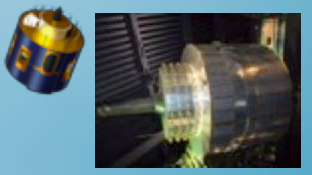
EUMETSAT Agency Presentation

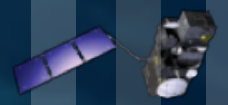
Jörg Schulz
+ Contributions of many
inside and outside of EUMETSAT

EUMETSAT Contribution to Climate Science and Services

- 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

Long-term Commitment: Multi-Satellite Programmes





YEAR... 1977 ... 2016 YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

METEOSAT FIRST GENERATION

METEOSAT SECOND GENERATION

METEOSAT-8

METEOSAT-9

METEOSAT-10

METEOSAT-11

METEOSAT THIRD GENERATION

MTG-I-1 : IMAGERY

MTG-S-1: SOUNDING

MTG-I-2: IMAGERY

MTG-I-3: IMAGERY

MTG-S-2: SOUNDING

MTG-I-4: IMAGERY

EUMETSAT POLAR SYSTEM (EPS)

METOP-A

METOP-B

METOP-C

EUMETSAT POLAR SYSTEM SECOND GENERATION (EPS-SG)

METOP-SG A: SOUNDING AND IMAGERY

METOP-SG B: MICROWAVE IMAGERY

JASON (HIGH PRECISION OCEAN ALTIMETRY)

JASON-2

JASON-3

SENTINEL-6 (JASON-CS)

COPERNICUS

SENTINEL-3 A/B/C/D

SENTINEL-4 ON MTG-S

SENTINEL-5 ON METOP-SG A

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

Mandatory Programmes

Optional Programmes

Third Party Programmes

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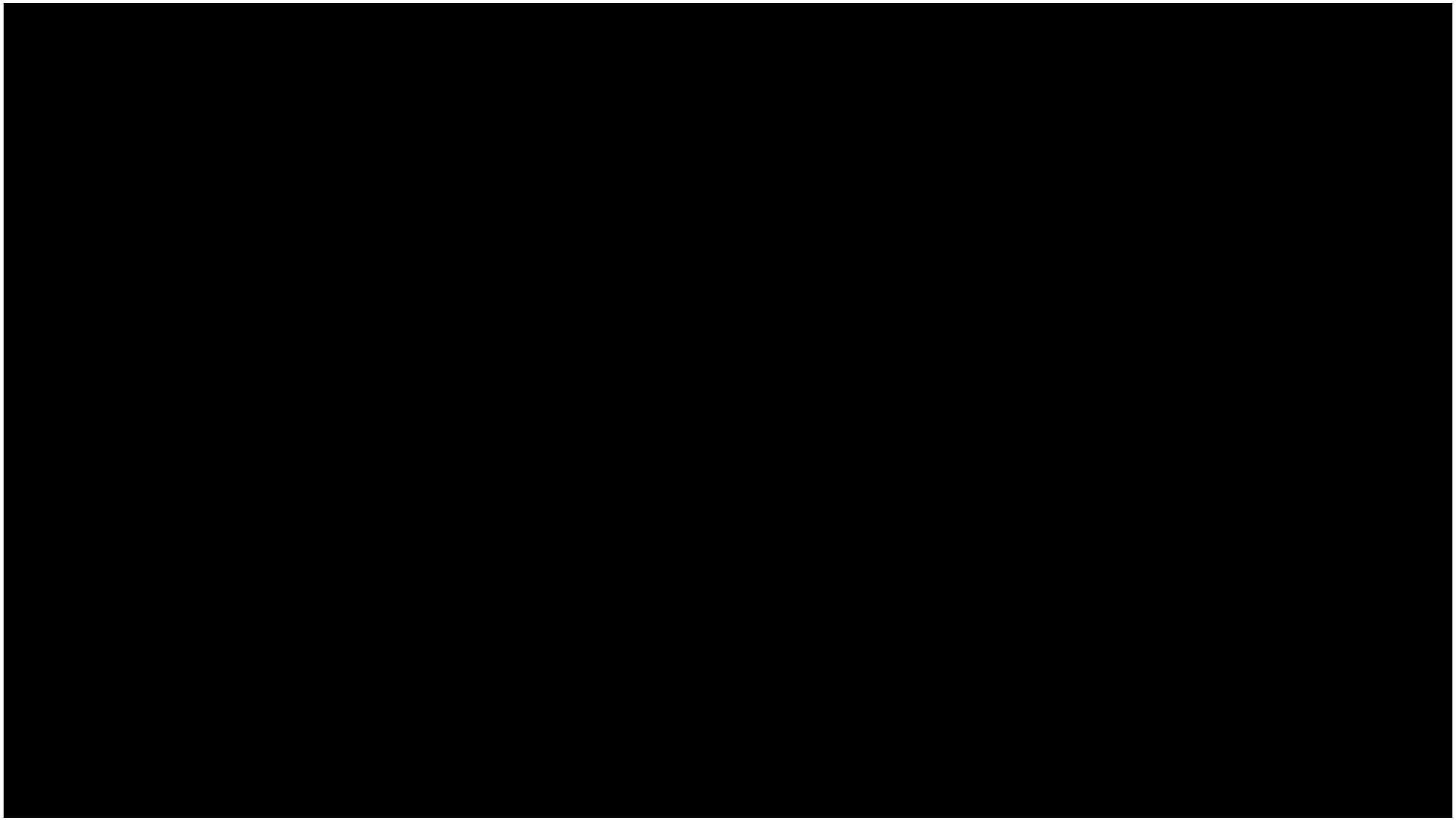
Metop-C Lift-off (7 Nov 2018)

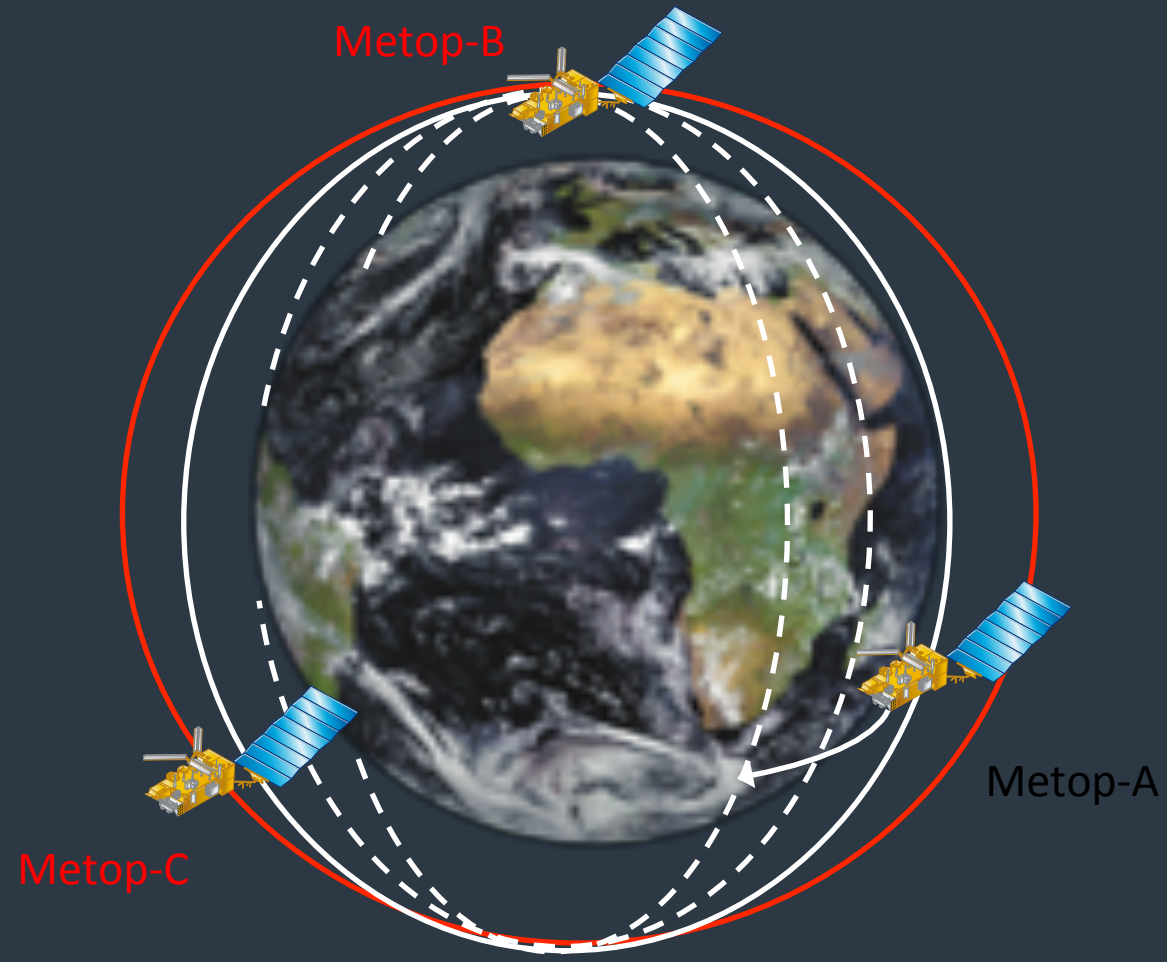


We have three Metop satellites in orbit ~ 2018 – 2021 expected

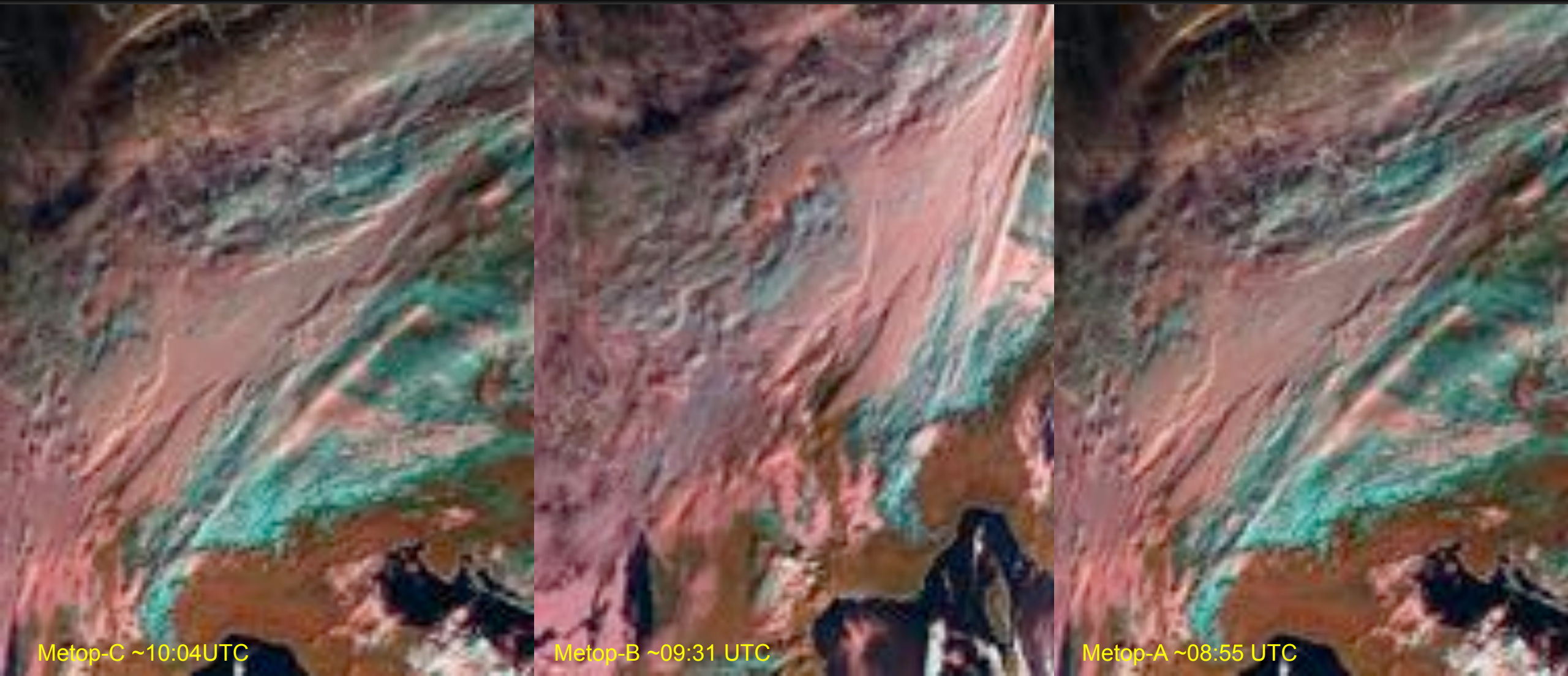
- Metop-A in drifting orbit; last OOP manouevre in Aug. 2016
- EOL ~end 2021(22)

