EUMETSAT operational IASI Level 2 version 6

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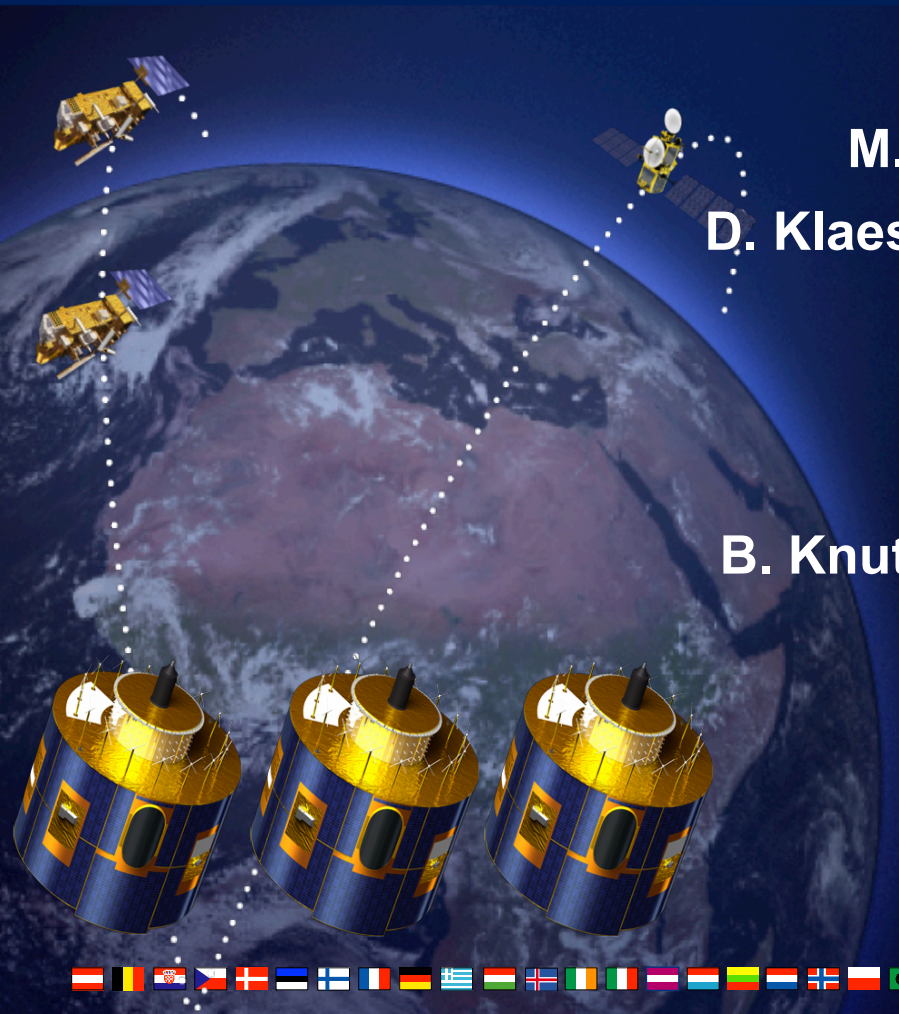

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The IASI L2 products

From processor v5 to v6

Disseminated in near-real time

TWT	**Temperature (vertical profiles)** **Humidity (vertical profiles)** **Surface Temperature (Land & Sea)**	**+ Averaging Kernels**
EMS	**Surface emissivity**	
CLD	**Cloud detection, cloud fraction & top height**	
OZO	**O_3 profiles + Averaging Kernels**	
TRG	**CO, N_2O, CH_4, CO_2 Total columns**	
	CO profiles + Averaging Kernels, (SO_2, HNO_3)	

v6

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Outline

1. The IASI L2 processor v6
2. Products assessment results
3. Summary

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1. The IASI L2 processor v6

Pre-processing

- **Collocation of auxiliary microwave measurements: AMSU & MHS L1B**

- Collocation of ECMWF forecasts (for cloud test)
- Collocated AVHRR radiance analyses and integrated cloud fraction
- Land/Sea mask (AAPP atlas)
- Land surface emissivity atlas (Borbas et al.)
- Digital Elevation Model (GTOPO30)

- **Principal Components Analyses ➔ reconstructed radiances**

IASI L1C
NWP AMSU/MHS AVHRR
Conf. data Static db

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1. The IASI L2 processor v6

PWLR: MW+IR retrievals

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PWLR: MW+IR retrievals

- ✓ **~All-sky statistical retrieval**, followed by OEM(IASI) in clear IFOVs
- ✓ The retrievals come at the **IASI single footprint resolution**

Principle: Joint **MW+IR** piece-wise linear regression **(PWLR)** retrieval with different coefficients for different classes of observations to account for non-linearity between the observations and the atmospheric state vector.

- Predictors: **AMSU, MHS** and **IASI** measurements, satellite zenith angle, surface elevation
- Outputs: Ts, **profiles of T, WV** & O_3, Ps + **Quality indicator**
- Training set: **Real observations** & co-located ECMWF analyses.
- **64 regression classes** based on MHS, AMSU and IASI radiances for sea, ice, low land and high land. No *ad hoc* latitude striping. This ensures good geographical continuity in the retrievals.

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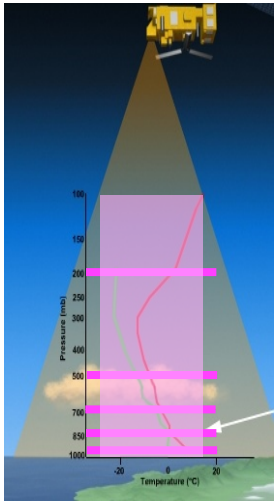
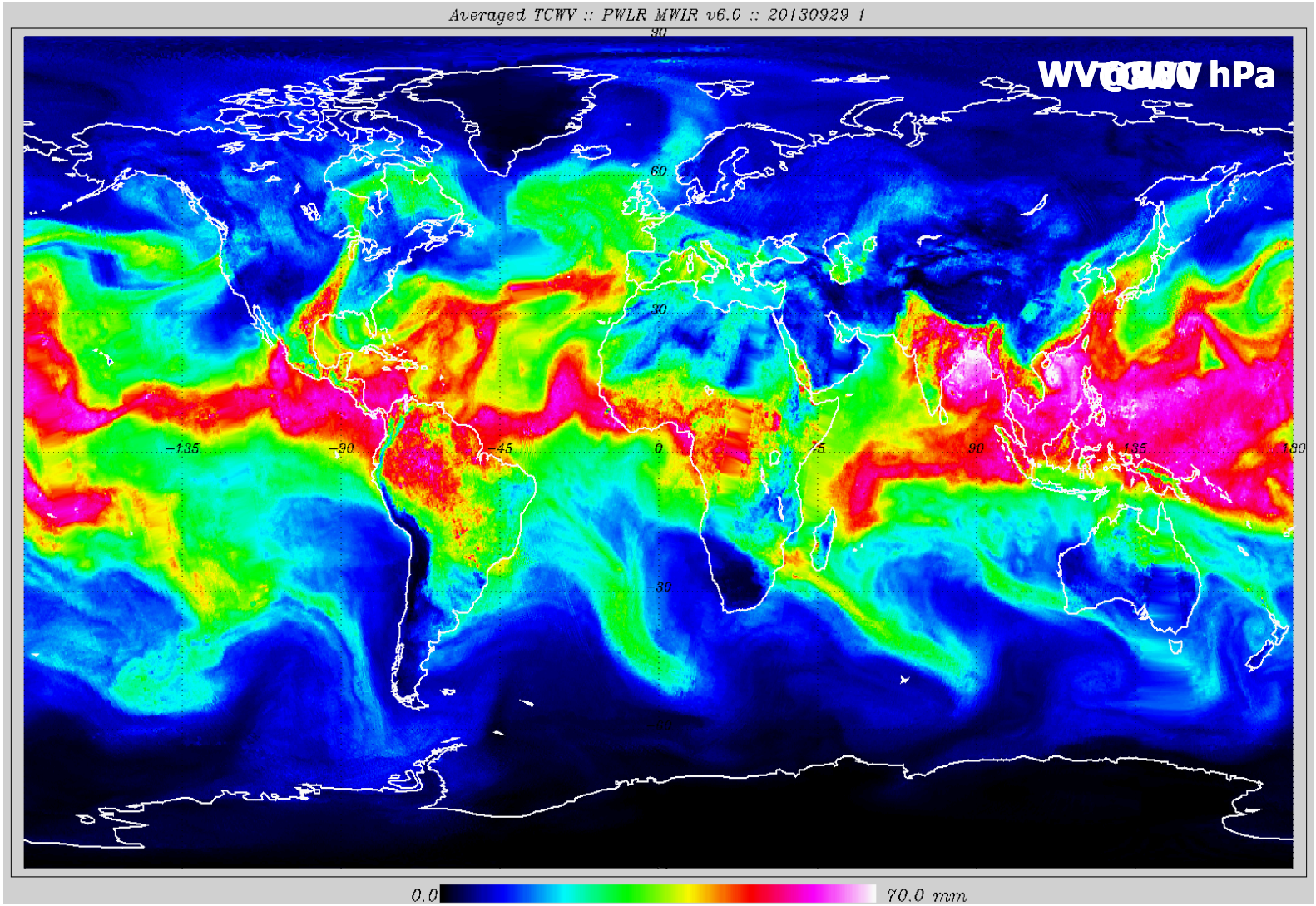
1. The IASI L2 processor v6

PWLR: MW+IR retrievals





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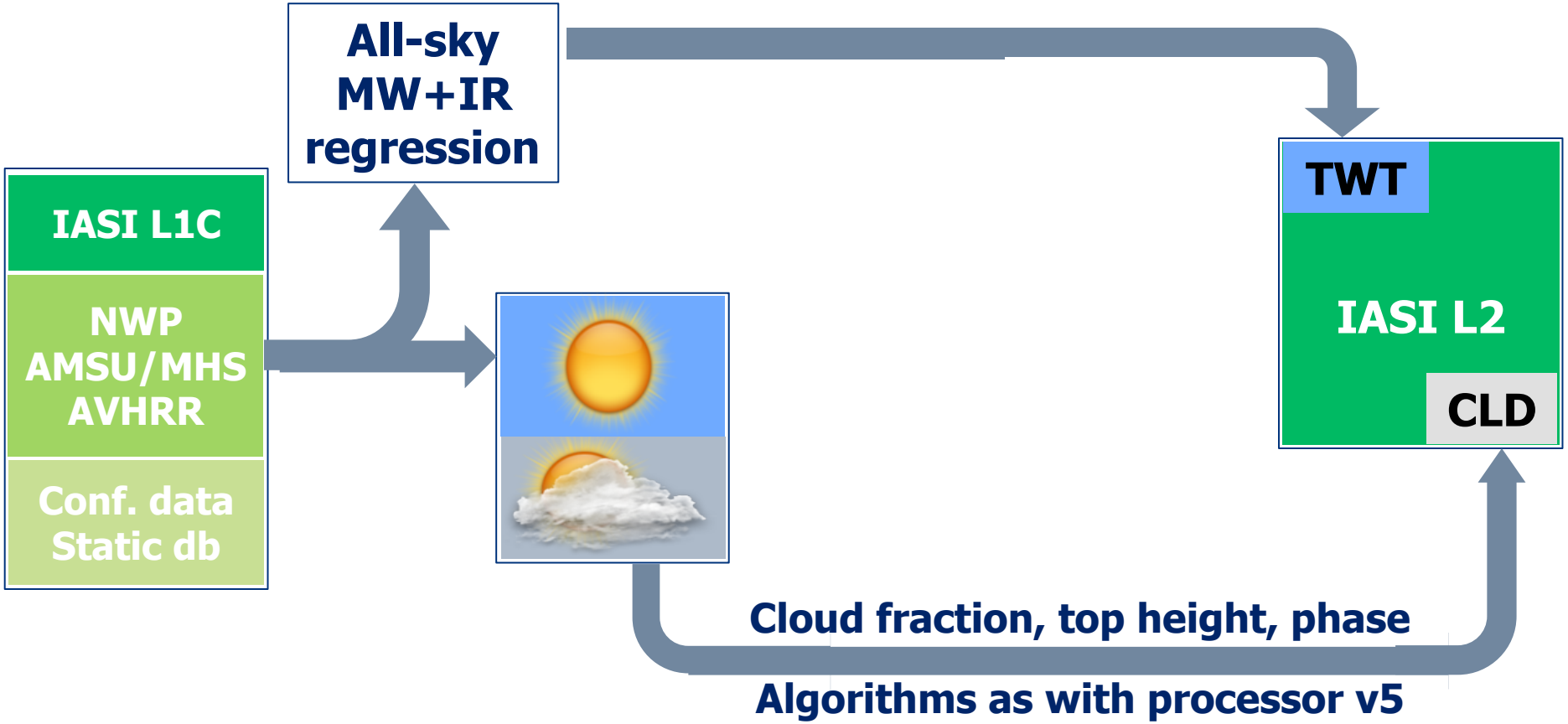
1. The IASI L2 processor v6

The cloud product



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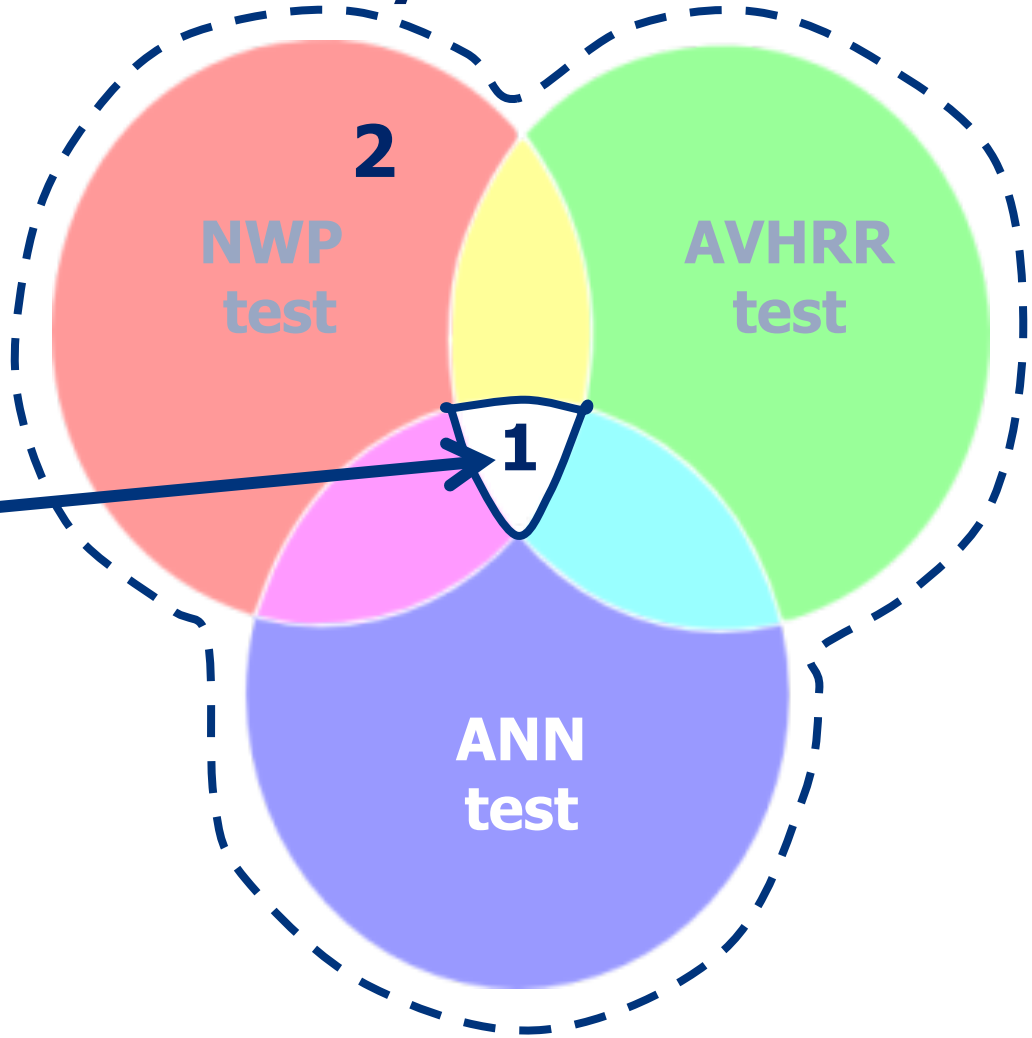
Clear-sky identification

Cloudiness flag FLG_CLDNES	
1	Clear-sky

+ High confidence

- Low yield

! Some areas are systematically excluded



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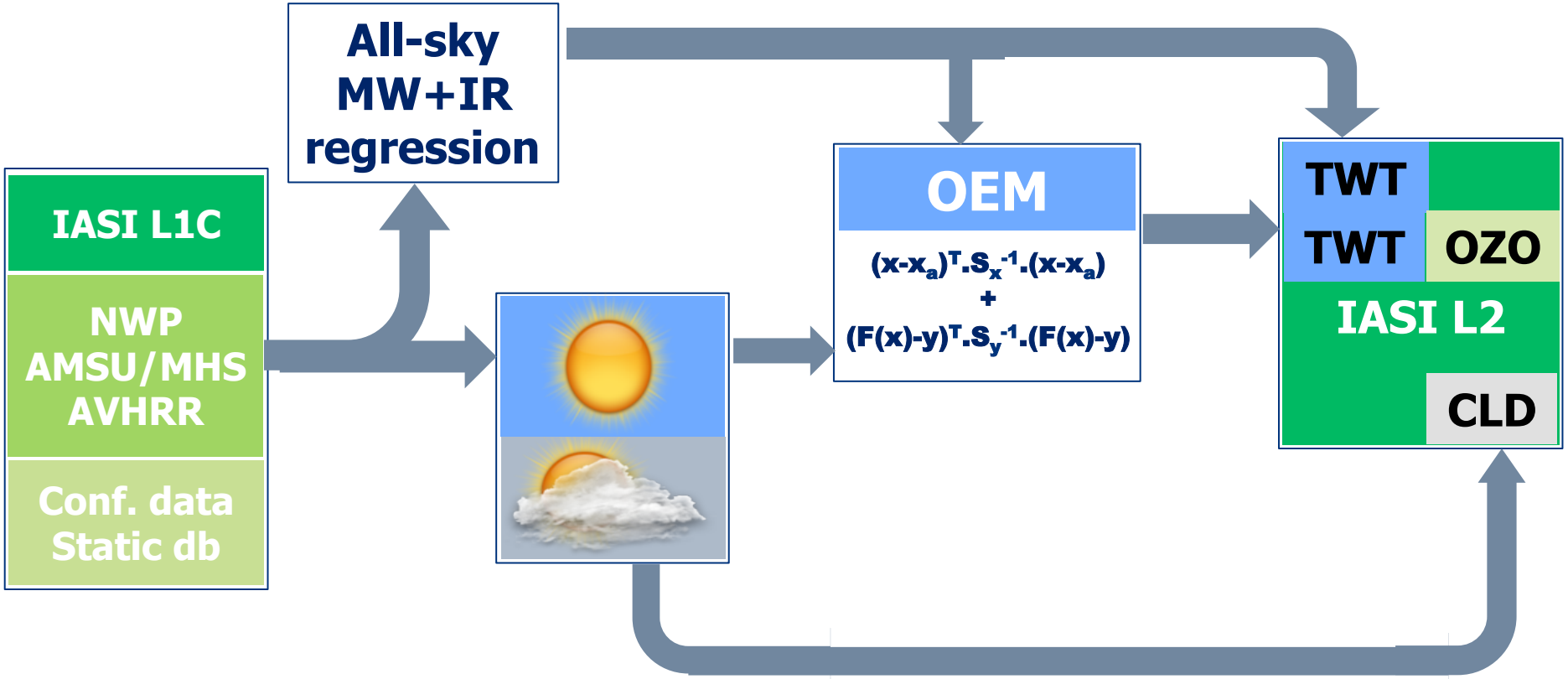
1. The IASI L2 processor v6

