Climate@EUMETSAT

EUMETSAT contribution to climate science and services

Jörg Schulz

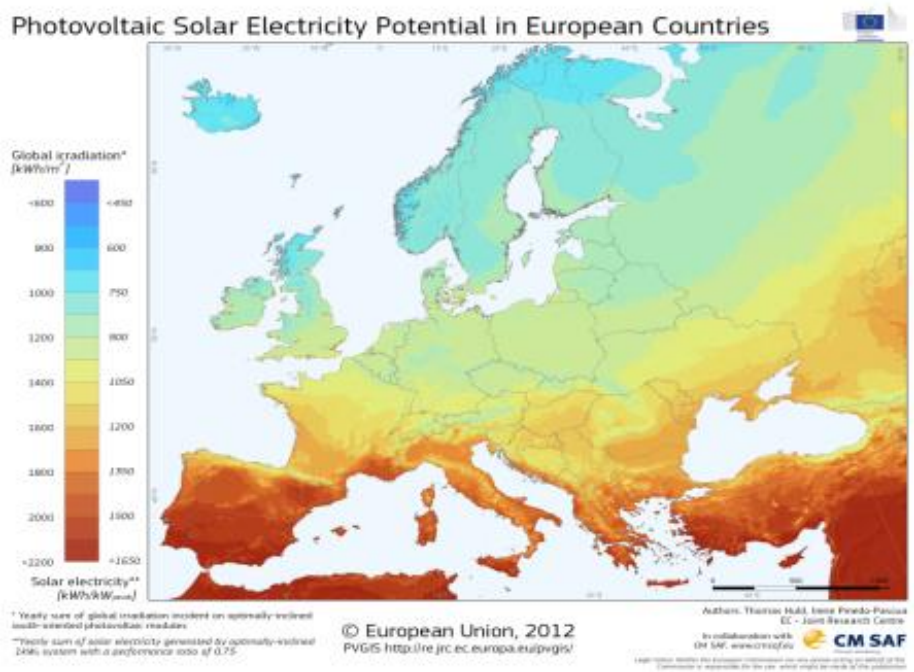
EUMETSAT Climate Team

many experts inside and outside of EUMETSAT

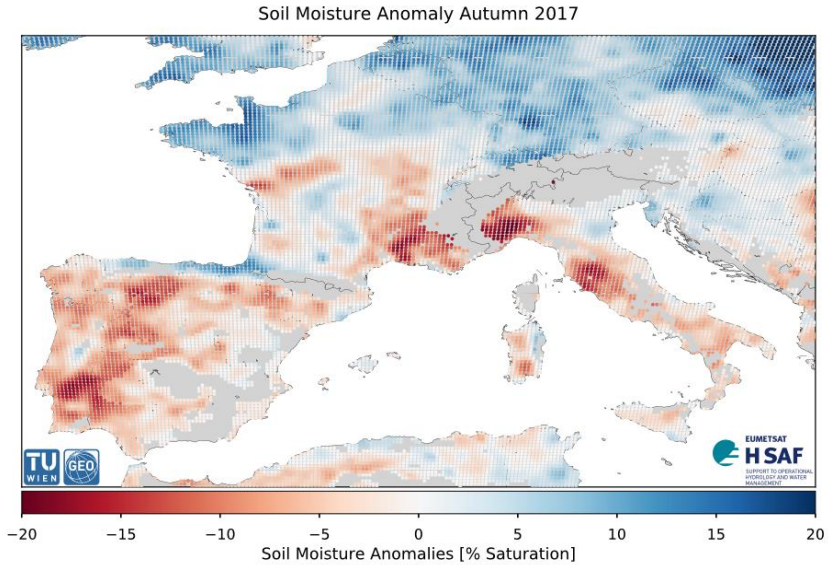
EUMETSAT Contribution to Climate Monitoring

- Long term, multi-satellite programmes, with service continuity
- Continuous improvement, expansion of portfolio of observations
- Unique patrimonial archive: decades of observations
- Data rescue (historic satellite observations)
- Recalibration and production of climate records
  - Physical parameters directly observed by satellites: level 1 (mostly done at EUM HQ)
  - Geophysical parameters: ECVs (ocean, atmosphere, land) (mostly done by EUM SAF)
  - Estimation of uncertainties
- Data access
- Cooperation with users: validation, research, applications
- Training, support to climate-related capacity building initiatives

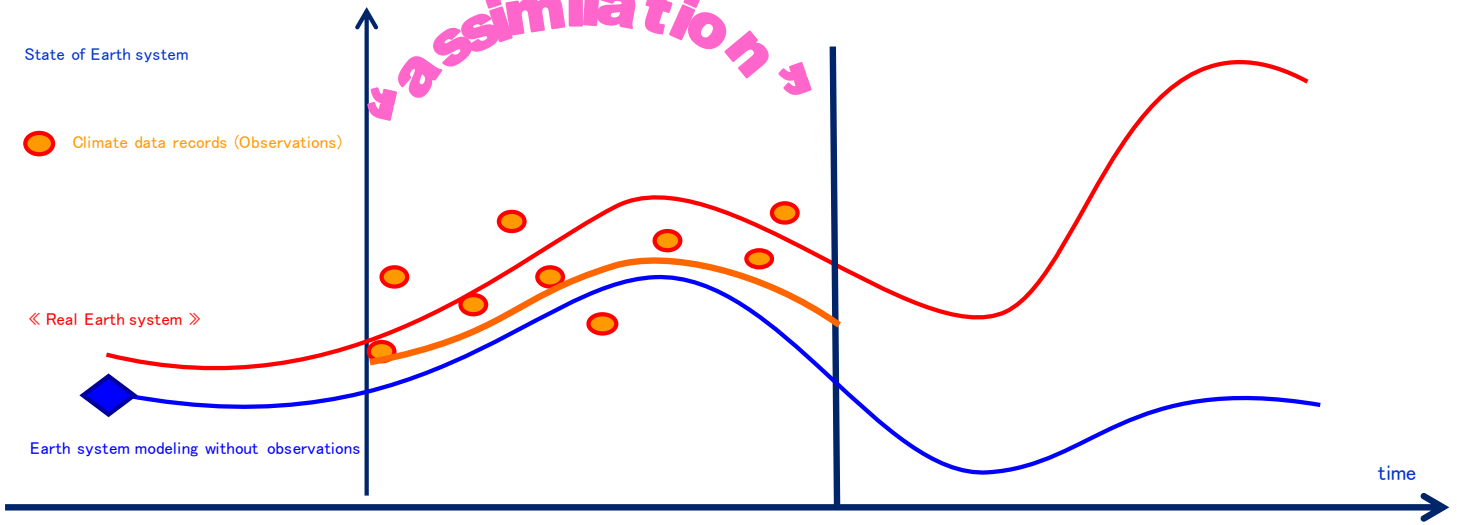
Use of Data Records



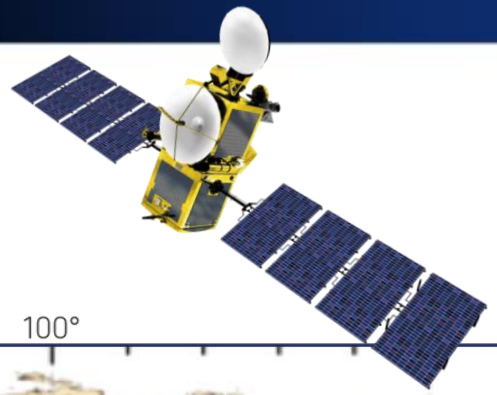
DIRECT USE

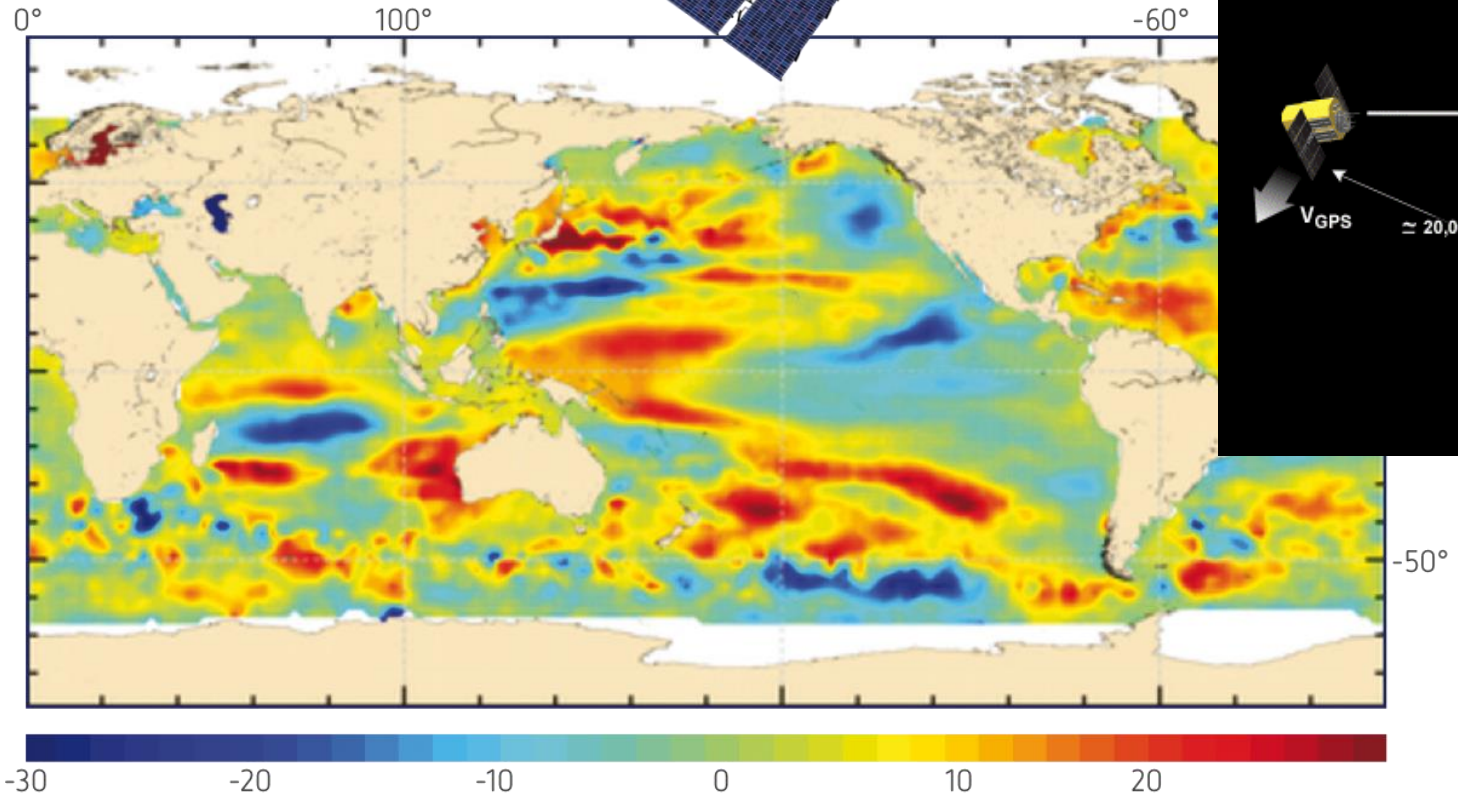


REANALYSIS USING EARTH SYSTEM MODELS

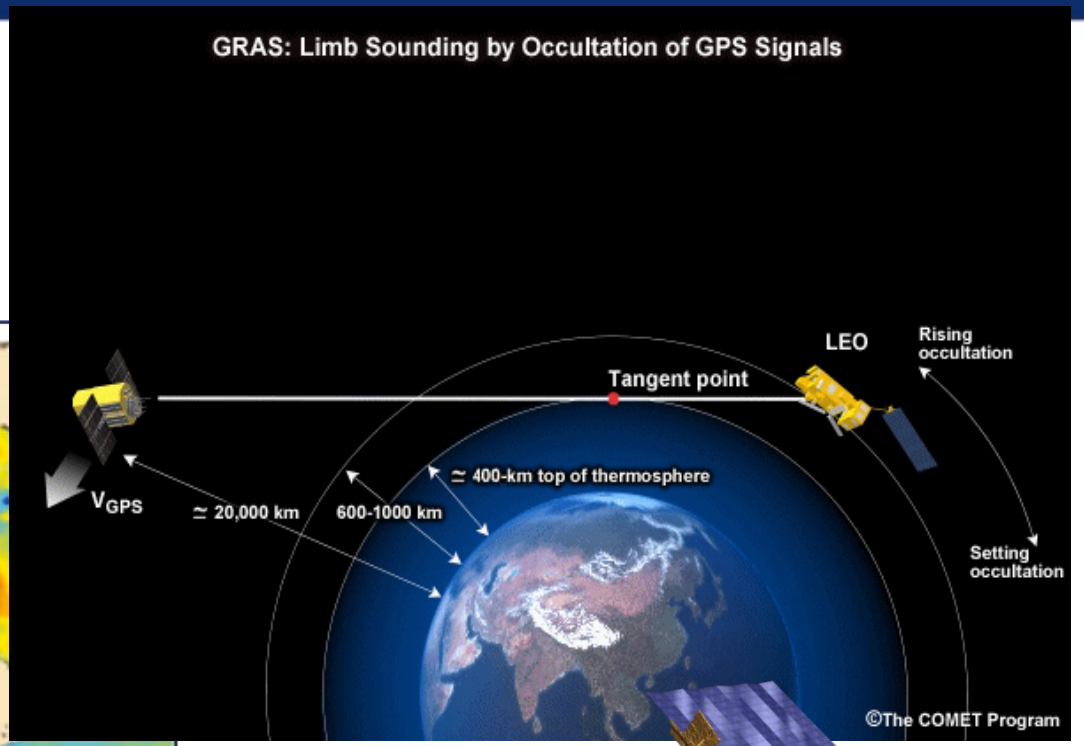


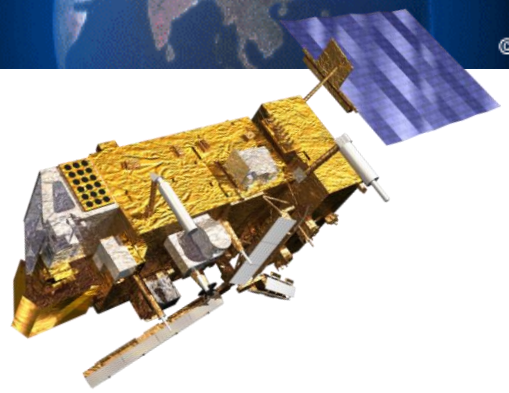
Some missions are optimised for climate monitoring …





