Climate Monitoring at EUMETSAT and the role of Satellite Application Facilities
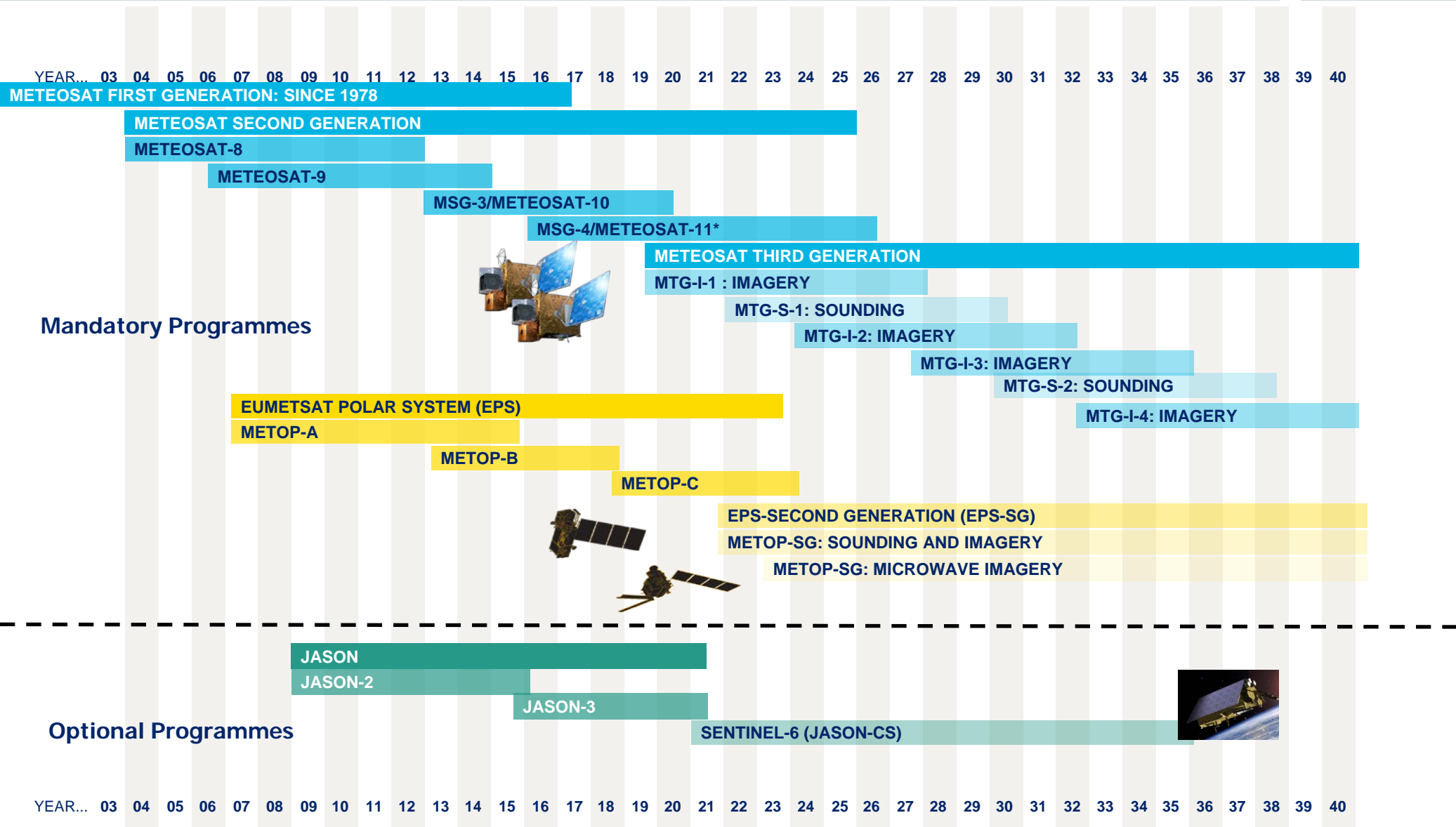
EUMETSAT
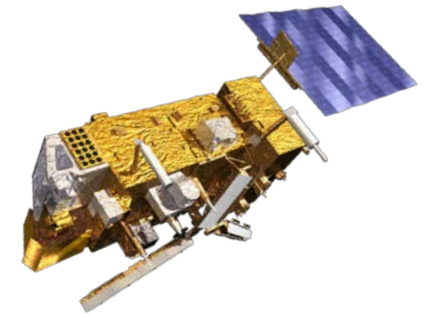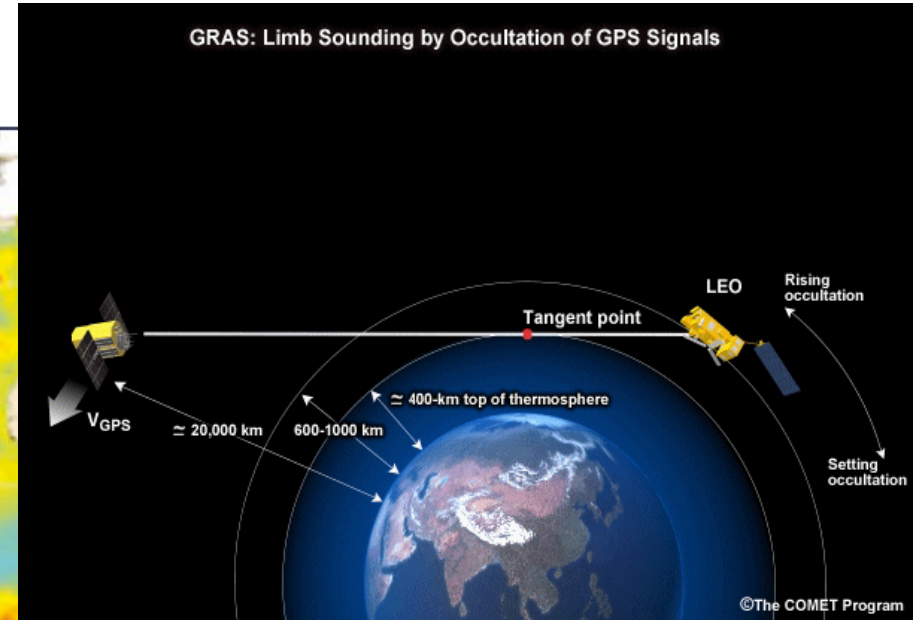
Lothar Schüller
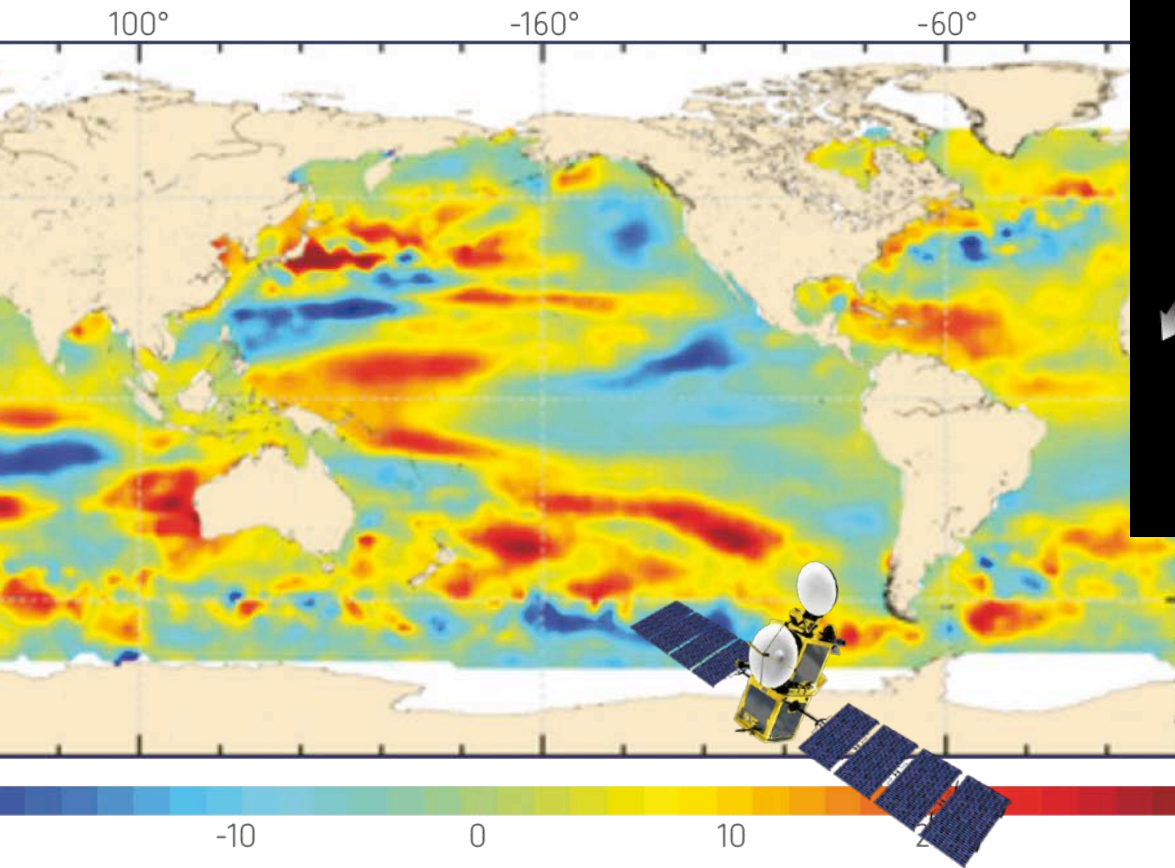
SAF Network Manager

EUMETSAT's mission/Convention:

- The primary objective is to establish, maintain and exploit European systems of operational meteorological satellites, taking into account as far as possible the recommendations of WMO

