

Ammonia and Ammonium Measurements from the Southeastern U. S.

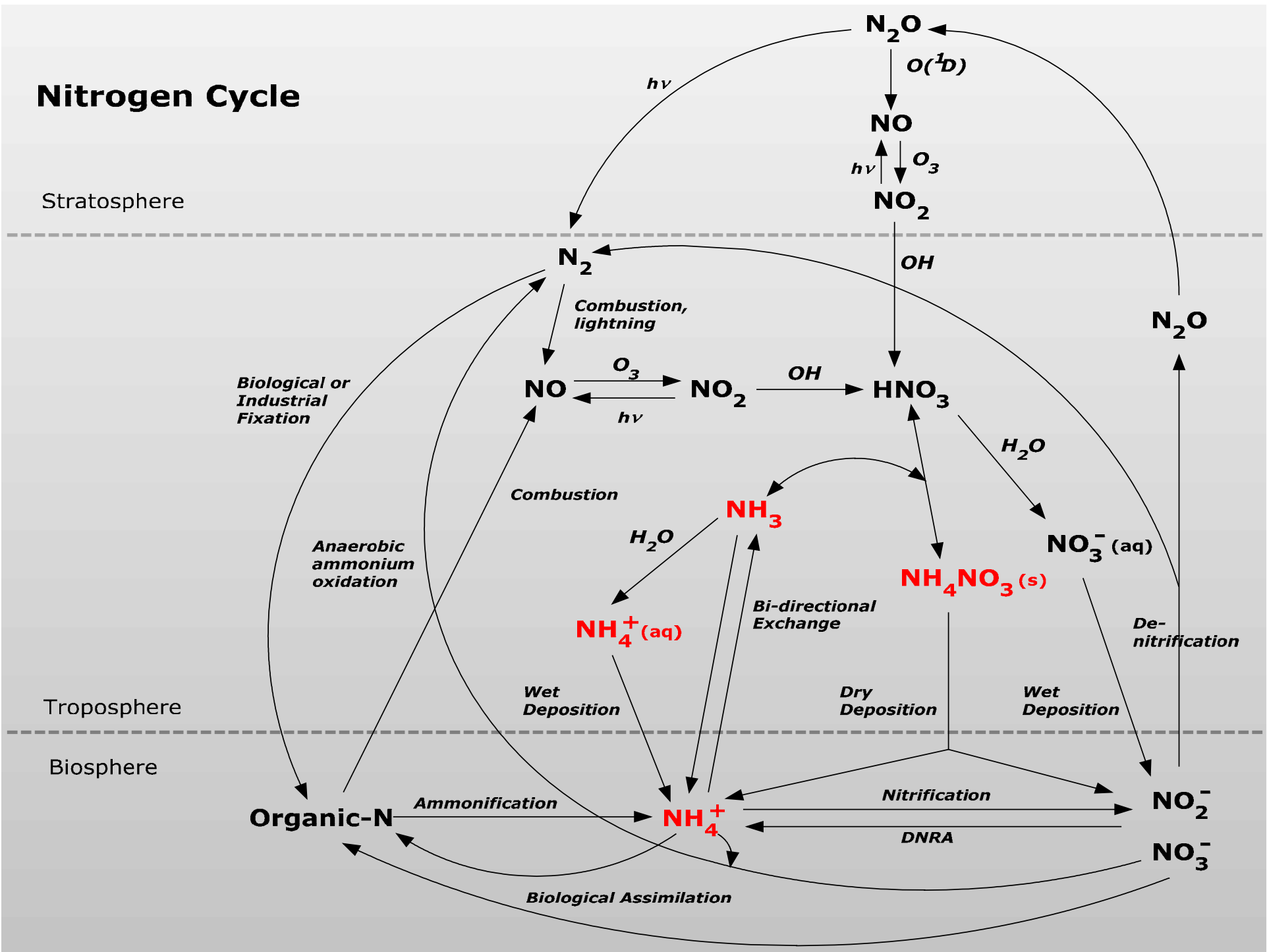
Rick D. Saylor, Karsten Baumann, Eric S. Edgerton,
and Benjamin E. Hartsell
Atmospheric Research & Analysis, Inc.

NADP Annual Meeting and Scientific Symposium
Madison, Wisconsin
October 14-16, 2008

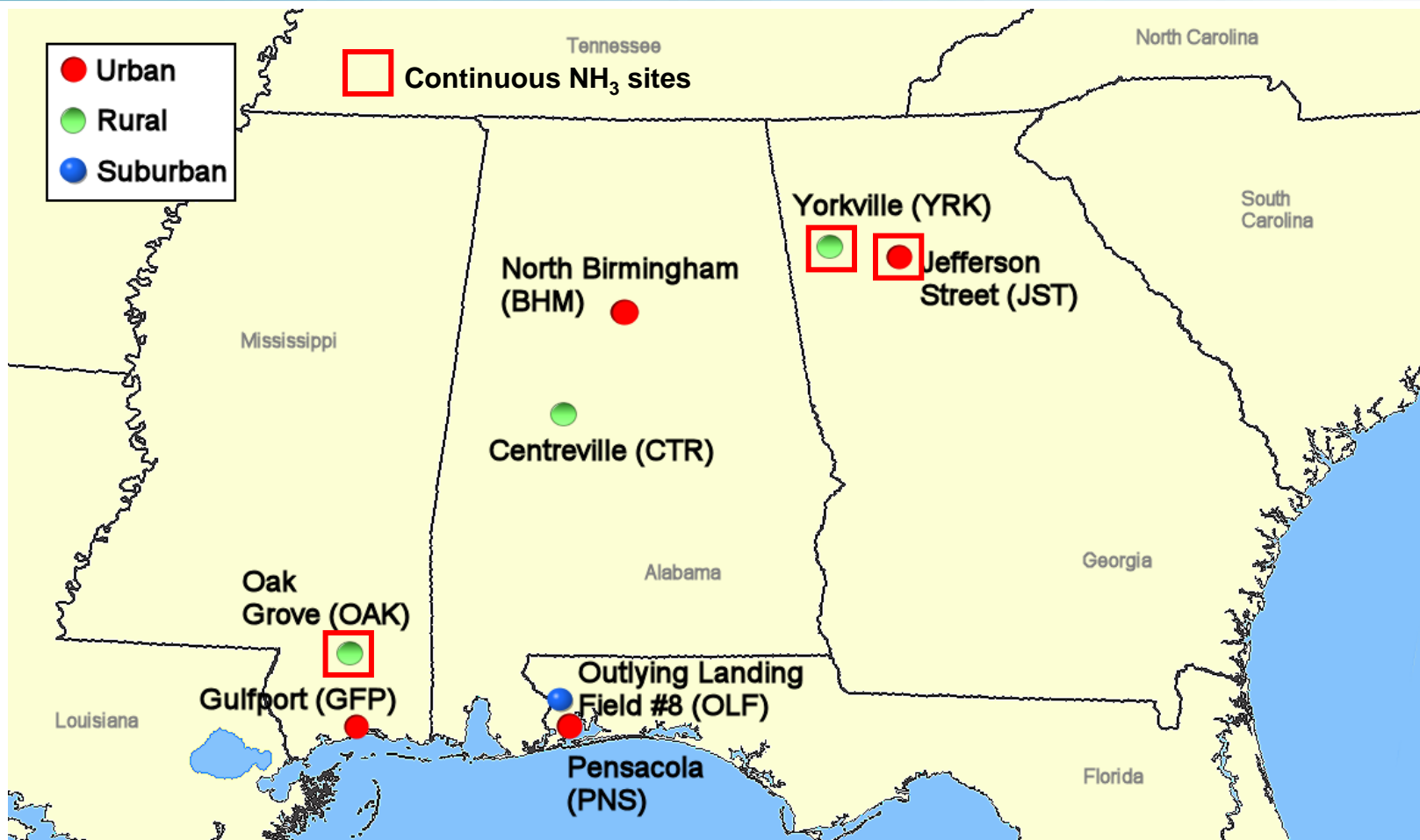
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Nitrogen Cycle



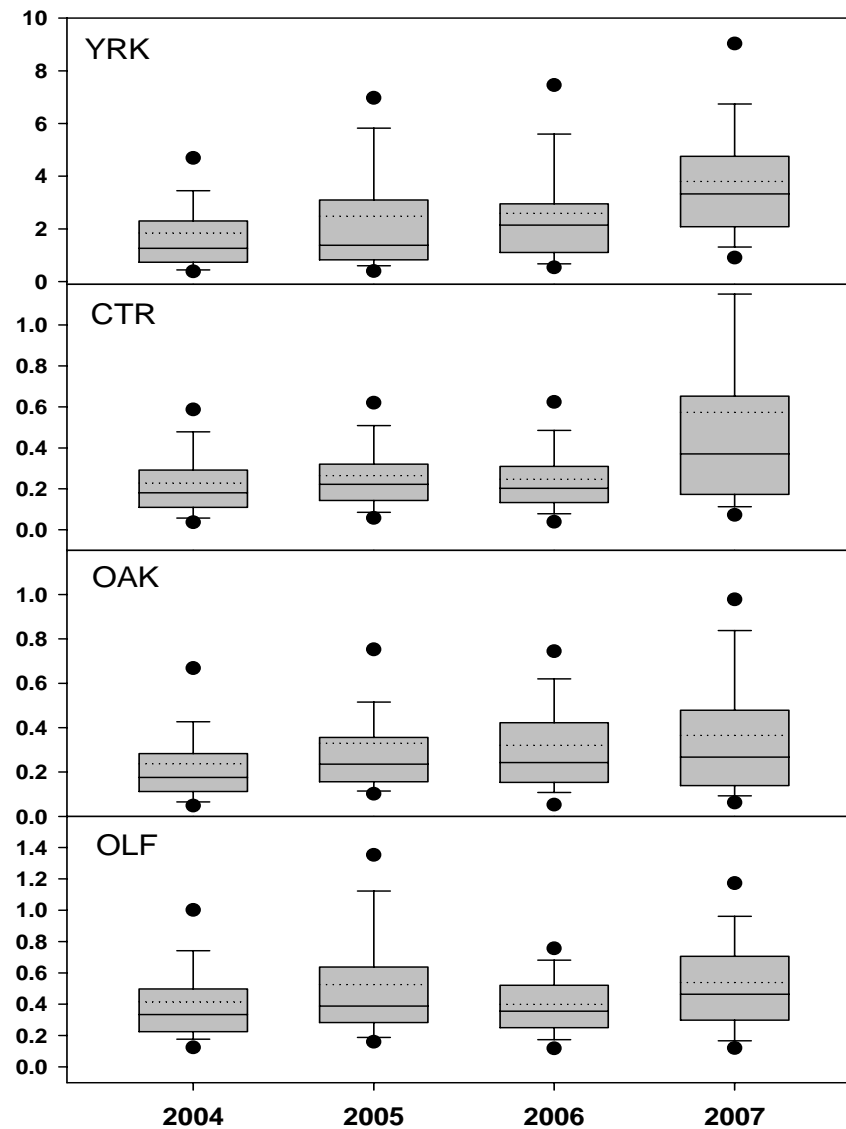
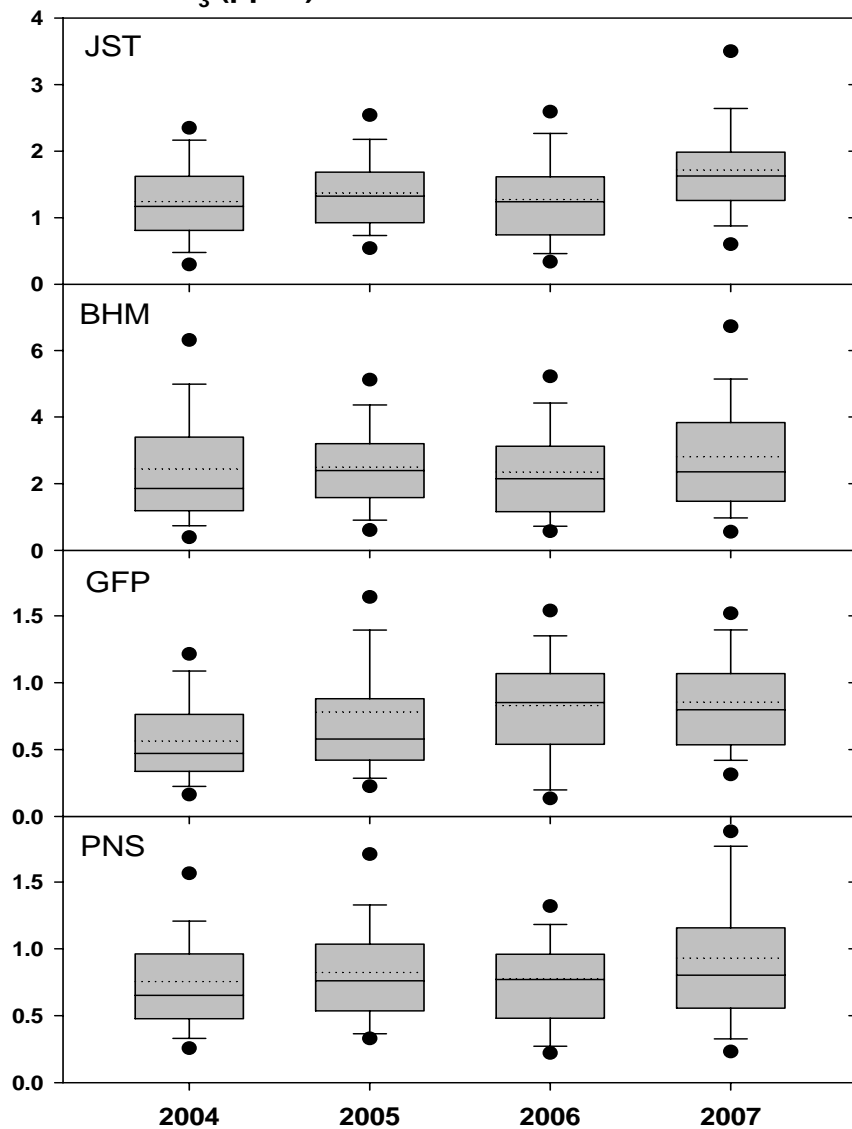
SEARCH Measurement Network



