UPDATE on: Consistency for water vapour of GRUAN, LBLRTM and IASI

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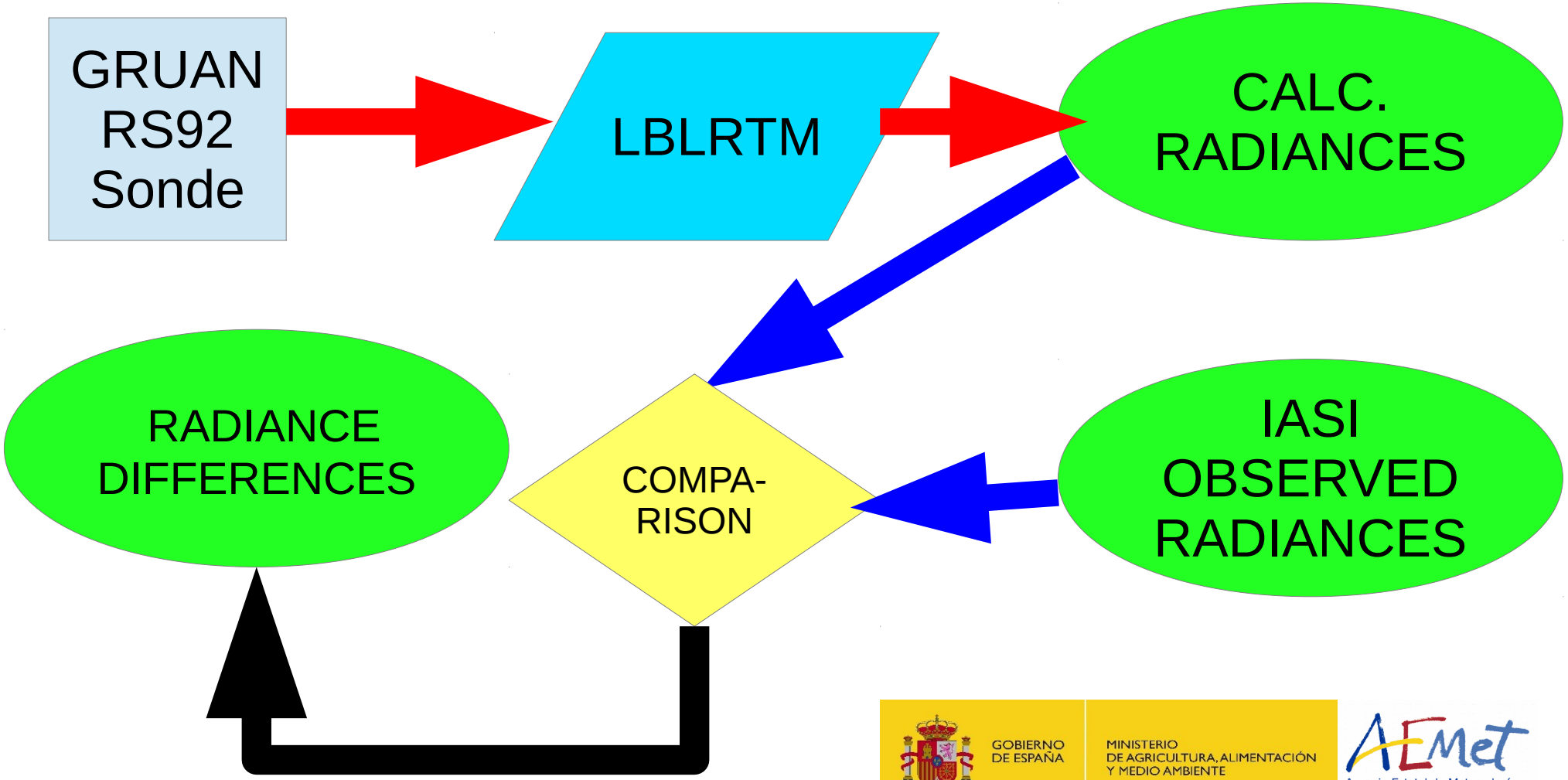
Paper in press:

Calbet, X., Peinado-Galan, N., Ripodas, P., Trent, T., Dirksen, R., and Sommer, M.: Consistency between GRUAN sondes, LBLRTM and IASI, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2016-344, in review, 2016.

13 June 2017

GRUAN ICM-9 2017

PRINCIPLE



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Why consistency?

