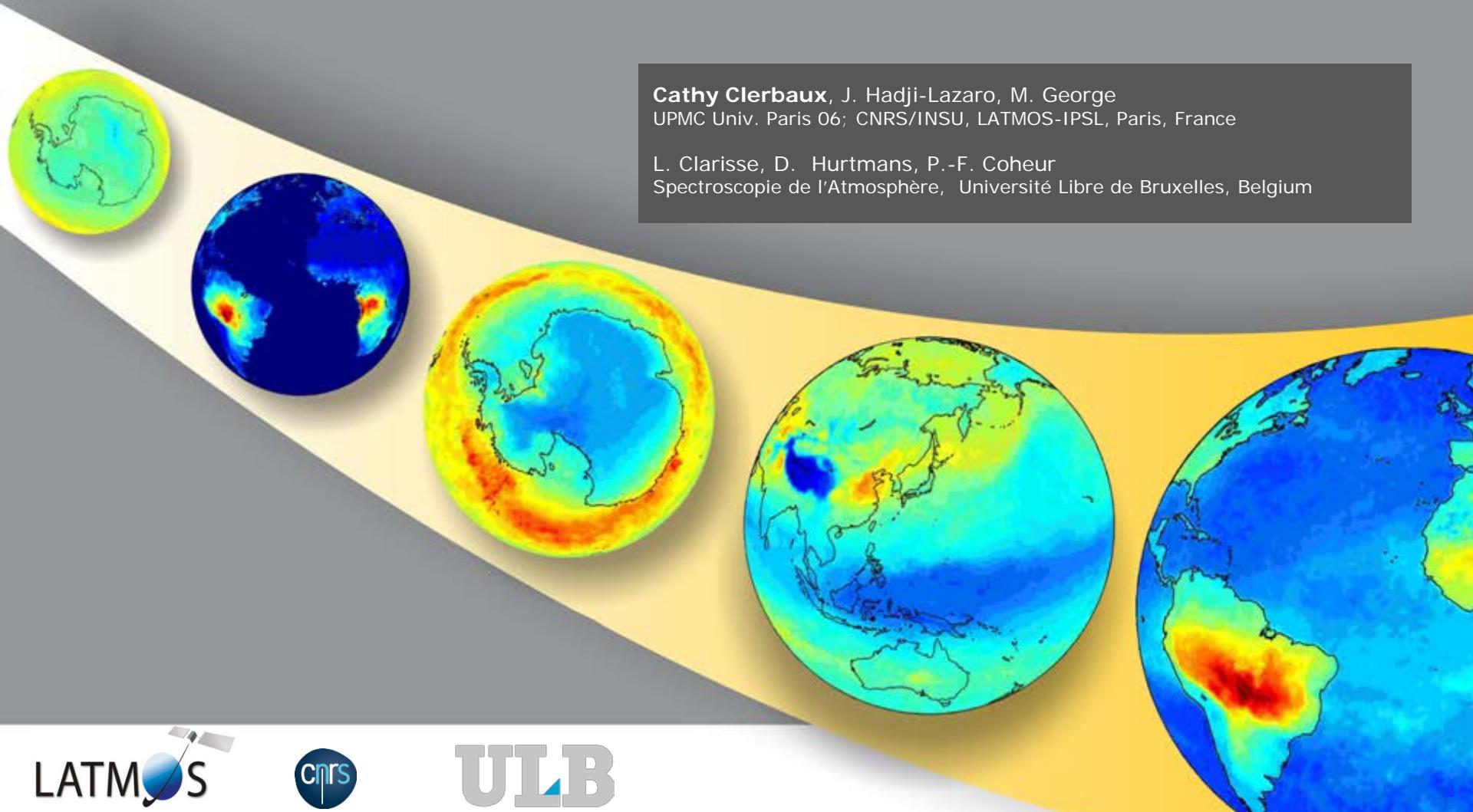


Remote sensing of high altitude volcanic SO₂ and ash with IASI

Cathy Clerbaux, J. Hadji-Lazaro, M. George
UPMC Univ. Paris 06; CNRS/INSU, LATMOS-IPSL, Paris, France

L. Clarisse, D. Hurtmans, P.-F. Coheur
Spectroscopie de l'Atmosphère, Université Libre de Bruxelles, Belgium



What we thought we would measure with IASI ...

CO_2

N_2O

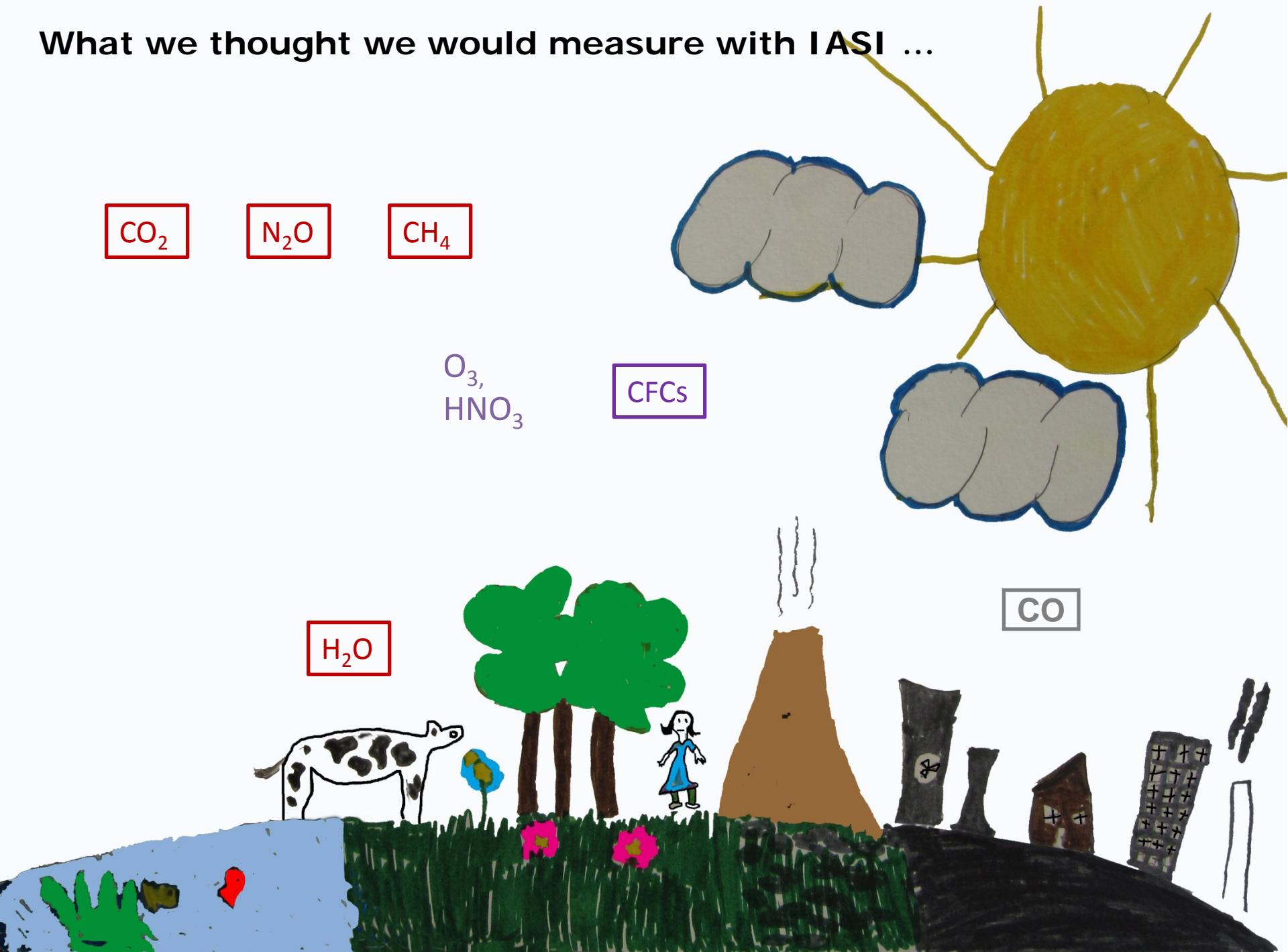
CH_4

O_3 ,
 HNO_3

CFCs

H_2O

CO



What we measure with IASI ...



