香港中文大學
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Modeling NH_3-aerosol-climate feedbacks using an earth system model: Implications for food security & air quality

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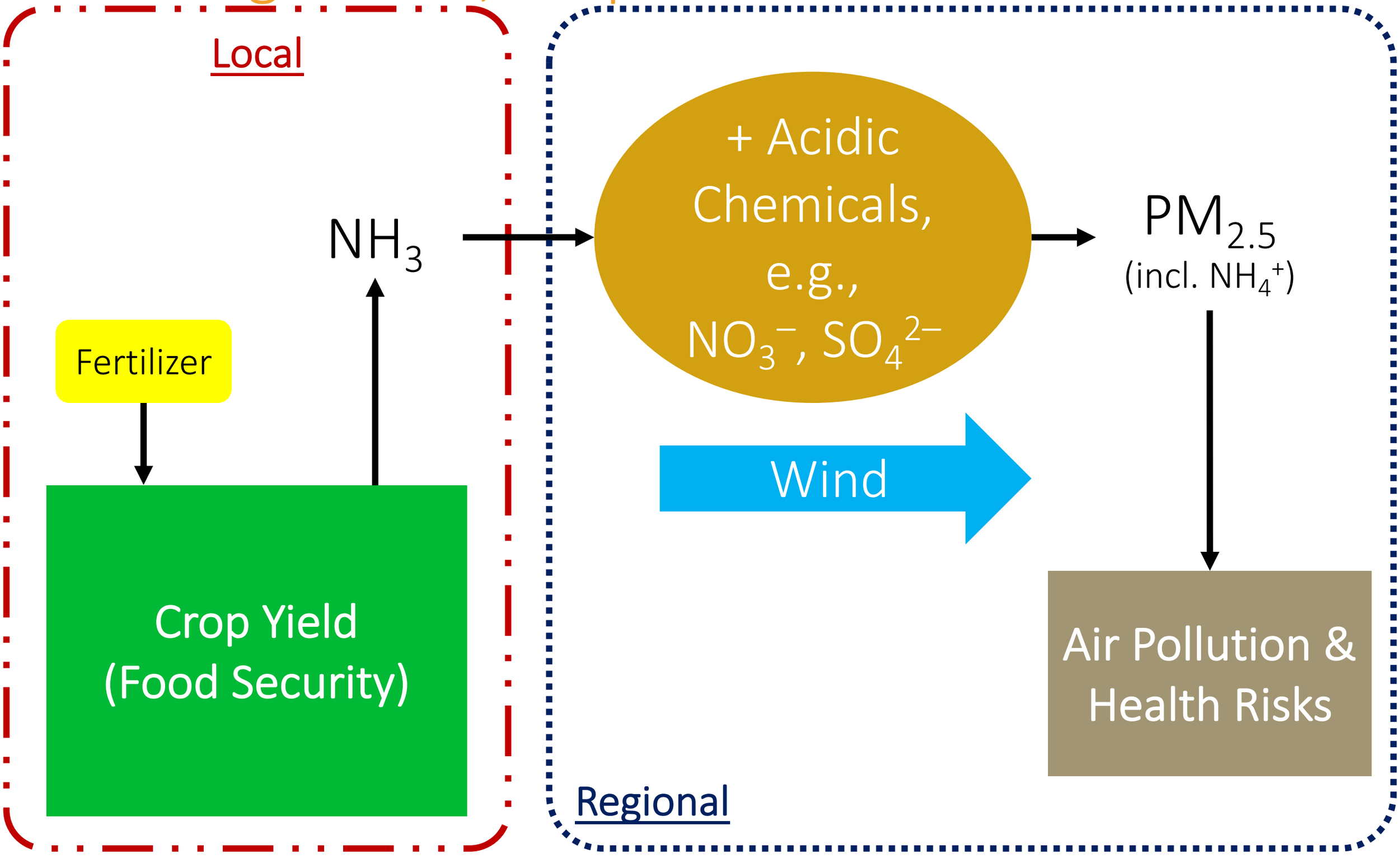
Agriculture is a main contributor (>85%) to atmospheric NH_3 in Europe, China, and the US, resulting in >600,000 premature deaths in 2010



?

Aerosol-climate Interactions

Magnitude?
Sign?
Spatially?
Temporally?
Joint effect?

?

Deposition

NH_3

+ Acidic Chemicals, e.g., NO_3^-, SO_4^{2-}

$PM_{2.5}$ (incl. NH_4^+)

