Sustained generations of upper tropospheric humidity Climate Data Records from multiple sensors with multi-agency cooperation

Team composition

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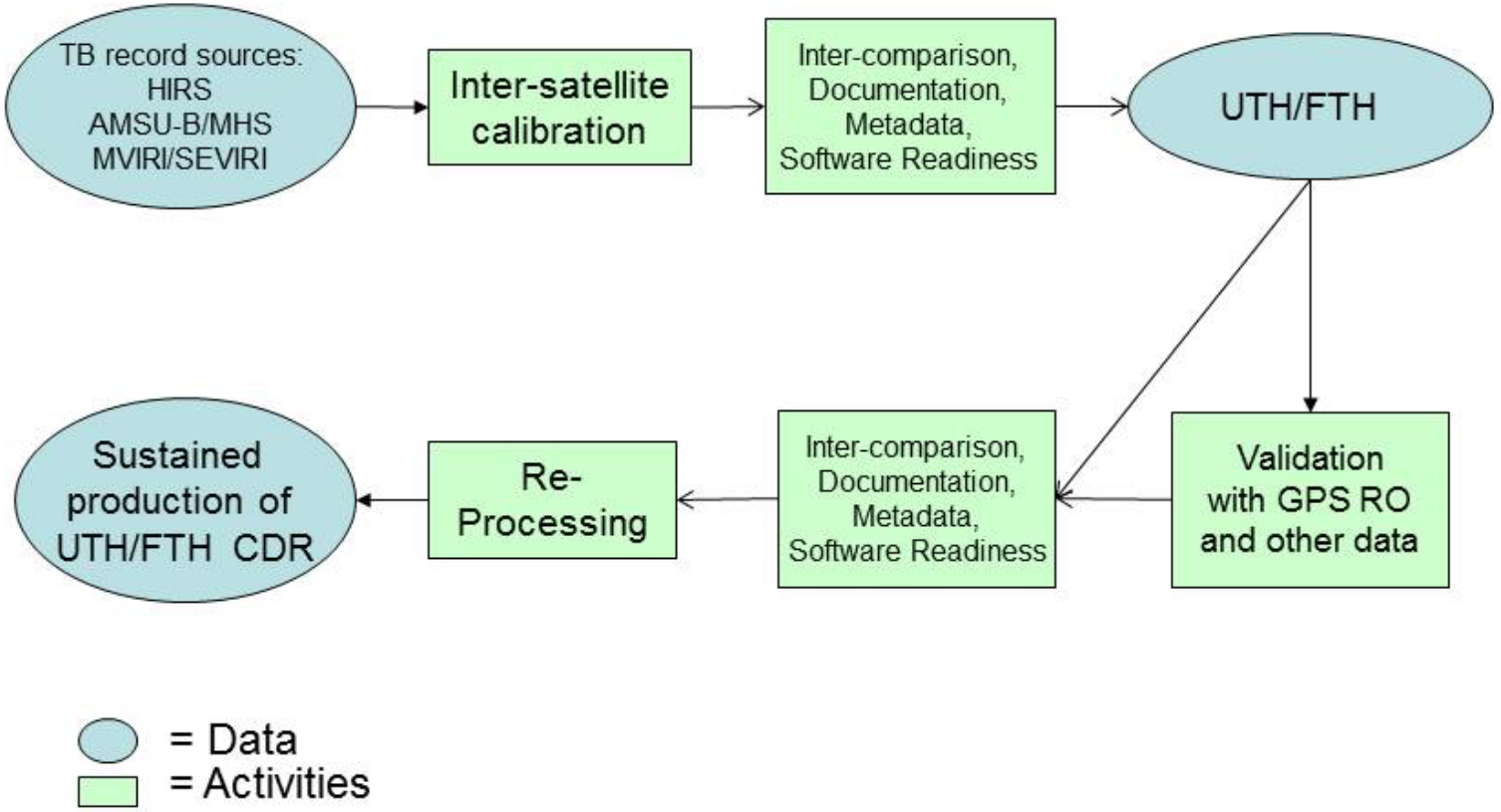
- **Stefan Buehler**, Lulea University of Technology, Kiruna, Sweden and Meteorological Institute, University of Hamburg, Germany
- **Shu-peng Ho**, National Center for Atmospheric Research, Boulder, CO, USA
- **Viju John**, Met Office Hadley Centre, Exeter, UK and EUMETSAT
- **Marc Schröder**, Deutscher Wetterdienst, Satellite Based Climate Monitoring, Offenbach, Germany
- **Lei Shi**, NOAA NESDIS National Climatic Data Center, Asheville, NC, USA
- **Brian Soden**, University of Miami, Rosenstiel School of Marine & Atmospheric Science, Miami, FL, USA

Project Summary

- Sustained generation of upper tropospheric humidity (UTH) (also named as free tropospheric humidity (FTH))
- Datasets derived from HIRS since late 1978, from AMSU-B and MHS since late 1998, and from MVIRI and SEVIRI since 1983
- Satellite records improved by bias correction and homogenization procedures
- Redundancy of records from multiple sensors facilitates the examination of the homogeneity and stability of each satellite data record and to explain the differences among data records
- Working to advance maturity levels established by the SCOPE-CM Maturity Matrix Model

UTH/FTH Data Flow



First Year Plan

- Write ATBD for both FCDR and TCDR products
- Update netCDF attributes to adopt CF convention
- Develop capabilities to process UTH/FTH in an operational environment
- Make available a geo-ring FTH demonstrator product in cooperation with Noveltis and CNRS
- Understand differences among upper tropospheric water vapor measurements through inter-comparison

Status - Metadata

- The netCDF attributes for HIRS channel 12 brightness temperature gridded dataset are updated to comply with CF convention
- METEOSAT FTH product is available in netCDF following CF convention

Status - Documentation

- An ATBD for inter-satellite calibrated HIRS channel 12 brightness temperature dataset is drafted.
- ATBD, Product User Manual and Validation Report for homogenised METEOSAT FTH product is drafted, successfully reviewed and released in 2013 (available at: www.cmsaf.eu/docs).
- In support to the EU project CoreClimax the System Maturity Matrix for the METEOSAT FTH product has been filled. This SMM is currently in the consolidation process.

