Band Residual Difference algorithm for retrieval of SO_2 from the AURA OMI

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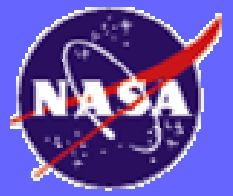
With thanks to all the OMI Science and Support Teams



UMBC

JCET

GEST
Goddard Earth Sciences and Technology Center

Global Sulfur Sources

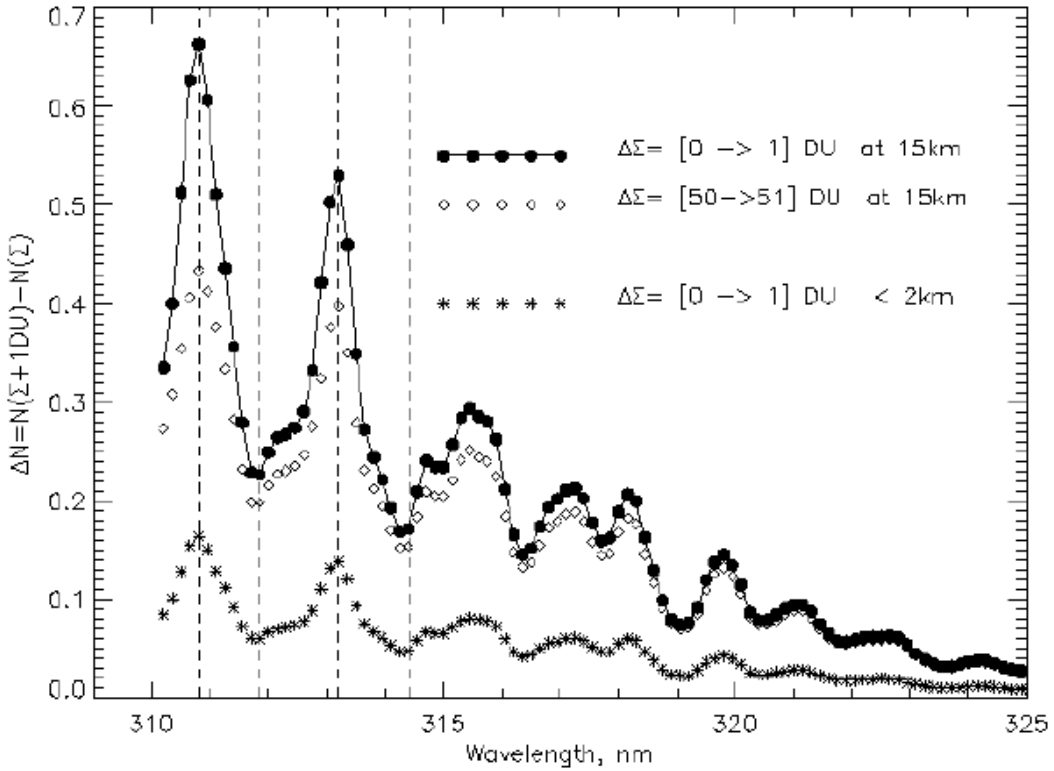
	Northern Hemisphere	Southern Hemisphere	Global
Marine and Terrestrial DMS	7.5	11.0	**18.5**
Volcanic SO_2	10.0	4.0	**14.0**
Explosive degassing	0.5-4		
Passive degassing	5-10		
Biomass Burning	1.0	1.5	**2.5**
Fossil Fuel Use and Industry	60.5	6.3	**66.8**
TOTAL (S, Tg)	79.0	22.8	**101.8**

[Bluth *et al.*, 1993; Pyle *et al.*, 1996; Graf *et al.*, 1997; Andres & Kasgnoc, 1998]

Ozone Monitoring Instrument (OMI)

The NASA EOS Aura platform, launched on July 15, 2004, carries the Ozone Monitoring Instrument (OMI), a hyperspectral UV/Visible spectrometer with a 2600 km swath for daily, global contiguous mapping that was provided by the Netherlands's Agency for Aerospace Programs (NIVR) in collaboration with the KNMI and Finnish Meteorological Institute (FMI) to the EOS Aura mission for continued monitoring of ozone and other trace gases.

OMI SO_2 algorithm



An OMI SO_2 Band Residual Difference (BRD) algorithm uses calibrated residuals at SO_2 absorption band centers produced by the NASA operational ozone algorithm (OMTO3)

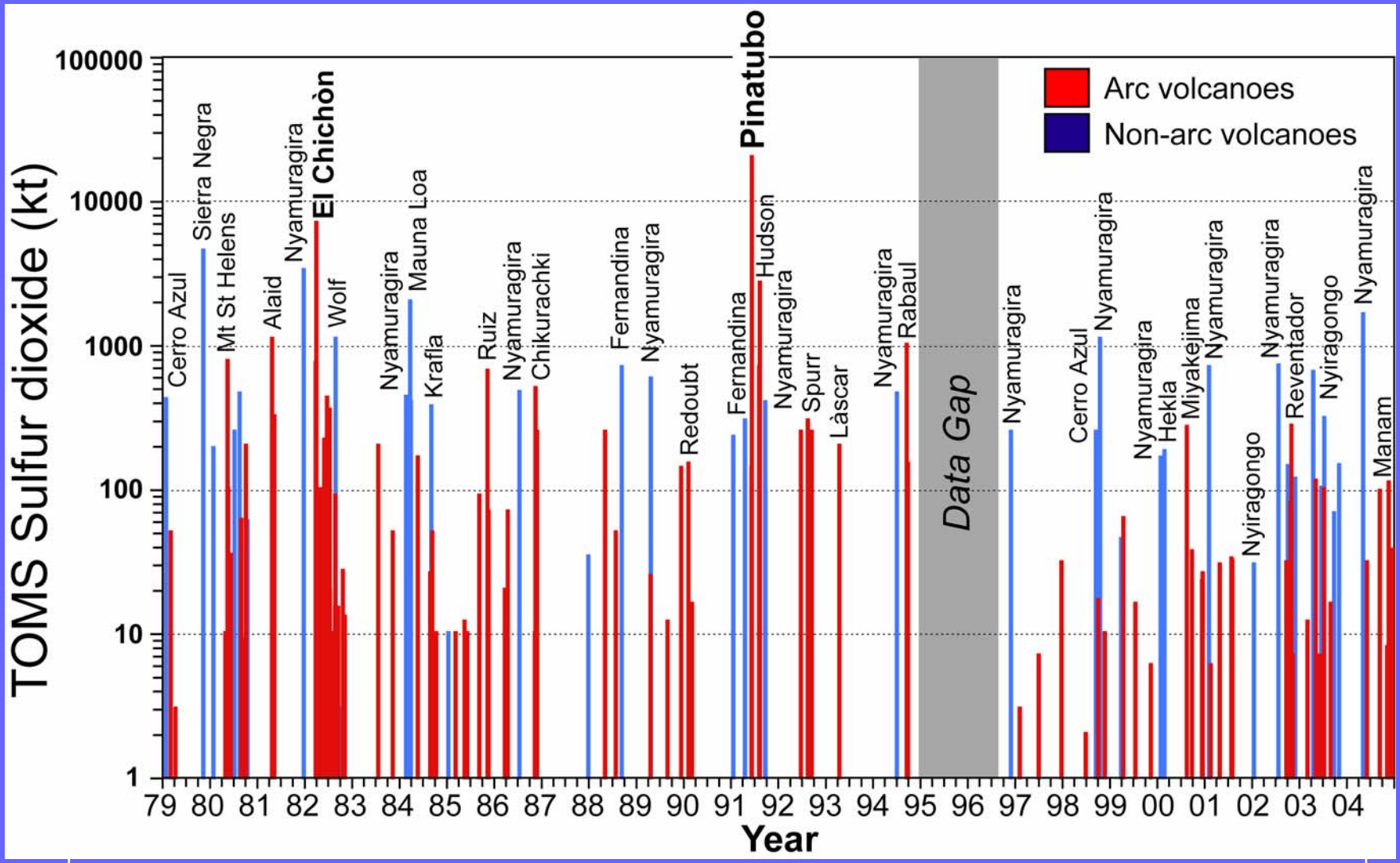
[Bhartia et al 2002]

