Support to Aviation Control Service

SACS & SACS2
an overview and recent developments

L. Clarisse [1], N. Theys [2], H. Brenot [2], J. van Gent [2], R. van der A[4], P. Valks[5], M. Van Roozendael[2], D. Hurtmans [1], P.-F. Coheur [1], C. Clerbaux [1,3]

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(2) ULB, Brussels, Belgium.
(3) LATMOS-IPSL, Paris, France.
(4) KNMI, De Bilt, The Netherlands.
(5) DLR, Oberpfaffenhofen, Germany.

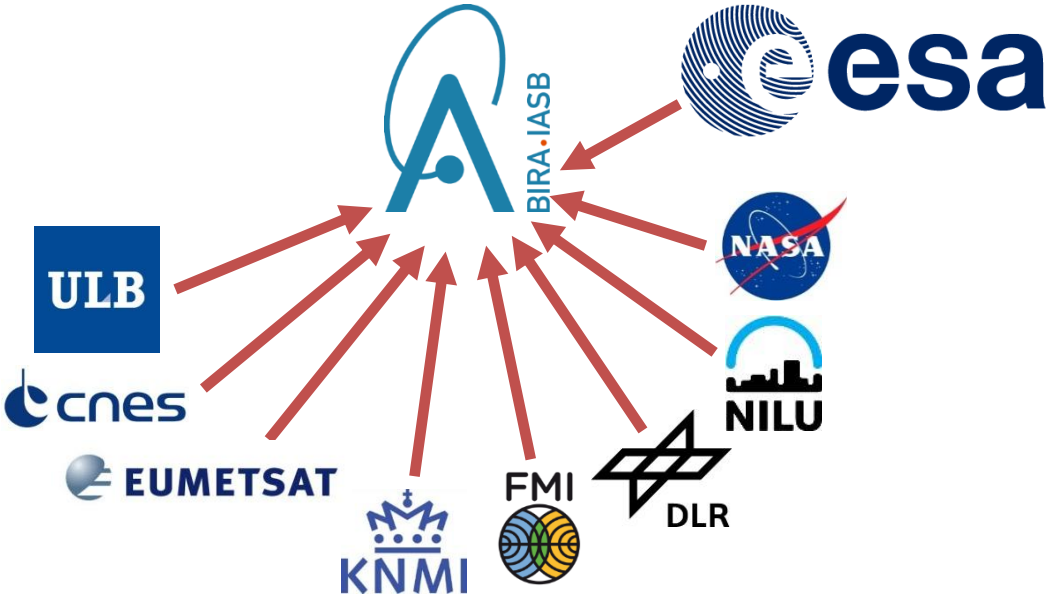
The objective of SACS is –with respect to **volcanic SO_2 and ash**.:

1. Deliver in **near-real time space observations**
2. Provide **near-real time notifications** (email and webbased)
3. Provide access to **archive data**

>> Useful for operational and research applications

SACS is an ESA project

Hosted by BIRA-IASB



2006 — 2009 — 2010 — 2012 — 2014

SACS first phase
(TEMIS, PROMOTE)

SCIAMACHY, OMI, GOME-2
UV-visible sat. sounders

SACS second phase

SCIAMACHY, OMI, GOME-2
UV-visible
IASI, AIRS
Infrared

As of April 2012:
Multi-sensors warning system

SACS2

SCIAMACHY, OMI, GOME-2 (A&B)
IASI (A&B), MODIS
Improved SO_2 and ash products

Satellite data

New products

Instruments	*Data type*	*Data availability*	*Overpass time*	*Resol. (km²)*	*Participants*	*Data products*
SCIAMACHY (*ENVISAT*)	UV/visible	2004/04 ➔ 2012/04	10:00	30x60	BIRA KNMI	SO_2 vertical columns absorbing aerosol index
GOME-2 *(MetOp-A)*	UV/visible	2007/01 ➔ present	09:30	40x80 /40x40	DLR BIRA KNMI	SO_2 vertical columns SO_2 plume height absorbing aerosol index
GOME-2 *(MetOp-B)*	UV/visible	2012/12 ➔ present	09:00	40x80	DLR KNMI	SO_2 vertical columns absorbing aerosol index
OMI (*Aura*)	UV/visible	2004/09 ➔ present	13:30	13x24	KNMI	SO_2 vertical columns absorbing aerosol index
IASI *(MetOp-A)*	Infrared	2007/10 ➔ present	09:30 21:30	12x12	ULB	SO_2 index and columns ash indicator
IASI *(MetOp-B)*	Infrared	2013/01 ➔ present	09:00 21:00	12x12	ULB	SO_2 index and columns ash indicator
AIRS *(Aqua)*	Infrared	2002/09 ➔ present	01:30 13:30	15x15	NILU ULB	SO_2 columns ash indicator

aeronomie.be

http://sacs.aeronomie.be

Support to Aviation Control Service

SACS home > Nrt > near real-time

Belgian Institute for Space Aeronomy

NEAR REAL-TIME | SO2 NOTIFICATIONS | PRODUCTS | HIGHLIGHTS

data→ obs. of: SO_2 | Aeros. / Ash | Cloud

info last notification | subscribtion SACS notif.

sounder→

Instruments

UV-Vis: GOME 2 | OMI | SCIAMACHY

InfraRed: IASI | AIRS

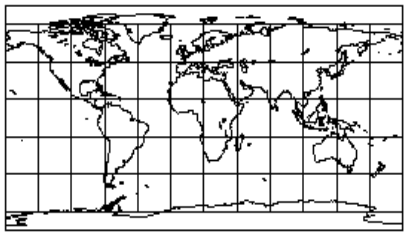
Time of observations

< day | < month | < year — 14 June 2011 — day > | month > | year >

period→

Select a date: today | 2011 | Jun | 14 | NRT

region→



World view

Either click on a region in the map to submit or select a region from the list-menu and click 'submit'

submit

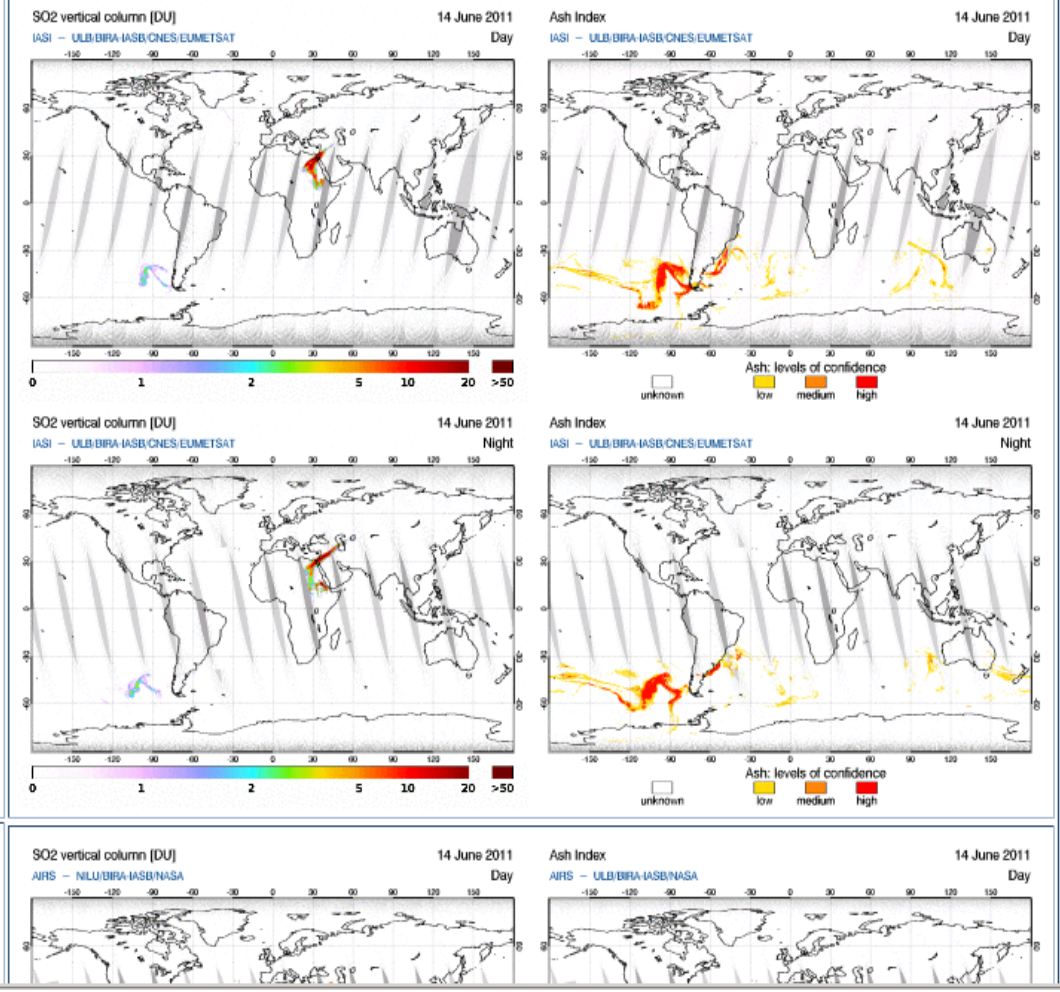
000 == World view

(region defined by the centre longitute and latitude)

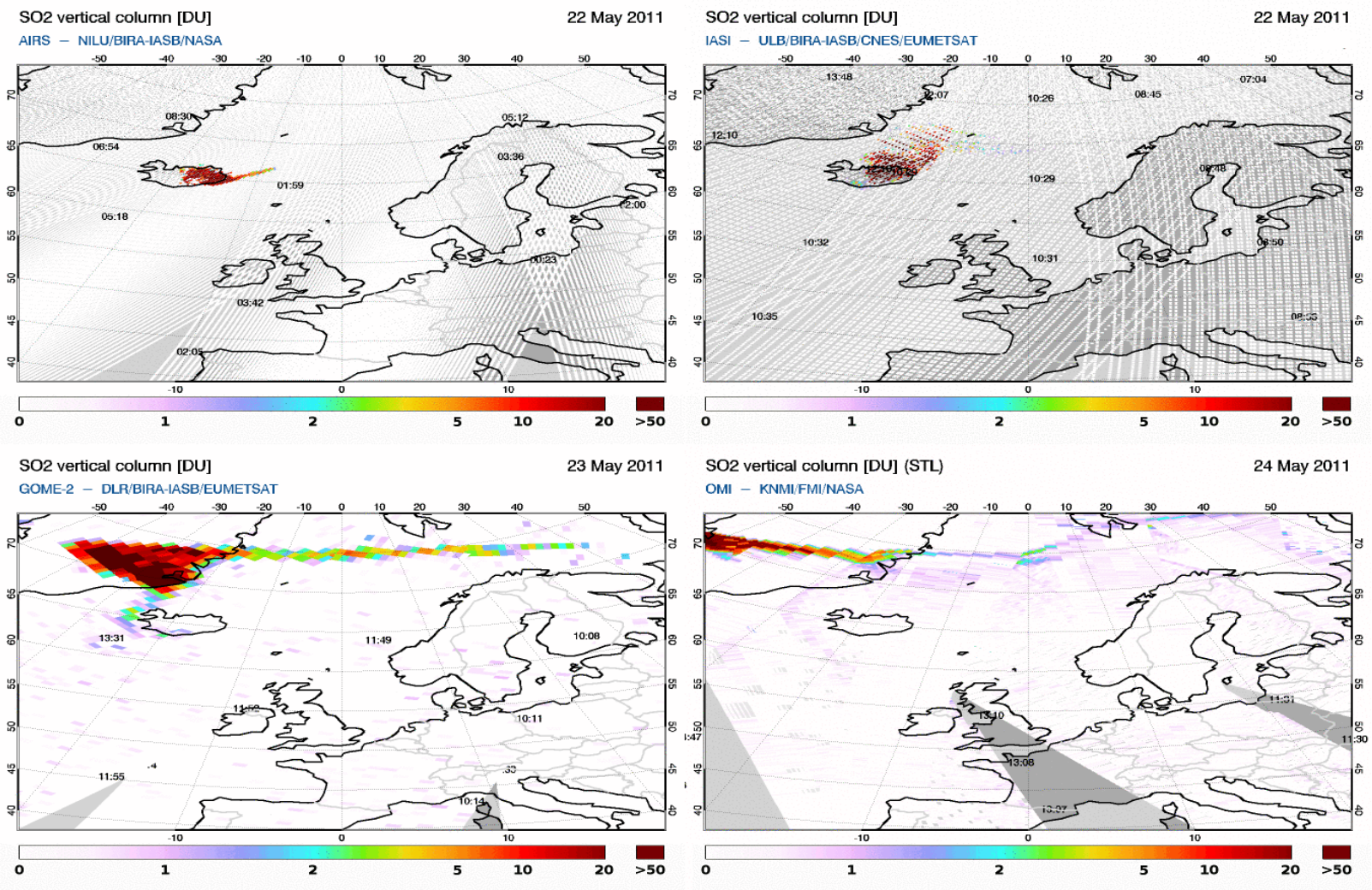
To navigate to another region, select one from the map or in menu just above

