IASI L2 processor at EUMETSAT: status and perspectives

Thomas AUGUST

Xavier CALBET, Dorothée COPPENS, Marc CRAPEAU, Tim HULTBERG, Dieter KLAES, Rose MUNRO, Anne O'CAROLL, Bertrand THEODORE, Dan Zhou, Frank Goetsche, Folke Olesen, Cathy CLERBAUX, Pierre COHEUR, Daniel HURTMANS

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Outline

1. The current operational IASI L2 products: version 5

2. IASI L2/Metop-B: preliminary results

3. On-going developments, towards the version 6

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1. IASI L2 version 5

The products structure

Disseminated in NRT (sensing +2 h)

TWT	Temperature (vertical profiles) Humidity (vertical profiles) Surface Temperature (Land & Sea)	+ AK
EMS	Surface emissivity	
CLD	Cloud detection and characterisation	
OZO	O_3 total & partial (0-6, 0-12, 0-16 km) columns	
TRG	CO, N_2O, CH_4, CO_2 Total columns	

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v6	CO & O_3 profiles + AK, SO_2, HNO_3

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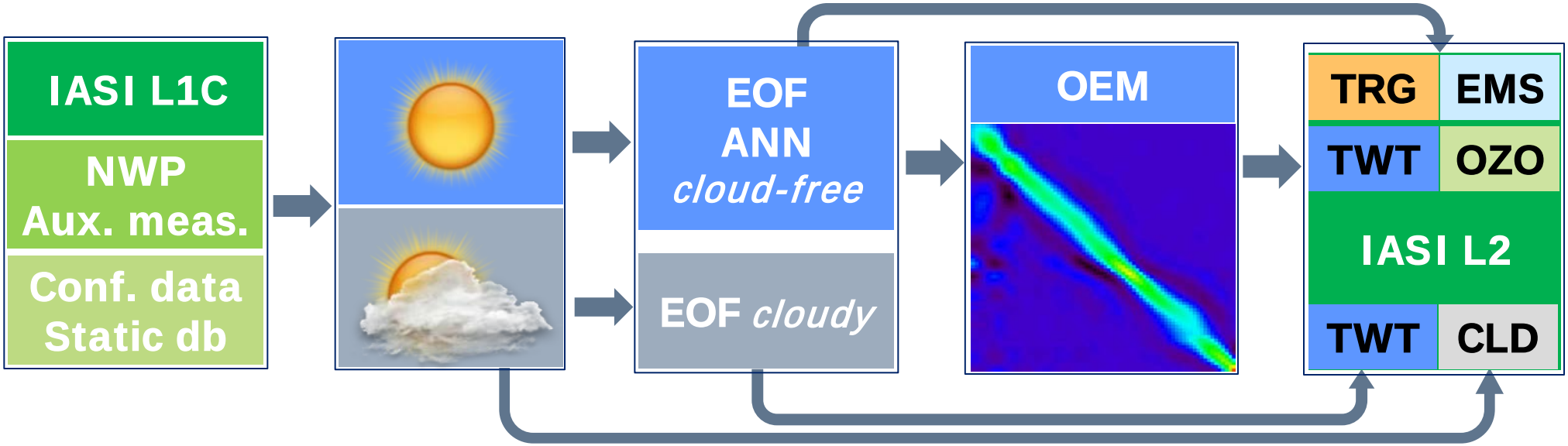
1. IASI L2 version 5

The operational processor

1. Input data pre-processing
2. Cloud detection and characterisation
3. Statistical retrievals: T, q, Ts, ε, CO (N_2O, CH_4, CO_2)
4. Optimal Estimation Method (OEM): T, q, Ts, O_3



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1. IASI L2 version 5: Revision history

Date	Revision number	Short description
14/09/2010	v5.0.6	**Improved T profiles, CO** and **O_3 operational** [...]
30/11/2010	IASI L2 PPF v5.0.6	**Surface emissivities** disseminated in trial-mode
02/12/2010	IASI L2 PPF v5.1.0	Production and dissemination of **T,q retrievals** under **partly cloudy** conditions in answer to a user request
07/02/2011	IASI L1 PPF	Auxiliary spectral database update to **reduce inter-pixel differences** in band 3
14/03/2011	IASI L2 PPF v5.1.1	**CO** & N_2O retrieved and disseminated for **all IFOVs**
24/03/2011	IASI L2Pcore SST	**IASI SST** becomes part of the **GHRSST** (Group for High Resolution SST) project
20/10/2011	v5.2.1	**Improved cloud screening** for cloudy T,q retrievals Fixed polar cloud-top pressure retrievals Changed RTM to **RTTOV-10**
28/02/2012	v5.3	New algorithm for cloud fraction and height assignment, **cloud product yield increased by 30%**
16/07/2012	v5.3.1	Bug fix in WV profiles encoding => low humidity encoded as NaN. Very rare occurrence. SST L2P SSES update Adapted chain to M01 products
2013	**v6**	**... In the next slides ...**

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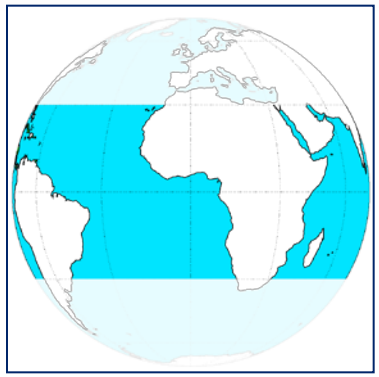
1. IASI L2 version 5

Temperature profiles: validation

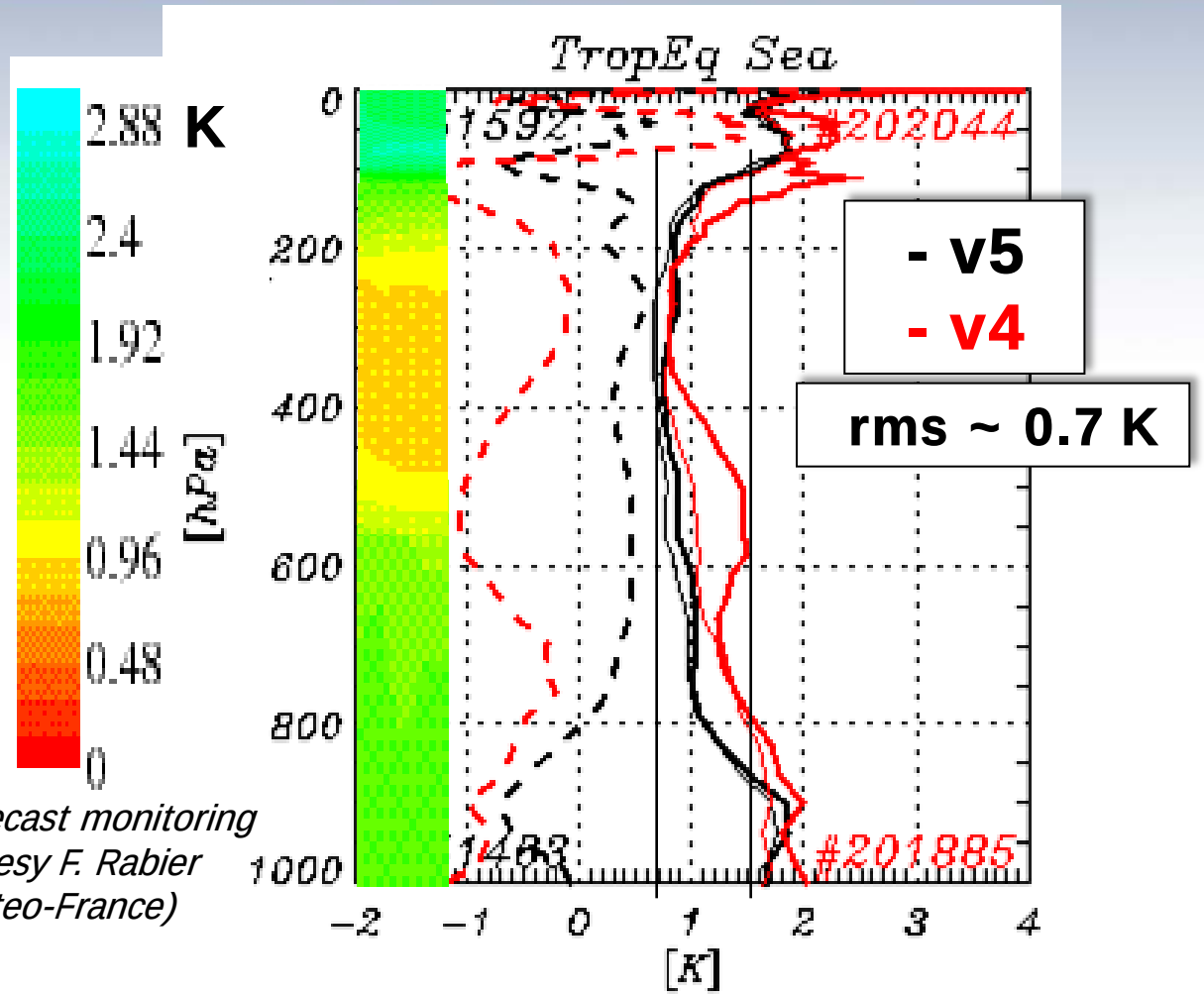
19-24 March 2010

Temperature profiles

IASI L2 – ECMWF Analysis



Intertropical Ocean cases



NWP forecast monitoring
Courtesy F. Rabier
(Meteo-France)

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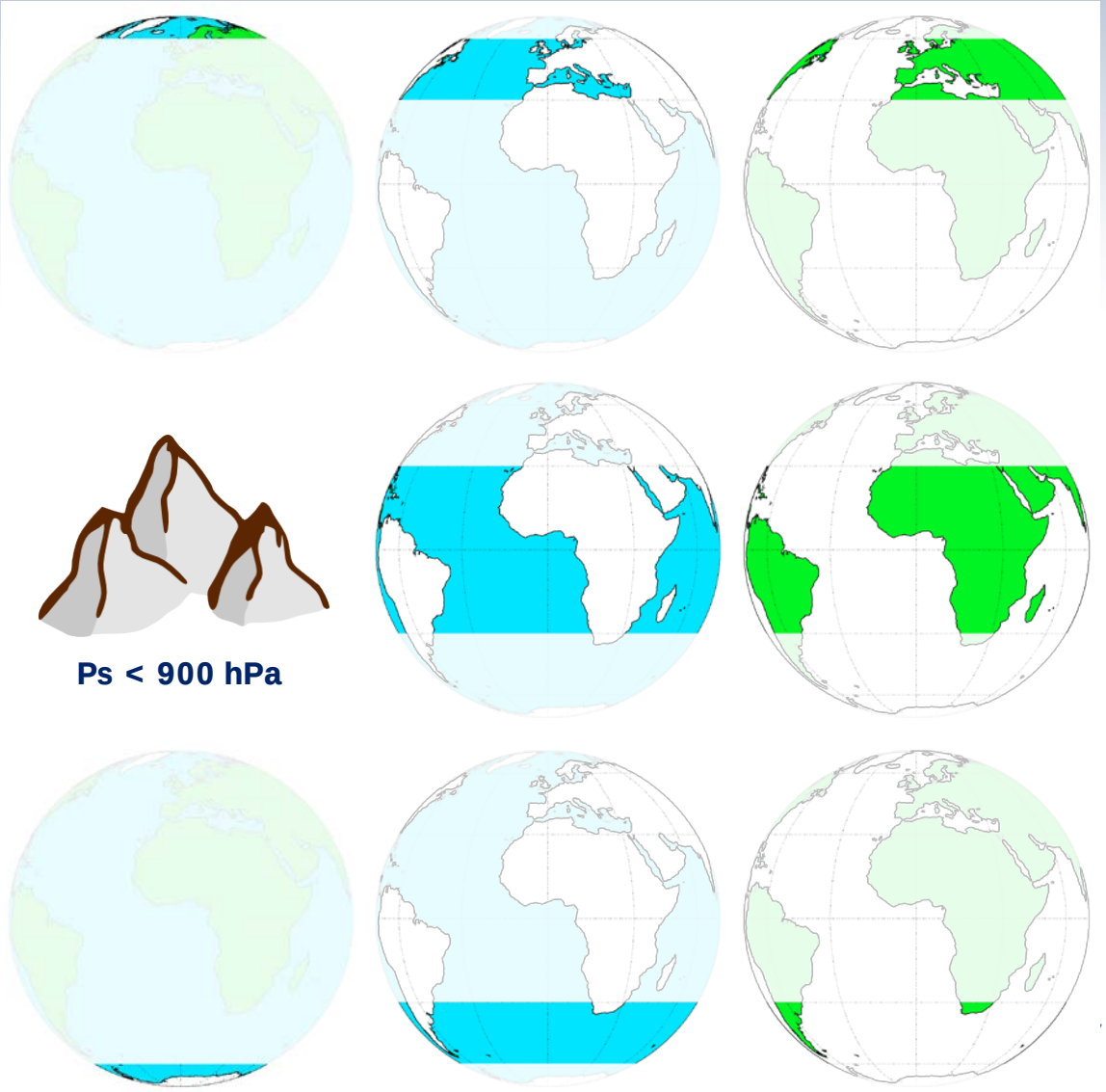
1. IASI L2 version 5

Temperature profiles: validation



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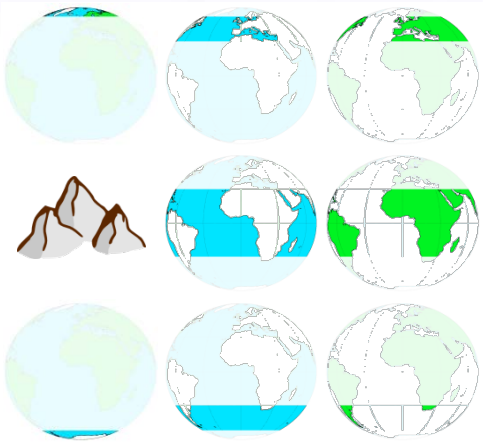
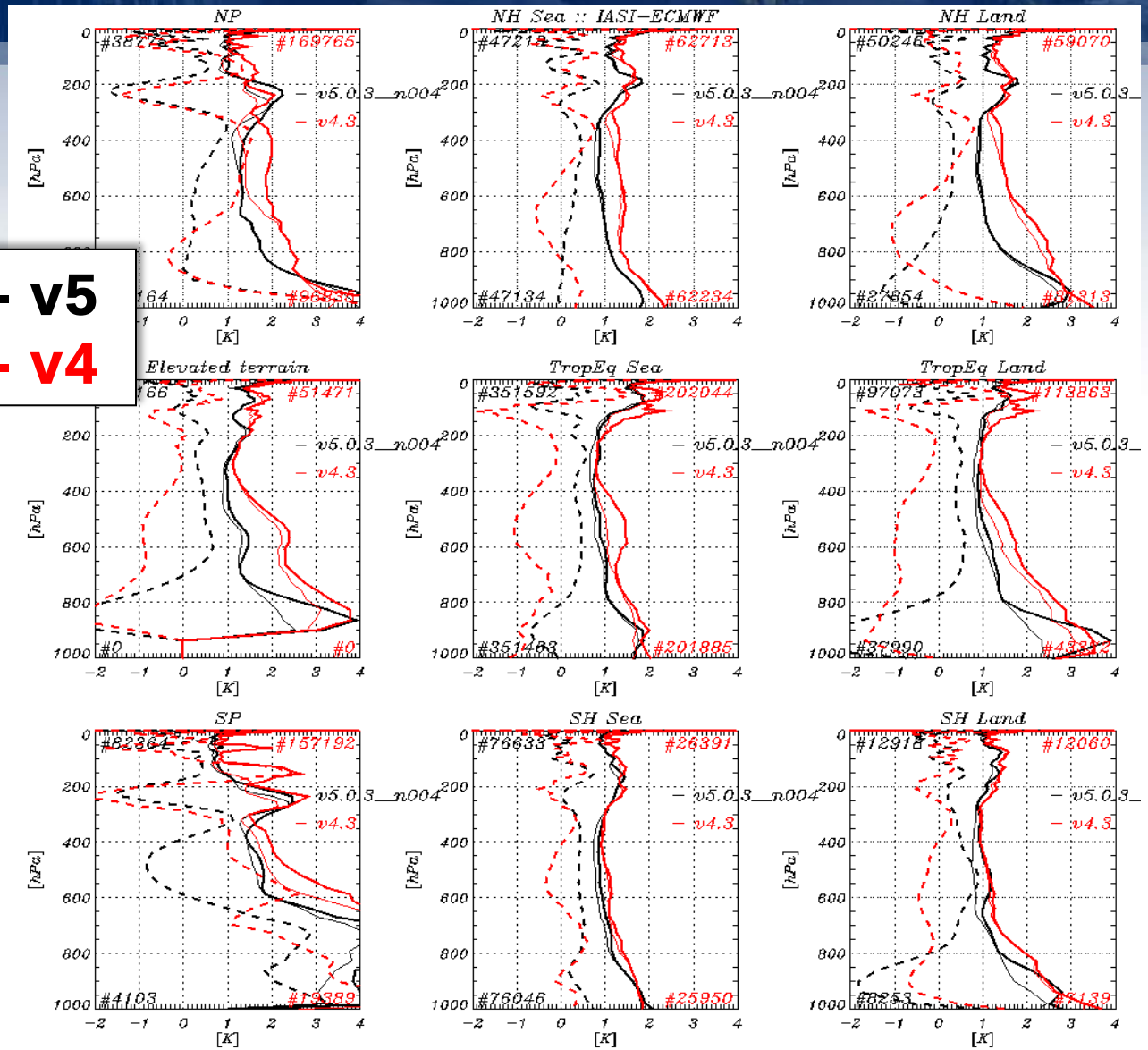
1. IASI L2 version 5

Temperature profiles assessment

19-24 March 2010

IASI - ECMWF





- ✓ **Yield increased x1.7**
- ✓ **rms ≤ 1 K [200-800 hPa]**

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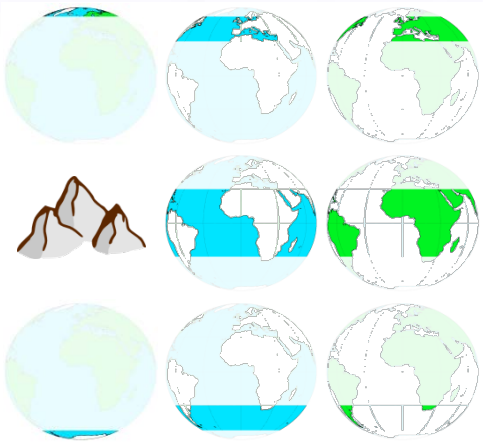
1. IASI L2 version 5

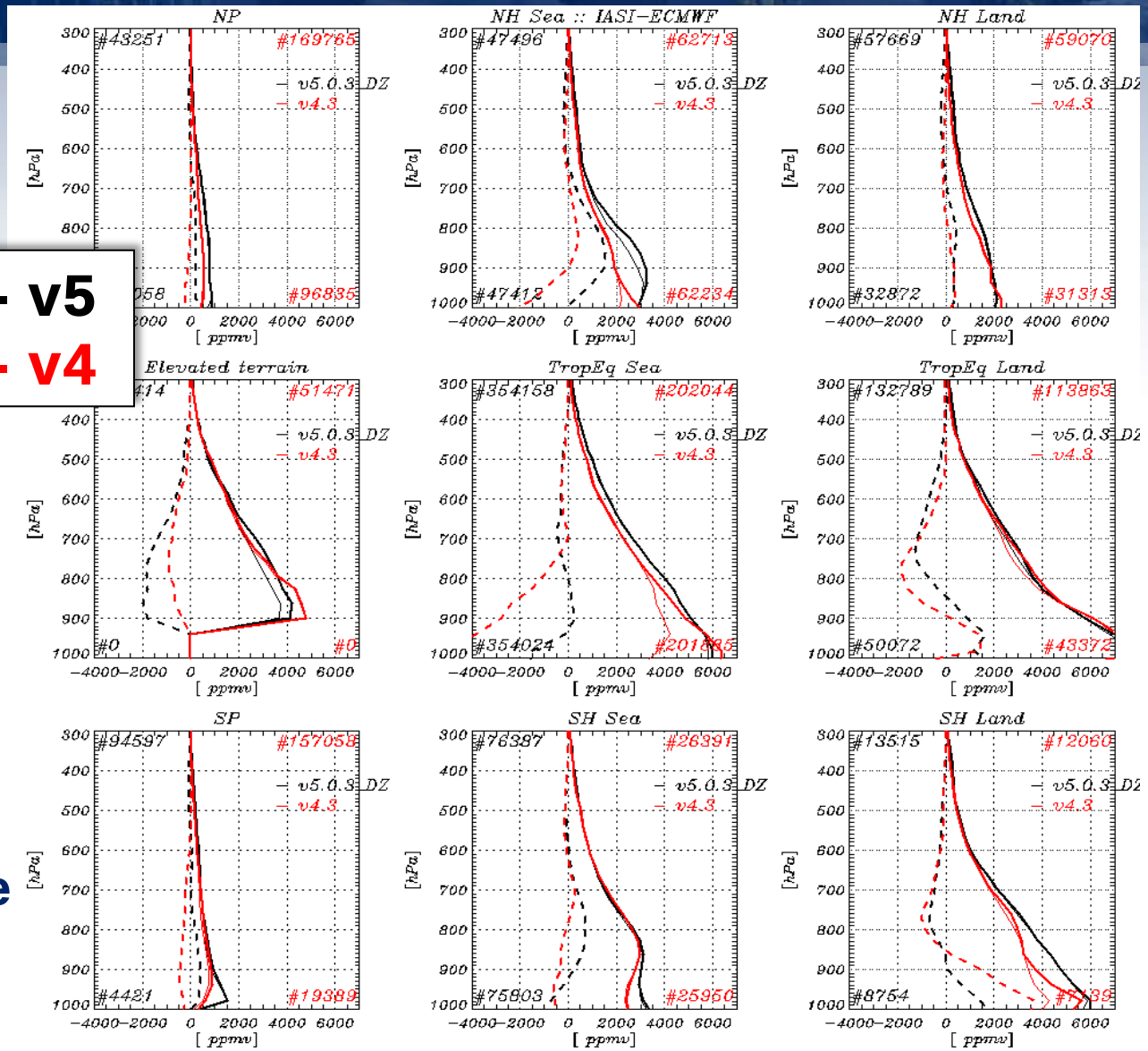
Humidity profiles assessment

19-24 March 2010

IASI - ECMWF

- v5
- v4





- **Improve retrievals in the lower troposphere**

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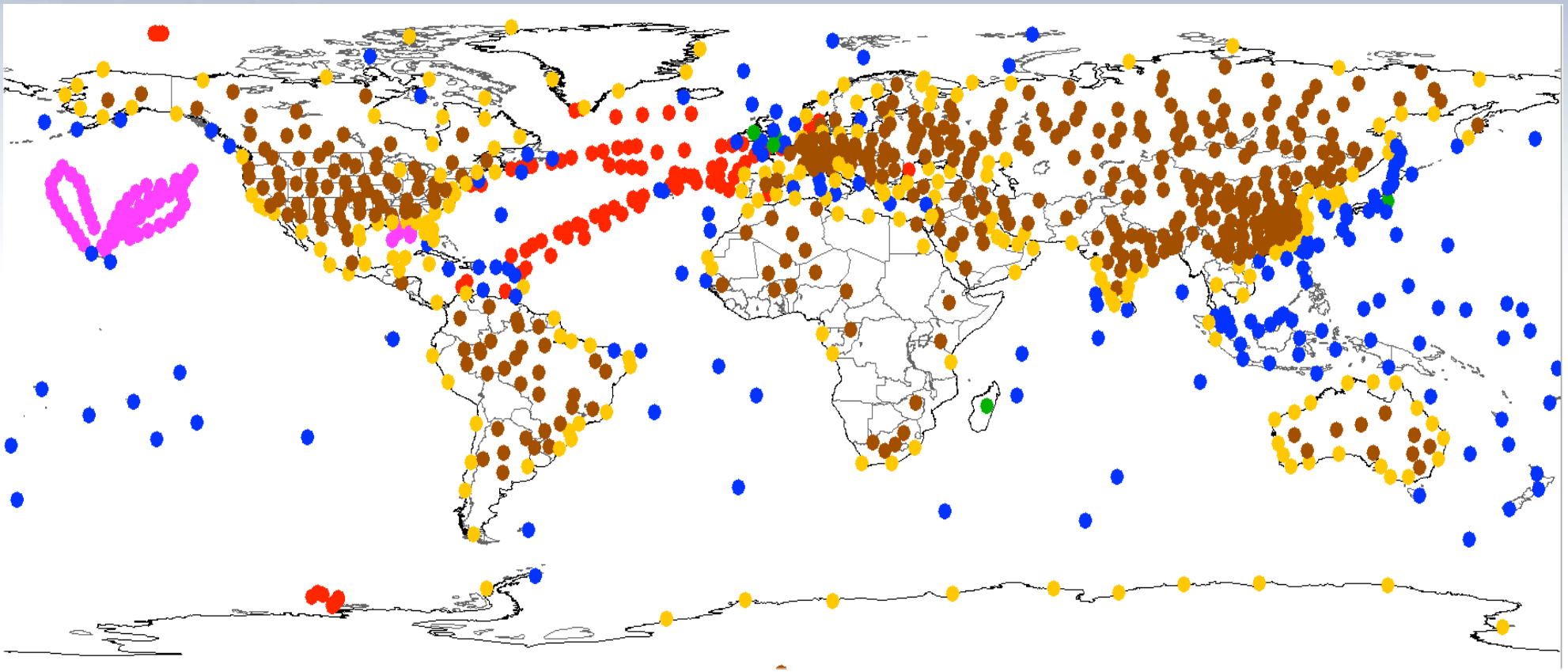
1. IASI L2 version 5

