Measuring Tropospheric NO_2 from SCIAMACHY During INTEX and Improving NOx Emission Inventories

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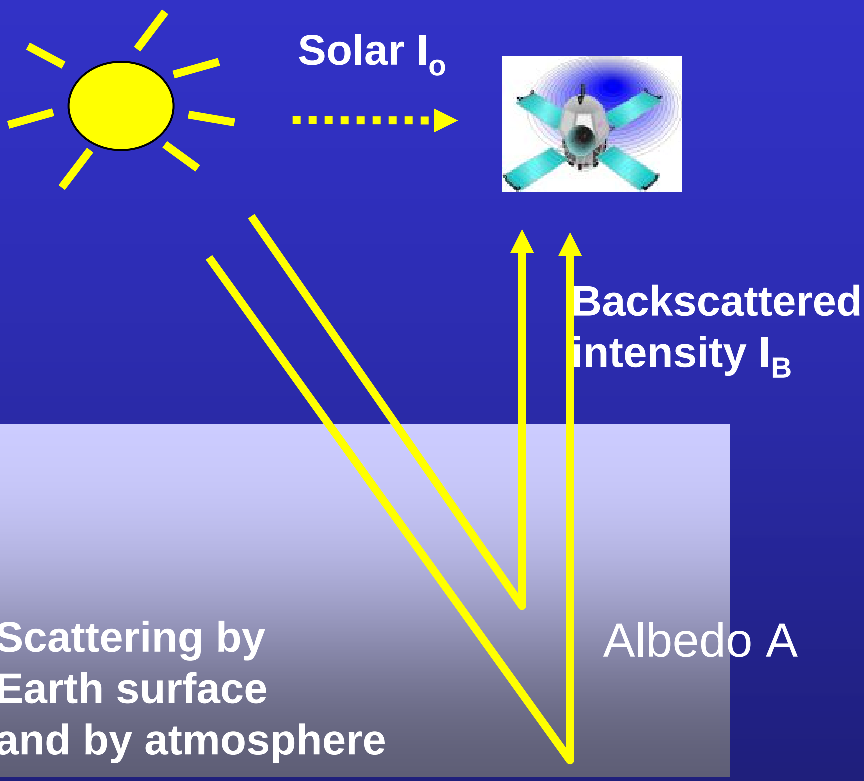
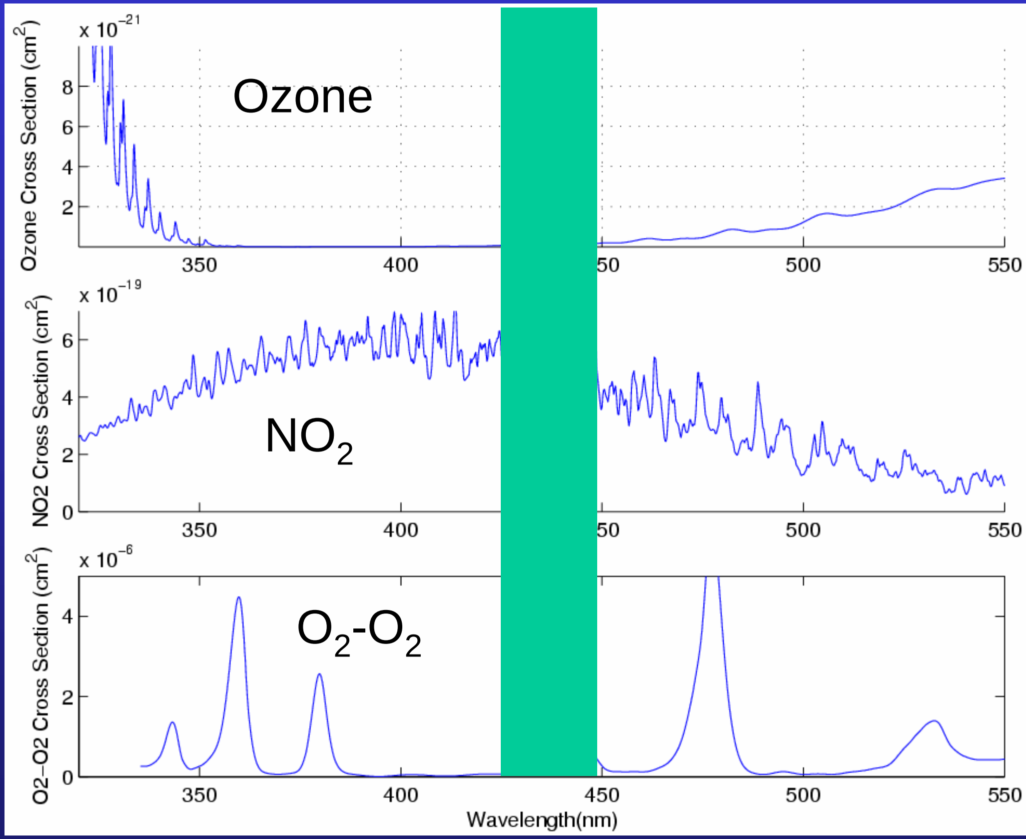
Spectral Fit of NO_2



Distinct NO_2 Spectrum



Nonlinear least-squares fitting

$$I_B(\lambda) = A(\lambda) I_0(\lambda) e^{-\sum \tau_s} + Ring$$

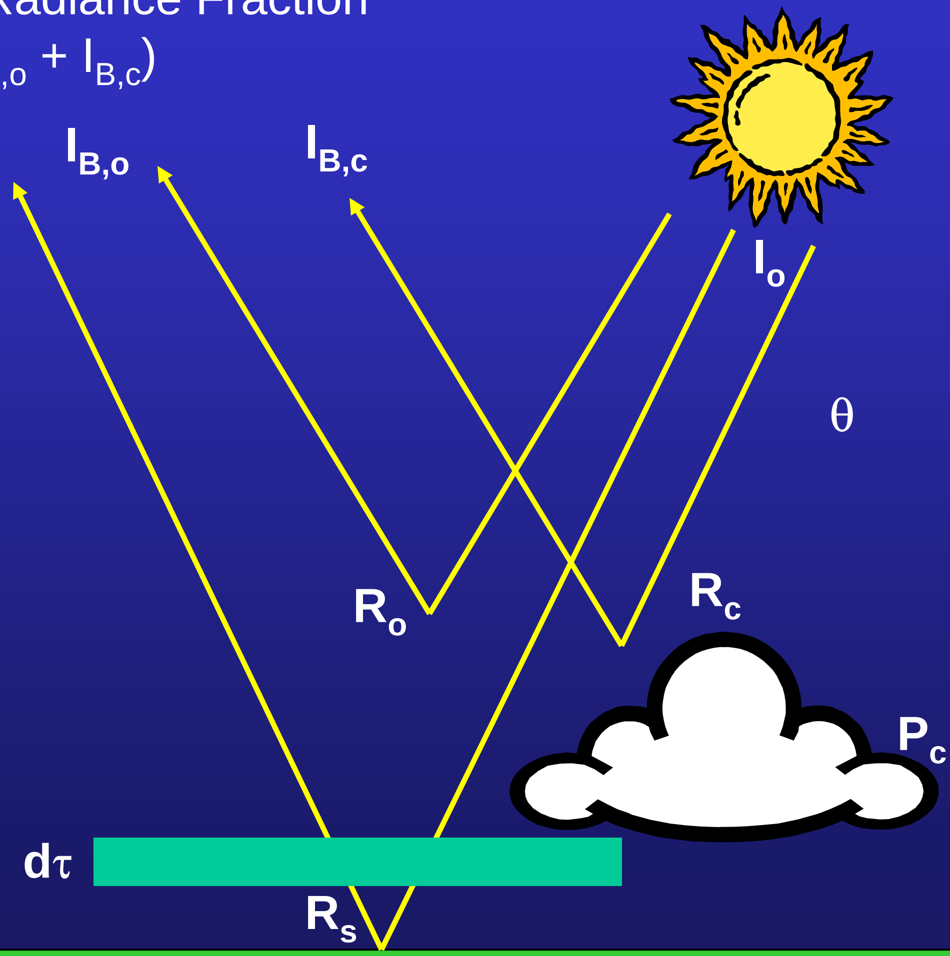
Also Weak H_2O line

Based on Martin et al., 2002

Perform a Radiative Transfer Calculation to Account for Viewing Geometry and Scattering

