EarthCARE Airborne Campaigns Overview

Jonas von Bismarck, Robert Koopman, Stephanie Ruslie, Thorsten Fehr, Kotska Wallace, Timon Hummel, Bjoern Frommknecht, Vasileos Tzallas, Georgios Tzemeres, Michael Eisinger, Alex Hoffmann, Montserrat Pinol Sole, et al.

EarthCARE Science and Validation Workshop 2025
1-5 December 2025 | The University of Tokyo | Tokyo, Japan

Airborne Validation for EarthCARE

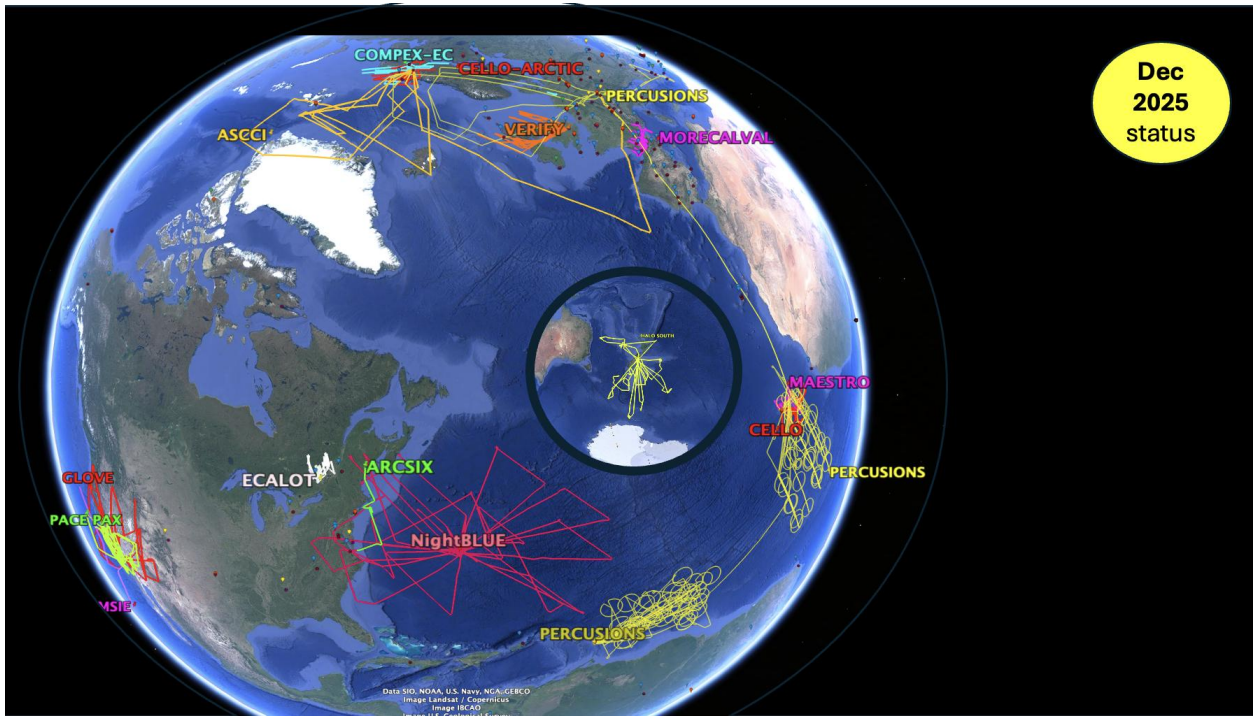
- Identified as extremely suitable approach, fulfilling the complex validation needs (SVIP).
- International joint effort of nationally and agency supported activities for the validation of ESA and JAXA products
- Unprecedented number of activities already during commissioning, commencing directly after EarthCARE's readiness for corellative observations!

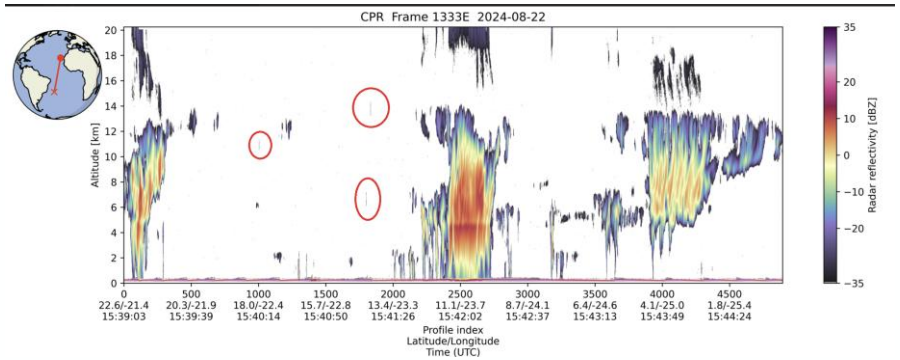
Airborne campaigns provide an abundant number of matchup samples! Complementary to ground based and network long-term measurements

Airborne EarthCARE Underflights for Validation - Numbers

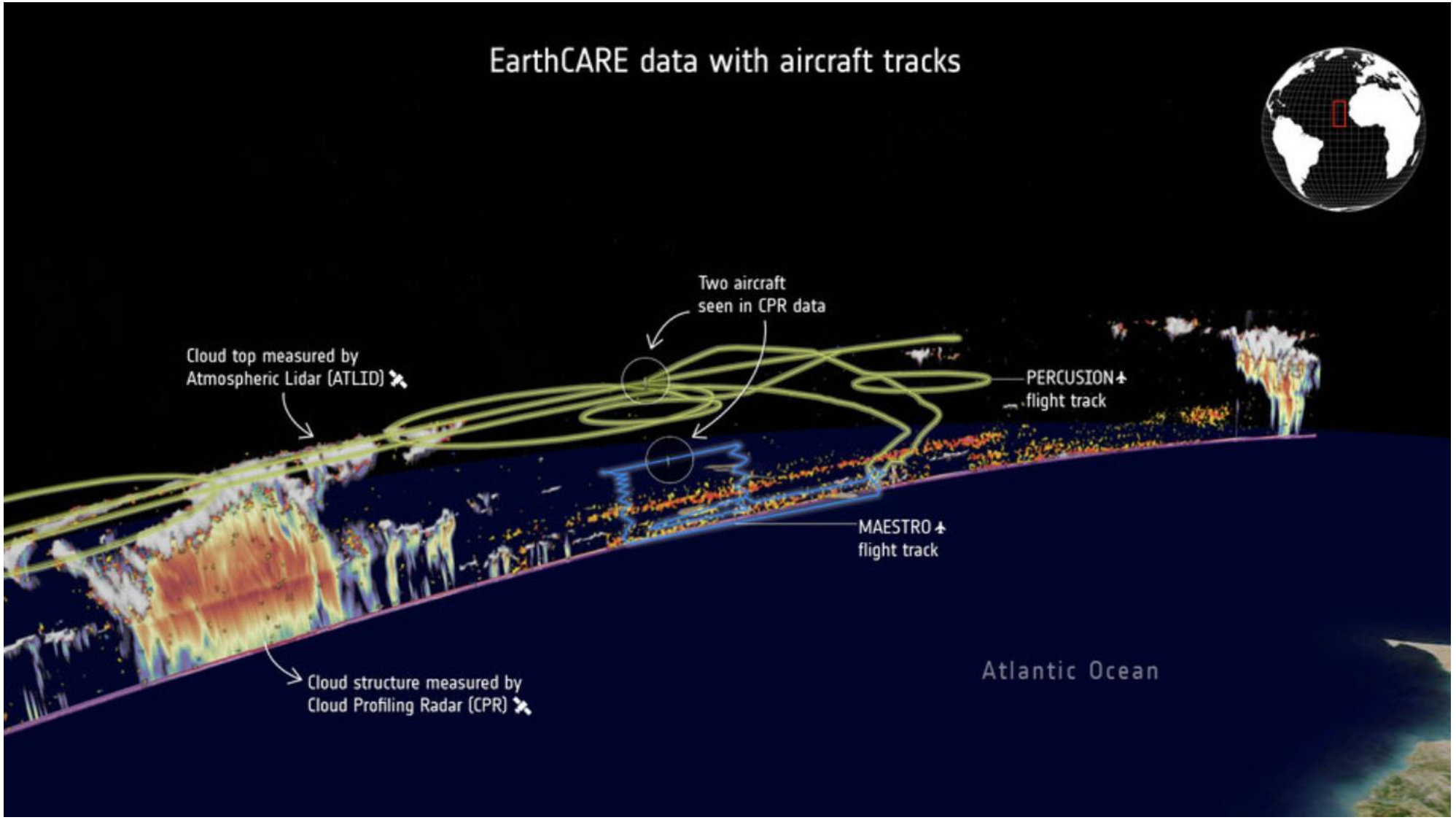
- **63 underflight during commissioning, 100 in September 2025, 127 (123 orbits) at present!**

- **15+ Airborne campaigns thus** far (ARCSIX, PERCUSION, MAESTRO, CELLO, PACE-PAX, ECALOT, WHyMSIE/APEX, VERIFY, GLOVE, ASCCI, POST-MAESTRO, COMPEX-EC, NightBLUE, HALO South, CELLO ARCTIC. **Balloon:** (BAIVEC, BalNEO, Timmins/CNES). **Next up : PONEX, PRE-NURTURE, NAWDIC, …**
- **10+ Aircraft** (**HALO**, **G-III**, **SAFIRE ATR**, **INCAS KingAir**, **ER-2**(806), **Twin Otter** (NASA), **Convair** ECCC, **ER-2**(809), BAe146 **FAAM**, **POLAR 5** Basler
- **10 lidars** (WALES, HALO(2x) , LNG/RALI+, HSRL-2, ECCC/NRC, AWP&CPL, aerosol lidar, AWALI,..)
- **7+ radar suites** (HAMP, BASTA, NAW&NAX&KPR, CRS, FMCW, mulitple on P5)
- **7 imagers** (SpecMACS, AVIRIS-NG, PICARD, PRISM, eMAS, EAGLE, HAWK)
- **8 diverse in-situ sampling suites** (MAESTRO, CELLLO, PACE PAX, VERIFY, BAIVEC, BalNEO, HALO SOUTH)
- **2 polarimeters** (AirHARP, SpexONE)
- **several radiometers**



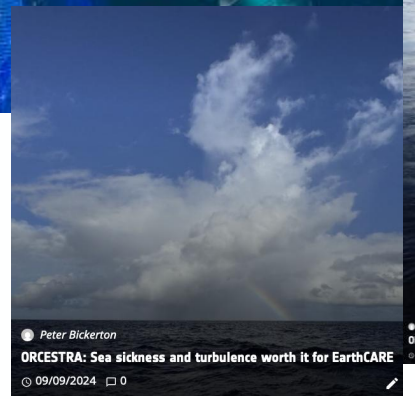


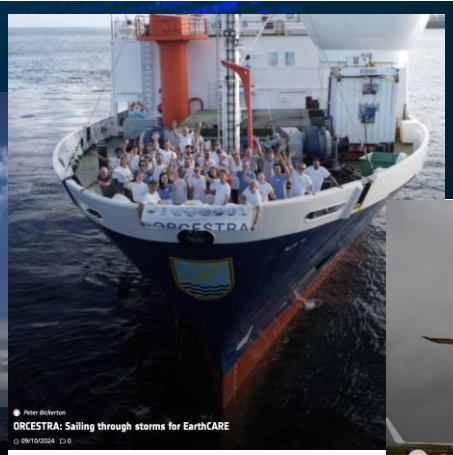
Overview of Airborne Validation Campaigns for EarthCARE

