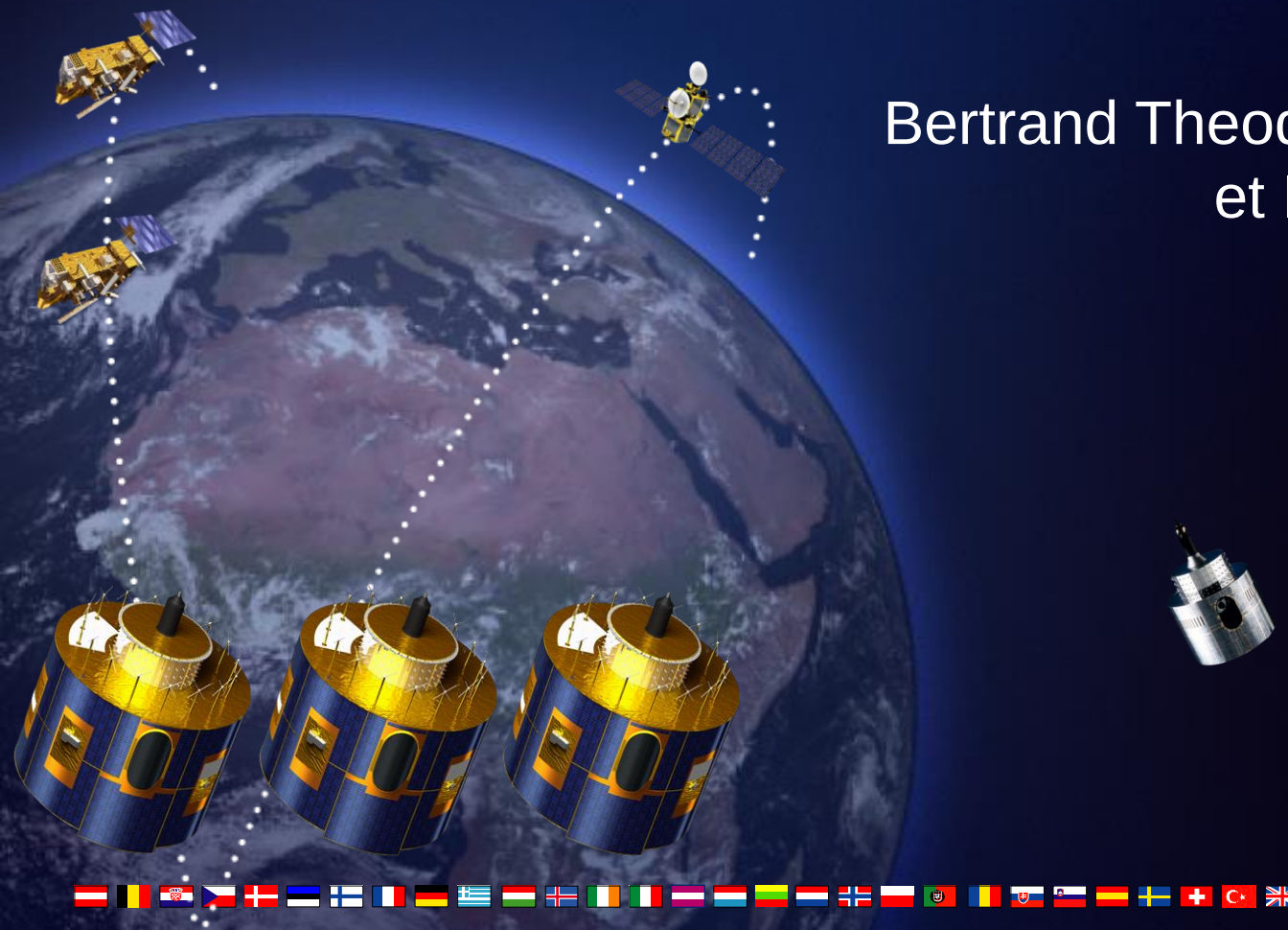
LES PRODUITS HYPERSPECTRAUX EUMETSAT

Bertrand Theodore, Dorothee Coppens et Dieter Klaes



Sommaire

- Introduction
- IASI: un sondeur hyperspectral opérationnel
- Produits de niveau 1
- Produits géophysiques
- Monitoring
- Futurs instruments
- Conclusion

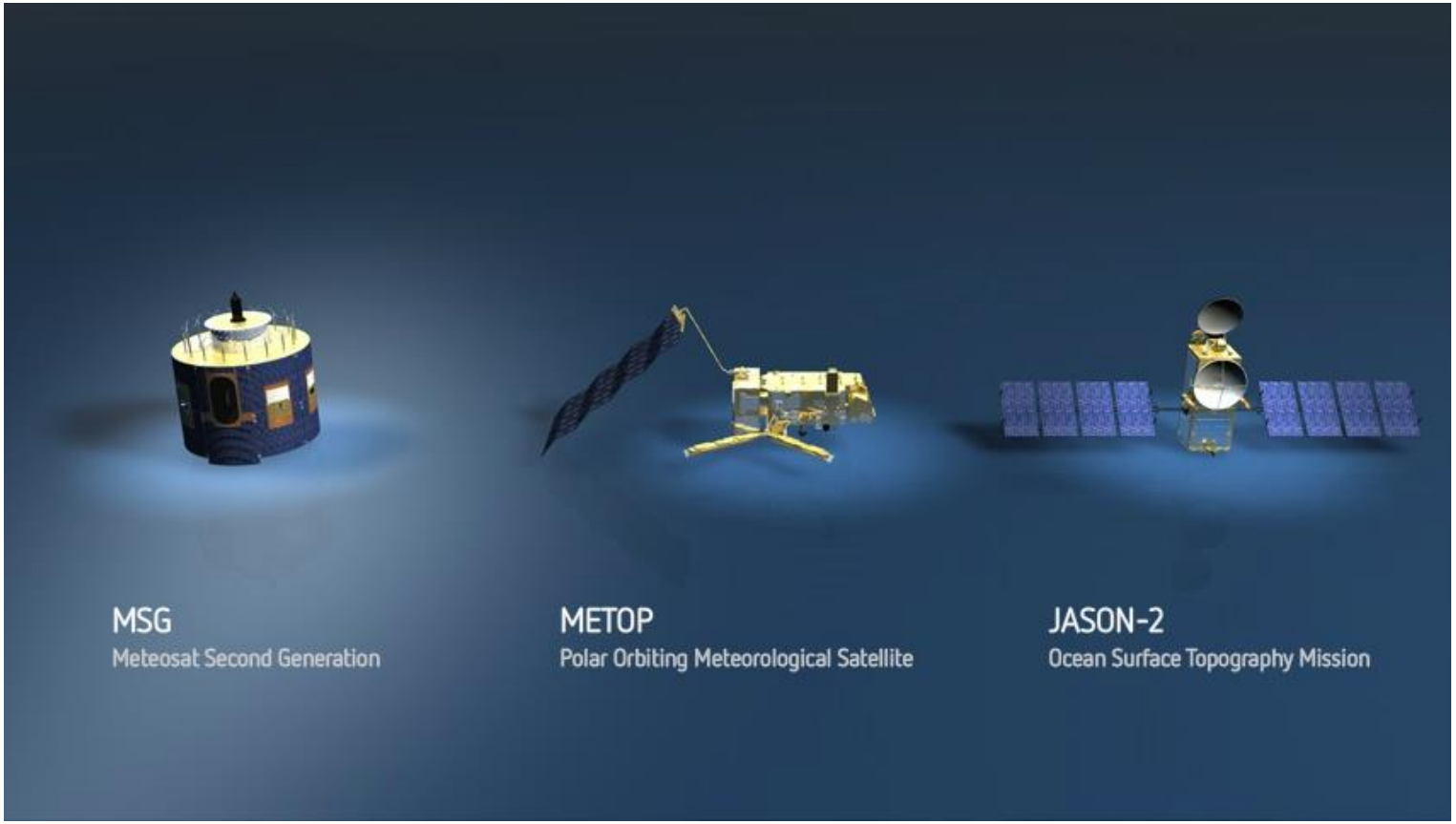
EUMETSAT

- **EUMETSAT is an intergovernmental organisation with currently 29 Member States and 2 Cooperating States**

➢ **aims at establishing, maintaining and exploiting systems of operational meteorological satellites (24 hours a day, 365 days a year, over decades)**

➢ **contribute to the operational monitoring of the climate and the detection of global climatic changes.**

Satellites actuels



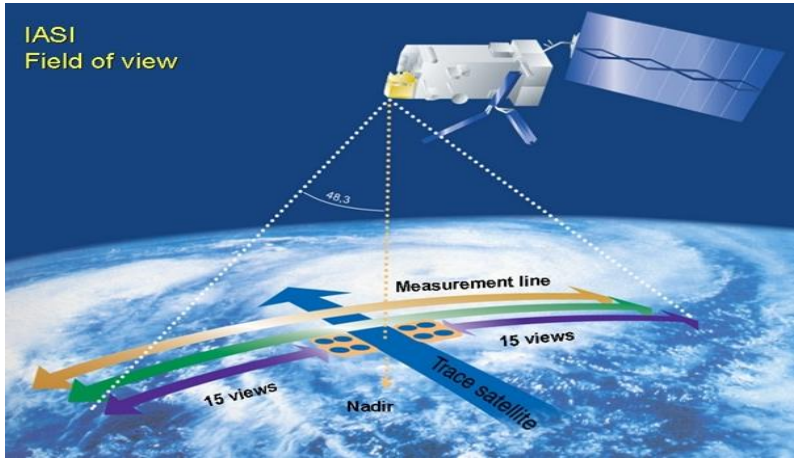
Imageur multispectral
12 canaux dont 8 dans le TIR
Resolution: 3 km au nadir
1 image/15 minutes

12 instruments dont:
HIRS: imageur IR 19 canaux
AVHRR: imageur 6 canaux
IASI: spectrometre IR

Altimetre radar
Radiometre MW

- IASI: un sondeur hyperspectral operationnel

IASI: un sondeur hyperspectral sur Metop



Infrared Fourier transform interferometer

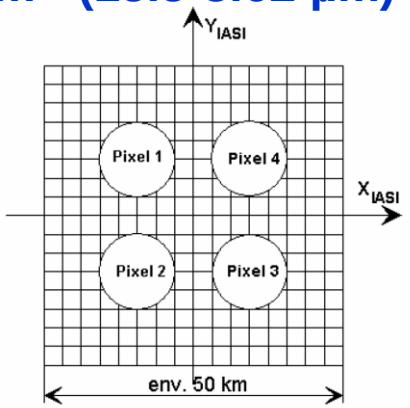
Spectral range: 645 to 2760 cm^{-1} (15.5-3.62 µm)

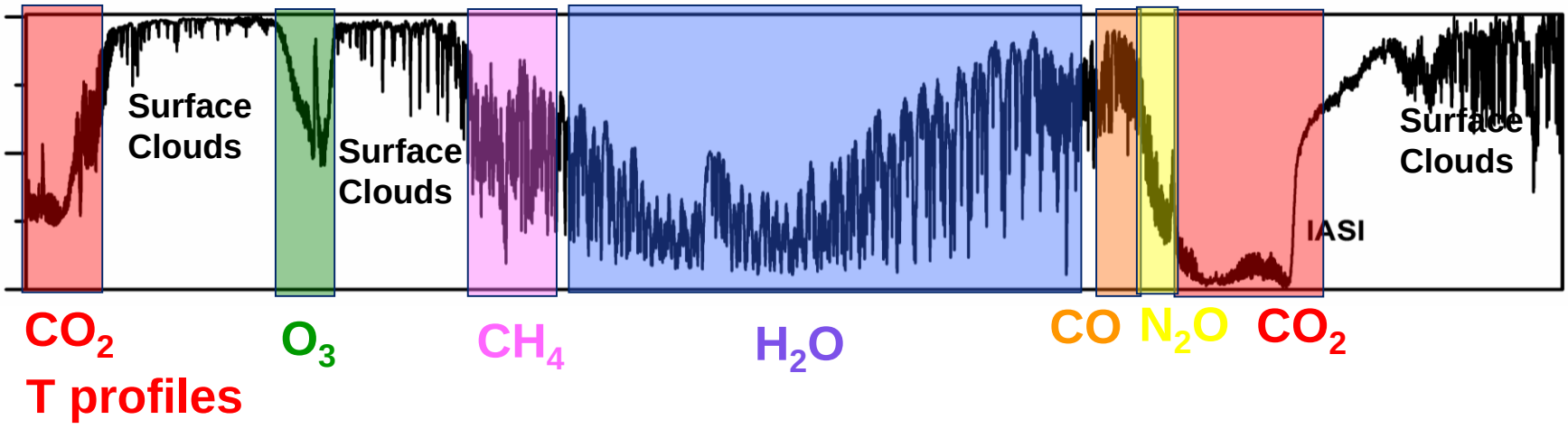
Spectral sampling: 0.25 cm^{-1}

Footprint: 12 km (Nadir)

