Volcanic SO_2 algorithms for MEaSUREs: (Making Earth System Data Records for Use in Research Environments)

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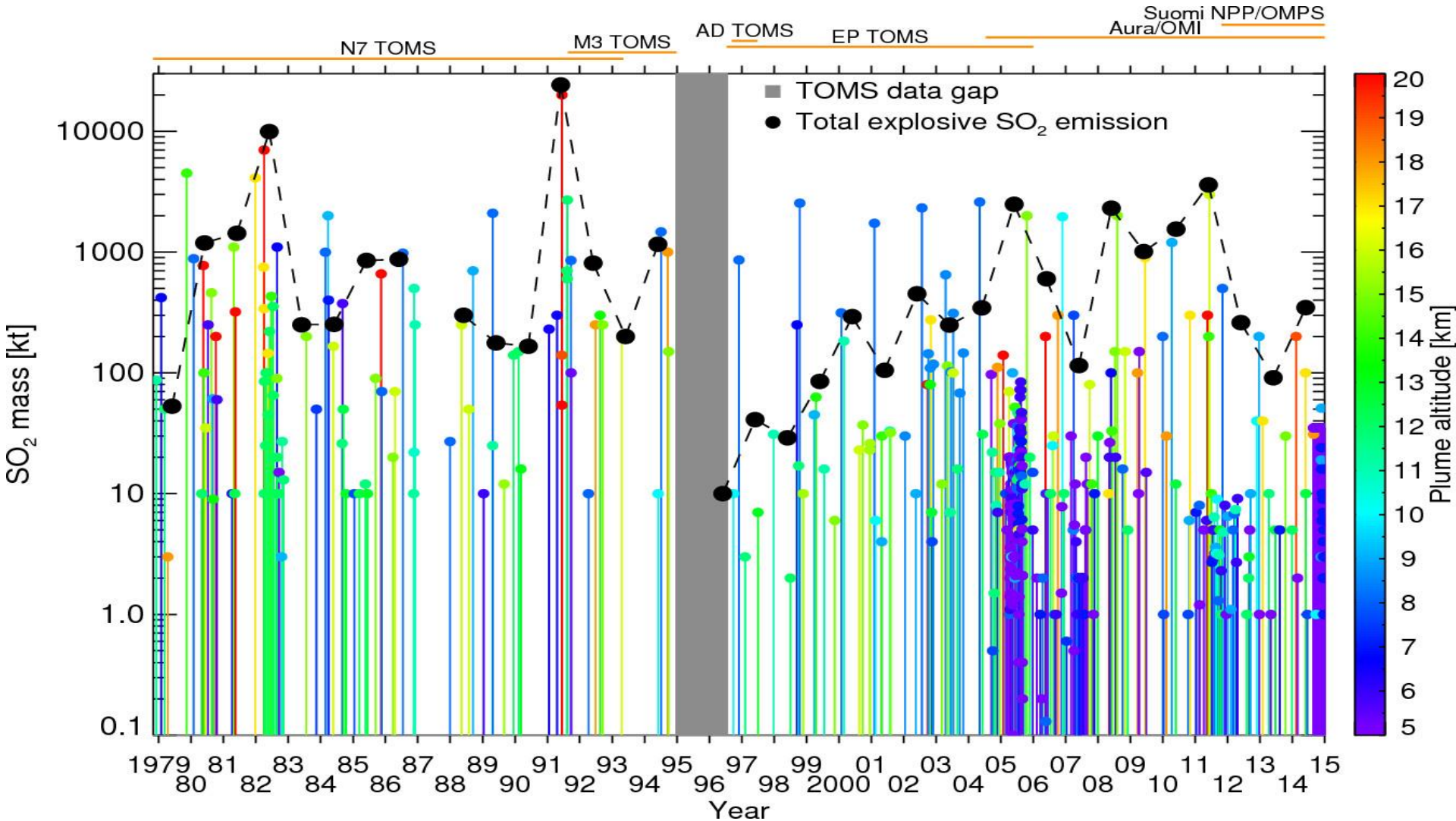
OMPS ST Meeting

