Operational hyperspectral sounding Validation and monitoring

Thomas August, EUMETSAT

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GRUAN ICM-10, 25 April 2018, Potsdam

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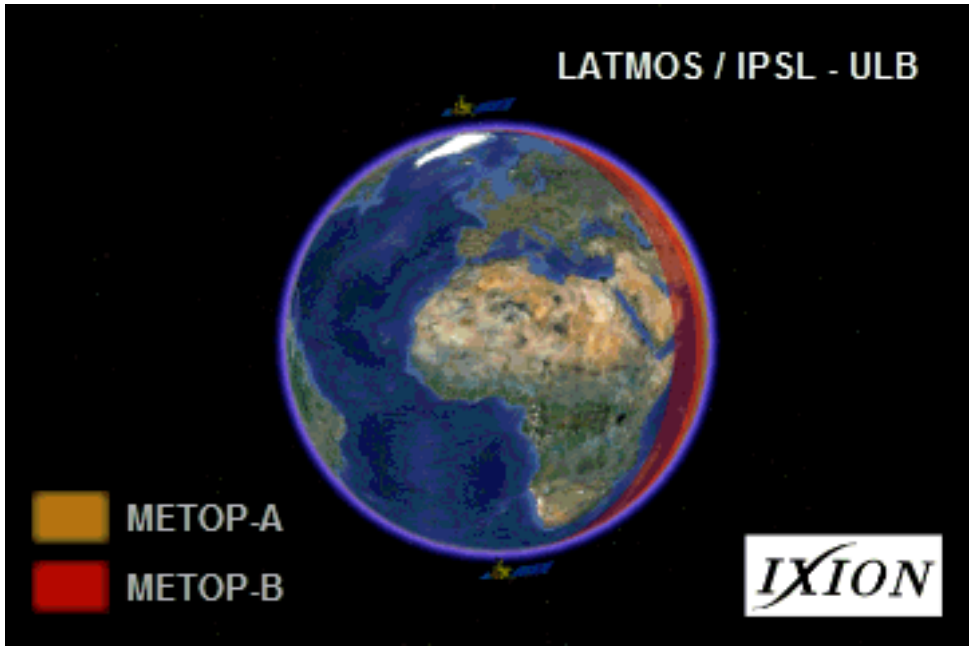
Outline

1. EUMETSAT sounding missions
2. Example of validation results
3. Upcoming needs & challenges
4. Coordination with GRUAN

The EPS programme EUMETSAT Polar System



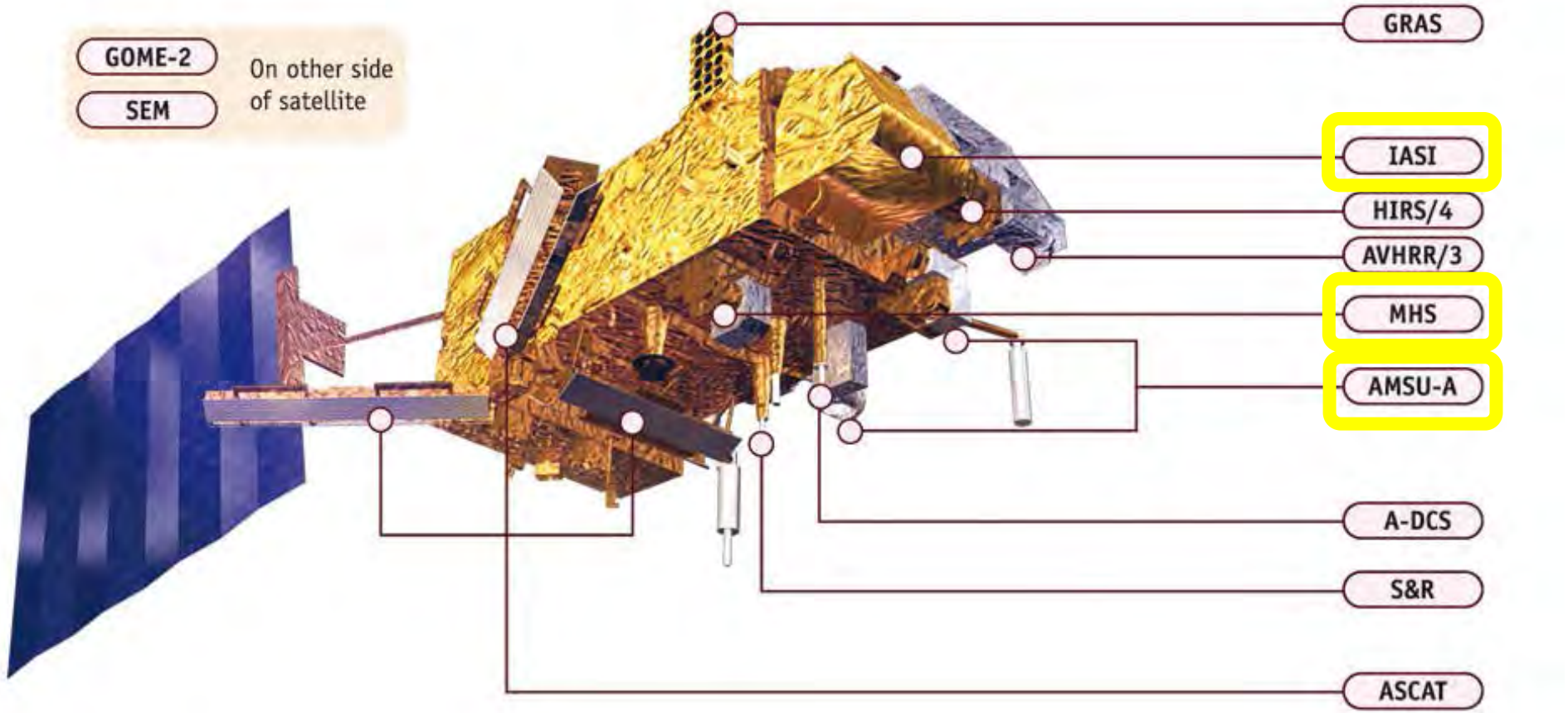
3 satellites, sun-synchronous orbit (817km)

Metop-A, 19 October 2006
Metop-B, 17 September 2012
Metop-C, September 2018

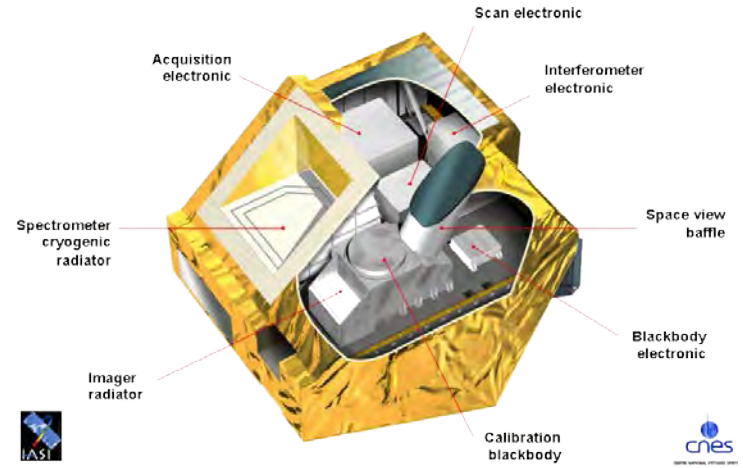
European contribution to the Initial Joint Polar System Agreement (IJPS), between EUMETSAT and NOAA.

Metop in the local 'morning' orbit
US satellites in the 'afternoon' orbit

The Metop platform



IASI: Infrared Atmospheric Sounding Interferometer



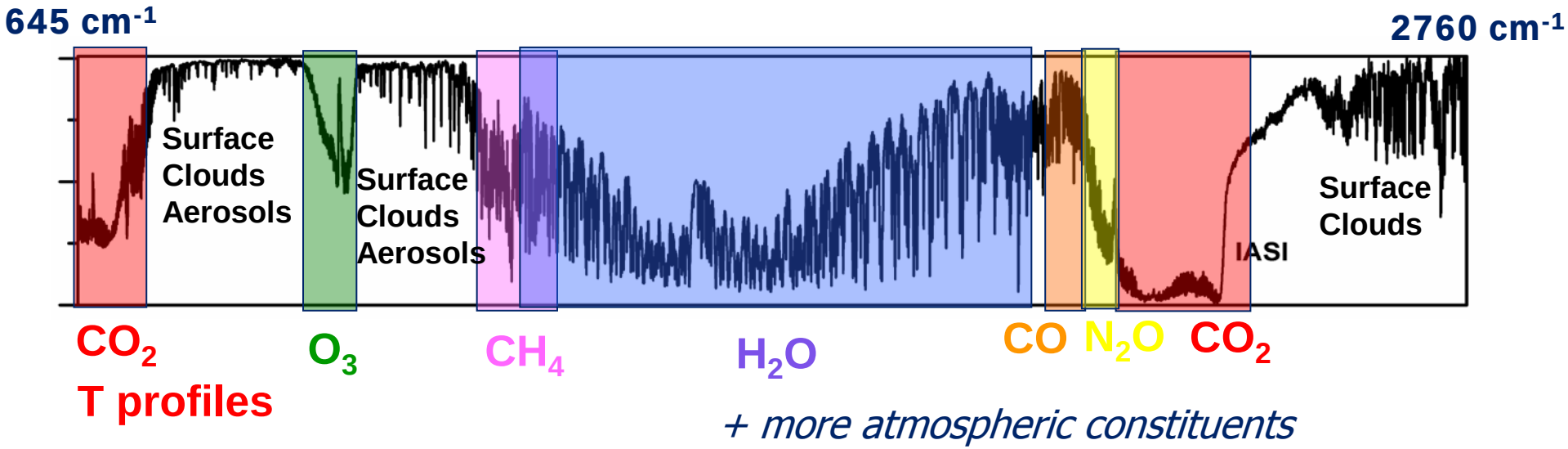
Infrared Fourier transform interferometer

