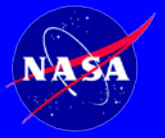

Continuation of Global Anthropogenic and Volcanic SO_2 Monitoring from OMI to OMPS

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Trace Gas Session
3rd Annual JPSS Meeting
August 11, 2016
College Park, MD

Outline

- Background and motivation
- PCA algorithm – data driven, straightforward to implement, small noise and artifacts
- Application to OMI – operational algorithms for new OMI PBL and volcanic SO_2 data
- Application to OMPS – implementation of OMI PCA algorithms with OMPS shows good consistency between two instruments

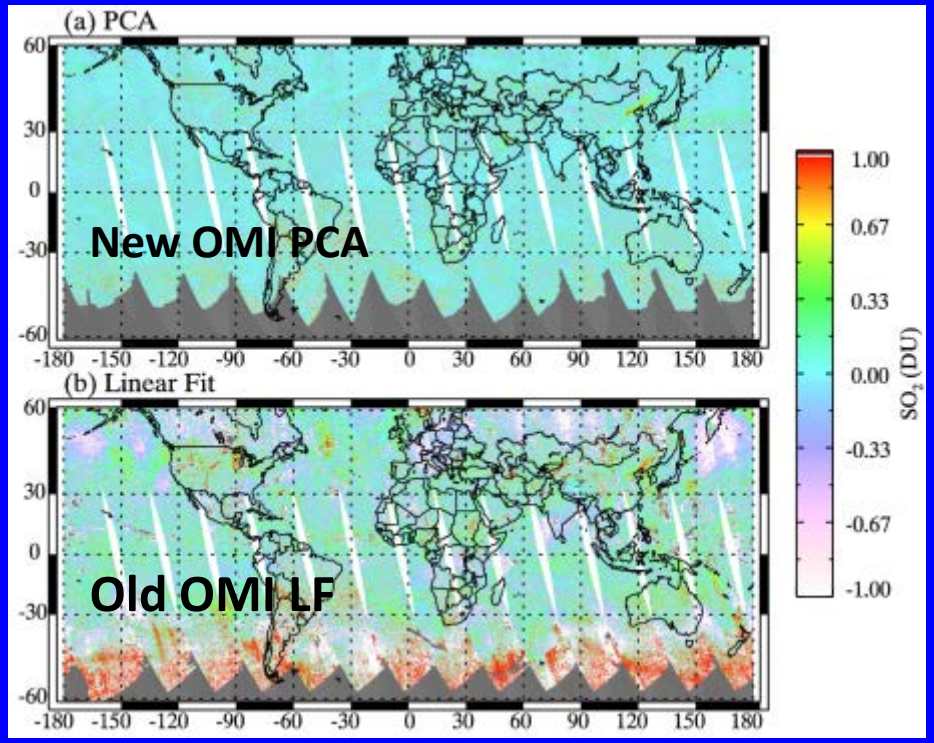
NASA SO_2 processing

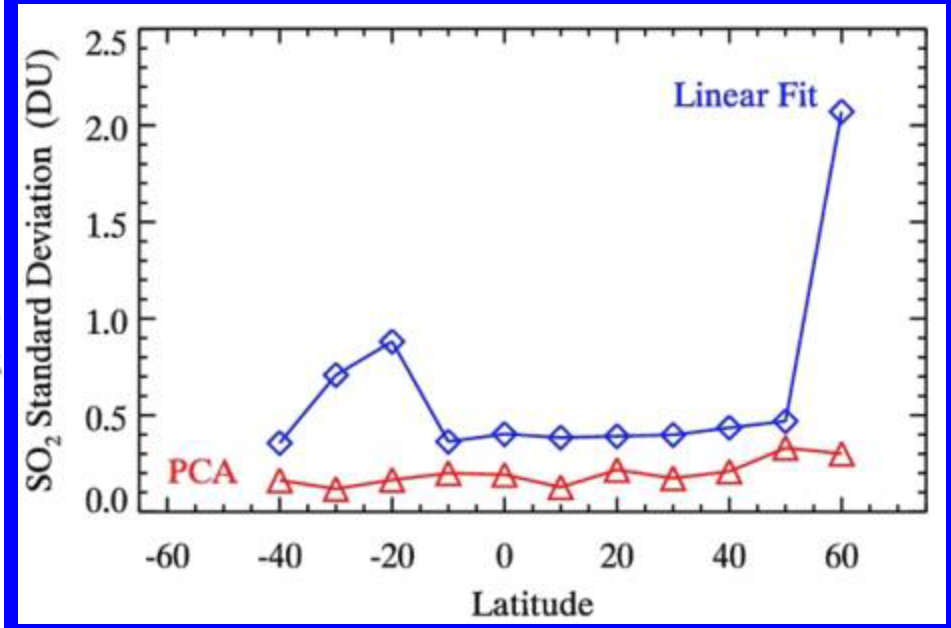
- Developed new PCA algorithm [Li et al., 2013]
  - data driven,
  - efficient,
  - smallest noise and artifacts
  - Does not require soft calibration => good consistency
- Application to OMI – operational algorithms for new OMI PBL and volcanic SO_2 data
- Application to OMPS – implementation of OMI PCA algorithms with OMPS shows good consistency between two instruments
- Data are available on our web site: http://so2.gsfc.nasa.gov

Execution Speed of the PCA SO_2 Algorithm

- ~4 min per OMI orbit (~70,000 pixels) using simplified SO_2 Jacobians LUT ;
- 5 days used for reprocessing 10-year OMI data for the current operational PBL product;
- ~65 min per OMI orbit using full LUT - can be reduced to ~10 min if cross-section is used in fitting for SCD and then converted to VCD using AMF;
- ~20 s per OMPS orbit (~10,000 pixels) using simplified SO_2 Jacobians LUT

OMI: New Operational OMI Volcanic SO_2 Product Greatly Reduces Bias and Noise over Background Areas

