Diabatic processes in the Warm Conveyor Belt of the Stalactite Cyclone

Sensitivity to two deep convection schemes of the global Météo-France model ARPEGE

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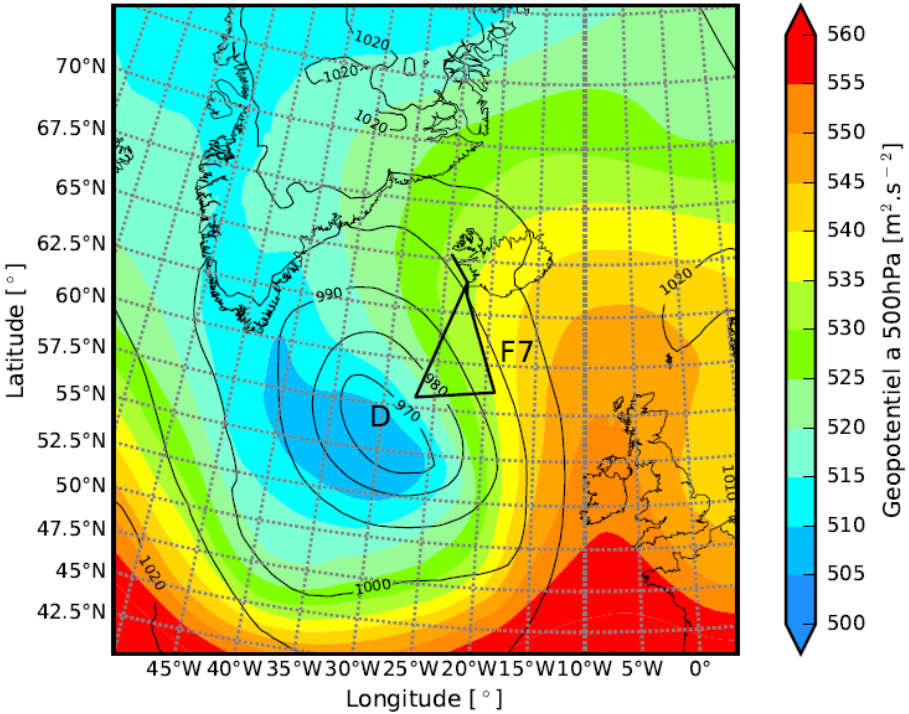
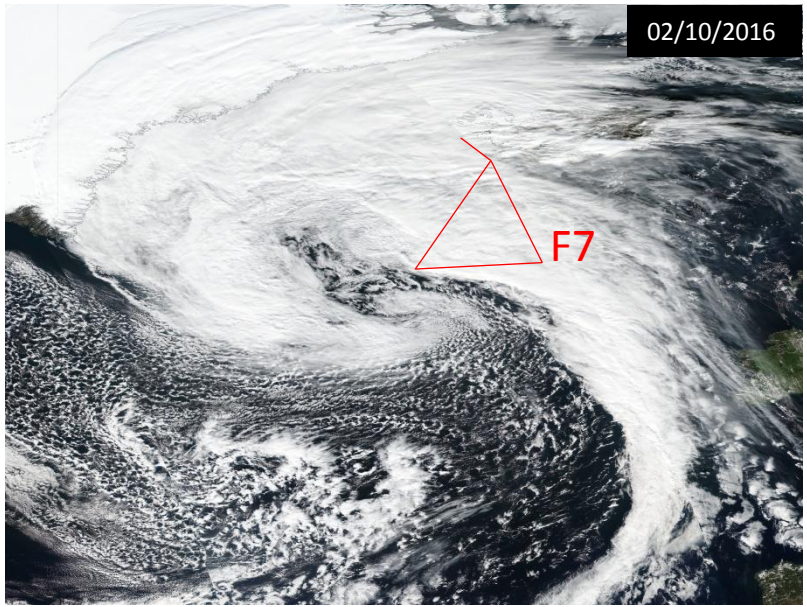
Workshop WCB, ECMWF, 11 March 2020

Stalactite Cyclone / IOP 6 of NAWDEX

Geopotential at 500 hPa and
Mean Sea Level Pressure



ARPEGE Analysis, 02/10/2016 at 12h UTC



MODIS, Nasa Worldview Application

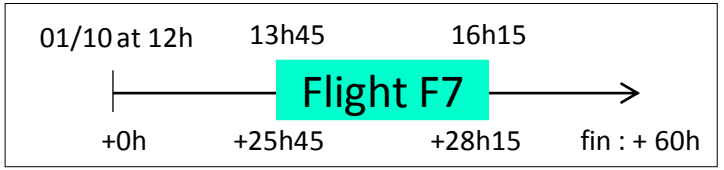
The model: ARPEGE-EPS (cy41.op1)

NWP :

- Resolution : 10km on France, 20km on Islande (TL798 C2.4)
- Level : 90 from 14m to 50km (1hPa)
- Time step : 514,3s
- Initial Condition : ARPEGE analysis of the 01/10/2016 at 12h UTC

Outputs :

- Resolution : 0,5°
- Time step : 15min
- Heating and PV tendencies



Deep convection scheme in ARPEGE-EPS

Bougeault, 1985 (B85)

- Mass-Flux scheme
- Closure : moisture

➡ Used in high-res oper run

Piriou et al, 2007 (PCMT)

- Mass-Flux scheme
- Closure : CAPE
- Microphysic and transport schemes
- Strong entrainment

➡ Used in climate version

Shallow convection : KFB (Bechtold et al. 2001) // PMMC (Pergaud et al. 2009)

Influence of these two deep convection schemes on the Stalactite Cyclone WCB

Research questions

- Along the flight track, in particular in the WCB region, what are the differences in PV and wind between the two runs with two distinct convection schemes ?

- Which scheme leads to a more skillful forecast when compared with NAWDEX observations ?

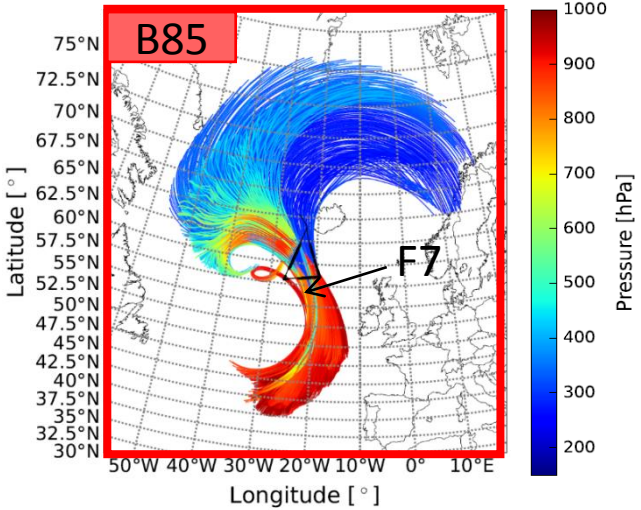
- What are the differences between the two convection scheme in the upper level ridge building ?