OMI SO_2 provisional products released for validation in July 2005:

1. **Explosive Eruptions: 15km**
2. **Passive degassing: 5km**
3. **Anthropogenic SO_2 pollution : PBL (<700mb)**

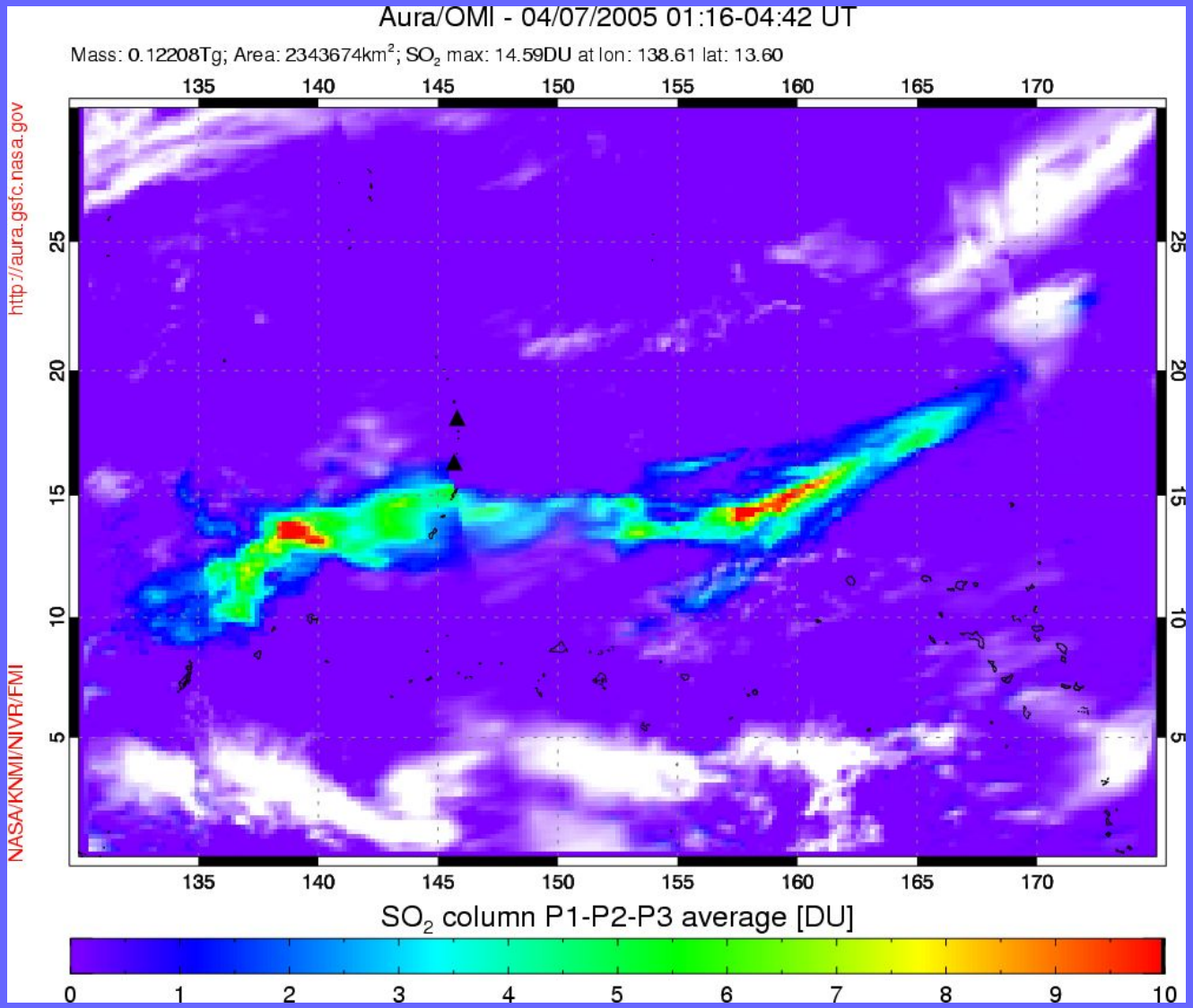
Validation scientists are welcome to collaborate

TOMS climatic SO_2 record from Explosive eruptions



The AURA OMI SO_2 volcanic data set will continue the TOMS SO_2 record, which covers a quarter-century: http://toms.umbc.edu

Anatahan eruption plumes

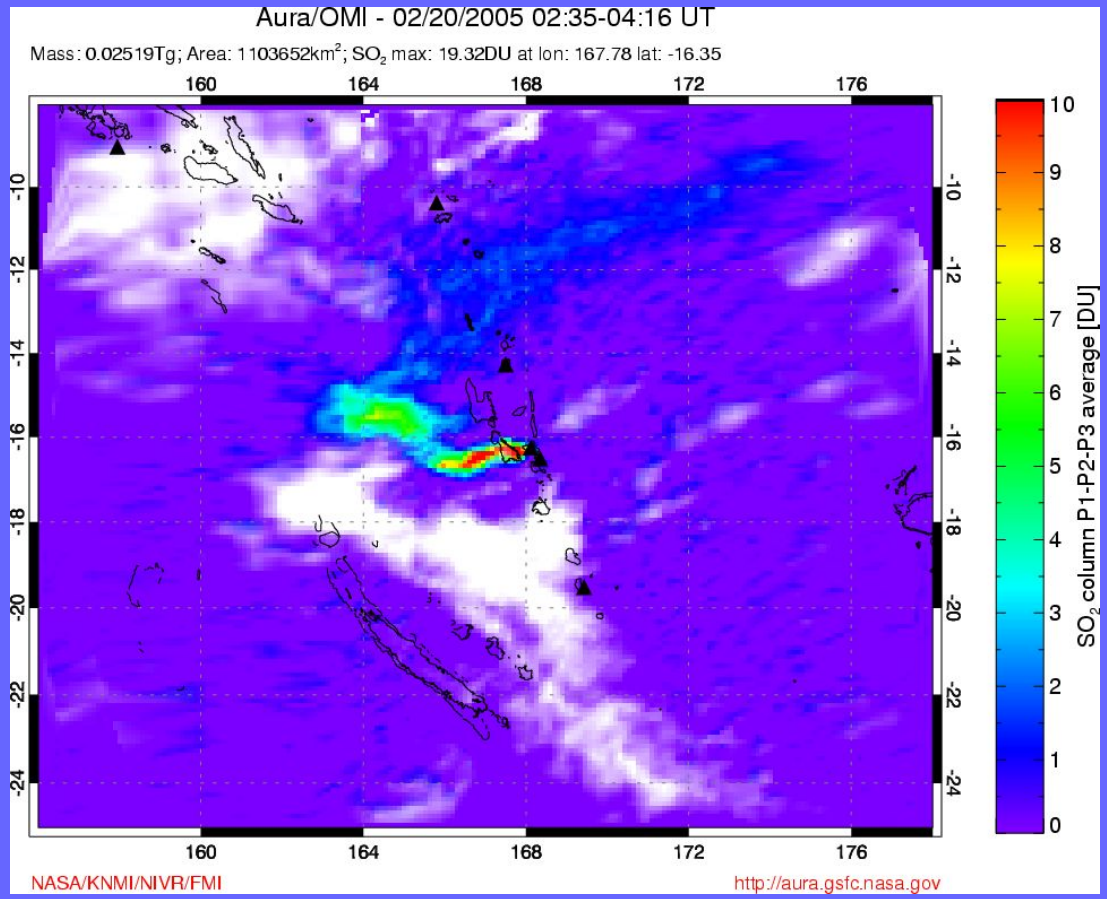


OMI SO_2 image of the Anatahan (Mariana Islands) eruption cloud on April 7, 2005, produced by an explosive eruption on April 6.