Trends (mm/year I.B. : applied / wet tropo. :RADIOMETER-derived, seasonal signal removed)





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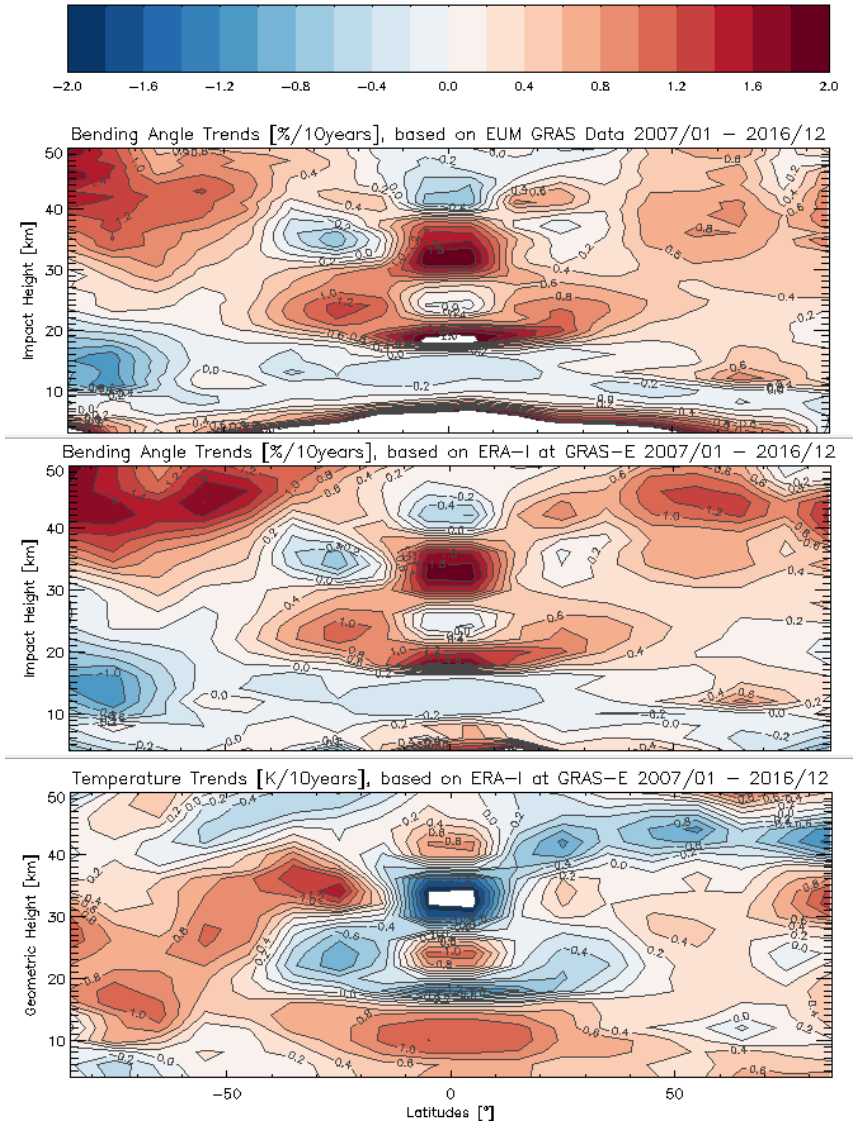
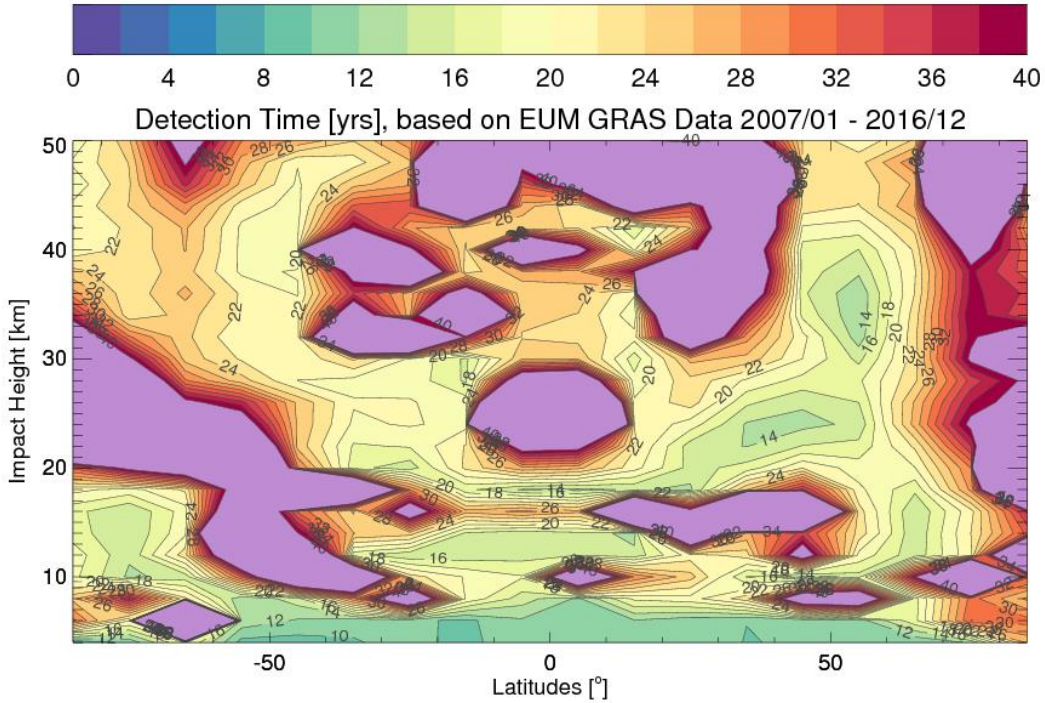
Preliminary Trends from 10 years of GRAS Data



Reprocessing v1.4 bending angle trends for 10yrs of GRAS / Metop-A data.

Detection time of trends (purple >40yrs)



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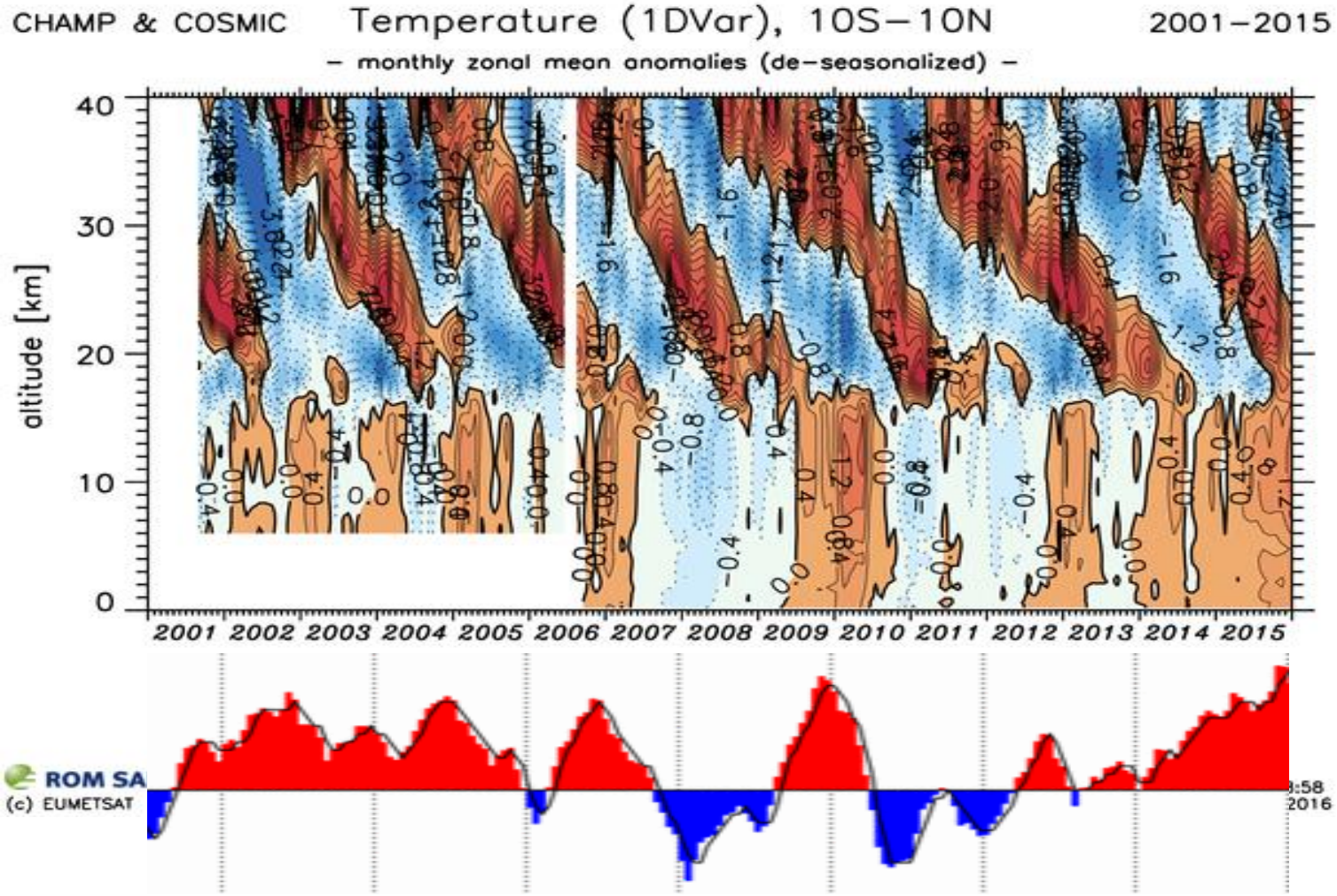
Radio-Occultation: Data Record Example

EUMETSAT ROM SAF
RADIO OCCULTATION METEOROLOGY

Champ and Cosmic data record monthly mean time series covering the period from September 2001 to June 2015.



