First Romanian LIDAR investigation of the EYJAFJALLAJOKULL volcanic ash

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Research conducted in two projects: ROLINET (National: NASR- National Authority for Scientific Research) RADO (Norwegian Funidng-NILU)

University "Alexandru Ioan Cuza" of Iasi: the partner in the first LIDAR system network in Romania, the only on the North-Eastern region of Romania.

• *The installation is completed at the ground level with modern equipment for monitoring environmental pollution. All these devices are called* ***ATMOSPHERIC OBSERVATORY 3D*** *(Three Dimensional Atmospheric Research Observatory).*

•*The current* ***ATMOSPHERIC OBSERVATORY 3D****-Iasi is built on the basis of two projects- one with national funding (ROLINET), the other with international financing (RADO).*

•*At the national level were created five such observatories.*

MOTIVATION

Having this in view, our research focuses on the analysis of the physical phenomena in the atmosphere and the perturbations that occurred with the eruption of this volcano on the 14^{th} of April 2010, which gave off an ash cloud in the atmosphere.

On this occasion, the role and importance of the LIDAR systems have been again underlined, not only for the fundamental research but mainly for the practical one, in order to give exact information to the scientific community and to the public opinion, concerning the evolution of the atmospheric system and the meteo-climatic influences.

PRESENTATION PLAN

- *Preliminary data;*
- *Meteorological and satellite data for the case studied;*
- *Volcanic Ash Advisory*
- *LIDAR data comparative results on the plume;*
- *Conclusions*

INTRODUCTION

Our case study will show the occurrence of this volcanic ash plume over Romania, Bucharest city (lat: 44.4 N, long: 26.0 E), starting on the 17th of April 2010 when the volcanic ash plume covered this area, and also the weather conditions.

SOURCES

- There have been analyzed and interpreted prognostic materials from **ECMWF** (European Centre for Medium-Range Weather Forecasts), the synoptic maps at the ground level of the **DWD** (German Weather Service), the prognostic materials for the ash (**Volcanic Ash Advisory**-Met Office), **LIDAR** data, data from the geostationary satellite **MSG** (Meteosat Second Generation) obtained with the help of **Eumetcast** and the model for backwards trajectories **HYSPLIT** - Hybrid Single Particle Lagrangian Integrated Trajectory Model.
- In order to analyze the satellite images, we used IR images, (8.7 µm, 10.7 µm, 12.0 µm), differences of channels in IR (10.7 µm-12.0 µm) and RGB (IR8.7, IR10.8 si IR12.0) products during the 14th and the 17th of April 2010.

Preliminary data

1. The data obtained was integrated by means of the satellite, together with the synoptic data from the ground level and the maps of altitude.

From their analysis there has been obtained data concerning the atmospheric circulation and the **LIDAR data was validated**.

2. The **synoptic data** gives us important information on the circulation of air streams, **satellite data** shows us the “film” of the event and the **LIDAR data** establishes exactly the moment of the intrusion and the height which the plume of volcanic ash particles was at.

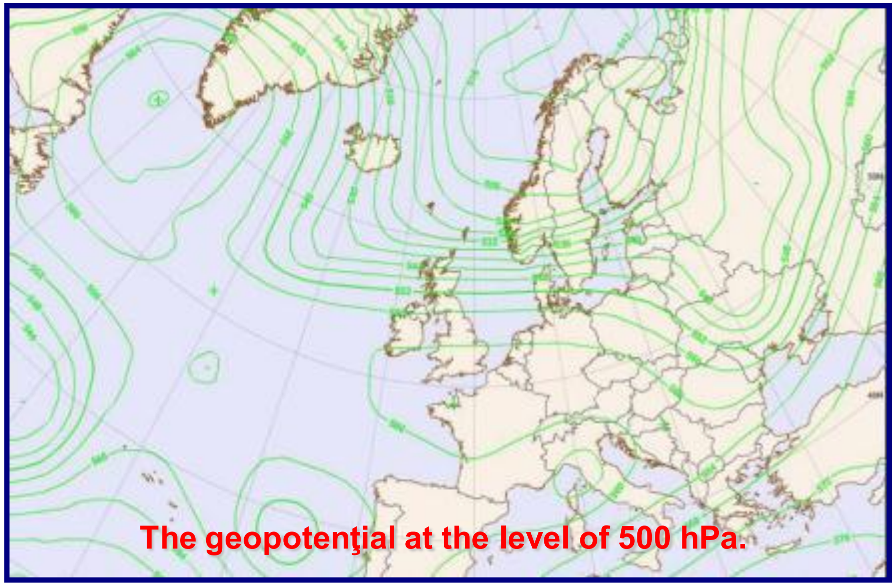
3. Finally, the **backwards trajectories** of the particles were utilized in order to be able to determine the source of the “particle suspensions”.

The simultaneous analysis of this data allowed for the precise detection of the intrusion of the volcanic ash plume over our country.

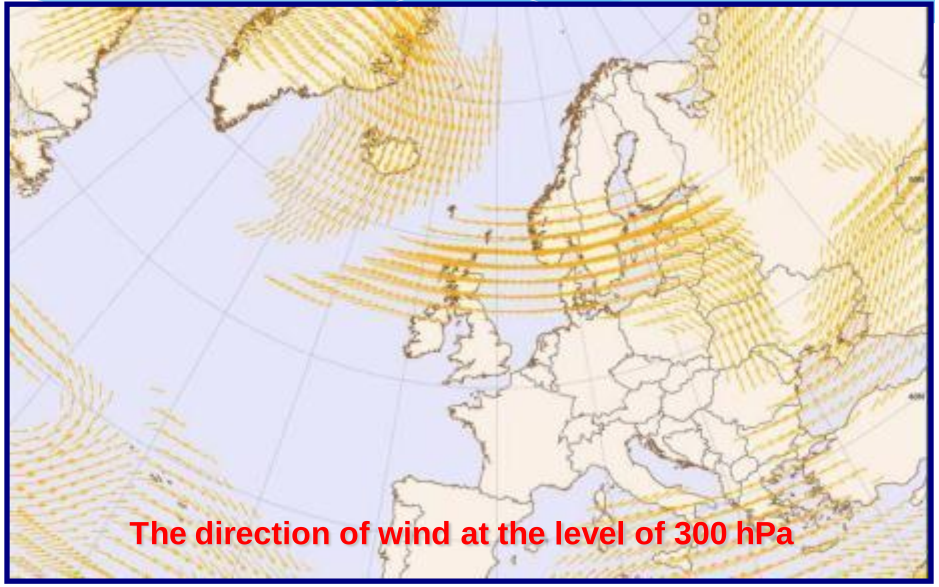
Meteorological and satellite data for the analyzed case

