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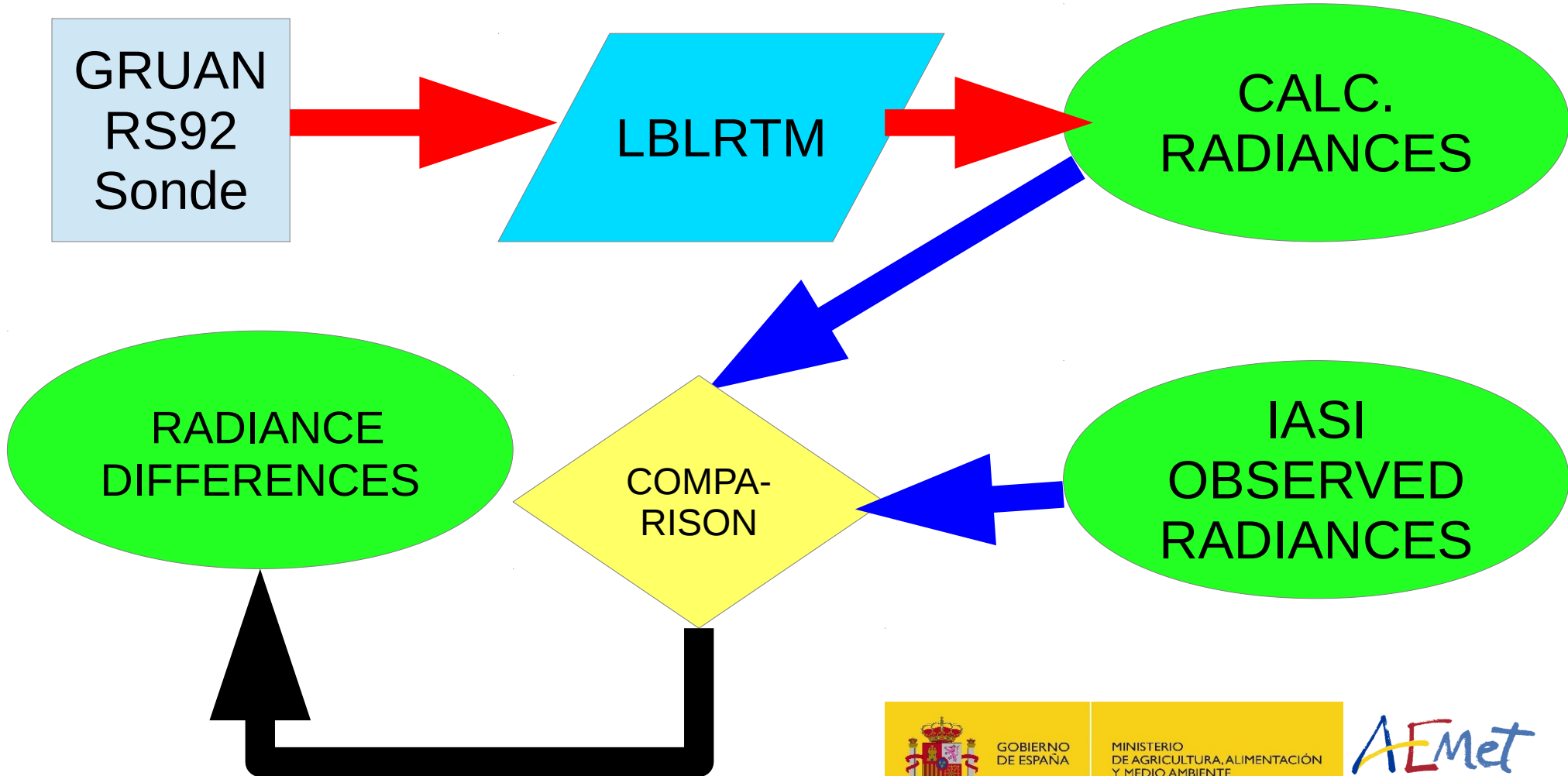
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Consistency for water vapour of GRUAN, LBLRTM and IASI

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PRINCIPLE



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**

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?

Are GRUAN and IASI **consistent** within 5%?

