Characterization of aircraft icing conditions in Western Europe and the North-East Atlantic. Case studies using aircraft reports, satellite, and synoptic data

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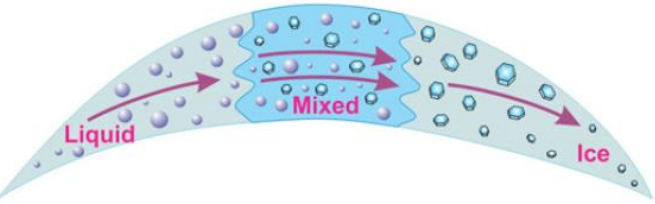
Casqueiro, B. C., Trigo, I., **Belo-Pereira, M.**, 2023: Characterization of Icing Conditions using Aircraft Reports and Satellite Data. *Atmospheric Research*, 293, 106884

Background



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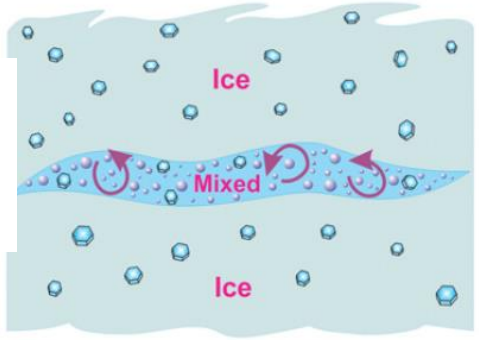

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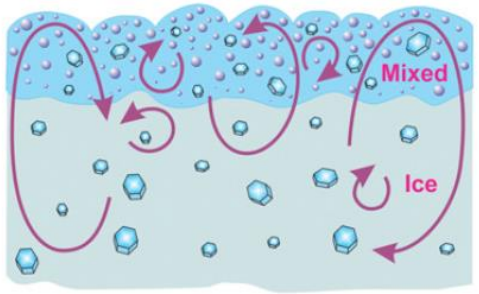
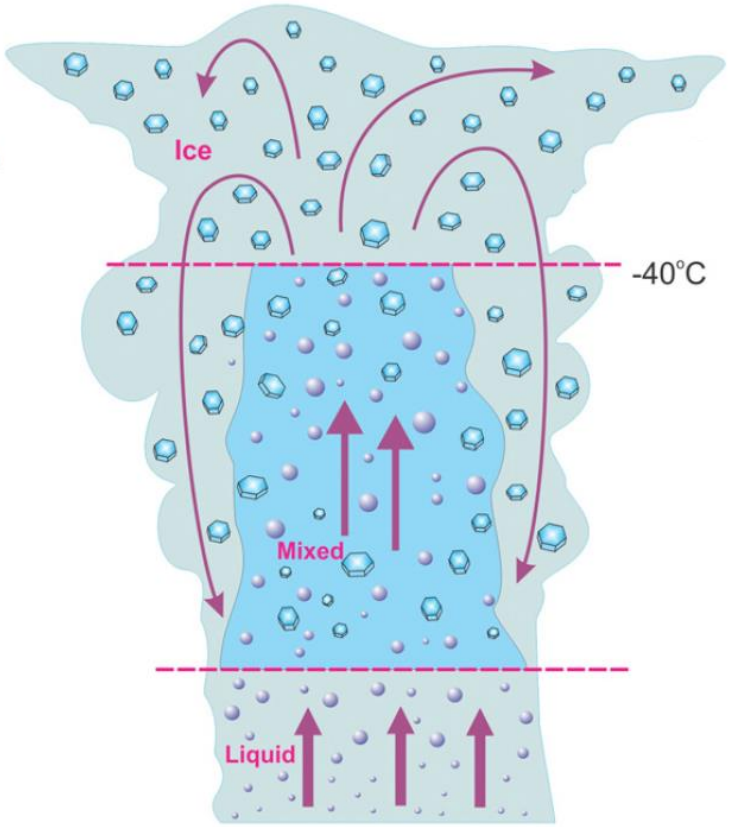
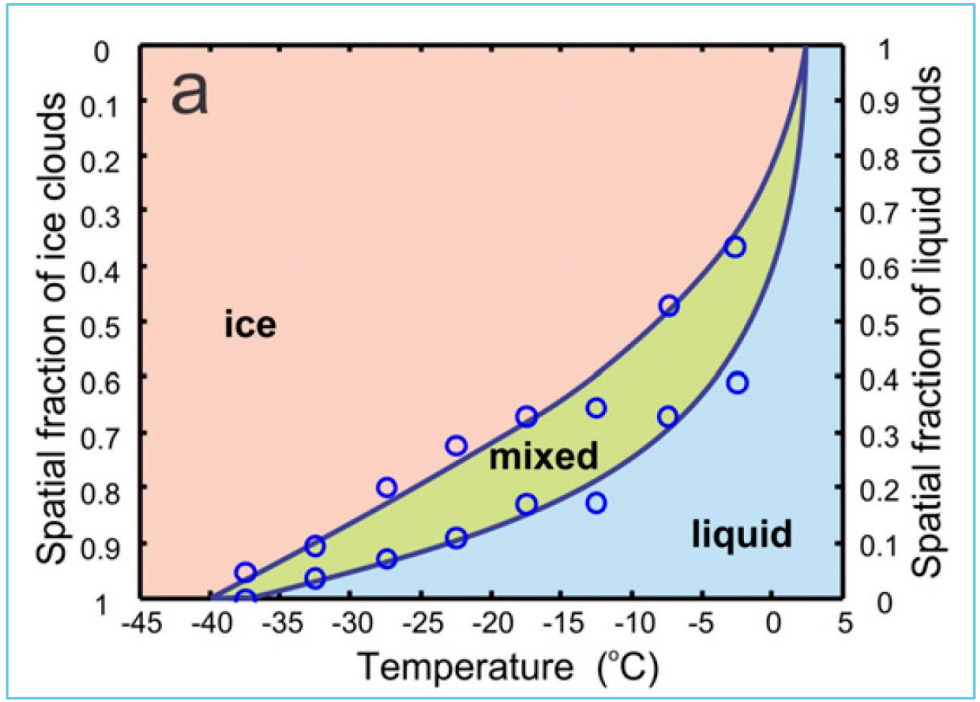




Korolev et al (2017)
DOI: 10.1175/AMSMONOGRAPHS-D-17-0001.1

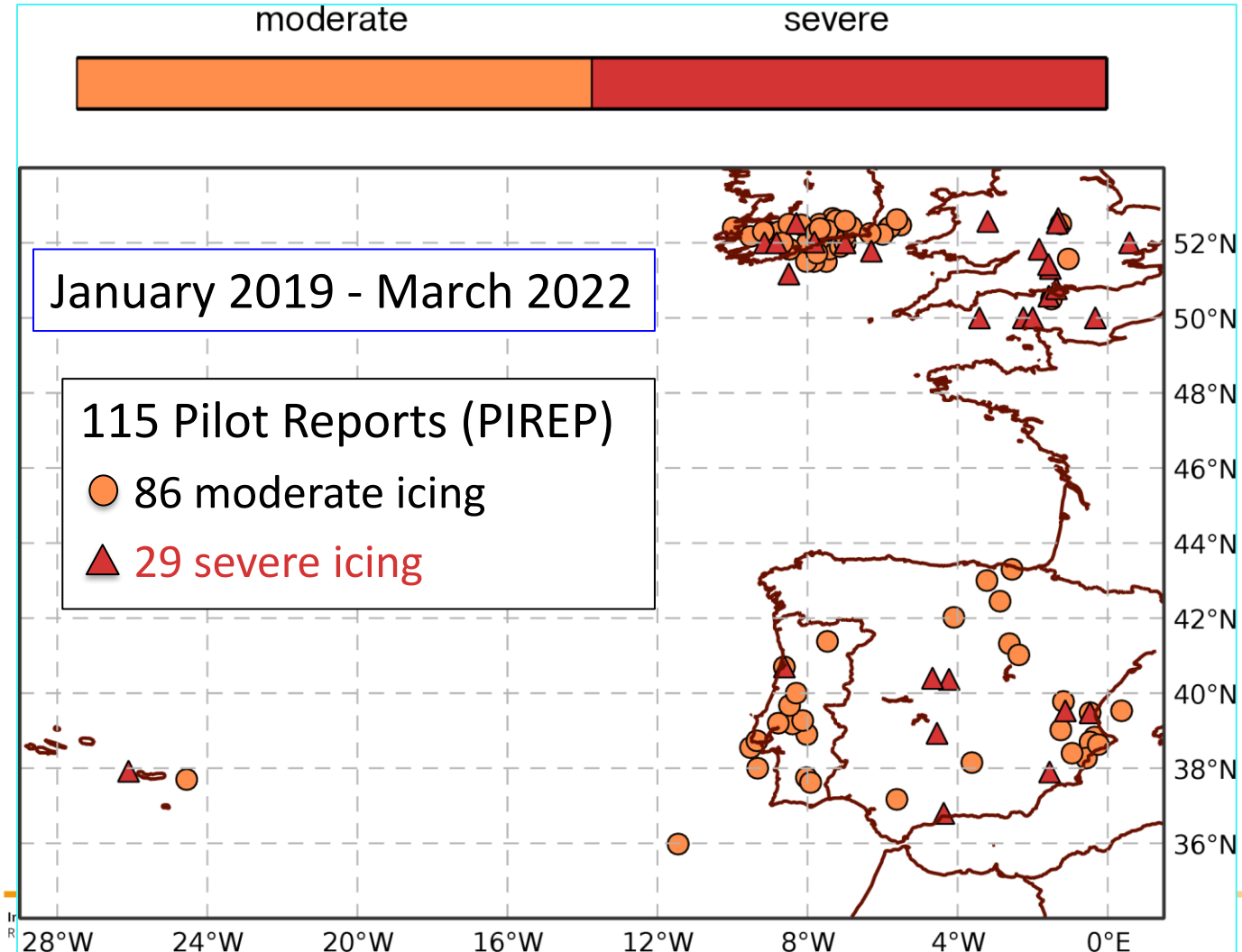
Supercooled liquid water can exist in different types of clouds at temperatures down to ≈ -40/-38°C
(for colder temperatures, homogeneous freezing occurs)

