Ammonia Emissions from Large Animal Colonies

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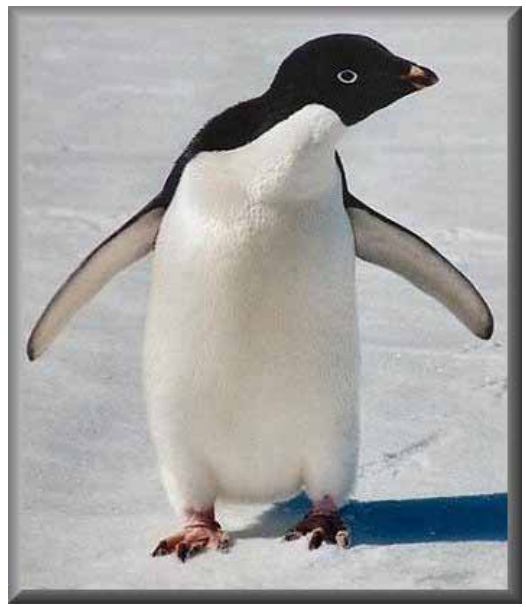
Outline

- **Why study large colonies?**

- **Study 1: Cape fur seals in Namibia**
  - **Atmospheric concentration measurements**
  - **Inverse atmospheric dispersion modelling**

  → Emission estimate
- **Study 2: Adelie penguins in Antartica**
  - **Atmospheric concentration measurements**
  - **Stable isotope (^{15}N) measurements**



Why study large colonies?

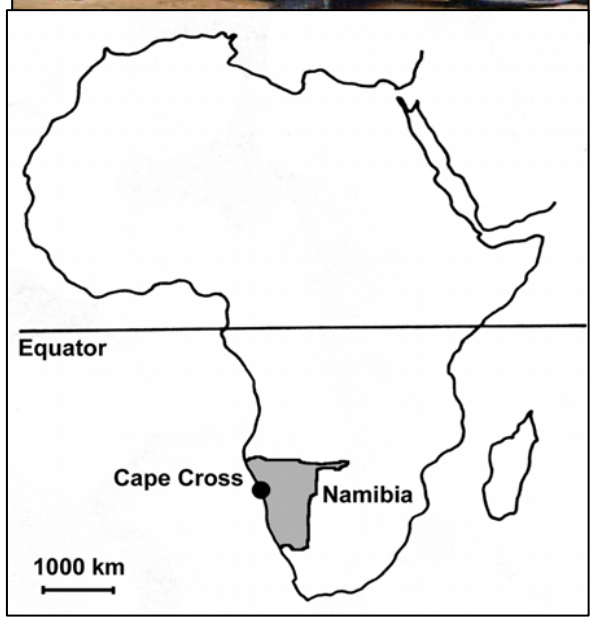
- Lot of research has gone into studying agricultural emissions of ammonia
- Large colonies of wild animals emit significant quantities of ammonia
- e.g. 2 Scottish seabird colonies:
  - Isle of May (19 tonnes NH_3 yr^{-1})
  - Bass Rock (152 tonnes NH_3 yr^{-1})
- But in most cases we don't know how much
- Large colonies are often in remote locations

