Global free tropospheric NO_2 Abundances Derived using a Cloud Slicing Technique from Aura OMI

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Aura Science Team Meeting
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Free Tropospheric NO_2

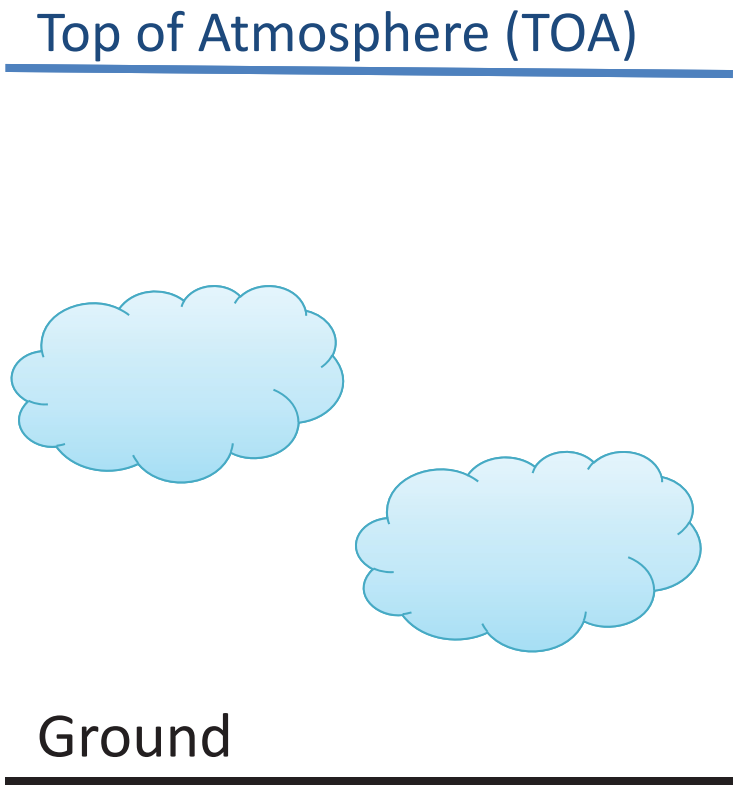
- Atmospheric NO_2
  - Produced by combustion, lightning, and in soil
- Indirect radiative impacts in troposphere
  - Ozone has largest warming effect in upper-troposphere
  - Impacts methane concentrations
- A few types of **free-**tropospheric NO_2 measurements available
  - Aircraft in situ measurements, MAX-DOAS, NO_2 sondes, etc.

Cloud Slicing Technique

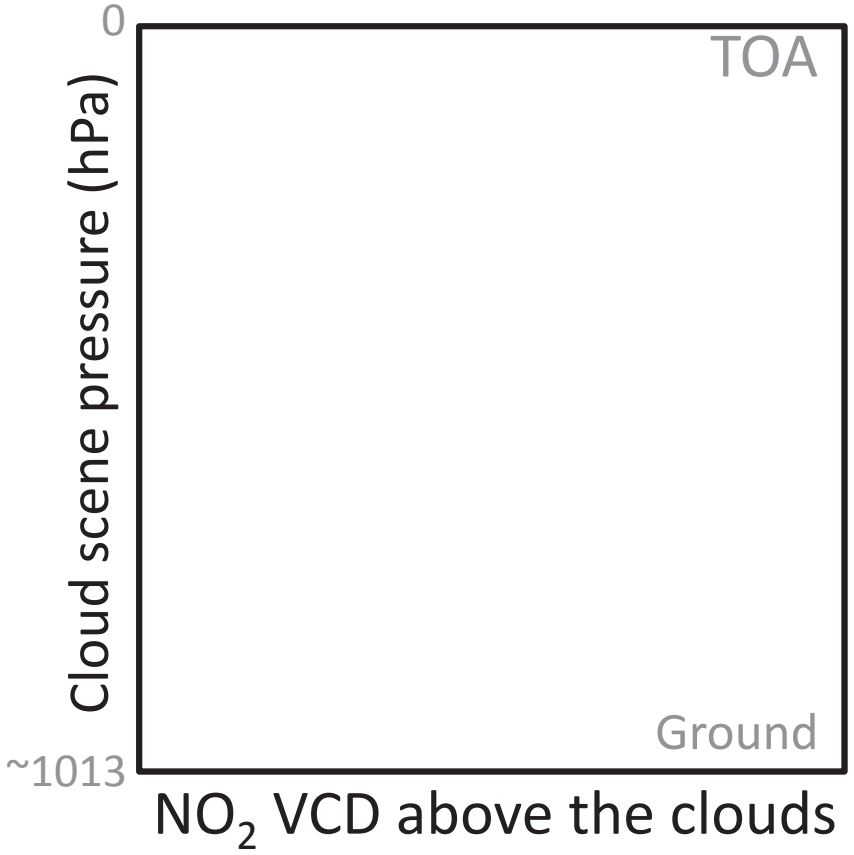
- Utilize **above-cloud** NO_2 column (where CRF > 0.9)
  - Good quality column measurements as clouds provide bright surface
  - Usually neglected in the view of surface pollution
- Data obtained
  - Free tropospheric NO_2 volume mixing ratio (VMR)
- Independent of prescribed stratospheric column estimate

Cloud Slicing Technique

Measurement at Cloudy Scenes

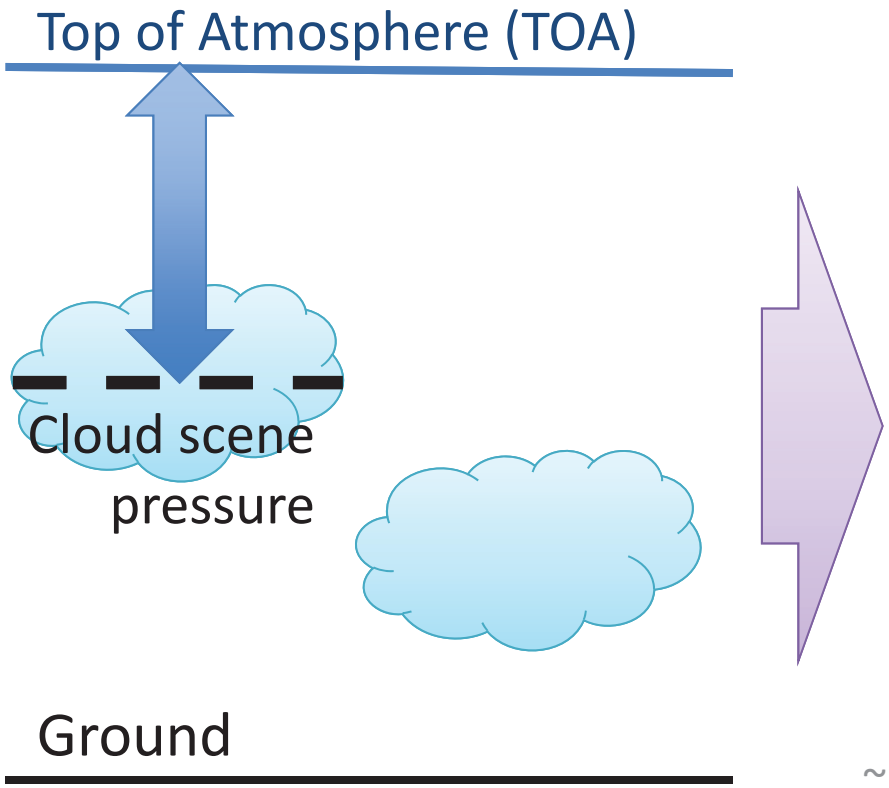


Observed Column vs Pressure



Cloud Slicing Technique

Measurement at Cloudy Scenes



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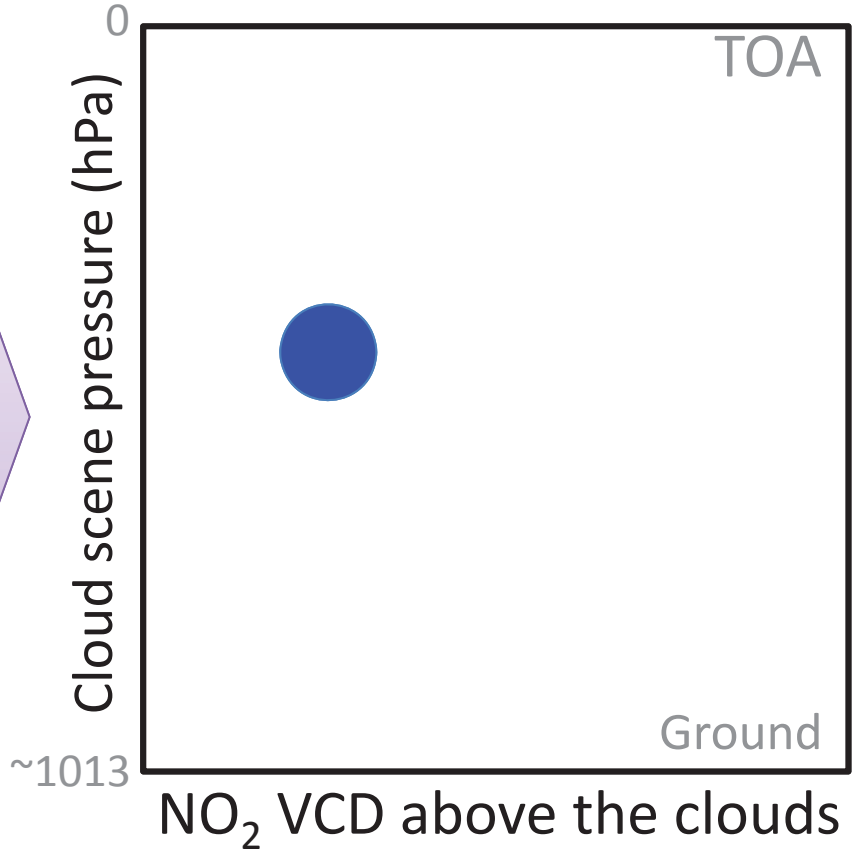

