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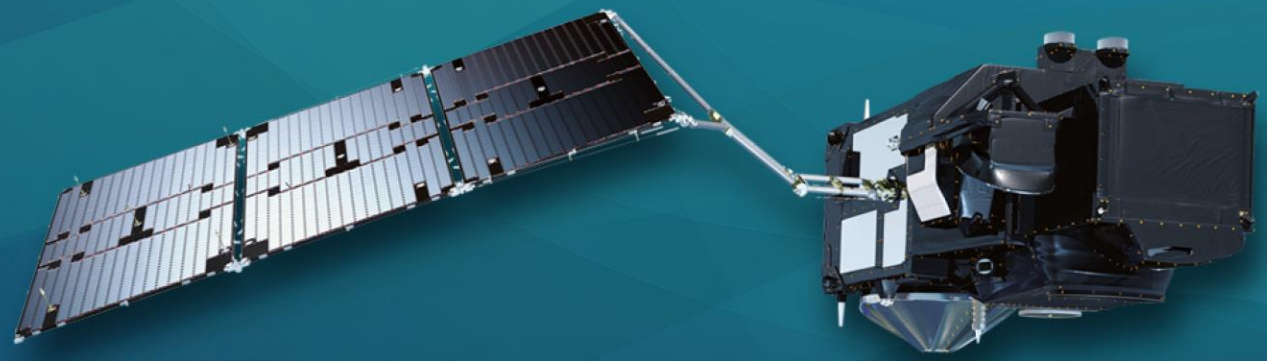

9th Sentinel-3 Validation Team meeting 2026

30 March–01 April 2026 | ESA–ESRIN | Frascati (Rome), Italy

Plans for the development of NRT Level-2 Clouds products in Copernicus Sentinel-3

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*1 - EUMETSAT (Germany); 2 - LOA (France); * - formerly EUMETSAT (Germany), now ESA-ESRIN (Italy)*

Context

- Many Sentinel-3 cloud mask algorithms in the community (→ primarily tailored to L2 Marine / Land application), e.g.:
  - Bayesian Cloud mask (in L1 SLSTR product for L2 SST – SLSTR-based)
  - Naïve Probabilistic Cloud/Aerosol detection (part of the L2 NRT AOD processor – SLSTR-based)

  But no dedicated NRT L2 Cloud products yet…

EUMETSAT is now entrusted by Copernicus and Member States to build the Sentinel-3 NRT Cloud portfolio dedicated to Cloud expert users, NWP and Meteo services, as much as possible relying on Sentinel-3 multi-spectral synergy.

To that end, in the past years, EUMETSAT lead some preparatory Phase 1 activities:

- Science studies in the previous years at EUMETSAT (existing prototypes available)
- Internal developments.
- Regular interactions with many cloud physics experts in the scientific community
- Connection with the EUMETSAT operational cloud missions & lessons learned: e.g. EPS-SG, MSG / MTG, etc…

Science study: Cloud Top Pressure from OLCI O2-A (OCTPO2)