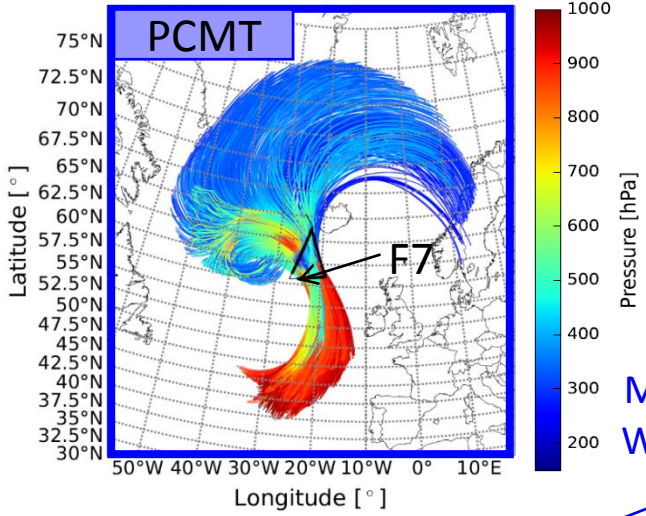
Warm Conveyor Belt trajectories crossing Flight F7

Trajectories : -24h / +24h

WCB : -300hPa in 24h for every 24h in 48h of trajectory + P_0>850hPa

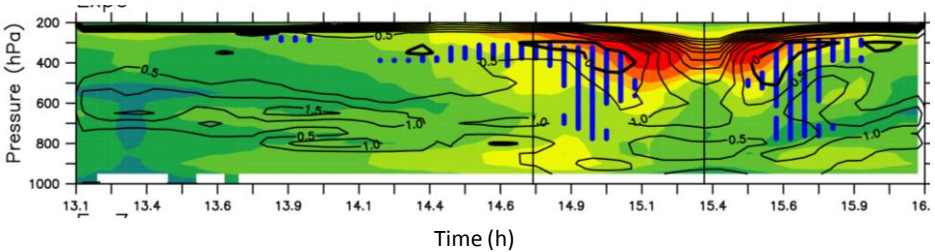
909 traj

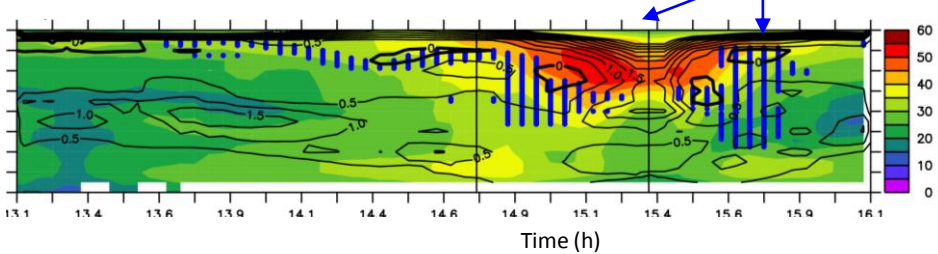




978 traj

Most ascending WCB (600hPa in 48h)





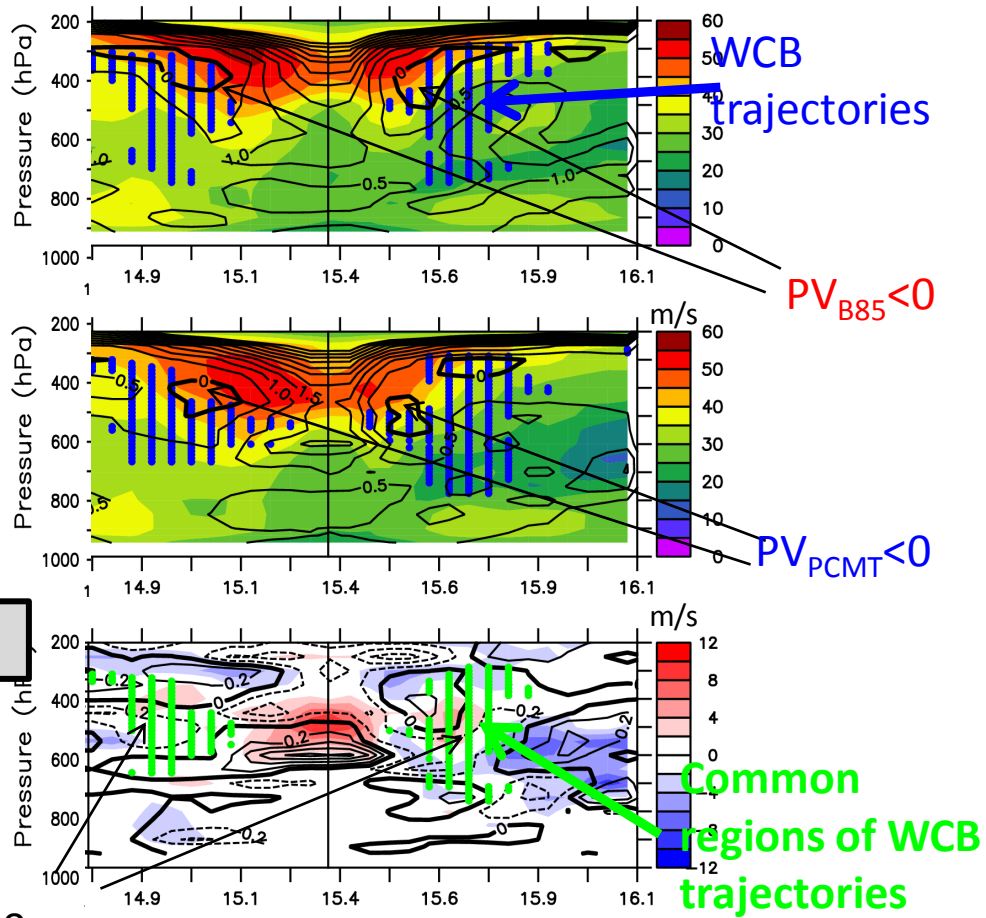
Horizontal wind (shadings; m/s) and Potential Vorticity (contours, PVU)

Link between PV (contours) and wind (shadings)