Cloud Slicing Technique

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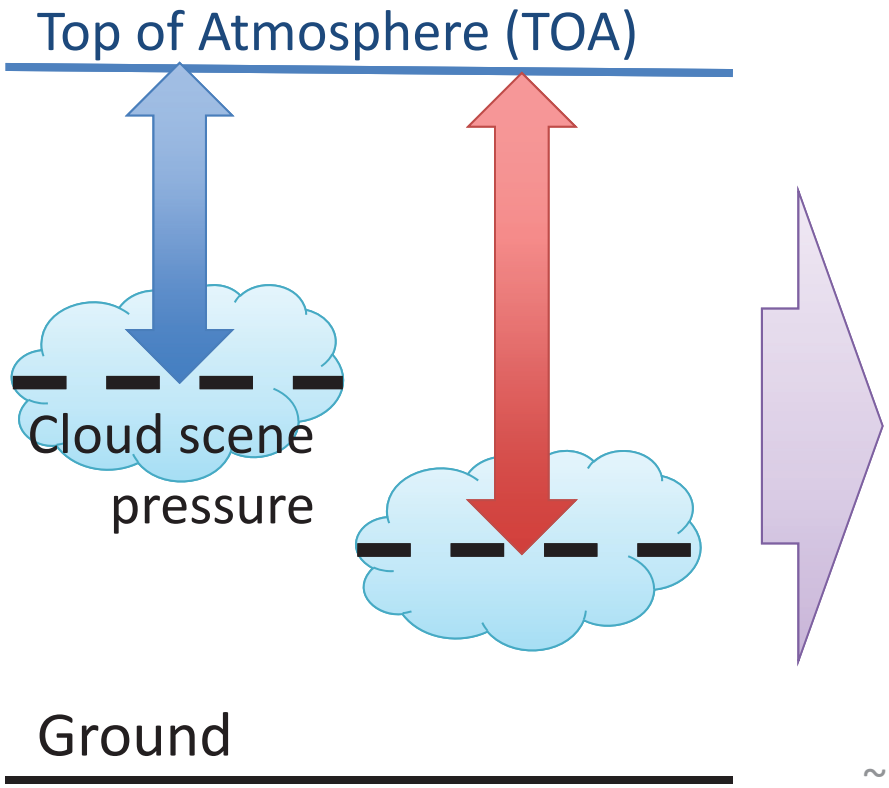

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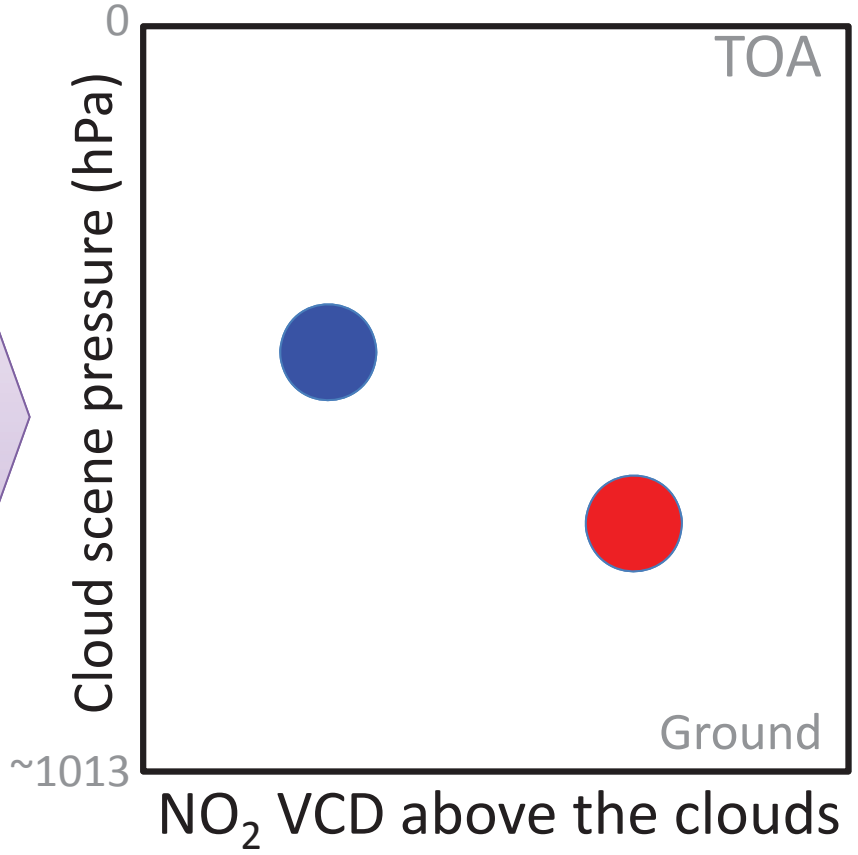

Cloud Slicing Technique

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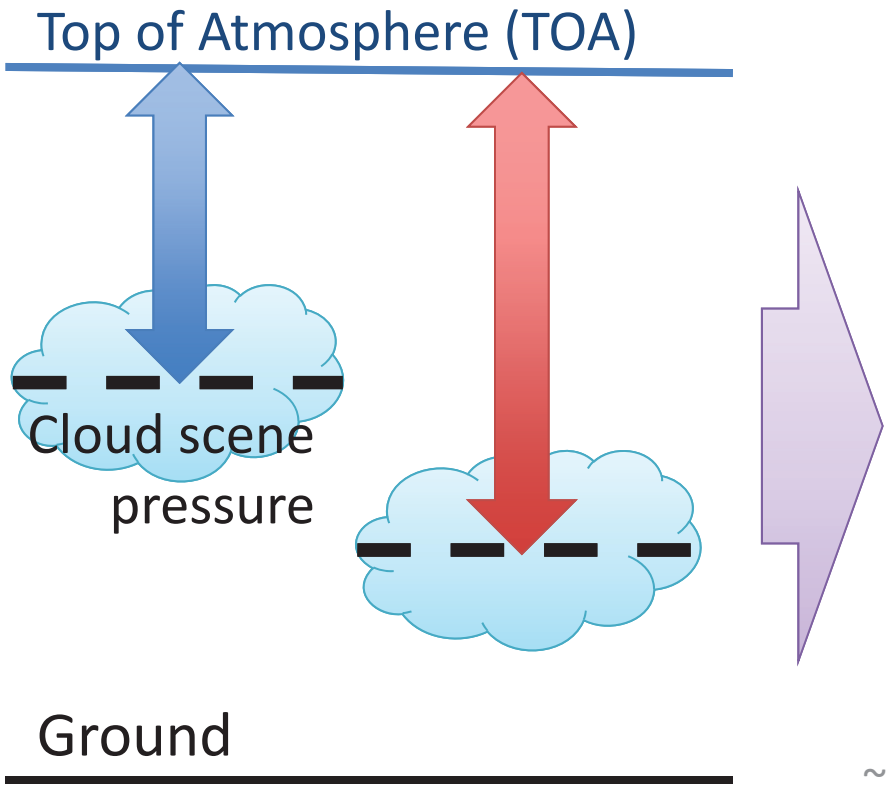

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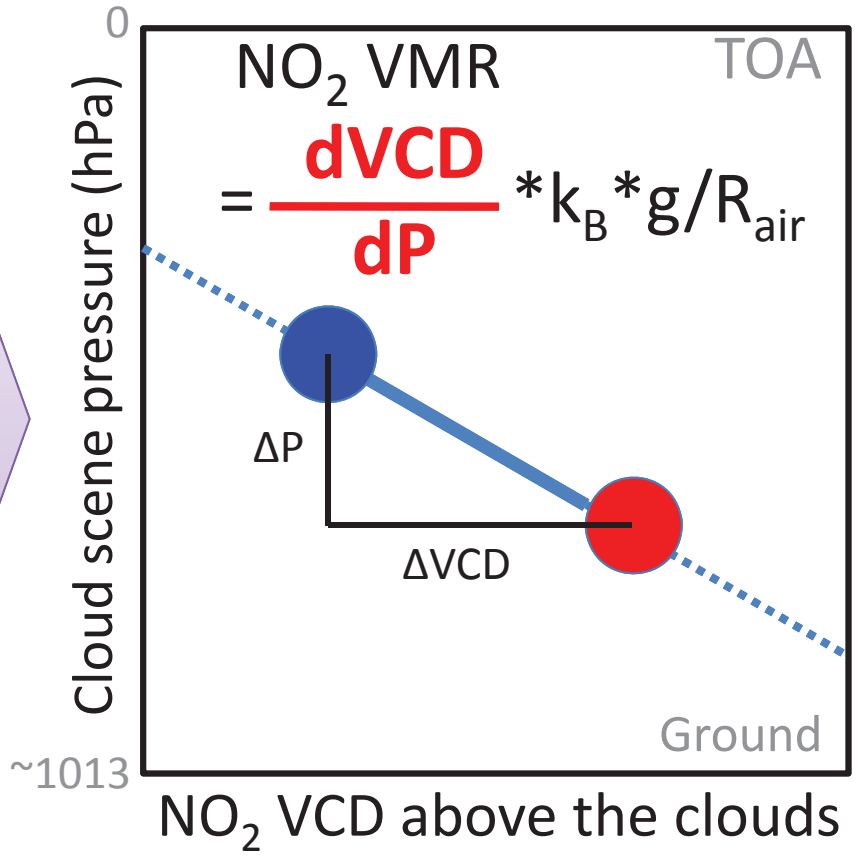

Cloud Slicing Technique

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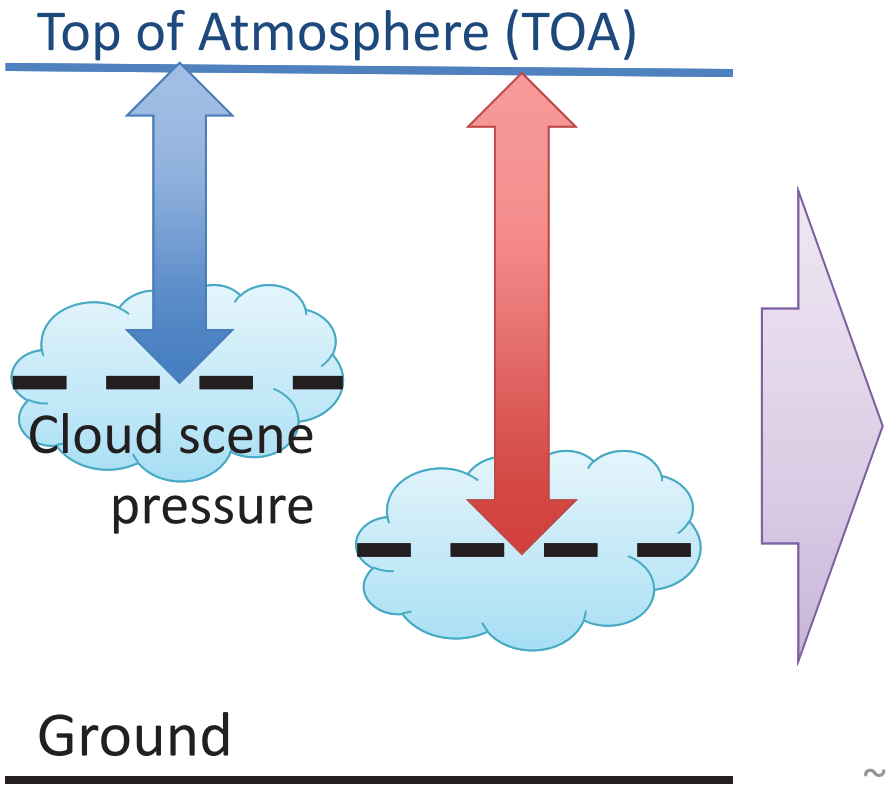