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

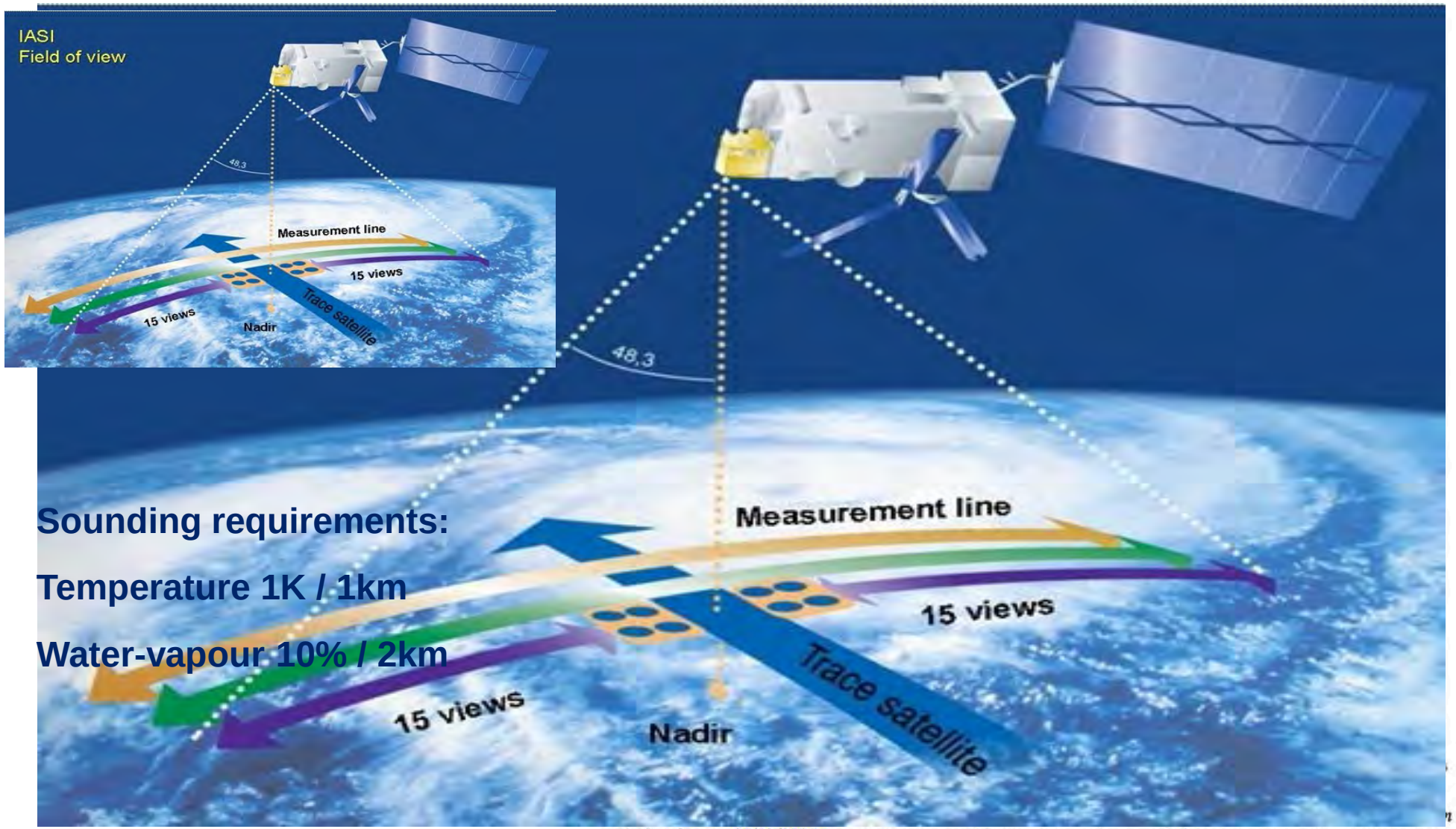
Spectral sampling: 0.25 cm^{-1}

Footprint: 12 km (Nadir) - 40 km (Swath edge)

Swath: ±1000km (± 48.3° scanning)

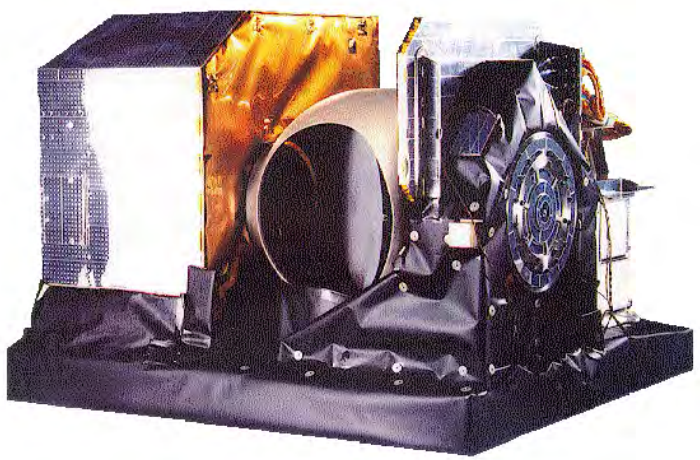


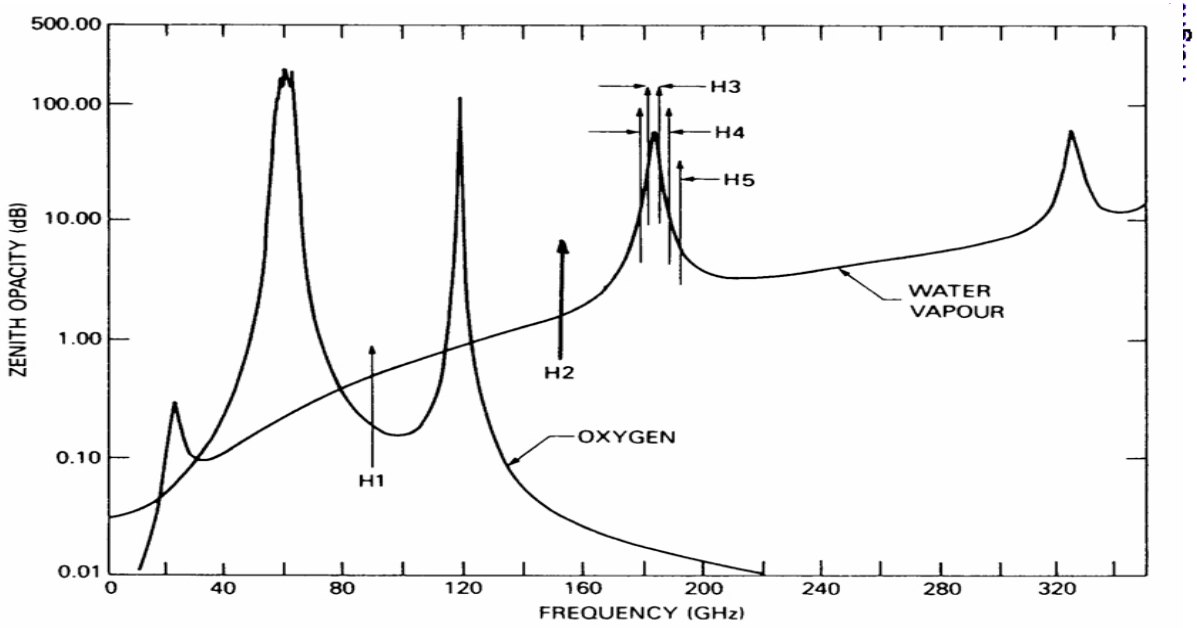
IASI: Infrared Atmospheric Sounding Interferometer

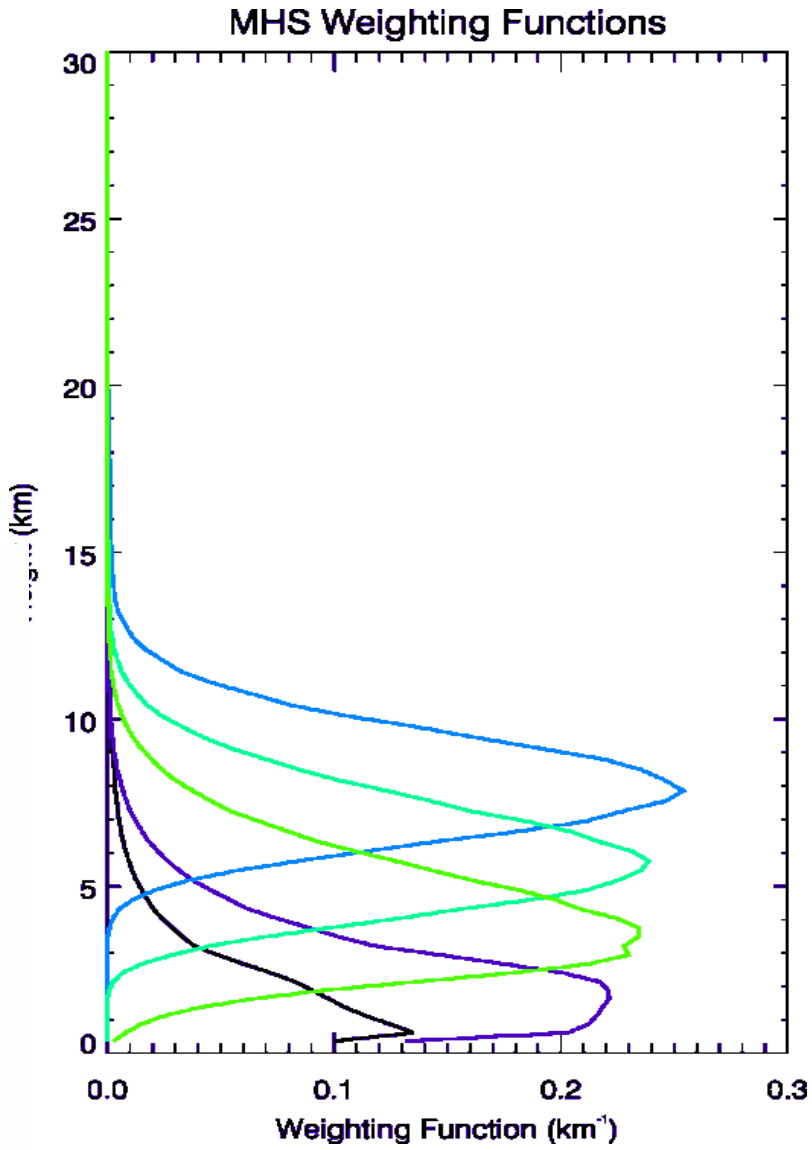


sample taken on 12/09/2014.

