Sustained CDR Generation at EUMETSAT

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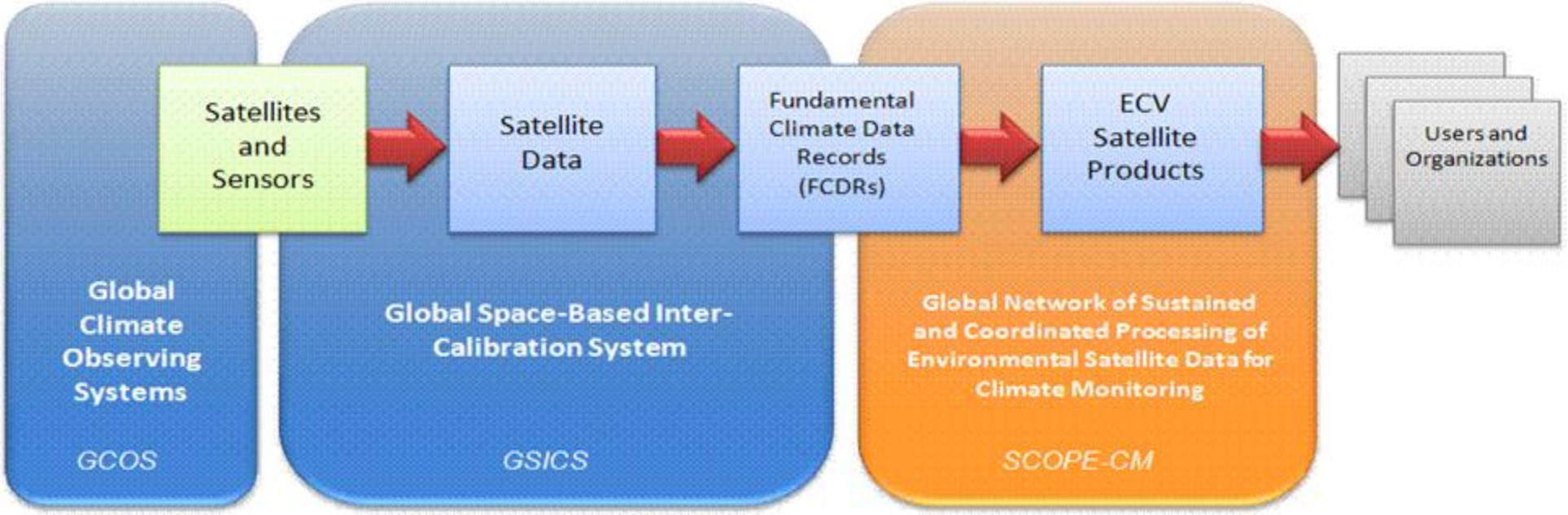
EUMETSAT

What we do


USER REQUIREMENTS
European National Meteorological Services
Operating Agency
European Space Industry
Private Enterprises, Value-Added Services, End-Users
Interface with users and overall system design and development. Responsible for procurement of ground segment and launch services.
esa
Satellite development and procurement agency
Science Institutions (in particular important for climate)
EUMETSAT
DELIVERY (Data and specific products)

Conceptual View of End-to-End Provision of ECV CDRs



The architecture for space-based for climate monitoring contributing to the Global Framework for Climate Services in the context of WMO considers the whole chain from observations to decision making.

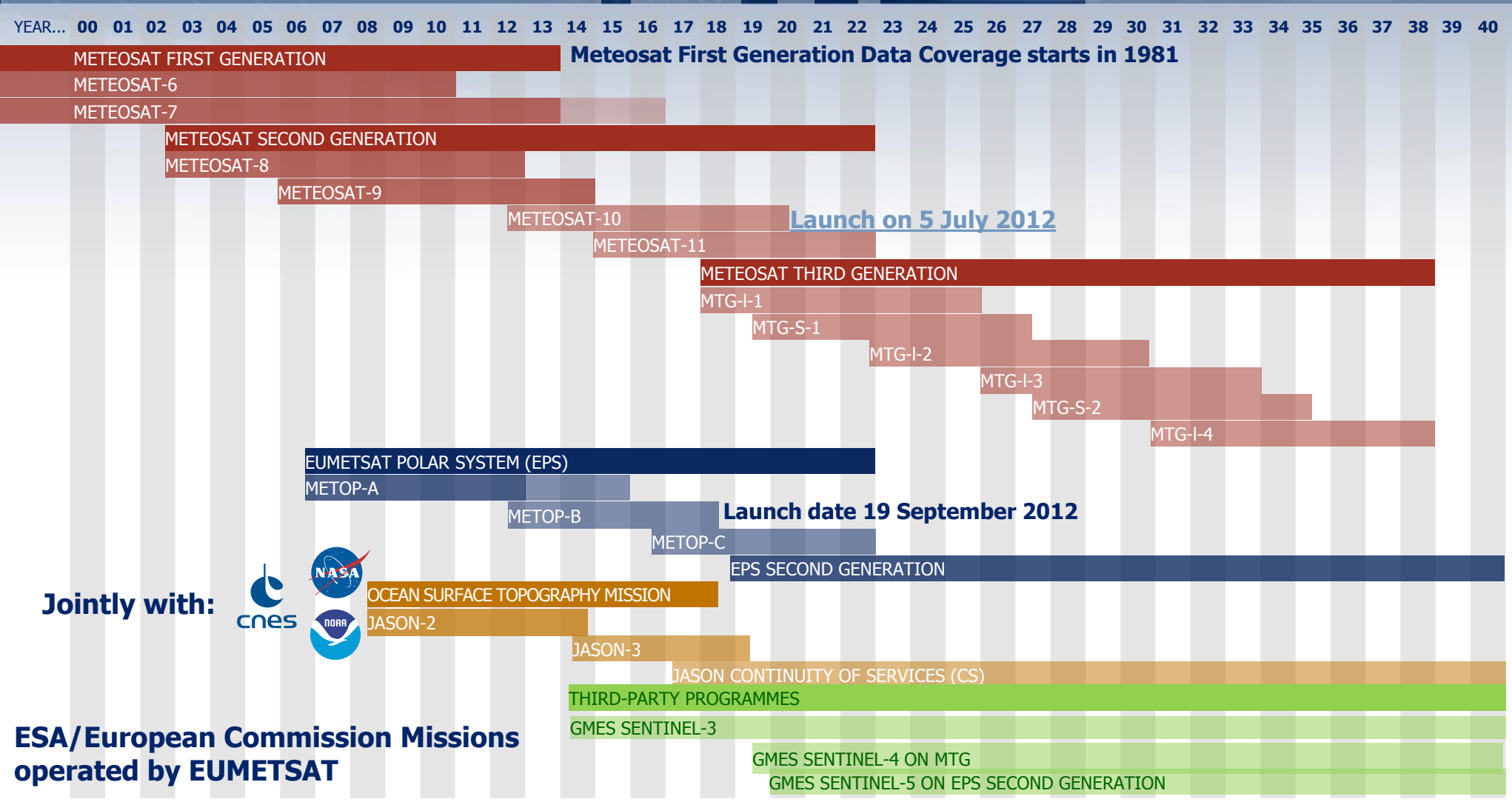
Coordination Group for Meteorological Satellites

GSICS Global Space-based Inter-Calibration System

SCOPE•CM

CGMS

EUMETSAT Space Segment



ESA/European Commission Missions operated by EUMETSAT

EUMETSAT

MSG-3 Launch


esa
ariane
ariane
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Recent Activities (2011/2012)

- EUMETSAT has set up operational infrastructure for fast reprocessing of data that ensures reproducibility and update of data sets;
- EUMETSAT has set up a data set generation plan for its Central Application and distributed Satellite Application Facility (CAF and SAF) network covering 2012-2017;
- Working Group on Data Set Generation Decided to implement DOI reference system for all CAF and SAF data records;
- The CAF is concentrating on improvements of Fundamental Radiance Records used for both DA in reanalysis and retrieval schemes;
- The SAF network has significantly increased its commitments towards production of Climate Data Records including data for atmosphere, ocean, land and ice surfaces as well as atmospheric composition;
- Many of these activities are performed in the frameworks of GSICS and SCOPE-CM.

