Investigating the NH_3 Daily Cycle over SE Asia Using Combined IASI and CrIS Satellite Observations

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1. The Threat: Big Agriculture and Ecological Collapse

- The agricultural sector emits NH_3 into the atmosphere that contributes to environmental degradation (soil, water, air) and respiratory diseases
- Largest NH_3 hotspots: agricultural areas in South and East Asia
- NH_3 concentrations are expected to rise with average global surface temperatures due to climate change

2. The Challenge: Rapid Changes and Sparse Measurements

- NH_3 is difficult to monitor due to its short atmospheric lifetime (a few hours)
- Ground observations are sparse and not many networks monitor NH_3 regularly
- IR satellite observations require large thermal contrast near the surface for a better NH_3 signal

3. The Solution: Combined Global Satellite Observations with ULIRS and CRAFT (optimal estimation based retrievals)

- The University of Leicester IASI Retrieval Scheme (ULIRS) and the CrIS Algorithm For Trace gases (CRAFT) were used to perform NH_3 retrievals.
- A Fast Detection method was applied (so far only for IASI): the NH_3 a-priori profile is scaled depending on the pollution level, day/night and season.
- A scaling factor x is used in the Fast Detection method for the calculation of NH_3
- *x* is retrieved using a one-step linear process:

$$\boldsymbol{x} = \left(\boldsymbol{K}^T \boldsymbol{S_y}^{-1} \boldsymbol{K}\right)^{-1} \boldsymbol{K}^T \boldsymbol{S_y}^{-1} (\, y - \bar{y}\,)$$

