Validation of vertical moisture structure in cold sectors of extratropical cyclones based on airborne lidar observations during NAWDIC

2026 AR Recon workshop and 2nd Observational campaigns workshop for better weather forecasts

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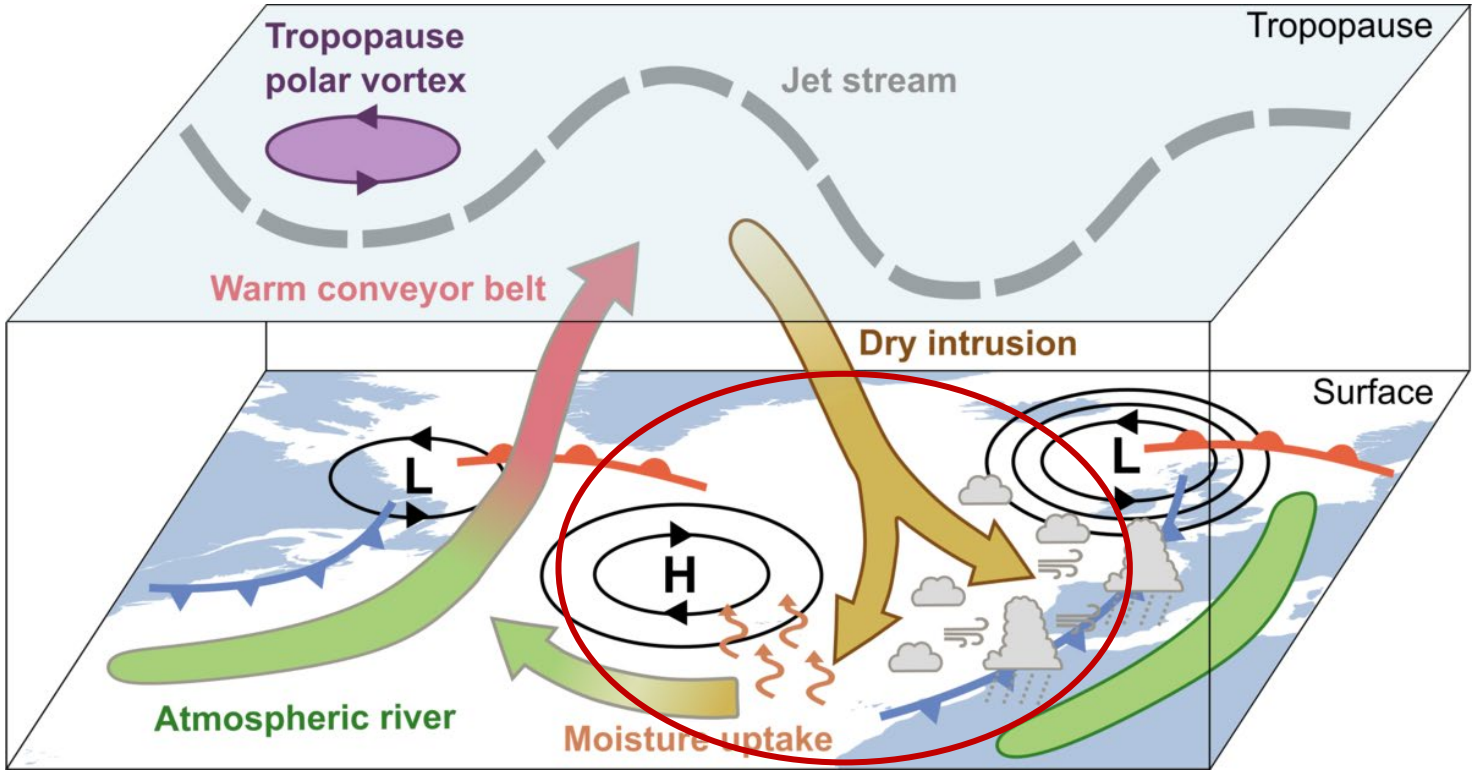
NAWDIC 2026

North Atlantic Waveguide, Dry Intrusion and Downstream Impact Campaign

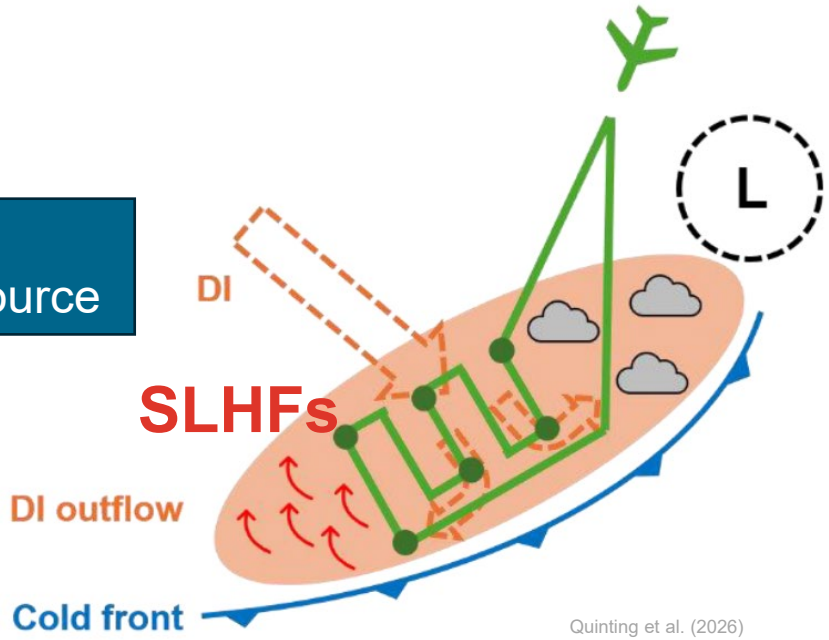
DLR

NAWDIC-FLUX: Surface Latent Heat Fluxes (SLHFs) in Cold Sectors



Surface Latent Heat Fluxes (SLHFs) in Cold Sectors

Important moisture source



Quinting et al. (2026)

Influence on cyclone strength & precipitation

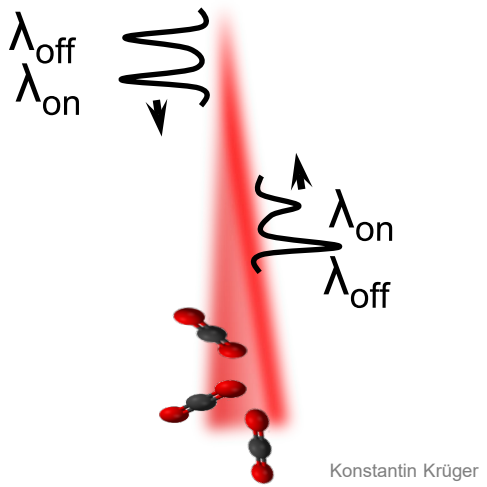
Project goals

- Derive Surface Latent Heat Fluxes (SLHFs) from wind and water vapor lidar observations
- Characterize Marine Boundary Layer (MBL) structure in cold sectors and influence of SLHFs
- **Validate representation of LHFs and MBL moisture distribution by NWP models**

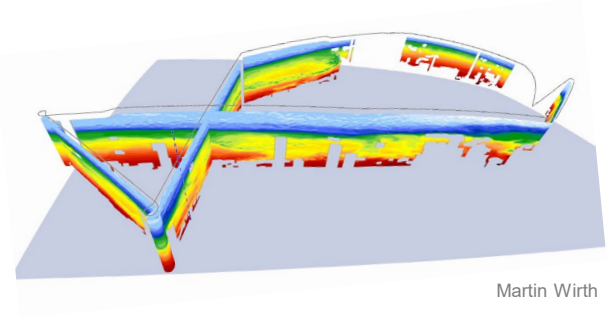
Current focus on WALES water vapor observations:

➔ **How well is the moisture distribution in cold sectors represented by NWP models?**

