



INGV



Eyja volcanic ash retrievals by using MODIS data

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volcanic ash ws

European Space Agency

**ESRIN
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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])

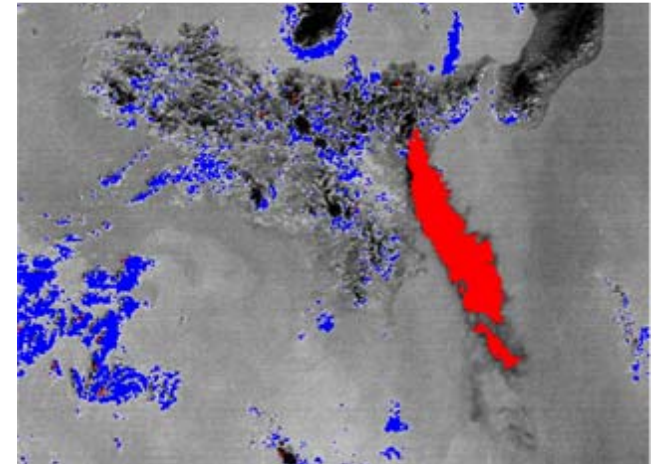
$$\text{BTD} = T_b(11\mu\text{m}) - T_b(12\mu\text{m})$$

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

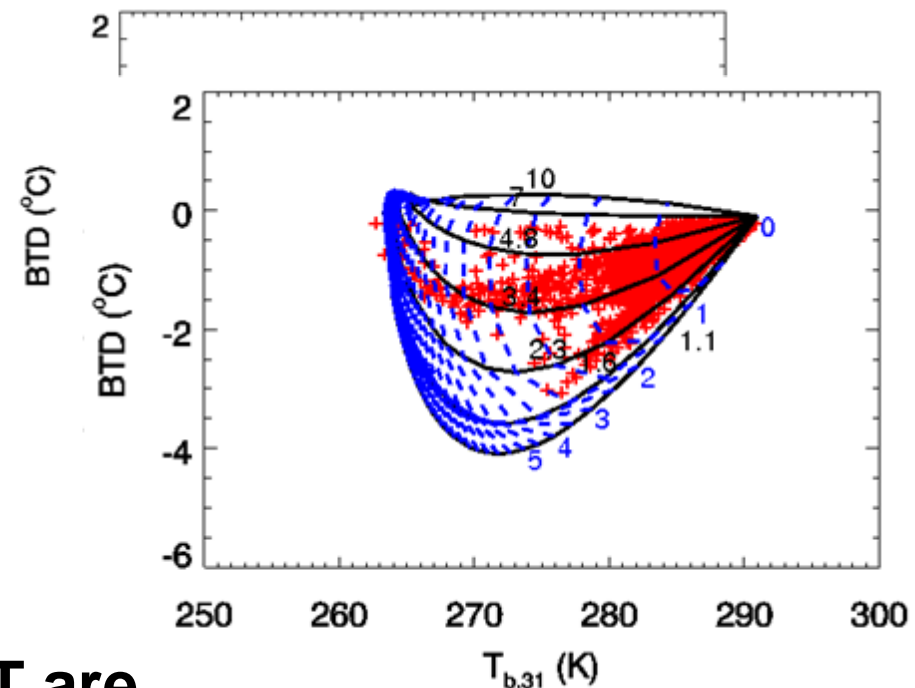
$$M_{tot} = \frac{S_4 / 3 \rho r_e^{(n,m)} \tau^{(n,m)}}{Q_{ext}(r_e^{(n,m)})}$$

The TOA simulated Radiances LUT are computed using MODTRAN 4 RTM

BTD < 0 volcanic ash



BTD > 0 meteo clouds



Radiance computation (LUT)

Volc. cloud geometry

Sat. geometry



Spectral surface

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

ment
ctions

Optical
Properties

- 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 cycle: 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 downloaded from the NASA-LAADS archive ...

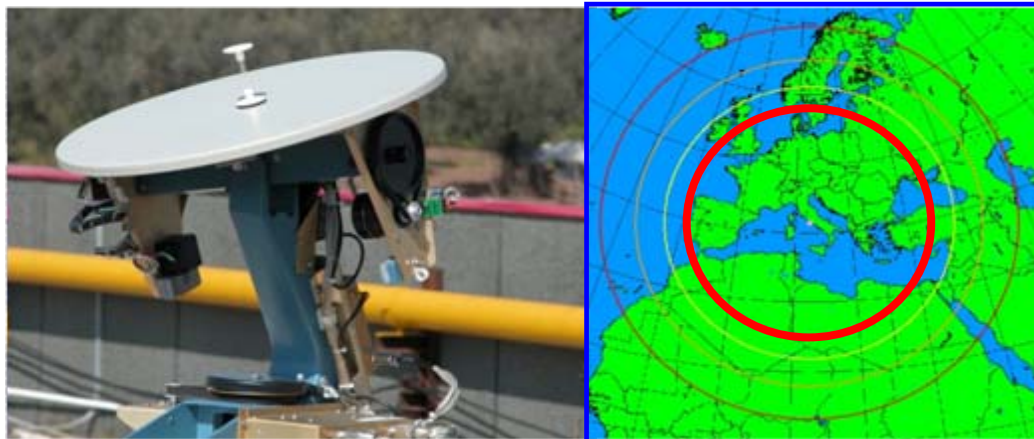
... a complete L/X band' "multi-mission" + EUMETSAT antenna systems have been installed at INGV in 2010.

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

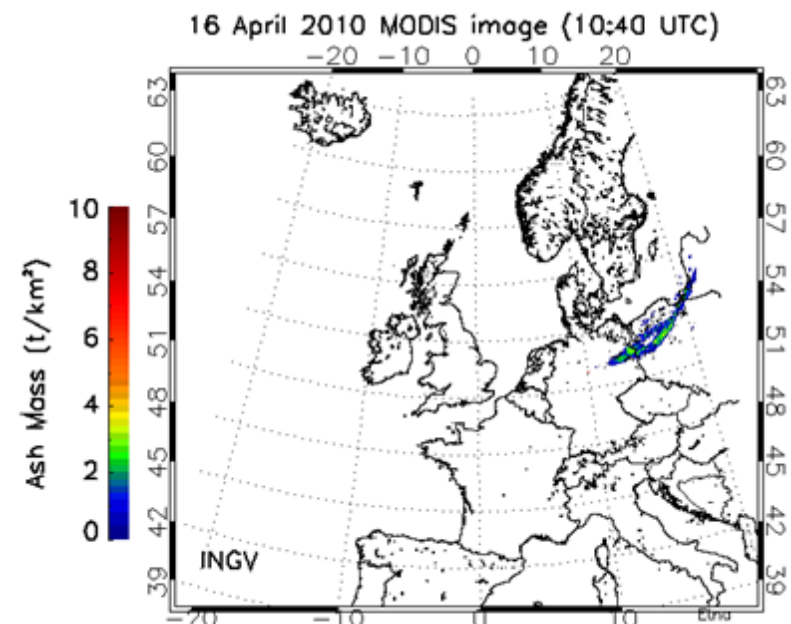
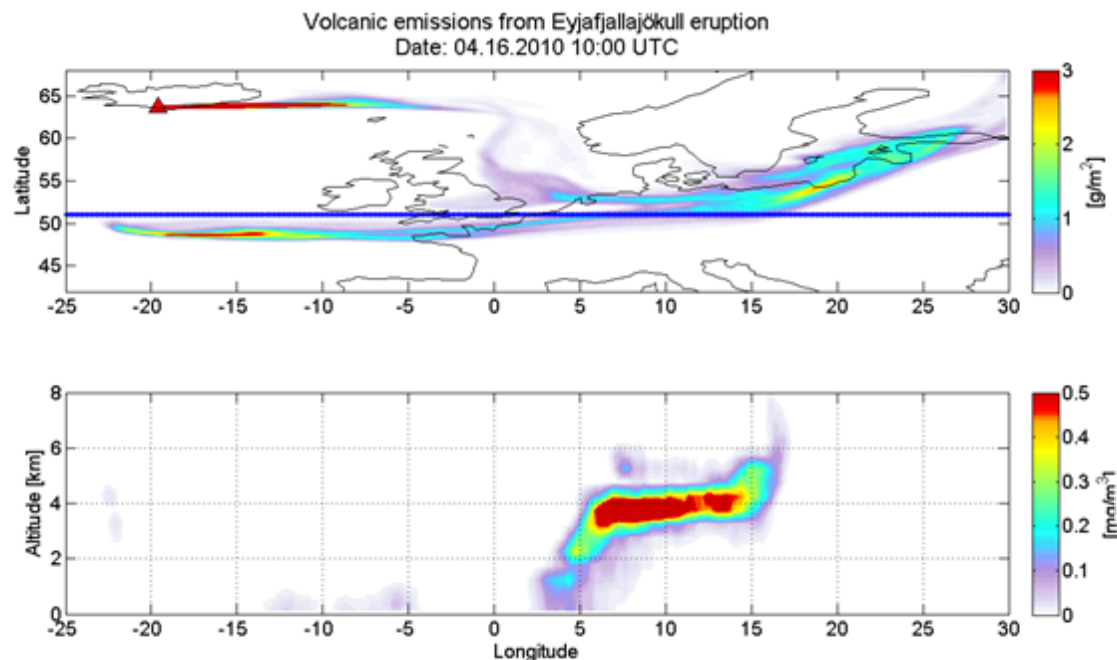