European Reanalysis of Global Climate Observations

Prepare input data and assimilation systems for a new global atmospheric reanalysis of the 20th century

http://www.era-clim.eu/

Key objectives for ERA-CLIM are to:

- Improve the available observational record for the early 20th century
- Prepare data sets and assimilation tools needed for global reanalysis
- Provide information about data quality by means of pilot reanalyses
- Develop an Observation Feedback Archive facility for users
- Assess and reduce uncertainties in reanalysis data

Data Record Release Overview I

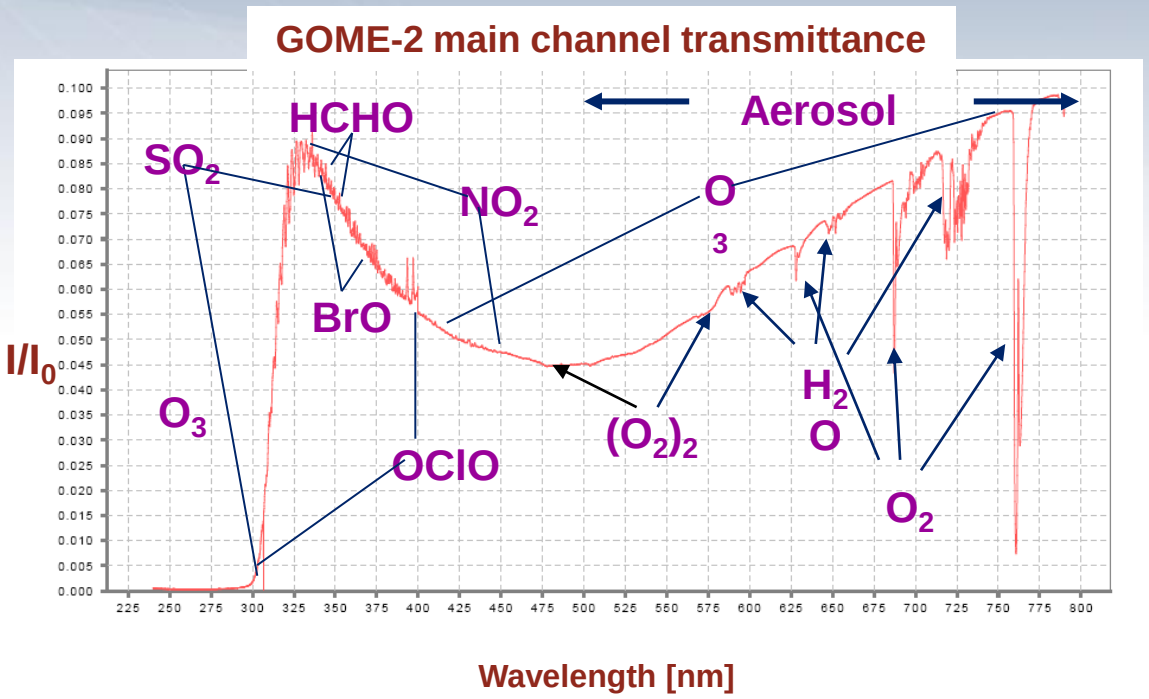
Identifier	Satellites/Instrument	Data Record	Coverage	Delivery
CAF-014	Met-8 and Met-9 / SEVIRI	Level 1.5	Meteosat 0° 2004 - 2008	Available
CAF-004	Metop-A / GOME-2	Level 1a and 1b	Global 2007 - 2011	Available
CAF-007	Met-7 / MVIRI	Surface Albedo	IODC 2006 - 2011	Available
CAF-008	Met-3 / MVIRI	Surface Albedo	ADC 1991 - 1993	Available
CAF-009	Met-3 / MVIRI	Surface Albedo	XADC 1993 - 1995	Available
CAF-012	Met-8 to Met-9 / SEVIRI	AMV, CSR and ASR	Meteosat 0° 2004 -2012	Q4/2012
CAF-005	Metop-A/ AVHRR	Polar AMV (Two algorithms)	Arctic and Antarctic	Q4/2012

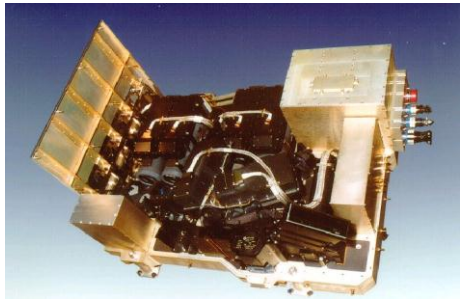
Data Record Release Overview II

Identifier	Satellites/Instrument	Data Record	Coverage	Delivery
CAF-002	Metop-A / GRAS	Level 1B (Bending Angle)	Global 2007 - 2012	Q4/2012
CAF-016	COSMIC / IGOR	Level 1B (Bending Angle)	Global 2006 – 2012	Q4/2012
CAF-017	CHAMP / BLACKJACK	Level 1B (Bending Angle)	Global 2001 - 2008	Q2/2013
CAF-018	GRACE / BLACKJACK	Level 1B (Bending Angle)	Global 2005 - 2012	Q2/2013
CAF-010	Met-2 to Met-9 / MVIRI and SEVIRI	IR and WV Radiances (referenced to IASI and HIRS)	Meteosat 0° IODC	Q3/2013 (will be released piecewise)
CAF-015	Met-2 to Met-7 / MVIRI	AMV, CSR and ASR	Meteosat 0°, IODC 1982 -2011	Q4/2013
CAF-019	Metop-A / GOME-2, IASI, AVHRR	Ozone (total and profile)	Global 2007 -2012	Q4/2013
CAF-003	Metop-A / ASCAT	ASCAT Level 1b Soil moisture Level 2	Global 2007 - 2012	Q4/2013
CAF-001	Metop-A / IASI	Level 1c	Global 2007 - 2012	Q4 2013

The GOME-2 instrument on Metop

Measuring atmospheric composition





Orbit file sizes

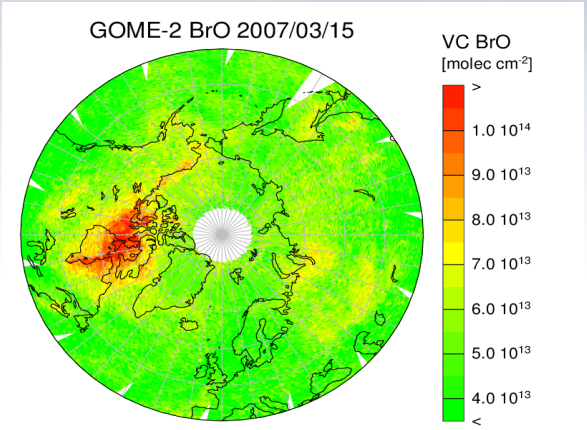
GOME-2 L1B ~ 1GB
IASI L1C ~ 2GB

GOME-2:

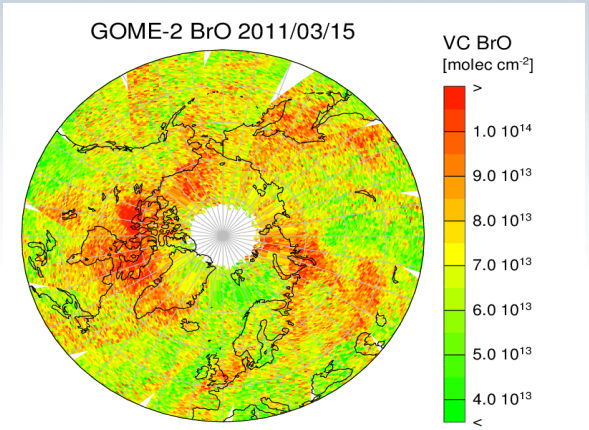
- series of 3 instruments on Metop (Metop A launched in 10/2006)
- sun-synchronous orbit, 09:30
- 412 orbits (29 days) repeat cycle
- Global coverage 1.5 days
- 240 nm to 800 nm
- 0.25 to 0. 5 nm spectral resolution (FWHM)
- 4 channels with 4098 energy measurements of polarisation corrected radiances (40 x 80 km^2)
- 2 channels with 512 energy measurements of linear polarised light in perpendicular direction (S/P) (40 x 10 km^2)