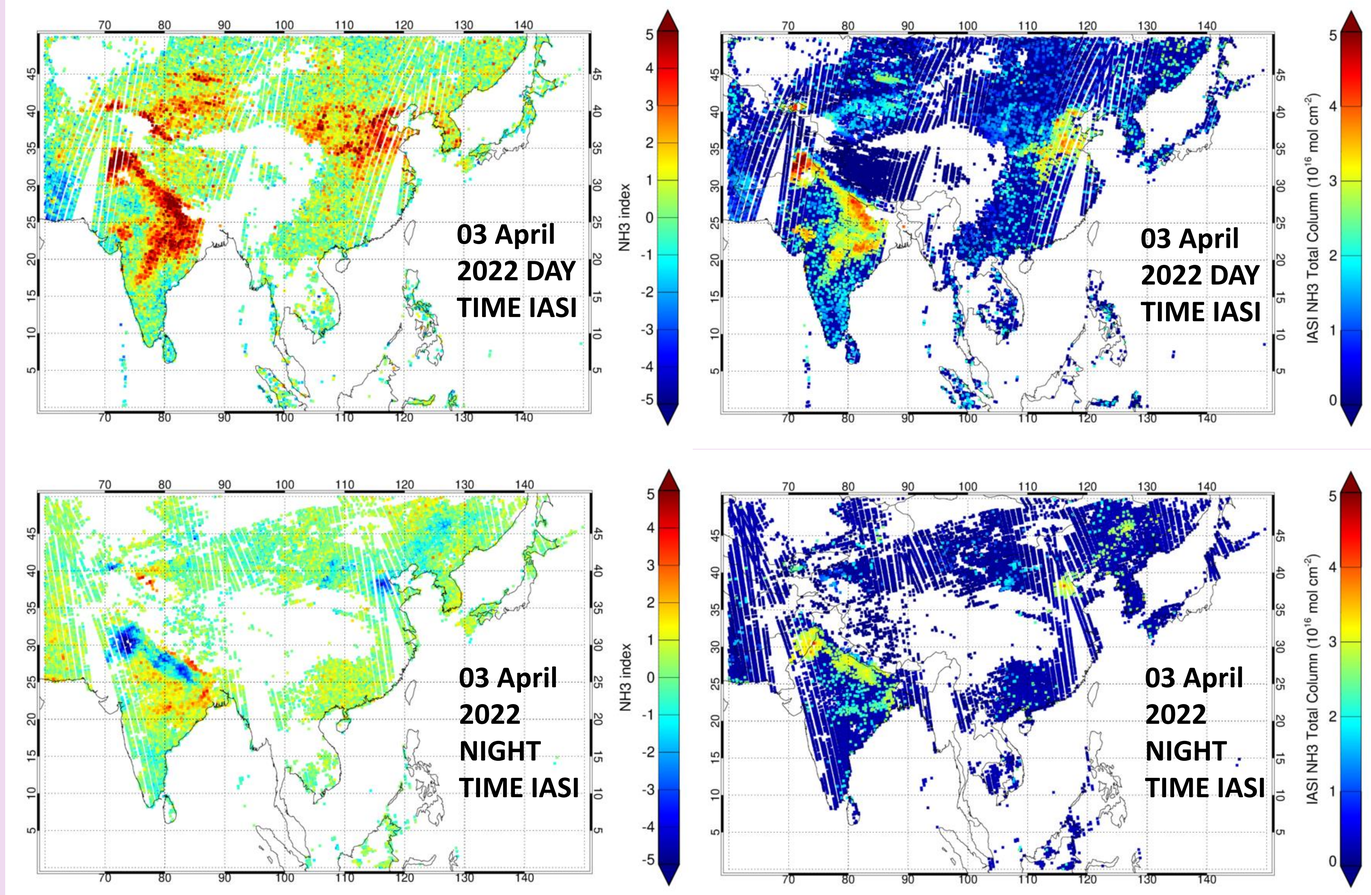

Fig.1 Comparison between the NH_3 index from the Fast Detection Scheme and the retrieved NH_3 total column from IASI shows a good spatial correlation for both day and night time observations. The high negative NH_3 index observed at night time arises due to a temperature inversion between the surface and the atmospheric layer where NH_3 concentrations peak (negative thermal contrast).

4. IASI and CrIS Satellite Observations of NH_3

- IASI and CrIS satellite observations were performed between 25th-31st January and 4th-10th April 2022 over South East Asia.
- The different overpass times 9:30 AM/PM for IASI and 1:30 AM/PM for CrIS allow for the investigation of the NH_3 daily cycle. Studying the NH_3 diurnal cycle provides valuable information on its sources, surface exchange, deposition and transport processes, and the impact on these by weather and surface conditions; all these are crucial for improving atmospheric models.

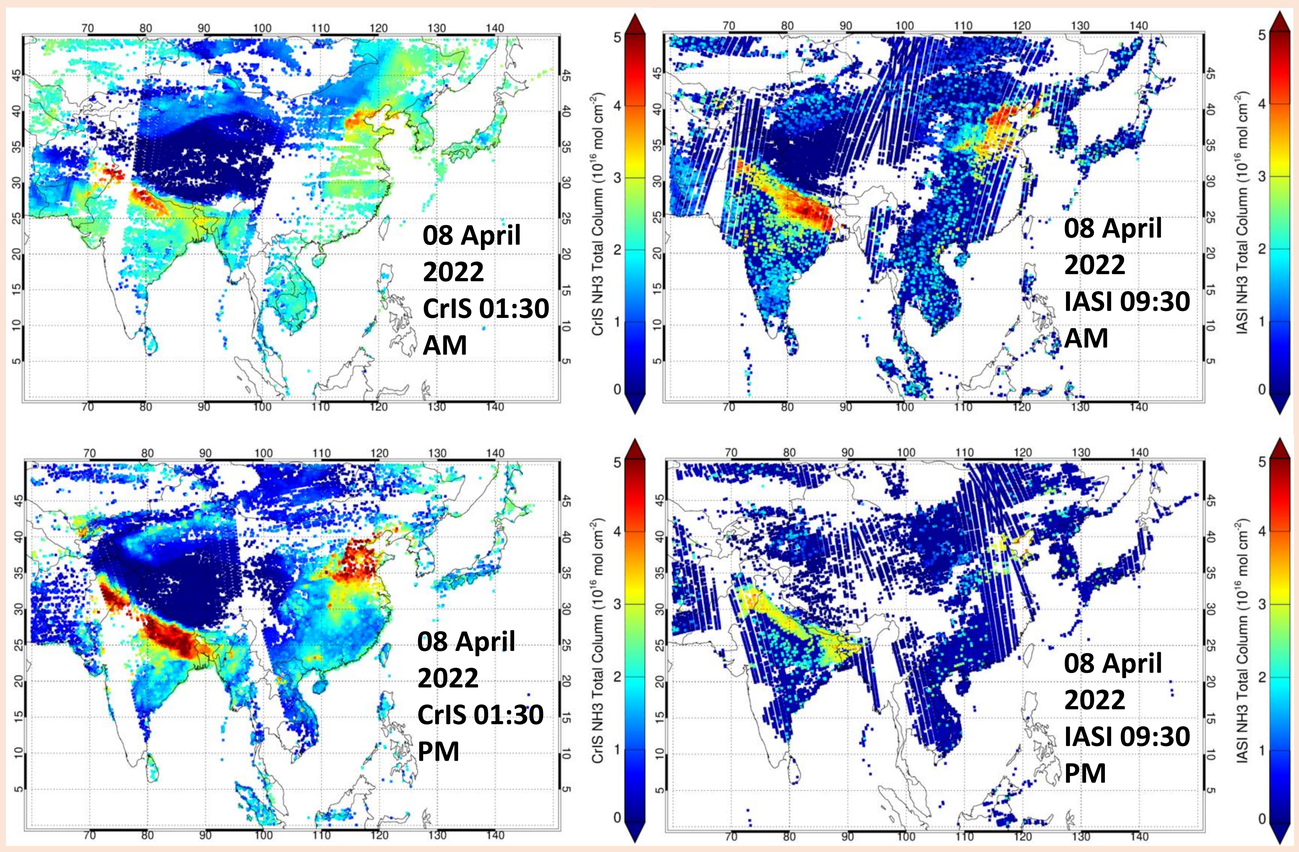

Fig.2 NH_3 total column concentrations from IASI and CrIS observations over SE Asia.