Status - Software

- In support to GEWEX Water Vapor Assessment (G-VAP) tools for the analysis of long-term homogeneity and changes in FTH have been implemented and applied to METEOSAT FTH.
  - This will be extended to UTH from HIRS and AMSU-B in near future.
- A geo-ring FTH demonstrator product (July 2009, all longitudes, <45°N/S) was developed and produced in cooperation with Noveltis and CNRS (see sample slides later).
  - FTH software was transferred from CM SAF to Noveltis and installed and operated at Noveltis.
- Feedback from Noveltis on the FTH software was received and will be implemented in FTH code.
  - The demonstrator data will be transferred to the FTH edition 1 format, together with additional metadata.

Status – Product Inter-comparison and Validation

- Started characterising biases of the microwave humidity sensors using SAPHIR instrument on Megha-Tropiques satellite. Initial results were presented at EUMETSAT satellite conference 2013.
- Characterised inter-satellite biases, scan-depended biases, and impact of orbit drift of satellites in microwave observations.
- A visiting scientist study on behalf of CMSAF by Eui-Seok Chung, Uni. of Miami has been conducted to characterise SSM/T-2 radiances in order to take the microwave UTH data back to 1992 (report available).
- CM SAF (UKMO, DWD) launched a Visiting Scientist cooperation. Q. Yang inter-compared UTH products from AMSU-B, HIRS and METEOSAT and will devise an inter-comparison strategy.
- DWD/CM SAF analysed the impact of different Jacobians on FTH/UTH estimates. An average difference of 20% can be caused by the utilisation of different Jacobians.
- Metop-A HIRS channel 12 is compared to IASI simulated HIRS channel 12, and calibration for Metop-A HIRS channel 12 is derived.

Publications

- Chung, E.-S., B. J. Soden, B. J. Sohn, and L. Shi (submitted 2014), **Upper tropospheric moistening in response to increased anthropogenic greenhouse gases**, Nature Geoscience.
- Chung, E.-S., B. J. Soden, and V. O. John (2013), **Intercalibrating microwave satellite observations for monitoring long-term variations in upper and mid-tropospheric water vapor**, *J. Atmos. Oceanic Technol.*, ***30***, 2303–2319, doi:10.1175/JTECH-D-13-00001.1.
- John, V. O., D. E. Parker, S. A. Buehler, J. Price, and R. W. Saunders (2013), **Analysis of upper-tropospheric humidity in tropical descent regions using observed and modelled radiances**, *Atmos. Chem. Phys. Discuss.*, ***13***, 10547–10560, doi:10.5194/acpd-13-10547-2013.
- Kottayil, A., S. A. Buehler, and V. O. John (submitted 2013), **Evaluating the diurnal cycle of upper tropospheric humidity in two different climate models using satellite observations.**, *J. Geophys. Res.*
- Shi, L., Schreck III, C. J., and John, V. O. (2013): **HIRS channel 12 brightness temperature dataset and its correlations with major climate indices**, Atmos. Chem. Phys., 13, 6907-6920, doi:10.5194/acp-13-6907-2013.

Sample Figures (1)
Geo-ring

The EUMETSAT Network of Satellite Application Facilities

CM SAF Climate Monitoring

LEGOS

NOVELTIS

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Wetter und Klima aus einer Hand

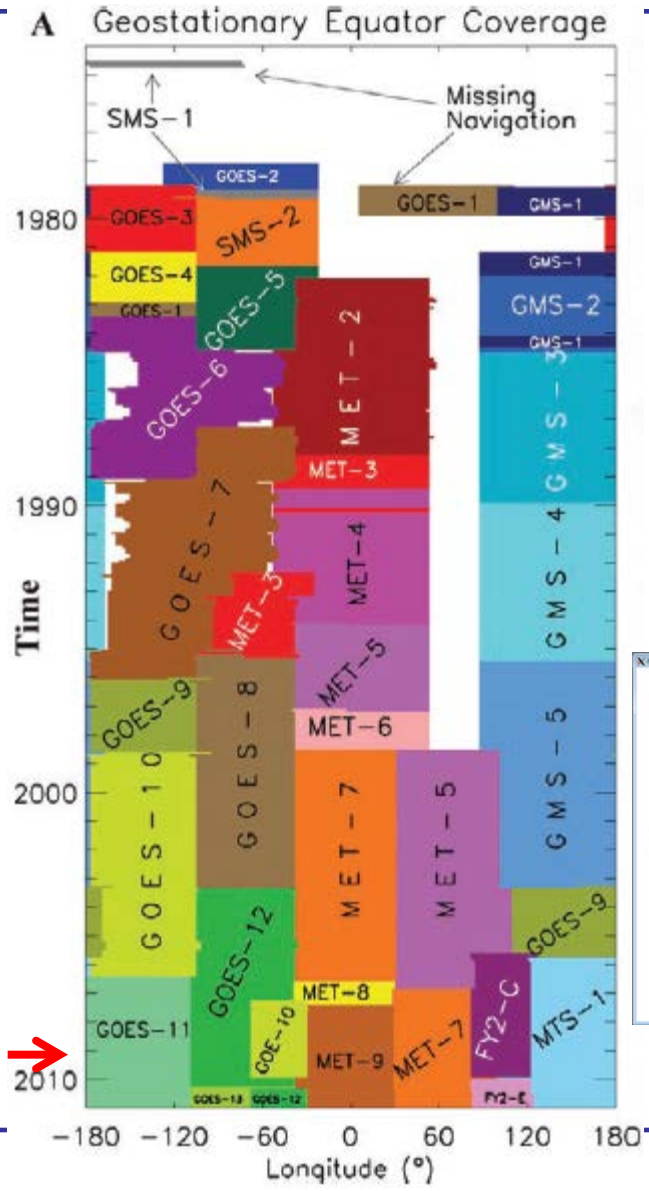
DWD

Towards a free tropospheric humidity product with global longitudinal coverage: georing FTH

