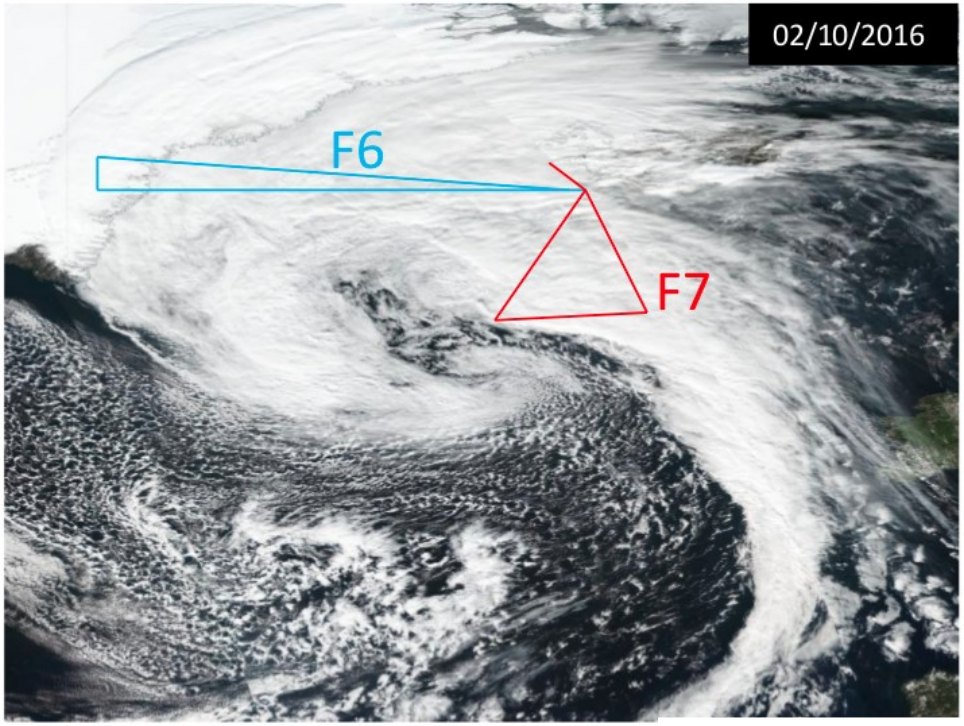
Influence of diabatic processes in warm conveyor belt of the Stalactite Cyclone in Meso-NH simulations and comparison between two microphysical schemes



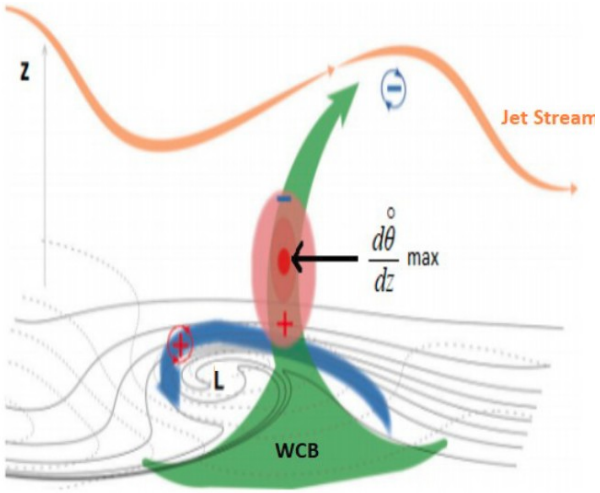
MODIS ***Figure M. Wimmer***

Marie Mazoyer (CNRM), Philippe Arbogast (CNRM), Didier Ricard (CNRM), Gwendal Rivière (LMD), Julien Delanoë (LATMOS), Quitterie Cazenave (LATMOS), Jacques Pelon (LATMOS), Benoit Vié (CNRM), Christine Lac (CNRM)

Workshop NAWDEX, Toulouse, 27/03/19

Diabatic processes in warm conveyor belt

- Extratropical cyclones : Prediction error in numerical weather prediction models -> **PV shift at the jet stream level**
- May be du to **representation of diabatic processes** through latent heat release (Roberston and Smith, 1983)
- **Microphysical** processes of importance (Joos and Wernli, 2012, Joos and Forbes, 2016)
- Many **uncertainties** in representation of warm-phase, mixed-phase and ice-phase microphysics and the role of aerosols (Thompson and Eidhammer, 2014)



Joos and Wernli (QJRMS, 2012)

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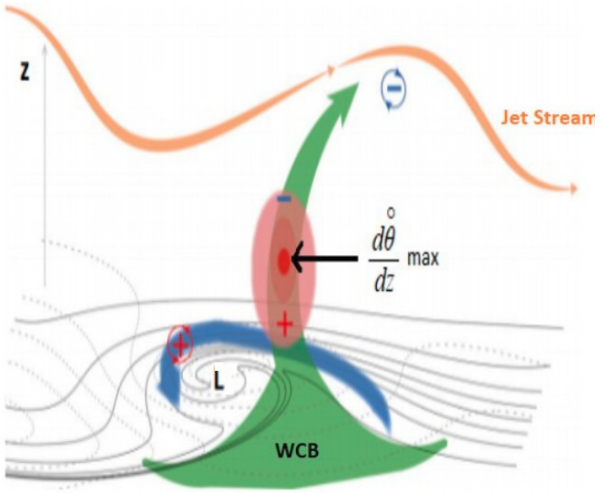
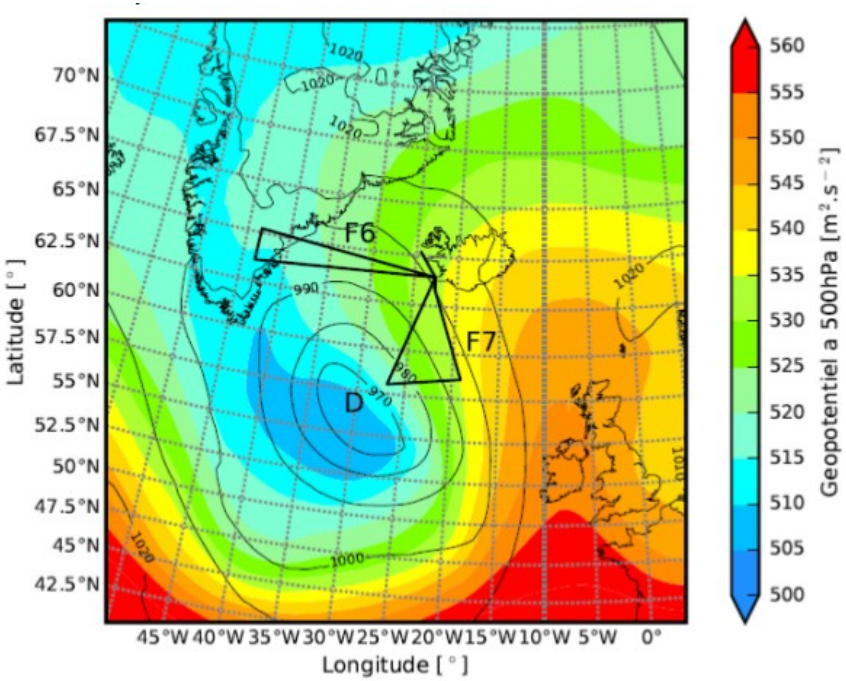


