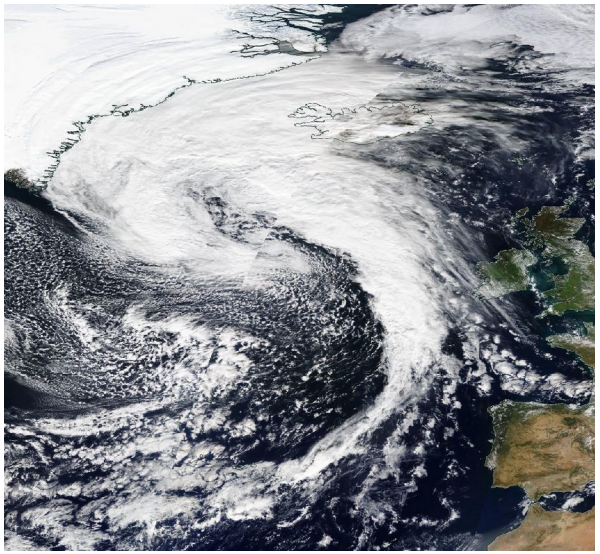
Microphysics impact on a **warm conveyor belt** and confrontation with observations from the **NAWDEX campaign**



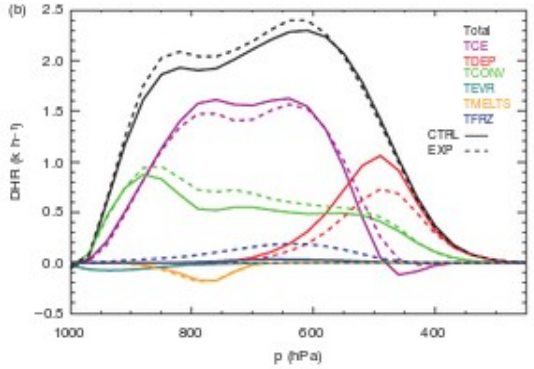
Stalactite cyclone (01 - 05/10/16)

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

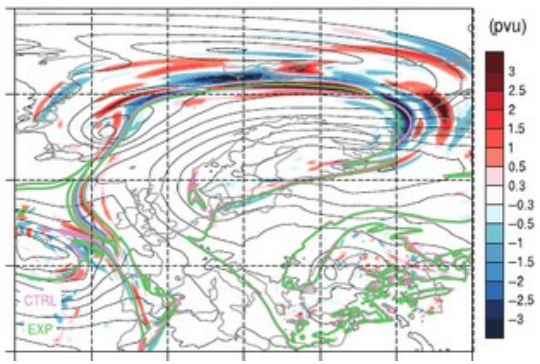
Microphysics impact on warm conveyor belt/extratropical cyclone
Where do we start ?

Using two different microphysics schemes in IFS (<> Accretion/Evaporation/Snow riming)

Differences of latent heating release on 48h along a WCB



Differences of PV at 310 K after 48 h

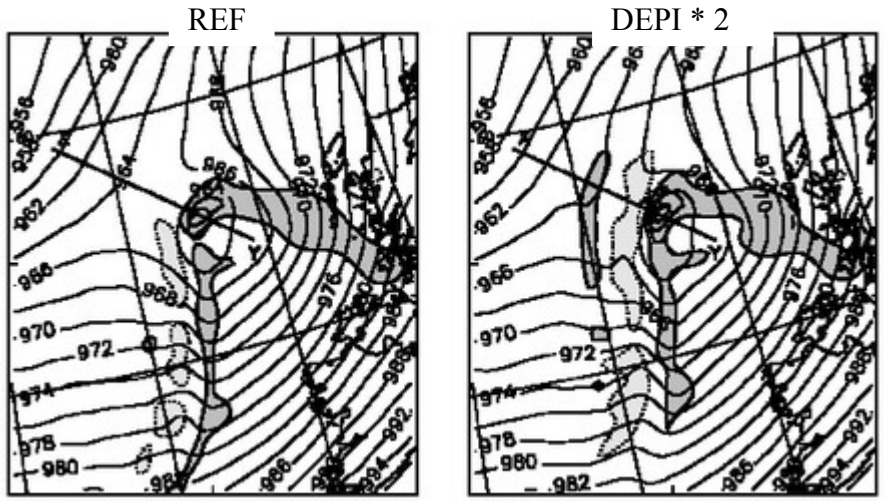


→ Impact on WCB strenght and ouflow position

Joos and Forbes, 2016

Doubling the ice deposition rate in Met Office Unified Model

MSLP and vertical velocities after 18 h



→ Impact on frontal updraught

Forbes and clark, 2003

→ Potential **misrepresentation of microphysical processes** can lead to **different cyclone structures** and **PV error along the jet stream**

→ **Confrontations with observations ?**

Scientific question

➢Using the French research convective permitting model Méso-NH with **two distinct microphysical schemes**, how does the **ridge building differ** and **why** and which ones provides the **best representation** ?

ICE3 (Actually used in french NWP)

- Droplet, rain, graupel, snow ice **mixing ratio pronostic** (one-moment scheme)
- Cold phase (and mixed) :
  -Explicit vapor deposition on snow and graupel only in mixed phase
  -Deposition of all vapor in excess on ice (droplets)
- **Subgrid condensation scheme** (allow to consider condensate in a mesh with RH < 100%)

≠

LIMA (In future ?)

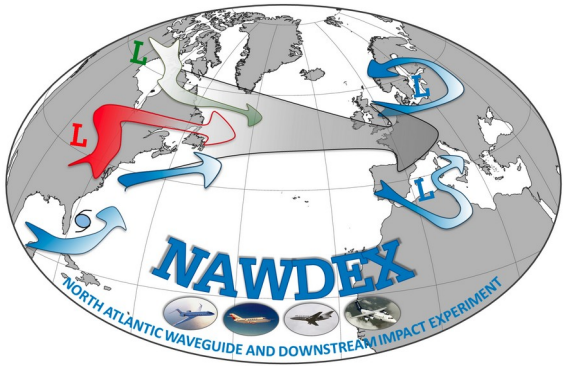
- Droplets, rain, graupel, snow ice **mixing ratio pronostics** and droplet, rain, ice **concentrations pronostics** (quasi two-moments scheme)
- Cold phase (and mixed) :
  - Explicit vapor deposition on ice, snow and graupel

Scientific question

➢Using the French research convective permitting model Méso-NH with **two distinct microphysical schemes**, how does the **ridge building differ** and **why** and which ones provides the **best representation** ?

How to evaluate the schemes?

➢**Remote sensing airbone observations** during the **Nawdex campain** in fall 2016: Reflectivity, IWC, wind speed, temperature, humidity, ...