CO_2

CH_4

O_3 ,
 HNO_3

CFCs

SO_2
 H_2S
 H_2SO_4
Ash

HONO $\text{C}_4\text{H}_4\text{O}$ CH_4 C_2H_2 C_2H_4 C_3H_6 CH_3OH HCOOH CH_3COOH CH_3CHO HCN OCS

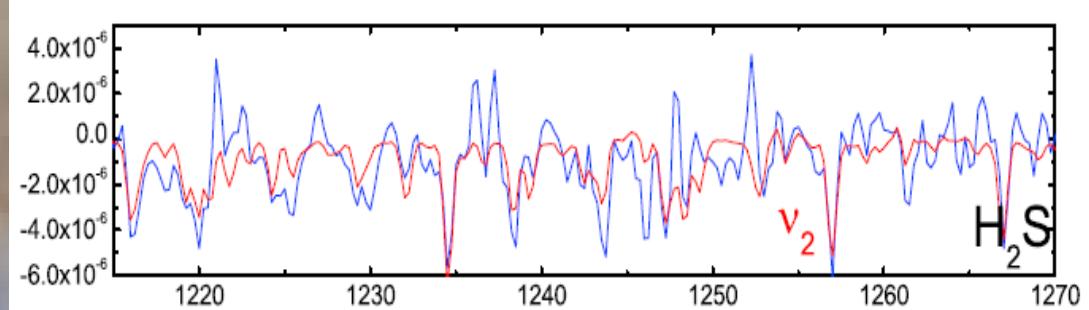
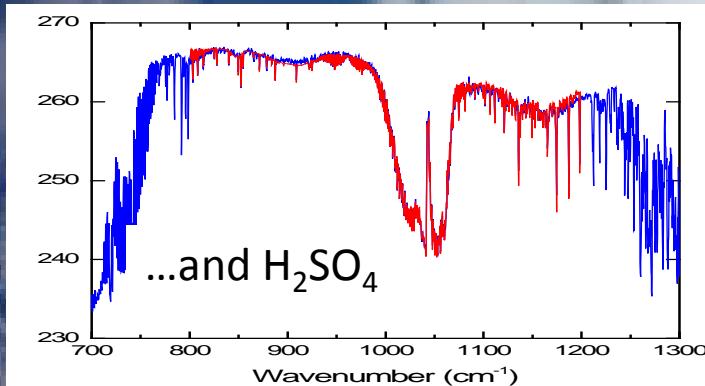
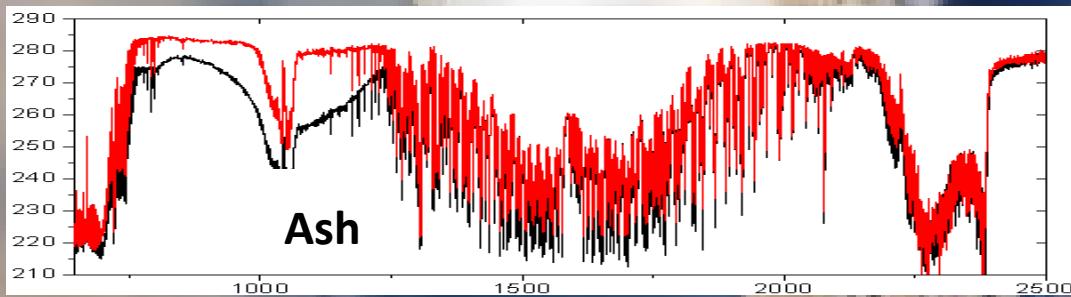
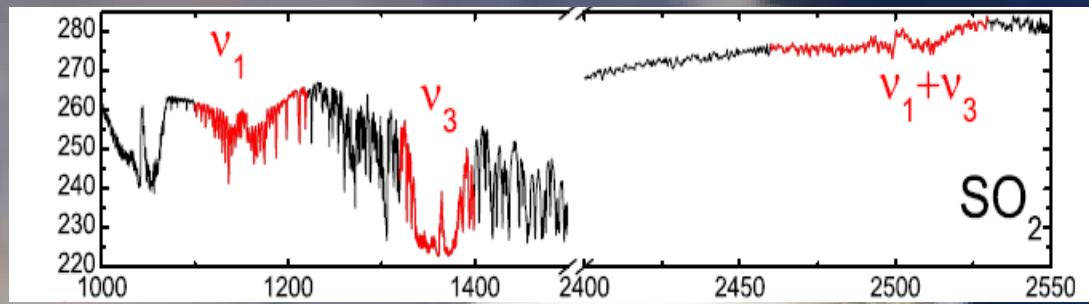
CO

NH_3

H_2O
HDO



Detection of volcanic plumes

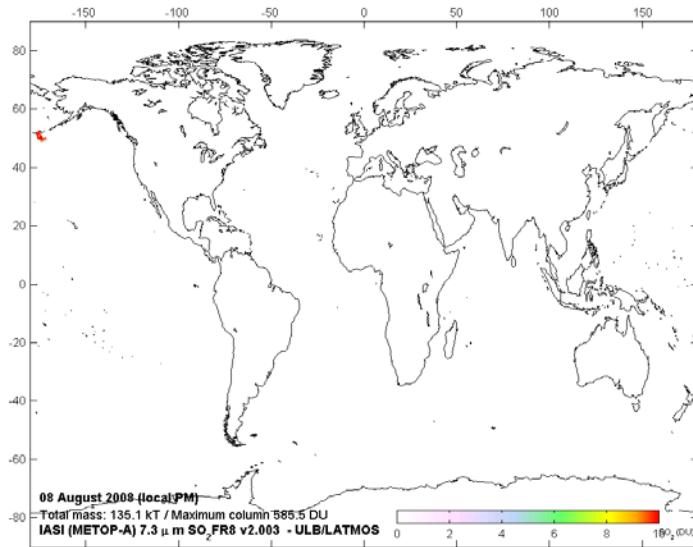


SO_2 retrieval from IASI spectra

Assume an atmosphere with a SO_2 cloud present at a given altitude;

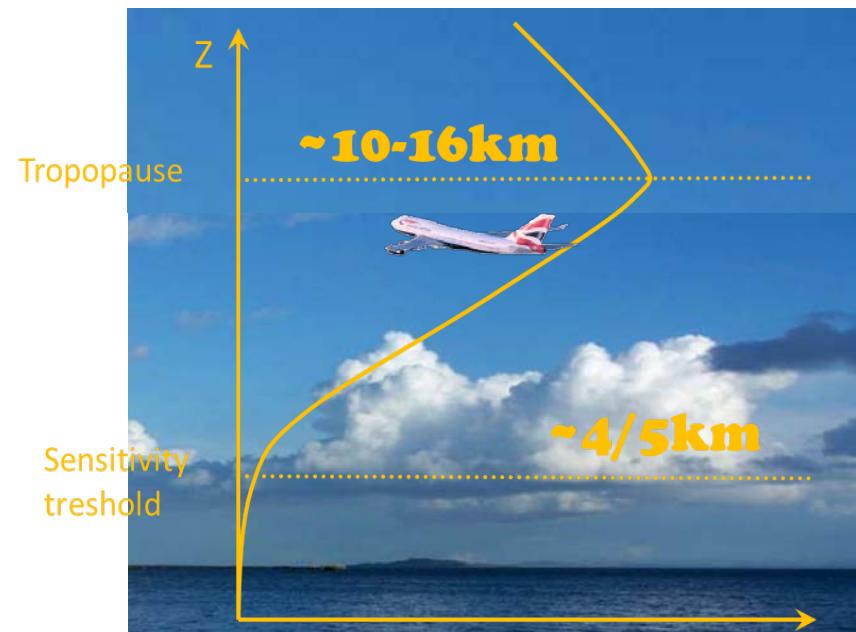
Selected channels and look-up table;

