INGV

Eyja volcanic ash retrievals by using MODIS data

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Outline

- Ash retrieval algorithms in the TIR spectral range and the MODIS sensor
- Ash retrievals Results
- The AERONET network
- GOSAT project overview
- Conclusions

Ash retrieval in the TIR spectral range

The cloud discrimination is based on Brightness Temperature Difference algorithm [*Prata et al., 1989*] (+ water vapor correction [*Corradini et al., 2008*])

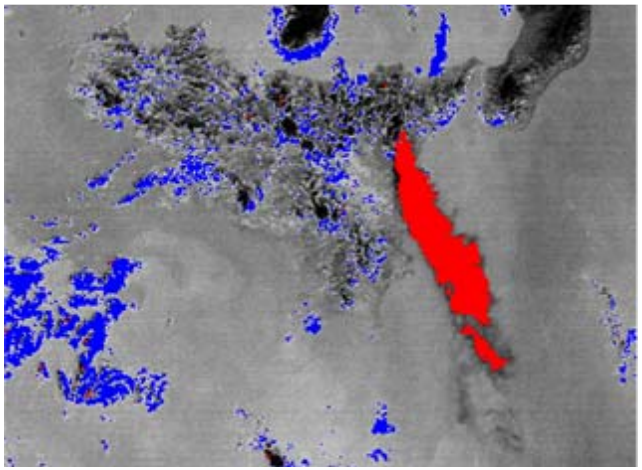
BTD= $T_b(11\mu m)-T_b(12\mu m)$

The ash retrievals are based on computing the simulated inverted arches curves "BTD-$T_b(11\mu m)$" varying the AOT and the particles effective radius [*Wen and Rose, 1994; Prata et al., 2001*]

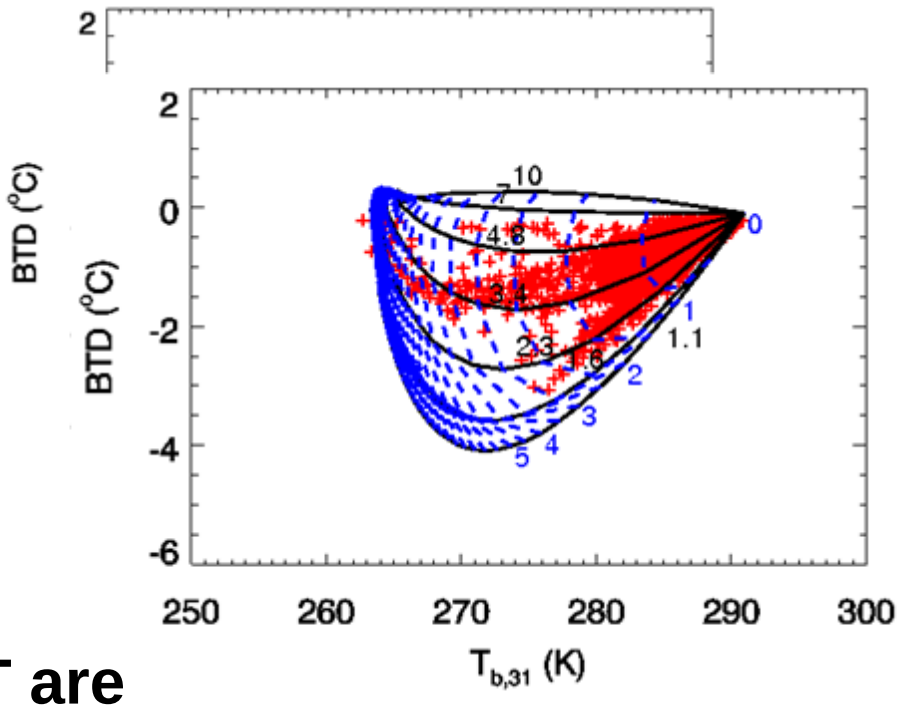
$$M_{tot} = \frac{S4/3\rho r_e^{(n,m)}\tau^{(n,m)}}{Q_{ext}(r_e^{(n,m)})}$$

The TOA simulated Radiances LUT are computed using MODTRAN 4 RTM

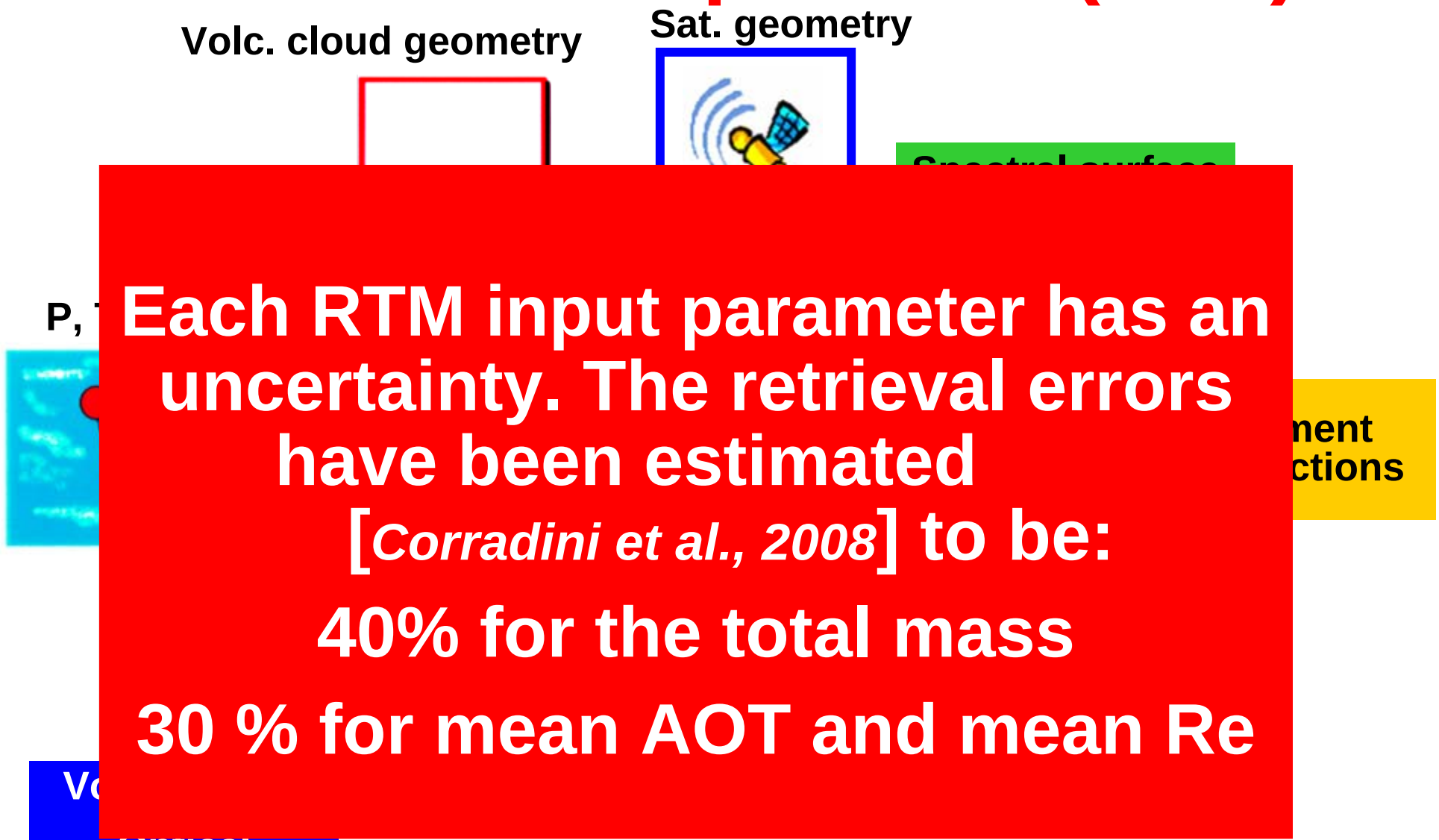
BTD < 0 volcanic ash



BTD > 0 meteo clouds



Radiance computation (LUT)



Each RTM input parameter has an uncertainty. The retrieval errors have been estimated [*Corradini et al., 2008*] to be:

40% for the total mass

30 % for mean AOT and mean Re

- 9 values of AOT (0 to 10, constant step in a log scale)
- 8 values of R_{eff} (0.7 to 10 μm, constant step in a log scale)
- 6 VZA (0 to 75, step 15°)

MODIS

http://modis.gsfc.nasa.gov/

Aboard the **Terra** and **Aqua** polar orbit satellites

36 bands from VIS to TIR

The channels 31 and 32, centered at 11 and 12 μm, are used for the ash detection and retrievals

