Impact of deep convection parameterization of a global atmospheric model on the warm conveyor belt and the jet stream

Meryl WIMMER

CNES, Laboratoire de Météorologie Dynamique, Paris

meryl.wimmer@lmd.ipsl.fr

G. Rivière, P. Arbogast, J.-M. Piriou, J. Delanoë, C. Labadie , Q. Cazenave, J. Pelon

Main questions

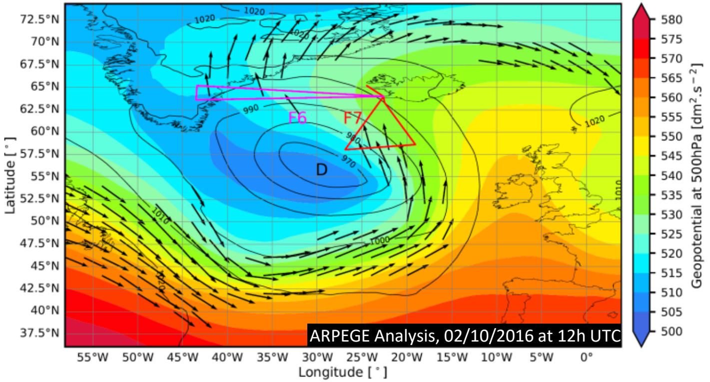
1) **How different the jet stream can be between two forecasts with different deep convection representations?**
2) **What are the underlying processes ?**
3) **Can NAWDEX observations be useful to determine the most relevant forecasts?**

<u>**Case study**</u>:

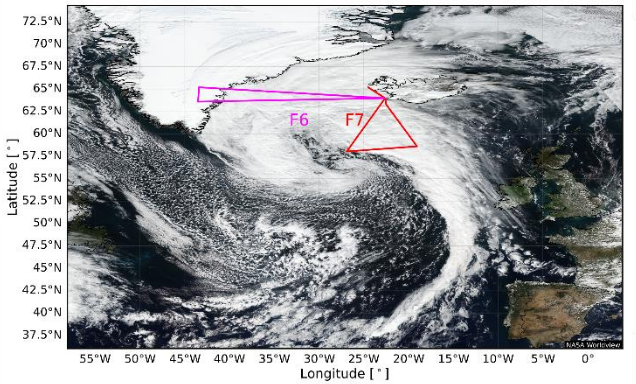
- **Stalactite Cyclone** : NAWDEX IOP 6

North Atlantic Waveguide and Downstream impact EXperiment (Sep-Oct 2016)

Geopotential at 500 hPa (shading)
Mean Sea Level Pressure (contour)
Wind speed and direction at 300hPa (arrow)



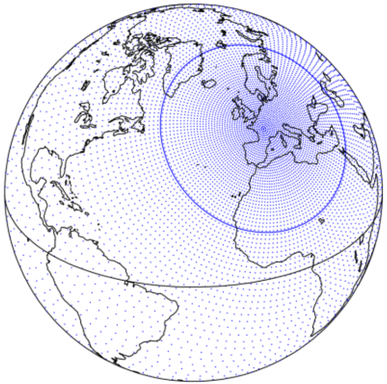
Visible picture from VIIRS of the Suomi NPP satellite



Global atmospheric model: ARPEGE-EPS

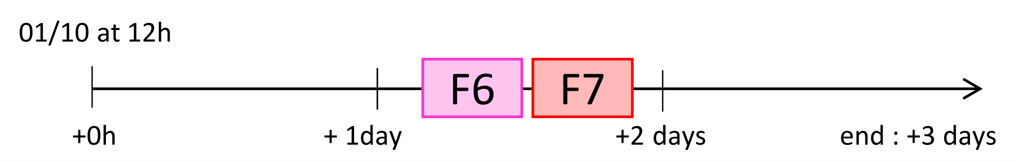
ARPEGE-EPS (Descamps et al. 2015)

- Based on the global ARPEGE model (Courtier et al., 1991; Pailleux et al., 2000)
- Horizontal resolution: TL798 with stretching C2.4
  -> 10km on France, 20km on Islande
- Levels: 90 from 14m to 50km (1hPa)
- Time step: 450s
- Initial Condition: ARPEGE operational analysis of the 01/10/2016 at 12h UTC
- Forecast: 3 days
- Members: **Multiphysics** with different parameterization schemes



Outputs:

- Horizontal resolution: lon × lat : 0,5° × 0,5°
- Level: model grid
- Time step: 15min (900s)
- Heating and PV tendencies



