Satellite Observations of Tropospheric Ammonia

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Minor species retrieval from TES data

- **TES standard products include:**
  - **Temp., H2O, O3, CH4, CO, HDO**
- **Investigate retrievals of species that have spectral signatures in the TES spectra in addition to the standard products**

  - **Ammonia (NH3)**
  - **Formic Acid (HCOOH)**
  - **Ethylene (C2H4)**
  - **Sulfur Dioxide (SO2)**
  - **Carbonyl Sulfide (OCS)**
  - **Methanol (CH3OH)**

  - *Hydrogen Cyanide (HCN), Acetylene (C_2H_2)*

Why measure ammonia?

Ammonia is an integral part of the nitrogen cycle

Nitrogen in ammonia is deposited to Earth's surface

- **Excess nitrogen leads to:**
  - **Nutrient imbalances**
  - **Change in ecosystem composition**
  - **Algal blooms**
  - **Hypoxia**

Ammonia reacts with sulfate and nitric acid to form ammonium sulfate and ammonium nitrate

➔10-20% of fine particulate matter (PM2.5) in atmosphere over the US

- **Excessive exposure to aerosol concentration is associated with :**
  - **increased chances of cardiovascular disease**
  - **inhibited lung development**
  - **premature death**

• Fine particulates are also responsible for reduced visibility in national parks and scenic areas

Why measure ammonia from space?

In the US regional and global models predict peak concentrations in different seasons

- during fertilization application in spring or with high temperatures in summer
- differences likely driven by uncertainty in emissions

Ammonia highly reactive ➔ short lifetime

+ point sources ➔ high temporal and spatial variability in emission sources

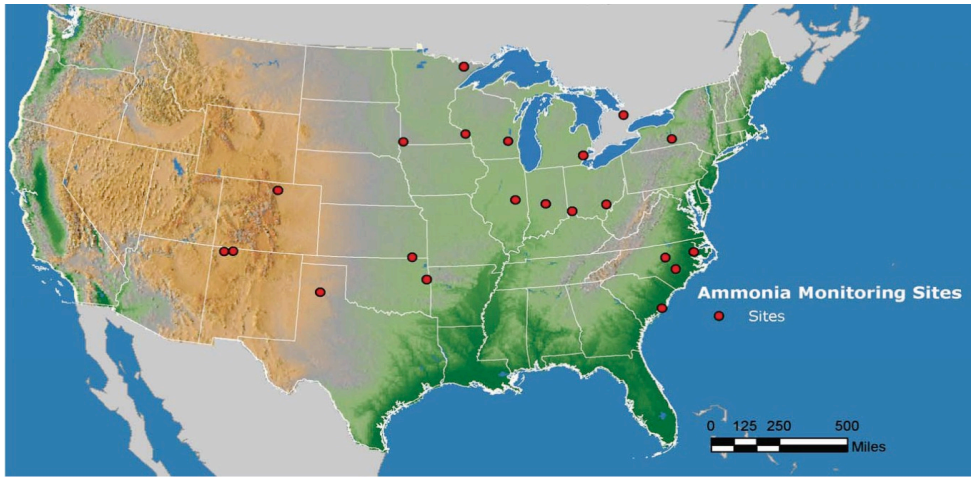
Models very sensitive to emission database used

- in-situ measurements are sparse

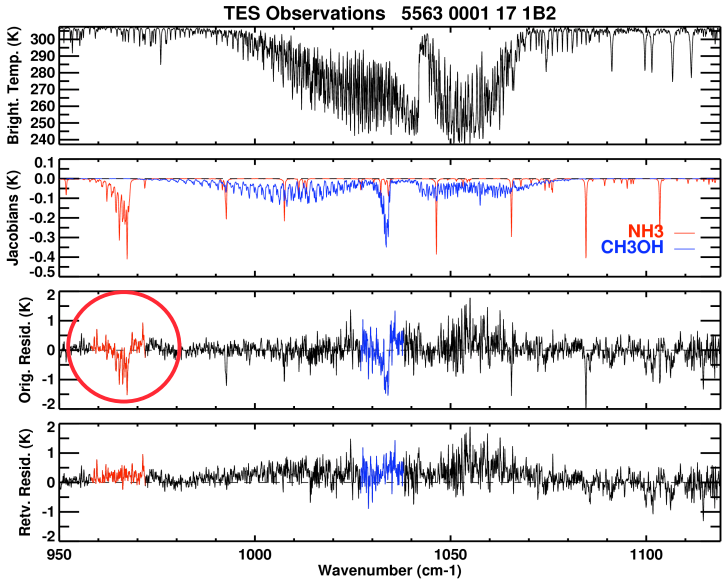
Measurements from space can add more information

EPA Monitoring Network

(Gary Lear)