Collaboration: Spectral Earth GmbH

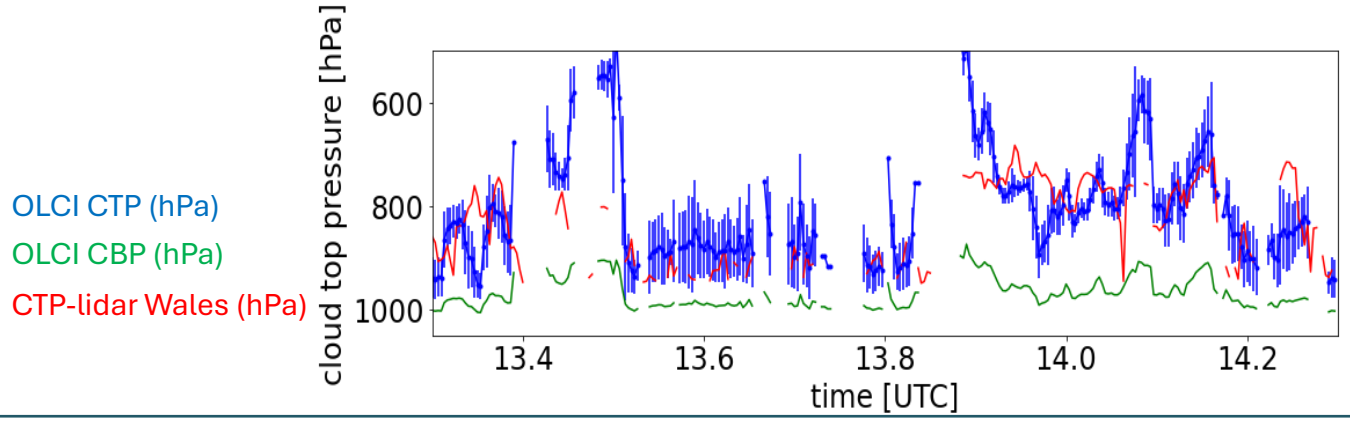
Prototype available internally at EUMETSAT: https://www.eumetsat.int/S3-OLCI-CTP

Use of 5 OLCI channels: (Oa12, Oa13, Oa14, Oa15, Oa16)
Three in the O2 A-bands, two as window channels

- 1d-Var approach using full uncertainty and full spectral harmonization
- OLCI L1B TOA radiances
- MODIS Land Surface Reflectivity climatology

→ Derivation of Cloud Top Height/Pressure + uncertainties

Extensive validation.



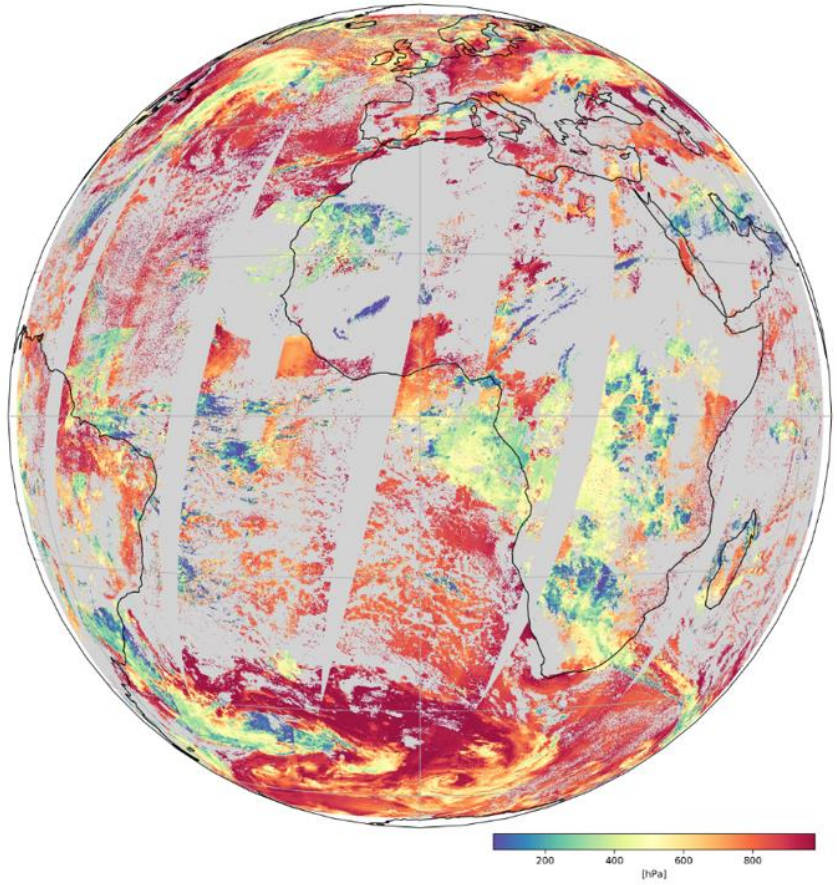


Figure 26: Cloud top pressure, derived from OLCI on the 18th of February 2020.