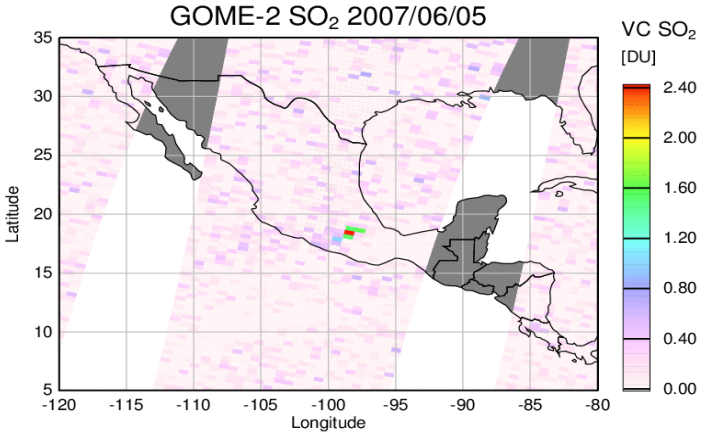
Motivation of GOME-2 Reprocessing

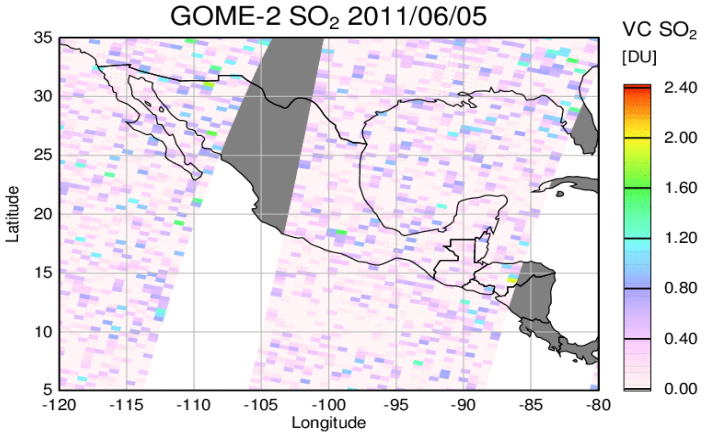
At beginning of mission



After 4 years of operation







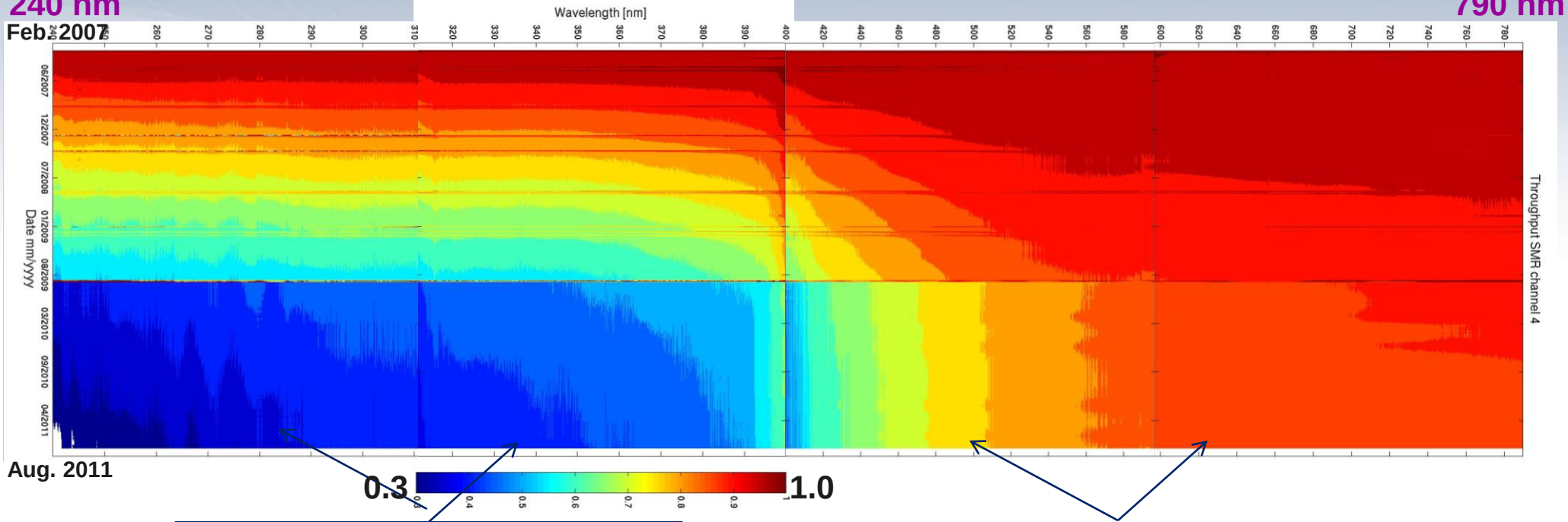
Figures courtesy of A. Richter, University of Bremen

GOME-2 Long-term throughput changes

Solar Mean Reference (SMR) spectrum

240 nm

790 nm



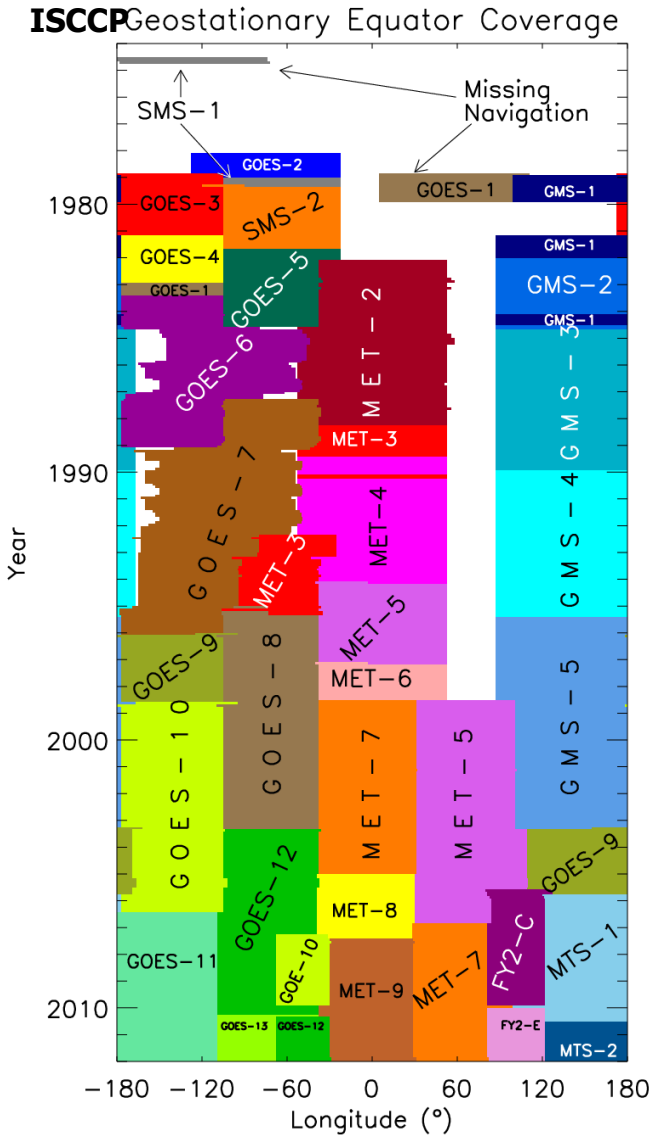
Slow onset of degradation observed after 2nd throughput test in channel 1 and 2.

Instrument is stable now in channel 3 and 4.

Reprocessed signals R2 PPF 5.2 until August 2011 relative to February 2007

- Its about 50TB of data;
- We currently distribute to 11 customers in parallel using DLT;
- Will be available from the EUMETSA Data Centre soon.

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 **<- WCRP involvement**;
- **GSICS and SCOPE-CM are the right frameworks to make progress and achieve GCOS goals.**