Marc Schröder, Remy Roca, Carsten Standfuss

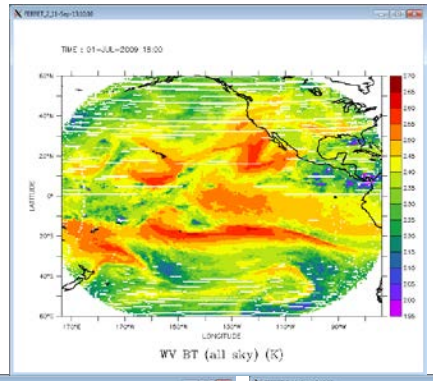
Geo-ring

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

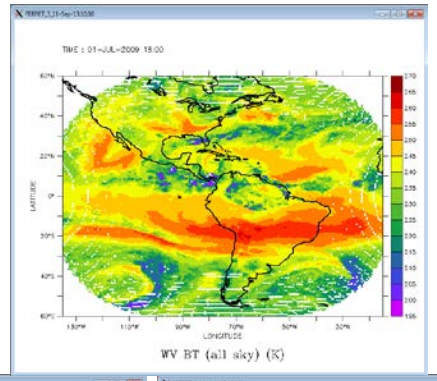


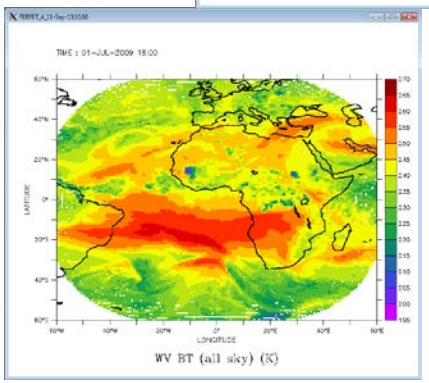
- **Use all geo-stationary satellites at exemplary period, here July 2009.**

GOES-11

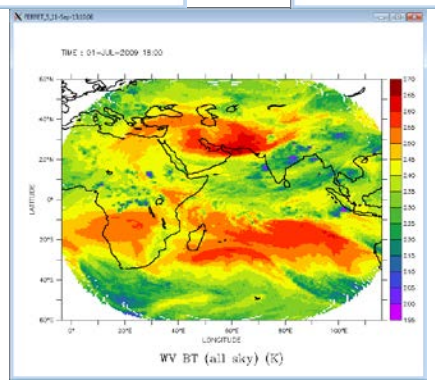


GOES-12

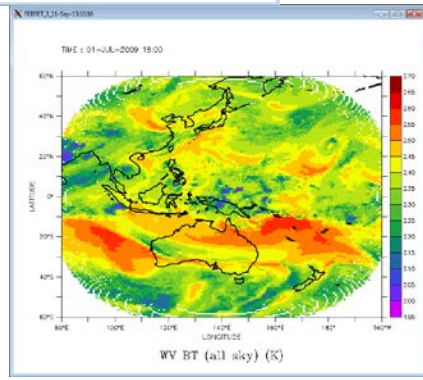




MET9



MET7



MTSAT-1

Knapp et al. 2011

Input

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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.**
- **p0 computed using ERA-Interim.**

FTH geo-ring

Exemplary instantaneous results

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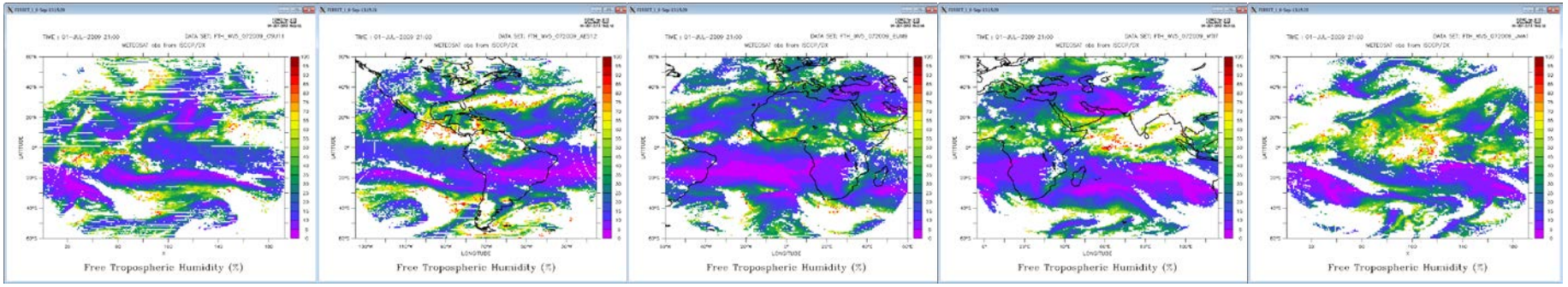