IASI

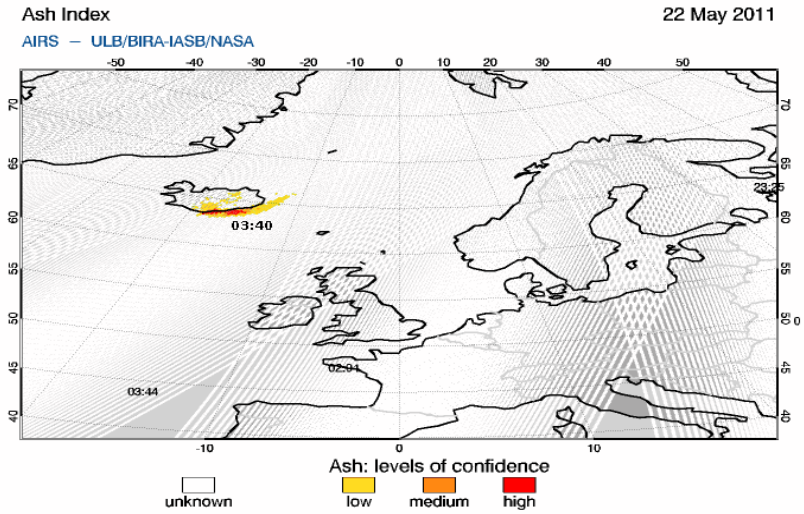
SO2 detection | Aerosols / Ash

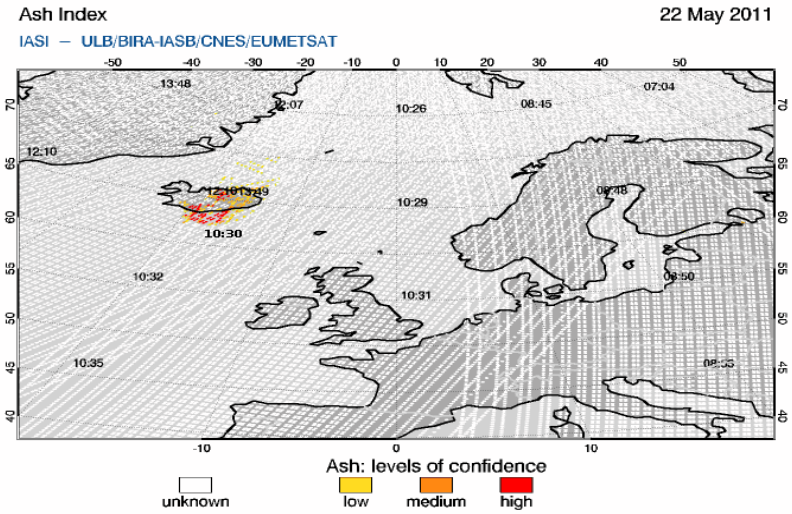


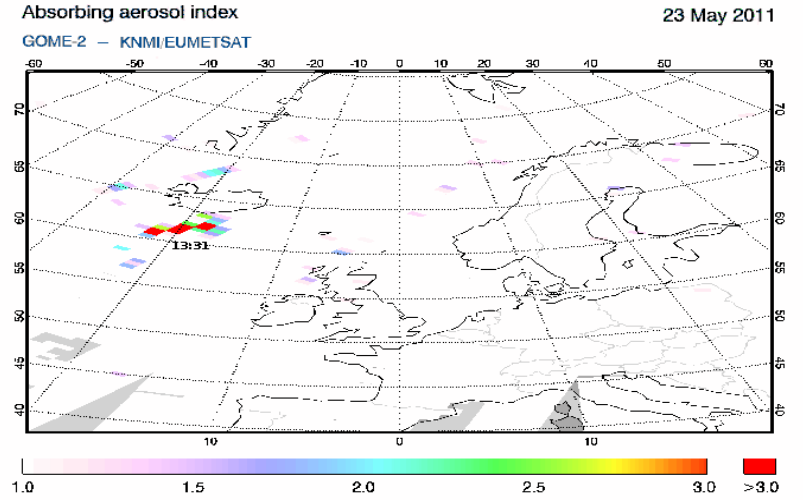
Grímsvötn eruption May 2011 (Iceland)

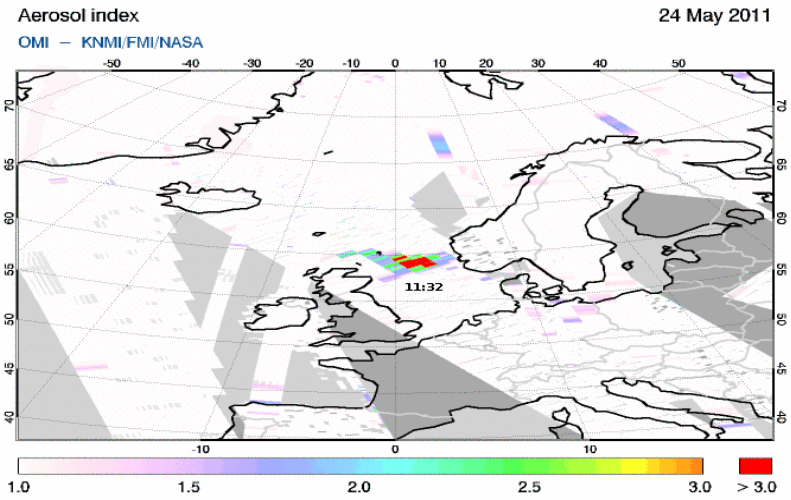


Grímsvötn eruption May 2011 (Iceland)





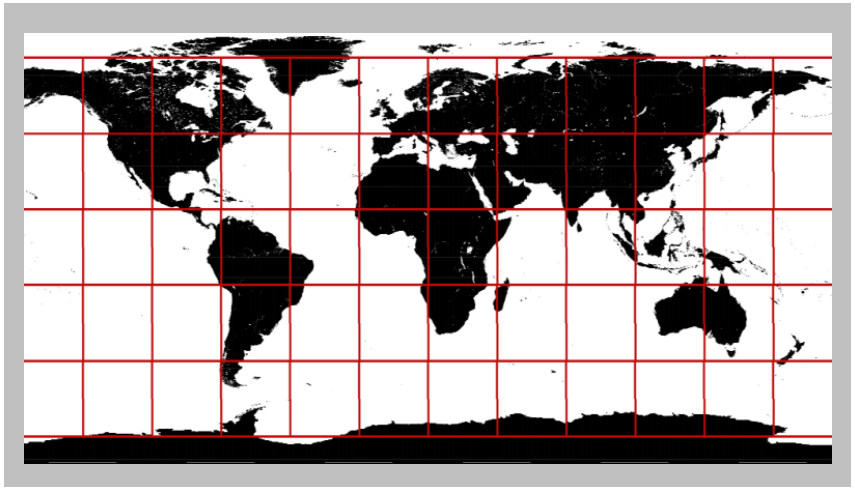




- **SO_2-based notification system.**

Main features

- One e-mail is sent per 12 hours and per 30 x30 predefined region (first instrument to detect SO_2).



- System optimized to avoid false notifications (e.g., anthropogenic SO_2) – success rate: >95%

- After a notification, all other warnings (confirmation during the next 12h) are available through the webpage.

Bezymianny eruption
November 2012

From SACS <sacs@aeronomie.be>
Reply | Forward
Subject **SACS notification -- GOME2 -- 2012/11/12 08:44 -- region 307**
To SACS users

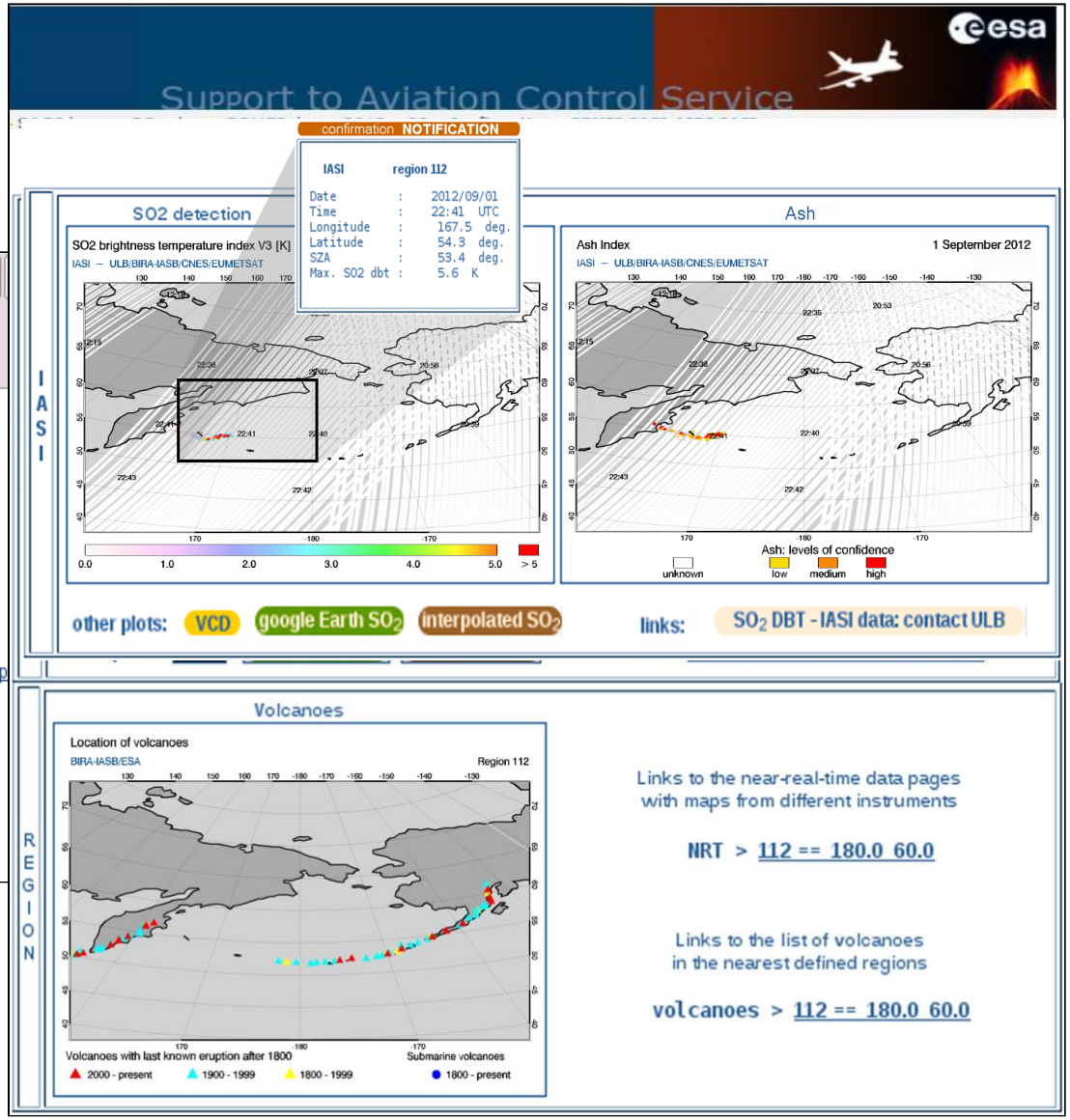
SACS multi-sensor notification of exceptional SO2 concentration

==========

Process date : 2012/11/12
Process time : 08:44 UTC
Instrument : GOME2

Warning region: 307
---
http://sacs.aeronomie.be/GOME2alert/2012/11/alertsGOME2_20121112_07h54_307.p

Date : 2012/11/12
Time : 07:54 UTC
Longitude : 28.3 deg.
Latitude : -1.5 deg.
SZA : 33.4 deg.
Max. SO2 vcd : 2.1 DU
Cloud data : used for VCD



Improvements within the SACS 2 project

1. IASI-AIRS ash based alert system in SACS
2. Development of a fast IASI ash retrieval
3. Development of a fast IASI SO2 altitude product
4. Development of an improved OMI SO2 product

1. IASI-AIRS ash based alert system in SACS

Atmos. Chem. Phys., 13, 2195–2221, 2013
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doi:10.5194/acp-13-2195-2013

