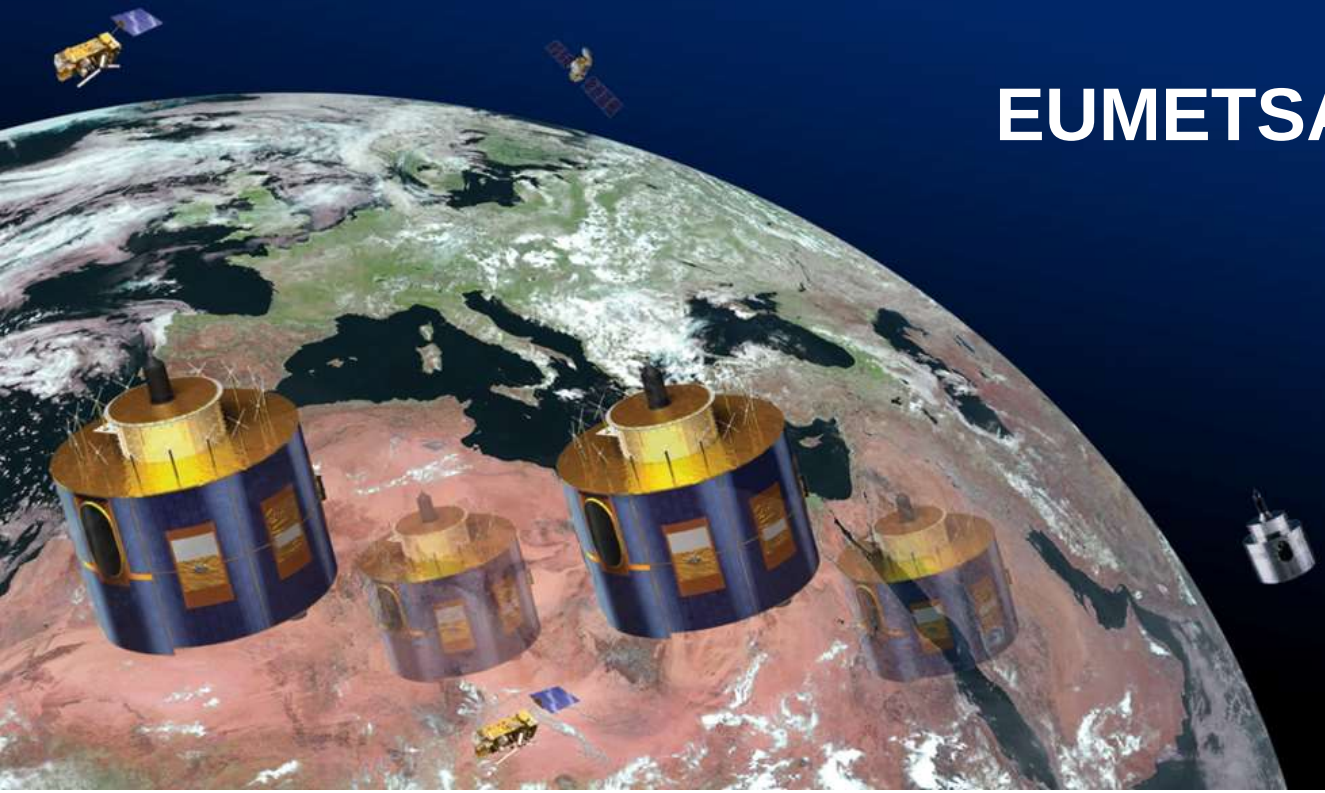
From User Requirements to Product Requirements: EUMETSAT's Snow Portfolio

Lothar Schüller

SAF Network Manager



EUMETSAT ground segment overview



METEOSAT



JASON-2



INITIAL JOINT POLAR SYSTEM
METOP NOAA SATELLITES

CONTROL AND DATA ACQUISITION

FLIGHT OPERATIONS

PRE-PROCESSING
EUMETSAT HEADQUARTERS

THIRD-PARTY DATA SOURCES

DATA CENTRE
EUMETSAT HEADQUARTERS

METEOROLOGICAL PRODUCT EXTRACTION
EUMETSAT HEADQUARTERS

Central processing and generation of products

SATELLITE APPLICATION FACILITIES
WITHIN EUMETSAT MEMBER STATES

Distributed processing and generation of products

REAL TIME DISSEMINATION OF DATA AND PRODUCTS VIA EUMETCAST

APPLICATIONS GROUND SEGMENT



USERS

What is a SAF ?

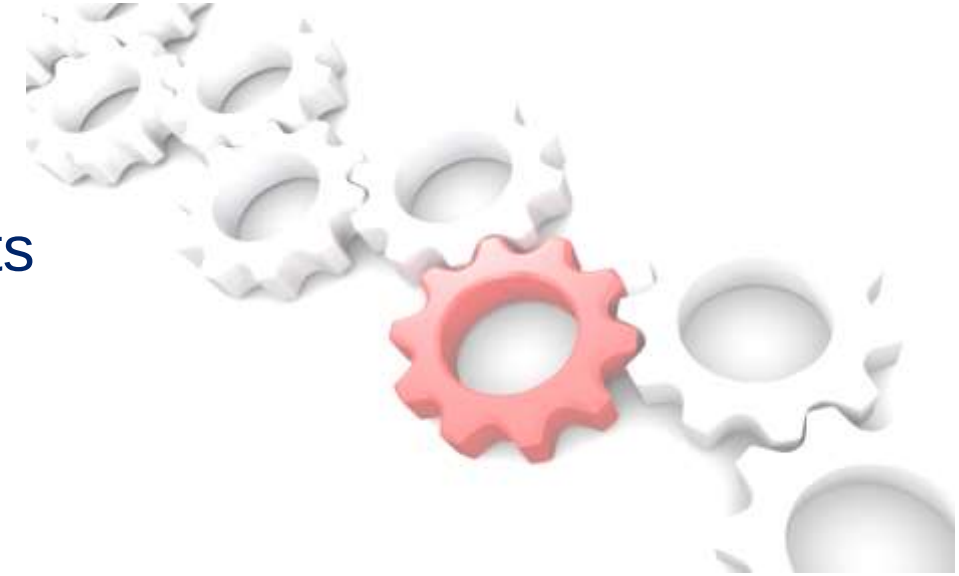


- SAF = **Satellite Application Facility**
- part of the EUMETSAT application ground segment
- providing operational products and services to users
- specialised on topics and themes
- complement production of standard meteorological products at EUMETSAT Secretariat
- located at Weather Services in EUMETSAT Member and Co-operating States
- developed and operated by consortium of partners