Figure: Courtesy of Ken Knapp, NOAA-NCDC

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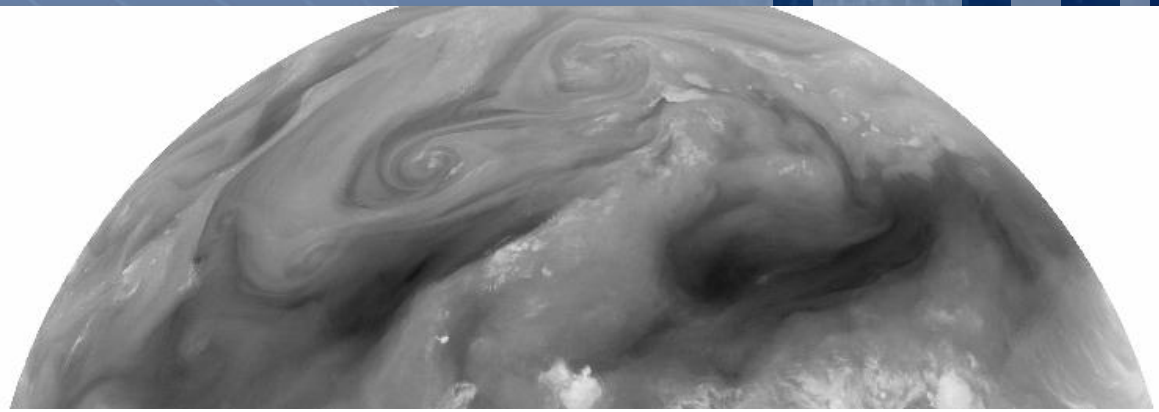
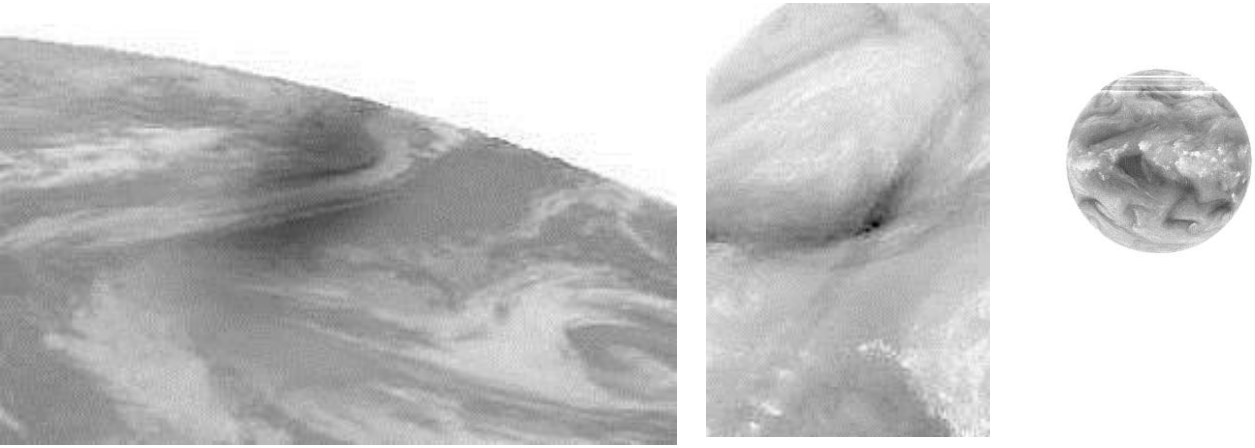
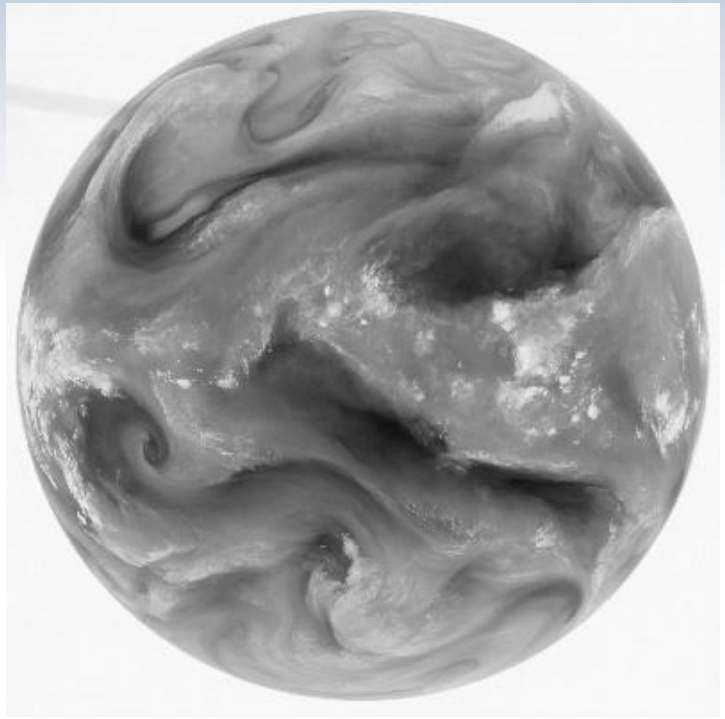
Meteosat First Generation Image Issues



7 WV images taken just after midnight on 4 August 2002 (Met-6 scans between 0:30–1:30 UTC)





Six WV images taken around midnight on 14–15 April 1997 (slots 46 to 3).

Scale of the Challenge

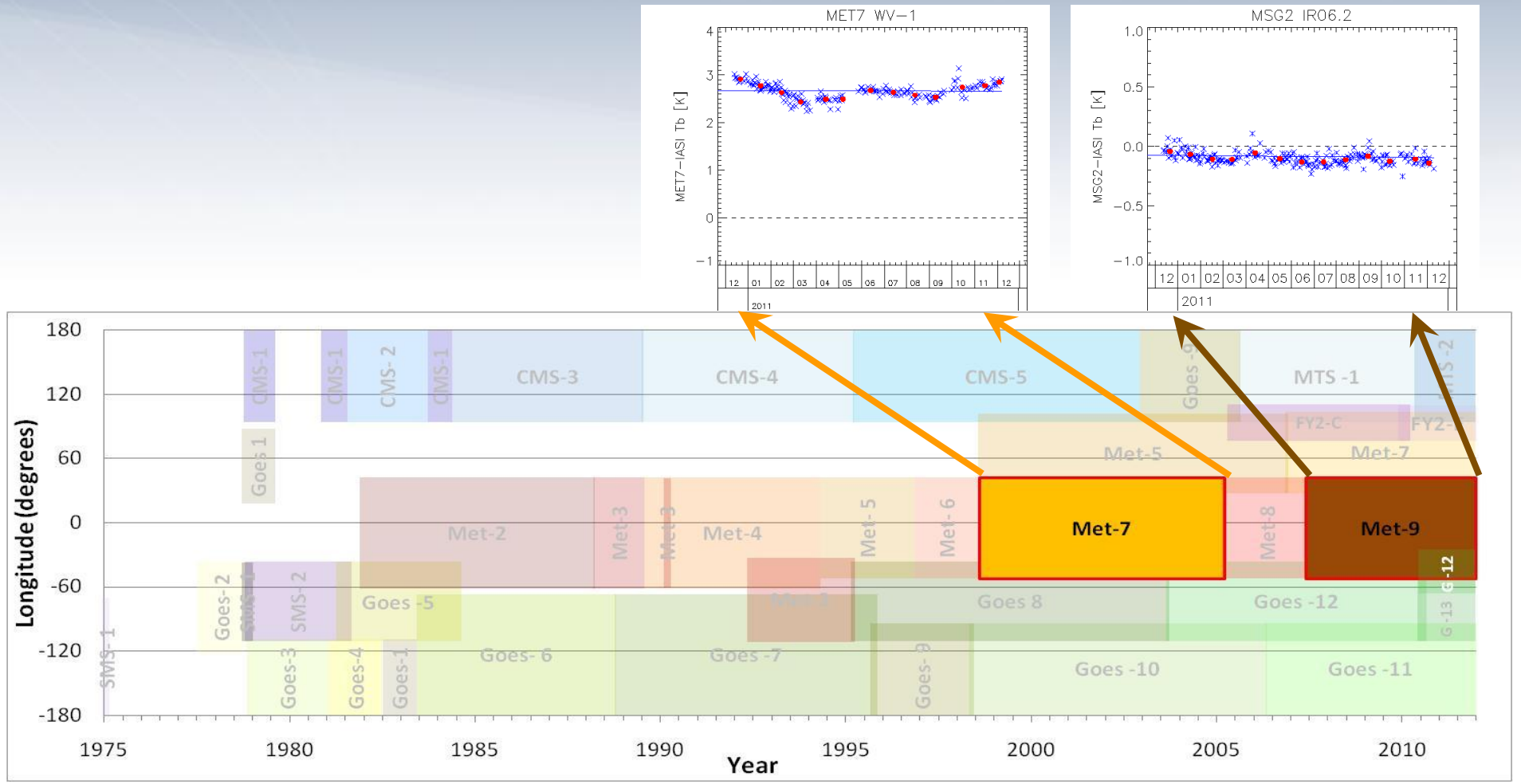
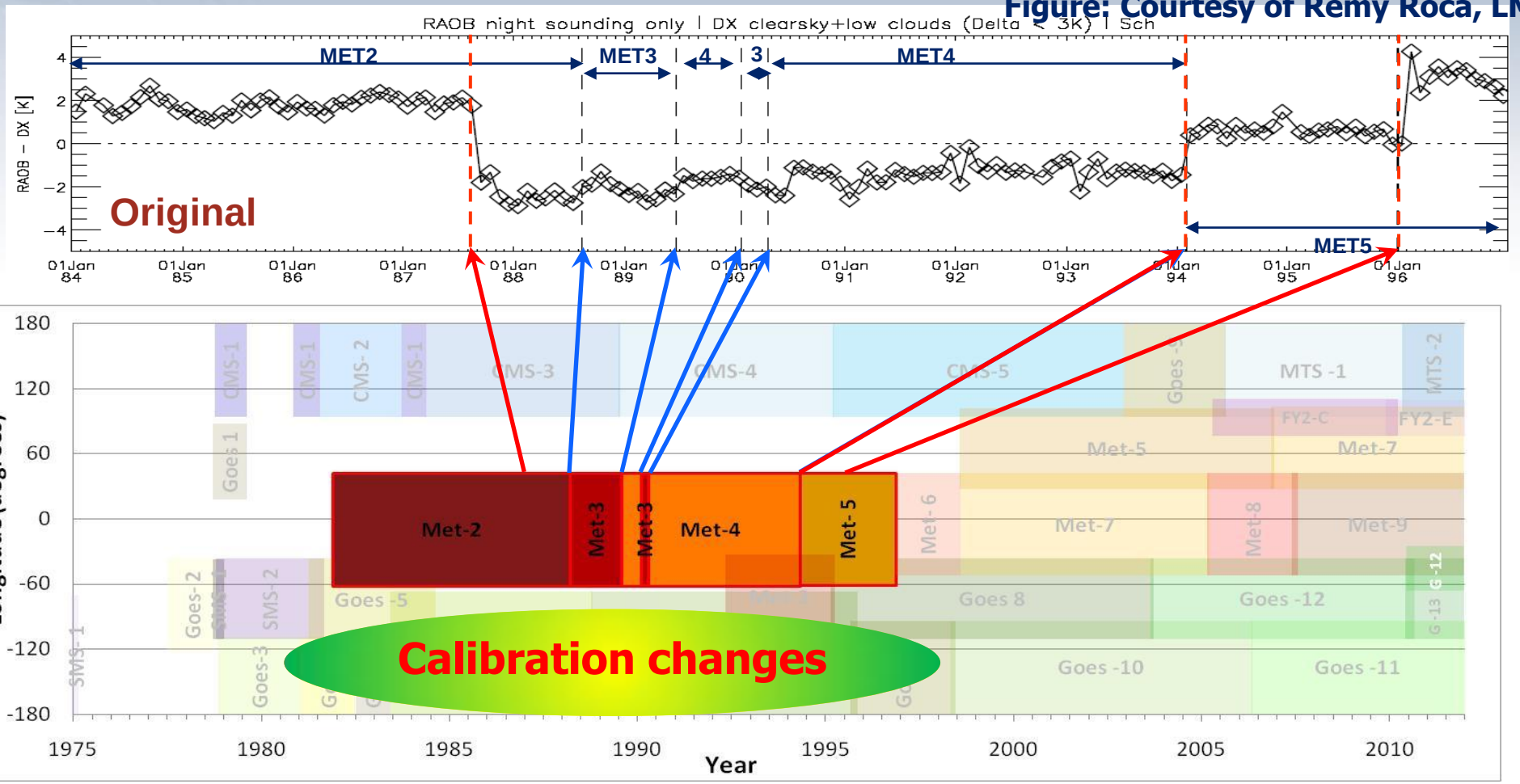