- *A further objective is to contribute to the operational monitoring of the climate and the detection of global climatic changes*

EUMETSAT

# The relevance of operational programmes: decades of observations for climate monitoring

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: SINCE 1978

METEOSAT SECOND GENERATION

METEOSAT-8

METEOSAT-9

MSG-3/METEOSAT-10

MSG-4/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

Mandatory Programmes

EUMETSAT POLAR SYSTEM (EPS)

METOP-A

METOP-B

METOP-C

EPS-SECOND GENERATION (EPS-SG)

METOP-SG: SOUNDING AND IMAGERY

METOP-SG: MICROWAVE IMAGERY

JASON

JASON-2

JASON-3

SENTINEL-6 (JASON-CS)

Optional Programmes

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

Some missions are optimised for climate monitoring…

GRAS: Limb Sounding by Occultation of GPS Signals

©The COMET Program

100°   -160°   -60°

-50°

-10   0   10

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

….but others require recalibration

FIRST IMAGE: 9 DEC 1977
COPYRIGHT ESA

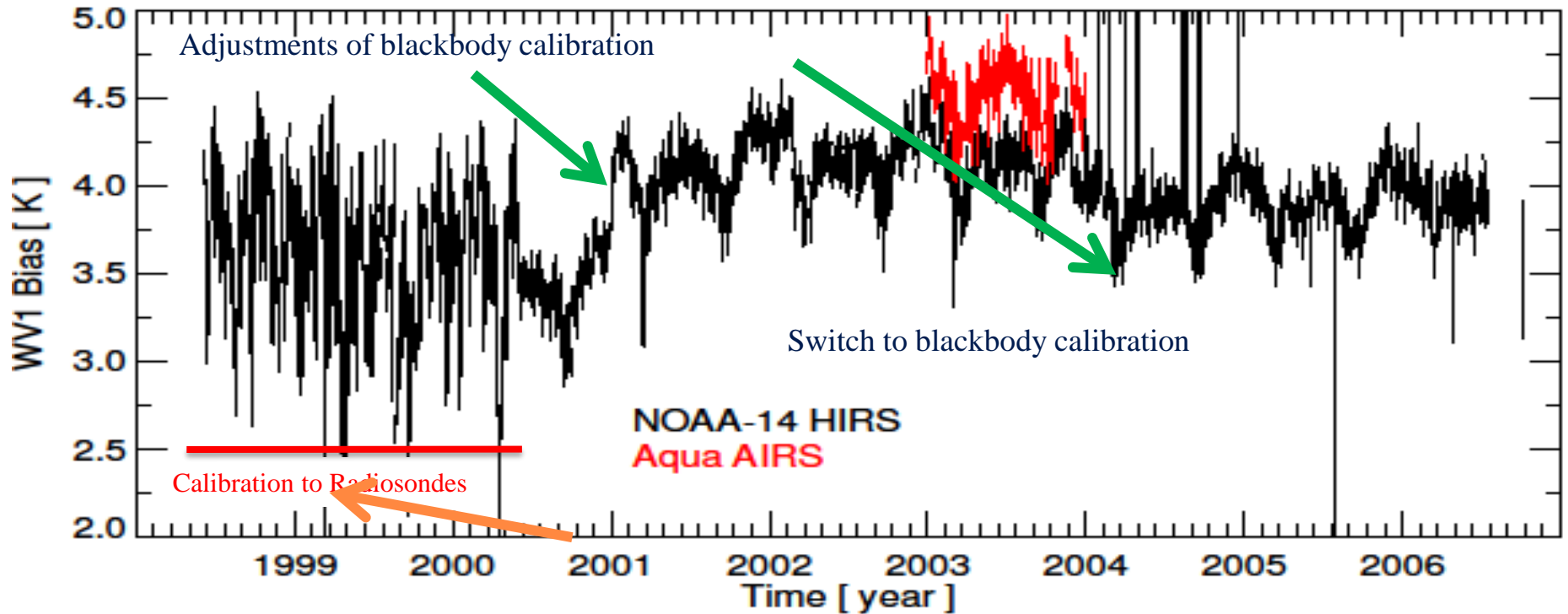Meteosat-2 (M-2) — M-3 — M-4 M-3 — M-4 — M-5
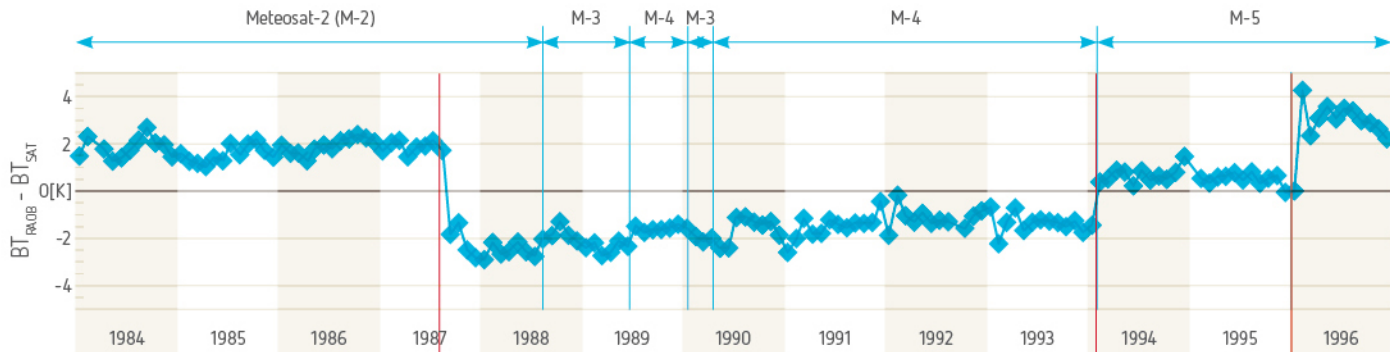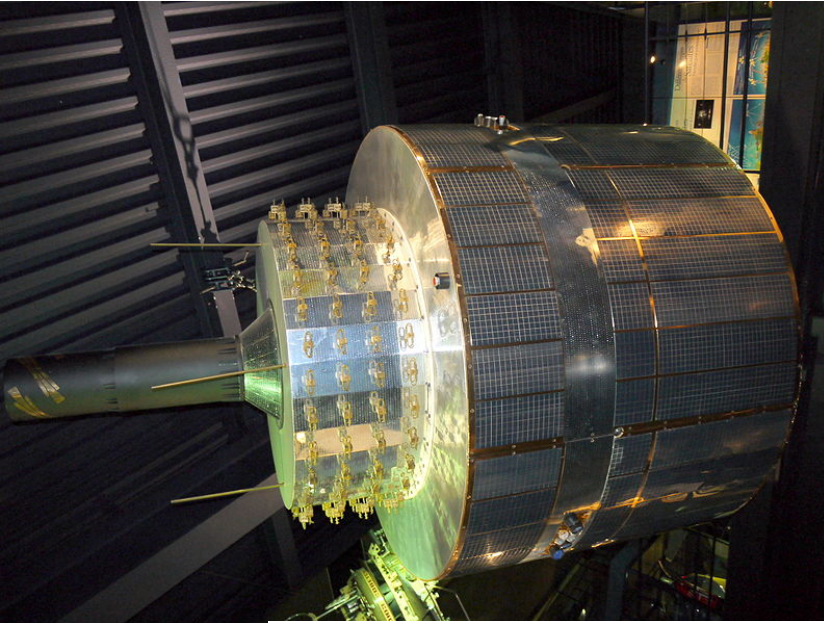
First implementation of operational calibration technique, 1 September 1987