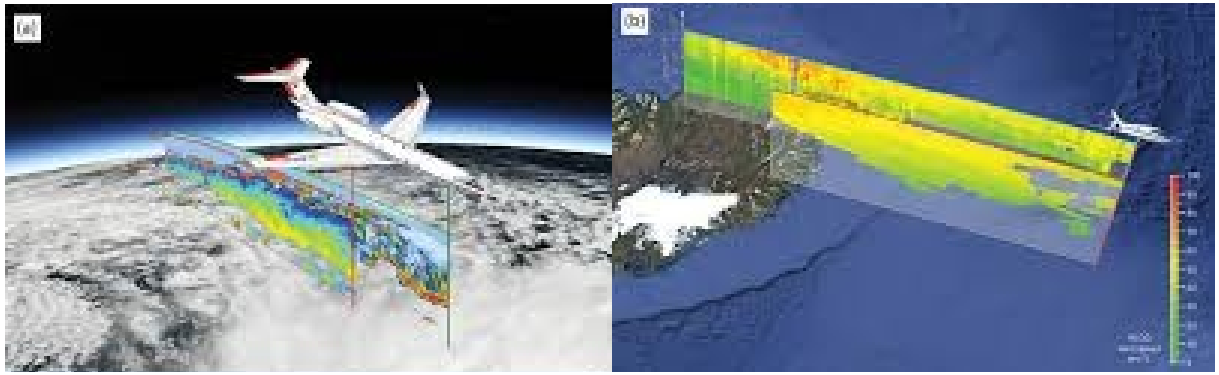
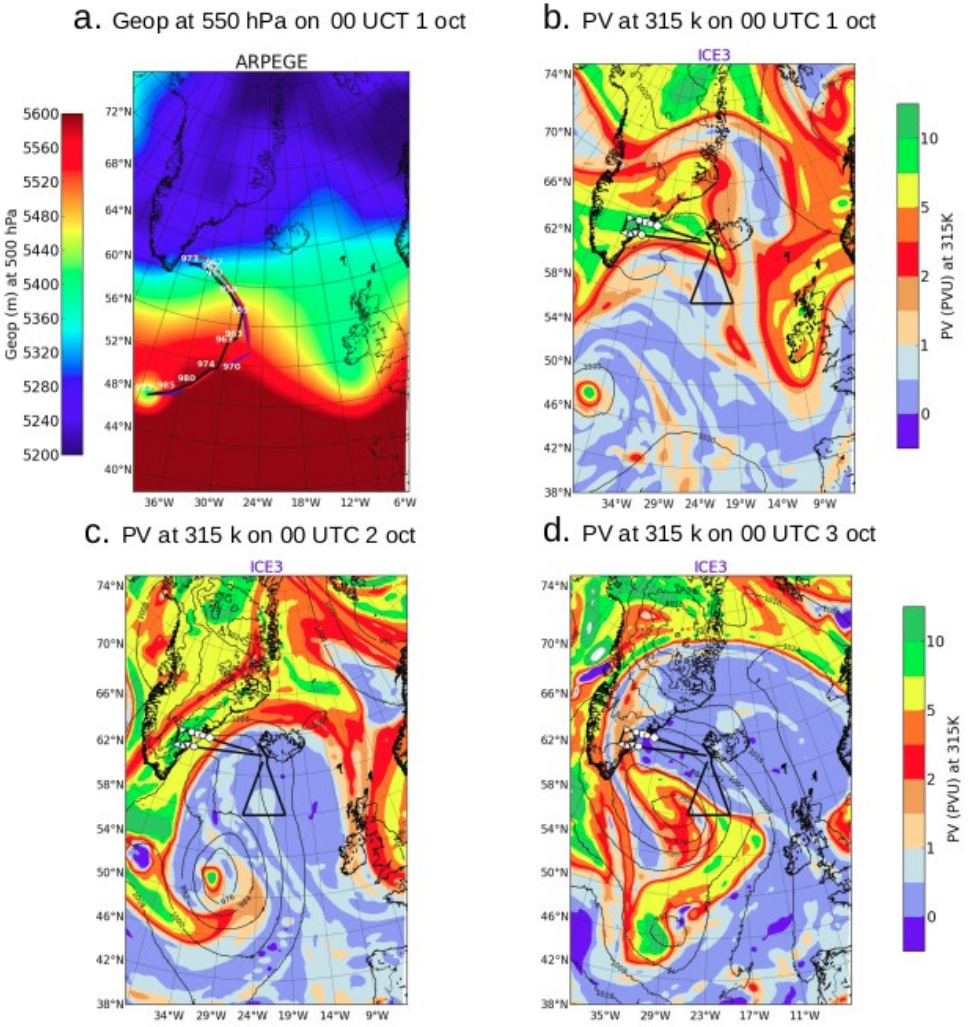


Illustration of aircraft measurements during NAWDEX. Figure from Schäfler et al., 2018.

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)

*Track from **00:00 01/10/2016 to 00:00 04/10/2016***

↳ 26 hPa decline in 24h

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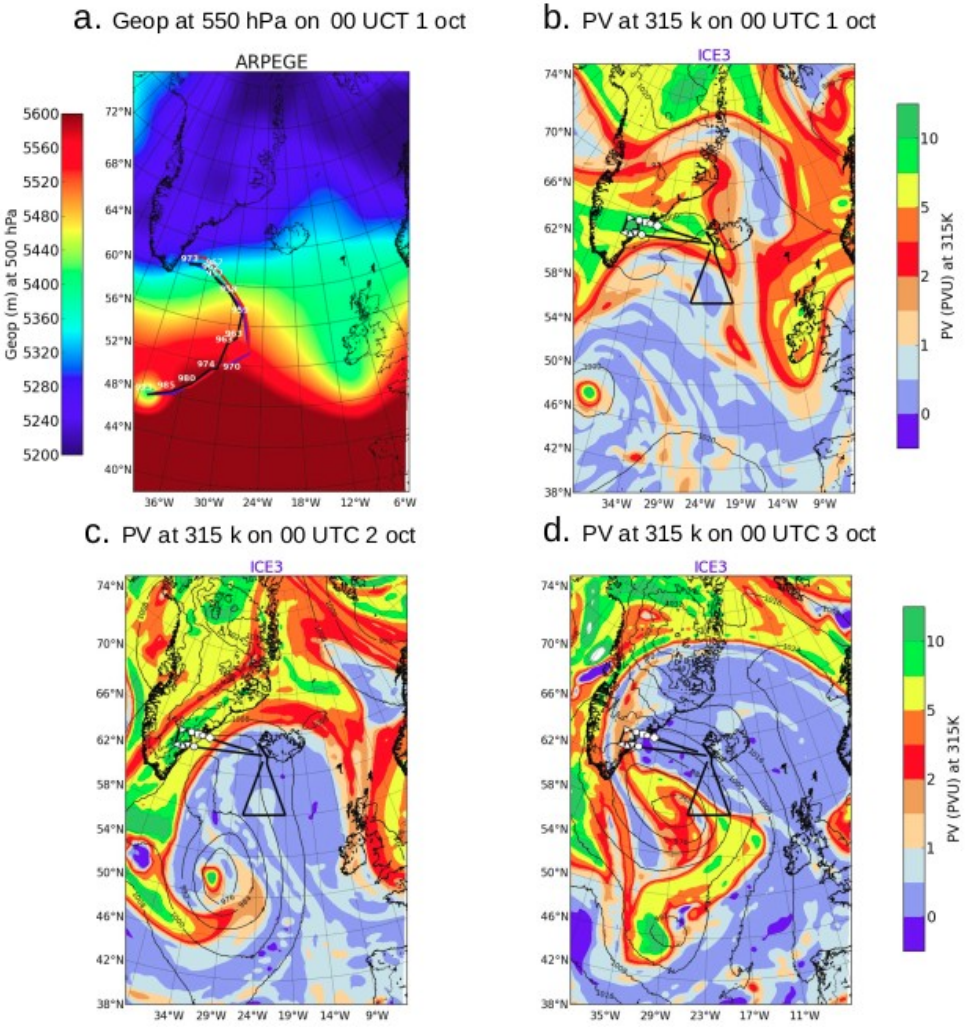

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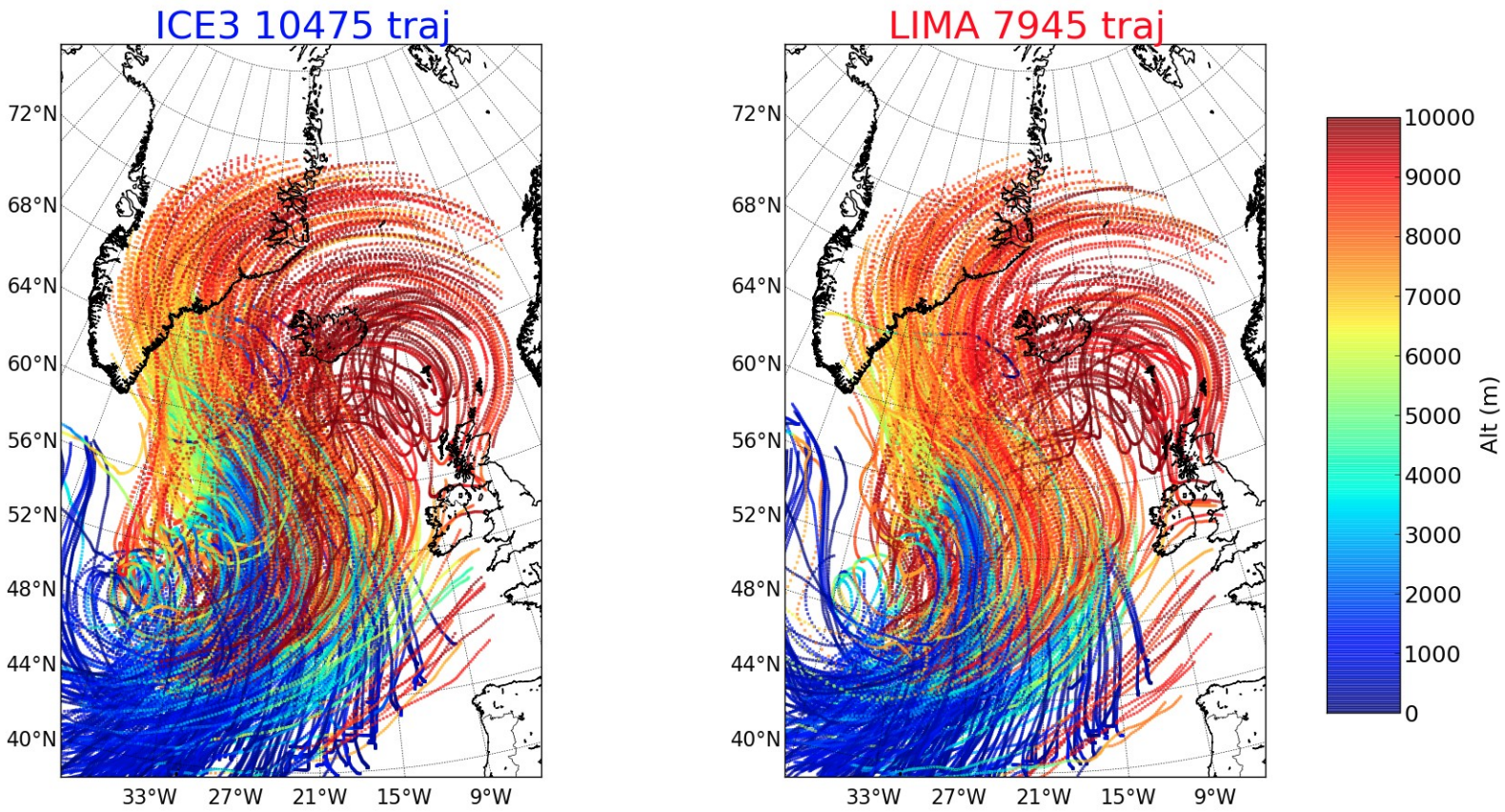
Meso-NH
mesoscale non-hydrostatic model