New OEM configuration



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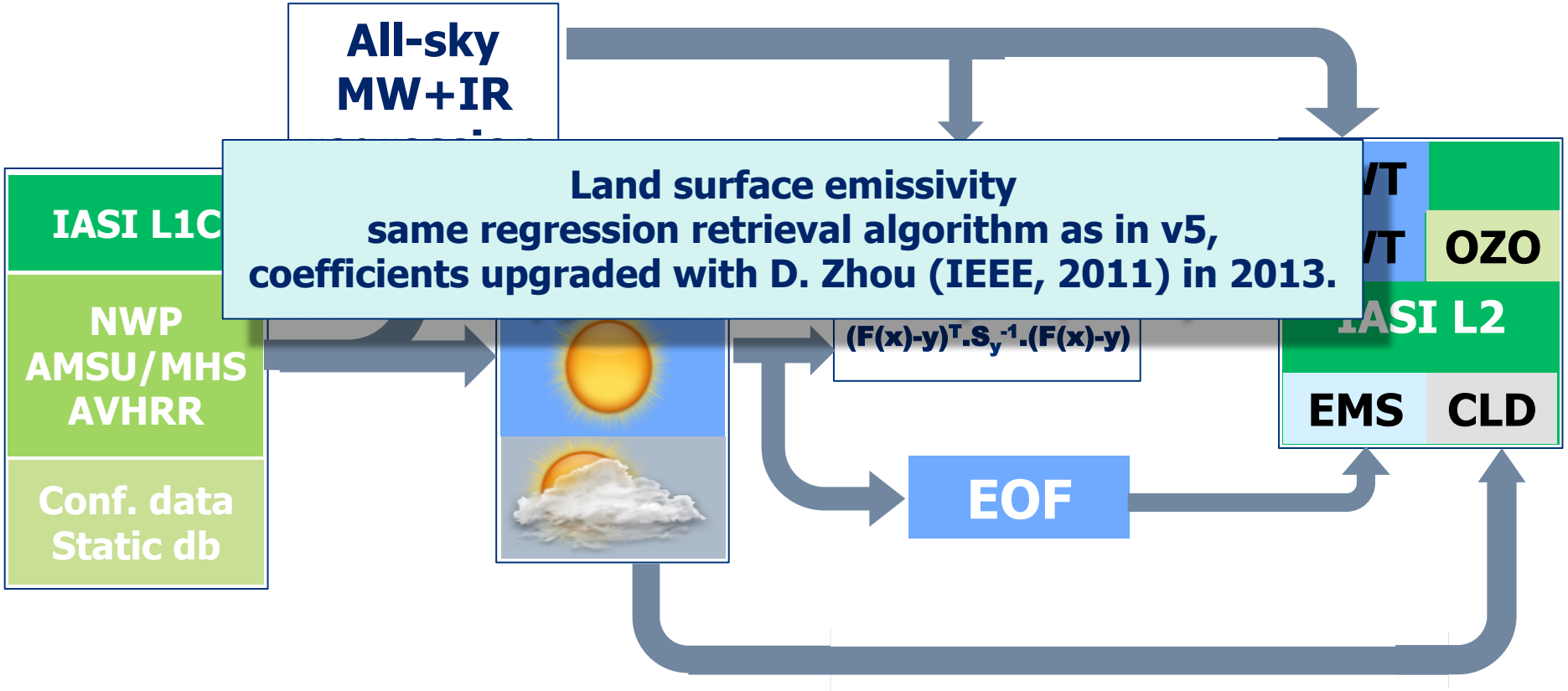
1. The IASI L2 processor v6 New OEM configuration

- So far **clear-sky** and using **IASI measurements** only (FLG_CLDNES = 1,2)
- Retrieved parameters: **T, WV and O3 profiles, Ts**
- Atmospheric profiles represented in PCs (as in v5)
- Identified **common directions** in measurement and forward model **subspaces**. Computing and using **reconstructed radiances** with these eigenvectors *(3rd IASI Conf., 2013; Met. Satellites Users Conf., Vienna 2013; NWP-SAF workshop on PC for hyperspectral data, 2013; ITSC-19 2014)*
- **New channel selection**, 139 channels in Band 1 and 2 *(ITSC-18 2012)*
- **Variable radiance tuning**, using the scan angle as predictor
- **Variable a priori**, from the atmospheric climatology mapped by the MW (AMSU/MHS) and IR (IASI) data
- Much **faster 1D-Var**, 1 or 2 pure Newton iterations only
- Provision of the **full retrieval error covariance matrix** (compressed) and ***a priori***; allowing post-computation of the **averaging kernels**.

1. The IASI L2 processor v6

Land surface emissivity



Land surface emissivity
same regression retrieval algorithm as in v5,
coefficients upgraded with D. Zhou (IEEE, 2011) in 2013.

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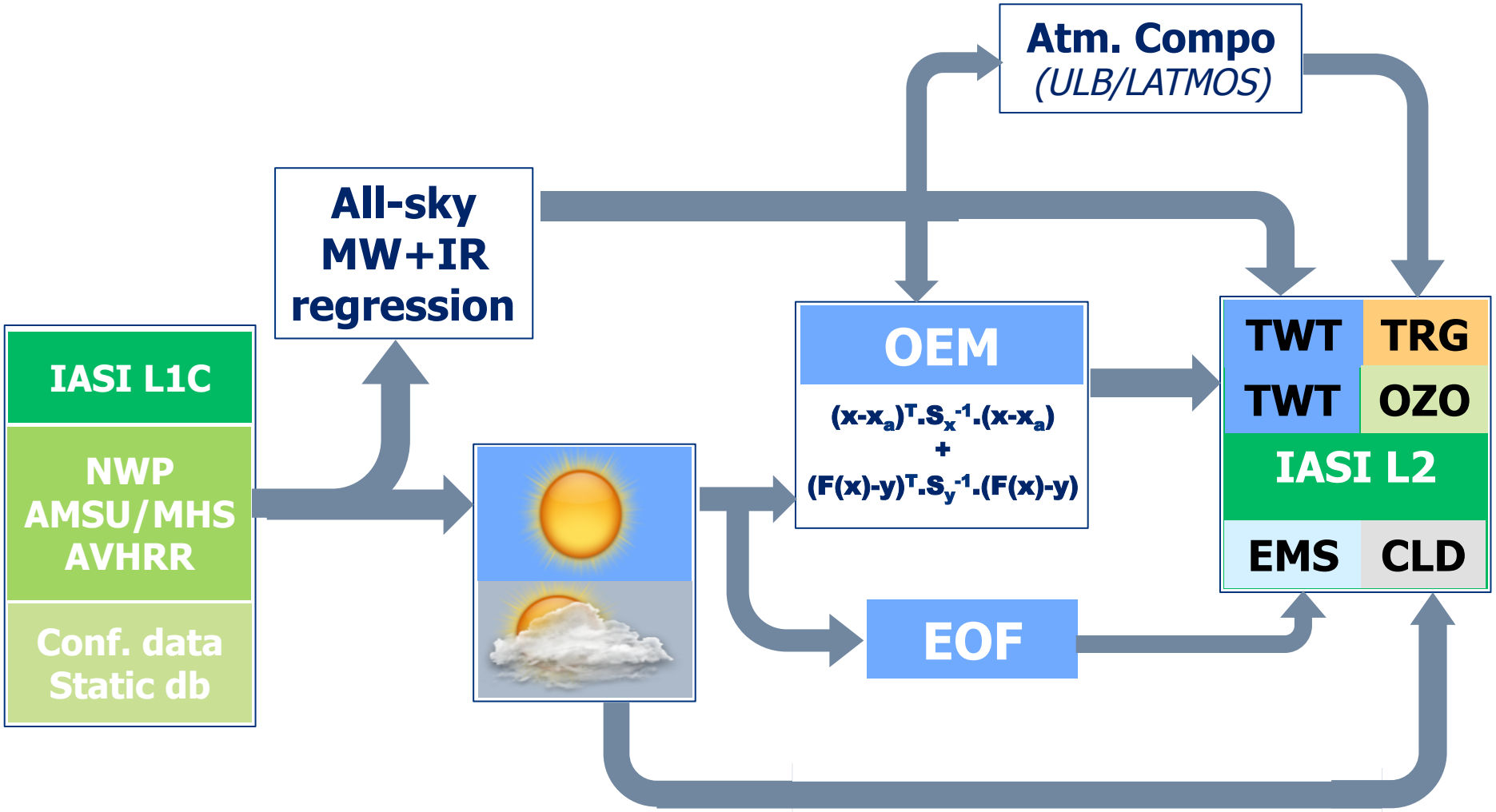
1. The IASI L2 processor v6

Atmospheric Composition



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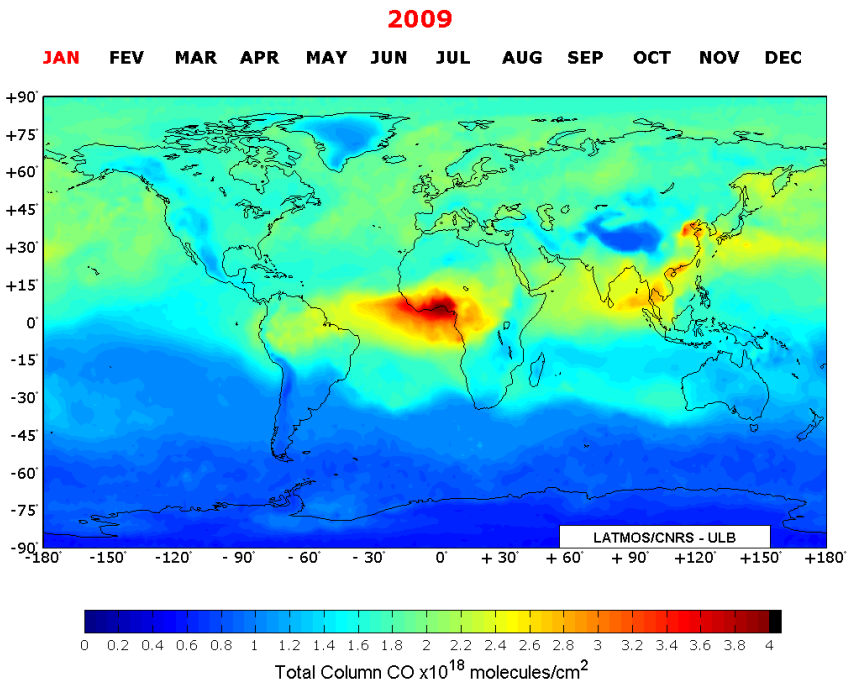
O3M-SAF CDOP-2 (2012-2017)

Implementation in the EPS ground segment of a series of atmospheric composition products developped by ULB/LATMOS.

Algorithm: **FORLI** (Fast Optimal Retrievals on Layers for IASI, *Hurtmans et al., JQSRT 2012*)



- **CO profiles + AK (2014)**
- **SO_2 columns** *(2015)*
- **O_3 profiles + AK** *(2016)*
- **HNO_3 profiles** *(2017)*

Credits: ULB/LATMOS
Coheur, Clerbaux et al.

Place-holders for SO_2, O_3 and HNO_3 have been prepared in the IASI L2 product files.

Outline

1. The IASI L2 processor v6
2. **Products assessment results**

   ➔ full details in “IASI L2 v6 Validation Report”
   EUM/RSP/REP/14/754105 *in press*
3. Summary

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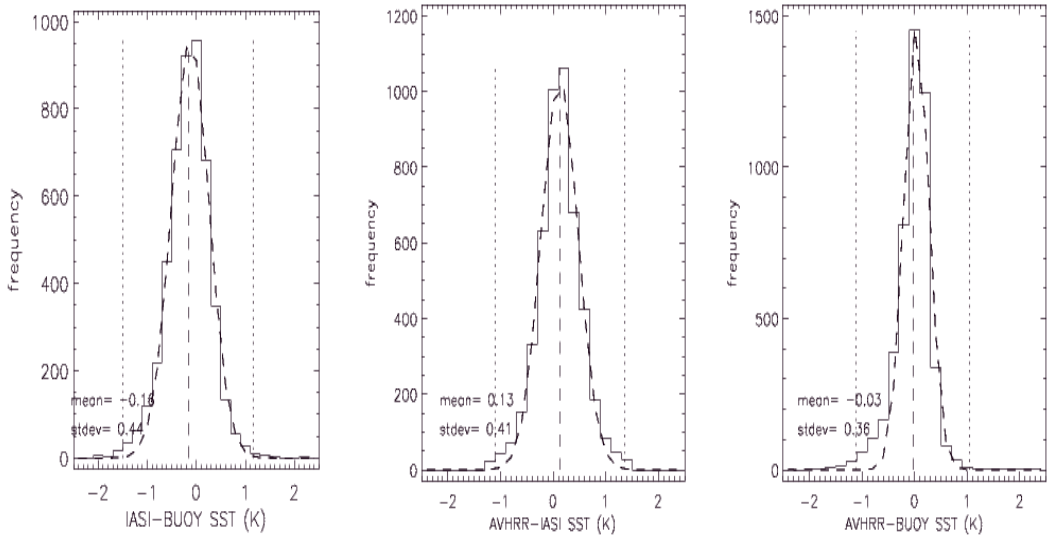
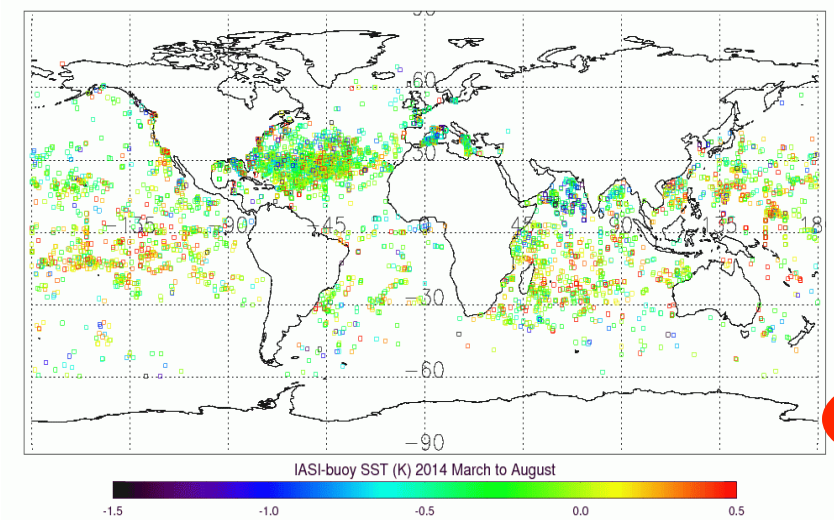
2. IASI L2 v6 assessment

SST vs drifting buoys

- **Results from March-August 2014, long-term monitoring on-going**
- **IASI-AVHRR-buoys 3-way analyses**
- **IASI L2P SST (joint CAF and OSI SAF) operational in 10/2014, contribution to GHRSST**

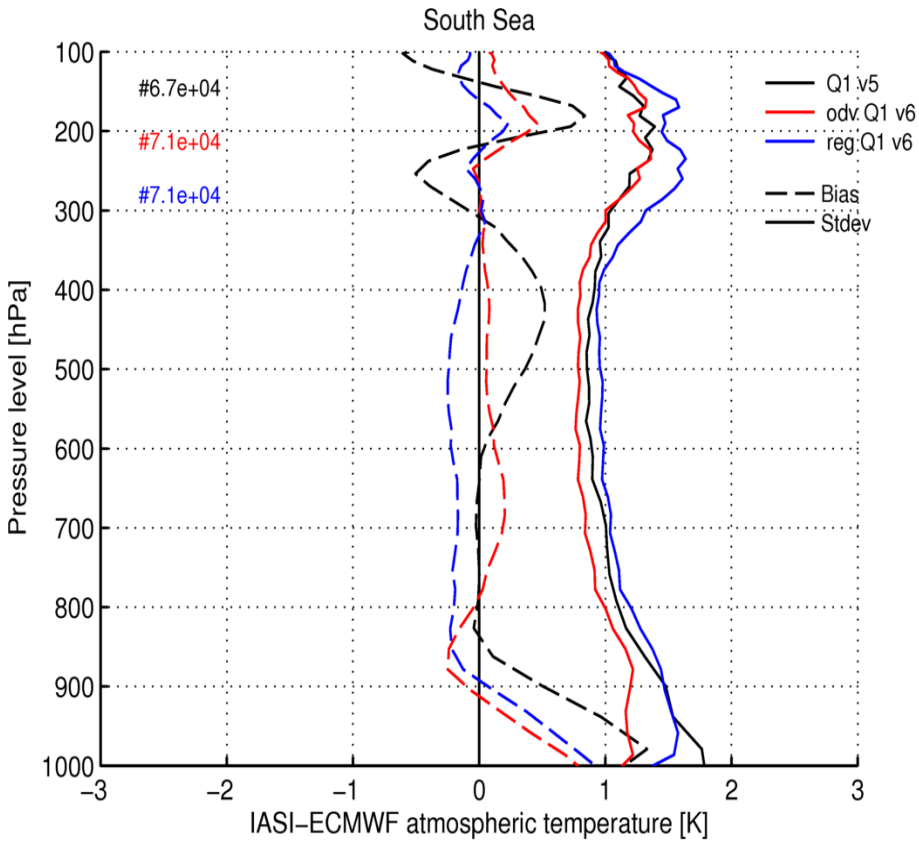


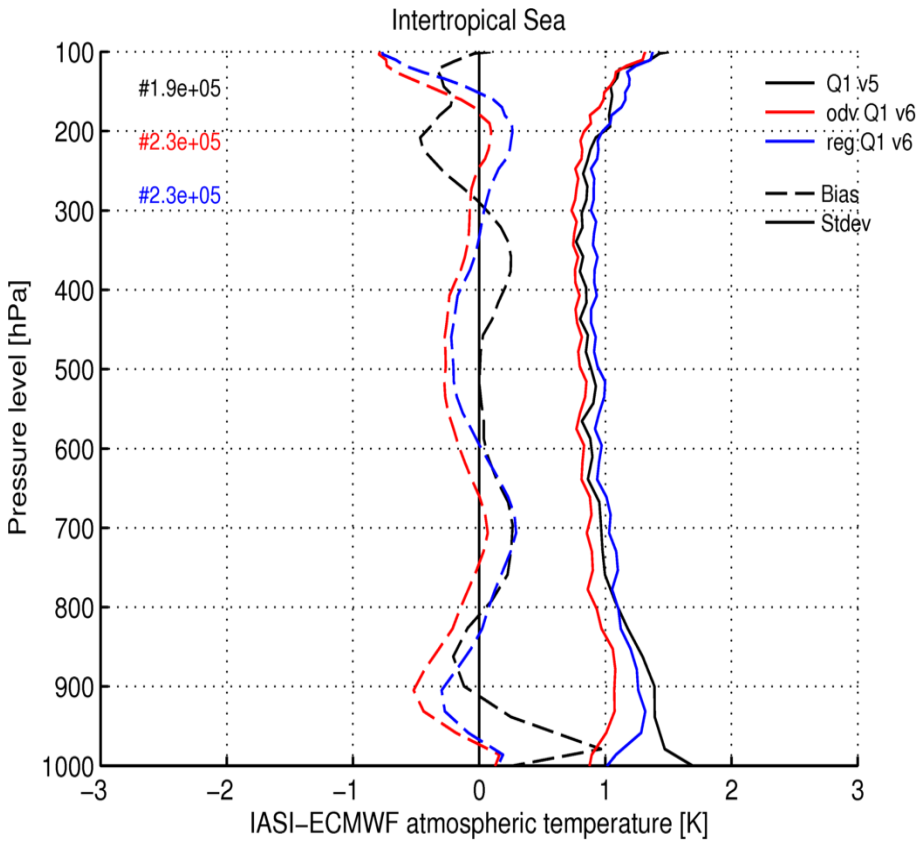


	Metop-A			Metop-B		
Quality classes	Mean (K)	σ (K)	#	Mean (K)	σ (K)	#
QL2	-0.27	0.52	187	-0.28	0.46	137
QL3	-0.27	0.46	207	-0.34	0.41	138
QL4	-0.17	0.40	724	-0.18	0.39	457
QL5	-0.09	0.33	628	-0.08	0.35	485