Repetition cicle: 1/2 days

TIR Spatial resolution : 1 km

DataSet

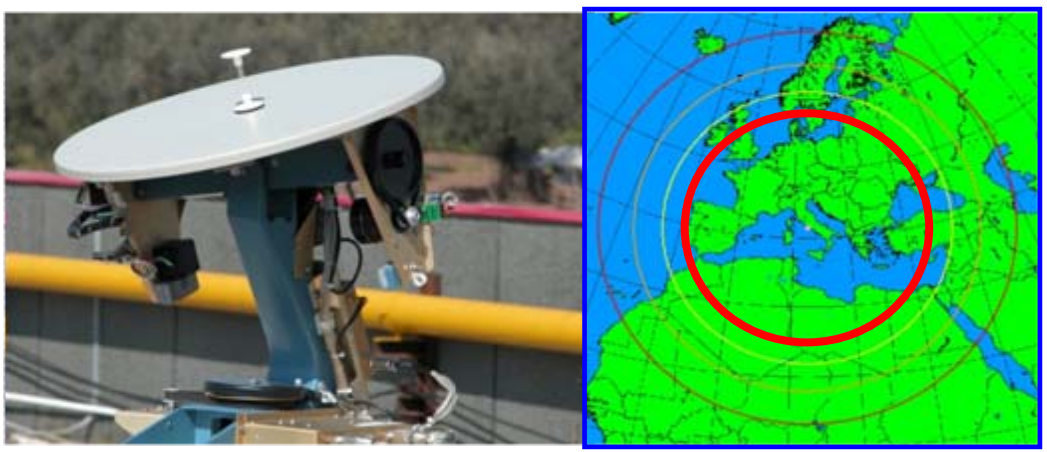
Date	Time (UTC)	Satellite
14/04	22:10	Terra
15/04	11:50	Aqua
15/04	21:10	Terra
16/04	10:40	Terra
16/04	23:35	Terra
17/04	11:25	Terra
17/04	14:55	Aqua
19/04	12:50	Terra
06/05	11:55	Terra
07/05	14:30	Aqua
08/05	13:20	Terra
09/05	12:25	Terra
10/05	15:00	Aqua
11/05	14:05	Aqua
12/05	12:55	Terra
13/05	12:00	Terra
14/05	13:00	Aqua
15/05	13:40	Aqua
16/05	12:30	Terra

… even if all the MODIS images processed have been dowloaded from the NASA-LAADS archive …

… a complete L/X band' "multi-mission" + EUMETSAT antenna systems have been installed at INGV in 2010.
The multi-mission antenna will permit the direct broadcast of MODIS, AIRS and AMSU aboard the NASA-TERRA and AQUA and MVISR data aboard the Chinese FY 1-D.
Both these antennas have been acquired according to the Italian Civil Protection which found these instrument improvements.

These systems will integrate the near real time monitoring based on L band antenna enabling the collection of AVHRR data acquired by NOAA constellation.

AVHRR-NOAA Antenna

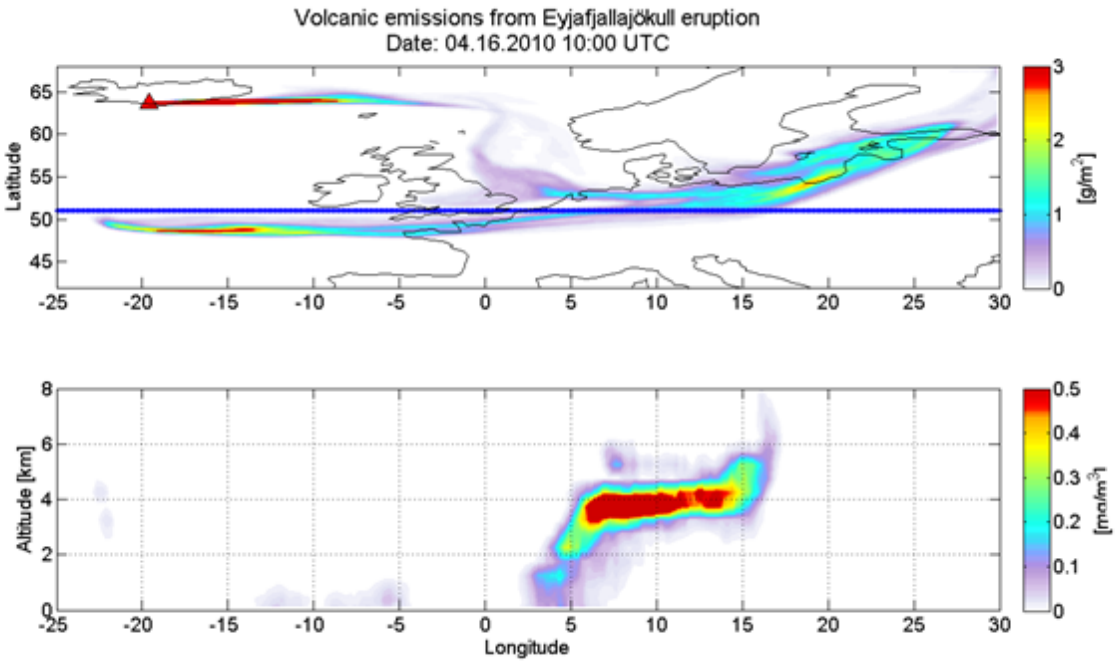


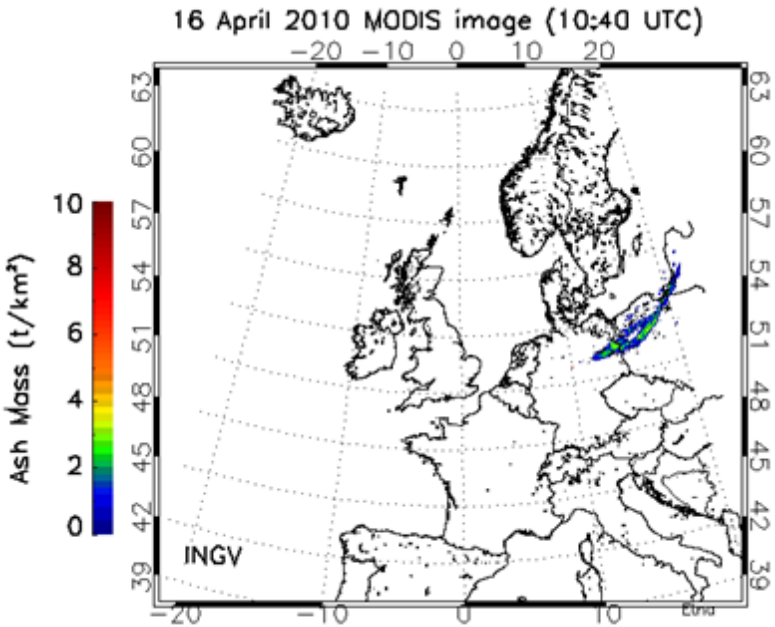
L/X band' "multi-mission antenna

MODTRAN Inputs:

- **P, T** and **H**: from the ash cloud nearest WMO Meteo Station measurements
(ash cloud over Iceland: Keflavikurflugvollur WMO station)

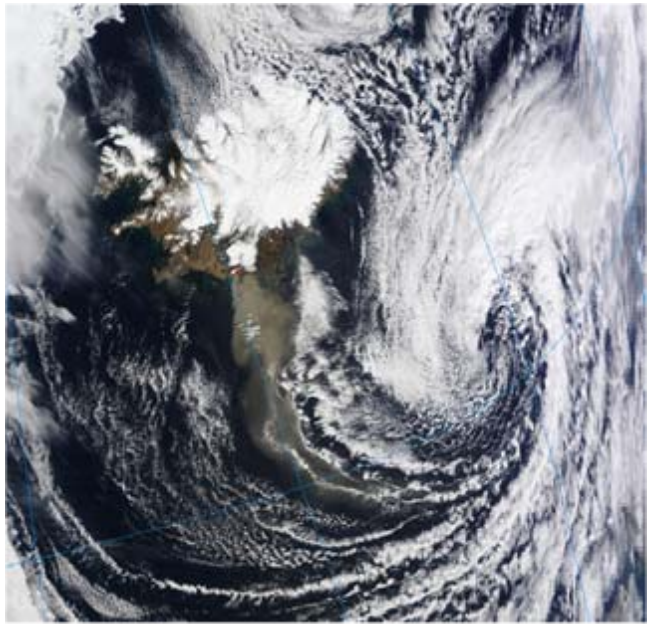
- **Ts**: from the TIR-RTE inversion using 11 and 12 μm channels
- **Aerosol type**: Andesite
- **Top Ash Cloud Altitude**:
- by comparing the 11 μm brightness temperature with the WMO temperature profile (when the opaque pixels exist)
- by using the FLEXPART model