L/X band' "multi-mission antenna

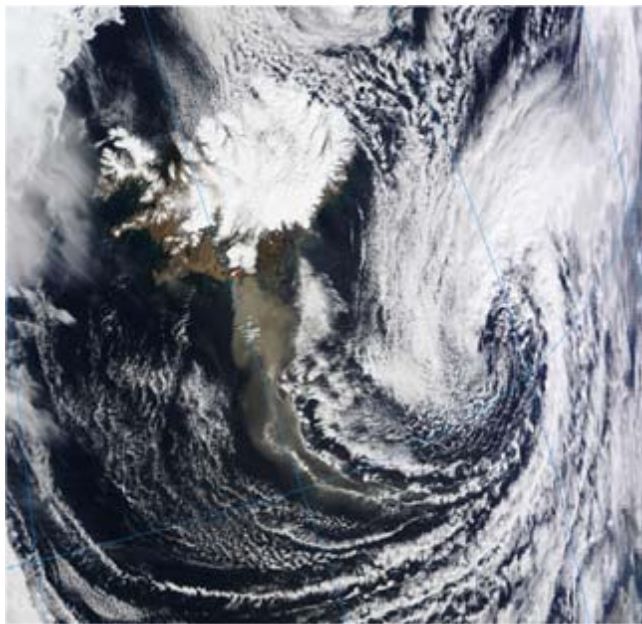


MODTRAN Inputs:

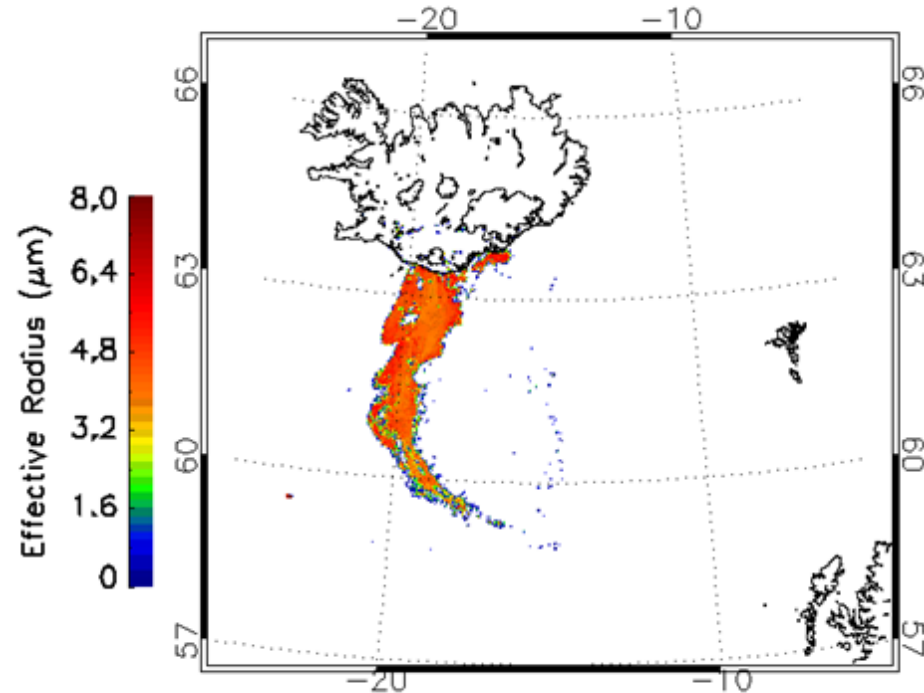
- **P**, **T** and **H**: from the ash cloud nearest WMO Meteo Station measurements
(ash cloud over Iceland: Keflavikurflugvollur WMO station)
- **Ts**: from the TIR-RTE inversion using 11 and 12 μm channels
 - **Aerosol type**: Andesite
 - **Top Ash Cloud Altitude**:
- by comparing the 11 μm brightness temperature with the WMO temperature profile (when the opaque pixels exist)
 - by using the FLEXPART model