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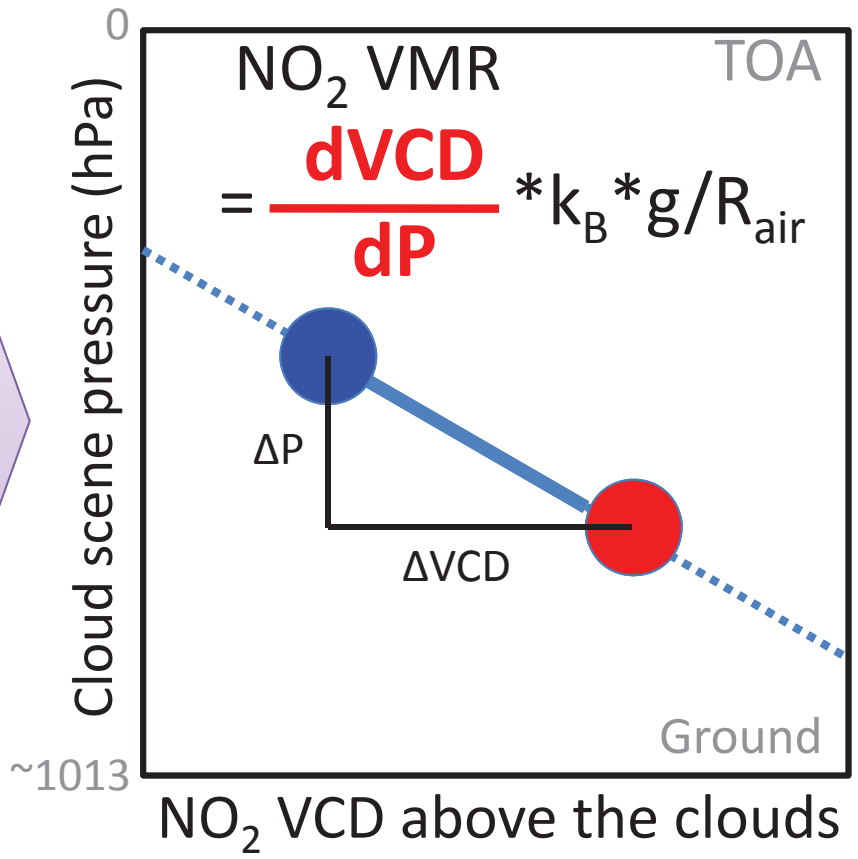
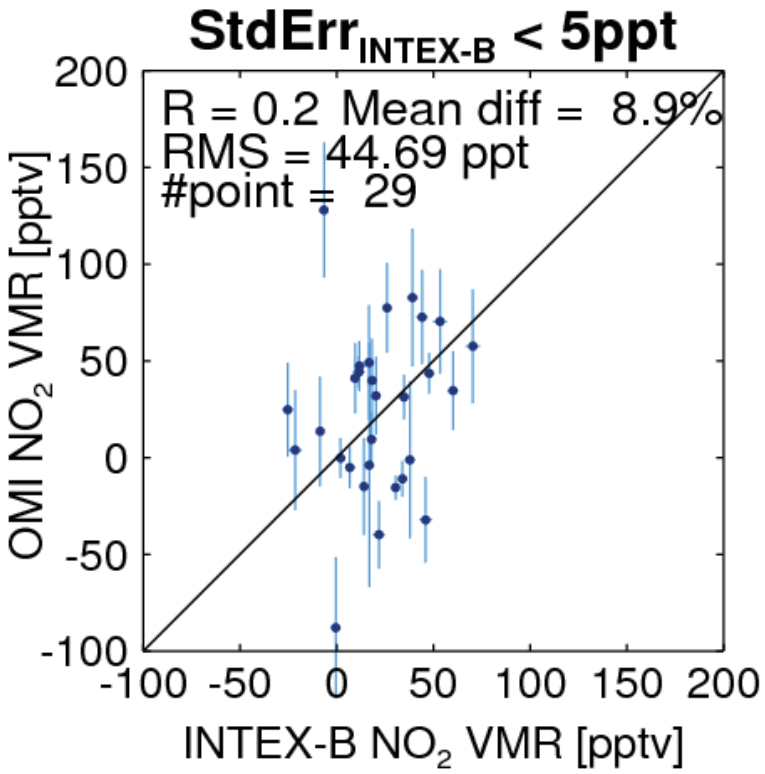


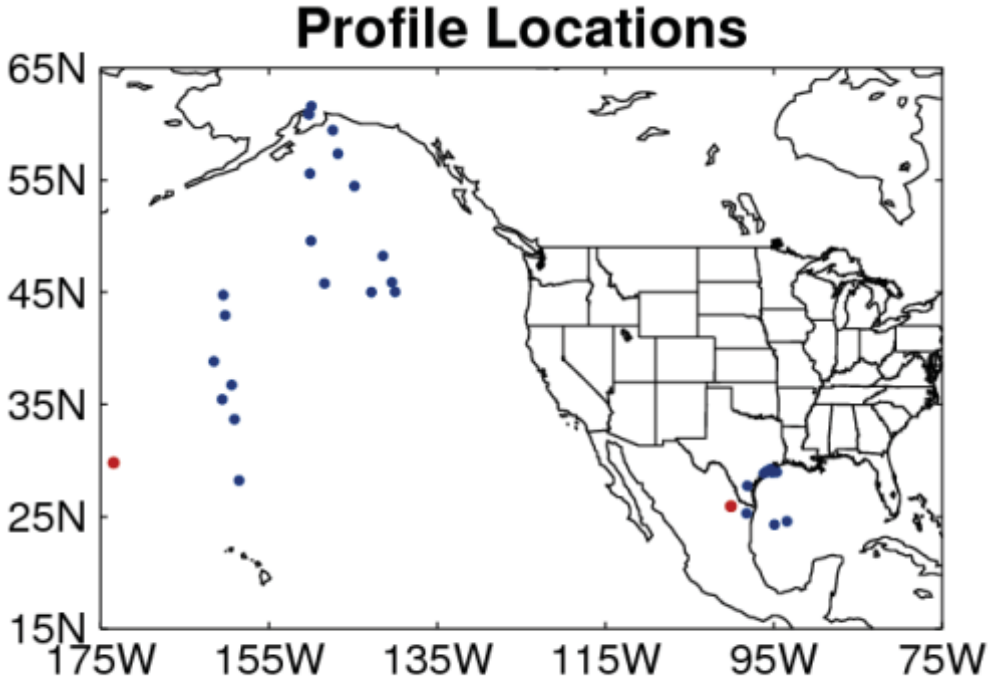
The slope between NO_2 VCD and cloud pressure is proportional to NO_2 volume mixing ratio (VMR)

Cloud Slicing Technique

- Using near-Lambertian cloudy AMF instead of geometric AMF
- Assumptions
  - Uniform NO_2 VMR in the sampling pressure ranges
  - No stratospheric variation in the sampling spatial/temporal ranges (6^ox 8^o, calculated per orbit)
- Limitations
  - Represent cloudy conditions only
  - Magnitudes only as accurate as above-cloud NO_2 VCD
    - Uncertainties in SCD, cloudy AMF