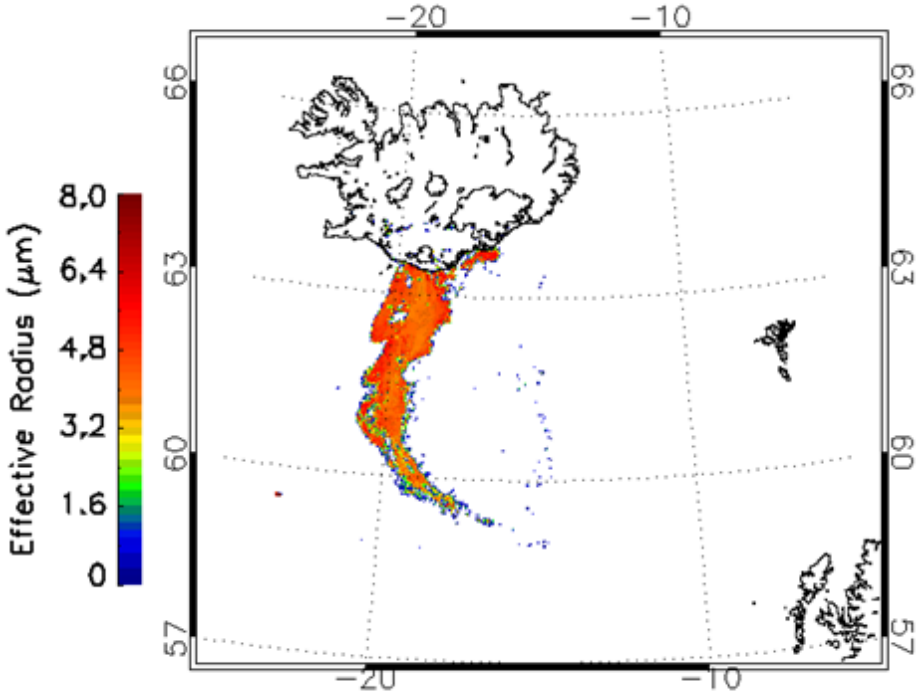


Credit: Nina Iren Kristiansen - NILU

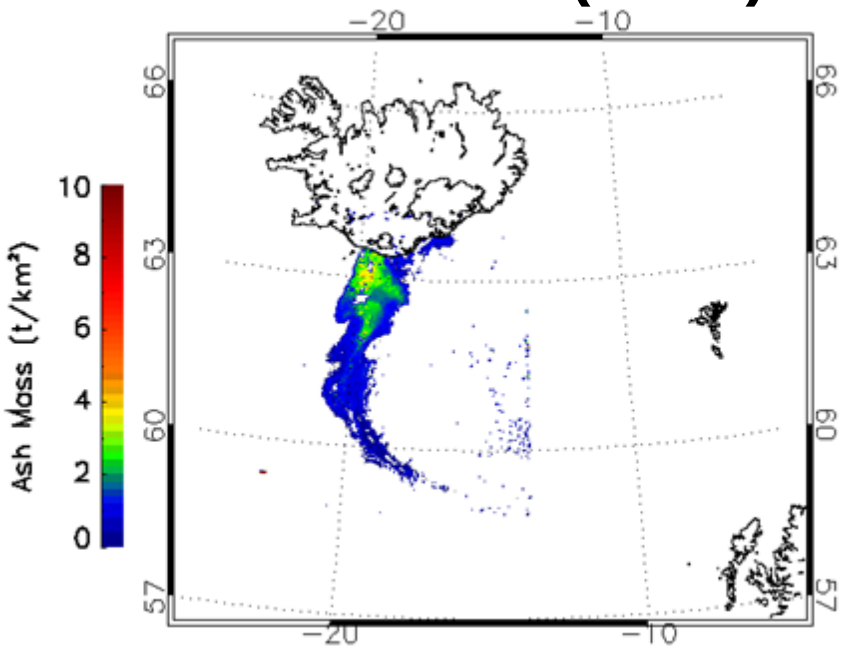
April 19, 12:50 UTC



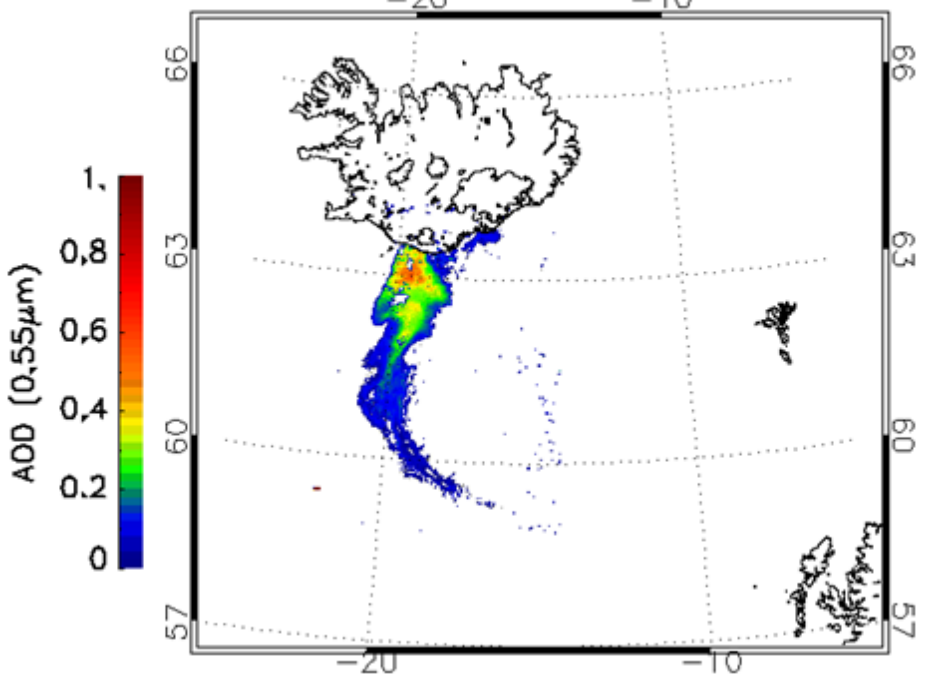
Effective Radius



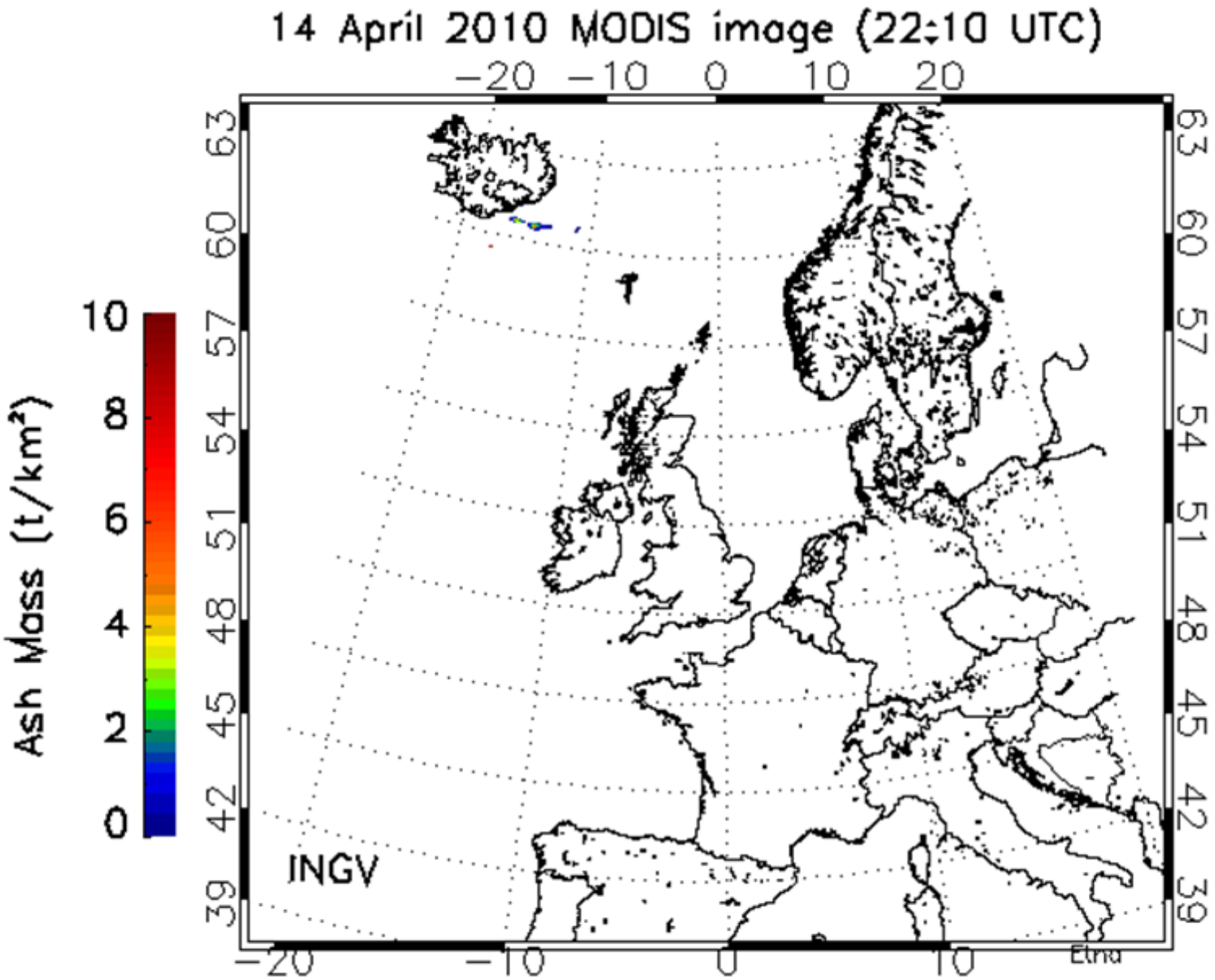
Total Mass (t/km²)



