Thirteen-years Ammonia Data Records Observed by AIRS

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Outline

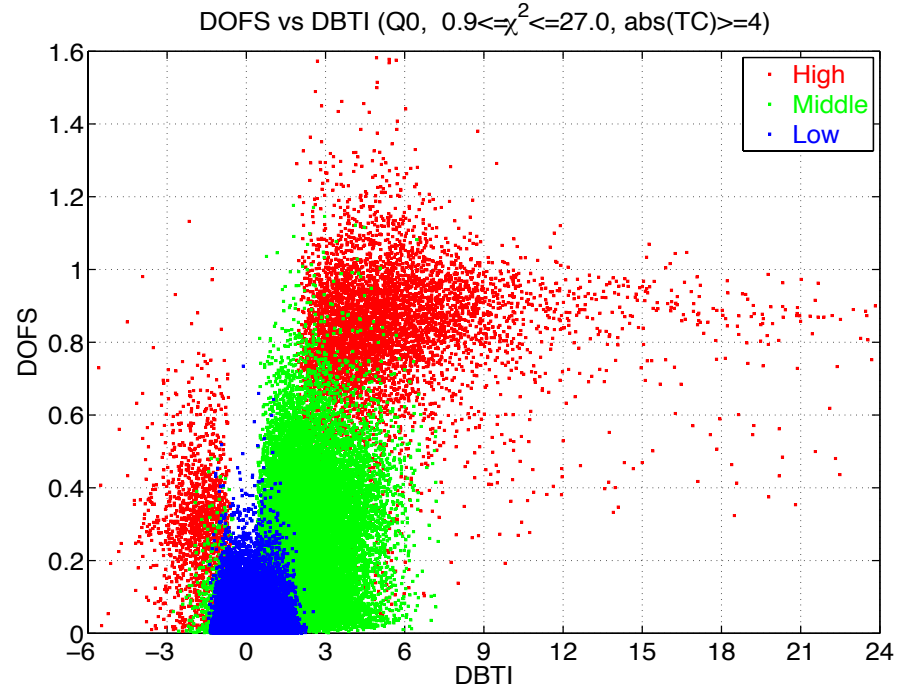
- Motivation
- Algorithm
- Validation examples
- Sources, trends, and variability
- Summary

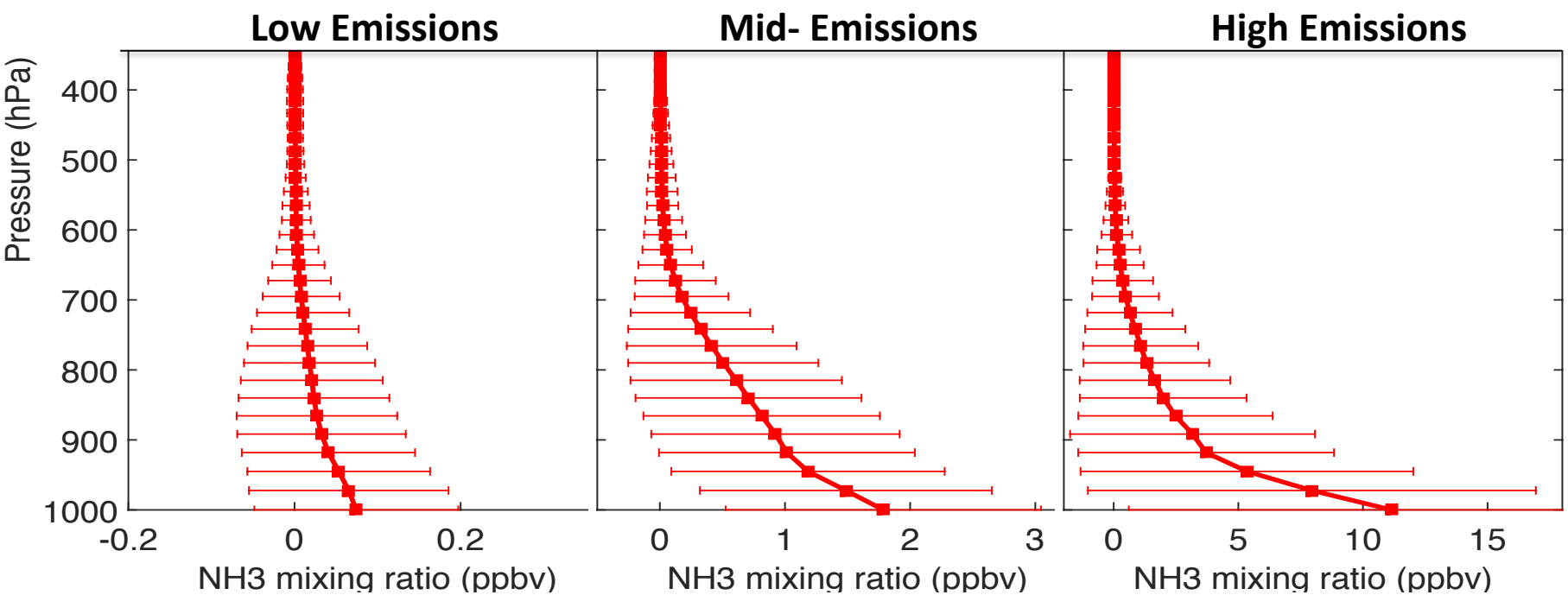
Why Ammonia

- Global ammonia (NH_3) emissions have been increasing due to the dramatically increased agricultural livestock numbers together with the increasing use in nitrogen fertilization (Sutton *et al.*, 1993).
- Atmospheric ammonia has impacts to the ecosystems on both local scales, acidification and eutrophication, and global (transboundary) scales through formation of fine ammonium containing aerosols.
- Measurements with daily and large global coverage are challenging and have been lacking partly because the lifetime of NH_3 is relatively short and partly because it requires high sensitivity for the retrievals that can be only obtained from areas with high thermal contrasts near the surface (Clarisse *et al.*, 2010).
- AIRS afternoon overpasses are best correlated with the daily emission peak time and during the daily period with the highest thermal contrast. Additionally, AIRS large coverage with wide swaths and cloud-clearing provide daily NH_3 maps. The 13-year data records makes AIRS the best sensor for NH_3 trends and variability studies (to date).