SAF
The EUMETSAT
SAF Network

Nature of operational satellite products

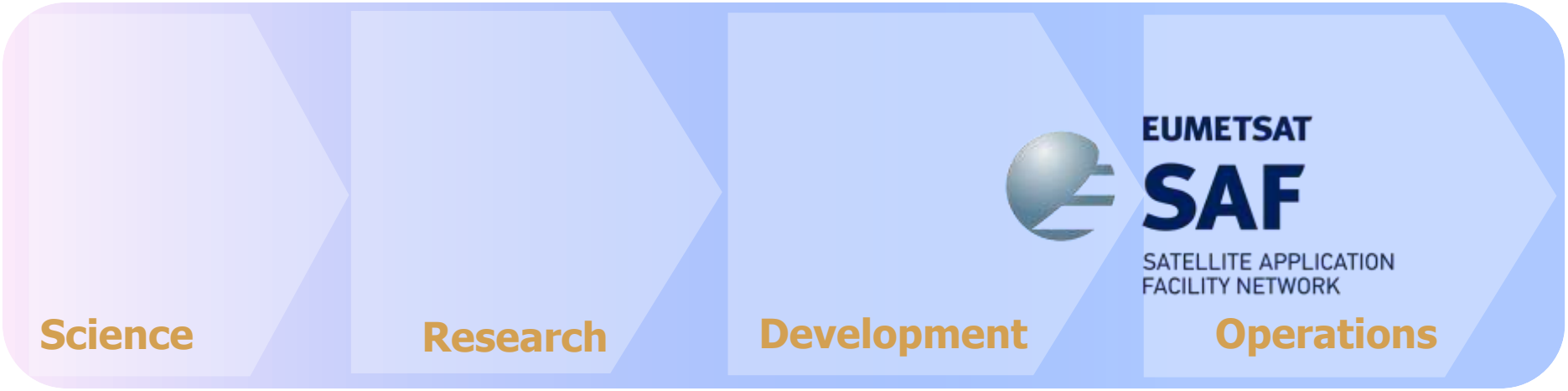
The goal of SAFs is to provide operational products.



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

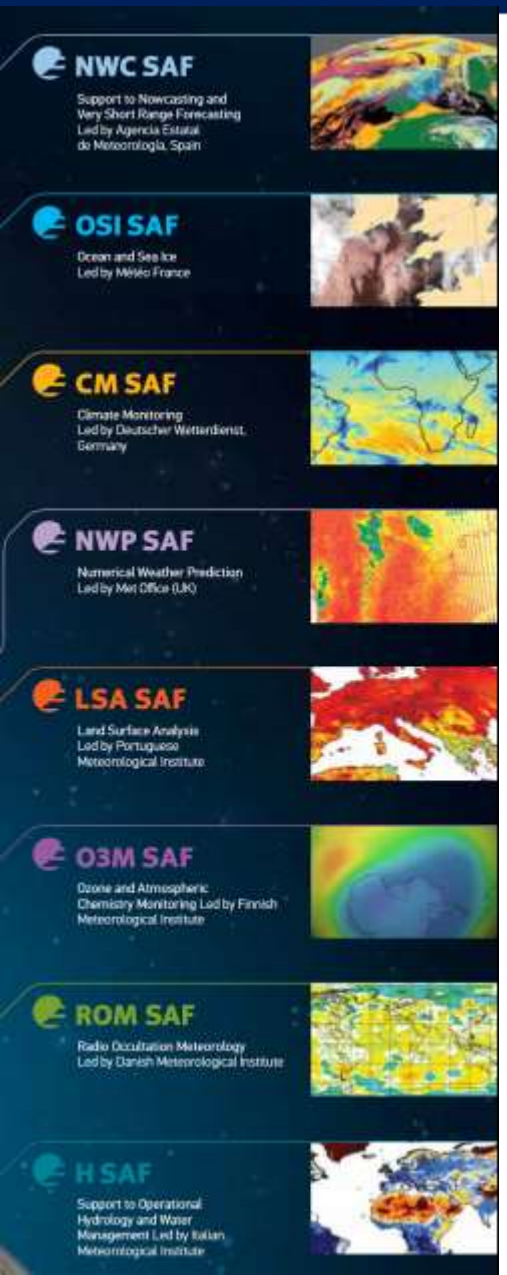
Science, Research, Development and Operations

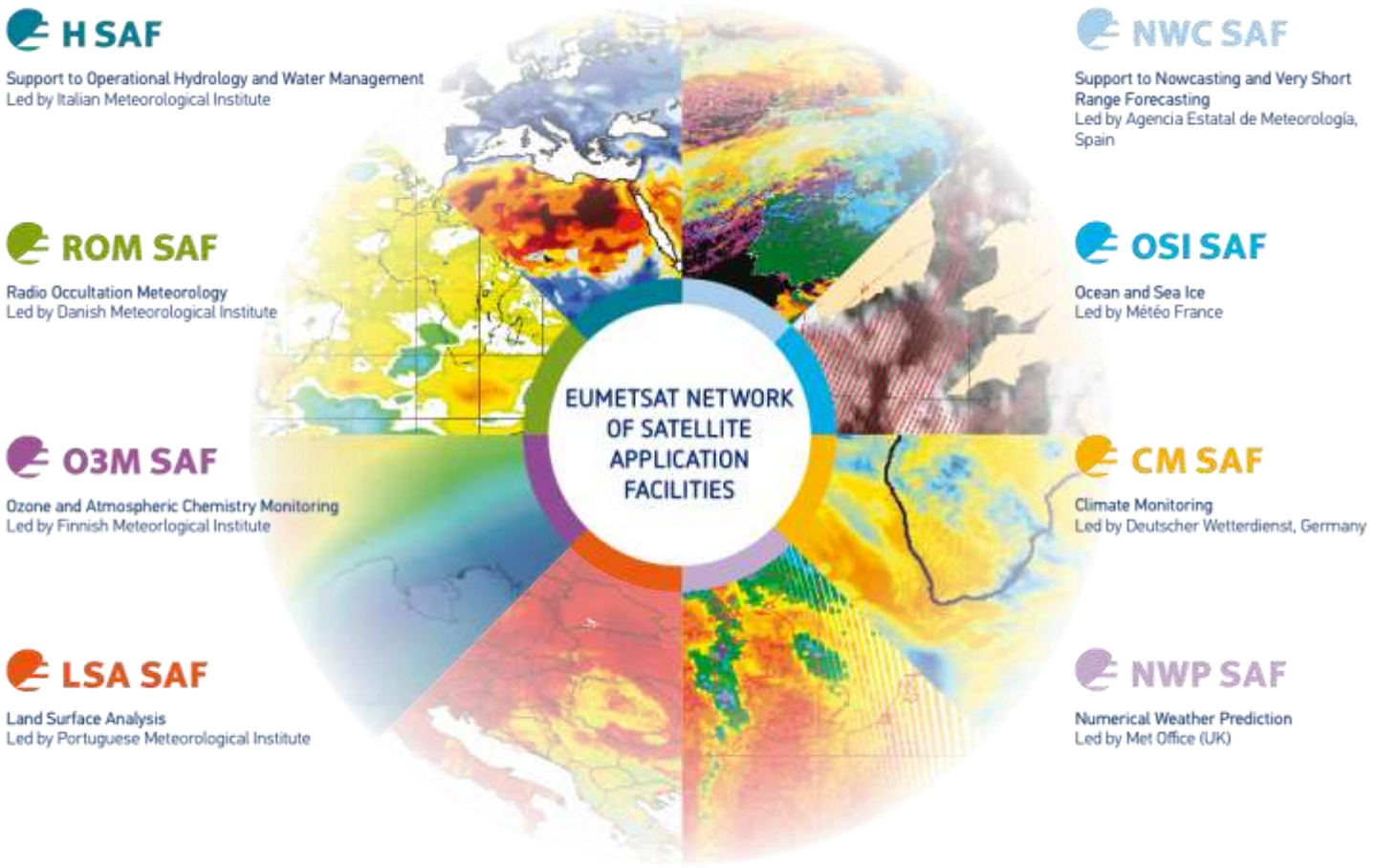
SAF Network Focus is **Development** and **Operations**.



