



Synergistic use of EarthCARE data for in-situ observations and modelling in CleanCloud

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and the CleanCloud consortium

EarthCARE 2026 Science & Validation Workshop

Oxford, 10 June 2026

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Horizon Europe Cluster 5 project

Clouds and climate transitioning to post-fossil aerosol regime



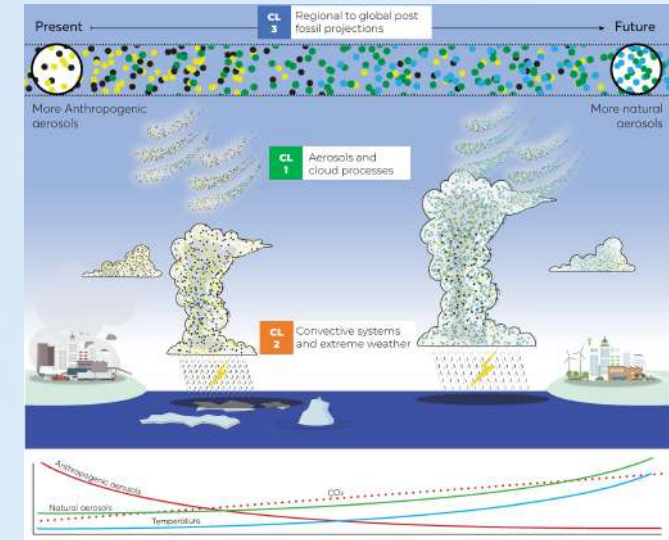
Aims to:

- Holistically assess the role of aerosols in the life cycle of convective systems and extreme events
- improve and constrain kilometer- and large-scale climate models (**EC-Earth 4**, ICON) using machine learning, data assimilation & model calibration.

20 partners, 12 countries (14 EU/2 CH/4 UK)

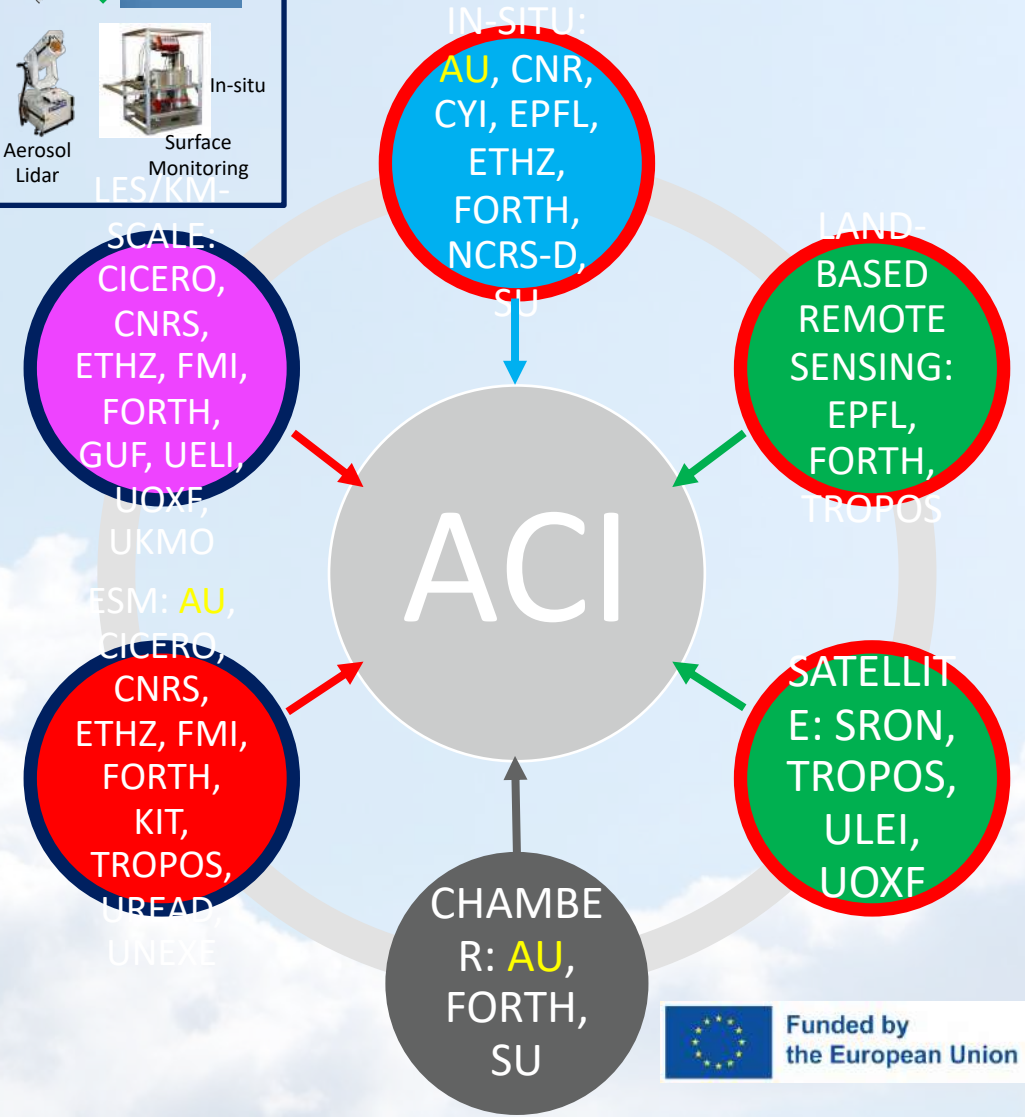
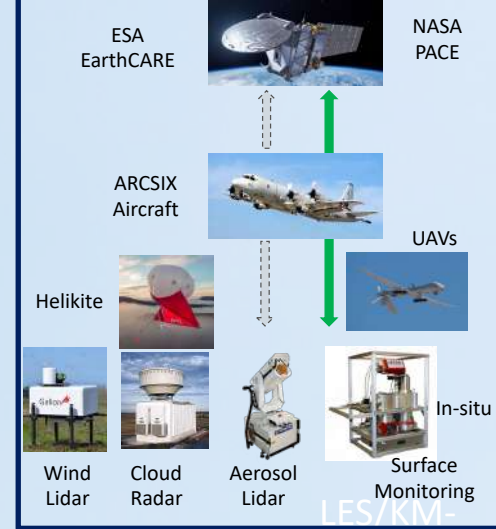
Coordination:

AU (Ulas Im), FORTH/EPFL (Athanasios Nenes)



Use of EarthCARE in CleanCloud

- Field closure experiments to develop new retrieval algorithms
- Use these new algorithms in EarthCARE Cal/Val activities
- Use new retrievals in creating PPEs in km-scale and large-scale climate models



• Arctic (Villum: Spring & Summer 2024)



• Mediterranean: Mt. Helmos (Autumn 2024)

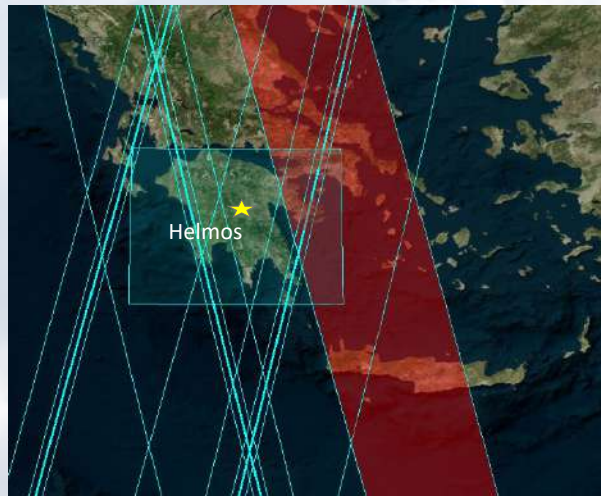
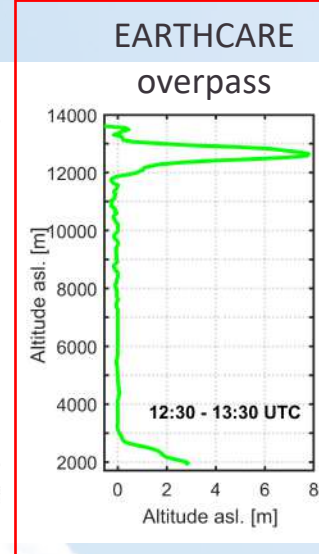
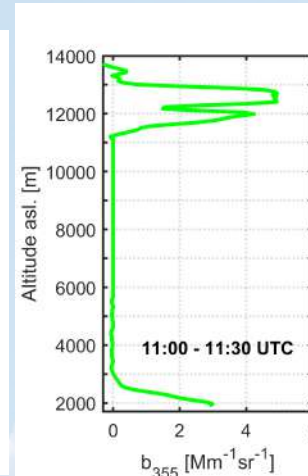
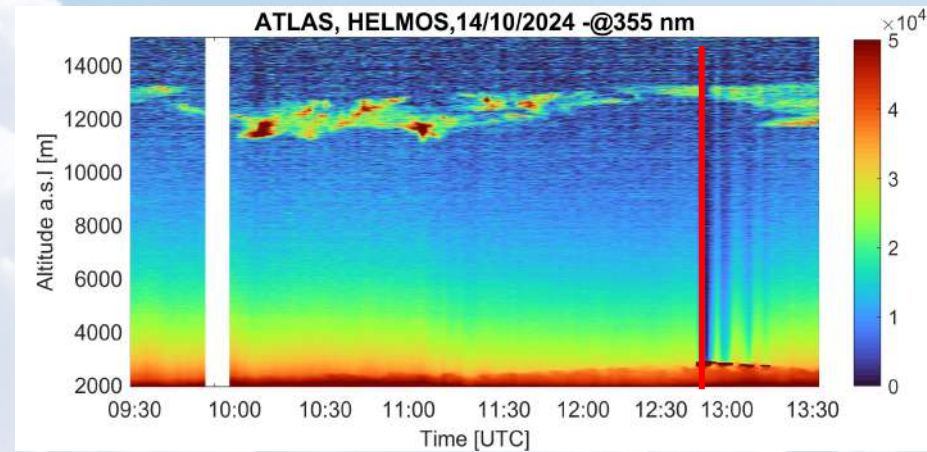