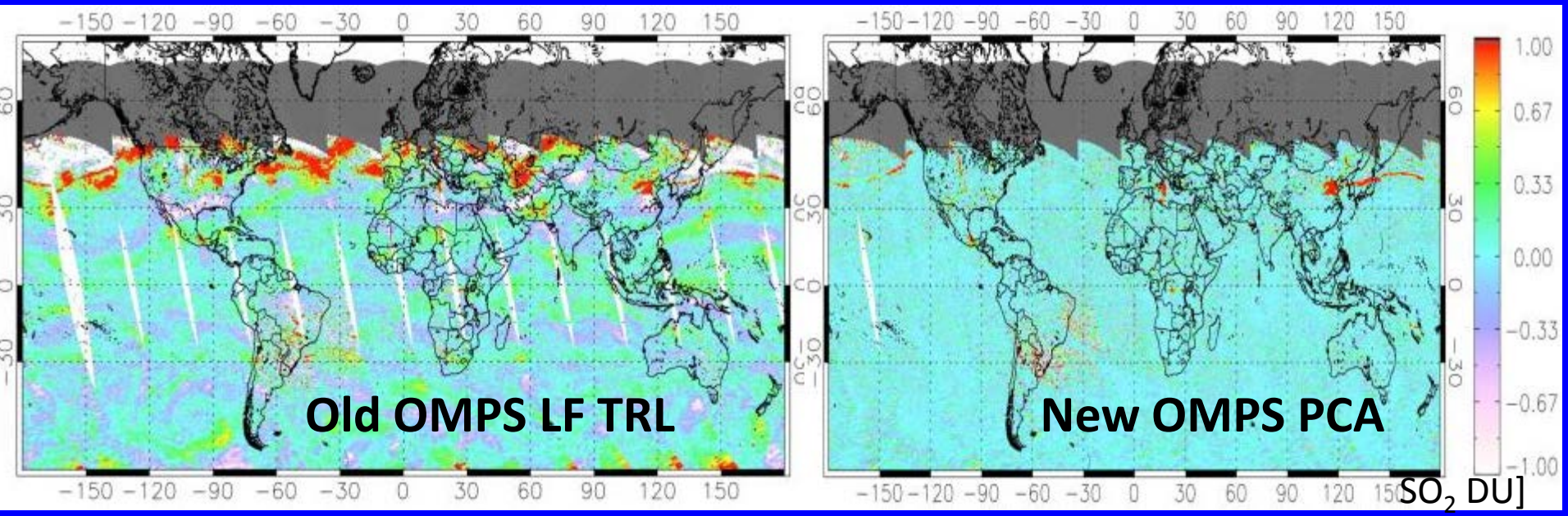




Retrieval noise reduced by a factor of two

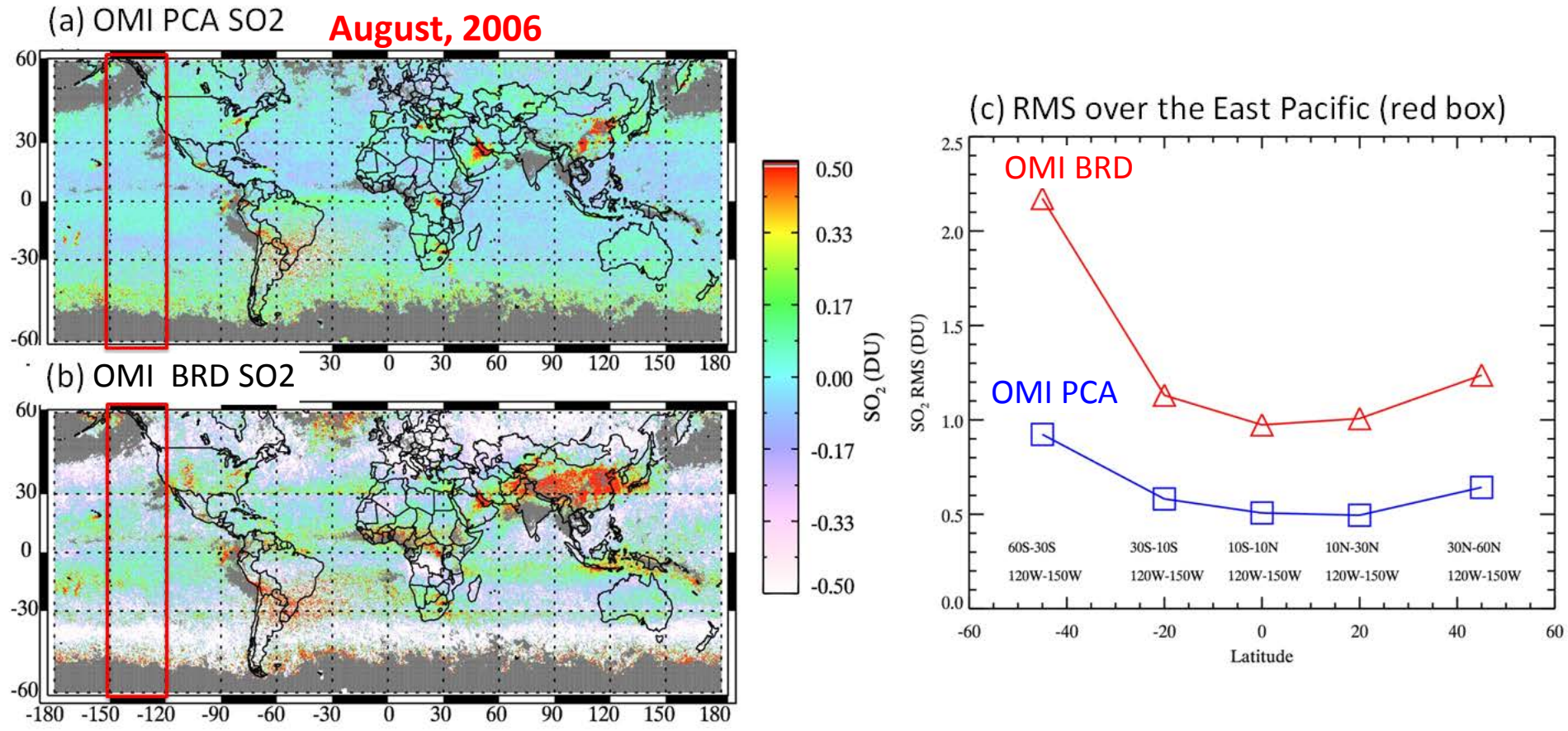
OMI TRL Retrievals, August 5, 2006 [Li et al., AMTD 2016]

