Measurements of Tropospheric BrO, HCHO, and CHO-CHO from the Ozone Monitoring Instrument on EOS Aura

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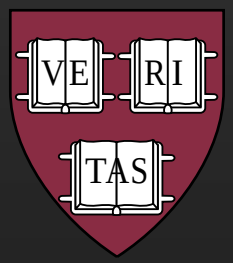

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Overview

- OMI instrument
- Retrieval algorithm
- Destriping of L2 data products
- Tropospheric BrO
  - Shelf-ice
  - Salt lakes
  - Volcanoes – a mystery?
- HCHO for 08/2005
- CHO-CHO for 08/2005 and 02/2006

OMI - the instrument

- Dutch (KNMI) / Finnish (FMI) / US (NASA GSFC) collaboration;
  PI: Pieternel Levelt (KNMI)
- On EOS Aura: sun-synchronous, 1330h equator crossing time, ascending node
- Nadir-viewing CCD spectrometer, 270-500 nm spectral range (divided into three channels); 0.42-0.63 nm spectral resolution
- Daily Global Coverage
- 60 across-track pixels (no scanning), 2,600 km total swath width
- Ground pixel size 15×30 km^2 at nadir, 42×162 km^2 at edges
  (exact/approximate sizes currently under discussion)

SAO role in OMI:

- Kelly Chance (lead), Thomas Kurosu (algorithm development)
- BrO, HCHO, OClO (standard operational data products)
- CHO-CHO (off-line research product)

Retrieval algorithm

- GOME heritage
- Based on non-linear least-squares, direct fitting
- Direct fitting:

  $I = (I_0\, e^{-Absorbers} + \text{Raman} + \text{Raman}) * Pol_1 + Pol_2$

  I_0: solar spectrum or radiance spectrum

  (the latter for possible "soft calibration" for tropospheric targets)

- First performs solar and radiance wavelength calibration for optimum retrieval performance
- Proceeds by individually fitting all ground pixel radiances
- Both on-line and post-processing "destriping" measures

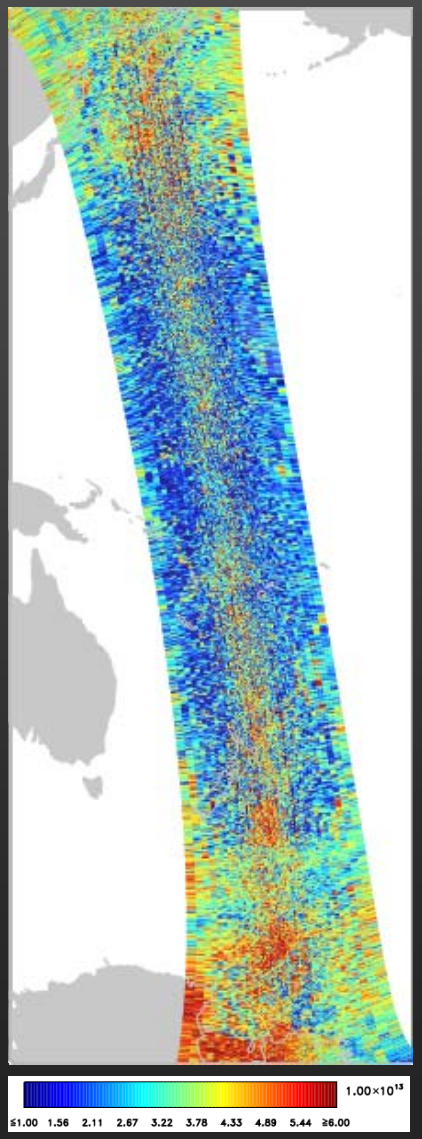
Destriping of L2 data products

OMI L1b data have residual errors from dark current correction, which leads to "stripes" in L2 products

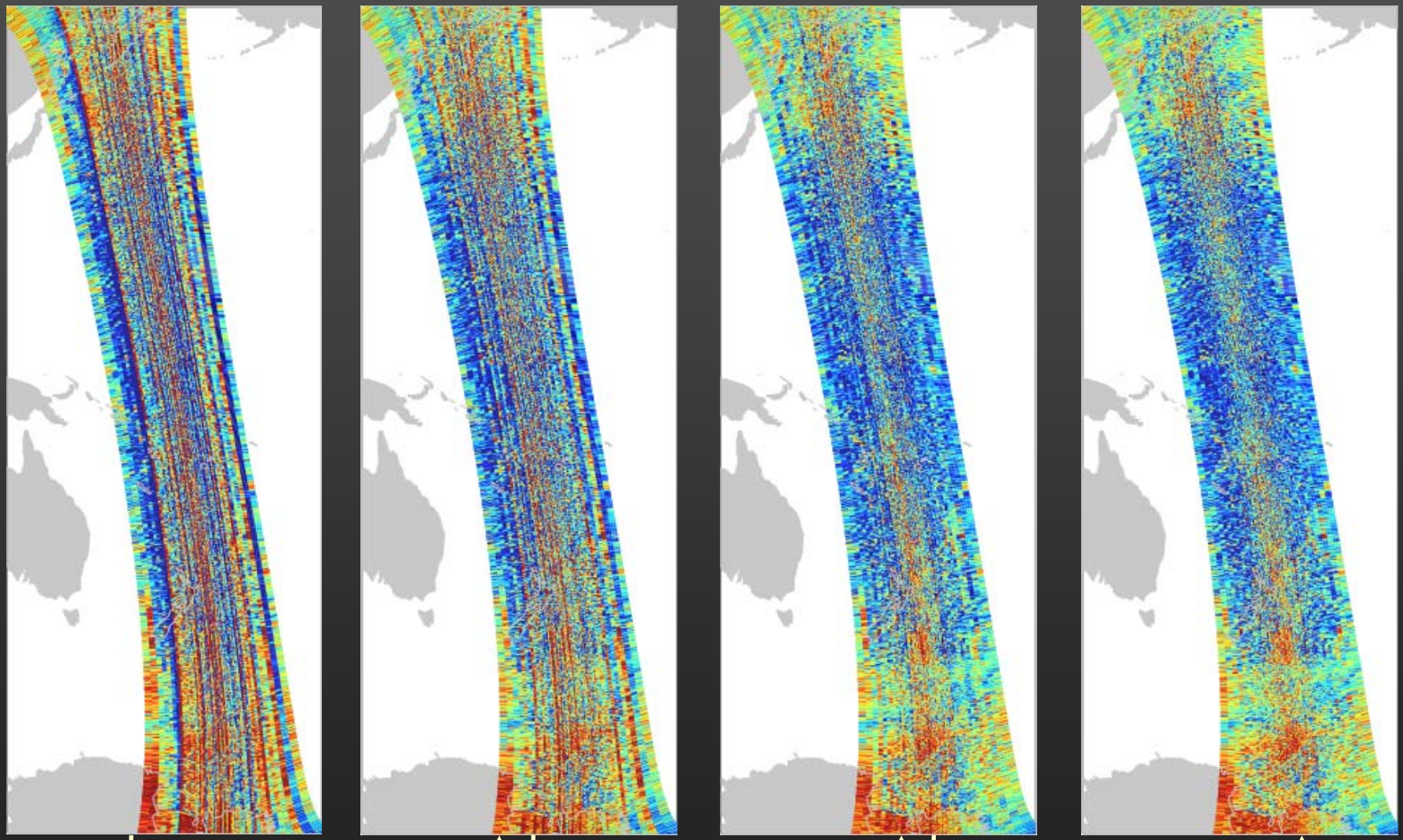
Destriping strategies:

