Towards a Standard AIRS SO_2 Product: A Multi-Sensor Camparison Exercise

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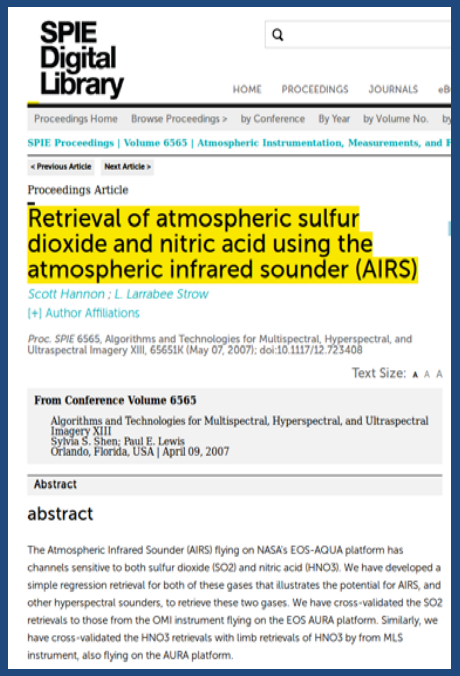
Outline

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



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Proceedings Article

Retrieval of atmospheric sulfur dioxide and nitric acid using the atmospheric infrared sounder (AIRS)

Scott Hannon ; L. Larrabee Strow

[+] Author Affiliations

Proc. SPIE 6565, Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XIII, 65651K (May 07, 2007); doi:10.1117/12.723408

Text Size: A A A

From Conference Volume 6565

Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XIII
Sylvia S. Shen; Paul E. Lewis
Orlando, Florida, USA | April 09, 2007

Abstract

abstract

The Atmospheric Infrared Sounder (AIRS) flying on NASA's EOS-AQUA platform has channels sensitive to both sulfur dioxide (SO2) and nitric acid (HNO3). We have developed a simple regression retrieval for both of these gases that illustrates the potential for AIRS, and other hyperspectral sounders, to retrieve these two gases. We have cross-validated the SO2 retrievals to those from the OMI instrument flying on the EOS AURA platform. Similarly, we have cross-validated the HNO3 retrievals with limb retrievals of HNO3 by from MLS instrument, also flying on the AURA platform.

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.

Both UMBC algorithms use a fast radiation transfer code SARTA . [*Strow, L., H. Motteler, R. Benson, S. Hannon, and S. De Souza-Machado(1998), Fast computation of monochromatic infrared atmospheric transmittances using compressed look-up tables, J. Quant. Spectrosc. Rad.Trans., 59(3-5), 481 – 493*.]

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

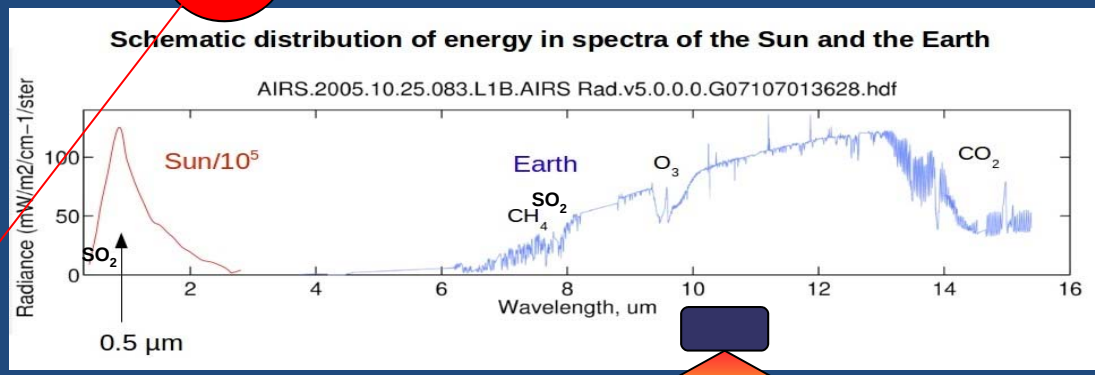
3) The UMBC retrievals are being compared with the retrievals by Scott Hannon (NILU, Norway) that is also in use at the GSFC in NRT mode.

Solar UV and thermal IR techniques

T ~ 6000 K

Solar radiance has a maximum near λ~ 0.5 µm (500 nm), and it is attenuated by scattering, clouds, aerosol, gases, etc

Thermal (or terrestrial) radiance has a maximum near λ~12 µm (ν=1/λ=800 cm^{-1})

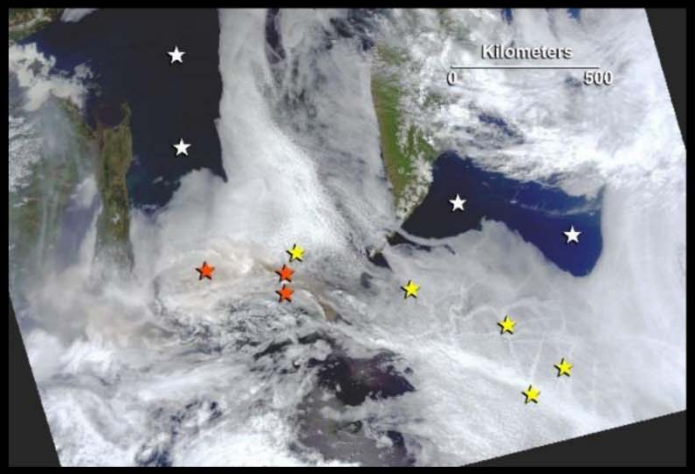


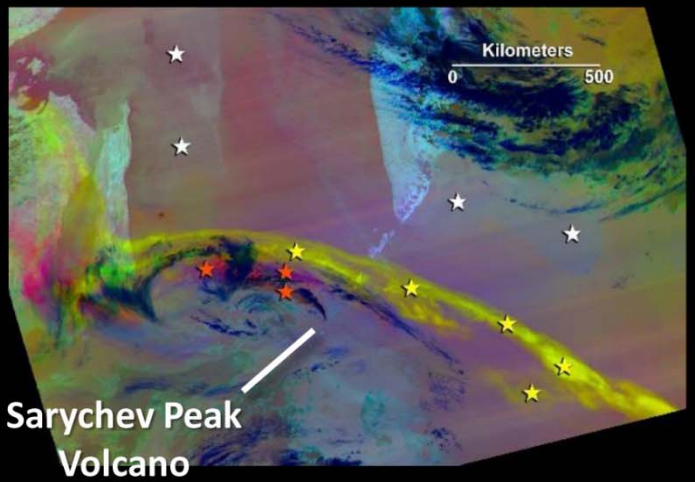
OMI, SCIAMACHY, OMPS, etc

AIRS, IASI, CrIS, etc

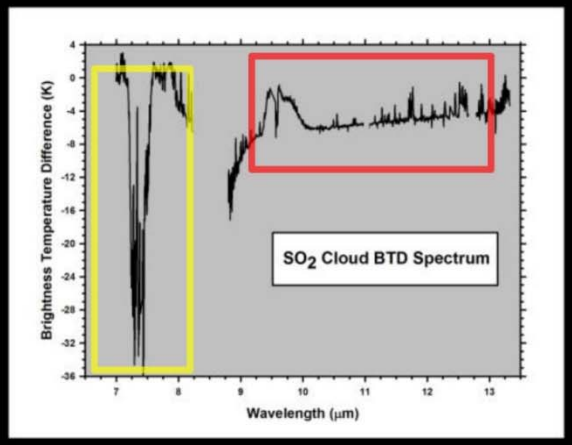
T ~ 270-300 K

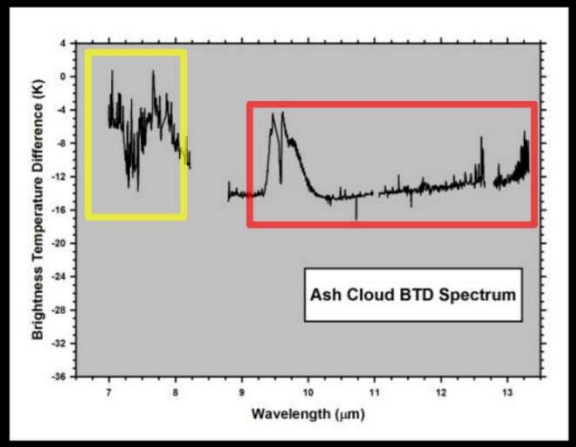
AIRS High-Resolution (2000+ Channels) Spectra: Unique Identification of Plume Constituents