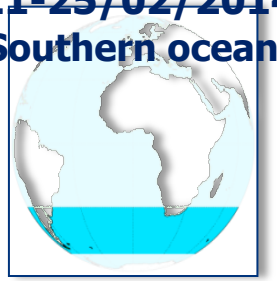
2. IASI L2 v6 assessment

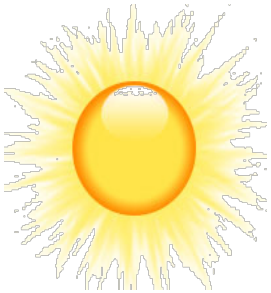
Temperature profiles vs NWP





21-25/02/2014
Southern oceans





Q1 PPF v5

Q1 OEM v6

Q1 PWLR v6

21-25/02/2014
Intertrop. oceans

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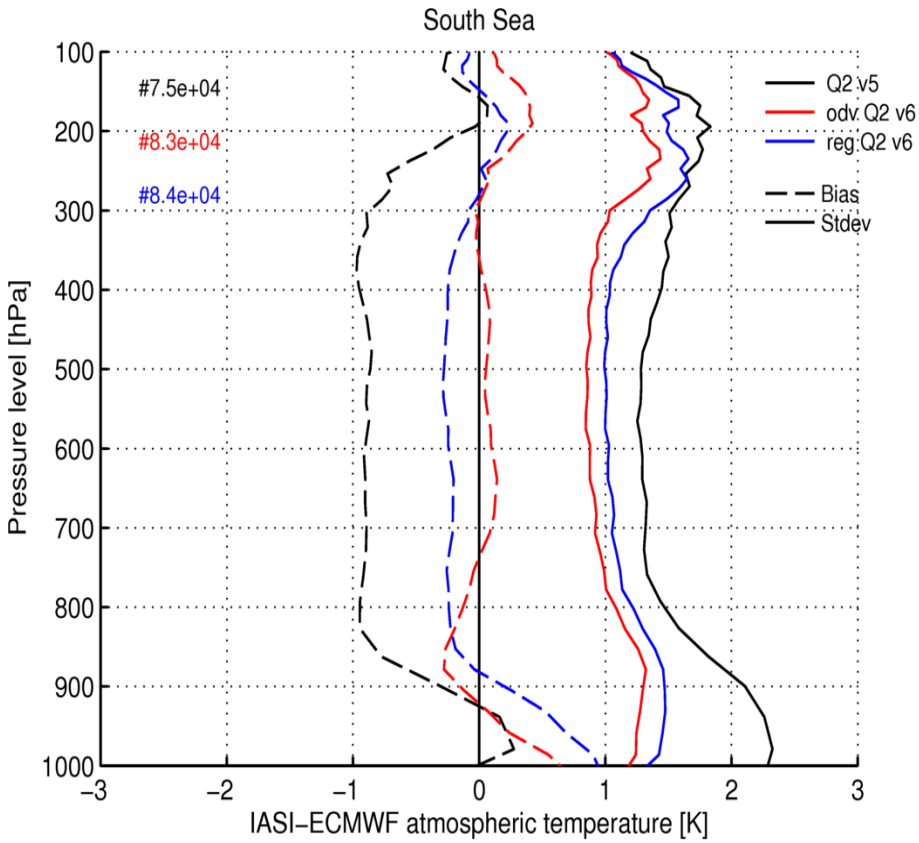
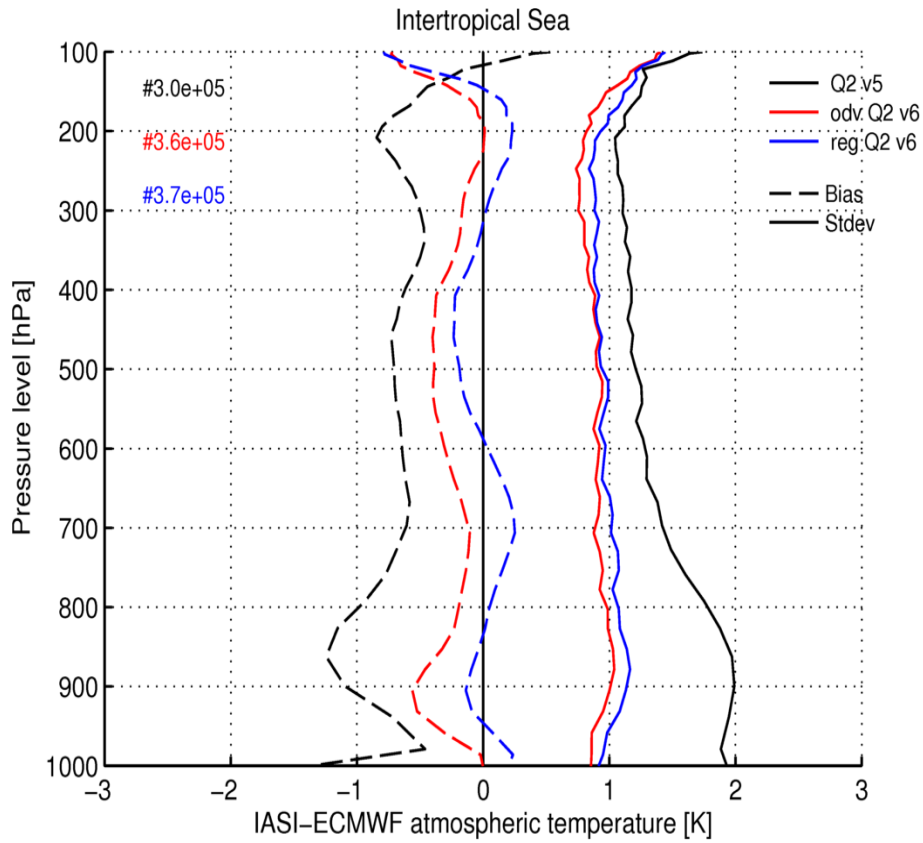
2. IASI L2 v6 assessment

Temperature profiles vs NWP





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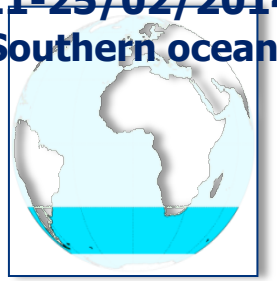
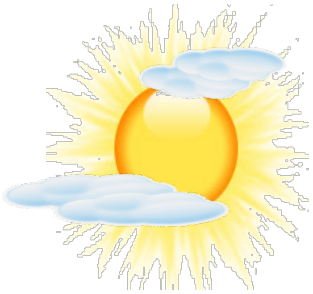
Southern oceans





Q2 PPF v5

Q2 OEM v6

Q2 PWLR v6

21-25/02/2014
Intertrop. oceans

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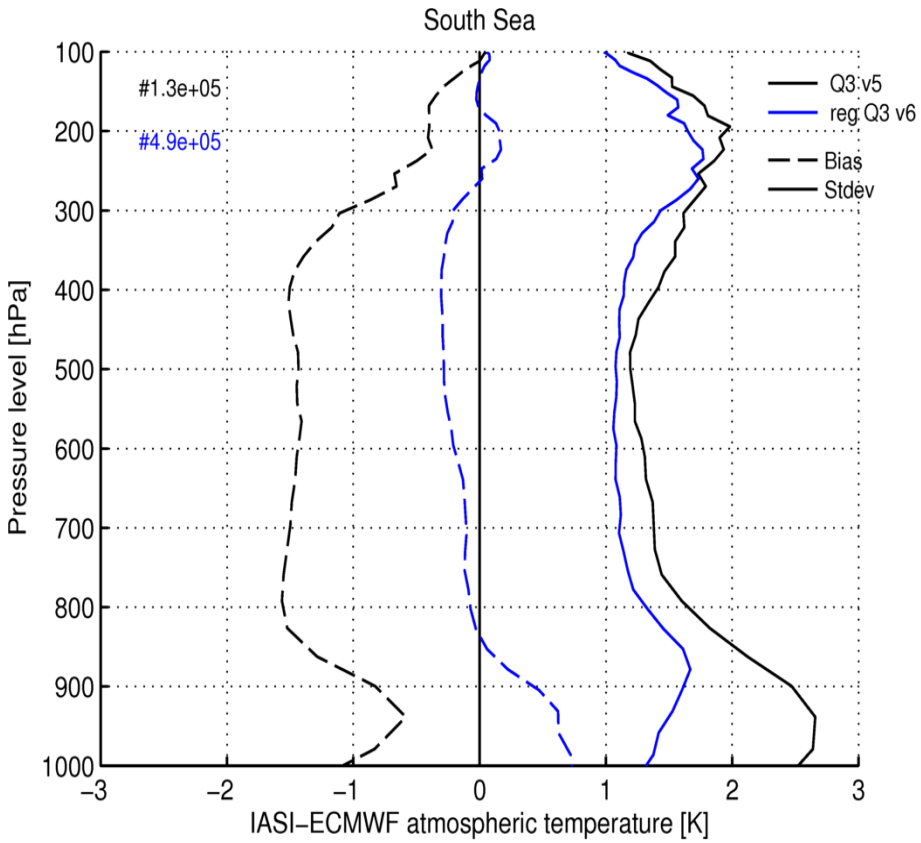
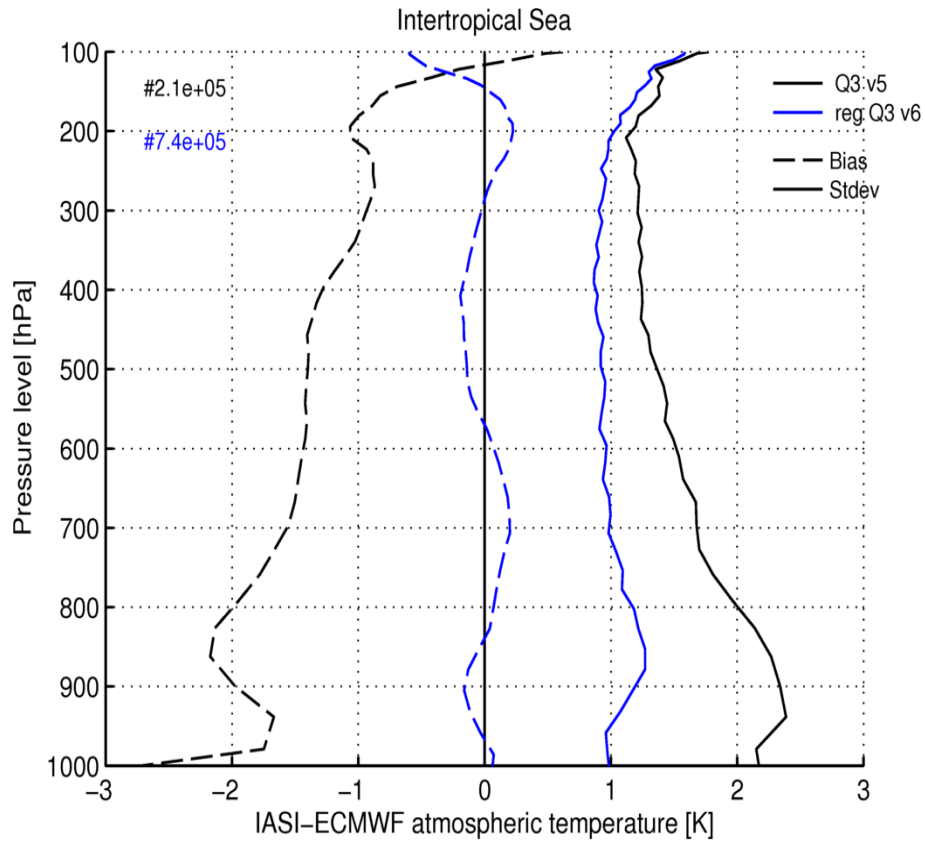
2. IASI L2 v6 assessment

Temperature profiles vs NWP





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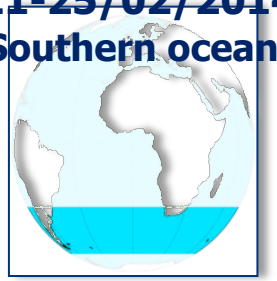
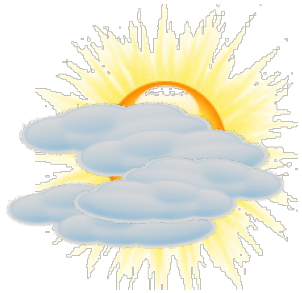
Southern oceans





Q3 PPF v5

Q3 PWLR v6

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Intertrop. oceans

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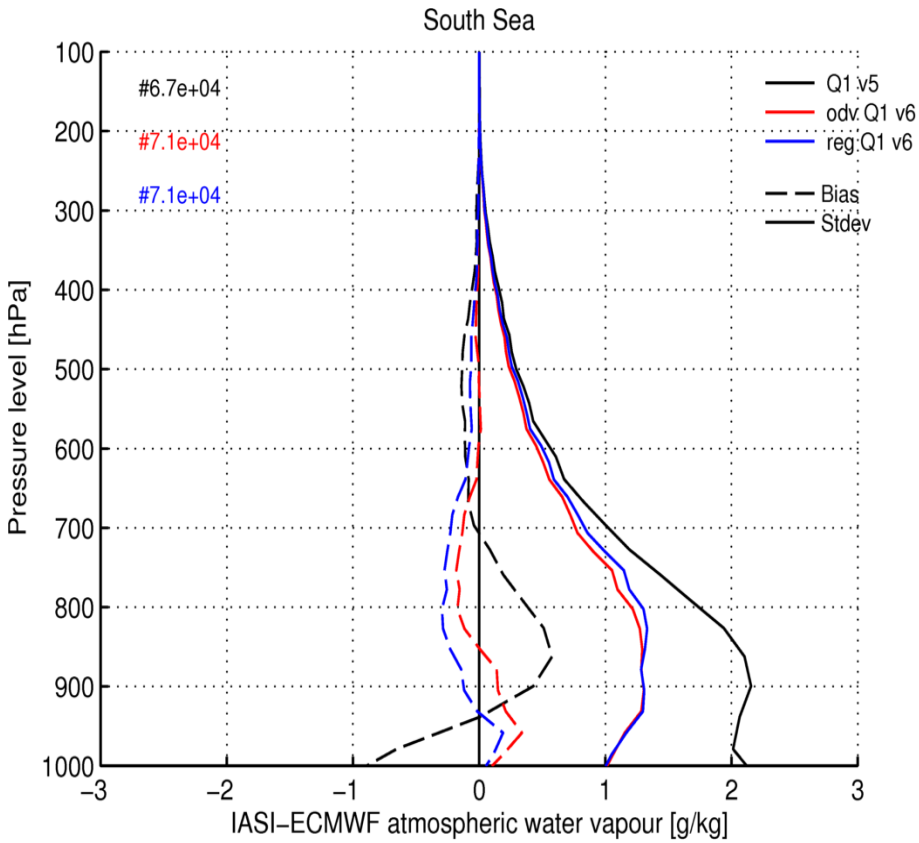
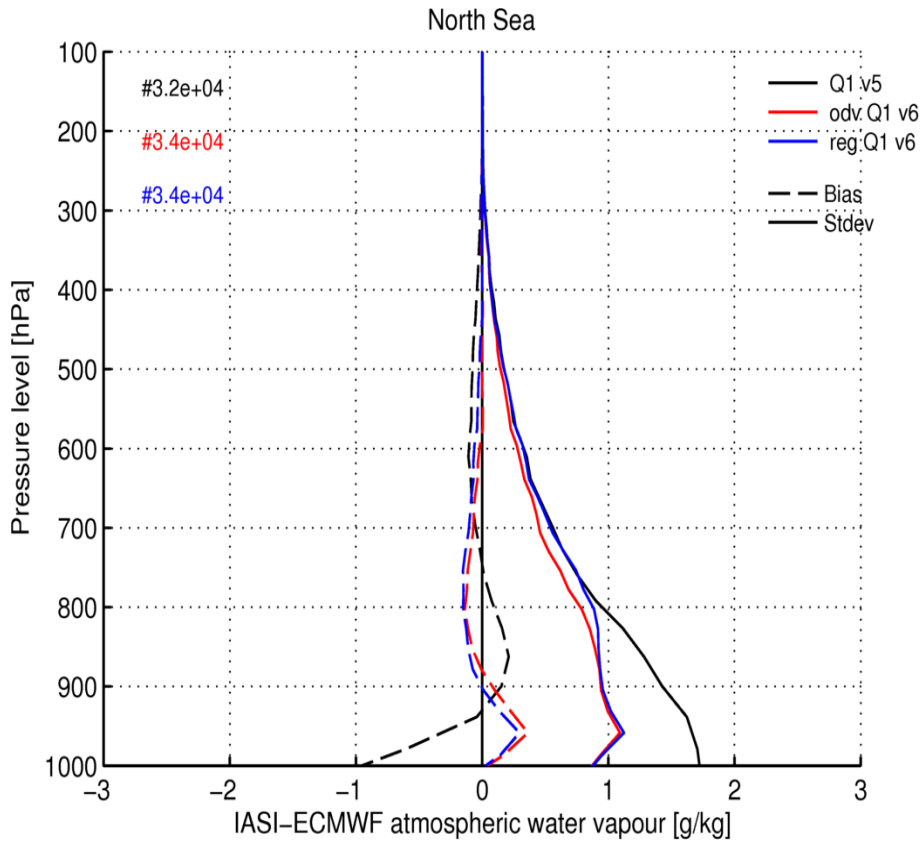
2. IASI L2 v6 assessment

Water-vapour profiles vs NWP





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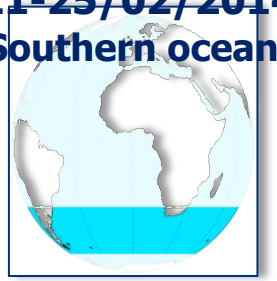
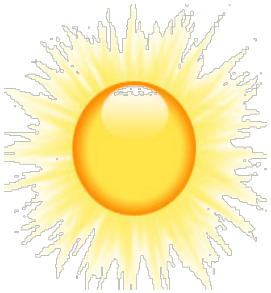
Southern oceans





Q1 PPF v5

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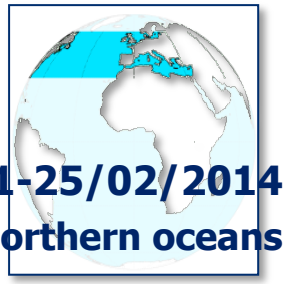
Q1 PWLR v6



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Northern oceans

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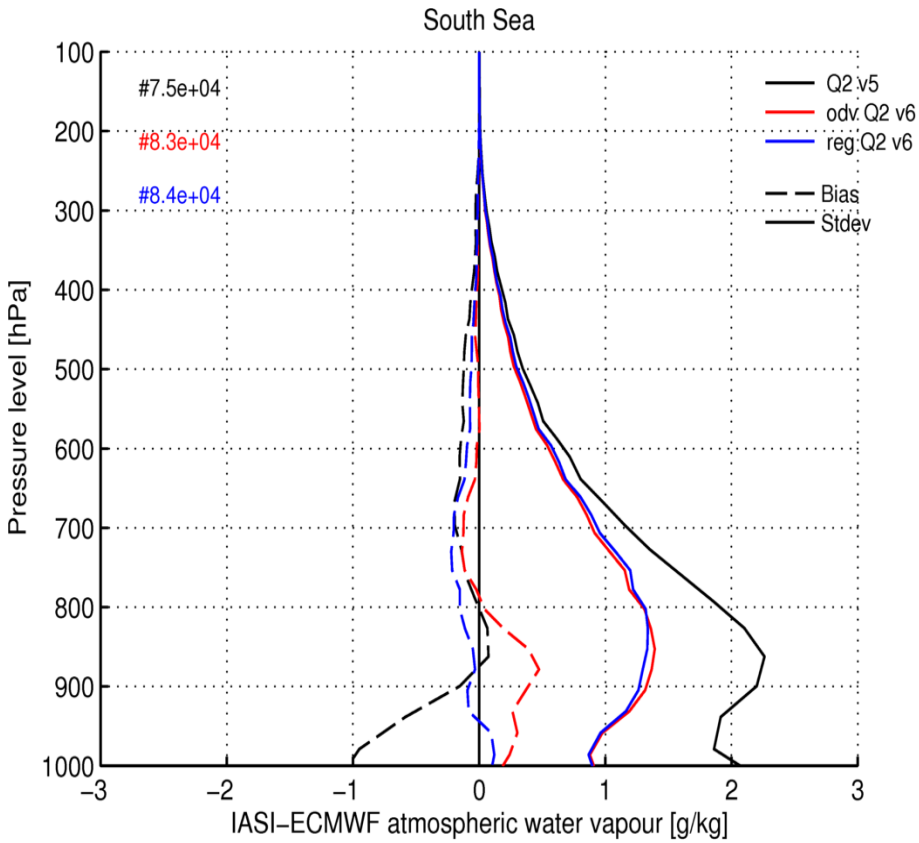
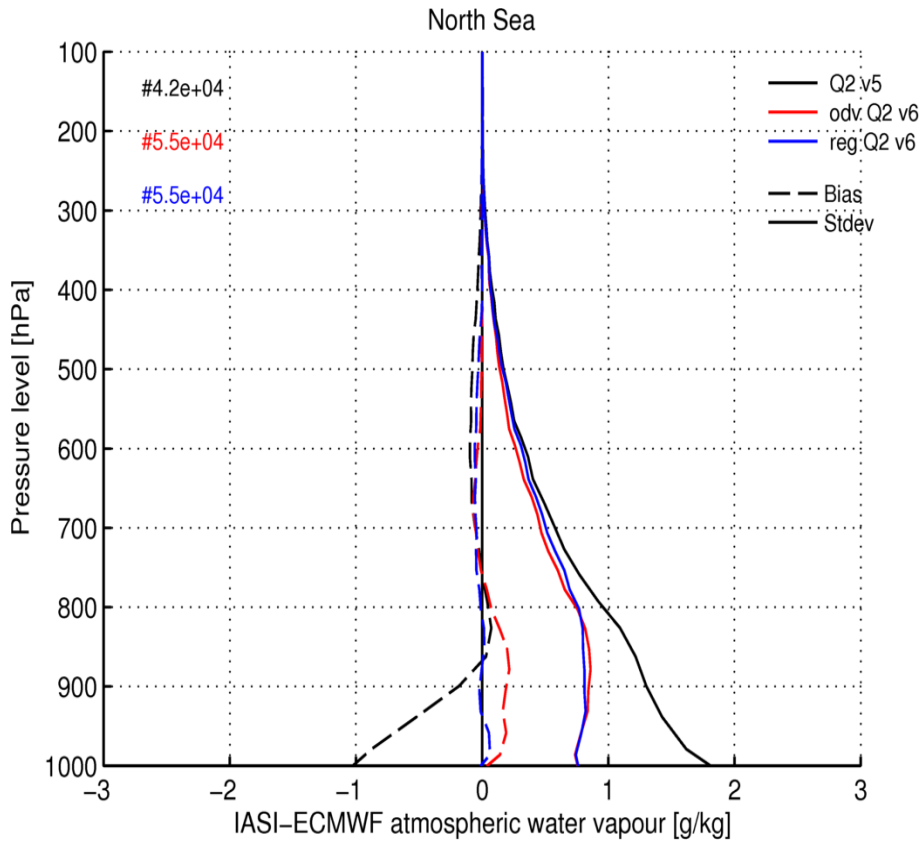
2. IASI L2 v6 assessment

