



EarthCARE 2026 Science and Validation workshop

8–12 June 2026 | Rhodes House | Oxford, UK

Operational monitoring and assimilation of EarthCARE cloud radar and lidar observations at ECMWF

Mark Fielding, Kamil Mroz, Michael Rennie, William McLean, Peter Hill

Operational assimilation has begun!



FS Department: Change to Operational Systems 2026225



● John Hodkinson <john.hodkinson@ecmwf.int>

To: ● John Hodkinson

EC M W F
FS Department
Operational Systems Change 225

Author: Hodge
Date: 2026-06-10

Server: 1_od
Suites: o
Family: 06bc/main/an/
Task: black

Files:
/ec/vol/ecflow_def/def/o_50r1/include/generate_ofb_mfb
/ec/vol/ecflow_def/def/compo_50r1/include/generate_ofb_mfb
/ec/ws[34]/tc/emos/data/50r1/an/black_ds2026061000

ECFLOW variable : IFS_BUNDLE_MODULE
Changed from CY50R1.20260527 to CY50R1.20260605
at server and o/eda/compo suite level

Description
Update from Mark Fielding to activate Earthcare CPR observations.

Revert:
Remove data selection file and rerun black task setting LFORCE_BL_COMPILE to true.



Today at 10:01

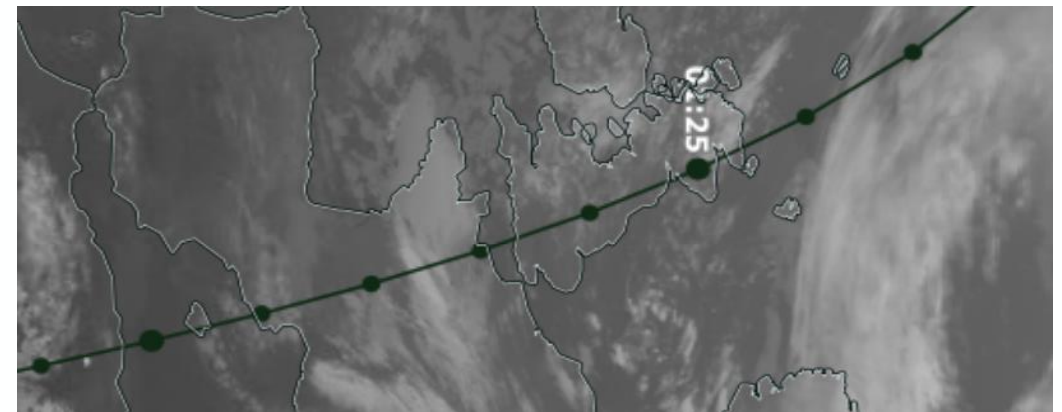
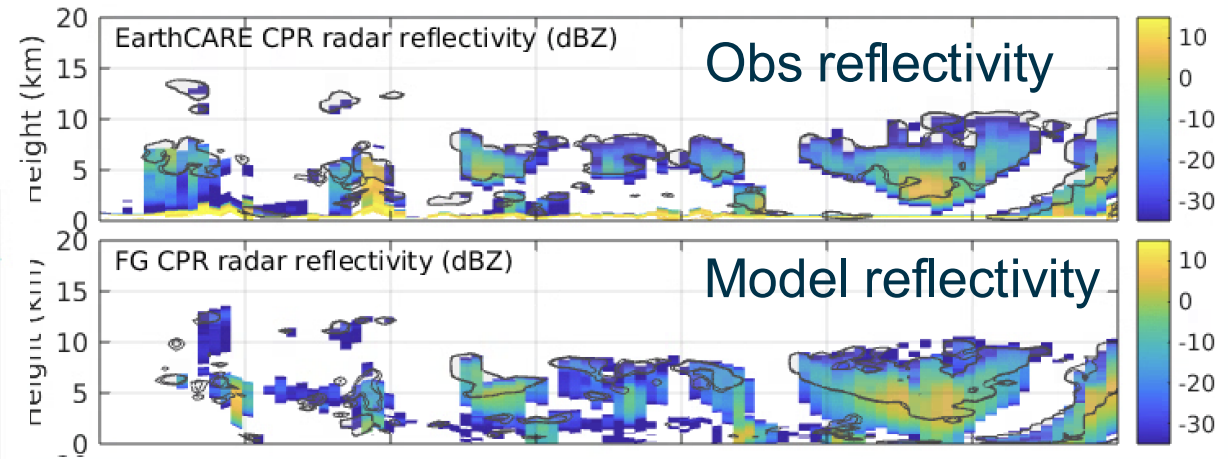
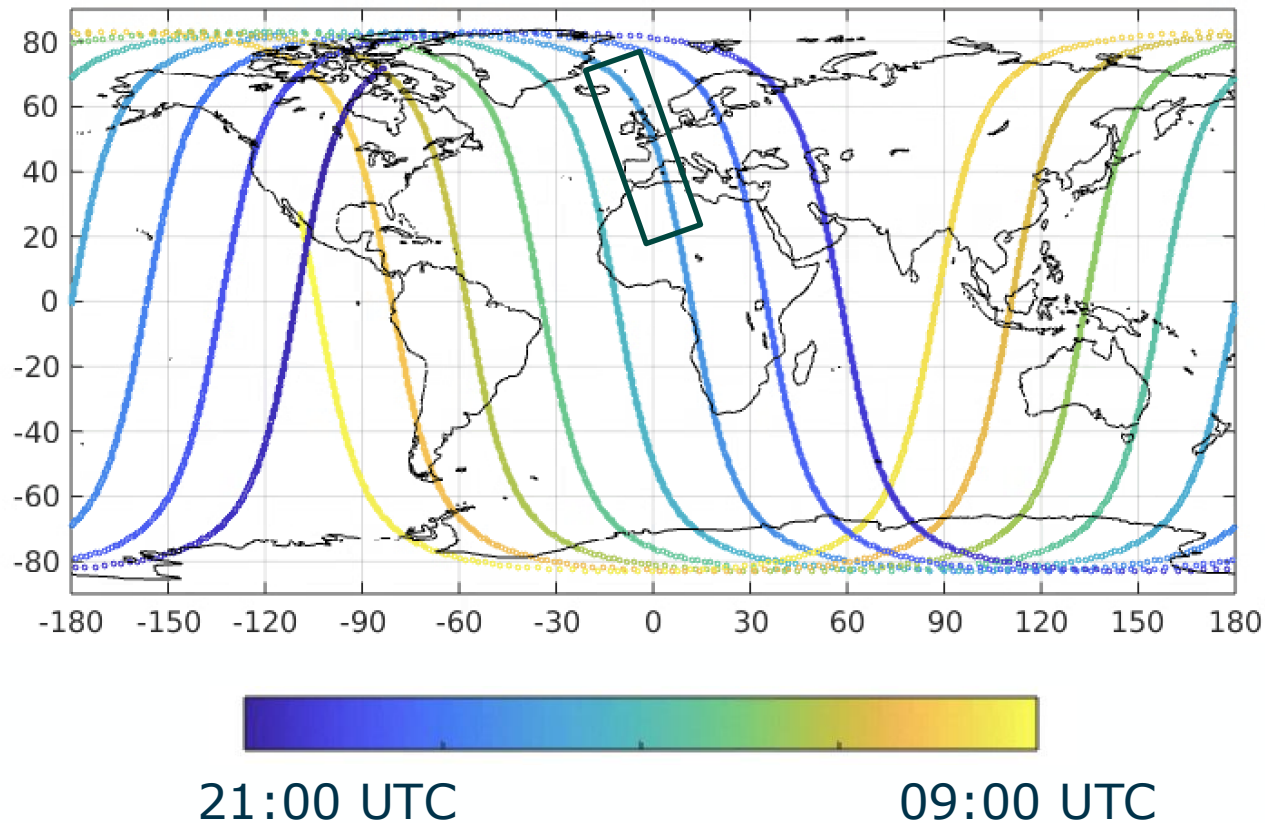
Obstype	19	===	Satellite cloud-aerosol lidar-ra			
Codetype	197	===	Cloud radar and cloud-aerosol li			
Variable			DataCount	Jo_Costfunction	J0/n	ObsErr
CRFL			44124	3152.583676548	0.07	0.483E+02
						BgErr
						0.300E+01
ObsType 19 Total:			44124	3152.583676548	0.07	