SSAI

March 12, 2015

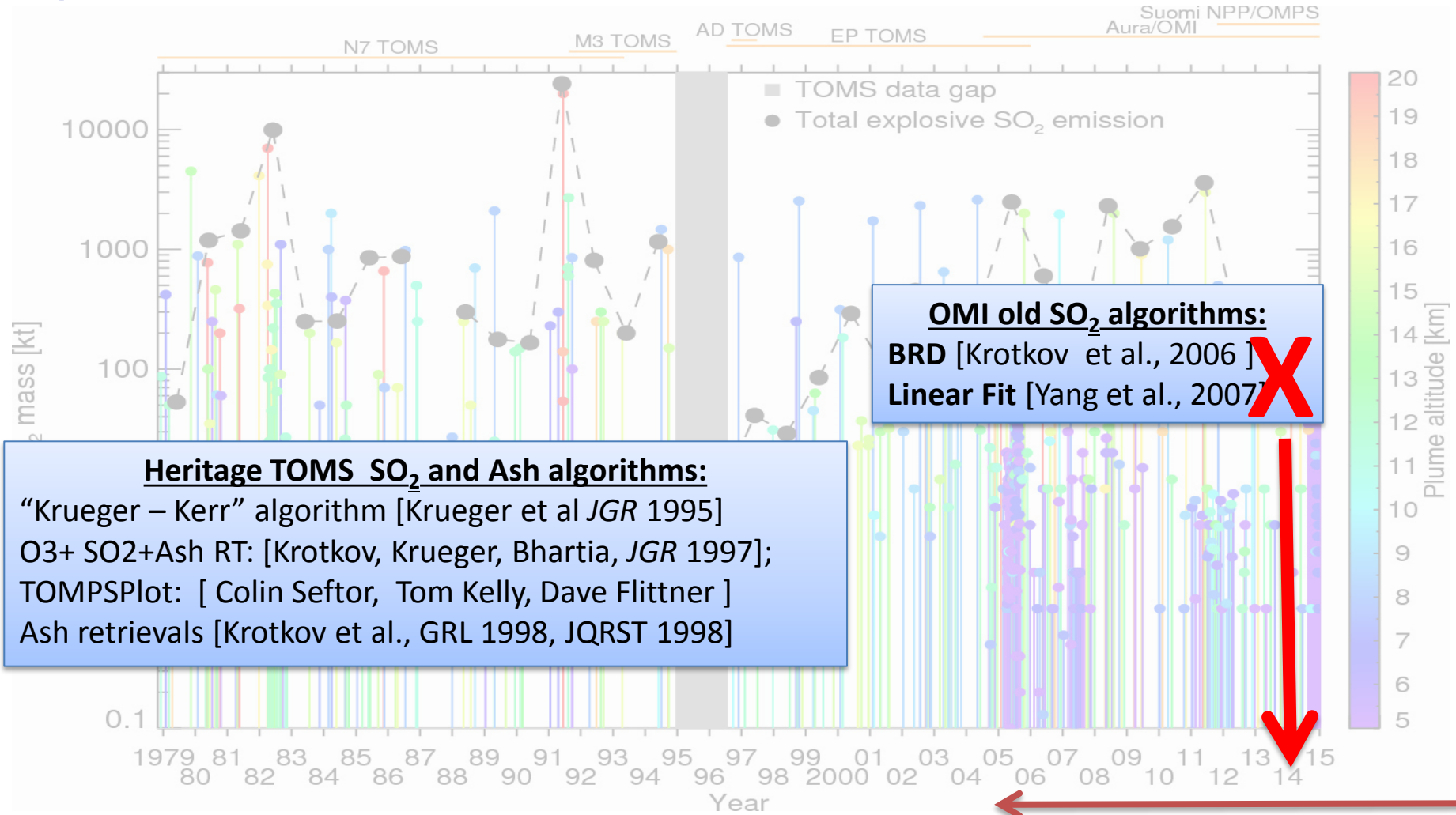
MEaSUREs volcanic SO_2 record: MSVOLSO2L4

http://so2.gsfc.nasa.gov/measures.html



[Carn *et al.*, GRL 2015]