- Metop-B prime sat. LTDN 9:30 LST

- Metop-C launch
  7 November 2018
  LTDN 09:30 LST



What three Metop satellites see
AVHRR sees Europe 11 January 2019



MTG-I Imaging lission

- Imagery mission implemented by two MTG-I satellites
- Full disc imagery every 10 minutes in 16 bands (FCI)
- Fast imagery of Europe every 2.5 minutes (FCI)
- New Lightning Imager (LI)
- Operational exploitation: 2022-2042

Meteosat: Spectral, Spatial and Temporal Sampling

	Meteosat 1st Generation			Meteosat 2nd Generation			Meteosat 3rd Generation		
'Core' channels	Central wavelength (μm)	Width (FWHM) (μm)	Spatial Sampling (km)	Central wavelength (μm)	Width (FWHM) (μm)	Spatial Sampling (km)	Central wavelength (μm)	Width (FWHM) (μm)	Spatial Sampling (km)
FC-VIS 0.4							0.444	0.06	1.0
FC-VIS 0.5							0.510	0.05	1.0
FC-VIS 0.6	0.7	0.35	2.5	0.635	0.08	3.0	0.645	0.08	0.5
FC-VIS 0.8				0.81	0.07	3.0	0.86	0.07	1.0
FC-NIR 0.9							0.96	0.06	1.0
FC-NIR 1.3							1.375	0.03	1.0
FC-NIR 1.6				1.64	0.14	3.0	1.61	0.06	1.0
FC-NIR 2.2							2.26	0.05	0.5
FC-IR 3.8 *				3.9	0.44	3.0	3.8	0.40	1.0
FC-IR 6.2	6.1	1.3	5.0	6.2	1.0	3.0	6.2	1.00	2.0
FC-IR 7.3				7.35	0.5	3.0	7.35	0.50	2.0
FC-IR 8.7 *				8.7	0.4	3.0	8.7	0.40	2.0
FC-IR 9.7				9.66	0.3	3.0	9.66	0.30	2.0
FC-IR 10.8	11.5	1.9	5.0	10.8	1.0	3.0	10.5	0.7	1.0
FC-IR 12.0				12.0	1.0	3.0	12.3	0.5	2.0
FC-IR 13.3				13.4	1.0	3.0	13.3	0.60	2.0
Repeat Cycle :	30 min			15 min			10 min		

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MTG-S Sounding Mission

- Hyperspectral infrared sounding mission (IRS)
- 3D weather cube: temperature, water vapour, O3, every 30 minutes over Europe
- Air quality monitoring and atmospheric chemistry in synergy with Copernicus Sentinel-4 instrument (UVN)
- Operational exploitation: 2023-2042

EPS-SG A Sounding and Imagery Mission

1. **IASI-NG**
   Infrared Atmospheric Sounding
2. **MWS**
   Microwave Sounding
3. **METImage**
   Visible-Infrared Imaging
4. **RO**
   Radio Occultation
5. **3MI**
   Multi-viewing, -channel, -polarisation Imaging
6. **Copernicus Sentinel-5**
   UN/VIS/NIR/SWIR Sounding

EPS-SG B Microwave Imagery Mission

1. **SCA**
   Scatterometer
2. **RO**
   Radio Occultation
3. **MWI**
   Microwave Imaging for Precipitation
4. **ICI**
   Ice Cloud Imager
5. **ARGOS-4**
   Advanced Data Collection System

EPS Second Generation – Instruments' Heritage

Metop-SG A Optical Imagery and Sounding	Instrument	Predecessor on Metop	Predecessor
Infrared Atmospheric Sounding (IASI)	IASI-NG	IASI	AIRS, HIRS
Microwave Sounding (MWS)	MWS	AMSU-A, MHS	MSU, AMSU-B, ATMS
Visible-infrared Imaging (VII)	METimage	AVHRR	AVHRR&VHRR
Radio Occultation (RO)	RO	GRAS	CHAMP, COSMIC, GRACE
UV/VIS/NIR/SWIR Sounding (UVNS)	Sentinel-5	GOME-2	GOME, Sentinel 5P
Multi-viewing, -channel, -polarisation Imaging (3MI)	3MI	-/-	POLDER

Metop-SG B Microwave Laboratory	Instrument	Predecessor on Metop	Predecessor
Scatterometer (SCA)	SCA	ASCAT	ERS-1 Scat
Radio Occultation (RO)	RO	GRAS	CHAMP, COSMIC
Microwave Imaging for Precipitation (MWI)	MWI	-/-	SSMIS, SSM/I, SMMR
Ice Cloud Imager (ICI)	ICI	-/-	GMI for 183Ghz
Advanced Data Collection System (ADCS)	Argos-4	Argos-3	DCS (Argos-2)

New mission 3MI imaging polarimeter on Metop SG A

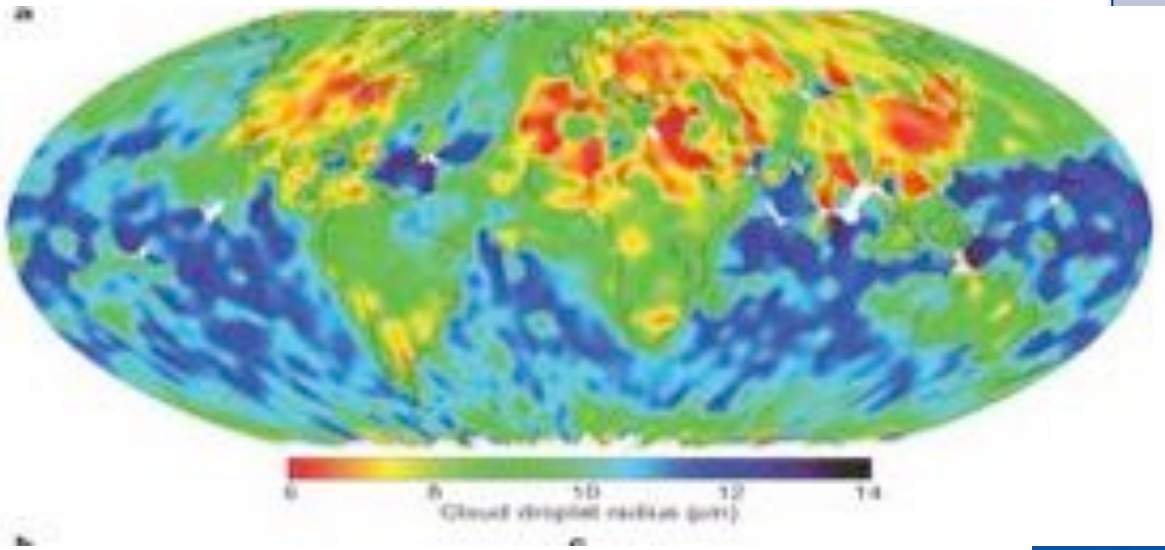
Mission objectives

- Aerosols
- Phase, altitude, properties of clouds
- Albedo, radiative budget (BRDF)

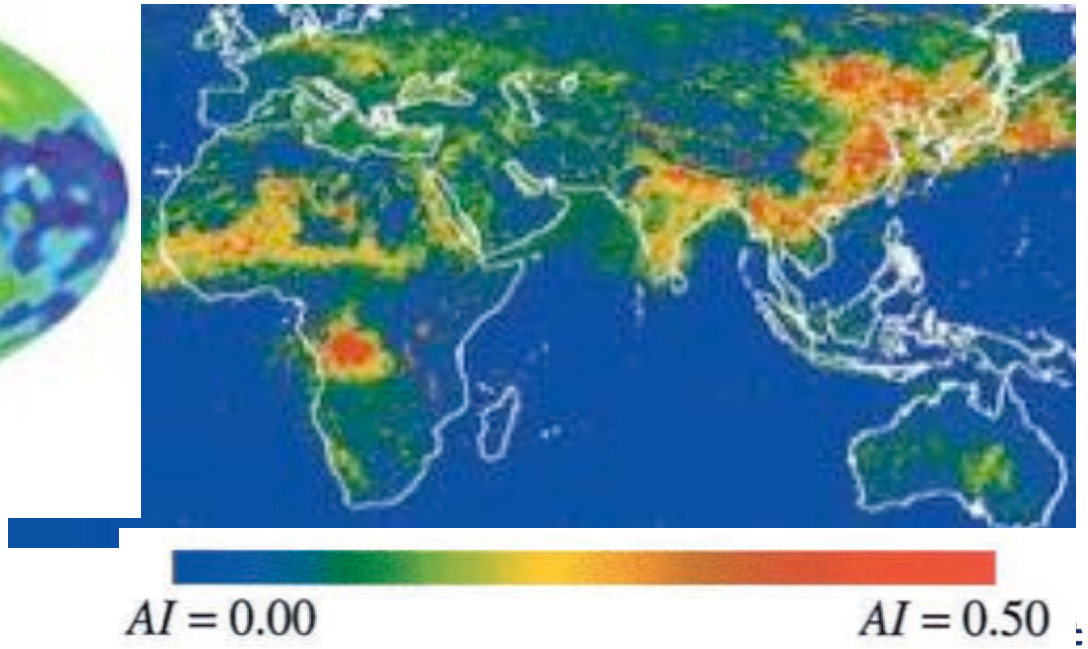
First operational polarimeter

Major improvements over POLDER

- **Horizontal Resolution: 4 km**
- **11 channels, extension to SWIR:**
  Better aerosol characterisation
- **Higher angular resolution (14 view angles)**



Kaufman et al. (2002)



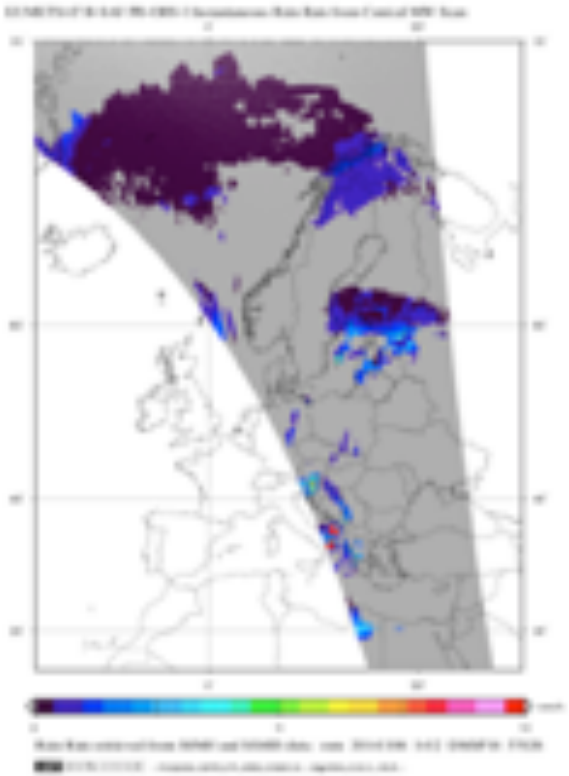
New mission: Micro-Wave Imager (MWI) on Metop-SG B

