EUMETSAT Meteosat-IASI Inter-calibration Algorithm

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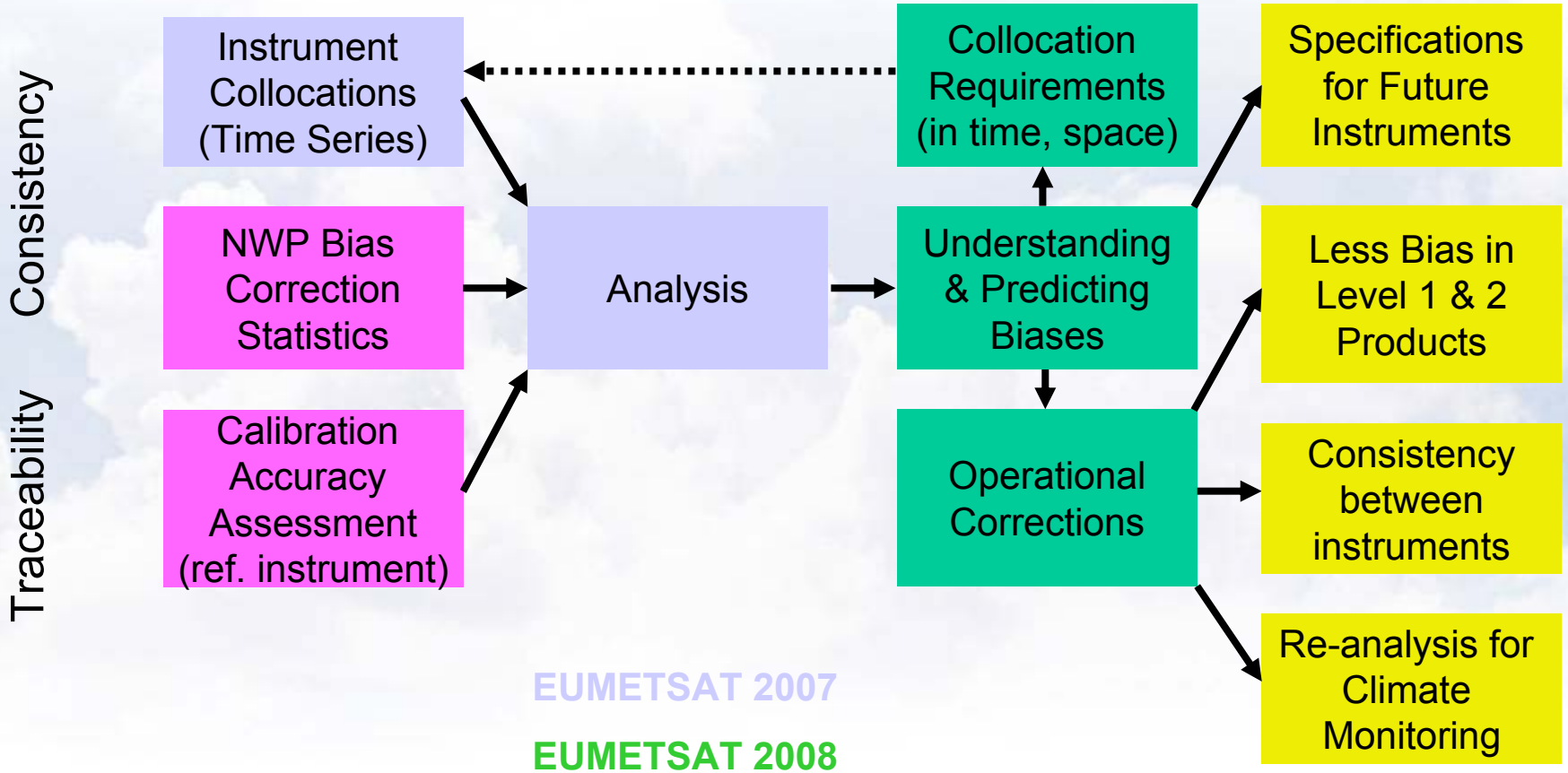
Inter-calibration Strategy

Principles Methodology Results Benefits



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Liaisons 2008

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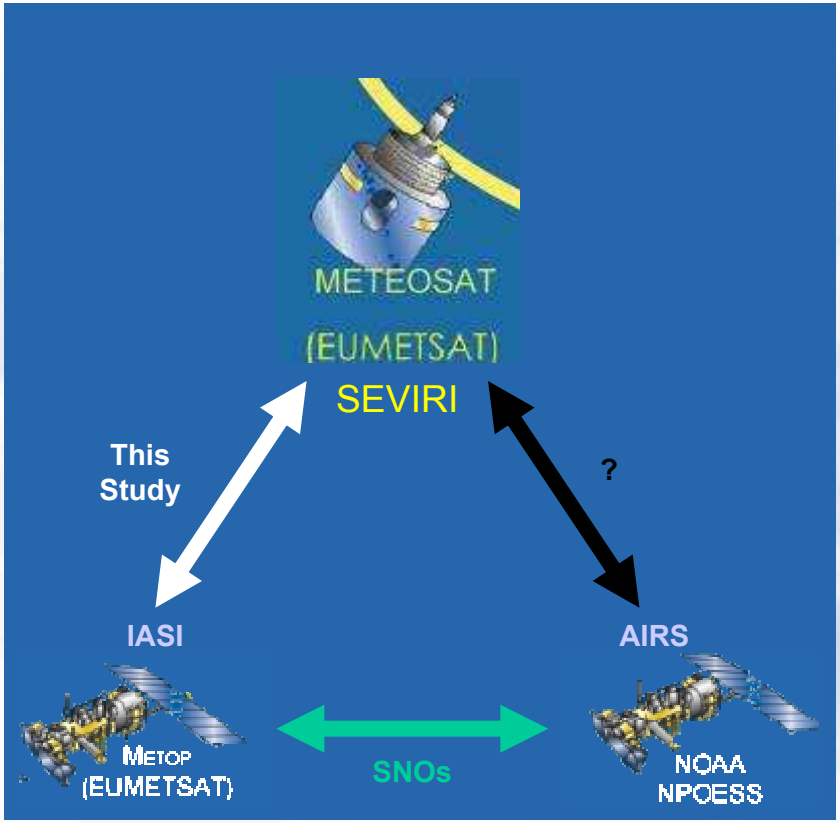
IASI and/or AIRS as a reference?