Comparison with INTEX-B Data



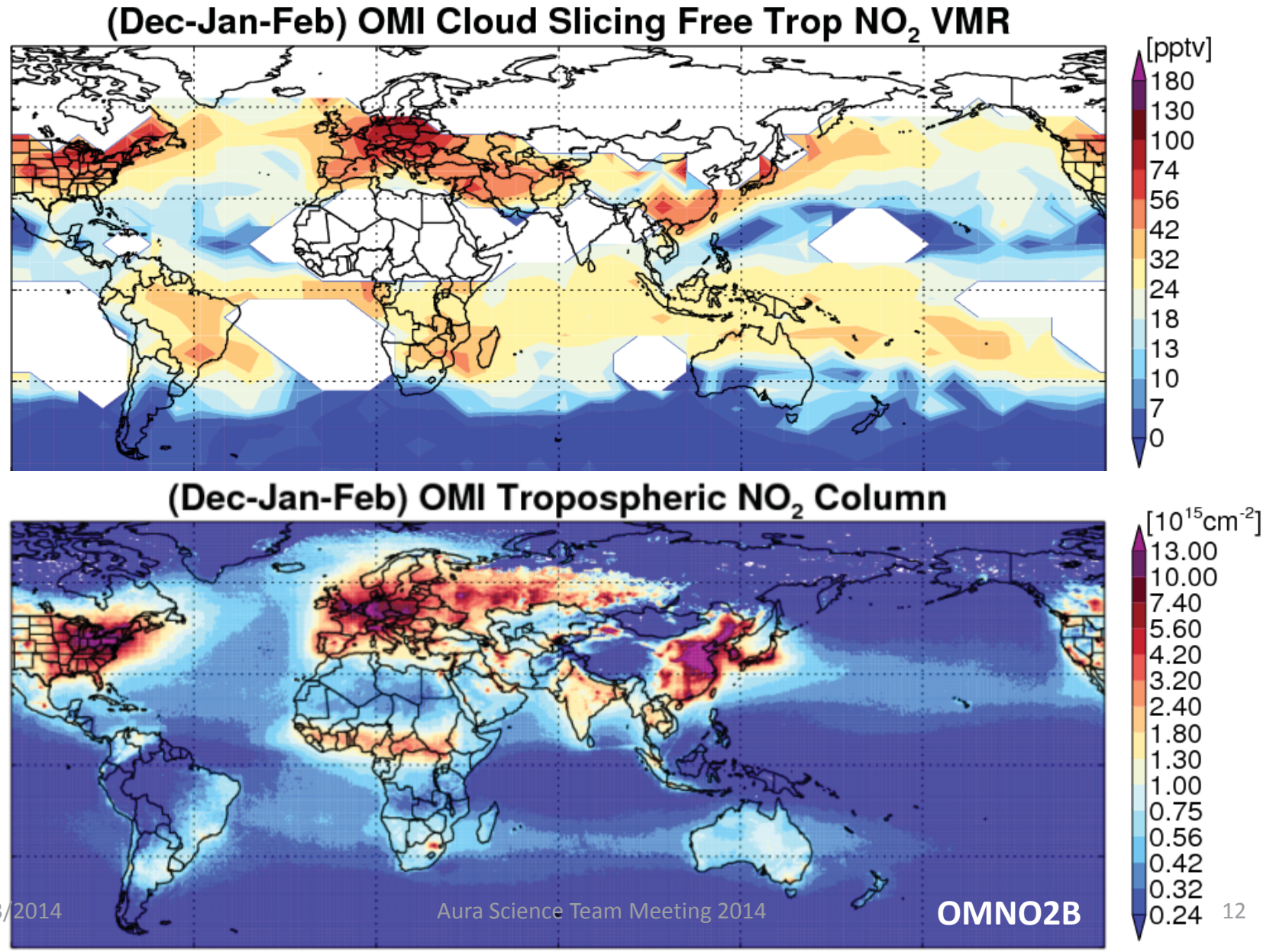


- INTEX-B VMR standard error < 5 pptv
- Similar magnitude but very weak correlation
- Reasonable agreement despite the intrinsic limits:
  - Poor collocation, small scale features, clear/cloudy conditions

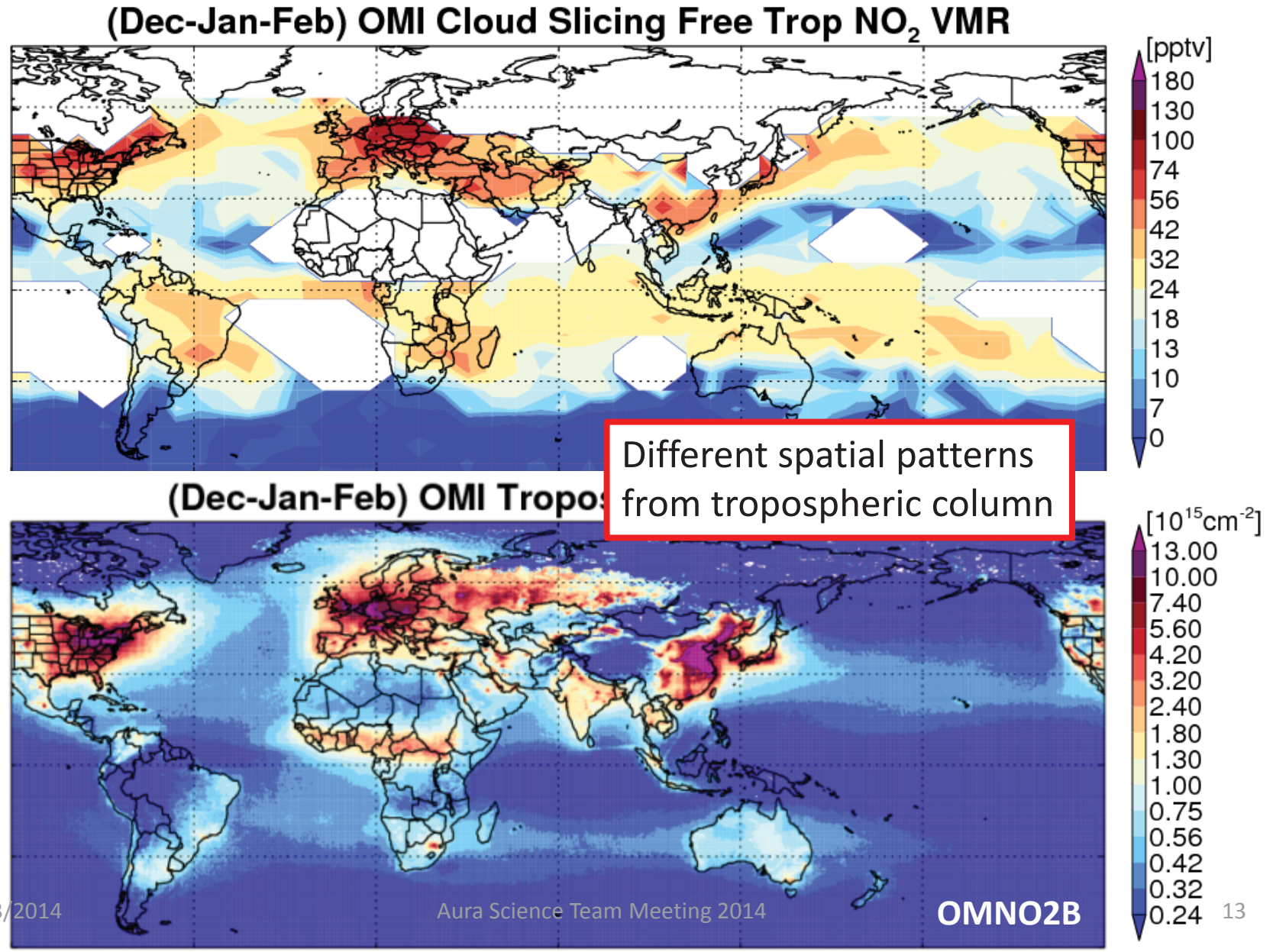
Global Seasonal Climatology

- Global seasonal free-tropospheric NO_2 climatology
  - Take advantage of high spatial/temporal coverage of satellite measurements
  - Concentrate on spatial and seasonal patterns
- Large volume of data required for reasonable results
  - 3-year OMI data accumulated (2005-2007)
  - Coarse resolution (6^o latitude x 8^o longitude)
- Distinct patterns in the free tropospheric VMR
  - Independent source of data to study free troposphere

Global Seasonal Climatology



Global Seasonal Climatology



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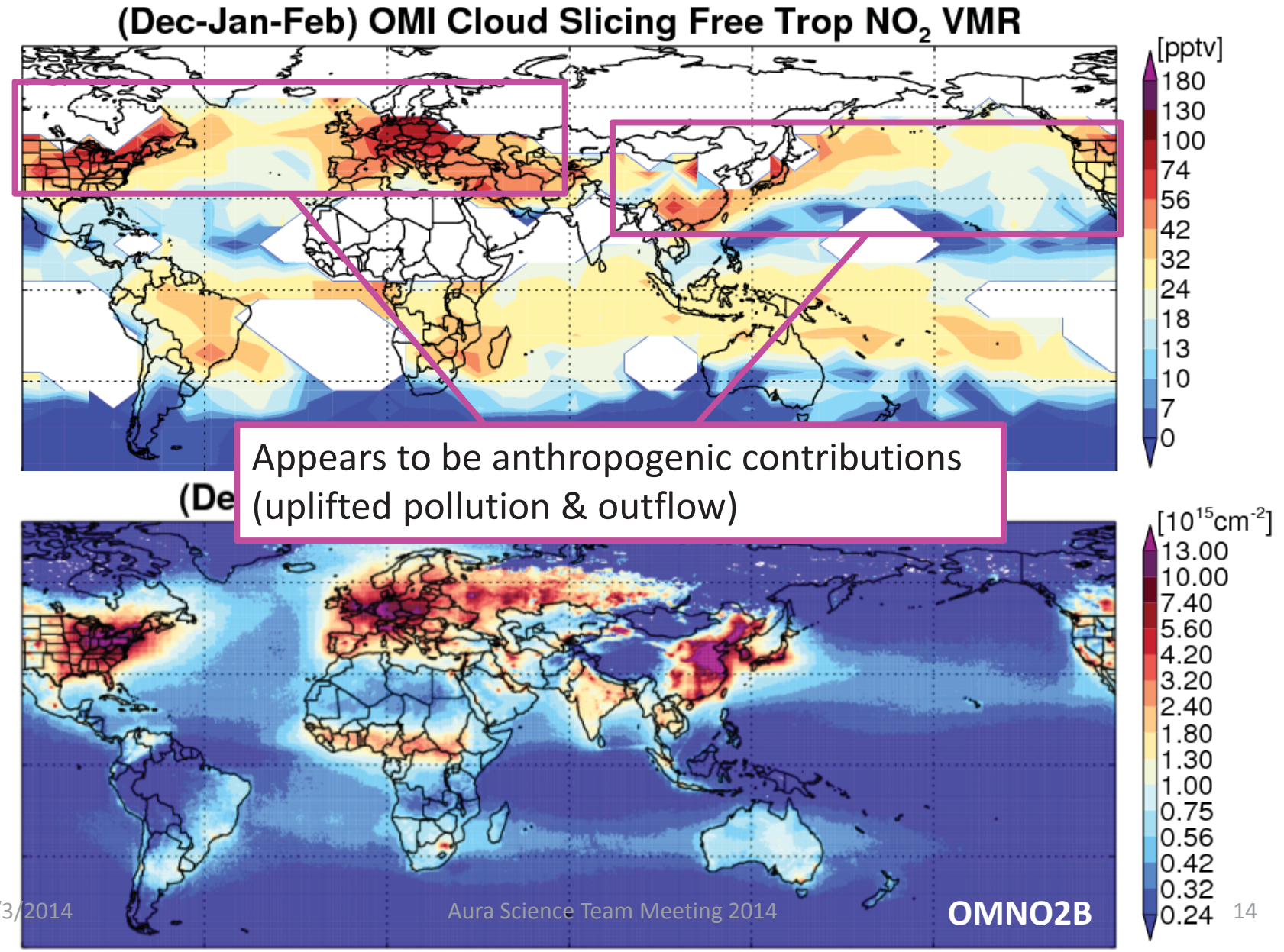