Joos and Wernli (QJRMS, 2012)

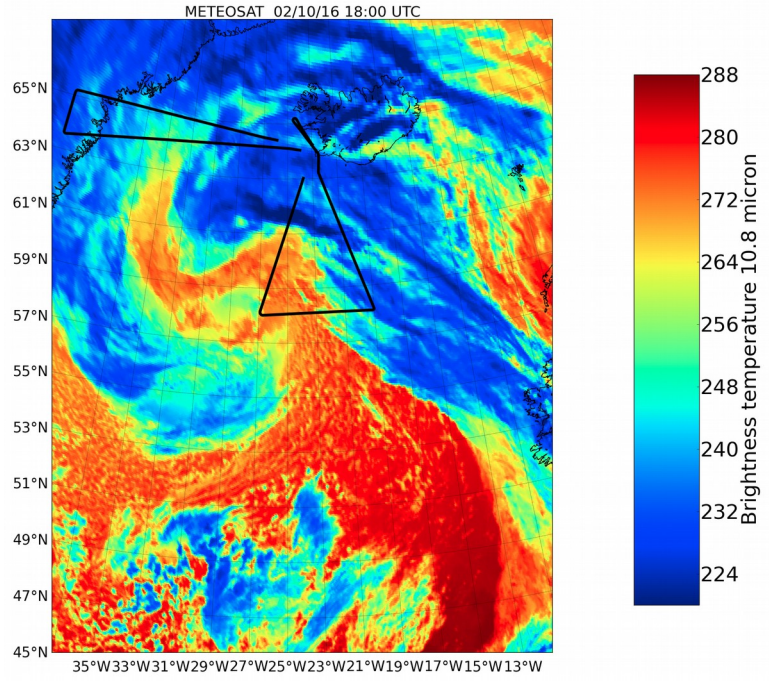
➡ Objectives : Comparison of two distincts microphysical schemes
(→ **mixed and ice phase and distribution's moments**)
and their impact on a WCB representation

02/10/2016 - **Stalactite cyclone** - Nawdex campaign

➡ Blocking situation over scandinavia during ~ 10 days
Apogee 02/10/2016 21:00 UTC (960 hPa)



Arpege analysis 02/10/2016 12:00



Meteosat brightness temperature at 10.8µm 02/10/2016 18:00

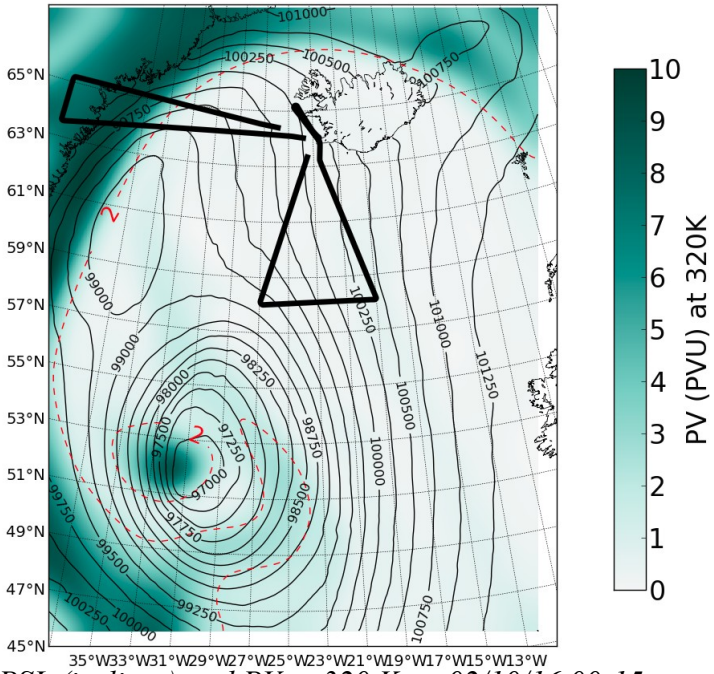
Falcon 20 flights : F6 - 09:30 → 11:30
F7 – 13:00 → 16:00

➡

RASTA embedded (Reflectivity, Ice Water Content, Wind)
+ F6 : Dropsondes (P,T,U,RH)

02/10/2016 - **Experiences**

- **Méso-NH** (Lac et al, 2018)
- 02/10/16 00h → 03/10/16 00h Output : every 15min
- CI and forcing : Arpege
- Domain : XY → **2.5 km*2.5 km** 800*1000 pts (Convection resolved)
  Z → 56 verticals levels ~[0-20]km



PSL (isolines) and PV at 320 K on 02/10/16 00:15

Obs 'model' :
+Flights collocated et cotemporalized
+Radar simulator
+'Satellite' simulator (RTTOV, Saunders et al, 2002)

-**Microphysics** : ICE3 (Pinty and Jabouille, 1998)
LIMA (Vié et al, 2016)

Microphysical schemes

ICE3

LIMA

Droplet, rain, graupel, snow, ice

One moment (r)

Two moments (r,N)
-Droplet, rain, ice

➡ **Concentration evolution with LIMA**
→ Simulation LIMA : aerosols loading homogeneous in space and configuration similar to ICE3
→ Differencies on the transition from a specy to an other
→ Differencies in precipitation velocities
→ Radiation interaction