Fertilizer

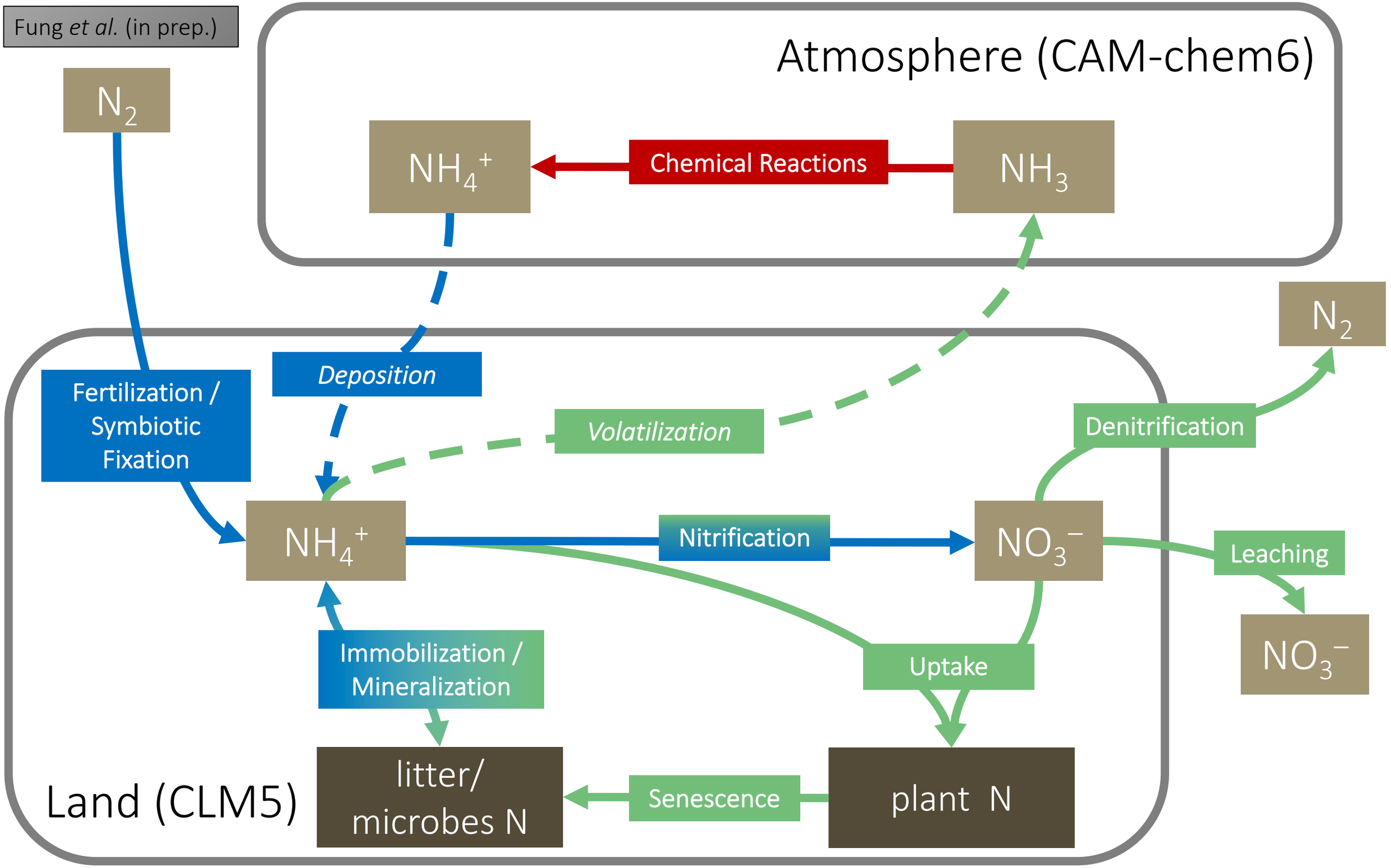
Wind

Crop Yield (Food Security)

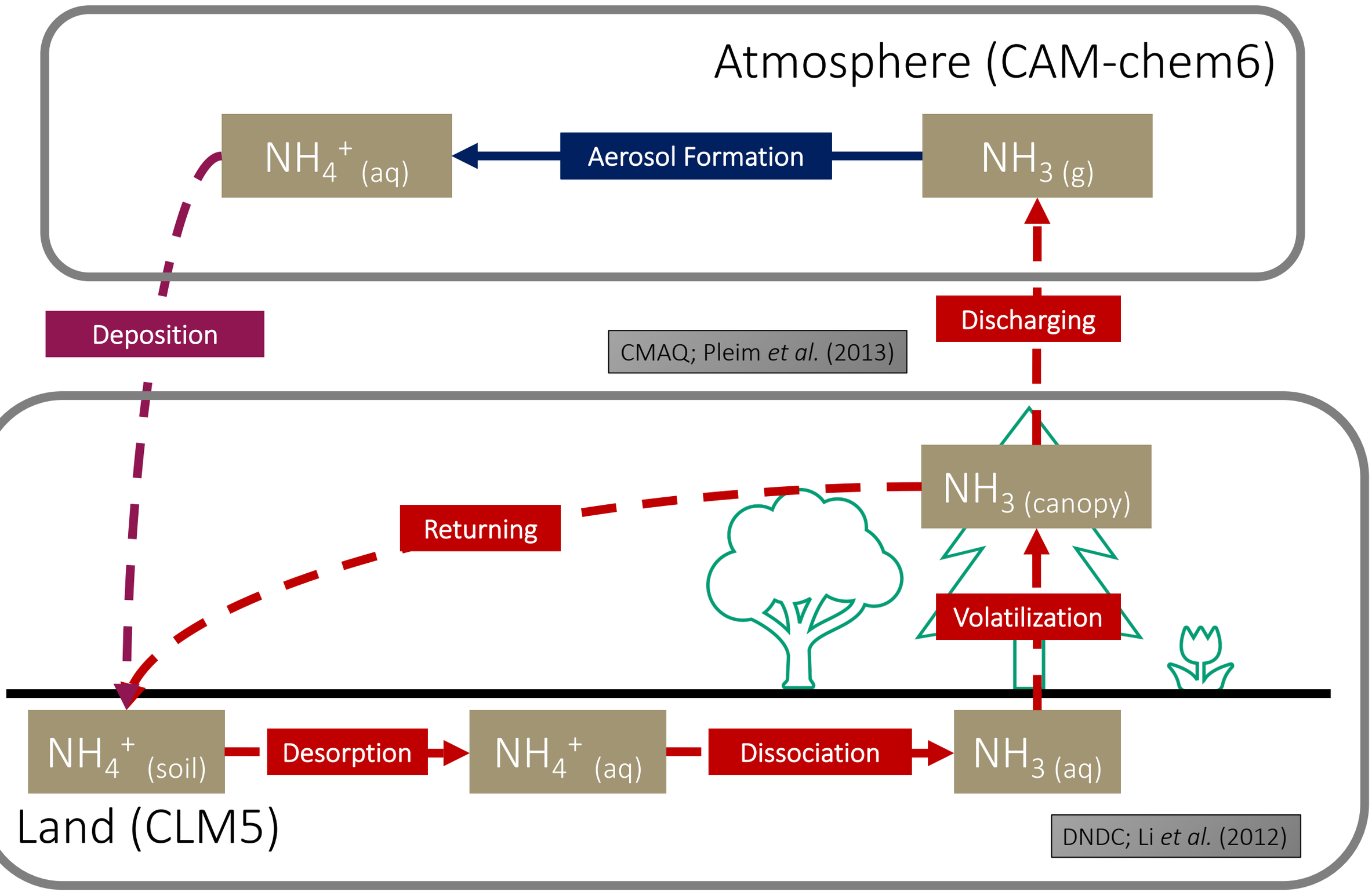
Air Pollution & Health Risks

Enabling land-atmosphere exchange of NH_3 in Community Earth System Model (CESM2)

Fung *et al.* (in prep.)

