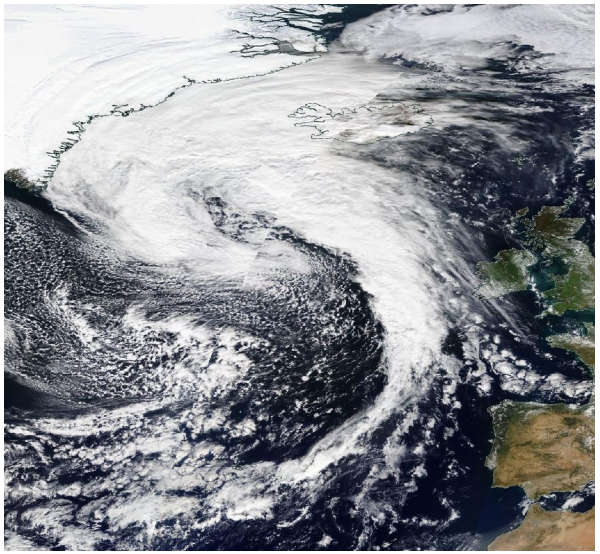
Impact of **different microphysics** on the **warm conveyor belt** of a deep **extratropical cyclone** observed during the **NAWDEX** campaign and on its associated **ridge building**



Stalactite cyclone (01 - 05/10/16)

Marie Mazoyer (CNRM), Didier Ricard (CNRM), Gwendal Rivière (LMD), Philippe Arbogast (Météo-France), Julien Delanoë (LATMOS), Benoit Vié (CNRM), Christine Lac (CNRM)

Scientific question

- Using **distinct microphysical schemes** to simulate an extratropical cyclones :
  -How does the **latent heating release differ** ?
  -How is the **ridge building impacted** ?
  -Which one of the schemes provides the **best representation** ?

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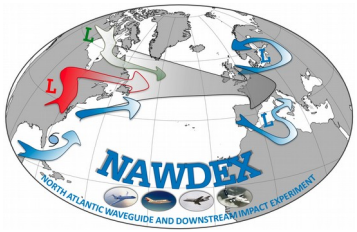
How ?

- Runs of the French research convective permitting model Méso-NH with two distinct microphysical scheme of an extratropical cyclone observed during Nawdex

Meso-NH
mesoscale non-hydrostatic model

ICE3 VS **LIMA**
(Used in French NWP)



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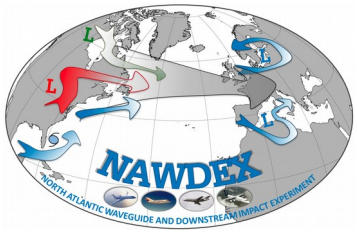


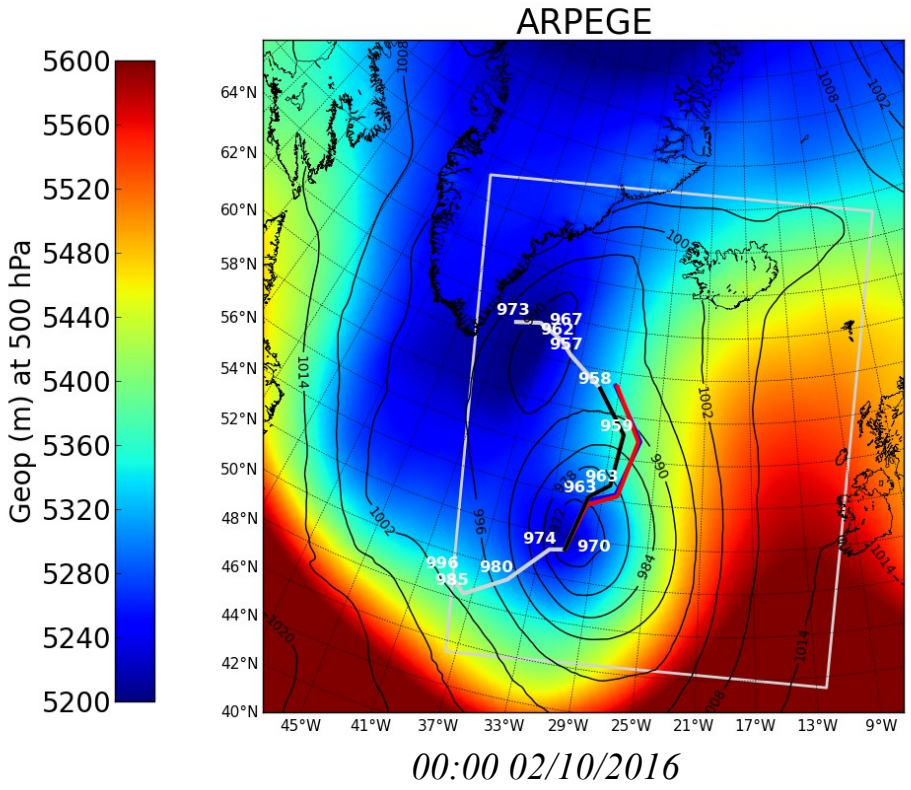
How to evaluate the schemes?

- Remote sensing airbone observations

We can not measure the latent heating release but we can use the reflectivity and retrieve the Ice Water Content ⚠ → It is uncorrelated metrics

Case study from the Nawdex campaign

➢01/10/2016 – 05/10/2016 → Initiation, development and decay of the **'Stalactite' cyclone**



Strong WCB amplifying the ridge building

Formation of a **Scandinavian blocking** that last until the end of the field campaign (several weeks)

Focus on the development on 02/10/2016

*Grey track from **00:00 01/10/2016 to 00:00 04/10/2016***

26 hPa decline in 24h

Numerical experiments and comparison with observations of the 'Stalactite' cyclone

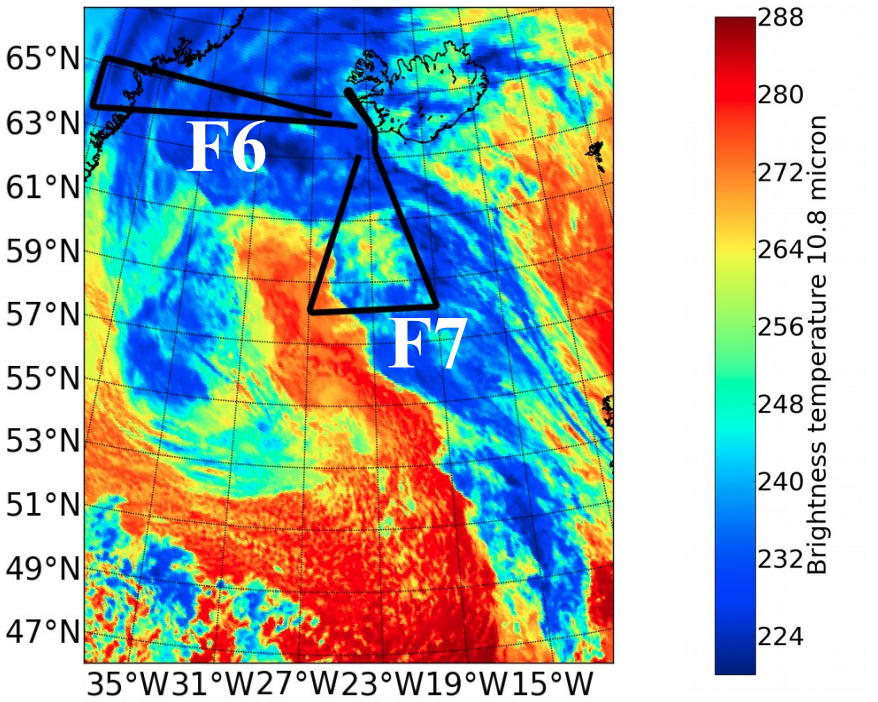
- **Flights of French Safire Falcon on 02/10/2016**:
  F6 Cyclonic WCB outflow region **[09:30 - 11:30]**
  F7 WCB ascending branch **[13:00 - 16:00]**

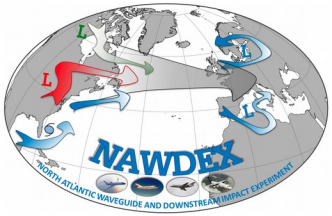
➢RASTA embedded :
Reflectivity, Ice Water Content (retrieved from variational algo; Delanoë and Hogan, 2008), Wind

