



# EUMETSAT Meteosat-IASI Inter-calibration Algorithm

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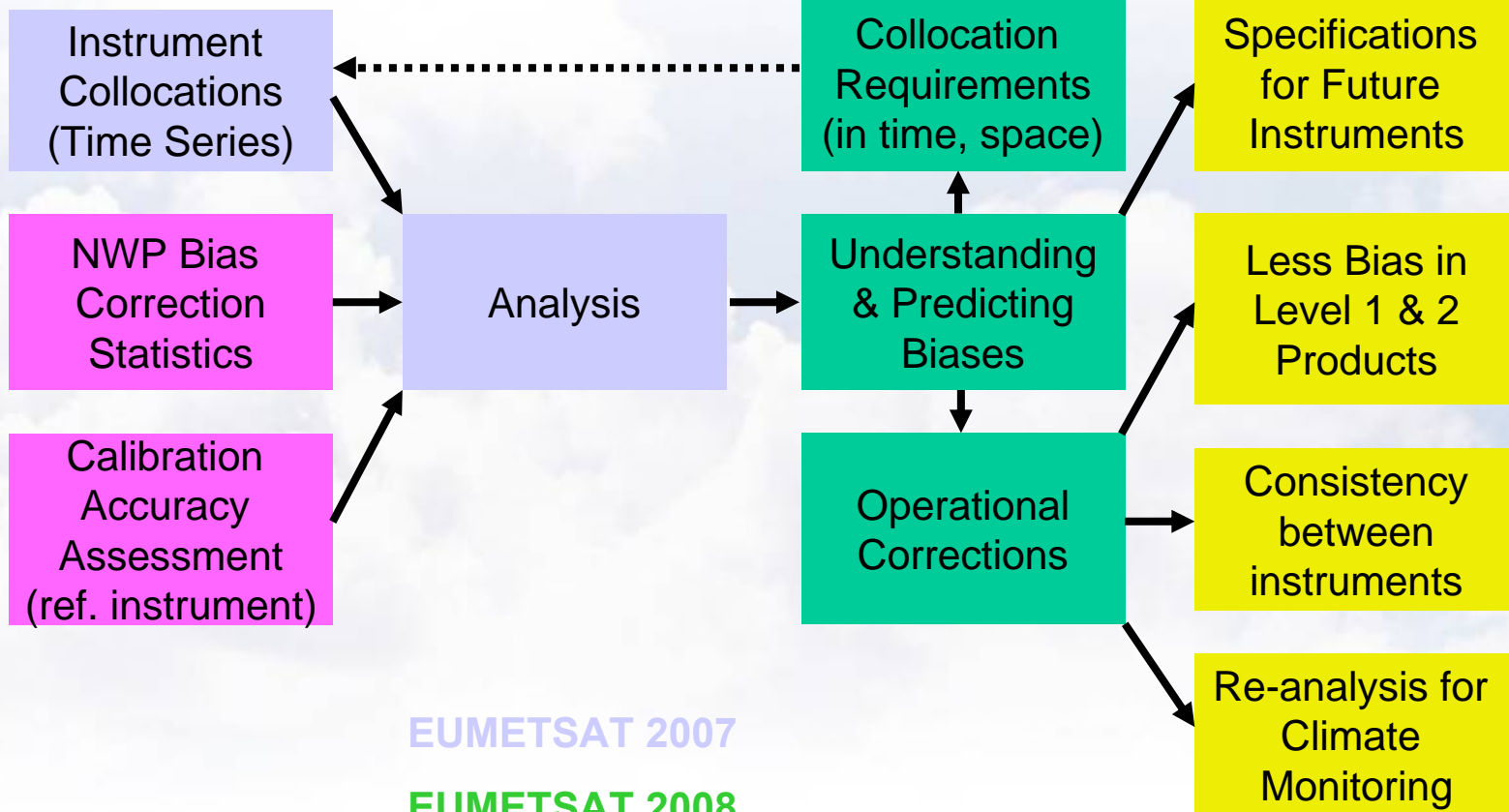
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# Inter-calibration Strategy

