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Updates to Fertilizer and Biogenic NH_3 emissions for the National Emissions Inventory

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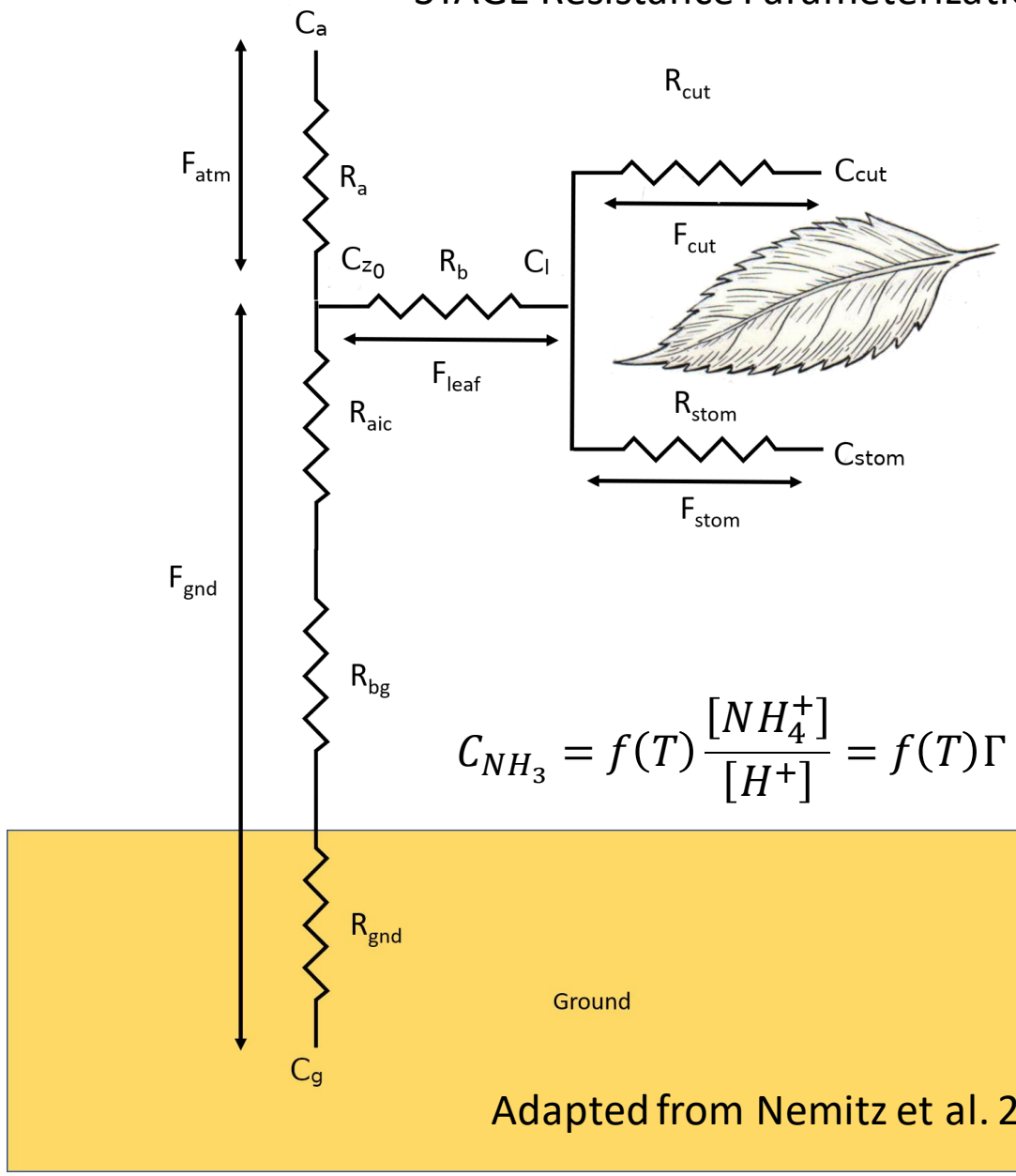
Outline

- 2020 NEI fertilizer NH_3 emissions methodology
  - Overview of the emissions model
  - Revisions to non-agricultural/biogenic NH_3 emissions
    - Based on recent measurements
- Fertilizer and biogenic NH_3 emission
  - Change in emissions from 2017 NEI
- Evaluation against network observations
- Summary and next steps

What is STAGE?