The water vapor dataset



Konstantin Krüger



Martin Wirth

WALES

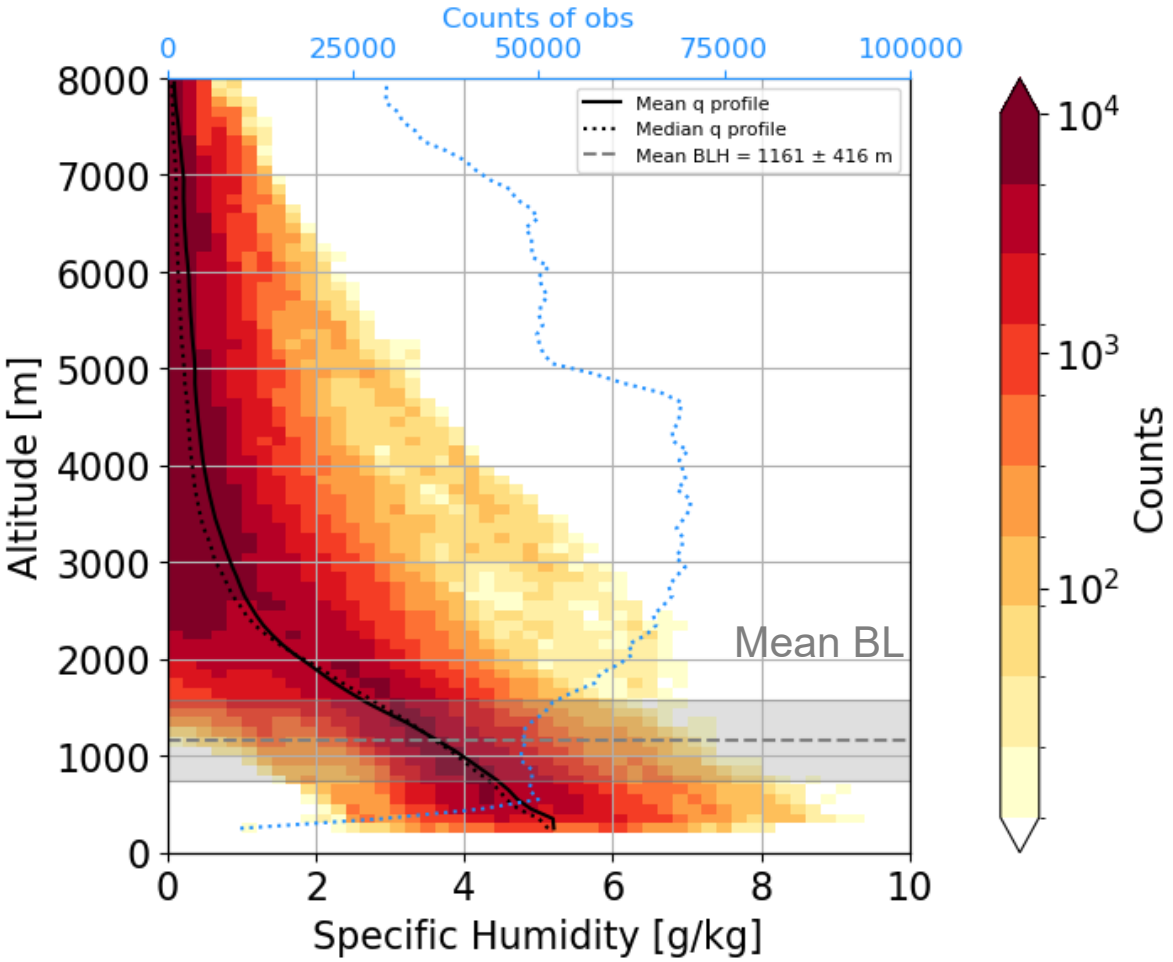
- Water vapor lidar Experiment in Space (WALES)
- 4-channel Differential absorption lidar (DIAL)

ECMWF - IFS

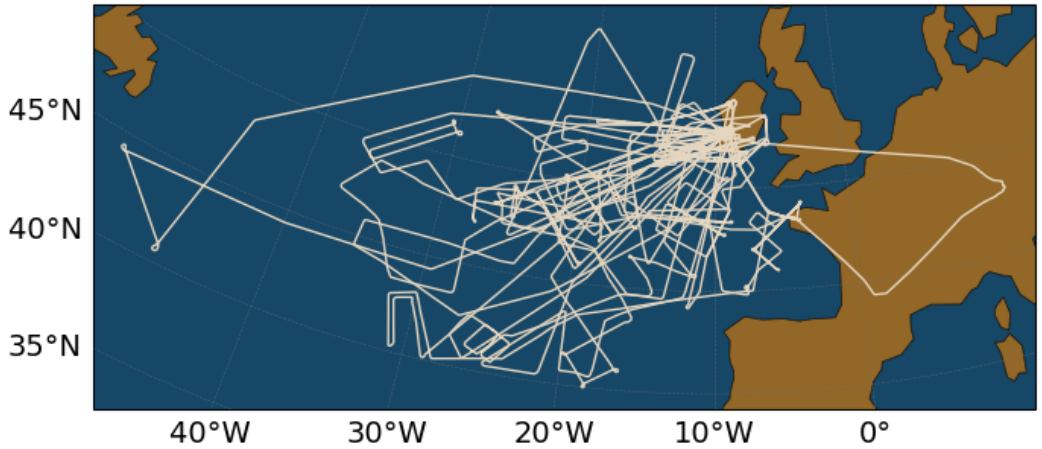
- Operational AN & FC data
- Spatially and temporally interpolated towards WALES profiles

Resolution	WALES	ECMWF-IFS
Temporal	1s / 24 s	Hourly (00 AN,*+01h FC*,..., 12AN, ...)
Horizontal	~200 m / ~5 km	~9 km