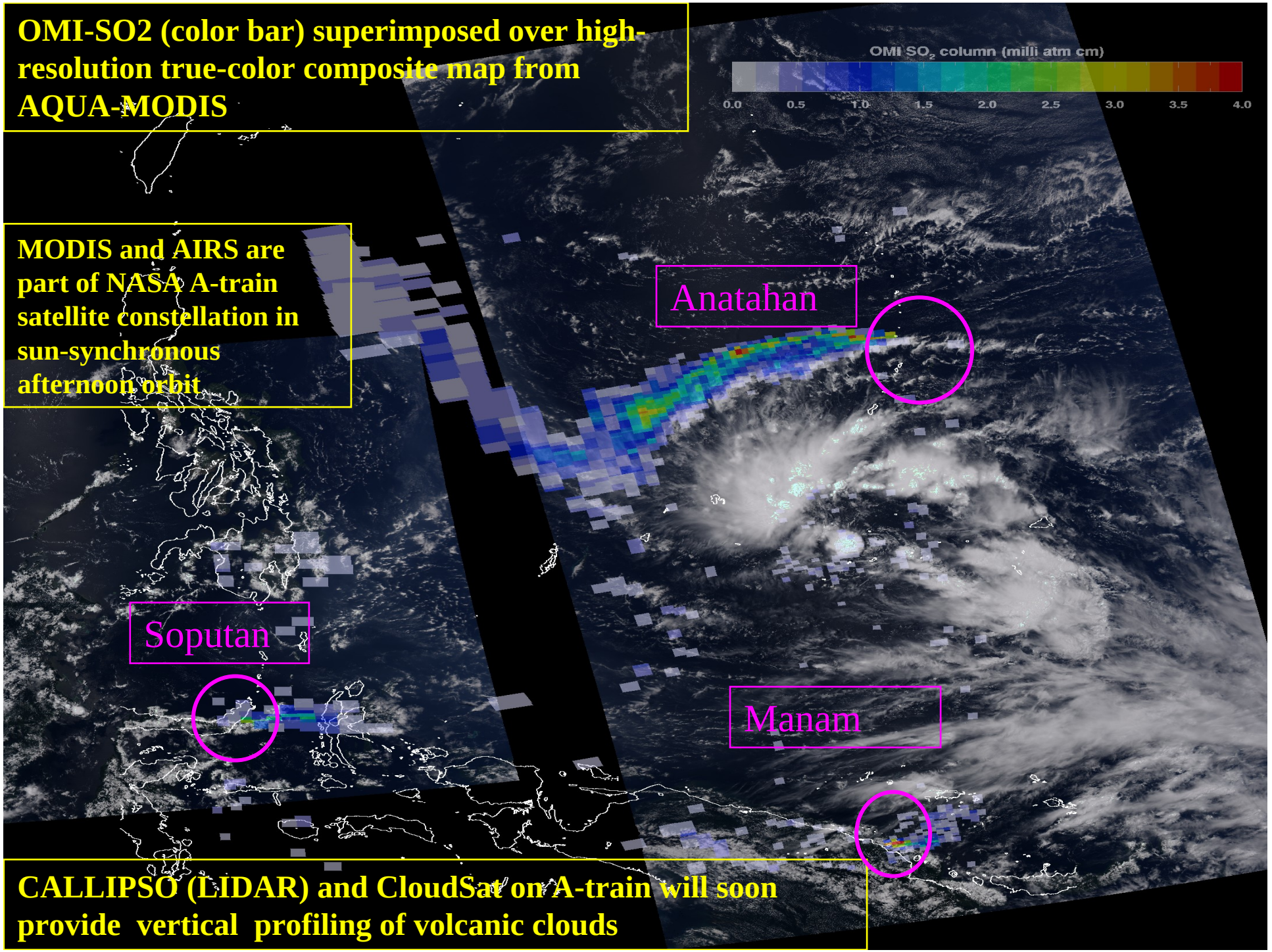
White regions are meteorological clouds.

Anatahan plume in July 2005, including the passage of some typhoons.

OMI has permitted the first routine, space-based measurements of passive volcanic SO_2 degassing

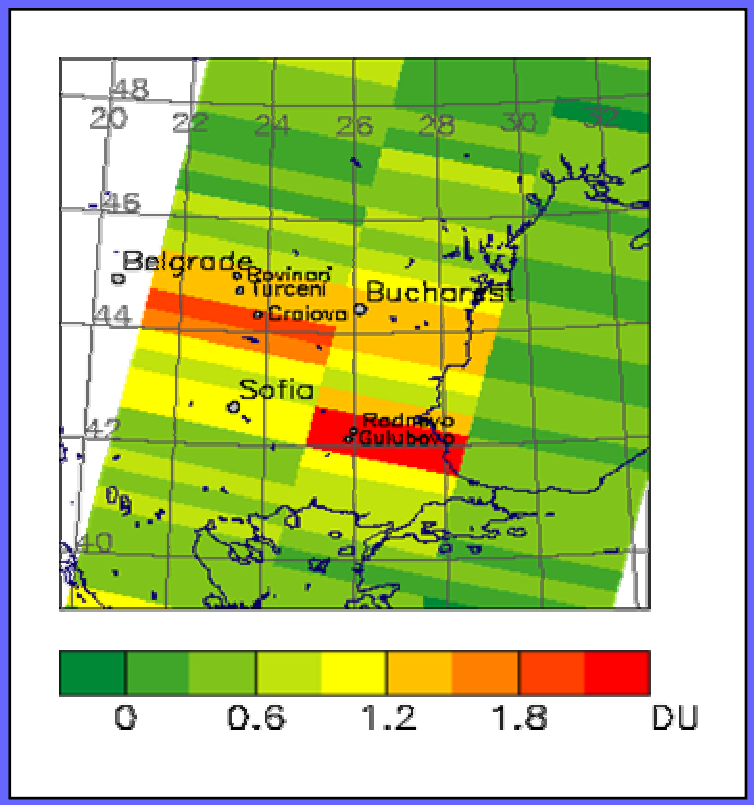


OMI SO2 image of passive degassing from Ambrym volcano, Vanuatu (16.25ºS, 168.12ºE) on February 20, 2005.