- Surface Tiled Aerosol and Gaseous Exchange (STAGE) model
- Land use specific gaseous and aerosol deposition
  - Fluxes area weighted to grid cell
  - Allows the output of land use specific emissions and deposition
- Models fluxes as gradient based processes
  - Using Kirchhoff's current law
- Estimates in-canopy fluxes and concentrations
- Bidirectional and unidirectional schemes use the same resistance model
  - Easy to add bidirectional exchange for modeled species

STAGE Resistance Parameterization



$$C_{NH_3} = f(T)\frac{[NH_4^+]}{[H^+]} = f(T)\Gamma$$

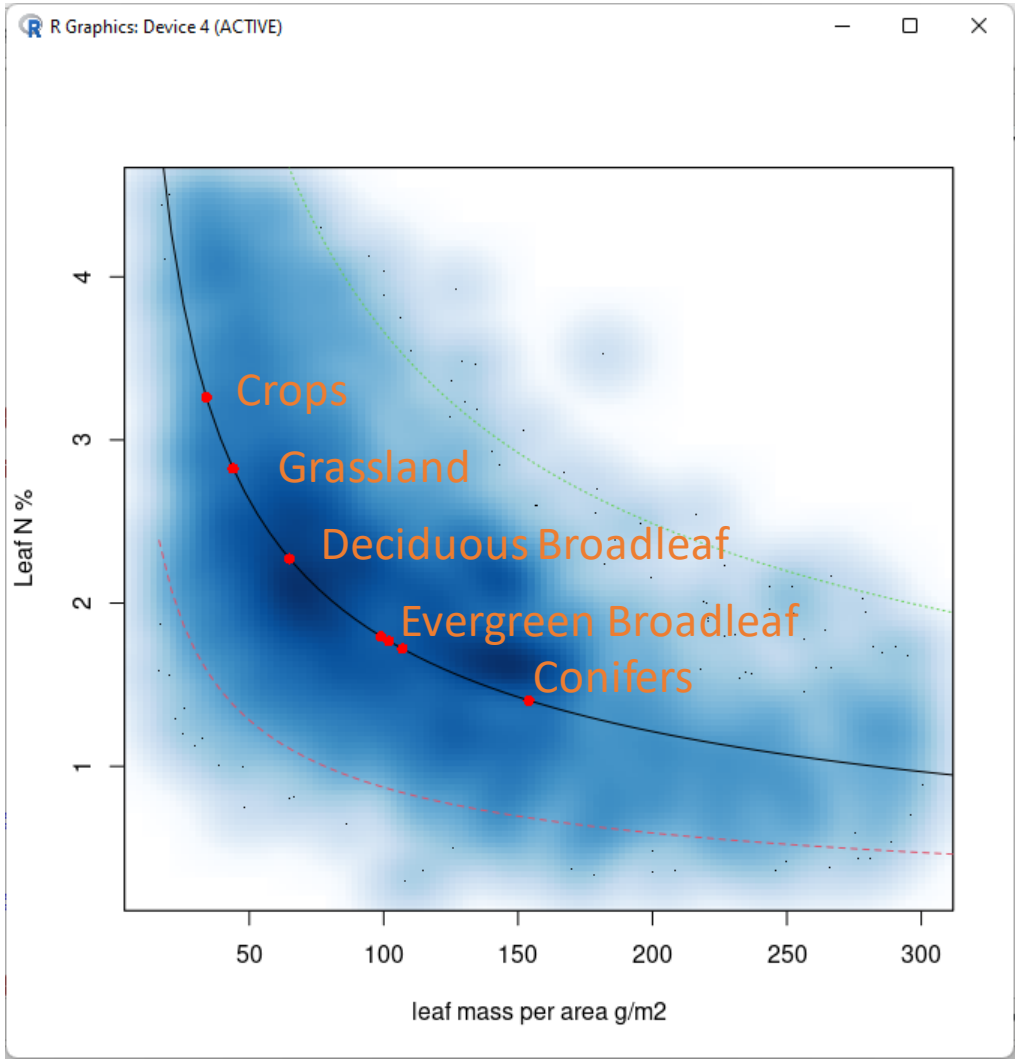
Adapted from Nemitz et al. 2001

NH_3 Land Use Emissions Potential (Γ)