Meteorological data

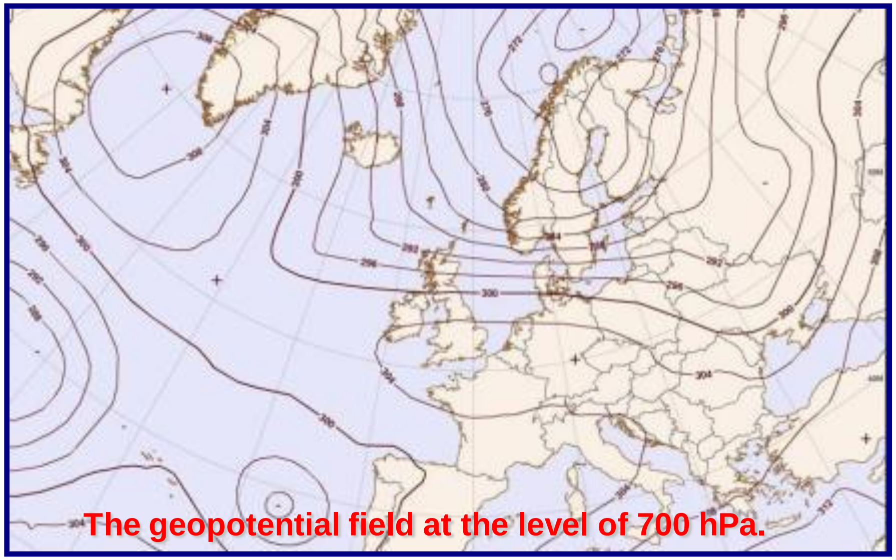
17th of April 2010 h 18 UTC



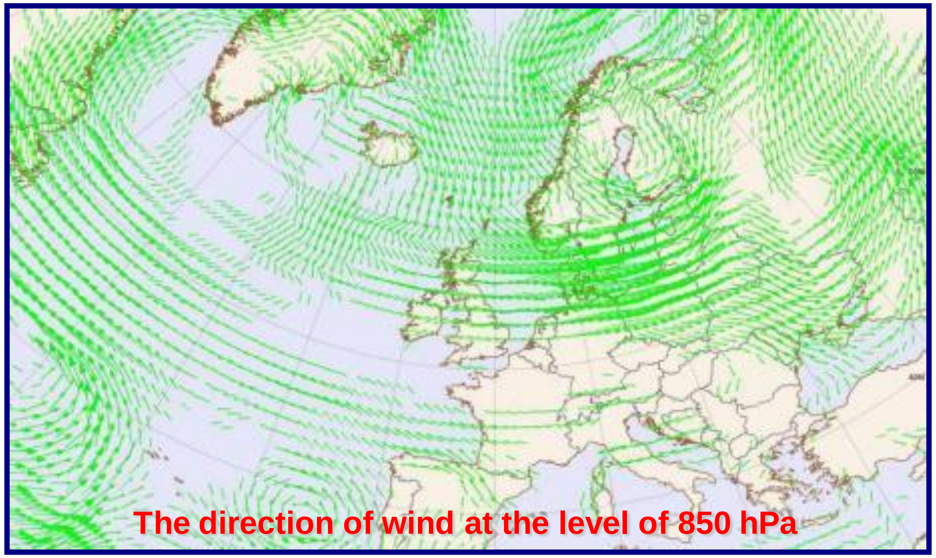
The geopotenţial at the level of 500 hPa.



The direction of wind at the level of 300 hPa

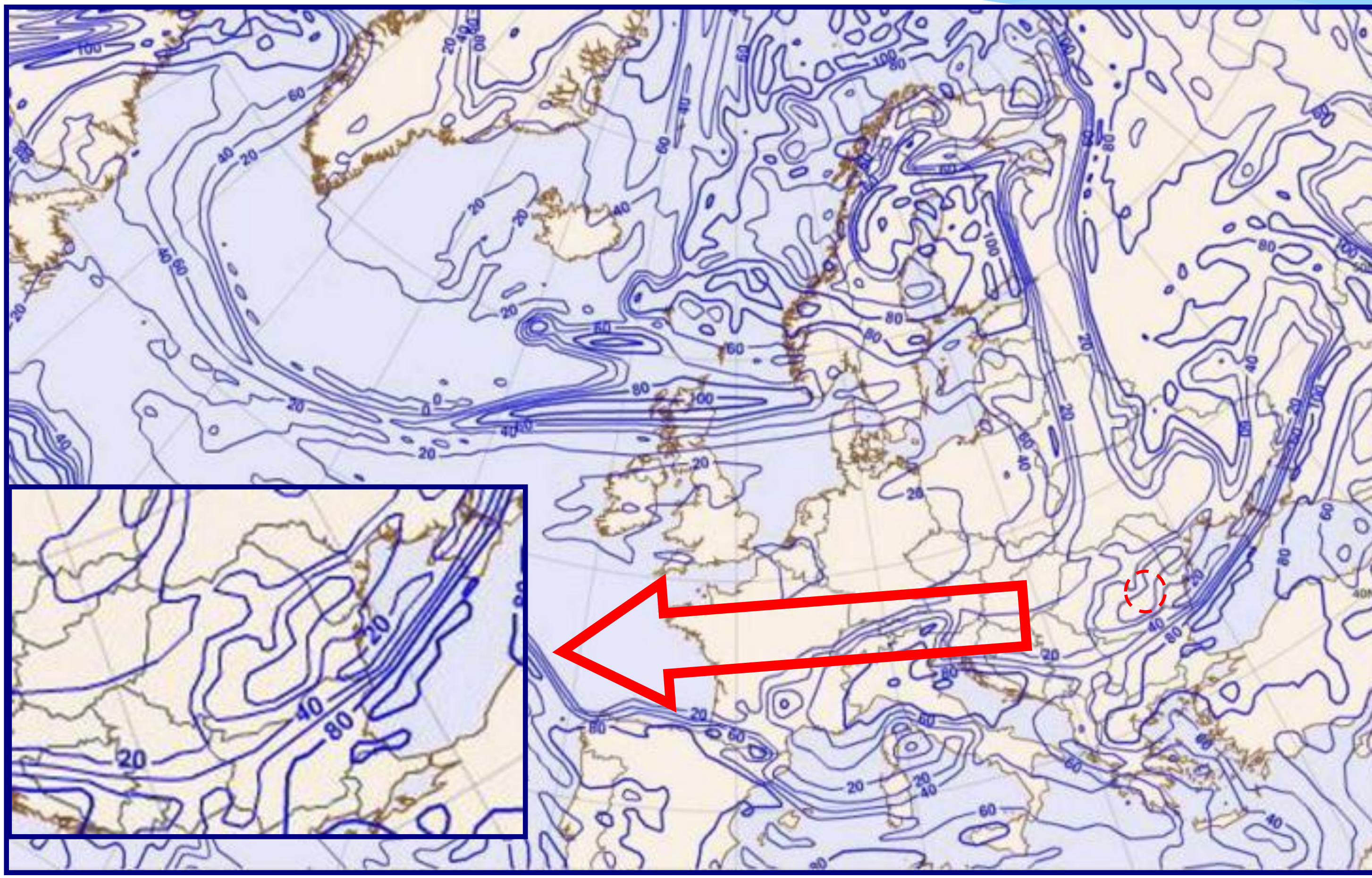


The geopotential field at the level of 700 hPa.