Principles    Methodology    Results    Benefits

Consistency  
Traceability



EUMETSAT 2007

EUMETSAT 2008

Liaisons 2008

# IASI and/or AIRS as a reference?

**EUMETSAT: Meteosat-IASI**

**NOAA: AIRS-IASI**

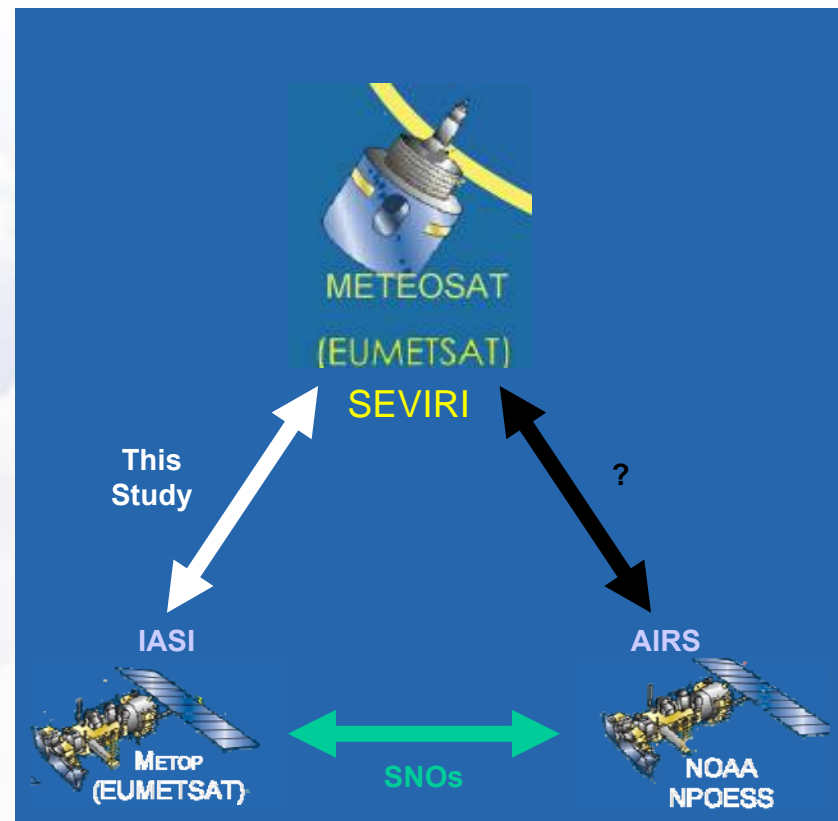
**IASI has no spectral gaps**

**IASI + HIRS/4 on same platform**

**A lot of work for us to  
complete the triangle:**

**Meteosat-AIRS**

**(Integrity check)**





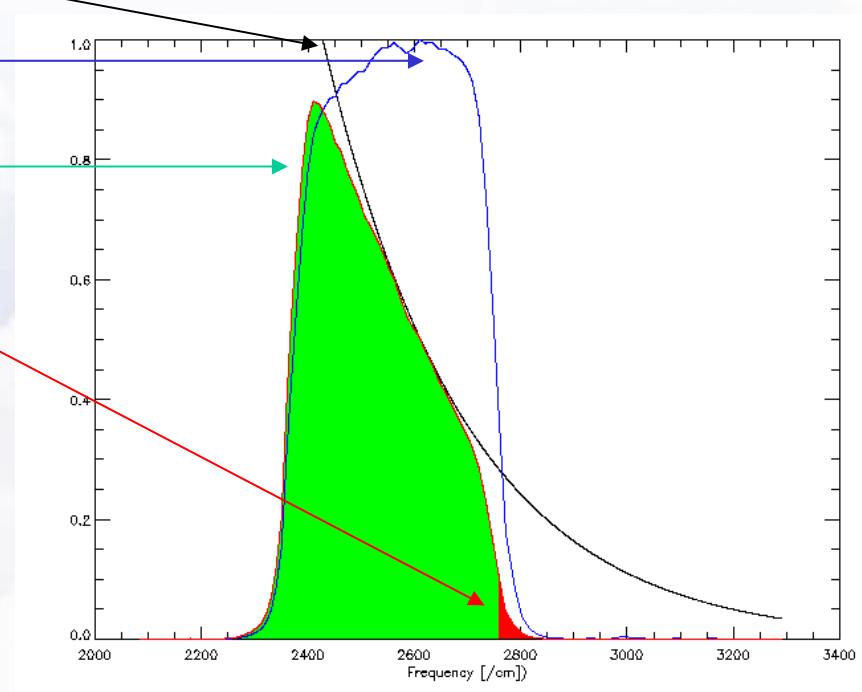
# Missing Energy in MSG 3.9 $\mu\text{m}$ channel

Black-body Planck function at 290K  
convolved with  
**Spectral Response Function of MSG**  
Integrate to calculate  
**Total Radiance**  
Missing energy not seen by IASI in the  
**Small fraction beyond 2760 $\text{cm}^{-1}$**   
Convert to Brightness Temperatures

Result:

IASI under-estimates MSG 3.9 $\mu\text{m}$   
radiance by 1.33% of scene radiance,  
or  $\sim 0.17\text{K}$  at 290K (Scene-dependent)

Not accounted for in analysis





# New Radiance Definition

**Marianne told us all about the new radiance definition  
ECP833 also includes changes to non-linearity corrections**

**As a temporary work around for 2007 data,  
needed to ensure consistent definition of radiance:**

- Read in old IMPF-defined radiances**
- Convert to brightness temperatures**
- Convert back to effective radiances**

**Archive Data will be re-processed according to new definition**



# Collocation Criteria

## Meteosat First Generation

$\Delta Lat < 30^\circ$ ,  $\Delta Lon < 30^\circ$  of SSP  
 $\Delta t < 30$  mins (=scan period)  
 $|\theta| < 15^\circ$  (Incidence angle)  
 $\Delta\theta < 2^\circ$  (Incidence angle diff.)  
3x3 MFG pixels / IASI iFoV

## Meteosat Second Generation

$\Delta Lat < 30^\circ$ ,  $\Delta Lon < 30^\circ$  of SSP  
 $\Delta t < 15$  mins (=scan period)  
 $|\theta| < 15^\circ$  (Incidence angle)  
 $\Delta\theta < 2^\circ$  (Incidence angle diff.)  
**5x5** MSG pixels / IASI iFoV