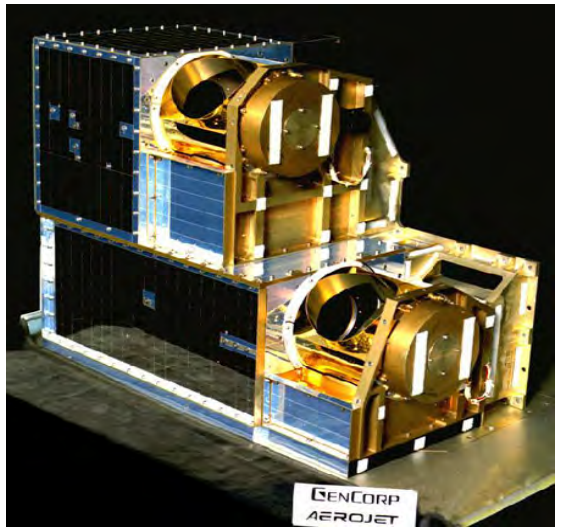
MHS: The Microwave Humidity Sounder

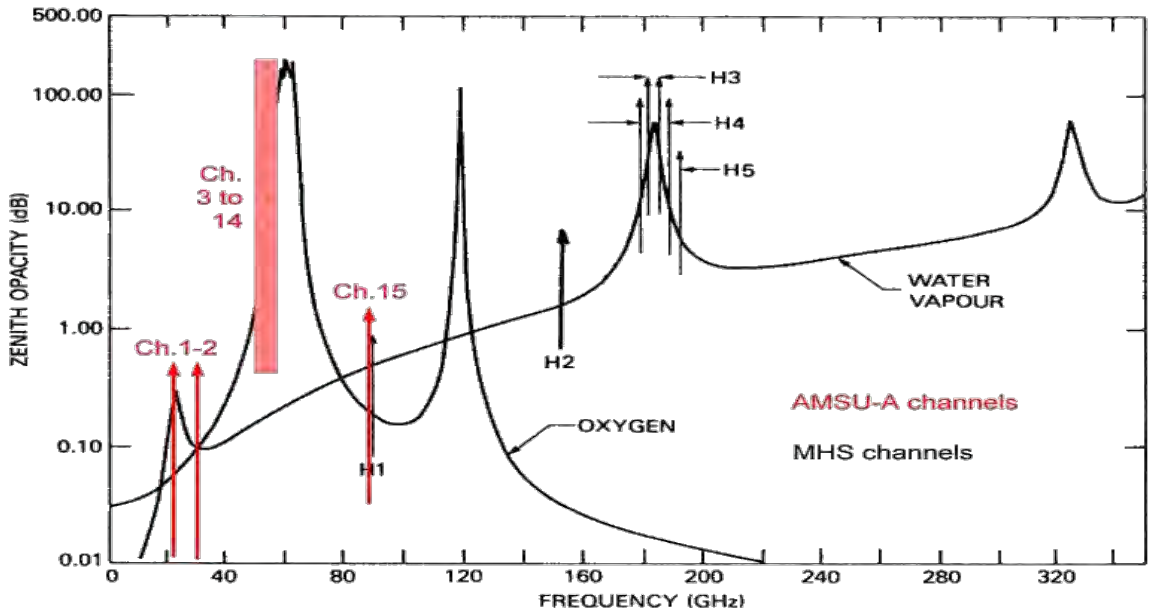


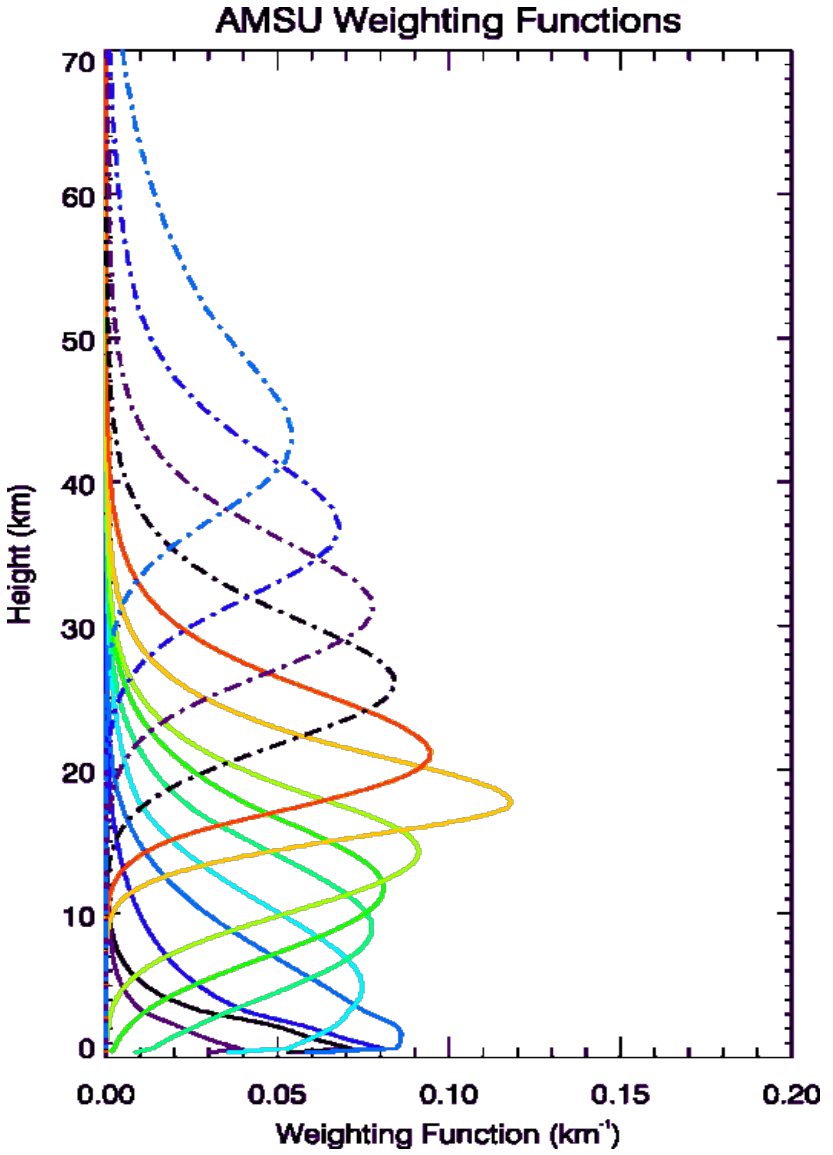




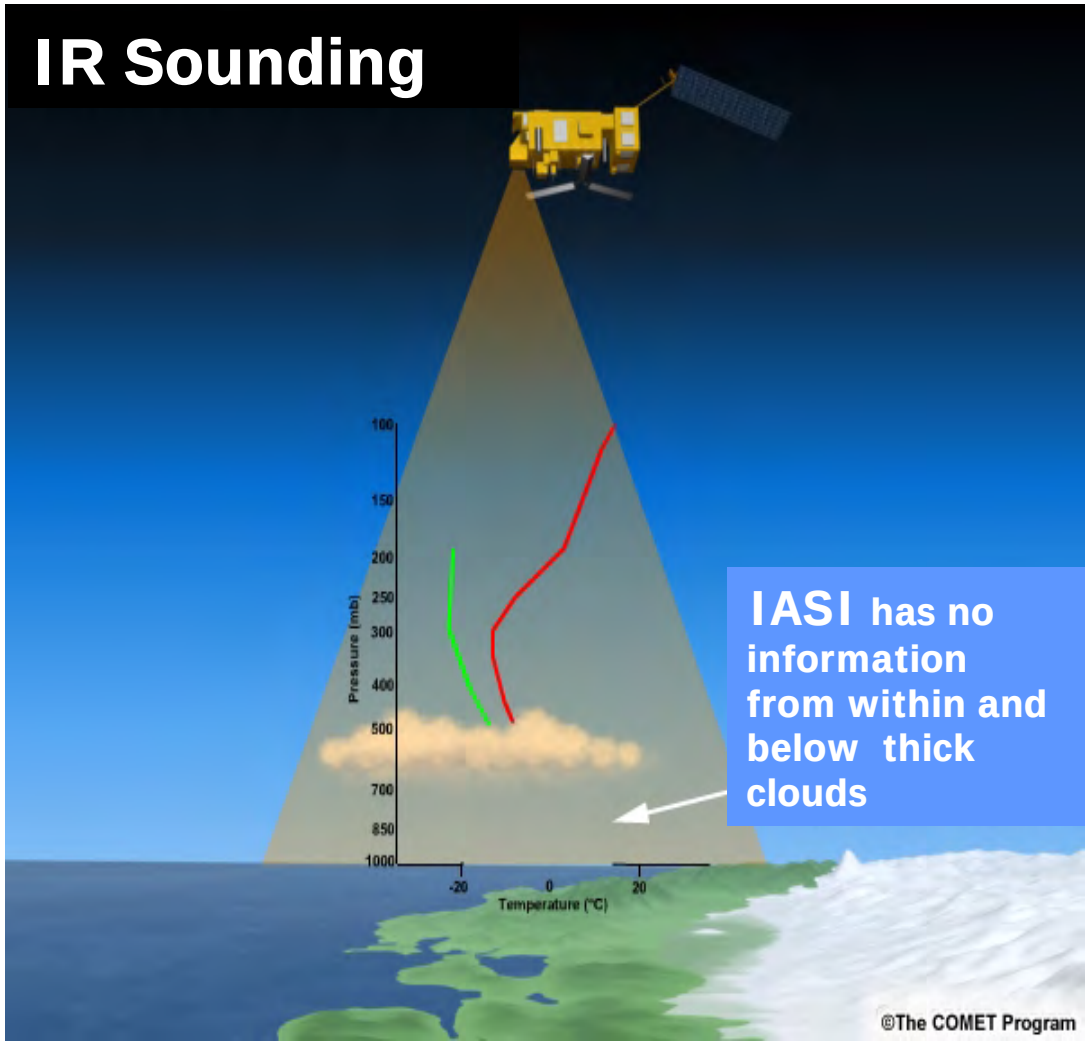
AMSU: The Advanced Microwave Sounding Unit

