Validation of radiative transfer models in the highly absorbing water vapor band for hyperspectral infrared sounders

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EUM/MET/VWG/10/0018
Issue 1
19.01.2010

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EPS/Metop Sodankylä Campaign (1/4)

- The Atmospheric Sounding Campaign took place in the Finnish Meteorological Institute, Arctic Research Centre (**FMI-ARC**) during the time period **June 4-September 5, 2007**

- **Surface, ground based remote sensing and balloon measurements** were made

- Here we only deal with **balloon measurements**

EPS/Metop Sodankylä Campaign (2/4)

- The balloon borne in situ instruments used:
  - **RS92-SGP** radiosondes by Vaisala (PTU sondes)
  - Reference level cryogenic frost point hygrometers(**CFH**)
  - **ECC** ozonesondes

- During the campaign altogether 360 PTU sondes, 40 ozone sondes and **7 frost-point hygrometers** were flown.

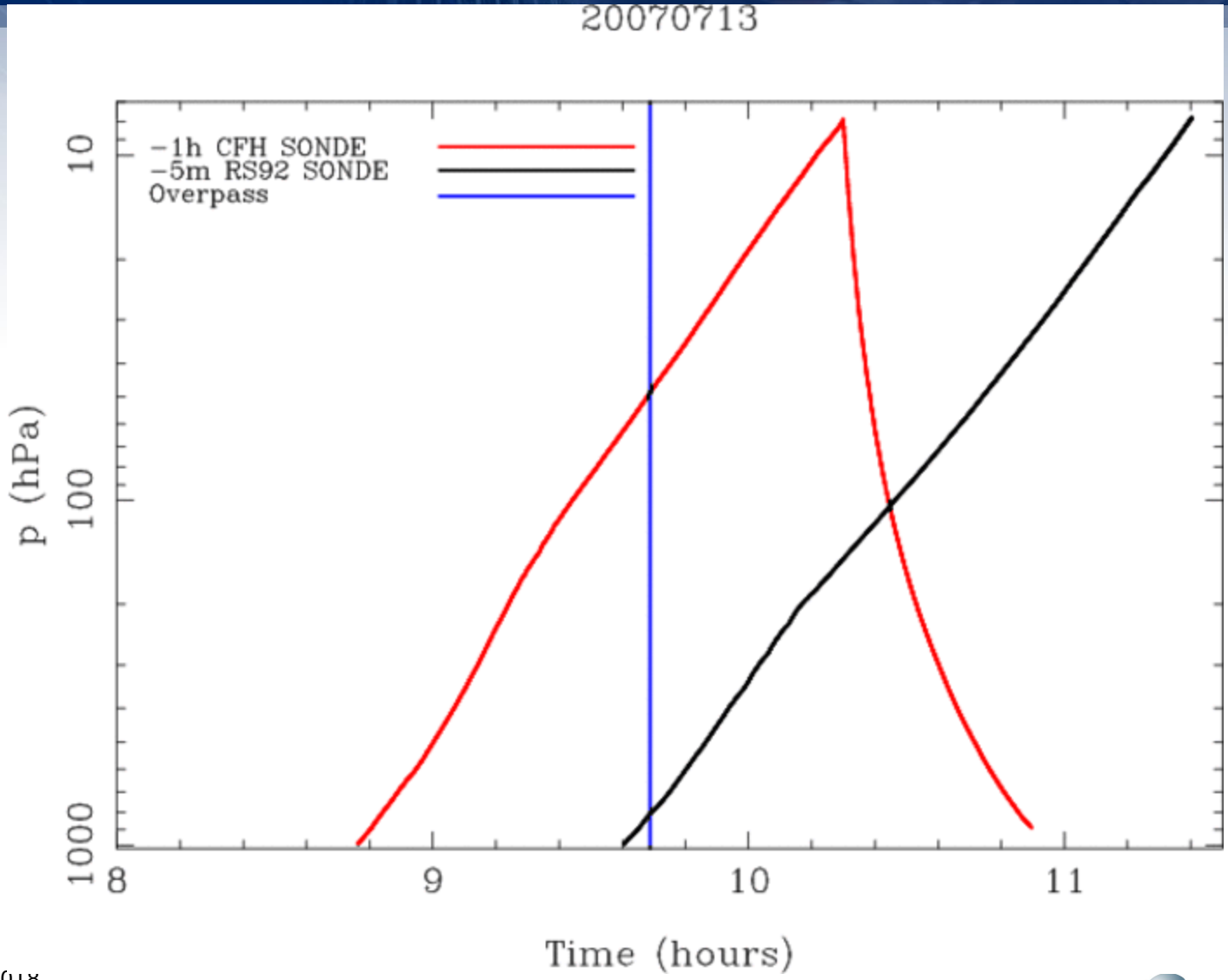
- Of the 7 CFHs, only **4 are useful** (2 are over cloud contaminated scenes and 1 does not have IASI data)

EPS/Metop Sodankylä Campaign (3/4)

- We will concentrate here on the **RS-92** and **CFH** sondes

- Launches in synchronization with **Metop overpass:**
  - **One hour before overpass**: one **RS-92** + one **CFH**
  - **5 minutes before overpass:** one **RS-92**

EPS/Metop Sodankylä Campaign (4/4)



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Sonde Accuracy

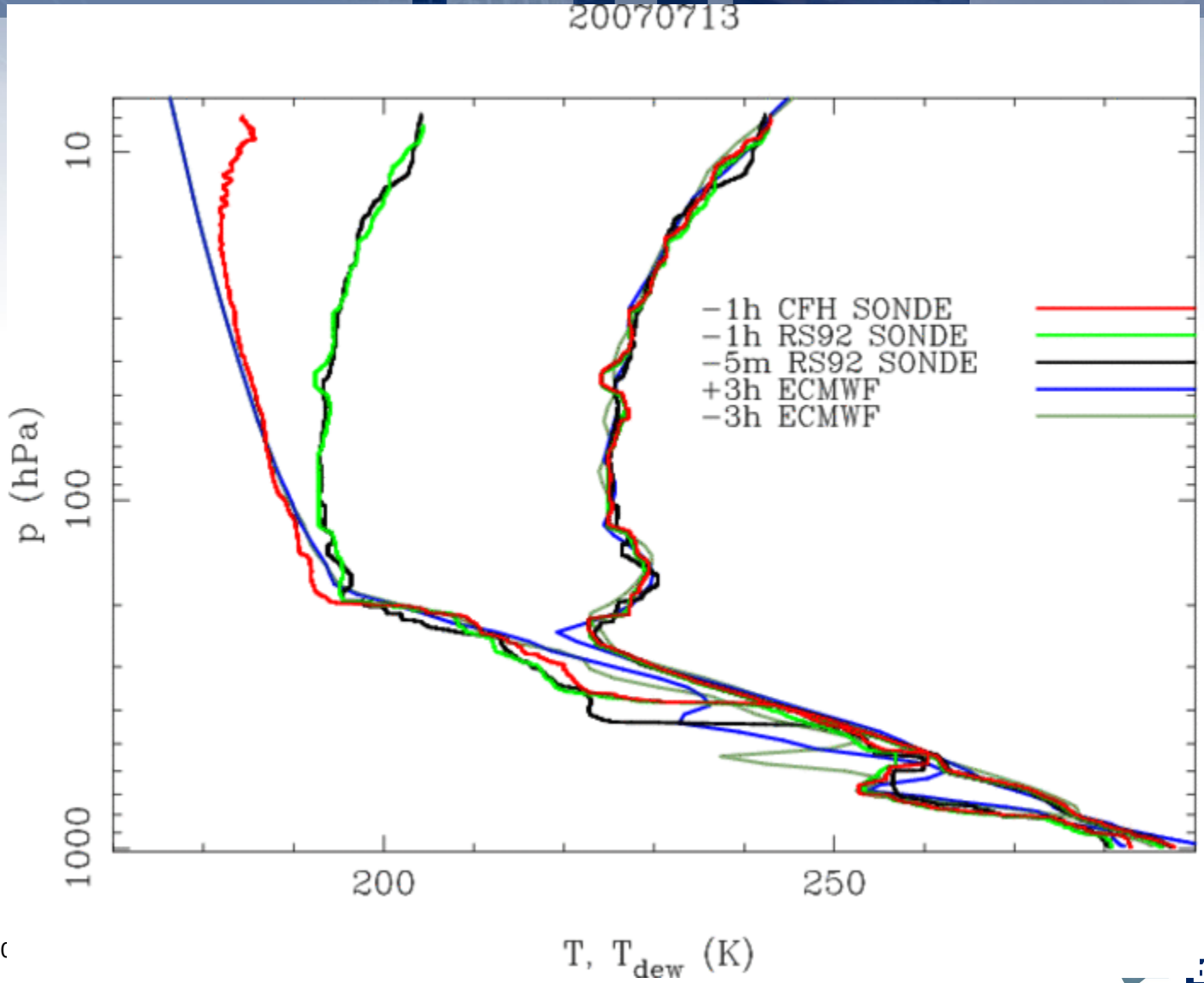
- **TEMPERATURE:** 0.2 K for RS-92

- **HUMIDITY:**
  - **RS-92** from 1 to 3% relative error (Miloshevich et al. 2006) → 0.2-3% error absolute RH

