

# Satellite Observations of Ash and SO<sub>2</sub> from Recent Volcanic Eruptions in Iceland

Janne Hakkarainen, Iolanda Lalongo, Simo Tukiainen, Rigel Kivi, Timo Ryppö, Seppo Hassinen, and Johanna Tamminen



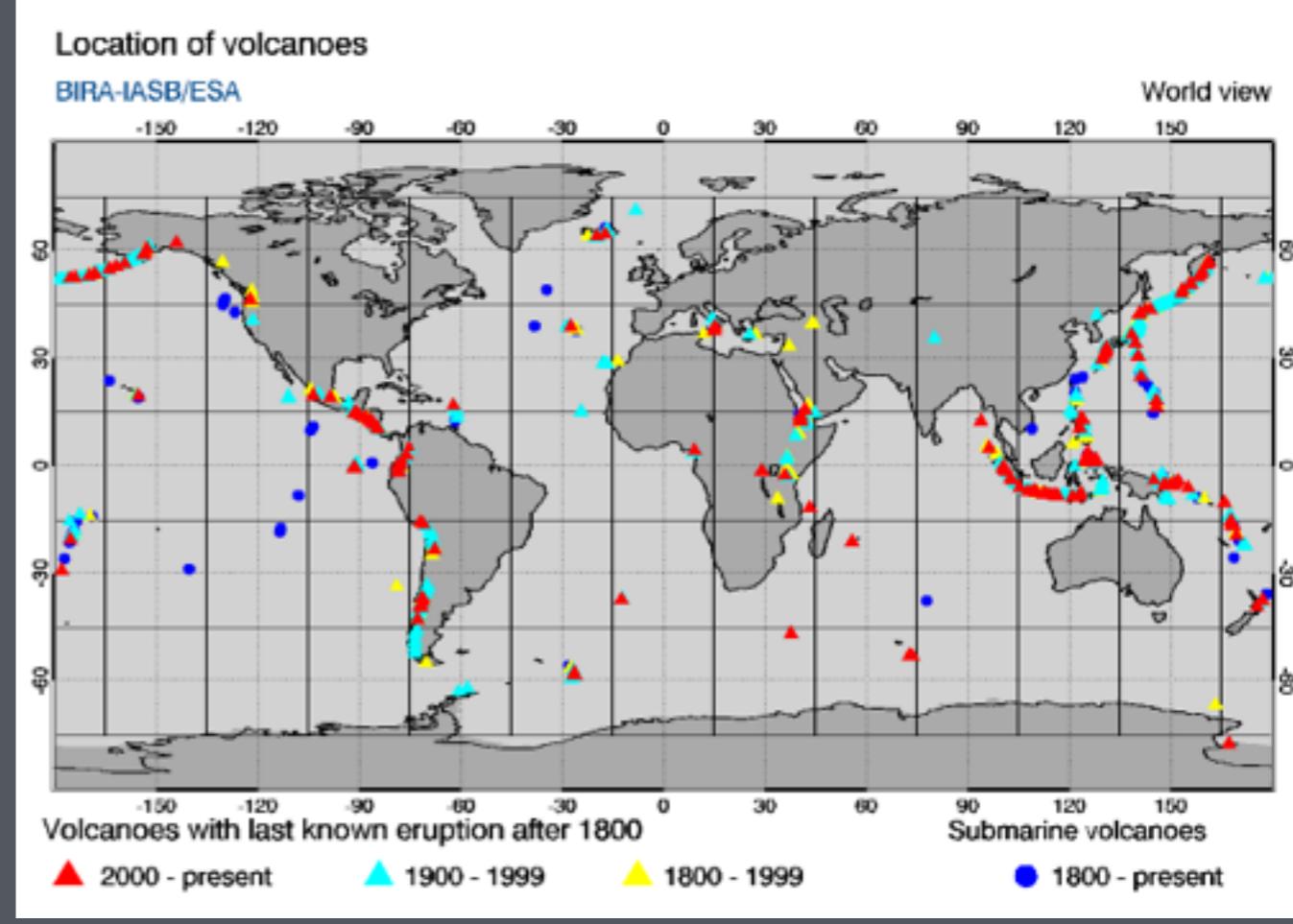
Finnish Remote Sensing Days 2014, Helsinki, Finland, 29–30 October

# Background

- Eyjafjallajökull eruption 2010: volcanic ash cloud caused the largest air-traffic shutdown since World War II



All Departures		
11:45 Heathrow	BA1443	Cancelled
11:55 Hahn	FR4283	Cancelled
12:10 Paris CDG	AF5055	Cancelled
12:15 Cologne	4U368	Cancelled
12:30 Birmingham	BE846	Cancelled
12:35 Newquay	BE673	Cancelled
12:35 Milan Malpensa	EZY2686	Cancelled
12:50 Amsterdam	KL1280	Cancelled
13:10 Belfast City	BE686	Cancelled
13:10 Paris CDG	EZY6955	Cancelled
13:20 Shannon	FR1147	Cancelled
13:30 Manchester	BE294	Cancelled
13:30 Copenhagen	DY3503	Cancelled
13:45 Frankfurt	BD3481	Cancelled
13:45 Heathrow	BA1445	Cancelled
14:00 Gatwick	BA2941	Cancelled
14:00 Kirkwall	BE6897	Cancelled
14:20 Niederrhein	FR6242	Cancelled
14:20 Isle Of Man	BE6813	Cancelled
14:20 Birmingham	BE858	Cancelled



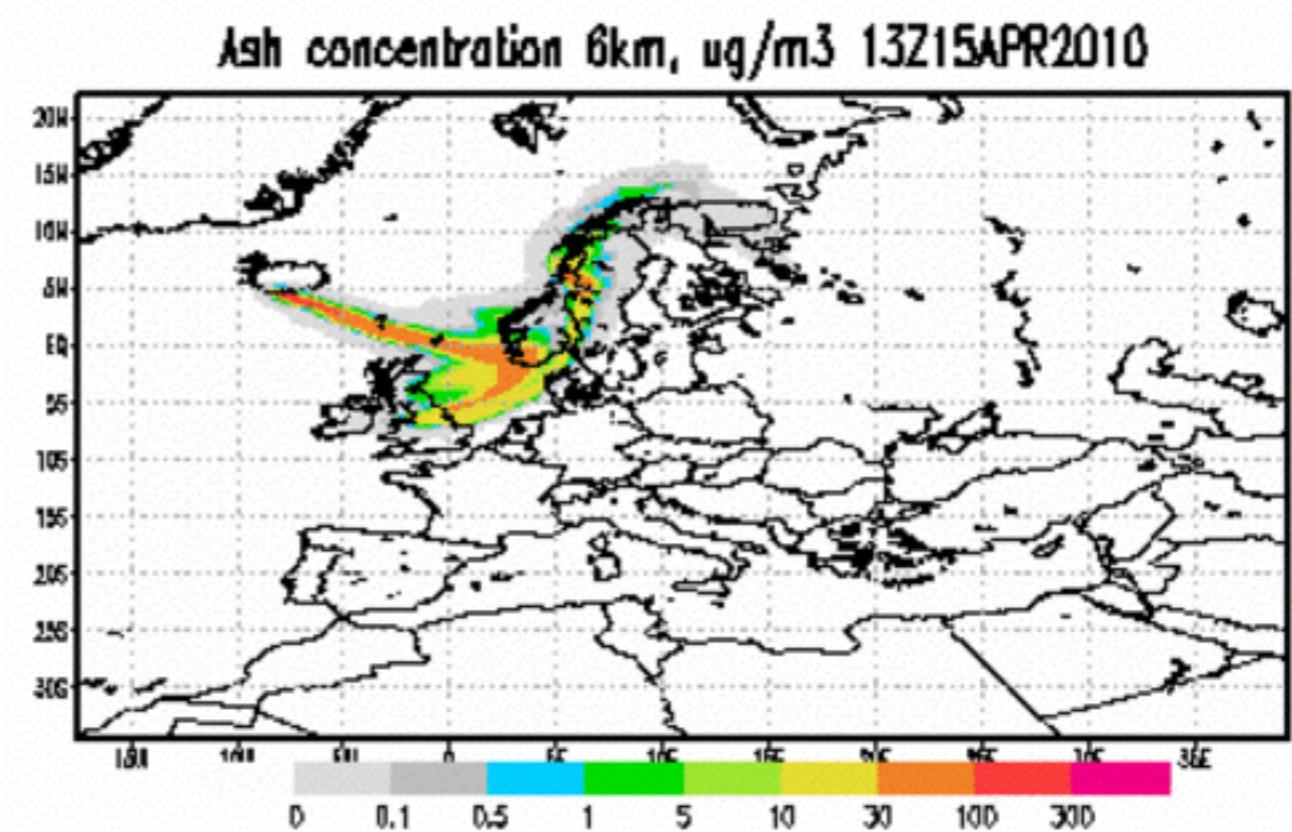
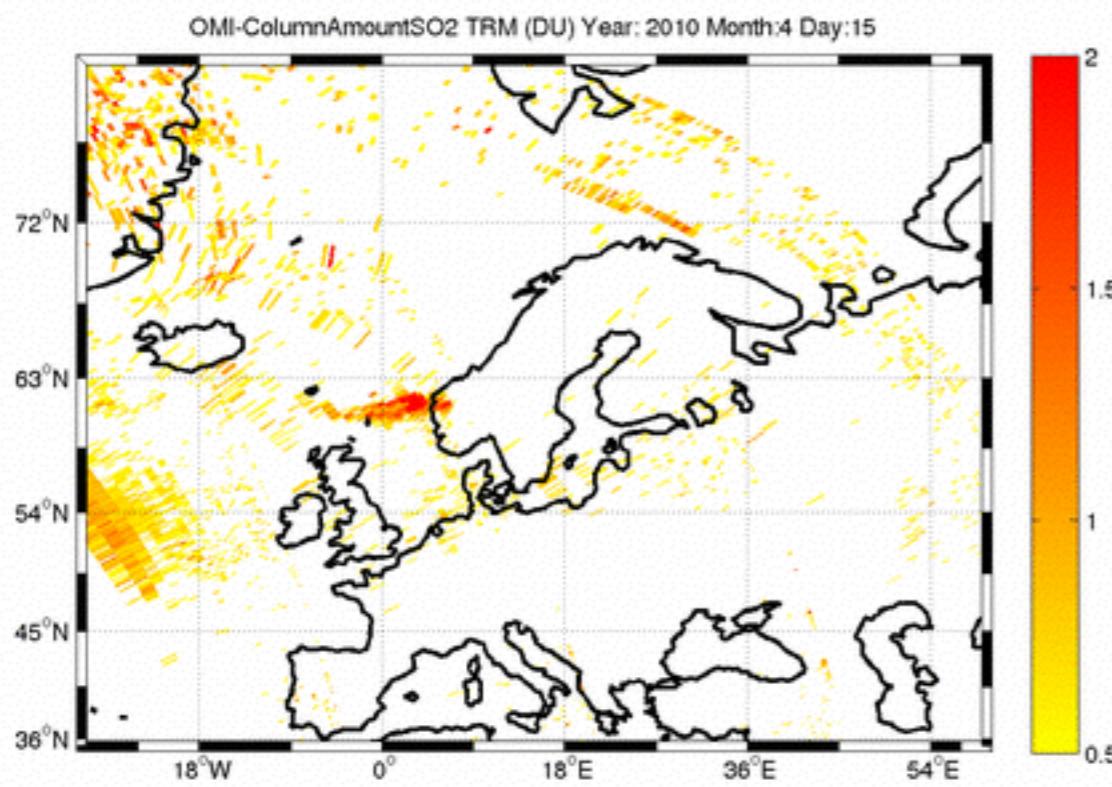
# Absorbing Aerosol Index (AAI)

- Absorbing Aerosol Index (AAI) is a qualitative measure that indicates the presence of UV-absorbing aerosols, such as smoke, dust and volcanic ash, in the atmosphere
- Algorithm is simple and robust and does not take assumptions on aerosol microphysics and compositions
- The advantage of the AAI is that it is useful indicator of aerosols over large variety of land surfaces as well as above sea
- AAI, while not a geophysical quantity, is also useful when the aerosols are present above clouds

# Sulphur dioxide ( $\text{SO}_2$ )

- Sulphur dioxide ( $\text{SO}_2$ ) has been measured from space since the 1982 eruption of El Chichòn
- These days,  $\text{SO}_2$  from volcanic eruptions and degassing are routinely monitored
- Satellite measurements of volcanic  $\text{SO}_2$  emissions can provide critical information for aviation hazard mitigation, particularly when ash detection techniques fail
- $\text{SO}_2$  has low background making the volcanic  $\text{SO}_2$  plumes clearly distinguishable even long distance from source
- Systems like SACS (Support to Aviation Control Service, <http://sacs.aeronomie.be>) use  $\text{SO}_2$  as an indicator for volcanic activity

