A new assessment of global and regional budgets, fluxes and lifetimes of atmospheric reactive N and S gases and aerosols

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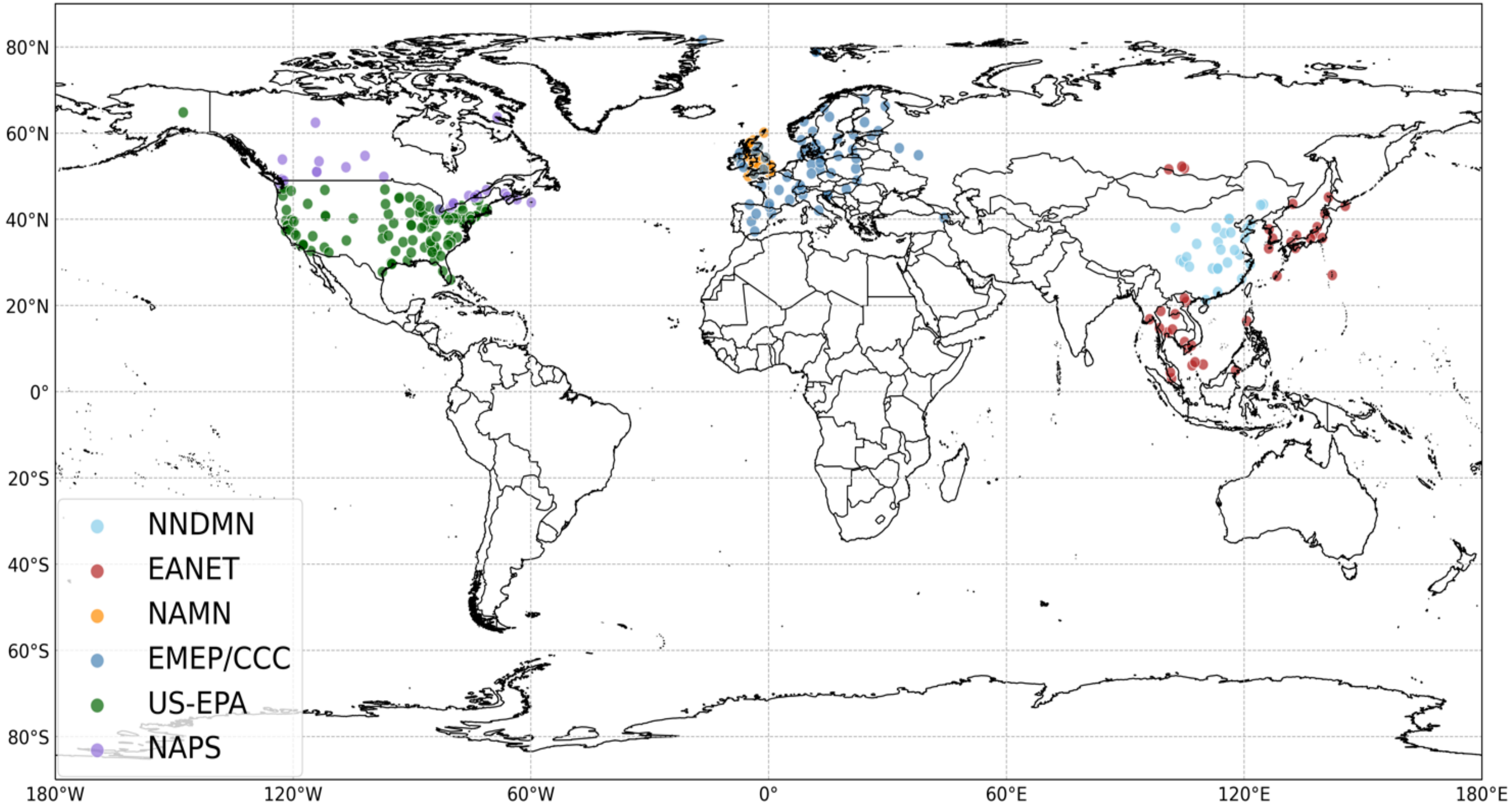
Motivation