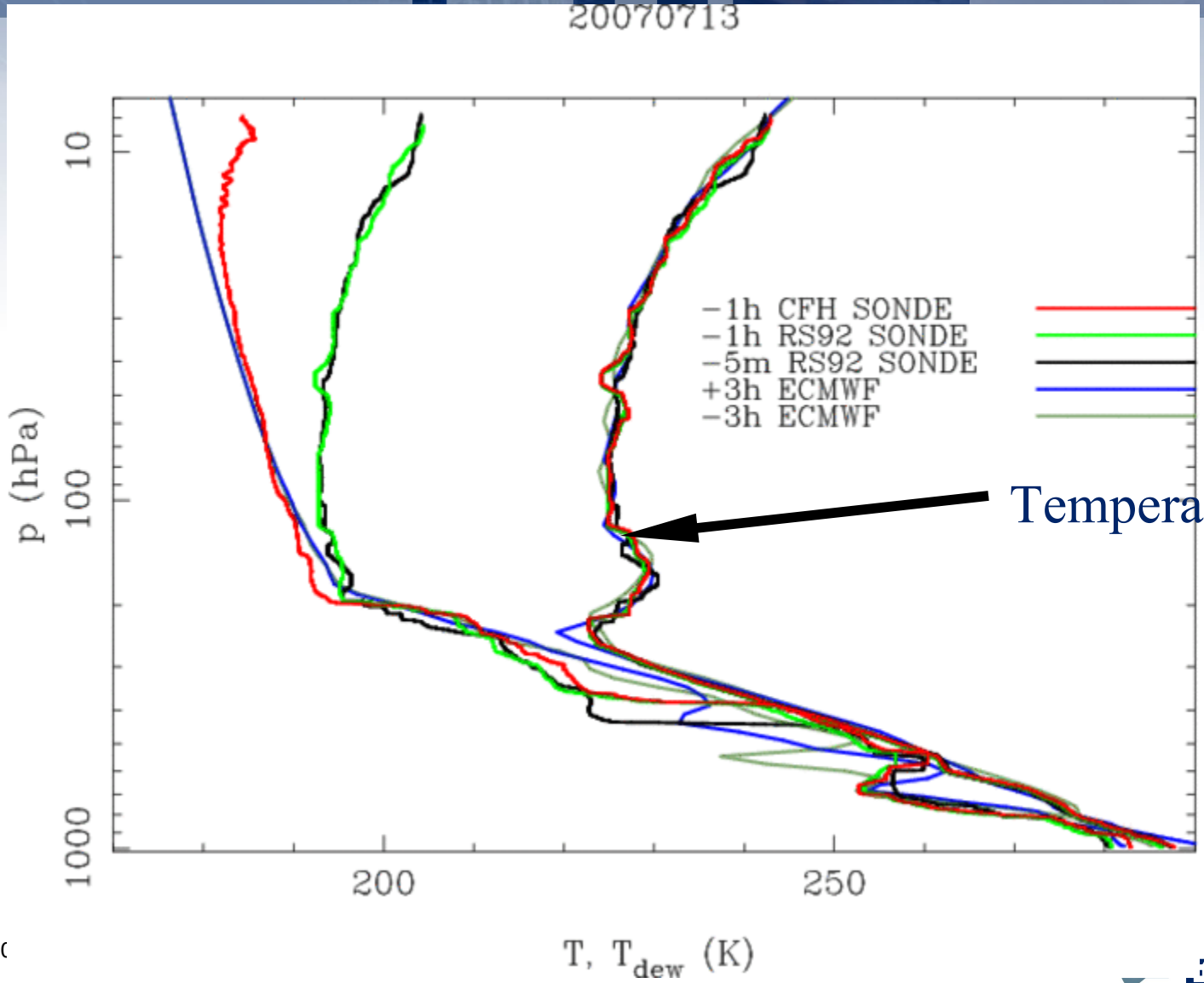
    BUT during **daytime** showing a big **bias** between 9 and 50% due to **solar radiation**

    (Vömel et al. 2007)
  - **CFH** 0.5K error in frost point →
    - Troposphere 0.5-5% error absolute RH
    - Stratosphere 0.5-0.02% error absolute RH

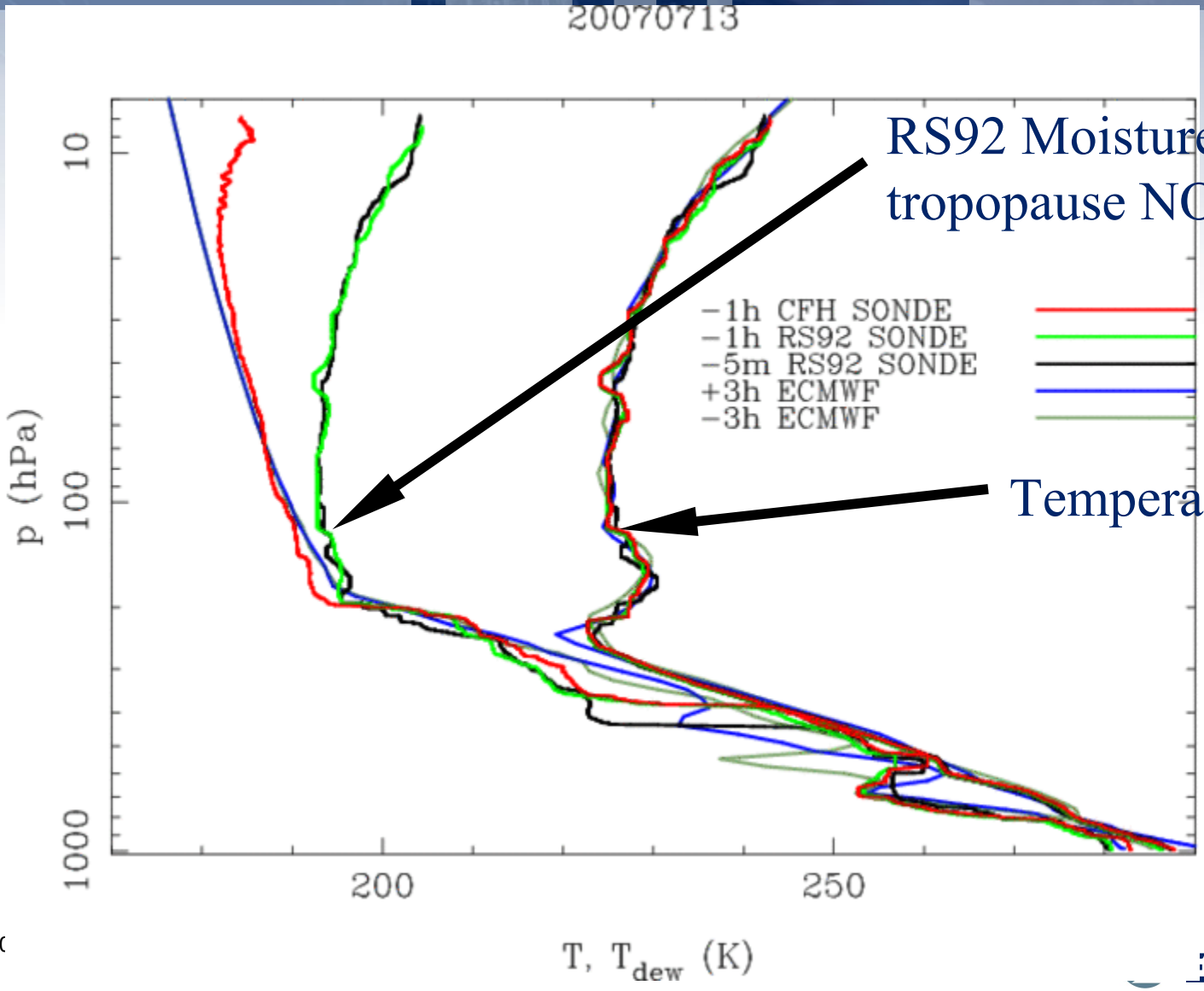
Sample Sonde (1/2)



Sample Sonde (1/2)



Sample Sonde (1/2)



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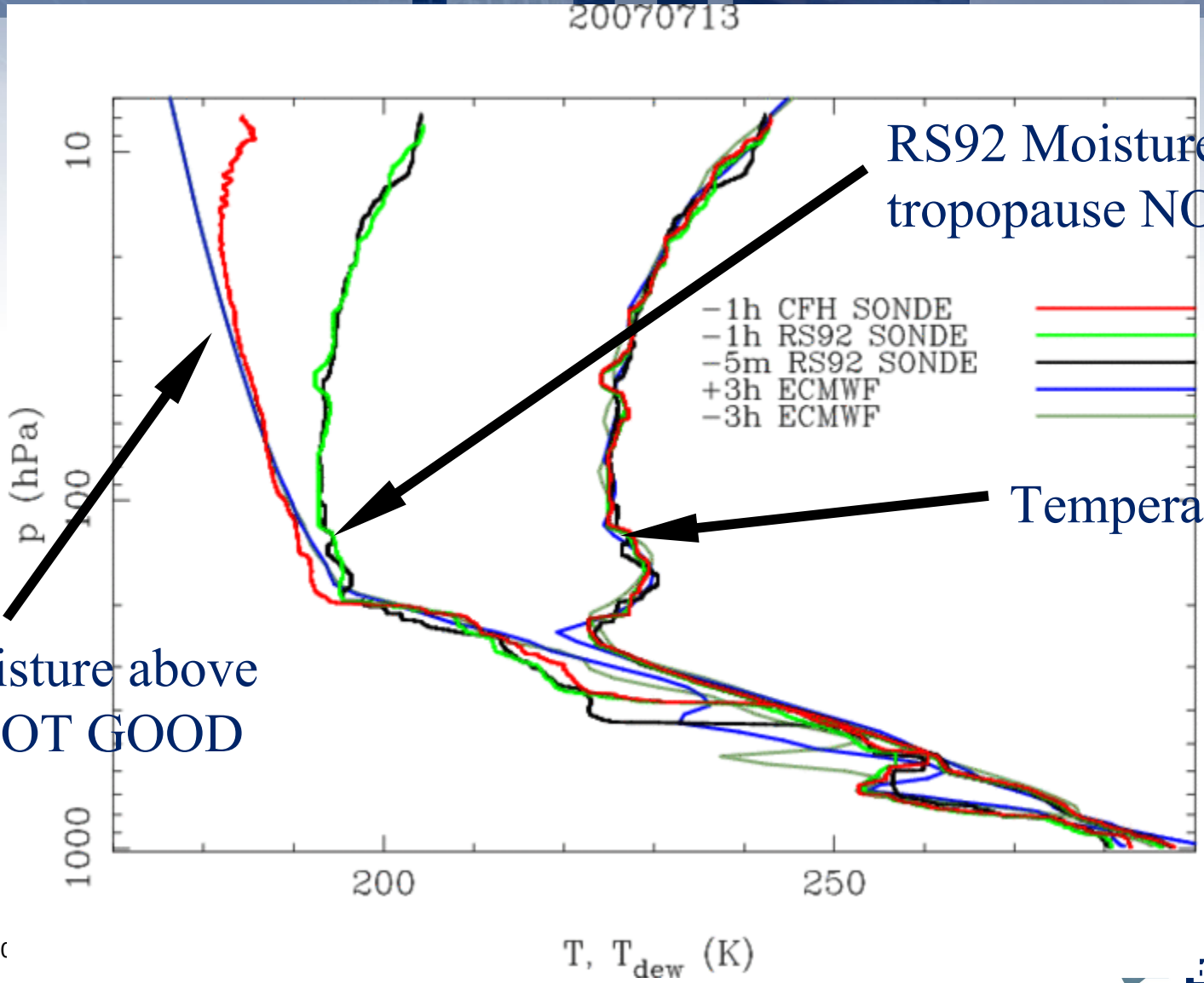
Sample Sonde (1/2)