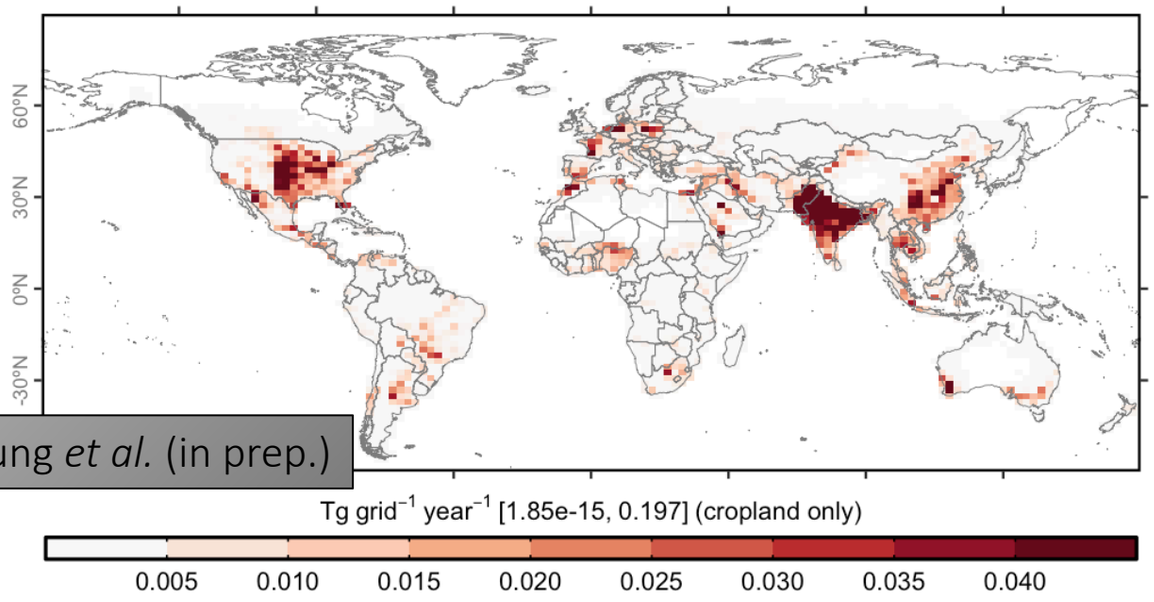


We estimate NH_3 emission using a "multi-stage" scheme



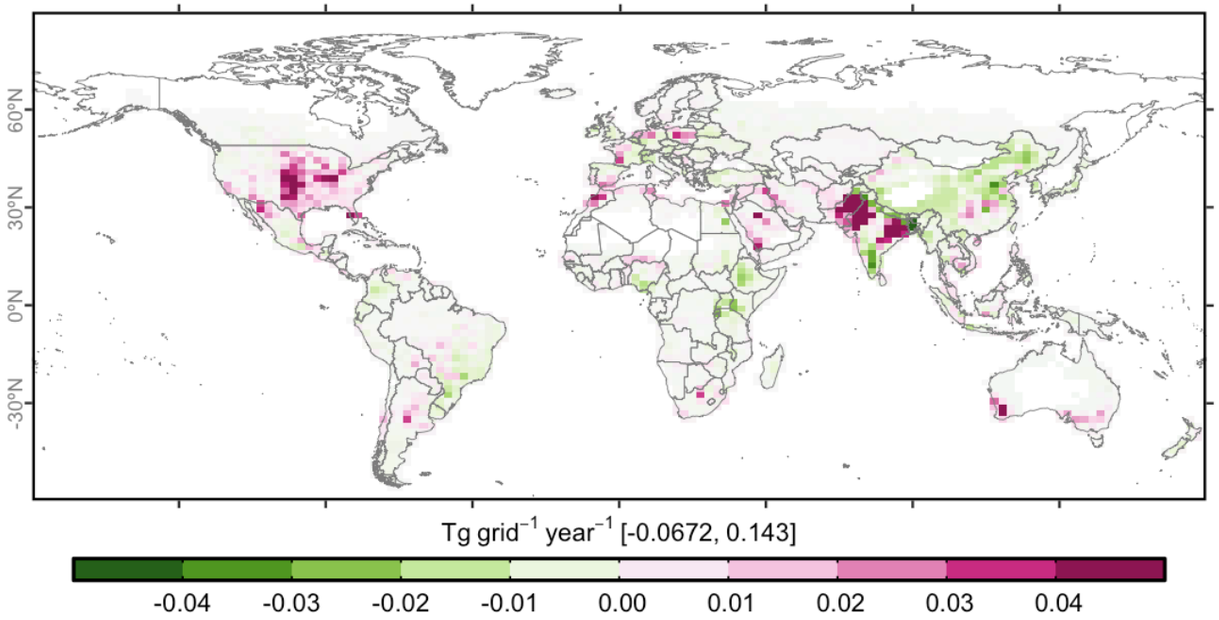
Our simulated NH_3 emission reasonably agrees with inventory estimates over/around hotspots