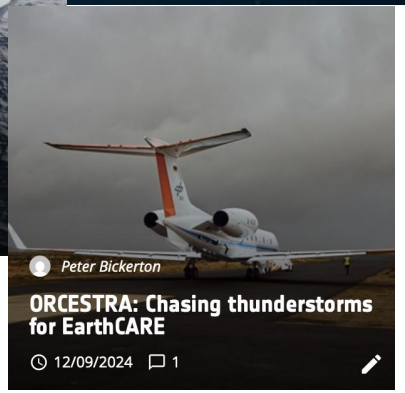


ORCESTRA Campaign Aug./Sep. 2024

(Lead: MPI-Meteorology, DE)





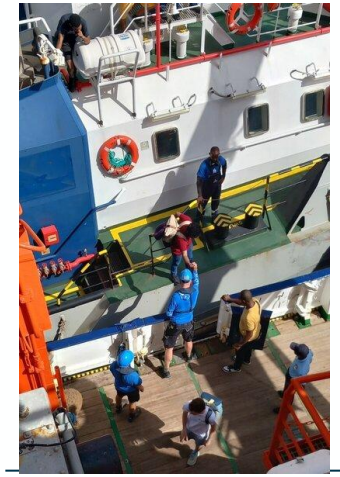


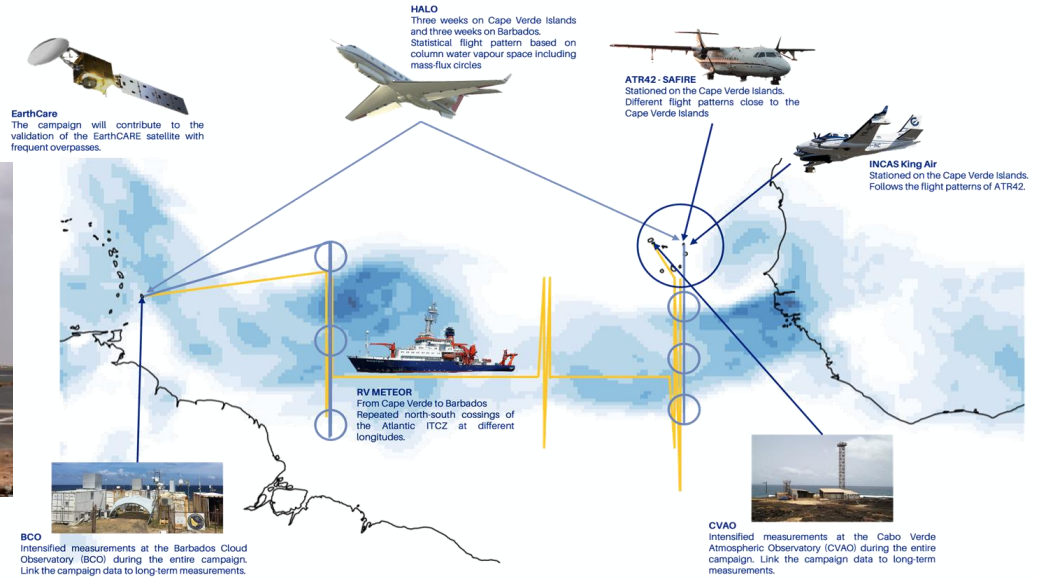
Contribute to understanding the physical mechanisms that organize tropical convection at the mesoscale, including:

- interaction of convective organization with tropical waves and air-sea interaction
- impact of convective organization on climate and the Earth's radiation budget and processes of tropical cyclogenesis.
- tropical meteorology and atmospheric processes,
- calibration and validation of satellite remote sensing (especially EarthCARE) and a new generation of global ocean-eddy and storm-resolving climate models.

- Various multi-aircraft EarthCARE underflights for validation performed !!

Credits: ORCESTRA Community





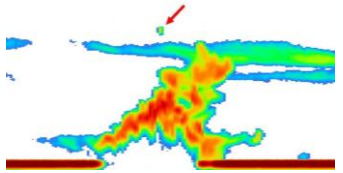
ORCESTRA : PERCUSION (+ASCCI)

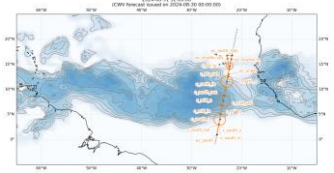
Key Features of WALES Lidar Payload (source : DLR)

- Includes Differential Absorption LIDAR (DIAL) at four wavelengths near 93
- Provides H2O mixing ratio profiles throughout the troposphere
- Offers 200 m vertical and 6 km horizontal resolution
- Maintains systematic errors under 5%
- Statistical errors around 5%, depending on conditions
- Measures aerosol backscatter, extinction, and depolarization at 532 nm and 1064 nm
- Uses efficient solid-state lasers (suited for space)

EarthCARE-like payload including lidar, radar, imager, …

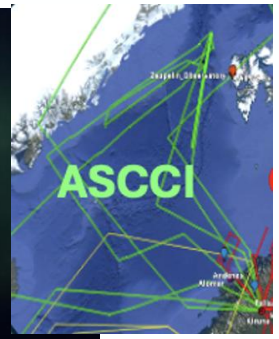
BACARDI | BAHAMAS | Dropsondes | HAMP | SMART | specMACS | VELOX | VELOX KT-19 | WALES

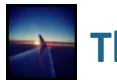




ASCCI

ASCCI : HALO with WALES lidar (etc) underflying EarthCARE in arctic Spring 2025 (Kiruna base)

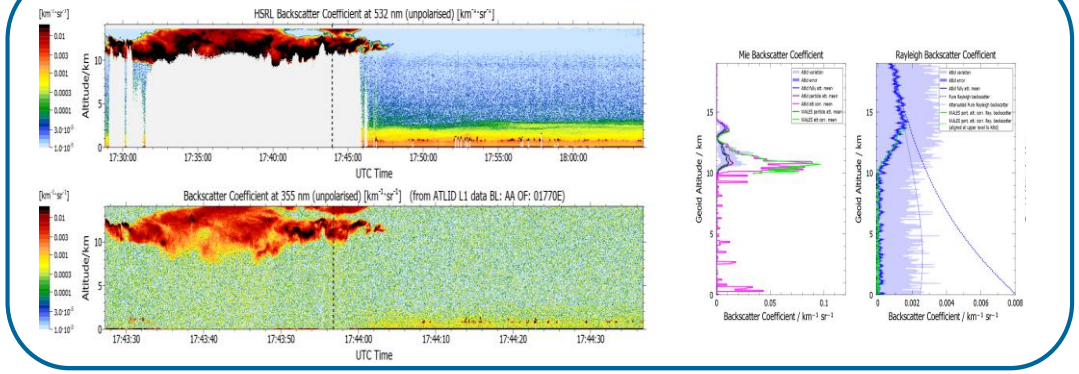


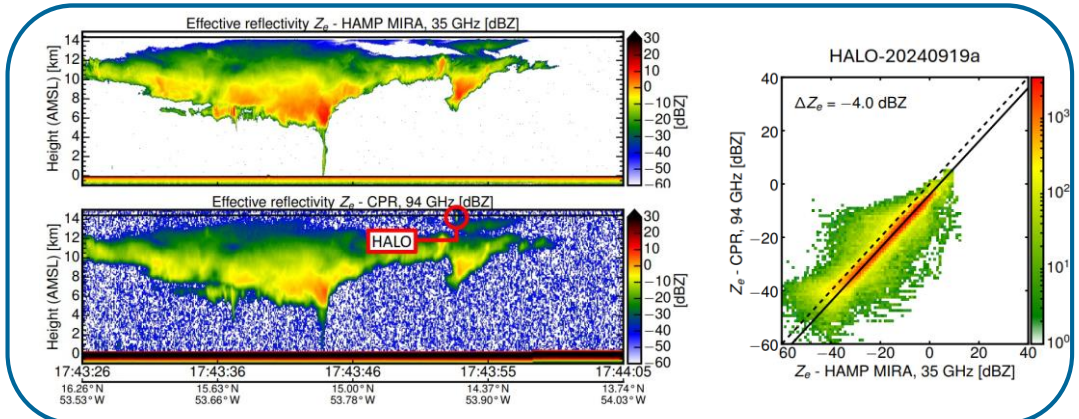


The HALO PERCUSION campaign

Validation measurements with EarthCARE-like payload in Aug./Sept./Nov. 2024

ORCESTRA DLR

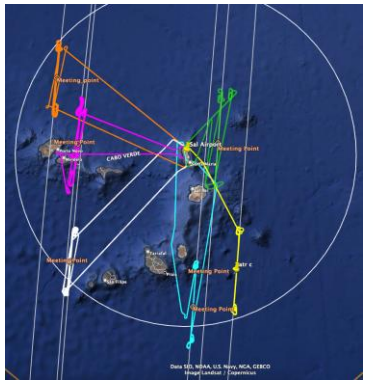




ORCESTRA : (Post-)MAESTRO (- MORECALVAL)

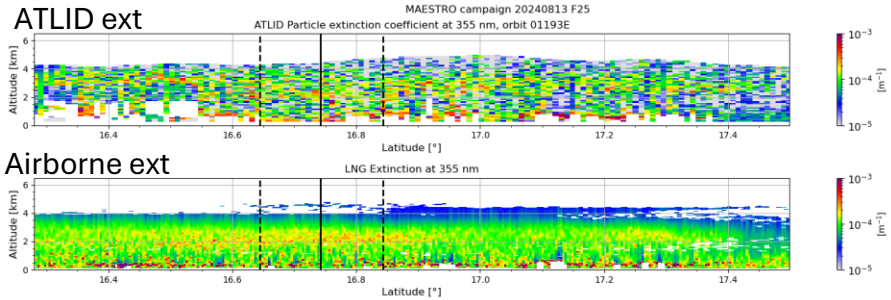
- MAESTRO *Mesoscale Organisation of Tropical Convection*, PI: Sandrine Bony (LMD)

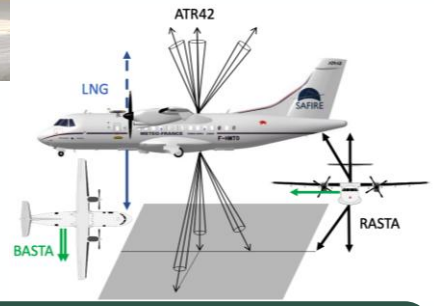
Operations out of Sal (Cape Verde), **10 Aug – 10 Sept 2024** → 86 F/H (24 flights)