Science study:
SYNergy Cloud Mask and obstruction

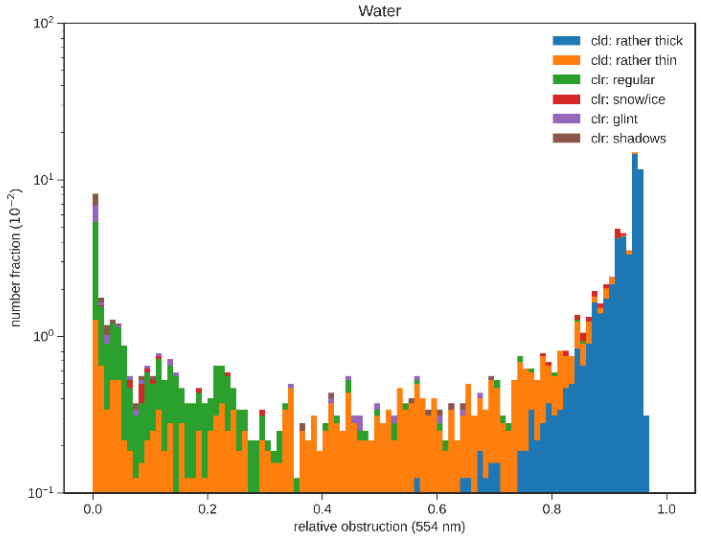
Collaboration: Brockmann Consult GmbH, Spectral Earth GmbH, GRASP SAS

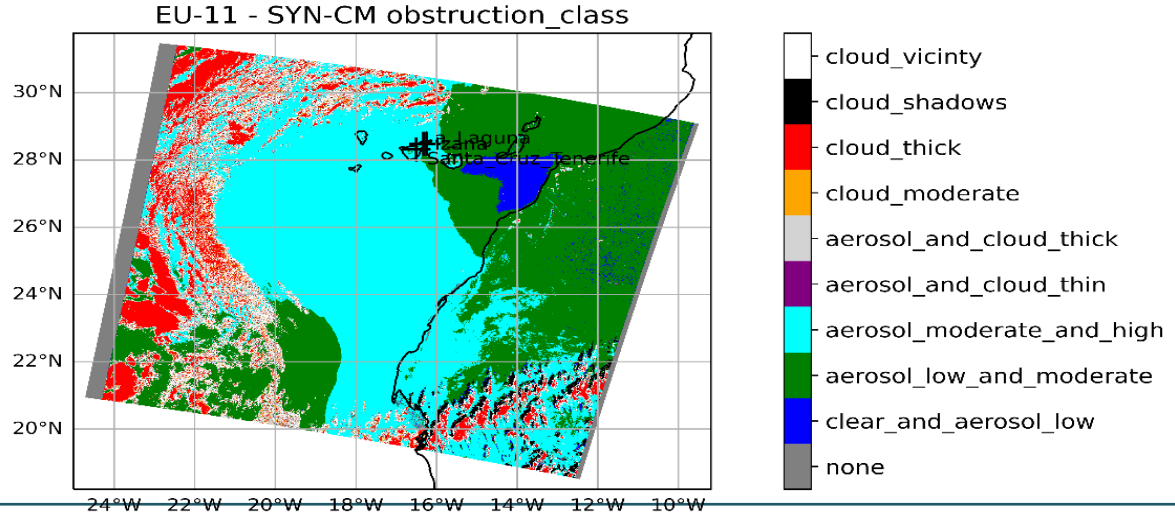
Prototype available internally at EUMETSAT + information available in: https://www.eumetsat.int/S3-synergy-cloud-mask

- Use of SLSTR L1B / OLCI L1B in a synergistic way
- Obstruction defined as *perturbation of a signal due to the presence of cloud particles*
- Optimal estimation with nD-interpolation for computation of Forward & Jacobians *(Rodgers, 2000)*

→ Retrieval of COD, optical properties, CTP,
=> Derivation of spectral obstructions