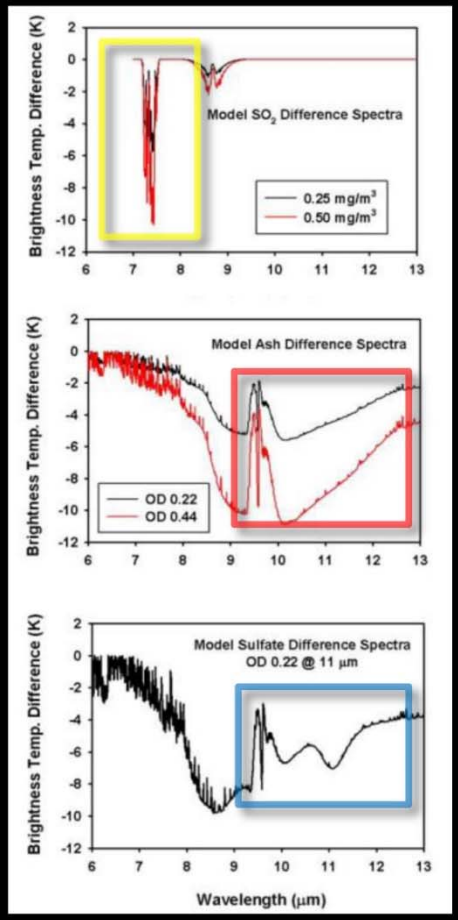


MODIS-Aqua
2009-06-16

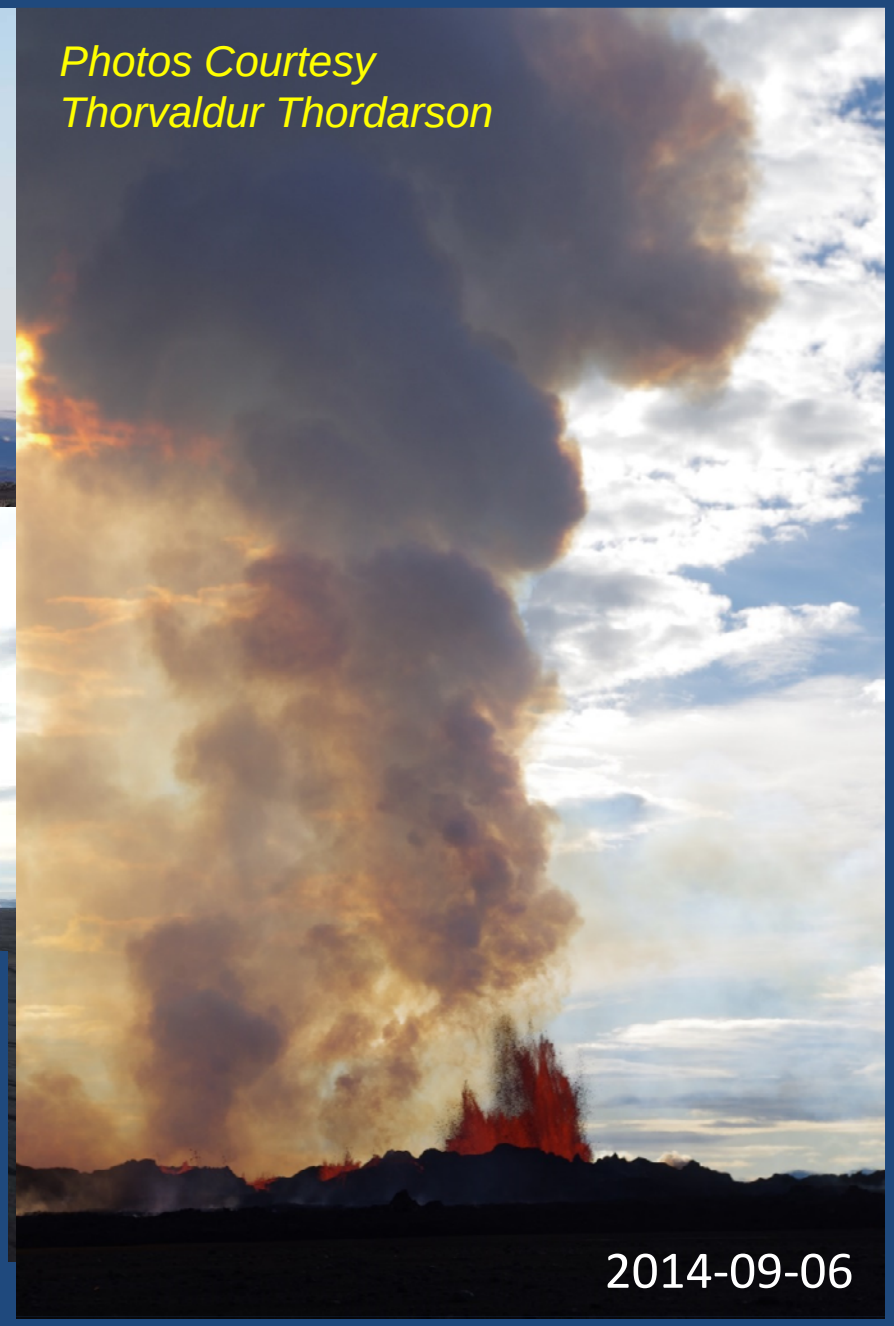




AIRS BTD Spectra
2009-06-16



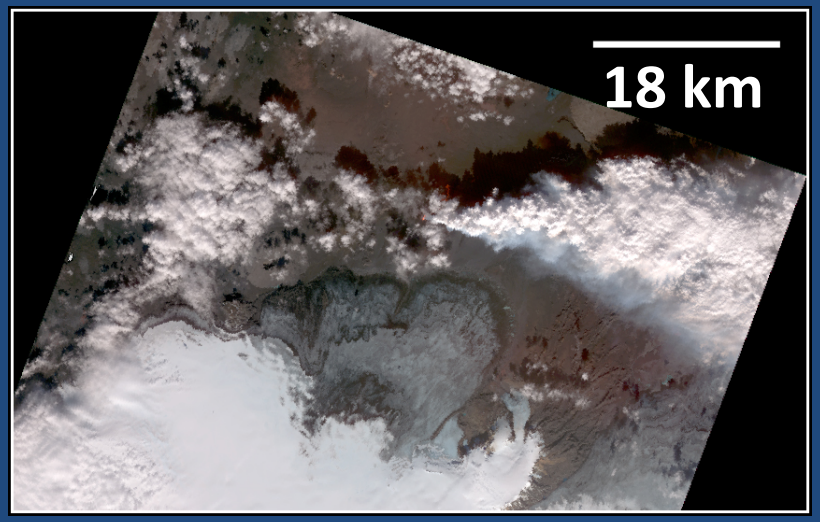
Model BTD
Spectra



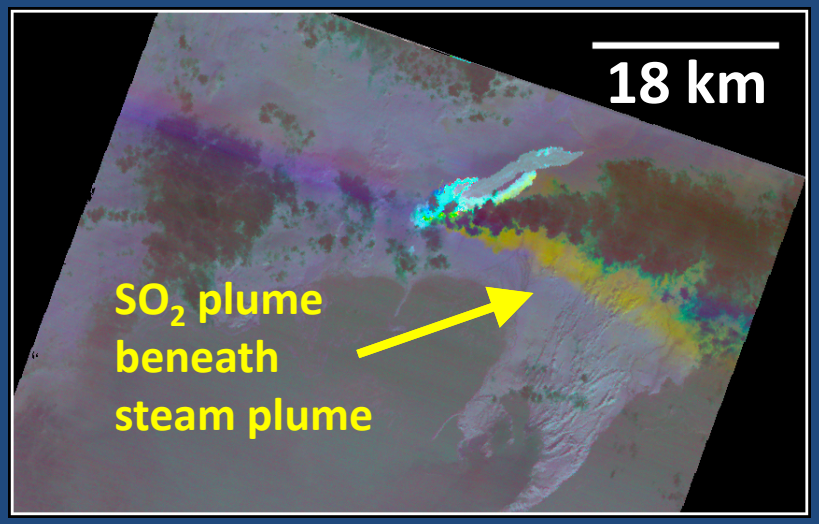
Holuhraun Fissure, Bardarbunga Volcano, Iceland

- 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

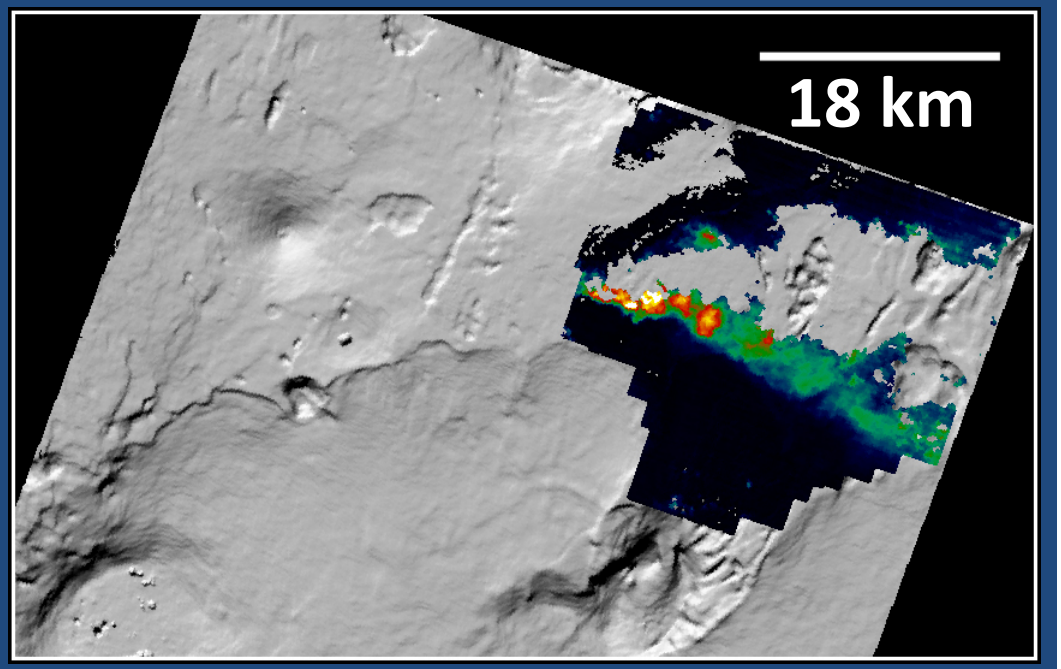
Bardarbunga Volcano
2014-09-23
12:39 UTC