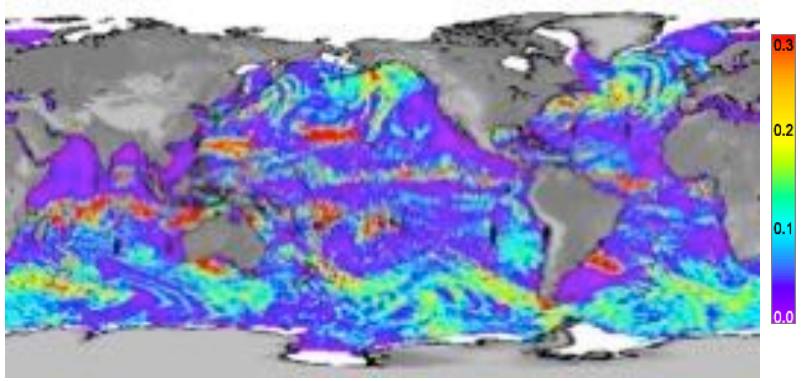
Mission objectives

- Precipitation and clouds
- Imagery and H2O profiles
- Sea ice, surface snow, wind

19 channels (18.7 - 183 GHz)

- **Enhancement wrt SSMI/S**
- **Addition of sounding channels**
  - Improve estimation of precipitation
  - Water vapour and clouds
- **European part of future GPM constellation**





mm

Cloud Liquid Column

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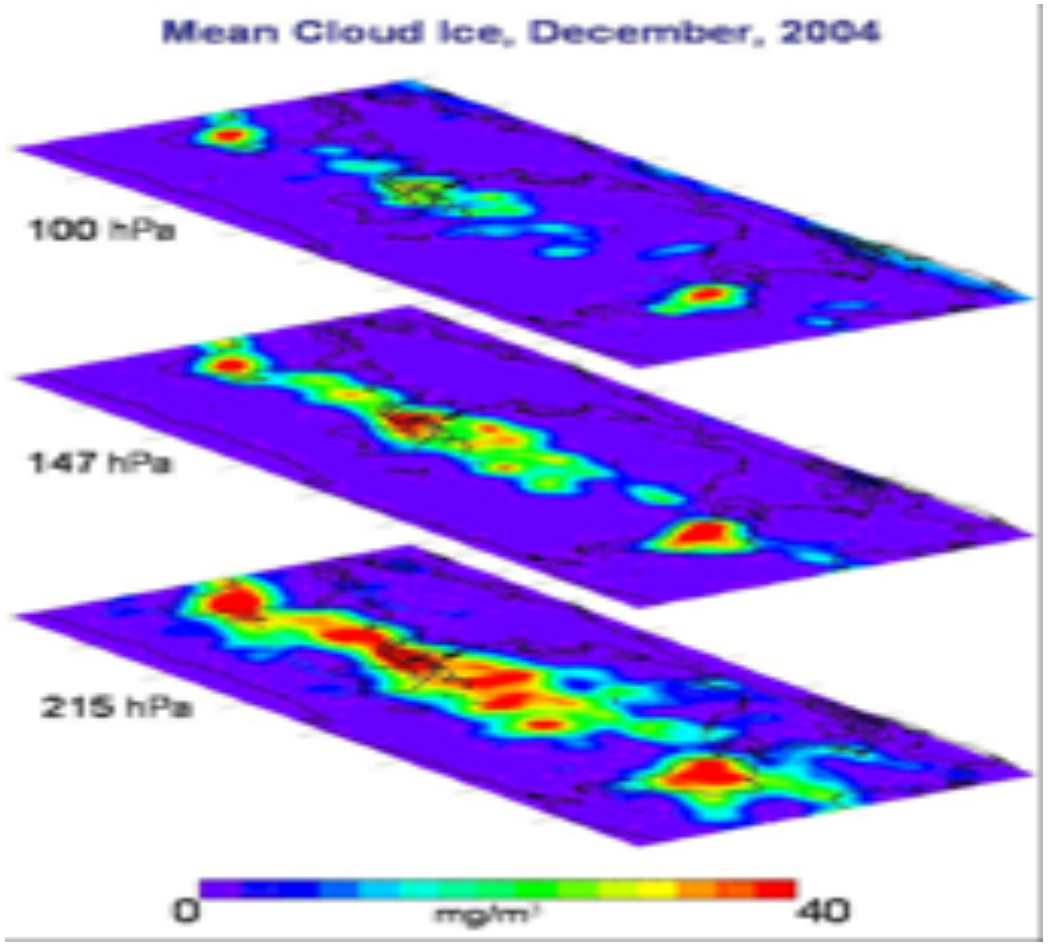
New mission: Ice-Cloud Imager (ICI) on Metop-SG B

Mission Objectives

- Cloud products, in particular ice clouds
- Snowfall detection and quantification
- Water-vapour profiles and imagery

11 channels (183 – 664 GHz)

- **First operational ice cloud imagery mission**
- **Meteorology and climate (Cirrus)**



NASA: Aura/MLS

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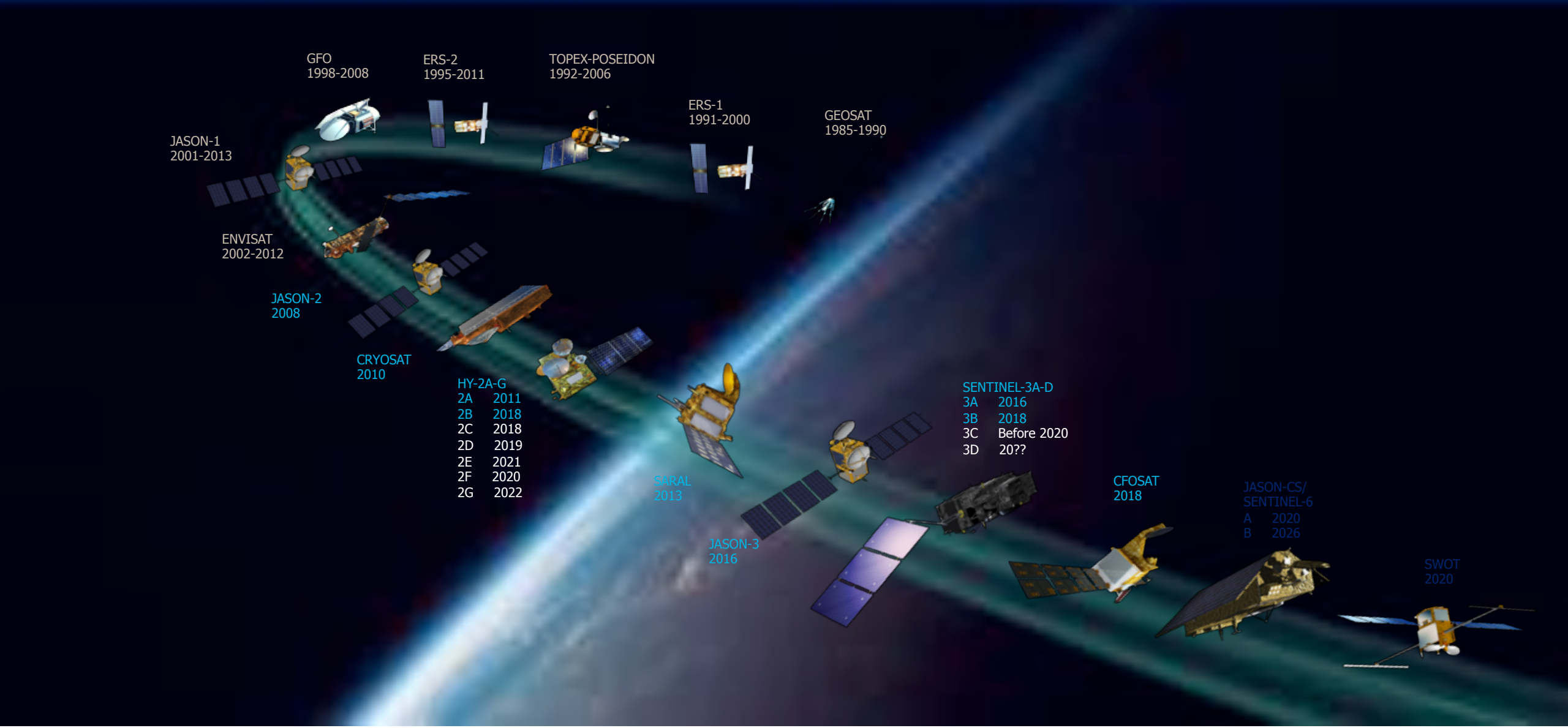
Altimetry missions – past, present, future



