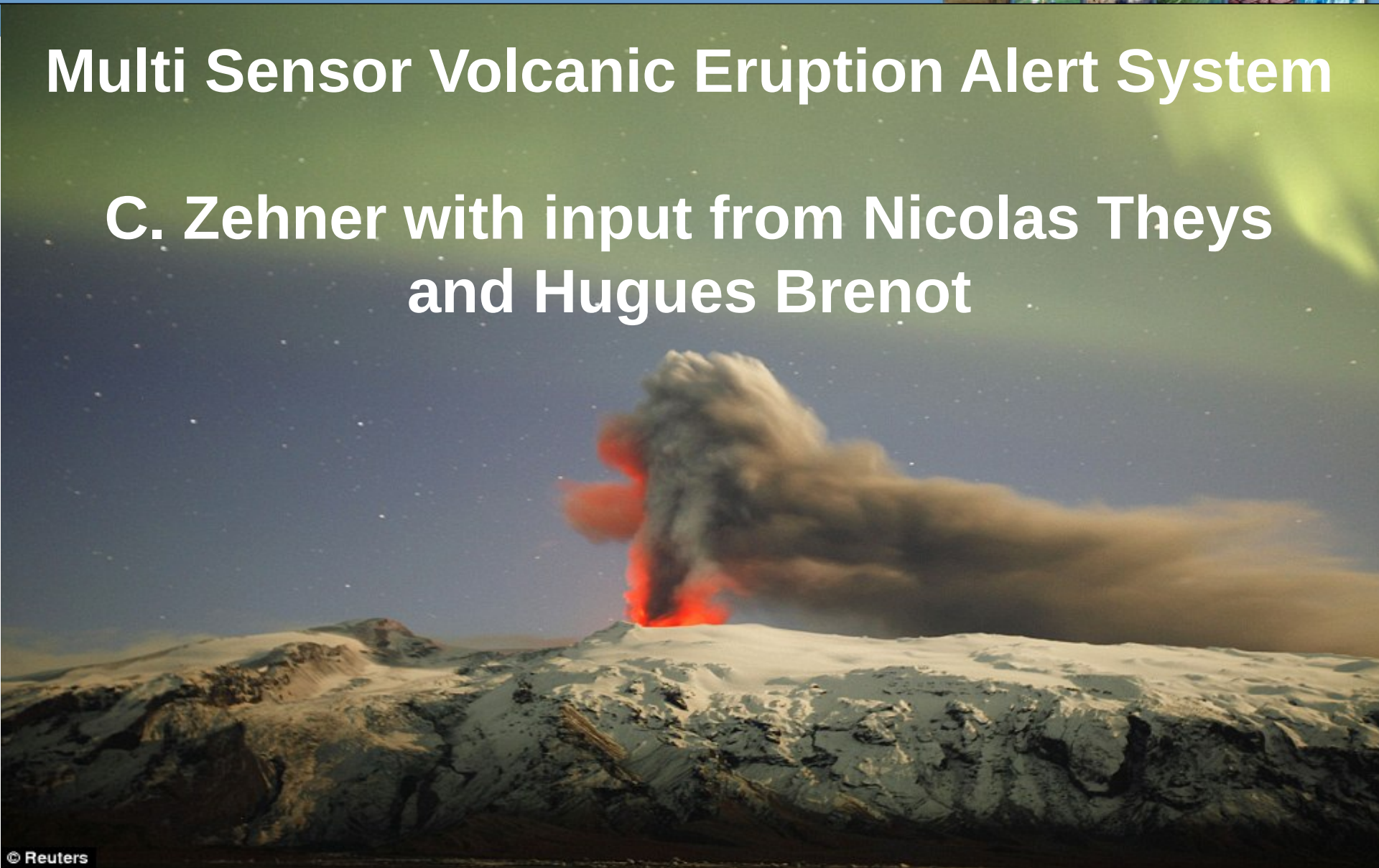
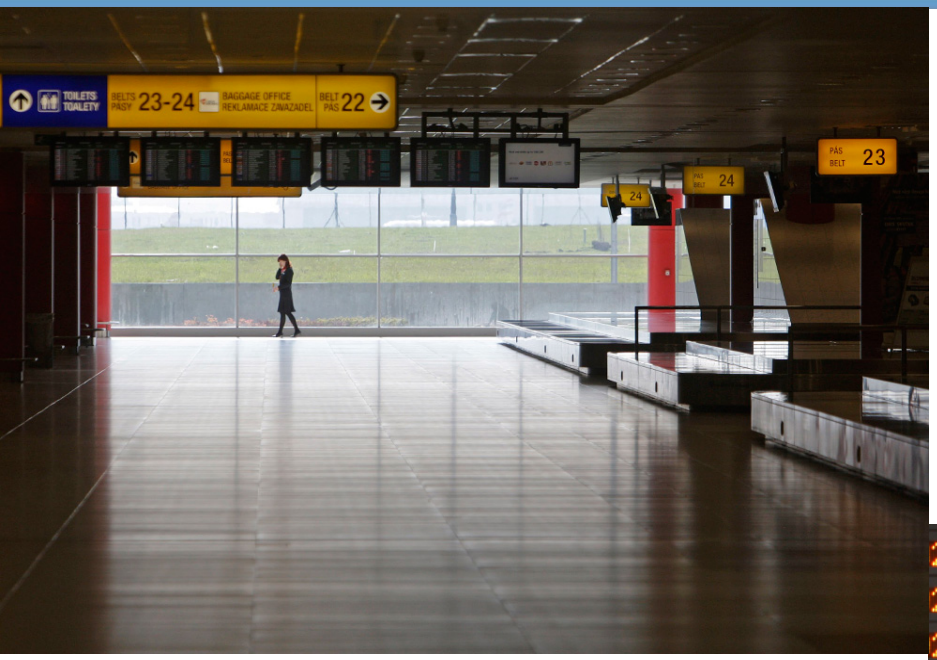
ACC-8 Meeting

Multi Sensor Volcanic Eruption Alert System

C. Zehner with input from Nicolas Theys and Hugues Brenot



World Airways DC-10 after ash plume encounter - 1991 Pinatubo eruption


TOILETS
TOALETY
BELTS
PASY 23-24
BAGGAGE OFFICE
REKLAMACE ZAWAZADEL
BELT
PAS 22
PAS
BELT 23
PAS
BELT 24
24


20 AMSTERDAM KL 1230 AF 8230 CANCELLED
25 BORDEAUX AF 7622 AZ 3642 CANCELLED
25 MARSEILLE AF 7662 DL 8362 CANCELLED
25 NICE AF 7702 MK 9086 CANCELLED
25 TOULOUSE AF 7782 DL 8582 CANCELLED
25 DUBLIN EI 521 1 DELAYED
25 VIENNA OS 412 AF 2638 CANCELLED
25 MALAGA UX 1034 AF 2630 CANCELLED
30 NEW YORK-JFK AF 012 DL 8654 CANCELLED
30 SEATTLE 306 DL 8628
30 SAO PAULO 456
30 HOUSTON DL 8657
30 CHICAGO DL 8494
raire
Destinations
Vol

Web-based alert service is operated by BIRA/IASB:

httpt://sacs.aeronomie.be

Number of subscribed Users (on-line subscribtion possible): 112

- Volcanic Ash Advisory Centres (6 out of 9 VAACs)
- Observatories (USGS Hawai, Ecuador, Colombia, Reunion Island, Italy, Alaska)
- Research institutions volcanoes/AQ (China, US, Europe), Universities, scientists
- Flight captains (3), Flight Safety Department of Lufthansa
- State Civil Defense (Hawai), US Department of Defense
- Commercial Companies (Boeing)
- Teachers: SACS is used as a teaching tool