5. The NH_3 Daily Cycle over South East Asia

- The NH_3 daily cycle was studied over the Indo-Gangetic Plain in India and the North China Plain over 1 week during January and April 2022.
- Large variations in the NH_3 total column between day and night time observations were found for the daily cycle in spring. There is a larger thermal contrast during the day, when the surface temperature is warmer than the atmosphere. Rising temperatures also facilitate the production of NH_3 from soils. The NH_3 concentrations peak around afternoon (1:30 PM CrIS overpass time).

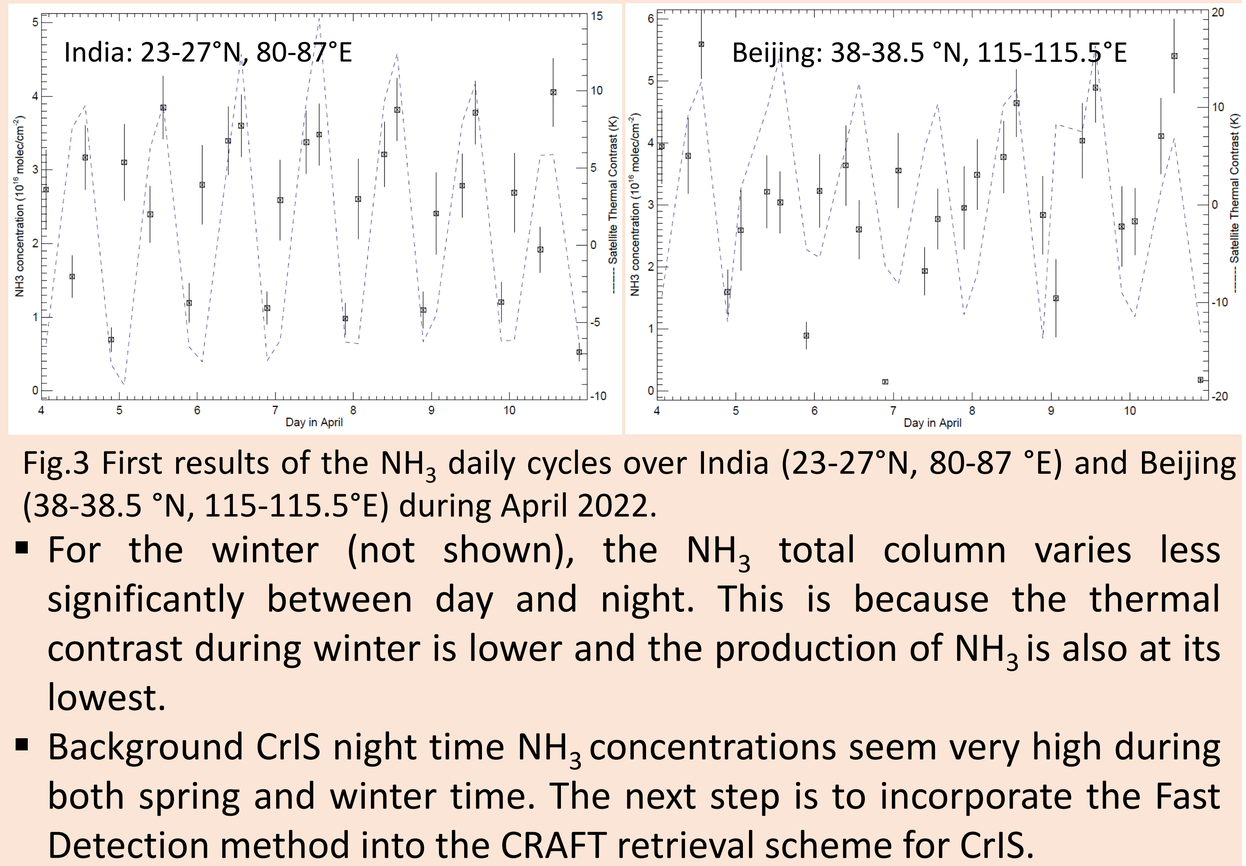

Fig.3 First results of the NH_3 daily cycles over India (23-27°N, 80-87 °E) and Beijing (38-38.5 °N, 115-115.5°E) during April 2022.

- For the winter (not shown), the NH_3 total column varies less significantly between day and night. This is because the thermal contrast during winter is lower and the production of NH_3 is also at its lowest.
- Background CrIS night time NH_3 concentrations seem very high during both spring and winter time. The next step is to incorporate the Fast Detection method into the CRAFT retrieval scheme for CrIS.

6. References

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