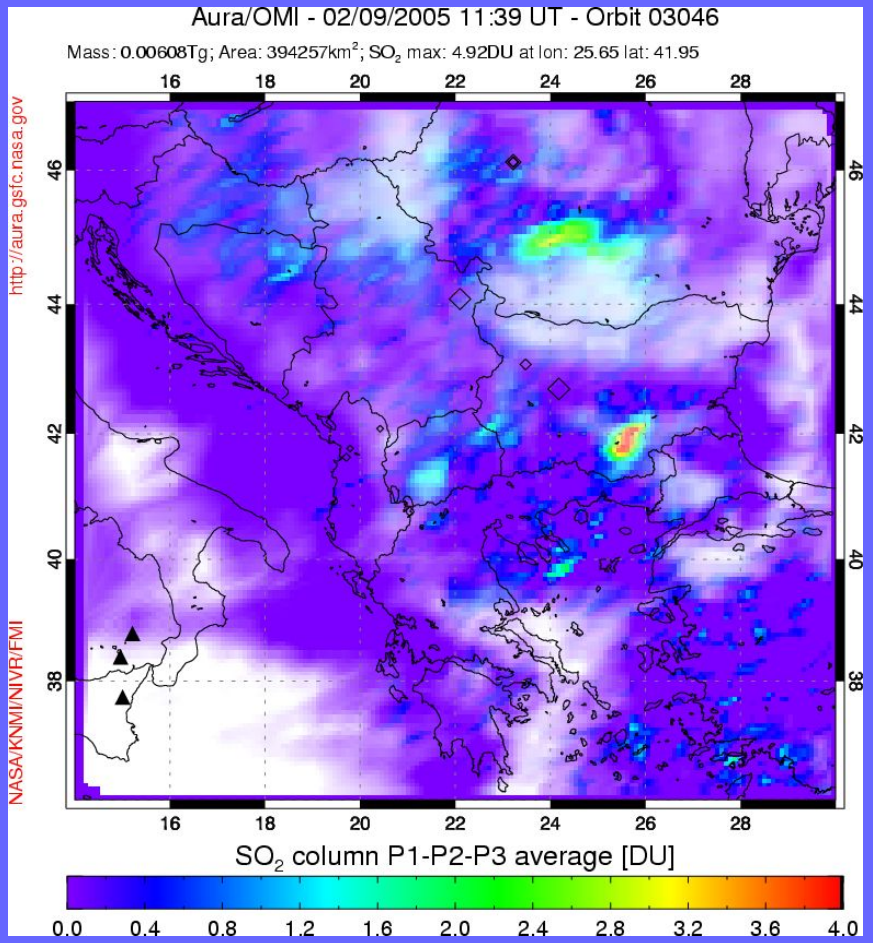

OMI-SO2 (color bar) superimposed over high-resolution true-color composite map from AQUA-MODIS
OMI SO2 column (milli atm cm)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
MODIS and AIRS are part of NASA A-train satellite constellation in sun-synchronous afternoon orbit
Anatahan
Soputan
Manam
CALLIPSO (LIDAR) and CloudSat on A-train will soon provide vertical profiling of volcanic clouds

Tropospheric SO2

SO_2 emissions from lignite-burning power plants in the Balkan region



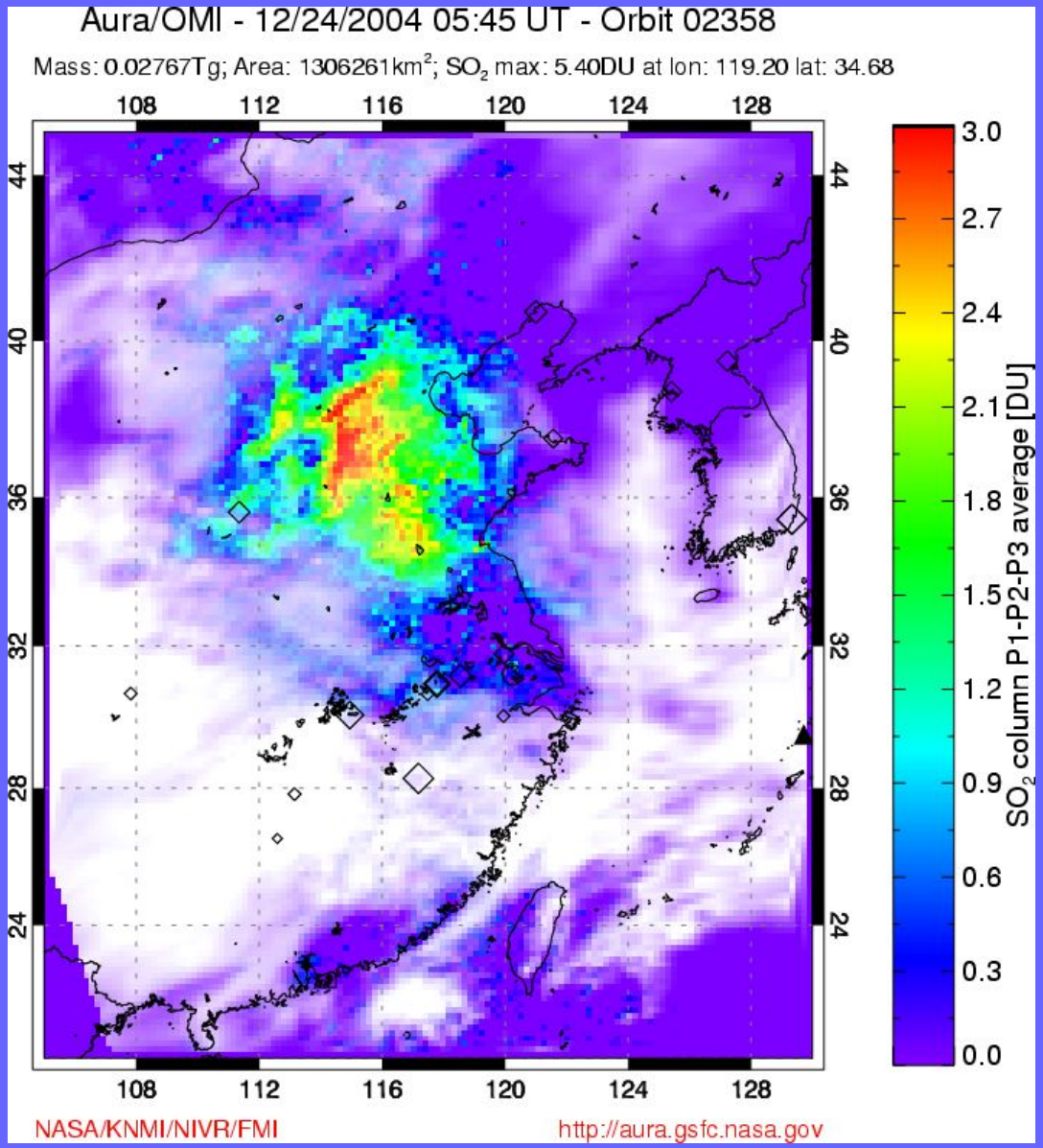
SO_2 enhancements observed by GOME in February 1998 [Eisinger and Burrows, GRL 1998].



