

# Atmospheric River Dropsonde Observations During the NAWDIC Campaign

How well are Atmospheric Rivers represented in the IFS and ICON model?

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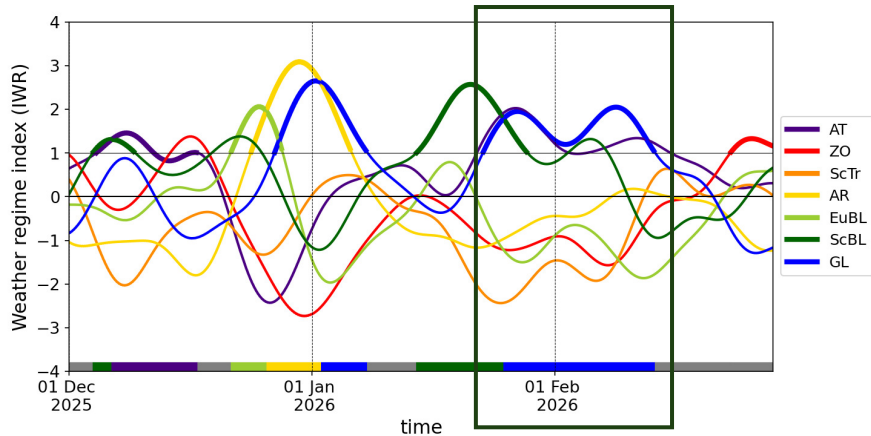


North Atlantic Waveguide, Dry Intrusion  
and Downstream Impact Campaign

# Motivation

- Atmospheric Rivers (ARs) cause precipitation over Western Europe – high impacts
- Good forecasts are important - still contain errors (e.g. Ramos et al. 2020)
- To improve AR forecasts:
  - evaluate representation in operational NWP models
  - Compare to observations
- Key aspect: observational campaigns
  - NAWDEX campaign 2016 – no systematic AR reconnaissance
- New assessment – NAWDIC campaign Jan/Feb 2026

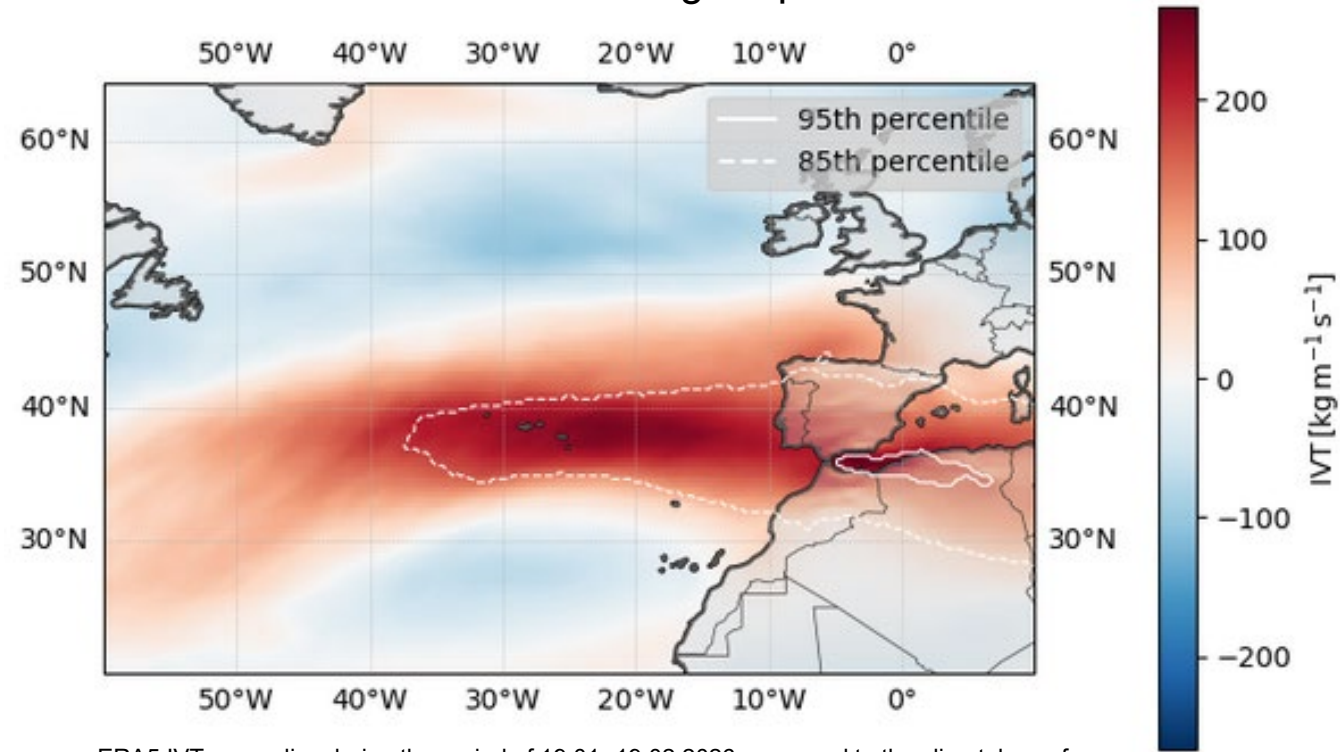
# January/February 2026



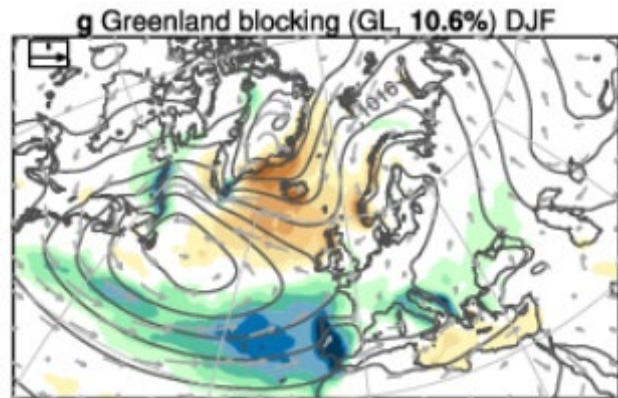
Weather regime index during the winter 2025/2026. Figure provided by Christian Grams.

## IVT Anomalies during 19.01.-19.02.2026

- Southerly flow
- ARs made landfall over Portugal/Spain



ERA5 IVT anomalies during the period of 19.01.-19.02.2026 compared to the climatology of DJF months from 1984-2024.



Precipitation anomalies during greenland blocking events in DJF.

Figure taken from Grams 2026 (Preprint).