Fig: *Satellites used for the ISCCP climate data record. (Courtesy of Ken Knapp, NOAA-NCDC)*

Scale of the Challenge

Figure: Courtesy of Rémy Roca, LMD



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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:

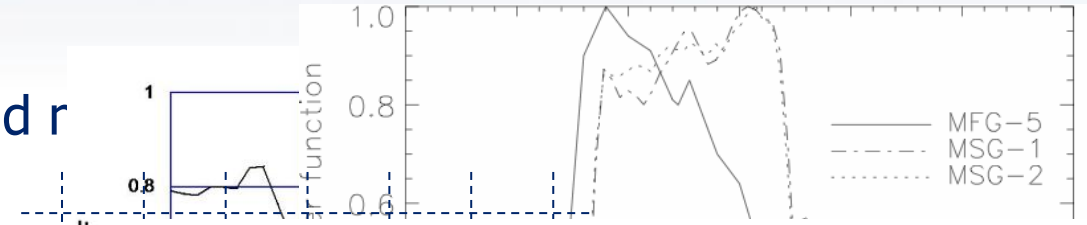
- Inter-calibration back to 1982
- Target accuracy over the time-series better than 0.5-1 K
- Inter-calibration with uncertainty estimate

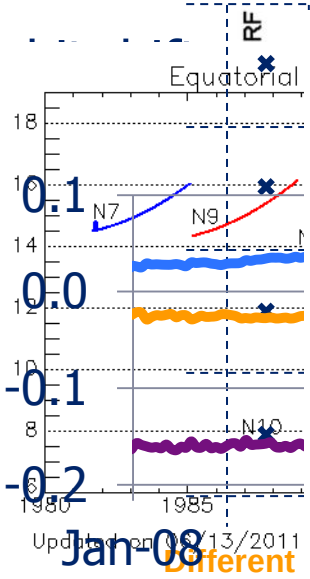
Method

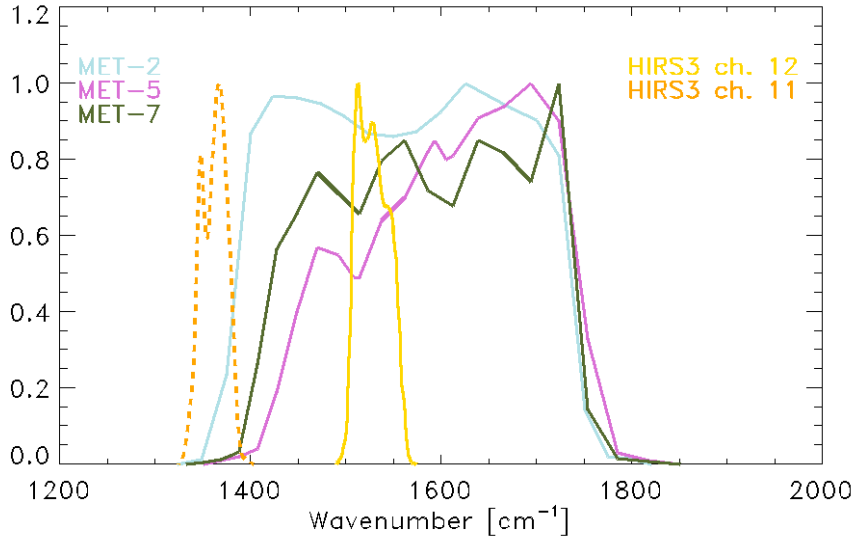
- Define reference instrument and standards (HIRS and ultimately IASI)
- Define the inter-calibration approach
- Estimate the uncertainties (spectral conversions, reference drift, calibration transfer uncertainty (e.g. for SNOs)
- Reprocess, verify and validate the re-calibrated data record

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. Reference instrument drift







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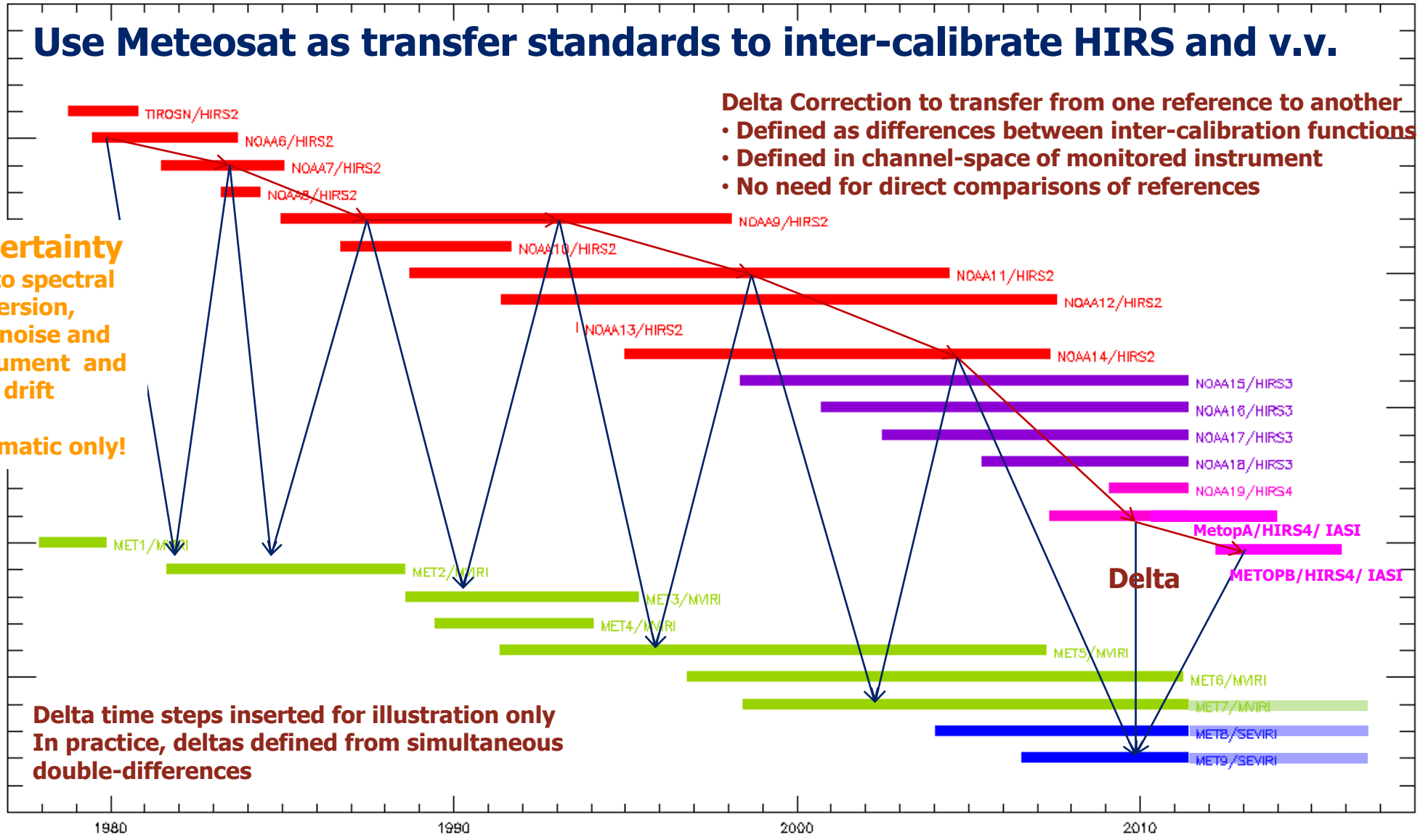
The Zipper Model of Transferring References