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FAMILY=main/00lw
FAMILY1=00lw
▶ obs ▲
▼ an ▲
  obs/fetchmars == complete and ../make == complete
  inlimit /o/limits:AN
  FAMILY=main/00lw/an
  FAMILY1=an
  ▶ black ▲
  ▶ odb
  ▶ preCleanFDB ✓
  ▶ vardata ▲
  ▶ fetcherr
  ▶ lowres ▲
  ▶ ocean_initial
  ▼ 4dvar ▲
    odb == complete and vardata == complete and lowres
    FAMILY=main/00lw/an/4dvar
    FAMILY1=4dvar
    ▶ uptraj_0
    ▶ uptraj_1
    ▶ uptraj_2
    ▶ uptraj_3
    ▶ uptraj_4 ▲
```

12 hours of EarthCARE data

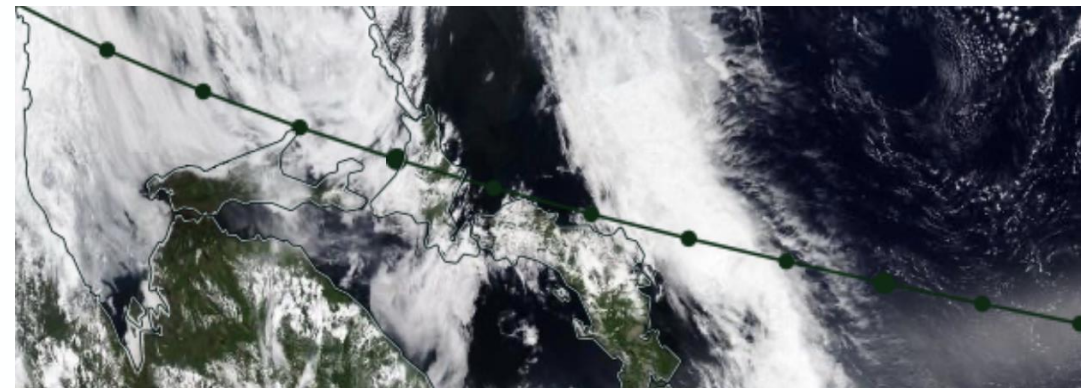
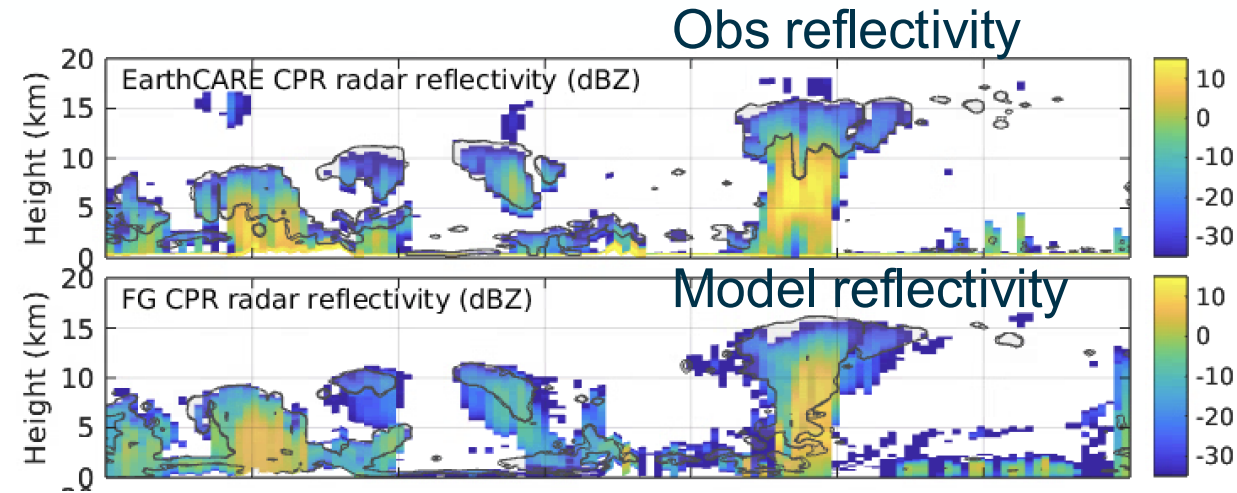
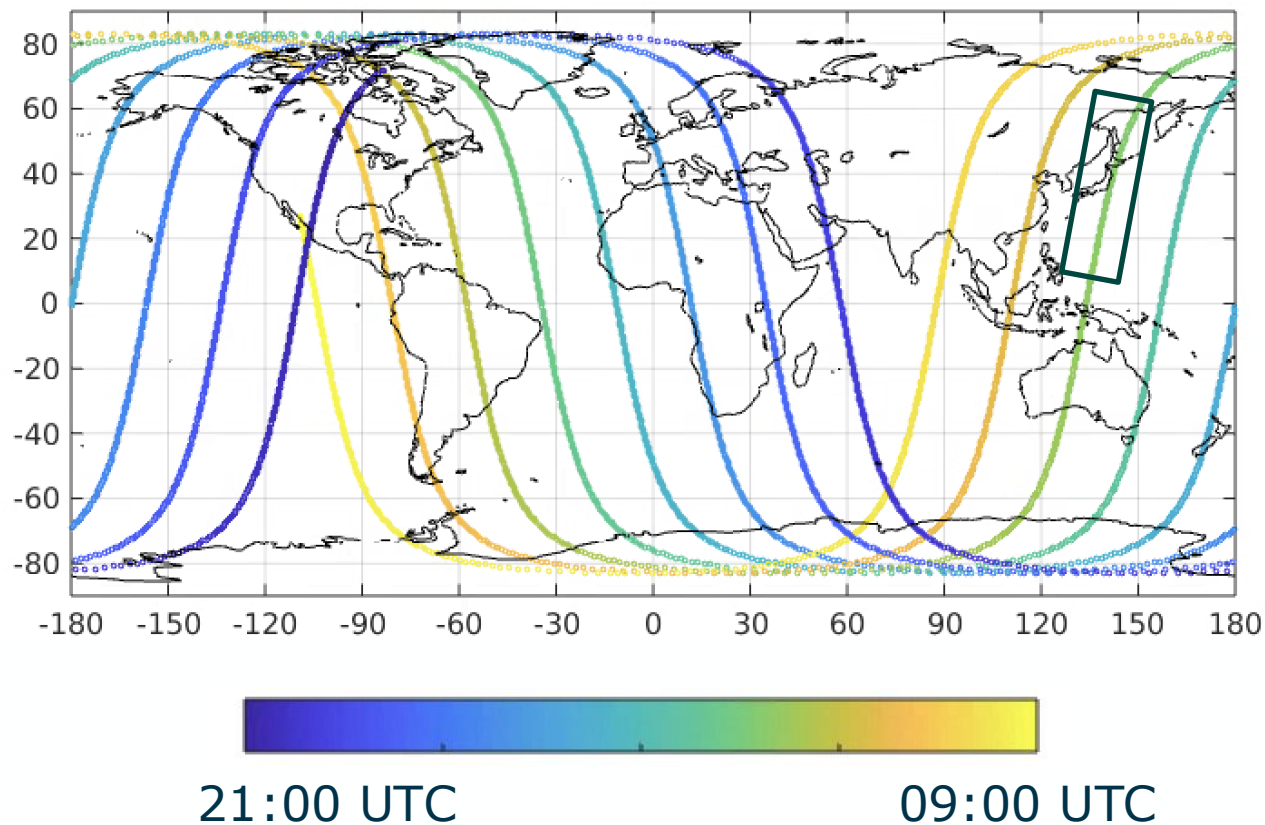


- Full 12-hours of EarthCARE data entered data assimilation



12 hours of EarthCARE data

- Full 12-hours of EarthCARE data entered data assimilation



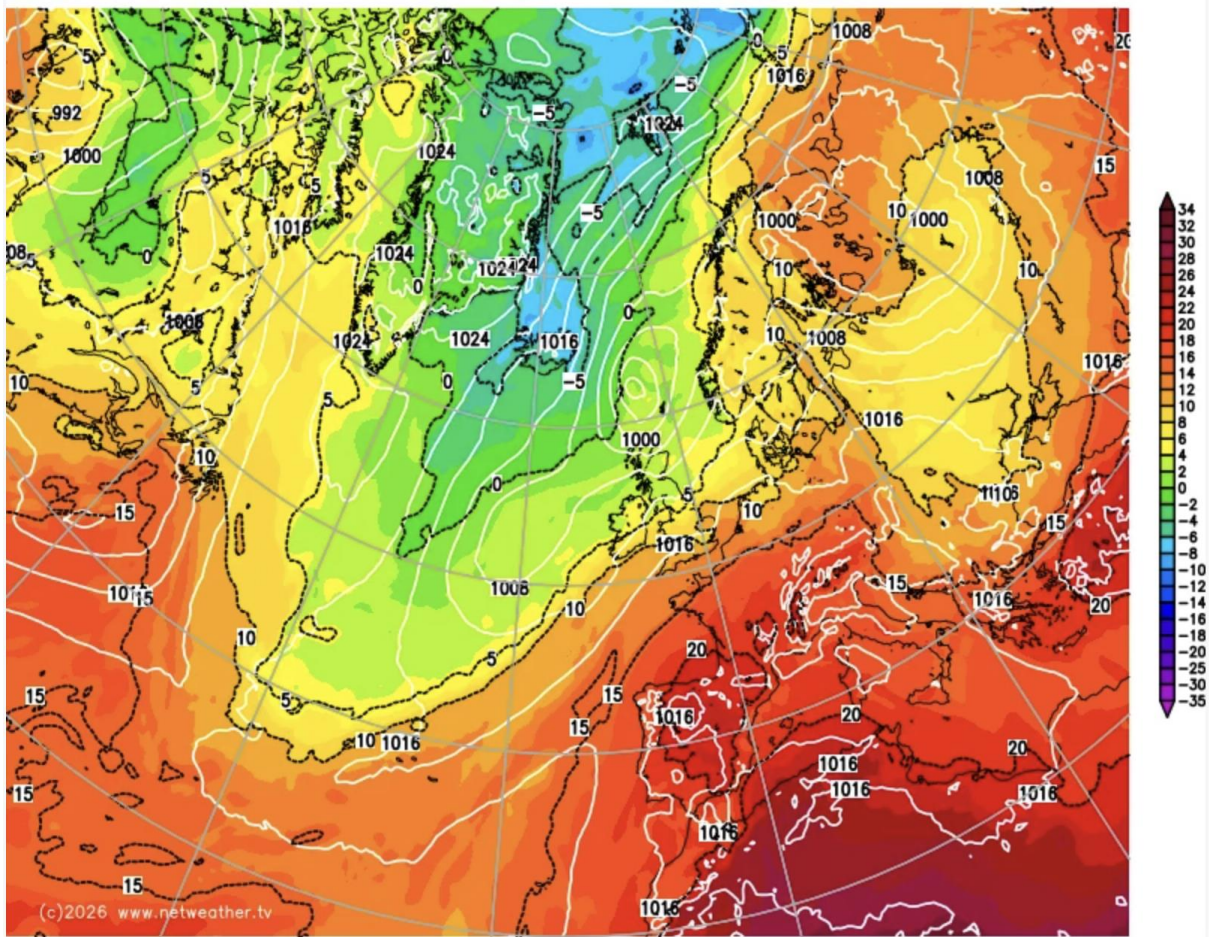