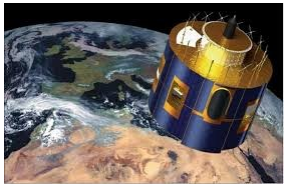
➢F6 : Dropsondes (P,T,U,RH)

MSG satellite

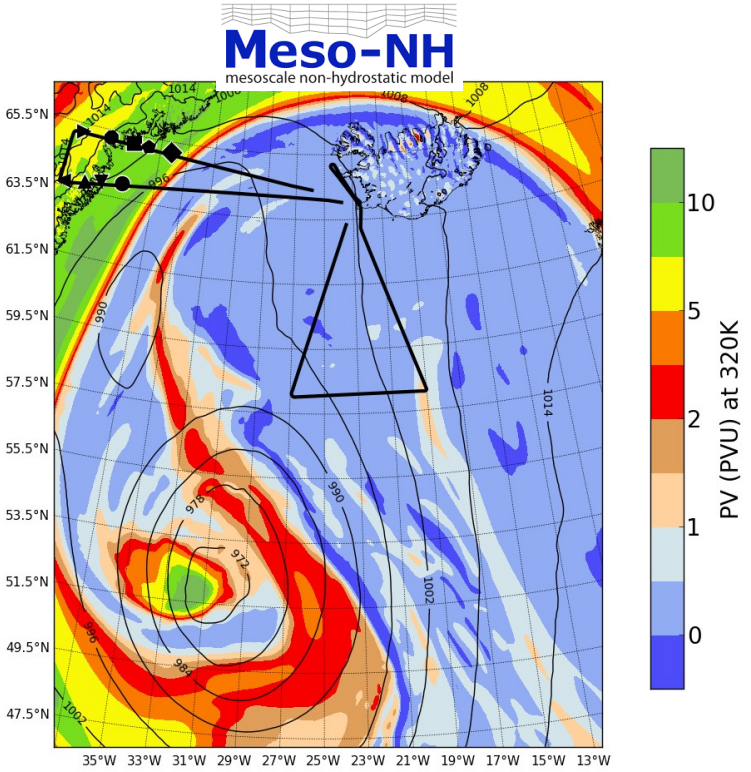
12:00 on 02/10/2016







Numerical experiments and comparison with observations of the ‘Stalactite’ cyclone



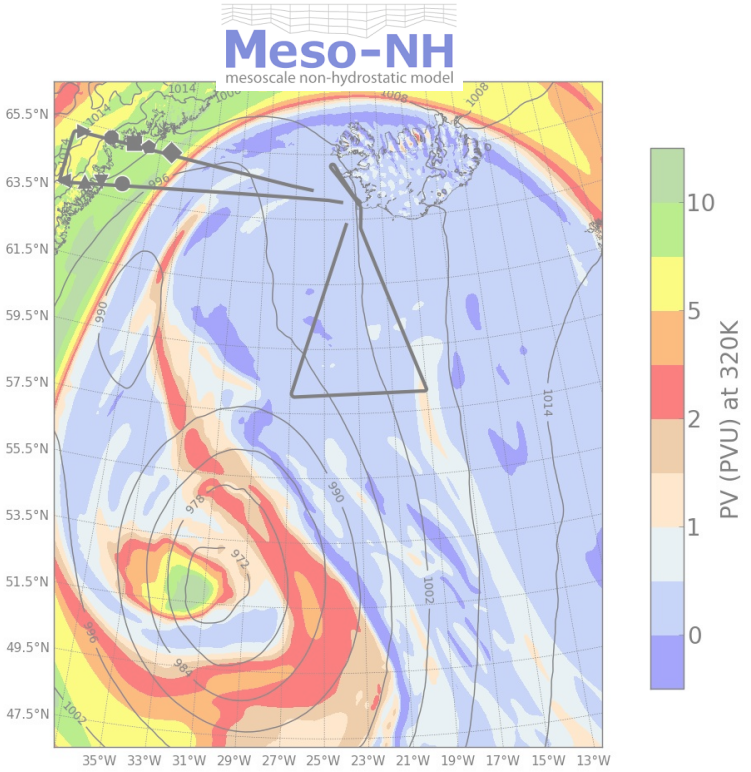
Initial condition
00:00 on 02/10/2016

- **02/10/16 00h → 03/10/16 00h**
  Output : every 15min
- CI and forcing : Global operational model ARPEGE
- ΔXΔY → **2.5 km*2.5 km**
  (explicit convection)
- Radar simulator colocated with the flight at the same time and satellite simulator

↳ 3 simulations with distinct microphysics:

1 - ICE3 (Pinty and Jabouille, 1998)
2 - LIMA (Vié et al, 2016)
3 - ICE3-NSC → Without subgrid condensation scheme

Numerical experiments and comparison with observations of the 'Stalactite' cyclone



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1 - ICE3 (Pinty and Jabouille, 1998)
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3 - ICE3-NSC → Without subgrid condensation scheme

ICE3 (Used in french NWP)

- Hydrometeor mixing ratio pronostic (one-moment scheme)
- **Cold phase (and mixed): deposition of all vapor in excess**
  → Linear function of temperature (Tao et al., 1989)
- **Subgrid condensation scheme**
  (allow to consider condensate in a mesh with RH < 100%)

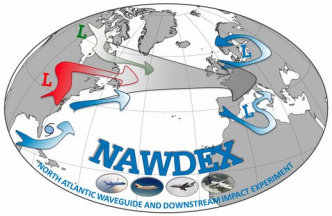
≠

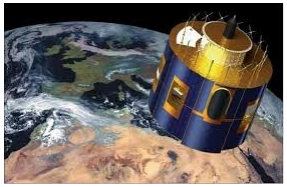
LIMA

- Hydrometeor mixing ratio and concentration pronostics (two-moment scheme)
- **Cold phase (and mixed) : explicit transfert mass**
- **All or nothing cloud in a mesh**

How to evaluate the schemes ?

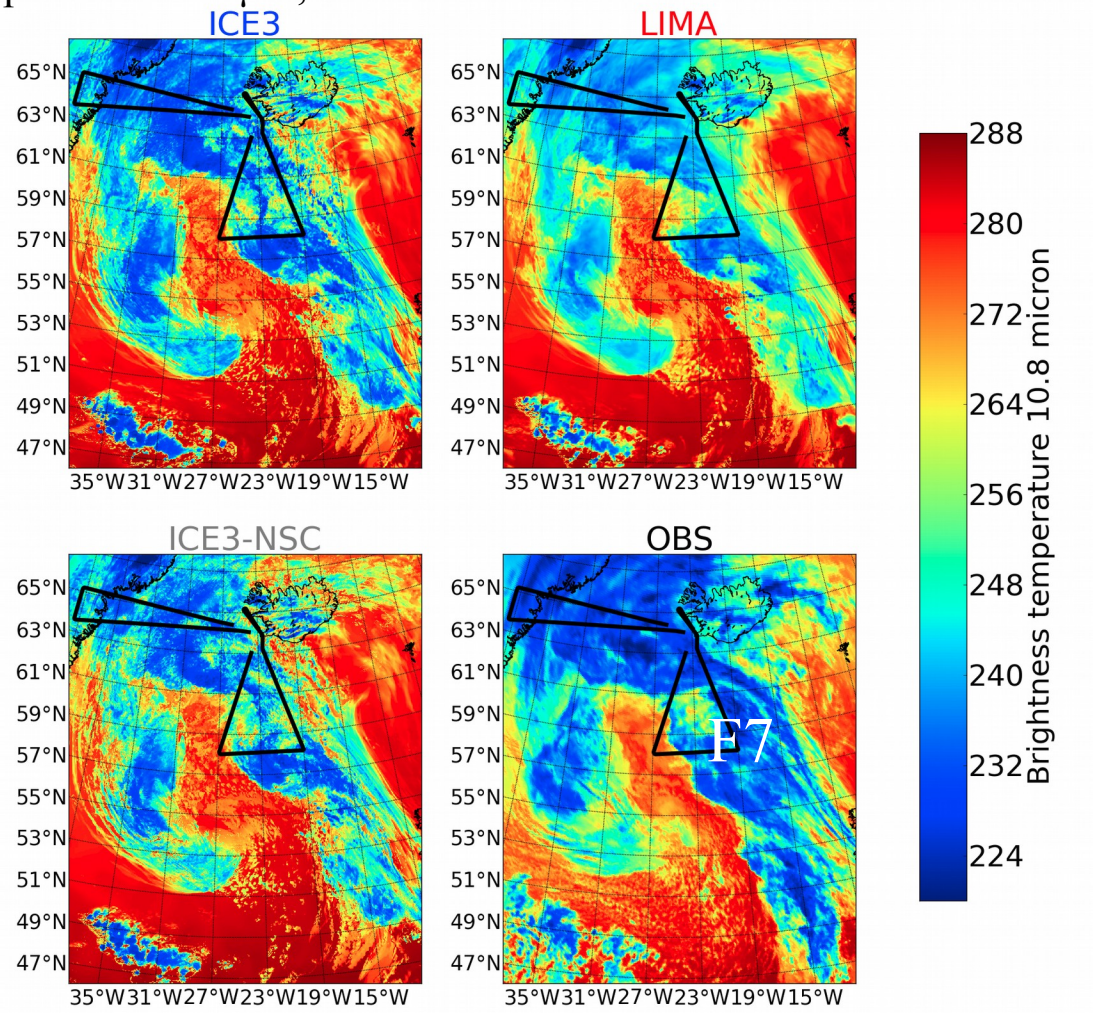
Which simulation is closest to observations ?
- Satellite (Meteosat Second Generation)
- Radar+Lidar platform embedded into the Falcon 20