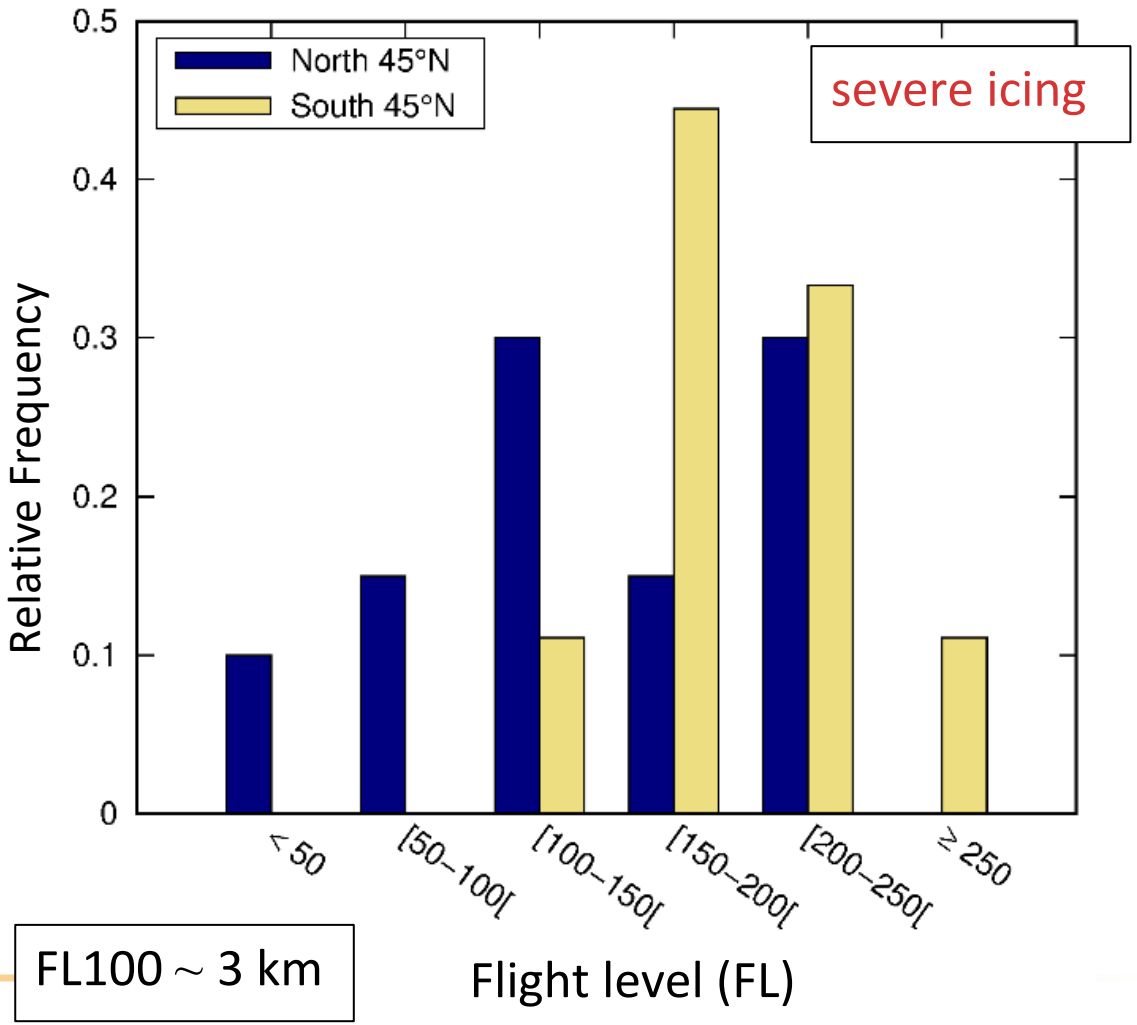


Aircraft icing

- **Aircraft icing** occurs when supercooled cloud droplets and/or precipitation droplets freeze on the exposed surfaces of an aircraft.

Moderate icing conditions are frequently (>80%) reported at mid-troposphere (3–7.6 km).





FL100 ~ 3 km

Data

Satellite data and products

- Brightness Temperature 10.8 µm (BT10.8)
- Cloud Mask
- Cloud-top Phase
- Cloud Type

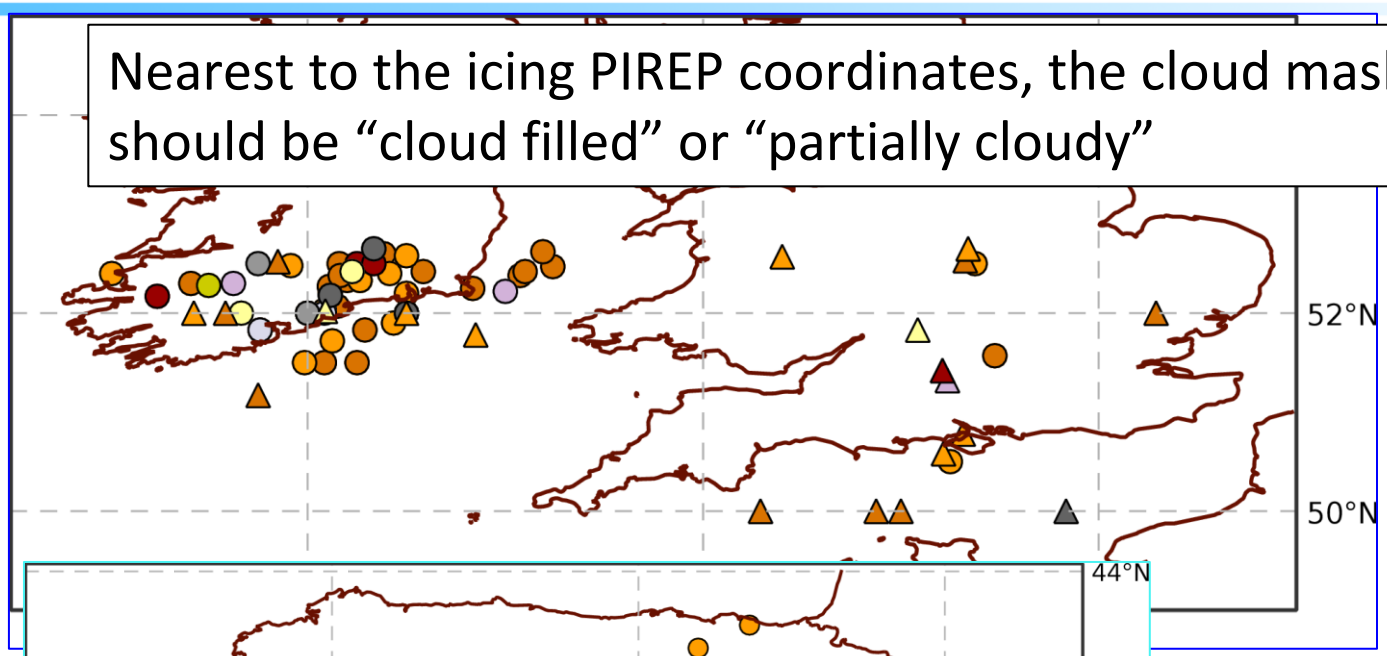
Synoptic observations and radiosonde data