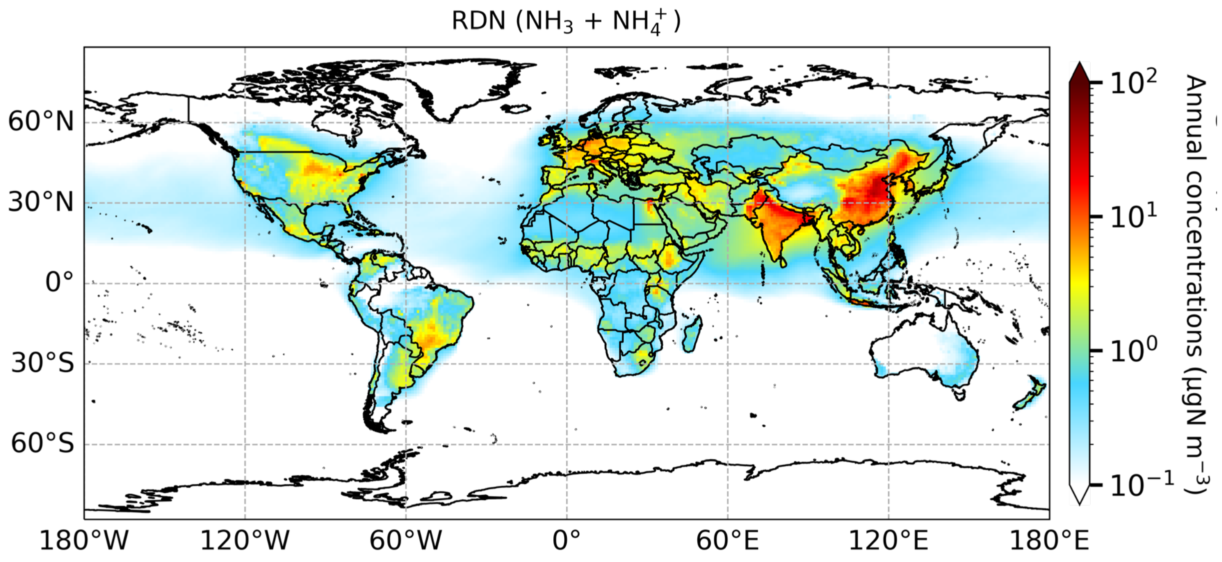
- Reactive N_r and S_r species (e.g., NH_3, NH_4^+; NO_2, NO_3^-; SO_2, SO_4^{2-}) have significant impact on human health, ecosystems and climate.
- Impacts and their mitigation are influenced by the particular chemical forms of N_r and S_r concentrations and deposition.
- Knowledge of regional variations in N_r and S_r constituents and budgets is important for implementing emissions controls in line with local conditions.