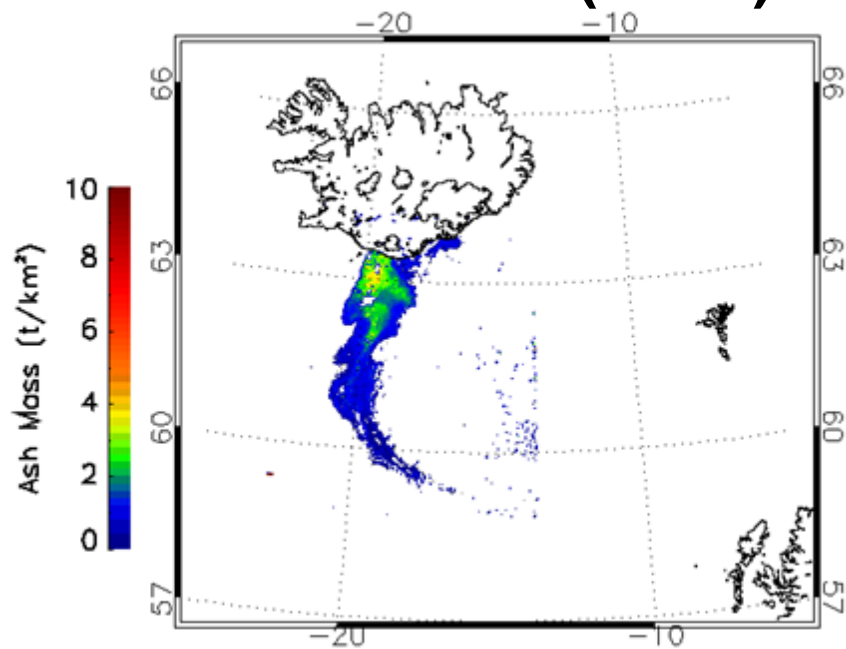
April 19, 12:50 UTC



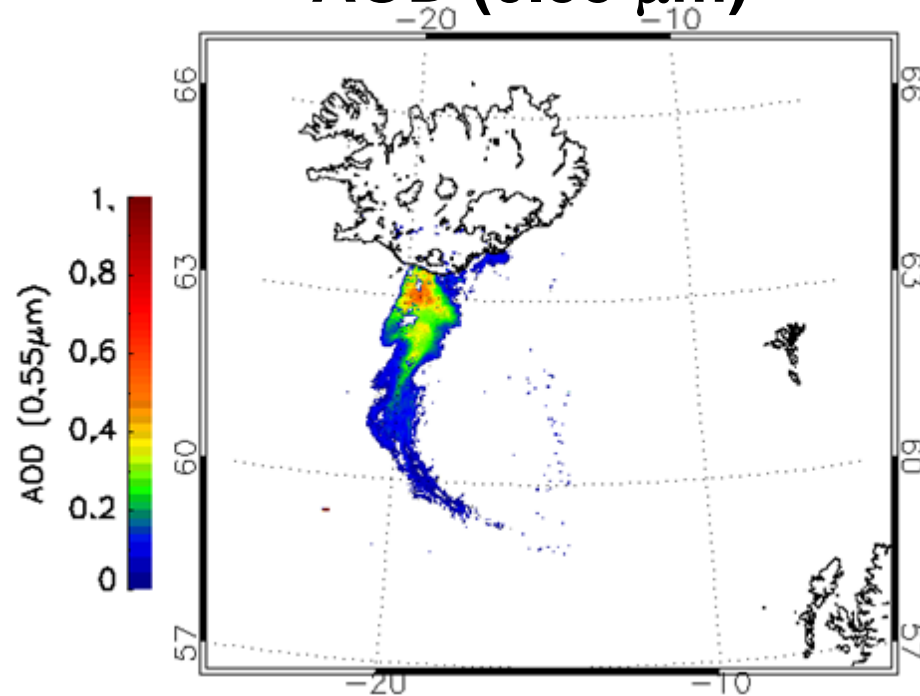
Effective Radius



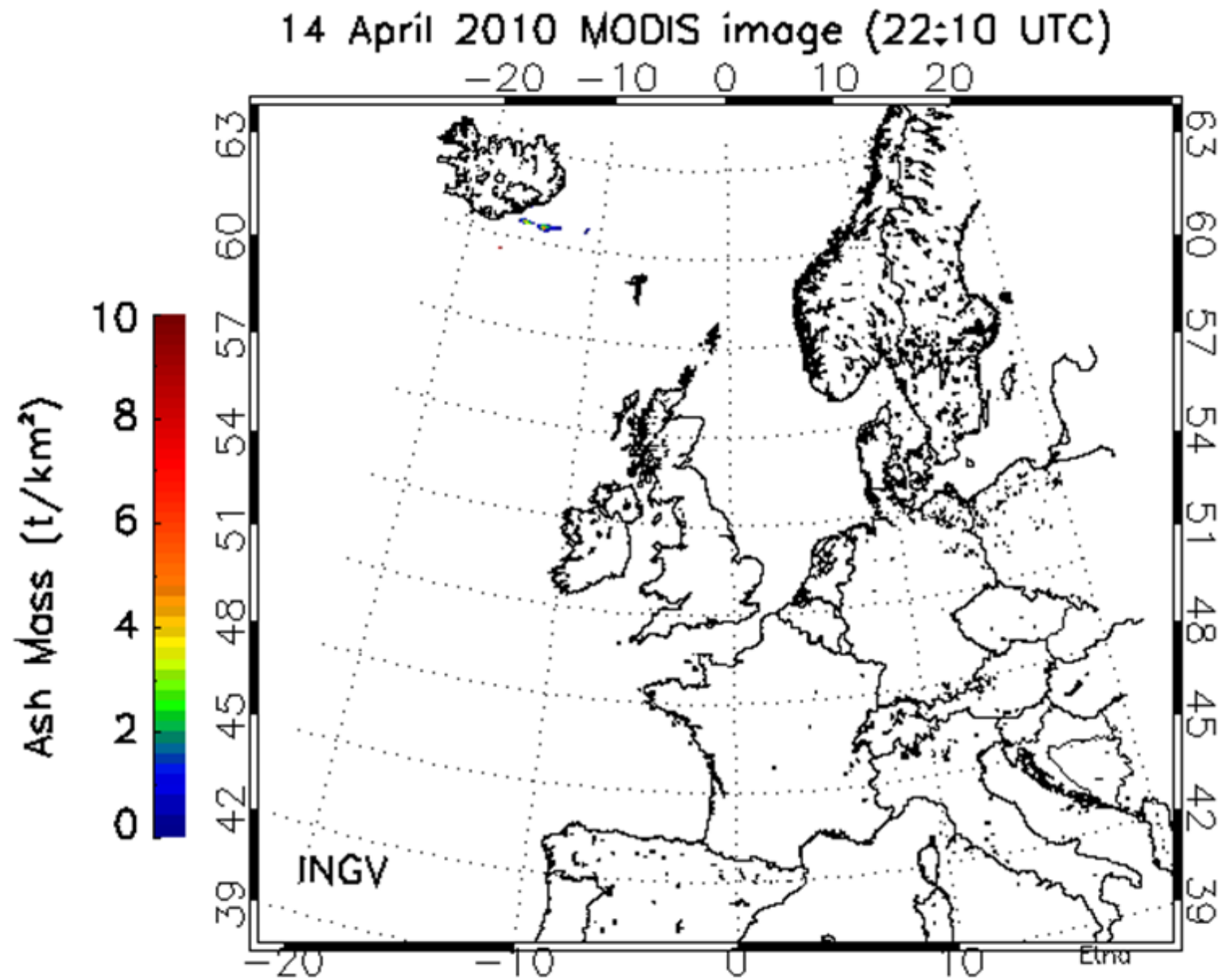
Total Mass (t/km²)



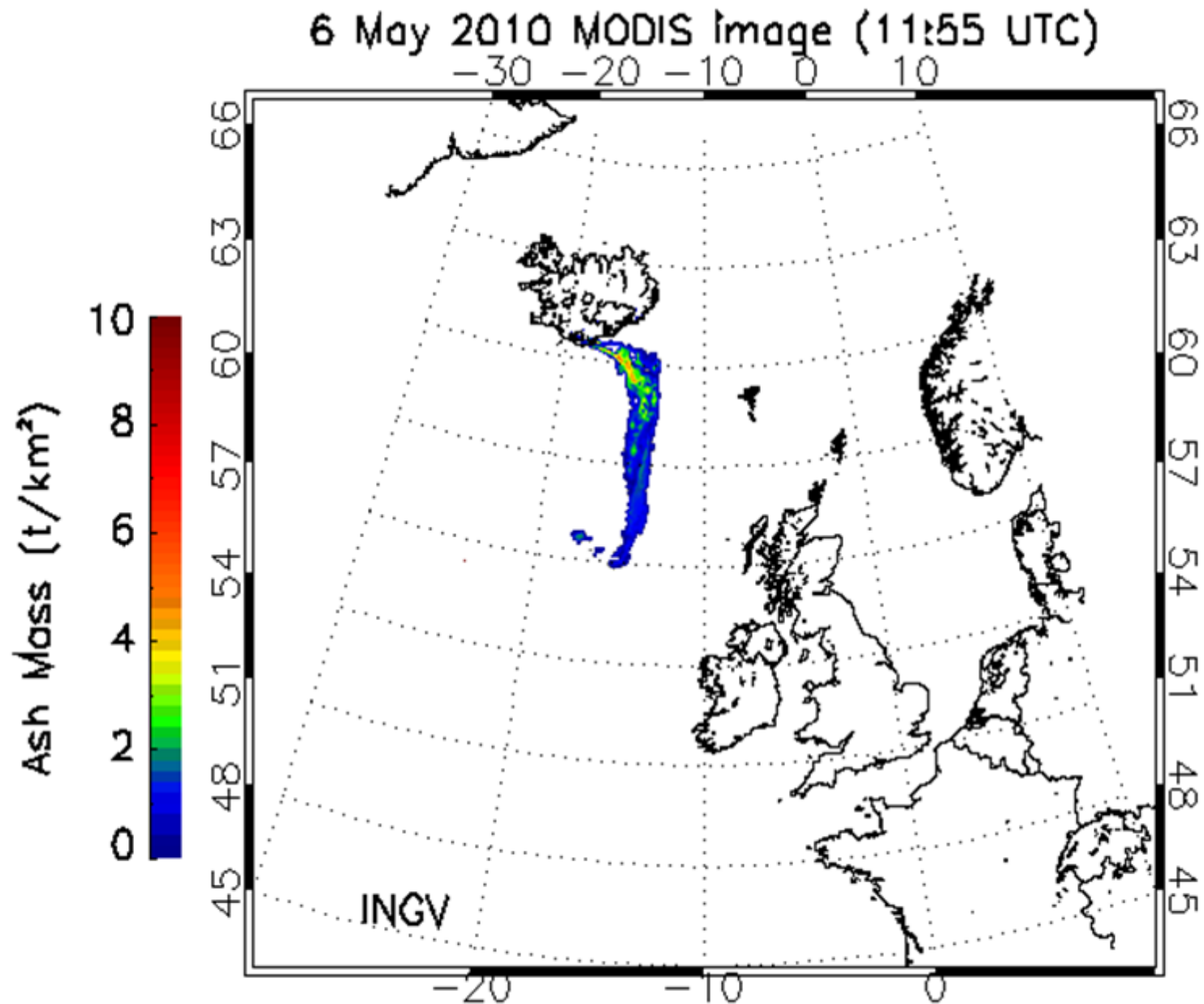
AOD (0.55 μm)