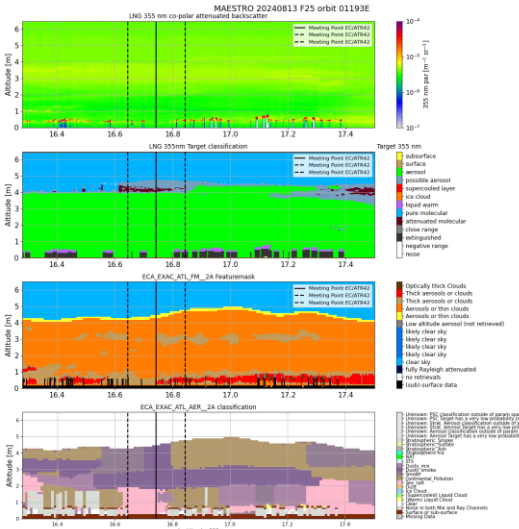


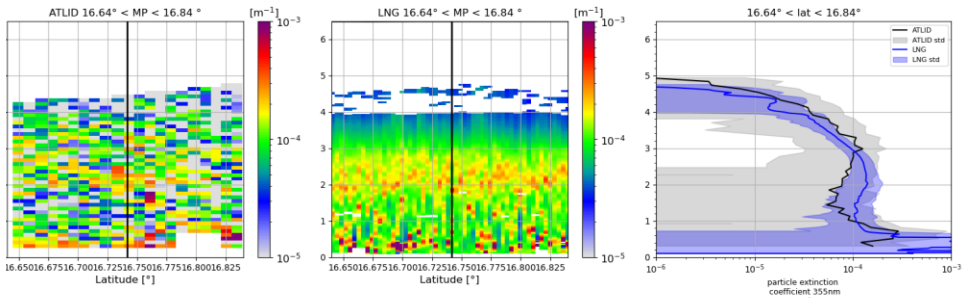
6 flights dedicated to EarthCARE CalVal

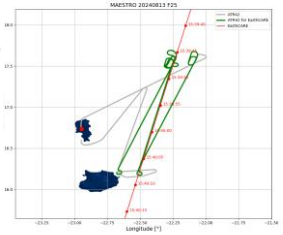
Payload includes LNG Lidar (355nm HSRL) as part of RALI (LATMOS, LMD) and Latmos RSTA (W-Band) radar











ATR42: 2 cloud radars (8 antennas), 2 UV lidars (one with HSRL), IR radiometer and Large in-situ payload

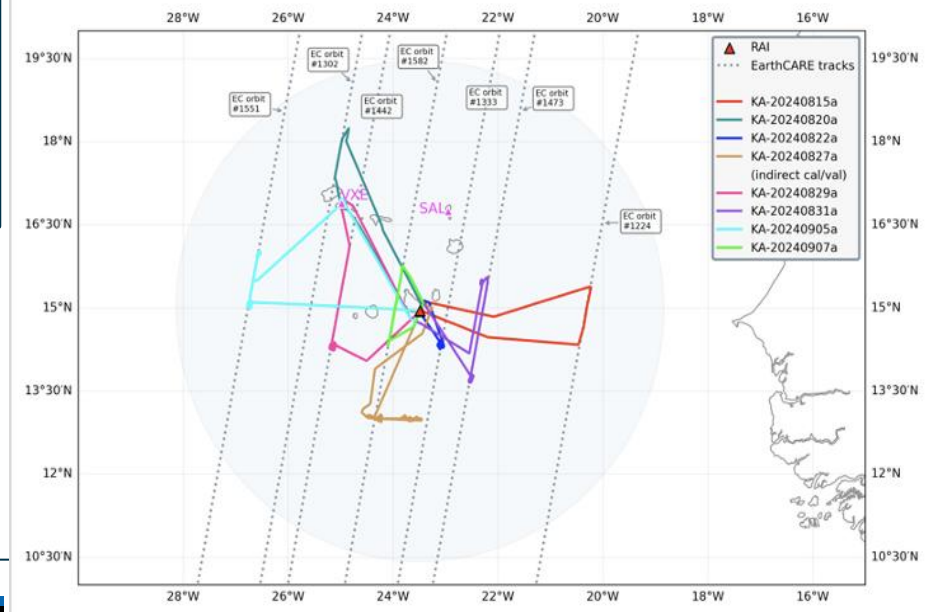
Supported by ESA, CNES, ERC grant MAESTRO and INSU

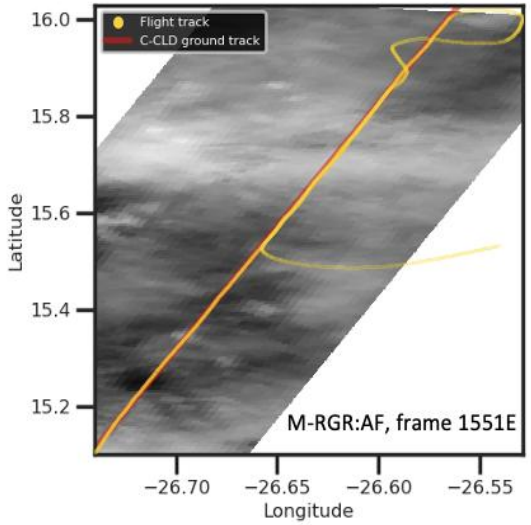
MORECALVAL- POST MAESTRO, PI: J. Delanoë (LATMOS)

- Operations out of Toulouse (France), **13 March – 4 April 2025** → 9 flights expected
- 2 w band cloud radars deployed on the ground (Lannemezan super site and Francazal)

ORCESTRA ‘24 : CELLO (+ CELLO-ARCTIC ’25) in-situ elemen

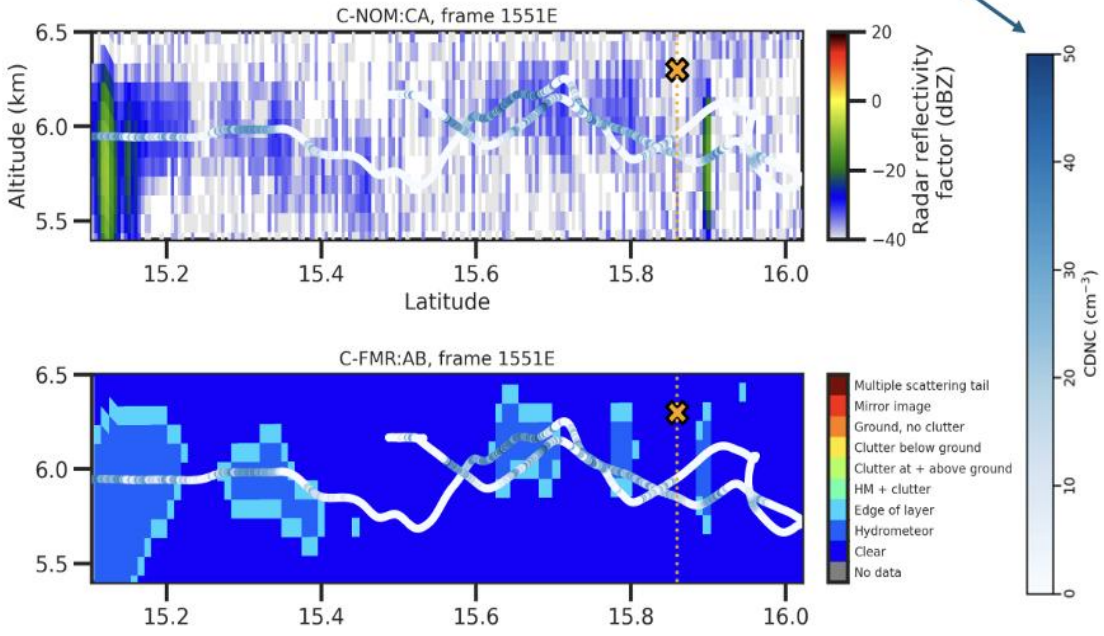
CELLO ARCTIC: Airborne EarthCARE validation in the arctic with in-situ cloud sensing instruments (base: Kiruna) Sep/Oct ‘25





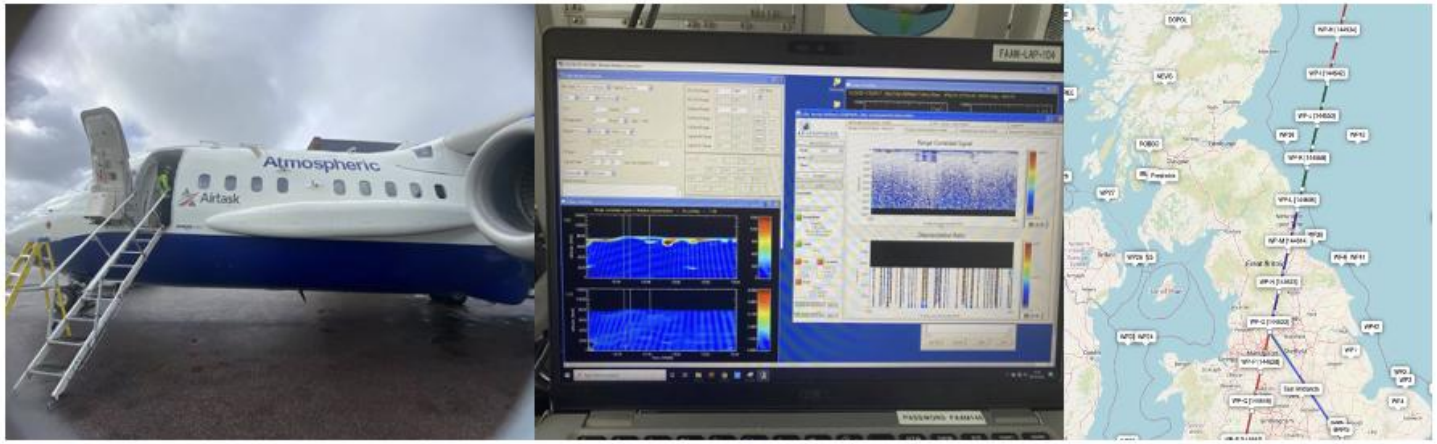
5 September 2024
Flying in thin clouds
as **seen by MSI and CPR**

Airborne cloud droplet number concentration



VERIFY ‘24/’25

UK FAAM VERIFY campaign



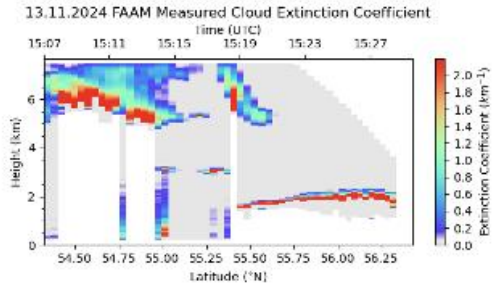
Flight	Date
C393	06 Nov 2024
C394	07 Nov 2024
C395	13 Nov 2024
C396	18 Nov 2024
C397	22 Nov 2024
C399	14 Jan 2025
C400	23 Jan 2025
C401	27 Jan 2025
C402	29 Jan 2025