Three hindcast simulations

Simulation B85

Bougeault (1985) 's scheme:
- Mass-flux scheme
- Closure in humidity convergence

➡ used in operational NWP version

Simulation PCMT

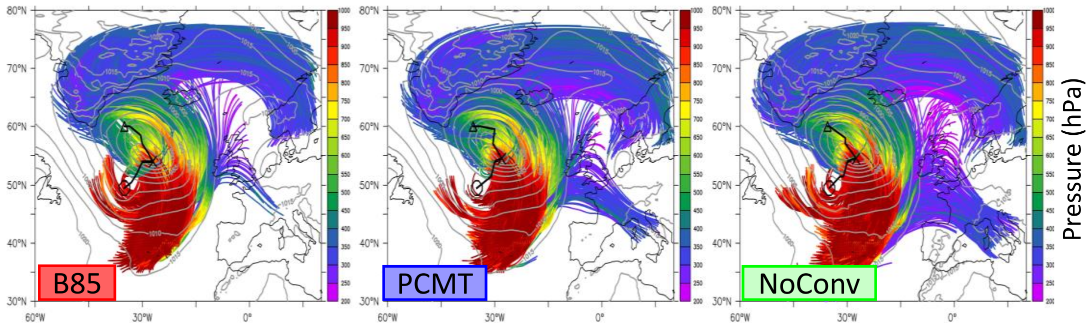
PCMT (Piriou et al, 2007):
- Mass-flux scheme
- Closure in CAPE
- Linked to microphysics and transport schemes

➡ used in CNRM-CMIP6

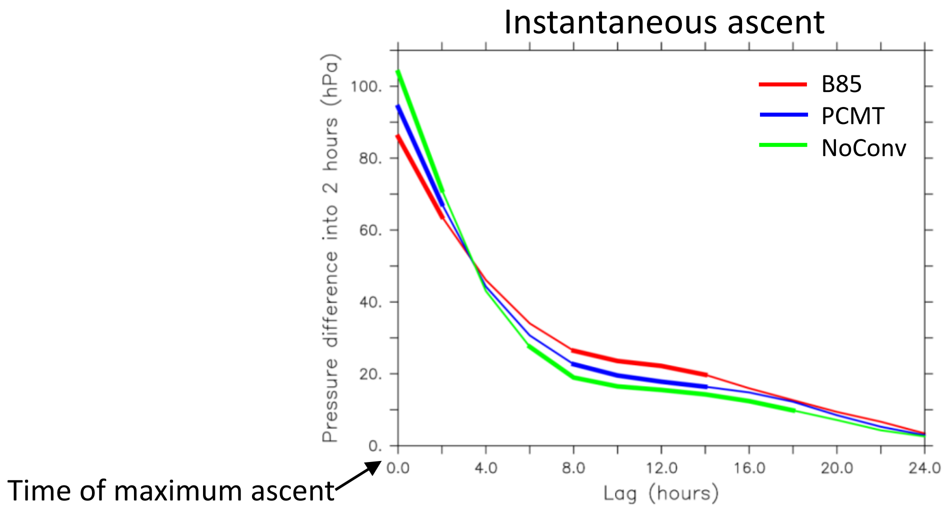
Simulation NoConv

No parametrized deep convection

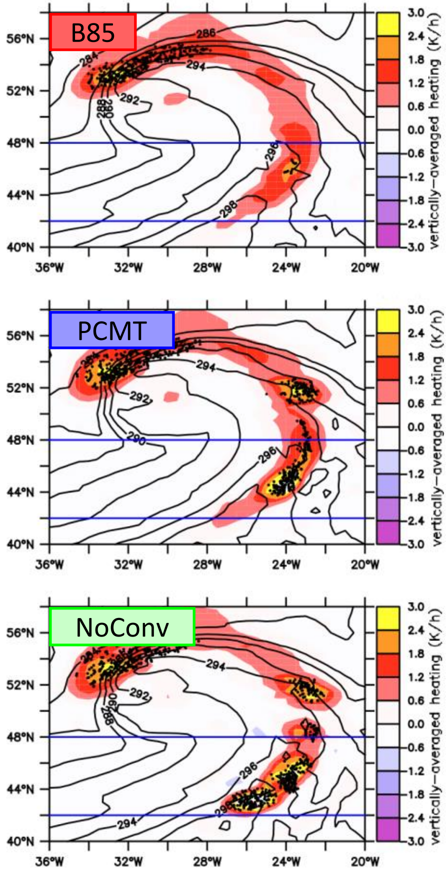
WCB representation:
48h Lagrangian trajectories with an ascent of 300hPa in 24h