B85

PCMT

PCMT-B85



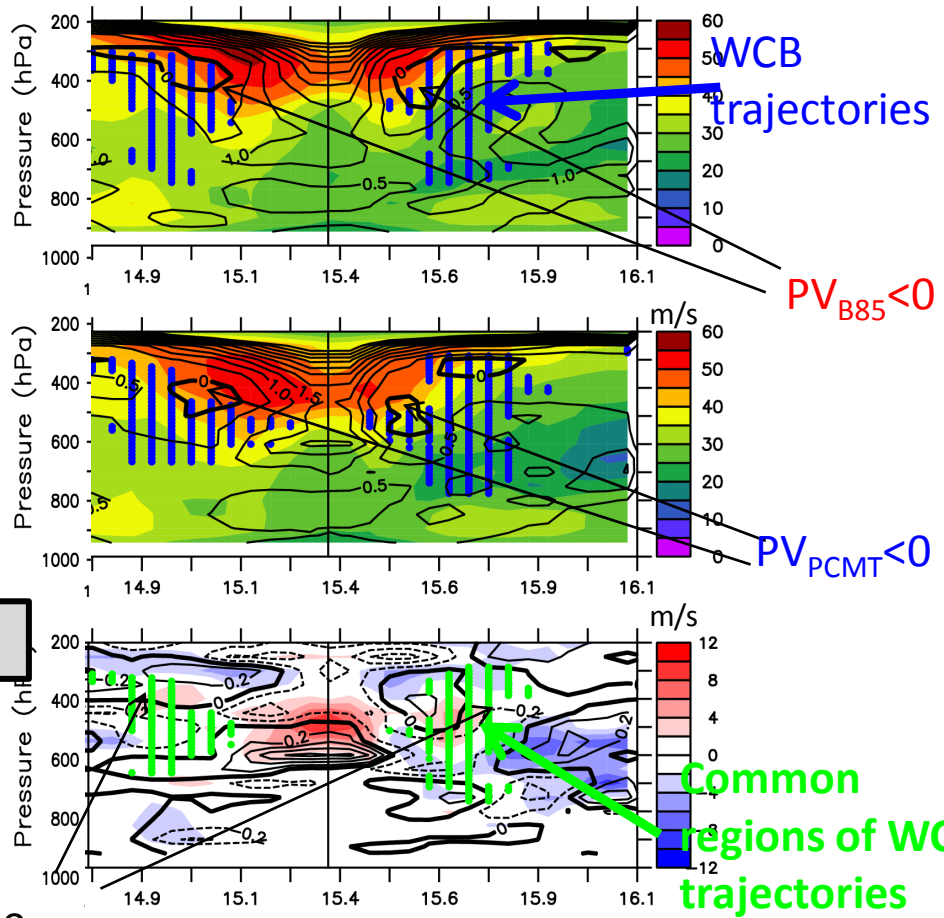
PV$_{PCMT}$-PV$_{B85}$<0

Link between PV (contours) and wind (shadings)

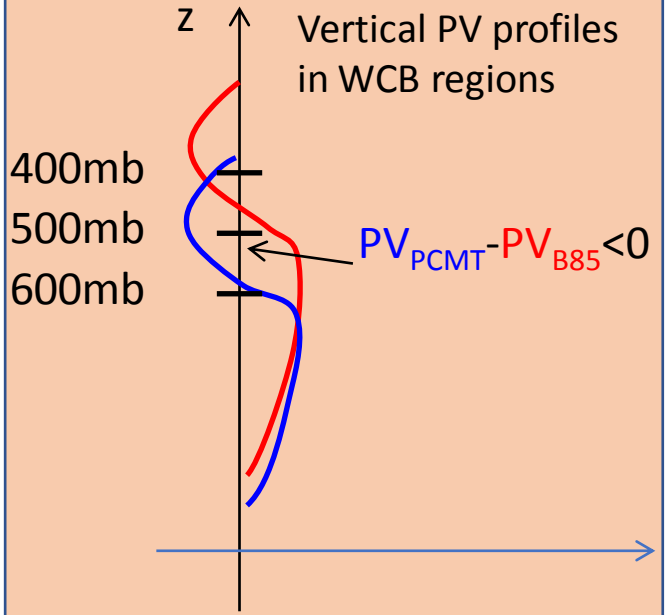
B85

PCMT

PCMT-B85



To summarize:

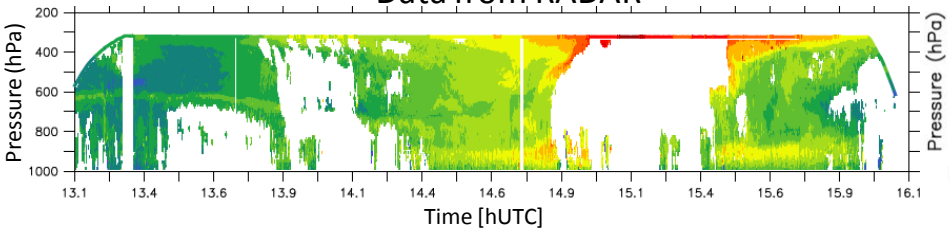


PV$_{PCMT}$-PV$_{B85}$<0

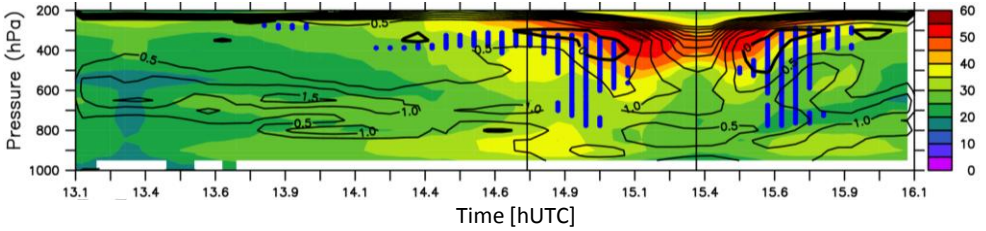
Method to compare model outputs to radar observations

Observations

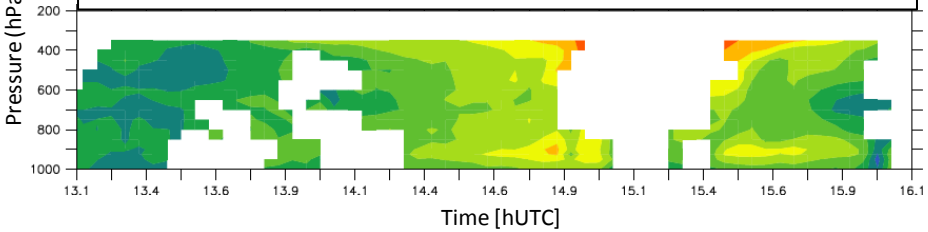
Data from RADAR



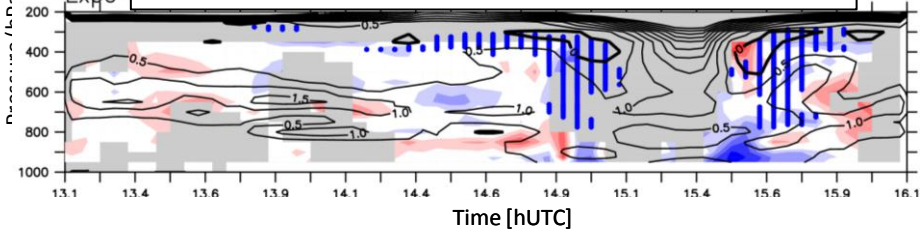
Model data from B85 (winds: shadings)



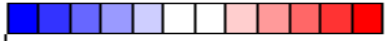
Data from RADAR on model grid + roll correction



Difference in regions where observations are



Horizontal wind [km/h]