Multi-sensor alert system relies on the combined use of UV-visible and infrared satellite instruments

System operation: synergistic use of UV-visible and infrared polar-orbiting satellites data

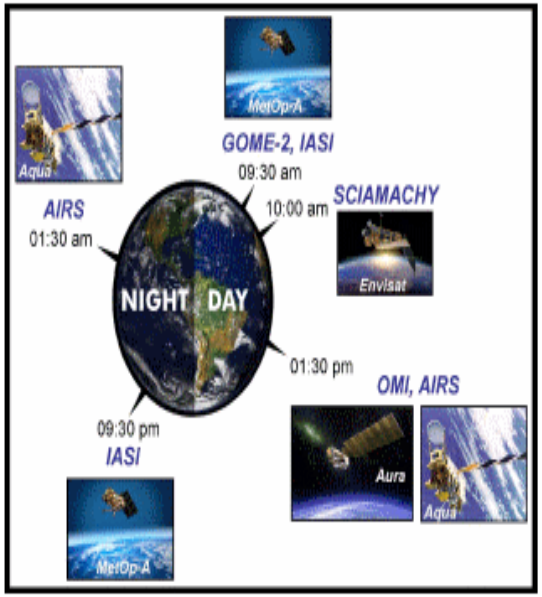


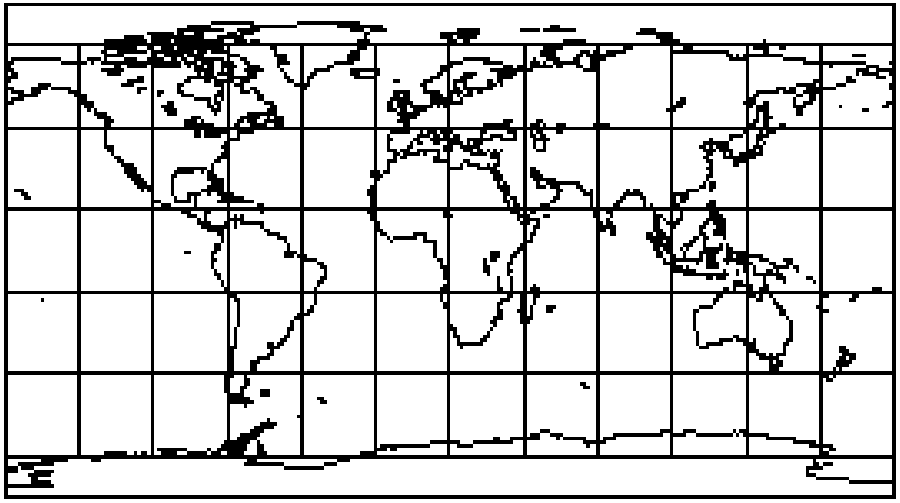
Figure 1: Polar-orbiting satellites equatorial overpass solar local times

Instruments	Data type	Overpass time	Resolution (km²)	Data products	Participants	Units	Delay
SCIAMACHY *(ENVISAT)*	UV/visible	10:00 am	30x60	SO_2 vertical columns Absorbing aerosol index	BIRA KNMI	DU -	2-3 h 2-3 h
OMI *(Aura)*	UV/visible	01:30 am	13x24	SO_2 vertical columns Absorbing aerosol index	NASA/KNMI/FMI KNMI	DU -	2-3 h (EU: 45') 2-3 h
GOME-2 *(MetOp-A)*	UV/visible	09:30 pm	40x80	SO_2 vertical columns SO_2 plume height Absorbing aerosol index	DLR BIRA KNMI	DU km -	1-2 h off-line 2-3 h
IASI *(MetOp-A)*	Infrared	09:30 am 09:30 pm	12x12	SO_2 index (and colums) Ash indicator	ULB ULB	K (DU) K	1-2 h 1-2 h
AIRS *(Aqua)*	Infrared	01:30 am 01:30 pm	15x15	SO_2 index	JPL	K	1-2 h

Table 1: List of data products available from SACS.

Multi-sensor alert system – its main features (developed based on SCIAMACHY data and on user requests/feedback)

- One e-mail shall be sent per 12 hours and per 30° x30° predefined region (first instrument to detect SO_2).
- Avoid wrong alerts



- After a notification, all other alerts (confirmation during the next 12h) will be available through the webpage and/or using the RSS tool.
- On Alert web page: interpolated plot and kml files (google earth) will be available

Simple e-mail alert with Webs-link to more detailed information about the eruption

```
SACS multi-sensor alert of exceptional SO2 concentration
========================================================

Process date : 2012/04/13
Process time : 08:54 UTC
Instrument   : GOME2


  Alert region: 207
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http://sacs.aeronomie.be/GOME2alert/2012/04/alertsGOME2_20120413_07h52_207.php?alert=20120413_085451_207

Date          :    2012/04/13
Time          :    07:52  UTC
Longitude     :     32.7  deg.
Latitude      :     31.2  deg.
SZA           :     35.2  deg.
Max. SO2 vcd  :     2.2   DU
Cloud data    :    used for VCD
```
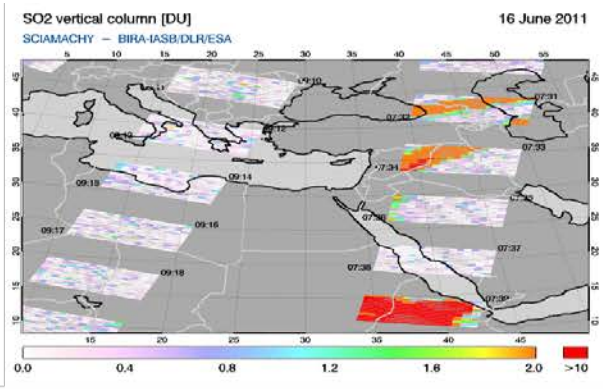
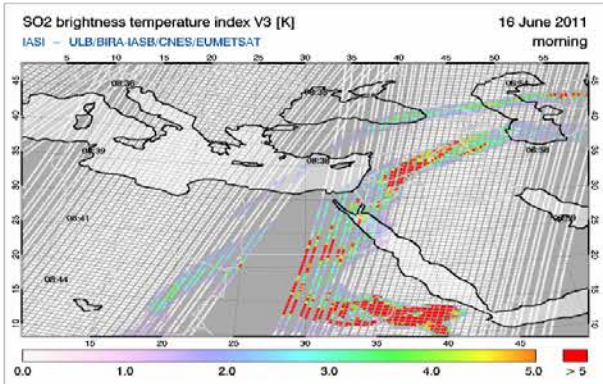
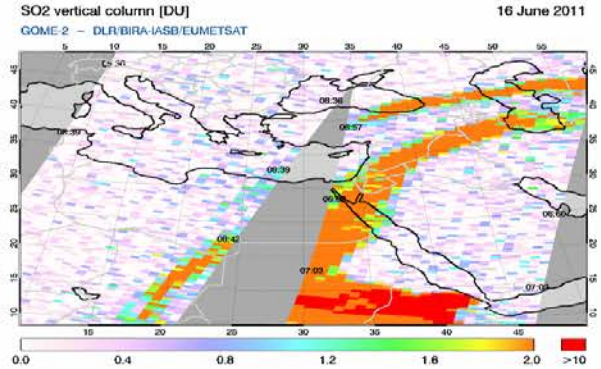
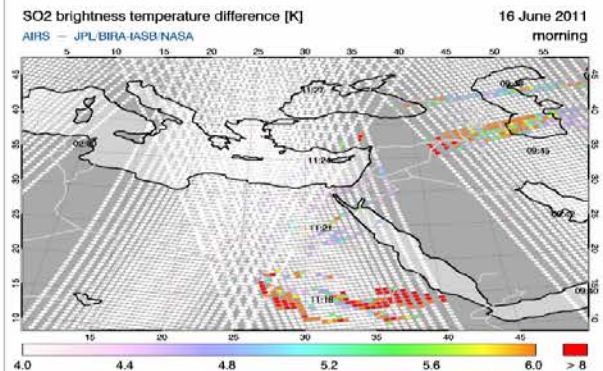

