Airborne EarthCARE Campaigns Overview

J. v. Bismarck, R. Koopman, M. Pinol-Sole, et Al.

Airborne Validation for EarthCARE

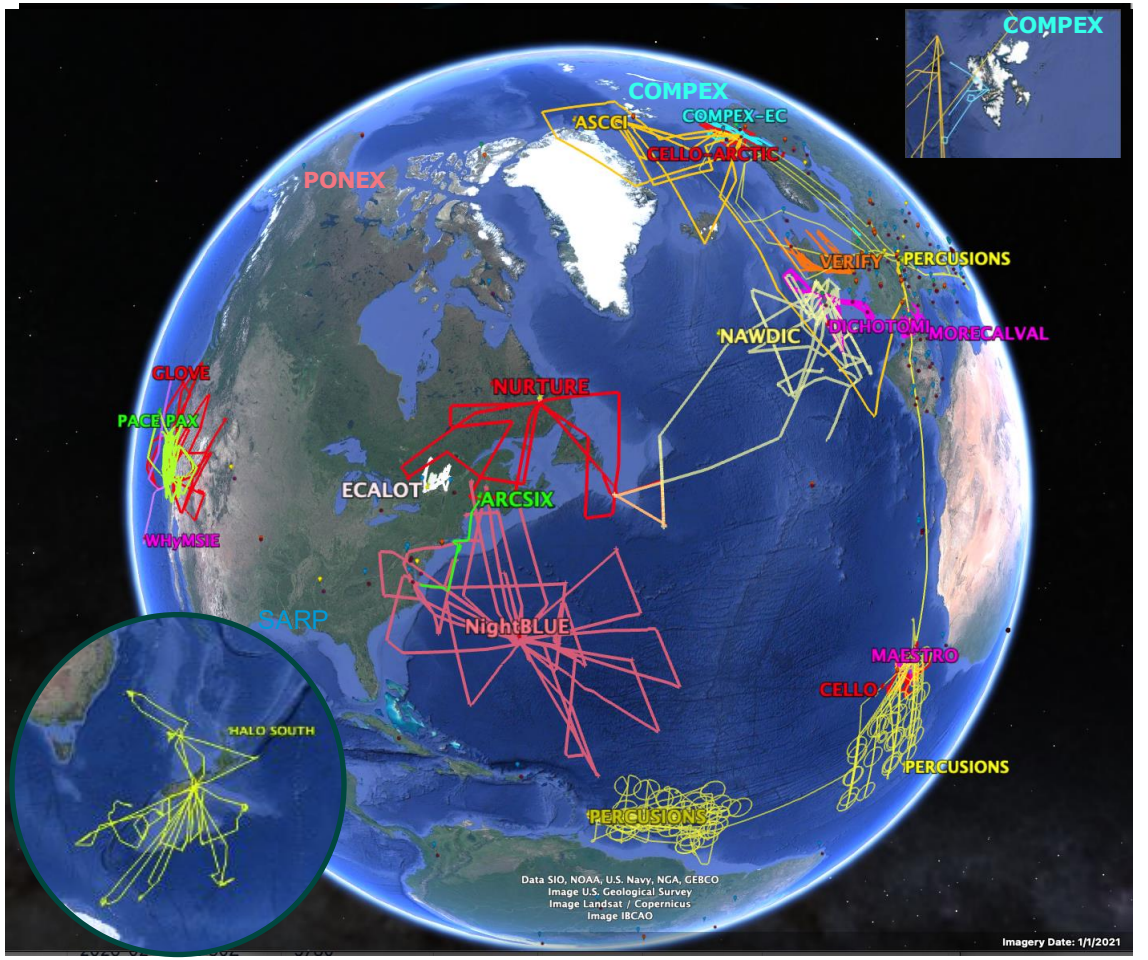
- Identified as extremely suitable approach, fulfilling the complex validation needs (SVIP).
- Airborne campaigns provide an abundant number of matchup samples! Complementary to ground based and network long-term measurements
- International joint effort of nationally and agency supported activities for the validation of ESA and JAXA products

- Target Scenarios : Discuss the evolution with us
- Datasets : Uploaded to EVDC (ESA's atm. Validation Data Center)

EarthCARE Underflights for Science and Validation - Record Breaking Statistics

Currently **144** flights under **137** orbits.