AIRS NH_3 Algorithm

- AIRS add-on module for NH_3 using Optimal Estimation technique;
- CCR and SARTA are used as in AIRS algorithm;
- Select *a priori* levels based on brightness temperature differences weighted by Noise (DBTI);
- The *a priori* levels are computed from GEOS-Chem and at levels of low, mid-, and high emissions;
- Globally one set *a priori*;
- The DOFS are primarily below 1, and increase as the radiance differences are larger.

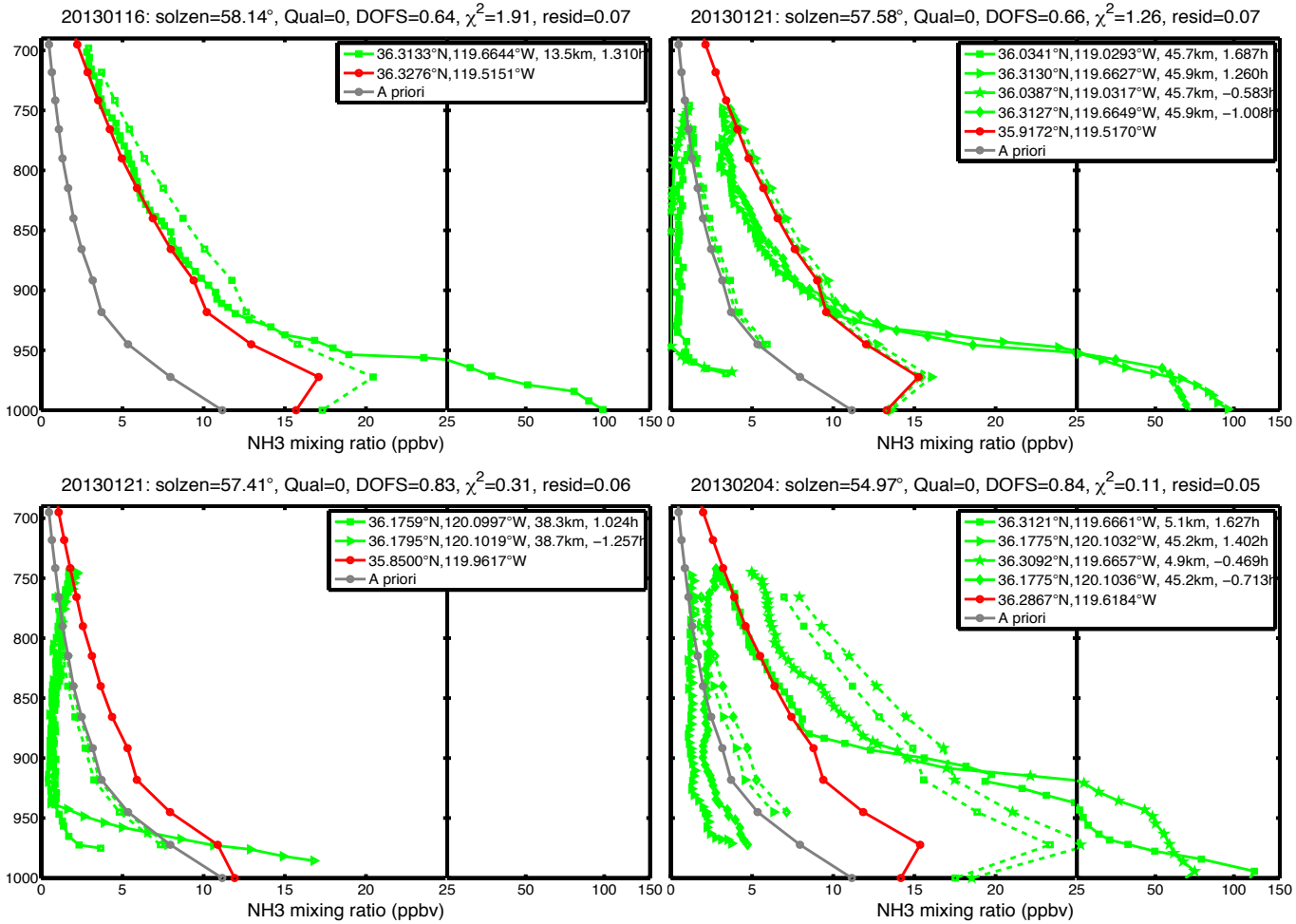




