The EUMETSAT Network of Satellite Application Facilities

CM SAF Climate Monitoring

LEGOS

NOVELTIS

Deutscher Wetterdienst
*Wetter und Klima aus einer Hand*

DWD

# Towards a free tropospheric humidity product with global longitudinal coverage: FTH geo-ring demonstrator

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# SCOPE-CM

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**One of the Sustained and Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) phase2 projects:**

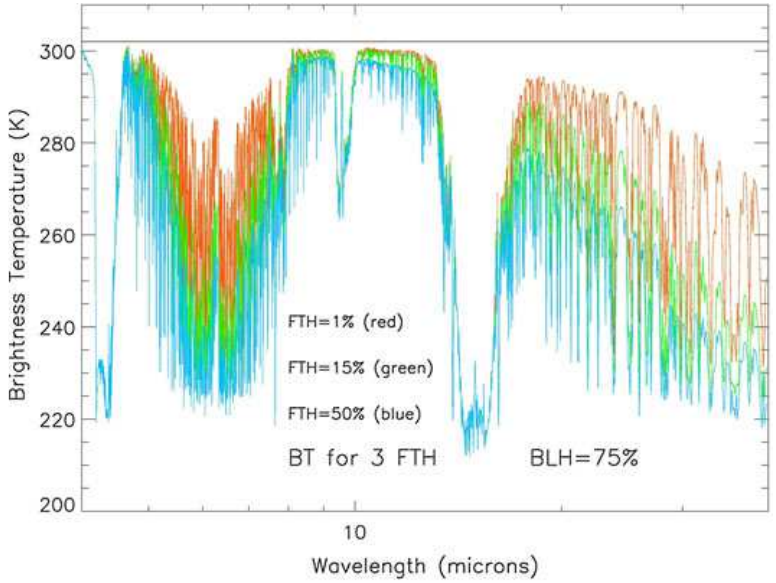
- **Inter-calibration of imager observations from time-series of geostationary satellites (IOGEO)**
  **IOGEO aims at the generation of a Fundamental Climate Data Record (FCDR) of calibrated and quality-controlled geostationary sensor data and is lead by EUMETSAT.**

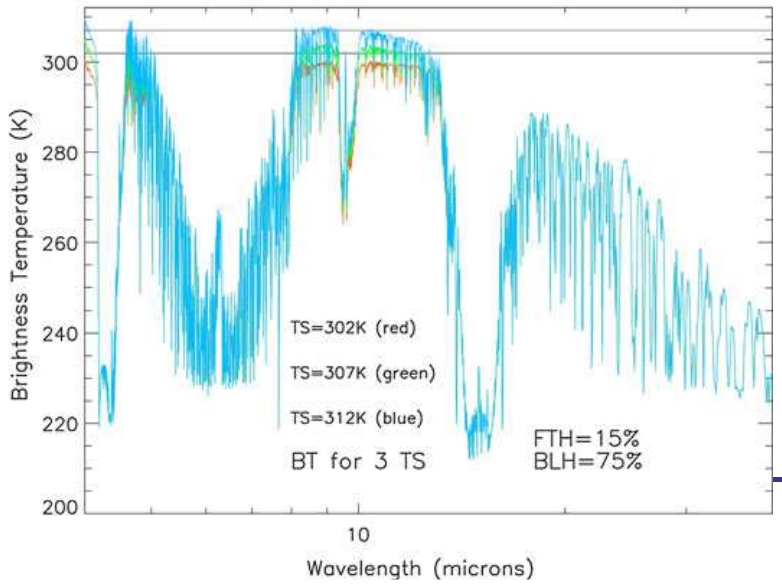
**CM SAF's contribution to IOGEO is:**

- **Development of FTH geo-ring demonstrator**

# Background





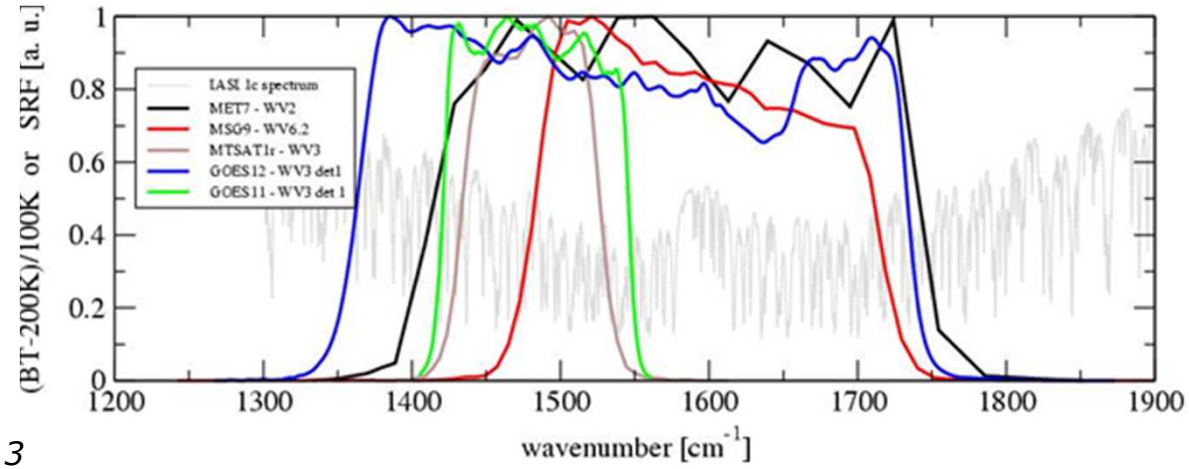

- **FTH strongly linked to Earth's radiation budget and atmospheric dynamics.**
- **Changes at the dry side of the FTH PDF have much larger impact on OLR than changes at the wet side.**
- **Climate models predict poleward and upward movement of dry regions and slight increase in frequency of occurrence of dry air.**