T, q profiles: monitoring at NOAA



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

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

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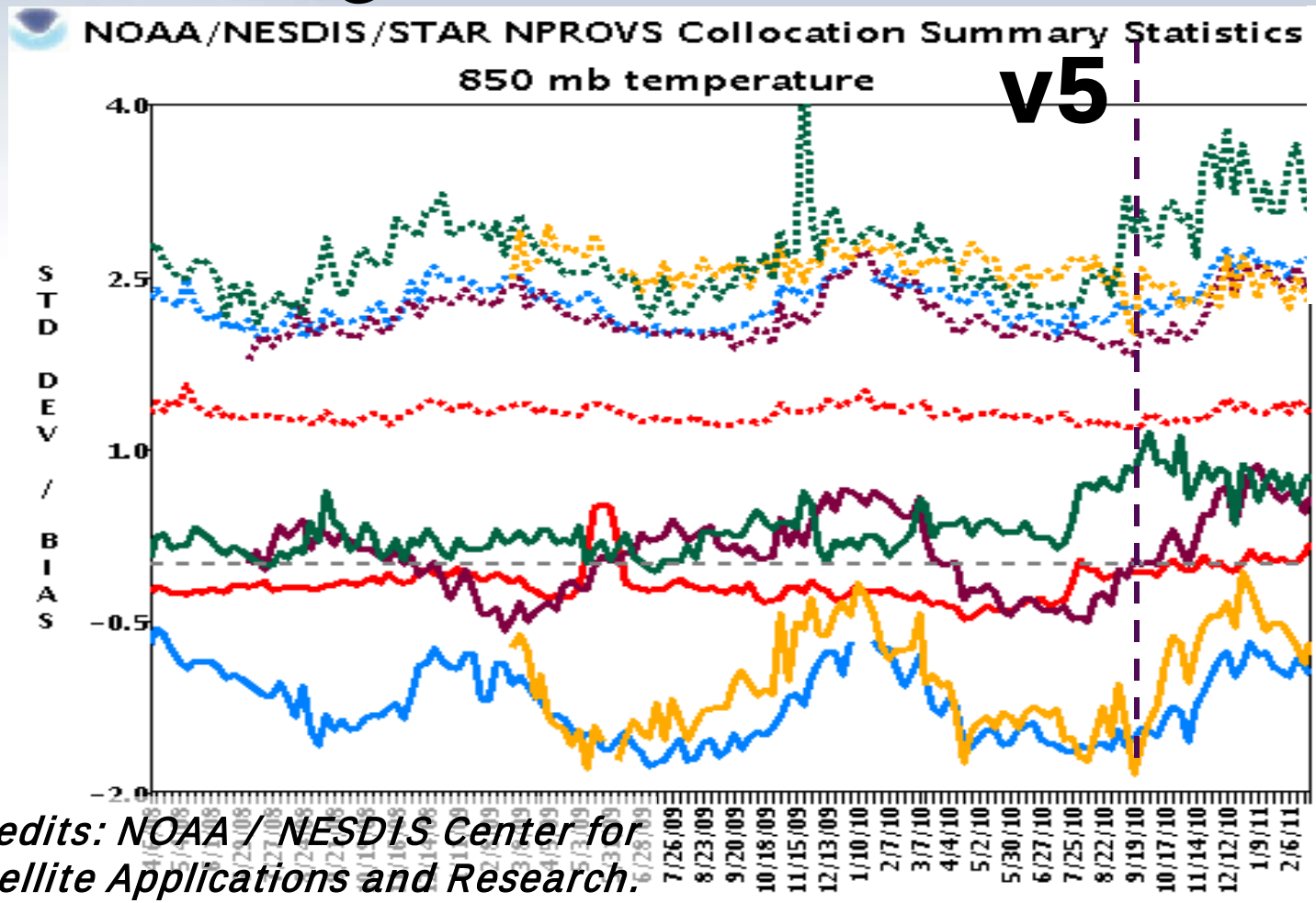
1. IASI L2 version 5

T, q profiles: monitoring at NOAA

T @ 850 hPa



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IASI NOAA
COSMIC UCAR
AIRS AQUA

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

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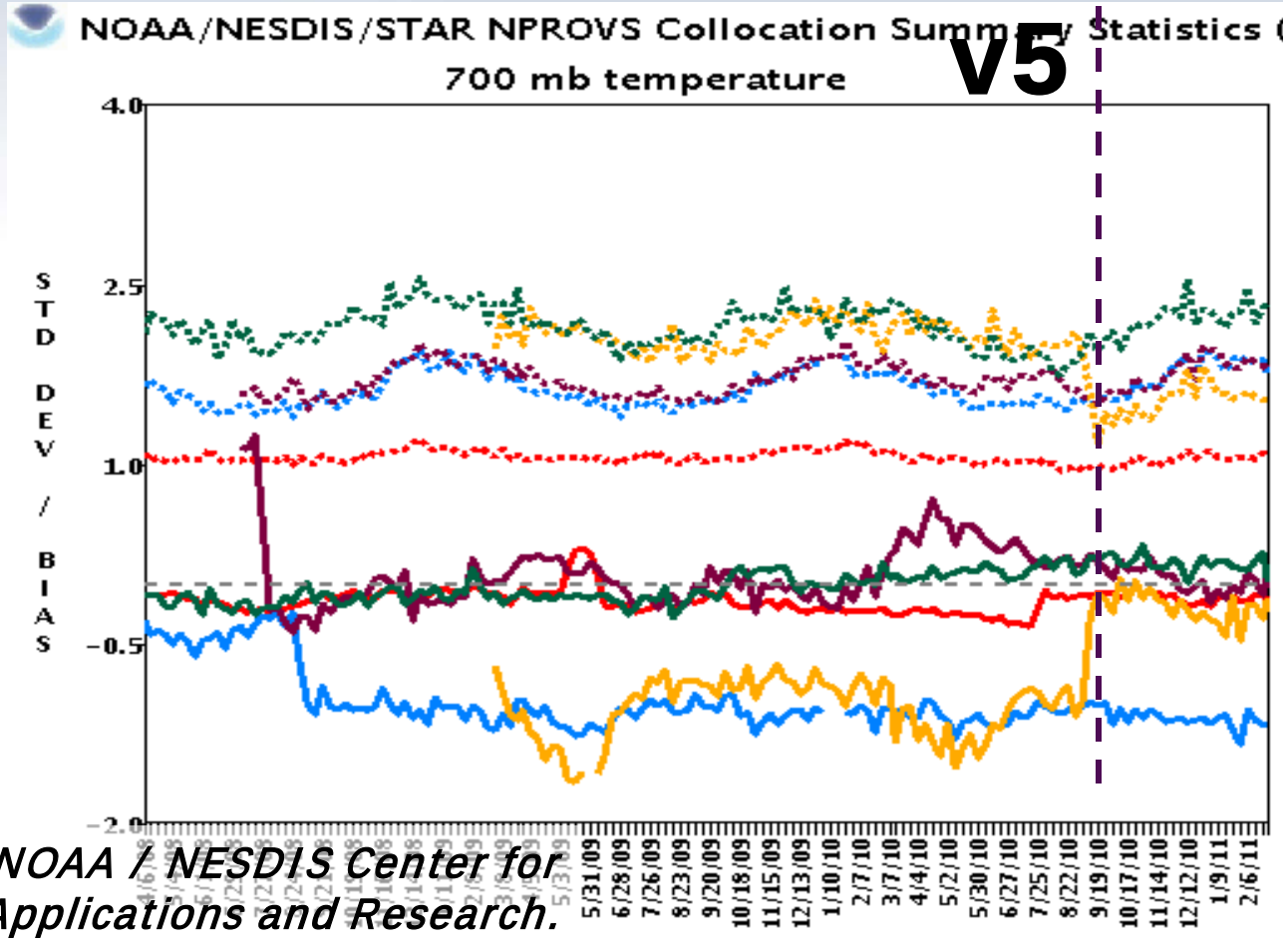
1. IASI L2 version 5

T, q profiles: monitoring at NOAA

T @ 700 hPa



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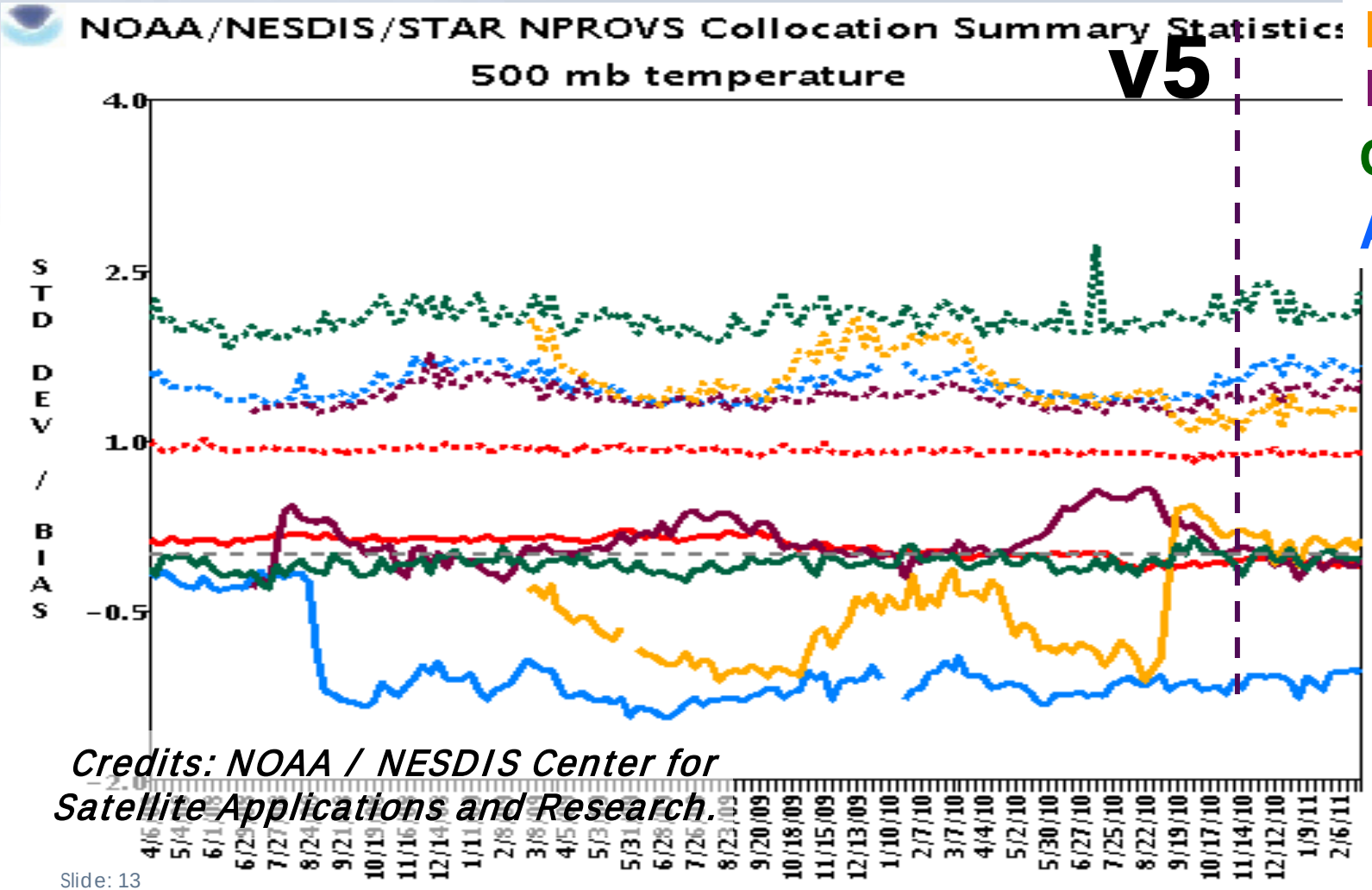
1. IASI L2 version 5

T, q profiles: monitoring at NOAA

T @ 500 hPa



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IASI NOAA

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AIRS AQUA

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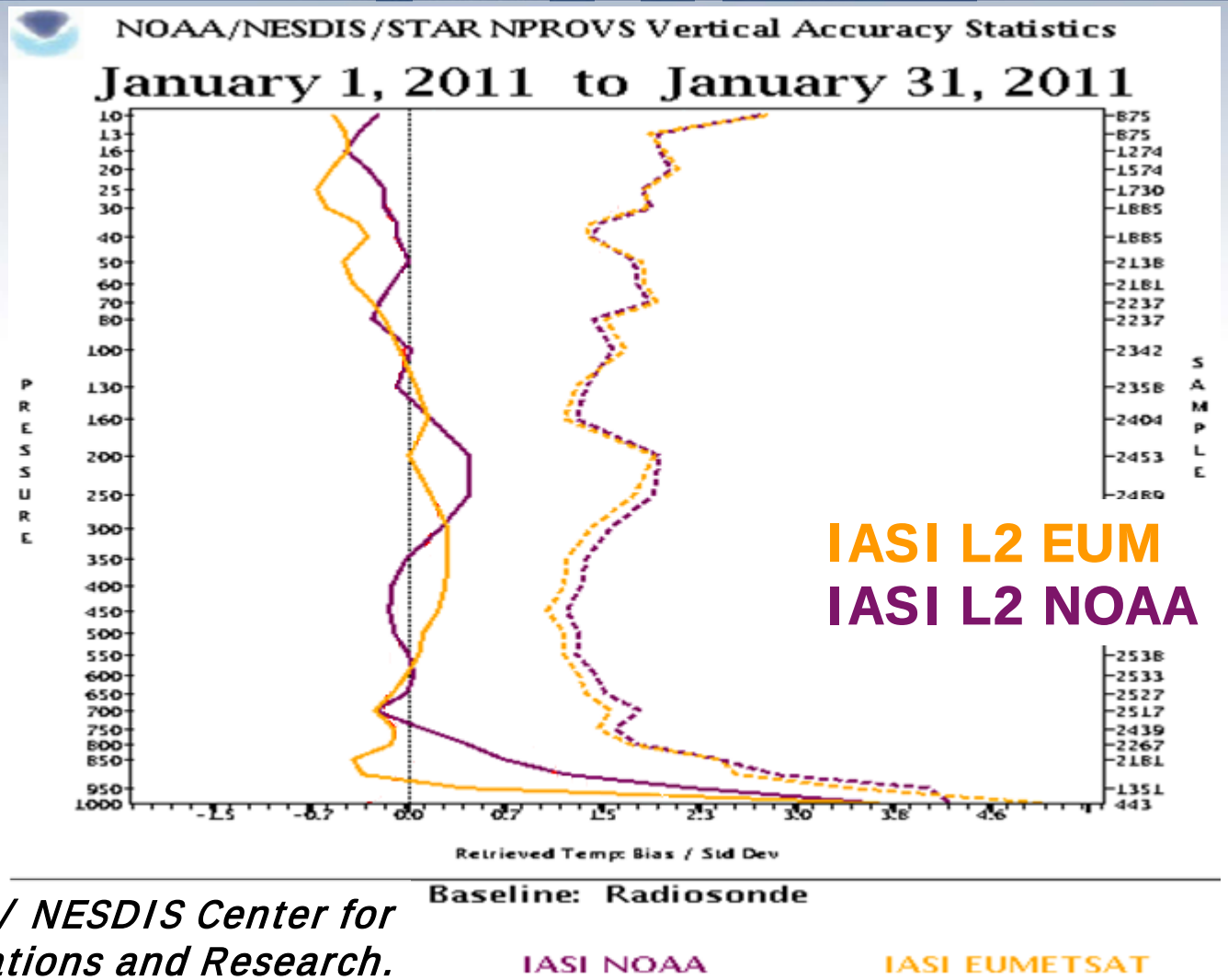
SAT

1. IASI L2 version 5

T, q profiles: monitoring at NOAA



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

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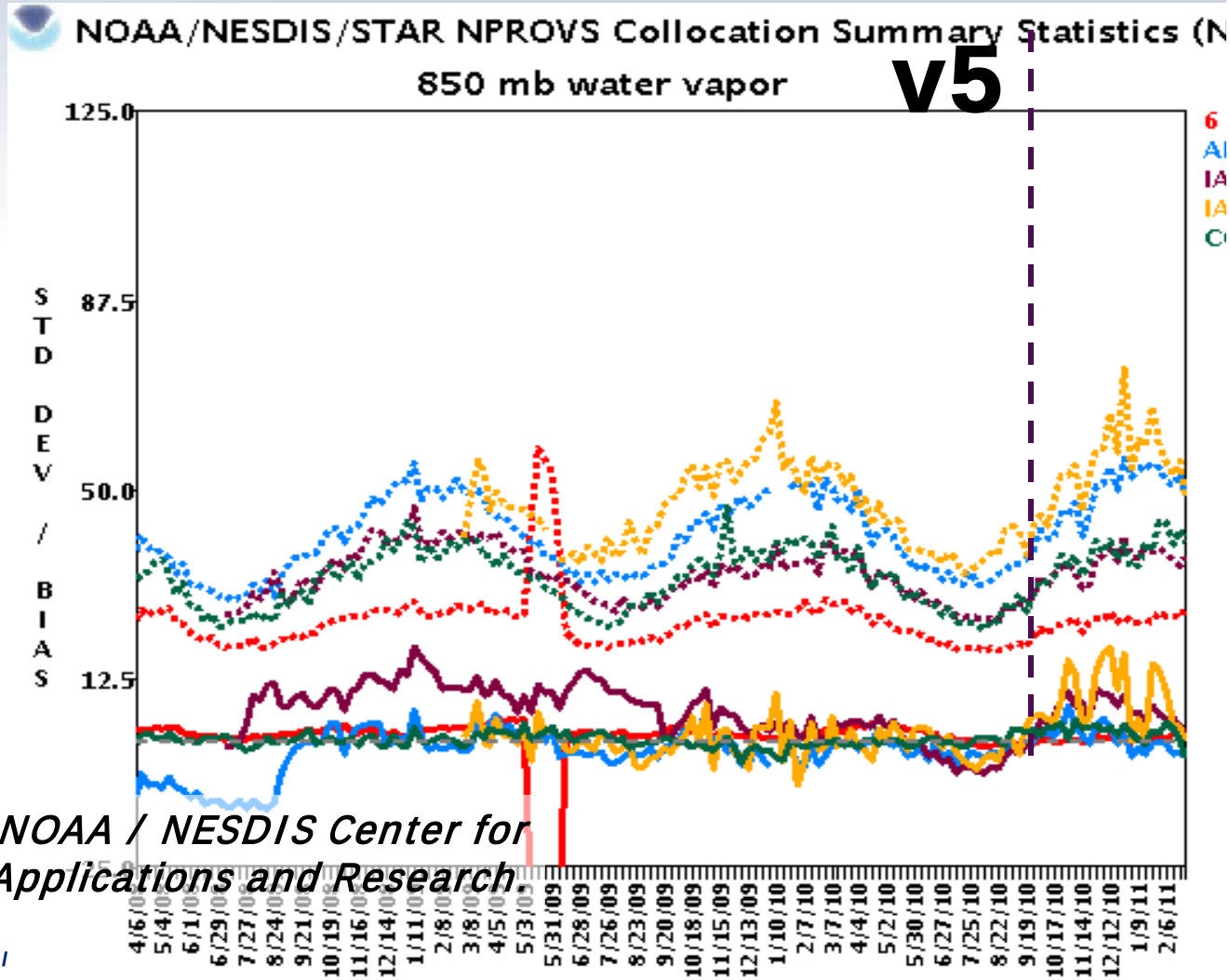
1. IASI L2 version 5

T, q profiles: monitoring at NOAA

WV @ 850 hPa



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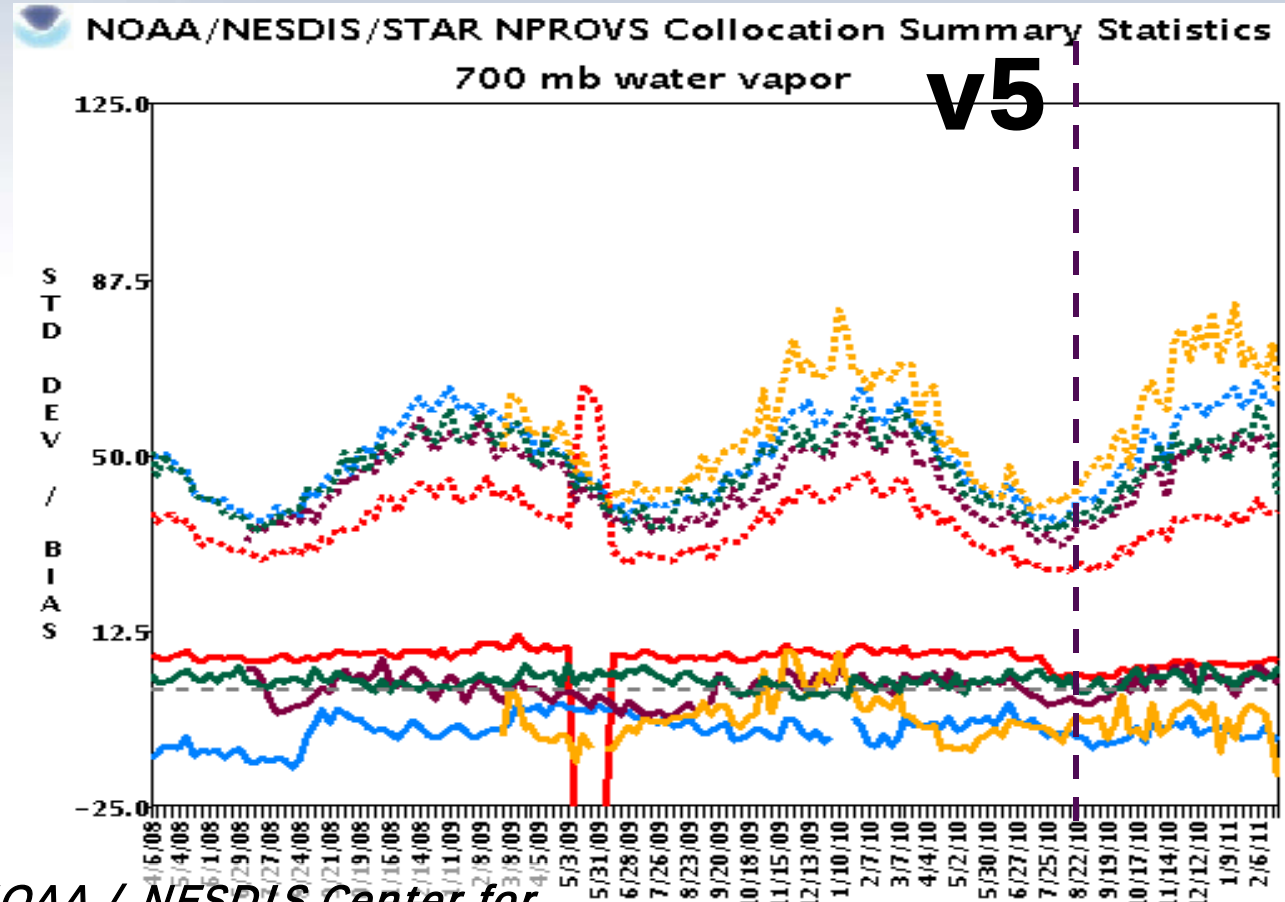
Credits: NOAA / NESDIS Center for Satellite Applications and Research.