Water-vapour profiles vs NWP





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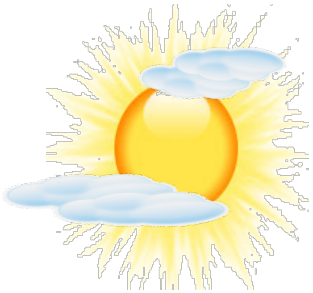
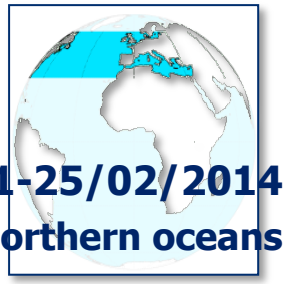
Southern oceans



Q2 PPF v5

Q2 OEM v6

Q2 PWLR v6



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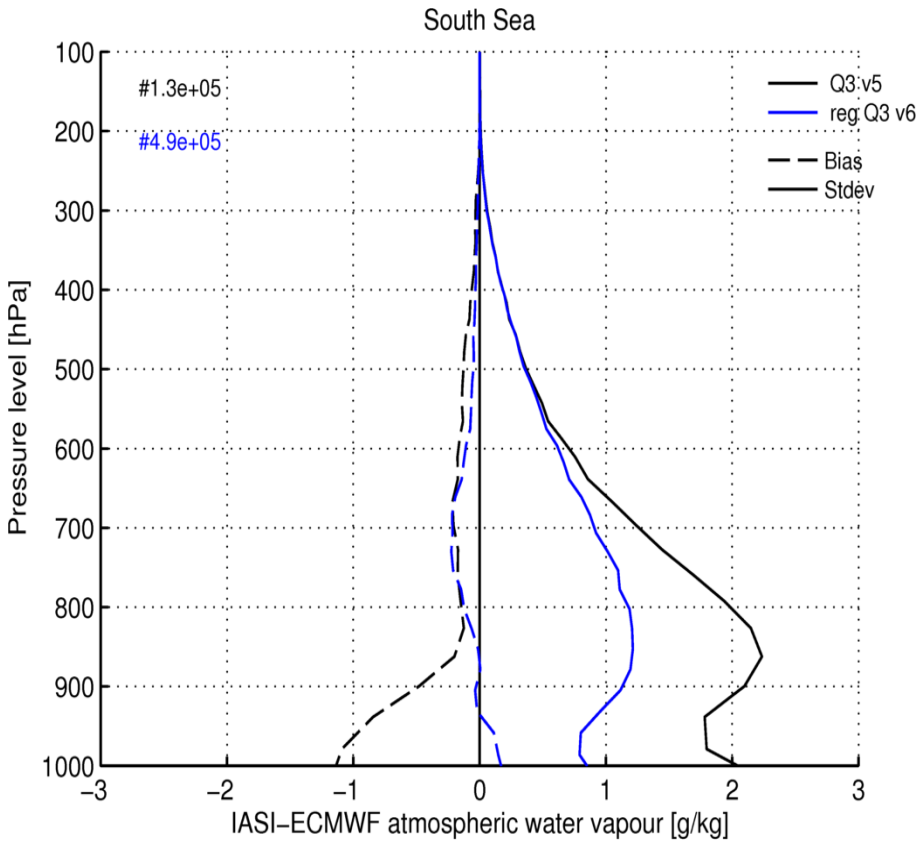
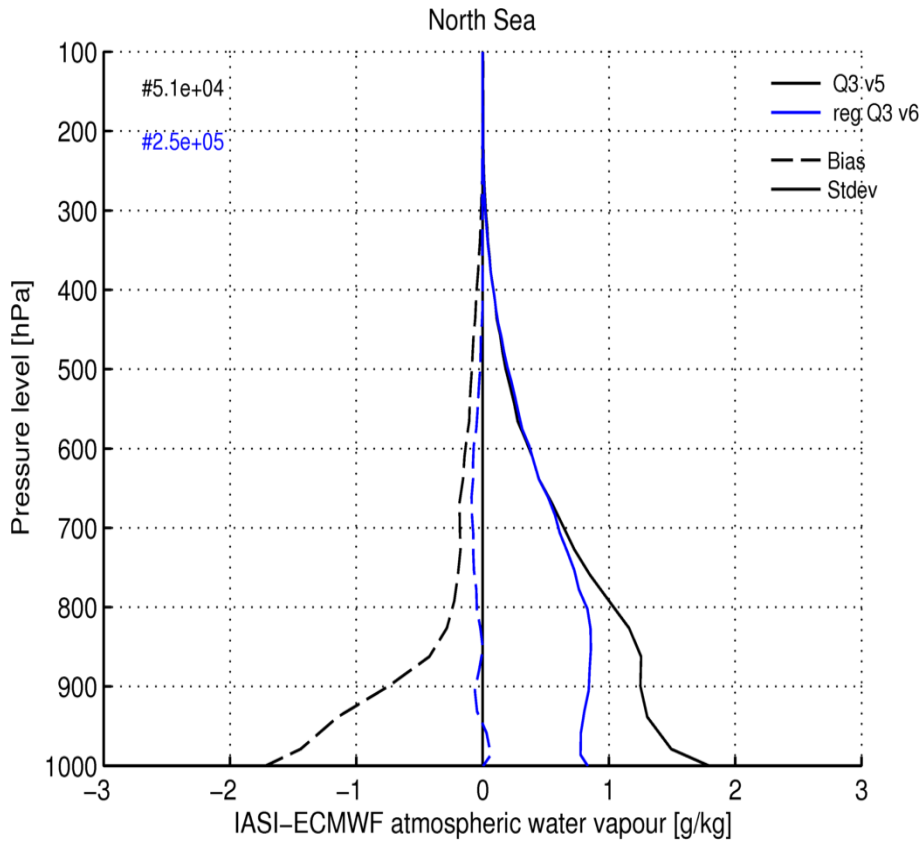
2. IASI L2 v6 assessment

Water-vapour profiles vs NWP





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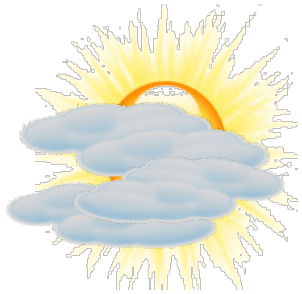
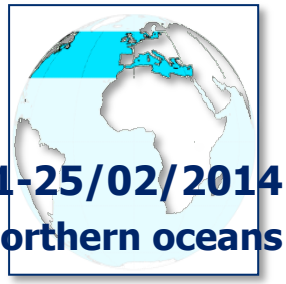


Q3 PPF v5

Q3 PWLR v6



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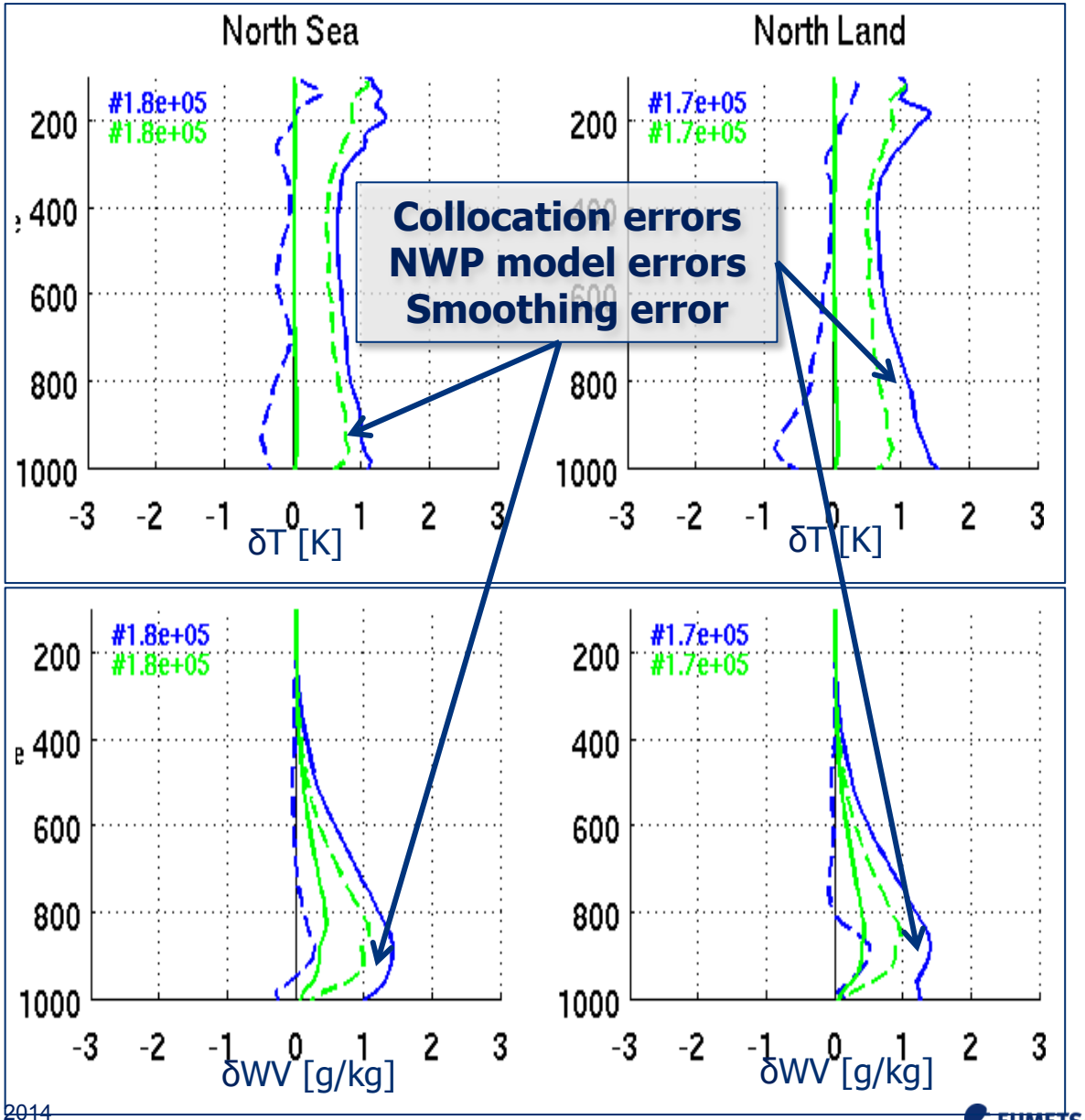
2. IASI L2 v6 assessment

Retrieval error estimate

--- error estimate (σ)
--- <IASI-ECMWF>
— σ (IASI-ECMWF)

Clear pixels
6-11 September 2014



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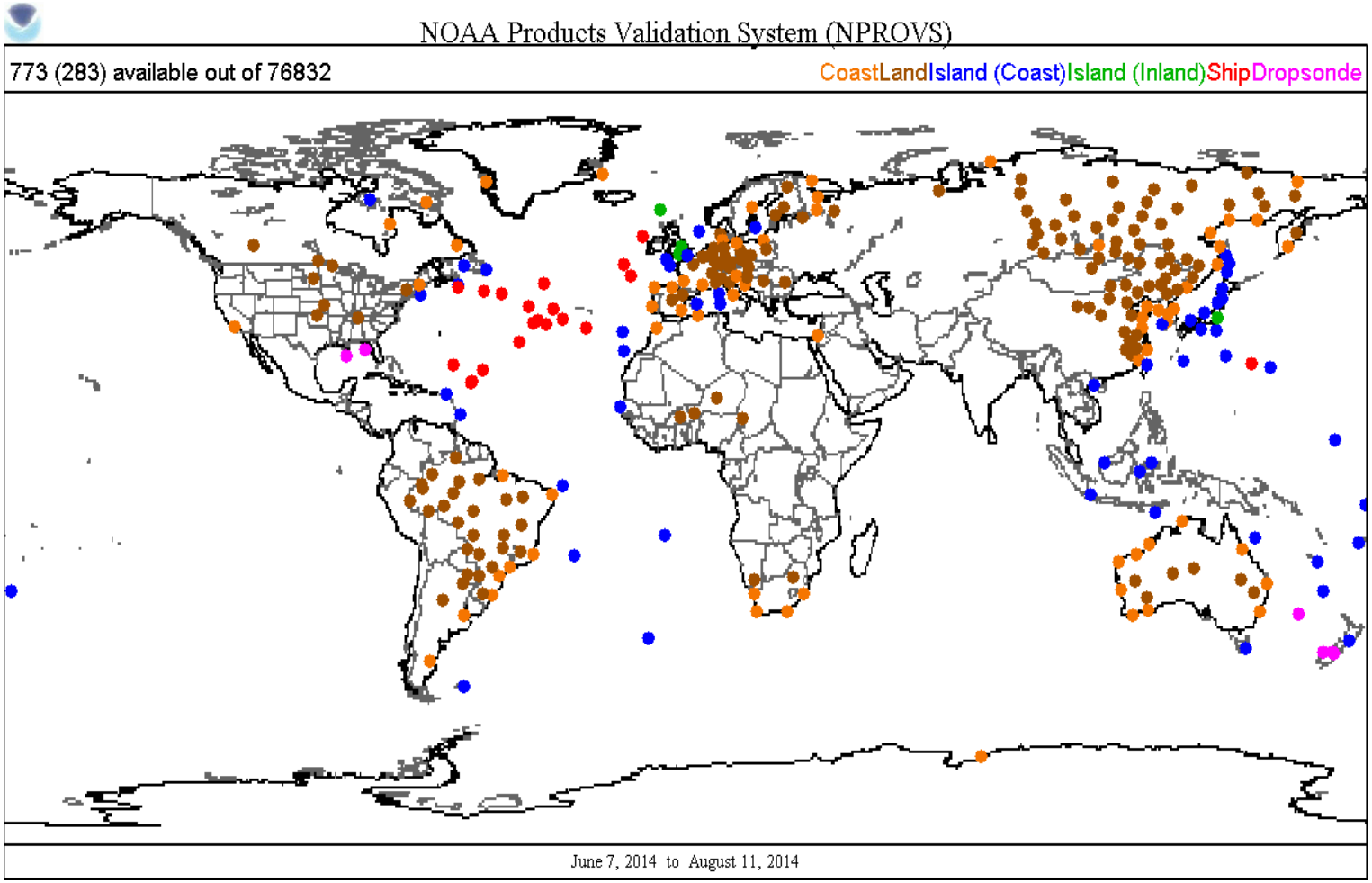
2. IASI L2 v6 assessment

T, q profiles vs *in situ* measurements



Credits: NOAA / NESDIS Center for Satellite Applications and Research.

http://www.star.nesdis.noaa.gov/smcd/opdb/poes/NPROVS.php

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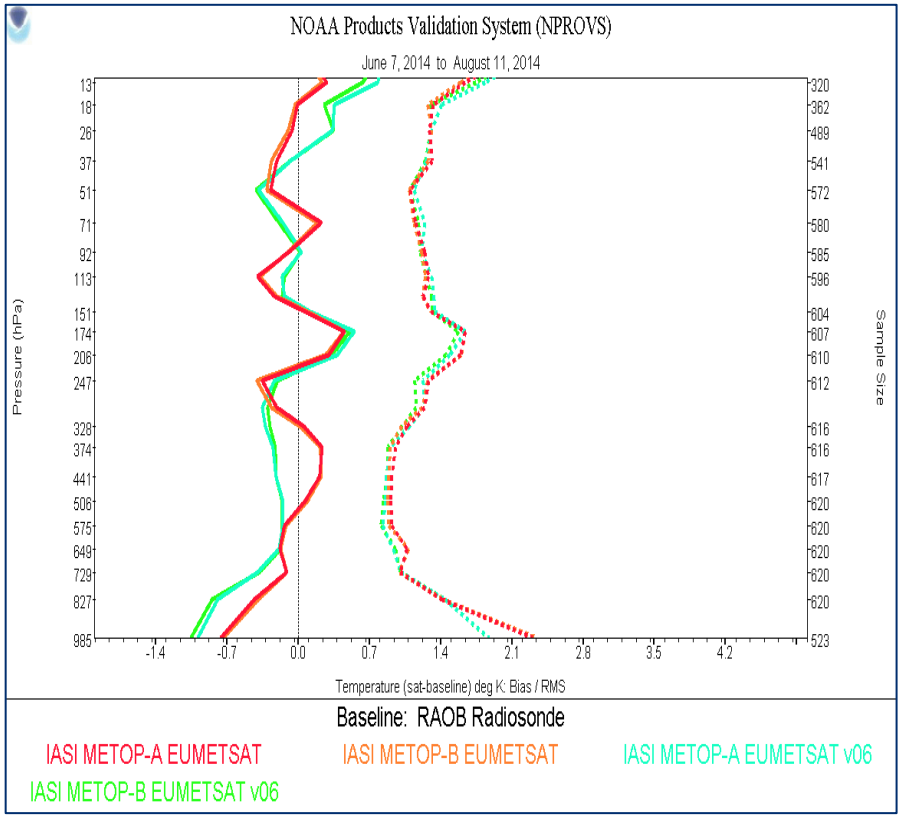
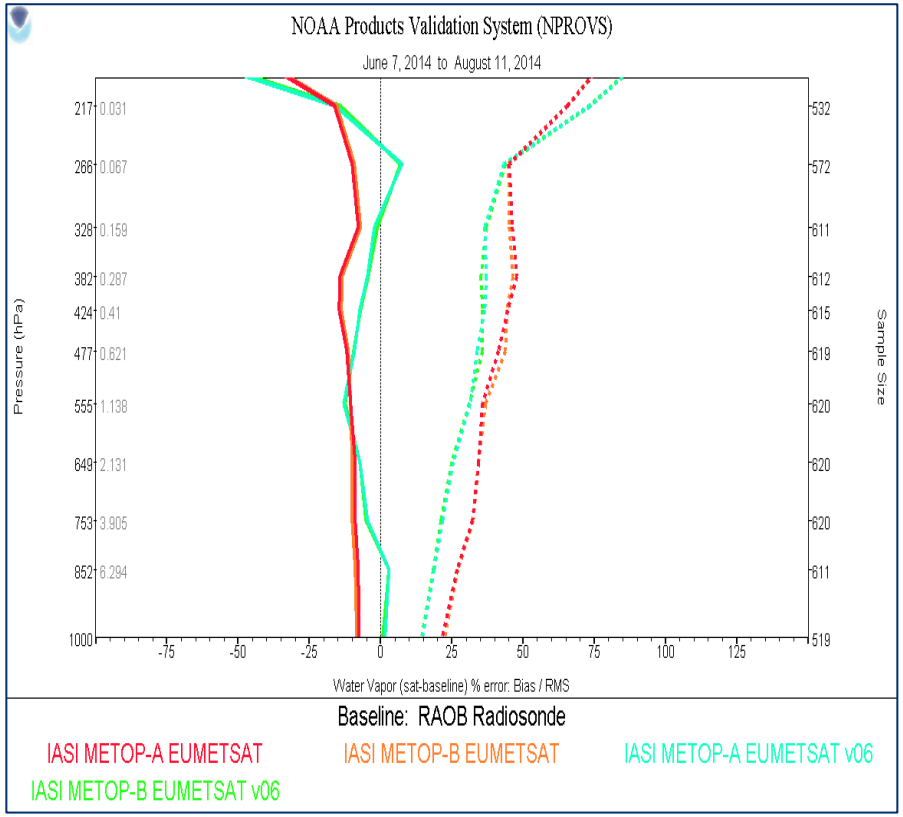
2. IASI L2 v6 assessment

T, q profiles vs *in situ* measurements



--- IASI L2 v5

--- IASI L2 v6



Results: B. Sun (NOAA)