Validation vs Picarro in DISCOVER-AQ CA

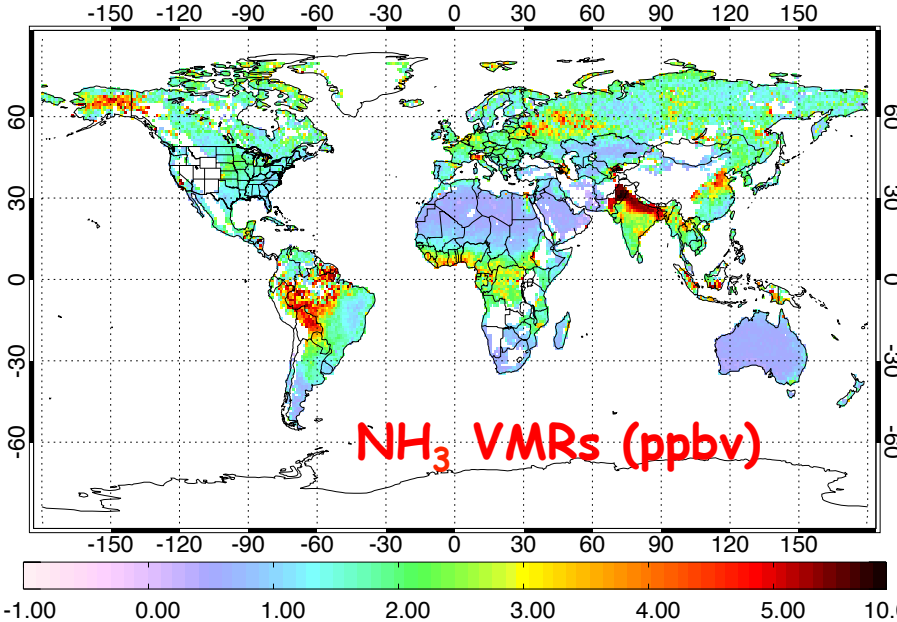
Spiral Profiles Only - 01/16-02/06, 2013

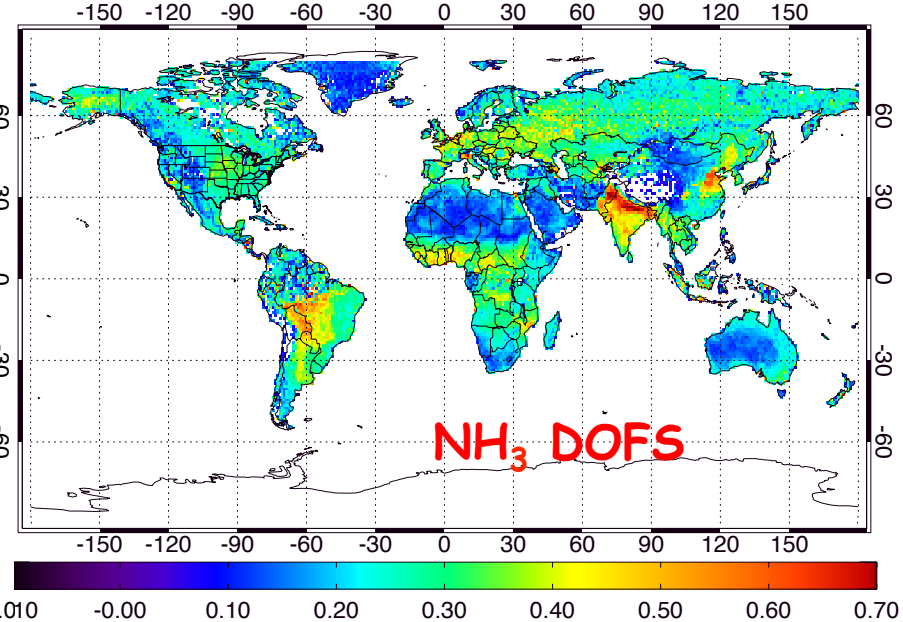
Picarro data courtesy of Co-author J. Nowak

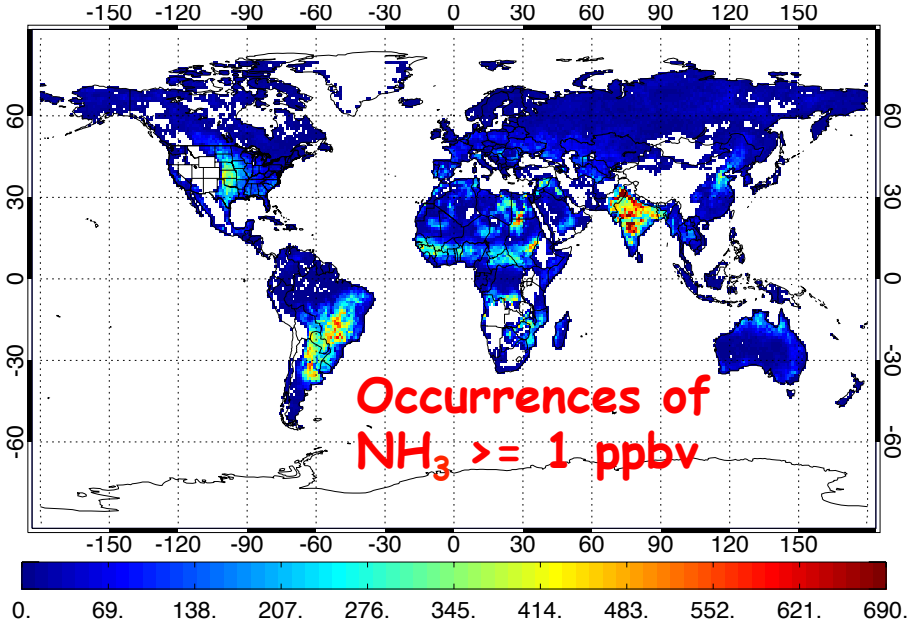


- Gray – a priori; Red – retrievals; Green solid – in situ; and Green dashed – convolved in situ.
- AIRS L2 pixel sizes are ~45km^2, can coincide with multiple in situ profiles.
- AIRS NH3 measurements are most sensitive at 850-950 hPa layer.