1. Important for climate: transforming FCDR (e.g. Radiances) into CDR of ECV (T, WV, etc.) should measure the same
2. Important for validation: if GRUAN, LBLRTM and IASI are not consistent → collocation uncertainties too high to compare reasonably (Calbet, 2015, AMTD)

GRUAN

1. GRUAN stands for GCOS Reference Upper-Air Network
2. Are providing uncertainties with the measurements
3. They have also made a great effort to reduce systematic errors from the measurements → Humidity measurements are very much bias free

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IASI

1. IASI is a Reference for GSICS (Global Space-based Inter-calibration System)
2. “Very stable” and “highly accurate” instrument

LBLRTM

1. LBLRTM (11.2) is one of the references for RTM

GCOS Requirements

Variable/ Parameter	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Accuracy	Stability
Total column-water vapour	25km	N/A	4h	2%	0.3%
Tropospheric and lower-stratospheric profiles of water vapour	25km (troposphere) 100-200km (stratosphere)	2km	4h (troposphere) daily (stratosphere)	5%	0.3%
Upper-tropospheric humidity	25km	N/A	1h	5%	0.3%

From GCOS-154: Accuracy for WV 5%

Are GRUAN and IASI consistent?

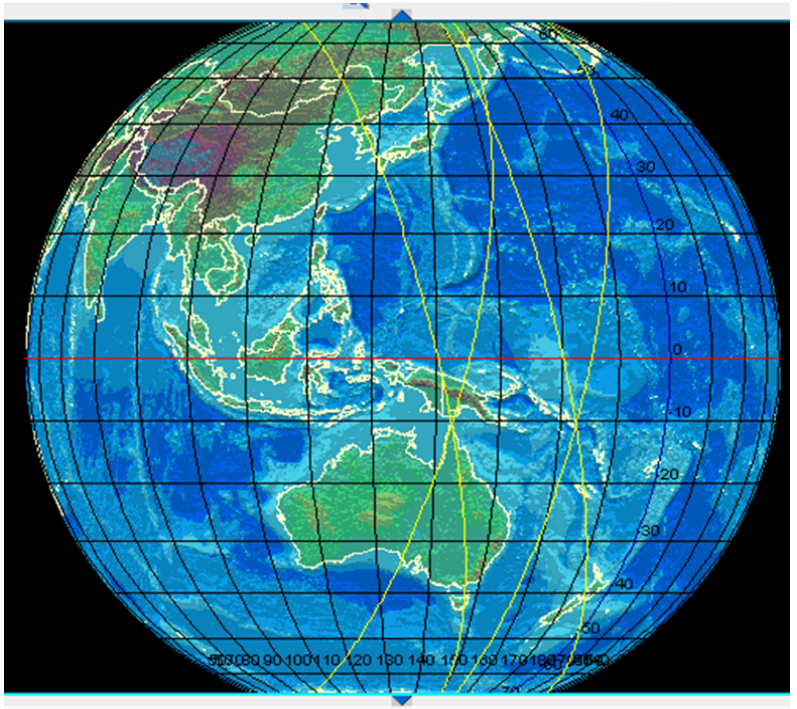
Immler et al. 2010:

$$|m_1 - m_2| < k\sqrt{\sigma^2 + u_1^2 + u_2^2}$$

k ≃ 2

GRUAN and IASI Collocation (minimum σ^2)

- Orbits close to 00Z and 12Z
- IASI FOVs less than 25 km and 30 min (Pugatchev et al. 2009 ACP) apart for Manus Island 2011-2013: 76 Clear Sky cases found



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	HIRS	HIRxxx1B	2011/06/05 02:09:56	2011/06/05 03:54:54
	HIRS	HIRxxx1B	2011/06/05 03:54:54	2011/06/05 05:36:59

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Consistency check

- Observed IASI radiances (OBS) are compared to
- Calculated radiances (CALC) using GRUAN Sonde profile + Radiative Transfer Model (LBLRTM 12.2)
- Radiance Uncertainties calculated varying GRUAN Sonde with its uncertainties using a Monte-Carlo approach.
- But assuming GRUAN uncertainties are completely independent between levels!!
- LBLRTM 12.2 is a reference RTM
- OBS-CALC should fall within uncertainties from Immler et al. 2010, within ±1σ IASI noise
- To avoid surface effects, we use highly absorptive water vapour channels only (700 hPa and up)