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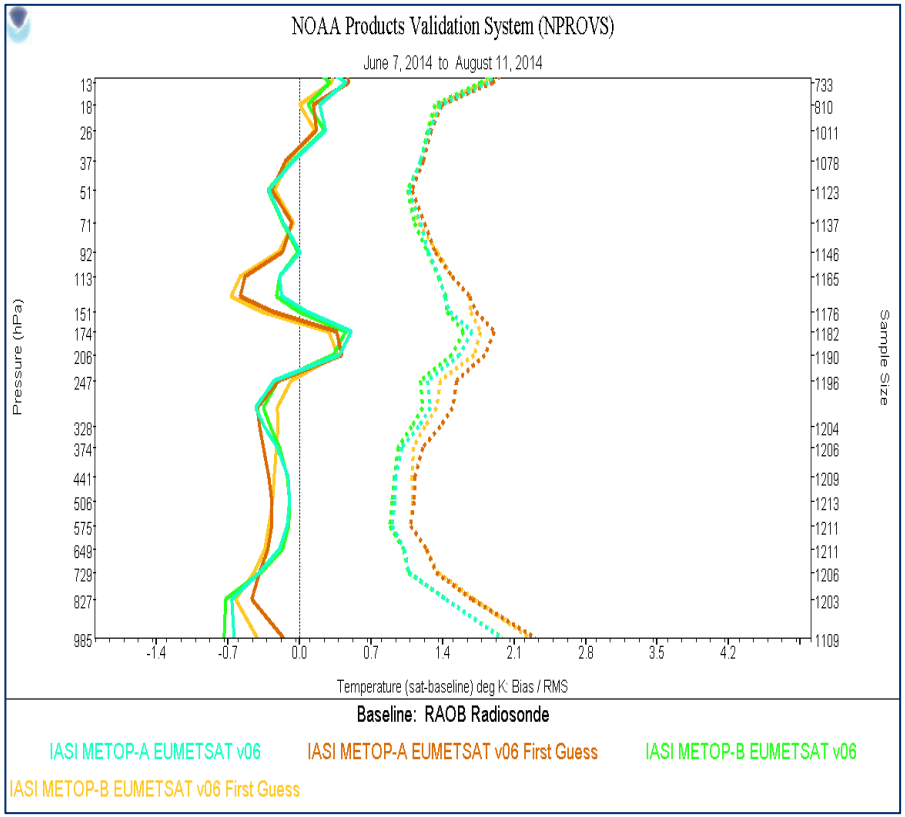
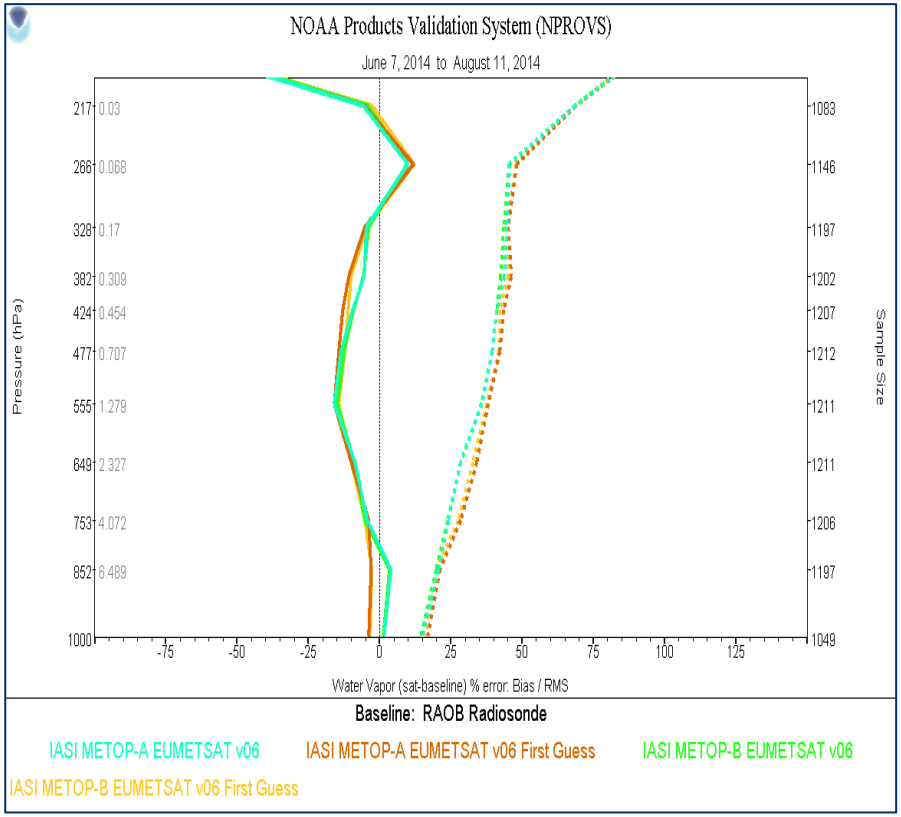
2. IASI L2 v6 assessment

T, q profiles vs *in situ* measurements



--- IASI L2 v6 PWLR (first guess)

--- IASI L2 v6 OEM



Results: B. Sun (NOAA)

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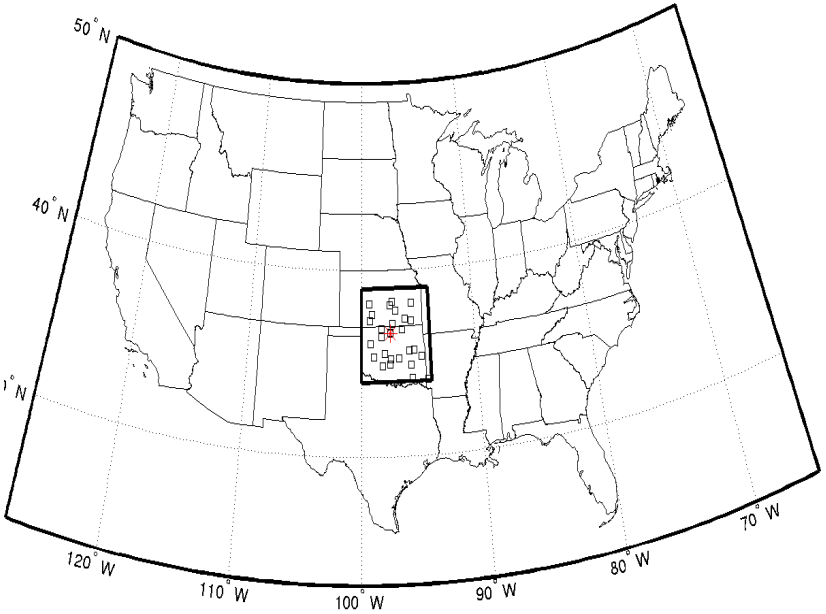
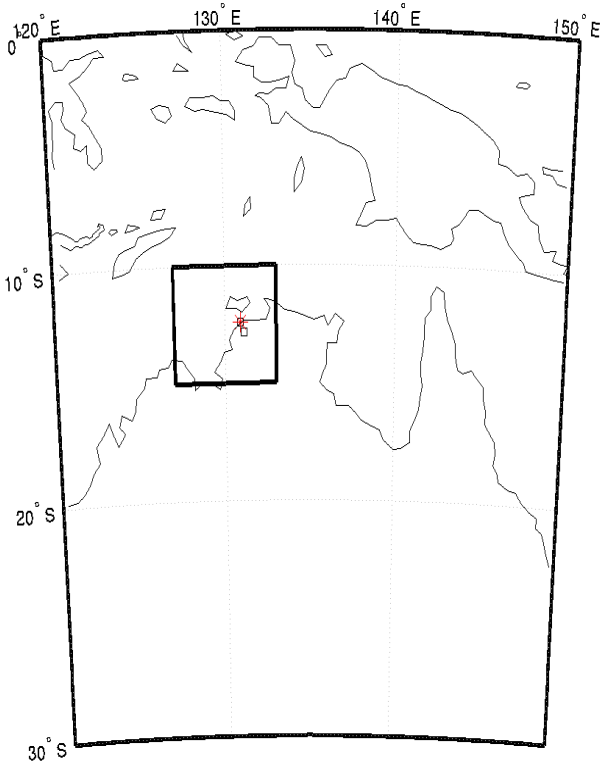
2. IASI L2 v6 assessment TCWV vs ground-based measurements

ARM site Lamont, US



ARM site Darwin, AUS



- IASI-A and –B full mission series (PWLR)
- ground-based **GPS-RO**, MW radiometer, Lidar and Sondes measurements.

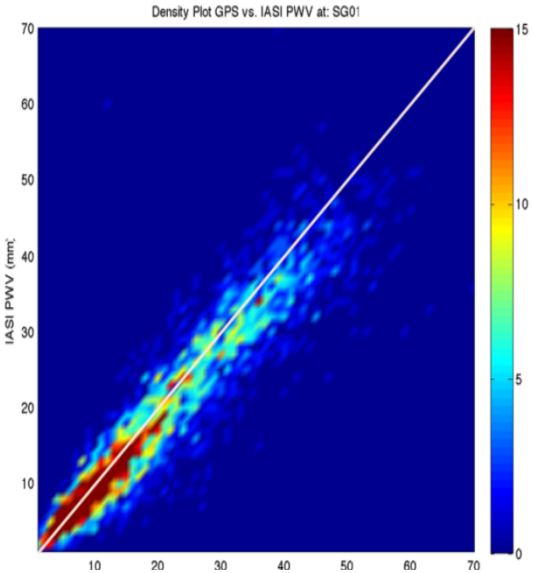
Credits: J. Roman (Uni. Wisconsin)
After Jacola et al, AIP Proc. 2013

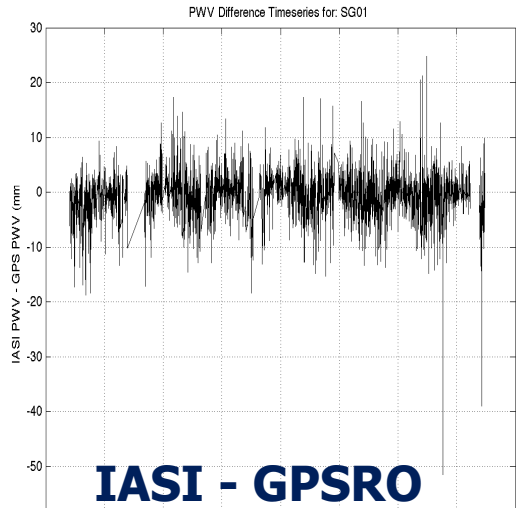
EUMETSAT

2. IASI L2 v6 assessment

TCWV vs ground-based measurements

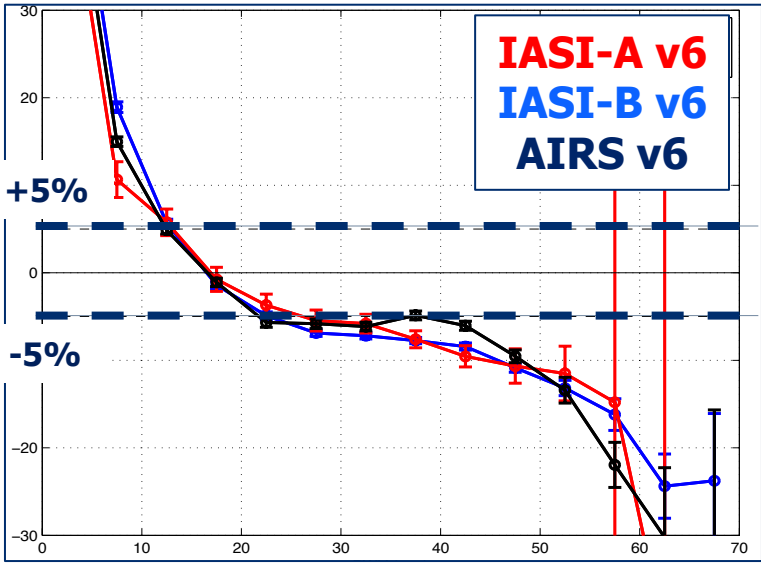
Lamont



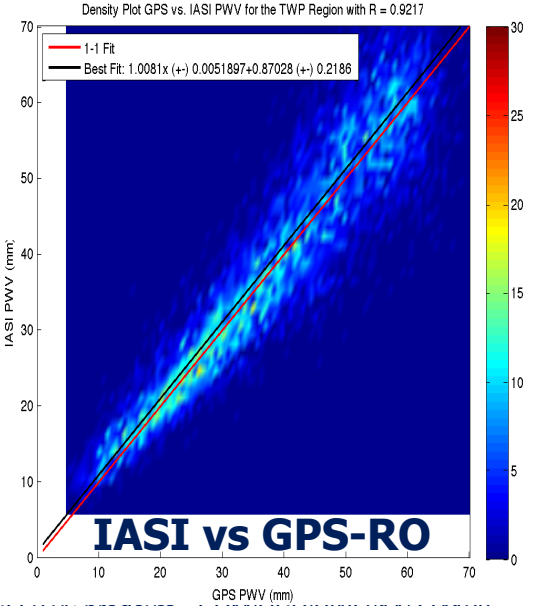


IASI - GPSRO

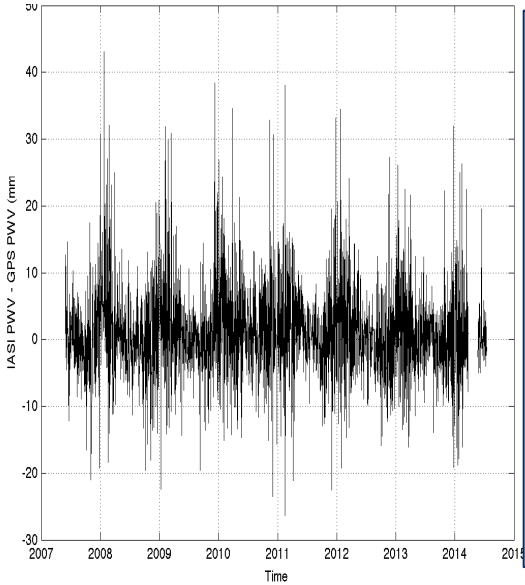
2007 → 2014

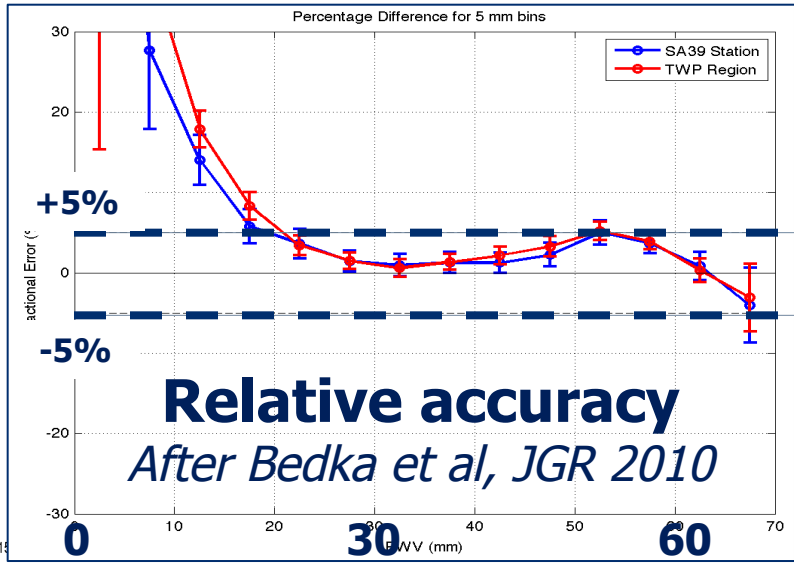


Darwin



IASI vs GPS-RO





Relative accuracy

After Bedka et al, JGR 2010

0 30 60

PWV [mm]

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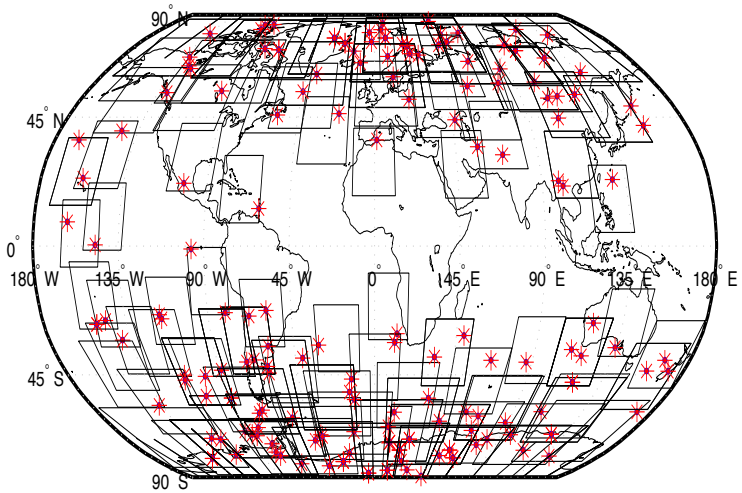
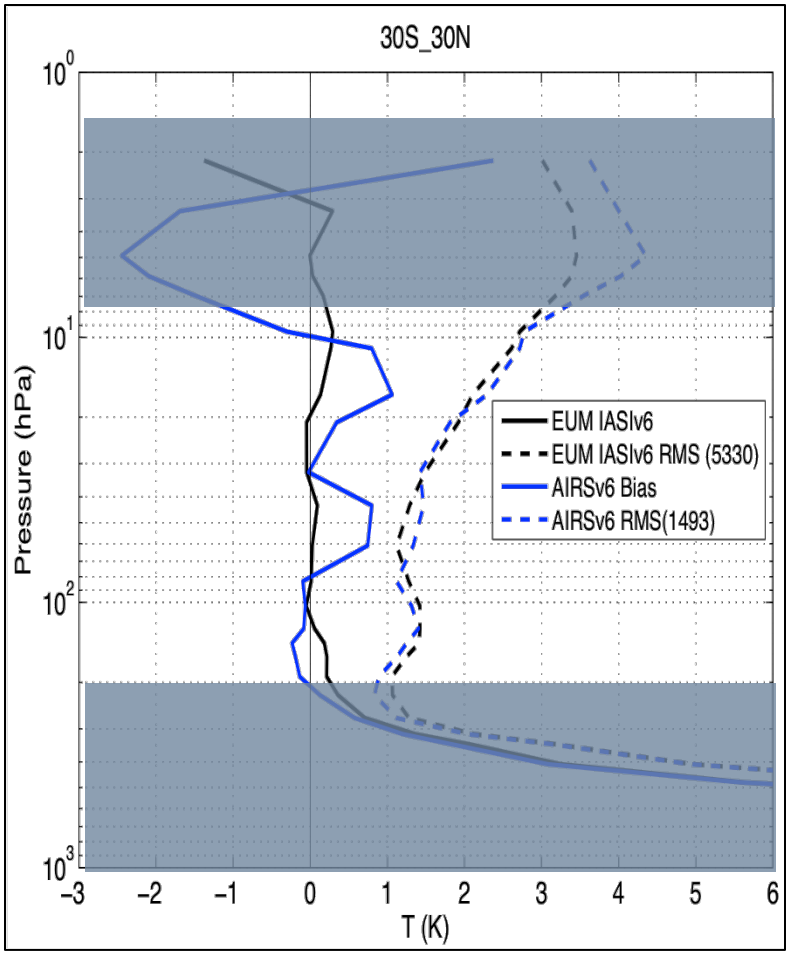
2. IASI L2 v6 assessment

Stratospheric temperature



Initial results of validation with GPS-RO dry temperature profiles (COSMIC UCAR product)