SEARCH Measurements

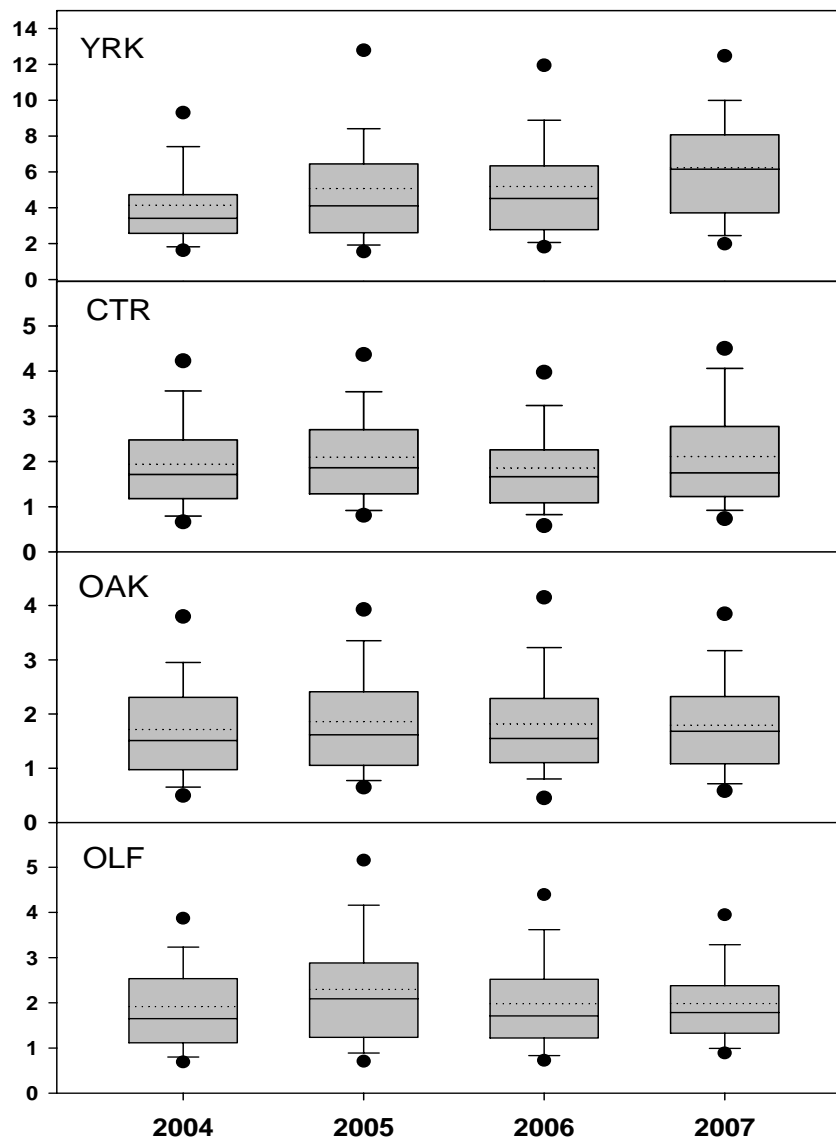
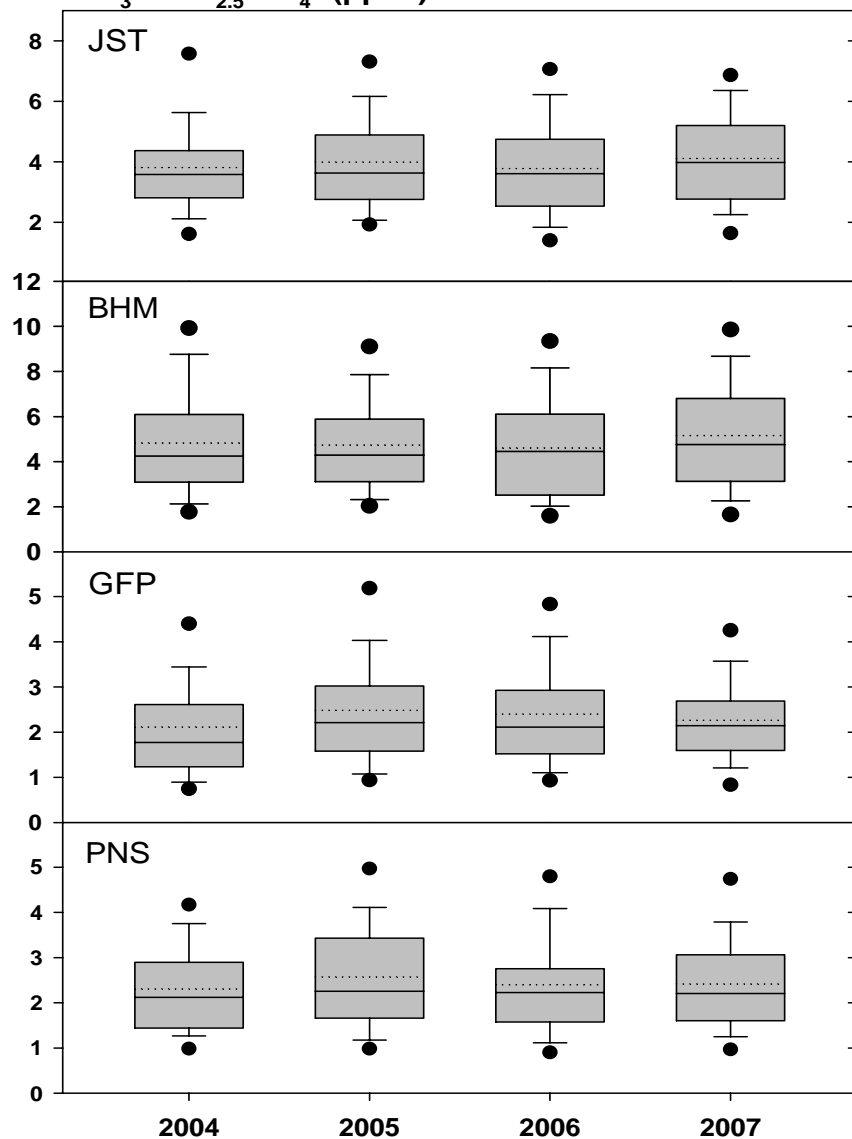
- Discrete Particles and Gases (24-hour)
 - » $PM_{2.5}$, $PM_{10-2.5}$ filter-based mass and chemical speciation (incl. $PM_{2.5}$ NH_4^+)
 - » NH_3 (denuder)
- Continuous Particles (5-min to 1-hr)
 - » $PM_{2.5}$, TC, OC, BC, NH_4^+ , NO_3^- , SO_4^{2-}
- Trace Gases (5-min to 1-hr)
 - » O_3 , NO, NO_2 , NO_y , HNO_3 , SO_2 , CO, NH_3
- Meteorology (5-min to 1-hr)
 - » WS, WD, T, RH, BP, SR, rainfall
- Visibility (5-min to 1-hr)
 - » B_{sp} (dry)

24-hr NH₃ (ppbv)



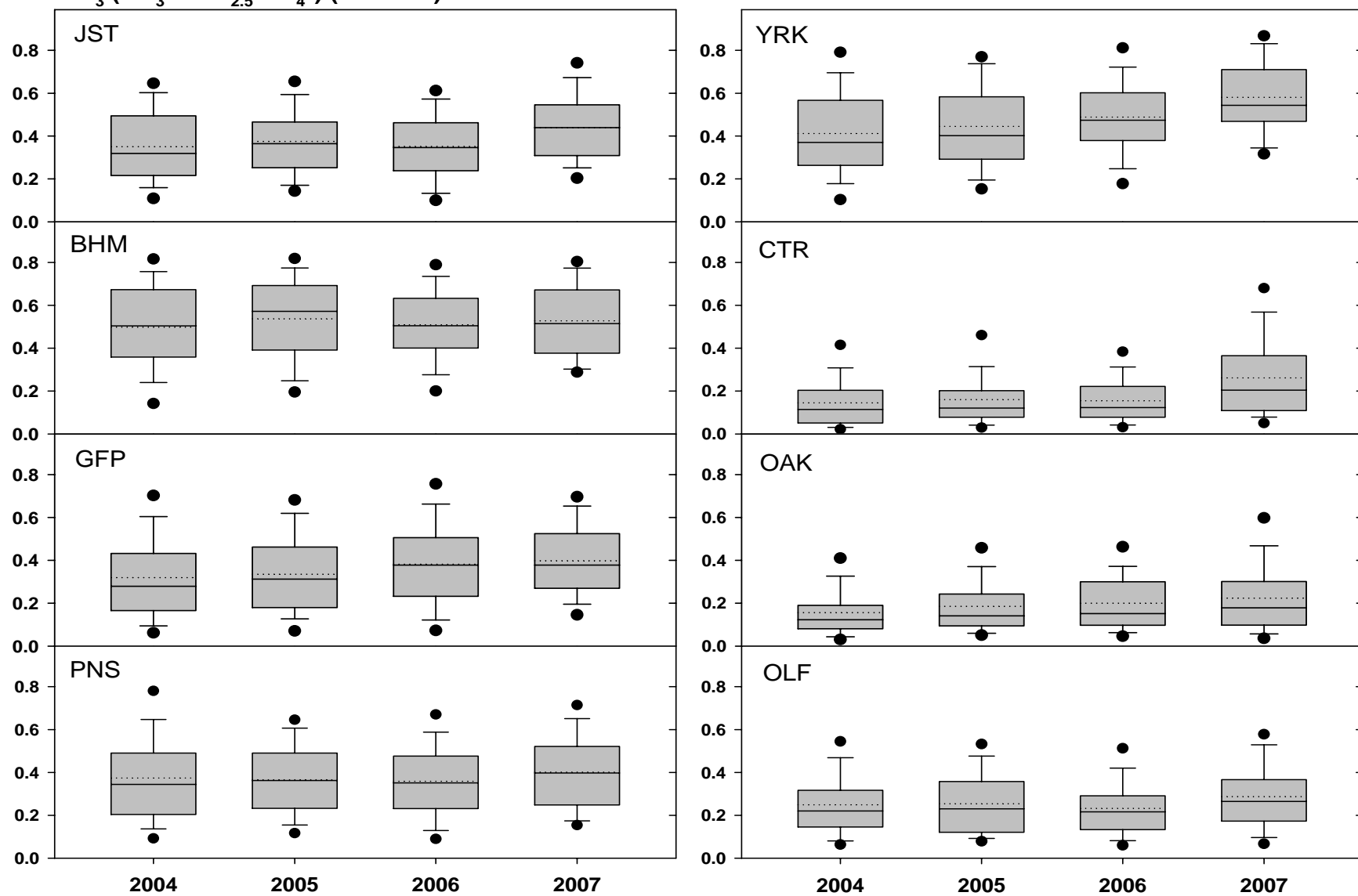
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NH₃ + PM_{2.5} NH₄⁺ (ppbv)

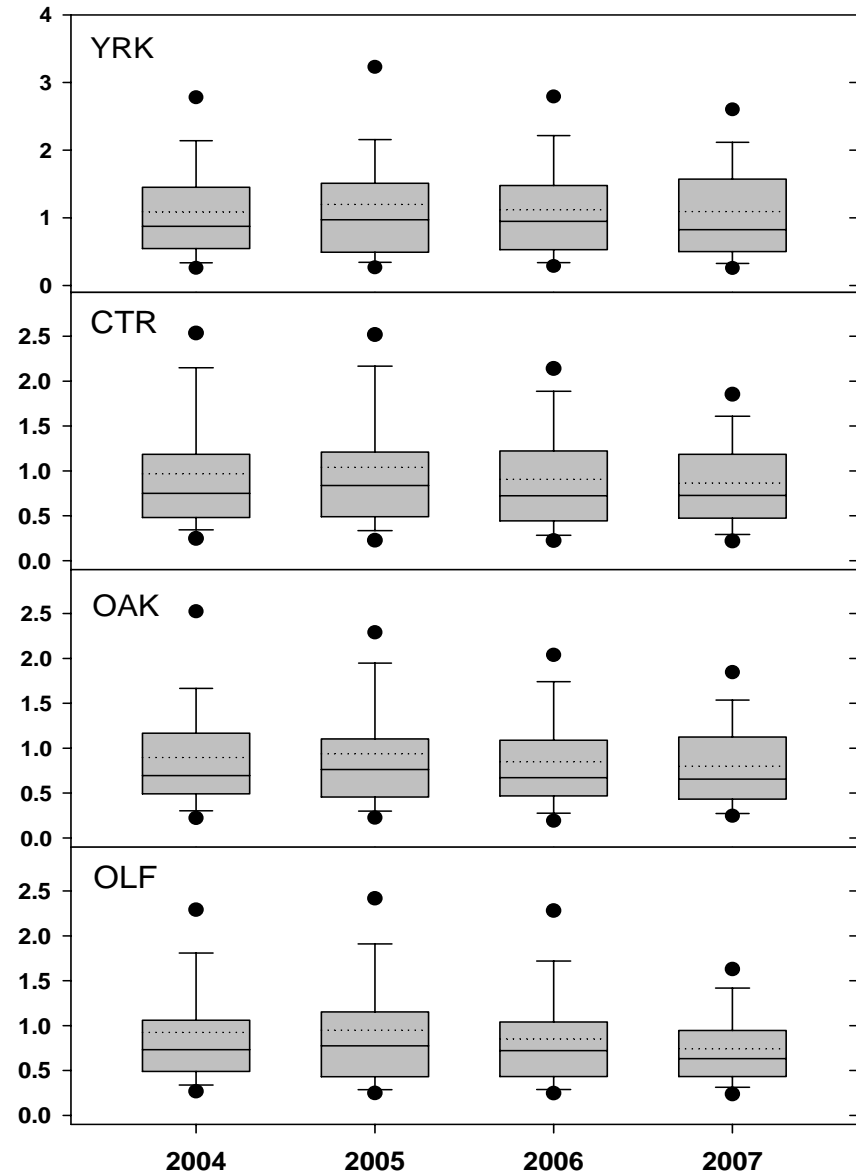
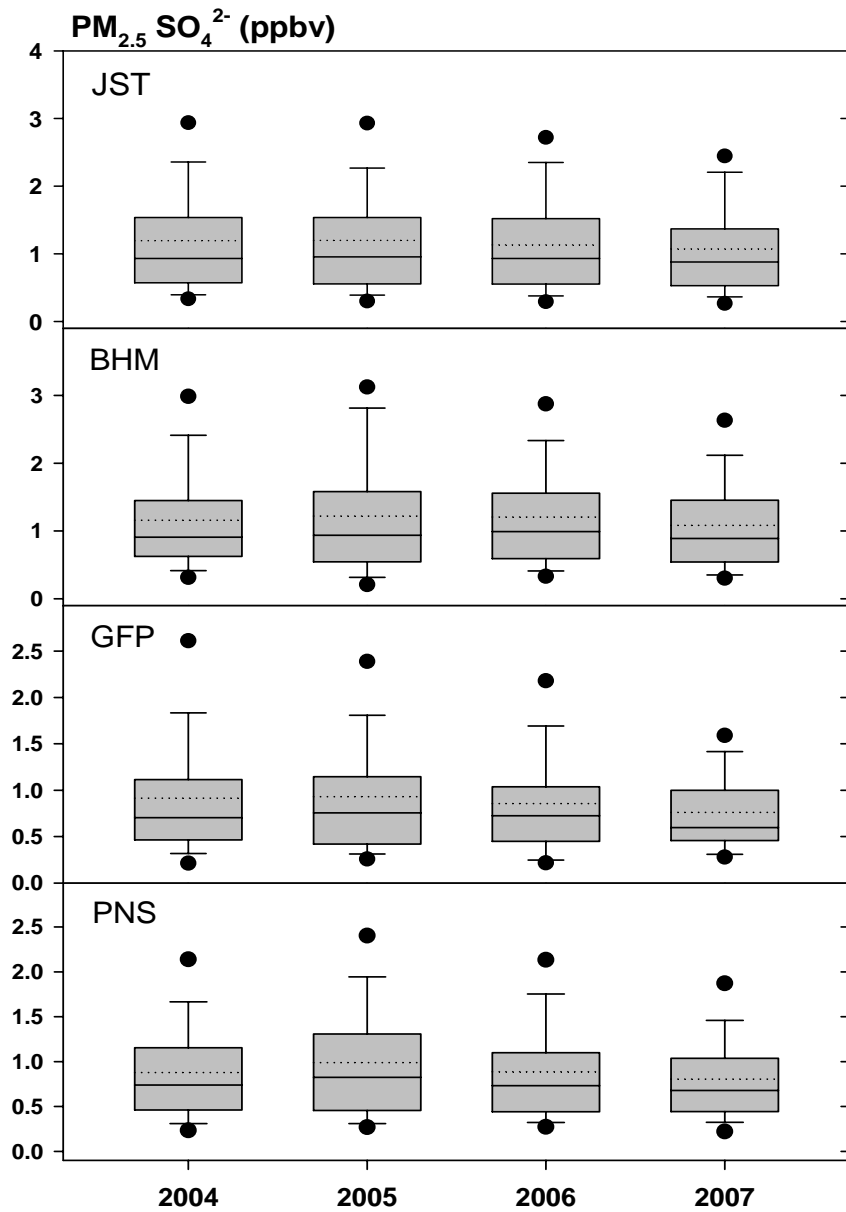