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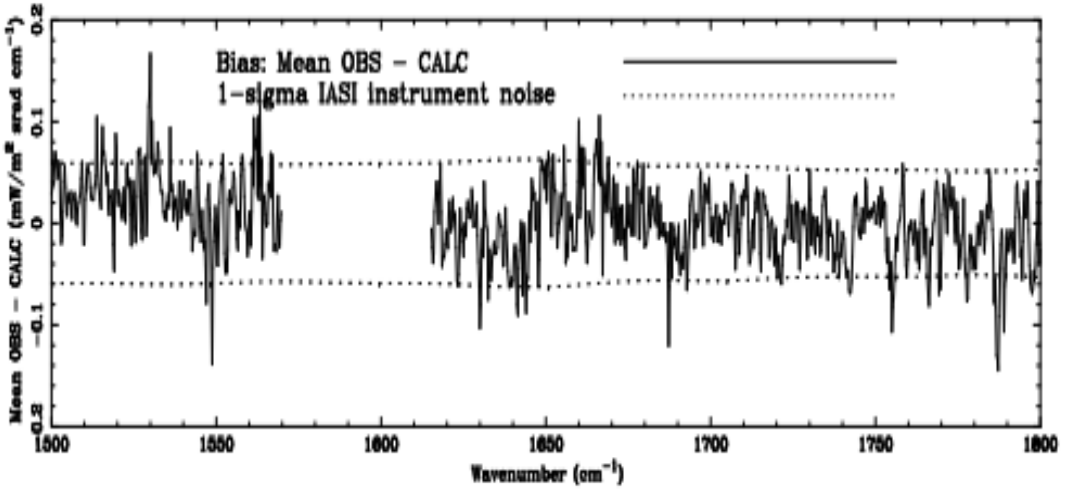
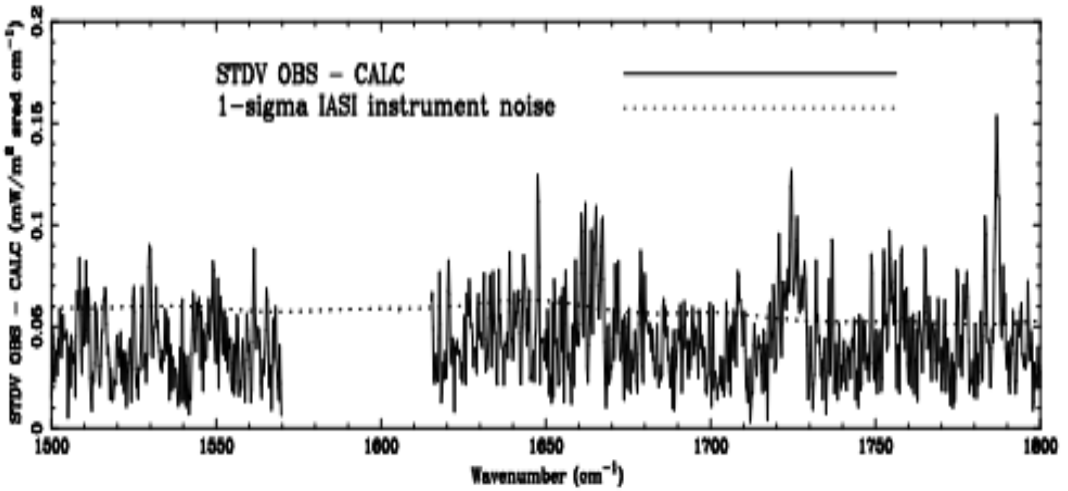
Consistency check: is this even possible?

Can OBS-CALC fall within ±3σ IASI instrument noise (= u_1)?: is this even possible?

