Sensitivity of the warm conveyor belt of a deep cyclone to microphysics and turbulence schemes of the mesoscale model

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Introduction

Potential **misrepresentation of diabatic processes** through latent heat release **along WCBs** can lead to **PV error along the jet stream → Prediction error in NWP models** (Gray, 2014)

- Importance of **microphysical** processes among them (Joos and Wernli, 2012, Joos and Forbes, 2016)
→ But **lots of uncertainties** (Khain et al., 2015, Yan et al., 2015) in their representation

Among these uncertainties:
- **IFN (Ice Forming Nuclei) concentration**
- **Transition diameter ice/snow**
- **Ice crystals shape**
- **Ice/snow fallspeed**

Forbes et al., 2002, Clark and al., 2005, and Dearden et al., 2014 → Can affect mesoscale dynamics and local diabatic heating rates

- **CCN (Cloud Condensation Nuclei) concentration**
- **Supercooled droplets repartition**
- **Subgrid condensation scheme**

Rosenfeld et al., 2008, Igel et al., 2013, Thompson and Eidhammer, 2014 and Joos el at., 2017 → Could affect cloud invigoration (diabatic heating rates in mixed phase)

- **Turbulent kinetic energy dissipation** could modify the latent heat release
Also, turbulence may have an impact on vertical velocities and consequently on microphysics
-Turbulence representation is often **1D** in models (vertical direction) but is **3D** in nature
-**Mixing length** can have various formulations (among others: Bougeault and Lacarrere, 1989, Deardorff, 1980)

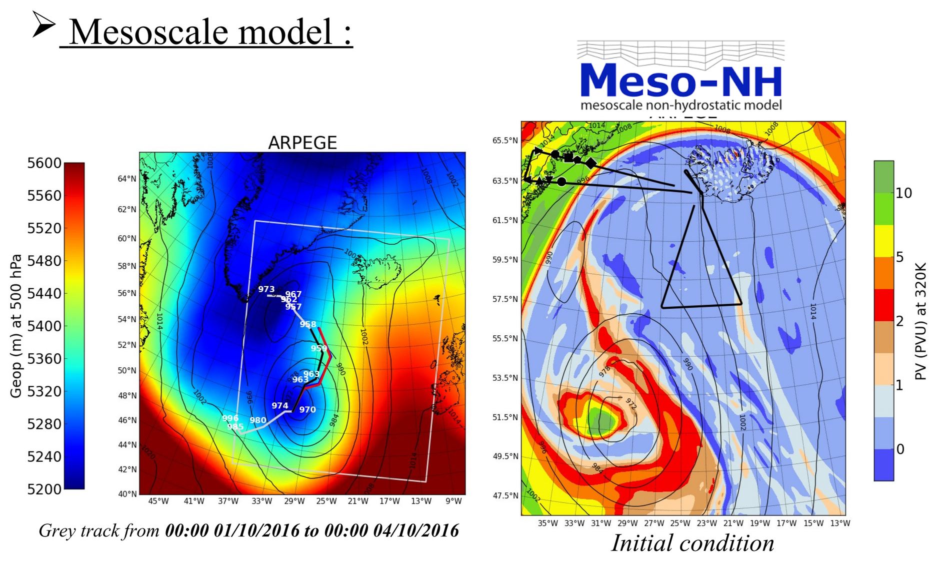
Larger vertical extension that a particle can perform consuming the TKE | Larger vortex of the mesh

- **How is the WCB representation sensible to the microphysics and turbulence schemes ?**
- **Are there any configurations that get closer to the obs ?**

Evaluation is made on the ridge development (PV at 320 K) and with remote sensing observations obtained during NAWDEX

Focus on Stalactite cyclone (observed during NAWDEX)

Mesoscale model :

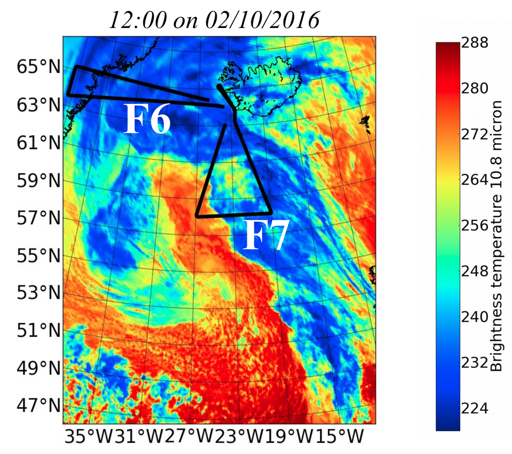


Grey track from 00:00 01/10/2016 to 00:00 04/10/2016
Initial condition 00:00 on 02/10/2016