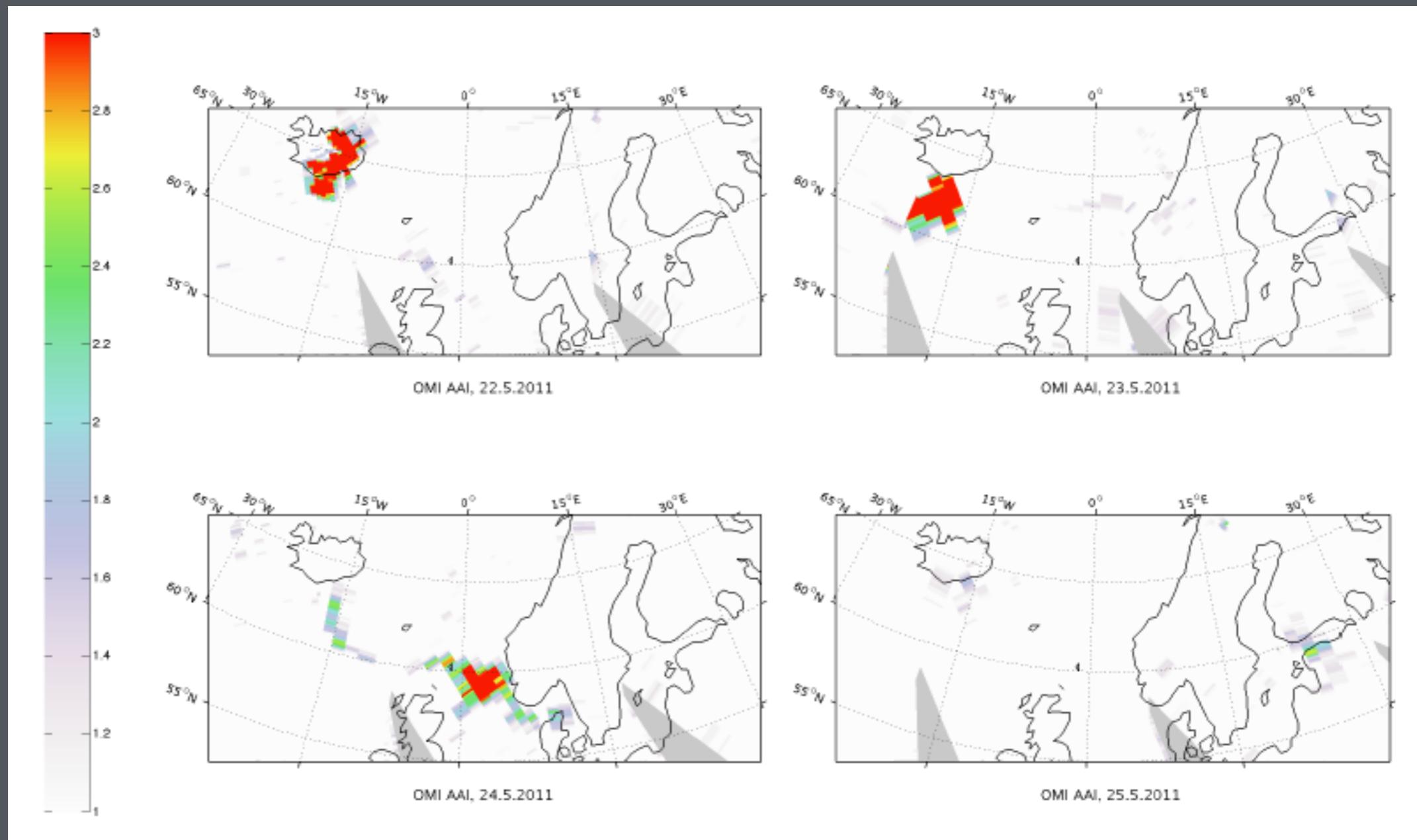
# Eyjafjallajökull 2010



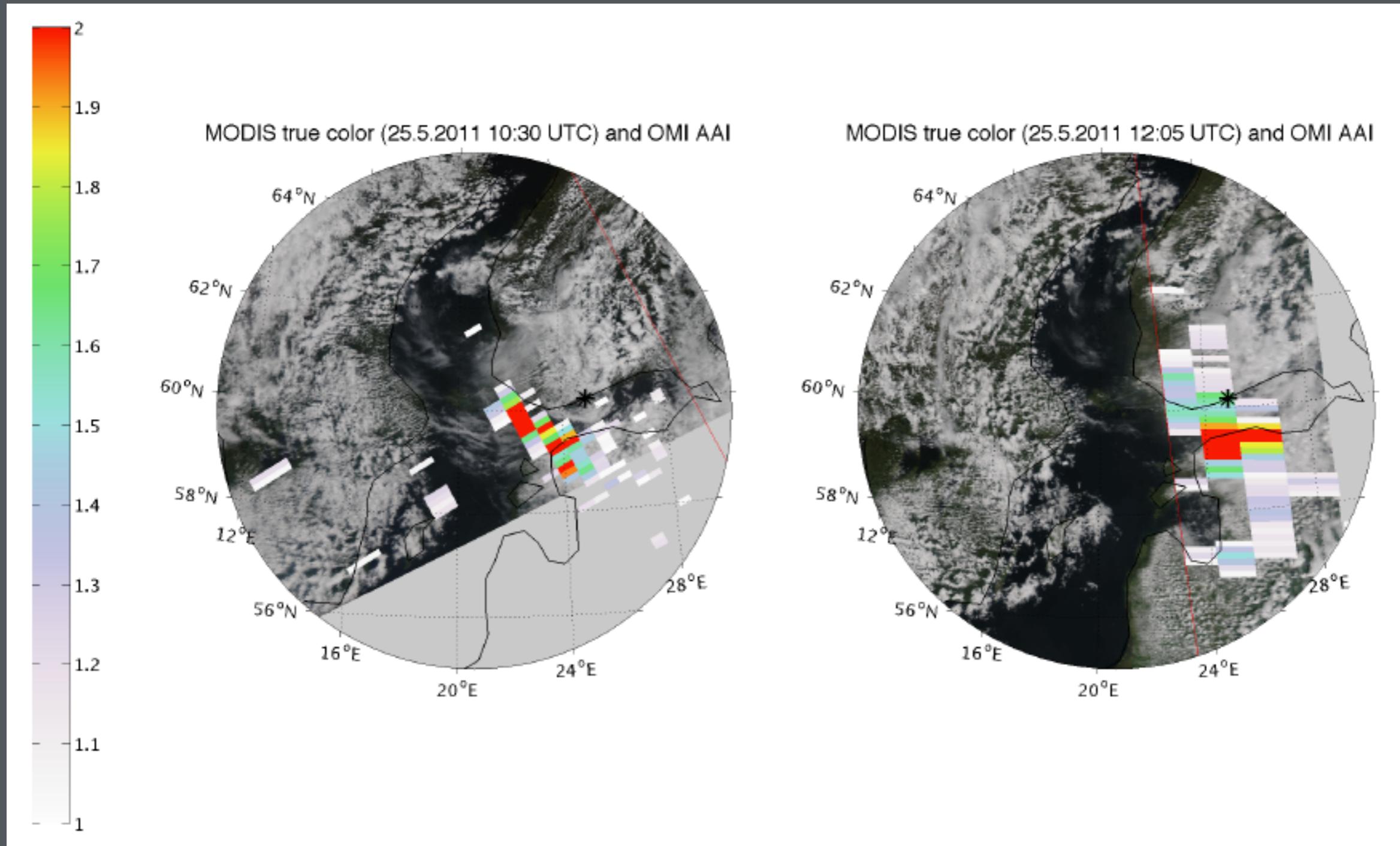
# Eyjafjallajökull 2010

- Gave us motivation to update our OMI VFD service for SO<sub>2</sub> and AAI products
- We get observations in 15 min — about 1.5 h faster than NRT
- 2014 observations from OMPS are processed too
- <http://sampo.fmi.fi>