- Use wider fitting window than for GOME - ☠AMF☠
  (on-line; fully implemented)
- Identify and exclude outliers in fitting residuals,
  e.g., $r(\lambda) \geq |r_{med} \pm 3\sigma|$
  (on-line; fully implemented)
- Use a composite solar spectrum instead of an individual measurement
  (on-line; implemented but still experimental)
- Determine cross-track stripe pattern in retrieved columns and remove from data
  (post-processing; fully implemented)

☺ L1b product with **OPF ≥ v25** (mid 10/2005 and later) shows significant improvements!

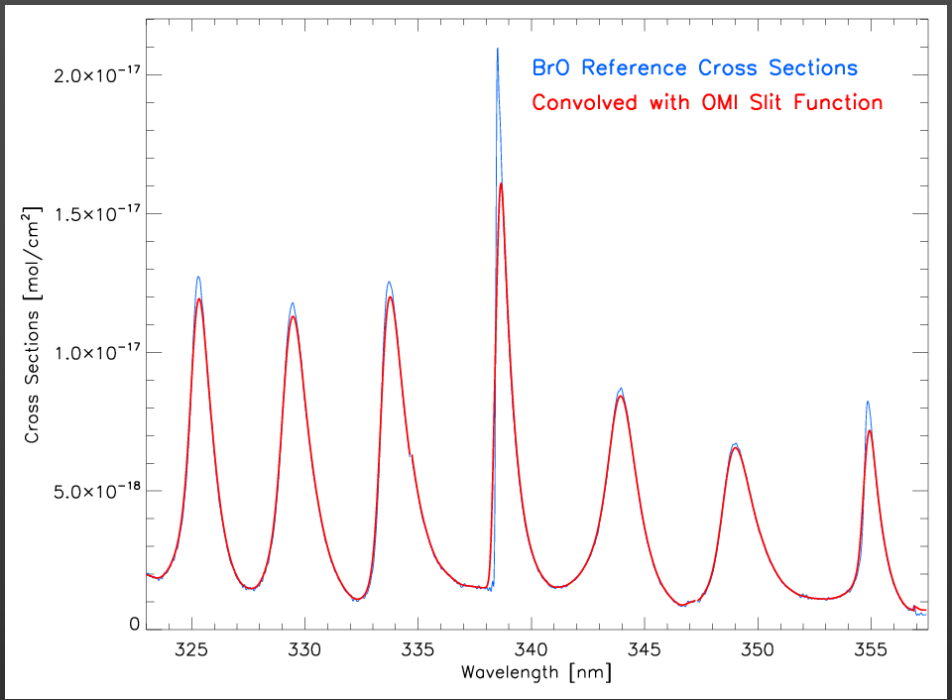


Destriping of L2 data products



BrO

- Bromine is an element in the destruction of stratospheric ozone, where the large abundance of BrO makes the catalytic Br+O_3 cycle 40-100 times more efficient than that of Chlorine
- Relatively uniform global distribution, with stratospheric minimum of 2-4×10^{13} mol/cm^2 at the equator
- Major tropospheric sources:
  Shelf Ice, Salt Lakes, Volcanoes



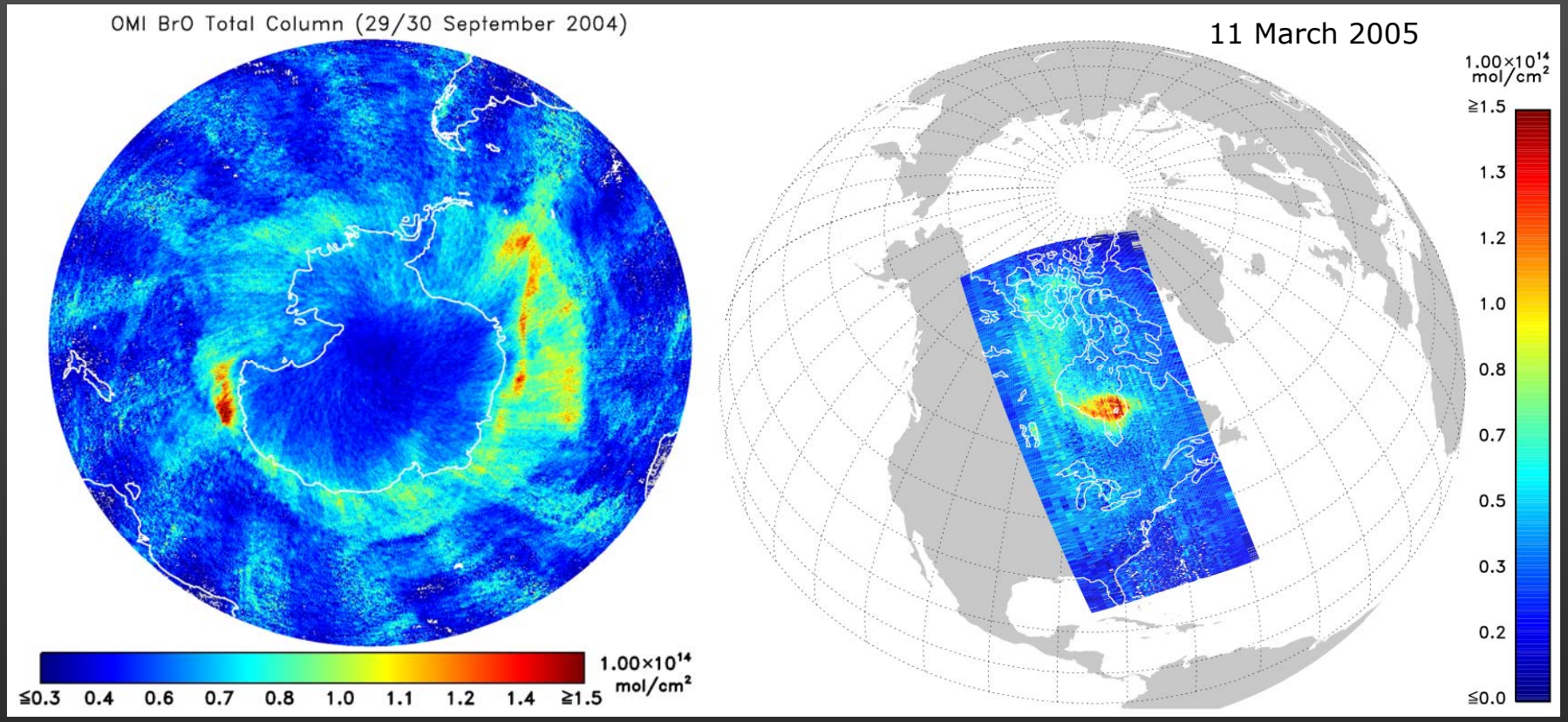
Fitting window: 323–357 nm (UV2 channel)