*Roca et al. 2011*

# FTH

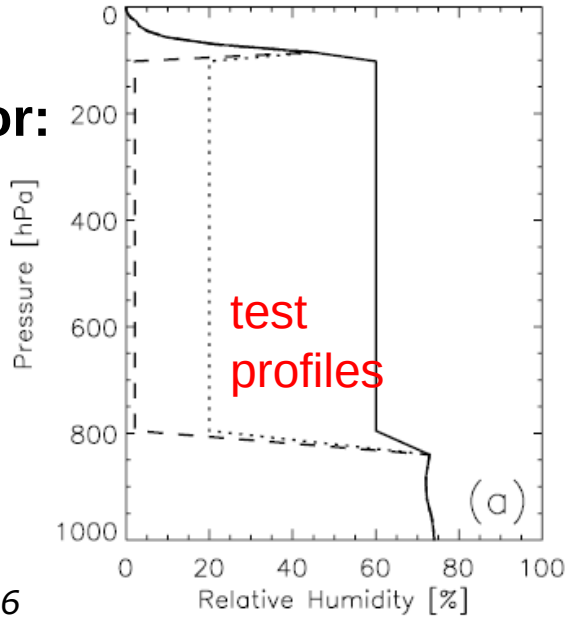


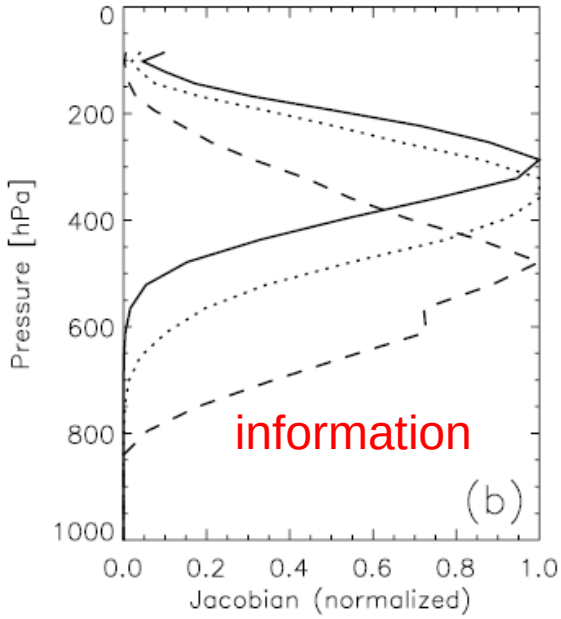
- **Input:**
  **MET2-5 and *7*-*9* observations at 6.3 microns (IR water vapour absorption band).**




*Standfuss et al. 2013*

- **Signal observed by sensor:**
  **Maximum position and width changes with profile.**




*Brogniez et al. 2006*

# Weighting function impact

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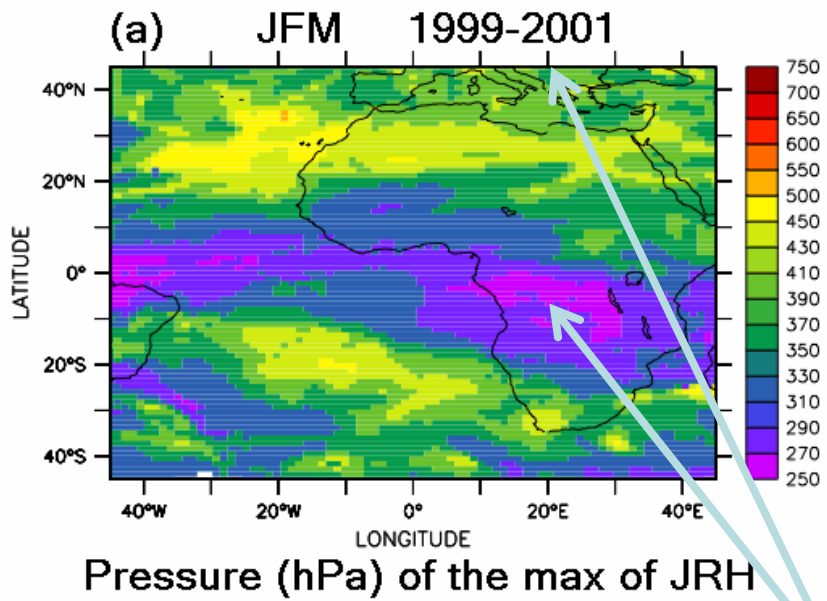
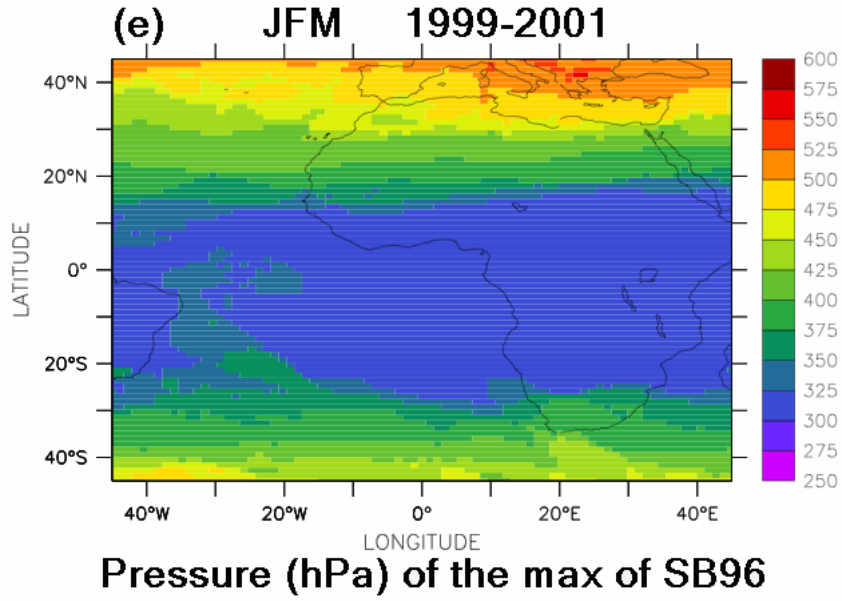
- ERA40 profiles input to RTTOV.
- Figures show peak heights.