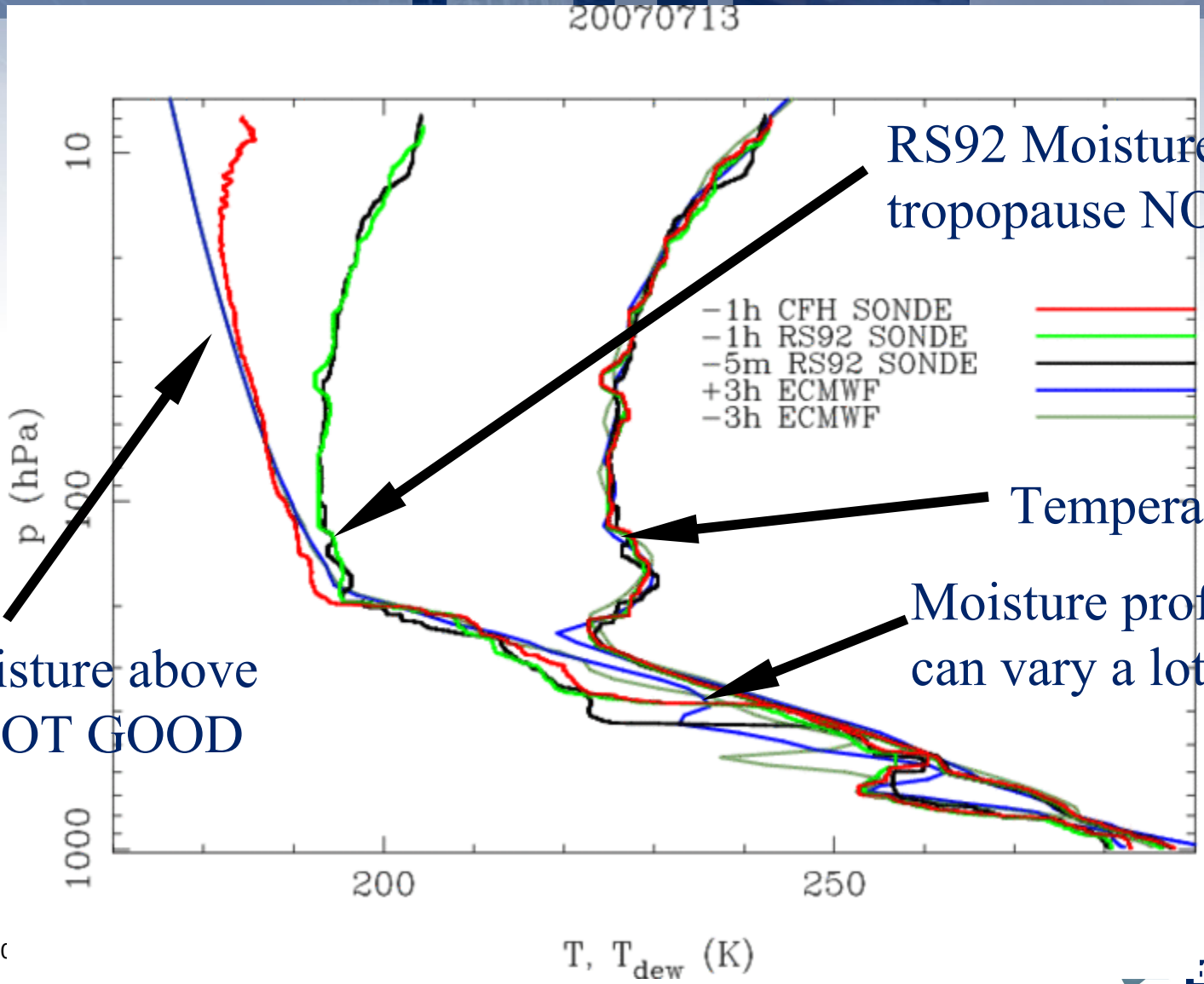


RS92 Moisture above tropopause NOT GOOD

Temperature OK!

CFH Moisture above 40 hPa NOT GOOD

Sample Sonde (1/2)



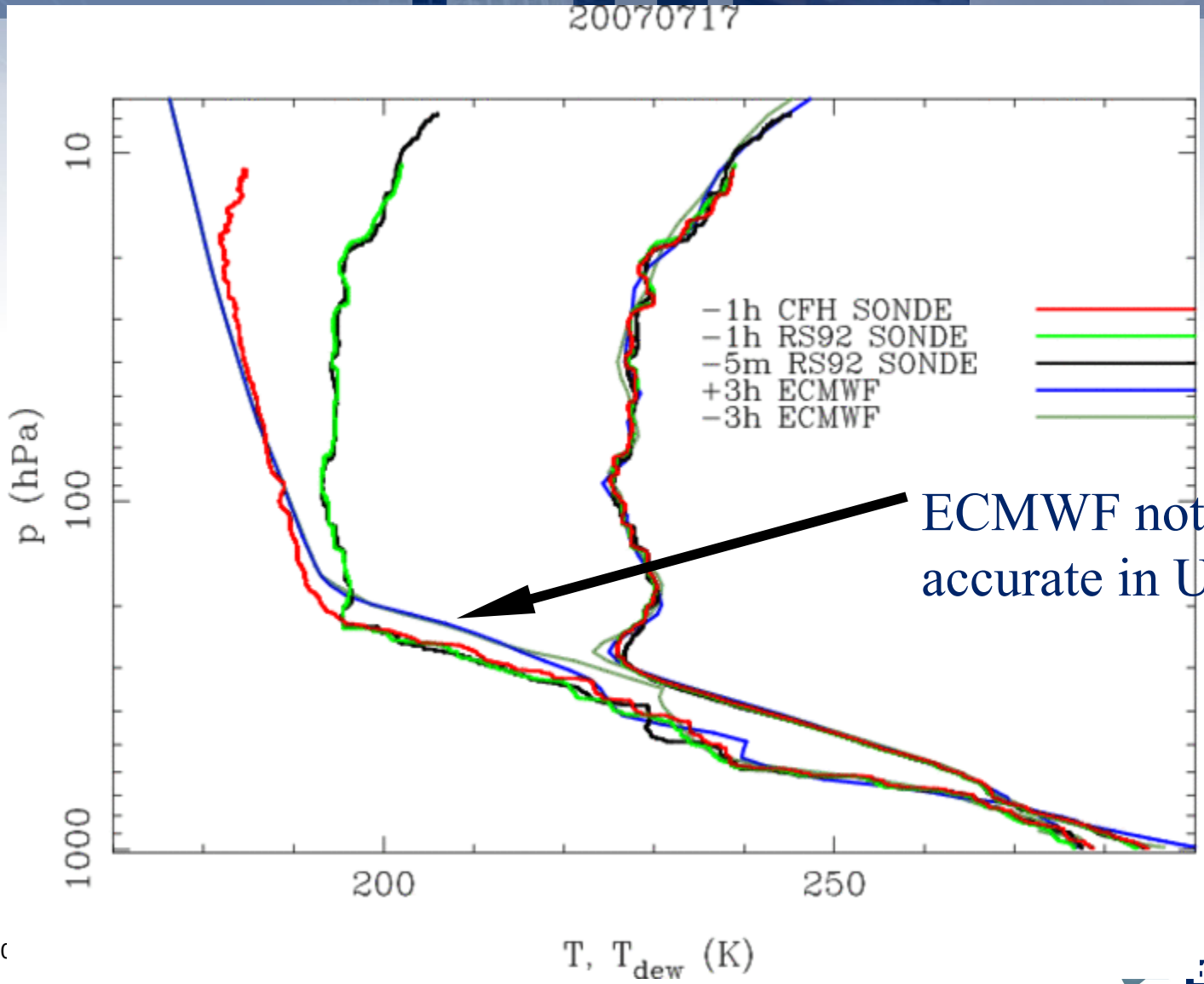
RS92 Moisture above tropopause NOT GOOD

Temperature OK!