Based on SO_2 from **5 instruments**

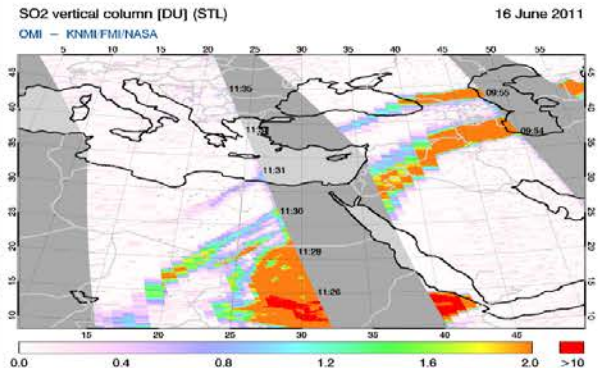
Example of Nabro eruption
(15th of June 2011)







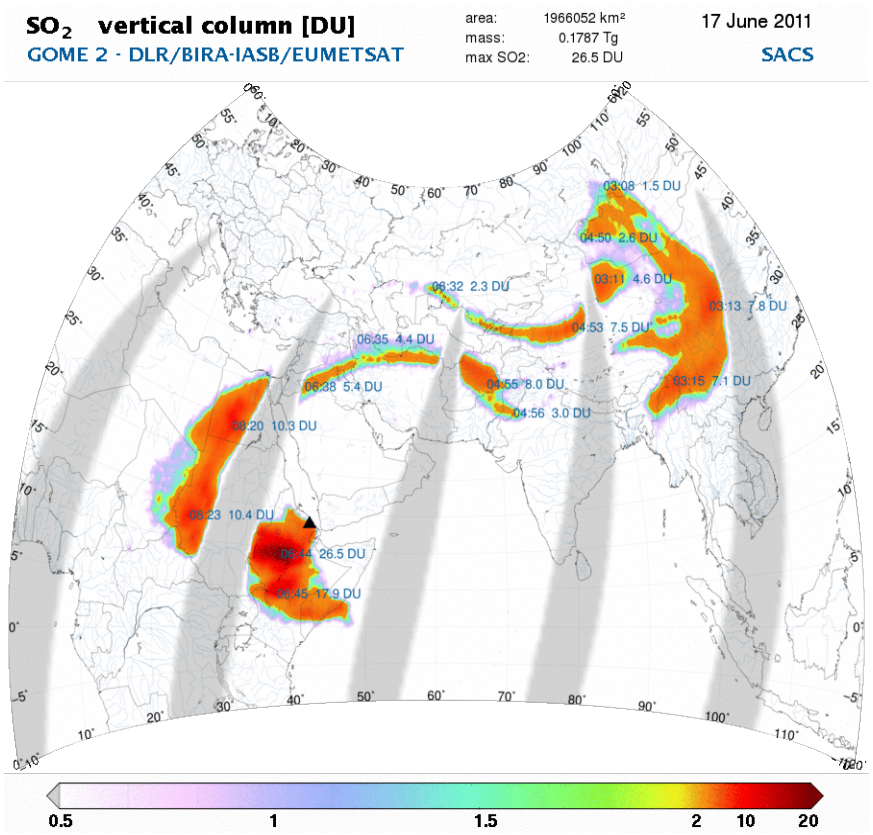


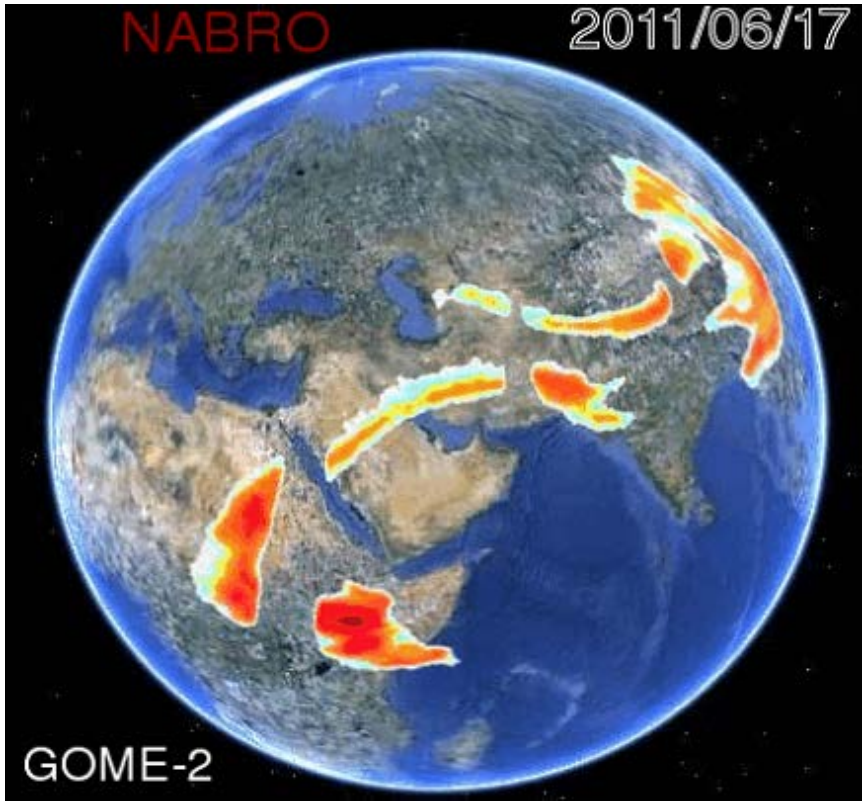


The objectives of our service are:

- ***allow NRT monitoring of SO_2 plumes***
- ***avoid false alerts***
- ***avoid too many alerts***

Nabro eruption





example of interpolated plot

example of google earth image

Criteria to obtain alert for UV instruments

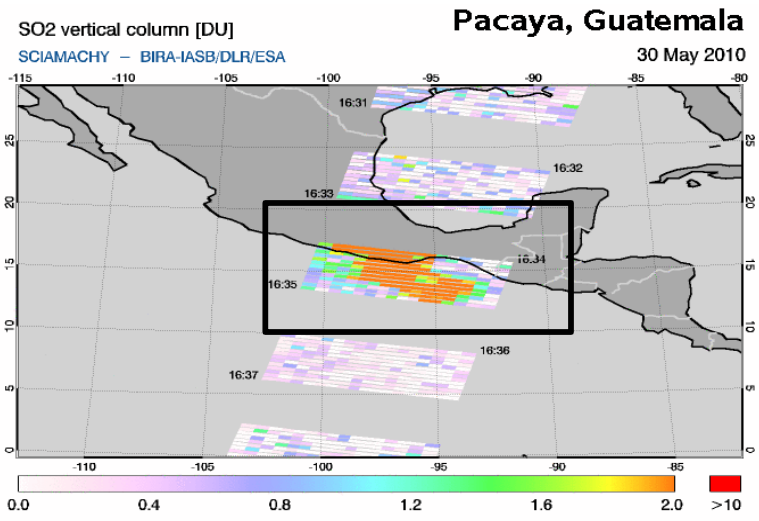
1. selection VCD> threshold value (ex: 2 DU)
2. nb pixels: pixels within threshold radius (e.g., 80 km for SCIAMACHY)
3. if N(VCD>threshold) > (nb pixels / 2)

