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Investigation of the distribution of aerosol-forming trace gases with ICON-ART

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1. Aerosol-forming trace gases

- Trace gases (e.g. NH_3) come from different sources (anthropogenic, biogenic, biomass burning). They are oxidized to acids in the atmosphere. Some oxidized trace gases can nucleate (e.g. H_2SO_4, HNO_3 and NH_3).
- Aerosols are important for cloud formation and radiative forcing
- Stratospheric aerosol[3]: mainly sulfate (60 – 80 %)
- Tropospheric aerosol[3]: Sulfate, nitrate, ammonium, organic and black carbon
- Depletion of NH_3[1]:

τ = 73.75 days [2] (with N_{OH} = 1e6, T = 298 K)

2. ICON-ART

- Global weather and composition model
- Gasphase reactions and aerosol formation
- Model settings:
  - ICON-ART 2.2
  - Horizontal resolution: R2B06 (~ 40 km), Vertical: 90 levels
  - Integration timestep: 300 s
  - Output: regular lat-lon grid: 0.5°

3. StratoClim campaign

- Duration: 20.07. - 11.08.2017
- Location: Kathmandu (Nepal)
- 8 successful flights with ‚Geophysica' in 21 km altitude (above the asian monsoon)
- Measurements of transported airmasses (UTLS-region) with GLORIA (Gimballed Limb Observer for Radiance Imaging of the Atmosphere; unique imaging Fourier-Transform-Spectrometer)

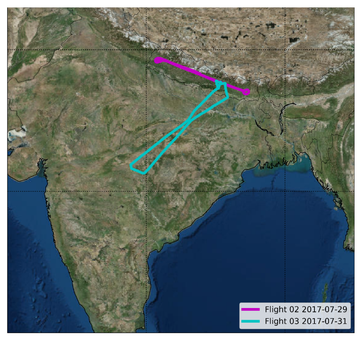

Fig.1: Flightpaths F02 (July 29, 2017) and F03 (July 31, 2017)

4. Proof of concept

- NH_3 concentrations along the flightpath (OH chemistry only):

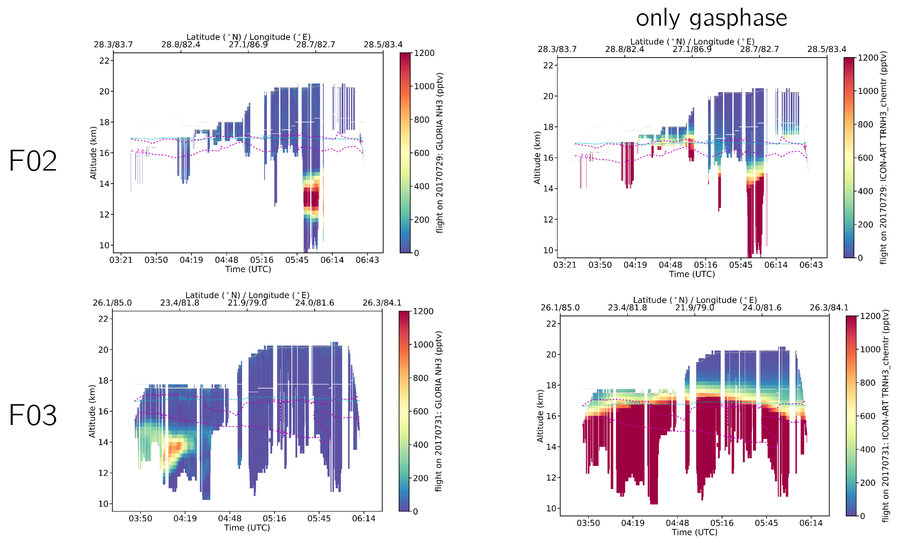

Fig.2: Flights F02 and F03; left: measurements of the NH_3 concentration in pptv along the flightpaths (Fig.1); right: simulation of gaseous NH_3in ICON-ART interpolated on the flightpath

5. Sources of NH_3

- NH_3 from the MACCity inventory:

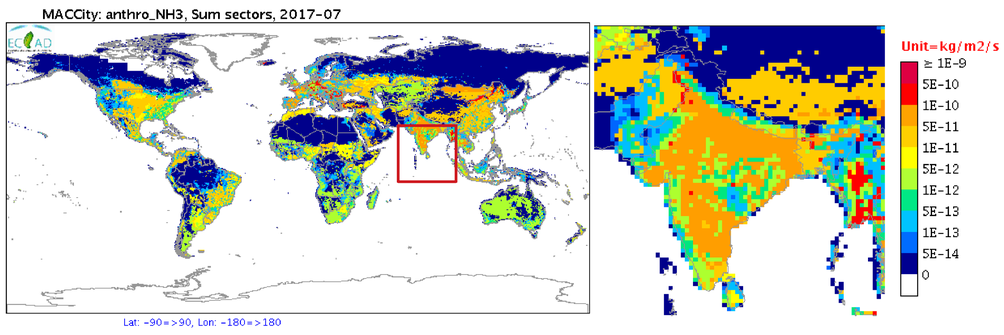

Fig.3: accumulated NH_3 emissions from the ECCAD-database (July 2017) [4,5,6,7]

- Emissions by sectors: The main surface source of NH_3 is agriculture:

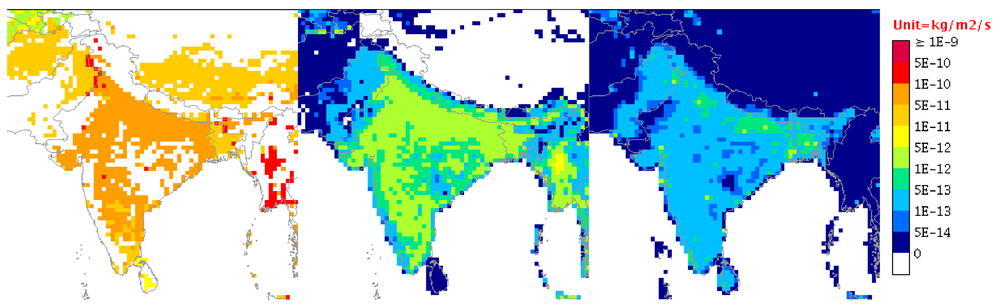

Fig.4: regional NH_3 emissions (July 2017) split up by their sectoral origin provided by the ECCAD-database from left to right: agriculture, agricultural waste, industries [4,5,6,7]

6. Results

- Accumulated NH_3:

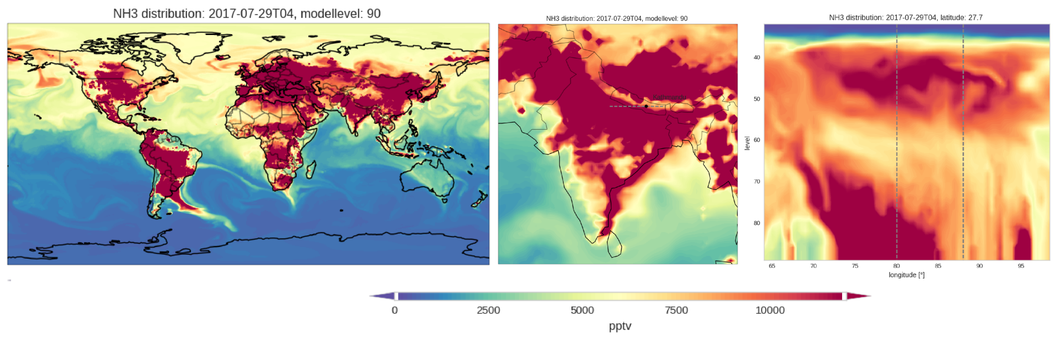

Fig.5: sum of NH_3 emissions from model output; from left to right:global and regional distribution in the lowest modellevel, vertical cross-section along the dotted line in regional plot

- Sectors with the largest contribution to the total emissions of NH_3:

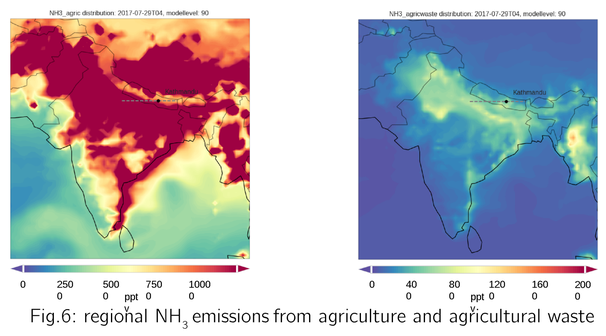

Fig.6: regional NH_3 emissions from agriculture and agricultural waste

7. Conclusion and Outlook

- As expected the model run shows too high values in comparison to the measurements, because NH_3 is only reduced by OH, the uptake of NH_3 by the aerosol phase and rainout/washout is yet to be implemented.
- Distinguishing NH_3 sources by sectors helps to understand how transport processes contribute to regional NH_3 concentration differences.
- Improved integrations using a comprehensive gas phase chemistry with coupling to the aerosol module are in preparation.
- Air mass origins will be diagnosed using artificial tracers

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