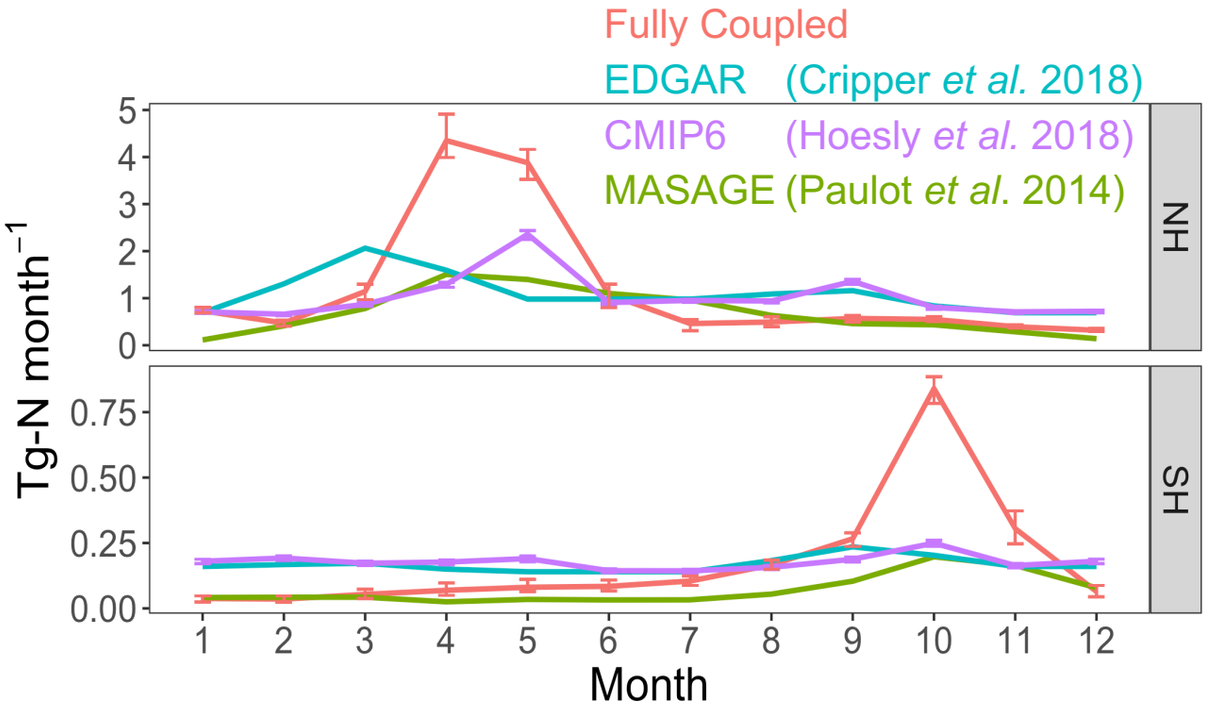
Fully Coupled: NH_3 Emission due to Fertilizers
(Global Total = 16.6 Tg-N year^{-1})



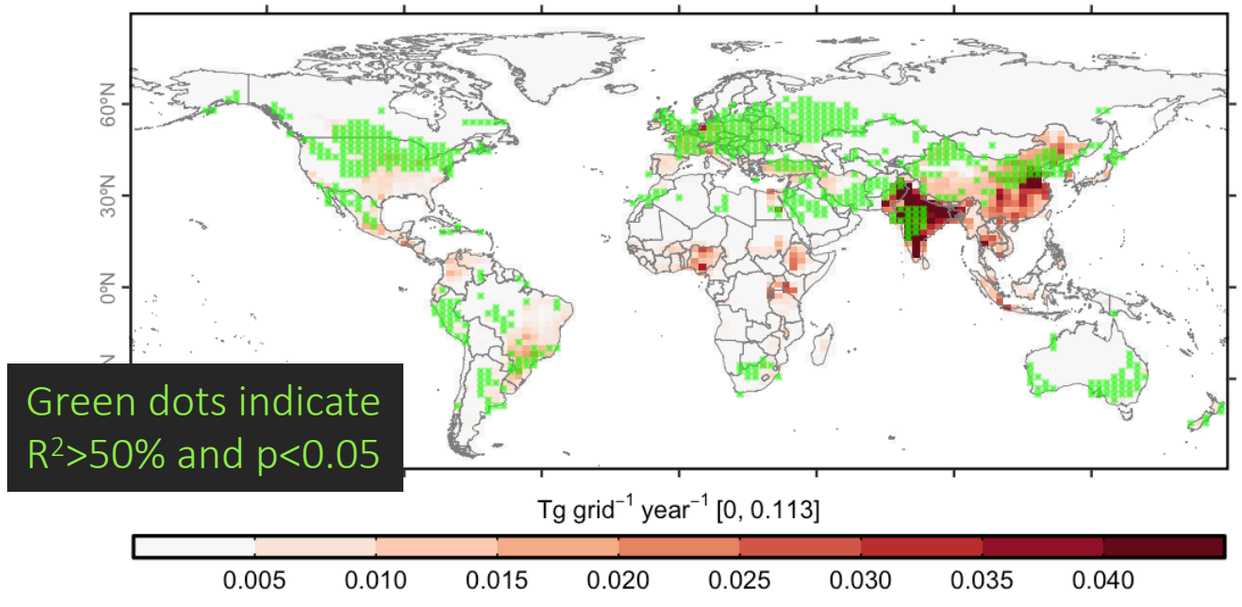
Fung *et al.* (in prep.)