The direction of wind at the level of 850 hPa

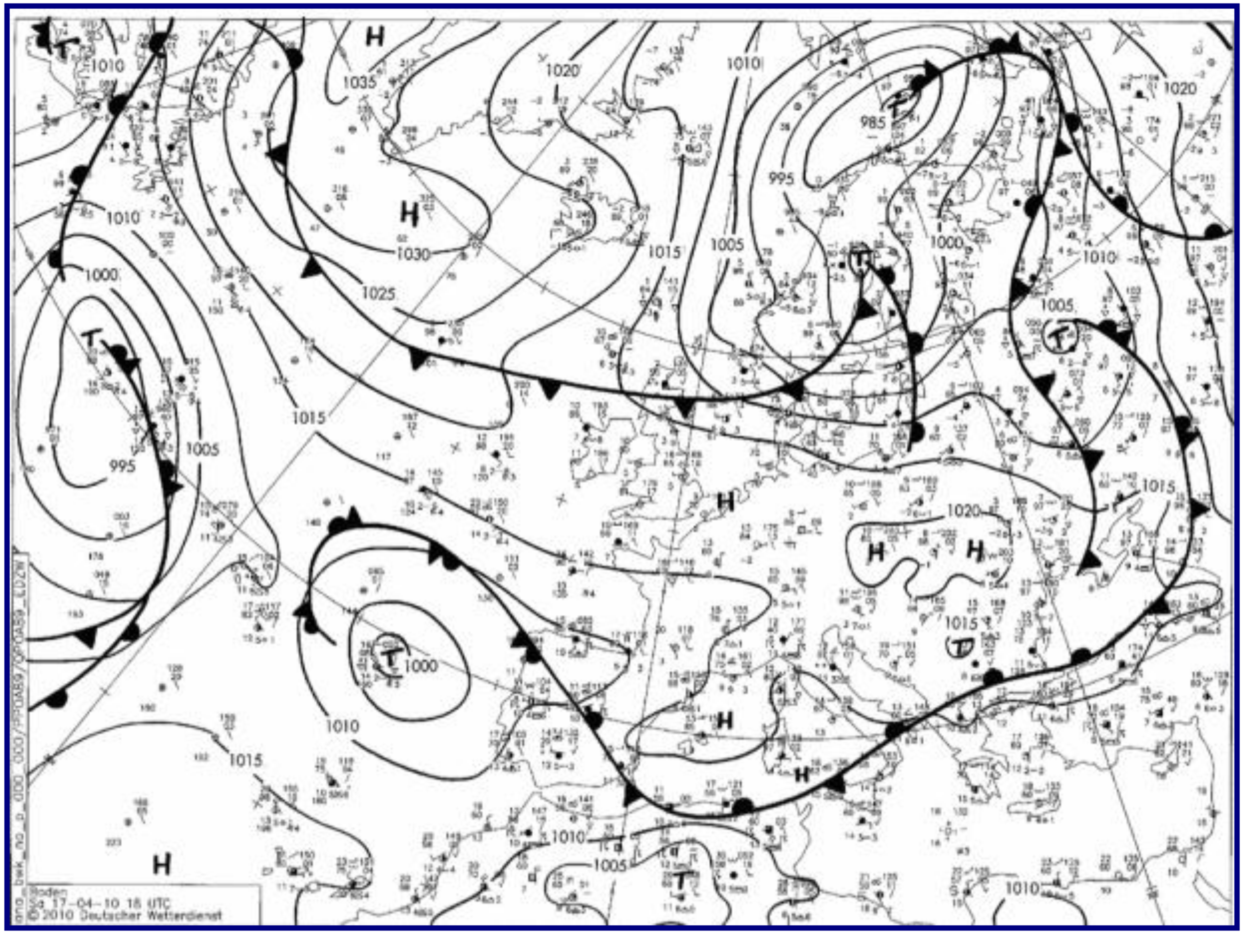
Meteorological data



Relative humidity (%) at the level of 700 hPa.

17th of April 2010 h 18 UTC

Meteorological data



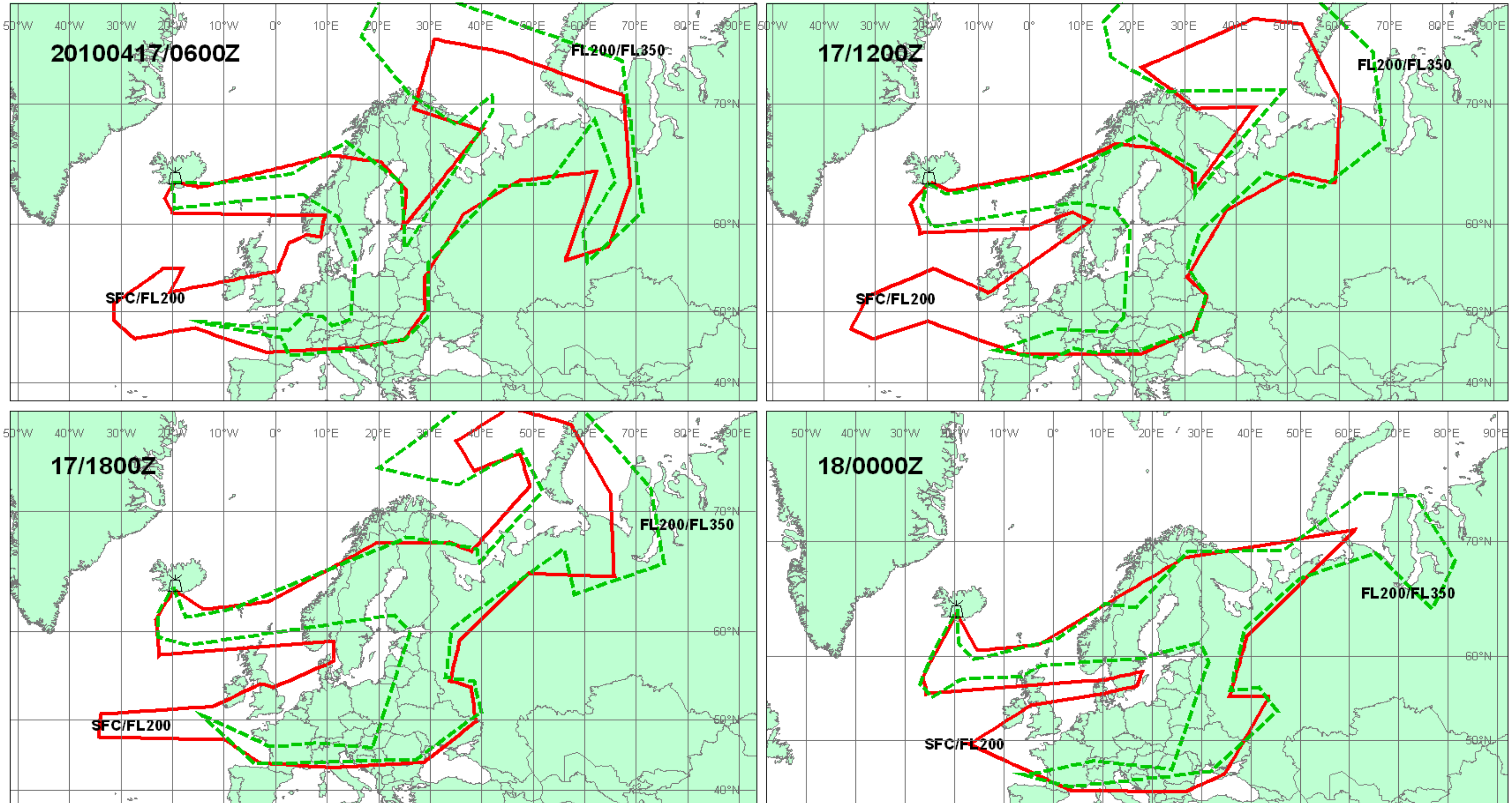
Synoptic situation on the ground level

17th of April 2010 h 18 UTC

In our area of interest (Magurele) , atmospheric pressure rise from 1017.1 hPa (h 14 UTC) to 1020.1 hPa (h 20 UTC)- upward movements were so discouraged .