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$\text{NH}_3/(\text{NH}_3 + \text{PM}_{2.5} \text{NH}_4^+) \text{ (mol/mol)}$

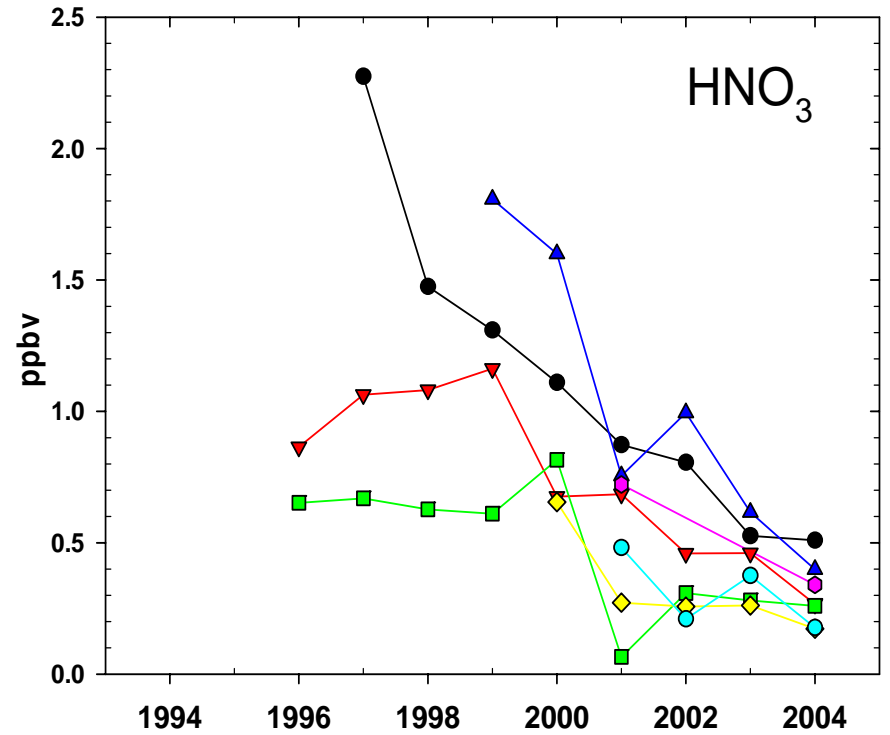
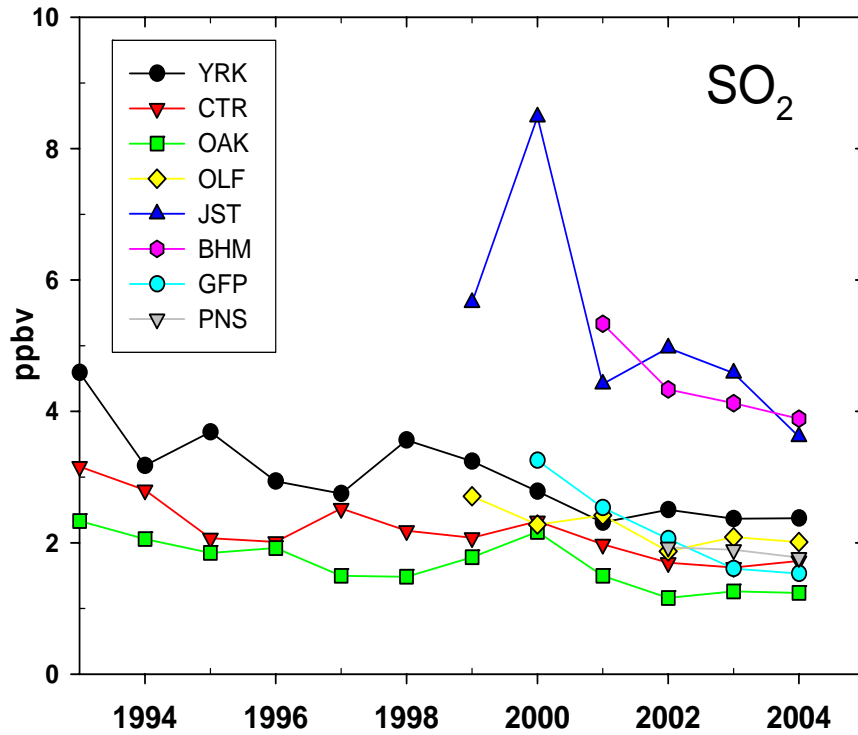


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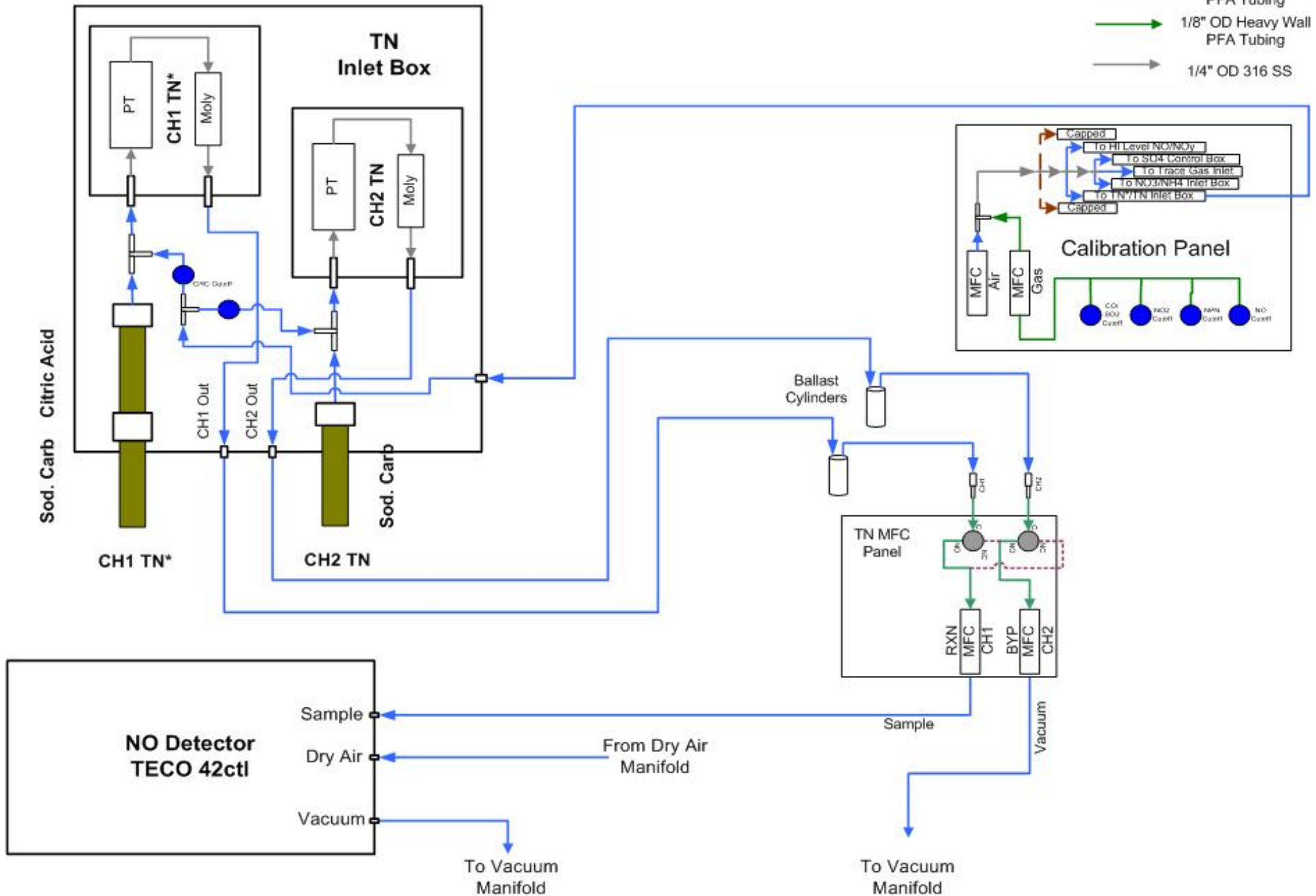
Annual Average SO₂ and HNO₃ at SEARCH Sites



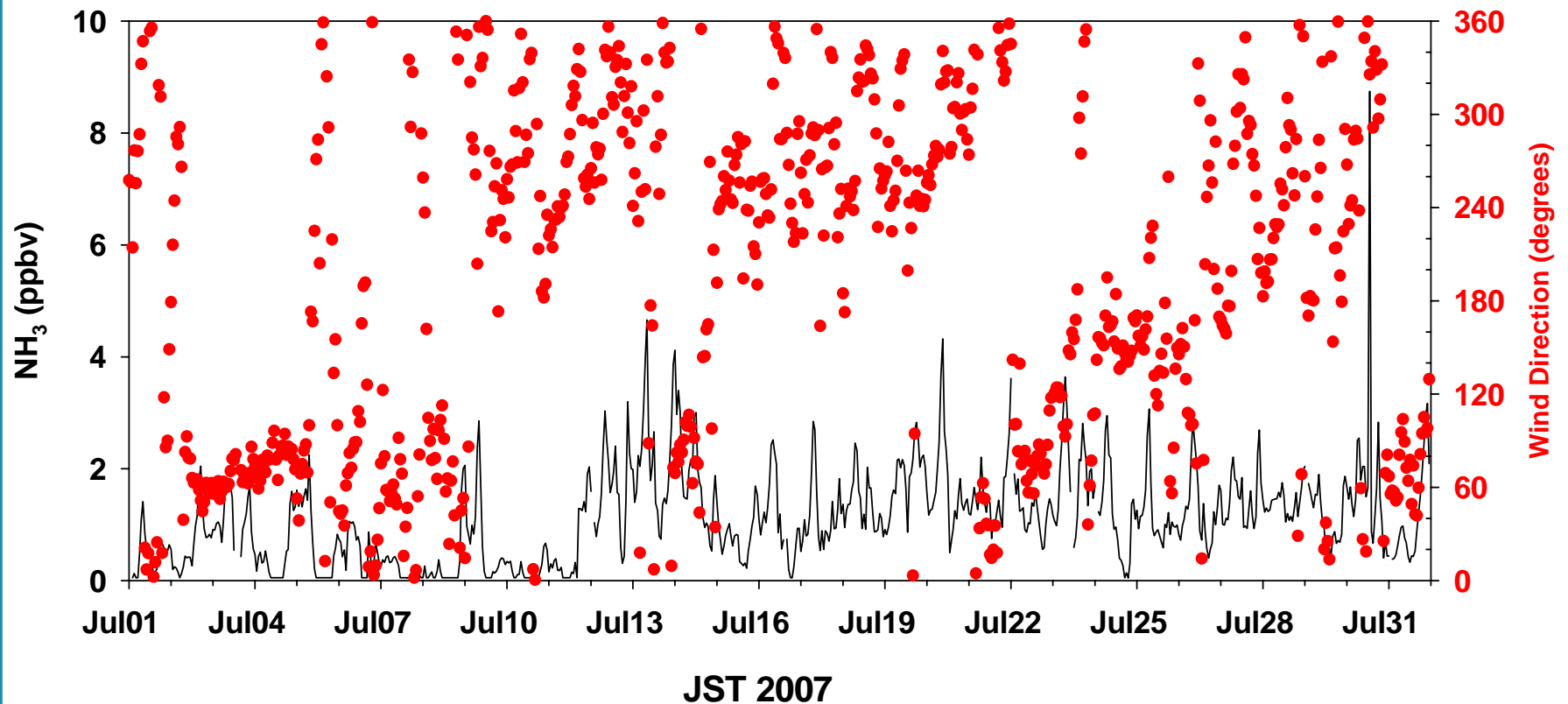
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TN Plumbing Overview

- Legend**
- 1/4" OD Heavy Wall PFA Tubing
 - 1/8" OD Heavy Wall PFA Tubing
 - 1/4" OD 316 SS