- **01/10/16 00h → 04/10/16 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
- Microphysics schemes : ICE3 and LIMA

Microphysic impact on WCB and on upper-level ridge

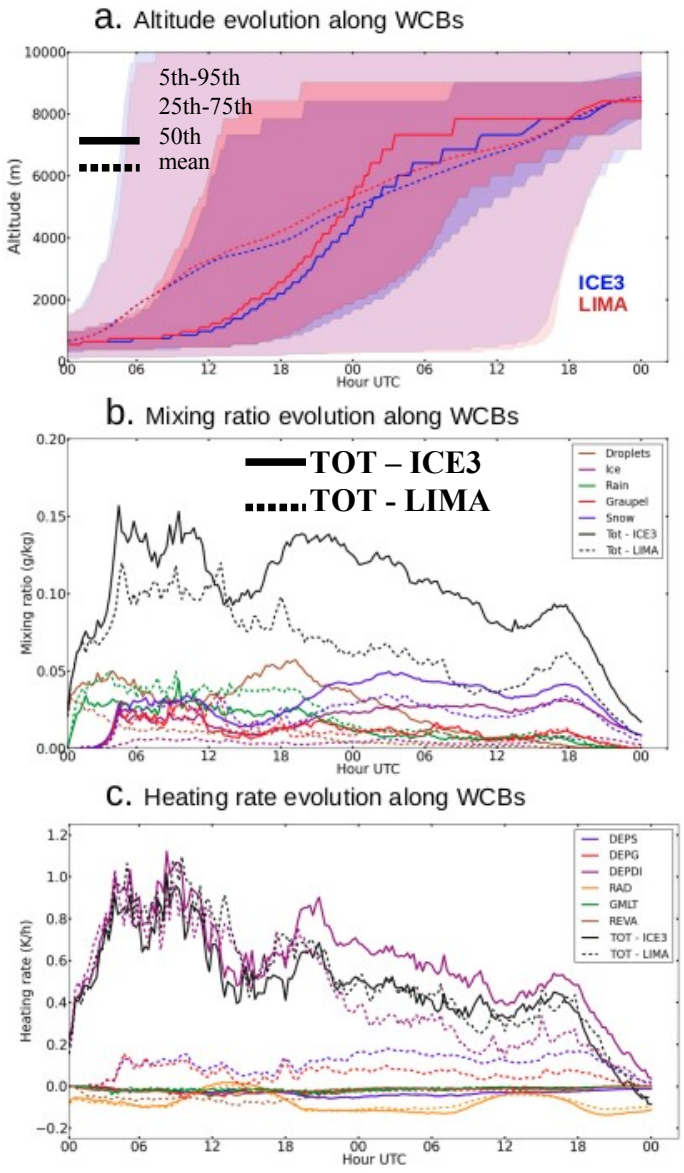
WCB strenght

- WCB : trajectories ascending at least 600 hPa in 48 h (Joos and Wernli, 2012)
  Trajectories seeded at 00 UTC on 3 oct (1 points over 8 in X/Y due to computational cost)



33 % more WCB trajectories with ICE3

Mean microphysic evolution along WCB



→ WCB ascent differs

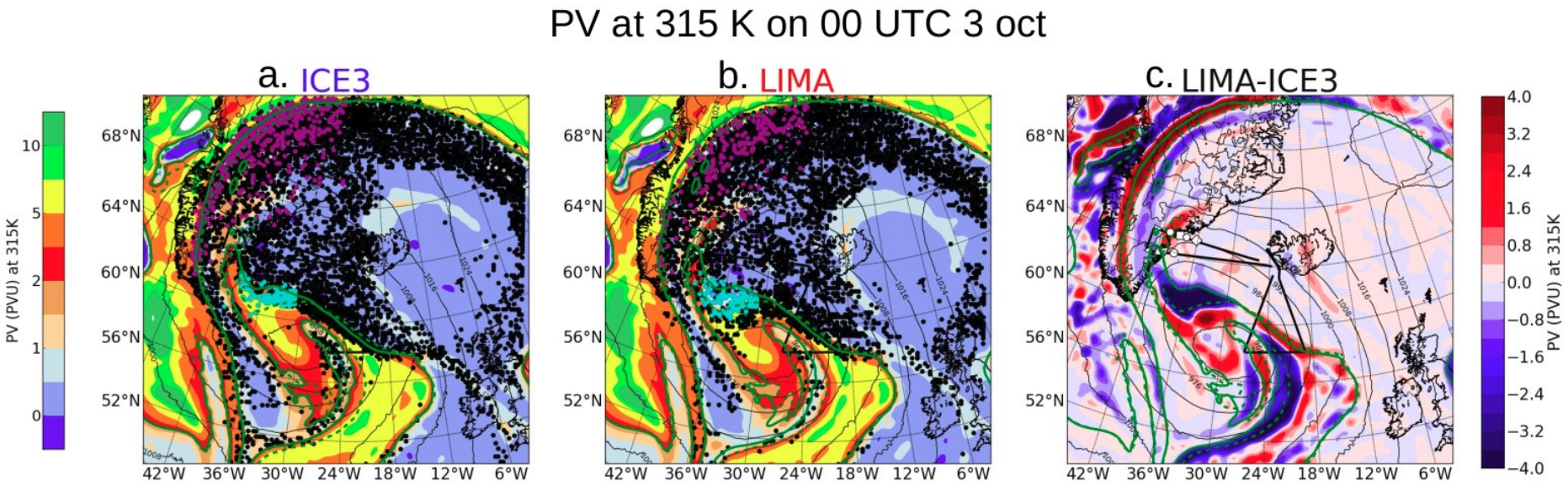
→ ICE3 gets far more hydrometeors mixing ratio

→ Total latent heating release is close but the contributing processes differs strongly :

-ICE3 : Quasi only vapor deposition on ice (droplets)