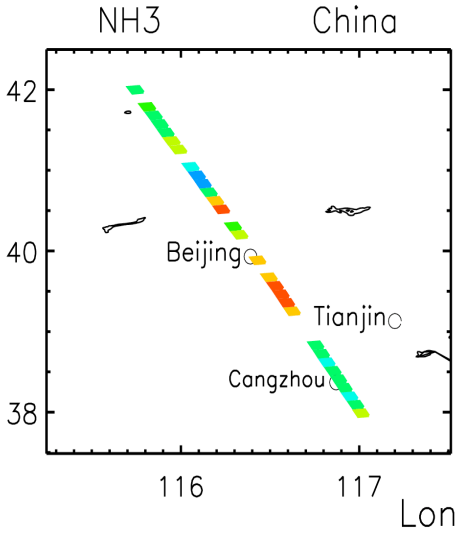


NH_3 retrieval from actual TES spectra

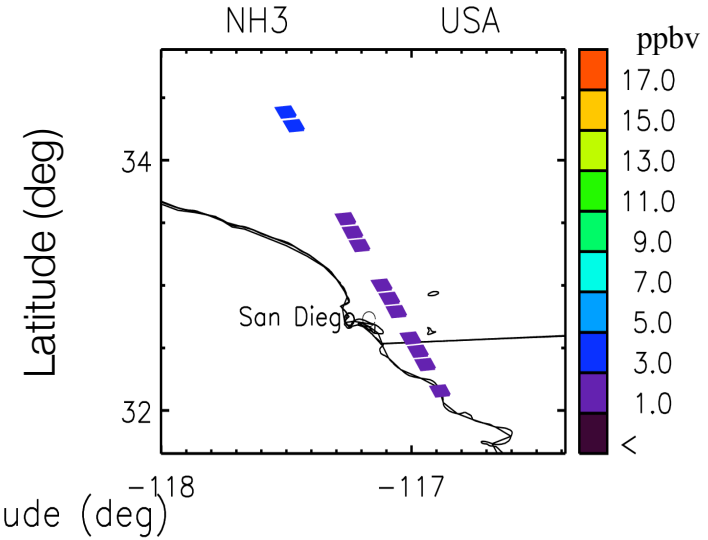


- **Selected TES transects over two distinct regions** (Beer et al., 2008)
  - **A highly polluted region: eastern China**
  - **A moderately polluted region: West Coast of North America**
  - **Similar surface temperatures and terrain**