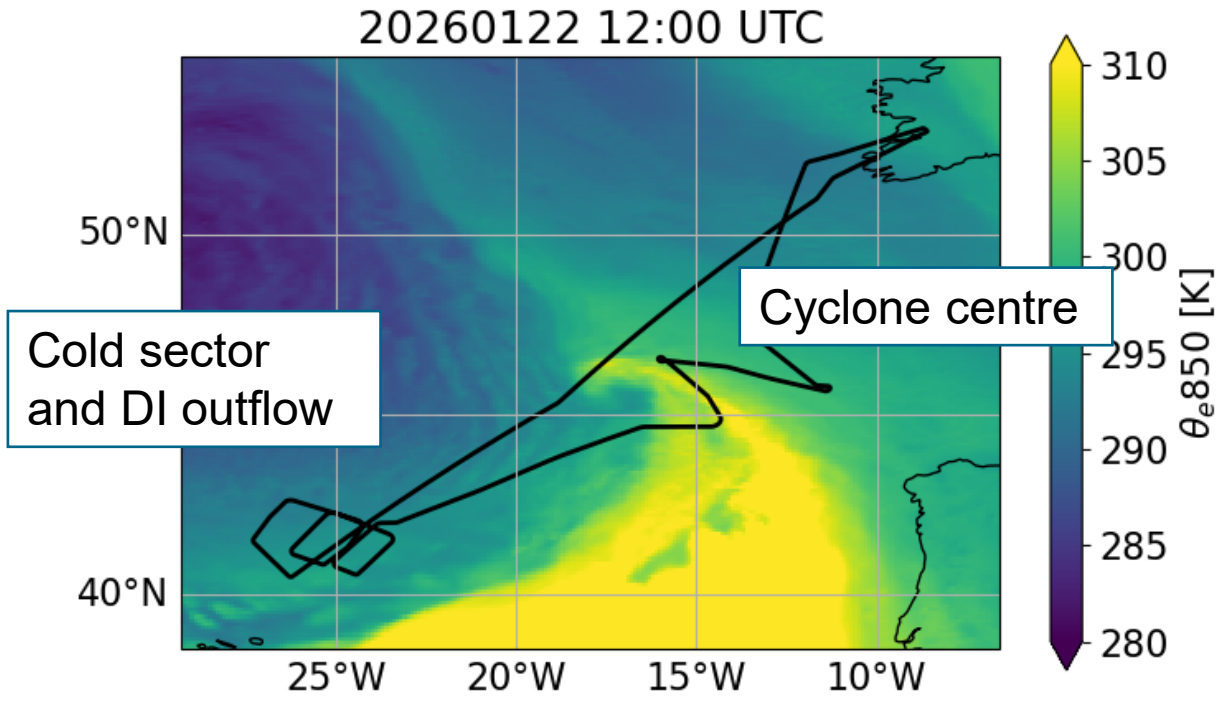
Humidity Observations during NAWDIC

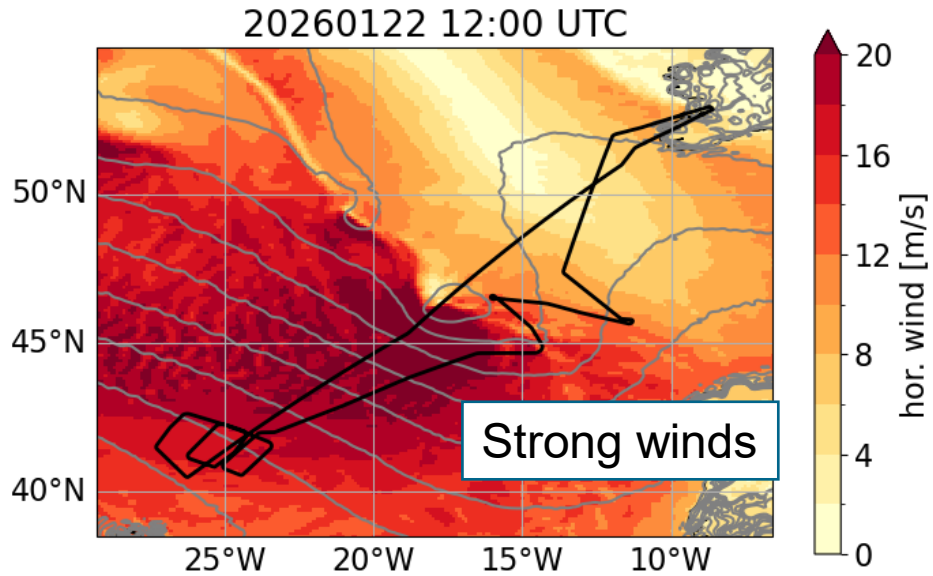


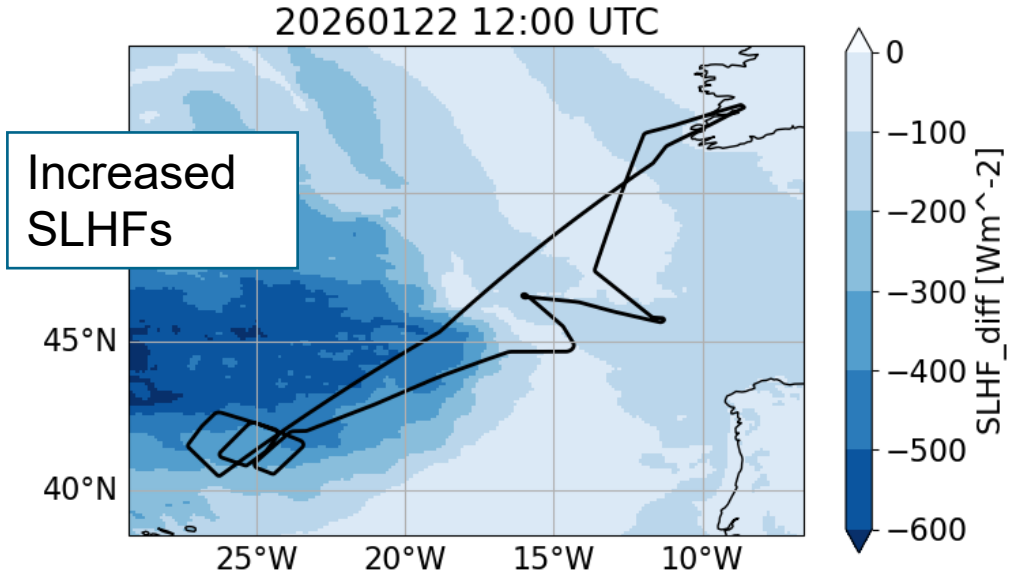
NAWDIC flight tracks:



IOP “Galway” on 22nd January 2026







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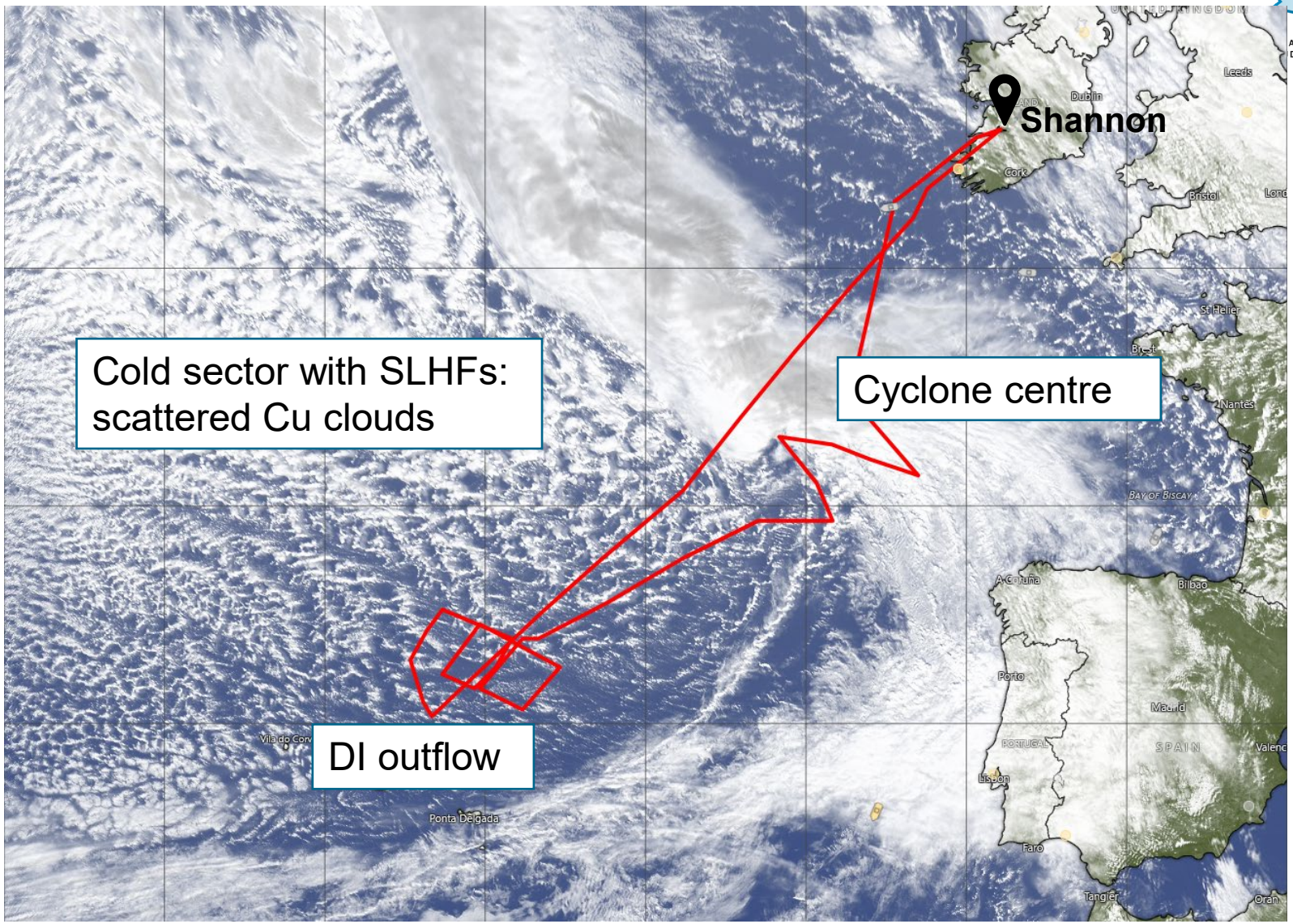

Satellite image from windy.com, 13:05 UTC.

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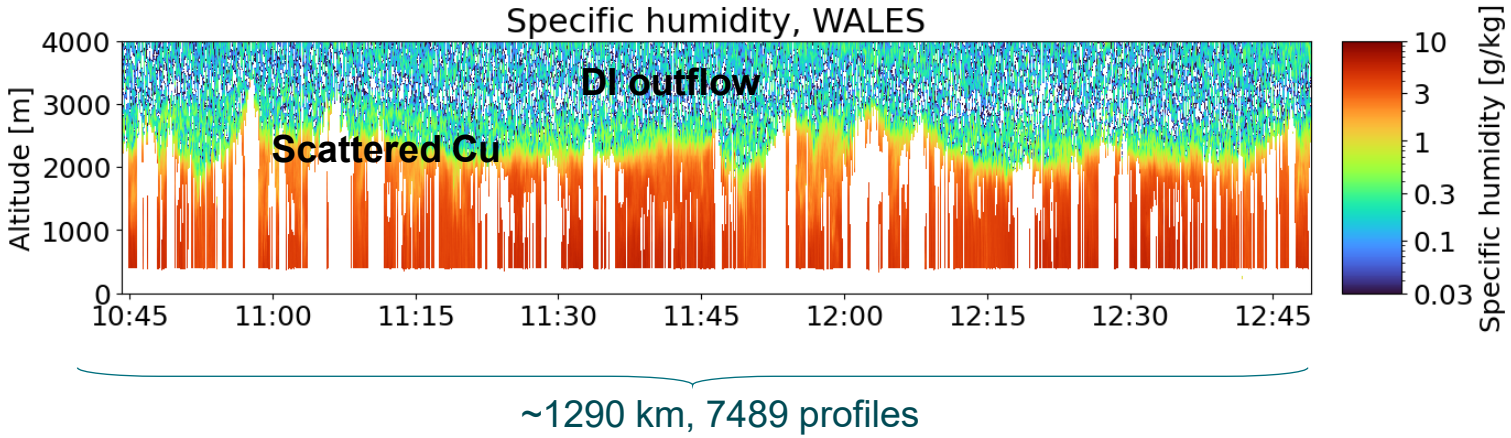
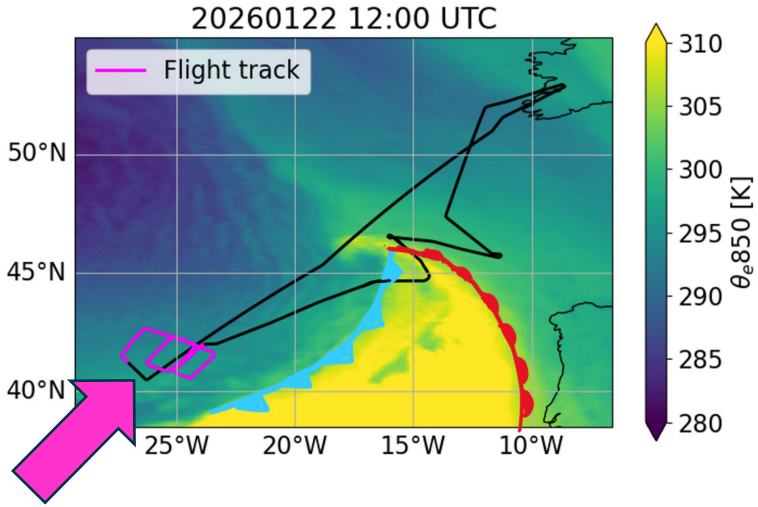