# January/February 2026

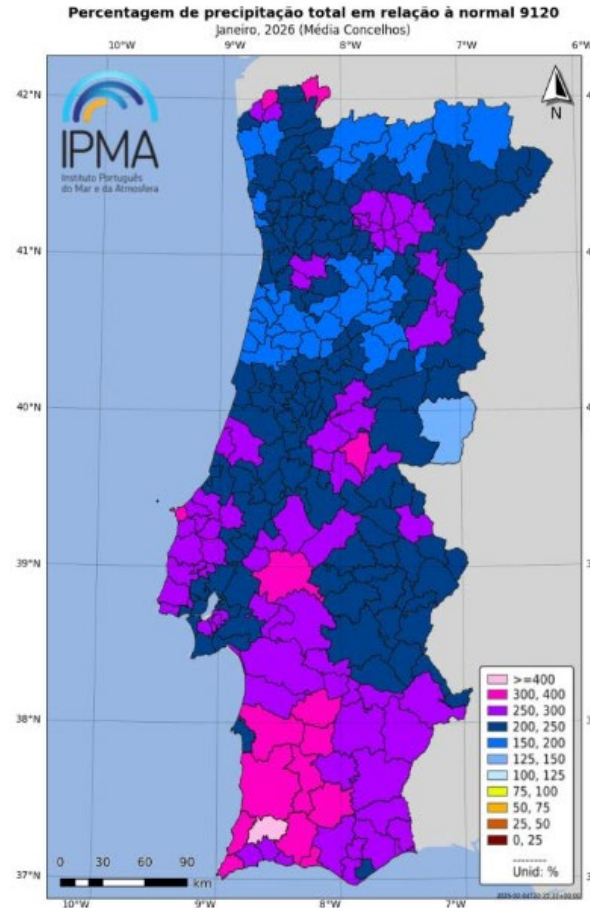
Series of intense ARs made landfall over Portugal, Spain and Marocco

- Intense floodings during late January/February 2026

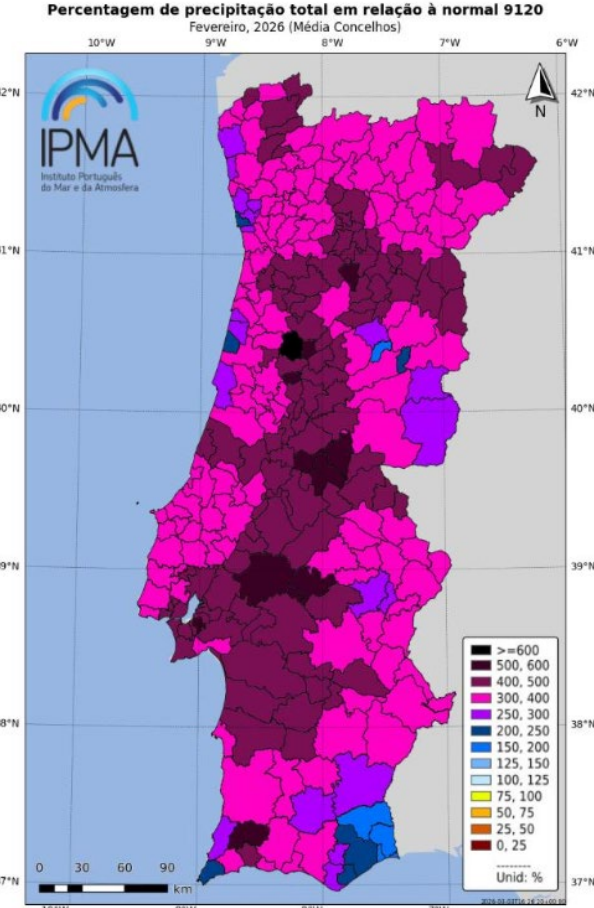


Photograph: Miguel A Lopes/EPA, A flooded area after a dike burst Sao Joao do Campo, Coimbra, Portugal, The Guardian (2026)

January 2026



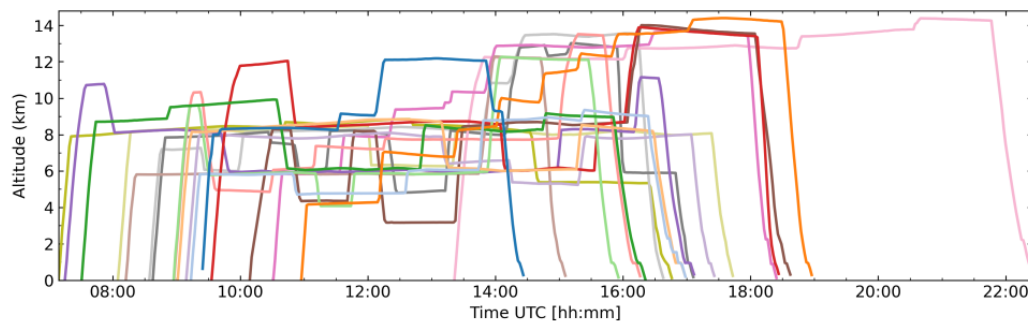
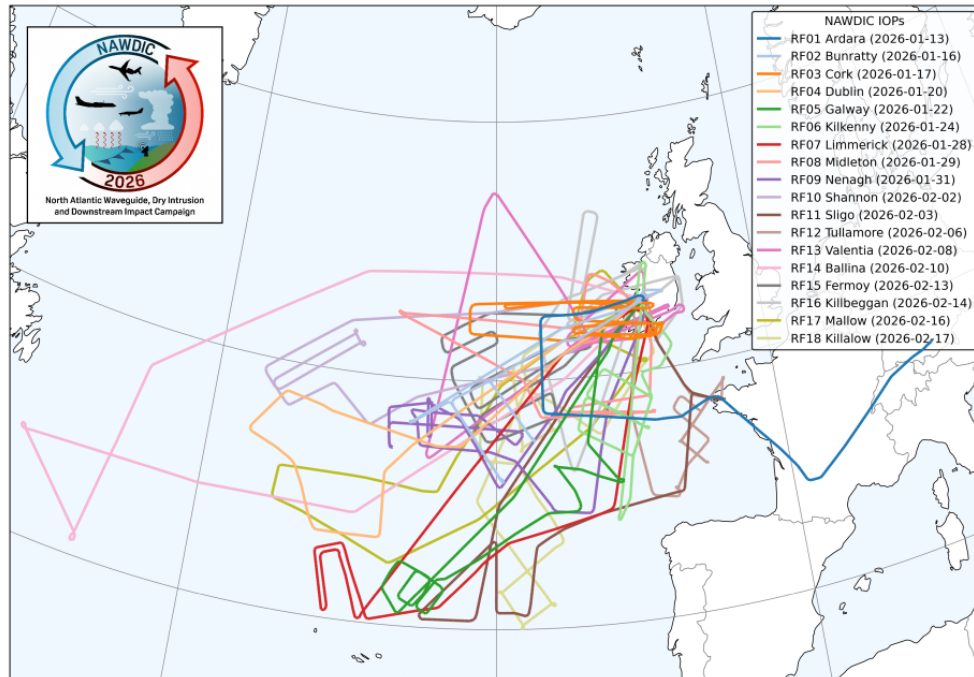
February 2026



Percentage of total precipitation with respect to climatology. Left panel: January 2026, Ref: IPMA Boletim Climatológico Janeiro (2026). Right panel: February 2026, Ref: IPMA Boletim Climatológico Fevereiro (2026).