Cloud Radiance Fraction

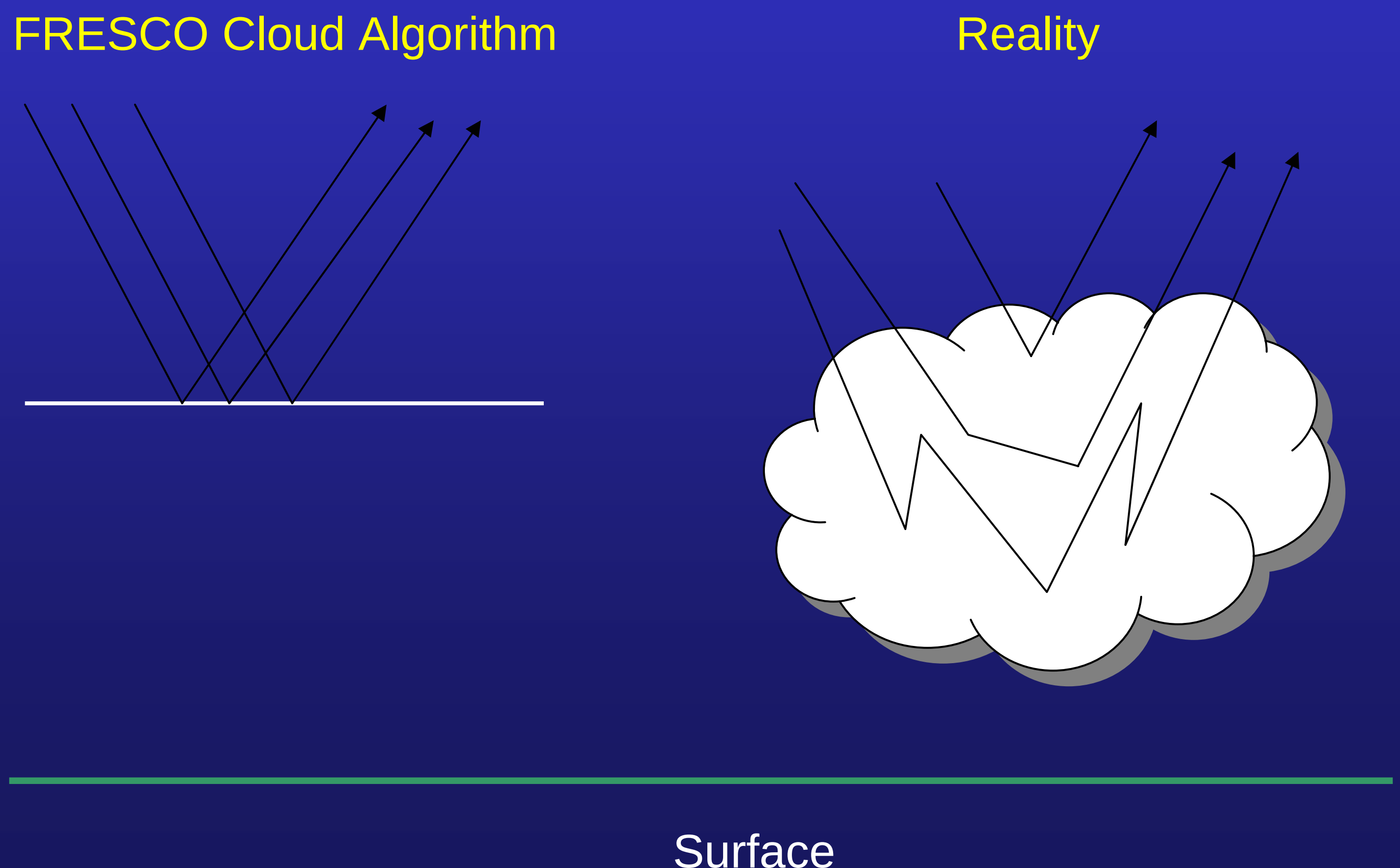
$I_{B,c} / (I_{B,o} + I_{B,c})$



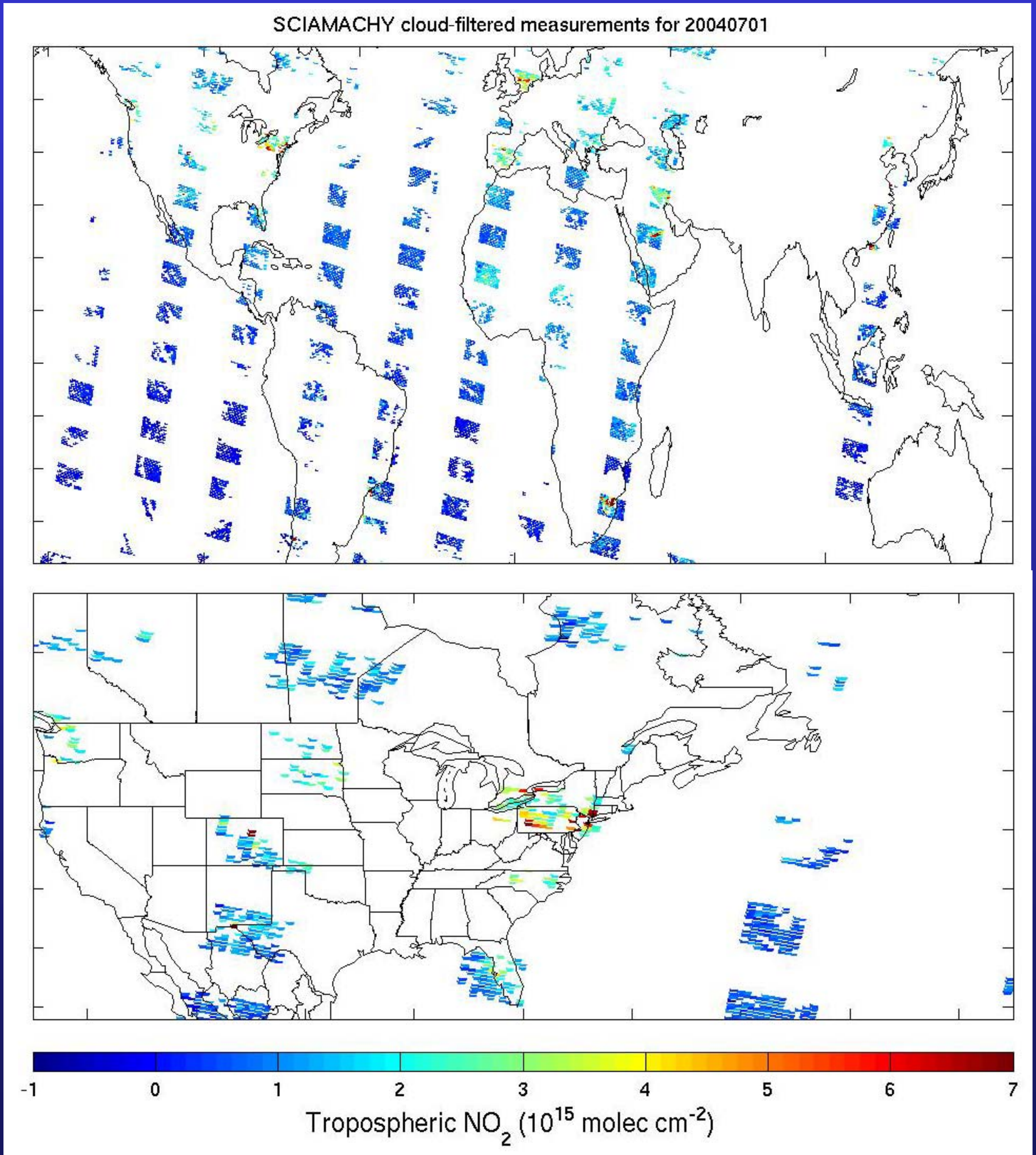
- FRESCO Clouds Fields [Koelemeijer et al., 2002]
- Surface Reflectivity [Koelemeijer et al., 2003]
- LIDORT Radiative Transfer Model [Spurr et al., 2002]
- GEOS-CHEM NO_2 & aerosol profiles

Based on Martin et al., 2002, 2003

Data Provided for all Cloud Fractions However
Use of High Cloud Fraction Data Is Discouraged!
Cloud Radiance Fraction <0.4 Recommended in Header



Sample JPGs Provided For Each Day



Missing Data:

Cloudy

Missing Cloud Fields

Satellite Downlink Issues

Typical Individual Measurement Uncertainty

$\pm(1 \times 10^{15}$ molec cm^{-2} + 40%)