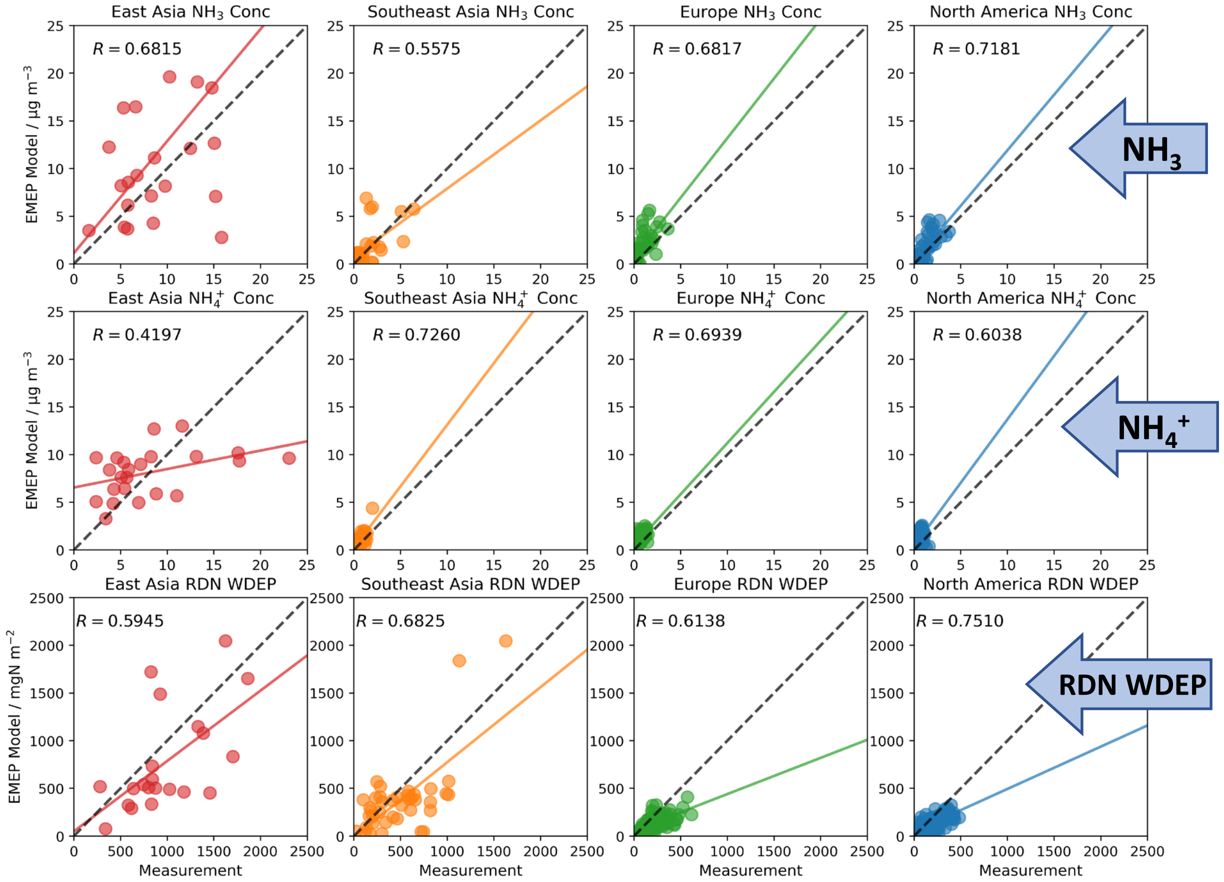
Model configuration

- EMEP MSC-W model – WRF model.
- Grid resolution: 1° × 1°.
- Emission inventory: HTAP(2010) and ECLIPSE(2010, 2015).
- N_r and S_r: NH_3, NH_4^+, NO_2, HNO_3, NO_3^-, SO_2, SO_4^{2-}, etc.
- Compared against 10 surface measurement networks.



Model-Measurement comparison (Ge et al., GMD, 2021)





Concentration data for 2015	East Asia	Southeast Asia	Europe	North America
$\overline{R_7}$ ($\overline{R_5}$ for EA)	0.35	0.73	0.67	0.63

- ➢ EMEP model captures regional spatial variations well
- ➢ Regional variation in model–measurement bias suggests shortcomings in regional emissions and/or measurements