Upgrade of calibration technique, 3 February 1994

ISCCP DX Normalised calibration instead of nominal, 1 January 1996

Inter-Satellite Calibration for Geostationary Satellites

Meteosat Water vapour channel at 6.3 μm compared to NOAA-14 HIRS and Aqua AIRS
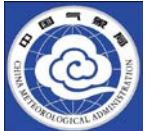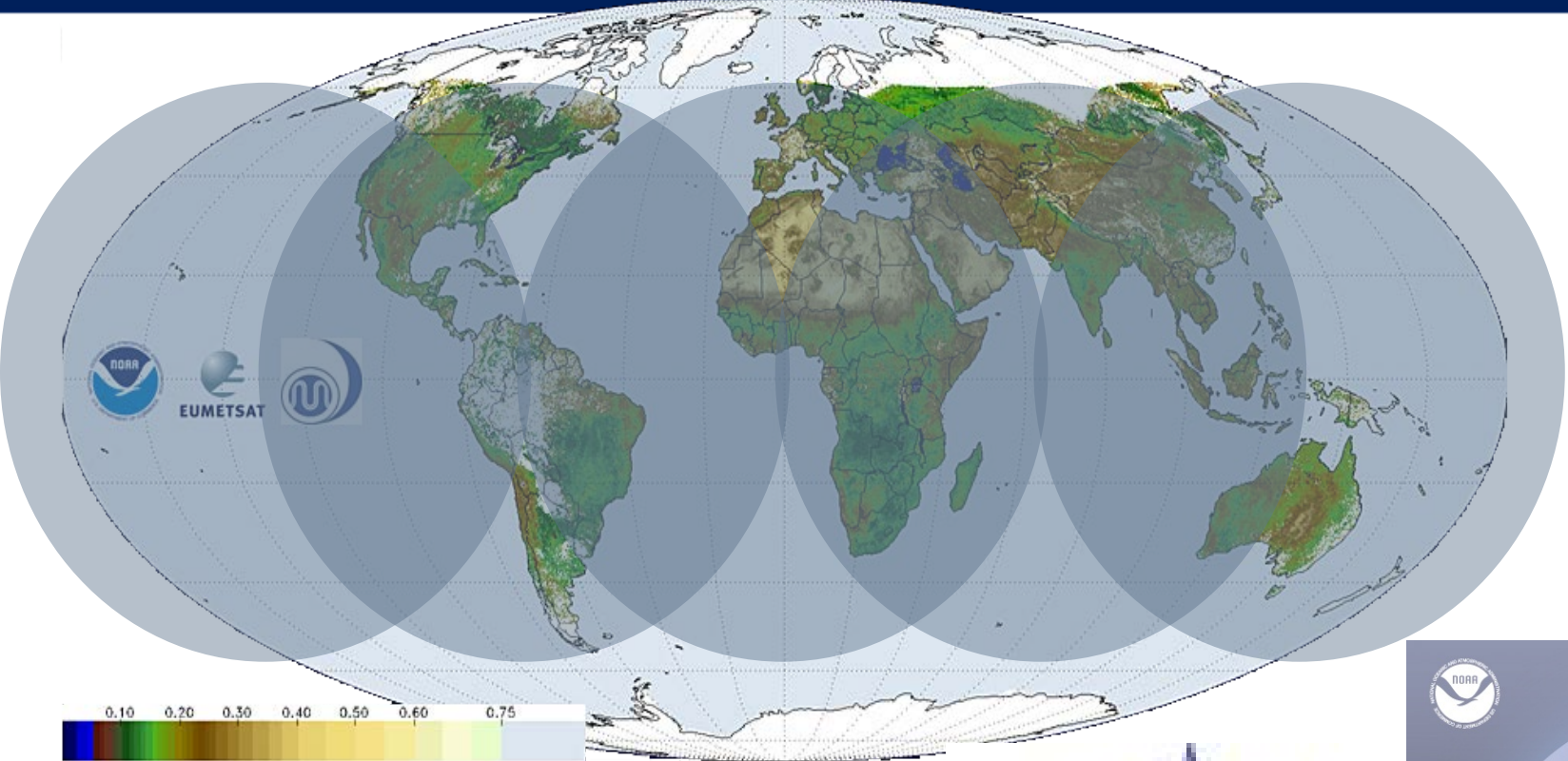
Scope of EUMETSAT climate monitoring activities

- Re-calibration and cross calibration of historical data

- Production of Fundamental Climate Data Records

- Production of Thematic Climate Data Records

- Delivery to users/projects with documentation, support to scientific validation

- Support to international projects

- Development of methods for maturity/quality/capacity assessment (CORE-CLIMAX, Q4ECV, SCOPE-CM)

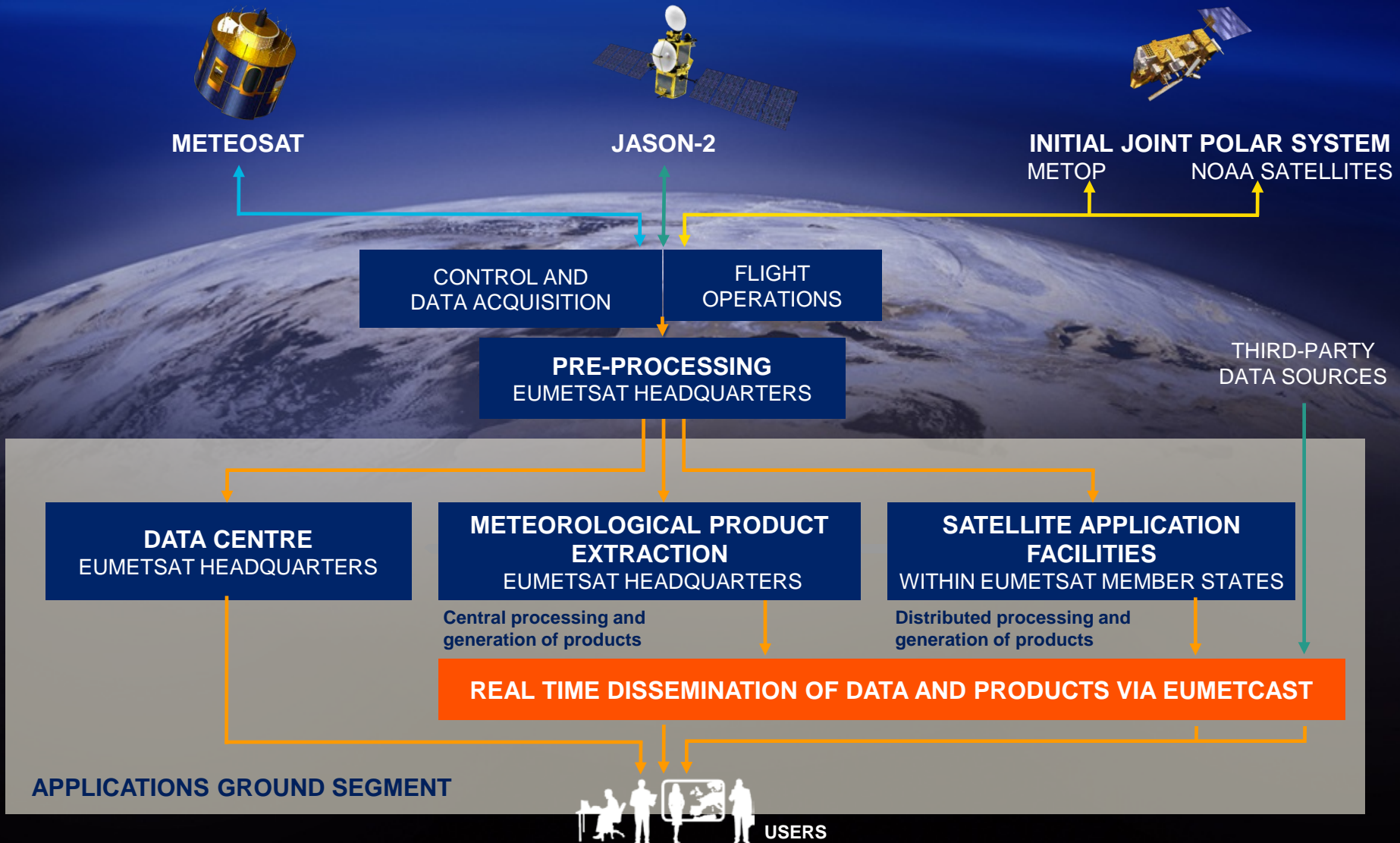- International coordination: WMO, architecture, CEOS-CGMS

EUMETSAT climate monitoring activities: how & who

- Climate monitoring implementation plan
  - prioritised EUMETSAT Secretariat's activities, and
  - contributions from SAF Network
  - EUMETSAT Working Group on coordination of CDR generation

- Activities embedded in/articulated with cooperative projects
  - WMO GSICS and SCOPE-CM projects
  - FP-7 / H2020 Projects: CORE-CLIMAX, QA4ECV, ERACLIM 2, FIDUCEO, GAIA-CLIM
  - ESA CCI

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International coordination and cooperation

EUMETSAT ground segment overview

METEOSAT

JASON-2

INITIAL JOINT POLAR SYSTEM
METOP   NOAA SATELLITES

CONTROL AND DATA ACQUISITION

FLIGHT OPERATIONS

THIRD-PARTY DATA SOURCES

PRE-PROCESSING
EUMETSAT HEADQUARTERS

DATA CENTRE
EUMETSAT HEADQUARTERS

METEOROLOGICAL PRODUCT EXTRACTION
EUMETSAT HEADQUARTERS

SATELLITE APPLICATION FACILITIES
WITHIN EUMETSAT MEMBER STATES

Central processing and generation of products

Distributed processing and generation of products

REAL TIME DISSEMINATION OF DATA AND PRODUCTS VIA EUMETCAST

APPLICATIONS GROUND SEGMENT

USERS

10

EUMETSAT

What is a SAF?

Satellite
Application
Facilities
SAFs

- SAF = **Satellite Application Facility**

- part of the EUMETSAT application ground segment

- complement production of standard meteorological products at EUMETSAT central facility

- providing products and services to users

- specialised on topics and themes

- located at Weather Services in EUMETSAT Member and Co-operating States

- developed and operated by consortium of partners

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Nature of SAF products

The goal of SAFs is to provide "operational" products.
What do we mean with operational?

- Continuity of product provision
- Continuity of product improvements
- Continuous quality monitoring
- Committed user services
- Validation and review before official release/launch
- Complete Documentation of Products, Algorithms, Validation Results
- ...