- SAF Network is not a Science/Research Programme however links to and interfaces with Science and Research essential.
- SAF Network provides infrastructure for Implementation of mature science products into SAF operational environment (Research to Operations).

EUMETSAT SAF network across Europe



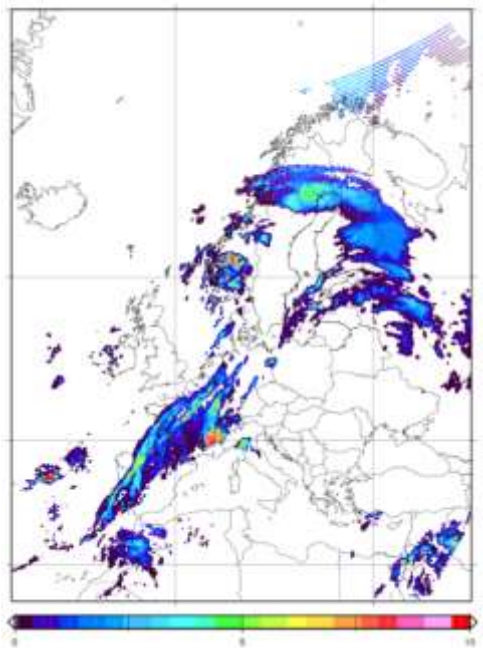


EUMETSAT

Hydrology SAF

- SAF on Support to Operational Hydrology and Water Management
- Leading Entity: Italian Meteorological Service (ITAF Met Service)
- SAF products focuses on
  - precipitation
  - soil moisture
  - snow parameters
  - utilisation of these parameters in hydrological models and NWP







Currently available snow products from H SAF

"operational":

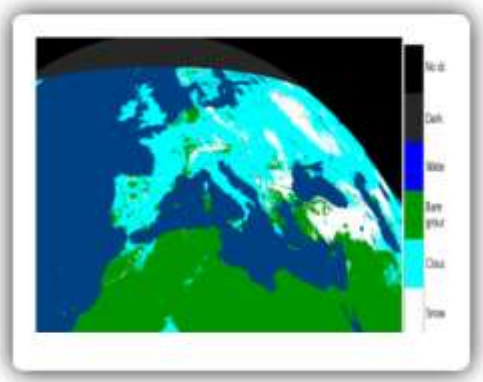
- **Snow detection (snow mask) by VIS/IR radiometry**
- **Snow water equivalent by MW radiometry**

"pre-operational":

- **Effective snow cover by VIS/IR radiometry**
- **Snow status (dry/wet) by MW radiometry**

Finnish Meteorological Institute

Turkish State Meteorological Service



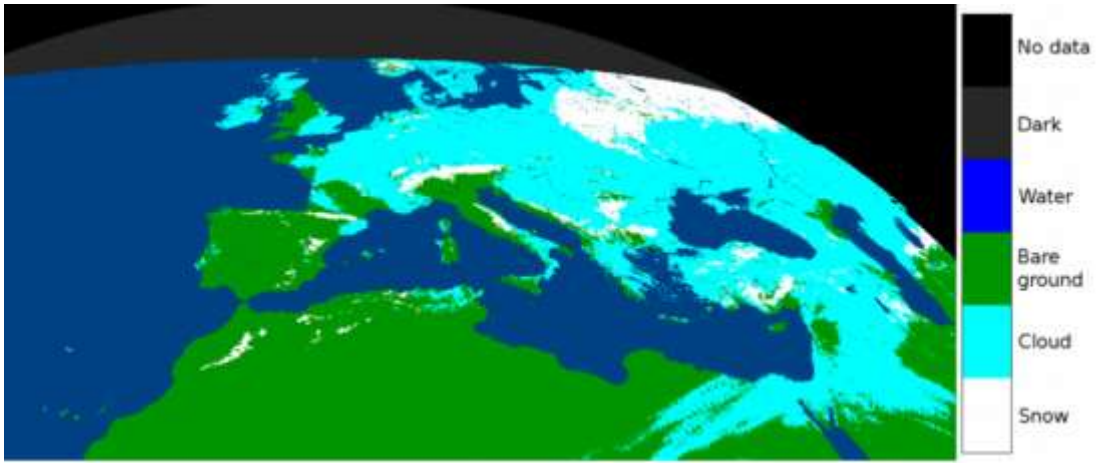


Snow detection by VIS/IR radiometry

- Binary map of snow / no-snow situation.
- Using Meteosat/SEVIRI observation
- Different methods used for flat/forested and mountainous regions
- Daylight product, output result every 24h
- Probability Of Detection (POD):