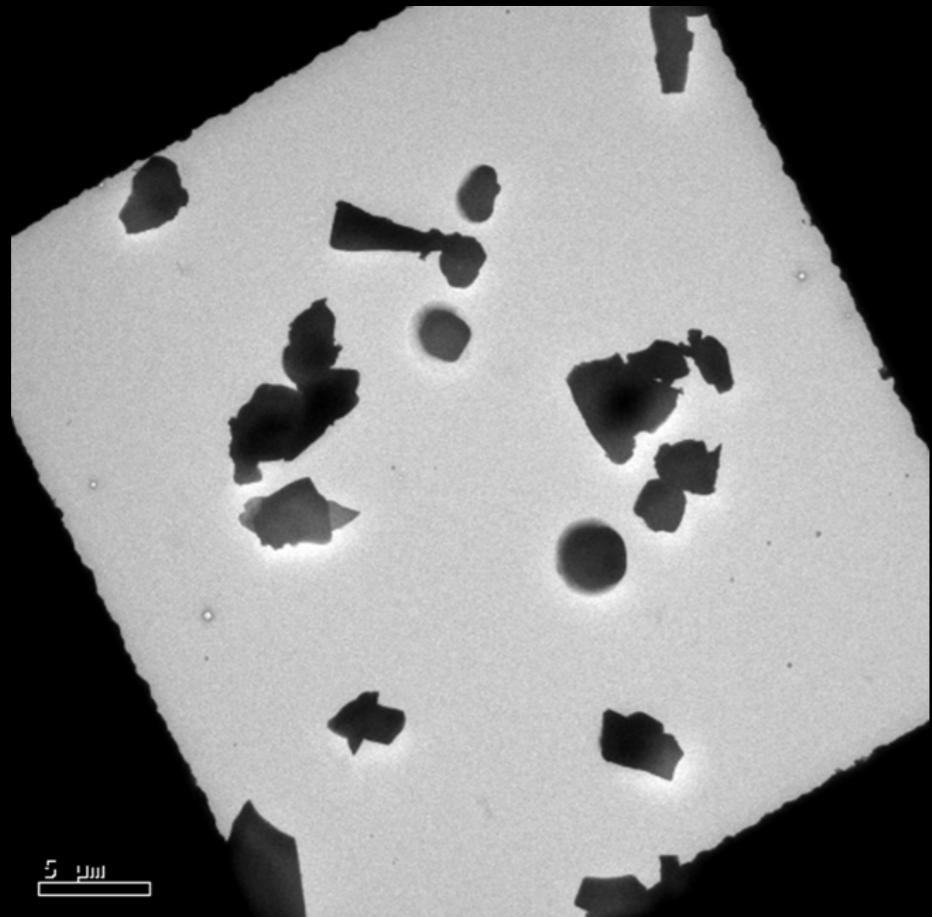
# Grimsvötn 2011



# Grimsvötn 2011



# Ash in Helsinki 2011

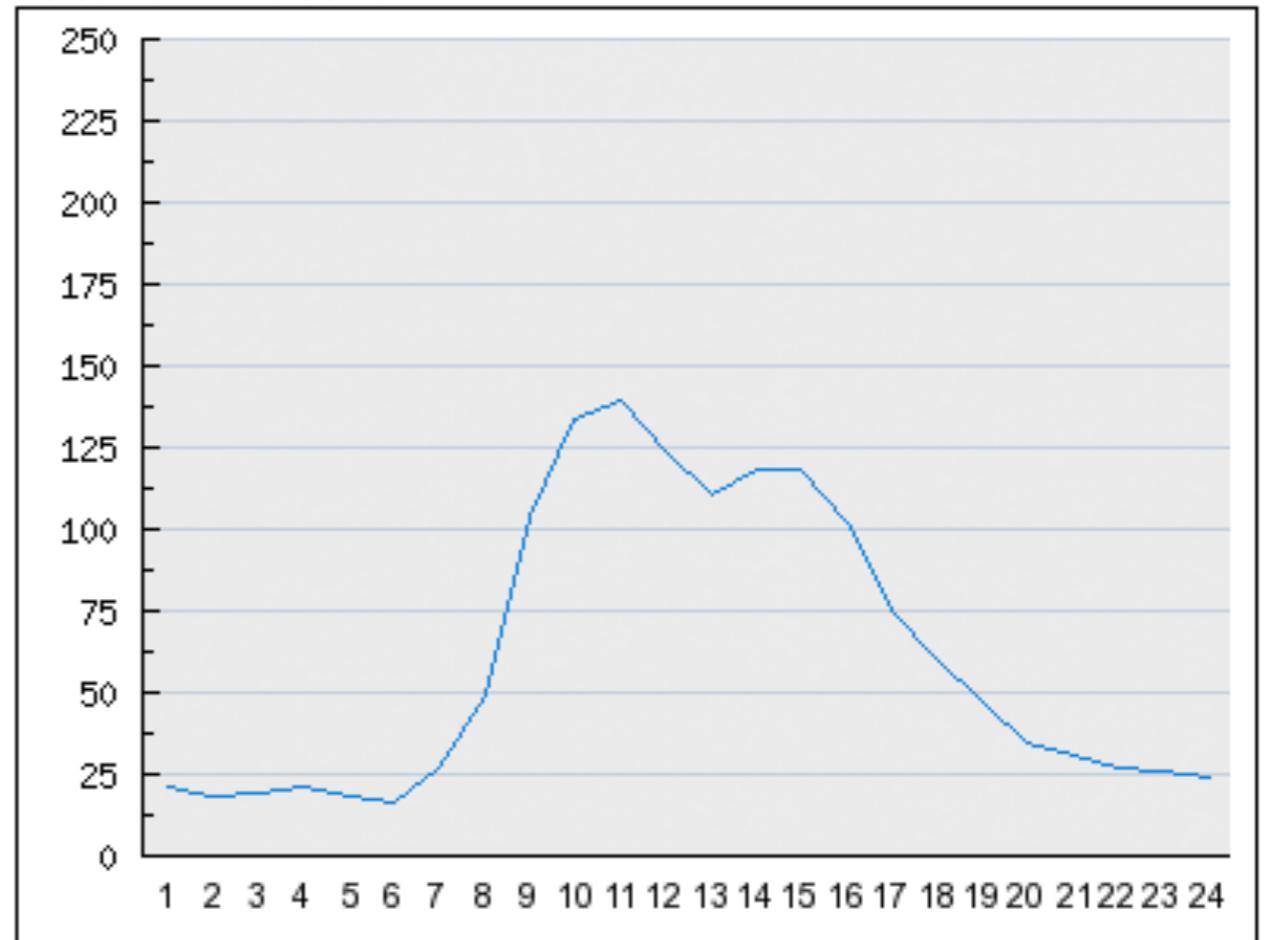


## Mittaustulokset

Helsinki: Mannerheimintie

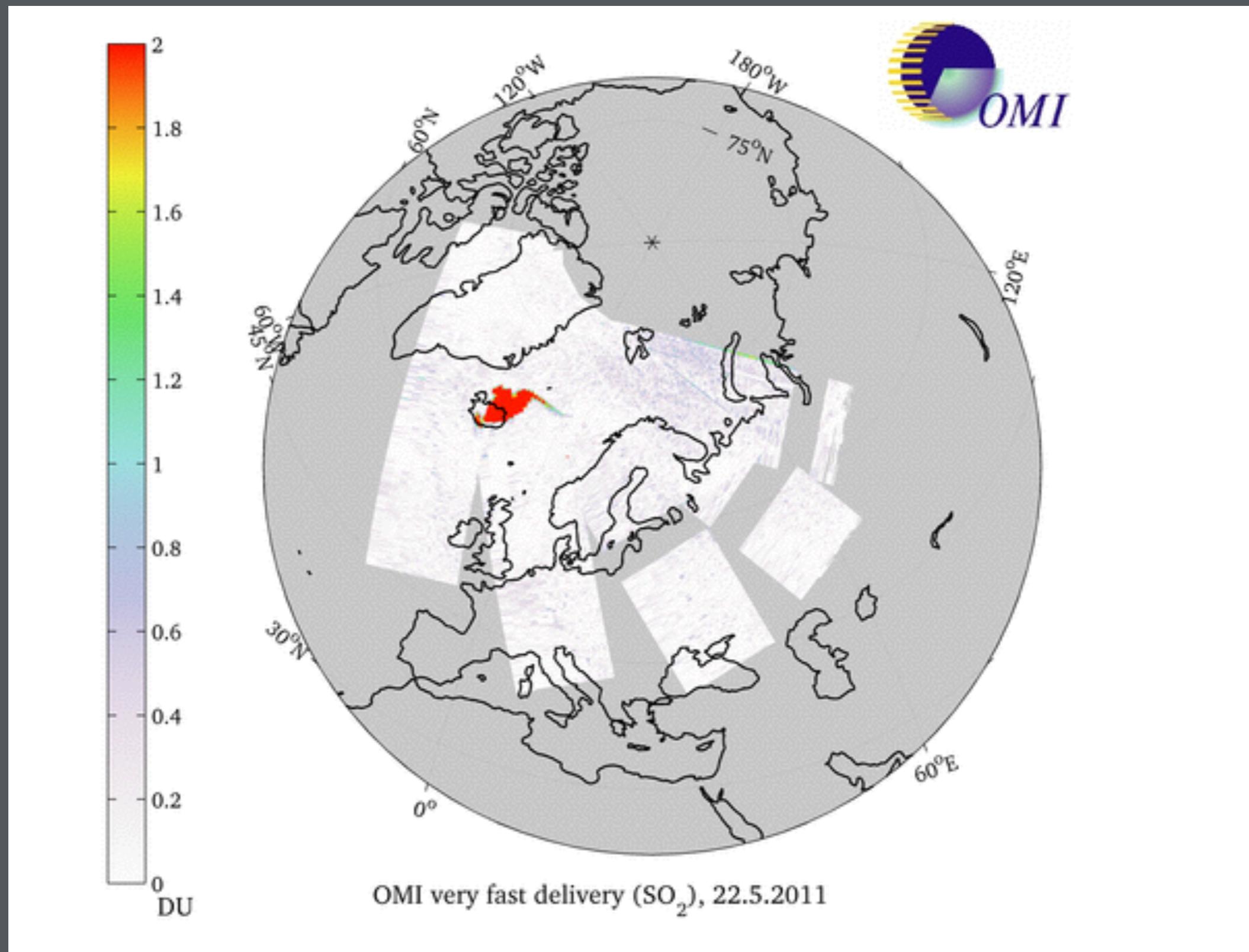
Hengittävät hiukkaset ( $\mu\text{g}/\text{m}^3$ )

25.05.2011 - 25.05.2011

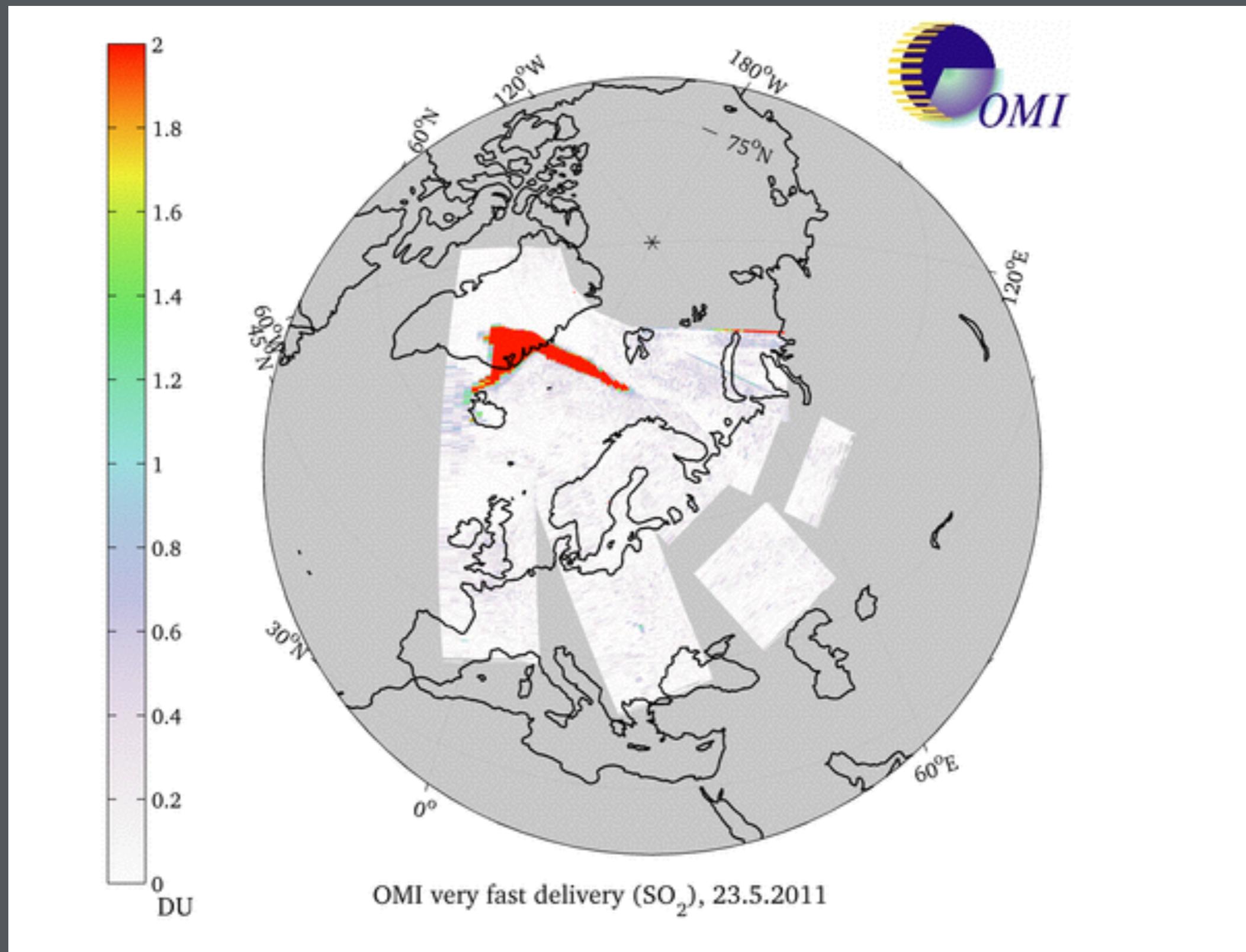


Kerminen, V.-M., Niemi, J. V., Timonen, H., Aurela, M., Frey, A., Carbone, S., Saarikoski, S., Teinilä, K., Hakkarainen, J., Tamminen, J., Vira, J., Prank, M., Sofiev, M., and Hillamo, R.: Characterization of a volcanic ash episode in southern Finland caused by the Grimsvötn eruption in Iceland in May 2011, Atmos. Chem. Phys., 11, 12227-12239, doi:10.5194/acp-11-12227-2011, 2011.

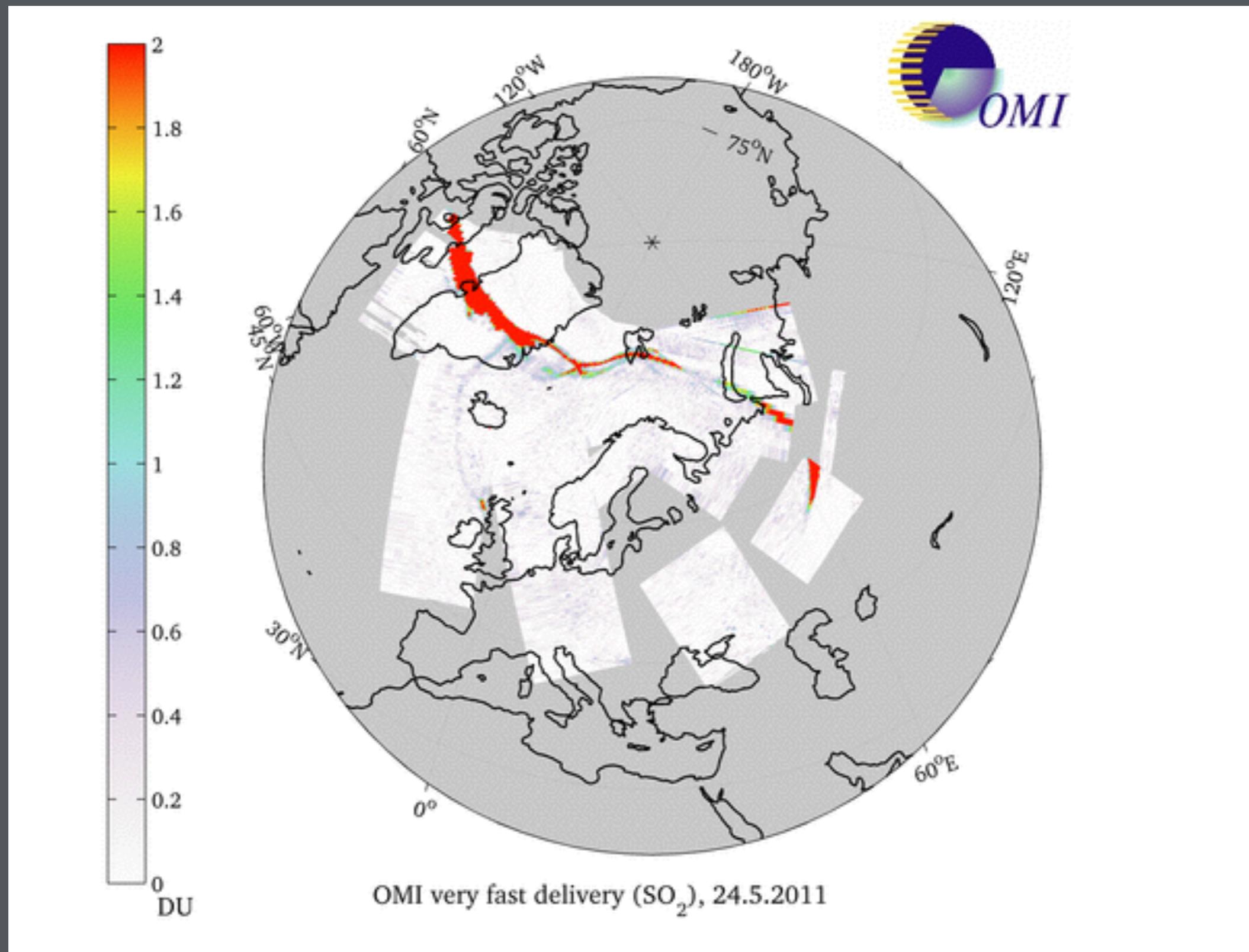
# $\text{SO}_2$ , 22.05.



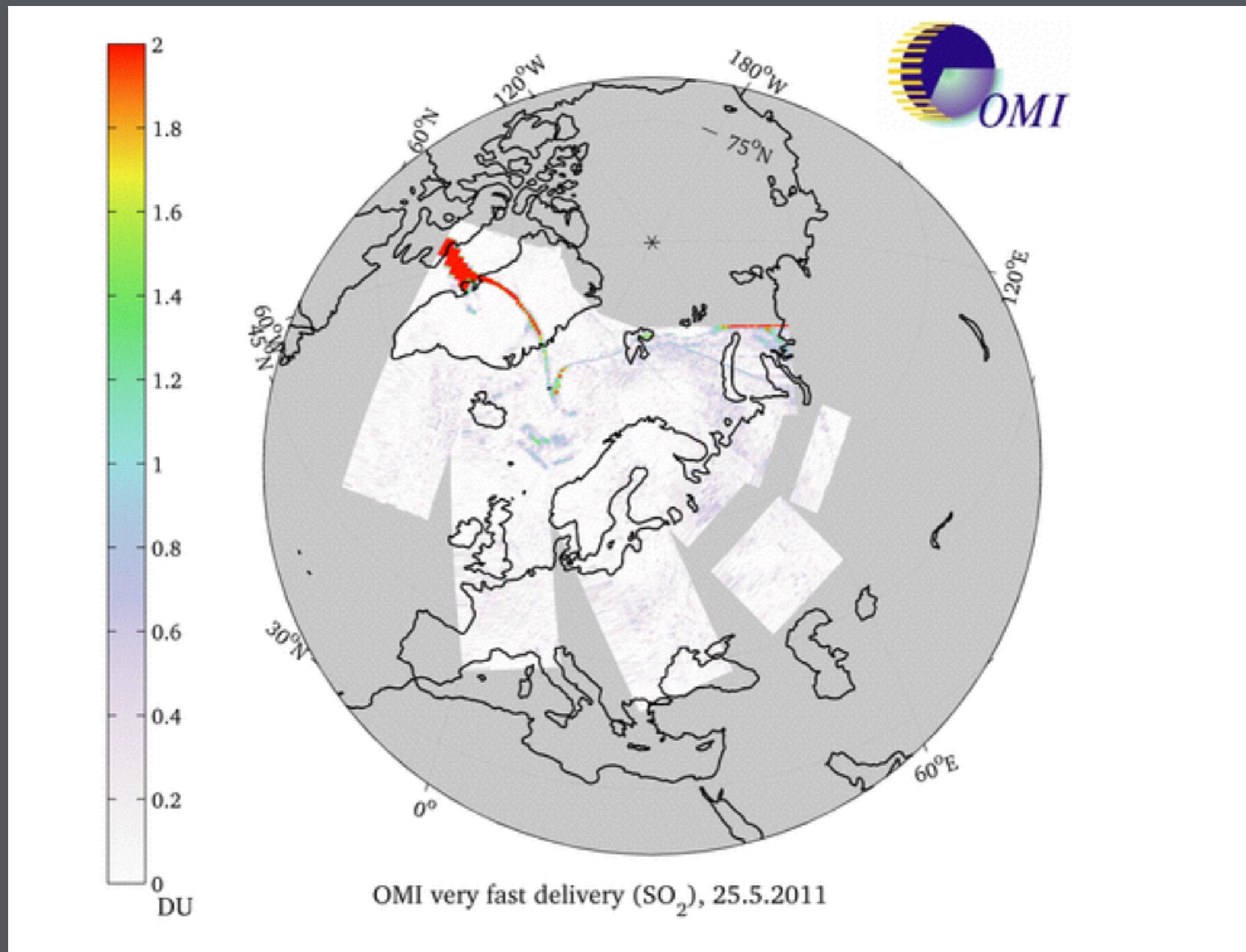
# $\text{SO}_2$ , 23.05.