Global NH_3 Sources over last 13 years

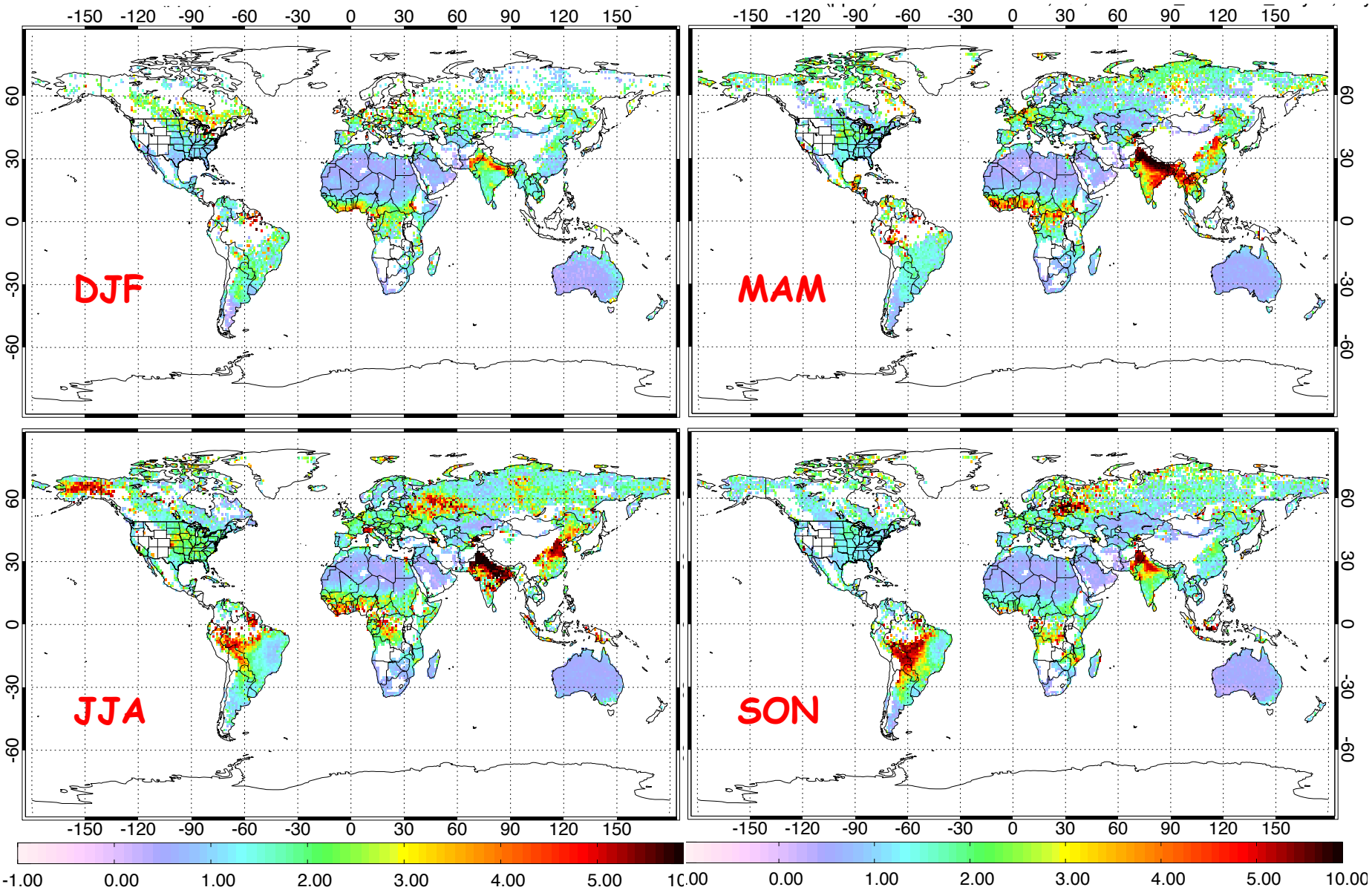






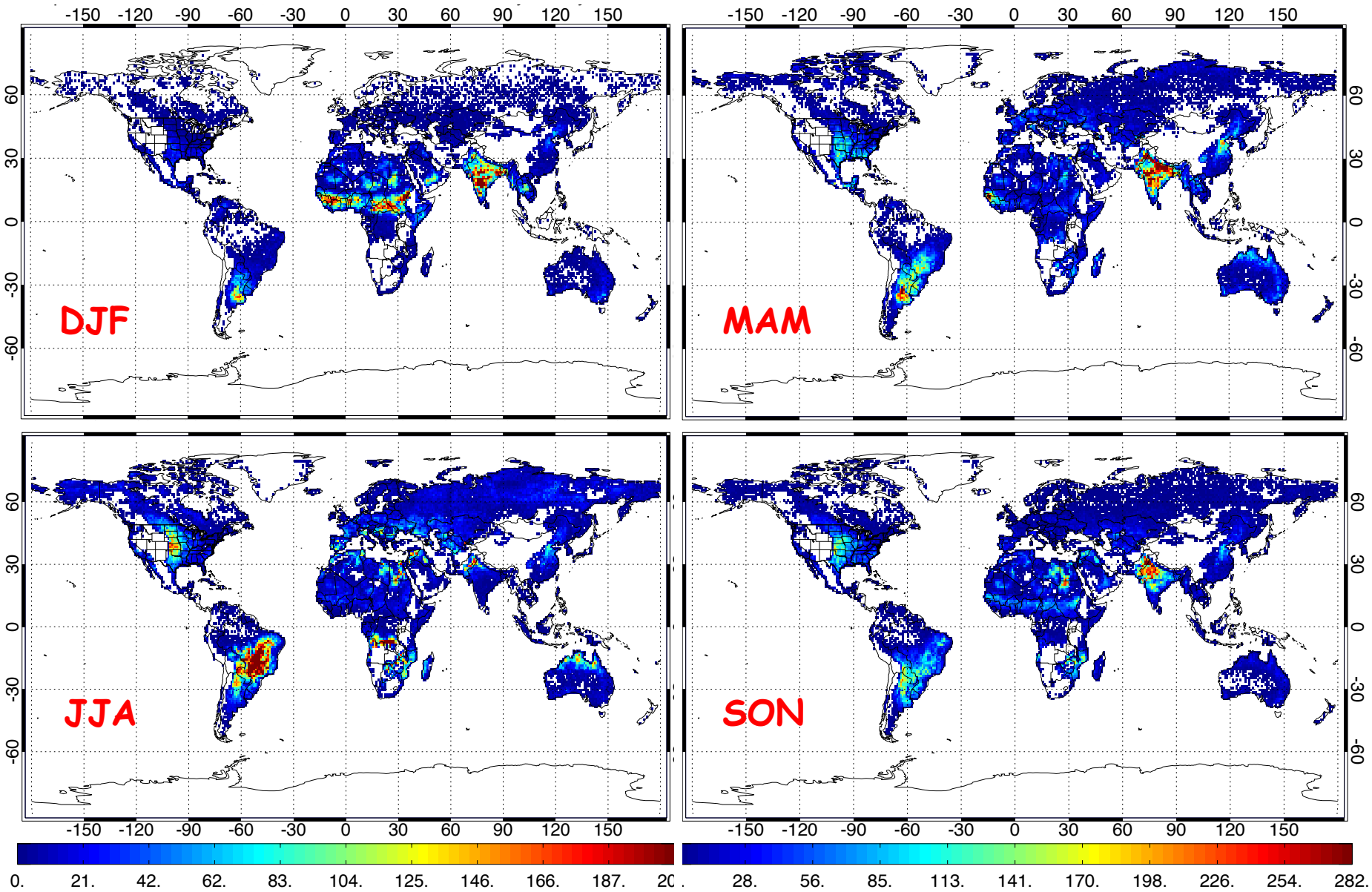
- AIRS NH_3 at 918 hPa for daytime and land only averaged over Sept. 2002 to June 2015;
- Use Q0; DOFS ≥ 0.05;
- High concentrations are mainly due to human activities and natural fires;
- Use occurrences of higher emissions to distinguish between the two major sources;
- DOFS equal or less than 1, higher over higher emission regions;