Your first-ever EarthCARE-powered forecast



Wed 10 June 2026 12Z

ECMWF T850 & Sea Level pressure

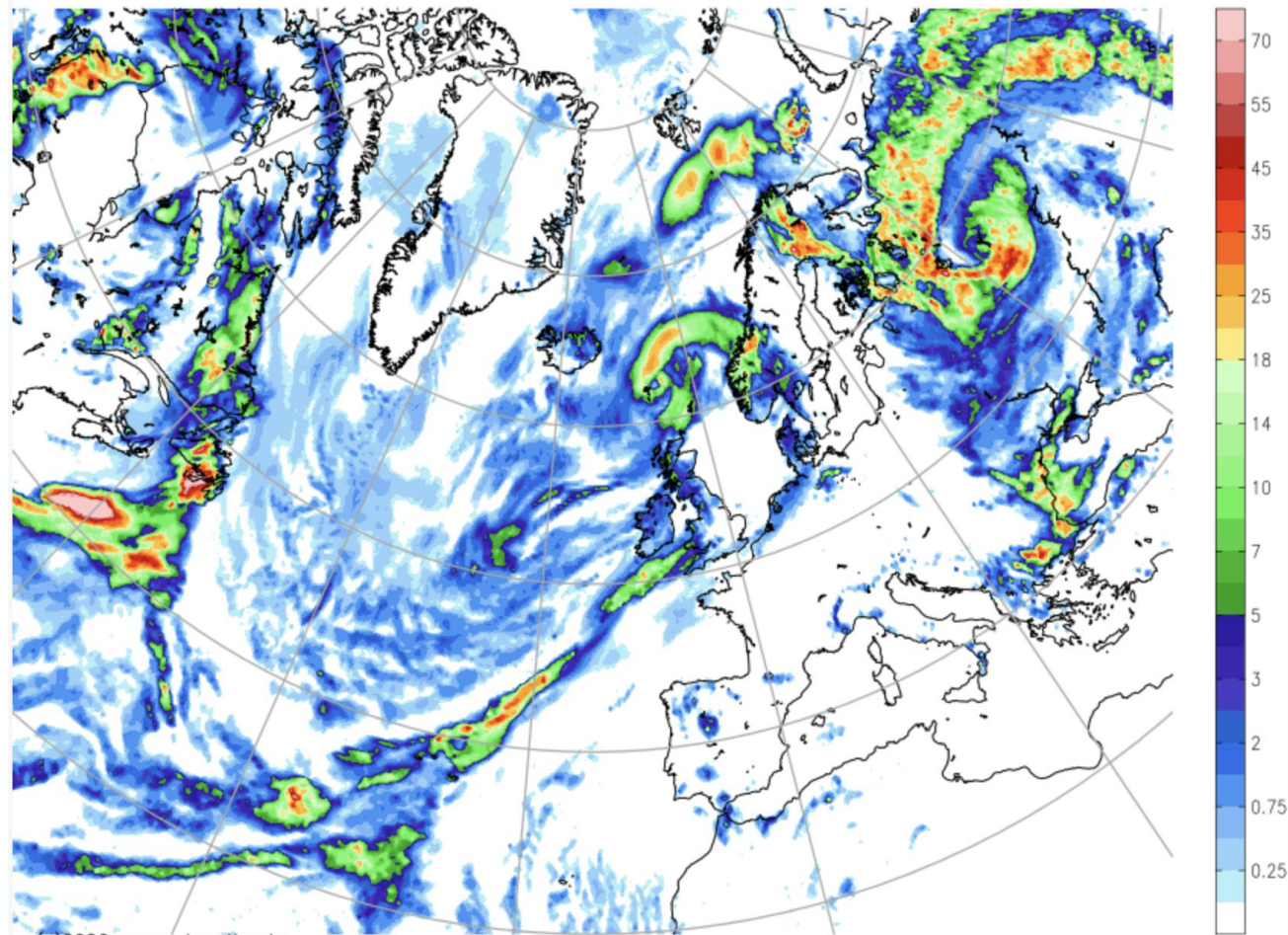
Wed 17 June 2026 12Z



Wed 10 June 2026 12Z

ECMWF North Atlantic Precipitation (mm)

Wed 17 June 2026 12Z



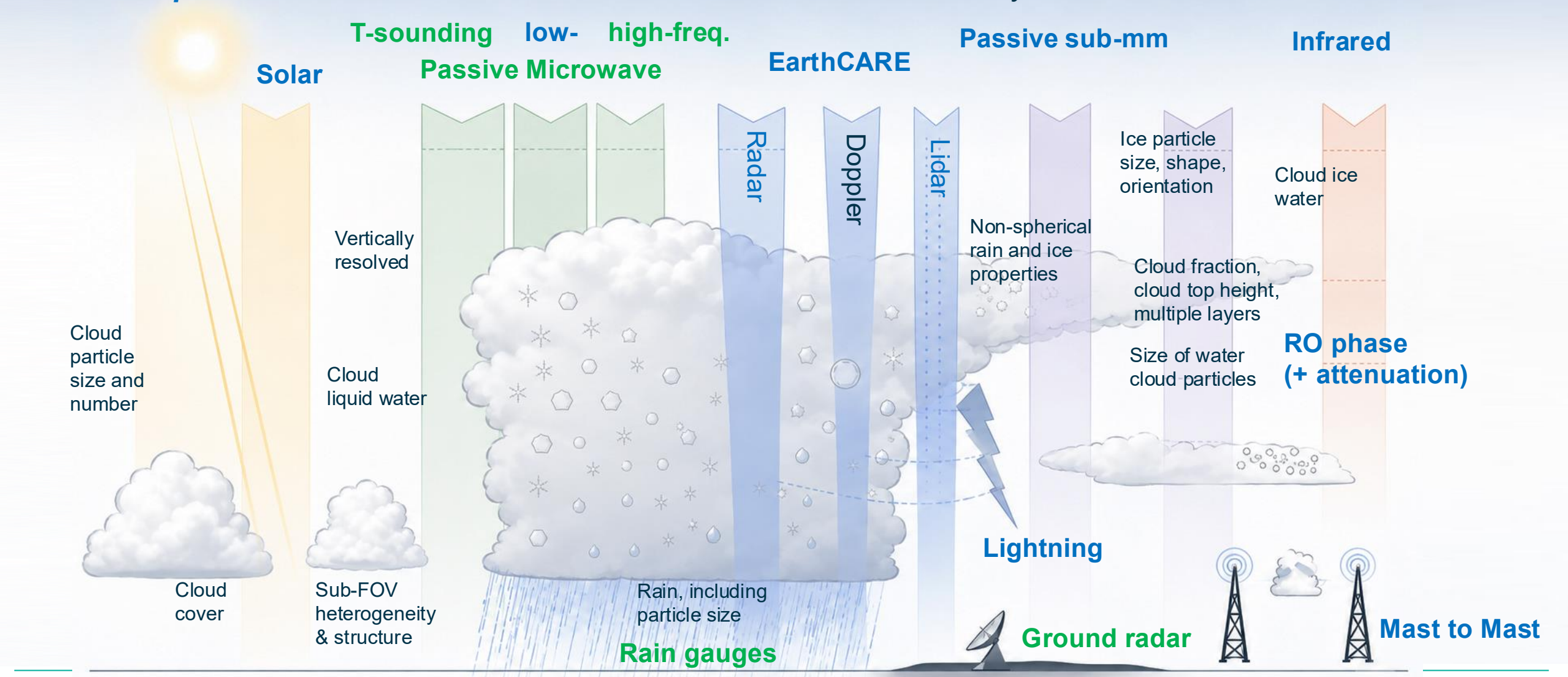
Why assimilate EarthCARE?



Reason #1: EarthCARE improves cloud analysis



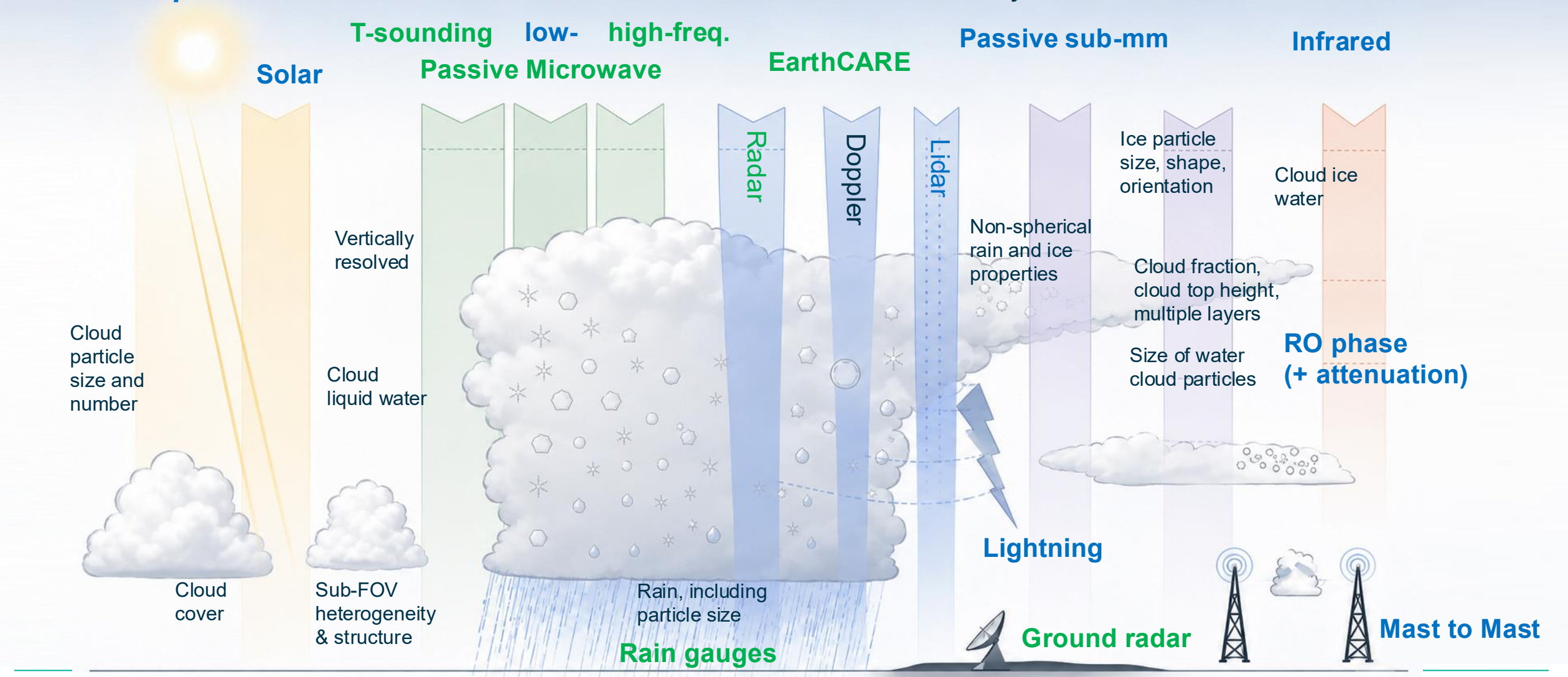
Current and planned cloud-sensitive observations in ECMWF assimilation system



Reason #1: EarthCARE improves cloud analysis

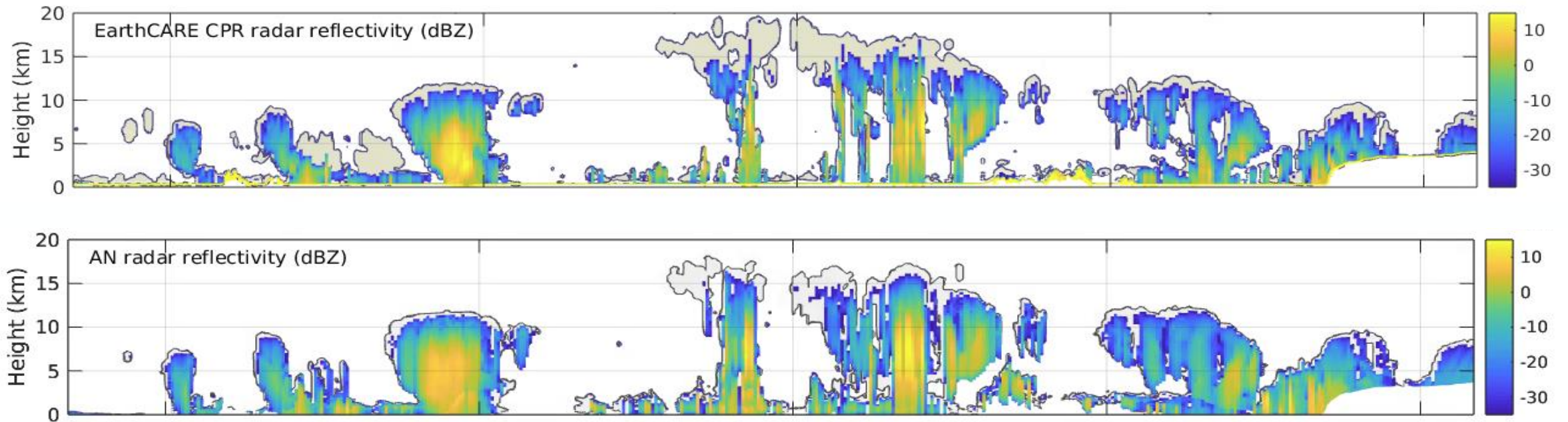
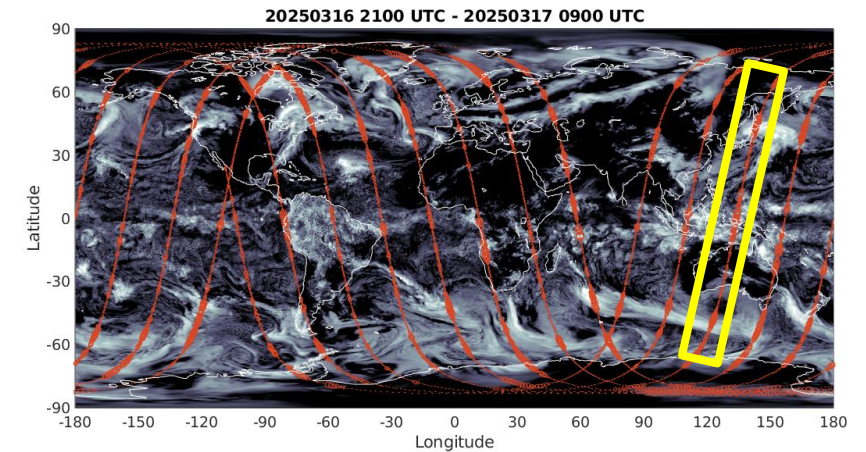


Current and planned cloud-sensitive observations in ECMWF assimilation system



Single orbit example for Pacific Ocean

- Example single-cycle 4D-Var assimilation experiment using TCo639 grid (~18 km) **17 March 2025**.