Spectral Fit

Stratospheric NO_2

Surface Reflectance

Clouds

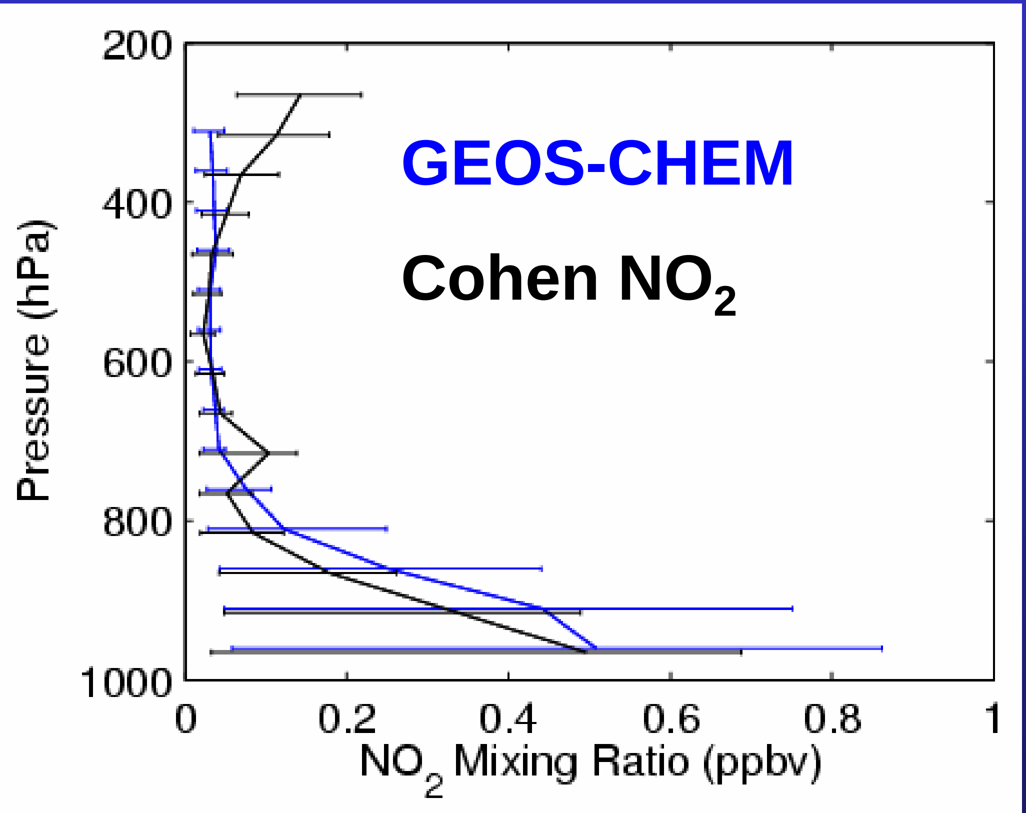
Aerosols

Assumed NO_2 Profile

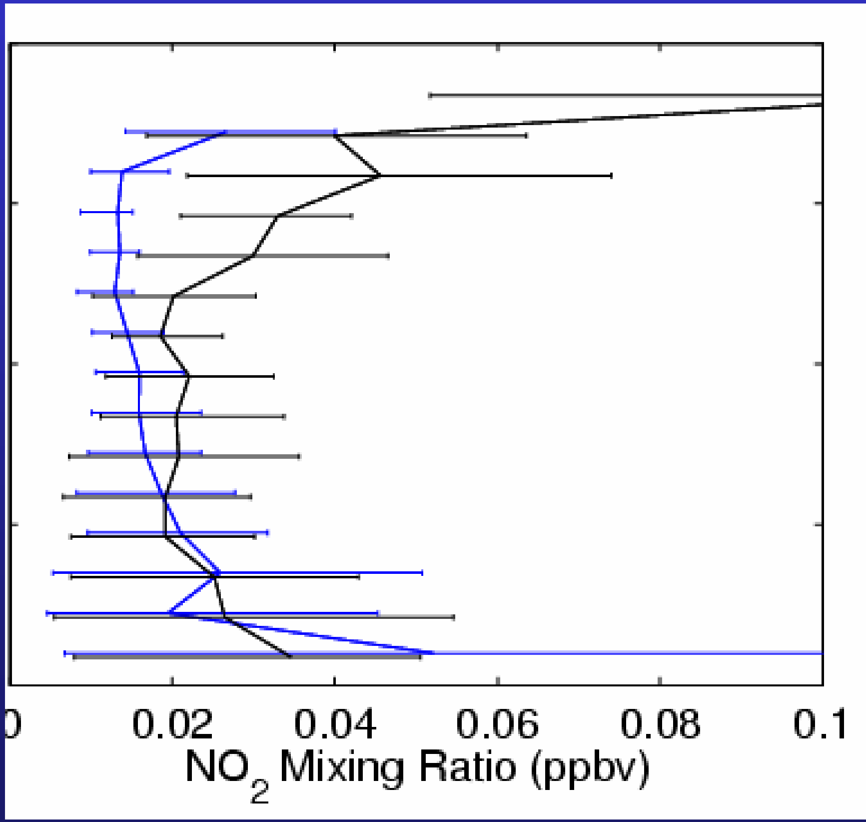
Preliminary Comparison Between Average Assumed and Measured NO_2 Profiles

Need to Continue Analysis for Individual Flights

West of -60 degrees lon, “land”



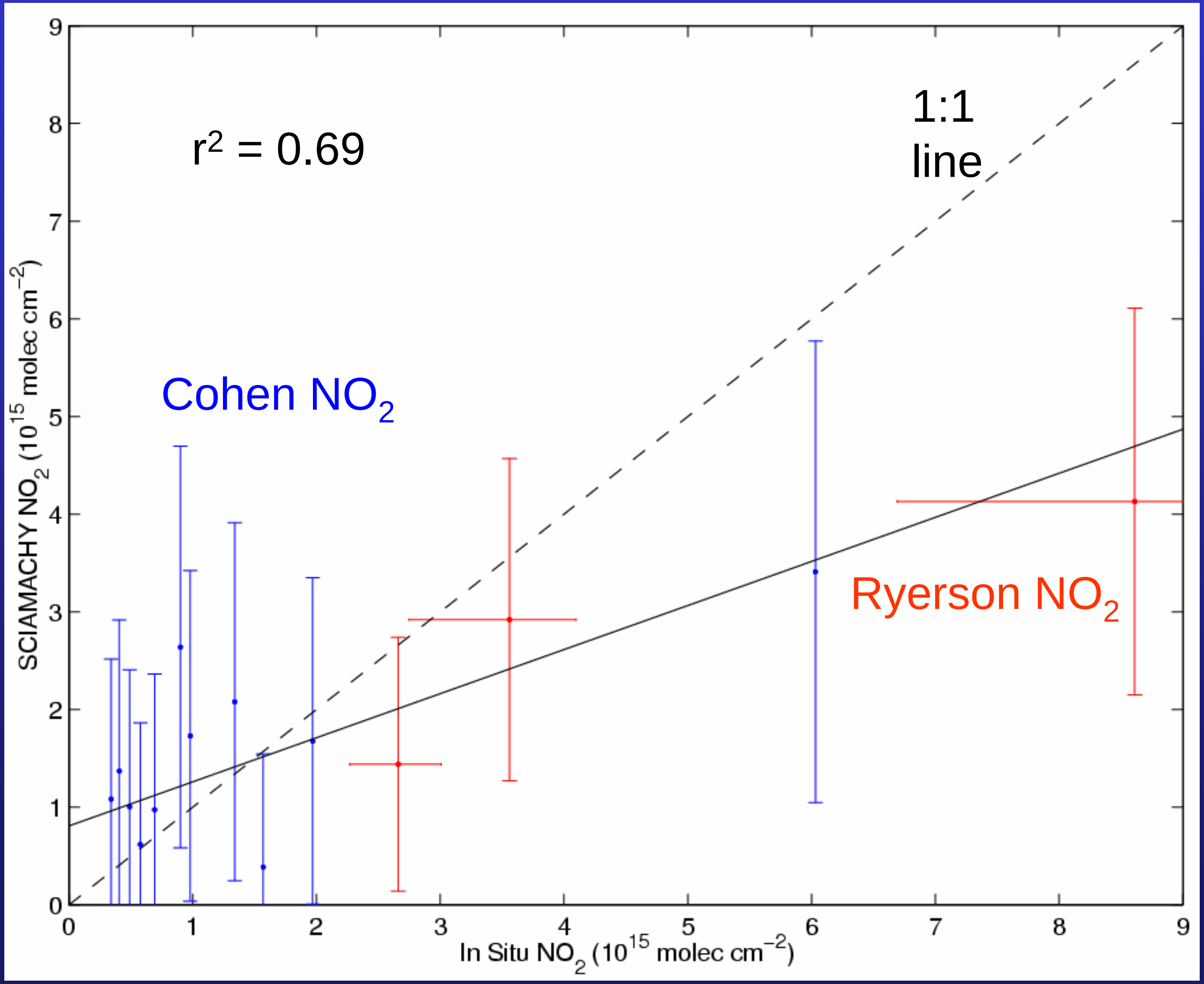
East of -60 degrees lon, “ocean”



Errorbars Show 17th and 83rd percentiles

Reasonable Agreement Between Coincident SCIAMACHY and In-Situ Cloud-Free Measurements