SARP (Student Airborne Research Programme) 2026 ongoing!
20 Airborne campaigns completed thus far (PERCUSION, **ARCSIX**, MAESTRO, CELLO, PACE-PAX, ECALOT, WHyMSIE, VERIFY, GLOVE, PostMAESTRO, ASCCI, COMPEX-EC, NightBLUE, CELLO ARCTIC, HALO SOUTH, NAWDIC, PONEX, NURTURE, DICHOTOMI, COMPEX).
10 Aircraft (HALO,(4x) G-III (4x), SAFIRE(3x), INCAS(2x), ER-2(806), CIRPAS Twin Otter, NRC Convair, ER-2(809) 2x, Bae146†, Polar 5)
10+ lidars (WALES,(3x) HALO(3x) , LNG(2x) , HSRL-2(2x), ECCC/NRC, AWP&CPL 2x, Roscoe, AMALI (2x), AWALI, ..)
9 radar suites (HAMP(2x), BASTA,(3x) NAW&NAX&KPR, CRS (2x), MIRAC&GRaWAC (2x) on AWI-P5), CloudCube
7 imagers (SpecMACS(2x), AVIRIS-NG, PICARD&PRISM, eMAS 2x, HAWK, EAGLE)
7 diverse in-situ sampling suites (MAESTRO/PostMAESTRO/DICHOTOMI, CELLO and CELLO ARCTIC, PACE PAX, VERIFY, ECALOT, HALO SOUTH
2 polarimeters (AirHARP and SpexOne**)**
several radiometers

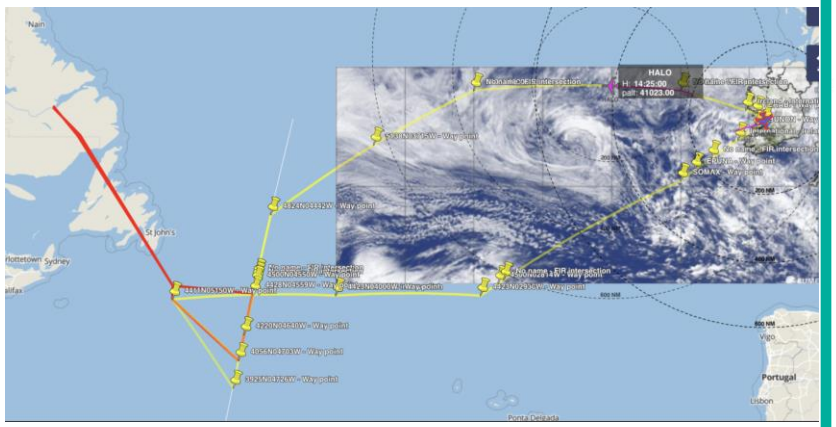


Next slides : Campaign activities since Tokyo Workshop Dec '25

NURTURE and PONEX - Jan/Feb ‘26

- Several EarthCARE underflights in the Northern Atlantic flying out of Goose Bay with NASA GIII.
- One coordinated flight with NAWDIC/HALO.

NURTURE/NAWDIC Coordinated underflight:



PONEX (ARCTIC POLAR NIGHT EXPERIMENT)

ECCC Airborne and Ground-based Campaign at Inuvik, CA

NURTURE 2026 (Phase 1) Instrument Payload

Paylaod abourd G-III aircrafti:

- **DIAL-HSRL:** H2O Differential Absorption Lidar implementing the High Spectral Resolution Lidar technique.
- **CloudCube Radar:** A compact radar for cloud profiling.
- **AVAPS Dropsondes:** Advanced Vertical Atmospheric Profiling System for measuring profiles of H2O, T, P, and wind

The **second phase** of NURTURE, scheduled for 2027, will use a larger suite of instruments on a **NASA Boeing 777**.

NURTURE

Overview

The *North American Upstream Feature-Resolving and Tropopause Uncertainty Reconnaissance Experiment* (NURTURE) is a NASA-funded large-scale aircraft field campaign.

- It will advance knowledge of the processes that lead to extreme high-impact weather (HIW) events during the winter, such as severe cold air outbreaks, windstorms and hazardous seas, snow and ice storms, sea ice breakup, and extreme precipitation.
- HIW events have significant socioeconomic costs and threaten national security (e.g., destabilizing supply chains and damaging infrastructure).