The accuracy depends knowledge of the plume altitude



>> About 4 orders of magnitude
0.5 DU to 5000 DU

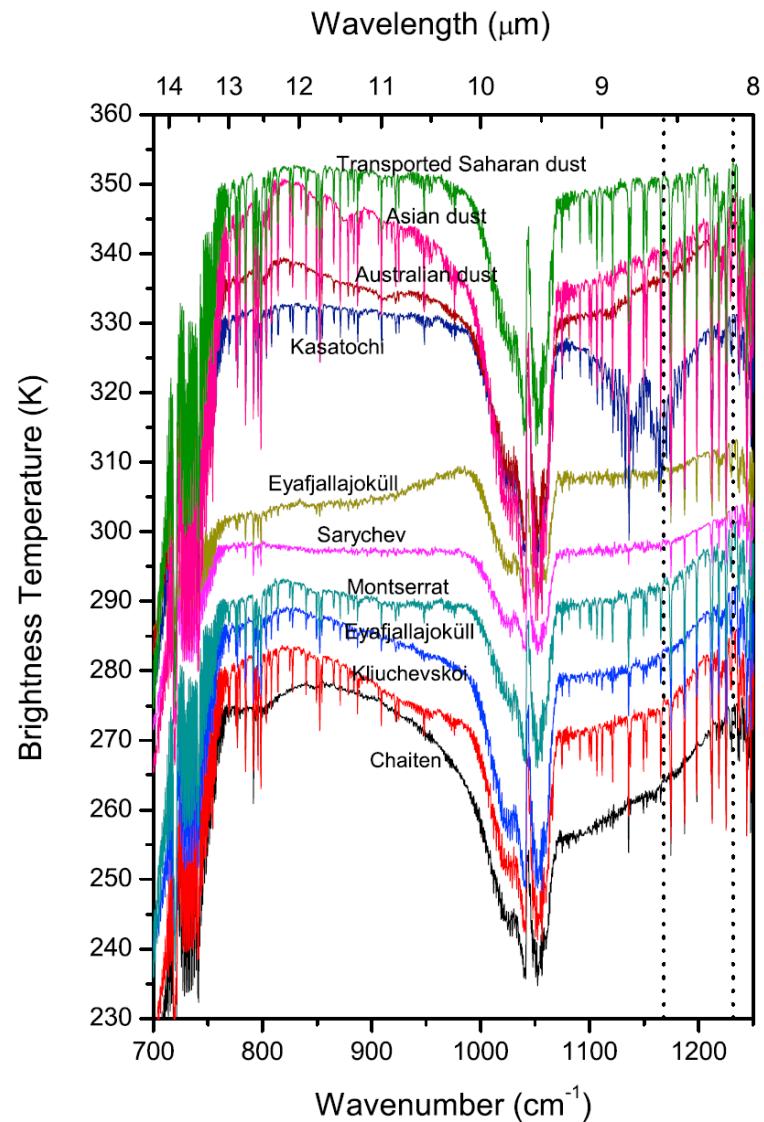
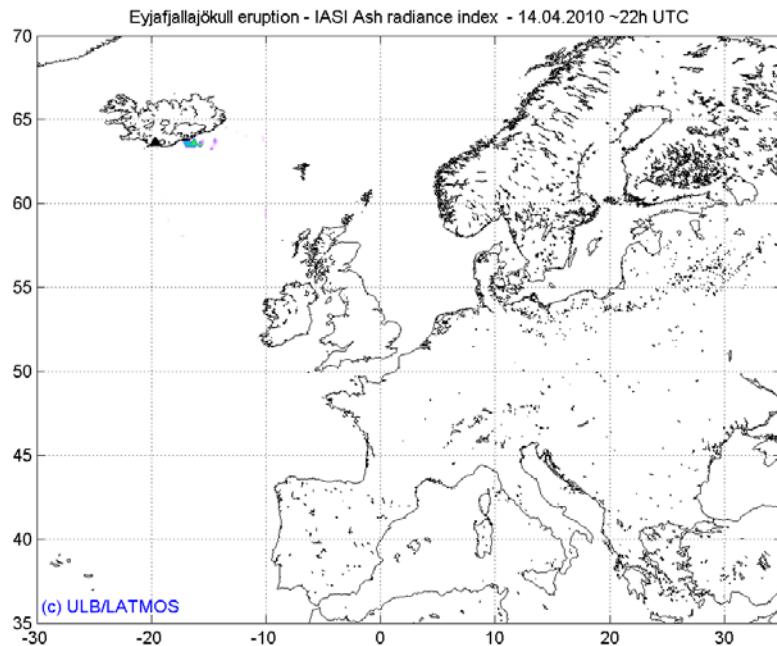
3% uncertainty for 0.5–100 DU 6%
for 100–5000 DU for assumed
altitudes above 500 hPa