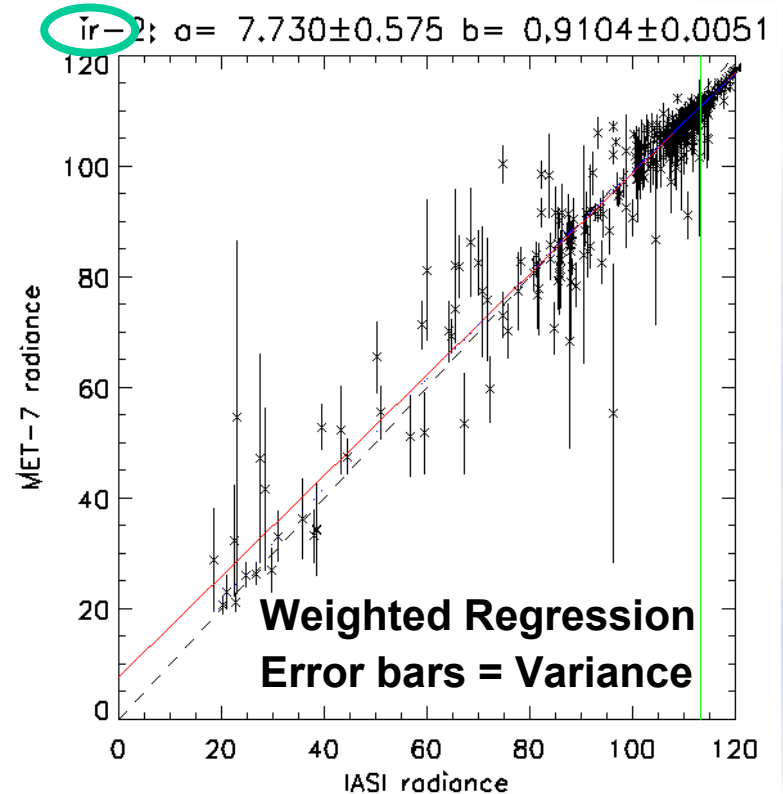
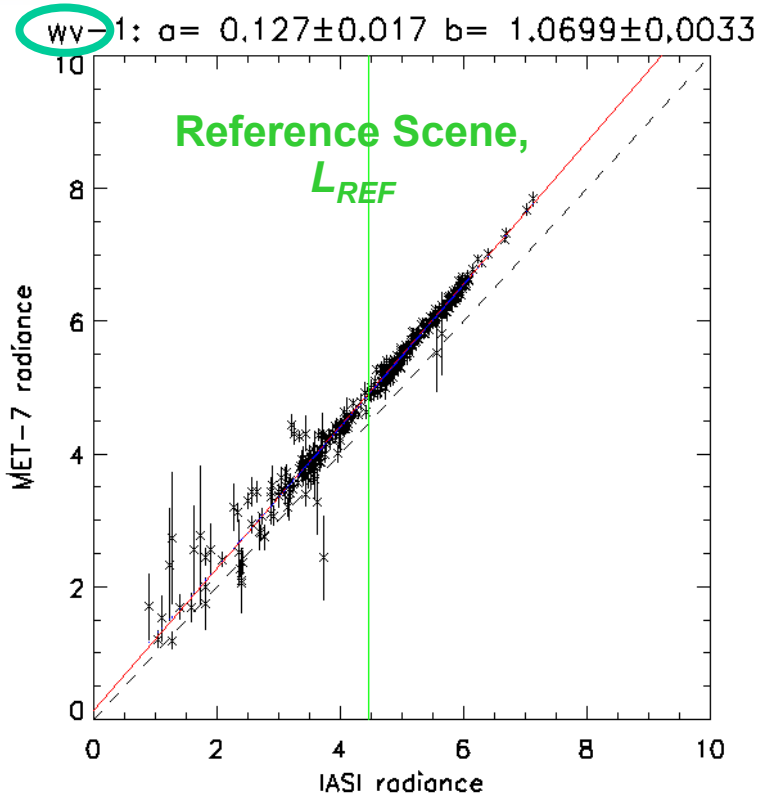
(Corrected Radiance Definition)

Can investigate temporal variability and angular dependence further using Rapid Scan data