-LIMA : Vapor deposition on ice, snow and graupel

Microphysic impact on upper-level ridge

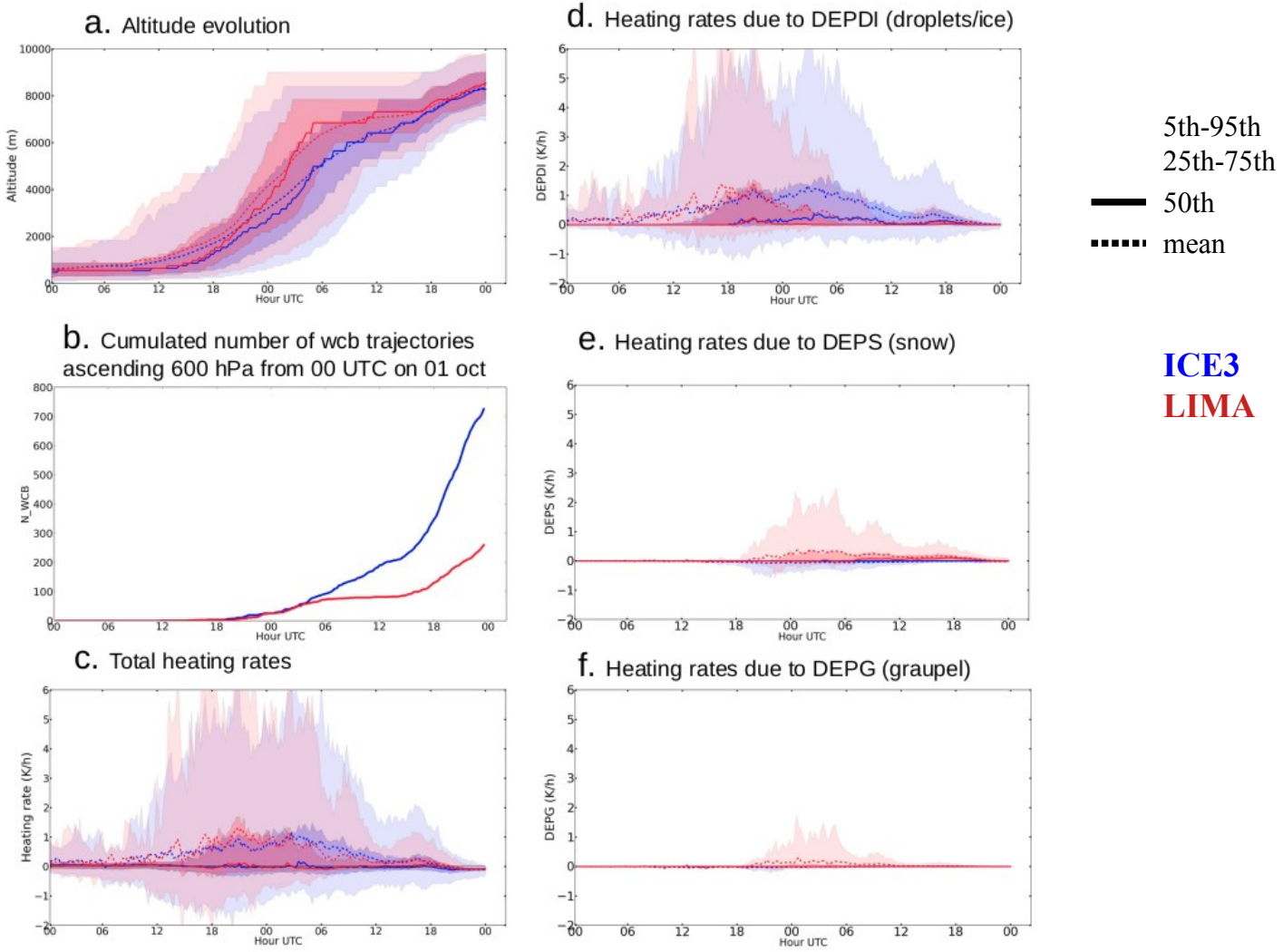


Two main PV anomalies :

- ICE3 north-west shift of the tropopause → **Anticyclonic red anomaly** (3° on 16°)
ICE3 : 723 WCB trajectories / **LIMA : 260** WCB trajectories

- LIMA south-west shift of the tropause → **Cyclonic blue anomaly** (12° on 2°)
ICE3 : 42 WCB trajectories / **LIMA : 101** WCB trajectories

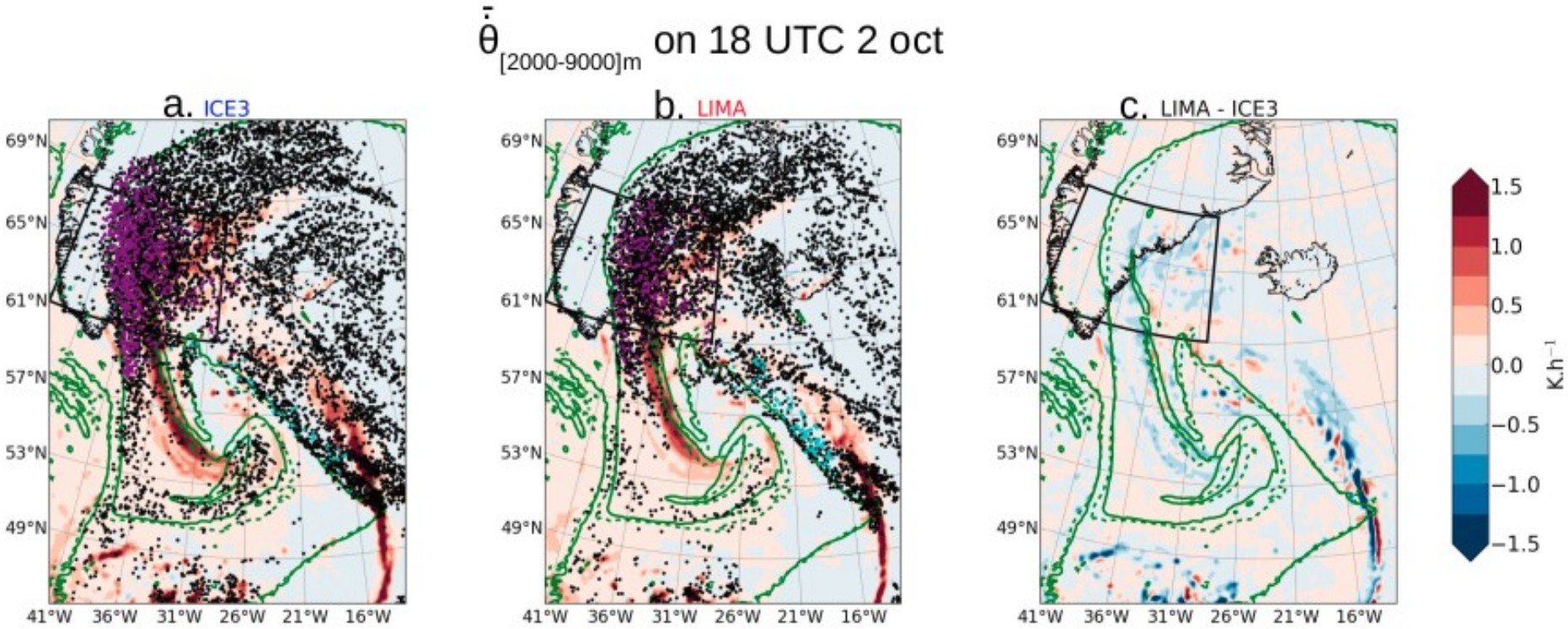
Evolution of WCB reaching anticyclonic red anomaly



→ **Stronger vapor deposition on ice** seems to explain **stronger WCB with ICE3**

→ Among microphysical schemes discrepancies ; adjustement to saturation is a good candidate to explain it