OMPS: Reduced Background noise and artifacts: volcanic SO_2



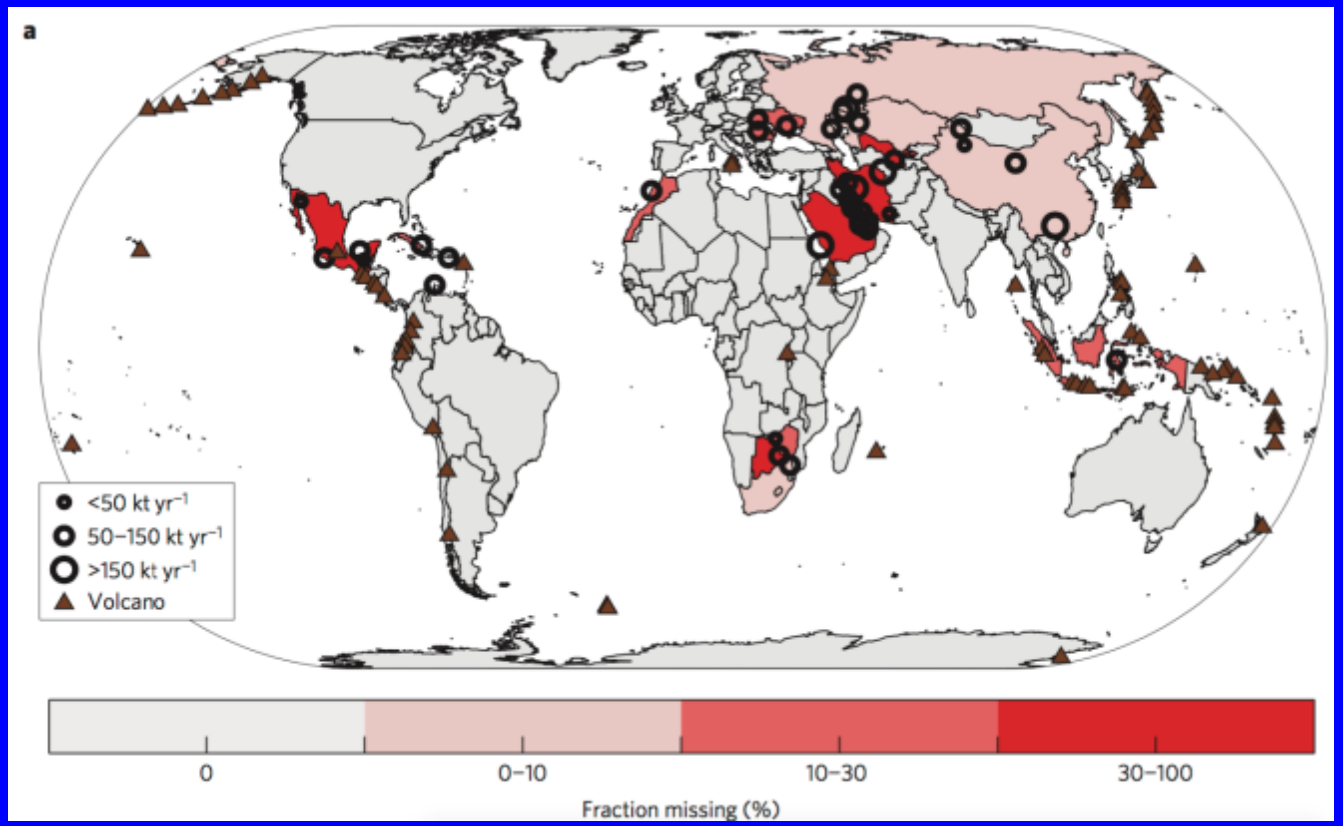
OMPS NRT LF TRL retrievals for 12/08/2015, a few days after the December 3 2015 Mt. Etna eruption.

Reduced Background noise and artifacts: PBL SO_2



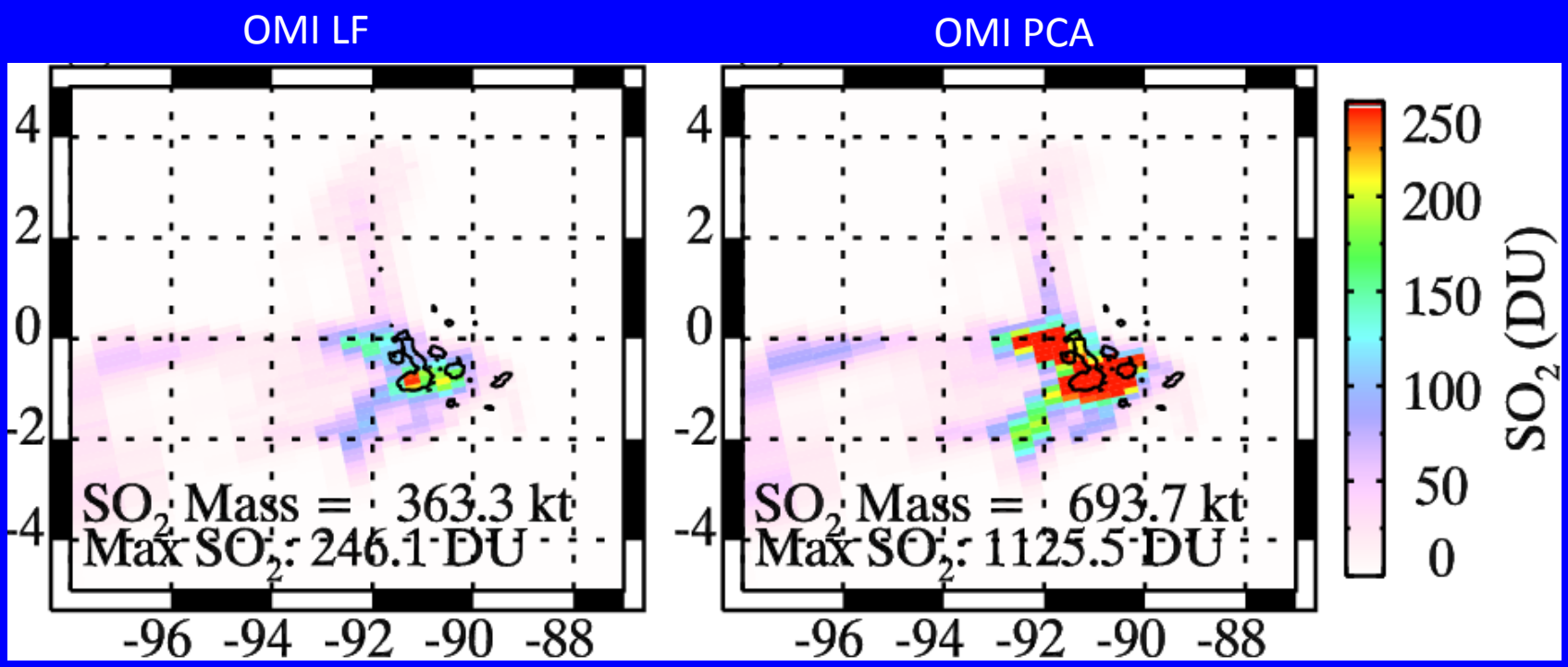
- PCA algorithm reduces retrieval noise by a factor of two as compared with the BRD algorithm
- SO_2 Jacobians for PCA algorithm calculated with the same assumptions as in the BRD algorithm