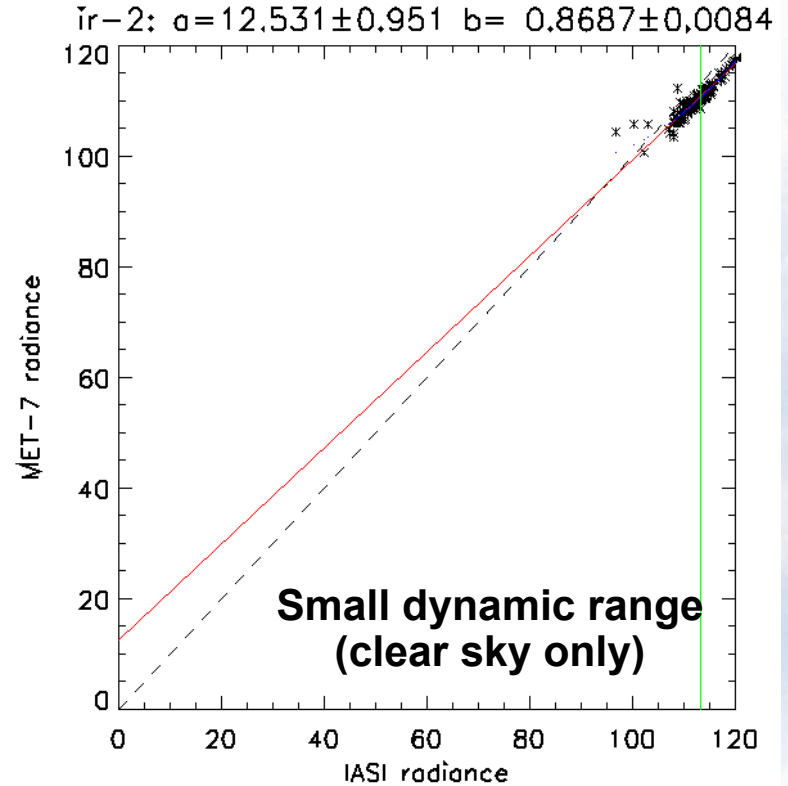
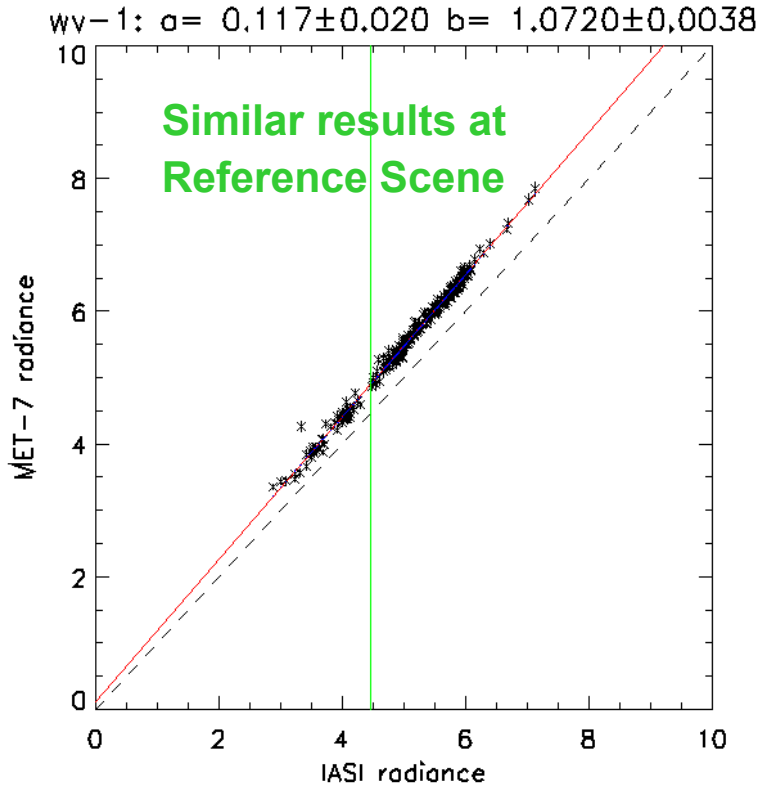
# Regression – no filtering