ENSO Index

… others are not: Data Rescue and Preservation Challenge – Meteosat-1 -

WV channel, Meteosat 1

4th February 1979, 15 images (Every hour from 08:30 UTC until 23:30 UTC *(missing images at 18:30 UTC)*

correspondence

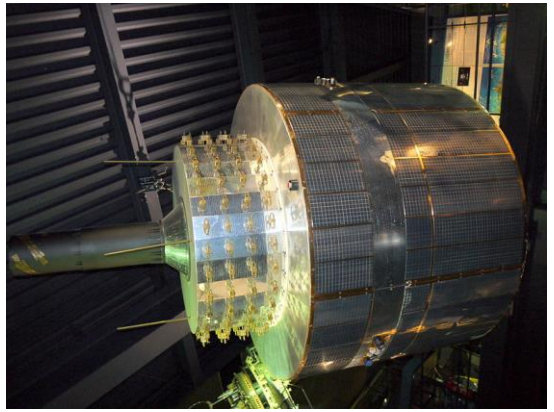
A New Insight into the Troposphere with the Water Vapor Channel of Meteosat

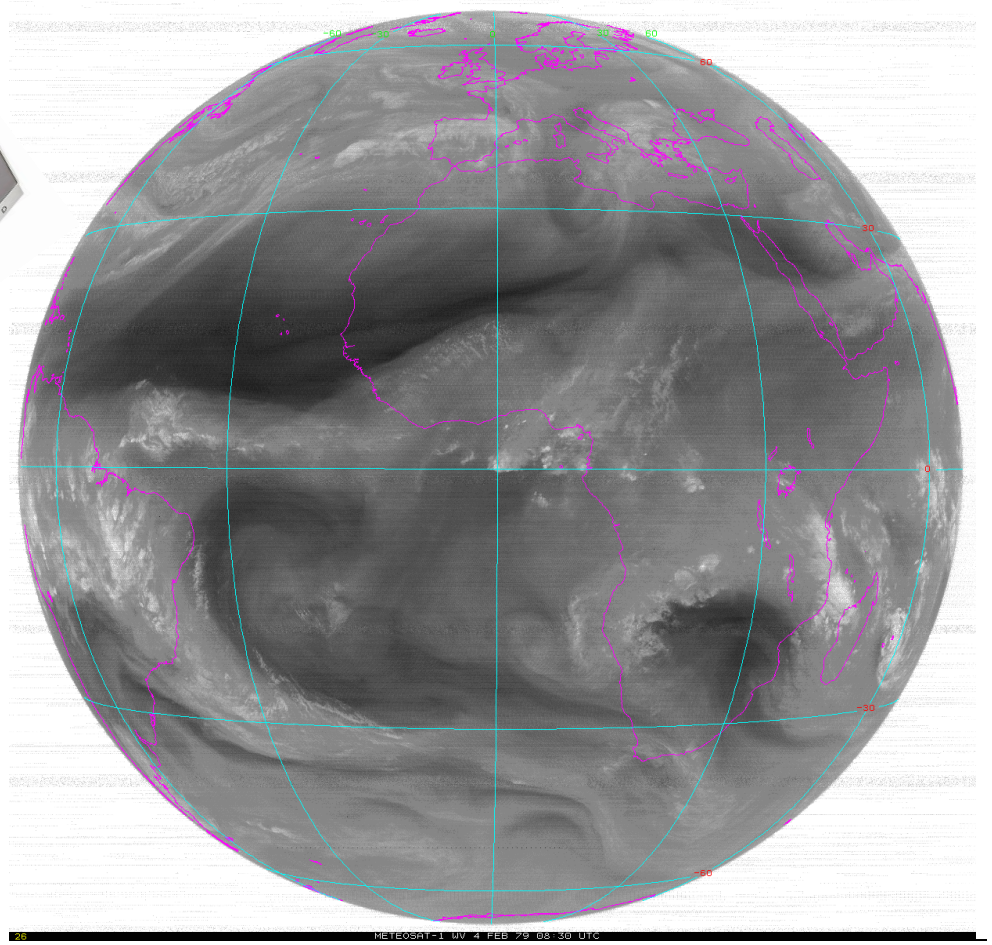
Pierre Morel, Michel Desbois, and Gérard Szejwach,
Laboratoire de Météorologie Dynamique, Centre National de la Recherche Scientifique, École Polytechnique, Palaiseau, France 91120

Abstract

Meteosat images in the three channels—visible (0.4–1.1 μm), thermal infrared (10.5–12.5 μm), and water vapor (5.7–7.1 μm)—are presented. The new possibilities offered by the water vapor channel on a geostationary satellite are outlined.

Bulletin of the AMS, 1978





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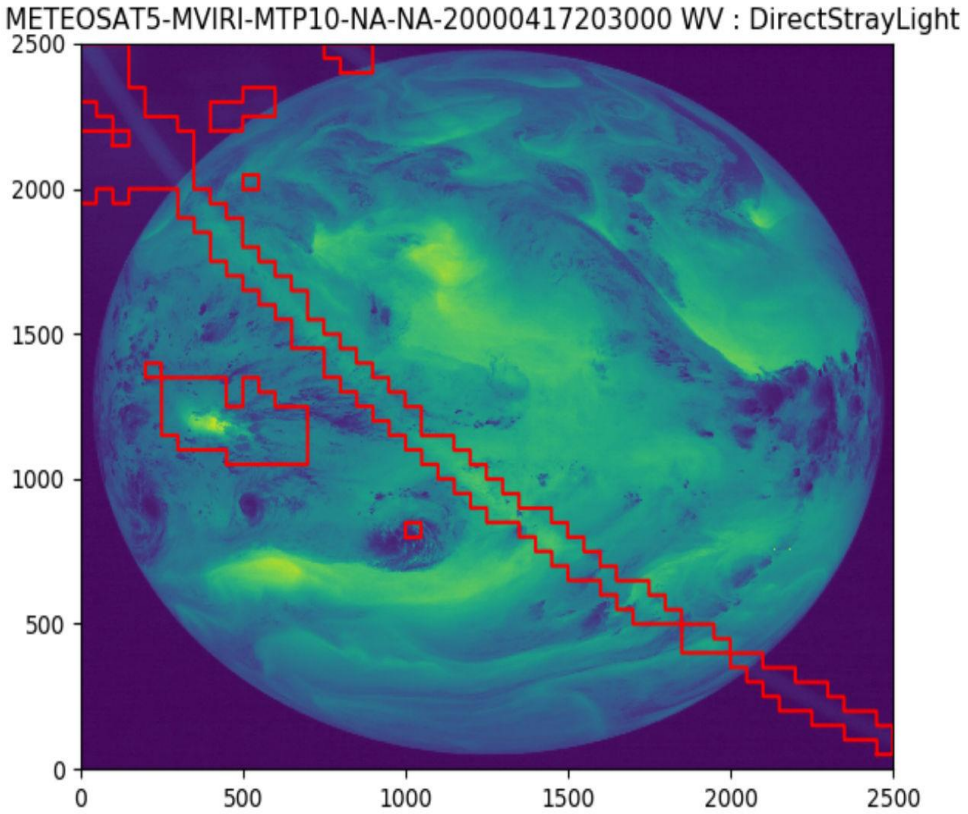
Every Image Counts: Data Rescue Meteosat First Generation

Enabling full image and product processing of Meteosat archive

- Image anomaly detection on raw data distinguishes 30 anomaly types and runs over 63 data years of data in ~24 hours;
- Preserved image processing software and migrate to modern computer system;
- Recalibrated IR channels referenced to IASI;
- Reconstructed VIS channel spectral response and recalibrated all MFG;
- Included uncertainty estimates for radiance;
- Implemented retrieval schemes for clouds, all sky radiance, atmospheric motion vectors, surface albedo, aerosol optical depth;
- Work on data processing improvements;
- Could be implemented for all geostationary satellites.

Automated detection of anomalies present in historical Meteosat imagery



Red marked areas: anomalies due to direct stray light in Meteosat-5 image (17 April 2000, 20:30 UTC)

Uncertainties are important

Decision making requires appreciation of uncertainties

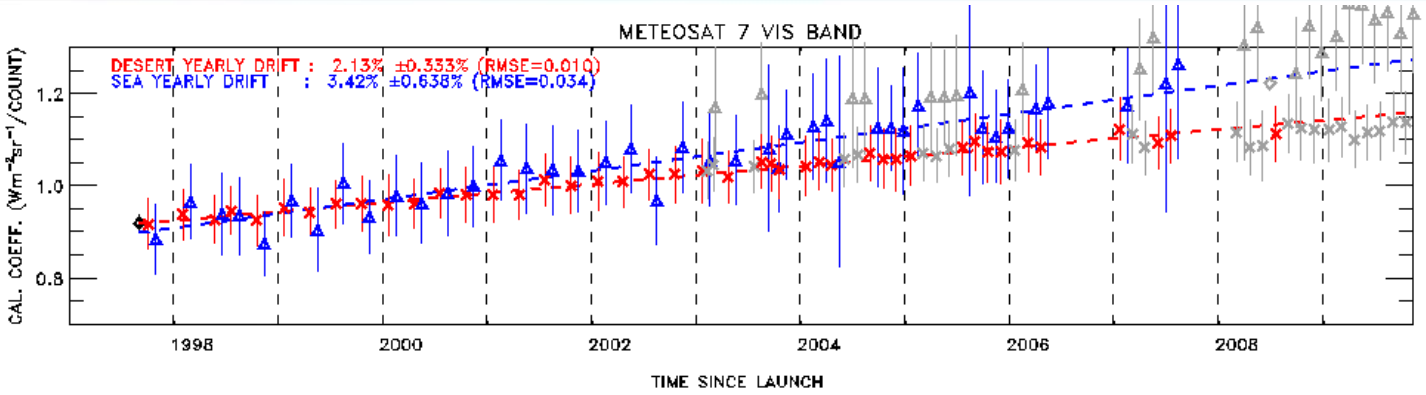
- Research is needed to *narrow down* uncertainties
- Science and reference data are needed to *document and trace uncertainties*

Traceability of uncertainties in observations

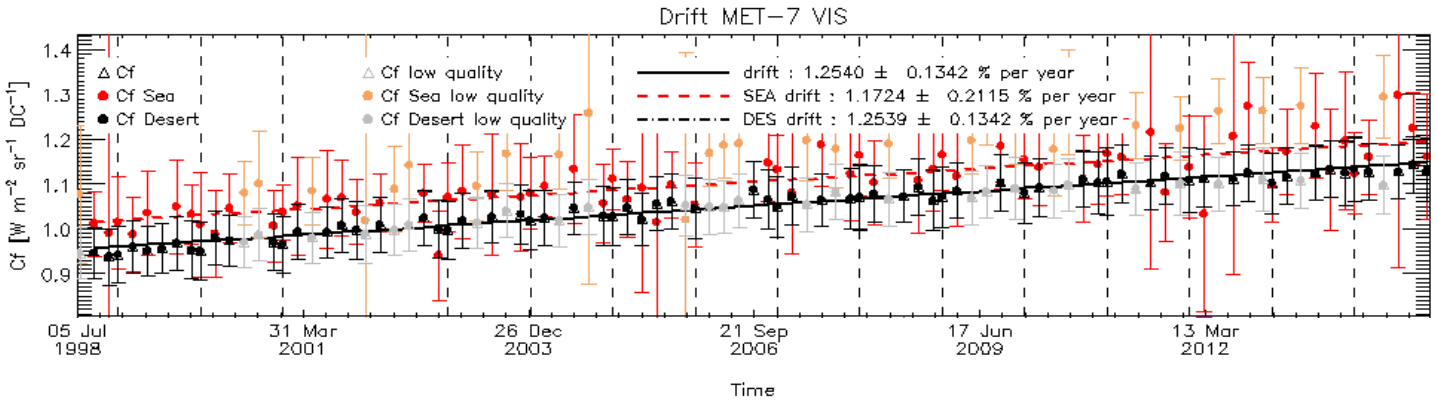
- Metrology
- Cross-calibration/validation against reference observations
- Evaluation of limitations of processing algorithms

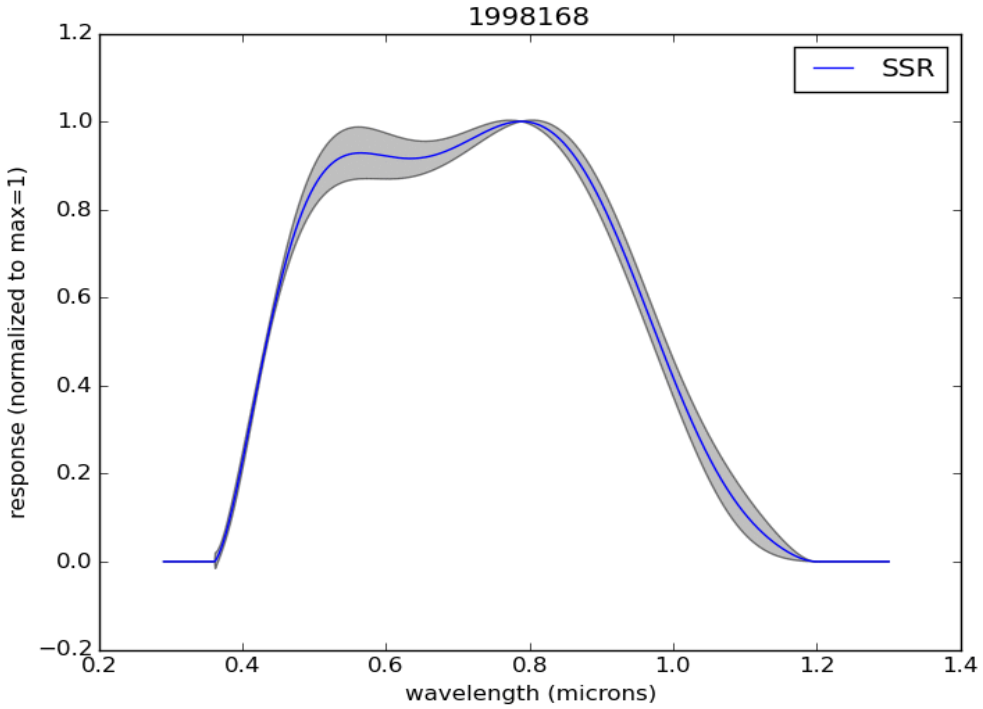
Mature Climate Records Include information on uncertainties

Recalibration of Meteosat Visible Imagery



Reconstruction of temporal variation of spectral response function due to detector ageing improves VIS calibration.