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)



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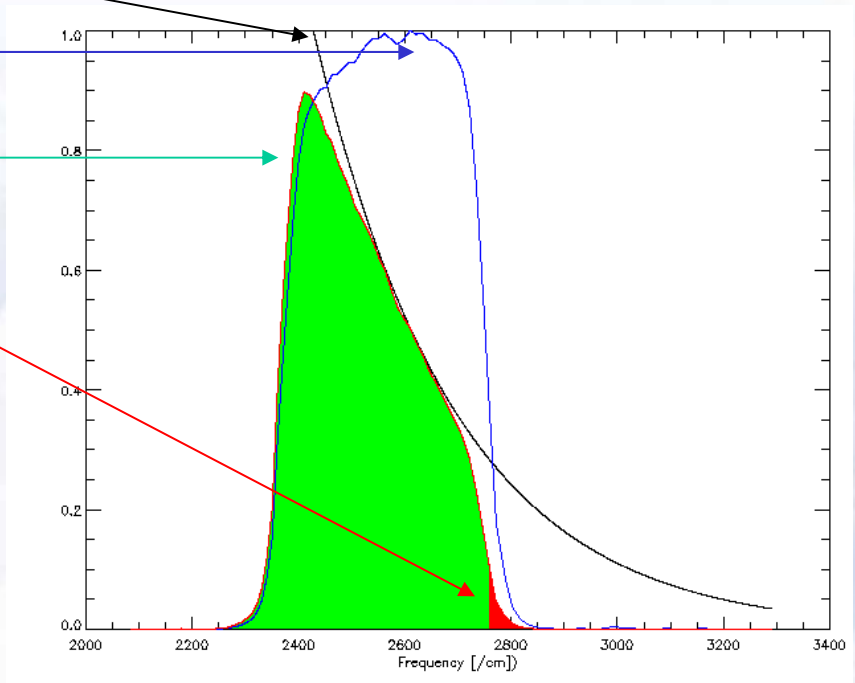
Missing Energy in MSG 3.9 µm channel

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 2760cm^{-1}
Convert to Brightness Temperatures



Result:

IASI under-estimates MSG 3.9µm radiance by 1.33% of scene radiance, or ~0.17K at 290K (Scene-dependent)

Not accounted for in analysis

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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

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

Meteosat Second Generation

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

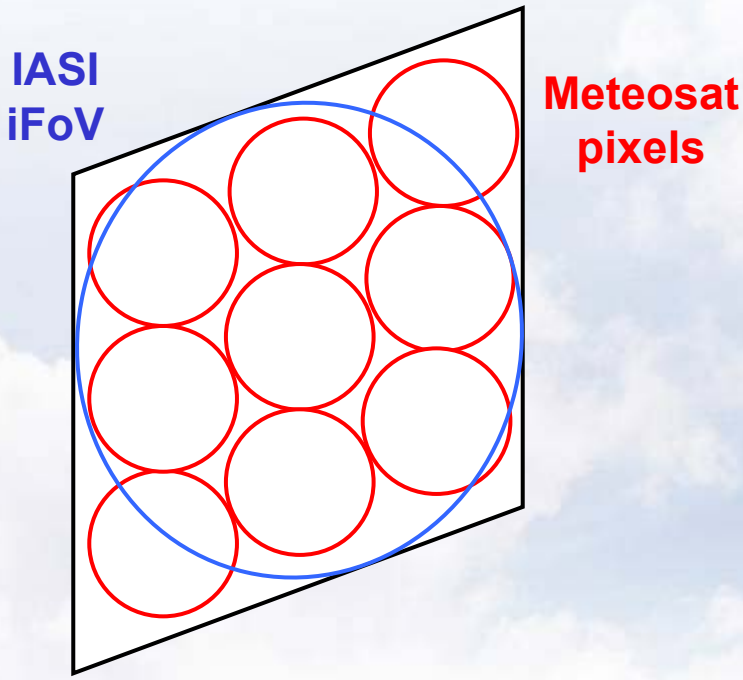
(Corrected Radiance Definition)

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

Uncertainty due to Spatial Variability

Estimate uncertainty due to spatial variability as Standard Deviation of Meteosat pixels within collocated IASI iFoVs

Use as error bars in weighted regression



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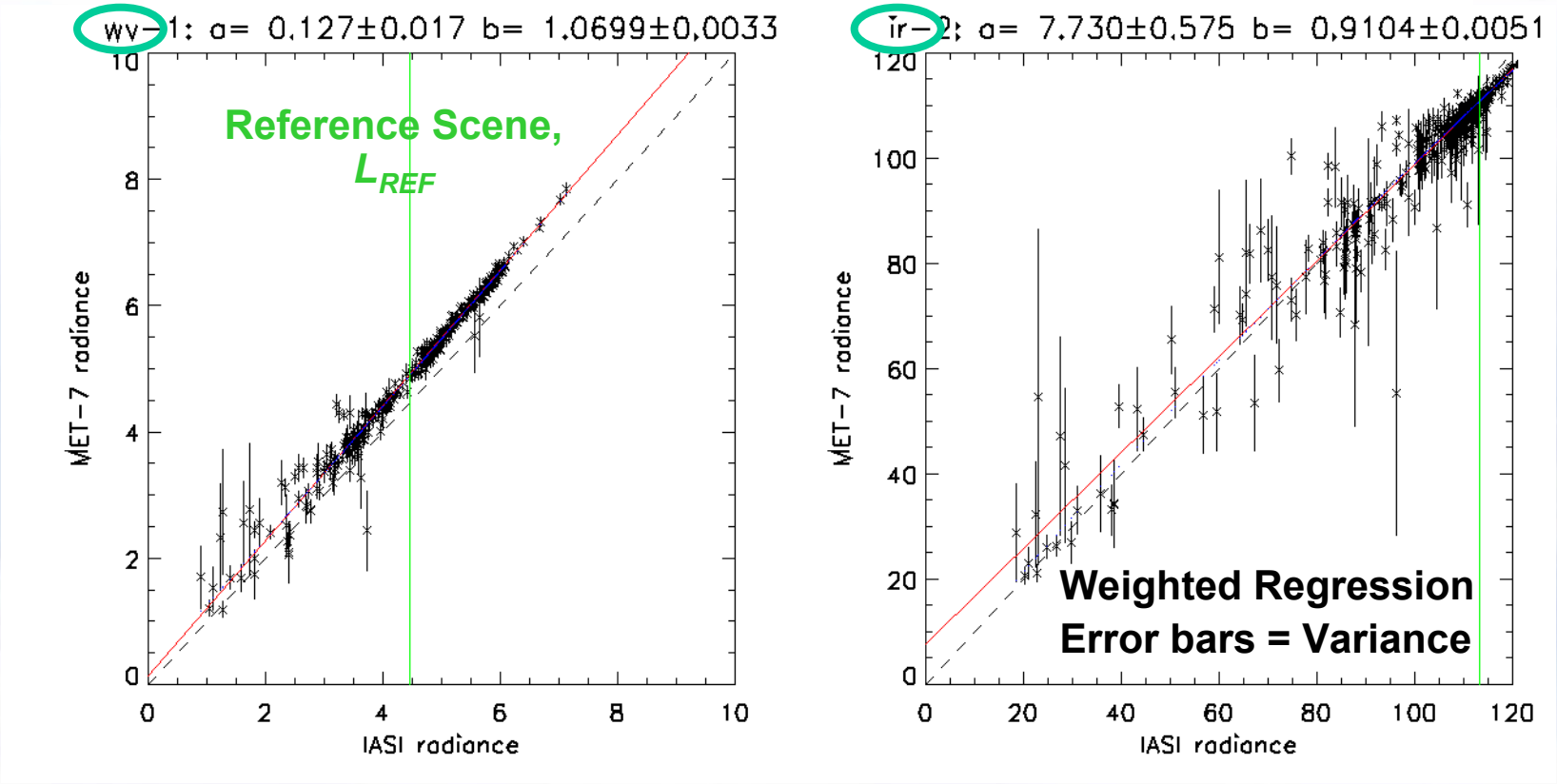
Regression – no filtering