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EUMETSAT SAF network across Europe

H SAF
Support to Operational Hydrology and Water Management
Led by Italian Meteorological Institute

ROM SAF
Radio Occultation Meteorology
Led by Danish Meteorological Institute

O3M SAF
Ozone and Atmospheric Chemistry Monitoring
Led by Finnish Meteorlogical Institute

LSA SAF
Land Surface Analysis
Led by Portuguese Meteorological Institute

NWC SAF
Support to Nowcasting and Very Short Range Forecasting
Led by Agencia Estatal de Meteorología, Spain

OSI SAF
Ocean and Sea Ice
Led by Météo France

CM SAF
Climate Monitoring
Led by Deutscher Wetterdienst, Germany

NWP SAF
Numerical Weather Prediction
Led by Met Office (UK)

EUMETSAT NETWORK OF SATELLITE APPLICATION FACILITIES

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# Climate Monitoring SAF

CM SAF
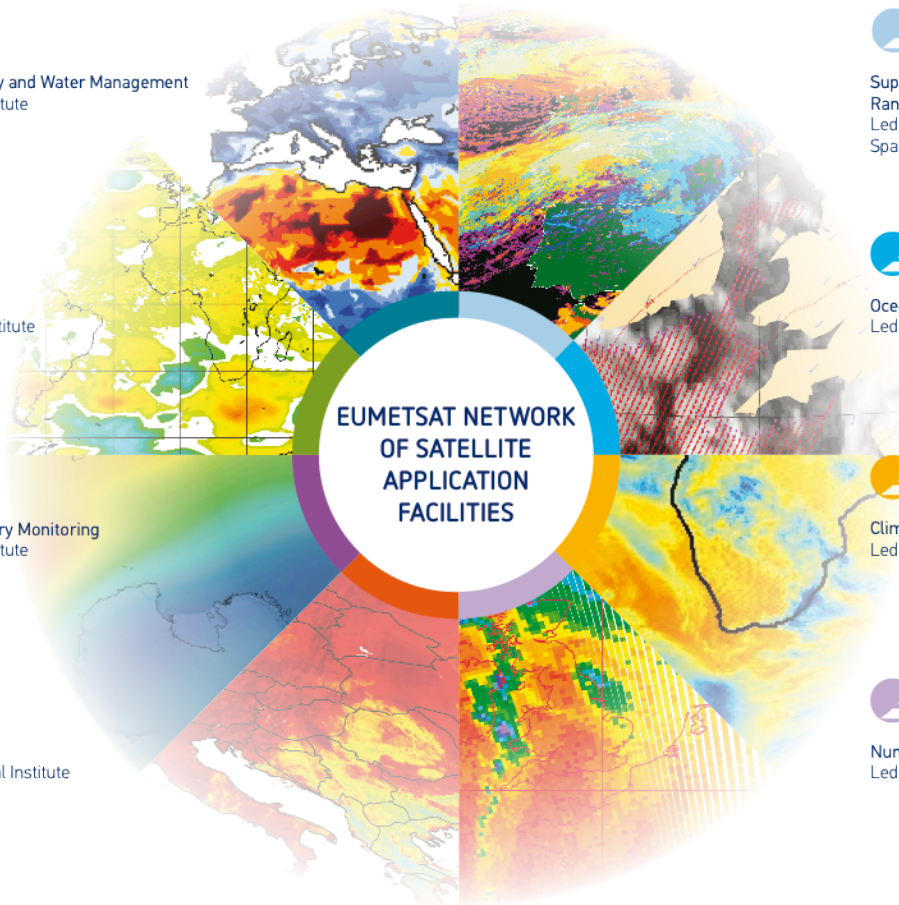
- SAF on Climate Monitoring

- generates and archives high-quality data-set for specific climate application areas

- Currently concentrates on:
    - cloud parameters
    - radiation budget parameters
    - atmospheric humidity

- Leading Entity is the German Weather Service DWD, Offenbach

- NOAA-AVHRR based data operationally produced since November 2004, MSG based data from October 2005, Metop data used since 2009.

- Climate Data Records (released in the last years):
    - HOAPS (precip, evap, hum., wind) from SSM/I (1987–2008)
    - FCDR SSM/I, Brightness-temperatures 1987-2008
    - NOAA-AVHRR based 20 years of homogeneous data record (clouds, surface radiation)
    - SEVIRI Cloud + radiation (2004-2012)
    - MVIRI/SEVIRI surface radiation (1982-2005(-2013))
    - GERB top of the atmosphere radiation (2004-2009)

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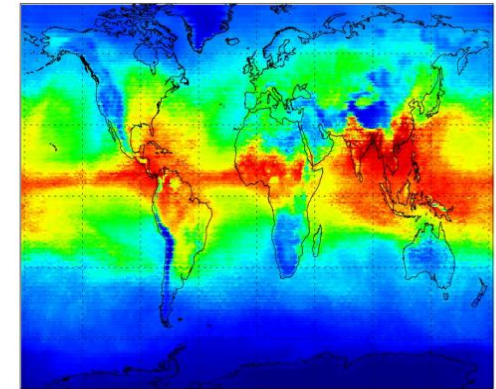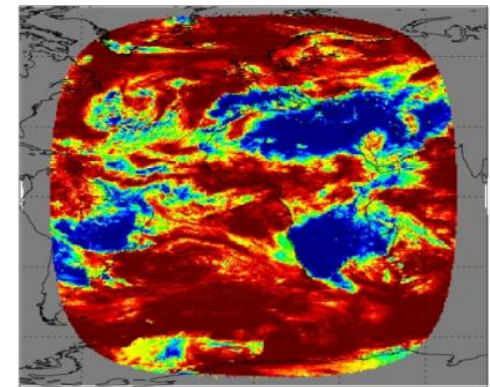
Sensor, Satellite resp.	Data Record, Parameter	Period	Coverage
Climate Data Records (CDR)			
MSG (SEVIRI)	**Cloud parameters, surf. radiation**	2004 – 2011	Europe & Africa
MSG (GERB/SEVIRI)	**Top of atmosphere radiative fluxes**	2004 – 2009	Europe & Africa
MSG (SEVIRI)	**Atmospheric Motion Vector, clear sky (all sky) radiance**	2004 – 2012	Europe
Meteosat (MVIRI/SEVIRI)	**Cloud parameters, surface radiation parameters, land surface temp., FTH**	1983 – 2005	Europe & Africa
Meteosat (MVIRI)	**Surface Albedo**	1982 – 2012	Europe & Africa
NOAA/Metop-A (AVHRR GAC)	**Cloud parameters, surface radiation parameters, incl. albedo**	1982 – 2009	global
Metop-A (AVHRR GAC)	**Atmospheric Motion Vector**	2007 – 2012	global
DMSP (SSM/I)	**HOAPS 3.2 (precip, evap, hum., wind, …)**	1987 – 2008	global ice free ocean
NOAA, Metop-A (ATOVS)	**Water vapour & Temp. profile**	1998 – 2008	global

All CDR's are accessible via DOI Numbers

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Ocean and Sea Ice SAF

OSI SAF

- Ocean and Sea Ice (OSI) SAF routinely produces and disseminates products characterising the ocean surface and the energy fluxes across the sea surface

- Operationally produces information on the sea ice characteristics (extend, concentration, …)

- Leading Entity is Météo-France in Lannion

- OSI SAF distributes near real-time products based on NOAA, MSG, Metop, DMSP and GOES data

- Climate Data Record Generation:

  Sea Ice Concentration (available)

  Scatterometer Winds (in progress)

Sea surface temperature

Sea ice concentration

EUMETSAT
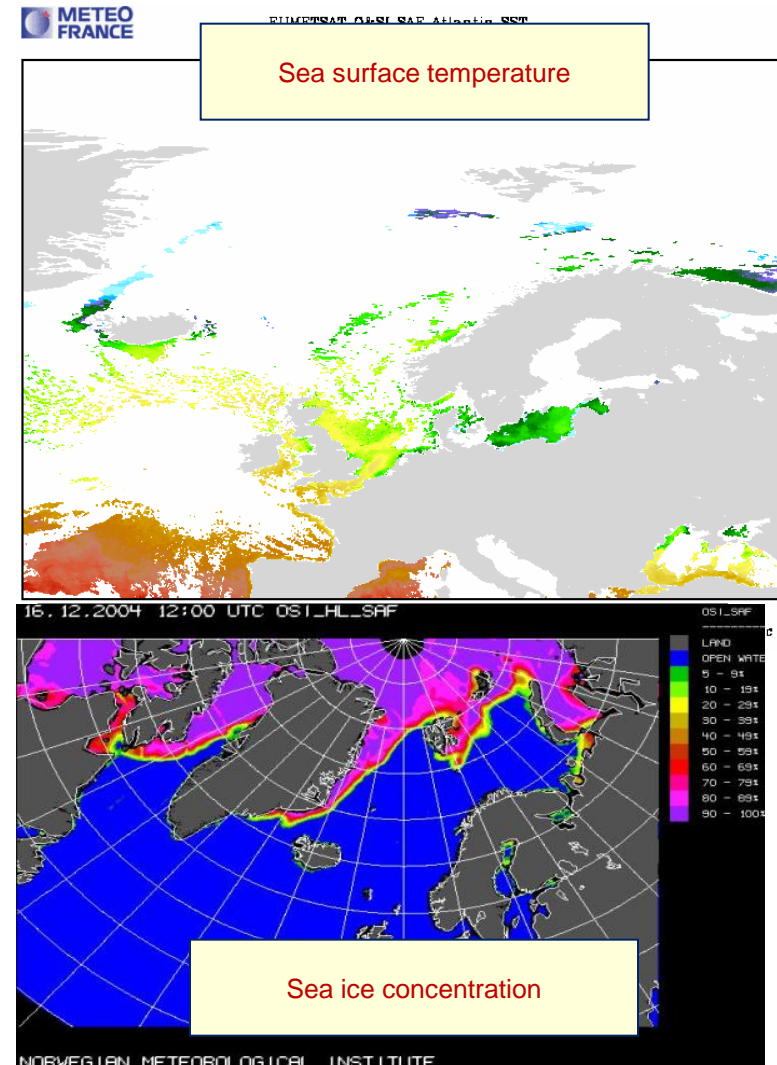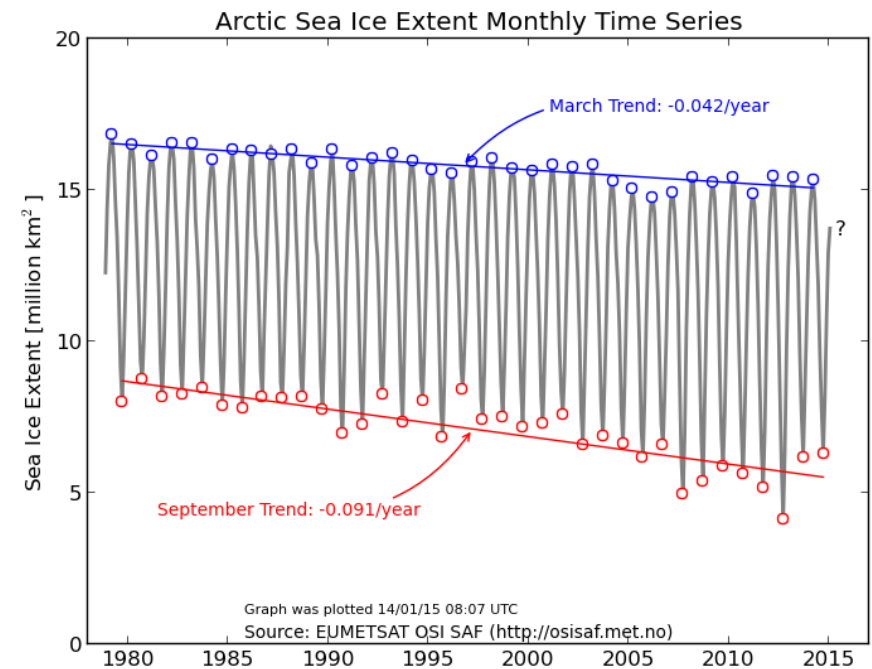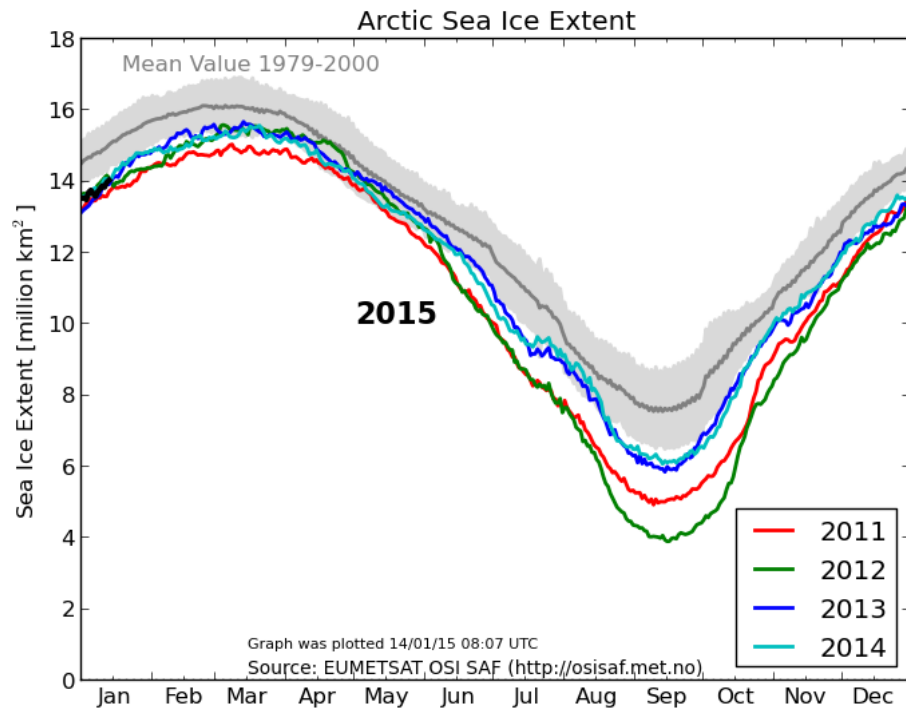
http://osisaf.met.no/p/ice_extent_graphs.php