Difficult Comparison over Source Regions Due to Ambiguous Column Below Aircraft and Spatial Heterogeneity



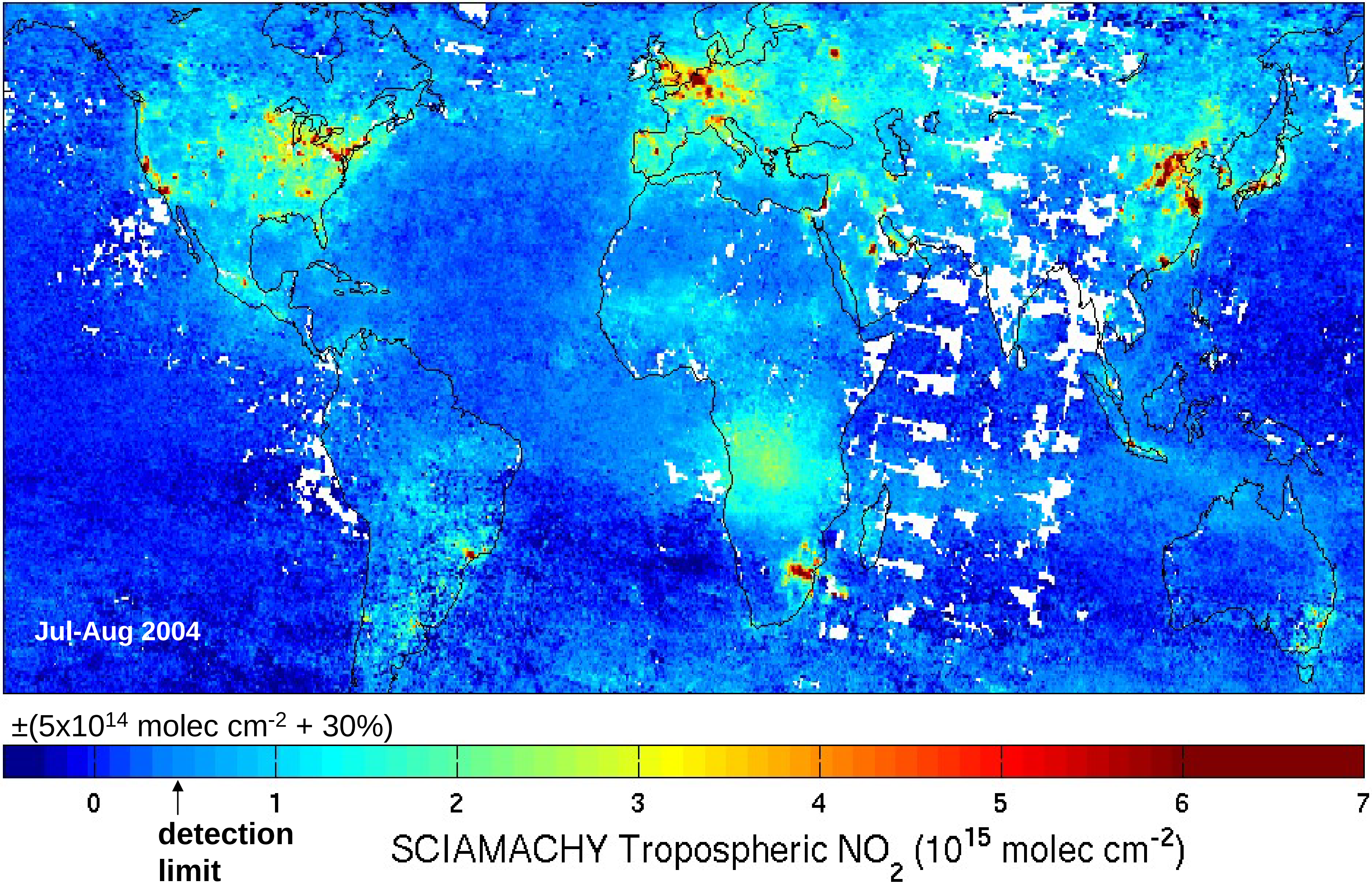
- Coincident measurements
- Cloud-radiance fraction < 0.4
- In-situ measurements below 1 km