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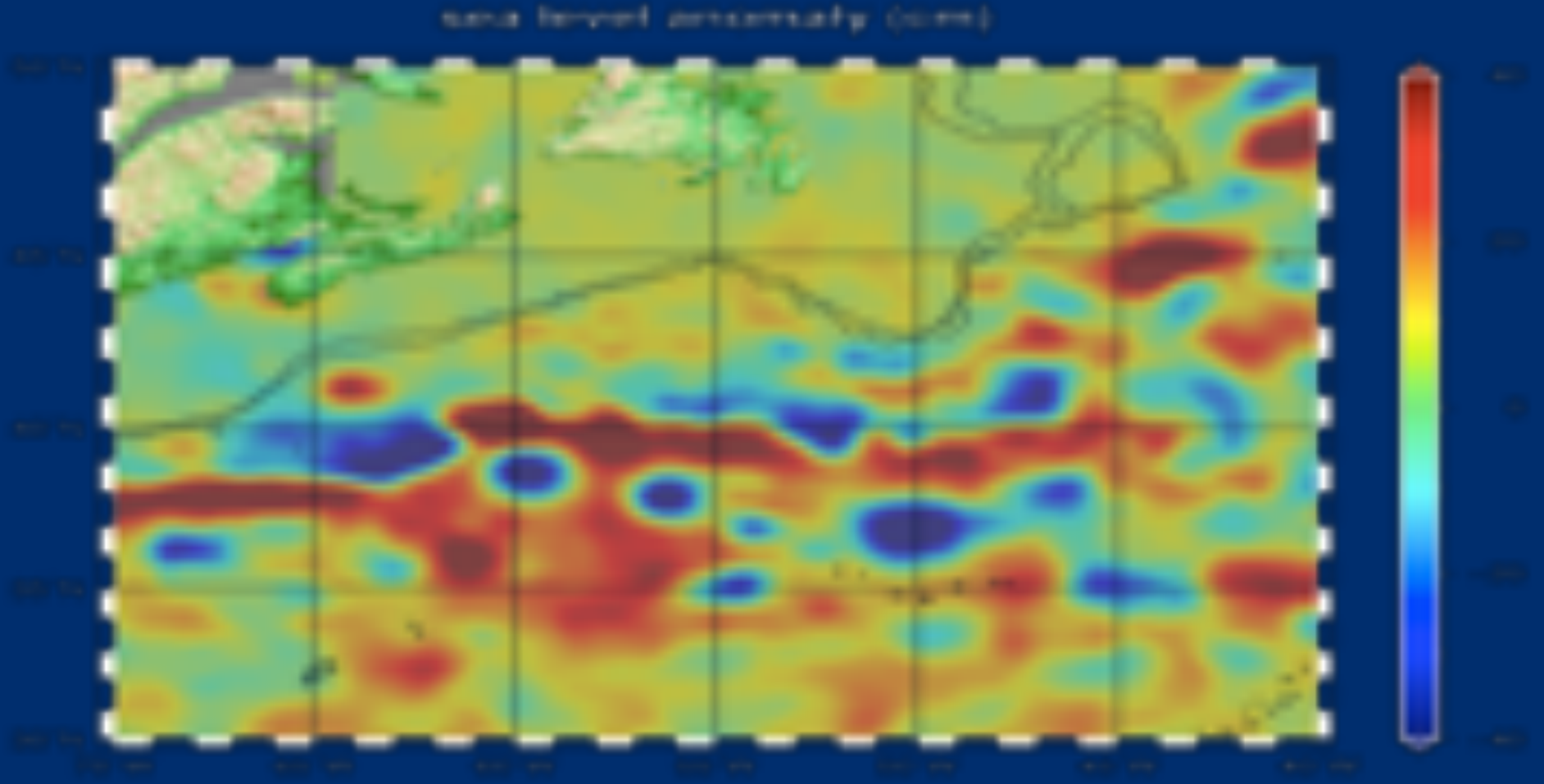
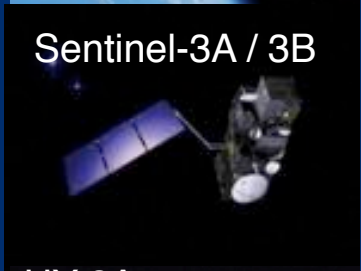
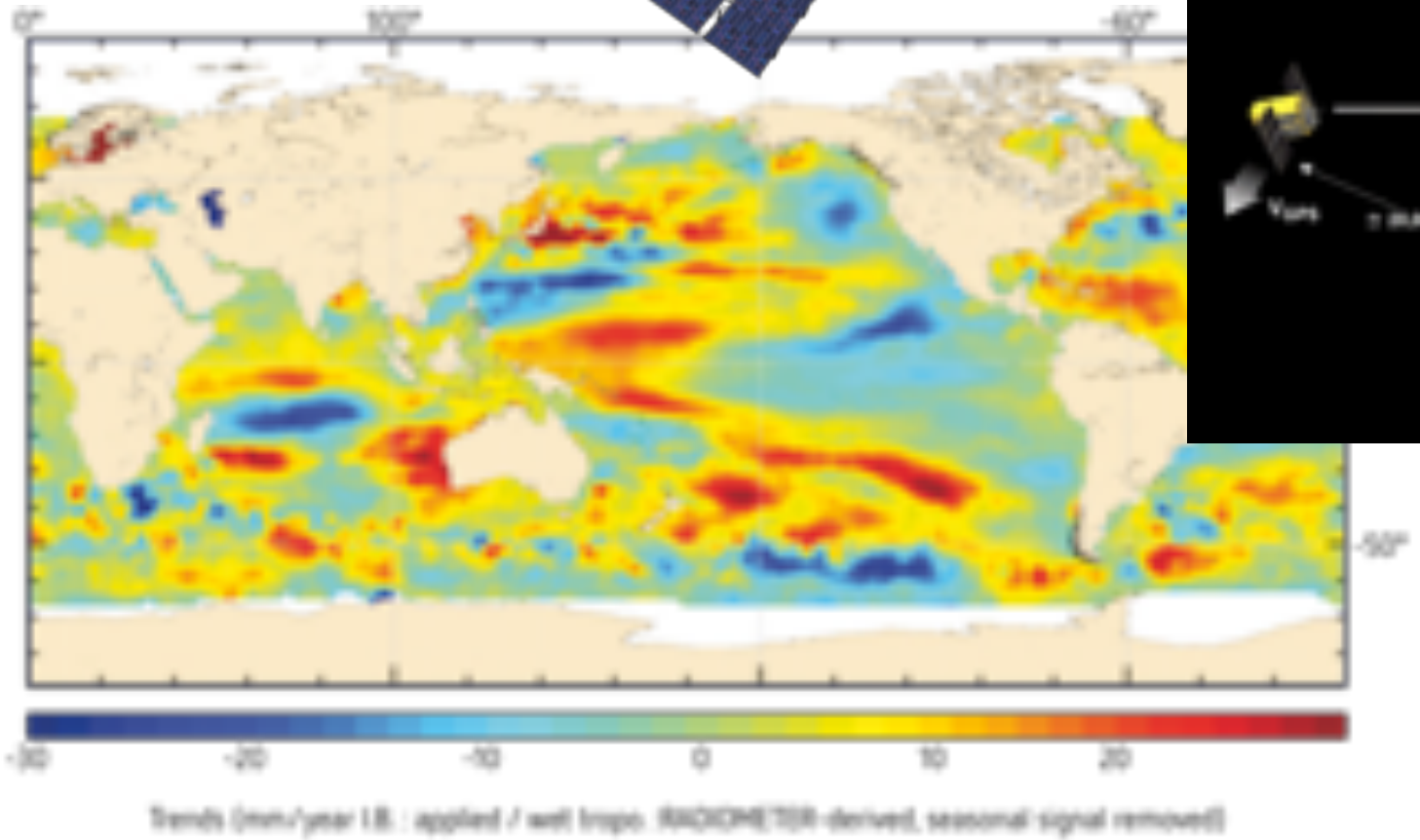
Sea Surface Topography: six missions are operational and interoperable by using the same QA tools

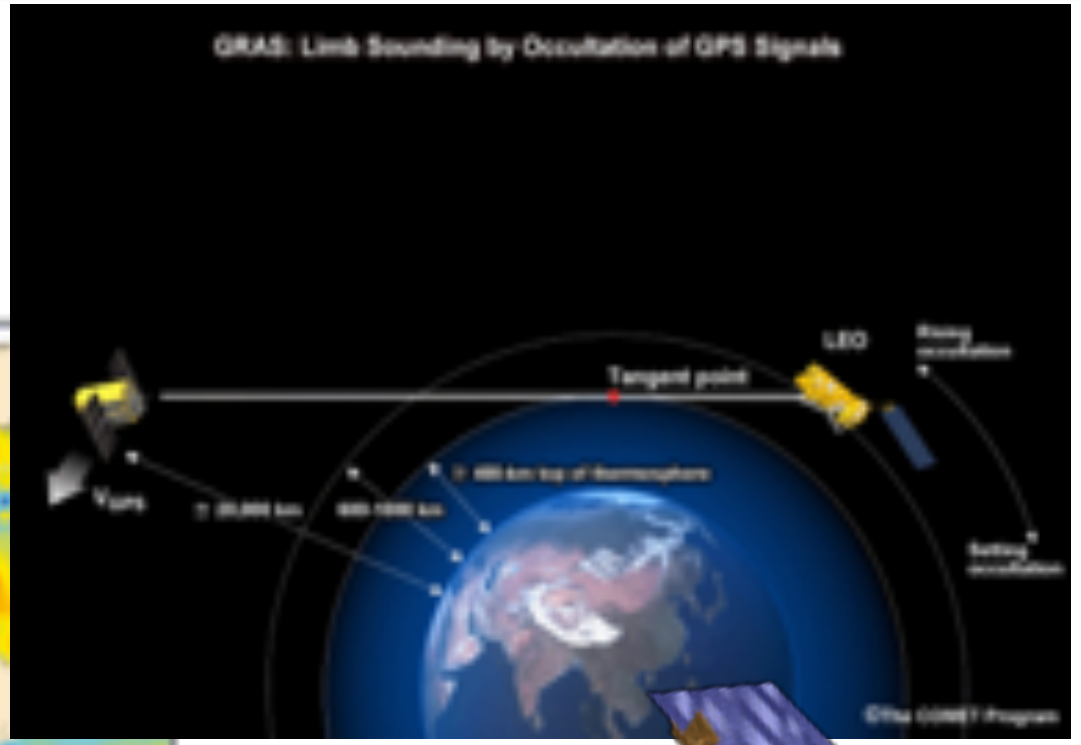


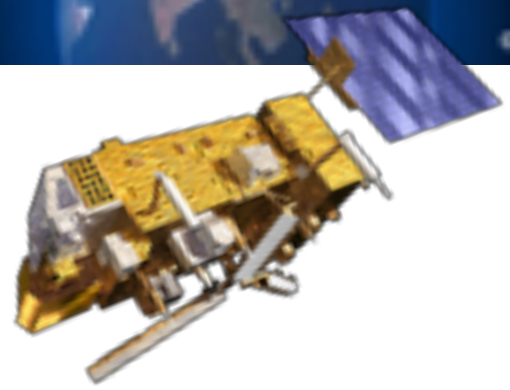
R. Scharroo, EUMETSAT



Some missions are optimised for climate monitoring …







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

WV channel, Meteosat 1

correspondence

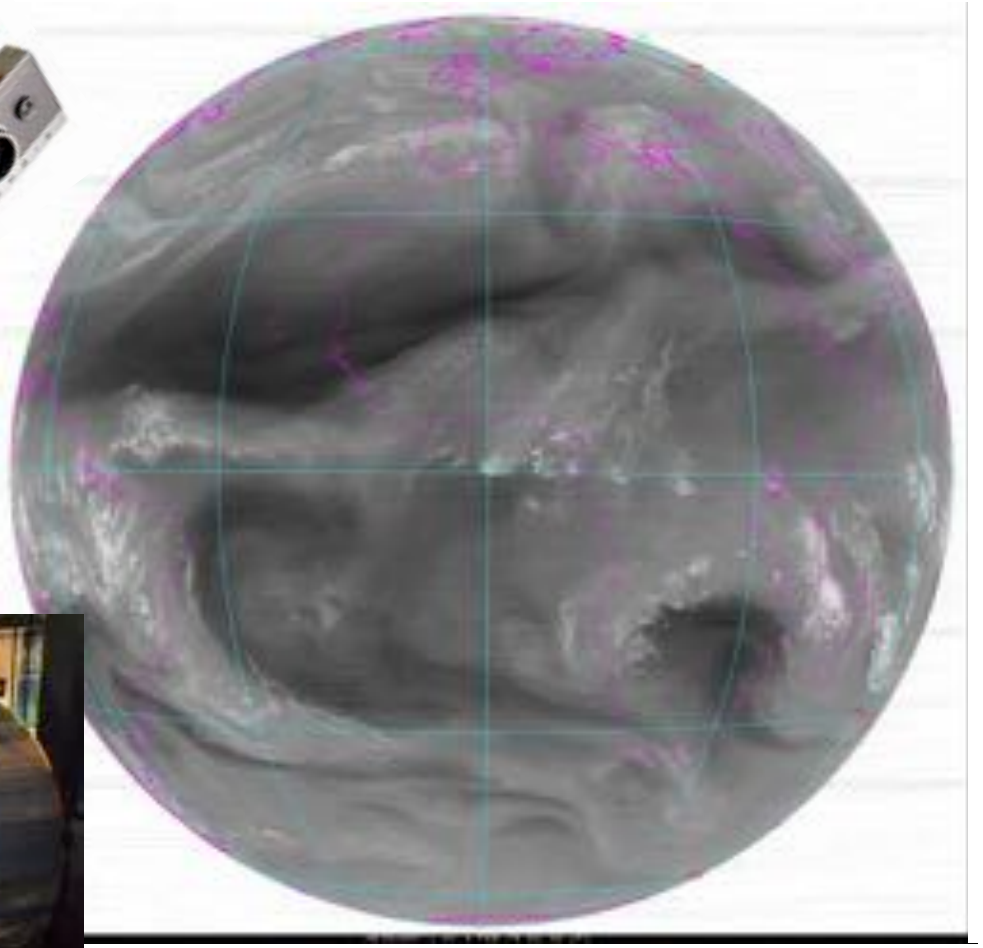
A New Insight into the Troposphere with the Water Vapor Channel of Meteosat