Ice supersaturation

Equilibrium humidity Ice/ Liquid : Linear temperature function between 0°C and -20°C

No equilibrium imposed for cold species
Explicit calculation of vapor deposition

➡ **Different vapor deposition for T<0°C (on cold species and on droplets)**
Latent heat release may differ (more important vapor ↔ liquid)

Influence of diabatic processes in warm conveyor belt of the Stalactite Cyclone in Meso-NH simulations and comparison between two microphysical schemes

00 – Case and simulation presentation

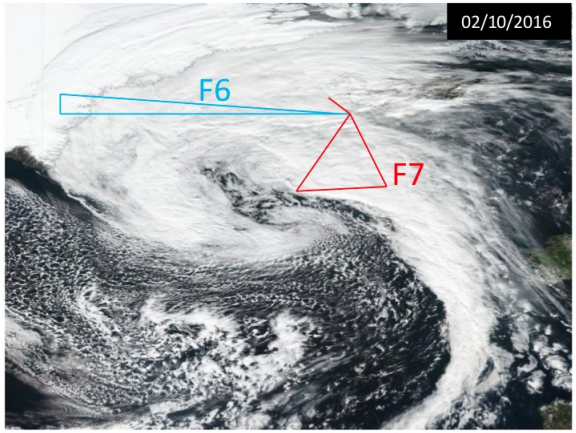
0 – Differences between two schemes ICE3/LIMA

1 – Comparisons with observations

2 – Comparisons of hydrometeors mixing ratio on the whole domain

3 – Impact on altitude anticyclone (lagrangian view point)