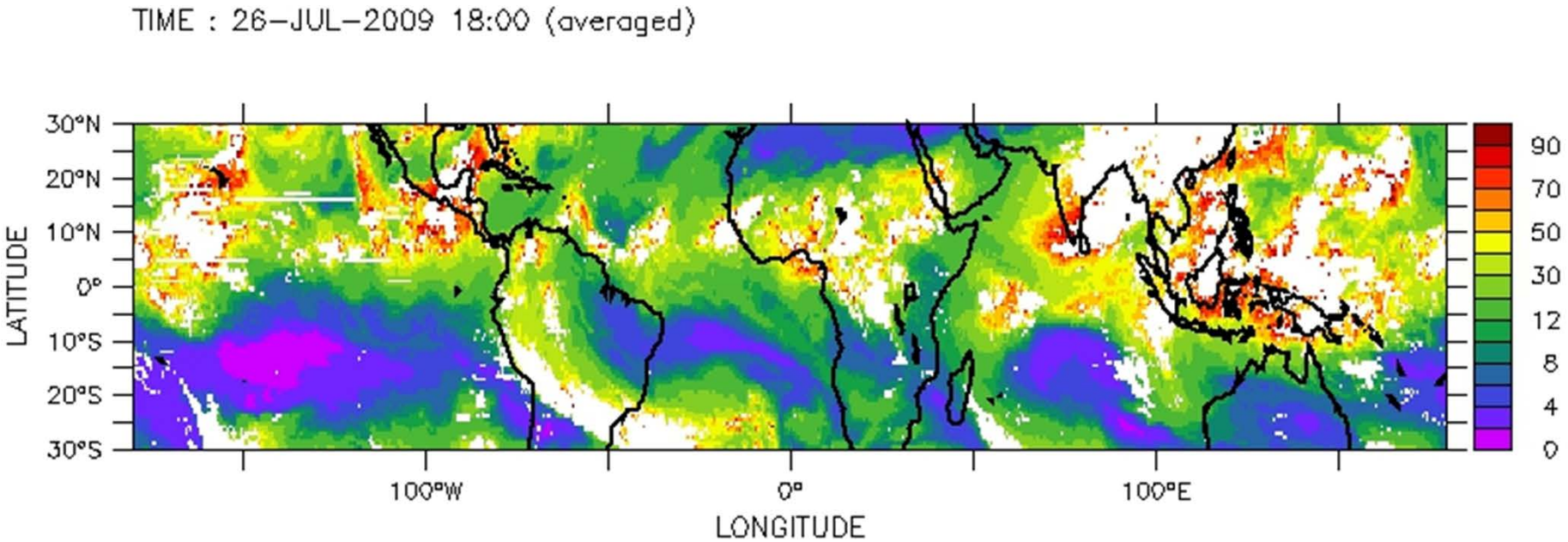

FTH geo-ring

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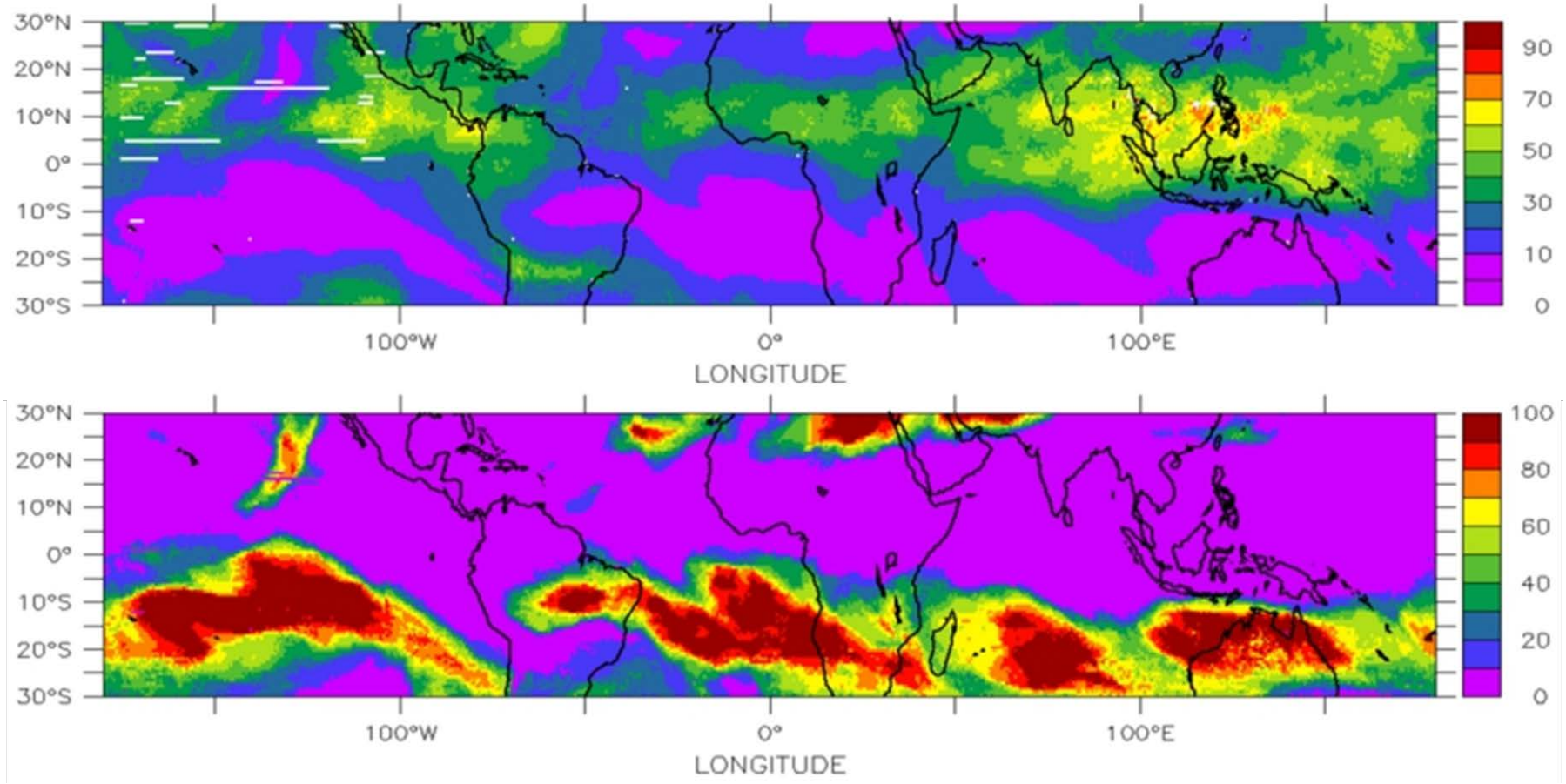
- **Frequency of occurrence of dry FTH, here: FTH<10%**



Sample Figures (2)
Inter-comparison
analyzed by Qiong Yang
with funding support from CM SAF

Figure 1

Geographical distributions of monthly mean UTH (%) from HIRS Metop, MHS Metop and Meteosat for December 2008. The spatial resolution is 2.5° by 2.5°.