Credits: M. Feltz (Uni. Wisconsin)
After Feltz et al in JGR 2013, and AMTD 2013



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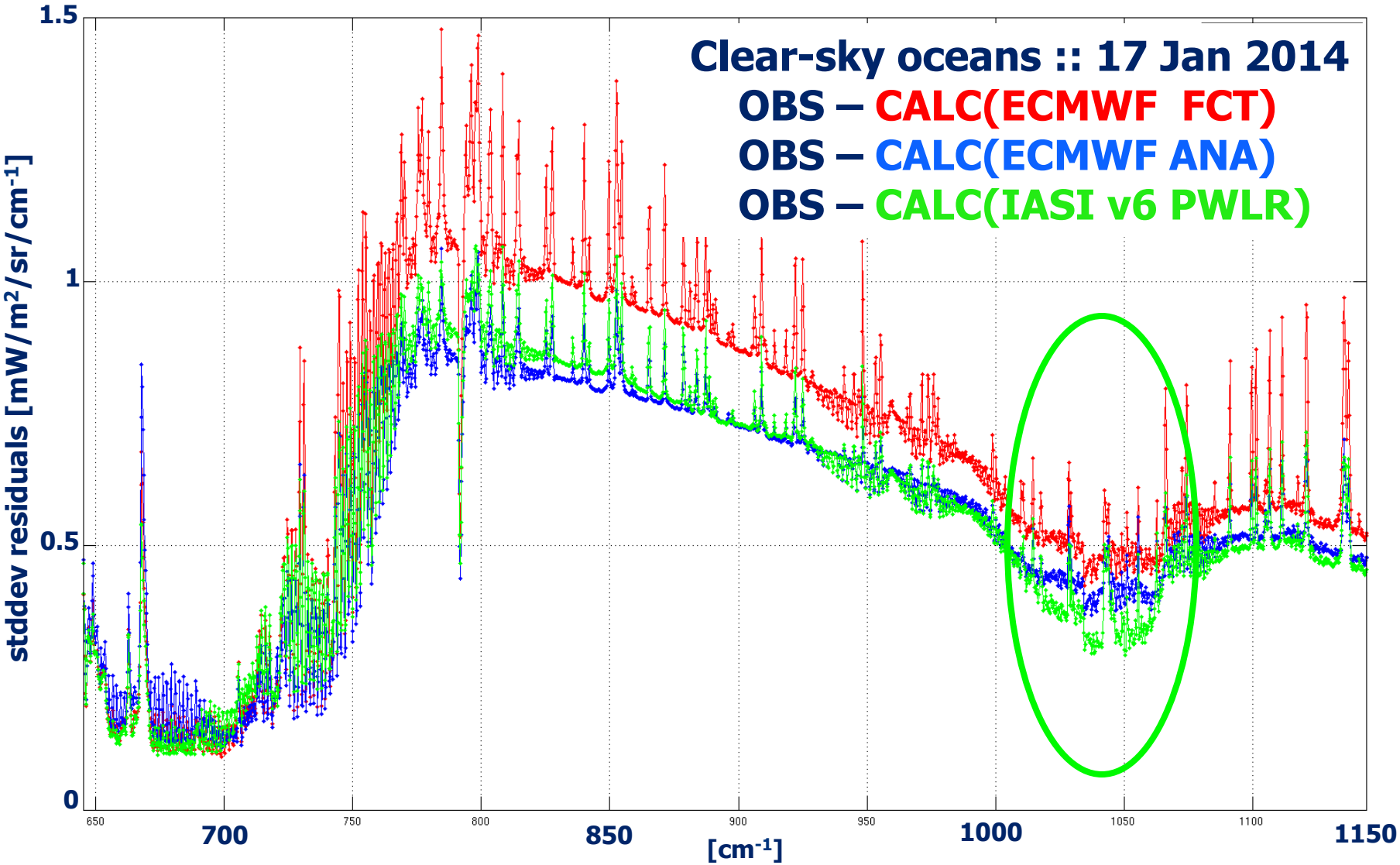
2. IASI L2 v6 assessment

Radiance residuals

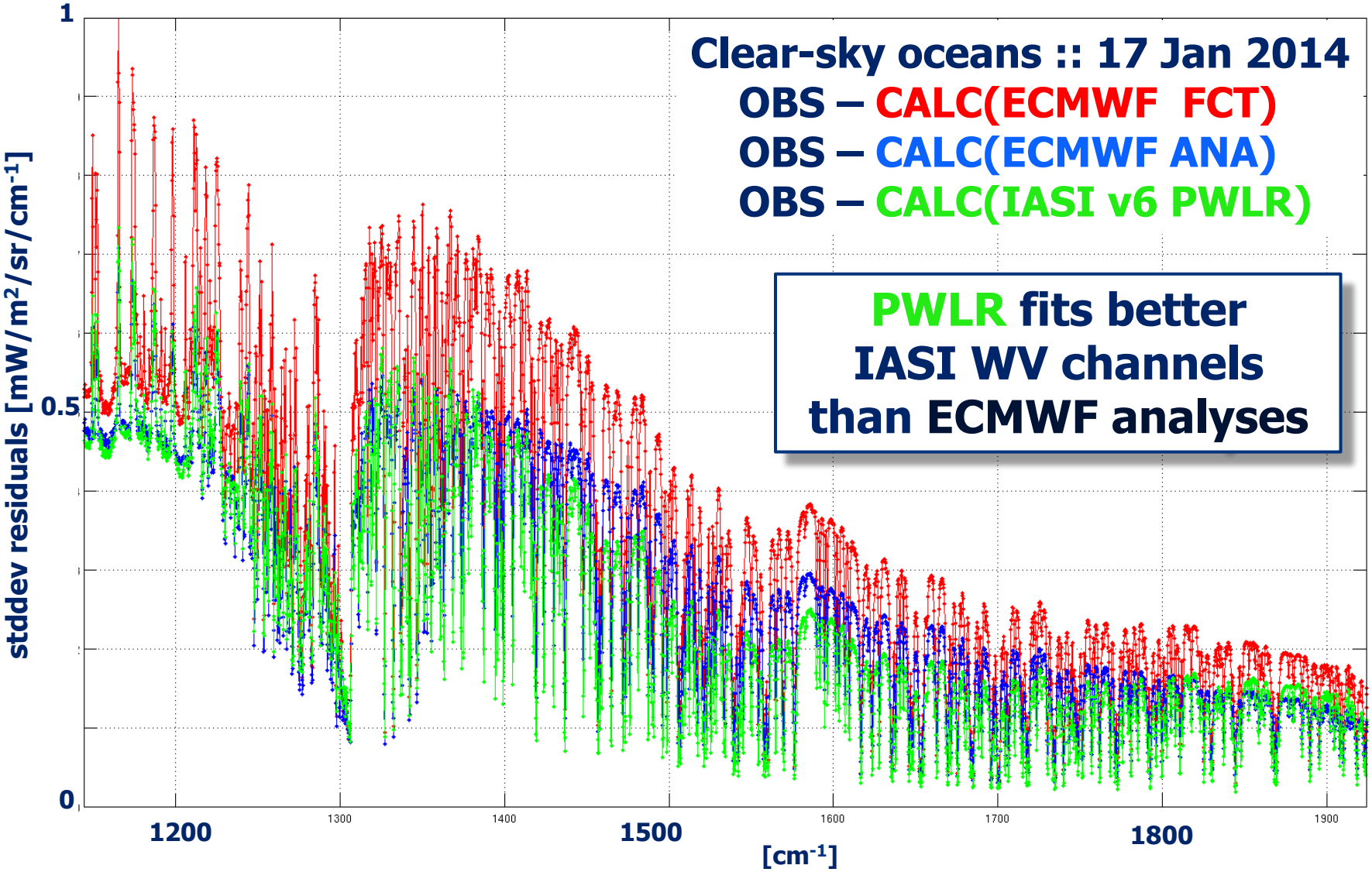


Band 1

EUMETSAT

2. IASI L2 v6 assessment

Radiance residuals



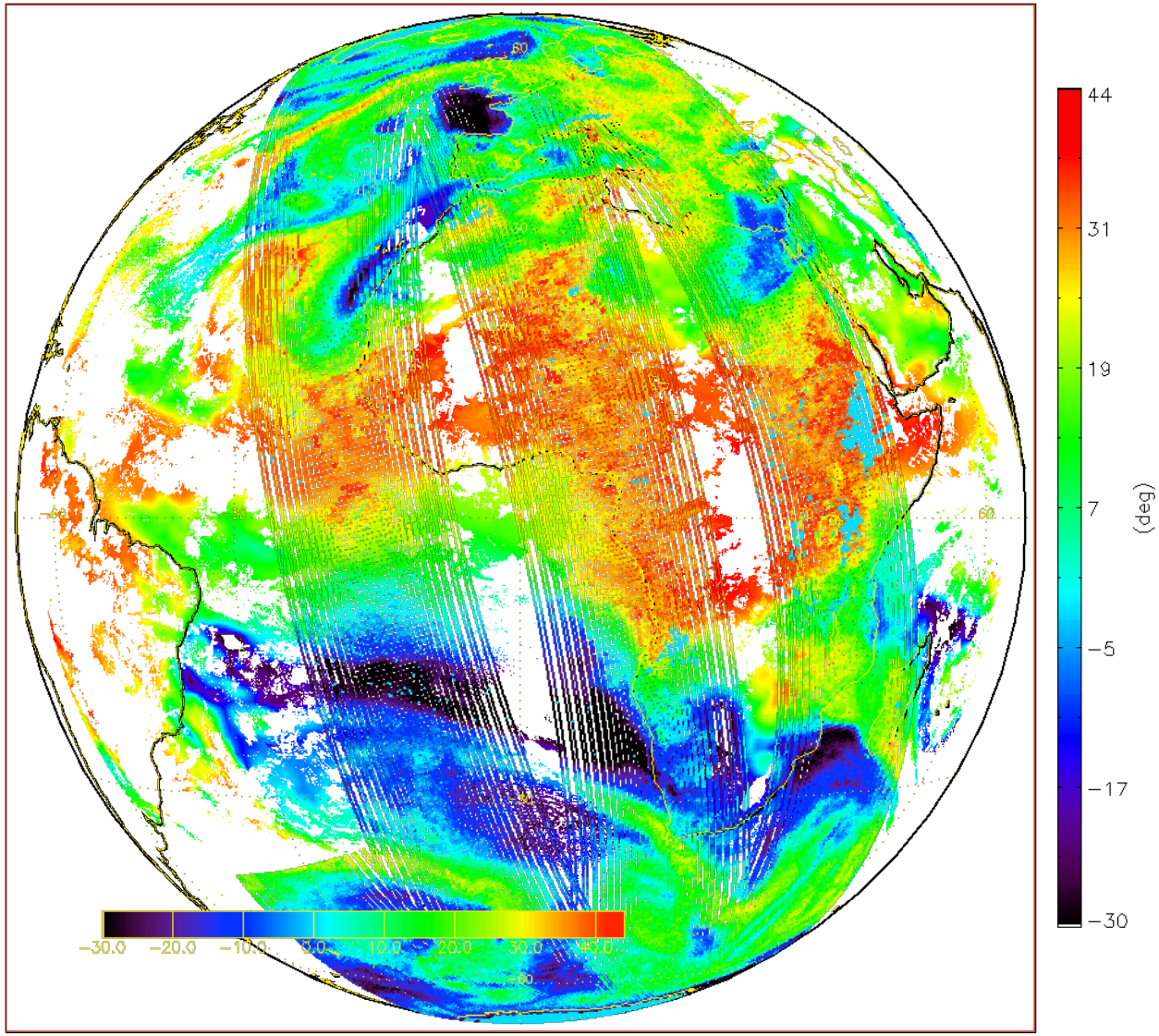
Band 2

EUMETSAT

2. IASI L2 v6 assessment

Instability Index vs MSG

MSG GII + IASI v6



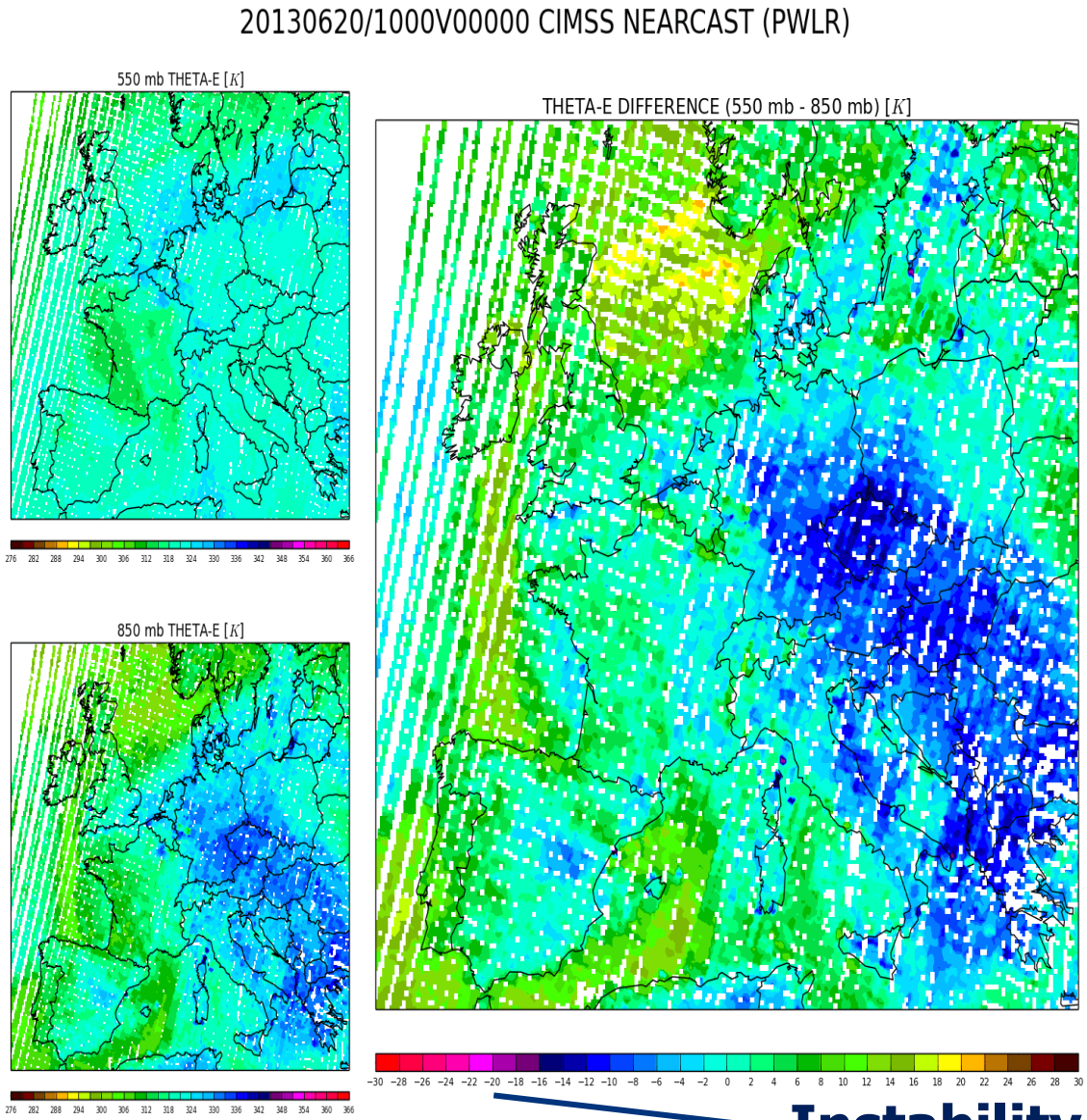
Results: M. Koenig (EUMETSAT)

EUMETSAT

2. IASI L2 v6 assessment

Instability Index & Nearcasting

Central Europe Flooding 20 June 2013



Instability

Results: L. Cronce, R. Petersen (Uni. Wisconsin)

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Outline

1. The IASI L2 processor v6
2. Products assessment results
3. **Summary**

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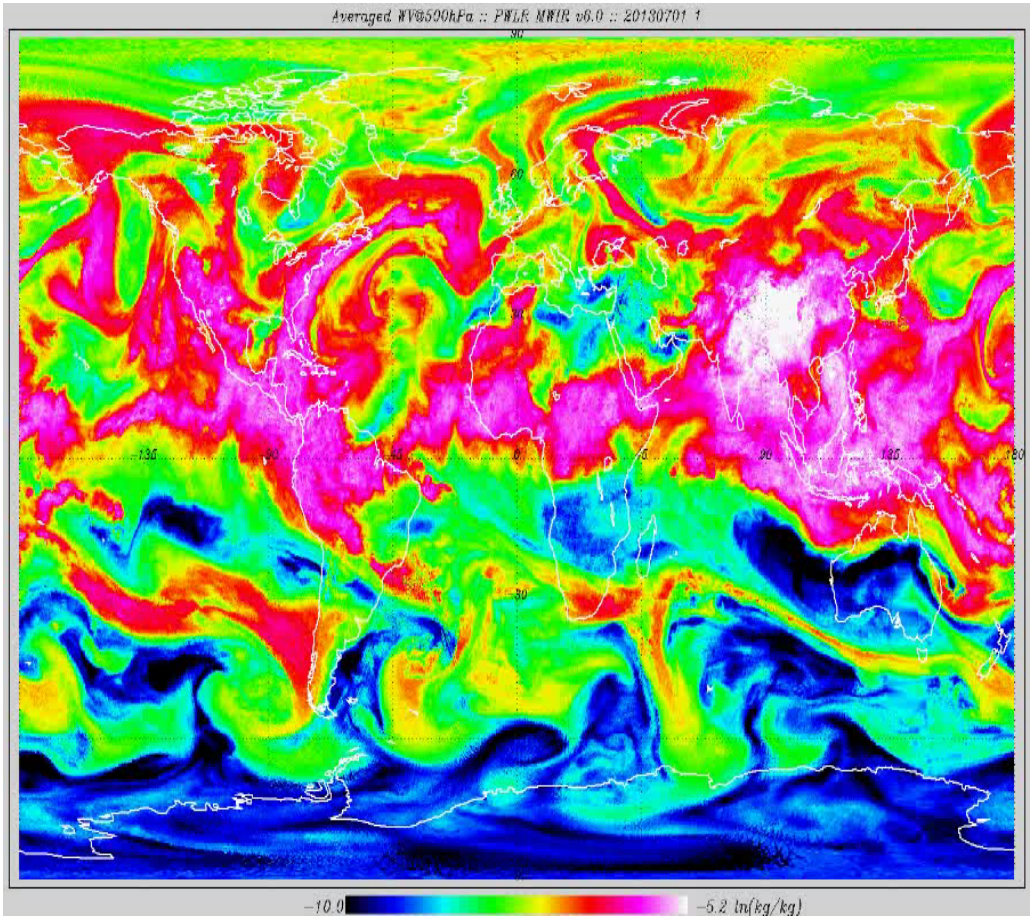
Summary

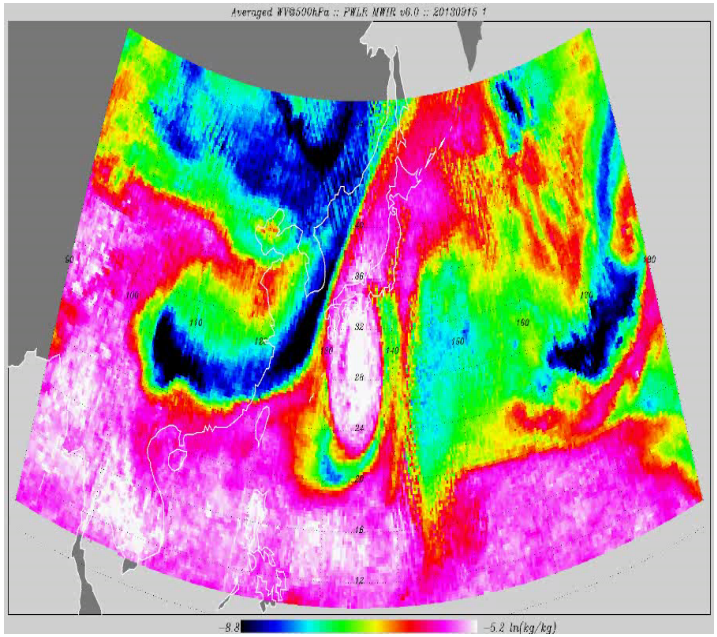
- ✓ **Simplified processing flags**, especially cloud information
- ✓ **MW+IR** allow **nearly all-sky T,q** statistical retrievals: ~95% yield
- ✓ **T & q profiles** significantly **improved**, especially in the **low troposphere** in clear and cloudy pixels (precision of T<1K, H_2O<1.2g/kg)
- ✓ Atmospheric profiles **yield doubled** with OEM (~20%)
- ✓ **Full retrieval error** estimate provided, from which the **averaging kernels** can be derived.
- ✓ New atmospheric composition products, starting with **CO profiles**
- ✓ **IASI L2P SST** products contribute to GHRSST

IASI L2 v6 … Operational since 30/09/2014 09:15 UTC

WV@500 hPa :: Global
July 2013 – July 2014



WV@500 hPa :: Eastern Asia
Sept-Oct 2013



Thank you
for your attention !