… and we have seen them all with OMI!

Fitting uncertainties:

5% (hot spots) to 50% (background); ~0.5-1.5×10^{13} mol/cm^2

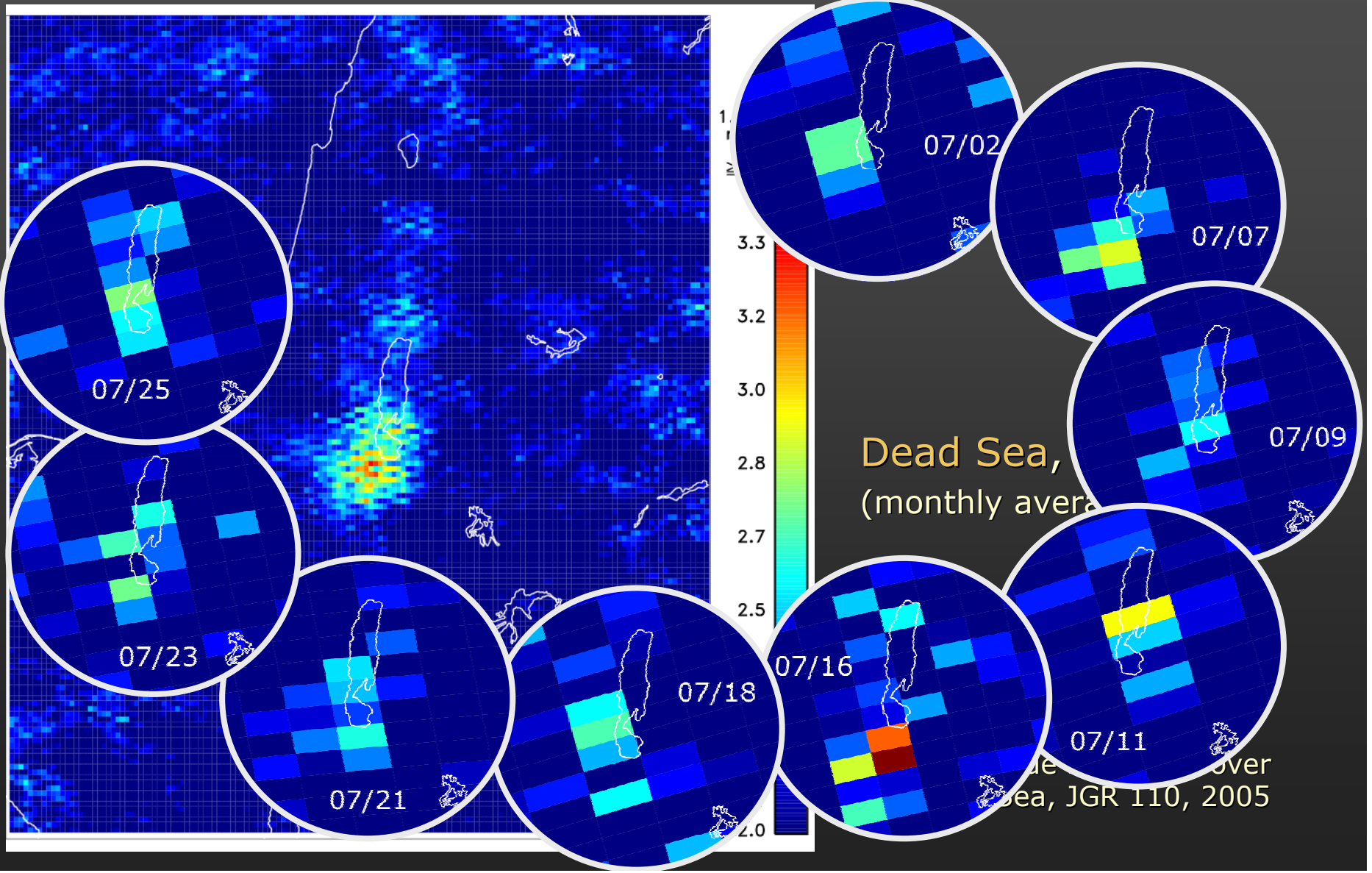
BrO Shelf ice



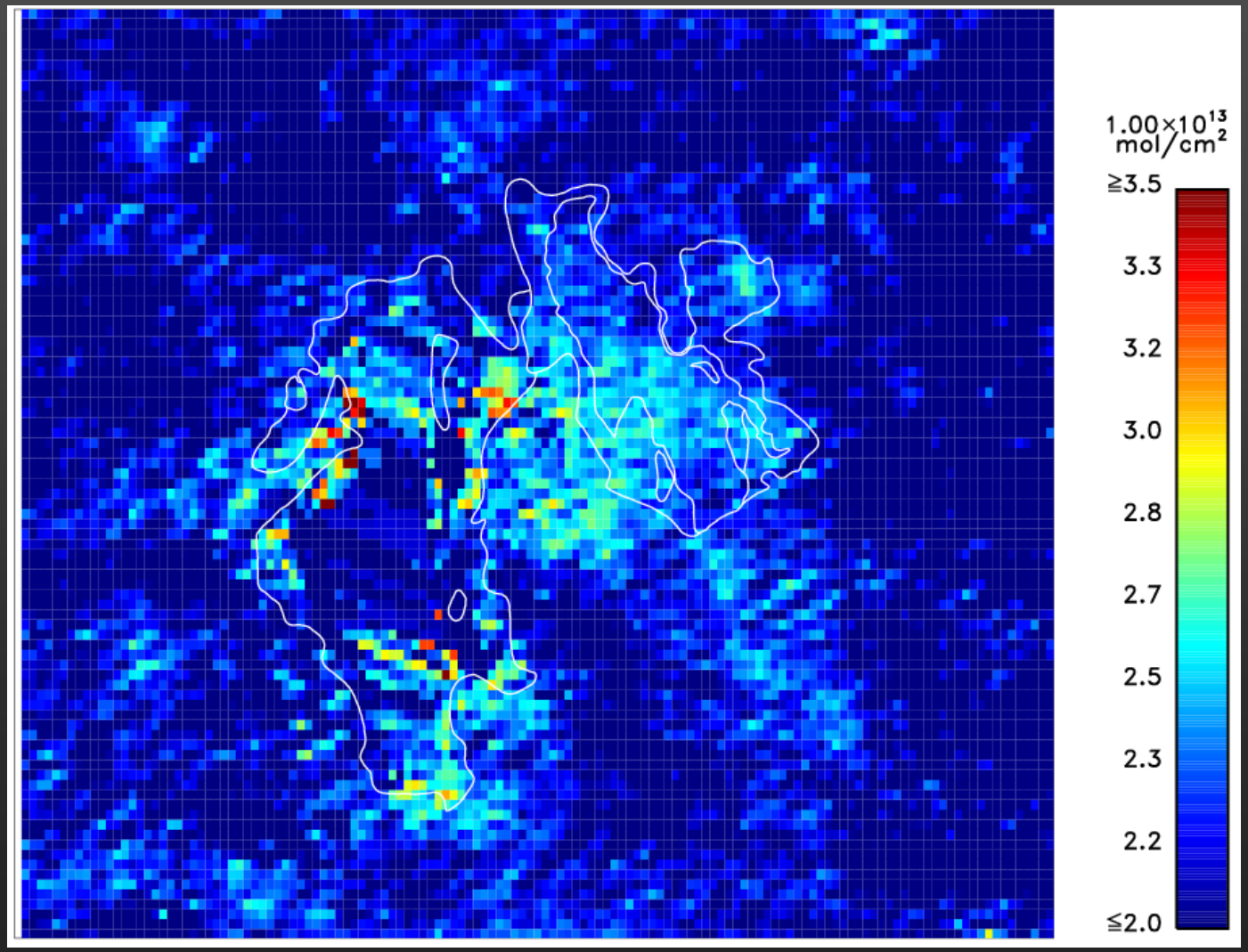
First observed from space by GOME