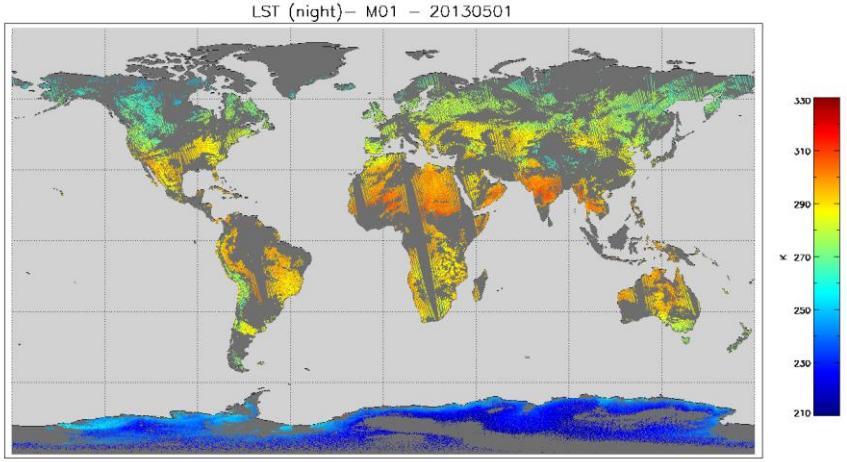
Swath: ±1000km (± 48.3°)

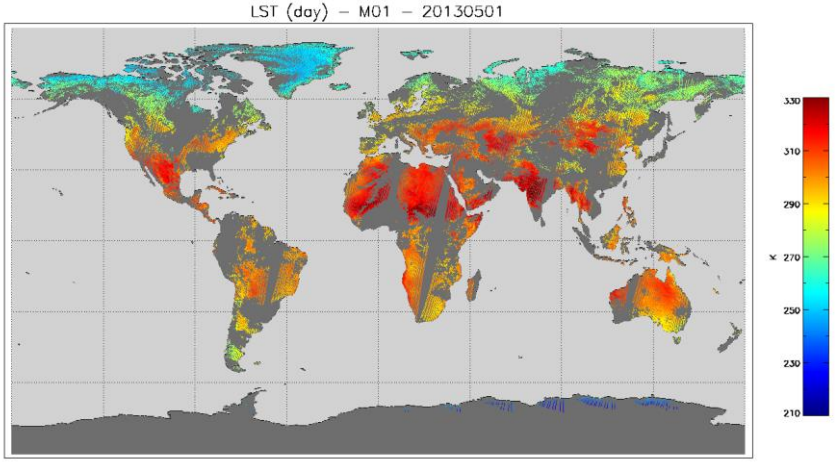
1 line: 30x4 spectra

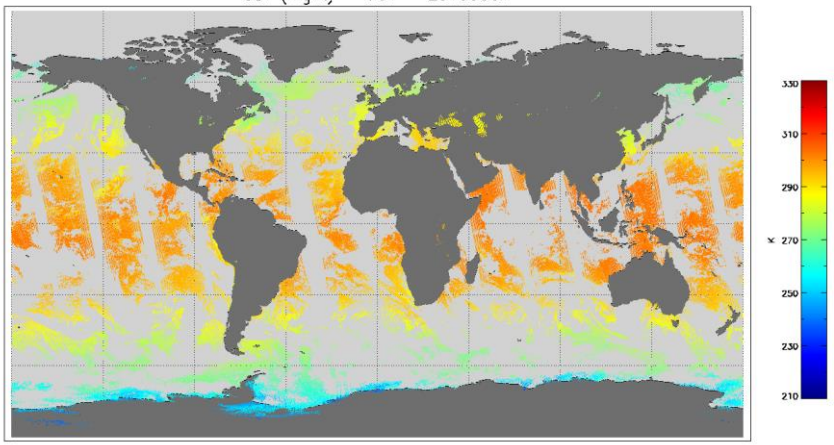


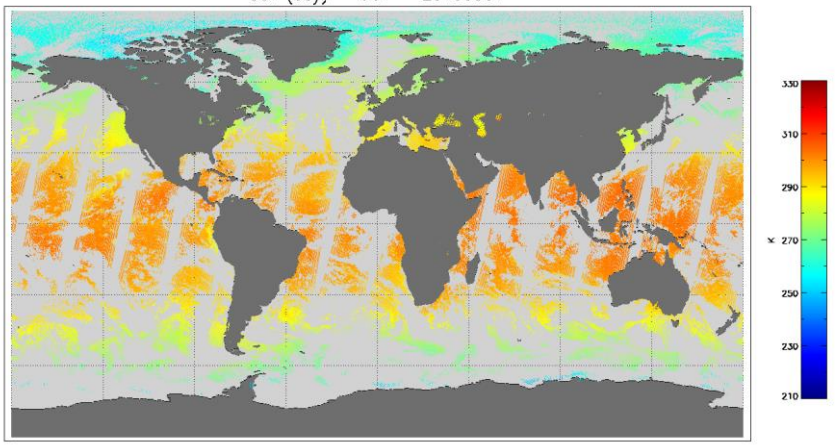


Resolution spatiale de IASI: exemple

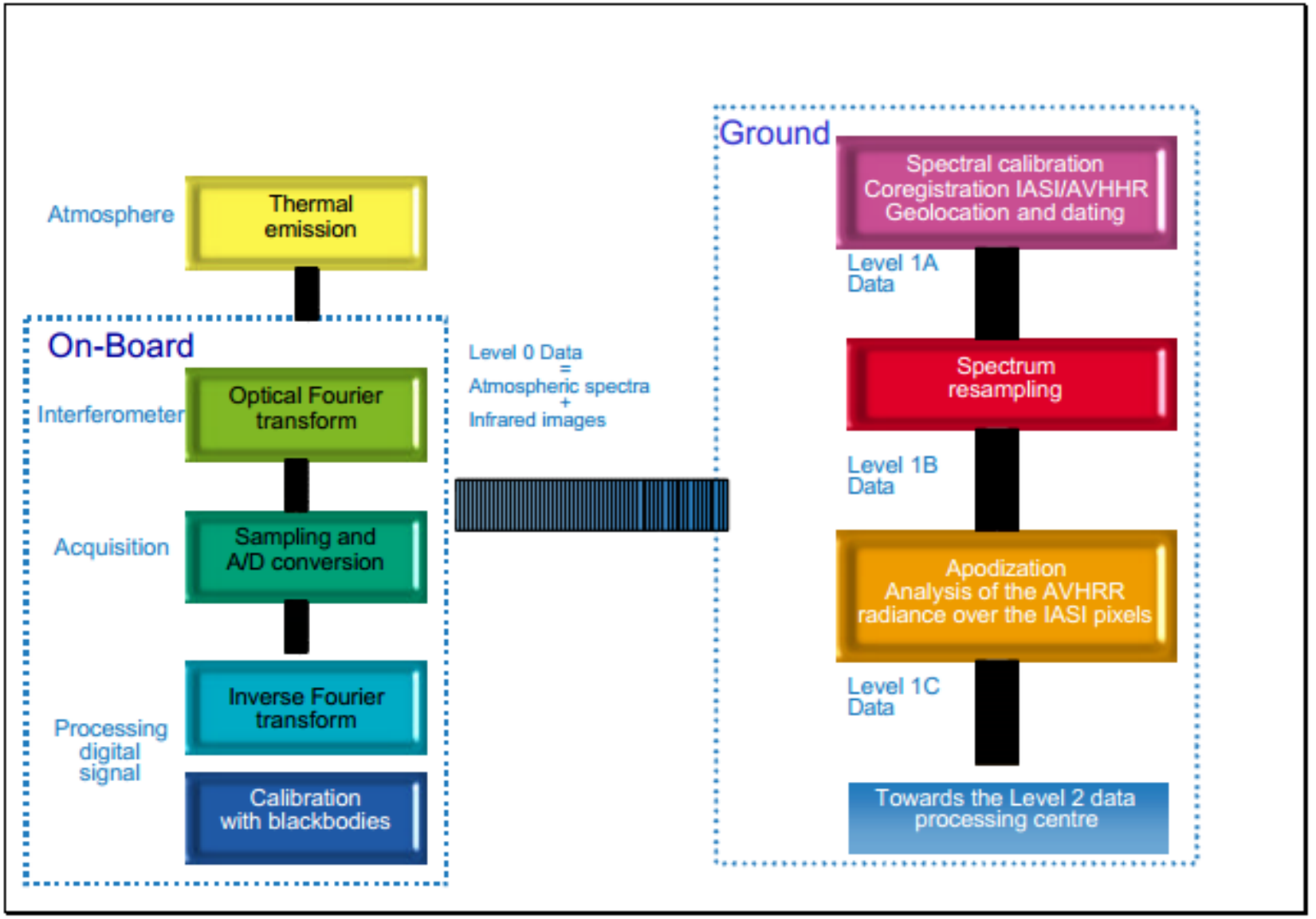






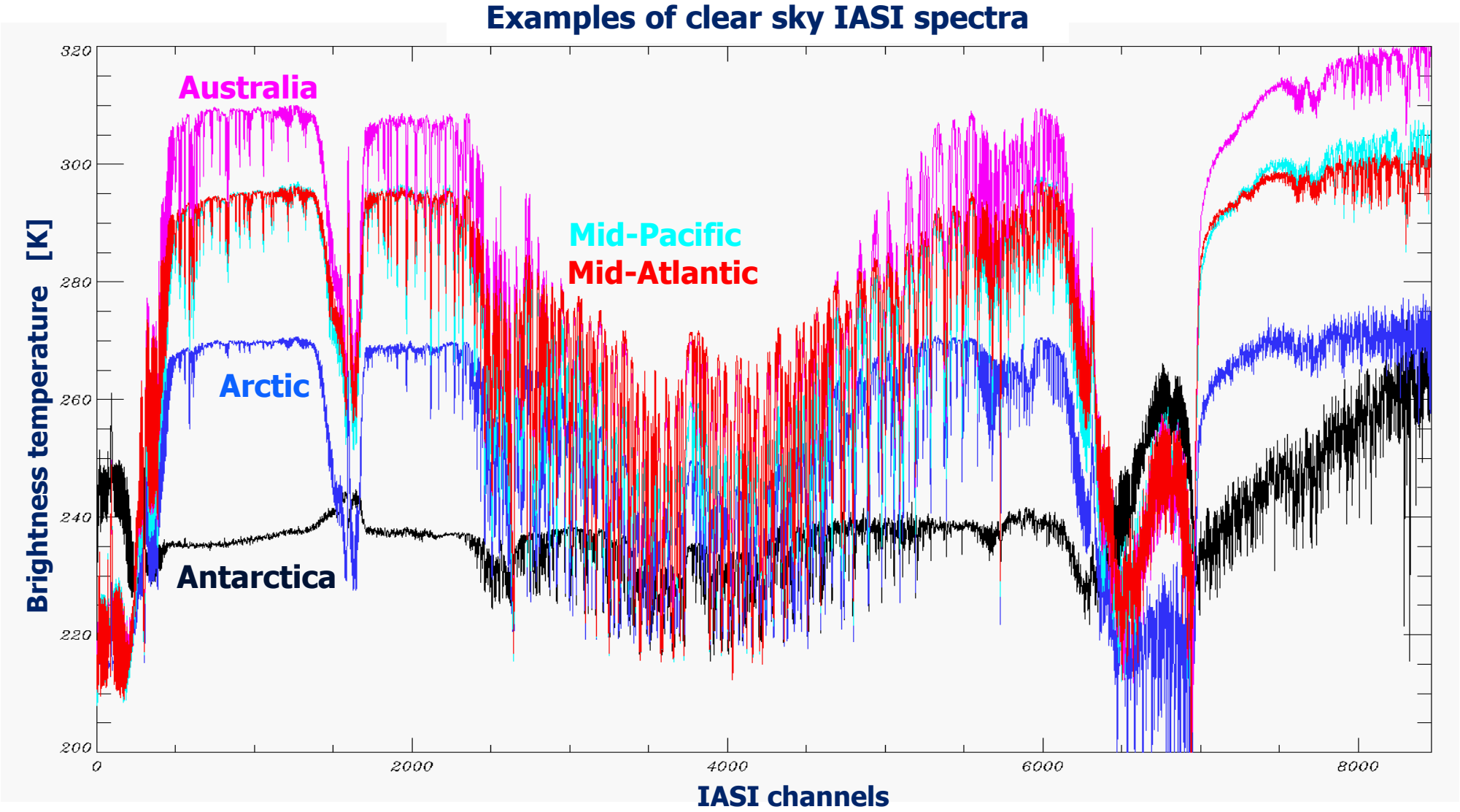


De la mesure brute aux radiances...