SO_2 enhancements detected by OMI in February 2005

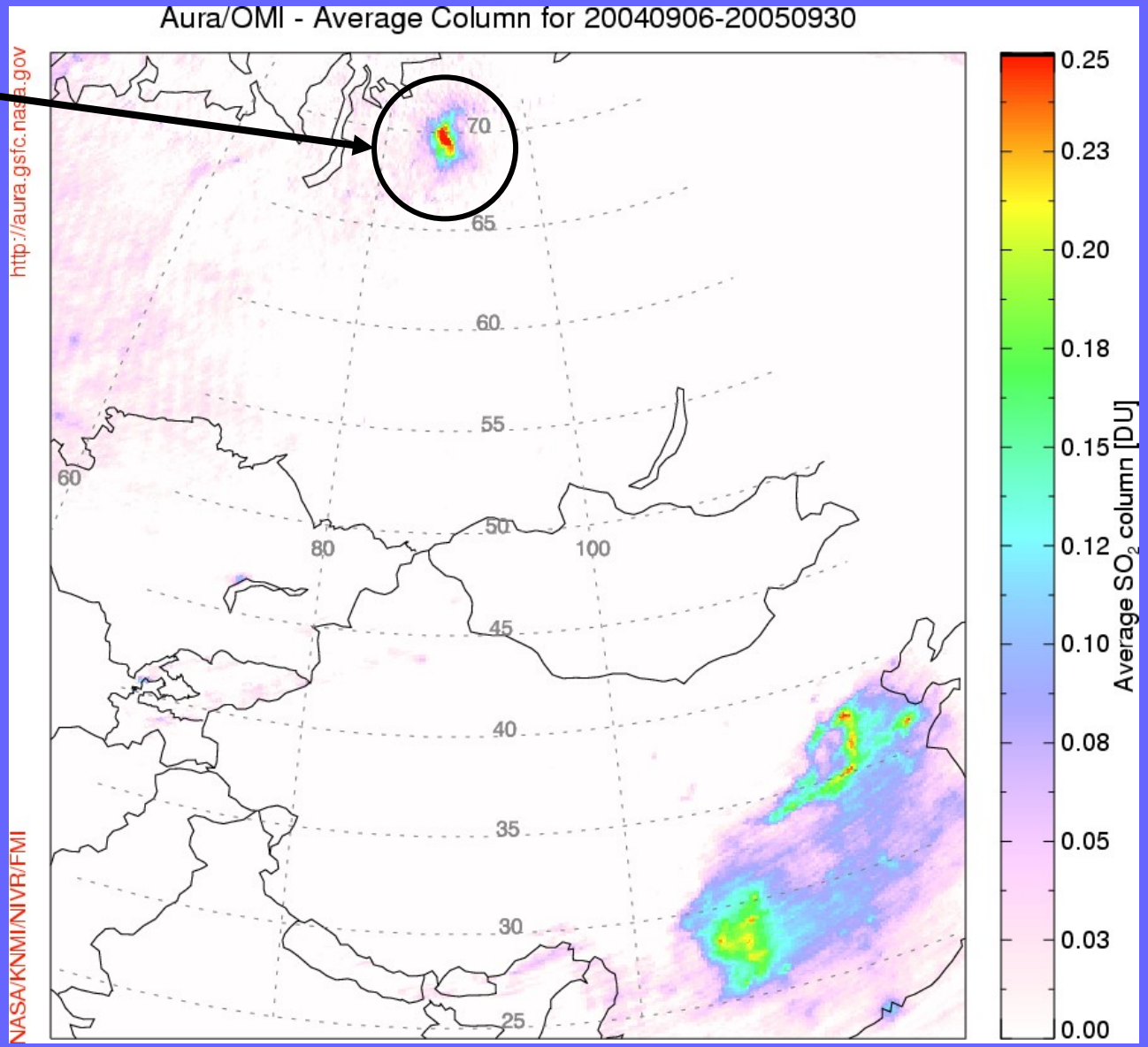
SO_2 burdens over China

- 70% of China's energy is derived from coal burning
- SO2 emissions increased at a rate 35%/decade in 1979-2000
- China's sulfate aerosol loading has increased by 17%/decade in 1979-2000 [Massie, Torres and Smith 2004]
- 65,000 SO_2 tons/day emitted in 1995 [Streets & Waldhof, 2000]



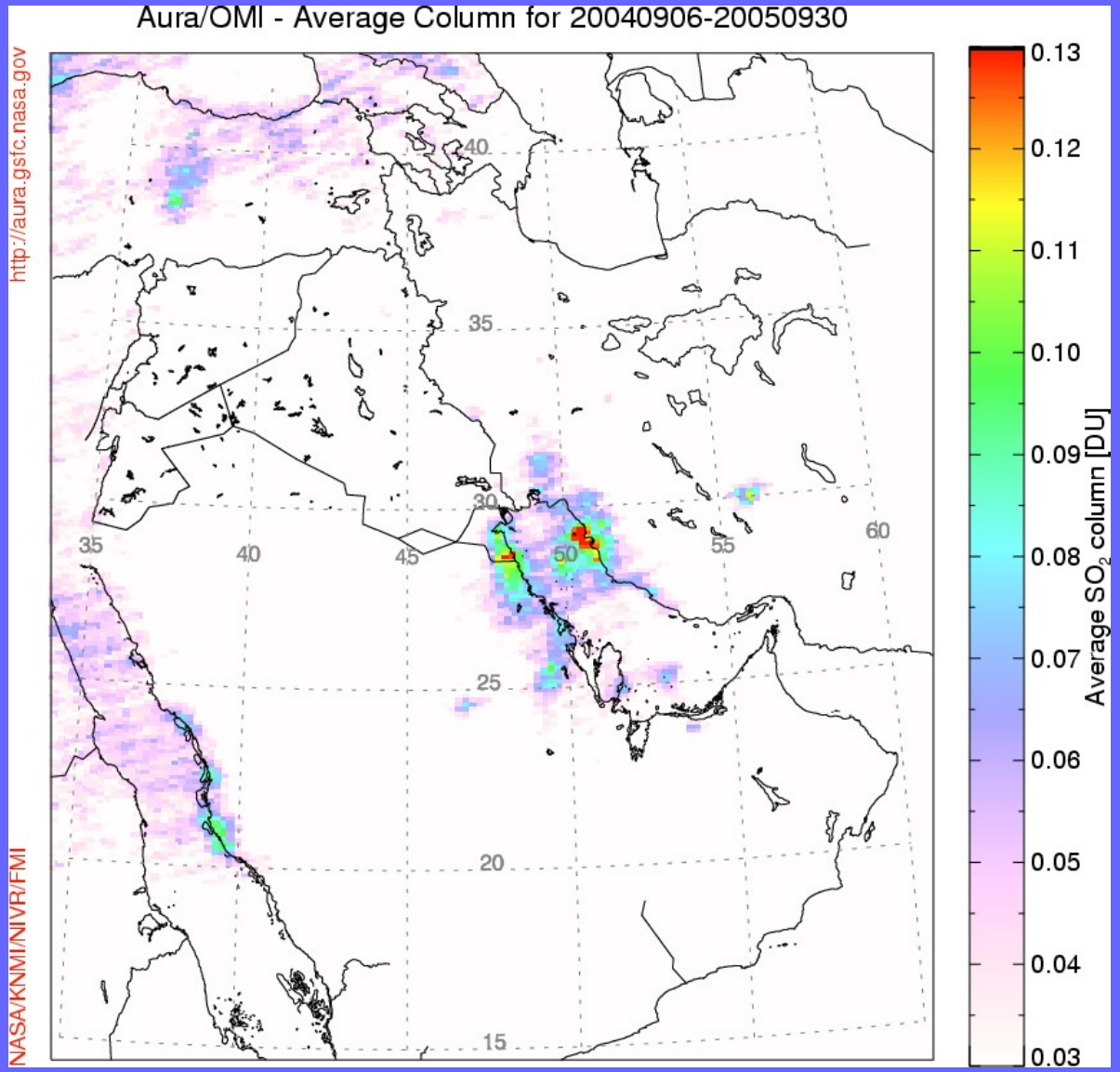
Anthropogenic SO_2 burdens in Asia

- **Norislk Nickel is one of Russia's heaviest industrial polluters**
- **World's biggest producer of nickel and palladium**
- **Plans to reduce SO_2 emissions by 80-90% by 2015**