Differences with and without deep convection parameterization scheme



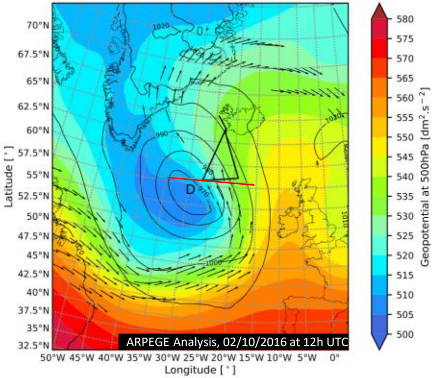
Vertically averaged heating between 300 and 800hPa (shading) and potential temperature at 850hPa. Time range: **+9h**



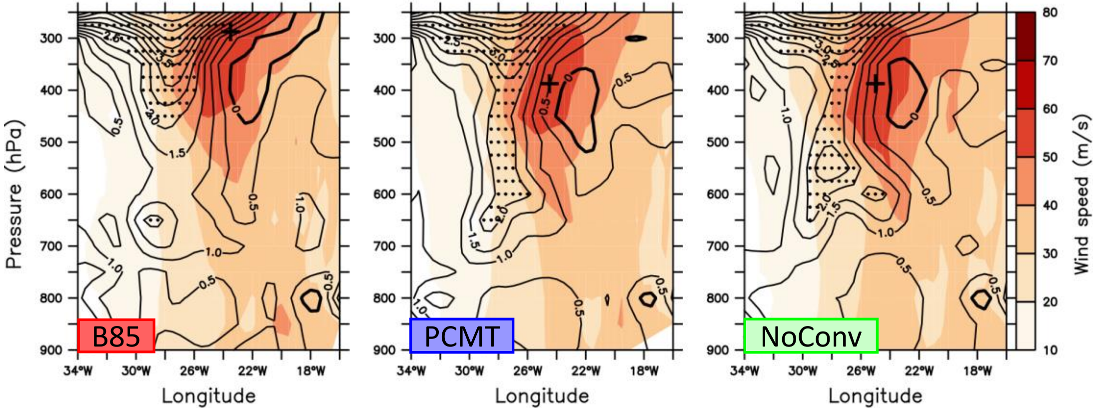
Without: localized cells with strong heating
+ more abrupt but rapid ascents of the WCB

With: more homogeneous heating
+ more moderate but more sustained ascent in the WCB

Impact on the vertical structure of the jet stream above the cold front



Wind speed (shading) and PV (contour) at 58°N, time range: **+24h**



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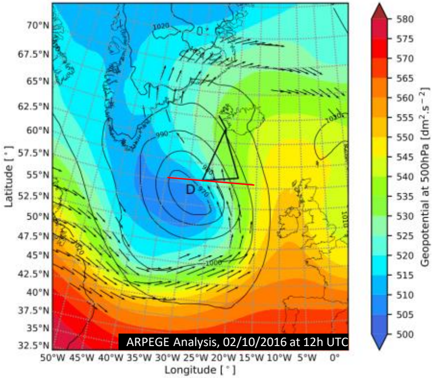

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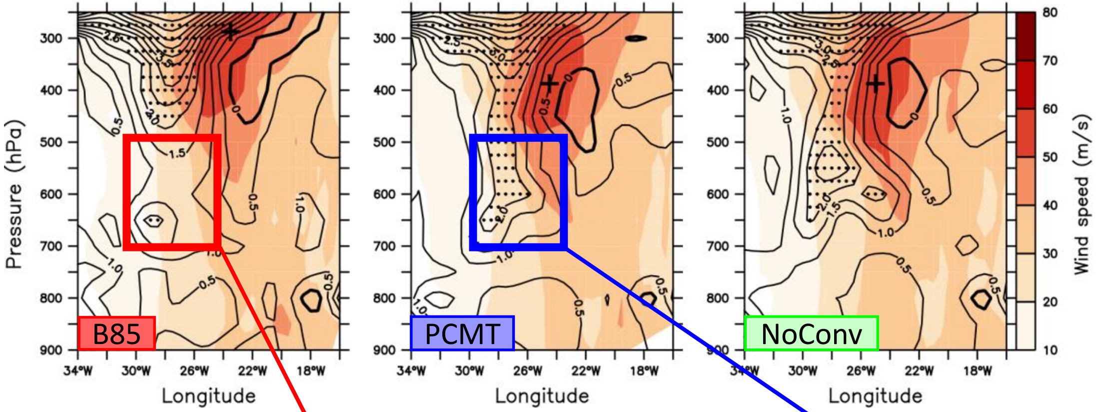
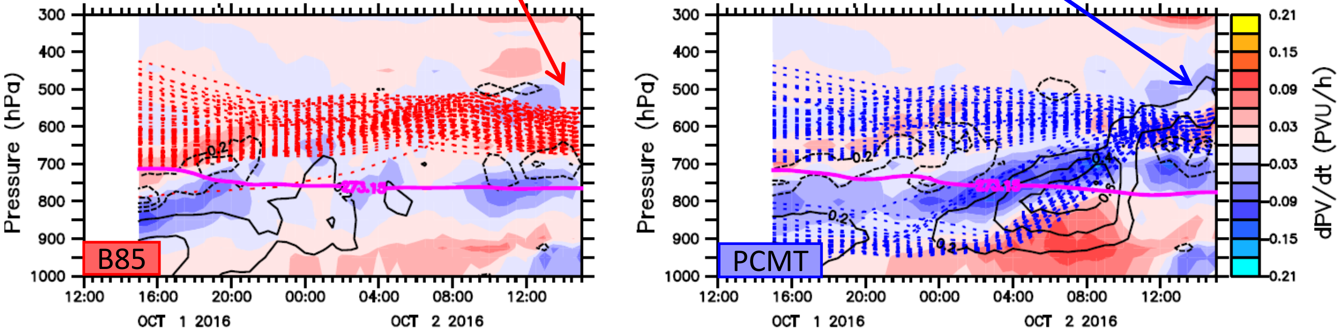