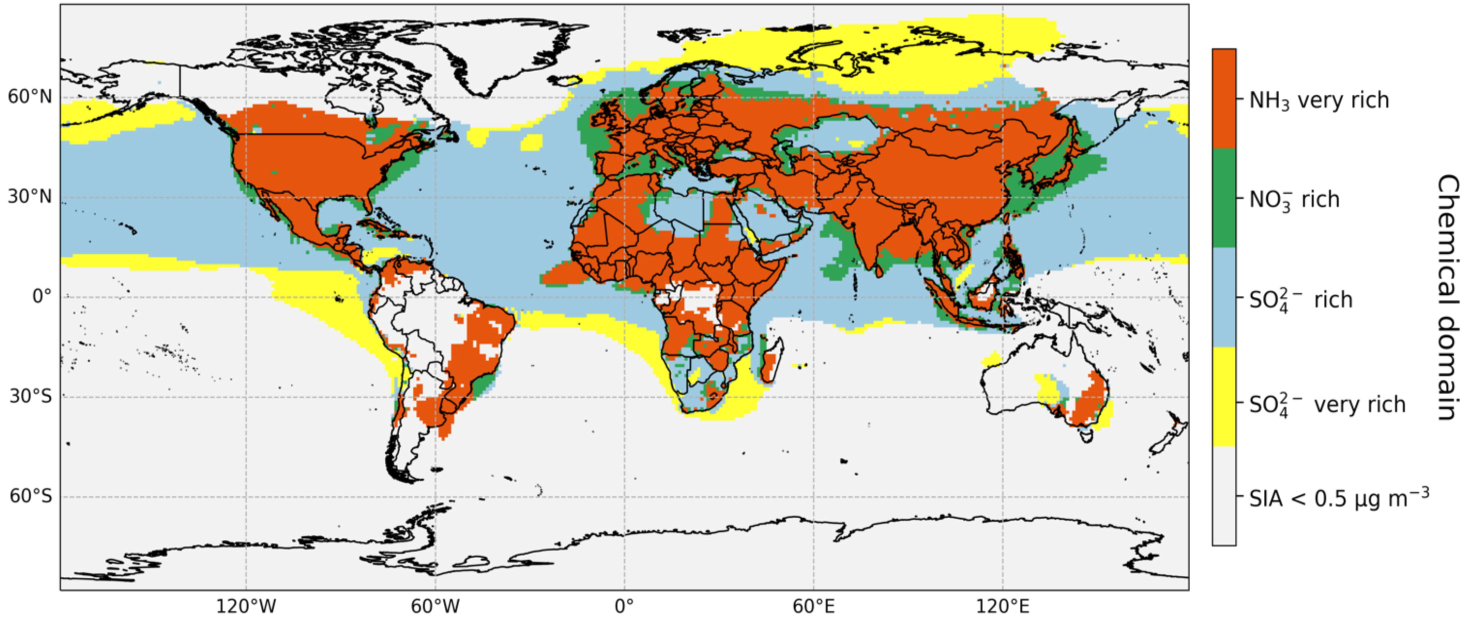
Global chemical domains for SIA formation (Ge et al., ACPD, 2022)

- $T_A = [NH_3] + [NH_4^+]$; $T_{A-free} = T_A - 2 \times T_S$
- $T_S = [SO_4^{2-}]$; $T_{N-f} = [HNO_3] + [NO_3^-\_f]$
- **(a):** Wherever $\frac{T_A}{T_S} > 2$: all sulphate is fully neutralised.

  Wherever $1 < \frac{T_A}{T_S} < 2$: SO_4^{2-} rich.

  Wherever $\frac{T_A}{T_S} < 1$: SO_4^{2-} very rich.
- **(b):** Wherever $0 < \frac{T_{A-free}}{T_{N-f}} < 1$: NO_3^- rich.