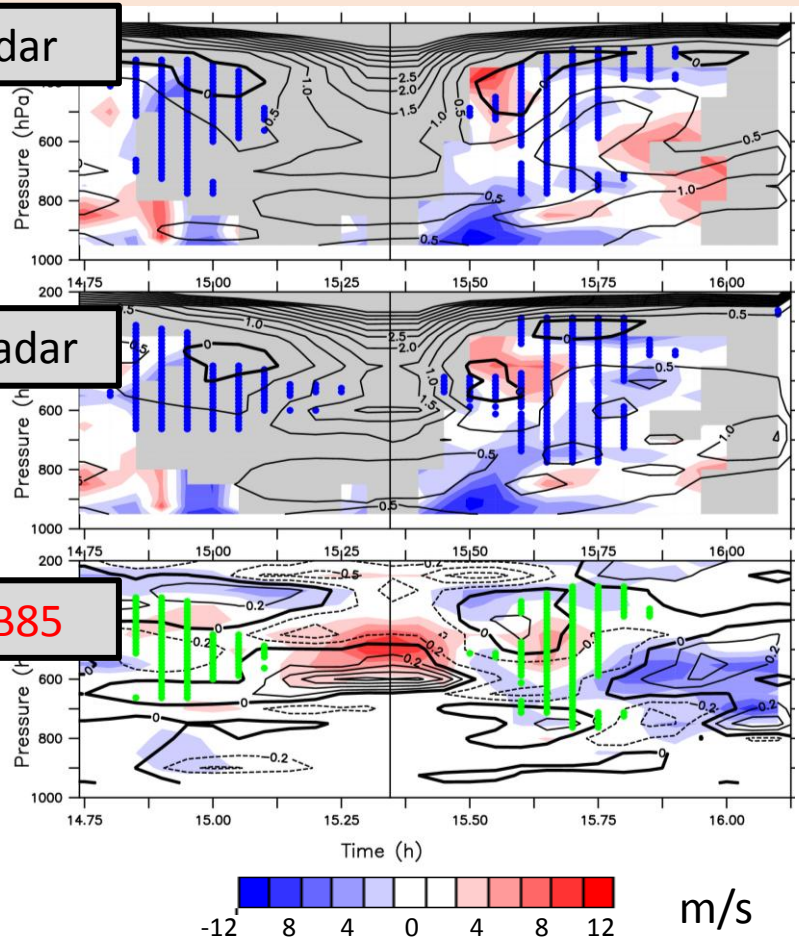
V(B85) –OBS [km/h]

Wind speed: comparison with radar observations

B85-radar

PCMT-radar

PCMT-B85



Wind speed: comparison with radar observations

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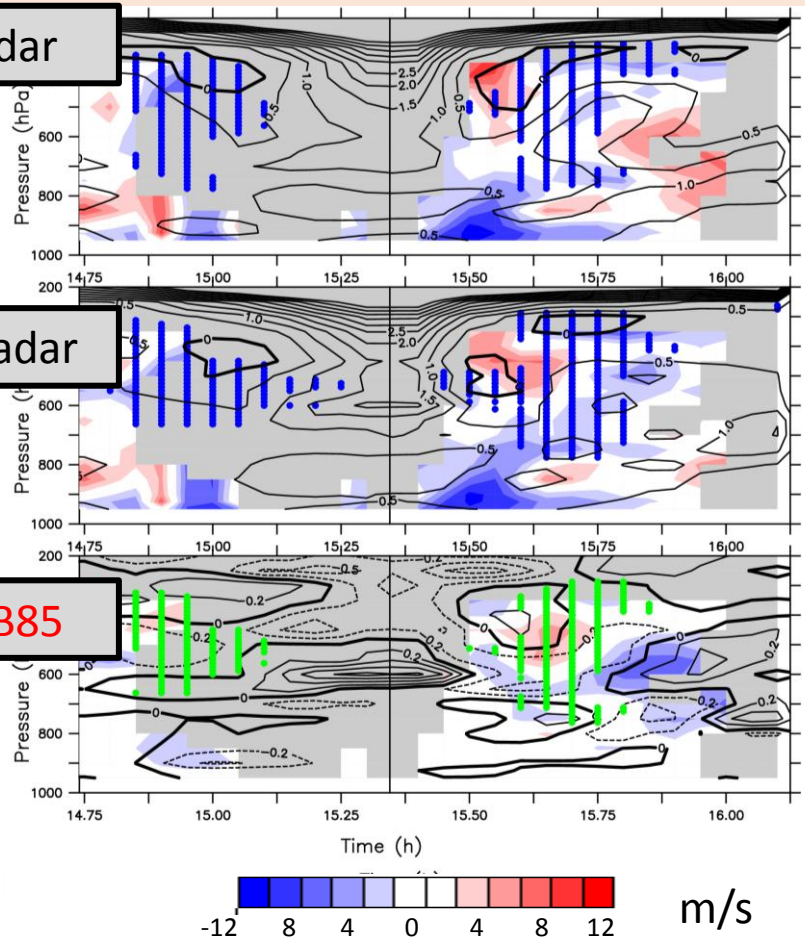
PCMT-B85



Wind speed: comparison with radar observations

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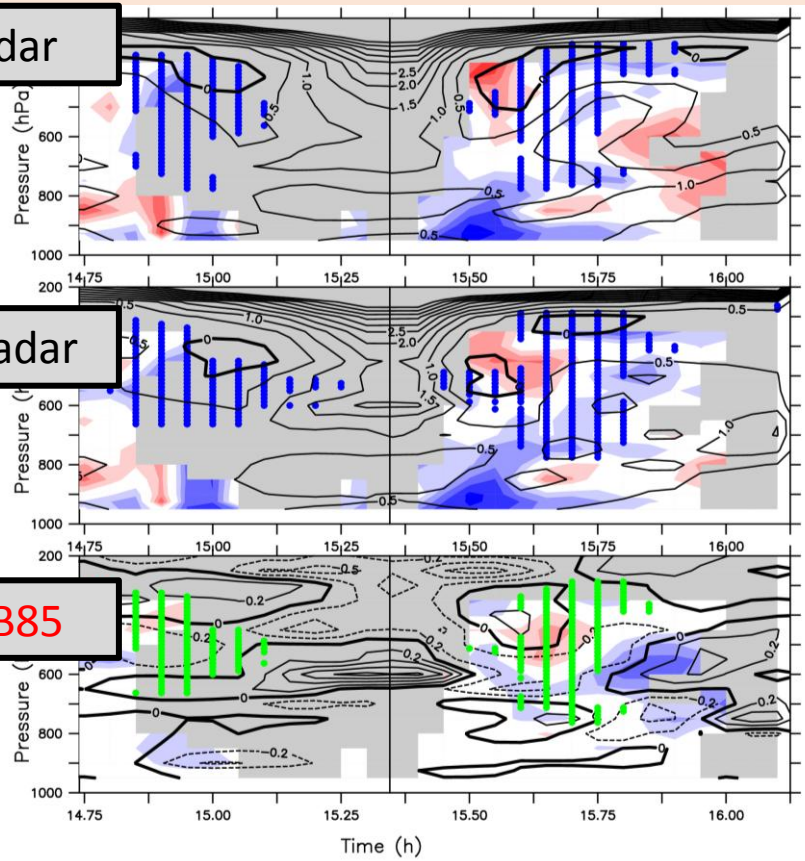
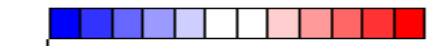
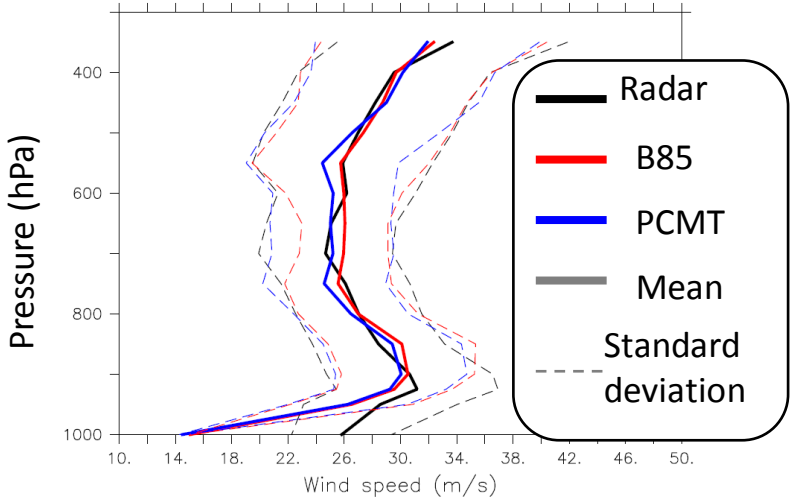
PCMT-B85