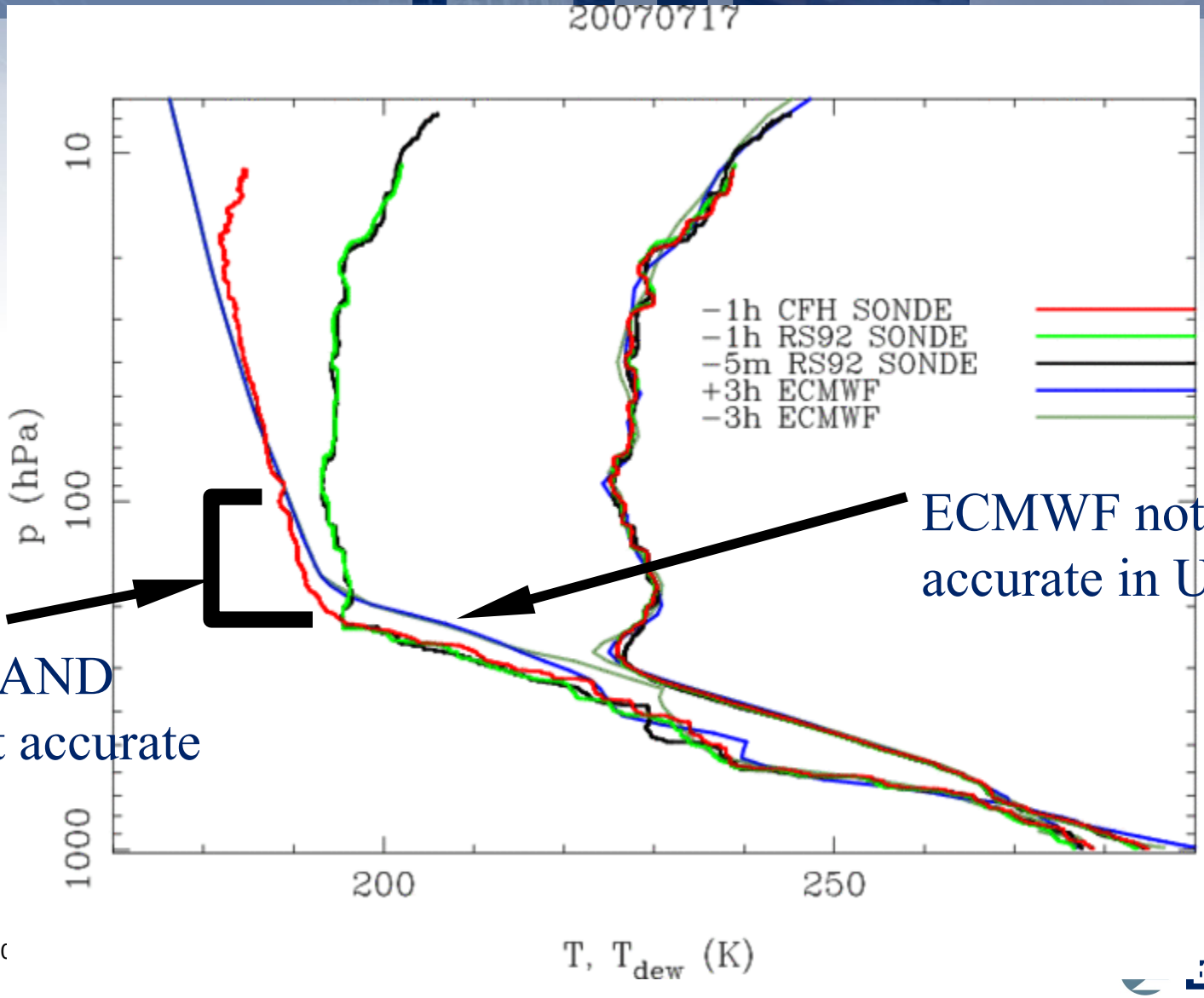
Moisture profiles can vary a lot in 1 hour!

CFH Moisture above 40 hPa NOT GOOD

Sample Sonde (2/2)



Sample Sonde (2/2)



ECMWF not very accurate in UT/LS

ECMWF AND RS-92 not accurate here

Spectral Region of Study

- From **1500 to 1800** cm-1
- Water vapour region with its **strongest absorption**
- The atmospheric layers that most greatly contribute to TOA in this spectral region are **mid to high troposphere** and **lower stratosphere**
- These wavenumbers are most **insensitive** to low level clouds and surface properties
- Problem is **simplified** greatly!

IASI noise

- We use the latest **CNES IASI noise**

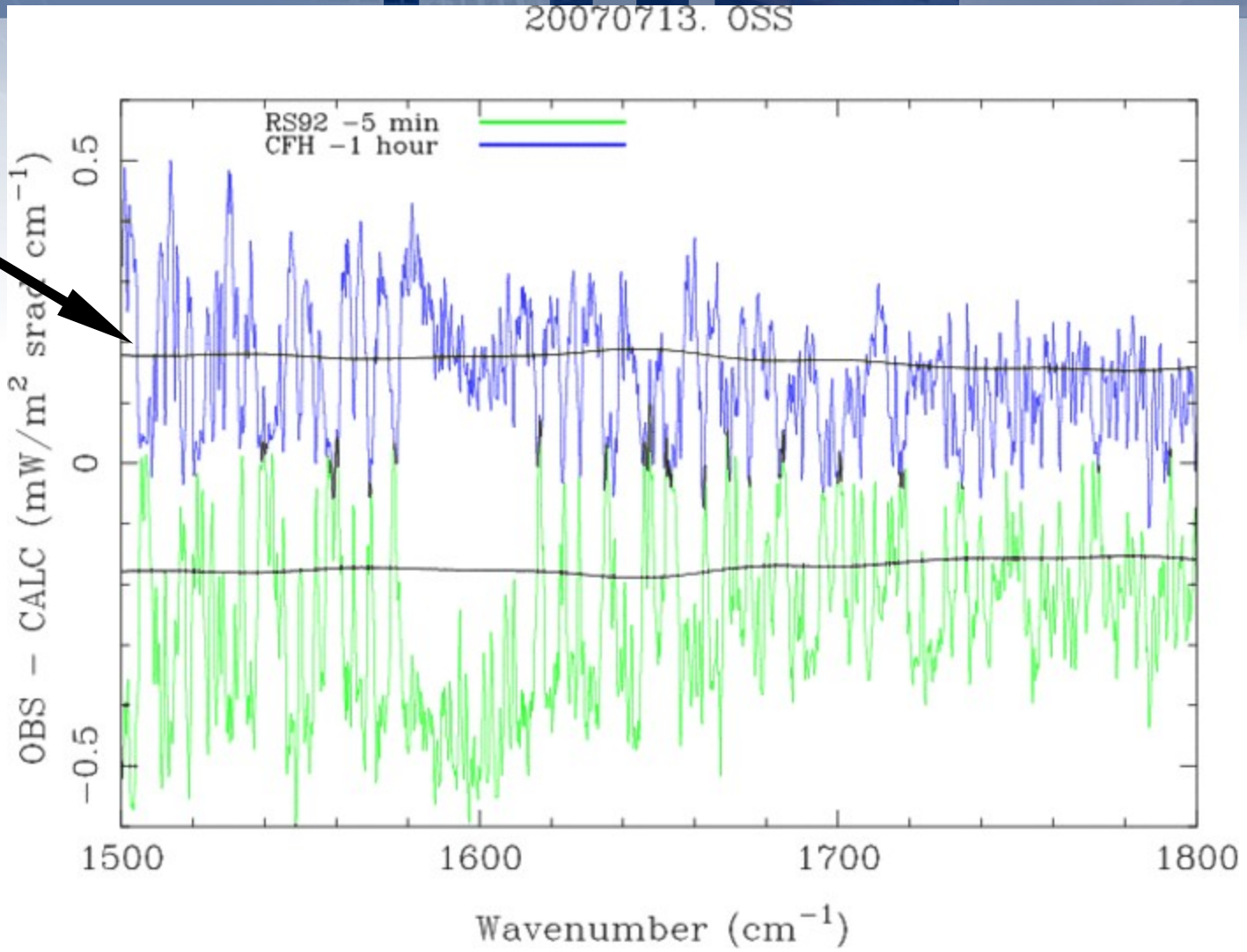
  IASI_NCM_xx_M02_20091217060000Z_20091217060000Z_20091216123652Z