Is the cloud structure well represented ?

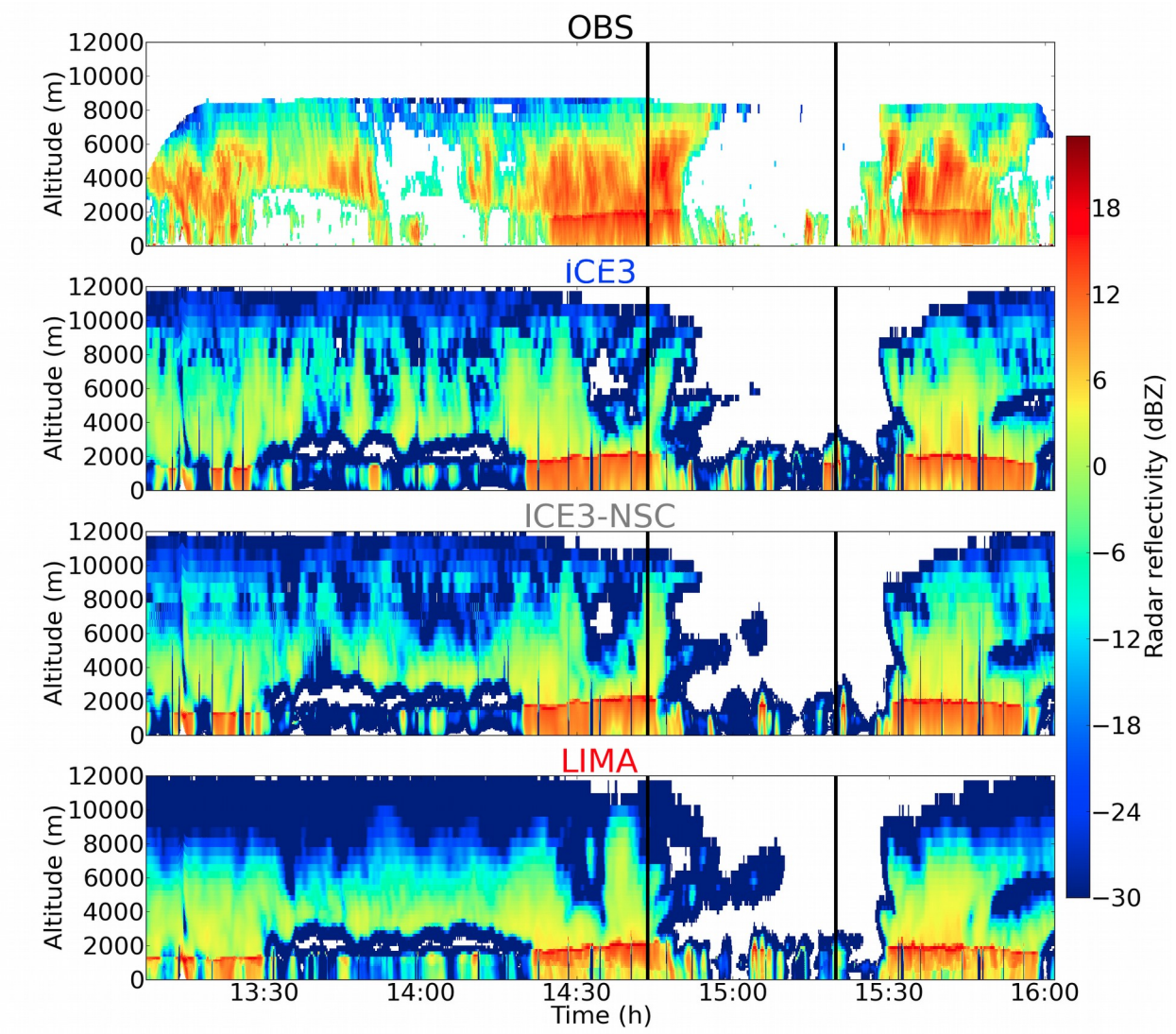
➢Meteosat, brightness temperature 10.8 µm, 12:00 02/10/2016



➡
- ◆ Cloud top warmer (→ lower) in the model runs
- ◆ Far more pronounced with LIMA
- ◆ Good location of the WCB

How is the cloud structure on the vertical ?

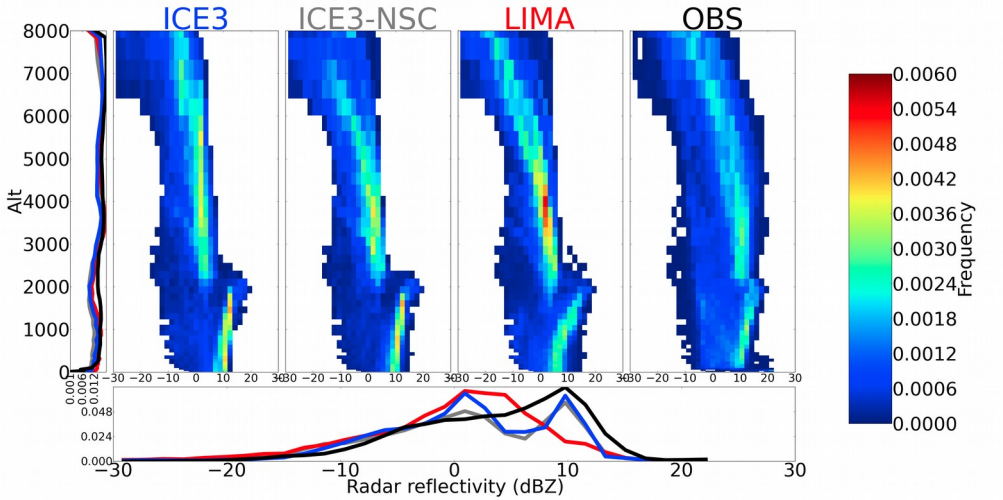
➢Model to radar approach: Radar reflectivity during F7



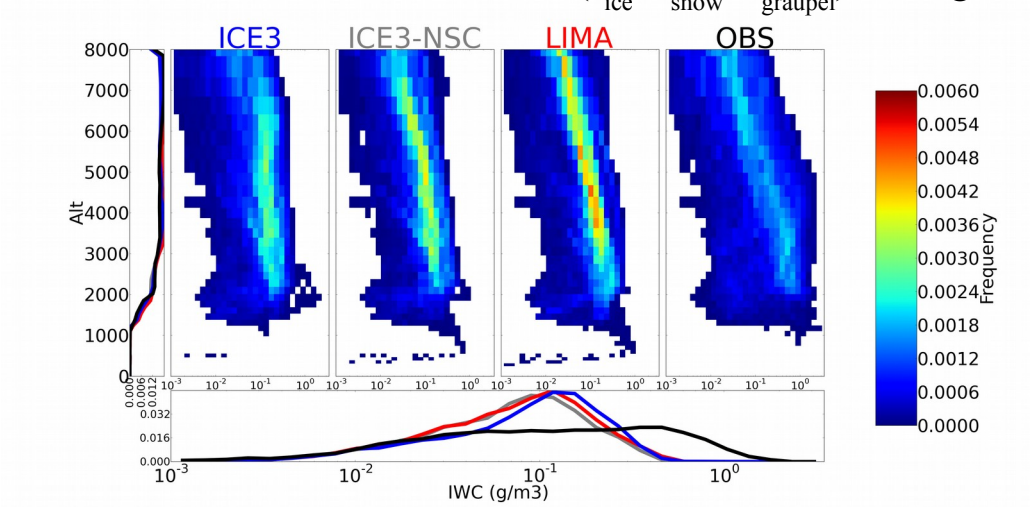
➡ ◆ Underestimation of radar reflectivity but quite a good location of radar structure

How are distributed the hydrometeors ?