- Ratio of leaf or soil surface NH_4^+ and H^+
  - Governs the emissions of NH_3 from aqueous media following Henry's Law
- Has been measured as a function of nitrogen deposition/application and leaf nitrogen content (Massad et al. 2010)
- Few measurements exist for plant functional types
- CMAQ v5.3 and 2017 NEI used a mean nitrogen deposition estimate from Massad et al. 2010
- CMAQ v5.4 and 2020 NEI based on measurements of NH_4^+ and H^+ at AMoN sites and available in the TRY global plant database (Kattge et al. 2020)

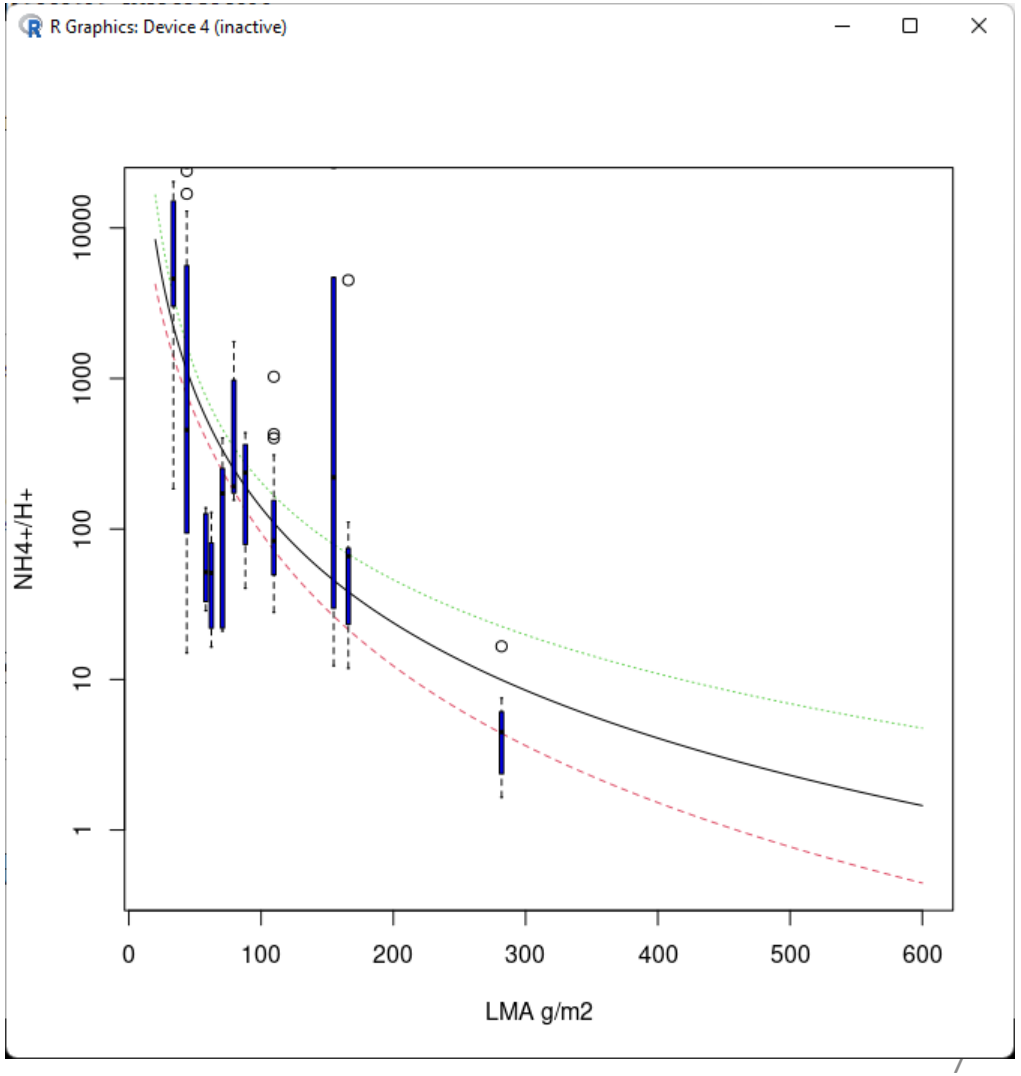
Developing Non-agricultural NH_3 Emission Potentials

