BIRA·IASB

aeronomie·be

Royal Belgian Institute for Space Aeronomy (BIRA-IASB)

Institut royal d'Aéronomie Spatiale de Belgique (IASB)

Koninklijk Belgisch Instituut voor Ruimte-Aeronomie (BIRA)

Aerosol detection / estimation with hyperspectral (thermal) infrared satellite measurements

Sophie Vandenbussche … and many more!!

KONINKLIJK BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT ROYAL D'AERONOMIE SPATIALE DE BELGIQUE ROYAL BELGIAN INSTITUTE OF SPACE AERONOMY KONINKLIJK BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT ROYAL D'AERONOMIE SPATIALE DE BELGIQUE ROYAL BELGIAN INSTITUTE OF SPACE AERONOMY KONINKLIJ

- Aerosols signatures
- Aerosols detection methods
- Desert dust retrievals with IASI
- Volcanic ash retrievals with IASI
- Transfer to other instruments

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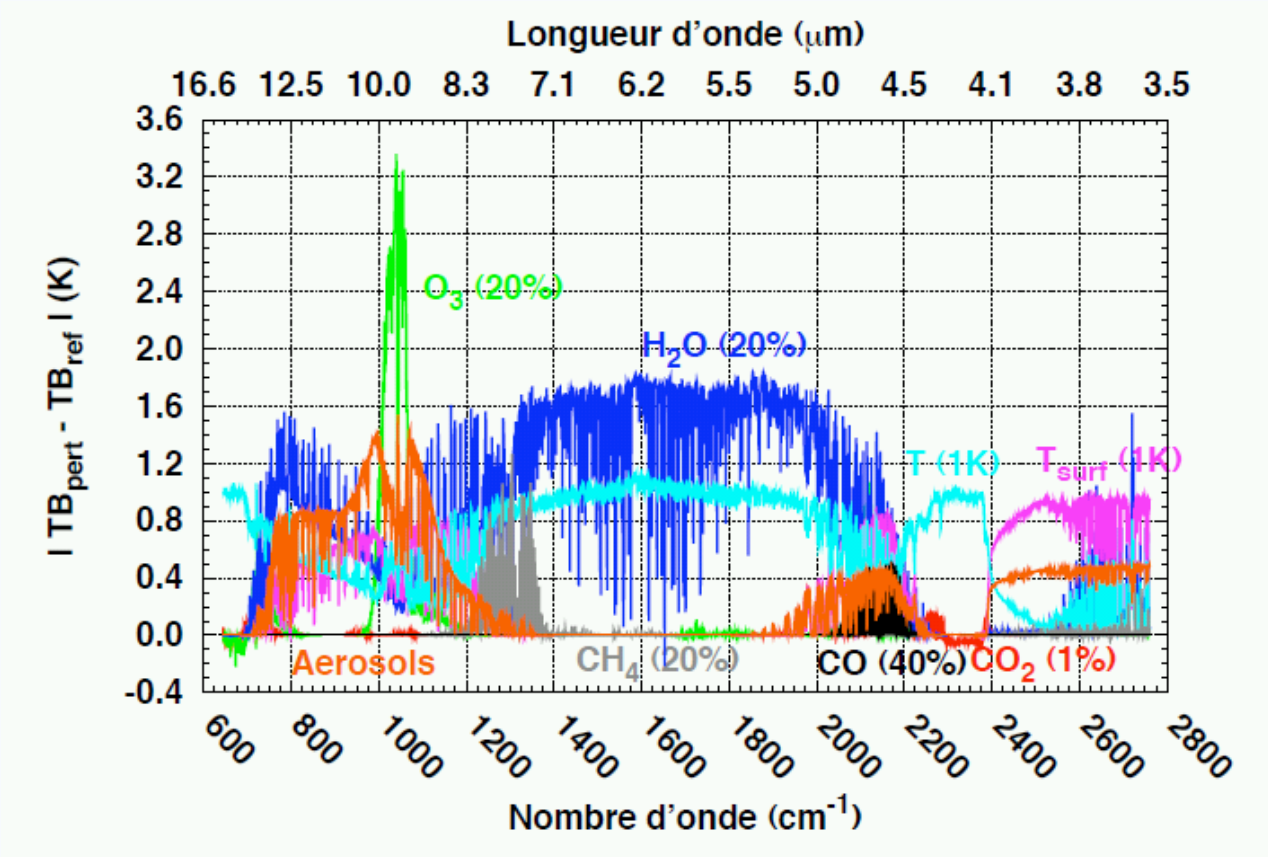
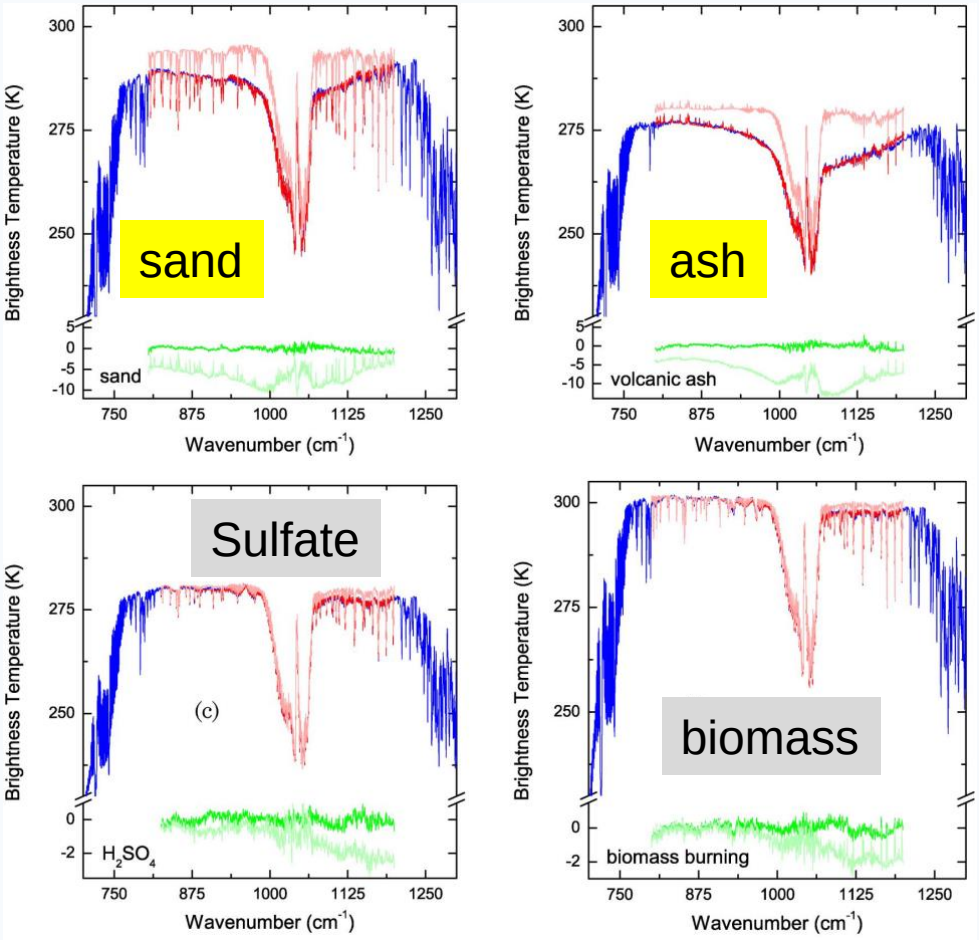
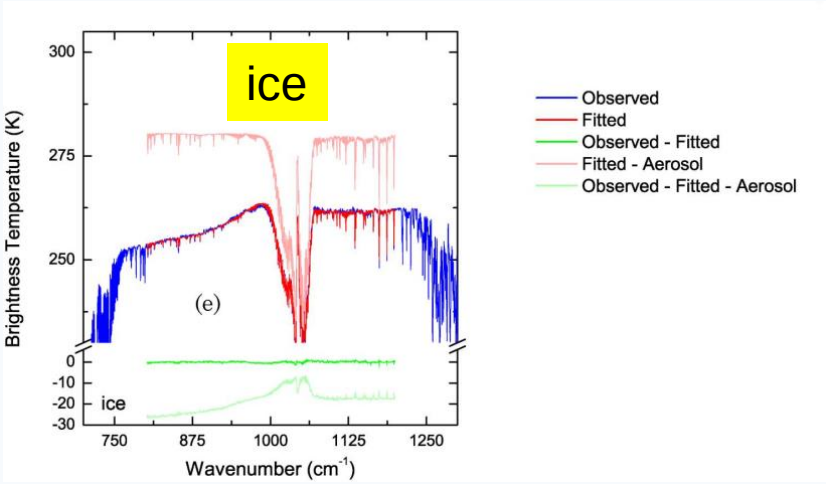
TIR aerosols signature in general