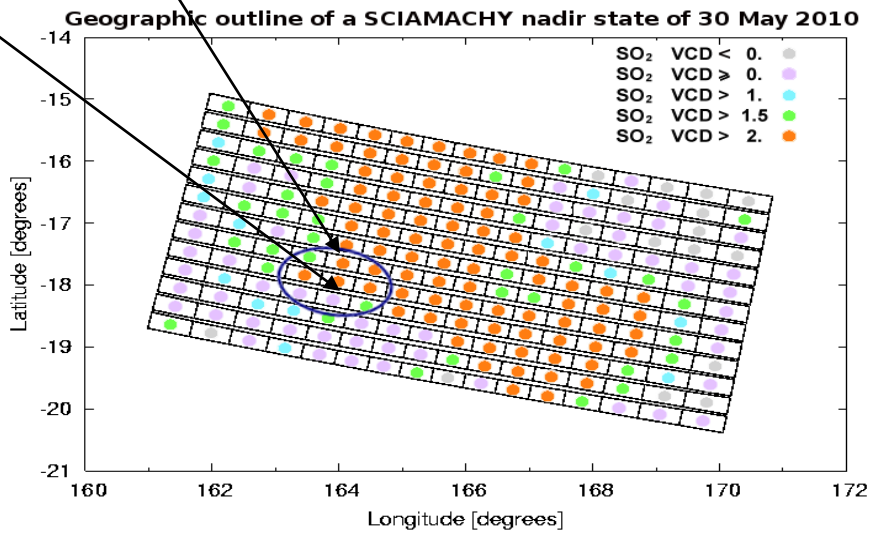
→ **ALERT**

for IR instruments

Threshold:

DBT > threshold

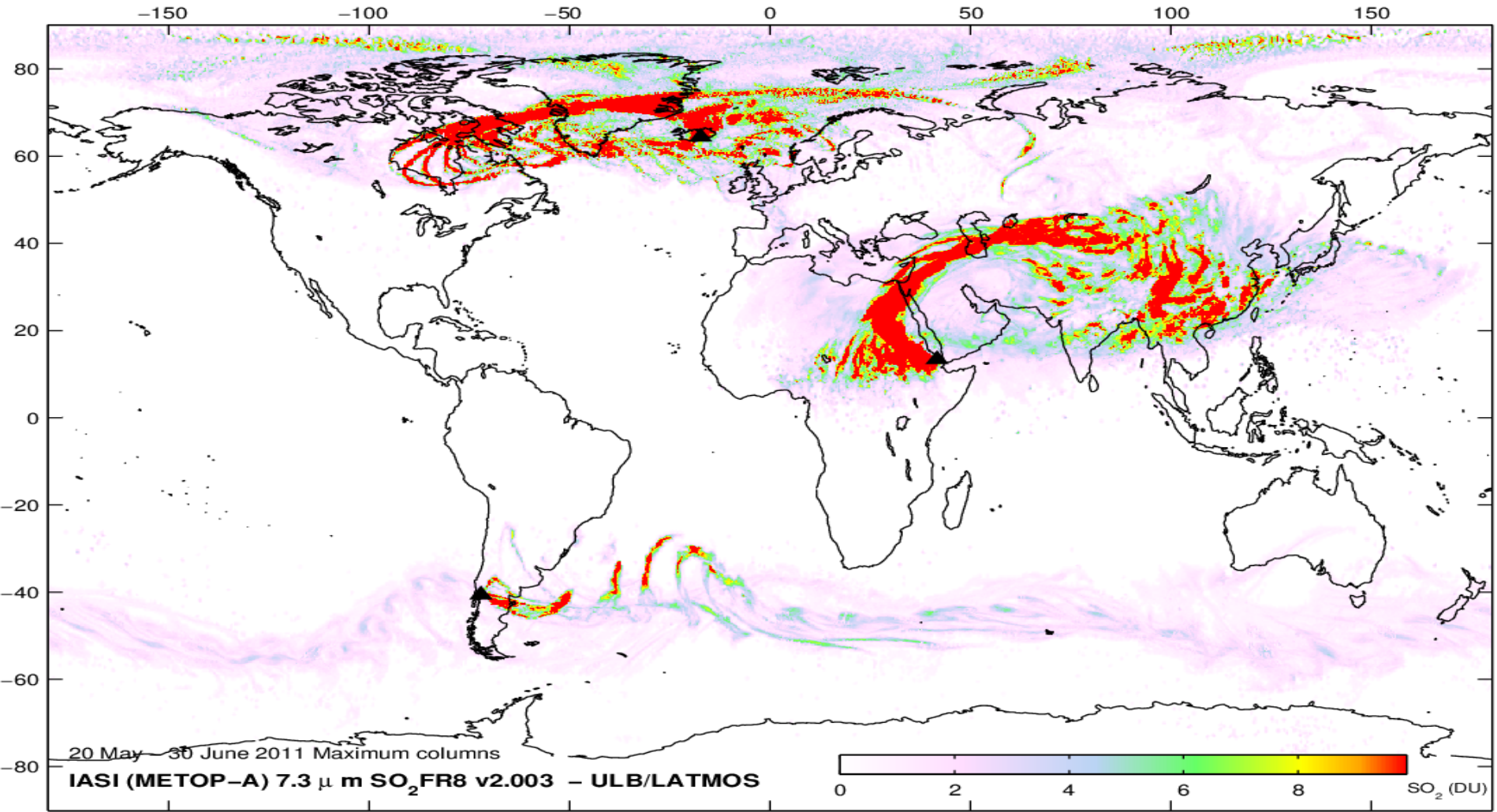




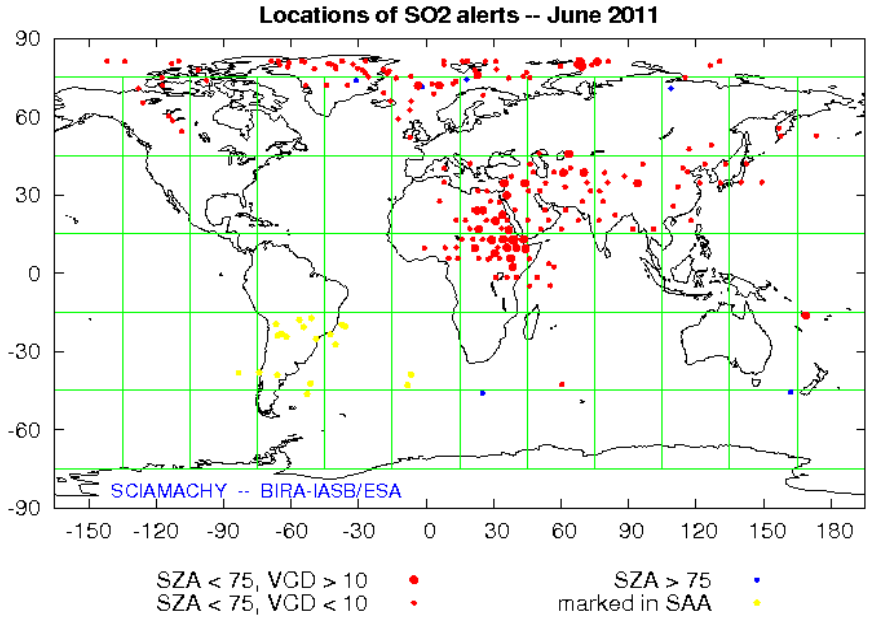
Instruments	SCIAMACHY	GOME2	OMI	IASI	AIRS
Threshold radius	80 km	85 km	50 km	no need	no need
Type Obs.	VCD	VCD	VCD	DBT	DBT
Threshold values	1.8 DU	1.8 DU	1.45 DU	2.9 K	6 K
Threshold value proximity volcano (< 300 km)	1.25 DU	1.45 DU	1.25 DU	no need	no need
Avoid SAA threshold value	Yes 3.25 DU	Yes 2 DU	no need	no need	no need
Avoid pollution threshold value	Yes 3.25 DU	Yes 2 DU	Yes 1.6 DU	no need	no need