• HALO-South & ATTO (Autumn 2025)

EPFL EARTHCARE and Ground-based EPFL ATLAS LiDAR: Preliminary Results and Next Steps

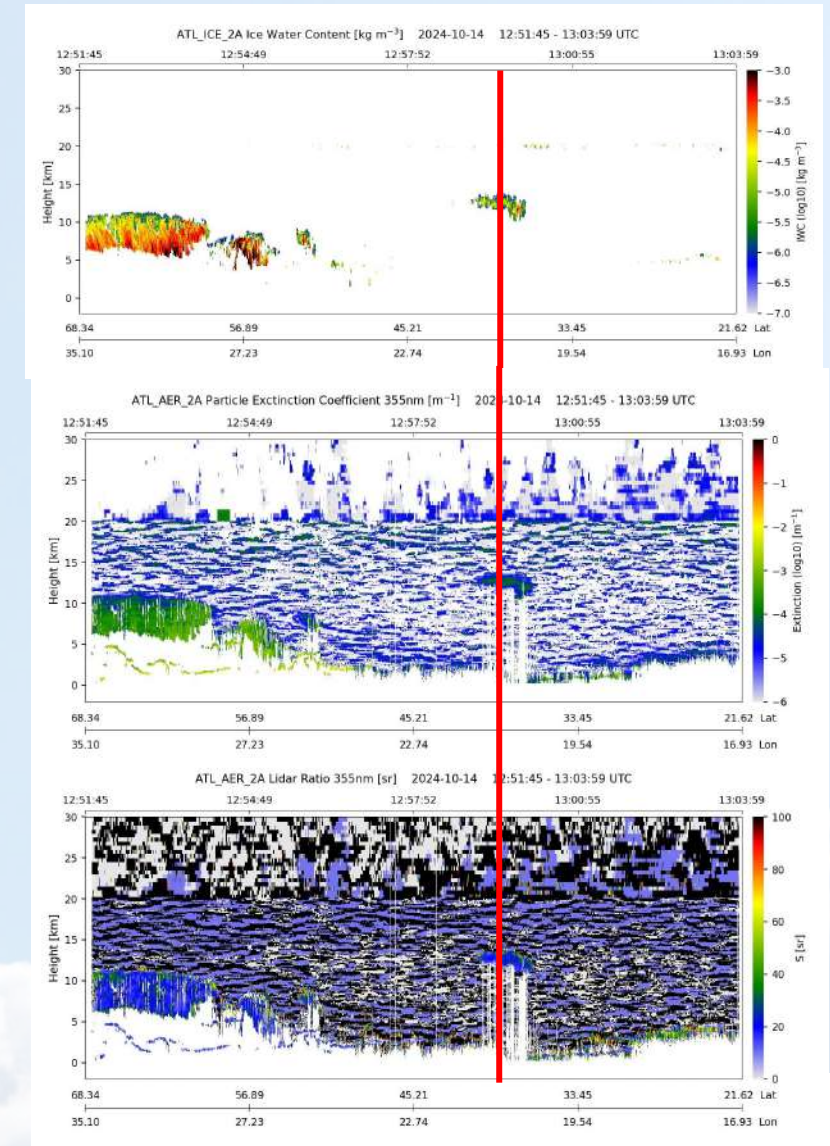


Co-located elevated layer at ~11-13 km in both IWC and extinction



Satellite-ground agreement at overpass
→ Likely thin cirrus-type ice cloud, optically detectable at 355 nm

- Continuous atmospheric monitoring between satellite overpasses via ground-based LIDAR
- Cross-validation of aerosol and cloud classification
- Improved retrieval constraints for extinction, phase discrimination, and lidar ratio (LR)
- Identification of aerosol-cloud interaction structures
- Regime-dependent bias correction for dust, smoke, cirrus, and mixed-phase conditions

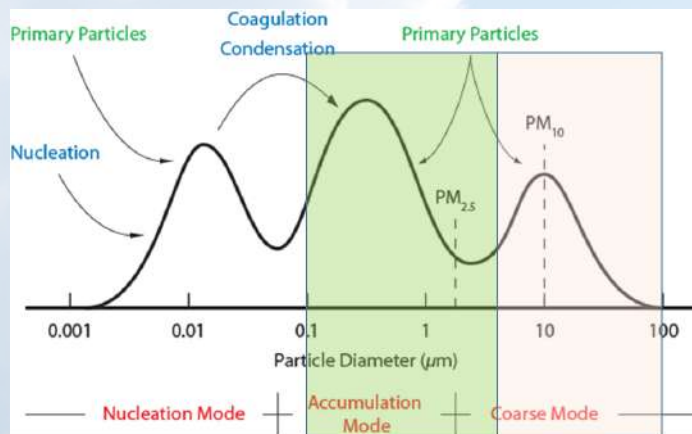




- Mt Helmos, Greece, 11 Oct – 3 Nov 2024
- Objectives: Aerosol-cloud interactions and EarthCARE cal/val
- Deployed USRL's UAVs with POPS, UCASS and impactors – **more than 50 flights! :D**