Volcanic Ash Advisory- Met Office

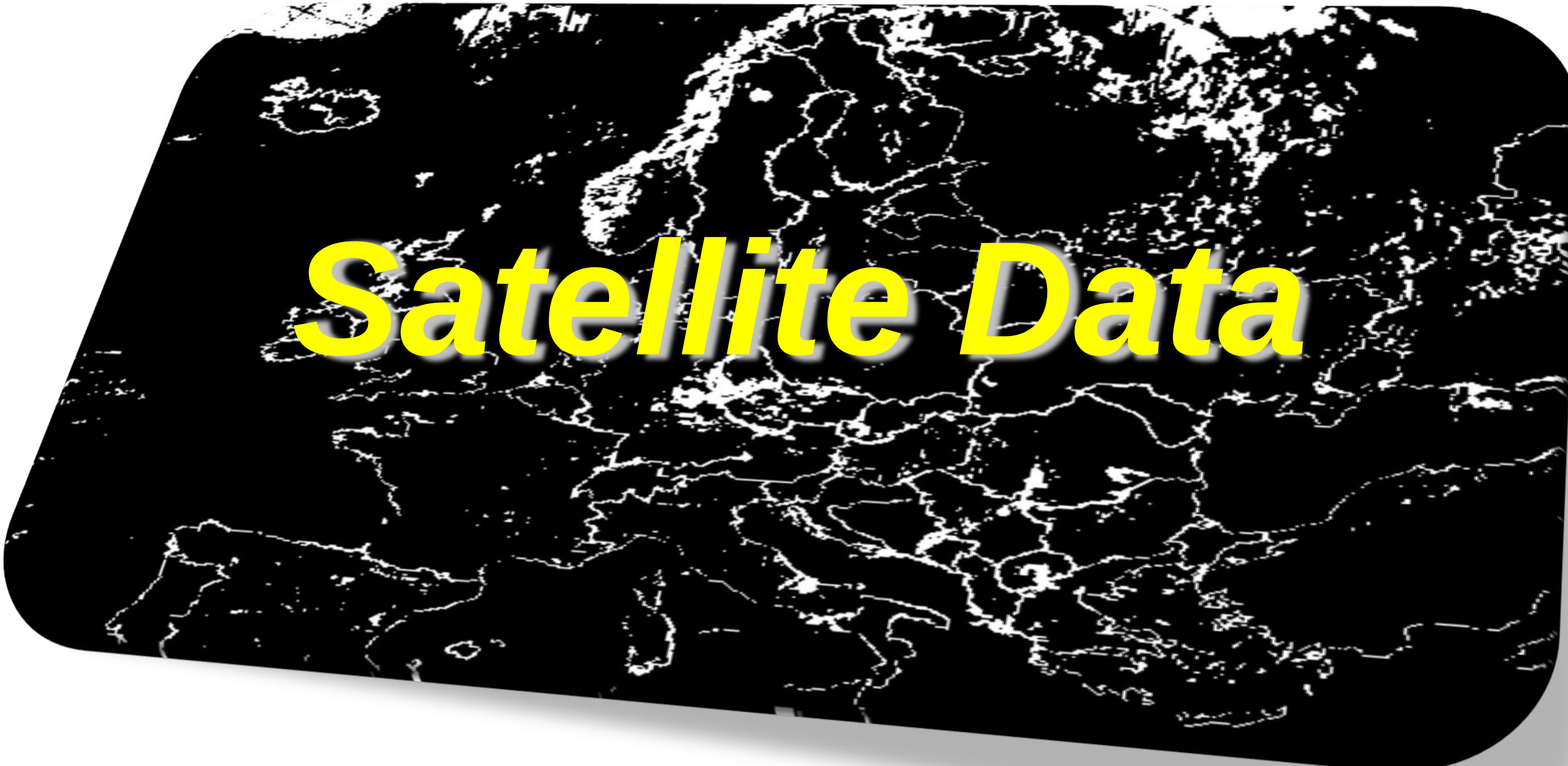
Volcanic Ash Advisory- Met Office



VA ADVISORY
DTG: 20100417/0600Z
VAAC: LONDON
VOLCANO: EYJAFJALLAJOKULL
PSN: N6338 W01937
AREA: ICELAND

SUMMIT ELEV: 1666M
ADVISORY NR: 2010/013
INFO SOURCE: ICELAND MET OFFICE
AVIATION COLOUR CODE: RED
ERUPTION DETAILS: SIGNIFICANT ERUPTION CONTINUING, CONSTANT, REACHING FL280.
ASH TYPE 58% Si02

RMK: NO SIGNIFICANT ASH RISK ABOVE FL350
NXT ADVISORY: 20100417/1200Z


Satellite Data

How to distinguish a cloud and/or an intrusion of dust (ash) with satellite imagery

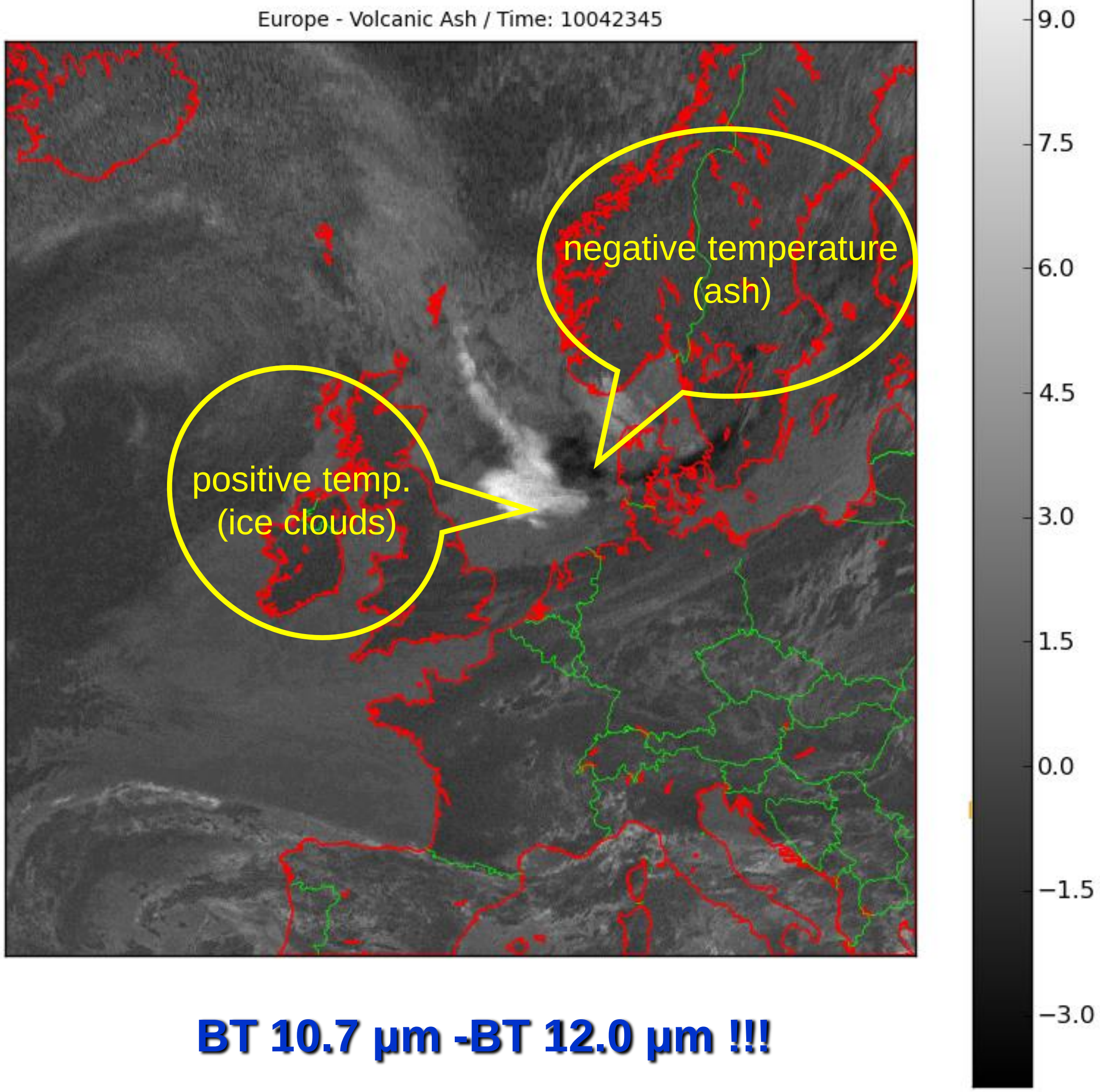
- **By means of multi-channel imagery!**
- **In our research we used the difference of two channels: 10.7 μm and 12.0 μm respectively.**

Temperature difference of 10.7 µm-12.0 µm (brightness temperature)

1. Volcanic ash clouds with a ***high concentration of silicate particles exhibit optical properties in the infrared (8-13 µm)*** that can be used to discriminate them from normal water/ice clouds.
2. Emissivity of silicate particles is lower at 10.7 µm than at 12.0 µm
3. Emissivity of water/ice particles is higher at 10.7 µm than at 12.0 µm,

therefore ...