From April 14 to 19



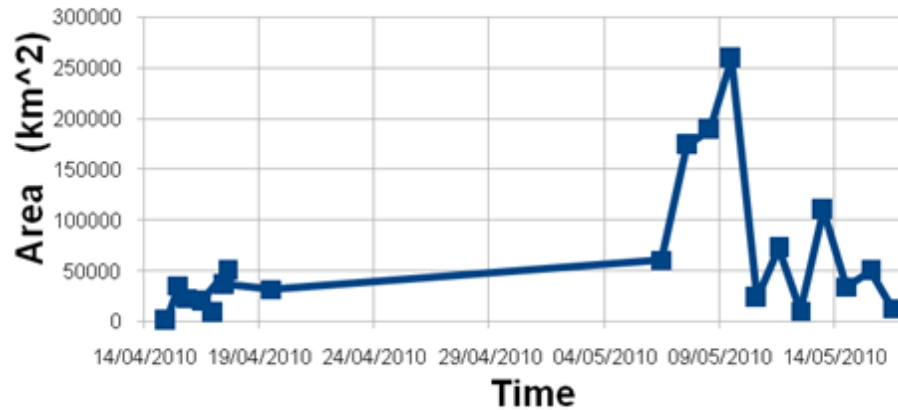
From May 6 to 16



Results Summary

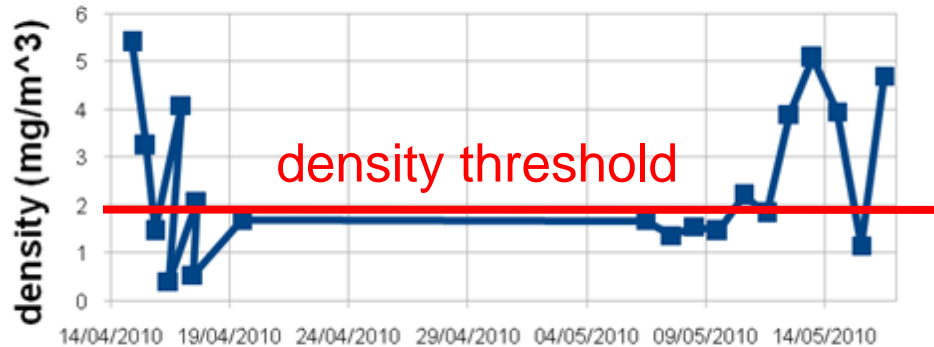
Date	Hour (UTC)	Tmass (kt)	Mean Re (μm)	Mean AOT
14/04/10	00:10	15	6.6	0.5
<p style="text-align: center;">Ash cloud total mass</p> <p>The graph displays the total mass of the ash cloud in kilotons (kt) over a period of one month. The data points are connected by a blue line. The mass starts at 15 kt on 14/04/2010, rises to about 120 kt on 15/04/2010, then fluctuates between 20 and 110 kt until 19/04/2010. It then shows a steady increase to 100 kt by 07/05/2010, followed by a sharp rise to 380 kt on 10/05/2010, a drop to 50 kt on 11/05/2010, a rise to 135 kt on 12/05/2010, a drop to 40 kt on 13/05/2010, and finally a massive peak of 560 kt on 14/05/2010, before dropping to 135 kt on 15/05/2010 and 610 kt on 16/05/2010.</p>				
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

Ash cloud total area



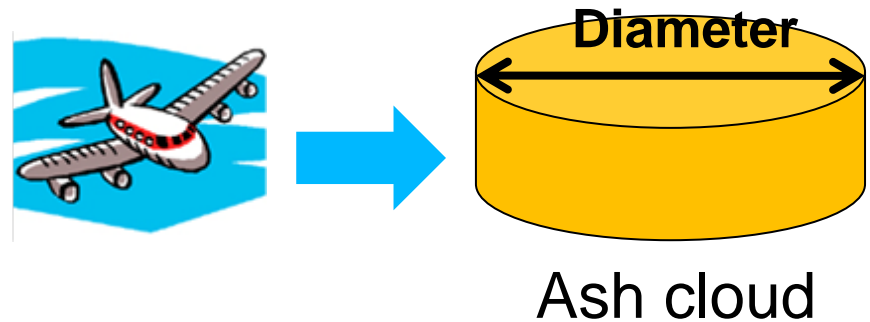
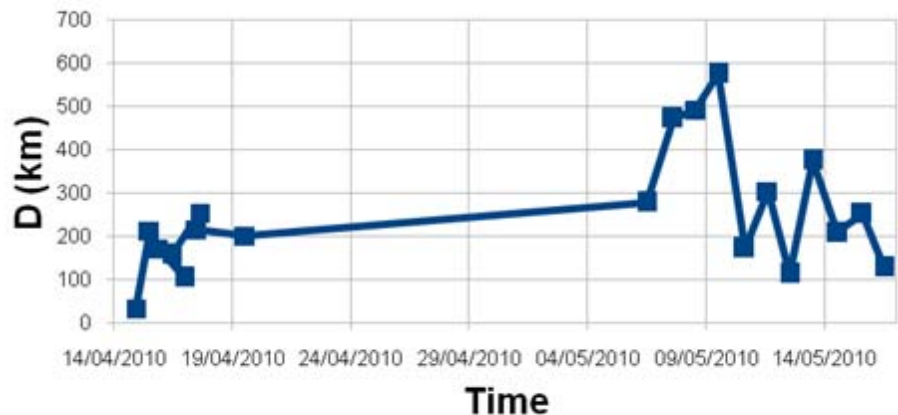
The mean ash density is computed from the total cloud area and considering the ash cloud thickness equal to 1 km

Ash cloud mean density



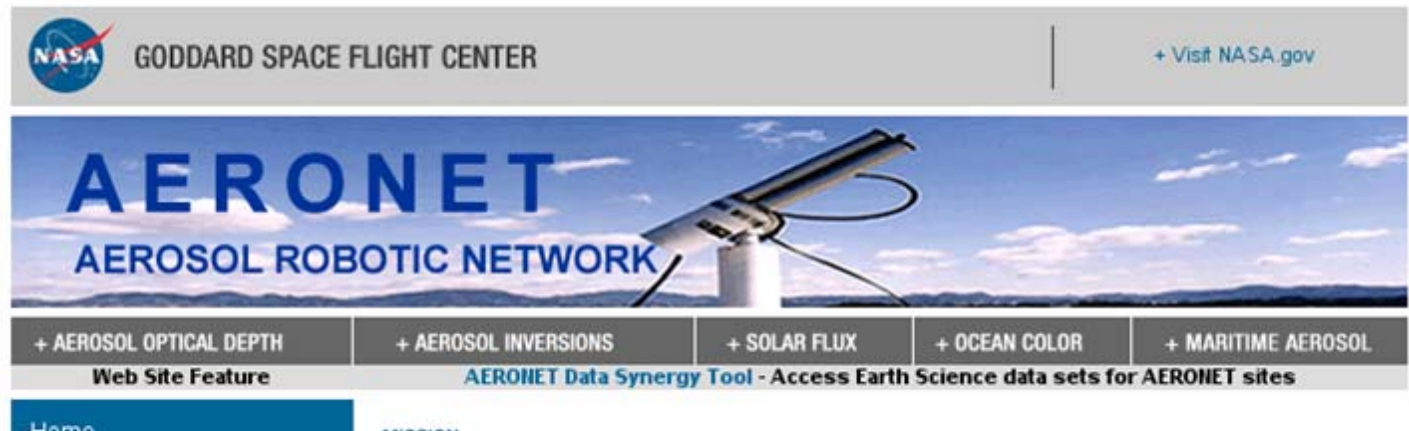
... considering that the flow through an engine at 75% thrust is $\sim 100 \text{ m}^3/\text{s}$ [Schneider, *volcanicclouds mailing list*], the total mass is about 720 g/h

Airplane path inside the cloud



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

<http://aeronet.gsfc.nasa.gov>



The AERONET (Aerosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA and PHOTONS (Univ. of Lille 1, CNES, and CNRS-INSU) and is greatly

+ AEROSOL/FLUX NETWORKS

+ CAMPAIGNS

+ COLLABORATORS

expanded by collaborators from national agencies, institutes, universities, individual scientists, and partners. The program provides a long-term, continuous and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases. The network imposes standardization of instruments, calibration, processing and distribution.

AERONET collaboration provides globally distributed observations of spectral aerosol optical depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Aerosol optical depth data are computed

are derived from these levels and may implement additional quality checks.

The processing algorithms have evolved from Version 1 to Version 2.0 (fully released in July 2006) and are available from the AERONET and PHOTONS web sites. Version 1 data may be downloaded from the web site through 2006 and thereafter upon special request. New AERONET products will be released as new measurement techniques and algorithms are adopted and validated by the AERONET research community. The AERONET web site also provides AERONET-related news, a description of research and operational activities, related Earth Science links, and an AERONET staff directory.