Yes! With two RS92 Sondes and a CFH Sonde. Sodankyla EPS/MetOp Campaign 2007

Calbet et al. AMT 2011





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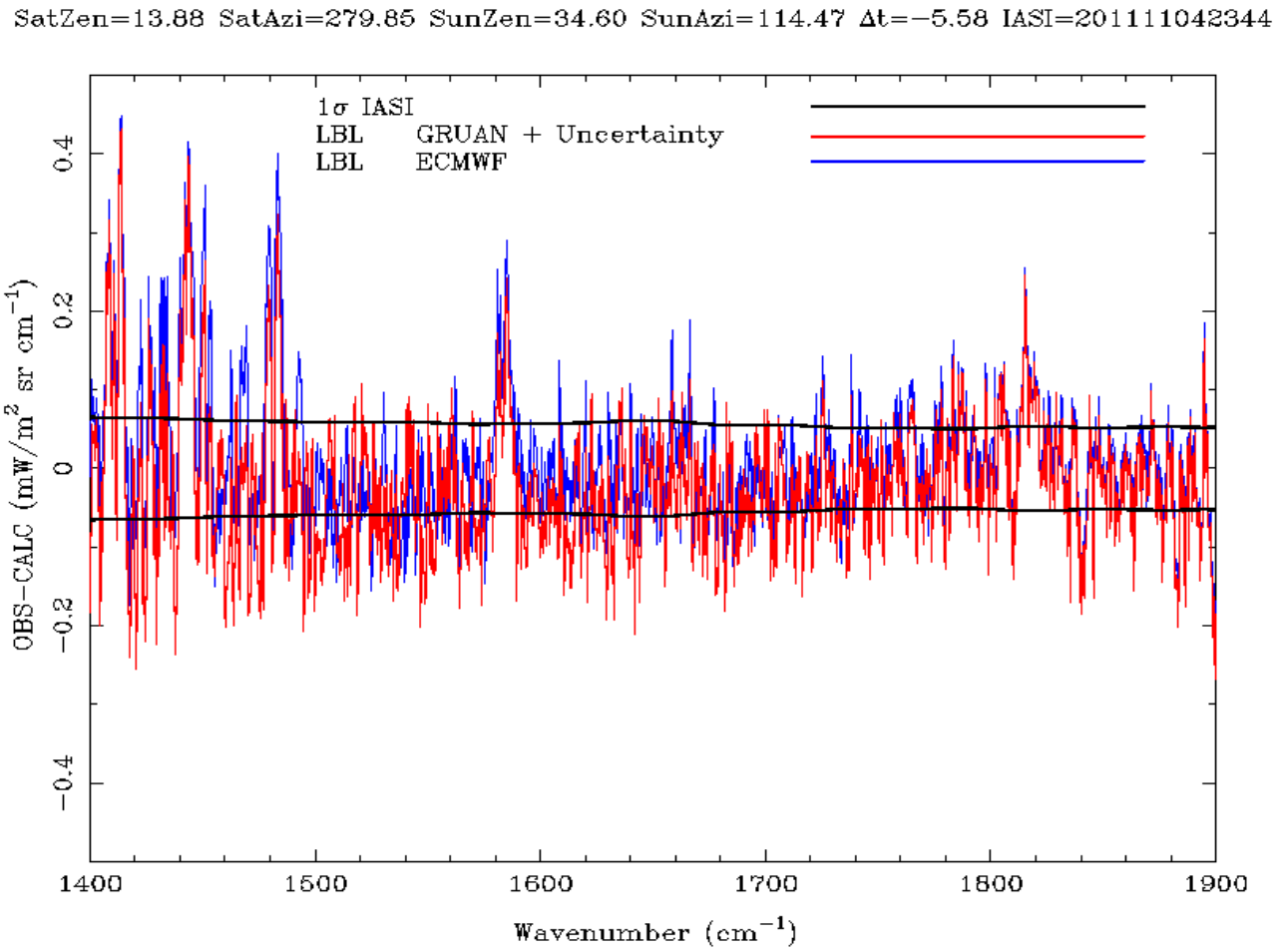
Consistency check: is this even possible?

Can OBS-CALC fall within ±3σ IASI instrument noise? This would give us a clear indication that both measurements are consistent. Pending the Immler et al. 2010 test

is this possible with GRUAN?