Offset  $\neq 0$  Slope  $\neq 1$   $\Rightarrow$  Difference is scene-dependent



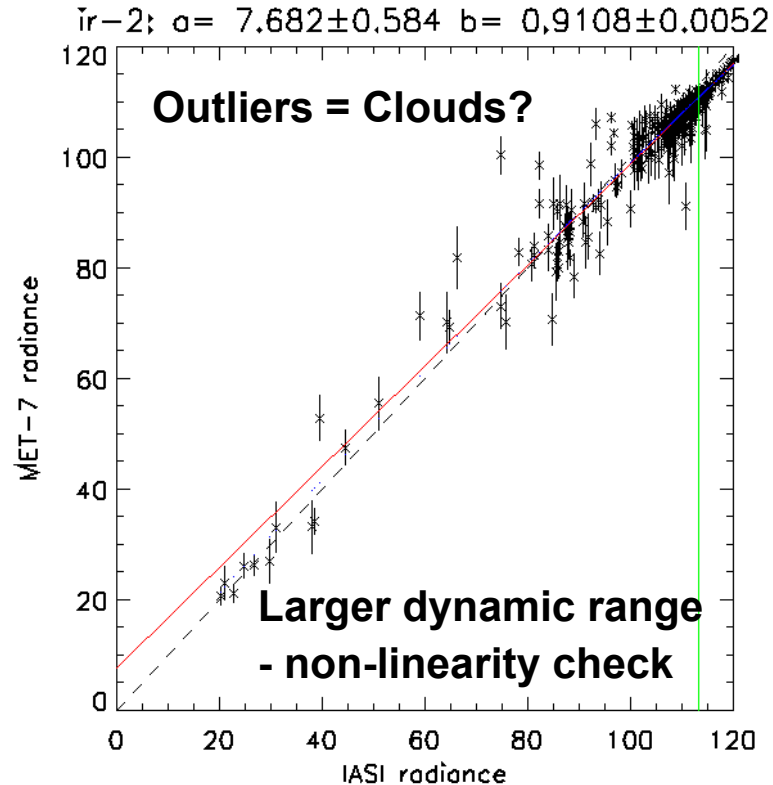
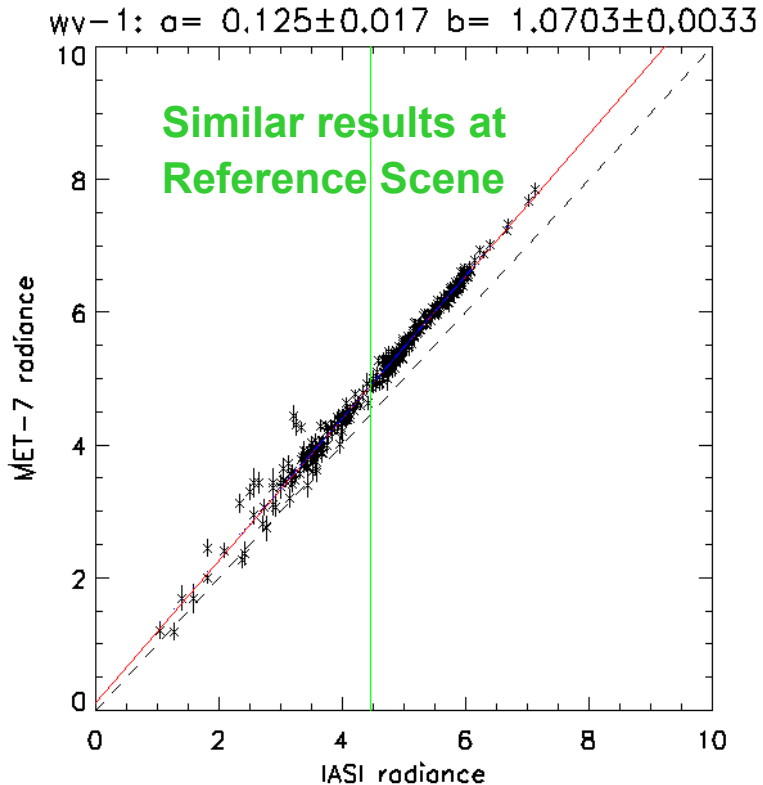


# Regression – $\sigma T_b < 0.5K$ filtering





# Regression – $\sigma L < 5\% L_{REF}$ filtering





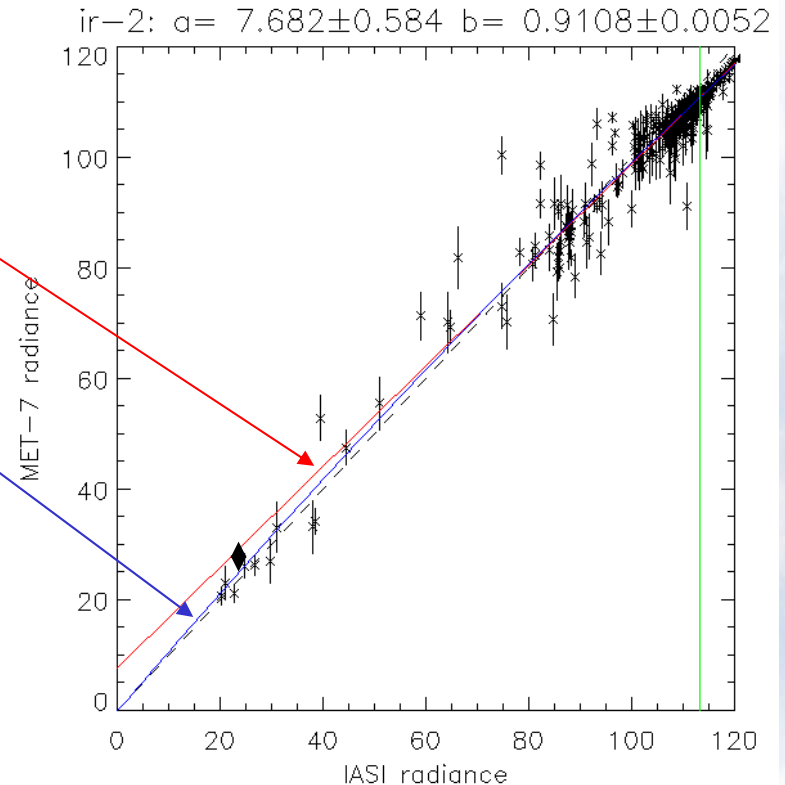
# Non-linearity

Compare **linear regression**  
with **quadratic fit**:

V. little difference at ref. scenes  
<0.05K

Difference increases for low  $T_b$   
As expected for non-linear errors  
Only significant for MSG 7.3 $\mu$ m  
channel and still <1K at  $T_b=220$ K

But differences are v. variable  
Error bars currently  
underestimated



# Accounting for Temporal Variability

Linearly interpolate SEVIRI radiances before and after IASI observation,  $L(t_b)$  and  $L(t_a)$ , to time,  $t_0$ :

$$L(t_0) = \left( \frac{t_0 - t_b}{t_a - t_b} \right) L(t_a) + \left( \frac{t_a - t_0}{t_a - t_b} \right) L(t_b)$$