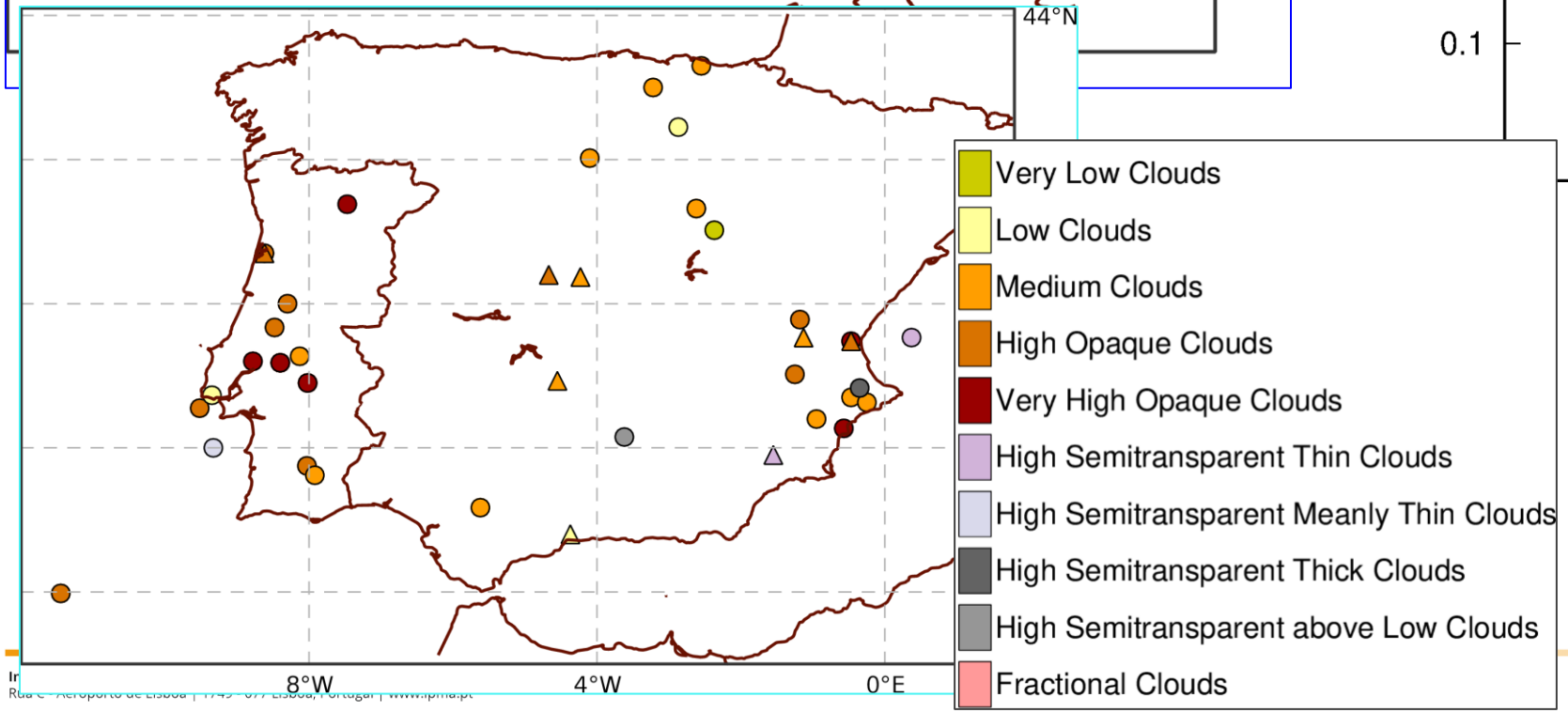
ECMWF deterministic model

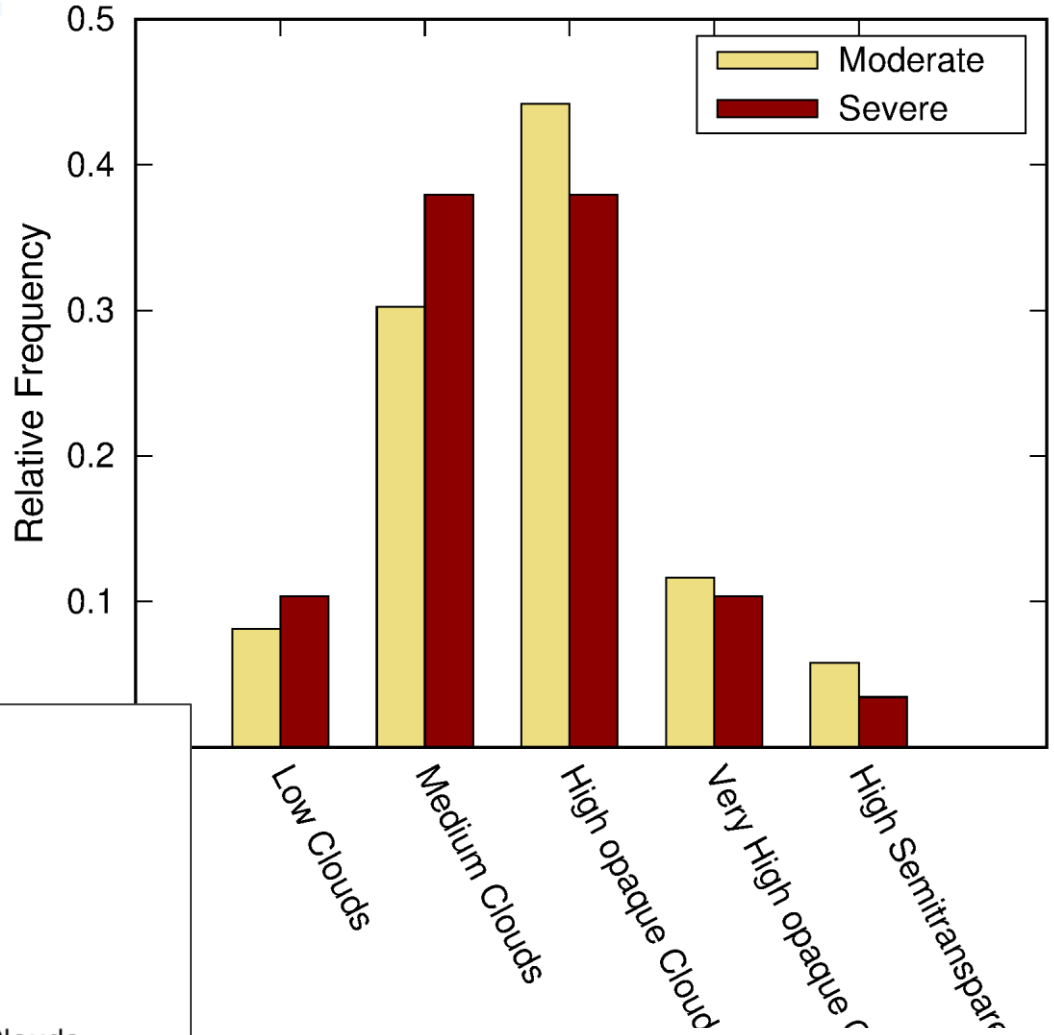
- Temperature (T)
- Relative Humidity (RH)
- Vertical velocity
- Cloud liquid and ice water Content

Cloud type (NWC SAF)

Nearest to the icing PIREP coordinates, the cloud mask should be “cloud filled” or “partially cloudy”





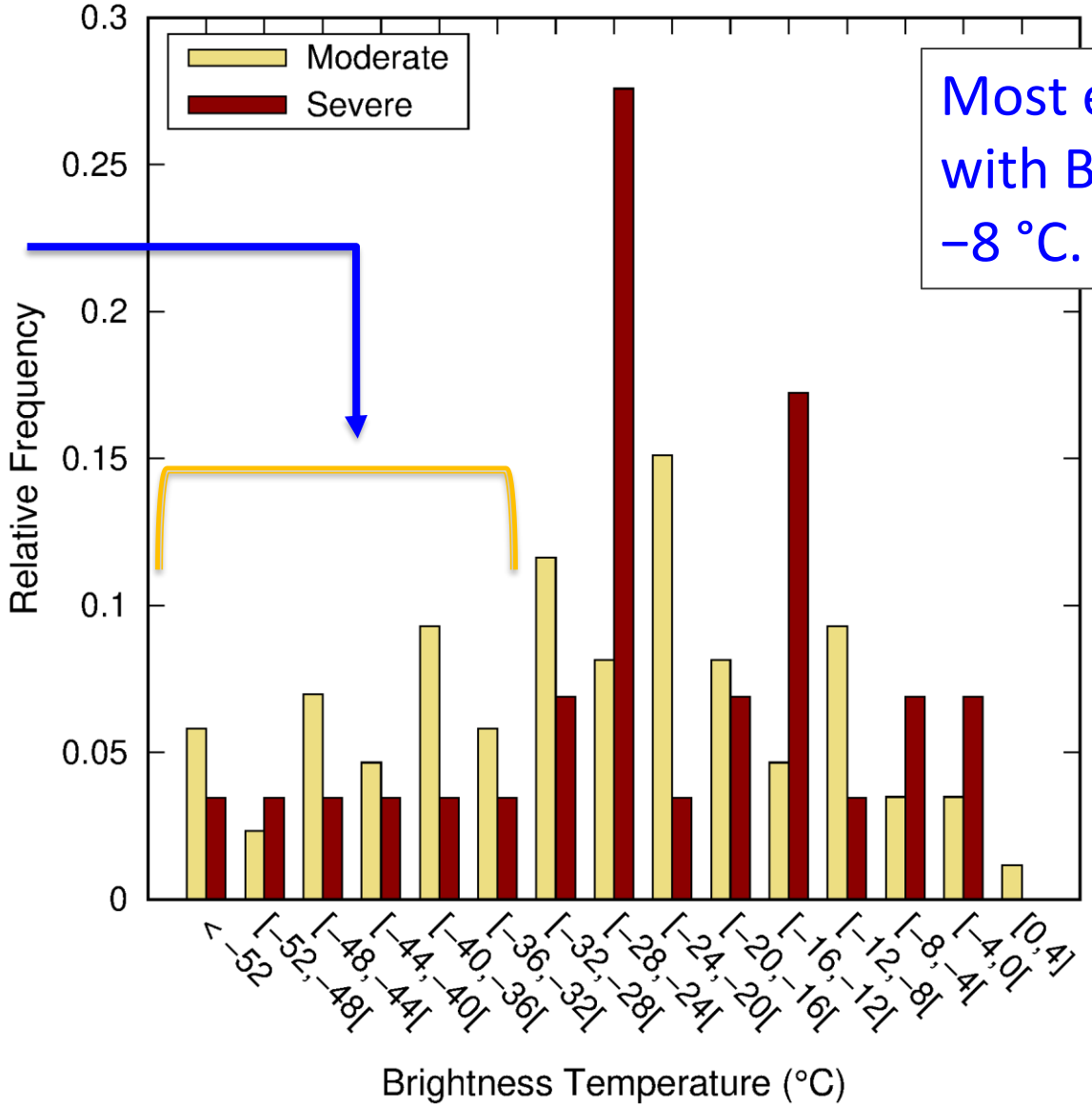


Aircraft icing occurs mainly under the presence of middle and high opaque clouds.

10.8 µm brightness temperatures and cloud-top phase

Multi-layer clouds, with semi-transparent upper-layer

OR very high opaque clouds



Most events (≈ 70%) are associated with BT10.8 between −40 and −8 °C.