- Elevated amounts over Beijing, China, July 10, 2007
  - High as 17 ppbv

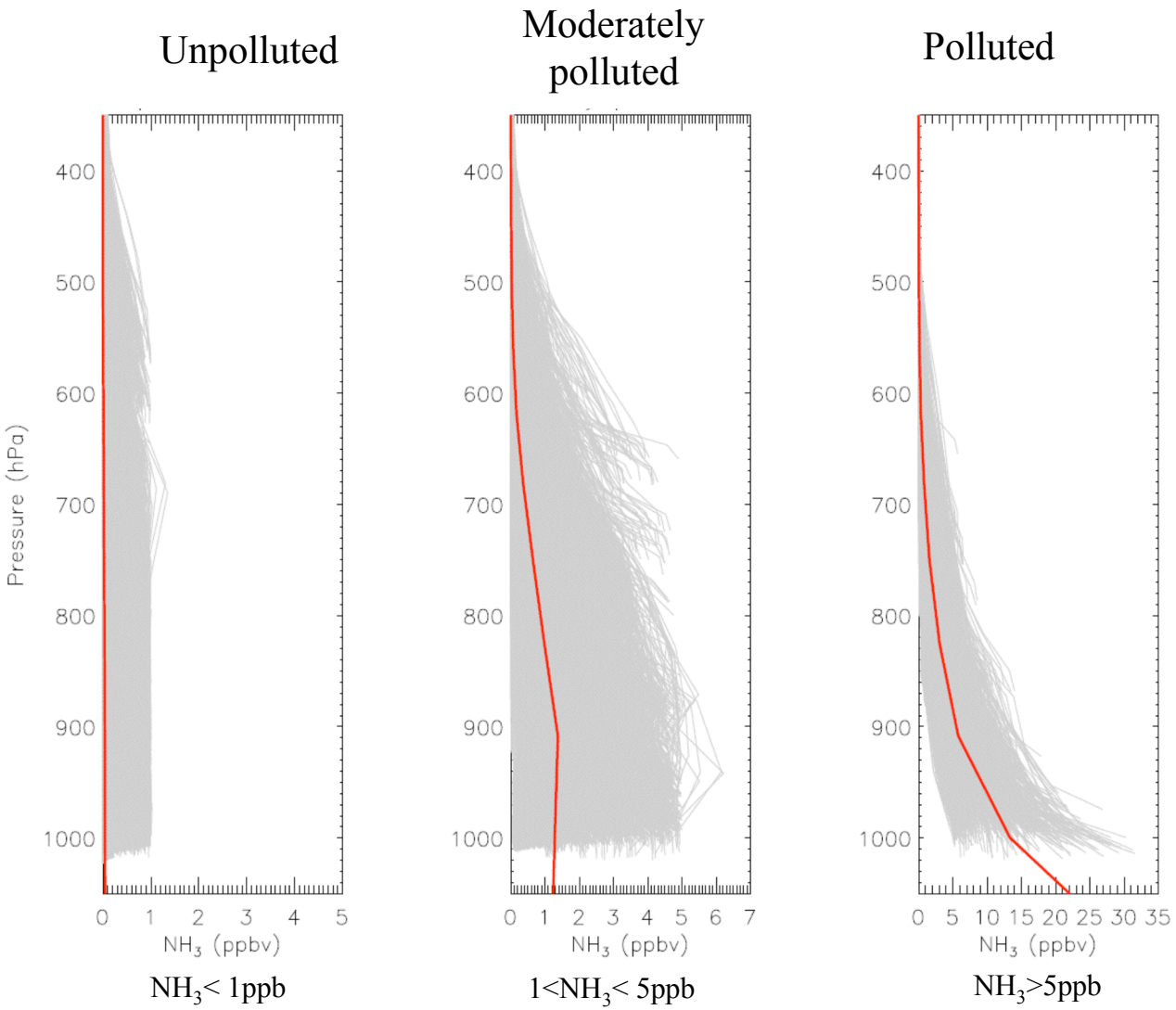


- Moderate amounts over West Coast, June 2007

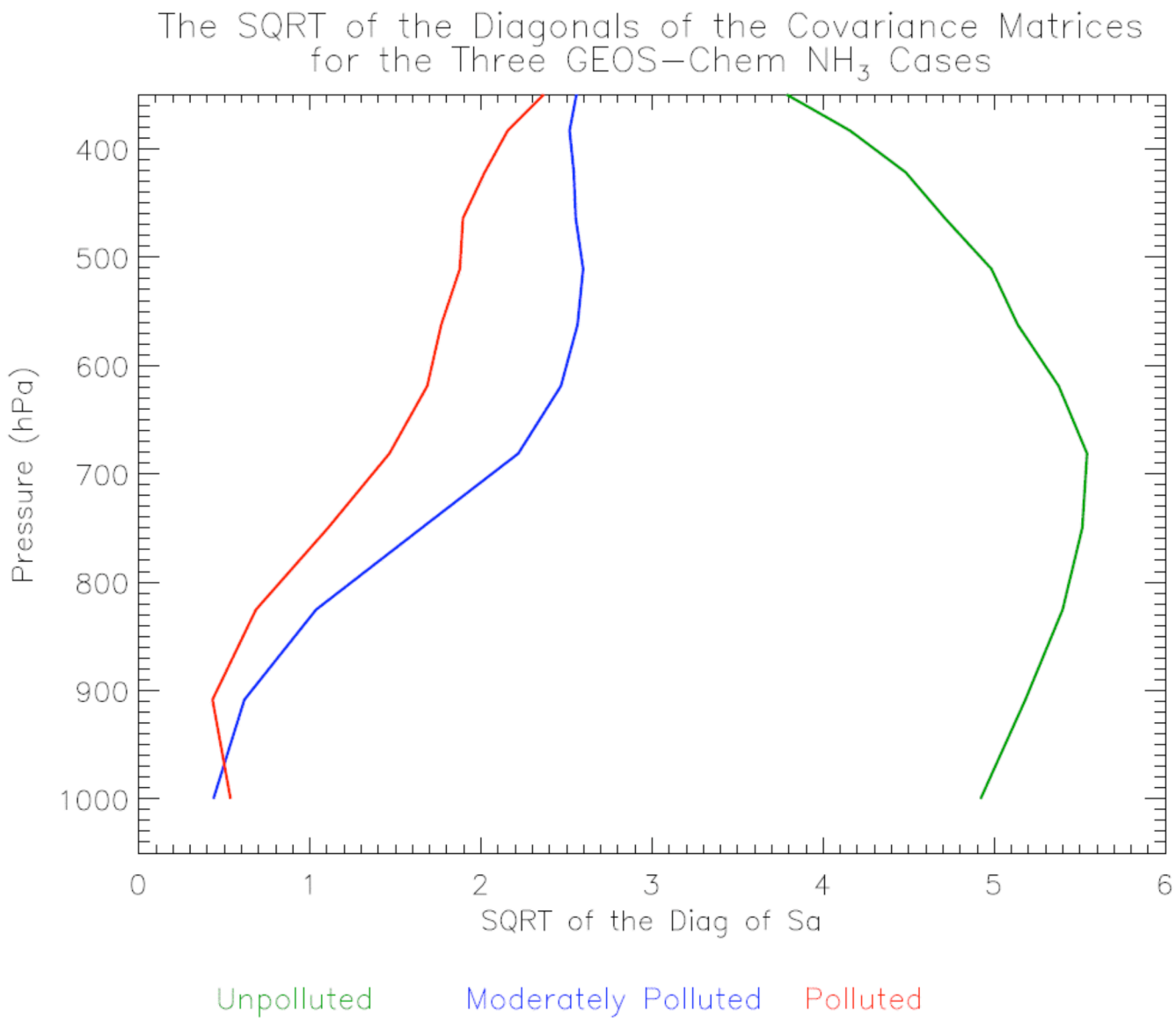


A priori estimates

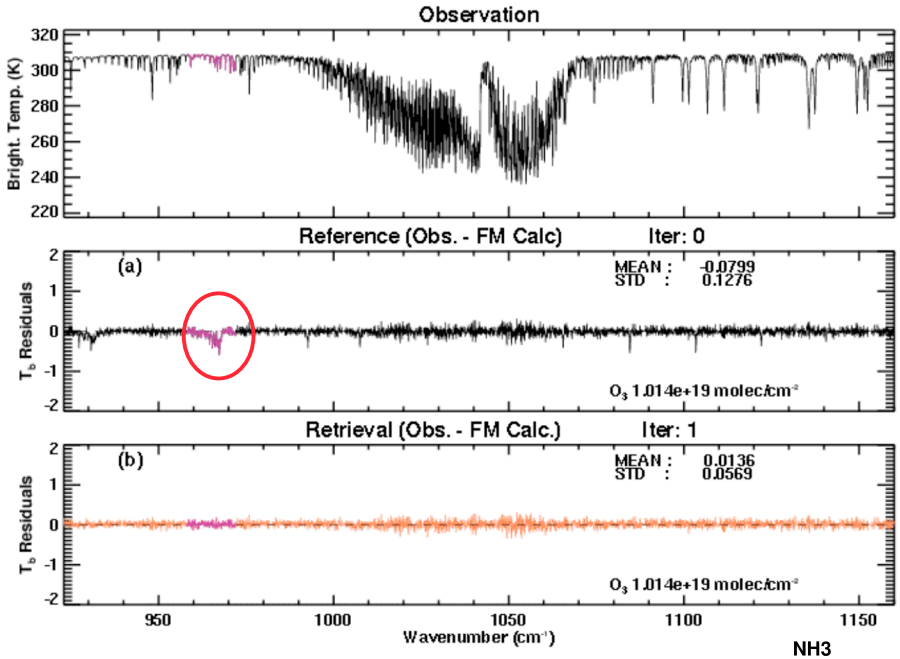
- **obtained from GEOS-Chem monthly mean output for 2005**
- **binned by ammonia level in lowest layers**



Covariance matrix derived from GEOS-CHEM