Study 1: Cape fur seals in Namibia

- **Cape fur seal (*Arctocephalus pusillus pusillus*)**

- **Cape Cross, Namibia**

Population estimate: 150-250 x10^3



Study 1: Cape fur seals in Namibia

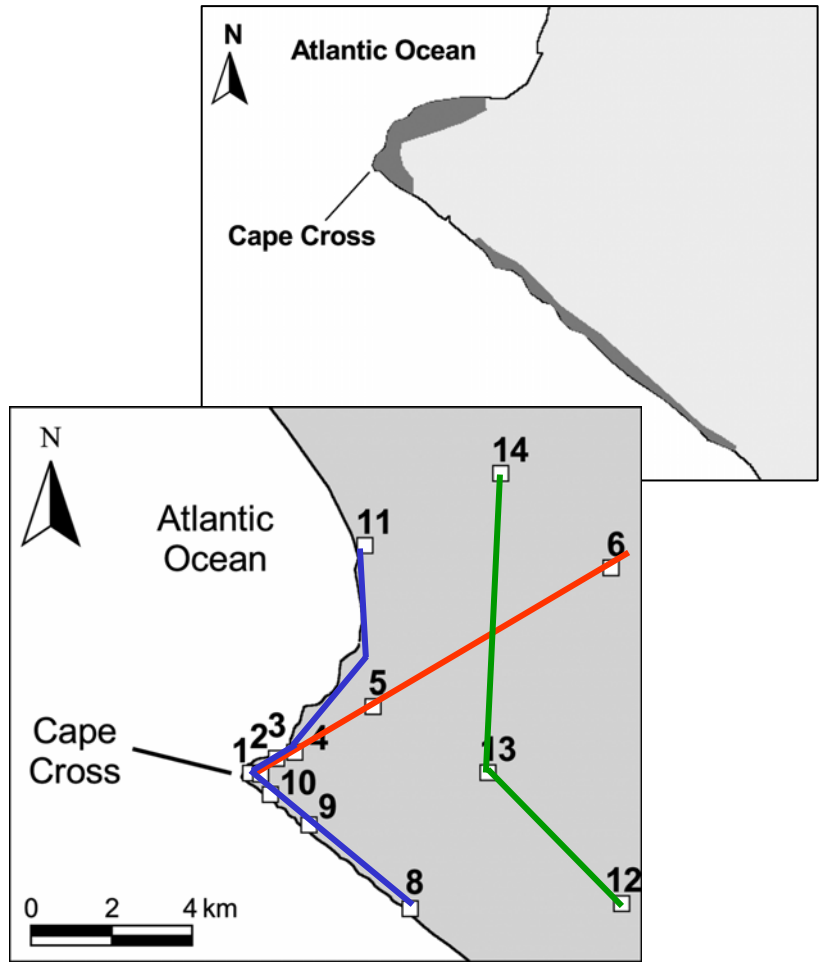
Project Overview

- Atmospheric NH_3 concentration measurements around the colony
- Inverse application of an atmospheric dispersion model to calculate the NH_3 emission rate per seal
- Estimation of the volatilisation rate of excreted nitrogen

Study 1: Cape fur seals in Namibia

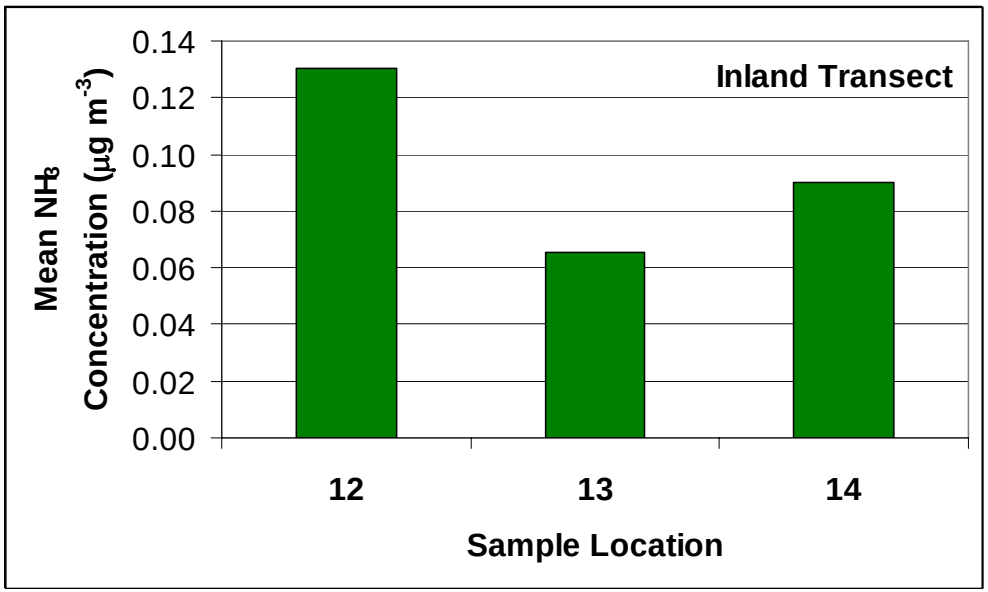
Atmospheric NH_3 concentration measurements