Algorithms for MEaSUREs volcanic SO_2 record



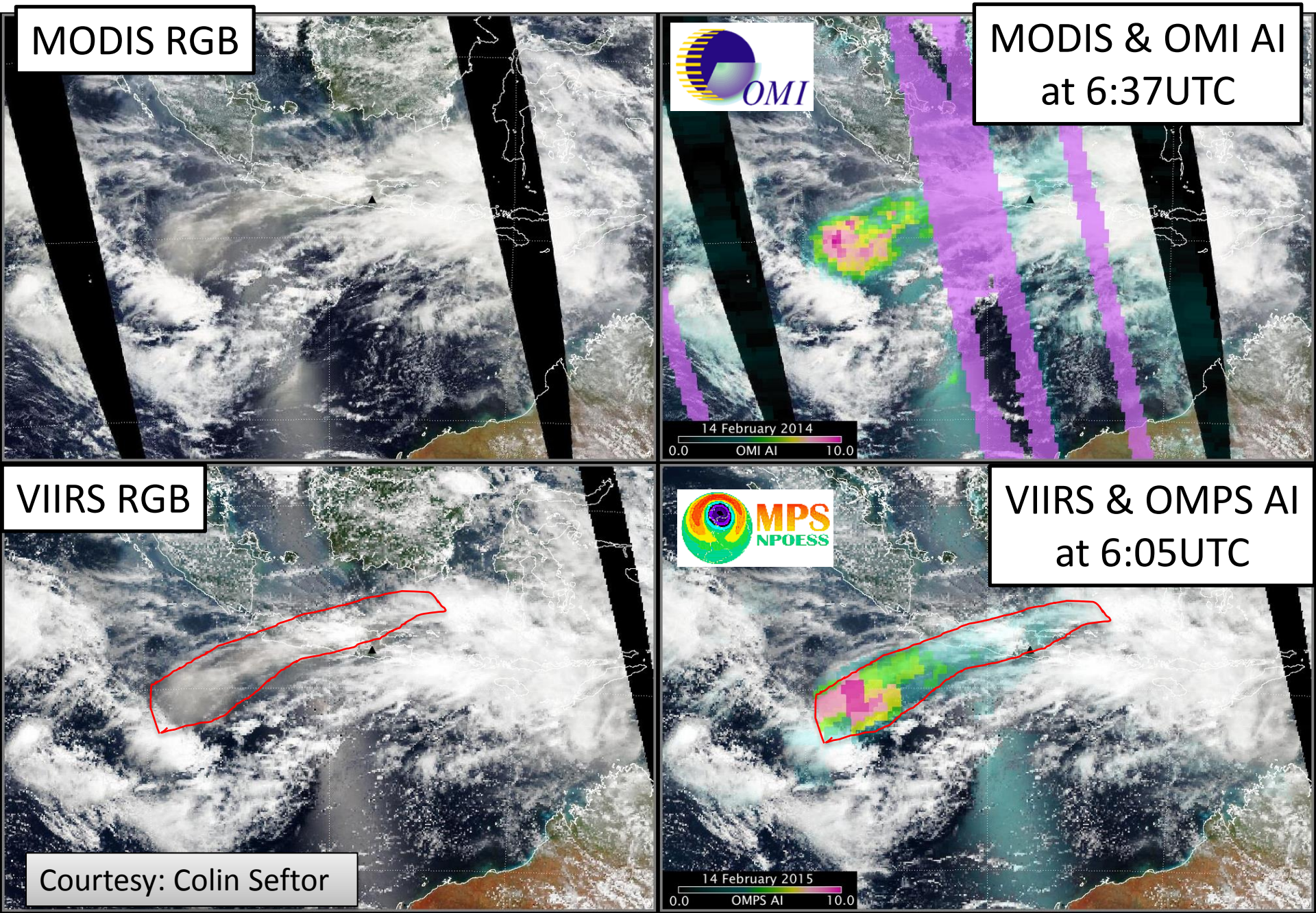
OMI old SO_2 algorithms:
BRD [Krotkov et al., 2006]
Linear Fit [Yang et al., 2007]

Heritage TOMS SO_2 and Ash algorithms:
"Krueger – Kerr" algorithm [Krueger et al *JGR* 1995]
O3+ SO2+Ash RT: [Krotkov, Krueger, Bhartia, *JGR* 1997];
TOMPSPlot: [Colin Seftor, Tom Kelly, Dave Flittner]
Ash retrievals [Krotkov et al., GRL 1998, JQRST 1998]

Hyperspectral Principal Component Analysis (PCA) algorithm [Li et al 2013]