16th of April 2010 h 23:45 UTC

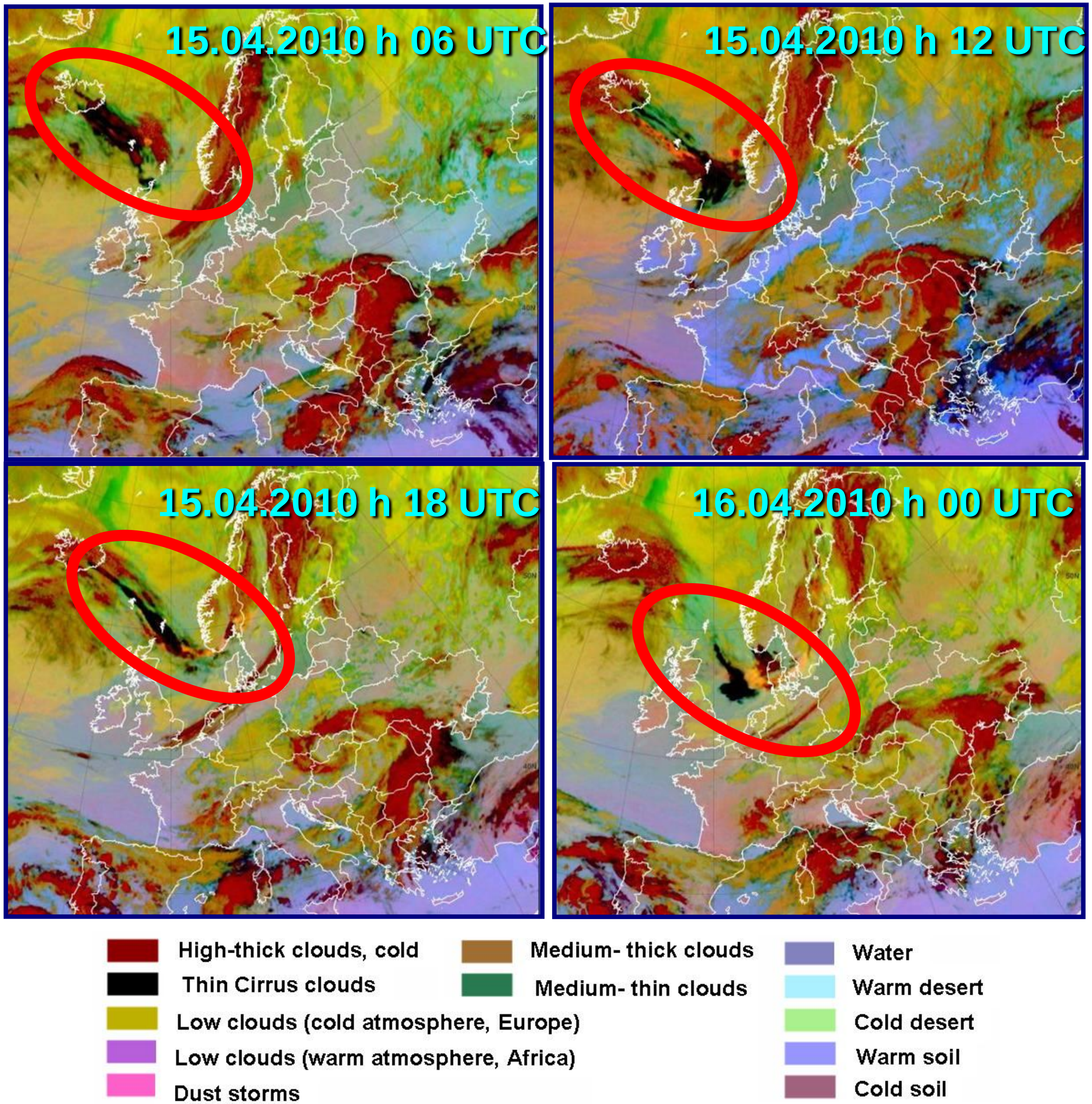


BT 10.7 μm -BT 12.0 μm !!!

Silicates appear warmer at 10.7 μm than at 12.0 μm. Water/ice particles appear warmer at 12.0 μm than at 10.7 μm.

BT 12.0 μm -BT 10.7 μm = positive for ash/dust
BT 12.0 μm -BT 10.7 μm = negative for ice/water cloud

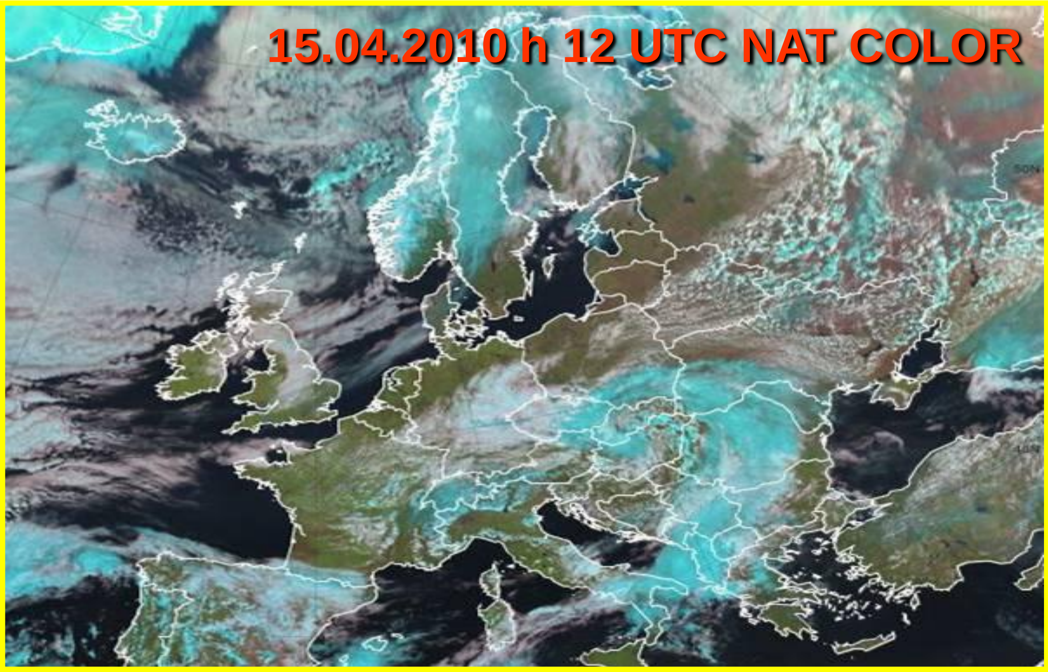
BT= BRIGHTNESS TEMPERURE



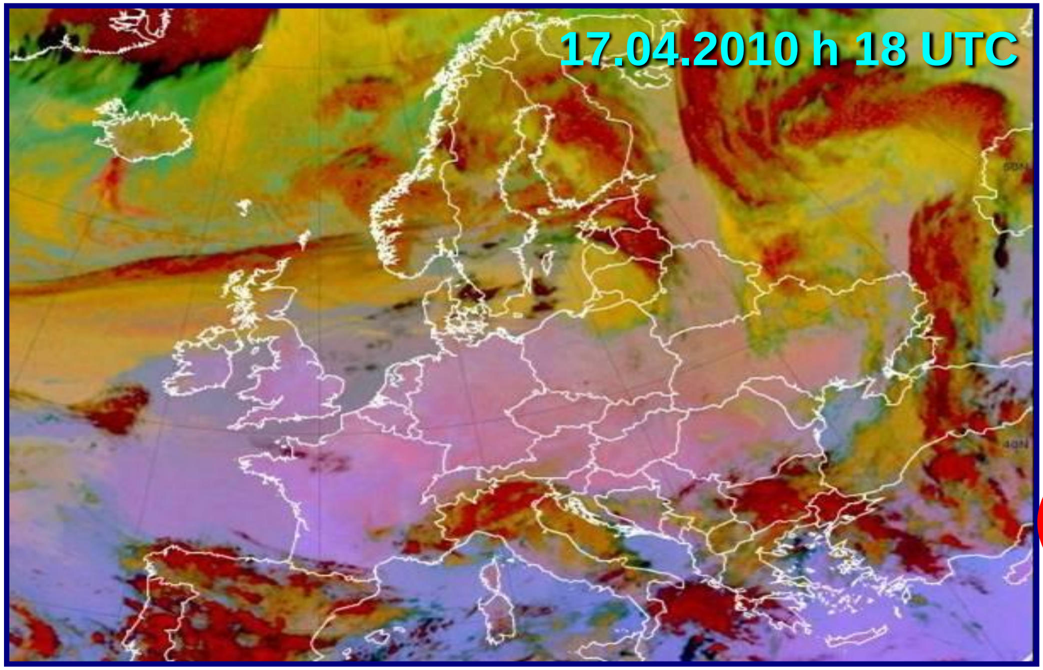
"Dust is an RGB composite based upon infrared channel data from the ***Meteosat Second Generation*** satellite. It is designed to monitor the evolution of ***dust storms during both day and night***.

The Dust RGB is composed from data from a combination of the SEVIRI (Spinning Enhanced Visible and Infrared Imager) IR8.7, IR10.8 and IR12.0 channels.

Other applications are moisture boundaries and SO_2 plumes emitted by Volcanoes."