Fully Coupled – CMIP6
(+2.4 Tg-N year^{-1})





Grid-by-grid Monthly Emission Correlation (Fully Coupled vs CMIP6)

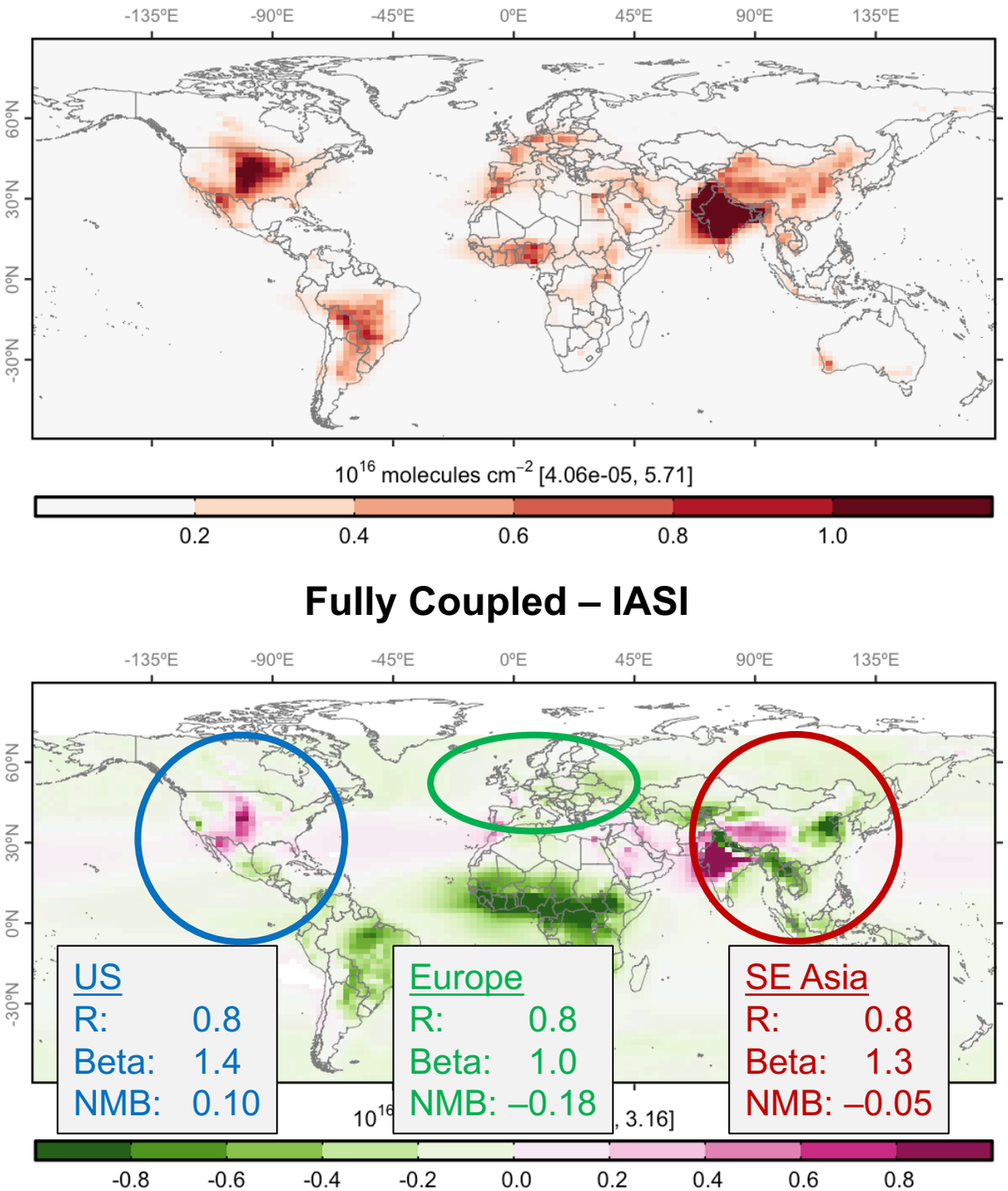


Please note that the colormaps are saturated at respective values.

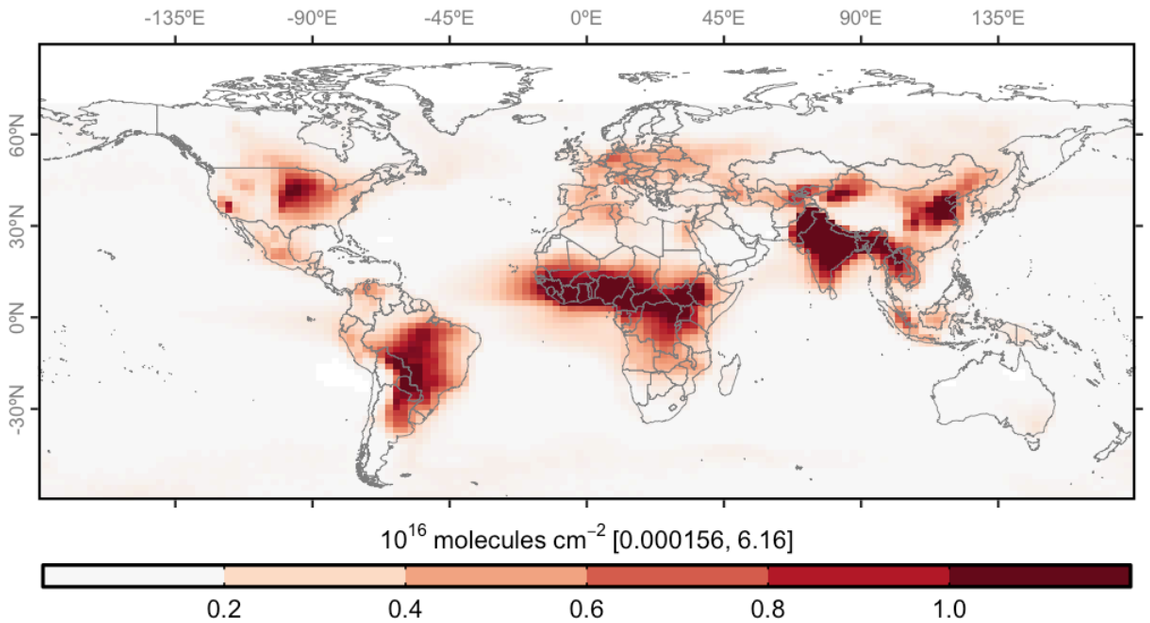
Less biases in modeling atmospheric NH_3, compared to default CESM

Van Damme *et al.* (2018)