When combined with wind data and careful, innovative data analysis …



- An independent "top-down" global SO_2 emission inventory [*McLinden et al.*, NG 2016];
- Annual emissions quantified for ~500 large sources, ~40 missing or unreported in "bottom-up" inventories, or ~6-12% of the total anthropogenic sources;
- Emissions quantified for 75 volcanoes – large differences between OMI measurements and the Aerocom database.

New OMI Operational PCA Volcanic SO_2 Greatly Reduces Low Bias in the old LF SO_2 for Large Eruptions

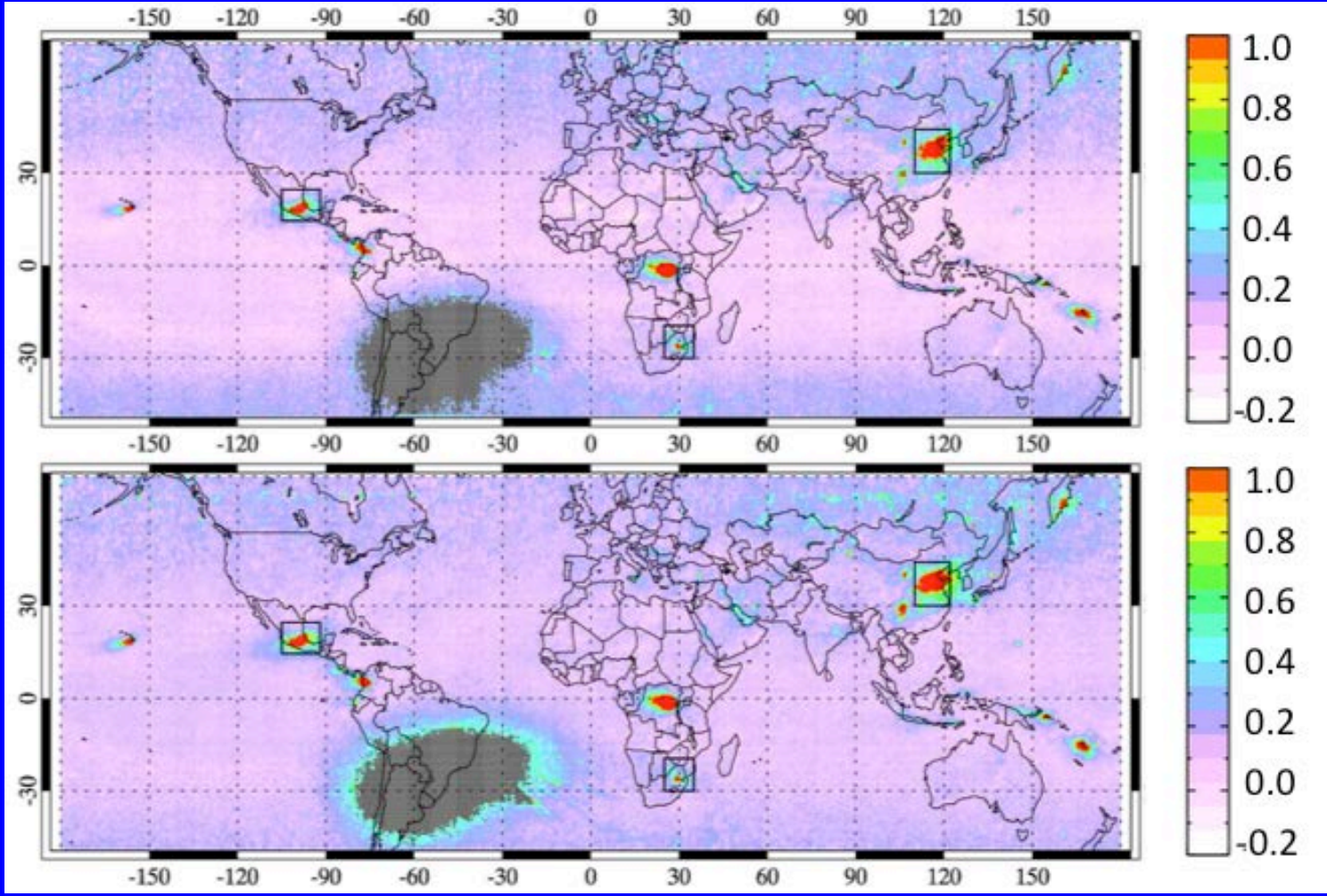


- Sierra Negra eruption in 2005, max SO_2 from new operational PCA algorithm ~1100 DU, in agreement with the offline ISF algorithm [*Li et al.*, 2016]
- Kasatochi eruption in 2008: PCA total SO_2 ~1700 kt, consistent with ISF and OE algorithms for OMI and GOME-2, a factor of two more than LF with known low bias [*Krotkov et al.*, 2010].