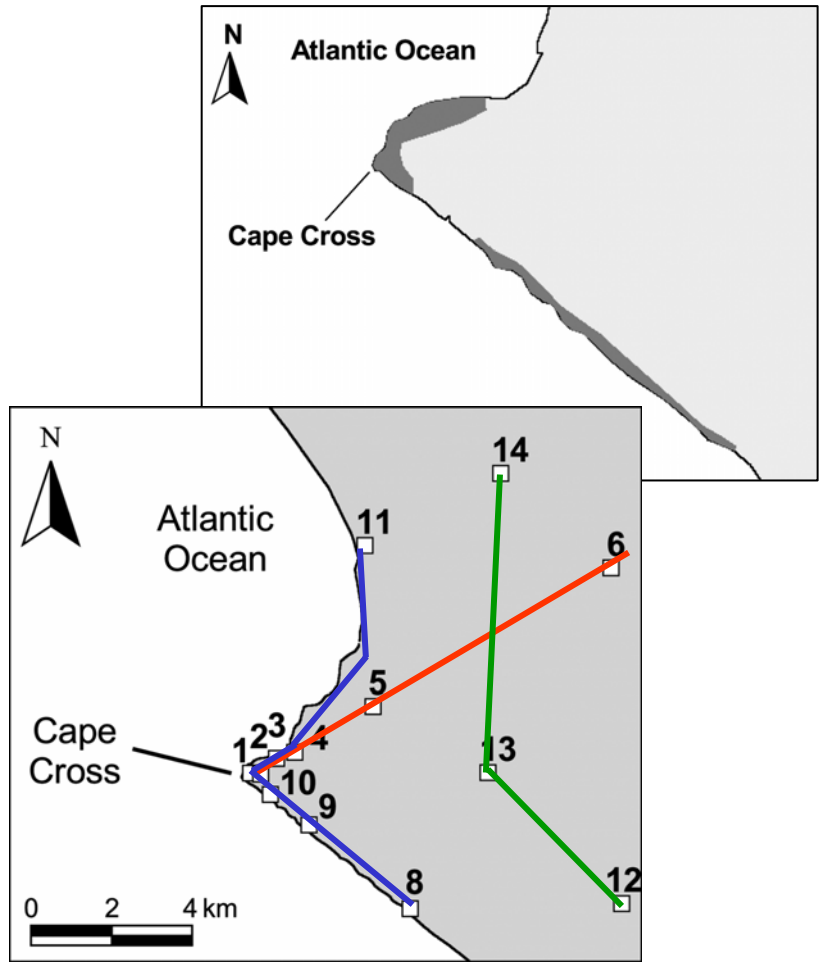
- **Measured over 2 periods of 14 days using ALPHA (**Adapted **L**ow-cost **P**assive **H**igh **A**bsorption**) samplers**
- **Measured along various transects through the colony or parallel to the coastline**



Study 1: Cape fur seals in Namibia

Atmospheric NH_3 concentration measurements





Study 1: Cape fur seals in Namibia

Atmospheric dispersion modelling

Model Description:

LADD (Local Atmospheric Dispersion and Deposition)

- ***Operates on a domain of 10-100 km ^{2}***
- ***Takes the ammonia emissions in the domain and disperses the ammonia across the domain (according to the wind/surface parameters)***
- ***During the dispersion, some of the ammonia is deposited to the surface at a rate determined by the surface parameters***
- ***Output: mean ammonia air concentration maps at different heights and ammonia deposition maps for the modelled area.***

Study 1: Cape fur seals in Namibia

Atmospheric dispersion modelling

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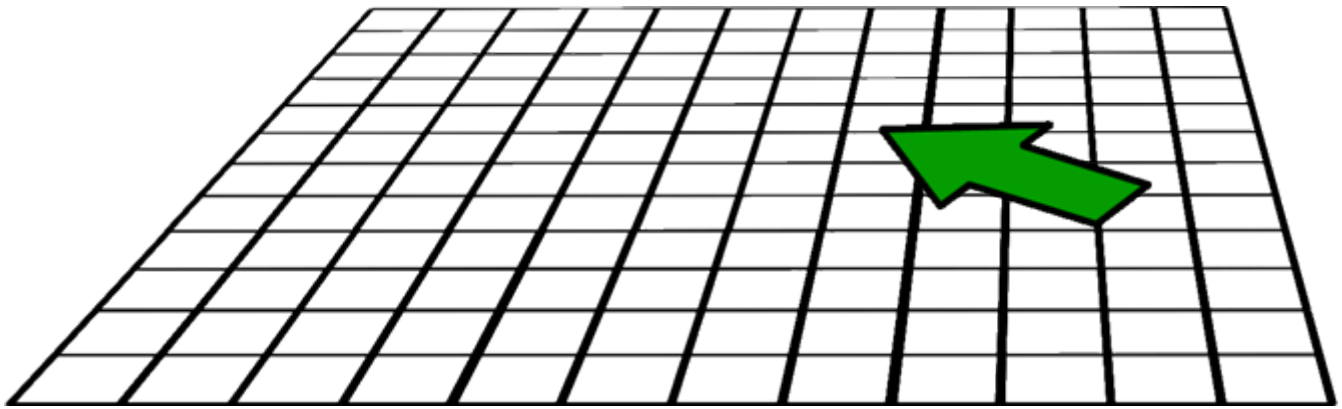