1. IASI L2 version 5

T, q profiles: monitoring at NOAA

WV @ 700 hPa



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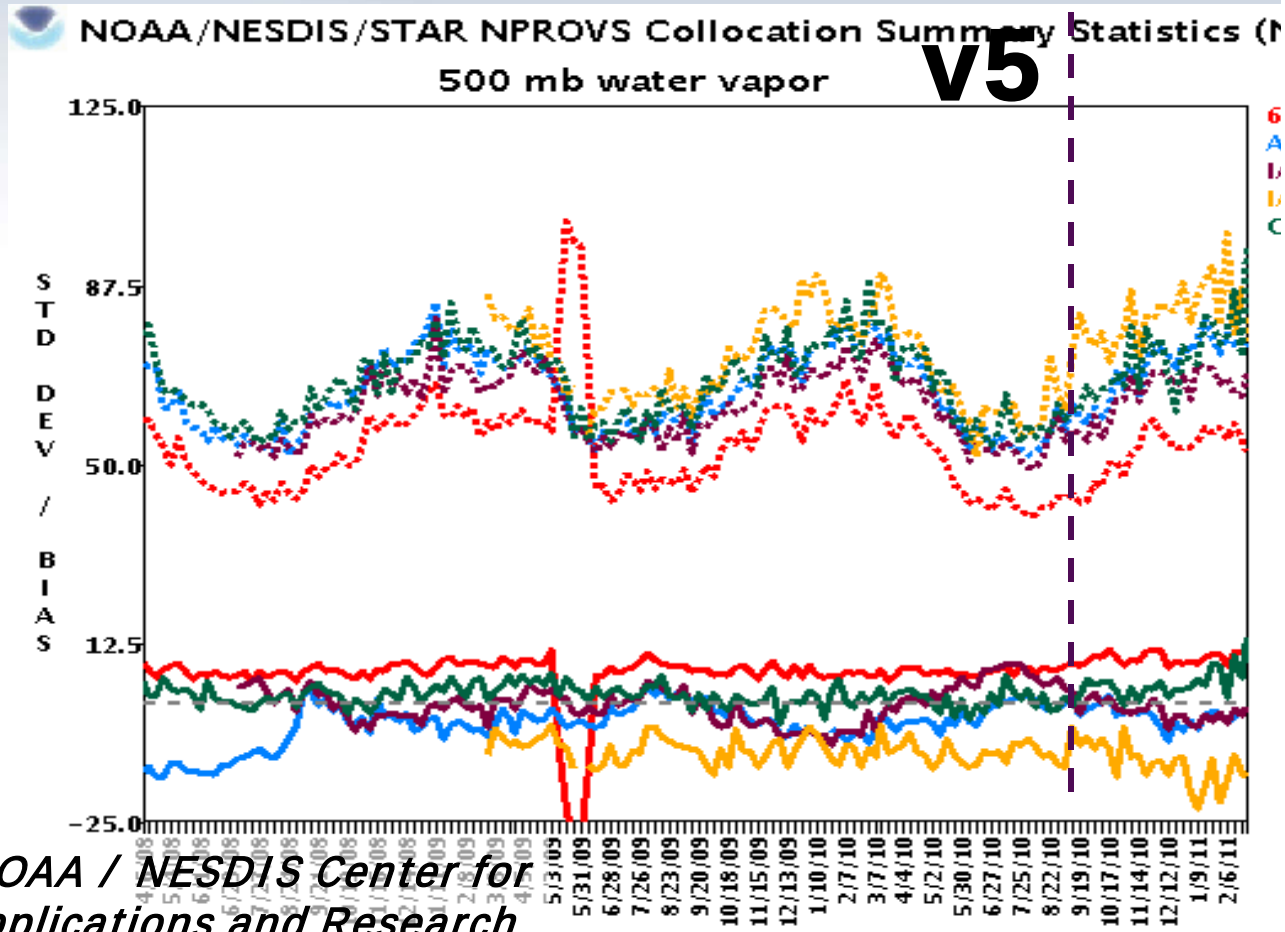
1. IASI L2 version 5

T, q profiles: monitoring at NOAA

WV @ 500 hPa



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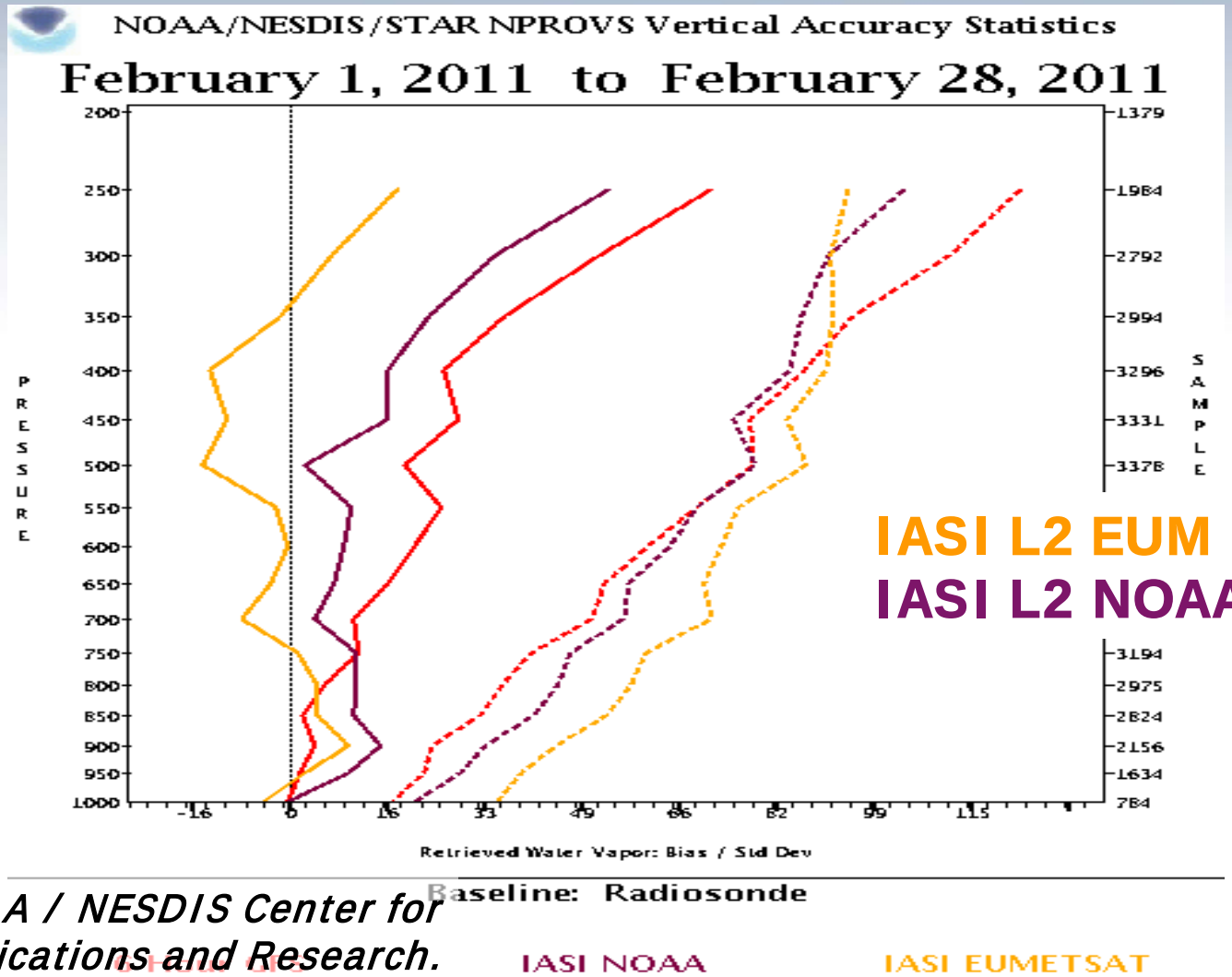
1. IASI L2 version 5

T, q profiles: monitoring at NOAA



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

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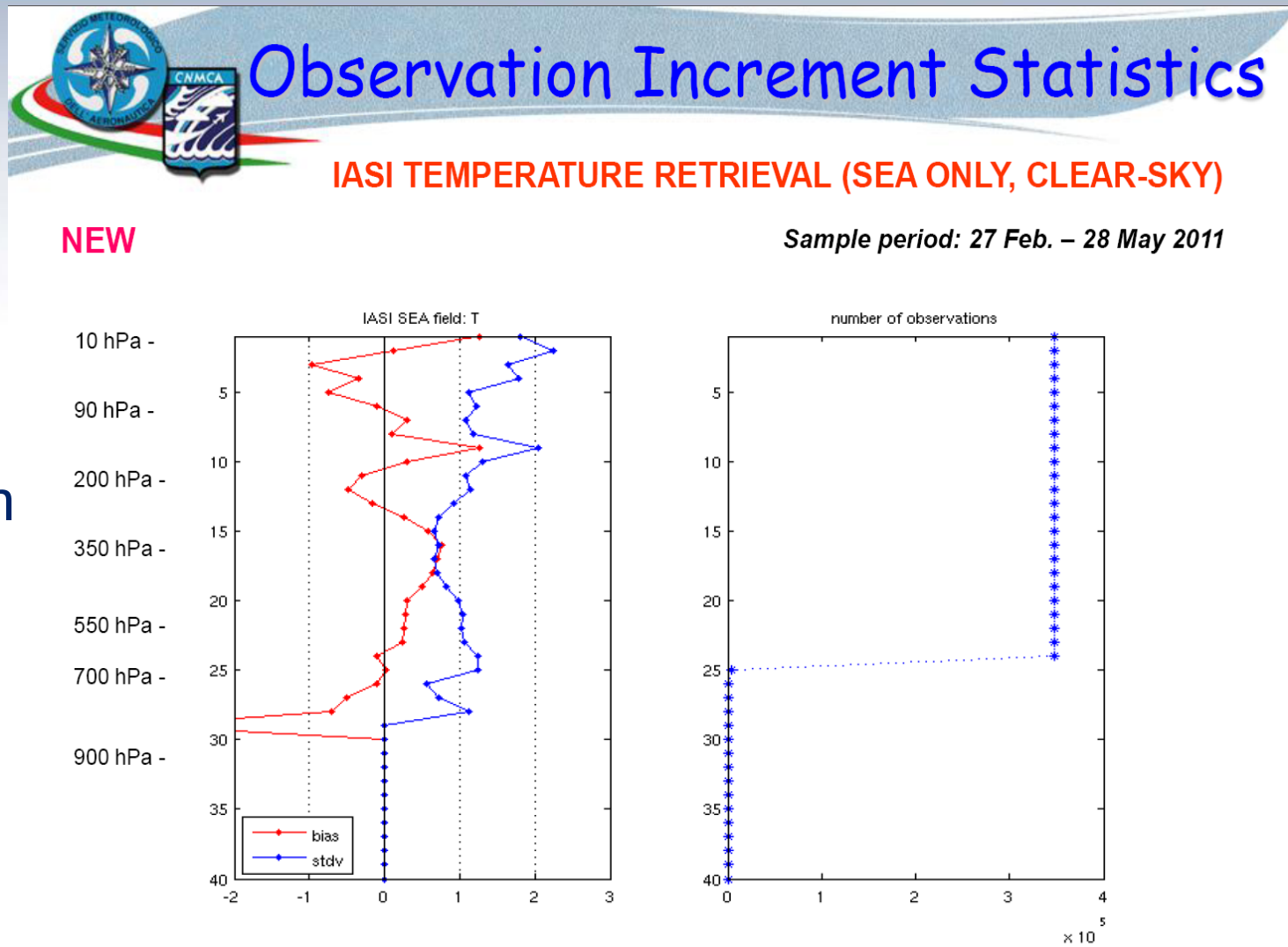
1. IASI L2 version 5

T profiles: monitoring at CNMCA

- IASI L2 products monitored since 2007 @ CNMCA
- Performances with v5 confirmed

Courtesy of **A.Vocino** (CNMCA)



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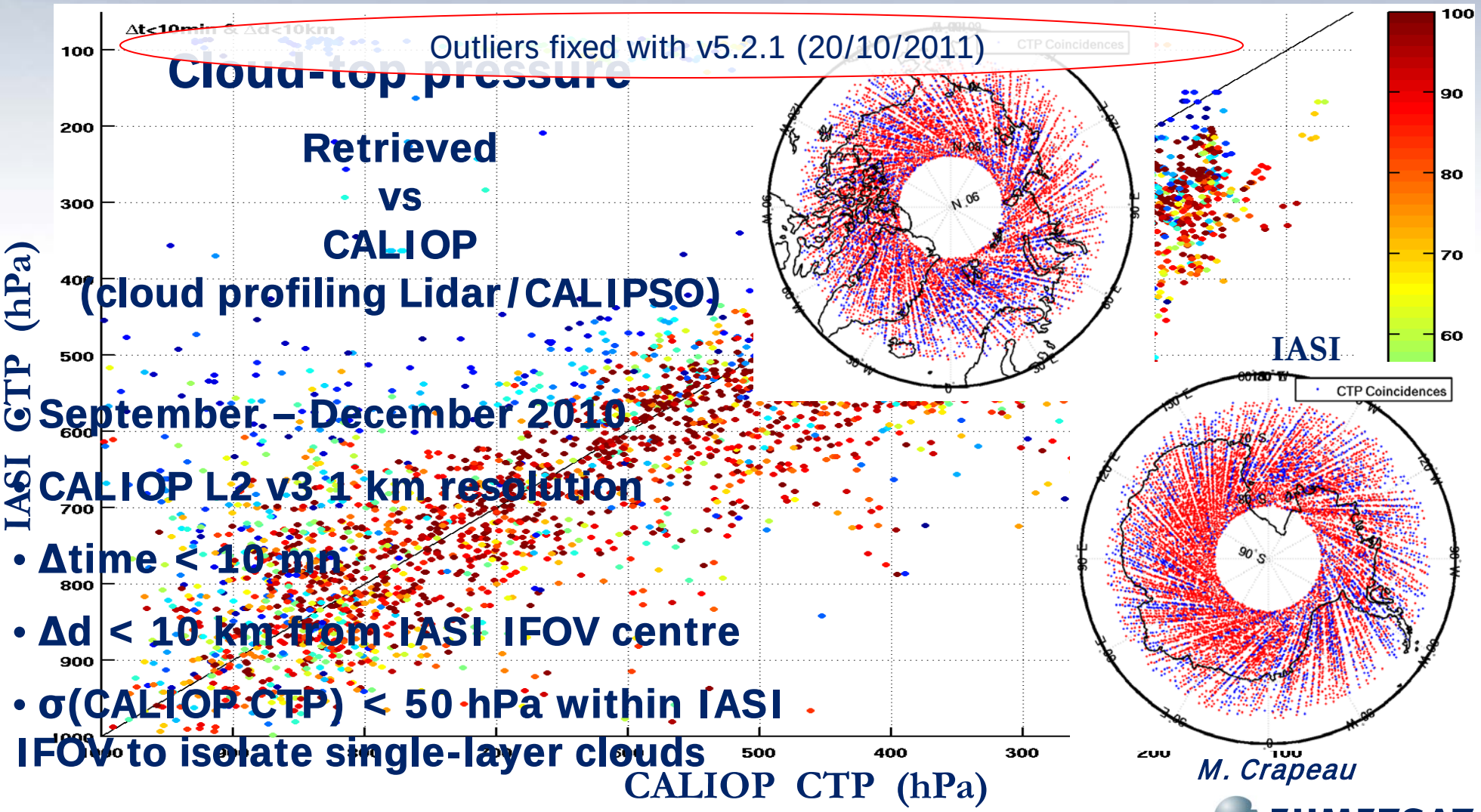
1. IASI L2 version 5

The cloud-top pressure

Outliers fixed with v5.2.1 (20/10/2011)



- September – December 2010
- CALIOP L2 v3.1 km resolution
- Δtime < 10 mn
- Δd < 10 km from IASI IFOV centre
- σ(CALIOP CTP) < 50 hPa within IASI IFOV to isolate single-layer clouds

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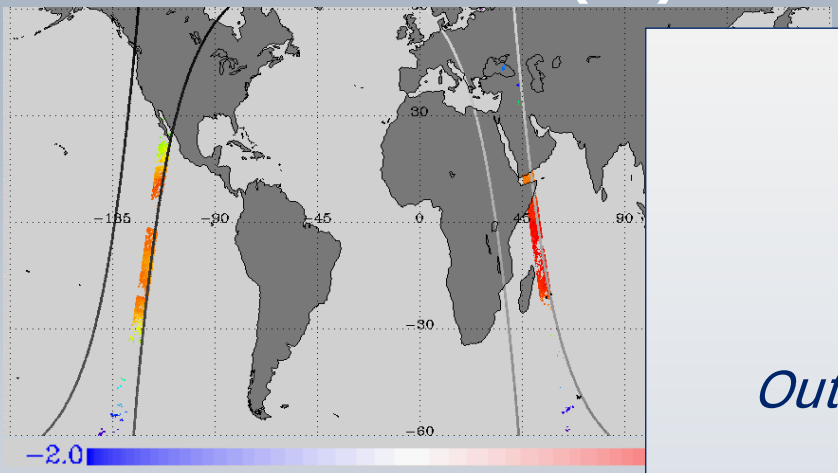
1. IASI L2 version 5

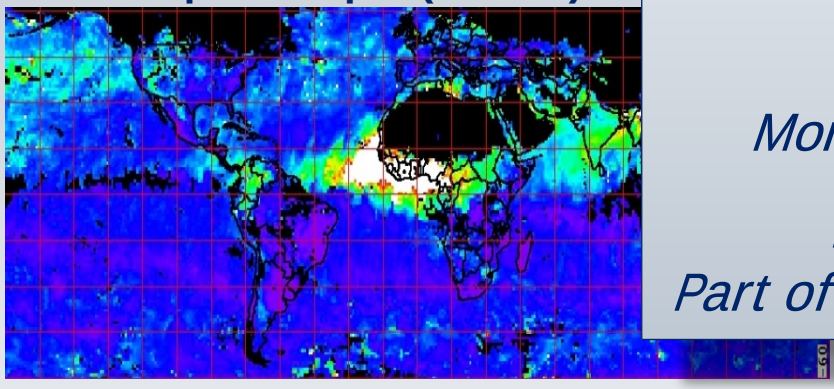
Sea Surface Temperature

19-24 March 2010

AATSR – IASI (v5)



aerosol optical depth (MODIS) 20



Global figures

Cold bias: 0.4 K

σ ~ 0.4 K

Outside aerosol areas

Cold bias: 0.25 K

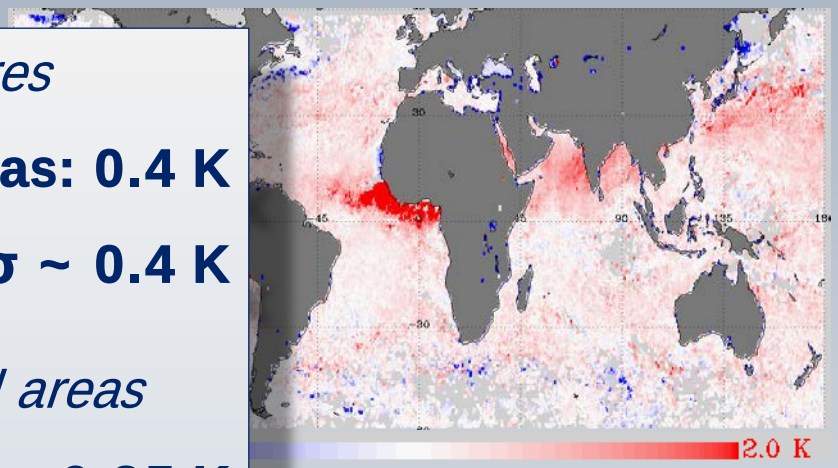
σ < 0.3 K

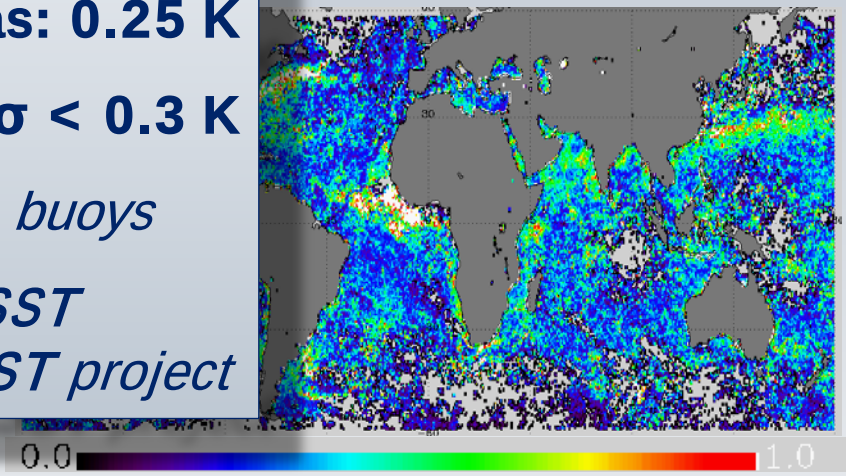
Monitored with buoys

IASI L2P SST

*Part of the **GHRSST** project*

ECMWF - IASI





1. IASI L2 version 5

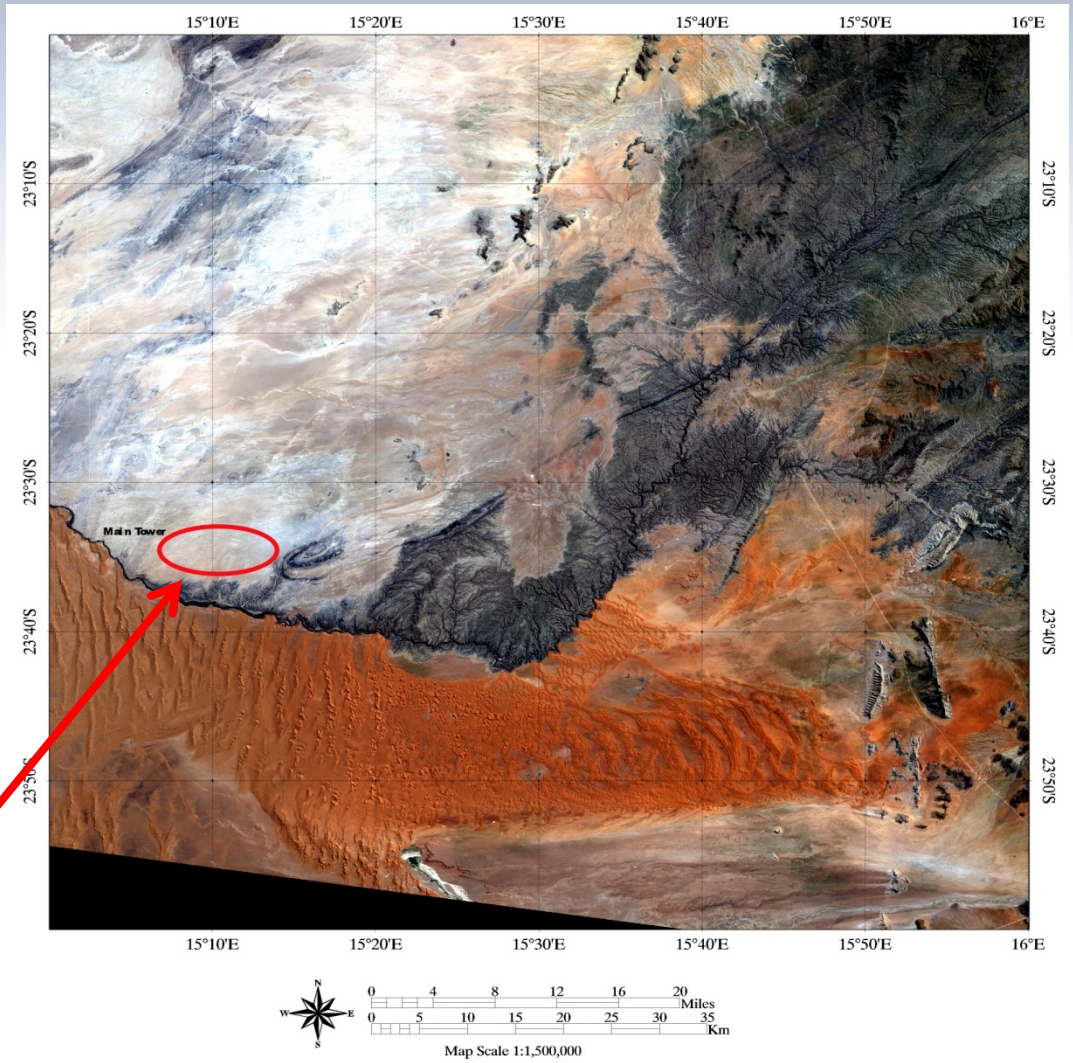
LST vs. *in situ* measurements

LST

Retrieved
vs
***in situ* measurements**

IR radiometers measuring ground and sky brightness temperature from 9.6 to 11.5 µm, operated by Folke Olesen and Frank Goettsche (IMK/KIT)

3 validation sites:
Evora (Portugal), Gobabeb and RMZ-farm (Namibia)