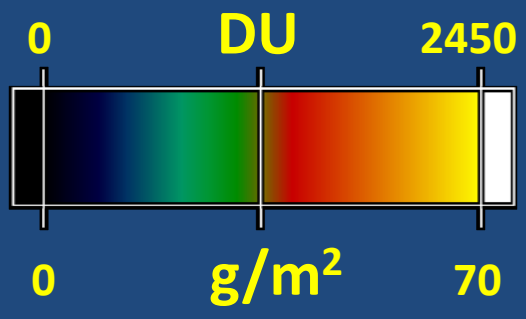


ASTER VNIR Color Composite

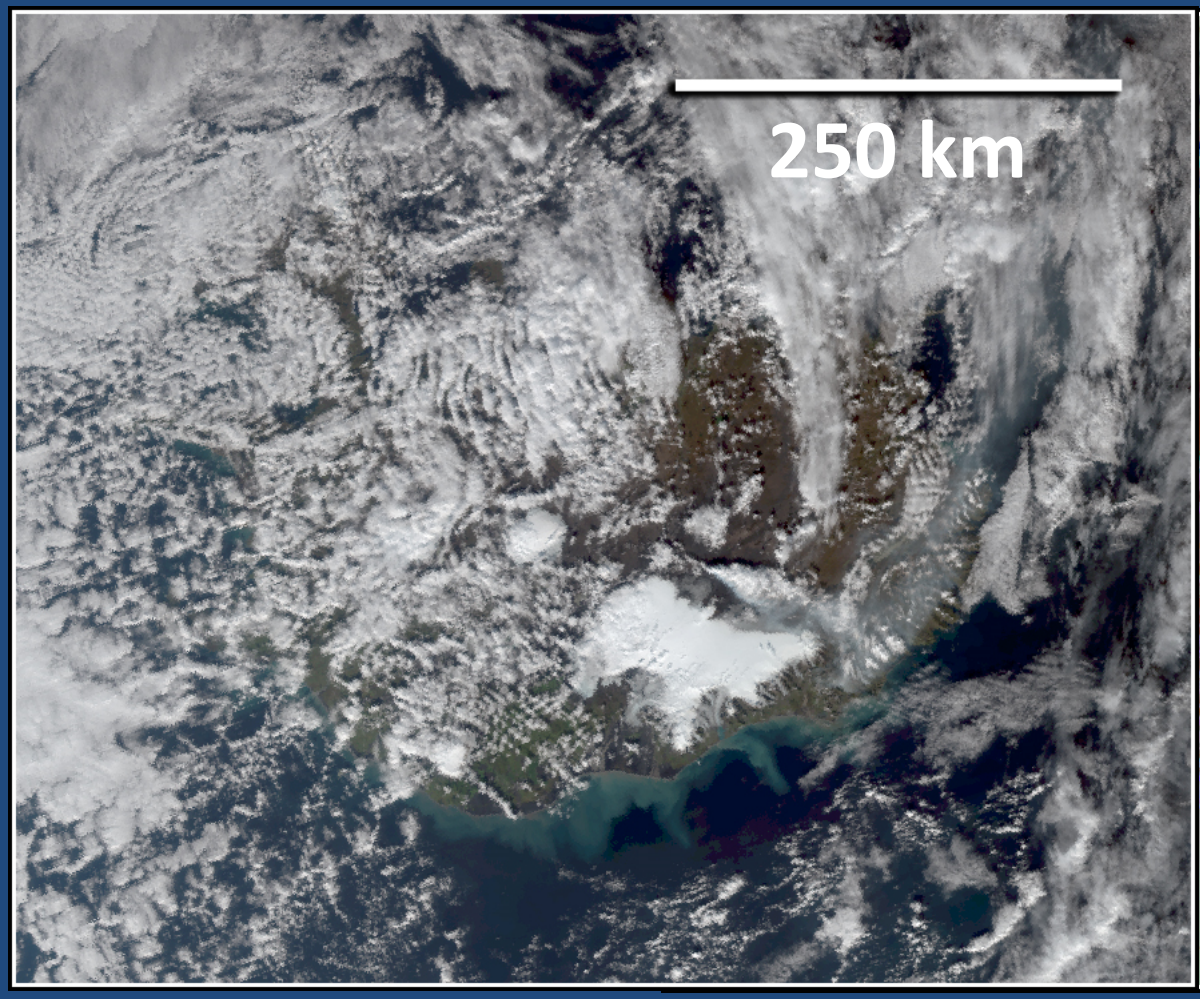


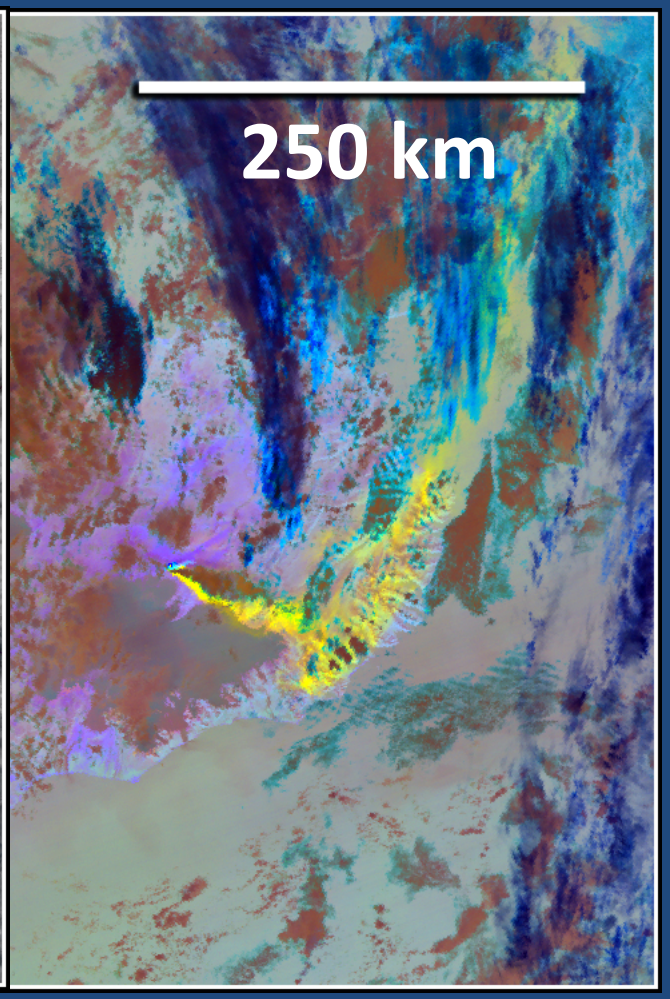
ASTER TIR Color Composite





VIIRS / 2014-09-23 / 12:30 UTC



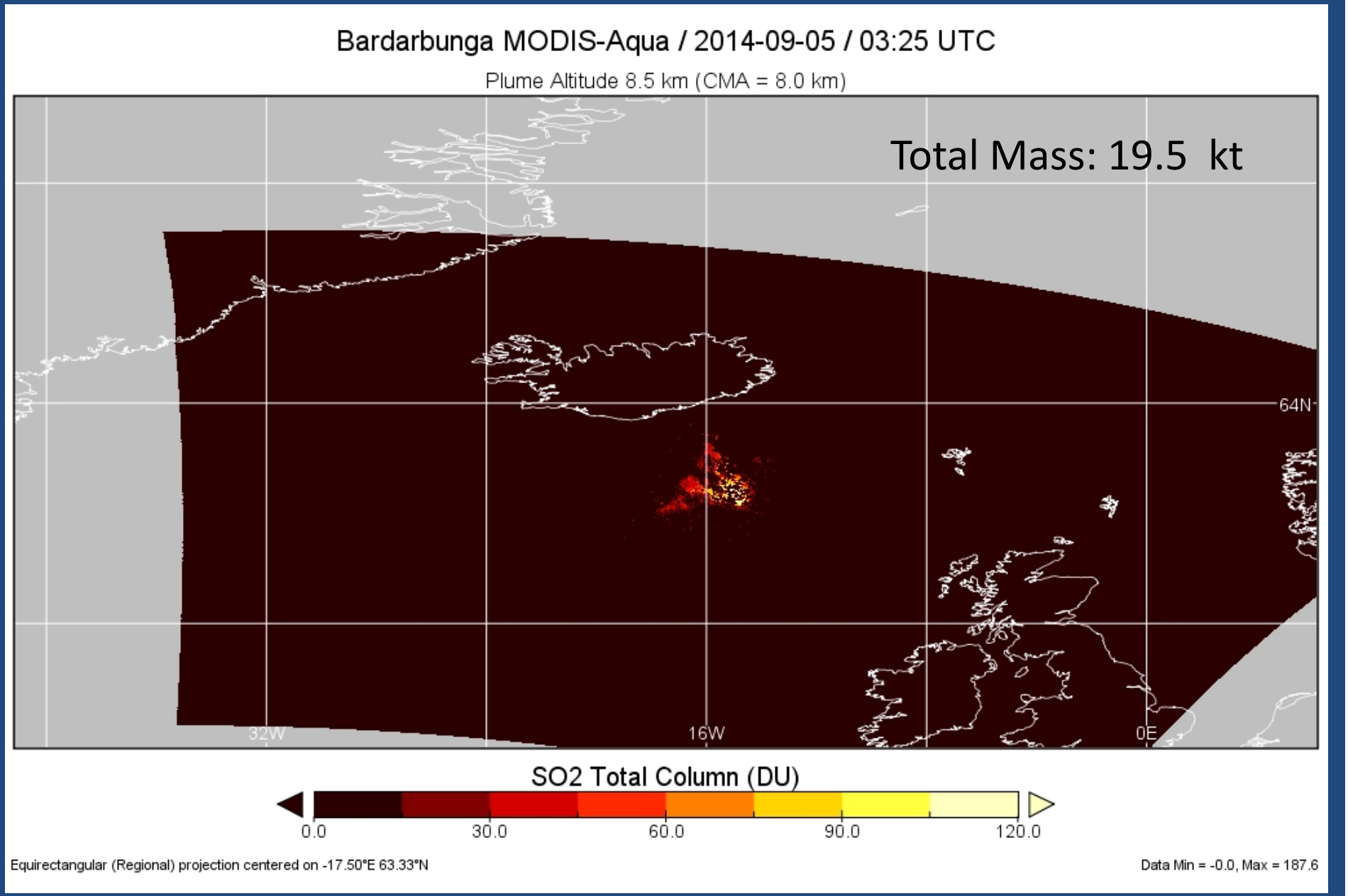


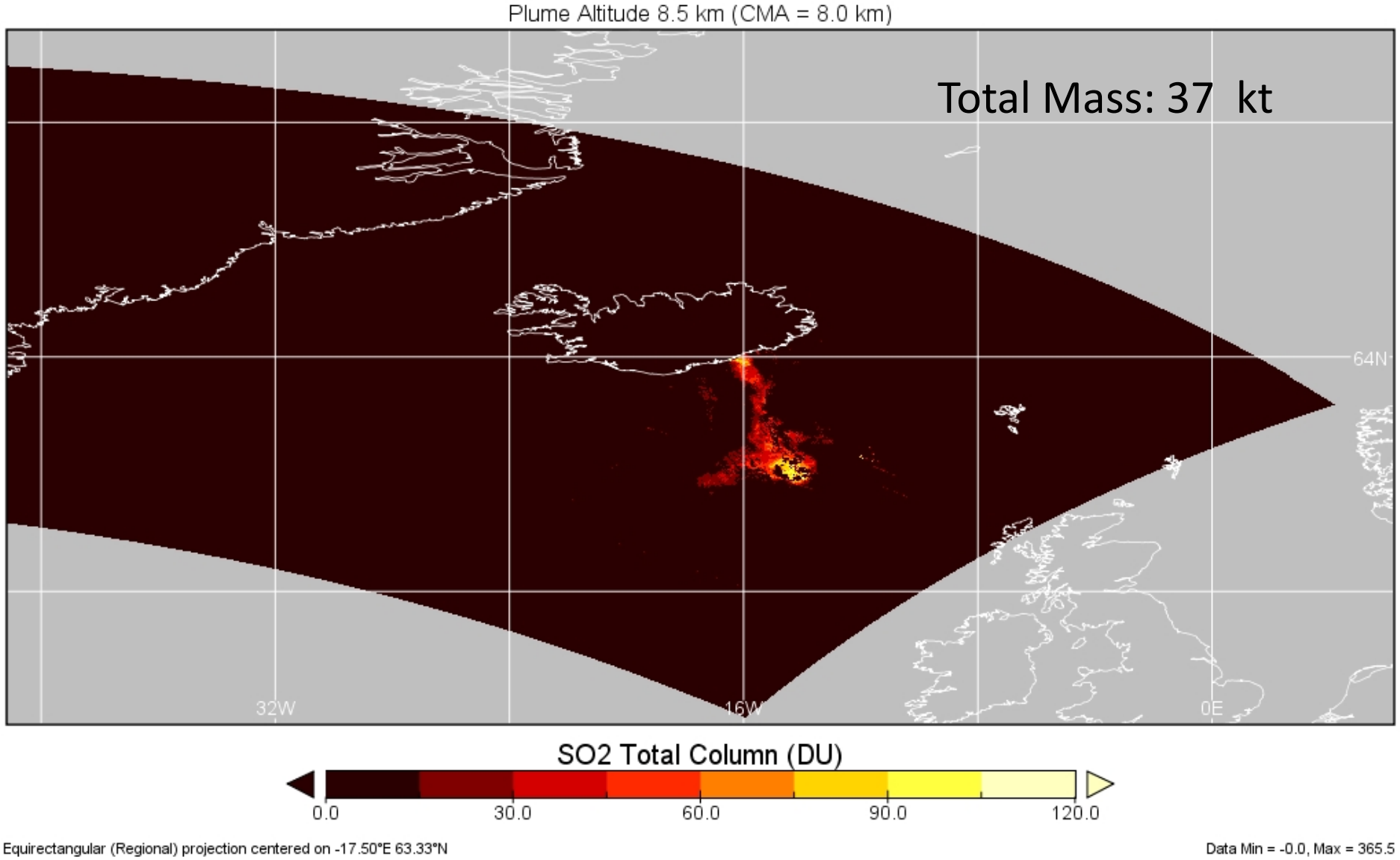
RGB Color Composite

TIR Color Composite

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

2014-09-05
Night-Time Observations


Bardarbunga MODIS-Aqua / 2014-09-05 / 03:25 UTC