GRUAN: one RS92 sonde very well processed

Radiation comparison: individual case 1/2



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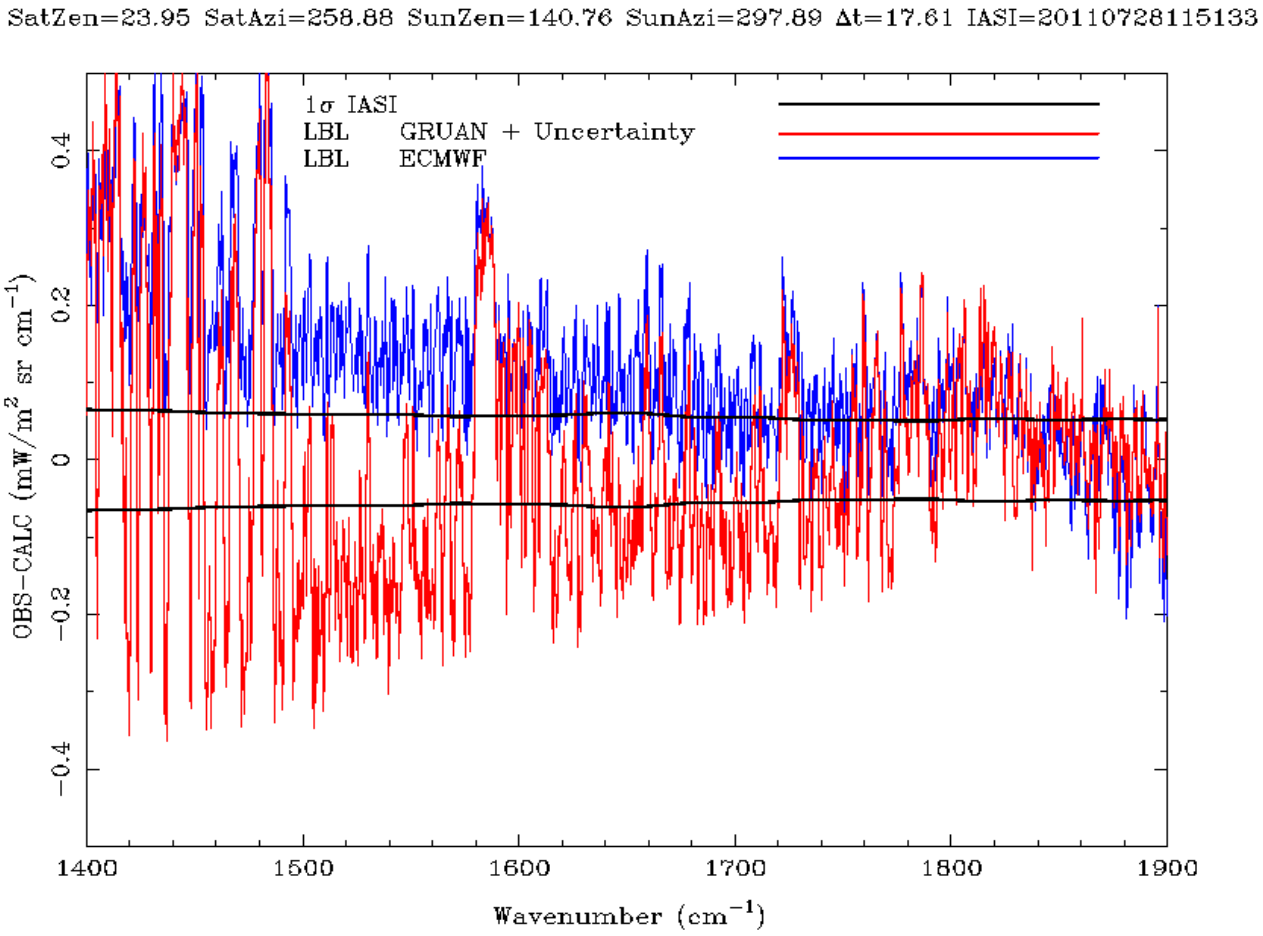
Radiation comparison: individual case 2/2

Water Vapour scale much smaller than 30 min., 25 km!!