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

Abstract

Bulletin of the AMS, 1978

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



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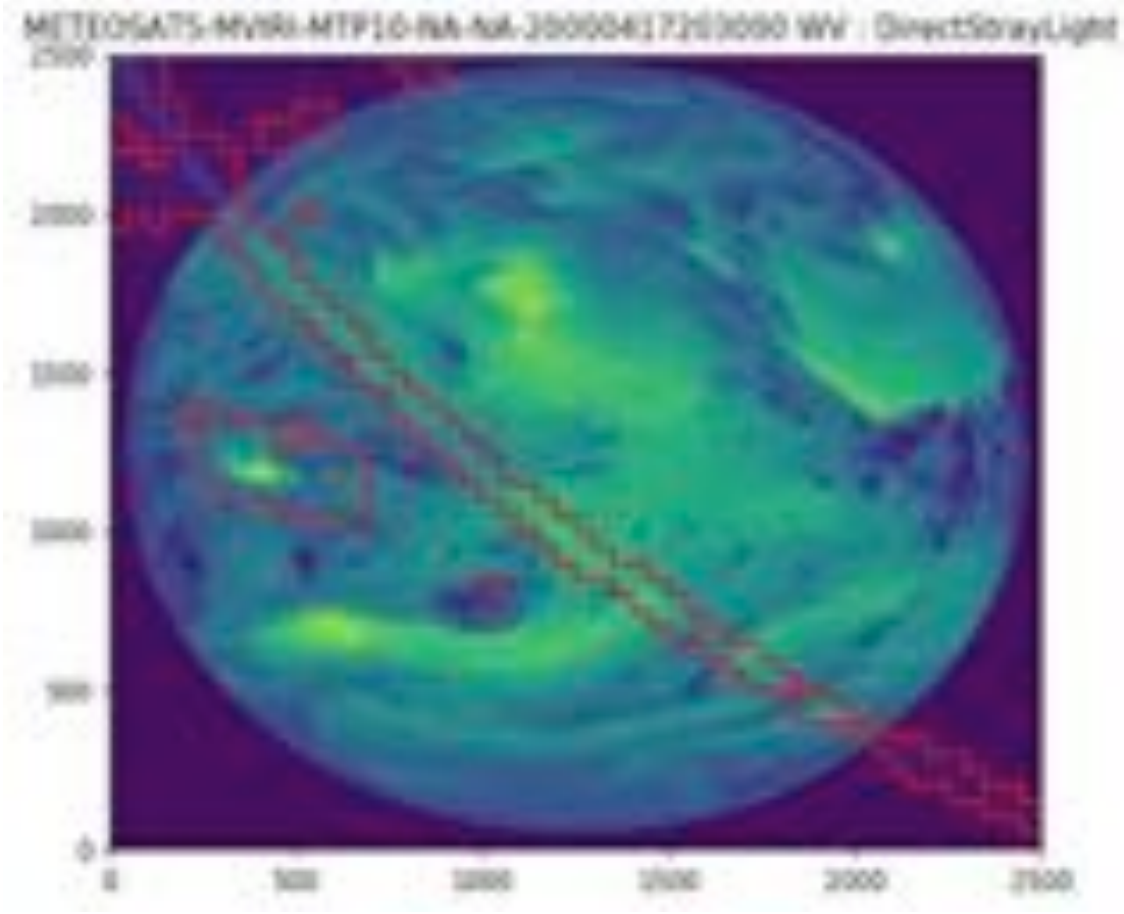
Data Rescue Meteosat First Generation

Enabling full image and product processing of Meteosat archive

- Image anomaly detection on raw data distinguishes 30 anomaly types and runs over 65 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.

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)

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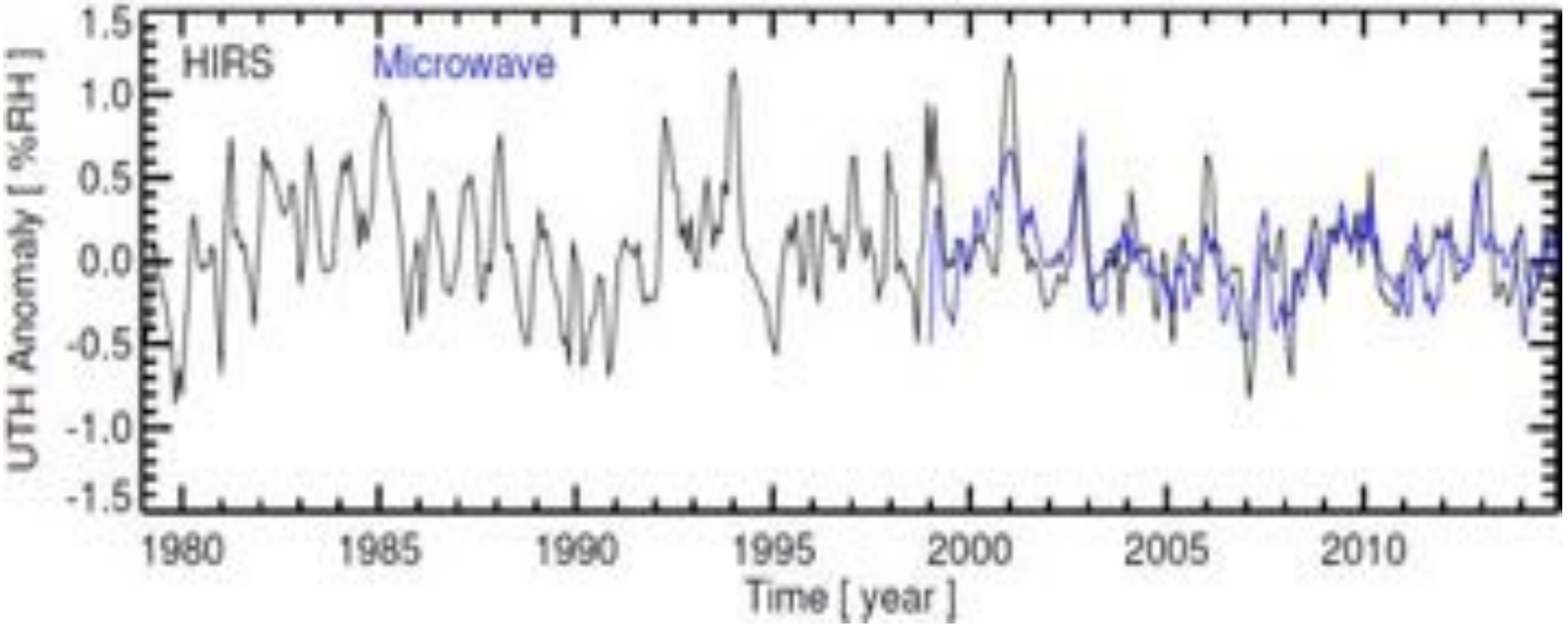
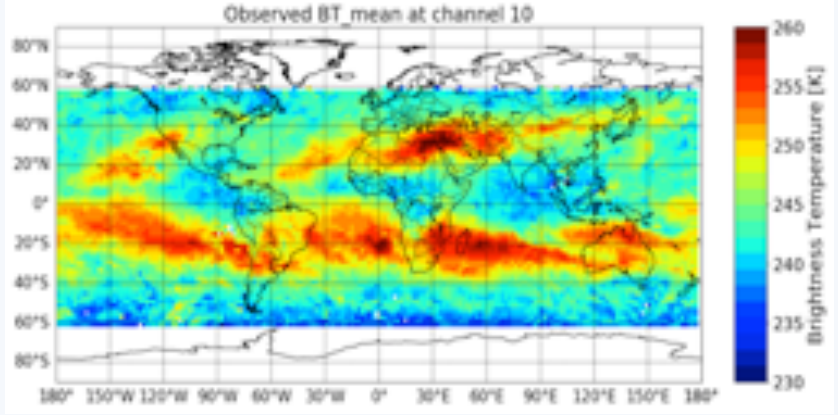
Upper tropospheric humidity with HIRS and MHS



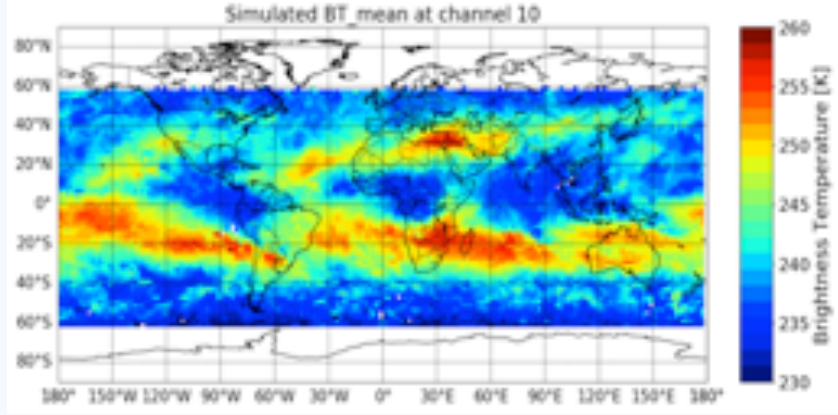
Time series of upper tropospheric humidity anomalies using HIRS (black) and microwave sounder (blue) datasets. Data during overlapping time periods are averaged for both datasets. The anomalies are computed with respect to the 2001–2010 average, and the time series are smoothed to remove variability on time scales shorter than three months. John et al., 2017

Climate Change

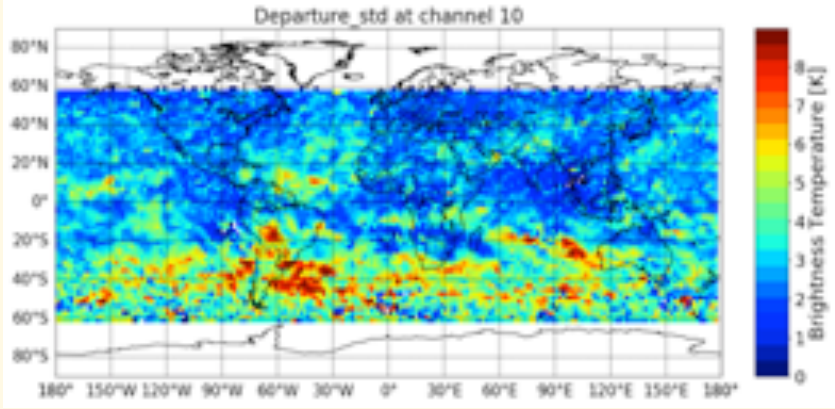
Analysis of NIMBUS-6 HIRS-1 Data



Nimbus-6 (Aug 1975)



ERA-5 (Aug 1975)



Standard Deviation
Nimbus-6 – ERA-5 departures

- HIRS-1 Data from NIMBUS-6 /noon orbit (August 1975 and February 1976);
- Reanalysis provides a tool to analyse historical data in absence of satellite and ground-based references;
- High standard deviations in SH may point to additional information from HIRS-1 if assimilated.

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ECMWF Copernicus Europe's eyes on Earth European Commission

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

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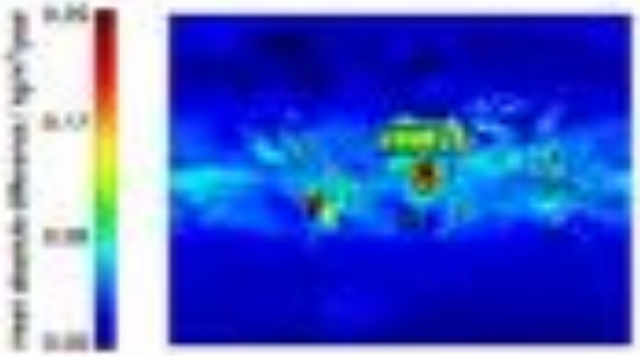
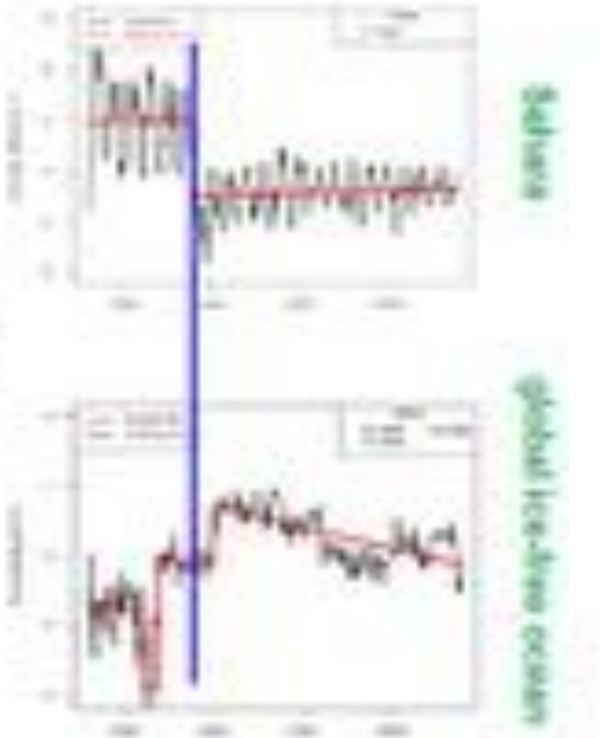
Support to GEWEX Water Vapour Assessment



Topc: mean absolute difference to trend estimates (based on 11 data records).