~1290 km, 7489 profiles



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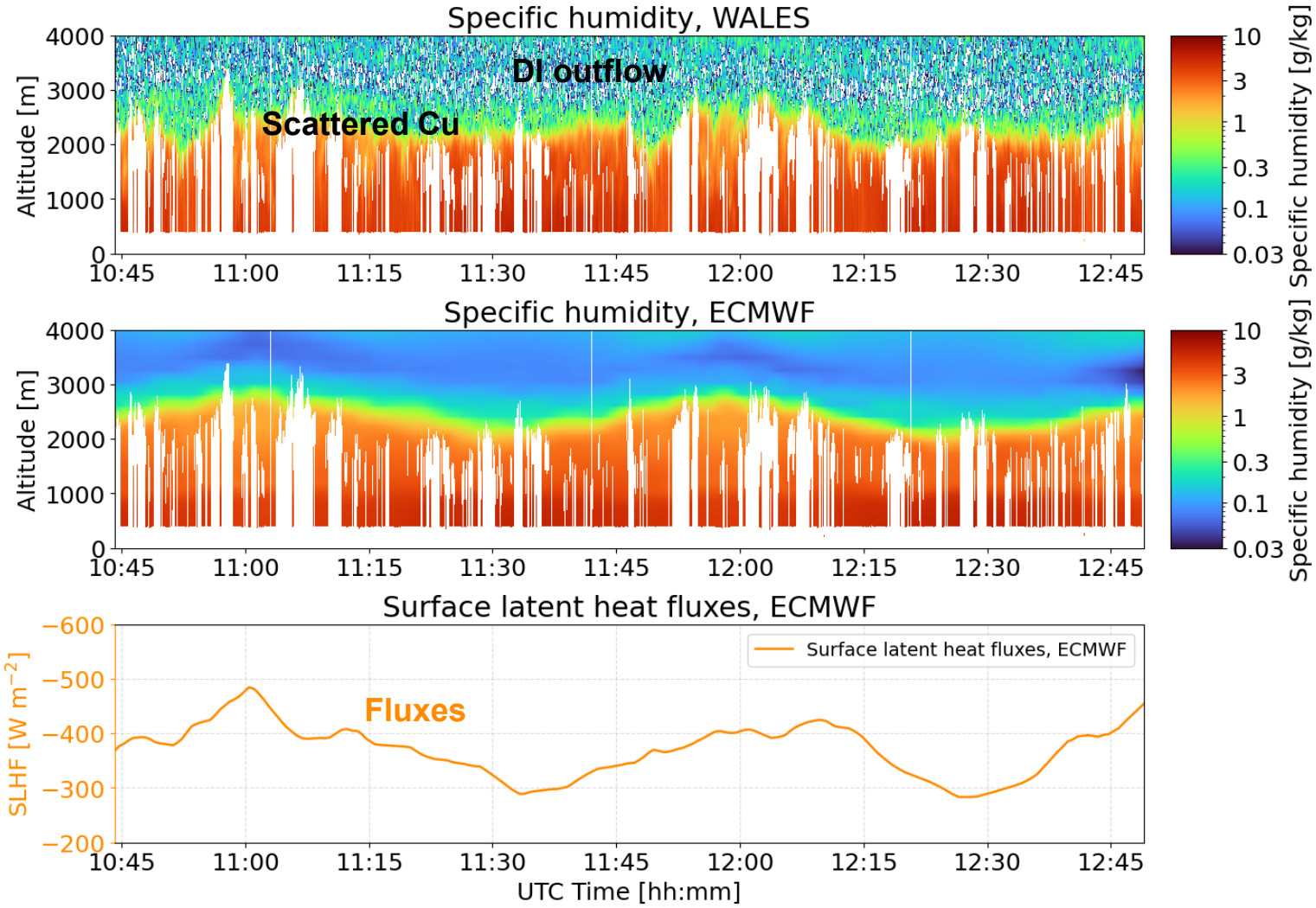