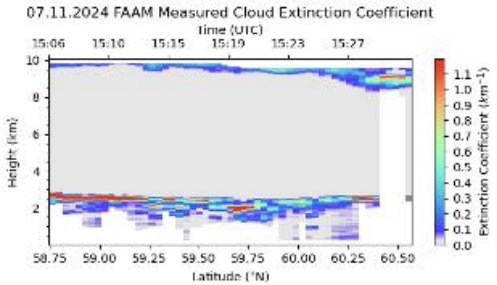
Instruments:

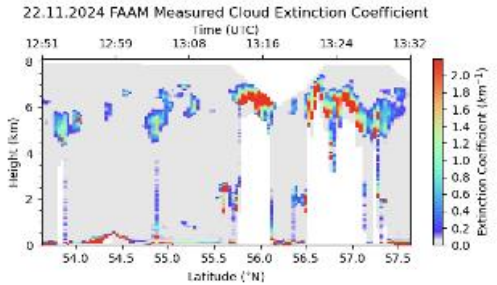
- Nephelometer
- Nevzorov probe
- Aerosol size spectrum optical probe
- Particle soot absorption photometer
- Clear & red BBRs
- Cloud imaging probe
- Cloud droplet probe
- Atmospheric lidar

extinction coefficient

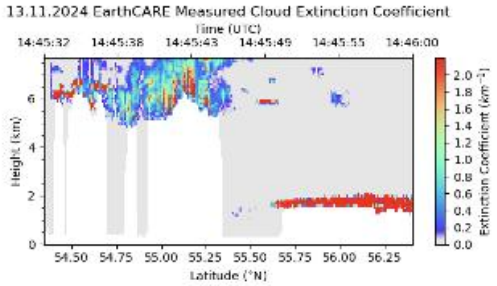
aircraft

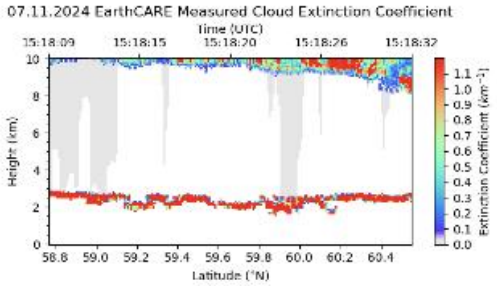


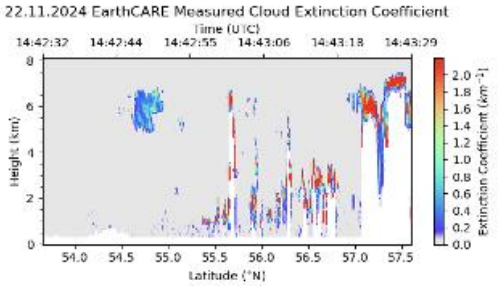




EarthCARE



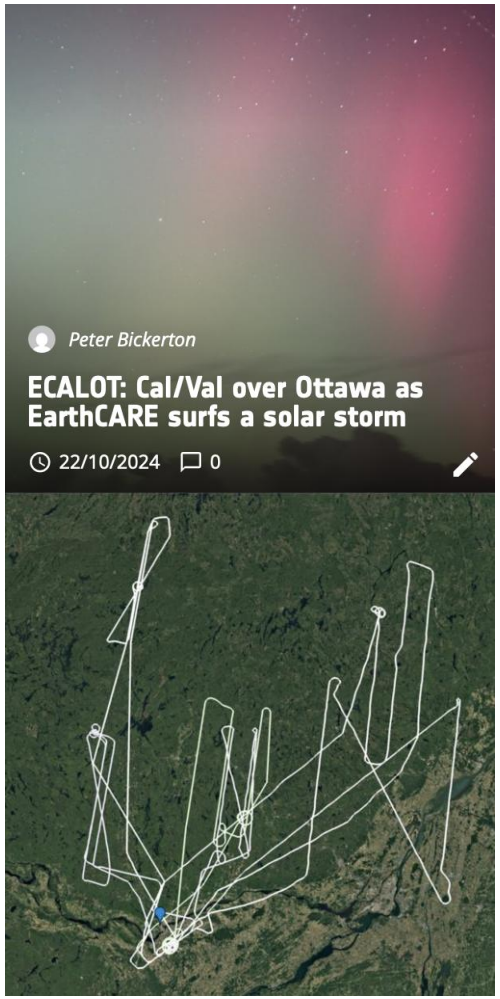




Contract in place to pursue further flight opportunity in 2025/26!

ECALOT '24/'25

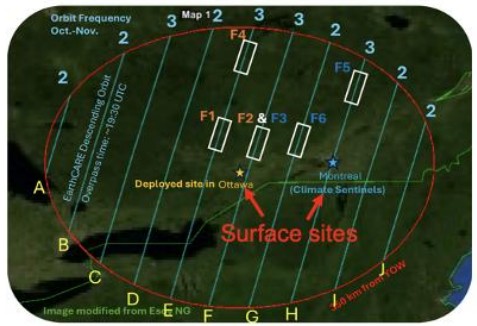
Includes ECCC/NRC Lidar



EarthCARE Commissioning Cal/Val Campaign in Ottawa (ECALOT)

Environment and Climate Change Canada · National Research Council Canada · McGill · UQÀM · University of Toronto · esa

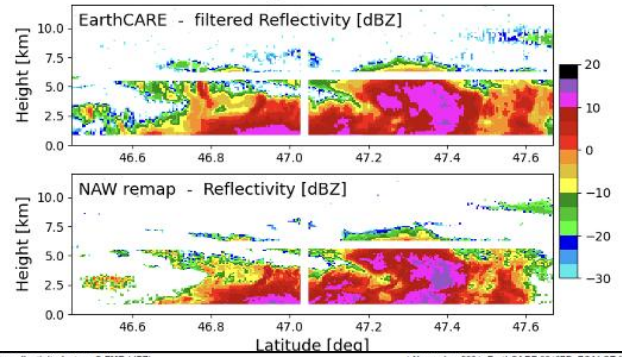
Flights

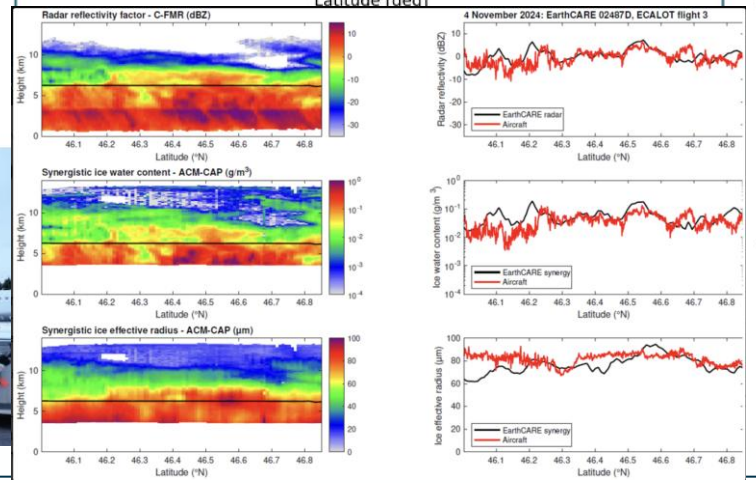


- Flight 1: Oct. 1st – Cu & Sc
- Flight 2: Oct. 10th – Sc + aerosols
- Flight 3: Nov. 4th – Ns + rain
- Flight 4: Nov. 20th – Sc + aerosols
- Flight 5: Nov. 22nd – Ci + Ns (example)
- Flight 6: Jan. 27th – Ns + snow

Level 1 - CPR reflectivity

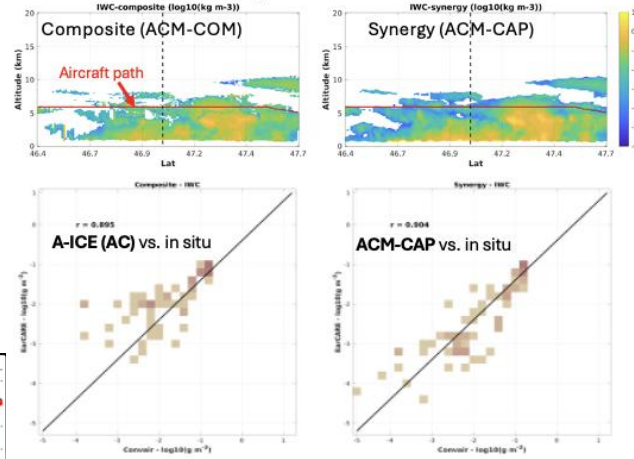
Flight 5 Nov. 22nd

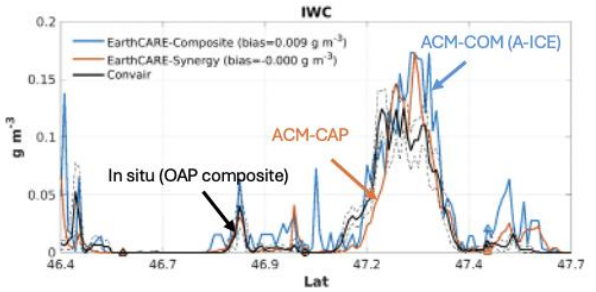




Level 2 - ice water content

Flight 5 Nov. 22nd





COMPEX EC ‘25

Kiruna - 2.-16.4.2025

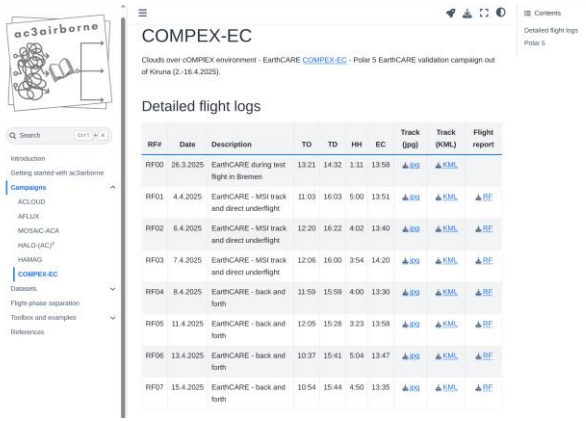
7 EarthCARE underflights each 30 mins

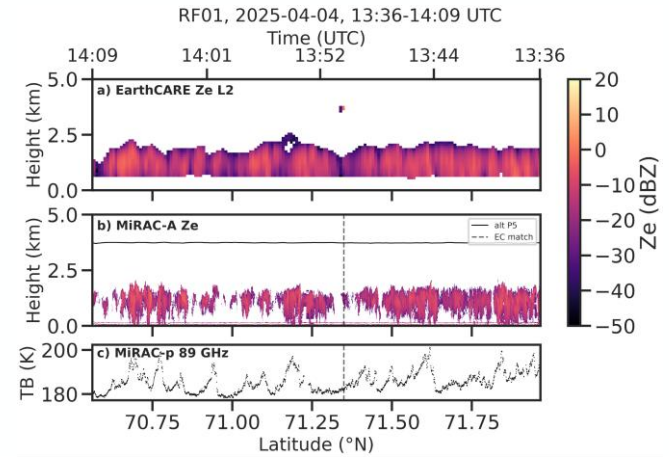
COMPEX-EC - Clouds over cOMPlEX environment - EarthCARE