Good consistency between OMI and OMPS Annual Mean PBL SO_2 Retrievals for 2012

OMI

OMPS

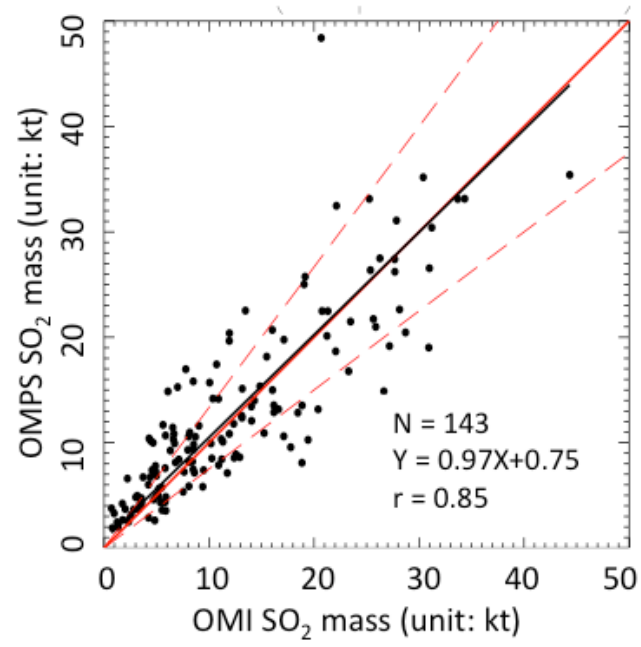


No soft calibration or L2 correction

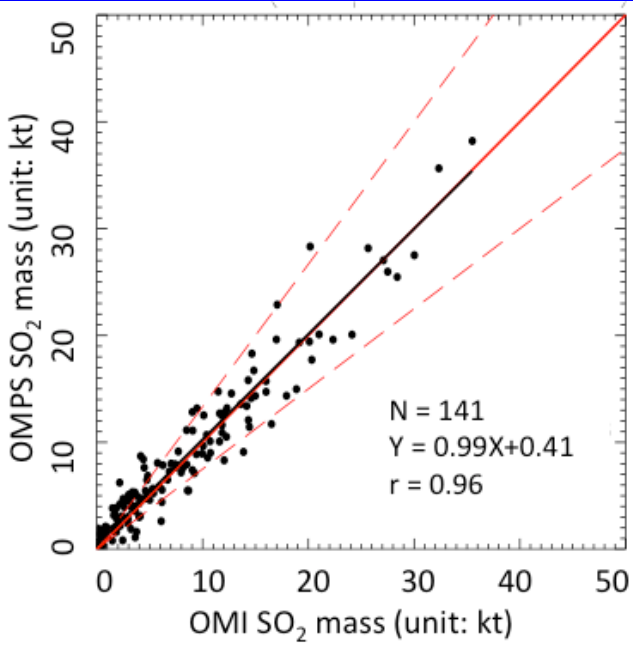
[*Zhang et al.*, 2016]

Daily regional SO_2 loading over the selected areas in 2012 (PBL retrievals)

