Inter-Calibration of Meteosat IR and WV channels using HIRS data

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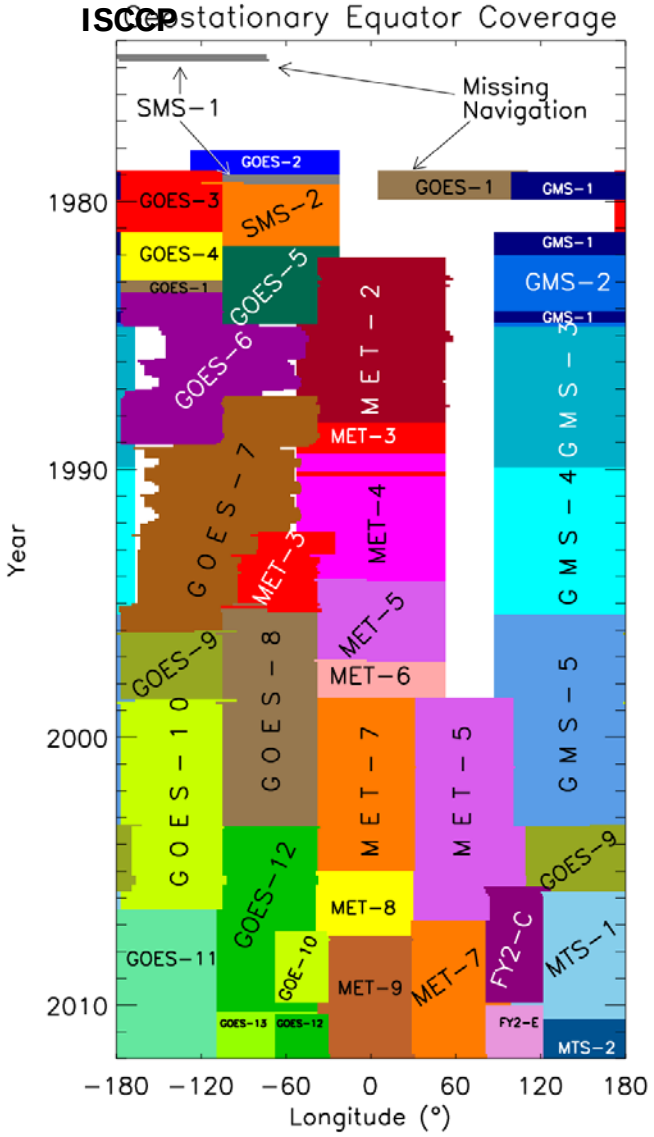
Content

- Fundamental Climate Data Record for geostationary satellites – The Challenge
- Approach to Inter-calibration using HIRS/IASI as a reference
- Spectral Conversion Functions
- Conclusions

FCDR Creation - Scale of the Challenge



- International community has embarked on the creation of FCDRs for archived data (EUMETSAT, NOAA-CDR program and similar programs);
- It is essential for fulfilling GCOS ECV requirements;
- Inter-calibration of the sensors to allow seamless products is a weakness in existing data records, e.g., GEWEX data projects;
- The creation of FCDRs has a large science component calling for collaborations of space agencies and scientists;
- **GSICS and SCOPE-CM are the right frameworks to make progress and achieve GCOS goals.**