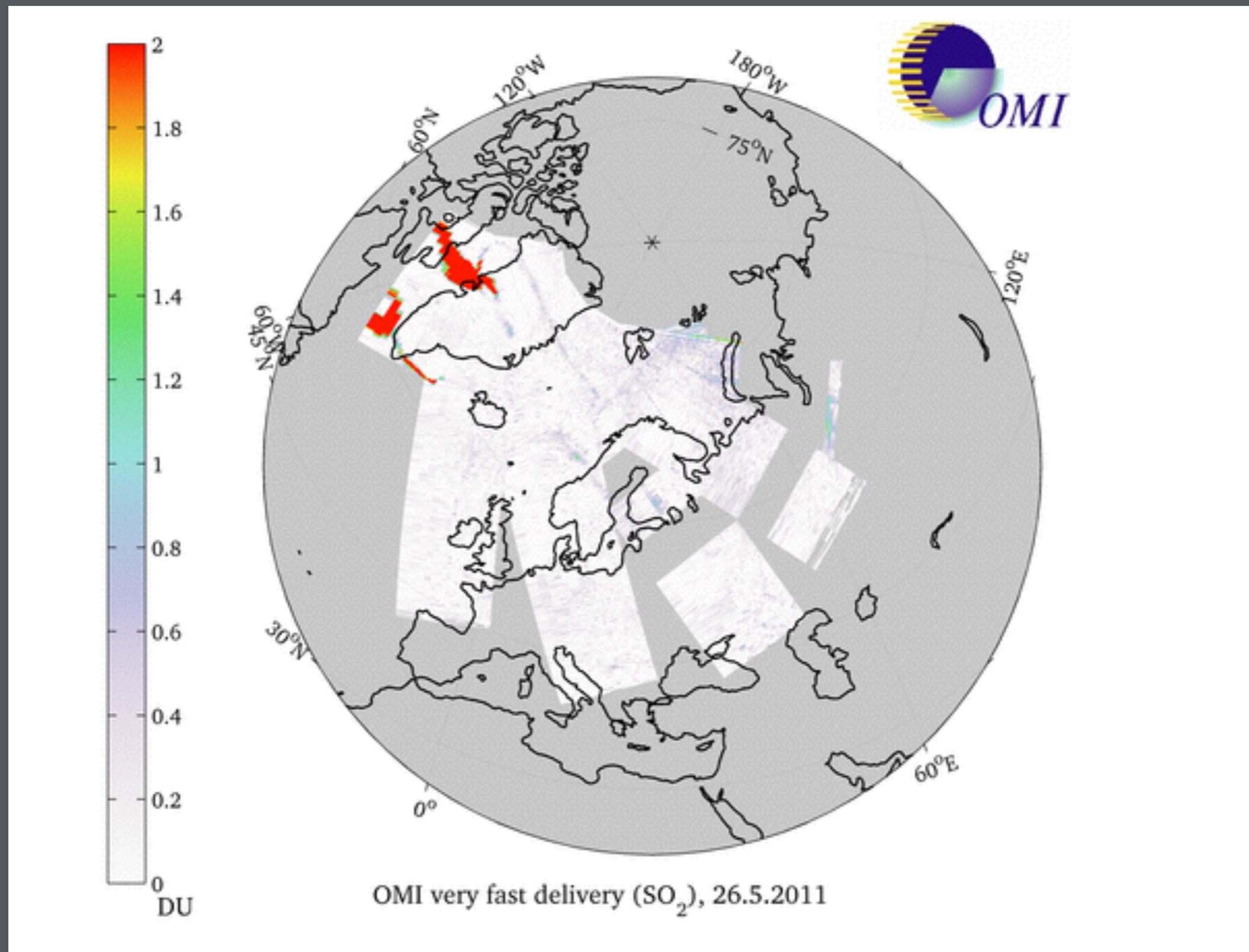
# $\text{SO}_2$ , 24.05.



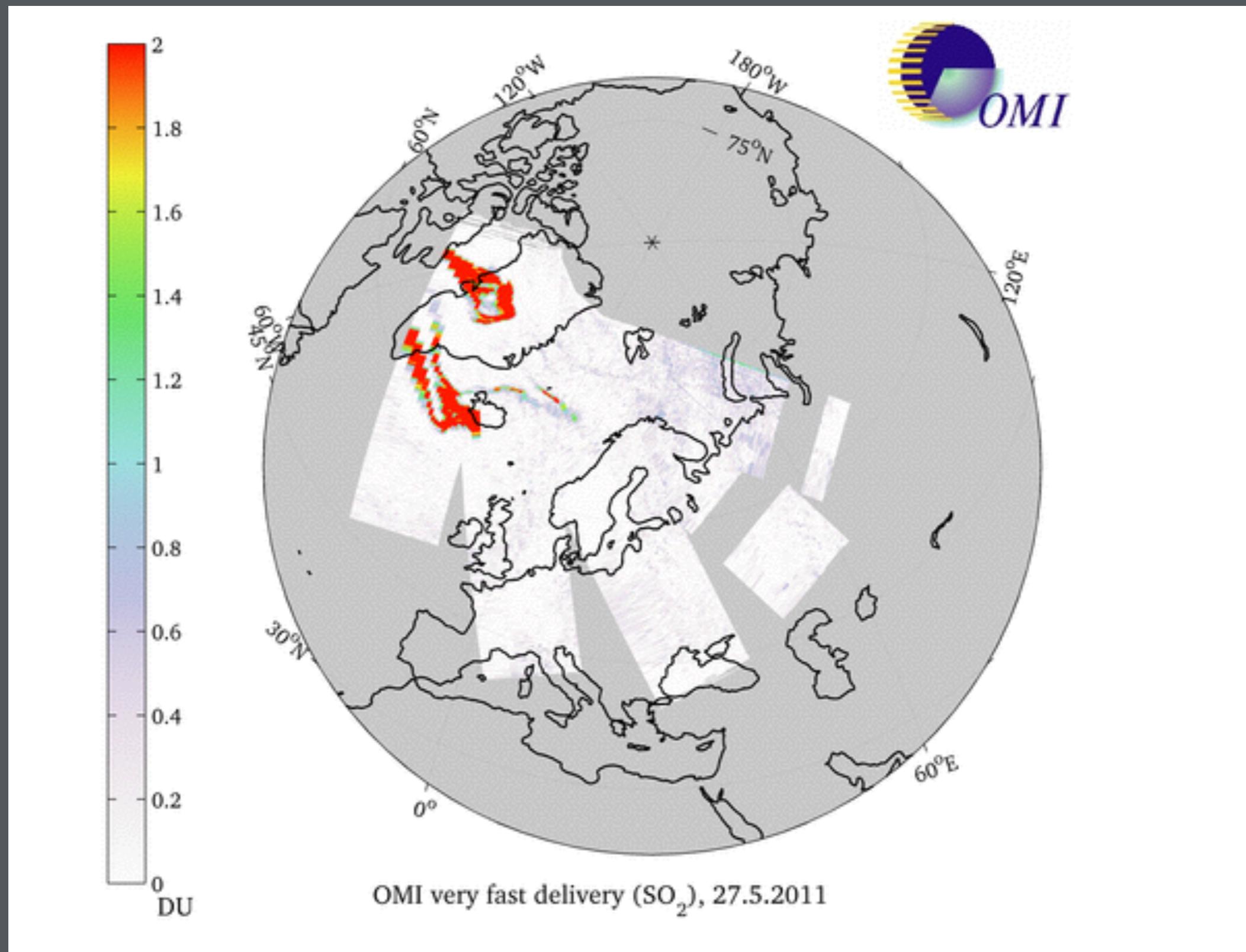
# $\text{SO}_2$ , 25.05.



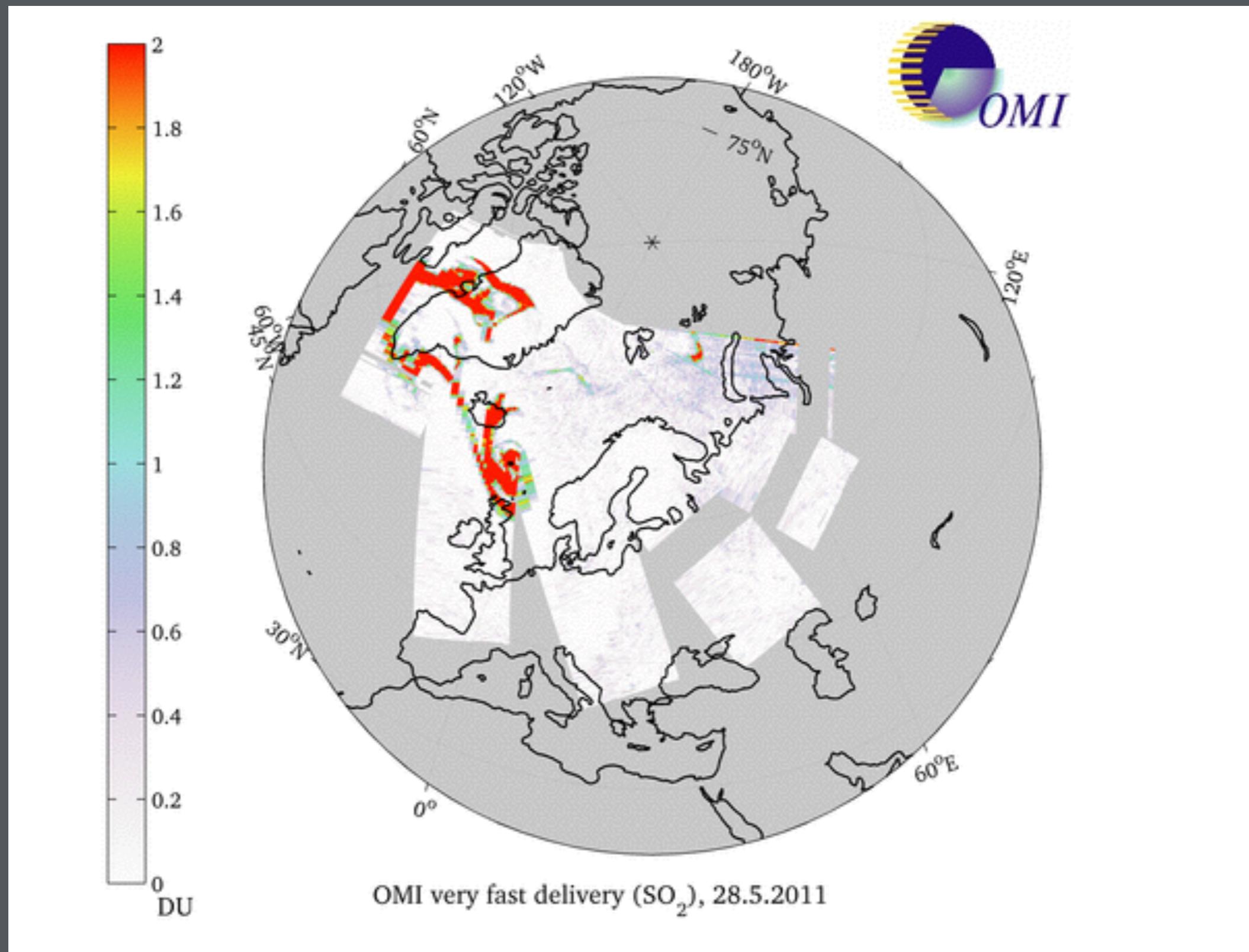
# $\text{SO}_2$ , 26.05.



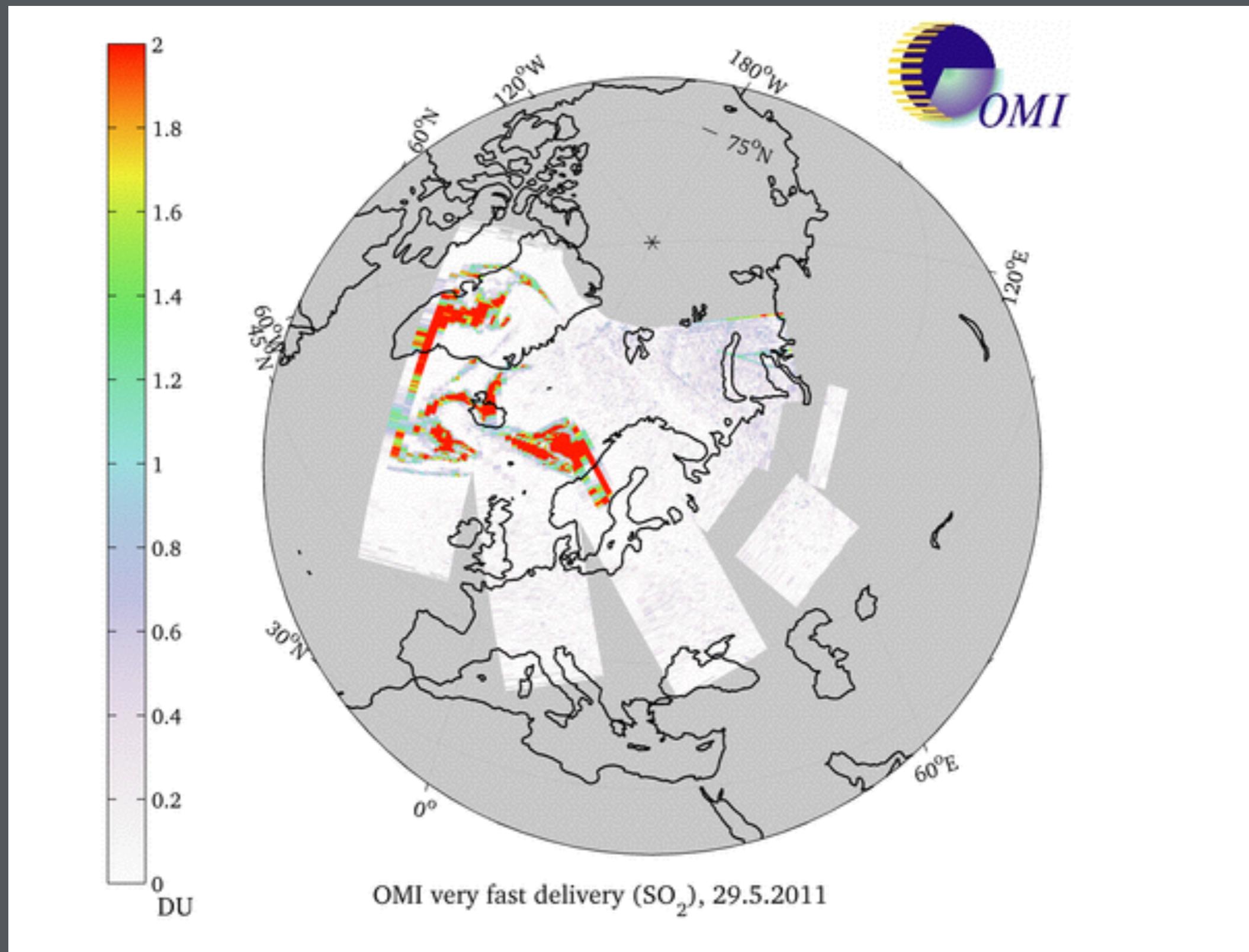
# $\text{SO}_2$ , 27.05.