Retrieval from simulated spectrum



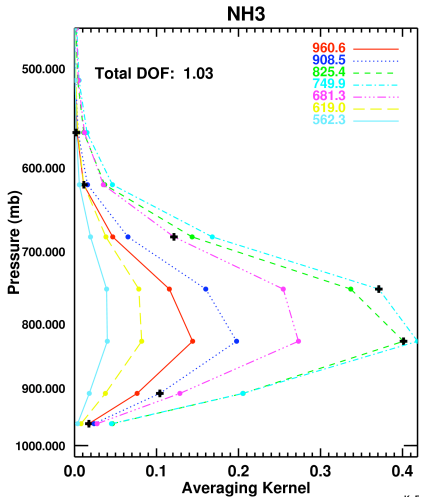
Simulated spectrum from polluted profile (+noise)

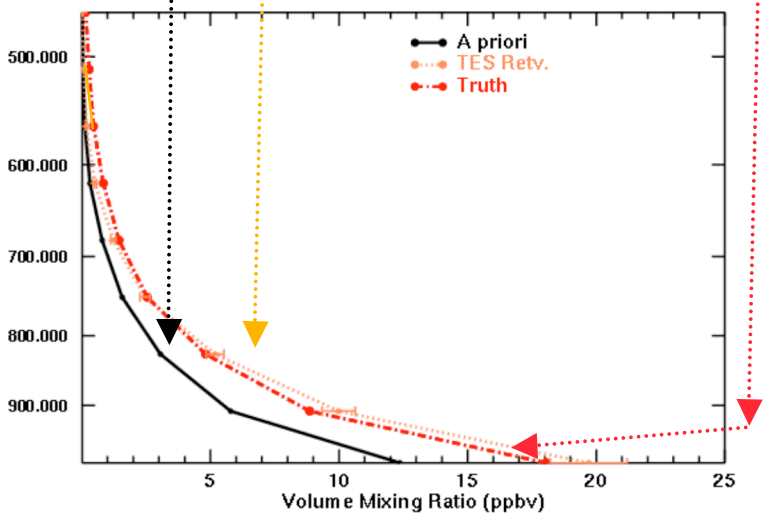
Simulated spectrum minus forward model run with *a priori* profile

Simulated spectrum minus forward model run with retrieved profile

Averaging Kernels

- **Show TES sensitivity at each level**
- **TES most sensitive a ~2km region centered around ~850 mbar**