Figure: Courtesy of Ken Knapp, NOAA-NCDC

Scale of the Challenge

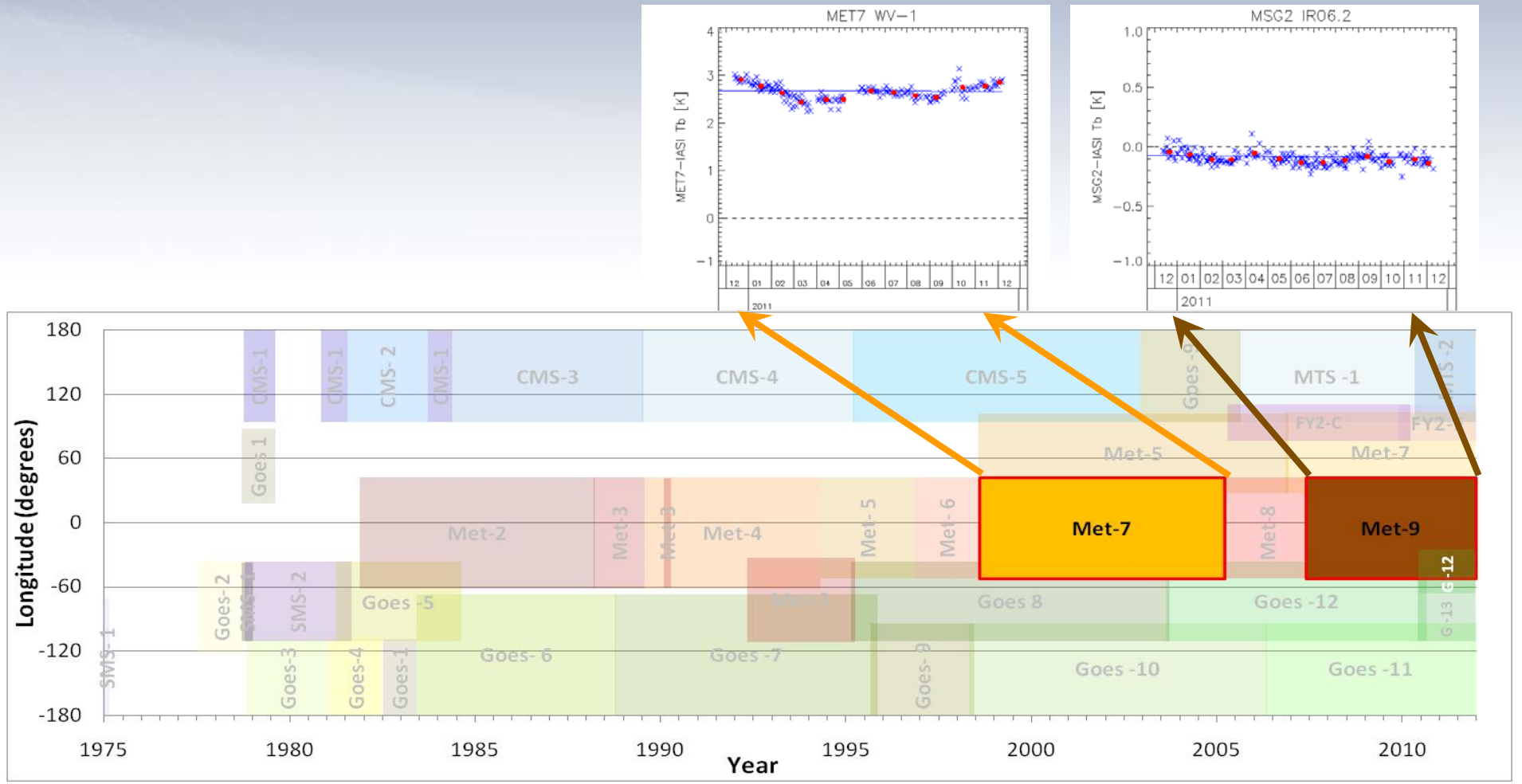
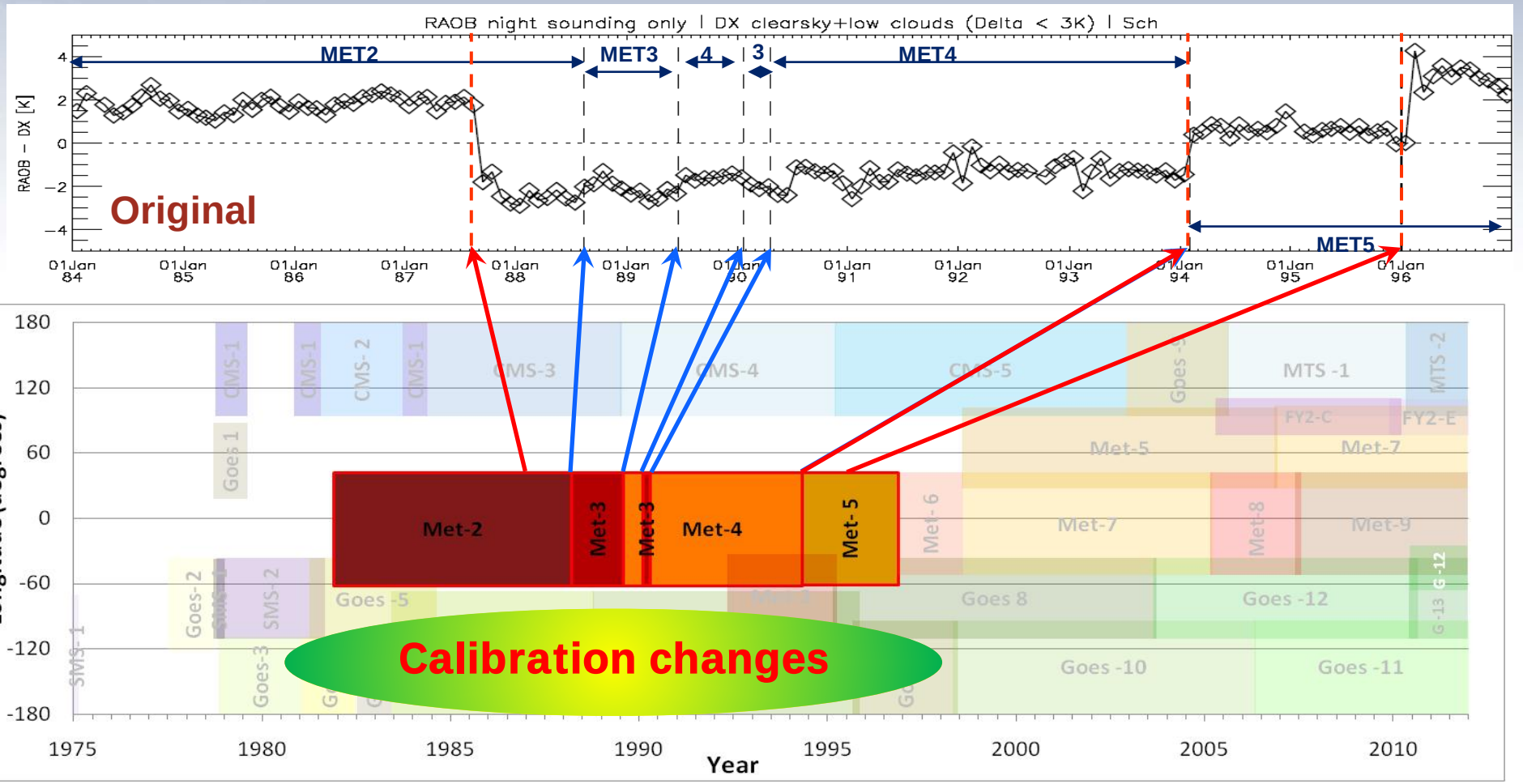