RTMs tested

- **OSS** trained with LBLRTM 11.3
- **LBLRTM 11.3**
- **LBLRTM 11.6**

Results for OSS and raw Sondes

3 sigma
IASI noise



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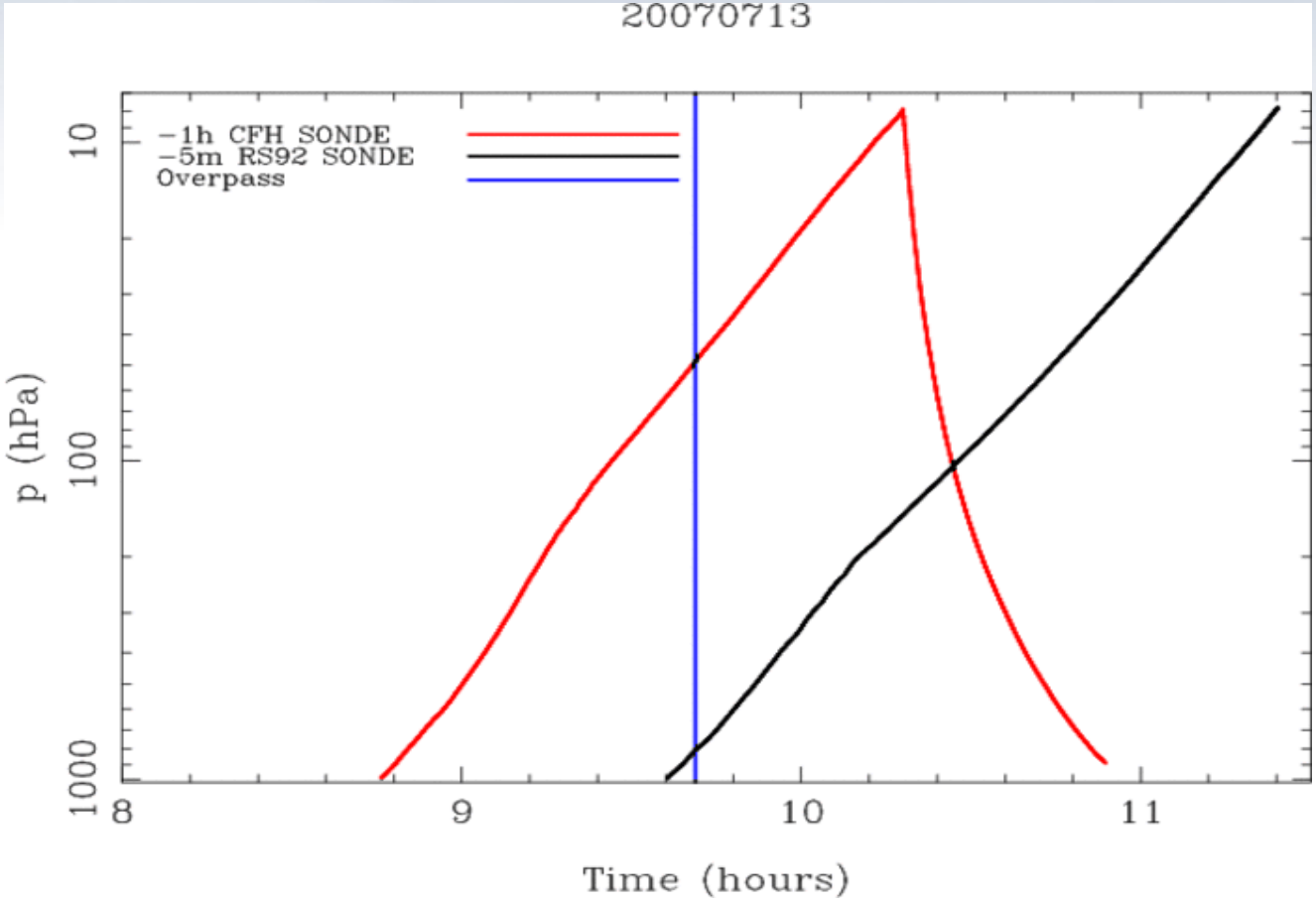
Necessary Corrections (1/2)

- **Dry bias** correction for RS-92:
  - From Rigel et al. (2009) (ala Vömel et al. 2007)
  - From Rigel et al. (2009) + 2%
  - “In situ”: get correction from RS92/CFH comparison launched 1 hour before overpass apply it to RS92 5 min before overpass

- **No space co-location**

Necessary Corrections (2/2)

- **Time interpolation**: ala Tobin et al. 2006



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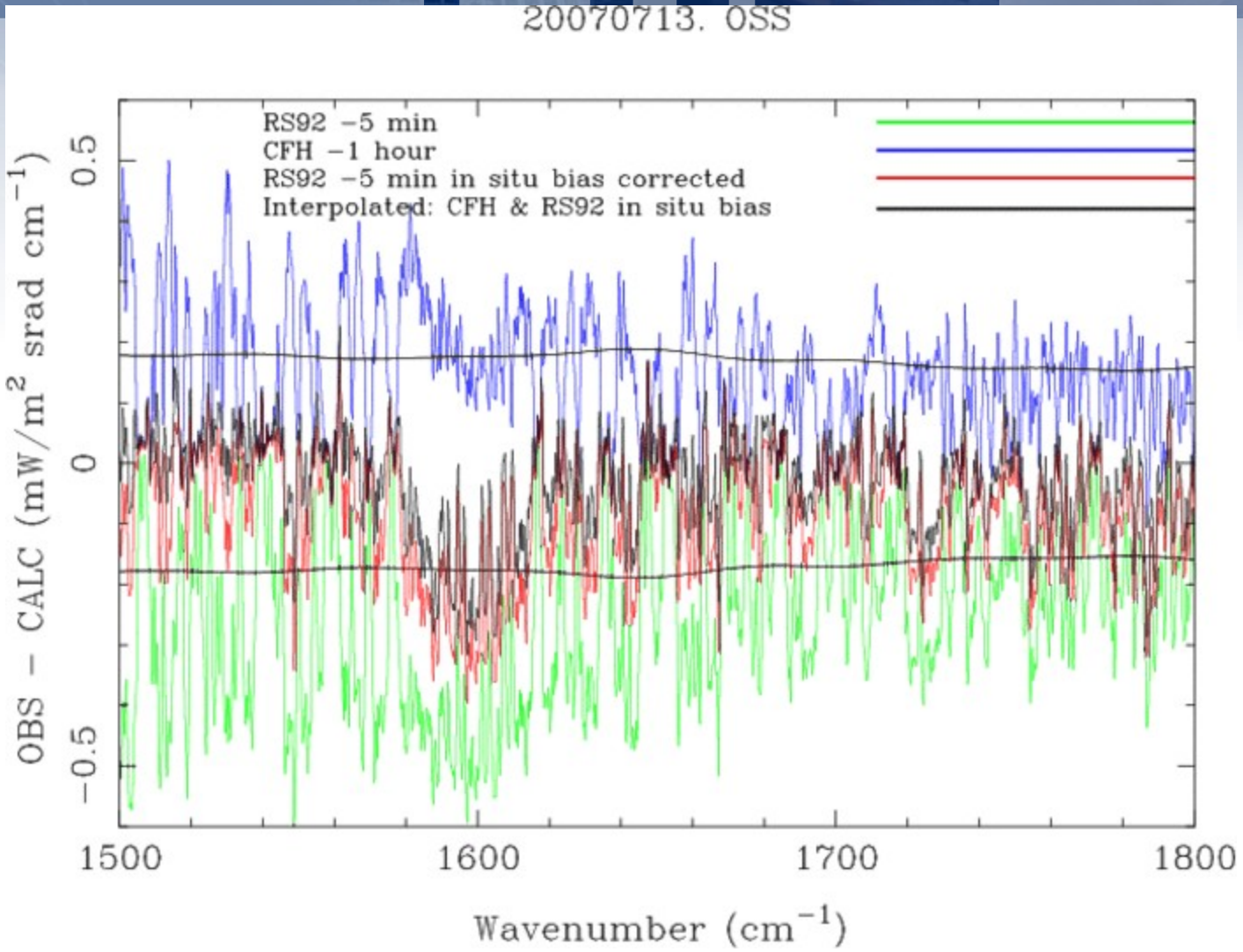
Results for OSS and Corrected Sondes



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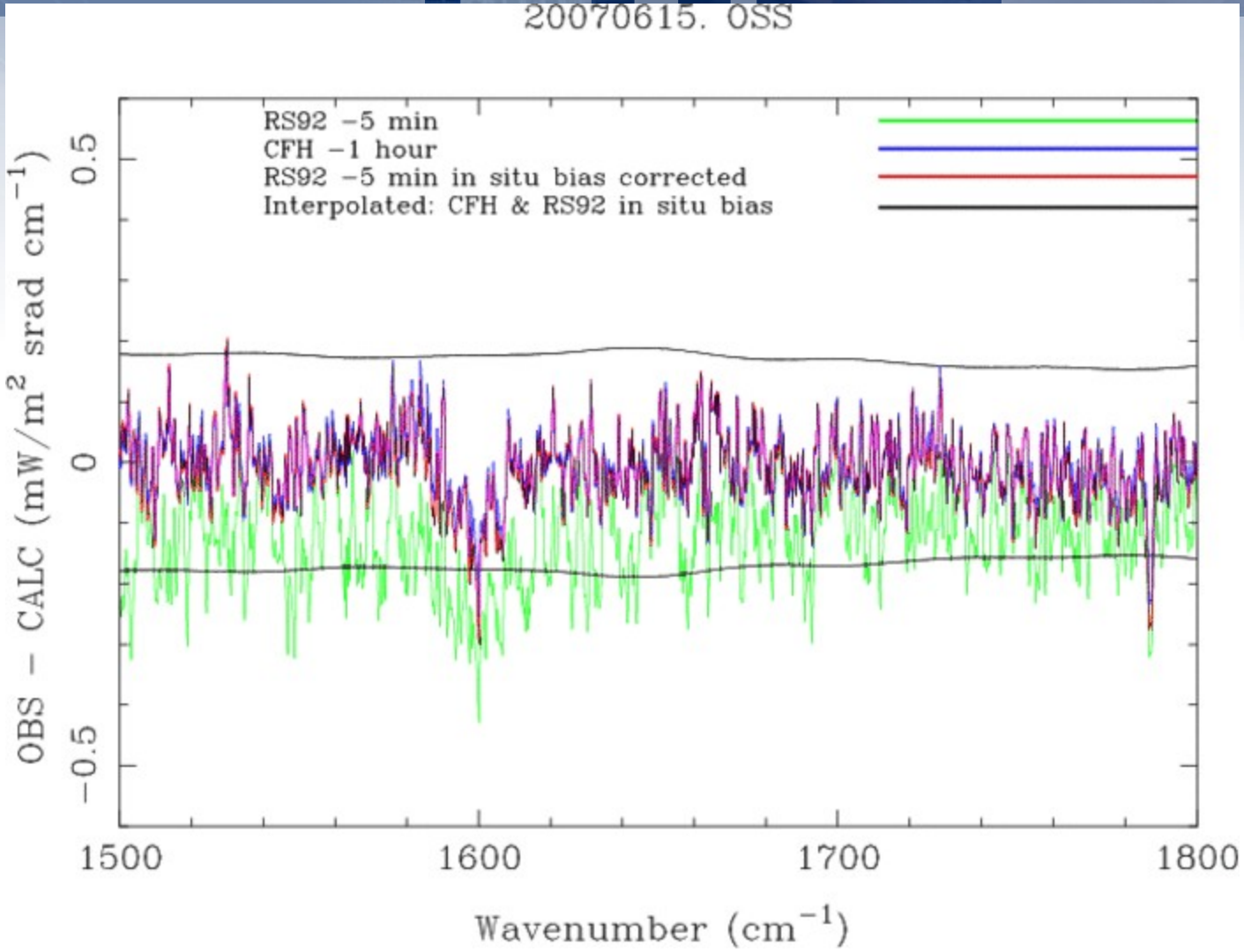