- 4D-Var control variables (such as temperature and humidity) are adjusted during minimization to improve forward modelled fit to observations.



NH mid-latitudes

Tropical deep
convection

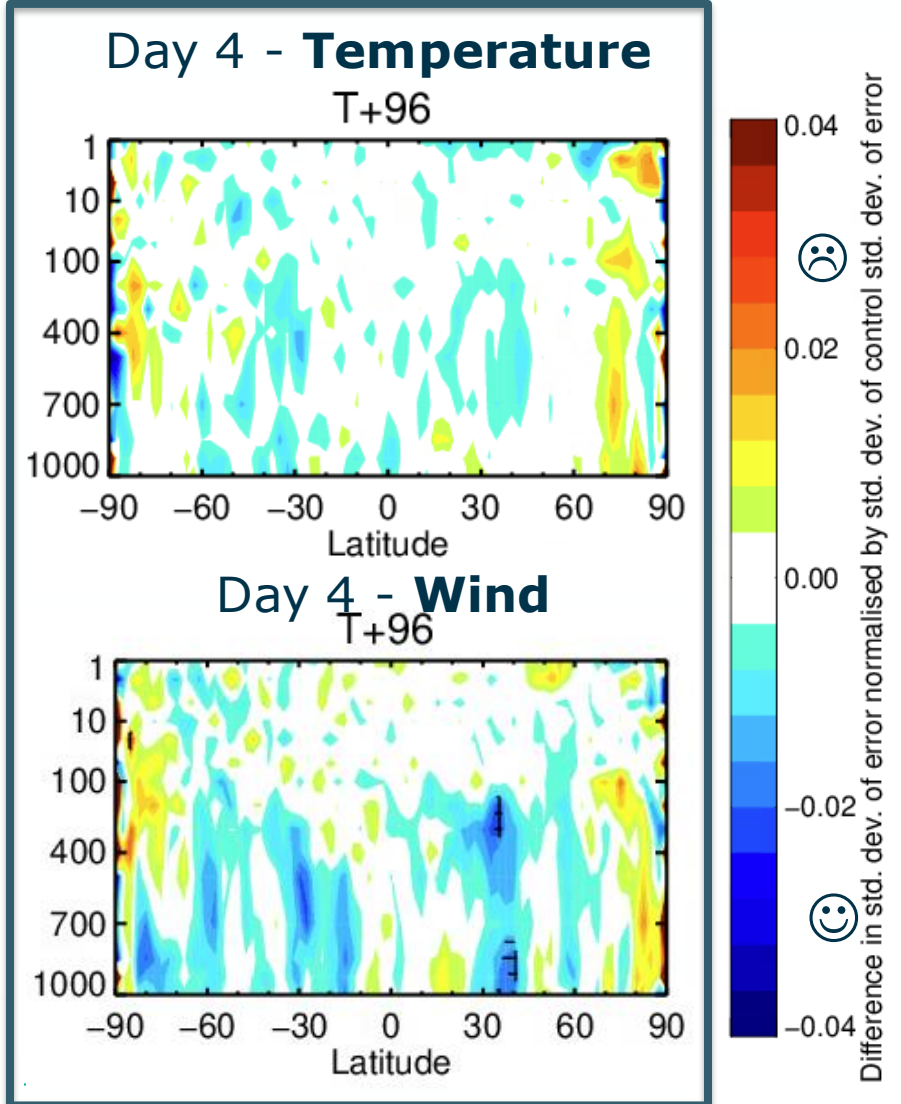
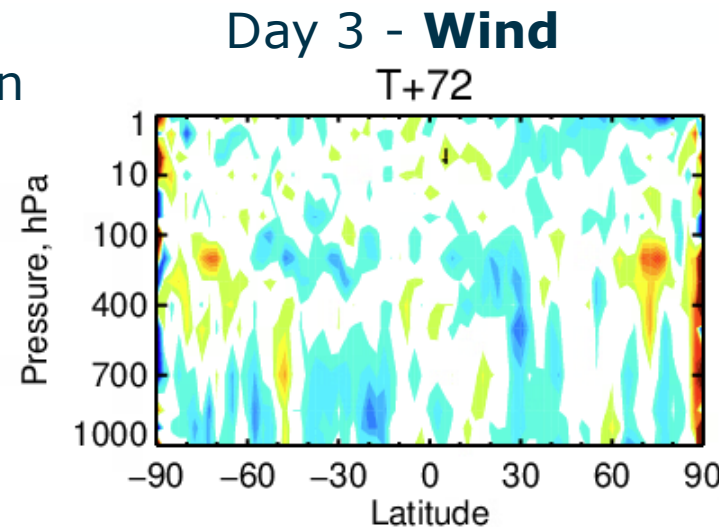
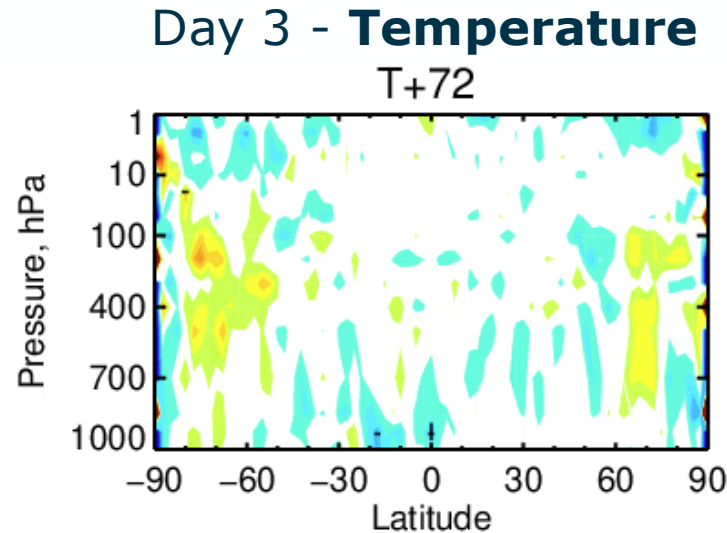
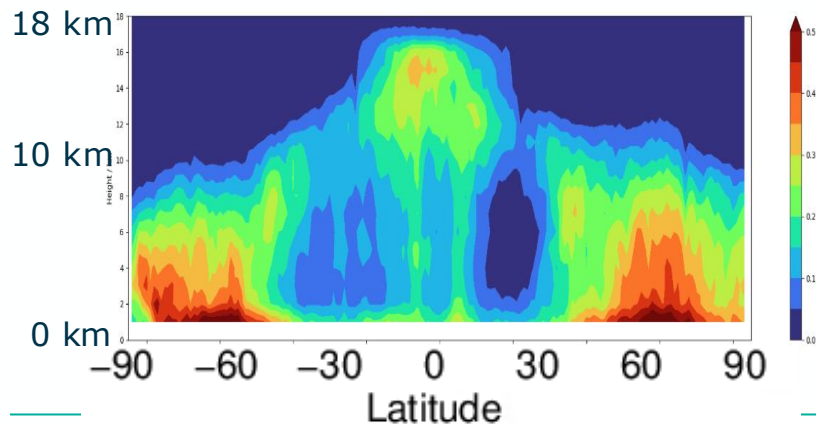
Southern ocean

Reason #2: EarthCARE improves forecasts

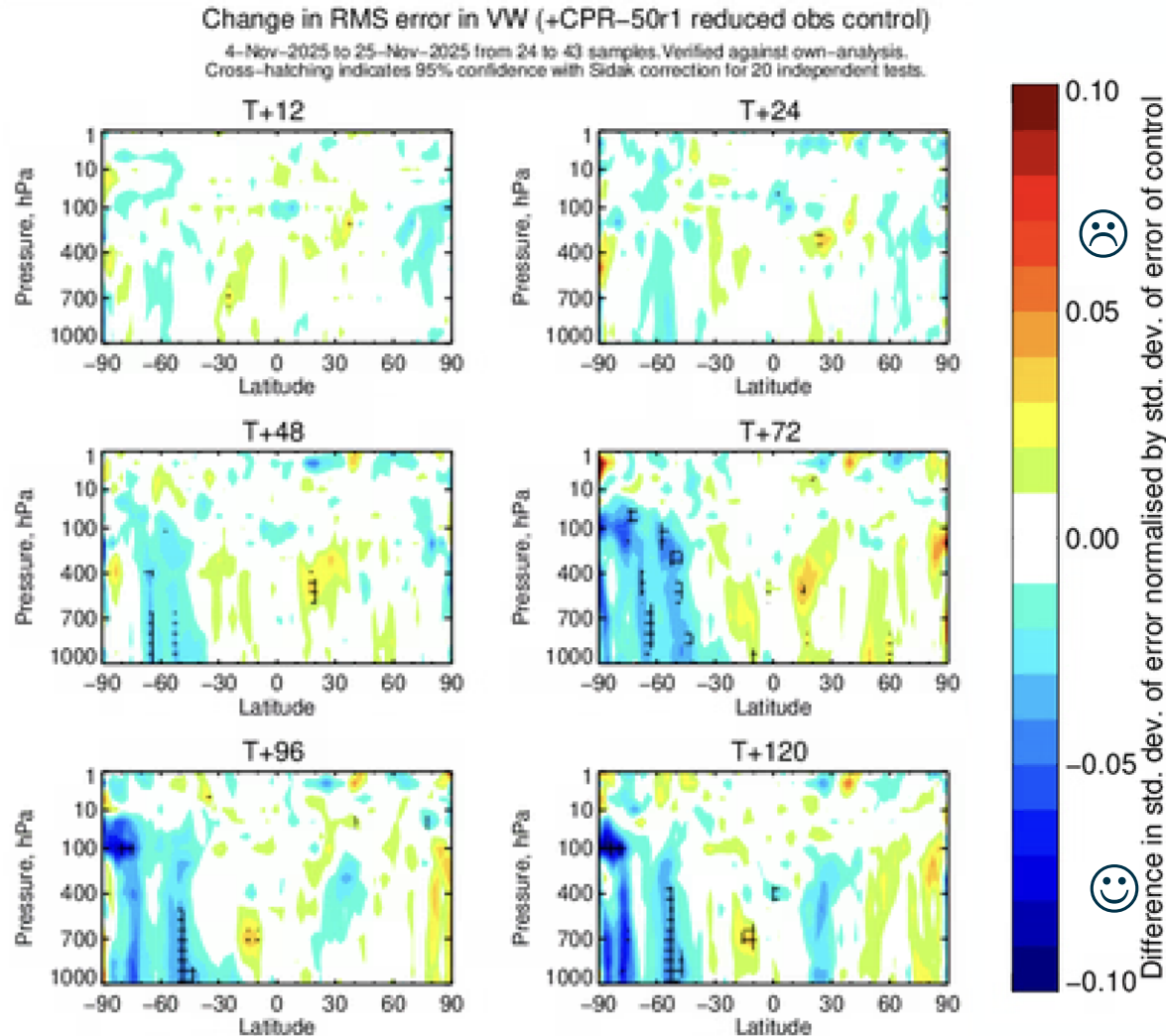
CPR-only OSE (20241201 to 20250406)

- Improvements of 0.5 - 1 % at day 3-4 in cloudy regions, consistent with CloudSat assimilation experiments.
- Smaller, positive impact on temperature scores.

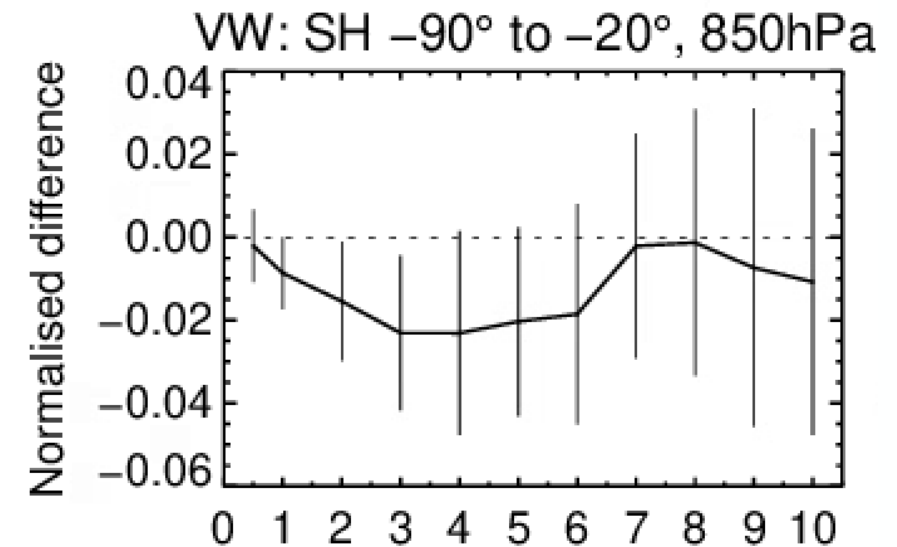
EarthCARE hydrometeor fraction



CPR impact in a reduced observing system



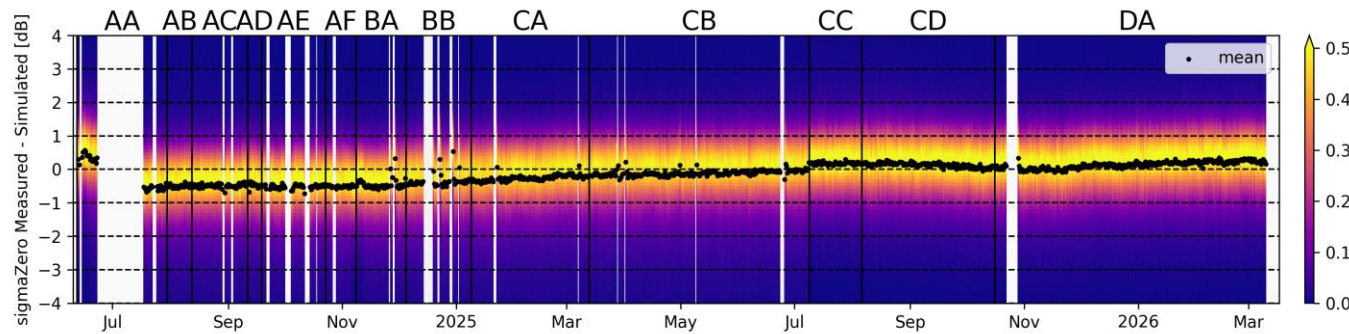