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1. IASI L2 version 5

LST vs. *in situ* measurements

LST

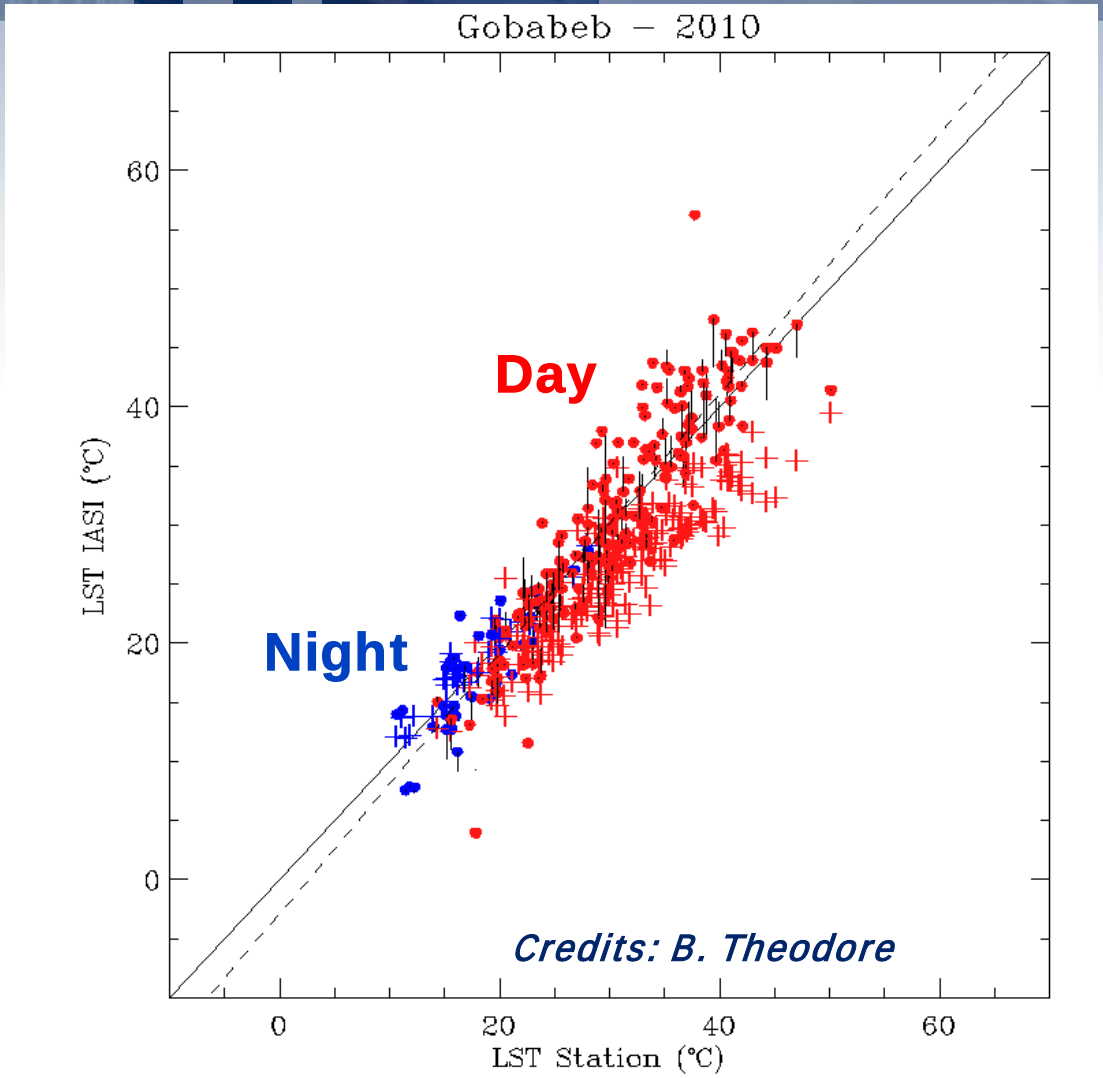
Retrieved
vs
***in situ* measurements**

Gobabeb (Namib desert)

405 m asl

IASI L2

ECMWF



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1. IASI L2 version 5

LST vs. *in situ* measurements

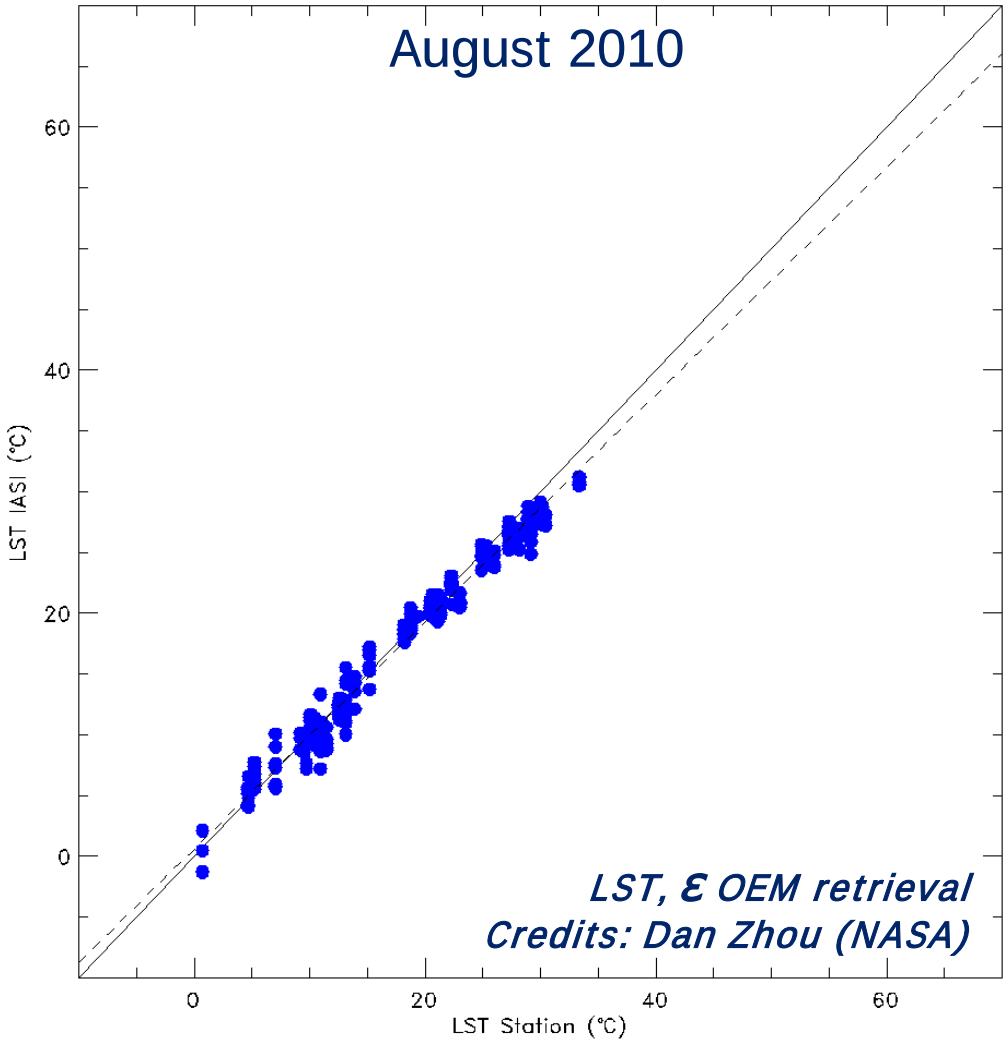
LST

Retrieved
vs
***in situ* measurements**

RMZ-Farm (Namibia)

1360 m asl

- **IASI L2**
- **ECMWF**



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1. IASI L2 version 5

LST vs. *in situ* measurements

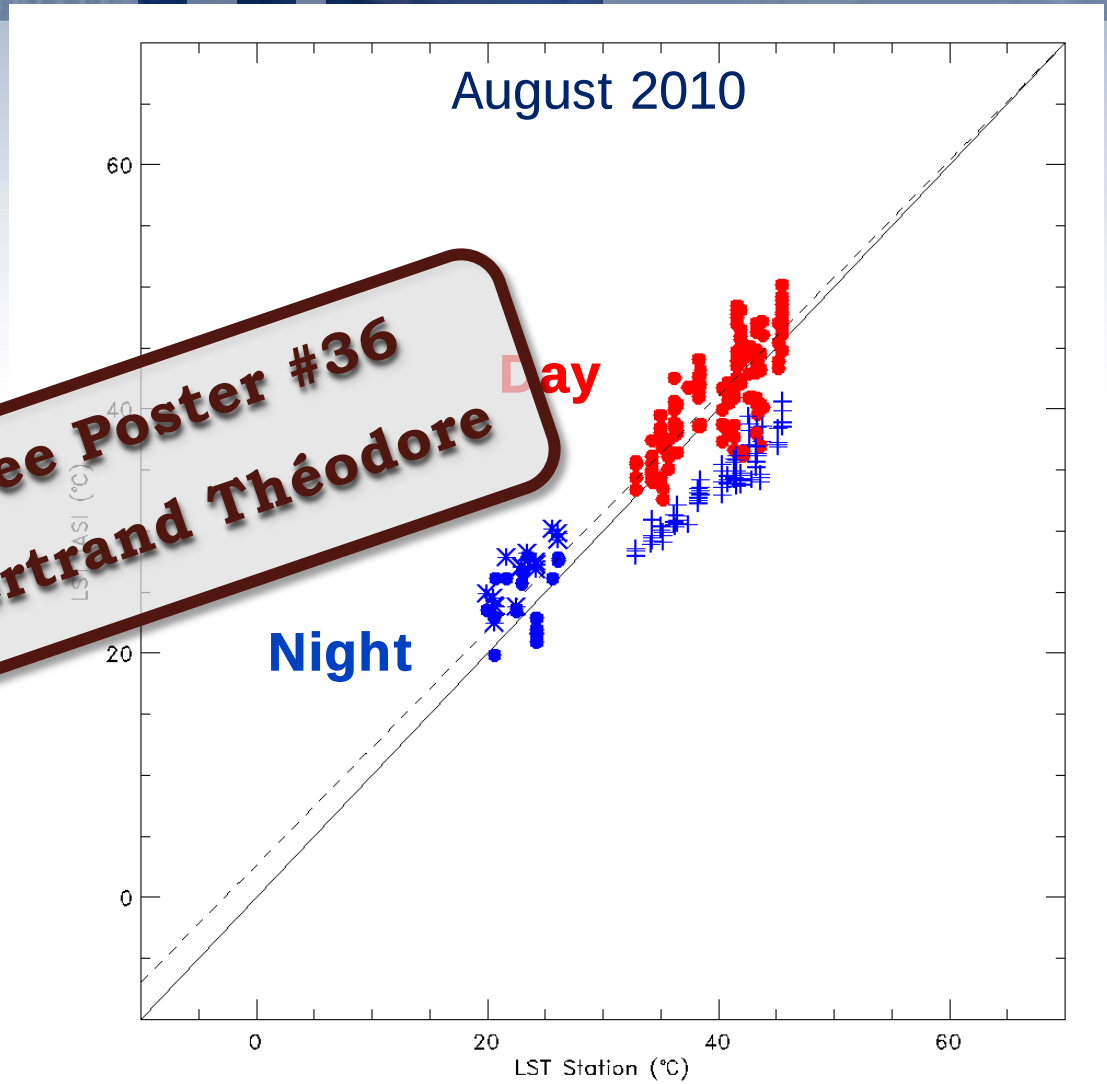
LST

Retrieved
vs
***in situ* measurements**

Evora (Portugal)

300 m asl

- **IASI L2**
- **ECMWF**



See Poster #36
Bertrand Théodore

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Outline

1. The current operational IASI L2 products: version 5

2. IASI L2/Metop-B: preliminary results

3. On-going developments, towards the version 6

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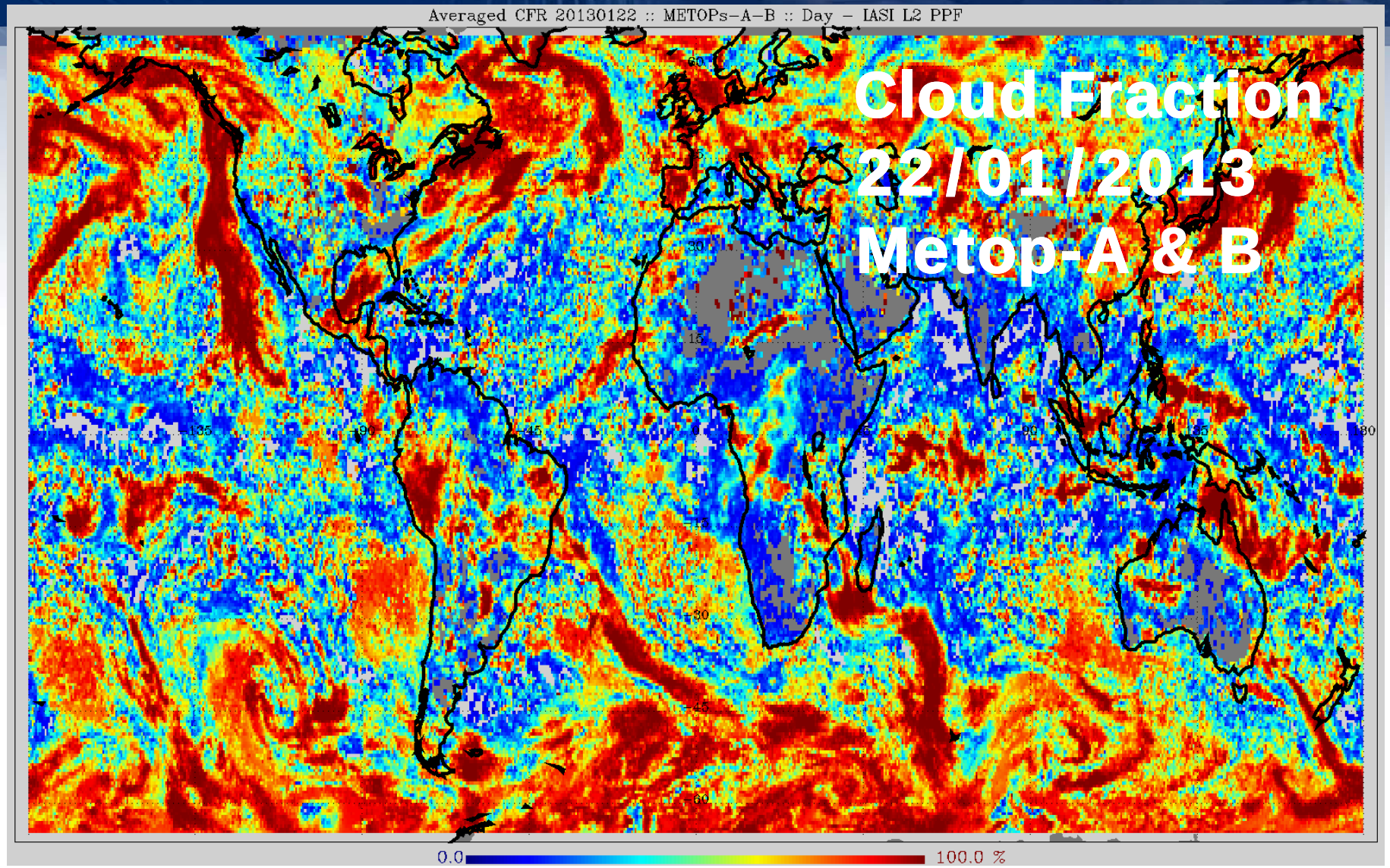
2. IASI L2 / Metop-B

Self-consistency checks



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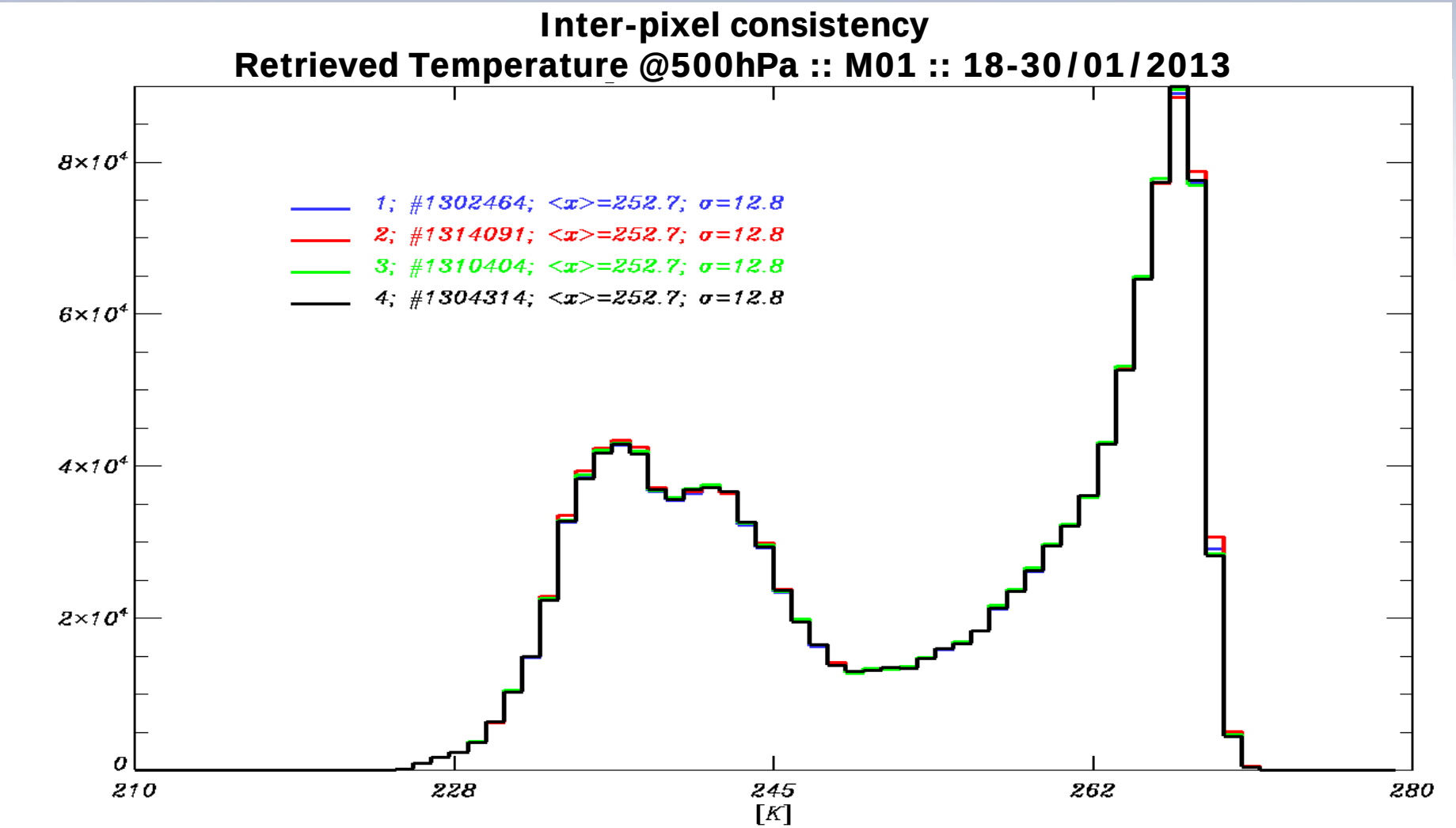
2. IASI L2 / Metop-B

Self-consistency checks



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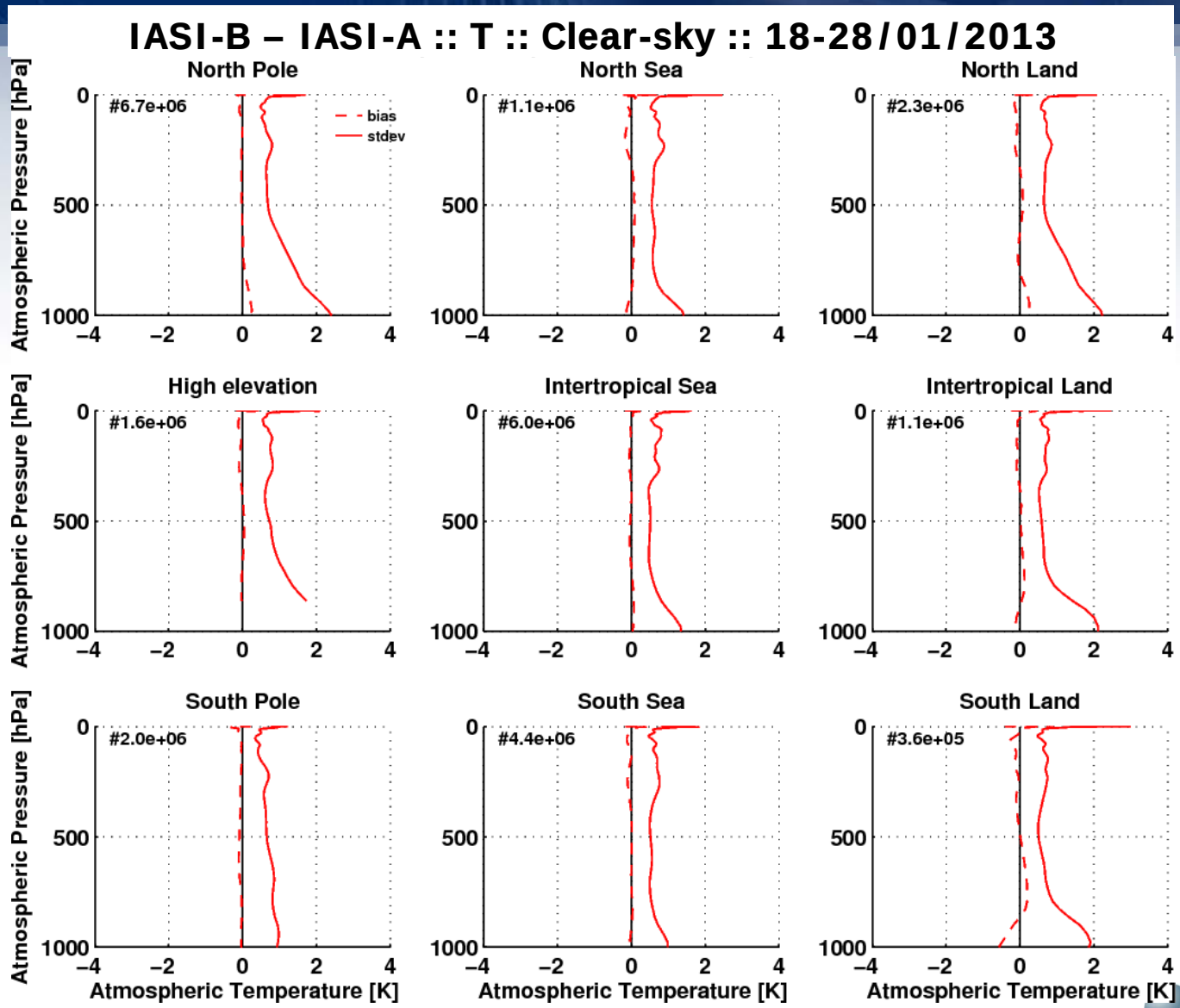
2. IASI L2 / Metop-B

Metop-B vs Metop-A



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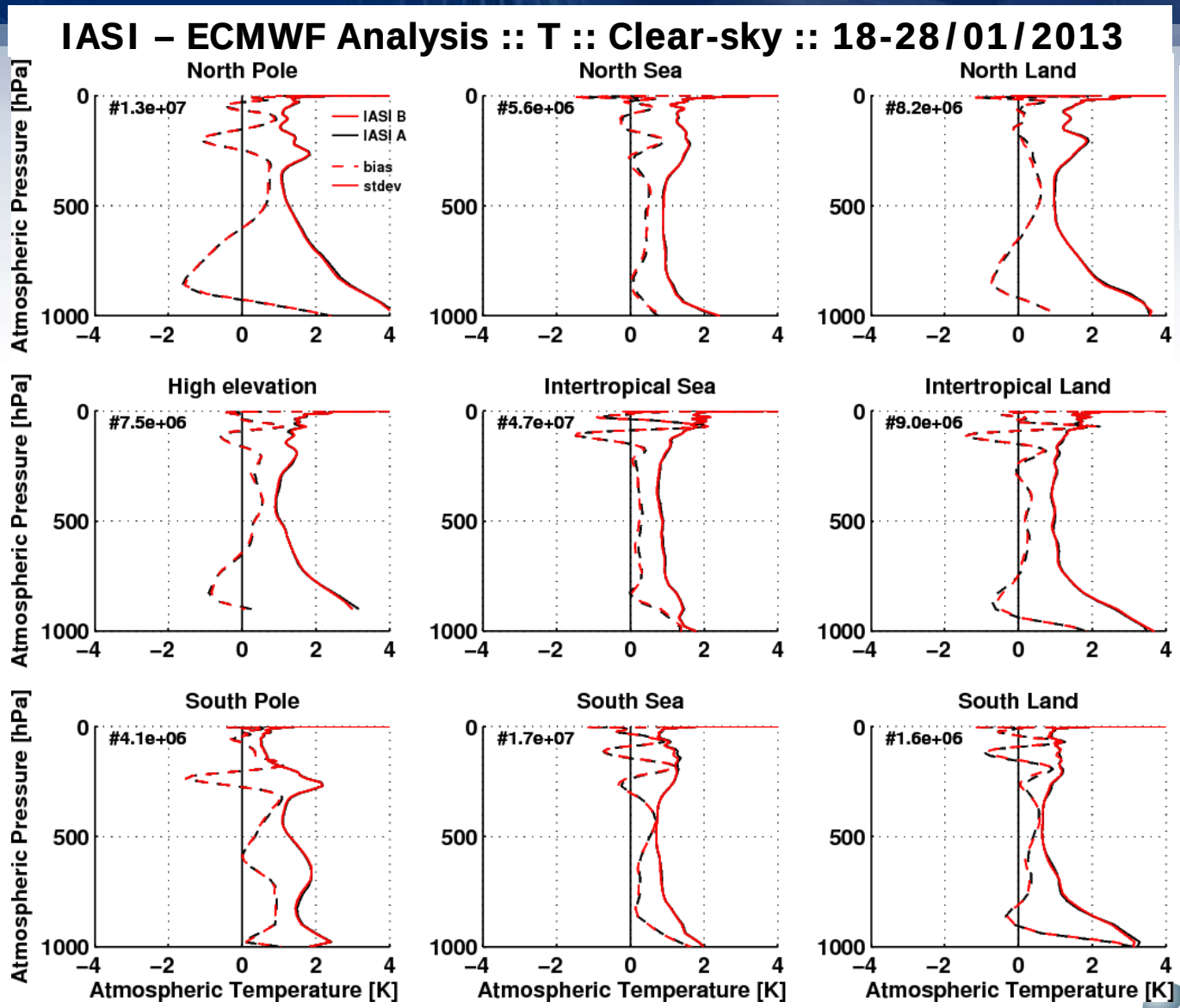
2. IASI L2 / Metop-B