## Relative humidity Jacobian




Pressure (hPa) of the max of JRH

## Weighting function from Soden and Bretherton (1996)




Pressure (hPa) of the max of SB96

*Roca et al. 2009*
*Schröder et al., 2014, submited*

**Smaller peak heights!**

# Geo-ring

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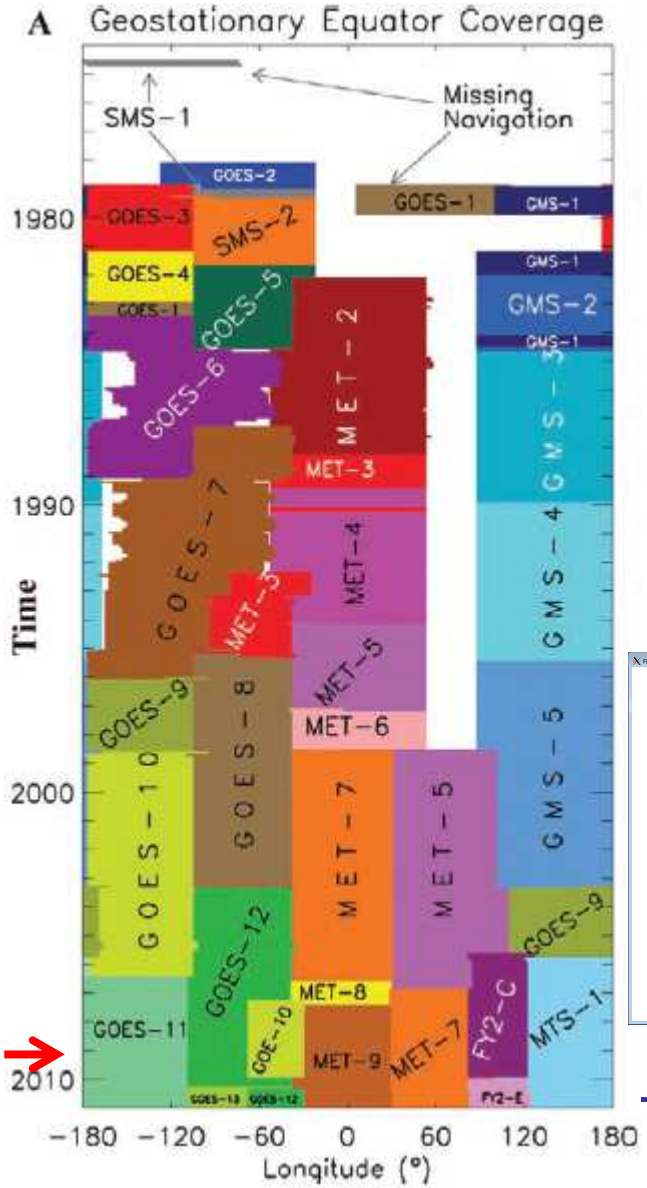
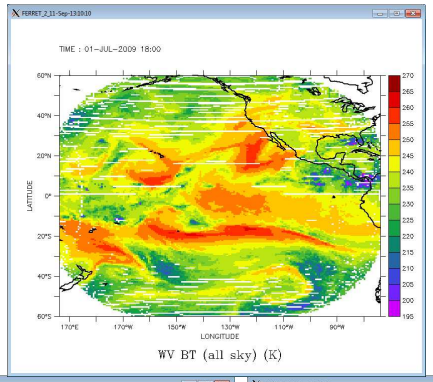
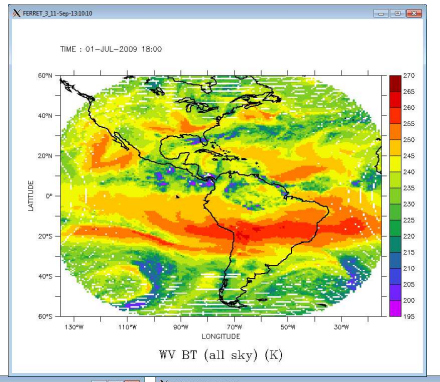


