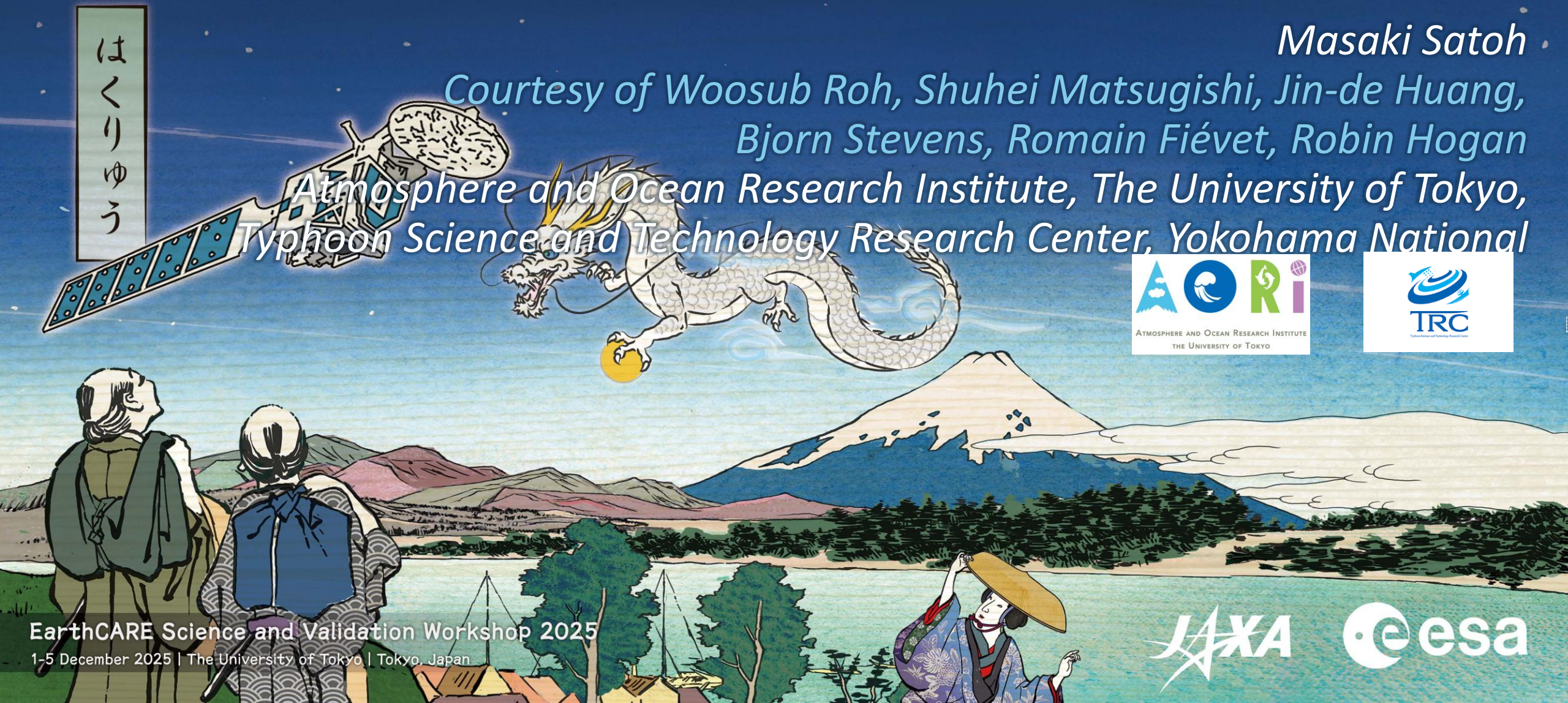
ECOMIP for shaping climate sensitivity in global atmospheric models by cloud-falling speed intercomparison



Masaki Satoh

Courtesy of Woosub Roh, Shuhei Matsugishi, Jin-de Huang, Bjorn Stevens, Romain Fiévet, Robin Hogan

Atmosphere and Ocean Research Institute, The University of Tokyo, Typhoon Science and Technology Research Center, Yokohama National

EarthCARE Science and Validation Workshop 2025

1-5 December 2025 | The University of Tokyo | Tokyo, Japan

https://www.earthcarescience.net/projects/ecomip

ECOMIP

EarthCARE-ORCESTRA Model Intercomparison Project

ECOMIP is a model intercomparison and model evaluation project using observatic
coordinated by Masaki Satoh (University of Tokyo, satoh at aori.u-tokyo.ac.jp) and R
that wishes to take part. As an unfunded collaboration the work is carried out on a l
hopefully lead on to a wider endeavour to improve models exploiting EarthCARE da

August-September, 2024

Experimental protocol

Simulations

Two simulation types are envisaged:

1. **48-hour forecasts** initialized at midnight every day between 00 U
   between models would be carried out on the second day of each fc
   simulations may be carried out but still initialized each day. Opera
2. **A free-running simulation** initialized at 00 UTC on 1 August 2024

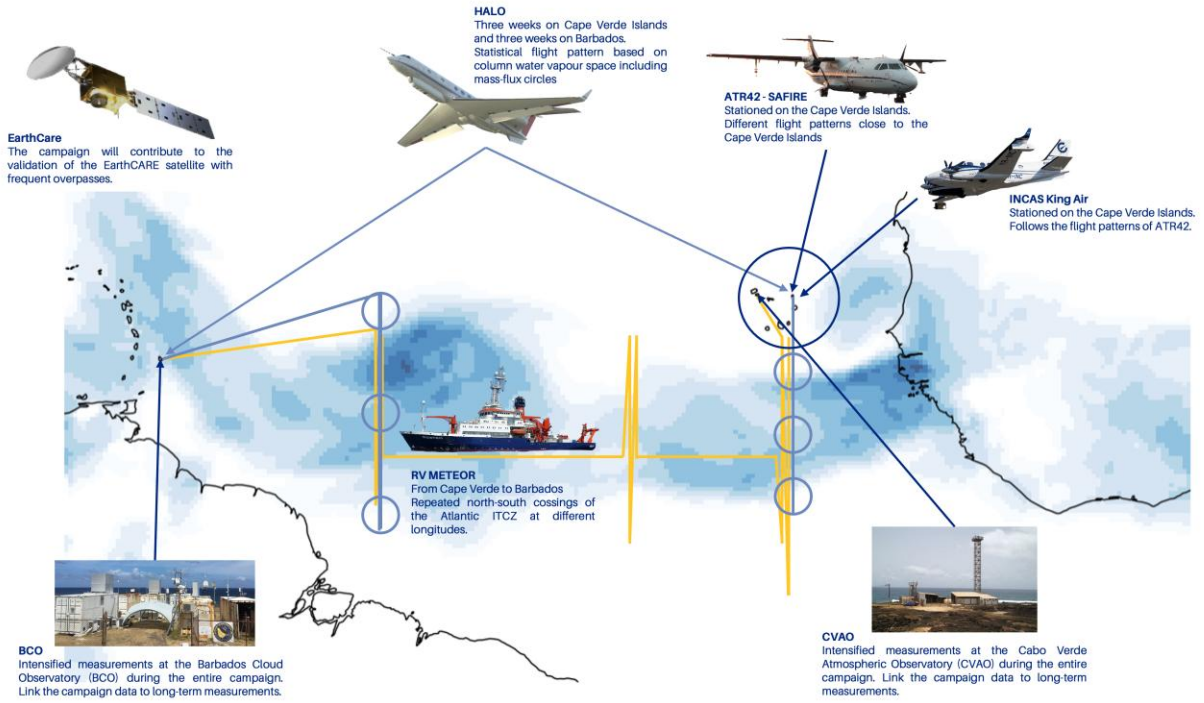
Since high resolution simulations are computationally intensive, son
the most interesting ORCESTRA case studies should be prioritized. Tl
convection are the following:

- 18 August
- 22 August
- 27 August
- 3 September: a golden case in terms of observations from EarthC
- 19 September

Note that the simulations themselves should be initialized at the beg

Note also that no CPR data were taken on 29 August and 22 Septembe

ORCESTRA: Organized Convection and EarthCARE Studies over the Tropical Atlantic



Strategy of the experiments

Phase 1 – Case studies (2-day simulations)

- Mandatory: 3 Sep 2024 for convection, or 13 Aug 2024 for aerosol
- Target champion cases during the EarthCARE and ORCESTRA observations
- Submission by the end of 2025 (JAXA server)

Phase 2 – Free run, submission in 2026

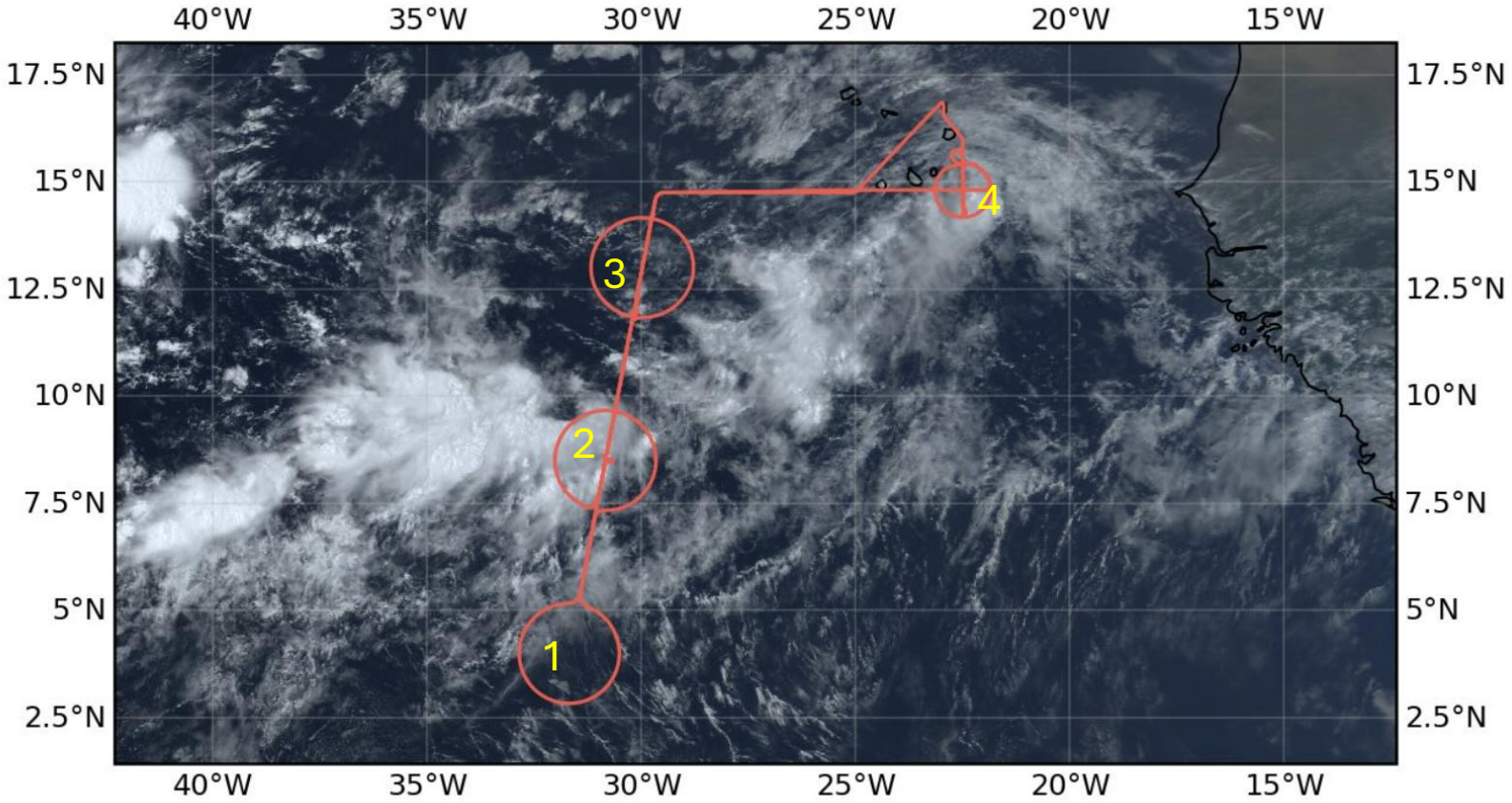
- Continuous simulations of at least two months.
- Optional cases: additional events selected based on participant interest.