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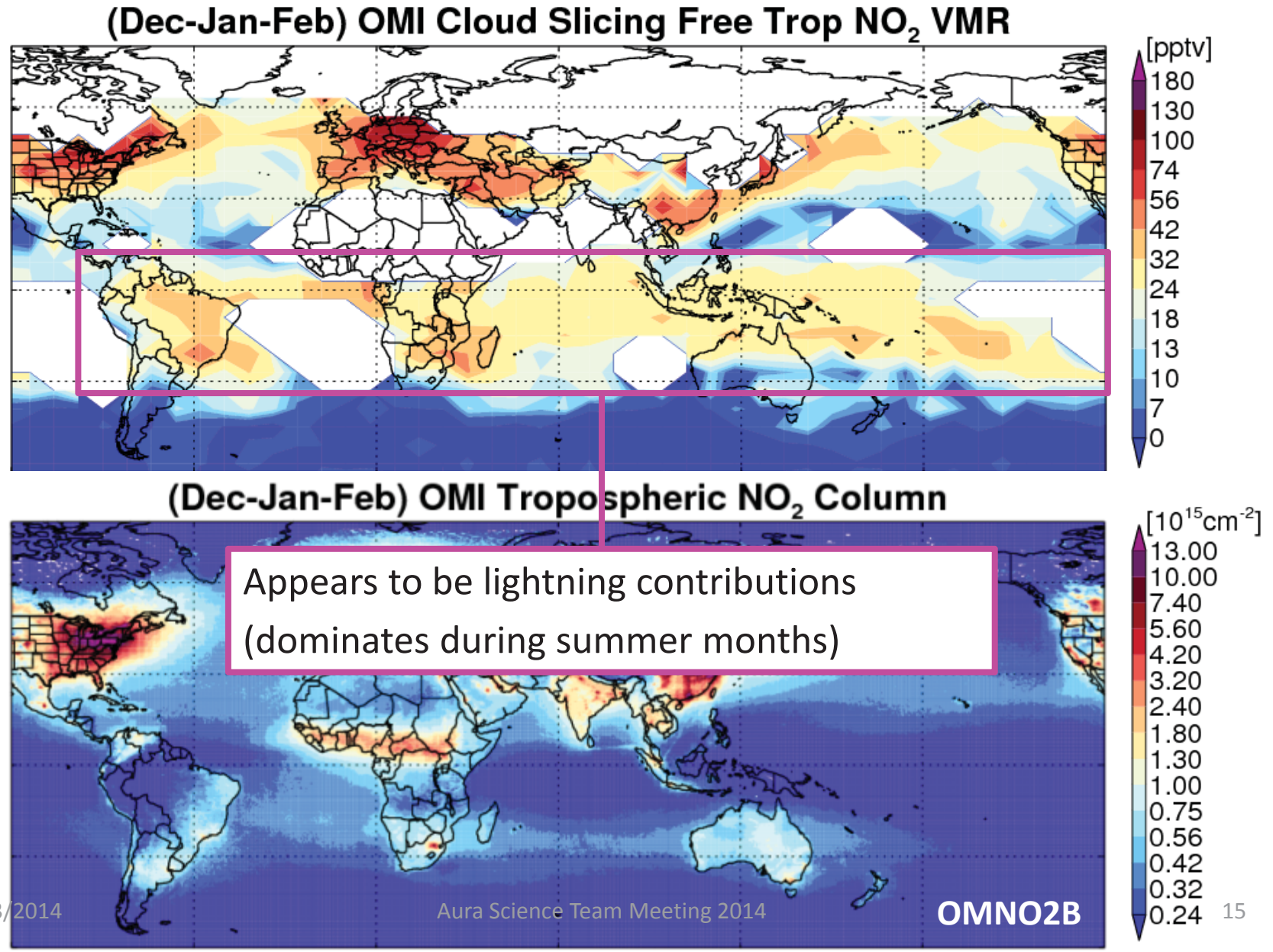

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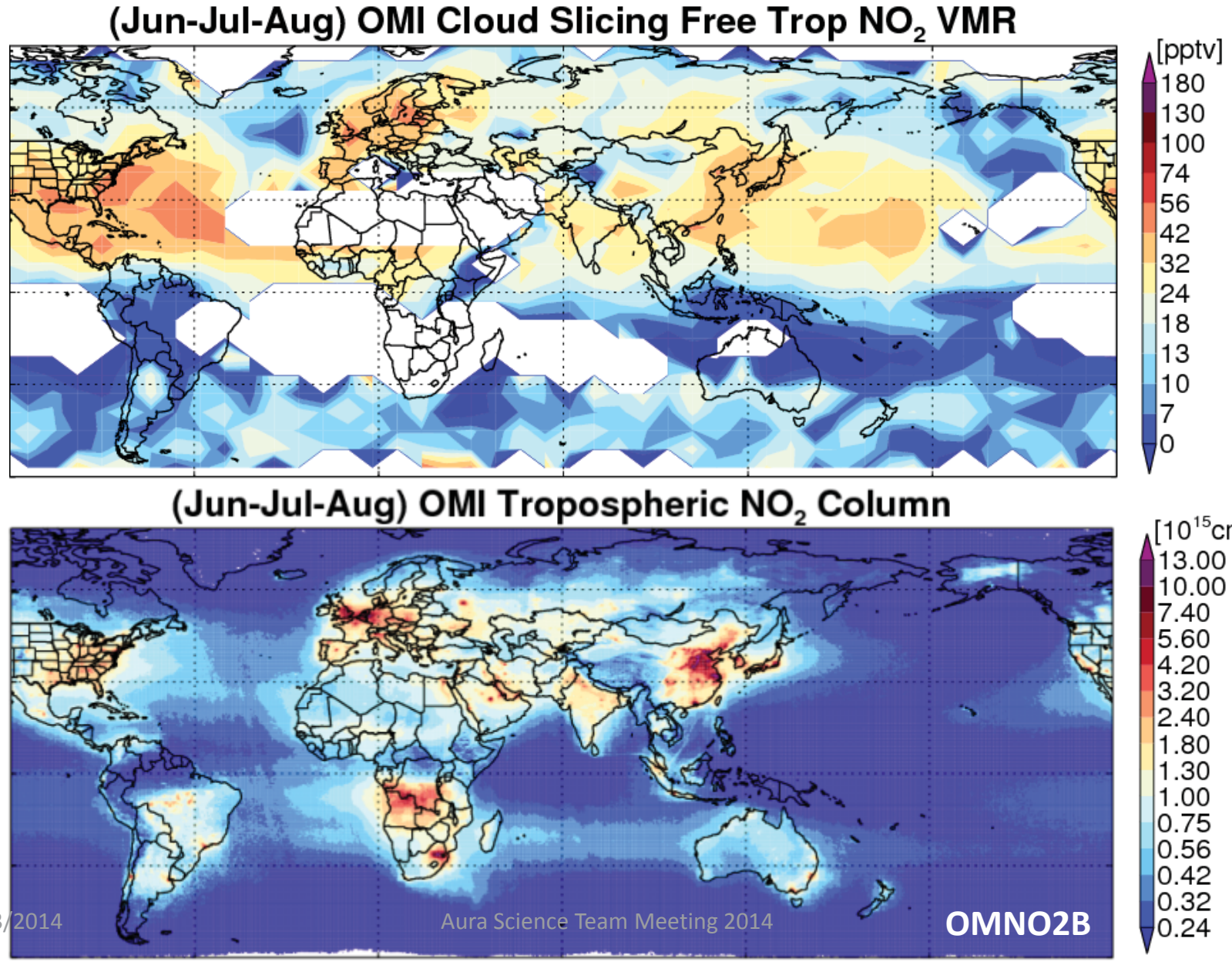

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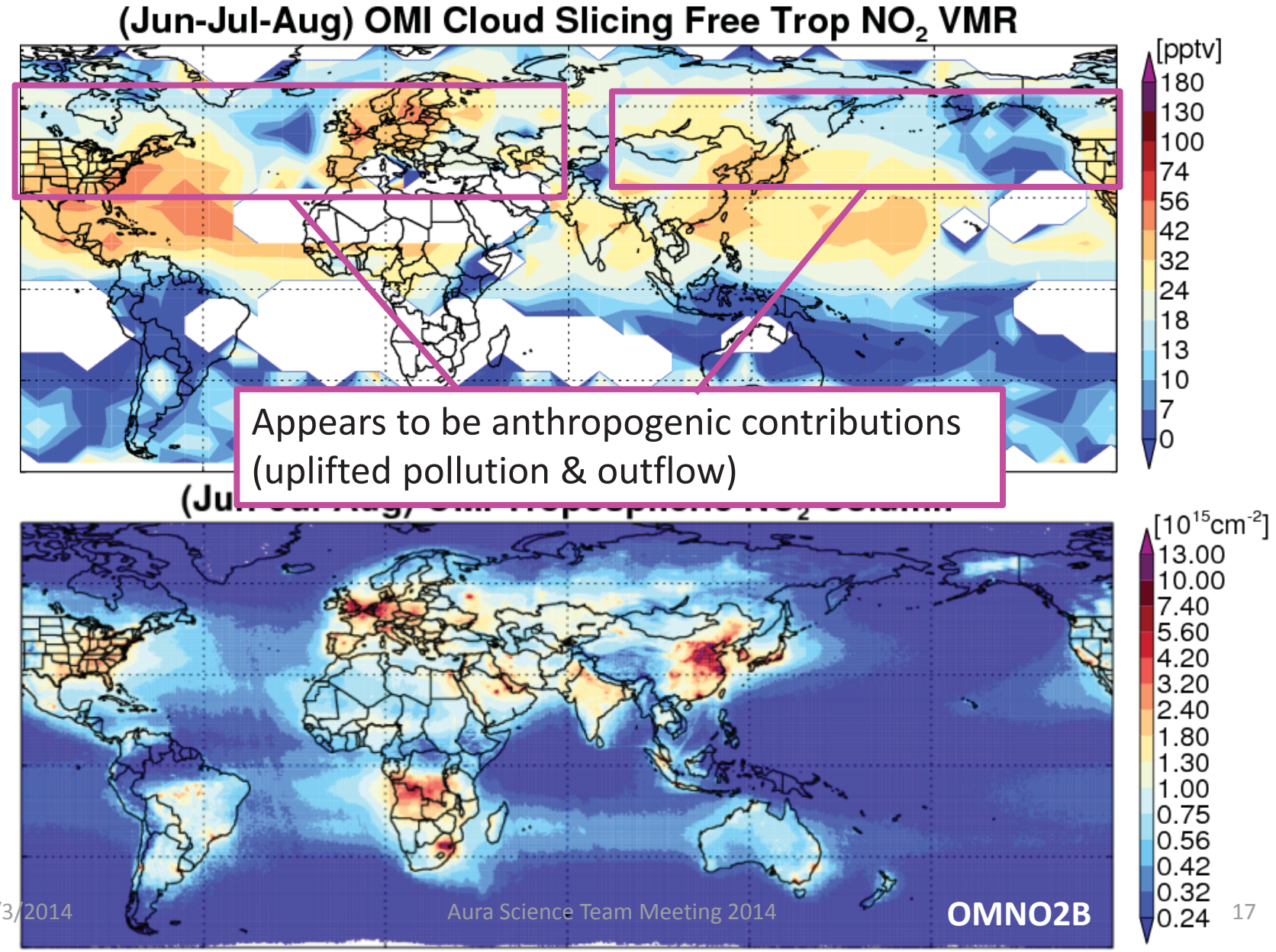