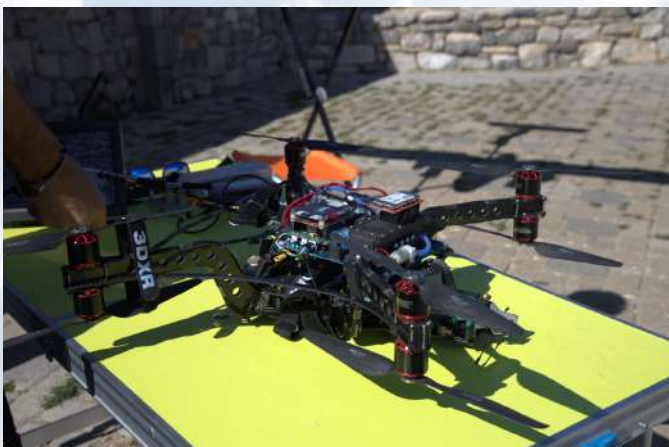
OCTOBER 2024

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	

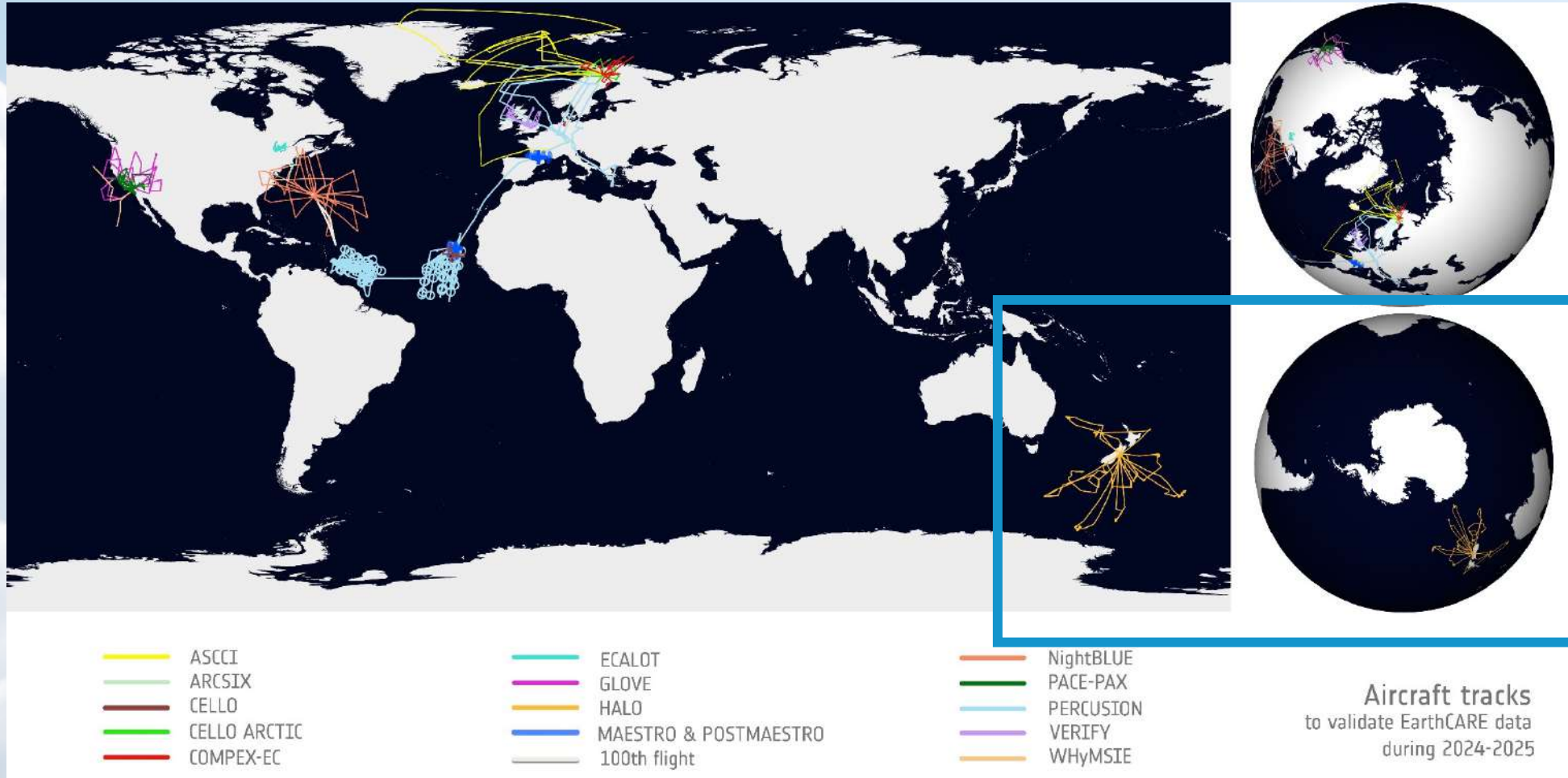


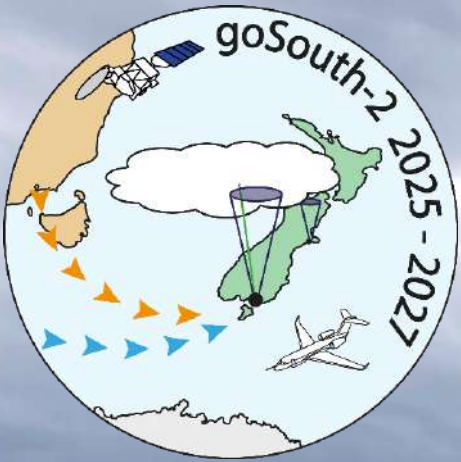
POPS

UCASS



Aircraft observations



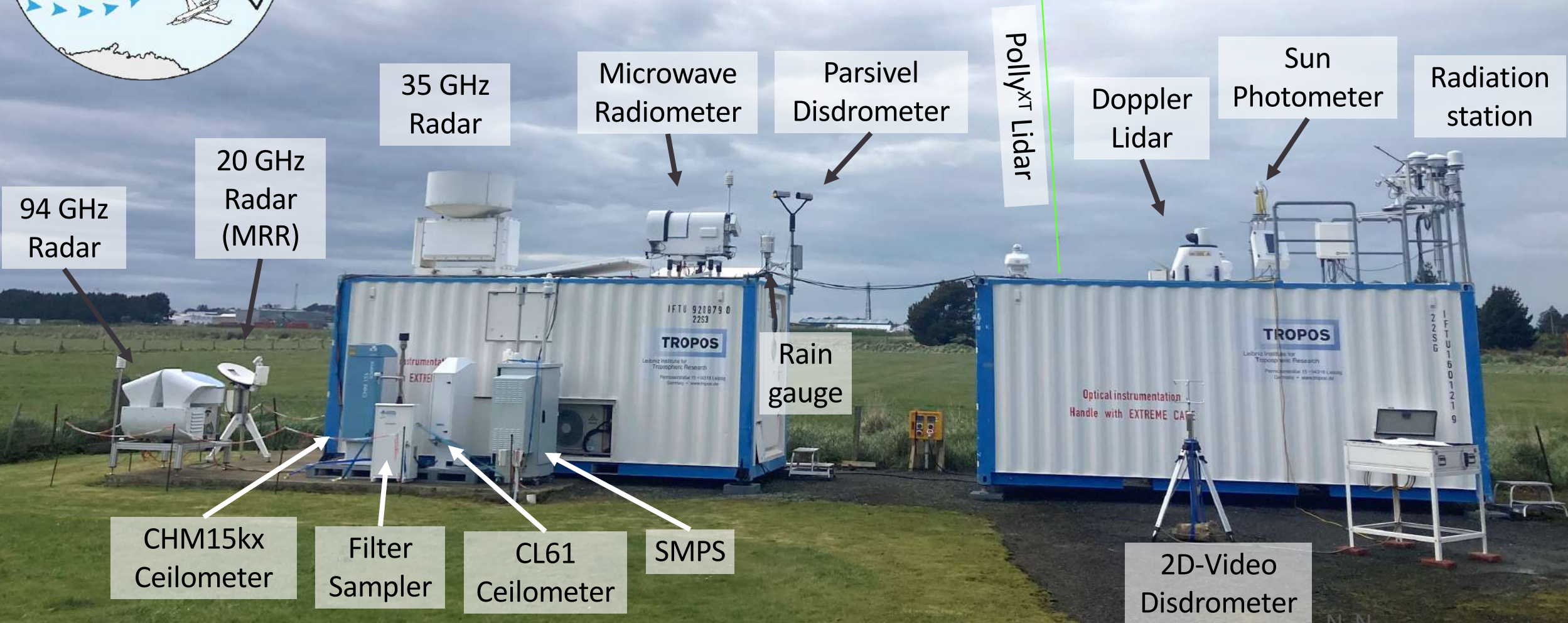


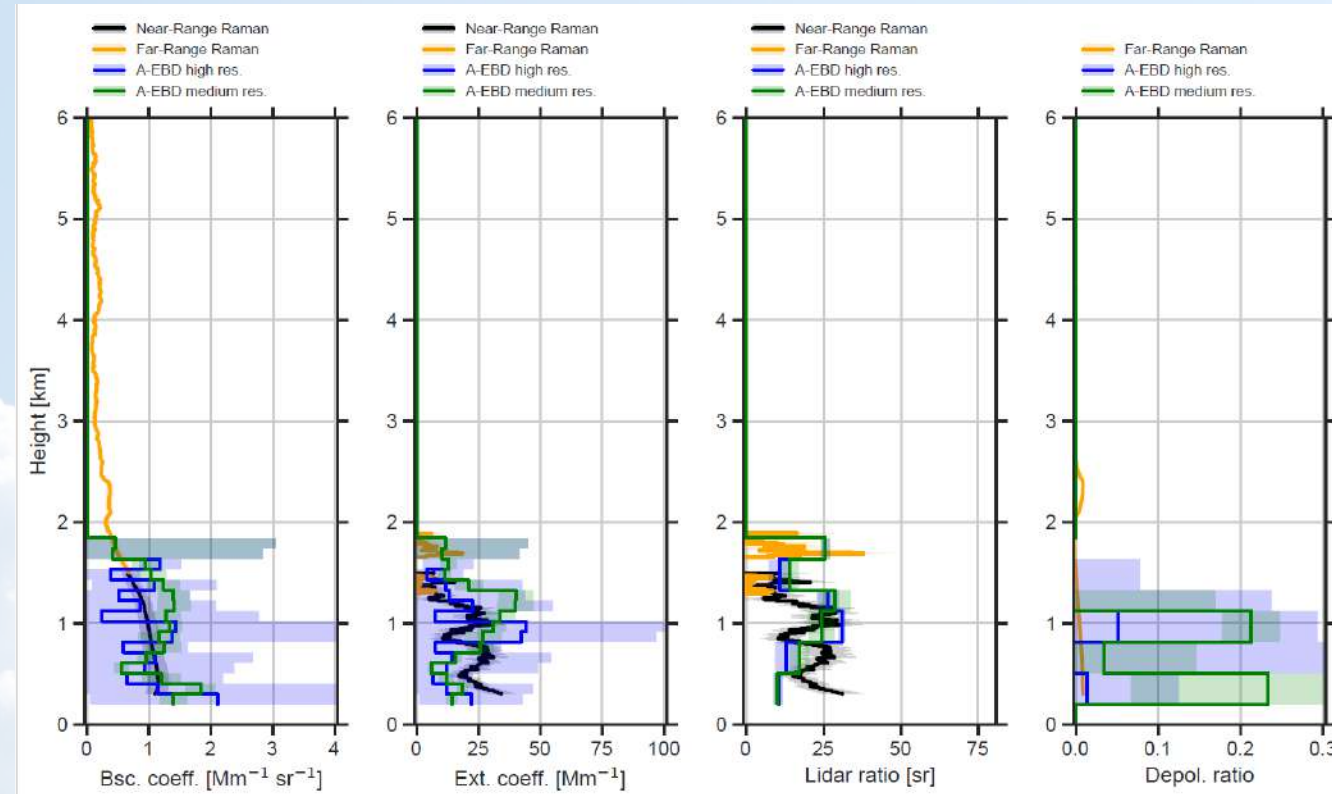