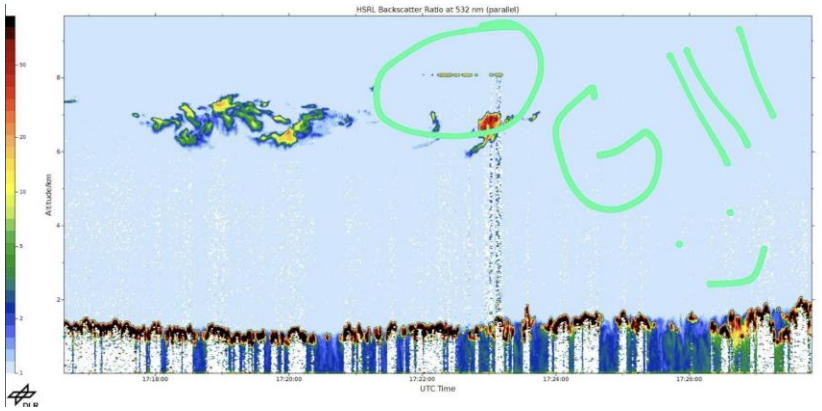
NAWDIC/DICHOTOMI Jan-Mar ‘26

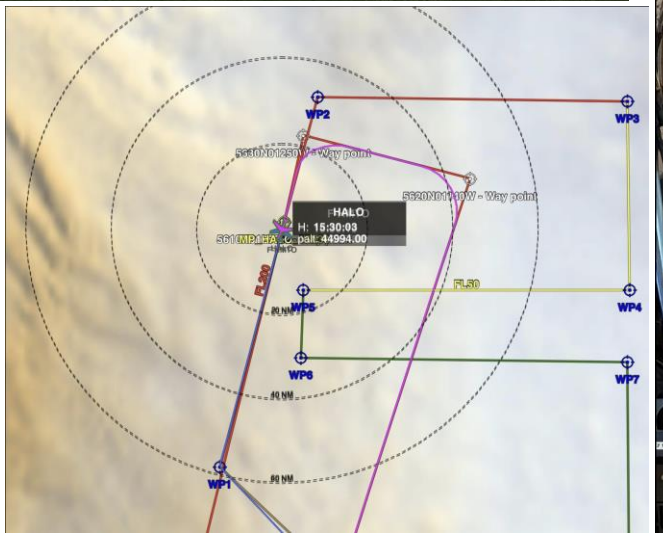
- Several EarthCARE underpasses with SAFIRE ATR (lidar, radar, in-situ) and HALO (lidar, wind lidar, imager, radiation)
- Coordinated flights HALO/ATR and HALO/NASA G3 (NURTURE)

Overview

The *North Atlantic Waveguide, Dry Intrusion, and Downstream Impact Campaign* (NAWDIC) is a new initiative for an international field campaign focusing on mid-latitude atmospheric dynamics with the aim to provide detailed observations for improving the understanding and modelling of the mesoscale tropopause structure, the dry intrusion air stream – planetary boundary layer (PBL) interaction, and their relation to high impact weather (HIW) in the North Atlantic region in winter. NAWDIC will build directly on insights of the *North Atlantic Wave guide and Downstream impact EXperiment* (NAWDEX; Schäfler et al. 2018; http://nawdex.org) that observed diabatic processes in ascending air streams and investigated their impact on the tropopause structure. NAWDIC is initiated through its German HALO-aircraft component, currently scheduled for January/February 2026, However, NAWDIC has now grown to an international campaign, consisting of several components, which are planned as stand-alone measurement campaigns by different groups, but will benefit from synergies if coordinated under the umbrella of NAWDIC.

NAWDIC is officially endorsed by the World Weather Research Programme (WWRP) of the World Meteorological Organization (WMO).