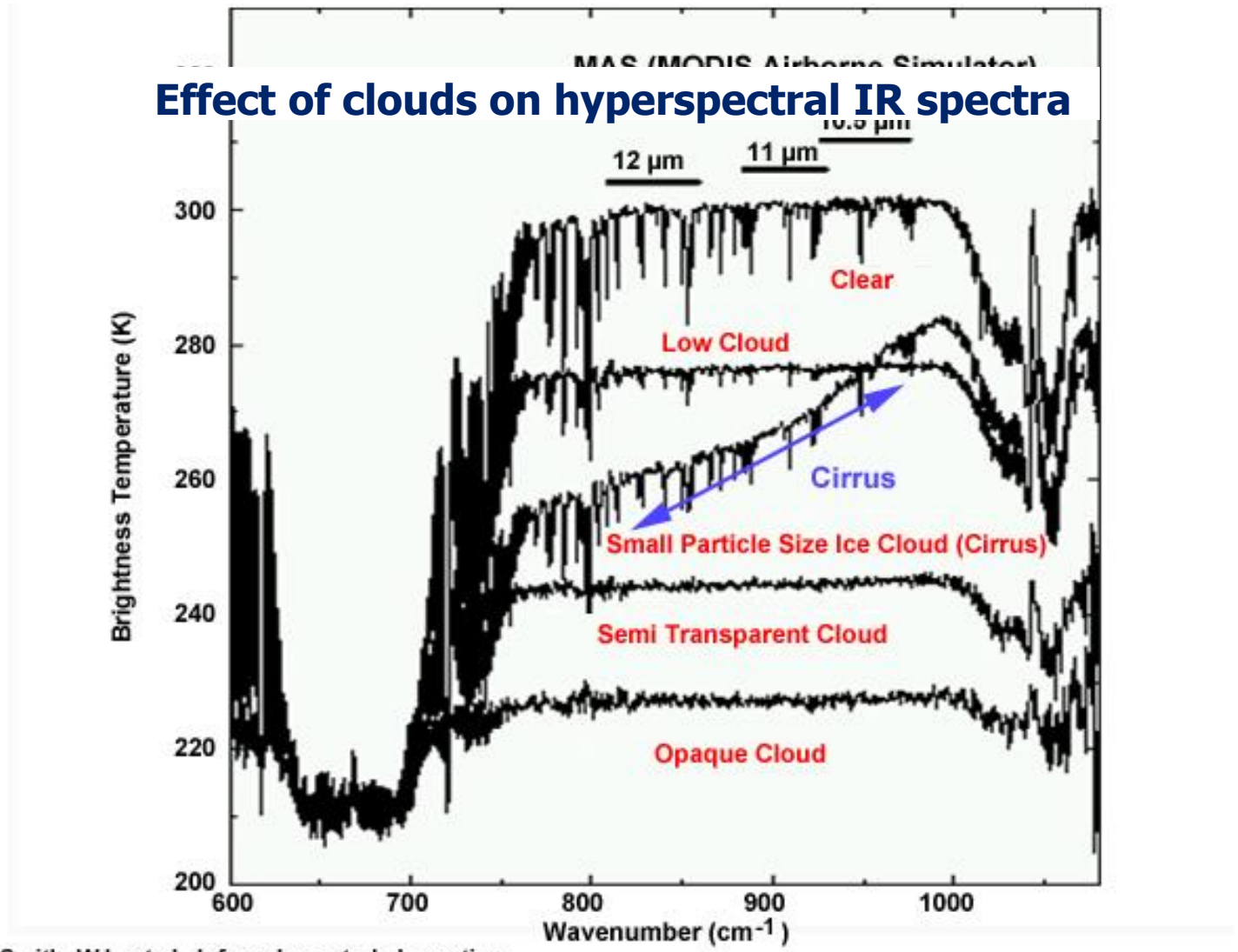


- Produits de niveau 1

Exemple de différents cas géographiques



Contenu des spectres IASI: cloud information



Smith, W.L. et al., Infrared spectral absorption of nearly invisible clouds, Vol. 25, No. 8, 1998.

Image Provided by Mitch Goldberg

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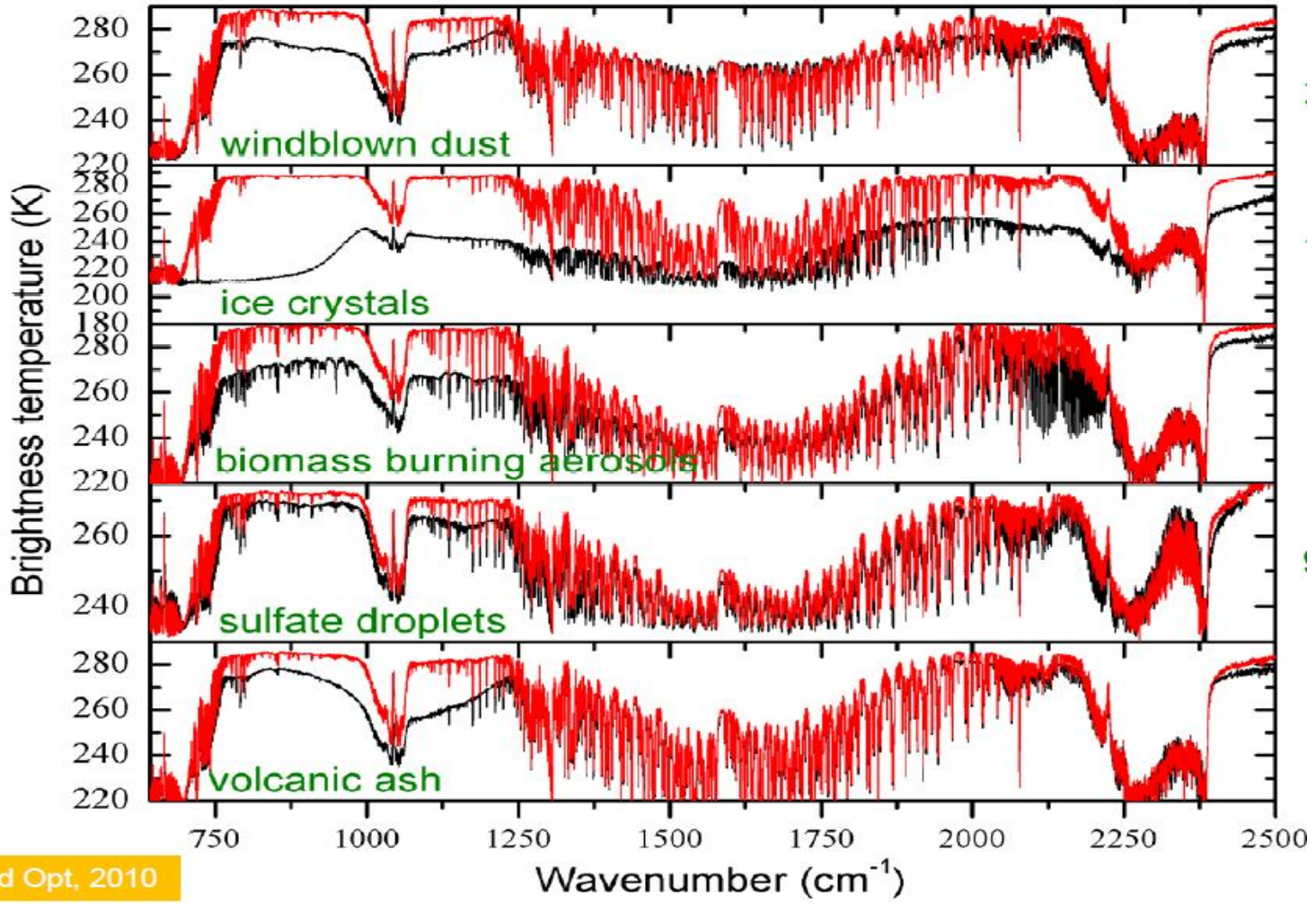
Contenu des spectres IASI: aerosols



Clarisse et al., Applied Opt, 2010

Extracted from a presentation by L. Clarisse (ULB)

- Utilisation des spectres IASI par les centres de prévisions météo

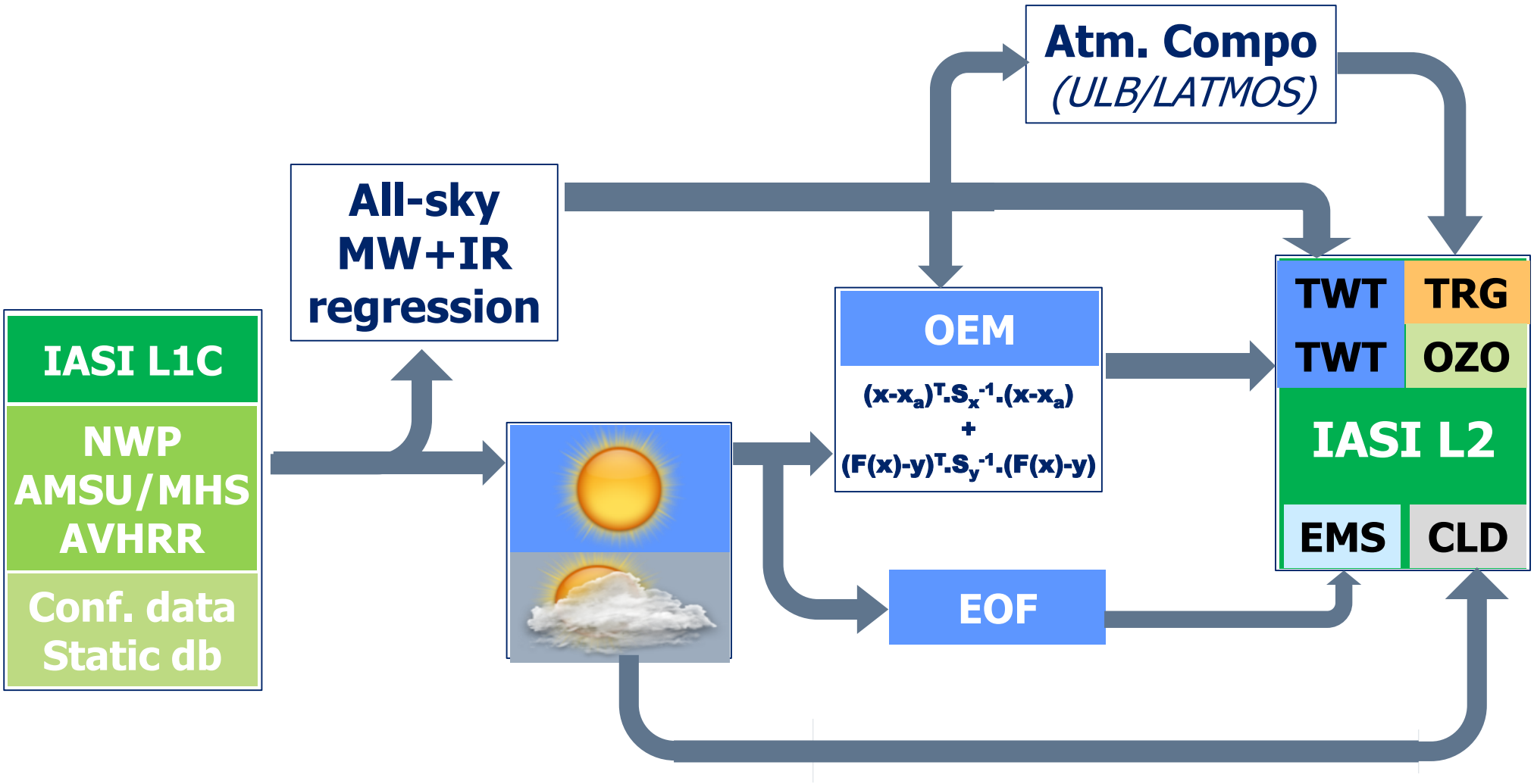
Utilisation des radiances IASI

L'application première de IASI est l'assimilation des radiances (en temps réel) dans les modèles de prévision numérique:

	Model	Domain	Model Top/ N Levels	Horiz. Resn.	Assimilation System	Bias Correction
Met Office	Global	Global	63km/L50	~60km	4D-Var	Harris&Kelly
	NAE	N Atlantic & Europe	39km/L38	~12km	4D-Var	Harris&Kelly
Météo-France	ARPEGE	Global	0.1hPa/L60	30-70km	4D-Var	VarBC
	ALADIN	W Europe	0.1hPa/L60	10km	3D-Var	VarBC
ECMWF	Global	Global	80km/L91	~25km	4D-Var	VarBC
DWD	GME	Global	10hPa/L60	40km	3D-Var	Harris&Kelly
	COSMO-EU	Europe	20hPa/L40	7km	Nudging	Harris&Kelly
met.no	HARMONIE	N Pole & Europe	0.2hPa/L60	11-16km	3D-Var	VarBC

- Produits de niveau 2

The IASI L2 processor

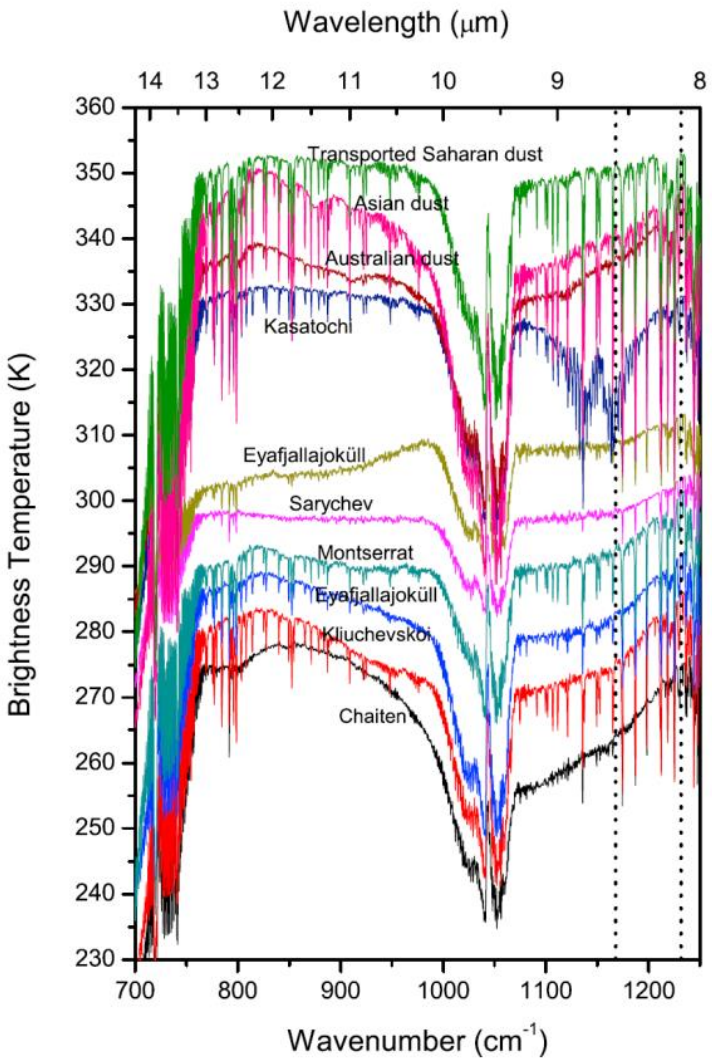


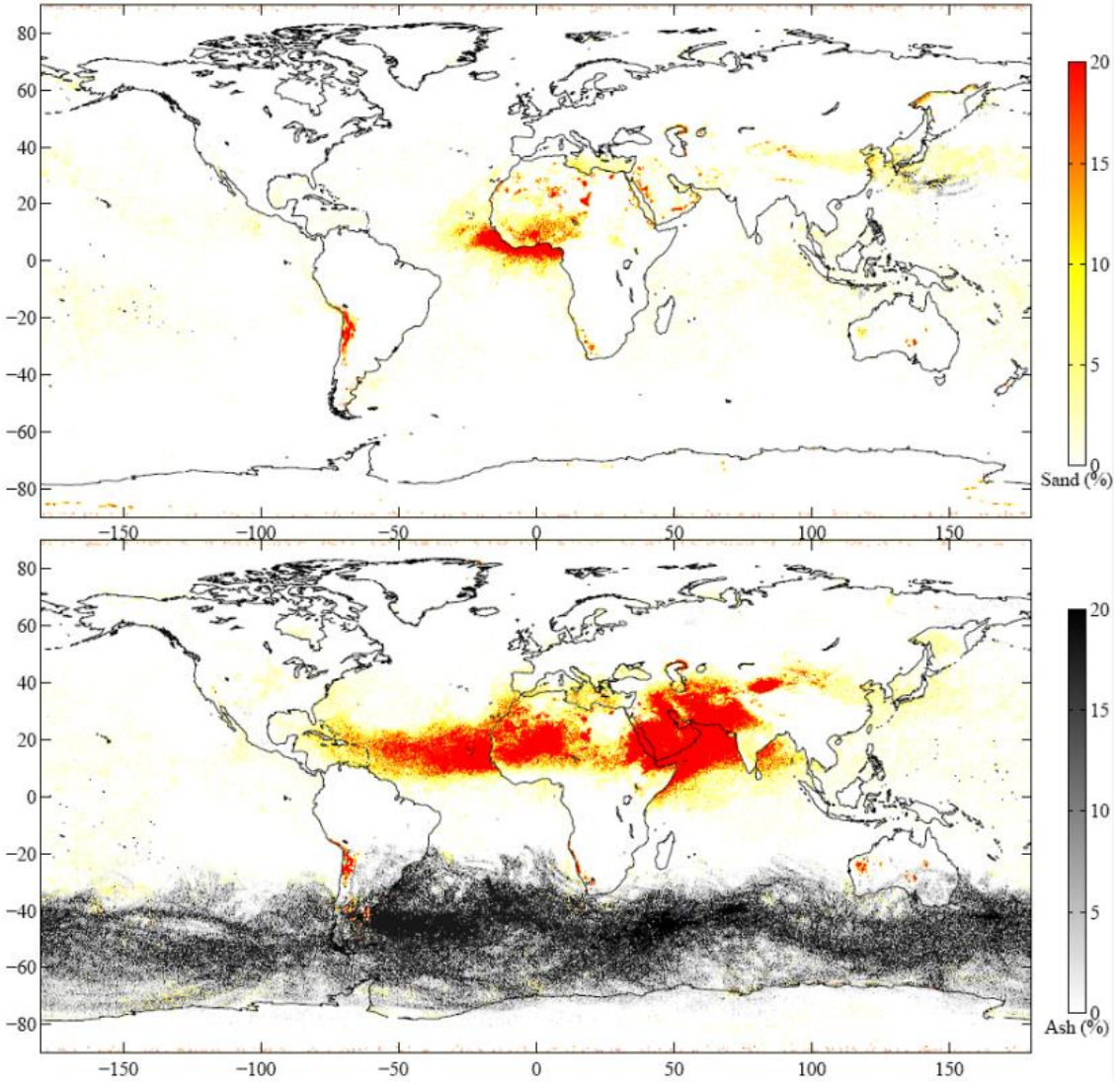
Produits IASI de niveau 2 distribués

TWT	Temperature (vertical profiles) Humidity (vertical profiles) Surface Temperature (Land & Sea)	+ Averaging Kernels
EMS	Surface emissivity	
CLD	Cloud detection and characterisation	
OZO	O_3 profiles + Averaging Kernels	
TRG	CO, N_2O, CH_4, CO_2 Total columns	
	CO profiles + AK, (SO_2, HNO_3)	

Soon

Autres produits géophysiques: cendres volcaniques





Clarisse et al, ACP, 2013

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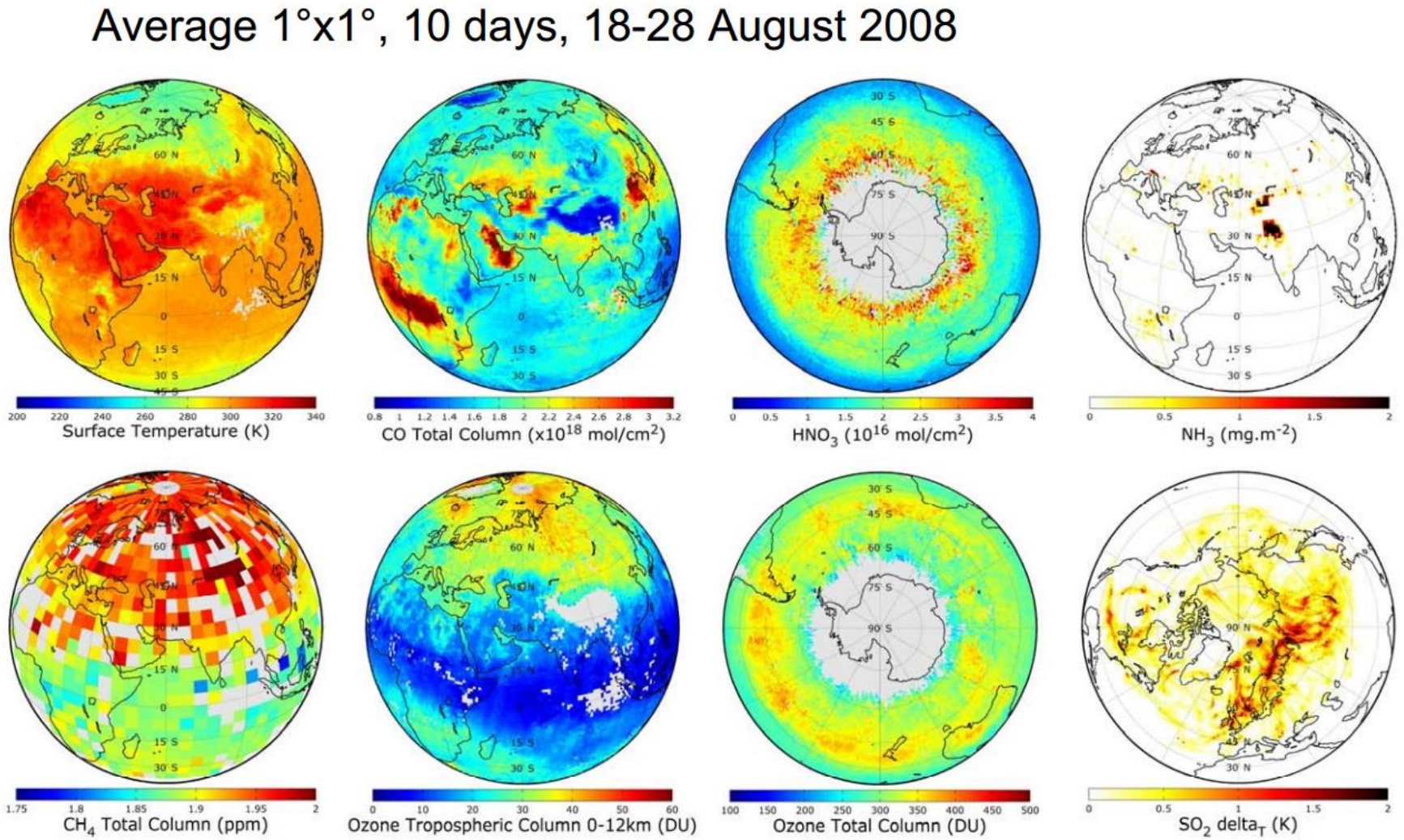
Autres produits geophysiques: gaz trace