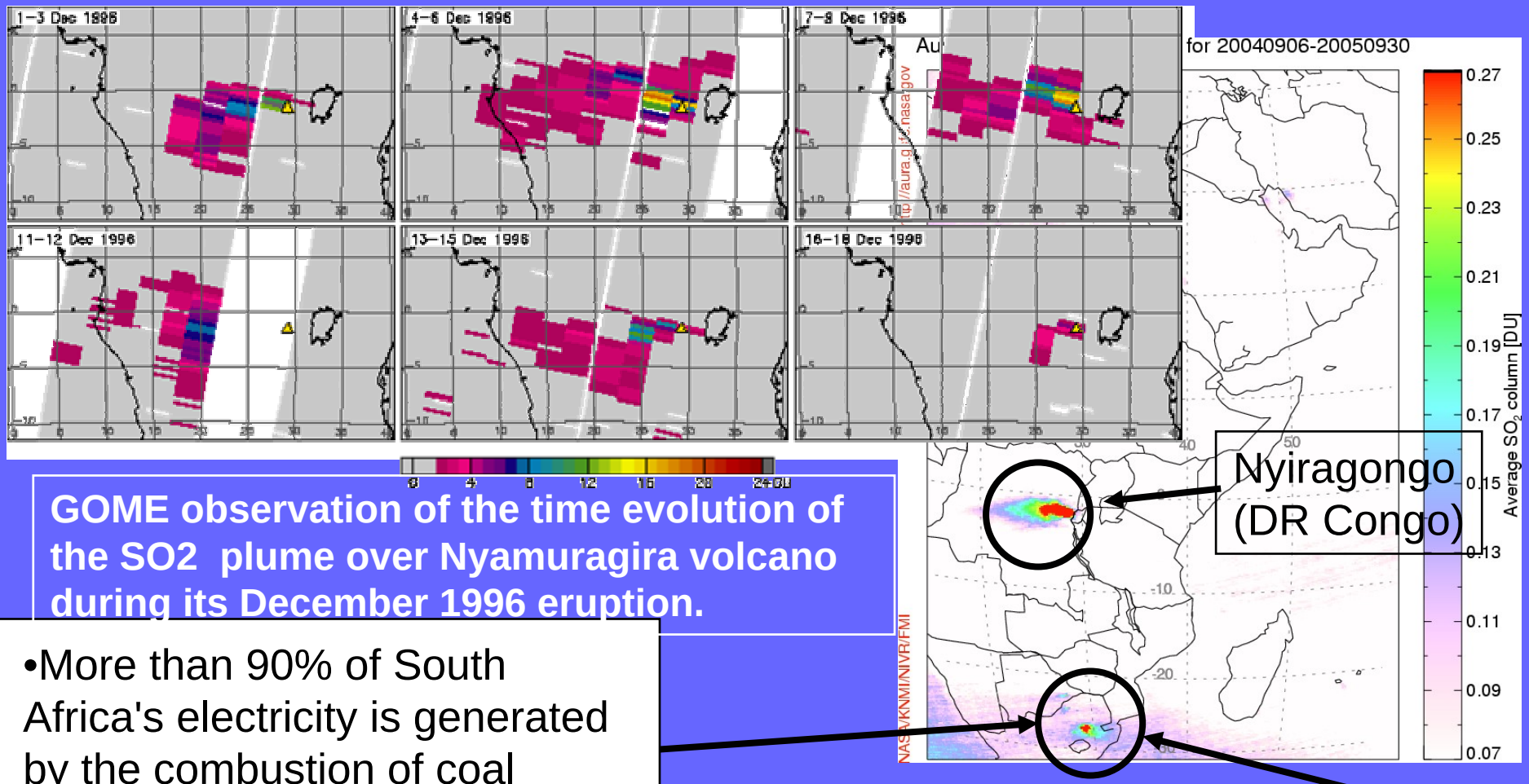


Persian Gulf region

- SO_2 emissions associated with oil and gas refining in the Persian Gulf (Kuwait, Saudi Arabia, Iran, UAE)
- Outgassing flares from oil fields in the Gulf produce detectable SO_2



Major SO_2 sources in Africa:

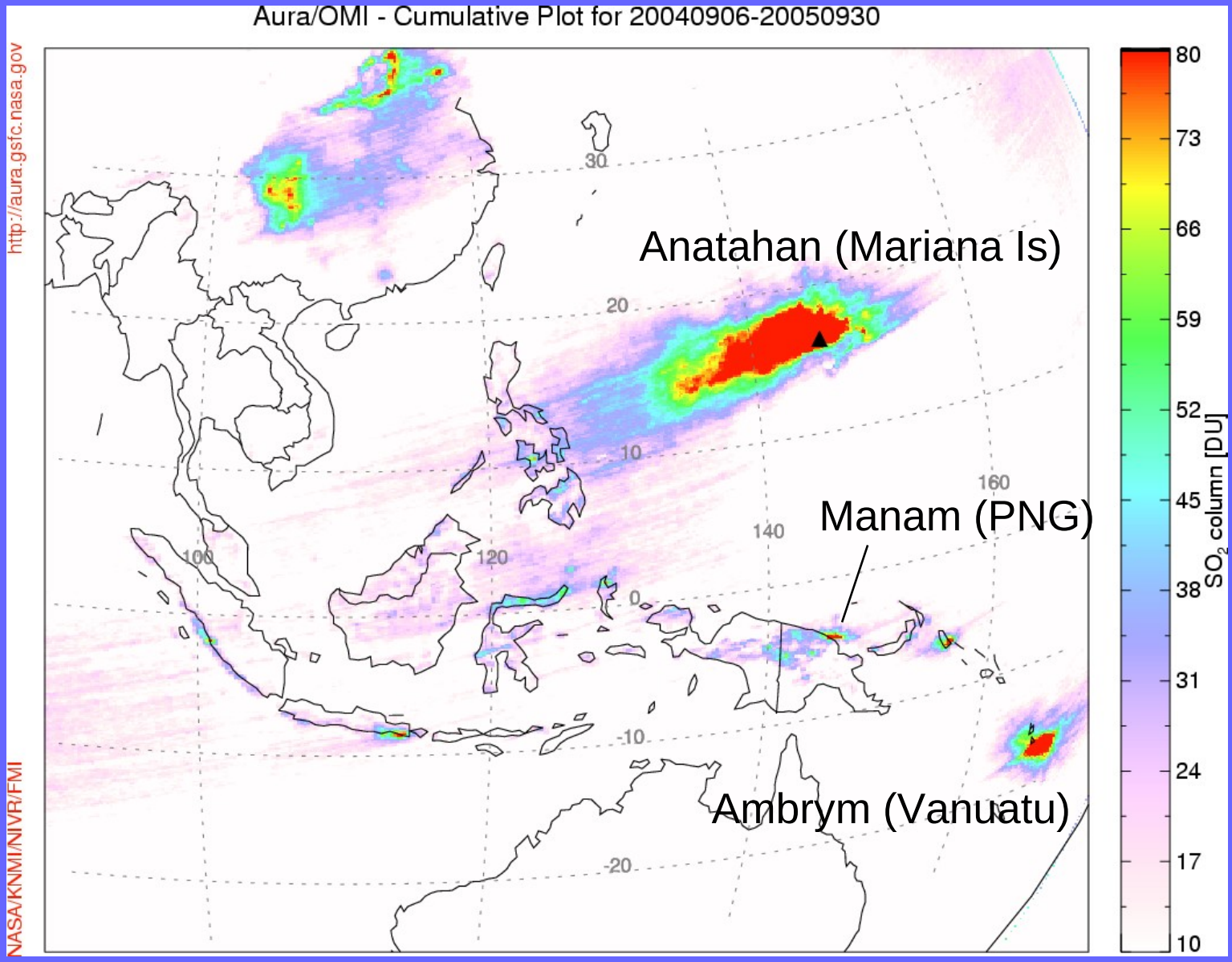


GOME observation of the time evolution of the SO2 plume over Nyamuragira volcano during its December 1996 eruption.

- More than 90% of South Africa's electricity is generated by the combustion of coal
- Coal-fired power plants not required to use scrubbers to remove sulfur from emissions

OMI: South African power plants (e.g., near Johannesburg); copper smelting

South East Asia



Conclusions

- The OMI SO_2 data set will continue the TOMS record but the improved sensitivity and smaller footprint of OMI will extend the range of detection to smaller eruptions and older clouds, and to degassing volcanoes.

- Anthropogenic SO_2 emissions measured over China, Peru, USA (Ohio Valley), Europe, Central America, Uzbekistan.

(Sources generally in agreement with 1985 GEIA database)

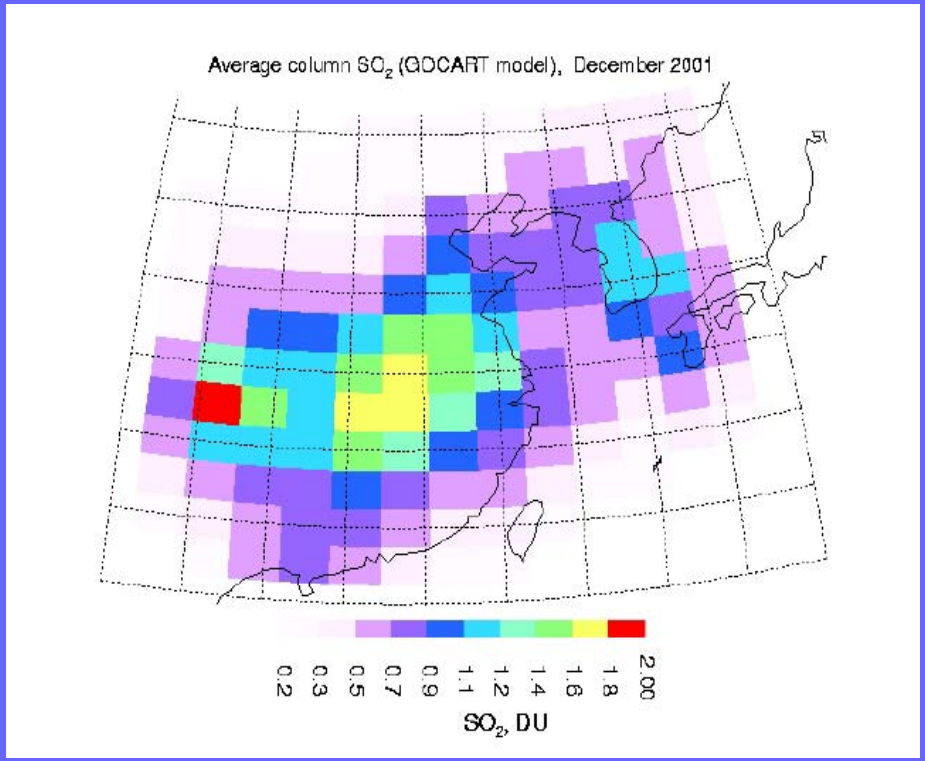
- Algorithm improvements are needed (realistic a-priori vertical SO_2 and temperature profiles, bias, noise) before public release of anthropogenic SO_2 data

- Validation collaborations are welcome

backup

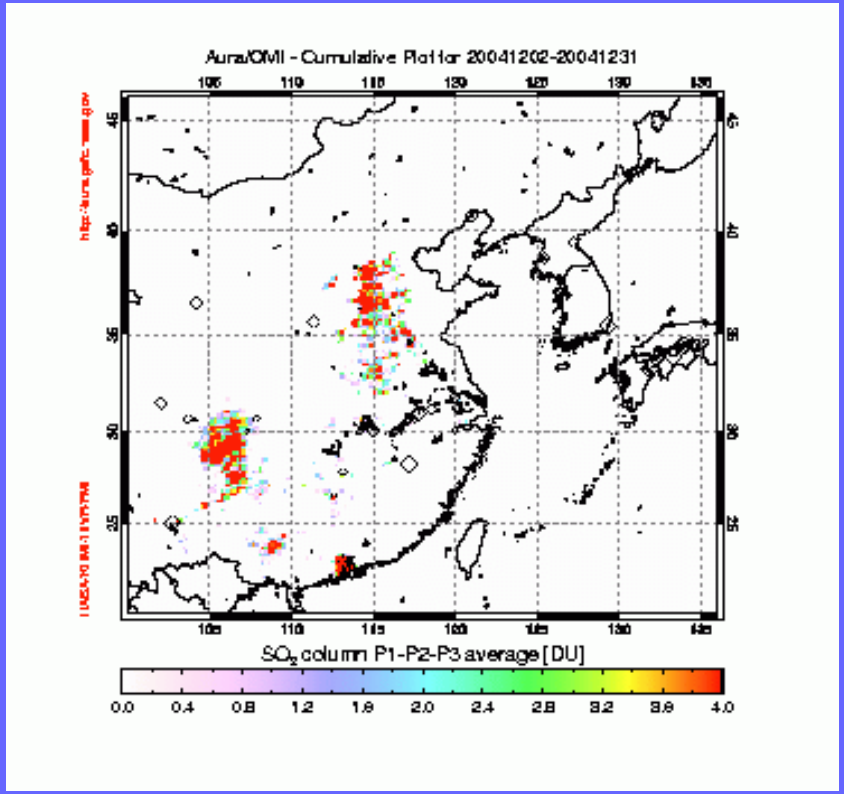
Comparisons with GOCART model

GOCART model
monthly average SO2
(December 2001)



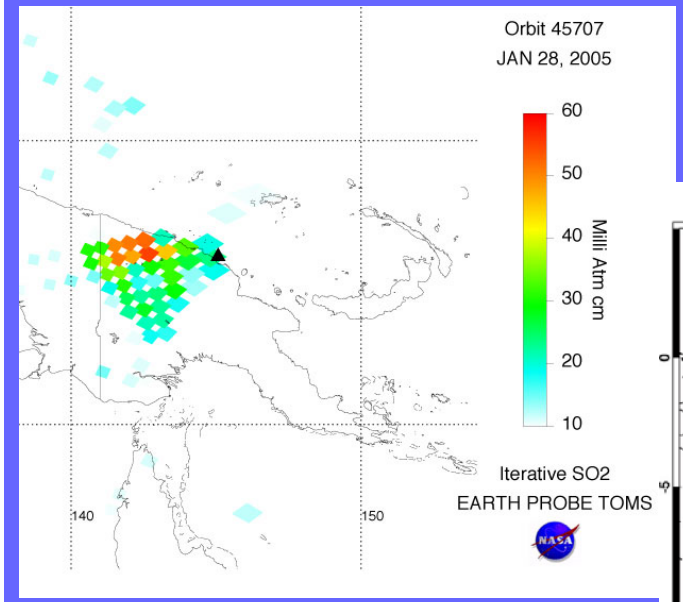
OMI cumulative SO_2

(December 2004)