- Assimilating CPR in a reduced observing system without all-sky radiances allows impact to be seen more clearly in shorter experiments.
- Conventional observations still assimilated -> less impact in NH



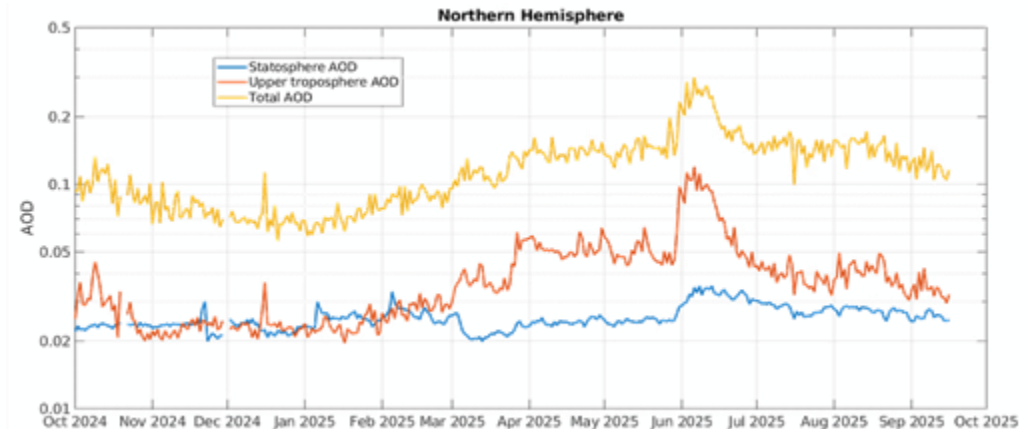
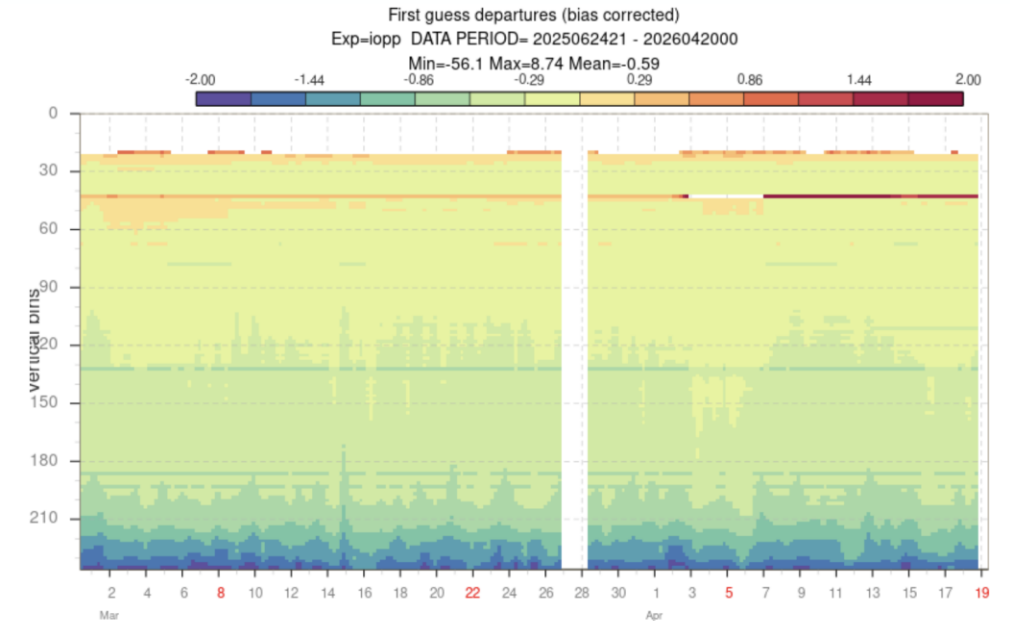
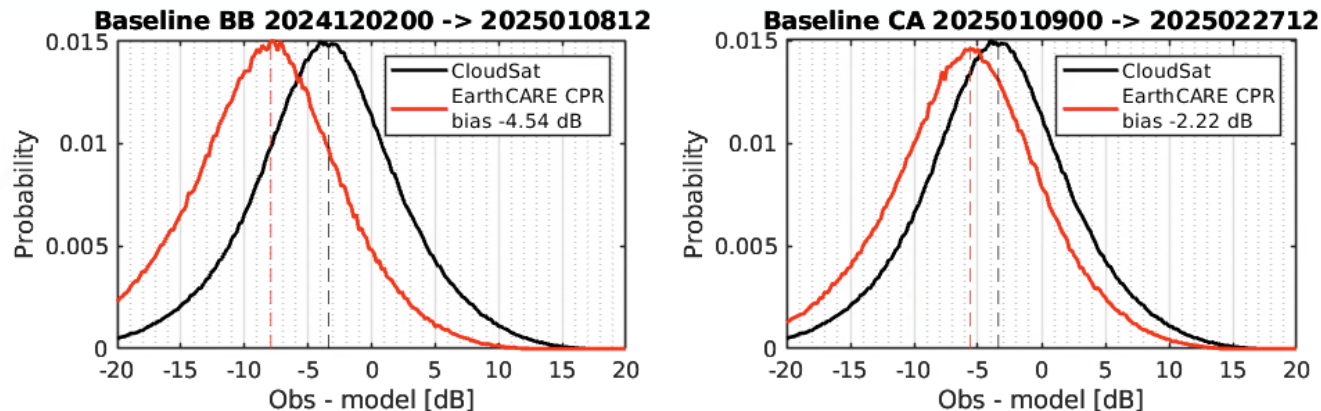
Reason #3: ECMWF can monitor EarthCARE

- Following preparations in the joint ESA-ECMWF PEARL project and subsequently in the EarthCARE DISC, EarthCARE data have been monitored in a parallel suite in NRT since launch in May 2024.

Monitoring radar calibration by simulating sea surface returns



Monitoring radar calibration by in ice clouds compared to CloudSat

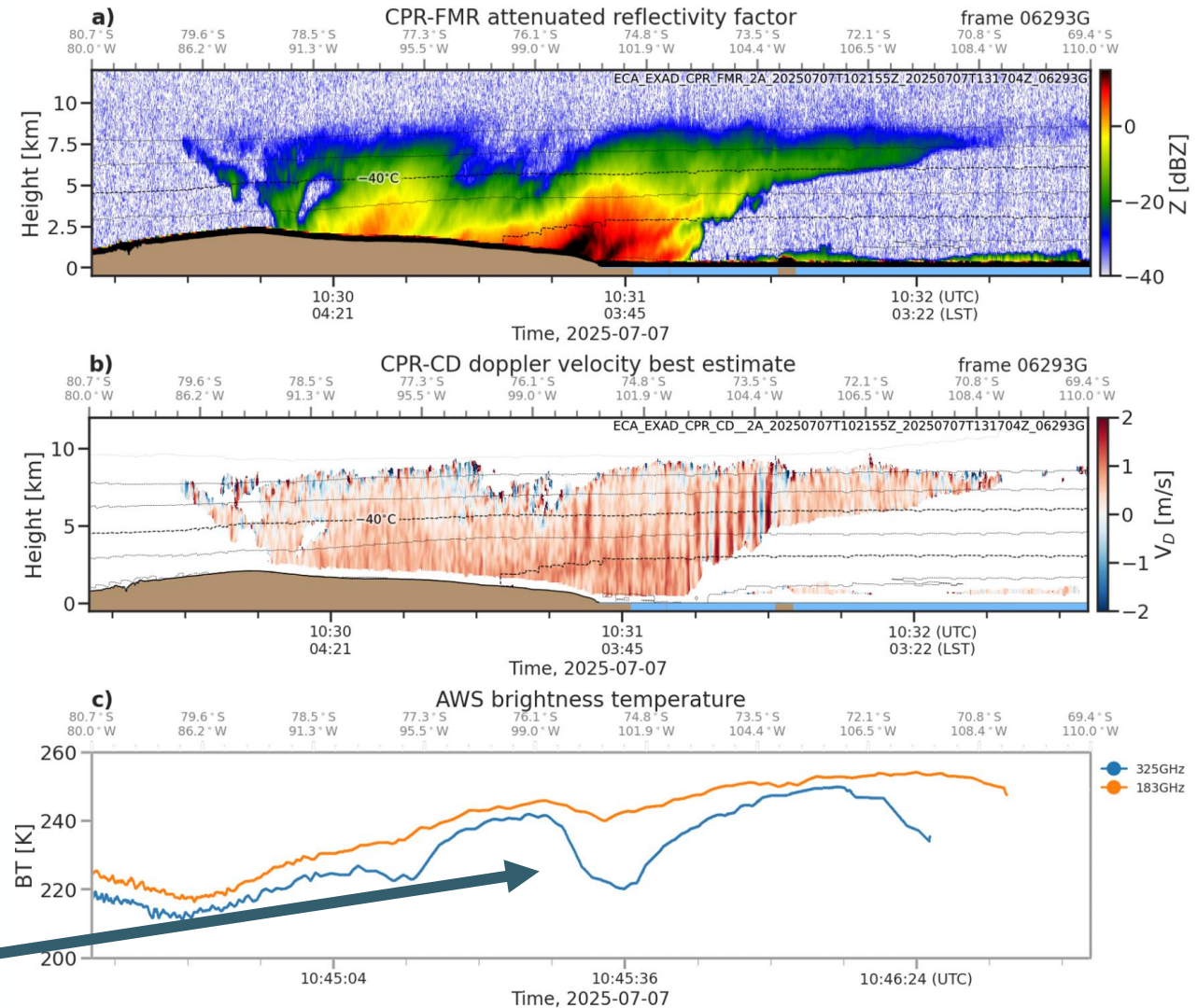


Reason #4: EarthCARE anchors all-sky assimilation



- Vertical profiles of cloud and precipitation provide context for interpreting and improving the assimilation of new ice-sensitive sensors.