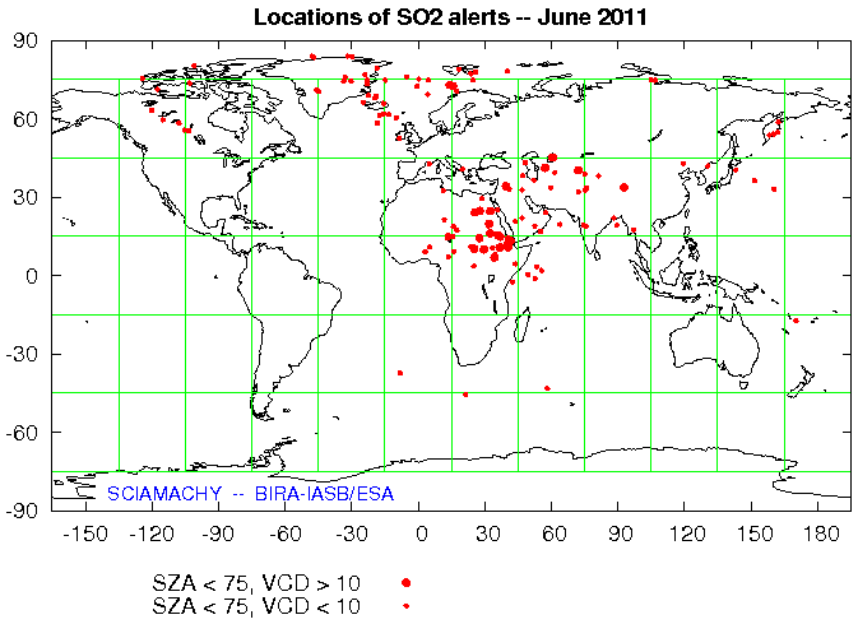
Detection of alerts processed in NRT for all instruments