Fig: *Satellites used for the ISCCP climate data record. (Courtesy of Ken Knapp, NOAA-NCDC)*

Scale of the Challenge



Objectives, Prerequisites and Method

Objective:

To recalibrate time-series Meteosat First Generation and Meteosat Second Generation infrared radiances from 1982 till date using an external reference (polar orbiting sounders).

Prerequisites:

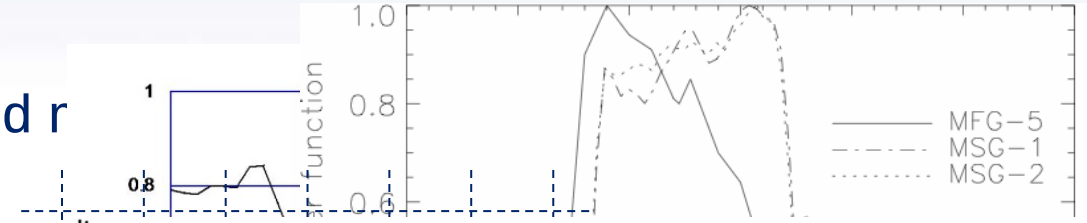
- Inter-calibration back to 1982
- Target accuracy over the time-series better than 1 K
- Inter-calibration with uncertainty estimate

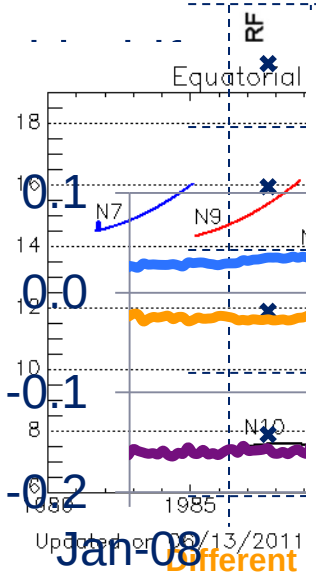
Method

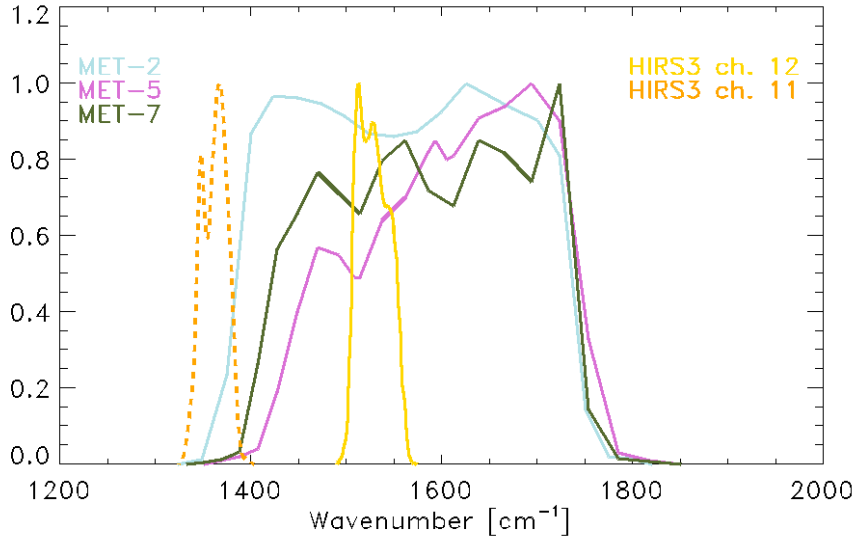
- Define reference instrument and standards (HIRS and ultimately IASI)
- Define the inter-calibration approach
- Estimate the uncertainties (spectral conversions, reference drift, calibration transfer uncertainty (e.g. for SNOs)
- Reprocess, verify and validate the re-calibrated data record