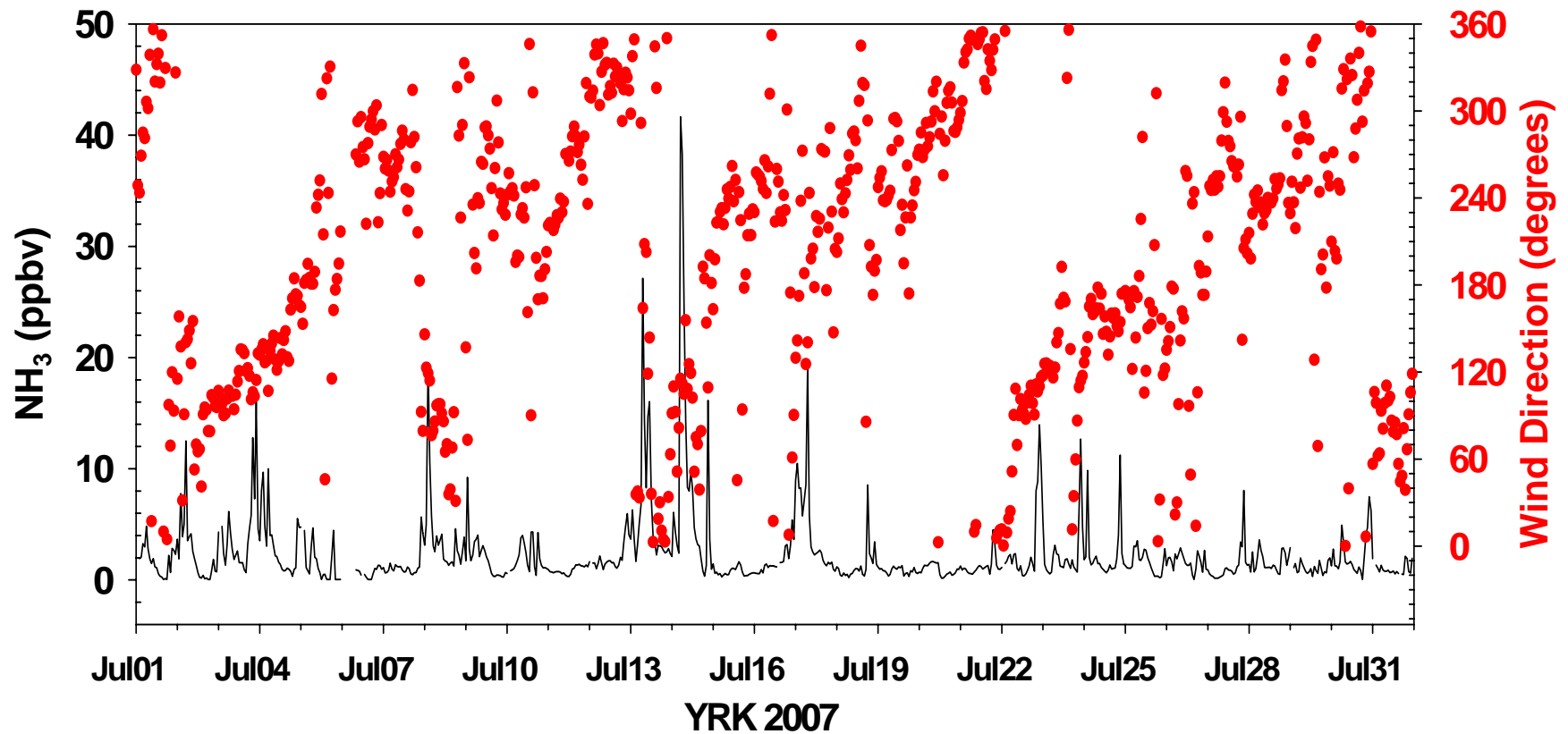


JST Hourly-Averaged NH₃ Jul 2007

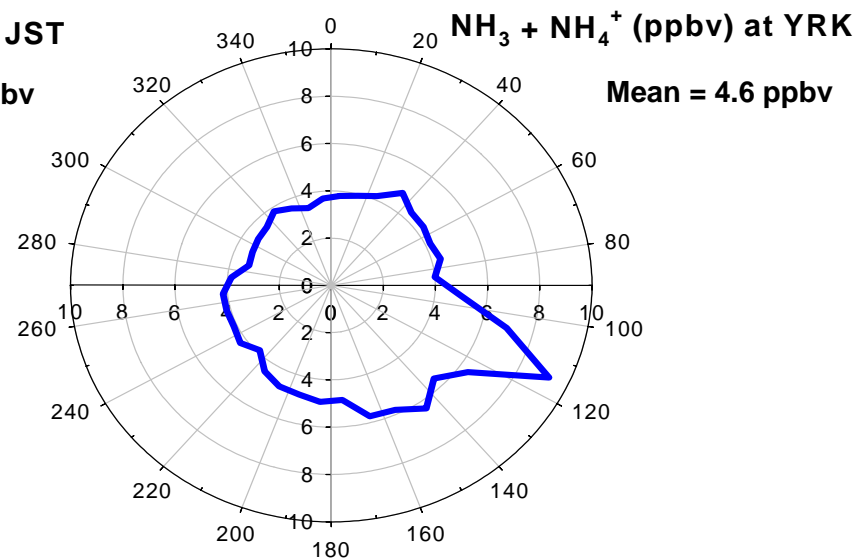
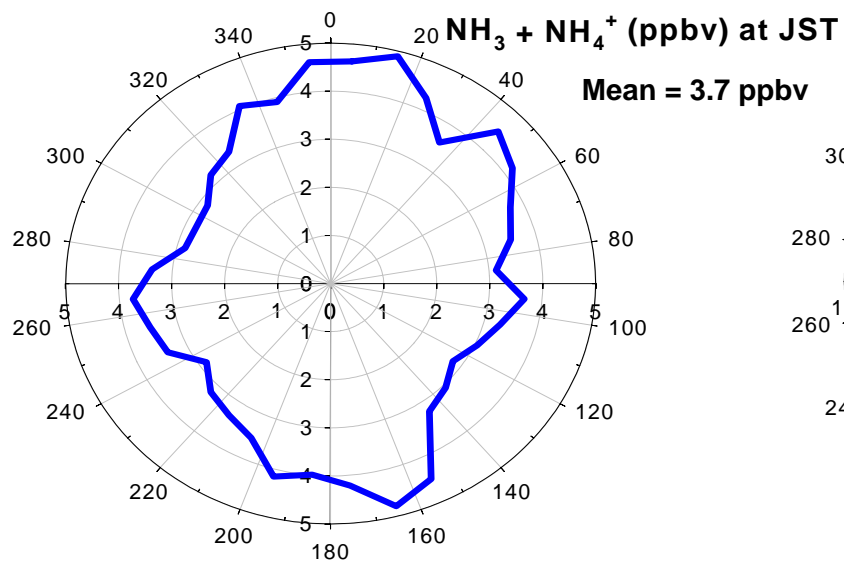
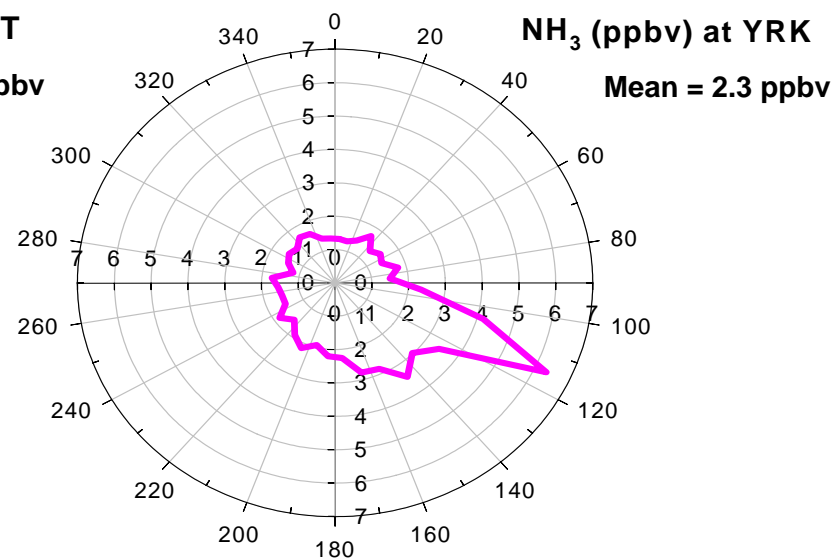
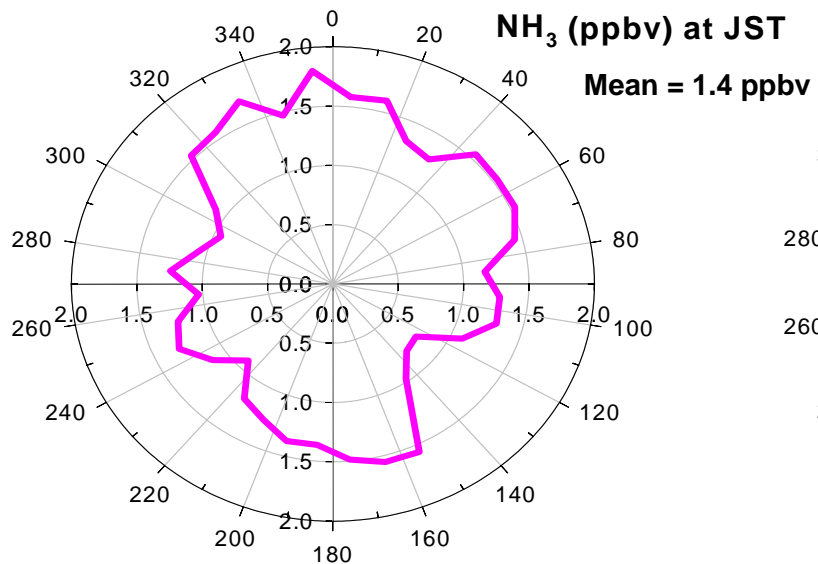


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YRK Hourly-Averaged NH3 July 2007

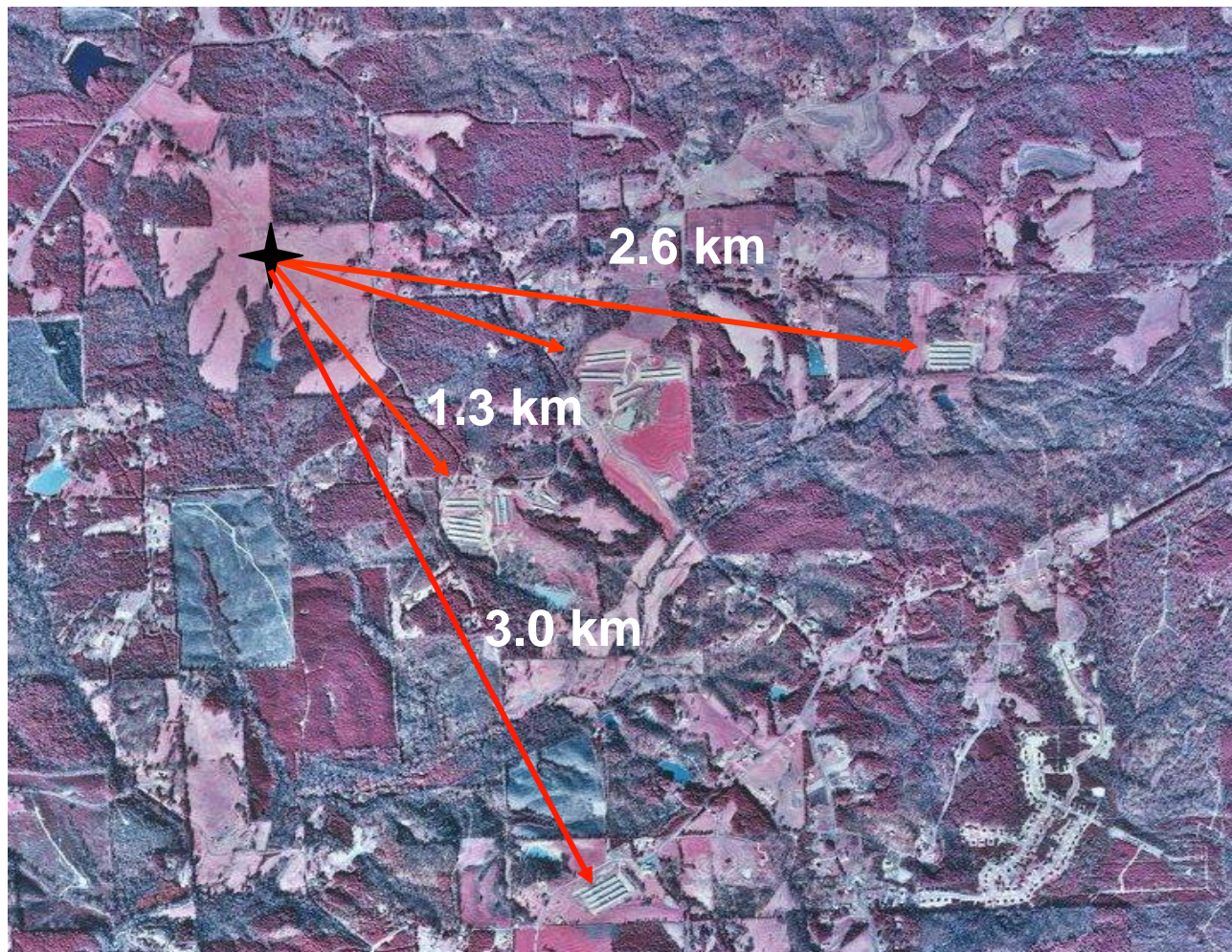


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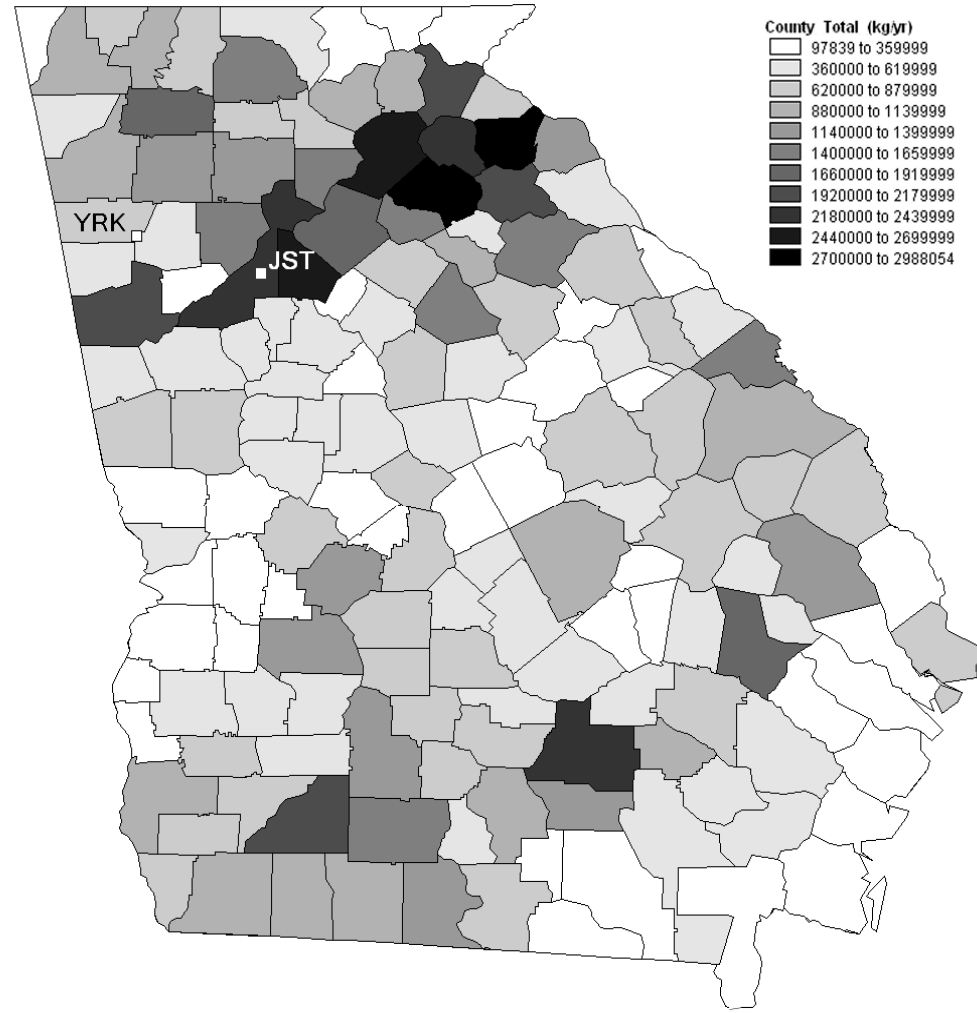