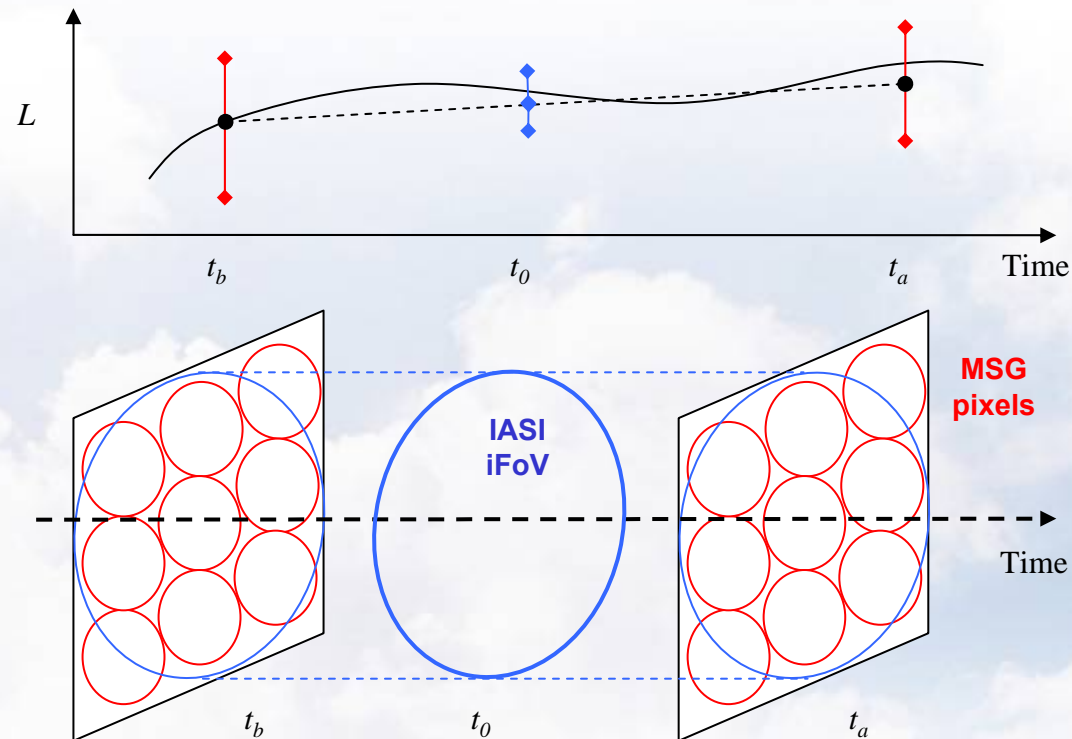
The variance of 2 groups  $m$  MSG pixels per IASI FoV:

$$S_0 = \frac{1}{2m-1} \left[ \begin{array}{l} (w_a^2 S_a + w_b^2 S_b) \\ + 2 \left\{ \begin{array}{l} (w_a L(t_a) - L(t_0))^2 \\ + (w_b L(t_b) - L(t_0))^2 \end{array} \right\} \end{array} \right]$$

Where  $S_b$  and  $S_a$  are the variances of the MSG pixels before and after the IASI observation and the weighting are given by:

$$w_b = \left( \frac{t_a - t_0}{t_a - t_b} \right) \quad w_a = \left( \frac{t_0 - t_b}{t_a - t_b} \right)$$

to linearly interpolate between observations at time  $t_b$  and  $t_a$ .



# Summary of Meteosat-IASI during 2007 (using original IMPF radiance definition)

Channel ( $\mu\text{m}$ )		3.9	6.2	7.3	8.7	9.7	10.8	12.0	13.4
Ref Scene $T_{bref}$ (K)		290	240	260	290	270	290	290	270
Meteosat-7	Mean Bias (K)		<b>+2.57</b>				<b>-1.63</b>		
	Std. Dev. (K)		0.12				0.19		
Meteosat-8	Mean Bias (K)	<b>0.46</b>	<b>0.56</b>	<b>0.77</b>	<b>0.22</b>	0.19	0.16	0.13	-0.13
	Std. Dev. (K)	0.09	0.08	0.18	0.09	0.14	0.07	0.07	0.16
Meteosat-9	Mean Bias (K)	<b>0.17</b>	<b>0.61</b>	<b>0.25</b>	0.02	0.00	0.03	0.05	<b>-1.63</b>
	Std. Dev. (K)	0.10	0.05	0.04	0.04	0.07	0.06	0.06	0.26

Brightness Temperatures,  $T_b$ , for Reference Scenes and Mean Difference between Meteosat and IASI during 2007.

Statistically significant (at >95% level) biases highlighted in **bold**.