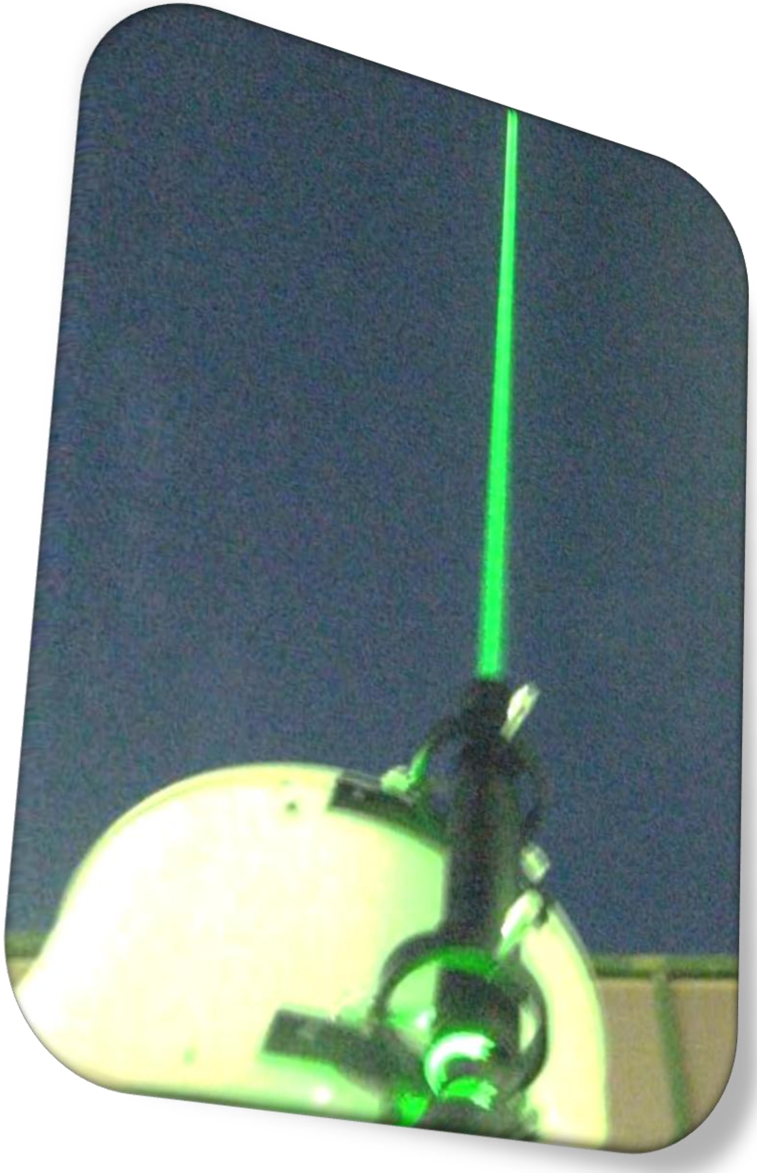


This product consists of a combination of RGB channels NIR1.6; VIS0.8; VIS0.6 of MSG



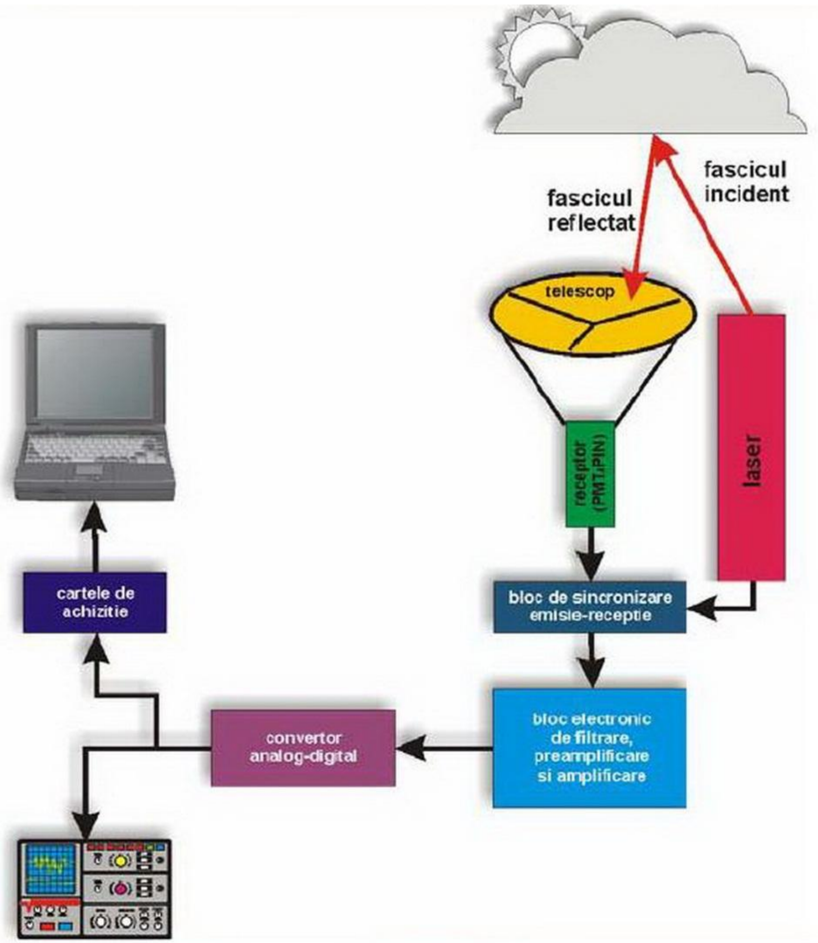
The Dust RGB is composed from data from a combination of the SEVIRI IR8.7, IR10.8 and IR12.0 channels.

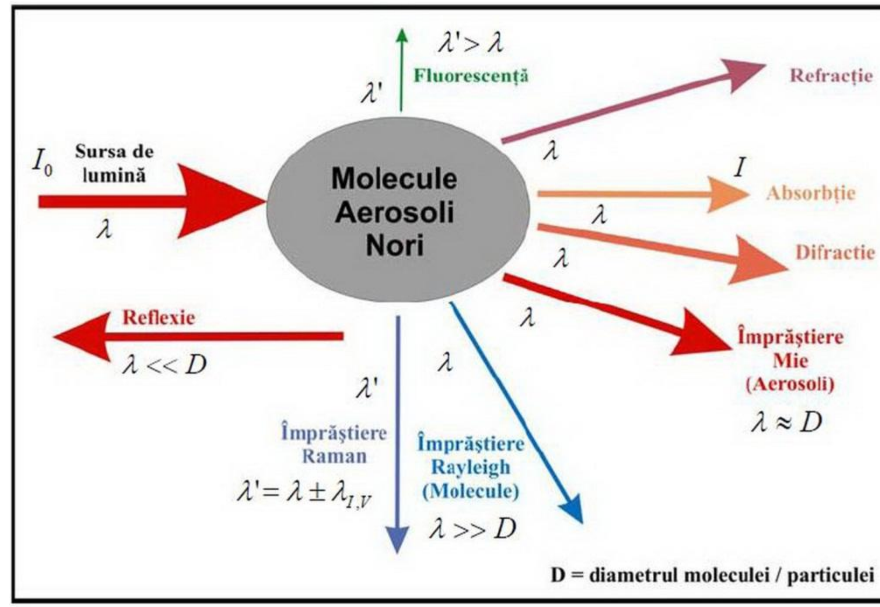
Where's the ash??!