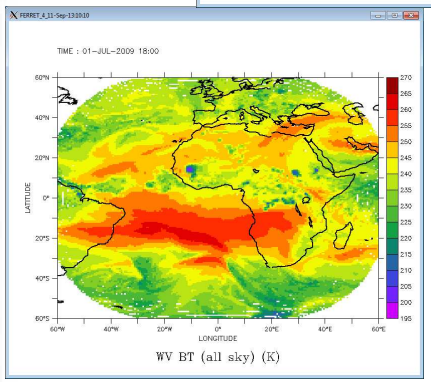

- **Use all geo-stationary satellites at exemplary period, here July 2009.**

**GOES-11**

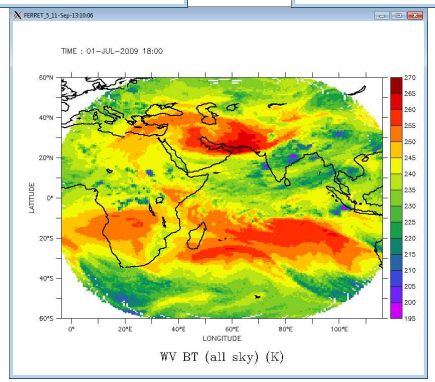



**GOES-12**

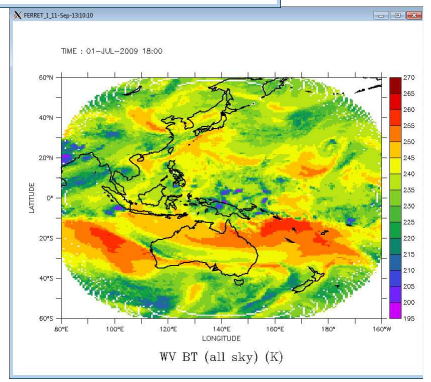



**MET9**




**MET7**




**MTSAT-1**

*Knapp et al. 2011*

# Input, flow chart

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- **MTSAT-1, GOES-11. GOES-12, MET7 radiances from ISCCP-DX.**
- **MET9 radiances from DWD archive, sampled to mimic ISCCP-DX.**
- **Cloud mask and cloud top pressure from ISCCP-DX.**
- **Inter-calibration to IASI from GSICS.**
- **$p_0$ computed using ERA-Interim.**

Extraction of ISCCP-DX WV channel counts and cloud mask

July 2009; 3-hourly; 30 km irregular sampling

↓

Cloud masking

↓

Re-projection onto 0.625°x0.625°-grid

↓

Radiometric calibration to IASI (GSICS coefficients)

↓

Spectral calibration to Common Reference Channel (CRC)

↓

CSR-to-FTH conversion, regression coefficients $a_{CRC}$ and $b_{CRC}$ with respect to CRC

# BT / radiance GSICS

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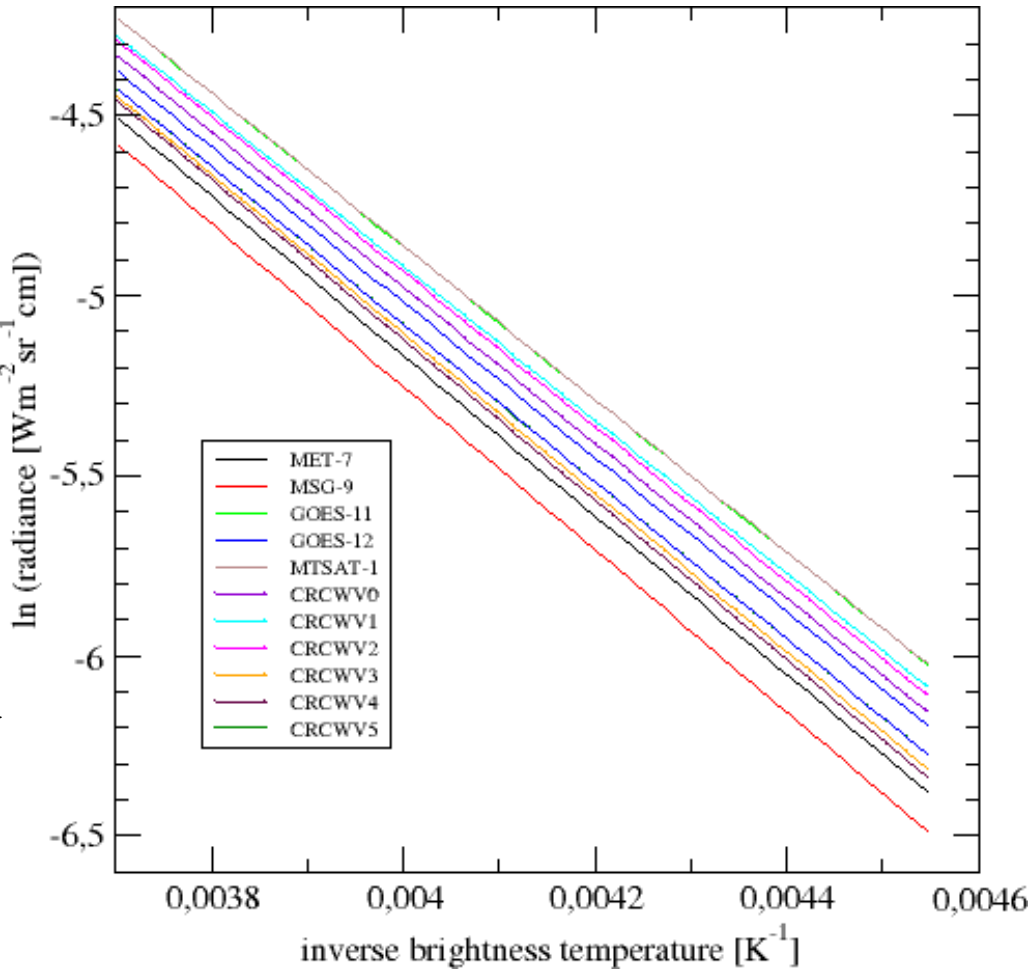
- **GSICS coefficients applicable in radiance space – ISCCP-DX data available in brightness temperature space.**