→ Obstruction classes and cloud/clear classes





Internal EUMETSAT development: Naïve Probabilistic Cloud/Aerosol Detection

- Implementation by E. Martins, J. Chimot (2023):
  - Motivated by urgent needs to enhance the discrimination of cloud perturbation (leading to AOD outliers) and medium / high aerosol plumes., maximising the exploitation of both Solar & TIR channels.
  - Capitalizing on lessons learned: MODIS, VIIRS, PMAP / AVHRR, MetImage / EPS-SG (credits L. Spezzi)

Reference cloud masking for **S3 NRT AOD** and the SLSTR-based directional Land Surface Reflectivity (**LSR) auxiliary database**

➔ **1st step: Application of state-of-the-art VIS-NIR-SWIR tests with naïve thresholds**

➔ Goal: Focus on contradiction between clouds vs. aerosols & clear-sky ocean spatial & spectral properties

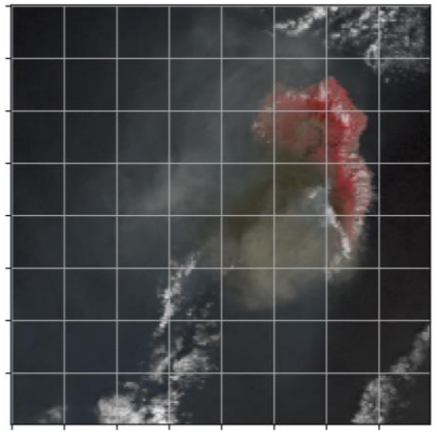
Thresholds derived from
- Selected expert cases
- Stat. analyses from PDF

➔ **2nd step:** Naïve **decision tree**

➔ Goal: apply a rational cloud-free vs. cloudy decision, Intended as not over-complex w.r.t. operational aerosol needs.

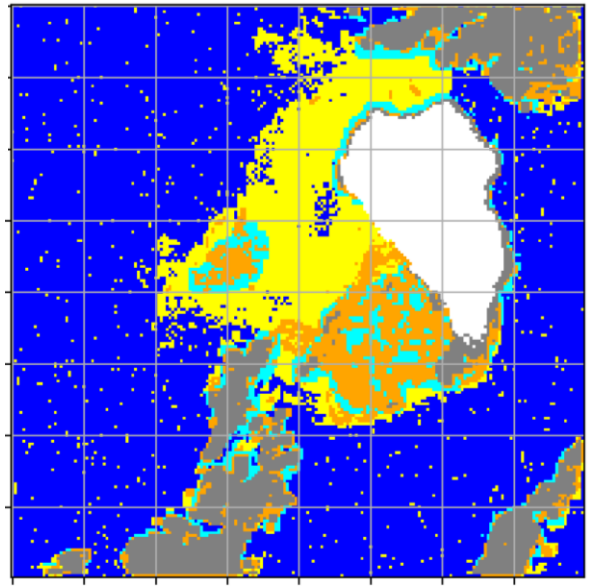
➔ **3rd step: Aerosol-restoral test (Dust & ashes)**

➔ Goal: To correct potential cloud ambiguities due to heavy dust / ash load.



Above Oceans

Ash Canaria island volcano



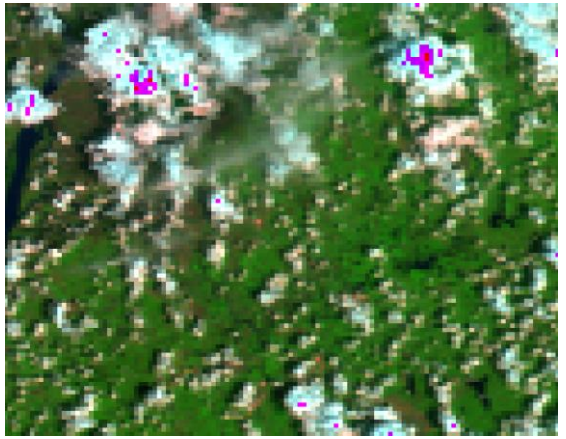
Internal EUMETSAT development: Naïve Probabilistic Cloud/Aerosol Detection