Assessment against ECMWF



- IASI-A
- IASI-B

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Outline

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3. Current developments

Routine IASI L2 monitoring

Ozone difference

Credits: Dorothée Coppens

- **Time series for Temperature & Humidity departures at 200, 500, 800, 980 hPa and the surface temperature**
- **Temperature and humidity departures statistics**
- **Generation of L3 maps and daily/weekly/monthly departure maps (O_3, SST ...)**
- **Daily Report generated every morning and will be available soon on http://oiswww.eumetsat.org/epsreports/html/index.php?instrument=IASI**

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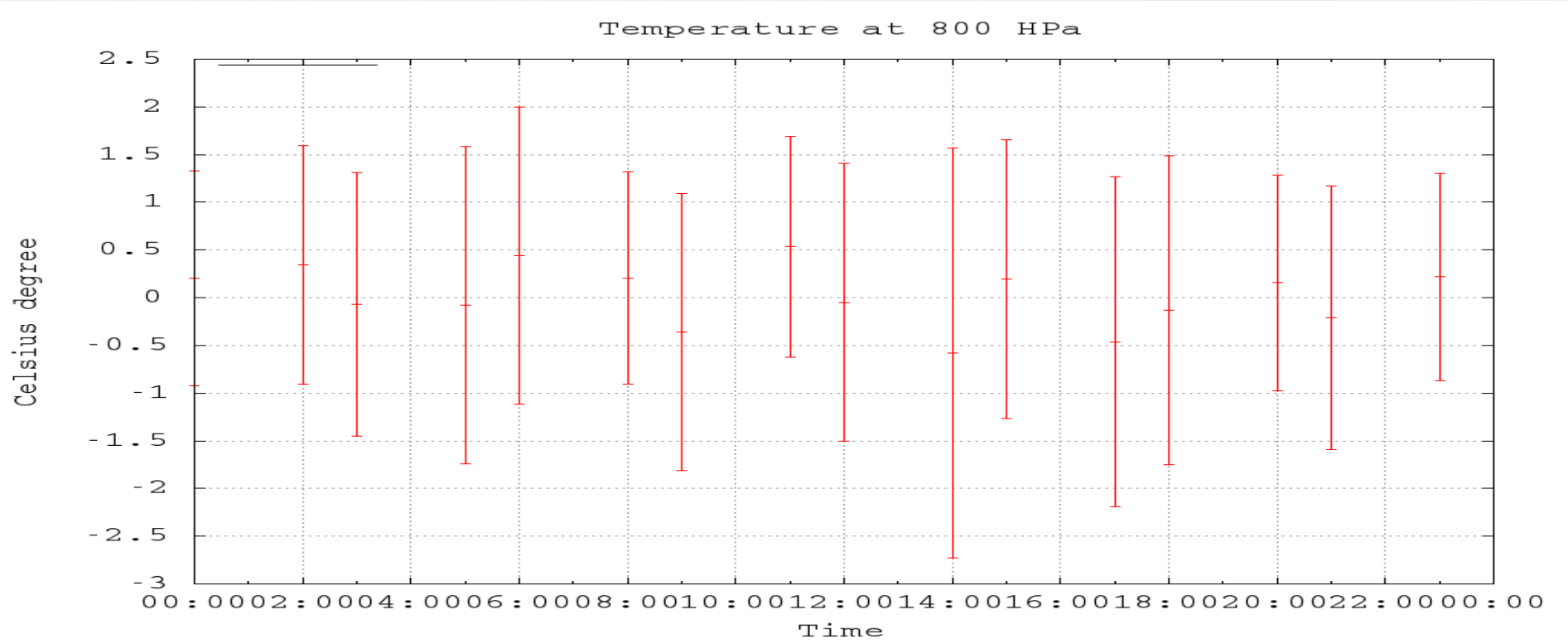
3. Current developments

Routine IASI L2 monitoring

Time series for Temperature & Humidity departures at 200, 500, 800, 980 hPa and the surface temperature



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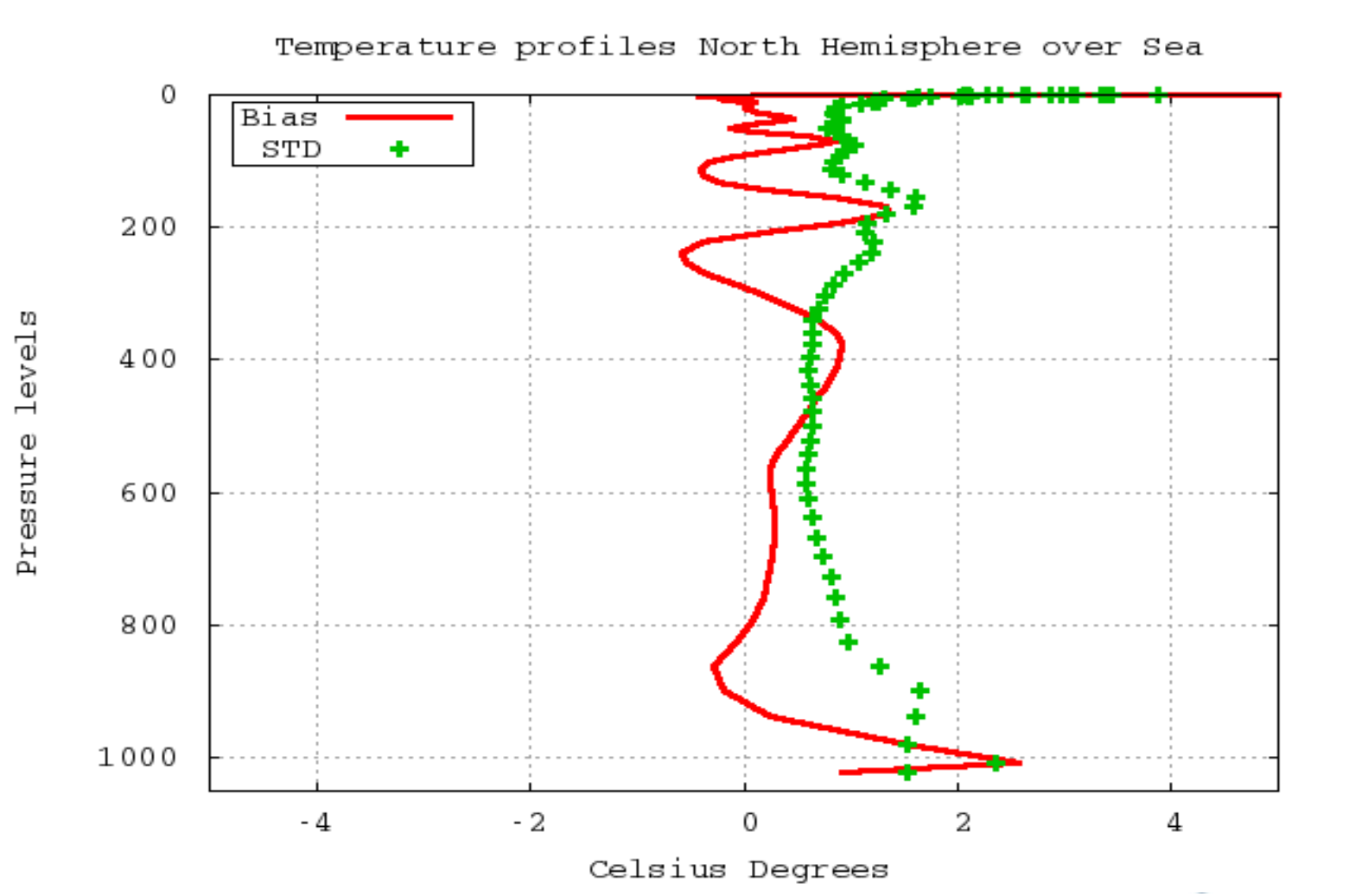
Temperature and humidity departures statistics

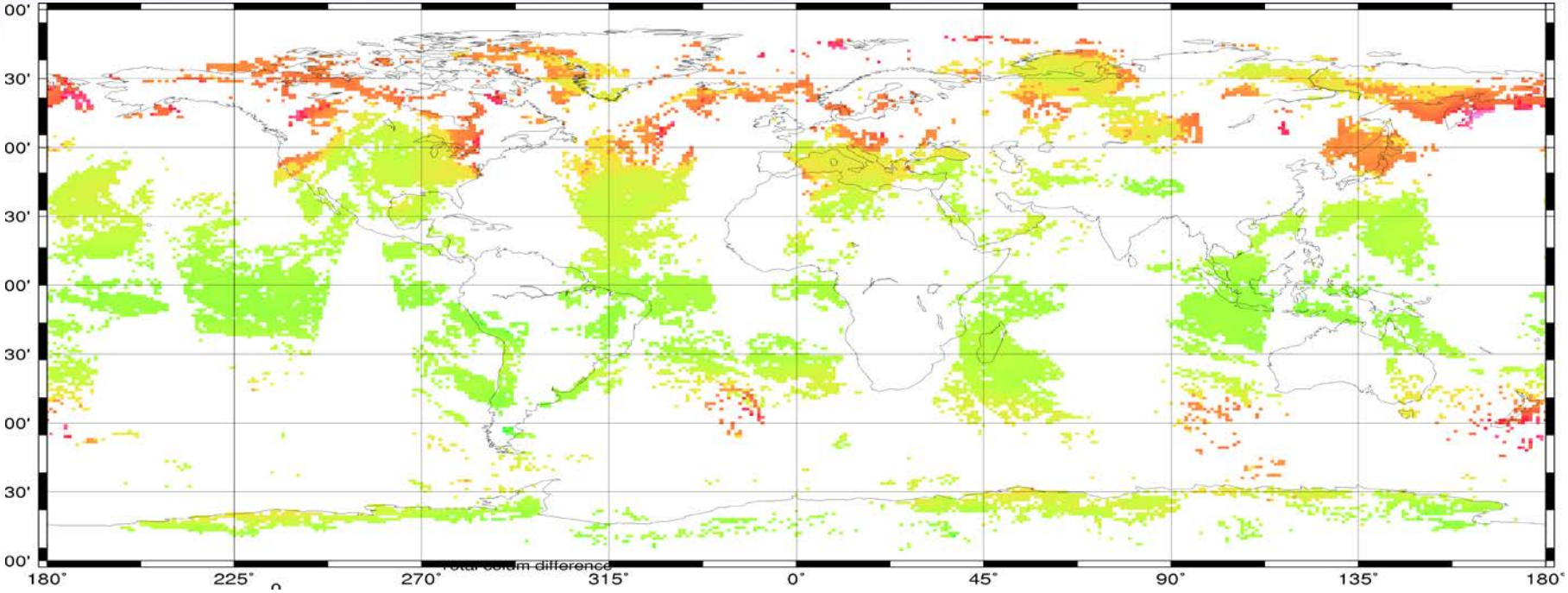


3. Current developments

Routine IASI L2 monitoring

Generation of L3 maps and daily / weekly / monthly departure maps (O_3, SST ...)

Ozone difference



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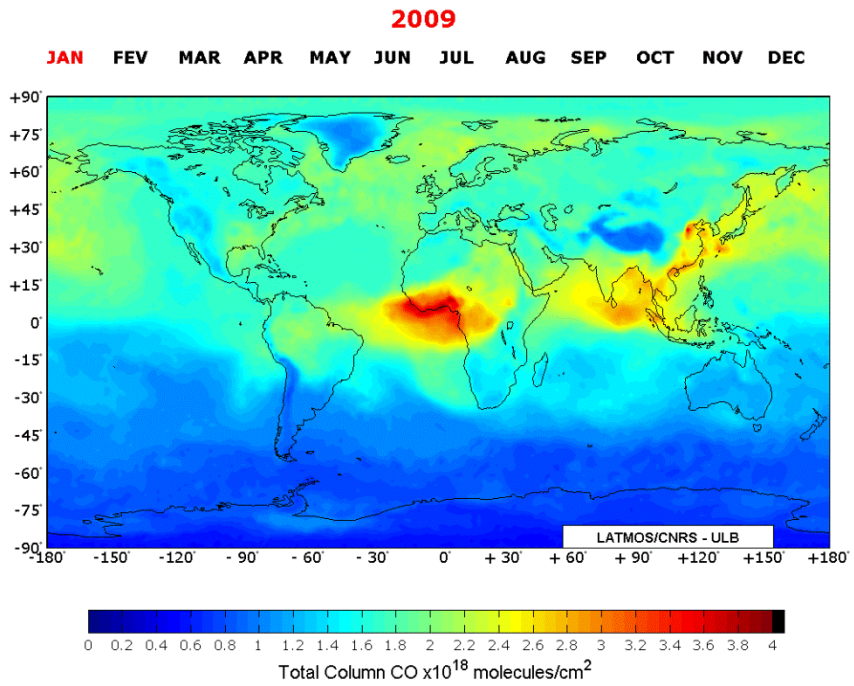
3. Current developments New products: CO, O_3, SO_2, HNO_3

O3-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 (2013)**
- **SO_2 column**
- **O_3 profiles + AK**
- **HNO_3 profiles**



Credits: ULB/LATMOS

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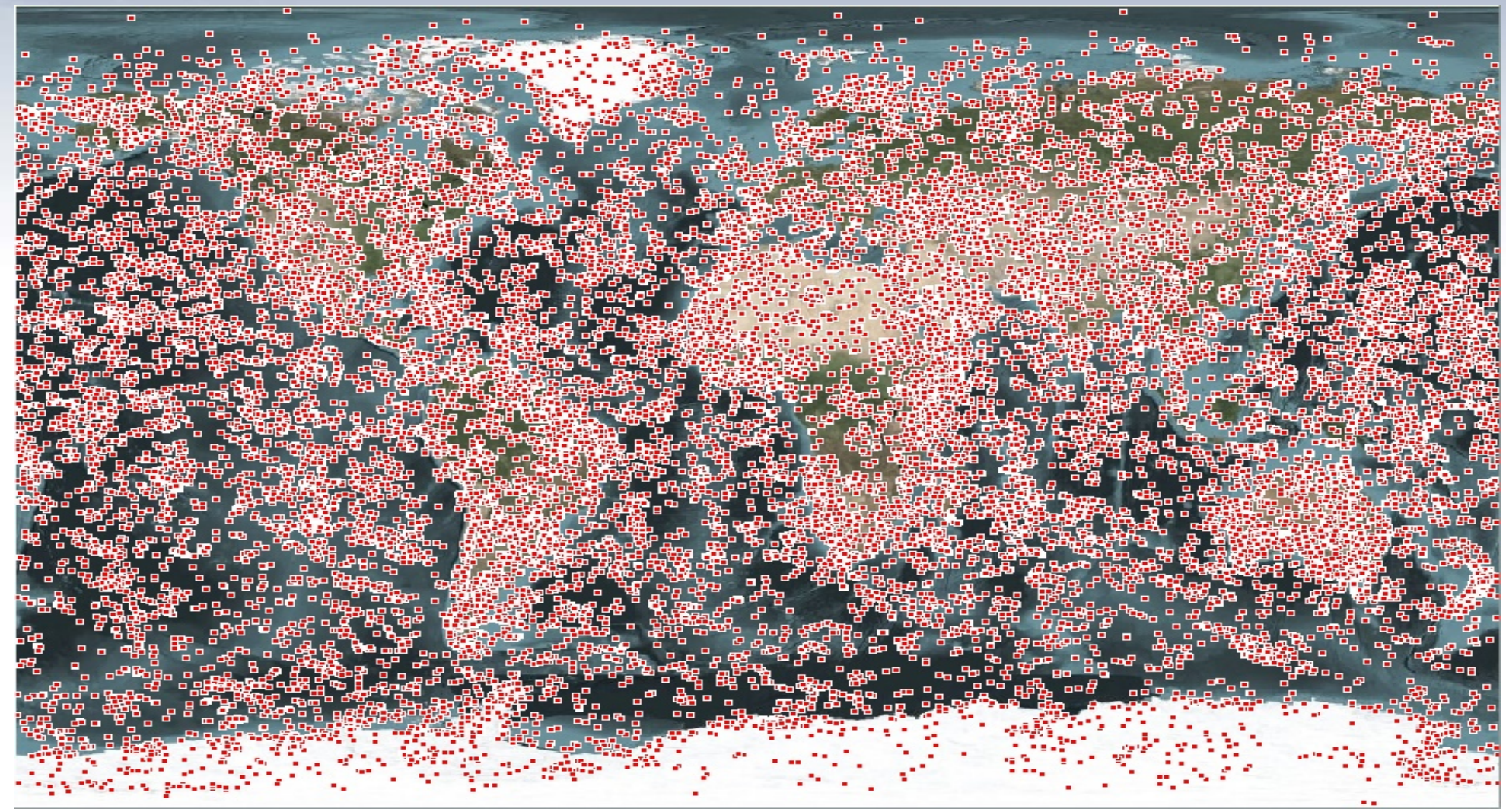
3. Current developments

Cloudiness & L2 quality flagging



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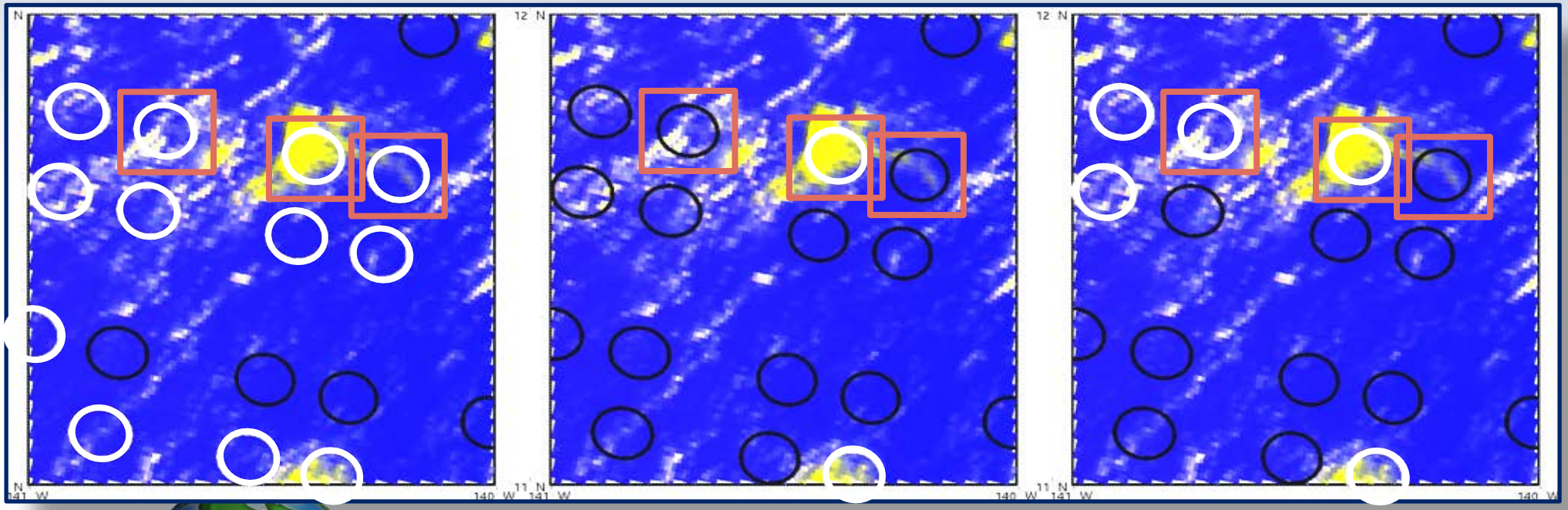
3. Current developments Cloudiness & L2 quality flagging

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



White: cloudy **Black: clear**

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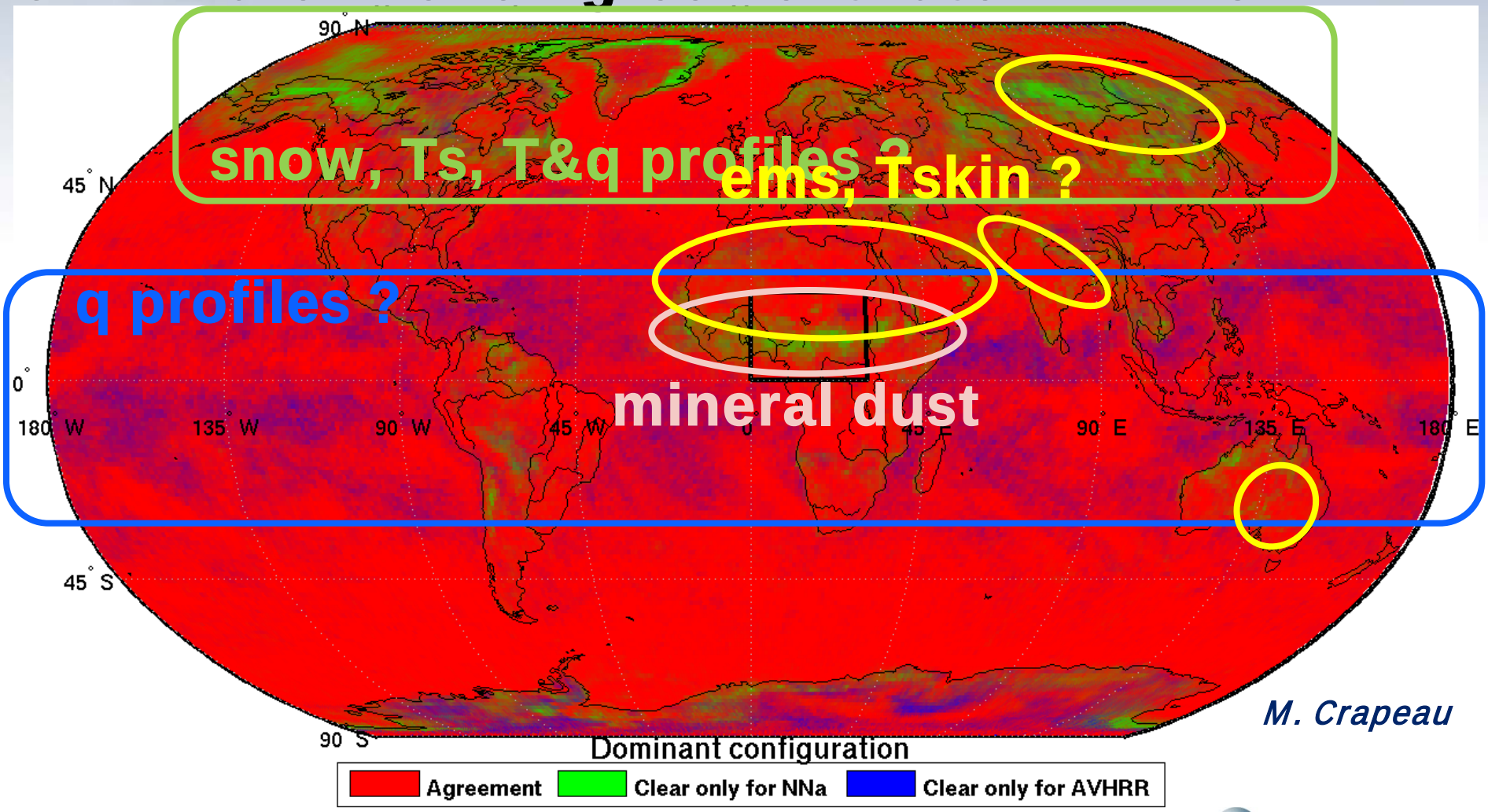
19-24 March 2010 Agreement rate: ANN vs AVHRR