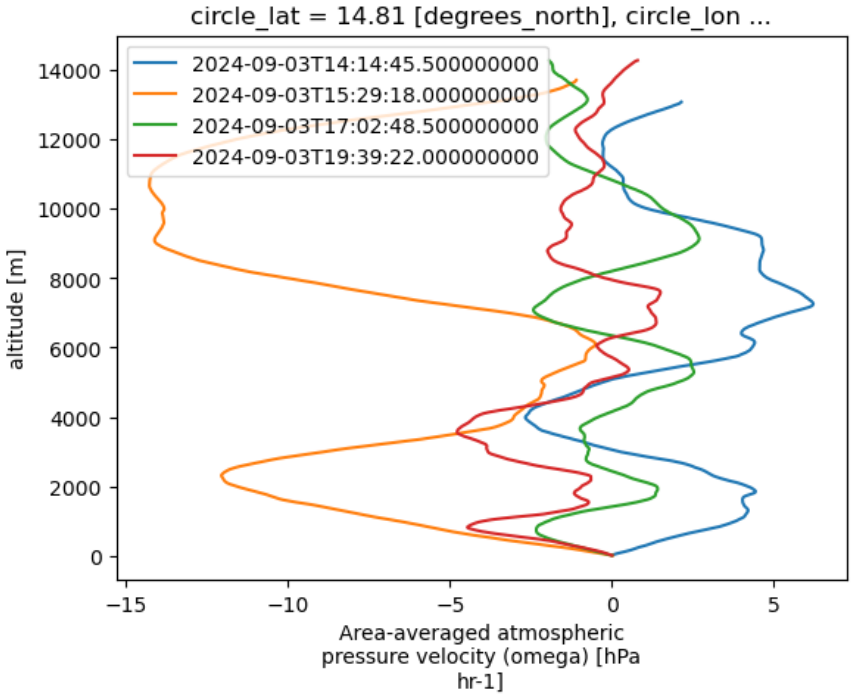
Phase 3 – Constrained free run in 2026 or afterwards

- Free runs with prescribed terminal velocity and other improved settings derived from EarthCARE/ORCESTRA insights.
- Common configuration applied across all participating models.

Evaluate climate sensitivity and its difference between the original and the improved models

Case: Sep. 3, 2024





Evaluations using dropsondes and HALO

Courtesy of Bjorn Stevens, Romain Fiévet

Data frequency and format

For 2-day simulations,

- Initial time: one day before 00 UTC, Integration for 48h

Frequency:

- All 30 min interval data for the second day, e.g. 49 snapshot data
- 5 min interval data: 2D-field of surface temperature, 10m-U & V, SLP, OLR, OSR, Precipitation (snapshot and 5min accumulated), IWP, LWP, precipitable water

Lat-lon grid & z levels for a standard format [*see remarks on data]

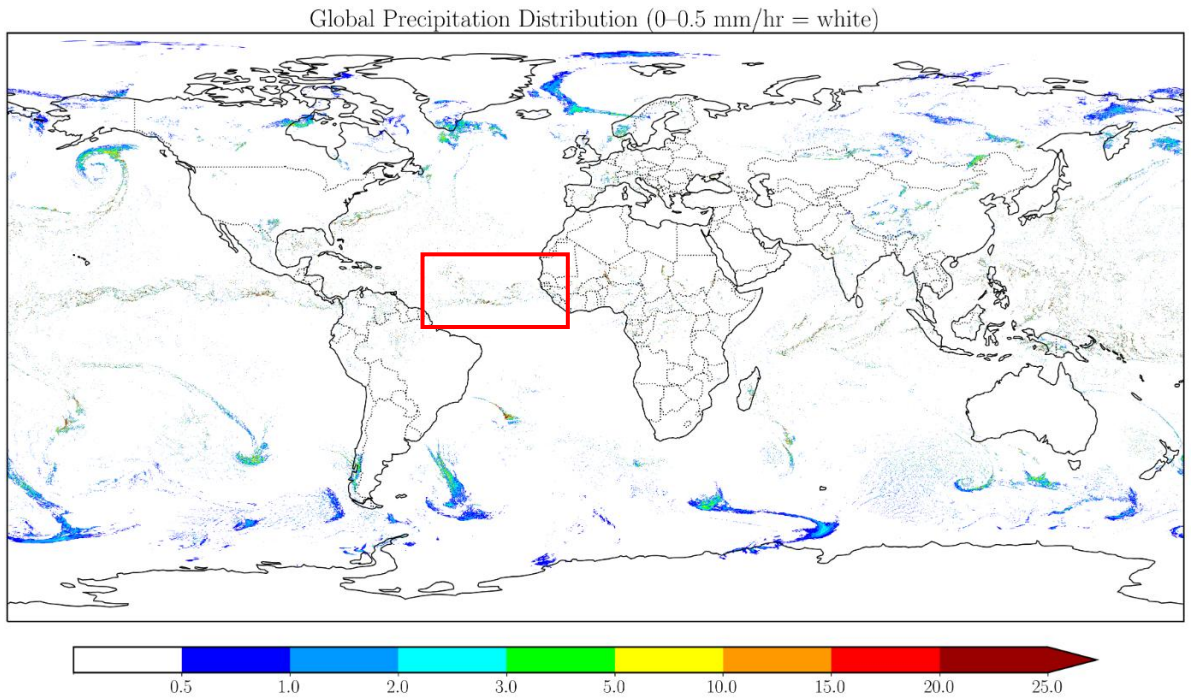
- Over the global domain for global models
- Over the ORCESTRA domain: (64W-8W, 4-24N) for regional models

Initial condition

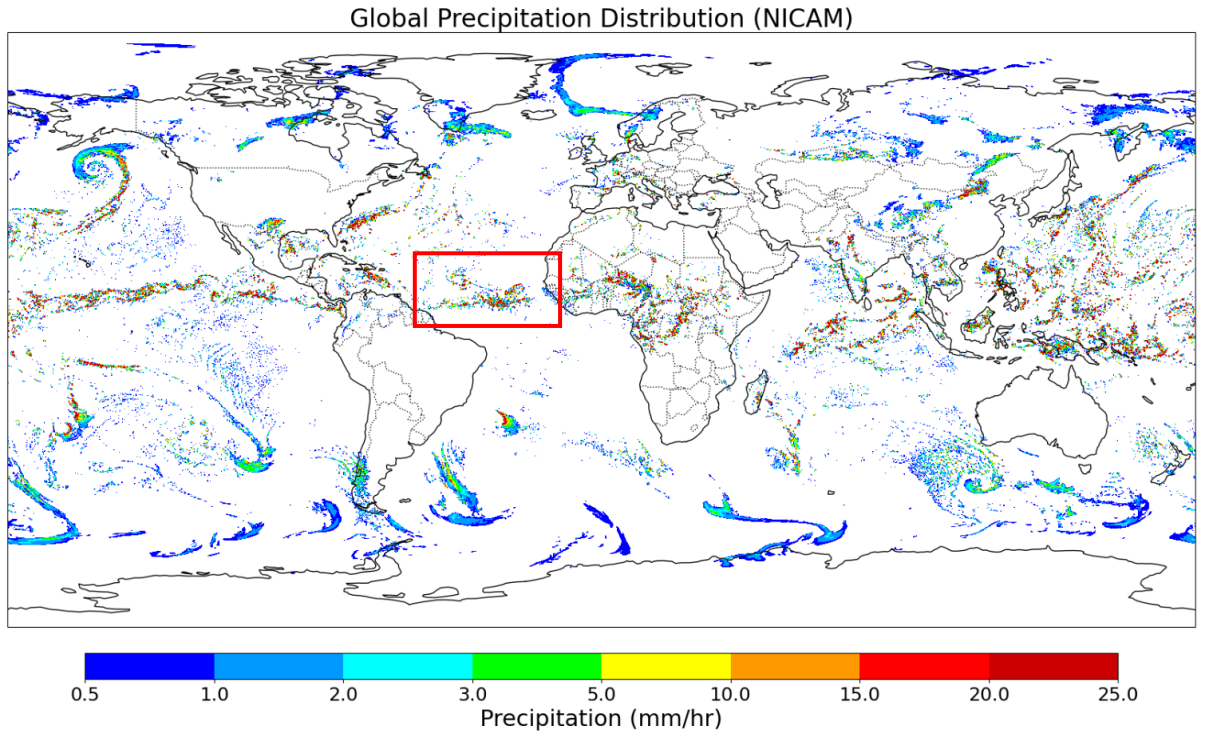
- IFS operational data provided by Robin Hogan:
  https://aux.ecmwf.int/ecpds/home/earthcare_public/earthcare-orcestra-mip/ifs_od-0001_global_analyses/