Atmospheric Chemistry and Physics Open Access

A unified approach to infrared aerosol remote sensing and type specification

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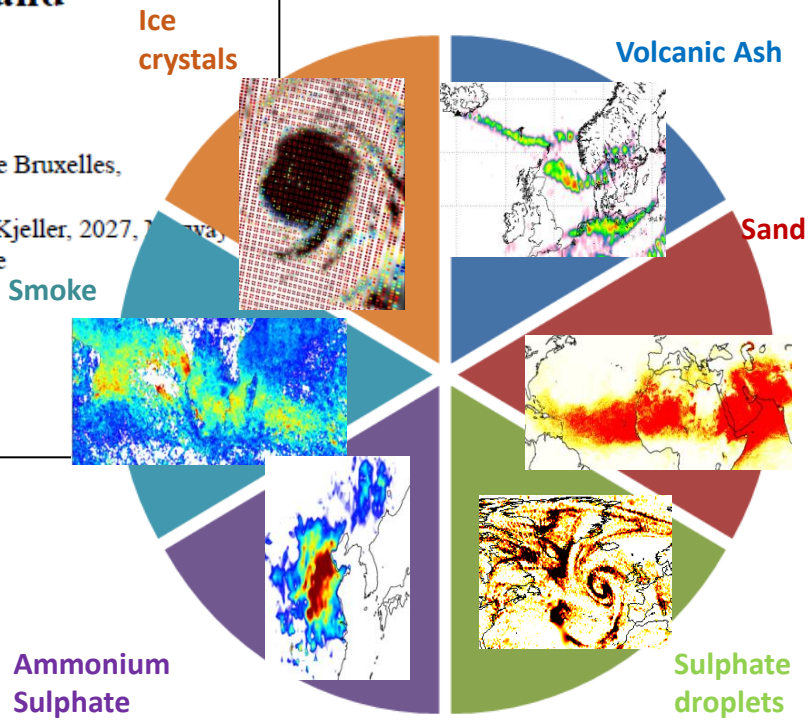
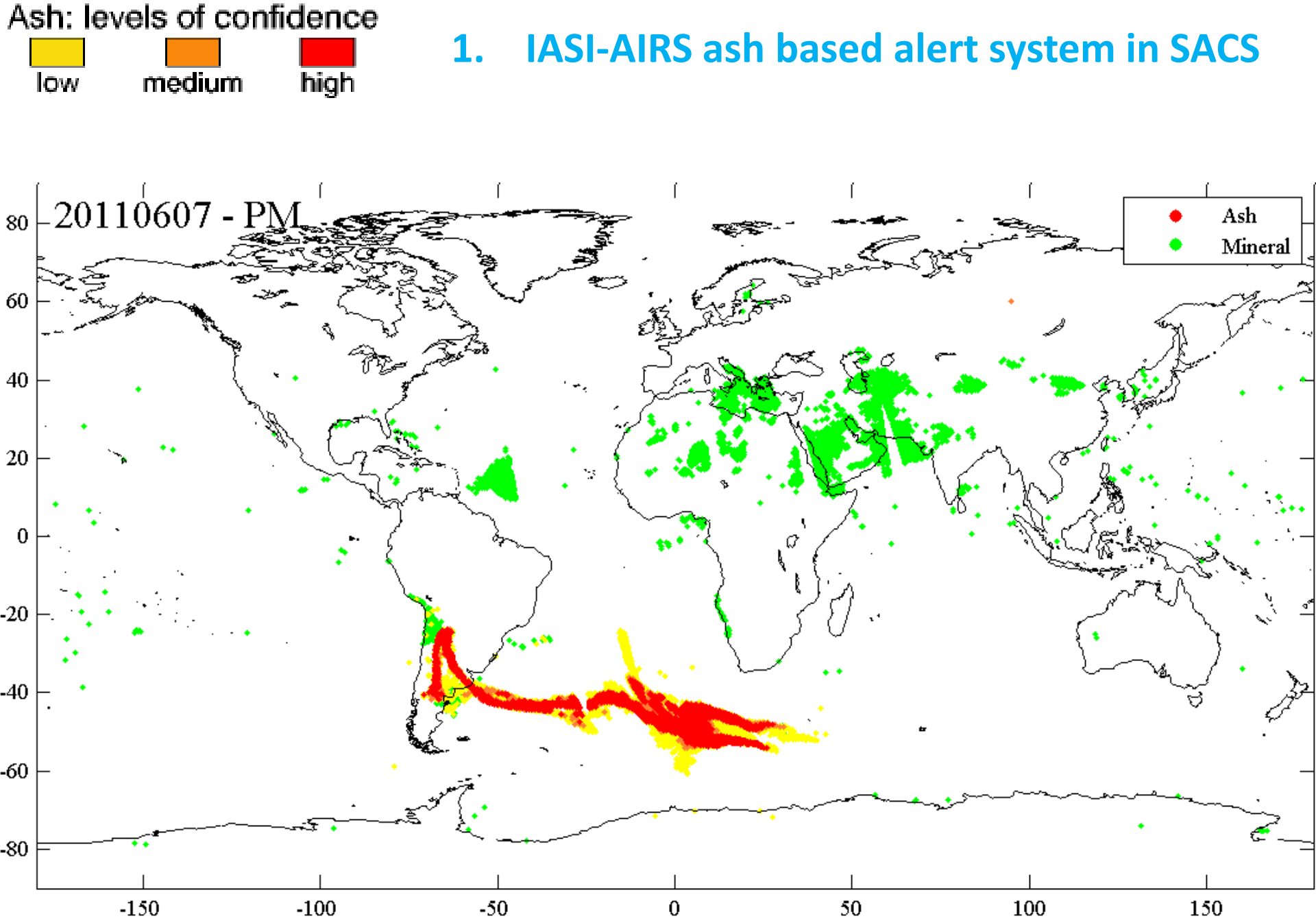
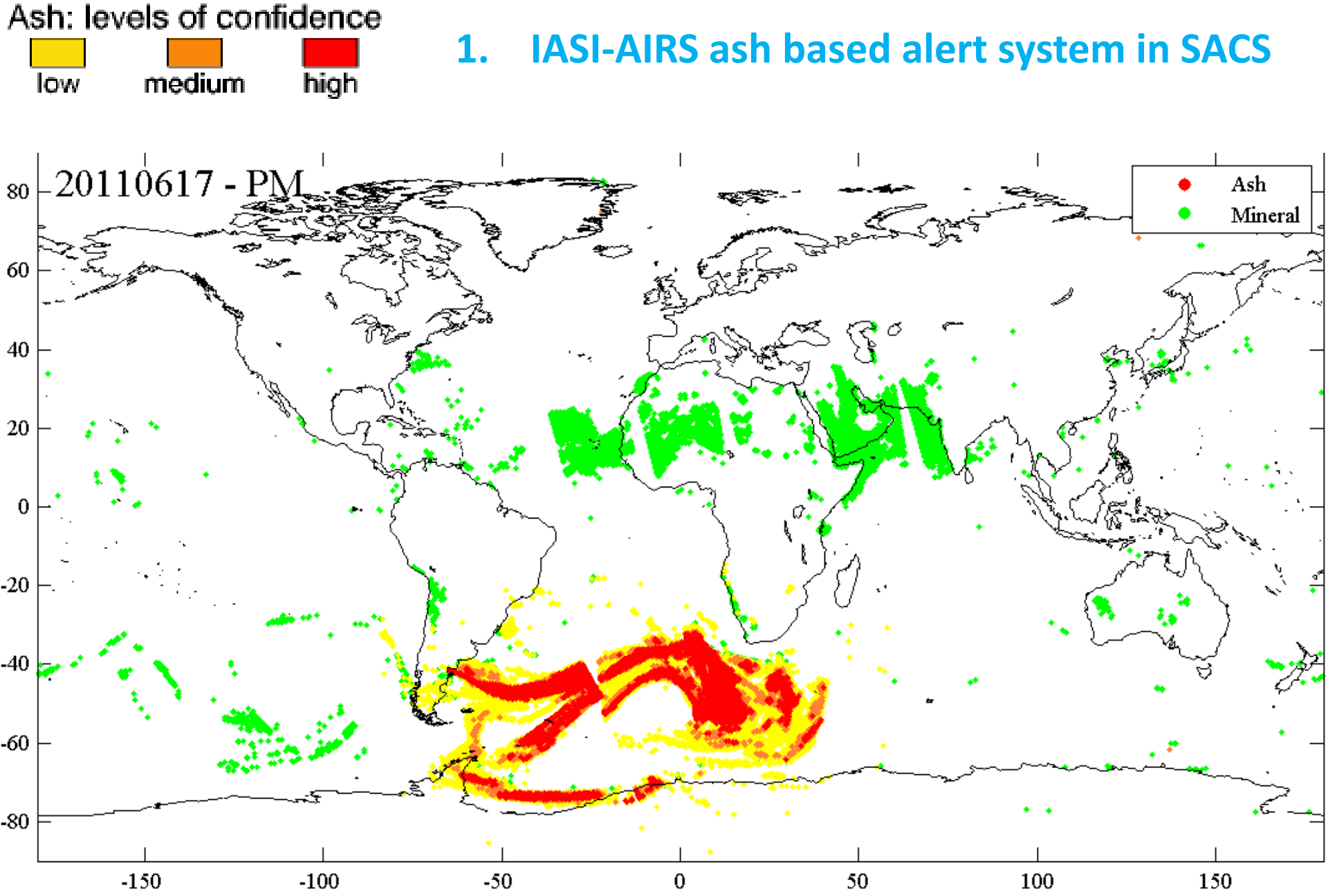
Revised: 18 January 2013 – Accepted: 12 February 2013 – Published: 25 February 2013



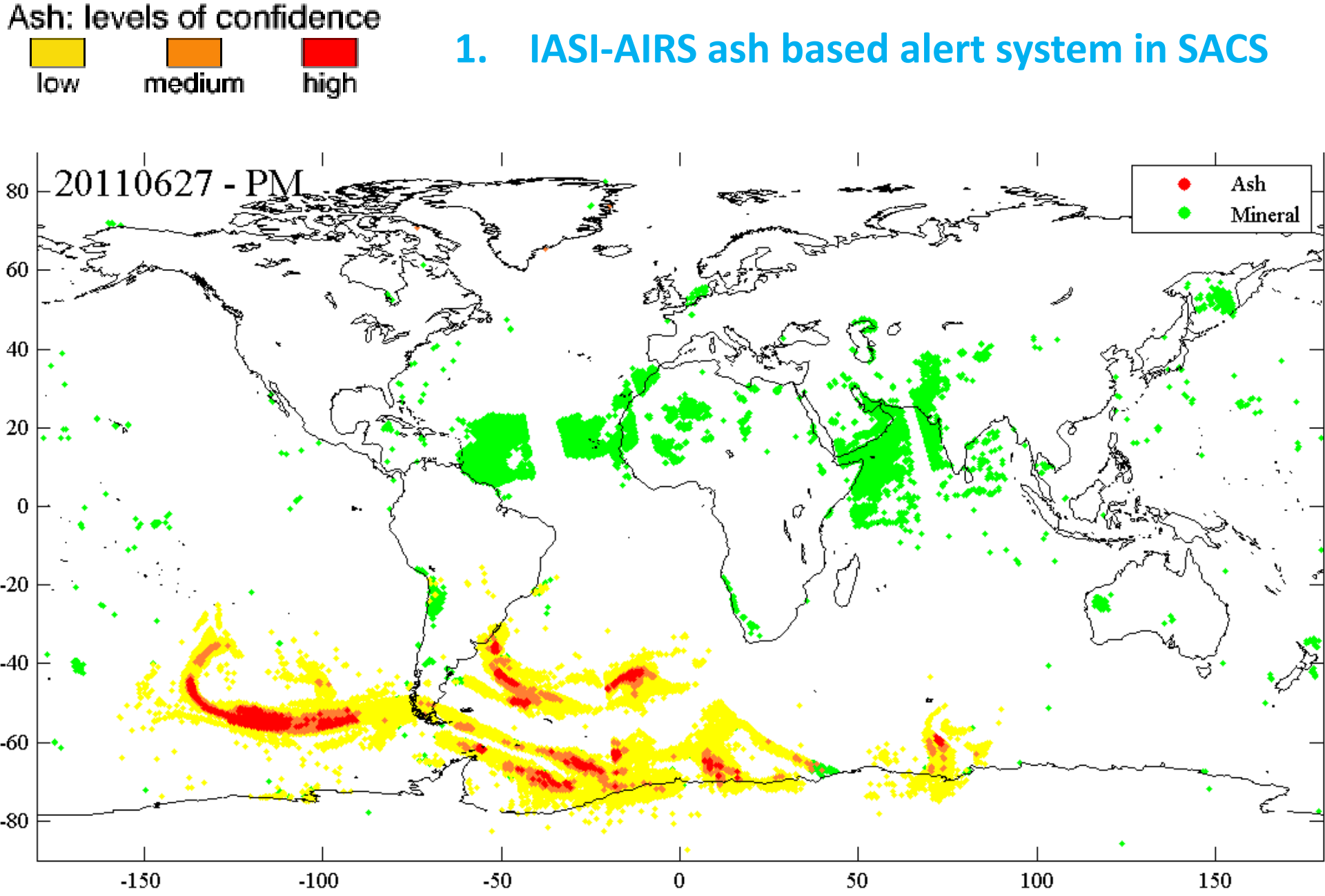
1. IASI-AIRS ash based alert system in SACS



1. IASI-AIRS ash based alert system in SACS



1. IASI-AIRS ash based alert system in SACS



1. IASI-AIRS ash based alert system in SACS

Some stats on ASH SACS 5/6 years

~ 75 000 high confidence detections;

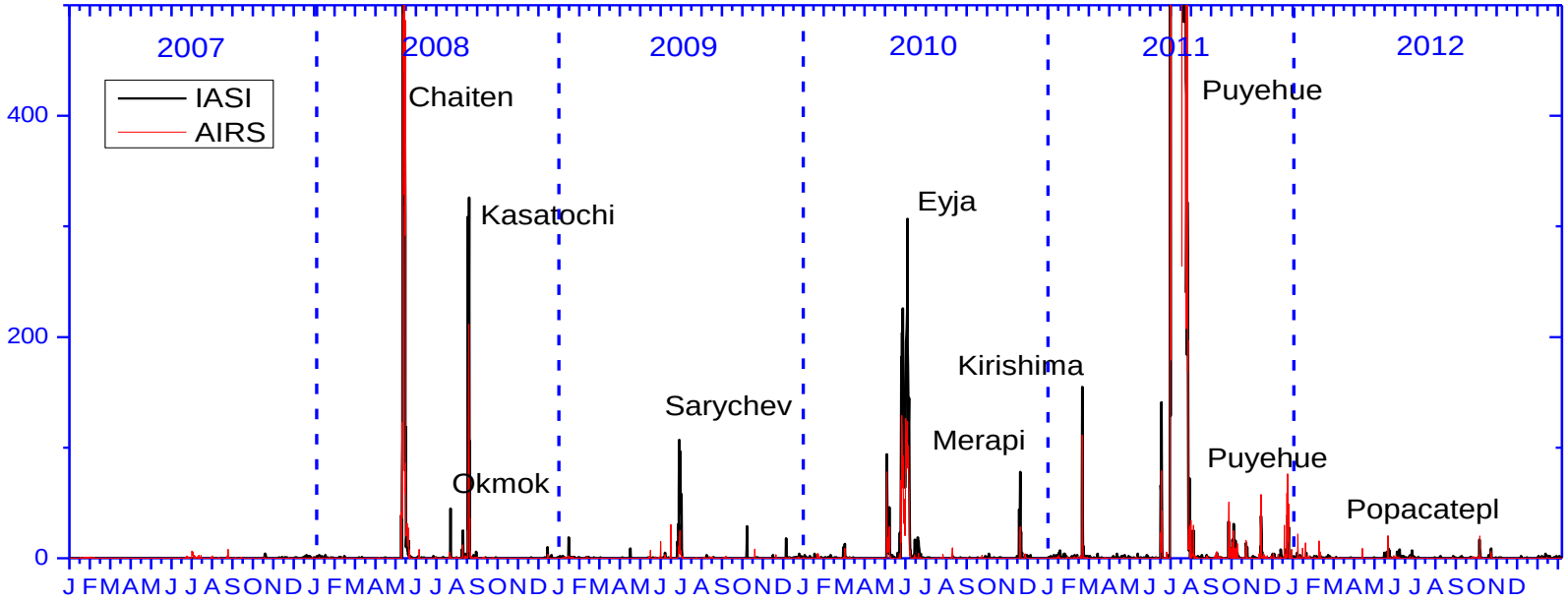
~ 400 days with detectable ash (note pixelsize >100 km^2)