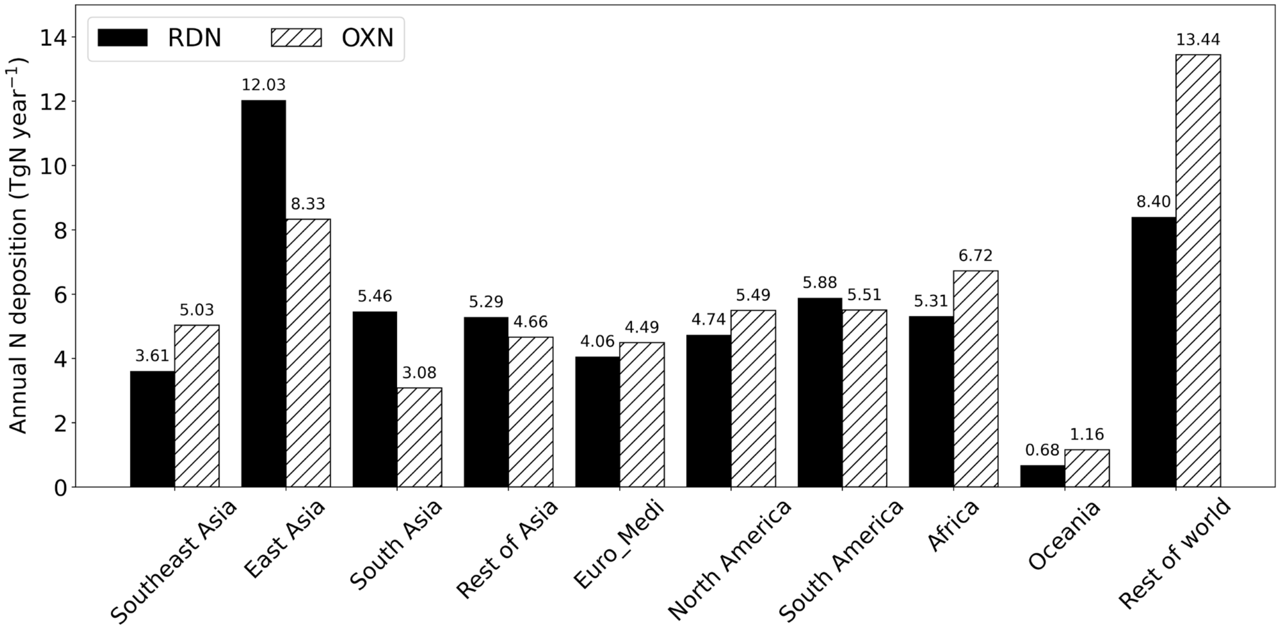
  Wherever $\frac{T_{A-free}}{T_{N-f}} > 1$: NH_3 very rich.