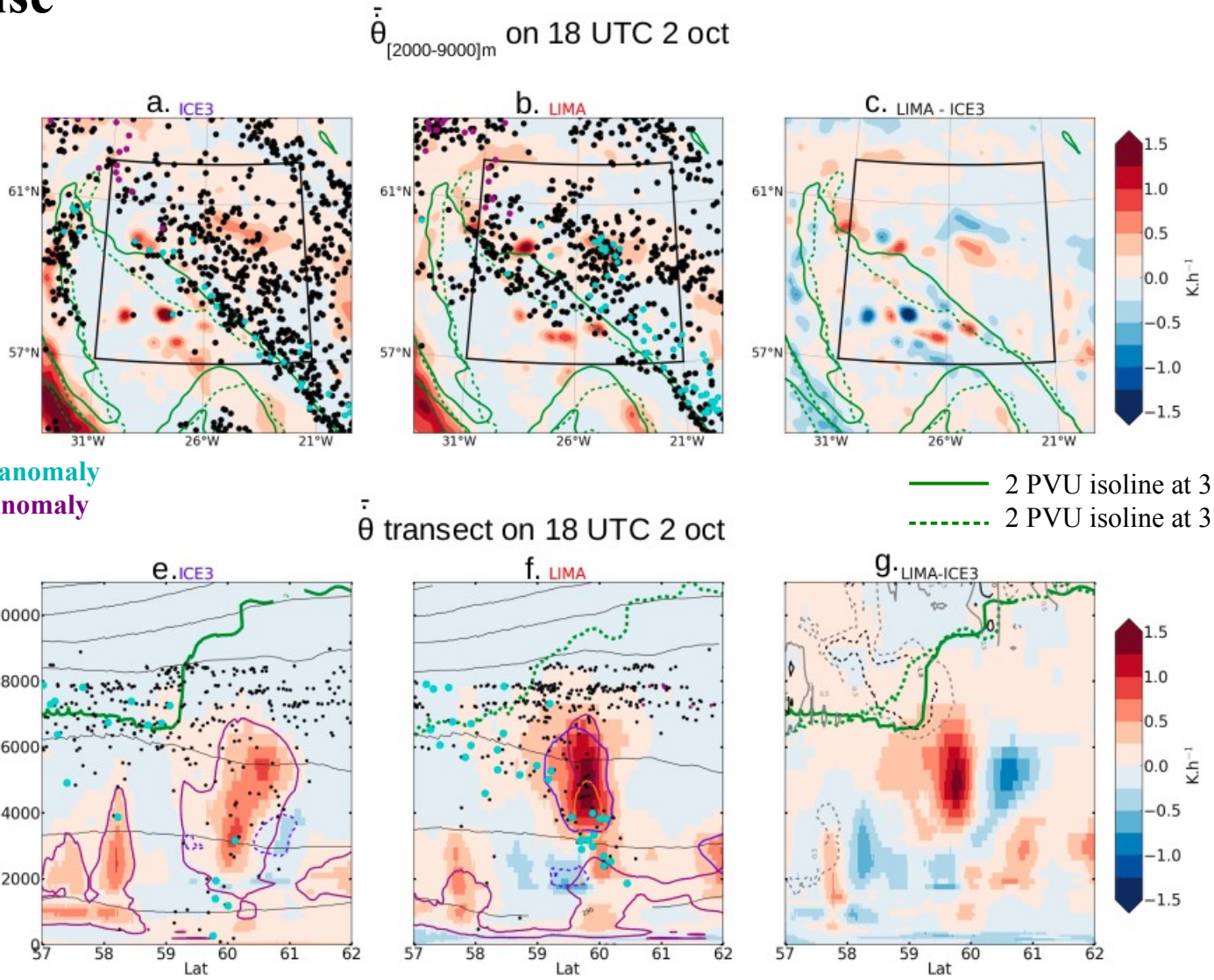
Cyclonic blue anomaly



→ Formation and enhancement along cold front assisted by embedded convection

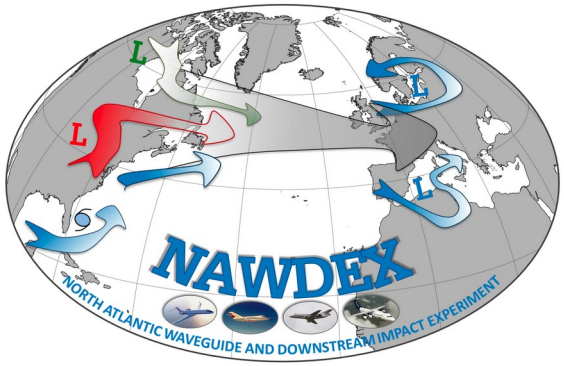
→ Discrepancies on cold front representation between ICE3 and LIMA (similar to Forbes and clark, 2003)

Cyclonic blue anomaly : Focus on convective cells close to the tropopause



→ LIMA gets 'heater' convectives cells closer to the ridge anomaly

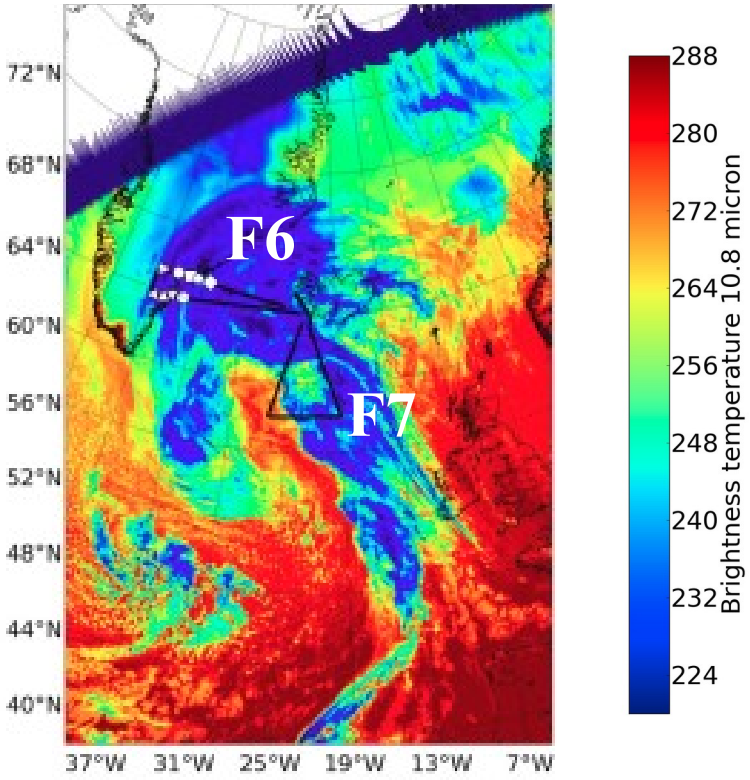
Which of the schemes is closest to the observations ?



Observations of the ‘Stalactite’ cyclone

MSG satellite

12:00 on 02/10/2016



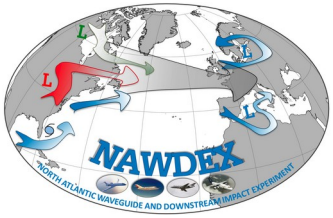
- **Flights of French Safire Falcon on 02/10/2016**:
  -F6 **WCB outflow regio**n [09:30 - 11:30]
  -F7 **WCB ascending branch** [13:00 - 16:00]

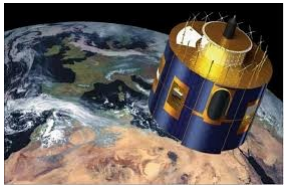
- RASTA embedded :
  Reflectivity, Ice Water Content (retrieved from variational algo; Delanoë and Hogan, 2008), Wind

- **French Safire Falcon** in situ measurements (U)

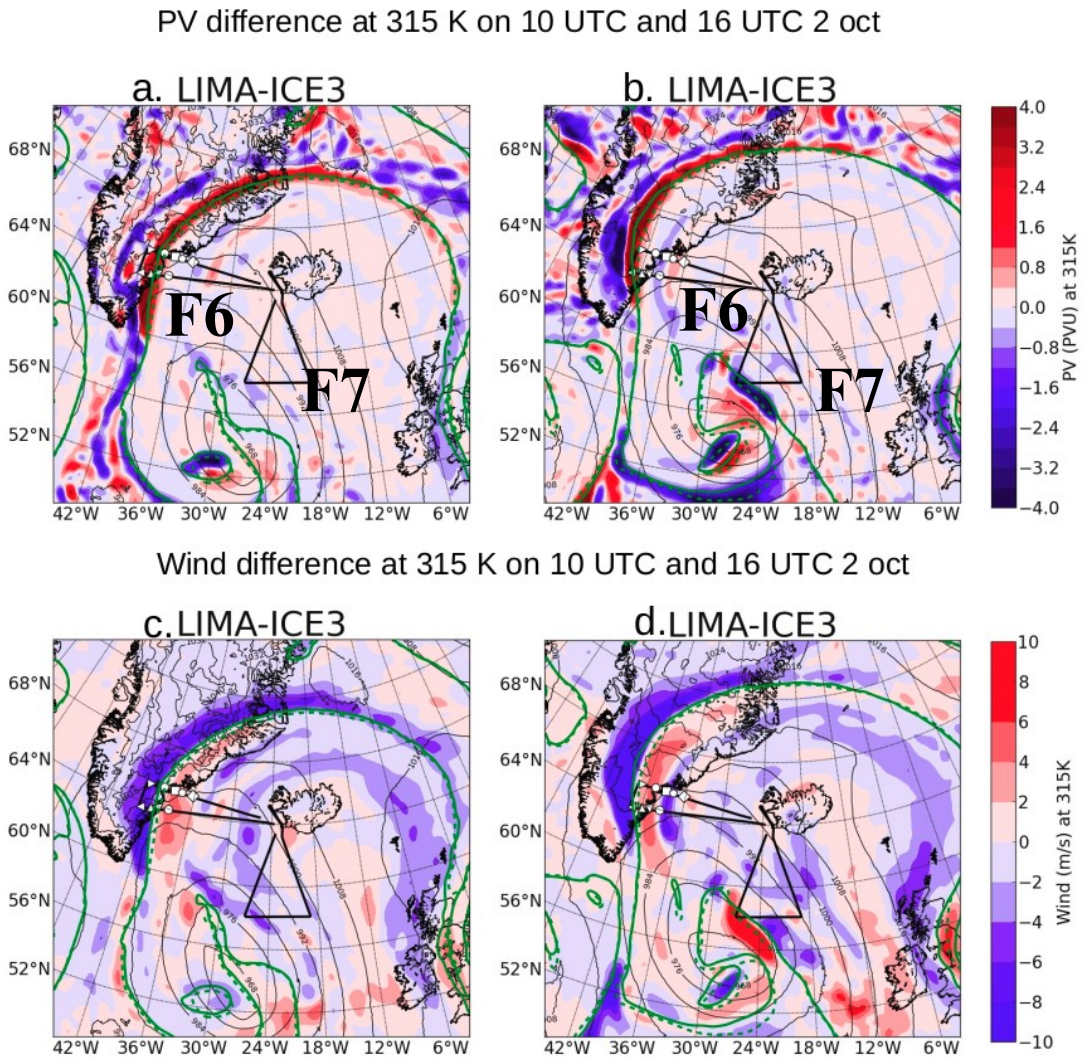
- F6 : Dropsondes (P,T,**U**,RH)