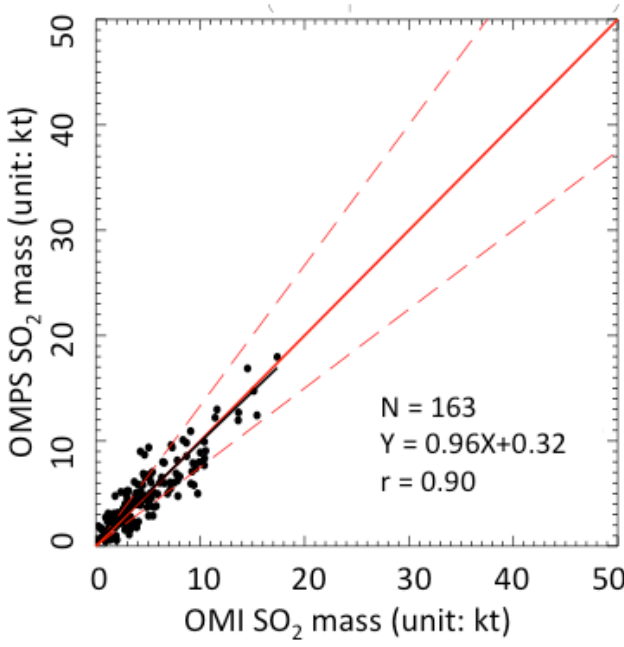
E China



Mexico

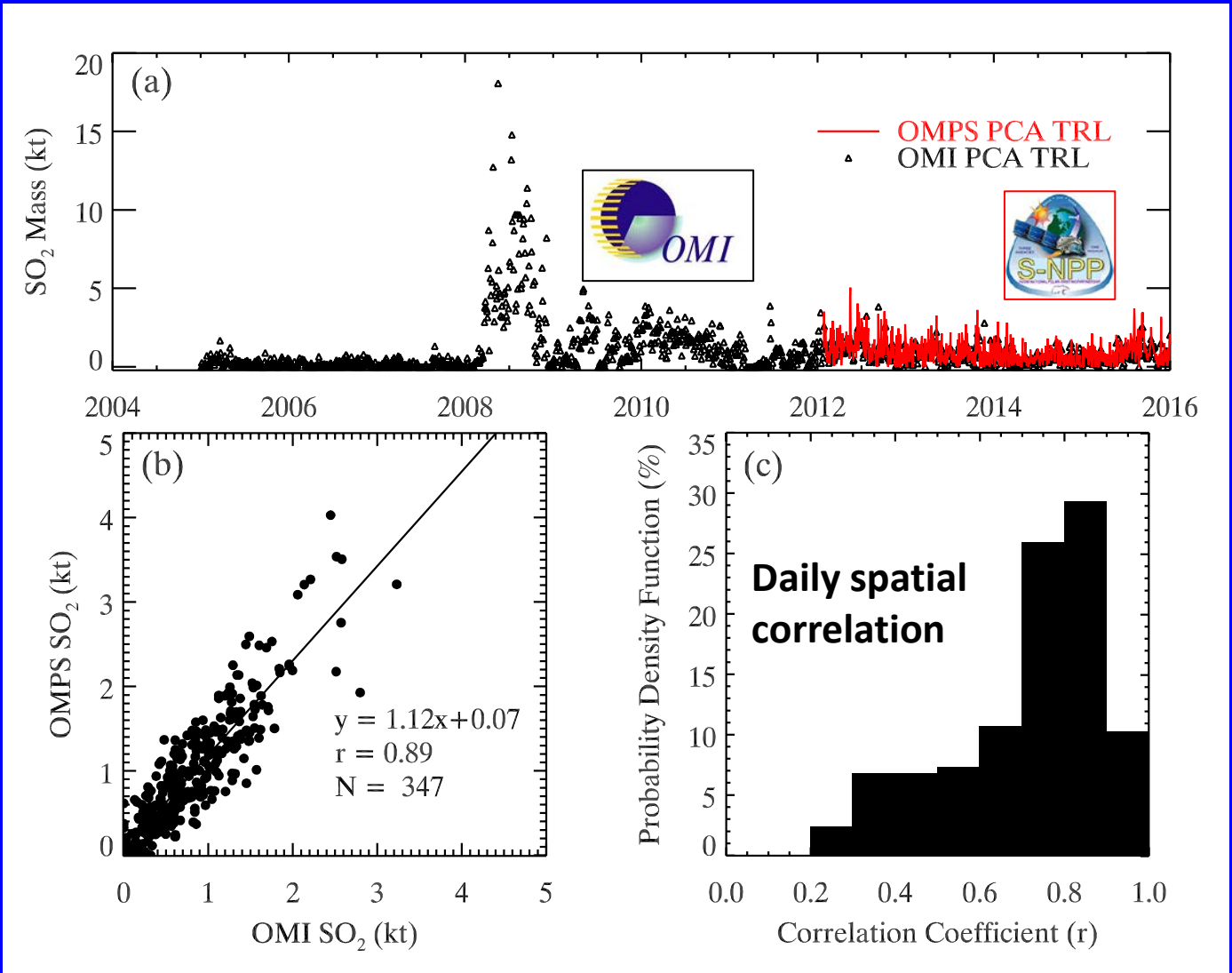


South Africa



[*Zhang et al.*, AMTD 2016]

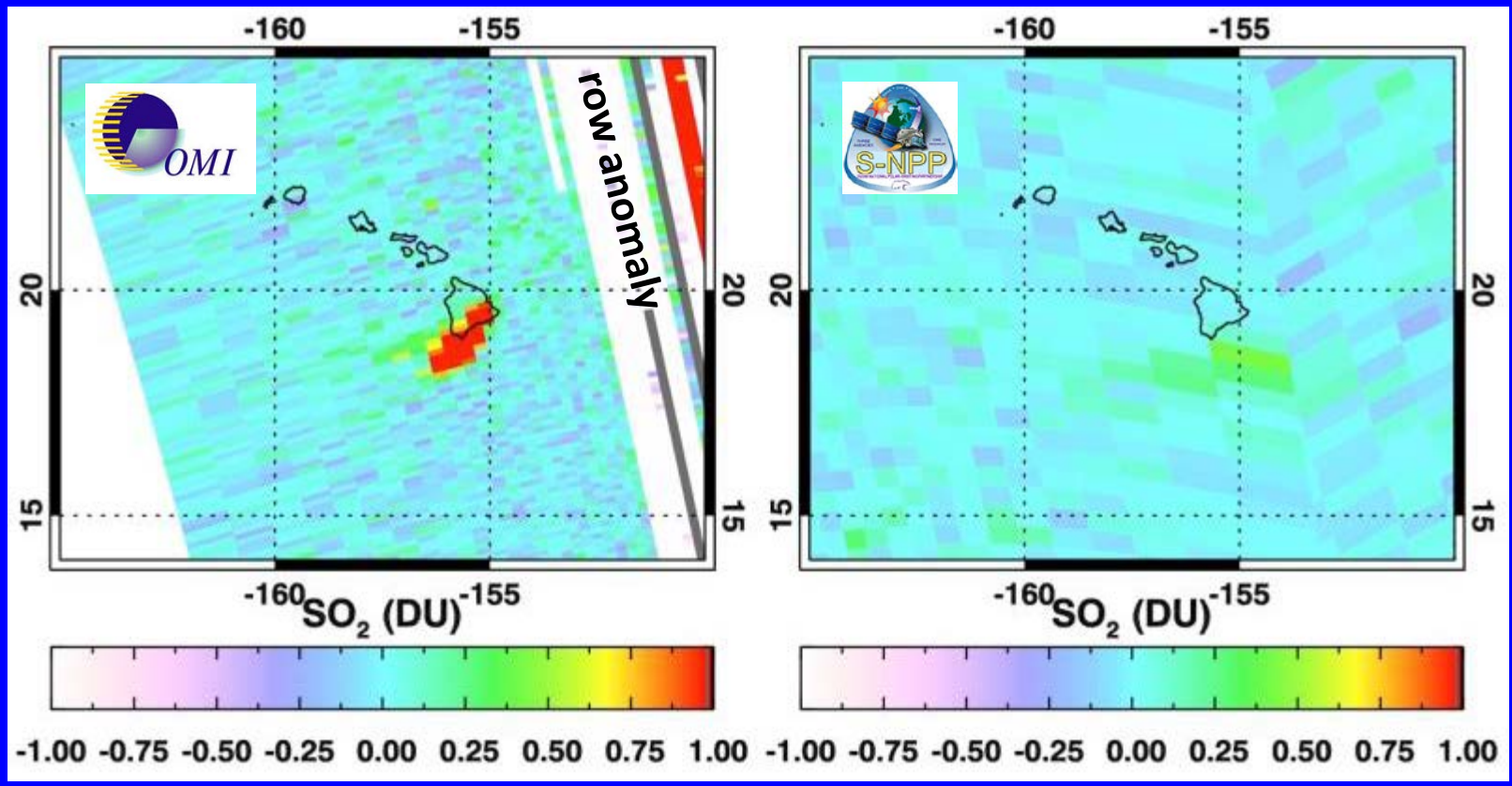
Daily OMI/OMPS regional volcanic SO_2 loading Hawaii (PCA 3-km/TRL retrievals)



[*Li et al.*, 2016]