ROM SAF

- SAF on Radio Occultation Meteorology

- GRAS: Global Positioning System (GPS) Receiver for Atmospheric Sounding flown on EPS/Metop satellites

- near real-time and offline:
  - ▸ sounding data (temperature, pressure, humidity)
  - ▸ corresponding validation products, and
  - ▸ assimilation software

- The Leading Entity is the Danish Meteorological Institute DMI, Copenhagen

- Software packages released since 2007, first NRT product dissemination in October 2008

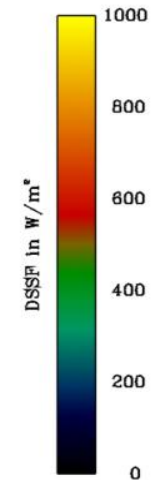EUMETSAT

ROM SAF: Climate Monitoring
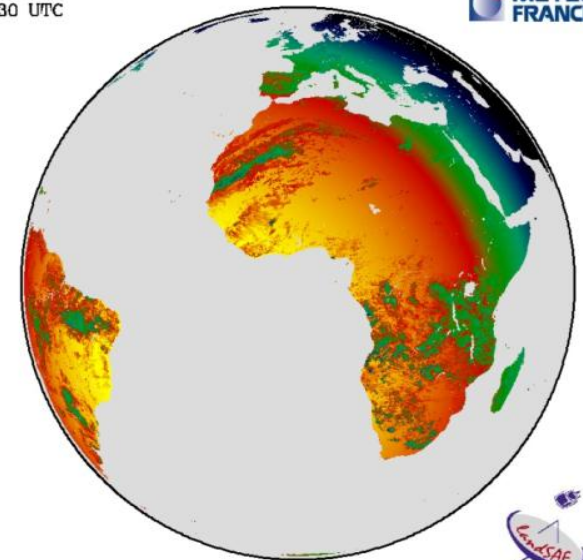
Land Surface Analysis SAF

LSA SAF

- **SAF on Land Surface Analysis (LSA SAF)**

- established to increase the benefit from MSG and EPS data related to land, land-atmosphere interaction and biospheric applications

- Generates operationally data services related to Surface Radiation, Vegetation and wild fire

