Towards a Standard AIRS SO$_2$ Product: A Multi-Sensor Comparison Exercise

V. J. Realmuto
Jet Propulsion Laboratory,
California Institute of Technology

Leonid Yurganov, JCET UMBC
Fred Prata, Nicarnica Aviation
Nickolay Krotkov, NASA-GSFC

This report presents comparisons between SO2 volcanic results obtained by 3 TIR techniques and 2 UV techniques.

1) A retrieval techniques developed at UMBC by Scott Hannon and Larrabee Strow (HSA).

2) A modified (fast) HSA. It is under testing now. Currently both algorithm are realized in MATLAB language. Our goal is a development of a FORTRAN-based code based on one algorithm or another. This code may be introduced into the GSFC computer system.


Multi-Sensor Comparison: UV SO2 retrievals for OMI/Aura and OMPS/NPP TIR retrievals for VIIRS and MODIS
Solar UV and thermal IR techniques

**Solar** radiance has a maximum near $\lambda \sim 0.5 \mu m$ (500 nm), and it is attenuated by scattering, clouds, aerosol, gases, etc.

**Thermal** (or terrestrial) radiance has a maximum near $\lambda \sim 12 \mu m$ ($\nu = 1/\lambda = 800$ cm$^{-1}$)

Schematic distribution of energy in spectra of the Sun and the Earth

- Sun/10^5
- Earth
- SO$_2$
- CH$_4$
- O$_3$
- CO$_2$

OMI, SCIAMACHY, OMPS, etc

T ~ 6000 K

T ~ 270-300 K

AIRS, IASI, CrIS, etc
AIRS High-Resolution (2000+ Channels) Spectra: Unique Identification of Plume Constituents

MODIS-Aqua 2009-06-16

AIRS BTD Spectra 2009-06-16

Model BTD Spectra
Holuhraun Fissure, Bardarbunga Volcano, Iceland

- Lava Fountains Give Rise to Gas Plumes
- Multiple Sources for Plumes along Fissure
- Gas Plume Lies Beneath Opaque Steam Plume
- Low-Altitude Plumes: 3 – 5 km
Bardarbunga Volcano
2014-09-23
12:39 UTC

ASTER VNIR Color Composite

ASTER TIR Color Composite

SO$_2$ plume beneath steam plume

0  DU  2450

0  g/m$^2$  70
VIIRS / 2014-09-23 / 12:30 UTC

RGB Color Composite

- Heterogeneous Viewing Conditions: Clouds, Land and Sea Surface, Glacial Ice
- Complexity within an AIRS IFOV

TIR Color Composite

250 km
2014-09-05
Night-Time Observations
Total Mass: 19.5 kt
Bardarbunga Volcano

AIRS Operational SO₂ Retrieval

2014-09-05 03:29 UTC

Coarse Spatial Resolution (~15 km) Dilutes SO₂ Conc. Relative to MODIS (1 km) or VIIRS (750 m)

0.6 0.3 0.0 g/m²
Calculations of Averaging Kernels

Background SO₂ profile with 0.133 DU is assumed.

1. 3 layers (## 10, 11, 12)* taken together were perturbed by 3 DU of SO₂, total 3.133
2. SARTA calculates outgoing radiance
3. This radiance is used as “observed” radiance for the Hannon-Strow retrieval algorithm.
4. SO₂ in the layer between 5 and 10 km is tuned until the “observed” radiance in SO2 lines coincide with calculated one.
5. AK for the given altitude is: HSA-retrieved delta (SO₂) in DU divided by 3 DU.
6. Go to (1) but for layers ## 12, 13, 14 and so on down to bottom.

AK Indicates Lack of Sensitivity Below 5 km.

Does HSA Miss Significant Amounts of Low-Altitude SO₂?

Total Mass (kilotonnes)
MODIS-Aqua: 19.5 kt
VIIRS: 37 kt
AIRS/HSA: 0.562 kt

Max. SO₂ (Dobson Units)
AIRS/Prata: ~ 28 DU
AIRS/HSA: ~ 7 DU
NEW Comparison Hannon-Strow and Fred Prata (RCOL>0.3) algorithms pixel-by-pixel
2014.09.05.034
Leonid Yurganov

I deleted points with RCOL<0.3. All these points are with low SO2, so the scattergram has not changed.

Plume is at [-15 62]. Points around are below HS detection limit, all of them are assigned values 0.321 DU. The threshold for HSA may be changed, however. The SO2 difference for the plume is obvious.
Blow up for the area determined by HSA as area with high SO2

Below HSA detection limit
2014-09-05
Day Time Observations
MODIS-Aqua: 13:05 UTC
VIIRS: 13:10 UTC

Bardarbunga Volcano
2014-09-05
True-Color Composites
Total Mass: 35.6 kt
Day-Time Observation Enables UV-Based Retrievals

Plume Height (CMA): 8 km

Total Mass (kilotonnes)
OMI: 93.7 kt
VIIRS: 35.6 kt
AK Indicates Lack of Sensitivity Below 5 km

Total Mass (kilotonnes)
OMI: 93.7 kt
VIIRS: 35.6 kt
AIRS/HSA: 0.093 kt

Max. SO$_2$ (Dobson Units)
AIRS/Prata: ~ 9 DU
AIRS/HSA: ~ 2 DU
Thanks for Your Attention.
Any Questions?