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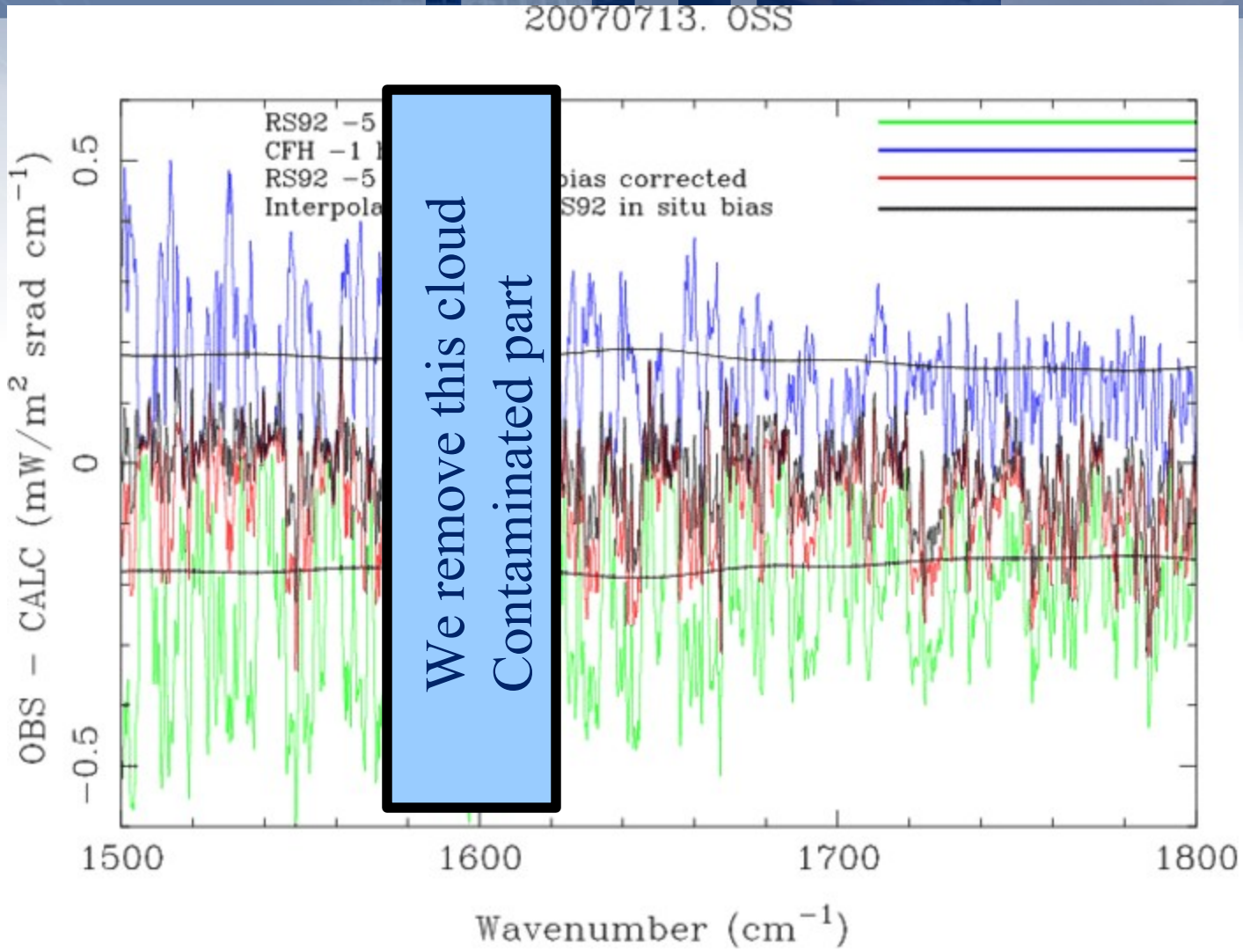

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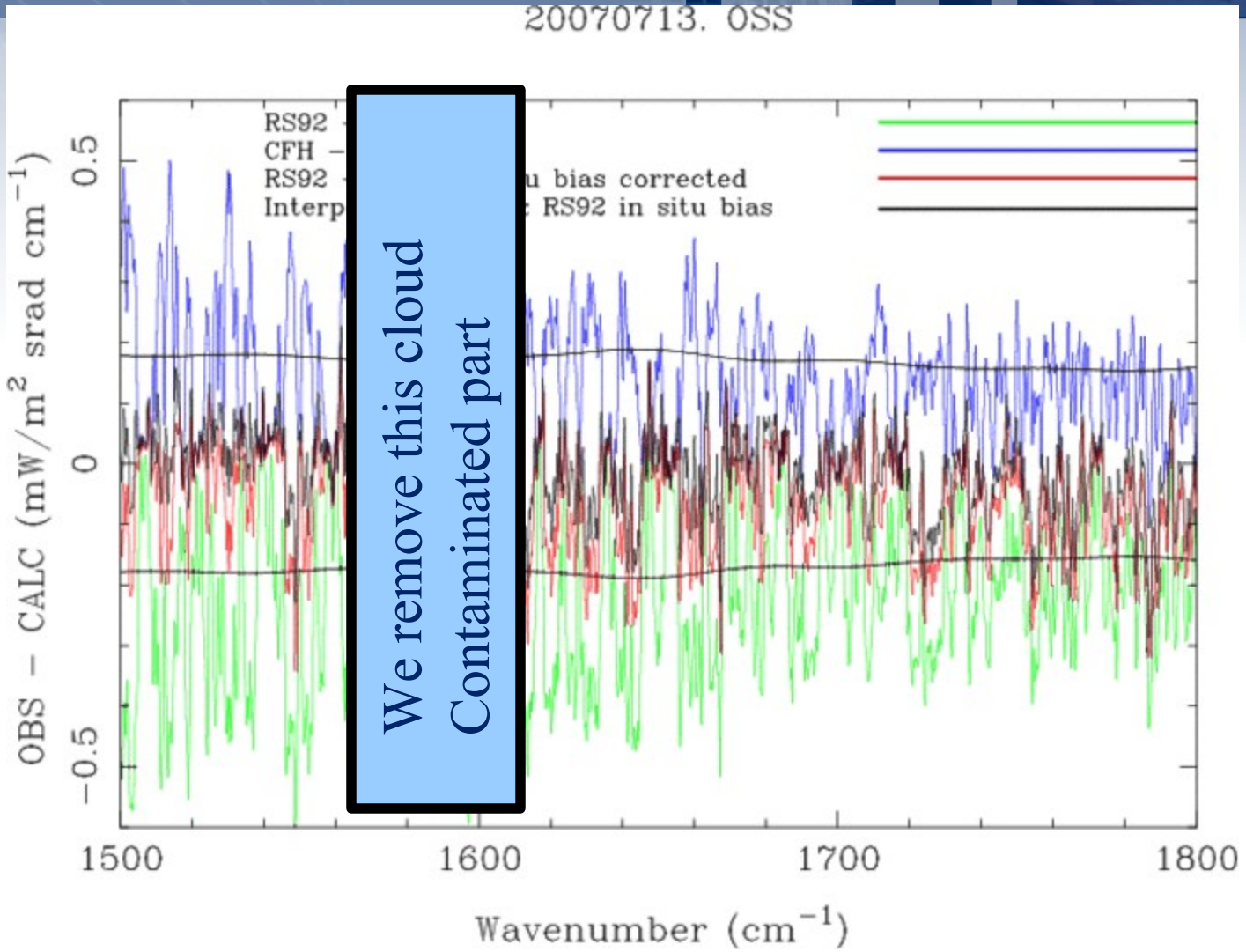
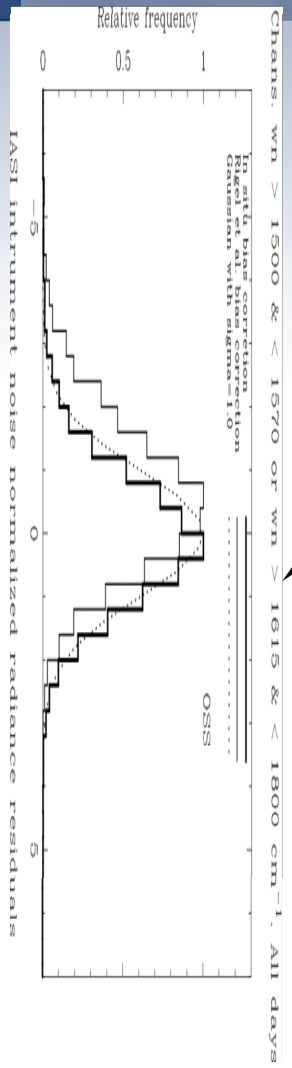
Results for OSS and Corrected Sondes