Case: Sep. 3, 2024:
Comparison: ICON, NICAM

Precipitation distribution



ICON

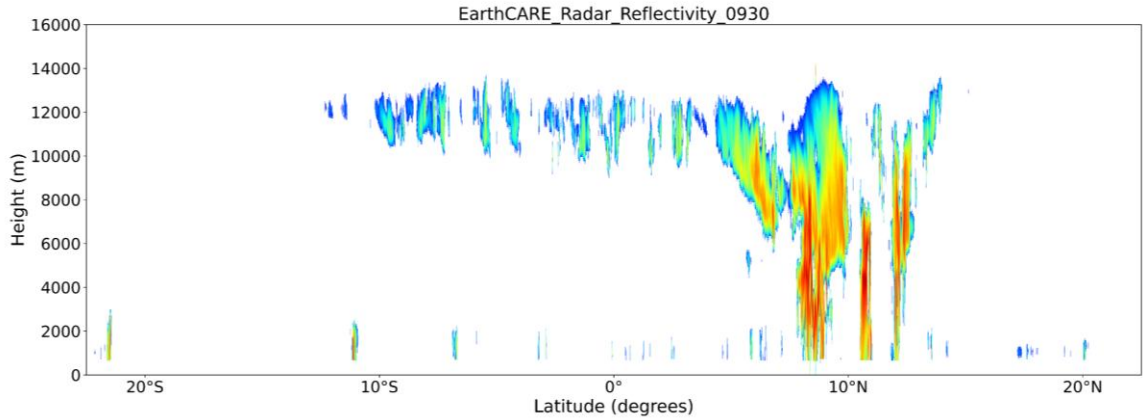


NICAM

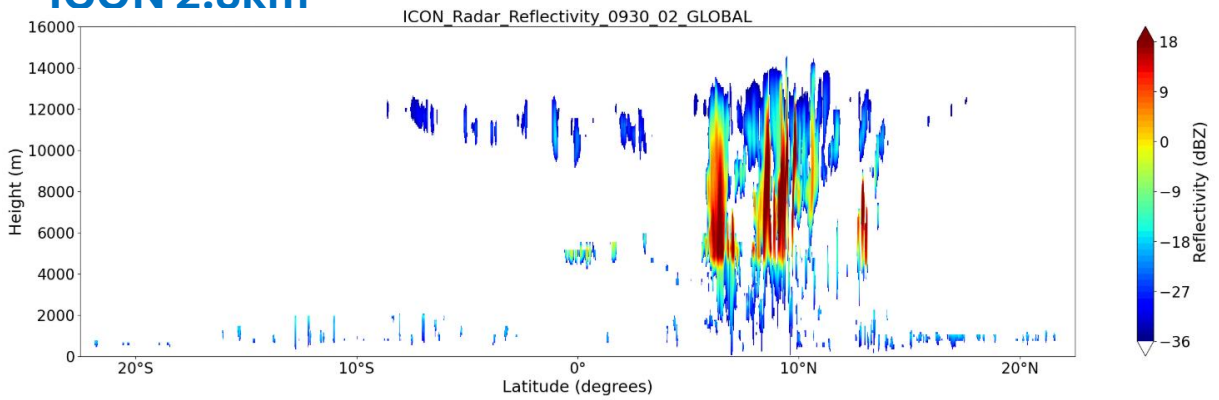
16:00 UTC, Sep. 3, 2024, Snapshot data

Application of Joint Simulator for Satellite Sensor (J-Sim)
ECOMIP: Case 3 Sep. 2024

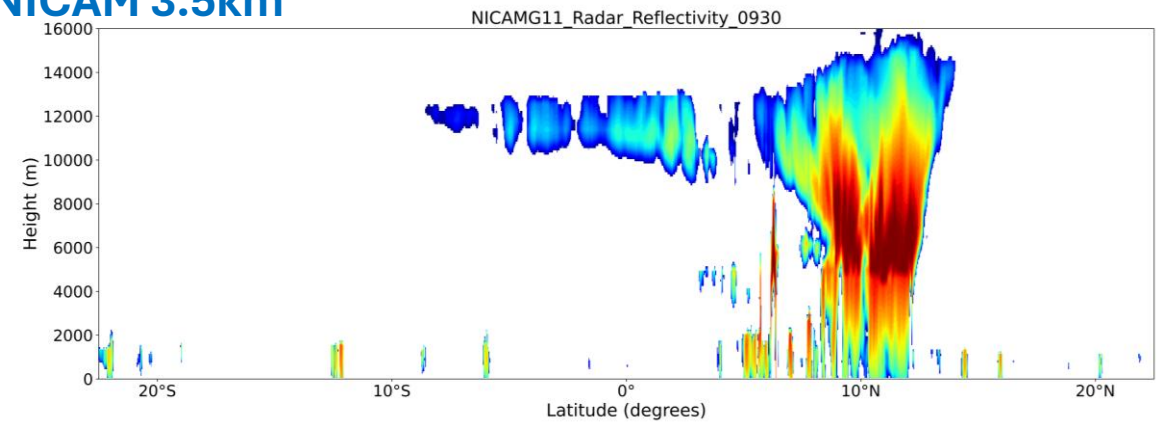
EarthCARE



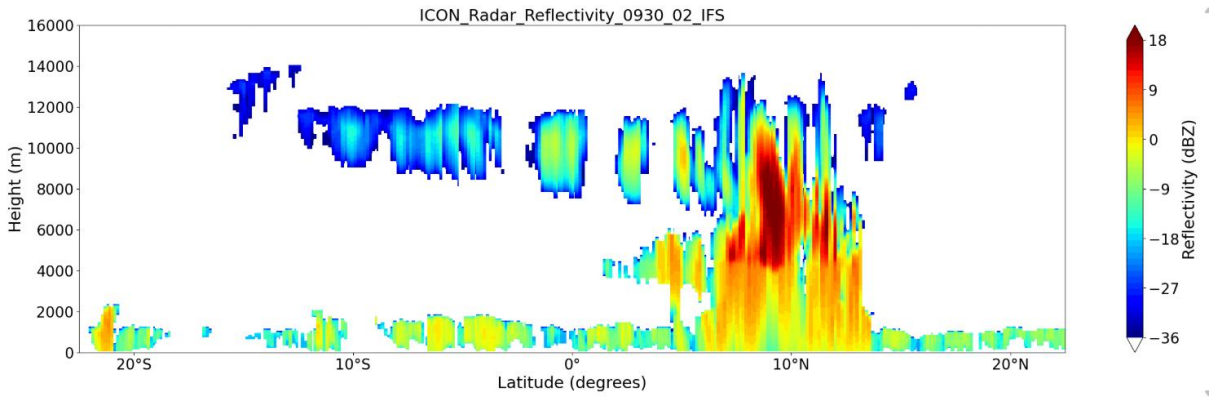
ICON 2.5km



NICAM 3.5km



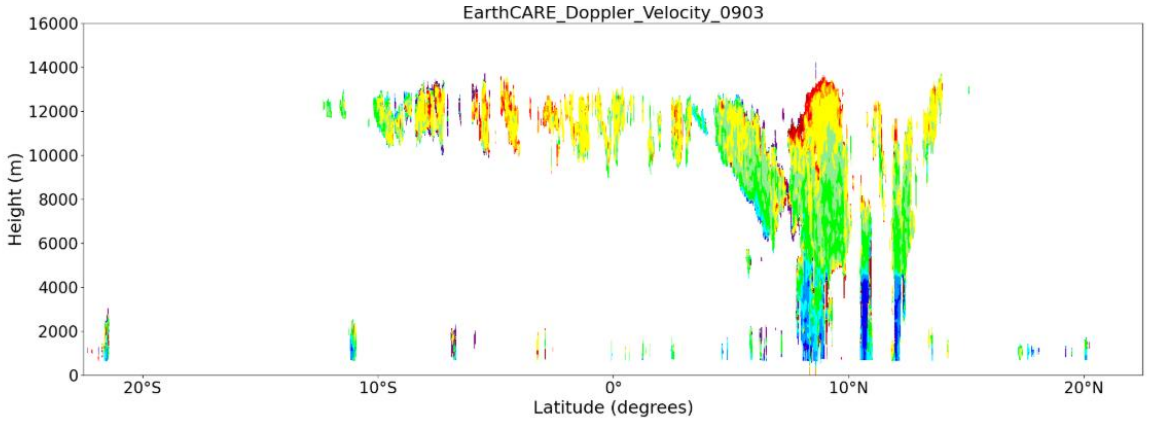
IFS 9km



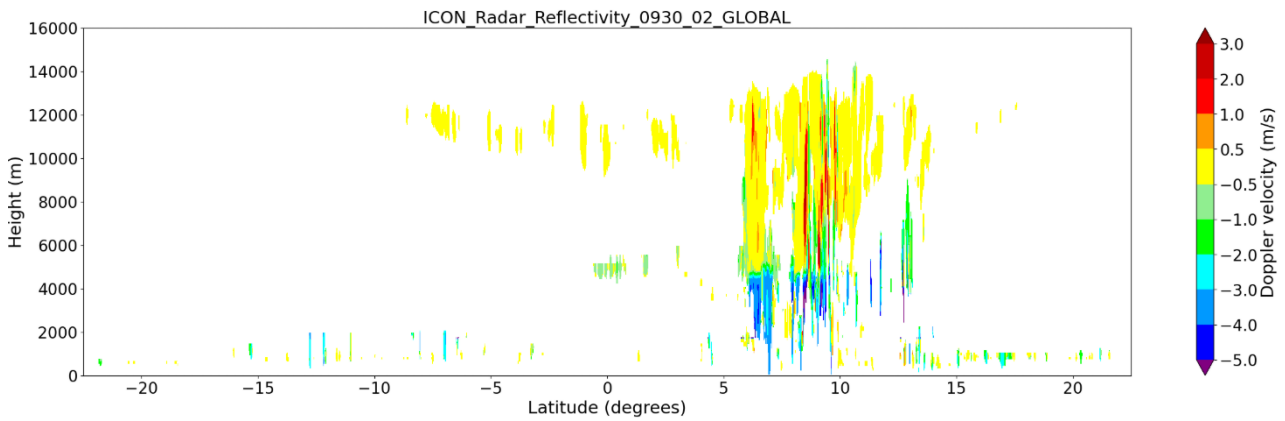
- Over the Atlantic region, where the ORCESTRA observations were conducted, all three models successfully reproduce the observed convective systems.
- However, we can see clear differences in the extent and thickness of high clouds around 12 km altitude and the representation of low clouds among the models.

Application of Joint Simulator for Satellite Sensor (J-Sim)
ECOMIP: Case Sep. 3, 2024