Plume Altitude 8.5 km (CMA = 8.0 km)
Total Mass: 19.5 kt
64N
32W
16W
0E
SO2 Total Column (DU)
0.0
30.0
60.0
90.0
120.0
Equirectangular (Regional) projection centered on -17.50°E 63.33°N
Data Min = -0.0, Max = 187.6

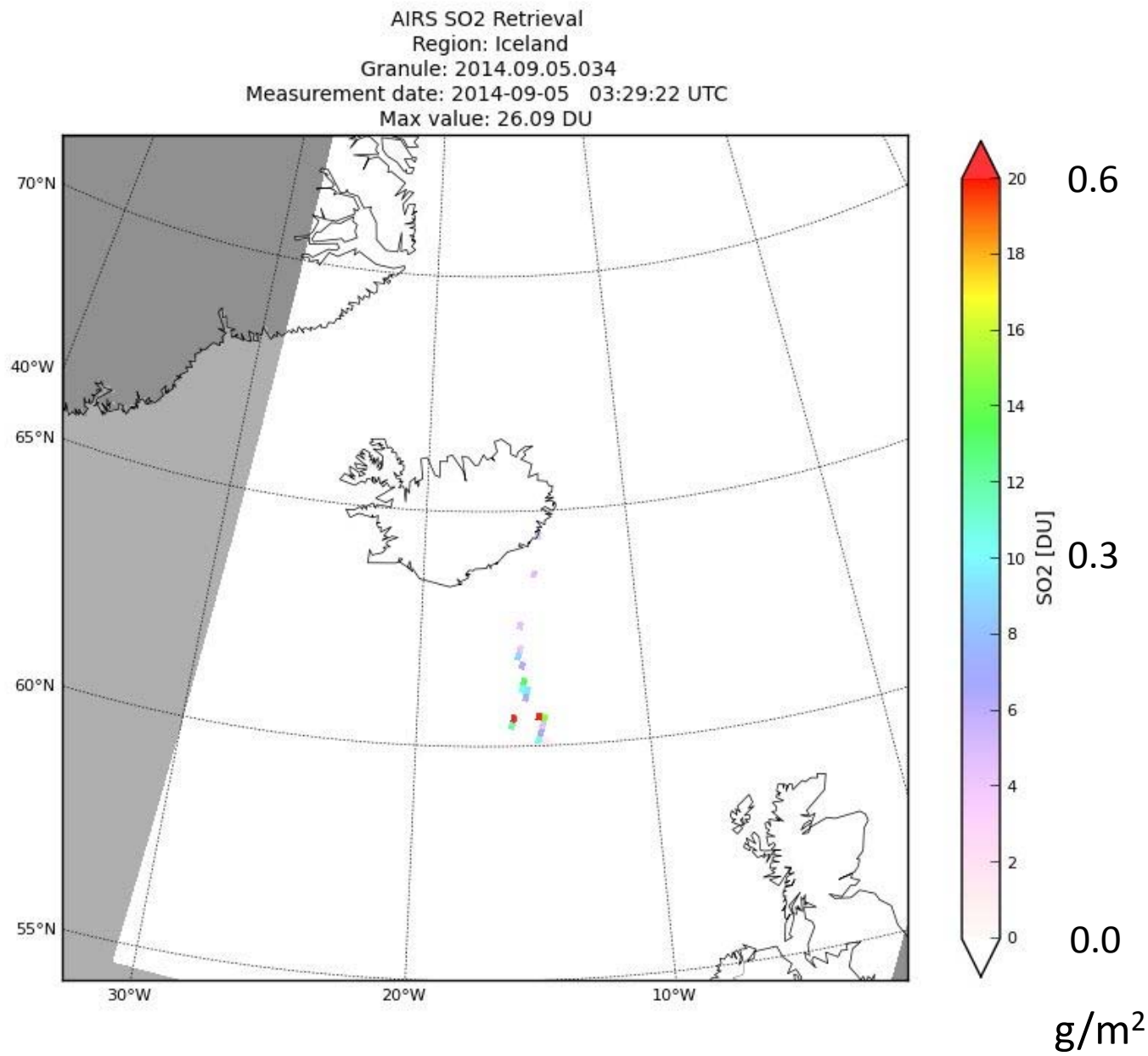

Bardarbunga VIIRS / 2014-09-05 / 04:55 UTC
Plume Altitude 8.5 km (CMA = 8.0 km)
Total Mass: 37 kt
64N
32W
16W
0E
SO2 Total Column (DU)
0.0
30.0
60.0
90.0
120.0
Equirectangular (Regional) projection centered on -17.50°E 63.33°N
Data Min = -0.0, Max = 365.5

