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

DATA CENTRE
EUMETSAT HEADQUARTERS

METEOROLOGICAL PRODUCT EXTRACTION
EUMETSAT HEADQUARTERS

SATELLITE APPLICATION FACILITIES
WITHIN EUMETSAT MEMBER STATES

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
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
- ...
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

**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)

**LSA SAF**
Land Surface Analysis
Led by Portuguese Meteorological Institute

**O3M SAF**
Ozone and Atmospheric Chemistry Monitoring
Led by Finnish Meteorological Institute

**ROM SAF**
Radio Occultation Meteorology
Led by Danish Meteorological Institute

**H SAF**
Support to Operational Hydrology and Water Management
Led by Italian Meteorological Institute
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
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
<table>
<thead>
<tr>
<th>Group</th>
<th>ID</th>
<th>Acronym</th>
<th>Product names</th>
<th>Input/ Heritage/ Comments</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDOP-2 Product</td>
<td>H10</td>
<td>SN-SE-HS</td>
<td>Snow detection (snow mask) by VIS/IR radiometry</td>
<td></td>
<td>(O)</td>
</tr>
<tr>
<td>CDOP-2 Product</td>
<td>H11</td>
<td>SN-WS-HE</td>
<td>Snow status (dry/wet) by MW radiometry</td>
<td>(failure of AMSR-E, replaced by SSMIS)</td>
<td>(O)</td>
</tr>
<tr>
<td>CDOP-2 Product</td>
<td>H12</td>
<td>SN-ESC-HE</td>
<td>Effective snow cover by VIS/IR radiometry</td>
<td></td>
<td>(O)</td>
</tr>
<tr>
<td>CDOP-2 Product</td>
<td>H13</td>
<td>SN-SWE-HE</td>
<td>Snow water equivalent by MW radiometry</td>
<td></td>
<td>(O)</td>
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<tr>
<td>CDOP-2 Product</td>
<td>H31</td>
<td>SN-SE-MS</td>
<td>Snow detection for flat land (snow mask) by VIS/NIR of SEVIRI</td>
<td>SEVIRI based</td>
<td>(O)</td>
</tr>
<tr>
<td>New Product on existing GEO/LEO</td>
<td>H32</td>
<td>SN-SE-MS-AVHRR</td>
<td>Snow detection for flat land (snow mask) by VIS/NIR of AVHRR</td>
<td>Metop/AVHRR based</td>
<td>(H)</td>
</tr>
<tr>
<td>New Product on existing GEO/LEO</td>
<td>H65</td>
<td>SN-SWE-HH</td>
<td>New Global (hemispherical) SWE 25 km resolution</td>
<td>Existing LEO/GEO SATs</td>
<td>5</td>
</tr>
<tr>
<td>New Product on MTG</td>
<td>H43</td>
<td>SN-SE-HS-FCI</td>
<td>Snow detection (snow mask) by VIS/NIR of MTG FCI</td>
<td>MTG</td>
<td>2</td>
</tr>
<tr>
<td>New Product on EPS-SG</td>
<td>H85</td>
<td>SN-SE-HS-MI</td>
<td>Snow detection (snow mask) by EPS-SG METimage</td>
<td>EPS-SG Metimage</td>
<td></td>
</tr>
</tbody>
</table>
SAF Network Focus is Development and Operations.

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Oversimplifications
Oversimplifications
Oversimplifications
Oversimplifications

Science

Exciting

Operations

Boring
Oversimplifications

Science

Operations

Exploring

Requirements

Freedom

Approval

Exciting

Boring

Agile

Planning

Algorithms

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

<table>
<thead>
<tr>
<th>H16</th>
<th>Large-scale surface soil moisture by radar scatterometer</th>
<th>SM-OBS-3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Product</td>
<td></td>
</tr>
</tbody>
</table>
| **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**  
Values in grid points of specified coordinates in the orbital projection (BUFR)  
**Means**  
FTP, EUMETCast  
**Type**  
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 assessment 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

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<tr>
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<th>Application and users</th>
<th>Characteristics and Methods</th>
</tr>
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<tbody>
<tr>
<td>Metop-B ASCAT NRT SSM orbit geometry 12.5 km sampling</td>
<td>Operational hydrological units, Climatology, Research &amp; development activities</td>
<td>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</td>
</tr>
<tr>
<td>SSM ASCAT-B NRT 012.5</td>
<td></td>
<td>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</td>
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<td>Comments</td>
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<td>Input satellite data</td>
<td>ASCAT on Metop-B</td>
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</tr>
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### Dissemination

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### Accuracy

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<th>Threshold</th>
<th>Target</th>
<th>Optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal to noise ratio: 0 dB</td>
<td>Signal to noise ratio: 3 dB</td>
<td>Signal to noise ratio: 6 dB</td>
</tr>
</tbody>
</table>

### 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

<table>
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<tr>
<th>Global</th>
<th>Spatial resolution</th>
<th>Timeliness</th>
</tr>
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<tr>
<td>Resolution: 25-34 km x 25-34 km</td>
<td>Spatial sampling: 12.5 km</td>
<td>2 hours</td>
</tr>
</tbody>
</table>

Specifications the constraints of algorithms and sensors

Specifications the validation criteria and methodology
Quality requirements and validation

H25 Signal-to-Noise-Ratio (committed area)

Possible Formulation of product evolution targets:

“increase the blue areas”
Requirements

User Requirements

Product Requirements

Planning
"doing the right things?"

Implementation
Validation
"Doing the things right?"

Impact
Validation
"Does it help?"

Operations

Product Performance

Product Impact

ORR

OR

RR
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

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
- LSA SAF
- H SAF

EUMETSAT SAF
SATELLITE APPLICATION FACILITY NETWORK
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)