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

Also need to:

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

Monitoring Change of Surface Albedo with Meteosat

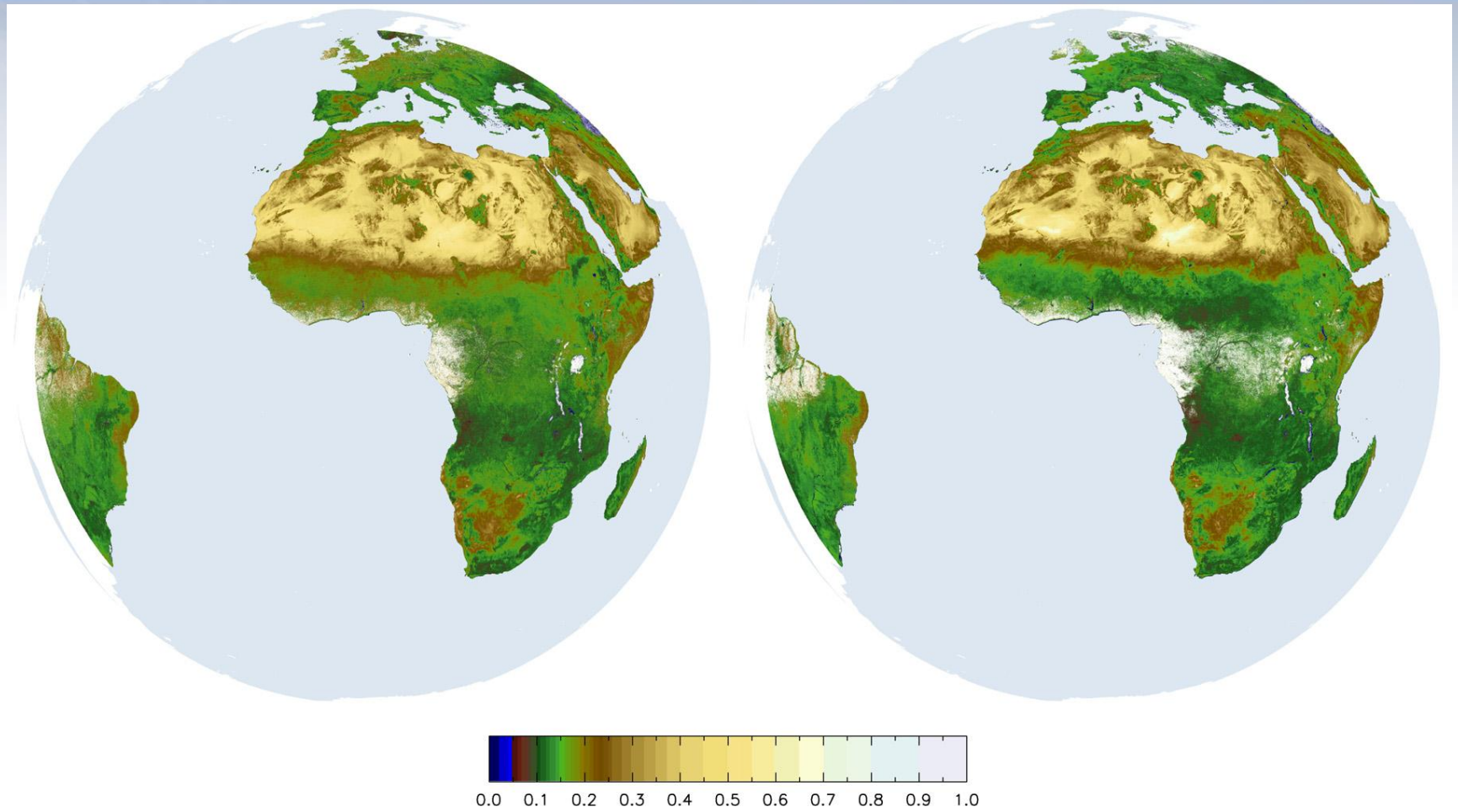
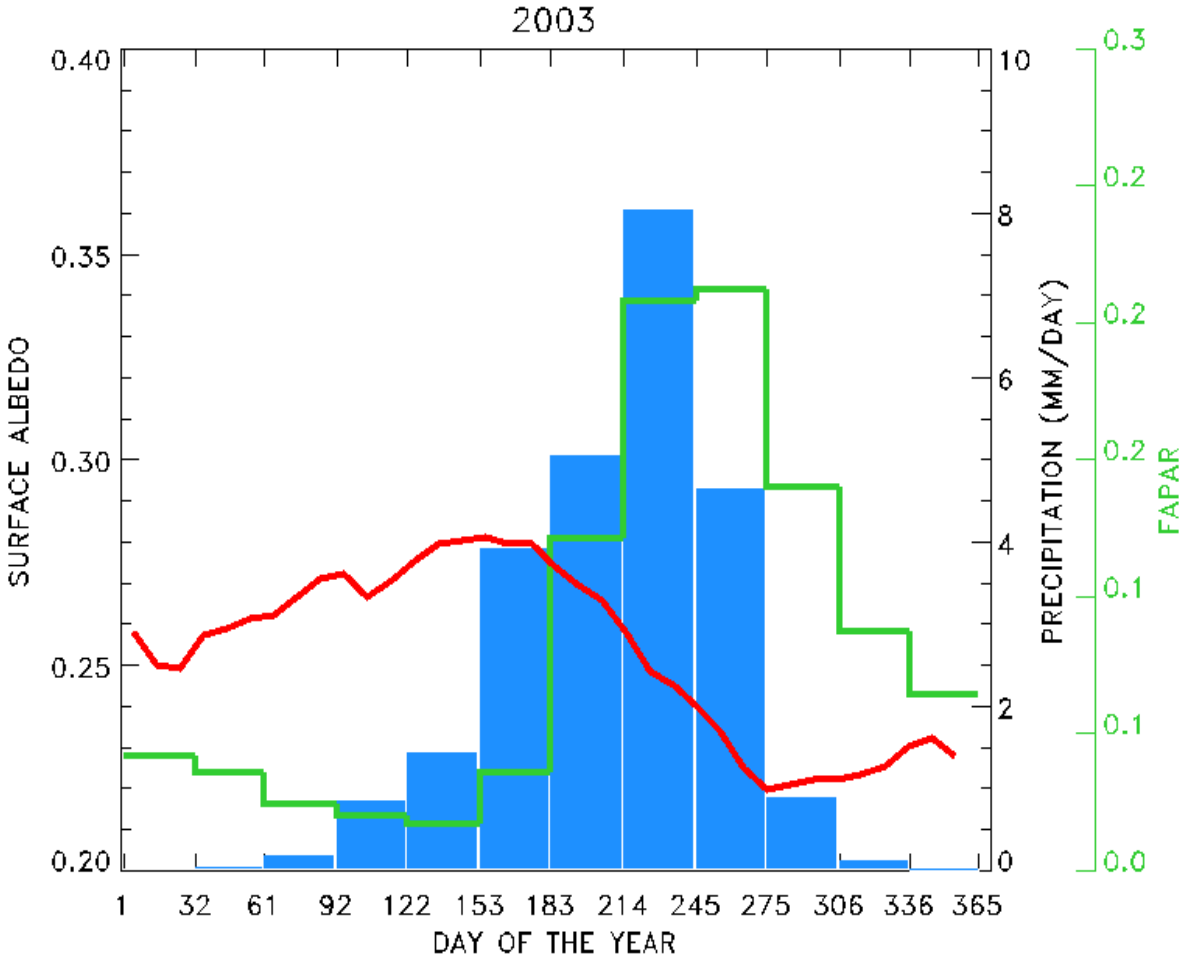
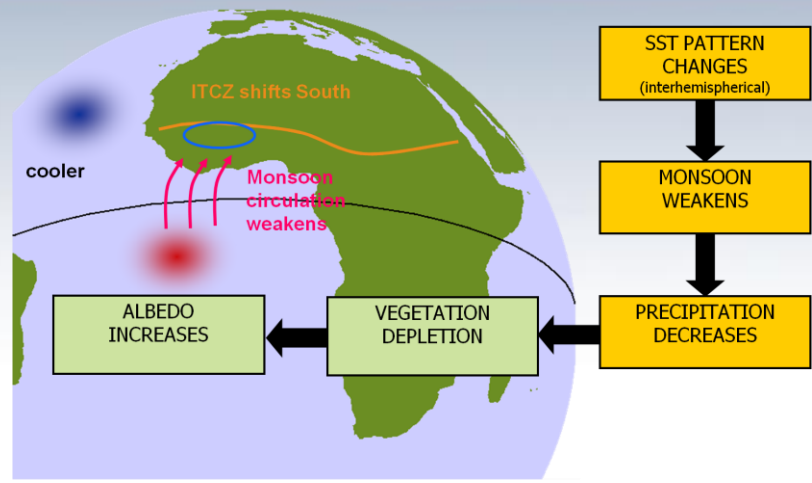


Fig. 4. Mean broadband surface albedo derived from Meteosat observations for the August–October (ASO) period for year 1984 (left) and 2003 (right). Unprocessed data are shown in white to the exception of oceans which are shown in light blue. Products available from www.eumetsat.int.