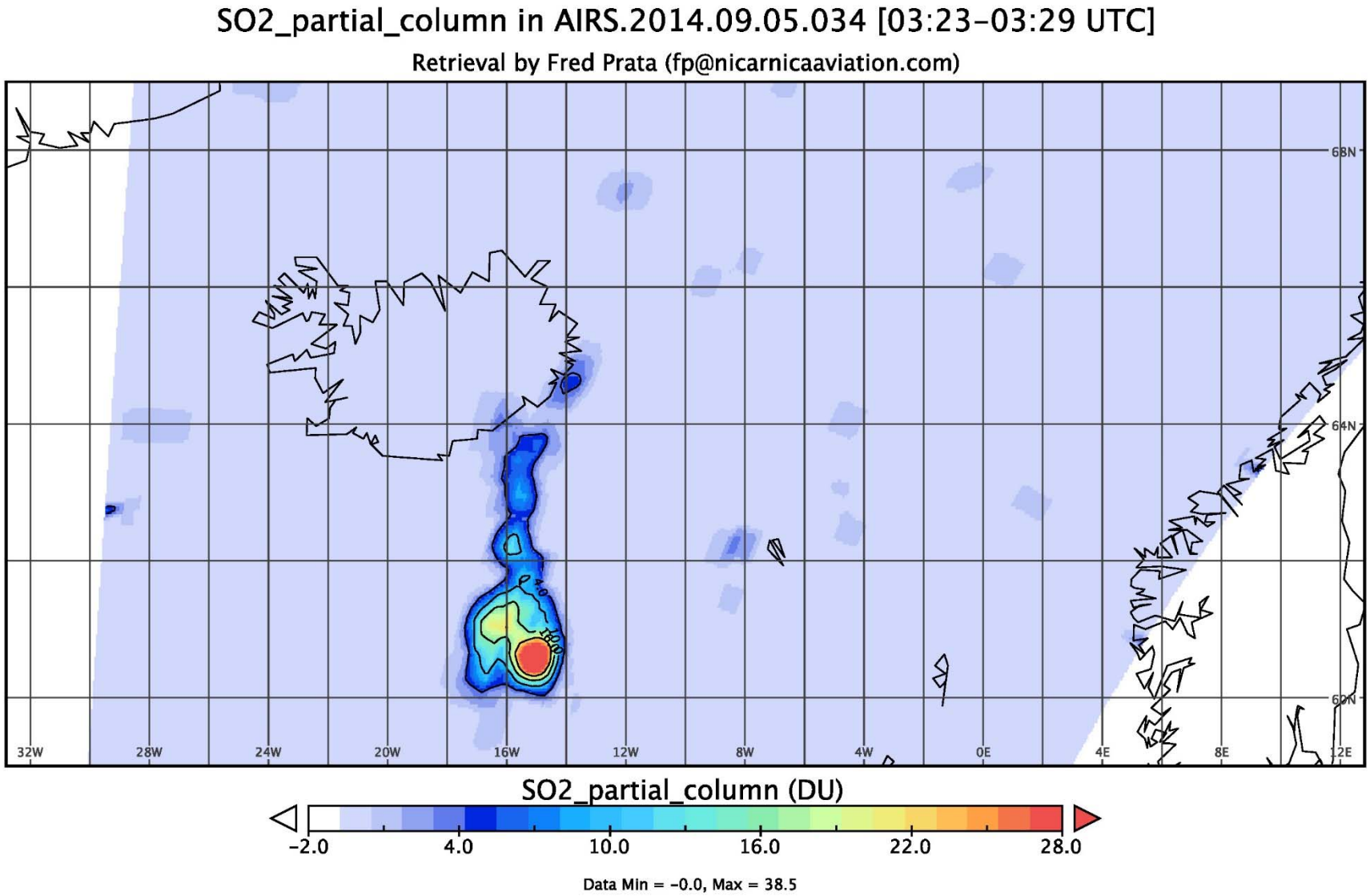
Bardarbunga Volcano

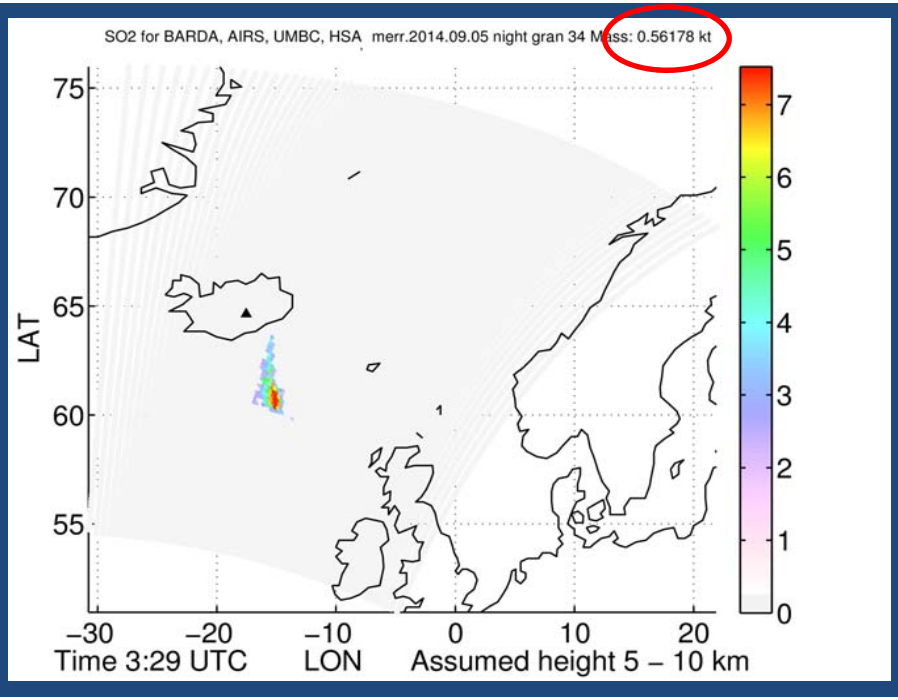
AIRS Operational SO_2 Retrieval

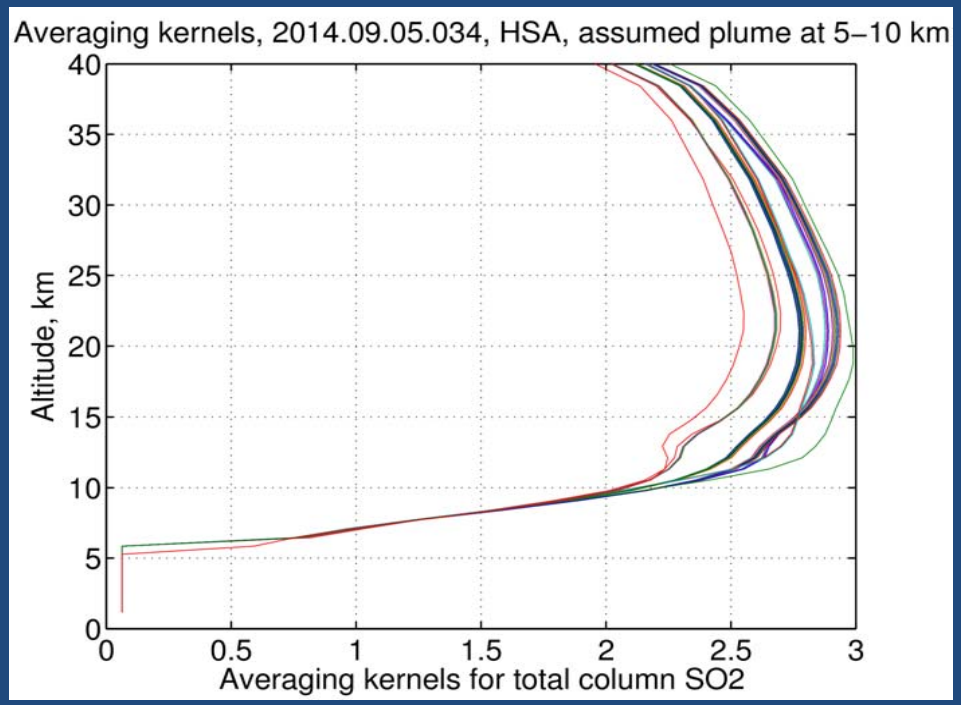
2014-09-05
03:29 UTC

Coarse Spatial Resolution (~15 km) Dilutes SO_2 Conc. Relative to MODIS (1 km) or VIIRS (750 m)




SO2_partial_column in AIRS.2014.09.05.034 [03:23-03:29 UTC]
Retrieval by Fred Prata (fp@nicarnicaaviation.com)
68N
64N
60N
32W
28W
24W
20W
16W
12W
8W
4W
0E
4E
8E
12E
SO2_partial_column (DU)
-2.0
4.0
10.0
16.0
22.0
28.0
Data Min = -0.0, Max = 38.5





Calculations of Averaging Kernels

Background SO_2 profile with 0.133 DU is assumed.