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Poultry Houses near YRK

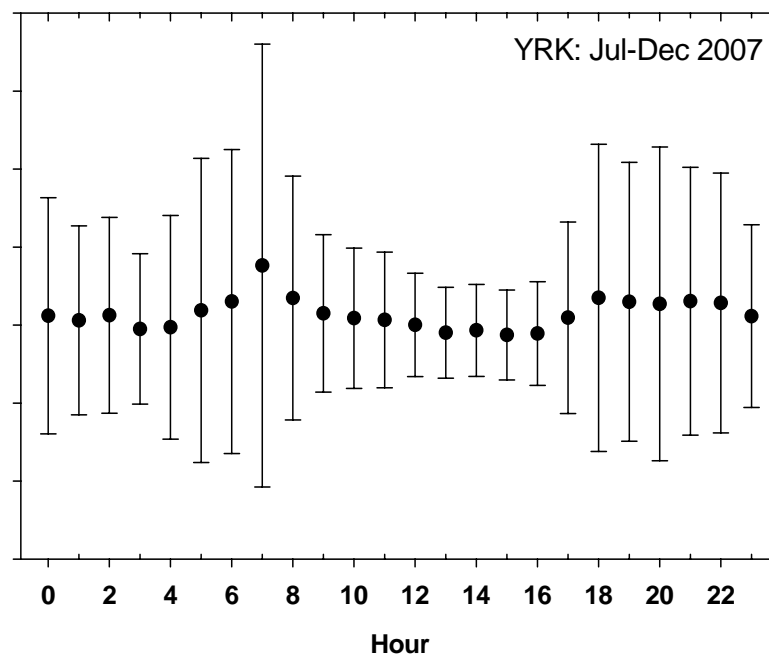
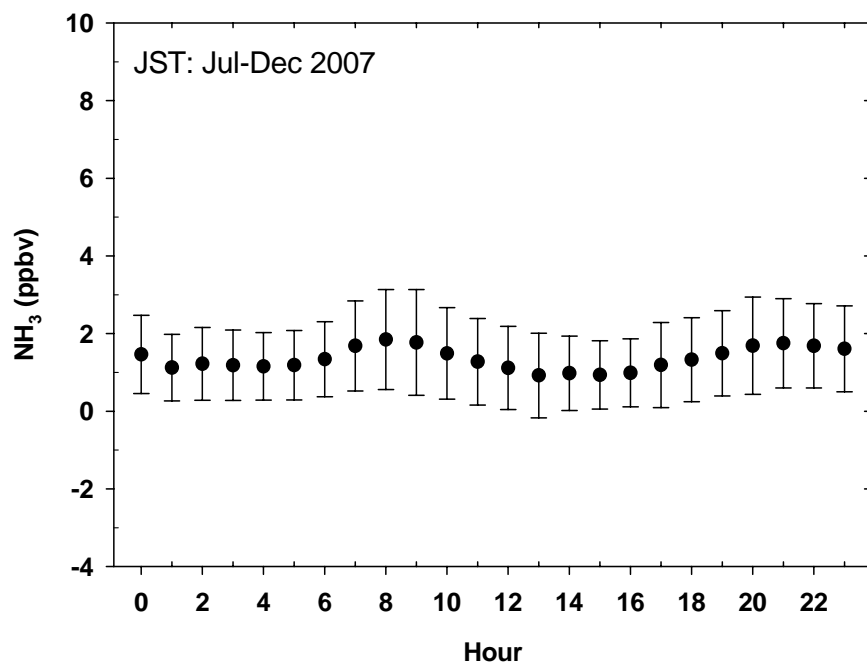


Annual NH₃ Emissions in Georgia (Cardelino 2000)



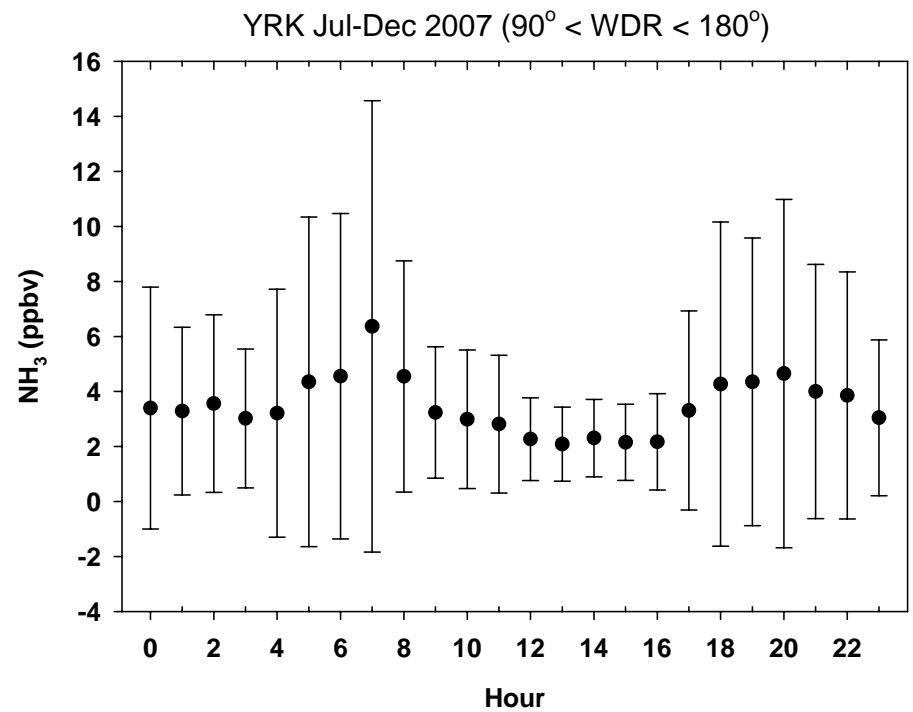
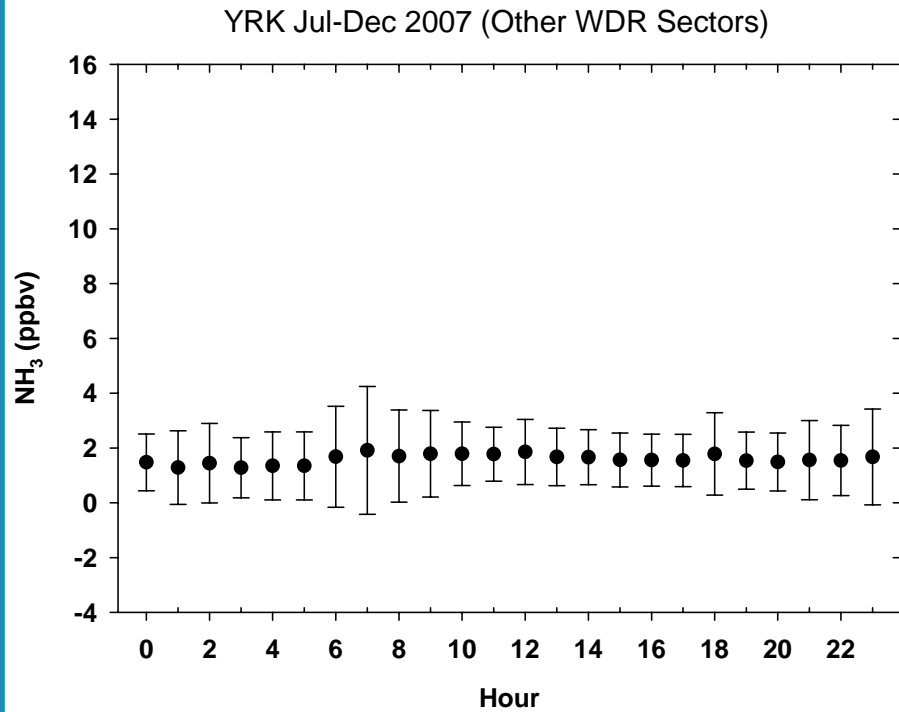
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Hourly Means/StdDev at JST and YRK for Jul-Dec 2007



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Wind Direction Dependence at YRK



Box Model - Equations

$$\frac{dC_i}{dt} = \frac{q_i}{H(t)} + R_i - \frac{v_{d,i}}{H(t)} C_i + k_v (C_i^b - C_i) \quad \frac{dH}{dt} \leq 0$$

$$\frac{dC_i}{dt} = \frac{q_i}{H(t)} + R_i - \frac{v_{d,i}}{H(t)} C_i + k_v (C_i^b - C_i) + \frac{C_i^a - C_i}{H(t)} \frac{dH}{dt} \quad \frac{dH}{dt} > 0$$

C_i = concentration of species i in the box ($\mu\text{g}/\text{m}^3$)

$H(t)$ = time dependent mixed layer height (m)

q_i = emission of species i into the box ($\mu\text{g}/\text{m}^2\text{-s}$)

R_i = chemical production rate of species i within the box ($\mu\text{g}/\text{m}^3\text{-s}$)

$v_{d,i}$ = dry deposition velocity of species i (m/s)

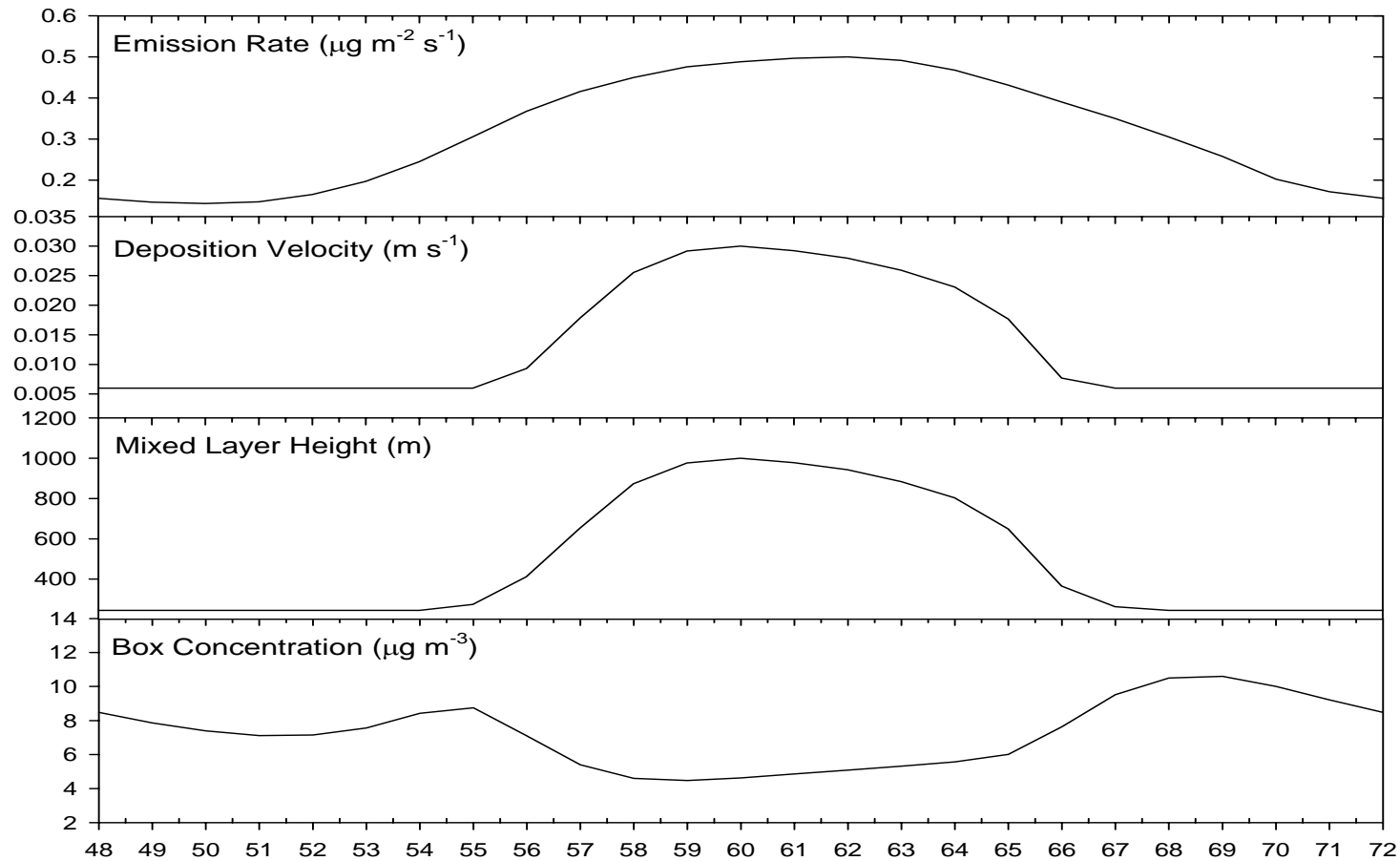
C_i^b = background concentration of species i ($\mu\text{g}/\text{m}^3$)

C_i^a = concentration of species i above the mixed layer ($\mu\text{g}/\text{m}^3$)

k_v = mixing rate of background air (s^{-1})