Discrete wavelengths: MEaSUREs SO_2 (MSO2) algorithm

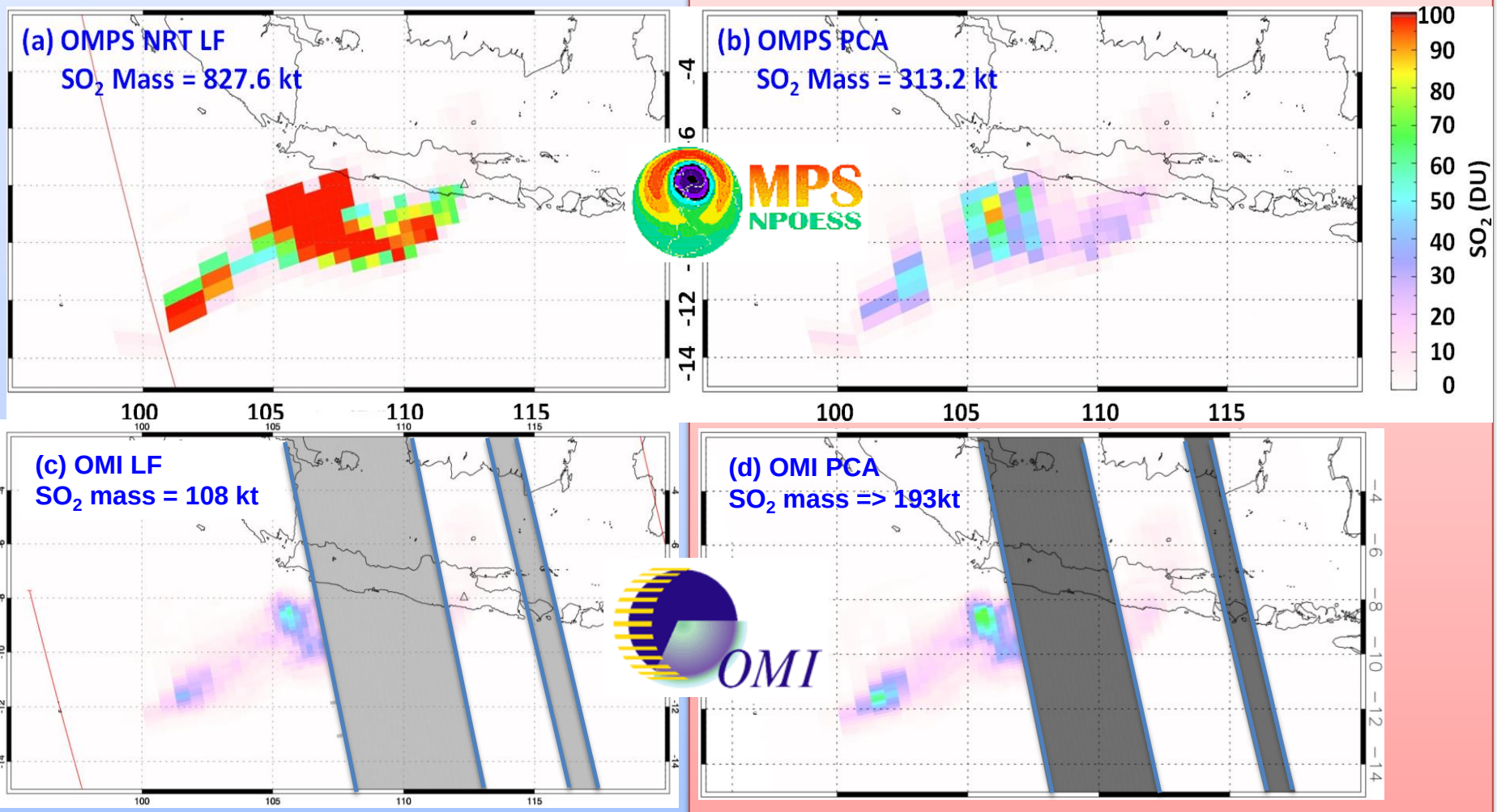
Volcanic Ash from Kelud volcanic eruption – 14 Feb 2014



Volcanic SO_2 from Kelud volcanic eruption – OMI and OMPS

Old LF algorithm
SO_2 mass: 168kt (OMI) -> 827kt (OMPS)