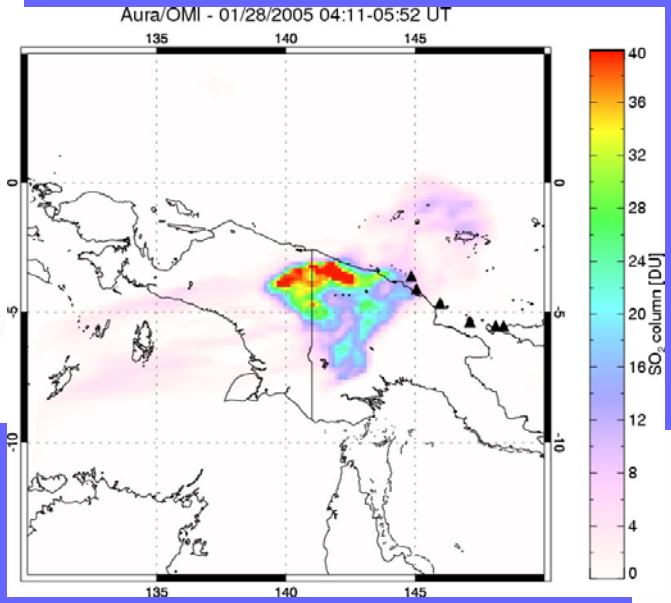


Manam volcano eruption: January 27-28 2005

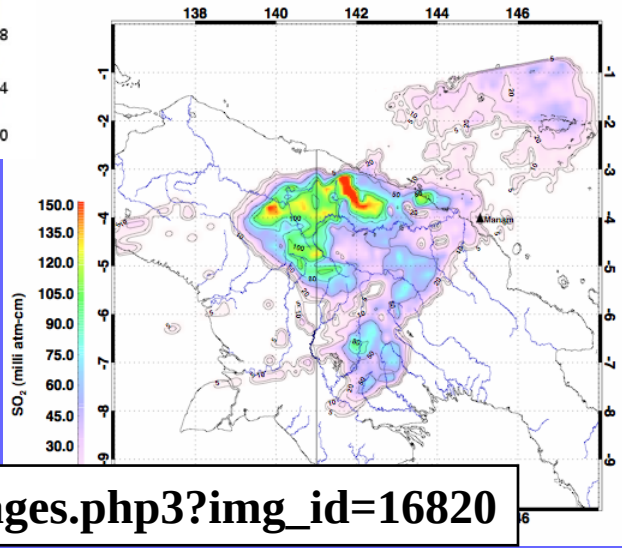
TOMS SO2



OMI SO2

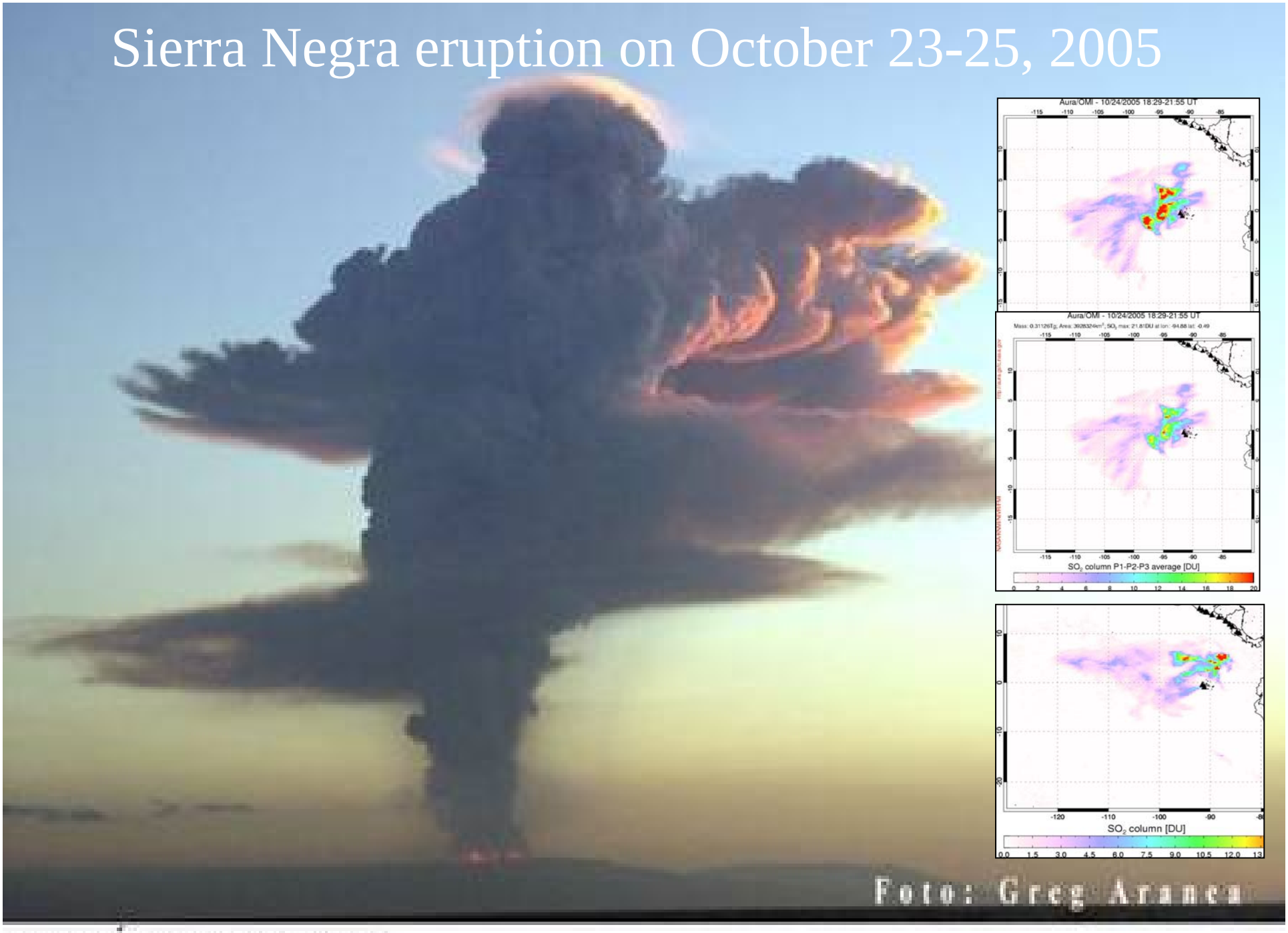


AIRS SO2



http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=16820

Sierra Negra eruption on October 23-25, 2005



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Africa

- Major SO_2 sources in Africa: Nyiragongo volcano (DR Congo); South African power plants (e.g., near Johannesburg); copper smelting
- More than 90% of South Africa's electricity is generated by the combustion of coal
- Coal-fired power plants not required to use scrubbers to remove sulfur from emissions