Fiduceo

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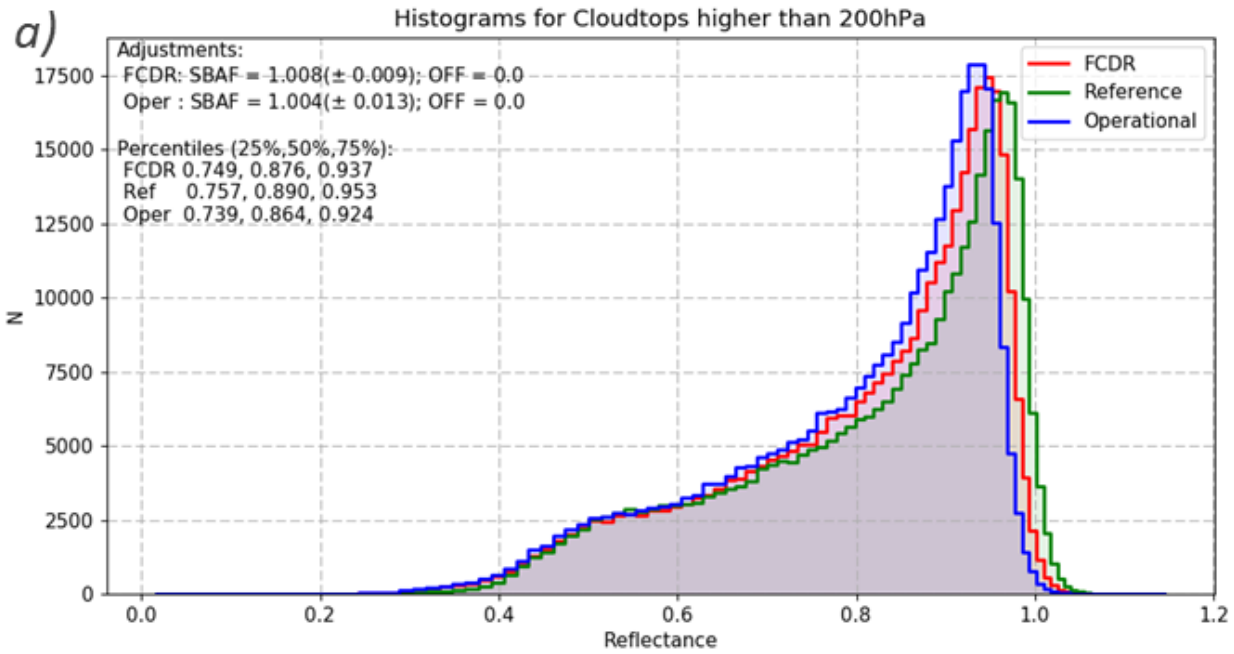
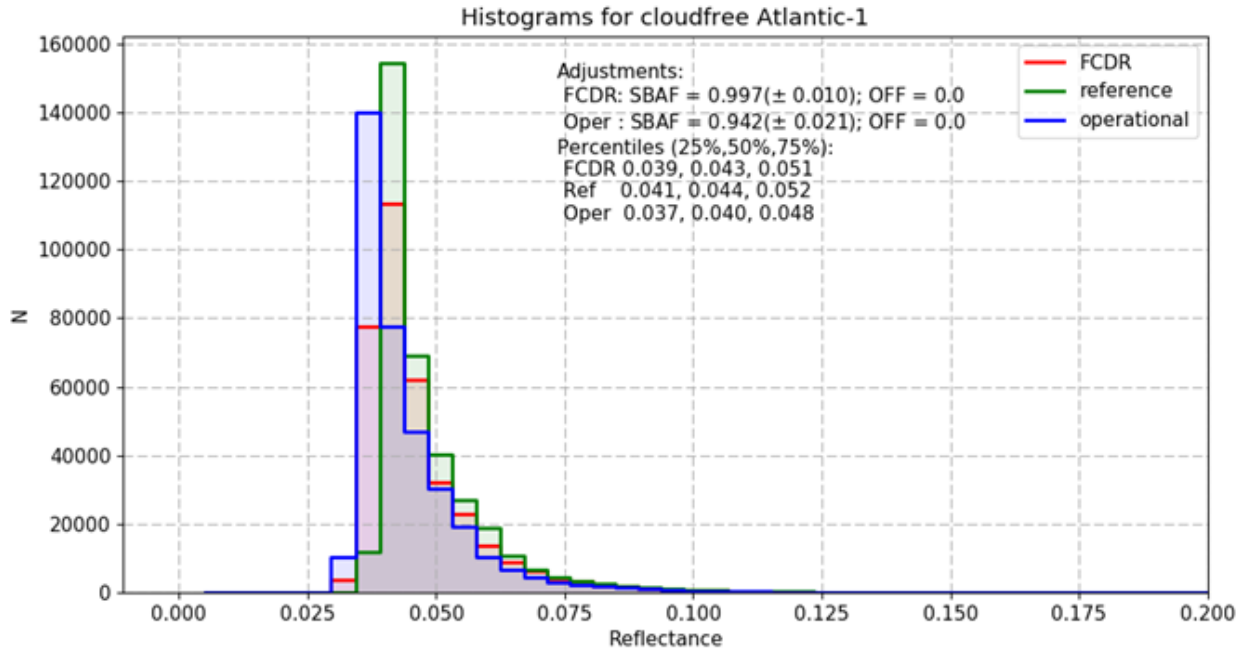
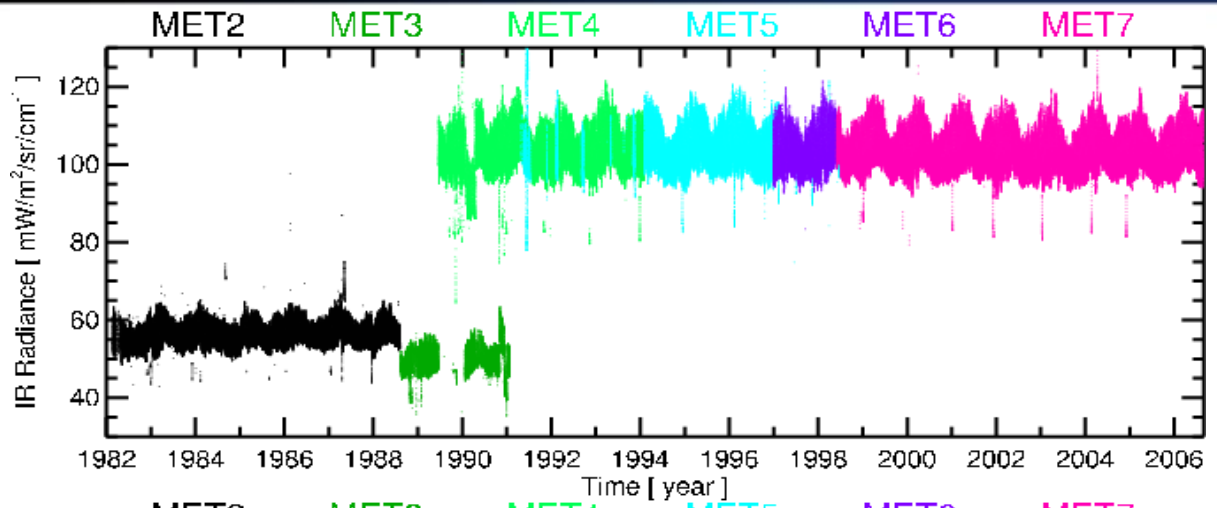
Impact on Reflectance

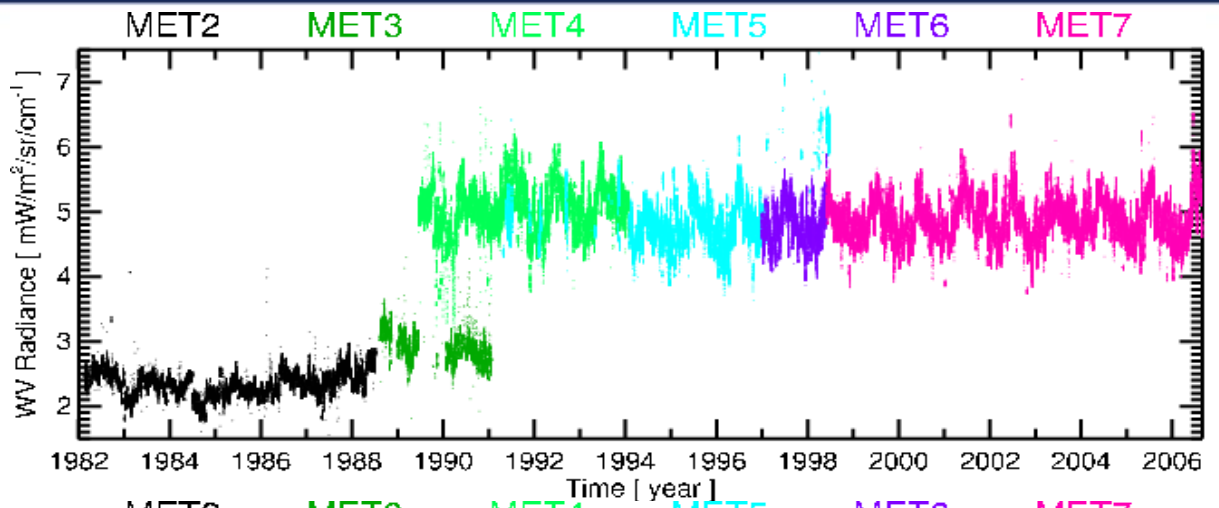


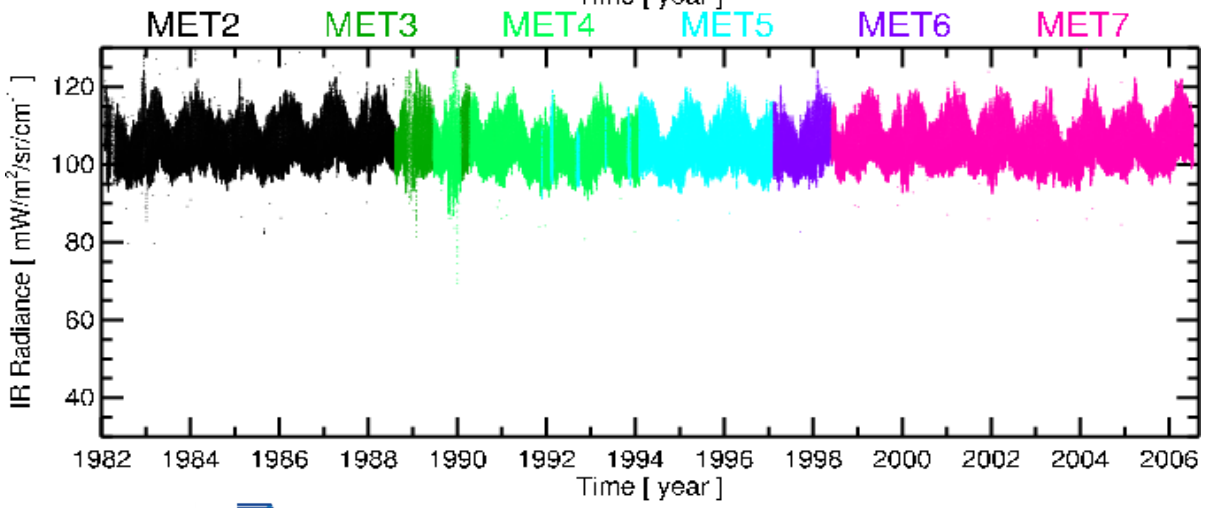


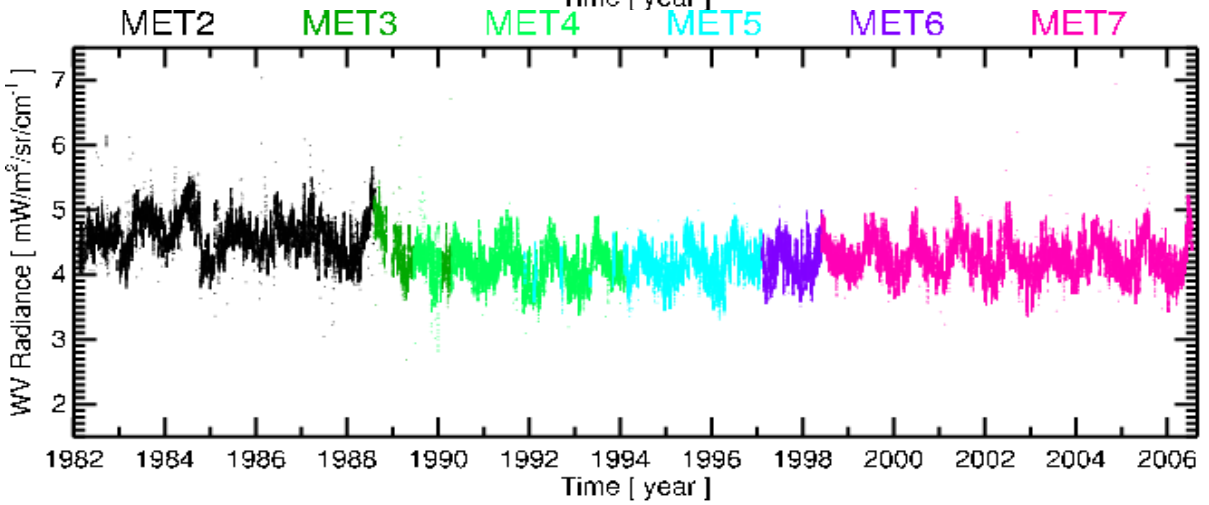
Rüthrich, F.; John, V.O.; Roebeling, R.A.; Quast, R.; Govaerts, Y.; Woolliams, E.R.; Schulz, J. Climate Data Records from Meteosat First Generation Part III: Recalibration and Uncertainty Tracing of the Visible Channel on Meteosat-2–7 Using Reconstructed, Spectrally Changing Response Functions. *Remote Sens.* **2019**, *11*, 1165.