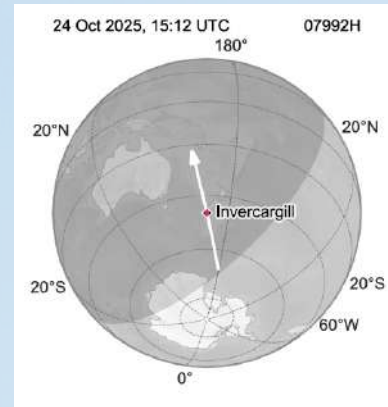
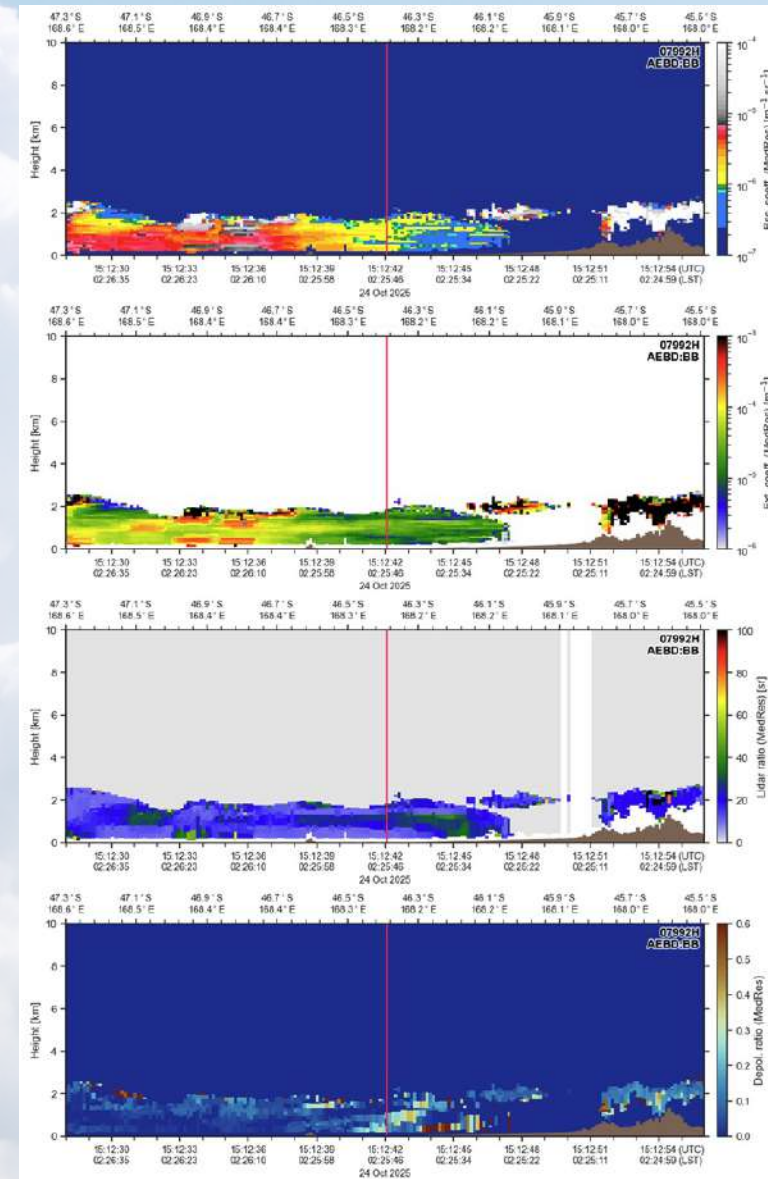
LACROS at Invercargill

- Fully operational since 1 Sep 2025
- Measurement to take place until March 2027



- Twice daily radiosondes
- Scanning precip. radar
- Surface observation
- Ceilometer (airport)