➢Model to radar approach: CFAD of radar reflectivity (~D^6) during F7



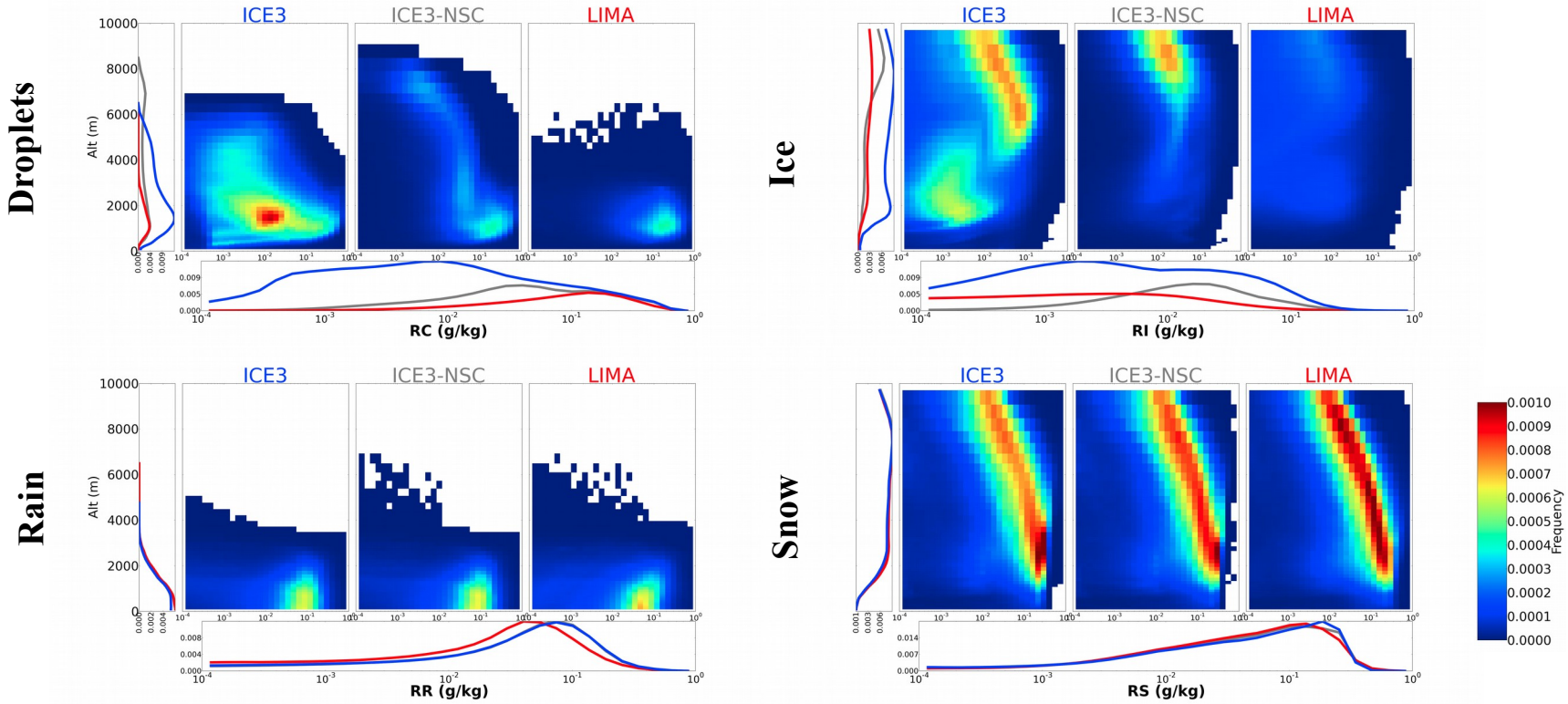
➢Radar to model approach: CFAD of Ice Water Content (r_{ice} +r_{snow} +$r_{graupel}$) during F7



- Large underestimation of reflectivity and IWC
- Lack of vapor deposition (→ lowest latent heating release) ? Fallspeed of hydrometeors too fast ?
- ICE3 higher reflectivity and IWC values → closer to OBS in terms of intensity
- LIMA better reflectivity and IWC shape → closer to OBS in terms of hydrometeor distribution

Can we explain the bivariate PDF by the hydrometeor distribution ?

➢ Hydrometeor mixing ratio PDF at different time steps on the whole domain



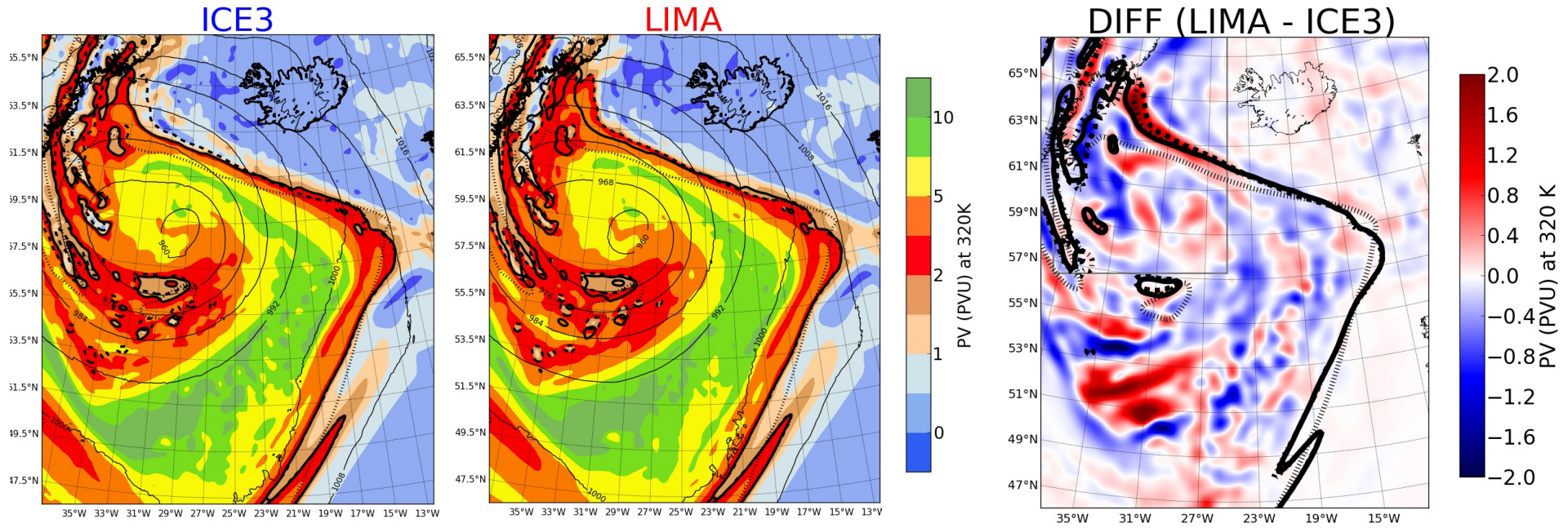
◆ LIMA: IWC and reflectivity profiles are close to the snow and graupel ones

◆ ICE3: higher reflectivity and IWC values → more ice at higher altitude

➢ Consequently, it is hard to say which is the closest to the observations between ICE3 and LIMA (shape vs intensity)

Impact on the ridge building

➢PV at 320 K on 00:00 03/10/2016 (after 24h of simulation)