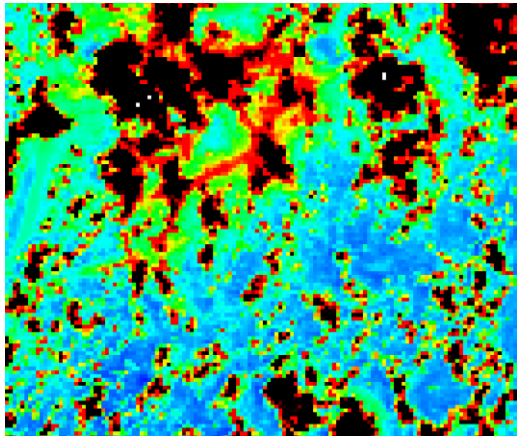
- Internal EUMETSAT developments (J. Chimot):
- Capitalizing on lessons learned: MetImage / EPS-SG (credits L. Spezzi)

→ Relying on dynamic land type identification with AFRI

Similar methodology (tests and decision tree)

Above Lands





- **Remark:**

Evaluation of all tests + thresholds (for Above Lands & Oceans) of the prototype with use of SLSTR L1B at the moment:

→ ongoing evolution of the Naïve Probabilistic Cloud/Aerosol prototype

towards the use of the Synergy NRT L1C product (under development by the L1 expert team at EUMETSAT)

SLSTR Atmospheric Motion Vectors Product

- Operational since **24 November 2025**.
- AMV products provide estimations of the wind at mesoscale, based on the same algorithm as for EPS-AVHRR.
- The purpose is to provide winds to meteorological services in polar areas during the transition EPS -> EPS-SG.
- A ECMWF impact study shows that the SLSTR AMVs have a positive impact on numerical weather prediction in the absence of AVHRR AMVs.
- The performance is in line with the WMO requirements for horizontal wind data, with a RMSE on wind speed below 5 m/s.

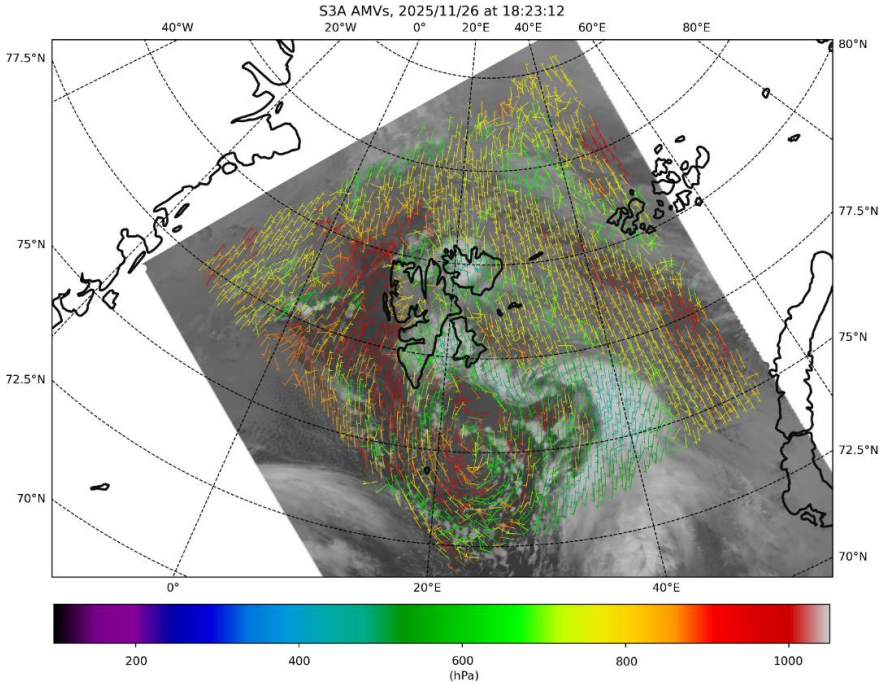


Figure: SLSTR AMVs (colour based on height in hPa) and brightness temperatures in band S8 (grey) around Svalbard, on 26 November 2025 at 18:23:12 UTC..