PhD thesis of S. Peyridieu, LMD 2010

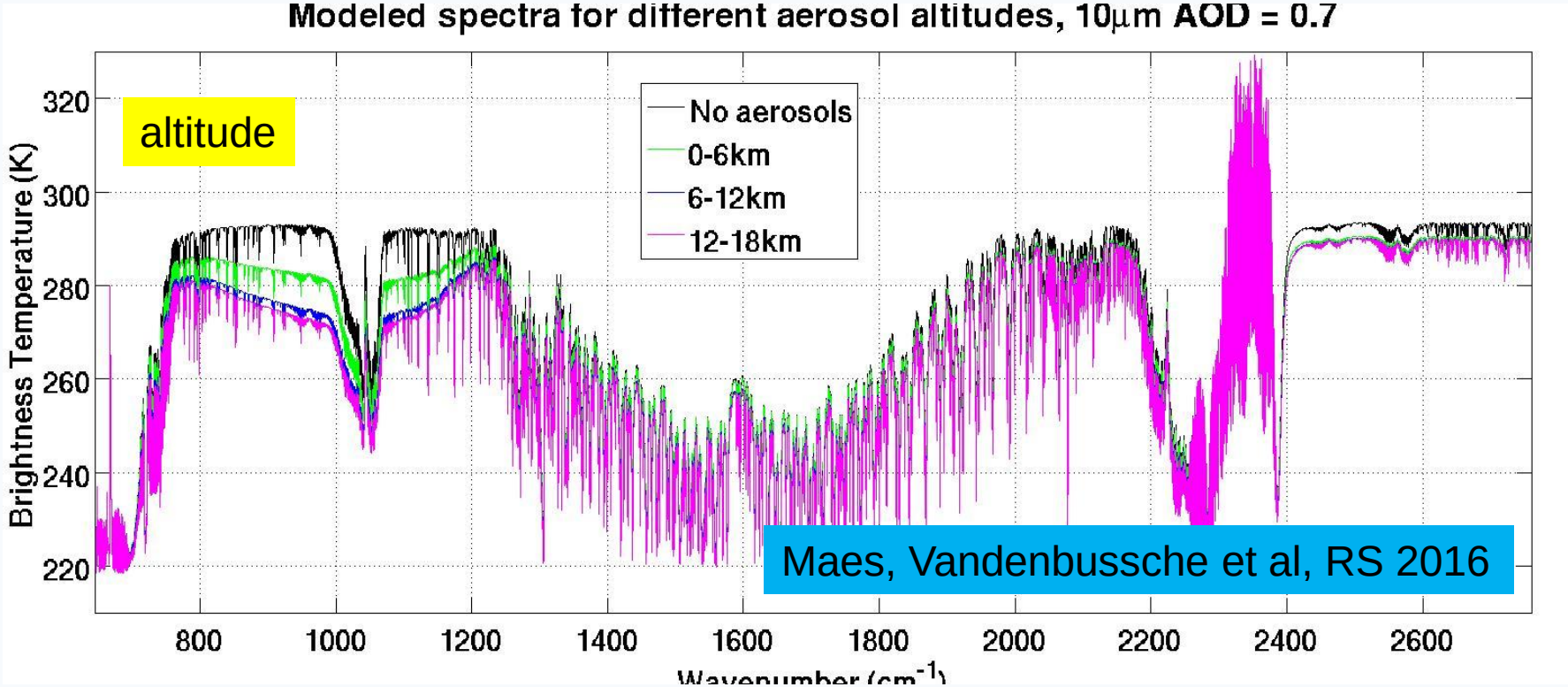
TIR aerosols signature: which type?





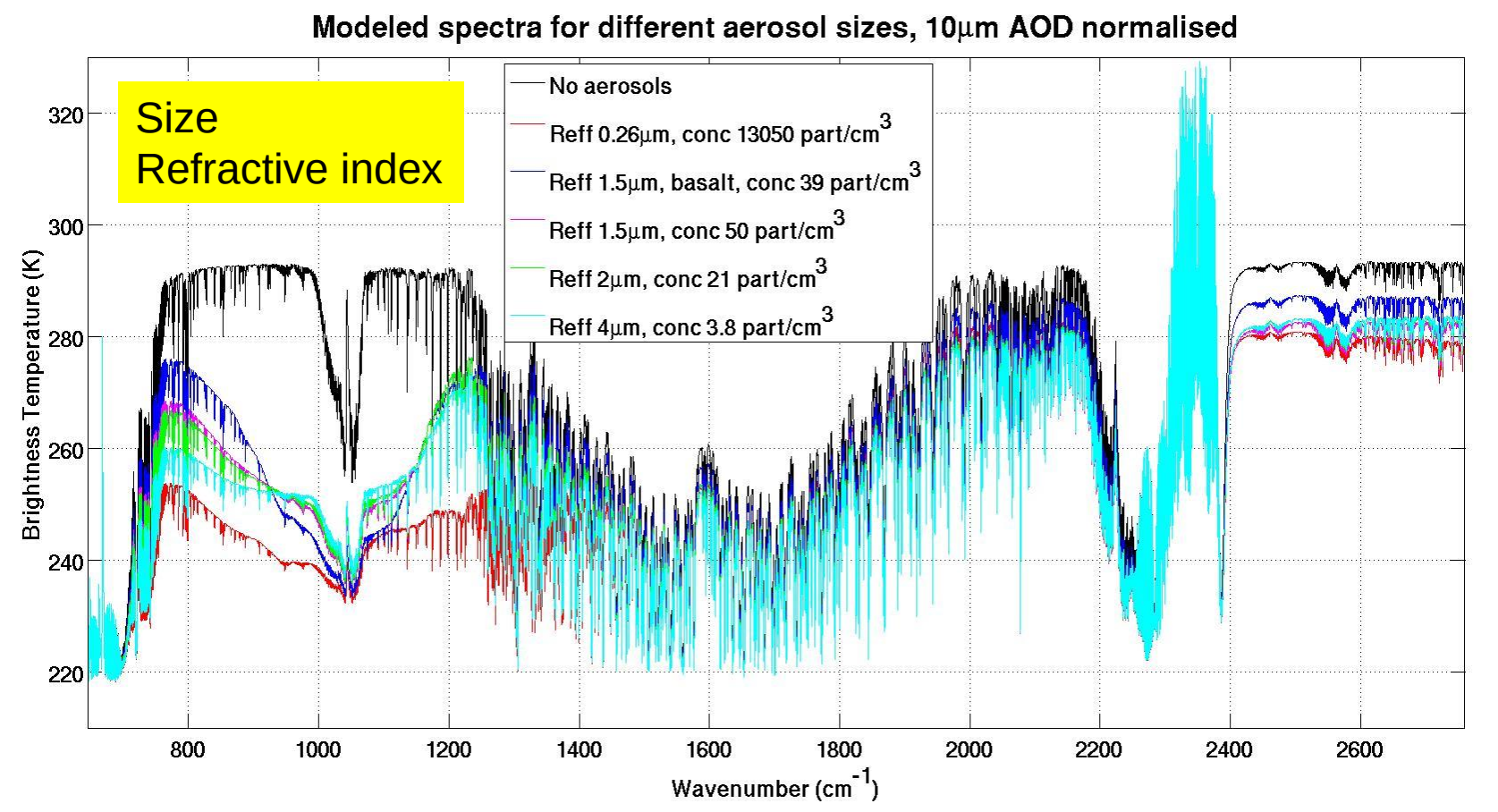
Clarisse et al, AO2010

Mineral aerosols signature: ash



The altitude effect depends on Ts, emissivity and the T profile
Altitude impact is significant only in 750-1250 window