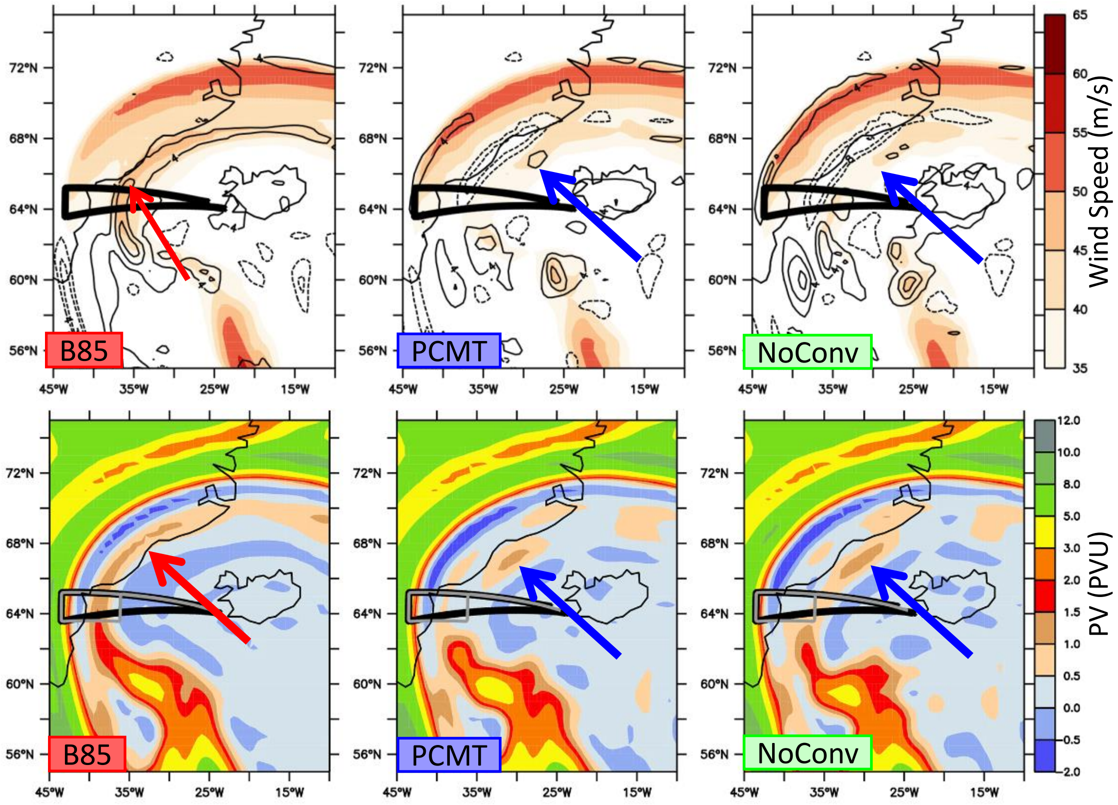
PV tendencies (shading) and heating (contour) along backward trajectories