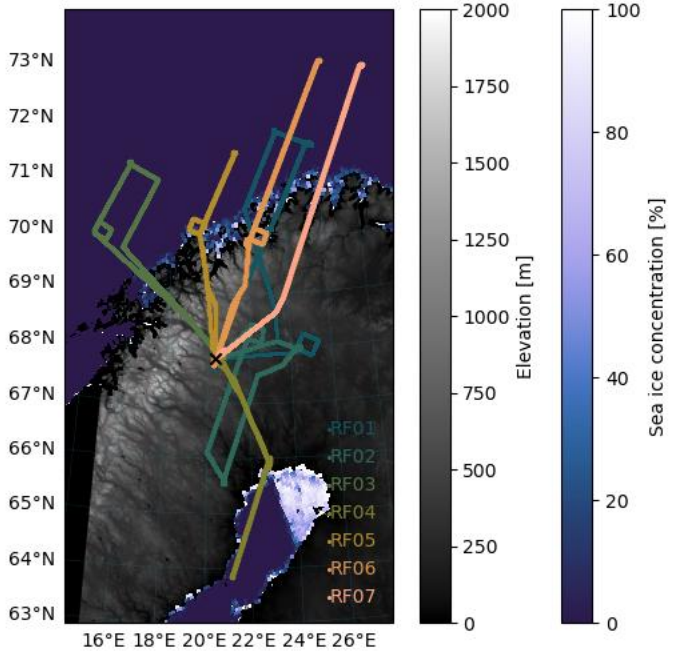
University of Cologne, University of Leipzig, Alfred-Wegener-Institute
Helmholtz Centre for Polar and Marine Research

Polar 5 - remote sensing setup:
Basler BT-67 (DC-3): 800 km range, 3-6 km, 1 t

- 94 GHz FMCW Doppler radar
- aerosol lidar (355 nm, 532 nm depol)
- passive MW, IR, VIS
- radiation
- dropsondes







NASA/US I : PACE-PAX ‘24

Instrument Team: HSRL-2 on ER-2 for PACE-PAX

HSRL measurements at 355 and 532 nm

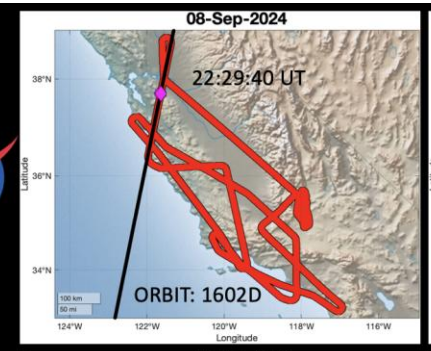
HSRL-2 Team Members

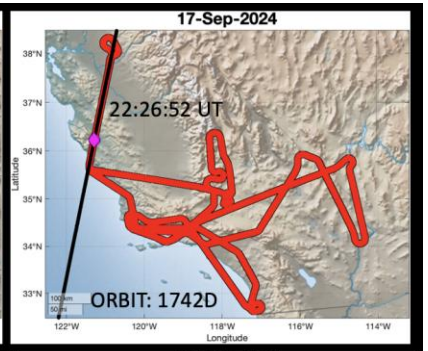
- Sharon Burton
- Brian Collister
- Tony Cook
- Marta Fenn
- Rich Ferrare
- John Hair*
- David Harper
- Chris Hostetler
- Madison Hetlage
- Amin Nehrir
- Tony Notari
- Amy Jo Scarino
- Taylor Shingler

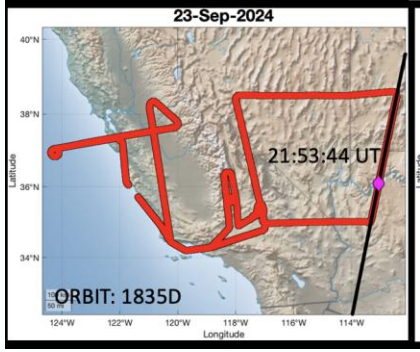
Nominal flight altitude – 20 km

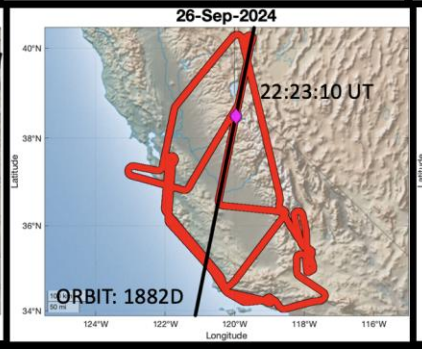
PACE-PAX HSRL-2/ER-2 flights along ATLID ground track

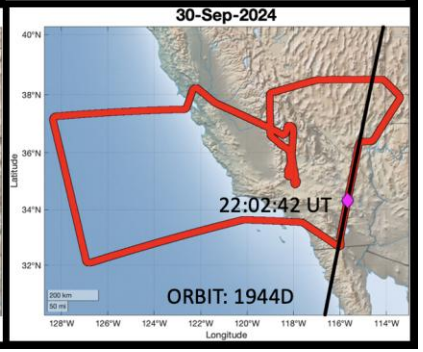
Spatial coordination within 1km
Orbits were all daytime: descending and “D” frame











NASA/US II : ARCSIX, WHYMSIE/APEX ‘24

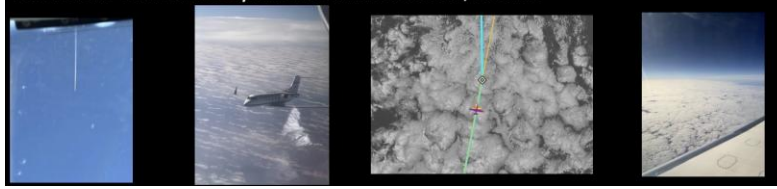
Westcoast & Heartland Hyperspectral Microwave Sensor Intensive Experiment (WH²YMSIE) & Active Passive PBL Profiling EXperiment (APEX)

https://www-air.larc.nasa.gov/missions/whymsie/index.html

Campaign Leads

Antonia Gambacorta and Amin Nehrir

Objectives: 1) Evaluation and validation of emerging passive microwave sounding technology. 2) Benchmark dataset for active (DIAL) / passive (infrared and microwave sounders) retrievals of temperature and moisture. 3) Calibration, validation, and interpretation of satellite retrievals of thermodynamics and aerosols/clouds



Arctic Radiation-Cloud-Aerosol-Surface Interaction Experiment(ARCSIX)

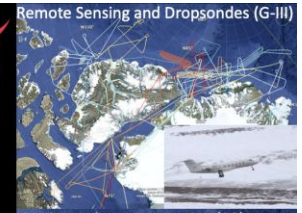
https://www-air.larc.nasa.gov/missions/arcsix/index.html

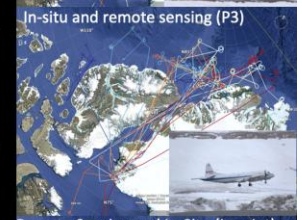
Campaign Leads

Sebsatian Schmidt, Patrick Taylor

Objective: quantify the contributions of surface properties, clouds, aerosol particles, and precipitation to the Arctic summer surface radiation budget and sea ice melt during the early melt season

Secondary Objective: calibration , validation, and interpretation of satellite retrievals of clouds, aerosols, and surface properties





Instrument Team: High-Altitude Lidar Observatory (HALO) on G-III for ARCSIX, WH²YMSIE, APEX

HALO Team Members

- Rory Barton-Grimley
- James Collins
- Brian Collister
- Ewan Crosbie
- Rich Ferrare
- John Hair
- David Harper
- Madison Hetlage
- Joe Lee
- Amin Nehrir *
- Tony Notari
- Taylor Shingler
- Ashwin Yerasi

HALO instrument and rack

HALO + AVIRIS-NG (ARCSIX)

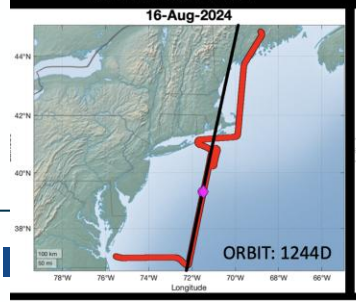
HALO + AWP(WH²YMSIE/APEX)

ARCSIX, WH²YMISE/APEX flights along ATLID ground track

Nominal spatial coordination: <1km
Orbits were all daytime: descending

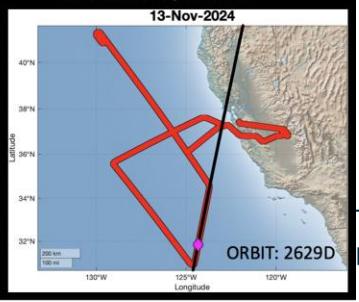
Note: 30 October 2024 does not have ATLID data (maneuver?). This flight was an out and back flight along the satellite ground track