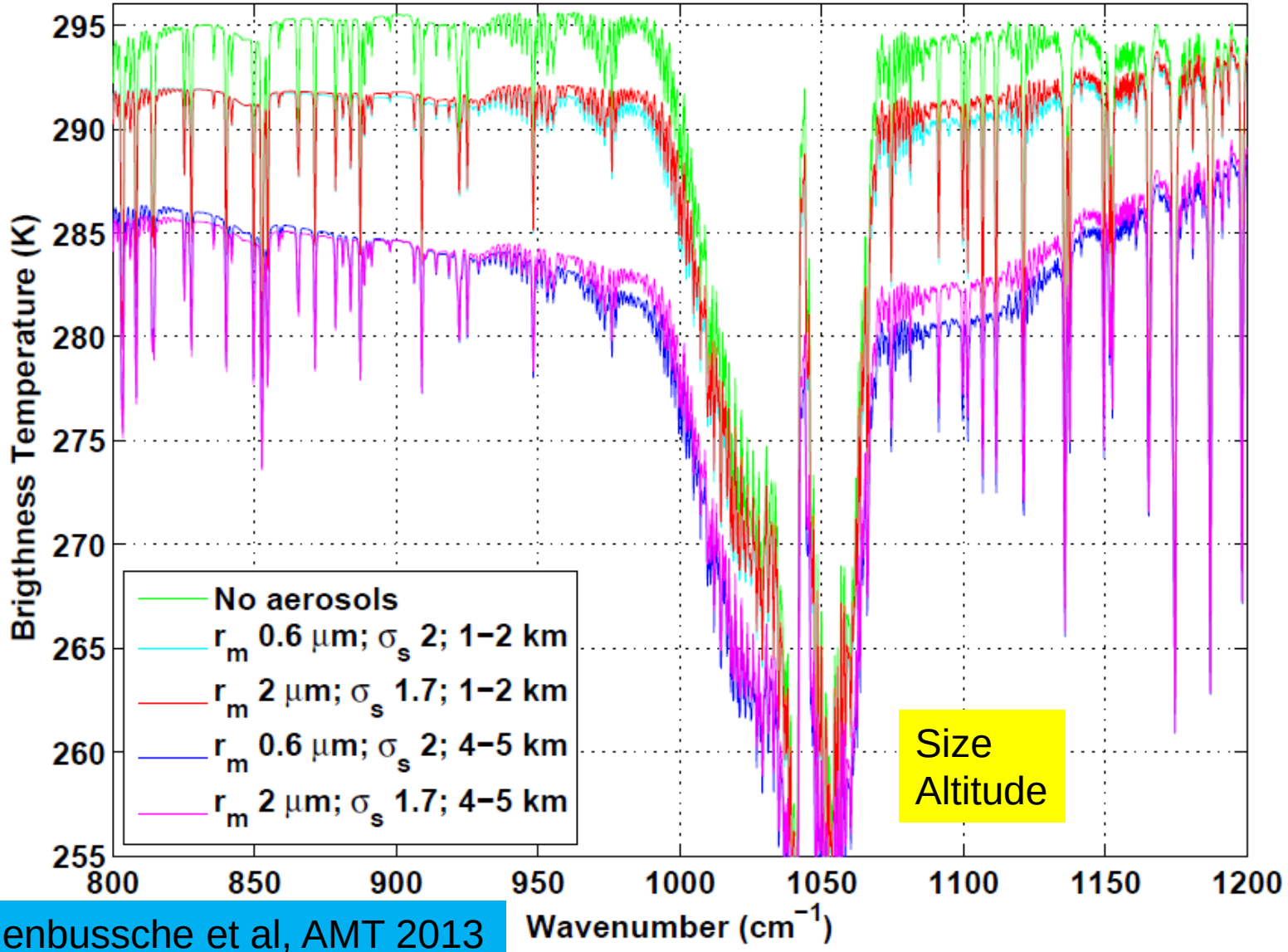
Mineral aerosols signature: ash



Each concentration was scaled for the same AOD of 2.2 at 10µm

Maes, Vandenbussche et al, RS 2016

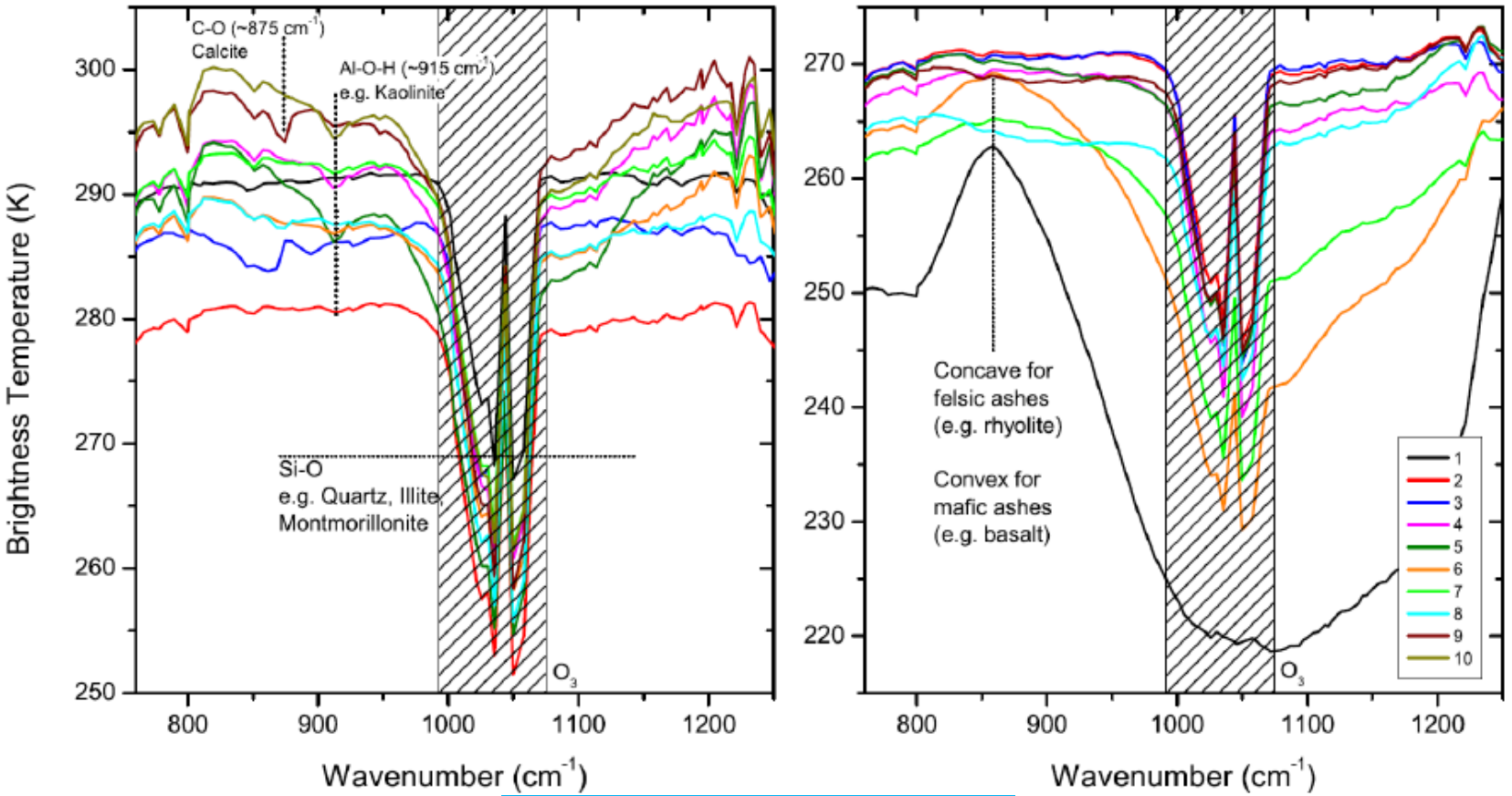
Mineral aerosols signature: dust



Vandenbussche et al, AMT 2013

Mineral aerosols signature: dust / ash

Clustered mean spectra for sand (left panel) and volcanic ash (right panel) as generated by the k-means algorithm on spectra observed over a variety of airborne sand and ash plumes, respectively.



Clarisse et al, ACP 2013

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Mineral aerosol detection in TIR

The goal is to detect aerosols in a scene:

- to avoid unknown contamination (would impact humidity analysis, therefore the whole NWP system)
- to run aerosol retrievals only on identified relevant scenes

↓

Detection must be independent from and faster than aerosol retrievals

↓

Not as easy as one could think…

Mineral aerosol detection in TIR

NWPSAF Cloud and Aerosol Detection Software (CADS)

- Pattern recognition algorithm
- First cloud/aer detection based on BT diff between obs and calc with good estimate of atmosphere
- Discrimination based on effect around 8µm

assessed vs ULB AOD by J. Vidot, Météo France

CADS detects desert dust and volcanic ash

26% of aerosol contaminated pixels are detected by CADS

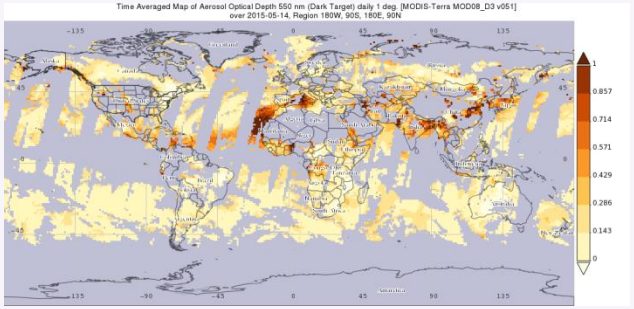
67% are classified as clouds by CADS

Remaining 7% classified as clear-sky by CADS have AOD<0.05

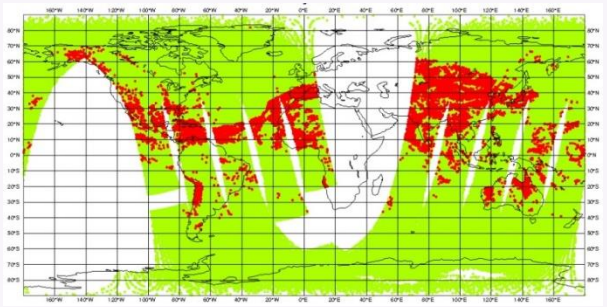
Mineral aerosol detection in TIR

ECMWF aerosol detection (from J. Letertre-Danczak)

