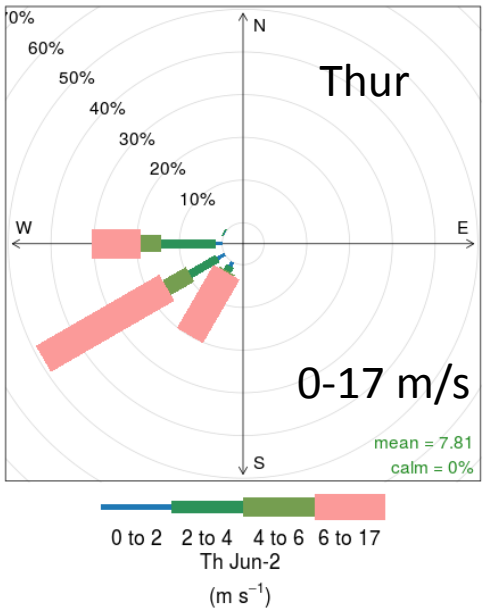

PM2.5 (ug/m3)
0
20
40
Wed
Thu
Fri
Sat
Sun
Mon

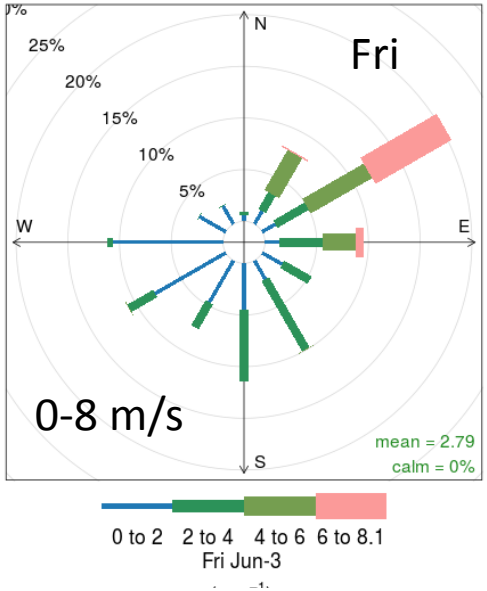

O3 (ppbv)
0
20
40
Wed
Thu
Fri
Sat
Sun
Mon

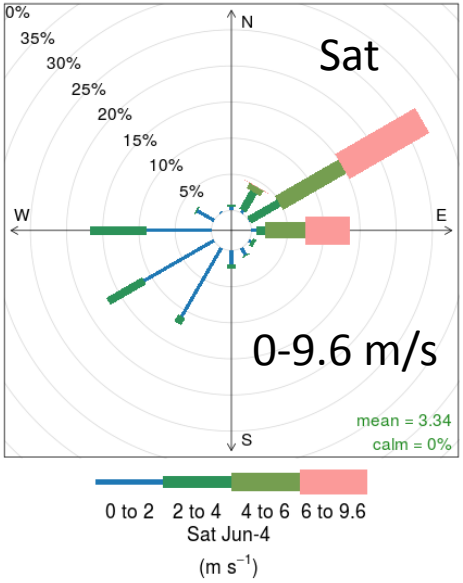
Thank you!