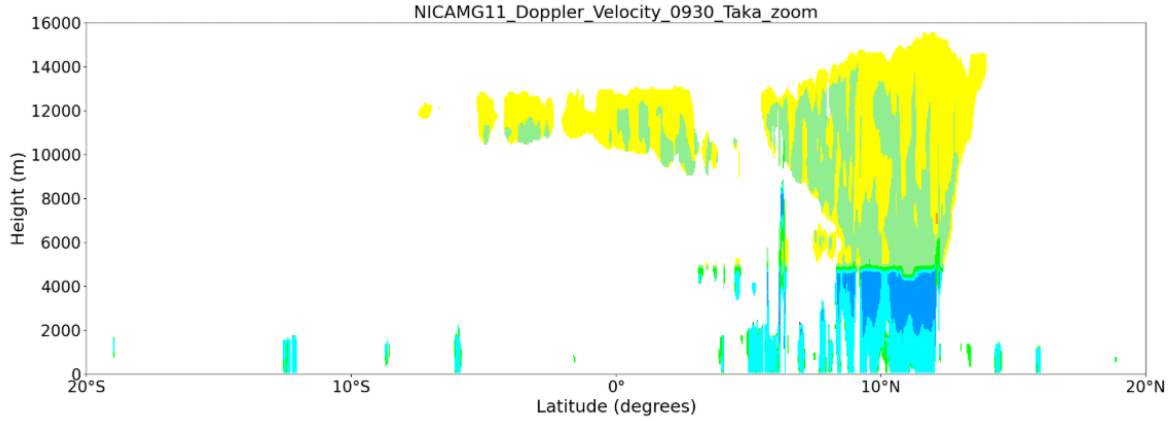
EarthCARE



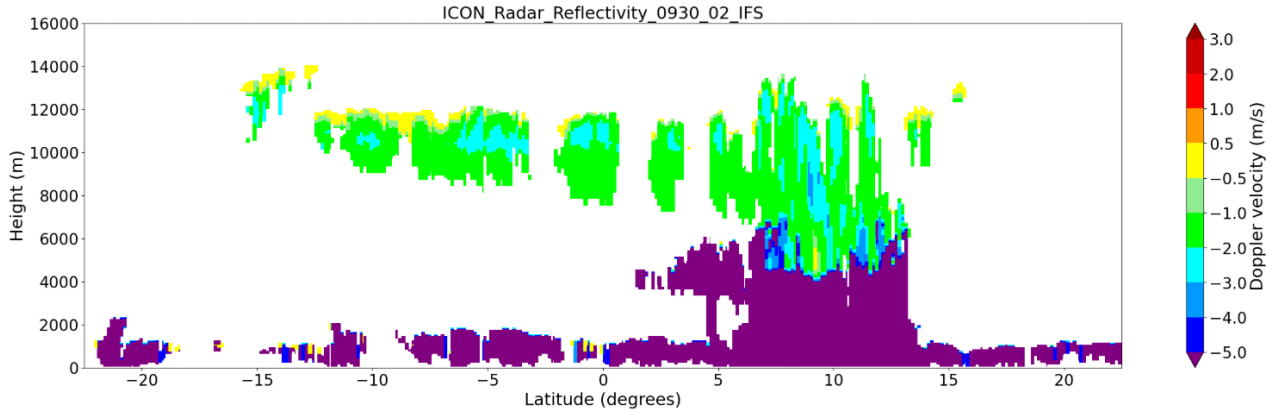
ICON 2.5km



NICAM 3.5km



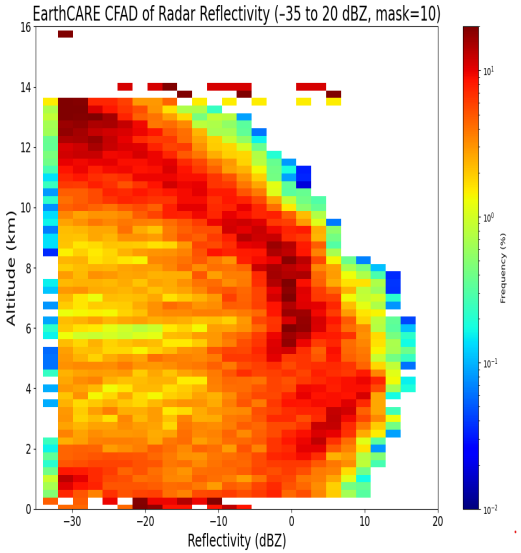
IFS 9km

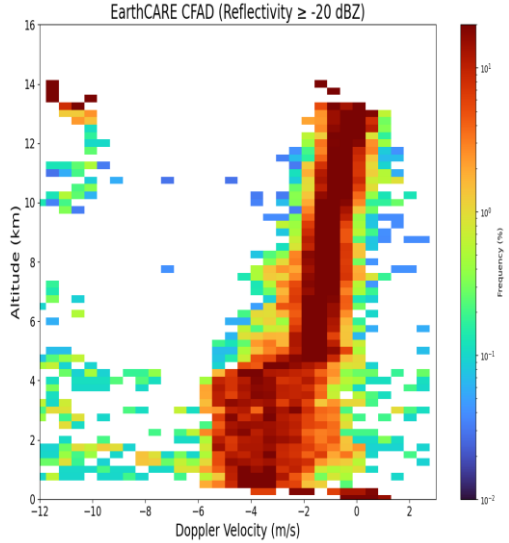


- We can see large differences in Doppler velocity among the models.
- This suggests that EarthCARE observations will play a key role in helping modeling groups improve their vertical motion and microphysics representations.

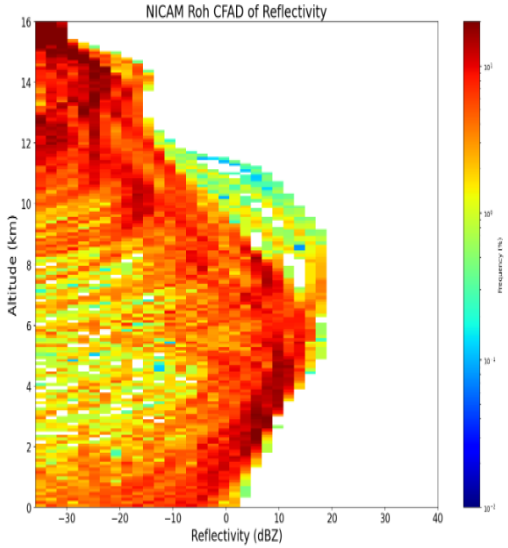
CFADs among EarthCARE, NICAM, ICON, and IFS

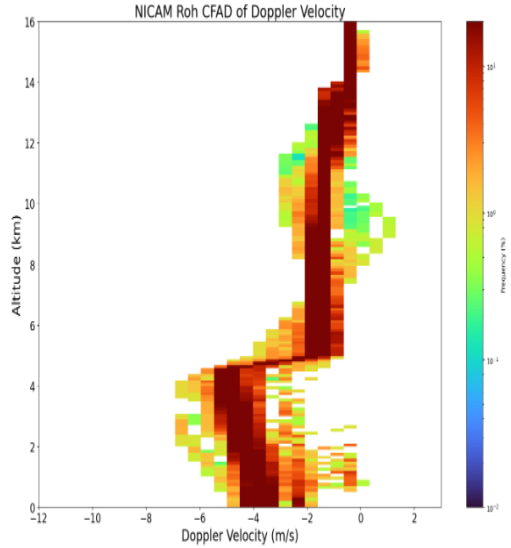
EarthCARE



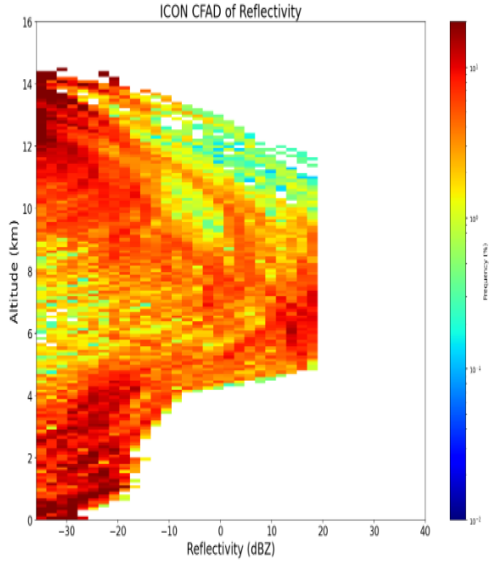


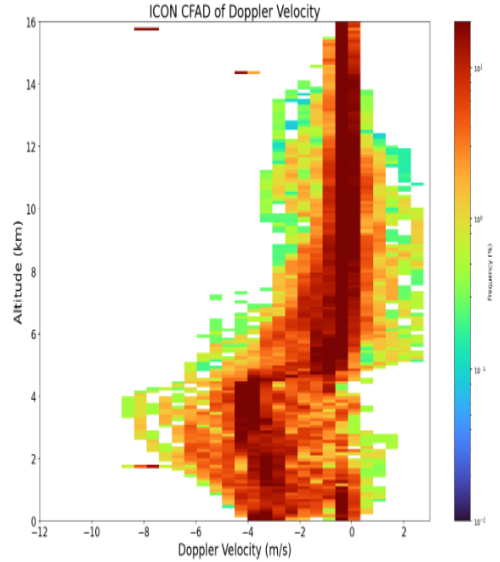
NICAM 3.5km



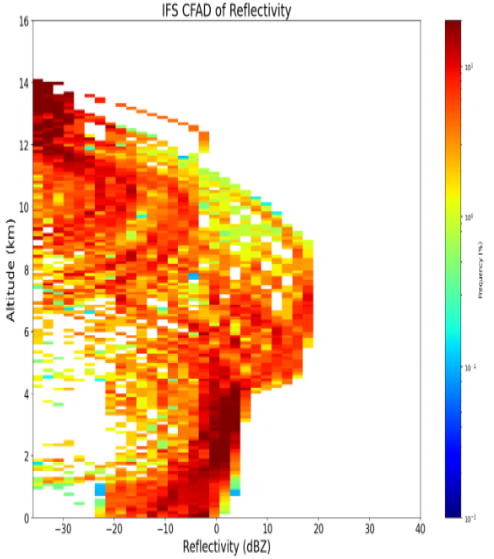


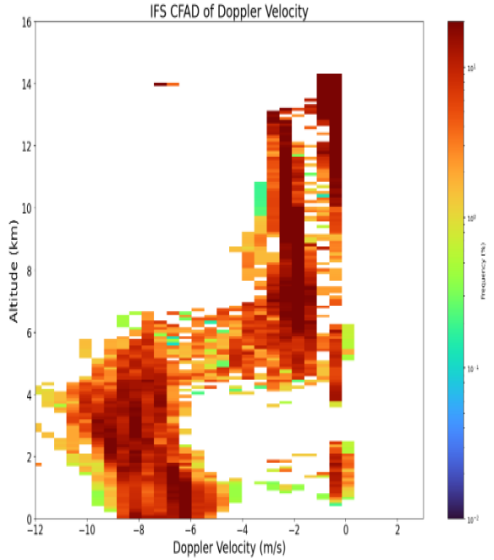
ICON 2.5km



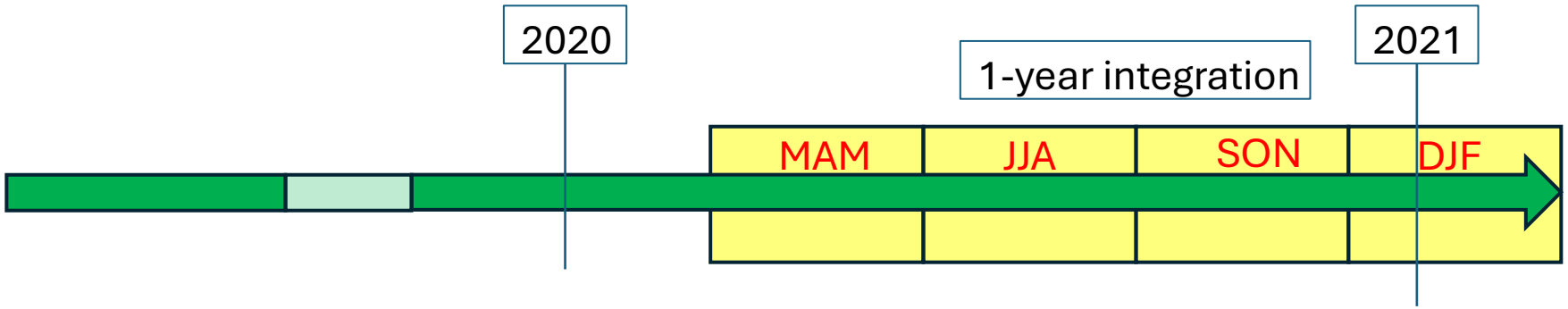


IFS 9km





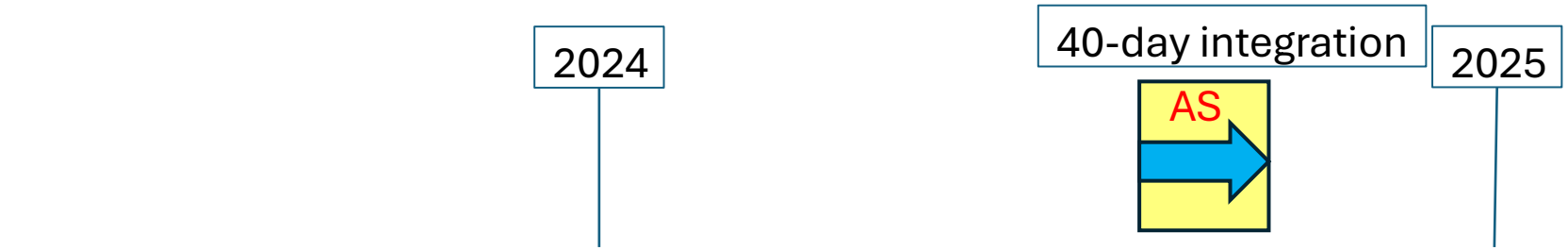
Global Storm Resolving Model Intercomparisons