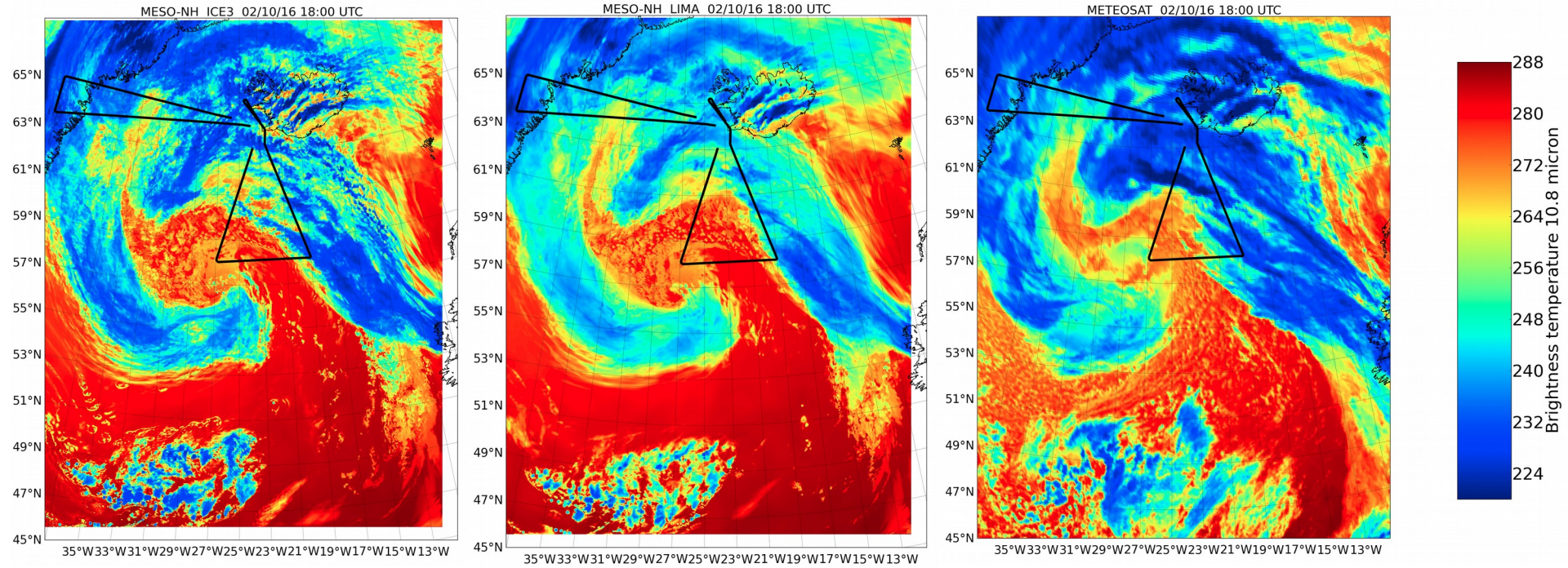
4 - Conclusions



Clouds top and structure

Meteosat, brightness temperature 10.8 µm, 18:00

ICE3 LIMA OBS

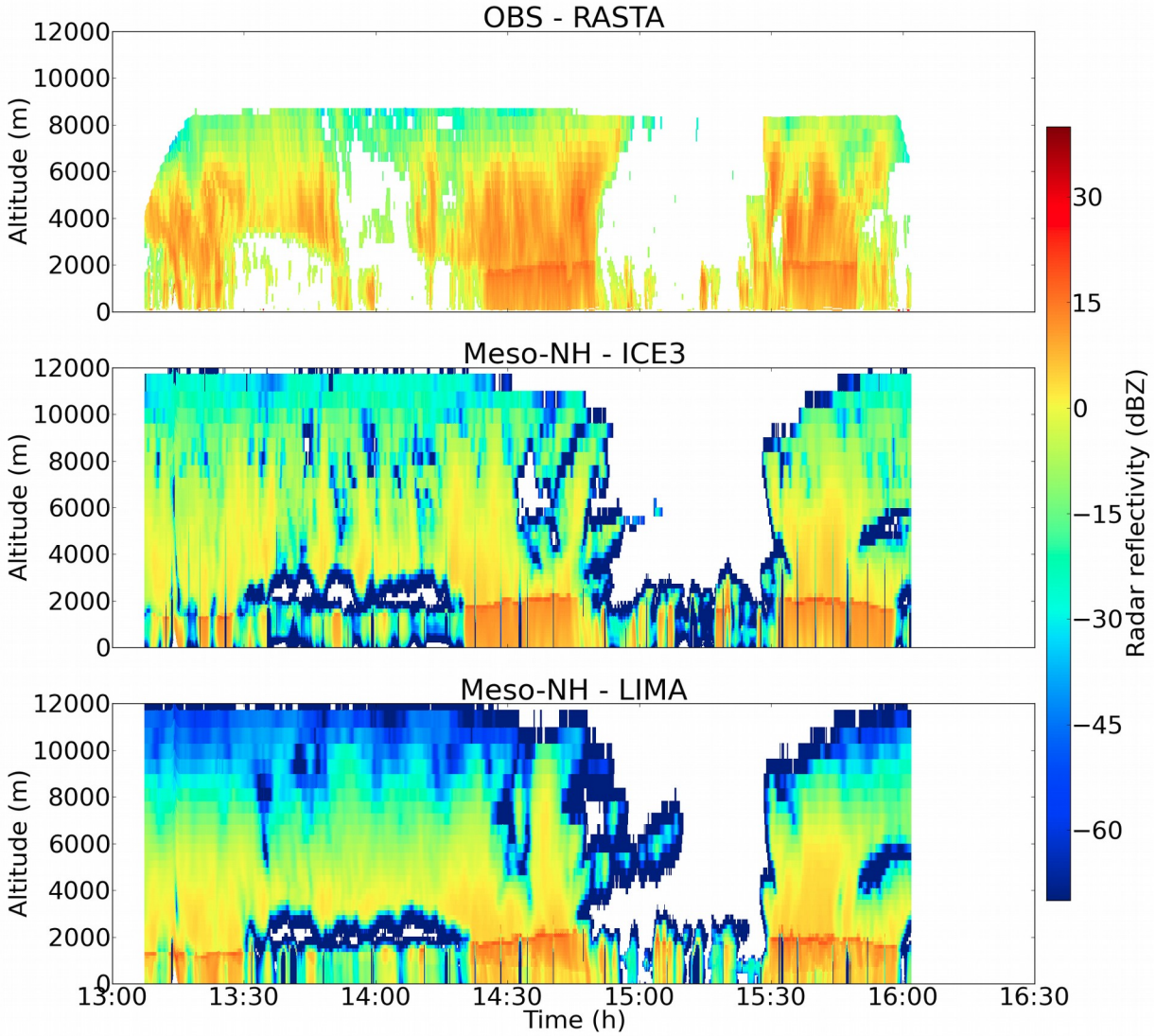


Clouds structure very similar

➡ WCB (LIMA/ICE3) more NE than obs

LIMA clouds temperature higher

Radar reflectivity - F7



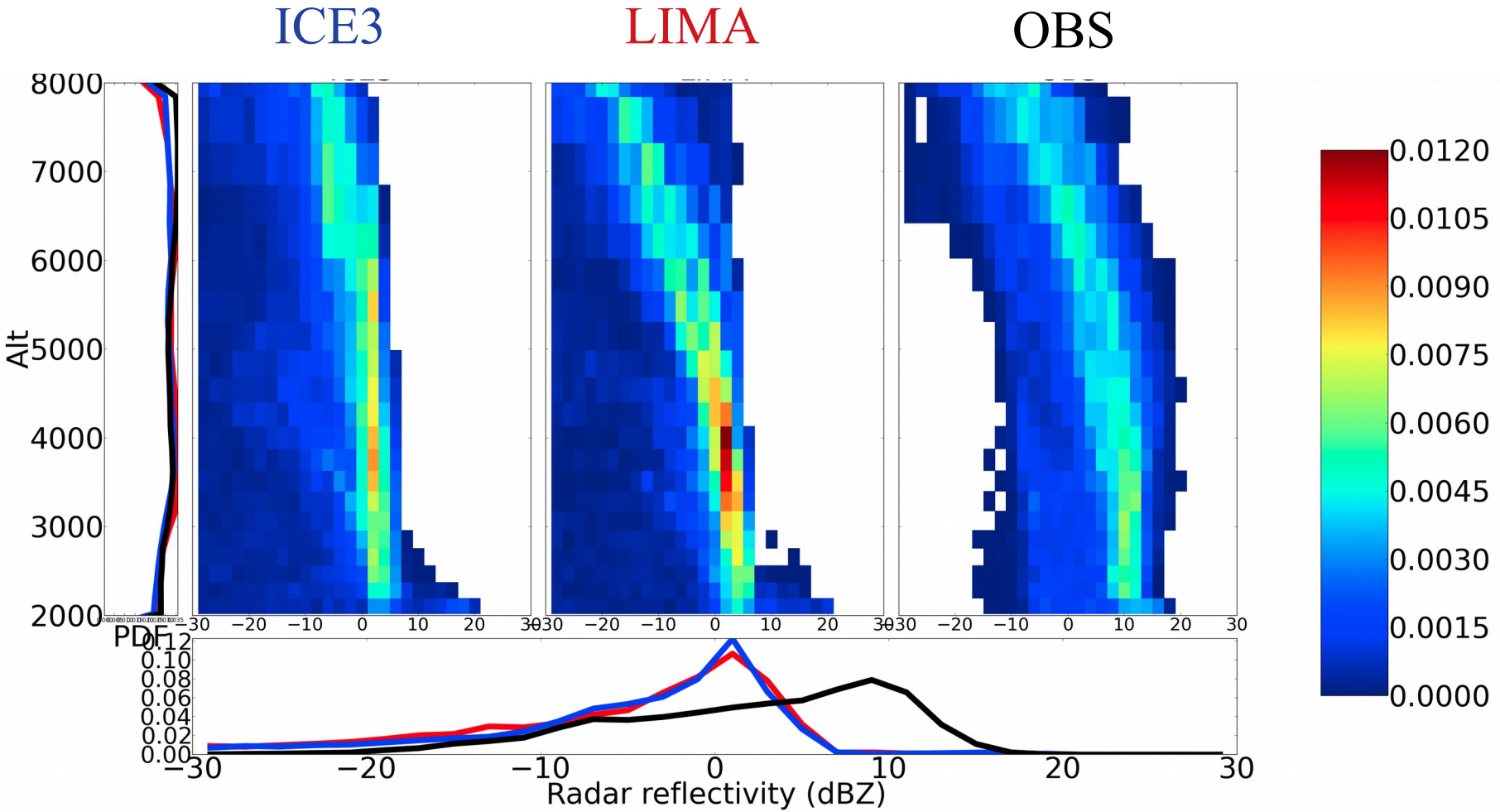
-**Very close structure** (ICE3 less diffuse, subgrid condensation scheme)

