SATACI

SATACI: Satellite observations to improve our understanding of aerosol-cloud interactions

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Project Objectives

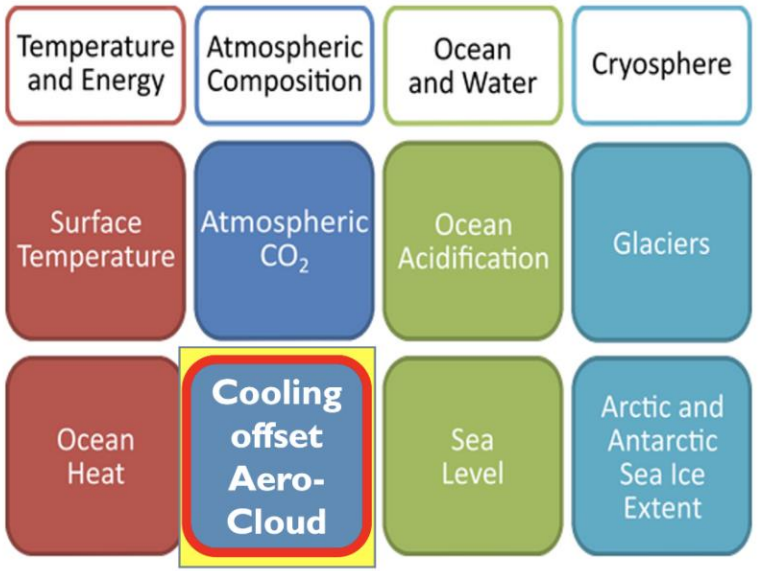
- SATACI is one of the successful studies funded in the framework of the **x-ECV** Climate Space theme.
- **Objective:** deepen our understanding of aerosol-cloud interactions and the associated Radiative Forcing, capitalising on the heritage from the **aerosol and cloud CCI** projects, while ensuring close collaboration with climate modelling (MetNO/NorESM).
- Timeline: **2024 - 2027**.
- SATACI is part of the **ACI-cluster** together with CERTAINTY, CleanCloud and Airsense

Skeleton overview of the approach

- Three main activities will be performed during this 3-year study:
  1. **Analysis of aerosol indirect effects on liquid clouds;**
  2. **Impact of dust concentration and cloud glaciation temperature;**
  3. **Feasibility study for a new aerosol-cloud climate indicator.**

- A method to test the usefulness of the outcome of these studies will be proposed, using the Norwegian Earth System Model (NorESM) model (Seland et al., 2020).

- Statistics obtained from regional satellite observations (1 & 2) will be compared with the climate indicator results for overlapping regions/periods.



Addition of the new aerosol-cloud cooling offset to the WMO climate indicators

ECVs being used

CISAR / SEVIRI	Provides (FM)AOD at hourly temporal resolution with pixel-level uncertainty. Ability to retrieve aerosol properties near clouds increases spatial coverage.
ORAC / SEVIRI	Optimal estimation retrieval providing both aerosol and cloud properties (AOD, COD, CER, cloud fraction, cloud phase) with pixel-level uncertainties at high temporal resolution (~15 min).
CLAAS-3	Long-term SEVIRI cloud climate data record providing COD, CER, CDNC, cloud fraction, and cloud phase with pixel-level uncertainties and strong validation against reference datasets.
RAL IMS Scheme Dust Product	Infrared-based mineral dust retrieval with all-sky capability and pixel-level uncertainty, enabling dust observations even in the presence of clouds.
C3S Aerosol Product	Provides a harmonised long-term global record of (FM)AOD from dual-view sensors, polarimetric retrieval of AOD, FMAOD, and SSA, DAOD and DALH from infrared observations with uncertainty estimates.
MODIS Terra 6.1 Dark Target	Long, consistent global aerosol record (2000–present) widely validated against AERONET and used as a community reference for aerosol climatology.
MODIS MCD06 COSP Cloud	Provides globally gridded cloud variables (CF, LWP, CDNC) derived from MODIS Level-2 retrievals; extensively validated and widely used for climate applications.
C3S / CCI ATSR-SLSTR Cloud Product	Multi-decadal cloud climate data record (1997–2023) retrieved with CC4CL/ORAC algorithm ensuring temporal consistency across sensors.
Cloud_CCI SEVIRI	Physically consistent retrieval of cloud properties with pixel-level uncertainty. It includes a ML-based retrieval providing internally consistent cloud phase and CTT with pixel-level uncertainty at 15 min resolution.

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Analysis of aerosol indirect effects on liquid clouds

ECVs being used

Impact of dust concentration and cloud glaciation temperature

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ECVs being used

Feasibility study for a new aerosol-cloud climate indicator

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ECVs being used

- **Strengths**
  - Existing validation and uncertainty characterisation.
  - Appropriate temporal and spatial resolution depending on the application.
  - Dataset accuracy is considered appropriate for each application.
  - Well-characterised biases can be corrected
- **Weaknesses**
  - Missing vertical information.
  - Substantial variability exists among the C3S IASI dust products.
  - SSA measurement only available with limited temporal coverage.
- **Wishlist on how to improve ECVs**
  - Keep investing in improving retrieval algorithms to reduce uncertainties in ACI estimates.
  - Continue efforts to merge/harmonise existing products to improve stability and reduce bias.
  - Include vertical information from EarthCare
  - Exploit new missions in combination with historical datasets to obtain LTDR of relevant variables.

Results & relevance to the CCI community

- **Co-located aerosol and cloud observations** are essential for robust ACI estimates.
- Strong dependence of CDNC–aerosol sensitivity on time lag, highlighting the importance of **temporal** collocation
- High **dust** loading tends to reduce **liquid cloud fraction** and promote earlier glaciation, but results show large spatial variability.
    - Strong regional and regime dependence (land/ocean, convective vs stratiform clouds).
    - Correlations change when restricting to lower CTT (< −10° C).
- The feasibility study for a new **climate indicator** allows monitoring ACI-related forcing via satellite-derived aerosol and cloud variables, demonstrating the potential for **long-term CCI datasets** to support climate indicators.

Upcoming publication
Luffarelli et al., 2026, Fit-for-purpose assessment of satellite aerosol and cloud datasets for constraining and monitor aerosol–cloud interactions, in preparation

Webpage: *https://climate.esa.int/en/Cross_ECV_Projects/sataci/*