K. Chance, Analysis of BrO Measurements from the Global Ozone Monitoring Experiment, GRL 25, 1998

BrO Salt Lakes 1st Observation from Satellite



BrO Salt Lakes

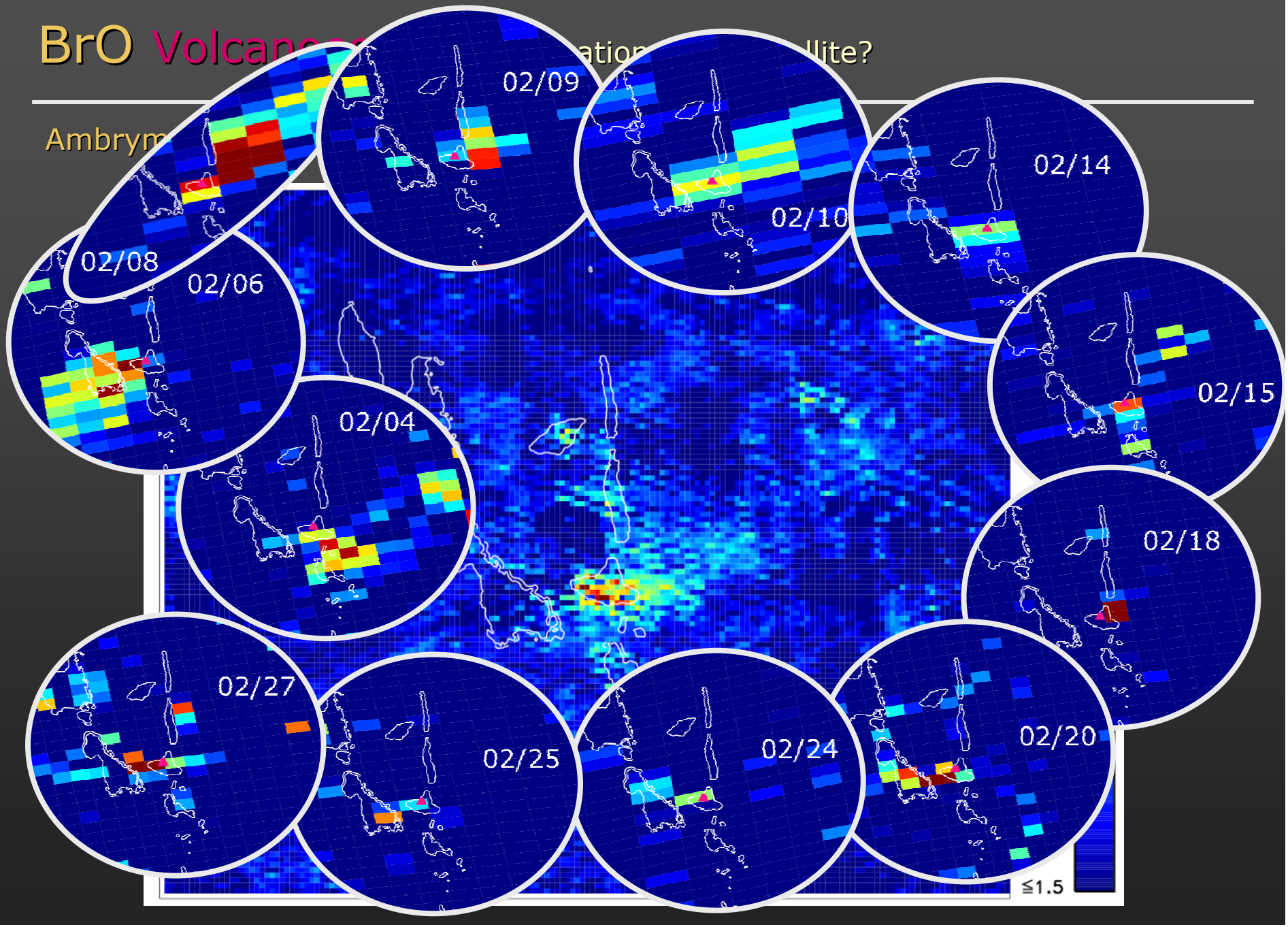


Salt Lake City, Utah (July 2005)