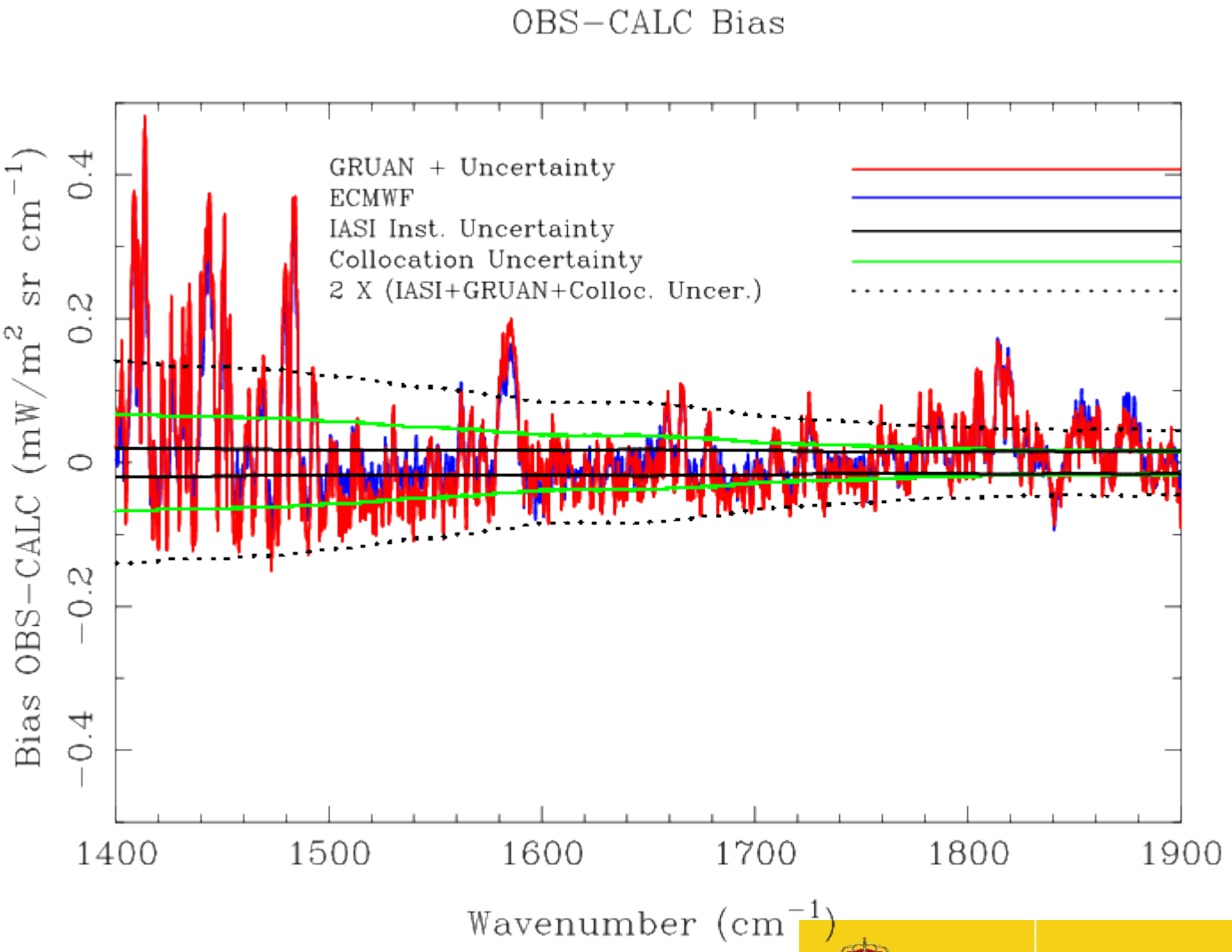
Systematic Uncertainties

- Here we will only consider systematic uncertainties (bias)
- Given enough observations, their average should lie within uncertainty bounds
- We are assuming this can be done: collocation uncertainty is random

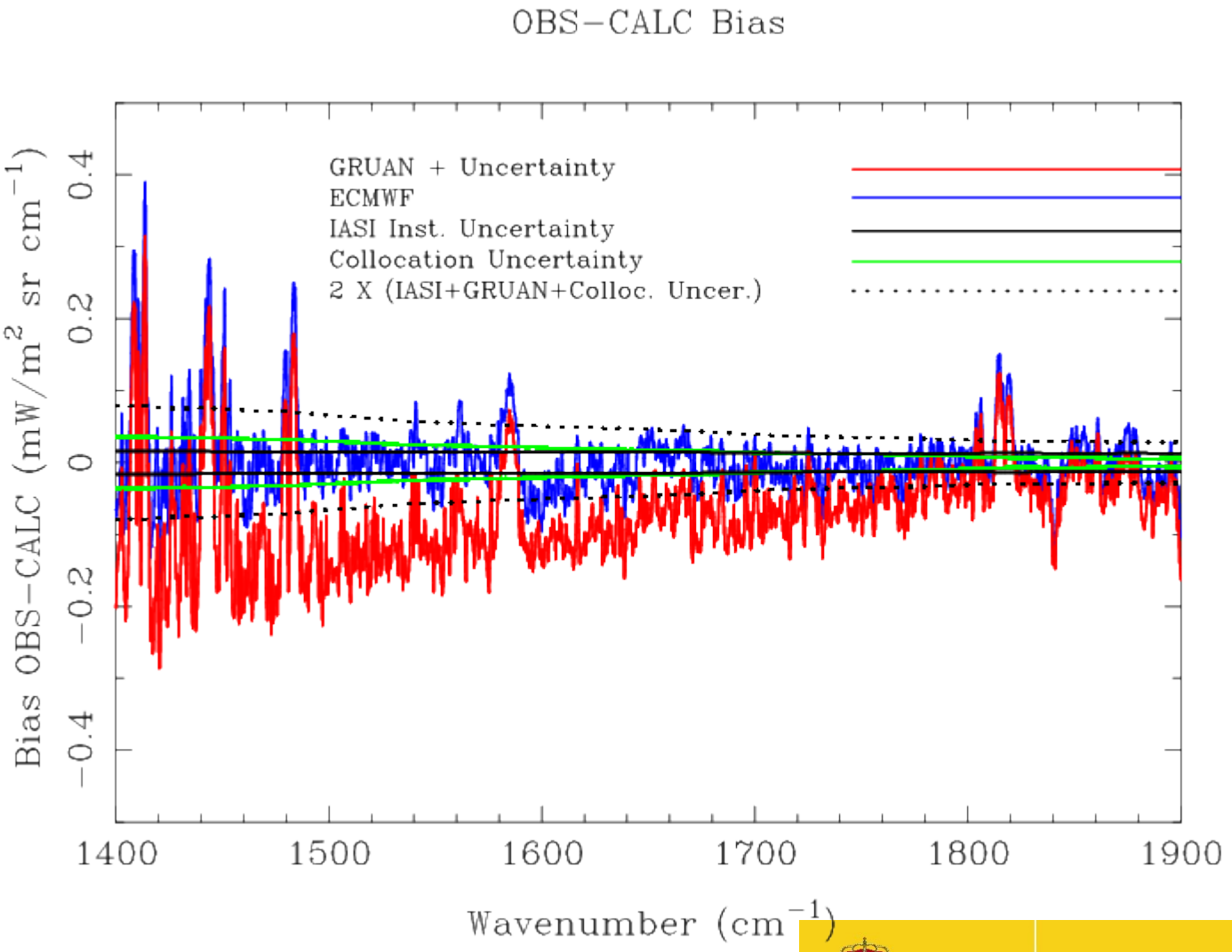
Radiation Bias: Final Result: Number of cases