Sooner heating in PCMT
-> acceleration of Jet Stream in mid-troposphere

Impact on the double structure of the jet stream in the WCB outflow

Wind Speed and PV at 300hPa (shading), Time range : **+24h**



Double structure of the jet stream along the Greenland coast

↓

PV dipole along the Greenland coast

Secondary jet too far East

↓

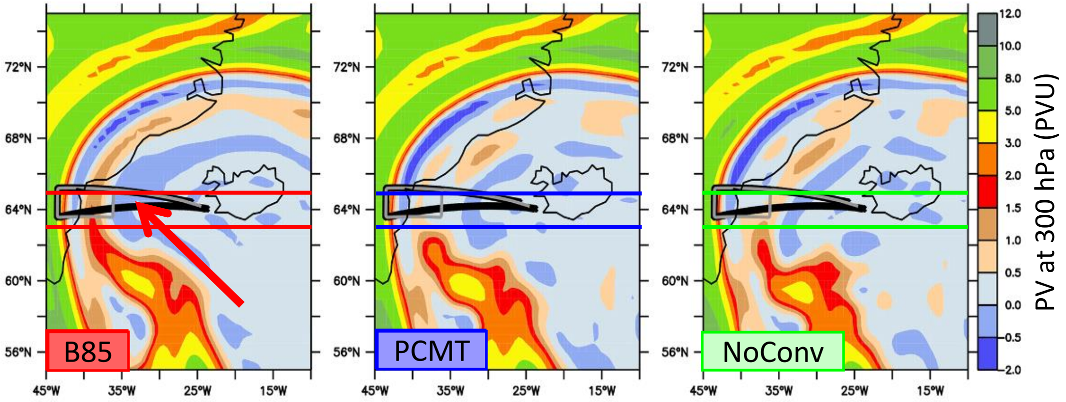
PV dipole too far East

Impact on the double structure of the jet stream in the WCB outflow

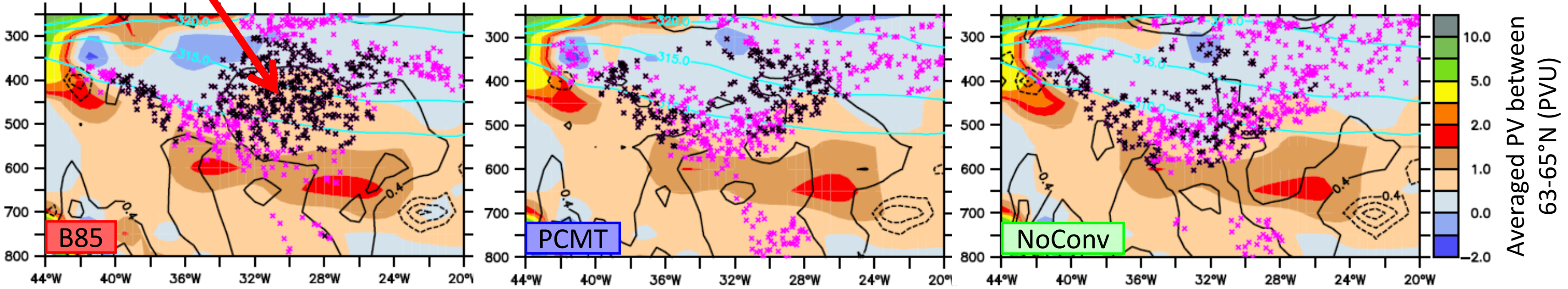
Heating and PV extend further up in B85
-> Impact the jet stream at high altitude

Numerous WCB trajectories in B85
-> ridge building in high altitude -> PV more in West