Bromine concentrations ~10-15 times smaller than over the Dead Sea

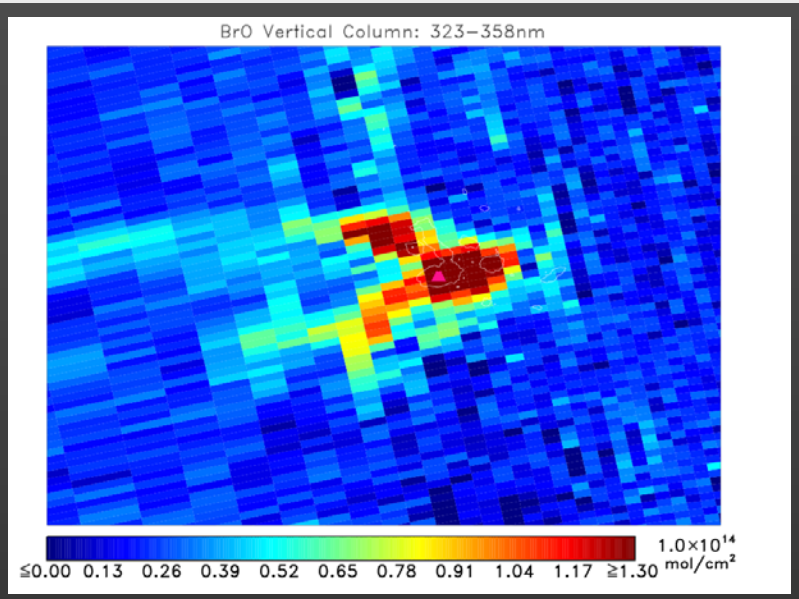
BrO Volcano ation llite?

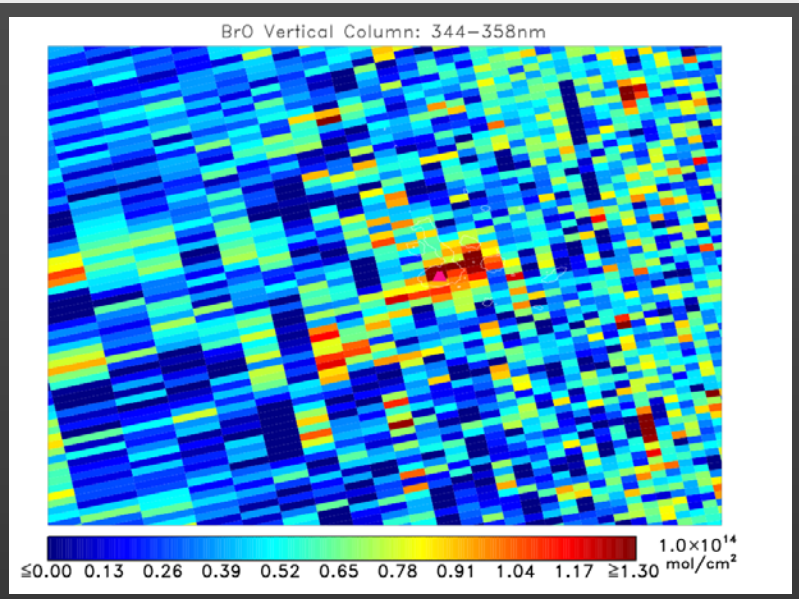
Ambrym



BrO Volcanoes ... a Mystery? Sierra Negra (Galapagos), 23 October 2005

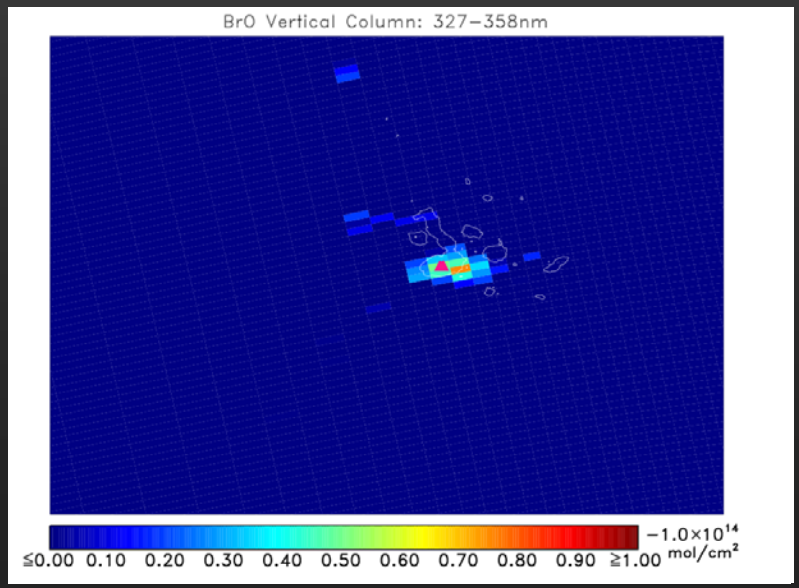
323 – 358 nm

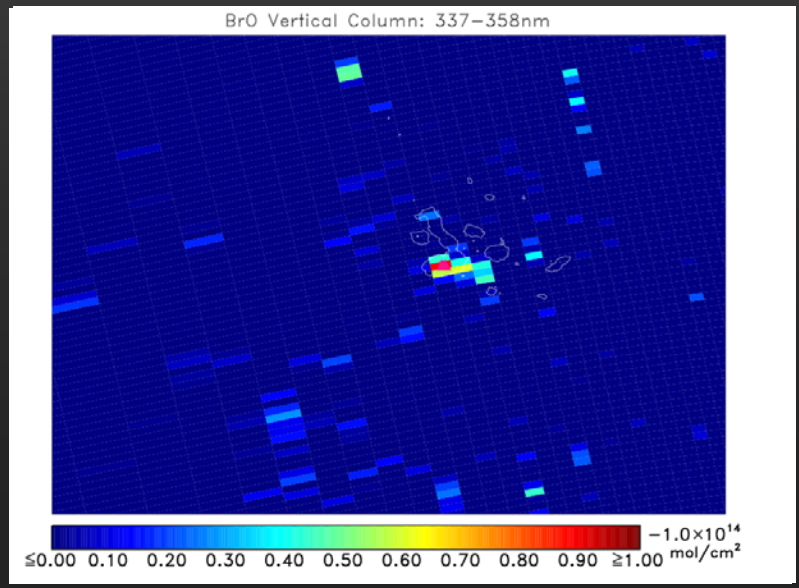




344 – 358 nm (GOME)