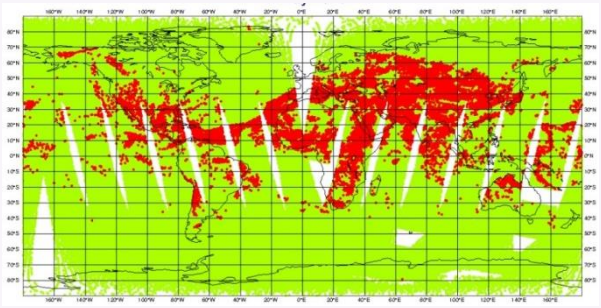
MODIS TERRA



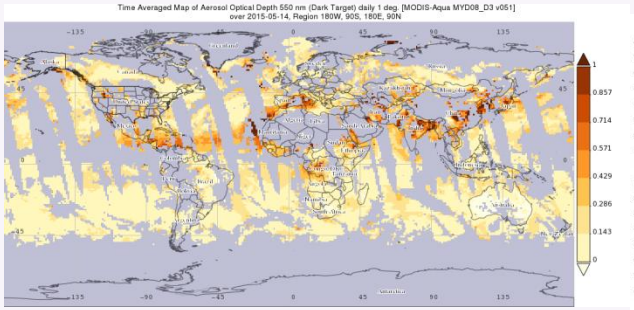
IASI METOP-A



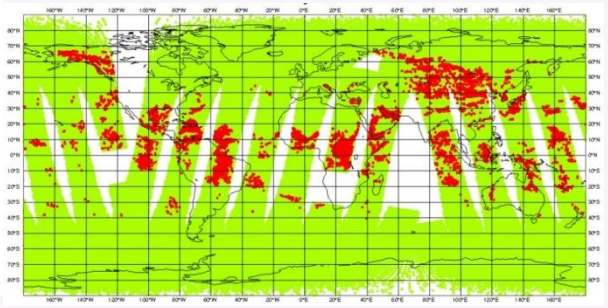
IASI METOP-B



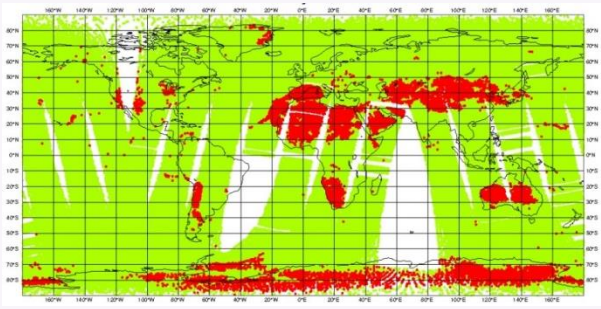
MODIS AQUA



AIRS



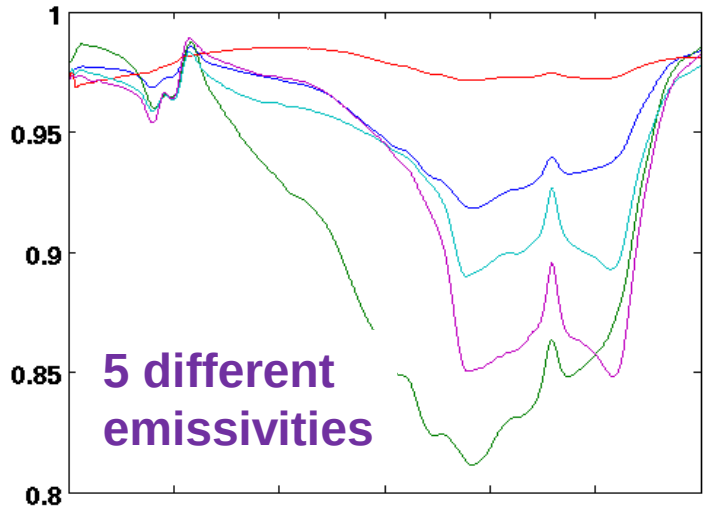
CrIS

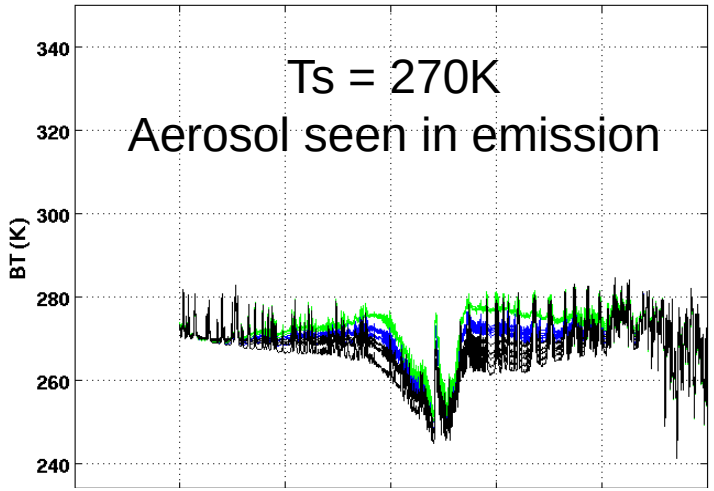


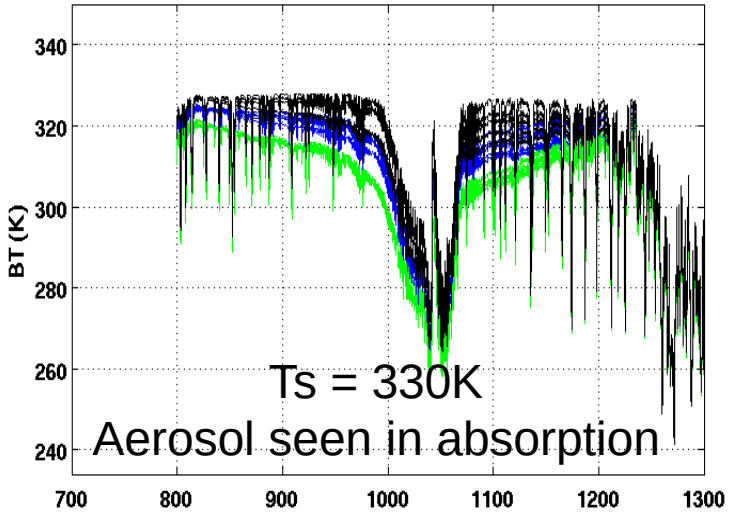
Mainly dust, can be extended to volcanic ash.

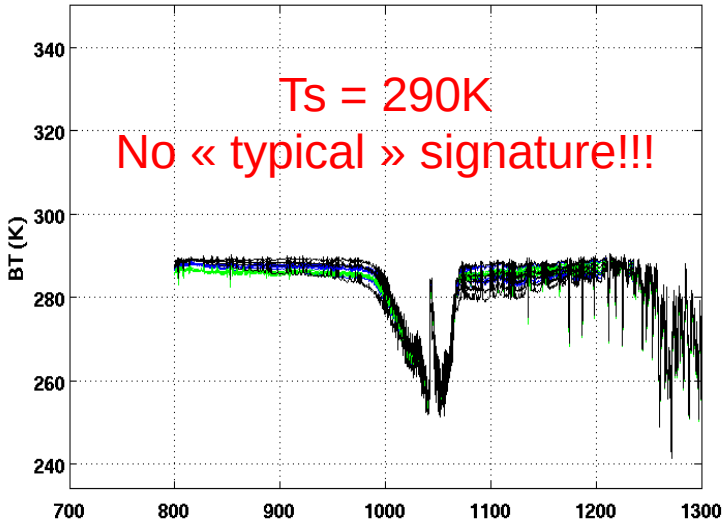
Mineral aerosol detection in TIR

Trying to use BTDs







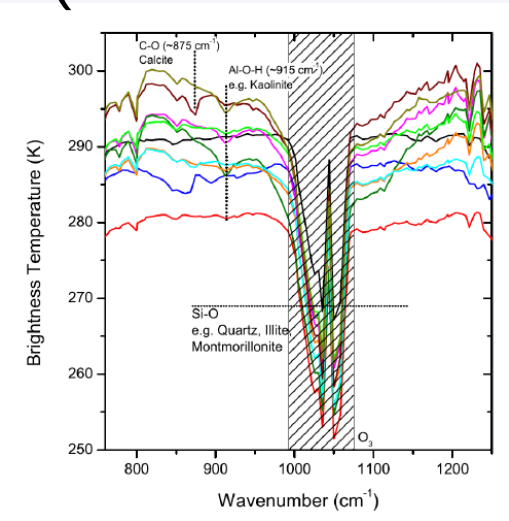


Clear sky
20 part/cm³ 0-7km
50 part/cm³ 0-7km

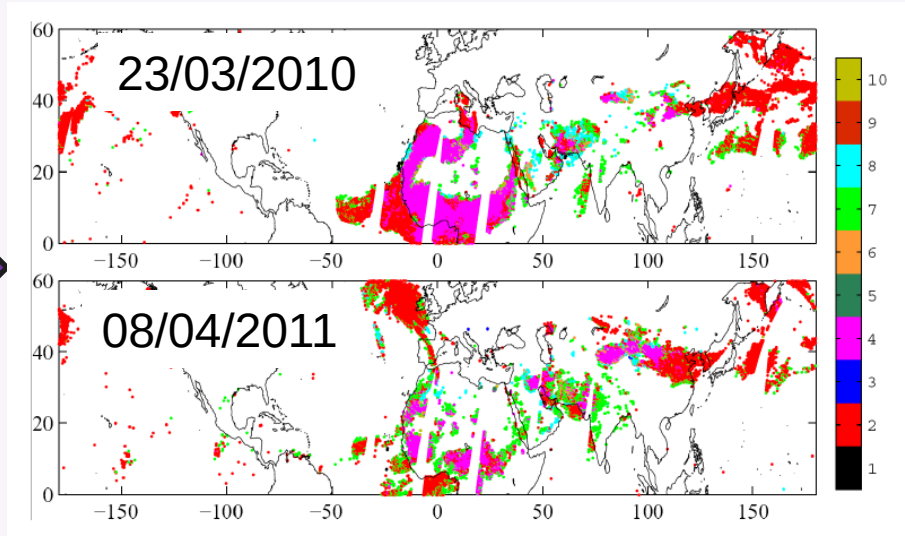
Mineral aerosol detection in TIR

ULB detection method: example of dust

10 different mean dust spectra
(from real obs. analysis)



10 tests

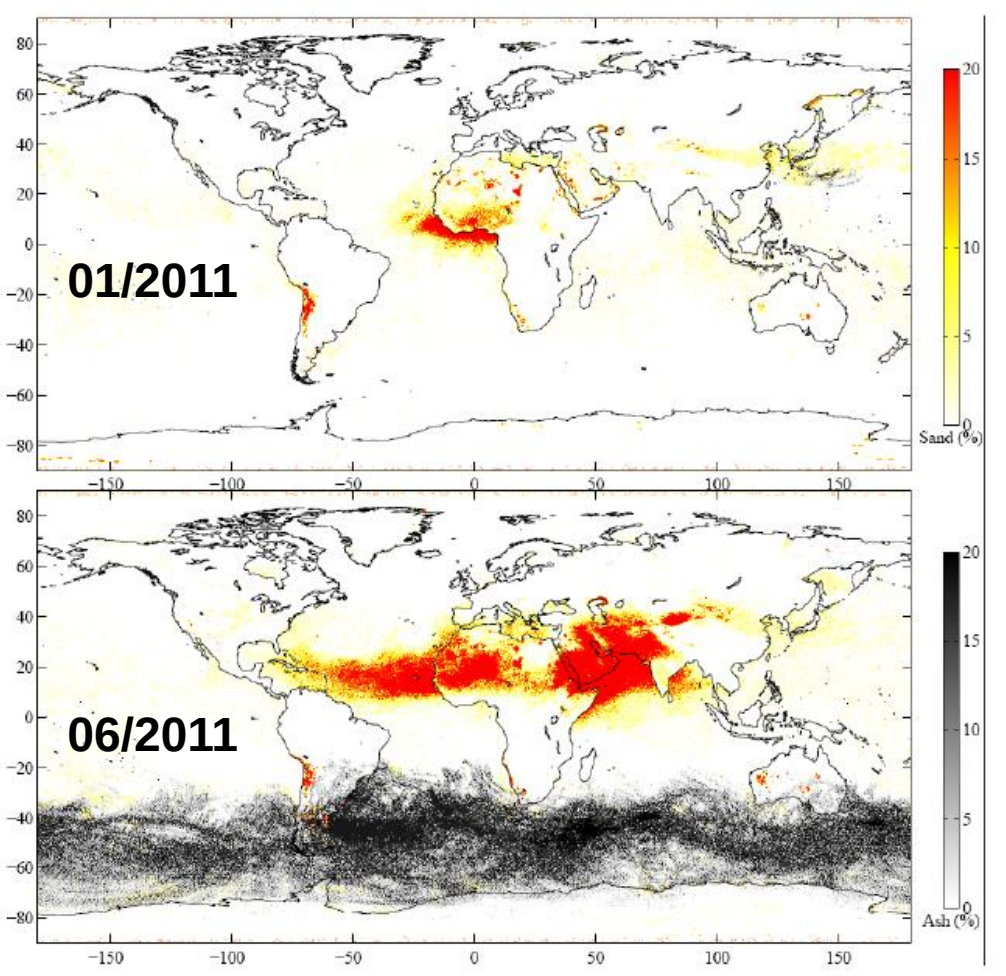


Different tests triggered over land and ocean, depending on the source area, on the temperature difference between the surface and the dust layer