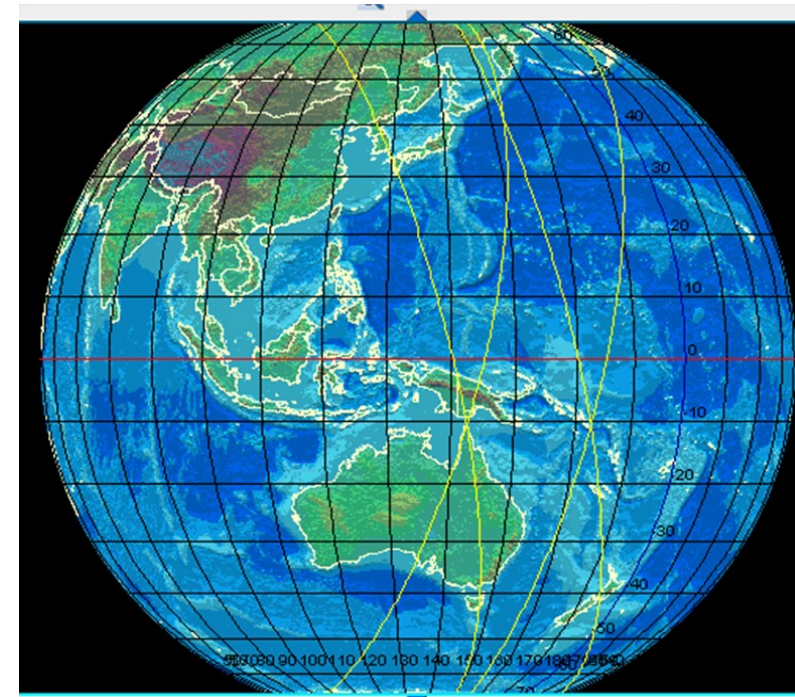
Immler et al. 2010:

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

$$k \approx 2$$

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



Instr/Category	Product Type	Start Date	Stop Date
HIRS	HIRxxx1B	2011/06/04 22:45:53	2011/06/05 00:27:58
HIRS	HIRxxx1B	2011/06/05 00:27:58	2011/06/05 02:09:56
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

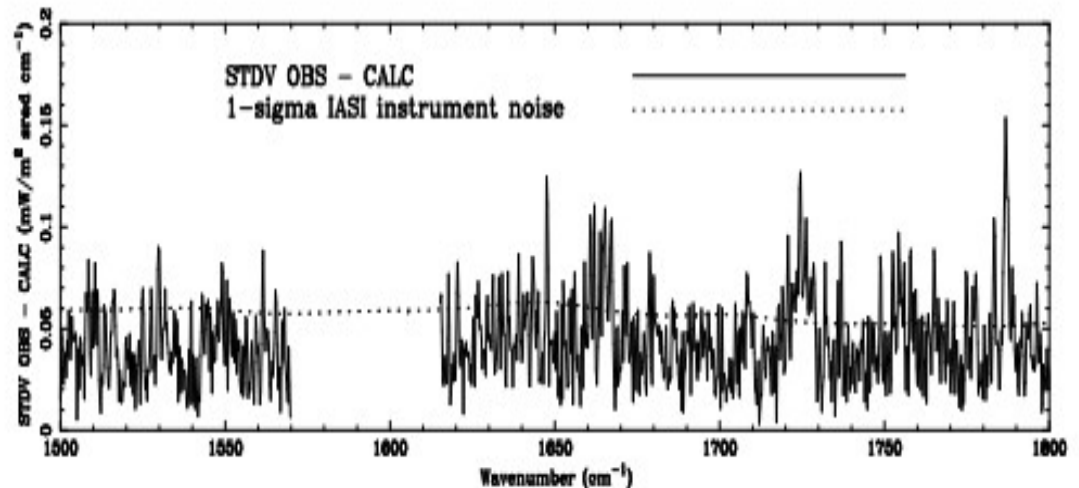
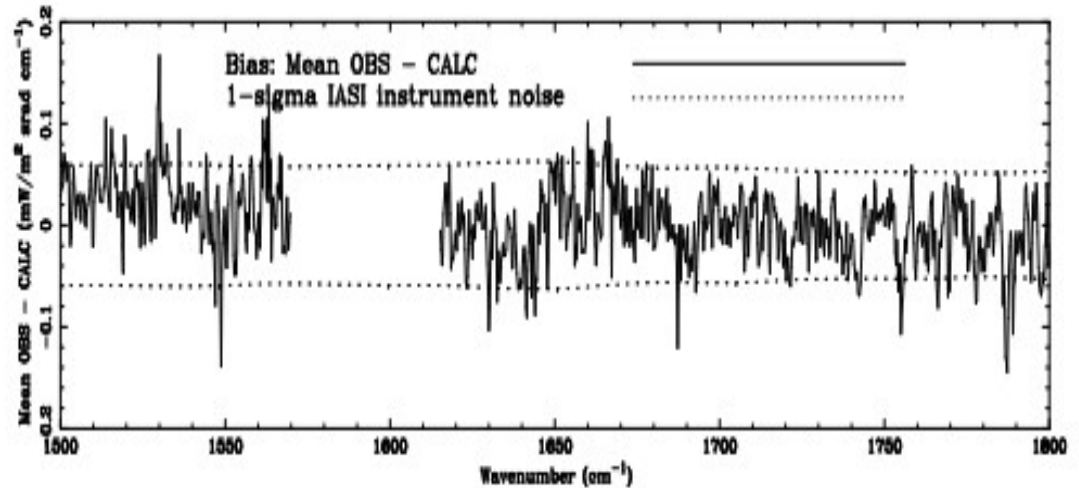
- **Observed IASI** radiances (OBS) are compared to
- **Calculated radiances** (CALC) using GRUAN Sonde profile + Radiative Transfer Model (LBLRTM 12.2)
- LBLRTM 12.2 is a **reference** RTM
- OBS-CALC should **fall within uncertainties** from Immler et al. 2010, within $\pm 1\sigma$ IASI noise
- To avoid surface effects, we use highly absorptive water vapour channels only (**700 hPa and up**)