-Melting area similar

-Strong Z understimation

-**LIMA top clouds** have **lower reflectivies** (as satellite data)

Radar reflectivity – F7 – Bivariate PDF



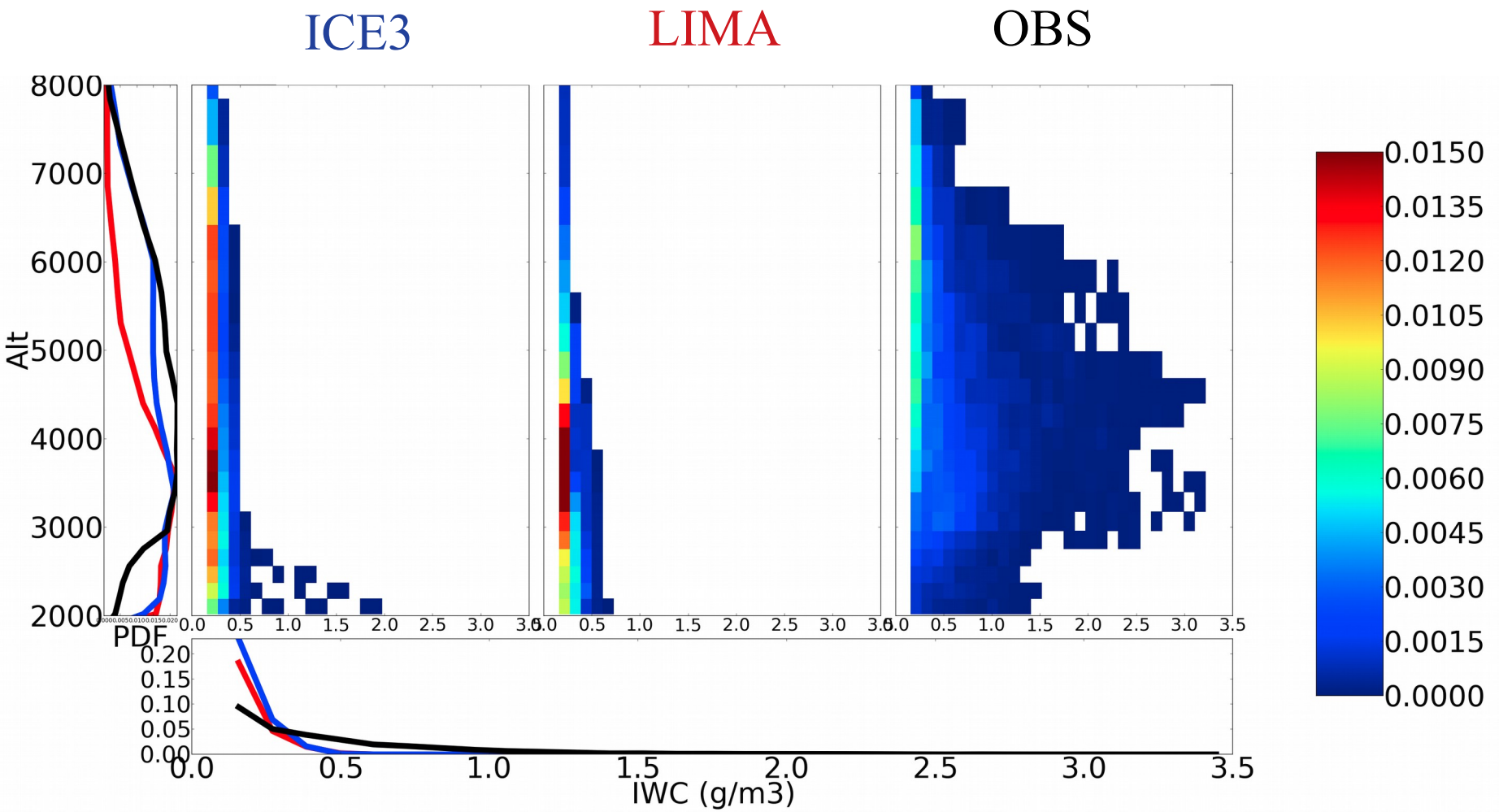
-Shift between models and obs

-PDF radar reflectivity : **Different repartition in intensity**

➡ **-ICE3 high intensity in altitude closer to the obs**

-LIMA shape slighty closer to the obs (same on HyMex campaign)

Ice Water Content – F7 – Bivariate PDF



-Lower IWC with LIMA and ICE3 than OBS

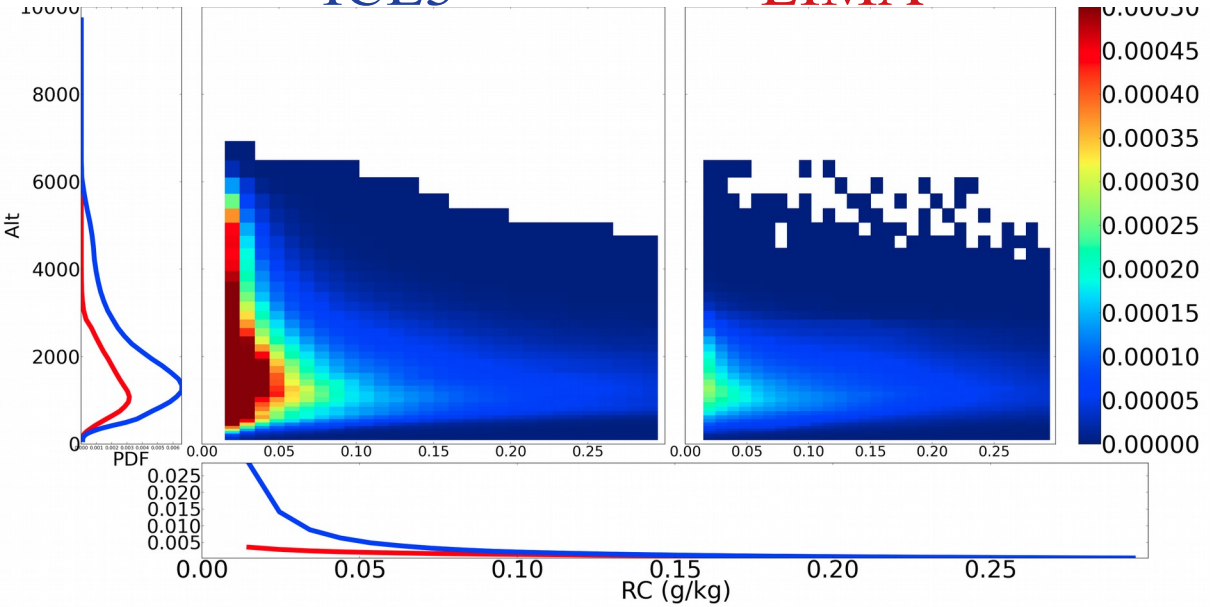
➡ **-Different repartition with altitude**