3 eruptions during June 2011 - good test cases for service development



Alerts for SCIAMACHY





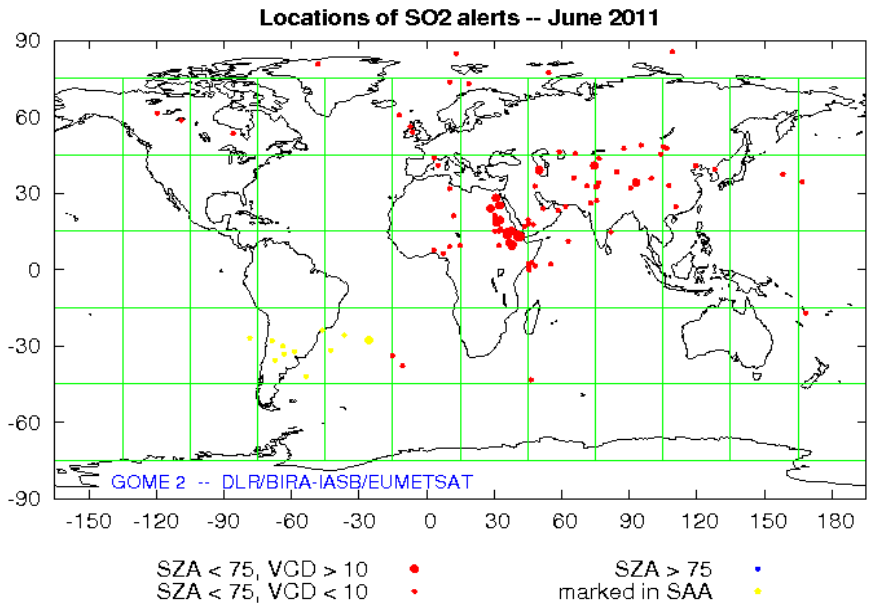
old alert system

new alert system

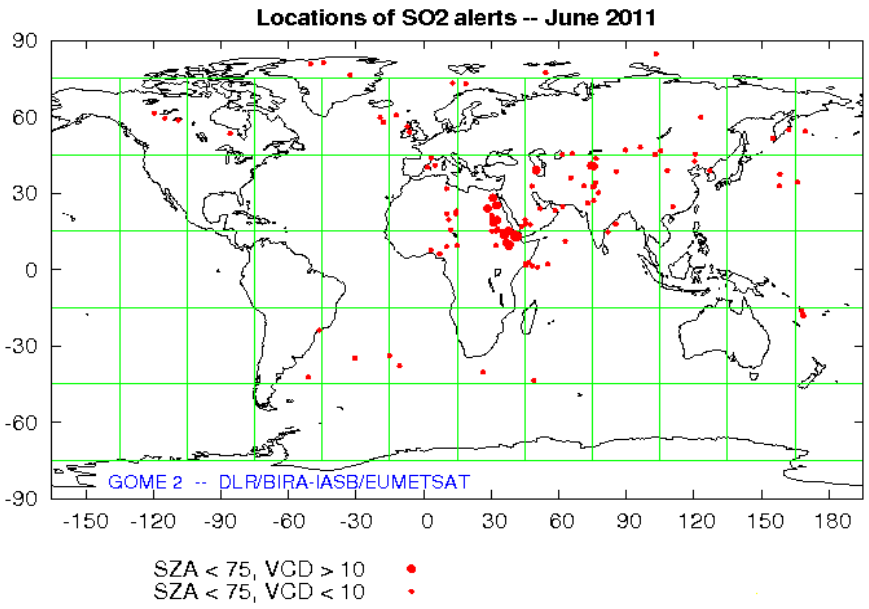
SAA restriction

pollution restriction

Alerts for GOME2



first alert system

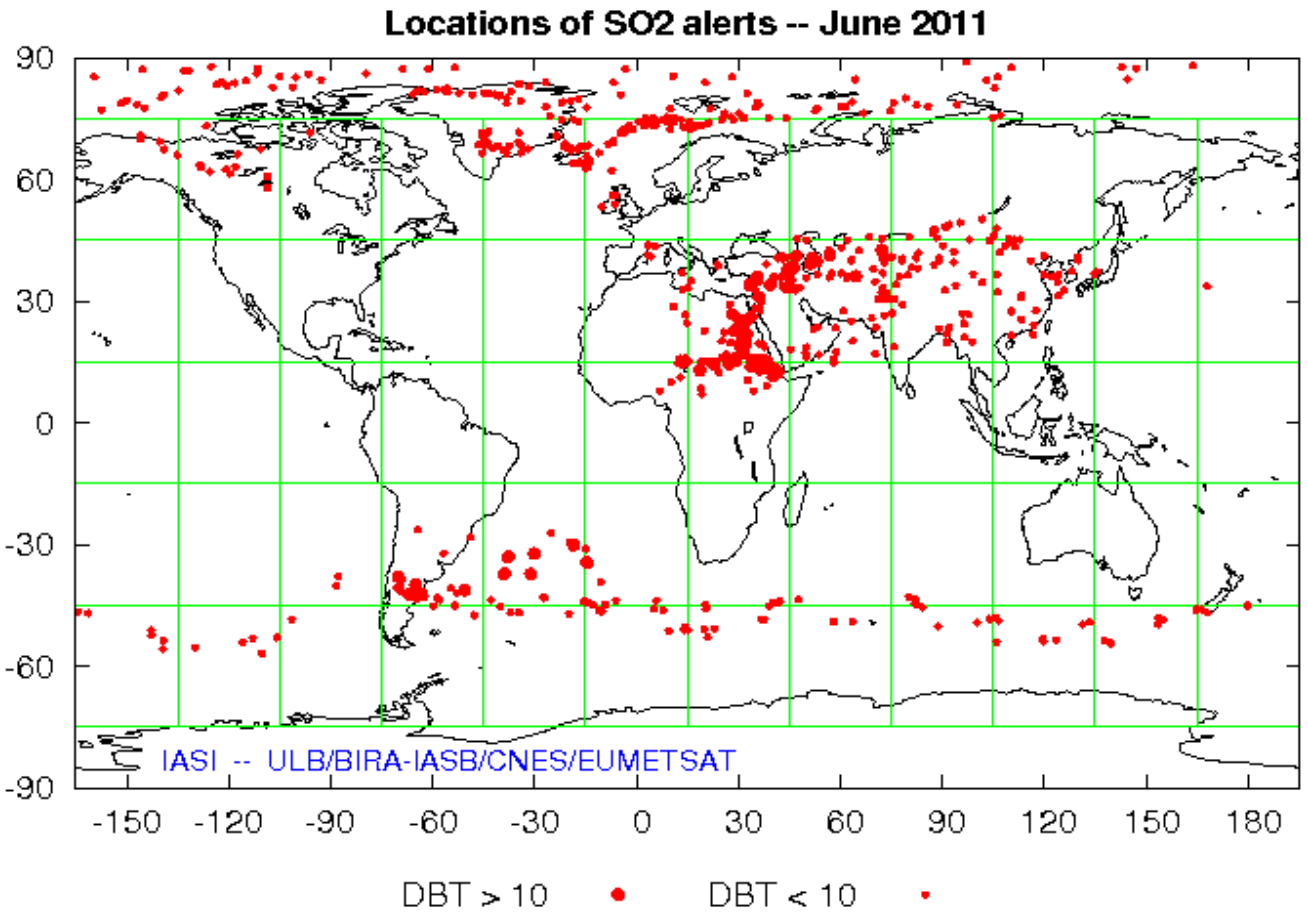


final alert system

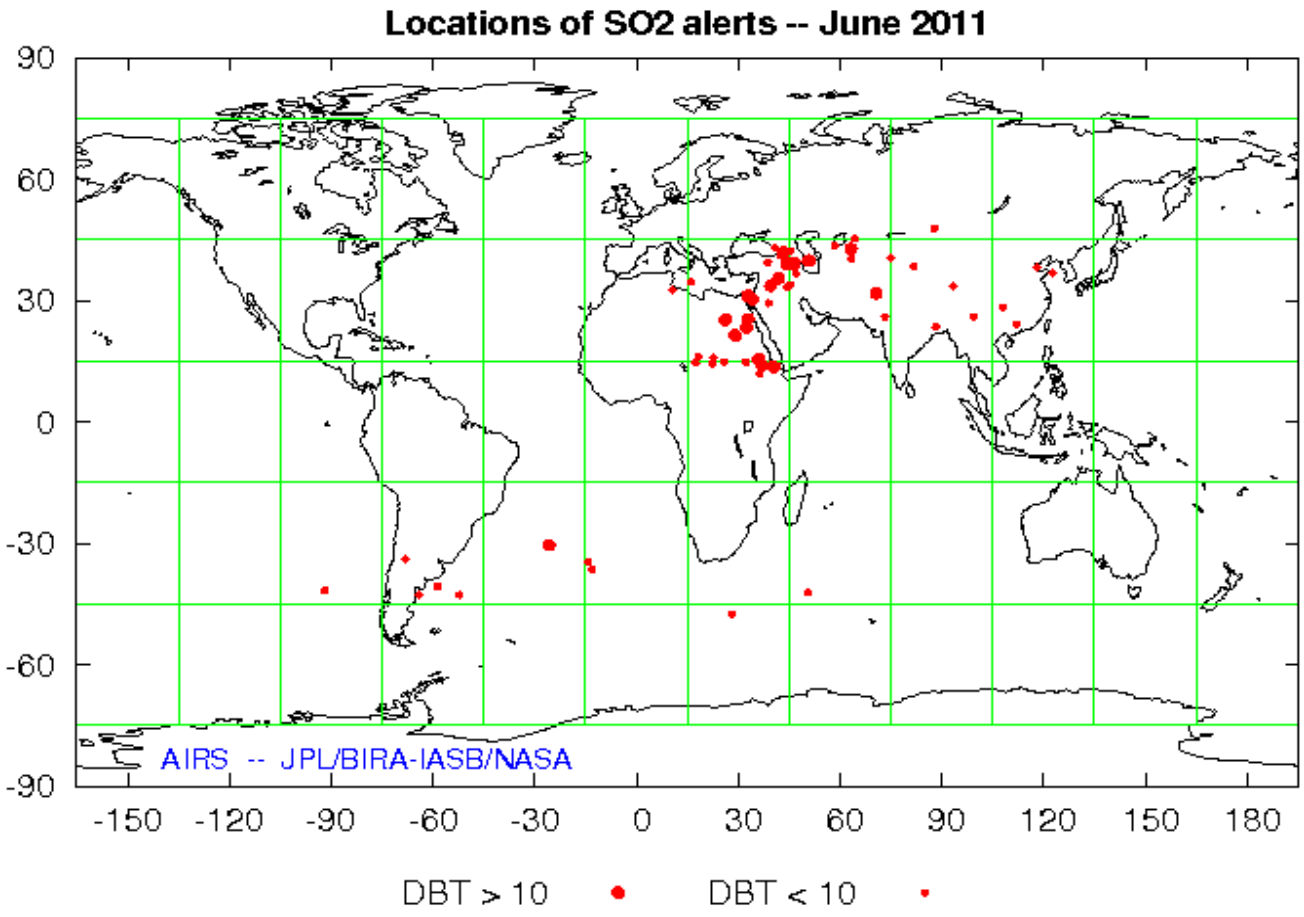
SAA restriction

pollution restriction

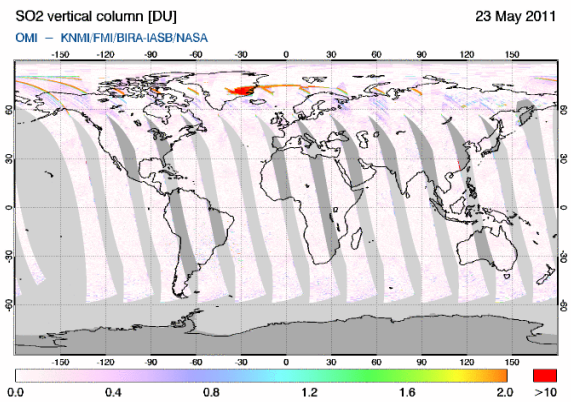
Alerts for IASI

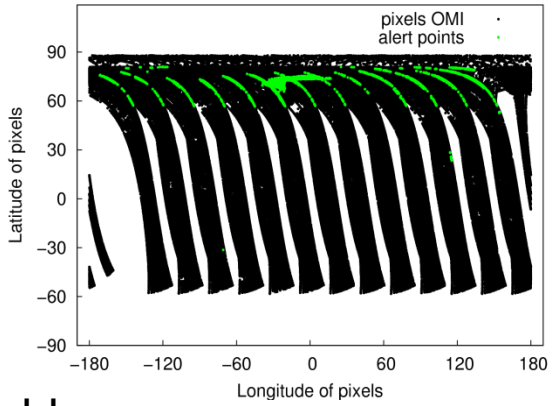


Alerts for AIRS

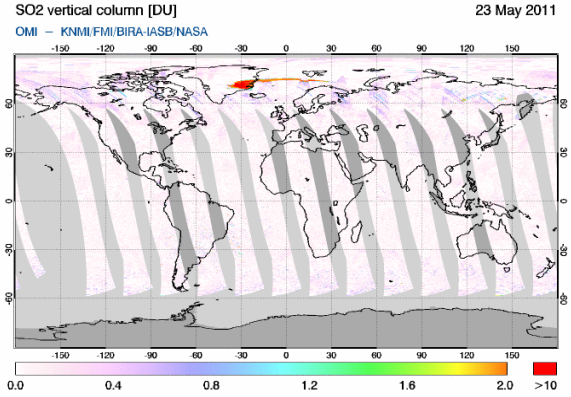


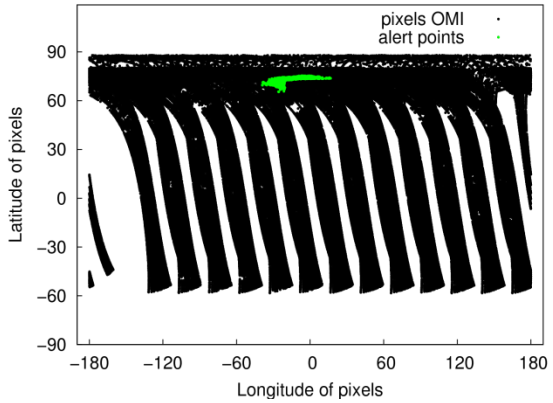
Alerts for OMI





row anomaly problem

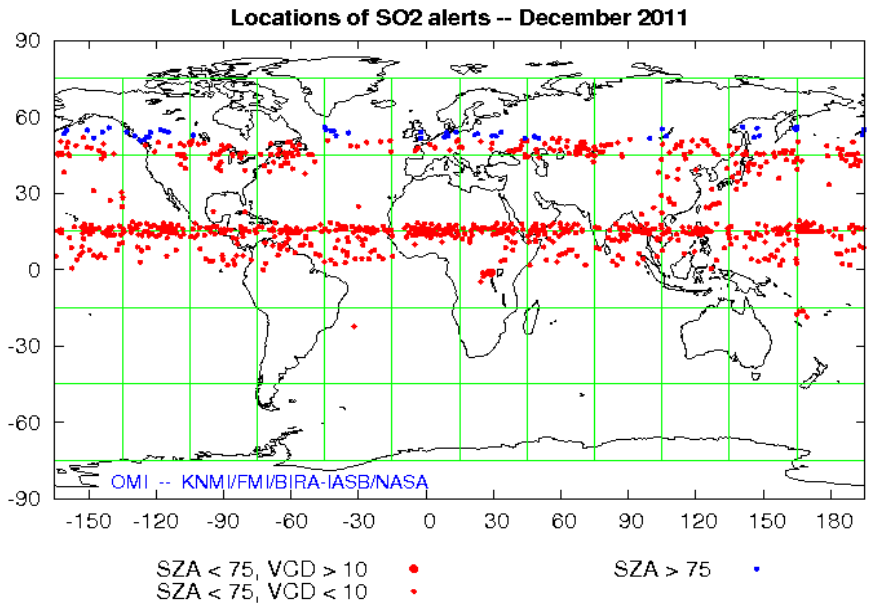


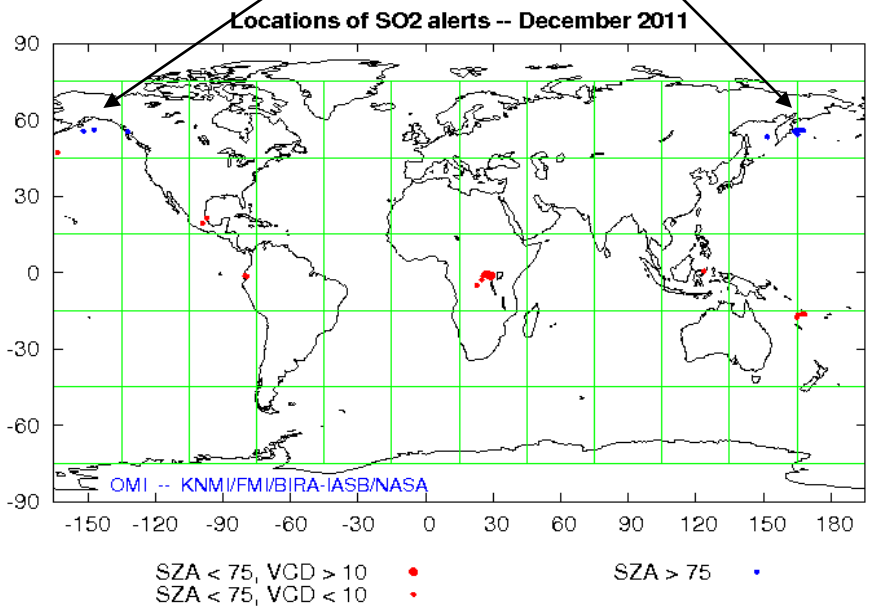


row anomaly column avoided

Alerts for OMI

false alerts at high SZA





alert system with row

alert system without row anomaly