Clerbaux et al, ACP IASI Special Issue, 2009

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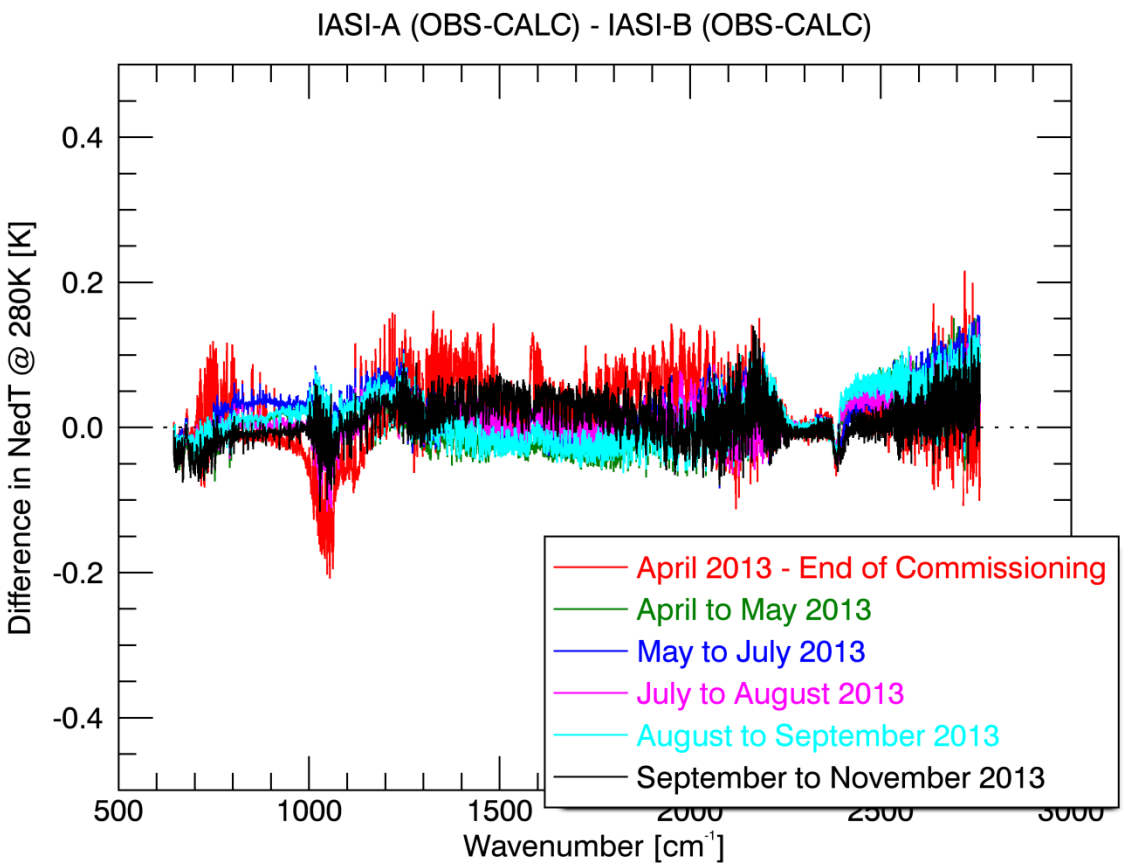
- Monitoring

Monitoring de IASI-A / IASI-B



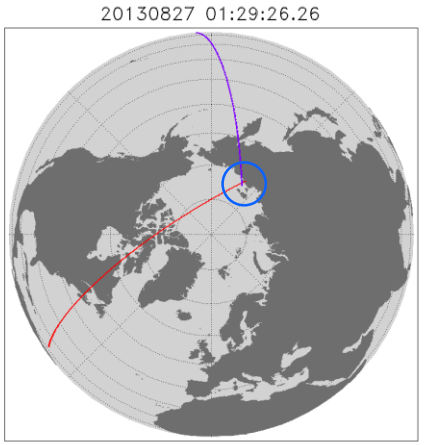
- On-ground update IASI-A and IASI-B
- On-board update IASI-B
- No update
- On-board update IASI-A
- On-ground update IASI-A and IASI-B

➢ Difference always lower than 0.1K NedT => good radiometric consistency

Monitoring de IASI / CrIS

SNOs

- Comparison of Simultaneous Nadir Observations of IASI and CrIS
- Selection: 2 minutes time difference and 6.5 km distance difference
- Occurrence: every 7 weeks at high latitude (+/- 70 deg)

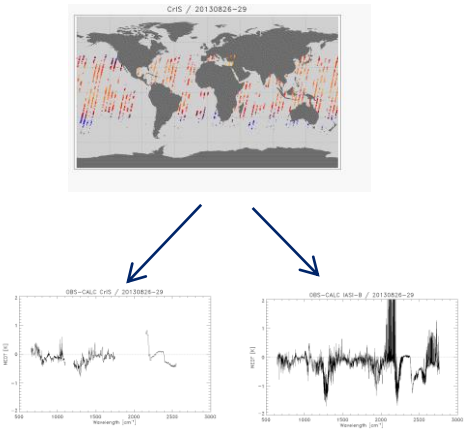


Double Differences

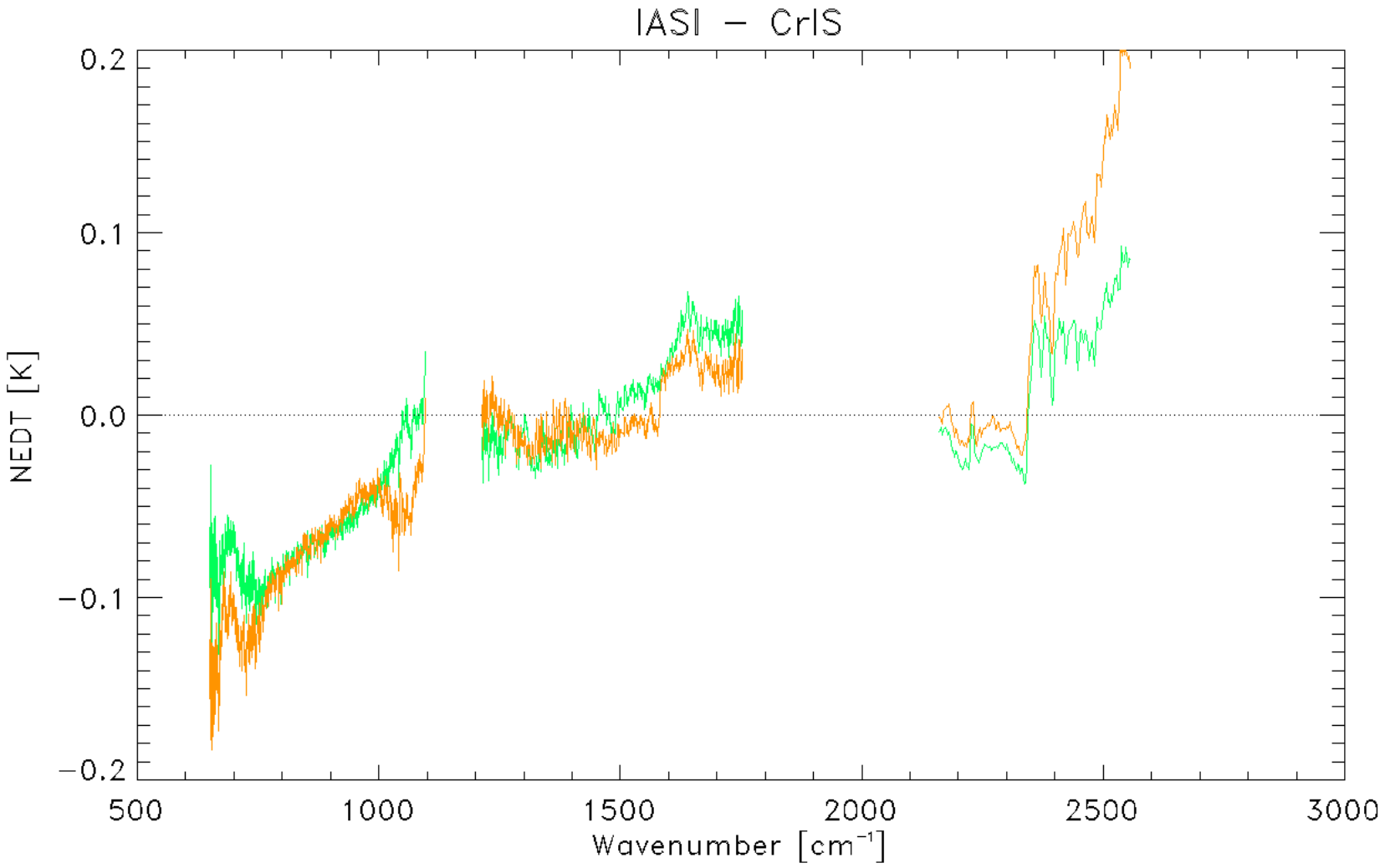
- Comparison of IASI with CrIS through synthetic spectra
- Use of ECMWF 3-hourly forecast files
- Examination of the double-difference of ECMWF bias:

$$DD=(RAD_{obs} - RAD_{calc})_{IASI} - (RAD_{obs} - RAD_{calc})_{CrIS}$$

=>Remove most inaccuracies in both RTM and ECMWF

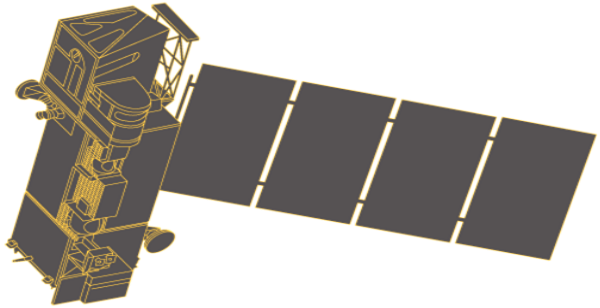


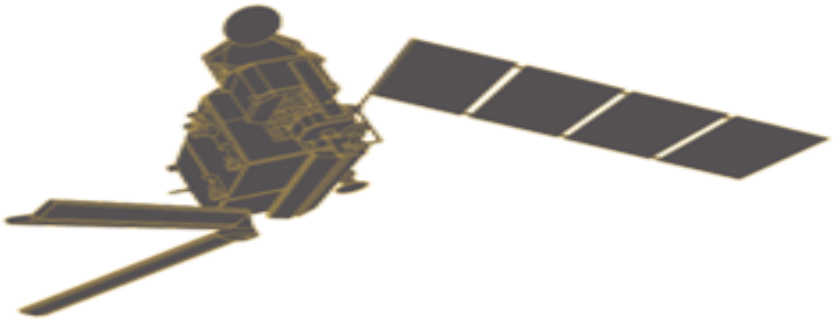
Monitoring de IASI / CrIS



- Futurs instruments: IASI-NG et MTG-IRS

Futurs Satellites: EPS-Second Generation





Sat A Payload:
- Infrared Atmospheric Sounding Instrument (IASI-NG)
- Visible-infrared Imaging Instrument (MetImage)
- Microwave Sounding Instrument (MWS)
- Radio-occultation instrument (RO)
- Multi-viewing, multi-channel, multi-polarization imager (3MI)
- **Copernicus Sentinel-5** implemented on EPS-SG

Sat B Payload:
- Scatterometer (SCAT)
- Radio-occultation instrument (RO)
- Microwave Imaging instrument (MWI)
- Ice Cloud Imager (ICI)
- Advanced Data Collection System (ADCS)

Caractéristiques instrumentales de IASI-NG

- Couverture spectrale: 645-2760 cm-1
- Résolution spectrale: 0.25 cm-1 (0.50 cm-1 pour IASI)
- Echantillonage spectral: 0.125 cm-1 (0.25 cm-1 pour IASI)
- Réduction du bruit radiométrique d'un facteur 2 par rapport à IASI
- Résolution spatiale: 12 km au nadir

  - ➢ Assure la continuité de IASI
  - ➢ Ameliore la qualité des produits operationnels dans la basse troposphere
  - ➢ Permet la mesure de nouvelles especes chimiques.