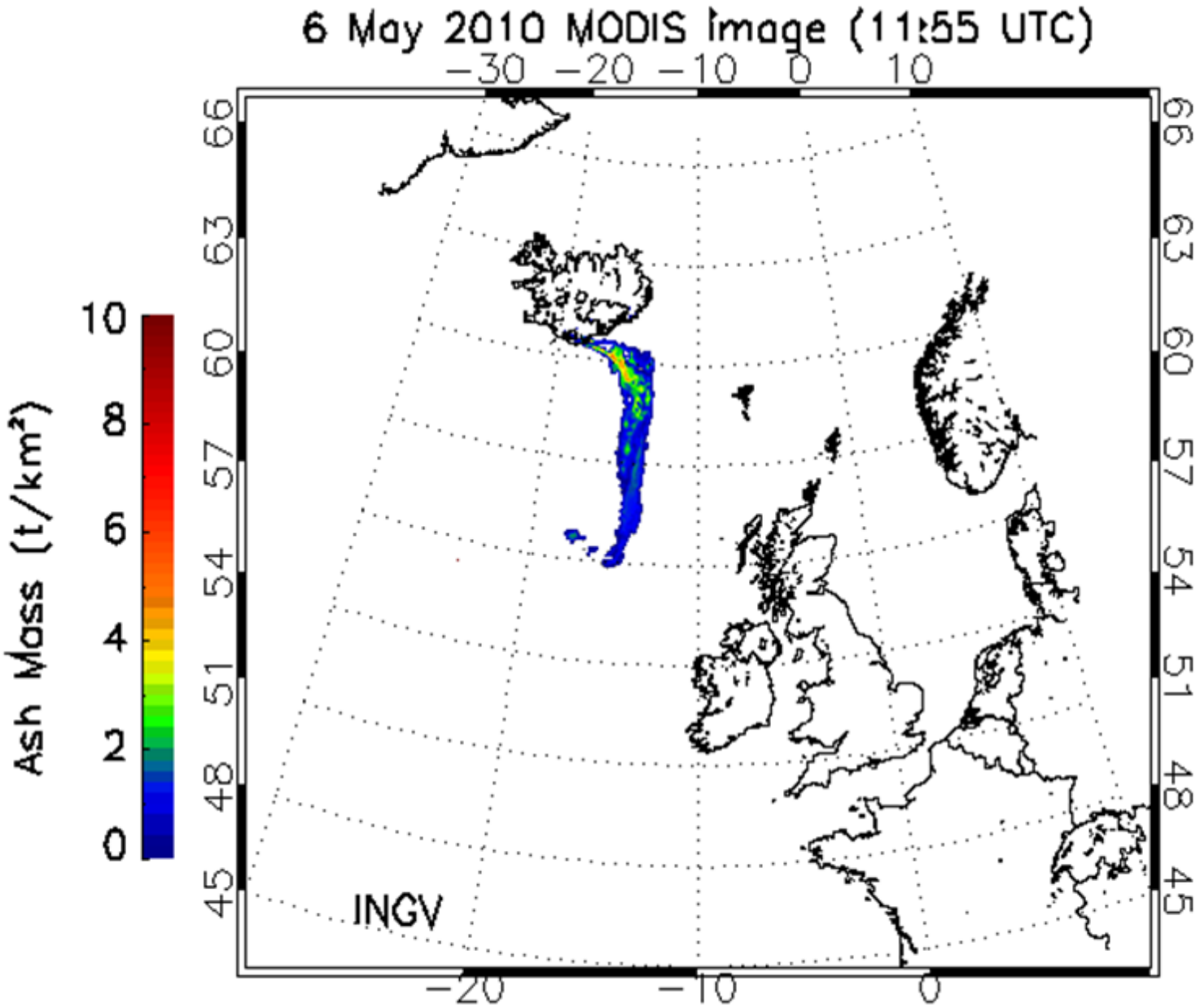
AOD (0.55 μm)



From April 14 to 19

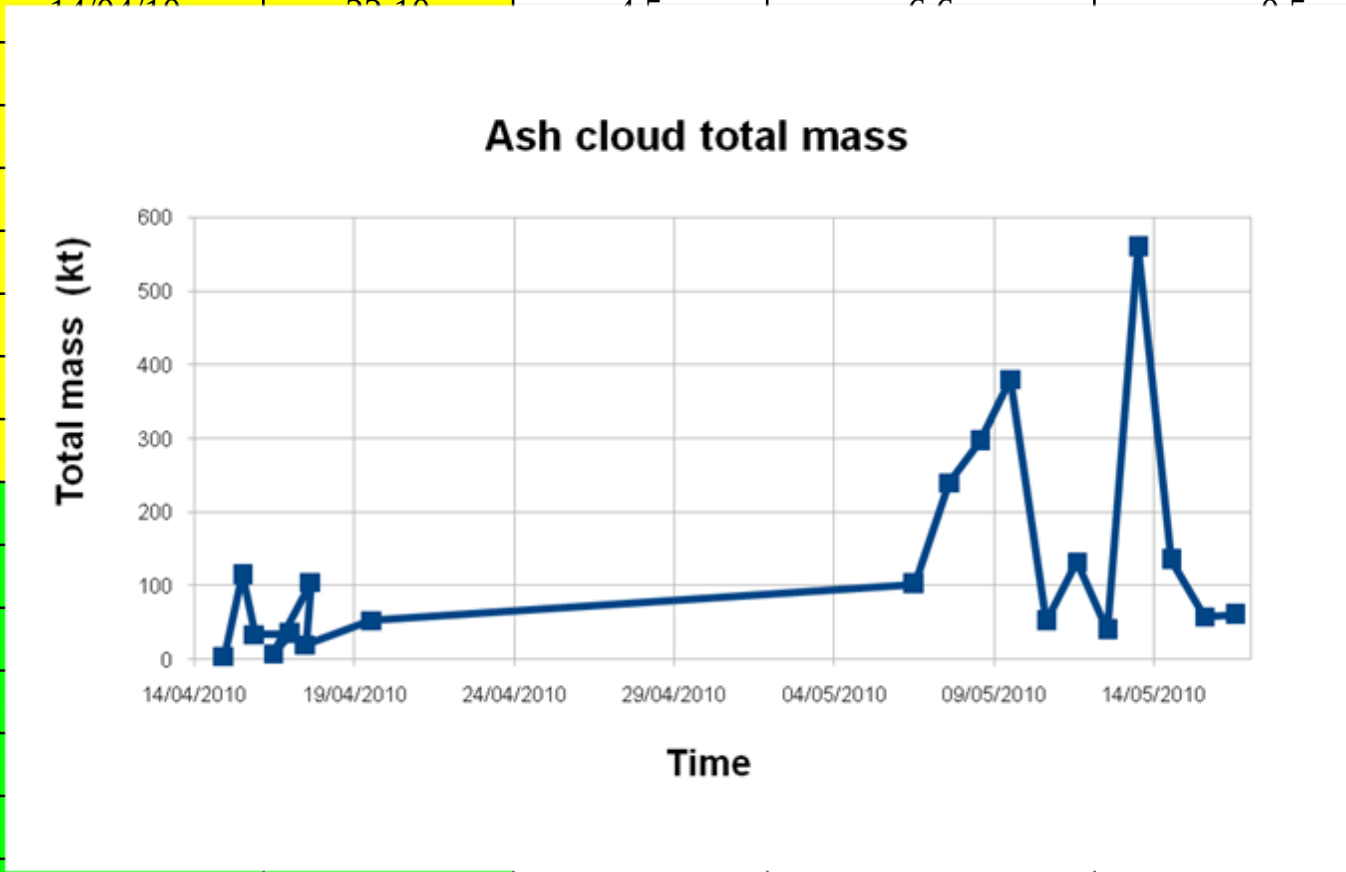


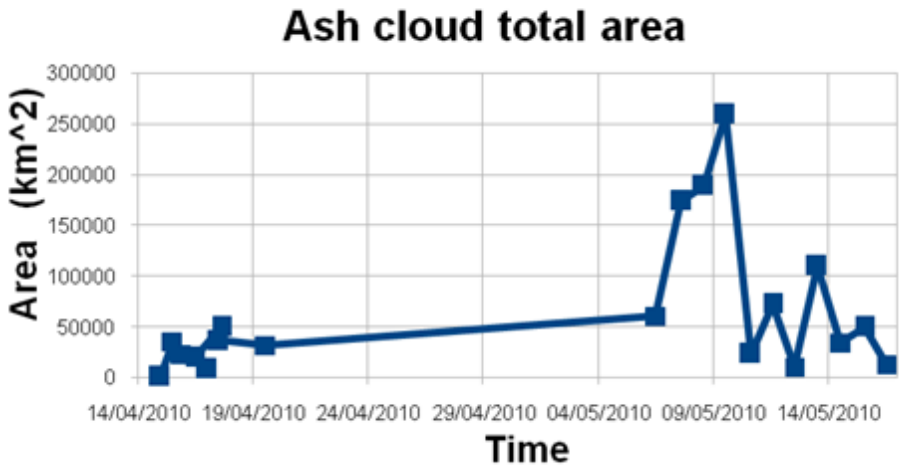
From May 6 to 16



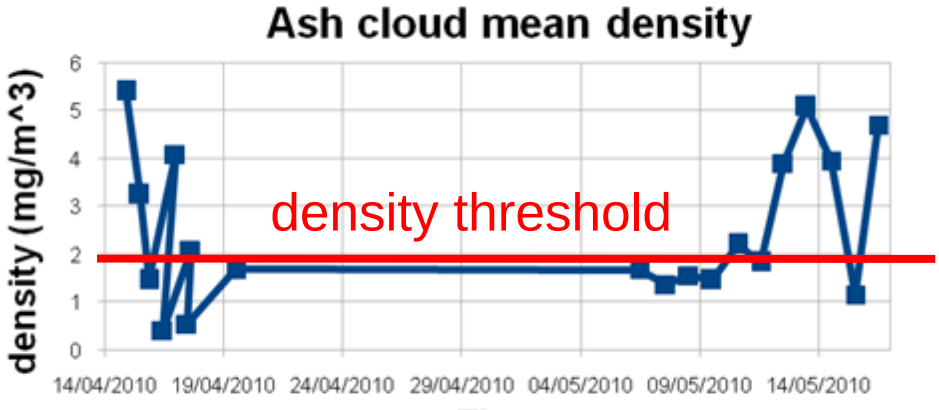
Results Summary

Date	Hour (UTC)	Tmass (kt)	Mean Re (μm)	Mean AOT
12/05/10	12:55	40	4.9	0.5
13/05/10	12:00	560	5.7	0.5
14/05/10	13:00	135	5	0.5
15/05/10	13:40	580	3.7	0.2
16/05/10	12:30	610	5.6	0.5