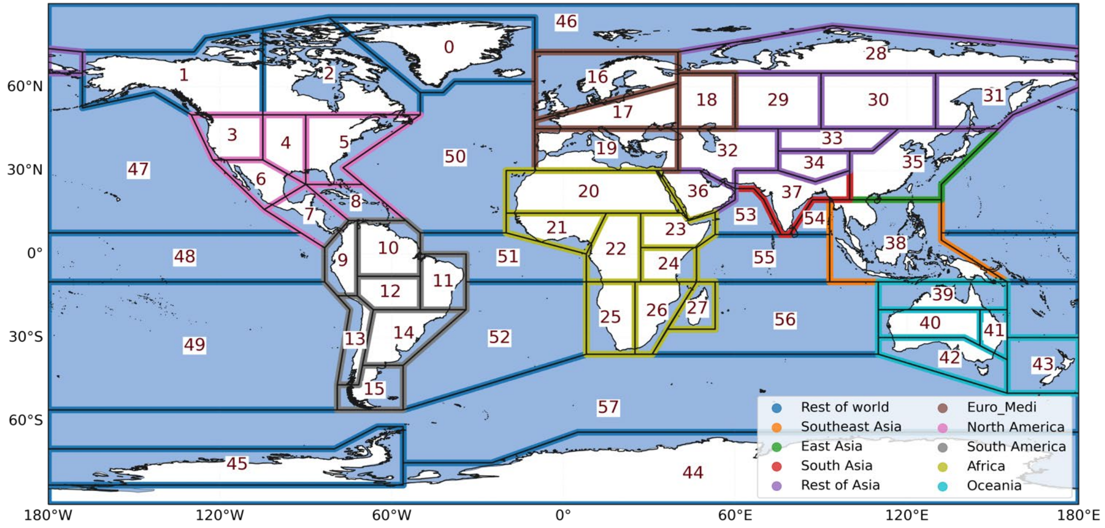


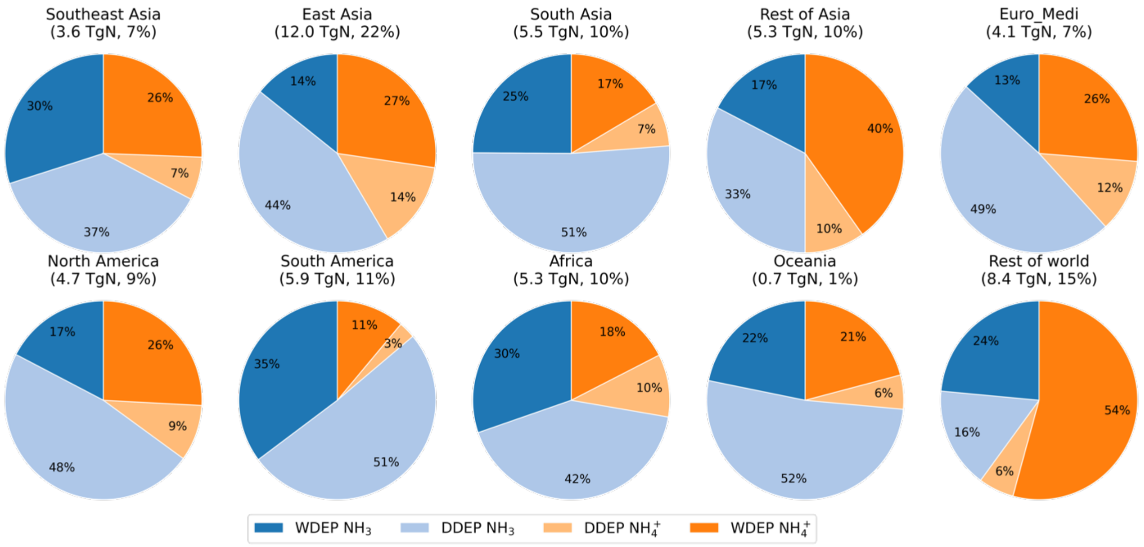
T_{A-free}/T_{N-f}	Mean
Southeast Asia	**1.9**
East Asia	**3.0**
South Asia	**9.6**
Rest of Asia	**4.1**
Euro_Medi	**2.5**
North America	**3.1**

- South Asia is most NH_3 rich, while Europe and Southeast Asia are least NH_3 rich
- Reducing NH_3 will have variable but small impacts on SIA mitigation

Assessment of N_r and S_r deposition (Ge et al., ACPD, 2022)