# NAWDIC Campaign

”North Atlantic Waveguide, Dry Intrusion, and Downstream Impact Campaign”



Overview over all HALO research flights during the NAWDIC campaign. Figure provided by Andreas Schäfer.

## Target:

North Atlantic extratropical cyclones

- 13.01. – 20.02.2026
- detailed observations to improve understanding and modelling

## Specific Aim:

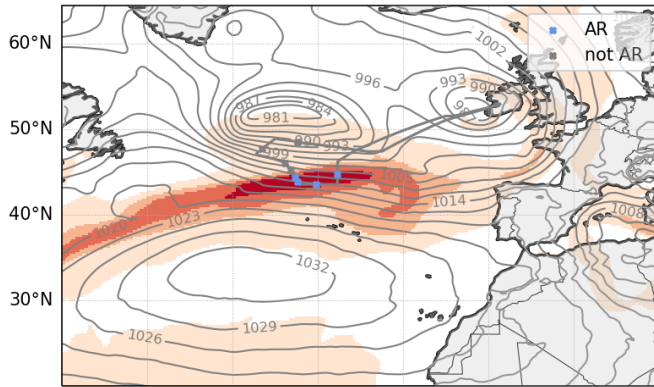
Improving Atmospheric River forecasts with enhanced observations in moisture source regions and regions of moisture transport

- 6 Intensive Observation Periods (IOPs) sampled ARs with **dropsondes**
- Dropsondes were sent to GTS/WIS 2.0 and were assimilated in
  - IFS model (ECMWF)
  - ICON model (German Weather Service)

# NAWDIC IOPs targeting ARs

IOP 4 (IVT valid 2026-01-20 12:00 UTC)

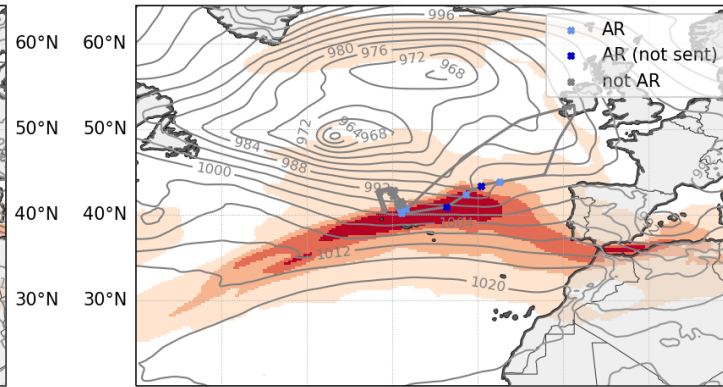
50°W 40°W 30°W 20°W 10°W 0°



50°W 40°W 30°W 20°W 10°W 0°

IOP 7 (IVT valid 2026-01-28 14:00 UTC)

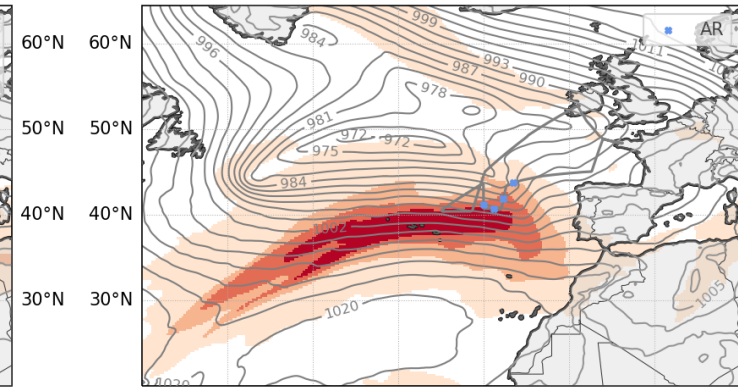
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IOP 11 (IVT valid 2026-02-03 14:00 UTC)

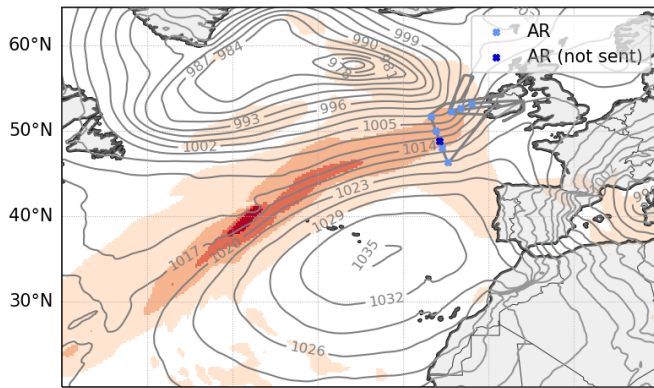
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50°W 40°W 30°W 20°W 10°W 0°

IOP 16 (IVT valid 2026-02-14 12:00 UTC)

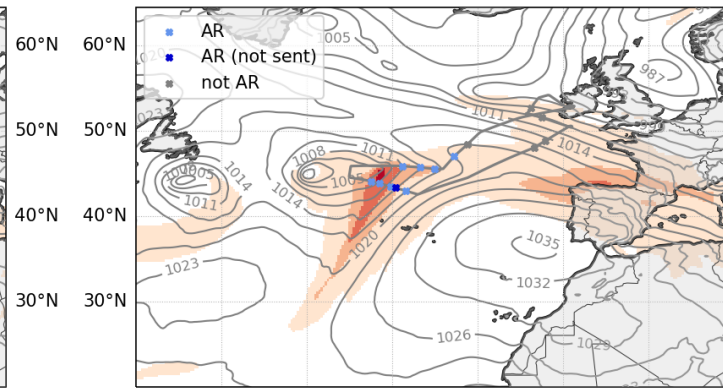
50°W 40°W 30°W 20°W 10°W 0°



50°W 40°W 30°W 20°W 10°W 0°

IOP 17 (IVT valid 2026-02-16 11:00 UTC)