~ IASI vs AIRS very consistent

~ no major eruptions missed (but compromise on sensitivity)

~ smaller puffs are regulary missed >> Expansion of SACS with « mineral product »

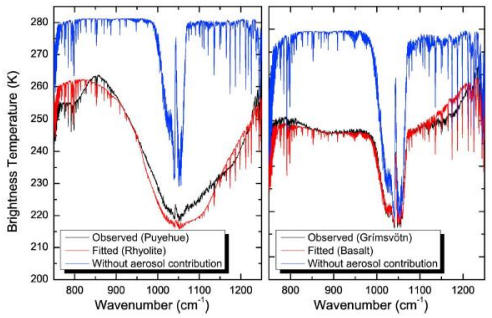
~ 3 false detections per year, alert system around 99% accuracy



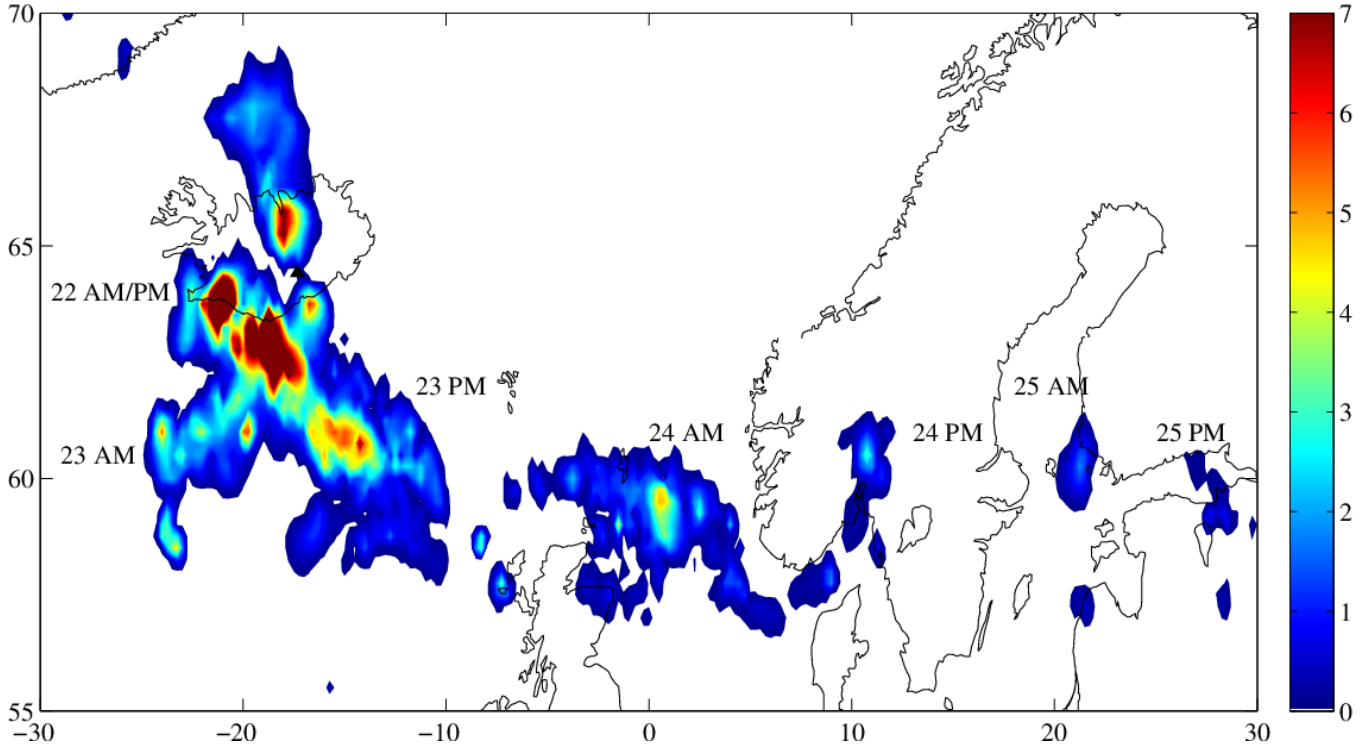
Lookup table approach

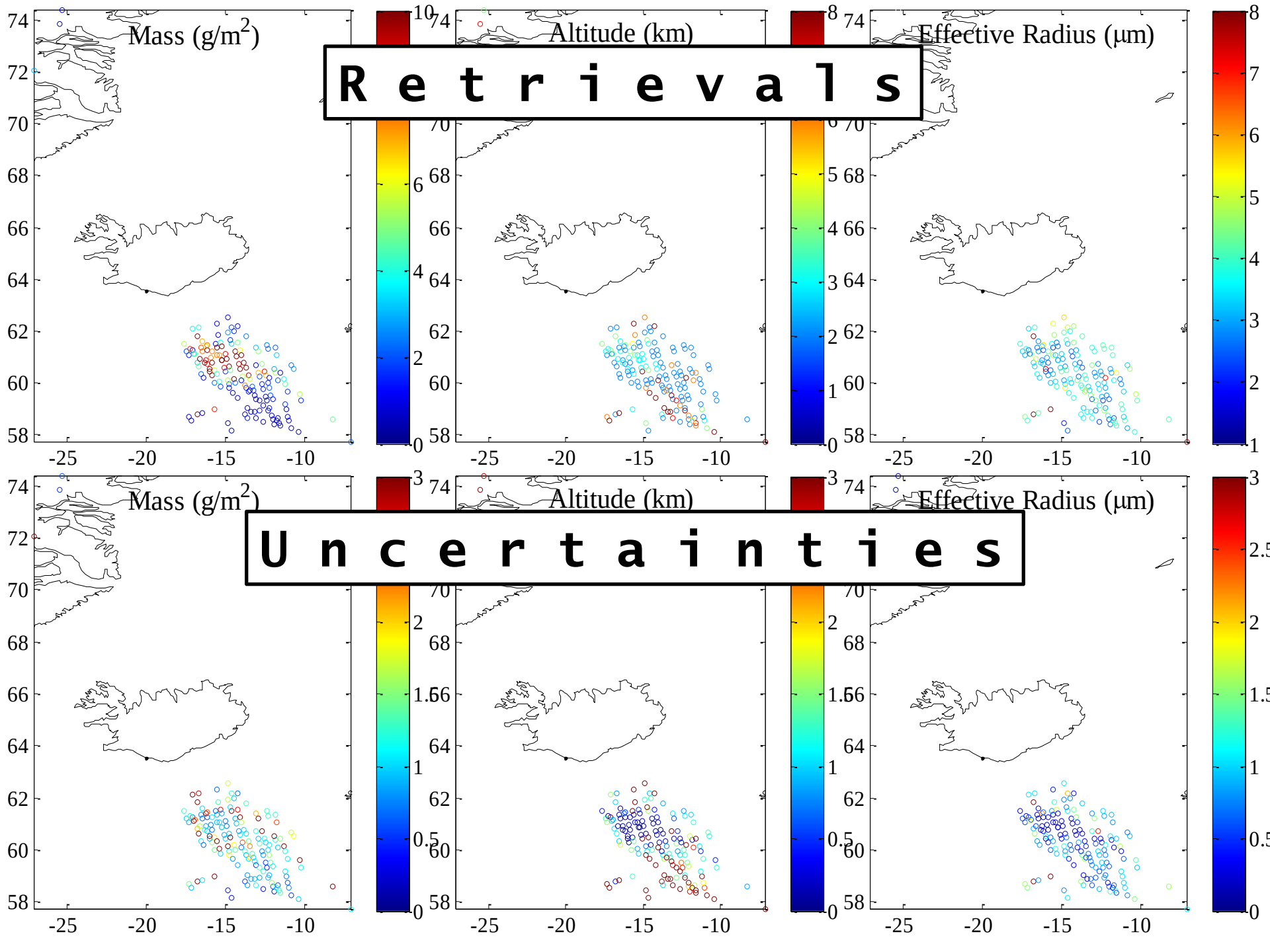
2. Development of a fast IASI ash retrieval

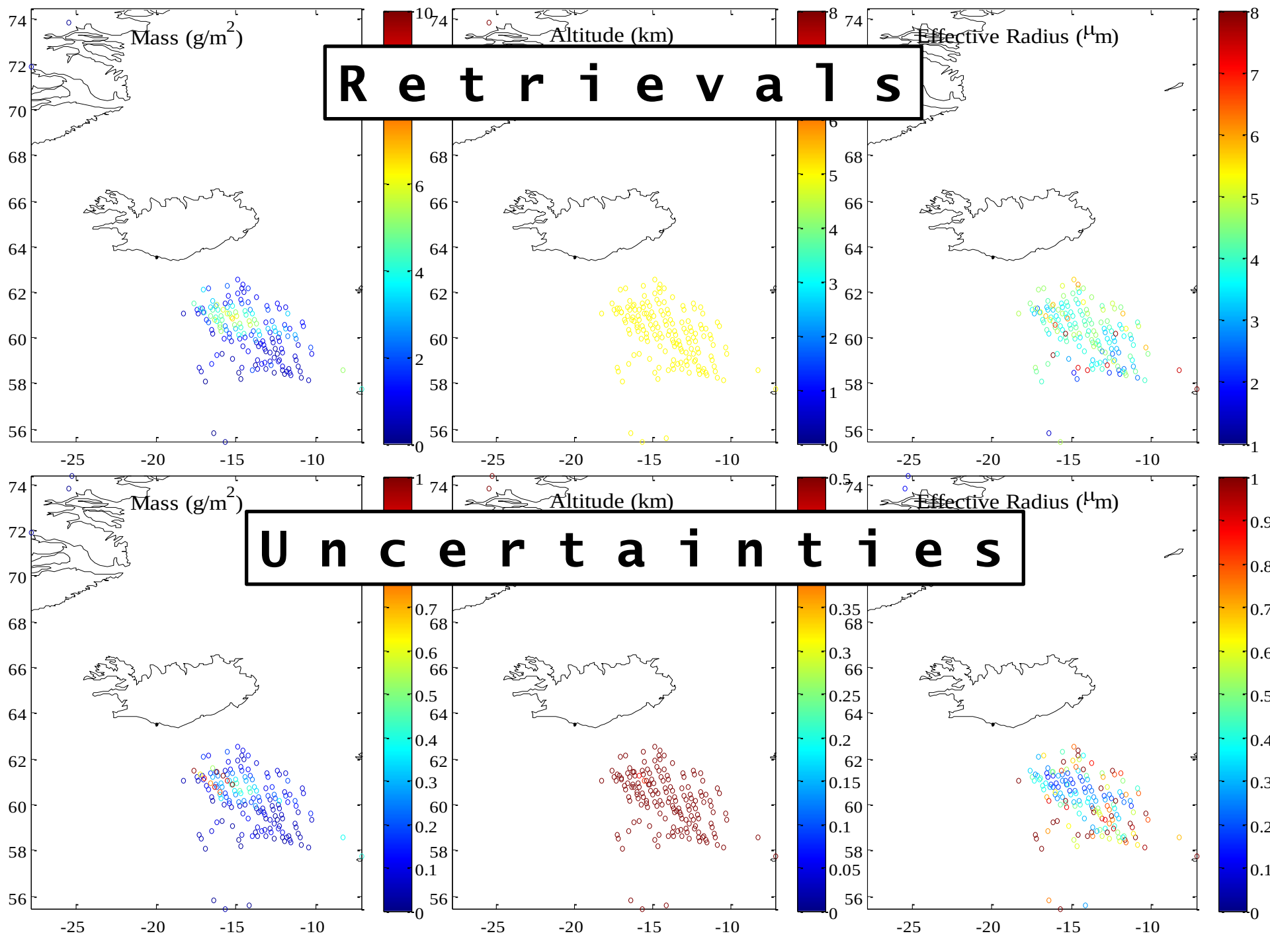
- On a representative atmosphere, build a lookuptable with varying
  - Altitude
  - Radius
  - Optical depth (mass)
  - « Surface » temperature (baseline temperature)



>>> radius, optical depth, mass and altitude +++ uncertainties!