- **Then, apply GSICS coefficients:**

$$BT_{geo,r} = \frac{b_{conv}}{\ln\left[\frac{-a_r}{b_r} + \frac{1}{b_r}\exp\left(a_{conv} + \frac{b_{conv}}{BT_{geo}}\right)\right] - a_{conv}}$$

# Spectral calibration

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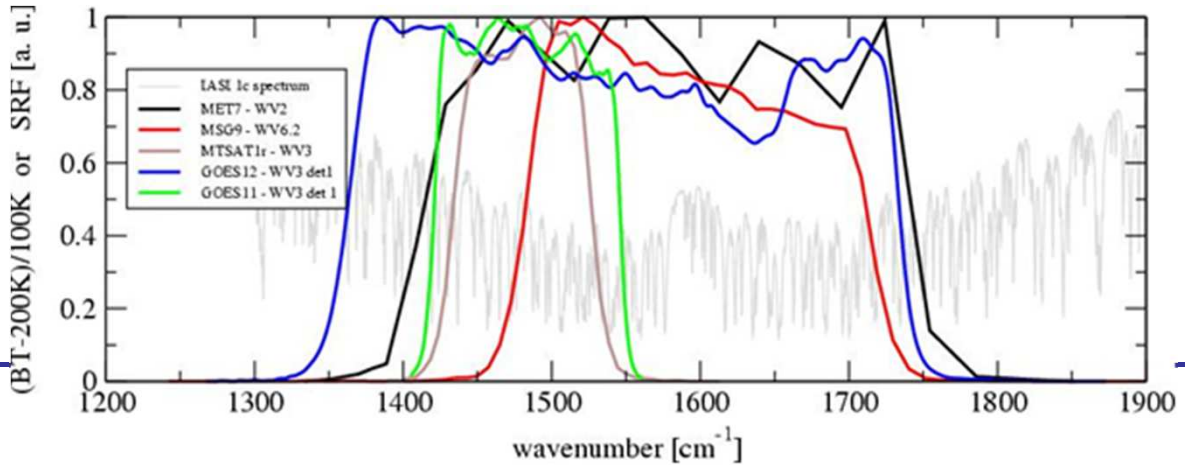
- **Achieve spatial homogeneity through spectral calibration to a single common reference channel**
  - CRCWV0: 1359.25 $cm^{-1}$ – 1639.00 $cm^{-1}$ (Hewison and Kessel, 2010);
  - CRCWV1: 1400 $cm^{-1}$ – 1600 $cm^{-1}$;
  - CRCWV2: 1450 $cm^{-1}$ – 1550 $cm^{-1}$;
  - CRCWV3: 1450 $cm^{-1}$ – 1650 $cm^{-1}$;
  - CRCWV4: 1500 $cm^{-1}$ – 1600 $cm^{-1}$;
  - CRCWV5: 1400 $cm^{-1}$ – 1700 $cm^{-1}$;
  - MET9



# Results

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- **Residual linear regression errors between GEO WV brightness temperatures and CRC WV brightness temperatures (1-sigma uncertainty in K).**

| CRC / GEO | WV0 | WV1 | WV2 | WV3 | WV4 | WV5 | MSG-9 |
|---|---|---|---|---|---|---|---|
| **MET-7** | 0.32 | 0.39 | 0.58 | 0.31 | 0.56 | 0.18 | 0.53 |
| **MSG-9** | 0.84 | 0.91 | 0.11 | 0.23 | 0.12 | 0.70 | 0 |
| **GOES-11** | 0.25 | 0.32 | 0.65 | 0.38 | 0.63 | 0.12 | 0.60 |
| **GOES-12** | 0.27 | 0.21 | 1.10 | 0.85 | 1.05 | 0.39 | 1.04 |
| **MTSAT-1** | 0.29 | 0.37 | 0.61 | 0.35 | 0.60 | 0.16 | 0.56 |