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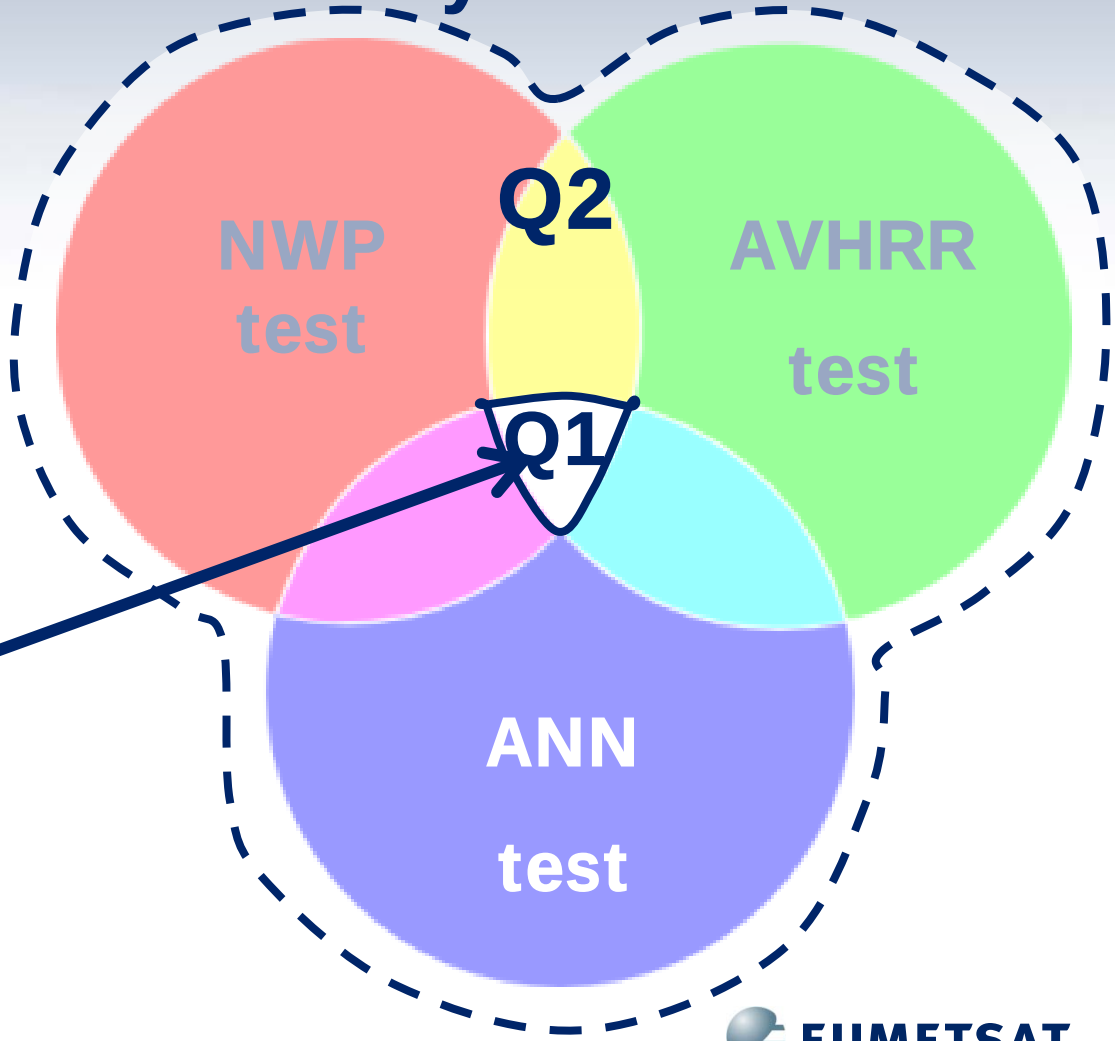
3. Current developments

Cloudiness & L2 quality flagging

Objectives: Relate cloudiness estimate to IASI L2 quality indicator

Cloudiness flag in v6	
1	Clear-sky
2	Potential small cloud contamination, cloud not characterised with confidence
3	IFOV partially cloudy
4	IFOV fully cloudy

Clear-sky identification



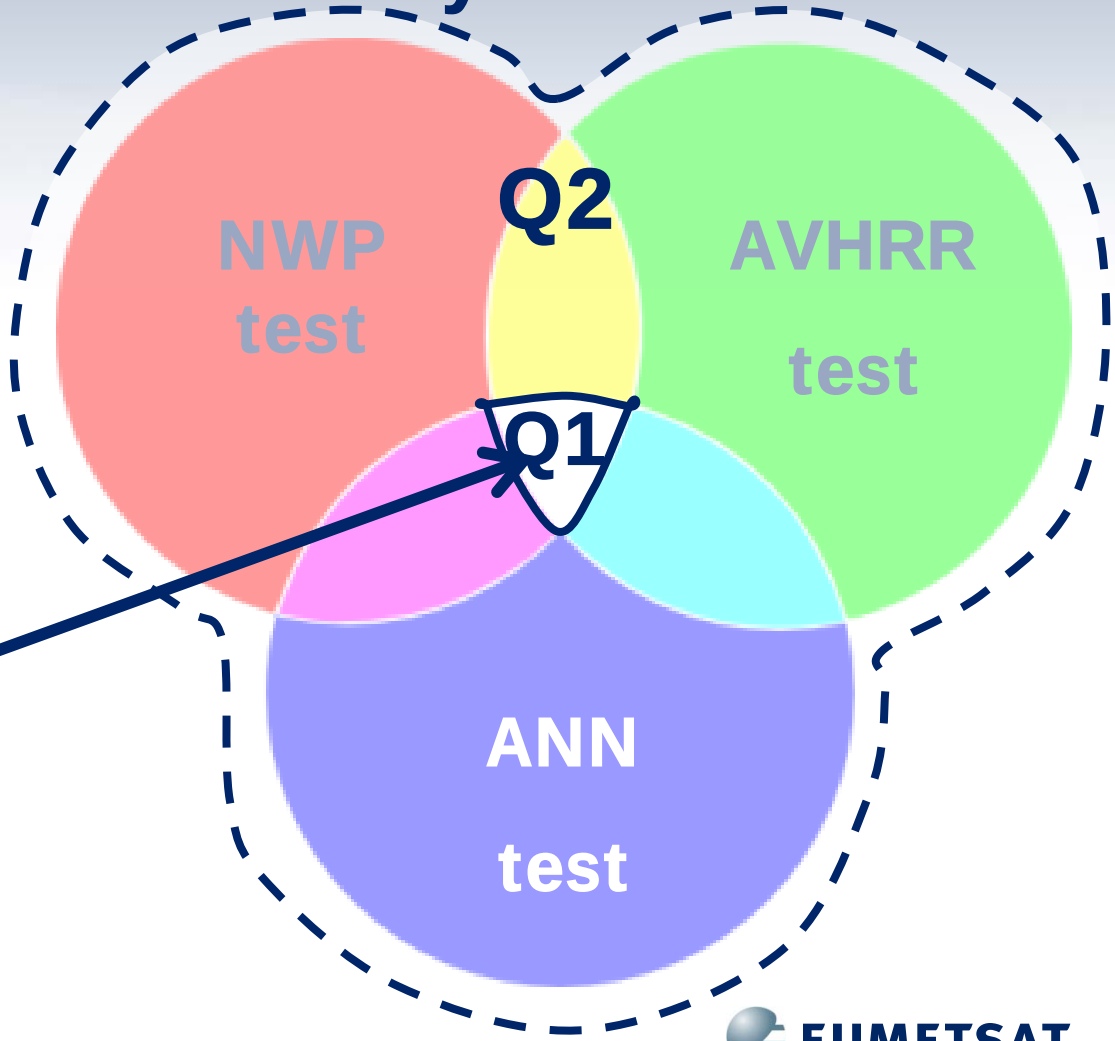
EUMETSAT

3. Current developments

Cloudiness & L2 quality flagging

Clear-sky identification

Objectives: Relate cloudiness estimate to IASI L2 quality indicator



+ High confidence

- Low yield

! Some area may be systematically excluded

EUMETSAT

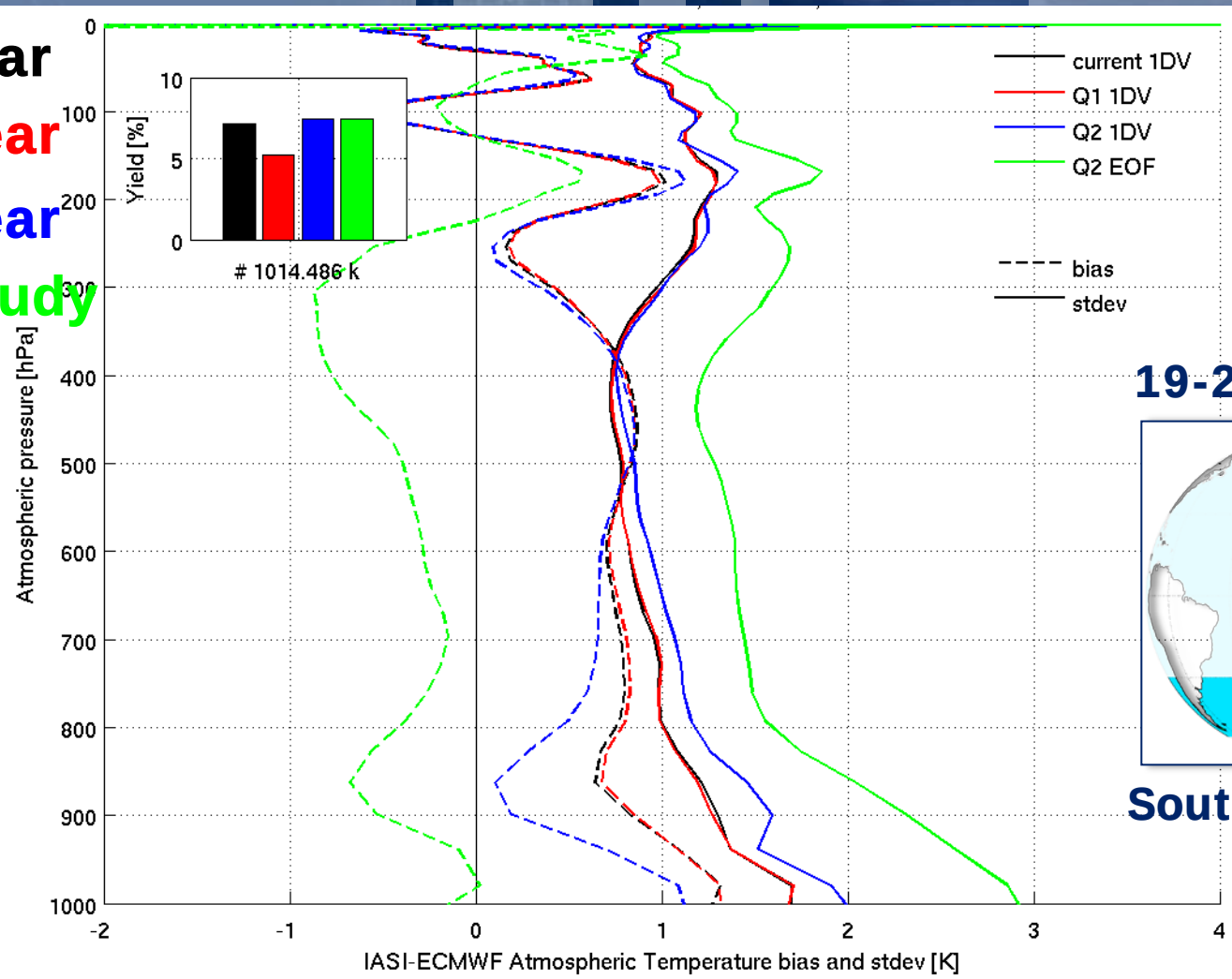
3. Current developments Cloudiness & L2 quality flagging

Current clear

Q1 OEM clear

Q2 OEM clear

Current cloudy



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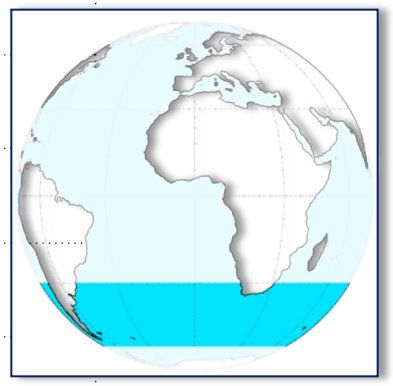


Southern oceans

EUMETSAT

3. Current developments Cloudiness & L2 quality flagging

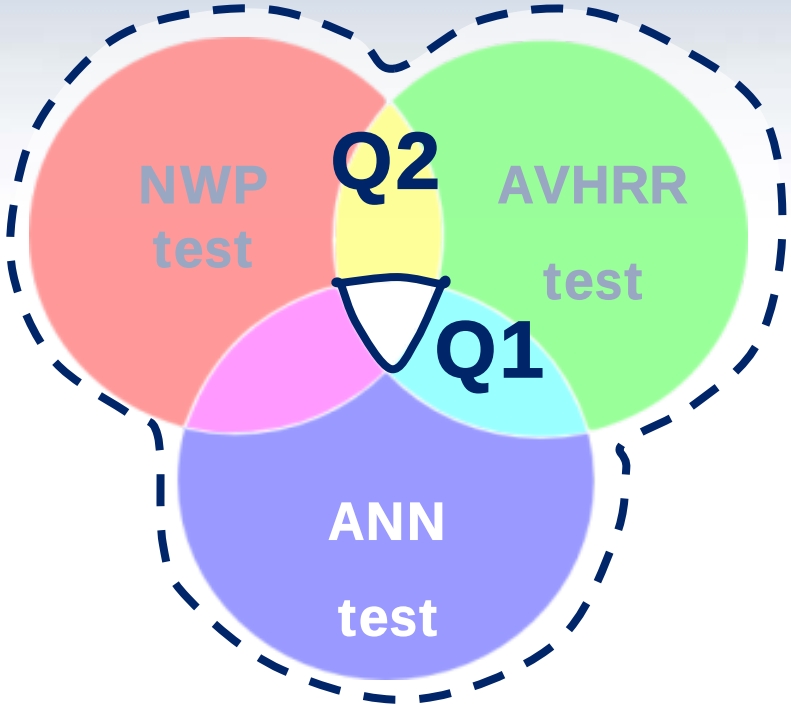
√ Quality improved/preserved in Q1

√ Quality improved in Q2

√ Overall yield increased

See Poster #37
Marc Crapeau

Clear-sky identification



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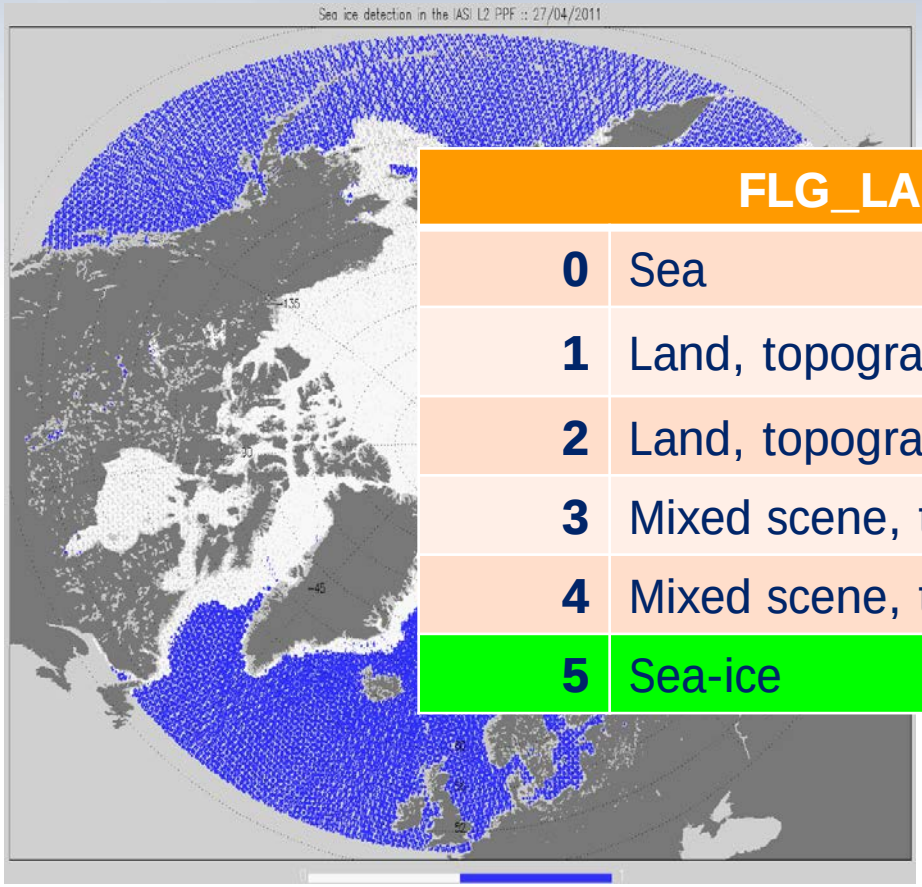
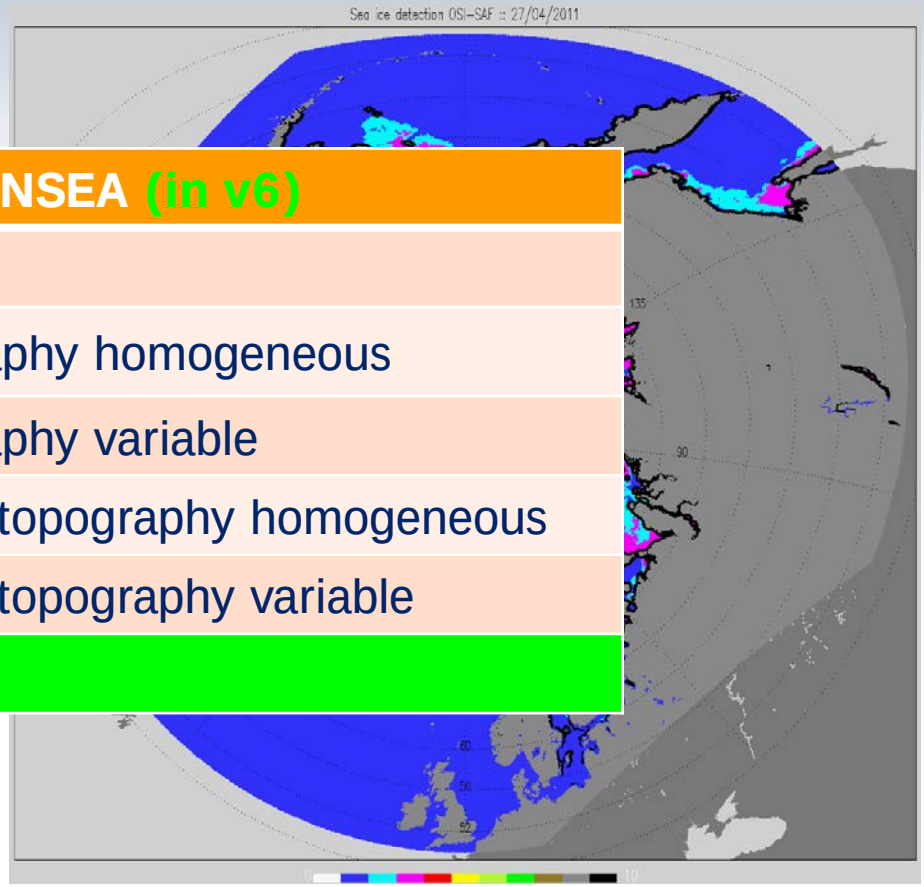
Sea ice classification





FLG_LANSEA (in v6)	
0	Sea
1	Land, topography homogeneous
2	Land, topography variable
3	Mixed scene, topography homogeneous
4	Mixed scene, topography variable
5	Sea-ice

Ice mask: Prototype using collocated AMSU data

OSI-SAF ice edge product

NLR: Non-Linear statistical Retrieval

- Predictors: **IASI radiances**
- Outputs: **Ts, profiles of T, q, O_3**
- Retrieval methods: combination of **linear regression, neural networks and support vector machines**
- Training set: **synthetic clear-sky IASI radiances** (RTM: OSS) and climatological database (Le Chevallier, ECMWF)
- External study lead by X. Calbet (EUM), performed University of Valencia (G. Camps-Valls et al.)

!! More accurate than Linear Regression

!! Precision comparable to OE

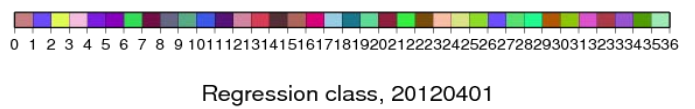
!! Speed-up computations by 300

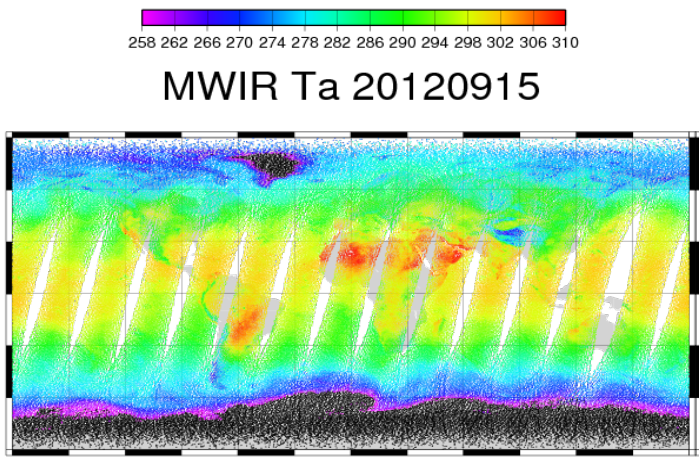
3. Current developments

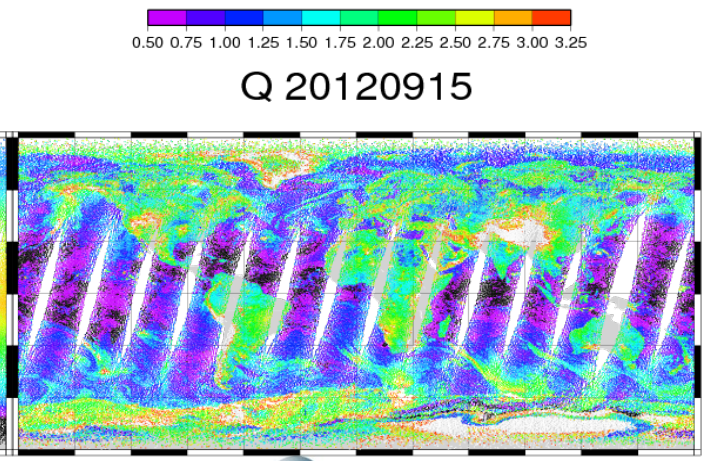
MW+IR all-sky linear retrieval

- Predictors: **AMSU, MHS, IASI and AVHRR** measurements in PCs
- Outputs: Ts, profiles of T, q & O_3 + error estimate
- Retrieval method: **Linear regression**
- Training set: **Real observations** & co-located ECMWF analyses.
- **36 regression classes** with specific regression coefficients, based on MHS, AMSU and IASI (band 2) radiances.