- ESA's Arctic Weather Satellite is first 325 GHz all-sky microwave radiance assimilated at ECMWF.
- EarthCARE can help untangle model temperature and humidity biases with cloud biases -> improved analysis and reanalysis.

Larger snow particles scatter more at high frequency

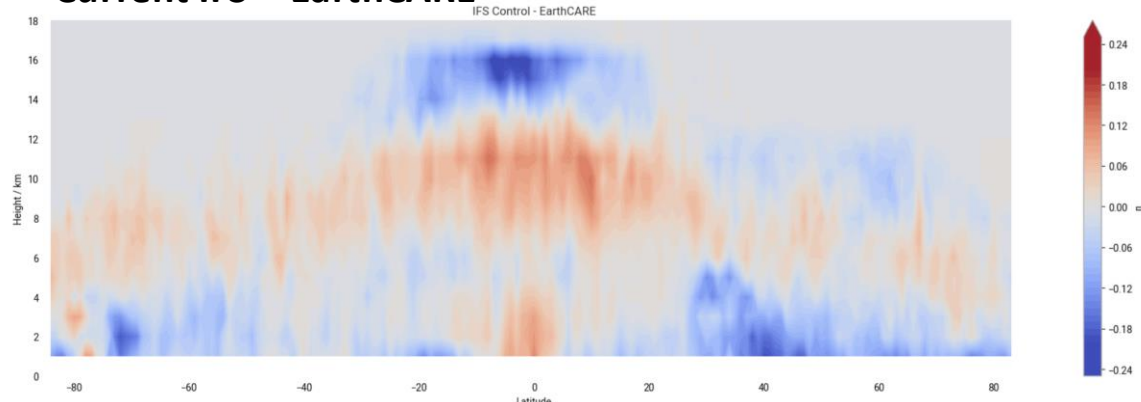


Reason #5: EarthCARE diagnoses model issues

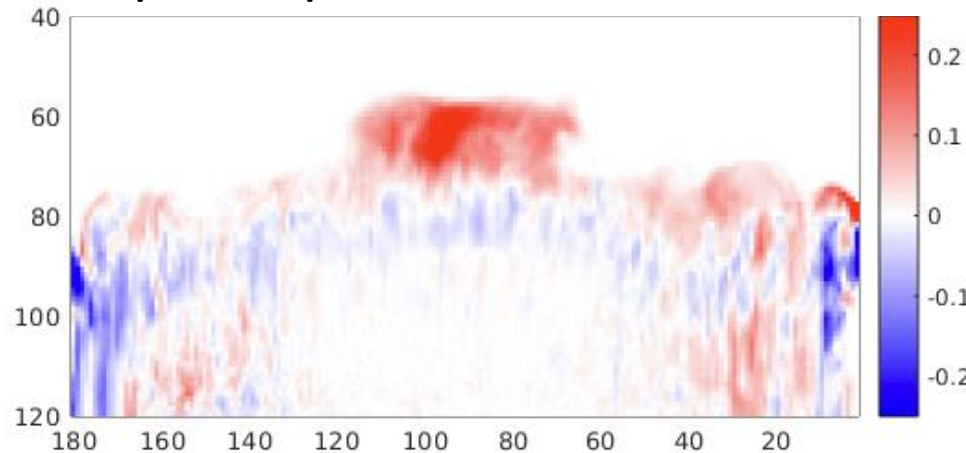


Hydrometeor fraction zonal cross-section

Current IFS – EarthCARE

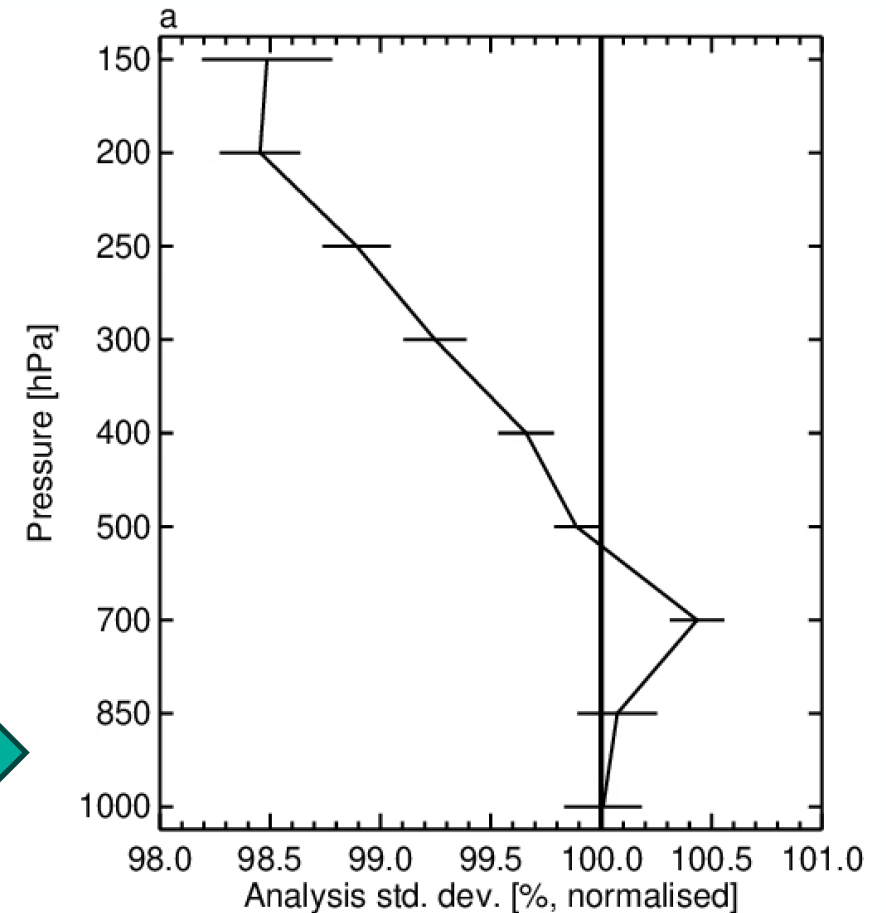


Improved representation of cirrus formation



Model
improvements

Analysis fit to AMV (cloud winds)



Conclusions



- First-ever assimilation of cloud radar in an operational global NWP model began 10th June 2026!
- Assimilation of EarthCARE CPR:
 - Improves cloud analysis globally.