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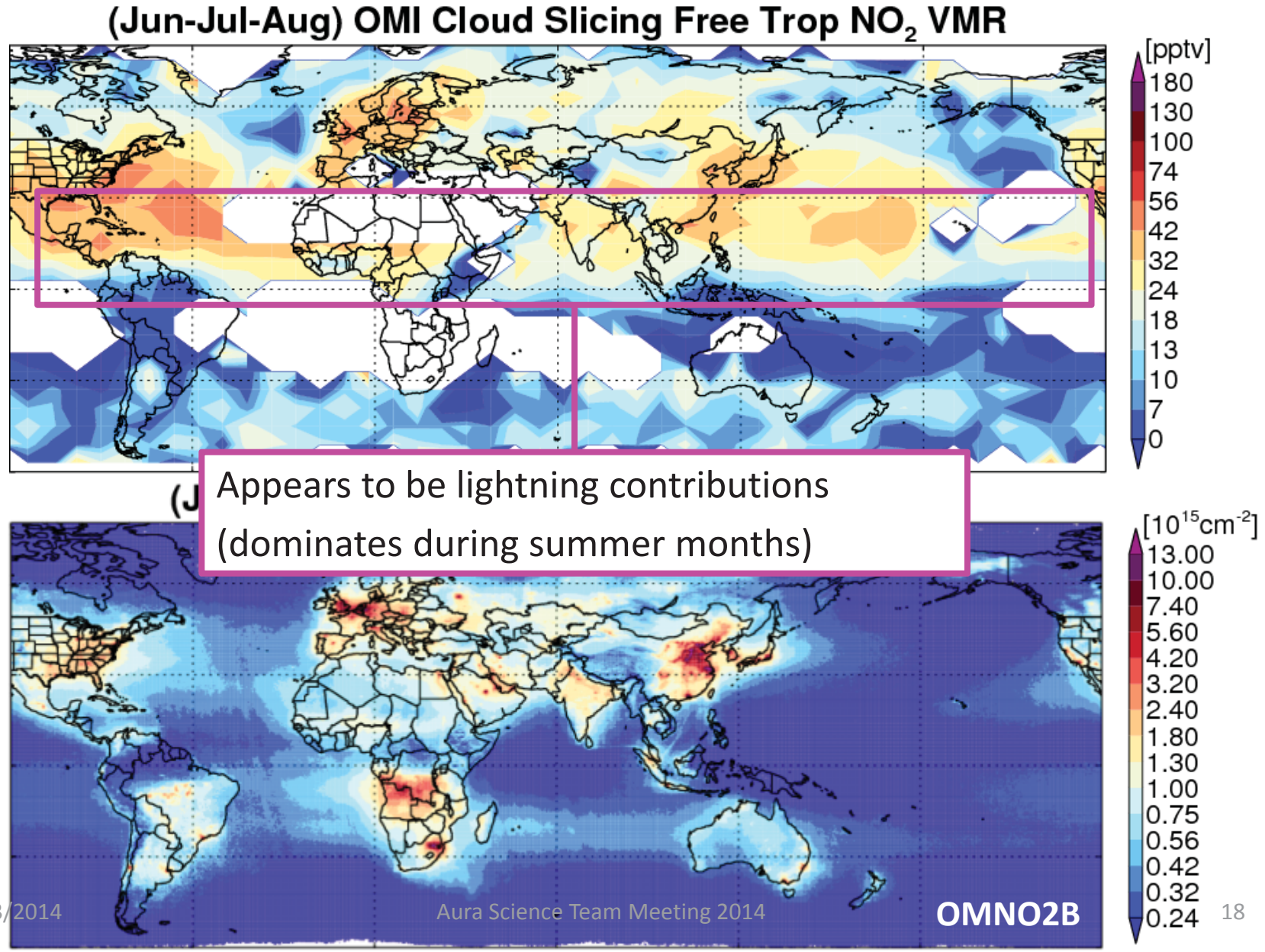
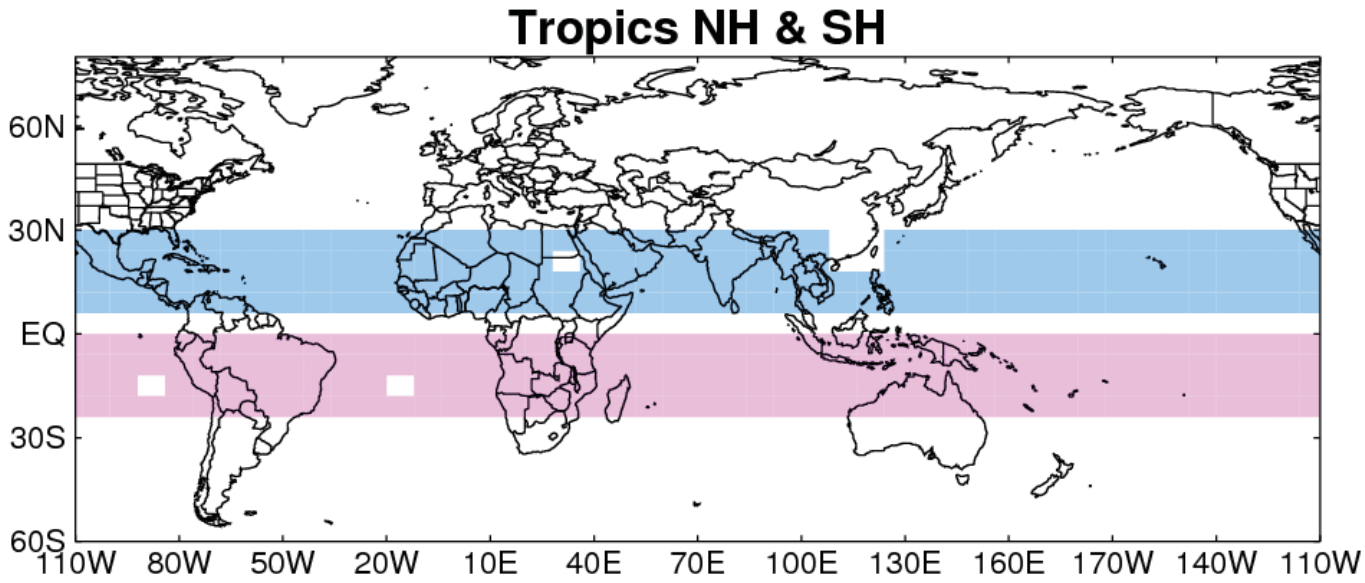


Profile Analysis

- Coarse profile analysis (~100 hPa resolution)
- Requires even more data with significant cloud pressure variability
- Example cases
  - Tropical oceans of NH and SH for lightning NO_2

Profile Analysis



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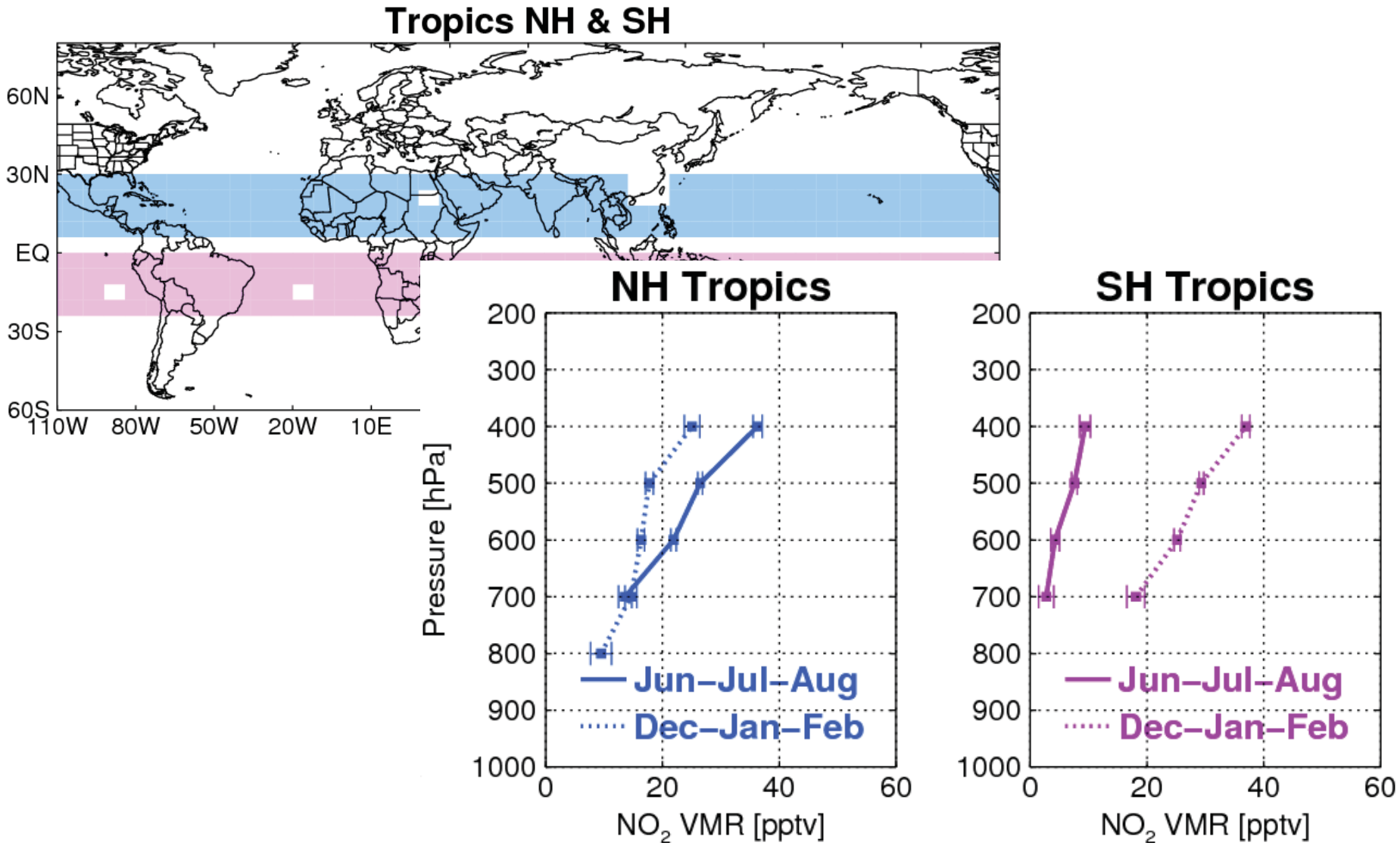