Global NH_3 Seasonality over 13 years



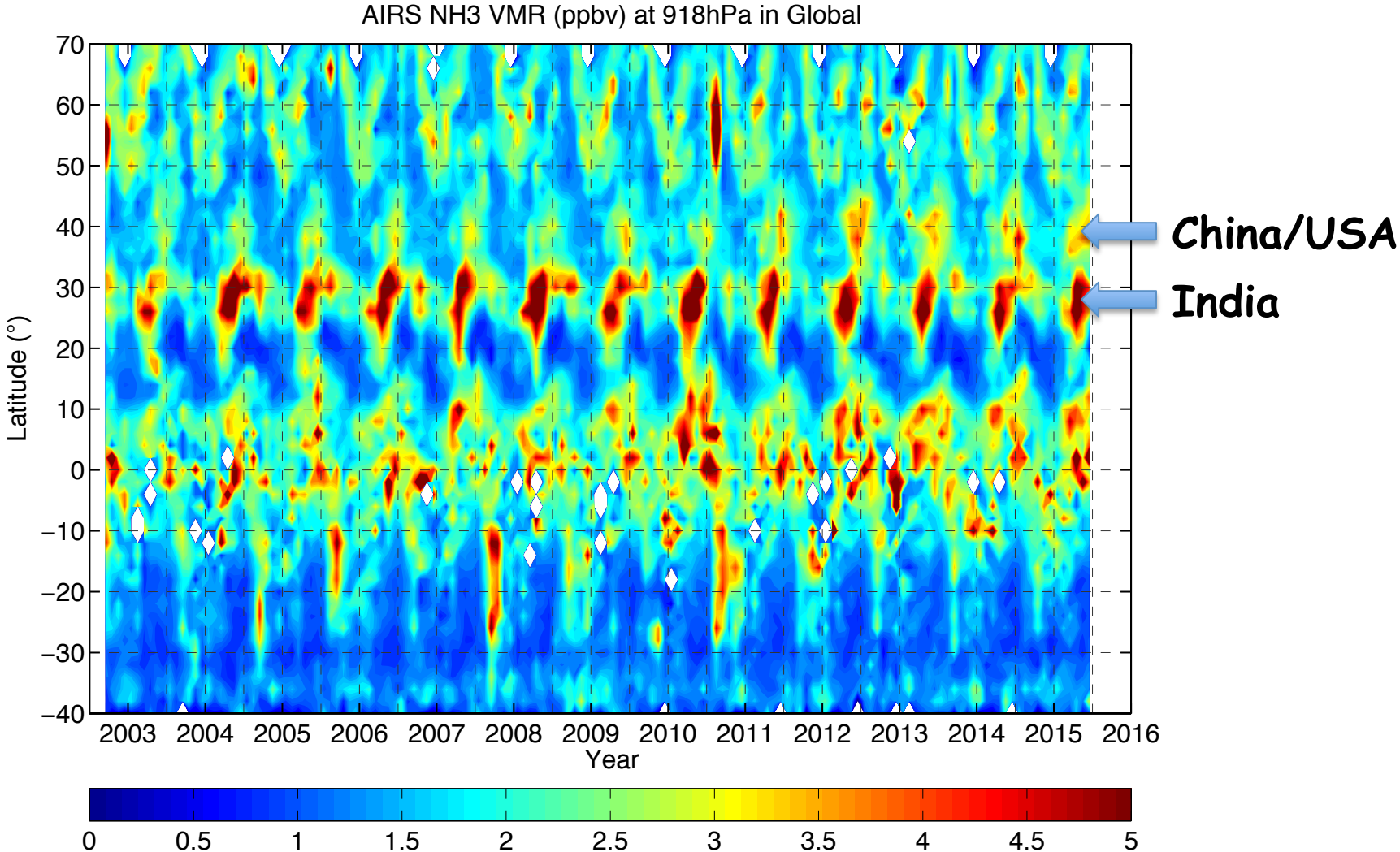
- The strongest non-BB emissions in the NH occur in the spring and summer
- Highest non-BB emissions are over India, China, USA, and Europe.