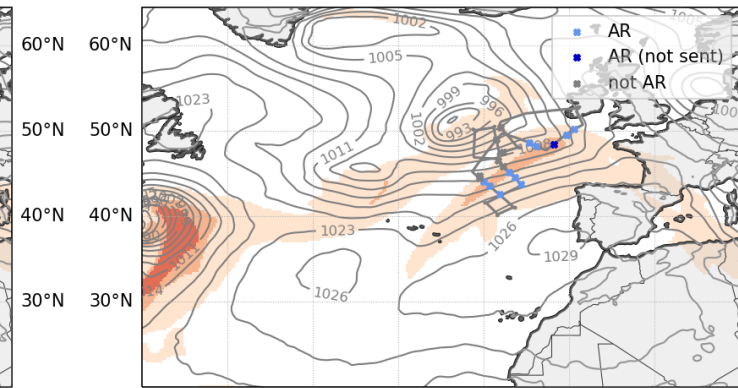
50°W 40°W 30°W 20°W 10°W 0°



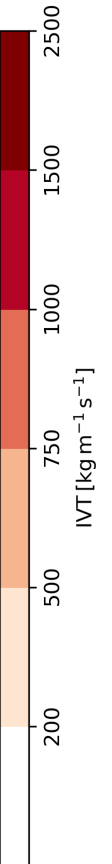
50°W 40°W 30°W 20°W 10°W 0°

IOP 18 (IVT valid 2026-02-17 11:00 UTC)

50°W 40°W 30°W 20°W 10°W 0°



50°W 40°W 30°W 20°W 10°W 0°



**Total AR  
sondes:**  
44

**Sent to GTS:**  
39

**Assimilated  
in IFS:**  
35

**Assimilated  
in ICON:**  
26

# Research Questions

Can the IFS and ICON model represent the vertical structure of selected, impactful AR events over the North Atlantic?

How large was the impact of data assimilation on the model estimates?

# Methods

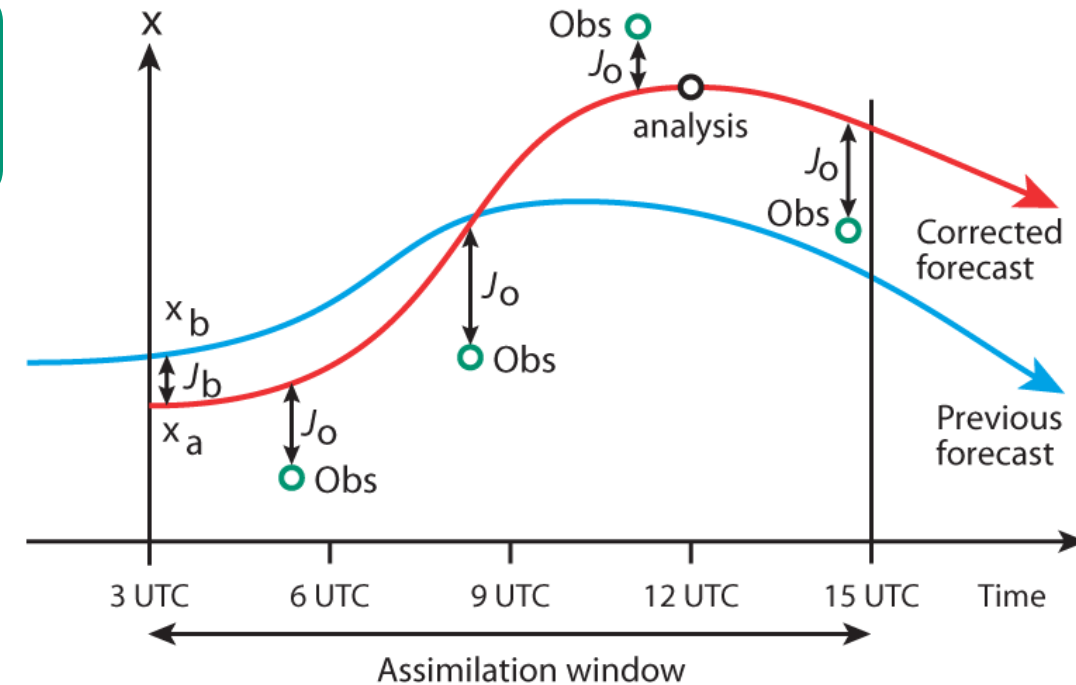
## Retrieve Feedback files from NWP data assimilation cycle

- First Guess (FG) and Analysis (AN) for each dropsonde observation

1. Look at specific profiles

2. Derive statistical departures

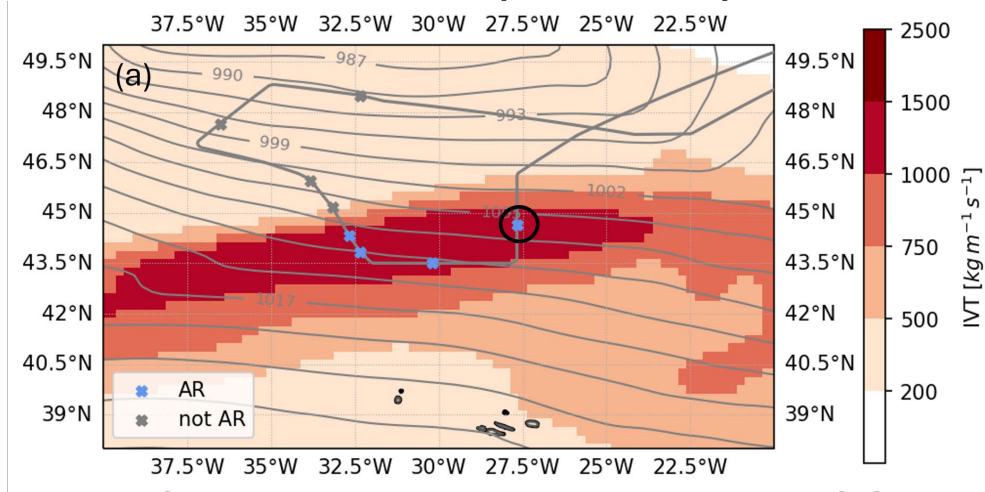
- $Dep\_FG = Observation - FG$
- $Dep\_AN = Observation - AN$



Schematic of 4D-Var data assimilation method (ECMWF 2017).