Fully Coupled: Atmospheric NH_3, Column Total

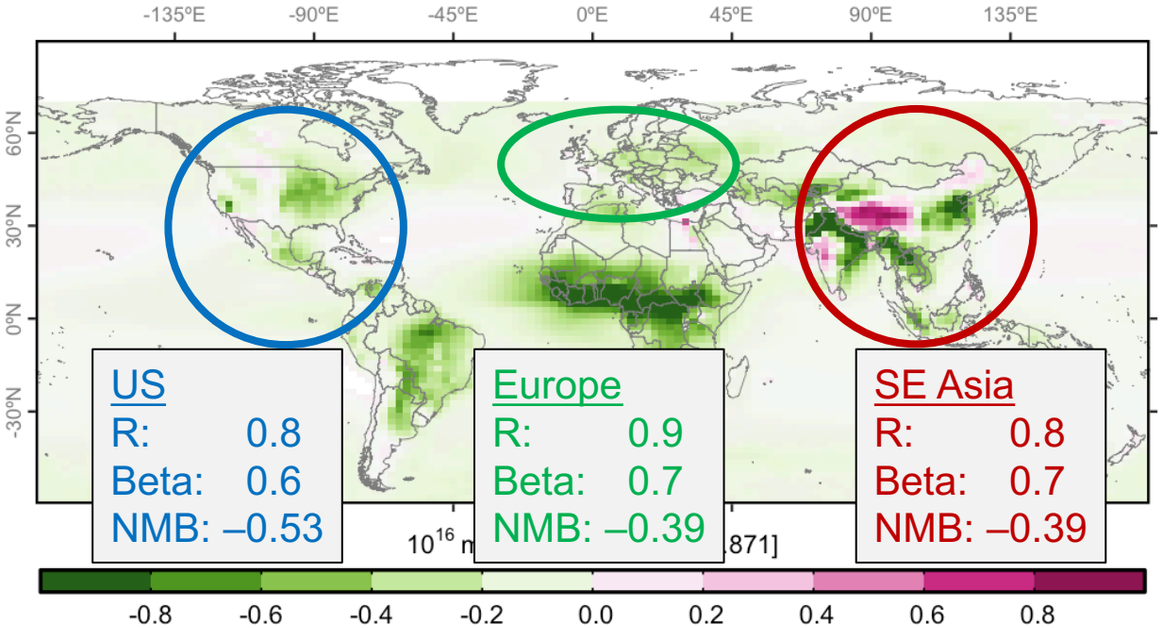


IASI NH_3 (2008-2016)



Fully Coupled – IASI

Default CESM2 (w/ CMIP6) – IASI



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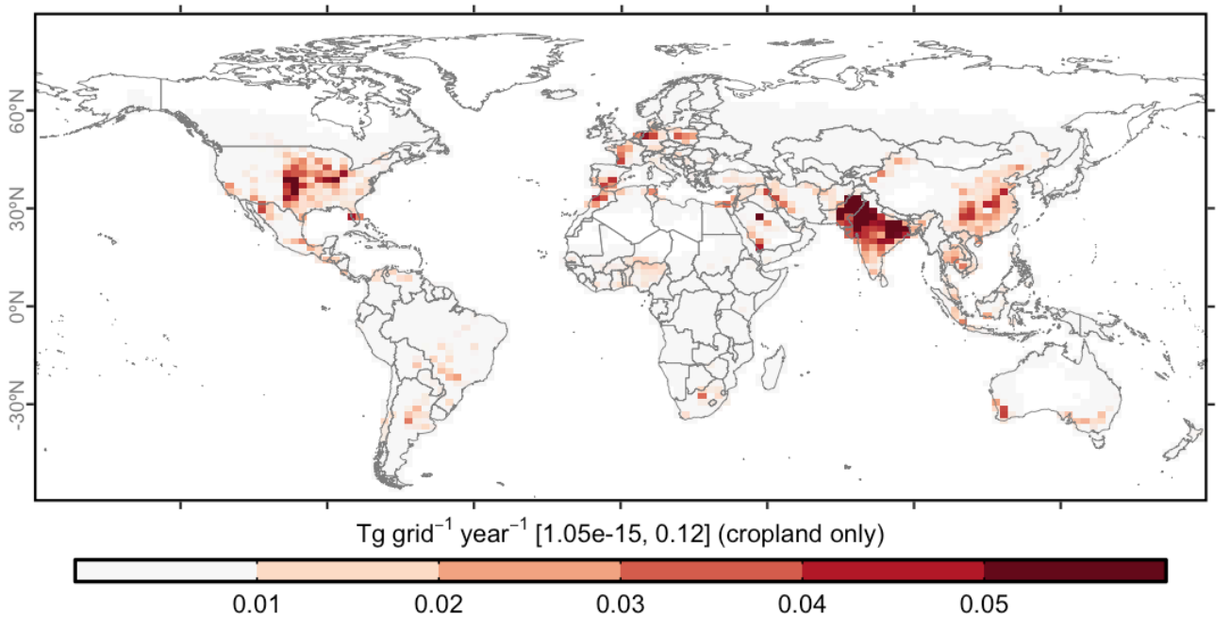
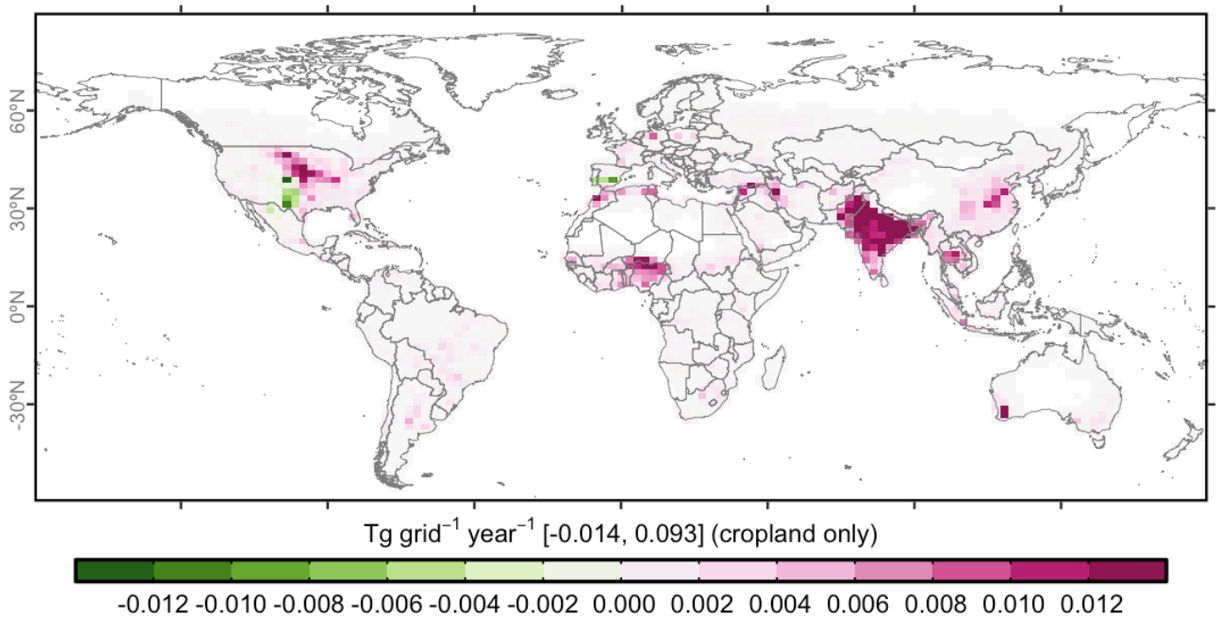
Cropland NH_3 emission suppressed by aerosol-climate interactions but raised by N deposition

