Microphysical and dynamical properties of warm conveyor belts near the SAFIRE Falcon flights during NAWDEX

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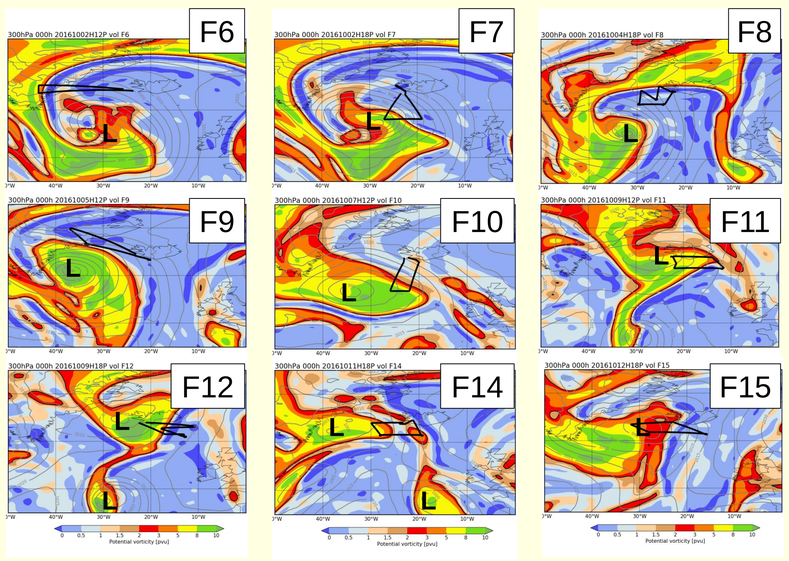
I. Introduction

To analyze microphysical and dynamical properties of the observed WCBs during the flights of the SAFIRE French Falcon. To detect systematic biases of the Arpege operational model by comparing short-term forecasts of the model with observations made with the radar-lidar platform (called RALI) on board the Falcon.

II. Observations



- F6, F7: IOP6 (Stalactite cyclone)
- F8, F9: IOP7 (deep cyclone originating from Newfoundland)
- F10, F11, F12: IOP8 moderate cyclones and Thor ridge formation
- F14, F15: IOP9 moderate cyclones north of cut-off Sanchez

III. Model, simulations, observations

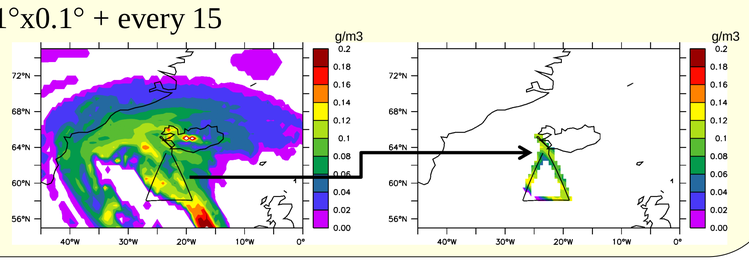
- **Arpege** 1-2 days forecast
- Resolution: T798 with stretching → 10km over France, 20km on Iceland
- Initial condition: Arpege operational analysis
- Two convection schemes associated to two members:
  → B85: Bougeault (1985): closure in humidity, used in operational NWP version.
  → PCMT: Piriou et al. (2007) « Prognostic Condensates Microphysics and Transport »; closure in CAPE, used in Arpege climate version.
- Output resolution: lon x lat: 0.1°x0.1° + every 15 minutes.

Used observations:
- **RADAR reflectivity**
- **Ice water content** retrieval (variational algorithm; Delanoë and Hogan, 2008; Cazenave, 2019)
- **Doppler wind components**

Indirect info on the heating rate

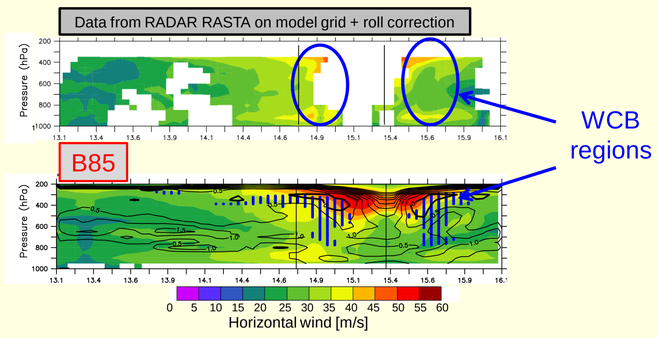
Info on circulation

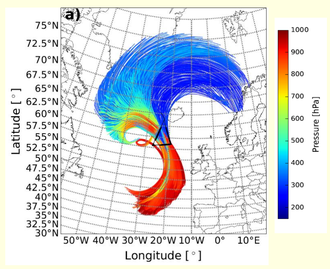
Snapshot of IWC for a 24-h forecast and data along the flights to be compared with observations