 - Improves medium-range weather forecasts in cloudy (stormy?) regions.
 - Enables automatic instrument monitoring against analysis.
 - Anchors other cloud and precipitation sensitive observations in assimilation system.
 - Propels model improvement studies.

Future

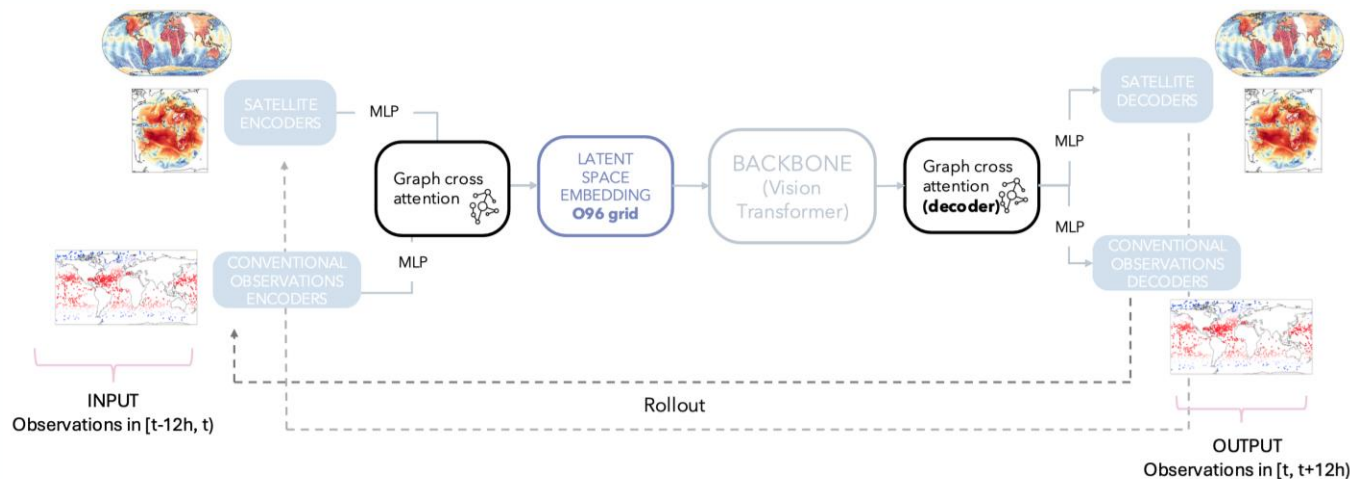
- Exploit ATLID observations in operational data assimilation
- Assist in developing active operators in RTTOV (community radiative transfer model)
- Re-analysis
- AI Direct Observation Prediction?

**Thanks to all who helped make
operational assimilation possible!**

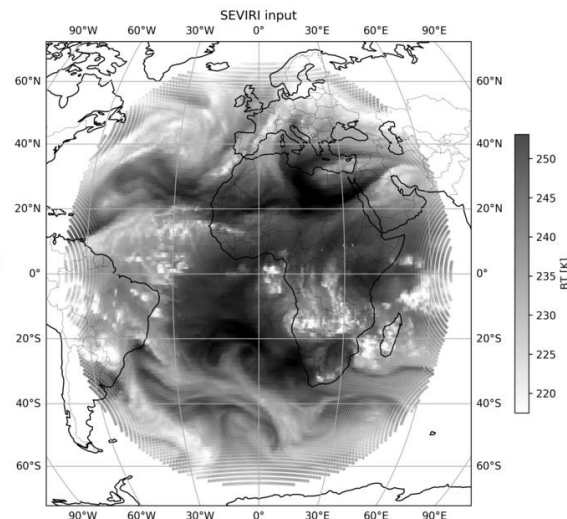
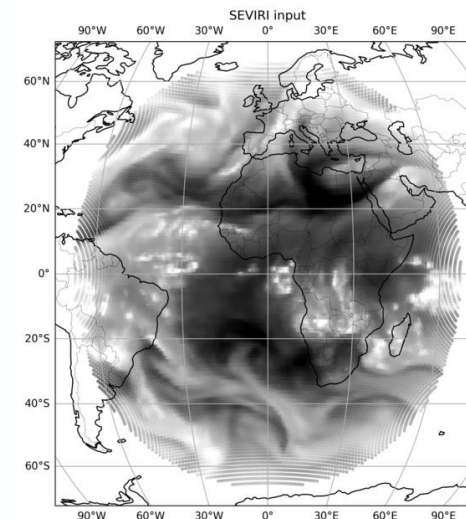
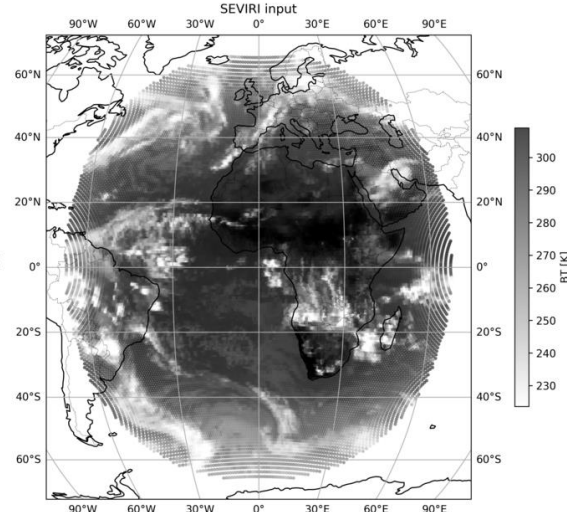
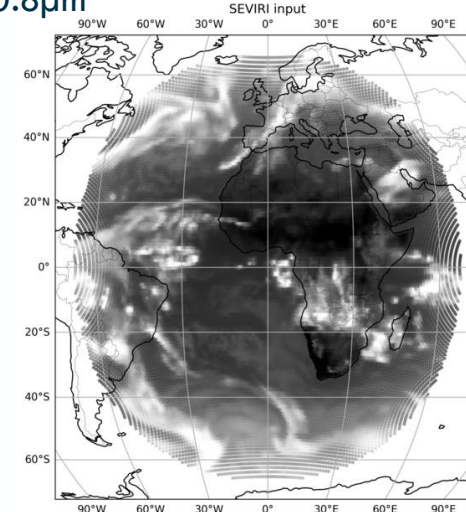
AI-DOP: How to learn a forecast from observations