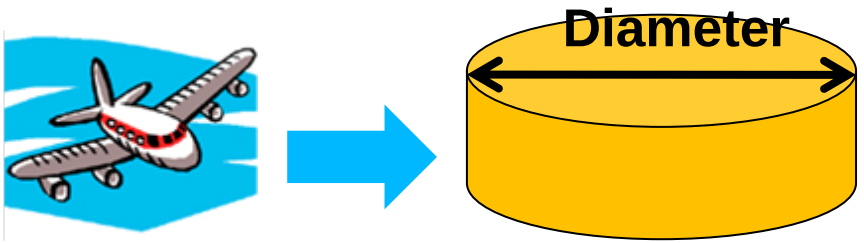




The mean ash density is computed from the total cloud area and considering the ash cloud thickness equal to 1 km



… considering that the flow through an engine at 75% thrust is ~100m^3/s [*Schneider, volcanicclouds mailing list*], the total mass is about 720 g/h



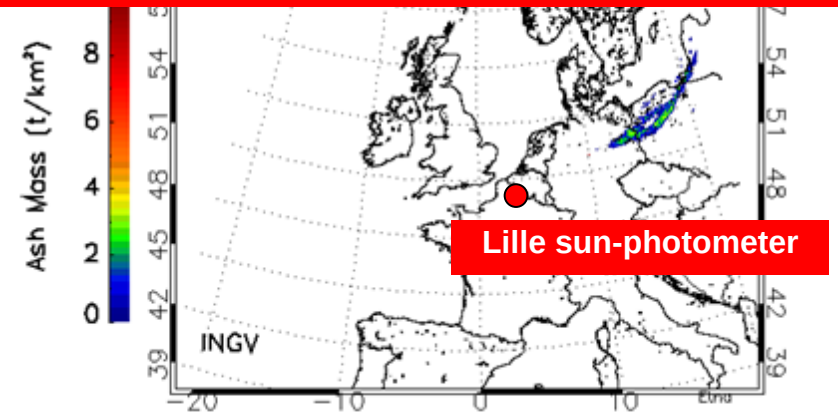
Ash cloud

Could the sun-photometer measurements, be used to detect and retrieve the volcanic ash?

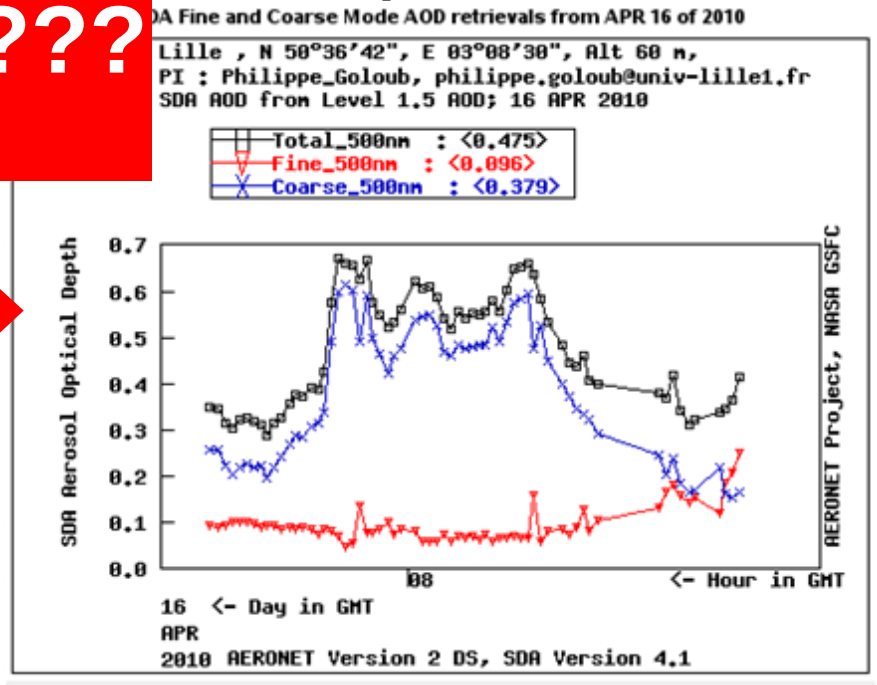
http://aeronet.gsfc.nasa.gov

- discrimination between coarse and fine aerosol
- aerosol optical properties

??? Is this volcanic ash ???