- "A universal spectrum of leaf economics consisting of key chemical, structural and physiological properties", Wright et al 2004.
- Biological strategies in plant carbon and nitrogen allocation
  - largely independent of plant functional type, growth form or biome
- Shown to be important in modeling nutrient fluxes
- Leaf N show a clear differences by plant functional type



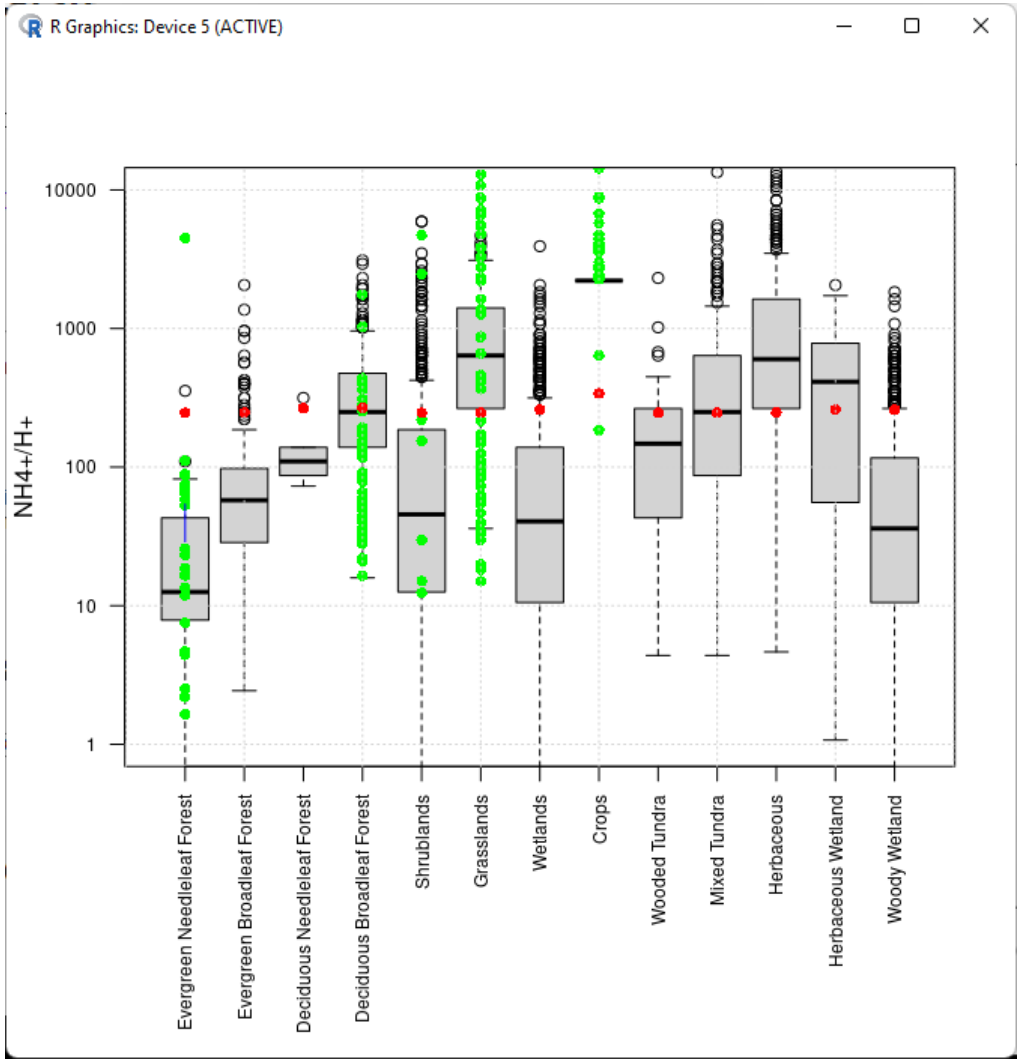
Developing Non-agricultural NH_3 Emission Potentials