Tim Hultberg's Talk
Thursday @ 16:00



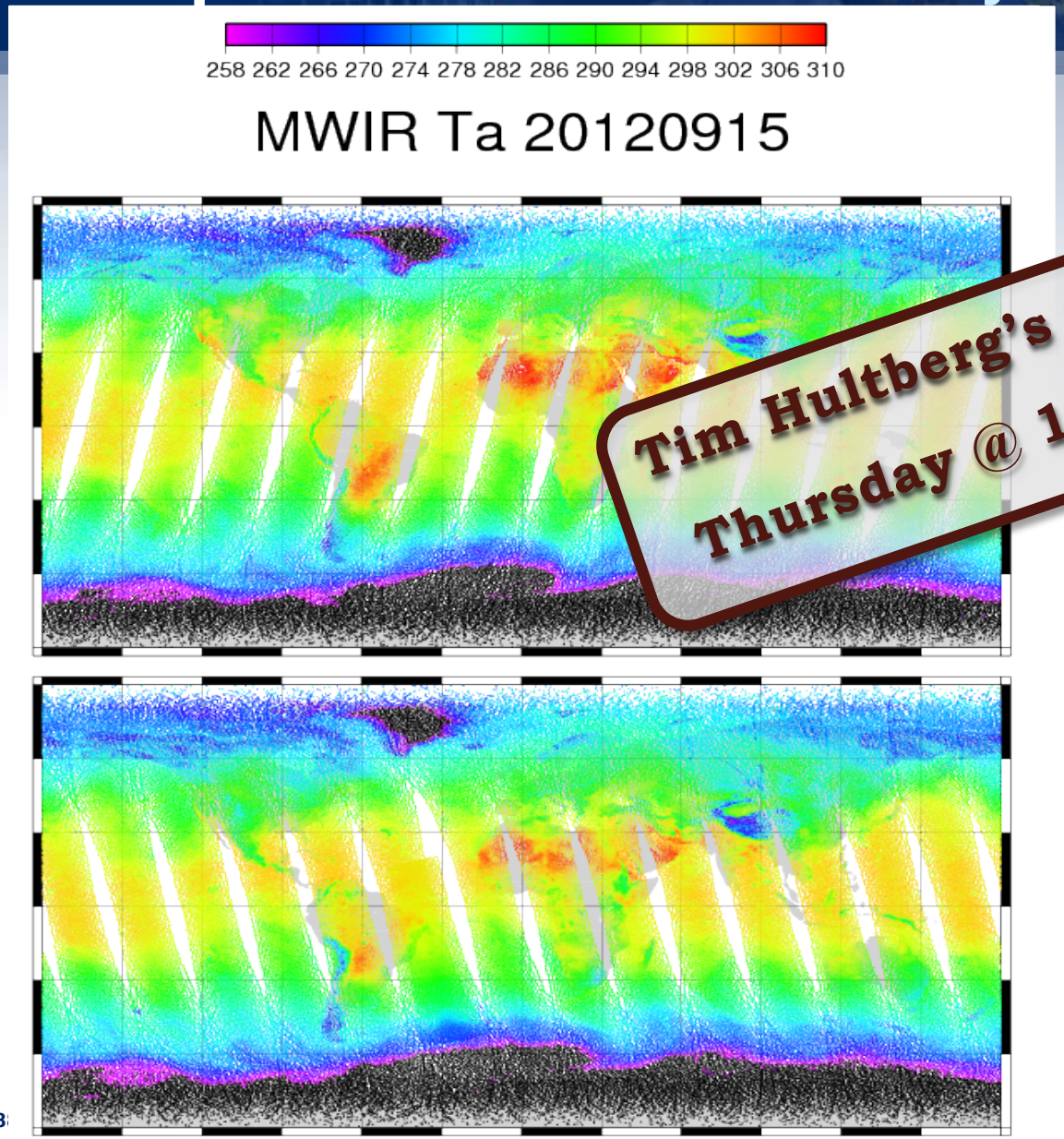




EUMETSAT

3. Current developments

MW+IR all-sky linear retrieval

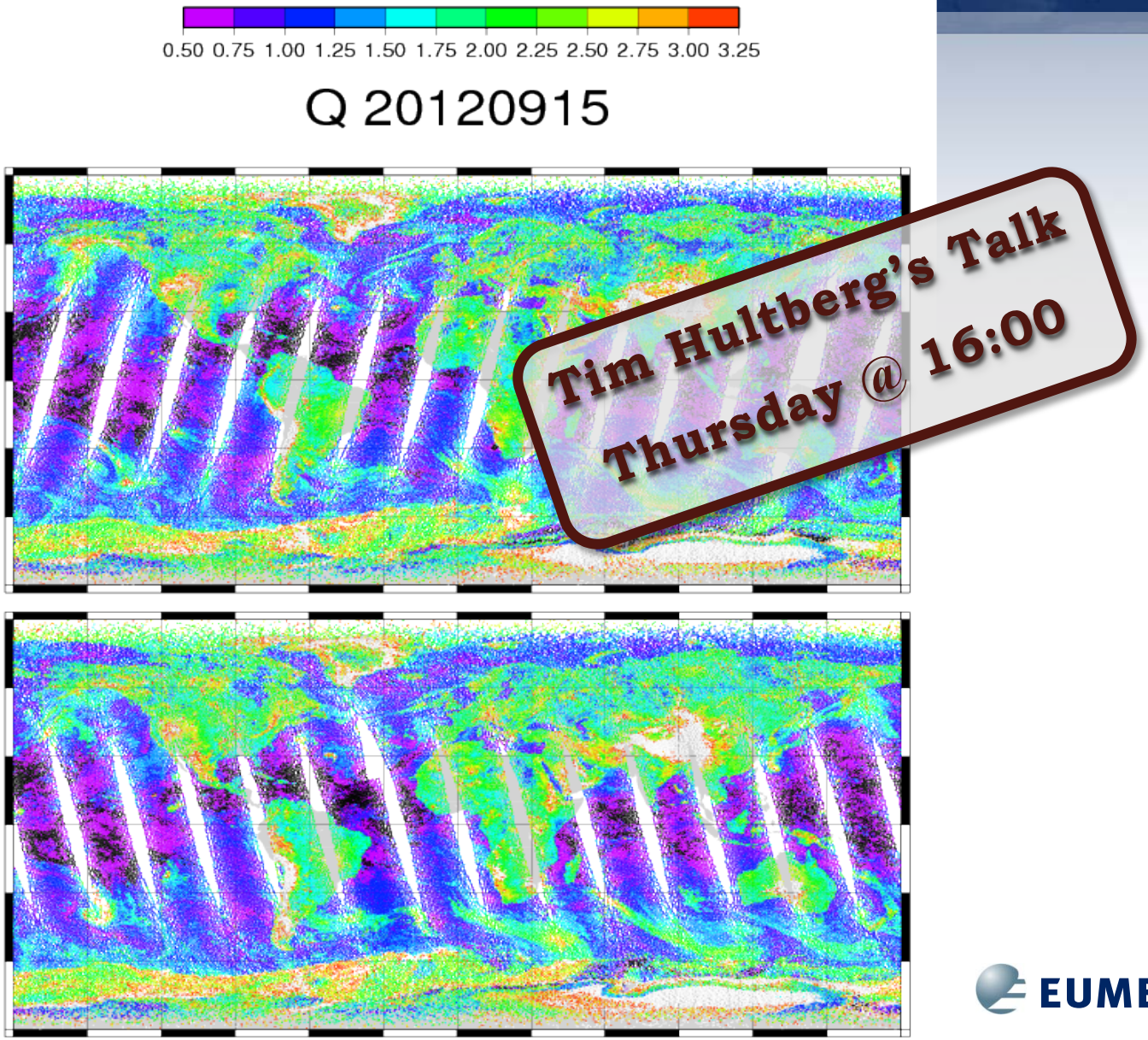


Tim Hultberg's Talk
Thursday @ 16:00

EUMETSAT

3. Current developments

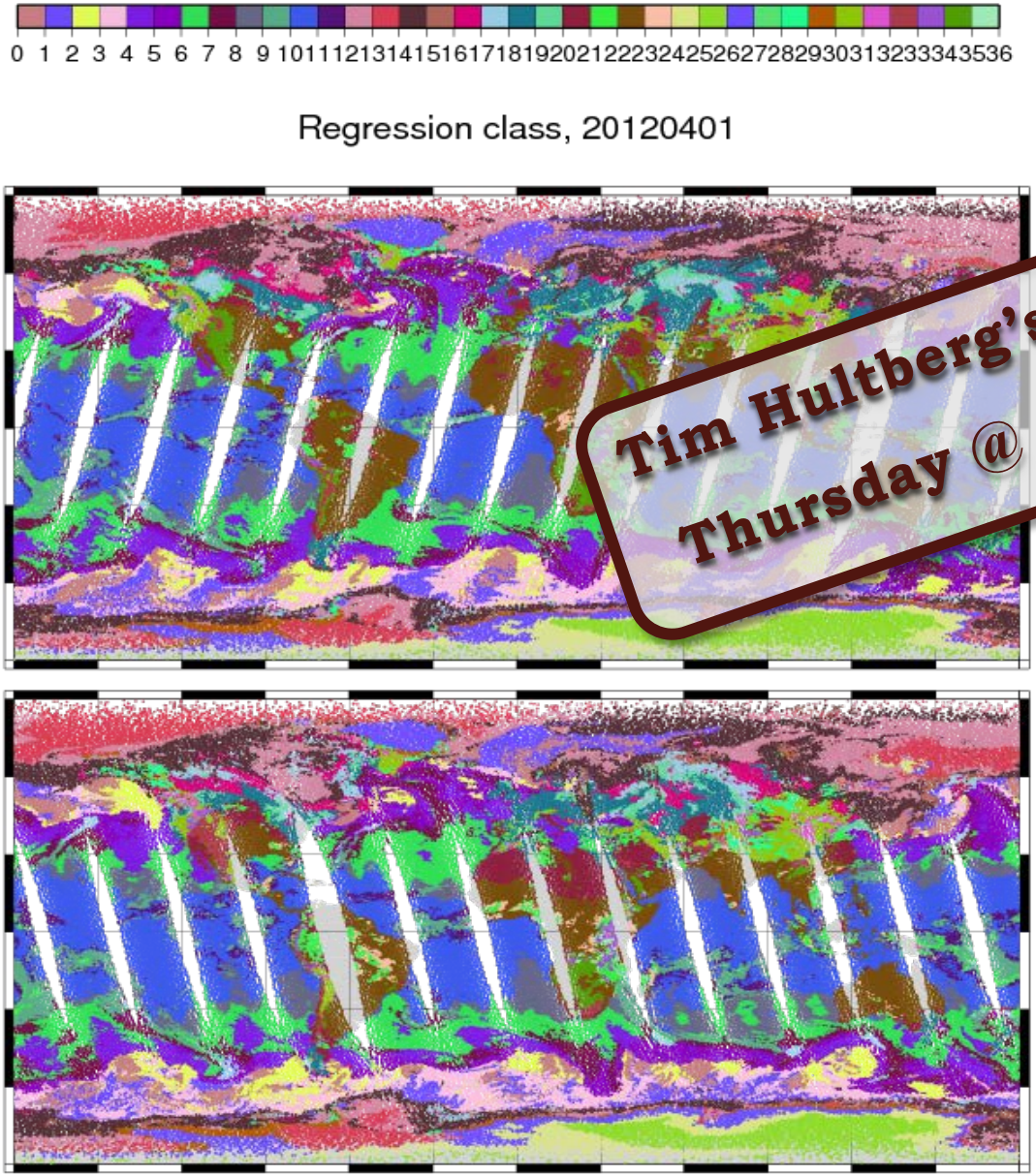
MW+IR all-sky linear retrieval



EUMETSAT

3. Current developments

MW+IR all-sky linear retrieval

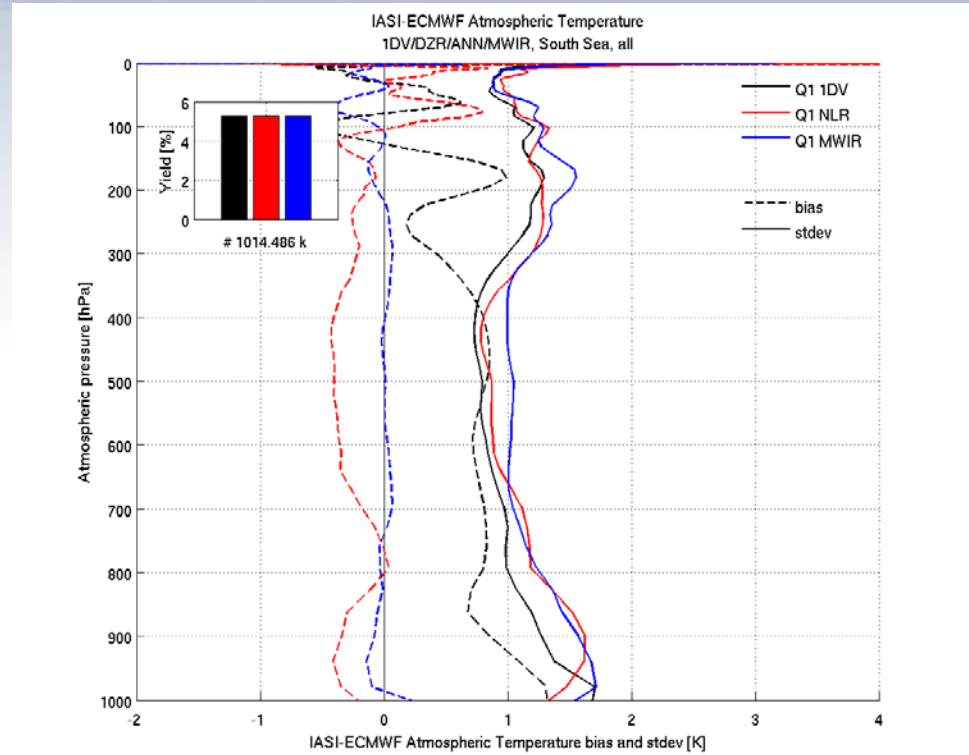


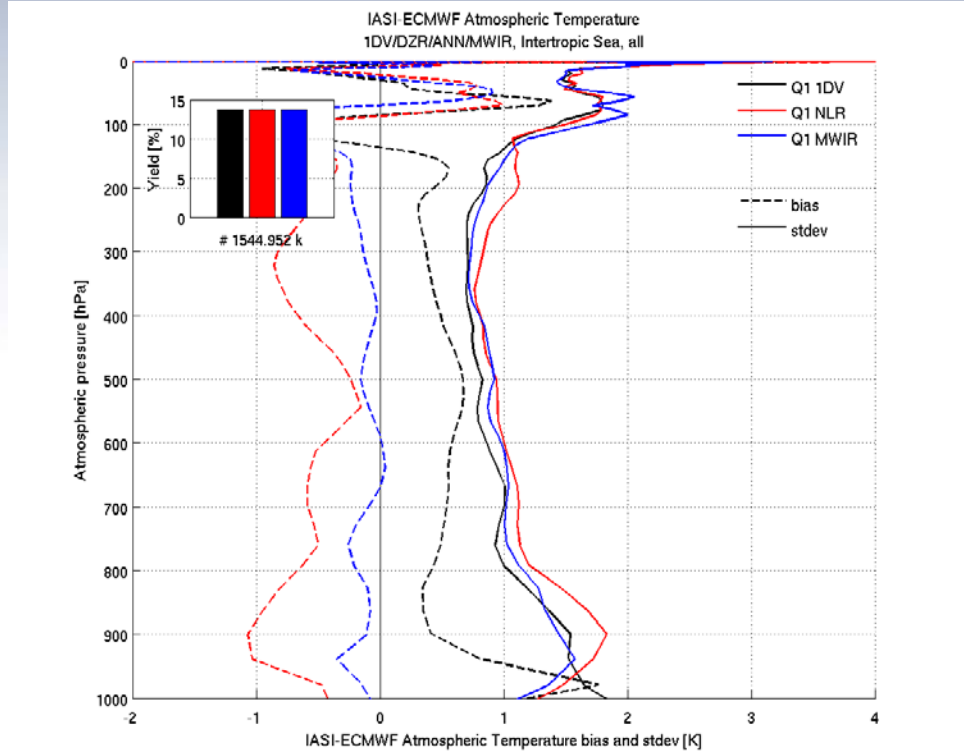
Tim Hultberg's Talk
Thursday @ 16:00

EUMETSAT

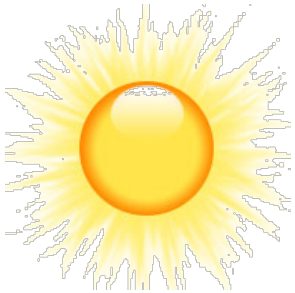
3. Current developments

Assessment of new T retrievals





19-24/03/2010
Southern oceans



Q1 PPF v5

Q1 NLR clear

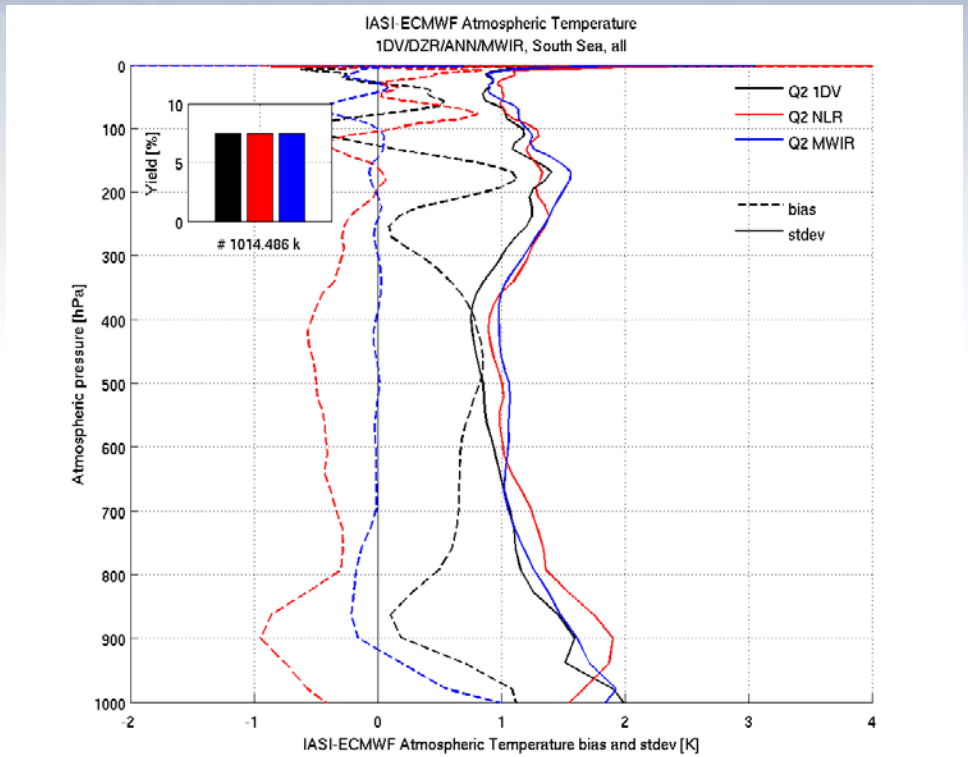
Q1 MWIR

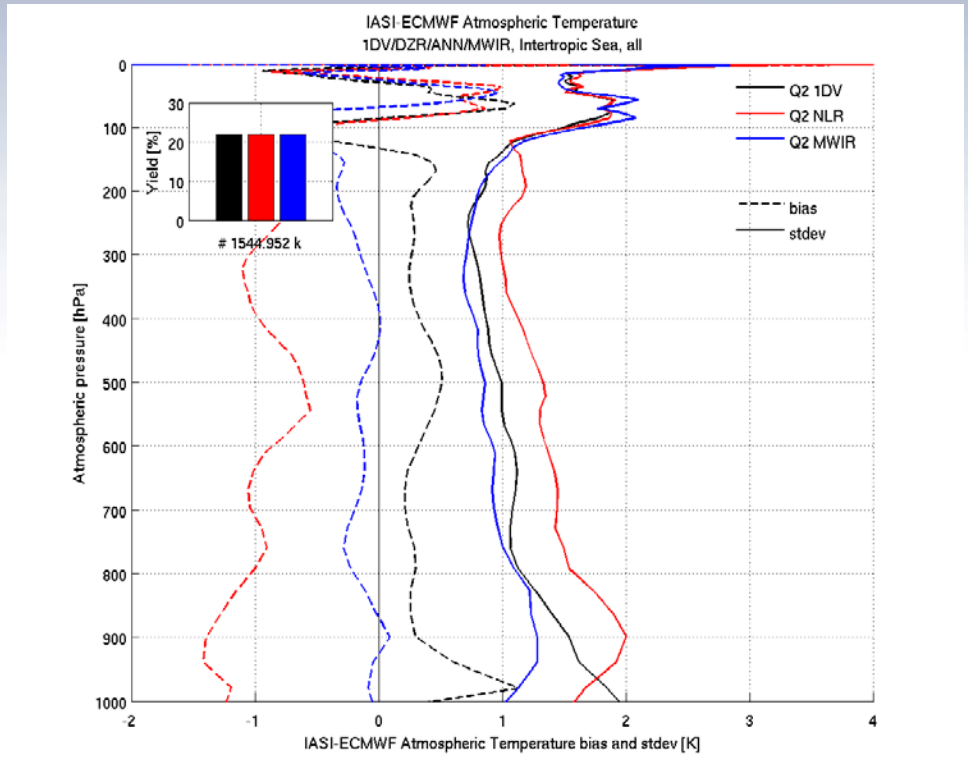
19-24/03/2010
Intertrop. oceans

EUMETSAT

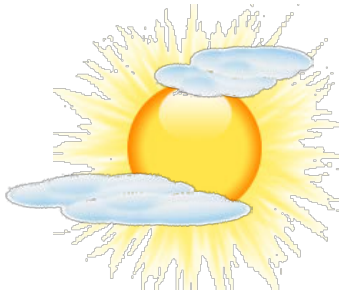
3. Current developments

Assessment of new T retrievals





19-24/03/2010
Southern oceans



Q2 PPF v5

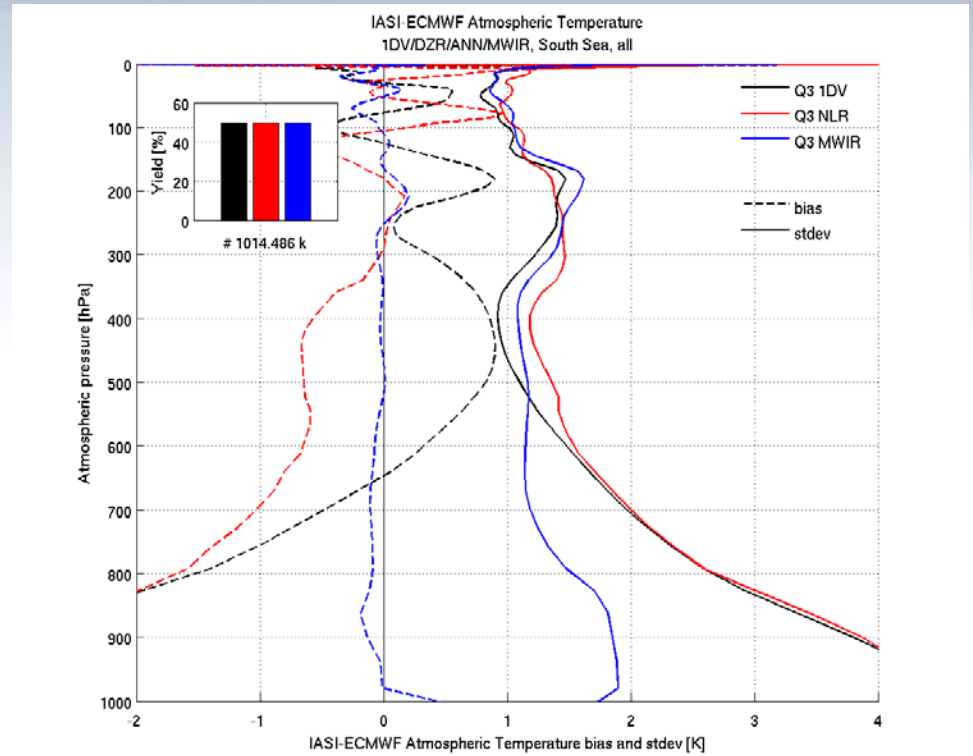
Q2 NLR clear

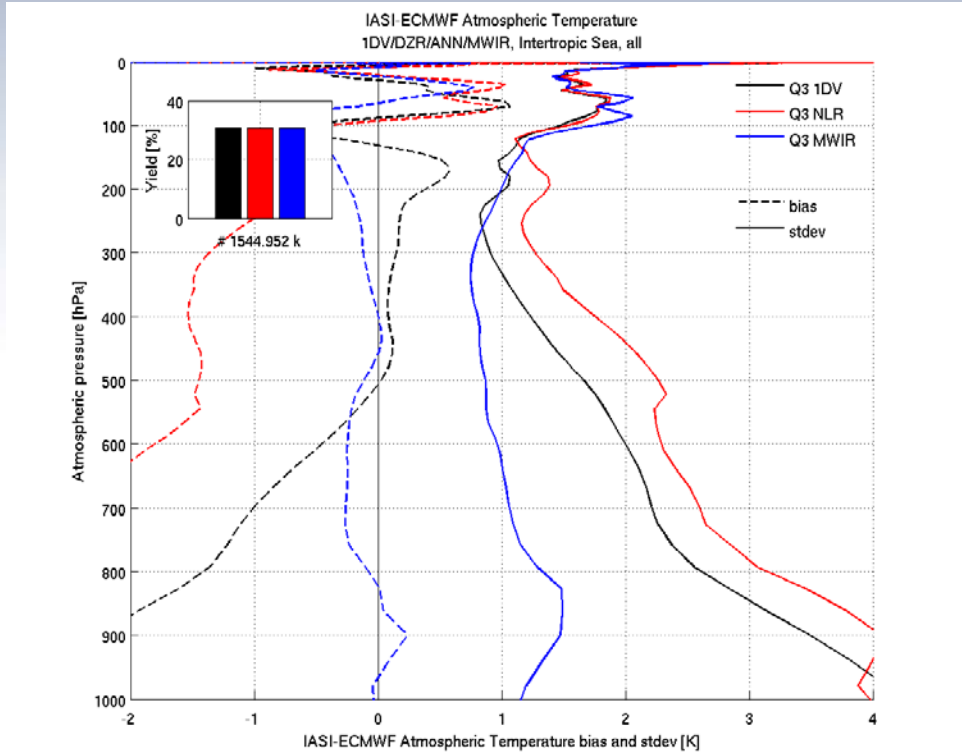
Q2 MWIR

19-24/03/2010
Intertrop. oceans

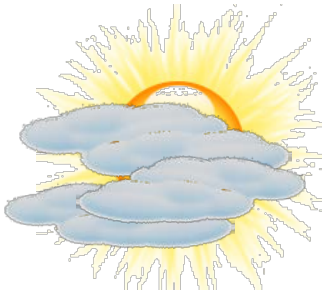
EUMETSAT

3. Current developments Assessment of new WV retrievals





19-24/03/2010
Southern oceans



Q3 PPF v5

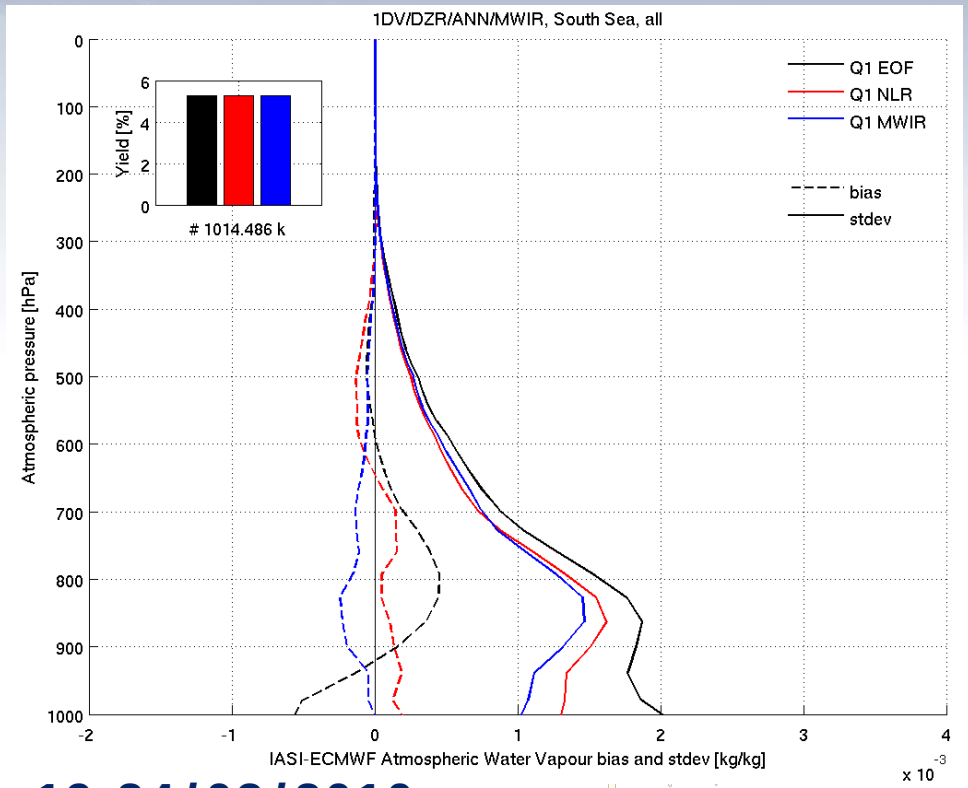
Q3 NLR clear

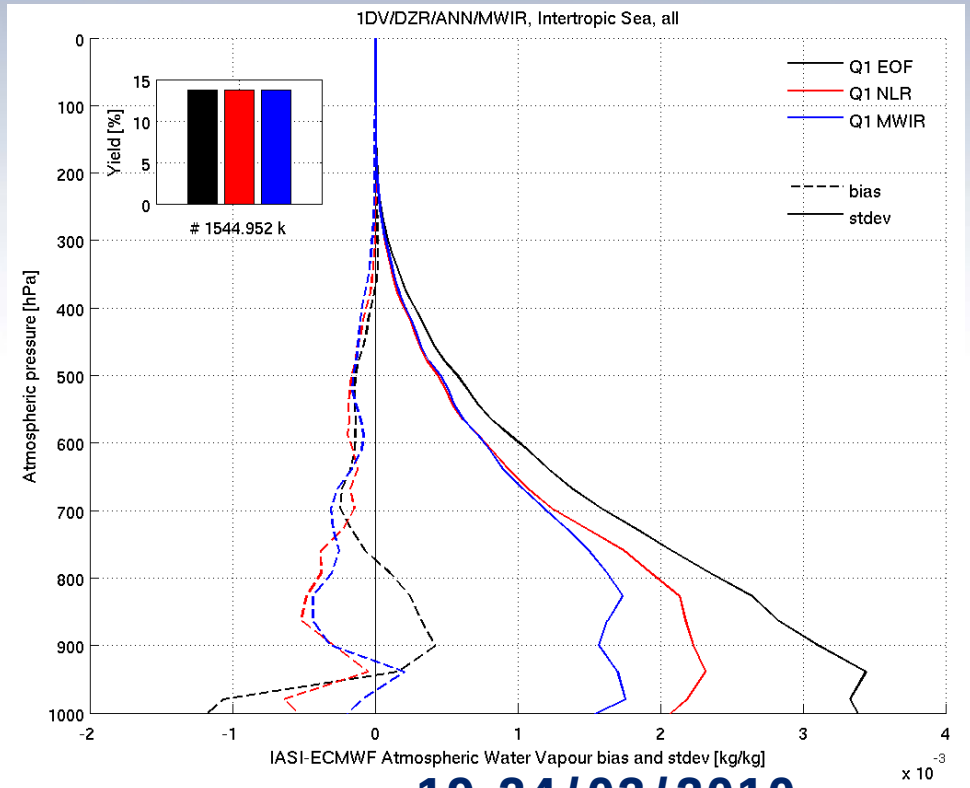
Q3 MWIR

19-24/03/2010
Intertrop. oceans

EUMETSAT

3. Current developments Assessment of new WV retrievals





19-24/03/2010
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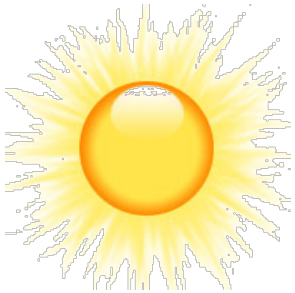

Q1 PPF v5

Q1 NLR clear

Q1 MWIR

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Intertrop. oceans

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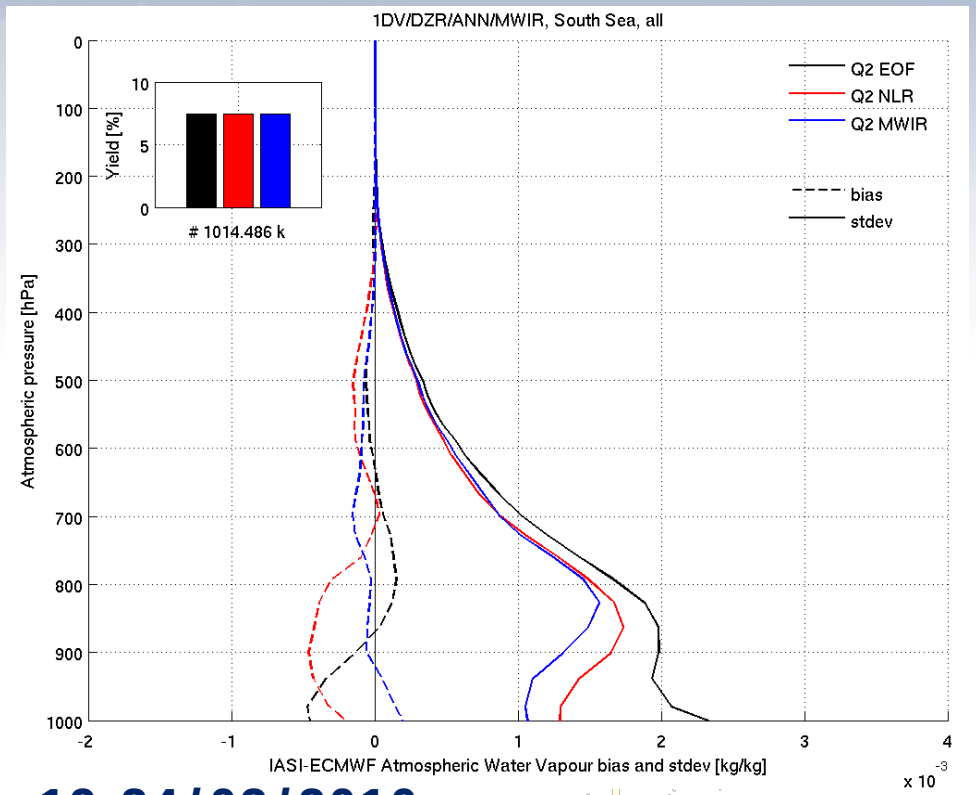
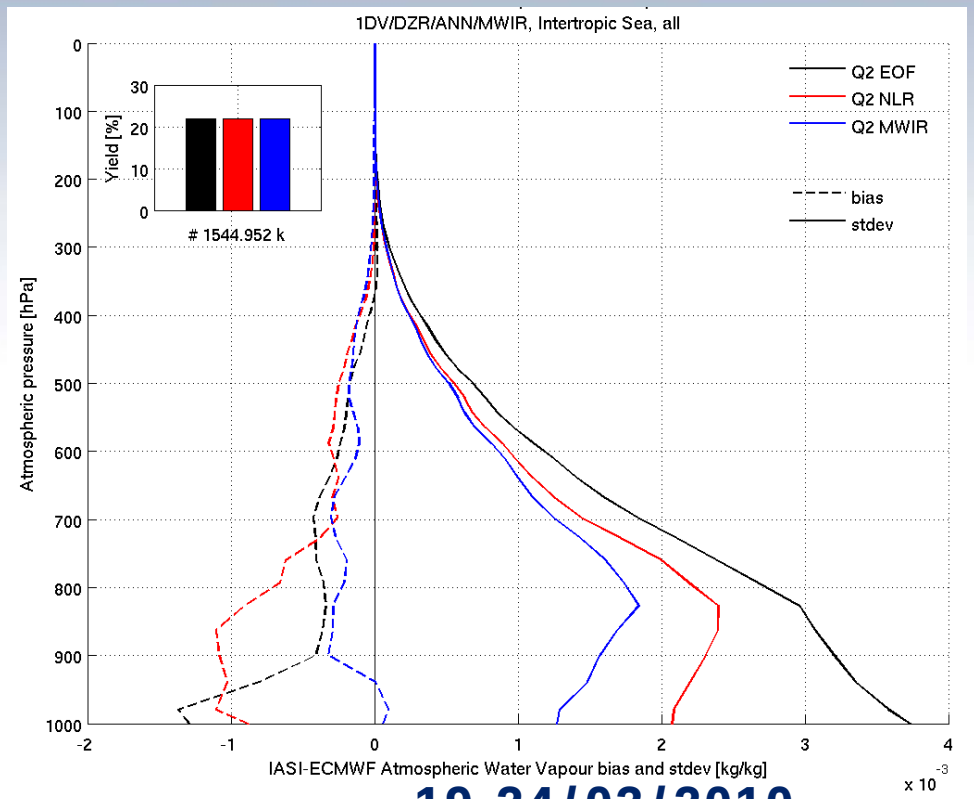
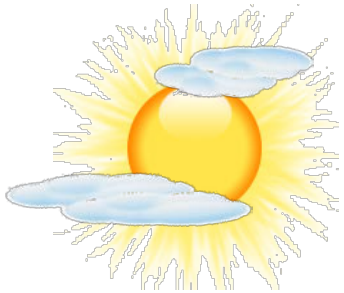
3. Current developments Assessment of new WV retrievals





19-24/03/2010
Southern oceans



Q2 PPF v5

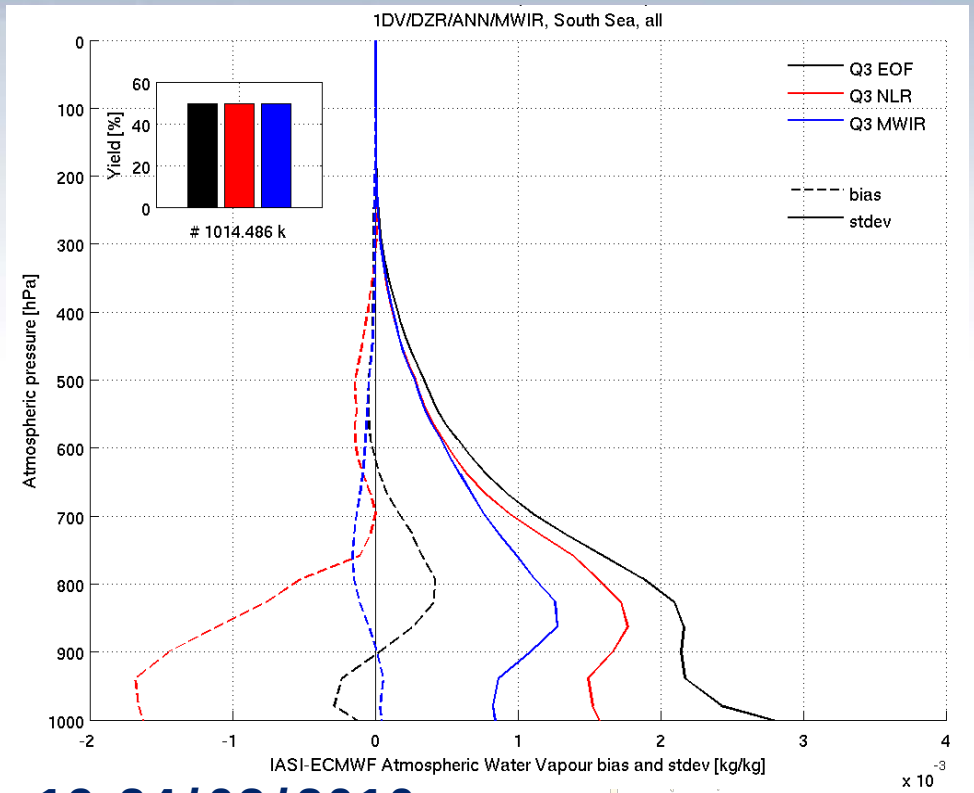
Q2 NLR clear

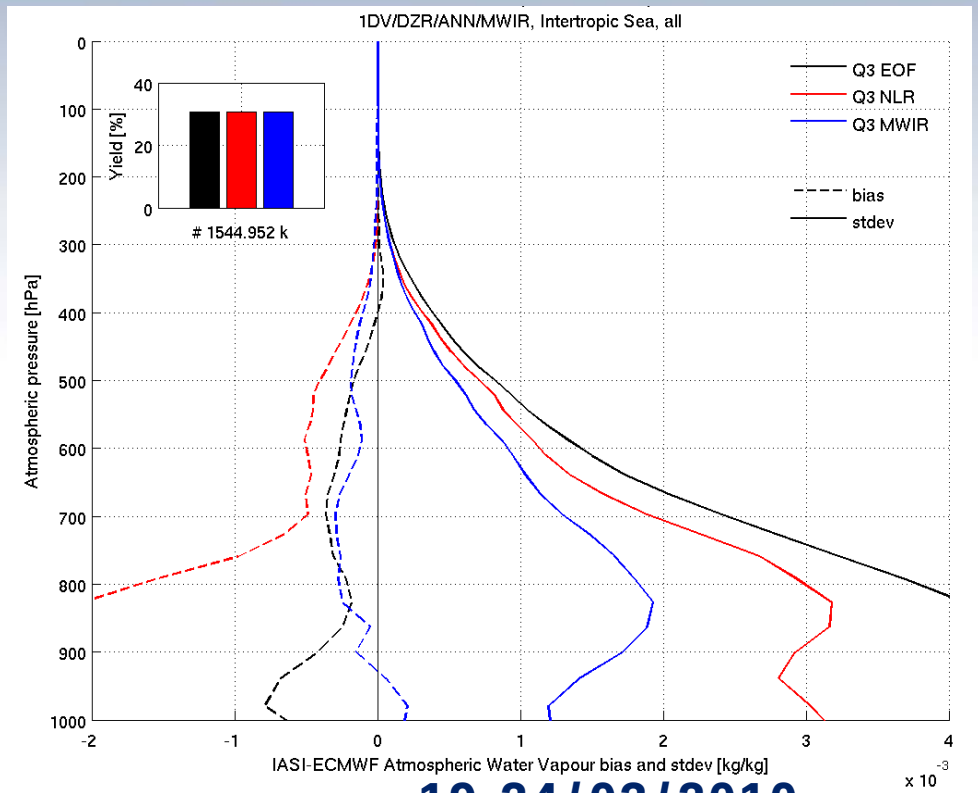
Q2 MWIR

19-24/03/2010
Intertrop. oceans

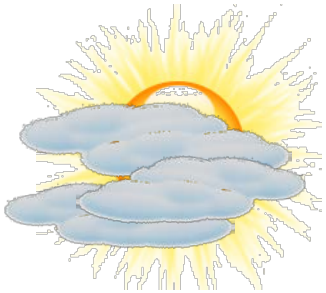
EUMETSAT

3. Current developments Assessment of new WV retrievals





19-24/03/2010
Southern oceans



Q3 PPF v5

Q3 NLR clear

Q3 MWIR

19-24/03/2010
Intertrop. oceans

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3. Current developments

New OEM configuration

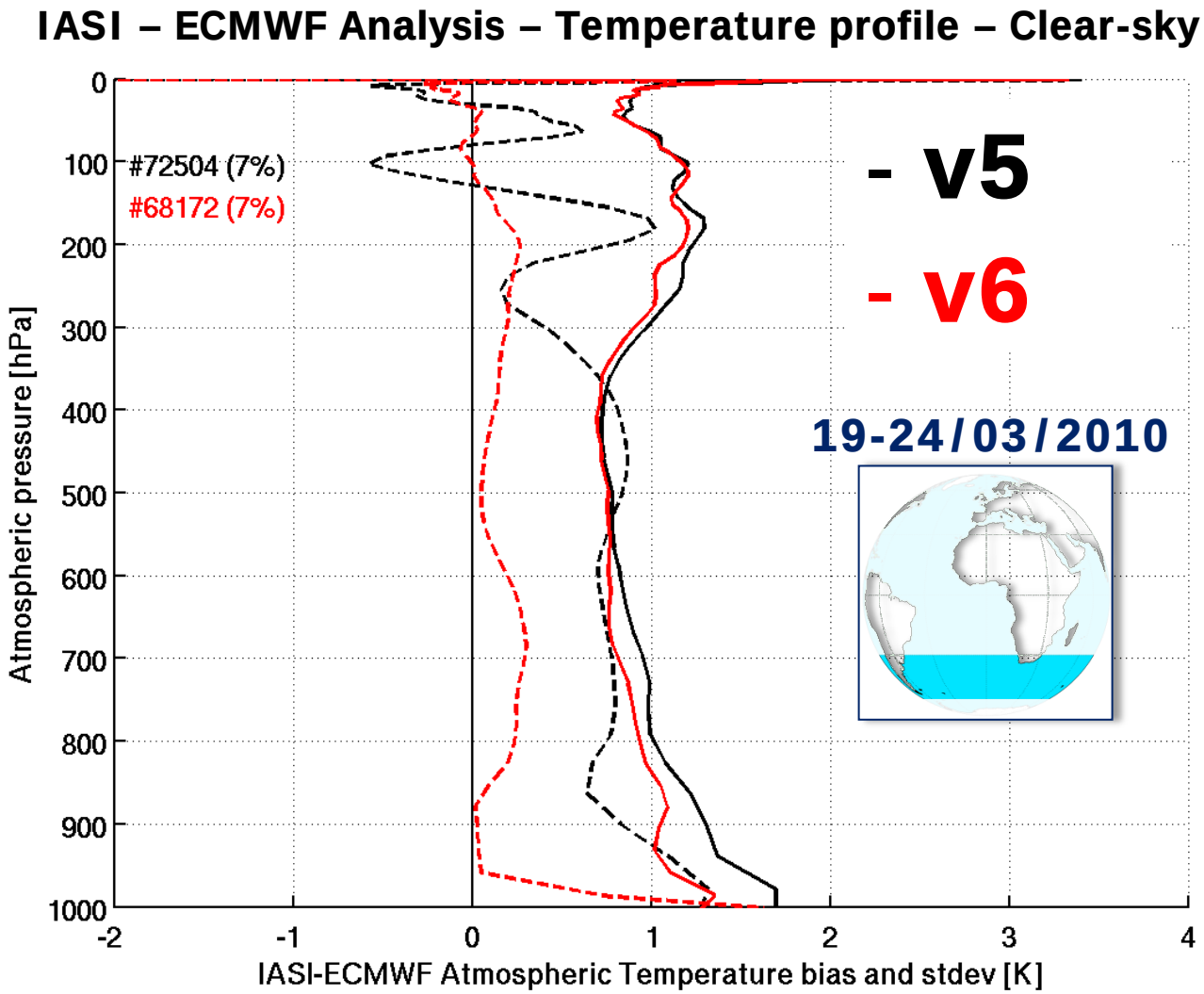
- Exploration of the observation and model (RTM) subspaces