1. 3 layers (## 10, 11, 12)* taken together were perturbed by 3 DU of SO_2, total 3.133
2. SARTA calculates outgoing radiance
3. This radiance is used as "observed" radiance for the Hannon-Strow retrieval algorithm.
4. SO_2 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 (SO_2) in DU divided by 3 DU.
6. 4. 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 SO_2?

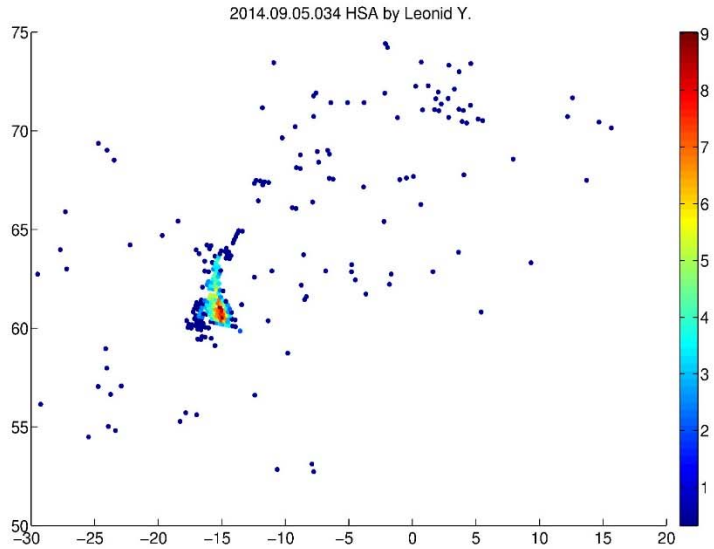
Total Mass (kilotonnes)

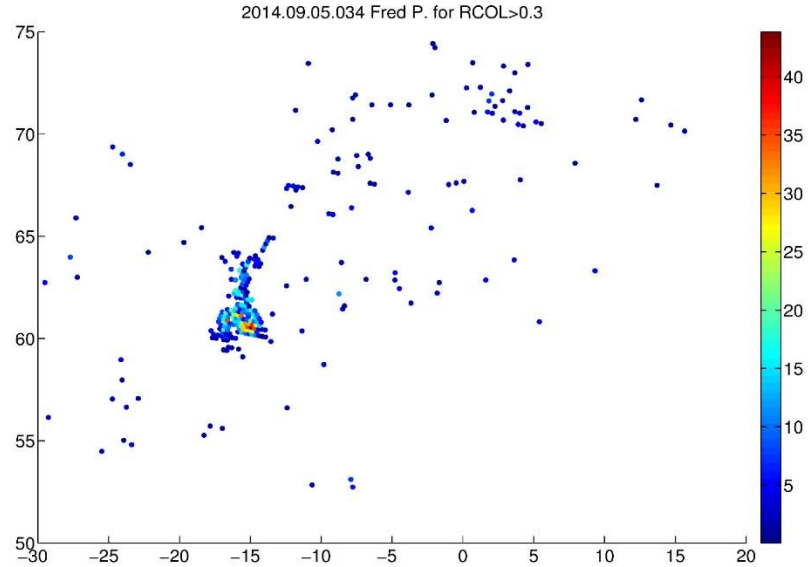
MODIS-Aqua:	19.5 kt
VIIRS:	37 kt
AIRS/HSA:	0.562 kt

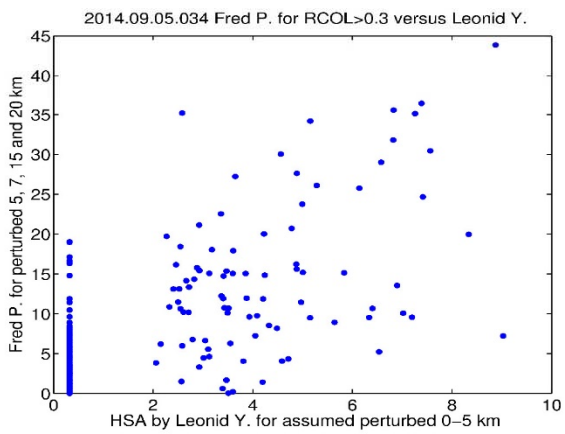
Max. SO_2 (Dobson Units)

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

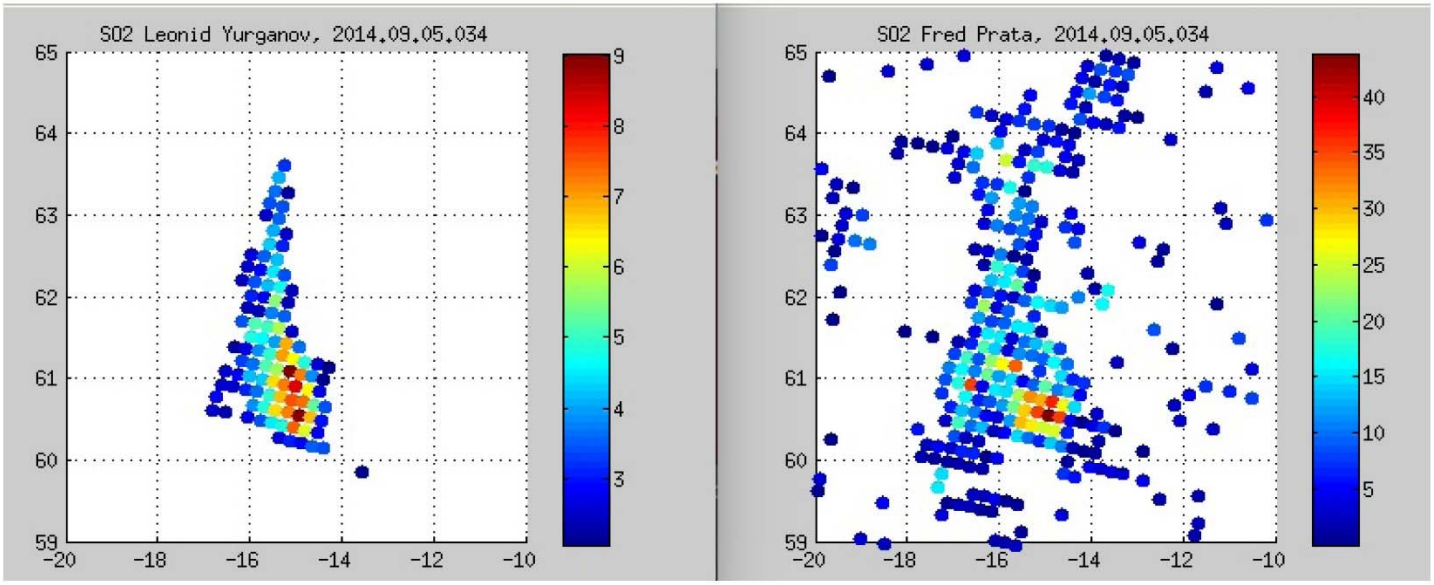




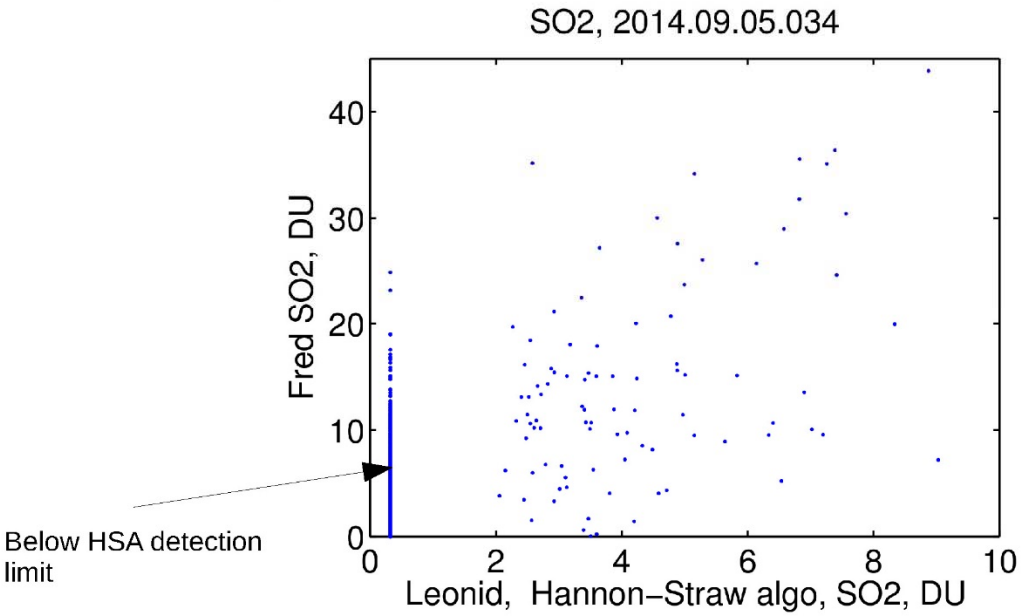


I deleted points with RCOL<0.3. All these points are with low SO2, so the scattergram has not changed.