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+ SITE INFORMATION
+ STAFF
+ SYSTEM DESCRIPTION

AERONET DATA ACCESS

DATA SYNERGY TOOL

+ Data Display

AEROSOL OPTICAL DEPTH

+ Data Display

+ Download Tool

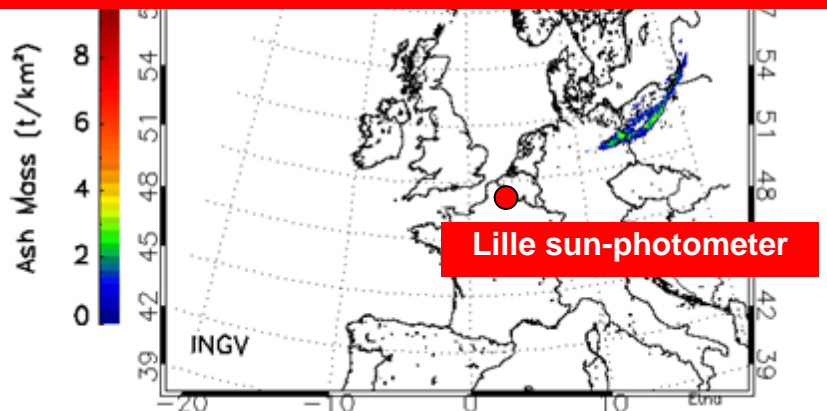
+ Download All Sites

• discrimination
between coarse and
fine aerosol

• aerosol optical
properties

April 16

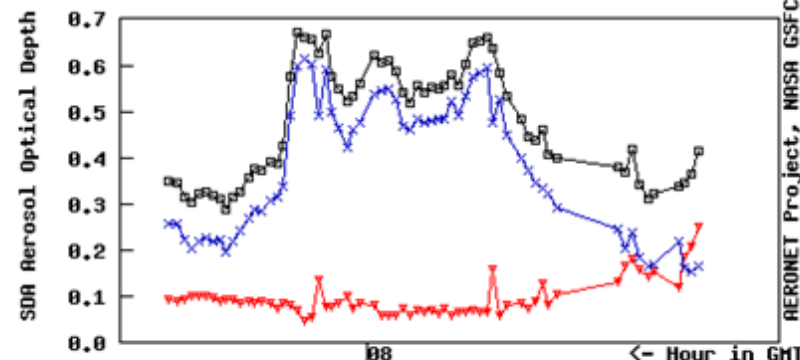
??? Is this volcanic ash ???



SDA Fine and Coarse Mode AOD retrievals from APR 16 of 2010

Lille , N 50°36'42", E 03°08'30", Alt 60 m,
PI : Philippe_Goloub, philippe.goloub@univ-lille1.fr
SDA AOD from Level 1.5 AOD; 16 APR 2010

Total_500nm : <0.475>
Fine_500nm : <0.096>
Coarse_500nm : <0.379>



16 <- Day in GMT
APR
2010 AERONET Version 2 DS, SDA Version 4.1

AERONET Project, NASA GSFC

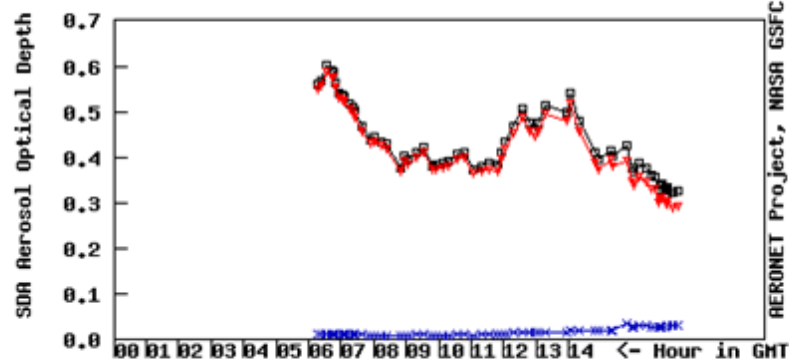
Fine and Coarse particles

April 15

SDA Fine and Coarse Mode AOD retrievals from APR 15 of 2010

Lille , N 50°36'42", E 03°08'30", Alt 60 m,
PI : Philippe_Goloub, philippe.goloub@univ-lille1.fr
SDA AOD from Level 1.5 AOD; 15 APR 2010

Total_500nm : <0.434>
Fine_500nm : <0.416>
Coarse_500nm : <0.018>



15 <- Day in GMT
APR
2010 AERONET Version 2 DS, SDA Version 4.1

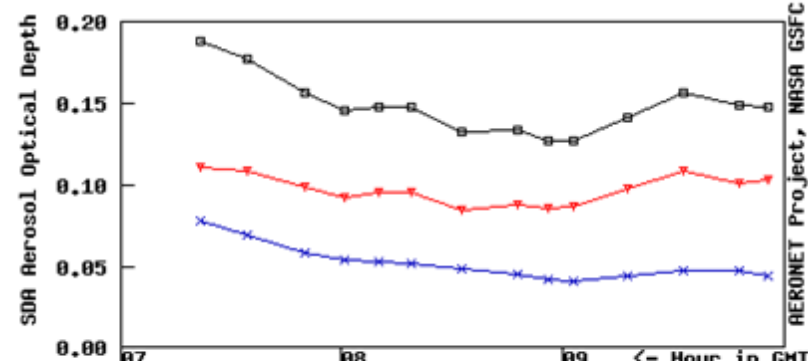
AERONET Project, NASA GSFC

April 17

SDA Fine and Coarse Mode AOD retrievals from APR 17 of 2010

Lille , N 50°36'42", E 03°08'30", Alt 60 m,
PI : Philippe_Goloub, philippe.goloub@univ-lille1.fr
SDA AOD from Level 1.5 AOD; 17 APR 2010

Total_500nm : <0.149>
Fine_500nm : <0.097>
Coarse_500nm : <0.052>



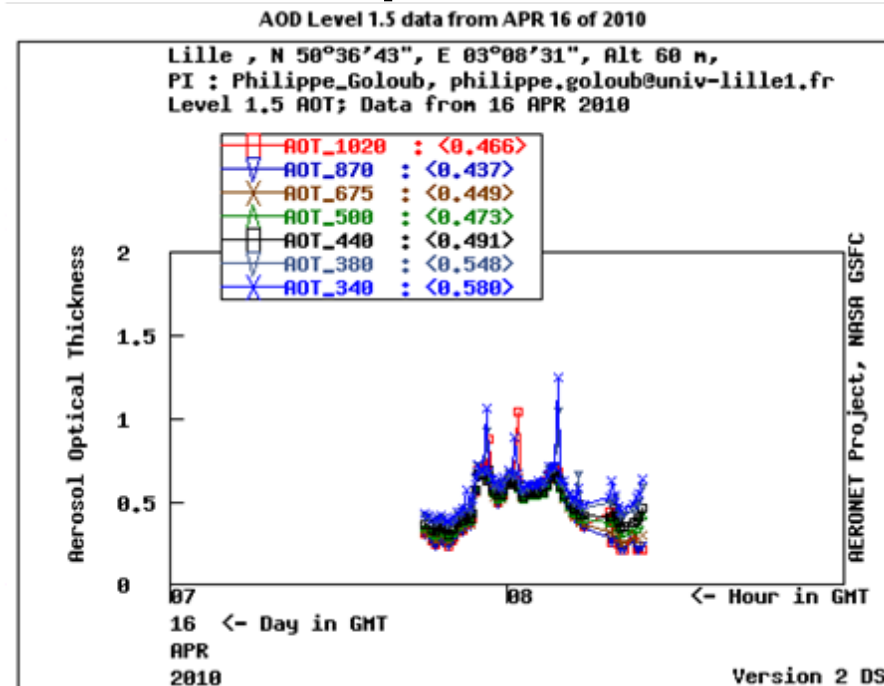
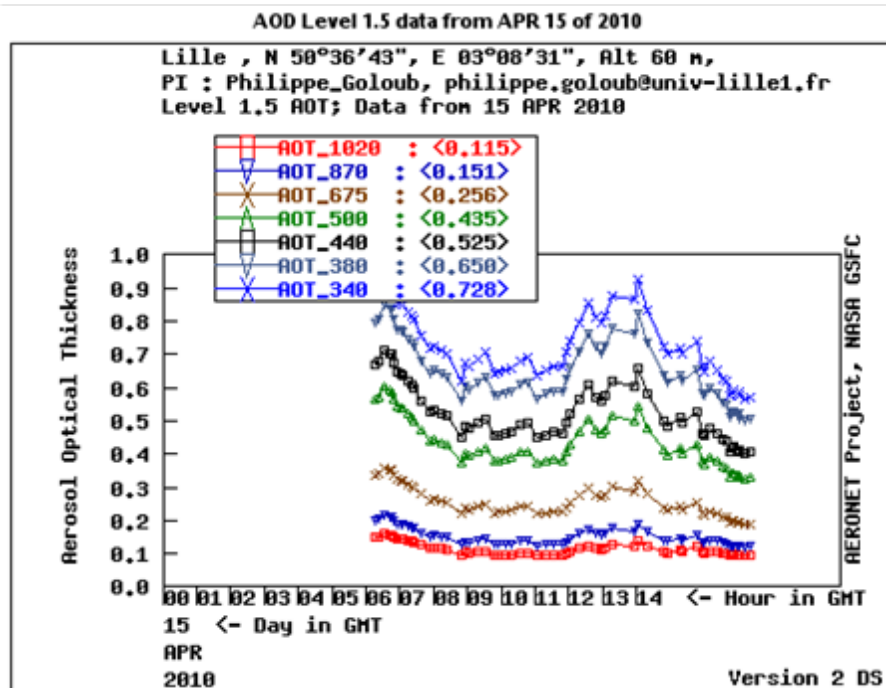
17 <- Day in GMT
APR
2010 AERONET Version 2 DS, SDA Version 4.1