Clarisse et al., AMT, 2012

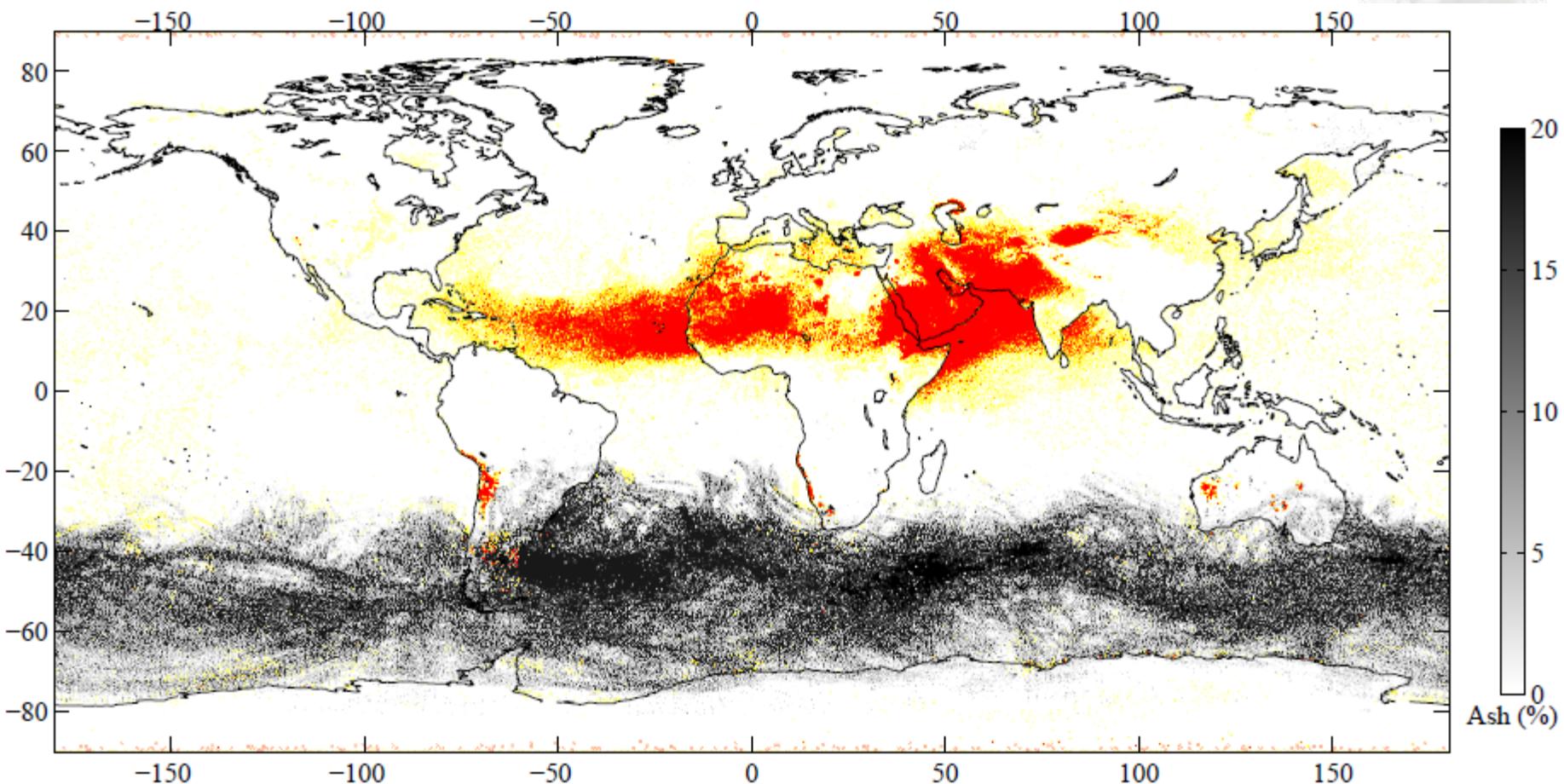
Ashes retrieval from IASI spectra

Correlation method: using a fixed database of example spectra

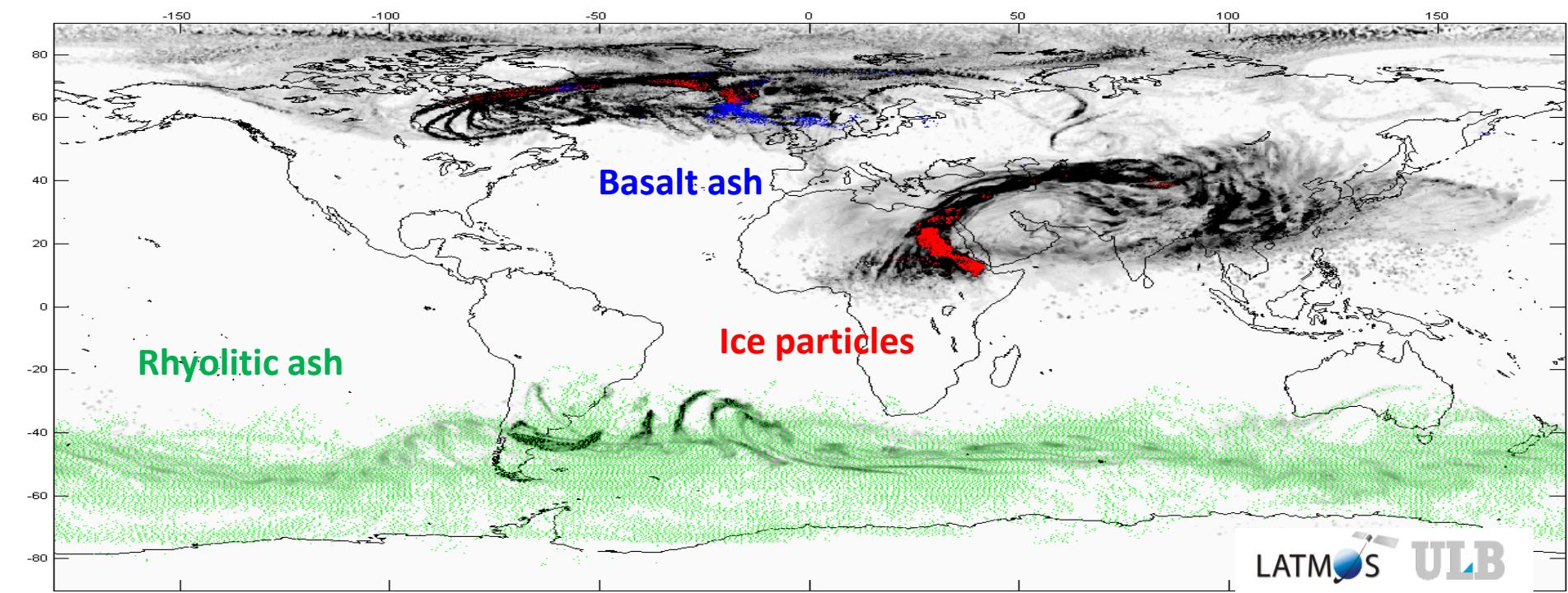
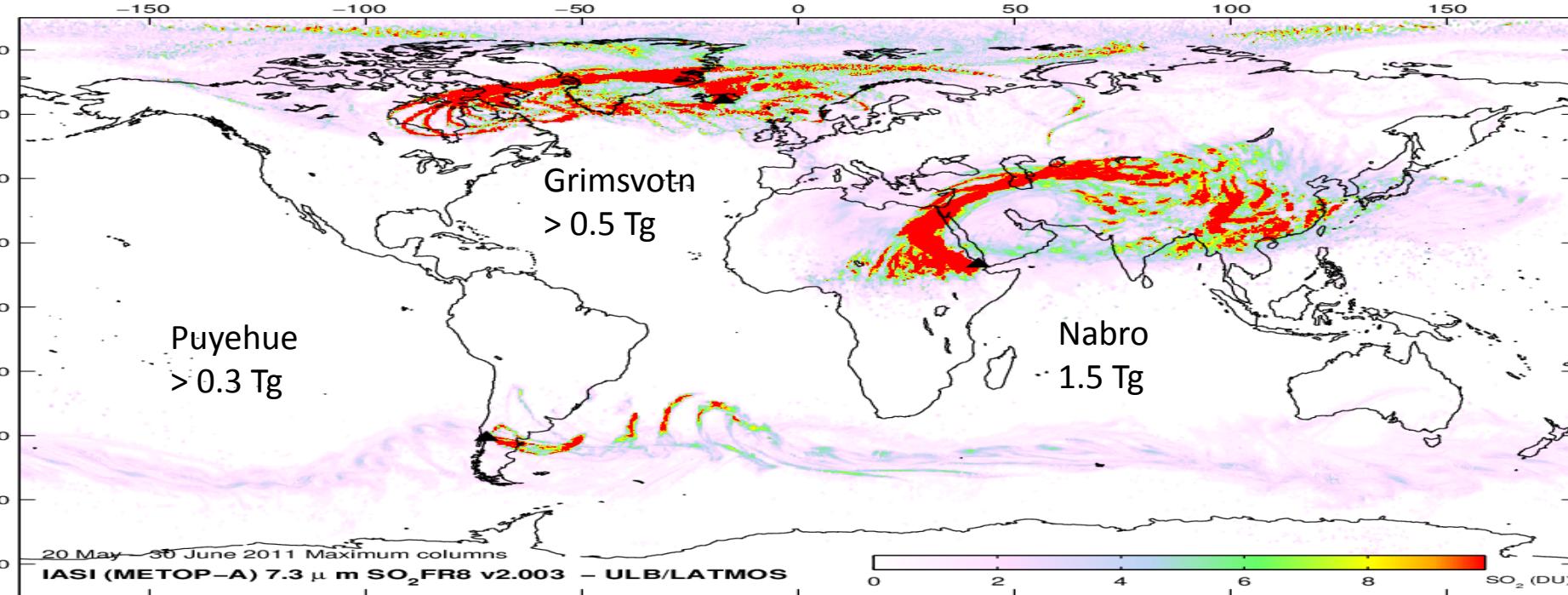


Clarisse et al., GRL, 2010

Ash and sand detection – June 2011



Clarisse et al., AMTD, 2013



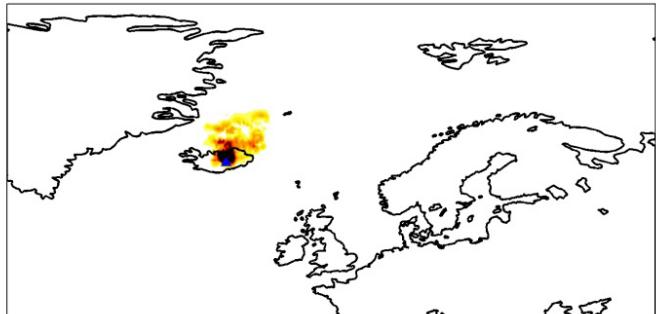
Grimsvötn

May 22 2011

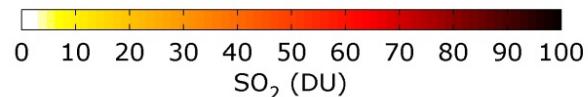
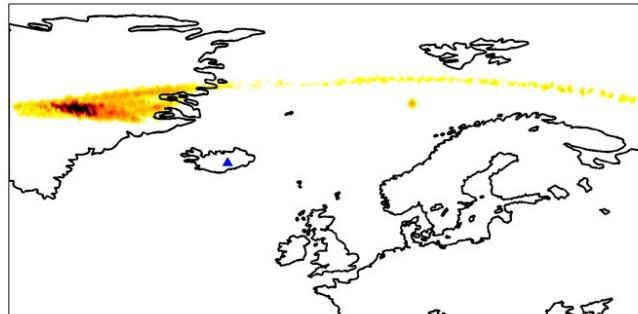
May 23 2011

SO_2

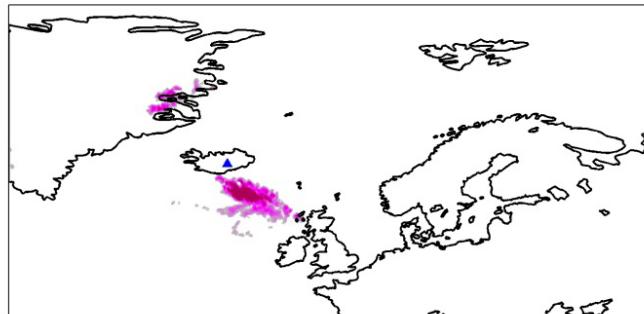
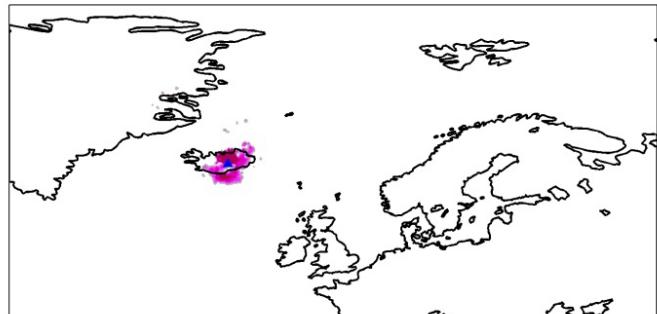
22 mai 2011 - 13h01 UTC