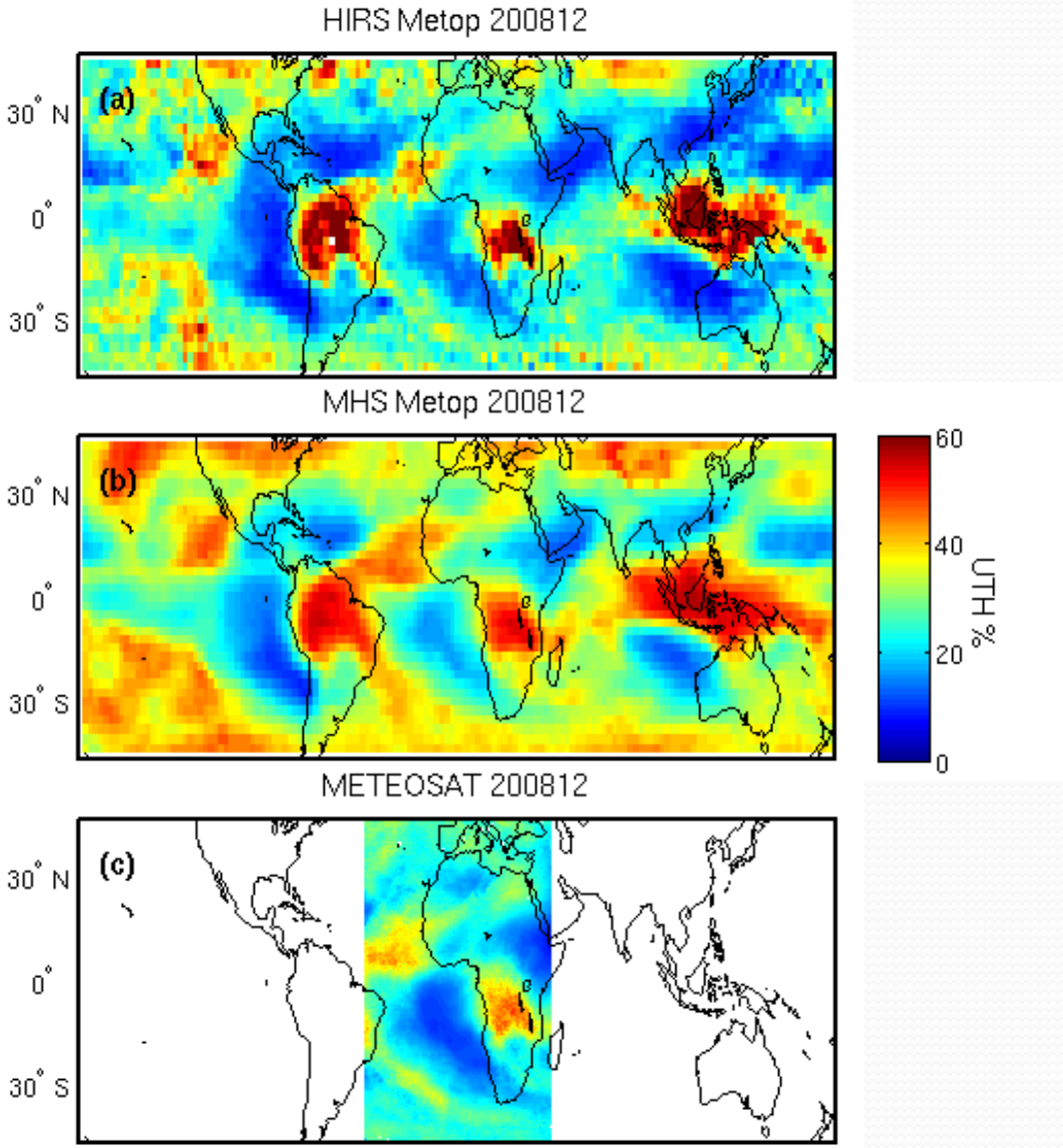


Figure 2

Differences in monthly mean UTH between HIRS Metop and MHS Metop for December 2008. The spatial resolution is 2.5° by 2.5°.

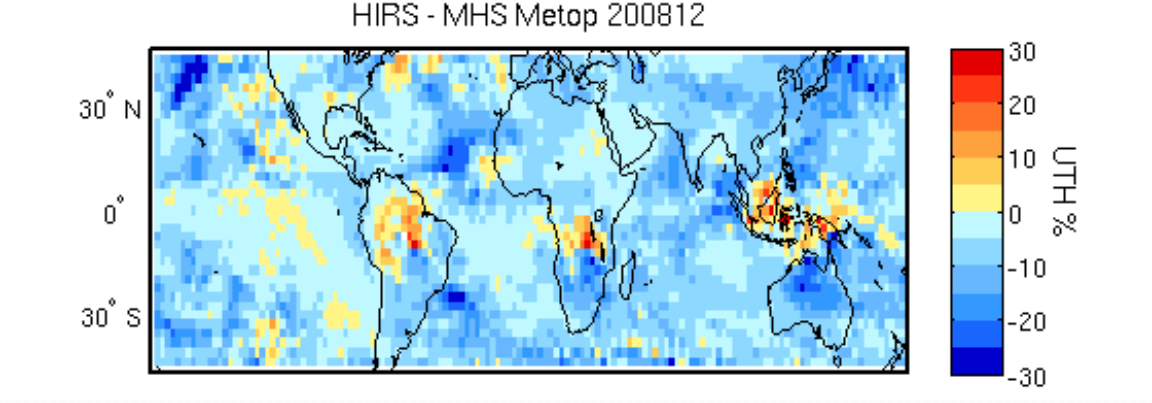


Figure 3

Differences in monthly mean UTH between HIRS Metop and Meteosat (a) and between MHS-Metop and METEOSAT (b) for December 2008. The spatial resolution is 2.5° by 2.5°.