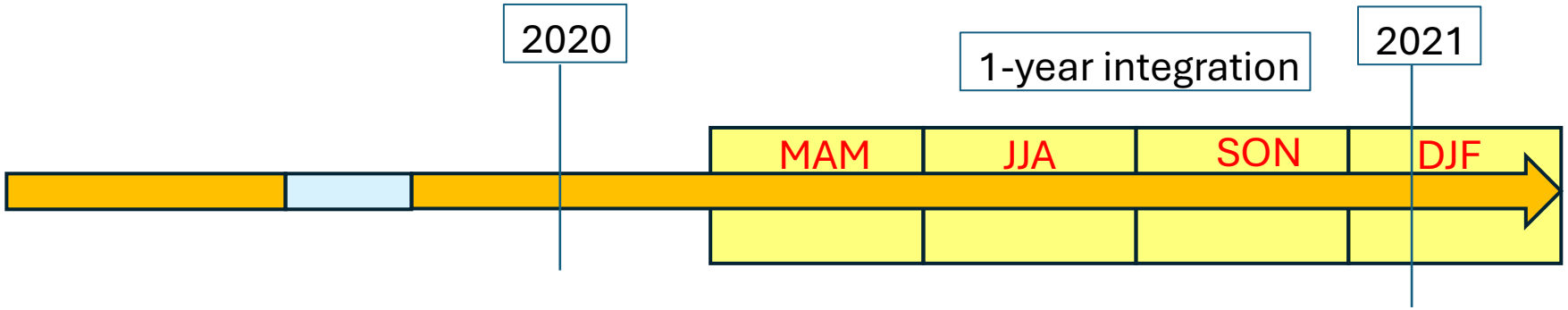
Sendai Protocol
- 1-year intercomparison

Global Hackathon: May 2025
- +4 K experiment

2024-2025



ECOMIP
2025-2026

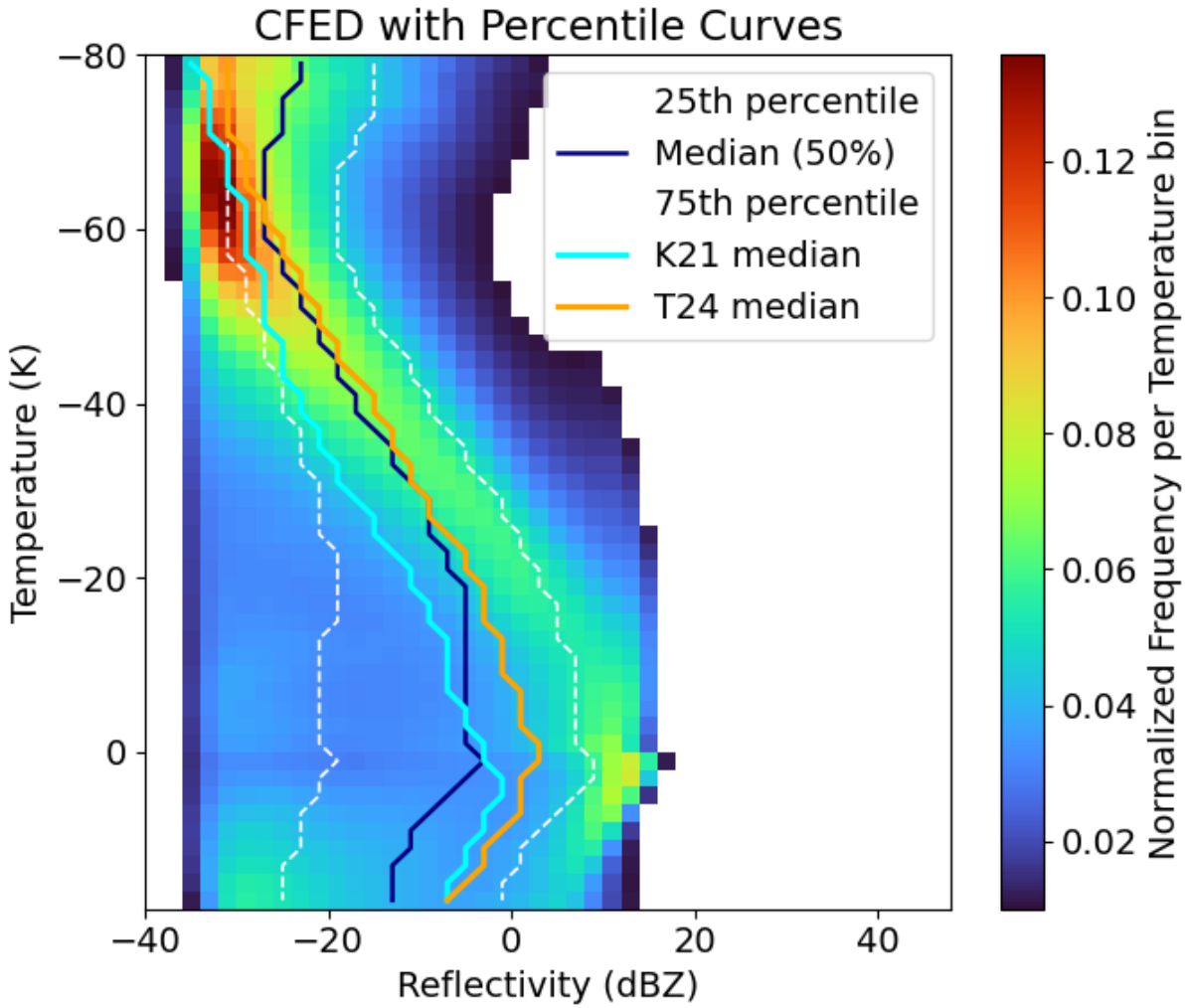


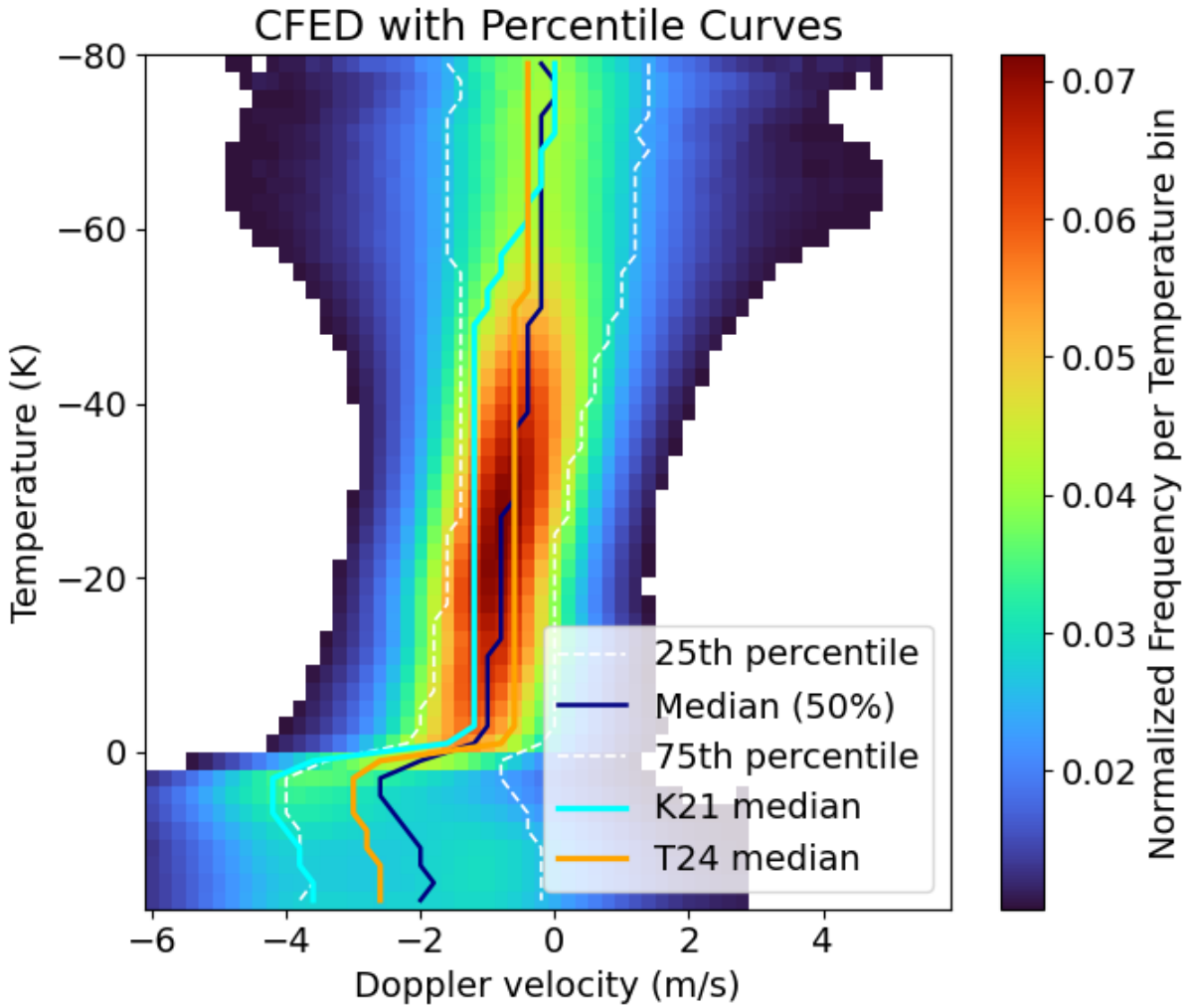
- 1-year intercomparison
- +4K experiment

2027-2028

Takasuka et al. (2024, PEPS)

EarthCARE CPR comparision with NICAM previous/new versions





Compared with two microphysics settings
K21: Kodama et al. 2021
T24: Takasuka et al. 2024