Consistency check: is this even possible?

Can OBS-CALC fall within $\pm 3\sigma$ 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



Consistency check: is this even possible?

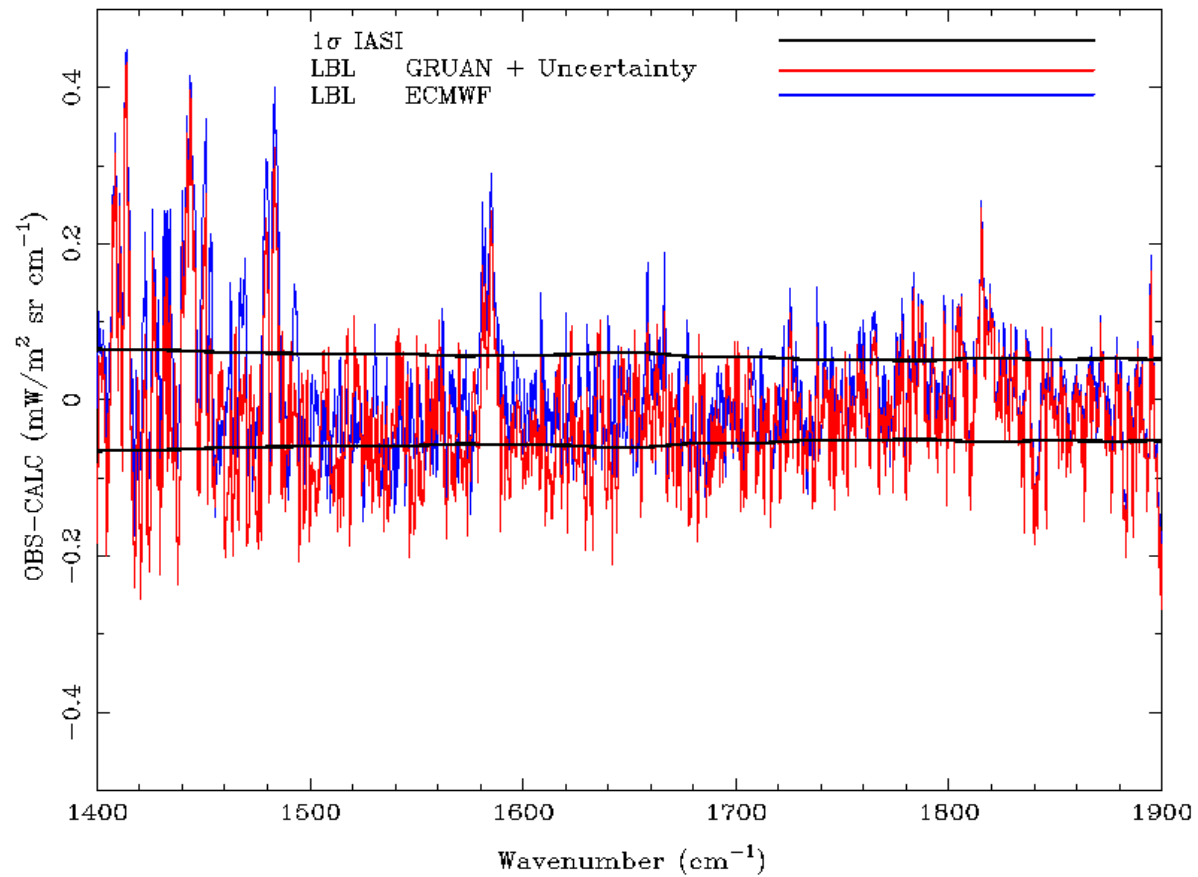
Can OBS-CALC fall within $\pm 3\sigma$ IASI instrument noise? This would give us a clear indication that both measurements are consistent. Pending the Immler et al. 2010 test