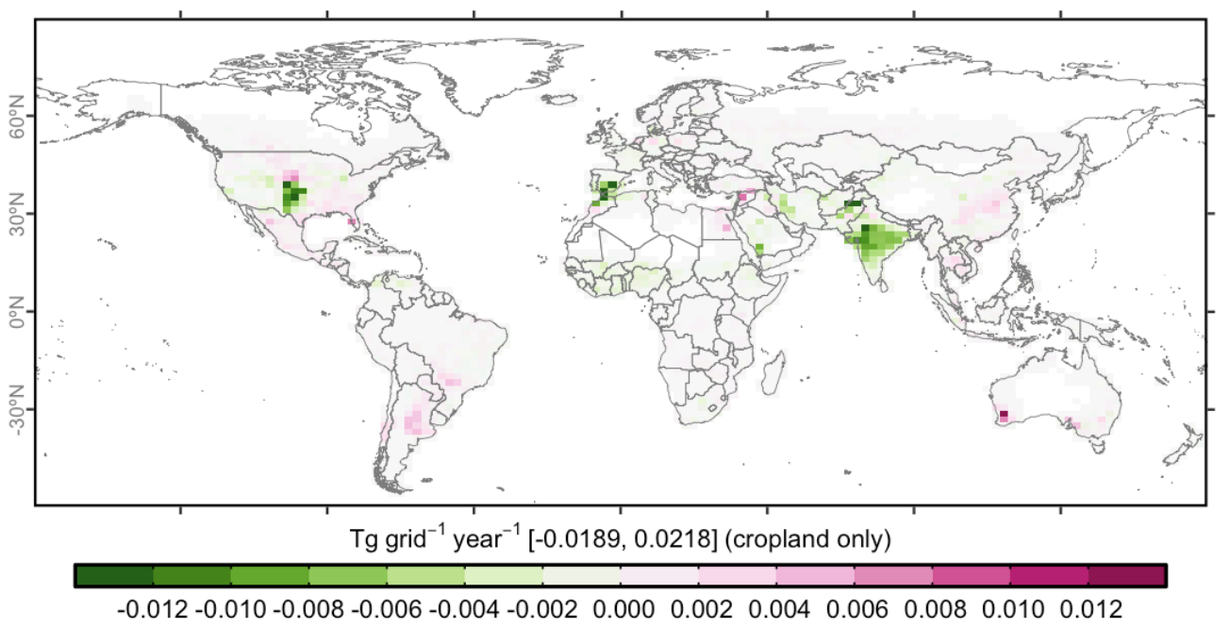
Baseline: NH_3 Emission due to Fertilizers
(Global Total = 13.9 Tg-N year^{-1})



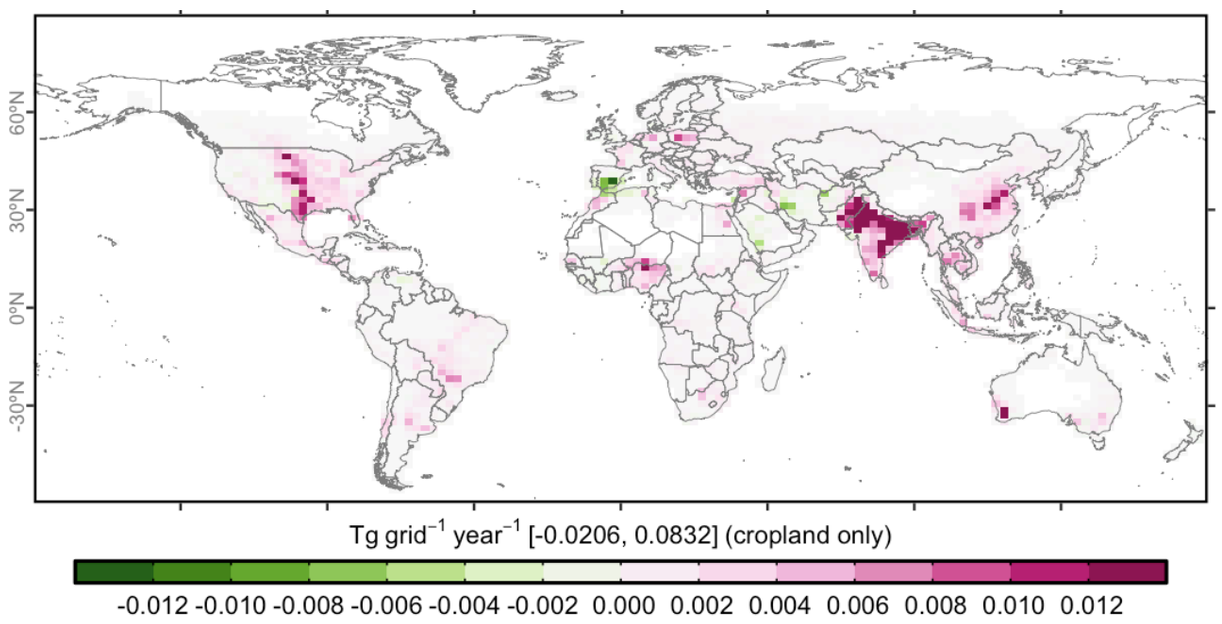
With Deposition Only
(+3.1 Tg-N year^{-1})