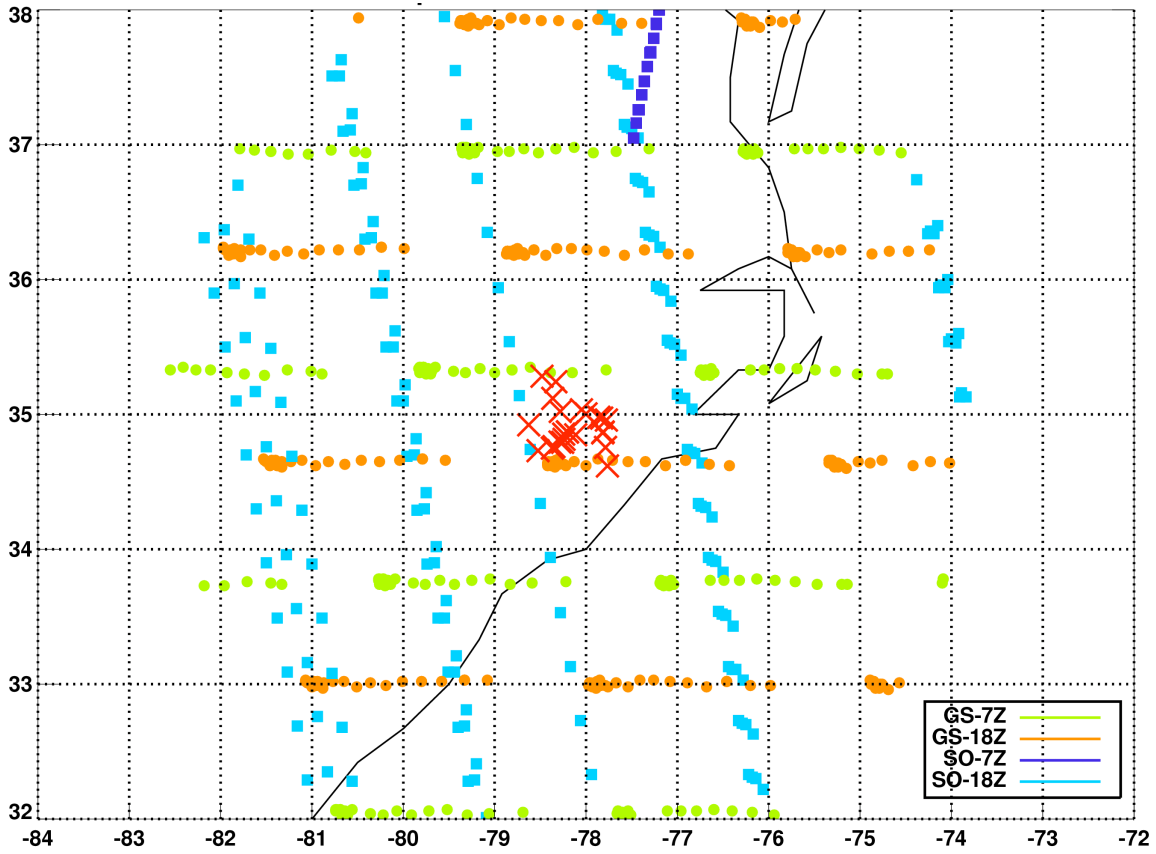


Obtaining validation data

TES overpasses in Southeast US: May 2007-May 2008

Initial Validation

- **monitoring data: collected in North Carolina in 2007/2008** X
- **Global Survey footprints not sufficiently co-located**
- **Special Observations (transects) scheduled for 2009**