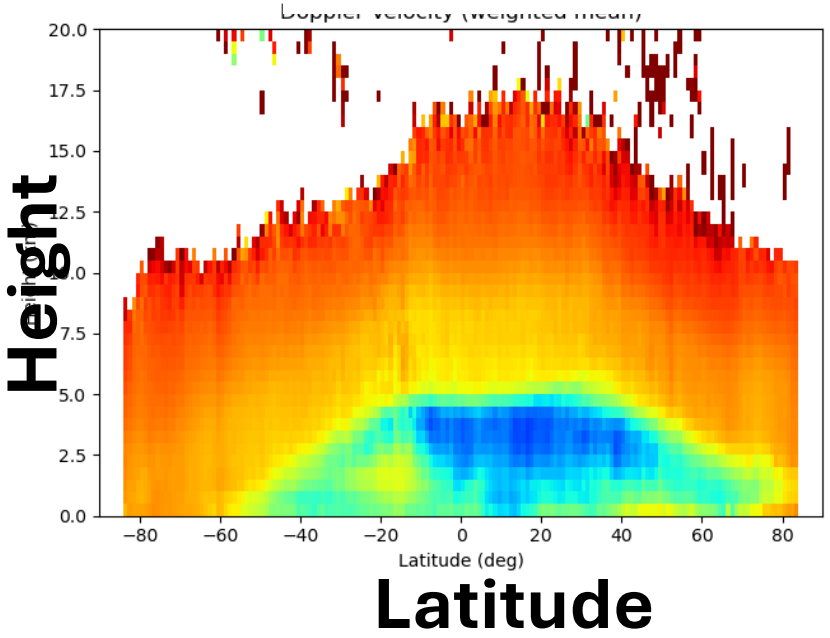
Shuhei Matsugishi's poster presentation

EarthCARE CPR comparision with NICAM previous/new versions

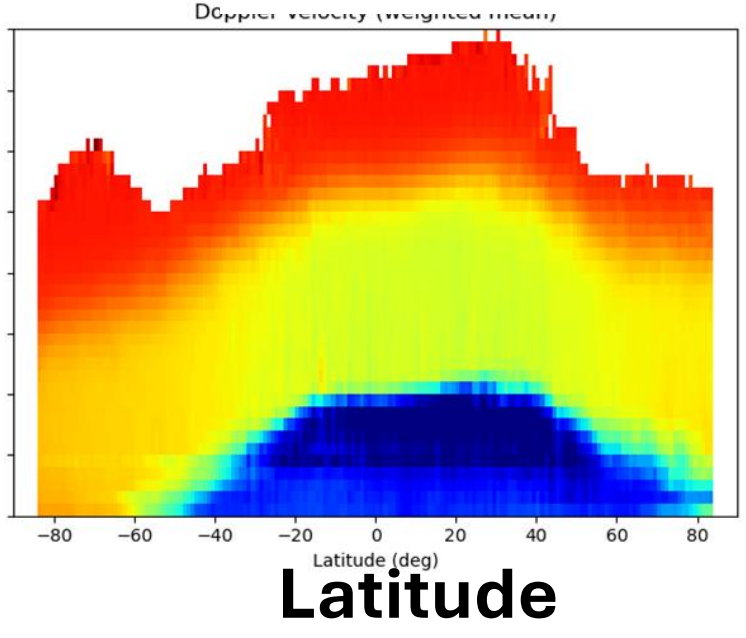
Zonal mean Doppler velocity

K21 has a higher fall speed in both rain and snow than EarthCARE
The fall speed of rain in T24 is close to that of EarthCARE. But Snowfall is slightly slower.

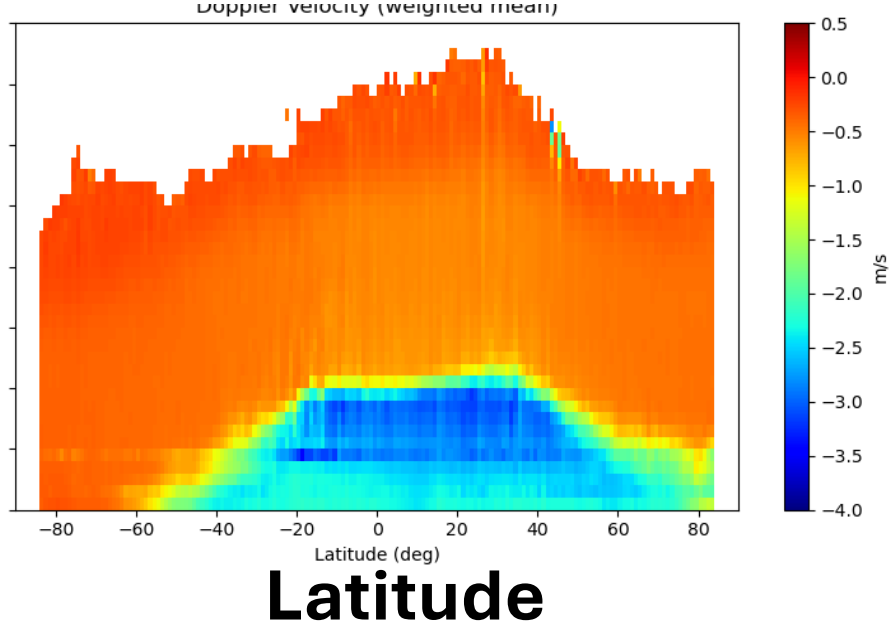
EarthCARE



NICAM ver K21



NICAM ver T24

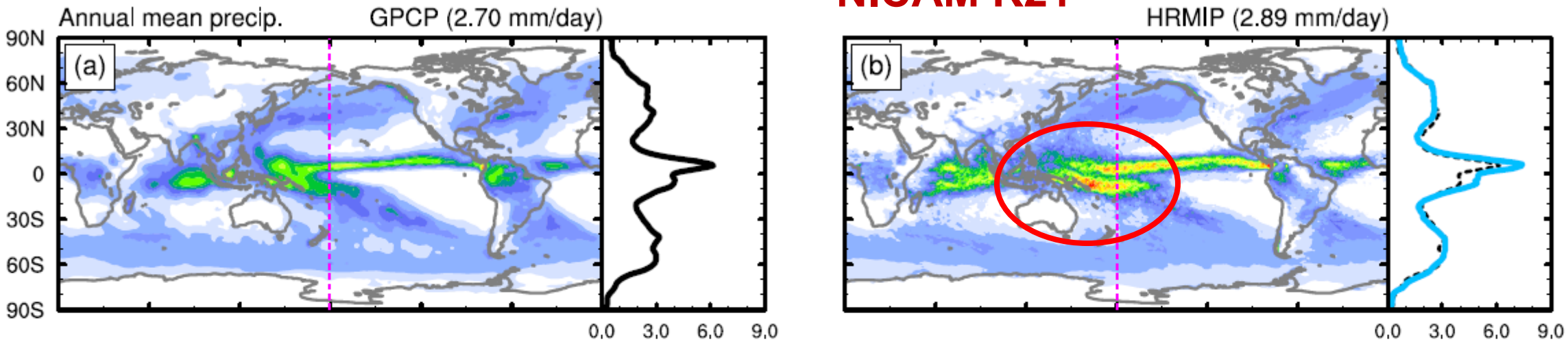


Shuhei Matsugishi's poster presentation

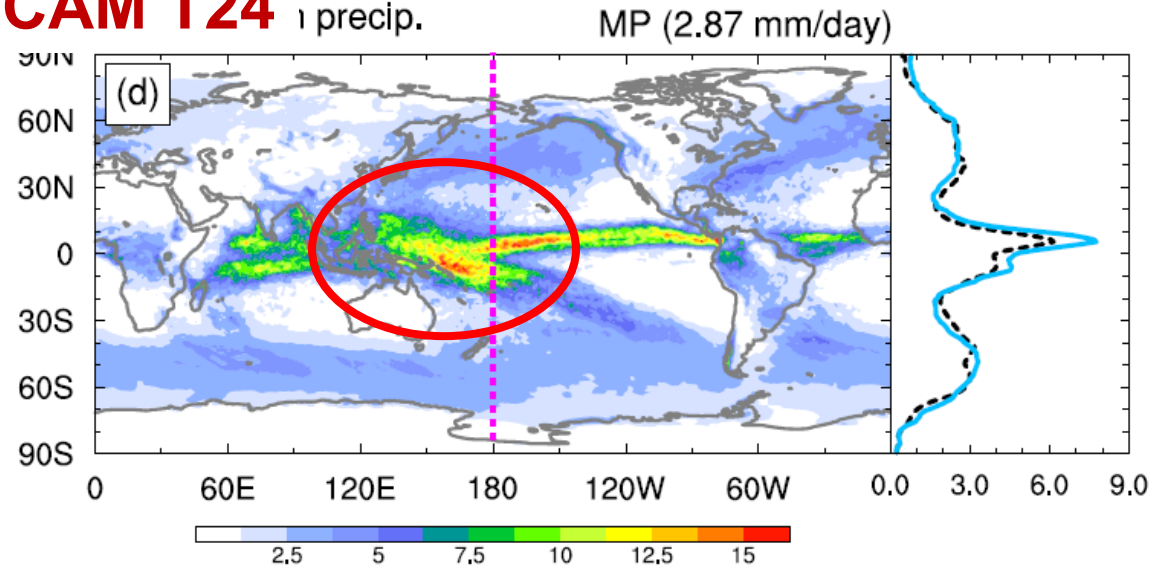
Example of the model improvement by referring the EarthCARE data

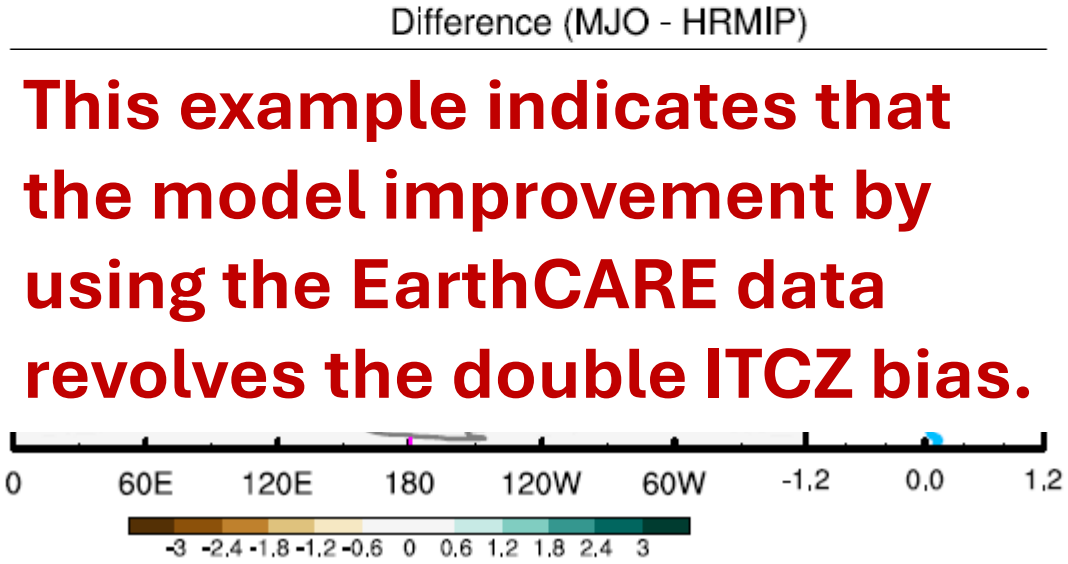
Takasuka et al. (2024,JAMES)