LIDAR Data

The principle of operation of a LIDAR system

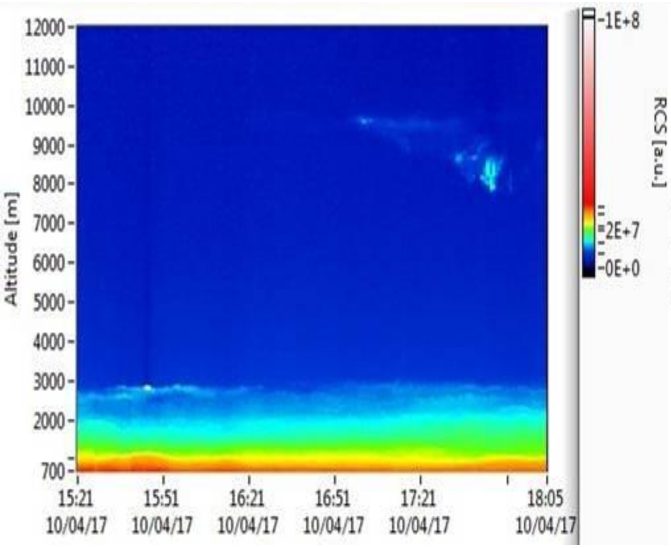




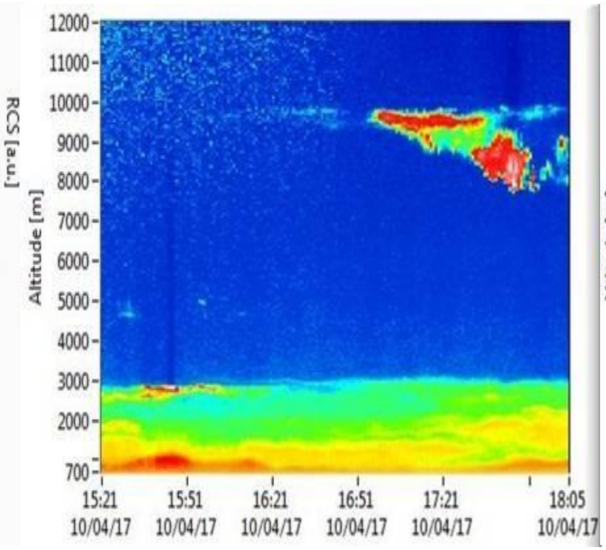
The main laser-atmosphere interaction processes related to detection LIDAR

LIDAR (LIght Detection And Ranging) is a system of laser sounding of the atmosphere in a direction that permits the detection of particles in suspension, with very good precision and in very short time (seconds).

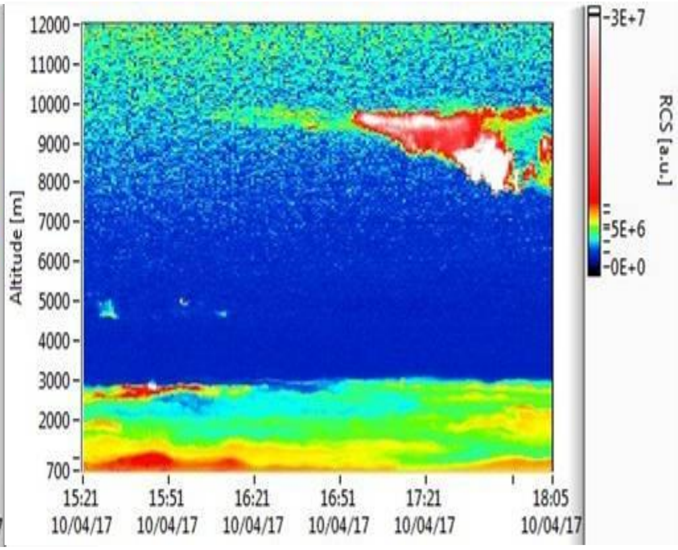
LIDAR Data



RCS time series for 355 nm
Spatial resolution: 3.75 m,
Time resolution: 60s



RCS time series for 532 nm
Spatial resolution: 3.75 m,
Time resolution: 60s

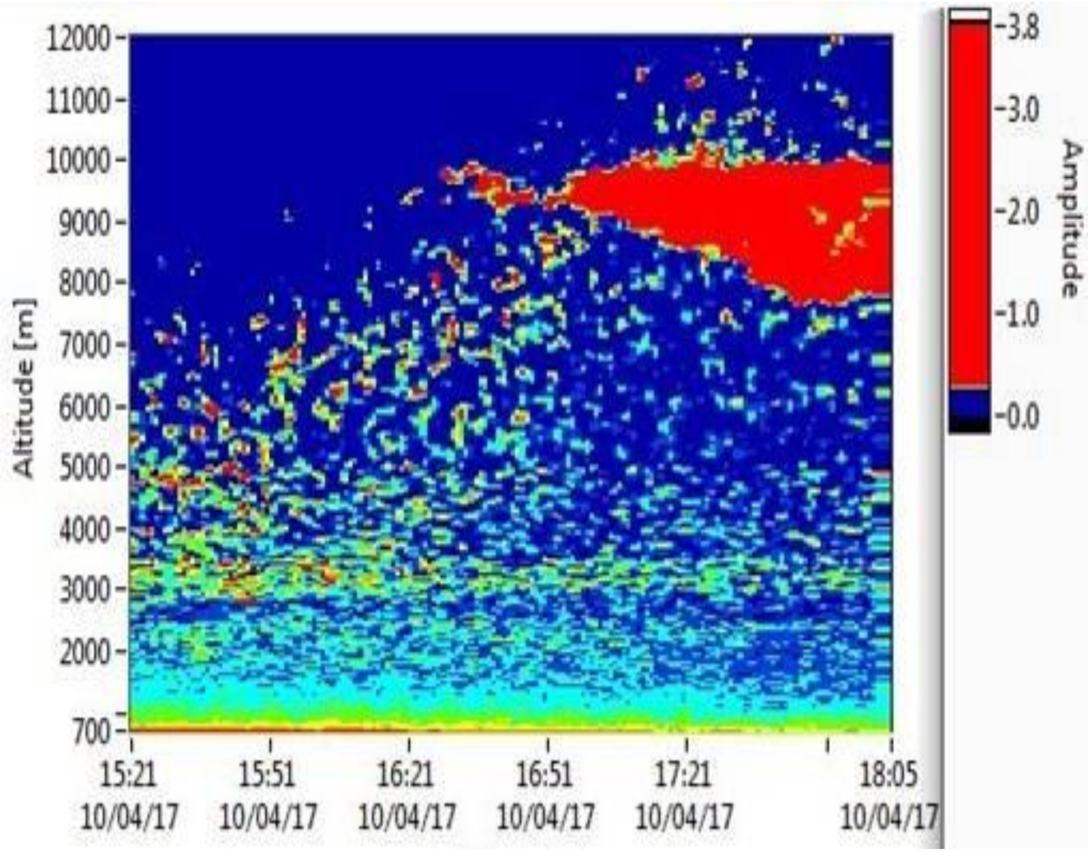


RCS time series for 1064 nm
Spatial resolution: 3.75 m,
Time resolution: 60s

In the visible, the atmosphere shows a large transparent window, so that we can study the phenomena of scattering on aerosols by means of lasers that emit in the visible (their radiation is poorly absorbed by gases in the atmosphere).

A narrow window in the IR at around 1000 nm also allowed the use of solid lasers with YAG: Nd (λ = 1064 nm).

These lasers can be doubled in frequency to obtain visible radiation (λ = 532 nm or λ = 355 nm).