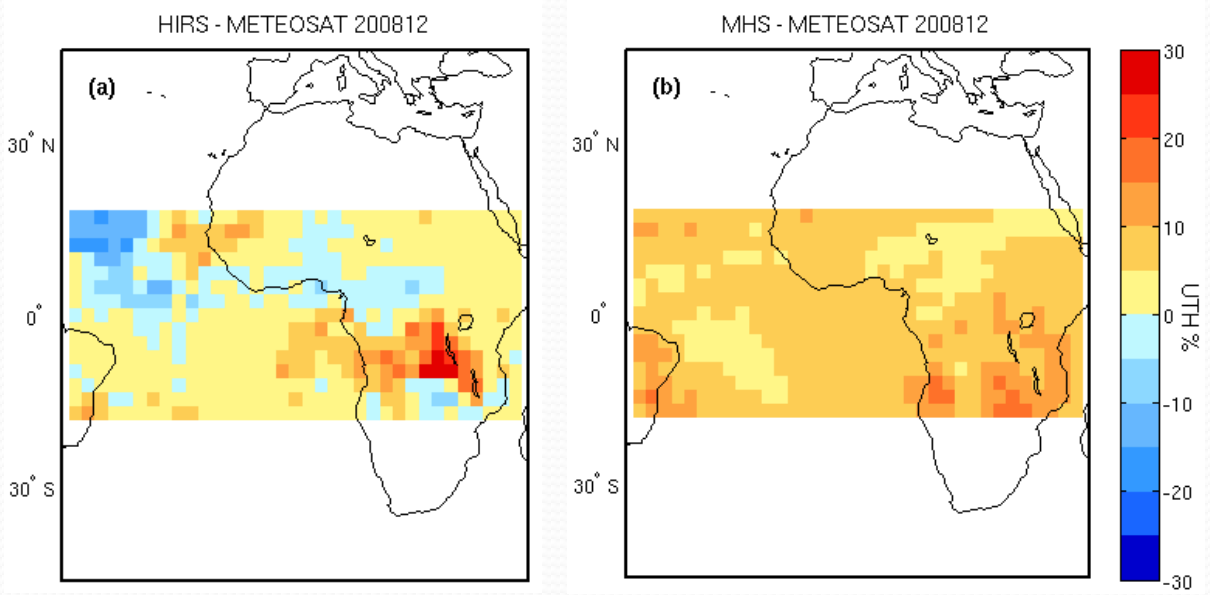


Figure 4

Time series of monthly UTH averaged over 20°S-20°N, 45°W-45°S from 13 HIRS satellites and METEOSAT.

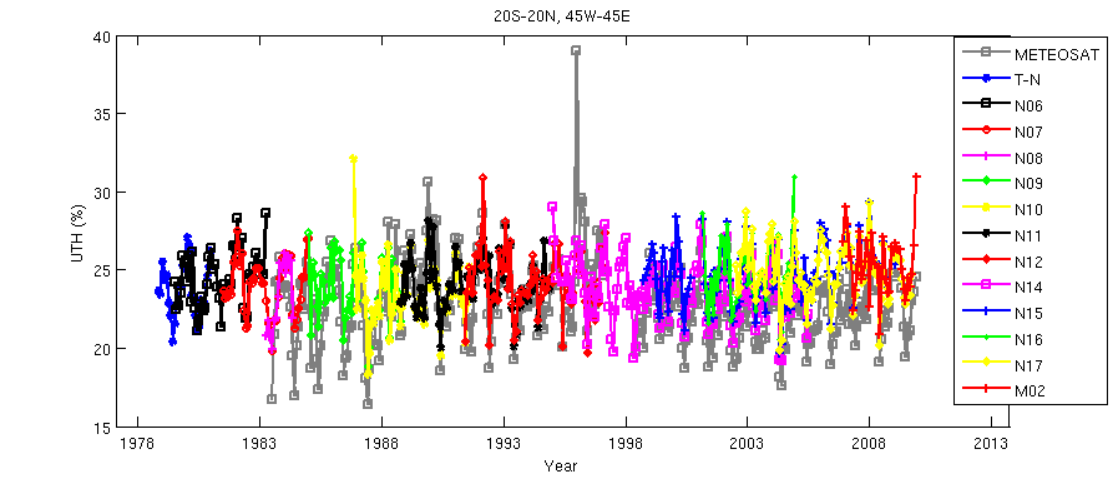
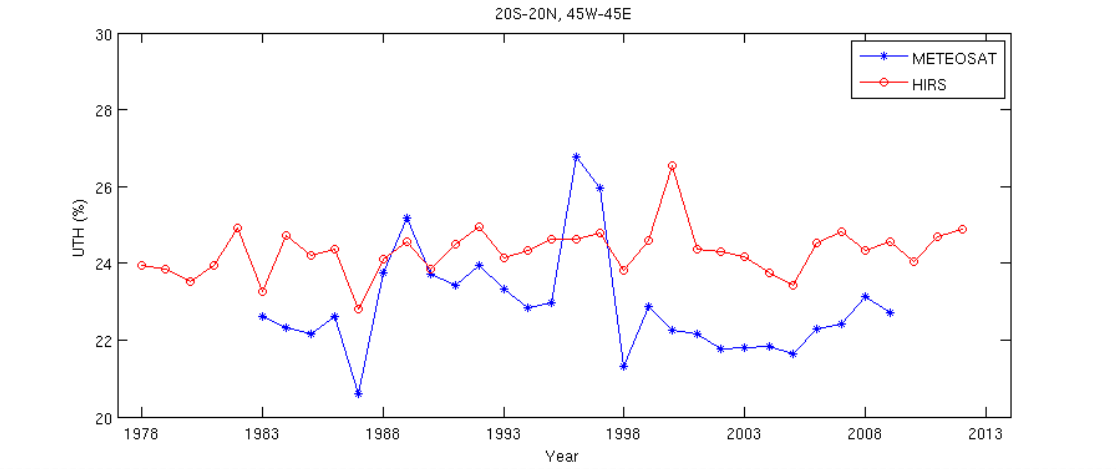