Cloud-top phase	SEV	MOD
ice	38%	55%
mixed	41%	33%

Severe icing: 26 February 2020

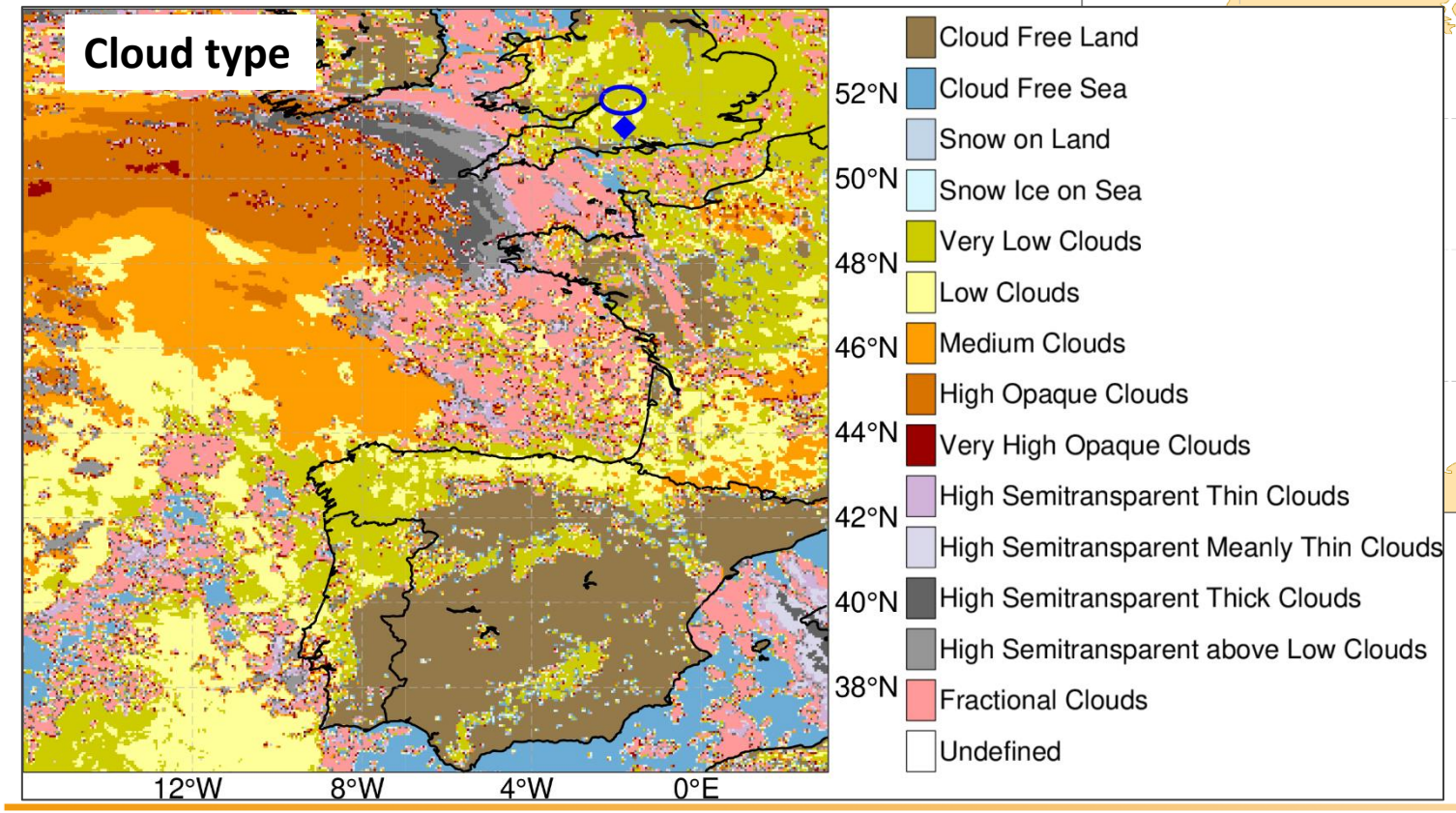
UAUK60 EGRR 261058
2EASY **SEV ICE OBS** AT 1048Z N5150 W00150 **FL035**=

FL035 ~ 1/1.1km

Cumulus
stratocumulus
showers

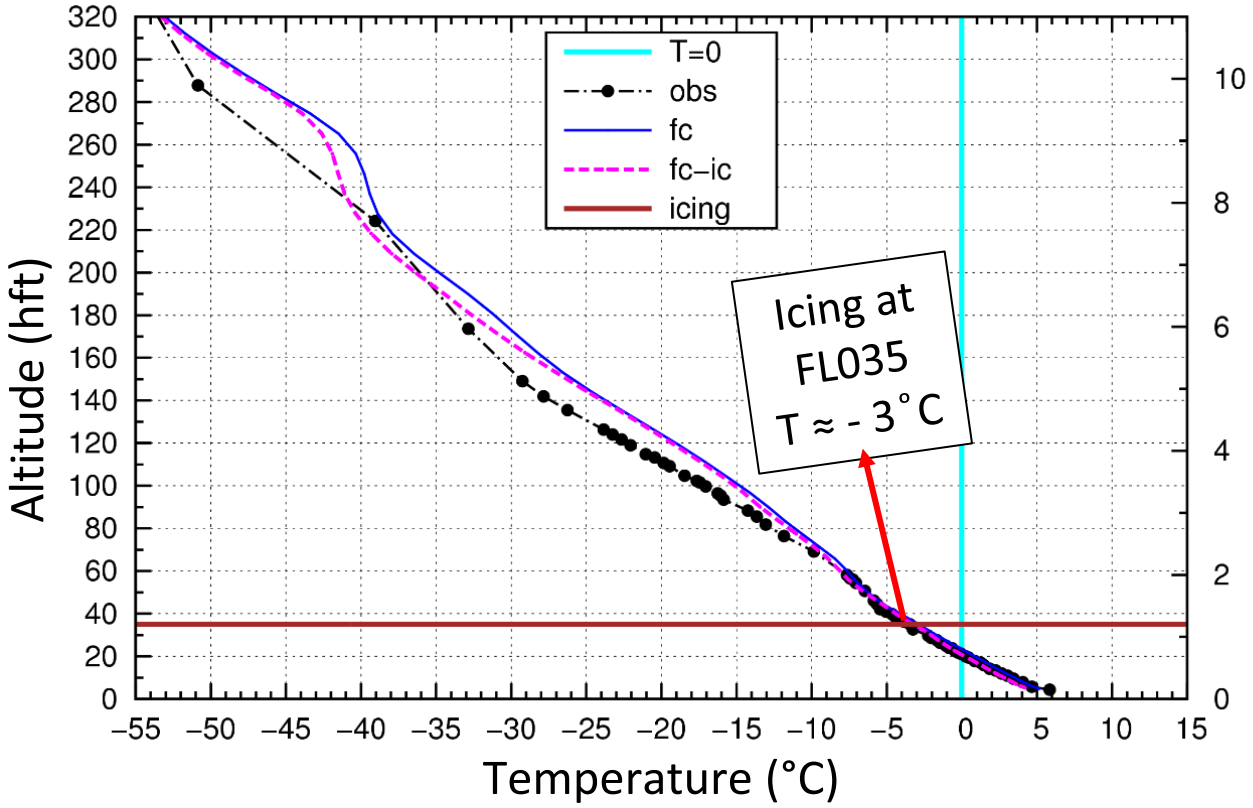
T2m = 6˚C

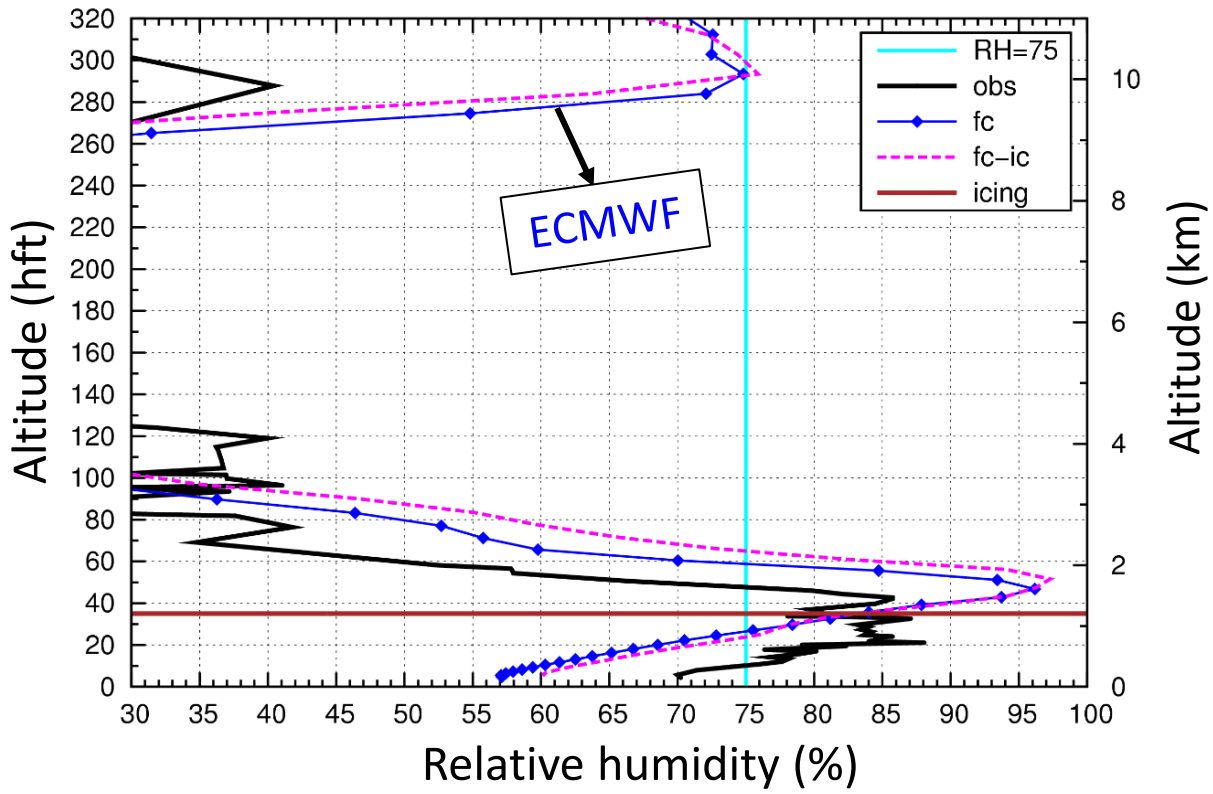
Radiosonde location



ECMWF and radiosonde profile

26 February 2020





Radiosonde (obs) and ECMWF profile
near the radiosonde (fc)
and at the PIREP site (fc-ic)

The model correctly predicts the temperature and the existence of an RH maximum at low levels, but overestimates the height of this maximum by about 2000 ft (≈ 600 m).