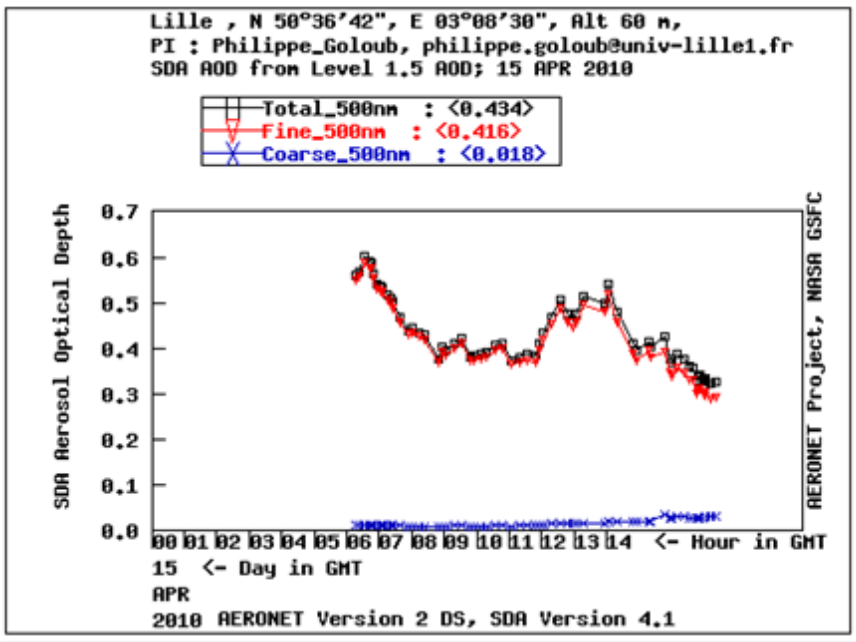


April 16

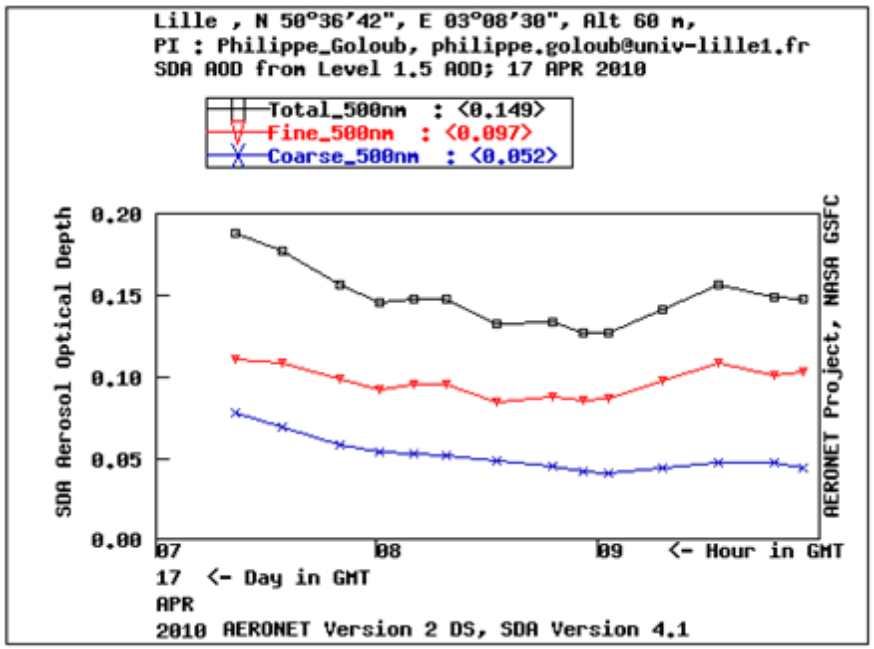


Fine and Coarse particles

April 15

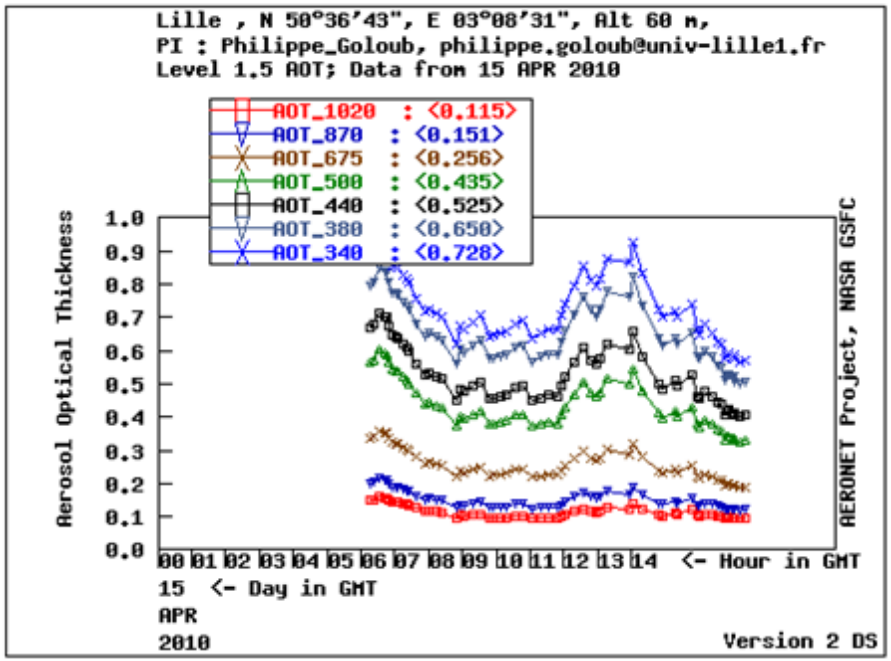


April 17

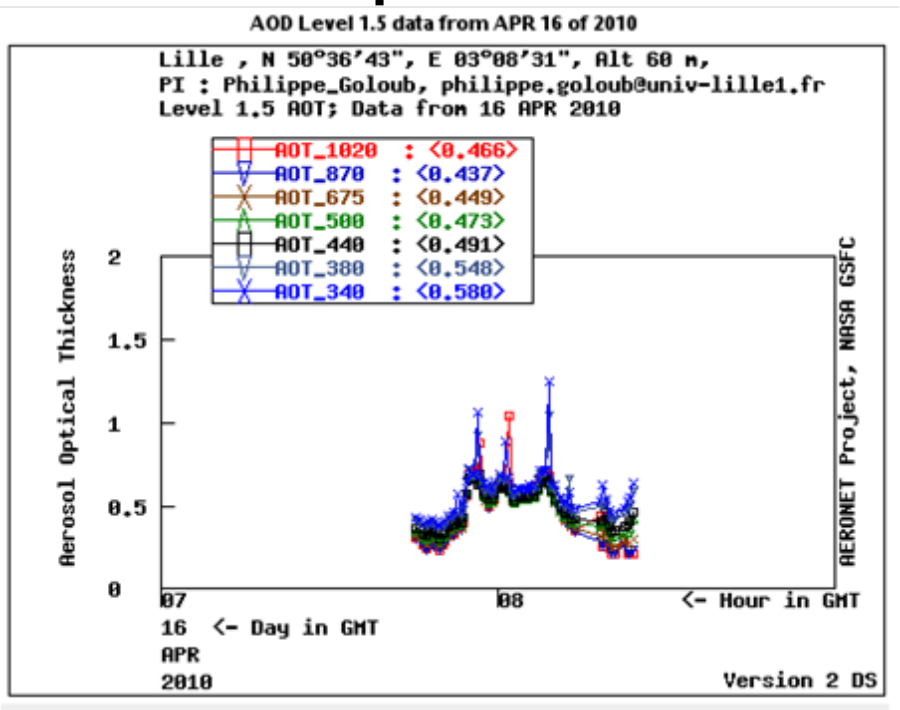


Aerosol Optical Thickness

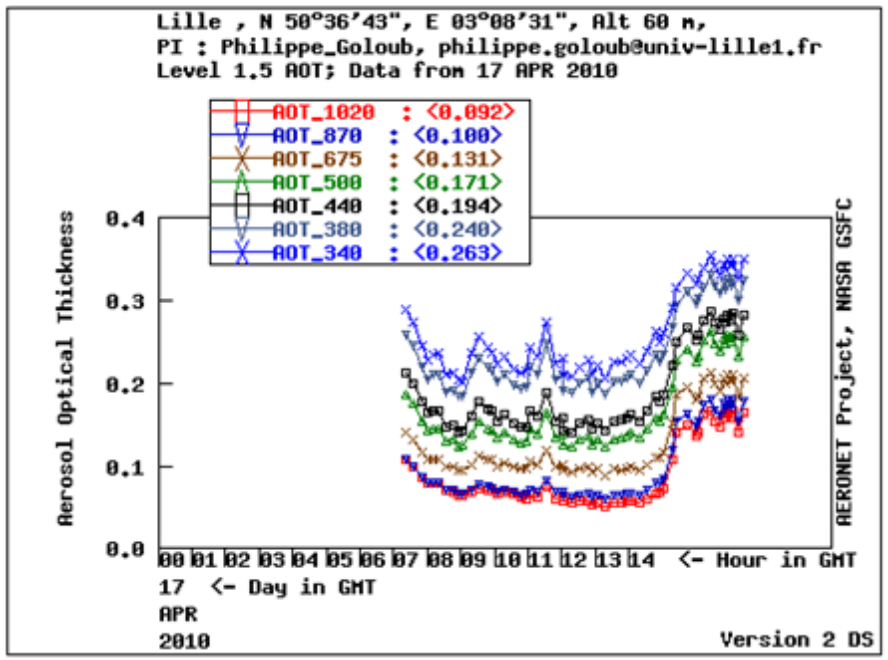
April 15



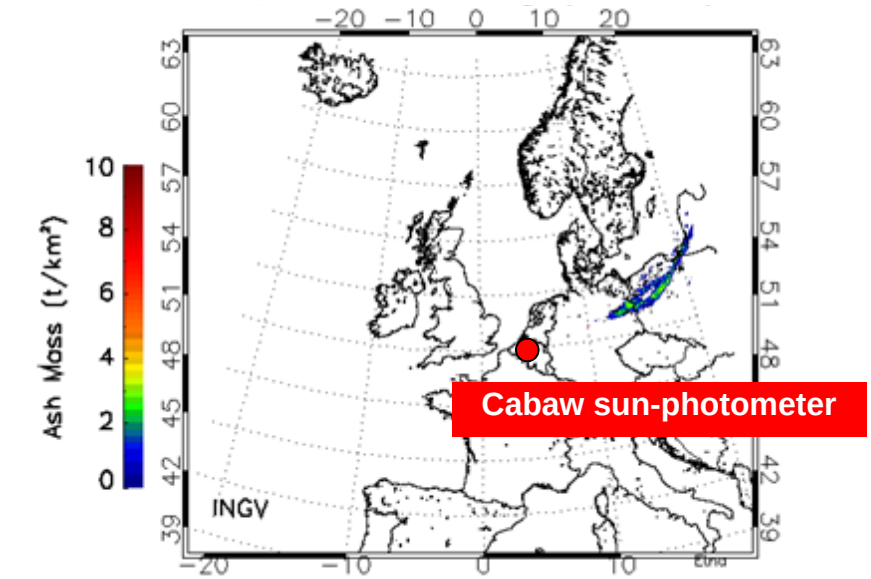
April 16



April 17

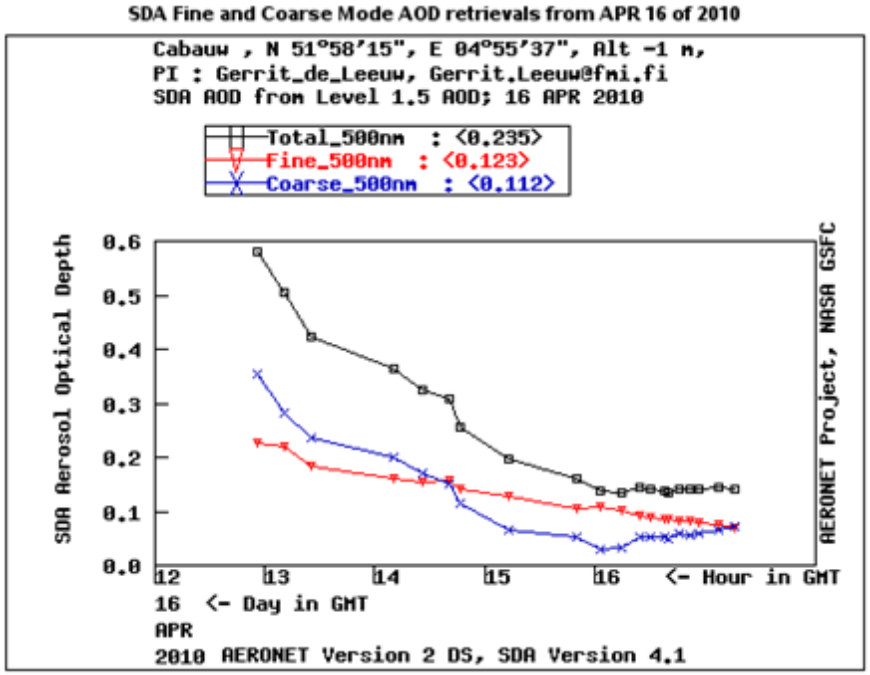


April 17, MODIS-Terra 10:40 UTC

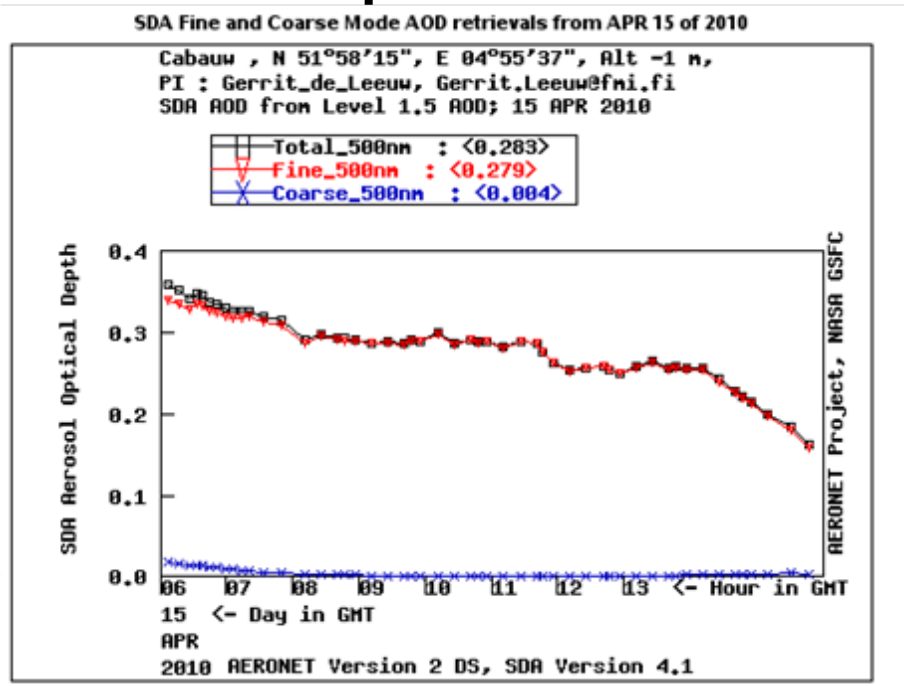


Fine and Coarse particles

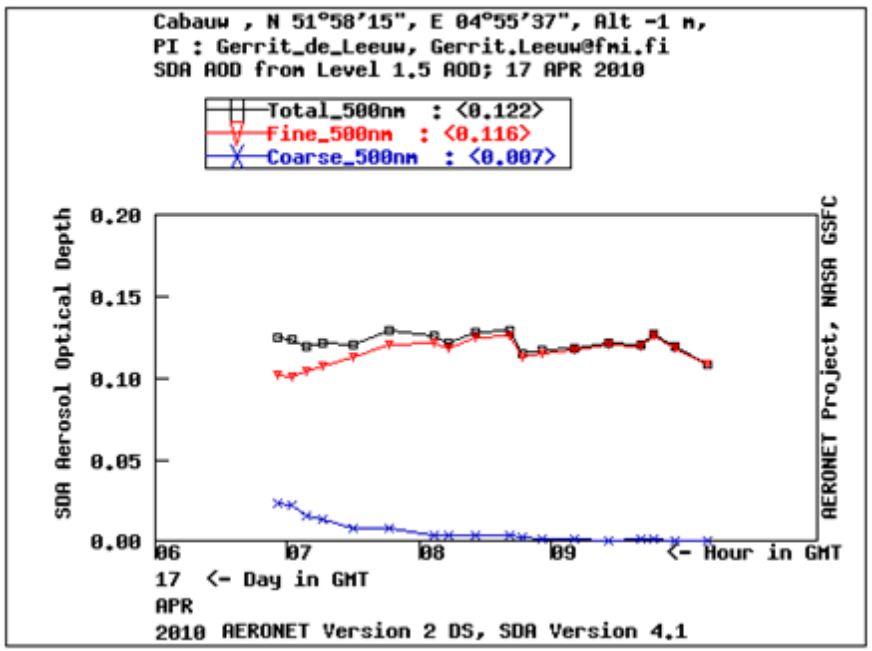
April 16



April 15



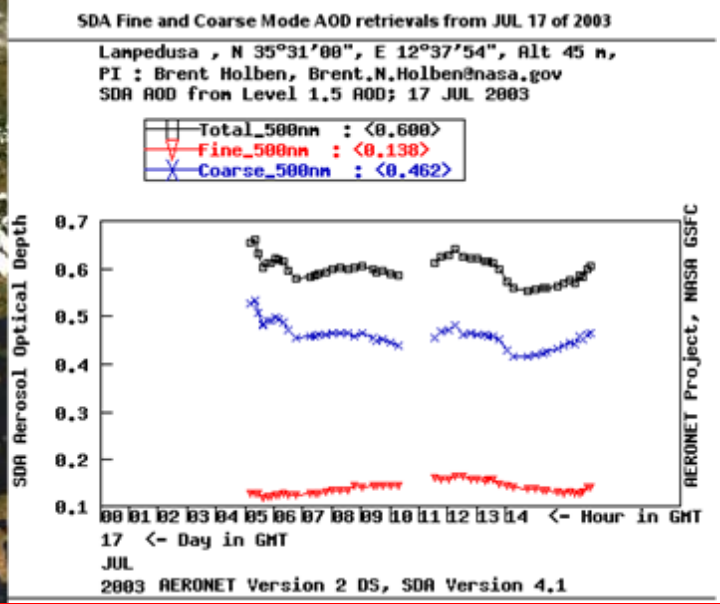