NAWDIC
2026
North Atlantic Waveguide, Dry Intrusion and Downstream Impact Campaign

COMPEX Mar/Apr ‘26

EarthCARE Campaign Key Points

- EarthCARE satellite operational during campaign
- underflights of approximately 20 minutes each
- 2 ESA EarthCARE underpasses flown for validation
- Similar patterns used in ACLOUD and AFLUX (cloudsat validation)
- Novel G-band radar as prototype mission

Objectives and Questions include i.e.:

1. How well do EarthCARE profiles agree with DRACO?
2. What benefits come from EarthCARE’s Doppler capability?
3. What knowledge gained from DAR water vapor profiling?

EarthCARE underpases in blue:

Clouds over cOMPlEX environment

March 14 to April 14 2026, Longyearbyen/Svalbard

Differential absorption radar (GRaWAC; UoC)
G-band Radar for Water vapor and Arctic clouds
167.3 / 174.7 ± 0.1 GHz, FMCW: Ze, Doppler vel., higher moments, differential absorption, IWV, in-cloud wv profiles

Cloud radar (MiRAC-A; UoC)
Microwave Radar/radiometer for Arctic Clouds
94 GHz, FMCW, 89 GHz passive: Ze, Doppler vel., higher moments, brightness temperature, liquid/ice water content, precip rate, liquid water path, vertical distribution

MiRAC-P radiometer (UoC)
6*183.31, 243, and 340 GHz, 1Hz
Sea ice emissivity, ice cloud properties, water vapor profiles

https://ac3-tr.de/pages/compex.html

Polar 5 - Alfred Wegener Institute
operated by Kenn Borek Air (CDN)
Basler BT-67 (former DC-3 build in 1943)
one-way range ~900 km, height < 5 km
2 pilots, max. 6 scientists/engineers

Airborne Mobile Aerosol Lidar (AMALi; AWI/UoC)
Attenuated backscatter signal at 355 and 532 nm
Profiles of aerosol, cloud layers, mask, and top height

AISA EAGLE/HAWK (LIM)
Imaging spectrometers, push broom sensor, 2D field of upward radiance, EAGLE (400-1000 nm), HAWK (930-2550 nm)

Broadband and spectral radiation (LIM)
Pyranometer (0.2-3.6 µm), Pyrgeometer (4.5-42 µm), SMART-Albedometer (300-2300 nm @ 2 Hz)

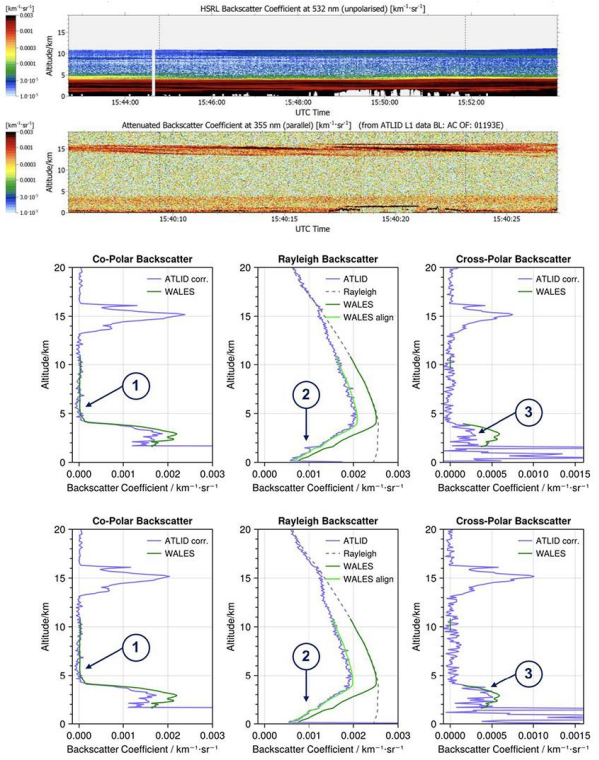
Nikon fish-eye camera, 80 dropsondes, KT-19

Validation with Airborne Campaigns – selected results

Removal of lidar artefacts

"A big advantage of airborne underpasses is they reduce the impact of atmospheric variability and at the same time provide a full scene characterisation, which allows direct comparisons with satellite data," explains Silke Groß of DLR, the EarthCARE DISC's Calibration and Validation Manager.

"Thanks to this we were able to identify artefacts resulting from insufficient fine layering in the retrieval of the Level-2 optical properties, allowing us to quickly solve the problem."