Study 1: Cape fur seals in Namibia

Atmospheric dispersion modelling

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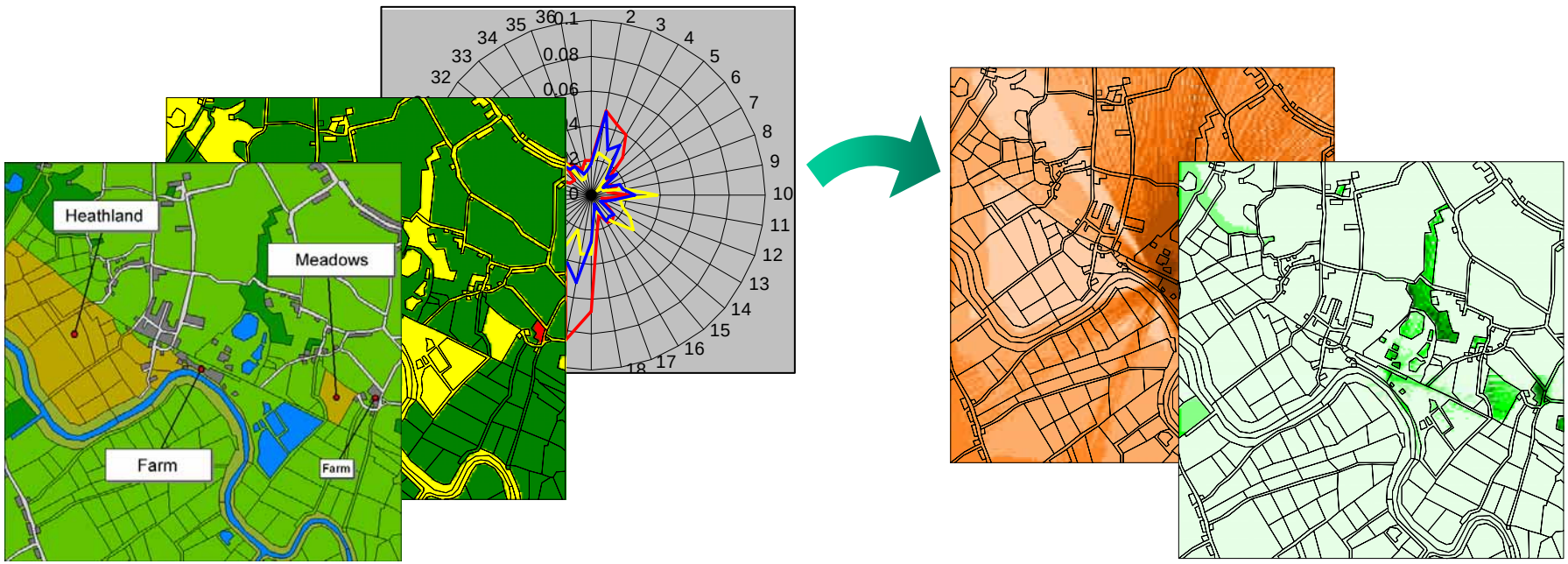


Study 1: Cape fur seals in Namibia

Atmospheric dispersion modelling

Using the model inversely:

- Since modelled concentration increases linearly with source strength
- Use any value for emission source strength (e.g. 100 kg NH_3-N ha^{-1} yr^{-1})
- Compare modelled concentrations with those measured