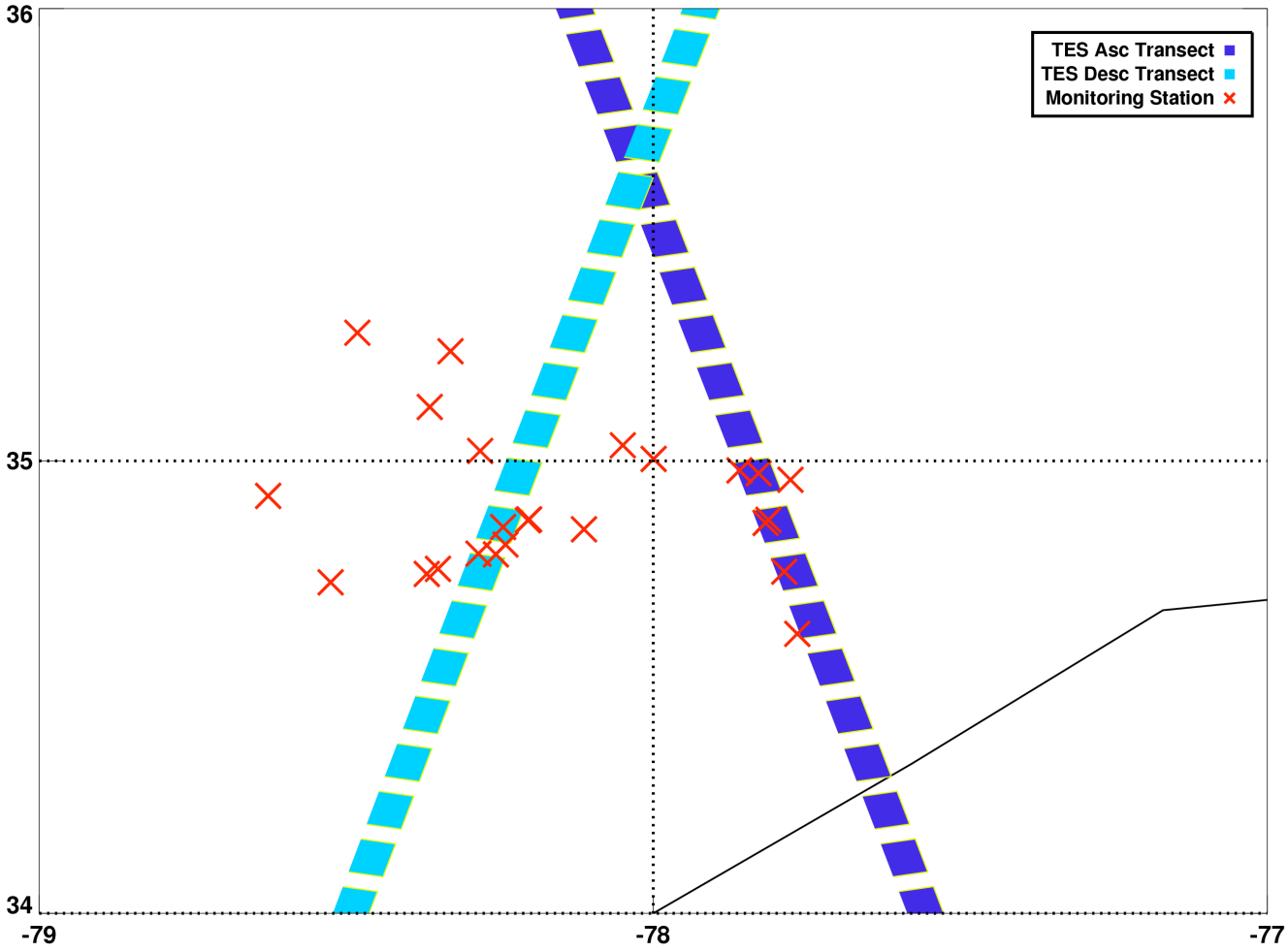


tes

aer
Atmospheric and Environmental Research, Inc.

Transects for ammonia validation

- **Started in early February**
- **Will run at least through December**
- **Will allow detection of spatial variability and seasonal trends**



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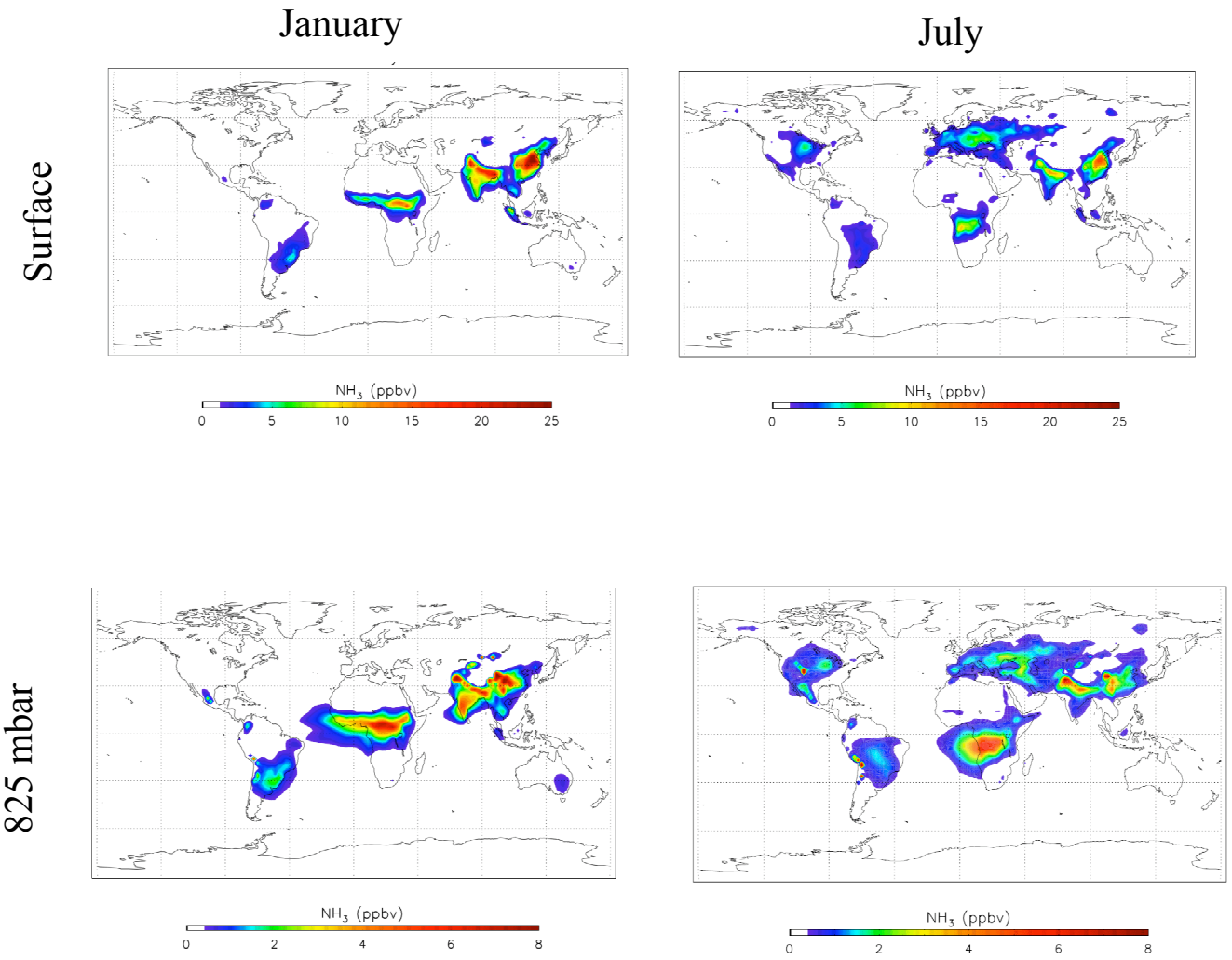
Evaluation and Application: GEOS-Chem Output