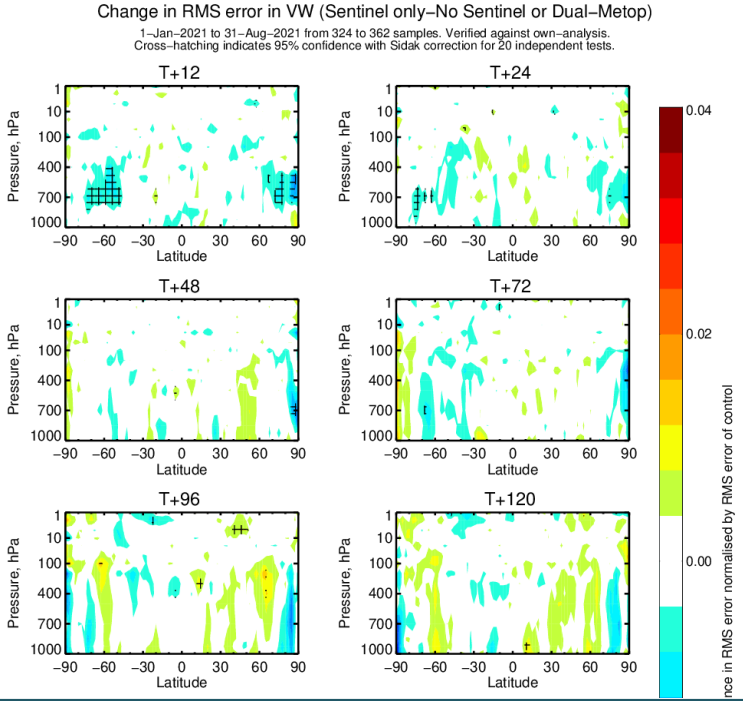


Figure: impact of SLSTR AMVs in the absence of AVHRR AMVs. Courtesy of Francis Warrick @ ECMWF.

Plans towards the use of L1C SYNERGY product

- Current cloud-masks/screening in S3 L2 NRT Atmospheric processors are based on channels from one sensor (AOD, Fires, AMV, TCWV)

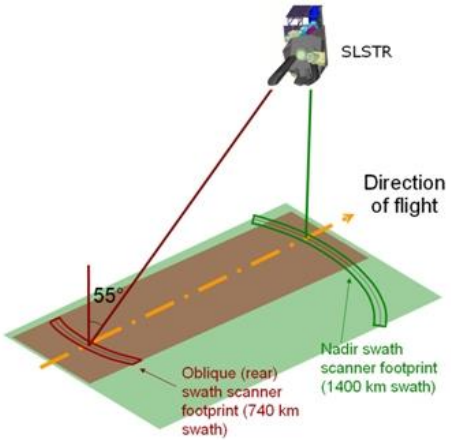
- Major advances in the development of NRT L1C SYNergy product led by EUMETSAT (prototype v3.2, intended to be OPErational)

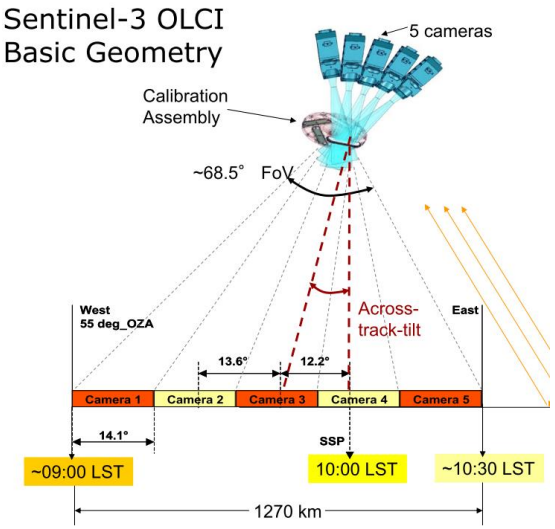
  → **Major input for the extension of the whole S3 NRT Atmosphere portfolio**