is this possible with GRUAN?

GRUAN: one RS92 sonde very well processed

Radiation comparison: individual case 1/2

SatZen=13.88 SatAzi=279.85 SunZen=34.60 SunAzi=114.47 Δt=-5.58 IASI=20111104234419

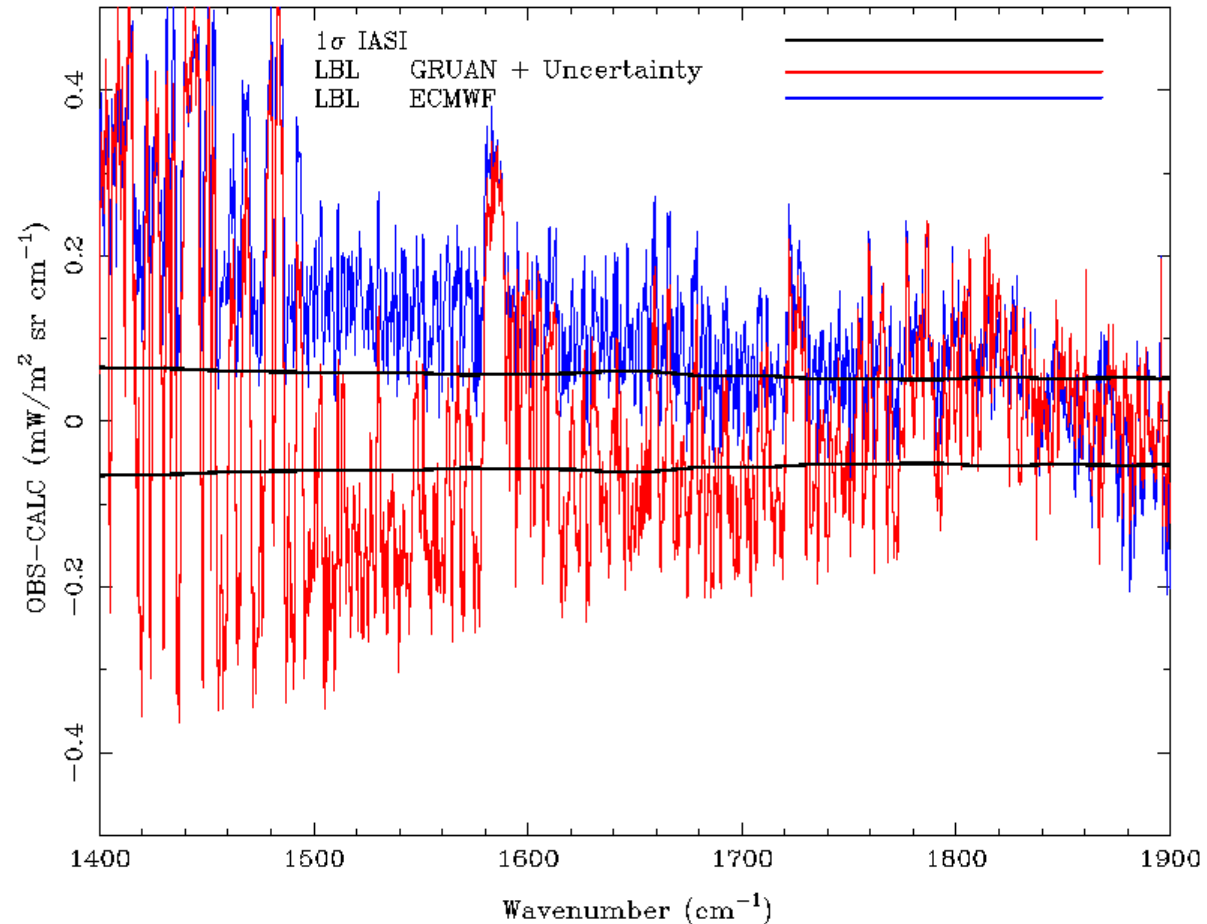


Radiation comparison: individual case 2/2

SatZen=23.95 SatAzi=258.88 SunZen=140.76 SunAzi=297.89 Δt=17.61 IASI=20110728115133