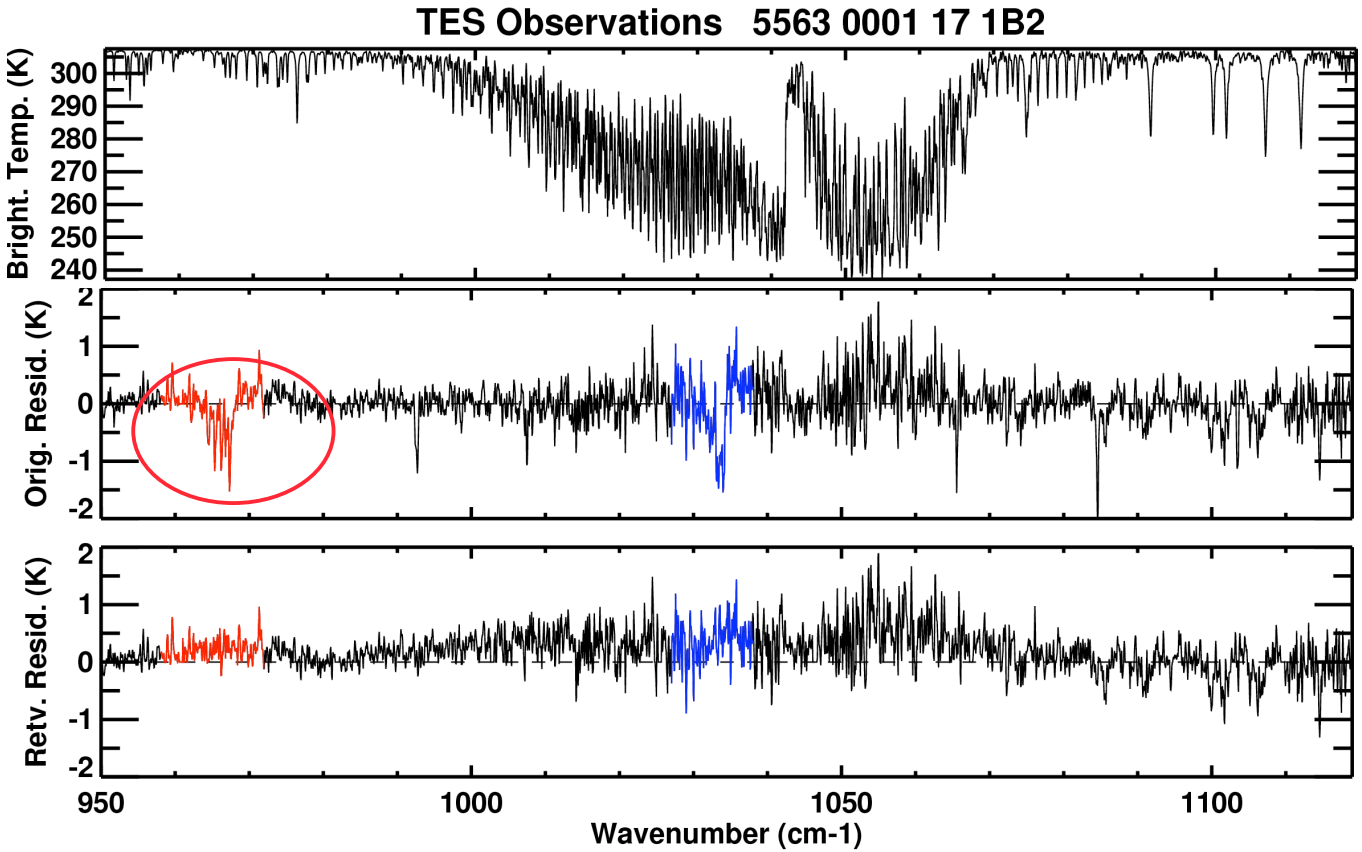
TES NH_3 measurements will be compared with global model output (e.g., GEOS-Chem)

- **TES most sensitive to concentrations around 850 mbar**
- **Distribution at this level is strongly correlated with surface values**