- Méso-NH (Lac et al., 2018)
- **Simulations from 02/10/16 00h to 03/10/16 00h**
Output : every 15min
- CI and forcing : Global operational model ARPEGE
- $\Delta X \Delta Y$ → **2.5 km*2.5 km** (explicit convection)
- Microphysics schemes
ICE3 (Pinty and Jabouille, 1998) – **1 moment**
LIMA (Vié et al., 2016) – **2 moments**

Observations :

MSG satellite
12:00 on 02/10/2016

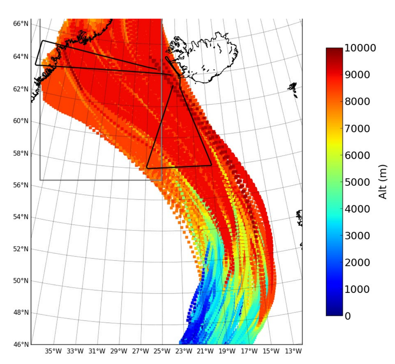


- **Flights of French Safire Falcon on 02/10/2016 during NAWDEX (Schäfler et al., 2018)**:
F6 Cyclonic WCB outflow region **[09:30 - 11:30]**
F7 WCB ascending branch **[13:00 - 16:00]**

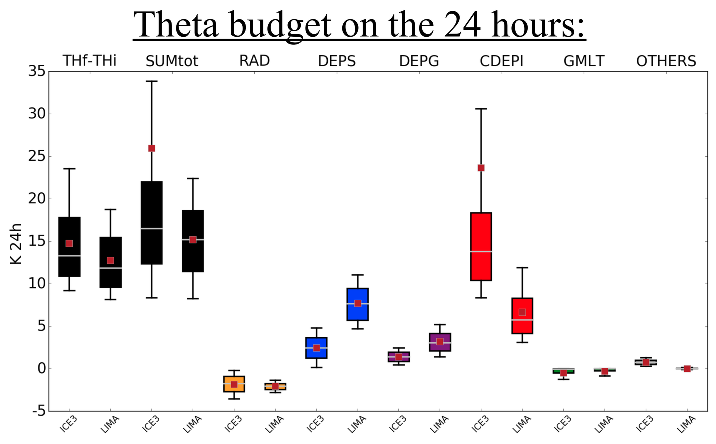
- RASTA + Lidar embedded :
Reflectivity, Ice Water Content (retrieved from variational algo; Delanoë and Hogan, 2008), Wind

Main diabatic processes along the warm conveyor belt

Trajectories ascending 300 hPa in 24 h:



Theta budget on the 24 hours:

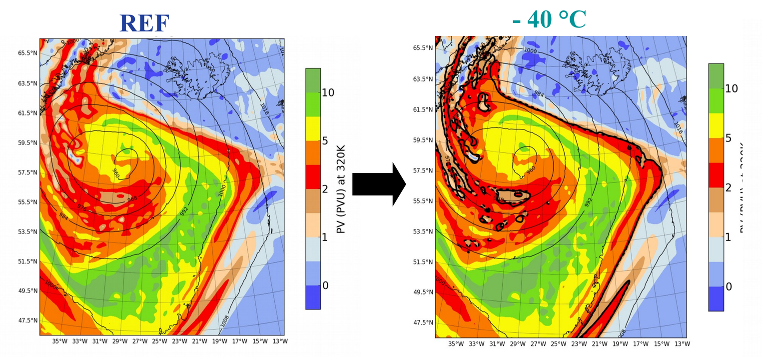


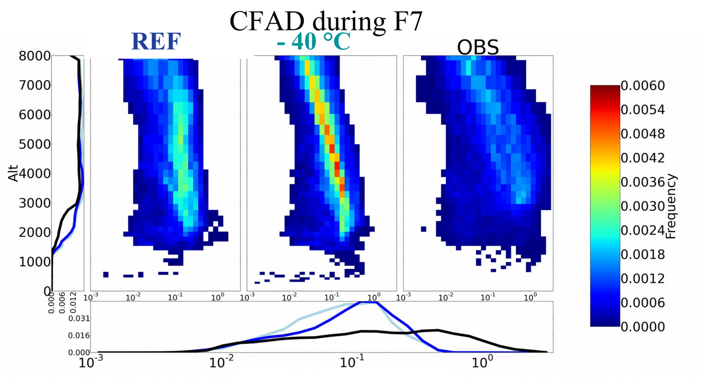
RADIATION
DEPOSITIONAL GROWTH ON SNOW
DEPOSITIONAL GROWTH ON GRAUPEL
DEPOSITIONAL GROWTH ON DROPLETS AND ICE
GRAUPEL MELTING
OTHERS (TURBULENCE,...)

Sensitivity to microphysics

On supercooled droplets repartition

In ICE3, it is possible to have supercooled droplets till -20°C, test is perform till -40°C (more consistent with literature)





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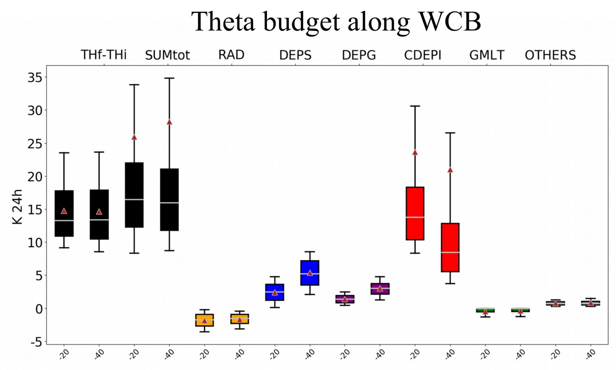
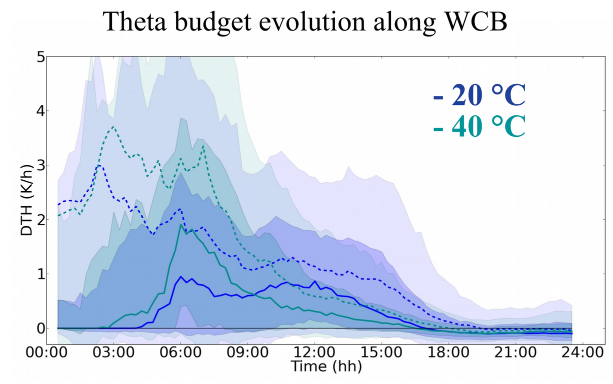
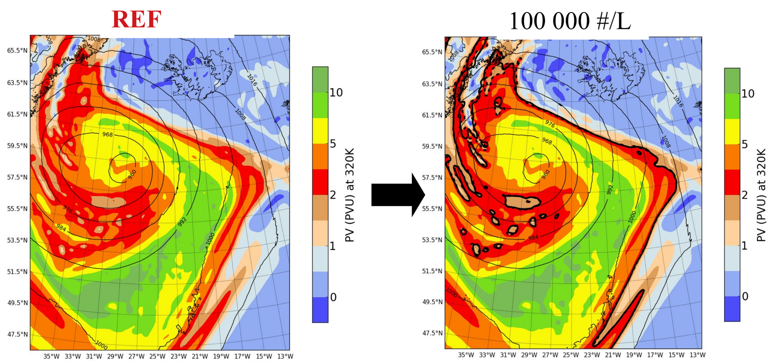




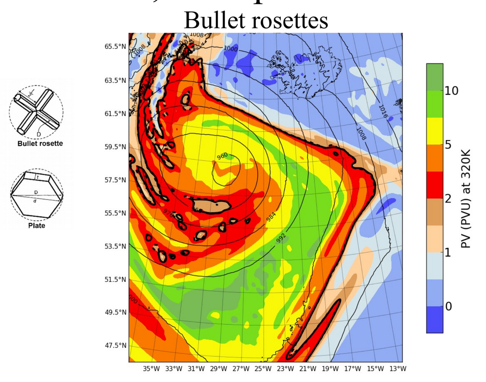
→ Ridge: Slight shift, less pronounced 'with -40 °C'
→ IWC: Slope closer to the observations
Intensity further from the observations
→ Budget: Same total budget but different processes importance and at different time and location. Thus it may impact the PV.