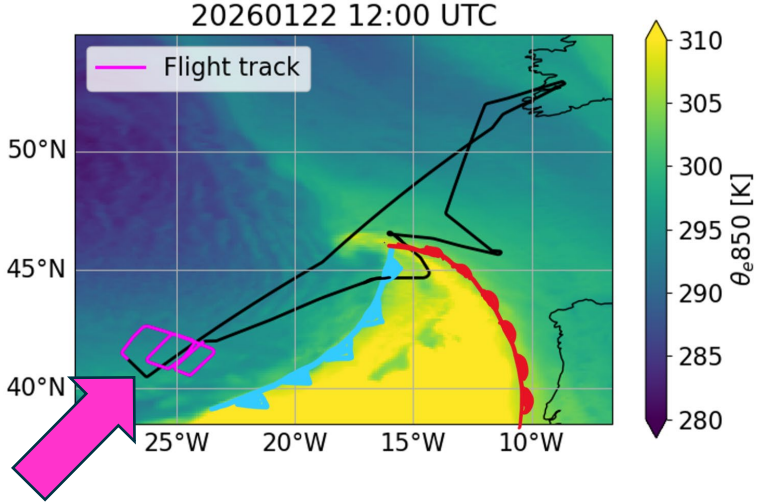

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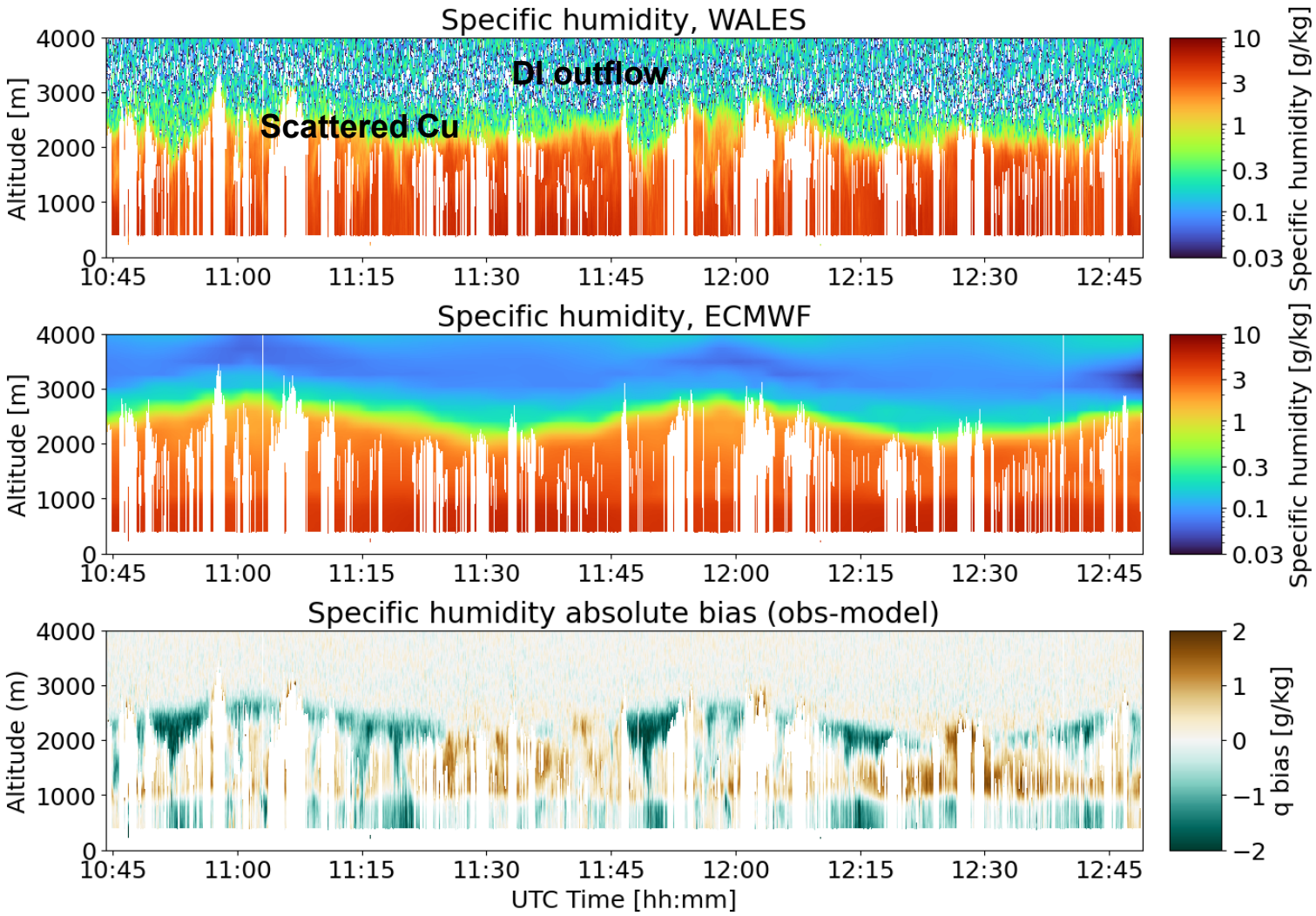
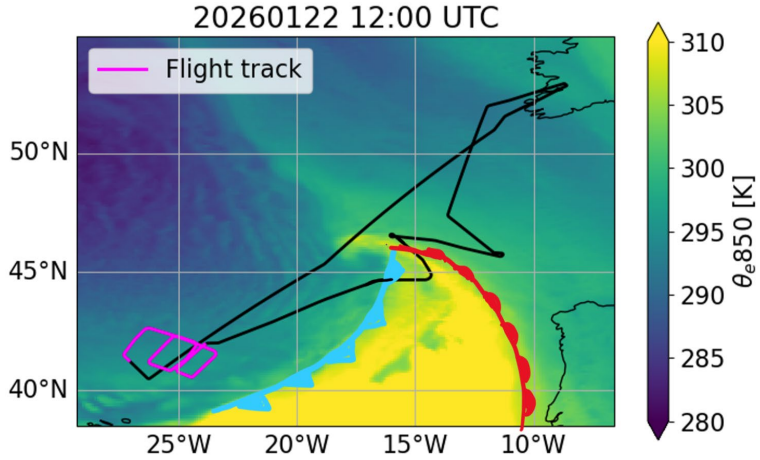
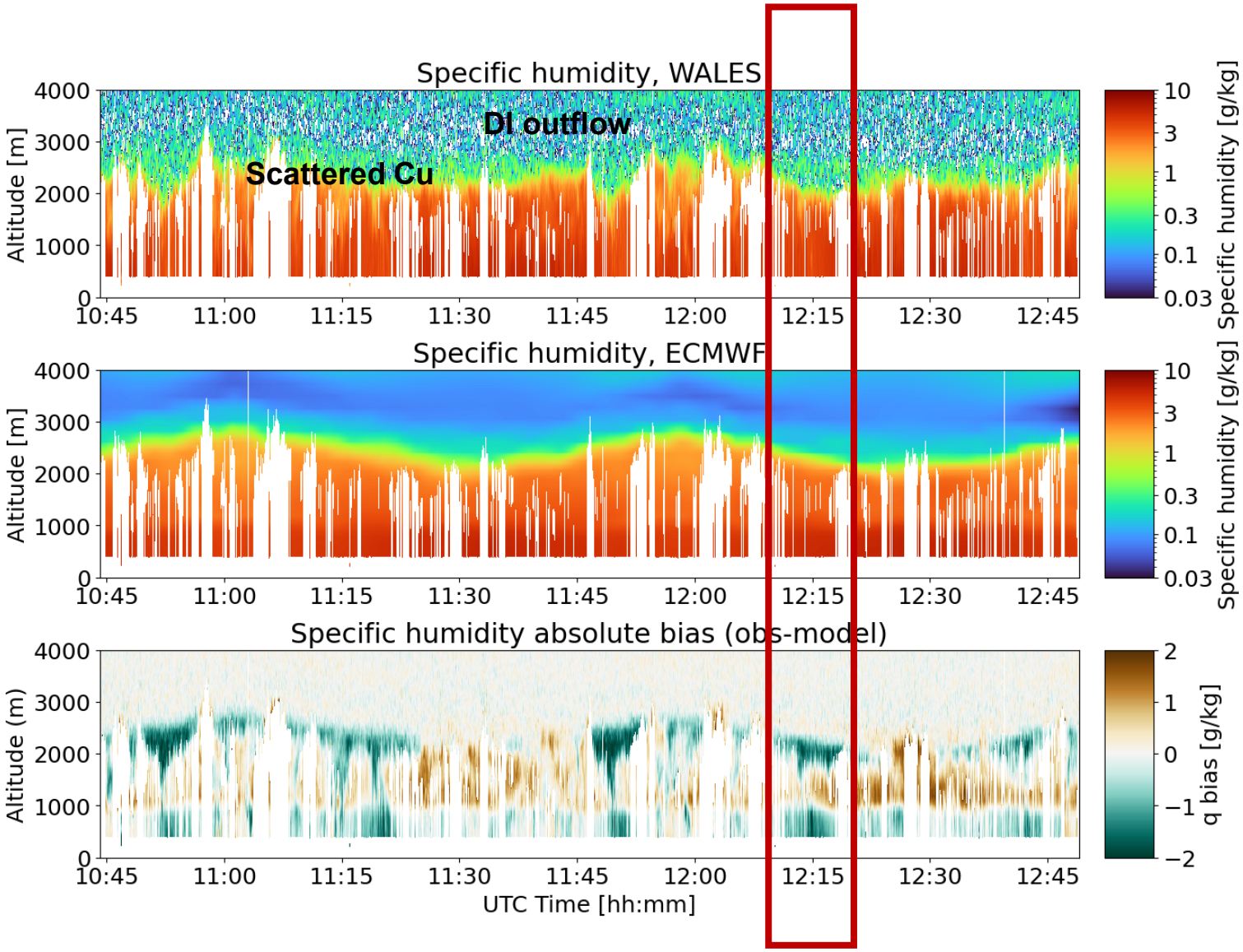


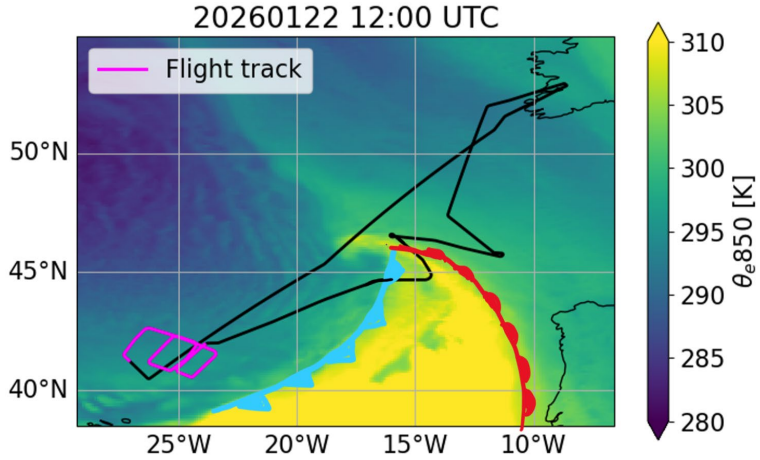


Model is too dry

Model is too moist

IOP “Galway” on 22nd January 2026





Model is too dry

Model is too moist

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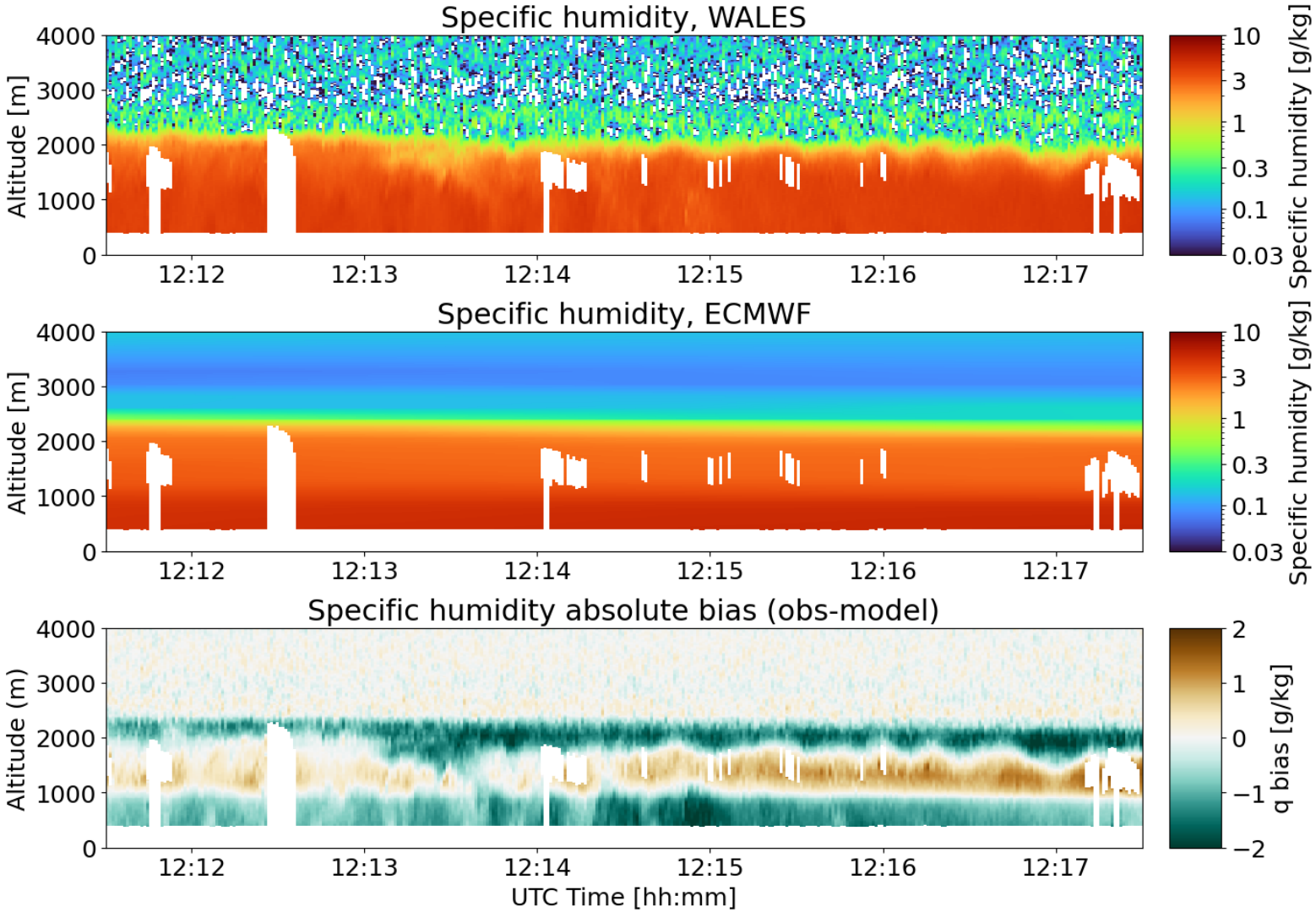