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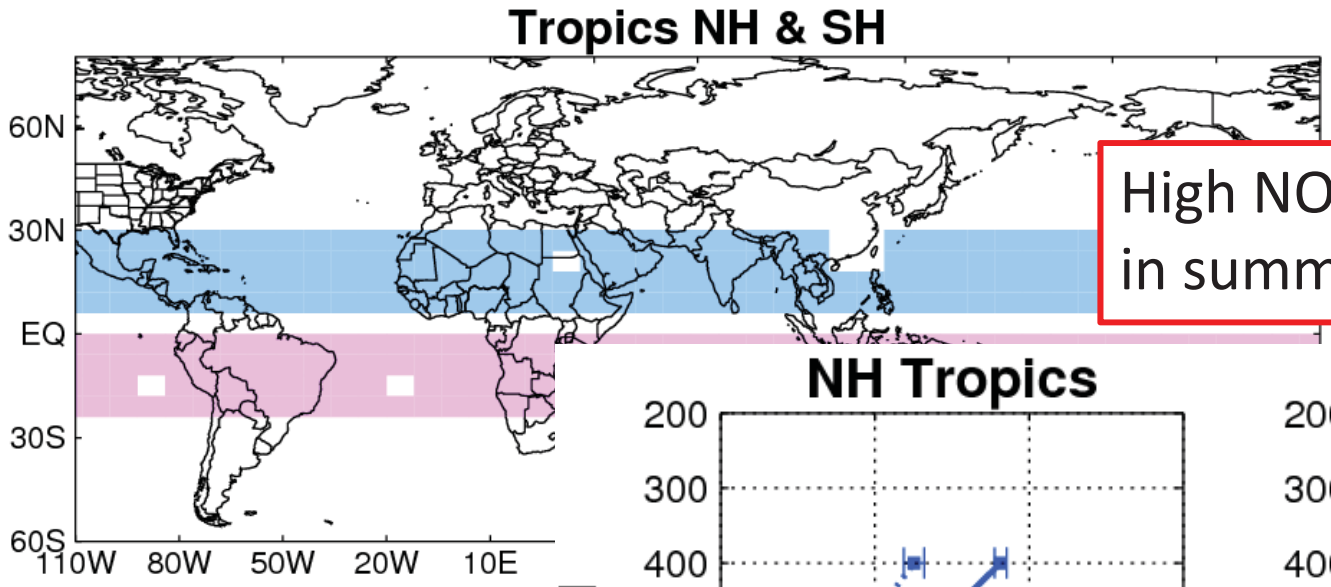
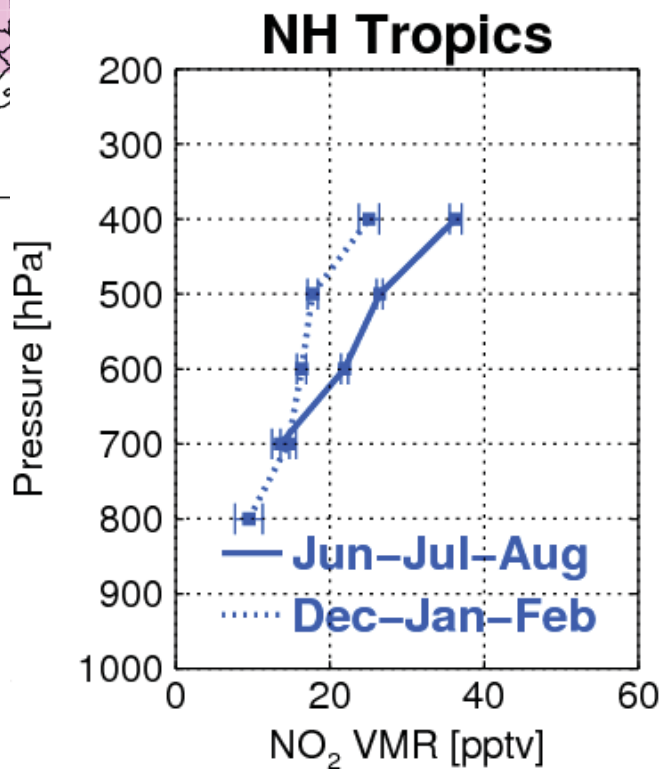
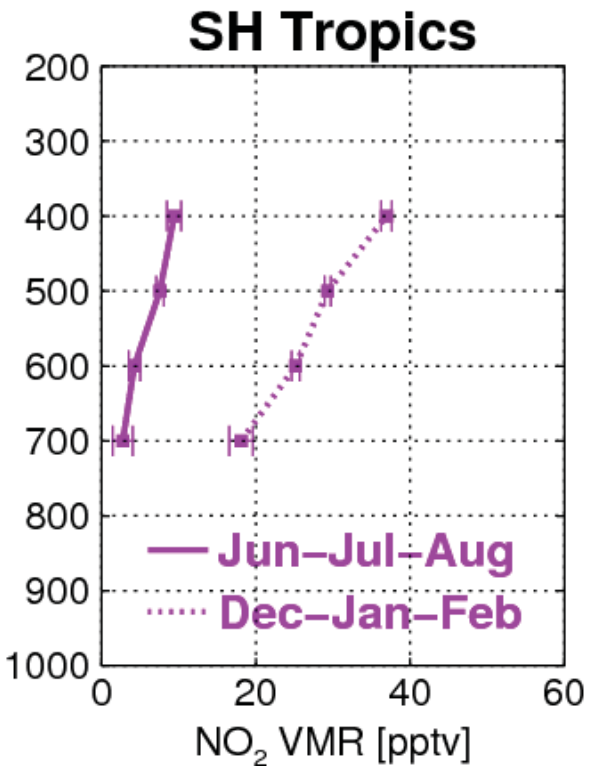


High NO_2 above 500 hPa in summer





Conclusions

- Free tropospheric NO_2 VMR derived using cloud slicing
- Comparison with INTEX-B measurements shows reasonable agreement
- Global seasonal climatology shows anthropogenic and natural (lightning) features of free tropospheric NO_2, independent of the tropospheric column
- Profile analysis shows lightning NO_2 in the upper troposphere
- Expect collaborations with various free tropospheric NO_2 measurements and models

Thank you!

S. Choi et al.: Global free tropospheric NO_2 Abundances Derived using a Cloud Slicing Technique from Aura OMI, *Atmos. Chem. Phys. Discuss.*, 2014

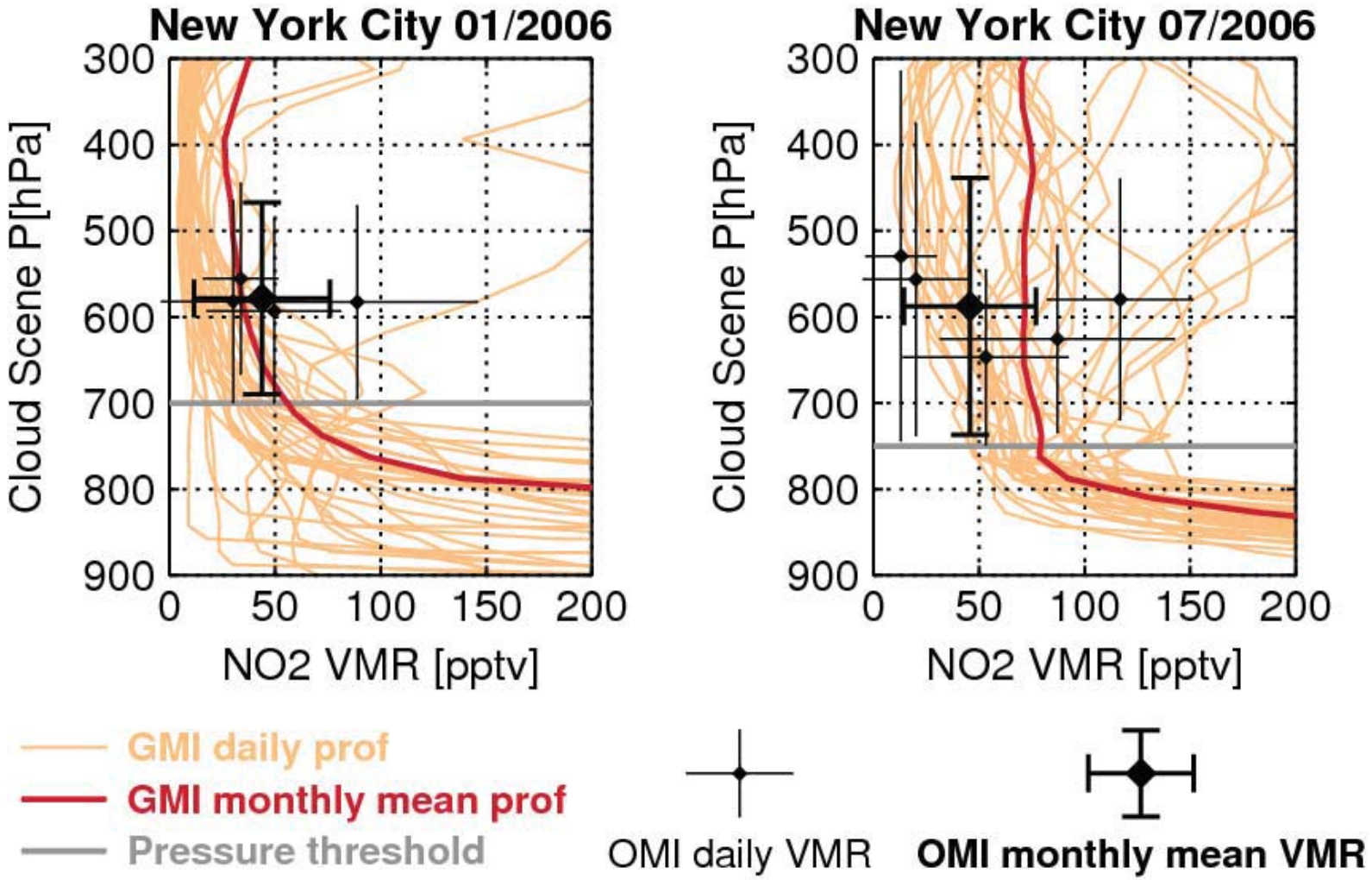
Backup slides

Detail/Data Screening Criteria

- Use slant column density (OMNO2A) and geometric AMF

- Cloud radiance fraction > 0.9
- Aerosol index < 1.0
- No snow/ice surface
- Solar zenith angle < 80 degree
- Gradient of NO2 VMR < 0.33 pptv / hpa (profiles from GMI model or INTEX-B measurements)