Offset ≠ 0 Slope ≠ 1 => Difference is scene-dependent



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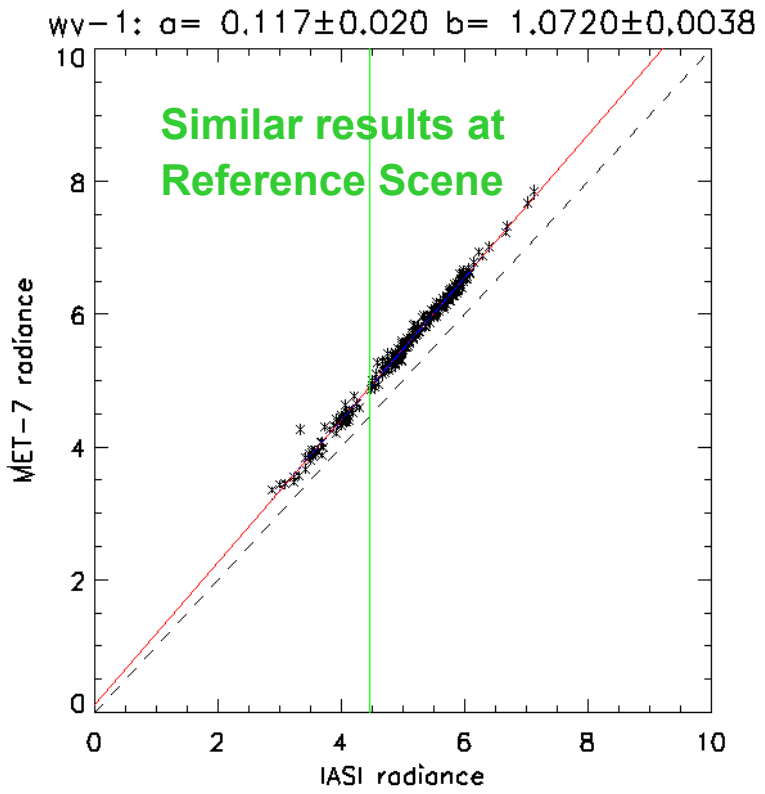
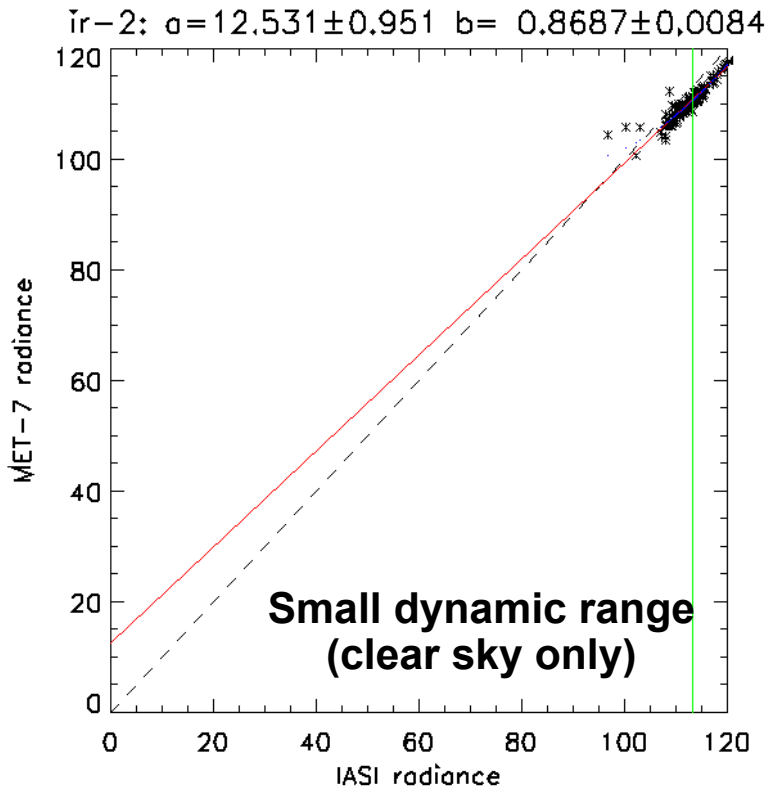
Regression – σT_b<0.5K filtering