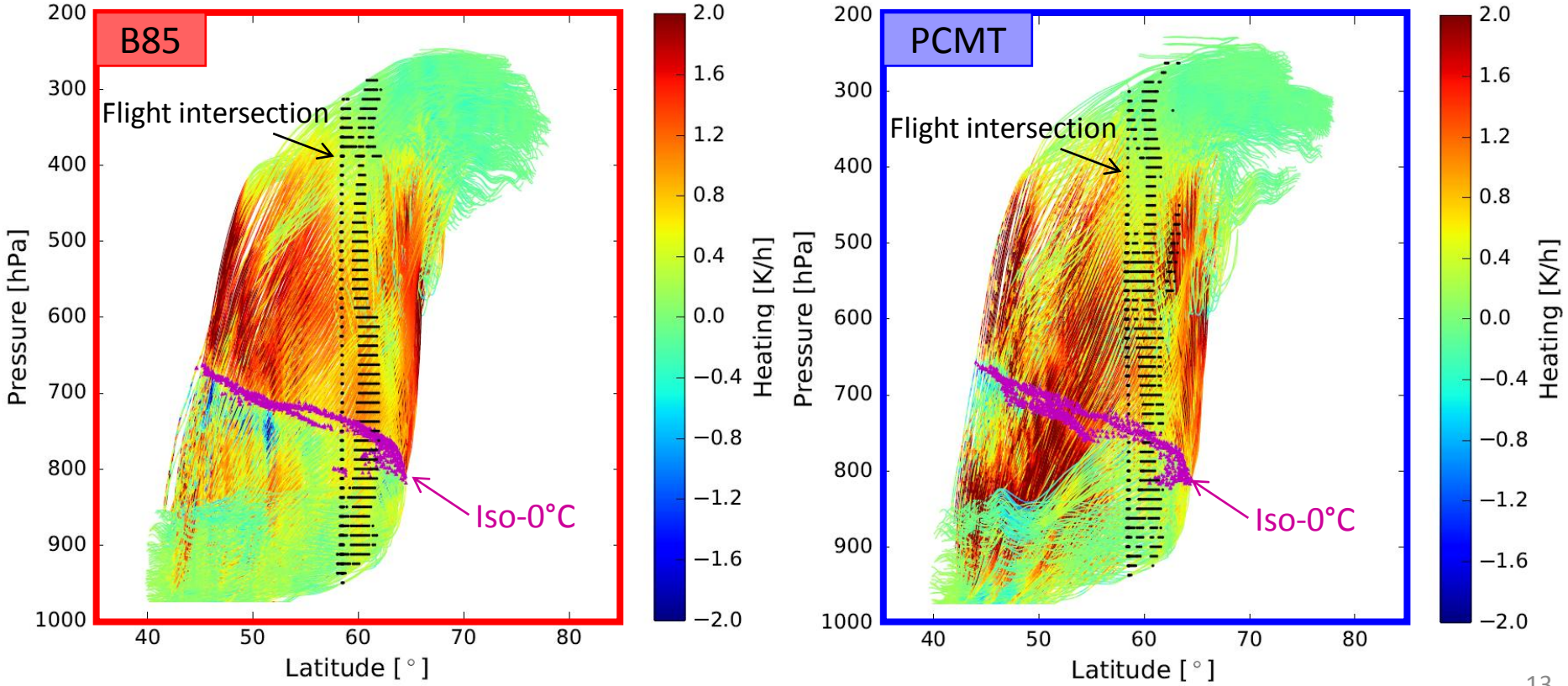
m/s

Mean wind speed over the flight

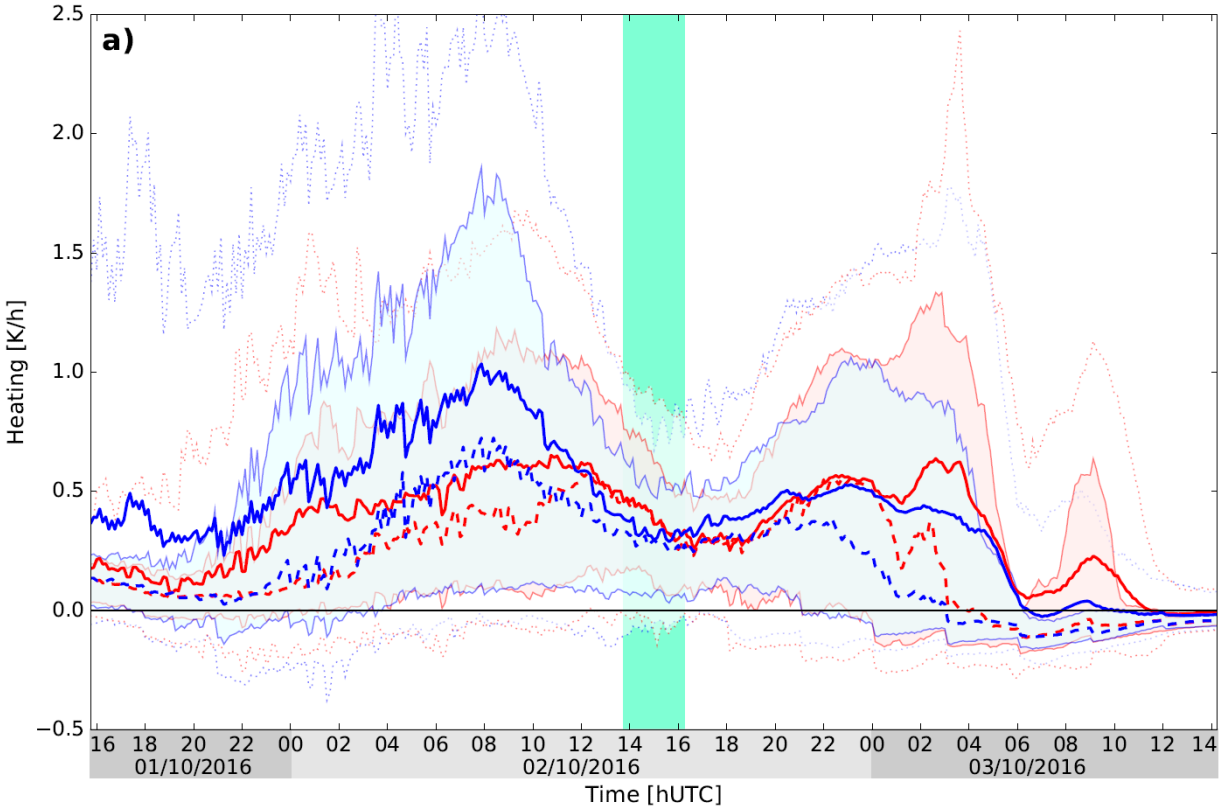


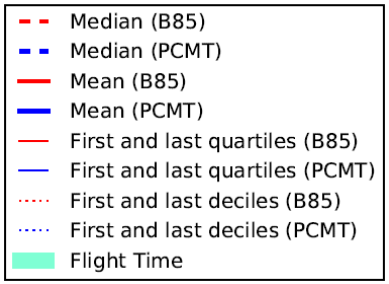
Slightly lower wind speed in PCMT than B85 between 500 and 800hPa in regions with observations (cloudy regions)

Heating along WCB trajectories



Time evolution of the heating along WCBs