pollution restriction

The system became operational on April 13 2012 and delivered following alert to users:

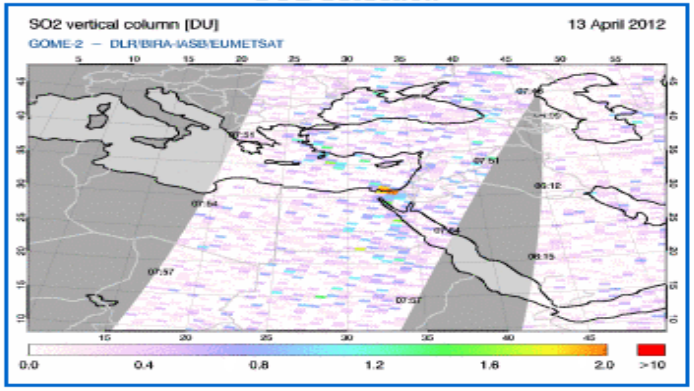
```
SACS multi-sensor alert of exceptional SO2 concentration
========================================================

Process date : 2012/04/13
Process time : 08:54 UTC
Instrument   : GOME2


  Alert region: 207
---------------------
http://sacs.aeronomie.be/GOME2alert/2012/04/alertsGOME2_20120413_07h52_207.php?alert=20120413_085451_207

Date          :    2012/04/13
Time          :    07:52  UTC
Longitude     :     32.7  deg.
Latitude      :     31.2  deg.
SZA           :     35.2  deg.
Max. SO2 vcd  :     2.2   DU
Cloud data    :    used for VCD
```

ALERT

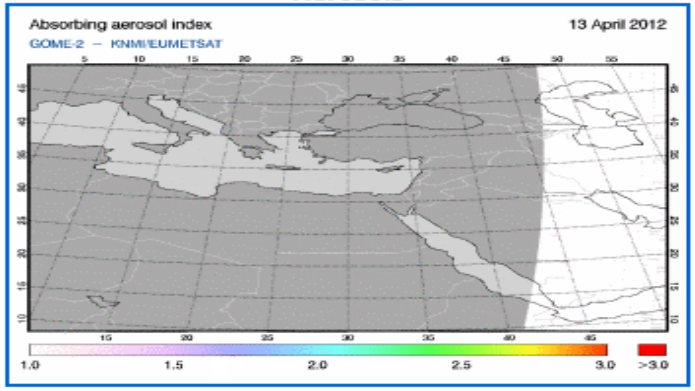
GOME2	region 207
Date	2012/04/13
Time	07:52 UTC
Longitude	32.7 deg.
Latitude	31.2 deg.
SZA	35.2 deg.
Max. SO2 vcd	2.2 DU
Cloud data	used for VCD