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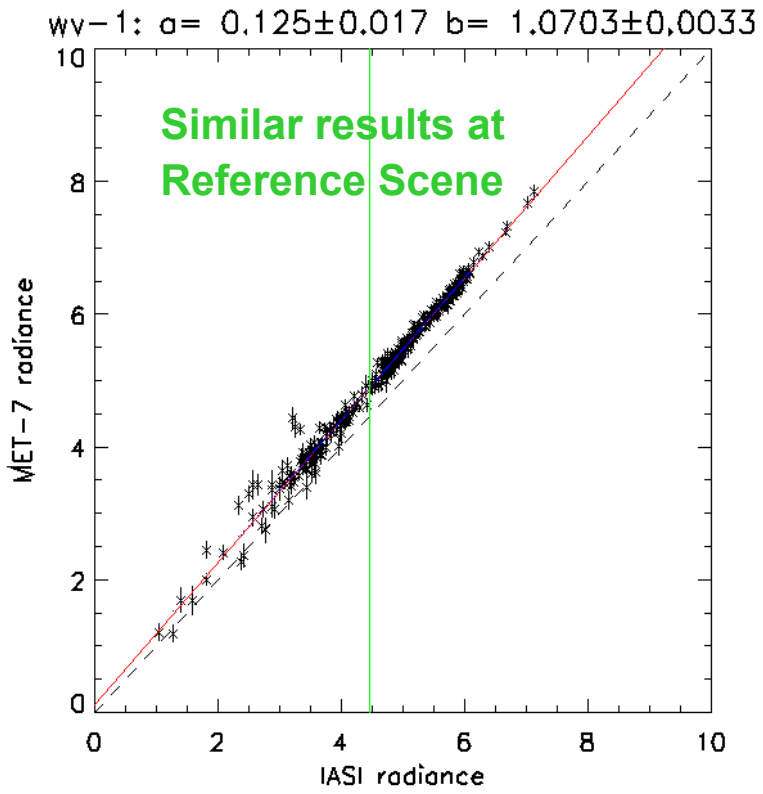
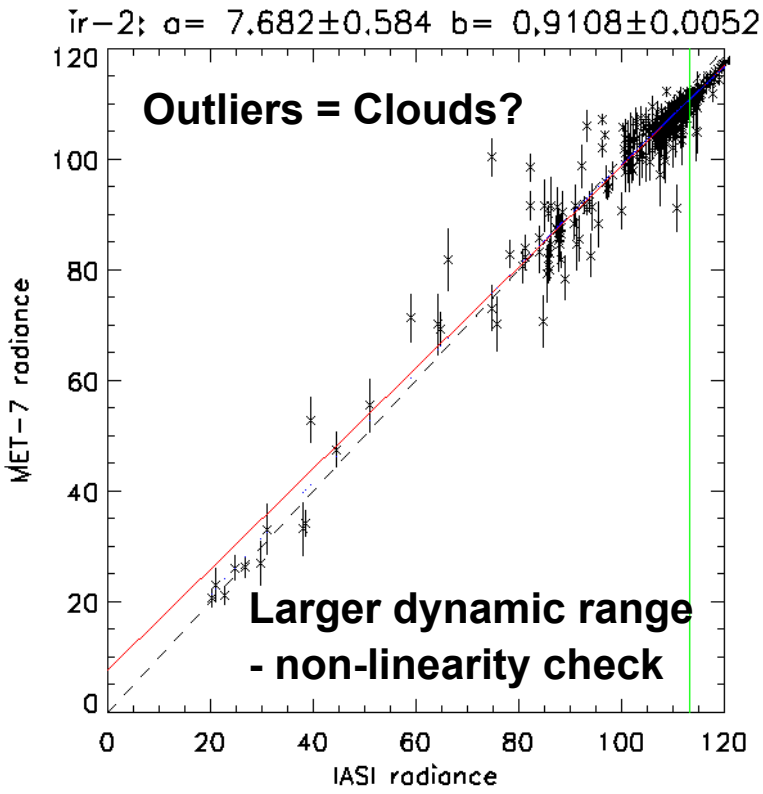
Regression – σL<5%L_{REF} filtering





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Non-linearity

Compare linear regression with quadratic fit:

V. little difference at ref. scenes <0.05K

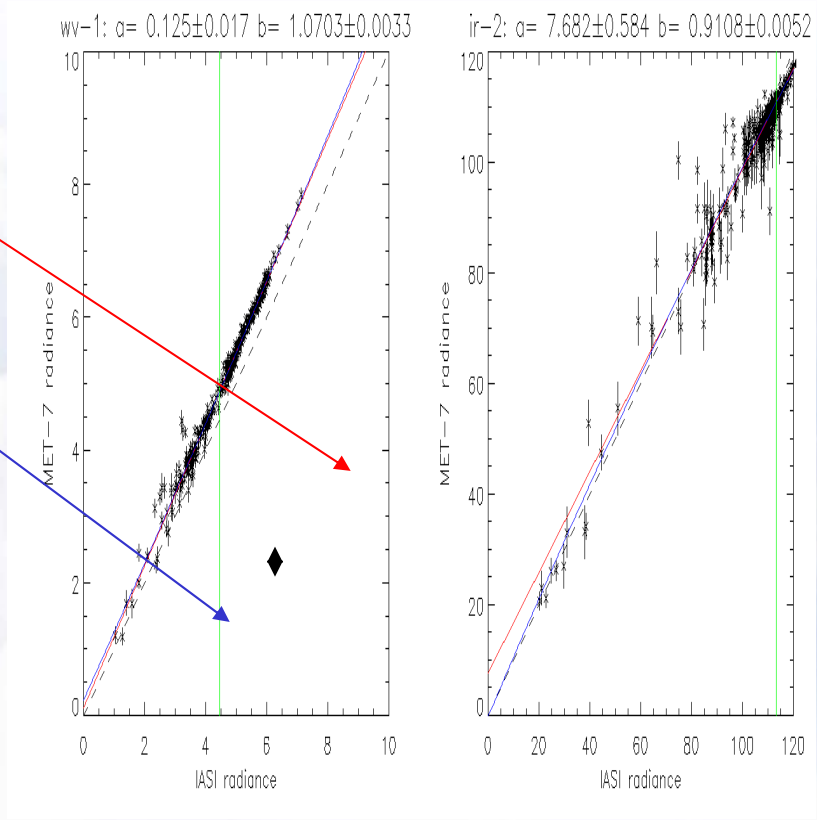
Difference increases for low T_b

As expected for non-linear errors

Only significant for MSG 7.3µm channel and still <1K at T_b=220K

But differences are v. variable

Error bars currently underestimated



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Accounting for Temporal Variability

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

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

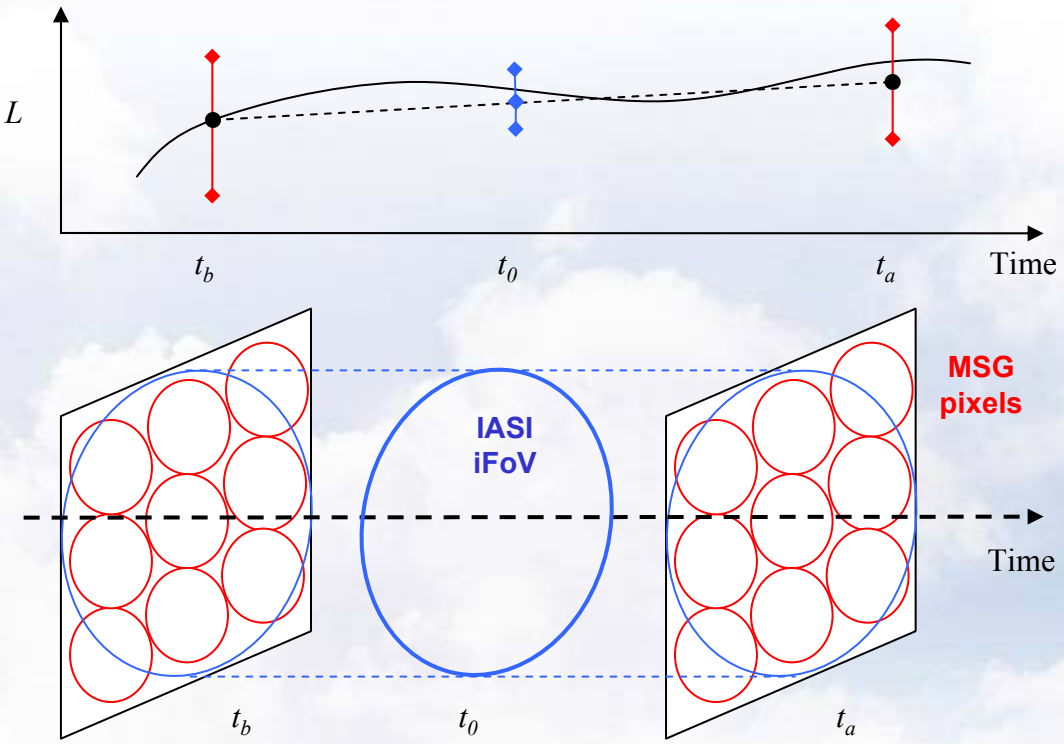
The variance of 2 groups m MSG pixels per IASI FoV:

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

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:

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

to linearly interpolate between observations at time t_b and t_a.



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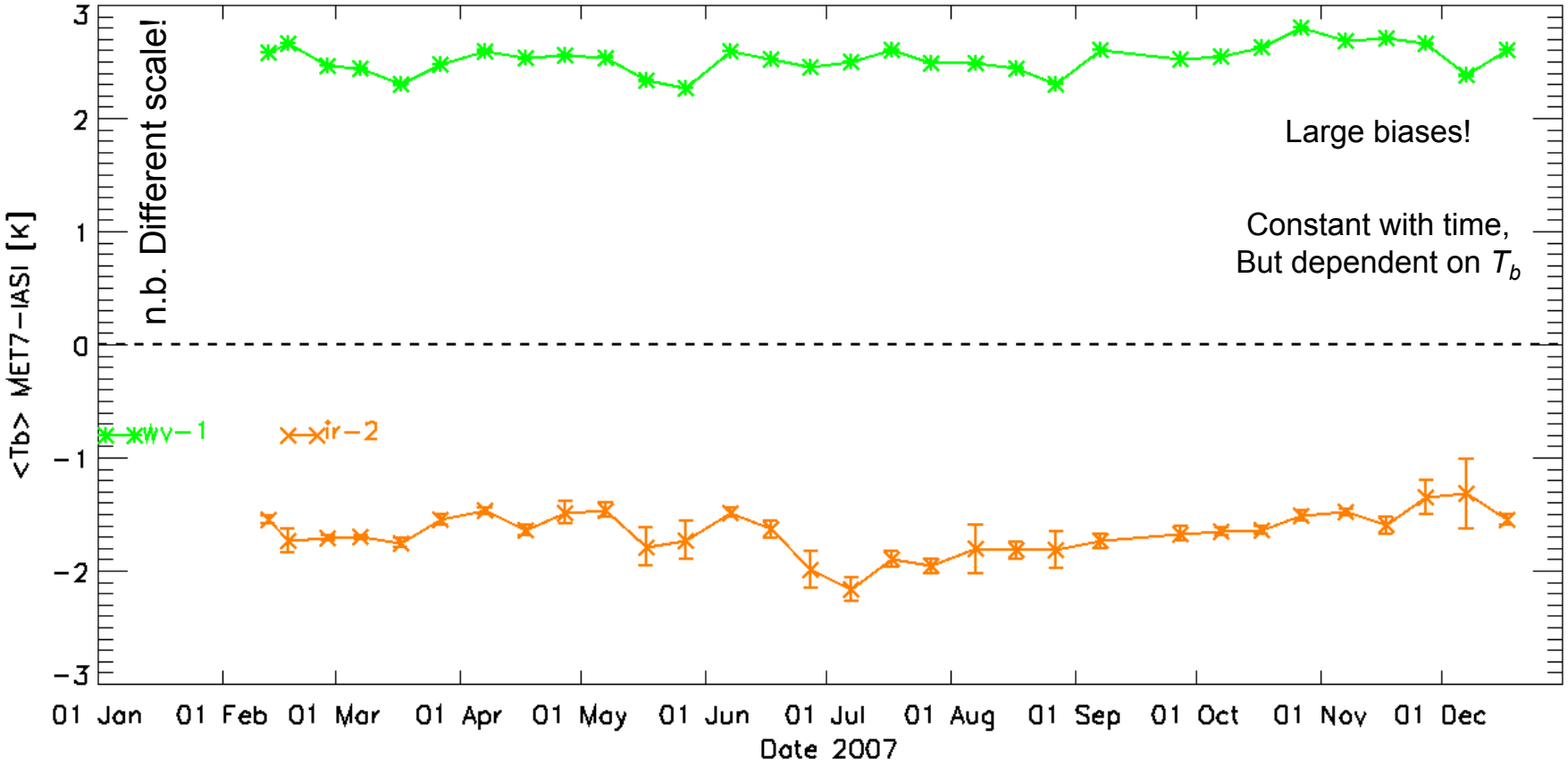
MVIRI on Meteosat-7 – IASI on Metop



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).