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

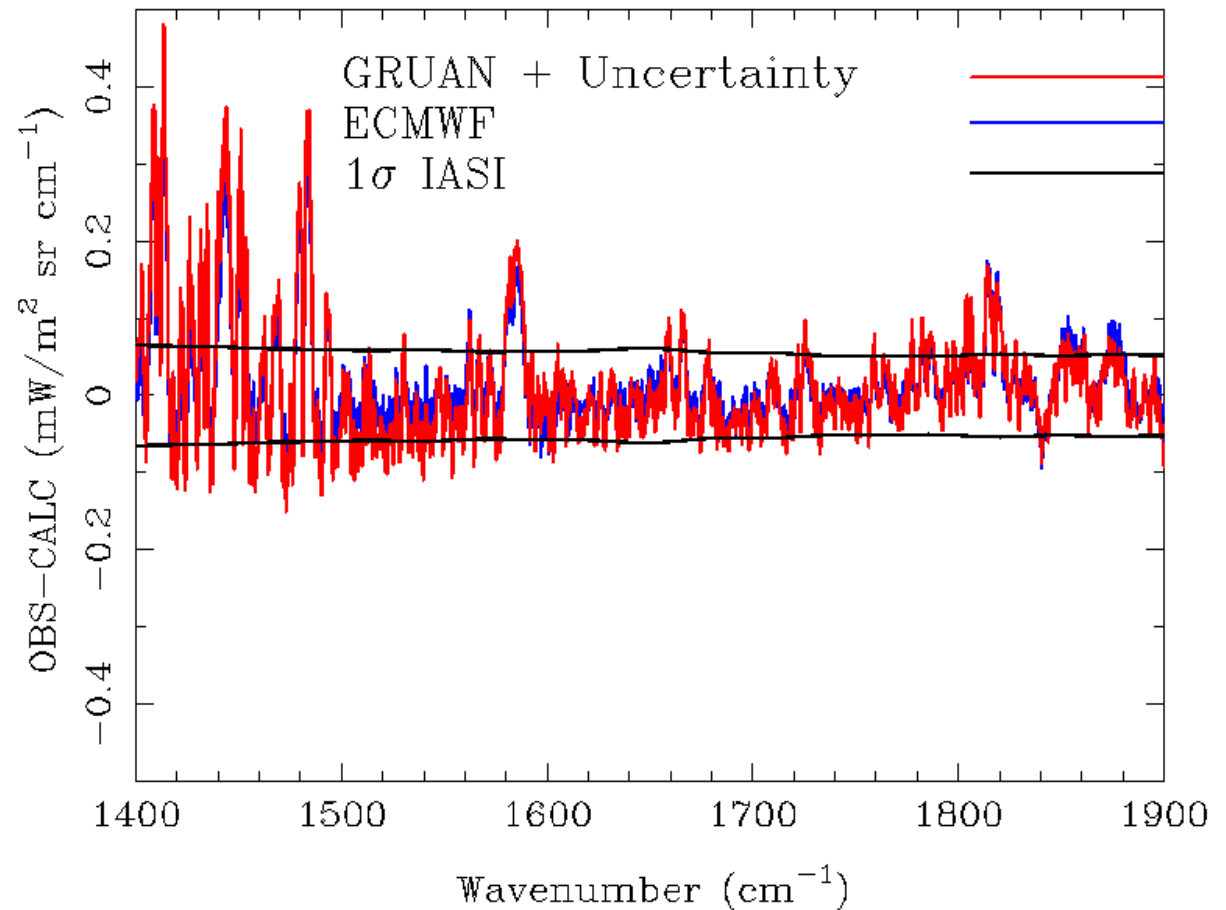


Systematic Uncertainties

- 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

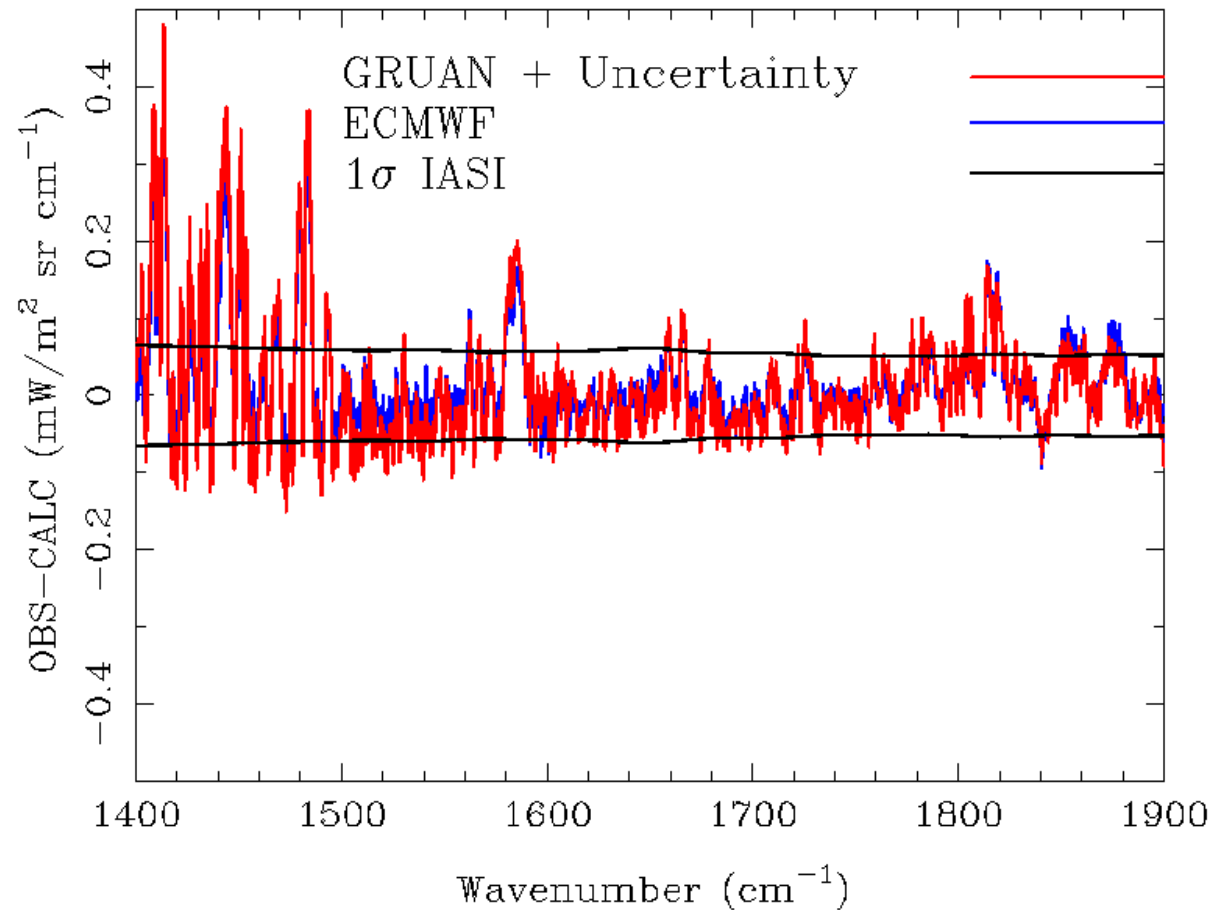
OBS-CALC Bias. GRUAN + HylandAndWexler Sat. Vap. Press.



Radiation Bias: Final Result

OBS-CALC Bias. GRUAN + HylandAndWexler Sat. Vap. Press.

Only 11
cases left!!



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**

CONCLUSIONS

- GRUAN and IASI are **compatible!!**
- There are many **critical issues**:
 - Adequate **collocation**: scale lengths and times of WV are extremely small
 - Water Vapour **saturation function**: Hyland and Wexler needed
 - **GRUAN processing needed!!** Mostly for humidity bias correction
 - Proper **cloud detection** is critical
 - GRUAN processing seems to have a **dry bias for daytime**