Assume constant mixing ratio below lowest measurement

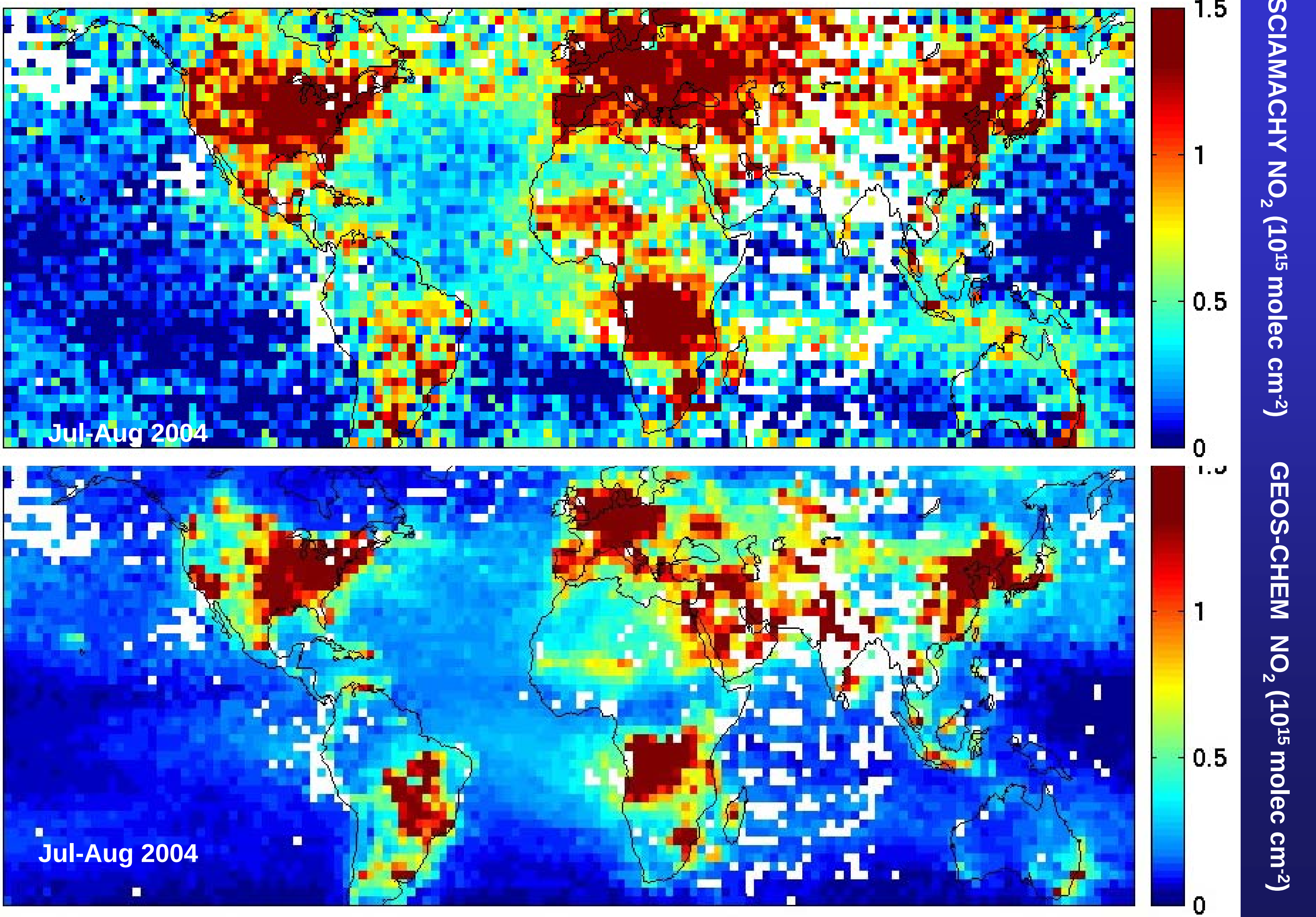
Chris Sioris

In situ errorbars show 17th & 83rd percentiles – not completed for DC8

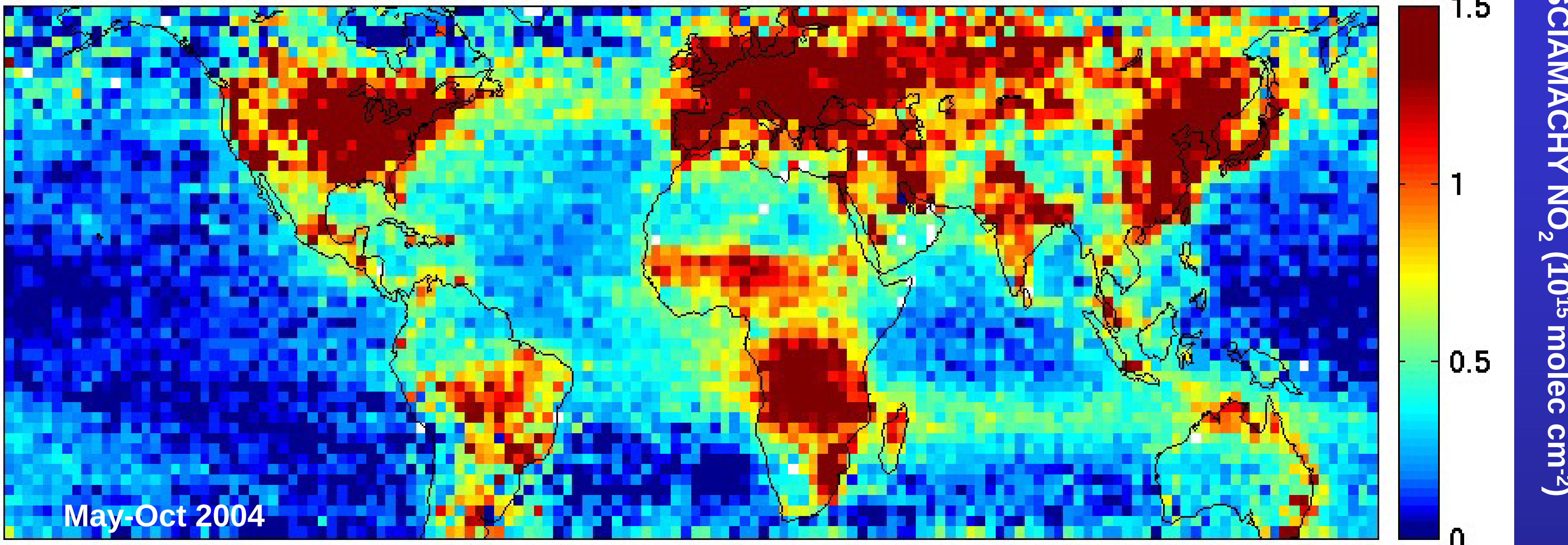
Cloud-filtered Tropospheric NO_2 Columns Observed from the SCIAMACHY Satellite Instrument

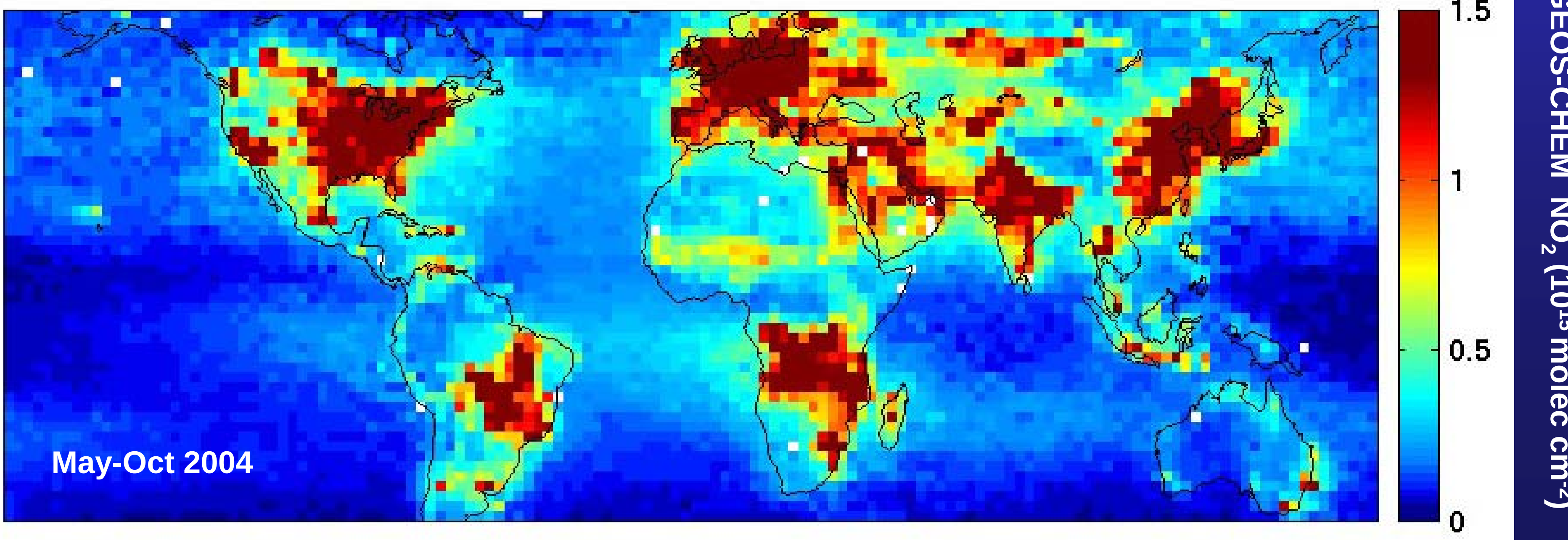


SCIAMACHY Shows Elevated NOx Export from North America



SCIAMACHY Shows Elevated NOx Export from North America

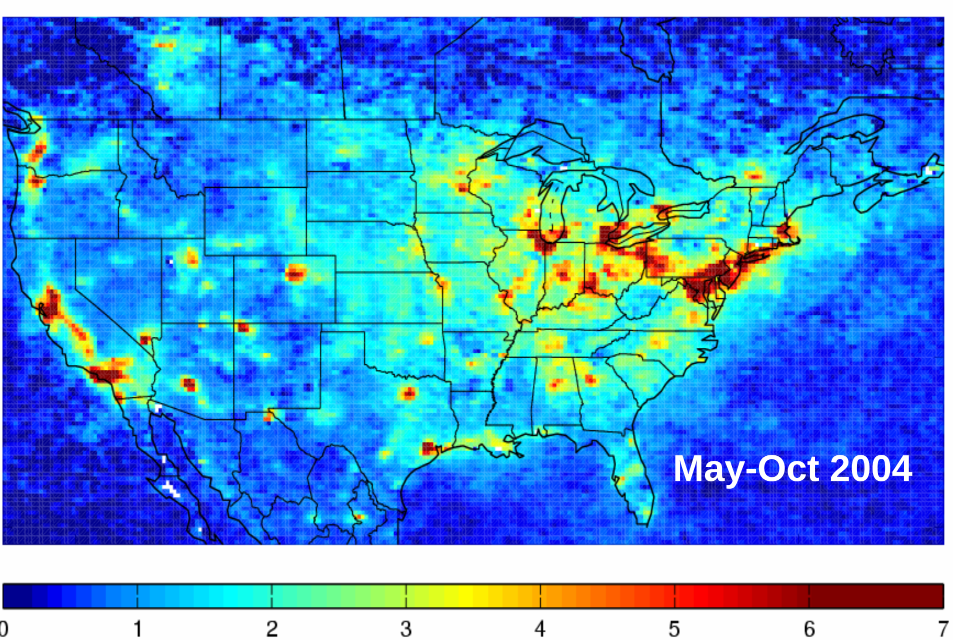




EMIS: Emissions Mapping Integration Science

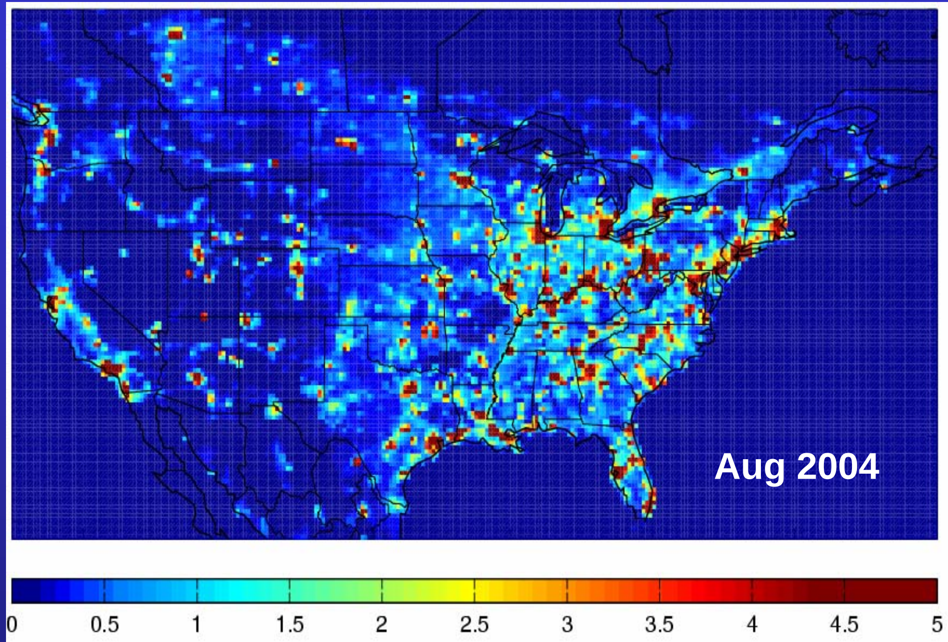
Optimize North American NO_x Emissions

SCIAMACHY NO_2 Columns



10^{15} molecules cm^{-2}

NOx Emissions (SMOKE/G.Tech)