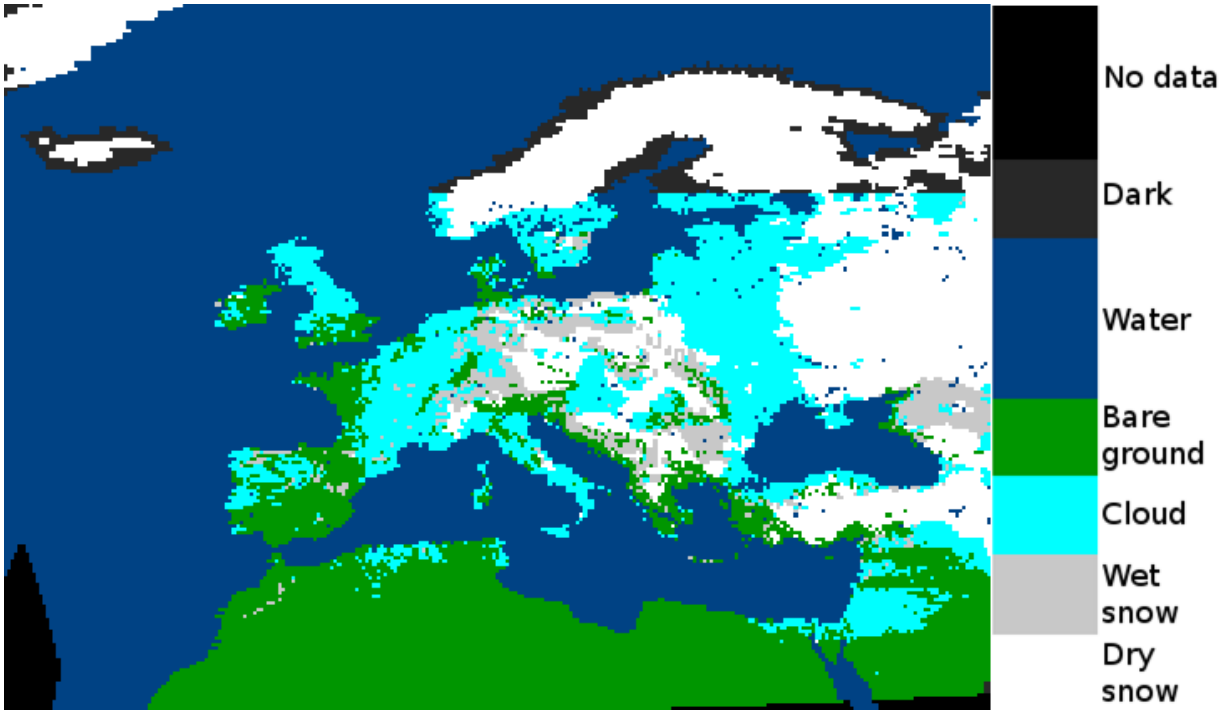
  Flat / Forested areas: 85 % Mountainous areas: 70%
- False Alarm Rate (FAR):

  Flat / Forested areas: 15 %, Mountainous areas: 20%



Snow status (dry/wet) by MW radiometry

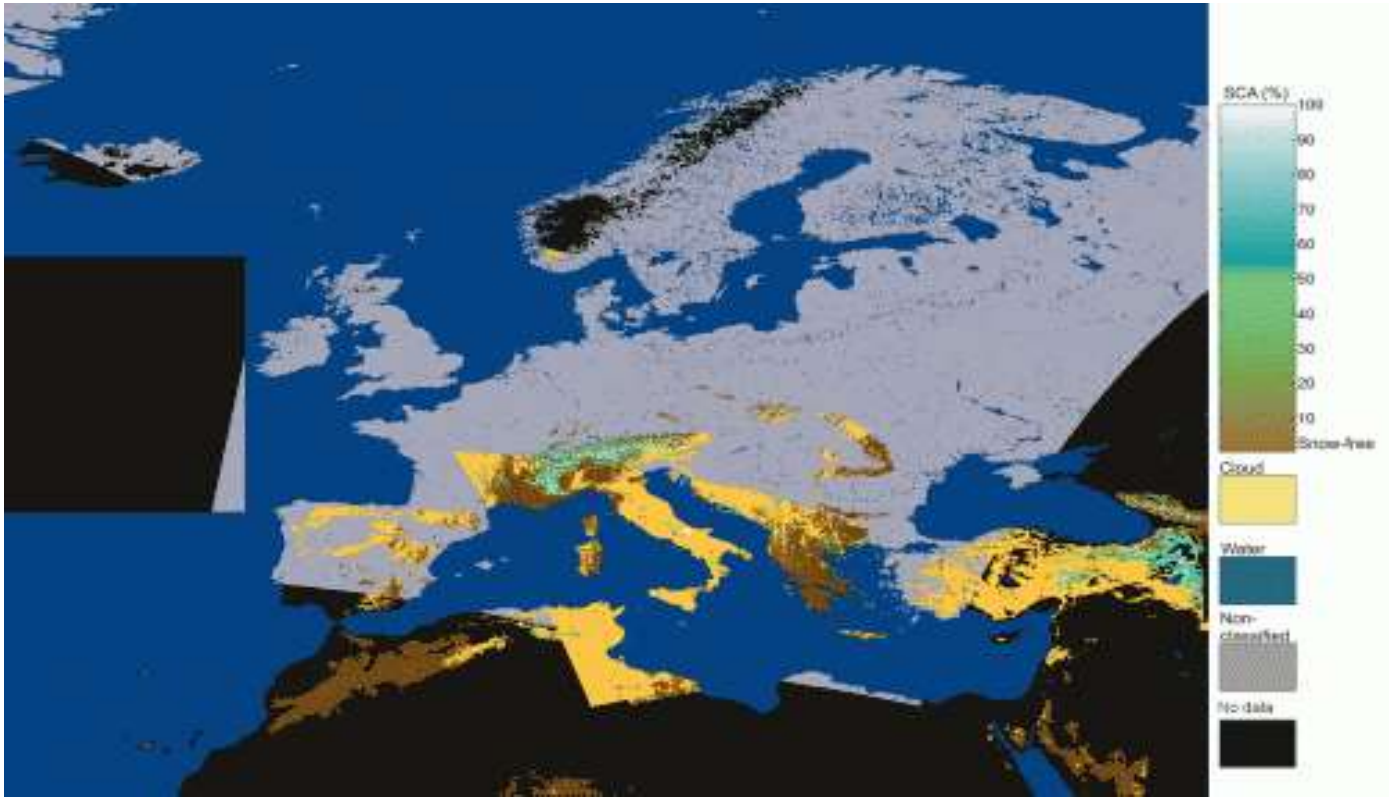
- status of the snow mantle, whether it is wet or dry and, in time series, thawing or freezing.
- Multi-channel MW observations SSMIS on DMSP (middle frequencies), and the algorithm is based on thresholding.
- Requirements:
  - Hit Rate (HR): 80 %
  - False Alarm Rate (FAR): 10 %



28 January 2017

Effective snow cover by VIS/IR radiometry

- Multichannel (VIS, NIR, IR) analysis
- AVHRR on NOAA and Metop satellites
- 0.01° sampling
- Requirement: 20% RMSE.
- Validation against snow observing stations