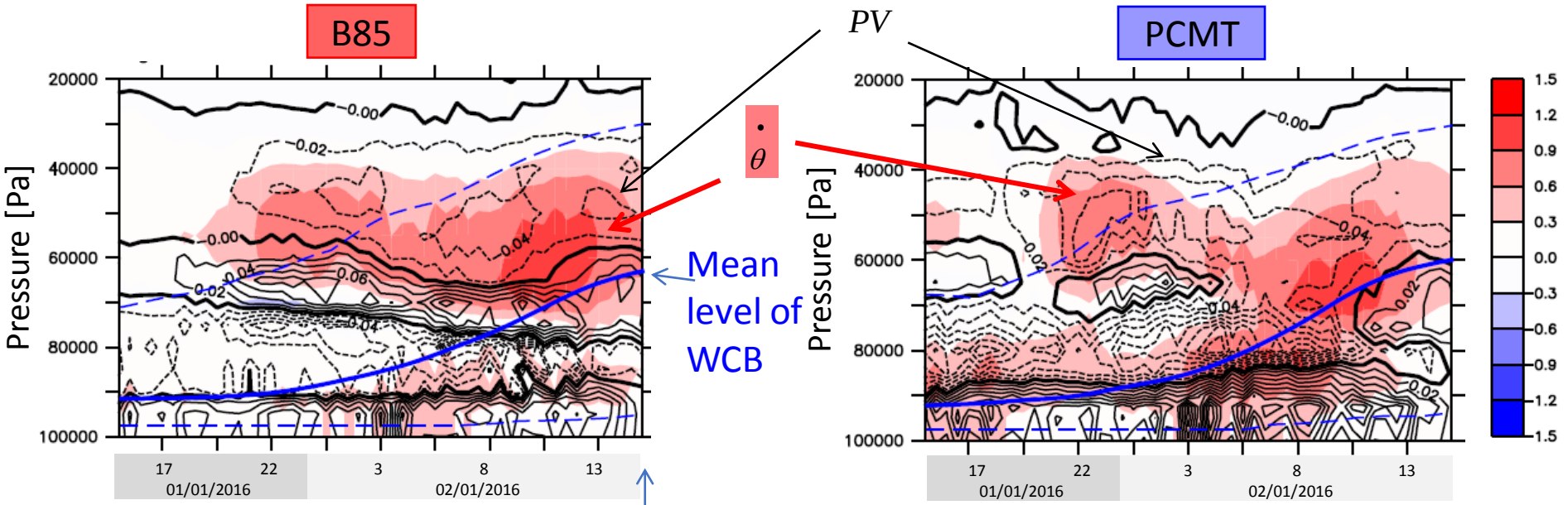




Sooner heating in PCMT

Later heating in B85

Vertical profile of the heating rate and PV tendency averaged over WCB trajectories during the 24h preceding the flight

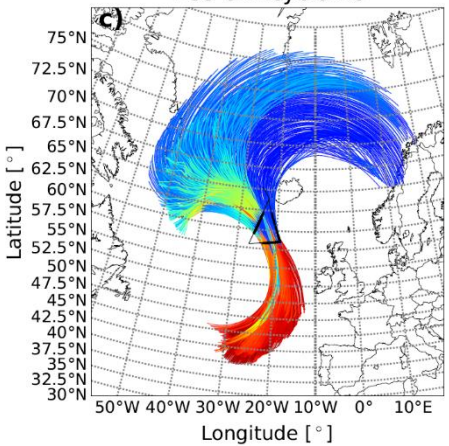


Separation anticyclonic/cyclonic trajectories

Mean direction during 3h -> to the left : cyclonic
-> to the right : anticyclonic