# Results – Case Study IOP 4

## IOP 4 „Dublin“ (20.1.2026)

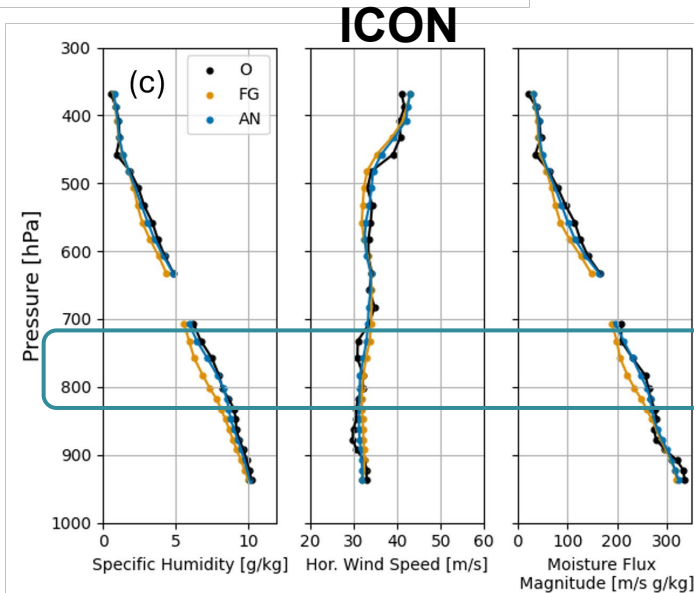
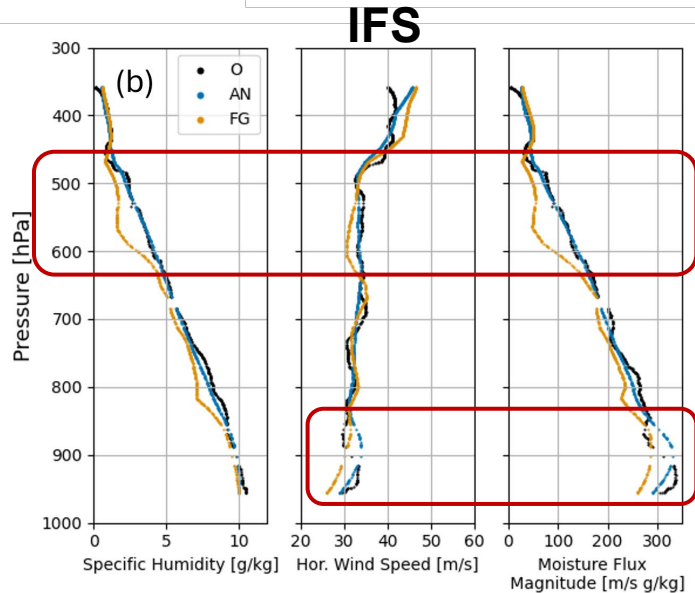


### IFS:

Slight humidity underestimation in upper layers  
Weaker winds in boundary layer

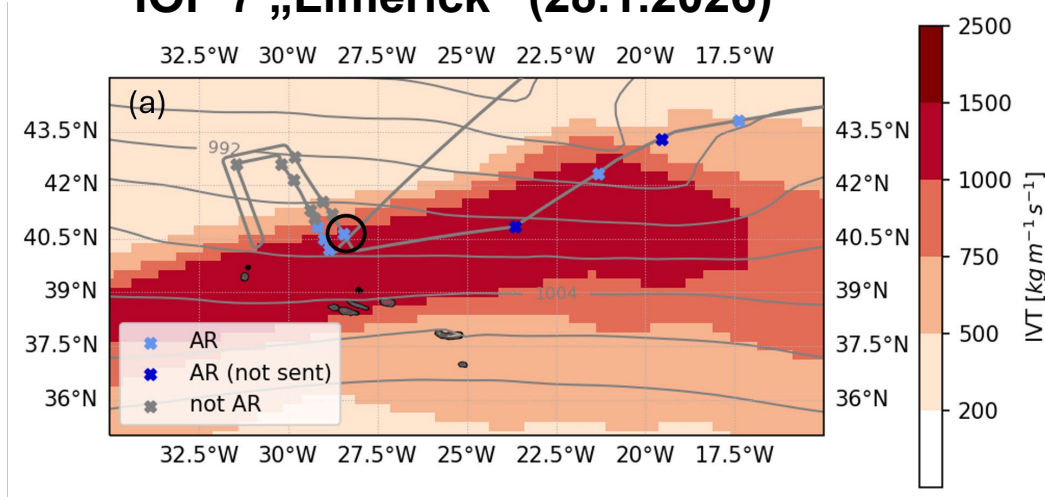
### ICON:

Accurate  
Small humidity underestimation around 800 hPa



# Results – Case Study IOP 7

## IOP 7 „Limerick“ (28.1.2026)

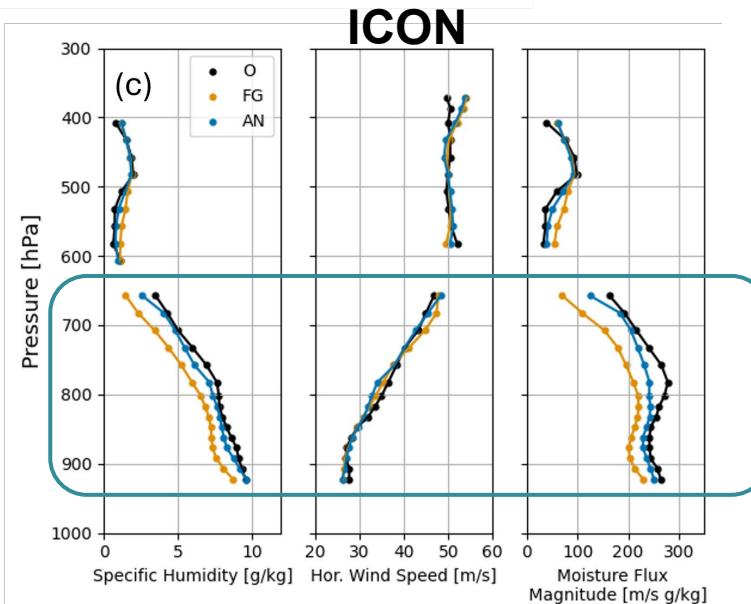
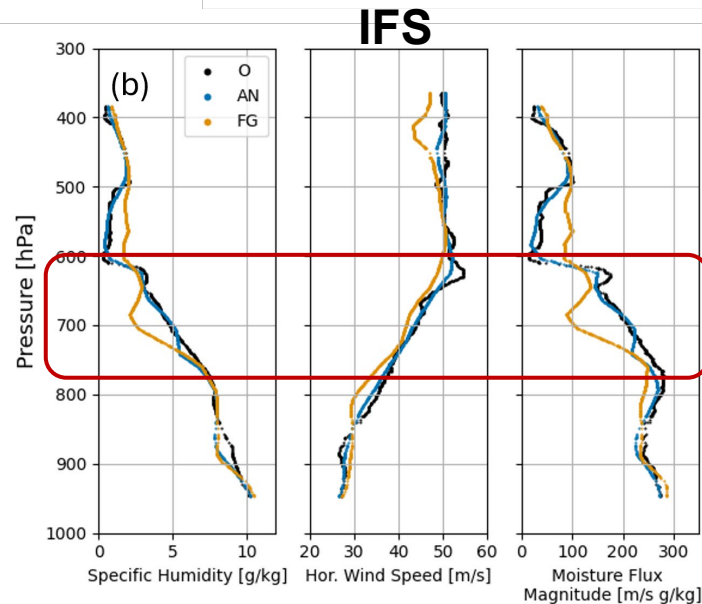