Clarisse et al, ACP 2013

Mineral aerosol detection in TIR

ULB detection method: dust and ash differentiation



Clarisse et al, ACP 2013

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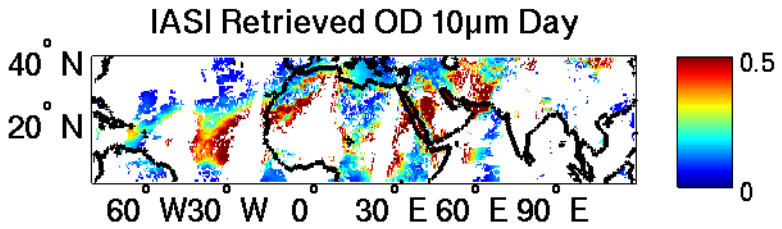
IASI mineral dust aerosols retrievals

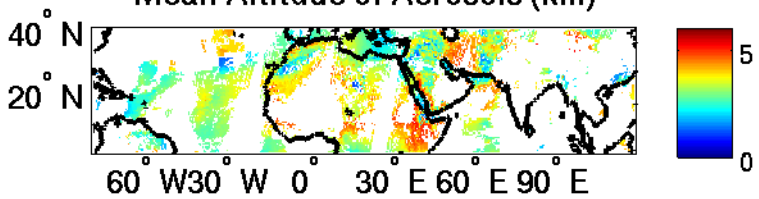
BIRA-IASB	DLR	LISA	LMD	ULB
MAPIR	IMARS	AEROIASI	-	-
S. Vandenbussche	T. Popp	J. Cuesta	V. Capelle	L. Clarisse
sophie.vandenbussche@aeronomie.be	thomas.popp@dlr.de	Juan.Cuesta@lisa.u-pec.fr	virginie.capelle@lmd.polytechnique.fr	lclariss@ulb.ac.be
Rodgers OEM	PCA, own a posteriori cloud filter	Tikhonov regularisation	LUT, own cloud filter & emissivity	NN
2007-2016	2007-2016	Different parts of the dust belt for different periods	2007-… (NRT)	2007-now
Tropical belt (A)	Globe (A)		Globe (A + B)	Globe (A)
3D distribution (->AOD, mean altitude), Ts	AOD, mineral composition, size	3D distribution (->AOD, mean altitude)	NRT: AOD, Ts, mean altitude, Climato: size, emissivity	AOD

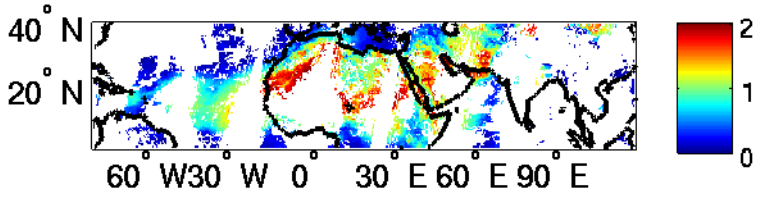
Obviously, all have improvements and new developments planned/undergoing