↳ Ridge building more pronounced with ICE3 → 2°NE tropopause shift between ICE3 and LIMA

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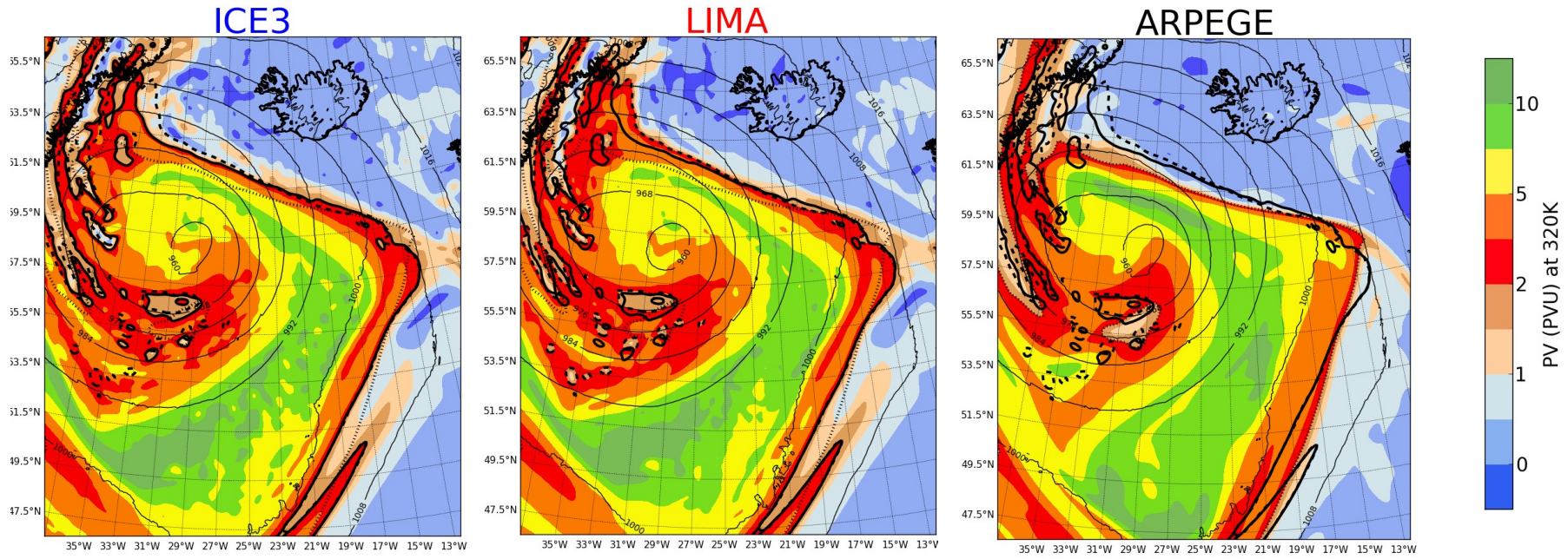
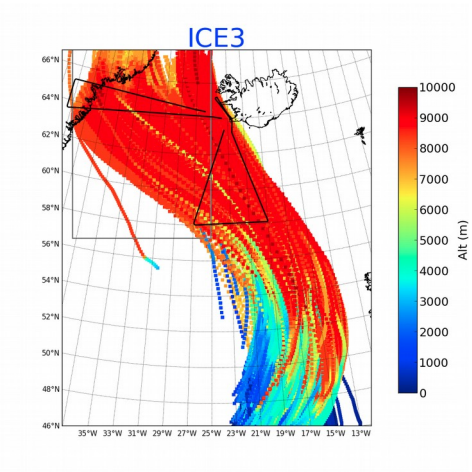


↳ Ridge building more pronounced with ICE3 → 2°NE tropopause shift between ICE3 and LIMA
But, ridge is more developed in the ARPEGE global model reanalysis

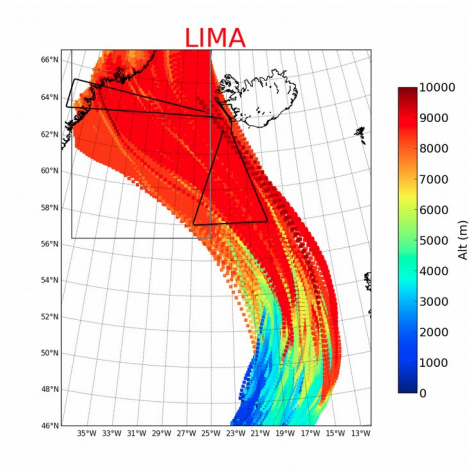
Is the latent heat release too weak in the Méso-NH model ?
→ We had weaker reflectivity and IWC in the Méso-NH model compared to the observations

Let's look at the WCB

- WCB : trajectories ascending at least 300 hPa in 24h (Joos and Wernli, 2012)
- **Backward WCB trajectories on 24h** (Gheusi and Stein, 2002) intersecting **isentrope 320 (+-5) K** on **03/10/16 00:00**



3 060 / 168 960



1 719 / 168 960

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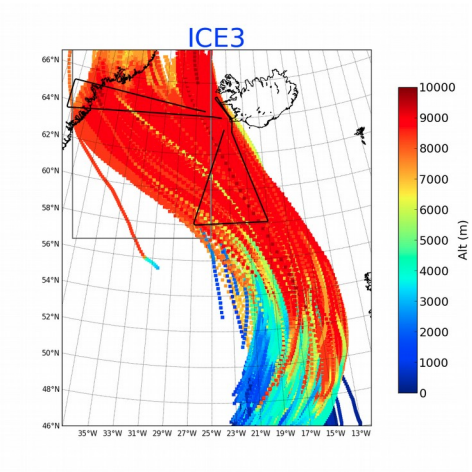
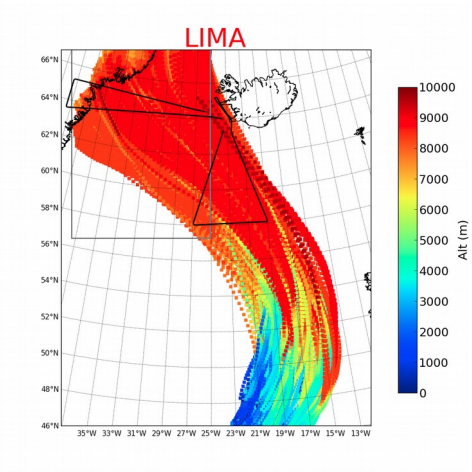
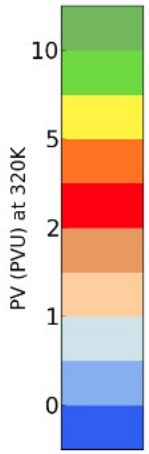


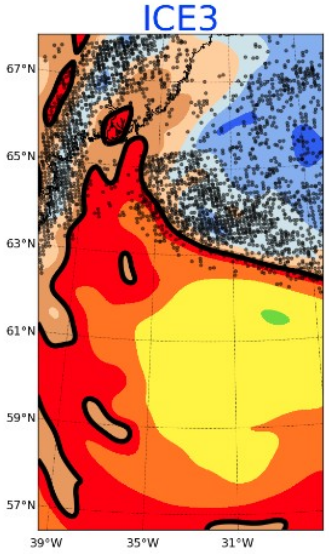


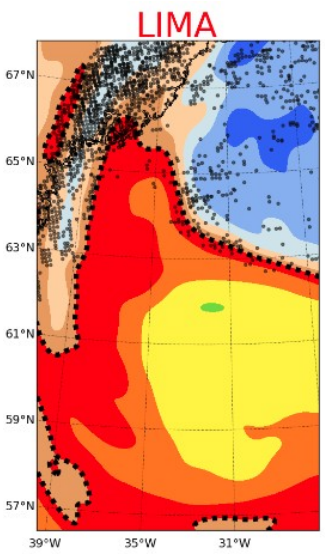
3 060 / 168 960

PV in the box at 320 K after 24h of simulations

1 719 / 168 960



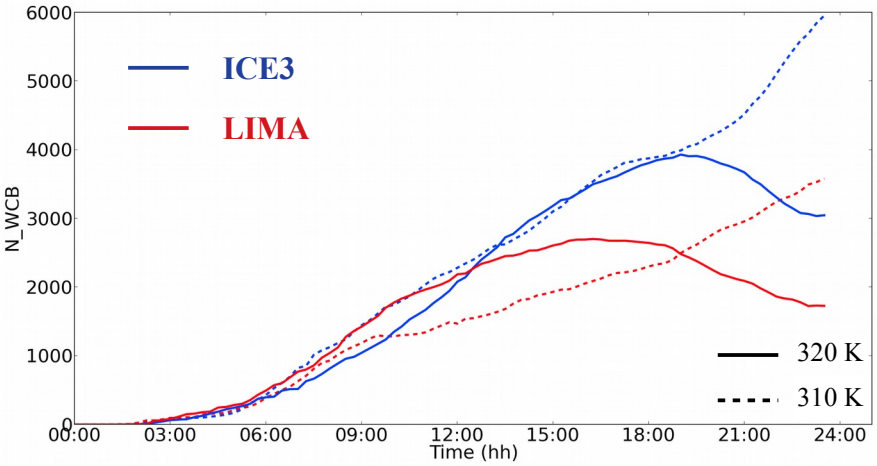




➡ Different strength of WCB leading to different PV structure at the tropopause level

Why do the numbers of the WCB differ ?