Error and Uncertainties sources

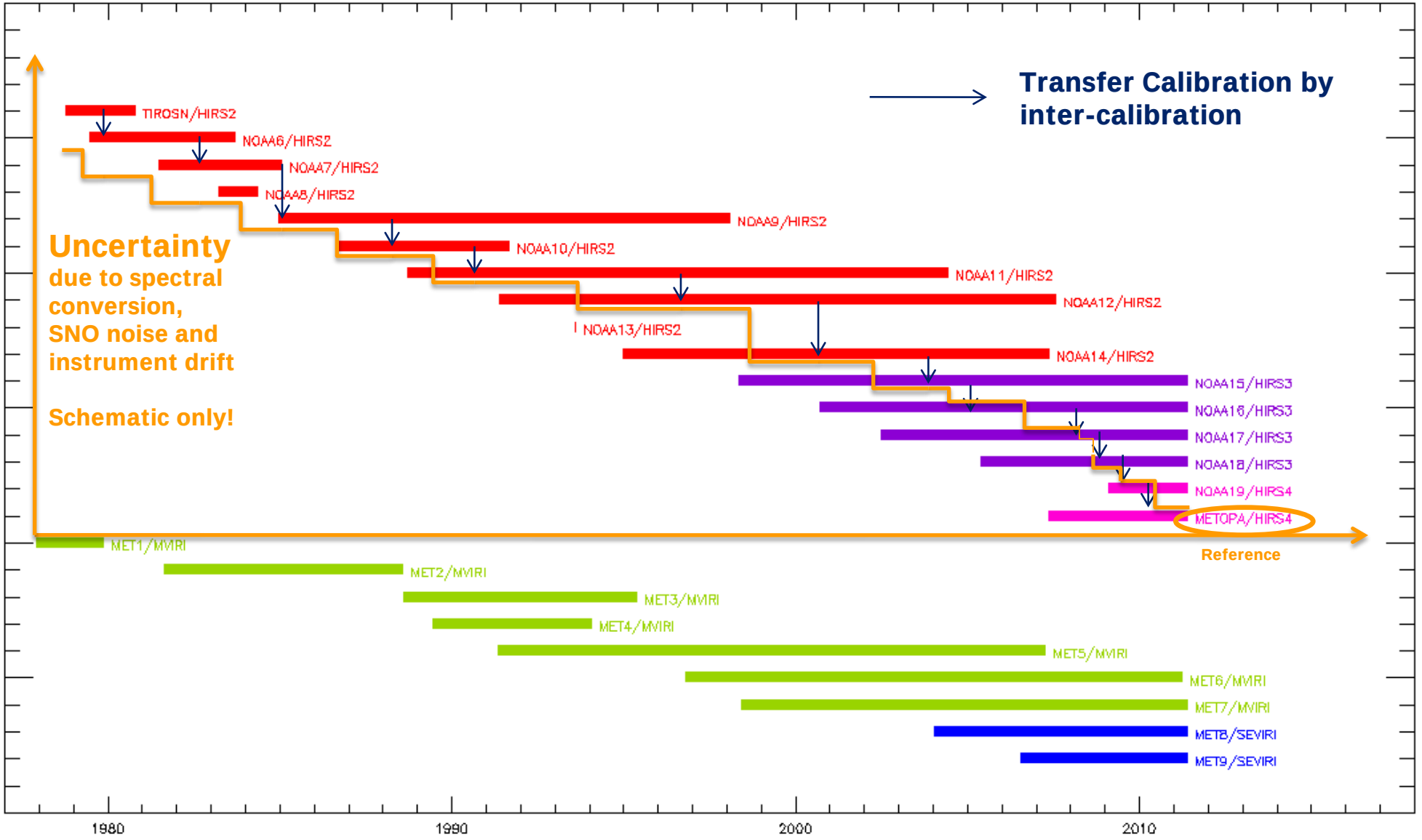
1. Differences between reference instruments over time *(HIRS/2 vs. HIRS/3 vs. HIRS/4)*
2. Differences between monitored instruments *(MVIRI vs. SEVIRI)*
3. Differences between reference and r
4. Synchronization errors & C
5. Collocation errors
6. Instrument drift