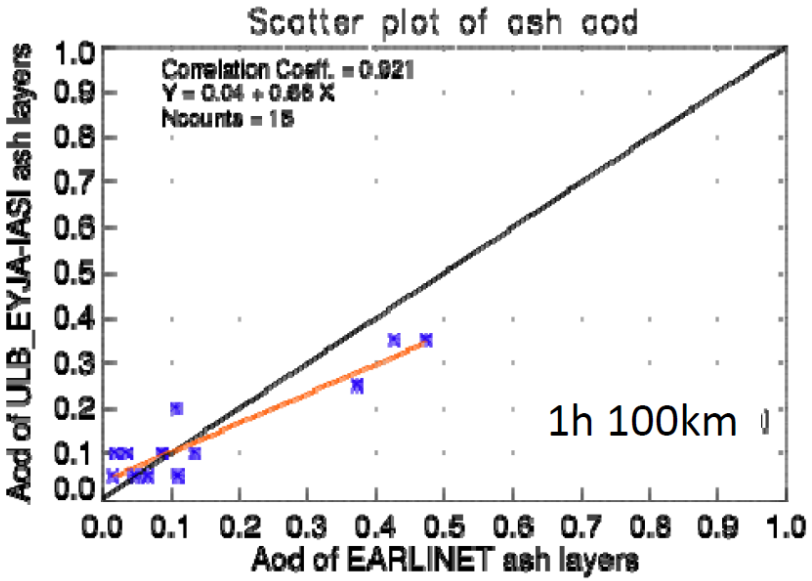



Retrievals
Mass (g/m2)
Altitude (km)
Effective Radius (μm)
Uncertainties
Mass (g/m2)
Altitude (km)
Effective Radius (μm)

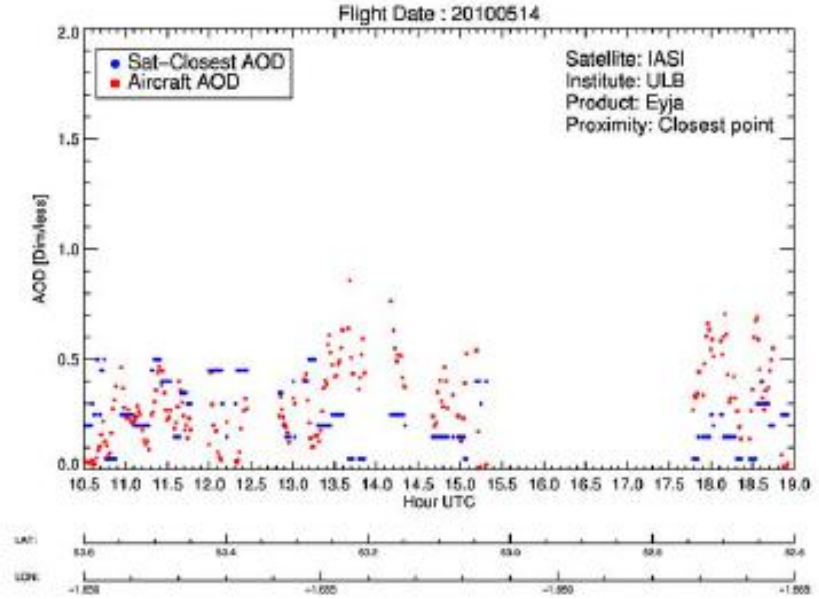

Retrievals
Mass (g/m^2)
Altitude (km)
Effective Radius (μm)
Uncertainties
Mass (g/m^2)
Altitude (km)
Effective Radius (μm)

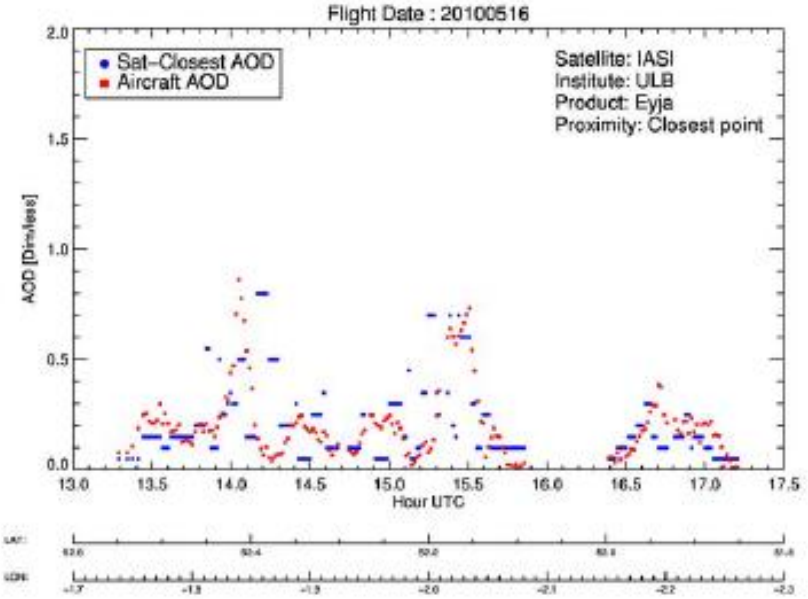
Earlinet groundbased
AOD comparison

2. Development of a fast IASI ash retrieval



Validation by
Laboratory of Atmospheric Physics
Aristotle University of Thessaloniki



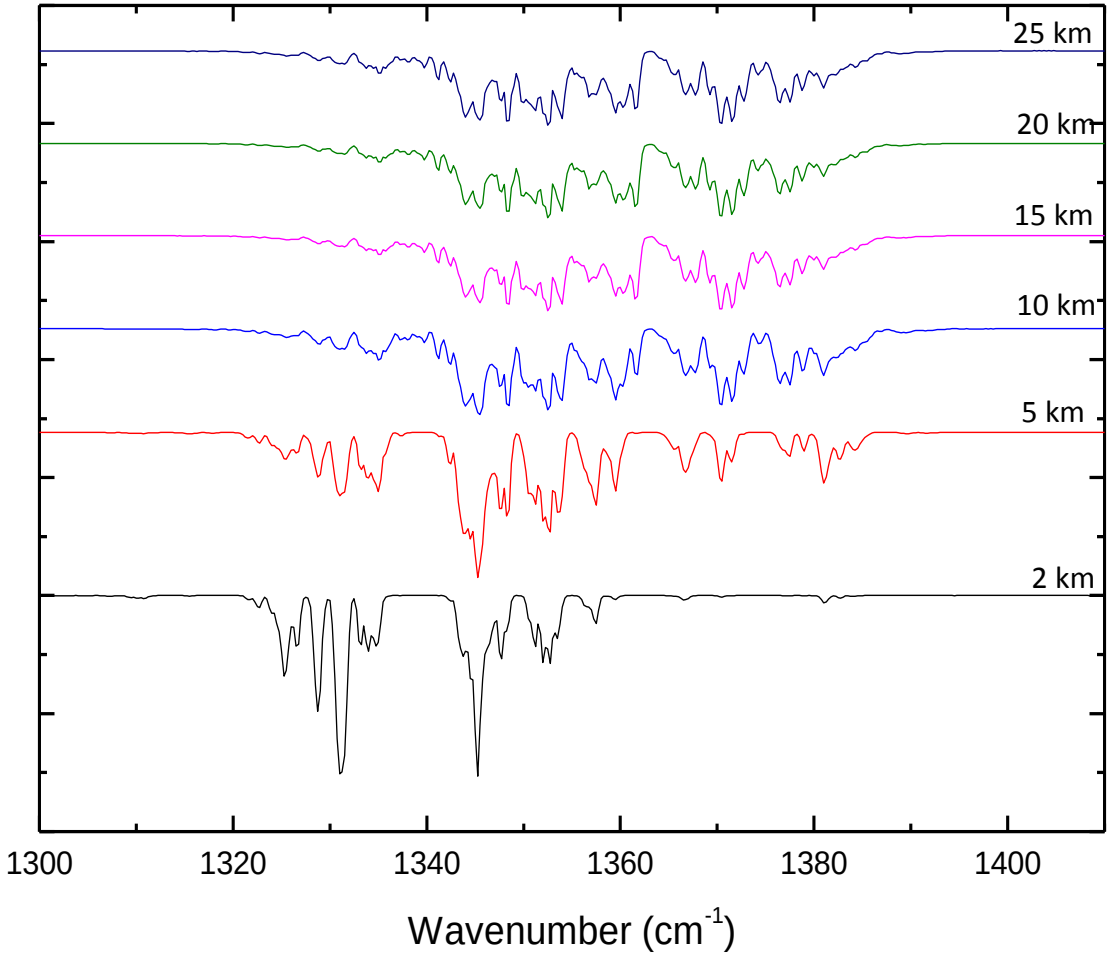


3. Development of a fast IASI SO2 altitude product

Walker et al (2011) sensitive detection
Carboni et al (2012) height - fitting approach

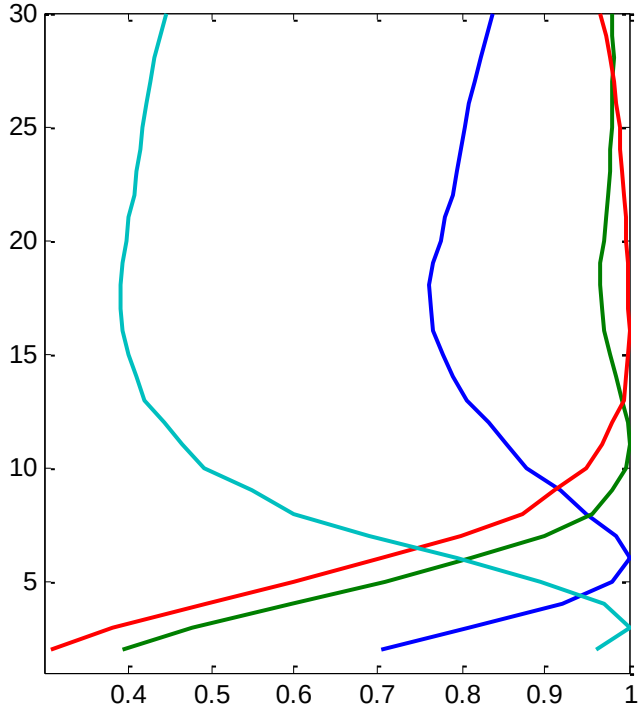
→ Fast retrieval approach?
Detection + height in one

