Next Generation Aura/OMI SO_2 Retrieval Algorithm: Introduction and Implementation Status

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Background and Motivation

- SO_2 is a designated air pollutant emitted from both anthropogenic and volcanic sources. As a precursor of sulfate aerosols, it also influences weather and climate
- The Ozone Monitoring Instrument (OMI) aboard the NASA/Aura satellite provides capabilities of monitoring SO_2 globally on a daily basis, with much improved sensitivity as compared to other satellite instruments
- The current operational OMI retrieval algorithm has relatively large noise and unphysical biases (Figure 1)
- We have developed a next generation retrieval algorithm that uses the full spectral content from OMI while maintaining computation efficiency

Operational OMI SO_2 (Sept. 2004 – Feb. 2008)

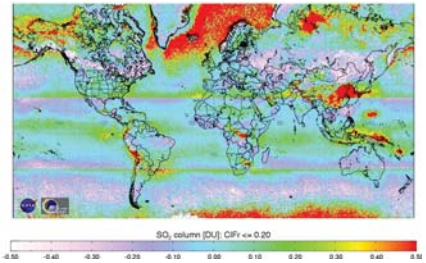
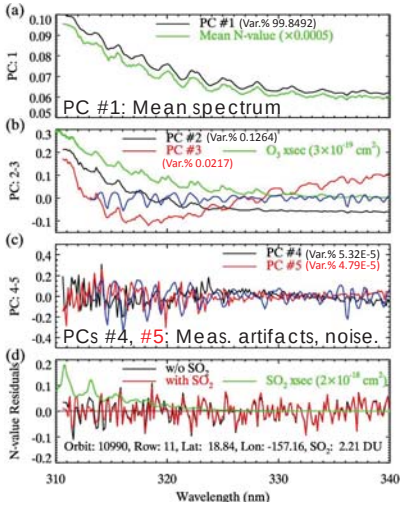


Figure 1. Current operational BRD (band residual difference) algorithm is sensitive to anthropogenic pollution in the boundary layer (PBL), but has unphysical biases

Methodology

Use principal component analysis (PCA) technique to directly extract spectral features (PCs) from the radiances.



First few PCs obtained from one row of an orbit over the Pacific are related to known physical processes

PC #2: O_3 absorption
PC #3: Surface reflectance (also RRS or Ring signature)

First five PCs explain over 99.99% of variance

Inclusion of SO_2 Jacobians in fitting reduces residuals

Methodology (cont.)

Use of PCs in spectral fitting to account for various interferences in SO_2 retrievals and other instrumental features.

Measured Sun-normalized radiance spectrum

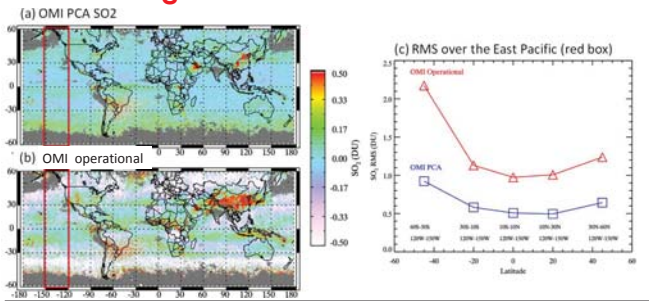
SO_2 column amount

$$N(\omega, \Omega_{SO_2}) = \sum_{i=1}^{n_v} \omega_i v_i + \Omega_{SO_2} \frac{\partial N}{\partial \Omega_{SO_2}},$$

PCs from SO_2-free regions for processes(O_3 absorption, RRS, etc.) **other than SO_2 absorption**

Pre-calculated SO_2 Jacobians (assuming O_3 profiles, albedo, etc.)

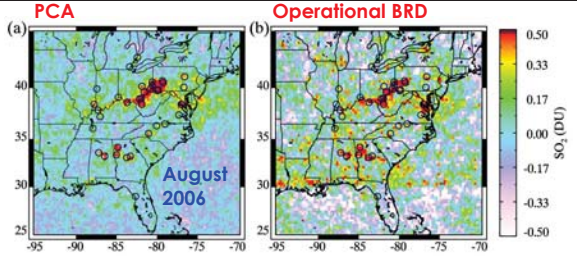
New PCA Algorithm Reduces Noise and Artifacts



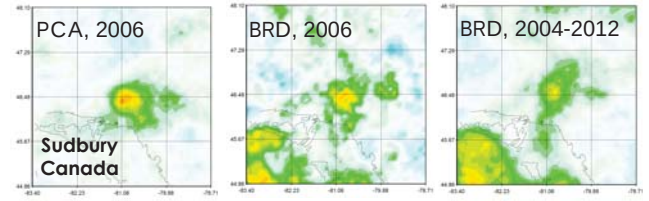
PCA algorithm reduces retrieval noise by a factor of two as compared with the BRD algorithm (same assumptions in retrievals)

Greater Sensitivity to SO_2 Pollution

PCA algorithm reveals major SO_2 point sources (below, circles), with much reduced noise and artifacts.

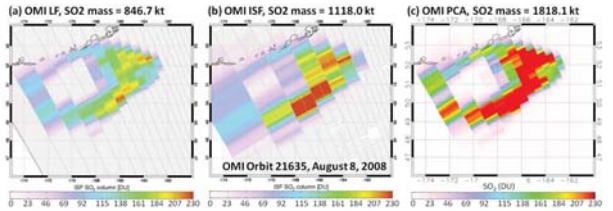


Analysis using the super sampling technique shows that **sources ~30 kt/yr are identifiable in PCA data (vs. ~70 kt/yr for operational data)**



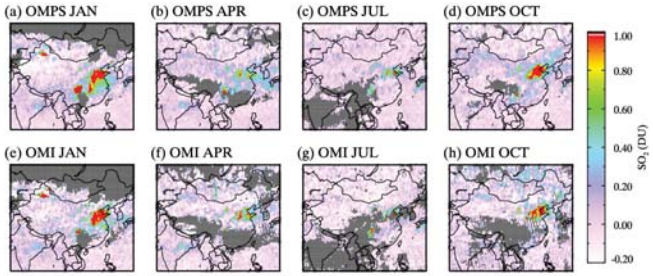
Reduced Negative Bias in Large Volcanic Plumes

Kasatochi eruption August 7-8, 2008, largest in Aura era



PCA closest to estimated released SO_2 mass of ~2200 kt based on observed decay of SO_2 [Krotkov et al., 2010]

Max Data Continuity between Instruments



OMI and OMPS PCA SO_2 data show similar seasonal patterns and SO_2 signals

Implementation Status and Next Steps

- The PCA algorithm has been operationally implemented for OMI PBL SO_2 retrievals
- Forward processing ongoing
- Reprocessing of the entire OMI mission finished within five days
- Initial evaluation done, public release pending approval
- Preliminary intercomparison with TROPOMI pre-launch algorithm shows good agreement
- A new version with more comprehensive error analysis and SO_2 Jacobians look-up table under development
- The same algorithm also being implemented on GOME-2 and OMPS for a long-term dataset on anthropogenic SO_2 pollution

For More Information

Li, C., J. Joiner, N. A. Krotkov, and P. K. Bhartia (2013), A fast and sensitive new satellite SO2 retrieval algorithm based on principal component analysis: Application to the ozone monitoring instrument, Geophys. Res. Lett., 40, doi:10.1002/2013GL058134.

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