Study 1: Cape fur seals in Namibia

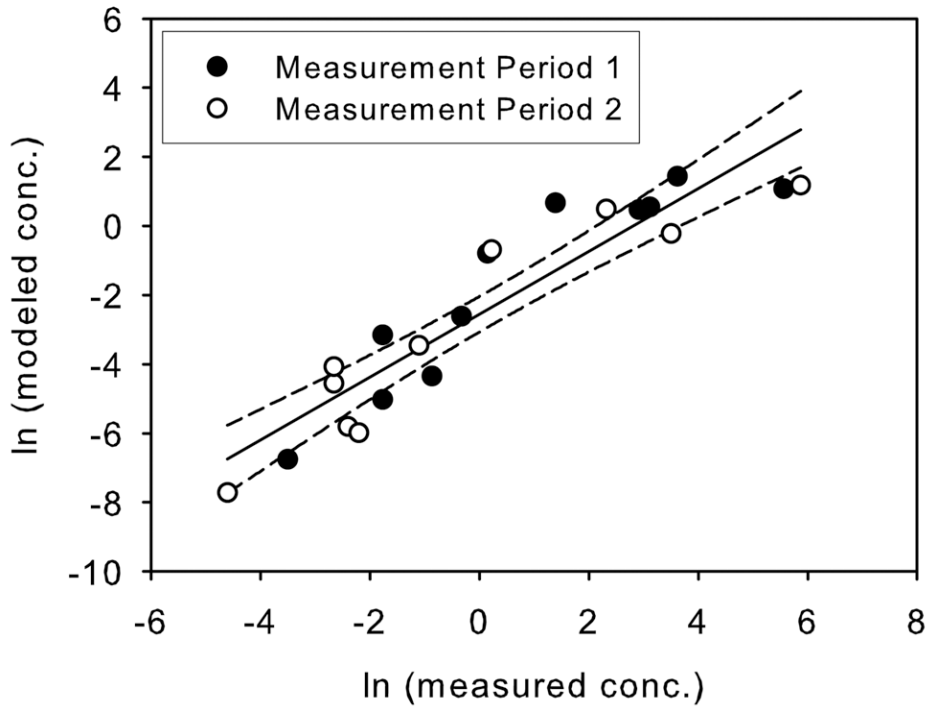
Emission estimate:

- **Best fit between modelled and measured concentrations is with an emission rate of:**

1150 kg NH_3-N ha^{-1} yr^{-1}

(95% CI: 700- 1900 kg NH_3-N ha^{-1} yr^{-1})

- **Seal Population: 190 000**
- **Colony Area: 36.5 ha**



0.60 g NH_3-N $seal^{-1}$ day^{-1}

(95% CI: 0.36 to 1.0 g NH_3-N day^{-1})

Study 1: Cape fur seals in Namibia

Volatilisation estimate:

- Seal daily prey consumption: 3.8 kg (N content: 2.6%)
- Approximately 87% of N ingested is excreted
- Seals are on land approximately 30% of the time
- Annual colony excretion estimate: 1360 Mg N
- Annual colony NH_3 emission estimate: 42 Mg NH_3-N

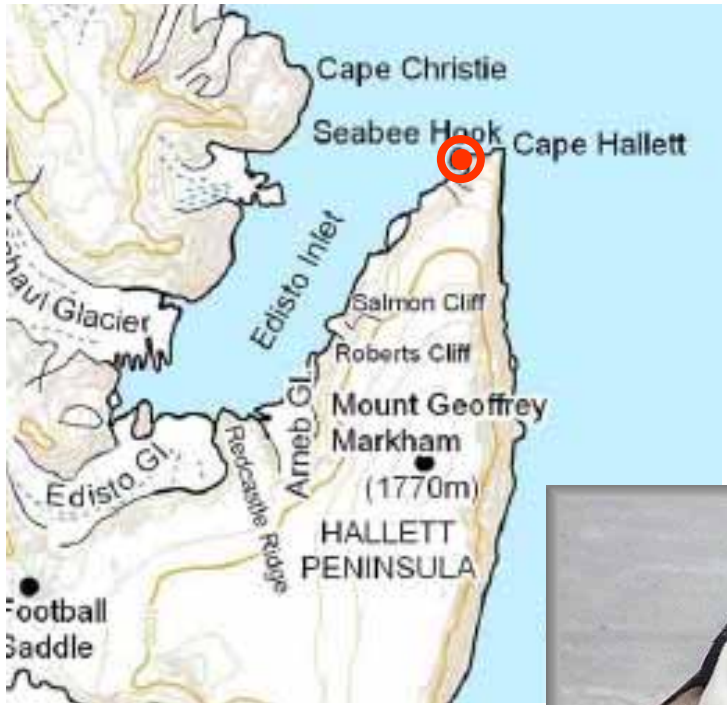
3.1% of excreted N is volatilised as NH_3
(seabird guano: 33% [*Wilson et al.*, 2004])