Jacobians to changing SO2 at different altitudes

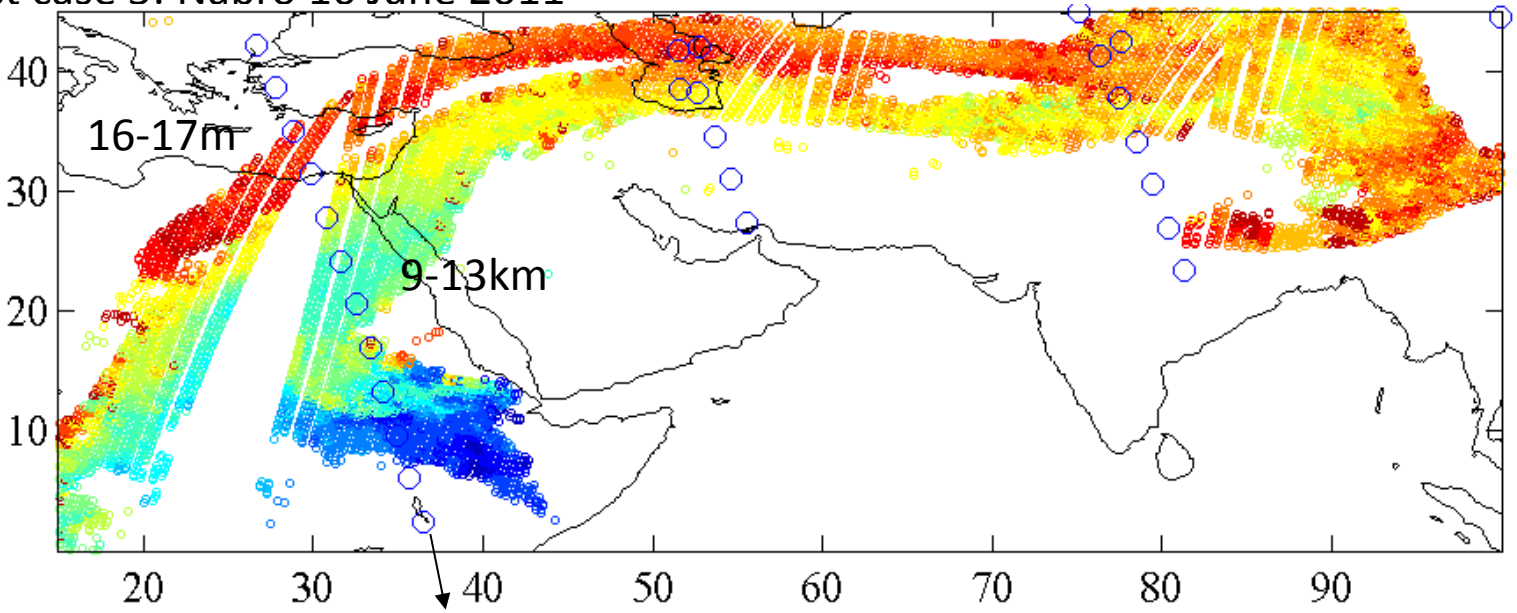


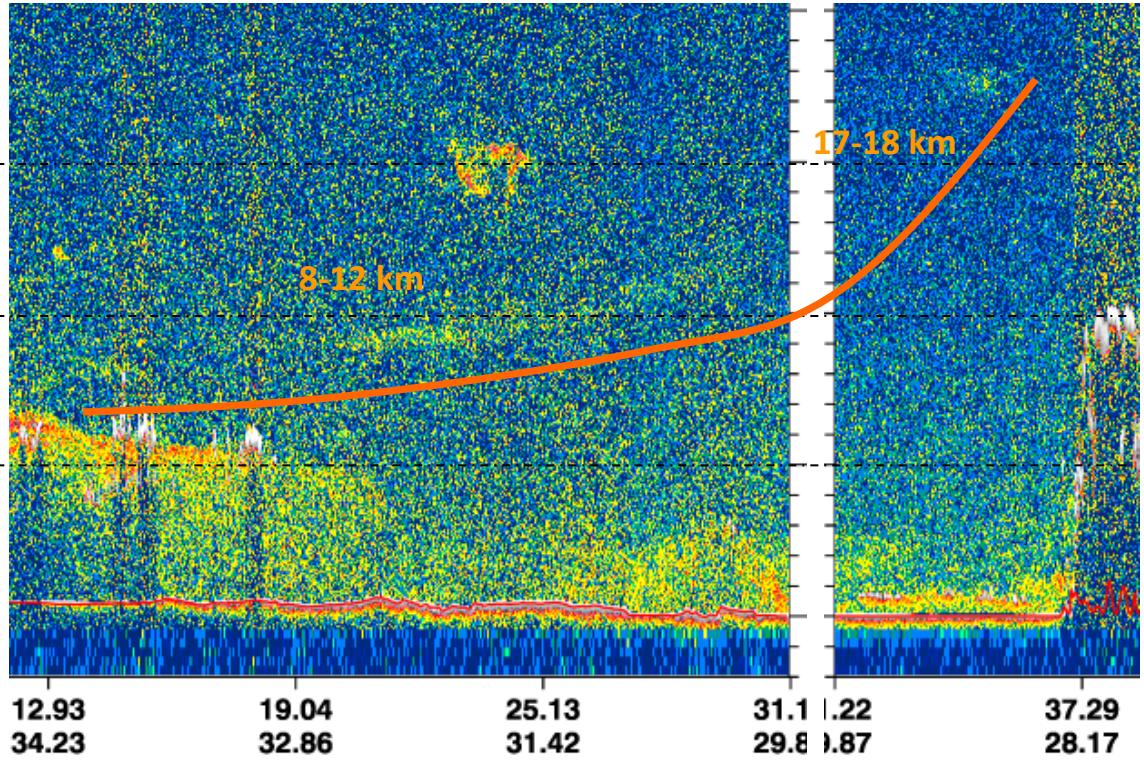
Spectral feedback function

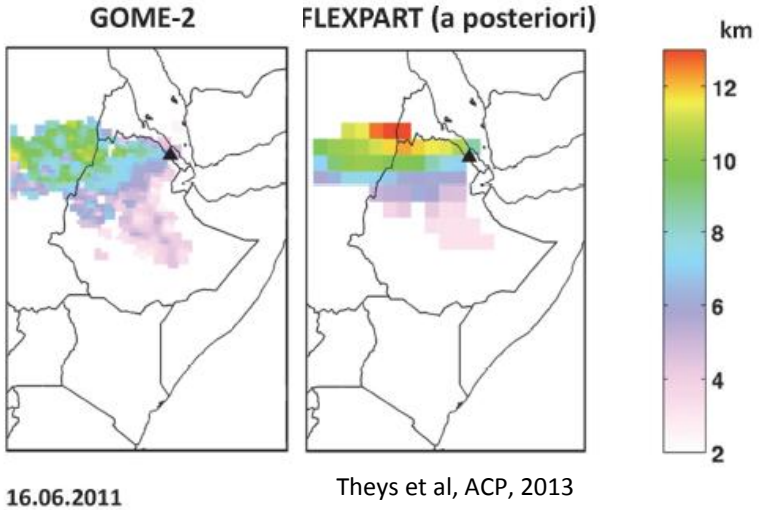
$$\frac{K_i S_\varepsilon^{-1} L}{\sqrt{K_i S_\varepsilon^{-1} K_i^T}}$$