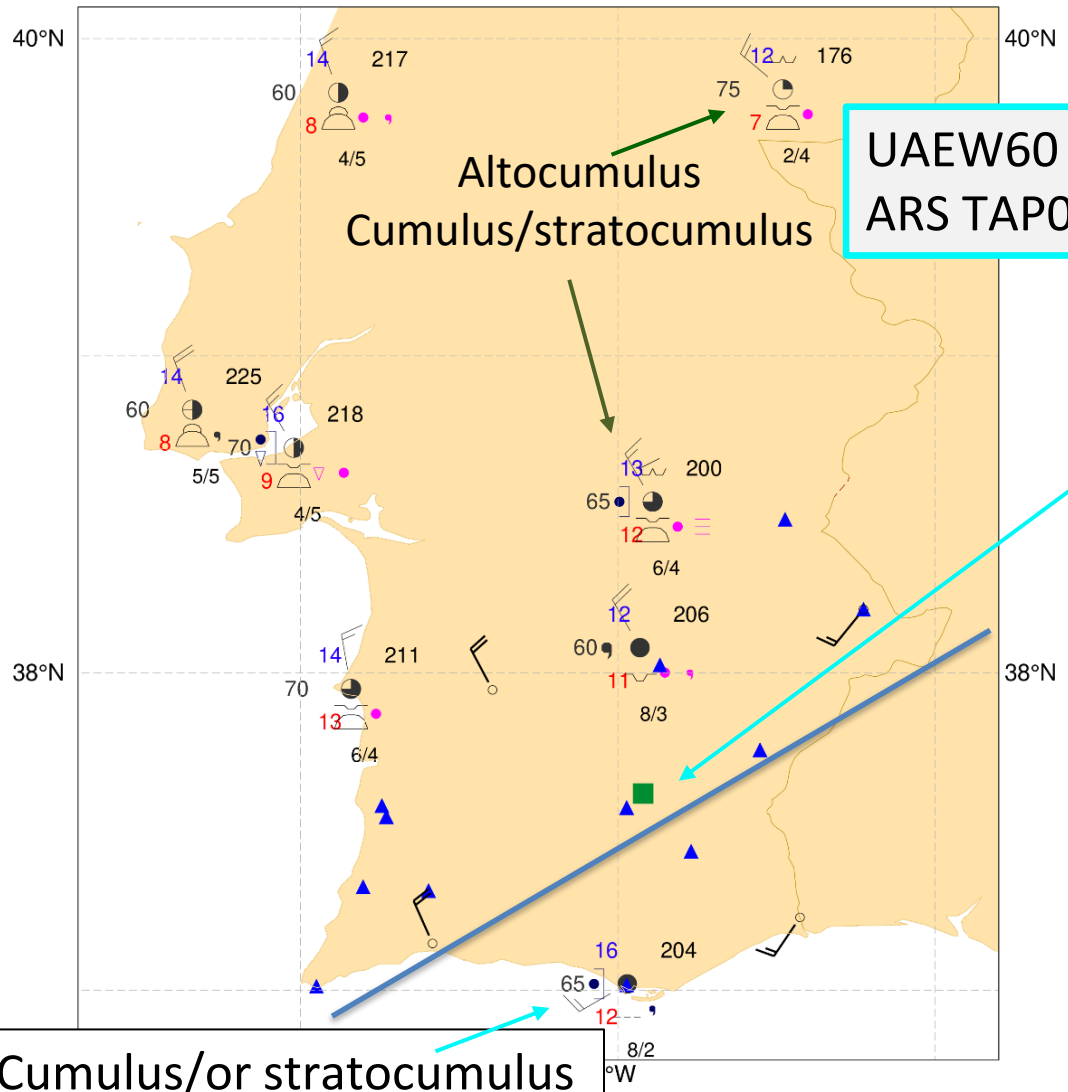
Moderate icing

3 mar 2022

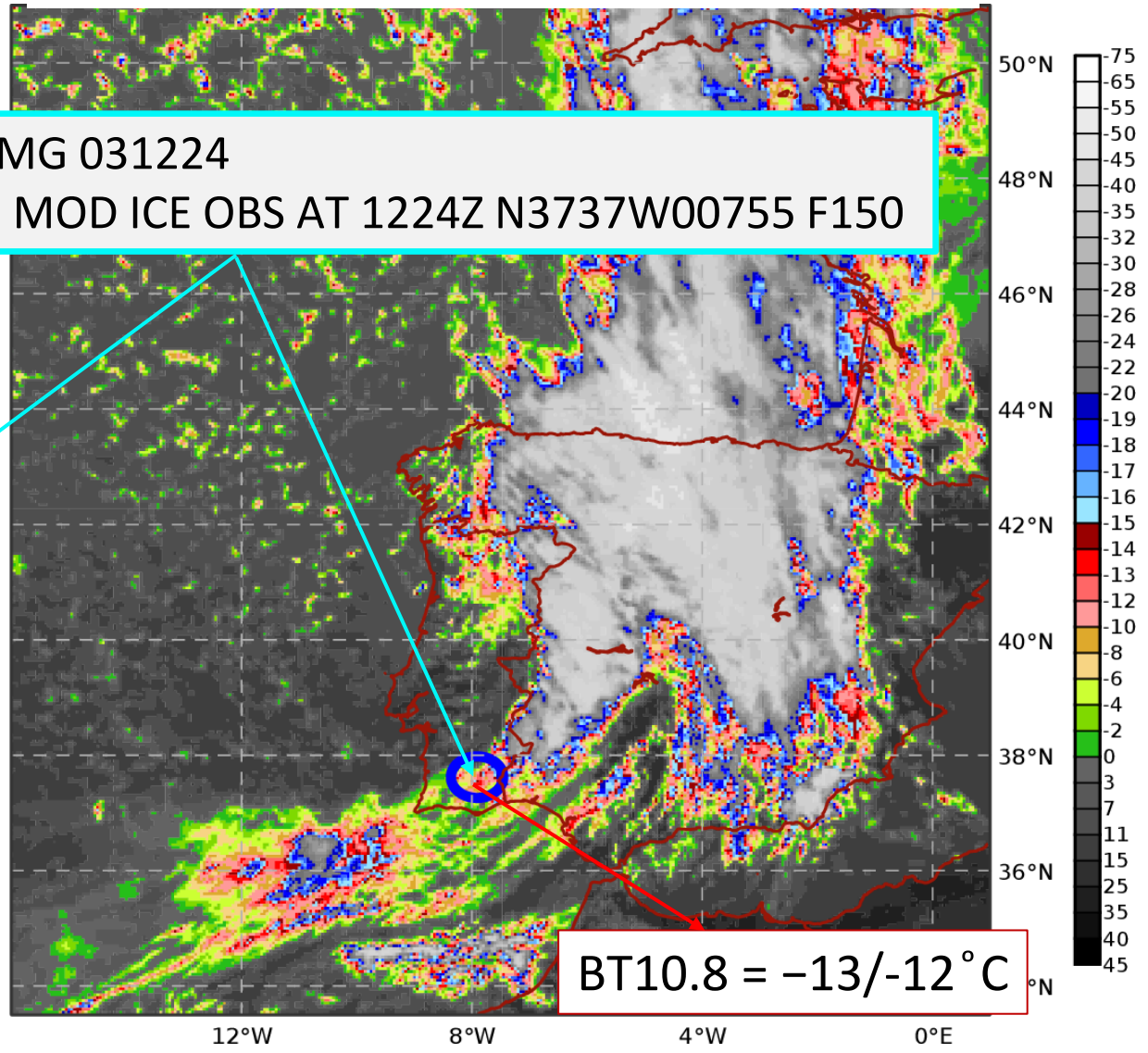
in association with a cold front

Moderate icing : 3 March 2022

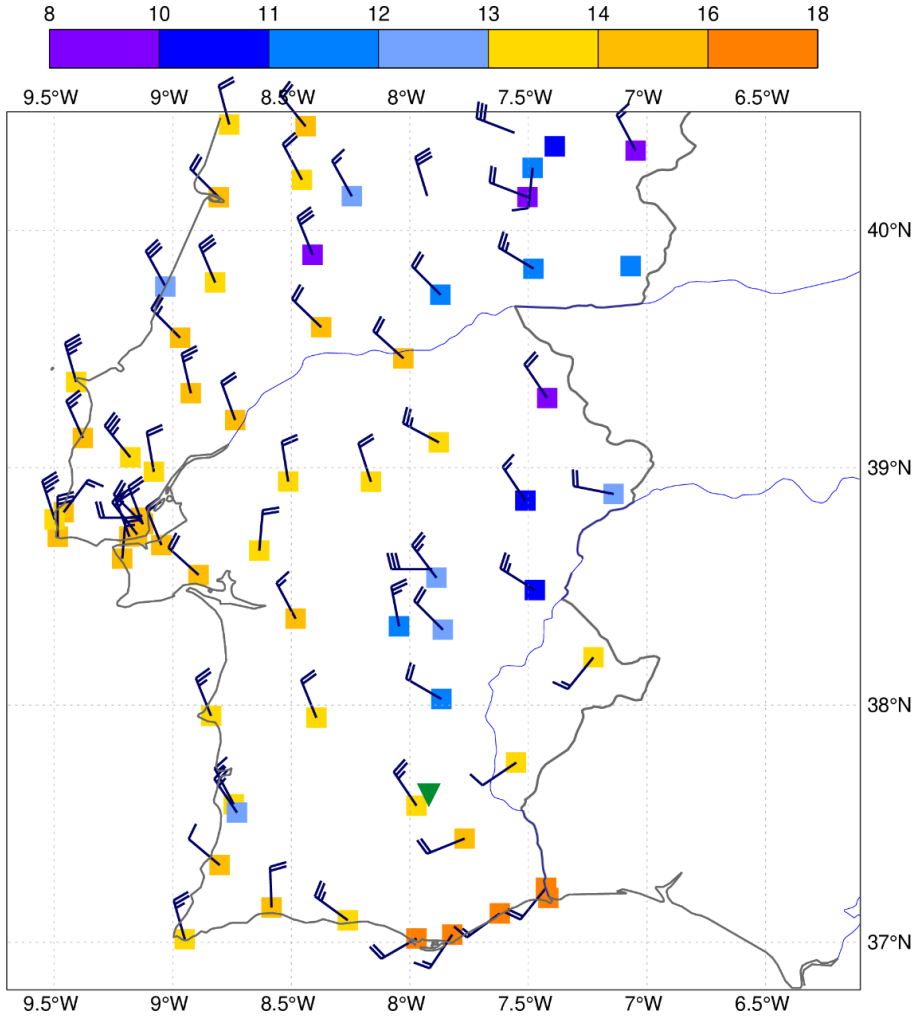
▲ Precipitation: 0.1-0.5mm/10min



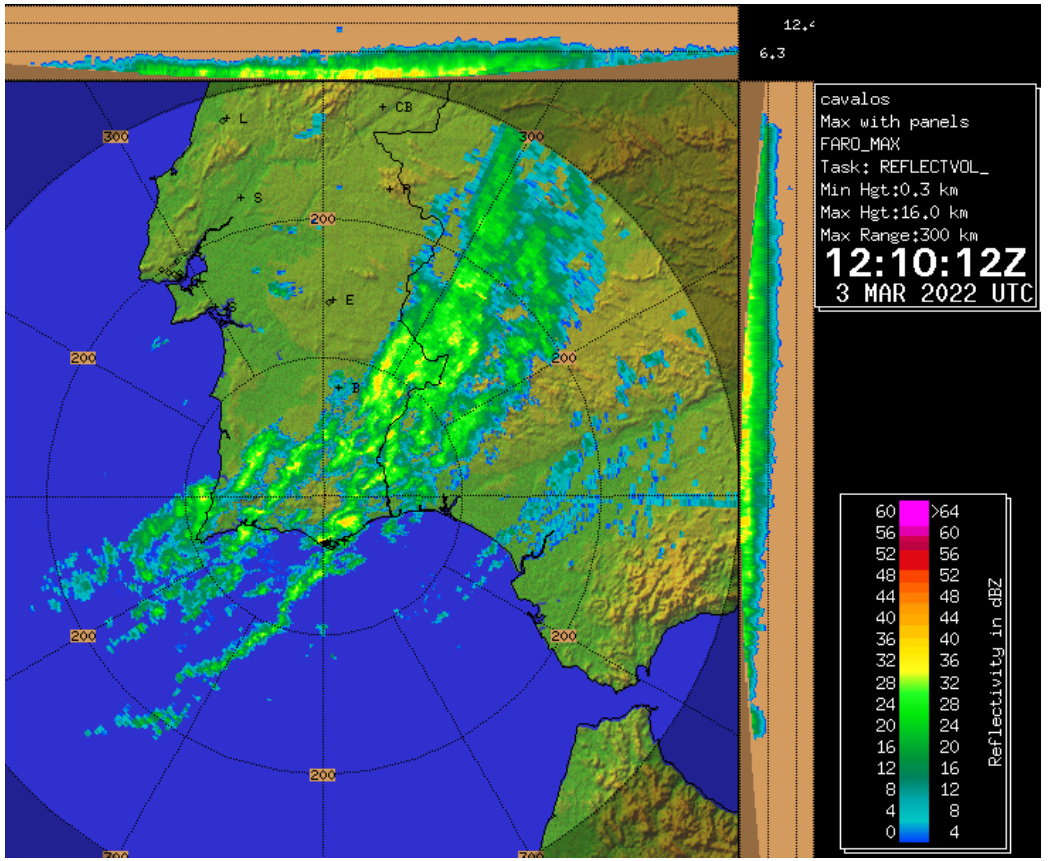