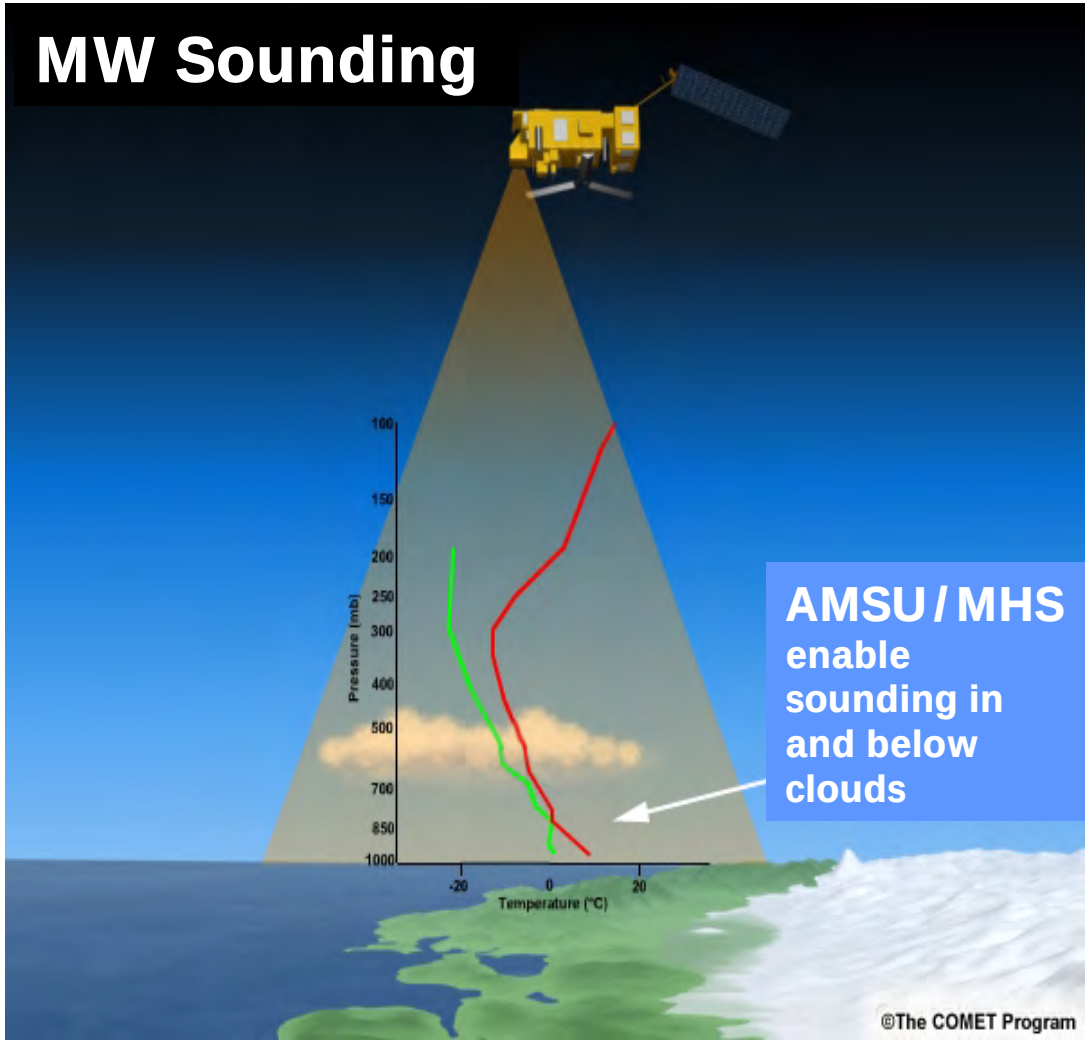






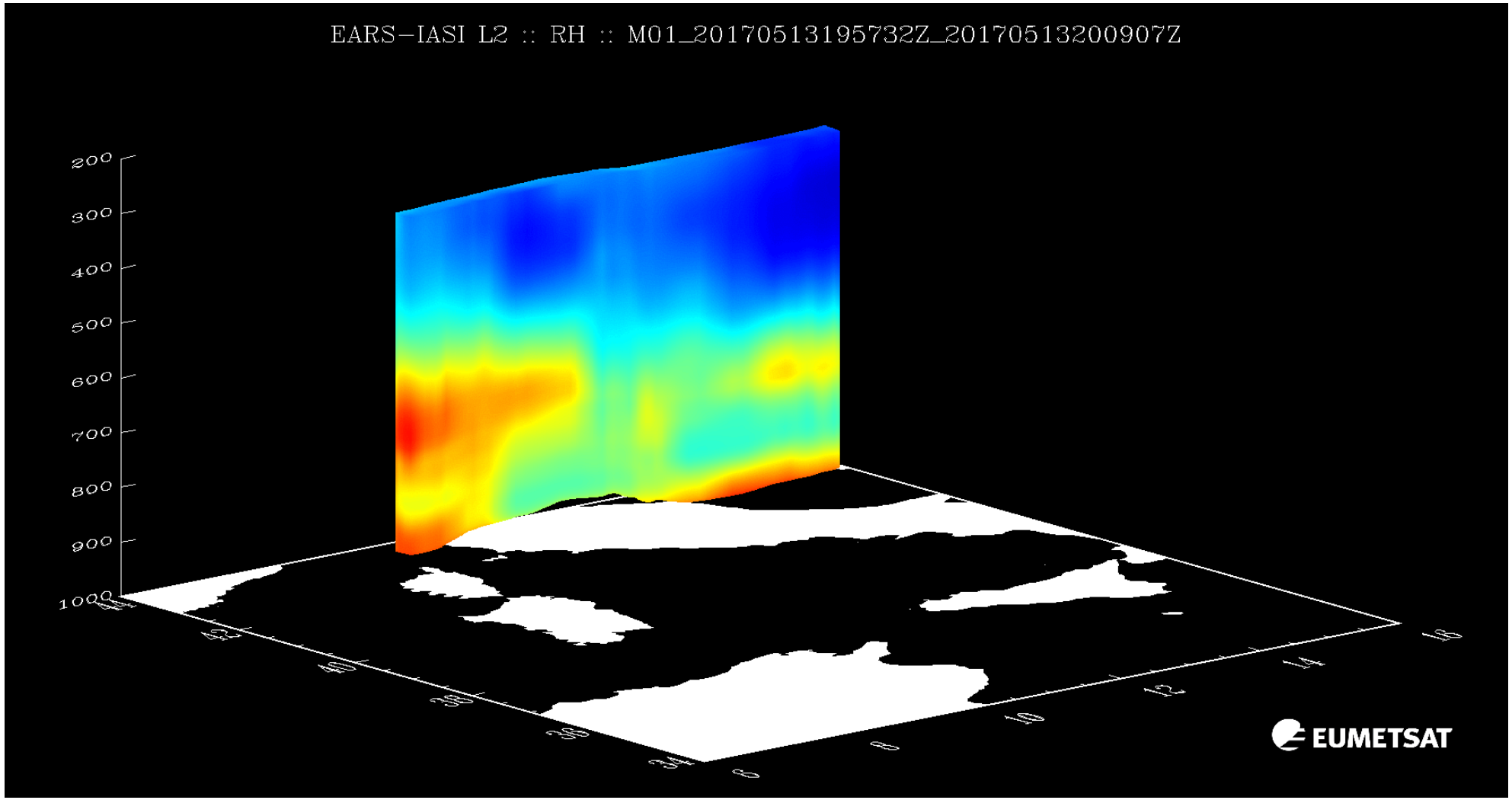
IASI L2 v6 ‘all-sky’ processor Synergy MW + IR





Adapted from MetEd UCAR material
(University Corporation for Atmospheric Research, Boulder CO, US)

3D humidity fields (%RH) with IASI L2 ‘all-sky’ processor



IASI L2 v6 processor Performance assessment

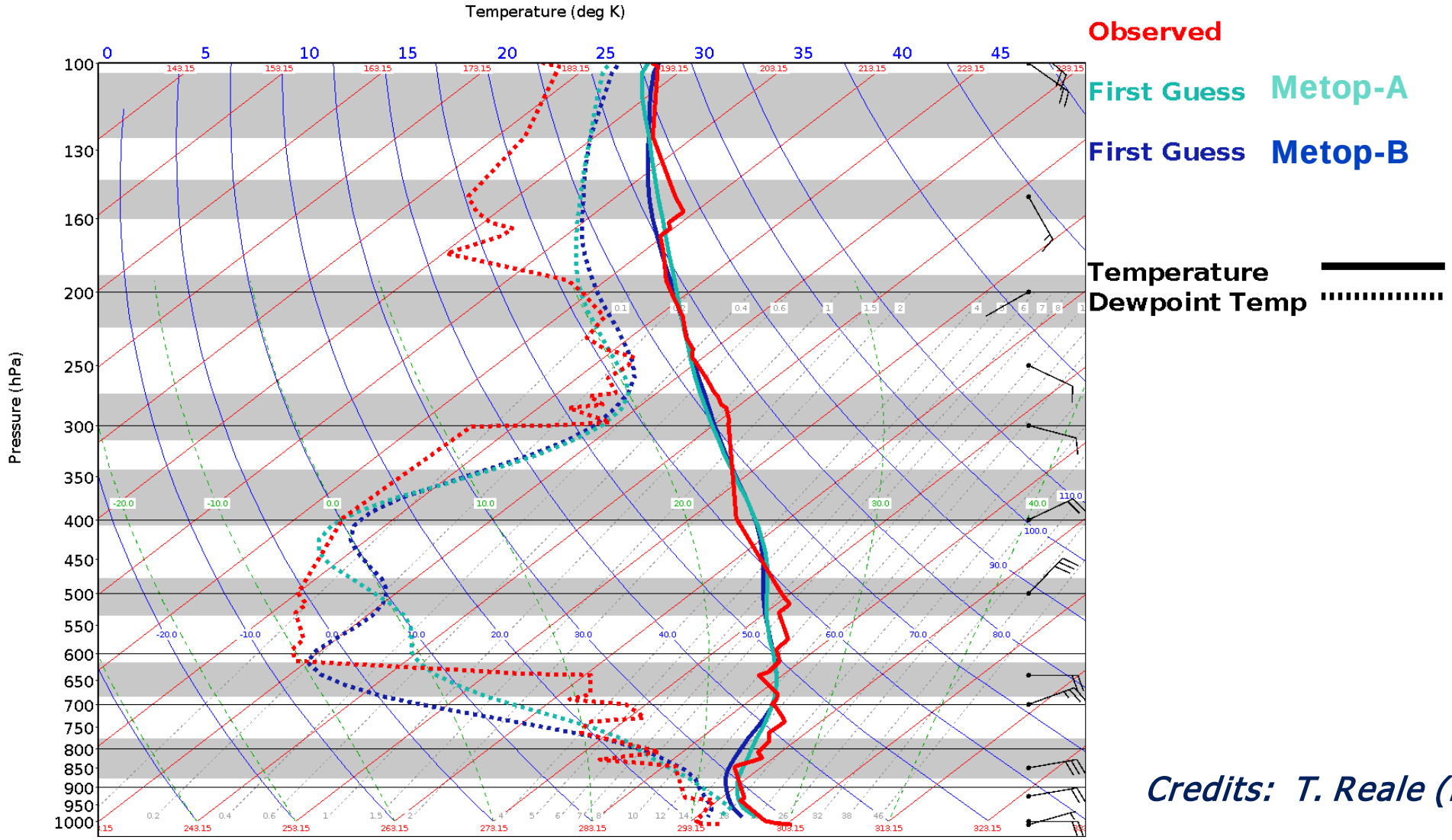
Extensive validation of temperature and humidity products:

- ✓ assessed in-house, with validation and routine monitoring tools
- ✓ through co-operations : CIMSS/U. Wisconsin, NCAR, NOAA…
- ✓ *vs* radiosonding, numerical models, ground-based measurements…

"IASI L2 v6 Validation Report" EUM/TSS/REP/14/776443, 290pp
"IASI L2 v6.2 Validation Report" EUM/RSP/REP/16/857500, 73pp
"IASI L2 PPF v6.3 Validation Report" EUM/RSP/REP/17/920559, 45pp
"IASI L2 PPF v6.4 Validation Report" EUM/RSP/REP/18/974859, 59pp
Feltz et al., JGR 2017, 10.1002/2017JD026504;
Roman et al., JGR 2016, 10.1002/2016JD024806;
Boylan et al., JGR 2015, 10.1002/2015JD024724;
communications in conferences
…

IASI L2 v6 performances

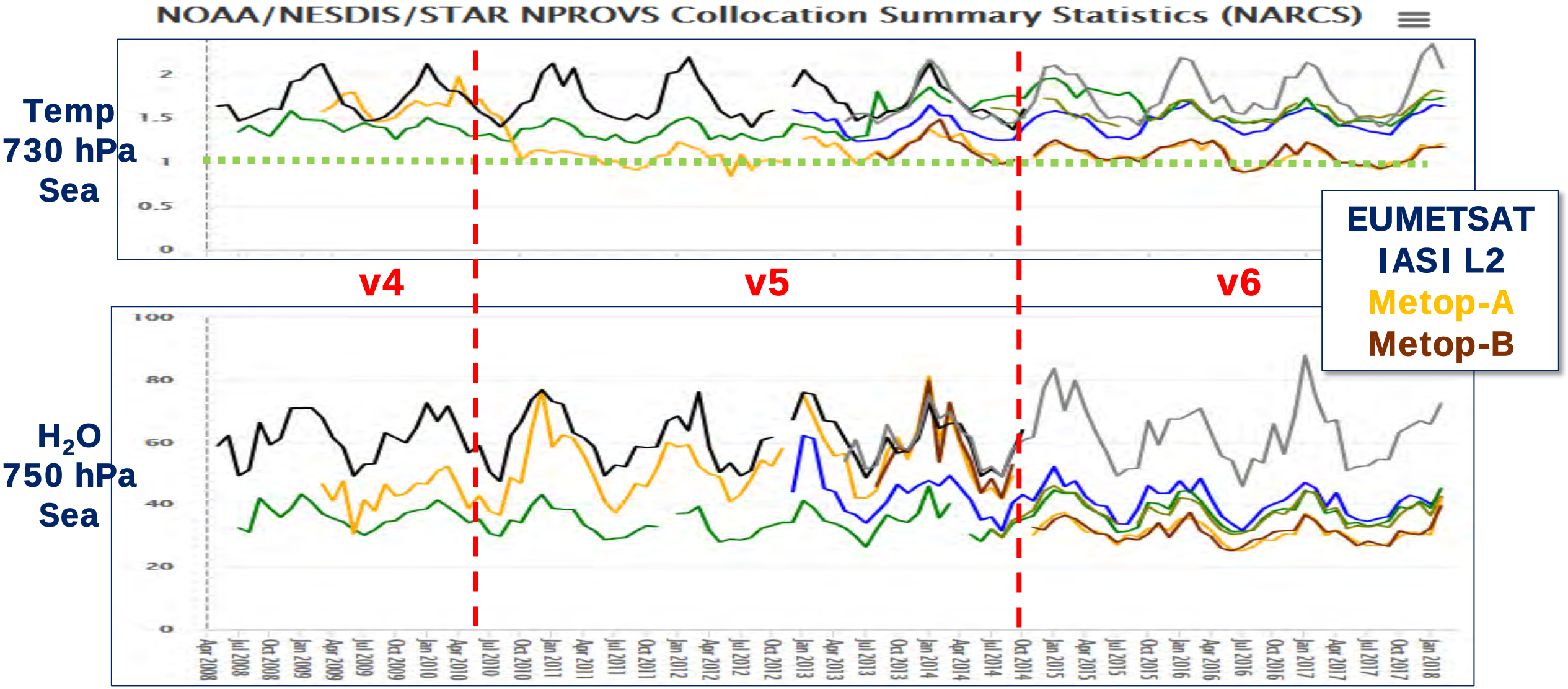
Monitoring with *in situ* data



Credits: T. Reale (NOAA)

EUMETSAT

IASI L2 long-term monitoring against sondes



https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/ *Credits: B. Sun, T. Reale (NOAA)*