Qu'apportera IASI-NG ?

	IASI		IASI-NG		
Chemistry	***DOFs***	***Error (%)***	***DOFs***	***Error (%)***	***What the 'NG' brings***
O_3	3-4	PBL : 60% Tropo : 11%	4-5	PBL : 40% Tropo : 8%	More information in PBL
CO	1-2	PBL : 16% Tropo : 8%	2-3	PBL : 10% Tropo : 6%	More information in PBL
HNO_3	1 or less		2		Both tropo and strato
NH_3[a]	detected	-	measured	-	> instrumental noise
Methanol[a]	detected	-	measured	-	> instrumental noise
C_2H_4[a]	detected	-	measured	-	> instrumental noise
SO_2-volcanos	If > 2DU	-	If > 1 DU	-	+ Altitude of the plume
Climate	***DOFs***	***Error (%)***	***DOFs***	***Error (%)***	***What the 'NG' brings***
H_2O	5-6	~13%	6-7	~10%	Error improved by 1.5
T	6	~0.6K	12	~0.45 K	Error improved by 2.5
CO_2	1 or less	~1%	1-2	<1%	Low troposphere
CH_4	1or less	~3%	1-2		Less interferences
N_2O	detected	-	measured	-	
Aerosols	dust				More types
Emissivity		0,04 @4µm		0,02 @4µm	

From Crevoisier et al., IASI conference 2013

Futurs satellites: MTG

1977 — 2002 — 2019 and 2021

MOP/MTP

MOP/MTP

MSG

MSG

MTG-I and MTG-S

Observation mission:
- MVIRI: 3 channels

Spinning satellite
Class 800 kg

Observation missions:
- SEVIRI: 12 channels
- GERB

Spinning satellite
Class 2-ton

Observation missions:
- Flex.Comb. Imager: 16 channels
- Infra-Red Sounder
- Lightning Imager
- UVN

3-axis stabilised satellites
Twin Sat configuration
Class 2,5 - 3 ton

Caracteristiques instrumentales de MTG-IRS

- Couverture spectrale: 700-1210 cm-1 et 1600-2175 cm-1
- Résolution spectrale: 0.625 cm-1
- Résolution spatiale: 3 km au nadir
- Résolution temporelle: 30 minutes (full-disk), 15 minutes (Europe)
- En comparaison avec IASI:
  - ➢ résolution verticale équivalente pour la vapeur d'eau
  - ➢... Legerement dégradée pour la température
  - ➢ résolution spatiale et temporelle grandement améliorée
  - ➢ une vue sans précédent des champs 3D de vent, température et humidité !

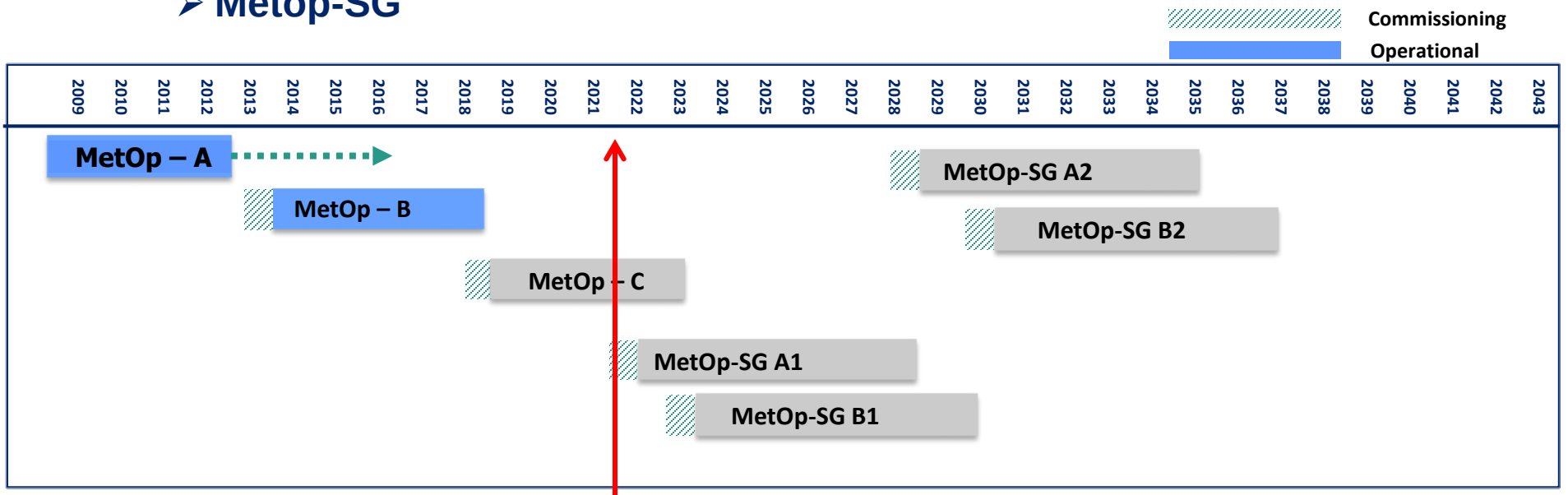
Conclusions

- **Après plus de 7 ans en orbite, les produits opérationnels IASI sont devenus indispensables à la prévision météo**
- **IASI apporte une contribution essentielle dans le domaine de la chimie atmosphérique**
- **IASI est devenu la référence pour inter-calibrer les intruments multi-spectraux**
- **Les mesures sont utilisables en temps réel ou à partir de l'archive d'EUMETSAT:**

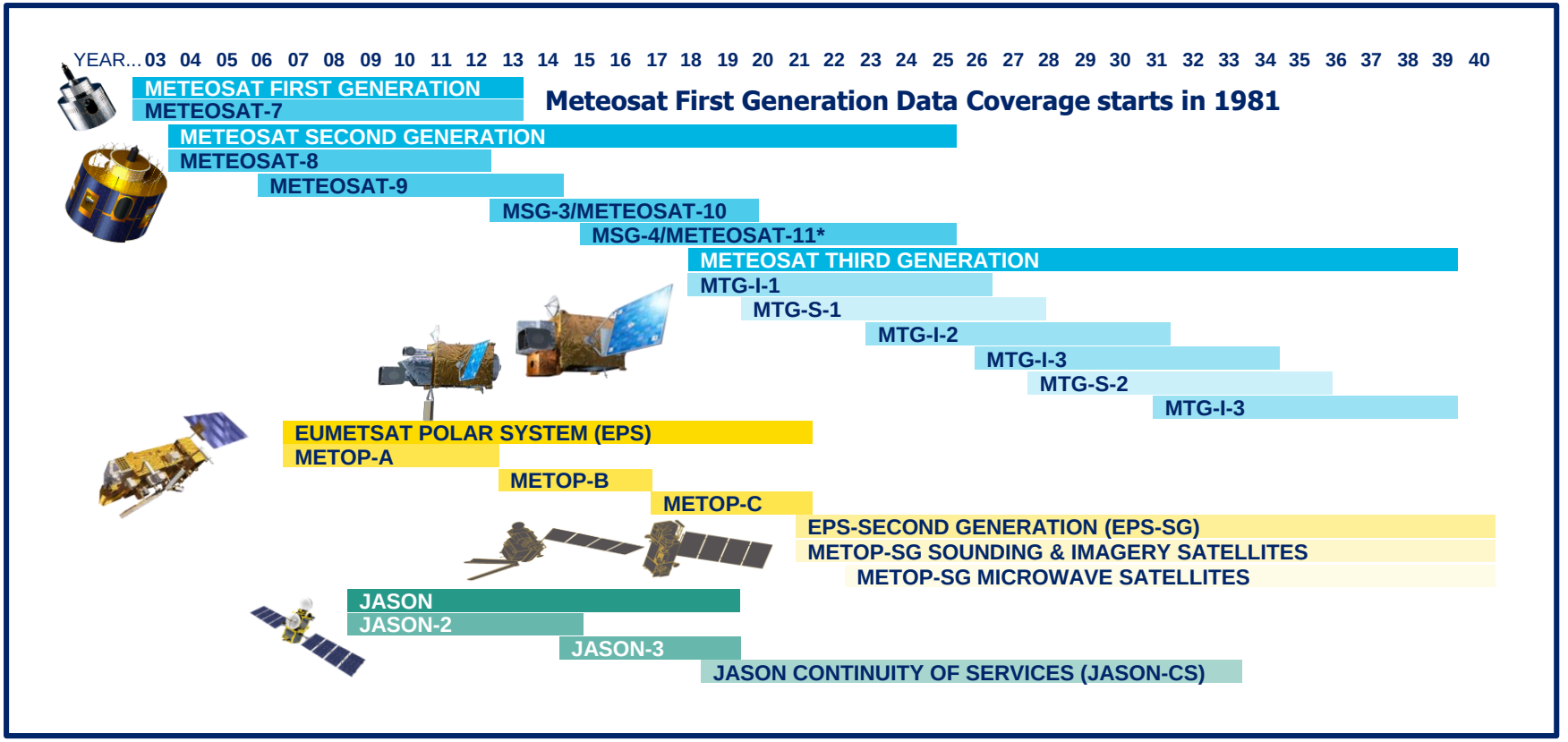
http://eoportal.eumetsat.int

Conclusions

- **Il est donc essentiel d'assurer la continuite opérationnelle de ces mesures**
  - ➢ **Metop-C**
  - ➢ **Metop-SG**



- **MTG-IRS sera le premier imageur hyperspectral en orbite géostationnaire: opportunité unique !**