➢ 'Number' of WCB (ascent of 300 hPa between 00:00 and hh) intersecting the isentrope 320 K(+- 5 K) at hh



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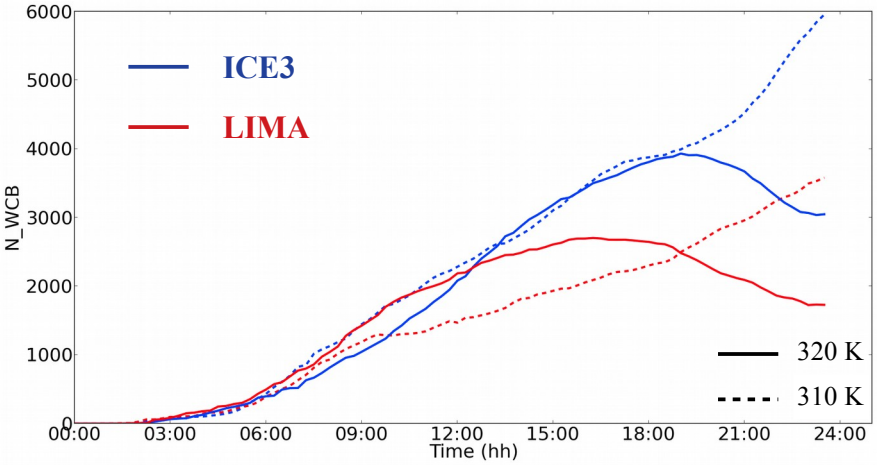
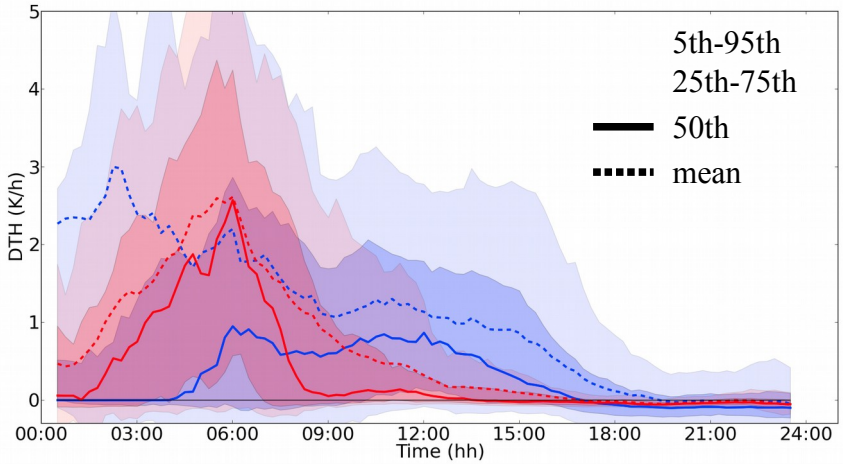


➢ Diabatic heating evolution



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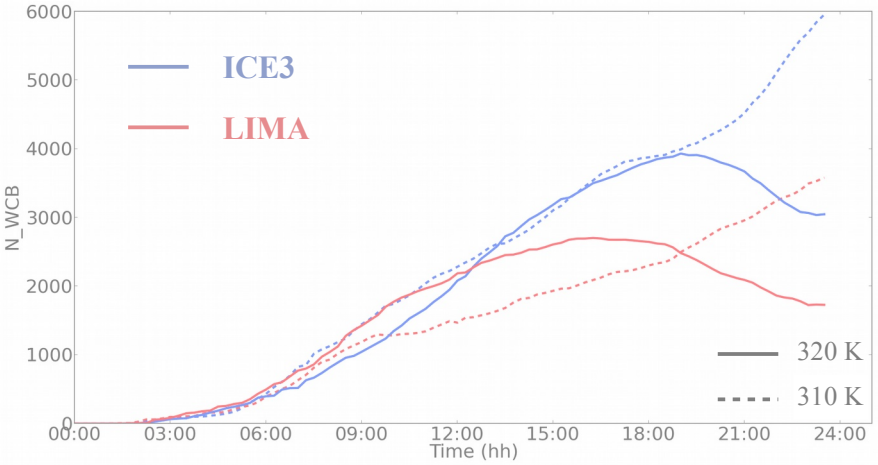

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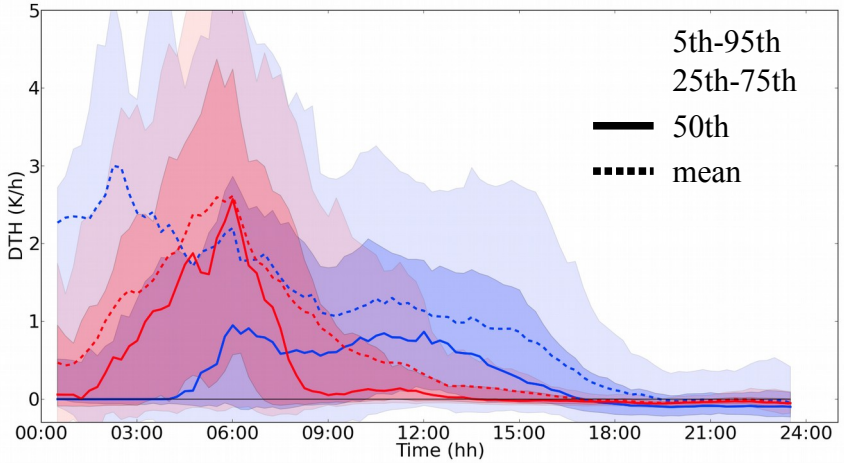

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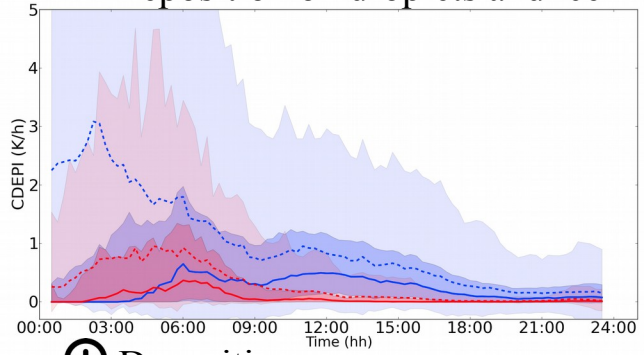
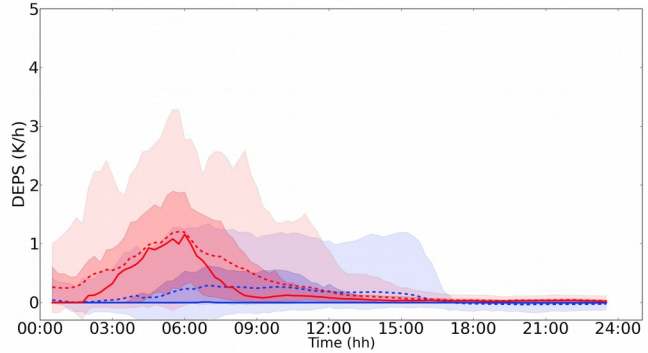
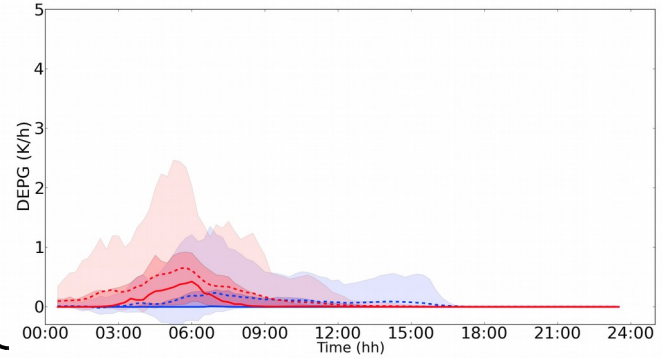
Deposition on droplets and ice



⊕ Deposition on snow



⊕ Deposition on graupel



Increase in WCB strength corresponds to a 'second' peak of ice production in ICE3 that

➡ LIMA does not have

Is that because ICE3 deposits more vapor in cold and mixed phases than LIMA ?