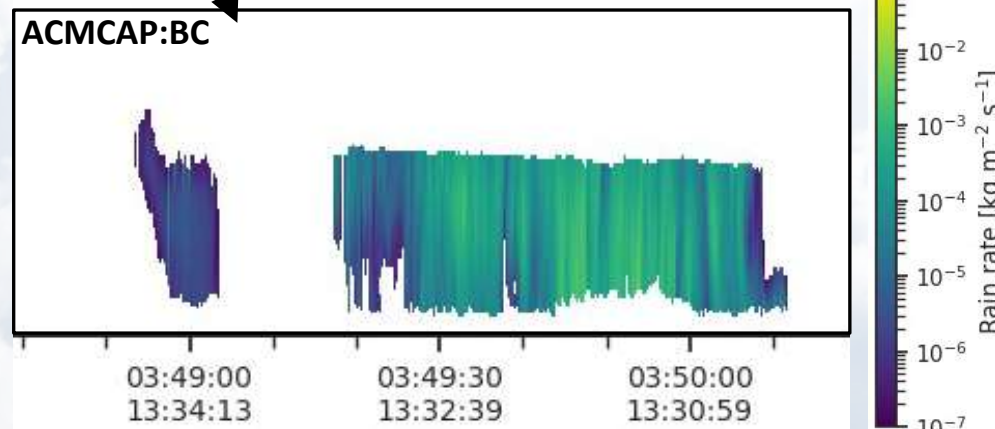
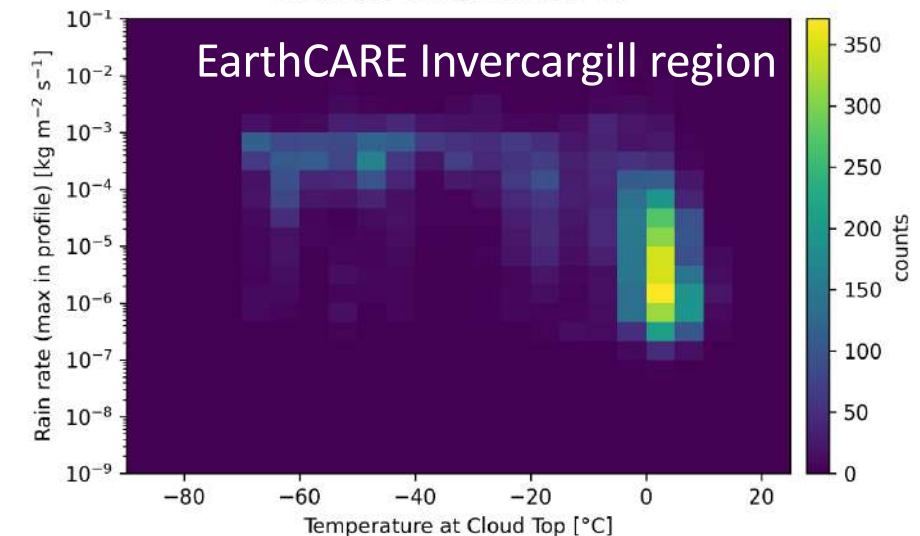
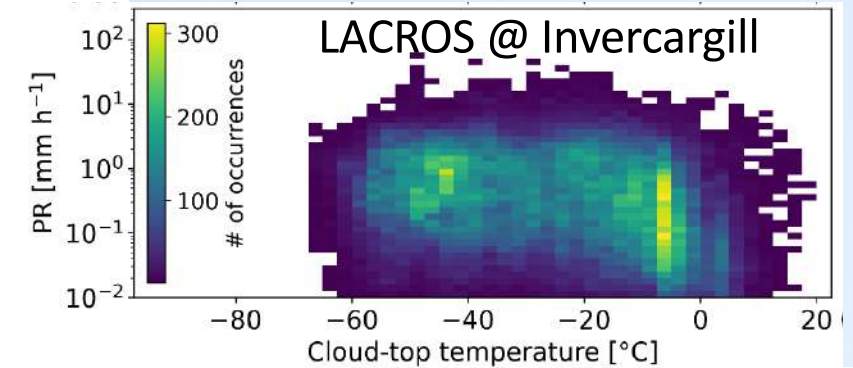
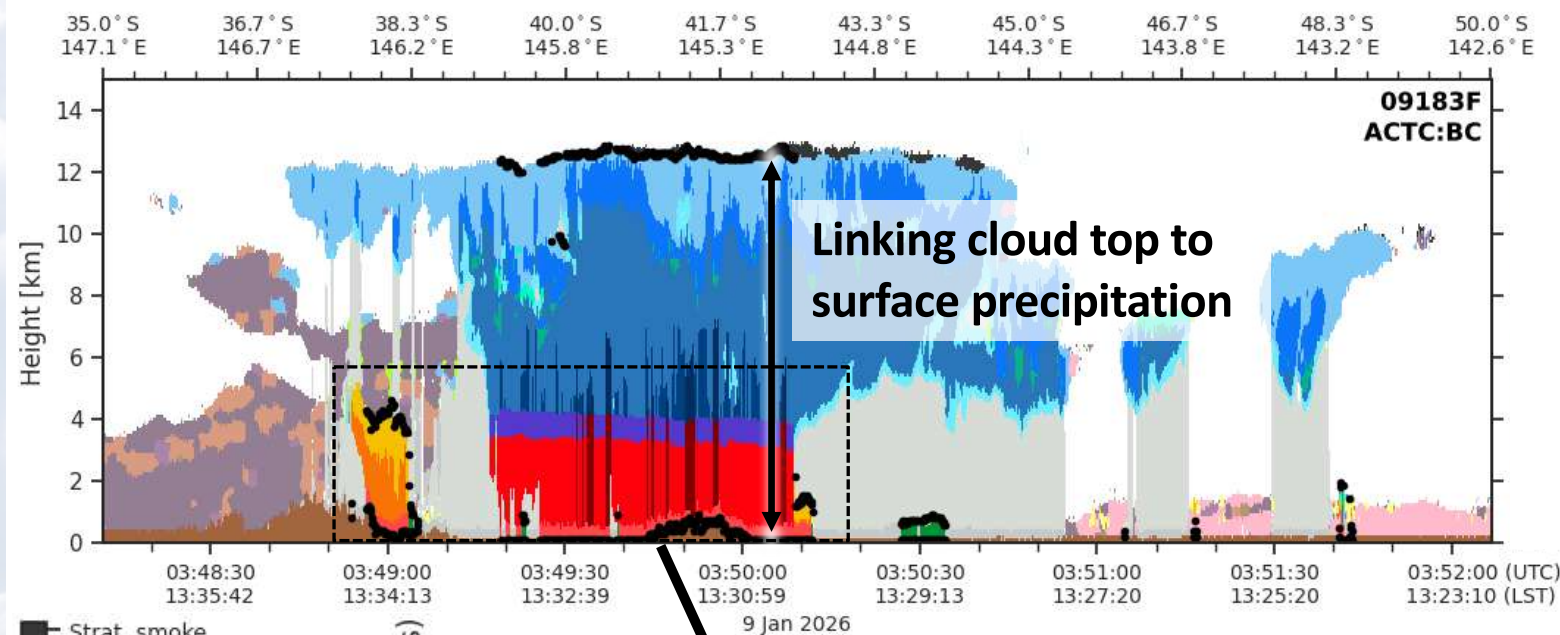
- LACROS observations also available for Cal/val activities
- Benchmark for (pristine) marine Southern Ocean (but also smoke and dust from Australia)

[Baars et al.: Validation of EarthCARE's ATLID L2 aerosol profiling products with ground-based lidar stations of PollyNET – case studies, <https://doi.org/10.5194/egusphere-2026-1490>, accepted for publication]



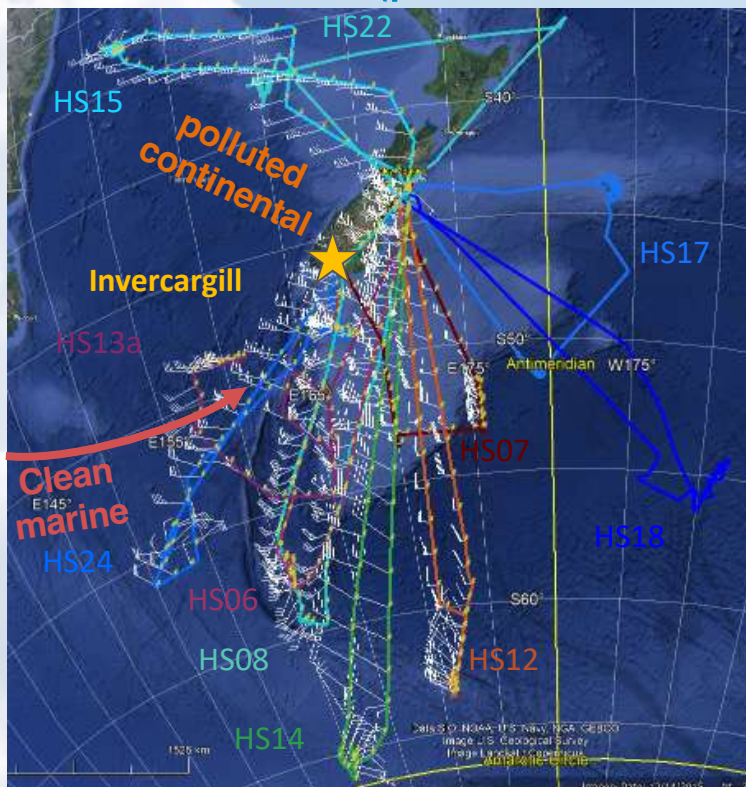
Outlook: Precipitation studies with EC CLOPPER

- Ground-based vs. EarthCARE-based precipitation statistics, considering cloud structure!