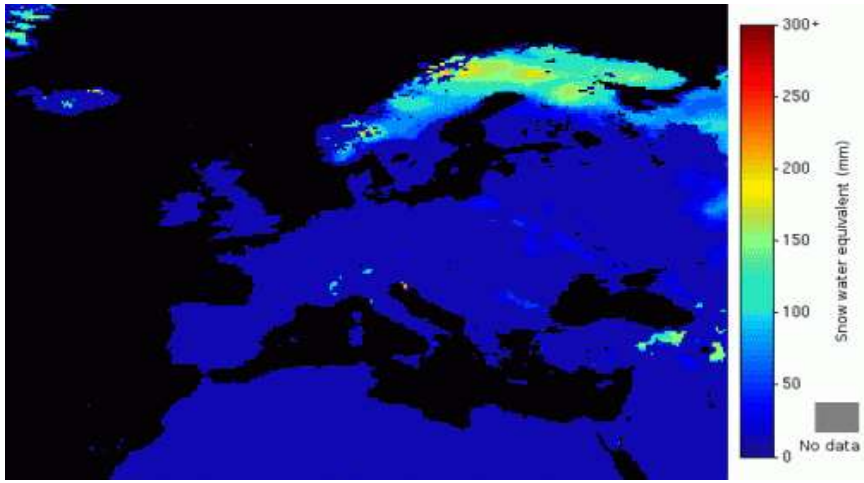


Snow water equivalent by MW radiometry

- Maps of snow water equivalent derived from MW measurements SSMIS on DMSP sensitive to snow thickness and density.
- Algorithm based on assimilating MW brightness temperatures of several channels at frequencies with different penetration in snow, into a first-guess field built by the (sparse) network of stations measuring snow depth.
- Requirements:

  Flat / Forested areas: 20 mm

  Mountainous areas: 25 mm

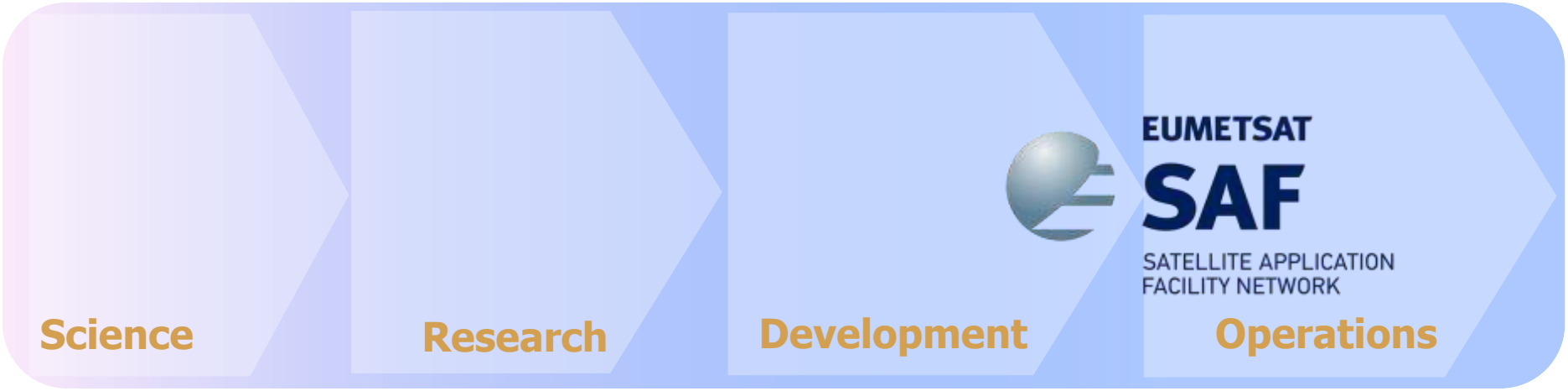


EUMETSAT Snow Portfolio H SAF

SNOW PRODUCTS					
Group	**ID**	**Acronym**	**Product names**	**Input/ Heritage/ Comments**	**Scenario**
CDOP-2 Product	H10	SN-SE-HS	Snow detection (snow mask) by VIS/IR radiometry		(O)
CDOP-2 Product	H11	SN-WS-HE	Snow status (dry/wet) by MW radiometry	(failure of AMSR-E, replaced by SSMIS)	(O)
CDOP-2 Product	H12	SN-ESC-HE	Effective snow cover by VIS/IR radiometry		(O)
CDOP-2 Product	H13	SN-SWE-HE	Snow water equivalent by MW radiometry		(O)
CDOP-2 Product	H31	SN-SE-MS	Snow detection for flat land (snow mask) by VIS/NIR of SEVIRI	SEVIRI based	(O)
New Product on existing GEO/LEO	H32	SN-SE-MS-AVHRR	Snow detection for flat land (snow mask) by VIS/NIR of AVHRR	Metop/AVHRR based	(H)
New Product on existing GEO/LEO	H65	SN-SWE-HH	New Global (hemispherical) SWE 25 km resolution	Existing LEO/GEO SATs	5
New Product on MTG	H43	SN-SE-HS-FCI	Snow detection (snow mask) by VIS/NIR of MTG FCI	MTG	2
New Product on EPS-SG	H85	SN-SE-HS-MI	Snow detection (snow mask) by EPS-SG METimage	EPS-SG MetImage	

Science, Research, Development and Operations

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- SAF Network provides infrastructure for Implementation of mature science products into SAF operational environment (Research to Operations).

Oversimplifications



Oversimplifications

Science



Oversimplifications

Science



Operations



Oversimplifications

Science



Exciting

Operations



Boring

Oversimplifications

Science



Exploring

Freedom

Exciting

Agile

Algorithms

Operations



Requirements

Approval

Boring

Planning

Data

User Requirements

In theory, it's simple:

Users define their requirements and
Data providers: Develop systems that fulfil these requirements

In reality, it's more difficult:

- *Who are the users?*
- *How to approach them?*
- *Who defines requirements ?*
- *Users/developers/provider are separate groups?*
- *How far to consider technology? (not achievable <-> incestuous)*
- *Can users know in advance what they need?*
- *User requirements are not static (as often assumed)*

Requirements

Some quotes:

- *“users want this product” – “?” – “we presented it at our user workshop and there was no complain”*
- “*The product is not compliant with user requirements, but it is still useful“*
- *“We cannot specify any requirements before the validation is completed”*
- *“...but it’s very clear that this algorithm does not work under these conditions”*
- *“we want to reprocess the operational product. The requirements will be the same”*