- Leaf N decreases with leaf mass per area (LMA)
- Leaf NH_4^+ concentration closely follows total leaf N concentration
- Leaf pH decreases with increasing LMA
  - Both pH and NH_4^+ govern NH_3 emissions
- NH_3 emission potentials show a similar relationship with LMA
- LMA is related to the plant functional type



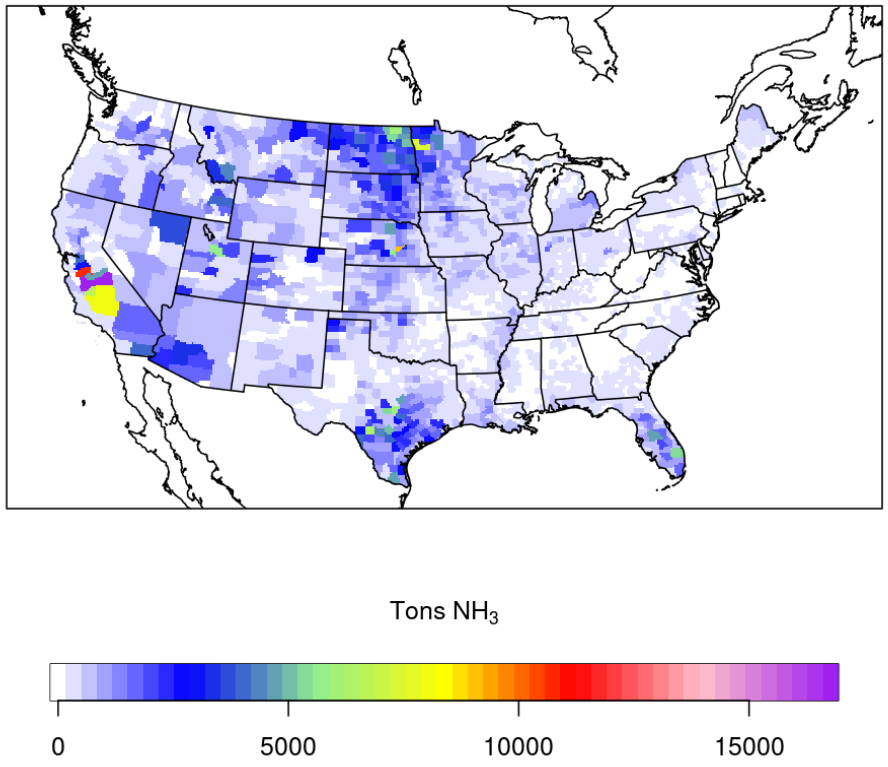
Developing Non-agricultural NH_3 Emission Potentials

- CMAQ v5.3 NH_3 emission potentials (red dots) were nearly constant across plant function types (PFT)
- Observations (green) show differences between PFT
  - Measurements are difficult and there is considerable scatter
- The model (box plots) captures the observations well ($r = 0.584$; $p < 0.001$)
  - CMAQ v5.4 uses the median values from the model for each PFT