High NH_3 Occurrences DOFS > 0.1



- Distinguish occasional BB events from the livestock and agricultural activities.

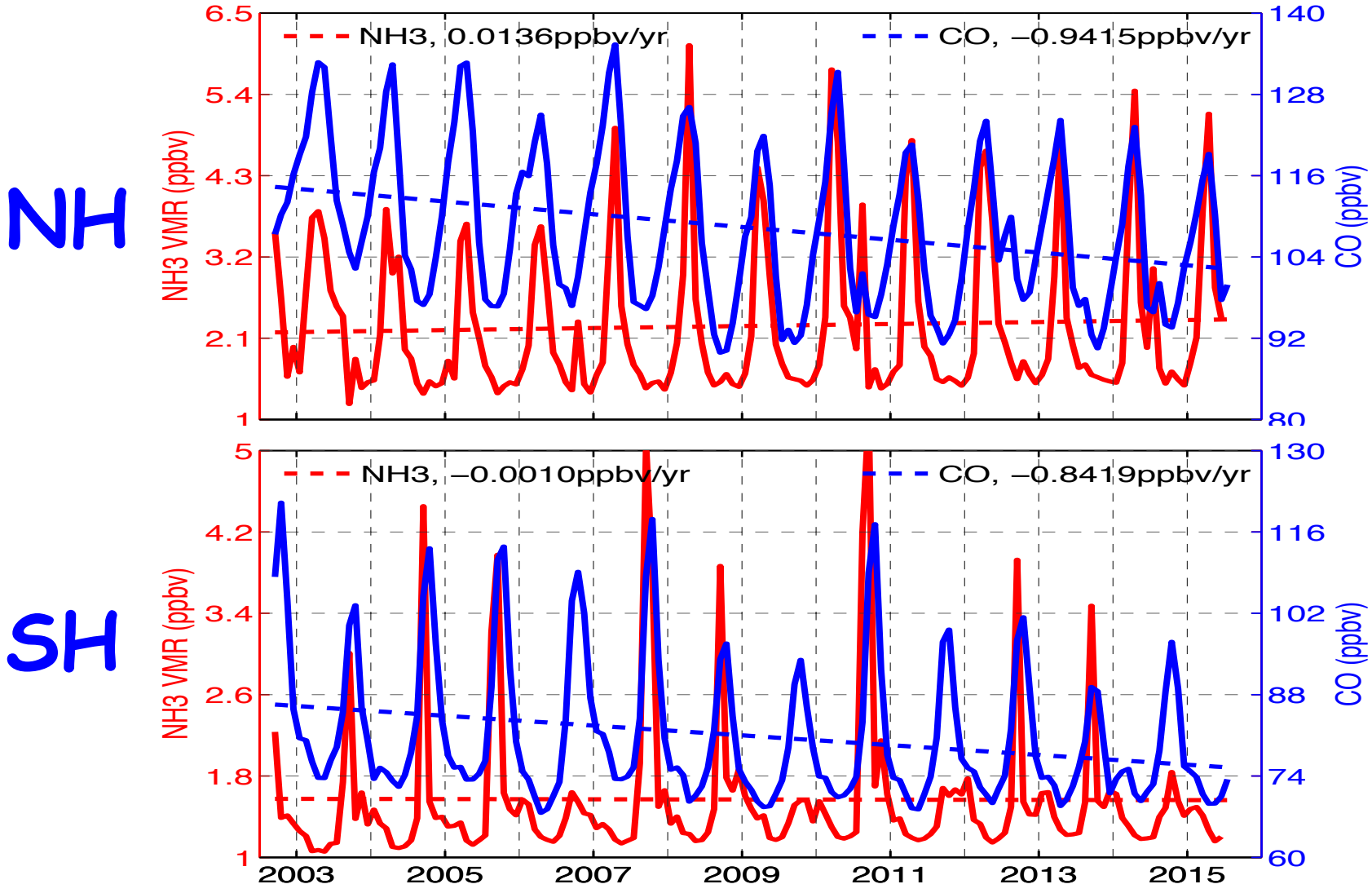
NH_3 Zonal Mean Temporal Variation over 13 years



- Shows NH_3 global sources, seasonality, and trends.
- Increasing trends over China and USA. BB signal are clear!
- South to north seasonal increase from spring to summer.