We normalize with IASI noise
and squash wavenumbers in a histogram

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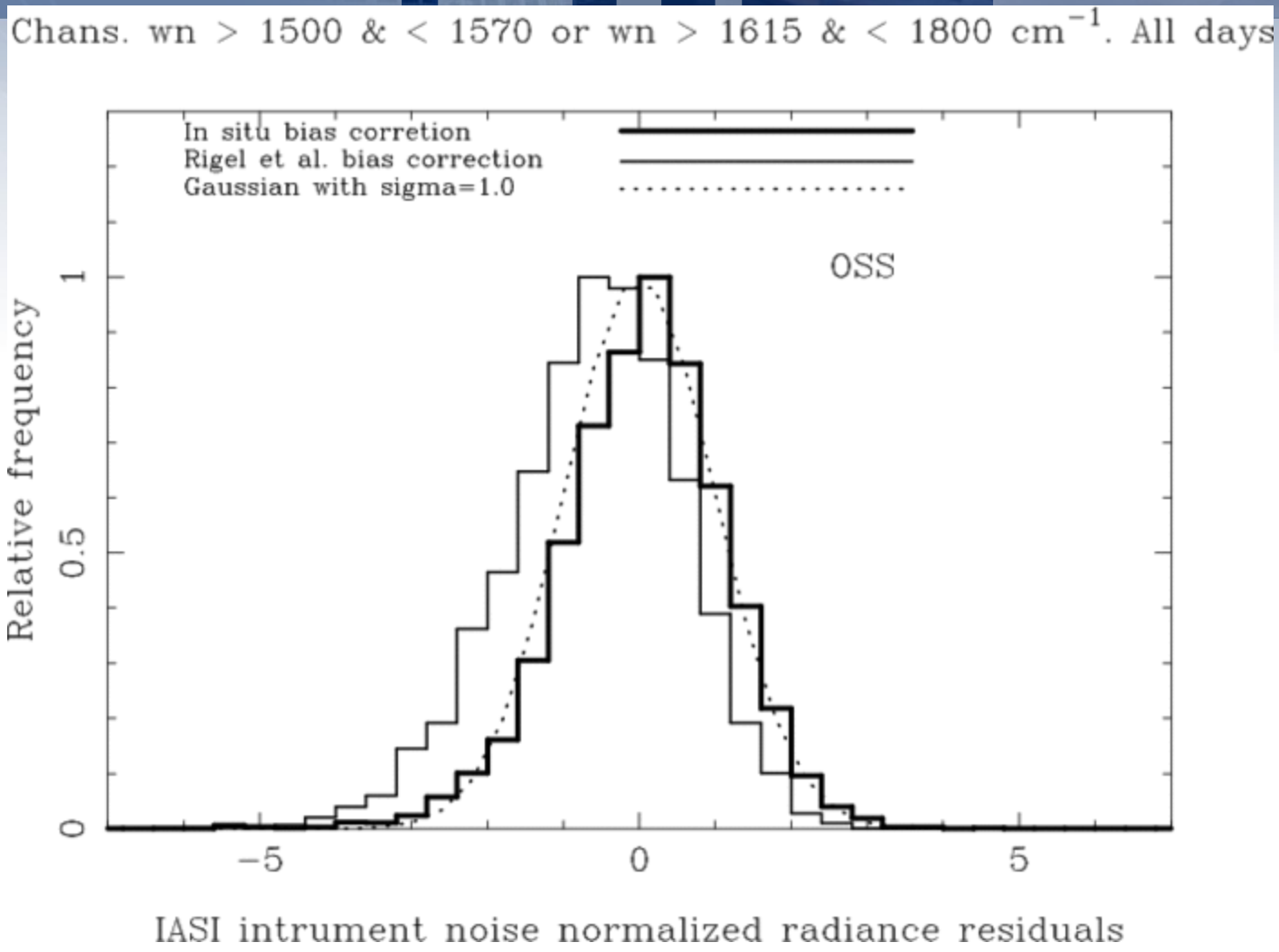
Results for OSS and Corrected Sondes ("In situ" and Rigel et al.)



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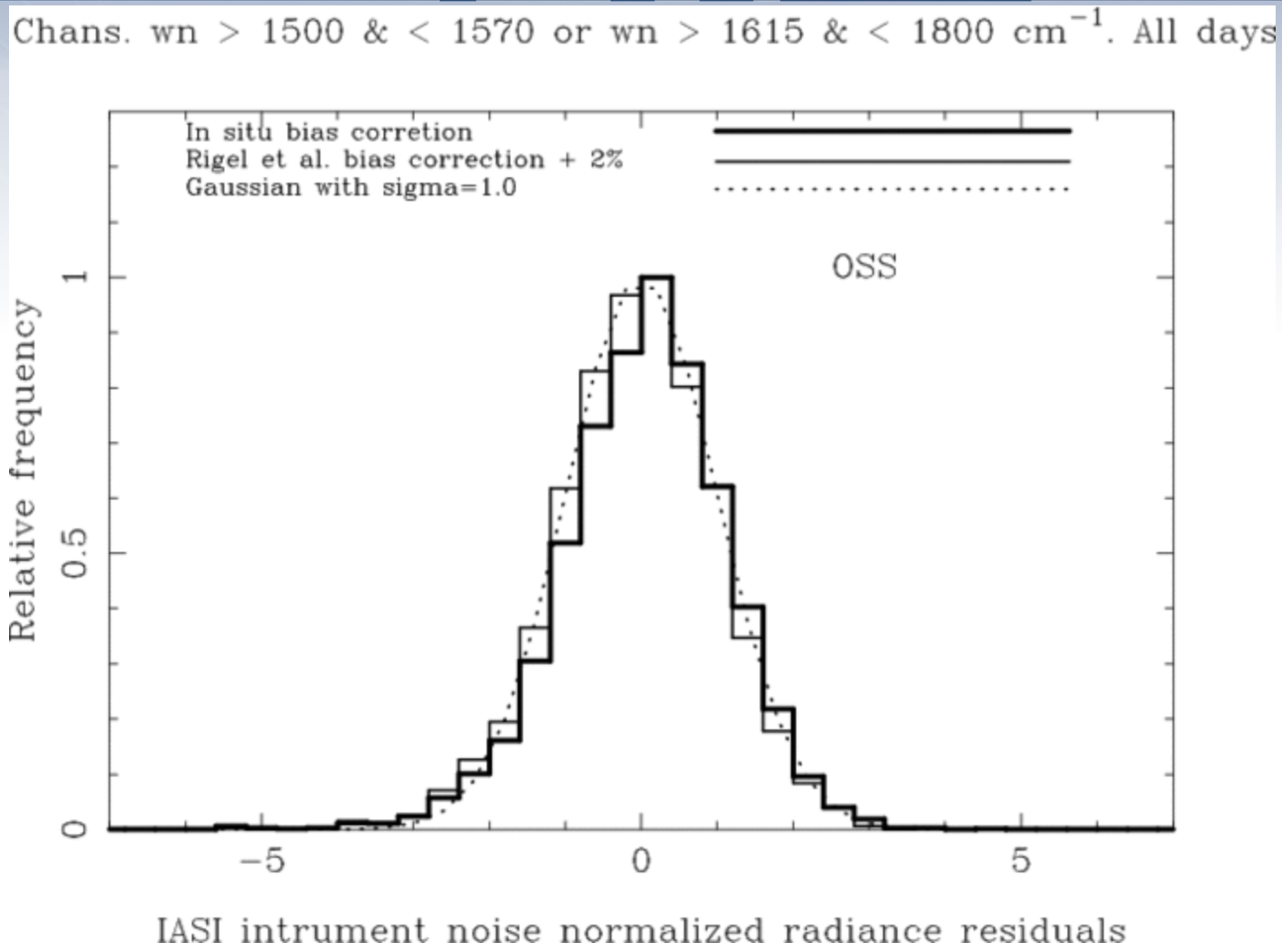
Results for OSS and Corrected Sondes ("In situ" and Rigel et al. + 2%)



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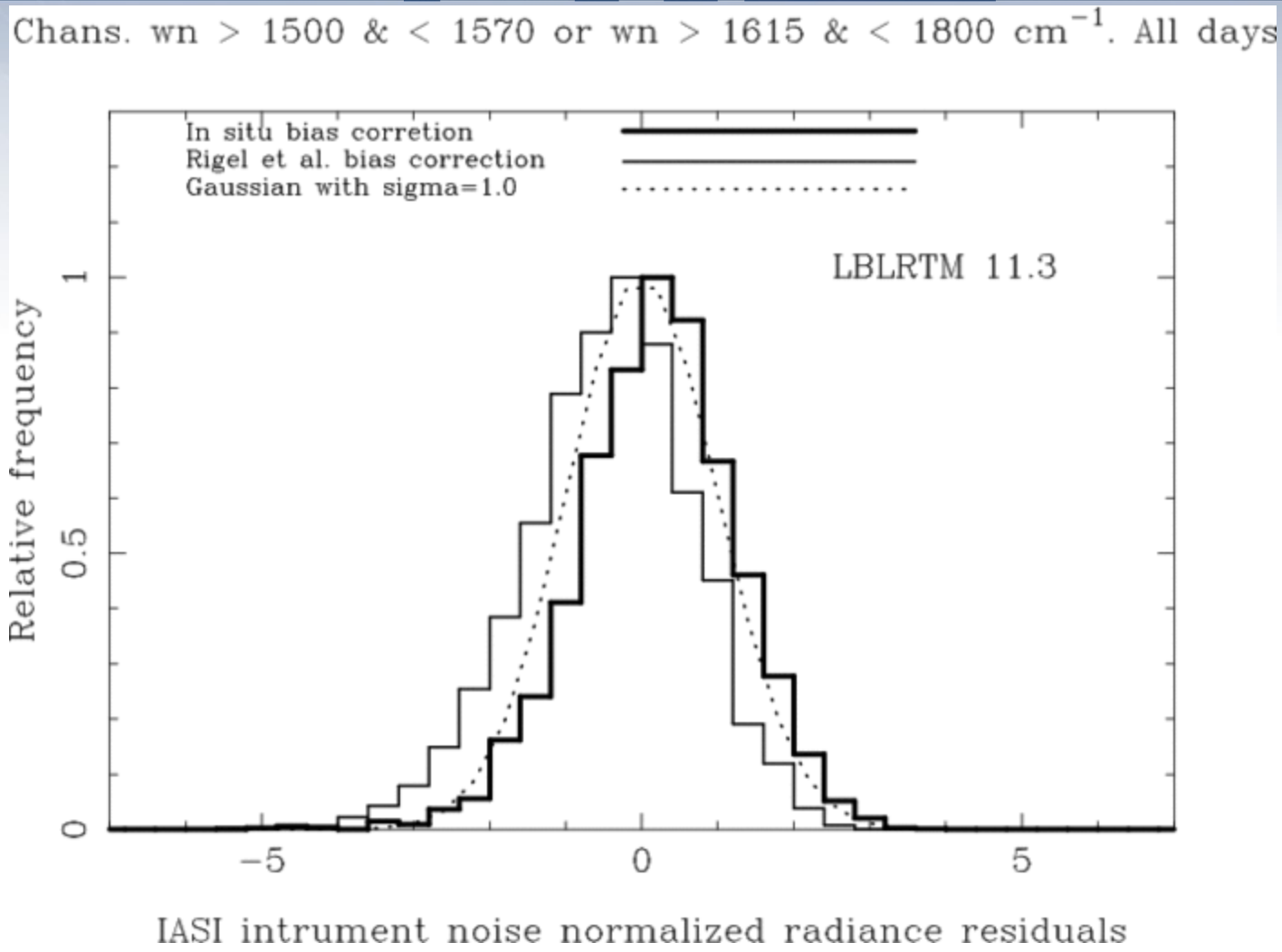
Results for LBLRTM 11.3 and Corrected Sondes ("In situ" and Rigel et al.)



