MARINE NH$_3$ EMISSIONS

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Marine NH$_3$ emissions account for ~50% of natural sources

8.2 TgN a$^{-1}$ (5-80!)

Present-day NH$_3$ emissions (Sutton 2013)

Impact on nucleation

Almeida 2013
Unlike DMS there is no global survey of NH$_3$ seawater concentrations.
Seawater NH$_x$

- **Equatorial Pacific**: Models are biased high
- **Equatorial Atlantic**: COBALT $>>$ BEC
- **Subtropical gyres**: Location of the NH$_{sw}$ minimum
- **Southern ocean**: COBALT peak is shifted North

**COBALT** (Stock, 2013)
**BEC** (Moore, 2004)
Can we use the atmosphere to test ocean models?
NH$_x$ is a central piece of the ocean N cycle
Can we use the atmosphere to test ocean models?

NH$_x$ can account for a large fraction of N uptake

Gruber (2008)
NH₃ oceanic emissions

GEIA

NAtl=0.8  NPac=2.4  Ind=1.7  SATl=1  SPac=2.2  Tot=8.2

COBALT

NAtl=0.7  NPac=1.7  Ind=1.3  SATl=0.9  SPac=2.3  Tot=6.9

BEC

NAtl=0.1  NPac=0.9  Ind=0.3  SATl=0.1  SPac=1.3  Tot=2.7

ΔpH~0.42
E(RCP 8.5) ~ 0.4 E(1850)

COBALT (Stock, 2013)
BEC (Moore, 2004)
The phase of atmospheric NH\textsubscript{x} is linked to other marine emissions.
The phase of atmospheric NH$_x$ is linked to other marine emissions.
Aerosol NH$_4$

- **Equatorial Pacific**
  Both models perform well
  => sulfate saturation

- **Equatorial Atlantic**
  Both models are low

- **Subtropical gyres**
  Underestimate in southern hemisphere

- **Southern ocean**
  Limited information
Both models perform well in the Equatorial Pacific, leading to sulfate saturation. In the Equatorial Atlantic and Subtropical gyres, there are inconsistent seasonal cycles. The Southern ocean shows the impact of bird emissions.
Observations
BEC
COBALT

Equatorial Pacific
Equatorial Atlantic
Subtropical (North)
Subtropics (South)
Seasonal sea (North)
Seasonal sea (South)

NH₄⁺ (g)
NH₃ (g)
NHₓ (sw)
Some candidates to resolve the discrepancy

- **NH₄/NO₃ assimilation**
  BEC has 6 to 20 times lower NH₄ half saturation than COBALT

- **Nitrification**
  Light inhibition is more severe in COBALT the BEC
Nitrification and NH$_4$ assimilation have different footprints

Lower KNH$_4$ can resolve much of the discrepancy with seawater measurements

Low observations in the equatorial Pacific cannot be solely explained by KNH$_4$

Unresolved discrepancy between seawater/atmospheric observations in equatorial regions.
1. Ocean NH₃ emissions are lower than predicted by GEIA (at least two).

2. Atmospheric+Seawater observations can help constrain uncertain processes at the global scale
   i. half saturation
   ii. nitrification

3. Ocean and atmospheric observations cannot be reconciled in equatorial regions

What does NH₄ in ice core tell us?