GOME 2

SO2 detection



Aerosols

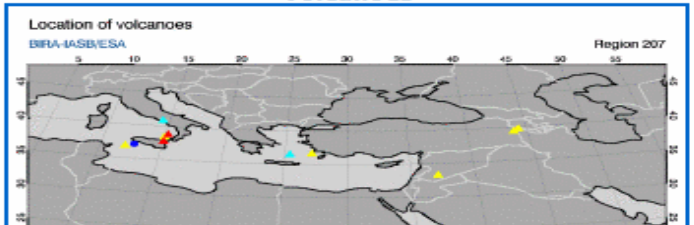


other plots: CCF | google Earth SO_2 | interpolated SO_2

link: VCD/SCD - GOME2 data (ASCII)

REGIO

Volcanoes



Links to the near-real-time data pages with maps from different instruments

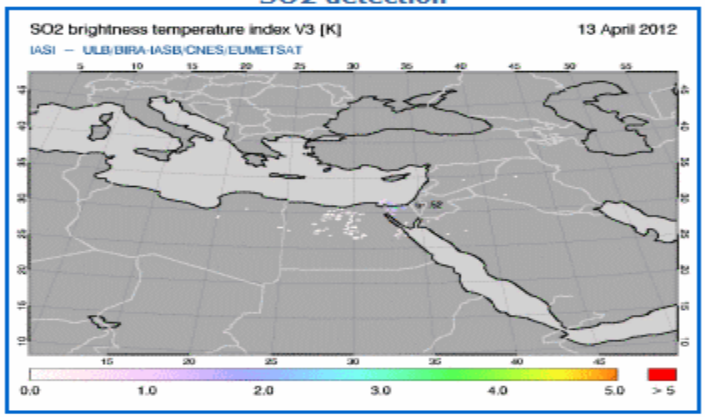
NRT > 207 == 30.0 30.0

confirmation ALERT

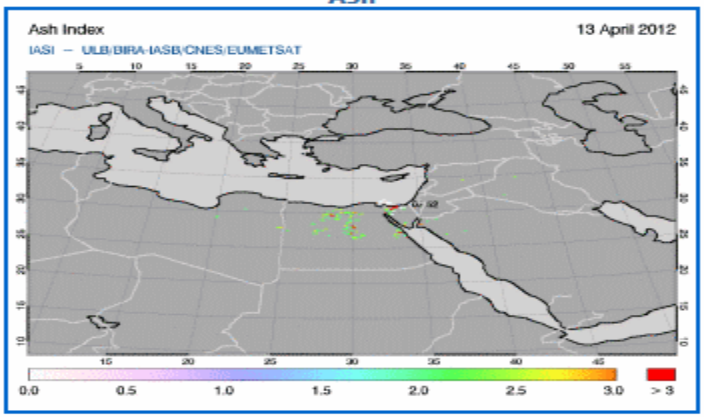
IASI	region 207
Date :	2012/04/13
Time :	07:52 UTC
Longitude :	33.2 deg.
Latitude :	30.8 deg.
SZA :	33.9 deg.
Max. SO2 dbt :	3.5 K

IASI

SO2 detection



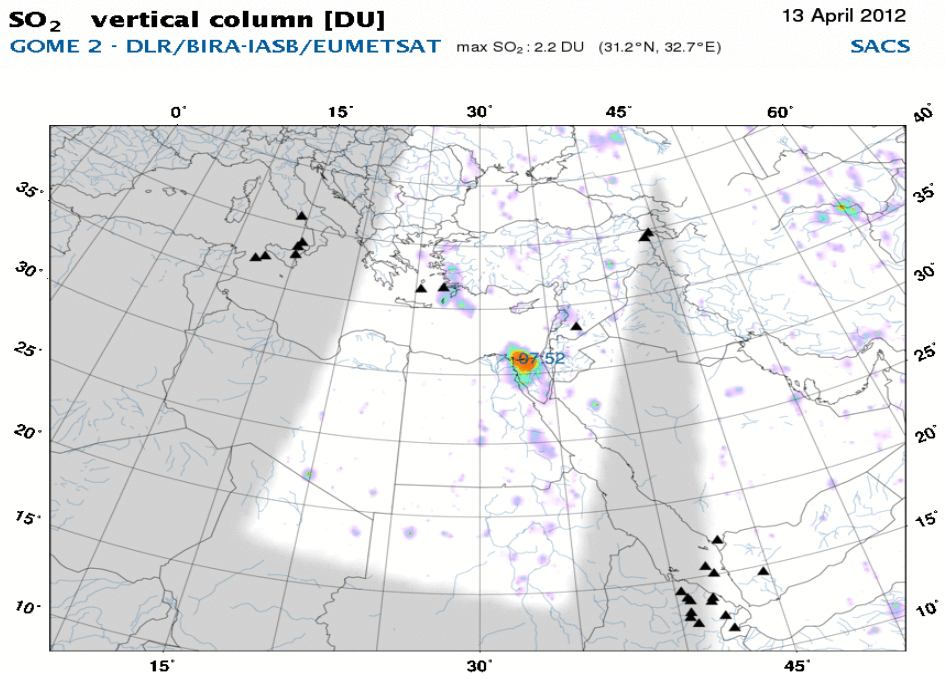
Ash

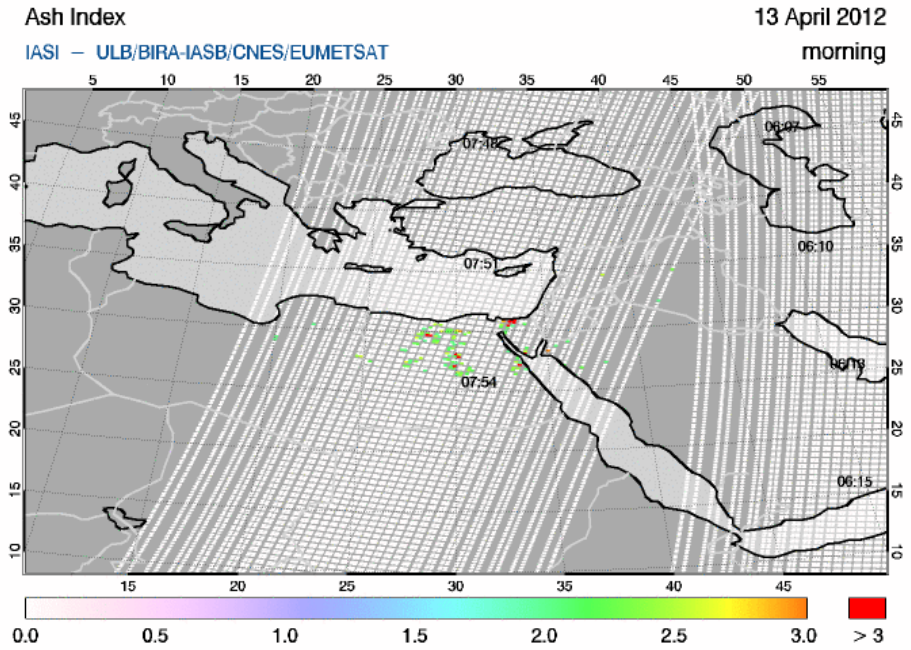


other plots: VCD | google Earth SO_2 | interpolated SO_2

links: SO_2 DBT - IASI data: contact ULB

SACS provides information about a SO2 and ash plume on April 14 2012 over North Africa





On its first day of operations SACS provided right alerts based on GOME-2 and IASI measurements on an Etna eruption with peak on April 12 2012 at 17.00 local time