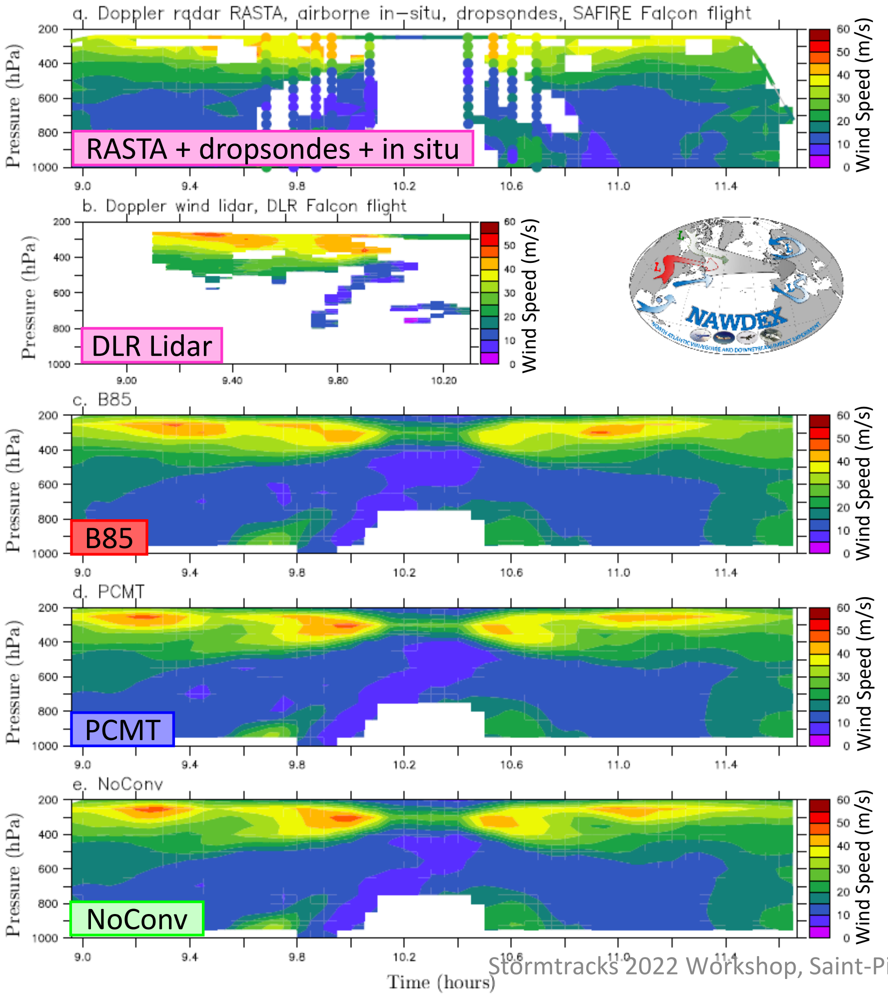
PV at 300hPa, Time range : **+24h**

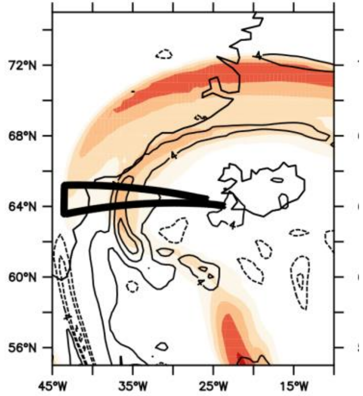


PV (shading), heating (black contour), θ (cyan contour) averaged between 63-65°N, Time range : **+24h**



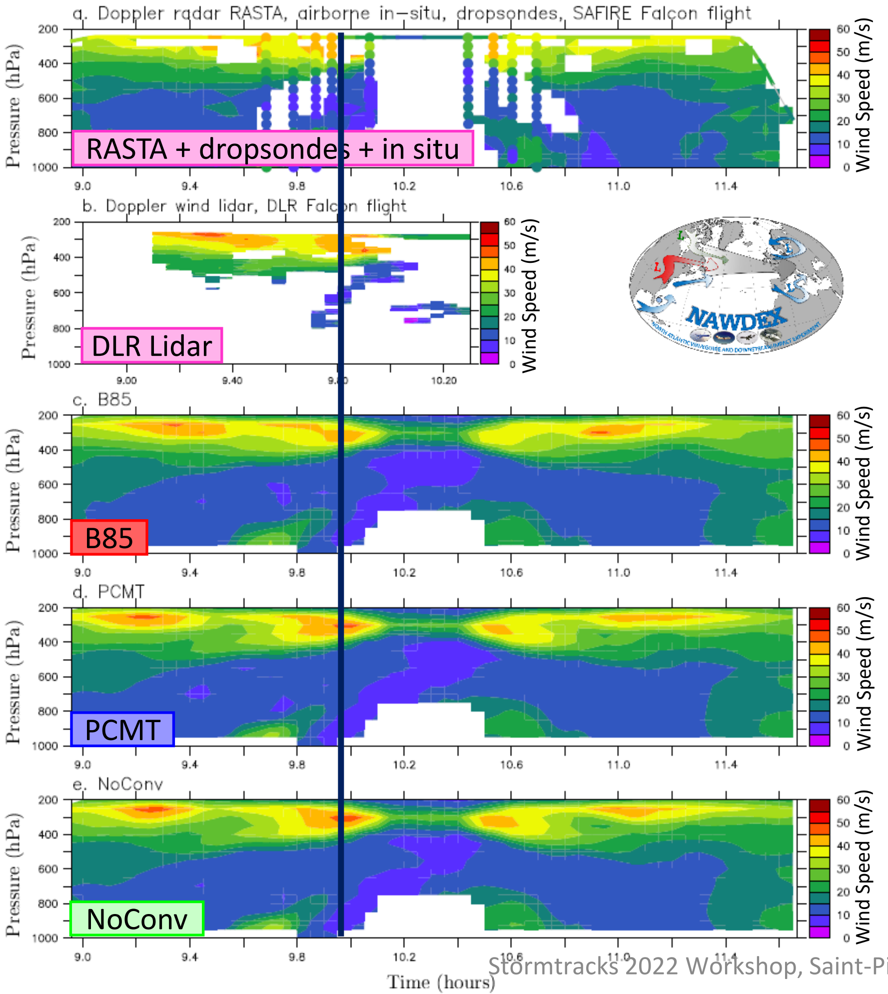
Comparaison between 1 day forecast to observations from the NAWDEX field campaign: RASTA Doppler Radar and DLR Lidar