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Base Simulation



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Compare Largest Removal Terms

$$\frac{v_{d,i}}{H(t)} C_i \ll \frac{C_i^a - C_i}{H(t)} \frac{dH}{dt}$$

$$v_{d,i} \ll \frac{dH}{dt}$$

0.005-0.03 m s⁻¹

200-240 m/3600s
= 0.06-0.07 m s⁻¹

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Summary

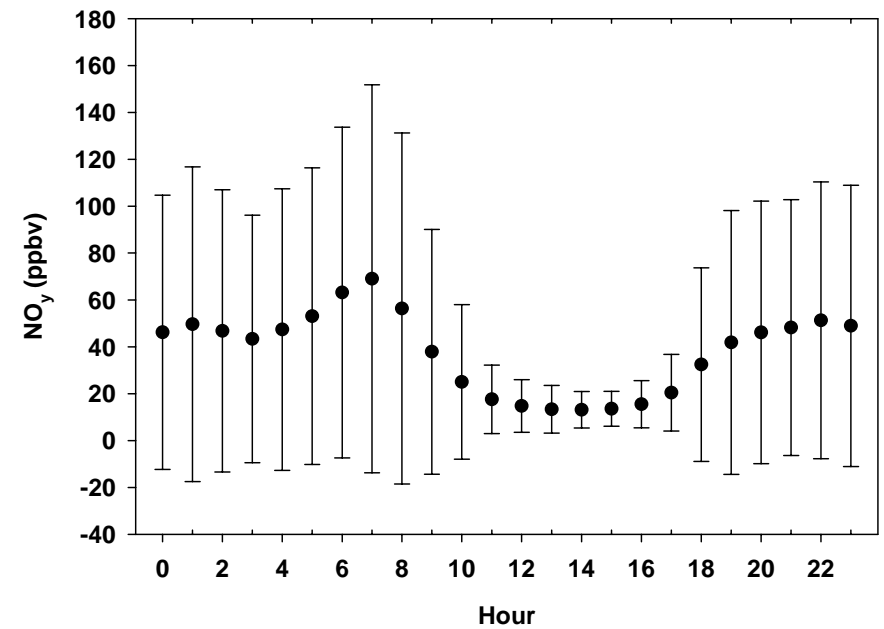
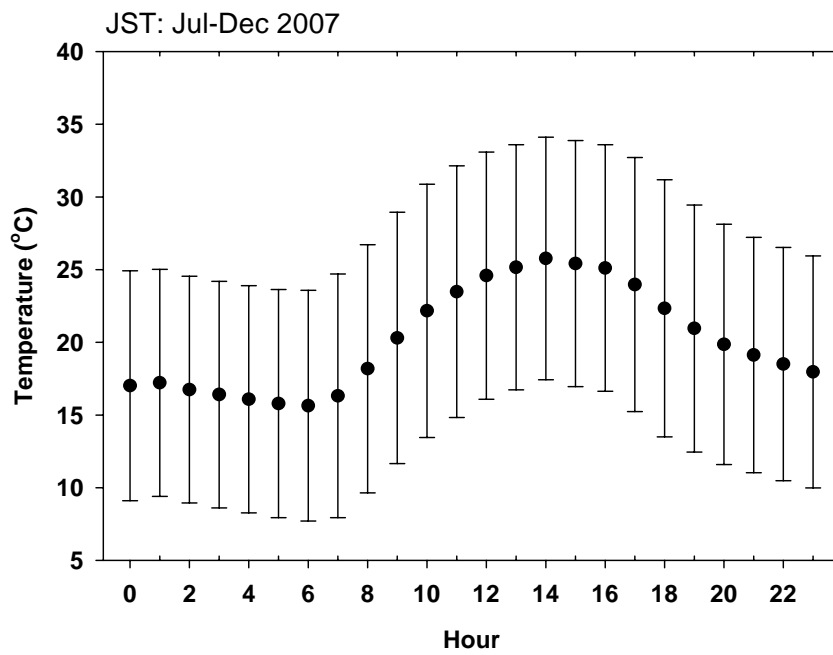
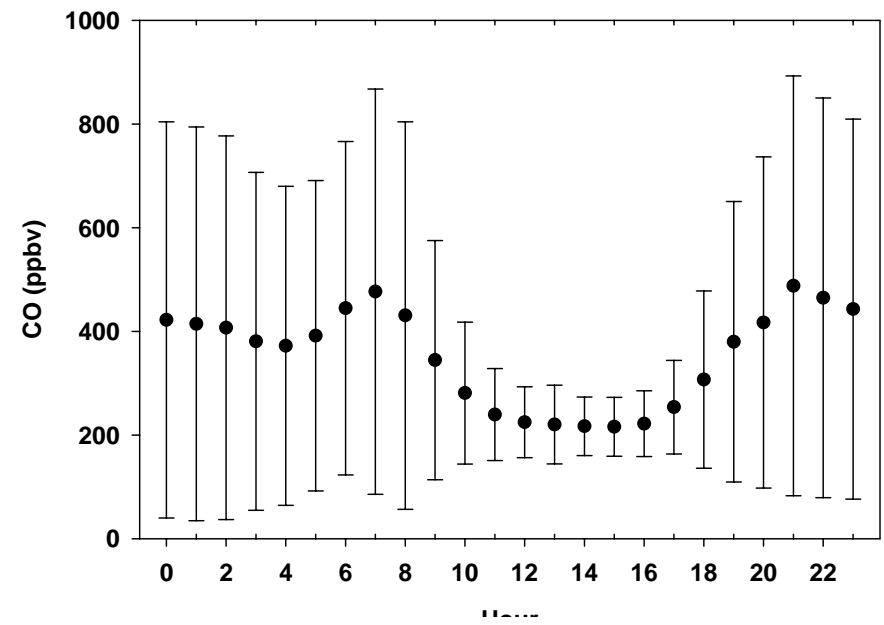
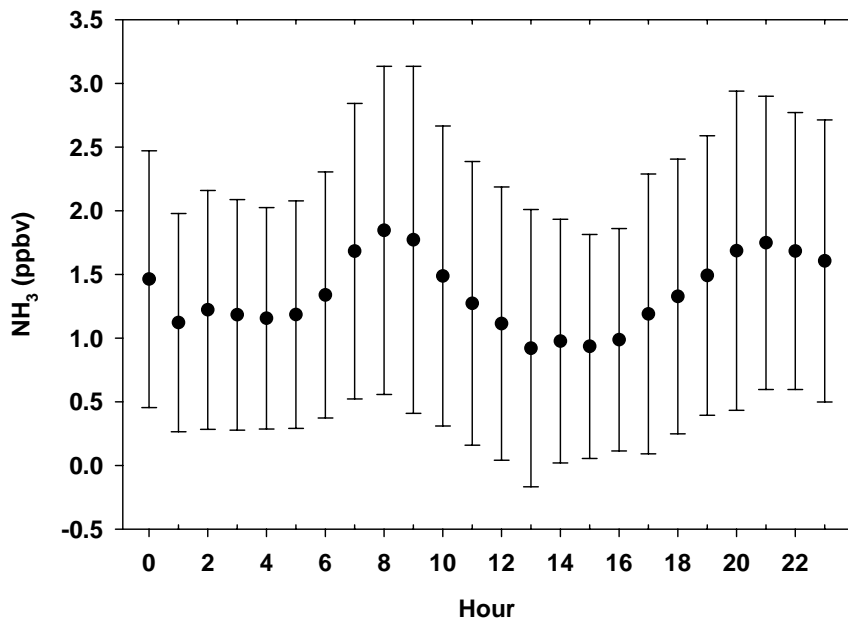
- Gaseous NH_3 and $\text{PM}_{2.5}$ NH_4^+ measurements from SEARCH ...
- 24-hr denuder-based NH_3 and filter-based NH_4^+ at all 8 SEARCH sites since 2004.
- Continuous NH_3 (and $\text{PM}_{2.5}$ NH_4^+) at 3 SEARCH sites since 2nd-half of 2007.
- Increase in annual NH_3 at many sites since 2004.
- Poultry operations impact measurements at Yorkville site (potential impact on NE Georgia, southern Appalachians?)
- Average diurnal profile of NH_3 affected by interaction of emissions and boundary layer dynamics.
- Data available at <http://www.atmospheric-research.com>.

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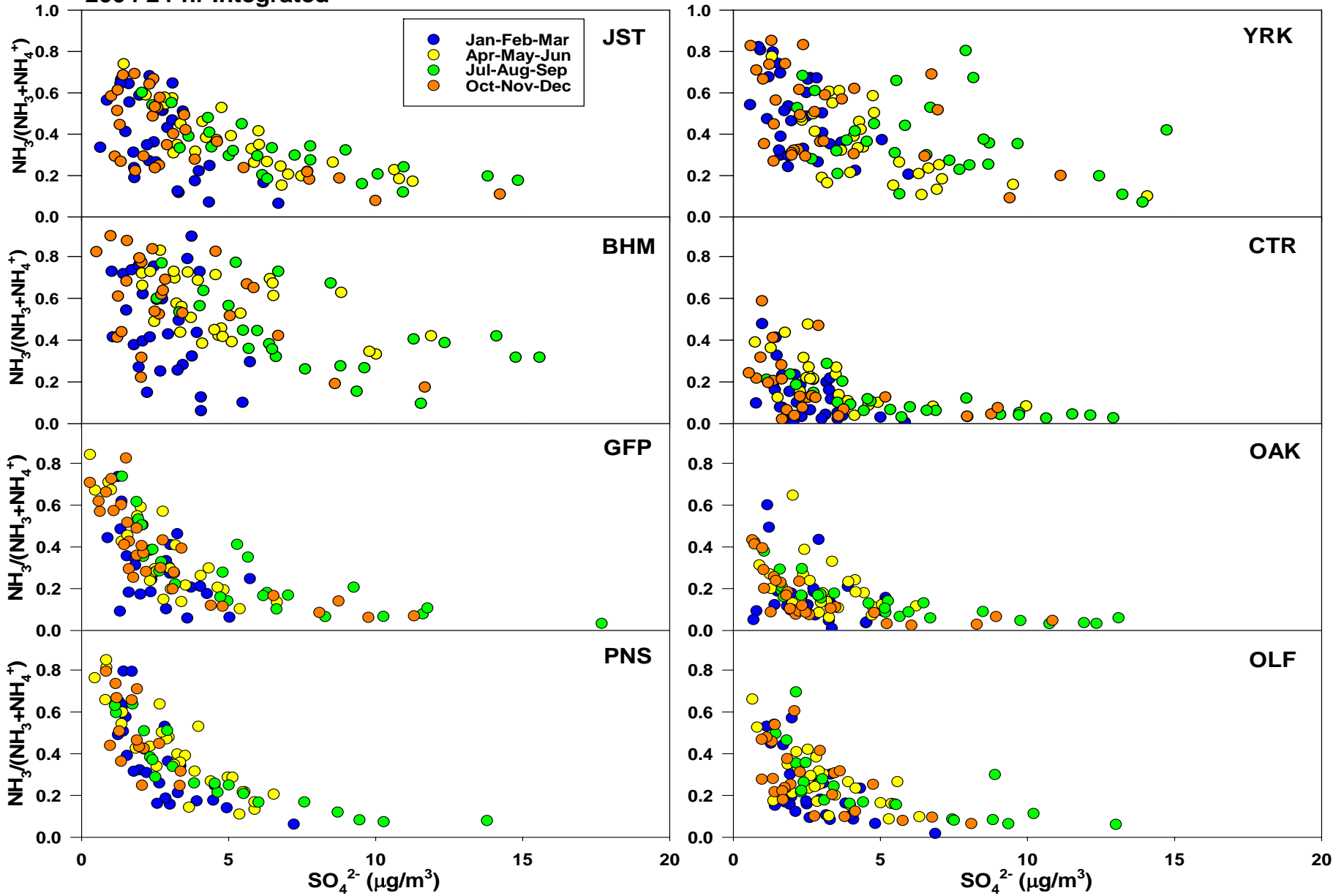
Acknowledgements

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Electric Power Research Institute.