Comparison of airborne and spaceborne HSRL measurements

Airborne radar measurements lift the clouds on CPR algorithms

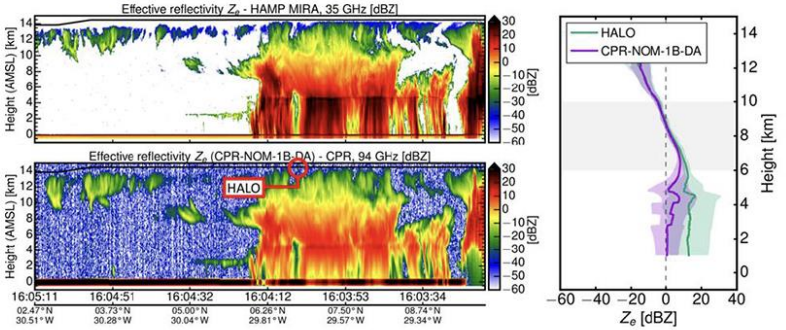
When it comes to thick clouds and heavy precipitation, nothing matches the penetration capability of radar.

Compared to the ultraviolet light emitted by ATLID, EarthCARE's cloud profiling radar (CPR) emits radiation in the millimetre region. It is therefore far less likely to interact with each small cloud particle and is scattered strongly only by larger cloud particles like snowflakes, rain or graupel. We can look through whole cloud systems, like thunderstorms, from space and even see the rain below them.

To convert the power of the signal, the radar reflectivity, shown in the figure below, into meaningful numbers of water content and cloud particle sizes, the instrument needs to be calibrated.

An important way to do this is direct underpasses with well characterised and well calibrated airborne radar systems, such as the MIRA cloud radar, looking at the same volume for a sufficient time. During the PERCUSION campaign many such underflights were performed in cloudy conditions - from ice clouds to weather systems and deep convection.

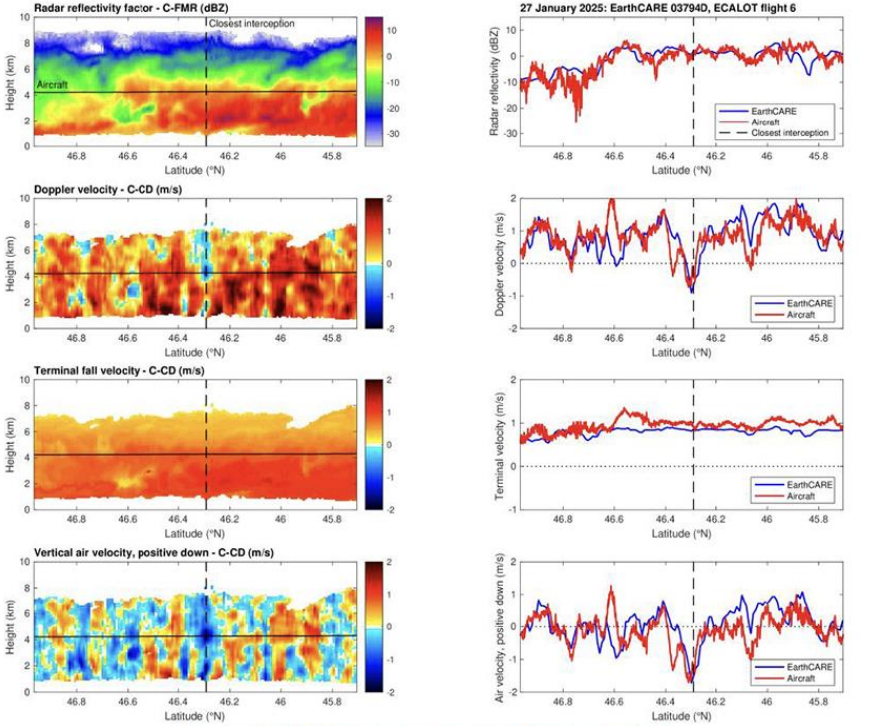
A comparison of CPR radar reflectivities found an initial calibration bias of -4 dB in a very early version of the CPR Level-1 data. Identifying this offset led to improvements in the general calibration methods and analysis, and comparisons with the current baseline show that this issue could be fully corrected.



Comparison of airborne and spaceborne cloud radar measurements

In-Situ measurements of fall speeds..