-LIMA less ice in altitude

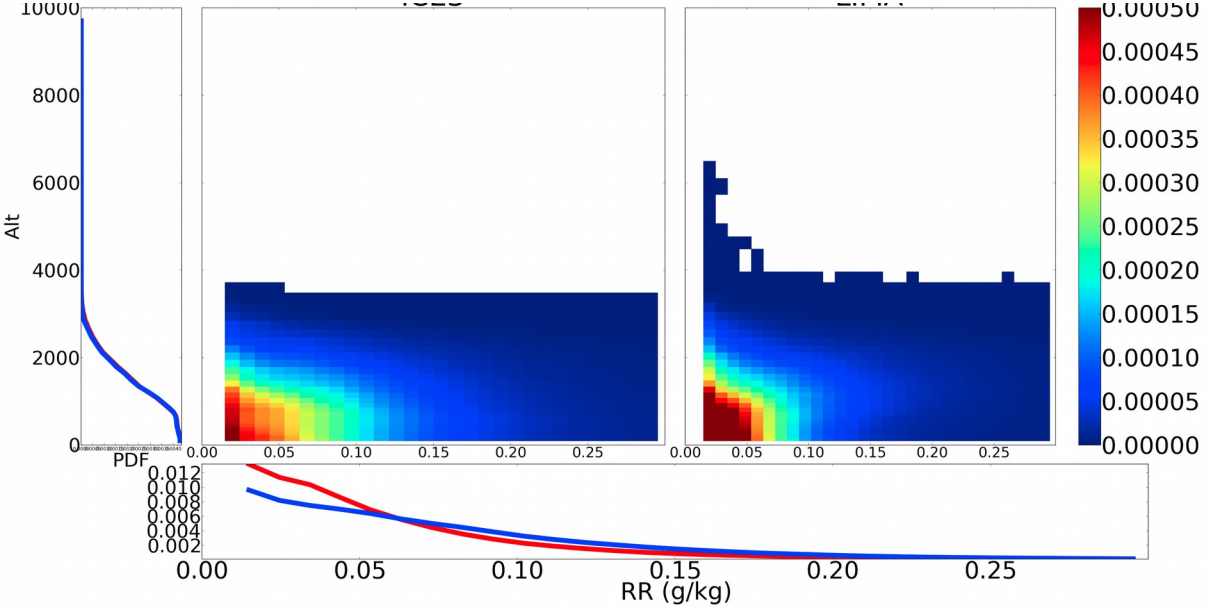
Hot microphysics mixing ratio **whole domain** (00h, 06h, 12h, 18h, 24h)

ICE3 LIMA

Droplets



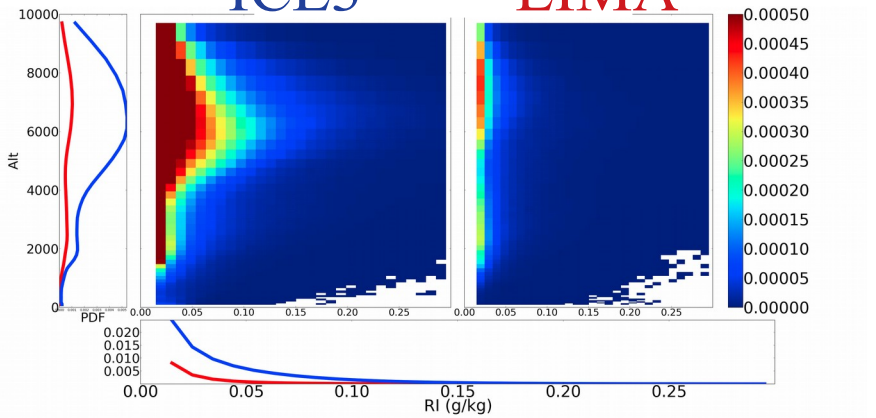
Rain



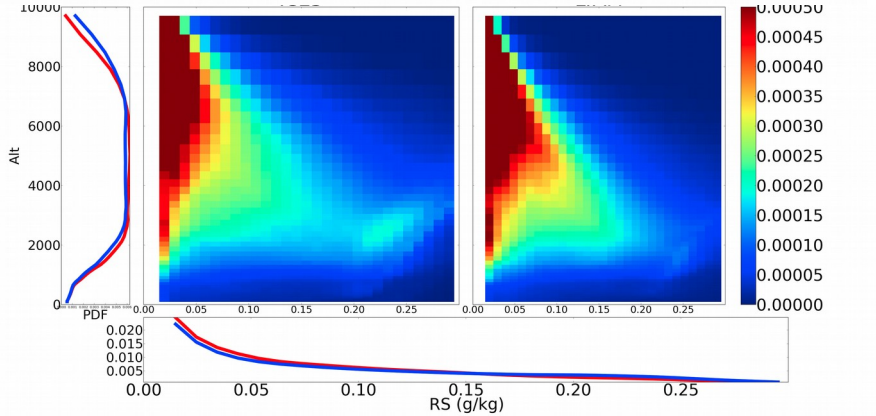
Cold microphysics mixing ratio **whole domain** (00h, 06h, 12h, 18h, 24h)