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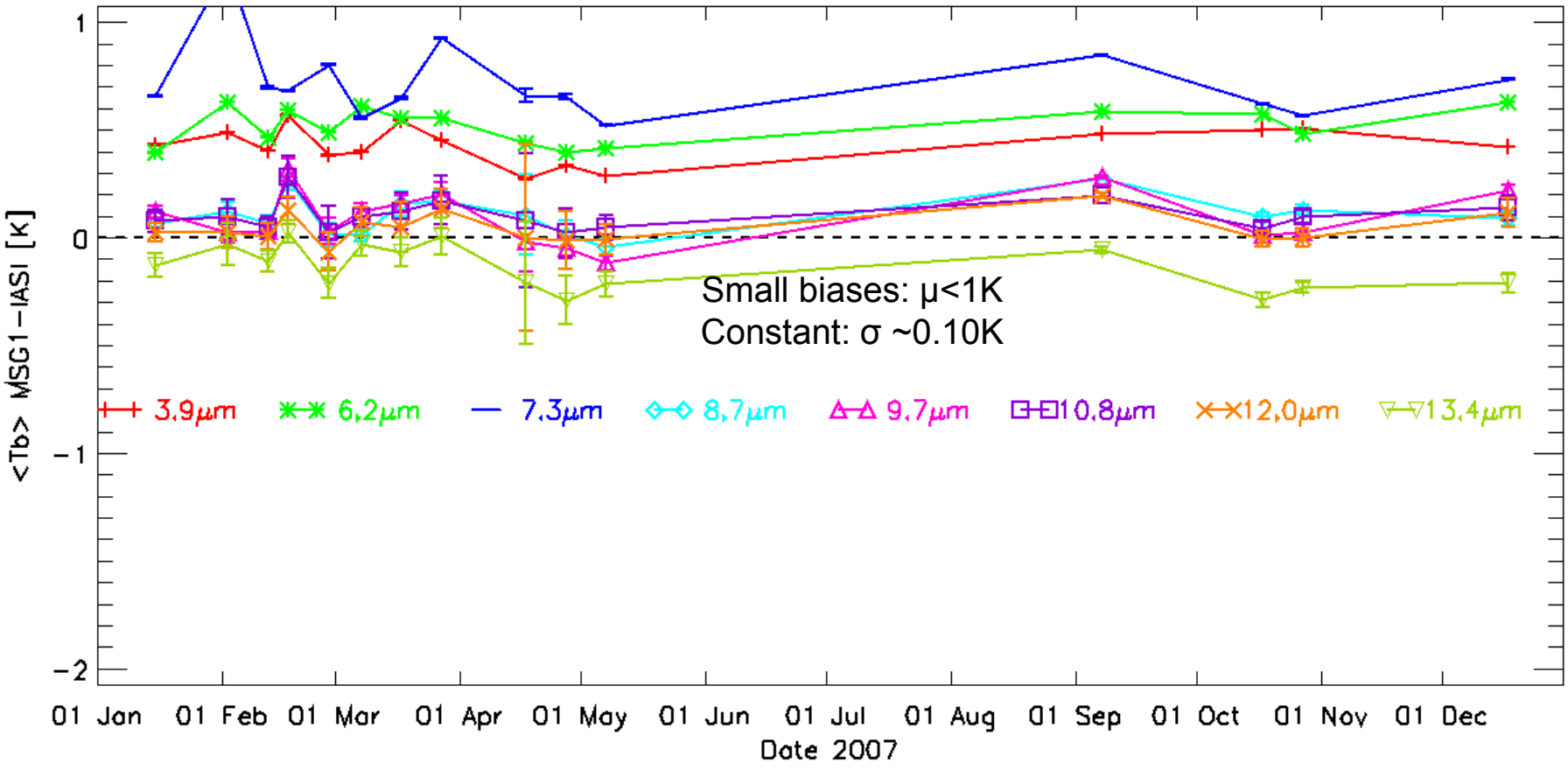
SEVIRI on Meteosat-8 – IASI on Metop



Time series of brightness temperature differences between MSG1-IASI for typical clear-sky radiances. Each MSG 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).

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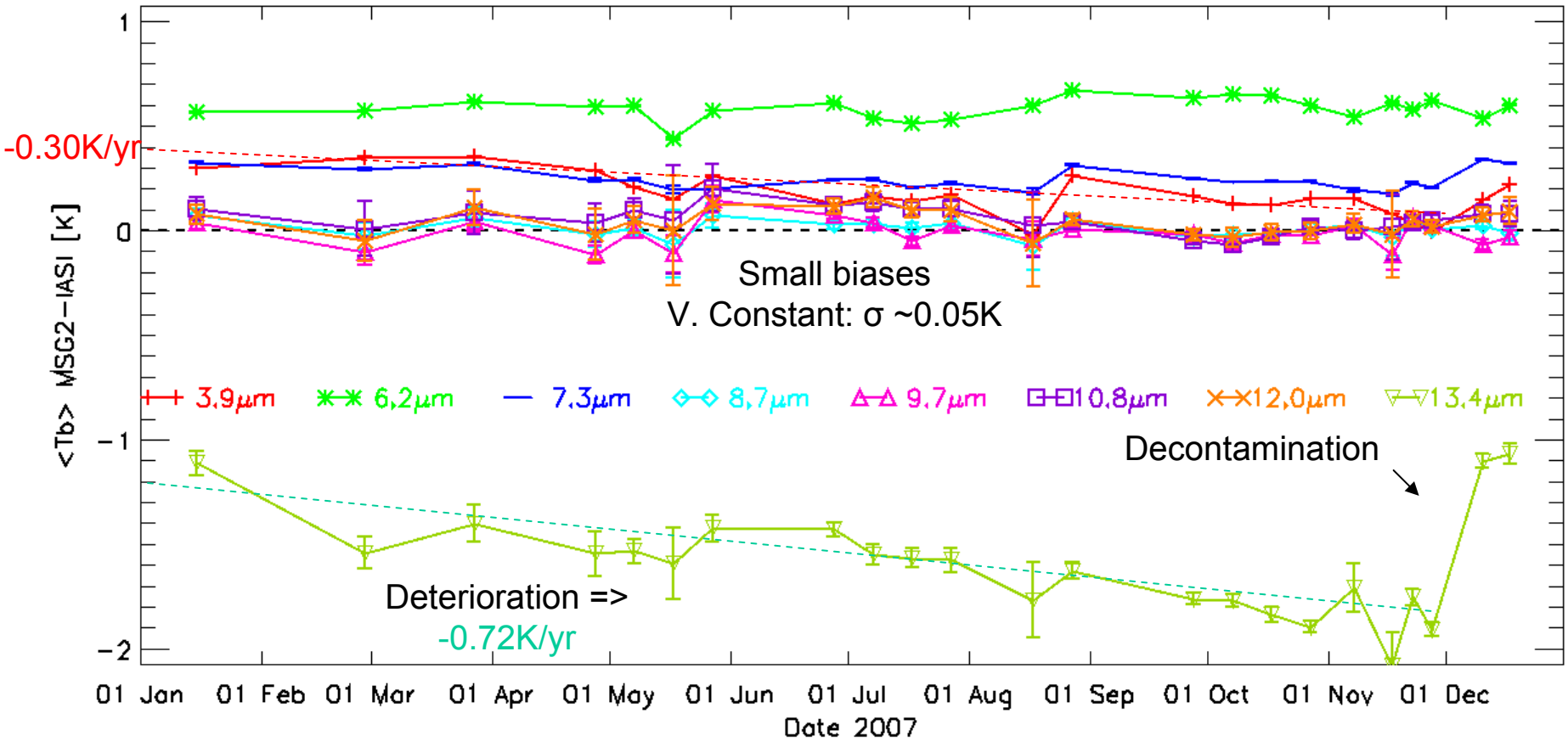
SEVIRI on Meteosat-9 – IASI on Metop



Time series of brightness temperature differences between MSG2-IASI for typical clear-sky radiances. Each MSG 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).