Figure 5

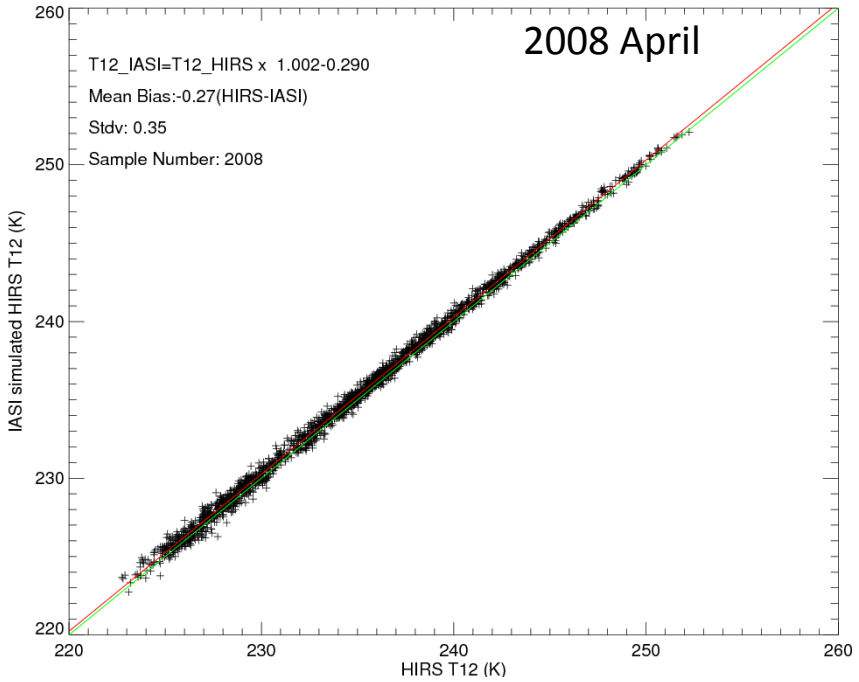
Time series of yearly UTH from HIRS and METEOSAT averaged over 20°S-20°N, 45°W-45°S.

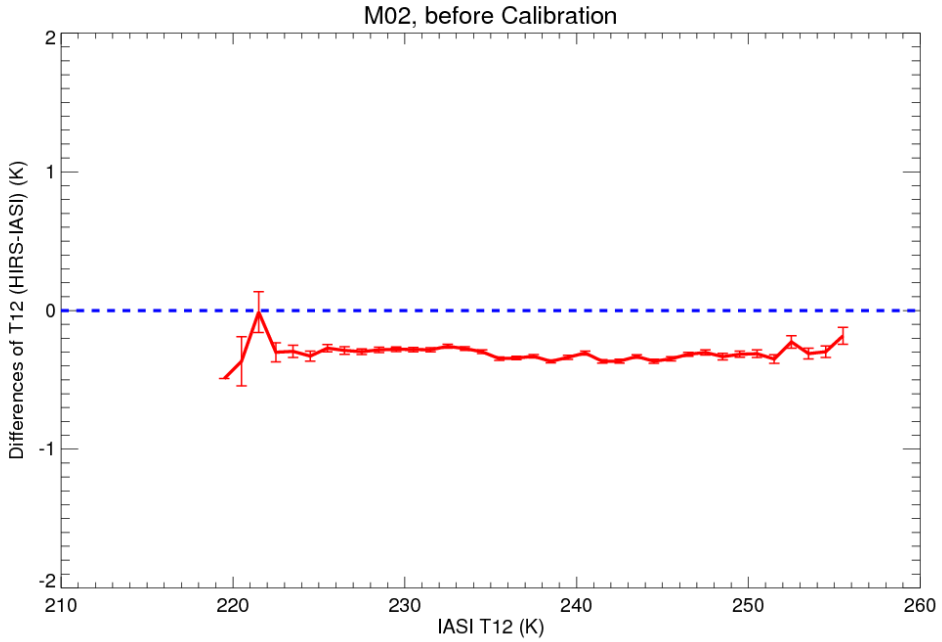


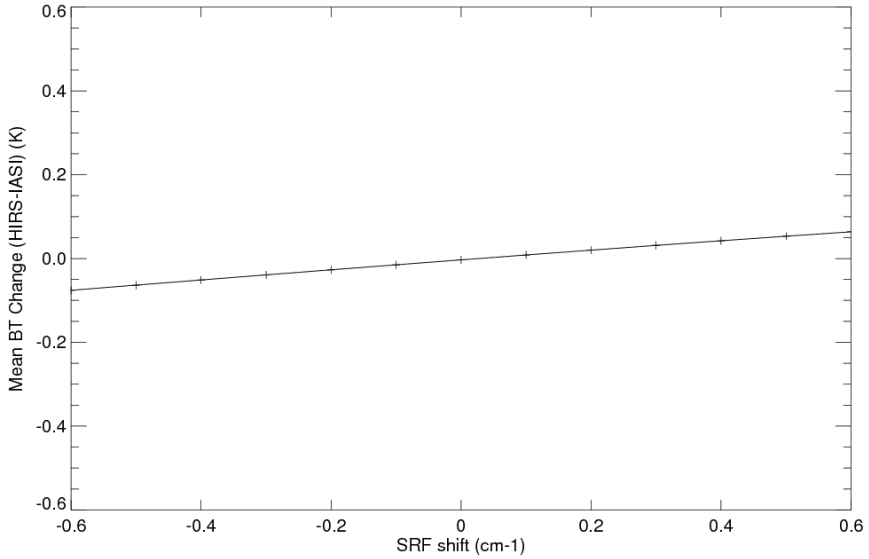
Sample Figures (3)
Using IASI simulated HIRS ch12 Tbs to calibrate M02 HIRS Ch12 Tbs