US North-East Coast

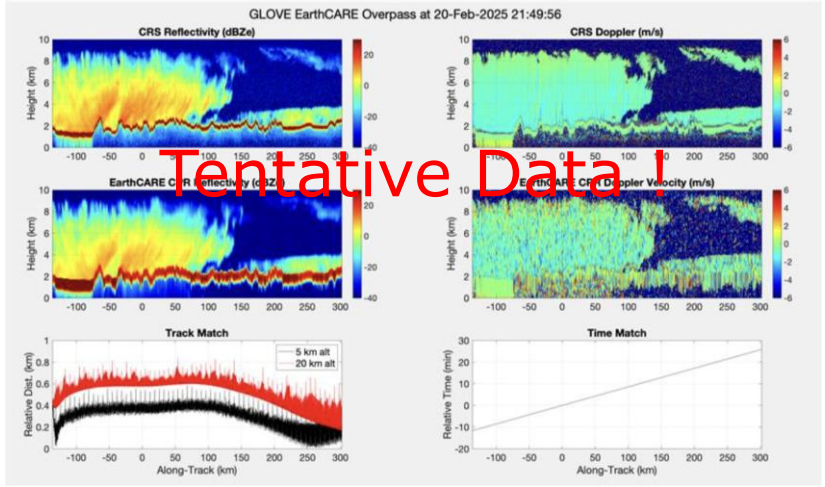


US West Coast/California/Baja

US West Coast/California

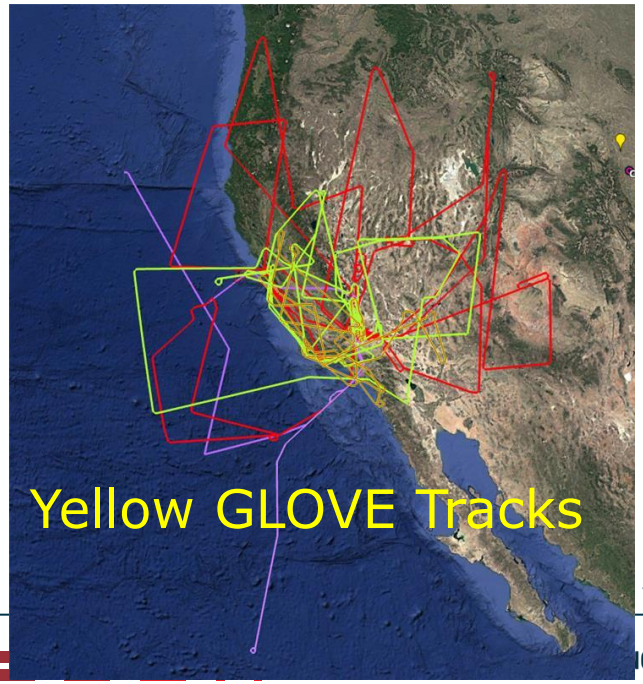


NASA/US III : GLOVE ‘25

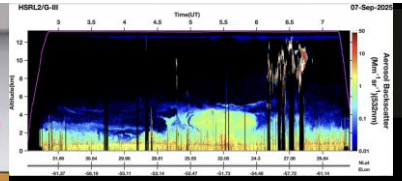


The **GSFC Lidar Observation and Validation Experiment** (GLOVE) will take place February 2025 based out of Edwards Air Force Base in California. Utilizing the NASA ER-2 outfit with the Cloud Physics Lidar (CPL), Roscoe, enhanced MODIS Airborne Simulator (eMAS), and Cloud Radar System (CRS), GLOVE will (1) validate new ICESat-2 atmospheric data products, (2) validate EarthCARE lidar, radar, spectrometer data products, and (3) test new Roscoe receiver alignment. Key Staff

- **Principal Investigator:** John Yorks
- **Project Scientist:** Edward Nowottnick



NightBLUE ’25



Nighttime Bermuda Lidar Underflights of EarthCARE - NightBLUE

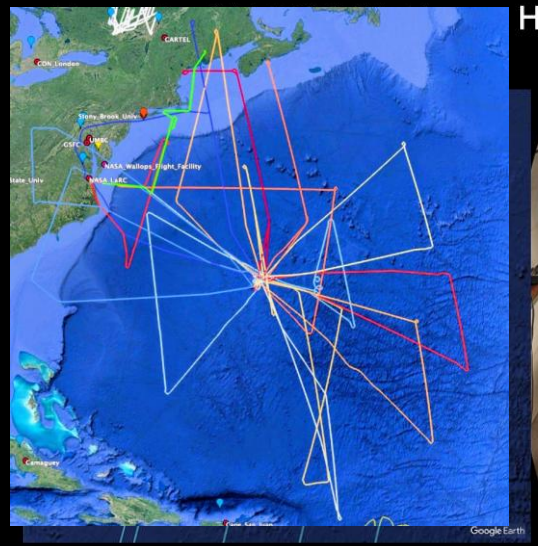
Objective: Collect nighttime 355-nm HSRL measurements to assess the performance EarthCARE’s Atmospheric Lidar (ATLID) L1B profiles and L2 aerosol and cloud data products.

Rationale: Nighttime validation is currently a high priority of the ATLID algorithm team. Lack of solar background noise makes nighttime observations optimal for investigating basic aspects of instrument performance and algorithm approaches.

Approach: Similar to CALIPSO nighttime validation flights from Bermuda conducted in 2022

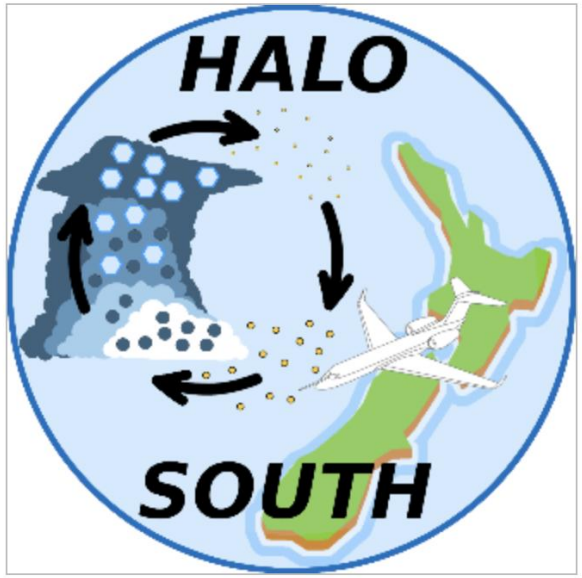
- Deploy NASA’s HSRL-2 on the G-III (13km)
- Base in Bermuda - September 2025, 3 weeks
- Conduct 10+ underflights along EarthCARE’s ATLID ground track at night (~2:30 AM local time)
- Coordinate targets (aerosols, warm clouds, cirrus clouds) with ATLID algorithm team

NASA LaRC Gulfstream III



High Spectral Resolution Lidar
HSRL-2 355nm & 532nm

HALO SOUTH (NZ) ‘25



- Together with the Leibniz Institute for Tropospheric Research, DLR is investigating the interaction between clouds, aerosols and radiation over the Southern Ocean as part of the HALO-South project.
- The researchers aim, among other things, to close knowledge gaps in existing climate models.
- For this, the HALO research aircraft is being used to measure atmospheric particles, trace gases and cloud properties, complementing satellite data.
- Focus: Aeronautics, atmospheric research

© Stephan Mertes

Scientific equipment inside HALO

For the HALO-South mission, the DLR research aircraft HALO has been fitted with a range of complex atmospheric instruments. During measurement flights, air samples are taken in through special inlets and analysed. This view of the cabin shows the installed racks with instruments for analysing cloud and aerosol particles, as well as the composition of trace gases.

Credit: DLR (CC BY-NC-ND 3.0) Download

PONEX: The Polar Night Experiment

Environment and Climate Change Canada

HOME | HAWC | EarthCARE | Logistics | Participants | Activities | Surface

EarthCARE's Calibration/Validation

EarthCARE's commissioning phase: **June – November 2024**

Across the globe: 13 airborne/shipborne campaigns during commissioning phase + more during mission lifetime.

Canada (ECCC, NRC, & Academia):

Ongoing Ottawa-based aircraft/surface calibration/validation campaign: ECALOT (Sep.-Nov. 2024);

- ✓ Similar payloads to EarthCARE's (radar, lidar);
- ✓ In-situ probes sampling clouds & aerosols;
- ✓ Mid-latitude continental fall conditions.

Beyond commissioning phase → Arctic Polar Night Experiment (PONEX) campaign (Jan. – Feb. 2026);

- ✓ In addition to ECALOT: HAWC instruments to observe far-infrared radiation (**FIRR**) & aerosols (**ALI**);
- ✓ **Unprecedented Arctic polar night conditions!**

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).

Next up in 2026

esa

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).

COMPEX - Clouds over cOMPlEX environment

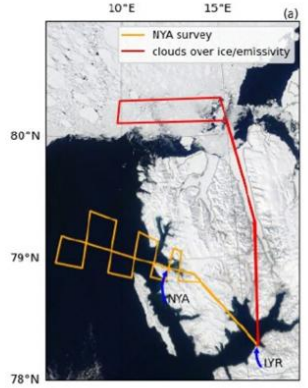
Campaign planed in the framework of **AC3**
(University of Cologne and Leipzig)

Arctic EC validation with payload
Similar to COMPEX-EC '25

Scientific goals:
(i) Spatio-temporal low level cloud variability in the Ny-Ålesund/Kongsfjorden area
(ii) Cloud characteristics over sea ice
(iii) Sea-ice emissivity
(iv) EarthCARE underflights

5 weeks granted in Mar/Apr 2026

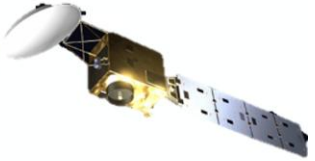
Base in Longyearbyen (Svalbard)



Outlook : Campaigns 2027 and beyond

- Airborne campaigns will remain an essential contribution to EarthCARE's validation throughout Phase E
- Focus broadening from direct L1 to validation of the whole L2 pruduction tree with both EarthCARE-like payloads and complementary in-situ suits.
- Mediterranean Campaign consept for 2027 (CoSENSE)
- Several Teams plan airborne campaigns in the coming years, including also antarctic coverage.

'27 CoSENSE (Collaborative Sensing in the Mediterranean)



CoSENSE aims to implement a multi-platform/sensor experimental campaign in the Mediterranean region to address atmospheric and ocean science challenges and run an extended harmonization effort for European and U.S. Cal/Val and satellite missions

Planned : Airborne
NASA HSRL-2

Participants: ESA, NASA, ECMWF, NOA (Greece), Cyprus Institute (Cyprus), World Radiation Center (Switzerland), DLR (Germany), CNR (Italy), KNMI (The Netherlands), SRON (The Netherlands), FMI (Finland)

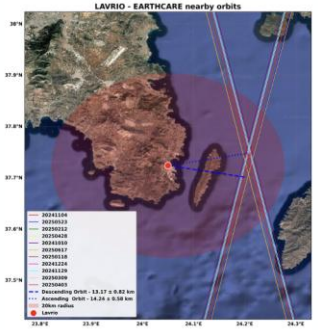
Research Infrastructures:

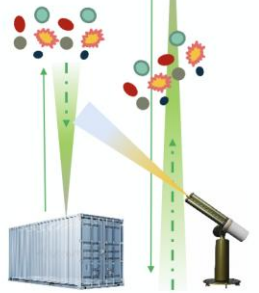
Surface-based: PANGEA ACTRIS climate observatory (Greece), Limassol ACTRIS station (Cyprus), Potenza ACTRIS station (Italy), Sunphotometric suite of the PMOD/ World Radiation Center (to be deployed in Greece), AERONET/MPLNET sites in Europe.