→ Mixed phases clouds differ according to the repartition between liquid and solid. On going tests on Tao et al. (1989) formulation, linear formulation according to temperature, Ice fraction given by the slow microphysics.

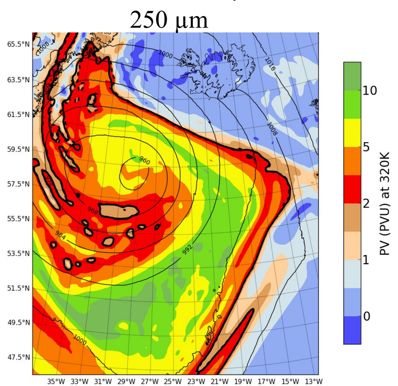
On IFN concentration
In LIMA, from 10 000 #/L to 100 000 #/L



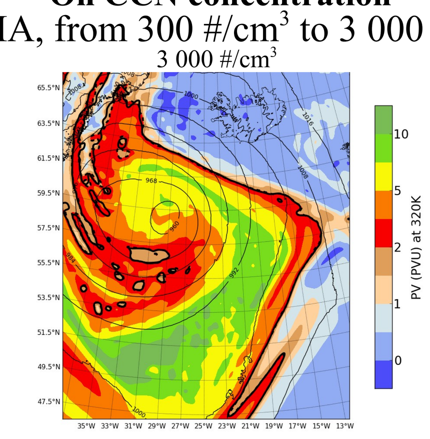
On crystal shape
In LIMA, from plates to Bullet rosettes



On transition diameter ice/snow
In LIMA, from 125 µm to 250 µm



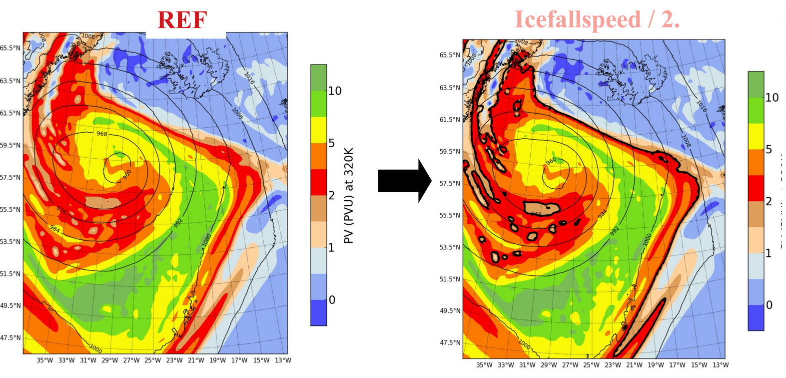
On CCN concentration
In LIMA, from 300 #/cm^3 to 3 000 #/cm^3

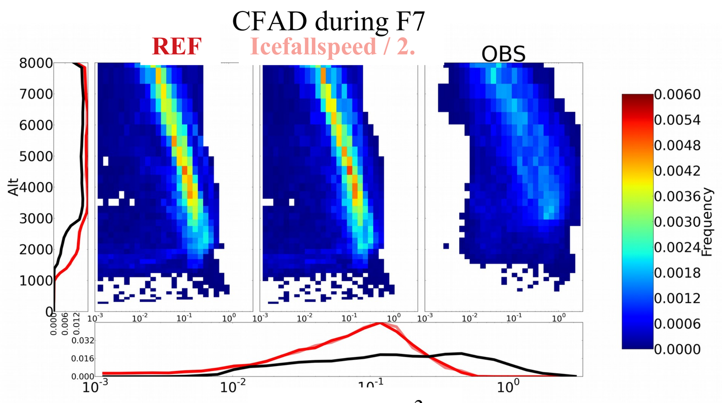


→ After 24h of simulations, very slight impact on the PV and very very slight impact on IWC

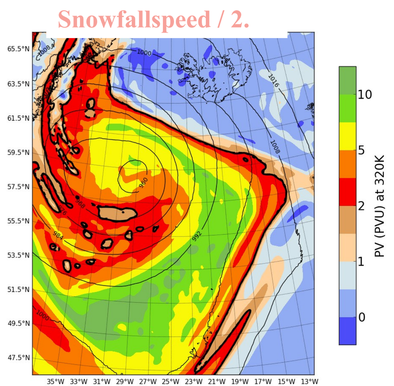
→ On going tests on a 48h simulation on a larger domain