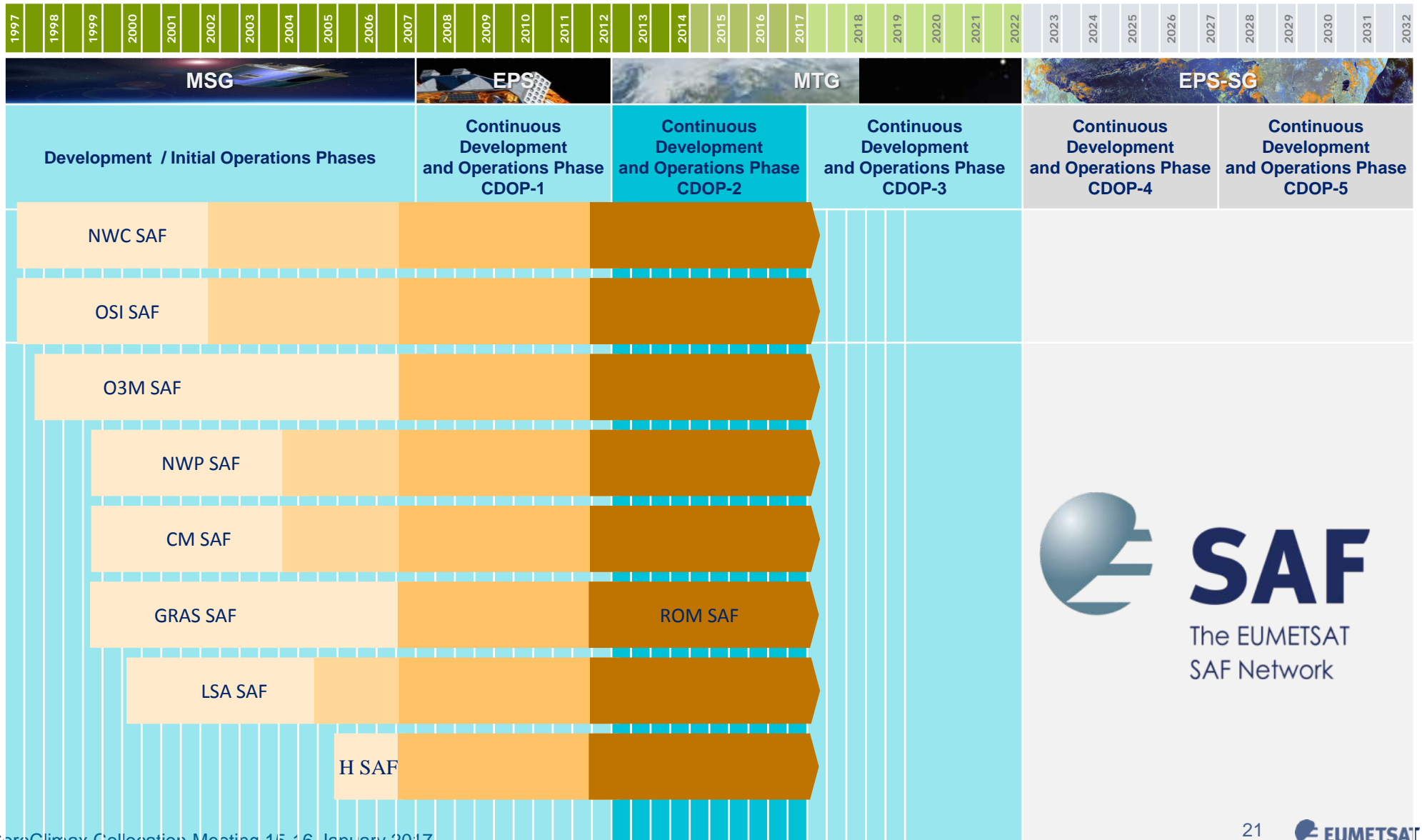- Leading entity is the Portuguese Sea and Atmosphere Institute, IPMA, Lisbon
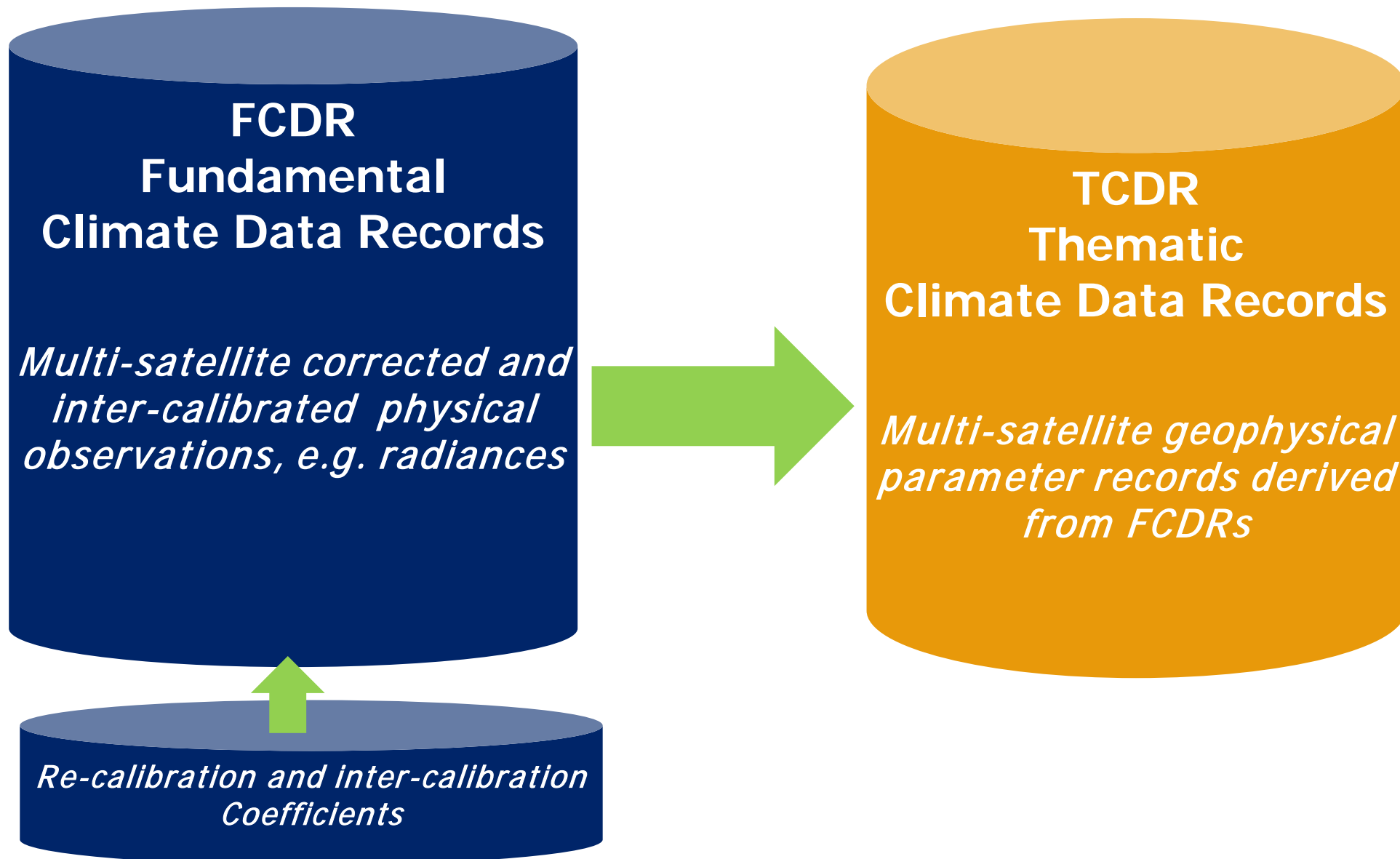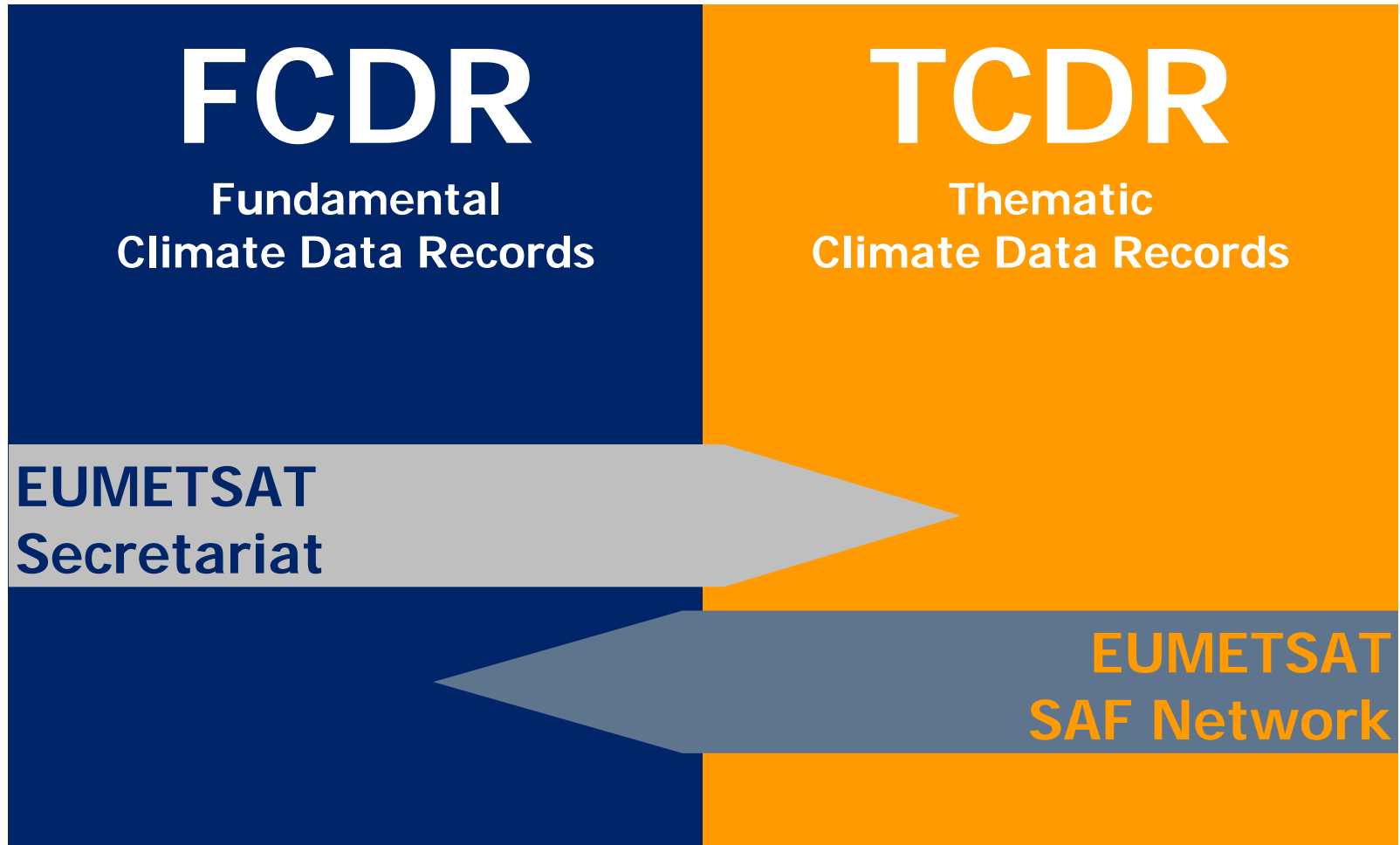
12.02.2003 13:30 UTC

METEO FRANCE

DSSF in W/m²

1000
800
600
400
200
0

MSG-1/SEVIRI

EUMETSAT

35 years of SAF Development and Operations

| 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |

MSG | EPS | MTG | EPS-SG

| Development / Initial Operations Phases | Continuous Development and Operations Phase CDOP-1 | Continuous Development and Operations Phase CDOP-2 | Continuous Development and Operations Phase CDOP-3 | Continuous Development and Operations Phase CDOP-4 | Continuous Development and Operations Phase CDOP-5 |

NWC SAF

OSI SAF

O3M SAF

NWP SAF

CM SAF

GRAS SAF — ROM SAF

LSA SAF

H SAF

SAF
The EUMETSAT
SAF Network

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Climate Data Records Dependency

**FCDR
Fundamental
Climate Data Records**

Multi-satellite corrected and inter-calibrated physical observations, e.g. radiances