IV. Flight 7, Stalactite Cyclone, IOP 6

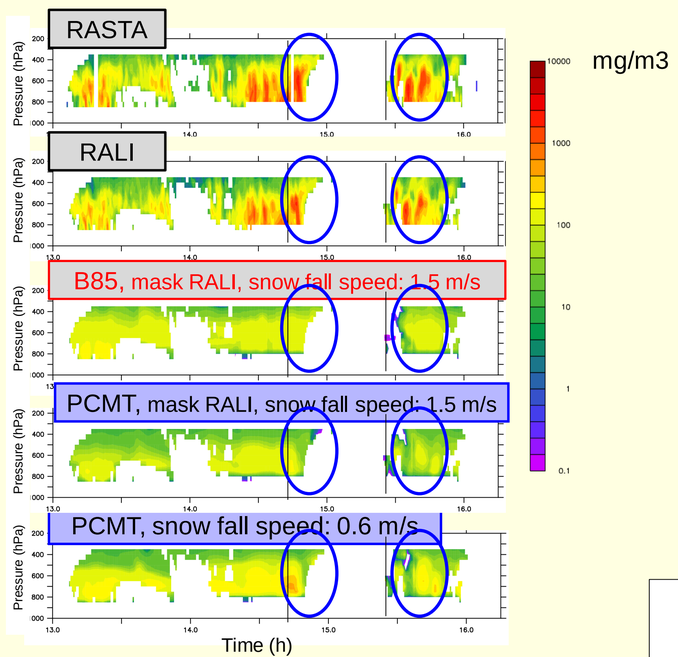
Wind speed and WCB regions crossing the flight legs



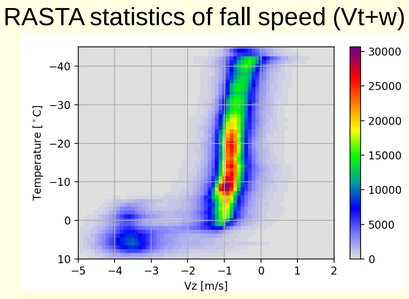


WCB crossing the flight legs computed in B85 run

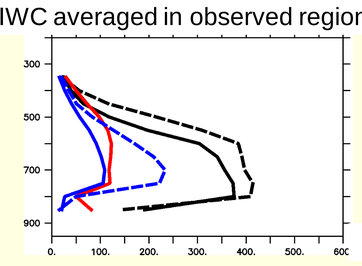
Ice water content = Cloud Ice Water content/3D cloud fraction+Snow/2D cloud fraction, ~forecast +24h



RASTA statistics of fall speed (Vt+w)



IWC averaged in observed regions

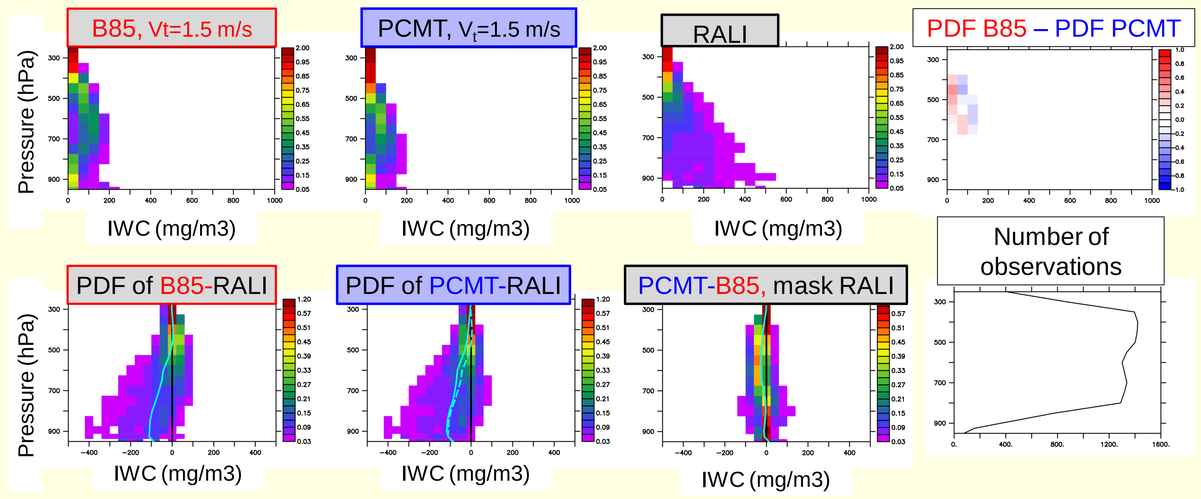


RASTA — B85 (V_t=1.5 m/s)
RALI — PCMT (V_t=1.5 m/s)
PCMT (V_t=0.6 m/s)

Large underestimation of IWC even for slowest snow fall speed: factor1.5 in the mean; 2.5 in the max