thomas.august@eumetsat.int

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Spare slides

2. Product changes

Simplified processing flags

FLG_ITCONV v5

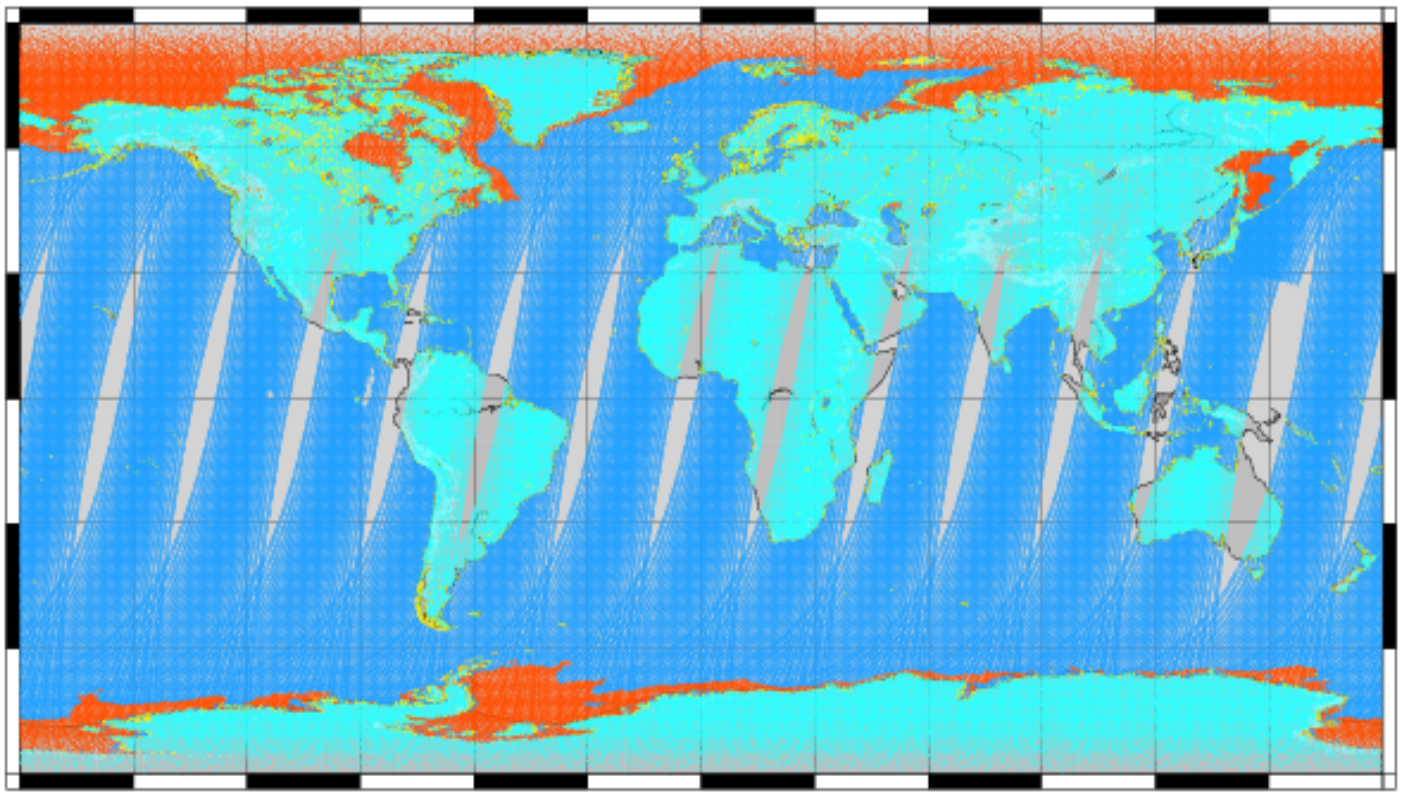
FLG_A
FLG_A
FLG_A
FLG_A
FLG_A
FLG_C
FLG_C
FLG_C
FLG_C
FLG_C
FLG_C
FLG_D
FLG_F
FLG_F
FLG_F
FLG_I
FLG_I
FLG_I
FLG_I

FLG__STER

v6 FLG_AMSUBAD

e detection
h MW

FLG_THICIR



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2. Product changes

BUFR products structure

V5	Content
TWT	Temperature, humidity profiles (90 levels) and surface temperature
CLP	Cloud detection and characterisation (phase, height, coverage)
EMS	Land surface emissivity (12 channels)
OZO	Ozone partial columns (0-6km, 0-12km, 0-16km) and total column
TRG	CO, CH_4, CO_2, N_2O Total columns

V6	Content
TWT	Temperature, humidity profiles (101 levels) and surface temperature
TWT_ERR	T,H_2O Retrieval error covariance matrix (can be large)
CLP	Cloud detection and characterisation (phase, height, coverage)
EMS	Land surface emissivity (12 channels)
OZO	Ozone profiles (101 levels) and retrieval error covariance matrix
TRG	CO, CH_4, CO_2, N_2O Total columns
CO	CO total column, profiles and averaging kernels
HNO3	HNO_3 total column, profiles and averaging kernels
SO2	SO_2 amount and plum height estimates

The EPS native format changes with v6 (format version 11.0).

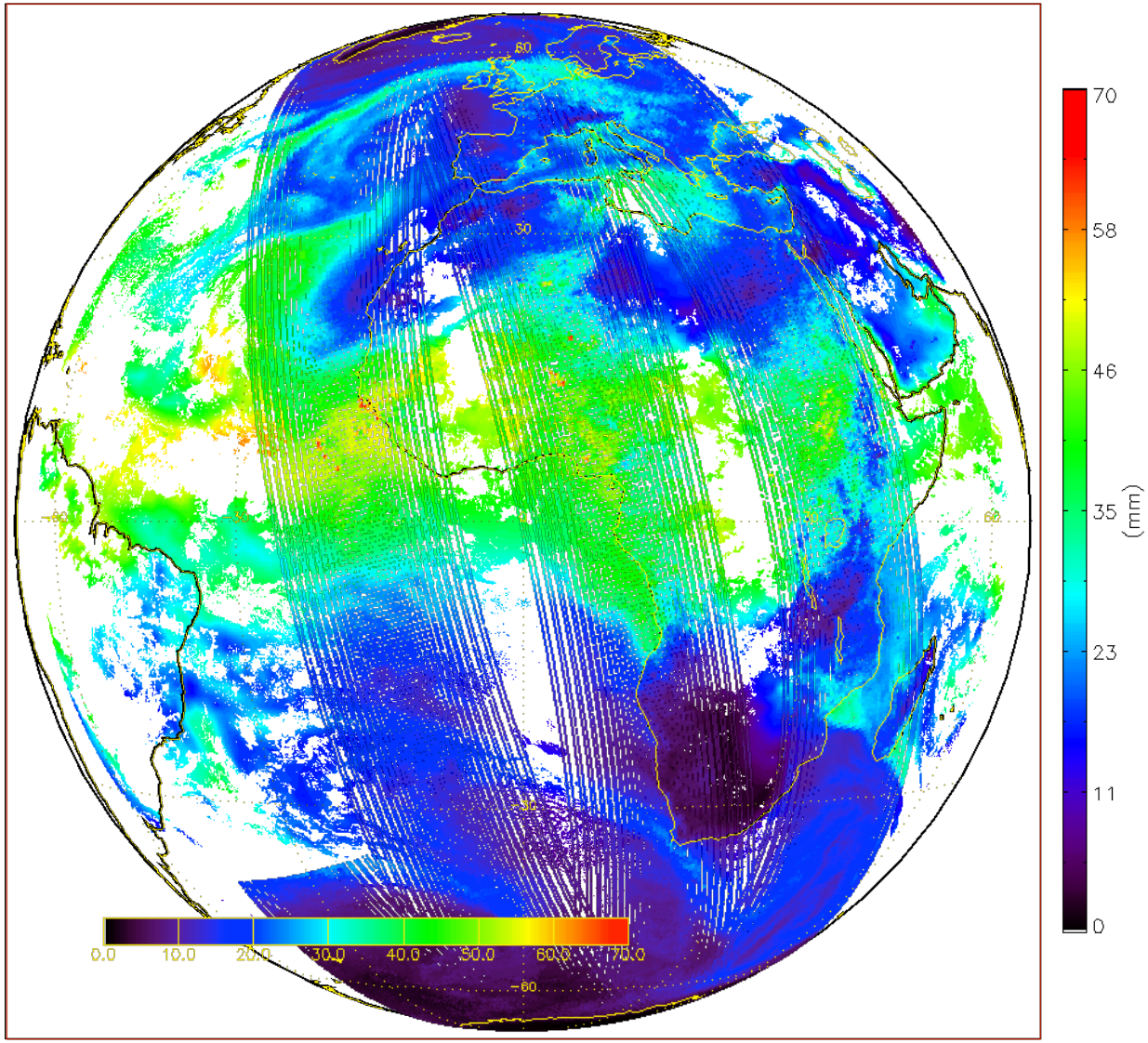
The format and content changes in the BUFR products also affect the existing packets.

For early information, implementation in 2015 and onwards. Place holders ready in EPS native format

3. IASI L2 v6 assessment

Total column WV vs MSG

MSG TPWV + IASI v6



Results: M. Koenig (EUMETSAT)

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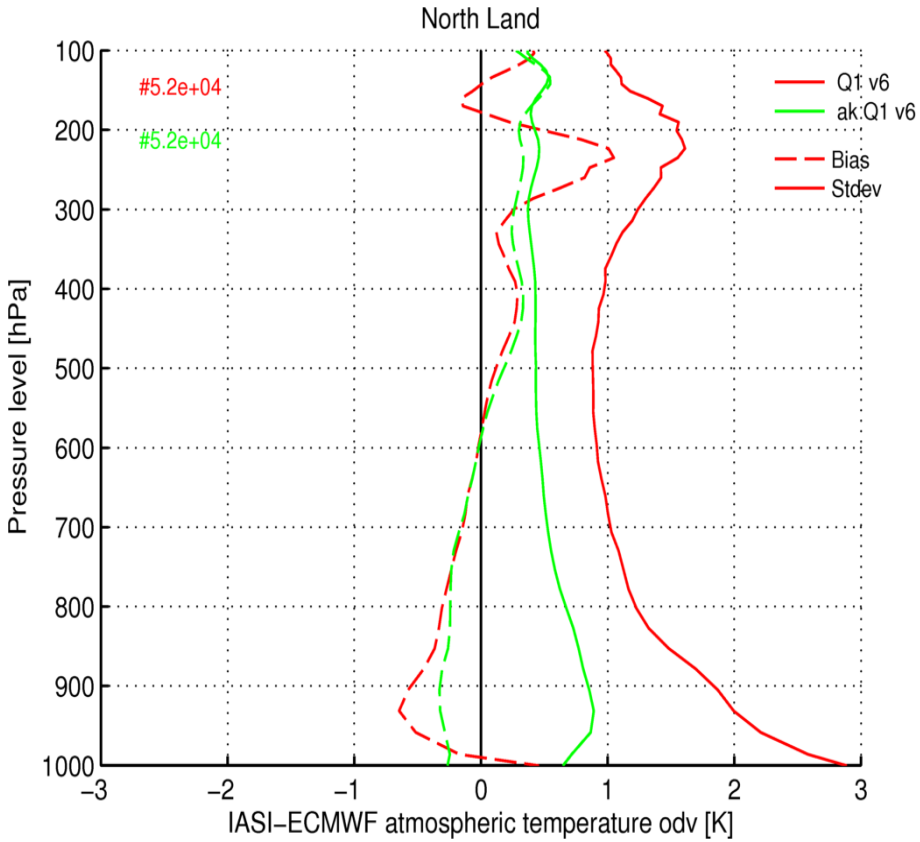
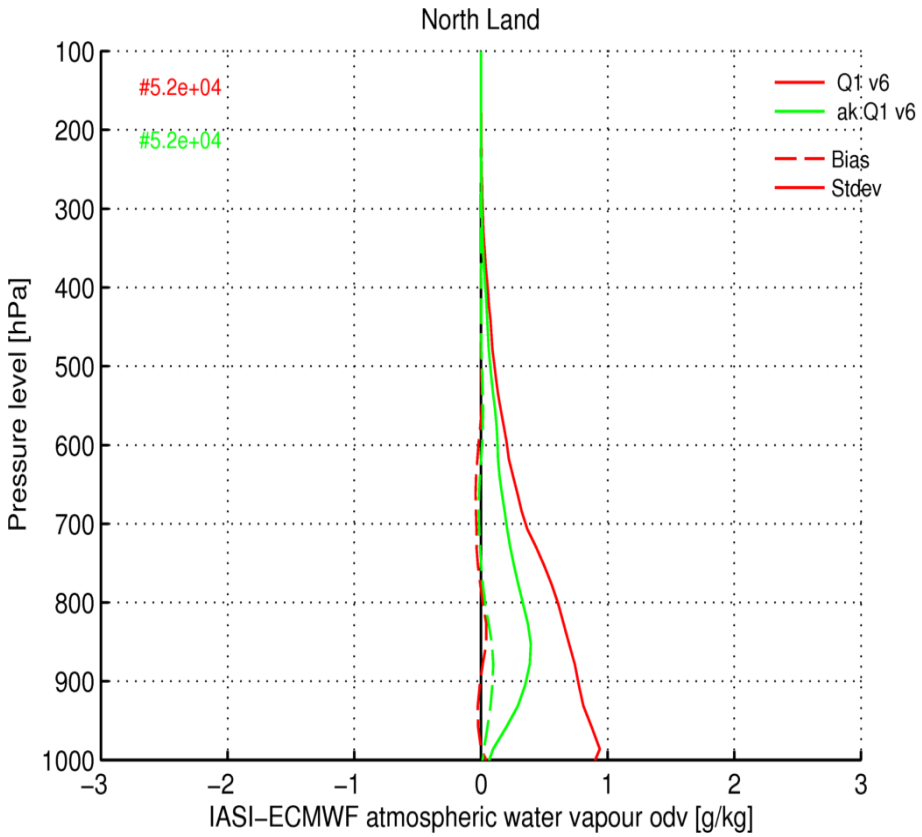
21-25/02/2014 :: clear-sky Land NH
IASI L2 – ECMWF forecasts
OEM(IR), AK(OEM(IR))

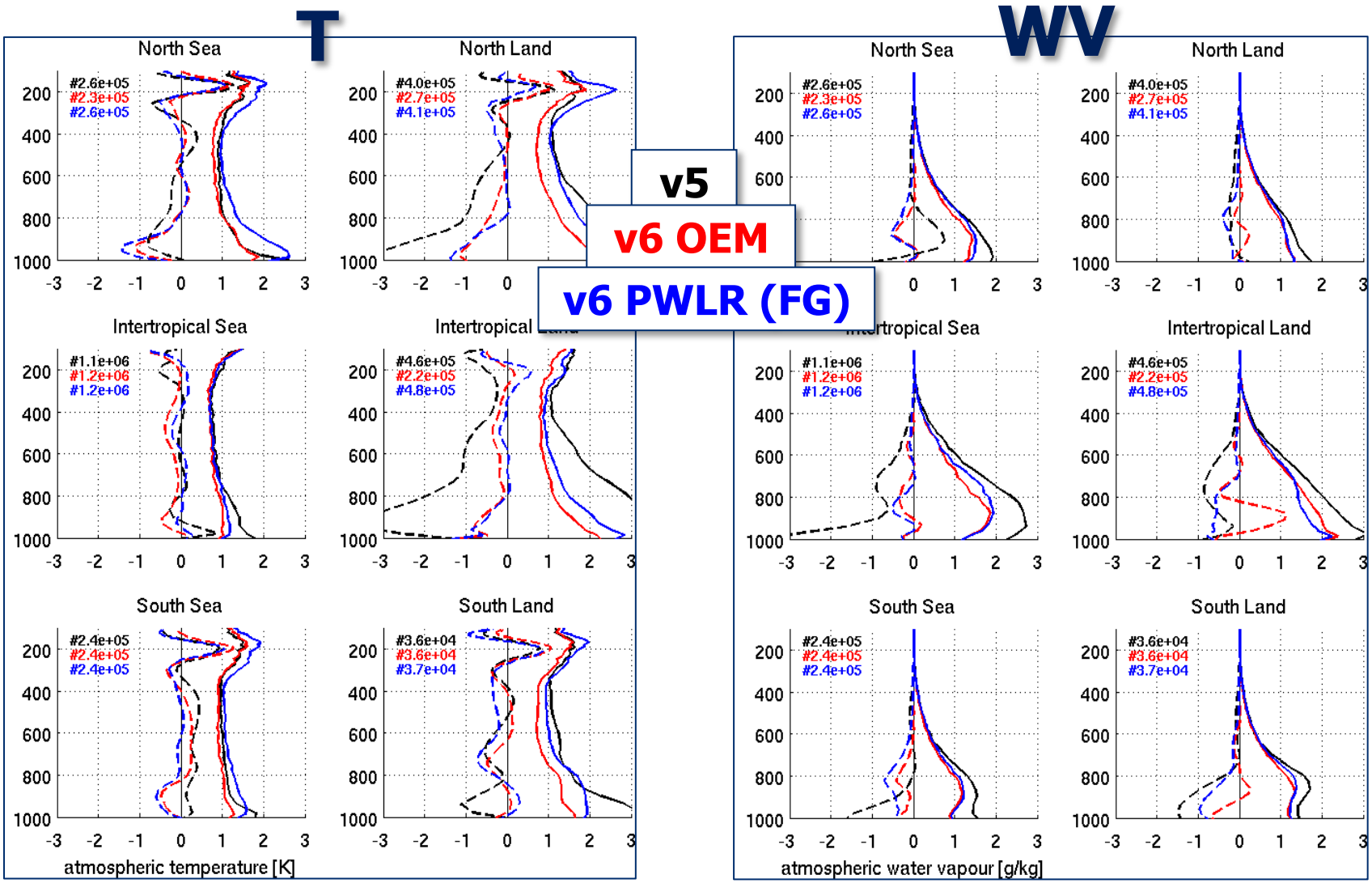




2. IASI L2 v6 assessment

Retrieval in IR-mode only

IASI-A L2 v6 – ECMWF analyses :: 25 April – 20 May 2014 during MHS failure



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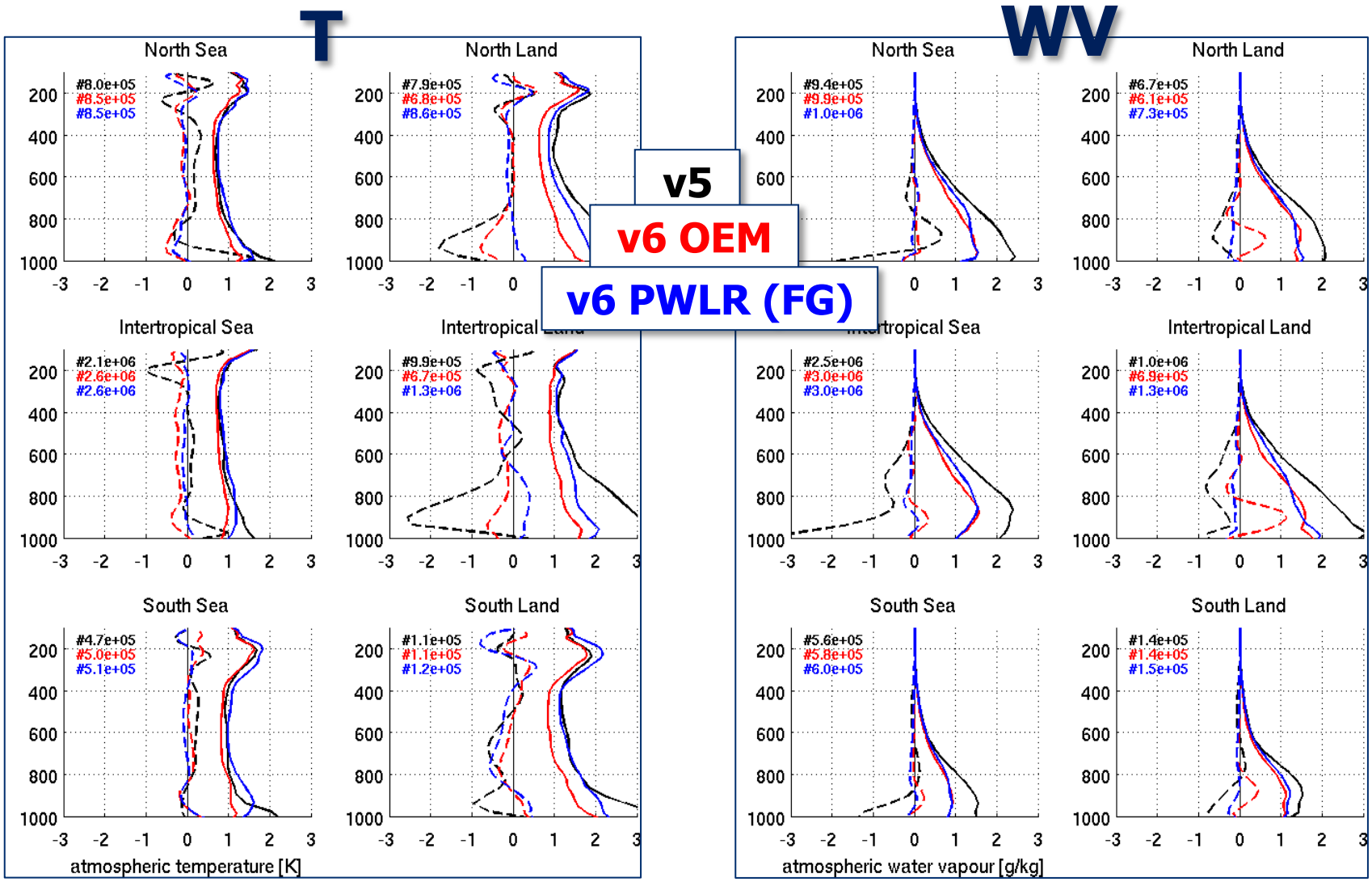
2. IASI L2 v6 assessment