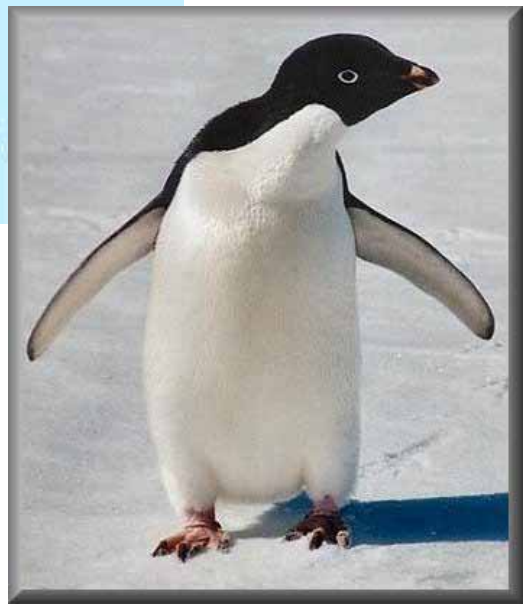
…and now over to Antarctica

…for Study 2

Study 2: Adelie penguins in Antarctica

Cape Hallett:





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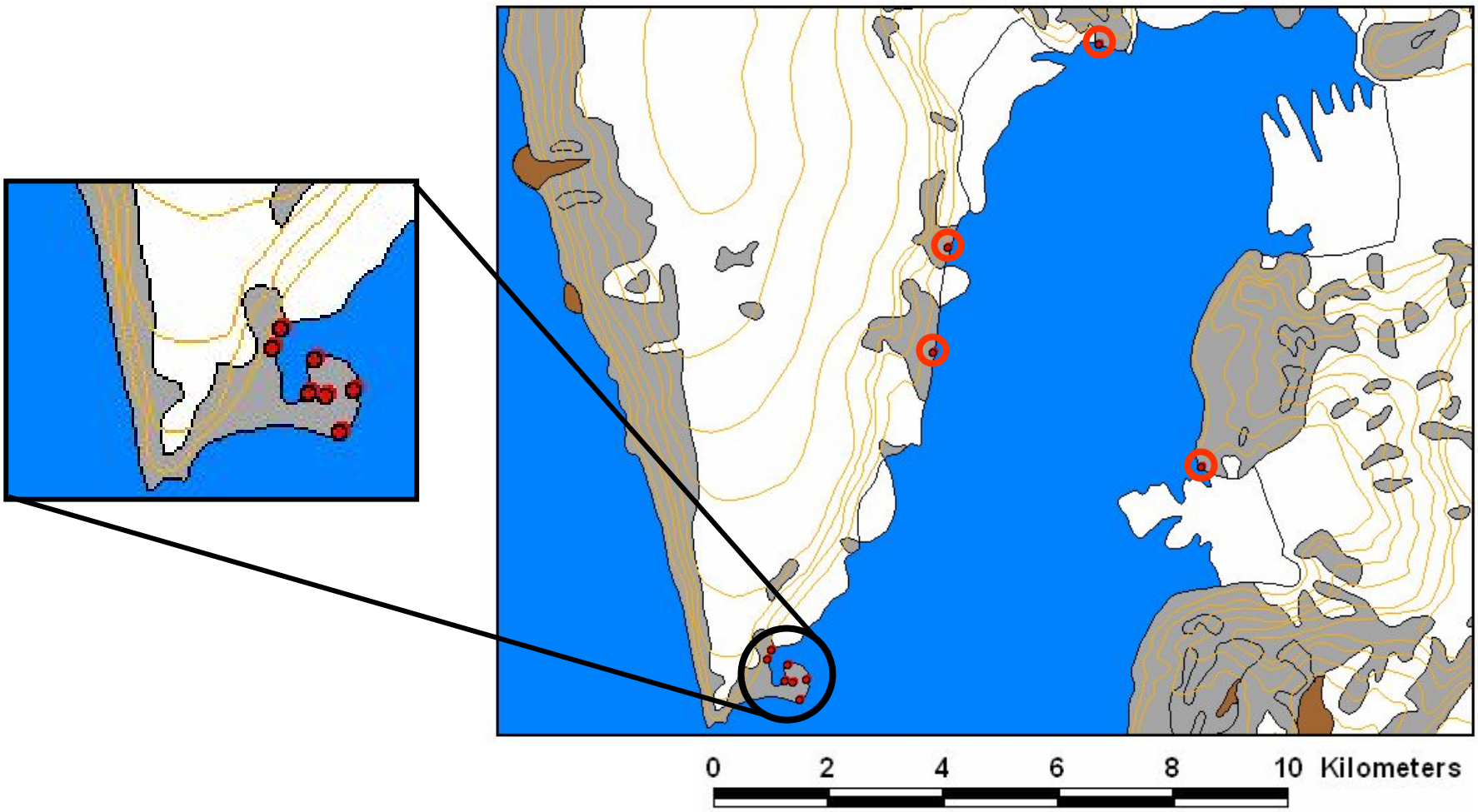
Study 2: Adelie penguins in Antarctica