- MSG Satellite





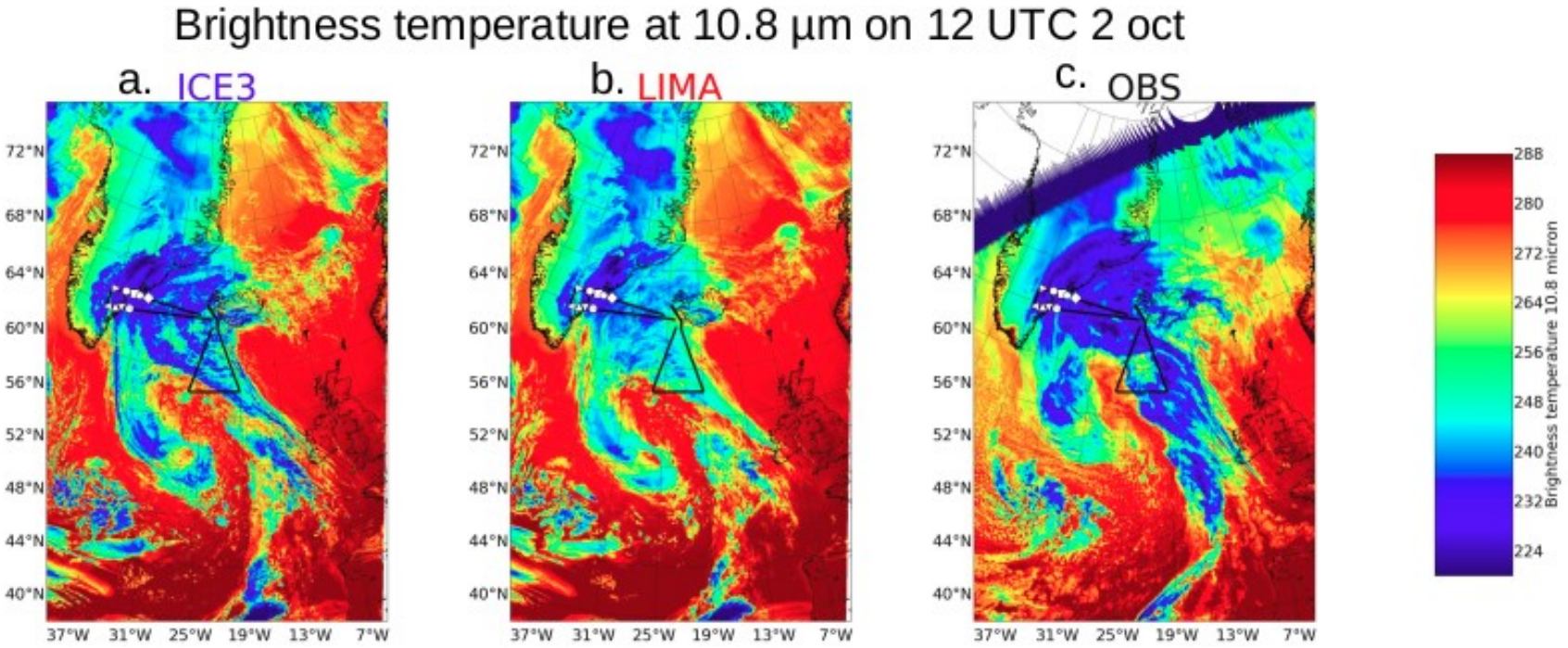
Positions of blue/red anomalies with observations



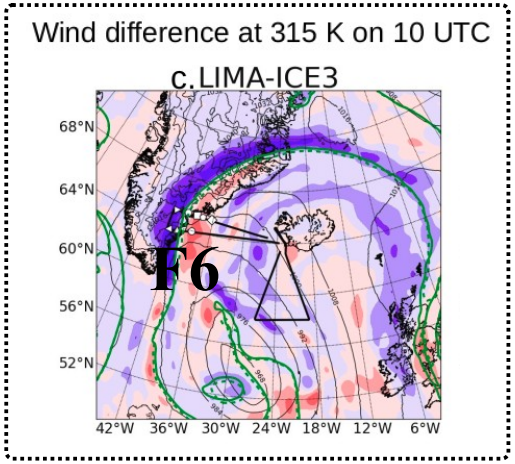
F6 [09:30 - 11:30]
F7 [13:00 - 16:00]

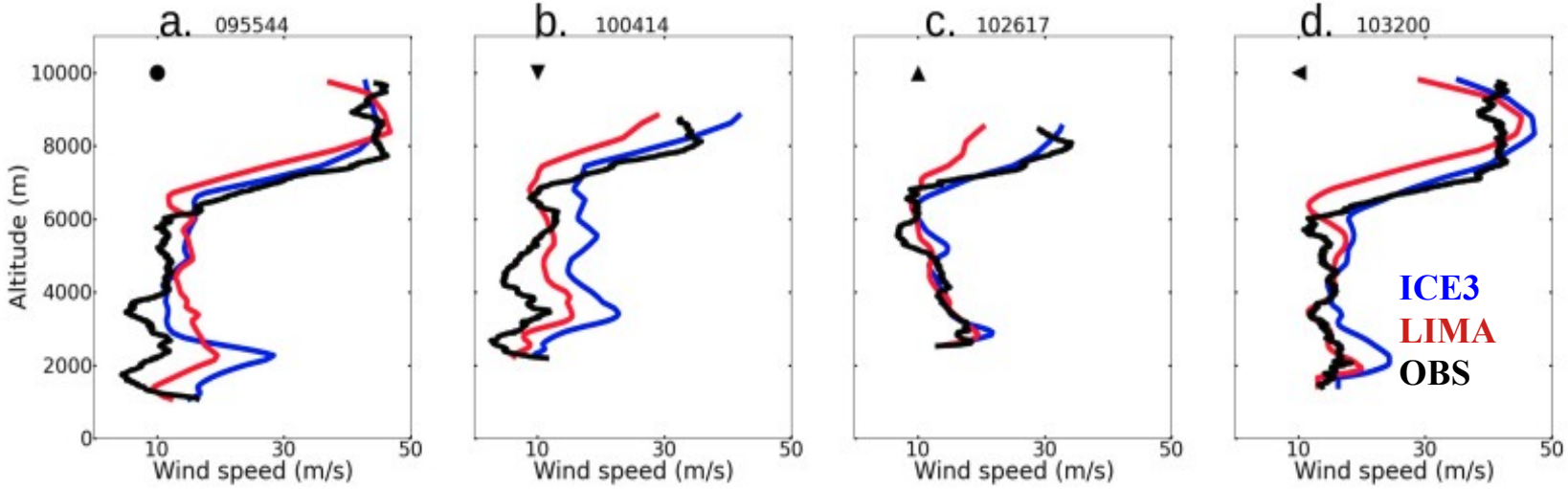
→ Red anomaly catches by F6
→ F7 in the vicinity of blue anomaly

Do representations of cyclones allow comparison of flight data ?