User Requirements and Product Requirements

Development and Operations driven by users needs

Introduction of an additional category of requirements

User Requirements

- Application specific
- Technology free / ignorant
- Evolving in time with evolving expectations/applications

Product Requirements

- Responding to user requirements (not necessarily identical with them)
- “what makes this product a good (enough) product” ?
- Formulation of the (committing) goals for development and operations)
- Reference for validation
- Reference for decisions on product release, qualification and evolution and the related allocation of resources

Requirements in an operational environment

"Product Requirements" have to be **SMART** :

- **S**: *Specific* — applications, sensors, users
- **M**: *Measureable* — quantitative/qualitative compliance, validation methods
- **A**: *Accepted* — stakeholders (users, funding agencies,..)
- **R**: *Reasonable* — realistic, achievable
- **T**: *Time bound* — goal for a given period

User requirements :

- Helpful to define product requirements
- Provide guidelines and visions
- Provide evidence of acceptability

Requirements evolution: Example Soil Moisture

H16	Large-scale surface soil moisture by radar scatterometer	SM-OBS-3
Type	Product	
Application and users	Operational hydrological units Climatology Research & development activities	
Characteristics and Methods	It refers to the soil moisture content in the surface layer (0.5-2 cm) generated from the Metop scatterometer (ASCAT). It is a coarse-resolution product (25 km), controlled by the instrument IFOV.	
Comments	Existing ASCAT product developed in cooperation between EUMETSAT and TU Wien within CAF	
Generation frequency	On completion of each orbit. Each orbit lasts 101 minutes (orbital period), resulting in ca. 14 orbits/day. Observing cycle over Europe: 36 h (full geographical coverage).	
Input satellite data	ASCAT on Metop	
Dissemination		
Format	Means	Type
Values in grid points of specified coordinates in the orbital projection (BUFR)	FTP, EUMETCast	NRT
Accuracy		
Threshold	Target	Optimal
Correlation coefficient (CC): 0.50	Correlation coefficient (CC): 0.65	Correlation coefficient (CC): 0,80
Validation method	In-situ measurements (e.g. Time Domain Reflectometers (TDR) Output of hydro-meteorological models Satellite data (e.g. SMOS, AMSU, SMAP)	
Coverage, resolution and timeliness		
Spatial coverage	Spatial resolution	Timeliness
global	Resolution: 25 km Sampling: 12.5 km	2 hours

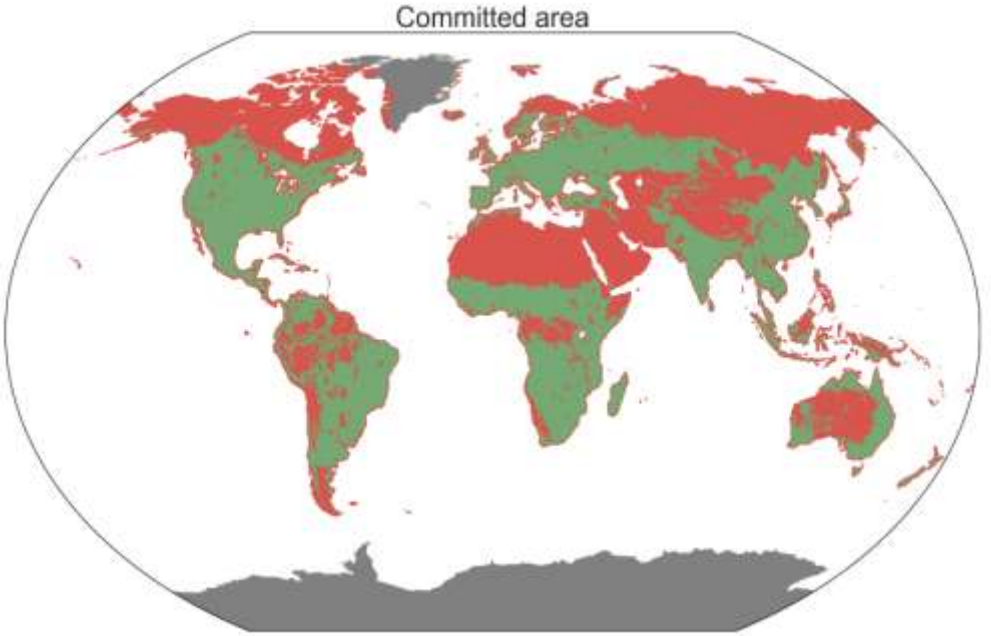
compliance assessement against one number ?

Requirements evolution: Example Soil Moisture

Accuracy commitments/requirements

Restricted to:

- low and moderate vegetation regimes
- unfrozen and no snow cover
- low to moderate topographic variations
- no wetlands and coastal areas



Validation Approach: Triple Collocation Analysis (TCA)

- ASCAT Soil Moisture product
- ERA-Interim
- Passive CCI soil moisture product

Obtained error variances are expressed as Signal-to-Noise-Ratio (SNR) following approach described by Gruber et al. 2016.

Requirements evolution: Example Soil Moisture

H16	Metop-B ASCAT NRT SSM orbit geometry 12.5 km sampling	SSM ASCAT-B NRT O12.5
Type	Product	
Application and users	Operational hydrological units Climatology Research & development activities	
Characteristics and Methods	Soil moisture content in the surface layer (0.5-2 cm) Unit: degree of saturation (0 – 100 %) Commitment and validation restricted to following conditions: • low to moderate vegetation regimes • unfrozen and no snow • low to moderate topographic variations • no wetlands and coastal areas	
Comments	ASCAT product developed in cooperation between EUMETSAT and TU Wien	
Generation frequency	On completion of each orbit. Each orbit lasts 101 minutes (orbital period), resulting in ca. 14 orbits/day. Observing cycle over Europe: 36 h (full geographical coverage).	
Input satellite data	ASCAT on Metop-B	

Dissemination		
Format	Means	Type
Values in grid points of specified coordinates in the orbital projection (BUFR)	FTP, EUMETCast	NRT