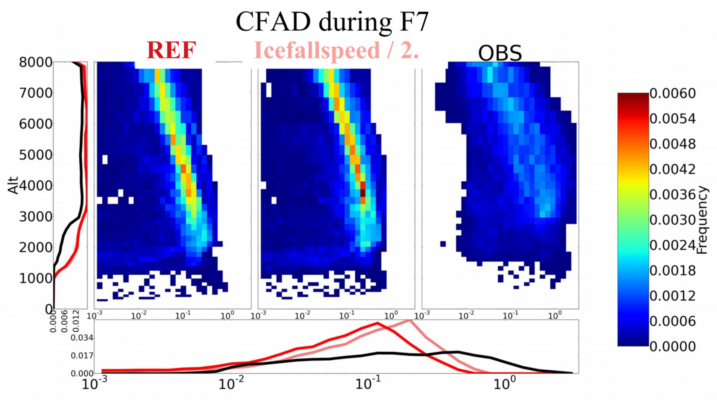
On ice fallspeed (getting closer to the obs)
In LIMA,





On snow fallspeed (getting closer to the obs)
In LIMA,



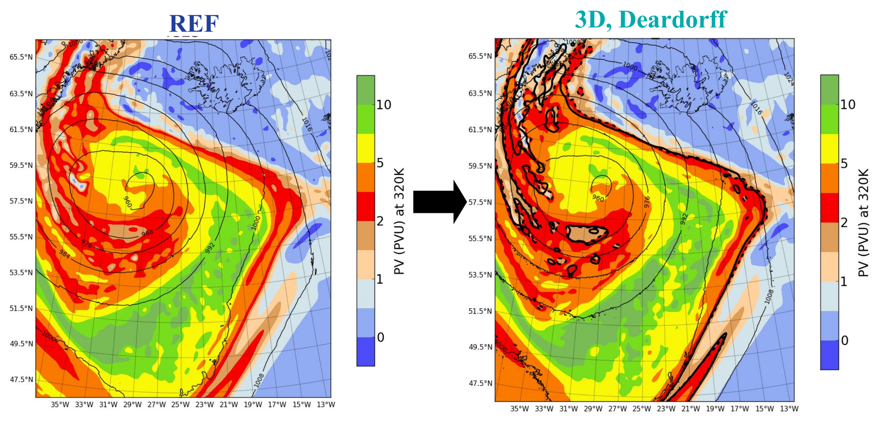


→ After 24h of simulations, very slight impact on the PV at 320 K but important impact on IWC when reducing the snowfallspeed (but it should not have a strong impact on latent heat release)

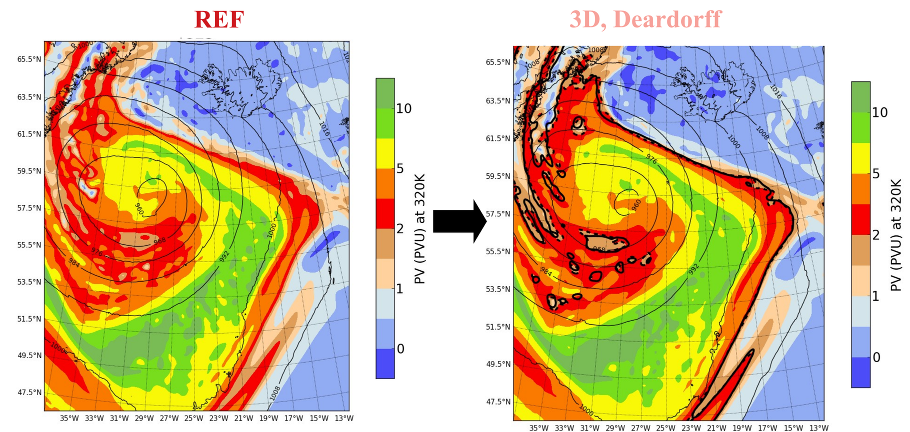
Sensitivity to turbulence

On mixing length and from 1D to 3D

In ICE3, mixing length from 1D BL89 (Bougeault, 89) to 3D Deardorff, 1980



In LIMA, mixing length from 1D BL89 (Bougeault, 89) to 3D Deardorff, 1980



→ Notable impact on the PV at 320 K, but depend on the microphysical scheme used.
Little impact on microphysic, more impact on the boundary layer.

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