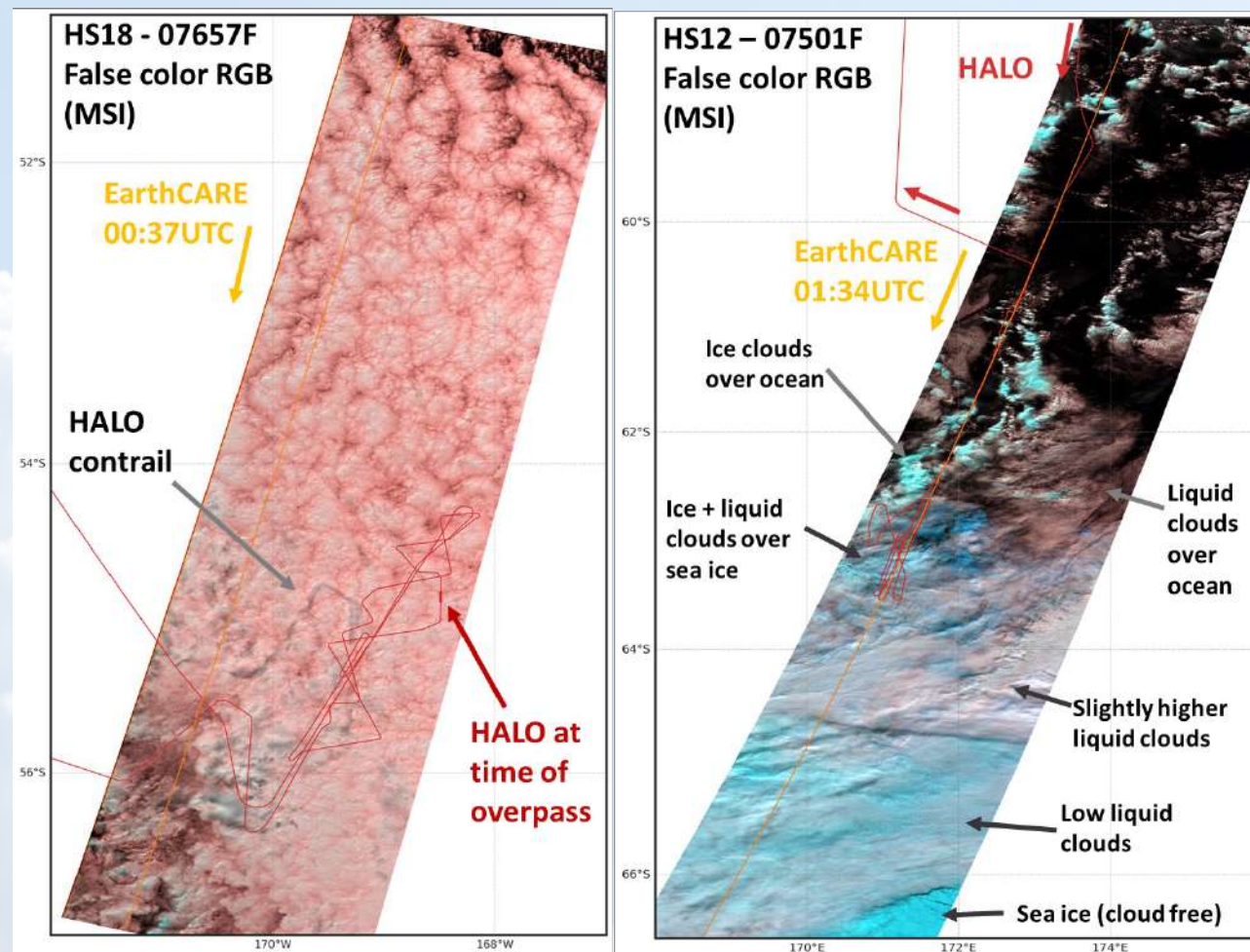


- 9 rendezvous with EarthCARE
- Partly directly below-satellite track, partly within MSI (passive sensor) swath

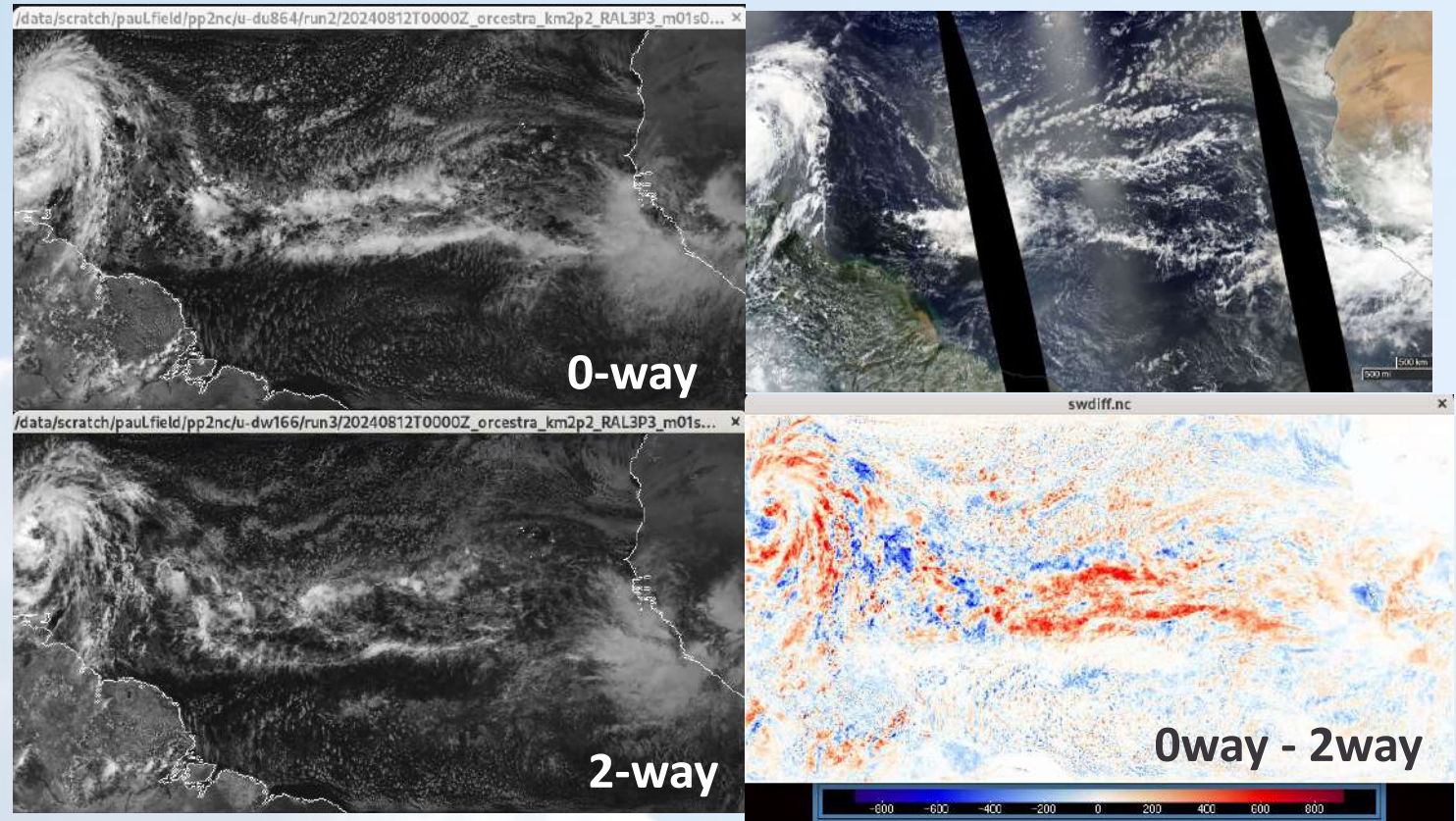


ESA ECVT page:

<https://ecvt.csde.esa.int/cofluence/pages/viewpage.action?pagelid=107488982>



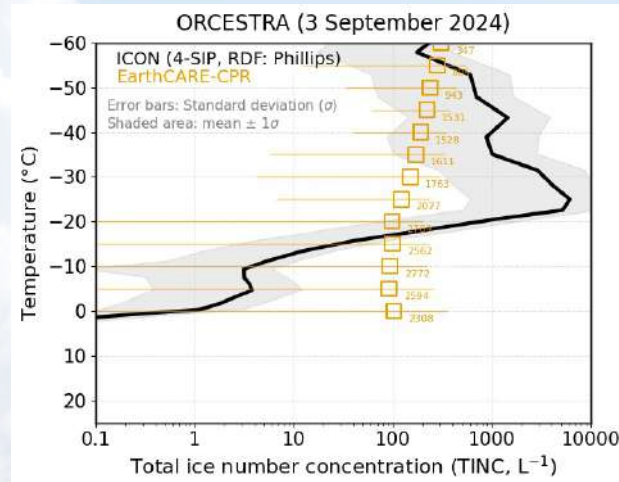
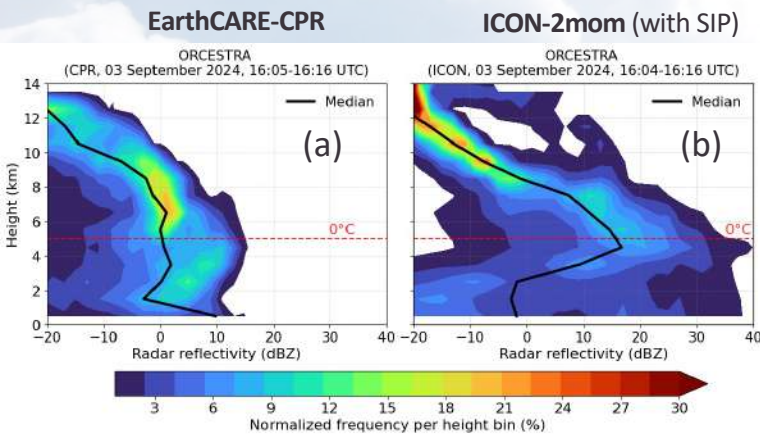
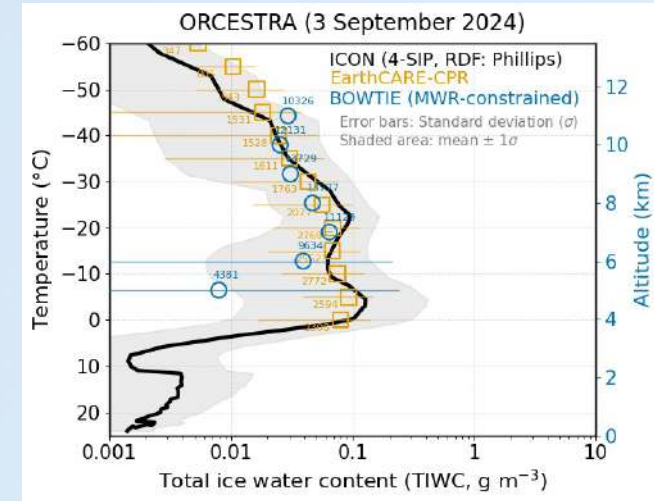
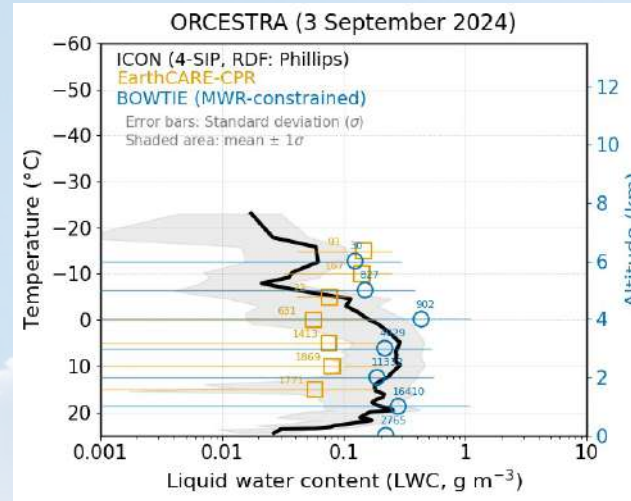
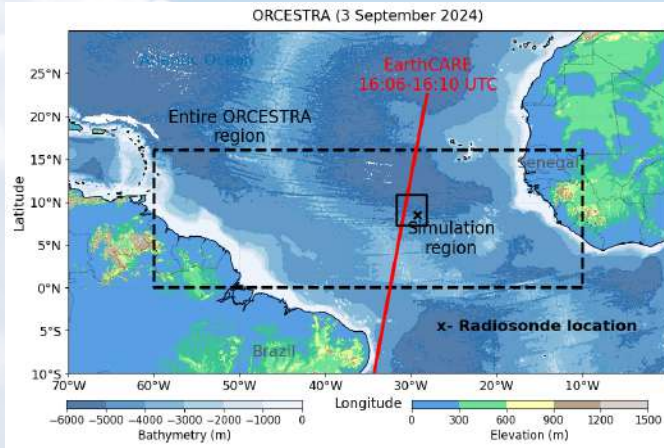
- UKMO regional model data for ECOMIP
- 2 sept 2024, 12 Aug 2024 for 2 days
- Providing 2 configurations with grid resolution 2.2km
 - Prescribed droplet and ice number concentrations (0-way)
 - Aerosol driven droplet number (CCN) and ice number (INP) concentrations based on Copernicus Aerosol Modelling System (CAMS). Aerosol interaction is 2-way with cloud - e.g. evaporation releases aerosol back to atmosphere (2-way)
- In progress- uploading 2.2km netcdf files to ECOMIP (6TB)