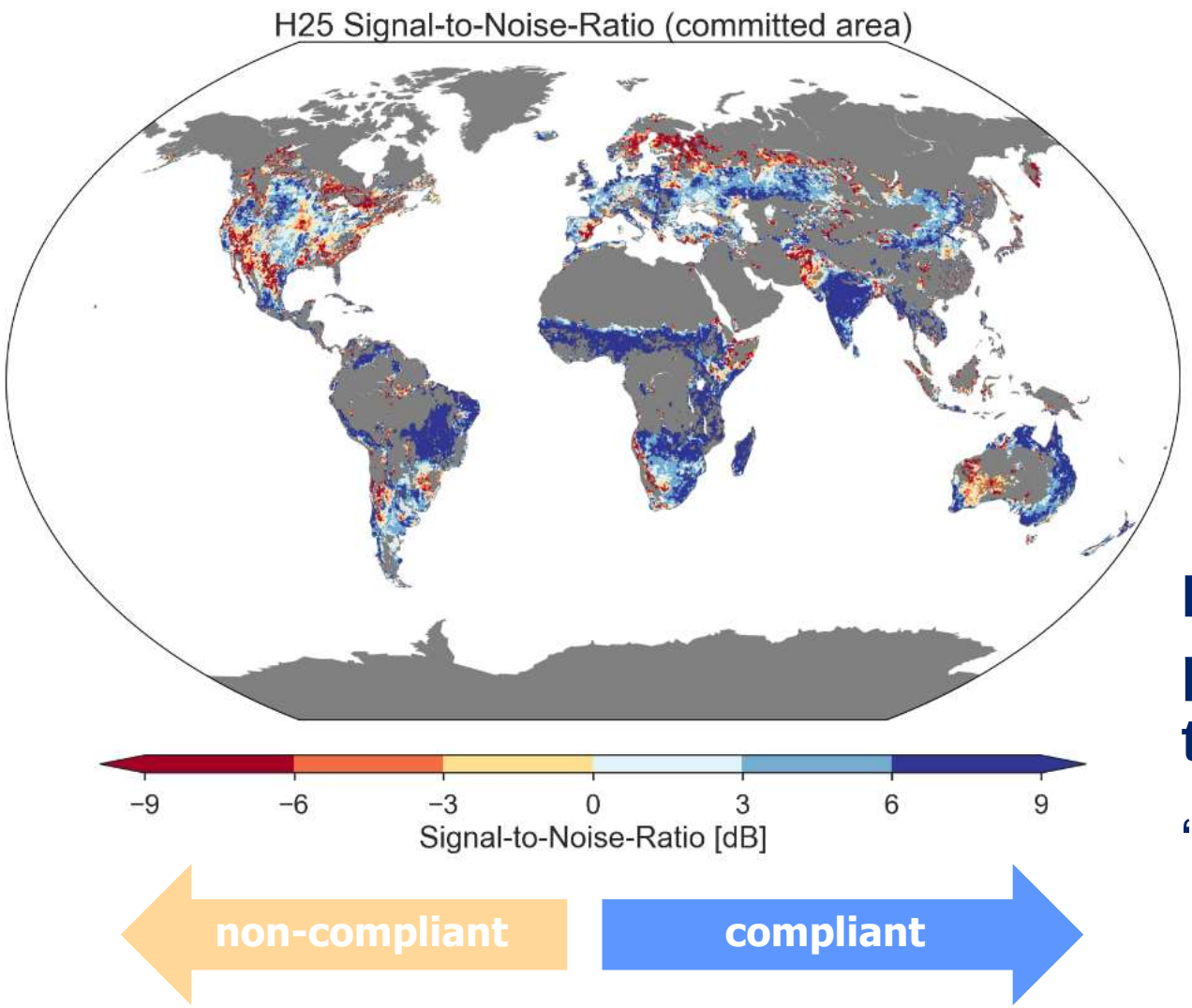
Accuracy		
Threshold	Target	Optimal
Signal to noise ratio: 0 dB	Signal to noise ratio: 3 dB	Signal to noise ratio: 6 dB
Validation method	Triple collocation applied to : • ASCAT SM Product (this product) • Land surface model SM simulation • Passive microwave satellite SM retrievals Additionally in-situ observations, in particular quality controlled, long term sites will be used to confirm the validation results.	

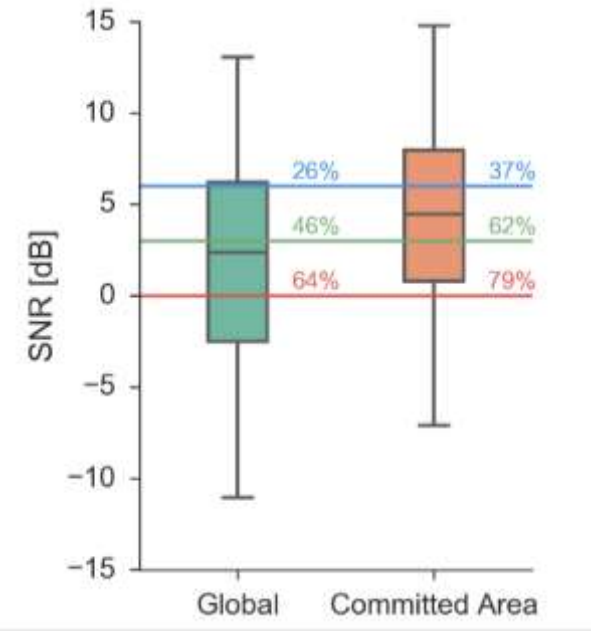
Coverage, resolution and timeliness		
Spatial coverage	Spatial resolution	Timeliness
Global	Resolution: 25-34 km x 25-34 km Spatial sampling: 12.5 km	2 hours