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Contamination of MSG2 13.4μm filter

Possible explanation:

Build-up of ice on filter

Use spectral response function of different thickness ice

To modify 13.4μm channel's nominal SRF

Repeat IASI comparison for each case

Test contaminated/nominal ratio is consistent with trend

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

Channel (μm)		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)		**+2.57**				**-1.63**		
	Std. Dev. (K)		0.12				0.19		
Meteosat-8	Mean Bias (K)	**0.46**	**0.56**	**0.77**	**0.22**	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)	**0.17**	**0.61**	**0.25**	0.02	0.00	0.03	0.05	**-1.63**
	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 (μm)		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-9 **BEFORE**	Mean Bias (K)	**0.17**	**0.61**	**0.25**	0.02	0.00	0.03	0.05	**-1.63**
	Std. Dev. (K)	0.10	0.05	0.04	0.04	0.07	0.06	0.06	0.26
New-Old (non-linear corr^{n})	Mean Bias (K)	**-0.14**	**-0.65**	**-0.11**	**-0.06**	-0.01	-0.01	-0.02	**0.29**
	Std. Dev. (K)	0.01	0.04	0.02	0.00	0.01	0.03	0.02	0.05
Meteosat-9 **AFTER**	Mean Bias (K)	0.03	-0.04	**0.14**	-0.04	-0.01	0.02	0.03	**-1.34**
	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 13.4μm

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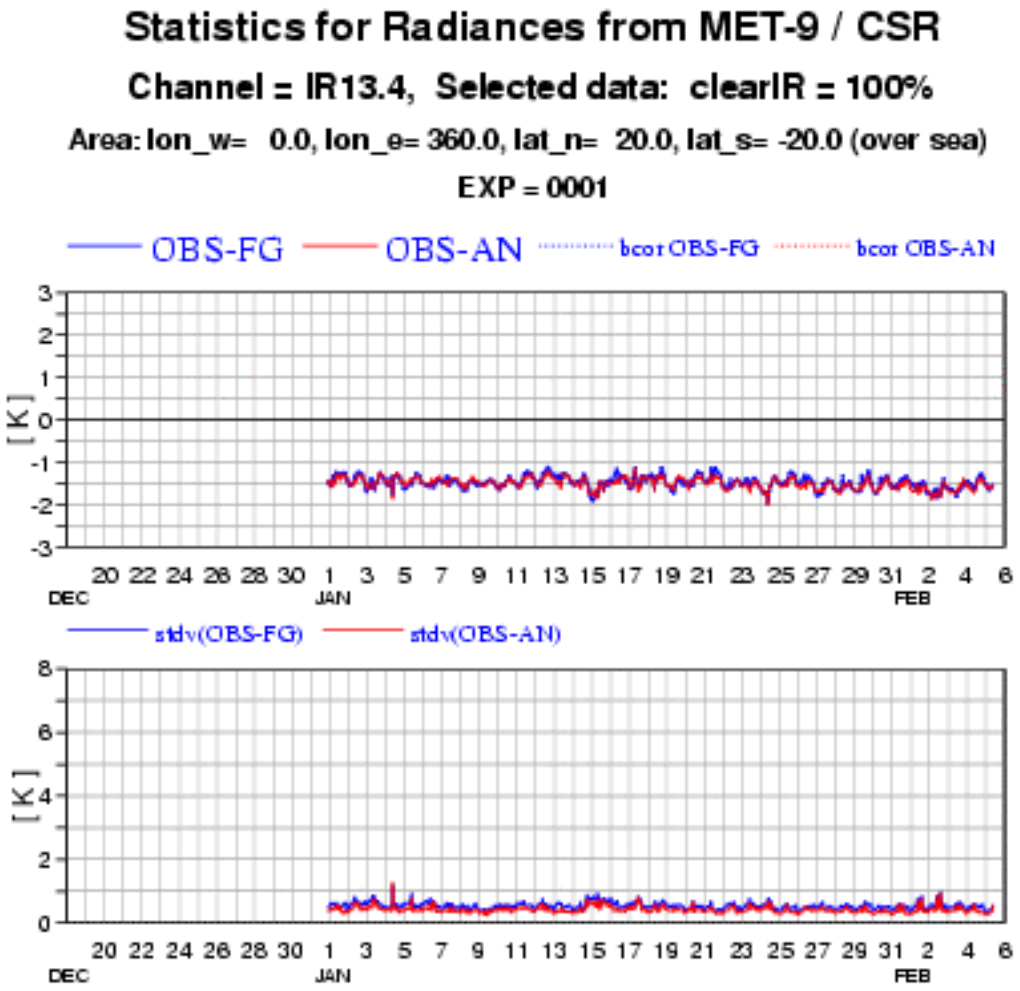
Comparison with NWP bias monitoring

- 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



Example from ECMWF website

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ECMWF bias monitoring for AIRS & IASI

Channel (μm)	<AIRS-FG> (K)	< IASI-FG> (K)
14.98	**-3.3**	**<-2**
14.33	-0.3	-0.1
14.03	-0.3	0.0
10.90	-0.6	-0.1
9.622	+0.1	**-1.6**
8.840	-0.3	-0.5
7.513	-0.1	-0.1
7.130	+0.8	-0.2
6.426	**>+2**	+0.1
4.426	+0.9	+0.6
4.186	**+1.5**	+0.4
4.175	-0.5	-0.5
4.013	**+1.1**	+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**