Test case 5: Nabro 16 June 2011



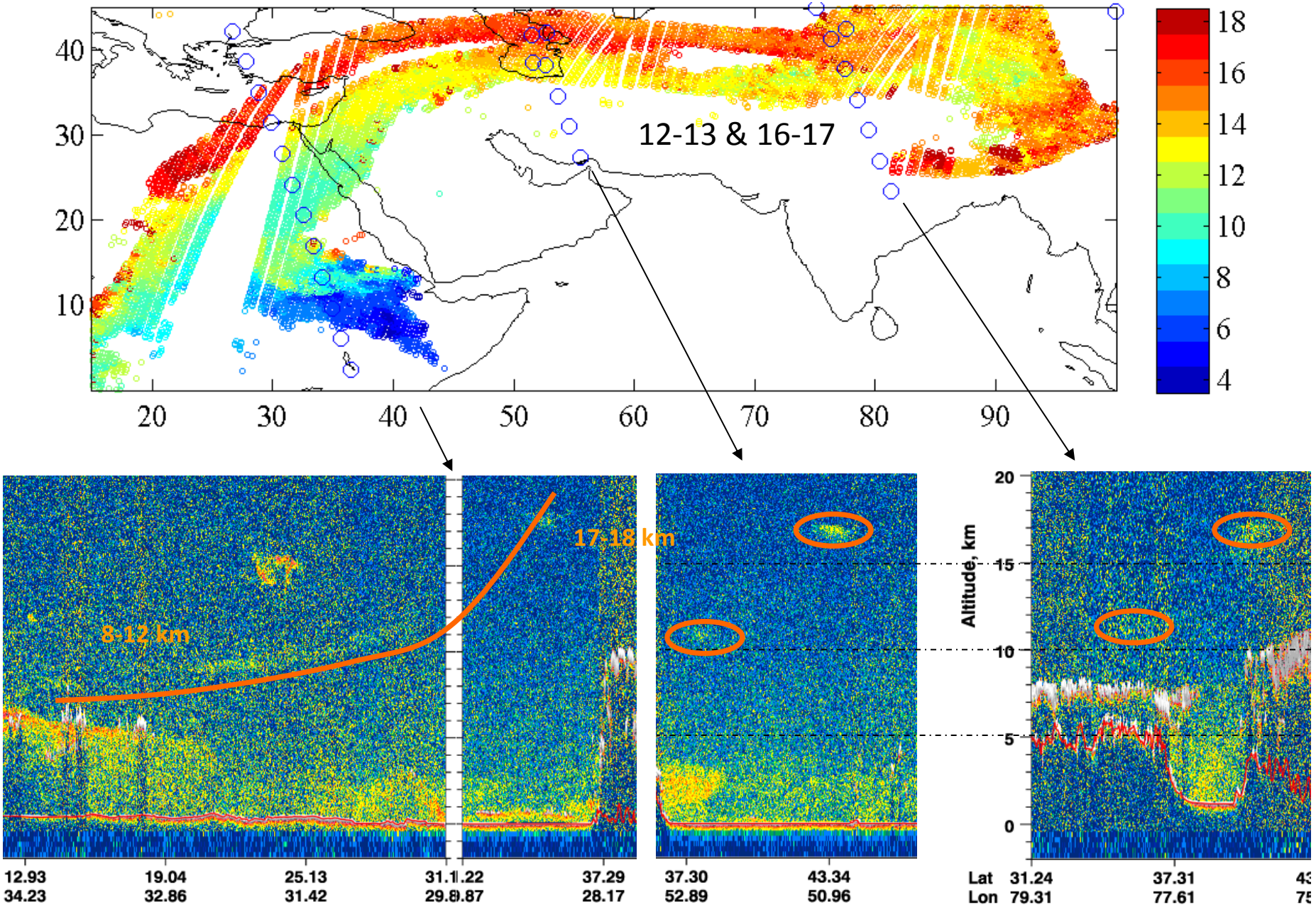


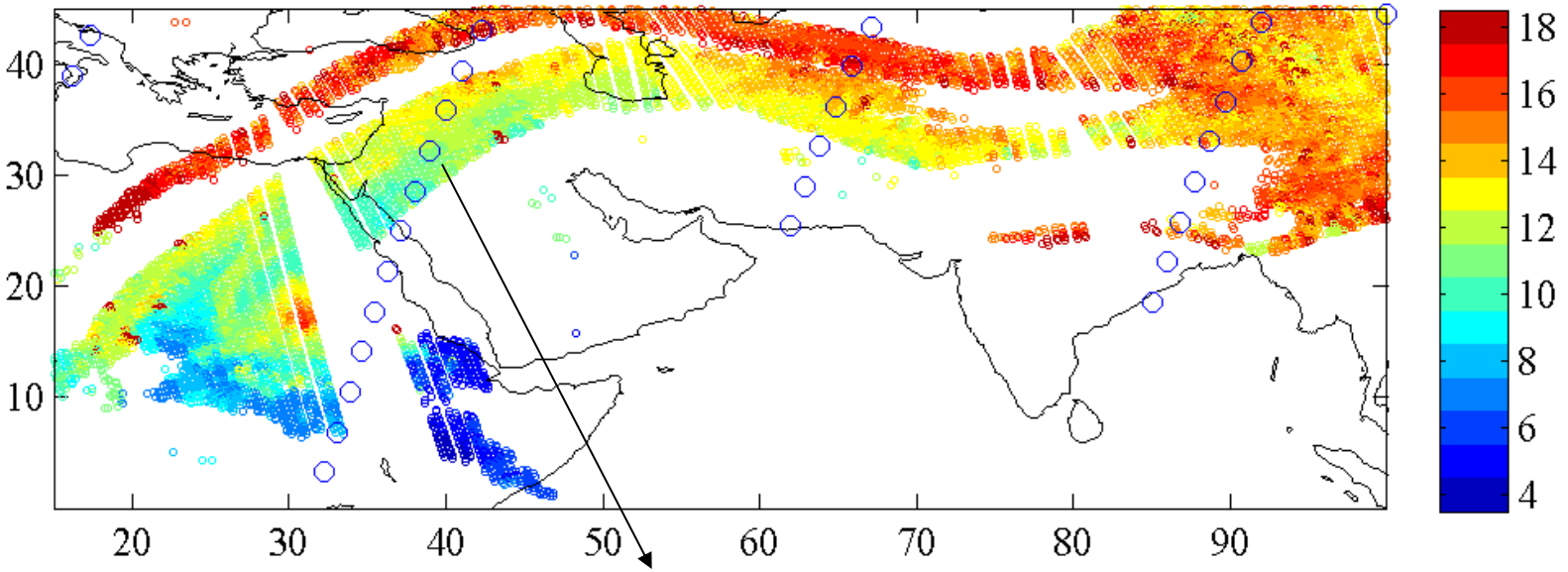


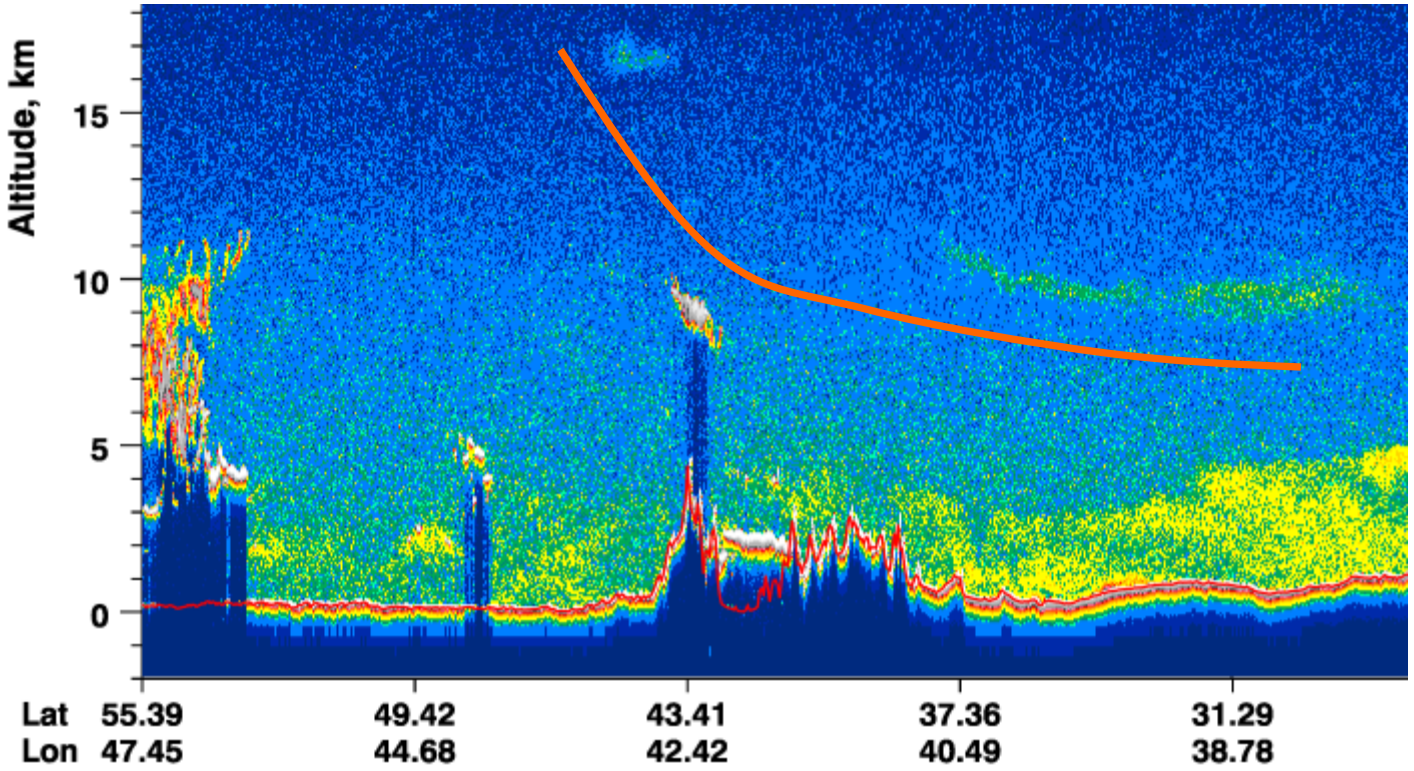
Theys et al, ACP, 2013

Error ~1 km

Test case 5: Nabro 16 June 2011



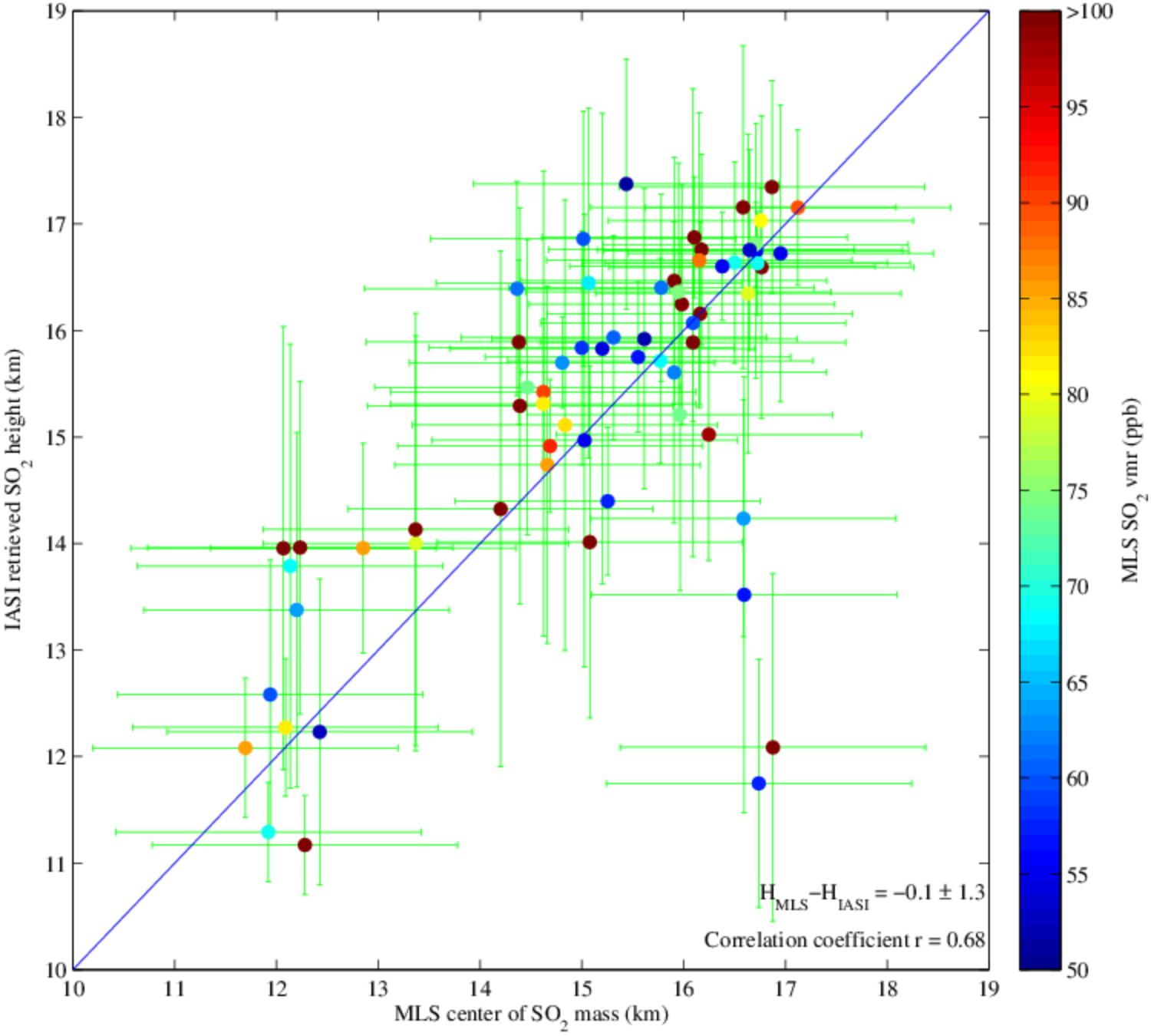




17 km

9-12 km

Perfect match!


IASI retrieved SO2 height (km)
MLS center of SO2 mass (km)
MLS SO2 vmr (ppb)
H_MLS – H_IASI = –0.1 ± 1.3
Correlation coefficient r = 0.68
10
11
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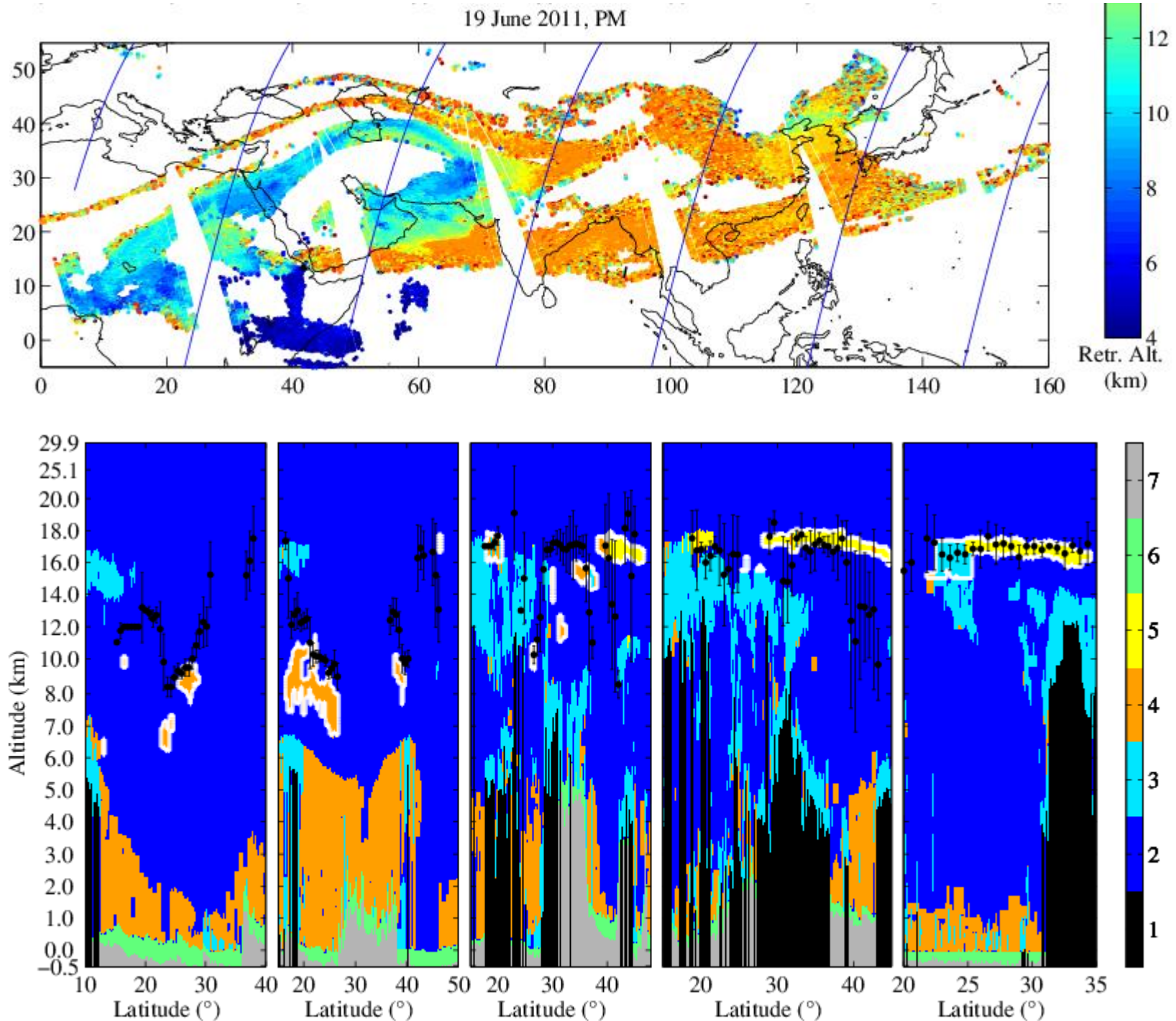
70
75
80
85
90
95
>100

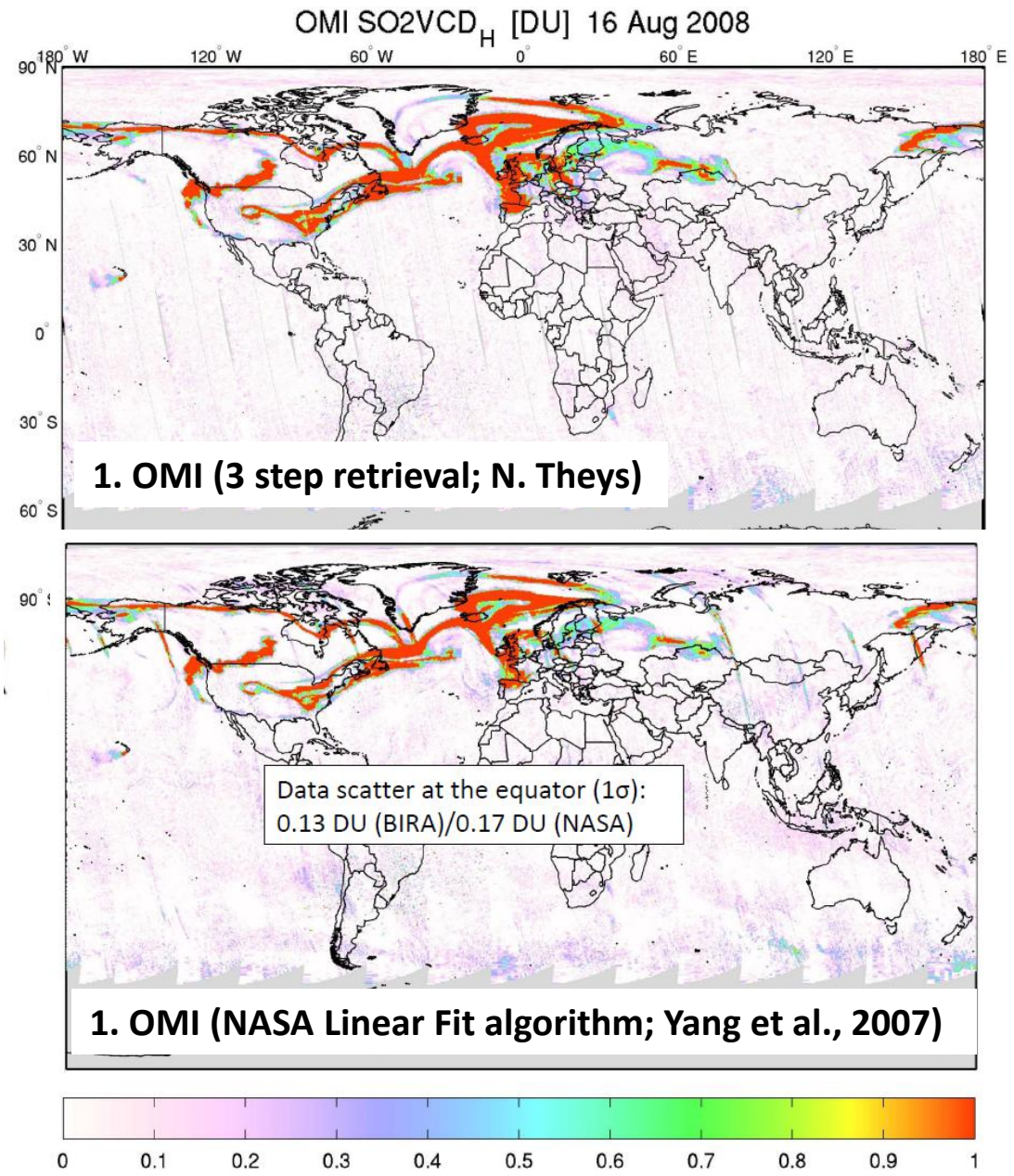

19 June 2011, PM
Retr. Alt. (km)
Altitude (km)
Latitude (°)
Latitude (°)
Latitude (°)
Latitude (°)
Latitude (°)

4. Development of an improved OMI SO2 product

3 step retrieval:

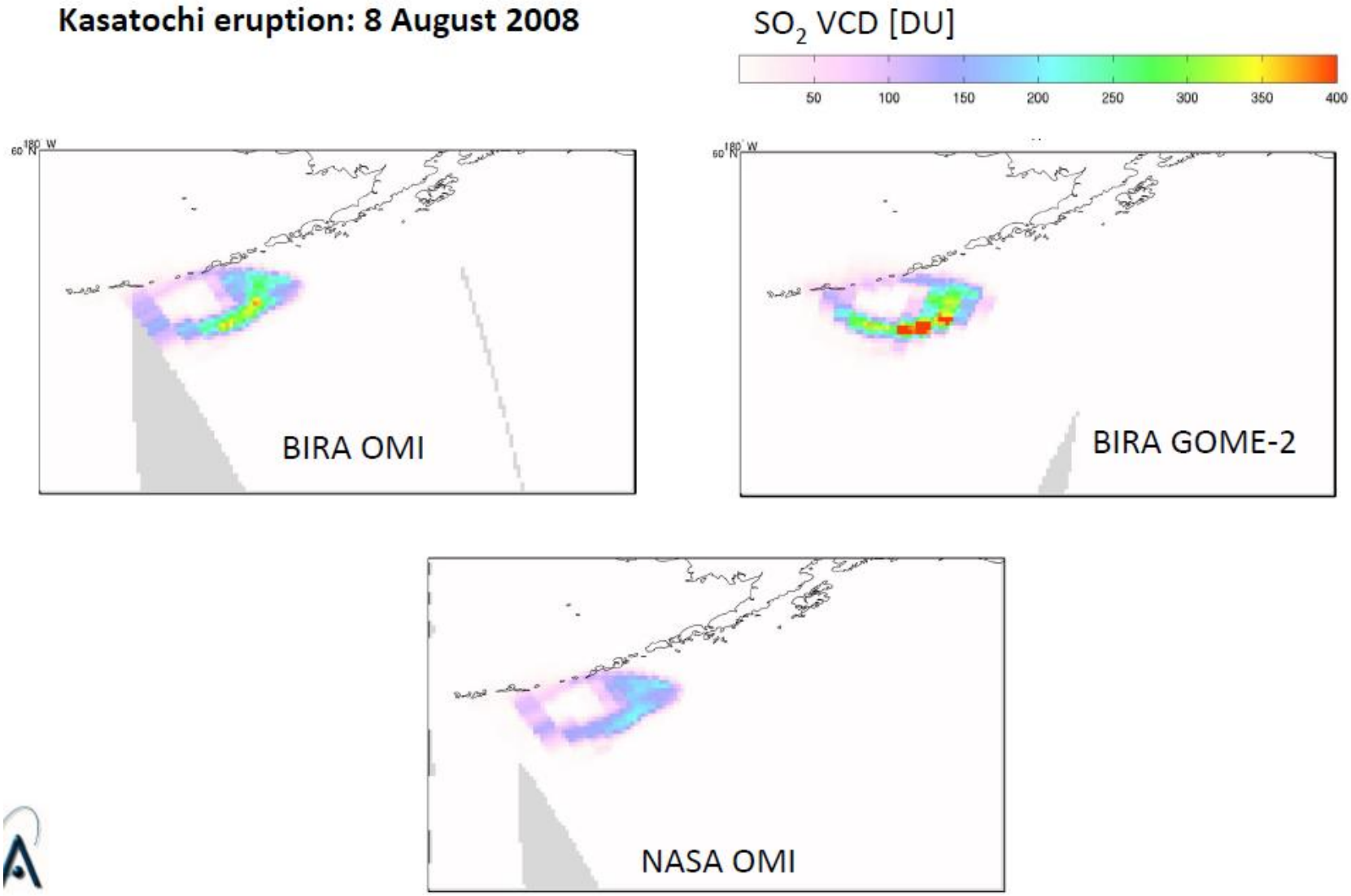
1. DOAS fit (3 spectral windows)
2. Background correction
3. Air mass factors