**TCDR
Thematic
Climate Data Records**

Multi-satellite geophysical parameter records derived from FCDRs

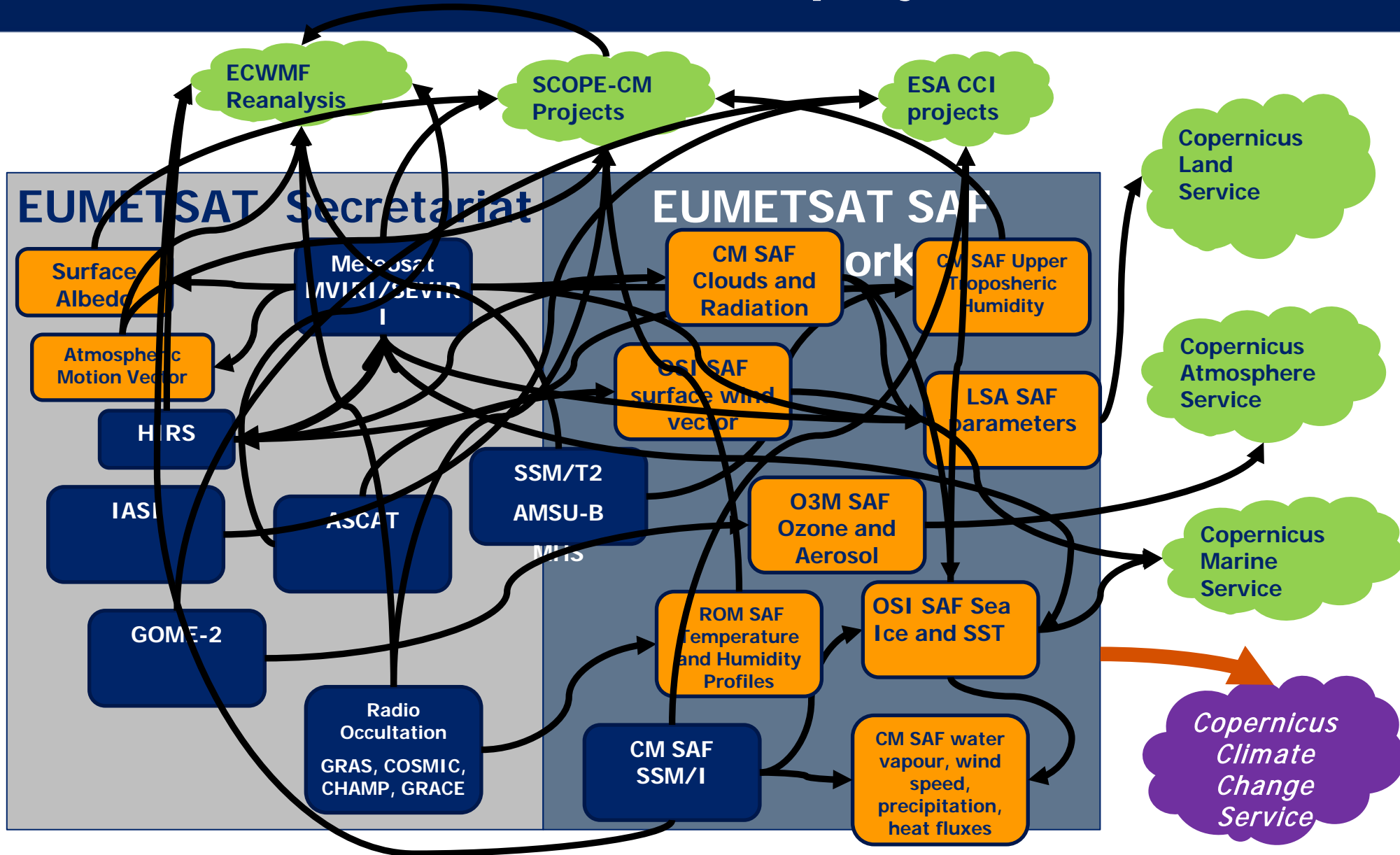*Re-calibration and inter-calibration Coefficients*

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EUMETSAT Climate Data Records: responsibilities

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Climate Data Records Interdependencies: example
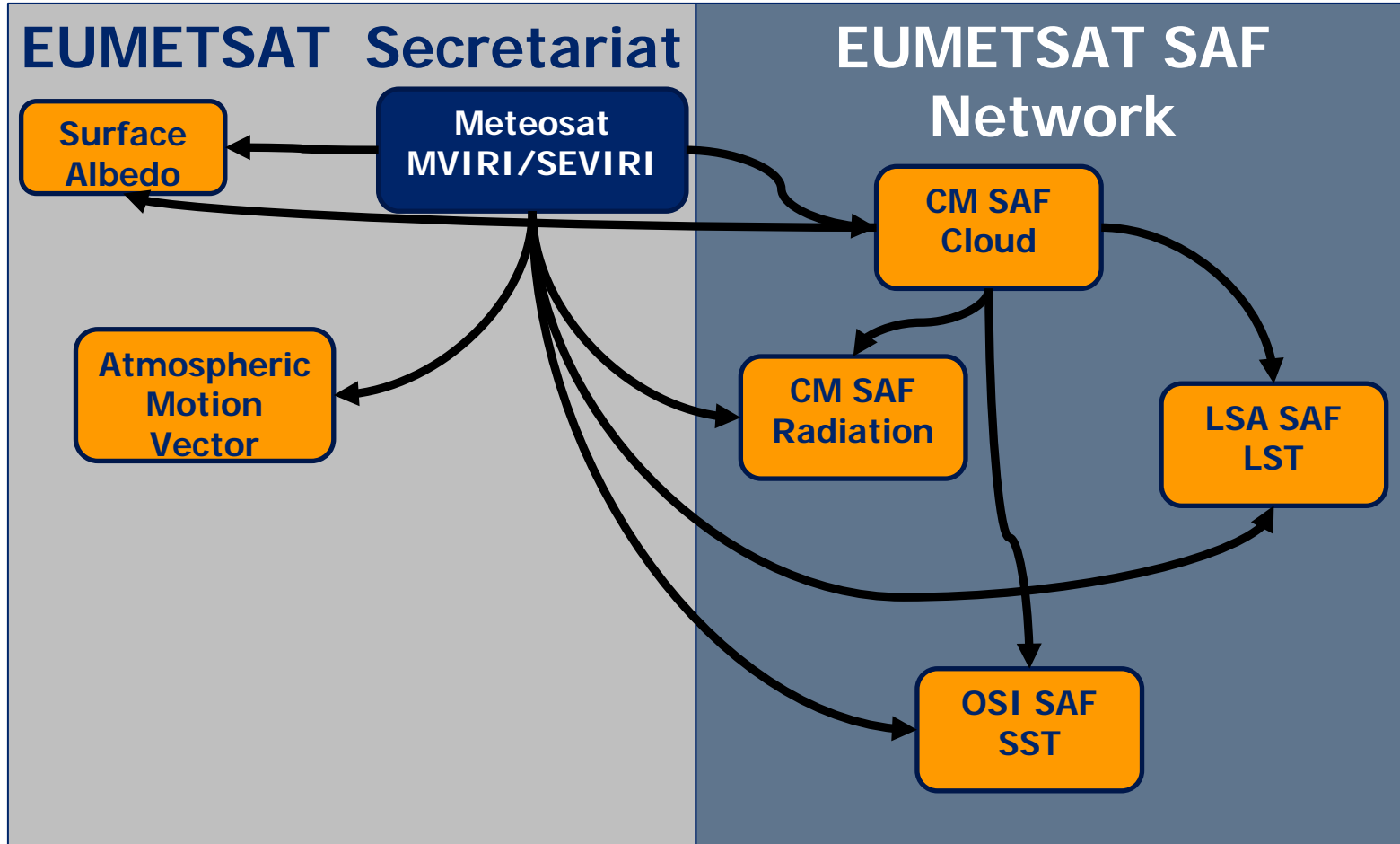
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From Climate Data Records to projects and services

EUMETSAT

How to transfer existing results into the Copernicus Climate Change Services (C3S) ?

- EUMETSAT committed to sustained production and delivery of Climate Data Records

- C3S as a user of EUMETSAT CDR activities to
  - Identify possible usage of the currently committed EUMETSAT CDRs.
  - Identify requirements on additional CDR generation by EUMETSAT fitting in the mandate and concept of EUM Secretariat and SAFs.

- Specific, documented requirements from Copernicus Services (including C3S) would be extremely instrumental for the definition of CDR commitments in the 2017-2022 timeframe (CDOP-3)

- SAF CDOP-3 proposals to be submitted until October 2015

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Maturity Matrix Concept

Software readiness	Metadata	User documentation	Uncertainty Characterisation	Public Access, Feedback and Update	Usage
Are the codes compliant with standards, stable, portable and reproducible?	Do the metadata meet international standards, and allow provenance tracking?	Are the formal documents and peer-reviewed papers up-to-date and public?	Are the uncertainties assessed systematically in a standard manner?	Are the data, source code, and documents publicly available and regularly updated?	Are the data widely used in the scientific, and decision and policy making communities?