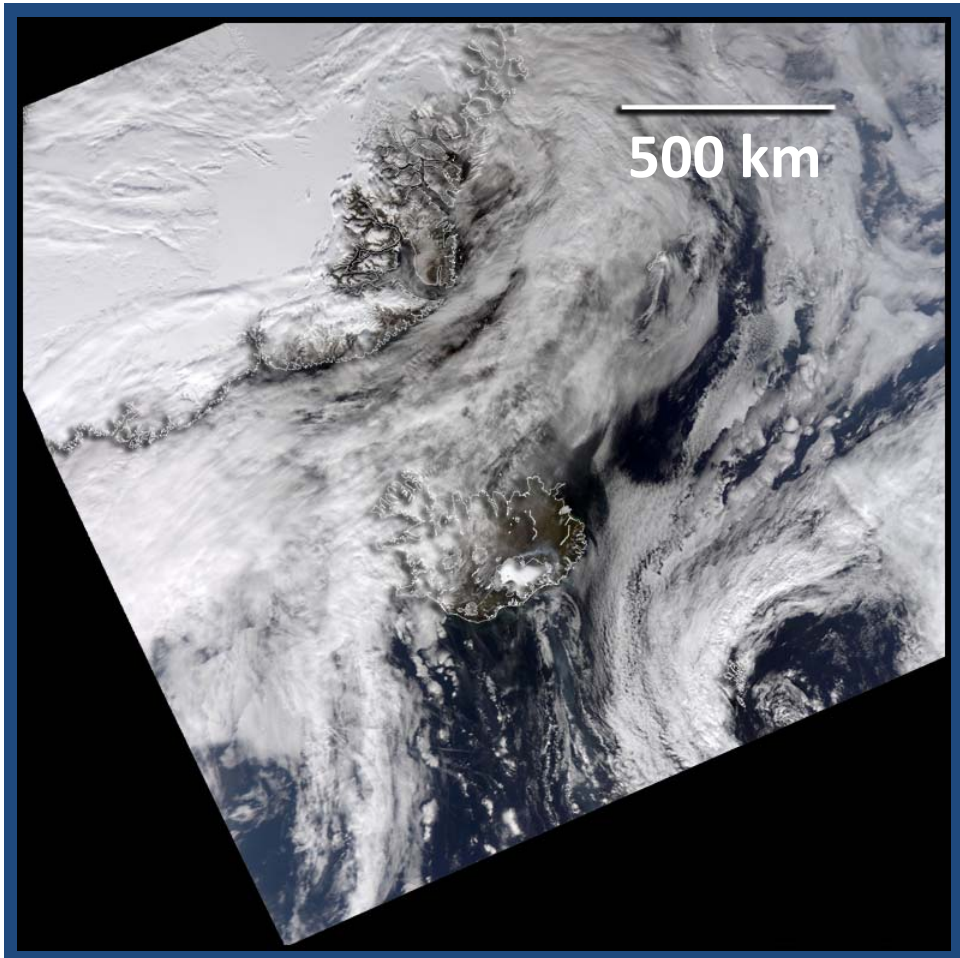
Plume is at [-15 62]. Points around are below HS detection limit, all of them are assigned values 0.321 DU. The threshold for HSA may be changed, however. The SO2 difference for the plume is obvious.



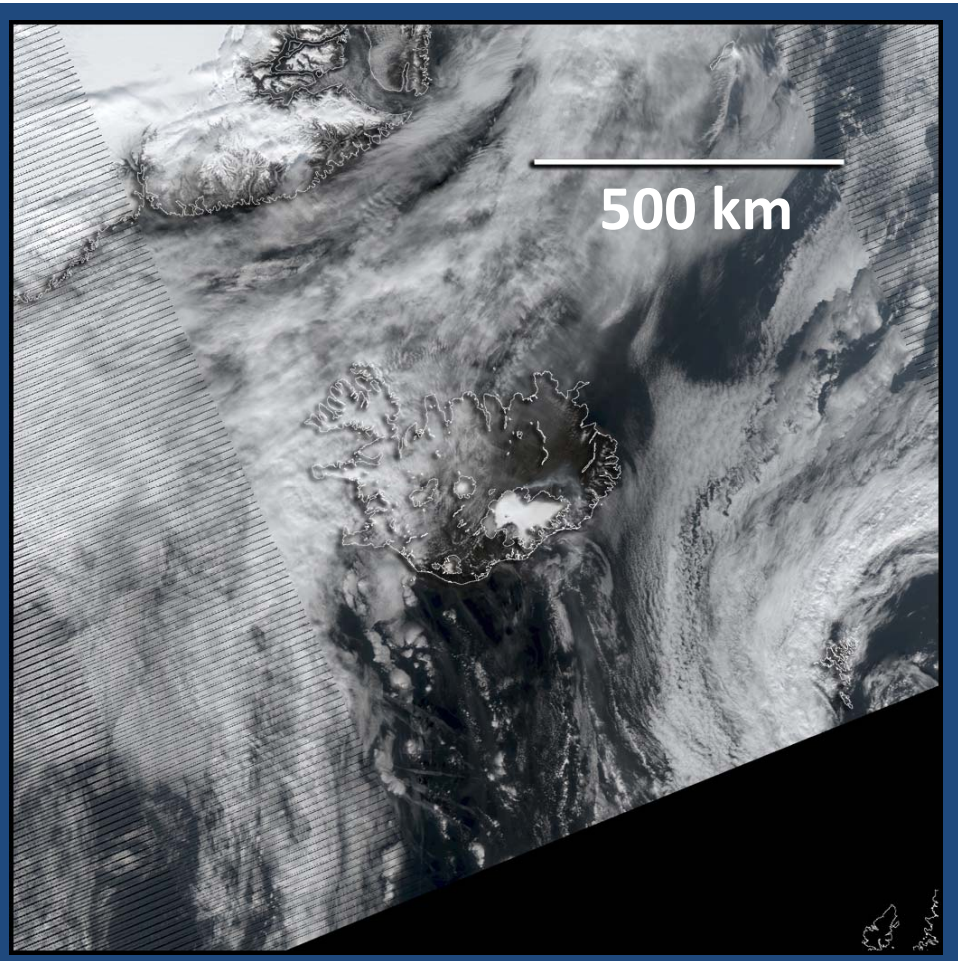
Blow up for the area determined by HSA as area with high SO2