- The **use of the NRT L1C SYNergy product is envisioned for the S3 NRT Cloud products**

- Challenges:
  - different observation geometries,
  - impact / benefits of interpolated SLSTR radiometry on OLCI-grid
  - parallax effect

OLCI λ [nm]		SLSTR λ [nm]
400	VISIBLE	
412.5		
442.5		
490		
510		
		555
560.0		
620.0		
		659
665.0		
673.75		
681.25		
708.75		
753.75		
761.25		
764.375		
767.5		
778.75	NIR	
865		
885		868
900		
940	SWIR	
1020		
	TIR	1375
		1613
		2250
		3742
		10854
		12022





Phase 2 starting – Towards S3 NRT Cloud portfolio

- **Collaboration with LOA (J. Riedi team) in Q2 2026 - S2CLOP EUMETSAT project (A. Bozzo):**
  - Optimization of the decision tree and all tests/thresholds of the Naïve Probabilistic prototype by ML techniques
  - Validation of the Naïve Probabilistic prototype with the GEO/LEO match-up framework

- **Extension of the Naïve Probabilistic prototype to future processors:**
  - Addition of OLCI-based tests for smoke detection above Oceans for future Day-3 of the S3 NRT AOD processor
  - Ongoing tests with the S3 NRT ALH internal prototype (collaboration: M. De Graaf (KNMI), J.Chimot & D. Malik (EUM))

- **Optimizing the S3 SYN Cloud Mask prototype (in the upcoming years):**
  - Improve and assess performance by directly using the future L1C SYNergy product (still under development)
  - Use of the Land Surface Reflectivity as auxiliary (collaboration: P. Litvinov (GRASP))
  - Assess quality of the retrieved cloud parameters (COD, CTP, COG, CER, etc.)

- **Development of operational NRT cloud products suite (COD, CTP, CER…):**
  - support to operational users (e.g., meteorological agencies)
  - support to S3 NRT AMV products (identification of cloud patterns + CTP for their tracking)

- **Preparation of the validation:**
  - intercomparison with other space-based products (from L2A/B EarthCARE, MTG/FCI…)
  - validation towards ground-based networks (EARLINET, ACTRIS…)

Preparation of scientific framework for S3 NRT Clouds

- **Recommendation of products from Cloud experts**
  - Possibilities with passive imagery (SLSTR + OLCI)
  - User needs

- Selection of **suitable inputs and auxiliaries**
  - Use of L1C SYN as main input (→ **very important user feedback** for the ongoing developments of L1C SYN product)
  - Use of LSR and definition of additional auxiliary files
  - Important user feedback

- **Evaluation and validation of the S3 Cloud products**
  - Use/Integration of the GEO-LEO tool (Collaboration with J. Riedi – LOA, France)
  - Creation of quality control tools for each cloud product (match-ups, inter-comparisons, time series…)

- **Towards the development of future S3 Cloud products**
  - Use of existing prototypes from previous studies: OCTPO2, SYNergy Cloud Mask
  - Identification of technical bottlenecks of the prototypes
  - Optimization of these prototypes by mitigating their current limitations with resources: computation time, memory…

Outcome & perspectives

EUMETSAT is preparing the development of the S3 NRT Cloud portfolio with extension to S3-NGO

- Existence of **scientific prototypes** – OCTPO2, SYN-CM, Naïve Probabilistic Cloud/Aerosol Mask to be optimised and further exploited
- **Needed feedback from Cloud experts** on the current **L1C NRT SYNergy product** (for future tailoring of S3 NRT Clouds products)
- **Collaboration to be continued with experts** for definition/consolidation of S3 NRT Clouds products
- New **science procurement to be issued** during the next Quarter