# Retrieval



**Inversion:**

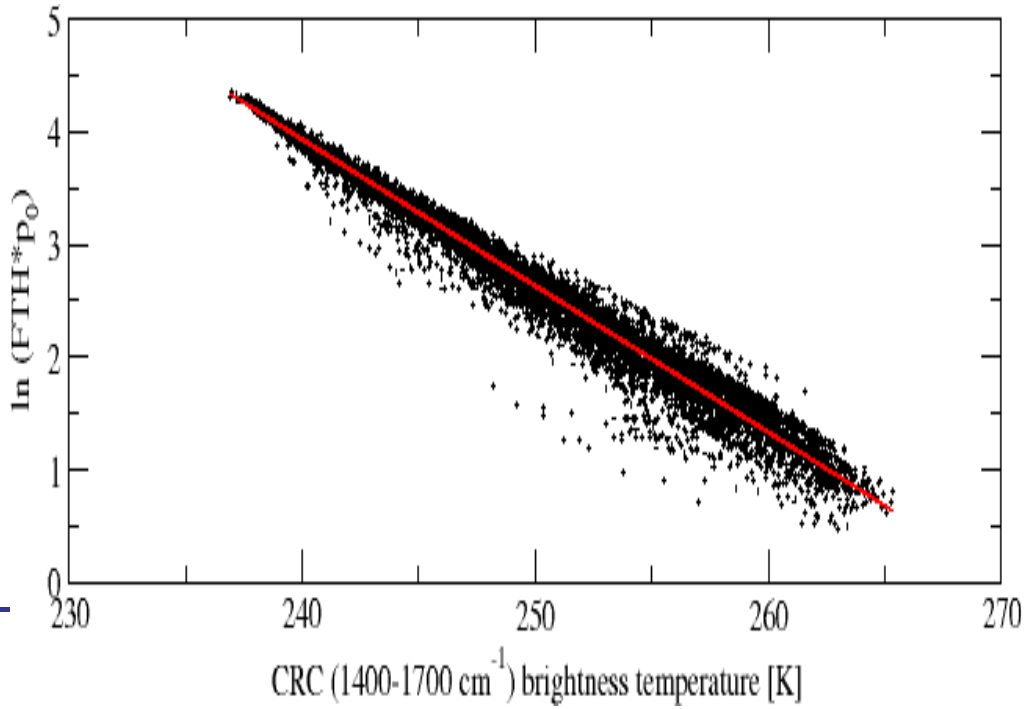
$$\ln\left(\frac{FTH \cdot p_0}{\cos\theta}\right) = a_{CRC} + b_{CRC} \cdot BT_{CRC}$$

**with**

$$FTH = \frac{\int \frac{\partial BT_{CRC}}{\partial RH}(p) \cdot RH(p)\, dp}{\int \frac{\partial BT_{CRC}}{\partial RH}(p)\, dp} \qquad p_0 = \frac{p(T = 240K)}{300hPa}$$

**CRC5 definition requires recomputation of inversion coefficients (done also at CM SAF).**

**Required installation and test of line-by-line model, here 4AOP (Scott and Chedin, 1981).**



# GOES issue

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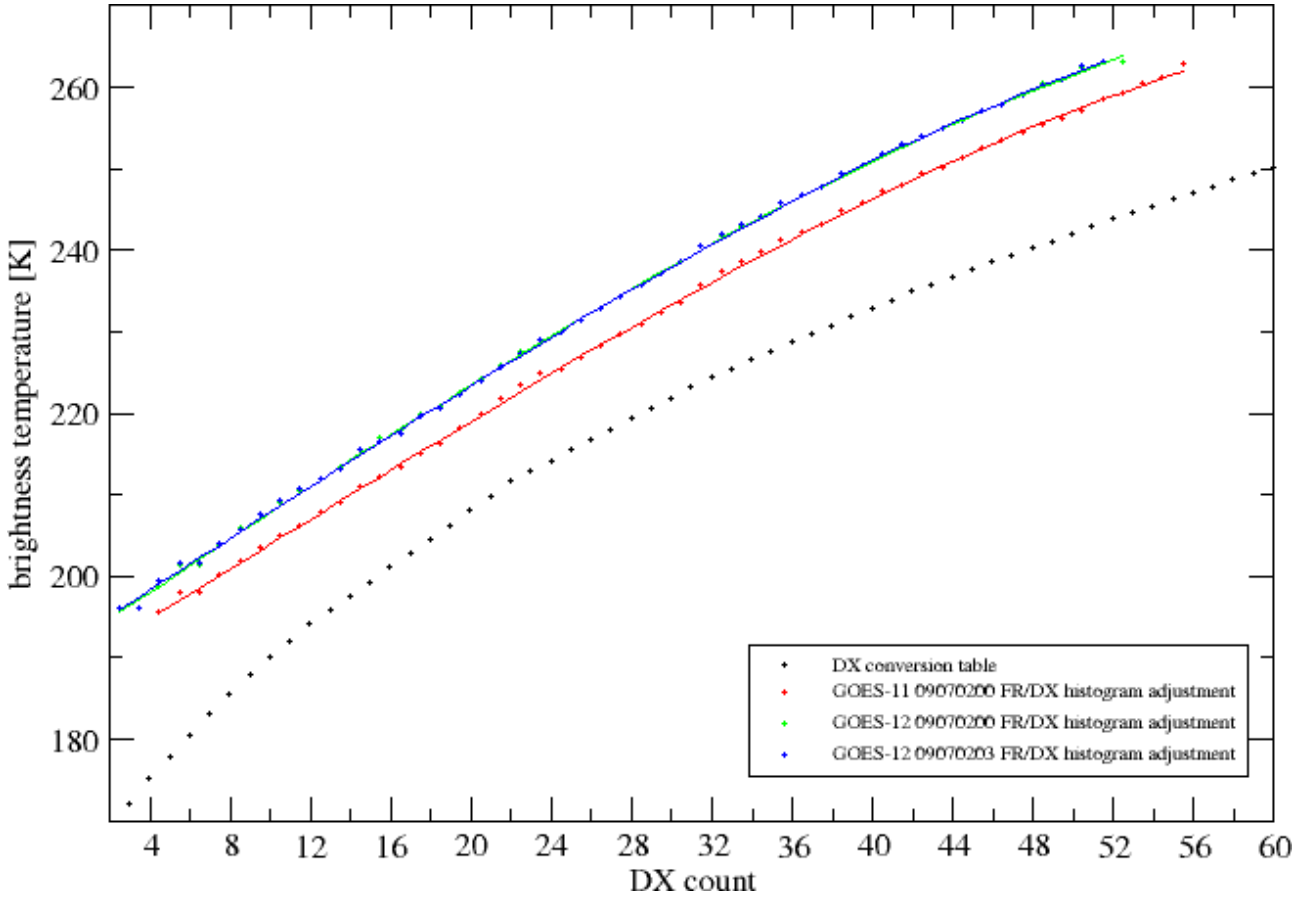
- **When using ISCCP-DX data GOES-11 and GOES-12 seem to have a bias of 15-20 K.**