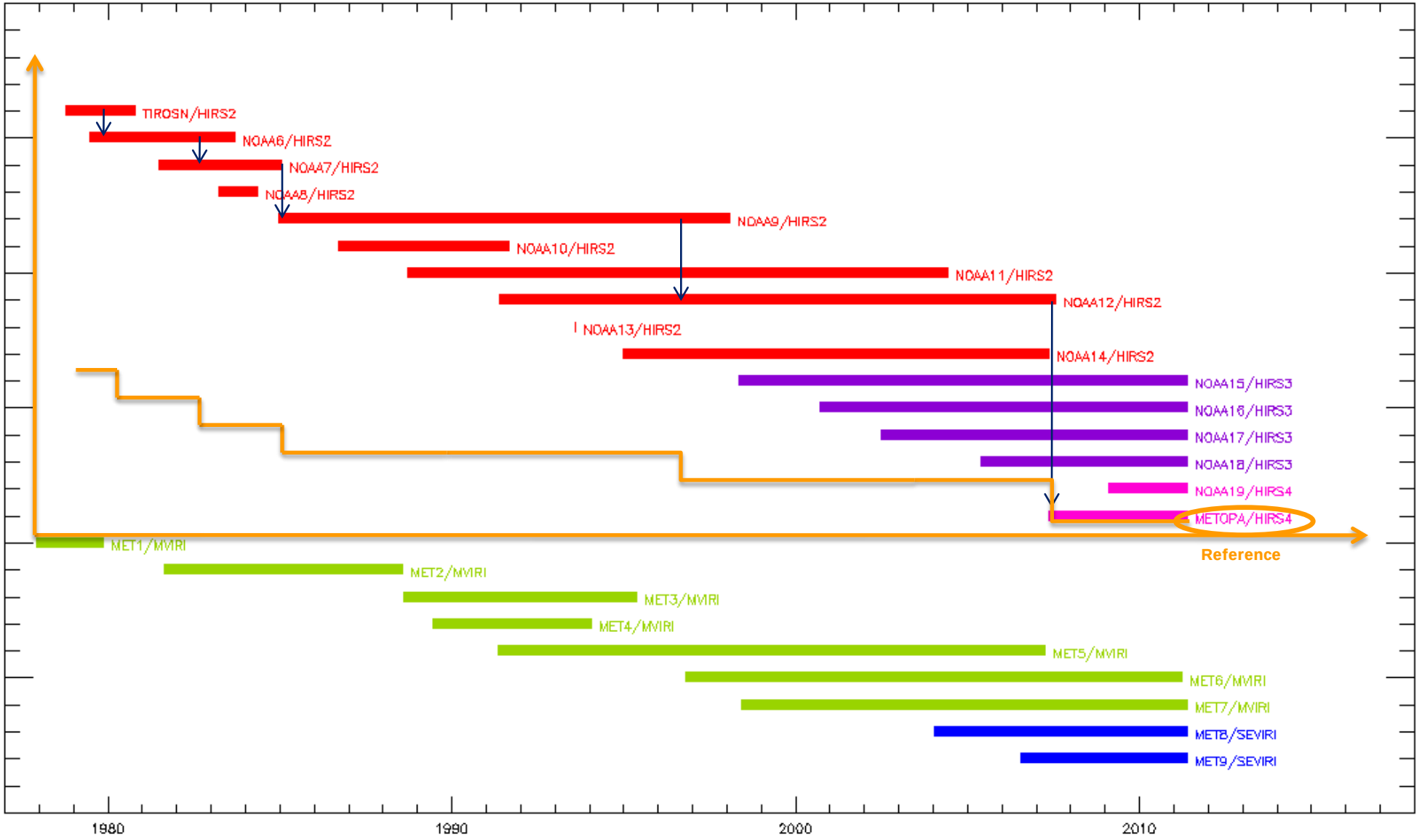




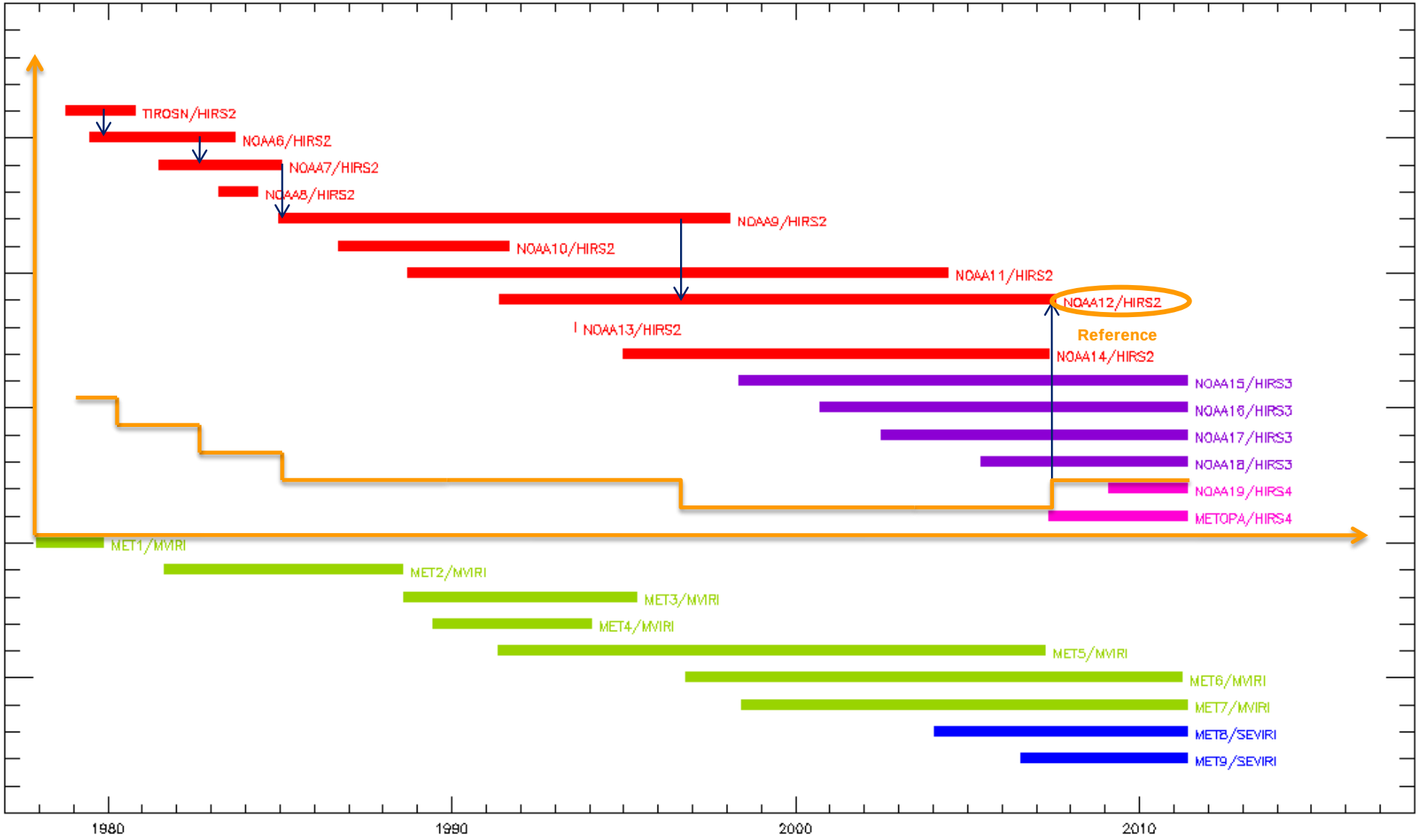
Define the Calibration Method: Cumulative uncertainty from calibration transfer