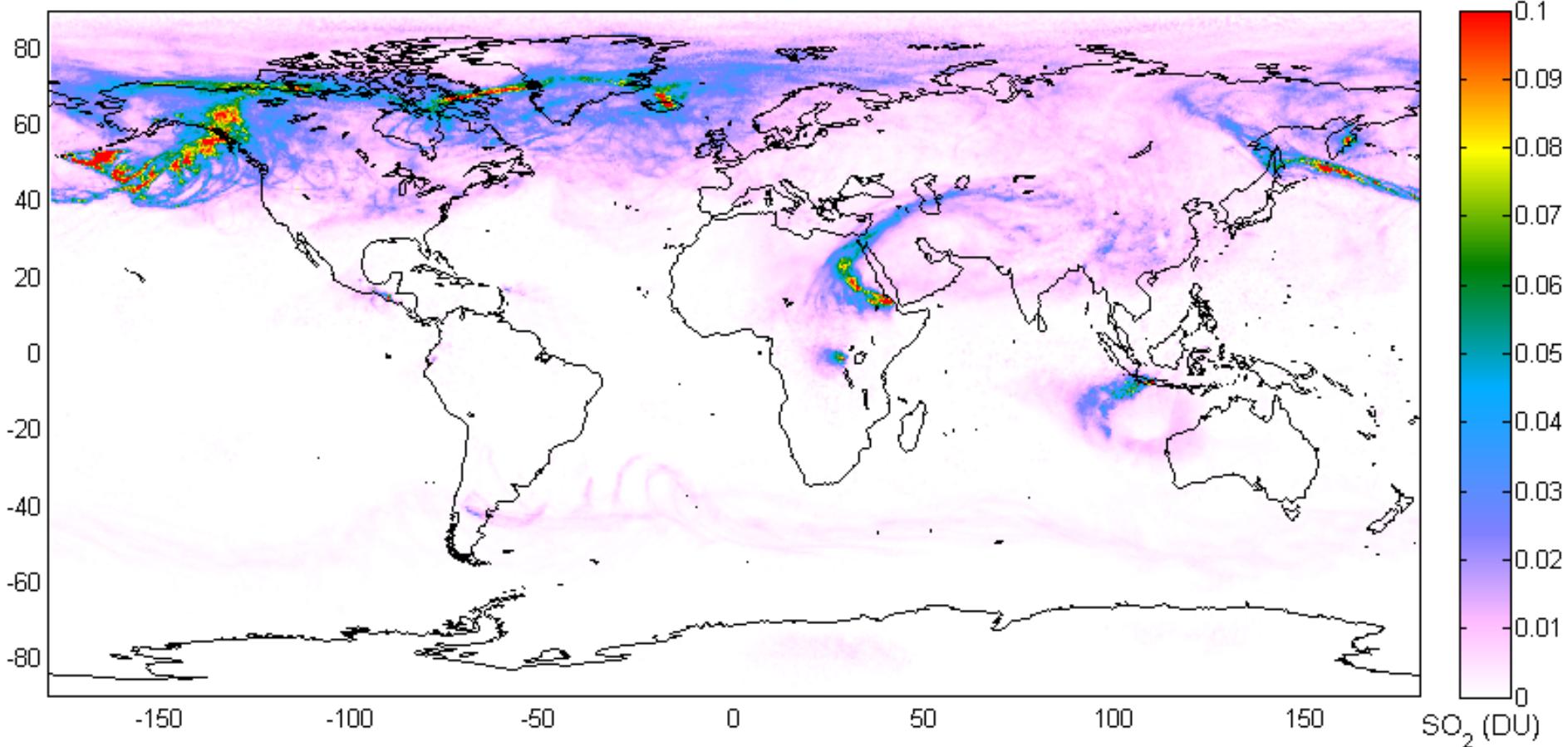
23 mai 2011 - 20h10 UTC



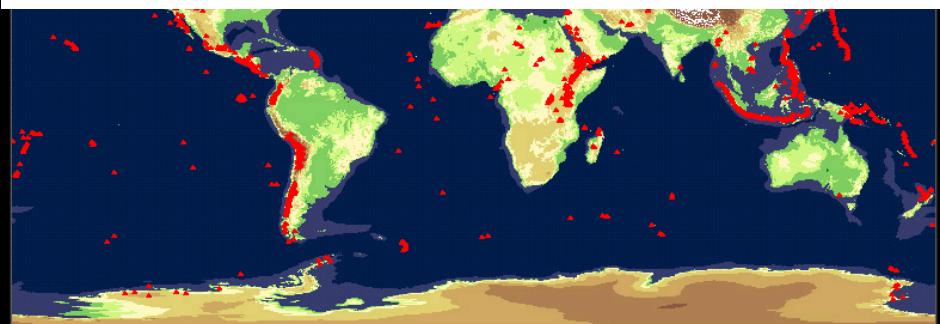
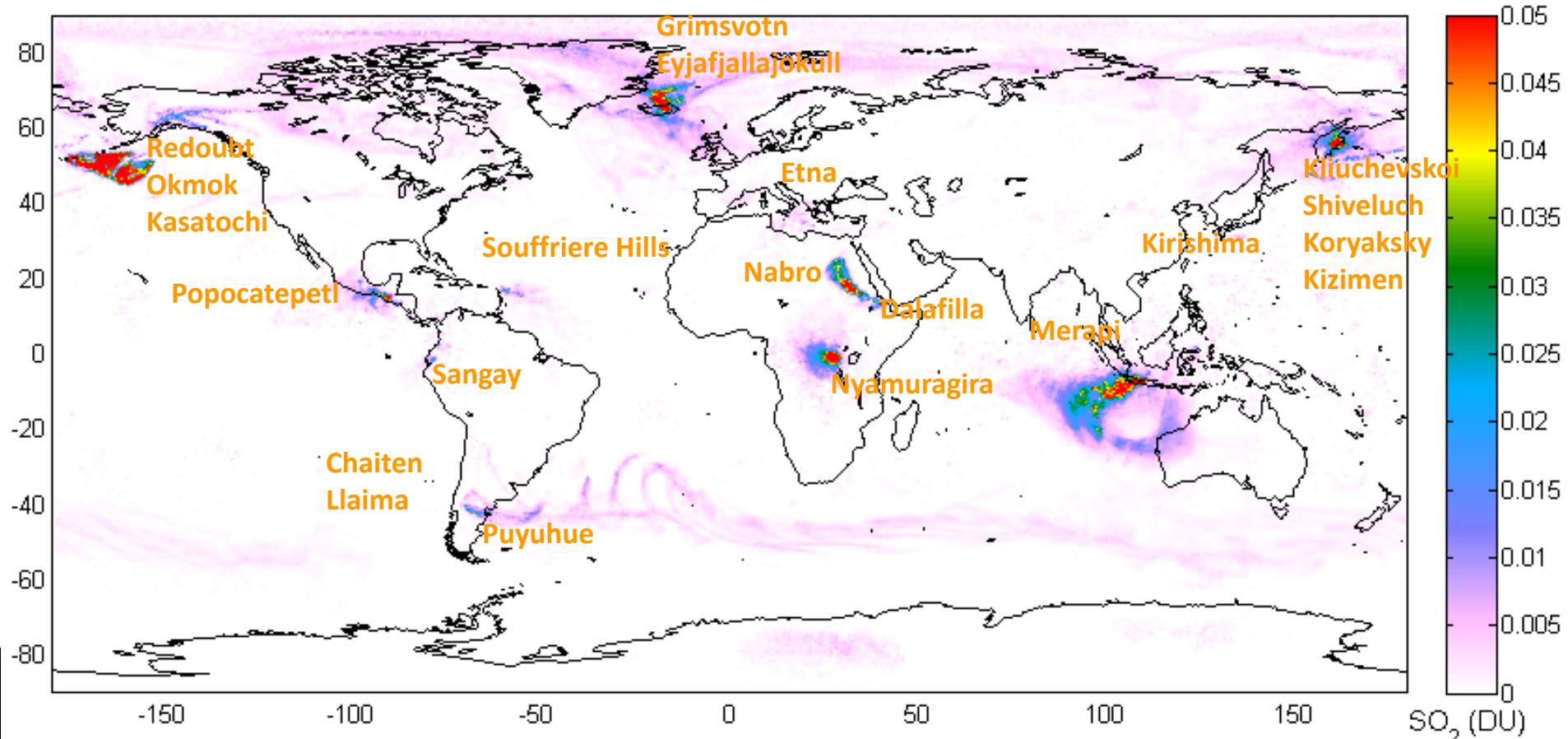
ASH