Right: anomaly differences at two regions, based on NVAP-M.

Homogeneity
(regional dependence, TCWV)



- (All) data records exhibit break points.
- The time, sign and the step size of break points are a function of data record and region.
- The break points temporally coincide with changes in the observing system (see Schröder et al., 2017, 2018).

Schröder et al. (2018, 2017) in JAMC and WCRP report

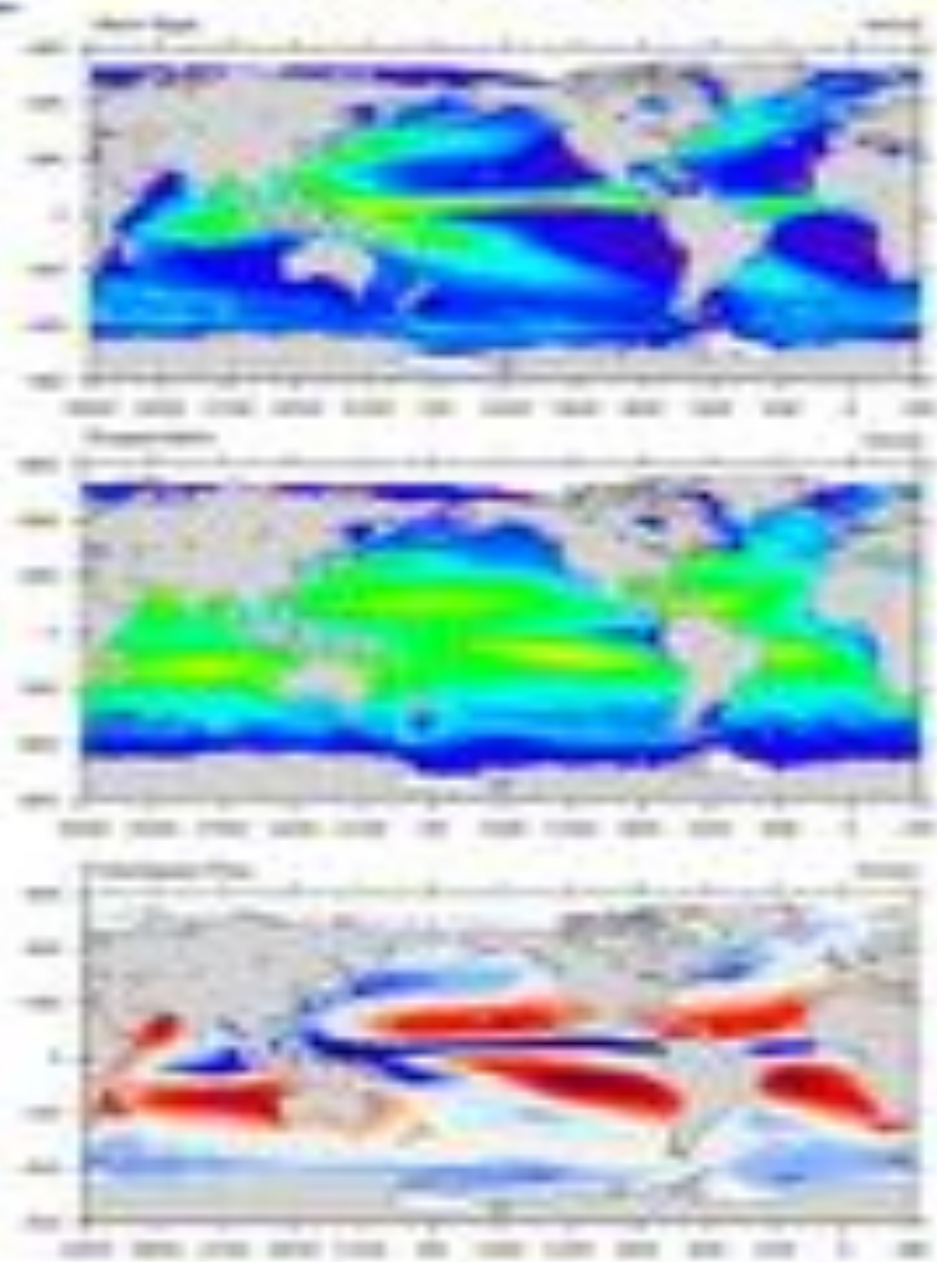
GEWEX

CM SAF · Deutscher Wetterdienst · esa · EUMETSAT · INFORMUS · Freie Universität Berlin · University of Leicester

Schröder, Brogniez, Peng Ho

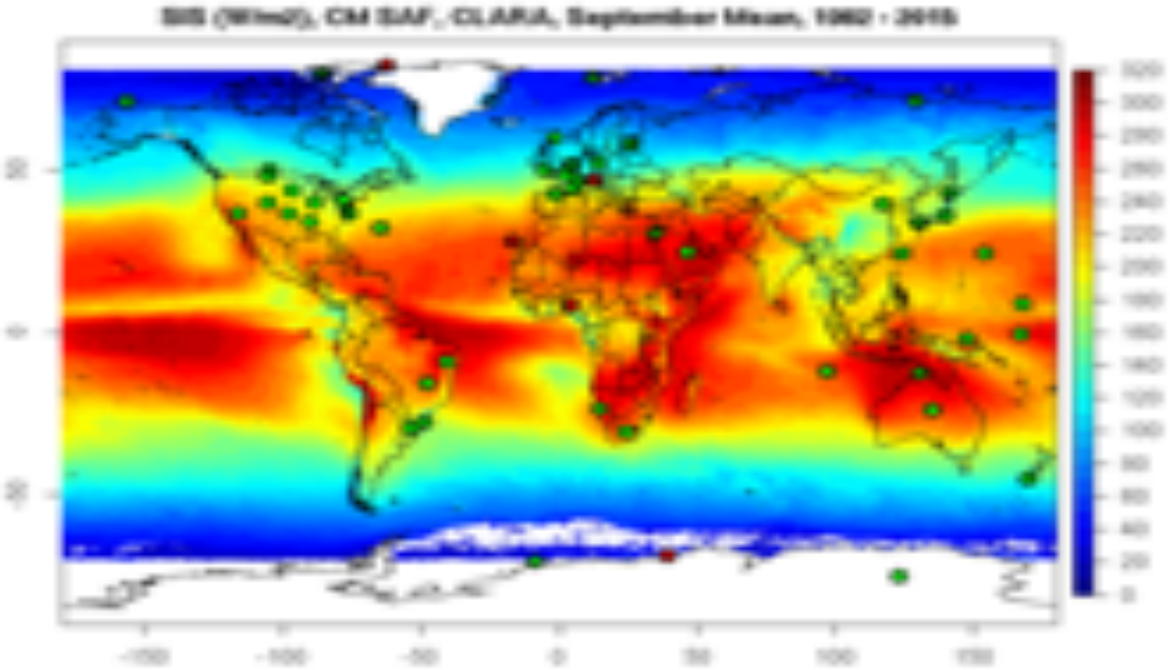
HOAPS products

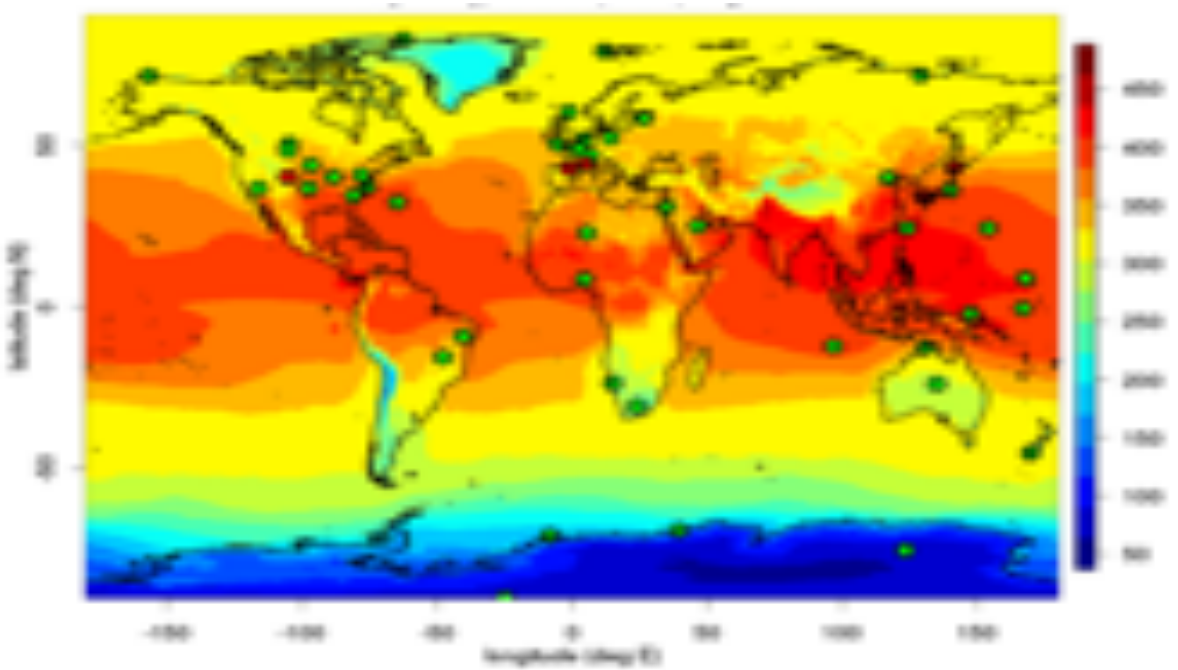
- The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite (HOAPS) was developed at Uni-HH/MPI-M and successfully transferred to CM SAF.
- doi: 10.5676/EUM_SAF_CM/HOAPS/V002, available at http://www.cmsaf.eu/wui
- Global ice-free ocean in 0.5°,
- Monthly averages, 6-hourly composites,
- July 1987 – Dec 2014.
- Based on the passive instruments SSM/I and SSMIS measuring MW radiation coming from the earth on-board the polar orbiting DMSP satellites.
- Eight products:
  - Integrated water vapour (1D-Var),
  - Near surface humidity (Bentamy et al., 2003),
  - Near surface wind speed (1D-Var),
  - Precipitation (Andersson et al., 2010),
  - Latent heat flux (Fairall et al., 1996, 2003),
  - Evaporation (Fairall et al., 1996, 2003),
  - Freshwater flux (E-P),
  - SST (auxiliary, basis: OI SST)