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Model is too moist

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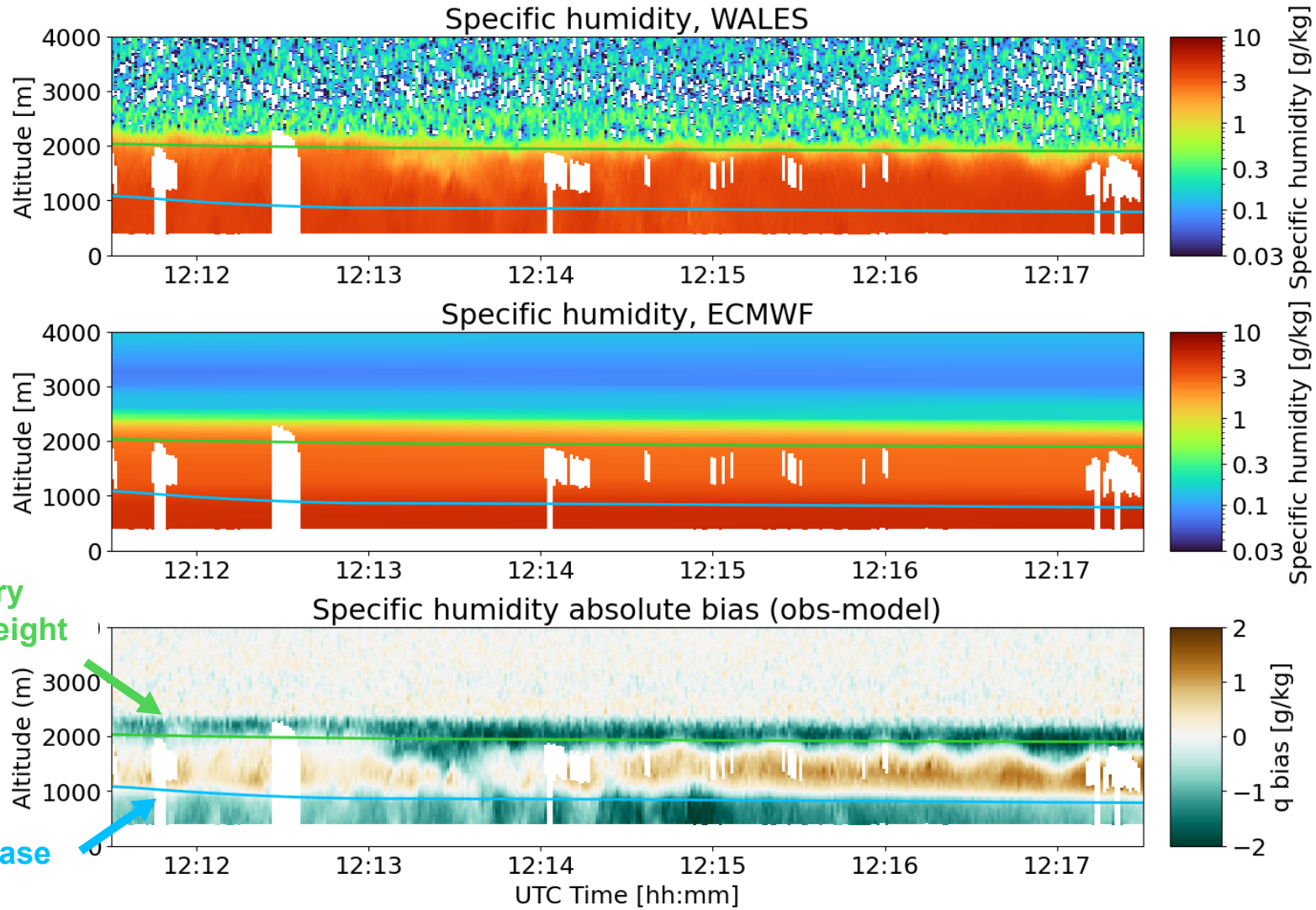