IR10.8 Brightness Temperature (BT10.8)



Moderate icing



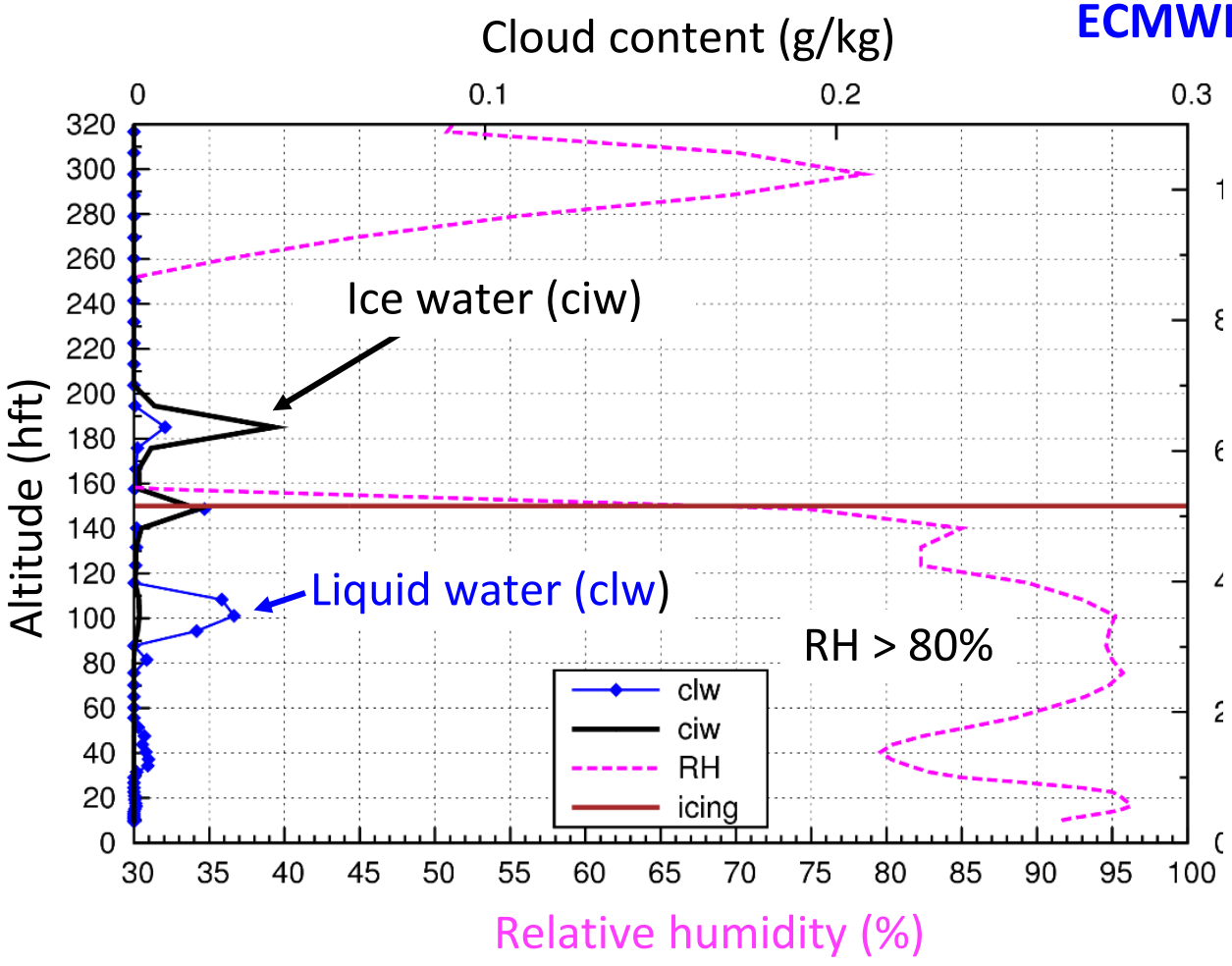
Observations of wind gust at 10m (barbs) and 2m temperature (°C) in central and southern Portugal. The location of the icing PIREP is marked with a green triangle).