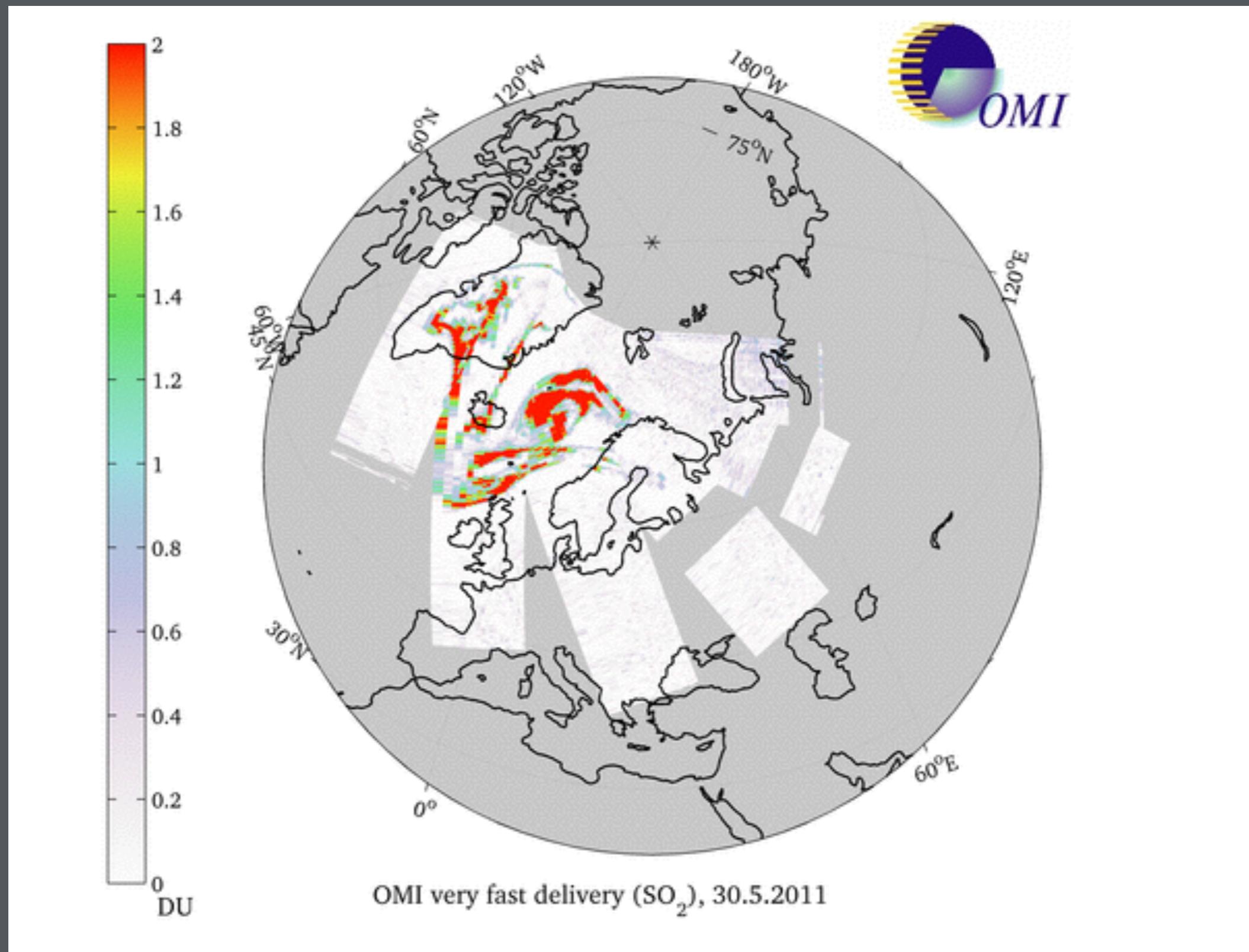
# $\text{SO}_2$ , 28.05.



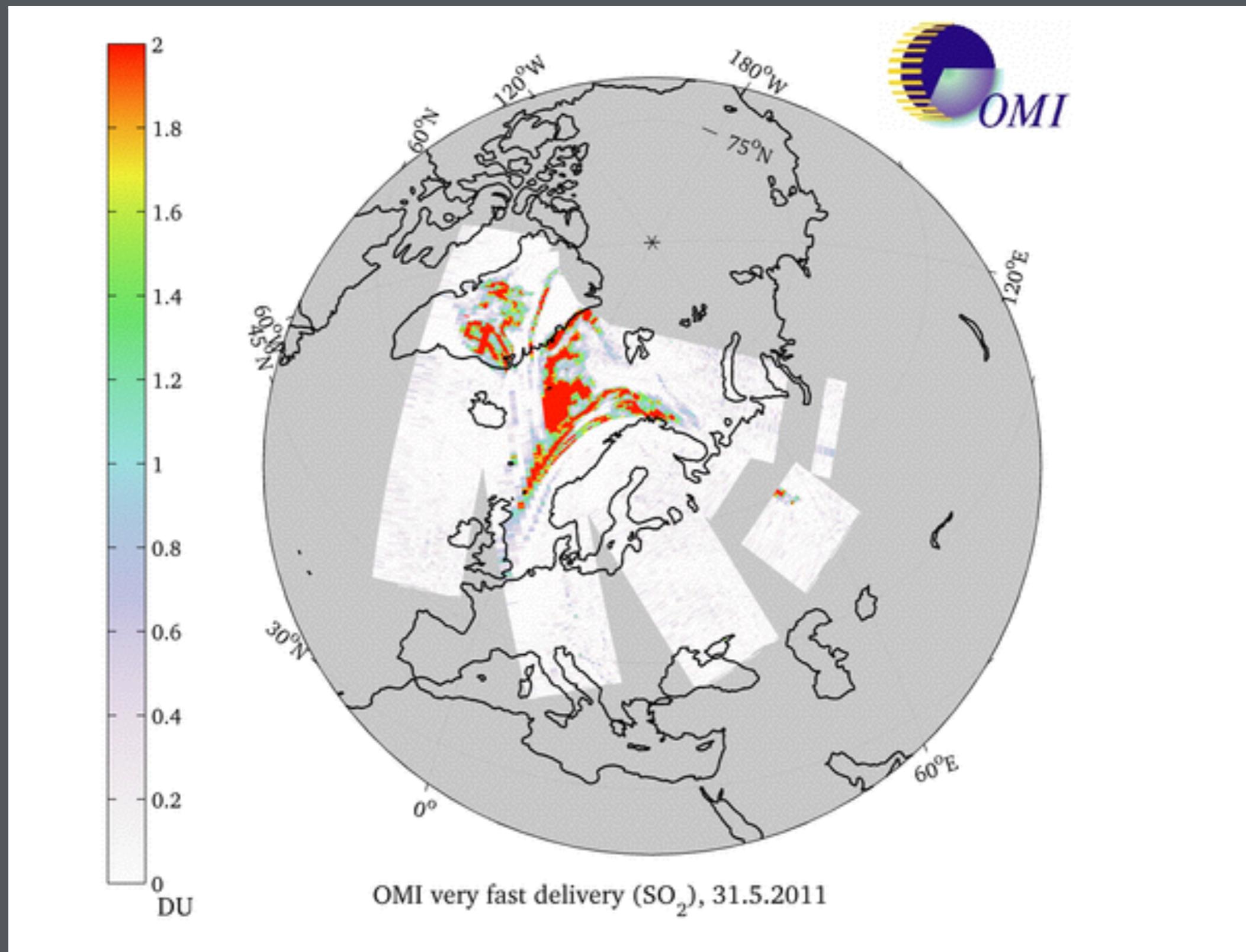
# $\text{SO}_2$ , 29.05.



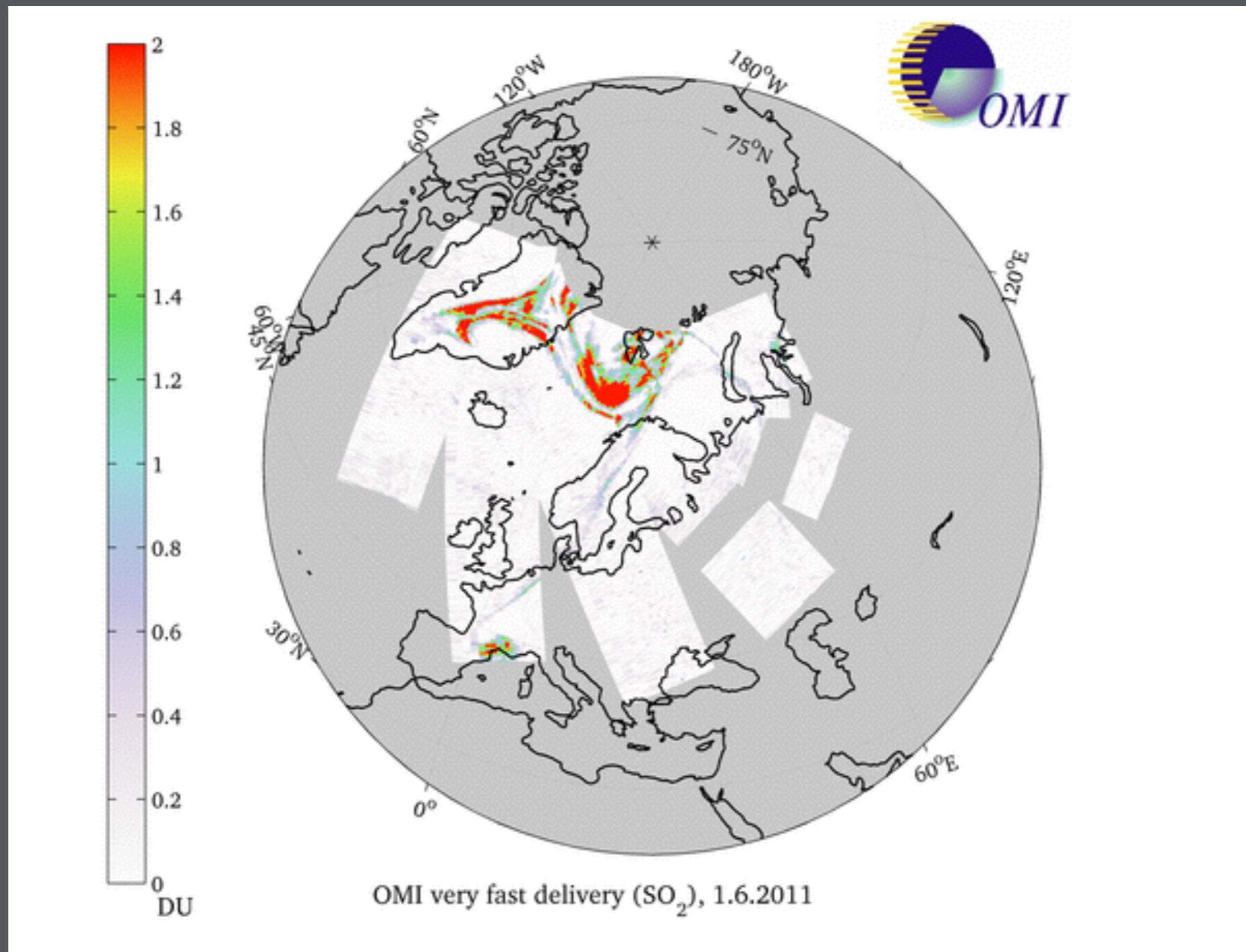
# $\text{SO}_2$ , 30.05.