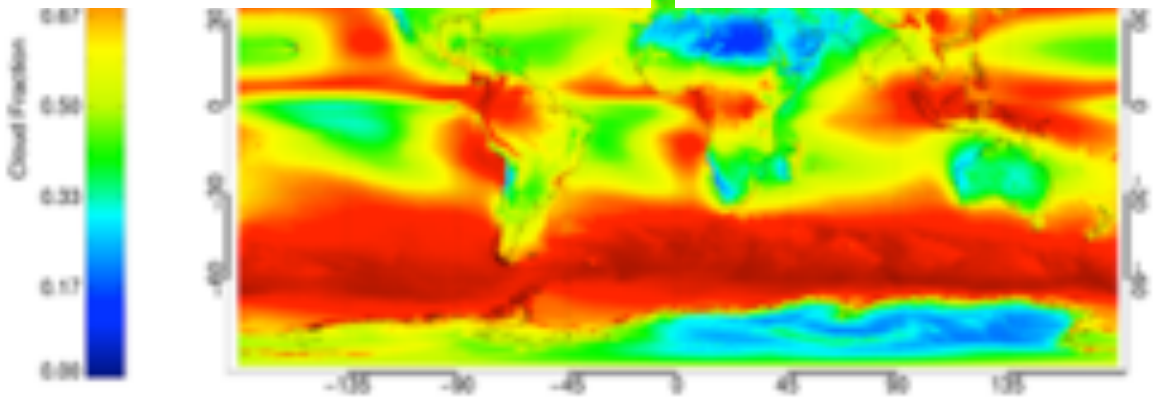


Clouds and radiation at the surface from AVHRR

Surface incoming radiation (short and longwave) 1982 – 2015







Long-term average cloud fraction (1982-2015)

EUMETSAT CM SAF CLIMATE MONITORING

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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

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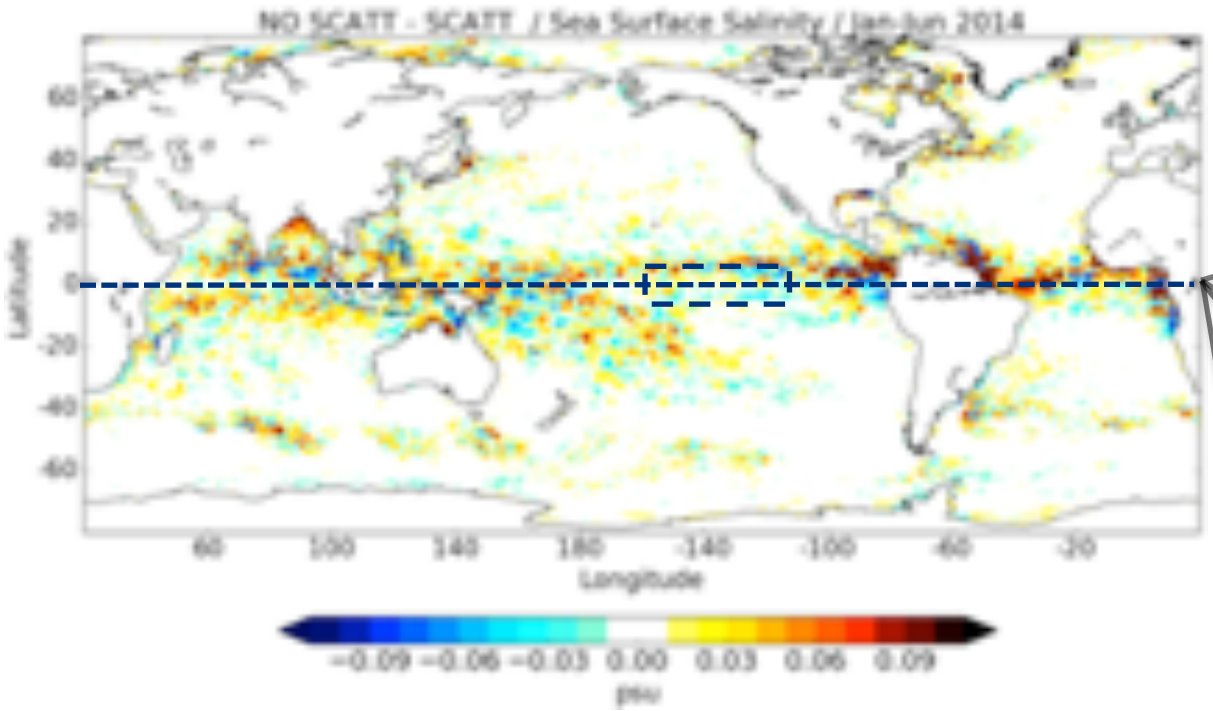
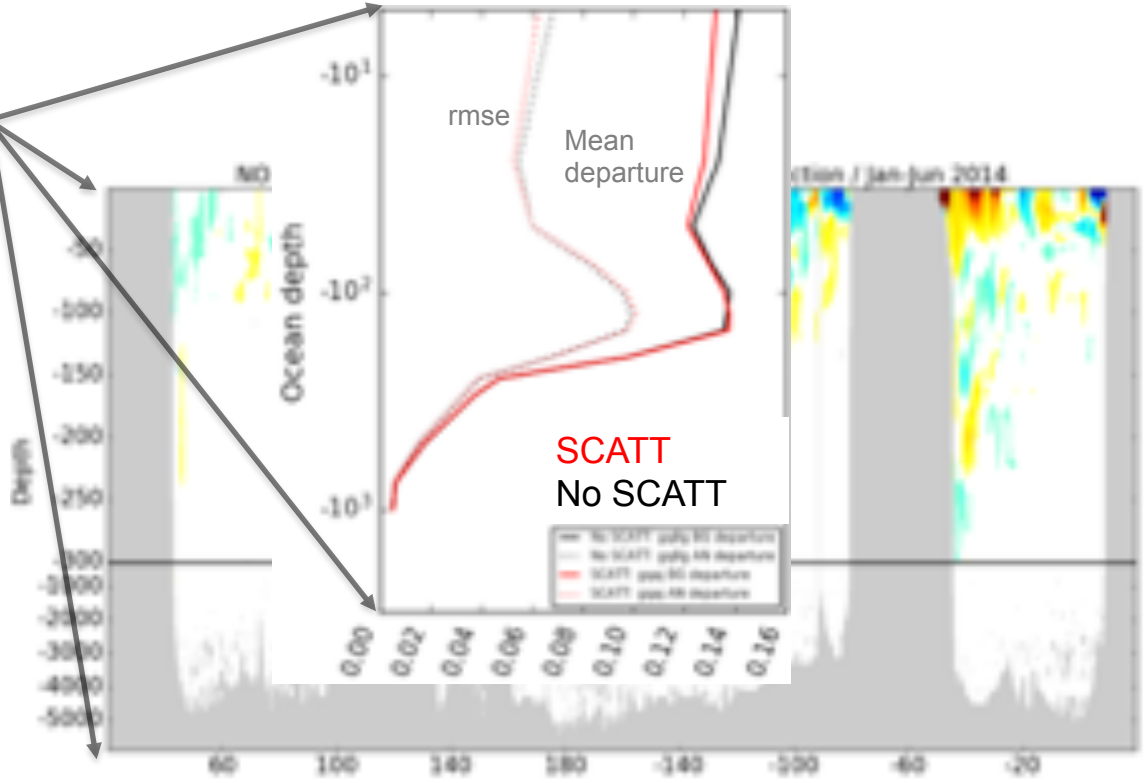
Coupled Assimilation - Atmospheric winds impact salinity



Improved fit to in-situ observations



Courtesy of ECMWF

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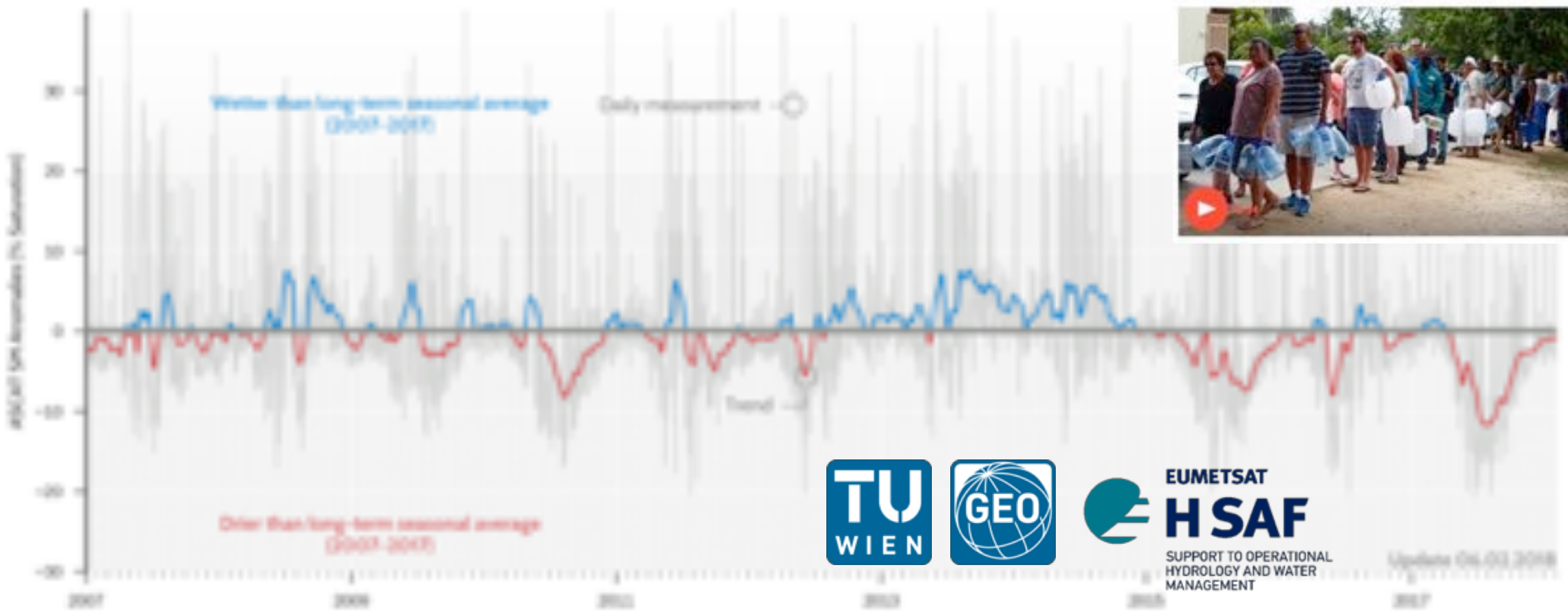
Water Shortage 2018 Capetown



Courtesy Mariette Vreugdenhil/TU Wien, EUMETSAT H SAF

PART

The Joint CEOS/CGMS Working Group on Climate

Jörg Schulz, EUMETSAT

John Dwyer, USGS

Chairs Joint CEOS/CGMS Working Group on Climate

Short History of Joint WGClimate

- The joint development of the high-level architecture for climate monitoring from space led to the formation of the Joint CEOS/CGMS WGClimate first endorsed by CEOS in 2010 and then joined by CGMS in 2013;
- Major Task is: Coordinate and encourage collaborative activities between the world's major space agencies in the area of climate monitoring.

JWGClimate
Chair: Jörg Schulz (EUMETSAT) until 2020
Vice Chair: John Dwyer (USGS) until 2019

Major objectives of WGClimate

- Provision of a structured, comprehensive and accessible view as to what Climate Data Records are currently available from satellite missions of CEOS and CGMS members or their combination;

- Creation of the conditions for delivering further Climate Data Records, including multi-mission Climate Data Records, through best use of available data to fulfil GCOS requirements (e.g. by identifying and targetting cross-calibration or re-processing gaps/shortfalls);

- Optimisation of the planning of future satellite missions and constellations to expand existing and planned Climate Data Records, both in terms of coverage and record length, and to address possible gaps with respect to GCOS requirements.