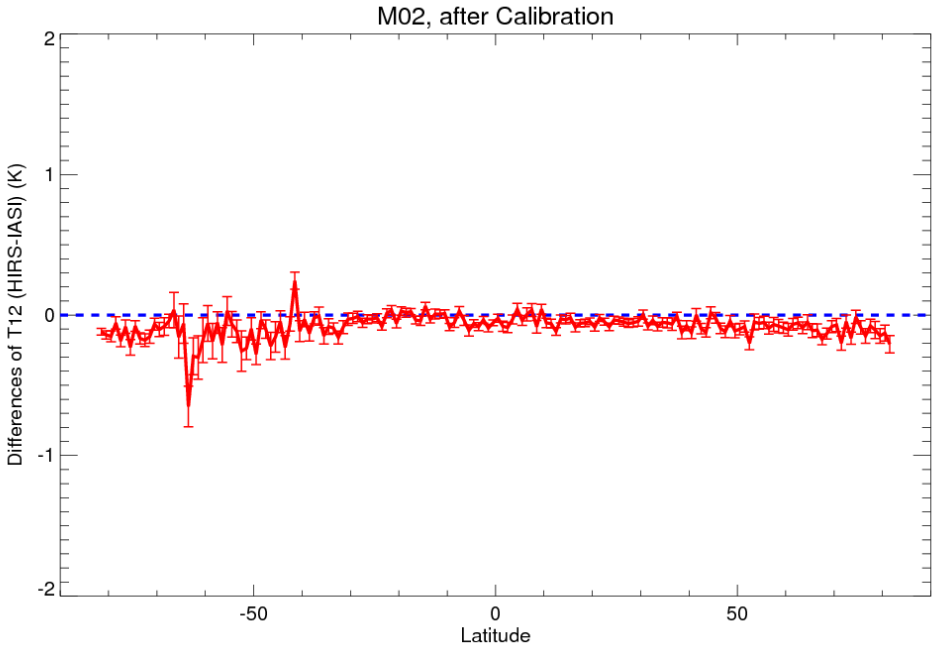
by Ben Ho

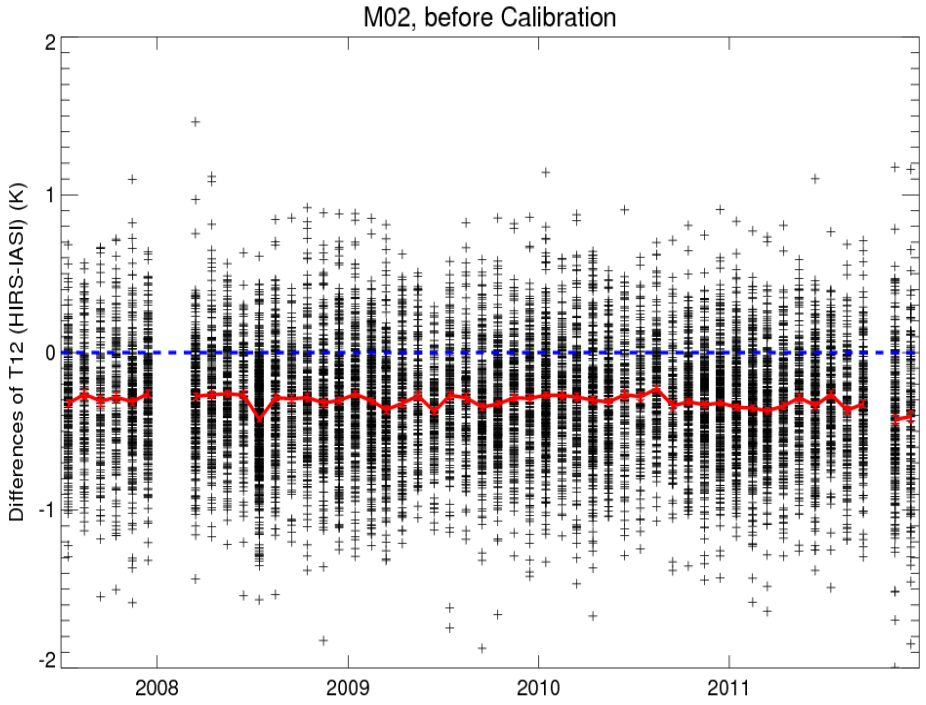
HIRS M02 vs. IASI simulated ch 12 Tb

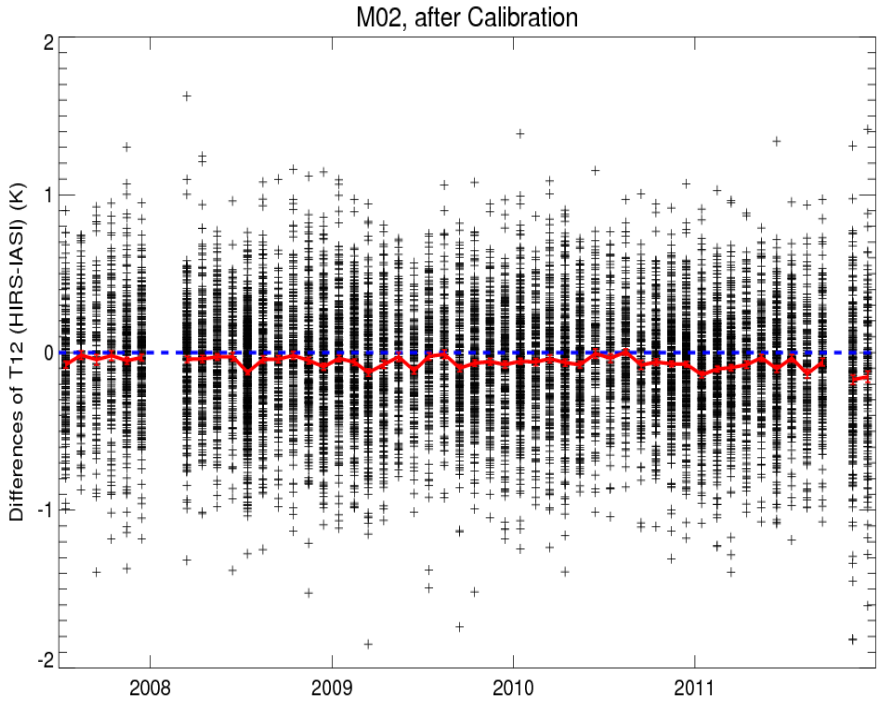









M02, before Calibration
Differences of T12 (HIRS-IASI) (K)
2
1
0
-1
-2
2008
2009
2010
2011


M02, after Calibration
Differences of T12 (HIRS-IASI) (K)
2
1
0
-1
-2
2008
2009
2010
2011