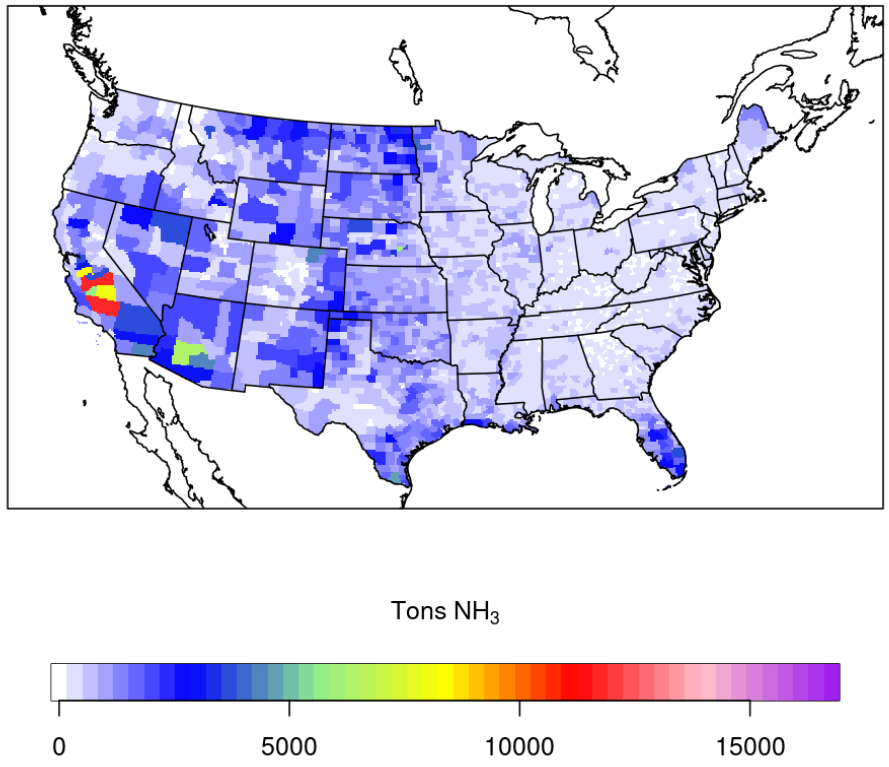


2020 Fertilizer and Biogenic NH_3 Emissions

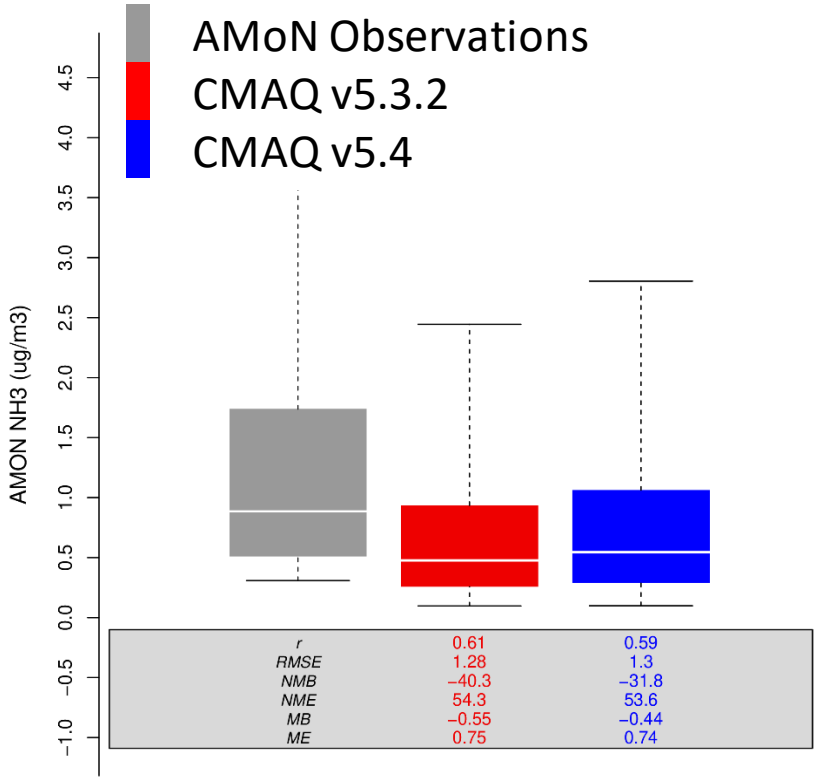
2020 Draft Fertilizer Emissions

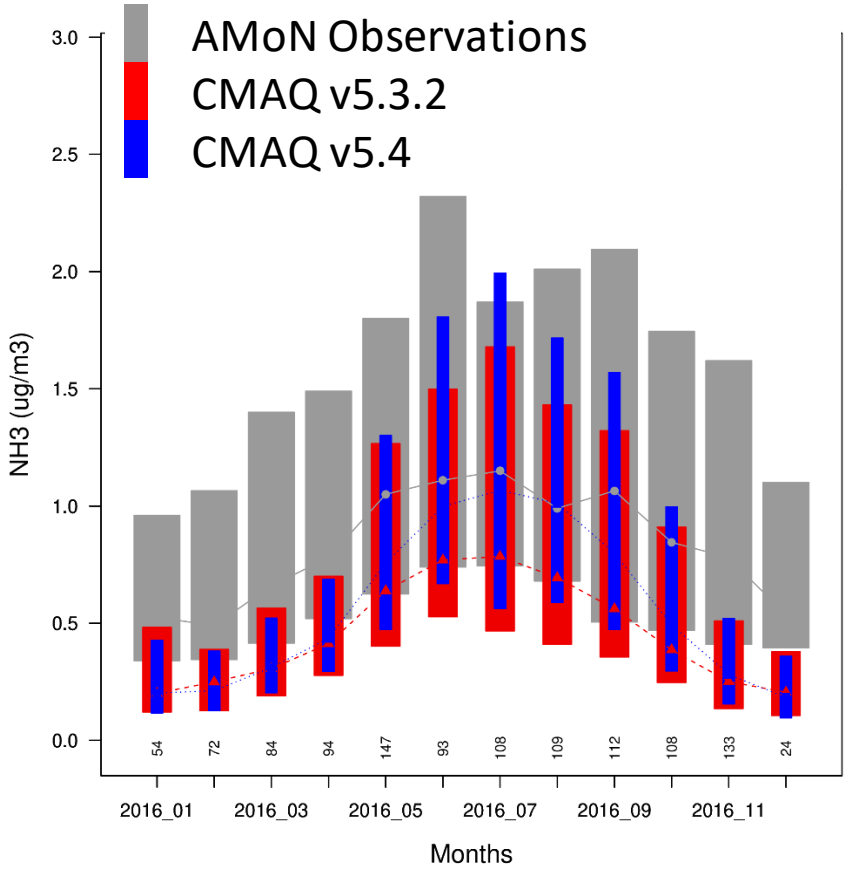