2014-09-05
Day Time Observations

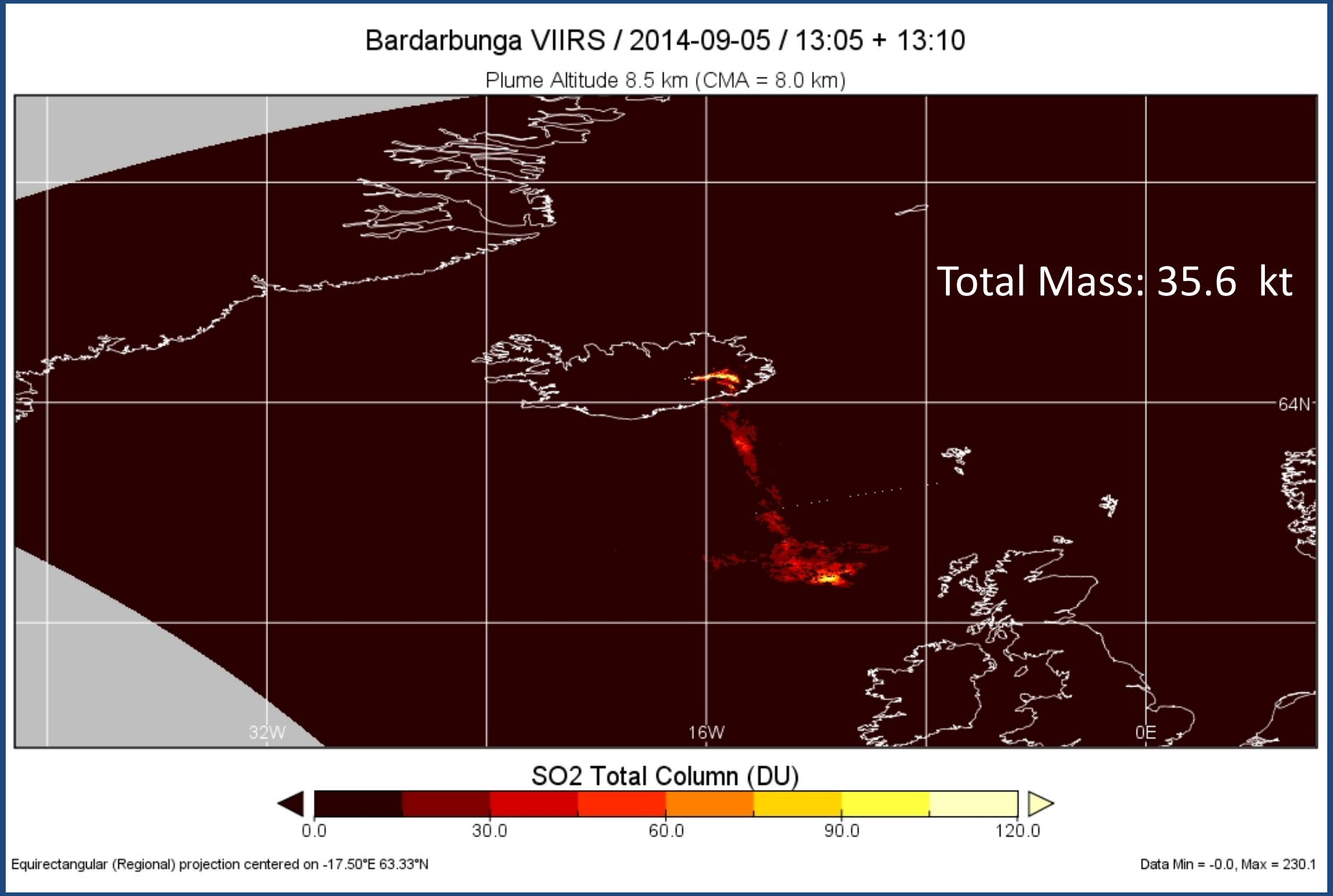


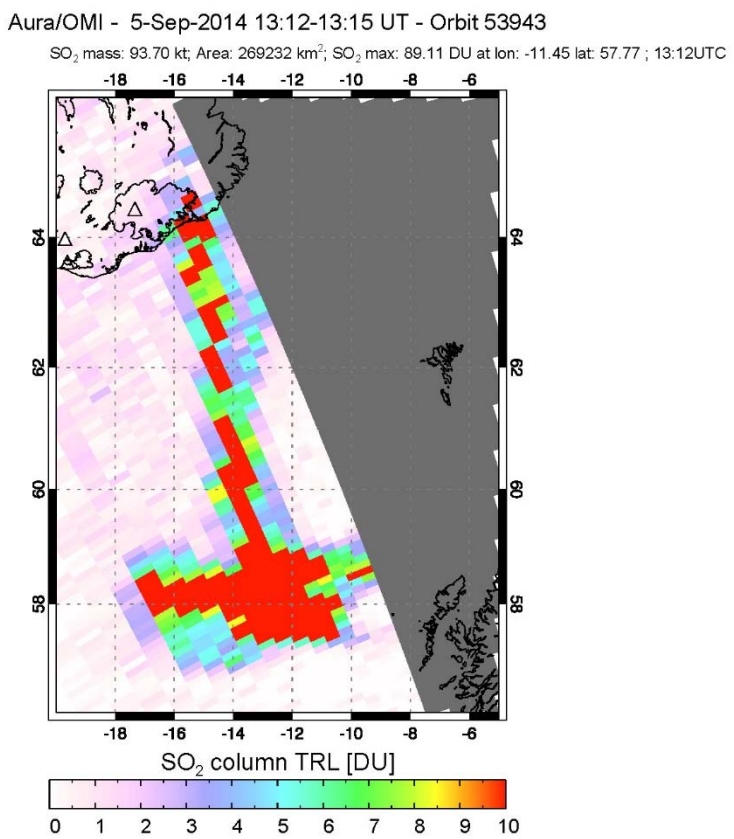
MODIS-Aqua: 13:05 UTC



VIIRS: 13:10 UTC

Bardarbunga Volcano
2014-09-05
True-Color Composites

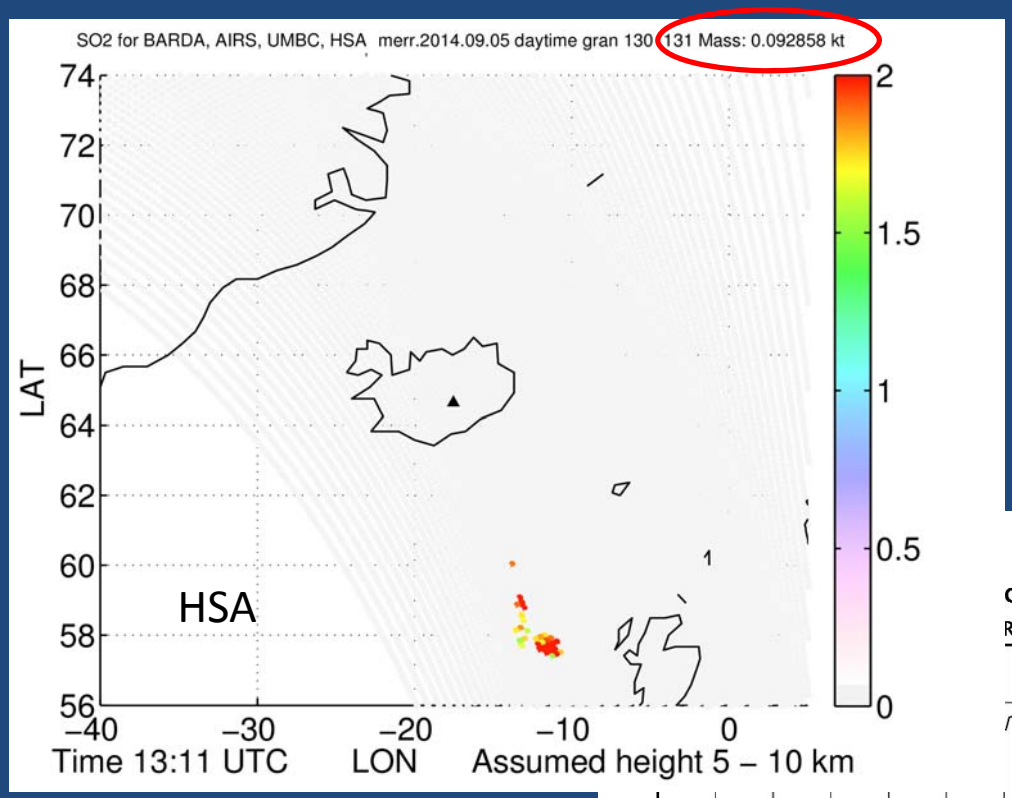

Bardarbunga VIIRS / 2014-09-05 / 13:05 + 13:10
Plume Altitude 8.5 km (CMA = 8.0 km)
Total Mass: 35.6 kt
64N
32W
16W
0E
SO2 Total Column (DU)
0.0
30.0
60.0
90.0
120.0
Equirectangular (Regional) projection centered on -17.50°E 63.33°N
Data Min = -0.0, Max = 230.1

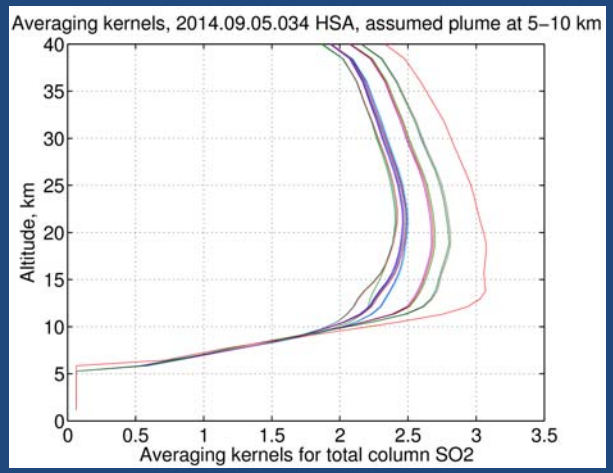


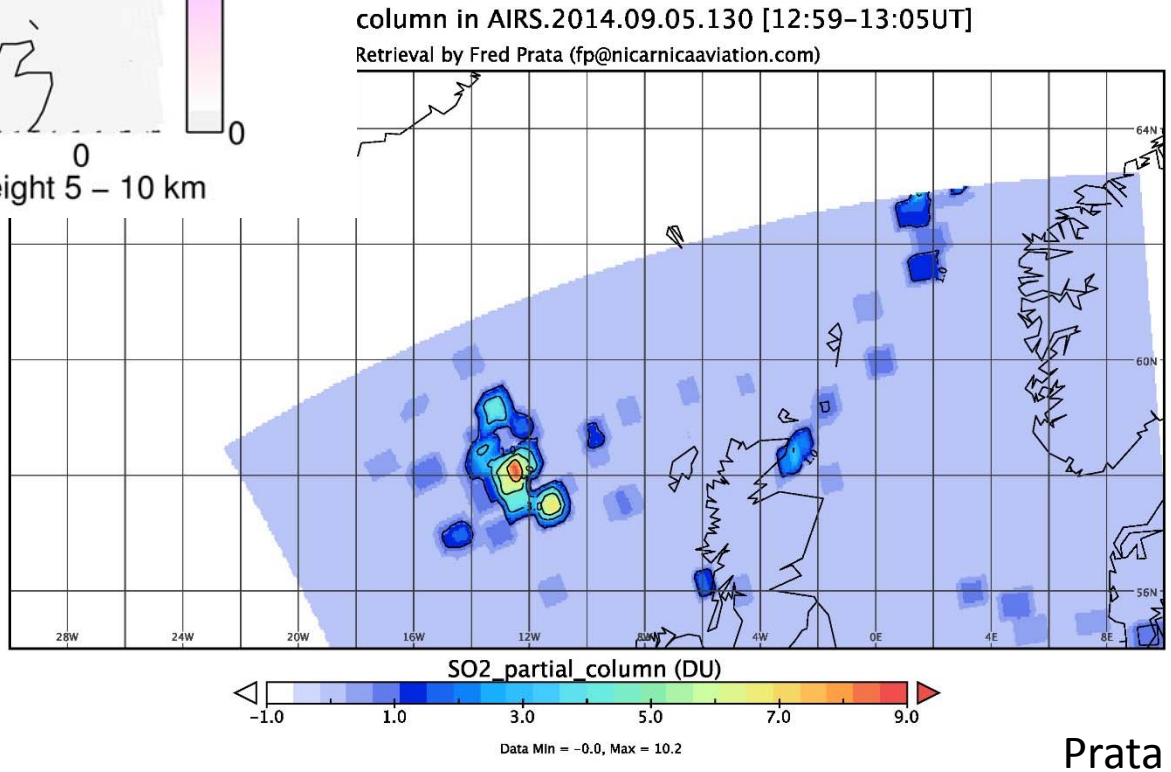
Day-Time Observation Enables UV-Based Retrievals

Plume Height (CMA): 8 km

Total Mass (kilotonnes)
OMI: 93.7 kt
VIIRS: 35.6 kt







Prata

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?