### IFS:

Underestimates AR height and dryness in upper layers

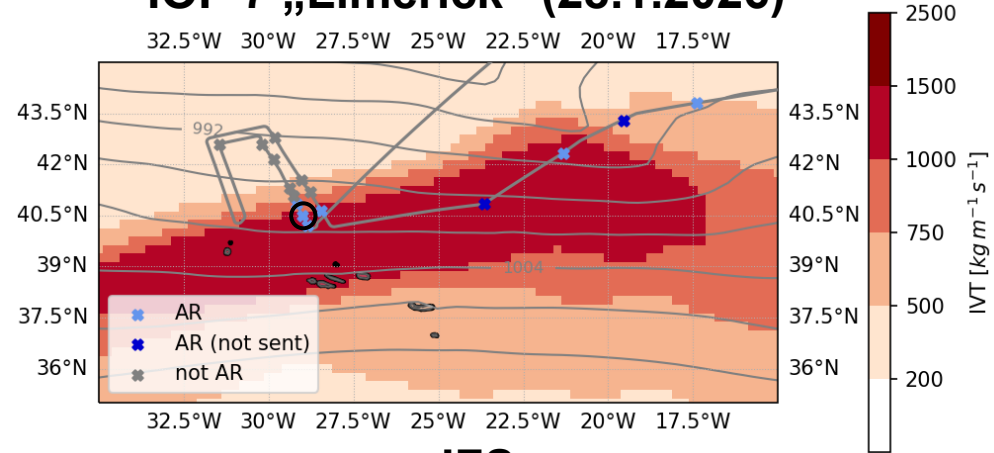
### ICON:

Underestimated humidity over large vertical extend



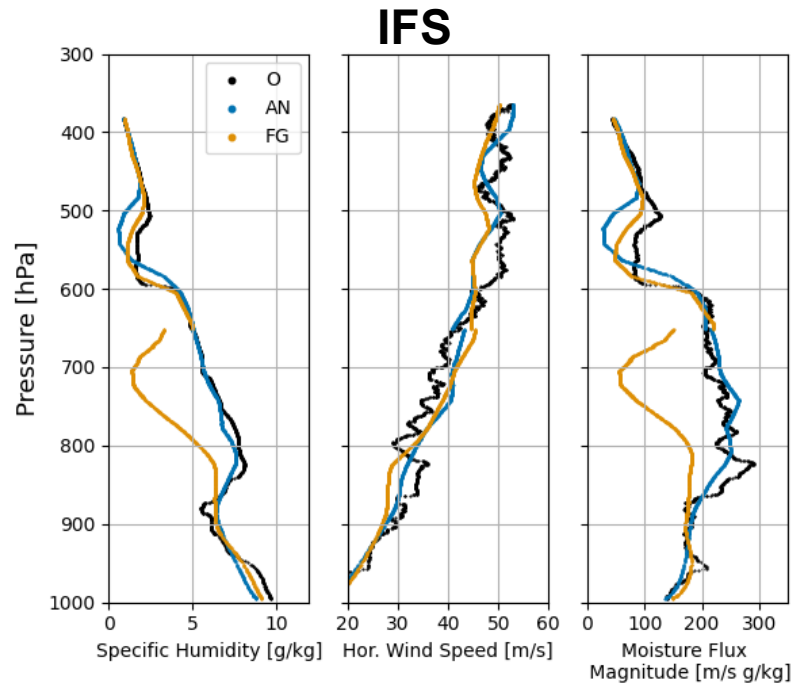
# Results – Case Study IOP 7

## IOP 7 „Limerick“ (28.1.2026)



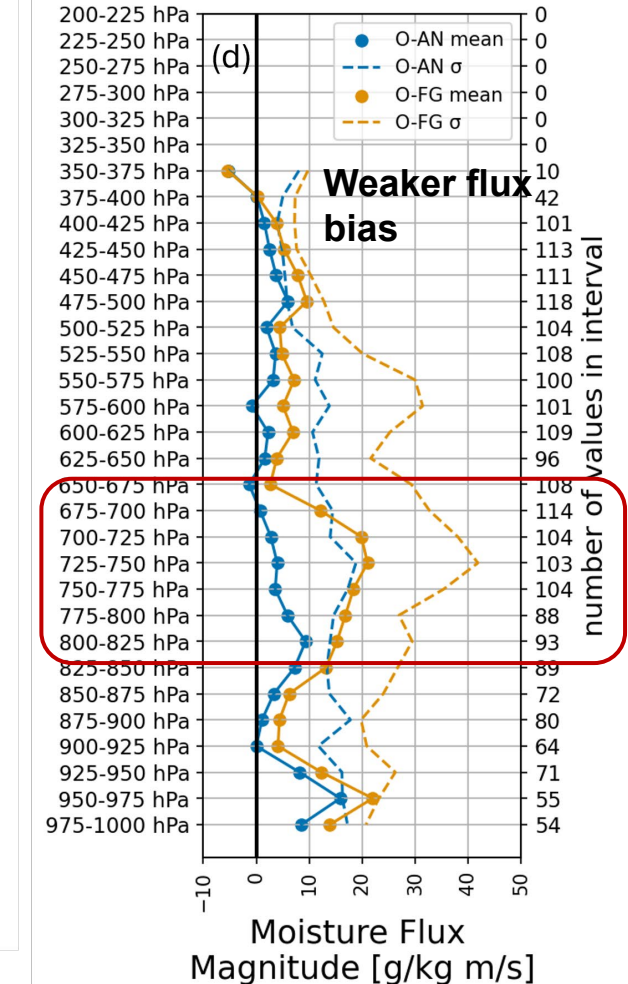
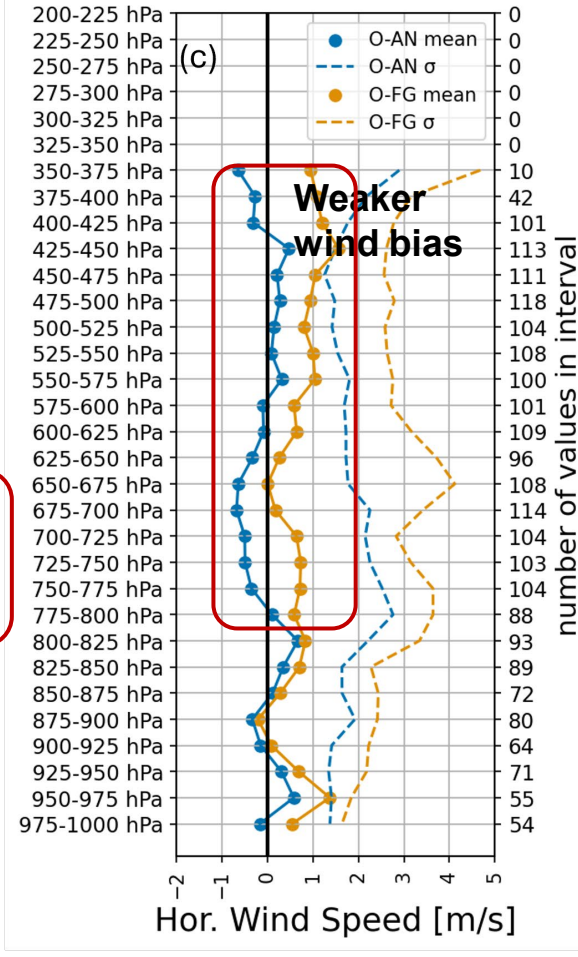
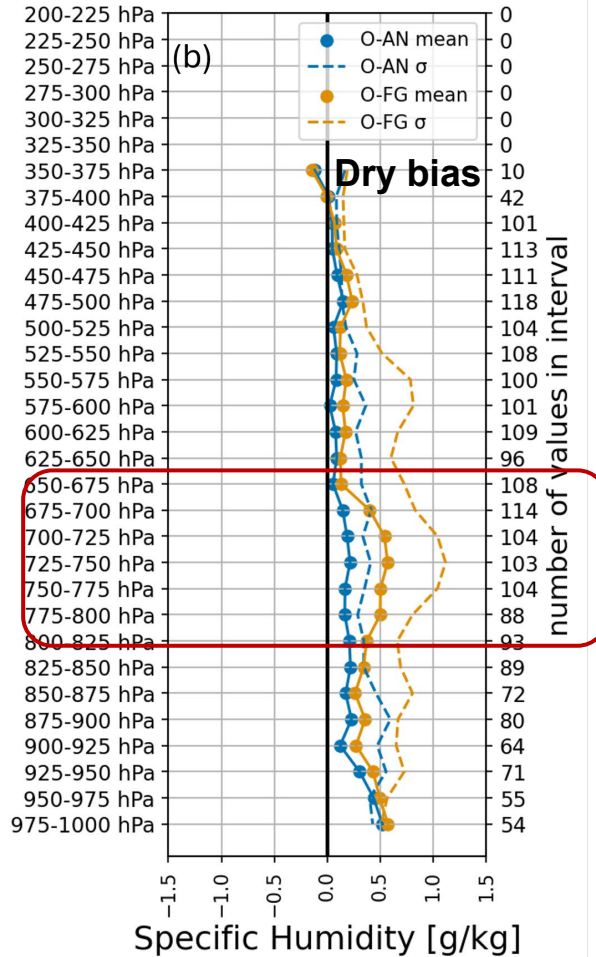
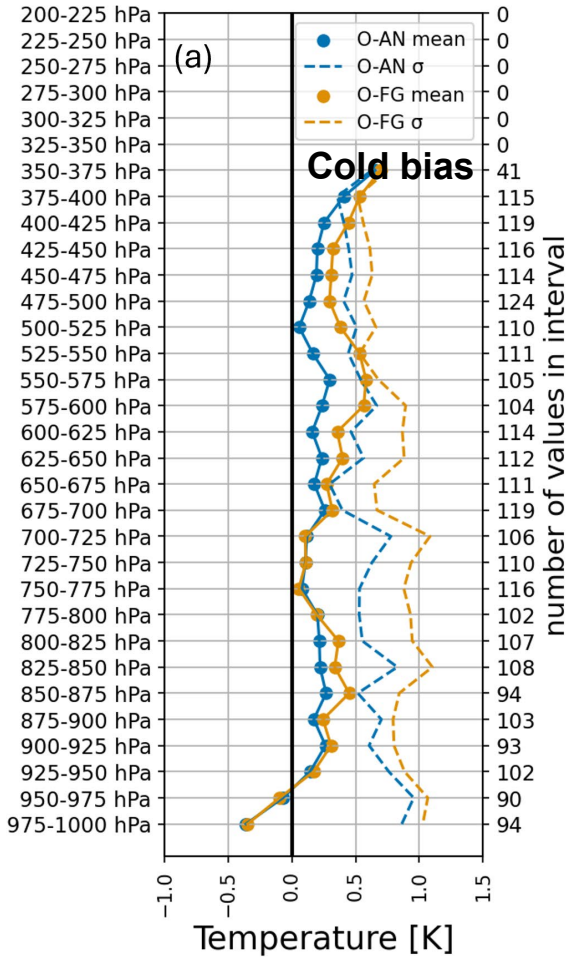
**IFS:**  
FG shows large underestimation of moisture