An Application of Meteosat Surface Albedo: Albedo Response to Precipitation Change





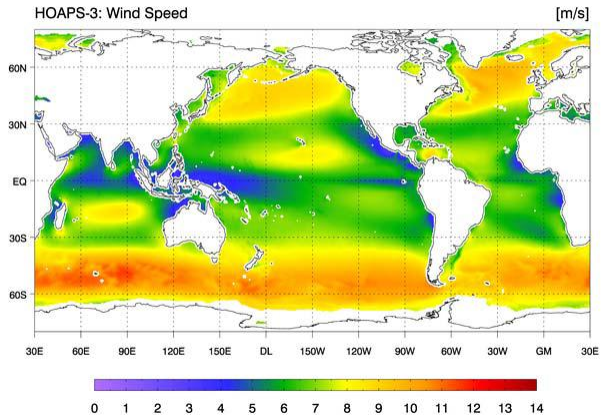
- Seasonal cycle (2003, spatial average over 8.5ºW–8.5ºE and 12.5º–15.5ºN) of monthly mean precipitation in mm/d (blue) from the Global Precipitation Climatology Project, Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) (green) derived from SeaWiFS and surface albedo (red) derived from Meteosat 7 data.
- The delay between the onset of precipitation and growing vegetation is ~ 1 month.
- The inverse proportional effect between vegetation growth and corresponding albedo change is indicating high consistency of observations.

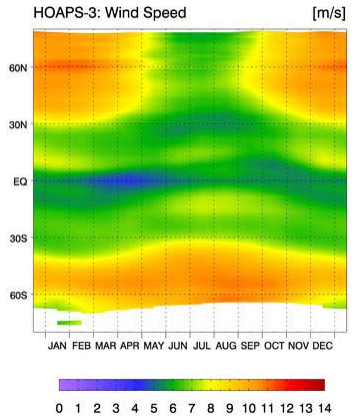
EUMETSAT

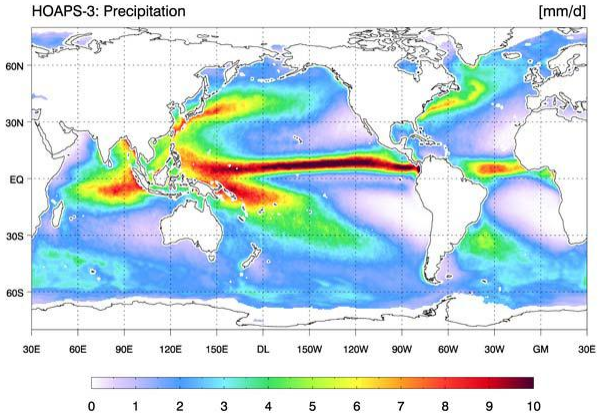
CM SAF CDR Product portfolio

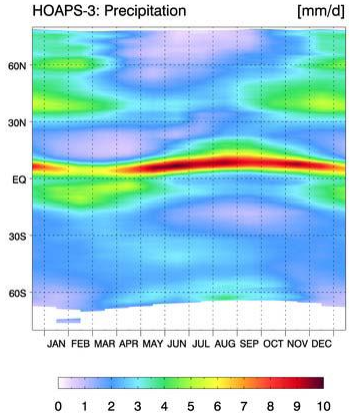
Sensor, Satellite resp.	Parameter	Release date	Period	Coverage
Fundamental **C**limate **D**ata **R**ecord (FCDR)				
SSM/I, SSMIS	Microwave Radiances **V1.0 November 2012**	2012 2014 2016	1987 – 2008 1987 – 2012 1987 – 2014	global ice free ocean
Thematic Climate Data Record (TCDR)				
SEVIRI	Cloud parameters, aerosol optical depth	2012 2015	2004 – 2009 2004 – 2014	Europe & Africa
GERB/SEVIRI	Top of atmosphere radiative fluxes	2012 2015	2004 – 2009 2004 – 2014	Europe & Africa
MVIRI/SEVIRI	Cloud parameters, surface radiation parameters **V 1.0 Released** FTH Land surface temperature	**2011** 2014 2016	**1983 – 2005** 1983 – 2012 1983 – 2015	Europe & Africa
MVIRI/SEVIRI/GERB	Top of atmosphere radiative fluxes	2015	1982 – 2014	Europe & Africa
AVHRR GAC	Cloud parameters, surface radiation p**V1.0 August 2012**	**2012** 2014 2016	**1982 – 2009** 1982 – 2013 1978 – 2015	**global**
TOVS/ATOVS	(high) cloud amount and top	2016	1984 – 2009	global
SSM/I, SSMIS	HOAPS (precip, evap, hum., wind, …) **V1.0 Released**	**2011** 2015 2017	**1987 – 2008** 1987 – 2012 1987 – 2014	global ice free ocean