Improved results :
1. noise level + several artifacts
2. extreme cases (>250 DU)
3. small columns



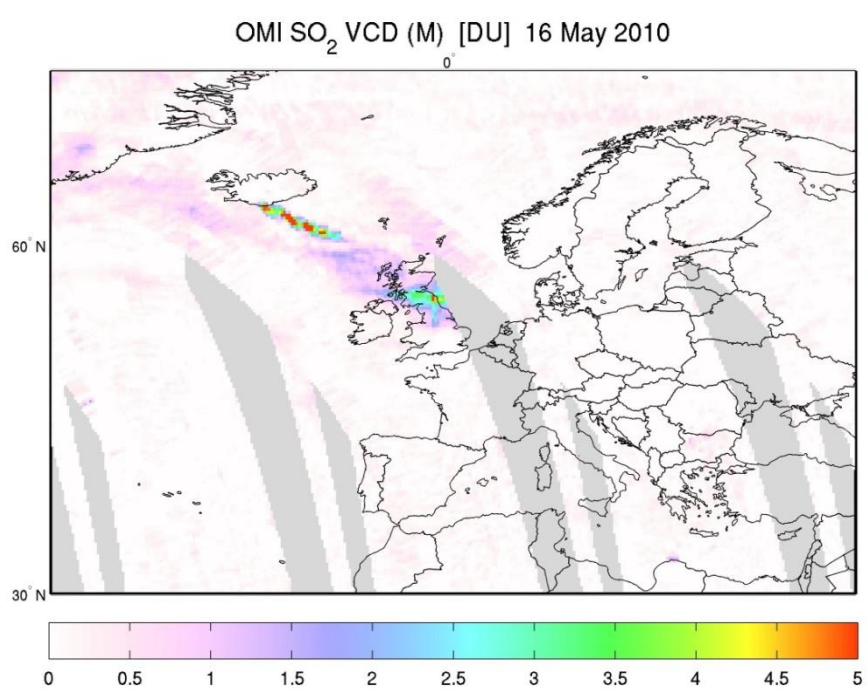
Courtesy Nicolas Theys

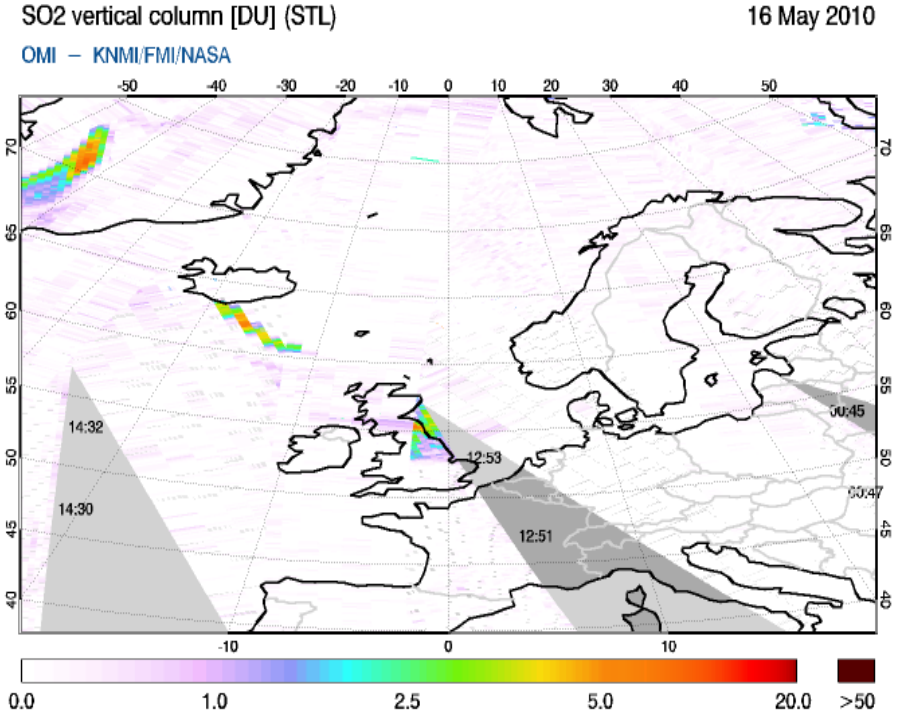
Kasatochi eruption: 8 August 2008

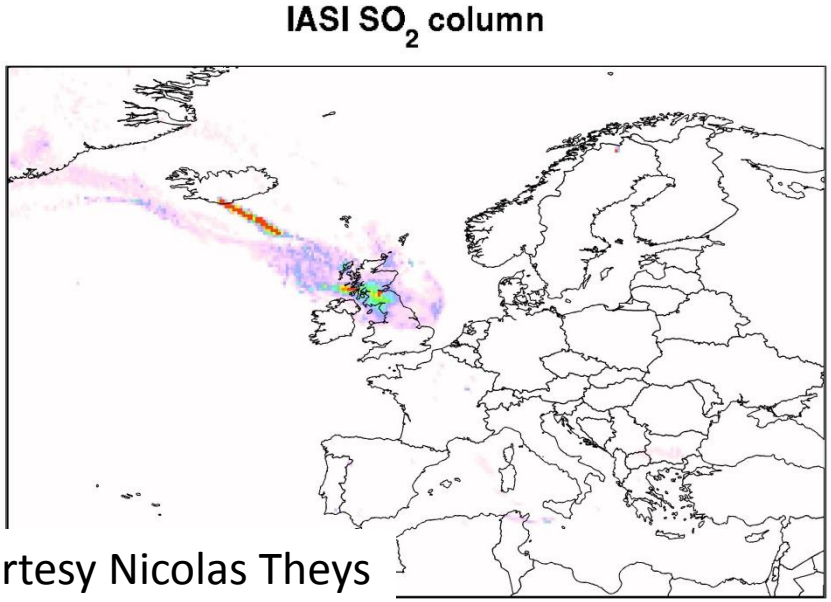


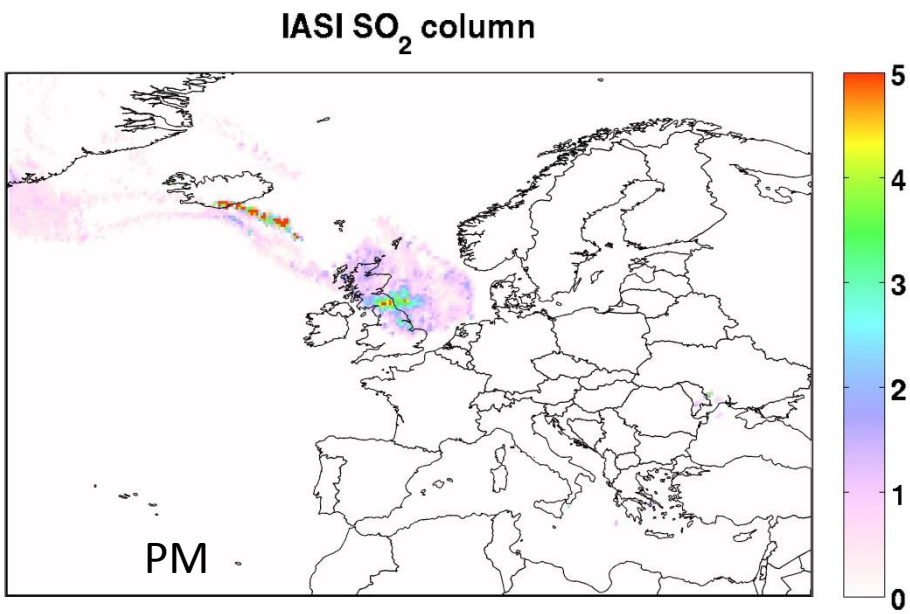
aeronomie.be

Courtesy Nicolas Theys









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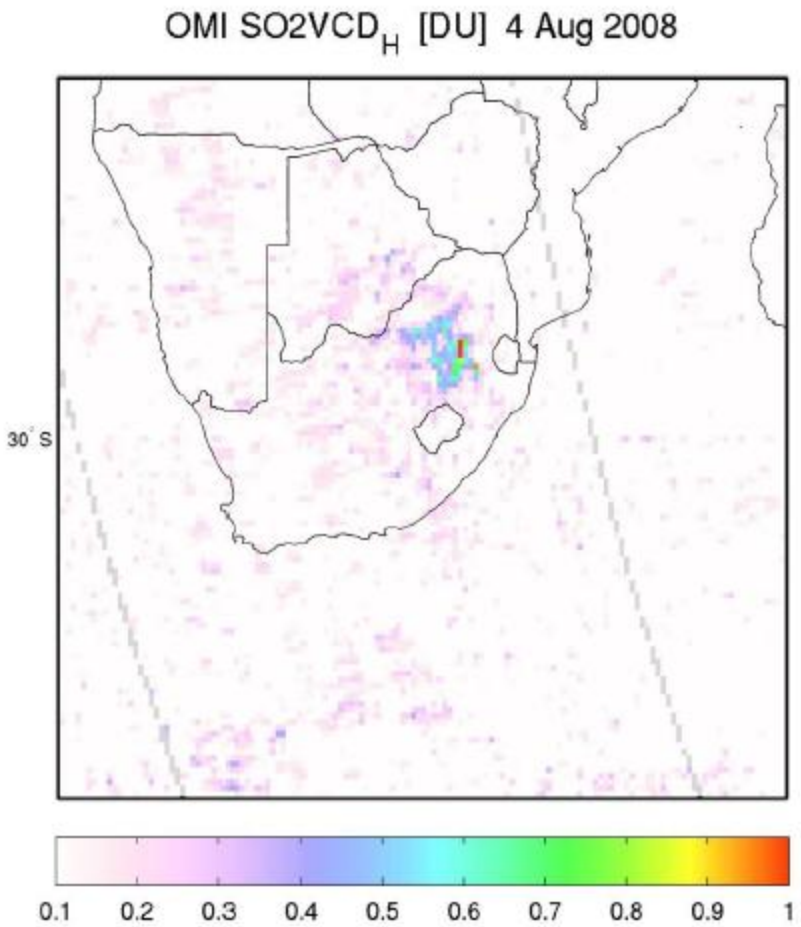

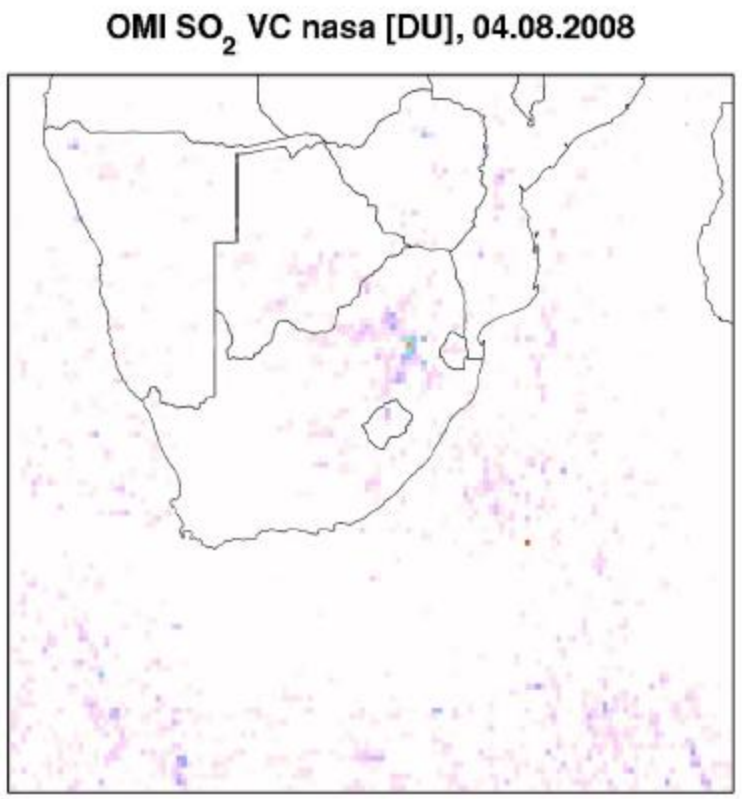

South Africa: power plants

Courtesy Nicolas Theys

Conclusions

The objective of SACS is –with respect to **volcanic SO_2 and ash**.:

1. Deliver in **near-real time space observations IASI/AIRS/OMI/GOME2**
2. Provide **near-real time notifications** (email and webbased)
3. Provide access to **archive data**

>> Useful for operational and research applications

http://sacs.aeronomie.be

SACS 2
Product developments

Recent improved and expanded products:

1. **IASI and AIRS ash detection** (including alert system)
2. Development of a fast ash retrieval algorithm for IASI
3. Development of a fast and accurate IASI SO_2 altitude product
4. Development of a new OMI SO_2 product