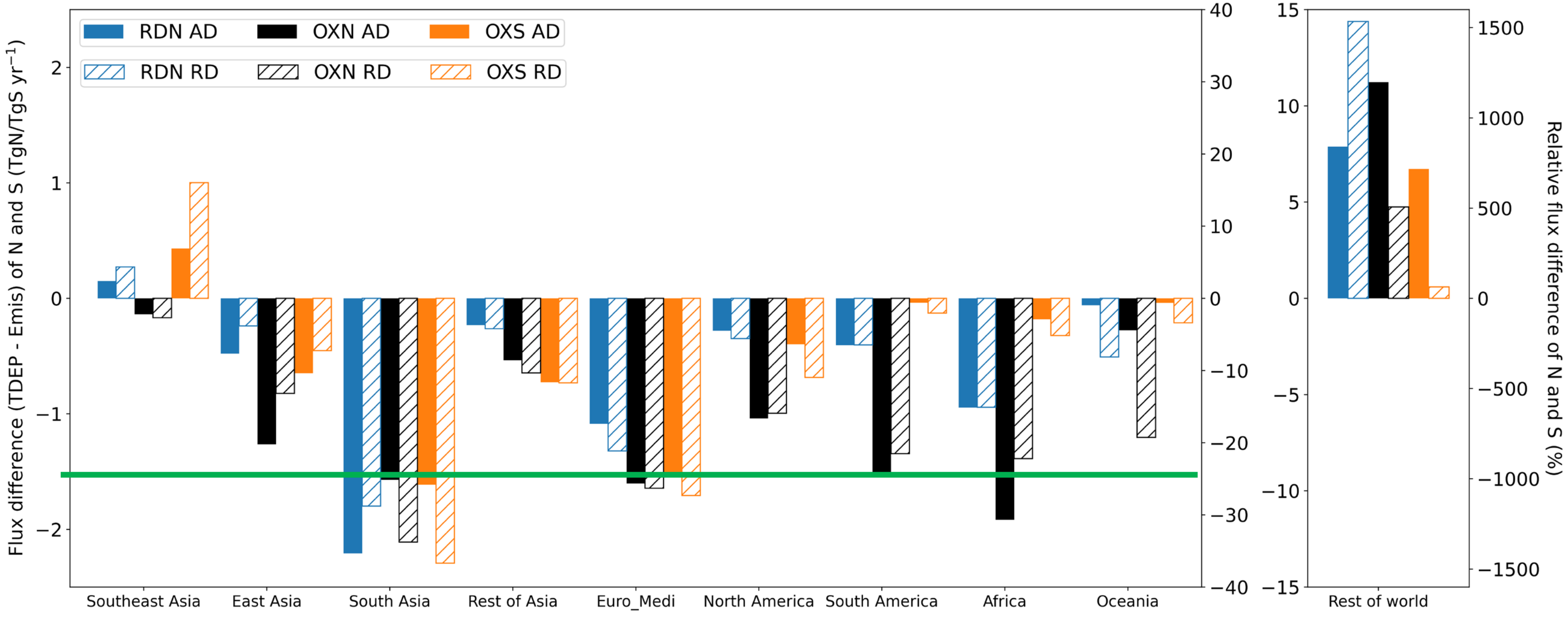






- RDN is a major fraction of total N deposition
- Dry deposition of NH_3 is the largest contributor to RDN deposition in most continental regions
- Reducing NH_3 is efficient for reducing total N deposition

Assessment of regional budgets & lifetimes (Ge et al., ACPD, 2022)



τ (days)	RDN	OXN
Southeast Asia	2.6	3.1
East Asia	3.0	4.5
South Asia	4.3	5.6
Rest of Asia	7.3	12
Euro_Medi	4.6	6.6
North America	3.6	5.0
South America	1.9	4.6
Africa	6.4	8.5
Oceania	3.2	8.4
Rest of world	10	12

- South Asia, Africa, Euro_Medi are largest exporters
- East Asia is largely responsible for its own N_r and S_r pollution
- Regional lifetimes of RDN, OXN, and OXS vary by a factor of ~4: shortest in Southeast Asia, East Asia, South America

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Thank you for your attention

Ge et al., GMD, 2021: https://doi.org/10.5194/gmd-14-7021-2021

Ge et al., ACPD, 2022: https://doi.org/10.5194/acp-2022-82

- **Model–measurement agreement varies between different networks**: Greater correlation and lower bias in Southeast Asia, Europe and North America than in East Asia suggests regional shortcomings in emissions and/or measurements.
- **Geographically-different 'ammonia richness'**: South Asia is the most NH_3 rich, while Europe and Southeast Asia are the least NH_3 rich. Reducing NH_3 has small impacts on mitigating continental SIA.
- **N_r deposition**: NH_3 dry deposition is dominant (~50%) in continental regions, while NH_4^+ wet deposition is dominant in Rest of world (54%). Reducing NH_3 is therefore efficient for reducing total N deposition.
- **Regional lifetimes**: Lifetimes of RDN, OXN, and OXS species vary by a factor of ~4 (e.g., OXN lifetime is 3.1 and 12 days in Southeast Asia and Rest of Asia respectively).