Wind Speed (m/s), Time range : **+21-24h**

Comparaison between 1 day forecast to observations from the NAWDEX field campaign: RASTA Doppler Radar and DLR Lidar



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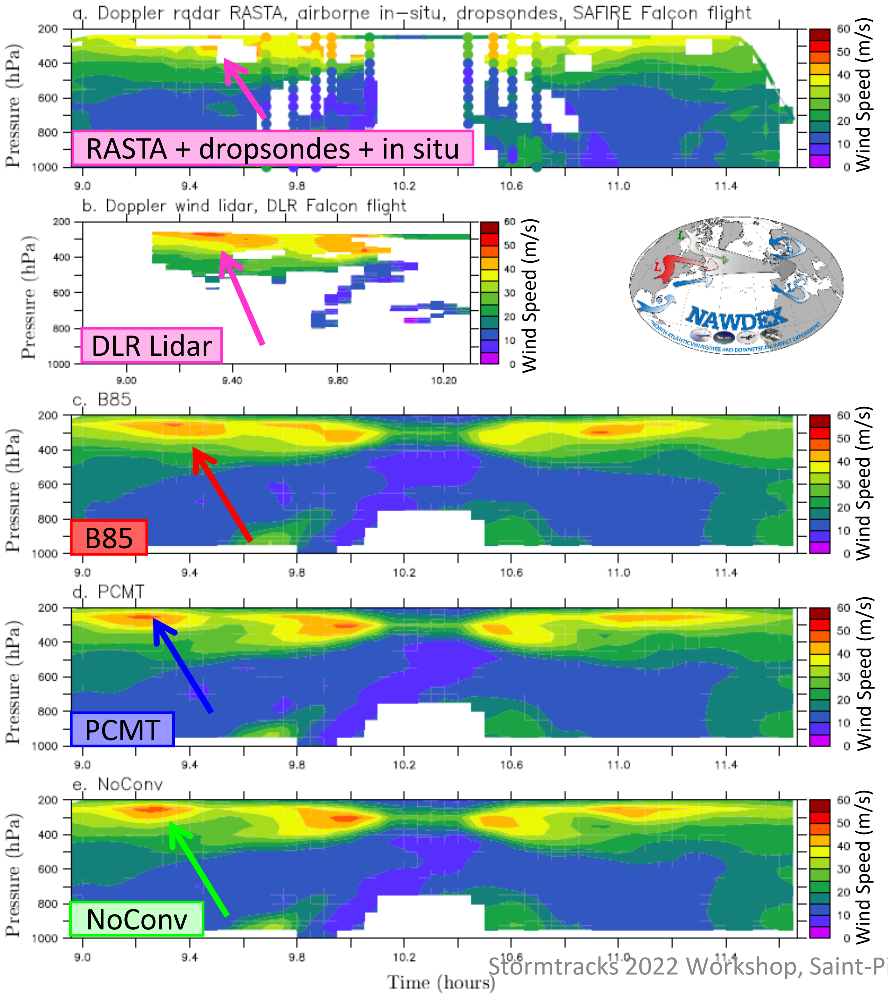


Comparaison between 1 day forecast to observations from the NAWDEX field campaign: RASTA Doppler Radar and DLR Lidar