2020 Final Fertilizer Emissions



Evaluation at AMoN Sites 2016





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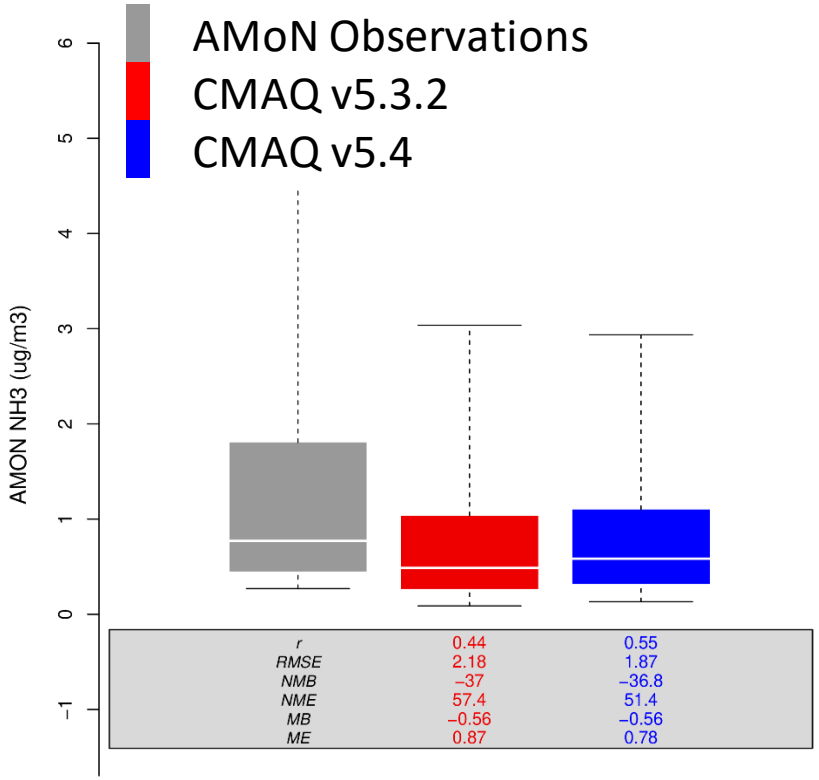