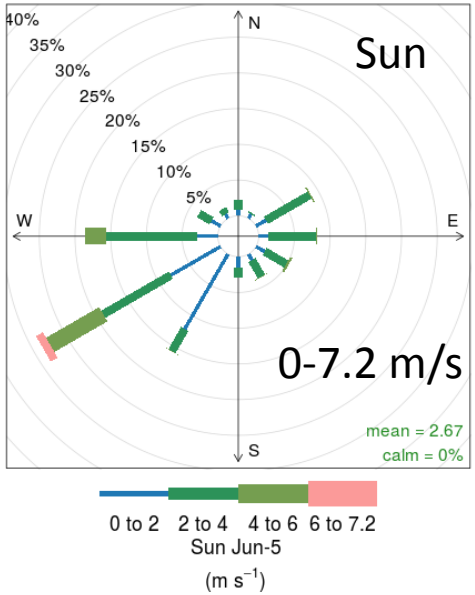
jmainord@pdx.edu

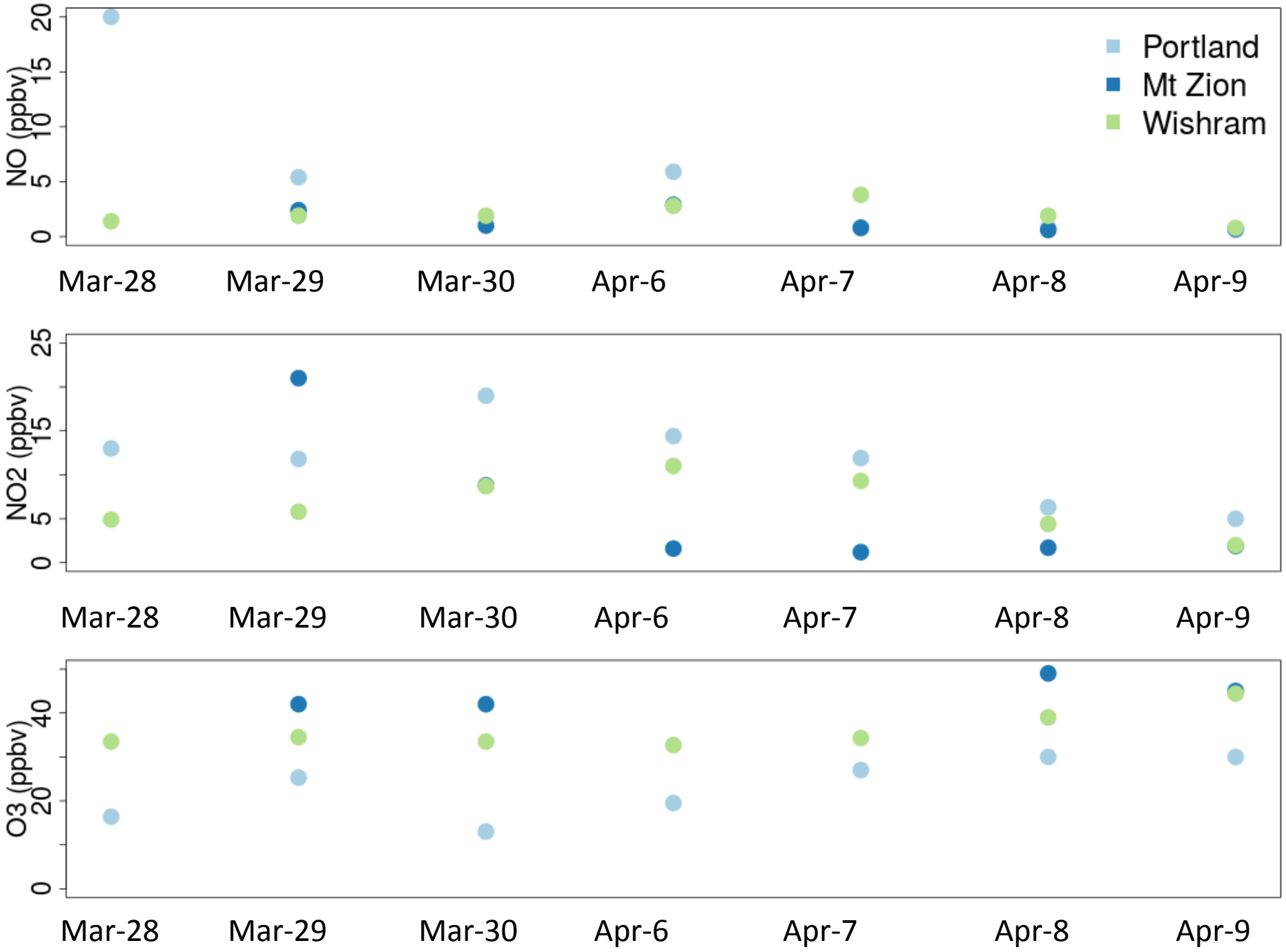
Rick Graw, United States Forest Service
Christine Kendrick
Meenakshi Rao
Holly Neill
Philip Orlando
Dr. Julie Fry, Reed College
Laura Krauss


Thur
0-17 m/s
mean = 7.81
calm = 0%
N
S
W
E
60%
50%
40%
30%
20%
10%
0 to 2
2 to 4
4 to 6
6 to 17
Th Jun-2
(m s⁻¹)


Fri
0-8 m/s
mean = 2.79
calm = 0%
N
S
W
E
25%
20%
15%
10%
5%
0 to 2
2 to 4
4 to 6
6 to 8.1
Fri Jun-3


Sat
0-9.6 m/s
mean = 3.34
calm = 0%
N
S
W
E
35%
30%
25%
20%
15%
10%
5%
0 to 2
2 to 4
4 to 6
6 to 9.6
Sat Jun-4
(m s⁻¹)


Sun
0-7.2 m/s
mean = 2.67
calm = 0%
N
S
W
E
40%
35%
30%
25%
20%
15%
10%
5%
0 to 2
2 to 4
4 to 6
6 to 7.2
Sun Jun-5
(m s⁻¹)


NO (ppbv)
0
5
10
15
20
Portland
Mt Zion
Wishram
Mar-28
Mar-29
Mar-30
Apr-6
Apr-7
Apr-8
Apr-9
NO2 (ppbv)
0
5
15
25
Mar-28
Mar-29
Mar-30
Apr-6
Apr-7
Apr-8
Apr-9
O3 (ppbv)
0
20
40
Mar-28
Mar-29
Mar-30
Apr-6
Apr-7
Apr-8
Apr-9