Meteosat MVIRI IR and WV Channel re-calibration



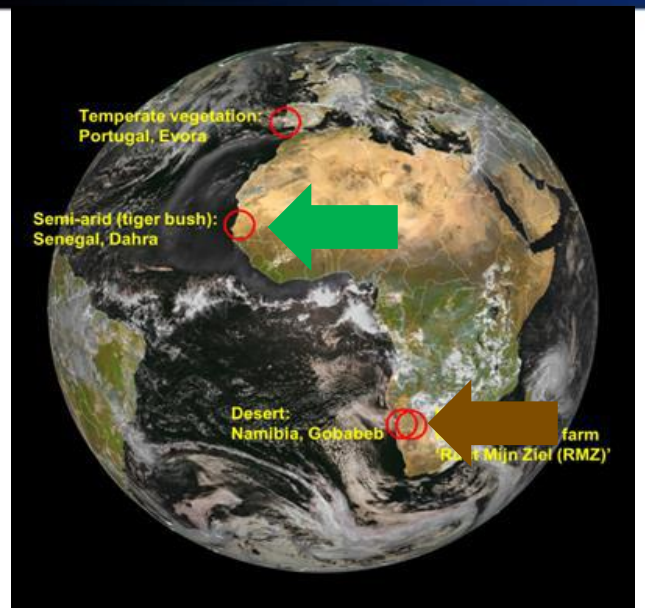






John, V.O.; Tabata, T.; Rüthrich, F.; Roebeling, R.; Hewison, T.; Stöckli, R.; Schulz, J. On the Methods for Recalibrating Geostationary Longwave Channels Using Polar Orbiting Infrared Sounders. *Remote Sens.* **2019**, *11*, 1171.

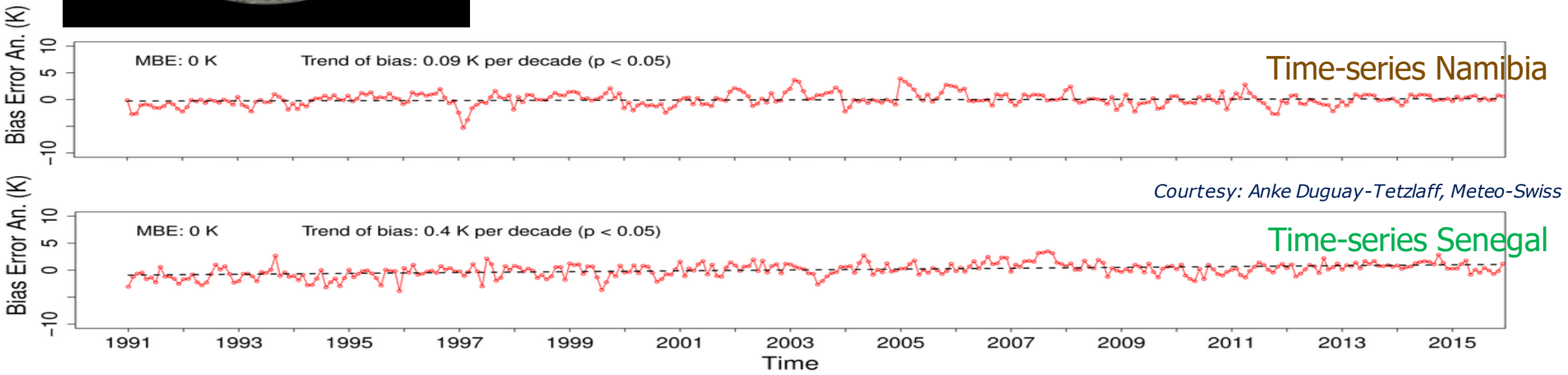
Validation of re-calibrated radiance against Land Surface Temperature measurements



- **CM SAF** validate re-calibrated MVIRI infra-red radiances against Land Surface Temperature (LST) measurements from stations in Namibia and Senegal;
- Trend of mean deviations at 95% significance are:
  -> 0.09 K/decade (Namibia)
  -> 0.40 K/decade (Senegal)
  (Note: global GCOS criteria is 1K/decade.

The EUMETSAT Network of Satellite Application Facilities

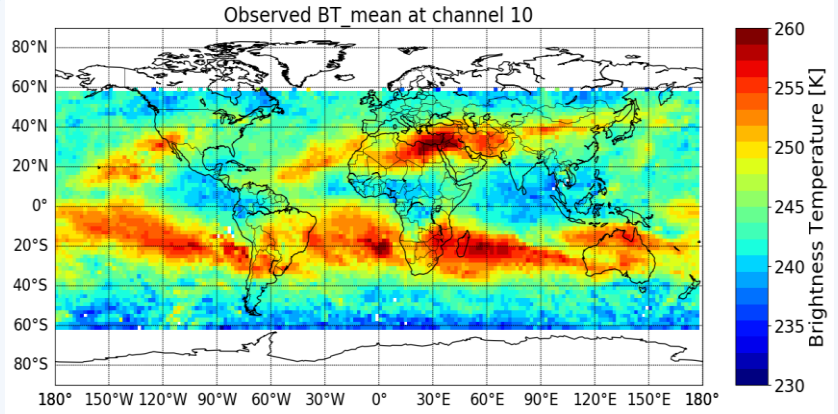
CM SAF Climate Monitoring



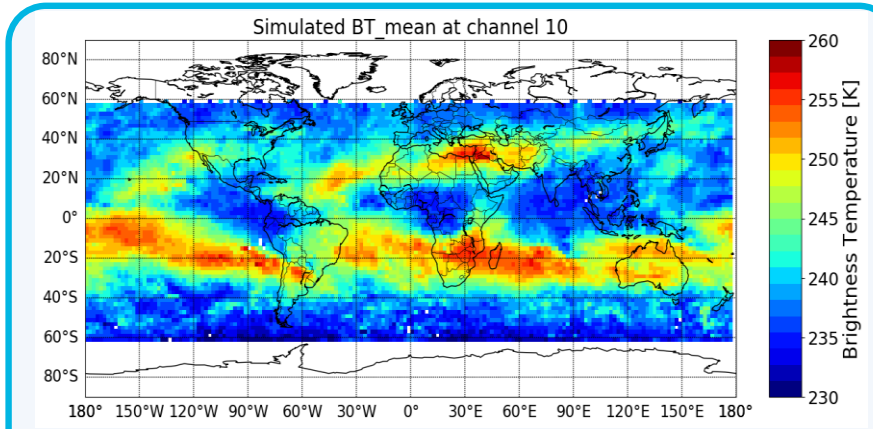
Courtesy: Anke Duguay-Tetzlaff, Meteo-Swiss

Climate Change

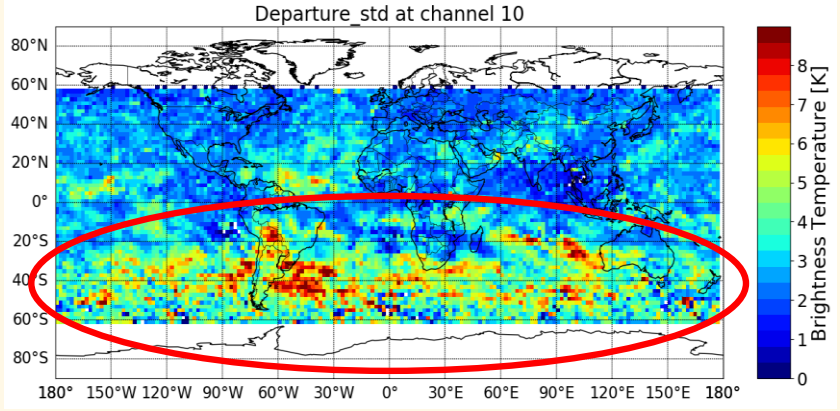
Analysis of NIMBUS-6 HIRS-1 Data (6.7 µm)



Nimbus-6 (Aug 1975)



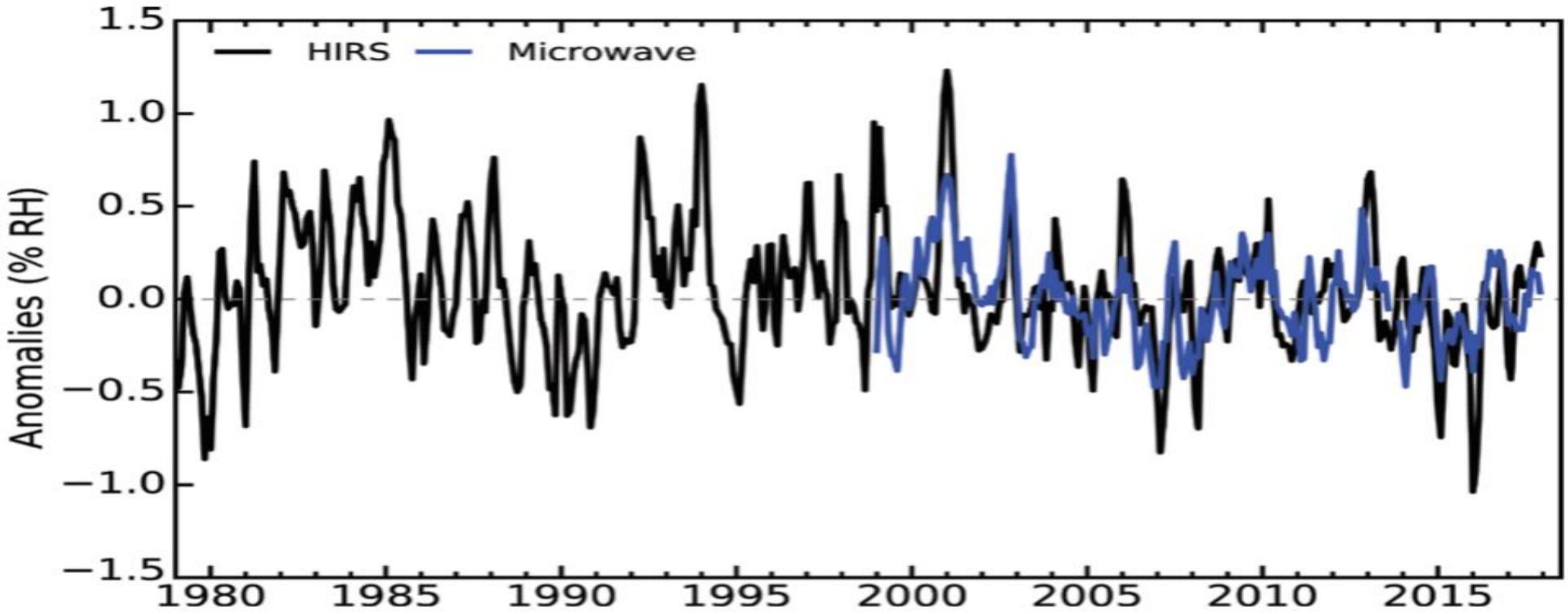
ERA-5 (Aug 1975)