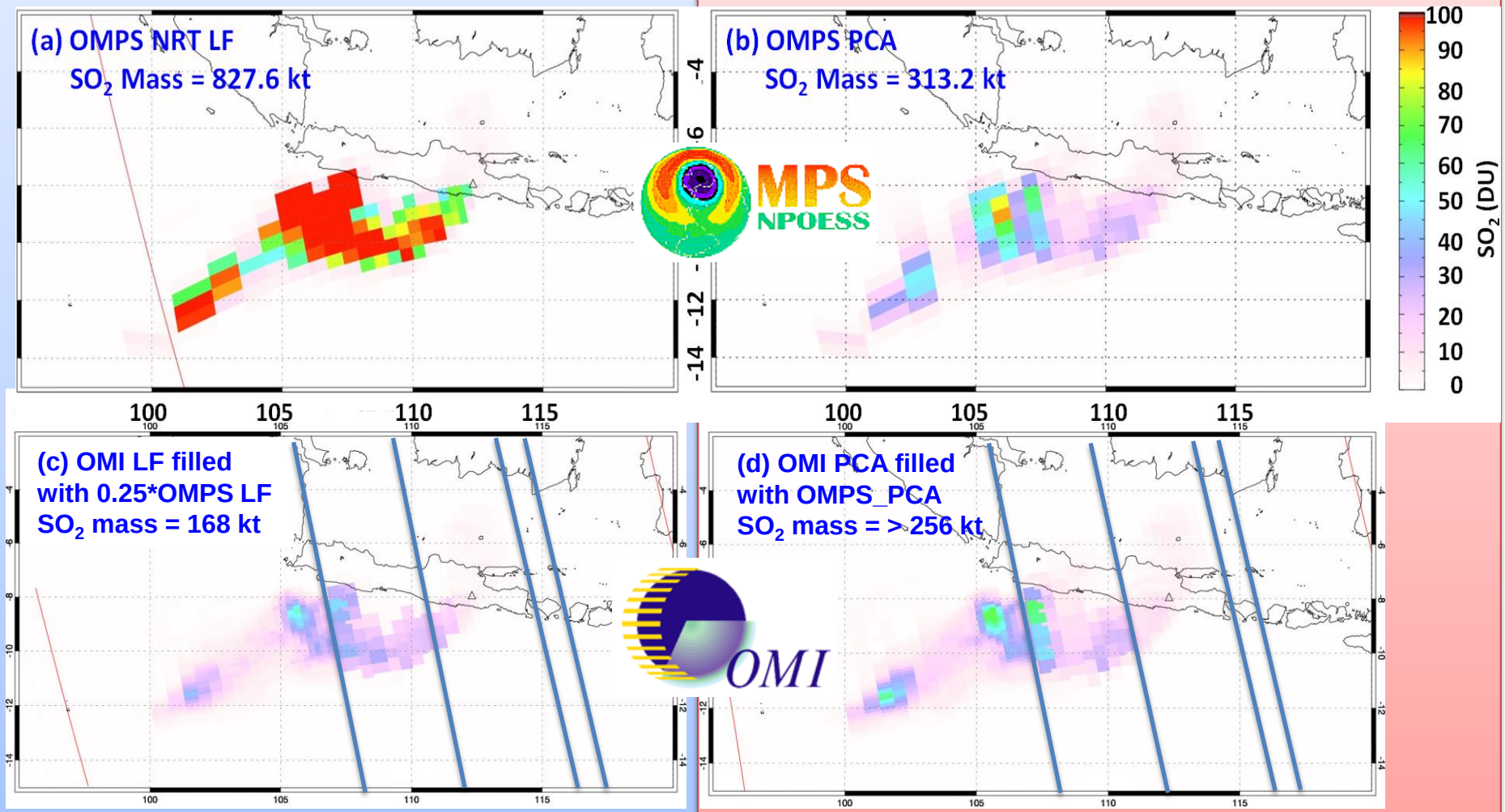
New PCA algorithm
SO_2 mass: 193kt (OMI) -> 313kt (OMPS)



Filling OMI RA gaps with scaled OMPS SO_2 data

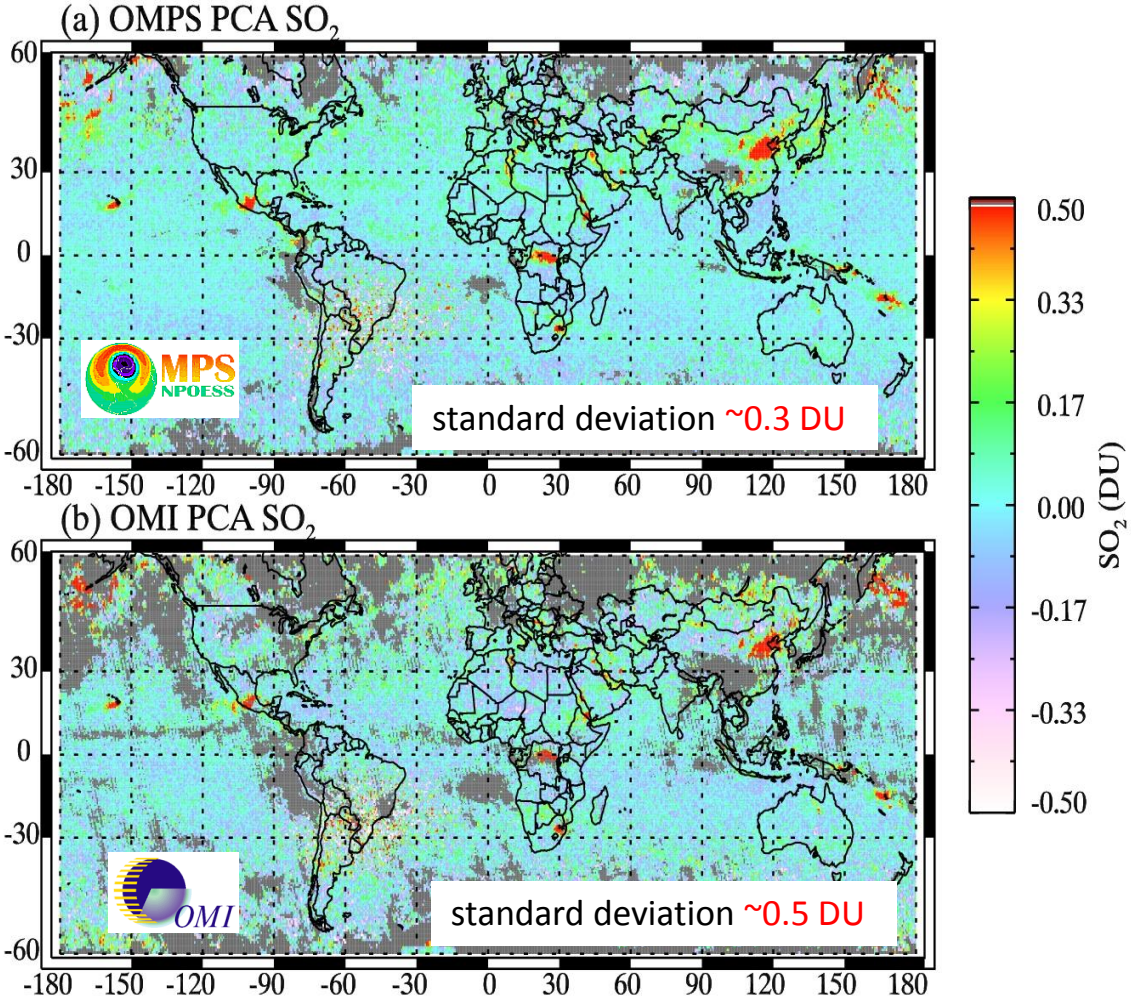
Old LF algorithm
SO_2 mass: 168kt (OMI) -> 827kt (OMPS)