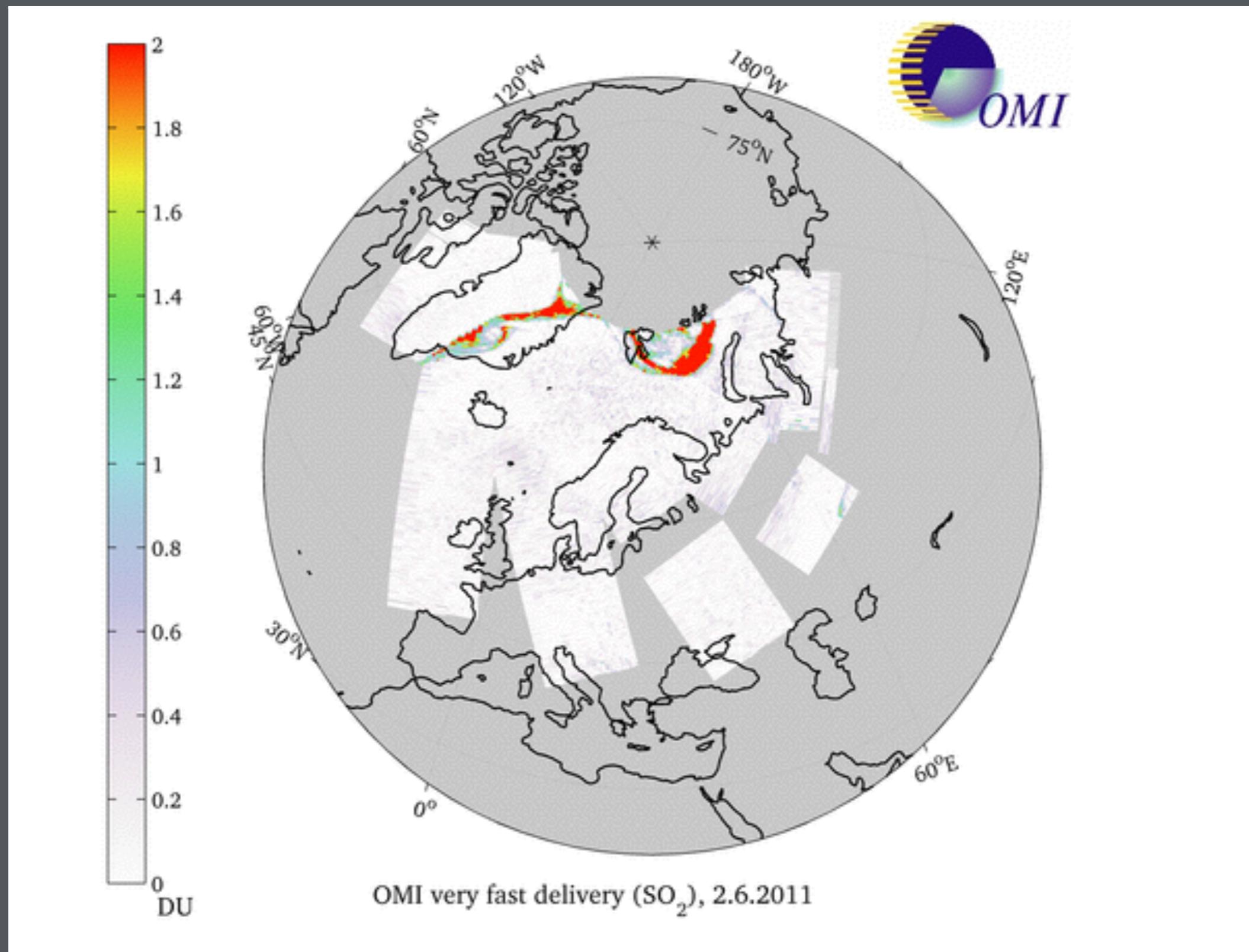
# $\text{SO}_2$ , 31.05.



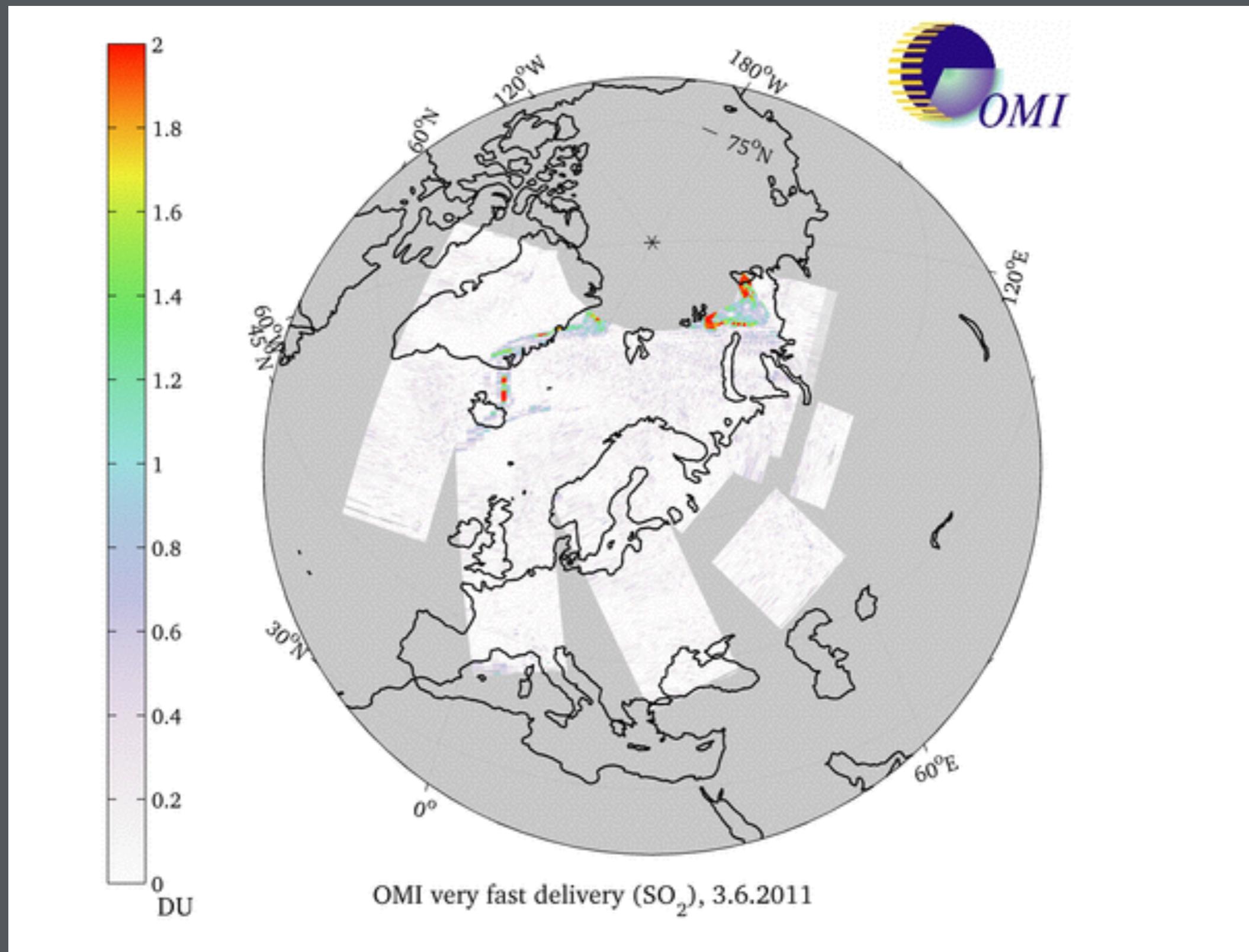
# $\text{SO}_2$ , 01.06.



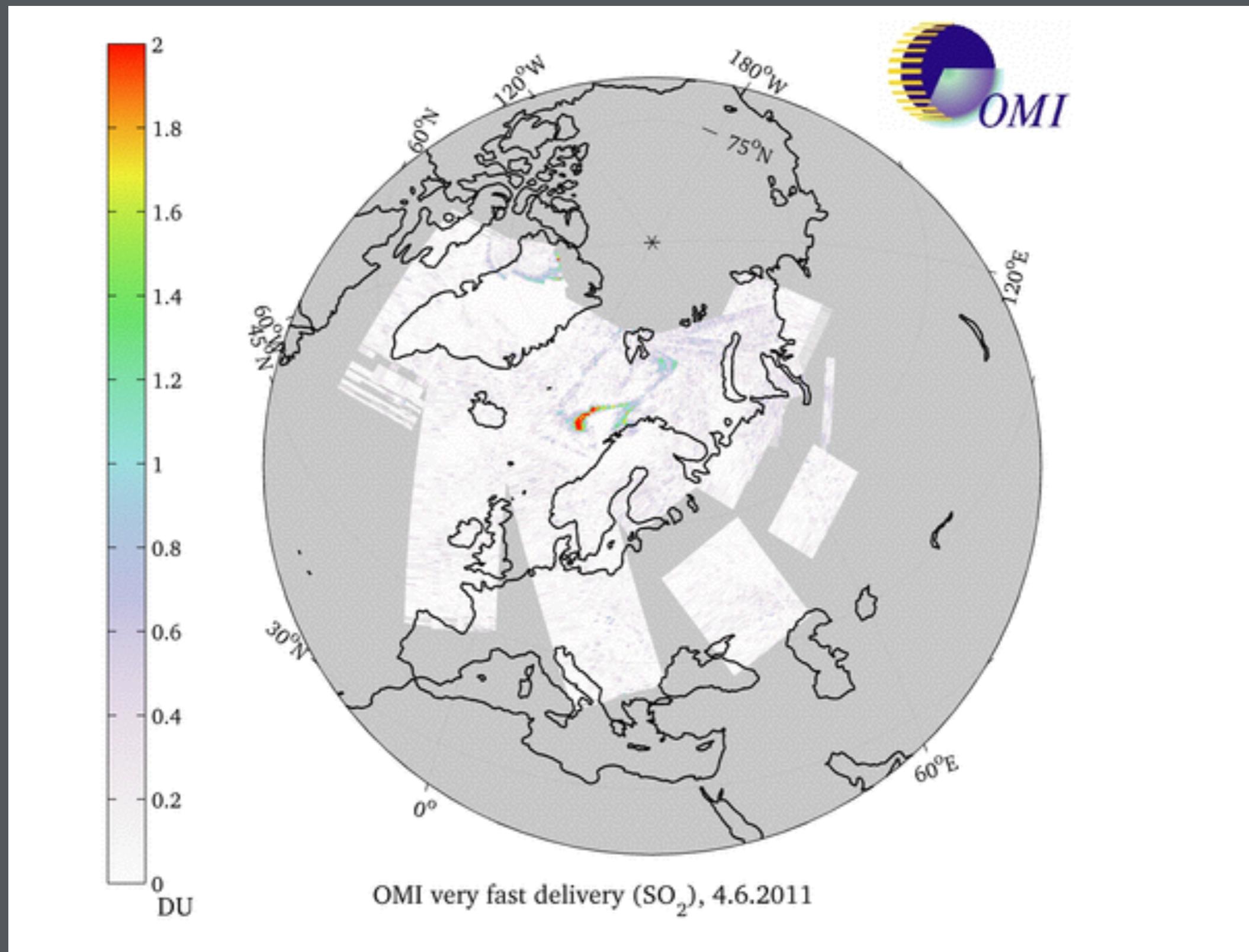
# $\text{SO}_2$ , 02.06.



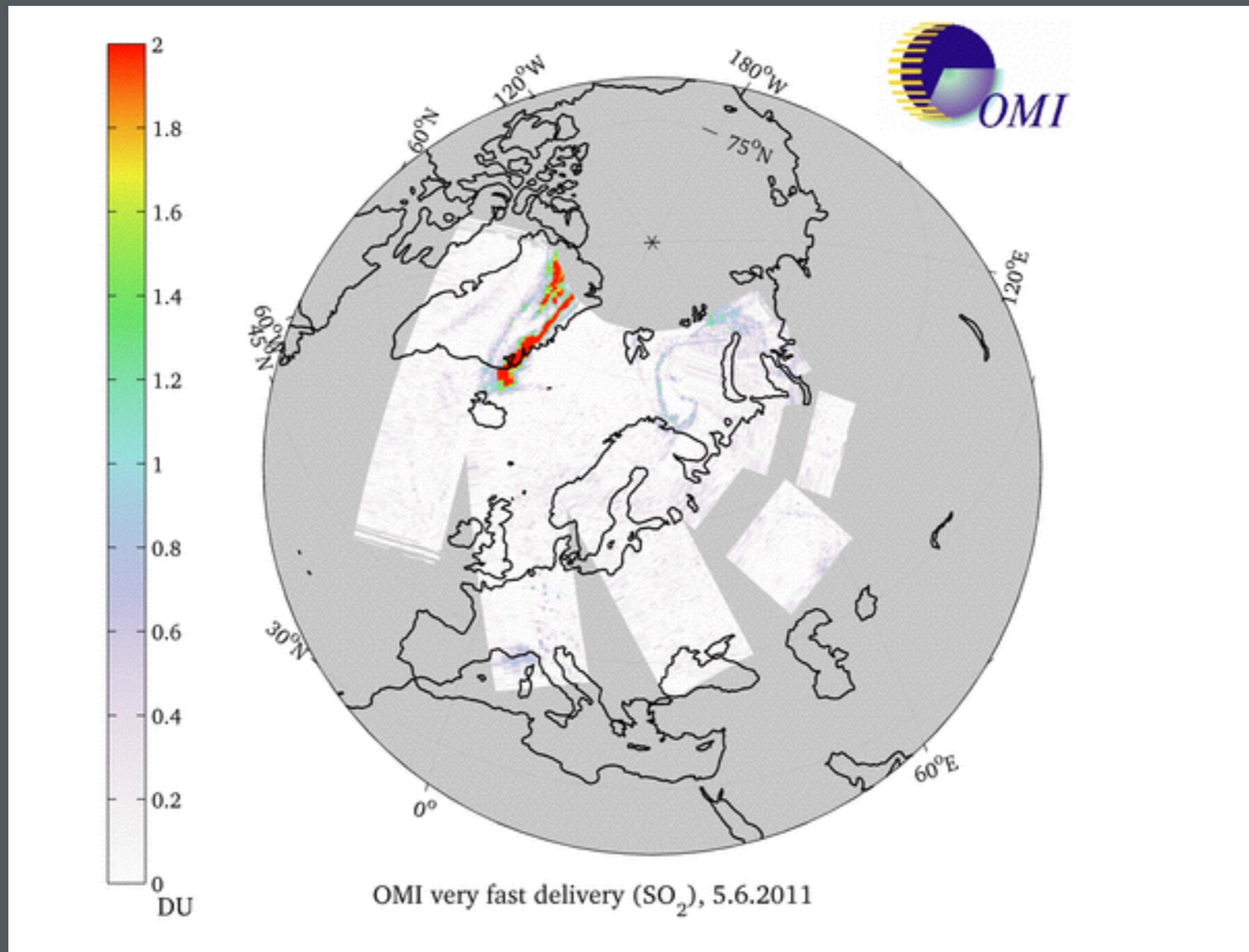
# $\text{SO}_2$ , 03.06.