Airborne: NASA, FAAM UK airborne facility (proposal pending), CyI drones (in-situ), Slovenian small aircraft (in-situ)

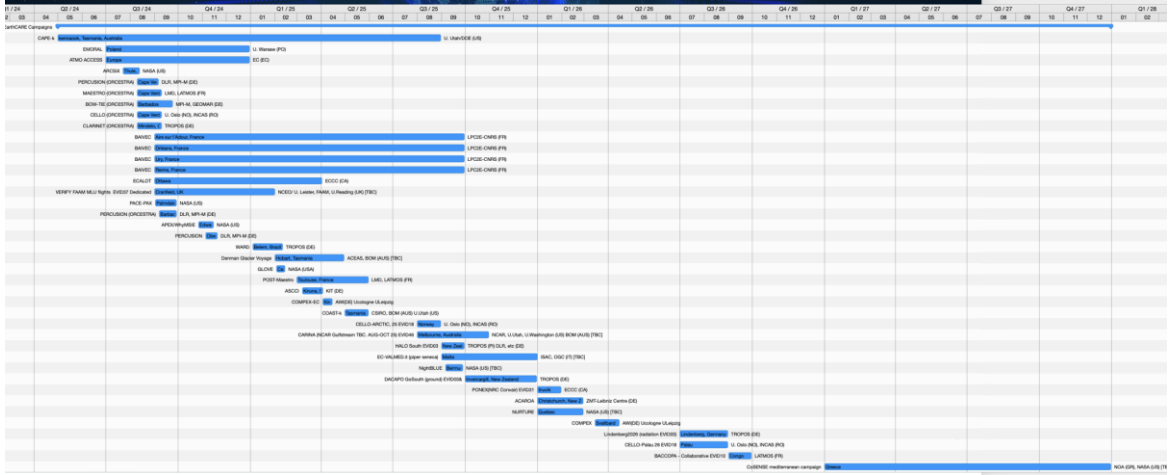
Related missions, programs, projects, initiatives: EarthCARE, PACE, ACTRIS, MIRA, CERTAINTY, CleanCloud, AIRSENSE, PANORAMA

Lavrio, Athens, Greece
Spring 2026 – Autumn 2027





Campaigns : Timeline overall

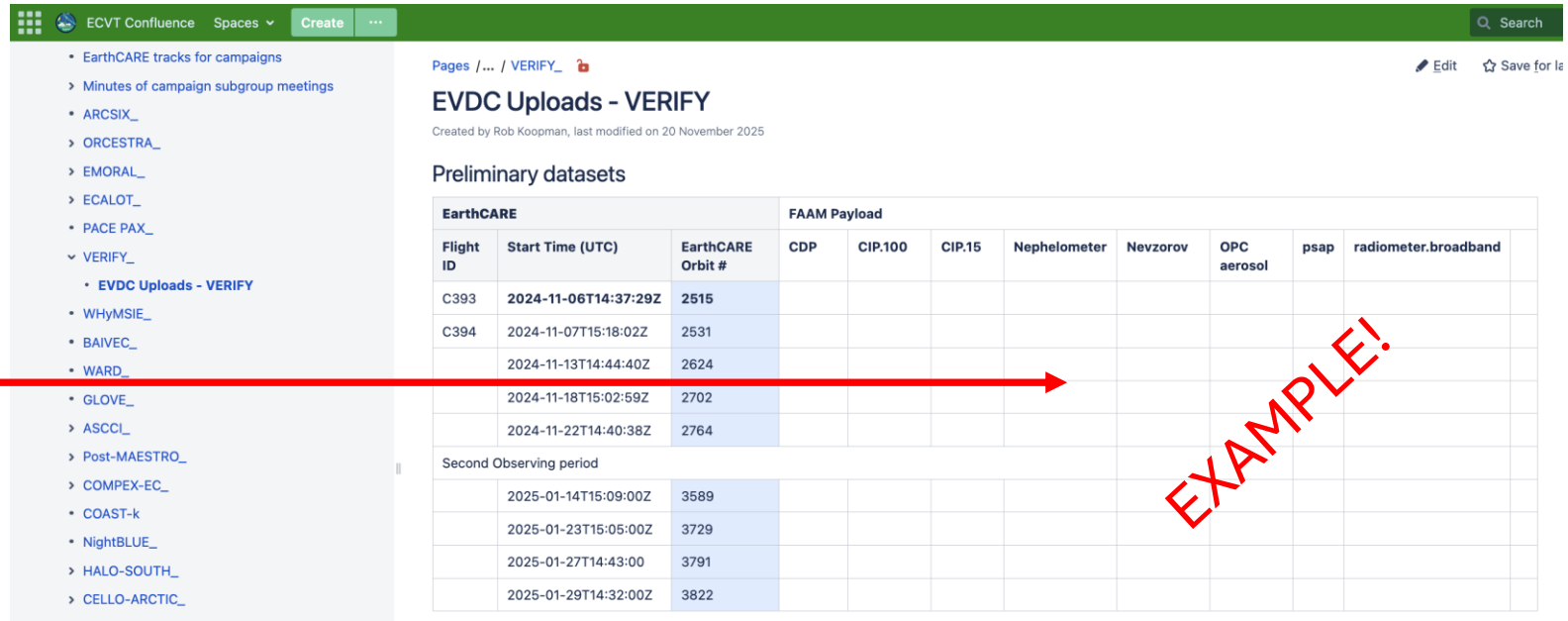


CAMPAIGN DATASETS – EVDC AND LOGISTICS

- Follow poster and demo of EVDC at 16:30!
- EVDC ready to host additional preliminary airborne campaign datasets from 2024/25
- New tables on confluence under “EVDC Uploads” to indicate available data by instrument.

DAY4: THURSDAY 4 DECEMBER 2025

Poster, Demo and EVDC Splinter Session						
-	16:30	90	**POSTER and DEMO**	16:30	90	EVDC Splinter Session
-	18:00	0	**END**			



EarthCARE			FAAM Payload							
Flight ID	Start Time (UTC)	EarthCARE Orbit #	CDP	CIP.100	CIP.15	Nephelometer	Nevzorov	OPC aerosol	psap	radiometer.broadband
C393	**2024-11-06T14:37:29Z**	**2515**								
C394	2024-11-07T15:18:02Z	2531								
	2024-11-13T14:44:40Z	2624								
	2024-11-18T15:02:59Z	2702								
	2024-11-22T14:40:38Z	2764								
Second Observing period										
	2025-01-14T15:09:00Z	3589								
	2025-01-23T15:05:00Z	3729								
	2025-01-27T14:43:00	3791								
	2025-01-29T14:32:00Z	3822								

EarthCARE Underflights – Workshop Session(s)

DAY1: MONDAY 1 DECEMBER 2025

Special Session: 3-Group and 4-Group Data Release				
H116	14:30	10	In pursuit of radiative closure above clouds: Insights from collocated airborne observations during PERCUSION (Online)	Florian Ewald
H117	14:40	10	Validation of EarthCARE&rsquo's 3D scene construction algorithm using in situ and remote sensing data from the ECALOT campaign	Zhipeng Qu
H118	14:50	10	Validation of EarthCARE Cloud and Precipitation Products Using FAAM Aircraft Observations: VERIFY Campaign	Adam Povey

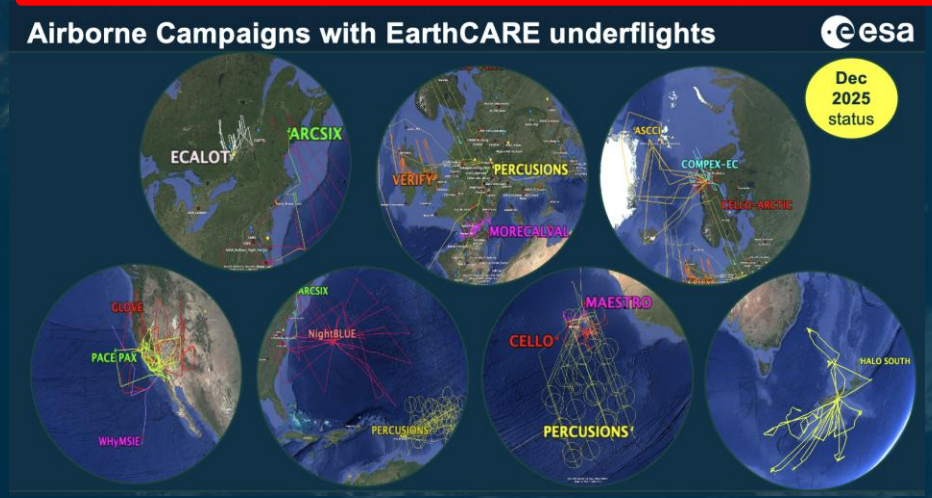
DAY2: TUESDAY 2 DECEMBER 2025

Cloud and Precipitation Microphysics and Convective Stream: Validation				
H217	13:50	10	Validation of EarthCARE Aerosol, Cloud, and Synergistic Products within ACROSS Activities	Eleni Marinou
H218	14:00	10	Airborne Validation of Cloud Spatial Properties from the ATLID Instrument on EarthCARE	Natalia Roldan-Henao

Don’t miss the posters related to airborne campaigns!

DAY3 - WEDNESDAY 3 DECEMBER 2025 (15:45-17:15)

Annex46	An airborne in-situ validation of ESA’s and JAXA’s cloud products in the Arctic	Chenqian Tang
Annex55	COMPEX-EC and COMPEX - Two Arctic airborne campaigns not only for EarthCARE validation	Mario Mech



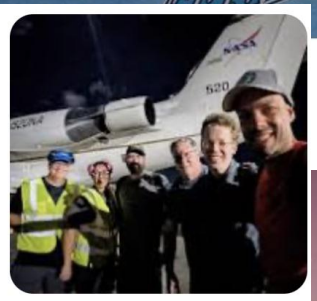
DAY4: THURSDAY 4 DECEMBER 2025

Aerosol: Validation				
Co-chairs: Yoshitaka Jin and Dave Donovan				
H406	9:30	12	EarthCARE validation with the PACE Postlaunch Airborne eXperiment (PACE-PAX) (Online)	Kirk Knobelspiesse