10^{11} molec N cm^{-2} s^{-1}

Models-3 | GEOS-CHEM

Top-Down Emissions

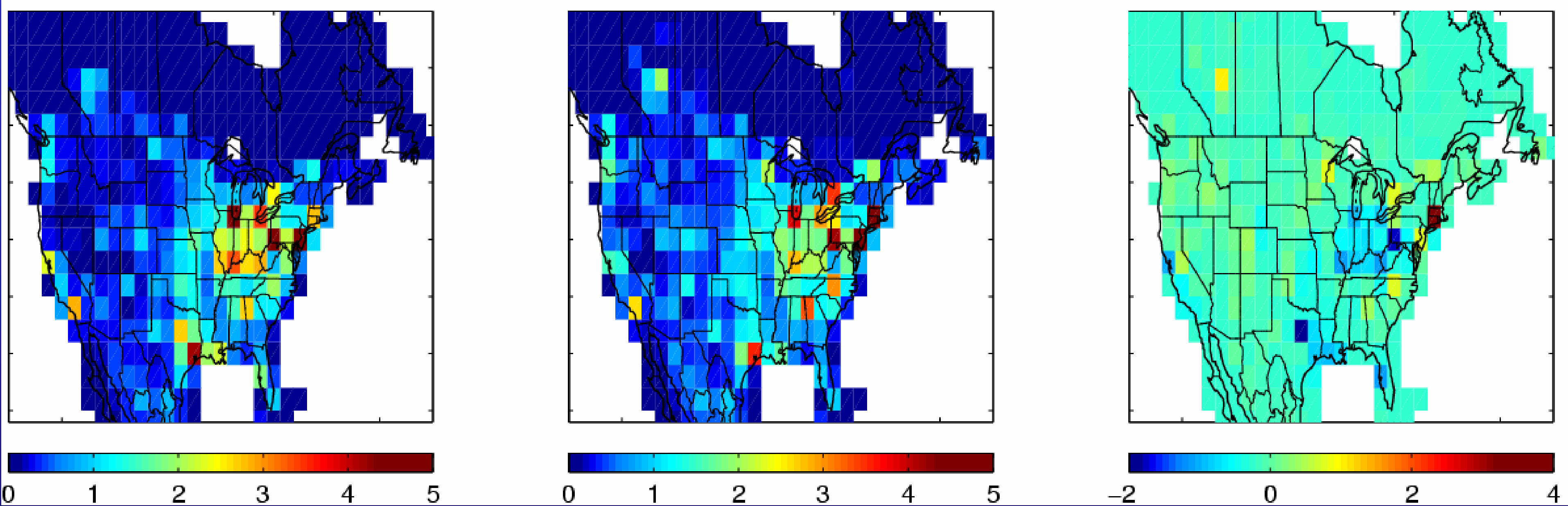
Error weighting

A posteriori emissions

North American NOx Emissions (May – October)
Largest Change in Northeastern US Coast

GEOS-CHEM

(NAPAP Scaled to 1998) | SCIAMACHY (2004) | SCIAMACHY - NAPAP



10^{11} atoms N cm^{-2} s^{-1} | 10^{11} atoms N cm^{-2} s^{-1} | 10^{11} atoms N cm^{-2} s^{-1}

$r^2 = 0.85$

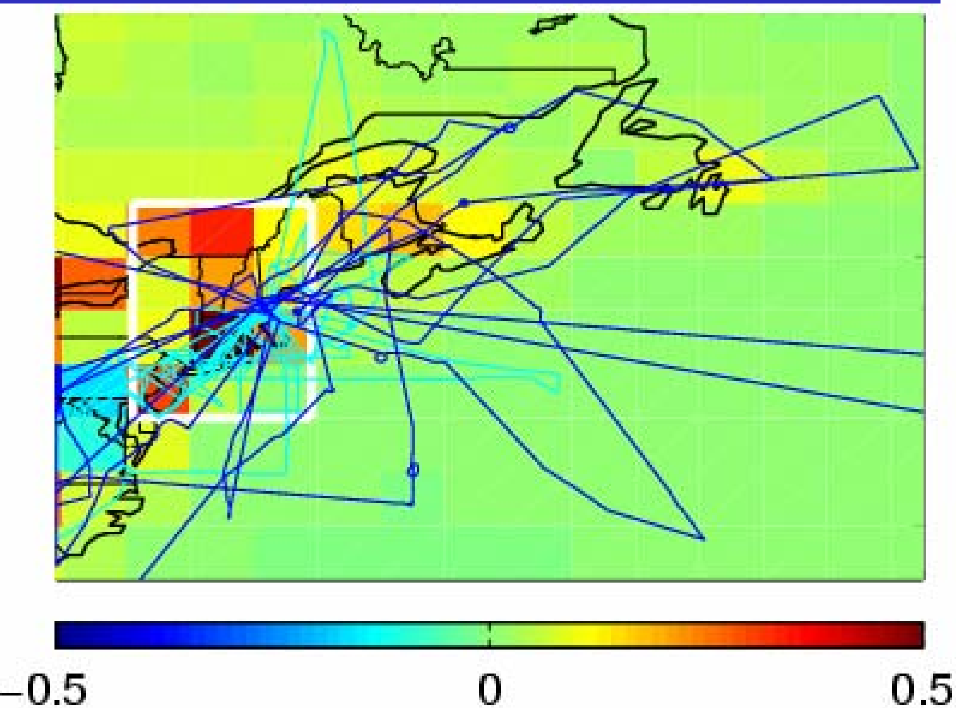
7.6 Tg N yr^{-1} | 8.4 Tg N yr^{-1} | 0.8 Tg N yr^{-1}

Evaluate Top-Down and Bottom-Up NOx Inventories

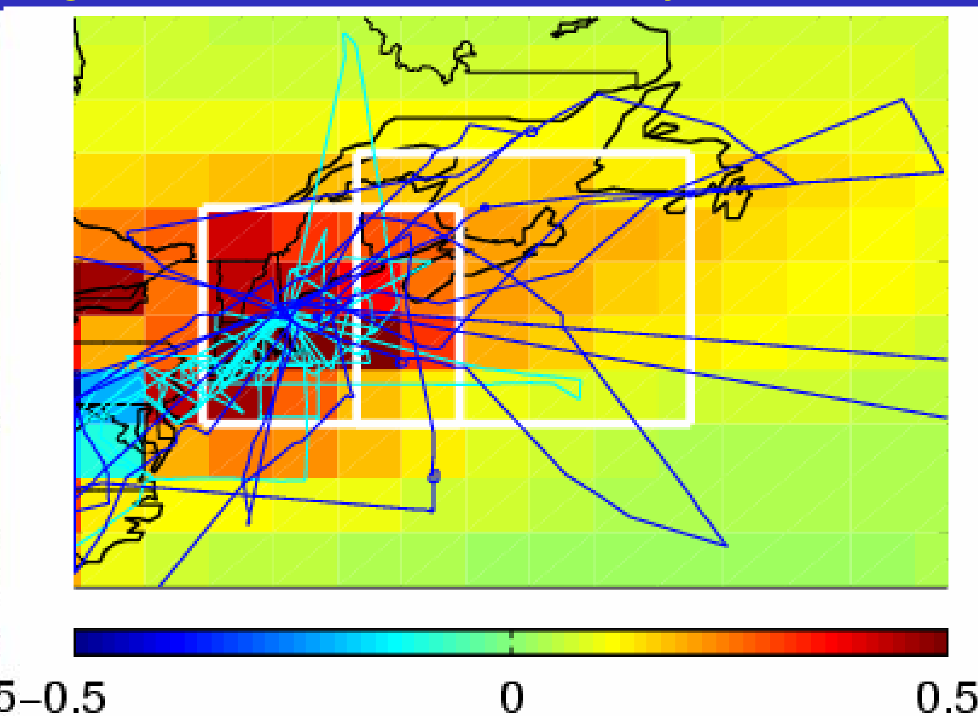
Conduct GEOS-CHEM Simulation For Each Inventory