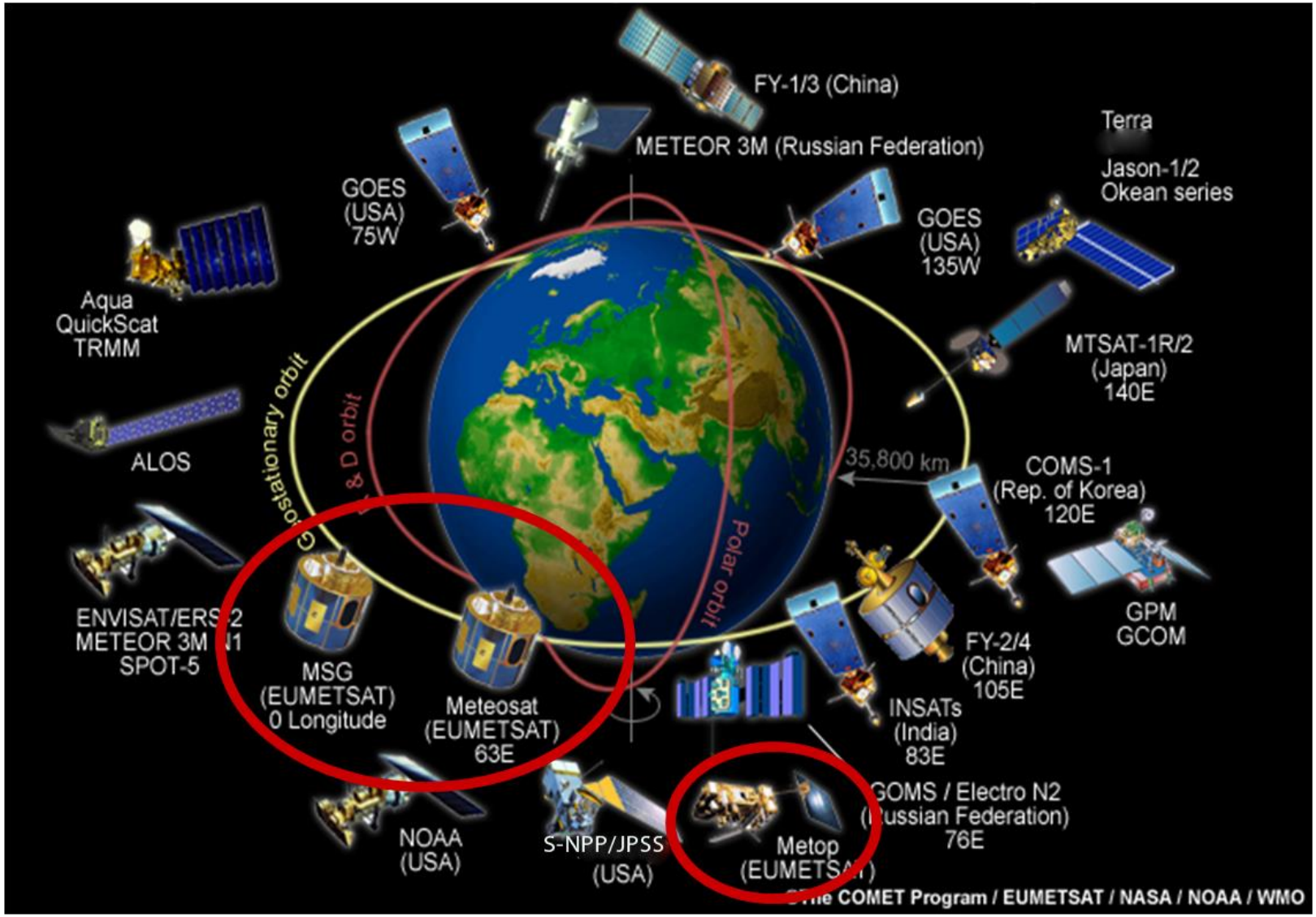


Merci de votre attention !

bertrand.theodore@eumetsat.int

spare

Contexte international



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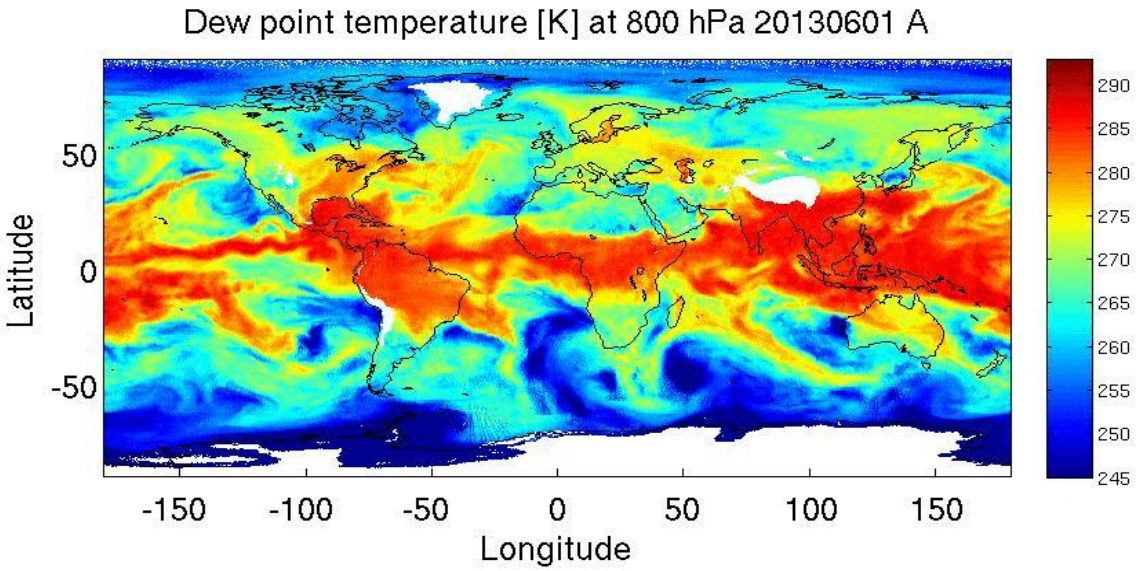

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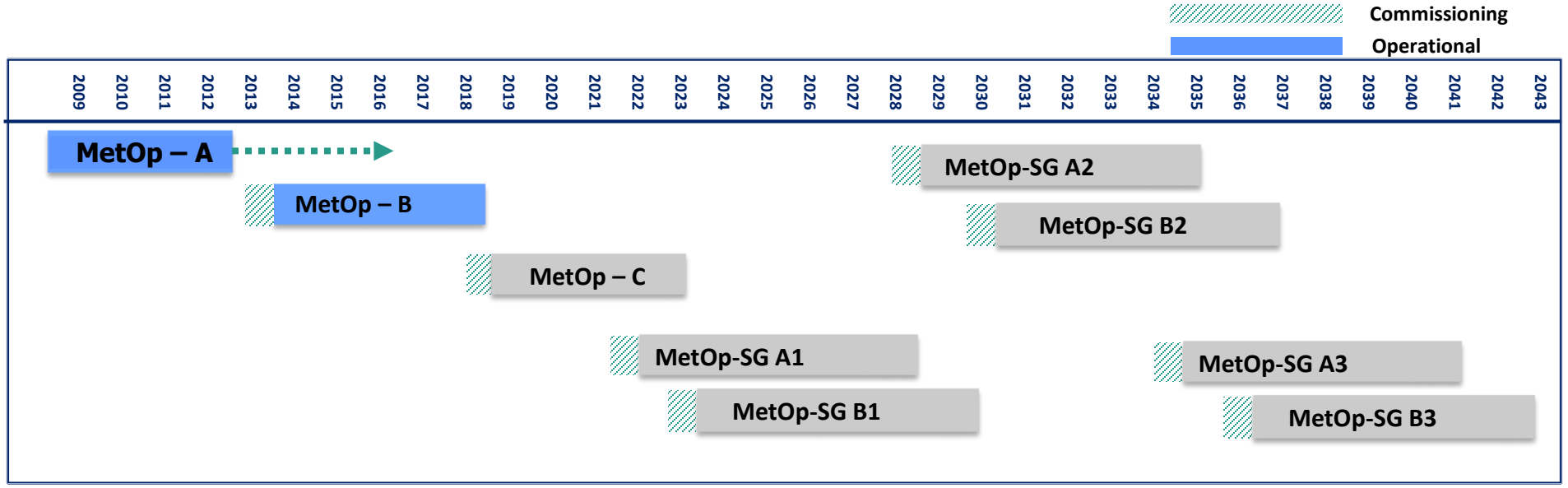
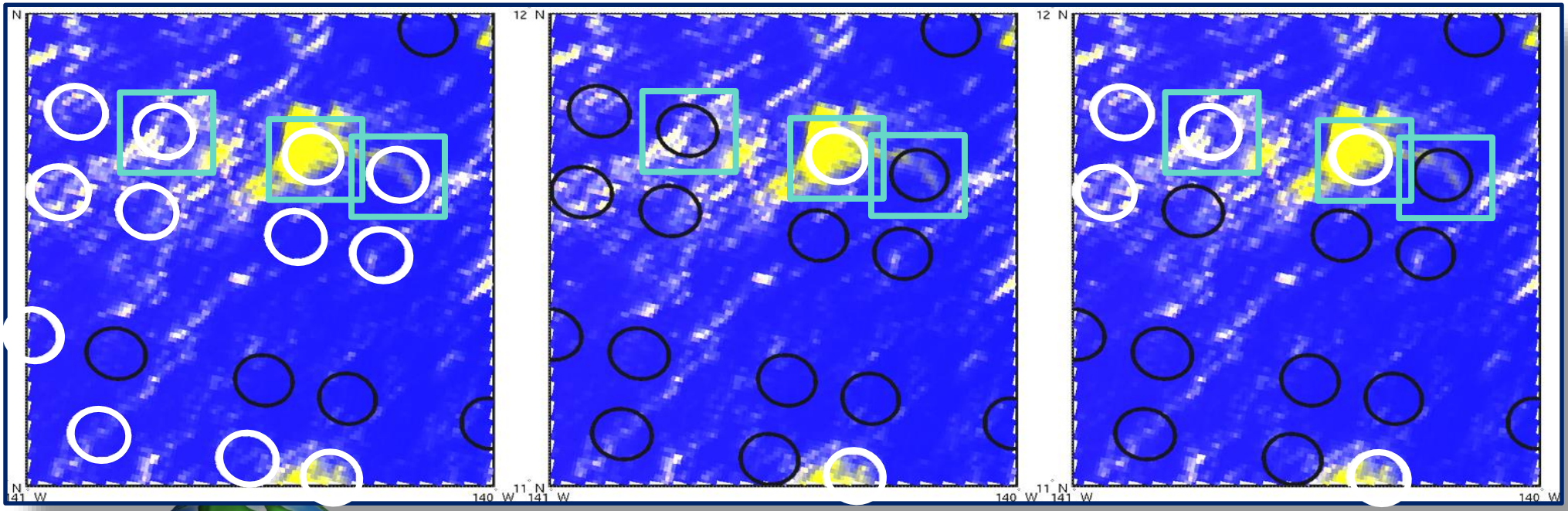
Futurs Satellites: EPS-Second Generation



- Metop SG-A1 FAR: **December 2020**
- Metop SG-A1 Launch: **April 2021**
- Metop SG-B1 FAR: **April 2022**
- Metop SG-B1 Launch: **October 2022**

Produits geophysiques (niveau 2)

ANN test **NWP test** **AVHRR test**

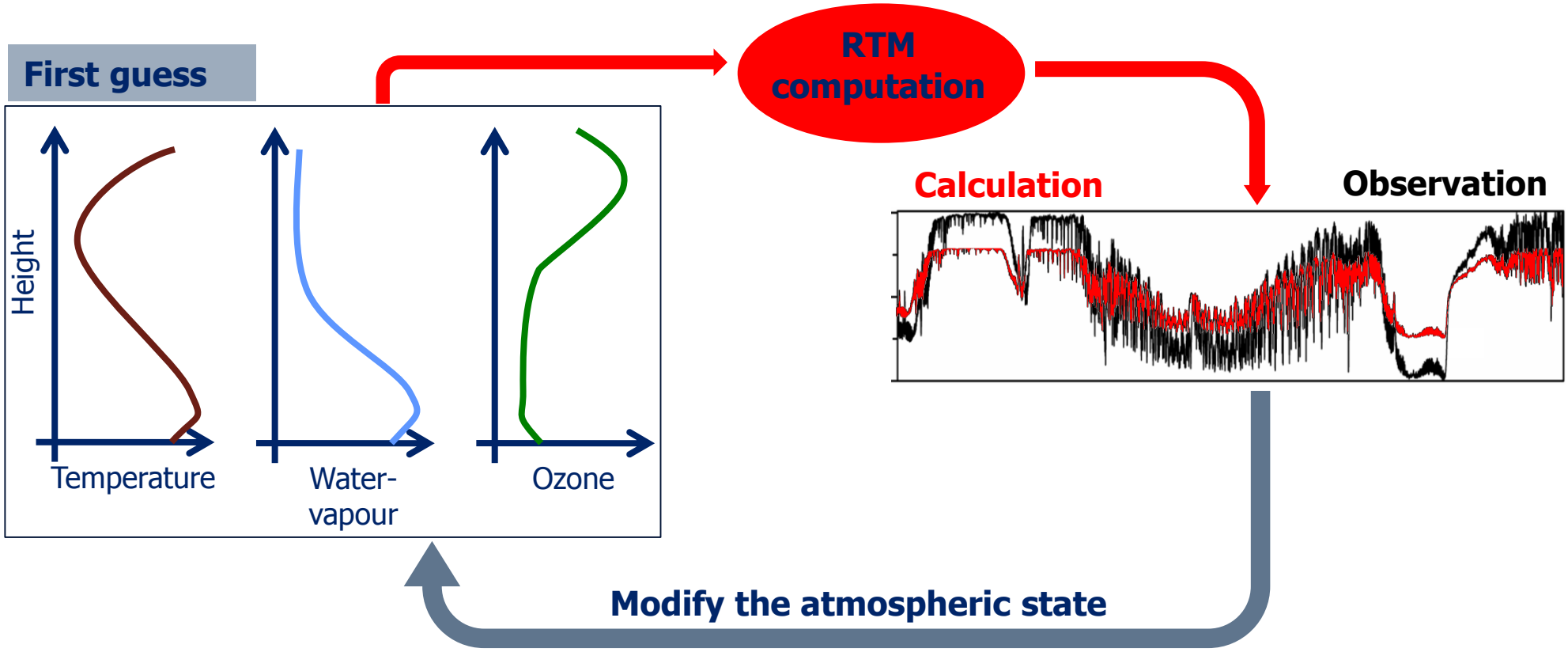


19/03/2010

White: cloudy **Black: clear**

Produits geophysiques (niveau 2)

This retrieval technique consists in adjusting iteratively an atmopheric state vector (profiles of temperature, humidity, ozone...) to fit the observations with simulated measurements calculated with a radiative transfer model.