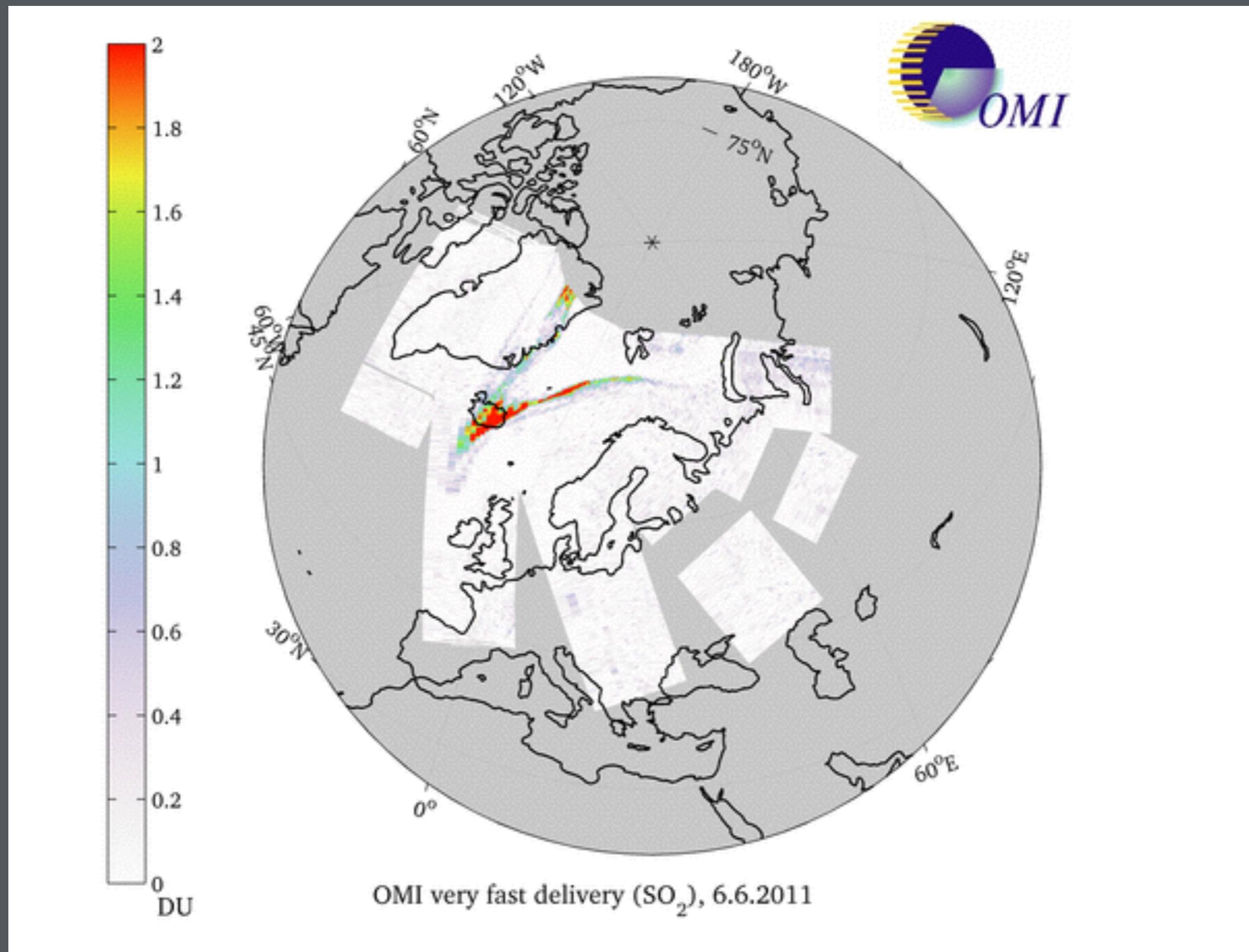
# $\text{SO}_2$ , 04.06.



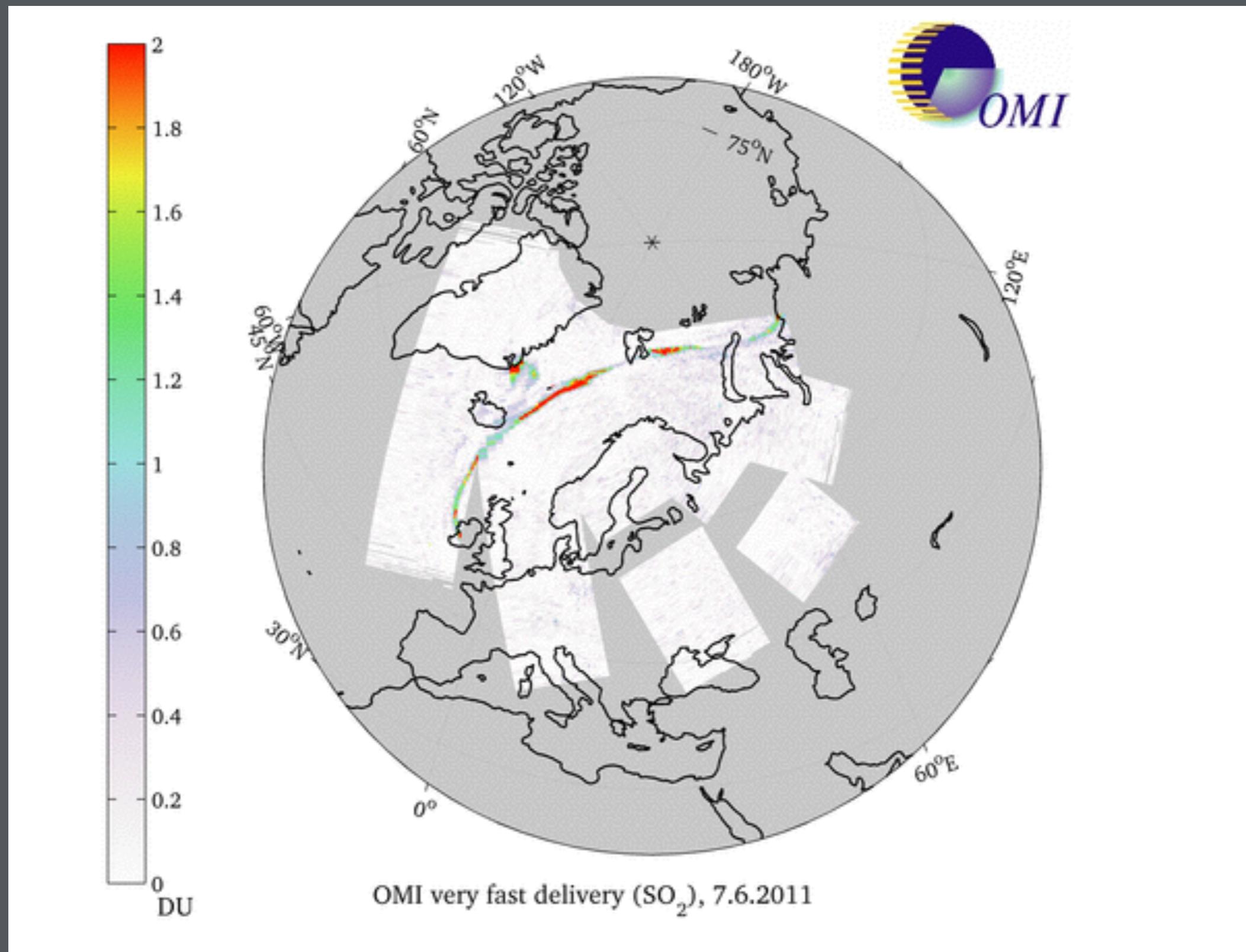
# $\text{SO}_2$ , 05.06.



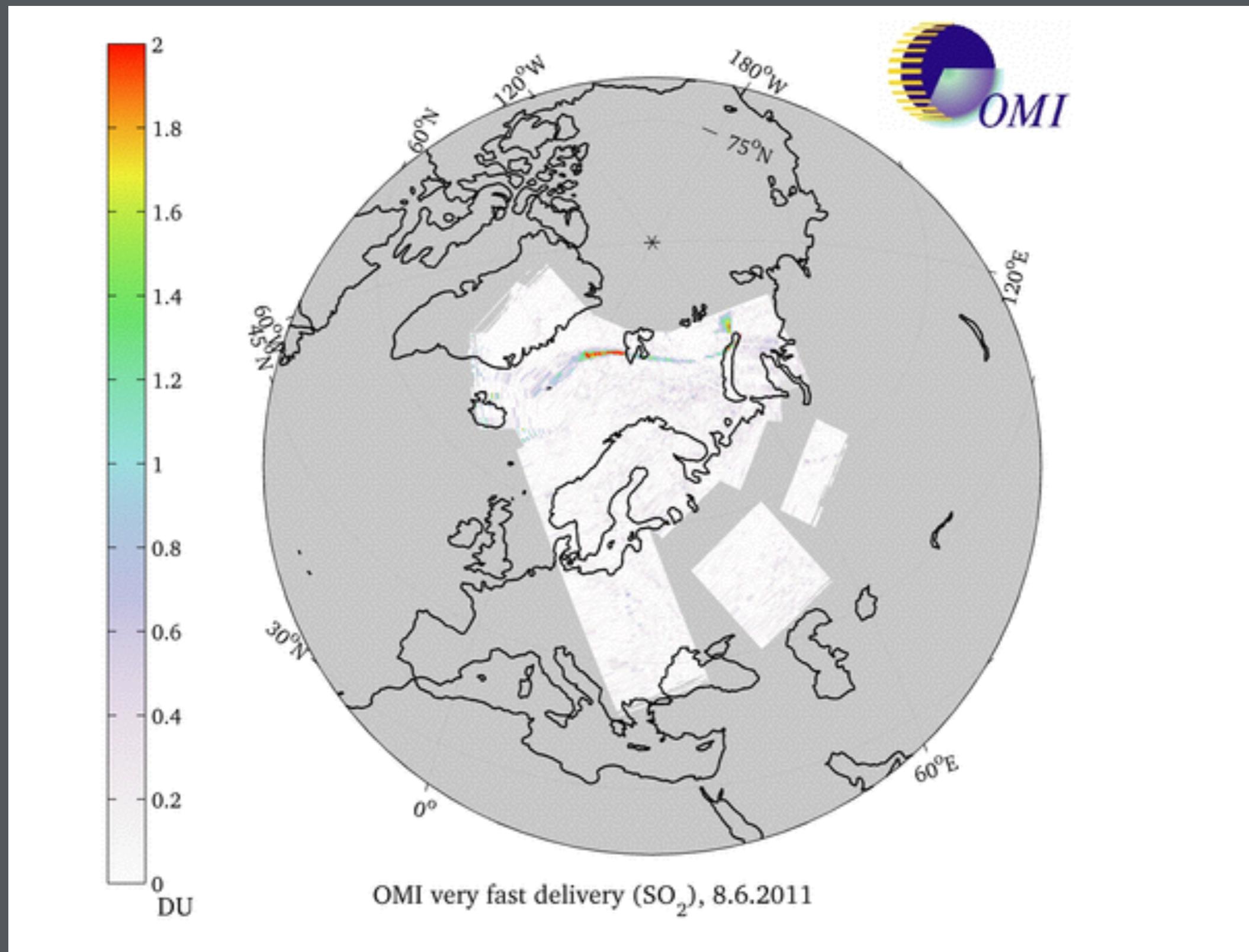
# $\text{SO}_2$ , 06.06.



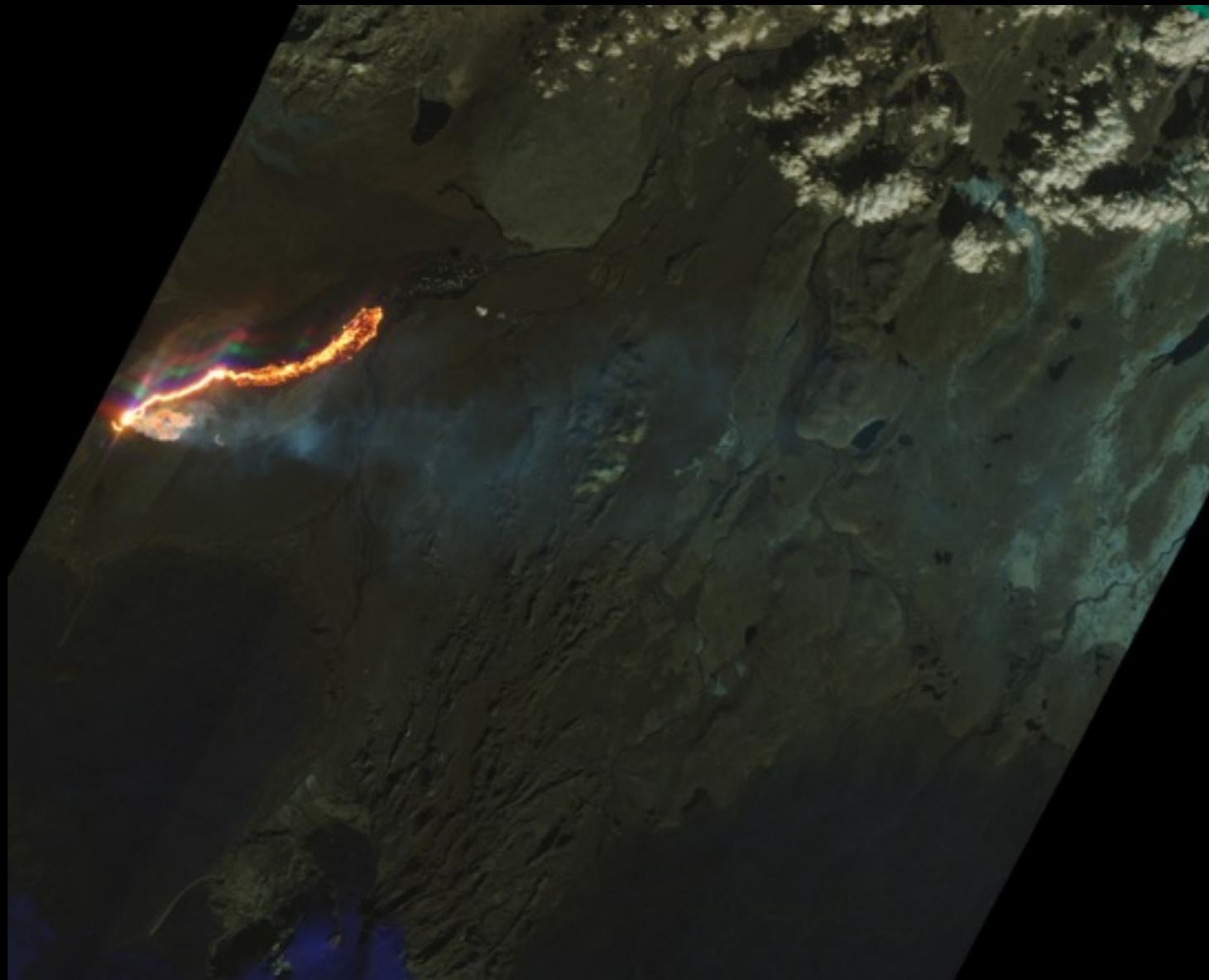
# $\text{SO}_2$ , 07.06.