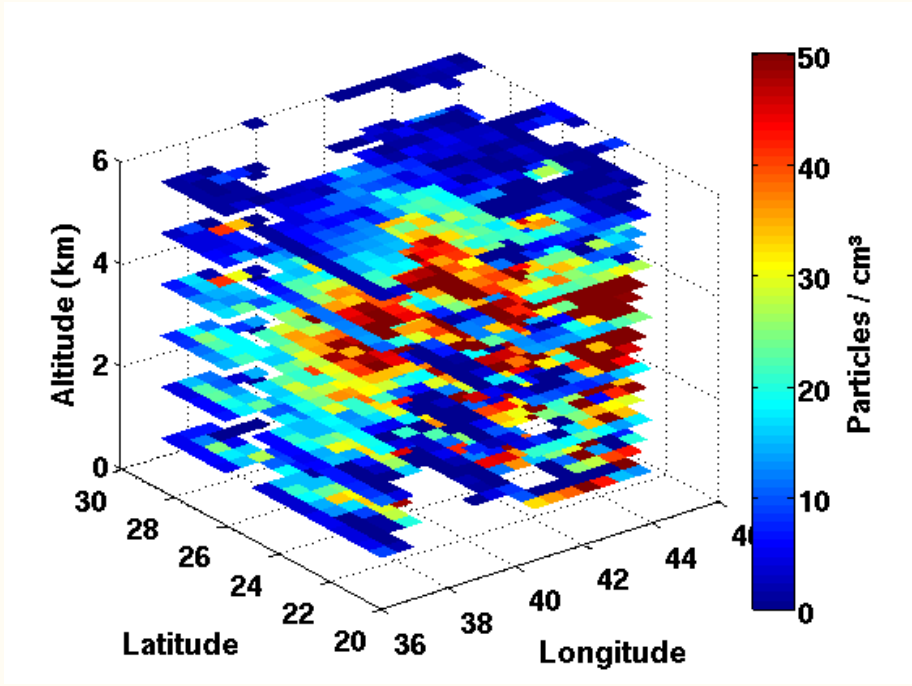
BIRA-IASB MAPIR algorithm

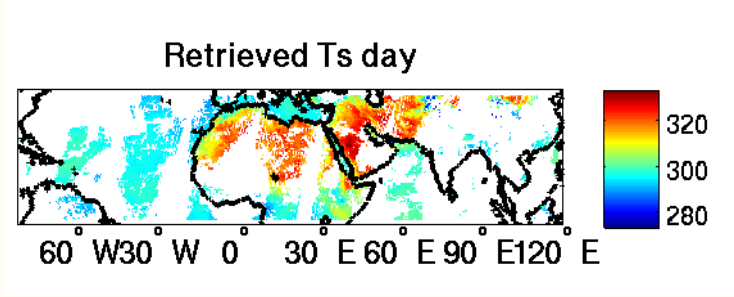
15/06/2015





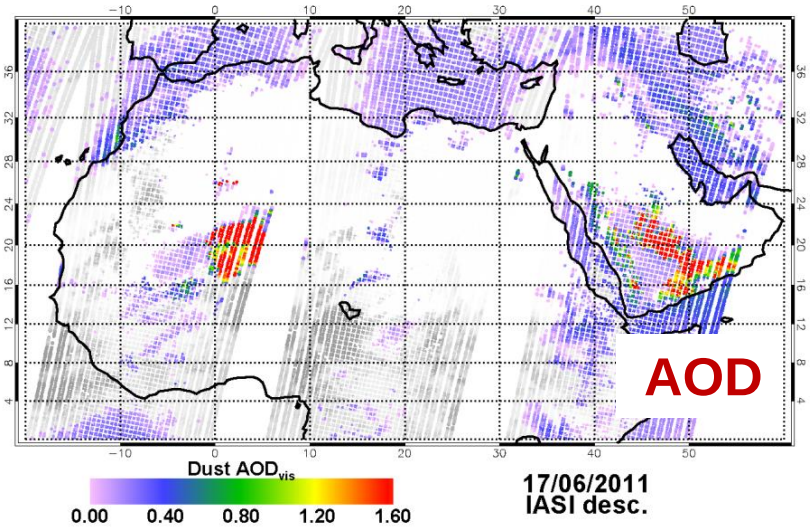


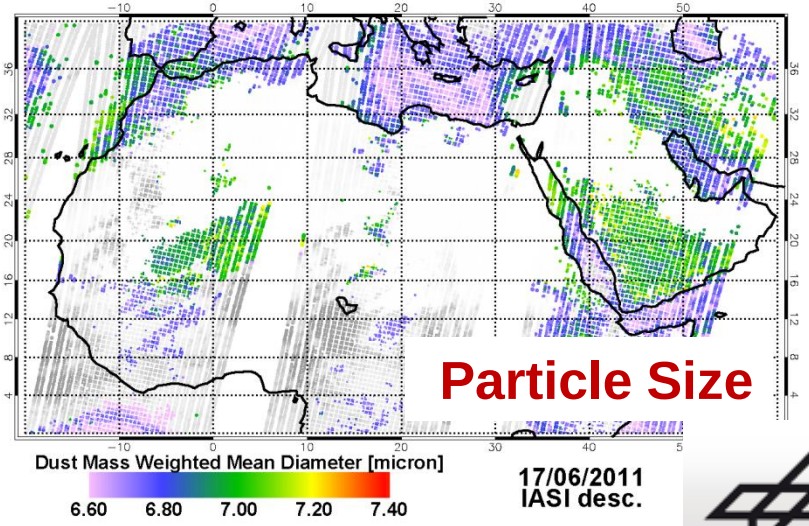


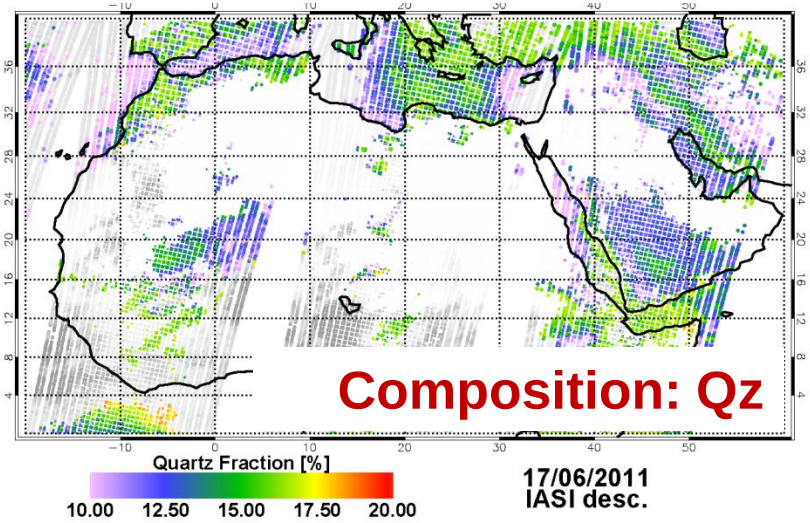


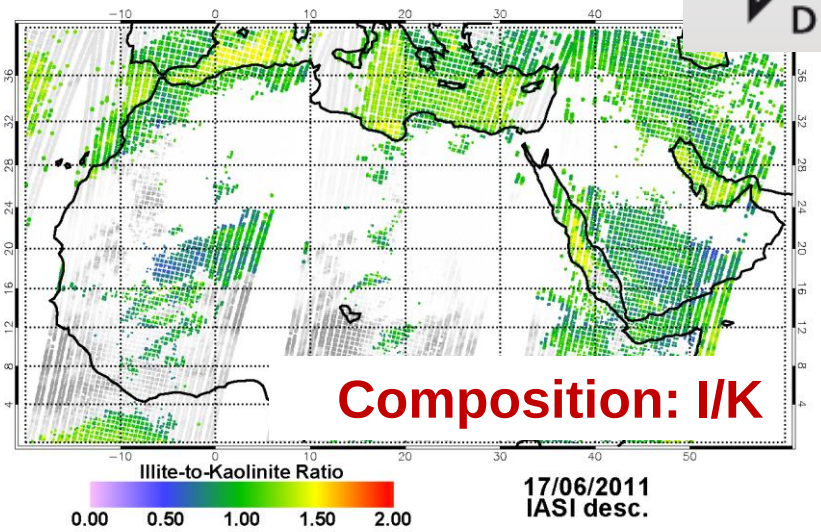
DLR IMARS algorithm

17/06/2011





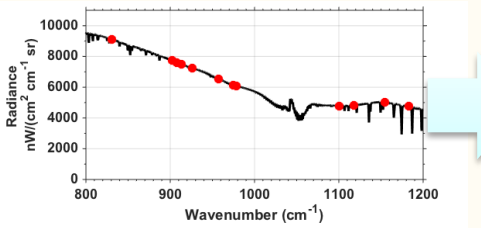




LISA AEROIASI algorithm

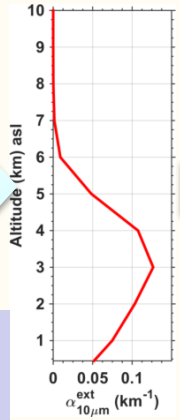
17/06/2011

Cloud-free IASI spectrum

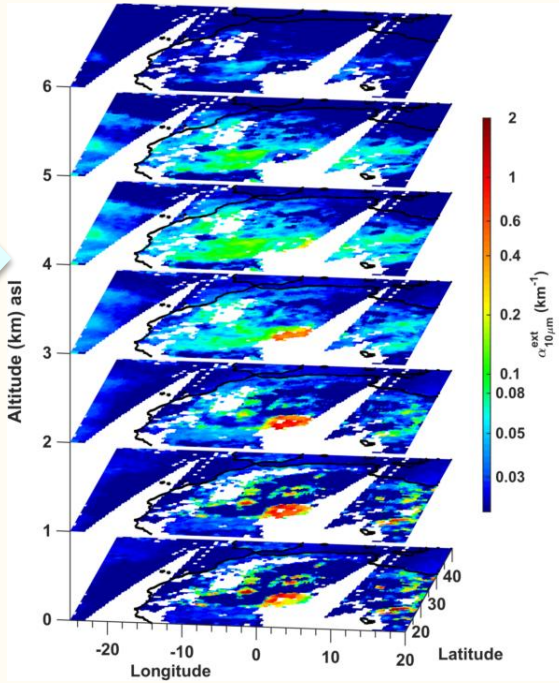


Hyperspectral fit of IASI thermal IR spectra, by auto-adaptive Tikhonov-Philips regularisation

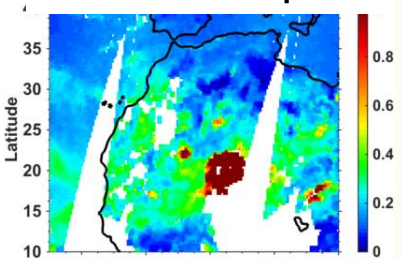
Dust extinction profile



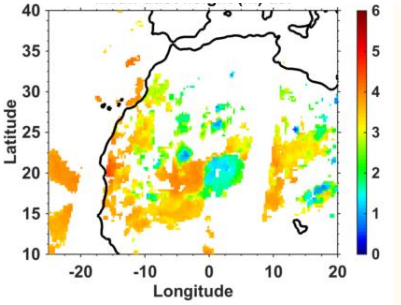
AEROIASI 3D distribution of dust



AOD at 10 µm



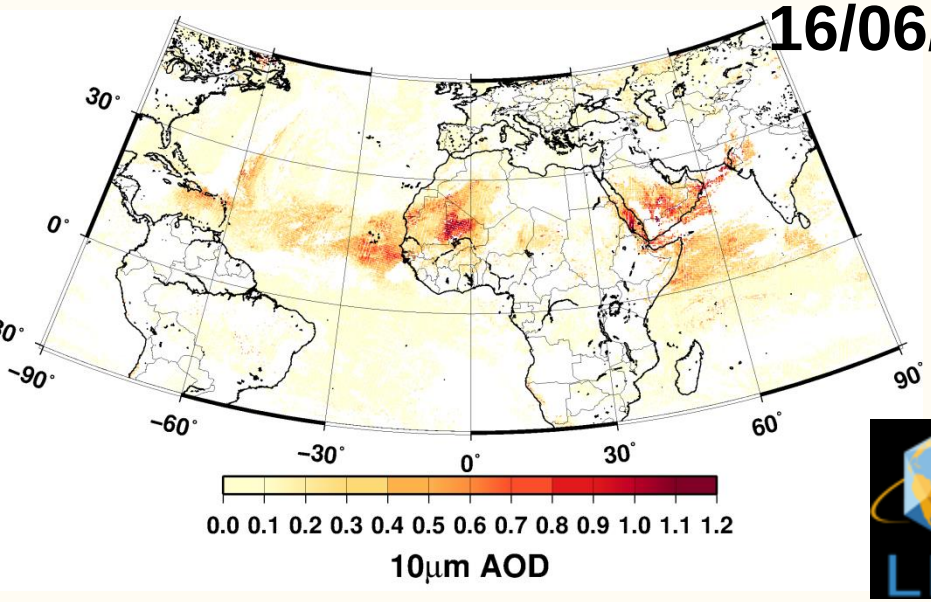
Altitude of dust

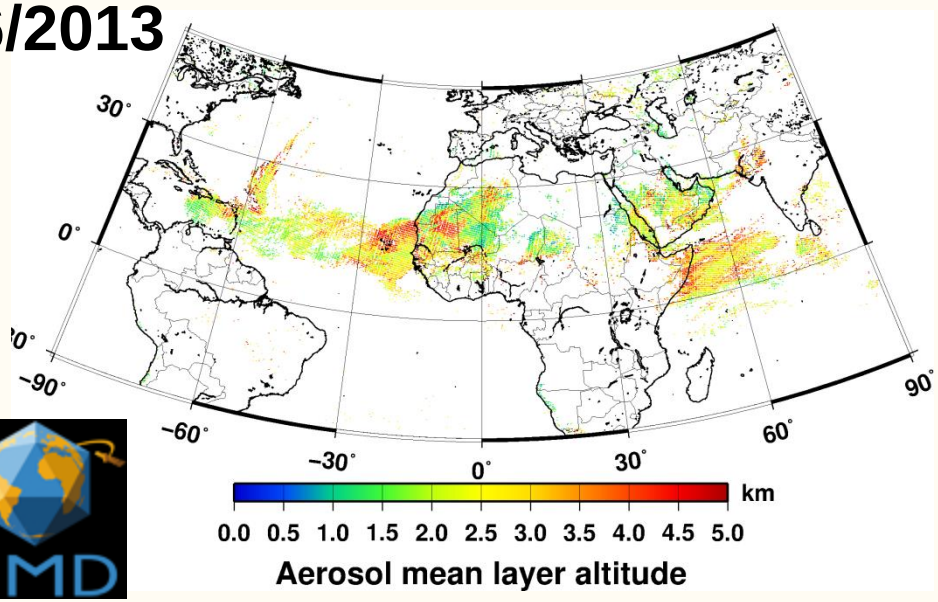


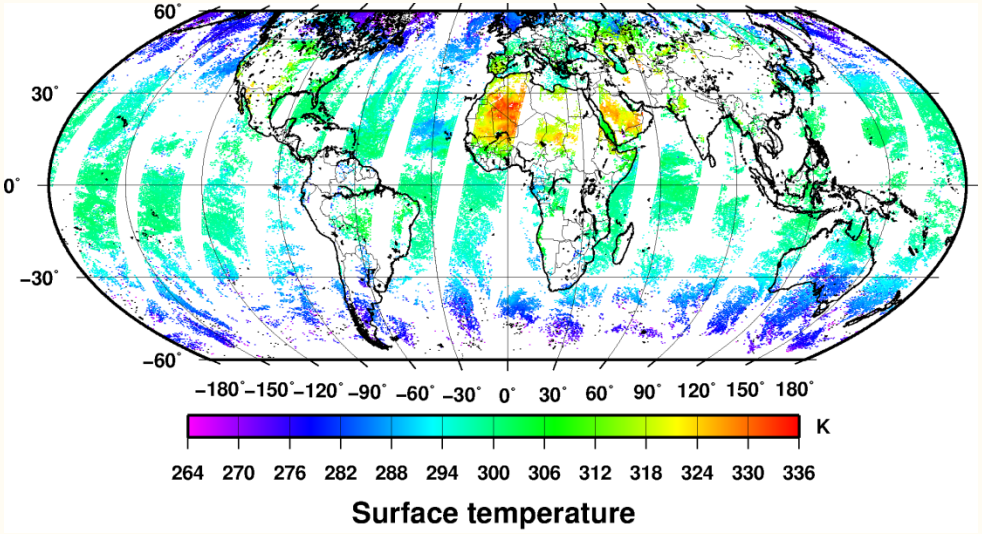
Based on the algo described in Cuesta et al., JGR 2015