ICE3 LIMA

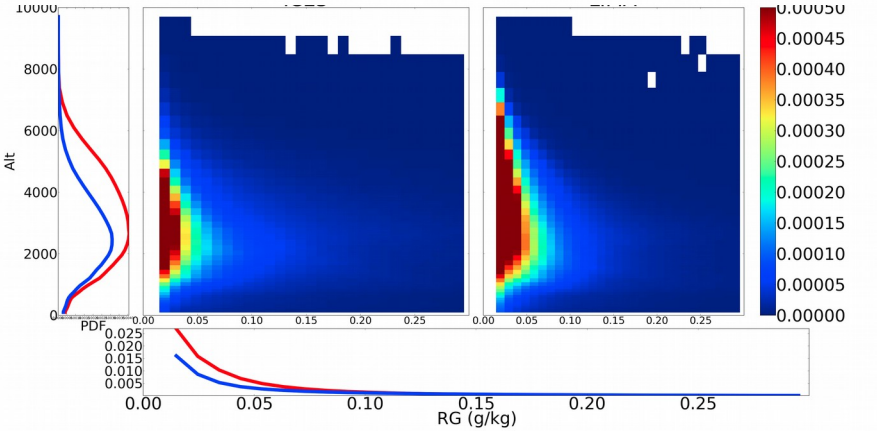
Ice



Snow



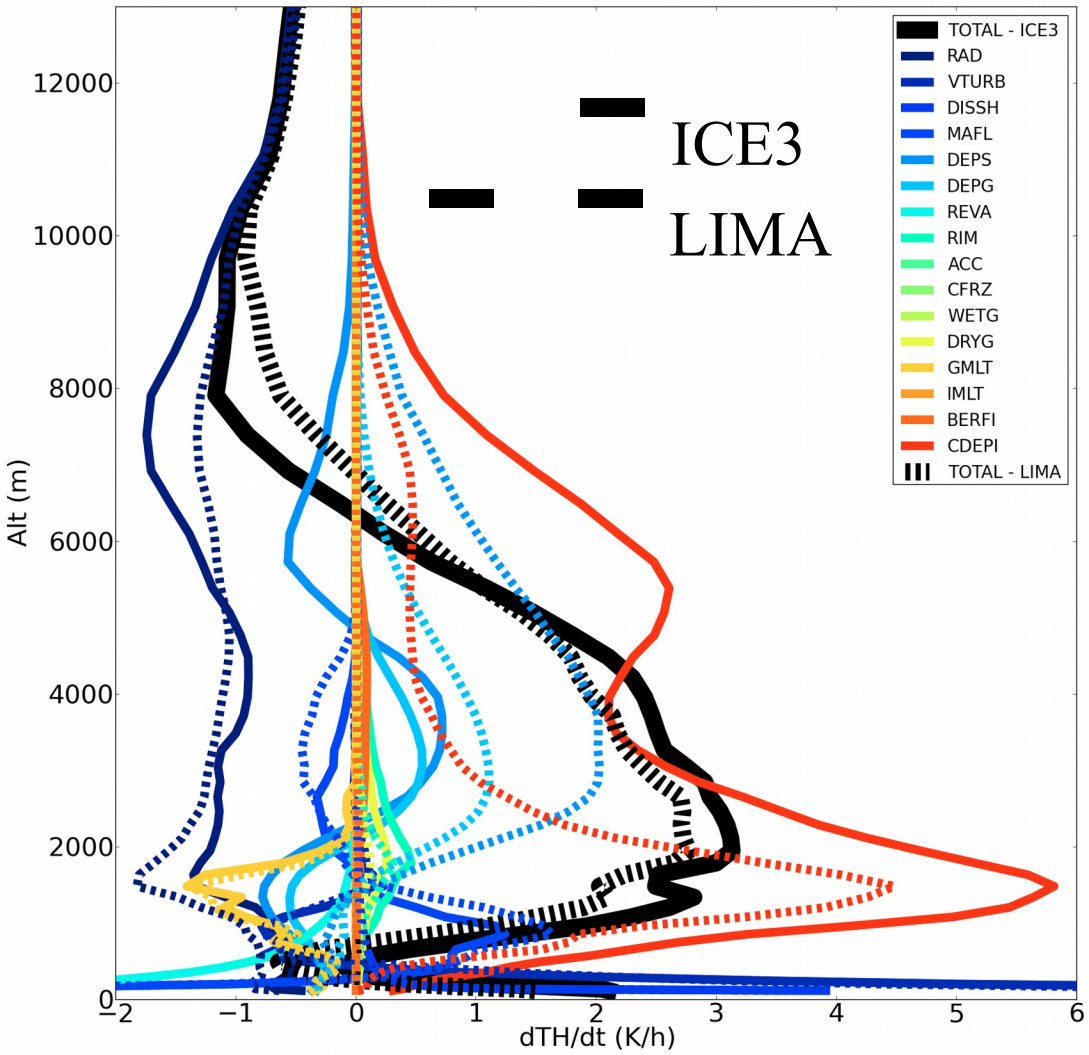
Graupel



Impact on **diabatic heating** ??

TH budget on the whole domain

03/10/16 00:00



Radiation

Depot on snow

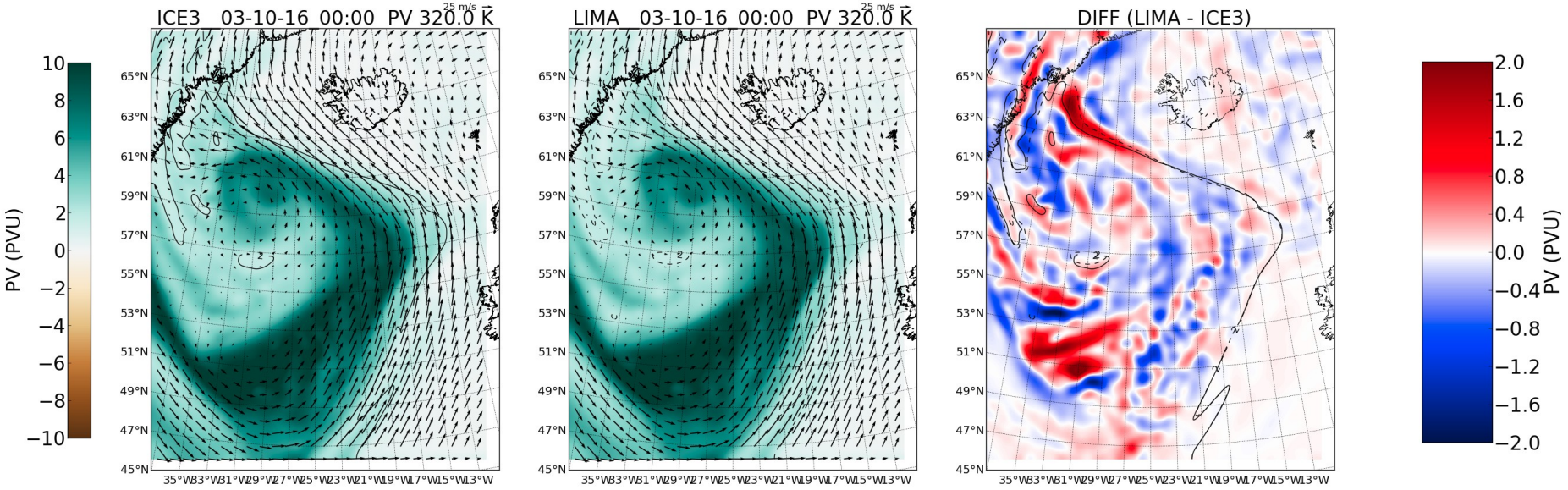
Depot on graupel

COND/EVAP (ice and liquid)