Addition to the Mandate 2018

Considering the specific importance of greenhouse gas monitoring as stated in the Conference of the Parties (COP) 21 Paris Agreement, it will:

- Coordinate activities of CEOS and CGMS defining and implementing an integrated global carbon observing system including a targeted observing system for monitoring the column concentrations of CO_2, CH_4 and other greenhouse gases from space as well as insuring that these activities are integrated into a broader approach on greenhouse gas monitoring, i.e., WMO IG^{3}IS, GCOS, and GEO-C;
- Oversee the implementation of the CEOS Carbon strategy.

UNFCCC/GCOS – CEOS/CGMS Relations

United Nations Climate Change

2015

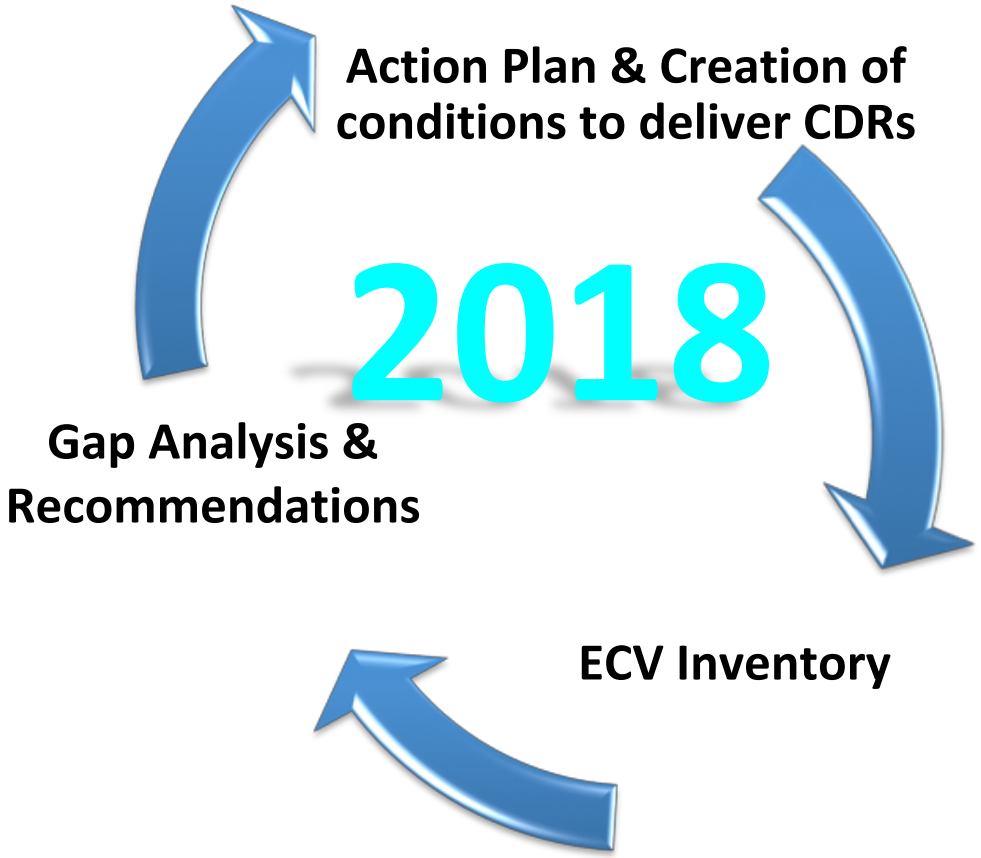
COP-21 Paris Agreement: Adaptation (Article 7(c)):
Strengthening scientific knowledge on climate, including research, **systematic observation of the climate system** and early warning systems, in a manner that informs climate services and supports decision-making.

Reports on Progress @ SBSTA/COP

Needs and Requirements

Coordinated Response

ECV Inventory - Resource for Coordinated Response

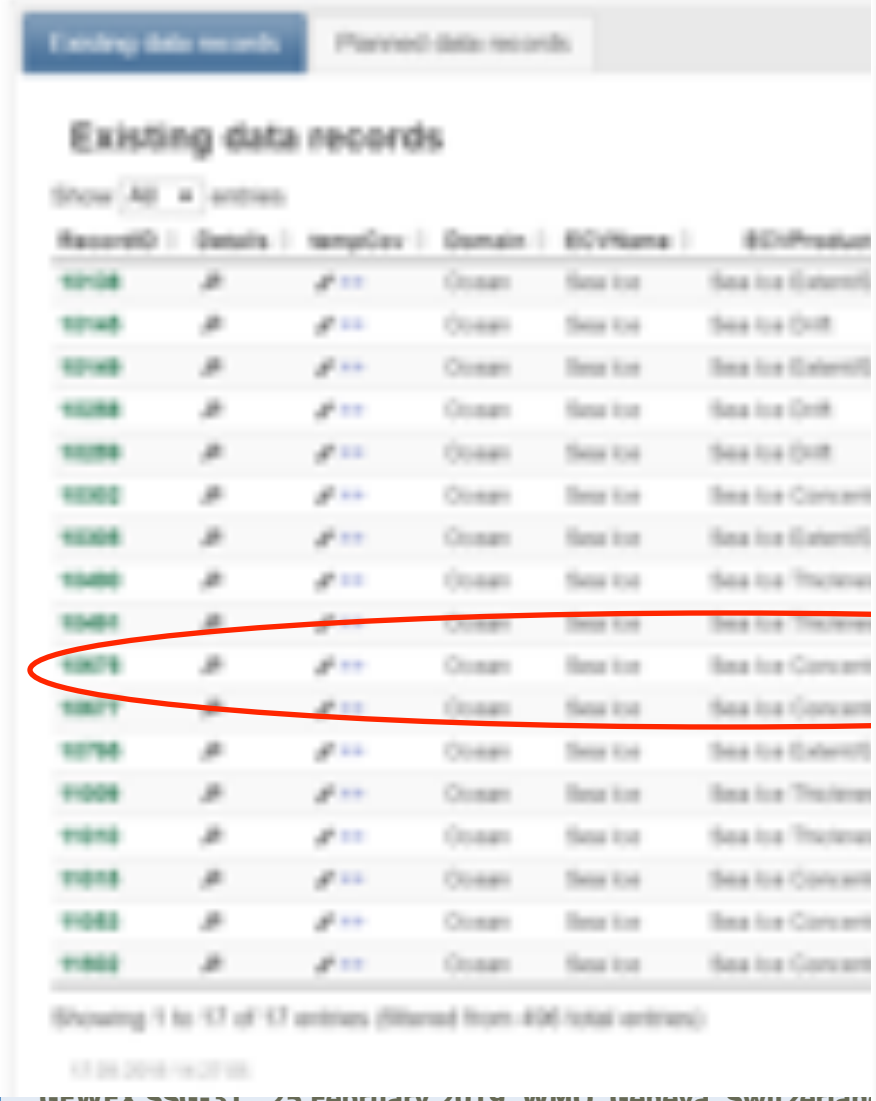


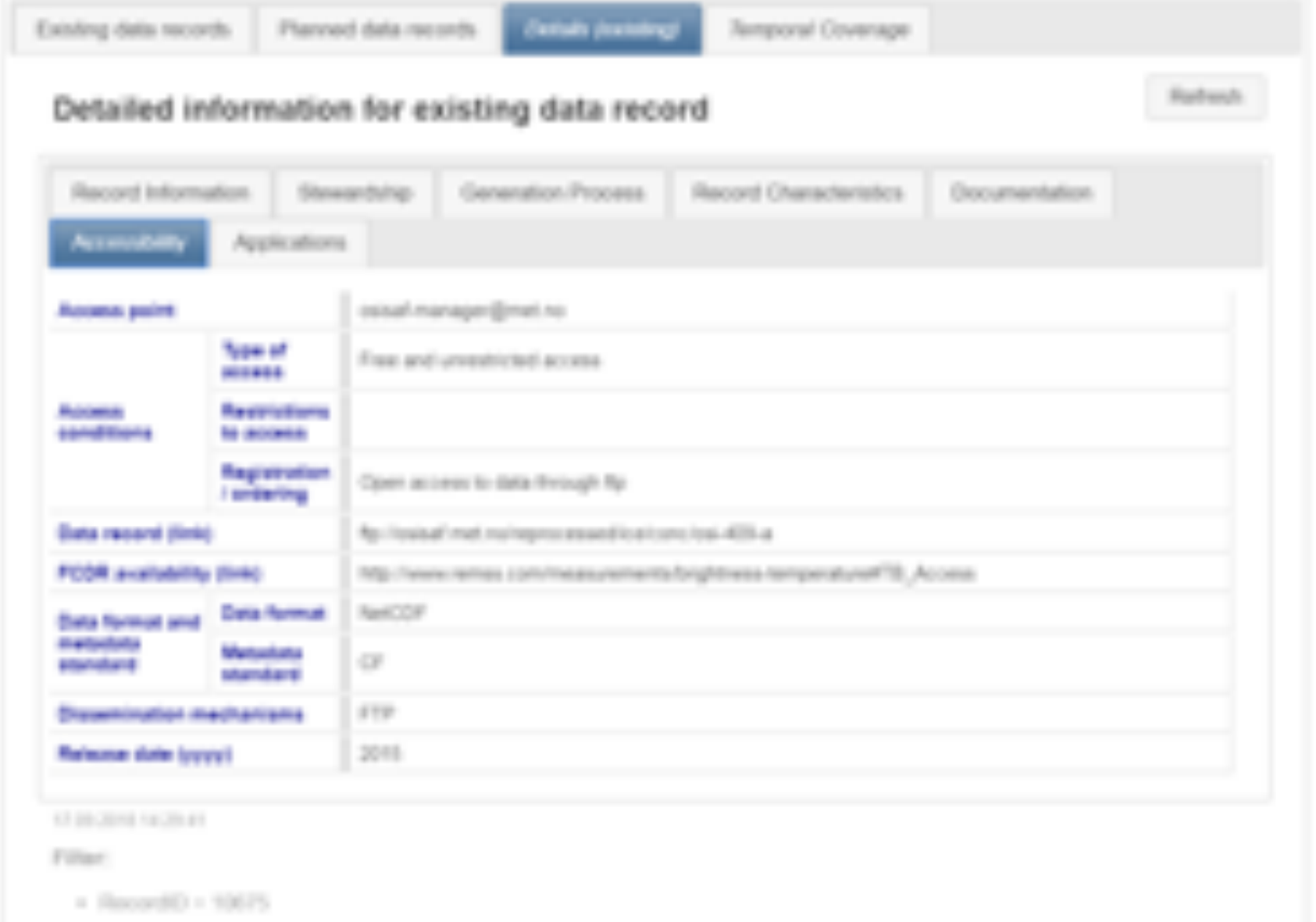
- ECV Inventory fully describes current and planned implementation arrangements (ECV-by-ECV) within the Architecture;
- Verified information about almost 1000 data records including direct access in many cases;
- Updated continuously with versions of Inventory (next ongoing since Nov 2018) , gap analysis, action plan created annually with approval from CEOS and CGMS;
- Recommendations and Coordinated Actions inform space agency planning, improve availability and interoperability of climate data;
- Feeds material for all future responses to the GCOS IP.

The ECV Inventory

- Public access to Inventory via climatemonitoring.info
- Users can:
  - Download the ECV Inventory content for own analysis;
  - Find direct access points to all CDRs in the Inventory;
  - Get access to WGClimate gap analysis results and planned actions;
  - Can access case studies analysing the use of CDRs for applications.

Access to the ECV Inventory





Summary

- EUMETSAT has long-term, multi-satellite programmes, with service continuity;
- Continuous improvement, expansion of portfolio of observations;
- Provides operational access to foreign satellite data through agreements;
- Works on science and operations for climate data records from historical to future observations;
- Joint CEOS/CGMS WGClimate is the focal of point of space agencies to address GCOS requirements;
- EUMETSAT partners in joint WGClimate with other agencies to improve observing system and conditions to develop data records.