Standard Deviation
Nimbus-6 – ERA-5 departures

EUMETSAT ECMWF Copernicus Europe's eyes on Earth European Commission

Upper tropospheric humidity with HIRS and MHS



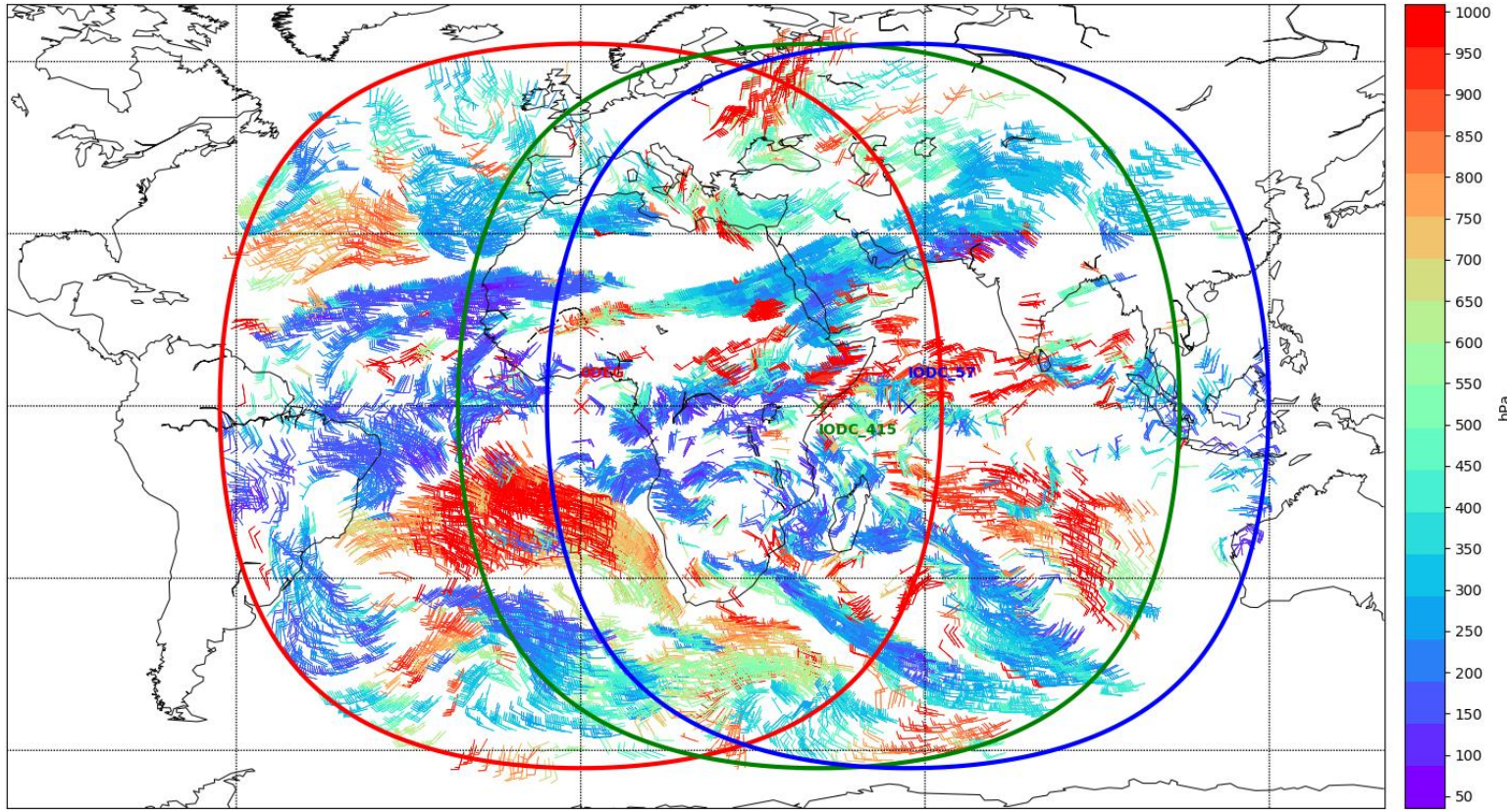
Time series of upper tropospheric humidity anomalies using HIRS (black) and microwave sounder (blue) datasets. Figure shows the area-weighted mean deseasonalized anomaly time series of UTH for 60°N– 60°S. The anomalies are computed with respect to the 2001–2010 average, and the time series are smoothed to remove variability on time scales shorter than three months.

John et al., 2018: State of the Climate 2017, BAMS.

Consolidated MFG&MSG AMV Retrieval

Consistent multi-satellite AMV field retrieved from MVIRI & SEVIRI IR imagery for C3S

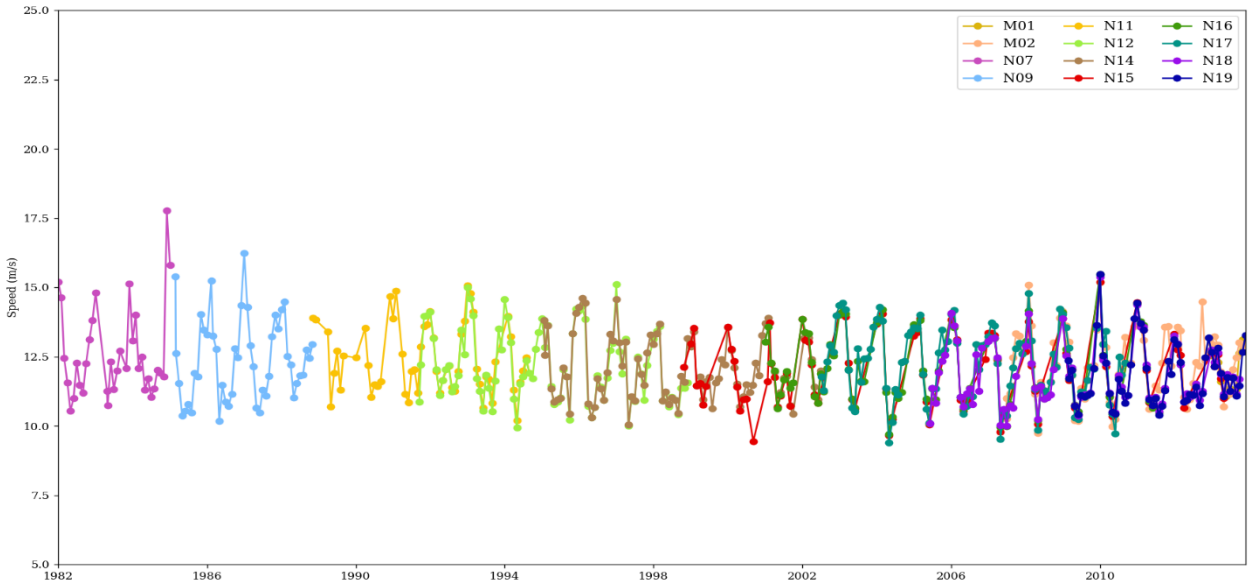
Example for 14 February 2017 at 12:00 UTC

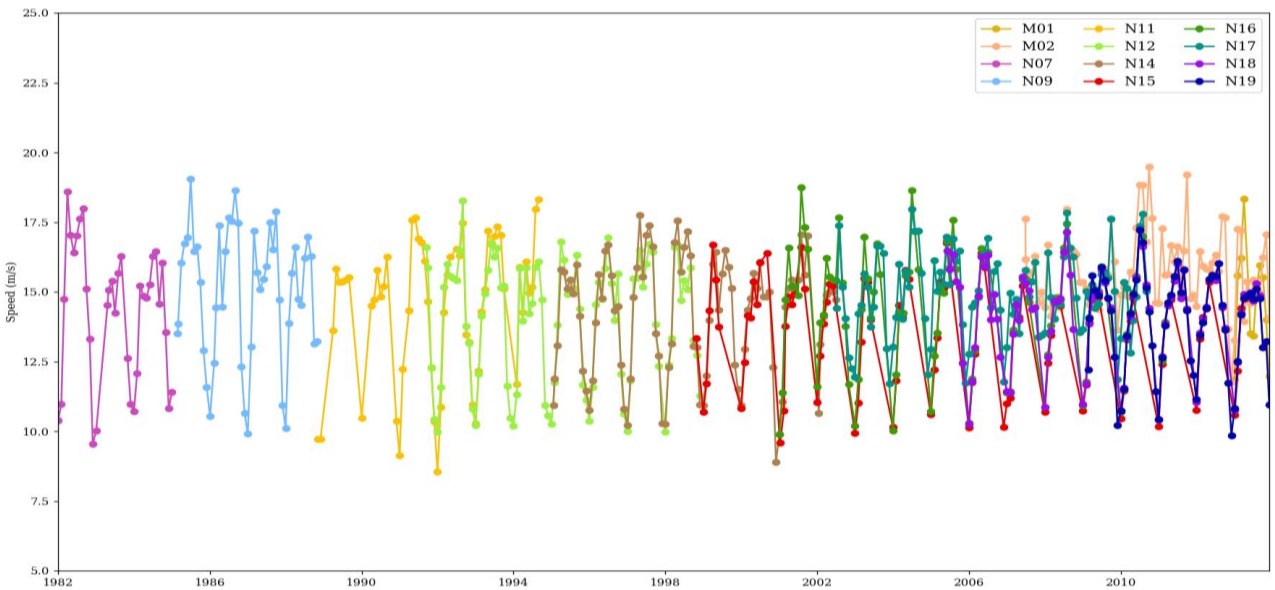


Meteosat Coverage
Red: SEVIRI@0°
Green: SEVIRI@41.5°E
Blue:MVIRI@57°E

Doutriaux-Boucher and Lattanzio, 2018

Polar Atmospheric Motion Vectors from AVHRR





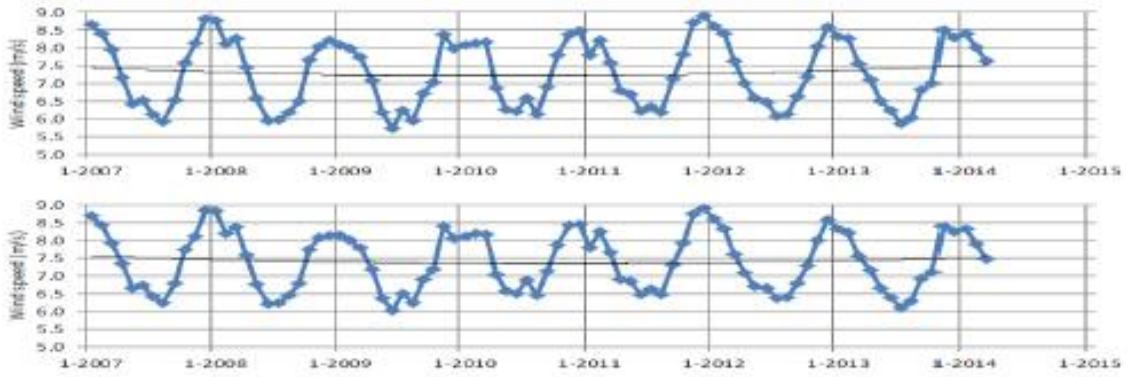
33 years (1982-2014) time series of the wind speed (m/s) of AMVs over the Arctic (left) and Antartica (right). Note that only AMVs with a quality index higher than 50 and a speed higher than 2 m/s are considered.

Doutriaux-Boucher et al., 2018

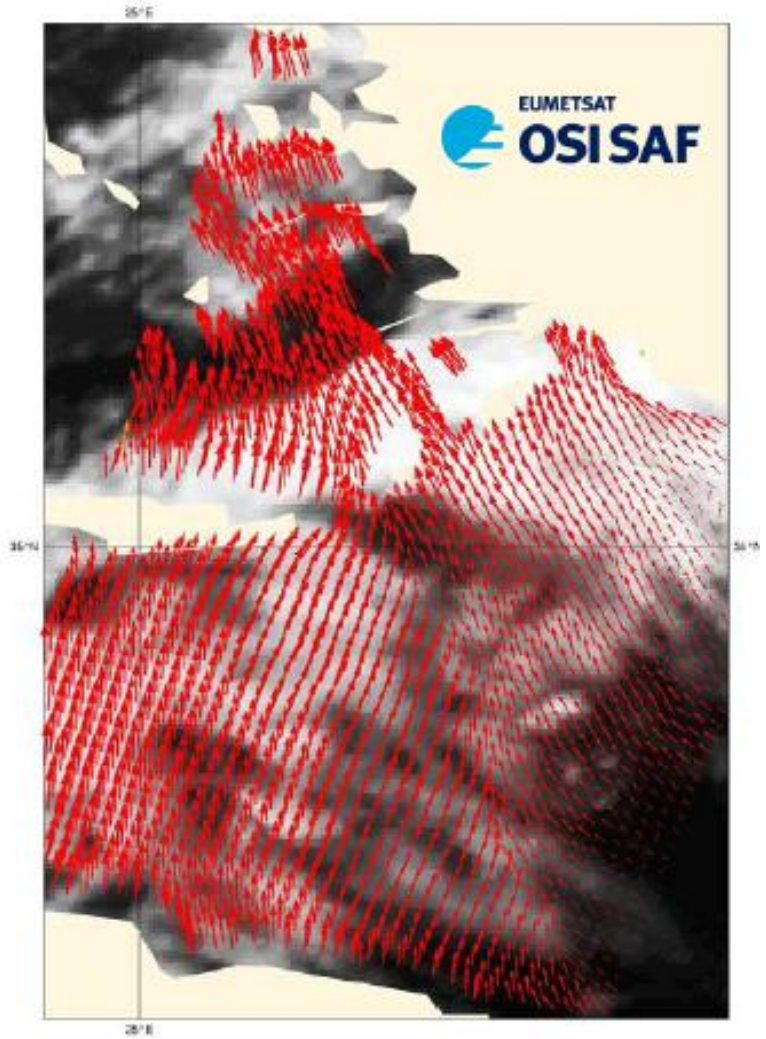
ASCAT Scatterometer Ocean Surface Winds

ASCAT Winds Data Record released in October 2016

- January 2007-March 2014
- Using reprocessed L1b data record, uniform calibration settings
- Single processing software
- 25km and 12.5km resolution swath grids
- ERS/1-2 based data record releasein preparation