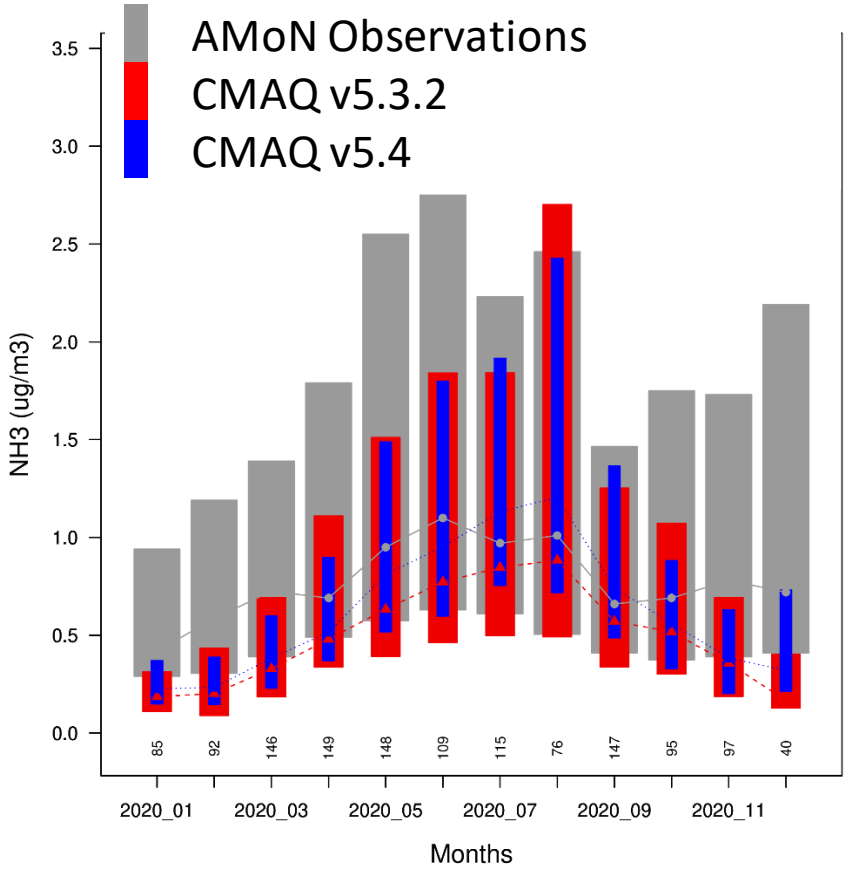

Summary

- Fertilizer emissions methodology was updated based on AMoN site survey and global observations of soil and vegetation NH_4^+ and pH
  - Resulted in approximately a 22% increase in the sum of fertilizer and biogenic NH_3 emissions
- Model updates decrease warm season NH_3 biases at AMoN sites
- Biogenic NH_3 emissions in Western US increased substantially
  - High temperature, high pH and low soil moisture
  - Currently conducting measurements for evaluation purposes *in situ* and in controlled laboratory settings
- Fertilizer and biogenic emissions for 2020 were substantially higher than 2017
  - About 30% higher when accounting for updated methodology
  - Likely meteorologically driven

Next Steps

- Separate fertilizer and biogenic NH_3 emissions
- Constrain NH_3 emissions processes with measurements
  - Field and laboratory experiments for alkali soils with low soil moisture
    - Targeting soils in the Western U.S. where the model estimates high emission factors/rates
- Explore how seasonality may impact biogenic NH_3 emission factors
  - How do vegetation emission factors vary from leaf out to senescence?
- Evaluation of model updates against recent satellite observations
  - Satellite observations from 2008 to 2020 show an increase in atmospheric NH_3
  - What are the driving factors of this trend?

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