Dropsondes comparisons along F6 [09:30 - 11:30]

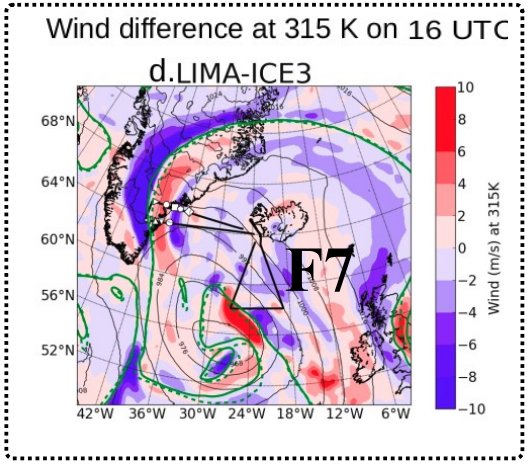


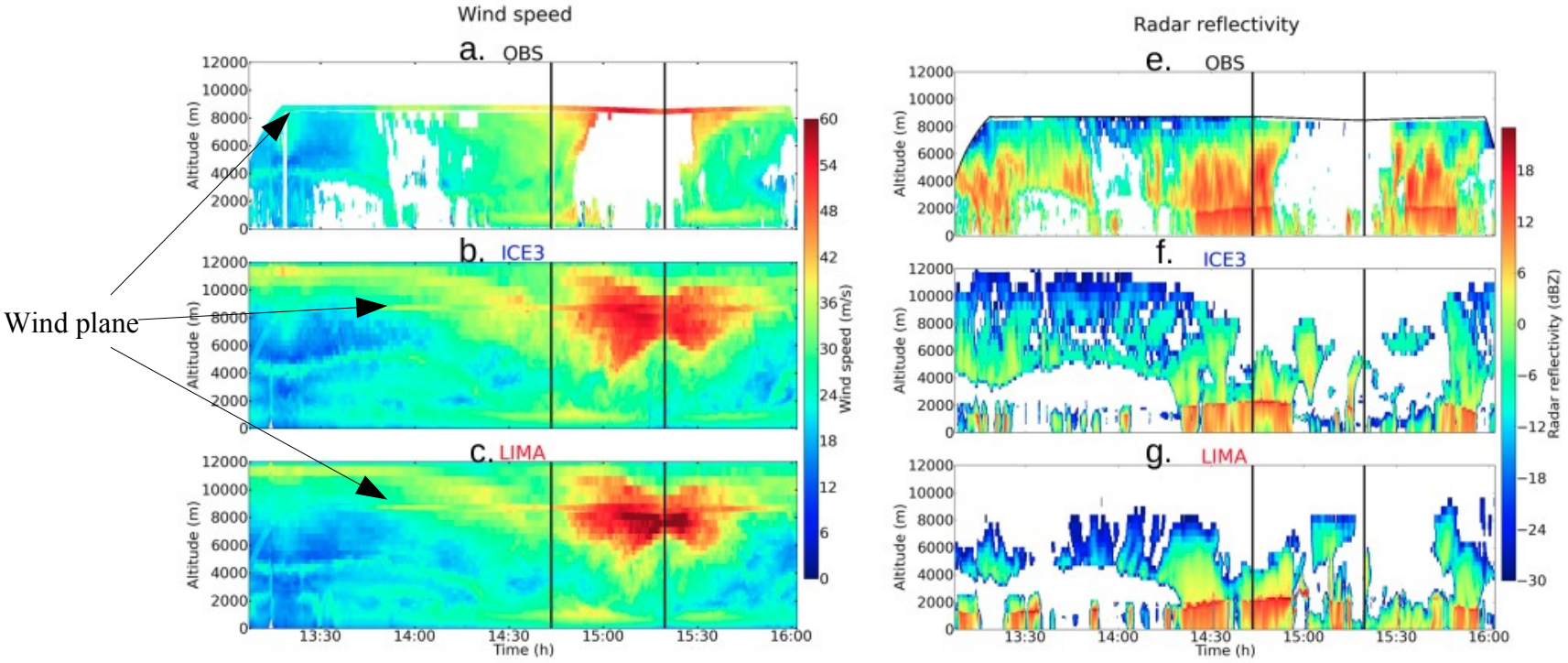


→ ICE3 better represents the north-west ridge extension

→ Could be due to adjustement to sursaturation in cold clouds (WCB of red anomaly differ strongly on ice deposition)

Remote sensing and in situ plane measurements along F7

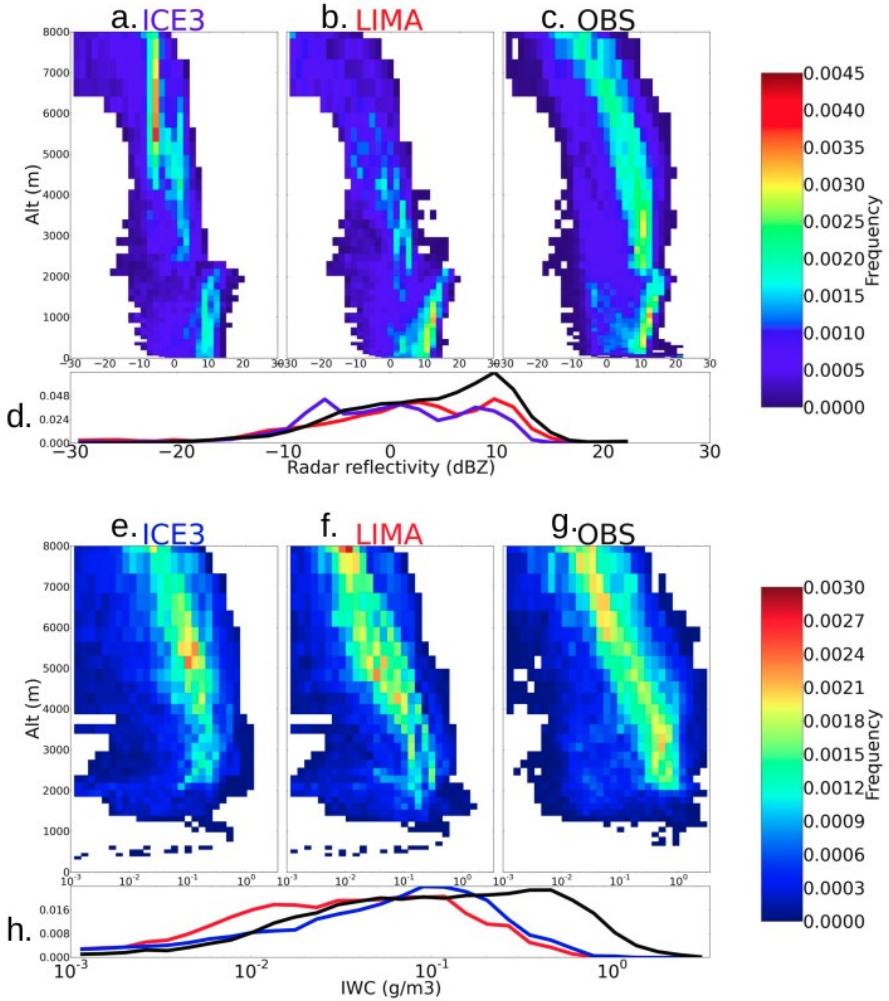




→ ICE3 more in agreement with plane wind measurements along jet stream

→ Strong underestimation of radar reflectivity with model

Radar to model and model ro radar approaches : CFAD of reflectivity and IWC along F7



⟶ Above melting layer :

- Closest intensity to the observations, reflectivity and IWC, with ICE3 (saturation adjustement)
- Better shape with LIMA (Most physical vapor deposition on ice, snow and graupel)

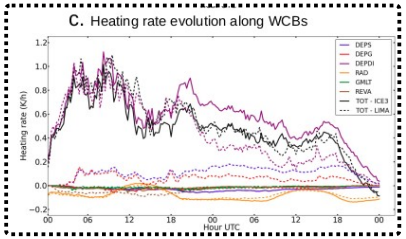
→ **ICE3 may be closest to observations for 'bad reasons'**

Conclusions

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

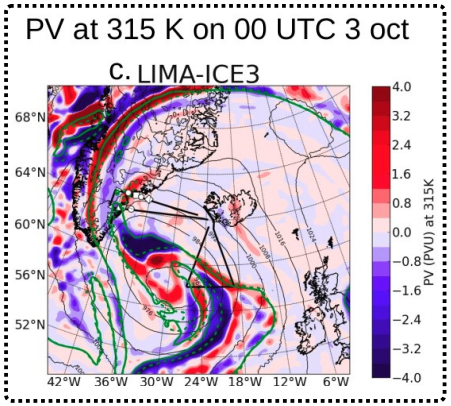
ICE3 VS **LIMA**

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



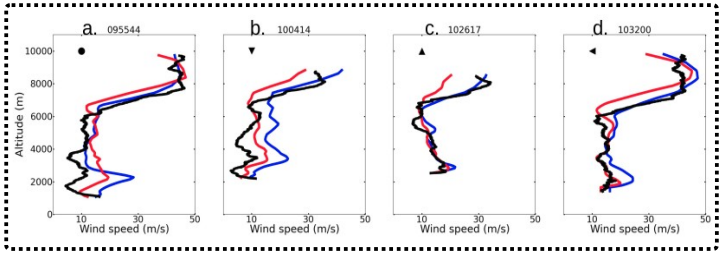
- ICE3 deposits more on ice (could be due to saturation adjustement)
- LIMA deposits on ice, snow and graupel (could be due to explicit deposition on ice, snow and graupel)