Sampled GEOS-CHEM Along Flight Tracks

Simulation with SCIAMACHY – Original NOx Emission Inventory

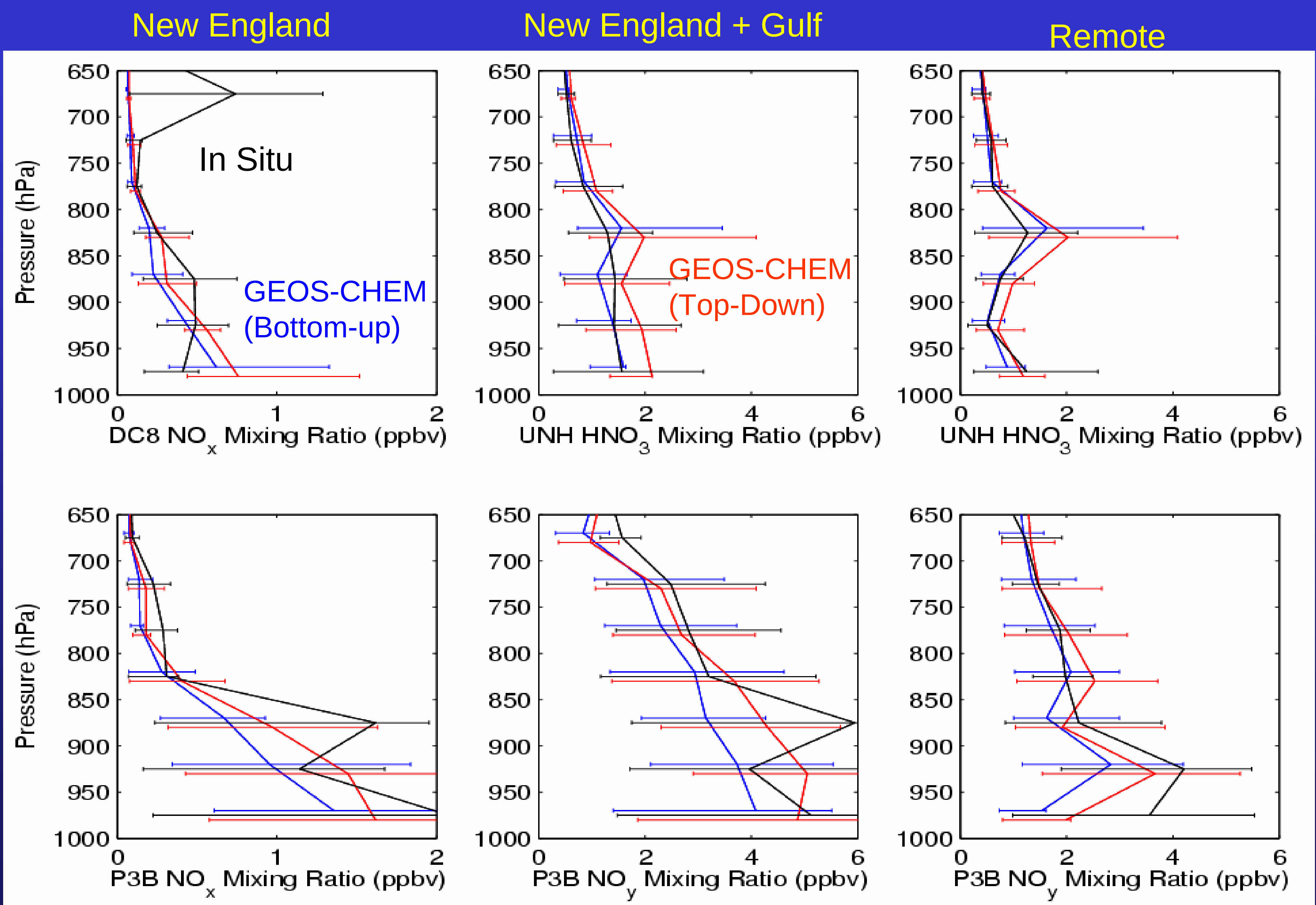


ΔNO_x (ppbv)

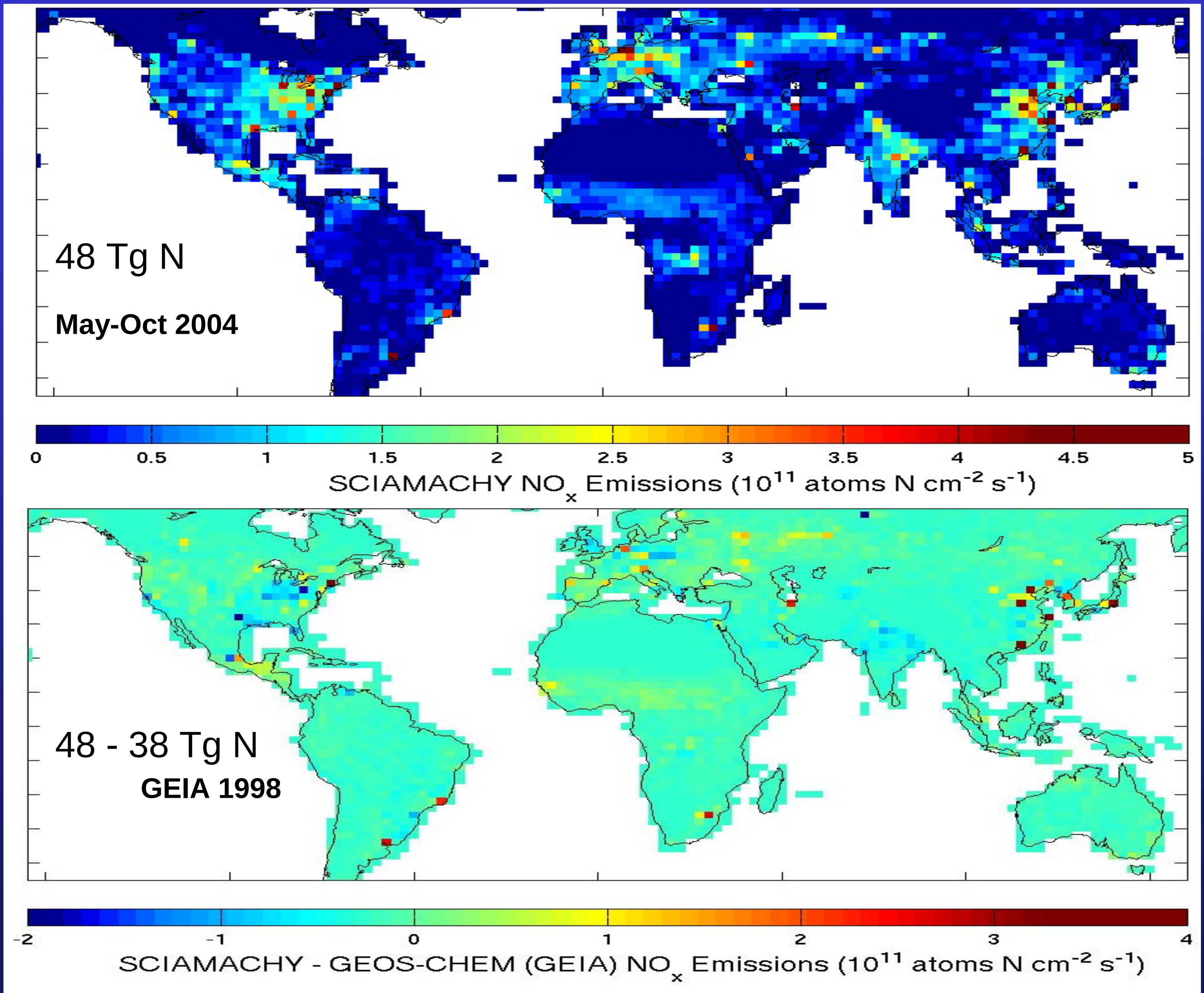


ΔHNO_3 (ppbv)