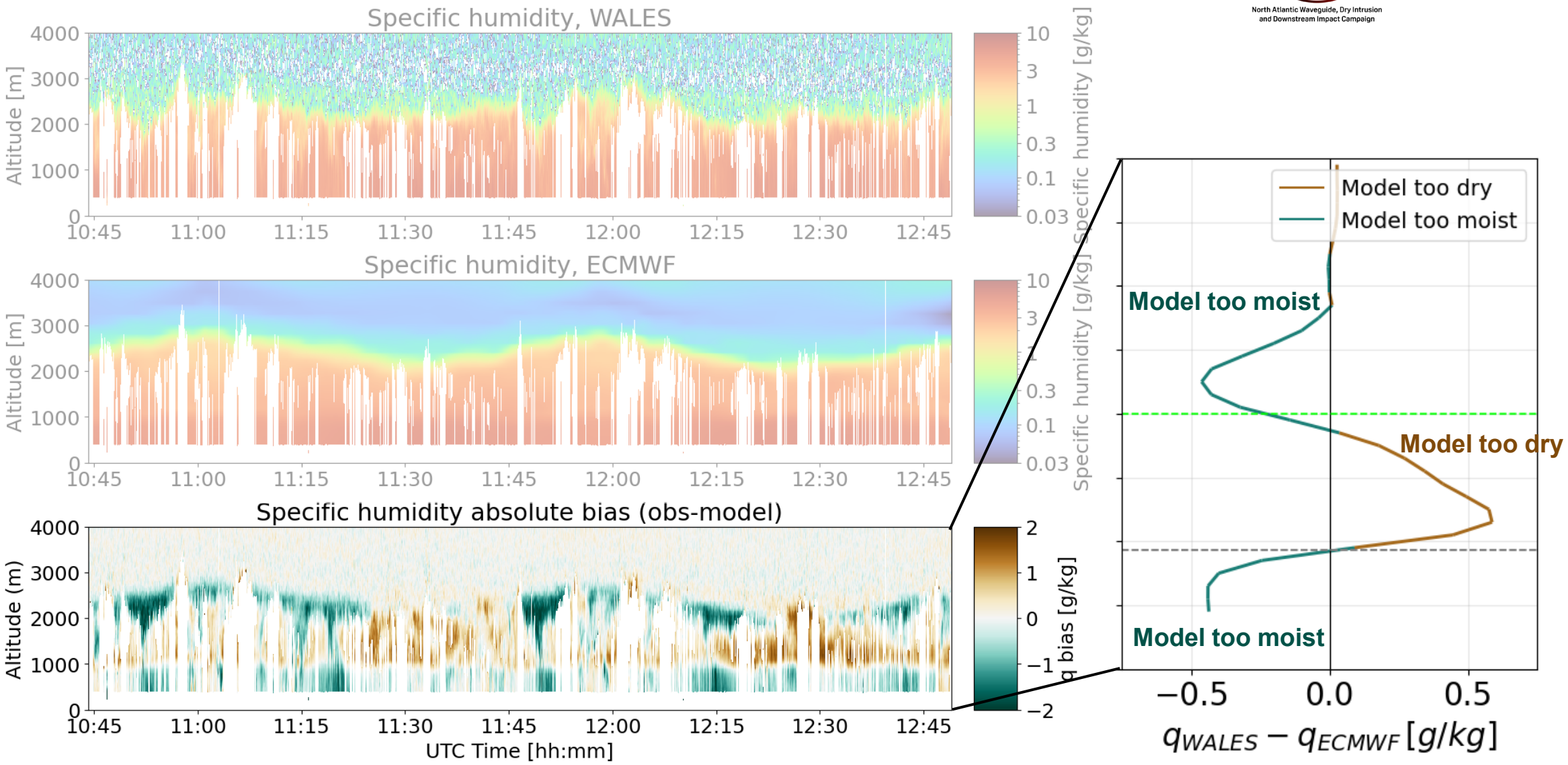
Boundary Layer Height

Cloud Base Height

Model is too dry

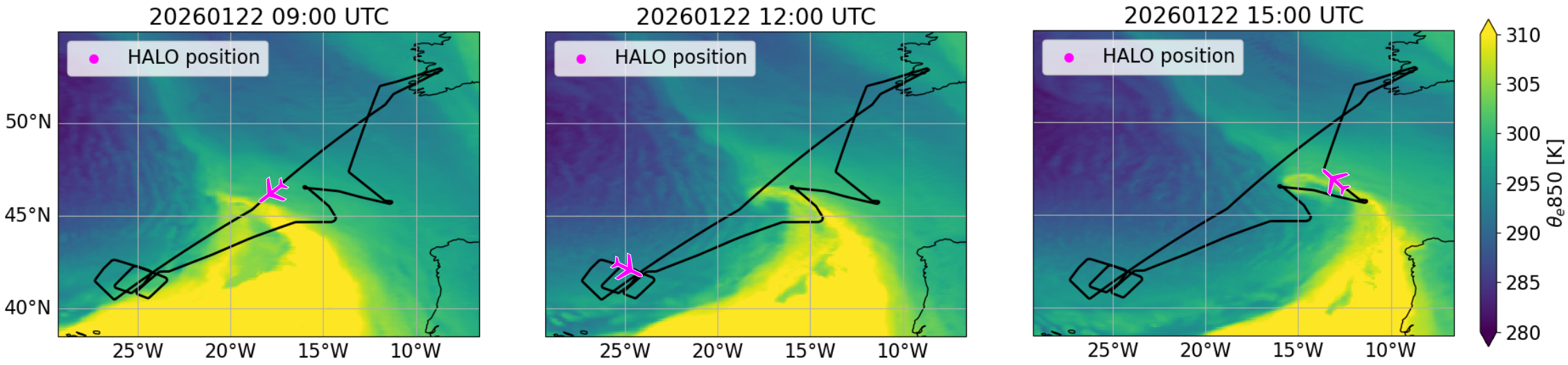
Model is too moist

IOP “Galway” on 22nd January 2026



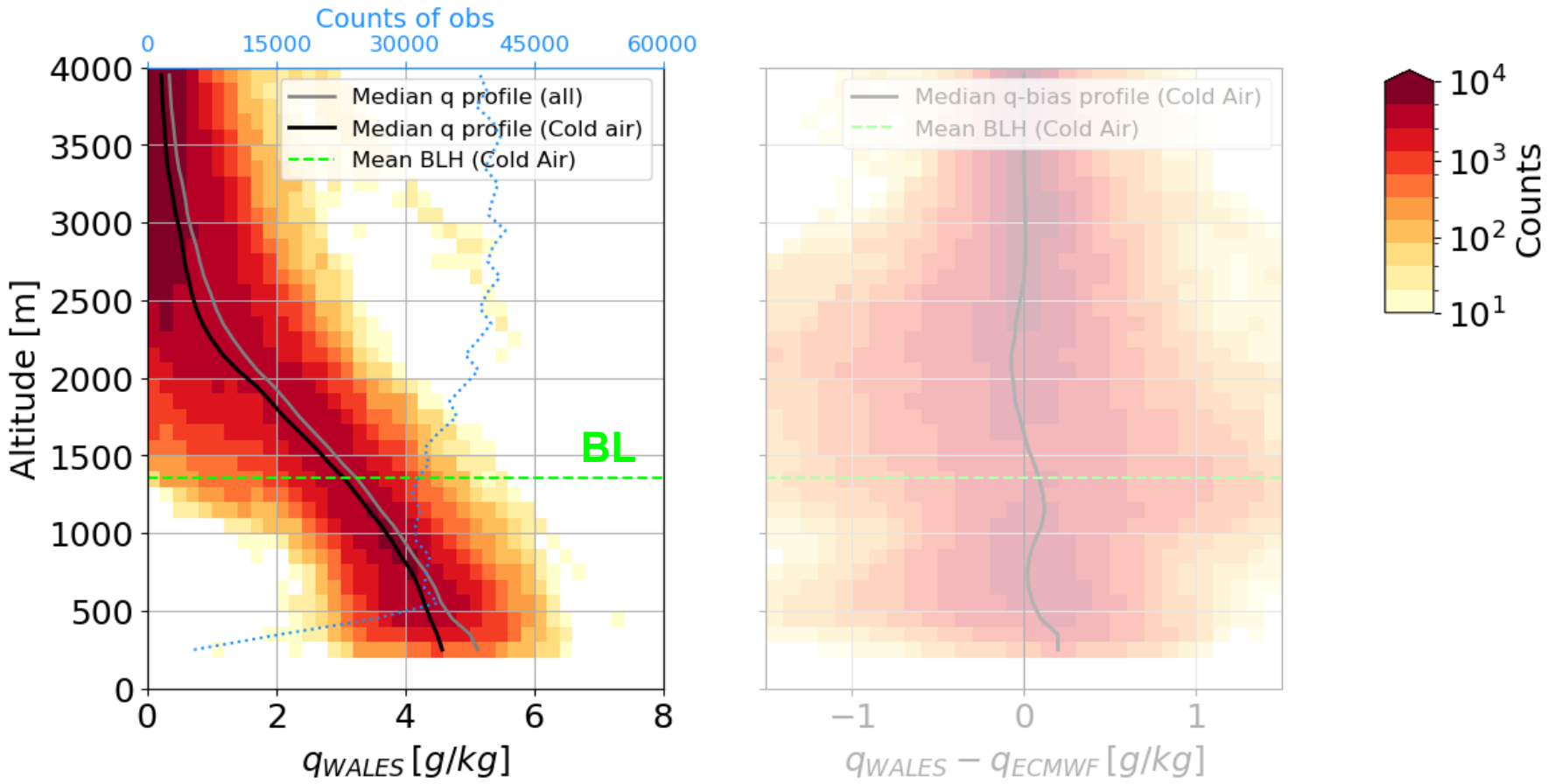
Identification of “Cold Air Regions”

Cold Air Region = Characterization based on θ_e at 850 and 925 hPa + Ocean mask + CAO index* > 0