Retrieval in MW+IR nominal mode

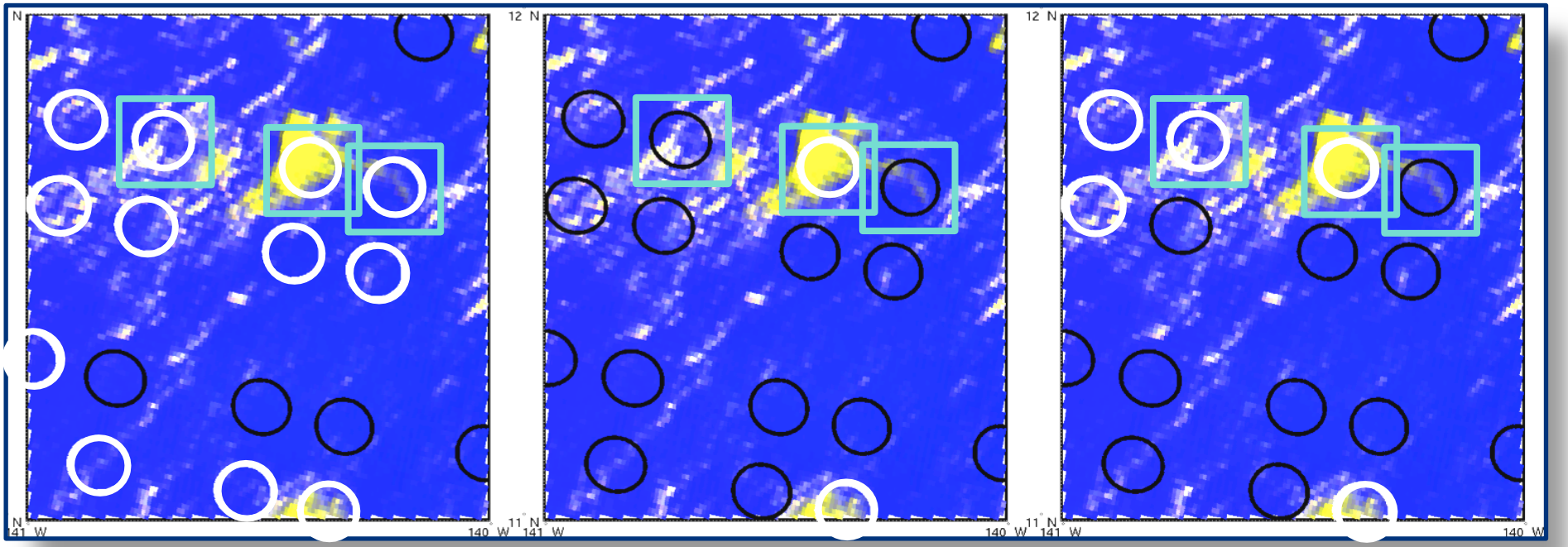
IASI-A L2 v6 – ECMWF analyses :: 27 June – 10 Sept 2014 :: MW+IR



1. The IASI L2 processor v6

The cloud detection

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



White: cloudy Black: clear

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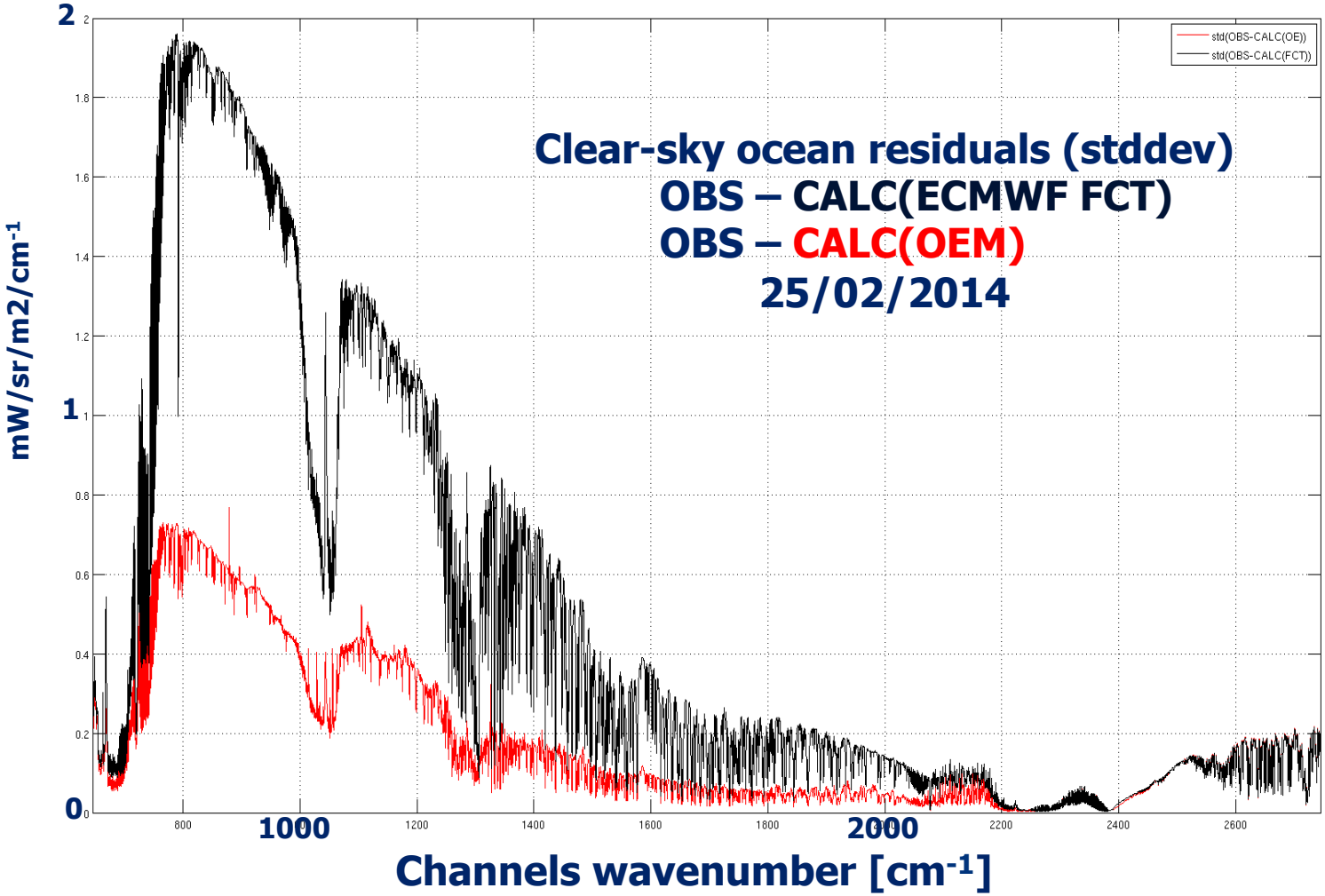
2. IASI L2 V6 assessment

Radiance residuals

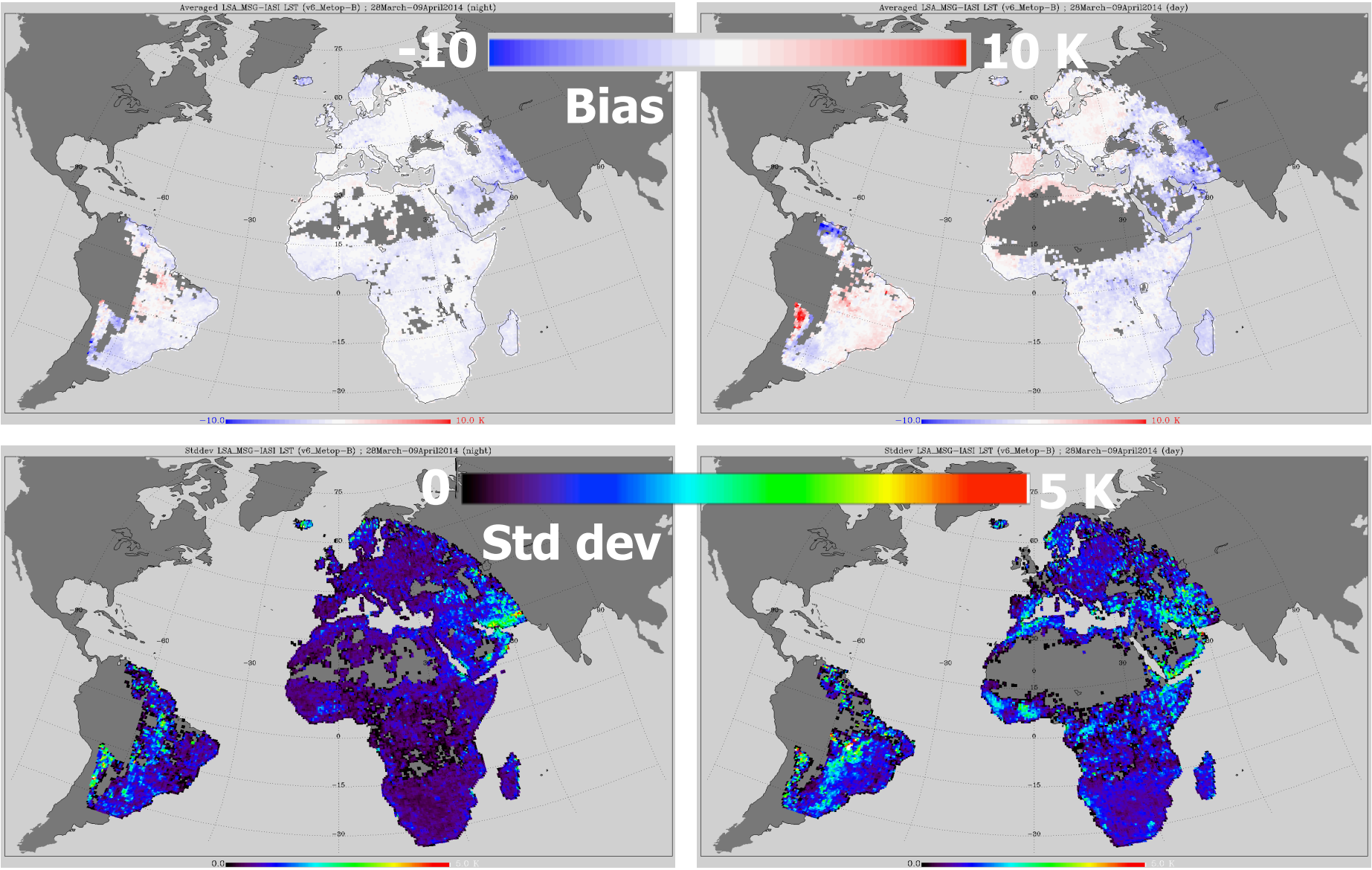


Results: T.Hultberg (EUMETSAT)

EUMETSAT

2. IASI L2 V6 assessment

Land Surface Temperature vs MSG



IASI L2 v6 prodcuts - EUM/RSP/VWG/14/774128
NASA Sounder Science Team Meeting, Greenbelt October 2014

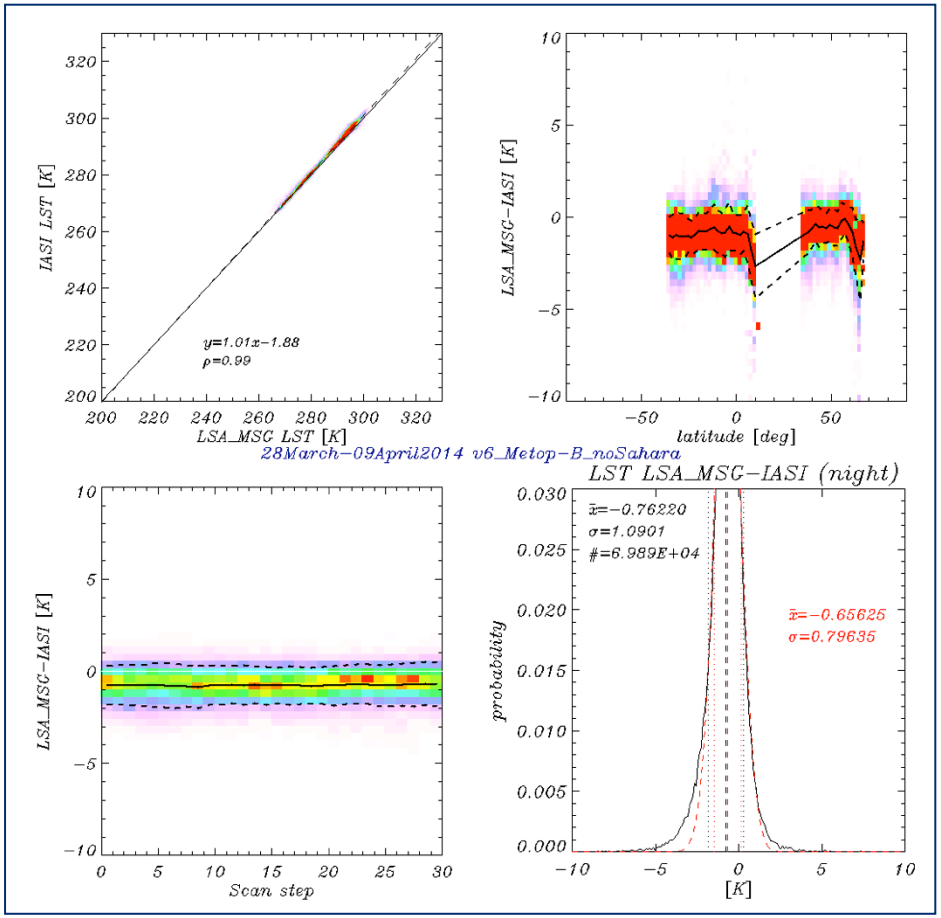
MSG - IASI-B LST :: 28 March – 09 April 2014

EUMETSAT

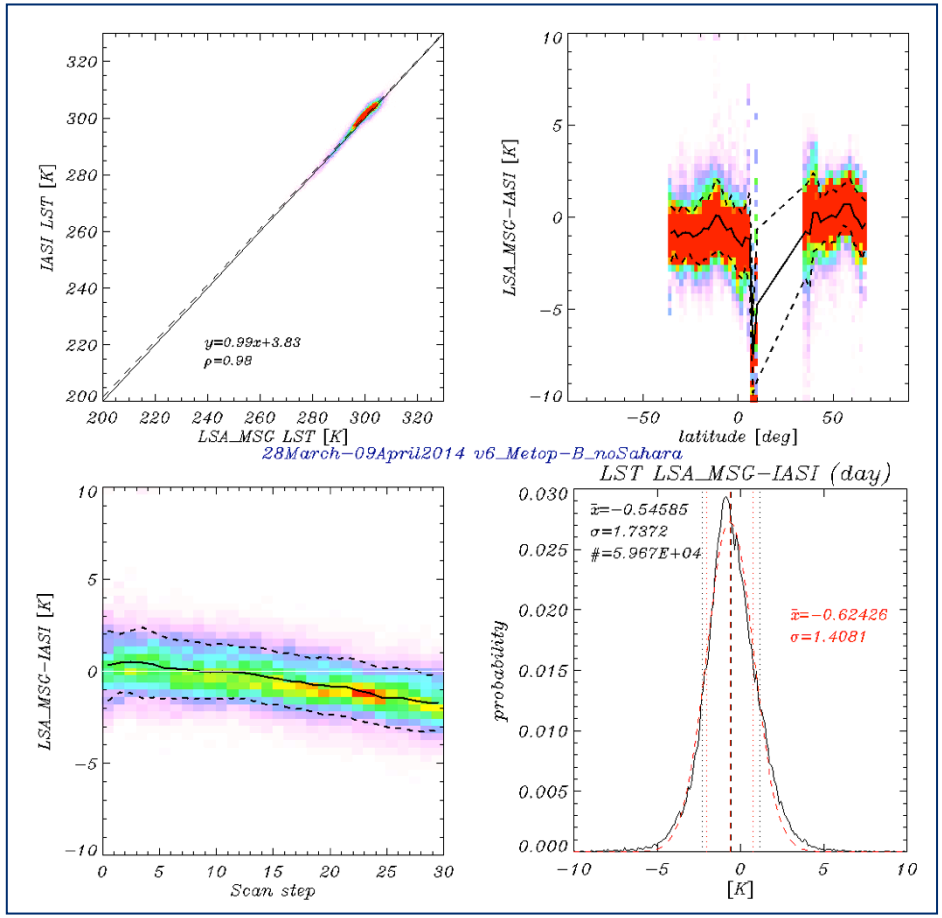
2. IASI L2 V6 assessment

Land Surface Temperature vs MSG

Night time



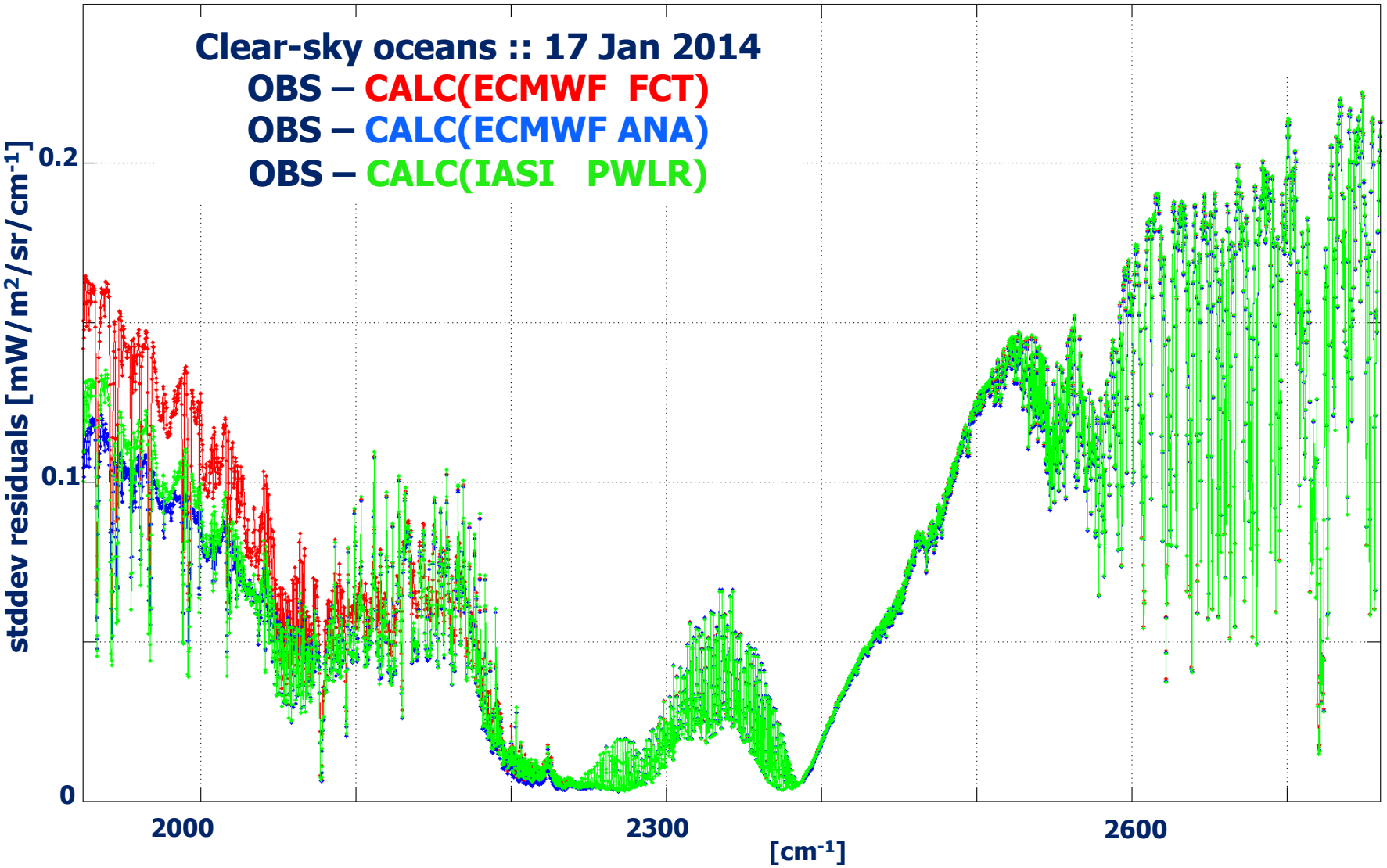
Day time



MSG - IASI-B LST :: 28 March – 09 April 2014

2. IASI L2 V6 initial assessment

Radiance residuals



Band 3

EUMETSAT

Future work

- **Include the micro-wave in the optimal estimation**
- **Study the retrieval of clouds and land surface emissivity in the OEM**
- **Include SO_2 and HNO_3, evolve O_3**
- **Implement state-of-the art CH_4 retrievals to serve MACC**
- **Prototype a dust flag for SST quality flagging**

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