P3-B Measurements Support Top-Down Inventory
DC-8 Measurements Inconclusive



Major Discrepancy in NOx Emissions from Megacities



INTEX Workshop

Virginia, USA, March 29, 2005

Intercontinental Transport of NO_2

Observations from GOME and SCIAMACHY

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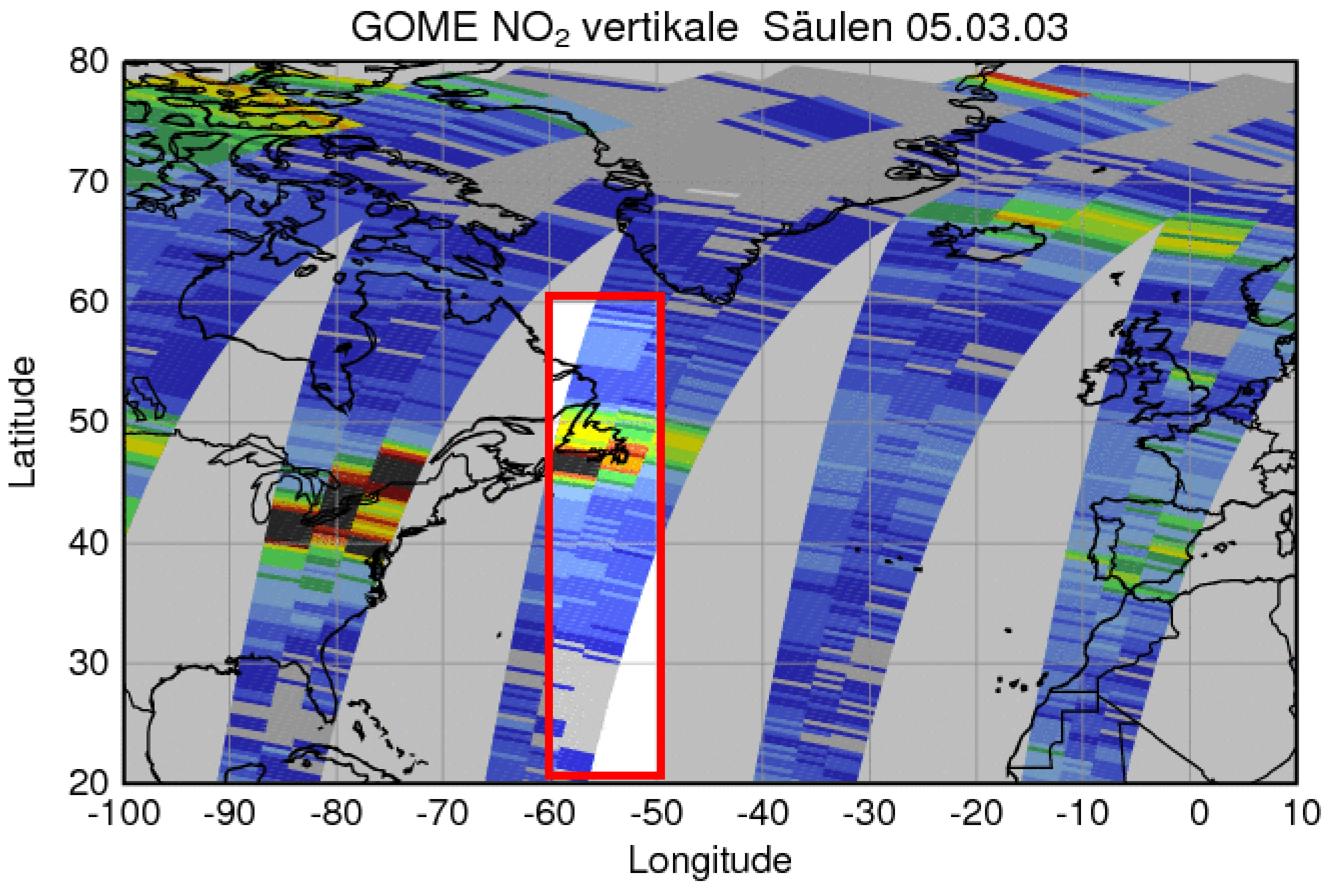
North American Export – Climatology

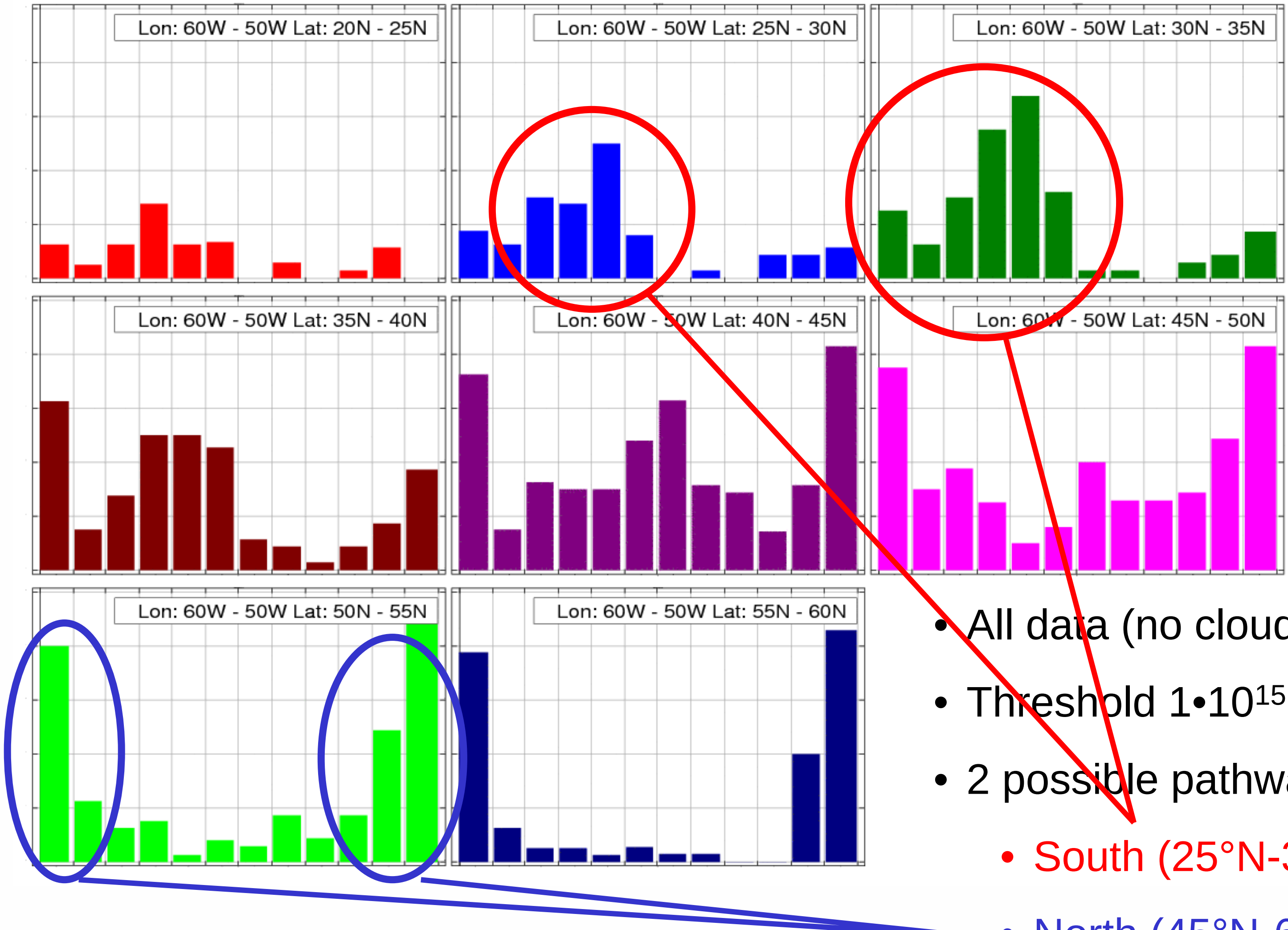
- **Aim:**
  - Identification of the typical export pathways in the satellite NO_2 data set
  - Quantification of the export amount and range
  - Impact on European air quality?
- **Approach:**
  - Using the 10 year GOME and SCIAMACHY time series
  - Detection of outflow events by applying thresholds to the NO_2 tropospheric columns over North Atlantic
  - Counting all events between 01.Jan 1996 and 01.Jul 2003
  - Selection for cloudy / clear scenes
  - Backwards trajectory analysis for selected cases
- **Limitations / Problems:**
  - Short lifetime of NO_2 => only “fast” events can be observed
  - Air Mass Factors do not yet account actual profile shape and clouds
  - Separation of transport and lightning NO_2 ?

Approach



- Longitudinal section between 60°W and 50°W
- Divided into boxes of 5° latitude from 20°N to 60°N
- Columns larger than $1 \cdot 10^{15}$ molec/cm^2
- Area of enhanced values larger than $1 \cdot 10^5$ km^2

First results - Histograms



- All data (no cloud screening)
- Threshold $1 \cdot 10^{15}$ molec/cm^2
- 2 possible pathways:
  - South (25°N-35°N) in spring
  - North (45°N-60°N) in winter

Acknowledgements

- NO_2 in situ data were provided by Ronald Cohen, University of California, Berkeley
- GOES and Meteosat IR imagery were provided by UNIDATA and Space Science and Engineering Center (SSEC), University of Wisconsin-Madison
- Owen Cooper from CIRES institute at University Colorado, Boulder
- Trajectories computed by NOAA HYSPLIT Web Interface
- SCIAMACHY lv0 and lv1 data were provided by ESA through DLR/DFD
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