327 – 358 nm

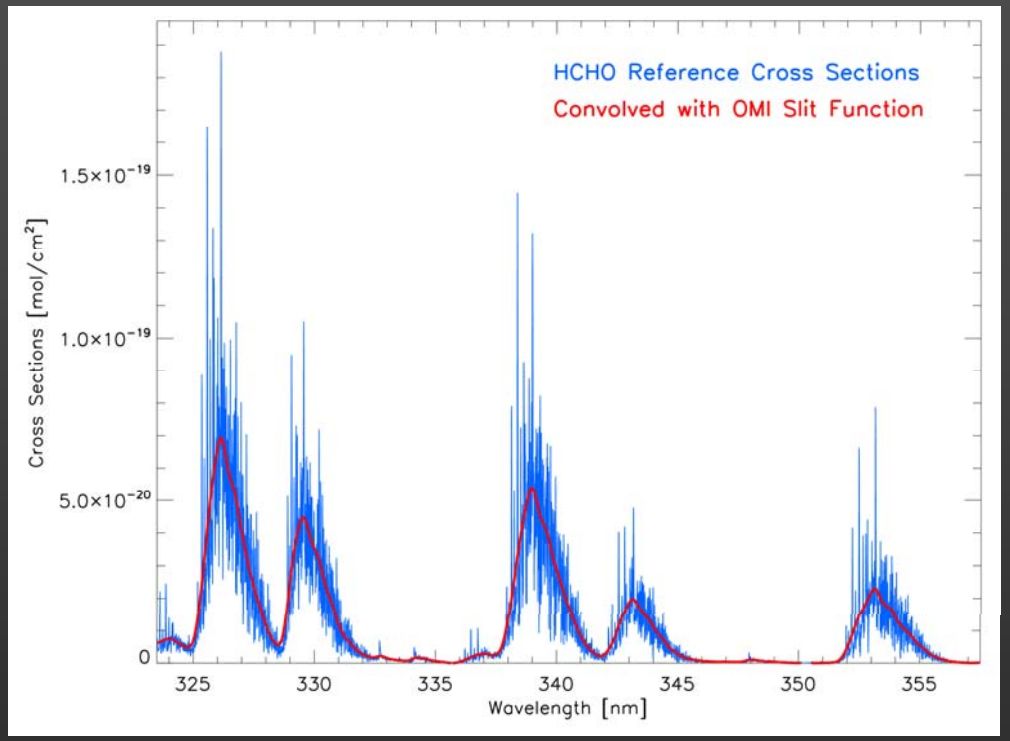




337 – 358 nm

HCHO

- Volatile Organic Compound
- Produced from Methane oxidation, isoprene emissions
- Indicator for Air Quality
- Average lifetime: ~4 hrs
- Main sinks: Photolysis, reaction with OH

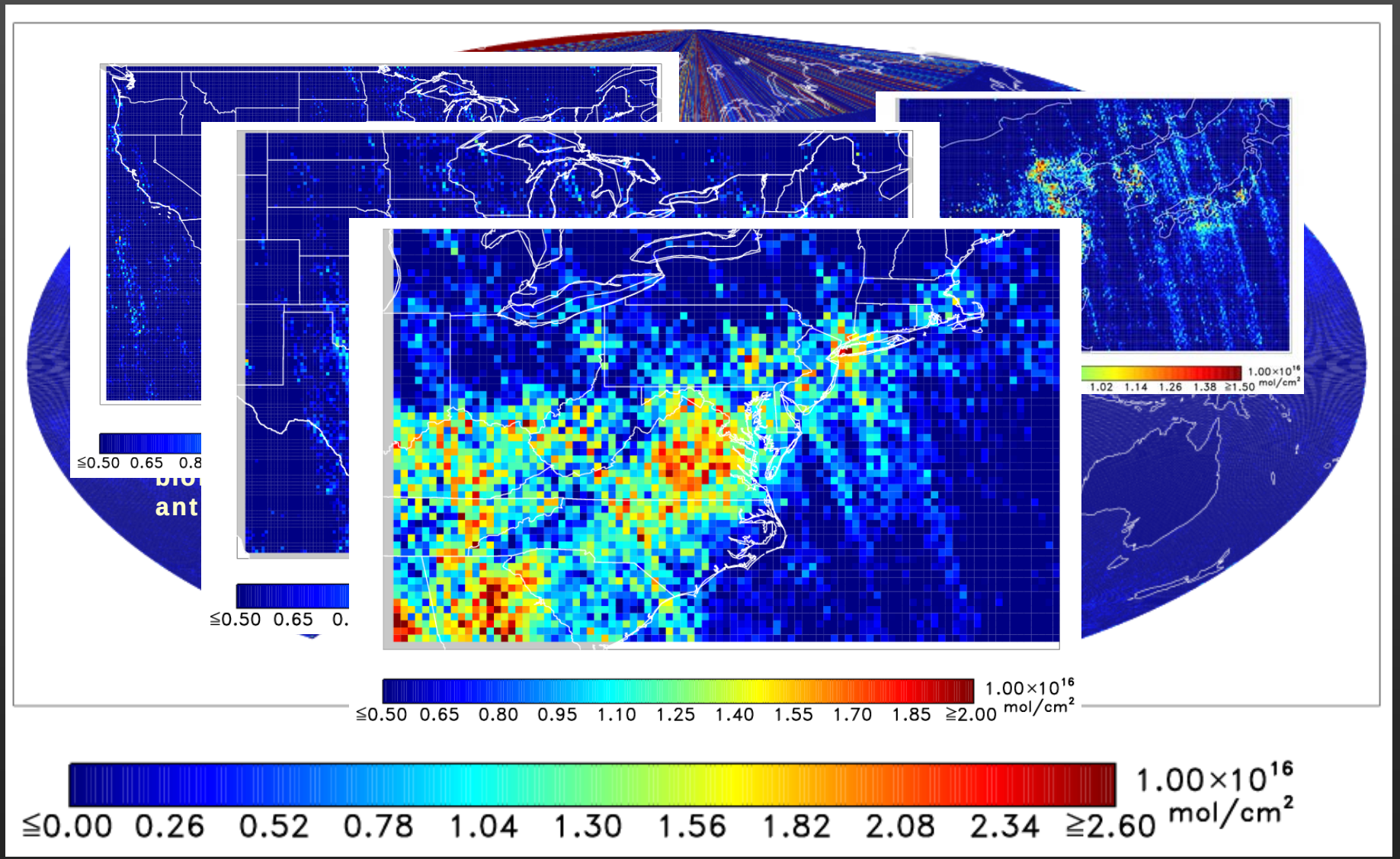


Fitting window: 324–357 nm (UV2 channel)