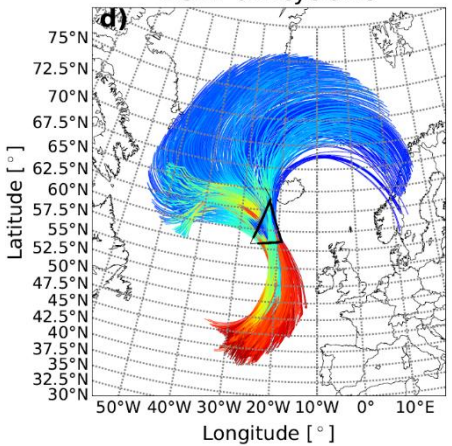
B85

755



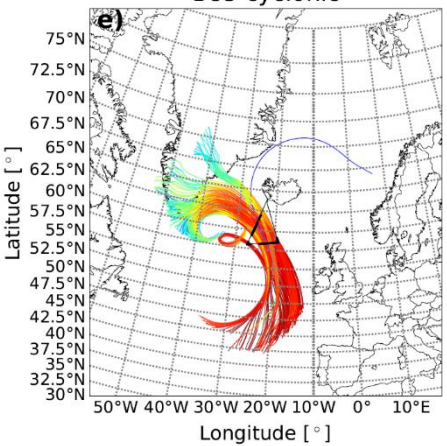
PCMT

708



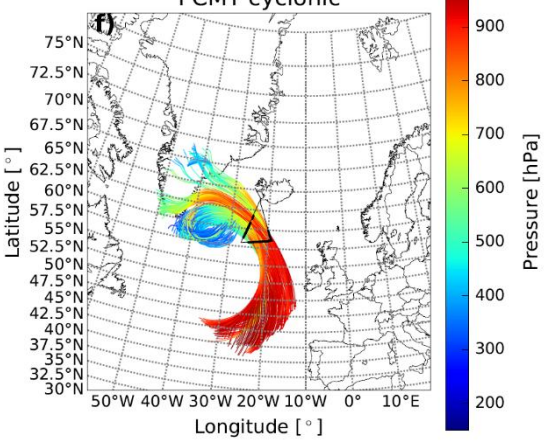
B85

154

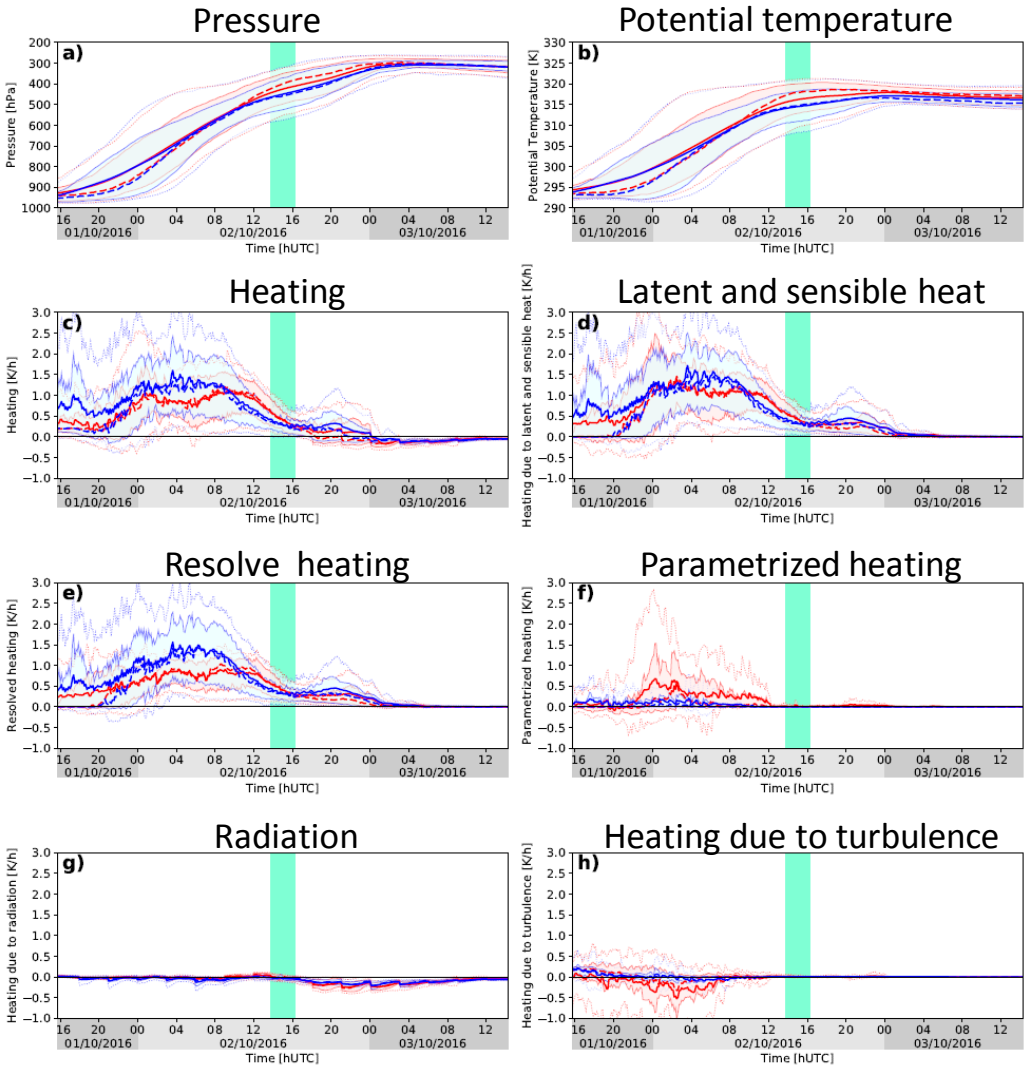


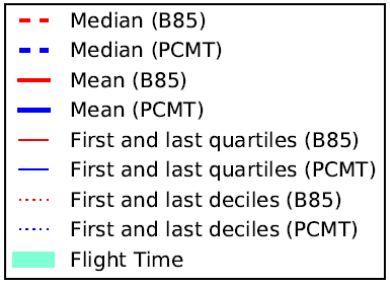
PCMT

270



Heating budget for anticyclonic trajectories above 315K



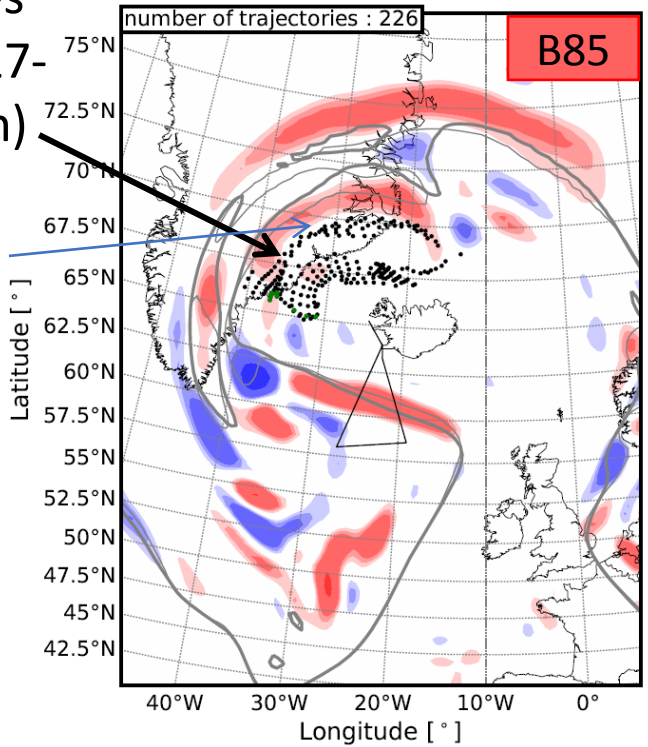


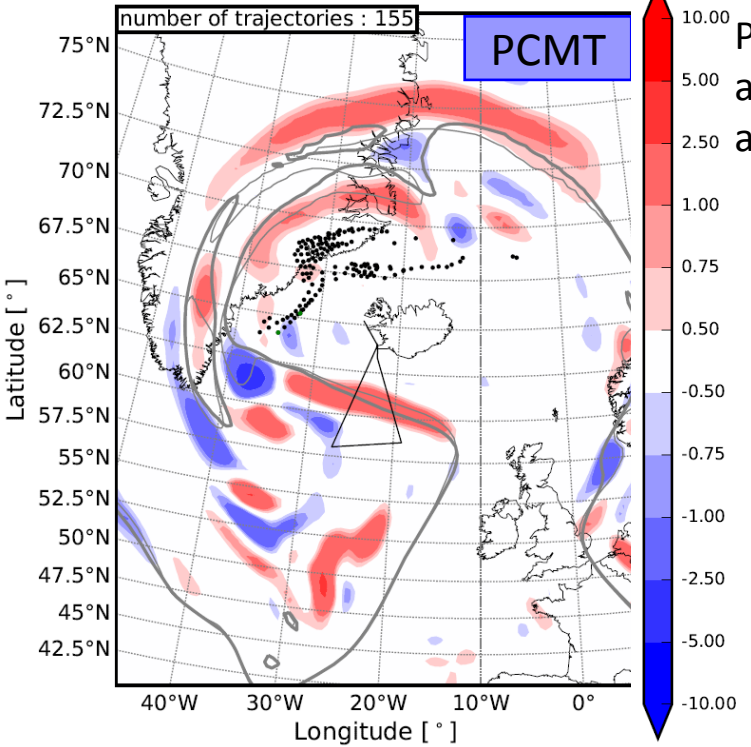
Heating in ice phase from parametrization with B85