AERONET Project, NASA GSFC

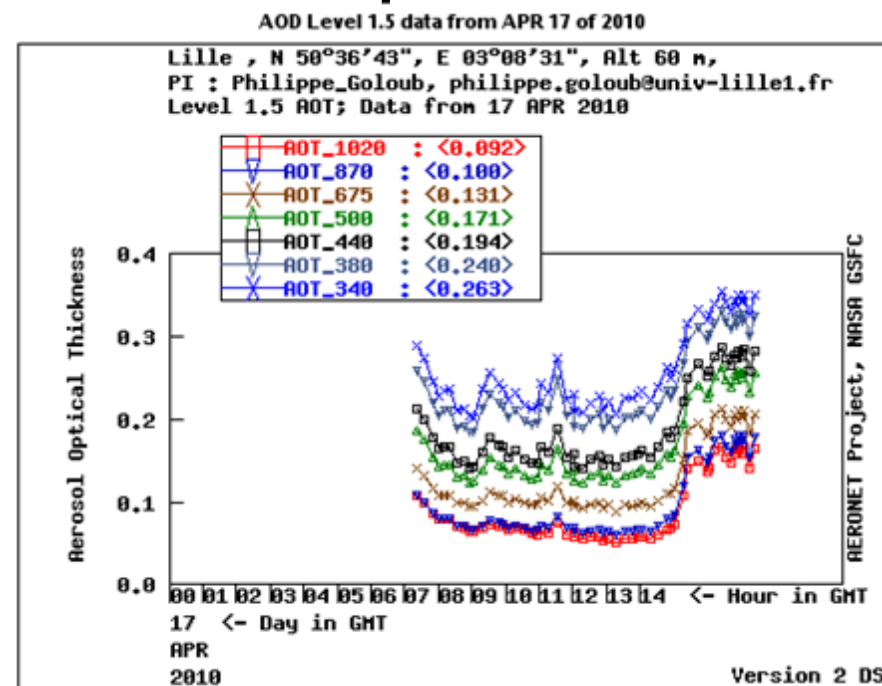
April 16

Aerosol Optical Thickness

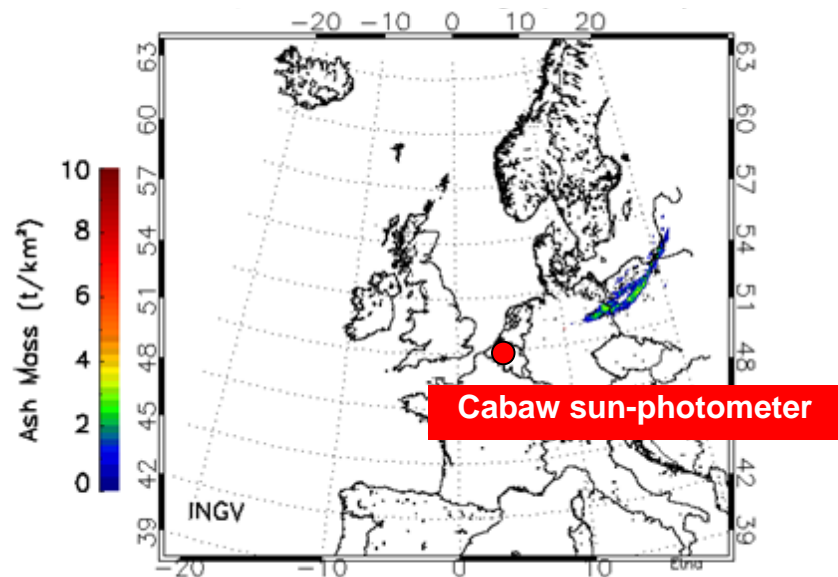
April 15



April 17

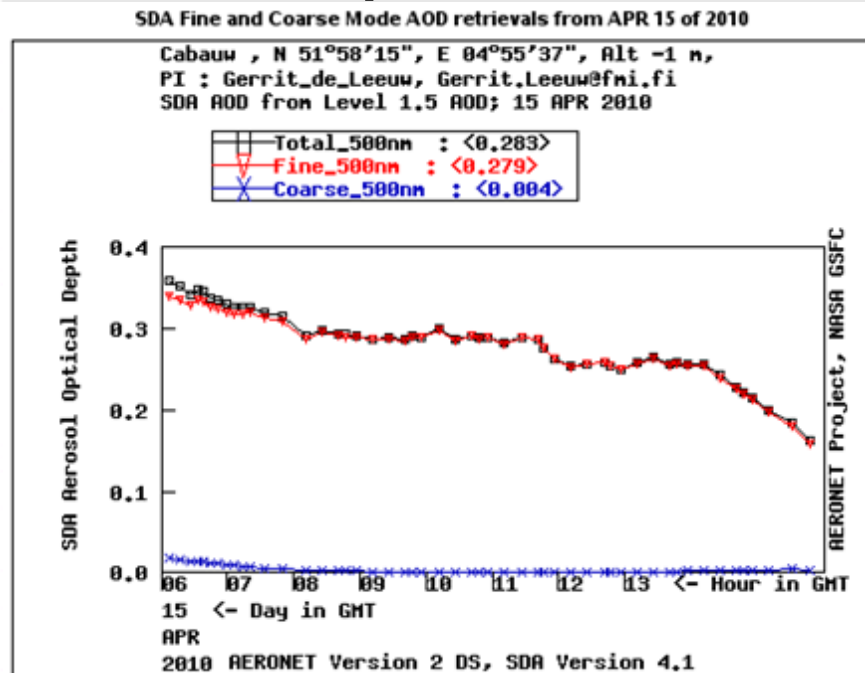


April 17, MODIS-Terra 10:40 UTC

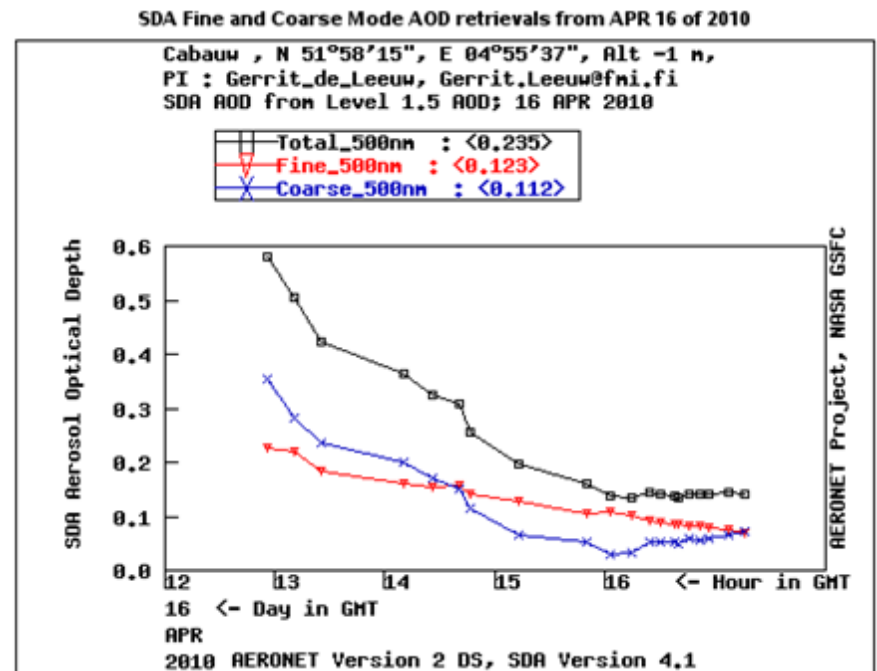


Fine and Coarse particles

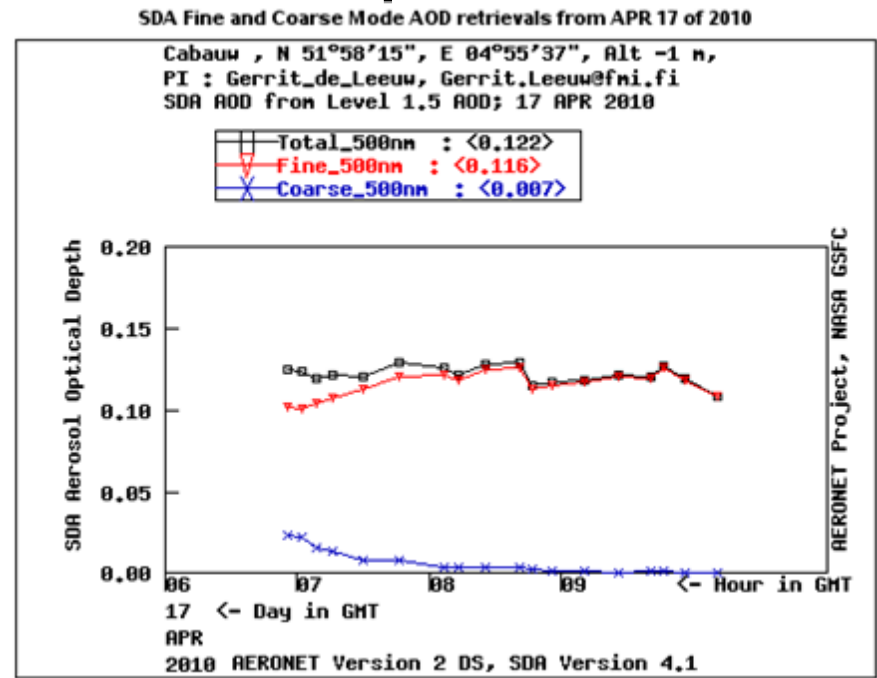
April 15



April 16



April 17



... another case

July 13, 2003

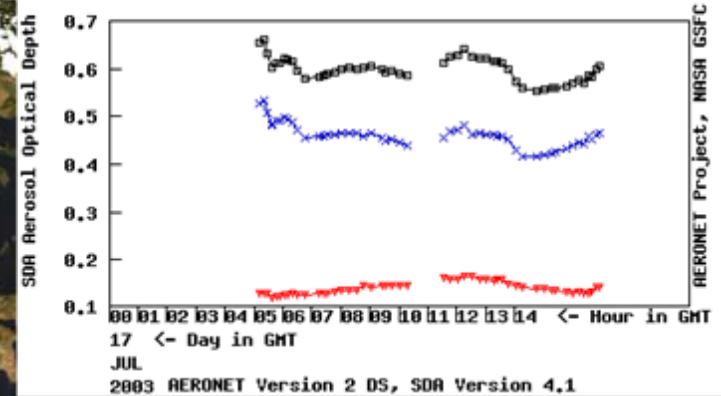


July 17, 2003

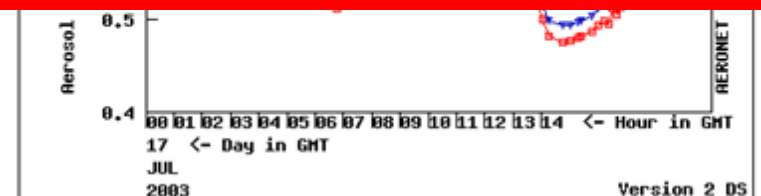
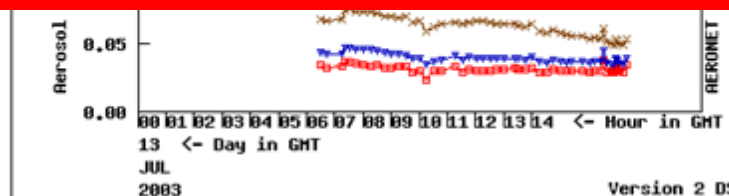
SDA Fine and Coarse Mode AOD retrievals from JUL 17 of 2003

Lampedusa , N 35°31'00", E 12°37'54", Alt 45 m,
PI : Brent Holben, Brent.N.Holben@nasa.gov
SDA AOD from Level 1.5 AOD; 17 JUL 2003

Total_500nm : <0.600>
Fine_500nm : <0.138>
Coarse_500nm : <0.462>



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

Greenhouse gases **GOSAT PROJECT** Observing SATellite

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[Observation data distribution and Observation request service are here](#)

GOSAT User Interface Gateway

NIES GOSAT PROJECT NEWSLETTER **NIES GOSAT PROJECT NEWSLETTER**

News

- ▶ (April 30, 2010) [NIES GOSAT PROJECT NEWSLETTER APR 2010 Issue is published. \(PDF 2.8MB\)](#)