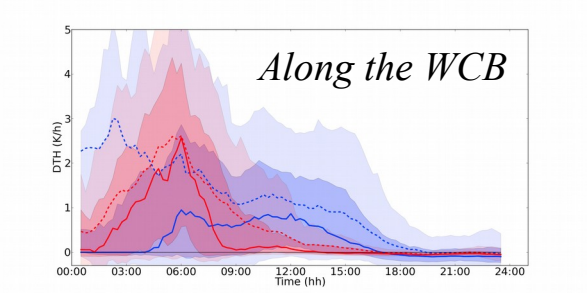
Conclusion

➢Using **distinct microphysical schemes** to simulate an extratropical cyclones :

ICE3 vs **LIMA**

(Used in French NWP)

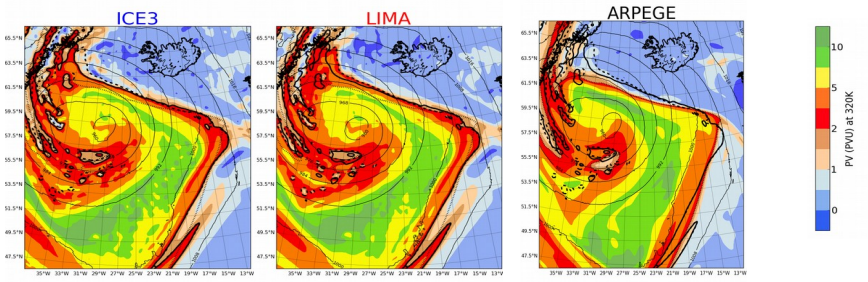
-How does the **latent heating release differ** ?



- ICE3 deposits more on ice
- LIMA deposits more on snow and graupel

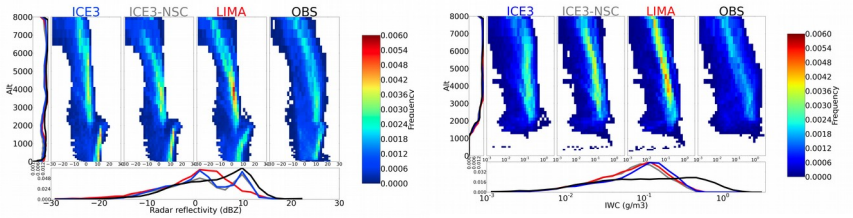
- Due to a second peak of ice production ICE3 gets a more powerful WCB

-How is the **ridge building impacted** ?



- As ICE3 gets a more powerful WCB, the ridge is more pronounced than in LIMA with a 2° NE shift of the tropopause.

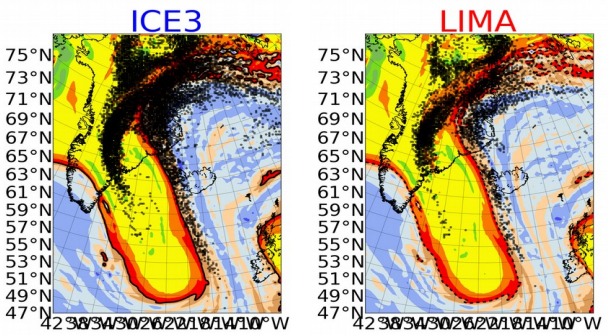
-Which one of the schemes provides the **best representation** ?



- Hard to conclude, LIMA gets a better hydrometeor distribution and ICE3 is closer in intensity to the observation.
- However, ICE3 is closer to the ARPEGE reanalysis in term of dynamic

Perspectives

➢ Do we have the same conclusions on a more moderate extratropical cyclone ?



◆ On the Thor ridge :
A priori → yes

➢ What if we play with the microphysics and turbulence schemes ?

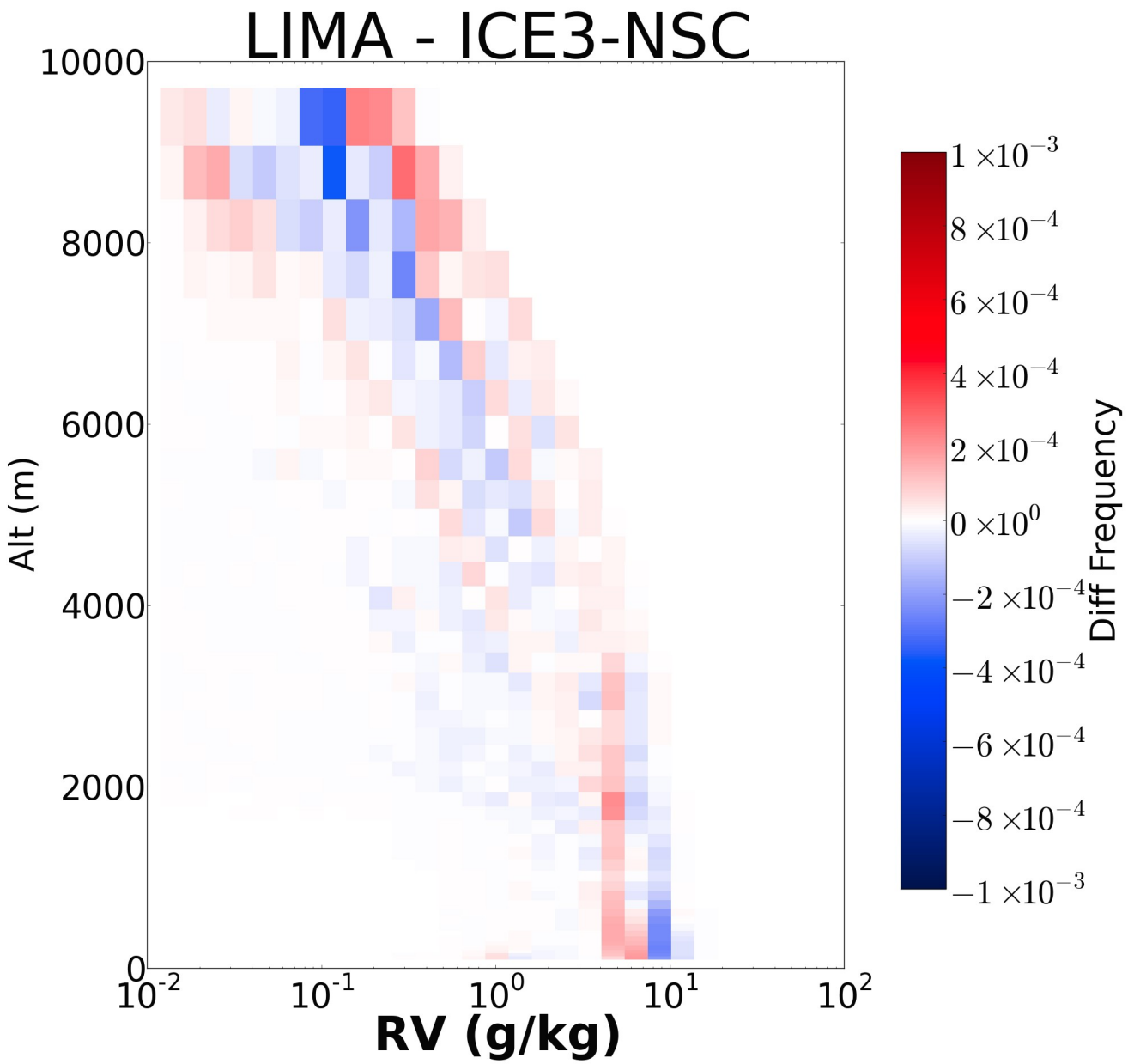
Poster session :