Fortunately, the Convair research aircraft was flying inside this cloud as part of the ECALOT campaign, measuring both the vertical air motion and the size and density of the snowflakes, from which the terminal fall speed could be estimated. These observations reveal that almost all the small-scale variations in Doppler velocity were due to air motions, while the terminal fall speed was much more constant at around one metre per second.



Comparing EarthCARE cloud measurements with in-situ aircraft data

https://earth.esa.int/eogateway/success-story/the-earthcare-detectives-hit-100-in-awe-inspiring-global-investigation

Outlook ‘26 and ’27 – Completing and Advancing Target Scenarios

September ’26 (several EarthCARE underpasses planned):

Biomass-burning Aerosol, Clouds, COnvection and Precipitation in central equatorial Africa – BACCOPA – CNRM etal., SAFIRE ATR 42,

Planned international Mediterranean Campaign in 2027:

COllaborative SENSing Experiment to deploy satellite and sub-orbital synergies over the Mediterranean hot-spot climatic area, addressing complex Aerosol Cloud Interaction (ACI) processes

Including correlative:

- collocated surface-based-,
- airborne remote sensing-,
- Airborne in-situ measurements-observation,
- under satellite overpasses

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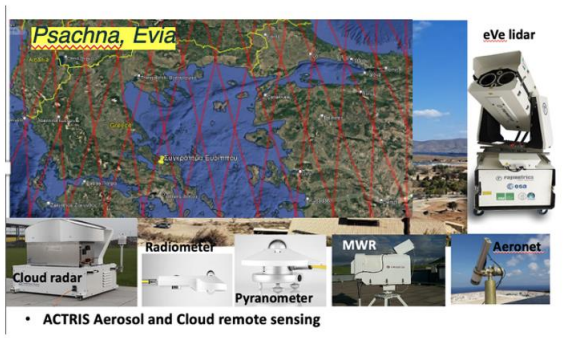
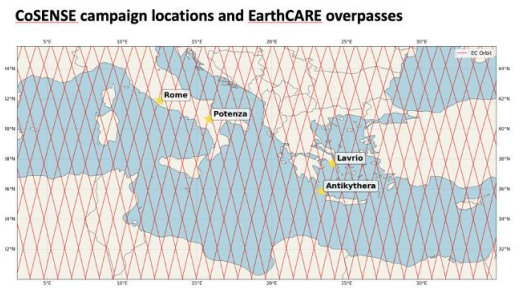


Credit : NOA



Increased EarthCARE life-time : stay tuned for more campaign plans 2027 and beyond!

Results – More presentations this week

Wednesday:

T301	9:00	12	Two Canadian aircraft cal/val campaigns in 14 months: ECALOT surface comparisons and PONEX campaign overview	Zen Mariani
T302	9:12	12	Comparisons between EarthCARE and ATR42 during the NAWDIC-DICHOTOMI field campaign (L2a and L2b products)	Emmeline Francois
T303	9:24	12	Airborne validation of the EarthCARE Cloud Profiling Radar in Arctic cold-air outbreaks during the COMPEX-EC campaign	Mario Mech
T304	9:36	12	NASA Activities Relevant to EarthCARE	Ed Nowottnick
T305	9:48	12	Status and data availability of the NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission and the PACE Postlaunch Airborne Experiment (PACE-PAX)	Kirk Knobelspiesse
T313	11:54	12	Quantifying 3D radiative transfer effects of clouds using ML-generated 3D cloud scenes for EarthCARE, and airborne observations from ORCESTRA/PERCUSION campaign	Dimitra Kouklaki
T322	14:42	12	Constraining Ice-Cloud Radiative Properties through Collocated Measurements: A Radiative-Closure Perspective from PERCUSION	Florian Ewald
T323	14:54	12	Validation of EarthCARE products under ACROSS Mediterranean activities	Eleni Marinou

Tuesday:

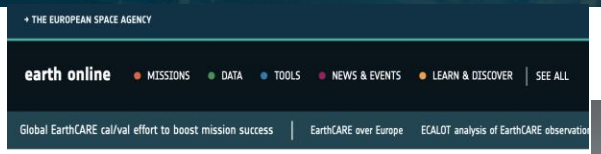
T205	9:48	12	First validation of CPR vertical wind data by airborne wind lidar measurements performed in the framework of the NAWDIC campaign	Benjamin Witschas
K206	10:24	30	**[Keynote 2] Bridging Observations and Models: Constraining Aerosol Effect on Deep Convection with EarthCARE and the ECOMIP intercomparison**	Philip Stier