- Use historical observations to train a Neural Network to forecast future observations (don't need analyses)
- Include all available observations of the full Earth system (atmosphere, ocean, land) simultaneously
- Once trained, initialize the model directly with the observations themselves
- The model can produce a forecast at unobserved locations (e.g., on a grid)



10.8 μ m

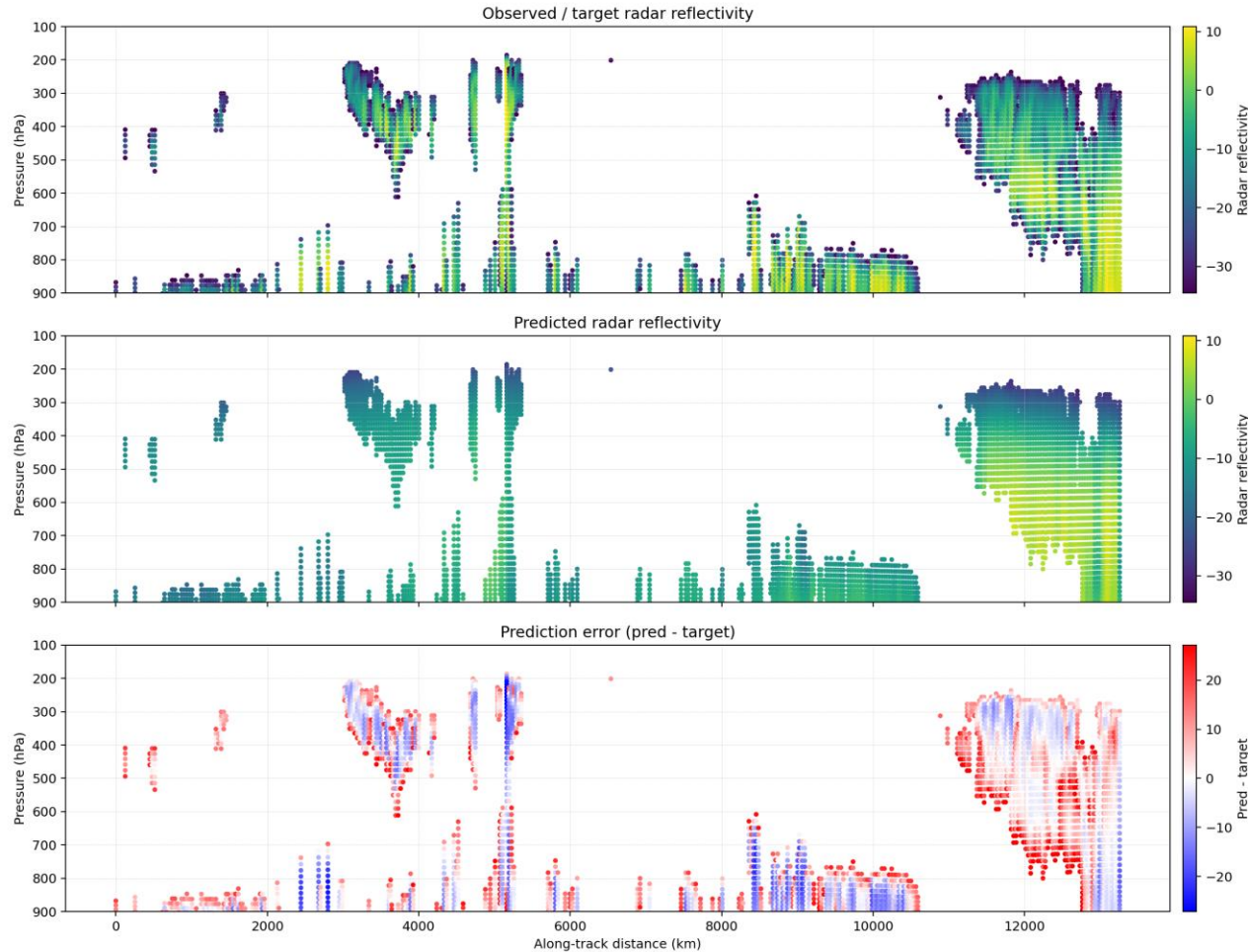


Slide courtesy: Mihai Alexe

A role for EarthCARE in AI forecasting?

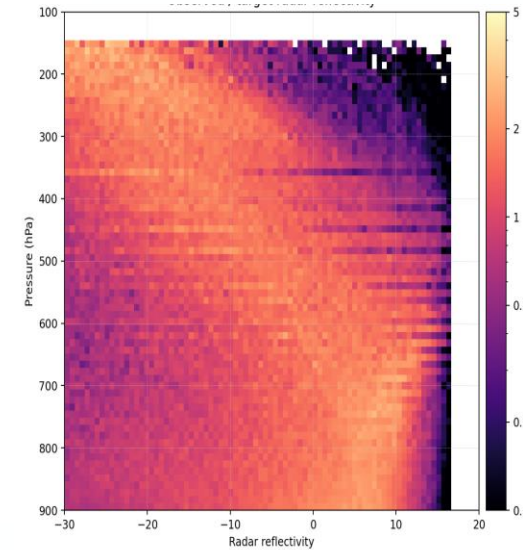


CloudSat Cross-Section
Segment 12 | 2015-01-03 00:14:35 to 2015-01-03 00:46:45 | 290 profiles | lat -54.6 to 60.8 | lead bin 12



- AI-DOP model trained with 5 years of CloudSAT reflectivity, in addition to set of conventional and satellite observations.
- 12-hour 'forecasts' of CloudSAT reflectivity produced for January 2016.

Observations



Predictions