13 Aug 2024, 16.30UTC



- ✓ Impact of secondary ice production (SIP) on microphysics and dynamics of convective clouds
- ✓ ICON 2-mom. microphysics scheme and evaluated it against EarthCARE-CPR

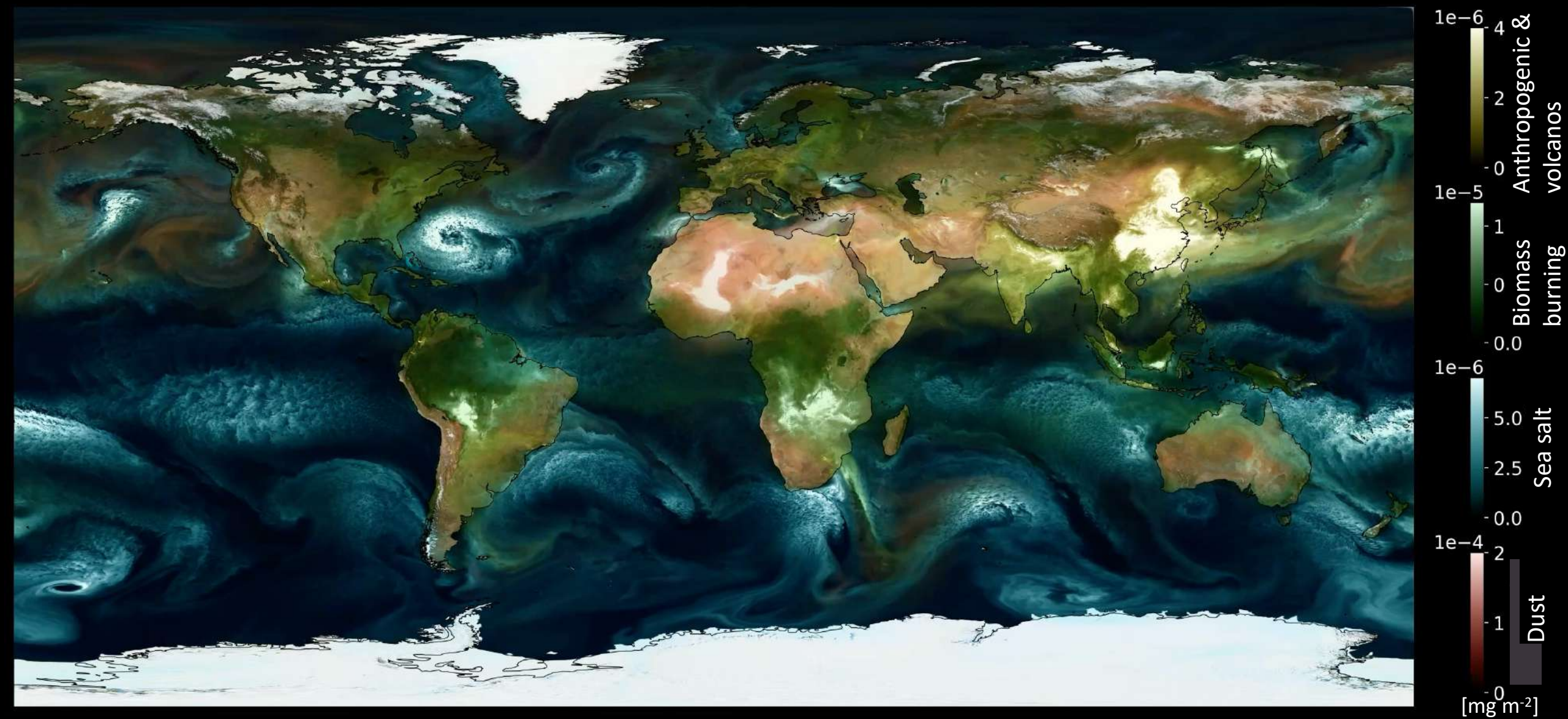


Waman et al. 2026 (In review, ACP)