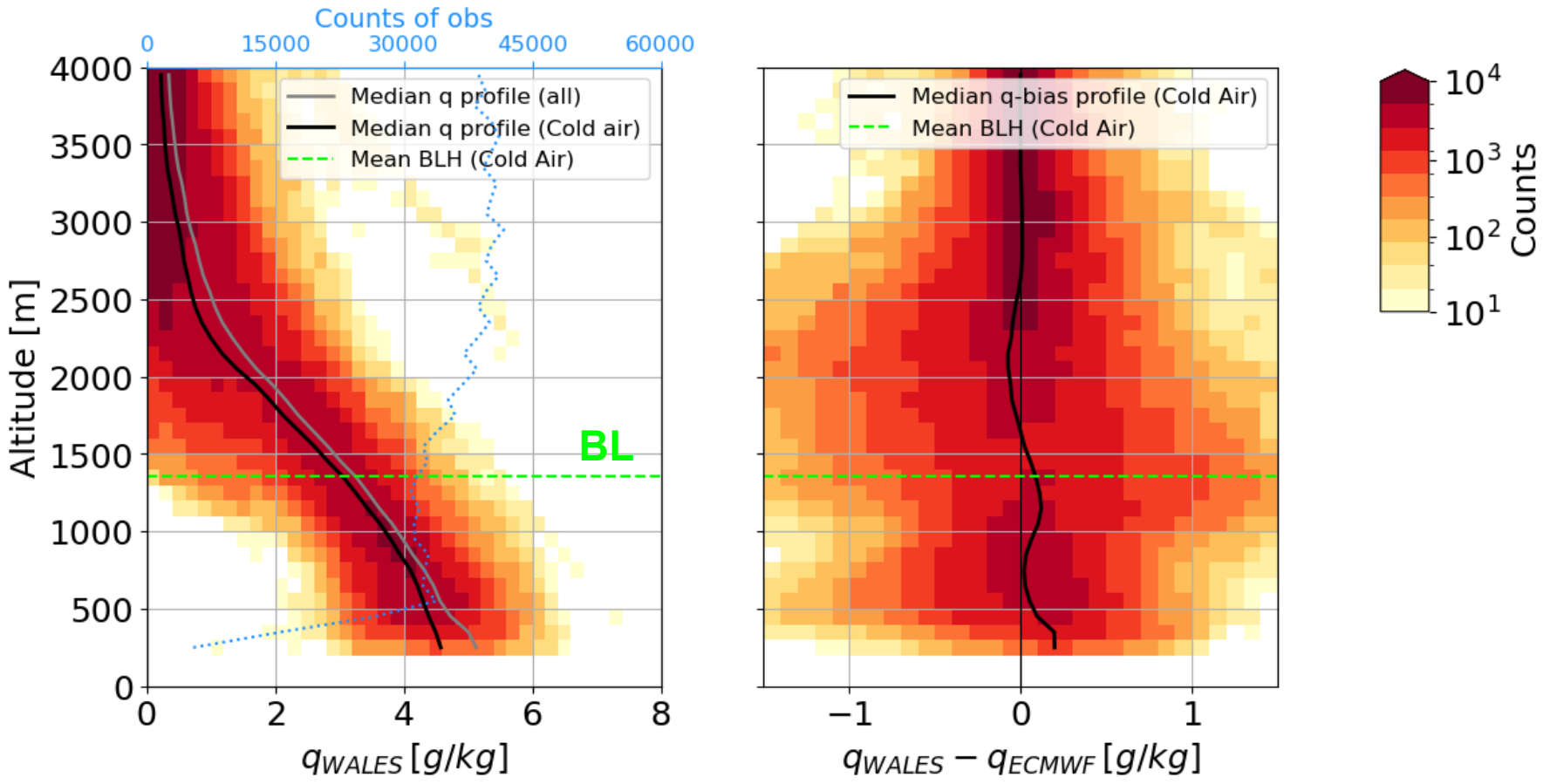


*CAO index = SST – $\theta_{e,925\ hPa}$

Moisture Distribution in Cold Air Regions



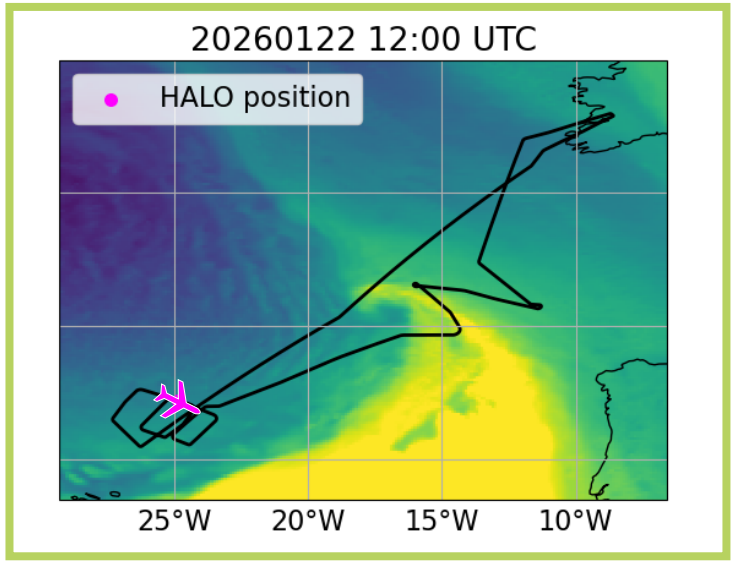
Moisture Distribution in Cold Air Regions

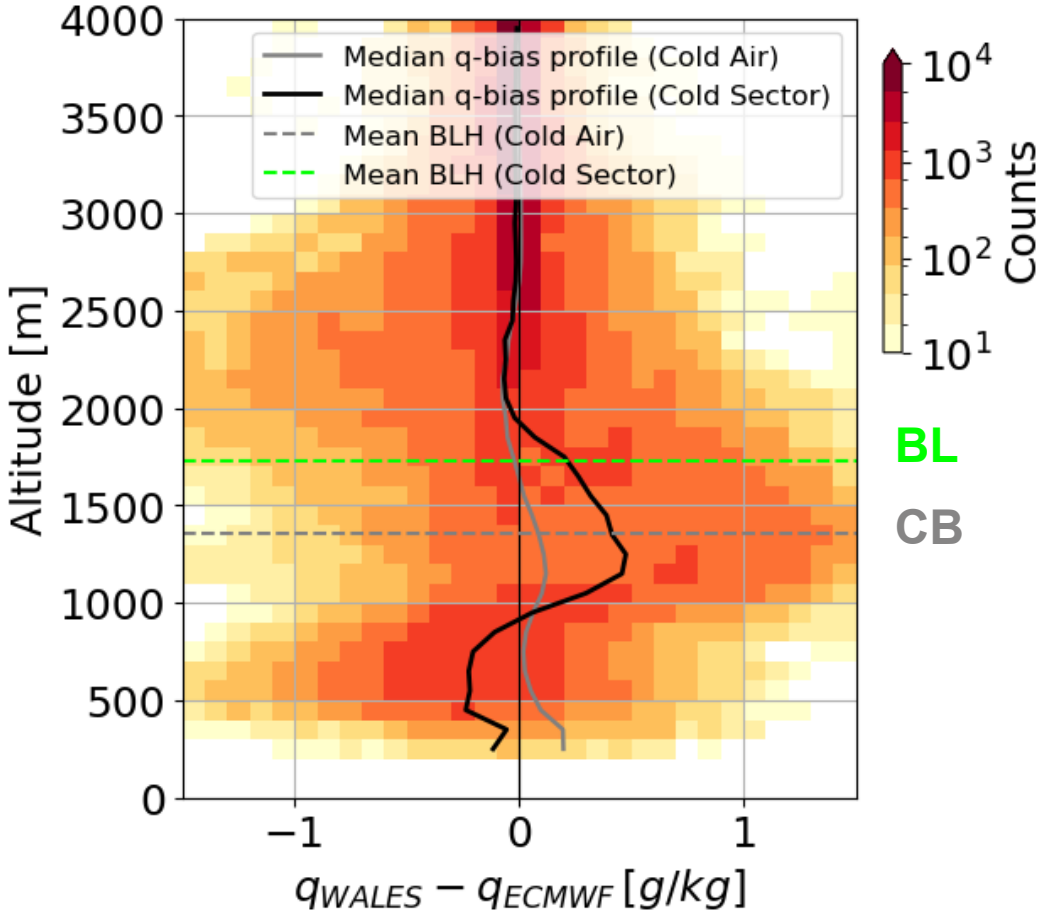


➔ Bias Structure indicated, but <u>high variability</u>

Work in progress: “Cold sectors near front”

Cold Air Region ✚ **Near Cold Front**

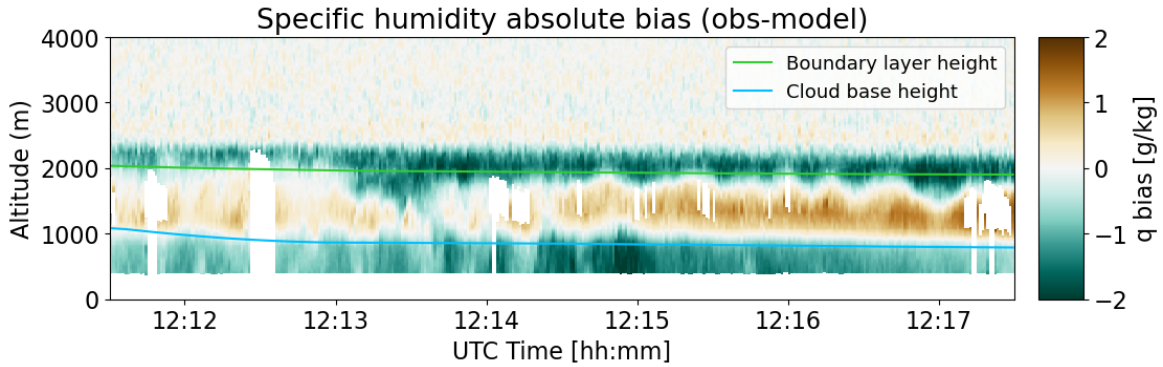




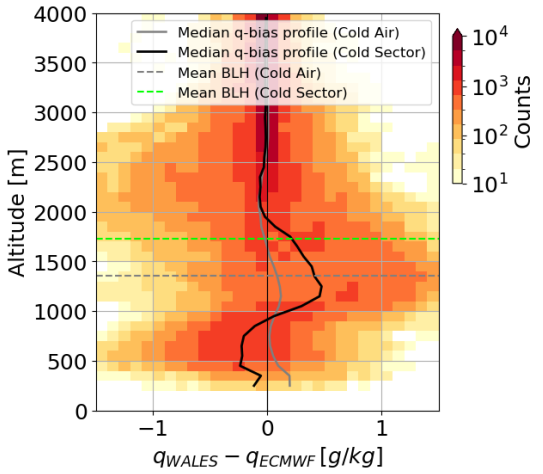
➔ Does the bias occur mainly in cold sectors near cold fronts?

Summary

- NAWDIC-FLUX: **surface latent heat fluxes** in cold sectors
- Cold Sector Cases during NAWDIC show distinct **bias structure**
  - Moist bias in lowest layer up to Cloud Base
  - Strong Dry bias in cloud layer between Cloud Base and Model Boundary layer
  - Moist bias above Boundary layer



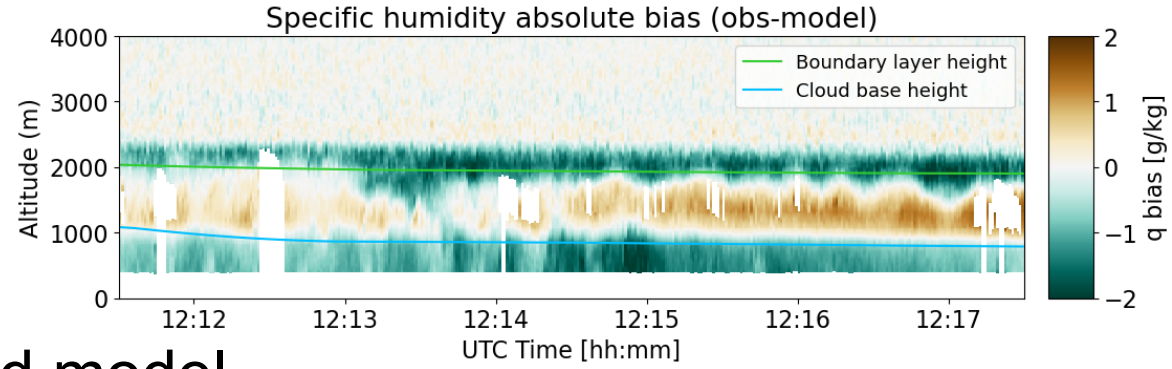
- Categorization in **Cold air regions** show dry bias layer but high variability
- **Cold sectors near front** shows 2-layer bias structure in BL



Outlook

Identify possible causes for bias structure:

- Stability analysis ➔ Dropsondes, ARO
- Air mass history ➔ Trajectories
- Role of DI outflow
- Boundary layer height in observations and model
- Role of surface latent heat fluxes



- Compare to ERA5 and high resolution simulations