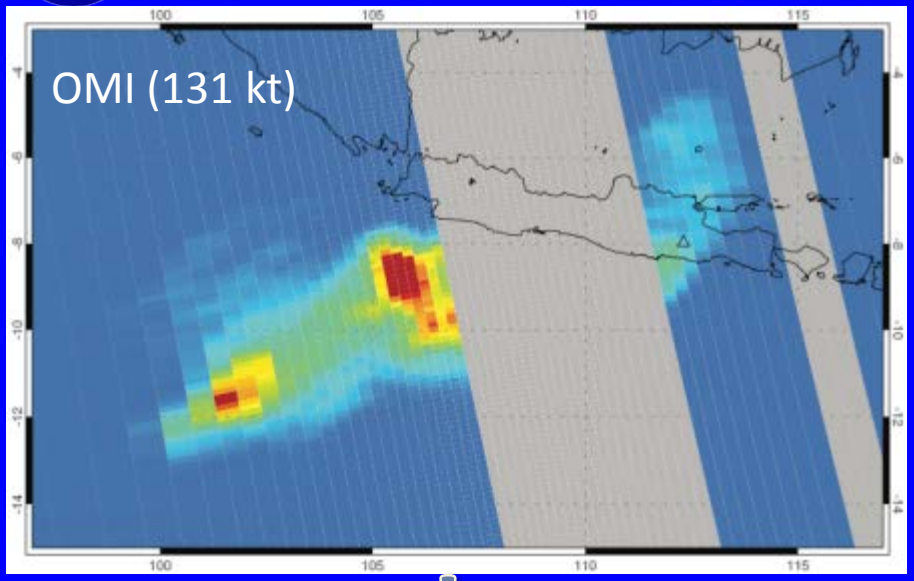
Five days with $r < 0.3$, why?

- ✓ Five days with $r < 0.3$: 02/05/2012, 10/02/2012, 05/14/2013, 11/06/2013, and 11/09/2014.
- ✓ For all five days, the plume was covered by OMI pixels near the nadir but by OMPS pixels near the edge of the swath.



11/06/2013

Large Eruption: Kelut in 2014



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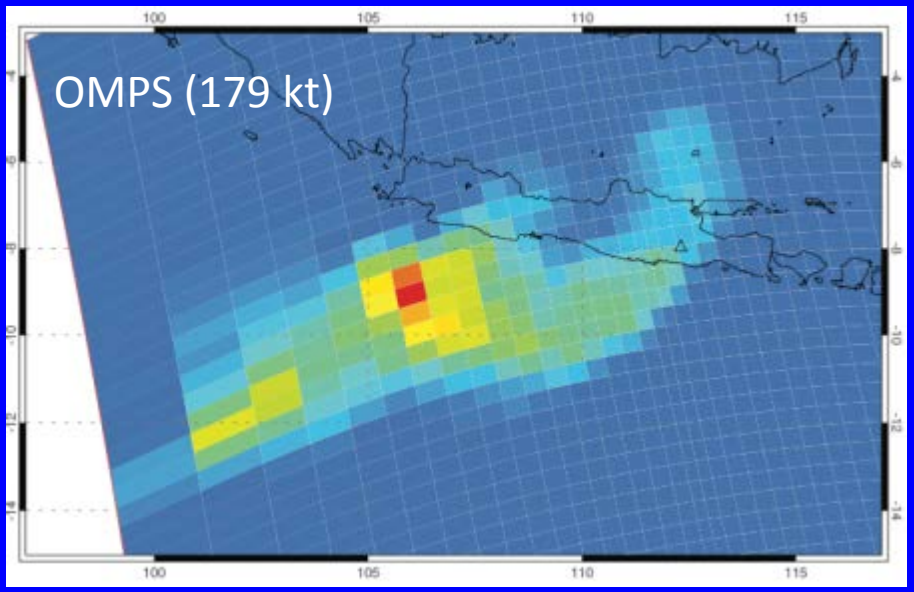

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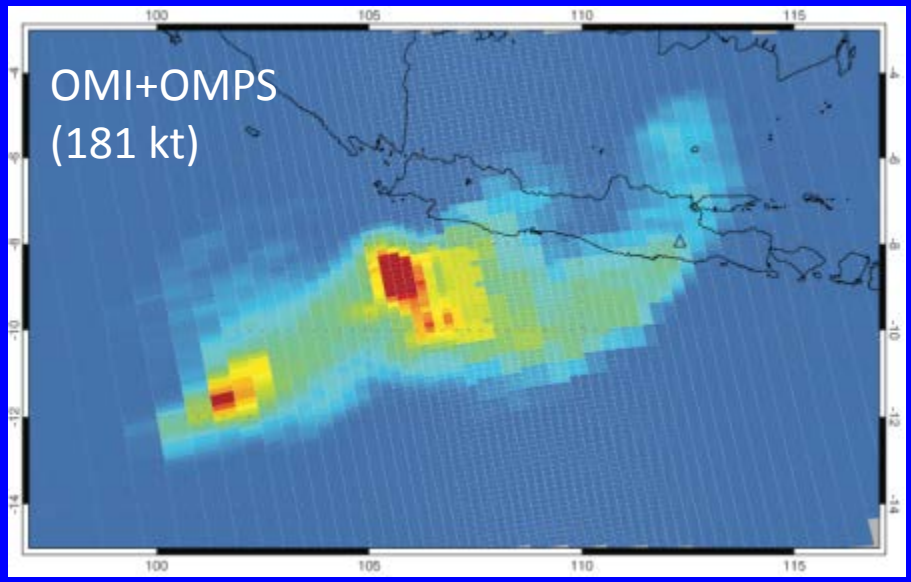