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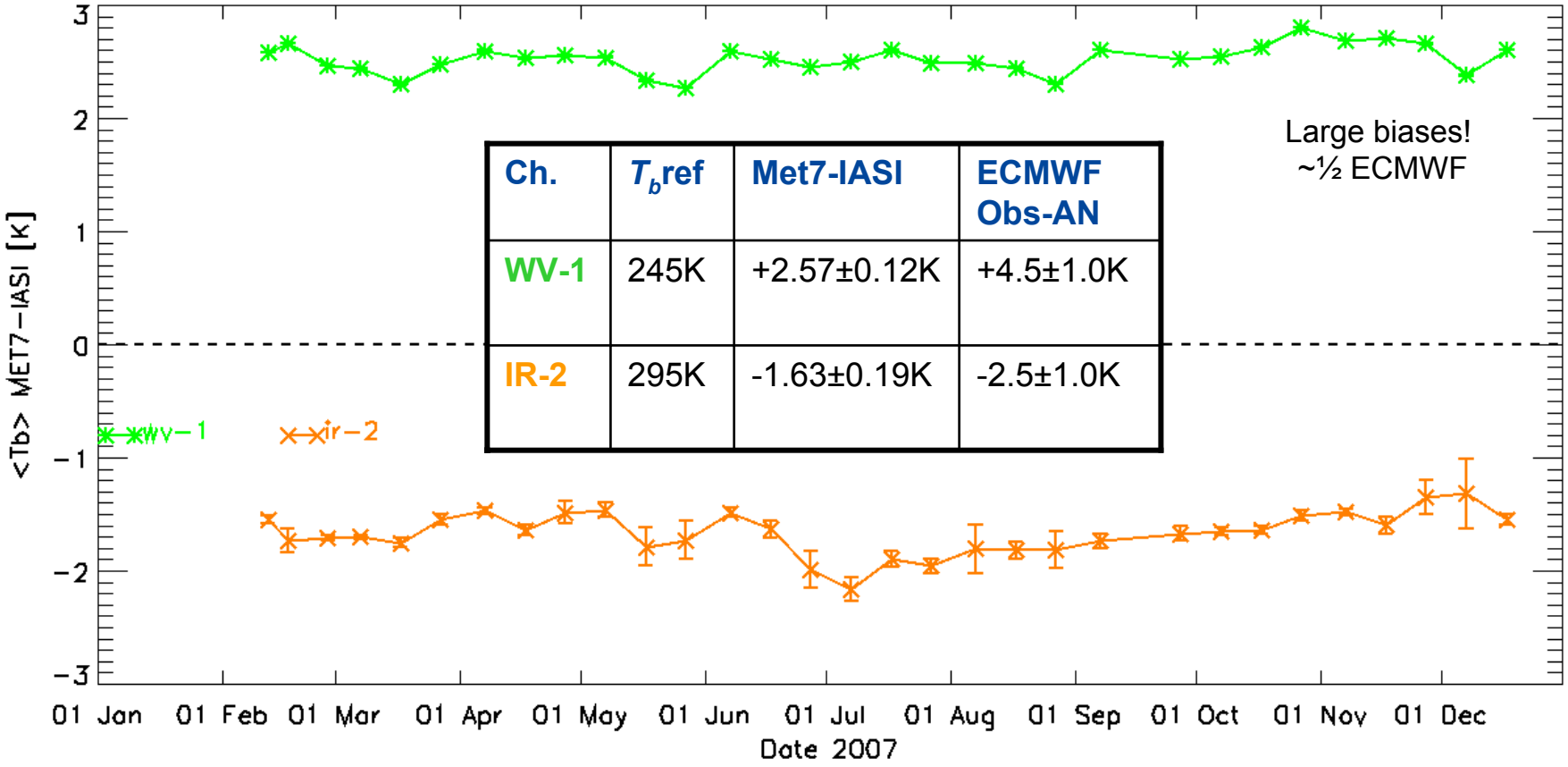
MVIRI on Meteosat-7 – IASI on Metop



Ch.	$T_b$ref	Met7-IASI	ECMWF Obs-AN
WV-1	245K	+2.57±0.12K	+4.5±1.0K
IR-2	295K	-1.63±0.19K	-2.5±1.0K

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).

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EUMETSAT Inter-calibration Plans: 2008

IASI – Meteosat intercalibration:

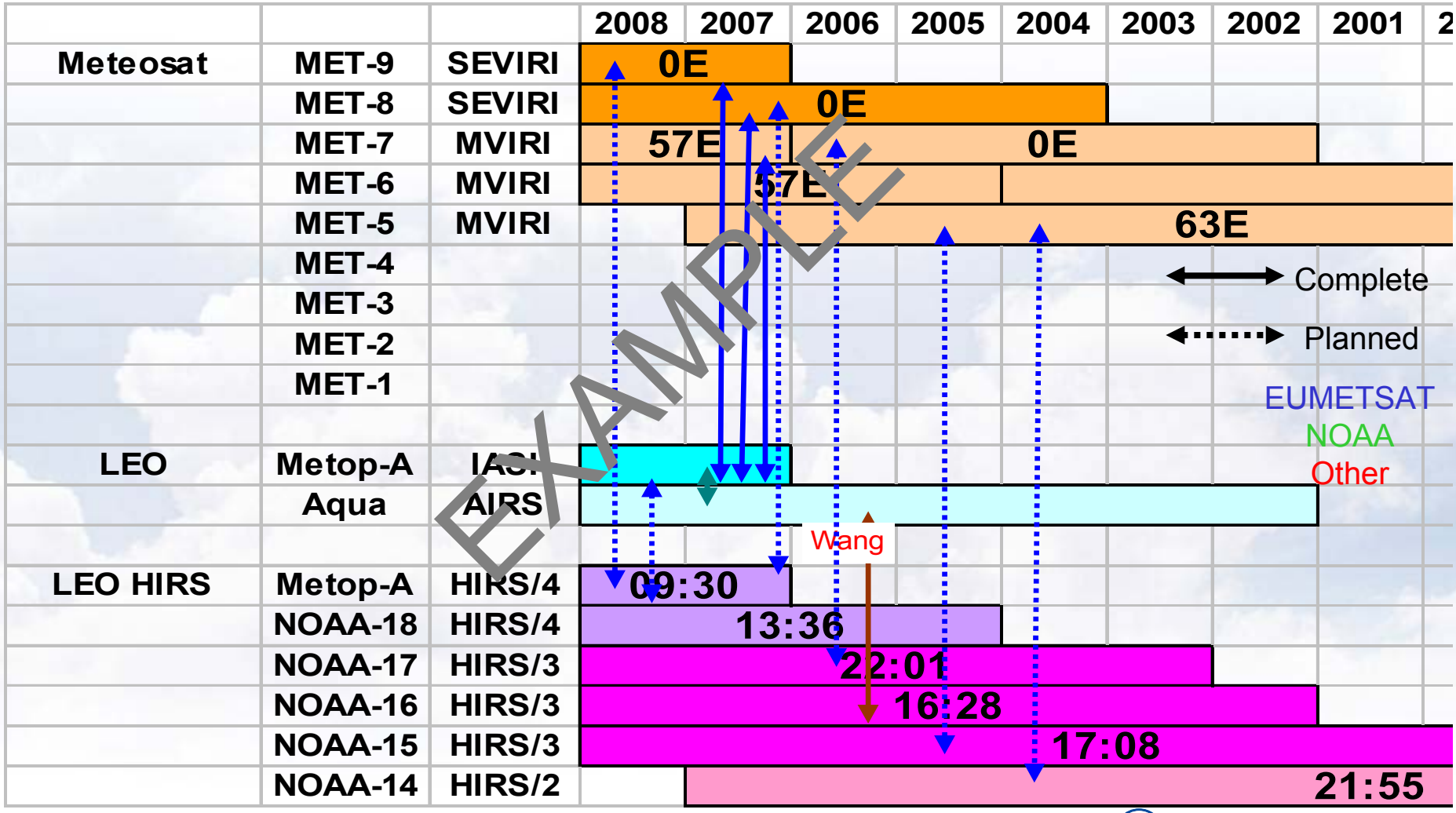
- Investigate impact of MSG radiance definition
- Include temporal variability in error propagation
- Investigate angular dependence using Rapid Scan at ~40°N
- Compare with NWP bias monitoring statistics
- Assess collocation requirements – WV, window, O_3 channels

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

Coordinating Inter-calibration Activities



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