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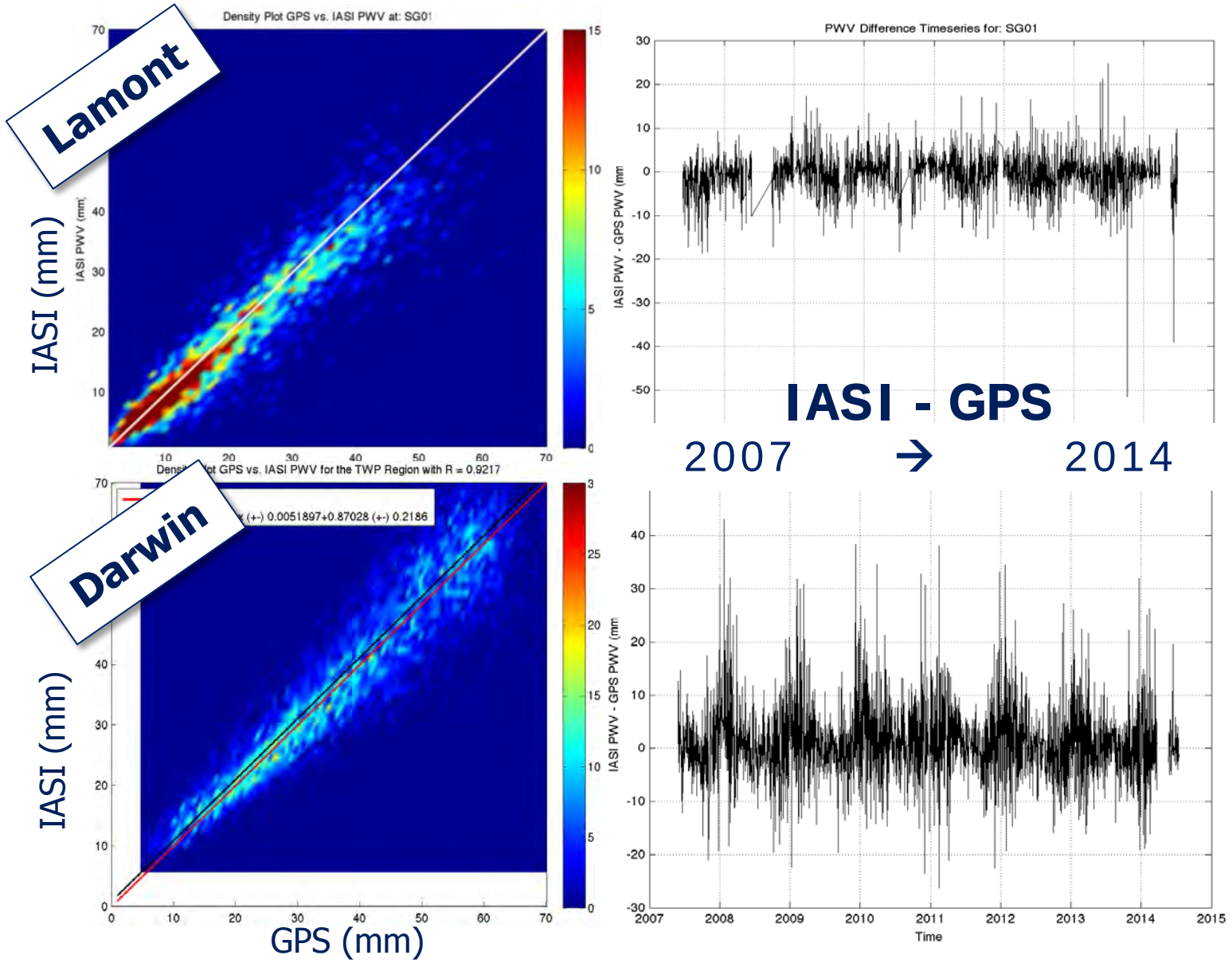
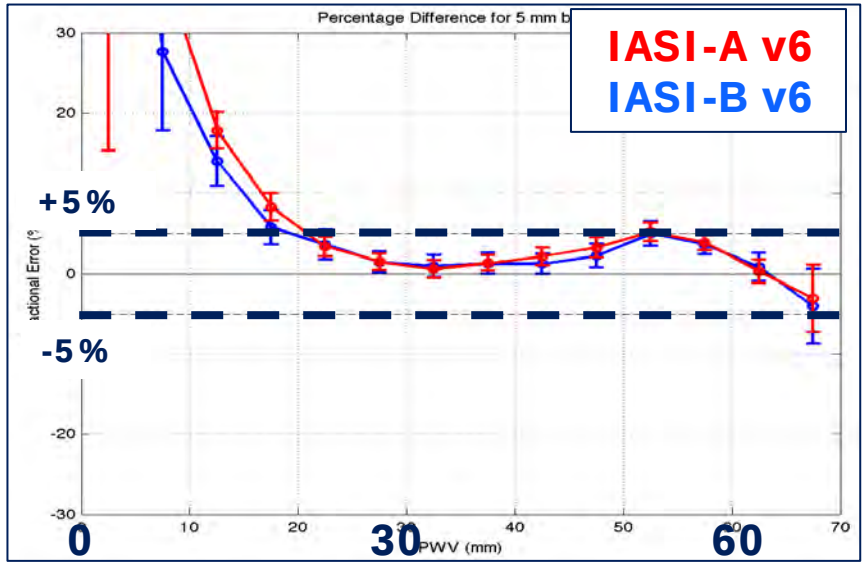
IASI L2 v6 performances TCWV vs ground-based GPS



Roman et al, JGR 2016

"A global assessment of NASA AIRS v6 and EUMETSAT IASI v6 precipitable water vapor using ground-based GPS SuomiNet stations"

Relative accuracy



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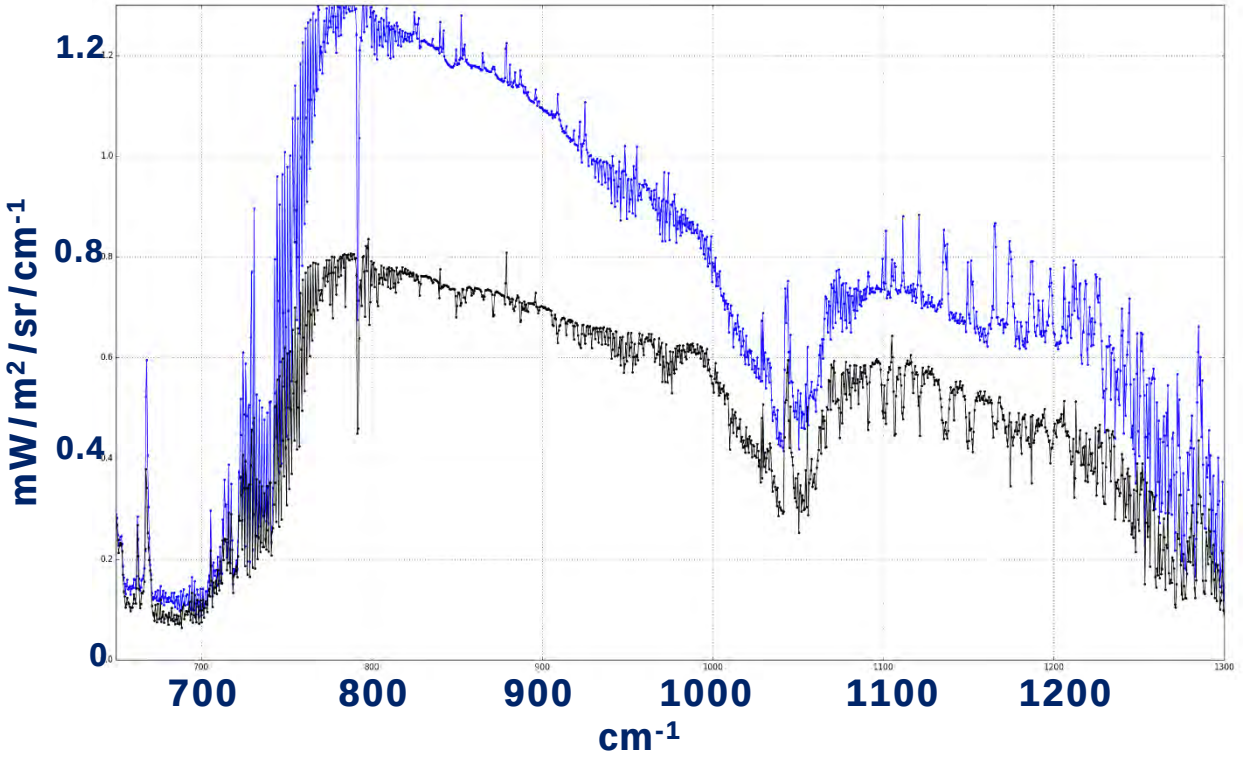
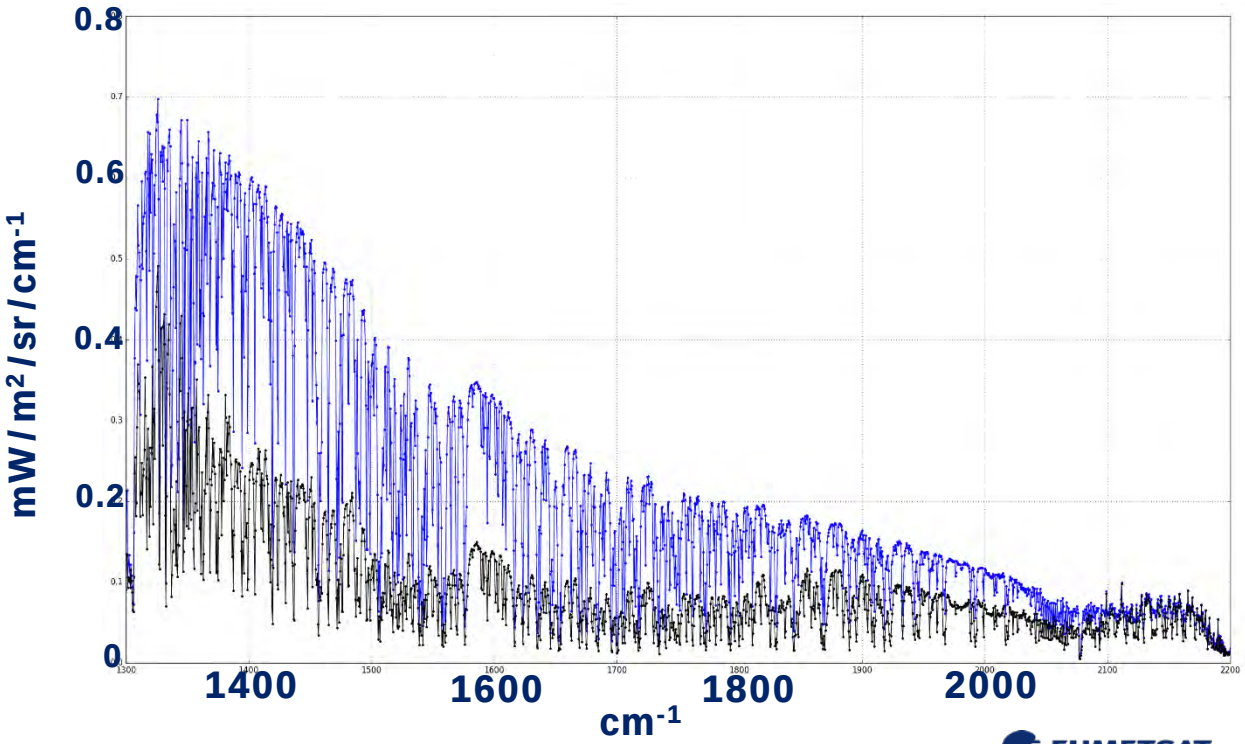
Assessment in radiance space - Ocean



OBS – CALC(ECMWF FCT)

OBS – CALC(PWLR³ v6.4)