**ICON** did not assimilate this sonde



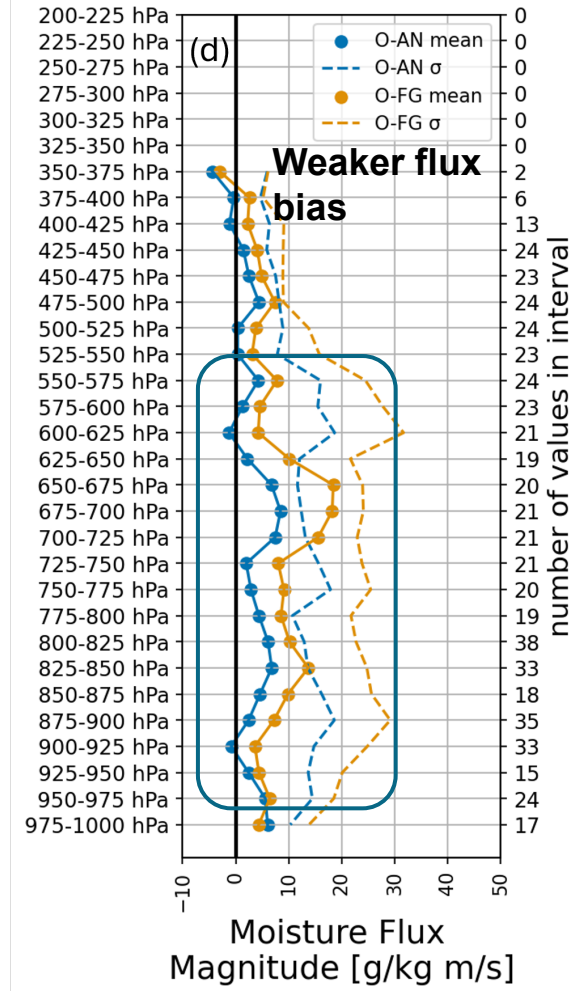
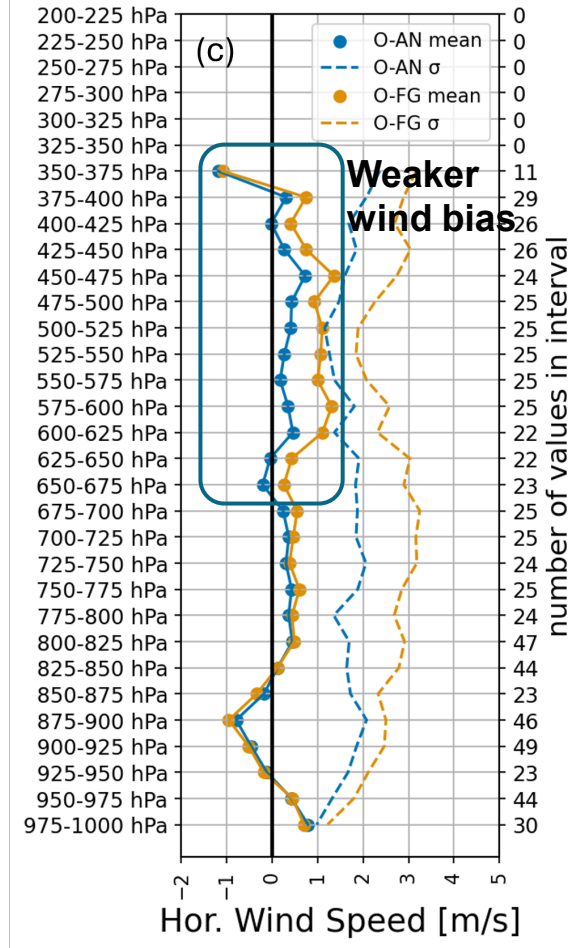
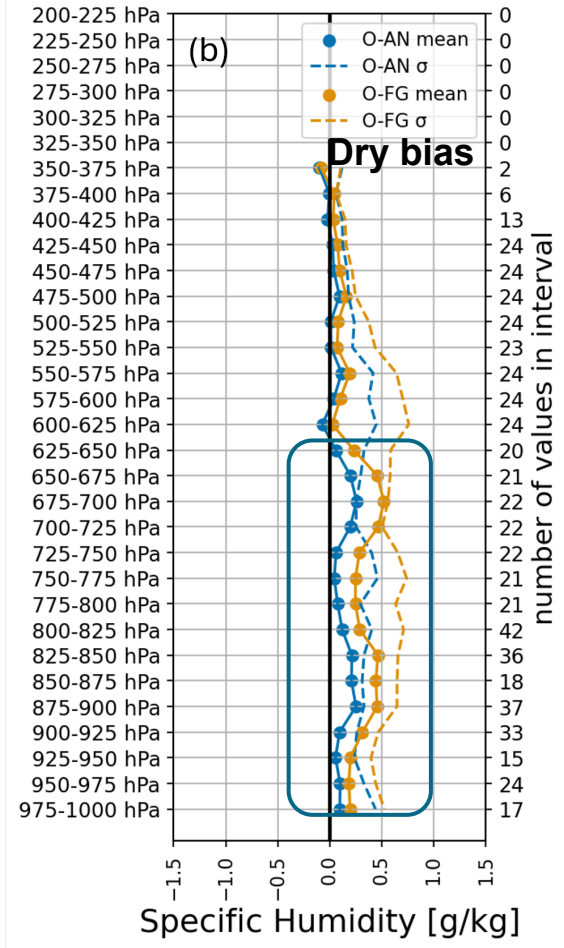
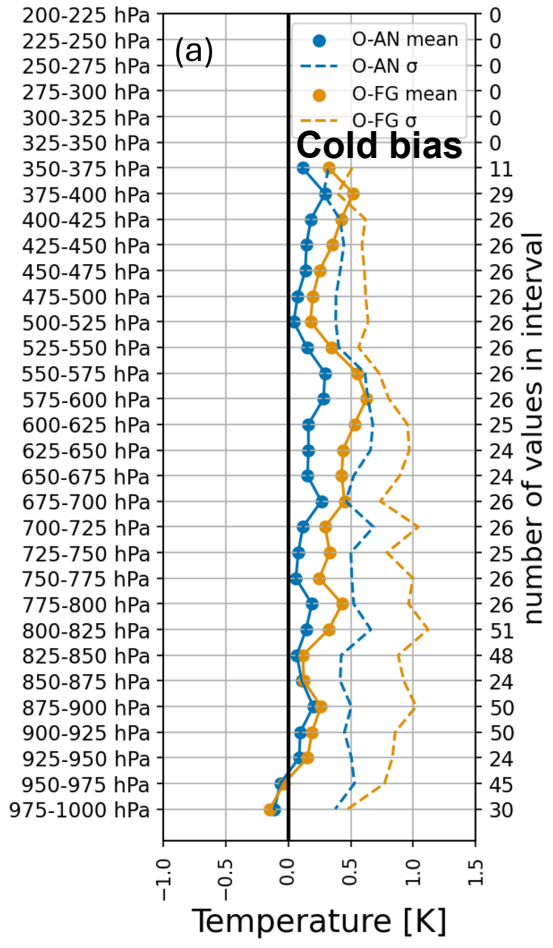
# Results - IFS departures

Statistics over 35 Profiles



# Results - ICON departures

## Statistics over 26 Profiles



# Conclusions

Can the IFS and ICON model represent the vertical structure of selected, impactful AR events over the North Atlantic?



Compared FG and AN to dropsonde observations of selected cases



Overall skillfull representation of AR stucture  
Performance differs between ARs

How large was the impact of data assimilation on the model estimates?



Derived statistical departures



**IFS:**

Small underestimation of humidity between 800-650 hPa

Locally large correction of AN

**ICON:**

Small dry bias over entire vertical extent below 625hPa

Consistent correction of AN

# Next Steps

## Data Denial Experiments

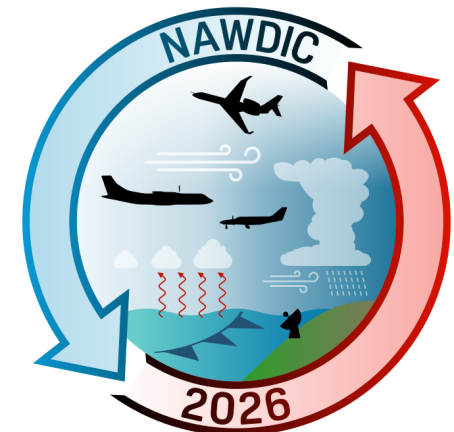
- IFS run
- denied all campaign data (AR Recon, NURTURE, NAWDIC)
- Impact on forecasts of ARs, secondary cyclogenesis, downstream impacts

# Thank you

Magdalena Kracheletz<sup>1</sup>, David Lavers<sup>2</sup>, Joaquim Pinto<sup>1</sup>,  
Alexandre Ramos<sup>1</sup>,

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