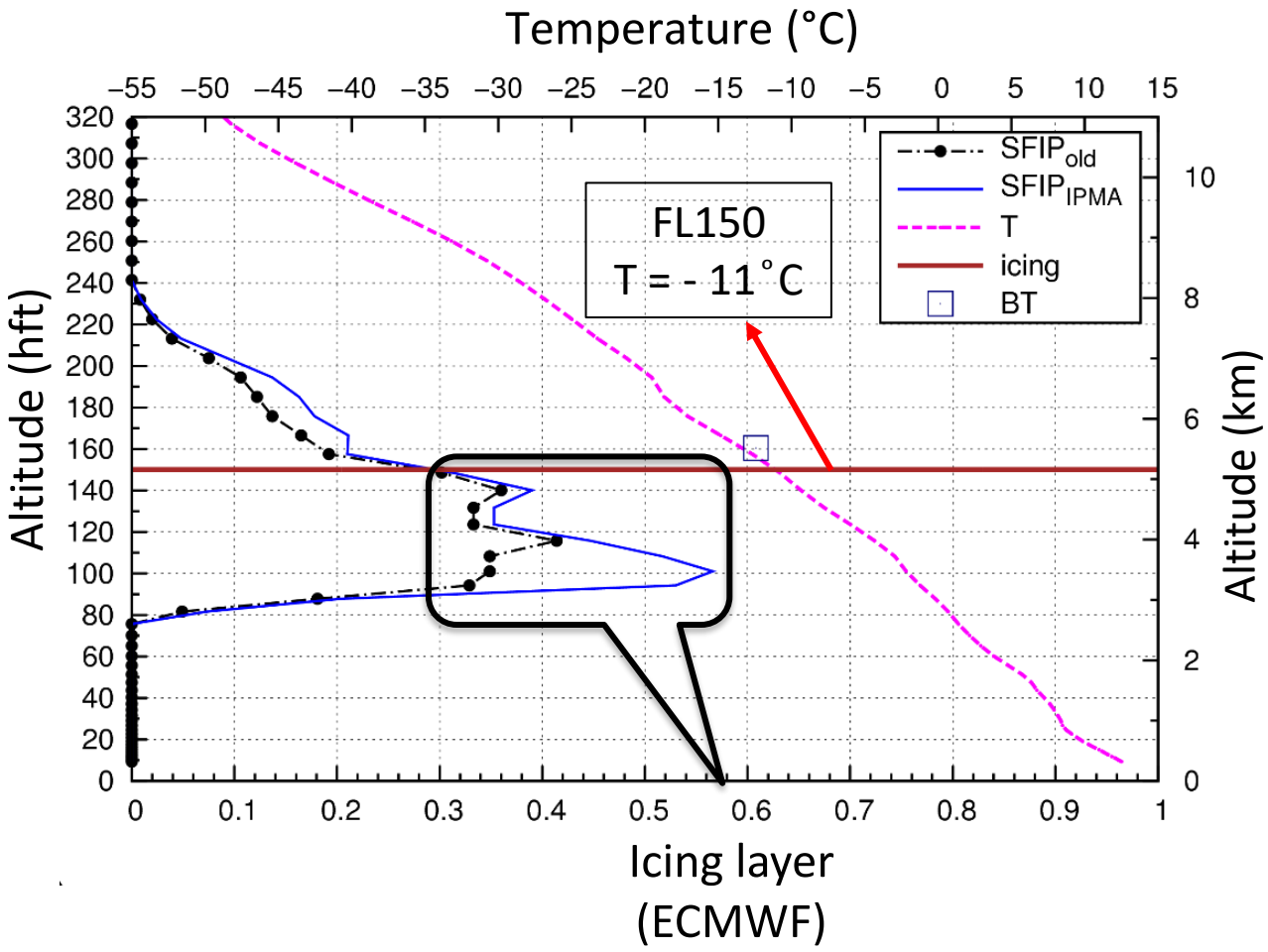


Maximum reflectivity (MAXZ, in dBZ) from Loulé weather radar.