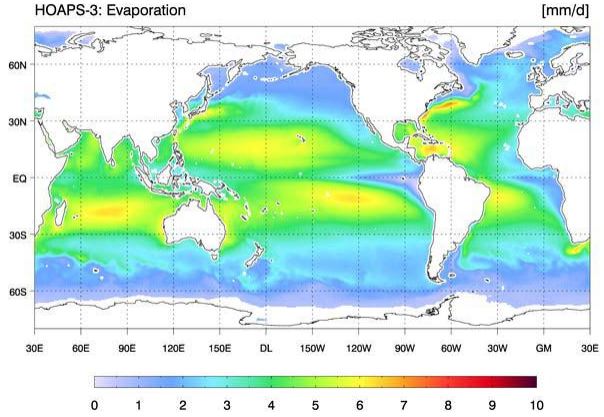
The HOAPS Freshwater Flux Climatology

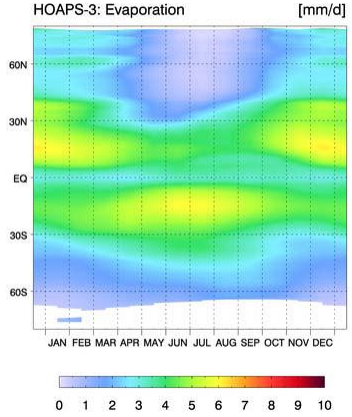


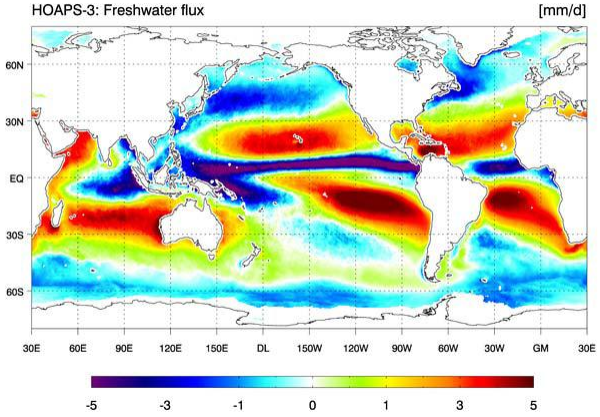


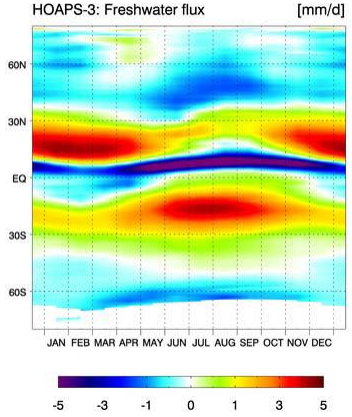










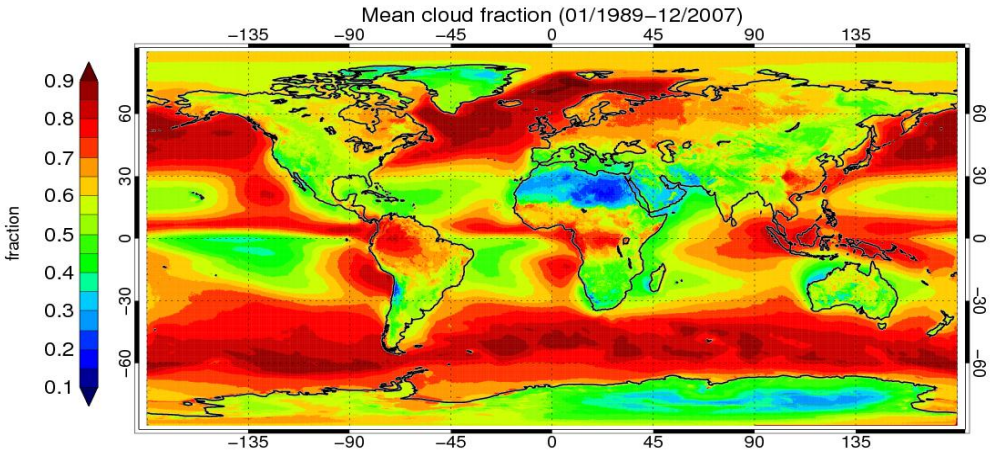


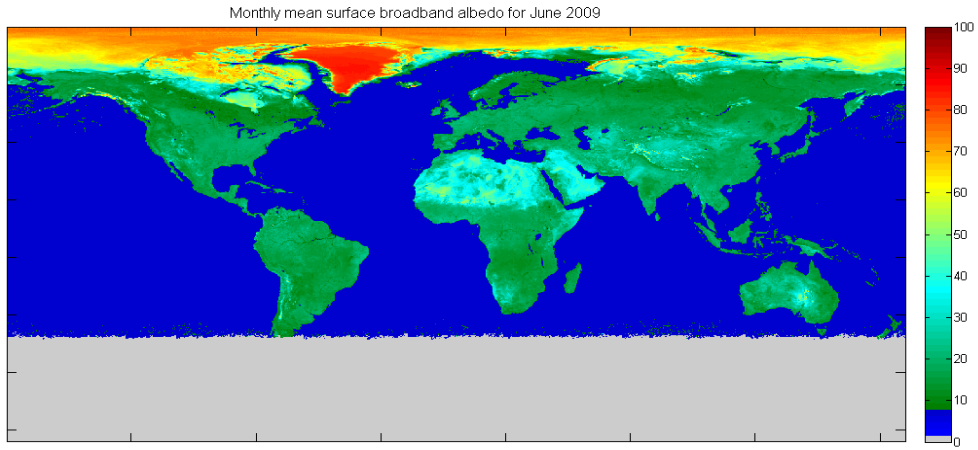
SSM/I derived climatology covering 1987-2008 employing inter-calibrated SSM/I radiances. Continuation with SSMIS data is subject of CDOP-2.

28-year AVHRR Cloud and Radiation Flux TCDR

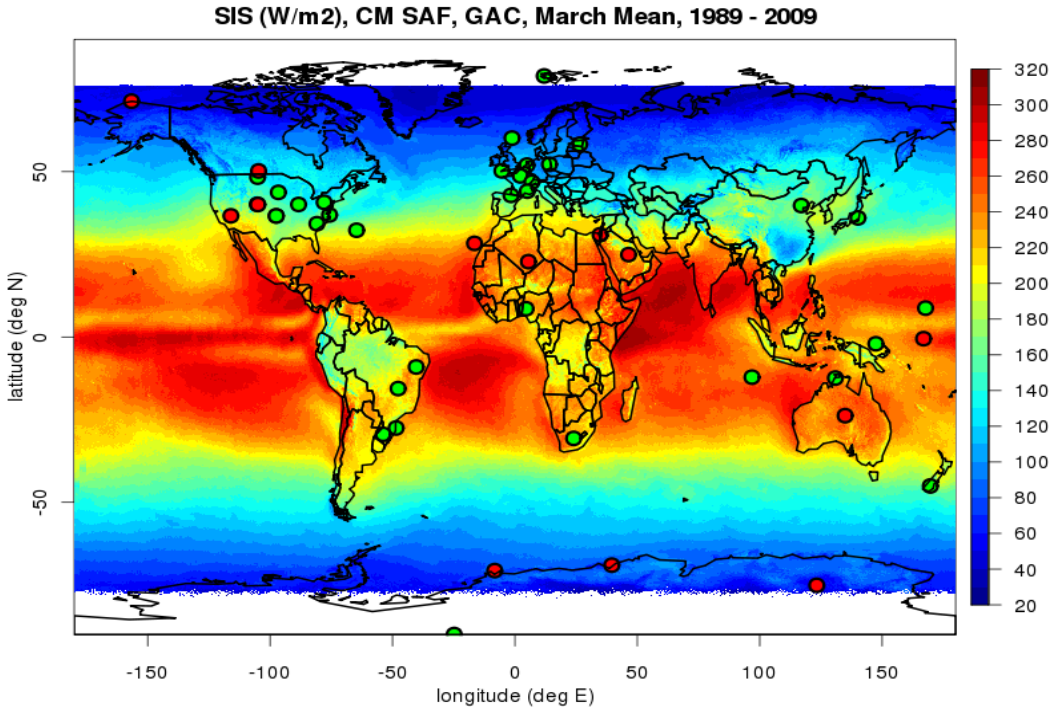
Cloud and Radiation Flux TCDR (CLARA)

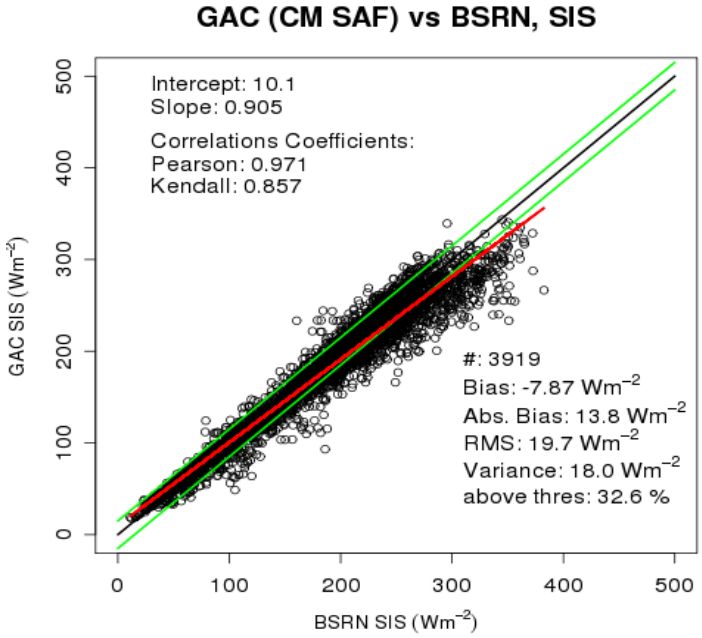
- Based on FCDR AVHRR-GAC (Heidinger et al. 2011)
- Available 1982 to 2009
- 0.25° spatial resolution
- daily, monthly
- Variables:
  - Shortwave radiation
  - Longwave radiation
  - Surface radiation budget
  - Surface Albedo
  - multiple cloud parameters





Validation CLARA Surface Solar Radiation





Data set	Analyzed Months	Bias (Wm^{-2})	Abs. Bias (Wm^{-2})	Variance (Wm^{-2})	Corr. Ano.	Frac. Months $> 15\ Wm^{-2}$,%
CM SAF, GAC	3919	−7.9	13.8	18.0	0.86	32.6

Conclusion

- EUMETSAT provides long term continuity of space observations – A key for the generation of Climate Data Records and input to NWP model based reanalysis.
- EUMETSAT generates data records from own and third party missions utilising its Central and Satellite Application Facilities (CAF and SAF) that shall benefit climate system analysis and reanalysis activities;
- Current CAF activities concentrate on preparation of Level 1 data supporting Reanalysis at ECMWF, the SAF network and ESA CCI;
- Activities towards referencing Meteosat IR and WV channels to IASI/HIRS are underway using a traceable chain of inter-calibrations. Further analysis of uncertainties is needed – The ERA-CLIM observation feedback archive will play a major role in this as well;
- The EUMETSAT SAF network has committed more work on CDRs in their CDOP-2 project phase (2012-2017), e.g., new versions of sea ice concentration and other atmospheric, oceanic and land data records;
- Data are available free of charge via the EUMETSAT Product Navigator (www.eumetsat.int) and the individual SAF web sites, e.g., www.cmsaf.eu.