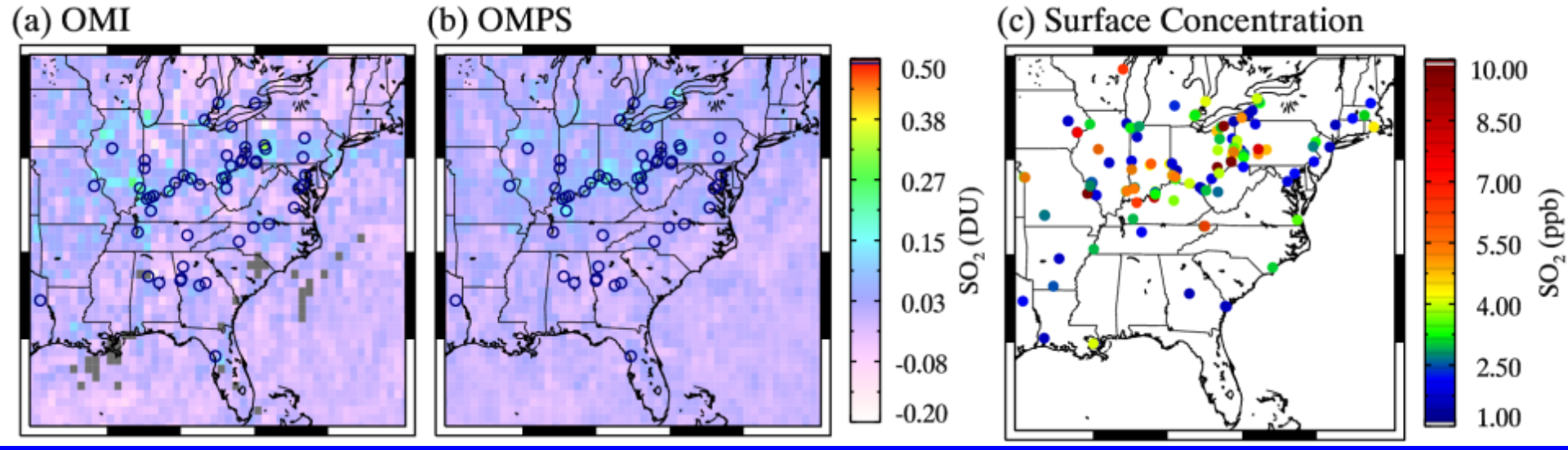
- ✓ **Merged OMI+OMPS provides full coverage and fine spatial detail**
- ✓ **Agrees with OMPS only SO_2 mass to within 3%**

[*Li et al.*, 2016]

New OMI and OMPS anthropogenic SO_2 retrievals with comprehensive LUT for Jacobians

Monthly Mean, August 2012

Monthly Mean at 2 pm Local Time



- ✓ Preliminary new OMI and OMPS pollution SO_2 retrievals both reveal emission sources over the Ohio River valley (circles are sources with > 50 kt emissions in 2006).
- ✓ Surface monitoring stations show qualitatively consistent pattern.
- ✓ If assuming the same mixing ratio for the lowest 100 hPa (~1000 m) of the atmosphere and no SO_2 above, 4 ppb translates into ~0.3 DU in column loading.

4+ Years of OMPS PBL SO_2 Research Product Now Available on NASA's SO_2 Website: http://so2.gsfc.nasa.gov

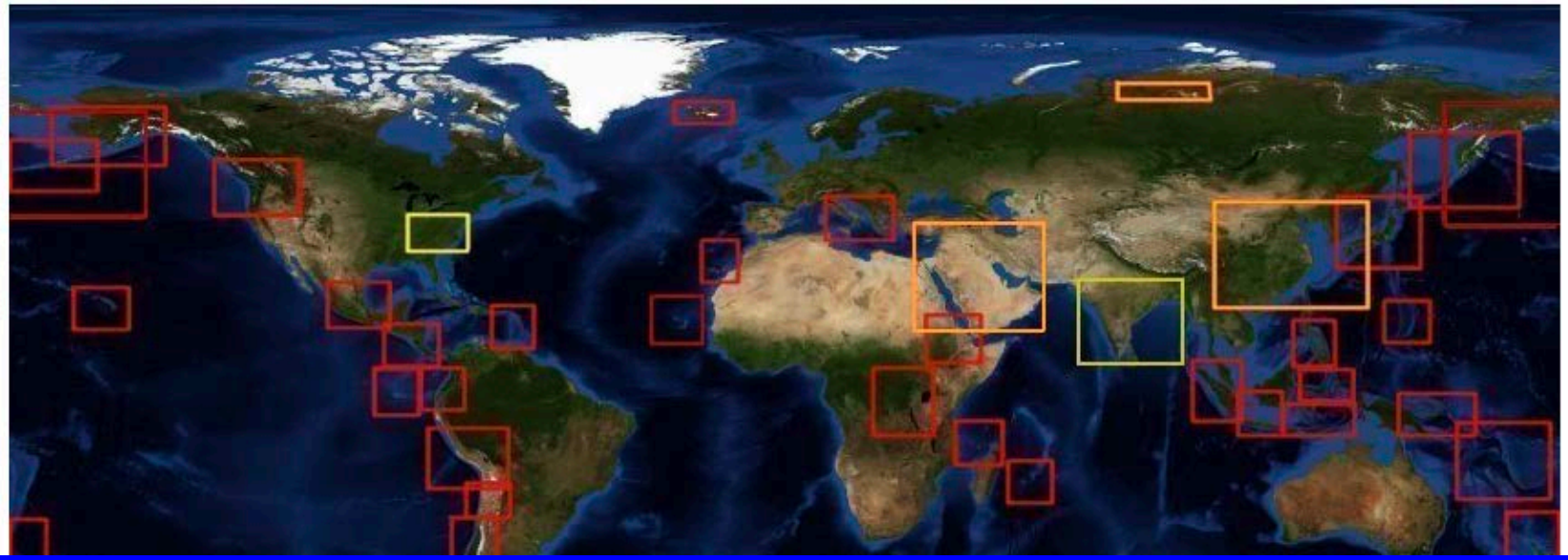
TOMS images (1979-2005) | AIRS images (2003-present) | OMI images (2004-present) | OMPS images (May 2012-present)

Global monthly OMI Boundary Layer SO_2 maps

Global monthly OMPS Boundary Layer SO_2 maps

Latest Daily (OMI/OMPS) Images of SO_2 (click on a highlighted rectangle)

Red = daily volcanic regions, orange = daily pollution regions, yellow = long-term pollution images



Conclusions

- The PCA SO_2 retrieval approach – data-driven, good quality, straightforward to implement.
- Operational OMI PCA PBL and volcanic SO_2 data show significant improvement over previous OMI data, also compare well with OMI DOAS SO_2 data using TROPOMI prototype algorithm [*Theys et al.*, 2015].
- Research OMPS PBL and volcanic SO_2 data based on PCA algorithms show good consistency with OMI data.