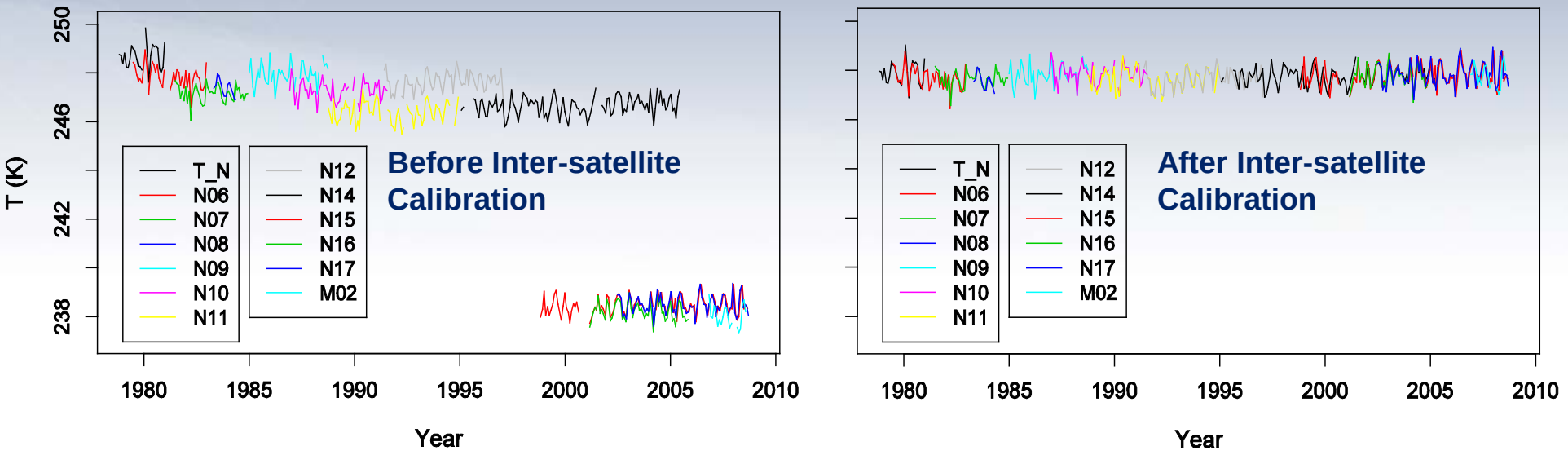
Define the Calibration Method: Reduced number of calibration transfers