# Meteosat-9 results Before and After new radiance definition & non-linearity corrections

Channel ( $\mu\text{m}$ )		3.9	6.2	7.3	8.7	9.7	10.8	12.0	13.4
Ref Scene $T_{\text{ref}}$ (K)		290	240	260	290	270	290	290	270
Meteosat-9 <b>BEFORE</b>	Mean Bias (K)	<b>0.17</b>	<b>0.61</b>	<b>0.25</b>	0.02	0.00	0.03	0.05	<b>-1.63</b>
	Std. Dev. (K)	0.10	0.05	0.04	0.04	0.07	0.06	0.06	0.26
New-Old (non-linear corr <sup>n</sup> )	Mean Bias (K)	<b>-0.14</b>	<b>-0.35</b>	<b>-0.11</b>	<b>-0.06</b>	-0.01	-0.01	-0.02	<b>0.29</b>
	Std. Dev. (K)	0.01	0.04	0.02	0.00	0.01	0.03	0.02	0.05
Meteosat-9 <b>AFTER</b>	Mean Bias (K)	0.03	-0.04	<b>0.14</b>	-0.04	-0.01	0.02	0.03	<b>-1.34</b>
	Std. Dev. (K)	0.10	0.06	0.04	0.04	0.07	0.07	0.06	0.26

Brightness Temperatures,  $T_b$ , for Reference Scenes and Mean Difference between Meteosat-9 and IASI during 2007.

**Before** and **after** reprocessing with new radiance definition and non-linearity corrections  
Statistically significant (at >95% level) biases highlighted in **bold** – only 7.3 and 13.4 $\mu\text{m}$



# Comparison with NWP bias monitoring

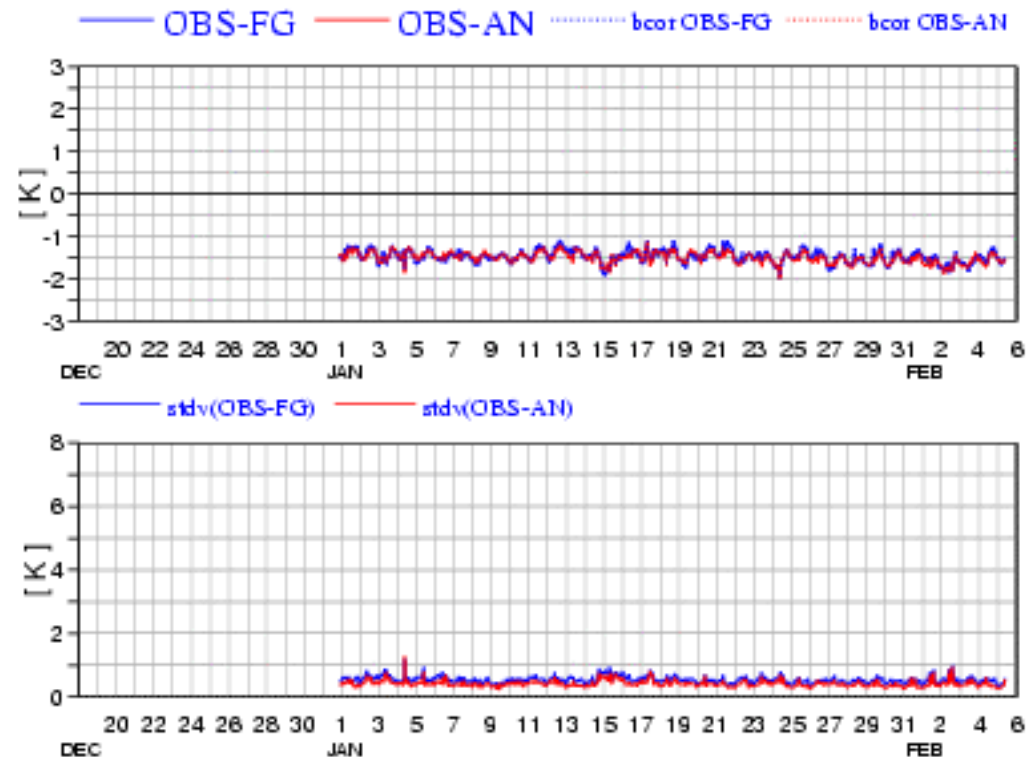
- Part of Assimilation cycle:
- Systematic comparison of observations with NWP model
- FG = First Guess
- AN = Analysis
- Mean difference + Std Dev.
- Can break-down by:
  - Geographic area
  - Scan angles
  - Time of Day
  
- Compare with inter-calibration
- BUT includes NWP errors

## Statistics for Radiances from MET-9 / CSR

Channel = IR13.4, Selected data: clearIR = 100%

Area: lon\_w= 0.0, lon\_e= 360.0, lat\_n= 20.0, lat\_s= -20.0 (over sea)