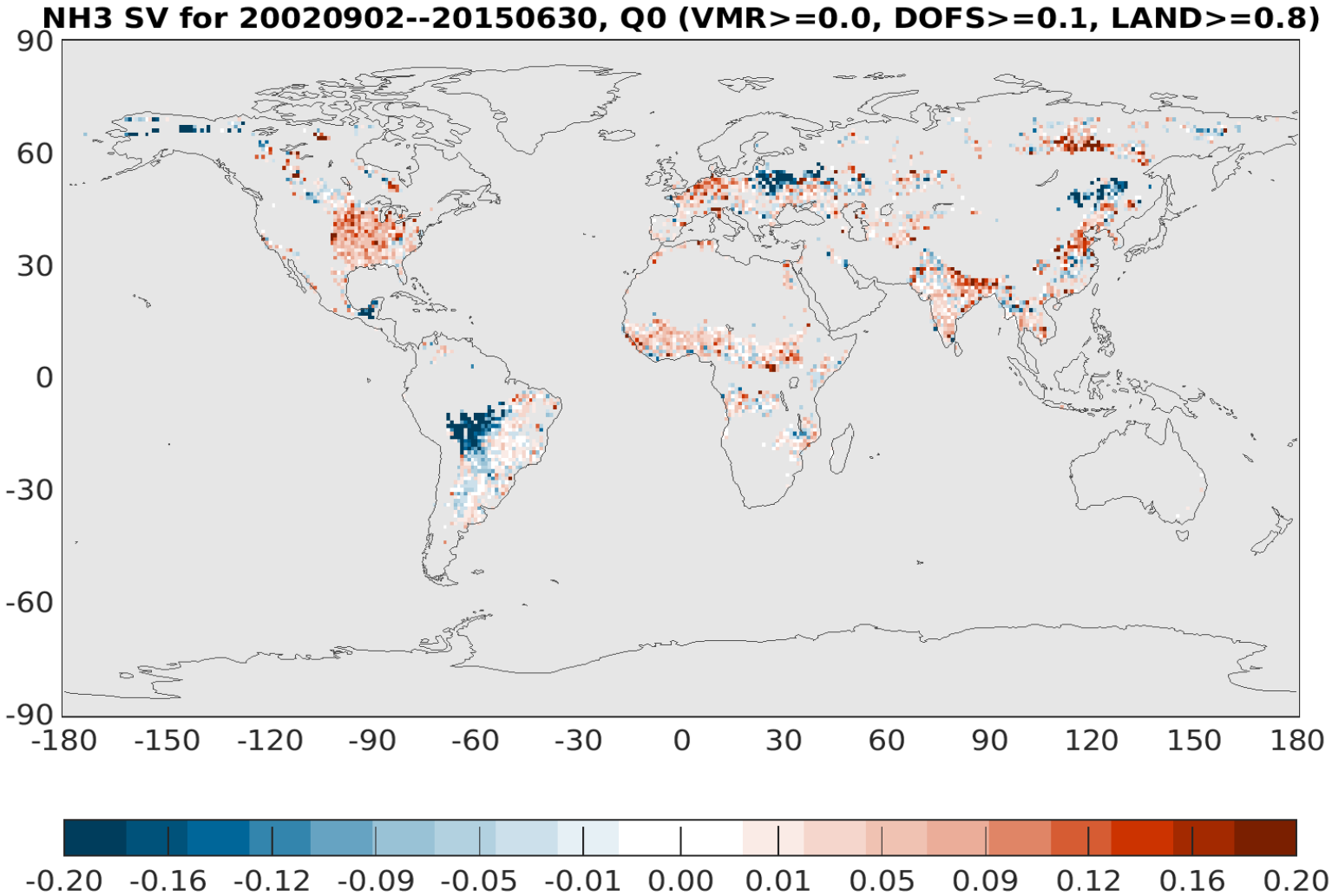
NH_3 and CO Hemispheric Trends

- DOFS>0.1 at 918hPa



- NH decreased CO and increased NH_3, mixed between human activities and BB
- Over SH, both CO and NH_3 decrease, and well correlated, primarily due to BB.

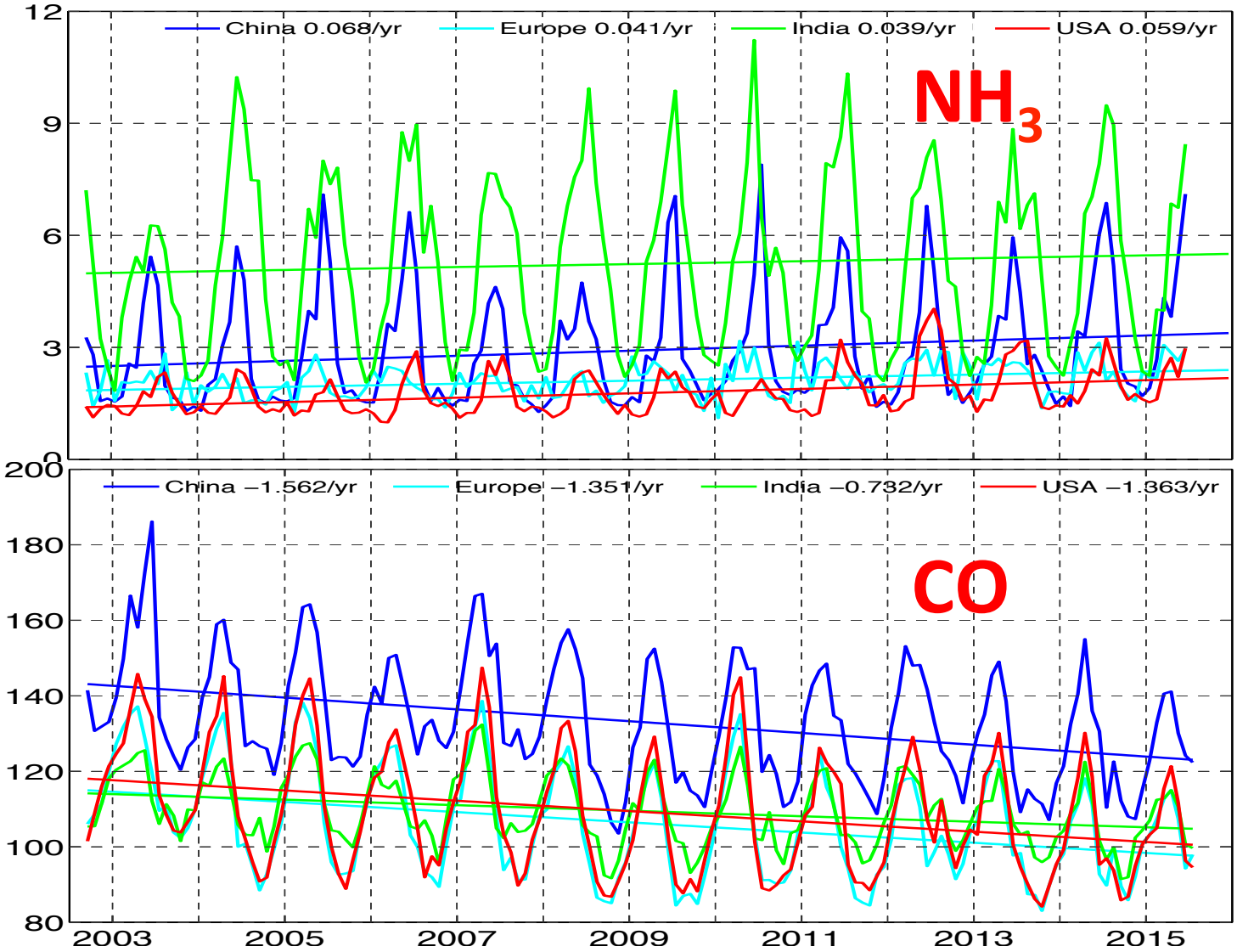
Regions with Strong NH_3 Trends
- over 13 years



- Slopes of linear fit of NH3 VMRs for each 1x1 grid.
- Trends due to BB are not conclusive due to the short record.