# FTH geo-ring

## Exemplary instantaneous results

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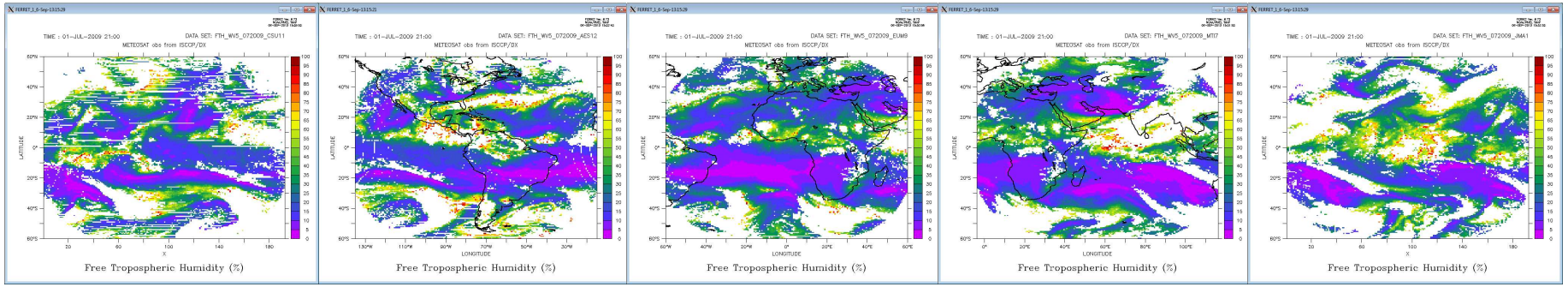