Example of Calculated NO_2 Climatology

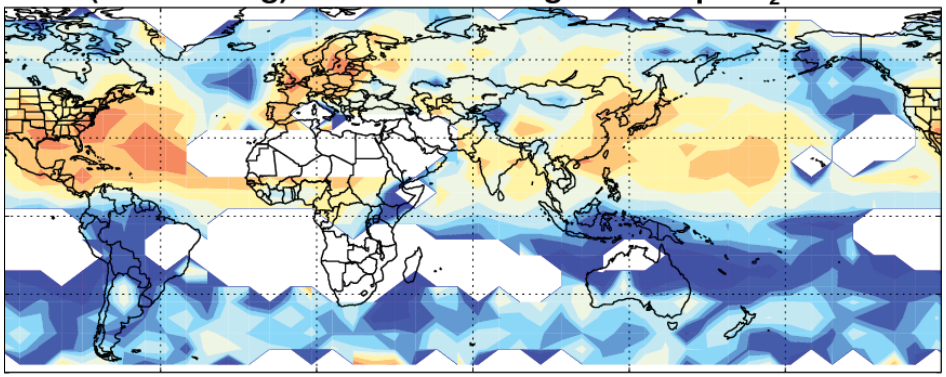


Free Trop. NO_2 VMR (OMI vs GMI)

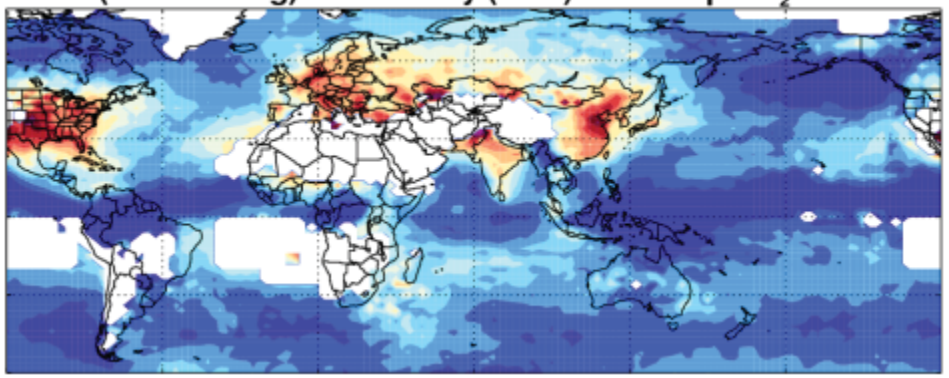
OMI

GMI

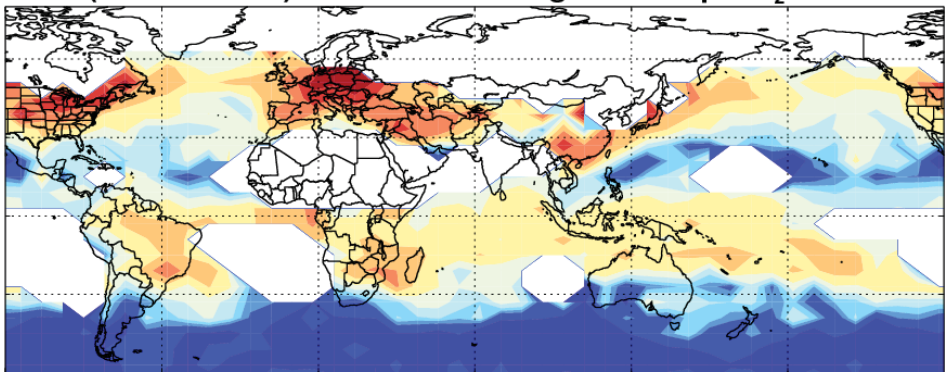
(Jun-Jul-Aug) OMI Cloud Slicing Free Trop NO_2 VMR



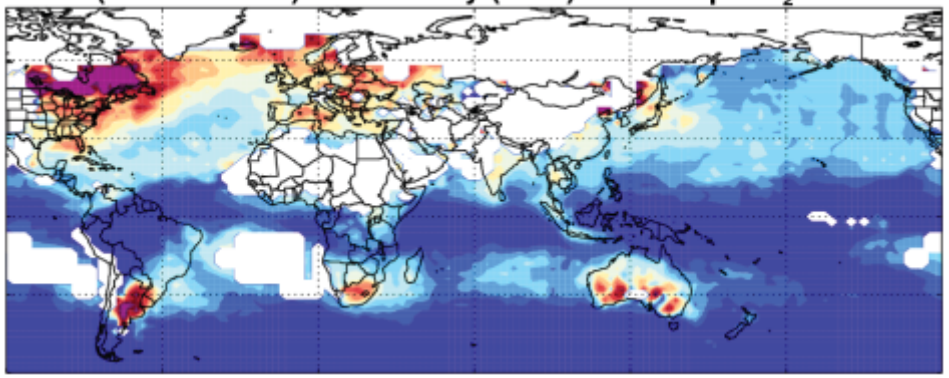
(Jun-Jul-Aug) GMI Cloudy (τ>10) Free Trop NO_2 VMR



(Dec-Jan-Feb) OMI Cloud Slicing Free Trop NO_2 VMR



(Dec-Jan-Feb) GMI Cloudy (τ>10) Free Trop NO_2 VMR

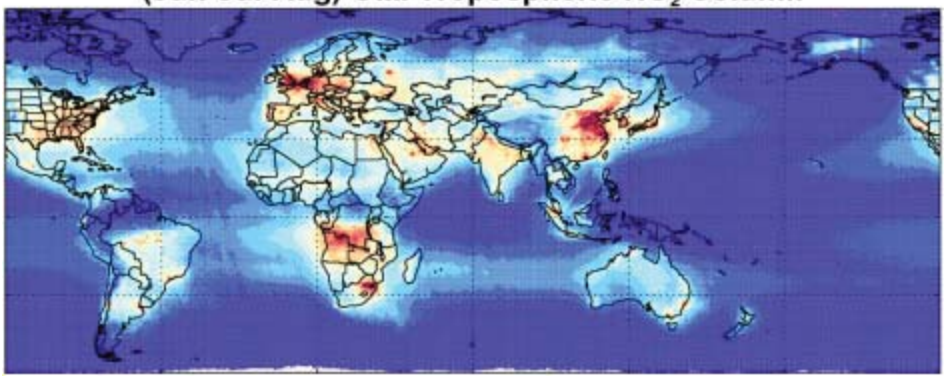


Tropospheric Column NO_2 (OMI vs GMI)

OMI

GMI

(Jun-Jul-Aug) OMI Tropospheric NO_2 Column



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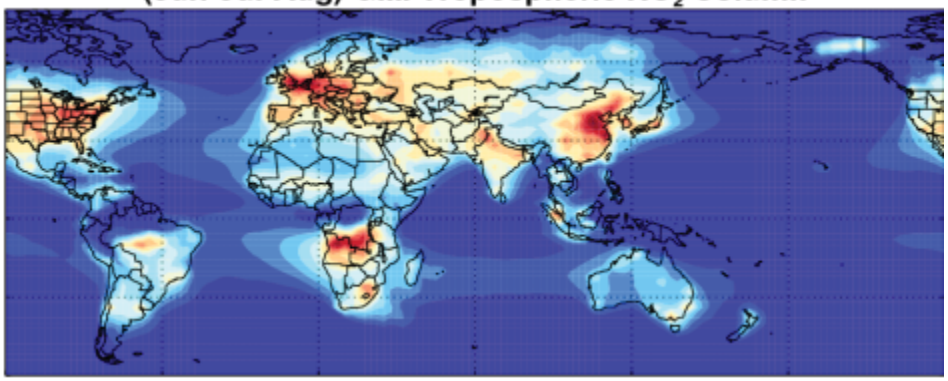

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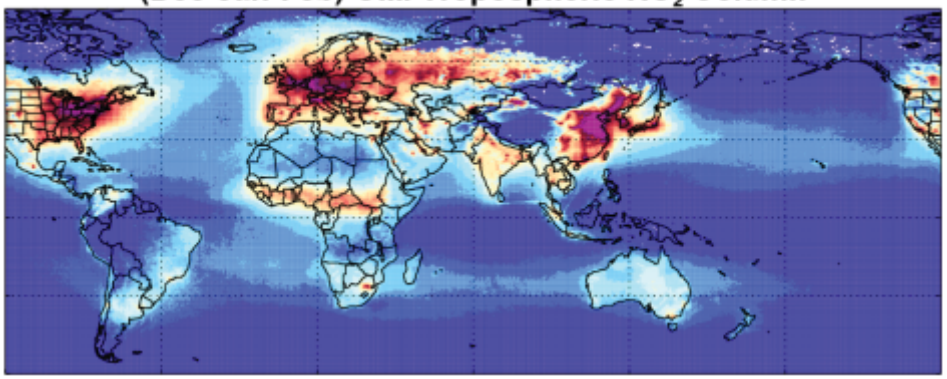

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