LMD algorithm

16/06/2013



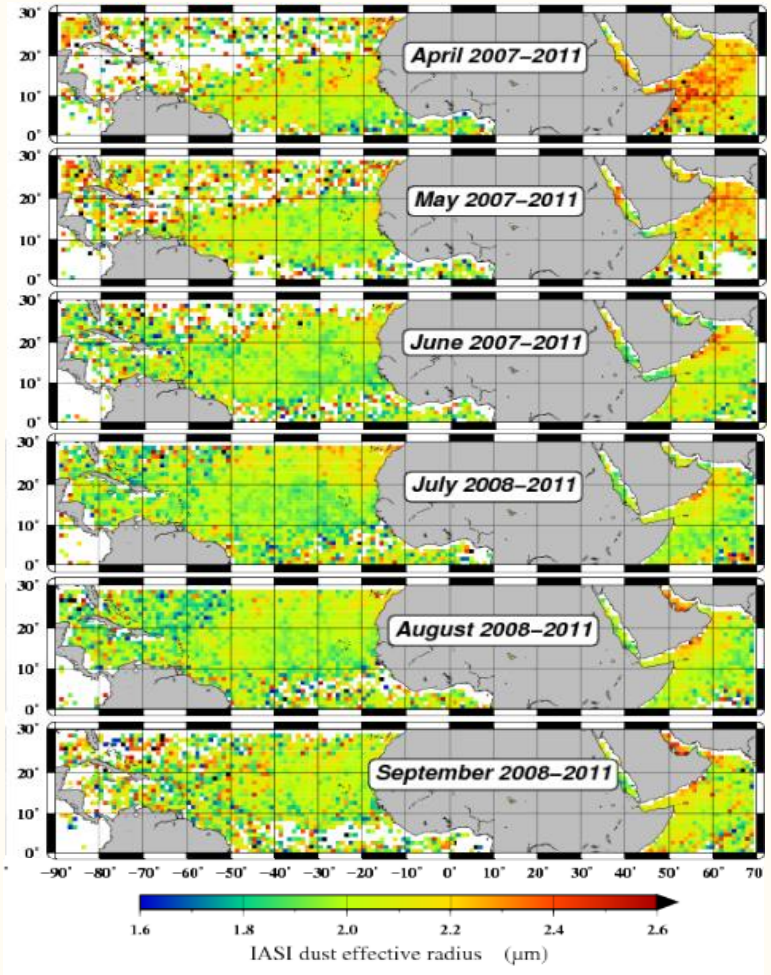




Database: ~10 years of IASI/Metop-A and 4 years of IASI/Metop-B available on http://ara.abct.lmd.polytechnique.fr/

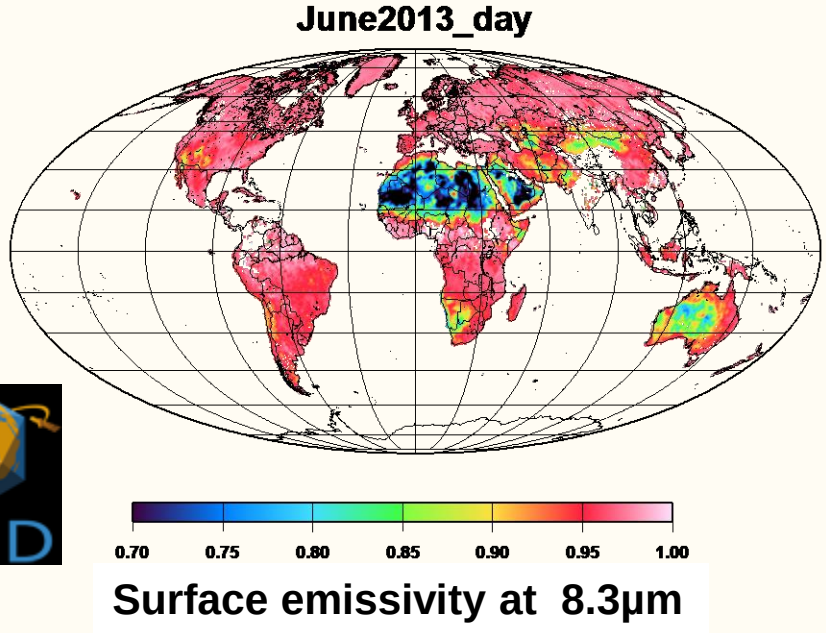
LMD algorithm

Size climatology



Peyridieu et al, ACP, 2013

Monthly emissivity

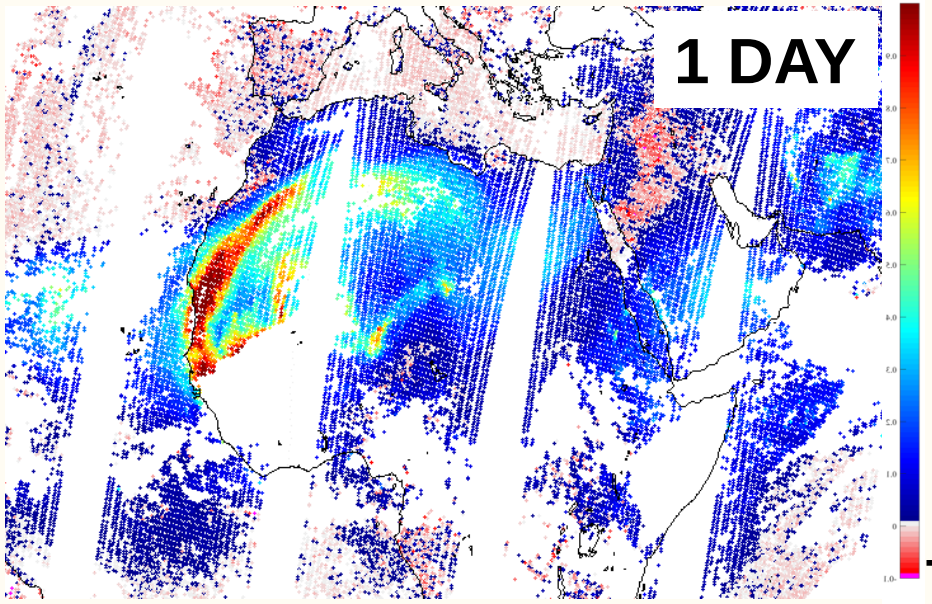


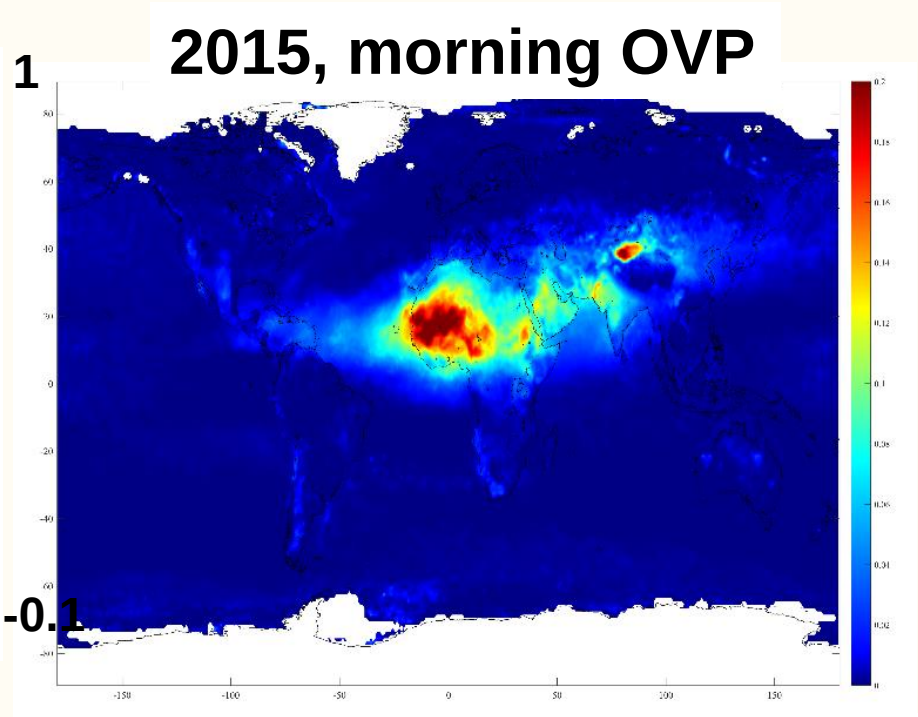
Surface emissivity at 8.3μm

Based on Capelle et al., JAMC, 2012, new publi in preparation

ULB algorithm

- Algorithm is based on a neural network conversion of a dust index
- OD retrieval only (assumes 3rd party altitude and size distribution)
- Sensitive to mineral dust (no other aerosols or clouds)
- Retrieval works on cloud free scenes
- Negative OD are allowed (similar to MODIS) to reduce bias over clear scenes