- We start with 597 collocations for Manus and IASI (30 min., 25 km)
- According to IASI L1 flag, only 76 cases are clear
- After AVHRR visual inspection, of these, only 27 cases are really clear
- After GRUAN processing, daytime cases seem to have a dry bias. We keep only night time cases → Final result of 11 cases

Radiation Bias: Final Result Night-time



Radiation Bias: Final Result Day-time



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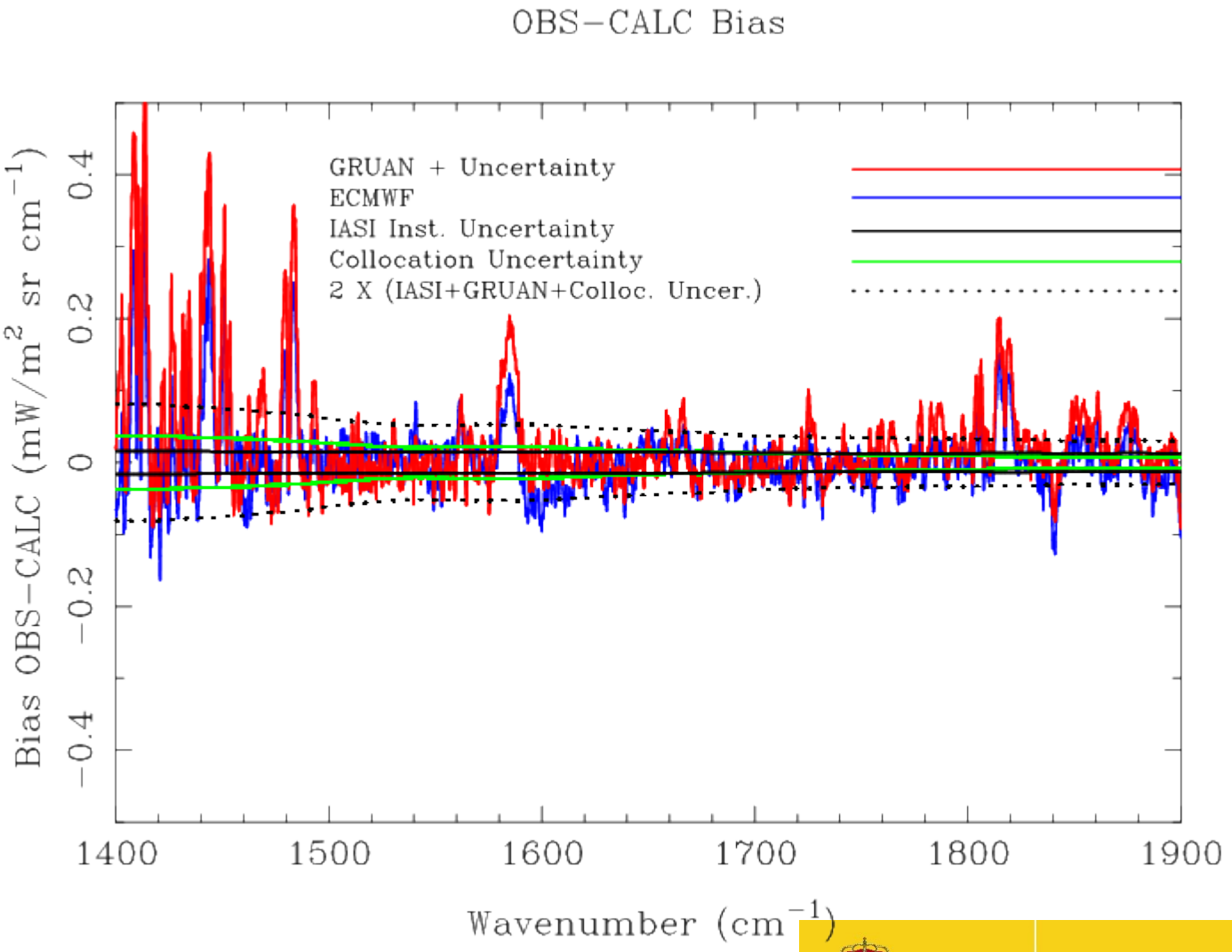
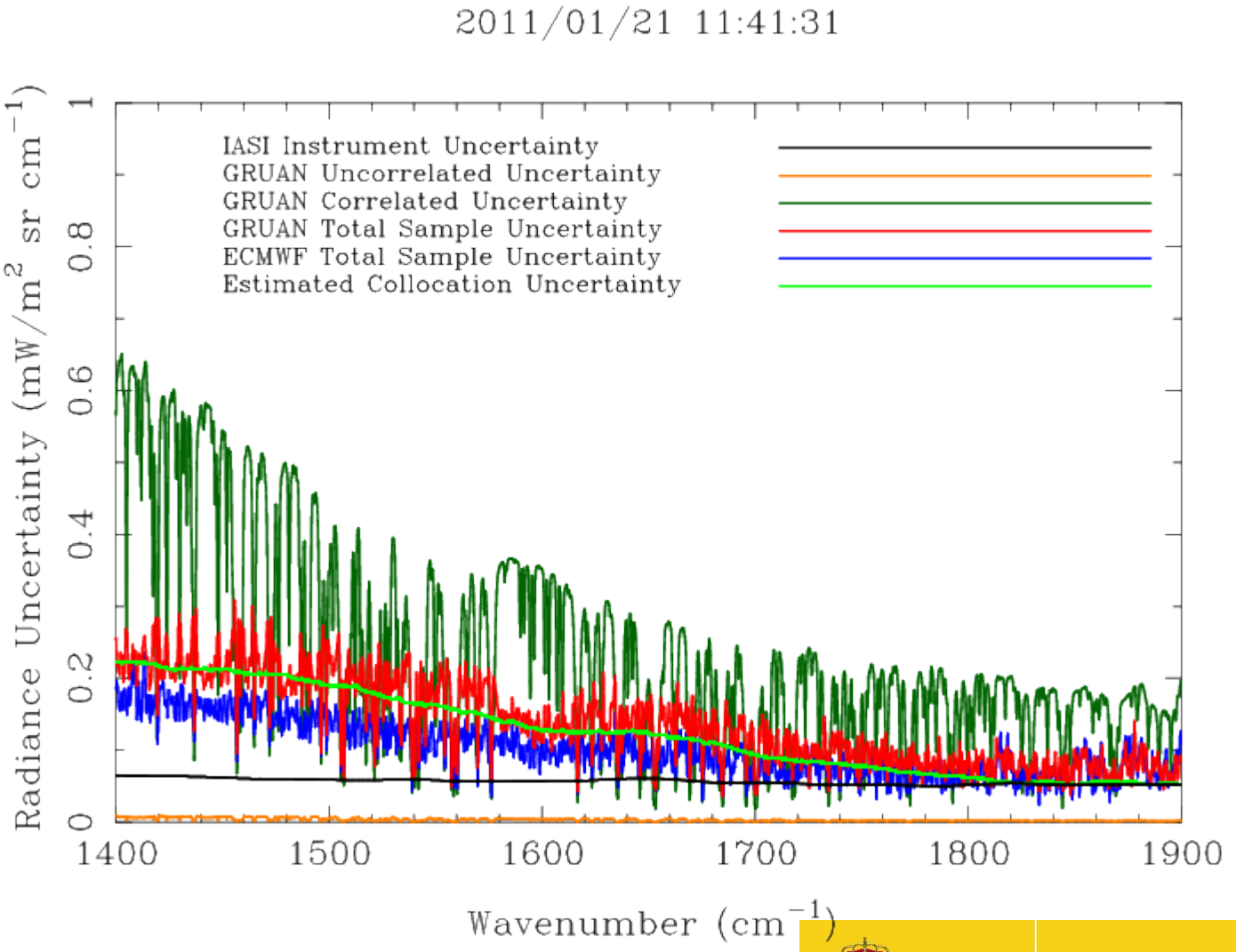
Radiation Bias: Final Result Day-time + 2.5% RH



Radiation Uncertainties



CONCLUSIONS

- GRUAN and IASI are consistent!!
- There are many critical issues:
  - Adequate collocation: scale lengths and times of WV are extremely small
  - Full closure achievable if full GRUAN uncertainty matrix (including correlation terms between levels) and collocation uncertainty are available
  - Water Vapour saturation function: Hyland and Wexler needed
  - If we want collocation unceratinty ~ 0 we need dual sondes
  - GRUAN processing needed!! Mostly for humidity bias correction
  - Proper cloud detection is critical
  - GRUAN processing seems to have a dry bias for daytime

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