01/11/2017
Maritime scenes ;|lat| < 60°
Clear-sky QC from IASI L2

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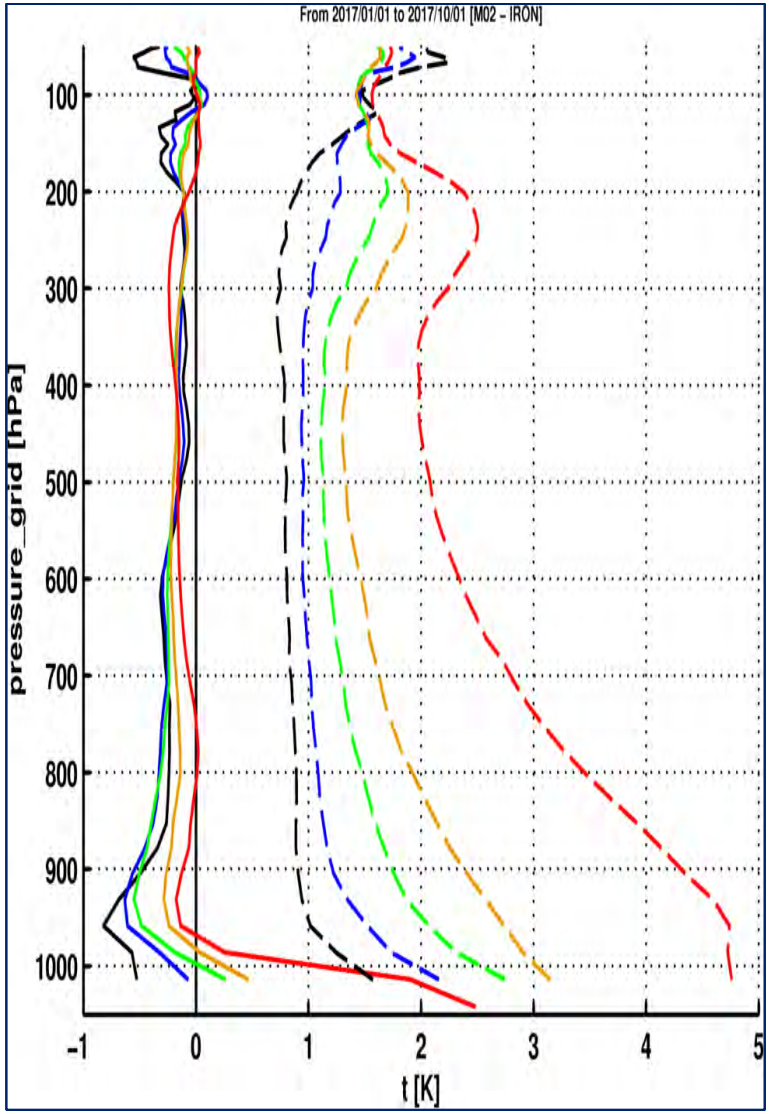
Quality indicator significance *vs* sondes [IGRA]

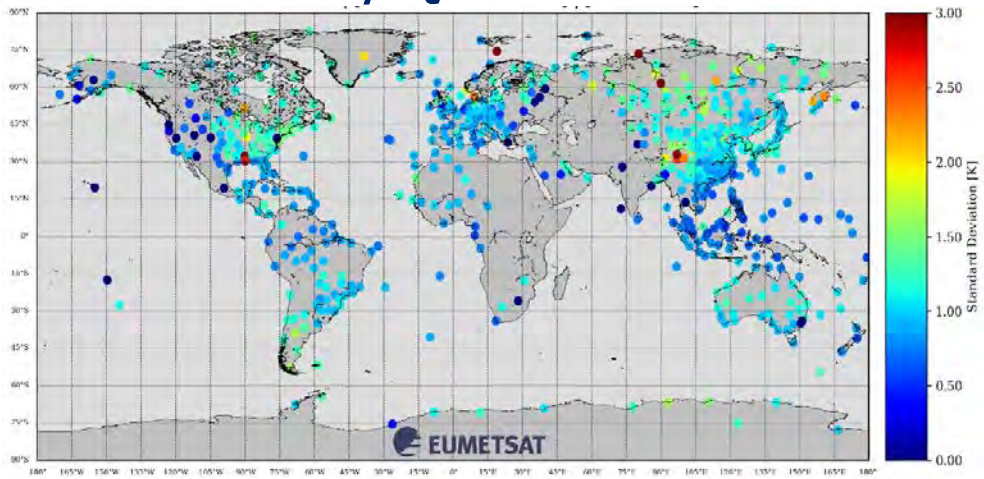
IR-only



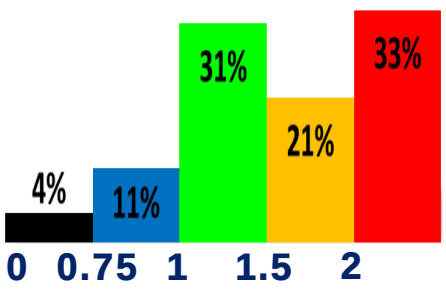
Jan. – Oct. 2017

< 50km ; < 3h

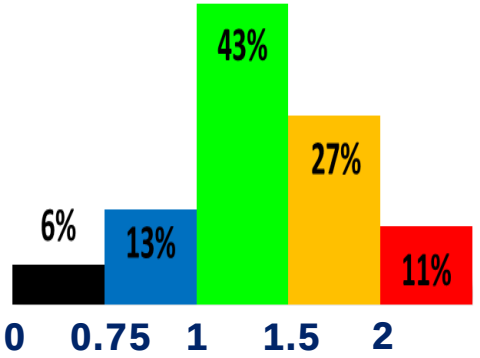
Match-up QC still needed



IR-only

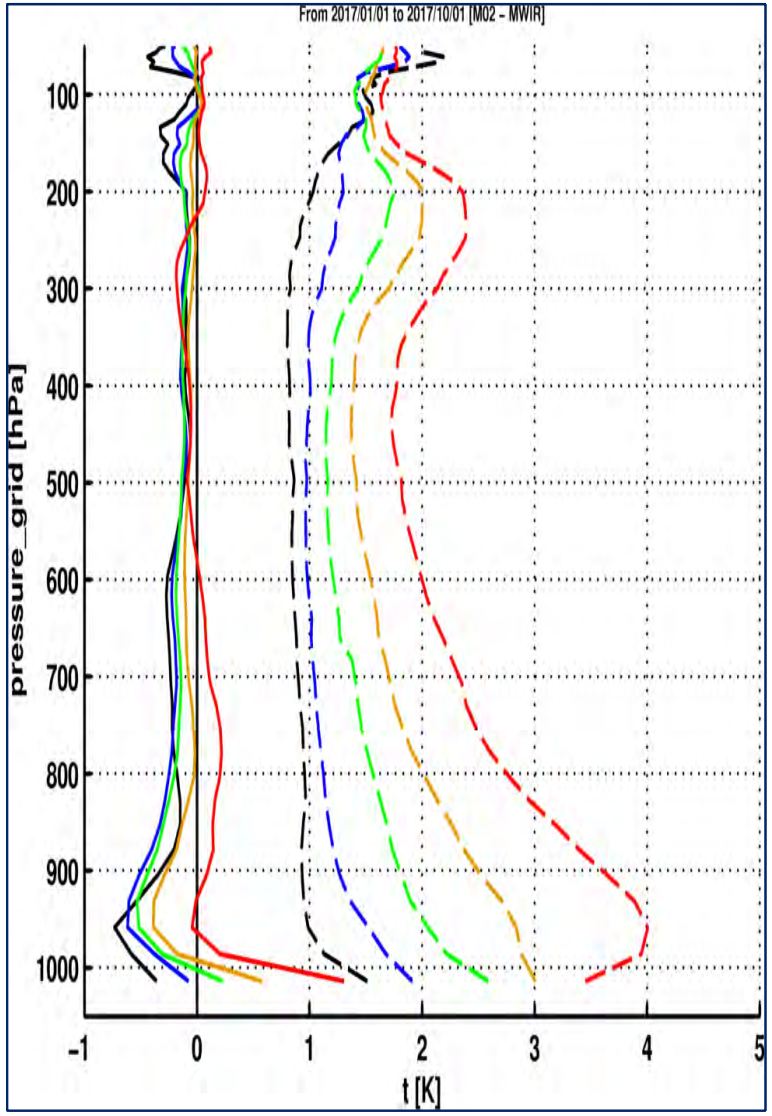


MW+IR



Error estimate in troposphere

MW+IR



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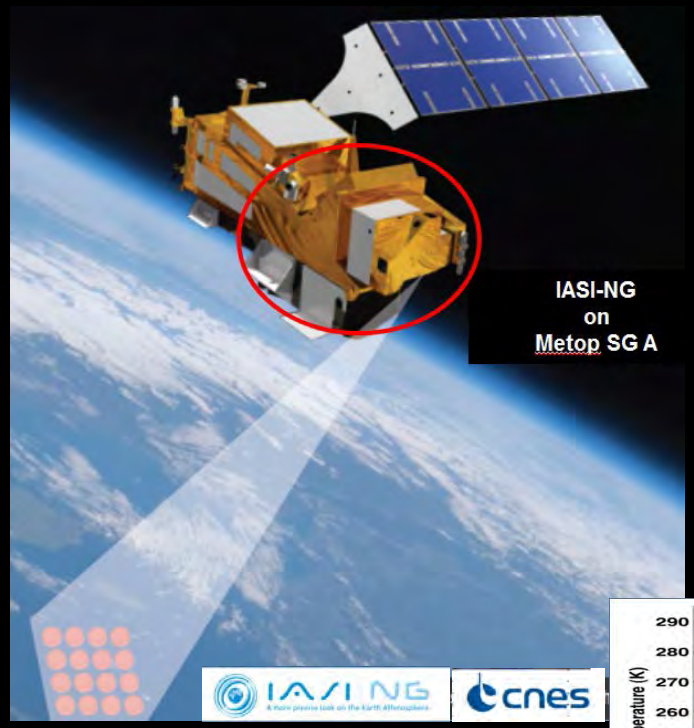
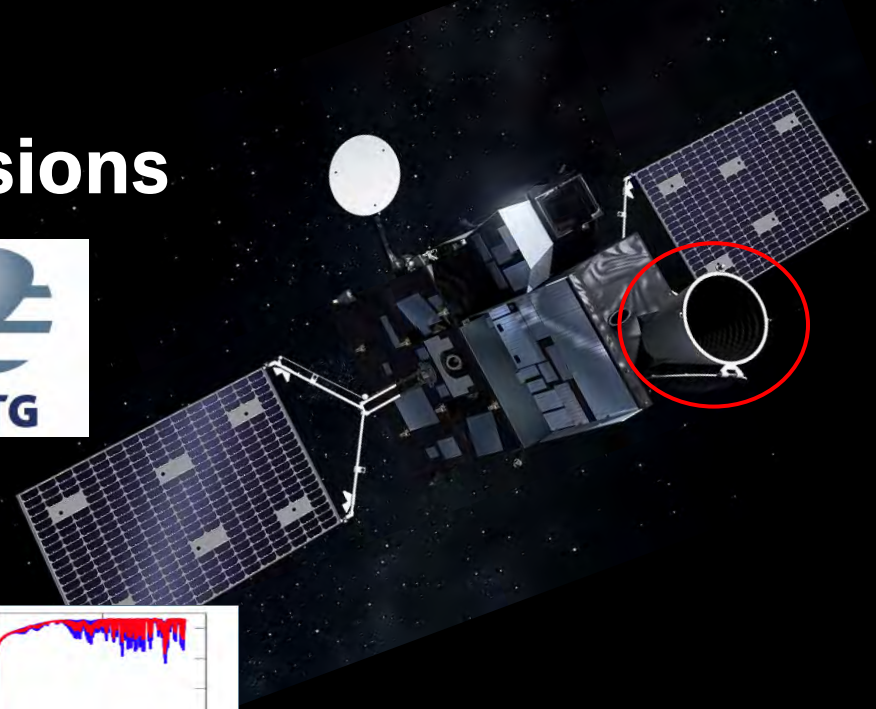
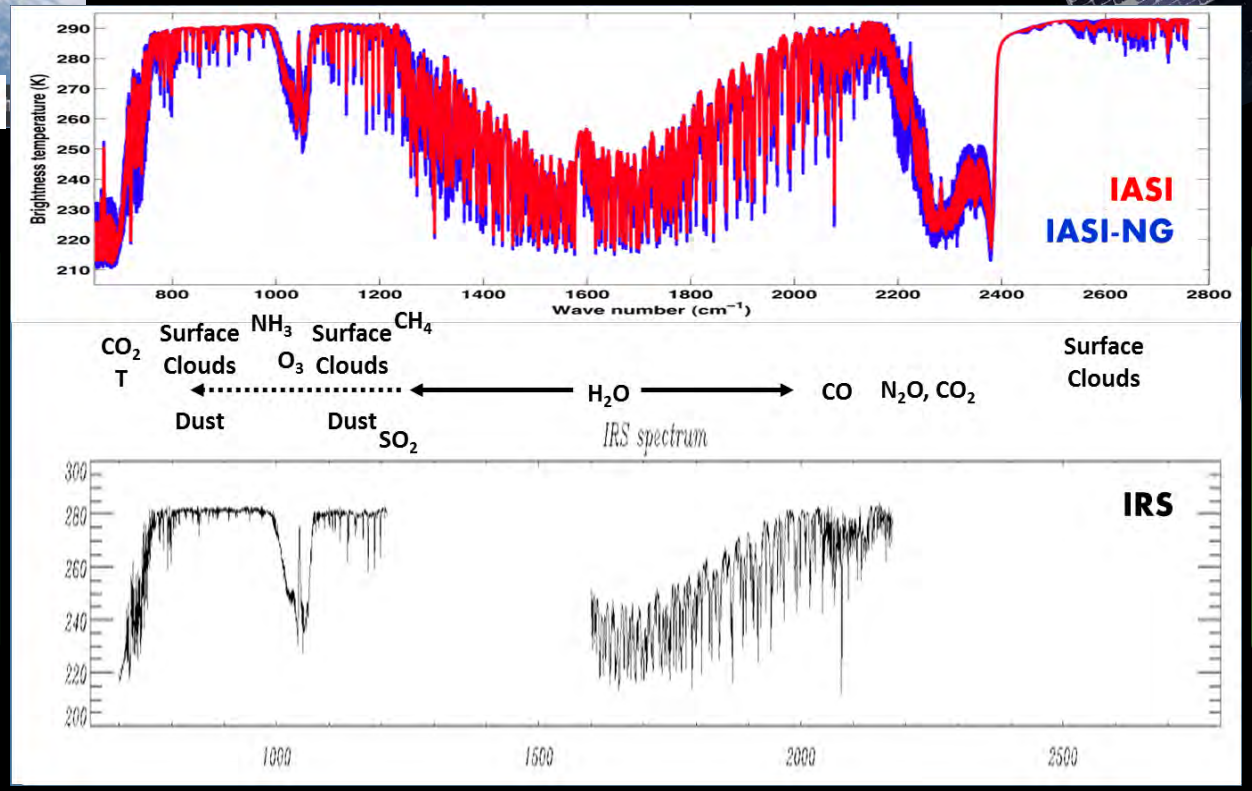
New hyperspectral missions