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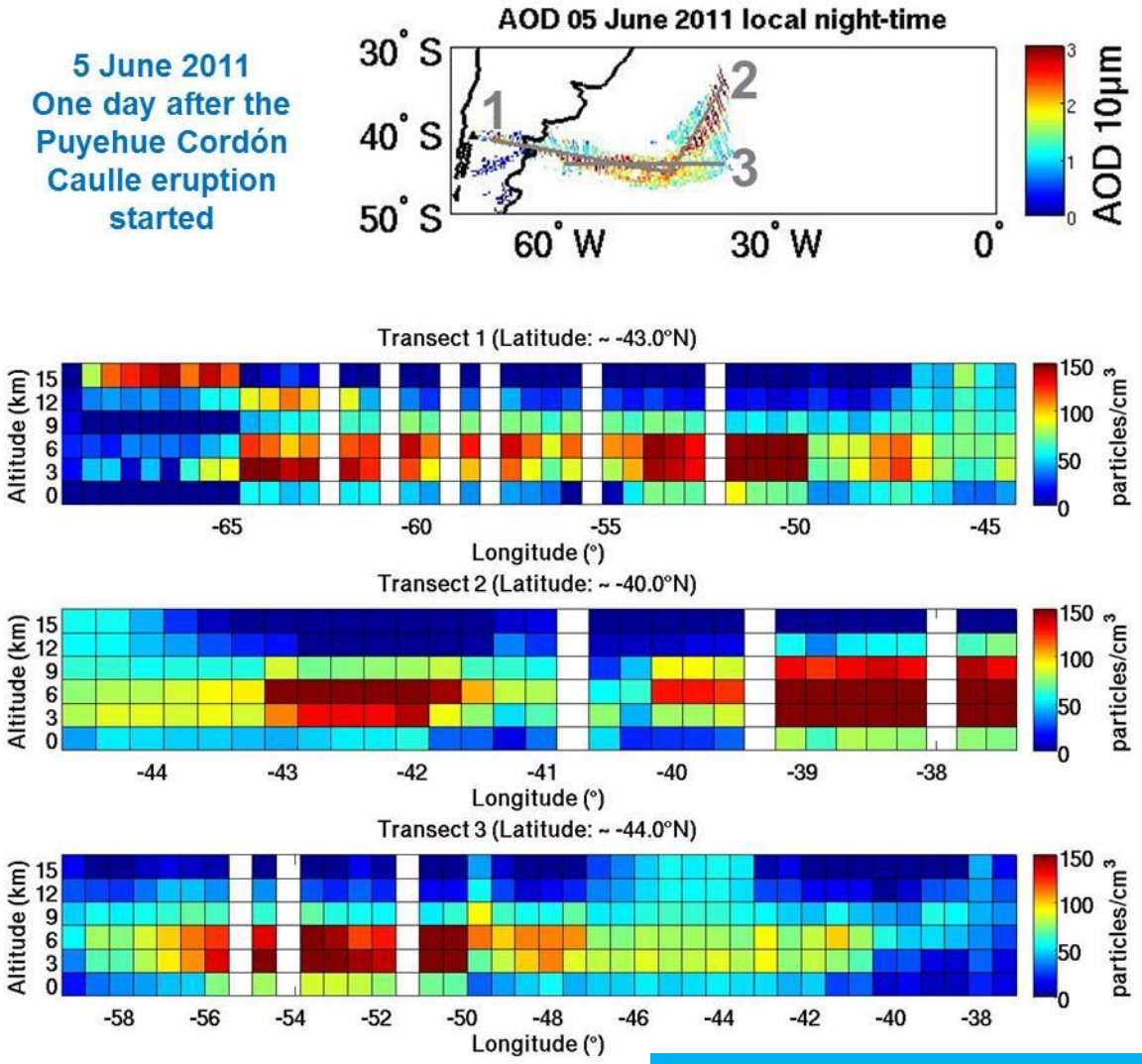
IASI volcanic ash aerosols retrievals

BIRA-IASB	ULB
MAPIR-ash	-
S. Vandenbussche	L. Clarisse
sophie.vandenbussche@aeronomie.be	lclariss@ulb.ac.be
Rodgers OEM	LUT
A few days	A few days
Puyehue	Eyjafjallajökull Grímsvötn
3D distribution (->AOD, mean altitude), Ts	AOD/mass, size, mean altitude

BIRA-IASB MAPIR algorithm (ash)

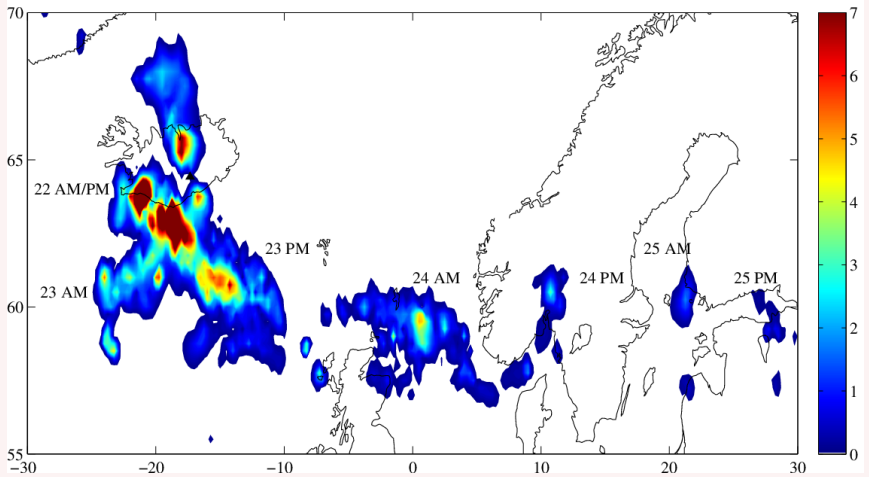
5 June 2011
One day after the Puyehue Cordón Caulle eruption started



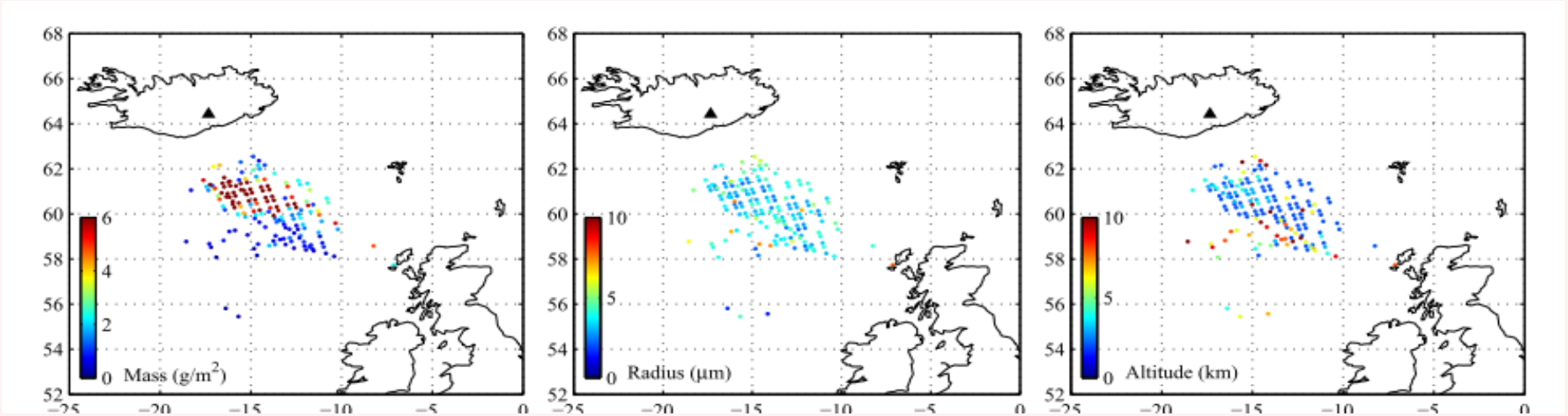
Maes, Vandenbussche et al, RS 2016

ULB algorithm (ash)

2011 Grímsvötn eruption



Maxnes, …, Clarisse et al, JGR 2013



OD/Mass **Radius** **Altitude**

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Applicability of retrieval methods to …

	AIRS	IASI	CrIS	IRS
Orbit	LEO 13h30	LEO 9h30	LEO 13h30	GEO
Time period	2002-…	2006-…	2011-…	2023-…
Spectral range (cm^{-1})	650-2700	645-2760	650-1095 & 1210-1750 & 2155-2550	700-1210 & 1600-2175
Resolution	2378 points	0.5	0.625 best	~0.74
Noise	<3%	<0.2K	0.5-0.7%	~0.2K
Coverage	13.5km, 12h	12km, 12h	14km, 12h	4km, max 5h
BIRA-IASB	Unsure	Done	Missing 2 retr. win.	Direct
DLR	Tested	Done	Unsure	Unsure
LISA	Unsure	Done	Unsure	Direct
LMD	In progress	Done	Easy (new LUTs)	Easy (new LUTs)
ULB	Easy	Done	Easy	Tested & OK

Conclusions

5 European teams work on mineral aerosol retrievals from Thermal Infrared !!!!!

All the work done on IASI aerosols (dust and ash) is almost immediately applicable to IRS – although the ash algorithms require more work intrisincally

IRS and its better temporal coverage will most probably improve the study of desert dust sources, and allow for better following ash plumes

The mineral aerosol detection (without retrieval) is not an easy task… It seems to require a complex algorithm.

The huge amount of data to be handled is a bit scary…

With special thanks to …

For inputs on their IASI aerosols research (and more…):

- Virginie Capelle, LMD
- Lieven Clarisse, ULB
- Thomas Popp & Lars Klüser, DLR
- Juan Cuesta, LISA
- Sieglinde Callewaert, BIRA-IASB

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- Jérôme Vidot, Meteo France
- Tony McNally, EMCWF

Infrared Atmospheric Sounding Interferometer

IASI provides valuable information on aerosol properties and is suited for Long-term evolution (IASI-1, 2, 3 + IASI-NG-1, 2, 3)

2006	2012	2018	2021	2028	2035
IASI/ Metop-A	IASI/ Metop-B	IASI/ Metop-	IASI-NG/ Metop-SG	IASI-NG/ MetopSG-B	IASI-NG/ MetopSG-C