Success Story for GOME:
Large number of science studies in collaboration with the Harvard Modeling Group – Daniel Jacob, Dylan Millet; Paul Palmer (now Leeds, UK)

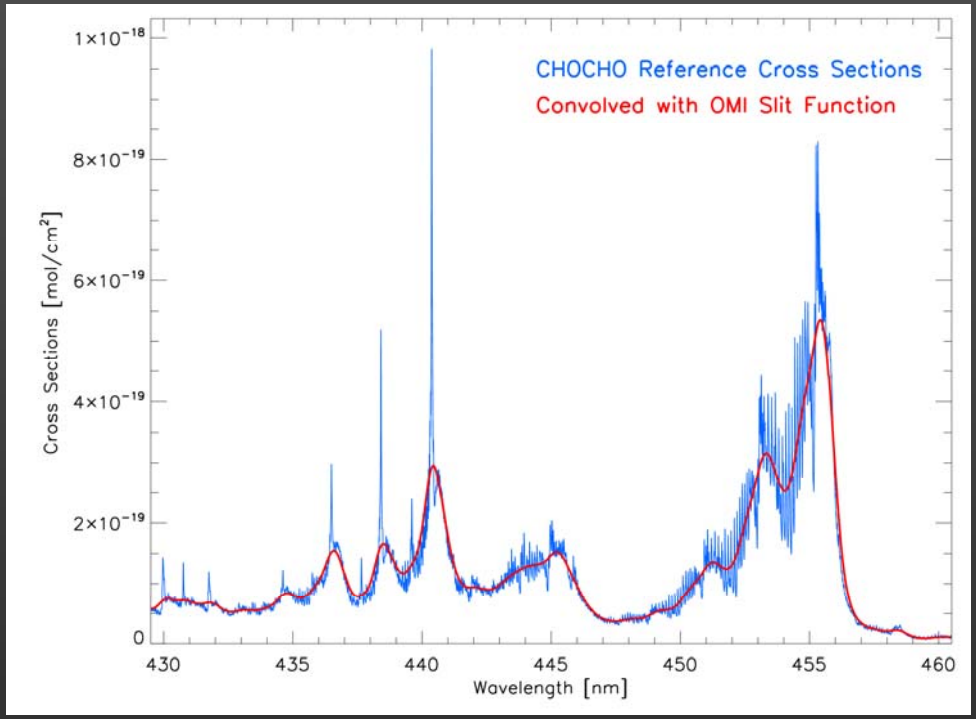
OMI monthly HCHO product has emerged, daily product is shaping up
Fitting Uncertainties: 50-100%

HCHO Global Monthly Average August 2005



CHO-CHO (glyoxal)

- Volatile Organic Compound recently observed in Mexico City (Volkamer et al., 2005); also MILARGO
- Produced from oxidation of a large number of other, mostly aromatic VOCs
- Unlike HCHO not directly affected by vehicle emission, hence a better indicator for VOC oxidation (photochem. smog)
- Average loading about 8% of NO_2: ~1.5×10^{15} mol/cm^2
- Average life-time: ~1.3 hrs
- Primary sinks: Photolysis, reaction with OH

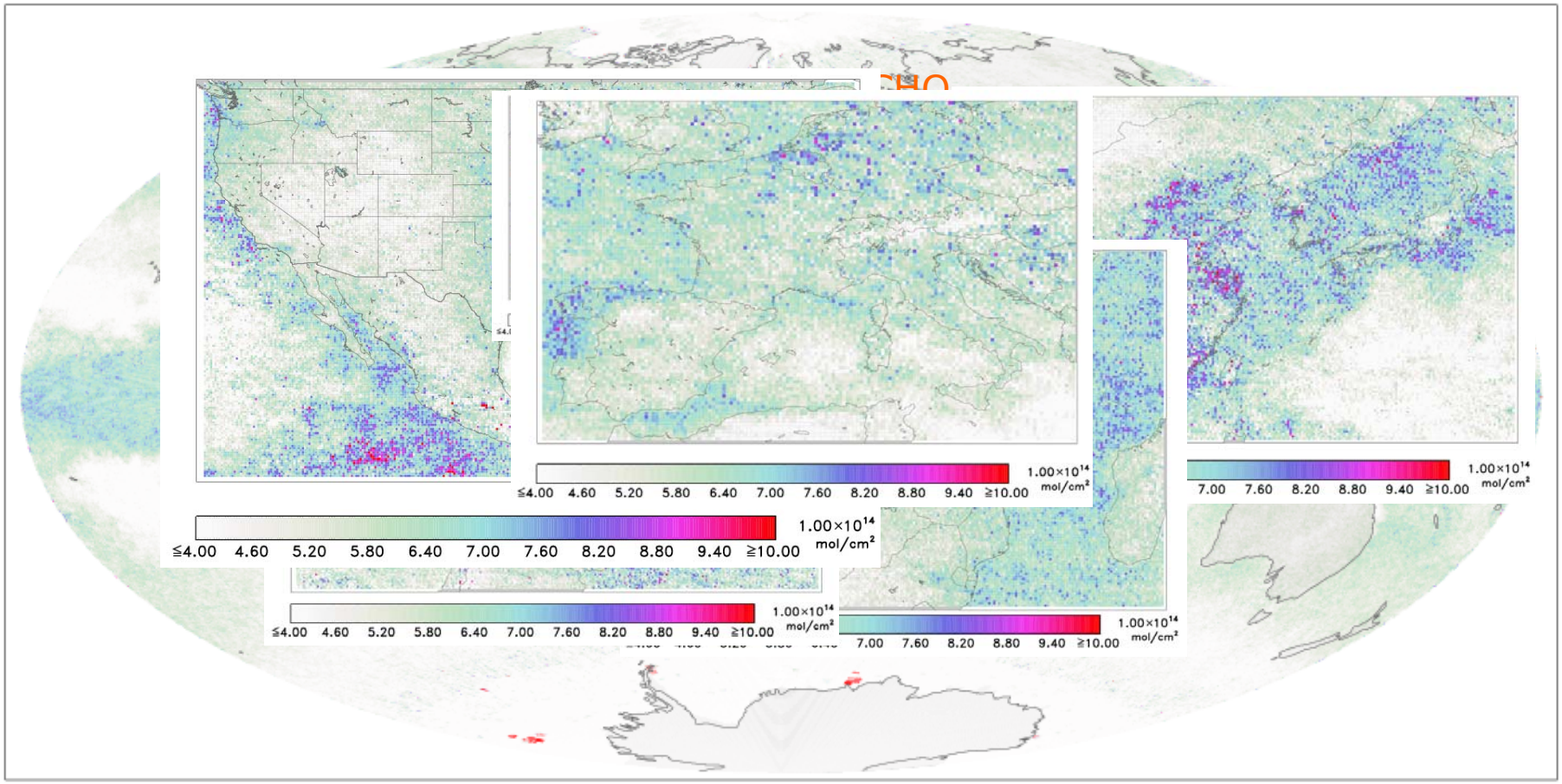


Fitting window: 430–460 nm (VIS channel)

First satellite-based observation from OMI!