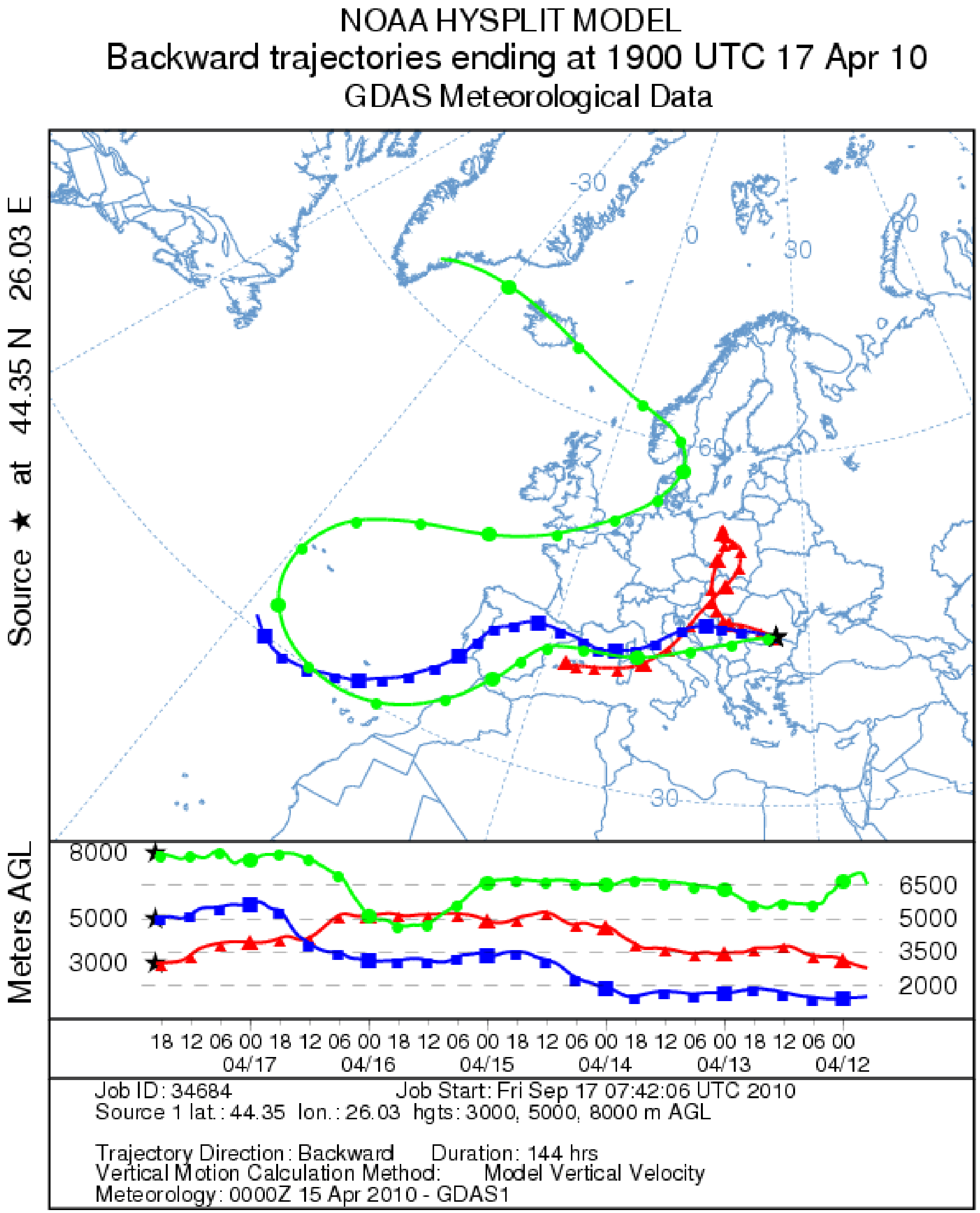


Uncalibrated depolarization ratio at 532 nm, Spatial resolution: 3.75 m; Temporal resolution: 60s

1. **The clouds are even easier to identify from lidar signals, and besides optical characterization that is still under study, the lidar signals can also provide information about of base, altitude and presence of aerosols.**

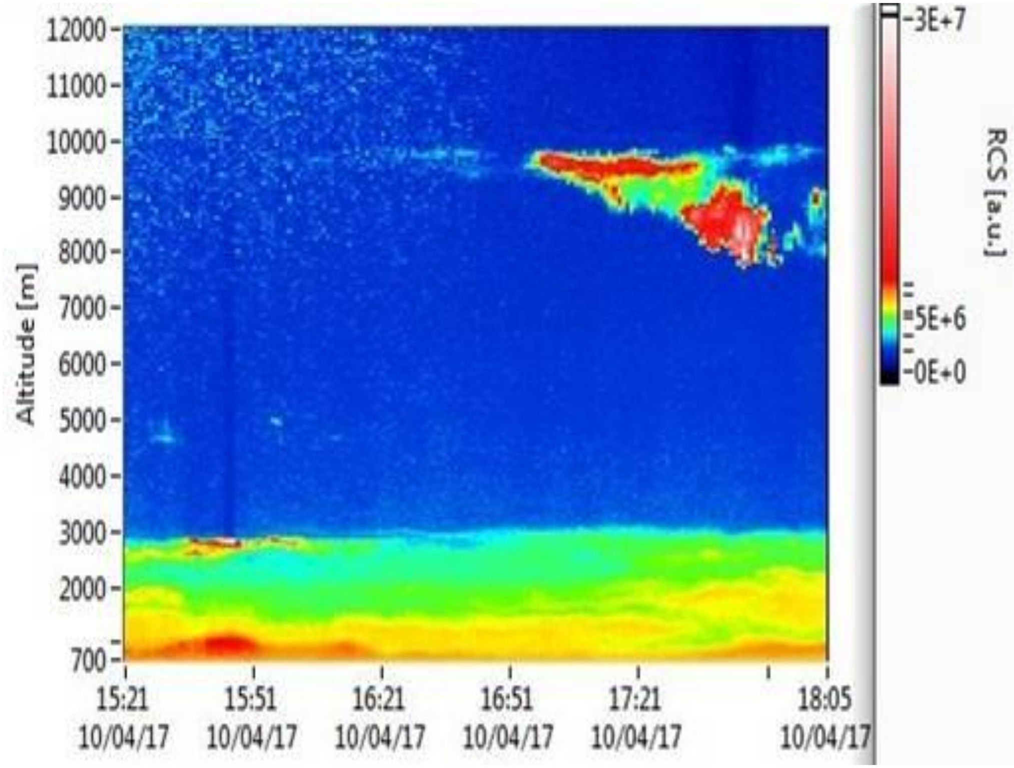
2. ***Cirrus* clouds give a high lidar ratio and a high degree of depolarization due to ice crystals shape.**

HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model



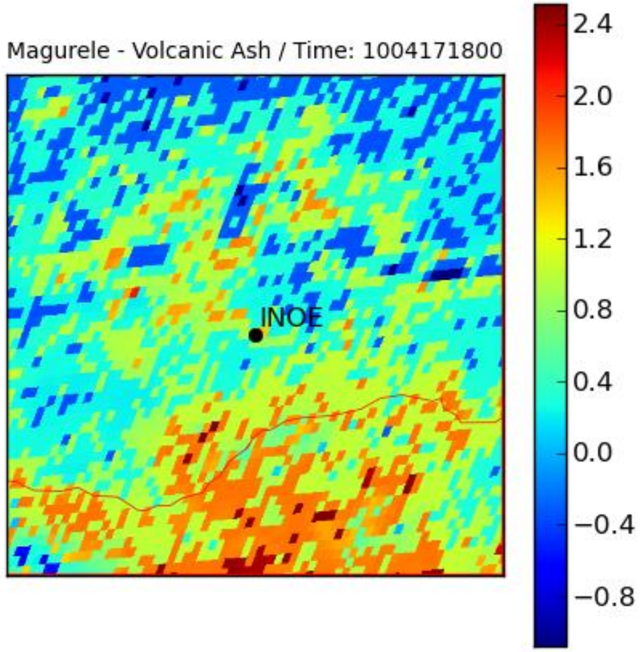
Running Backward Trajectories of air masses to *determine the origin of the source.*

LIDAR Data and Eumetcast



Cirrus clouds and volcanic ash plume at an altitude of 8000-10000 m

RCS time series for 532 nm
Spatial resolution: 3.75 m,
Time resolution: 60s



IR Satellite Image (BT 10.8-BT 12.0). Emphasizing positive temperatures (clouds formed from water/ice)

Sulfur emissions occur mostly in the form of SO_2, although other species of sulfur may be present. Volcanic sources are important for the supply of sulfate aerosols in the upper troposphere, where they can contribute to the formation of ice particles.

CONCLUSIONS

Ash cloud monitoring was performed by using the LIDAR measurements and satellite images (Meteosat Second Generation).

To determine the source of origin the HYSPLIT model (Hybrid Single Particle Lagrangian Integrated Trajectory Model) was used.

Satellite images allow us to visualize the times when the volcanic plume was formed, expanded and dispersed into the atmosphere.

With the LIDAR data we have determined the altitude and intrusion of volcanic ash plume over our observation point.

Simultaneous analysis of these data allowed the detection of the intrusion of the ash cloud over our country with a good accuracy.

Good agreement between the models which can predict the ash cloud intrusion and the reality on the ground was found.

MORE LIDAR STATIONS ARE NECESSARY FOR OPERATIONAL PURPOSES.

OUTLOOK

Determination of optical parameters such as:

-Angstrom parameter

-LIDAR ratio

-calibrated depolarization ratio,

to be certain that the layers from 3000 and 5000 m (17th of April 2010 h 15:21-16:21) contain volcanic ash particles.

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Thank you for your attention!

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