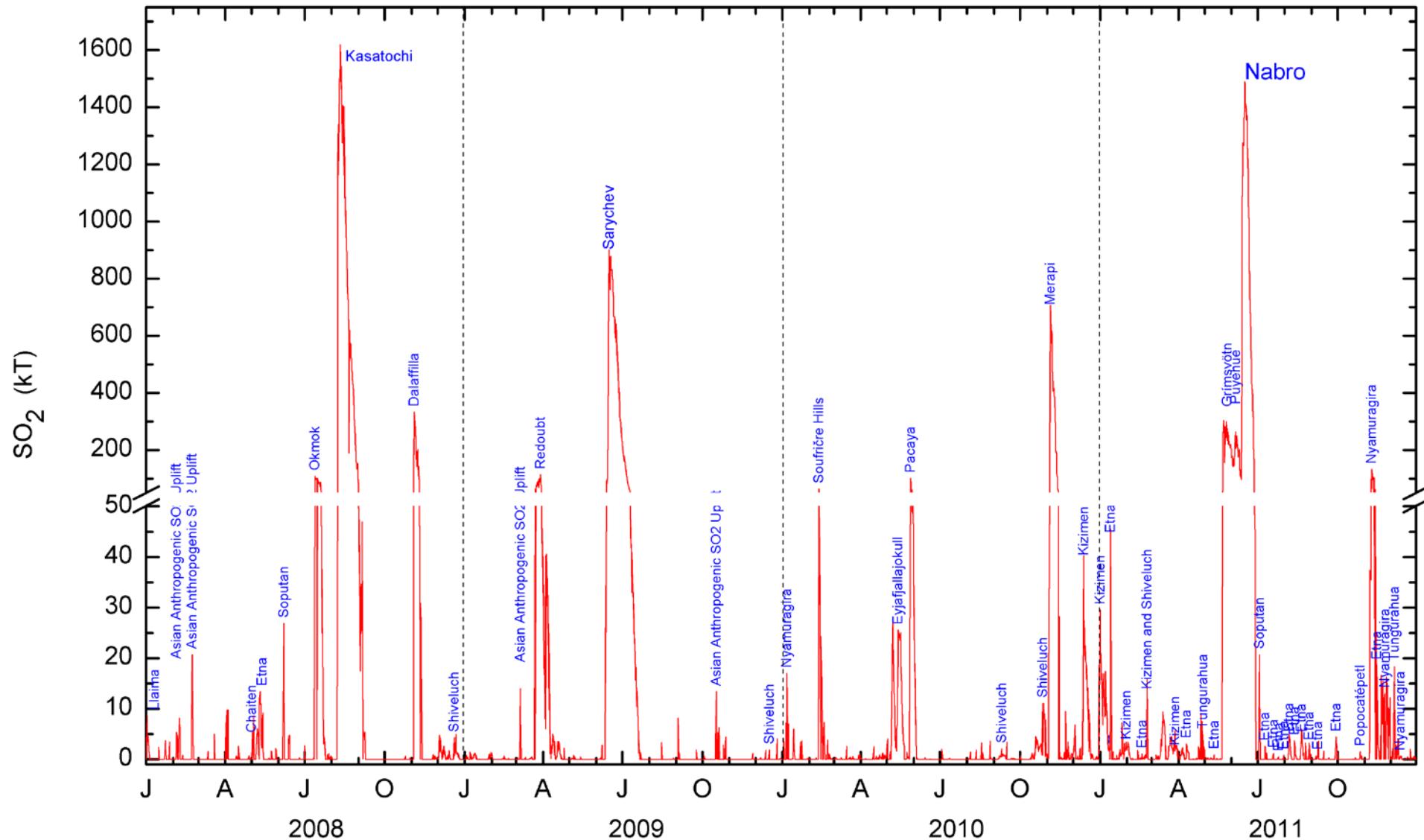
4 years time series of global FT SO₂ measurements



4 years time series of global FT SO₂ measurements (removing parts of Sarychev, Kasatochi, Nabro)