V. Statistics over 9 flights

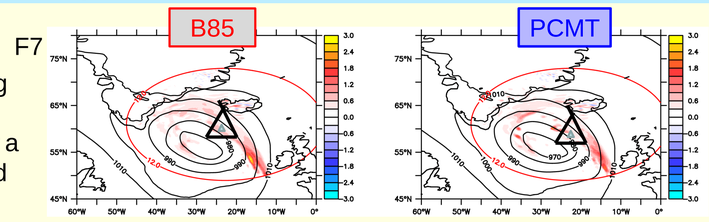
Pdfs of Ice Water Content or difference in Ice Water Content



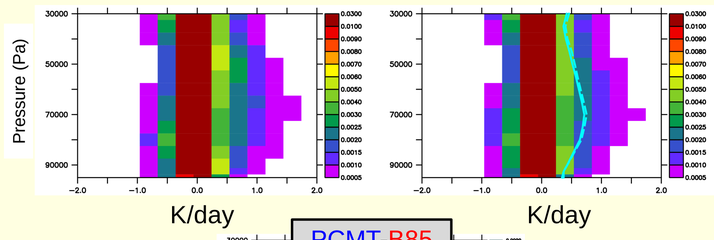
B85 has more ice at higher altitude than PCMT

Heating rates statistics around the different flights

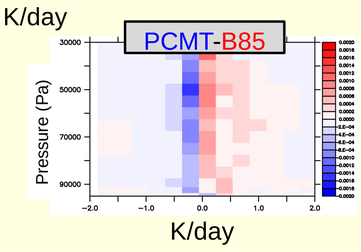
Snapshot of heating rate at 500 hPa. Statistics made over a large region centred on each flight



PDFs of heating rates over the 9 flights

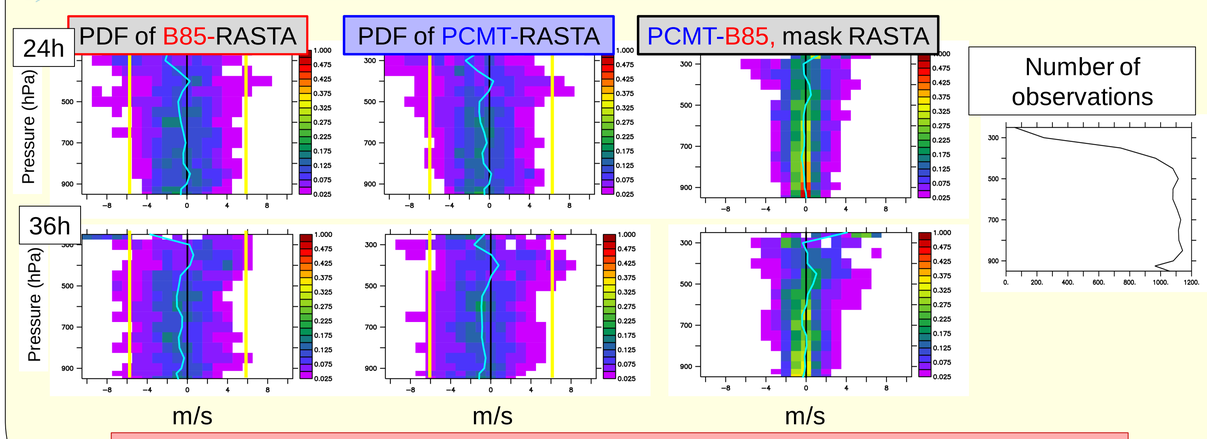


Difference of the two PDFs



Stronger heating rate in B85 than PCMT, consistent with higher ice water content.

Differences in horizontal wind speed with observations



Slight underestimation of the wind speed in the model compared to the observations over the whole column. No obvious difference between the two schemes

Conclusions

- Large underestimation of IWC below 600 hPa: factor 4 for the highest snow fall speed and factor 2 for the slowest.
- Underestimation of the IWC slightly more visible in PCMT than B85.
- Heating rate reaches higher values in B85.
- Very slight underestimation of the horizontal wind speed in both types of runs in comparison with RASTA observations.

Outlook

- Computation of WCBs for 9 flights → potentially WCBs reach higher altitude in B85 (to be checked)
- Focus on PV / wind speed anomalies in WCB regions of the flights only

References

- Bougeault, P., 1985: A simple parameterization of the large-scale effects of cumulus convection. Mon. Wea. Rev., 113, 2108-2121.
- Cazenave, Q., 2019: Development and evaluation of multisensor methods for EarthCare mission based on A-train and airborne measurements. PhD thesis, UVSQ.
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- Piriou, J.-M., J.-L. Redelsperger, J.-F. Geyleyn, J. P. Lafore and F. Guichard, 2007: An approach for convective parameterization with memory: separating microphysics and transport in grid-scale equations. J. Atmos. Sci., 64, 4127-4139.