Specifies the constraints of algorithms and sensors

Specifies the validation criteria and methodology

Quality requirements and validation

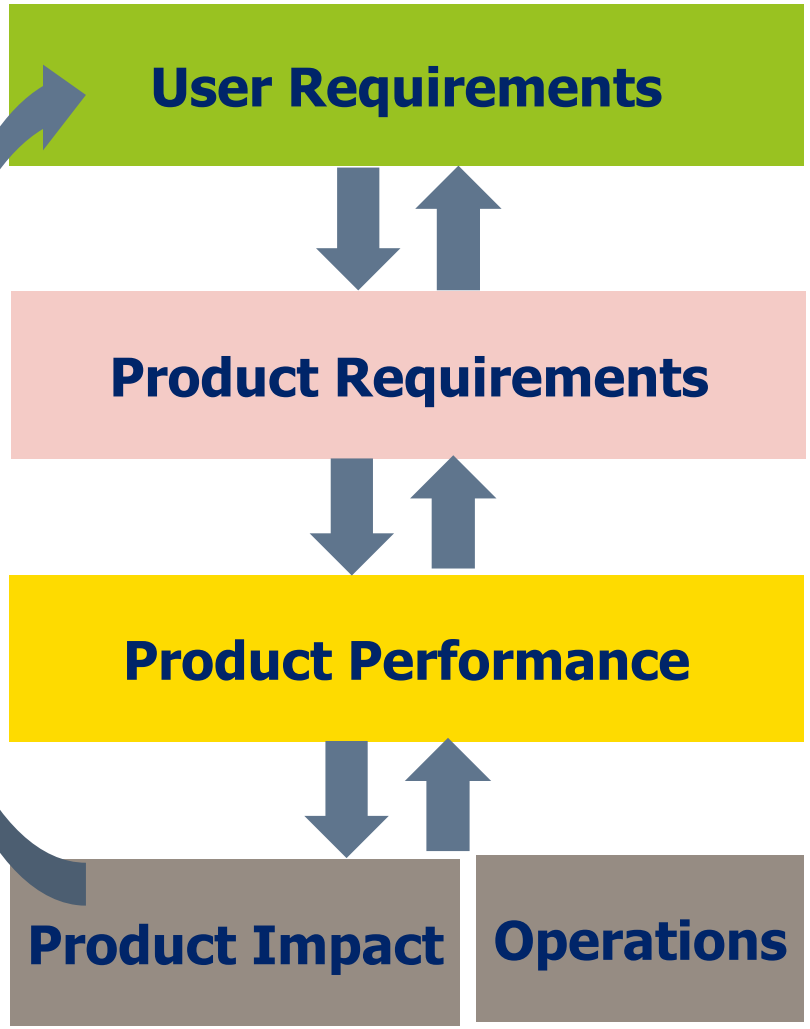




Possible Formulation of product evolution targets:

"increase the blue areas"

Requirements



Planning
"doing the right things?"

RR

Implementation Validation
"Doing the things right?"

ORR

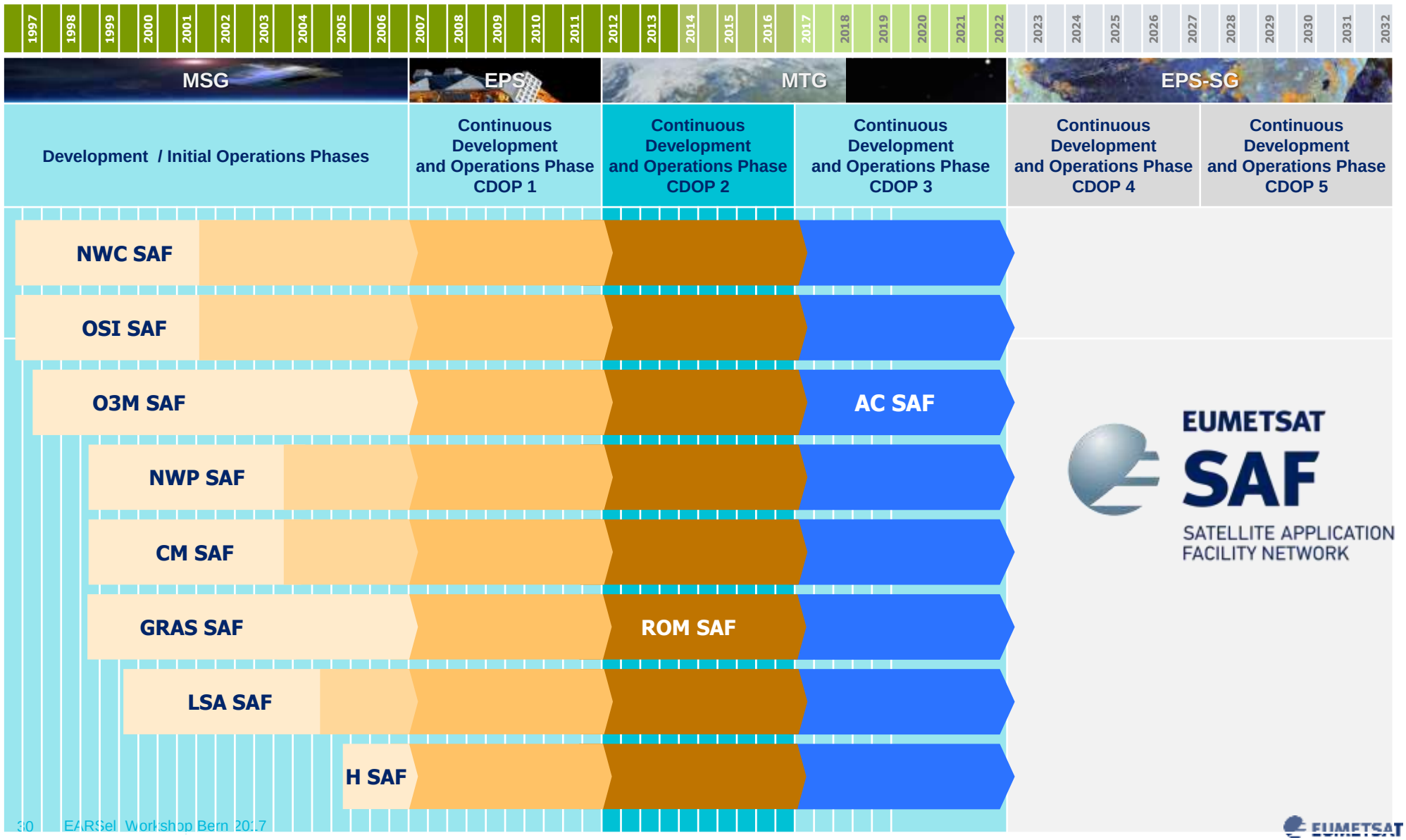
Impact Validation
"Does it help?"

OR

Conclusions

- Efforts in identification, specification, formulation and formalisation of requirements pay off as they lead to the key questions.
- “User Requirements” and “Product Requirements” are different categories. Mixing them creates confusion.
- User requirements provide a framework for specific product planning and commitment (funding). Good formulation and formalisation helps.

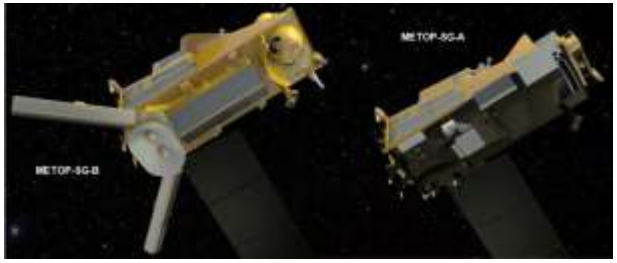
35 years of SAF Development and Operations



SAF Network and EUMETSAT Programmes

- SAFs embedded financially in EUMETSAT Mandatory Programmes beginning with MSG.
- New for CDOP 3: Within MTG and EPS-SG, SAFs have assigned responsibilities for Day 1 products (Council approved).
- Success of Programmes and operational status of satellites depend on SAF developments
- Extensive Interactions Programmes-SAFs to prepare CDOP 3 (e.g. Alignment of processes)





MTG EPS-SG

EUMETSAT