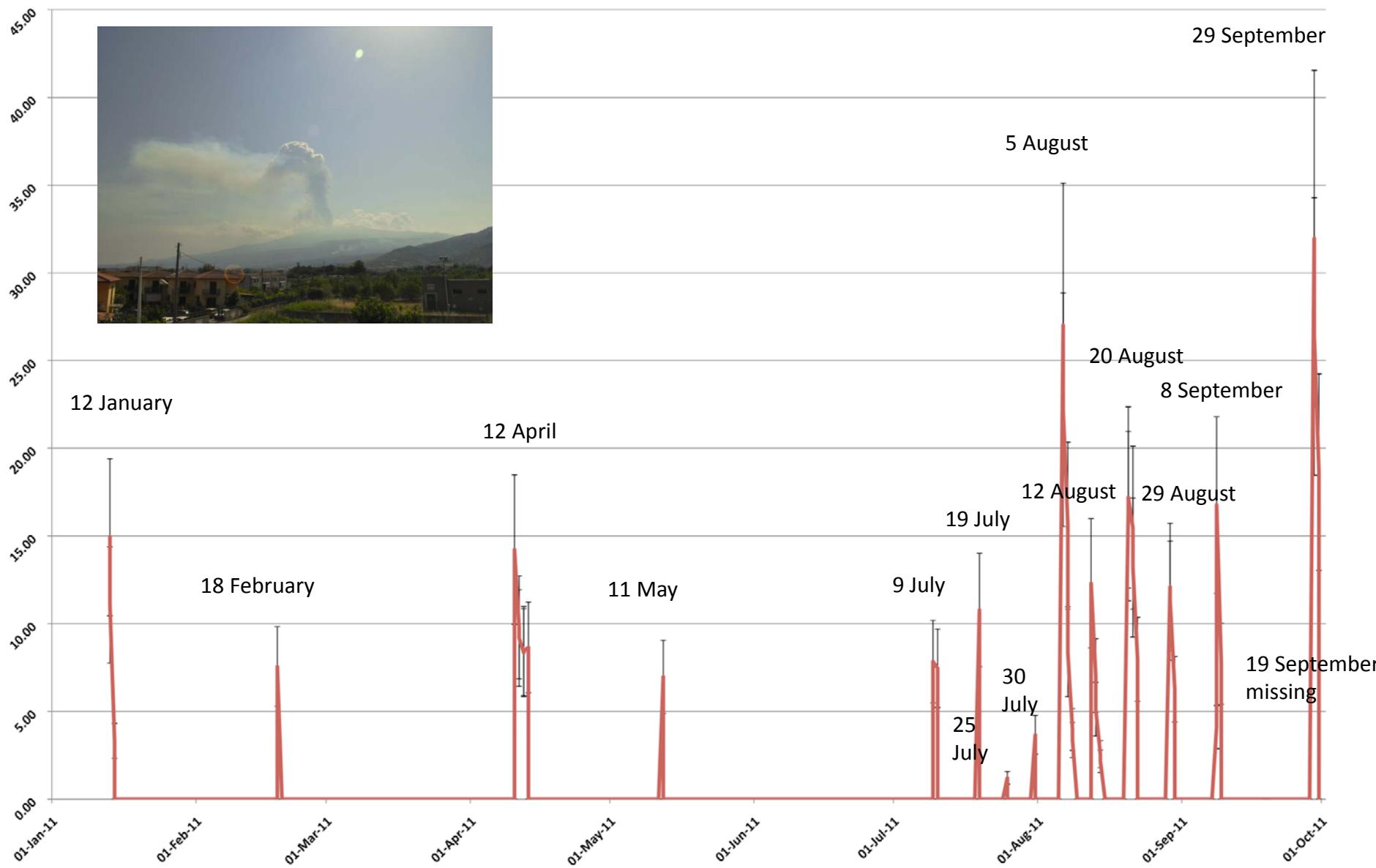


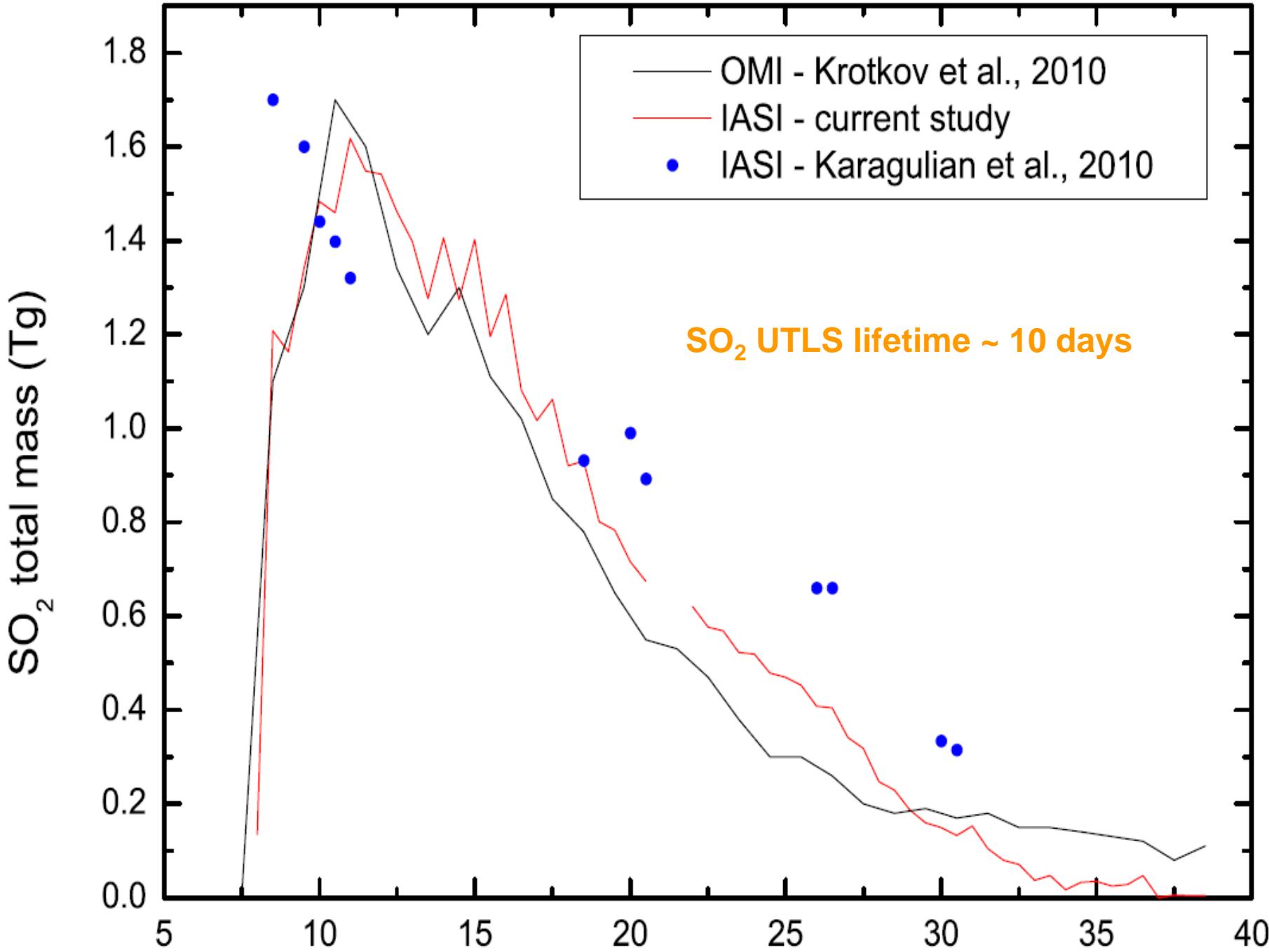
4 years timeseries of IASI SO₂



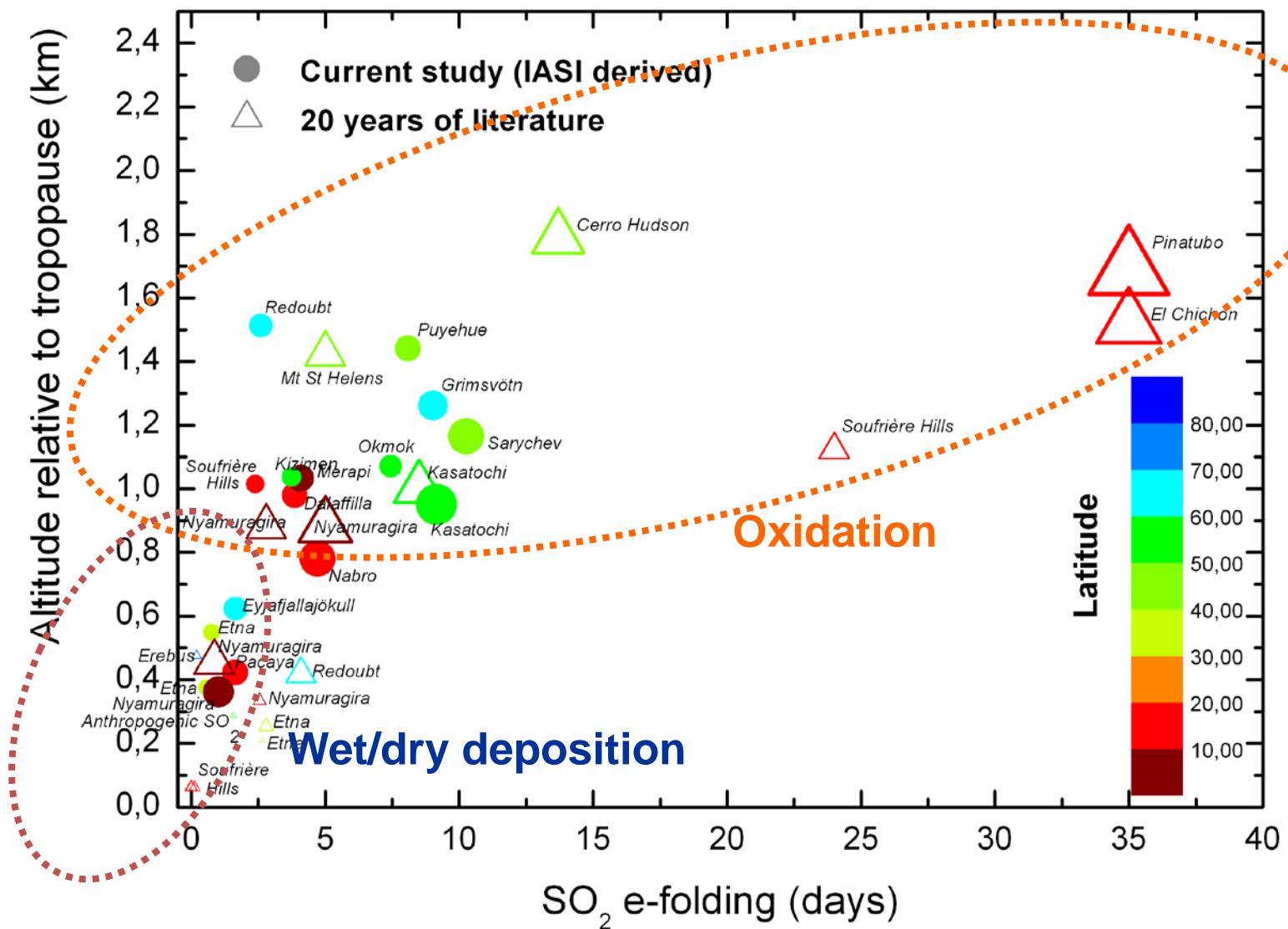
Courtesy L.Clarisse

Etna 2011 lava fountains: 14 / 15





4 years timeseries of IASI SO₂



Courtesy M.Tomasi

Operational alert systems

<http://cpm-ws4.ulb.ac.be/Alerts/>

Provides alerts from BT differences in SO₂ (ν_3 band) on BUFR basis (also e-mail system)
Useful for eruptions with emissions above the boundary layer

Objet: Automated SO2 Alert 20130206.022751
De: "Automated SO2 Alert" <dhurtma@ulb.ac.be>
Date: Mer 6 février 2013 7:27
À: undisclosed-recipients:;
Priorité : Normale
Options: [Afficher l'en-tête complet](#) | [Voir la version imprimante](#) | [Télécharger en tant que fichier](#)

```
Location > -15.420690 102.159300
Value      > 3.590567 K
#Points    > 4
File       >
W_BB-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPB+IASI_C_EUMC_20130206022657_02009_eps_t_11.bin
Link:      >
http://cpm-ws4.ulb.ac.be/Alerts/index.php?NewYear=2013&NewMonth=02&sel\_day=06&AlertList=SO2\_iiasi\_20130206\_022657\_metopb\_02009\_eps\_t.png
```

Implemented at Toulouse + London VAACs
Since beginning 2008, no false alert

Operational alert systems

ULB MeTop/IASI SO₂ Alerts

20130206

Spacecraft: Year: Month:

all 2013 2

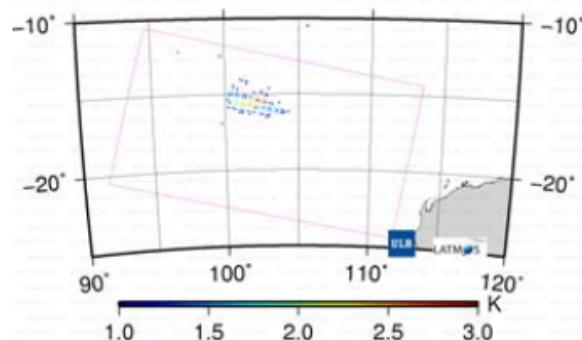
<< < # > >>

				01	02	
03	04	05	06	07	08	09
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

Alert time

022657
031159

SO₂ Alert 20130206.022657 (b 02009)