# $\text{SO}_2$ , 08.06.

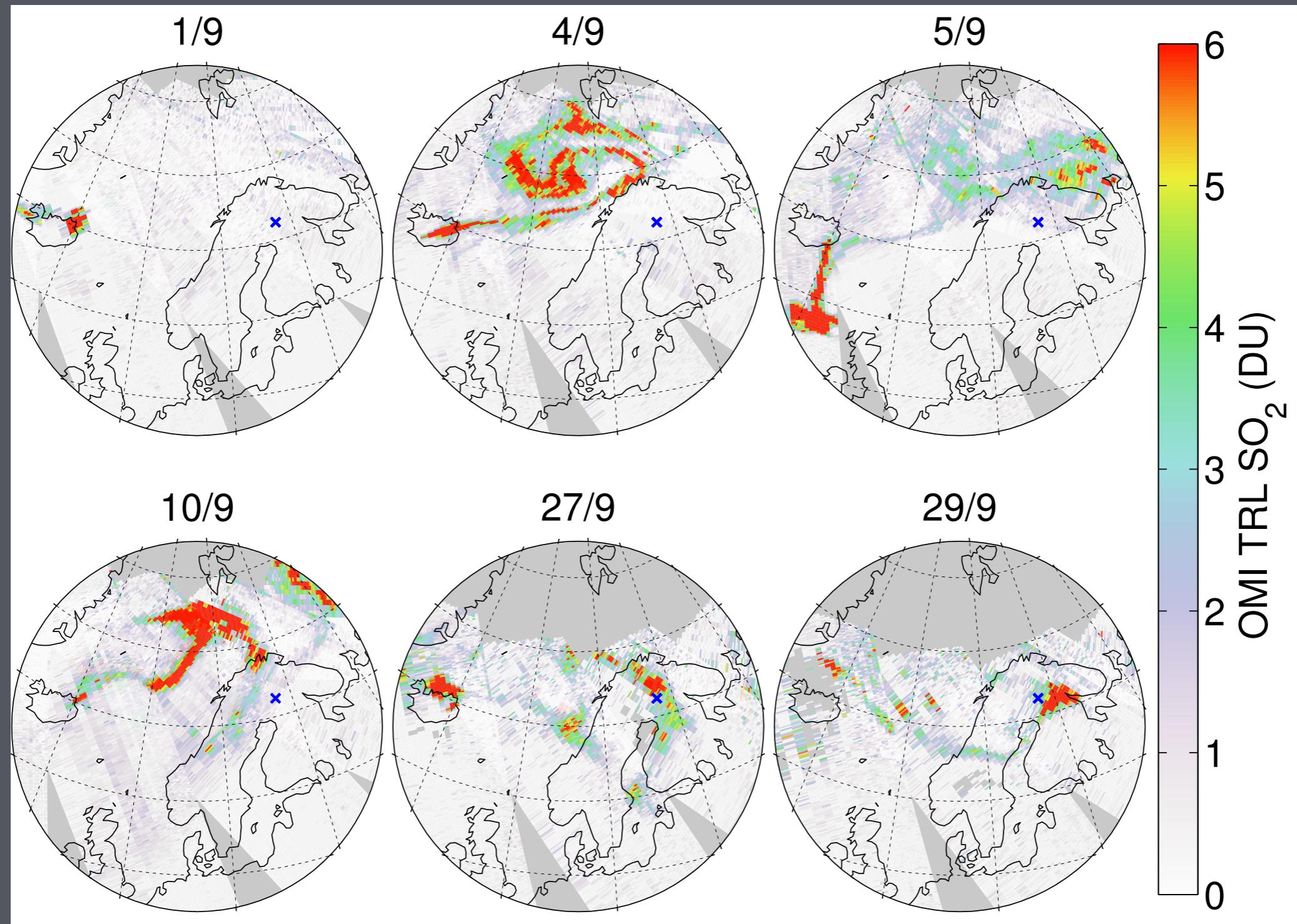


# Holuhraun fissure eruption 2014

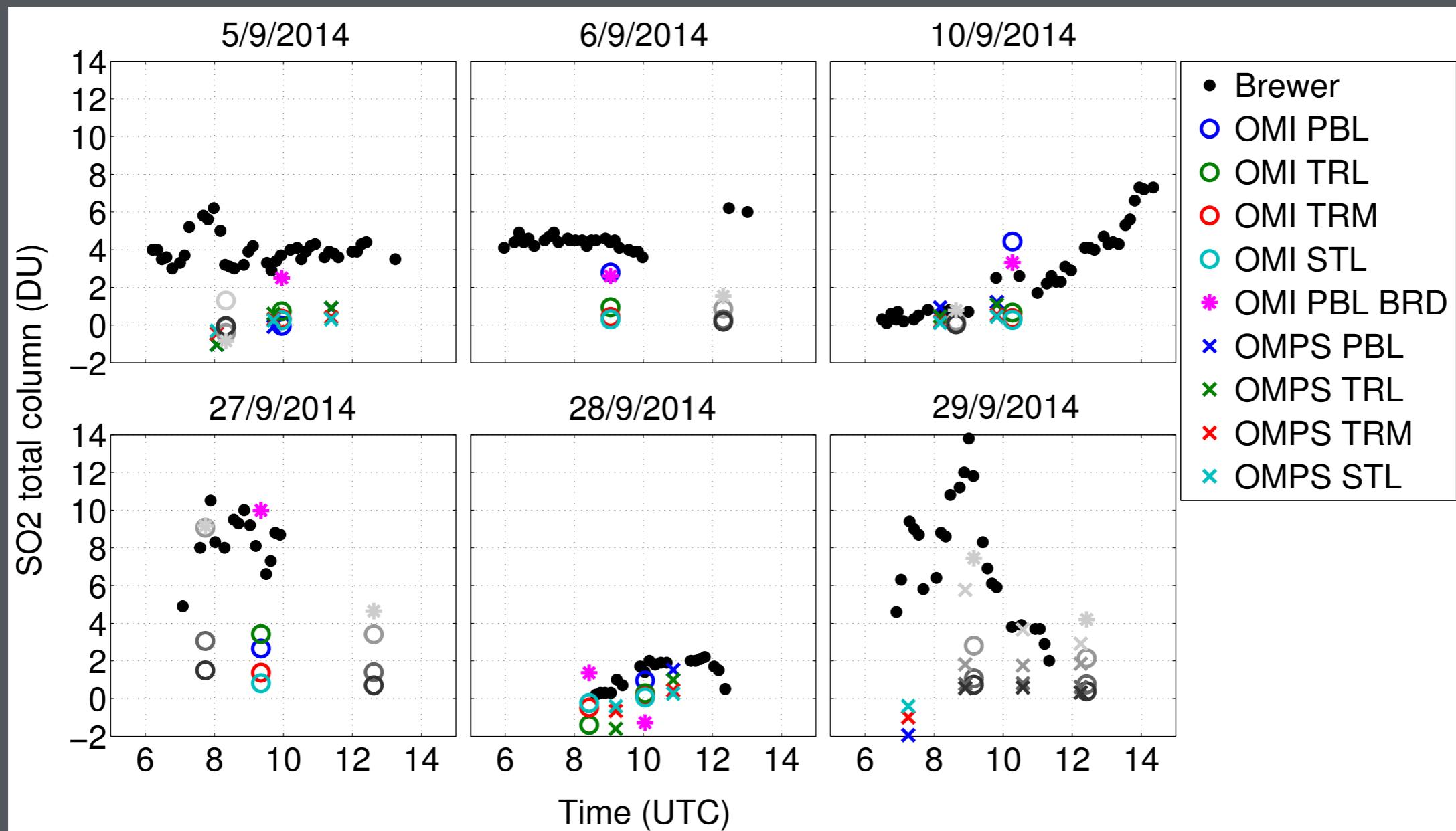


No ash. SO<sub>2</sub> only.

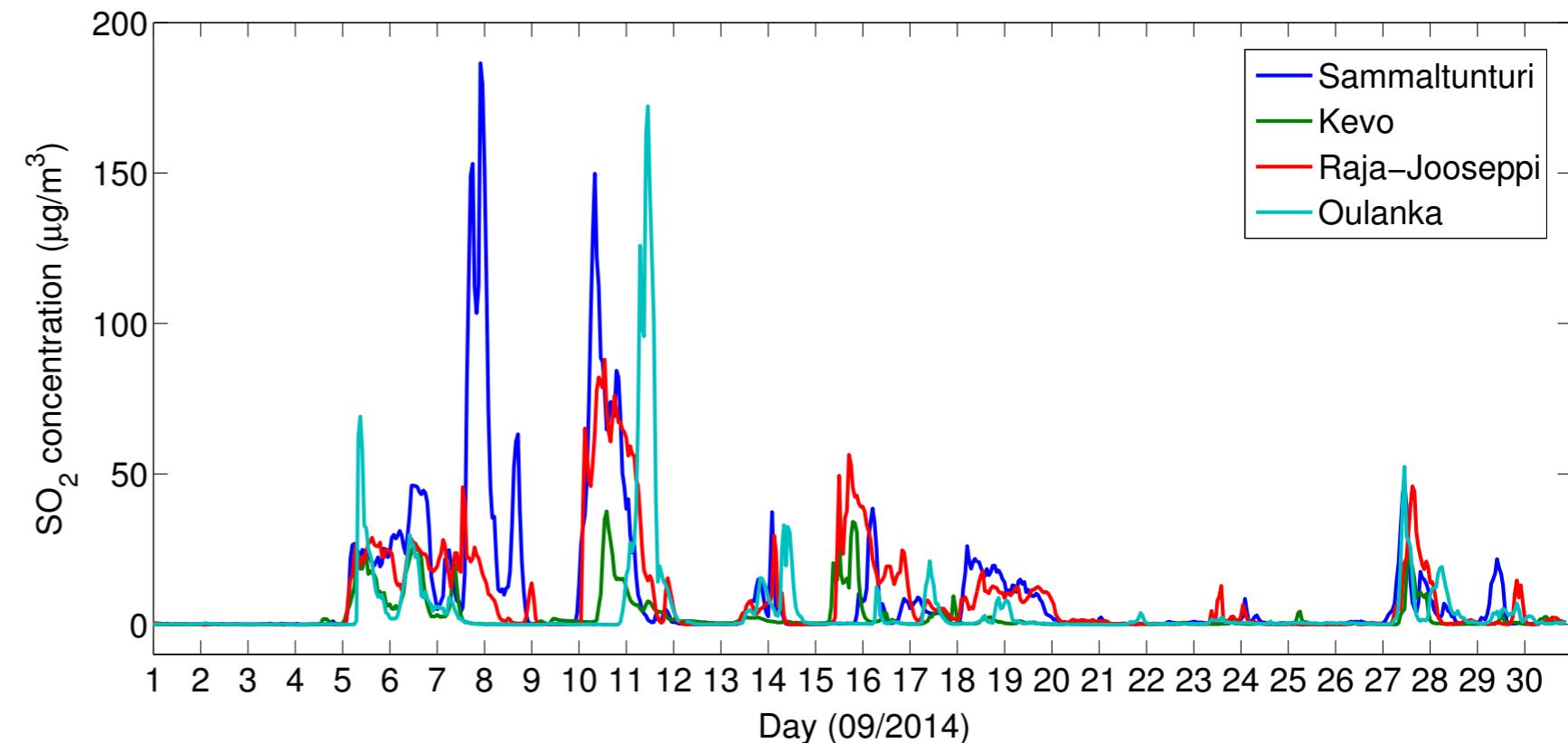
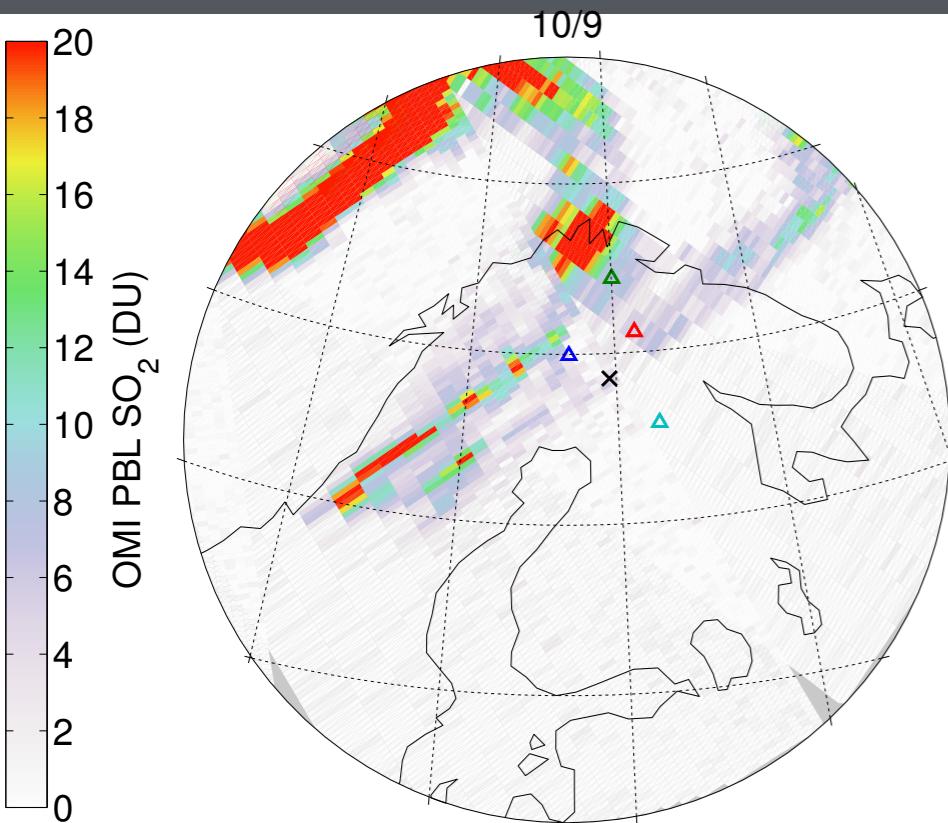
# Holuhraun fissure eruption 2014



# Holuhraun fissure eruption 2014



# Holuhraun fissure eruption 2014



Ialongo, I., Hakkarainen, J. et al.: Validation of satellite  $\text{SO}_2$  observations in northern Finland during the Icelandic Holuhraun fissure eruption, soon to be submitted to *Atmos. Meas. Tech.*, 2014.

# ★ Take home message ★



SO<sub>2</sub> and AAI are useful variables for monitoring  
volcanic clouds!