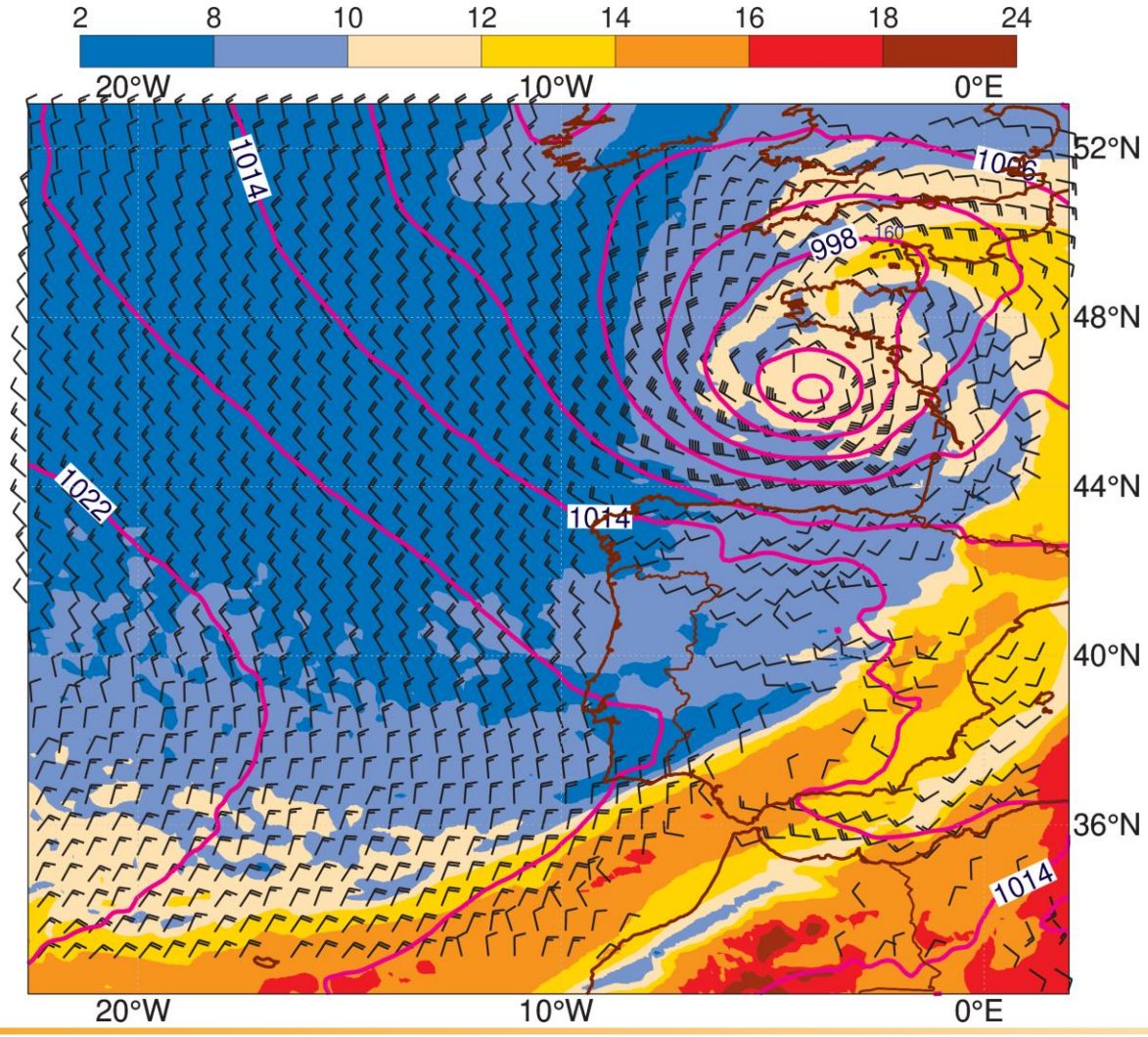
Moderate icing - 3 March 2022

ECMWF short-range forecast



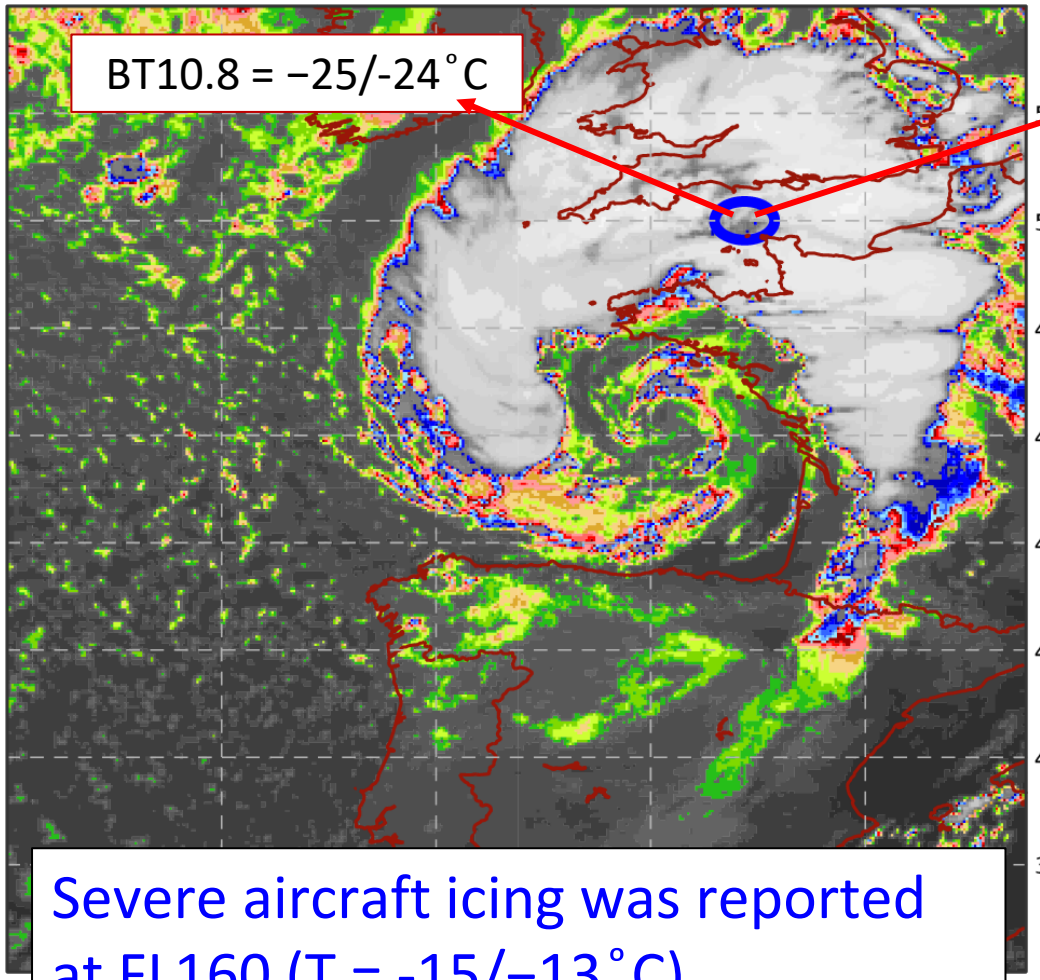


Severe icing Case: 7 June 2019 - 06h00



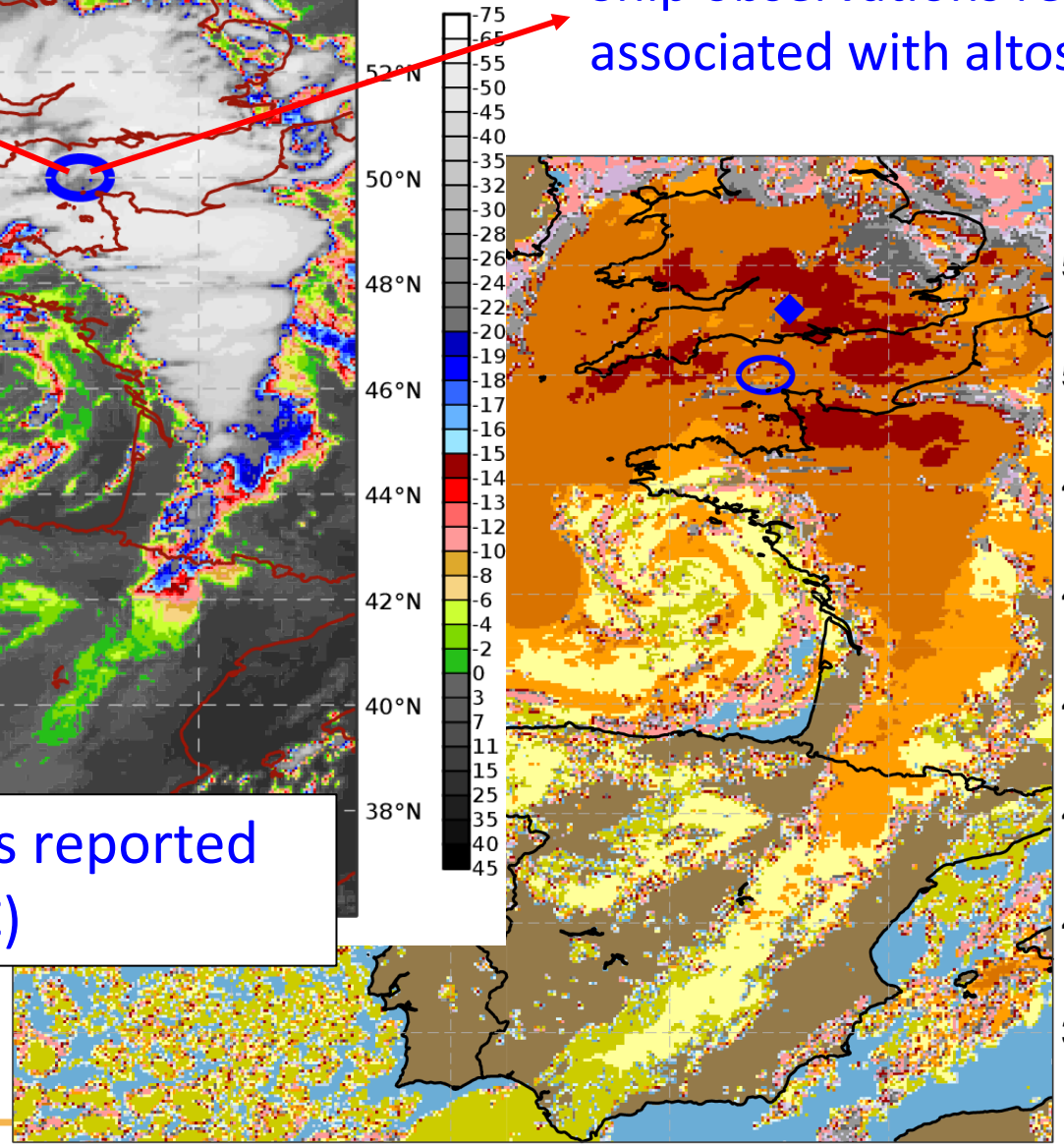
Mean Sea level pressure (isolines), 10 m wind (barbs) and 850 hPa wet-bulb potential temperature (shaded) from ECMWF analysis

Multi-layer clouds with nimbostratus



Ship observations reported intermittent rain associated with altostratus opacus and nimbostratus

Severe aircraft icing was reported at FL160 (T = -15/−13˚C)



- Cloud Free Land
- Cloud Free Sea
- Snow on Land
- Snow Ice on Sea
- Very Low Clouds
- Low Clouds
- Medium Clouds
- High Opaque Clouds
- Very High Opaque Clouds
- High Semitransparent Thin Clouds
- High Semitransparent Meanly Thin Clouds
- High Semitransparent Thick Clouds
- High Semitransparent above Low Clouds
- Fractional Clouds
- Undefined

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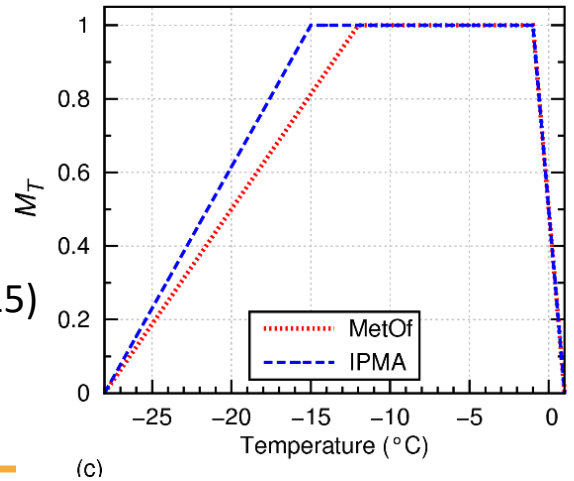
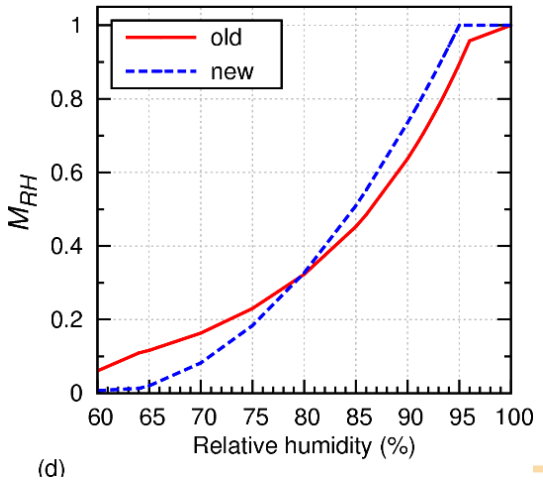
Future work

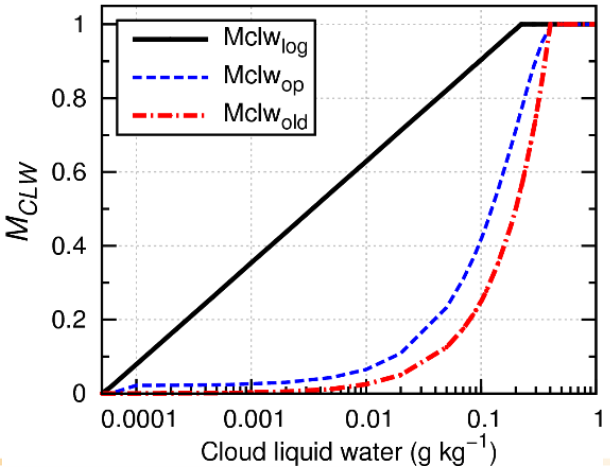
- The prevalence of icing events above FL100 (with BT10.8 ranging from −40 and −8 °C) with a predominance of ice and mixed-phase cloud-top suggests that, in the study region, aircraft icing is frequently linked to ice-dominant clouds (deep convective clouds, altostratus and nimbostratus).
- This hypothesis could be tested by comparing different sources of information for a vast number of aircraft icing events.
- Consider other satellite products, such as cloud optical thickness and effective droplet radius, so the icing potential could be derived from satellite data
- Test other membership functions (e.g. Kim et al, 2024) using validated PIREPs

MetOf:
Morcrette et al (2019)

IPMA:
Belo-Pereira et al (2015)







Casqueiro et al (2023)

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High-Impact Weather Events: Dynamics, Variability and Predictability

Special Issue Editors: Dr. Margarida Belo-Pereira and Dr. André Simon

Submission Deadline: 25 September 2024

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