Summary

- Ammonia can be retrieved from TES radiance measurements
  - have performed retrievals from simulated and real data
    - retrieval over China agrees qualitatively with GEOS-Chem
- special observations scheduled for validation during 2009
- TES measurements will provide modelers with:
  - validation of seasonal trends and spatial variability
  - data for assimilation approaches

Measuring ammonia from TES spectra



Measure radiation

Compare measurement with forward model run with *a priori* profile

Adjust profile to minimize residual

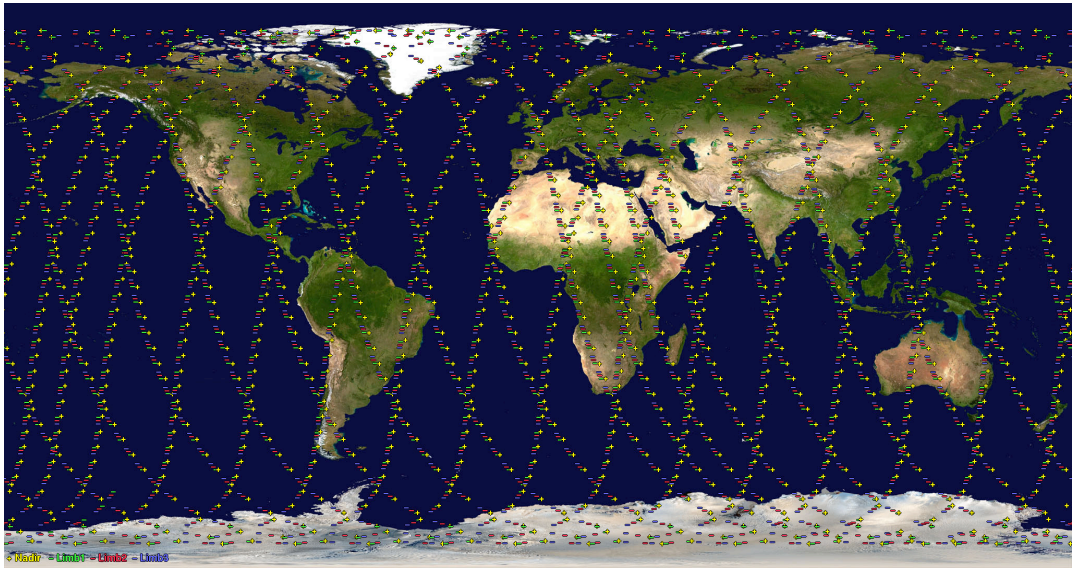
Advantage of measurements from space

Quantitative, global, long-term picture of NH_3 spatial and temporal variability

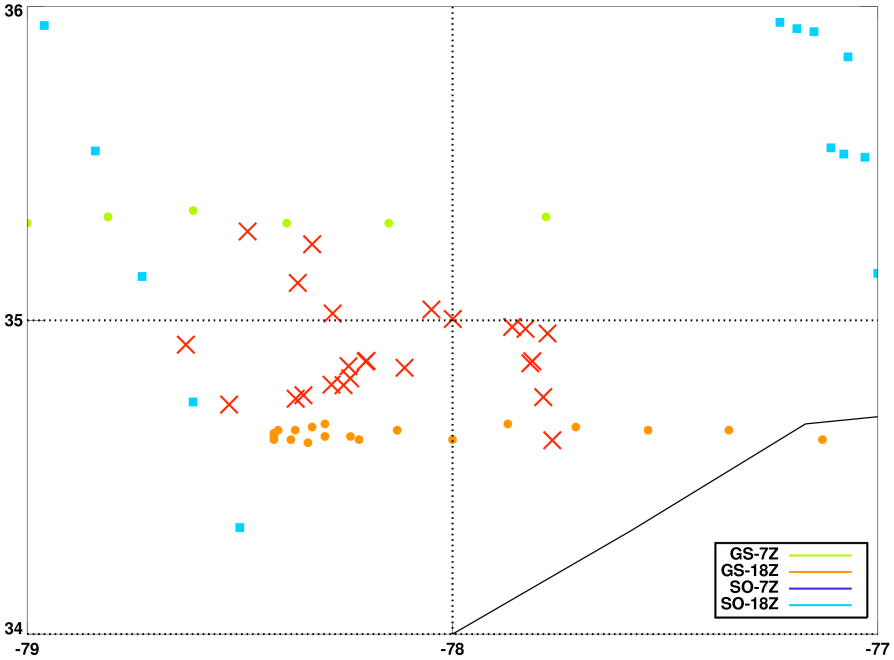
TES :Tropospheric Emission Spectrometer

TES was designed to retrieve trace gases

- **flies on NASA Aura (part of the "A-Train")**
- **launched in July 2004**
- **well calibrated**
- **FTS with a spectral resolution of 0.06 cm-1**
- **tropospheric chemistry with a footprint of 5 x 8 km**



- **Nearly 700 Global Surveys since July 2004**
  - **Each survey lasts approximately 26 hours; one survey every two days**
  - **Global coverage every sixteen days**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