Top boxes:
- Is the software robust and maintainable?
- Are the data and methods well documented?
- Has the trueness of the data been systematically assessed?
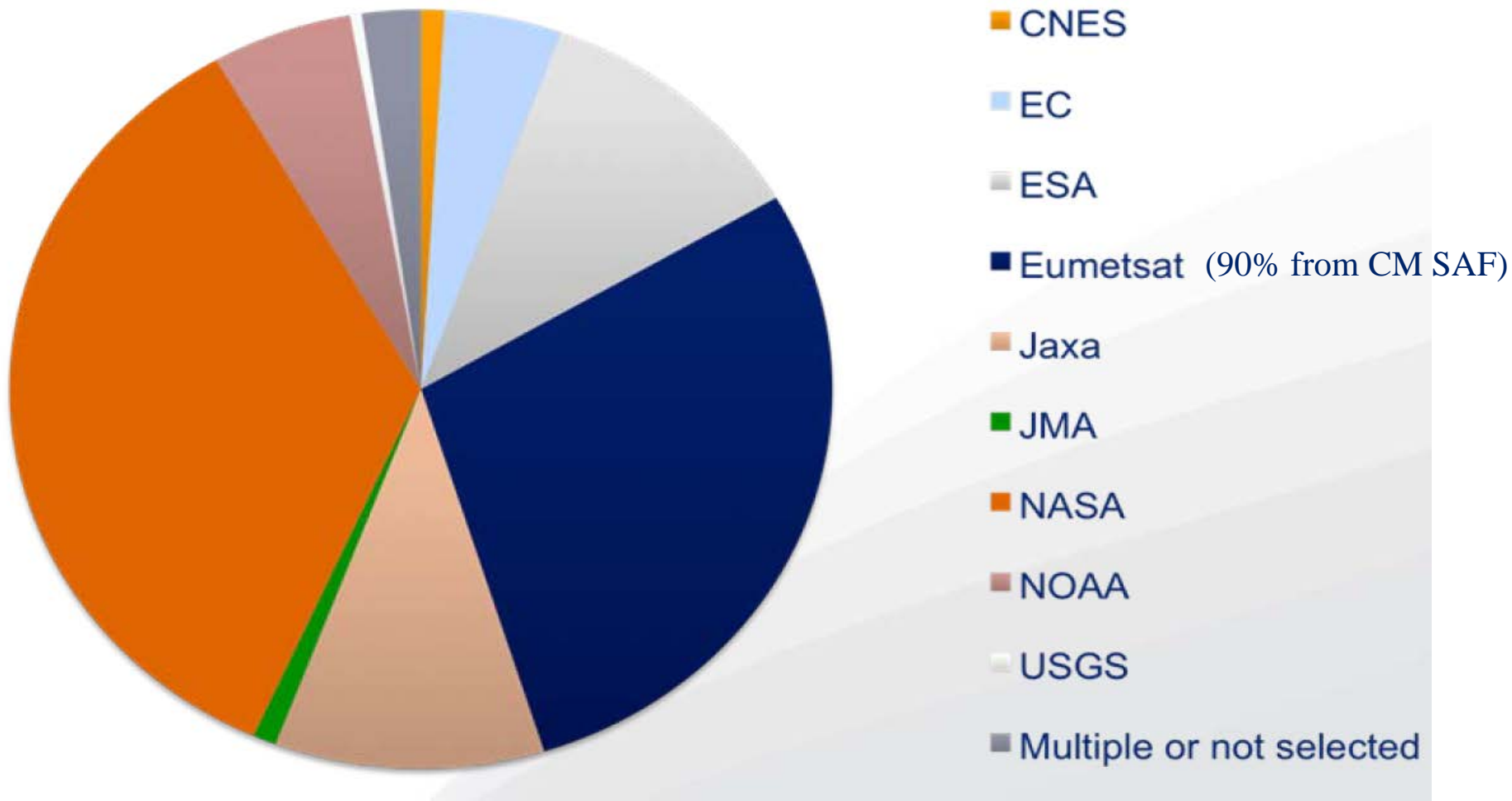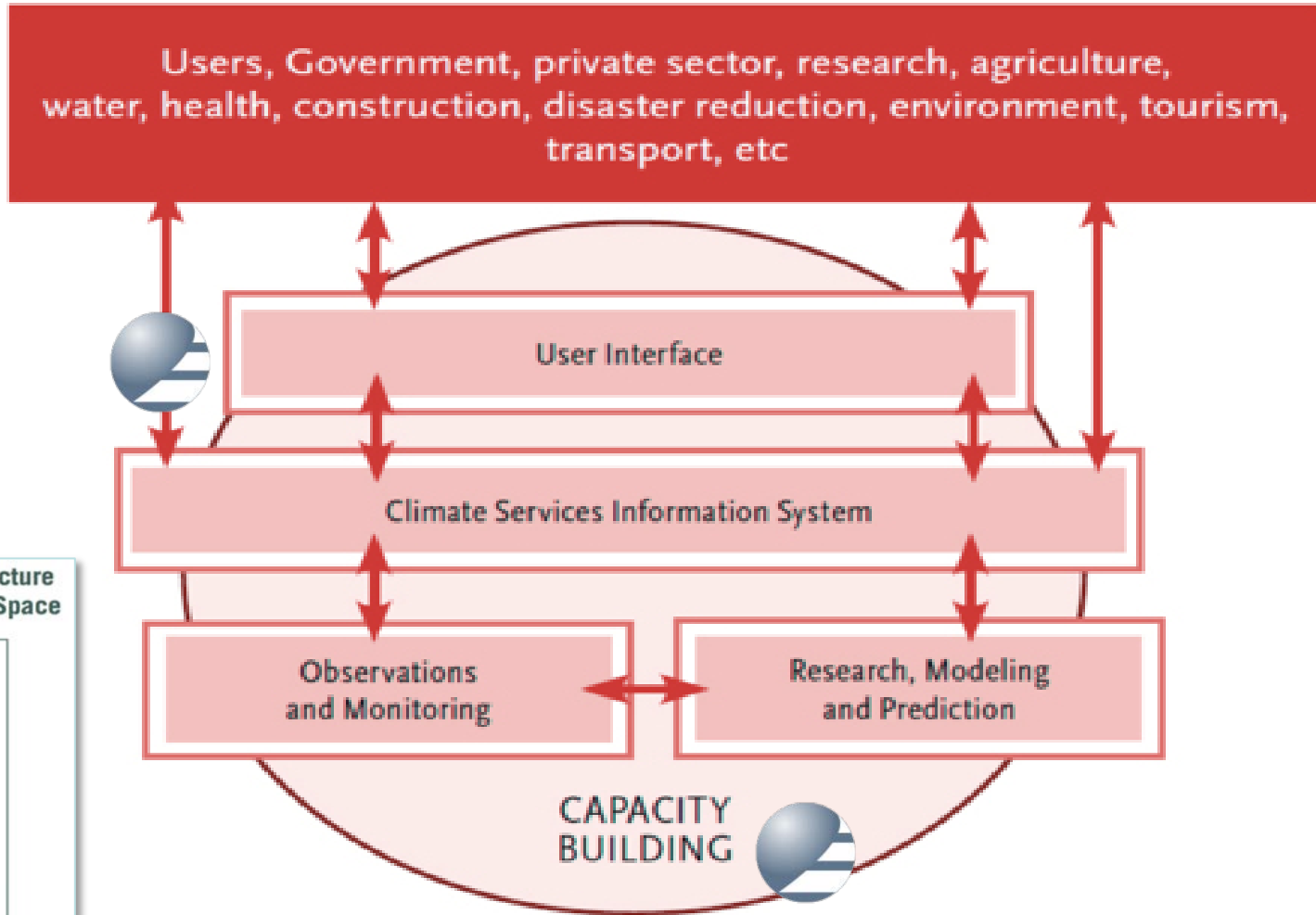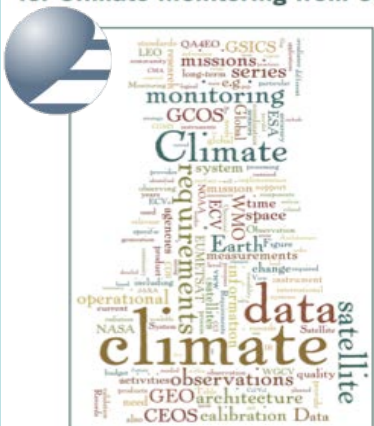- Are data well used and user feedbacks taken care of?

ECV-based inventory of TCDRs
(http://www.ecvinventory.com)

CE⊕S   **Essential Climate Variable (ECV) Inventory**   WMO   CGMS

- CNES
- EC
- ESA
- Eumetsat (90% from CM SAF)
- Jaxa
- JMA
- NASA
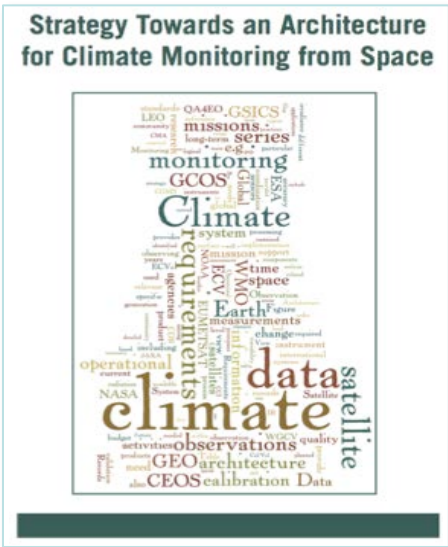- NOAA
- USGS
- Multiple or not selected

The value adding chain: Global Framework for Climate Services

The Value Adding Chain in the Architecture for climate monitoring from space

Strategy Towards an Architecture for Climate Monitoring from Space

CM SAF
ROM SAF
NWC SAF
LSA SAF
NWP SAF
H SAF
OSI SAF
O3M SAF

UERRA

cci

EURO4M

CLIPC

ECLISE
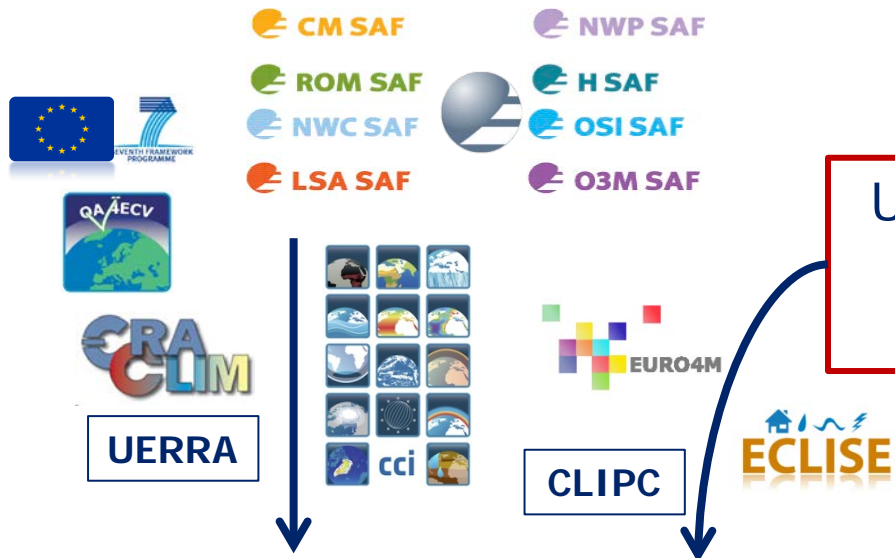
Users/projects converting records into relevant information

Earth Environment → Sensing → Observations → Climate Record Creation and Preservation → Records → Applications (Climate and other SBAs) → Reports → Decision-Making (Climate and other SBAs) → Decisions