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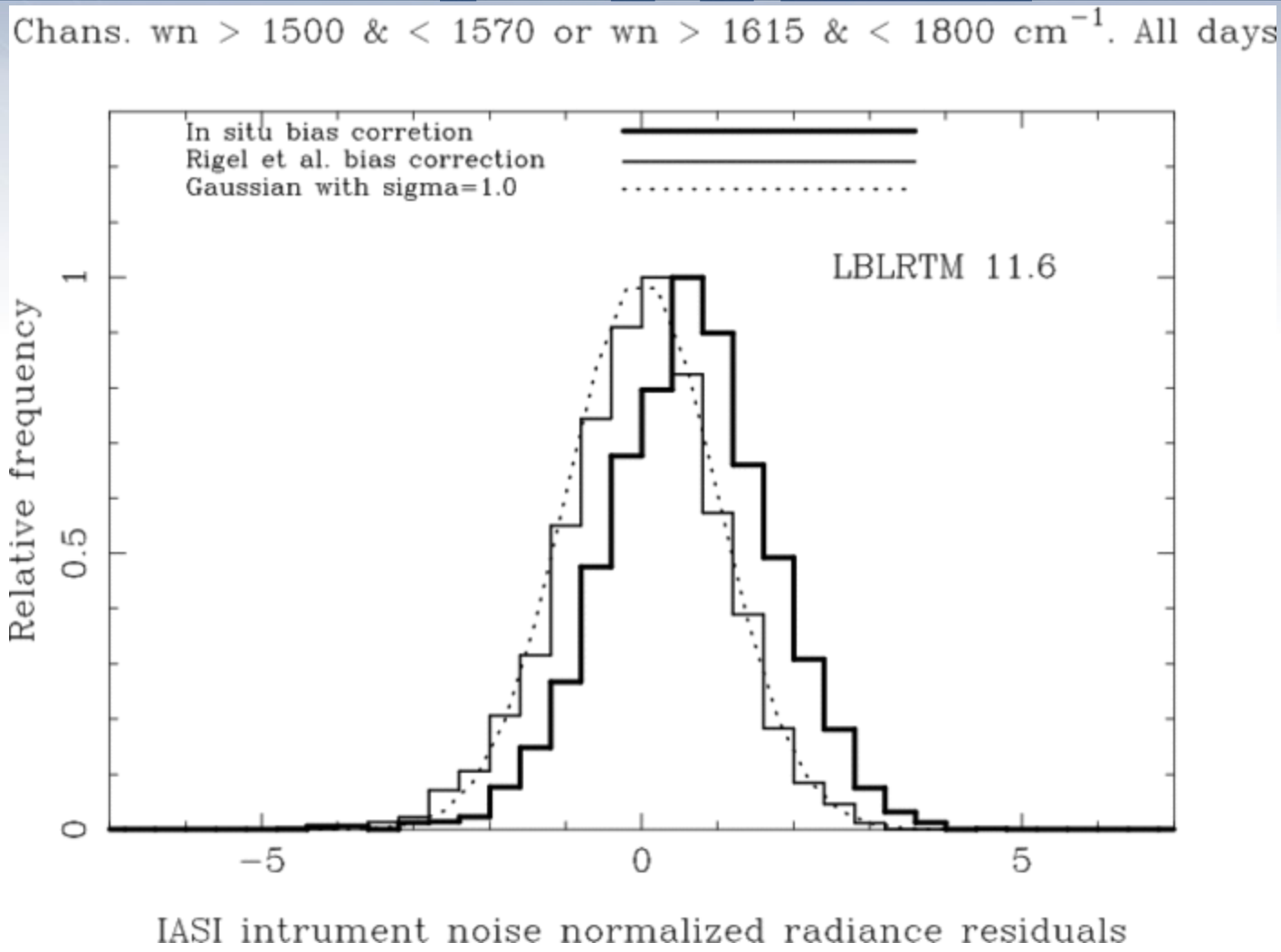
Results for LBLRTM 11.6 and Corrected Sondes ("In situ" and Rigel et al.)



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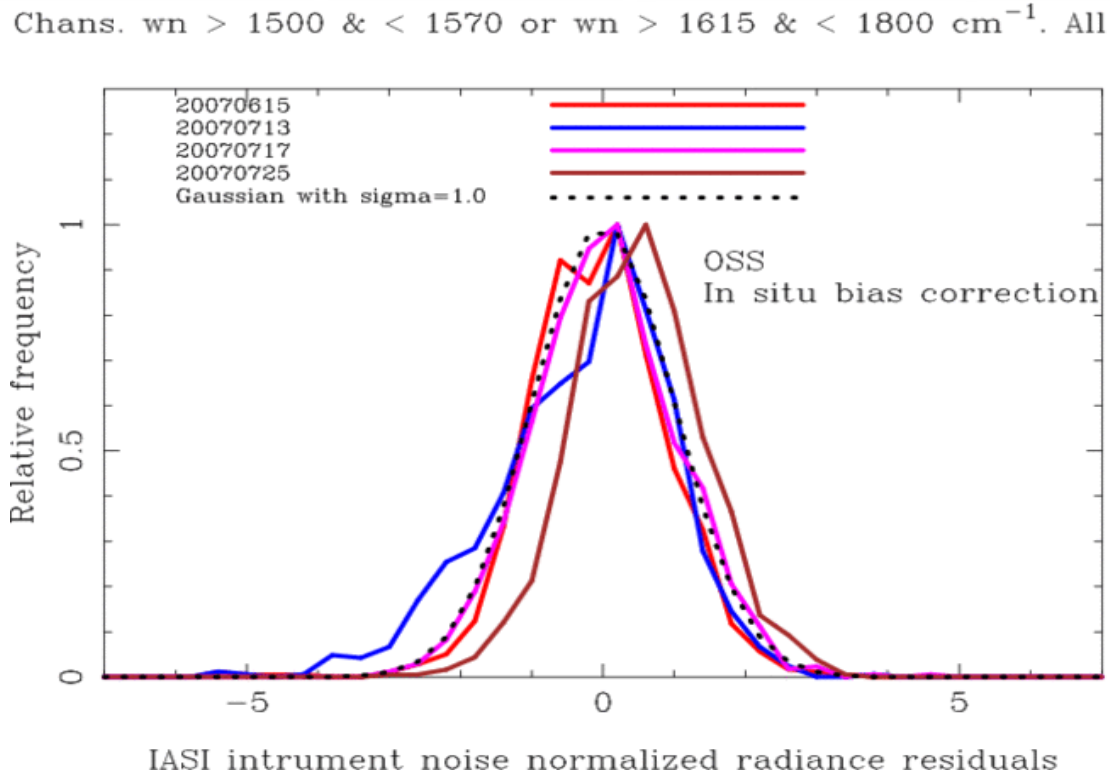
Questions (1/2)

- Fit to IASI **1-sigma instrument noise**:
  - Is **CNES IASI instrument** noise too **high**?
  - Where we just **lucky** these 4 days?



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Questions (2/2)

- Why has the **bias** shifted 1% in Relative Humidity in the **LBLRTM** when going from **11.3 to 11.6**?
  - Because of an **OBS-CALC** exercise similar to the one here?
  - Or because of something more **physical**?

Conclusions (1/2)

- With **IASI** we can differentiate **biases** with a difference of only **2%** in absolute terms of relative humidity
- We need sonde measurements with a low bias < **0.2%** in absolute terms and high accuracy of relative humidity in **UT/LS** → Only **CFH sondes** can provide this
- **RS92** sondes could be used as a replacement for CFH sondes using a proper bias correction: highly uncertain with this small campaign data sample whether this is achievable, or possibly use **nighttime** observations, but it will **never cover** properly the **UT/LS**
- **Spatial co-location** does **not** seem to have a big role in these radiance matching
- **Temporal co-location** is crucial

Conclusions (2/2)

- **OBS ↔ CALC** matching is important to:
  - Characterize measurement error covariance matrix for **optimal estimation**
  - Have a representative and quality sample to train statistical techniques (**EOF, ANN, SVM**)
- Ideally: **two CFH** sondes in campaigns launched with some time lag at satellite overpass
- Practical solution: **co-locate** campaign data with **IASI/AIRS/MTG-IRS**
  - GCOS Reference Upper Air Network (**GRUAN**)
  - Future **MTG-IRS** → Have a good collection of co-located radiosonde data