Thursday:

T411	14:18	12	Evaluation of NWP Simulations of Cold-Season Mixed-Phase Clouds Using EarthCARE and ECALOT Observations	Zhipeng Qu
T412	14:30	12	ECOMIP Update Toward Revealing Vertical Velocity Structures in Deep Convection through EarthCARE–Kilometer-Scale Model Synergy	Masaki Satoh
T415	15:06	12	Evaluating a Global Storm-Resolving Model with EarthCARE and ORCESTRA Observations	Woosub Roh
T423	17:12	12	Zooming in: In-situ validation of microphysical retrievals in mixed-phase clouds during CELLO	Robert David
T424	17:24	12	Zooming out: In-situ validation of target classifications in mixed-phase clouds during CELLO	Tim Carlsen

Dedicated Session “Campaigns and Other Validation Activities”
Co-chairs: Silke Gross and Yuichi Ohno, **Wednesday 9:00-10:00**
Posters : every day!

Thank you!



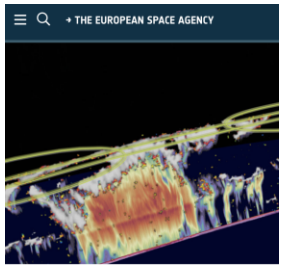
Learn & Discover / Global EarthCARE cal/val effor...

Global EarthCARE cal/val effort to boost mission success

24 Jun 2025

In its first year in space, ESA's EarthCARE satellite has m
interplay between clouds, aerosols, and Earth's energy ba
complex array of airborne, ground-based and maritime ca
measurements.

EarthCA

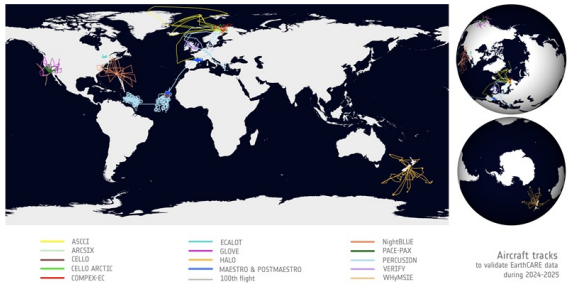


Learn & Discover / The EarthCARE detectives hit 1...

The EarthCARE detectives hit 100 in awe-inspiring global investigation

07 Jan 2026

In the early hours of 10 September 2025, the intrepid explorers of the NightBLUE campaign reached a remarkable milestone: the 100th underflight of the European Space Agency's EarthCARE satellite.



Milestone for EarthCARE campaign underflights

This was a significant moment in the quest to calibrate and validate data from the satellite's four trailblazing instruments, which work in synergy to shed light on a major mystery – how clouds and aerosols affect Earth's climate.

The EarthCARE Data, Innovation and Science Cluster produces the algorithms and science products that make EarthCARE data usable. Level-1 products focus on what each instrument observes, while Level-2 products help us characterise meteorological variables like clouds and aerosols, precipitation, and radiative fluxes.