- New channel selection, use of reconstructed radiances
- Use of MWIR regression in the background terms
- Narrow down the observation error matrix
- New radiance tuning

Tim Hultberg's Talk
Thursday @ 16:00

EUMETSAT

3. Current developments

New OEM configuration



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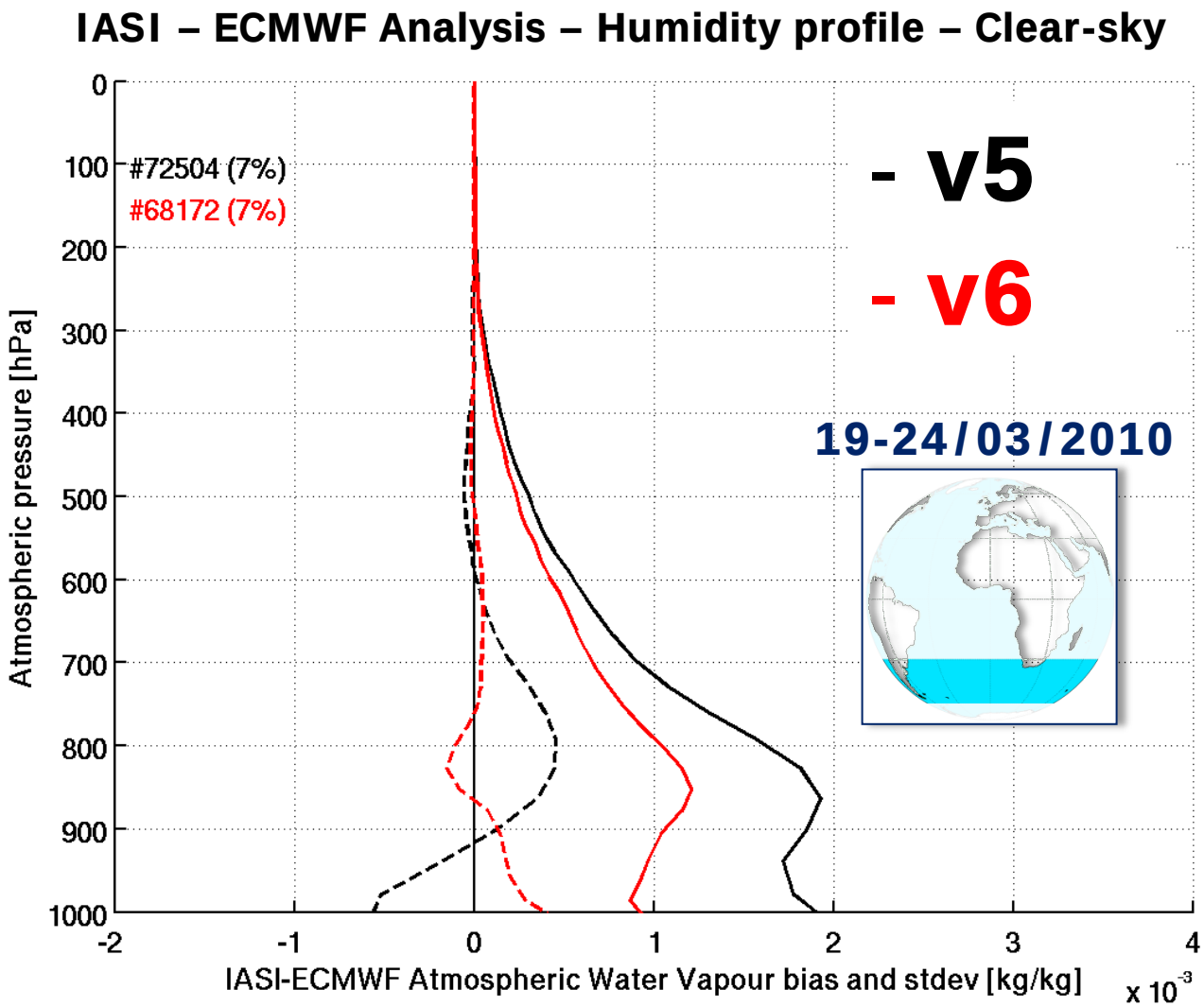
3. Current developments

New OEM configuration



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3. Current developments

Open questions

- clouds/aerosol detection/simulation from IR and impact on sounding products quality ?

- What WV products references for the validation of satellite retrieved profiles with ground resolution of 12-30 km ?

See Poster #101
Xavier Calbet

- Calibration instrument/RTM, esp. in WV channels and characterisation of the observation error matrix ?

- Retrieving GHG with IASI ?

- Validation of Land Surface Emissivity ?

Summary & Outlook

- ✓ **PPFv5 operational since 14/09/2010**
- ✓ **Significant improvements: T, LST, clouds, CO, O_3**

Upcoming in 2013:

- **Complete the Cal/Val IASI L2 / Metop-B**
- **Further validation (LSE, T & q) and algo. developments (atm. composition, aerosol detection...)**
- **Release the IASI L2 v6 (new algorithms & products)**
  - ➢ CO profiles + AK
  - ➢ T, q profiles yield increased, product quality flagging
  - ➢ More accurate T & q sounding in the lower troposphere, including in partly cloud-contamined IFOVs

Summary & Outlook

Parameter	Algorithm	Status	Plans for V6
Cloud detection	NWP, AVHRR	Operational	NWP+AVHRR+ANN
Cloud fraction & height	CO_2-slicing + χ^2	Operational	
Cloud phase	BT difference	Trial	
T profiles	OEM	Operational	NLR, MWIR OEM(q) **AK**
q profiles	EOF	Operational	
SST / LST	EOF	Operational	Fix angular variation OEM(LST & ems)
Emissivity	EOF	Trial	
O_3 total column	OEM	Operational	Profiles + AK
O_3 partial columns	OEM	Trial	
CO	ANN	Operational	Profiles + AK
N_2O, CH_4, CO_2	ANN	Experimental	SO_2, HNO_3, ???

References & contacts

- **Papers**

  August et al, *"IASI on Metop-A: Operational Level 2 retrievals after five years in orbit"*, JQSRT 2012

- **Validation reports (SST, LST, T&q, CO, O_3…)**

eumetsat.int/Home/Main/DataProducts/Resources/index.htm#val_reports

- **Product Generation Specification**

eumetsat.int/groups/ops/documents/document/PDF_TEN_990013-EPS-IASIL2-PGS.pdf

- **Product Guide**

eumetsat.int/Home/Main/DataProducts/Resources/index.htm#productguides

Contact: *thomas.august@eumetsat.int*

User Helpdesk (questions, feedback, requests…): *ops@eumetsat.int*