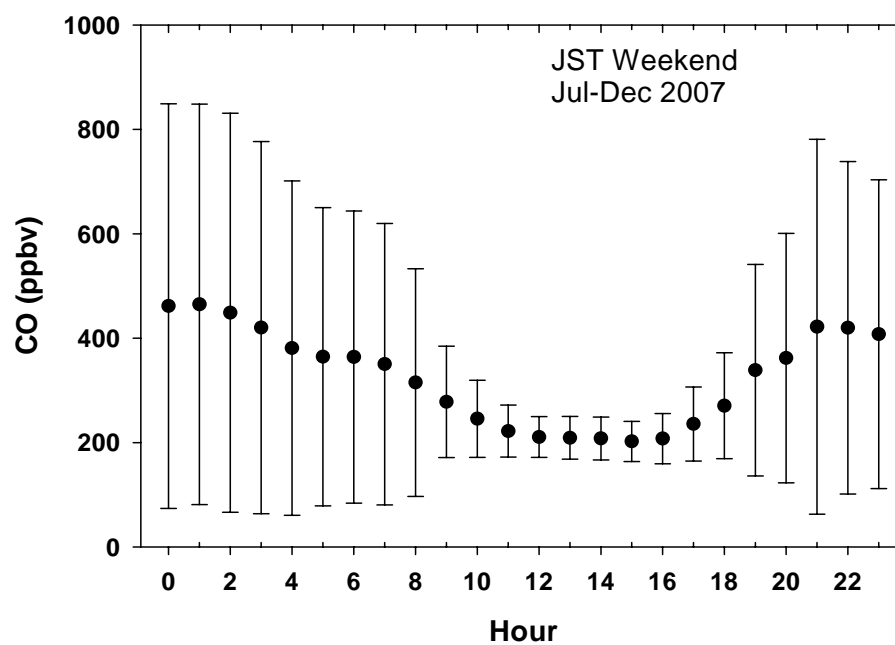
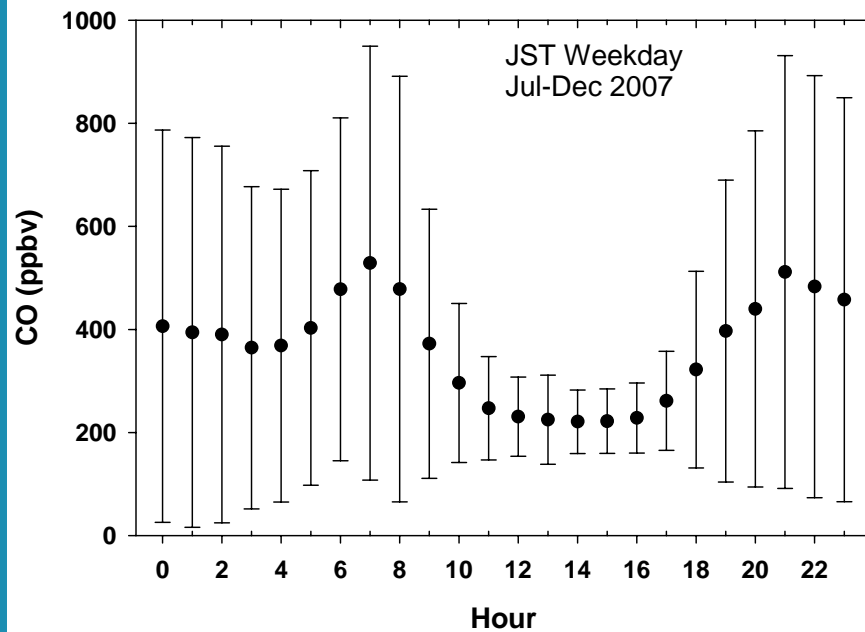
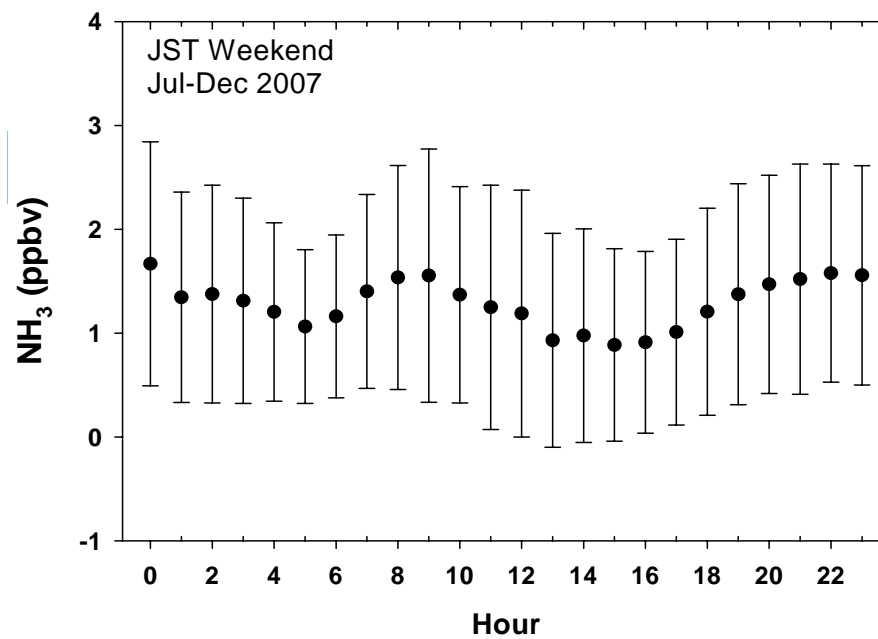
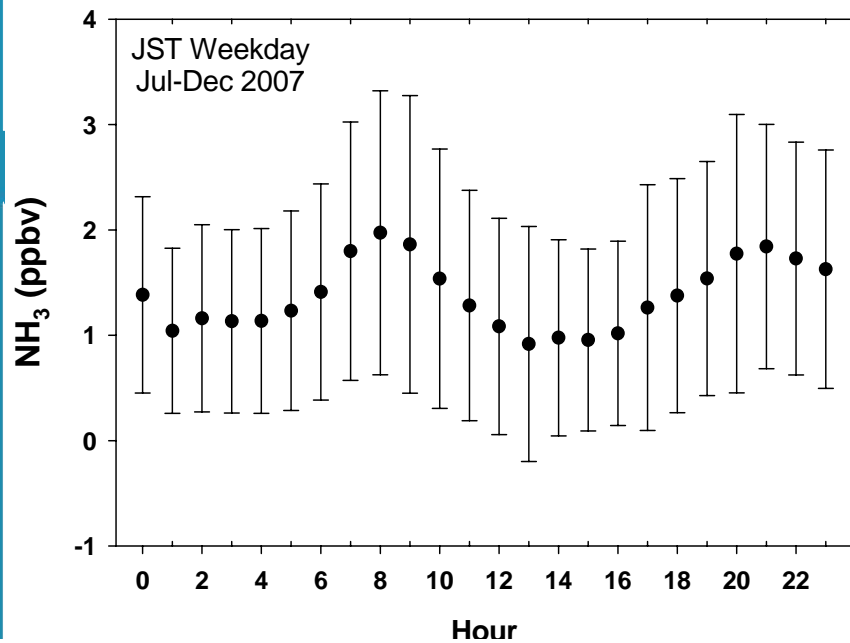
2004 24-hr Integrated

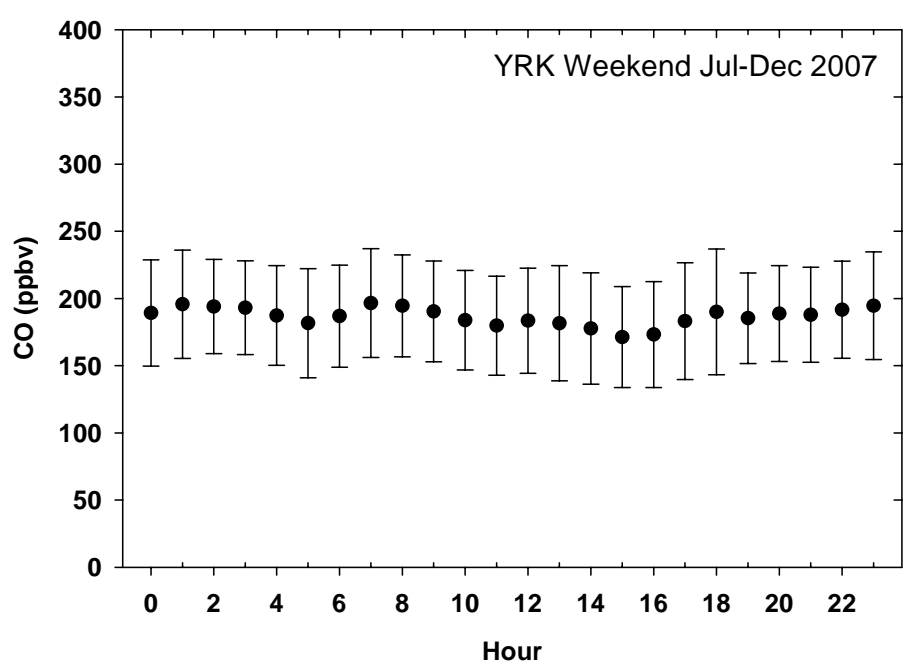
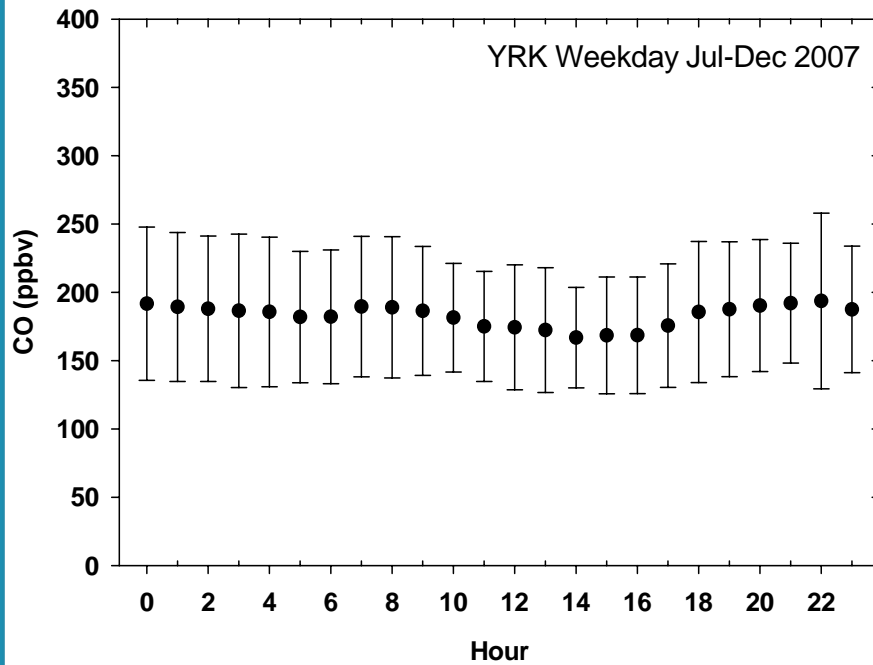
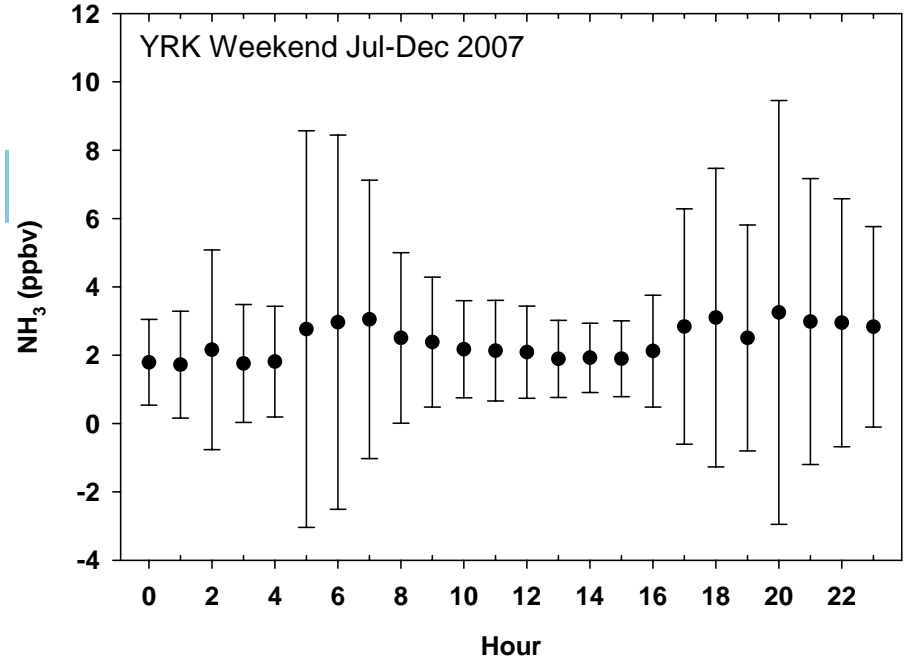
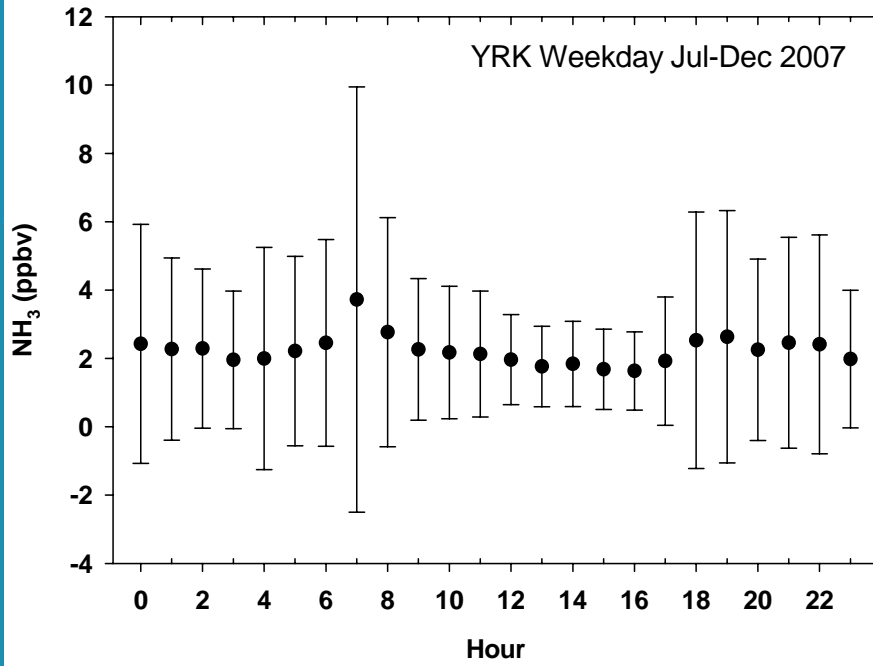


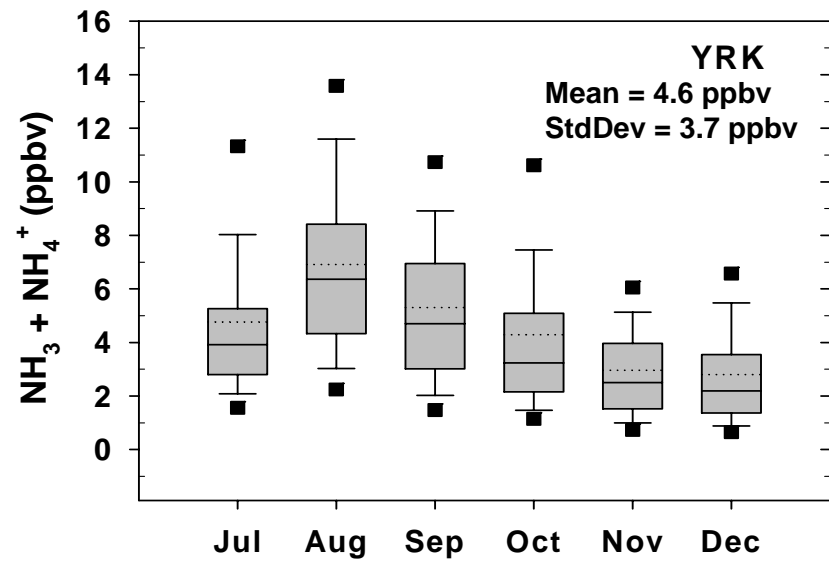
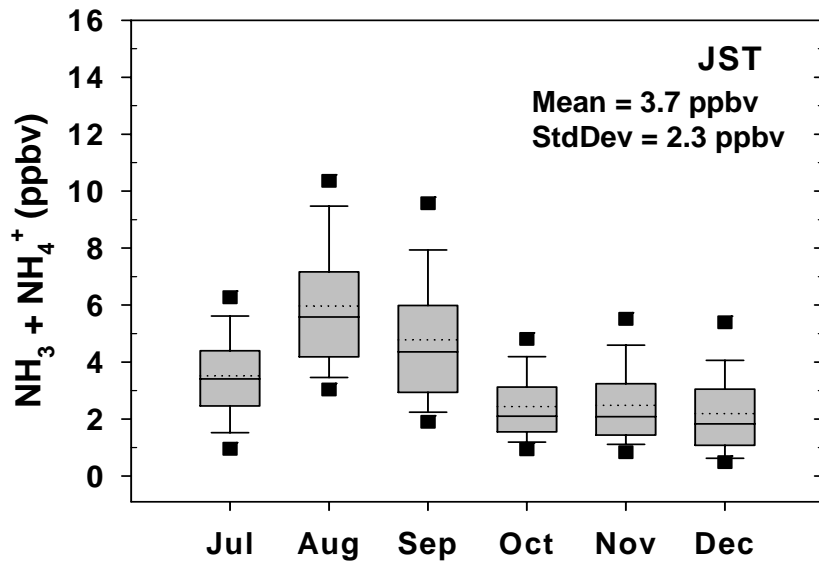
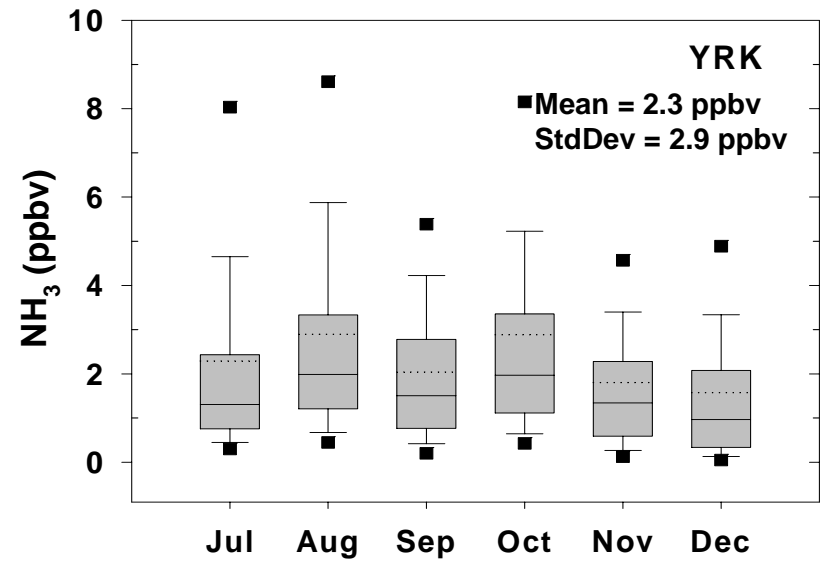
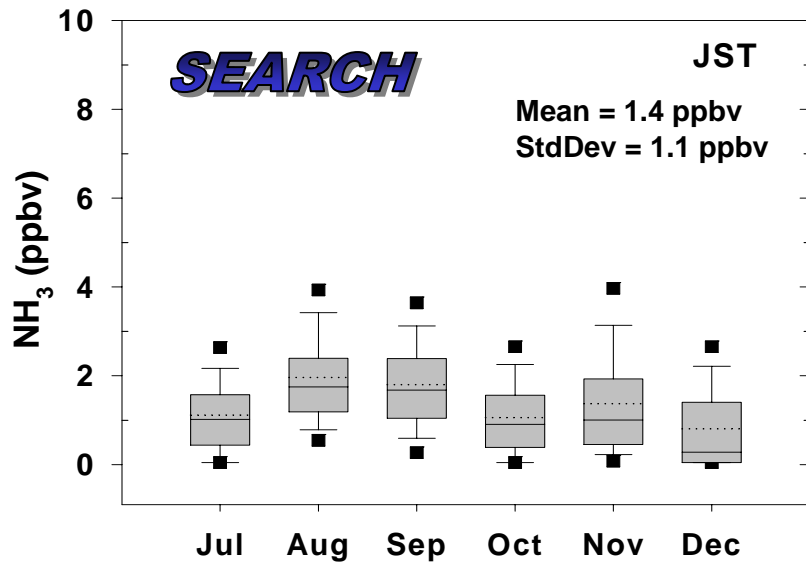
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Edgerton et al. (2007) *Atmos. Environ.*, 41, 3339-3351.