Project Overview

- Atmospheric NH_3 concentration measurements around the colony
- Inverse application of an atmospheric dispersion model to calculate the NH_3 emission rate per penguin
- ^{15}N Natural abundance measurements of penguins, atmospheric ammonia, soils and lichens

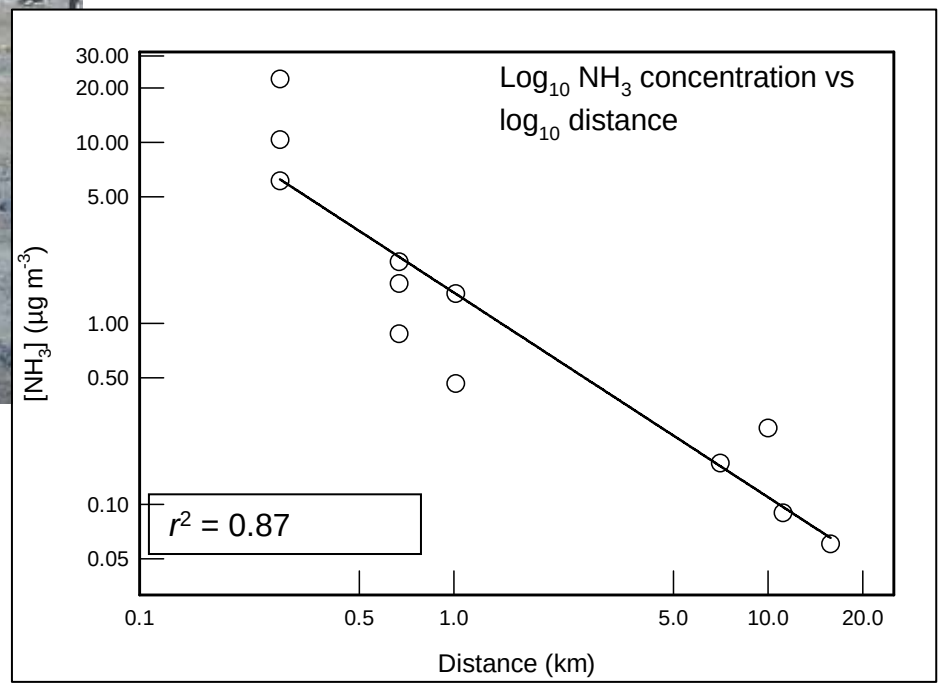
Study 2: Adelie penguins in Antarctica

Atmospheric NH_3 concentration measurements



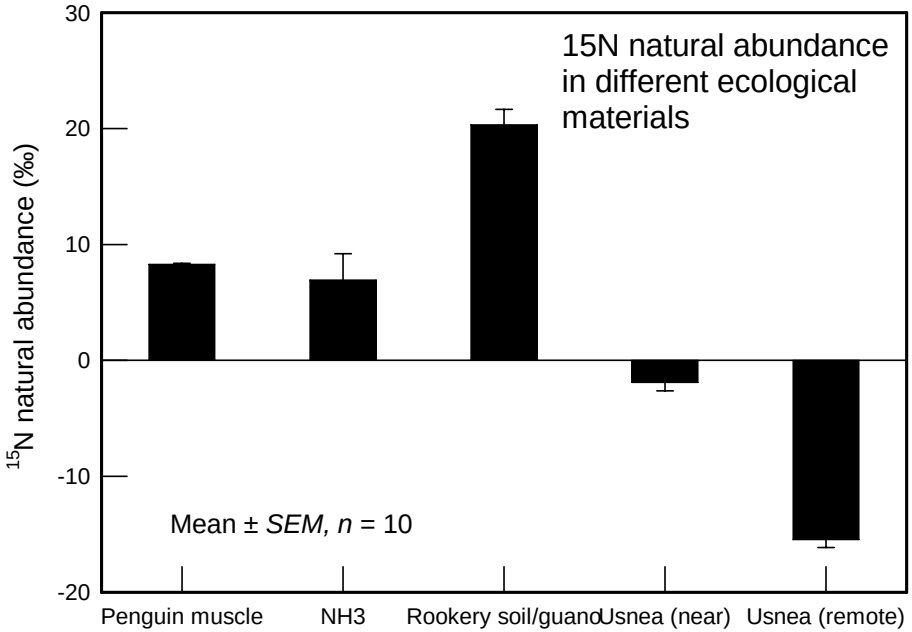
Study 2: Adelie penguins in Antarctica

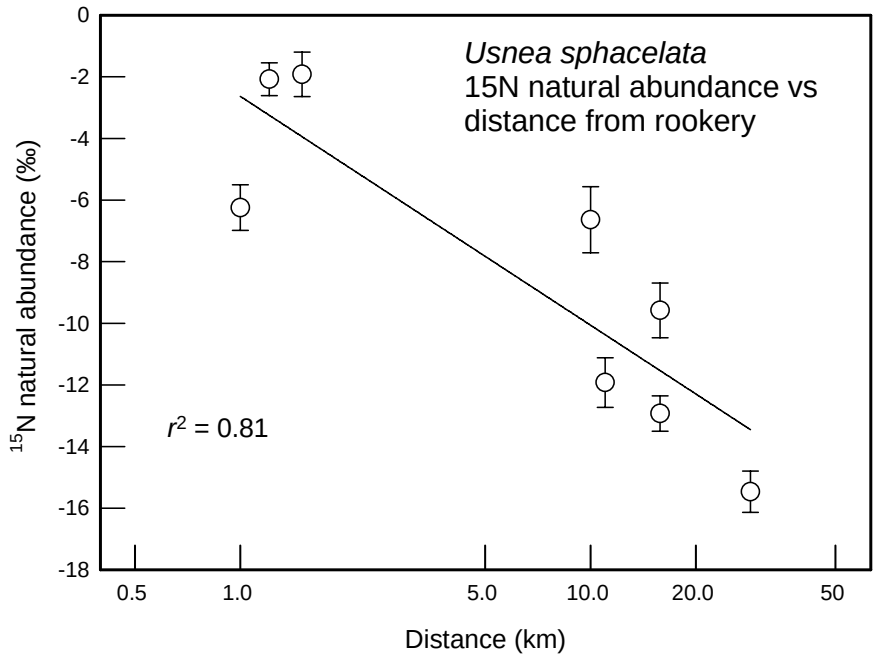
Atmospheric NH_3 concentration measurements



Study 2: Adelie penguins in Antarctica

Stable isotope ^{15}N measurements





To be continued..

Conclusions

Cape fur seals in Namibia:

- Significant quantities of ammonia are emitted by the Cape Cross colony
- Individual seal ammonia emission estimate:

  0.60 g NH_3-N day^{-1}
- Approximately 3% of N excreted is emitted as ammonia

Ref:

Ammonia emissions from a Cape fur seal colony, Cape Cross, Namibia. Geophysical Research Letters (2006).

Conclusions

Adelie penguins in Antarctica:

- NH_3 dispersion can be measured up to 10 km from rookery
- ^{15}N enrichment in *Usnea sphacelata* was detectable up to 15 km from the rookery
- ……..

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Thanks for listening

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