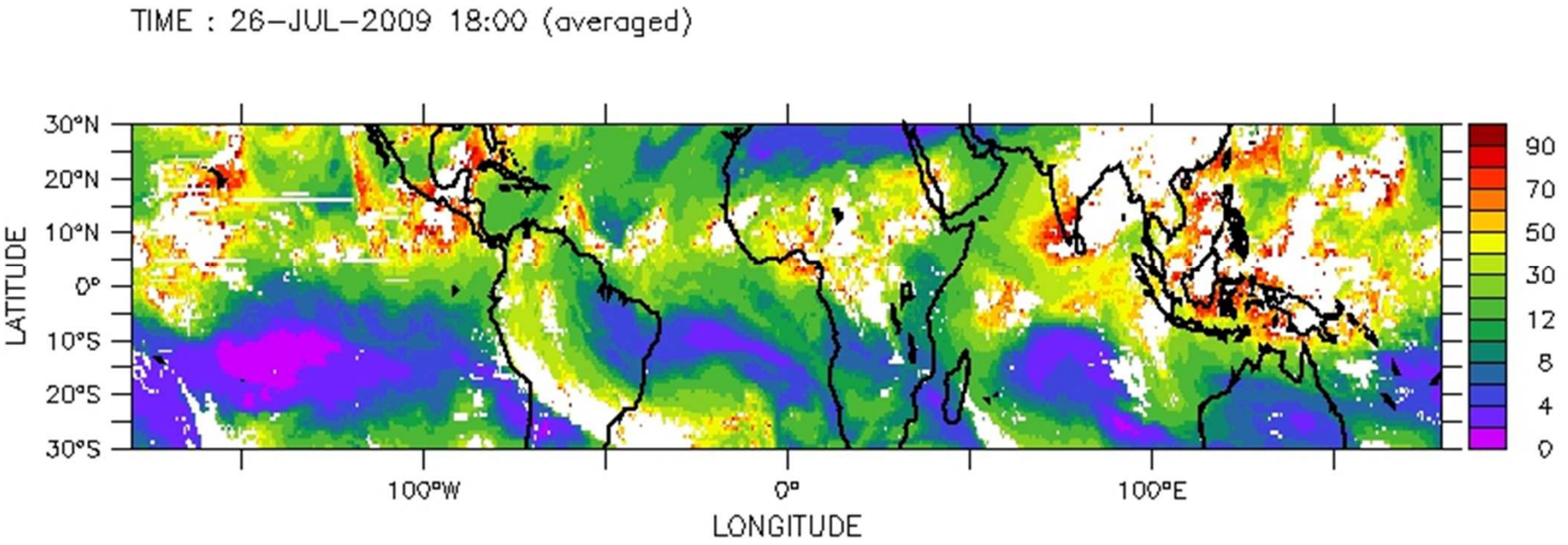

# FTH geo-ring

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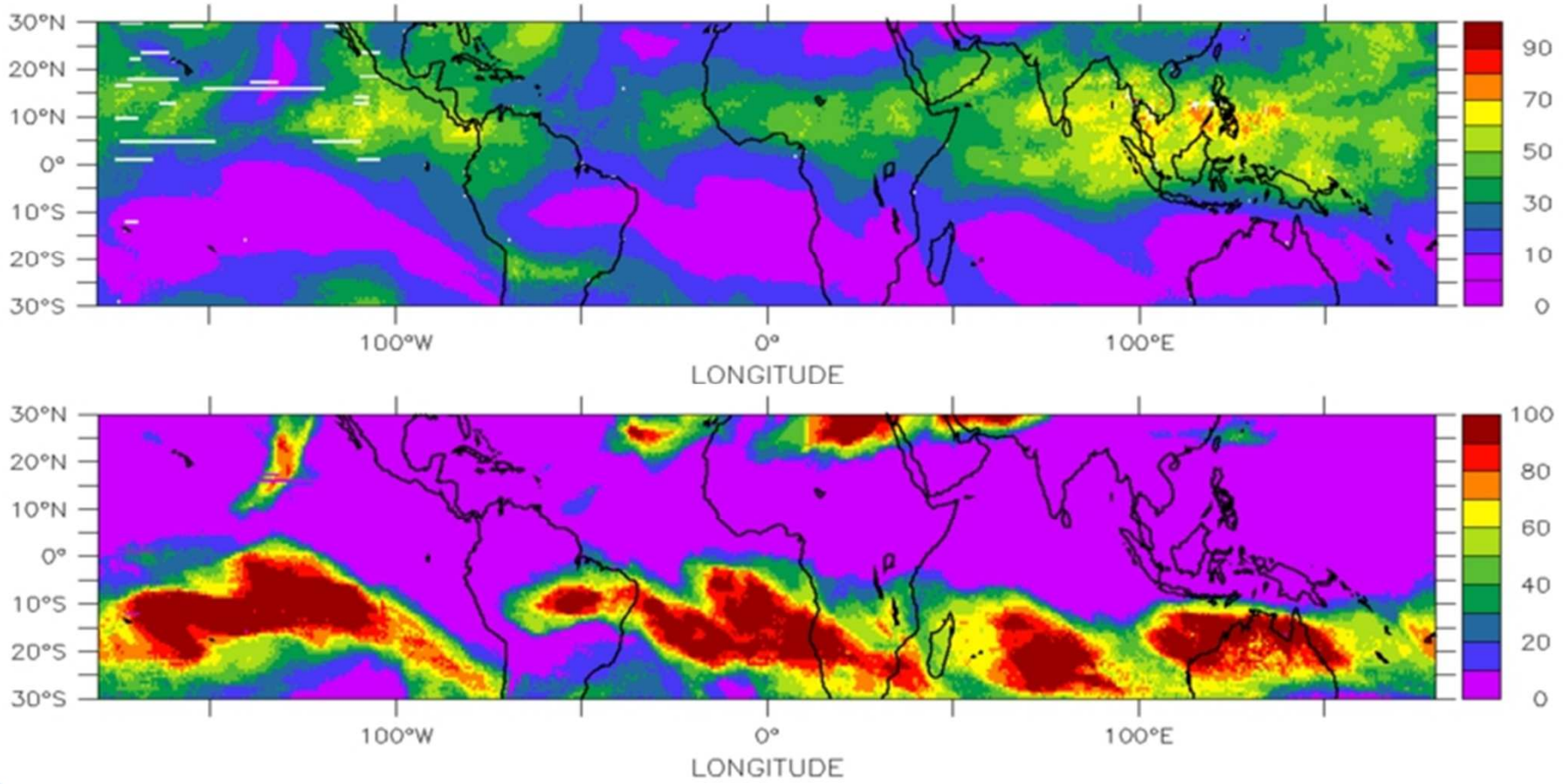
- **Frequency of occurrence of dry FTH, here: FTH<10%**



# Conclusions

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- Comparison against ARSA radiosondes implemented – evaluation work in progress.
- Comparison against HIRS UTH exhibits bias.
- Assessment of uncertainty relative to user requirements - work in progress.

- Spatial homogeneity eases applications (process and climate analysis)
- CRC approach eases application in model evaluation and assimilation.

- Updates:
  - Use original GOES data and sample ISCCP-DX.
  - Change to IOGEO FCDR, redo FTH geo-ring demonstrator and evaluate difference to precursor version.

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# Thanks for your attention!