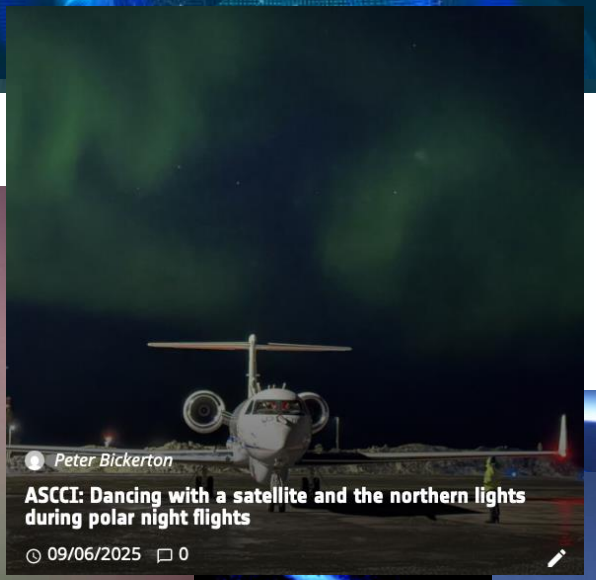
APPLICATIONS

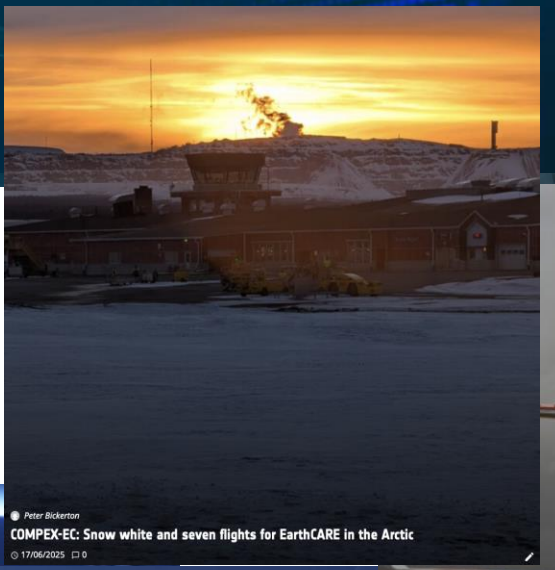
Ensuring these algorithms are accurate requires an international detective effort. We've now reached a staggering 127 underflights, from the Arctic Circle to the Atlantic Ocean and New Zealand, comprising hundreds of hours and many thousands of kilometres of coordinated measurements taken directly underneath EarthCARE.

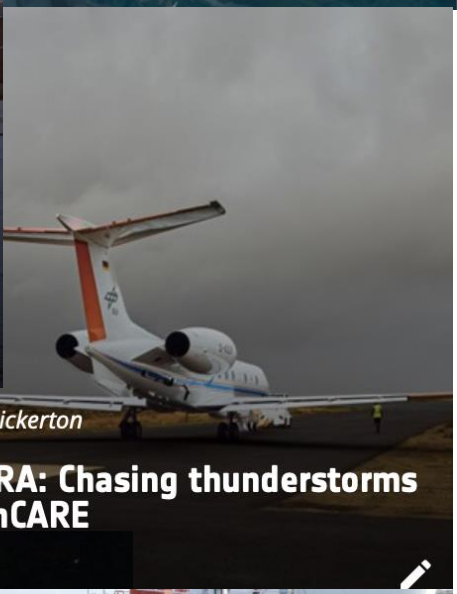
Taking to the skies for EarthCARE

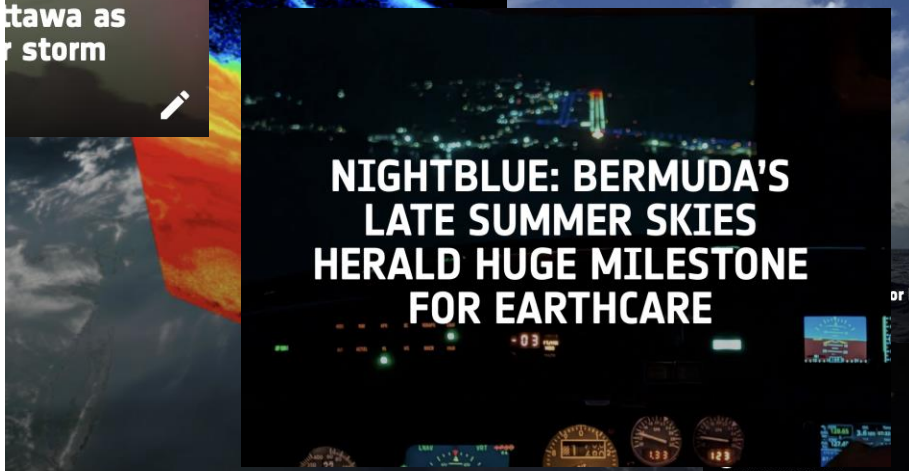
28/11/2024 1750 VIEWS 24 LIKES

ESA / Applications / Observing the Earth / FutureEO / EarthCARE









Exploring the EMORAL Lidar at MARS: a key ste
preparation
24/05/2024 1