April 17



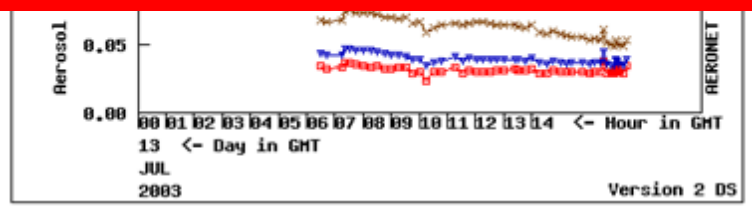
… another case

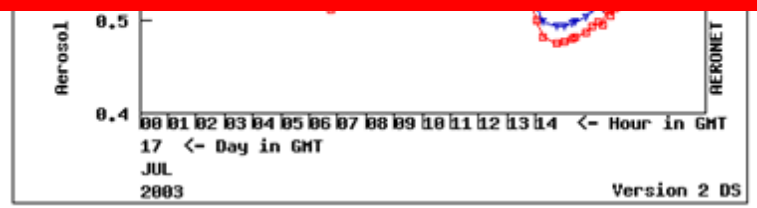
July 13, 2003

July 17, 2003

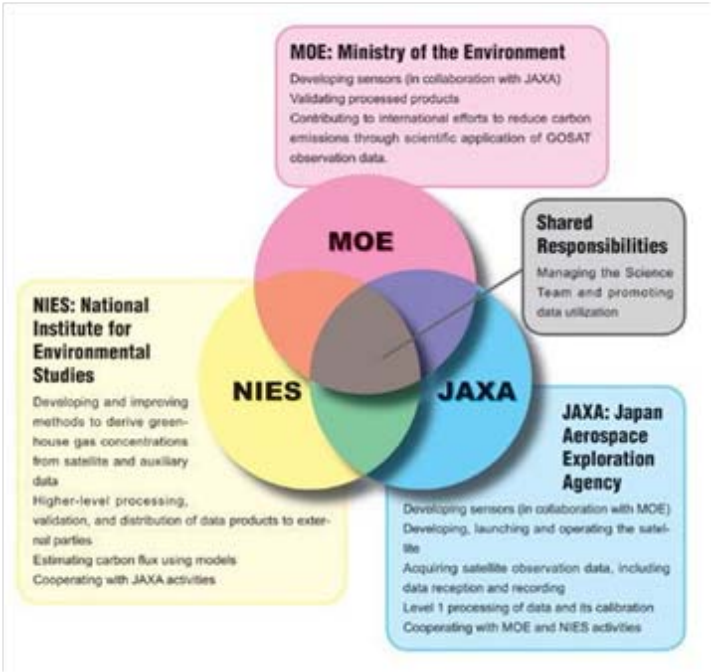


The prevalence of coarse particles and the higher total AOT are *necessary* but not *sufficient* conditions to confirm the presence of volcanic ash





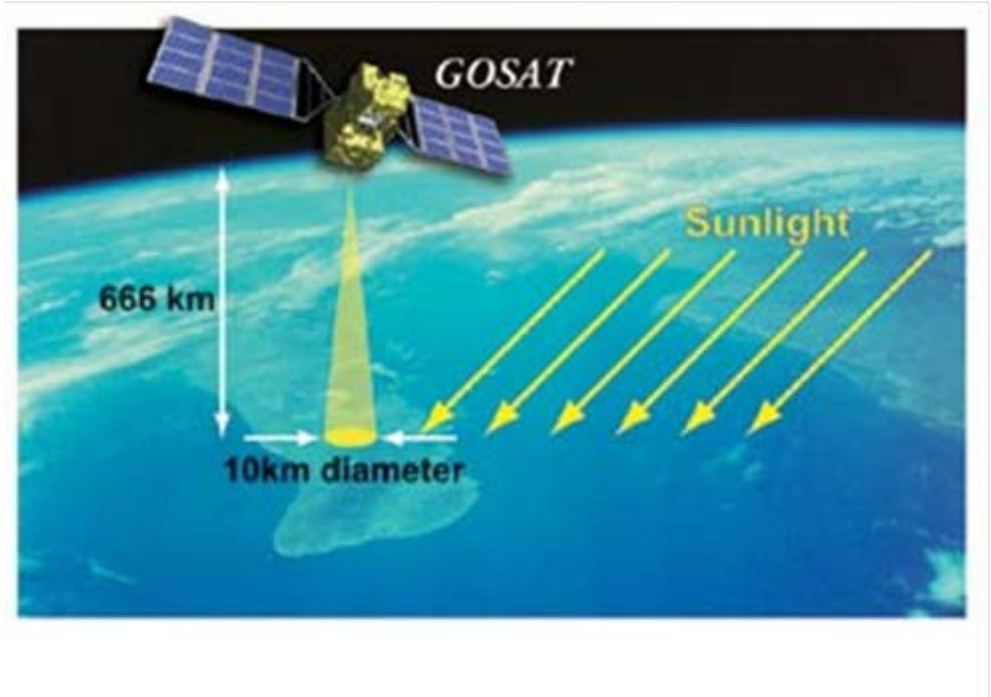
Lampedusa (Italy) Sun-Photometer



GOSAT goals:

global distributions of carbon dioxide (CO_2) and methane (CH_4) and the geographical distribution of seasonal and inter-annual variations in the flux (i.e., emission and absorption) of greenhouse gases.