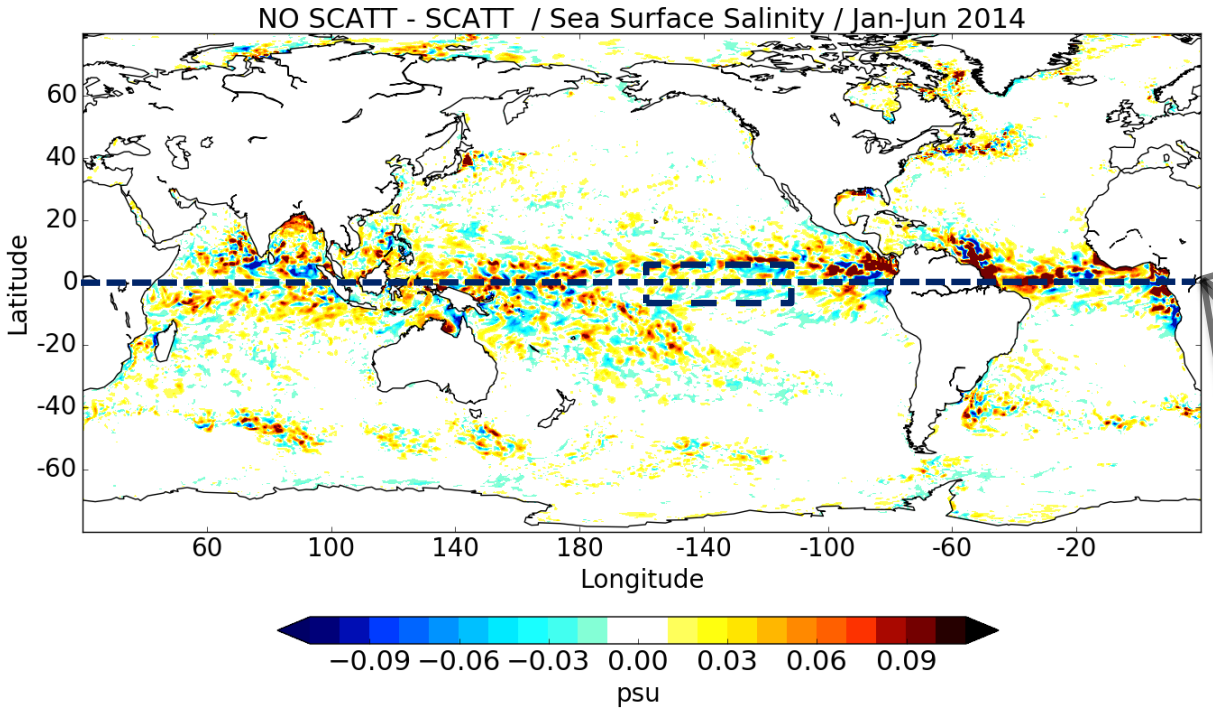


Average ASCAT wind speed (top) and collocated buoy wind speed (bottom) of 25km ASCAT winds. The plotted values are monthly averages.

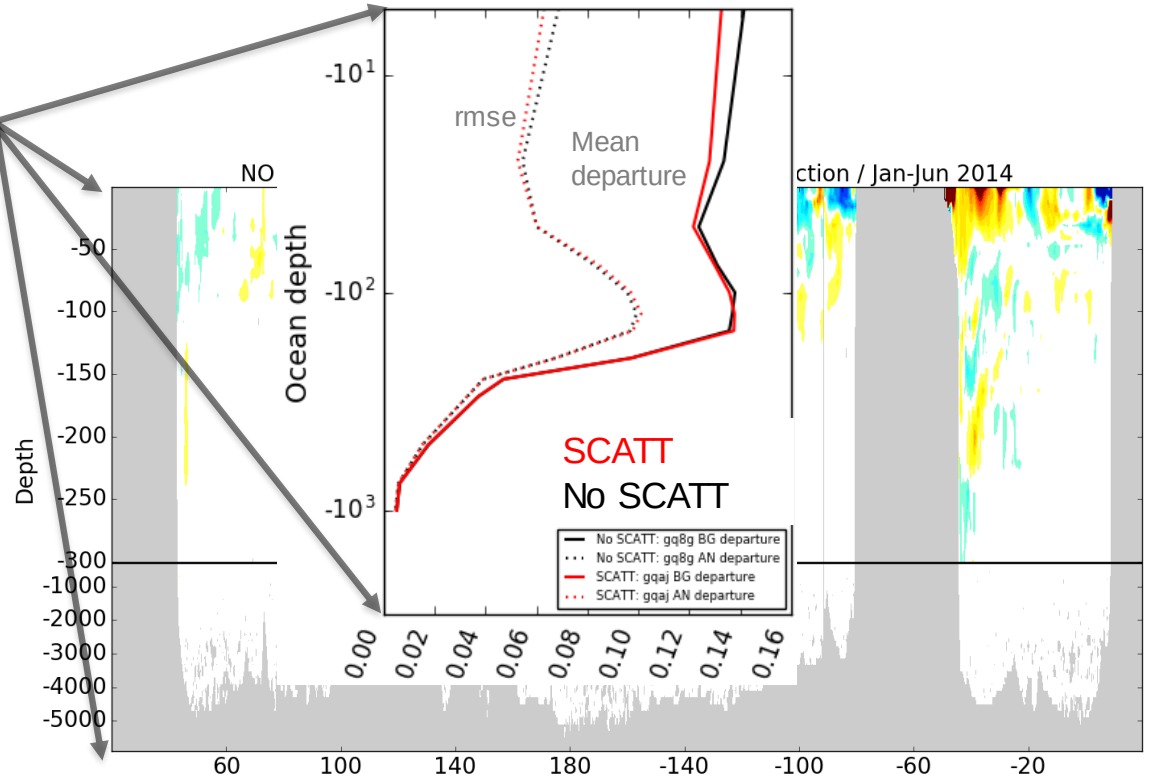


Coupled Assimilation - Atmospheric winds impact salinity

Impact of ASCAT derived winds on ocean salinity



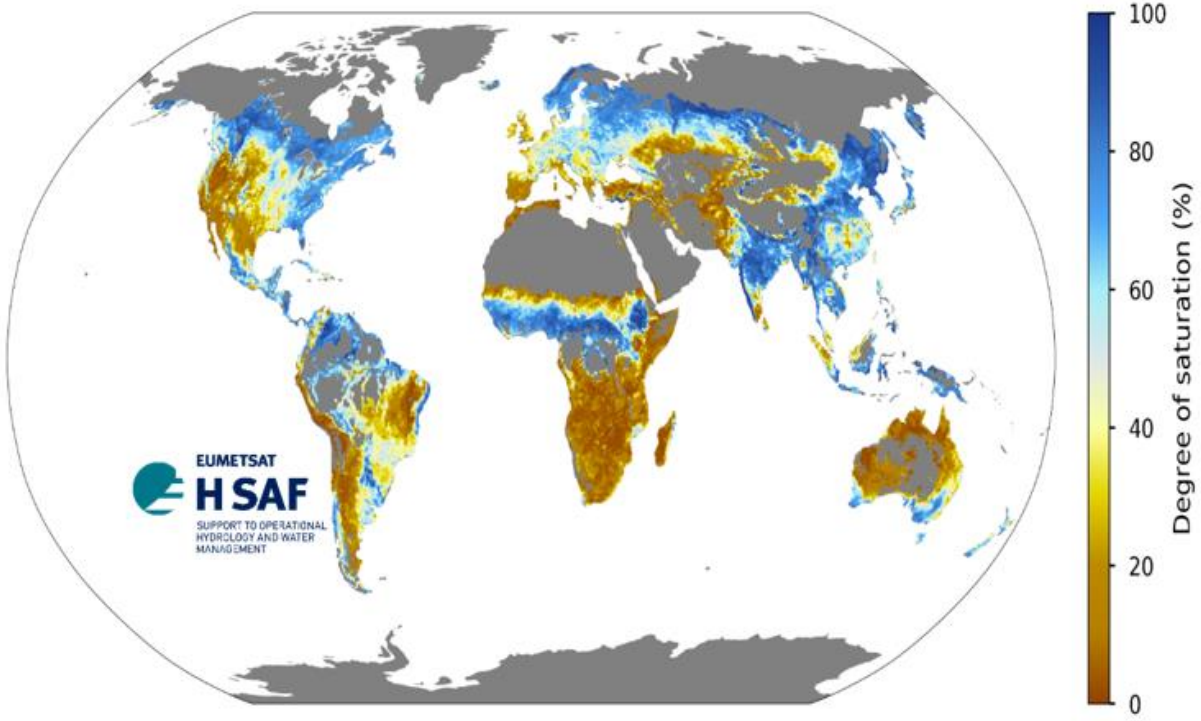
Improved fit to in-situ observations

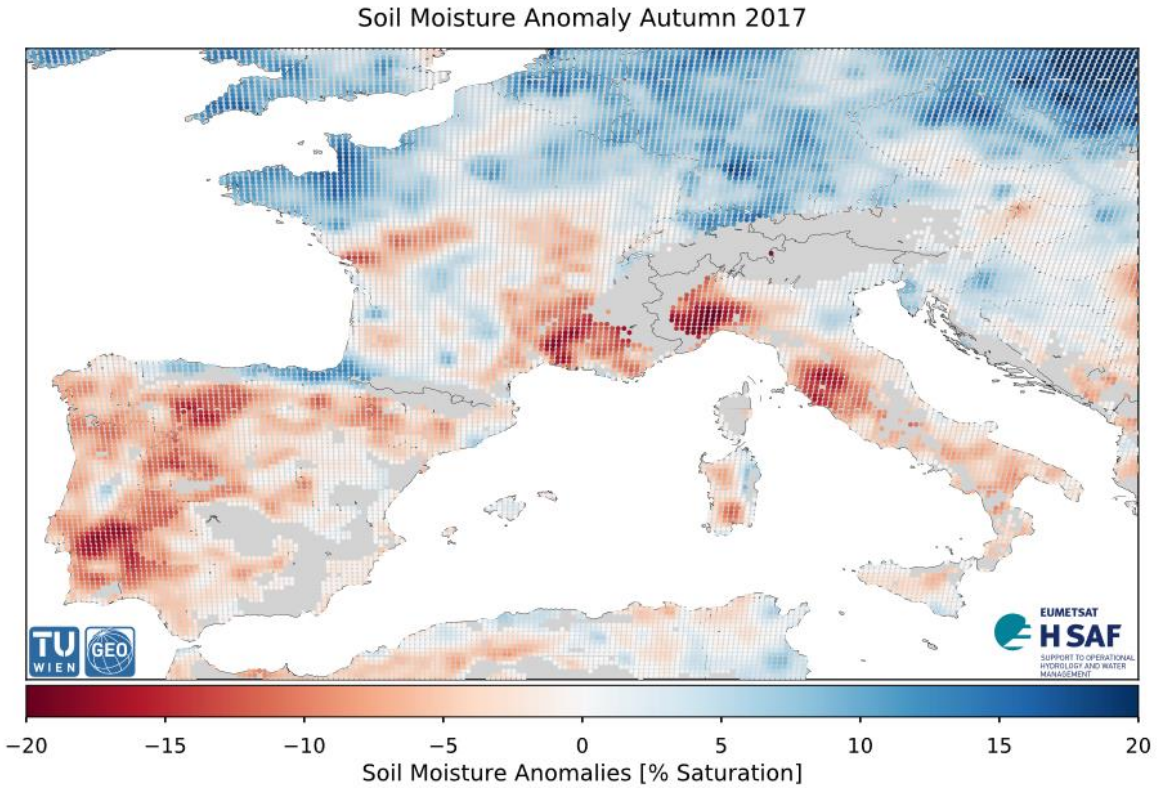


Courtesy of ECMWF

EUMETSAT

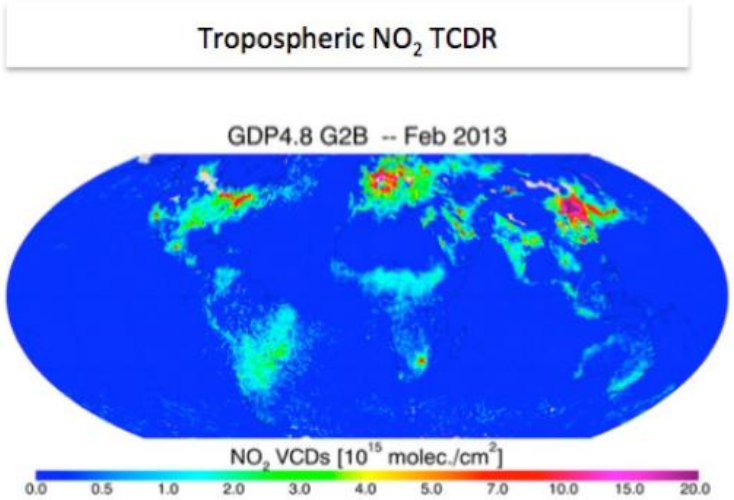
Analyse global and regional climate





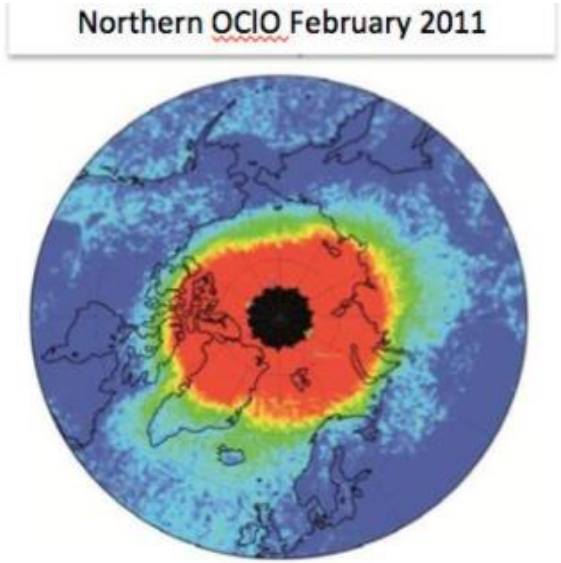
Monthly mean of ASCAT soil moisture relative to saturation in July 2013