New PCA algorithm
SO_2 mass: 290 +/-30 kt (~10%)



Hyperspectral PCA algorithm

- **Characteristics:**
  - ***Low bias, low noise*** (OMPS standard deviation ~0.3 DU for clear sky IFOV over equatorial Pacific assuming mid-lat PBL profiles (~0.1 DU or less if mid-trop profile and tropical O_3 amount used for Jacobians), for OMI ~0.5 DU)
  - ***Computation efficiency*** (CPU time ~20s/OMPS orbit, will increase if better Jacobians and more iterations added)
  - ***No soft calibration is necessary***
  - ***Less affected by clouds/aerosols than discrete wavelengths algorithms***
  - ***Max data continuity*** (best agreement between OMI and OMPS)
- **Needs:**
  - CAL/VAL, less dependent, but benefits from high quality data
  - **Continuous spectra (310-340 nm)**
  - Good spatial resolution for better sensitivity (sources become smaller due to emission reduction)
- **Implementation:**
  - Currently is implemented as ***OMI operational*** (NASA, Aura ST)



October, 2013

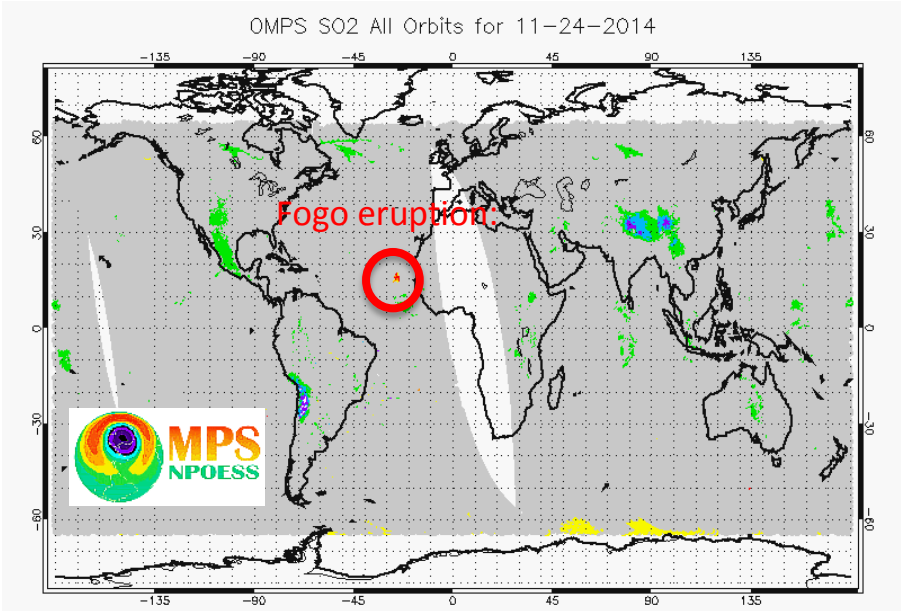
MEaSUREs SO_2 Goals:

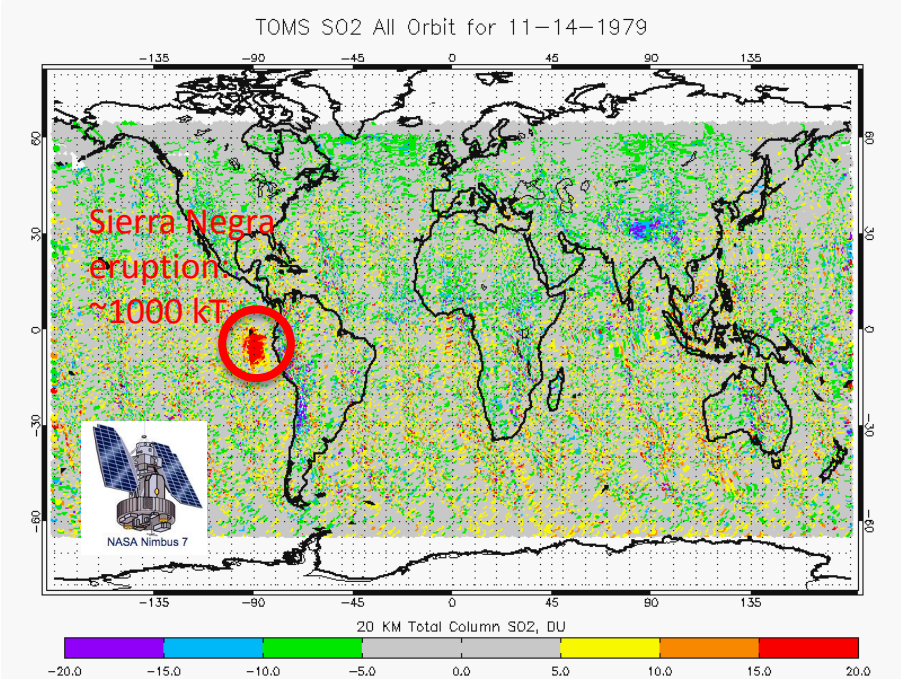
- Create a long-term record of volcanic SO_2 using a consistent discrete wavelength algorithm: MSO2
  - MSO2 algorithm will be applied to TOMS, OMI, OMPS and EPIC
- Validate MSO2 algorithm using PCA applied to OMI/OMPS data
- Quantify ash interference with MSO_2 retrievals

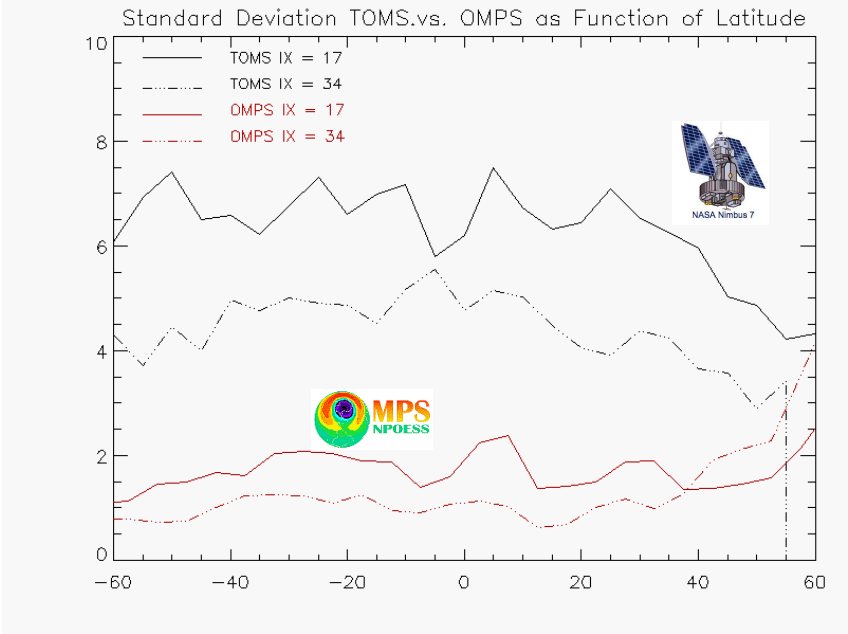
Discrete wavelengths MSO2 algorithm

- **Characteristics:**
  - Discrete wavelengths:
    - TOMS: 312.5,317.6,331,340,360,380nm
    - EPIC: 317, 325,340, 388nm
  - Highly dependent on CAL/VAL:
    - needs accurate soft calibration: 0.1N331 error produces up to 3.5DU SO2 error
  - Strongly affected by ash
- **Needs:**
  - a-priori O_3 and SO_2 profiles;
  - Instrument specific look-up tables;
  - Soft calibration of measured reflectance (N values)
  - Corrections for absorbing aerosols (ash), Raman and O2-O2 effects.
- **Implementation:**
  - Currently implemented for 4 N7/ TOMS wavelengths (317,331,340, 380nm).
  - Plan to study improvements due to 360nm and 312.5nm
  - Will be implemented for DSCOVR/EPIC wavelengths at 317,325, 340 and 388nm
  - Research version will be implemented with on-line VLIDORT forward RT model for advanced SO2 and ash retrievals