EXP = 0001



Example from ECMWF website



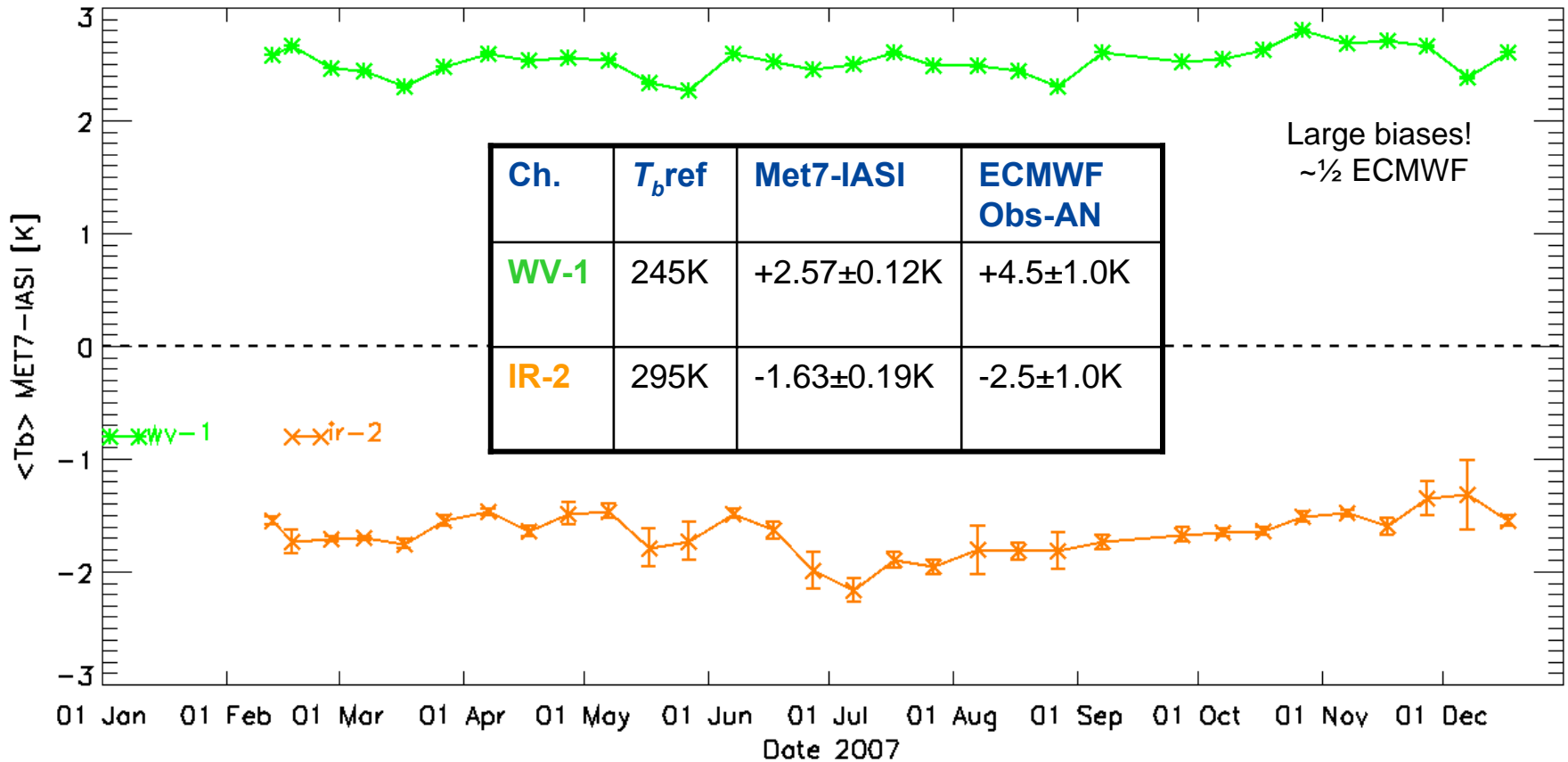


# ECMWF bias monitoring for AIRS & IASI

Channel ( $\mu\text{m}$ )	<AIRS-FG> (K)	<IASI-FG> (K)
14.98	<b>-3.3</b>	<b>&lt;-2</b>
14.33	-0.3	-0.1
14.03	-0.3	0.0
10.90	-0.6	-0.1
9.622	+0.1	<b>-1.6</b>
8.840	-0.3	-0.5
7.513	-0.1	-0.1
7.130	+0.8	-0.2
6.426	<b>&gt;+2</b>	+0.1
4.426	+0.9	+0.6
4.186	<b>+1.5</b>	+0.4
4.175	-0.5	-0.5
4.013	<b>+1.1</b>	+0.6

- Jan 2008
- Tropics, Clear Skies over Sea
- Day and night
  - But different orbits!
- Mean OBS-FG estimated
  - Same AIRS-IASI channels
- Significant biases (>95%) shown in bold:
  - 4 channels for AIRS
  - 2 channels for IASI

# MVIRI on Meteosat-7 – IASI on Metop



Time series of brightness temperature differences between Met7-IASI for typical clear-sky radiances: Each Met7 infrared channel is shown in a different color, with different symbols, following the legend. Error bars represent statistical uncertainty on each mean bias (may be very small).



# EUMETSAT Inter-calibration Plans: 2008

## **IASI – Meteosat intercalibration:**

**Investigate impact of MSG radiance definition**

**Include temporal variability in error propagation**

**Investigate angular dependence using Rapid Scan at ~40°N**

**Compare with NWP bias monitoring statistics**

**Assess collocation requirements – WV, window, O<sub>3</sub> channels**

## **Extend inter-calibration to HIRS:**

**Compare HIRS/4-IASI on Metop-A**

**Compare HIRS-Meteosat-8 and -9**

**Build-up time series with older HIRS and MVIRI**

## **Set-up GSICS Data and Products server**