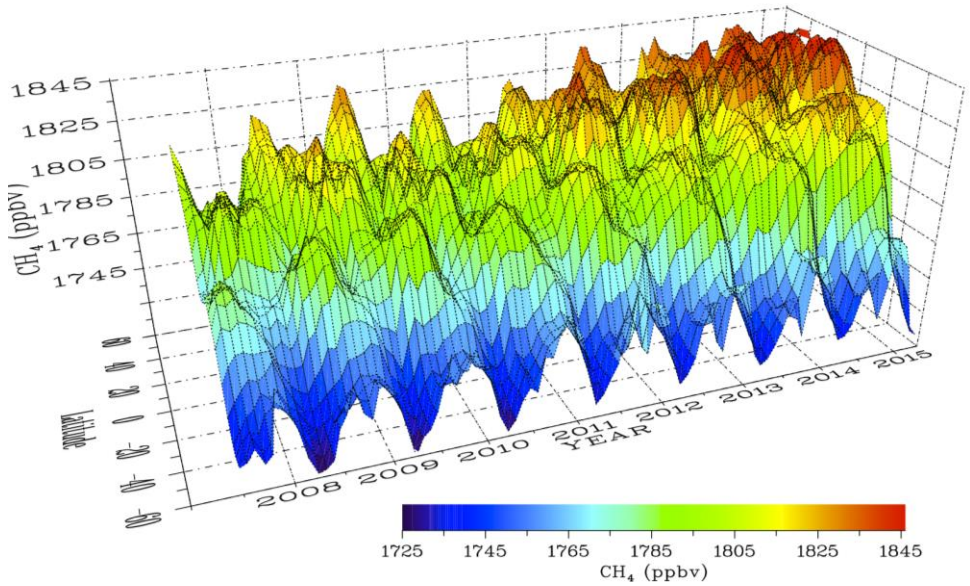
Towards Atmospheric Composition Records GOME-2 and IASI



Tropospheric NO2 2007-2017

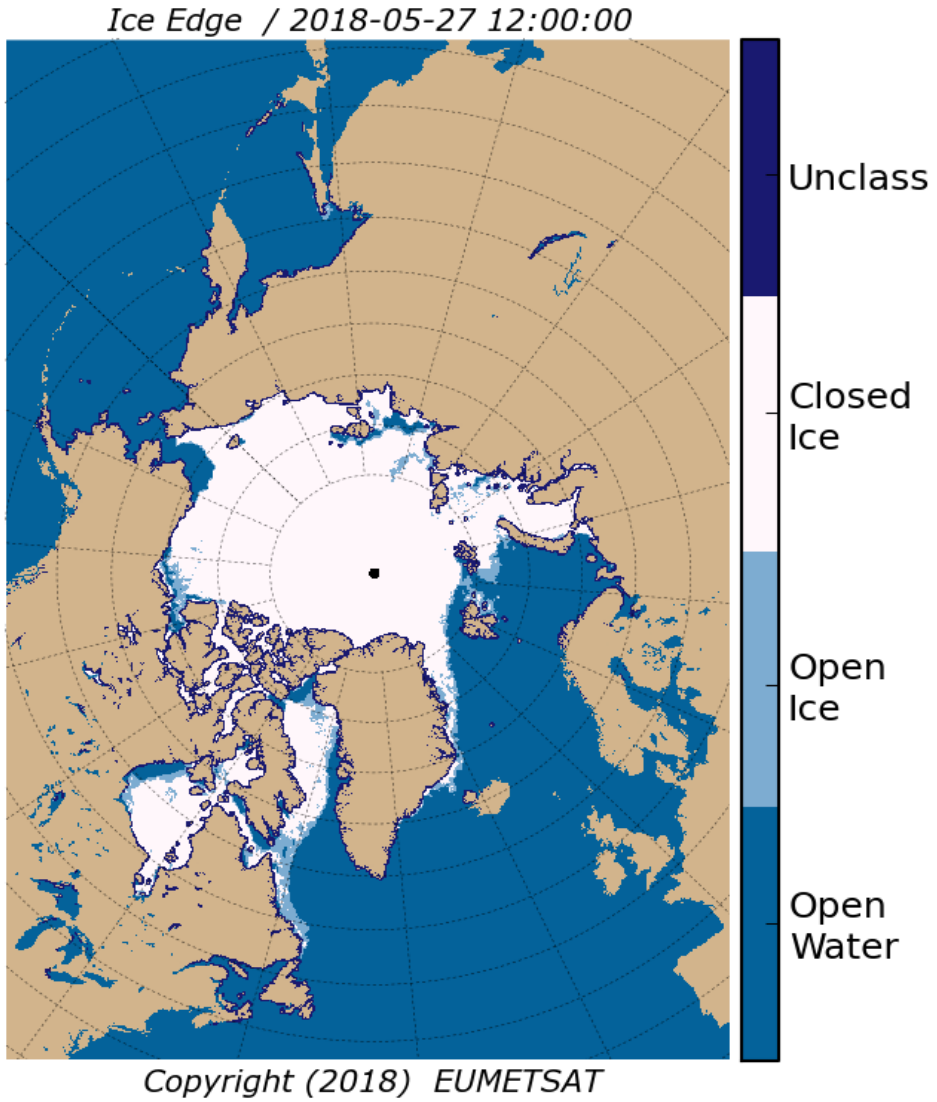
OClO 2007-2016

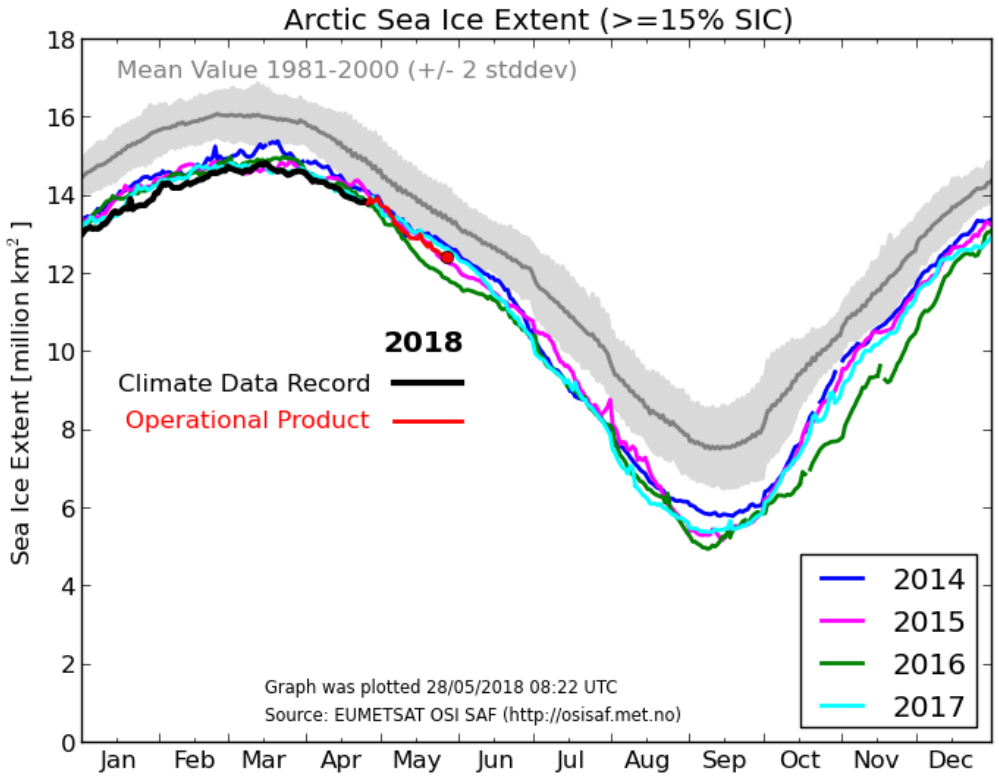




CH4 2007-2016

Interim Climate Data Record: Climate in "real time"



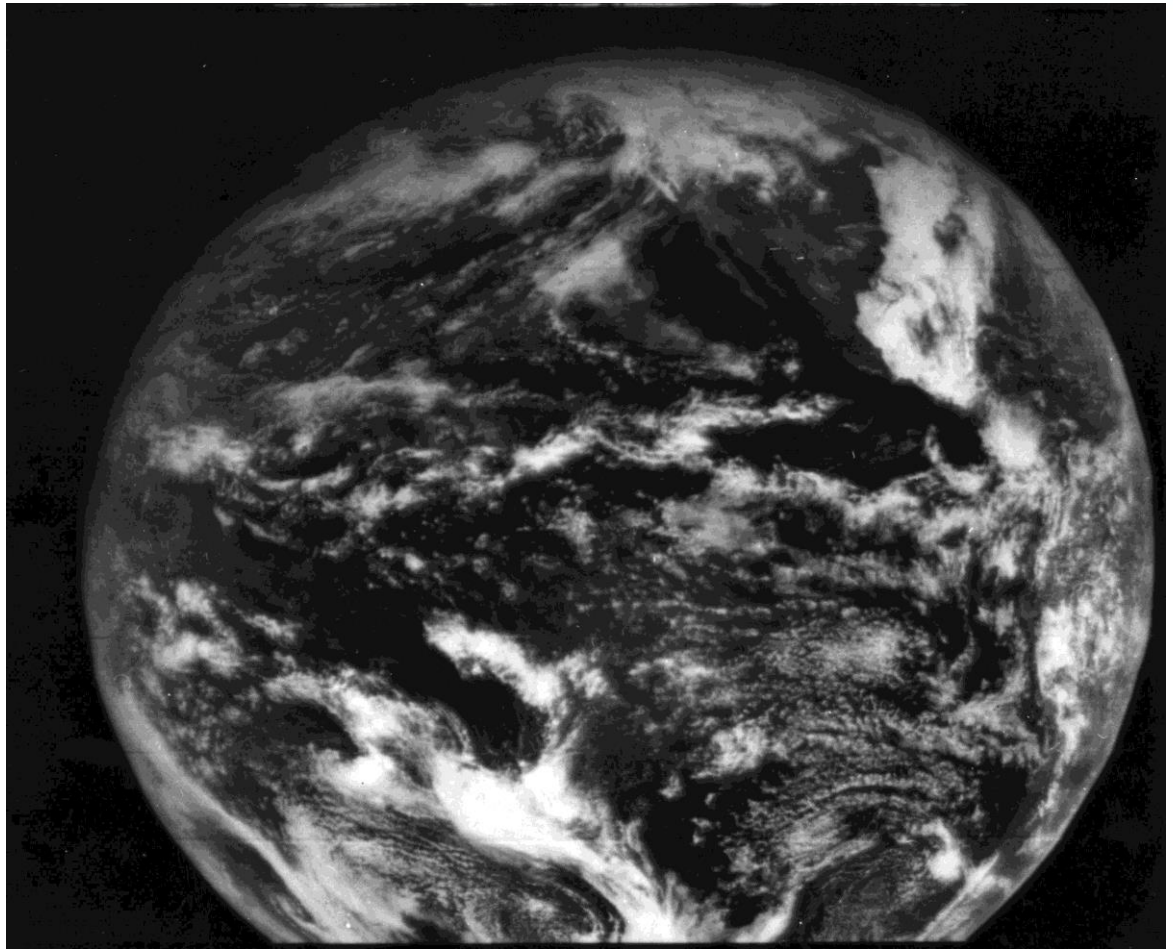


Daily updated Northern Hemisphere Sea Ice Extent compared to long term data record

Summary

- Satellites are essential for climate monitoring and science-based climate information services: 37 ECVs accessible;
- 40+ years of observations is a unique asset, data from operational satellite missions provide a big share of this;
- EUMETSAT is committed to continuity and improvement of observations for 20+ years, directly and through Copernicus;
- Data rescue is essential for satellite data to enable longest possible time series;
- Production of climate data records is a demanding scientific task:
  - Existing measurements need analysis and re-calibration per instrument once effects are understood;
  - Measurement series from same types of instruments can be harmonised leaving only expected differences, e.g., from SRF in the time series;
  - Analysis of measurements and harmonisation needs to establish uncertainty estimates which are crucial for use in data assimilation and retrieval.
- EUMETSAT supports forecasting of high impact weather attributable to climate change.

Where is the limit?



ATS-1 visible image (11 December 1966)

Visible channel of ATS-1 18 November 1967