With Aerosol-climate Interactions Only
(–0.4 Tg-N year^{-1})



Fully Coupled – Baseline
(+2.7 Tg-N year^{-1})



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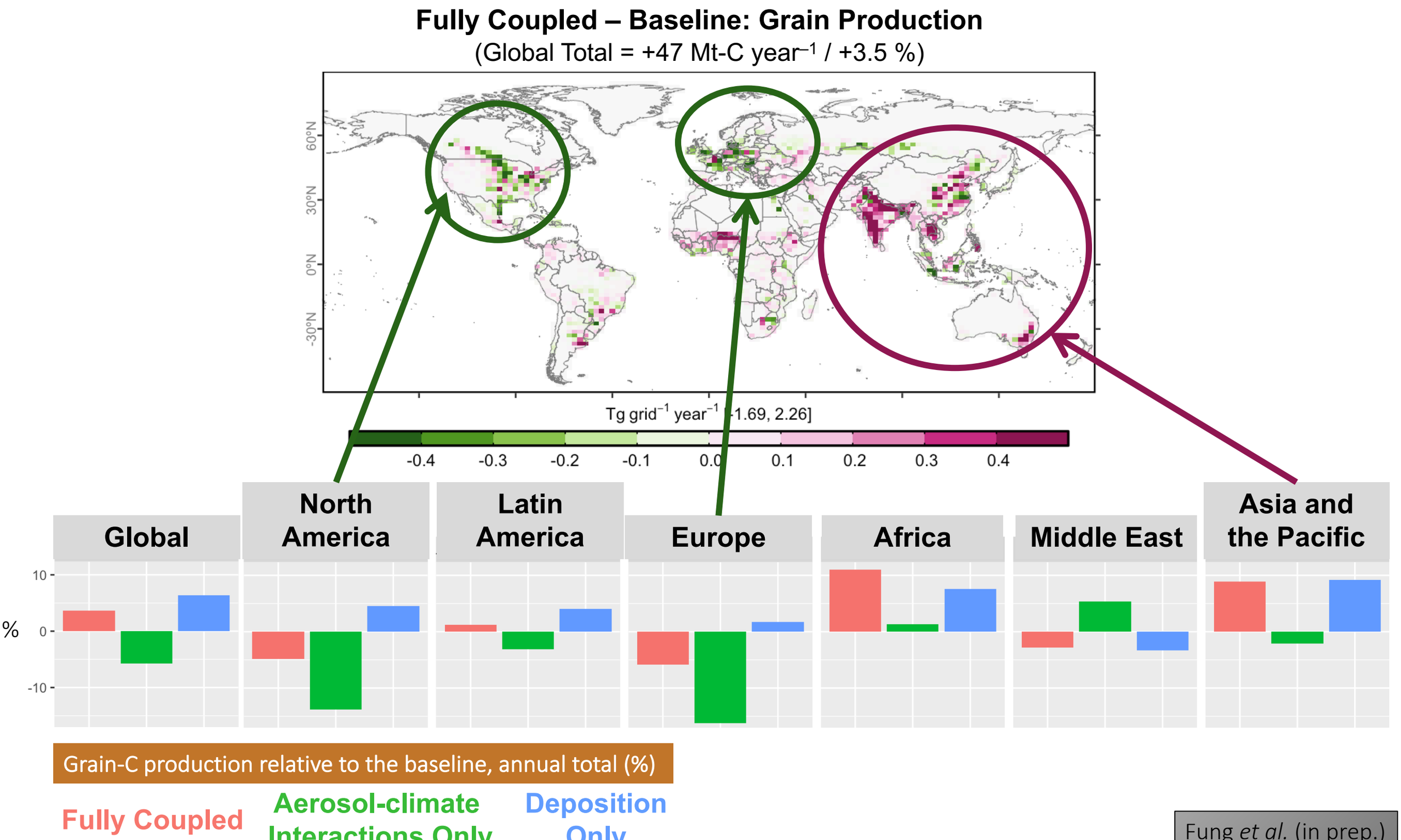
Fung *et al.* (in prep.)

Diverging effects on grain production: ups in Asia, downs in the US and Europe



Fung *et al.* (in prep.)

Summary

Thank you!

For relevant works, visit kamingfung.wordpress.com and Amos' talk (A43A-01, Thu 13:40)

- Enabling the **coupling of NH_3 emission** and **NH_4^+ deposition** between CLM5 and CAM-chem6
  - **Cropland NH_3 emission** agrees well with CMIP6 inventory
  - **Modeled atmospheric NH_3** is less biased than the default model when compared with IASI NH_3 observations
- Quantifying the effects of **deposition** and **aerosol-climate interactions**
  - NH_3 emission **raised by N deposition** (+22%) but **suppressed by aerosol-climate interactions** (–3%)
  - **Lower grain productivity in North America & Europe** (–5%) due to less rainfall, but **higher in Asia and Australia** because of deposition (+9%)
- Evaluating agricultural plans and their associated environmental consequences under future scenarios and climate with the improved CESM2