NICAM K21



NICAM T24

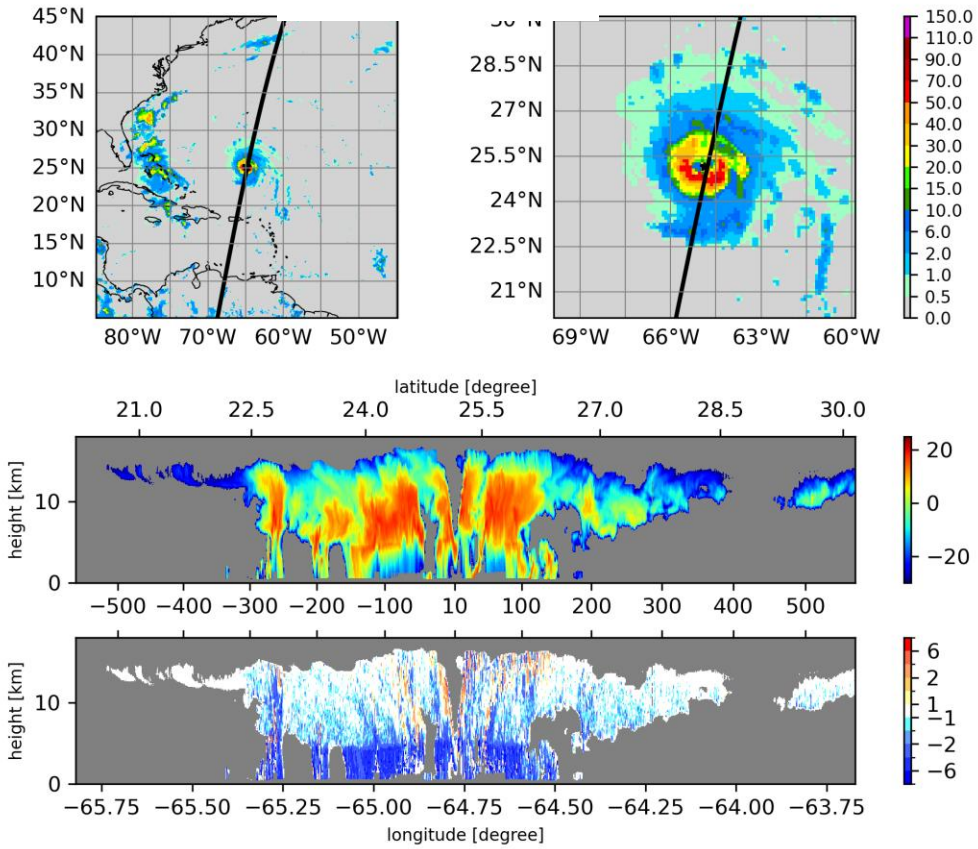




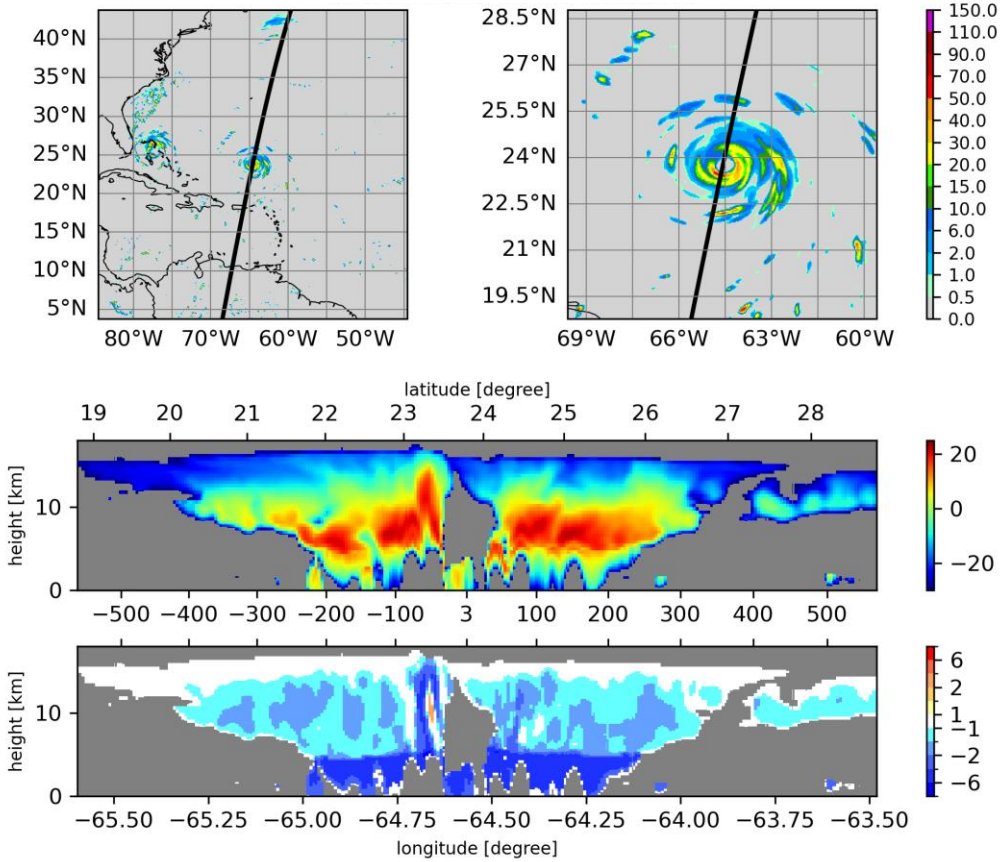
This example indicates that the model improvement by using the EarthCARE data revolves the double ITCZ bias.

Global km-scale model intercomparison: Hurricane Humberto

EarthCare 18:17:00



NICAM 3.5km By Jin-de Huang



Case: 28 September, 2025

Initialization: ERA5 at 27 September 00Z

Boundary condition: 15-m slab ocean nudged to OISST and NICAM low-resolution land climatology

Horizontal resolution: 3.5 km

Vertical resolution: 78 levels

Simulated period: 2 days

Output frequency: 1 hr

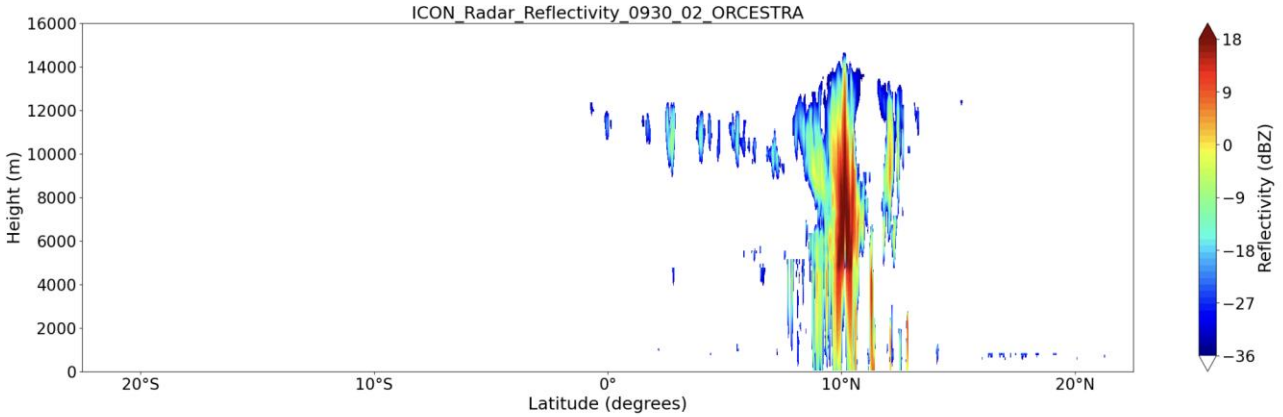
Output data: temperature, pressure, density, vapor mixing ratio, mixing ratio of all hydrometeors, U, V, W, surface temperature, 10-m U & V, sea level pressure, hourly accumulated precipitation, radiative fluxes at TOA and surface

Summary

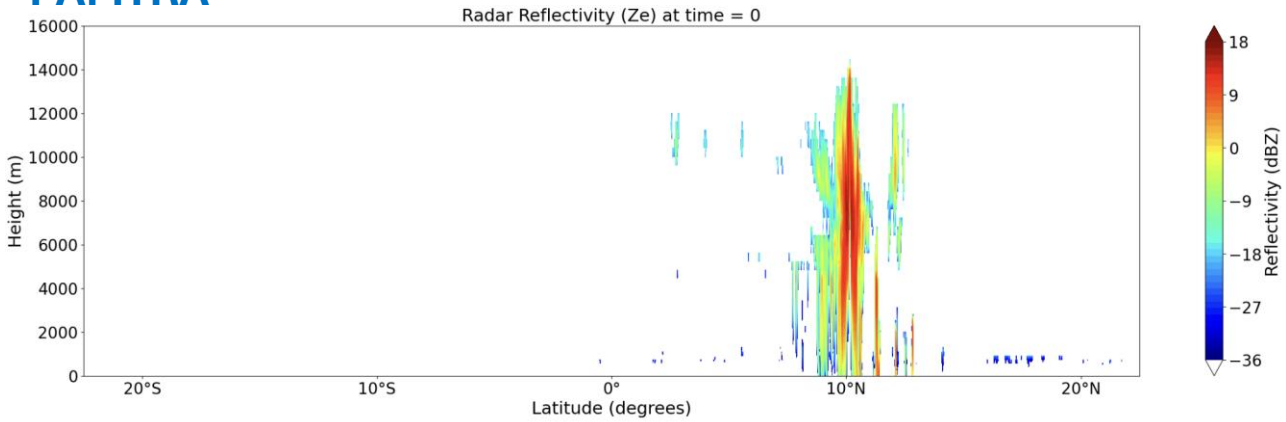
- ❑ Introduction to ECOMIP: EarthCARE, ORCESTRA MIP
- ❑ Example of a NICAM, ICON, IFS-simulations
- ❑ Phase 1: Case: 3 Sep 2024
- ❑ Timeline
  - Protocol paper led by Woosub Roh
  - Archive server will soon be open by JAXA, submission by the end of 2025 (TBD)
  - Submission of the 3D and 2D model data will be requested. Cross-section and application of satellite simulators will be processed off-line.
  - Microphysics information is requested.
  - Summarize ECOMIP Phase I by 2026, followed by Phase II & III
- ❑ Forthcoming meetings
  - 2026 events: km-scake modeling summit, Hamburg, 20-24 July 2026; EGU, JpGU, AOGS

Comparison of simulators: J-SIM and PAMTRA

J-SIM



PAMTRA



ECOMIP: Case Sep. 3, 2024

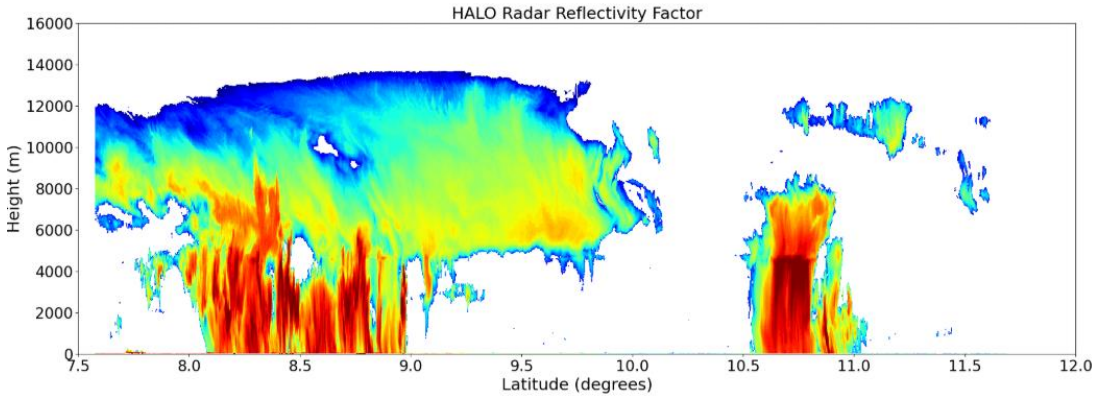
- The current results show that the size distribution of rain particles is consistent between the models, but the size distribution of ice particles does not yet match.
- We plan to improve the agreement for ice particles and compare the updated results in future work.
- Such intercomparisons between simulators (J-SIM and others) are expected to help identify weaknesses in each simulator and contribute to their improvement.