- ▶ (April 20, 2010) [Observation of volcanic eruptions in Iceland and their spreading ash plume by Greenhouse Gases Observing Satellite \(GOSAT or "IBUKI"\)](#)
- ▶ (April 2, 2010) [NIES GOSAT PROJECT NEWSLETTER MAR 2010 Issue is published. \(PDF 7.7MB\)](#)
- ▶ (March 23, 2010) [Now you can read GOSAT data \(CAL L1B and L1B+\) with ENVi extension.](#)
- ▶ (March 5, 2010) [Public Release of Concentration Data \(Carbon Dioxide and Methane\) Archived from](#)

Global Greenhouse Gas Observation by Satellite

GOSAT Project

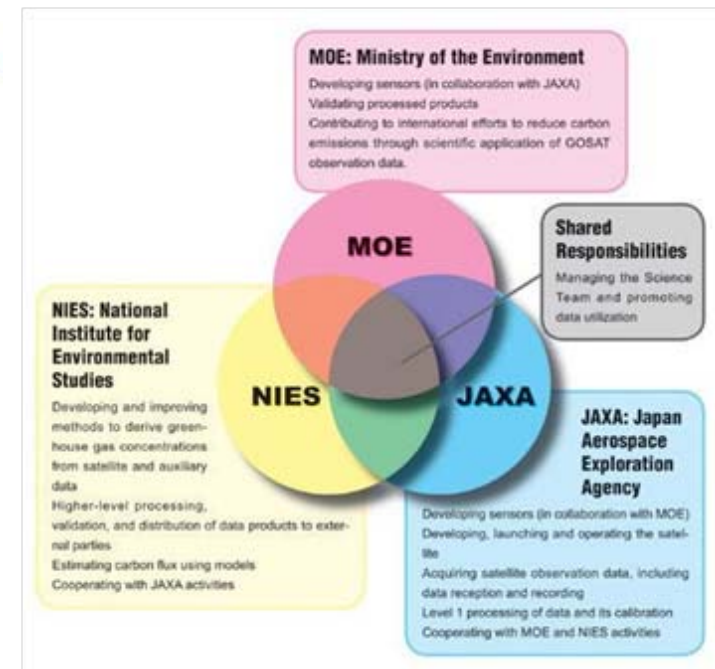
The Greenhouse gases Observing SATellite (GOSAT) Project is a joint effort promoted by the Japan Aerospace Exploration Agency (JAXA), the National Institute for Environmental Studies (NIES) and the Ministry of the Environment (MOE). NIES organized the research team dedicated to the GOSAT project within its organization in April 2004, and since then has been working for the research and development with respect to GOSAT "IBUKI".



(If you click the above image, and it opens in another window.)

What's New Last Update: April 30, 2010

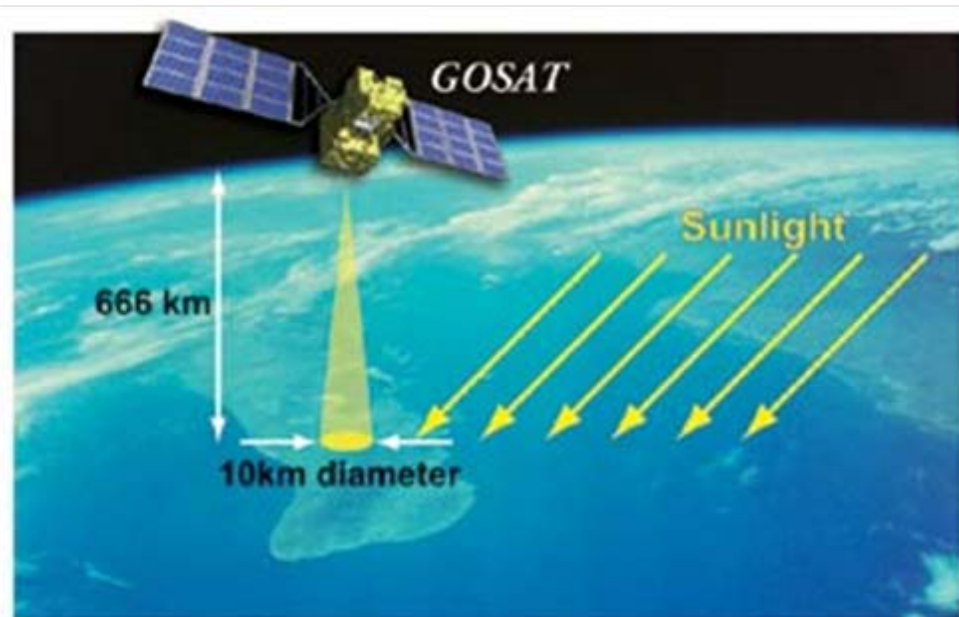
- ▶ (April 30, 2010) [NIES GOSAT PROJECT NEWSLETTER APR 2010 Issue is published. \(PDF 2.8MB\)](#)
- ▶ (April 27, 2010) ["Notice on the disclosure of RA research results" was published.](#)