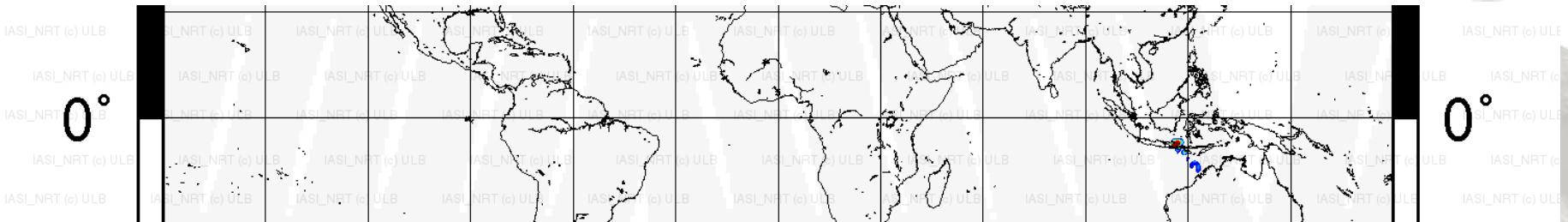
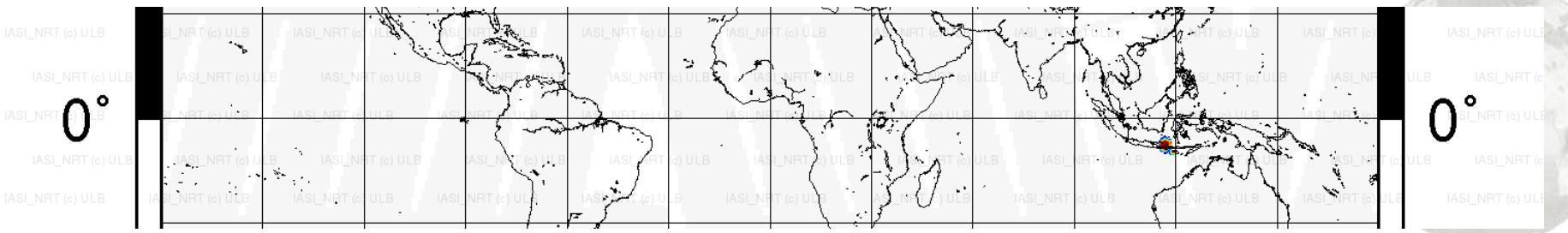
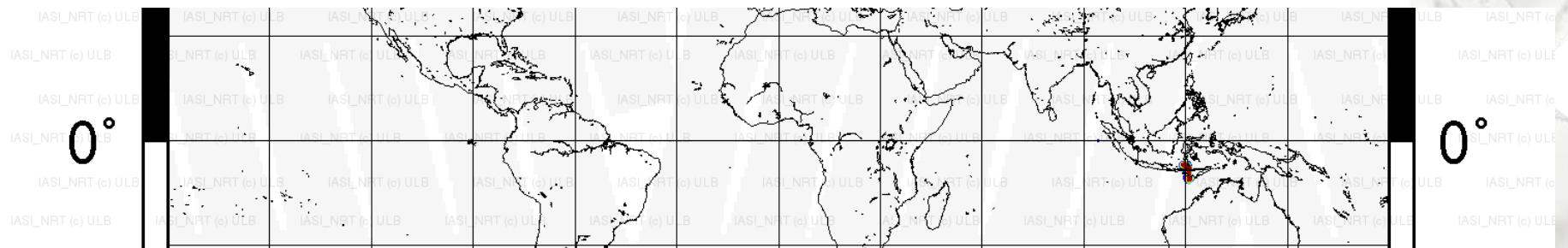
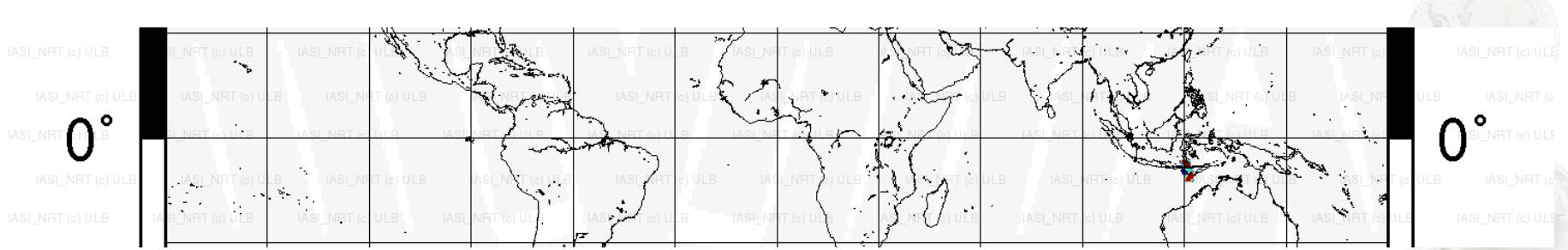
LATMOS / IPSL - ULB

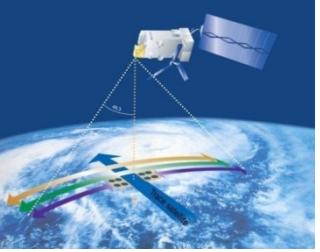


METOP-A

METOP-B

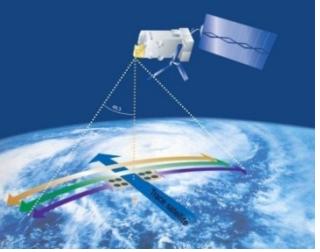
IXION





Total cost of IASI:
230 M€





Total cost of IASI:
230 M€



13 km of highway (17 M€/km)



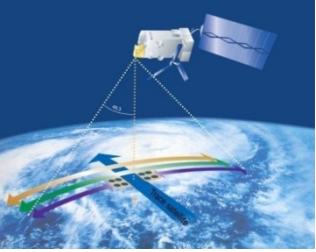
282 M€ = cost of the new Lille sport stadium



300 M€ = 4 months of french war in Libya



1850 M€ = removing asbestos from UPMC



Total cost of IASI: 230 M€

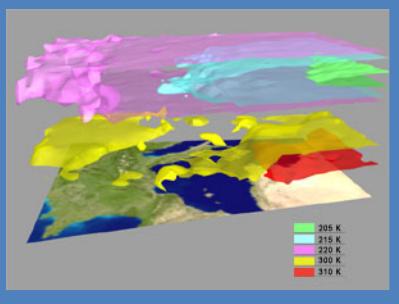


DEPARTURES				
Time	Destination	Flight	Gate	Remark
16:55	FRANKFURT	LH4809		DUE TO VOLCANIC ASH
17:10	ZURICH	LX465		DUE TO VOLCANIC ASH
17:10	EDINBURGH	BA8712		CANCELLED
17:20	DUBLIN	AF5119		CANCELLED
17:35	AMSTERDAM	VG240		CANCELLED
17:35	EDINBURGH	AF5165		DUE TO VOLCANIC ASH
17:45	NANTES	AF5209		DUE TO VOLCANIC ASH
17:50	ROTTERDAM	VG290		CANCELLED
17:50	AMSTERDAM	VG240		DUE TO VOLCANIC ASH
17:50	MILAN/LINATE	AP4219		CANCELLED
19:00	EDINBURGH	BA8708		CANCELLED
18:05	ANTWERP	AF5237		DUE TO VOLCANIC ASH
18:10	GLASGOW	BA8728		CANCELLED
18:20	ROTTERDAM	VG292		DUE TO VOLCANIC ASH
18:20	ZURICH	LX467		DUE TO VOLCANIC ASH
18:20	PARIS - ORLY	AF5027		CANCELLED
18:30	COPENHAGEN	QI3626		CANCELLED

Somn Thursday 15 April 2010

Looking forward to IASI-NG ...

Atmospheric profiling

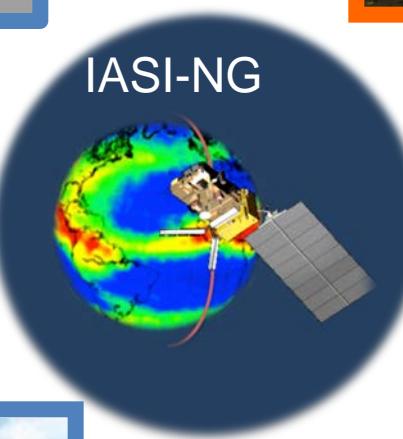


PIs: C. Crevoisier & C. Clerbaux

Essential Climate Variables monitoring and understanding
Clouds, GHG, aerosols



IASI-NG



Improvement on pollution forecast
3 EU controlled pollutants (CO, O₃ and NH₃)



Better tracking of long range pollution (e.g. fire emissions)



Improved volcano alerts
Early alerts possible + SO₂ and ash tracking

For T, WV, O₃, CO, CO₂, etc : more information on the vertical.

For weak absorbers : improved detection limit + more species measured instead of detected