Ground-based: Volkamer *et al.*, DOAS measurements of glyoxal as an indicator for fast VOC chemistry in urban air, GRL **32**, 2005

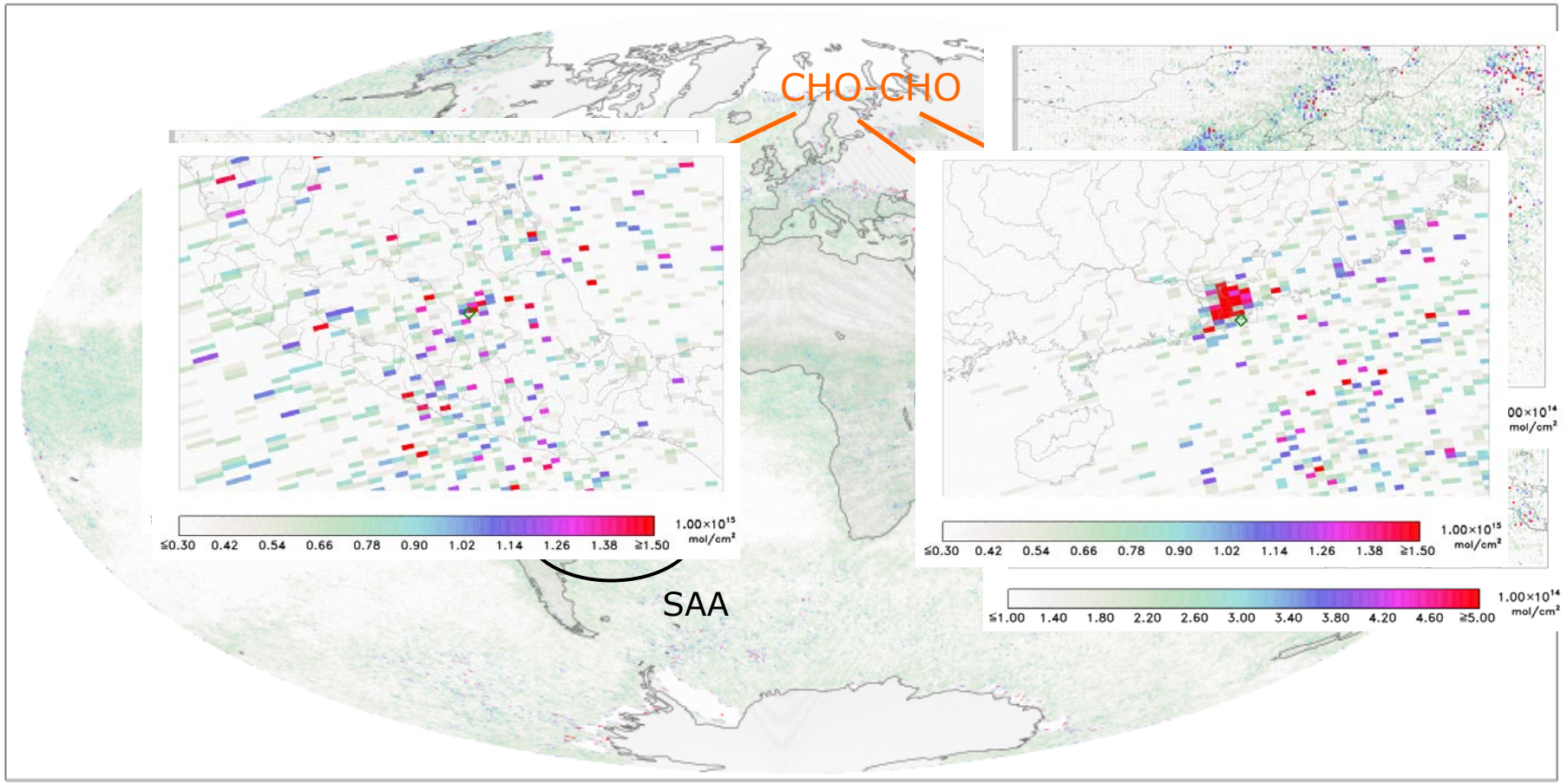
CHO-CHO Geometric Vertical Column (August 2005, monthly avg)

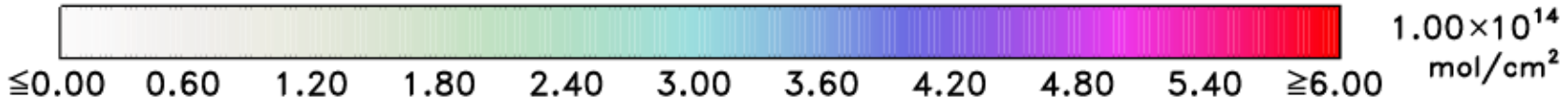


≦4.00 4.80 5.60 6.40 7.20 8.00 8.80 9.60 10.40 11.20 ≧12.00

1.00×10^{14} mol/cm²

CHO-CHO Geometric Vertical Column (February 2006, monthly avg)





Summary

- We have shown tropospheric measurements of BrO, HCHO, and CHO-CHO from the Ozone Monitoring Instrument on EOS/Aura
- Stripes in the OMI L2 data products are beginning to come under control due to both improved level 1-2 destriping strategies and advancements in the L1b data product.
- All major sources of tropospheric BrO (shelf ice, salt lakes, volcanoes) are observed by OMI, although volcanic BrO is currently under scrutiny due to conflicting information from different fitting windows
- HCHO spatial resolution shows great improvements over previous GOME results. Data quality of daily products is expected to improve with recent advancements in destriping and L1b product.
- CHO-CHO data quality is beginning to stabilize even though monthly averages still show strong albedo correlations. Daily observations are well within reach over strong source regions like Hong Kong.