GOSAT goals:

global distributions of carbon dioxide (CO₂) and methane (CH₄) 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 orbits the Earth in roughly 100 minutes at an altitude of approximately 666 km and returns 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	$\text{CO}_2 \cdot \text{CH}_4$	$\text{CO}_2 \cdot \text{H}_2\text{O}$	$\text{CO}_2 \cdot \text{CH}_4$
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			

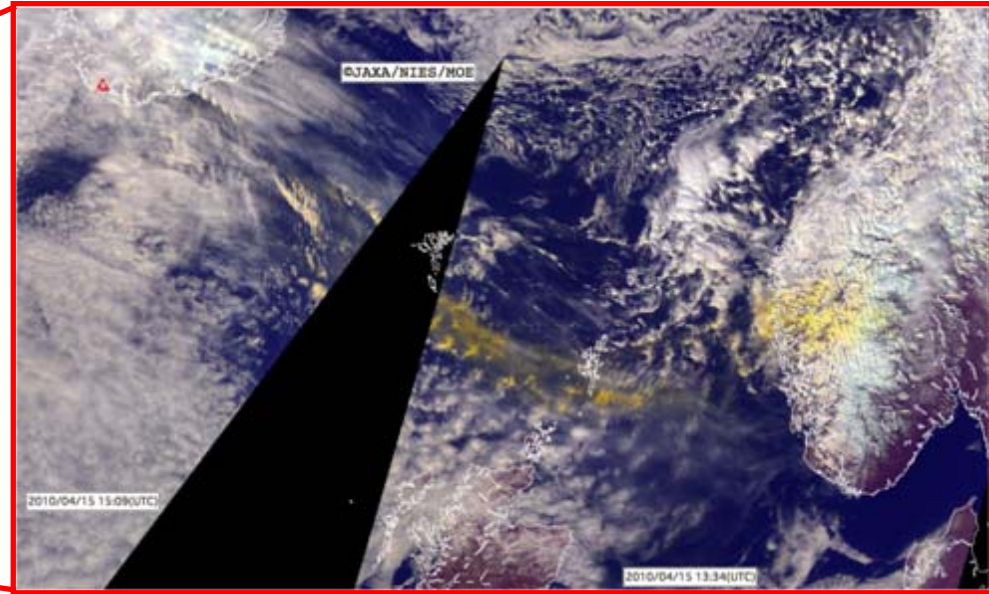
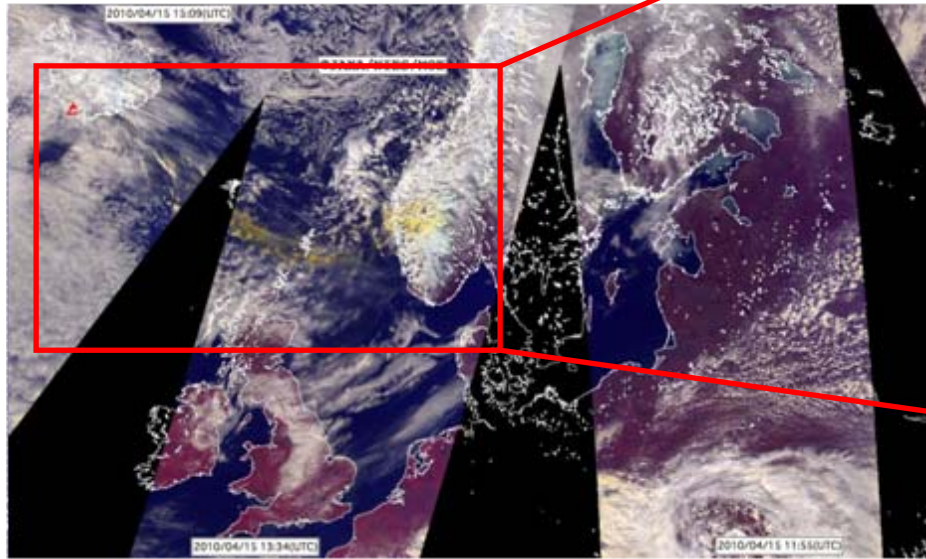
* $1 \mu\text{m} = 1/1000 \text{ mm}$

Cloud Aerosol Imager (CAI)

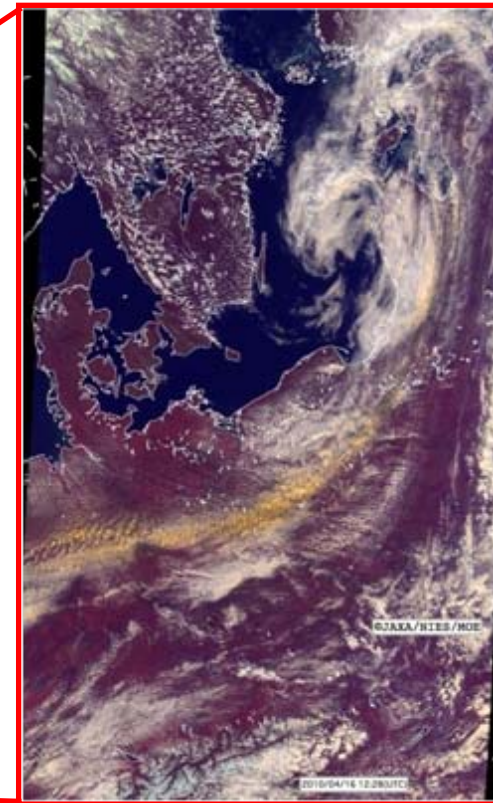
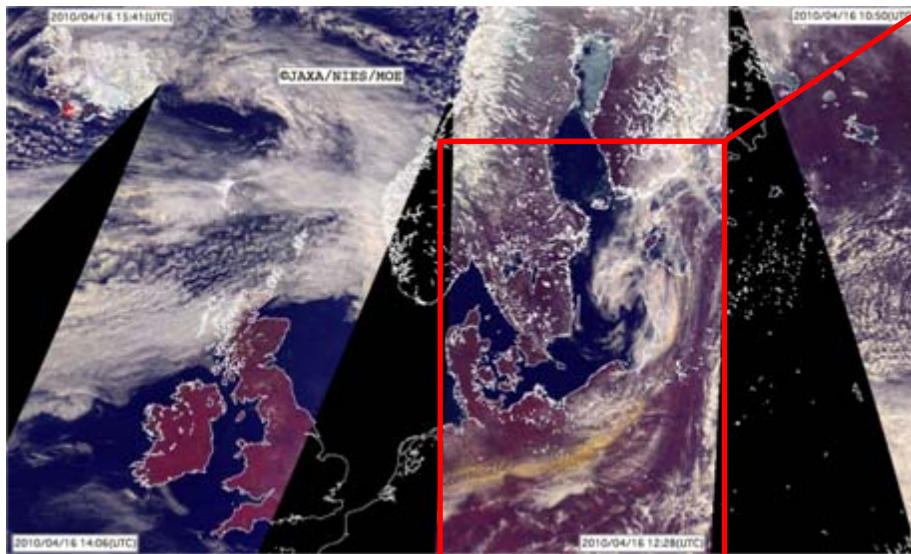
	Band 1	Band 2	Band 3	Band 4
Spectral coverage [μm]	0.370~0.390 (0.380)	0.668~0.688 (0.678)	0.860~0.880 (0.870)	1.56~1.68 (1.62)
Target substance	Cloud, Aerosol			
Swath [km]	1000	1000	1000	750
Spatial resolution at nadir [km]	0.5	0.5	0.5	1.5

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

- ⑩ The results show a greater ash emission during the May event compared to the April event (3-4 times);
- ⑩ 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;
- ⑩ The sun-photometer measurements (AERONET network) can be used to detect and retrieve the volcanic clouds.