Define the Calibration Method:
Taking a reference in the middle of time series



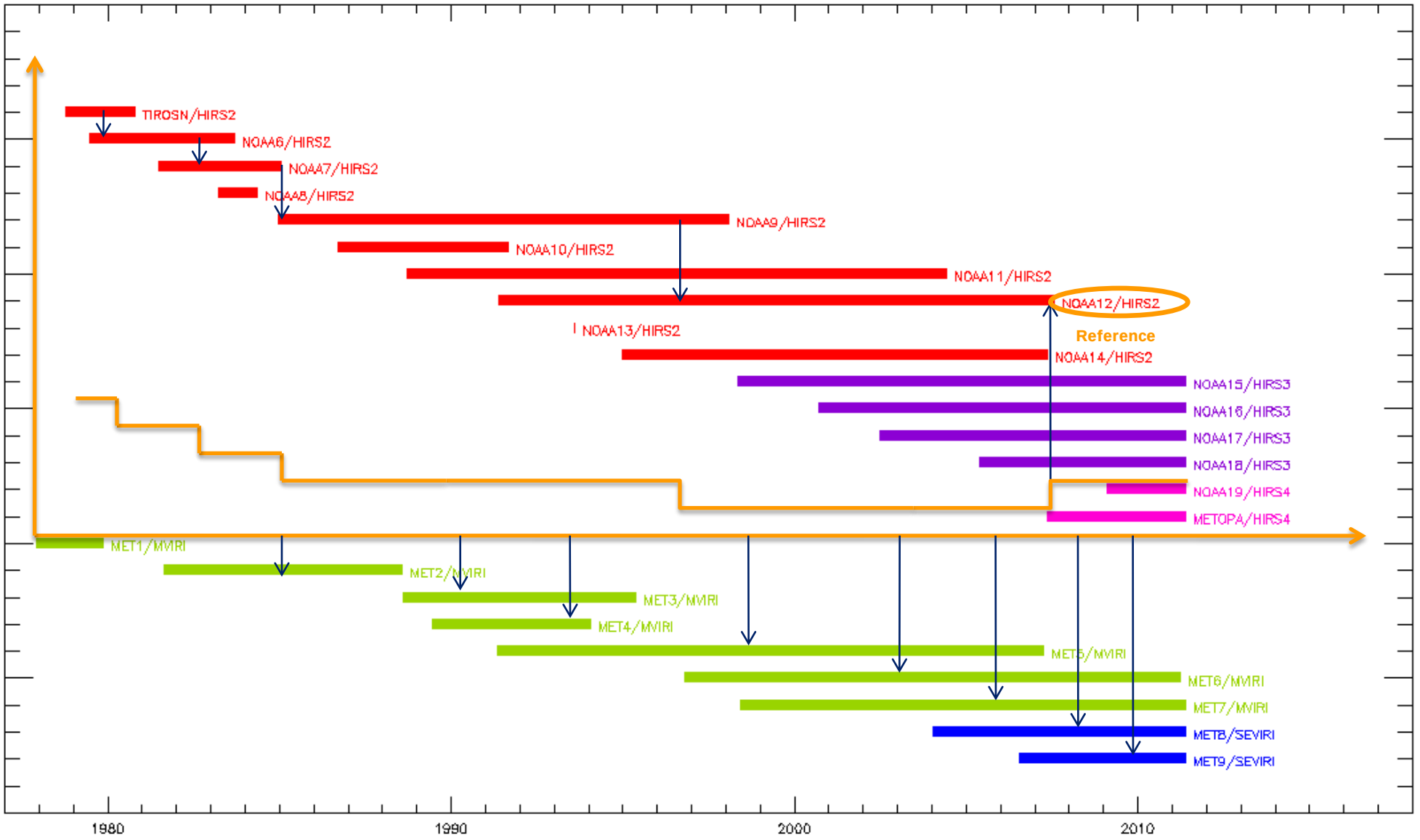
HIRS Inter-Calibrated Product NOAA/NCDC



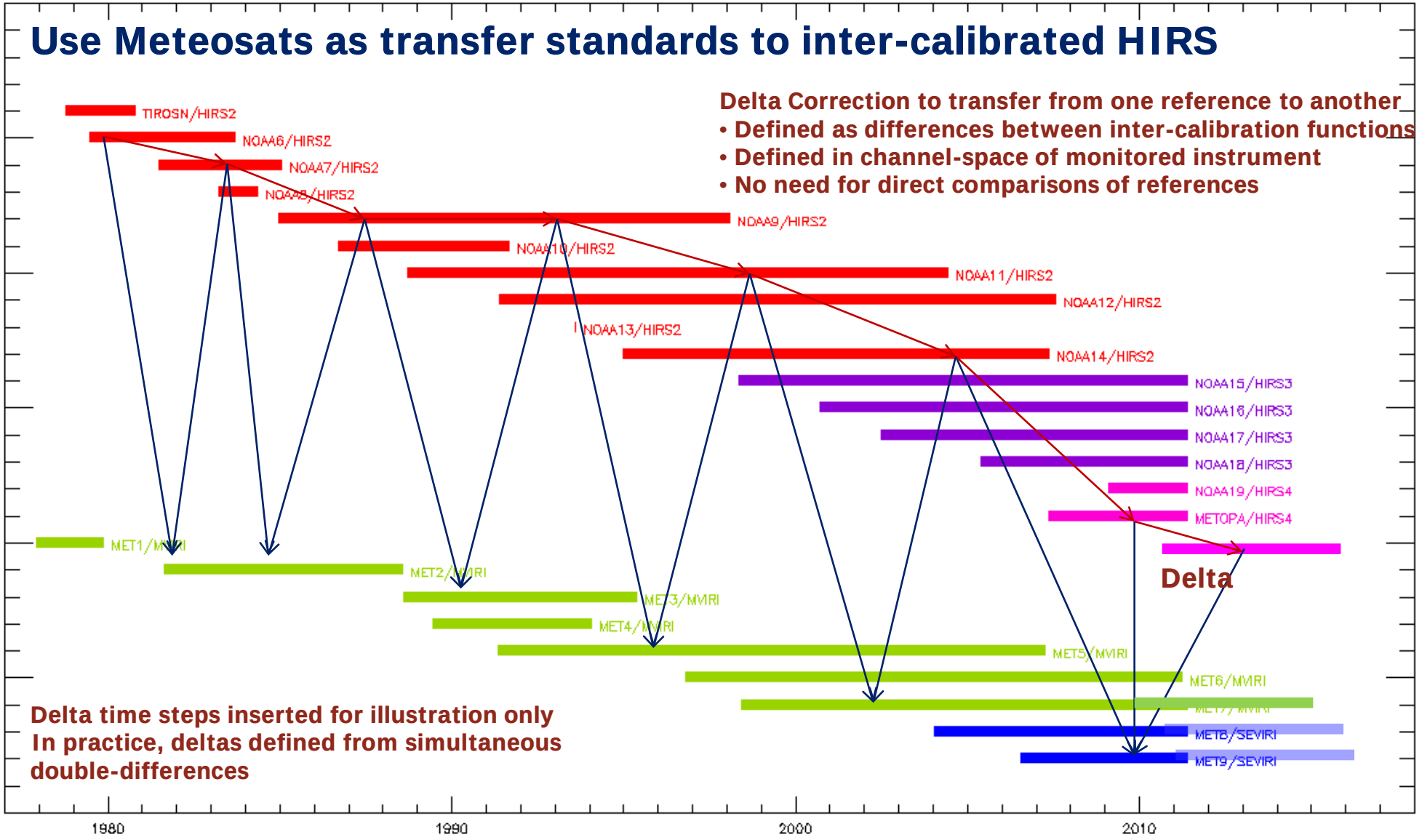
- Cloud-cleared and limb-corrected HIRS channel BTs (Nov. 1978 to Mar. 2009)
- Technique applied to all HIRS channels
- Monthly differences of inter-calibrated instruments mostly within ±0.2 K.
- Unclear: Uncertainty estimates for the HIRS inter-calibration.