Produits geophysiques (L2)

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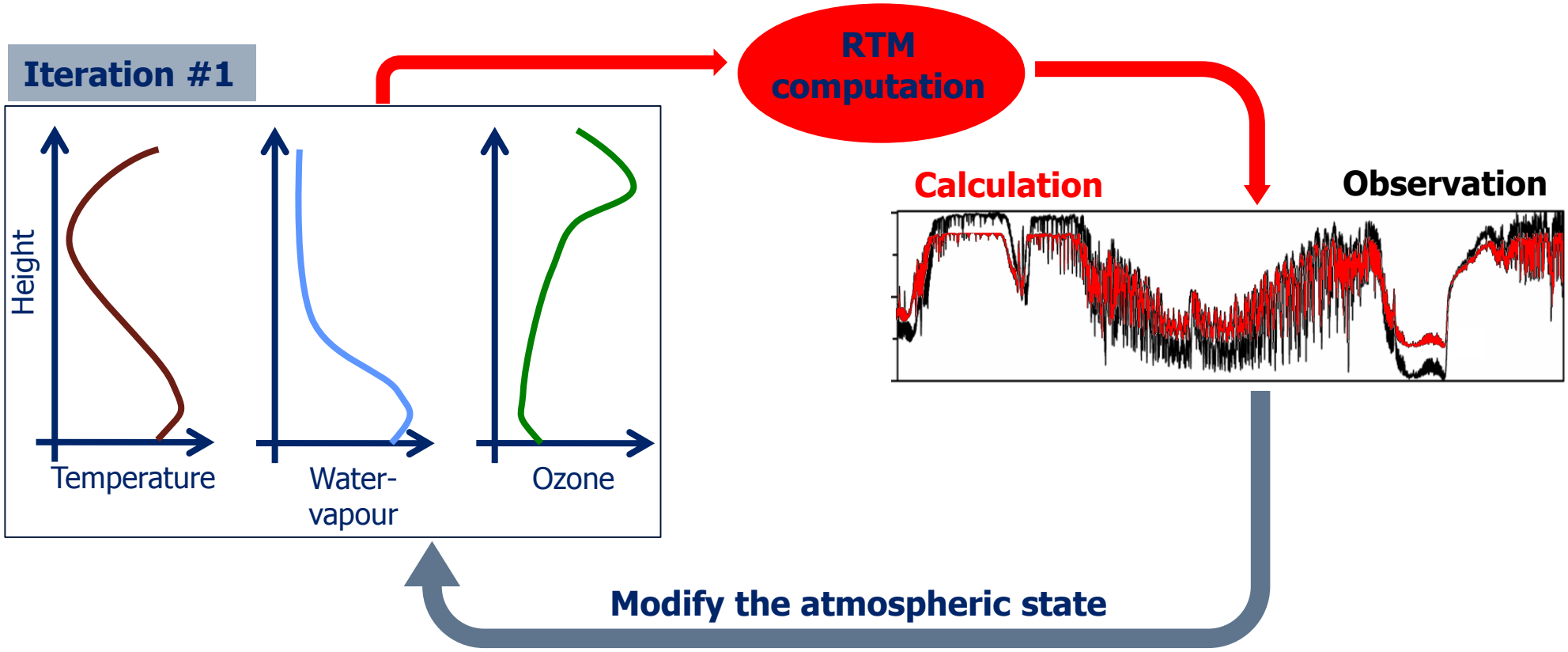

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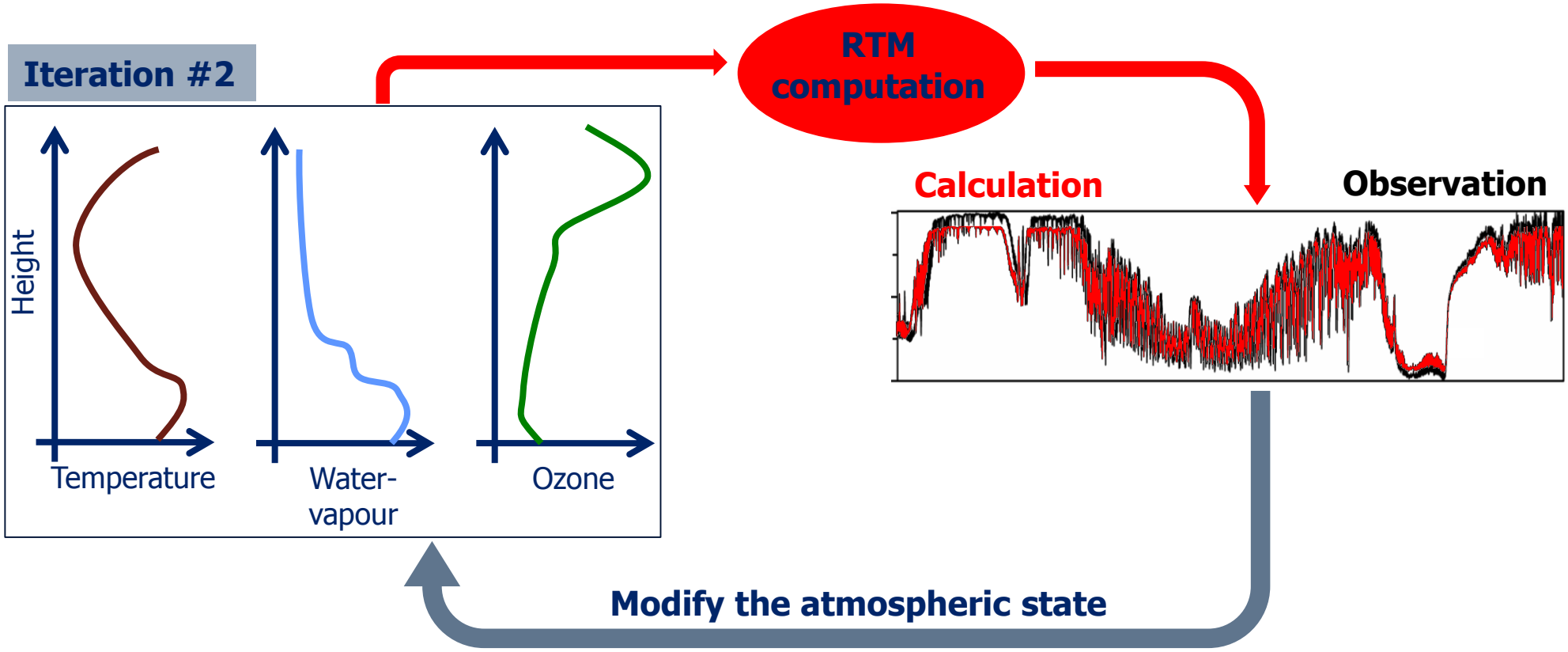

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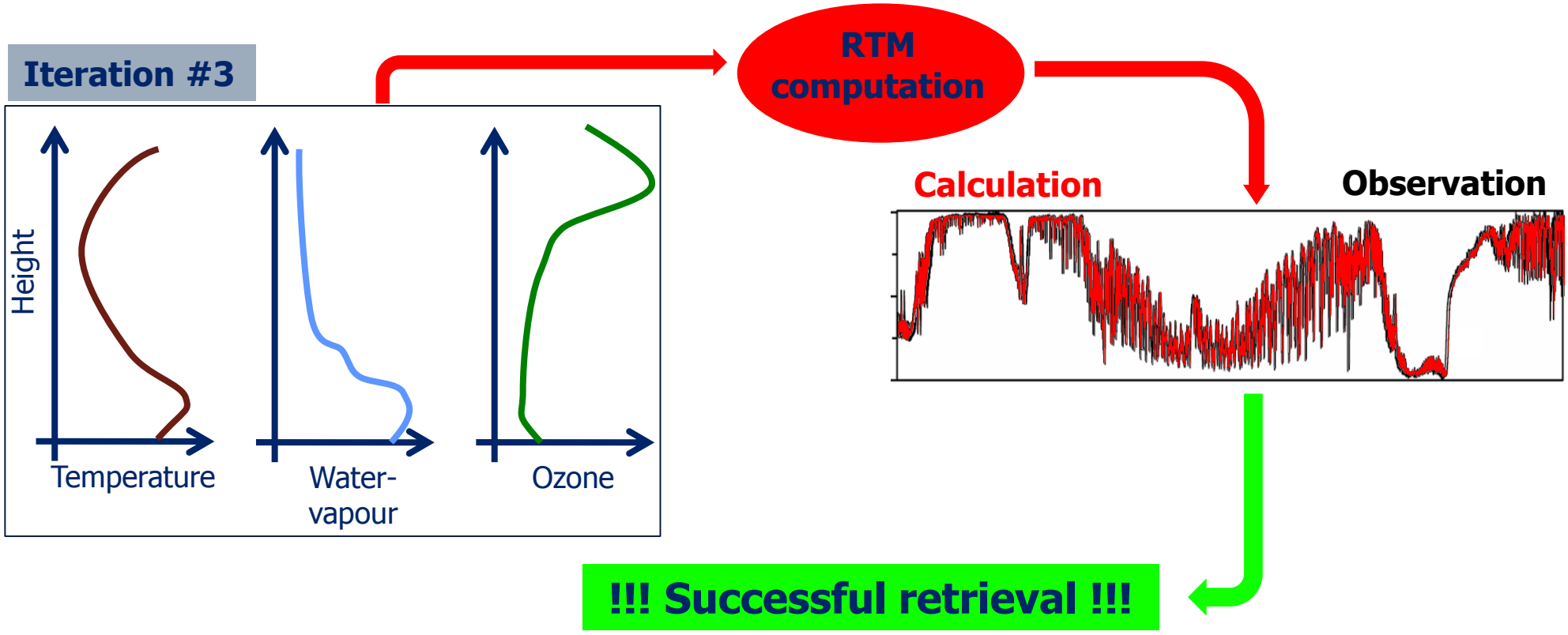

MTG-IRS mission

Primary objective :

- To support regional and convective-scale NWP in Europe, through
  - unprecedented detail on 3D fields of wind, temperature and humidity,
  - at high vertical, horizontal and temporal resolution.

Other objectives:

- To support nowcasting and very-short range forecasting (VSRF),
  - 3D fields of wind, temperature and humidity,
  - … and hence moisture convergence and convective instability,
  - to help improve warnings of location and intensity of convective storms
- To support global NWP - wind, temperature and humidity over Meteosat coverage area.

MTG-IRS instrument

- Fourier transform spectrometer
- Spectral resolution: 0.625 cm^{-1}
- Spectral ranges: 700-1210 cm^{-1} (LWIR) and 1600-2175 cm^{-1} (MWIR)
- Horizontal sampling: 4 km, at sub-satellite point (ssp)
- Temporal sampling: 30-60 min (full disk) or 7.5-15 min (Europe)

Compared with MetOp/IASI:

- slightly reduced spectral resolution
- comparable vertical resolution and accuracy on humidity
- … and slightly less on temperature
- much superior in terms of horizontal and temporal resolution