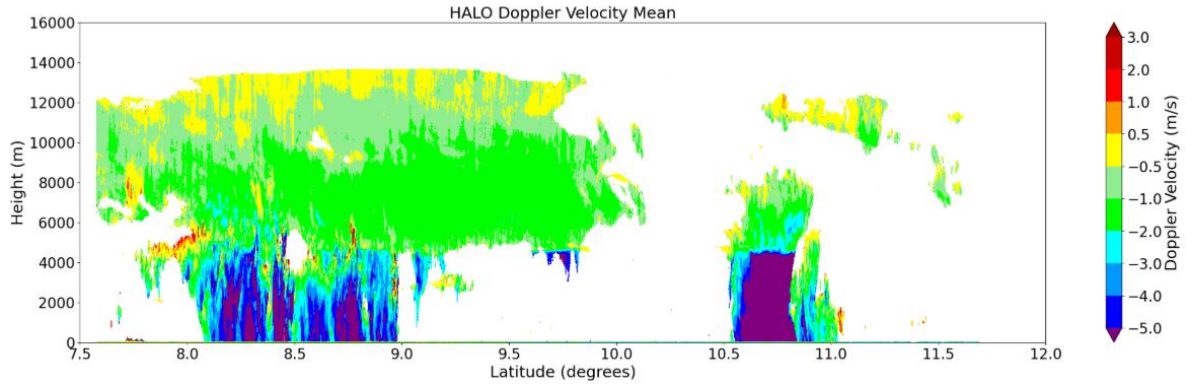
Data analysis

- Compare model with observations for either physical values or sensor signal values
- For the forward model, the use of satellite simulators is expected.
- Satellite simulators used by the individual ECOMIP participants are:
  - The Joint Simulator for Satellite Sensors: Roh et al. (2023,AMT)
  - PAMTRA: Passive and active microwave radiative transfer tool
  - ECSIM: used to simulate EarthCARE observations for the pre-launch special issue of AMT
  - RTTOV: used for simulating microwave, infrared and most recently solar radiances for data assimilation, used by European NWP centres. A radar simulator is under development.
  - COSP: used to simulate radar, lidar and radiometer data targeted at low-resolution climate models used in IPCC.
  - JEDI/CRTM: used to simulate radiances for data assimilation.
  - ZMVar: used by ECMWF for assimilating radar and lidar backscatter profiles.
  - The Spaceborne Radar Simulator (SR-SIM)

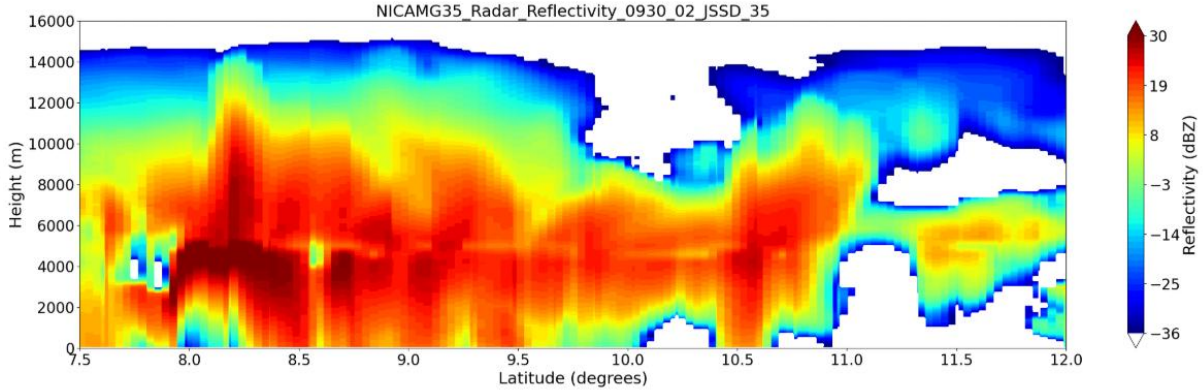
Halo and NICAM

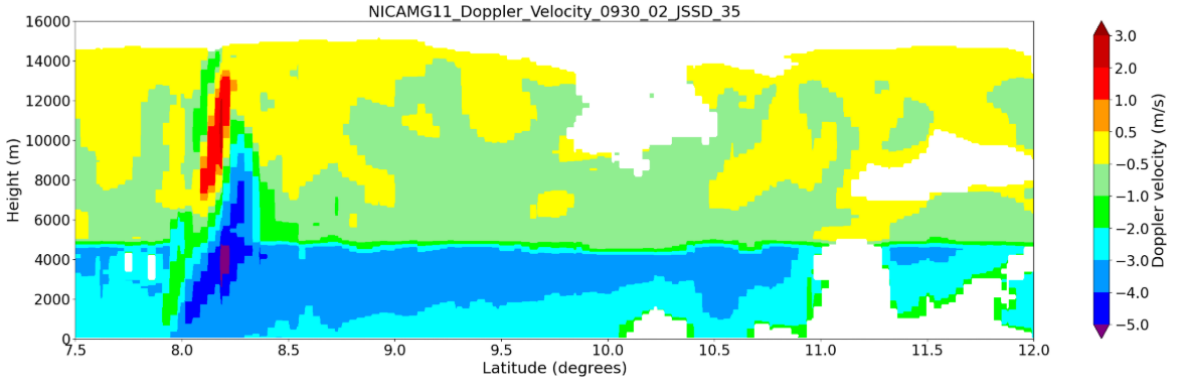
HALO





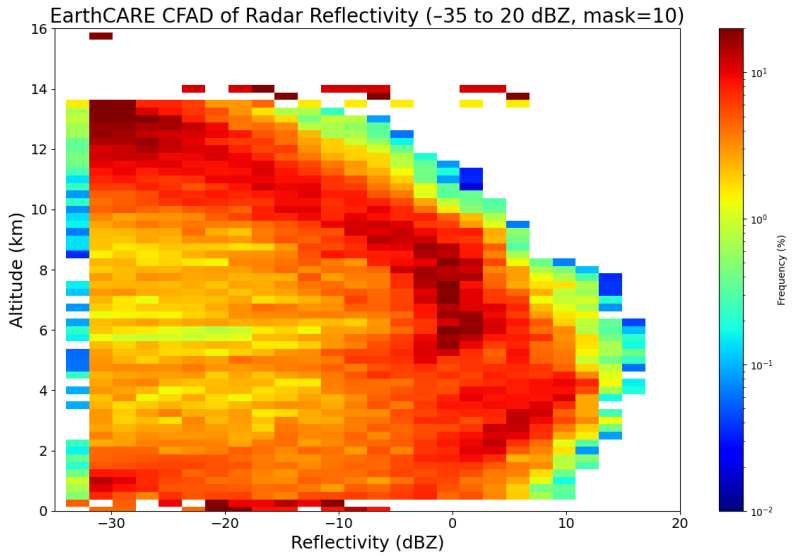
NICAM 3.5km

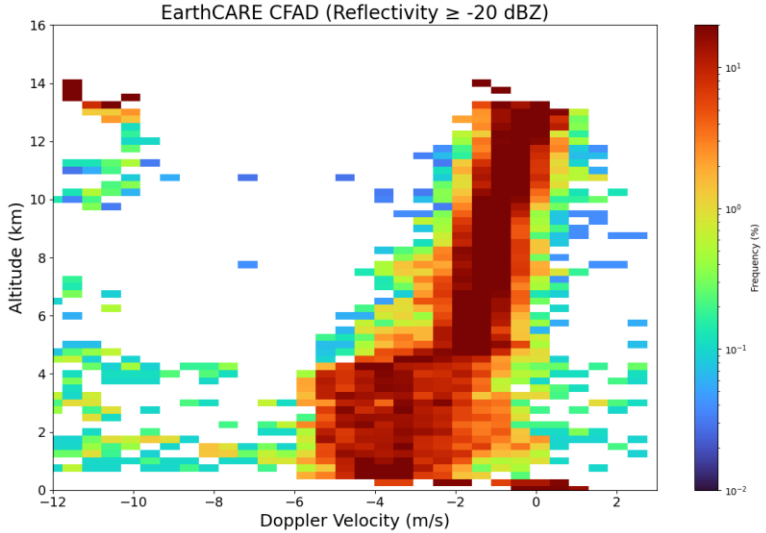




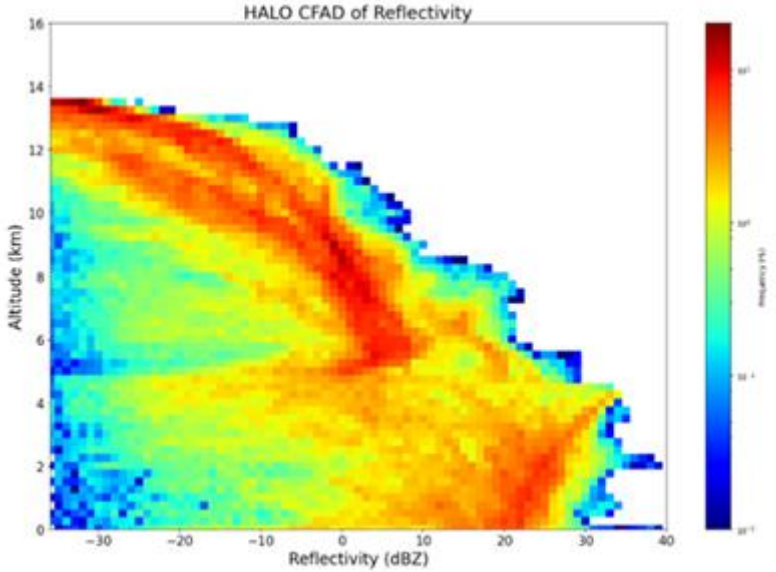
CFADs between EarthCARE and HALO

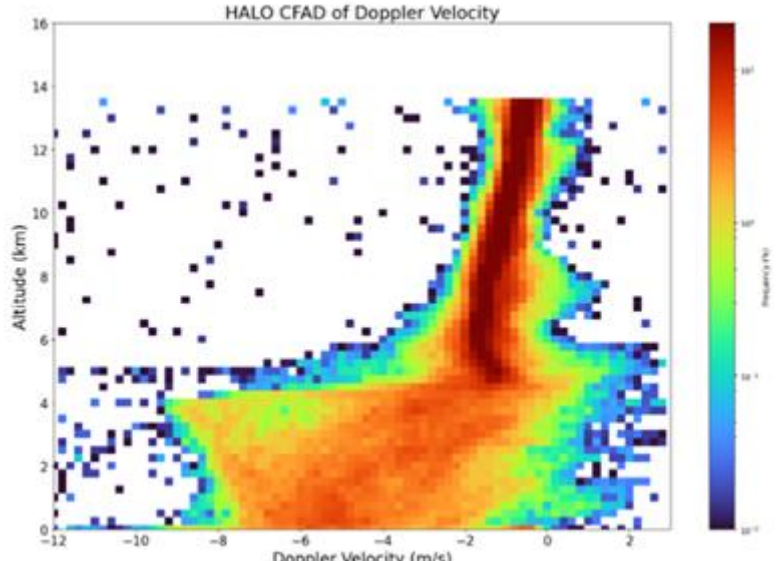
EarhCARE





HALO





NICAM