EPS-SG

MTG





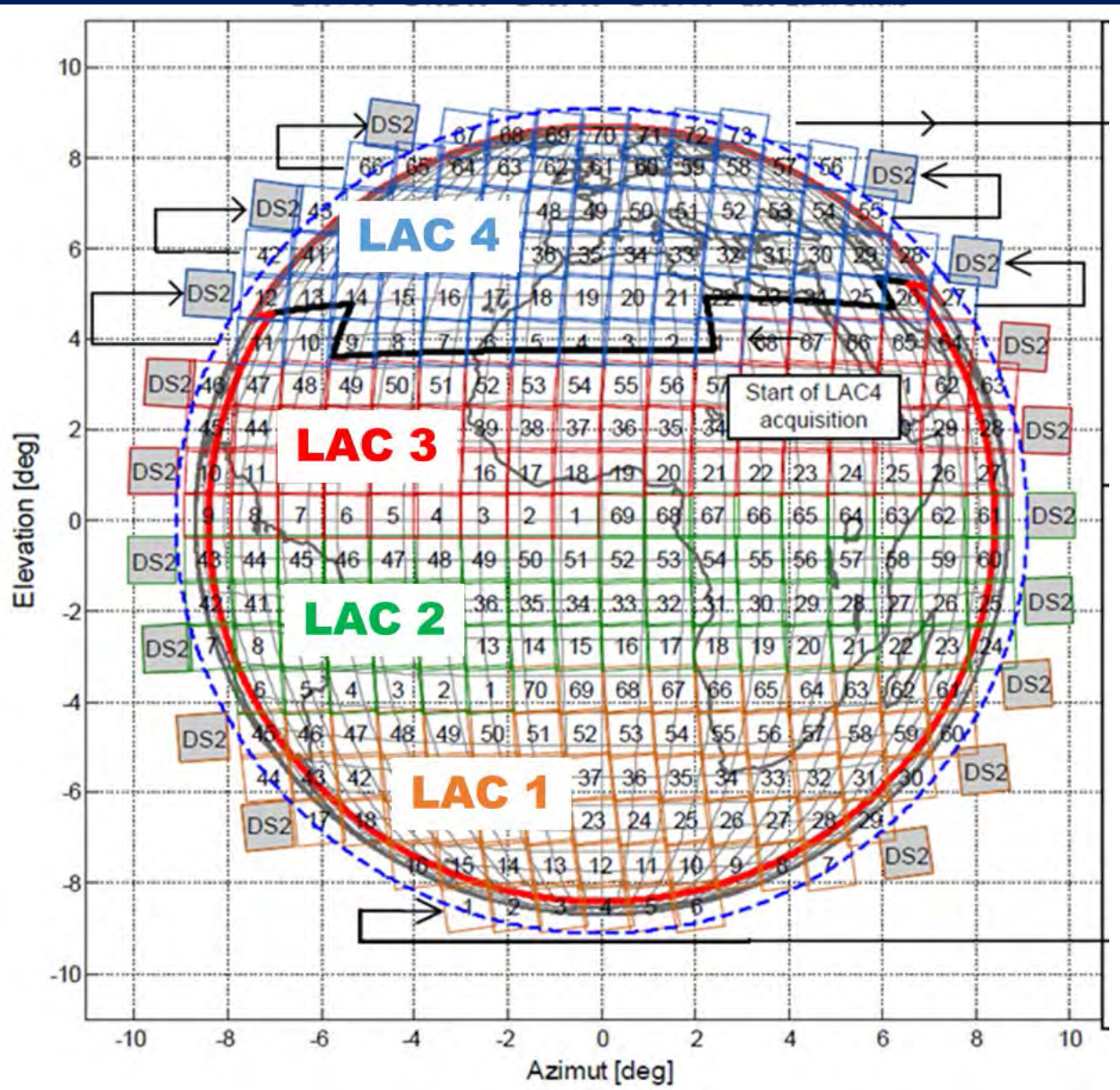
IASI-NG

- LEO orbit, sun-synchro.
- Mertz interferometer
- 4x4 pixel detector
- 12-km pixel at Nadir
- 4 spectral bands
- Sampling 0.125 cm^{-1}
- Swath ~2000km
- Launch 2021

MTG-IRS

- GEO orbit, 3-axis stabilised
- Imaging interferometer
- 160x160 pixel detector
- 4-km pixel at Nadir
- 2 spectral bands
- Sampling ~0.6 cm-1
- 30’ repeat over Europe
- Launch 2023

MTG-IRS scanning pattern



4 Local Area Coverage (LAC)

- One LAC acquired within 15’
- Overlapping step & stare dwells
- 160x160 pixels, ~4km at Nadir

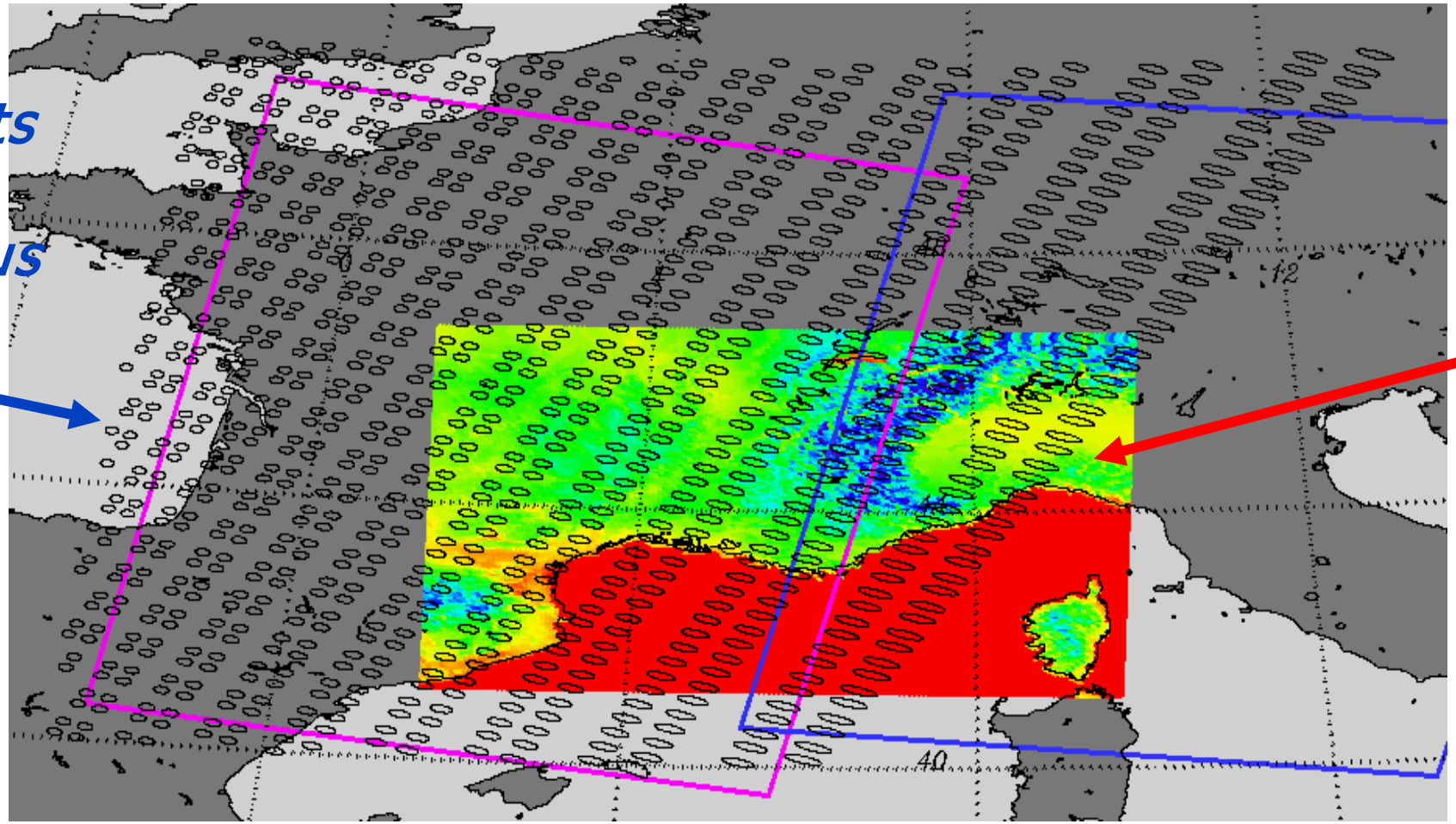
Europe (LAC 4) observed every 30’