Deepak Waman, Corinna Hoose

Finding: With SIP, good agreement between simulation and observations

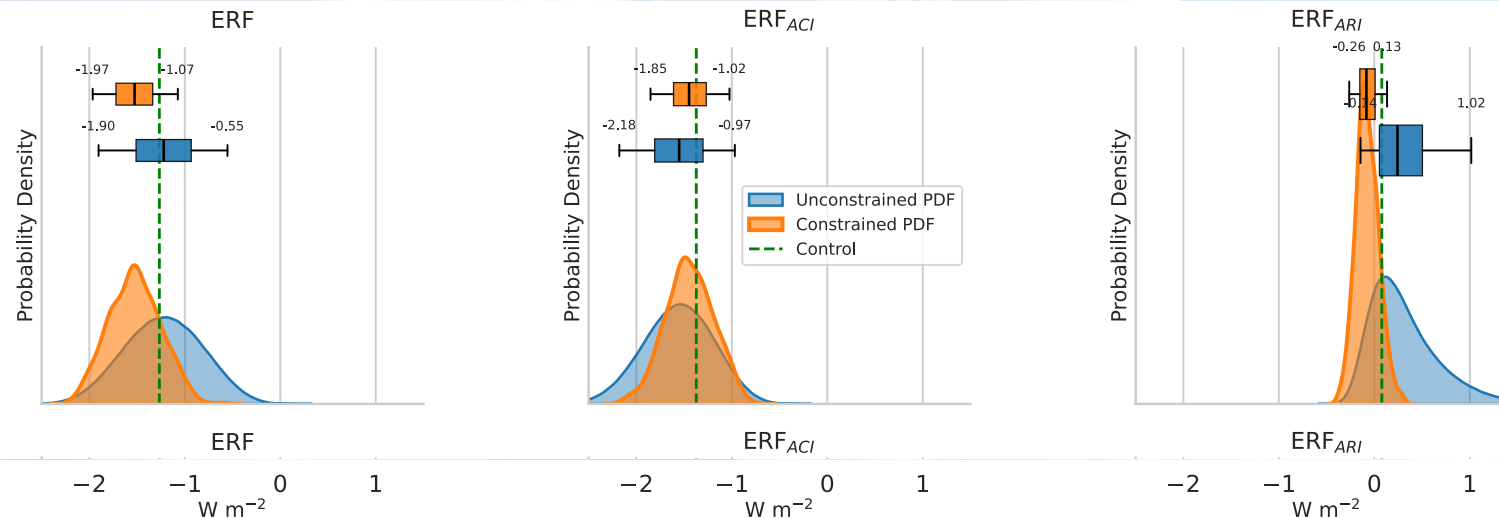
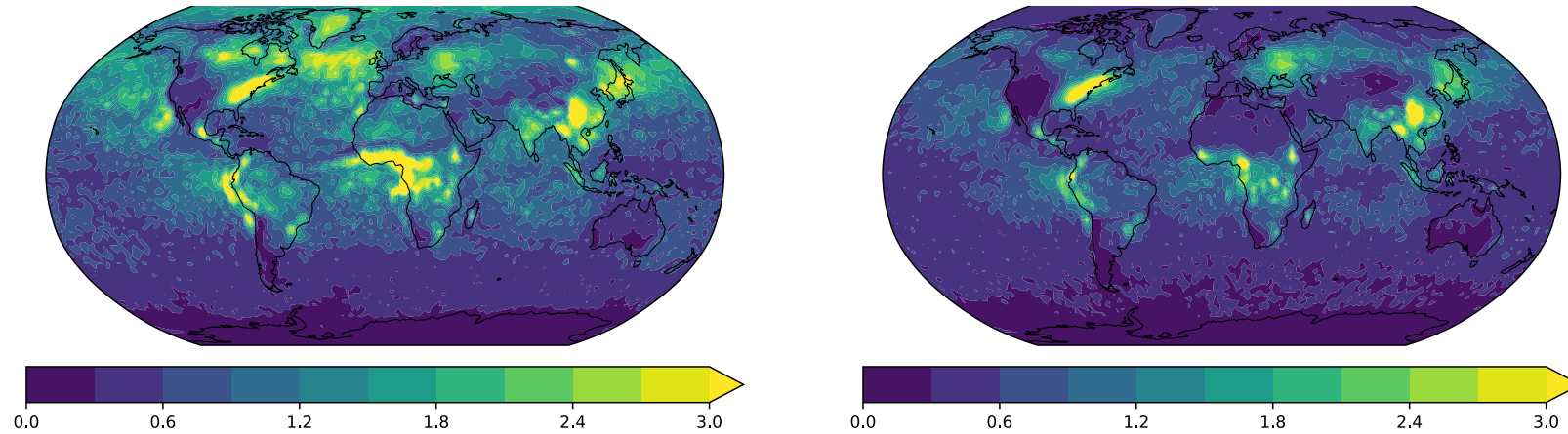
Global km-scale EarthCARE intercomparison for ORCHESTRA (ECOMIP)



Constraining Aerosol Climate Model Simulations (ECHAM-HAM) using PACE and EarthCARE



aerosol Effective Radiative Forcing (ERF) uncertainty before constraint after constraint



- Using ATLID (Earthcare) vertical profile information (fraction of extinction < 2 km).
- Using PACE aerosol amount, size, absorption (SPeXone) and CDNC (OCI).
- ATLID provides unique constraint on aerosol processes (e.g. Sulfate chemistry, wet deposition)

Bhatti et al., in preparation

ICON-HAM
ECHAM-HAM
EC-Earth

SRON

SPACE
RESEARCH
ORGANISATION
NETHERLANDS



FORTH

FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

MIROC-SPRINTARS

CIESM-PAM



EPFL



AARHUS
UNIVERSITY



MMPPE experiment (AeroCom Phase 4)

ACI-PPEMIP (CMIP7)



CAM6 + JCM (UC San Diego)
E3SM-APM (UAlbany)

UKESM
NorESM

Met Office
UNIVERSITY OF LEEDS



Norwegian
Meteorological
Institute



FINNISH METEOROLOGICAL
INSTITUTE

ECHAM-HAM-SALSA
ECHAM-MESSy



Max-Planck-Institut
für Meteorologie

IACETH



Funded by
the European Union

MMPPE Plan



- **Protocol:** based on ICON-HAM PPE
- **Perturbed parameters (~20 mandatory +20 optional):**

Emission	Aerosol Opt.	Hygroscopicity	Nucleation	Deposition	Chemistry
Activation	Cloud microphysics	cloud cover	Convection	Cloud Opt	Turbulence
- **Timeline:**
 - the 1st MMPPE meeting: 06 Mar 2026
 - model data collection begins in **summer 2026** → IPCC AR7

Contact h.jia@sron.nl for more details!

SUMMARY

CleanCloud exploits EarthCARE data and contribute to its Cal/Val by:

- ✓ Dedicated field observations (in-situ, remote sensing, aircraft) and algorithm development
- ✓ Participating dedicated modelling activities (e.g. ECOMIP)
- ✓ Constraining regional and large scale climate models and decrease uncertainty (PPEs)



<https://projects.au.dk/cleancloud>

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Bluesky: @cleancloud-he.bsky.social

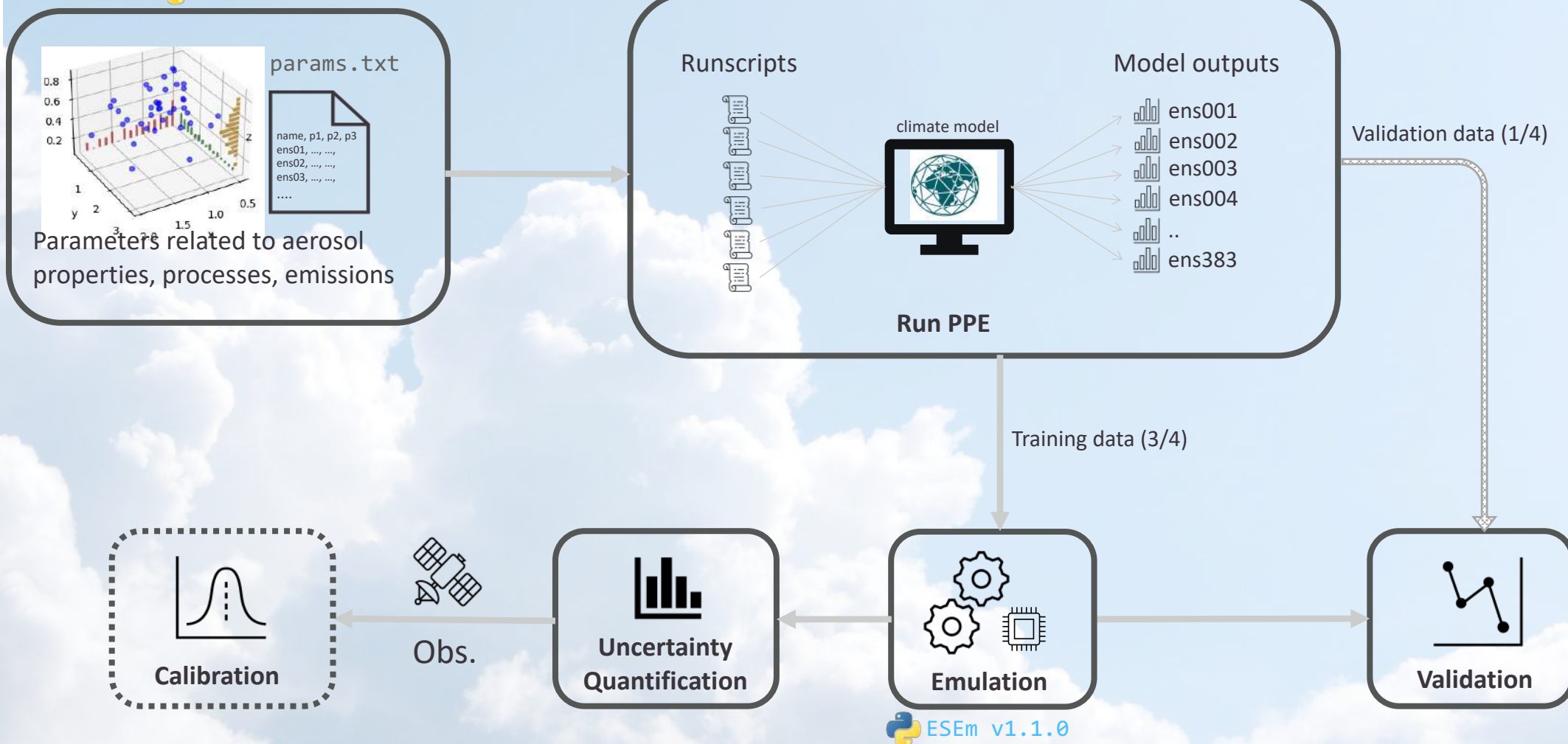
Videos: <https://mediaspace.epfl.ch/channel/CleanCloud>

Reducing Climate Model Uncertainty with Perturbed Parameter Ensembles (PPEs)

LHS.py

Install_PPE.sh

Launch_PPE.sh (50 runs at once)



Watson-Parris et al. (2021)