MSO2 algorithm: N7 TOMS vs OMPS





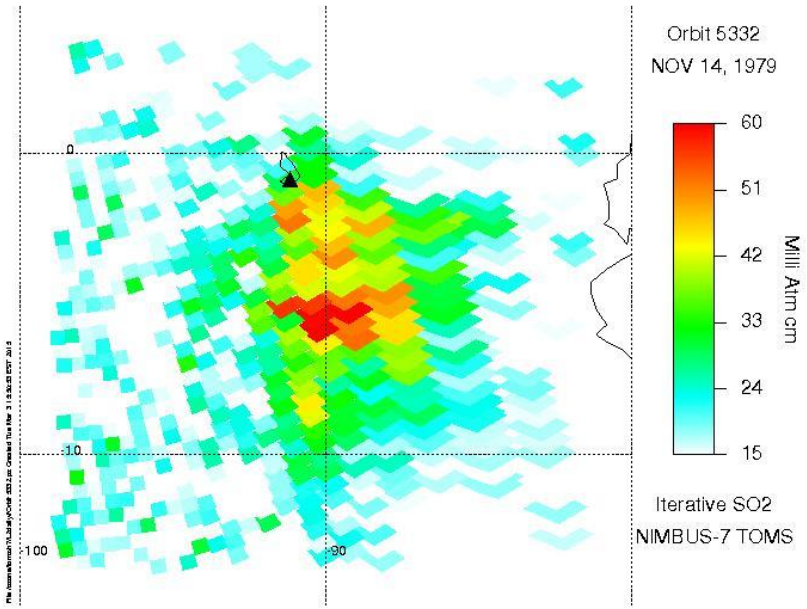


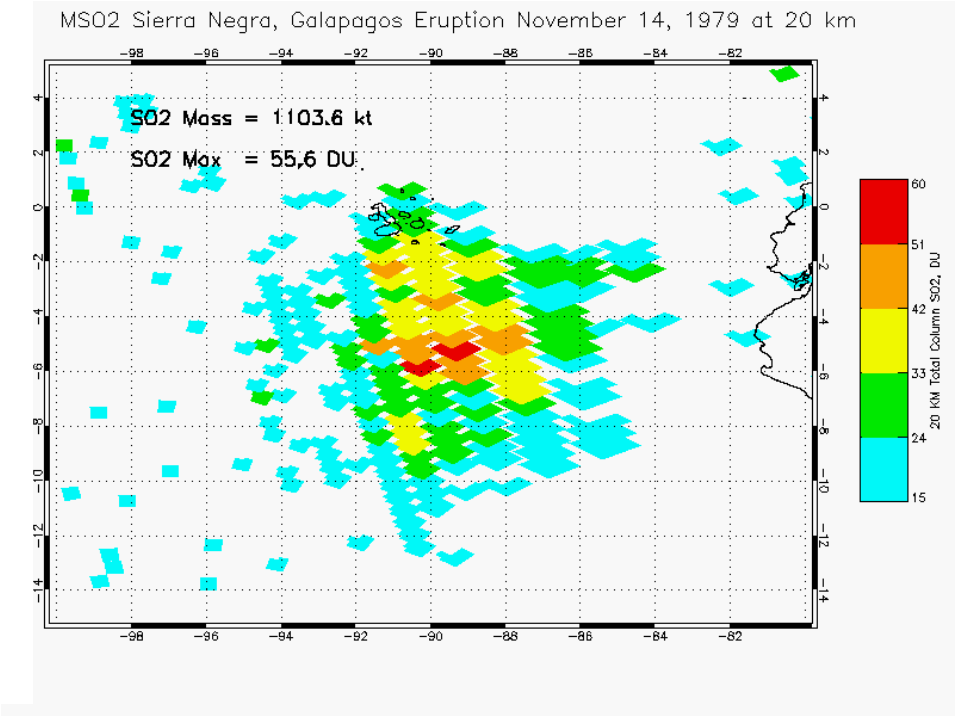
Standard Deviation of one day of background MSO2 data for N7 TOMS (black curves) and OMPS (red curves)

Re-processed SO2 from Sierra Negra eruption November 14 1979

Old Iterative algorithm (317,331,340,380): SO_2 mass ~1150 kt (SO_2 max: 64 DU)

MSO2 algorithm (317,331,340,380): SO_2 mass ~1101 kt (SO_2 max: 56 DU)





Plans for MEaSUREs SO_2 and ash algorithms

- Re-process OMI and OMPS volcanic data with PCA algorithm: reconcile OMI/OMPS differences
- Refine/validate discrete wavelengths (MSO2) algorithm by applying to OMI and OMPS data, validate with PCA algorithm
- Re-process all 4 TOMS SO2 records with the refined MSO2 algorithm
- Refine old TOMS ash algorithm [Krotkov et al 1997], re-process TOMS/OMI/OMPS data, document ash interference with SO2 retrievals