Courtesy of Lei Shi, NOAA-NCDC

Define the Calibration Method: Suspension Bridge Model of Transferring References



Alternative: Zipper Model of Transferring References



Estimate Uncertainty: Spectral Conversion Functions

Objective

To develop Spectral Conversion Functions to account for Spectral Response Function differences and select which HIRS channels represent the MFG and MSG infrared channels best.

Method

- Restricted evaluation to a sounding (~6μm) and a window (~10μm) channel;
- MFG, MSG and HIRS brightness temperatures are calculated for a selection of ECMWF profiles (from Chevallier 2001) using RTTOV;
- Uncertainties are assessed for three conditions: all latitudes, all sky, two angles (nadir and 60°);
- HIRS channels that fit best to MFG or MSG are determined by assessing different fitting methods and using RMSD as a verification metric

Statistics of different Spectral Conversion Functions

Channels	Fit	Latitude	Cloud	Angles	WV Tb RMSD [K]	IR Tb RMSD [K]
Single	Linear	±90°	All	0°, 60°	2.18	0.60
Multiple	Linear	±90°	All	0°, 60°	1.19	0.046
Multiple	**Quadratic**	**±90°**	**All**	**0°, 60°**	**0.74**	**0.034**
Multiple	Quadratic	±60°	All	0°, 60°	0.62	0.034
Multiple	Quadratic	±45°	All	0°, 60°	0.56	0.034
Multiple	Quadratic	±90°	Clear only	0°, 60°	0.76	0.040
Multiple	Quadratic	±90°	No high cloud	0°, 60°	0.78	0.035
Multiple	Quadratic	±90°	Cloudy only	0°, 60°	0.65	0.017
Multiple	Quadratic	±90°	All	0° only	0.77	0.029

- Fit much improved using multiple channels & quadratic form
- But not much by limiting range – **So keep it general: global, all sky, all angles!**

Uncertainties due to Spectral Conversion for each class of instrument: WV

Monitored→ Reference ↓	HIRS/2 NOAA6-14	HIRS/3 NOAA15-17	HIRS/4 NOAA18-MetopB	MVIRI Meteosat 2-3	MVIRI Meteosat 4-7	SEVIRI Meteosat 8-11
HIRS/2 NOAA6-14	0.04	1.03	1.07	0.07	0.16	0.41
HIRS/3 NOAA15-17	0.78	0.05	0.06	X	0.67	0.51
HIRS/4 NOAA18-MetopB	0.84	0.06	0.03	X	0.74	0.57

Mean RMSD Tb [K] of Spectral Conversion Functions for each class of instrument: WV

Also need to:

- Estimate Calibration Transfer Uncertainty (e.g. by SNO)
- Estimate drift in reference transfer standards

Conclusions

- The international community faces a complex and large task to inter-calibrate the whole fleet of geostationary and HIRS instruments for the IR and WV channels
- GSICS is the framework that needs to work to solve these issues and SCOPE-CM is to provide the community with the inter-calibrated radiances.
- Identified two different approaches to inter-calibrate Meteosat-HIRS
  - *Using SNOs or regional subsamples to inter-calibrate HIRS as a homogenised FCDR*
  - *Use Meteosats as transfer standards to inter-calibrate HIRS*
- Developed a systematic way to define spectral conversion functions
- Need to analyse uncertainties in final inter-calibrated radiances for each proposed method separately – will also use new reanalysis feedback archive.
- We aim to produce inter-calibrated Meteosat WV & IR archive by 2013.