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

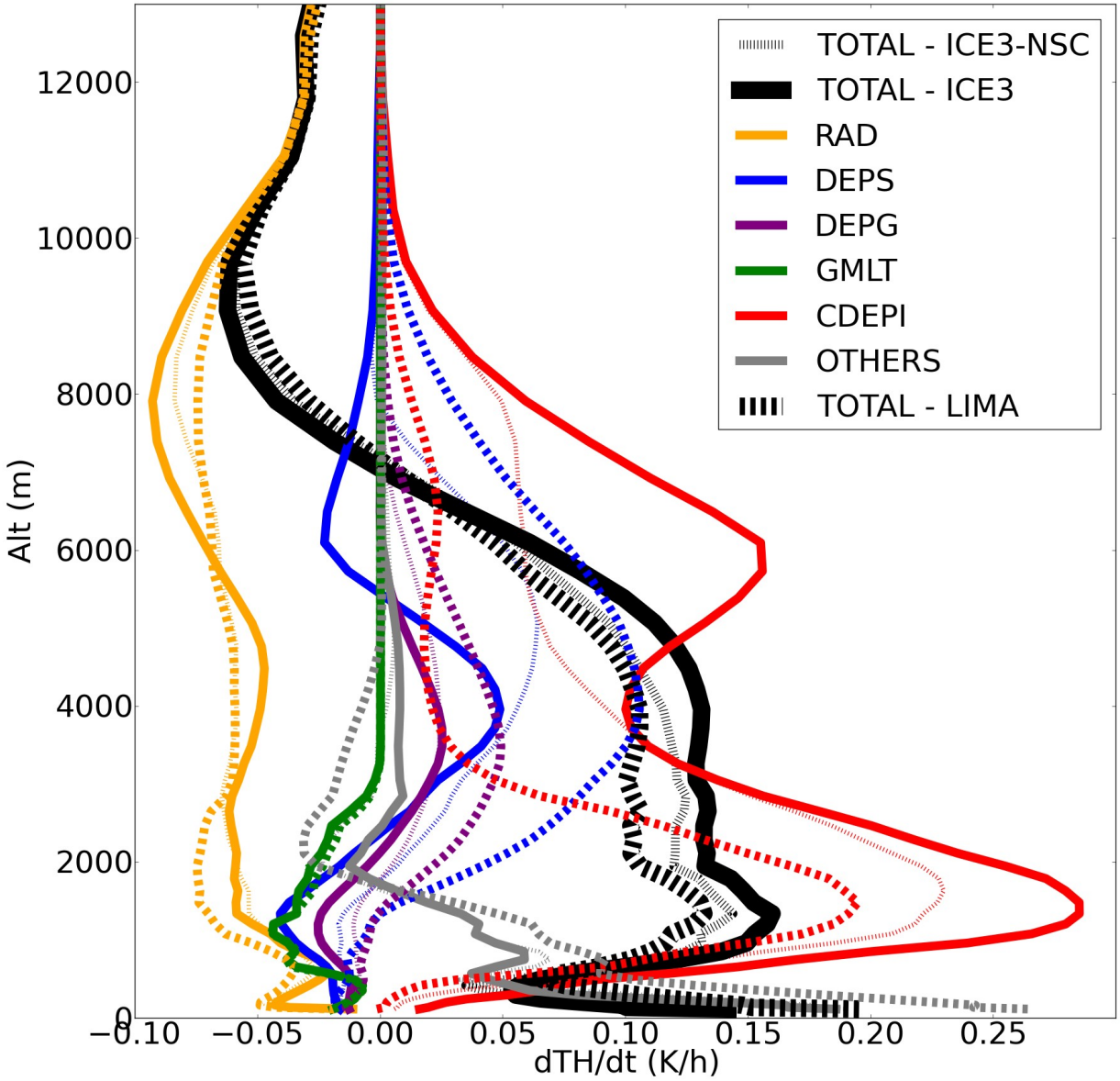
Thank you for your attention

Questions ? Suggestions ?

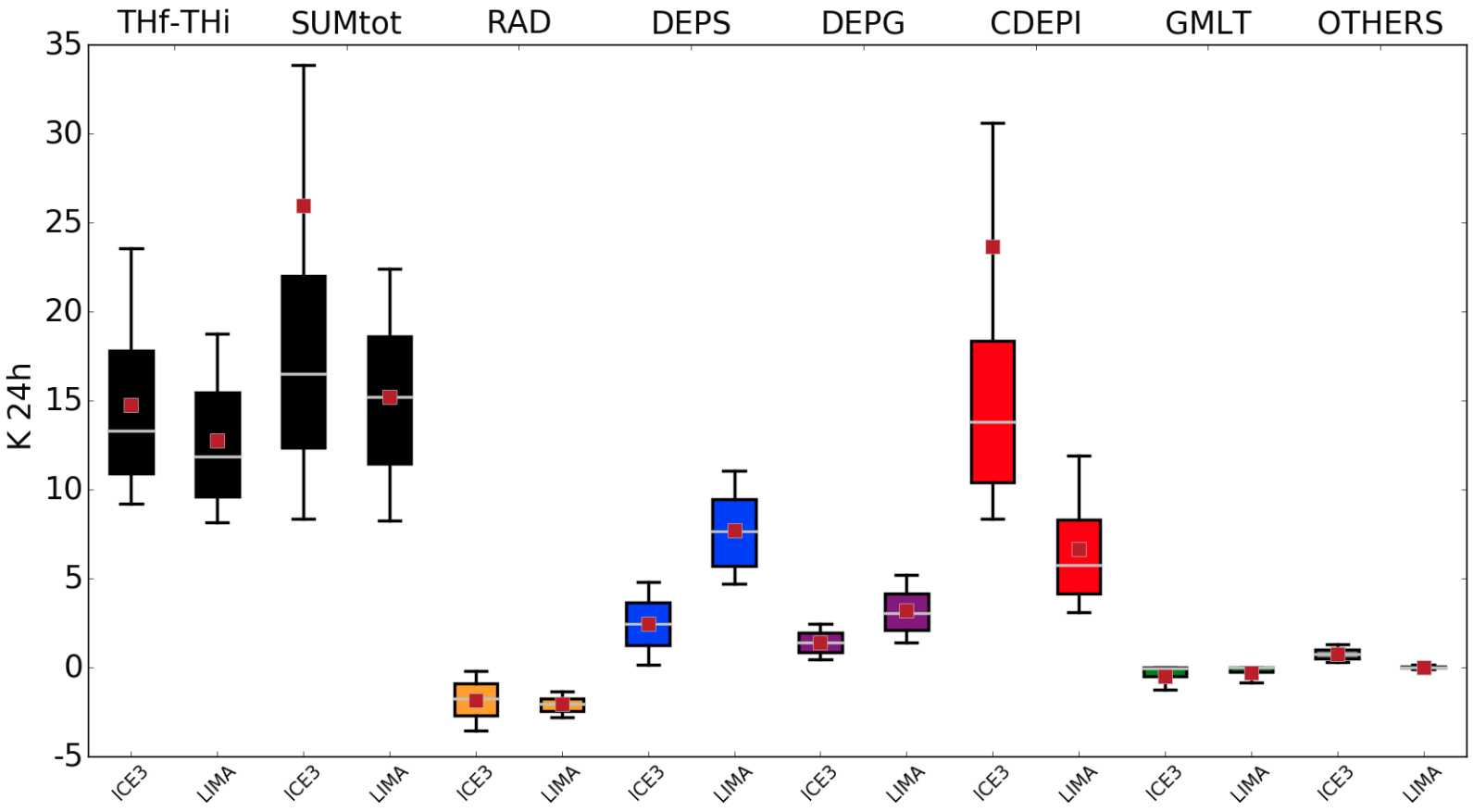
Difference of vapor mixing ratio distribution



Vertical evolution of TH budget (mean on the whole domain at different time steps)



Along the WCB



Dropsondes from F6