http://www.gosat.nies.go.jp/index_e.html



GOSAT orbit the earth in roughly 100 minutes at an altitude of approximately 666 km and return to the same orbit in three days

Thermal And Near-infrared Sensor for carbon Observation (TANSO)

Fourier Transform Spectrometer (FTS)

	Band 1	Band 2	Band 3	Band 4
Spectral coverage [μm]	0.758~0.775	1.56~1.72	1.92~2.08	5.56~14.3
Spectral resolution [cm^{-1}]	0.5	0.27	0.27	0.27
Target species	O_2	$CO_2 \cdot CH_4$	$CO_2 \cdot H_2O$	$CO_2 \cdot CH_4$
Instantaneous field of view/ Field of observation view at nadir	Instantaneous field of view: 15.8 mrad Field of view for observation (footprint): diameter of app. 10.5 km			
Single-scan data acquisition time	1.1, 2.0, 4.0 seconds			

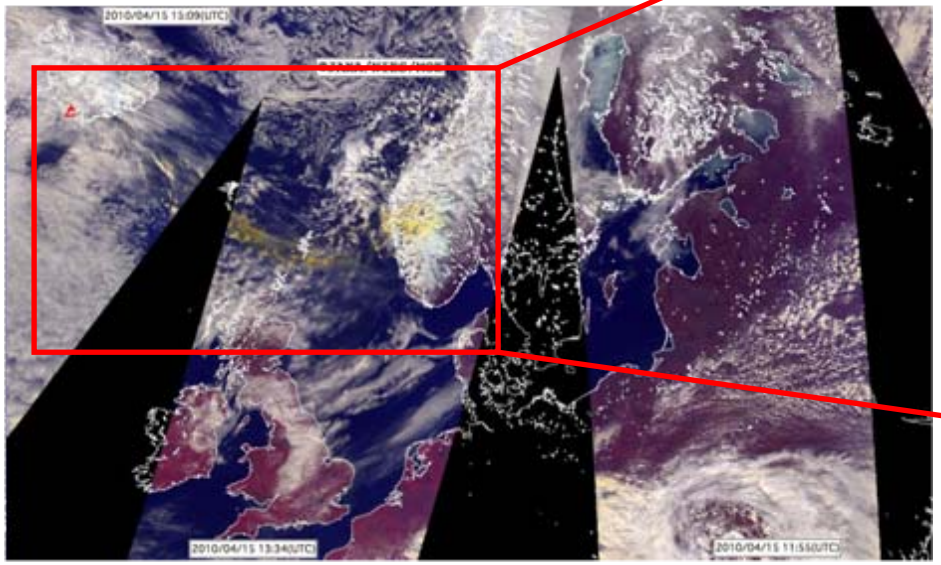
* 1 μm = 1/1000 mm

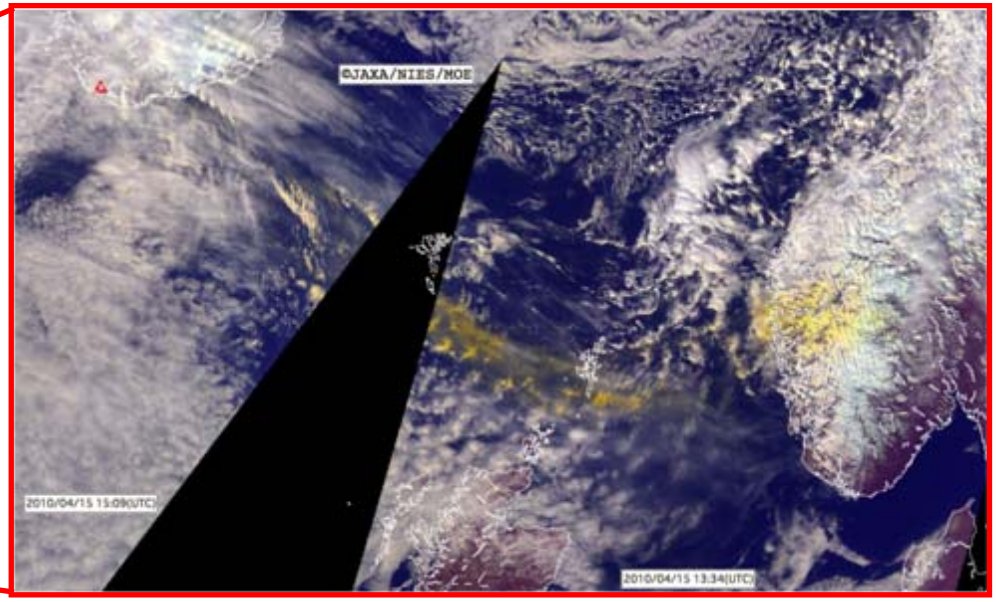
Cloud Aerosol Imager (CAI)

	Band 1	Band 2	Band 3	Band 4
Spectral coverage [μm]	0.370~0.390 (0.380)	0.668~0.688 (0.678)	0.860~0.880 (0.870)	1.56~1.68 (1.62)
Target substance	Cloud, Aerosol			
Swath [km]	1000	1000	1000	750
Spatial resolution at nadir [km]	0.5	0.5	0.5	1.5

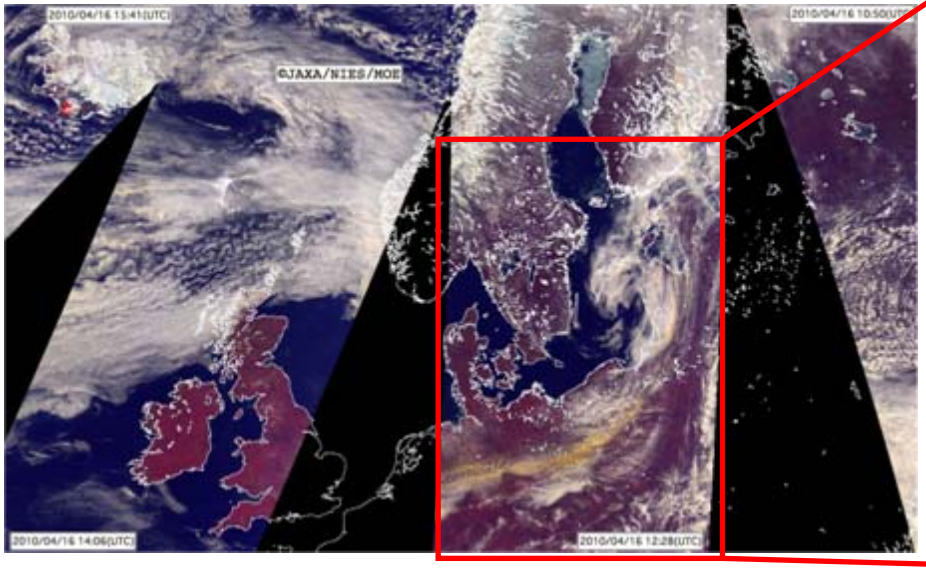
Color composite image in which red, green, and blue are assigned to 870 nm, 678 nm, and 380 nm spectral channels of TANSO-CAI

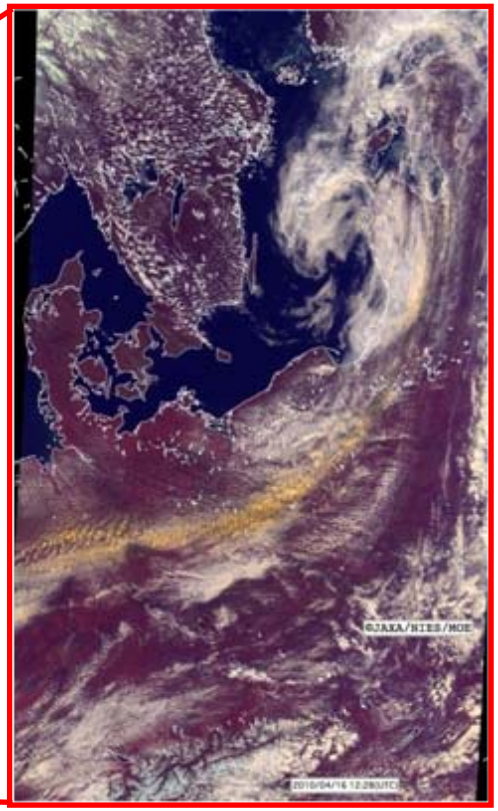
April 14 2010, 10:30 UTC





April 15 2010, 9:30 UTC





Conclusions

- The results show a greater ash emission during the May event compared to the April event (3-4 times);
- For an estimation of the aviation risk the ash density should be considered together with the estimation of the airplane path inside the ash cloud;
- The sun-photometer measurements (AERONET network) can be used to detect and retrieve the volcanic clouds.