NH_3 and CO Trends for Four Regions

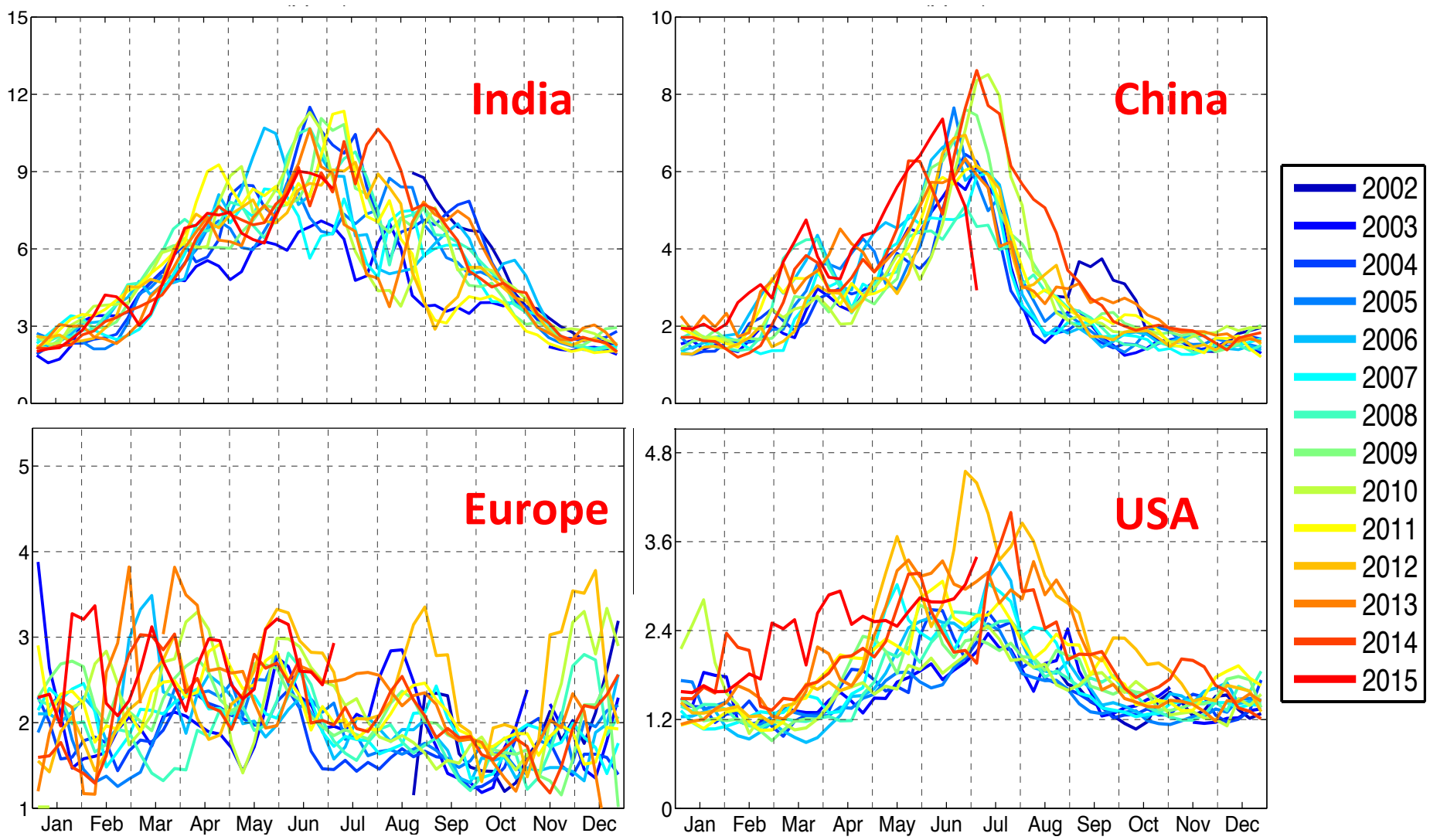
USA, China, Europe, and India



- NH3 increases and CO decreases in the NH, non-BB regions
- NH3 highest in India, lowest in CO. highest CO occur in China

NH_3 Monthly and Yearly Variations

- over USA, China, Europe, and India



- NH_3 in India seasonal variations are broad and no obvious trends in average;
- NH_3 for USA and China are similar, with peaks in both spring and summer;
- NH_3 low seasonal changes for Europe.

Summary

- AIRS NH_3 products not only include 13 years data record, it also provide daily maps!
- Validation results show high agreement with in situ airborne measurements.
- AIRS capture not only high biomass burning emissions, but also emissions due to agriculture activities.
- Ammonia trends increase over agriculture regions, where fertilizers are used as routine practice, decrease over BB regions (with insufficient records).
- Correlated studies with OMI SO_2 and NO_2 are continuing.
- Results are land only, daytime only, and over relatively higher thermal contrast regions. More work is needed to study more complicated surface types, and regions with lower thermal contrast.
- More validation over broader emission types and different regions are needed.