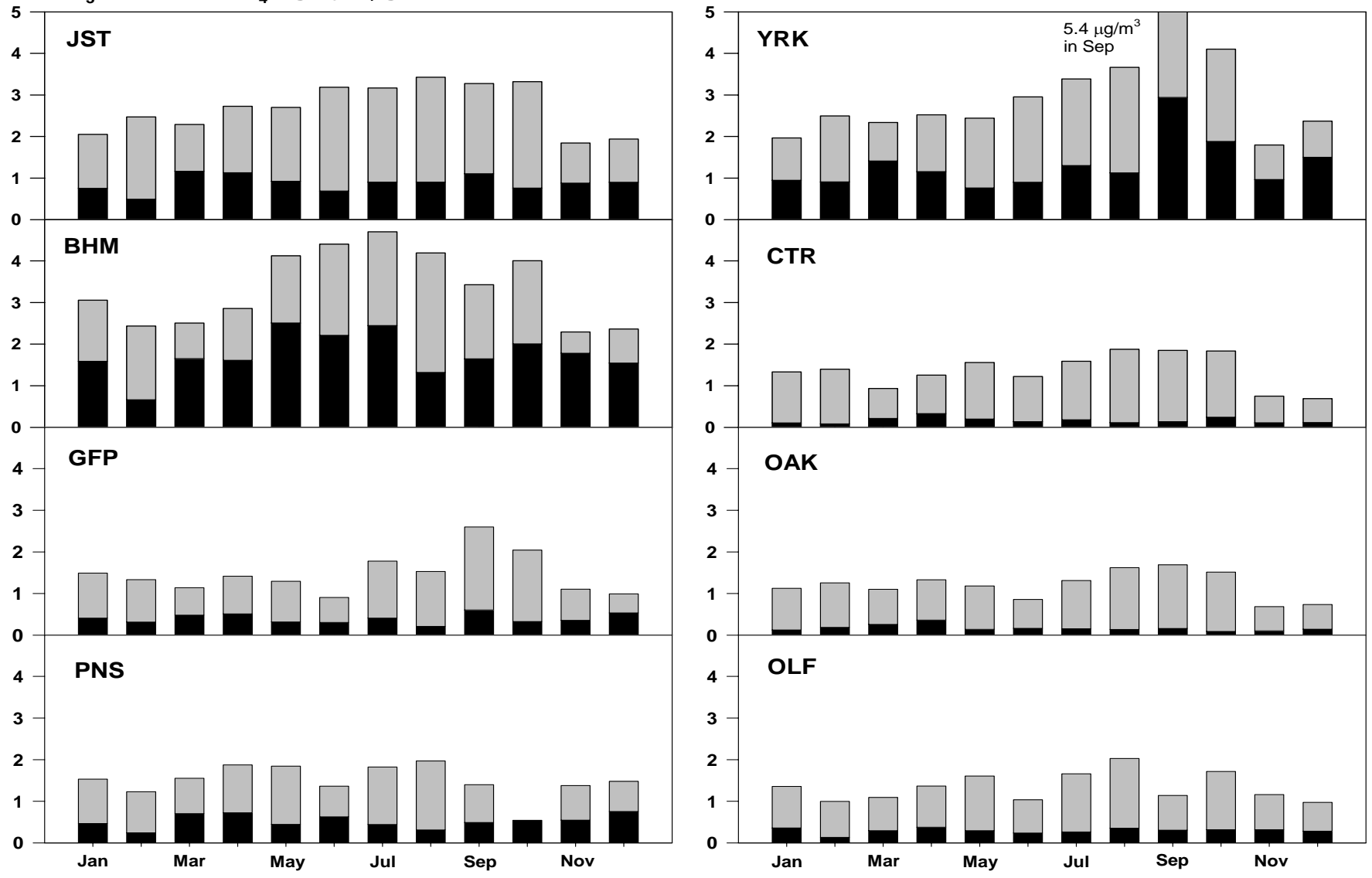






NH₃ (black) or NH₄⁺ (gray) (μg m⁻³)

2004

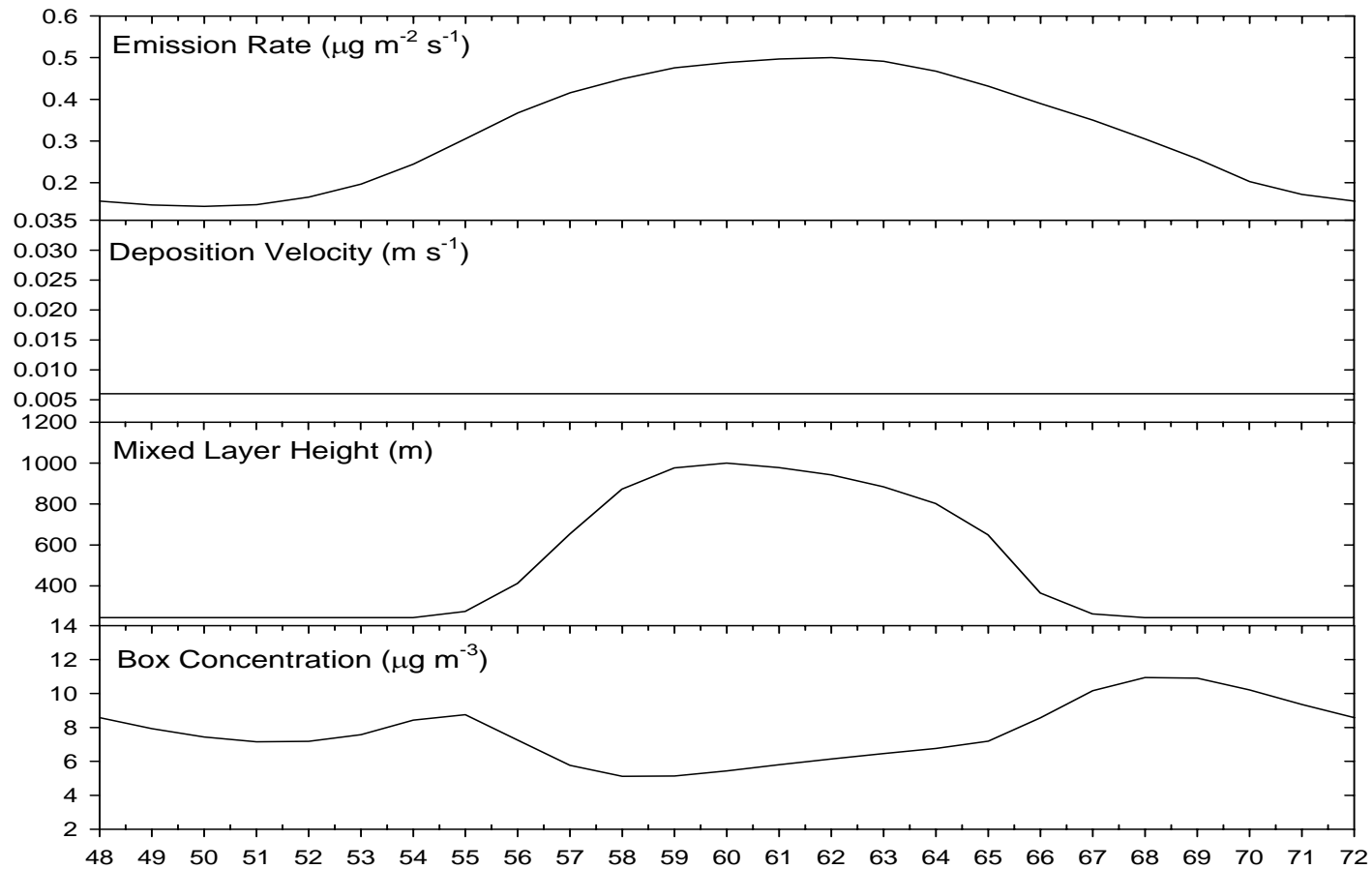


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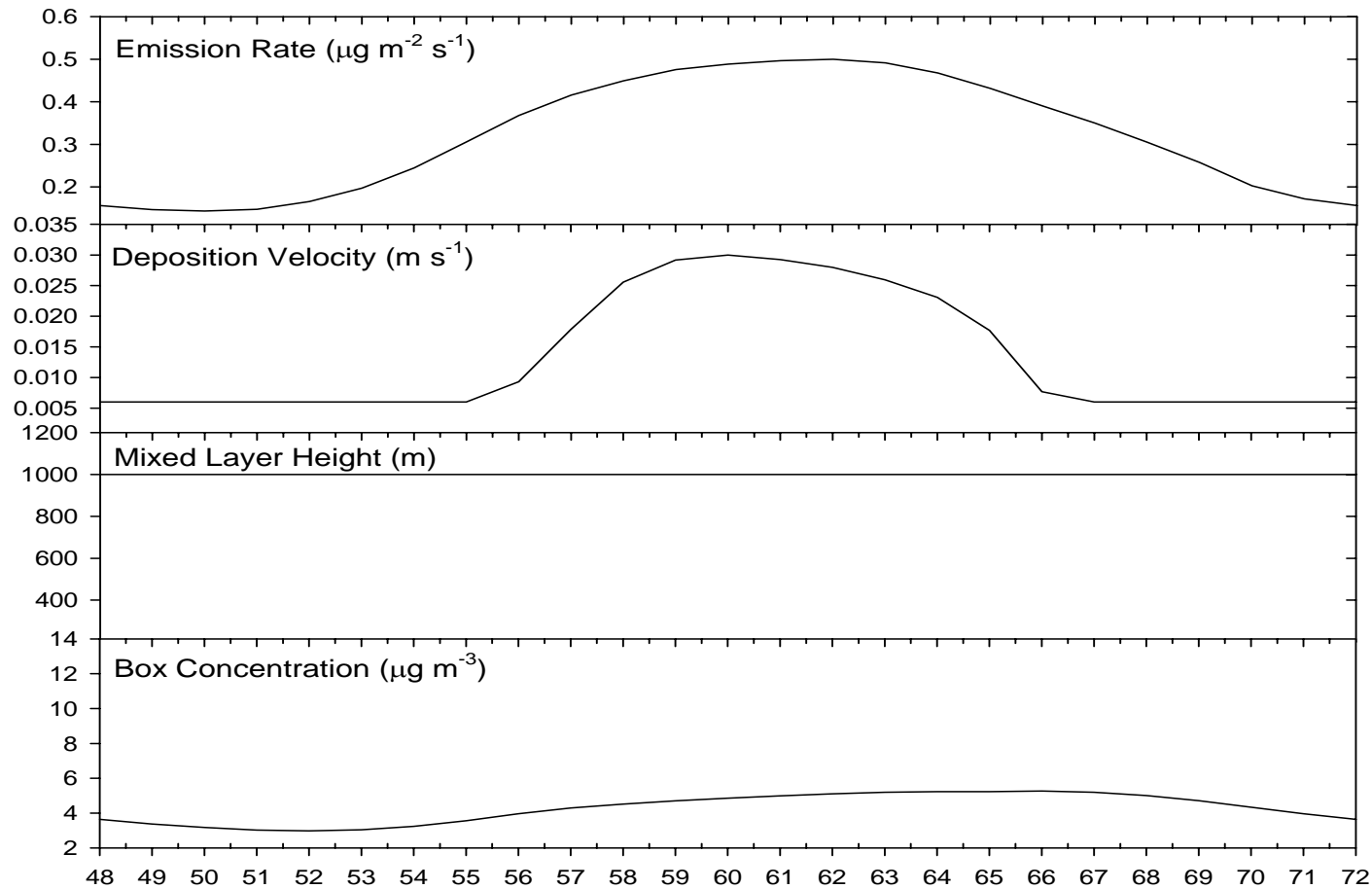


Constant V_d



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Constant H



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