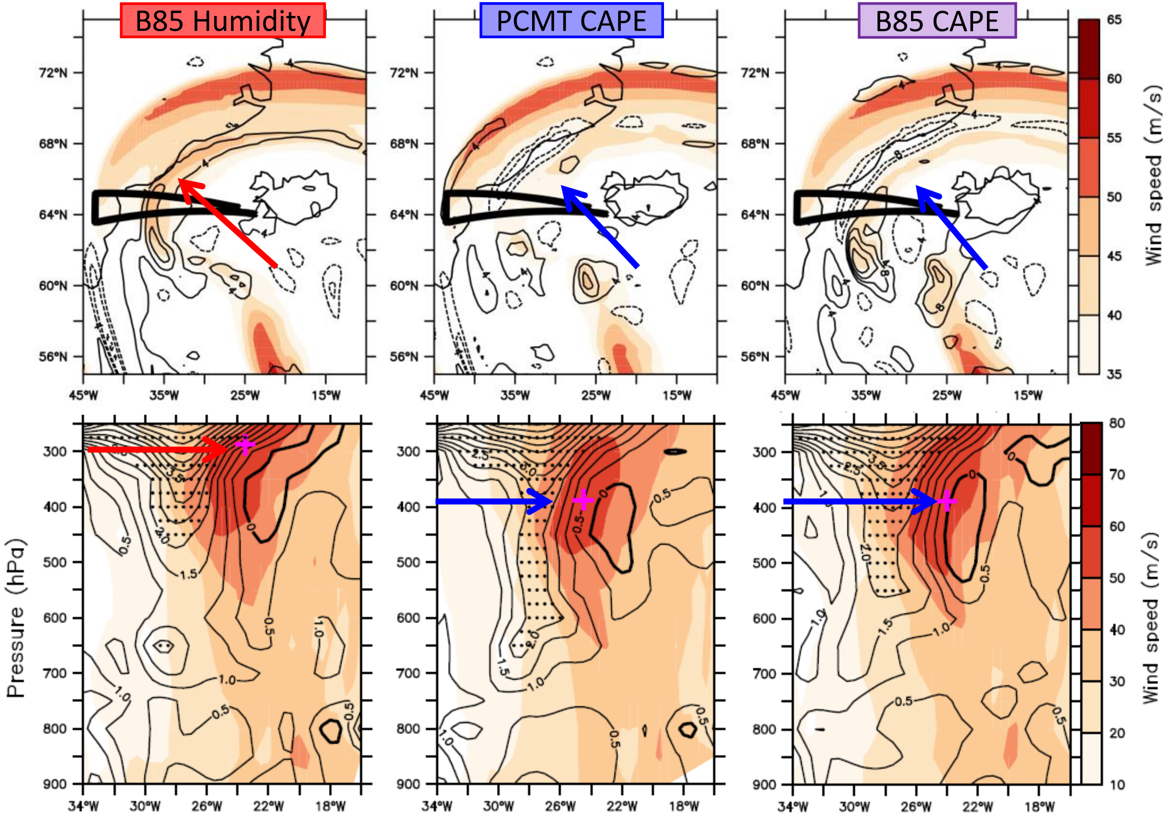
Main jet well localized with all ARPEGE simulations
Secondary jet better localized with B85

Wind Speed (m/s), Time range : **+21-24h**

Impact of closure of deep convection schemes

in the WCB outflow

above the cold front



CAPE closure less activated than humidity convergence closure

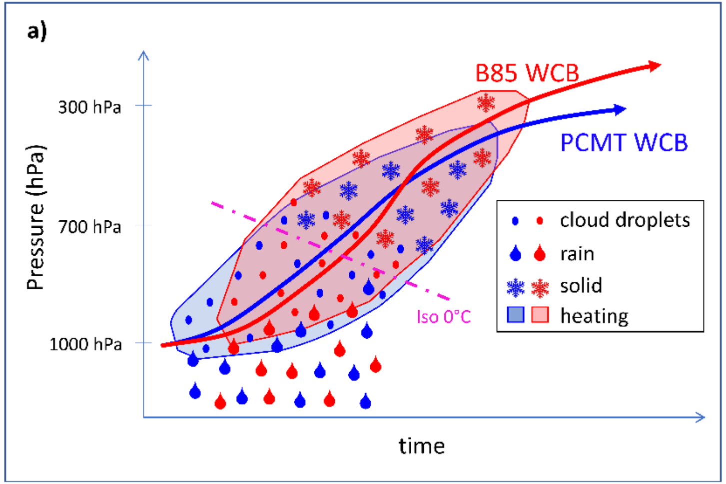
Conclusion

<u>Activation or not of the deep convection scheme</u>:

- **Without**: localized cells with strong heating + more rapid and abrupt ascents of the WCB
- **With**: more homogeneous heating + more moderate but more sustained ascent in the WCB

<u>Differences between deep convection parameterization</u>:

- **B85** : heating and PV extend further up
  -> impact the jet stream at high altitude
- **PCMT** : sooner heating
  -> acceleration of Jet Stream in mid-troposphere
- **Closure** of deep convection schemes plays a **key role** in B85-PCMT differences



➡ Rivière et al. (2021, WCD), Wimmer et al. (2022, WCD)

Thank you for your attention

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