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



- ICE3 gets a more powerful WCB
- North-west extension of the ridge with ICE3 due to vapor deposition on ice
- Southern extension of the ridge with LIMA due ton cold front representation discrepancies and some embedded convection closer to the anomaly with LIMA

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



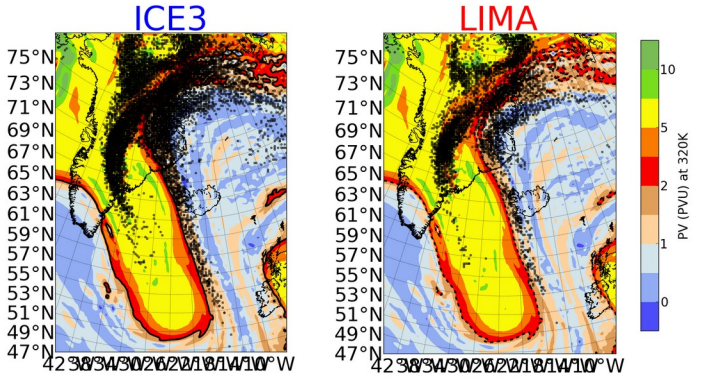
- ICE3 is closer to dropsondes observations in the anticyclonic red anomaly
- ICE3 is closer to wind plane and upper level IWC and reflectivity in the cyclonic blue anomaly
- ICE3 could be better for ‘bad reasons’

Are our conclusions still valid on other cyclones with less dynamical forcing ?

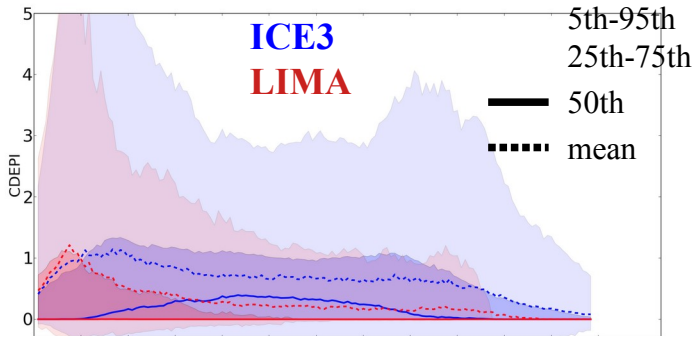
→ Simulation of moderate **'Thor' ridge** 12-15/10/2016

- ICE3 gets 55 % more WCB trajectories than LIMA
- ICE3 produces more IWC than LIMA
- ICE3 gets more vapor deposition on ice that LIMA (not compensated by vapor deposition on graupel and snow)

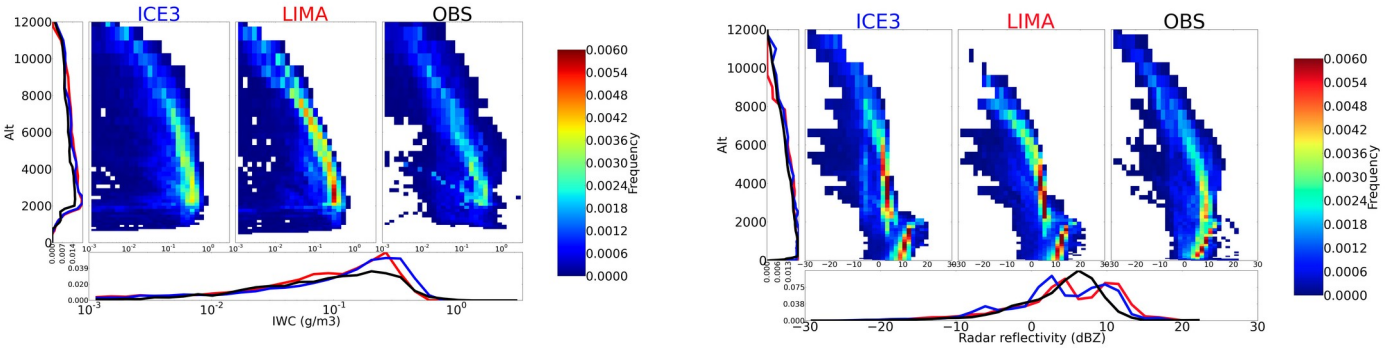
WCB arrival location after 36h of simulations



Vapor deposition on droplets/ice during 36h



Z/IWC CFAD in ascending part of the WCB

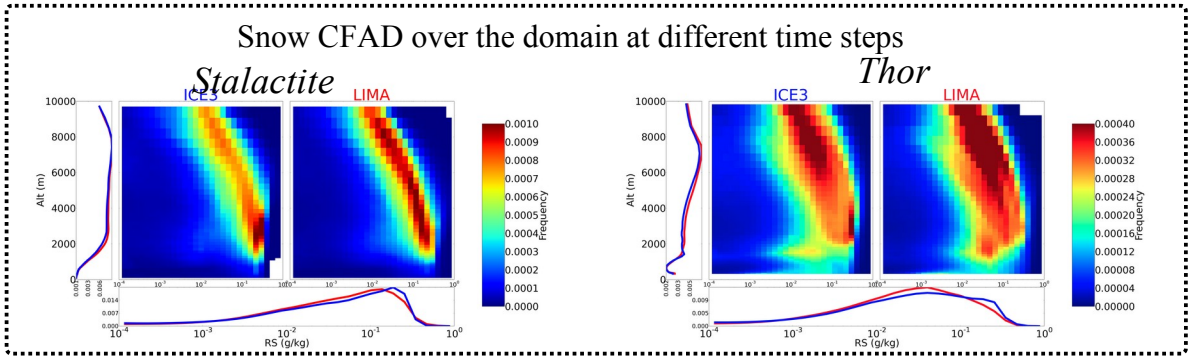


Next paper : Getting closer to the observations

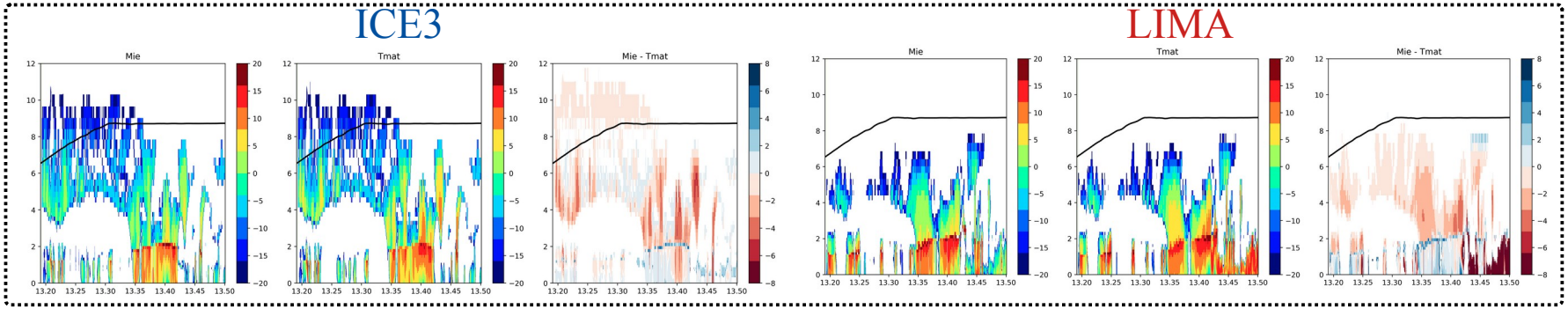
→ Numerous **sensibilities tests** performed on 24h Stalactite cyclone and 36h Thor (Nifn, Nccn, Crystals shape, ice and **snow fallspeed**, **subgrid condensation scheme**, ice-snow transition diameter, secondary ice production, **turbulence**). Not all tests relevant and always less anomalies than between ICE3 and LIMA.

→ Snow mass-size distribution is supposed to be wrong :

- New parameterisation proposed by Jean Wurtz. Sources being phased with MNH.
- LIMA fully two-moments, including snow and graupel pronostic concentrations, by M.Taufour. Sources available.



→ Radar simulator uses Mie theory, could uses T-matrix. Collaboration with M.Borderies.




Thank you for your attention
Questions ? Suggestions ?