DAY4: THURSDAY 4 DECEMBER 2025

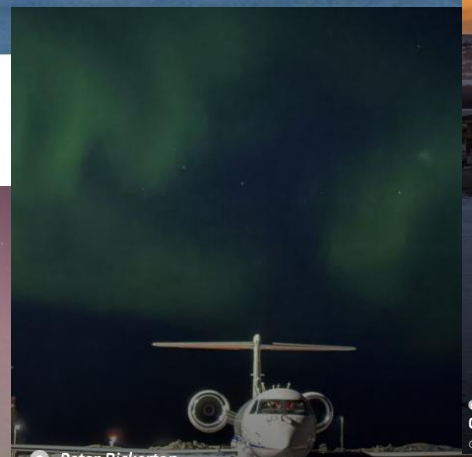
EarthCARE Underflights				
Co-chairs: Yuichi Ohno and Chris Hostetler				
H415	13:00	10	Validation of ATLID’s L1/L2 optical data using airborne lidar measurements during the PERCUSION campaign	Silke Groß
H416	13:10	10	Validation of ATLID extinction and lidar-ratio of cirrus clouds using airborne measurements with the research aircraft HALO during the PERCUSION campaign: assessment of the multi-scattering correction	Martin Wirth
H417	13:20	10	Validation of cloud macrophyisal properties from different ATLID L2 products (A-TC, A-FM, A-CTH) using co-located airborne HSRL lidar observations during PERCUSION and ASCCI	Konstantin Krüger
H418	13:30	10	Validation of MSI thermal-infrared radiance and BBR broadband irradiance by high altitude airborne measurements (Online)	André Ehrlich
H419	13:40	10	Evaluation of reflectivity and Doppler velocity structures from EarthCARE’s CPR with airborne W-band cloud radar observations during the ECALOT campaign	Paloma Borque
-	13:50	10	*Discussion*	
-	14:00	10	BREAK	
Co-chairs: Kaori Sato and Silke Gross				
H420	14:10	10	Comparison between EarthCARE and airborne measurements and products during MAESTRO and MORECALVAL field campaigns (L2 products)	Emmeline FRANCOIS
H421	14:20	10	EarthCARE’s ATLID Calibration and Validation Using the NASA LaRC Airborne HSRL-2 during the First Year in Orbit August 2024 – September 2025	Johnathan Hair
H422	14:30	10	Validation of ALTID products based on dedicated underflights from NASA aircraft campaigns ARCSIX, PACE-PAX and NightBLUE	Diko Hemminga
H423	14:40	10	Direct Comparisons of EarthCARE CPR and Airborne Cloud Radar System (CRS) Reflectivity and Doppler Data (Online)	Matthew Walker McLinden
H424	14:50	10	Calibration and Validation of EarthCARE’s Cloud Profiling Radar Data Products: Assessment of Doppler products	Simone Tanelli
-	15:00	10	*Discussion*	
-	15:10	45	COFFEE	
Co-chairs: Yuichi Ohno and Chris Hostetler				
H425	15:55	10	An Overview of the Polar Night Experiment (PONEX) Aircraft Campaign for HAWC and EarthCARE	Kaley Walker
H426	16:05	10	Validating EarthCARE’s CPR in the Arctic: Results from the COMPEX-EC Airborne Campaign	Lars van Gelder
H427	16:15	10	Arctic clouds from within: Comparing airborne in-situ data with EarthCARE’s microphysical retrievals during CELLO-Arctic	Tim Carlsen
-	16:25	5	*Discussion*	

Thank you!



ESA's EarthCARE mission on ...

X



Peter Bickerton

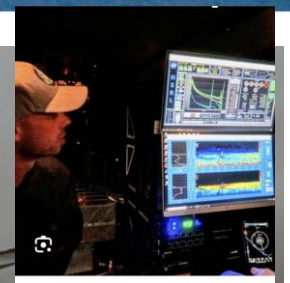
ASCCI: Dancing with a satellite and the northern lights during polar night flights

09/06/2025 0

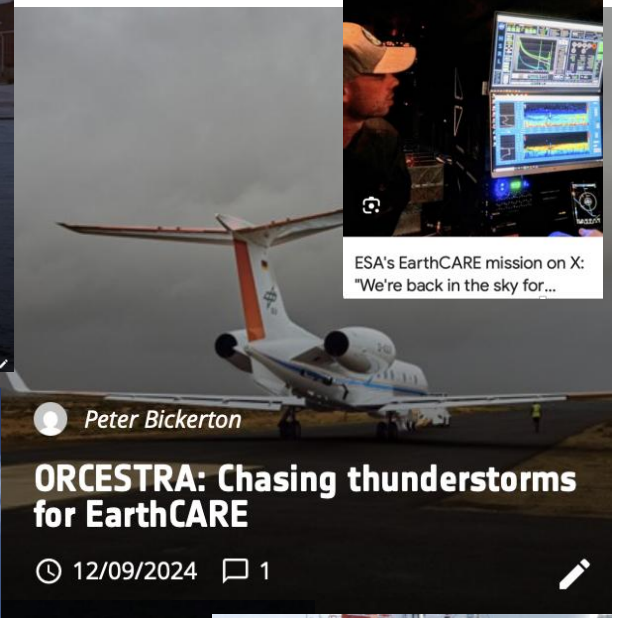
Peter Bickerton

COMPEX-EC: Snow white and seven flights for EarthCARE in the Arctic

17/06/2025 0



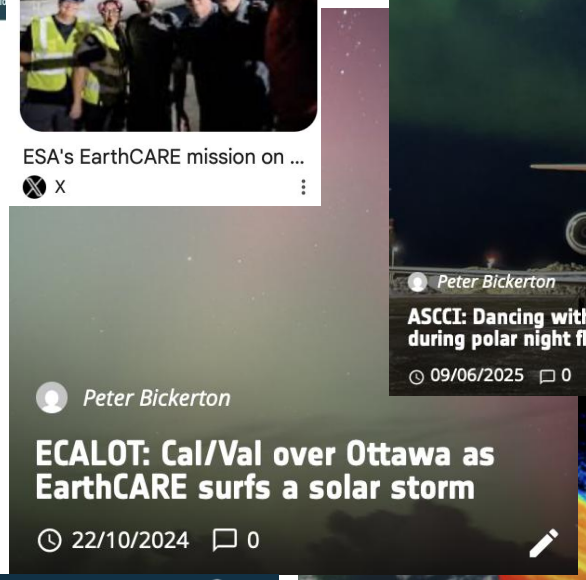
ESA's EarthCARE mission on X: "We're back in the sky for...



Peter Bickerton

ORCESTRA: Chasing thunderstorms for EarthCARE

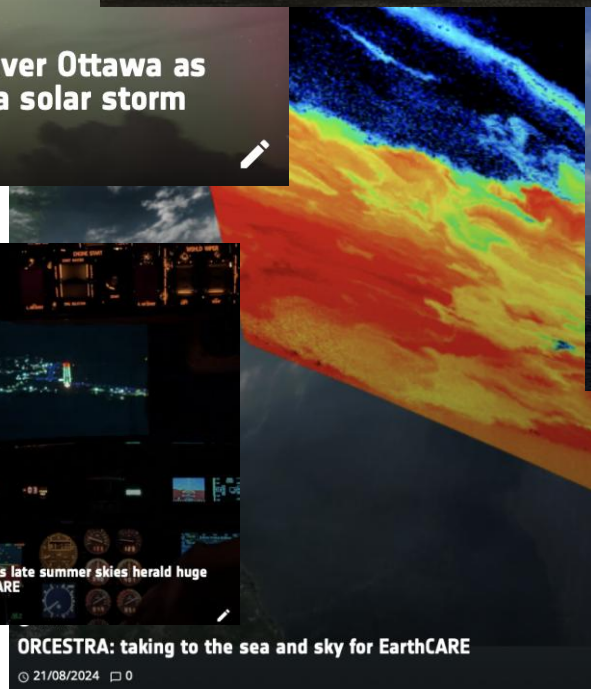
12/09/2024 1

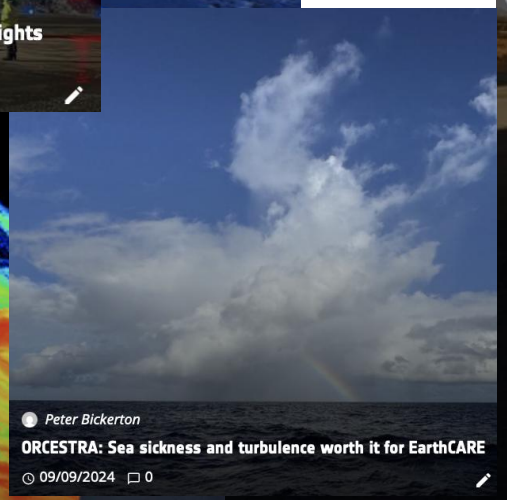


Peter Bickerton

ECALOT: Cal/Val over Ottawa as EarthCARE surfs a solar storm

22/10/2024 0



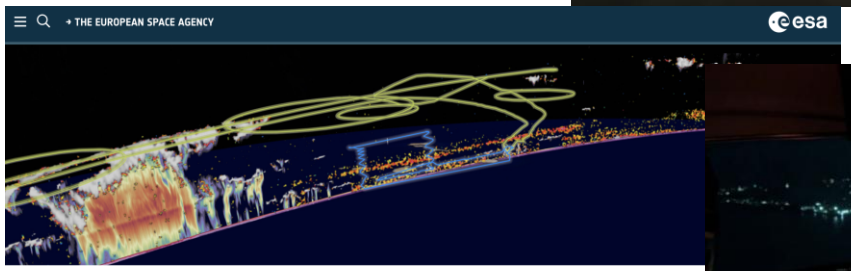


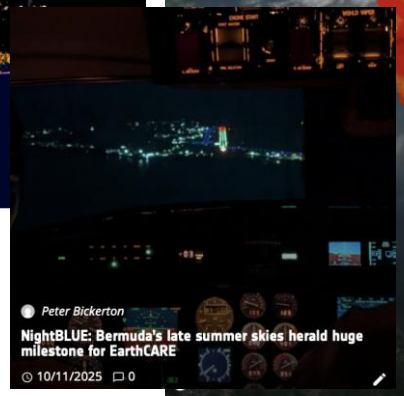
Peter Bickerton

ORCESTRA: Sea sickness and turbulence worth it for EarthCARE

09/09/2024 0

ORCESTRA: Sailing through storms for EarthCARE

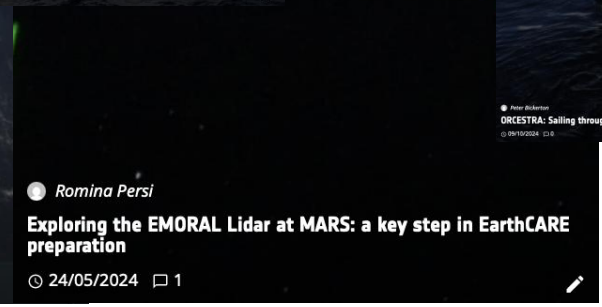




Peter Bickerton

NightBLUE: Bermuda's late summer skies herald huge milestone for EarthCARE

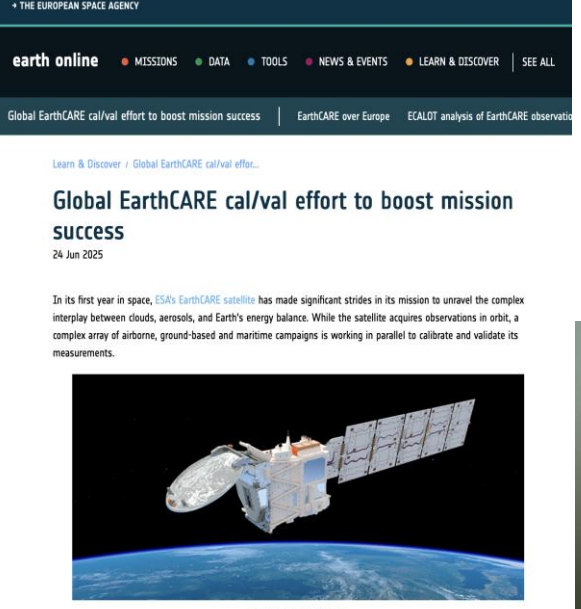
10/11/2025 0



Romina Persi

Exploring the EMORAL Lidar at MARS: a key step in EarthCARE preparation

24/05/2024 1



APPLICATIONS

Taking to the skies for EarthCARE

28/11/2024 1750 VIEWS 24 LIKES