Ridge Building

Trajectories between 317-323K (+36h)

PV_{PCMT}-PV_{B85}>0

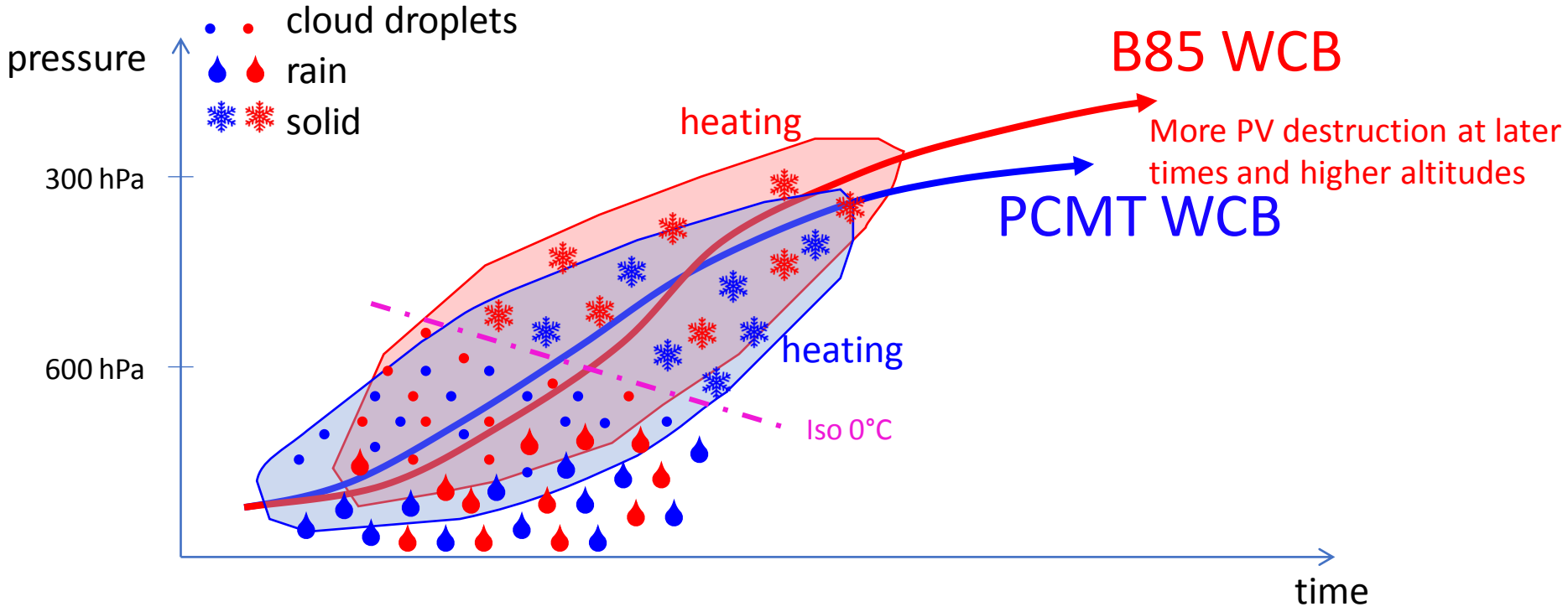




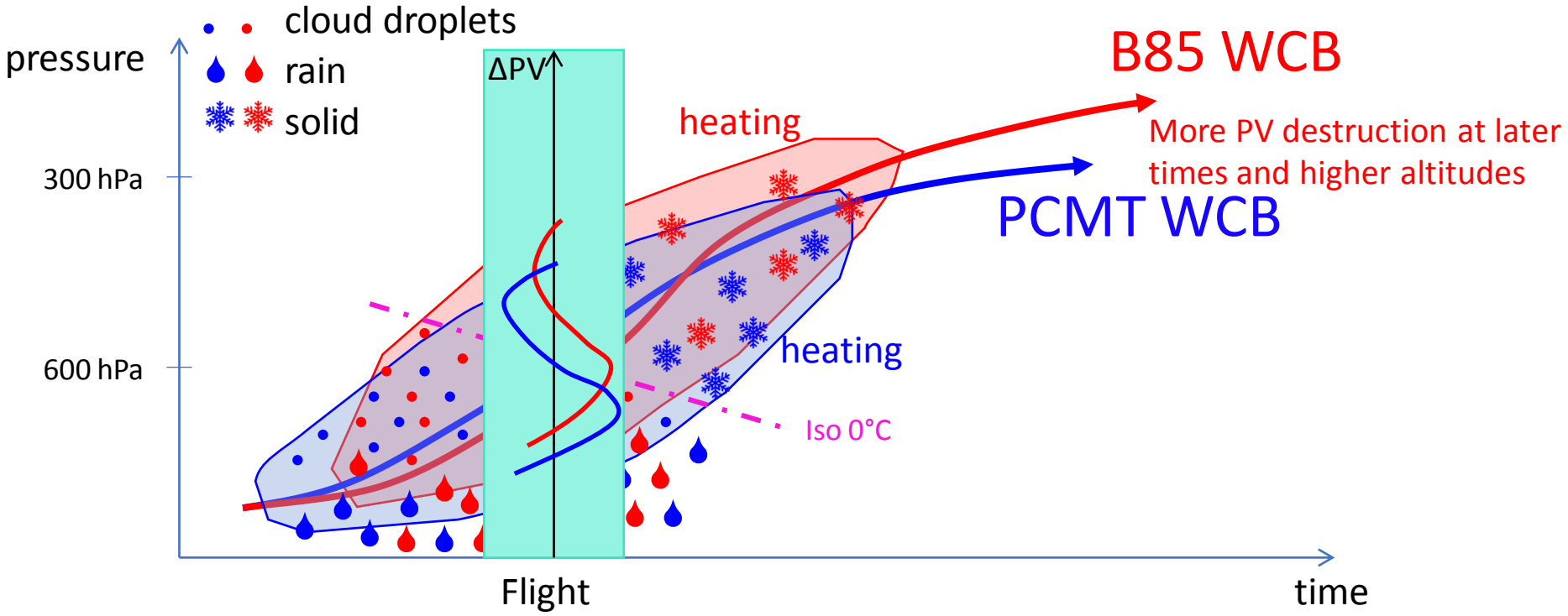
PV anomaly at 320K

Weaker ridge building and less WCBs reaching isentrope 320 K in PCMT than B85 at later stage

Conclusions



Conclusions



- More PV production
- Both PV production & destruction

Outlook

Short-term: (article)

- Improve heating and PV budget
- Generalize the results to all WCBs: computation of WCB trajectories from warm sector.
- Interpretation of the differences between the two schemes

Long-term:

- Confirmation on other flights (see poster)
- Use other convection schemes (new PCMT, Tiedke)

Thank you for your attention !