Major innovation

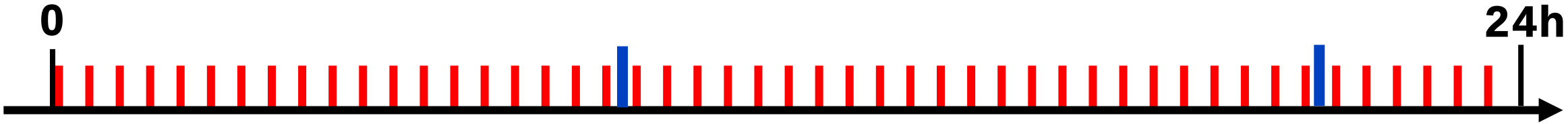
Operational spectro-imagery at high spectral, spatial & temporal resolution

IRS: spectro-imagery at high spatio-temporal resolution

IASI footprints
12-40km
Not-contiguous
2x per day



IRS pixels
~7km
Contiguous
Every 30'



Upcoming needs

EPS

- Metop-C commissioning (launch Sept. 2018, L2 Cal/Val in 2019)
- monitor 3 operational missions in space

EPS-SG

- tighter requirements

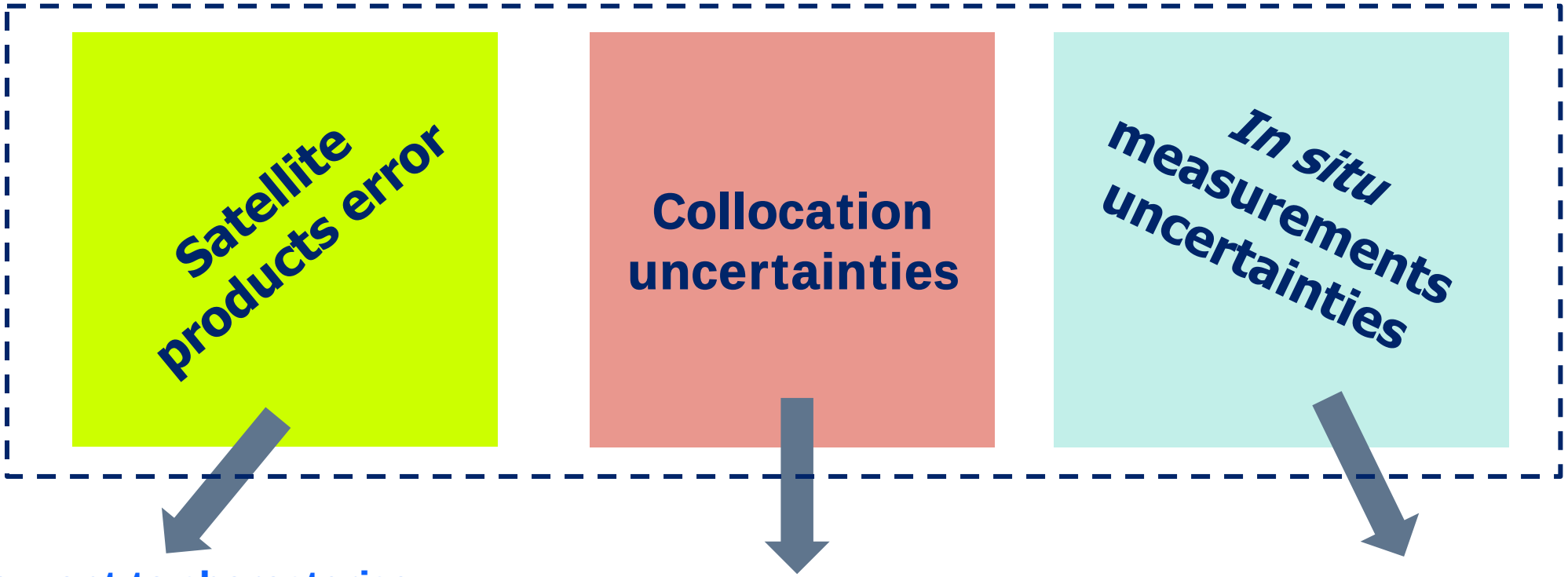
	EPS / IASI	EPS-SG / IASI-NG
T	1-1.7K / 1km	0.8K / 0.8km LT, MT 1.2K / 2km UT, S
H_2O	5-20% RH / 2km	5% / 1.2km LT 7% / 1.7km MT, UT 20% / 3km S

Do we have the reference measurements and validation methodology for this?

MTG-IRS

- 160 x 160 simultaneous obs. (4km at Nadir)
- every 30’ over Europe

Satellite *vs* sonde budget



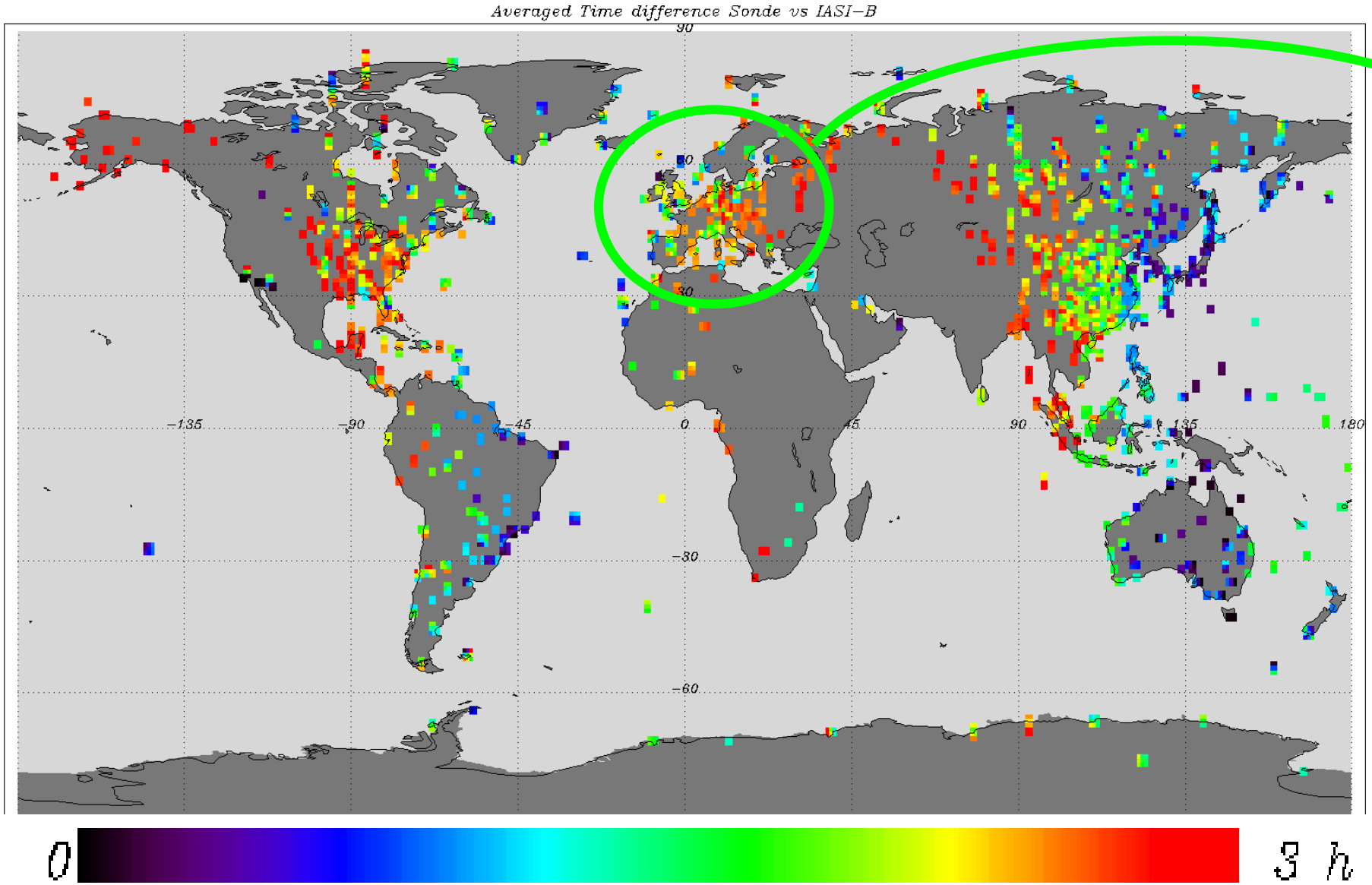
What we want to characterise wrt User requirements
Smoothing error
Retrieval noise
...

Delta Time
Delta Space
Match-up QC/strategy
Himmler et al., 2010

RS-41
GRUAN standards
Traceable uncertainties...

Representativeness of point (sonde) *vs* 12-40km (e.g. IASI)

IASI *vs* synotic sondes time difference



Coordinate favourable match-ups over Europe

High quality match-ups with GRUAN

Validation *(can be with delayed data/reprocessed products)*

- one-off qualification (e.g. new processor version)
- commissioning new missions
- products annual reviews

Monitoring *(routine streams)*

- long-term trend
- anomaly/change detection

GRUAN data	Monitoring	Validation
Sonde (T, q, O_3?)	Sample size?	δ-time?
GNSS PWV	NRT/format?	Yes
Lidar (T, q, O_3?)	NRT ?	Yes

Metop and GRAS-RO predictions

https://www.eumetsat.int/website/home/News/DAT_3514808.html
ftp://ftp.eumetsat.int/pub/OPS/out/test-data/Metop_Predictions/

REGISTER/SIGN IN

EUMETSAT

MONITORING WEATHER AND CLIMATE FROM SPACE

SEARCH

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METOP AND GRAS PREDICTIONS

NEWS
2018
2017
DECEMBER
NOVEMBER
OCTOBER
SEPTEMBER
AUGUST
JULY
JUNE
MAY
APRIL
MARCH
FEBRUARY
JANUARY
2016
2015
2014
2013
2012
2011
2010

GRAS occultation predictions and predictions for Metop sub-satellite positions are now available as a prototype product.

MONDAY, 12 JUNE 2017

EUMETSAT has developed a new prototype GRAS Level 1C product which includes predictions of the expected GRAS occultations for the operational Metop satellites, Metop-A and Metop-B, and information on predictions of the Metop sub-satellite positions.

The predictions are done over the next 14 days. The product allows for scheduling validation and reference measurements for all EPS (EUMETSAT Polar System) instruments.

There is one file generated per day, in netCDF-4 format.

Filename convention:

<inst>_OCP_1C_<sat>_<start_time>Z_<stop_time>Z_<create_time>Z_YARx_OCCORBPRED.nc

where:

<inst> is 4-character instrument ID (e.g., GRAS for the GRAS instrument)
<sat> is 3-character satellite ID (e.g., M02 for Metop-A but for 1C data generally XXX since several Metop satellites are included)
<start_time> is 14-digit sensing start time (e.g., 20170101000000 for 00:00:00 UTC on 01 January 2017)
<end_time> is 14-digit timestamp characterising sensing end time
<create_time> is 14-digit timestamp characterising product creation time

Example filename:

GRAS_OCP_1C_XXX_20170101000000Z_20170115000000Z_20170101100000Z_YARx_OCCORBPRED.nc

Latest products are available on our FTP server (currently on a best effort basis):

ftp://ftp.eumetsat.int/pub/OPS/out/test-data/Metop_Predictions

Already available to GRUAN

➔ talk to Axel von Engeln

Summary

- ✓ EPS/IASI v6: good quality profiles + quality indicators
  - ‘All-sky’, not so limited to cloud-free anymore
  - Regional service, within 30’ from sensing
  - Basis for future missions
- ✓ Validated with *in situ* measurements…
- ➢ Grow further validation and monitoring capabilities
  - Routine FRM + uncertainties
  - QC/match-up strategy
  - Optimise time coincidence
- ➢ Prepare Cal/Val and monitoring for new missions
  - More stringent requirements
  - Sounding at very high spatio-temporal sampling