➡ **TH dipole less pronounced** with **LIMA** (and associated with different processes)[14]

Impact on **altitude anticyclone** – PV at isentrope 320 K – 03/10/16 - 00:00

ICE3 LIMA LIMA-ICE3



2PVU ICE3

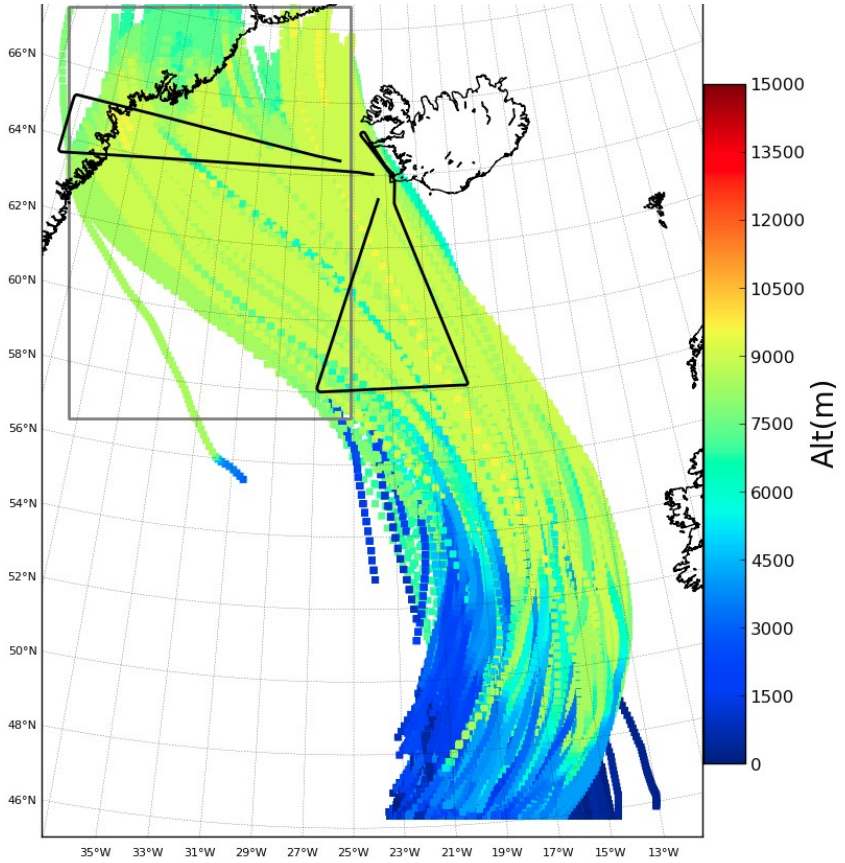
2PVU LIMA

➡ **LIMA** 2PVU **NE shift** (2°)

WCBs (300hPa elevation in 24h, Jood and Wernli, 2012)
BACKWARD TRAJECTORIES : 168 960

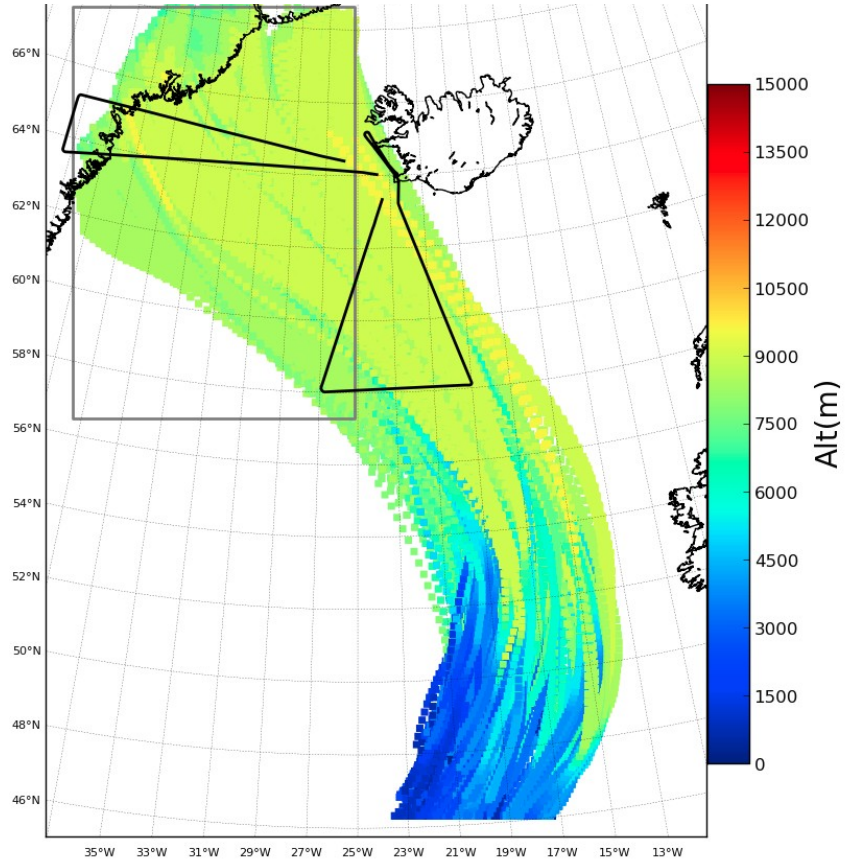
➡ **Trajectories** intersecting **isentrope 320 (+-5) K** on 03/10/16 00:00

ICE3



WCB : 3 060

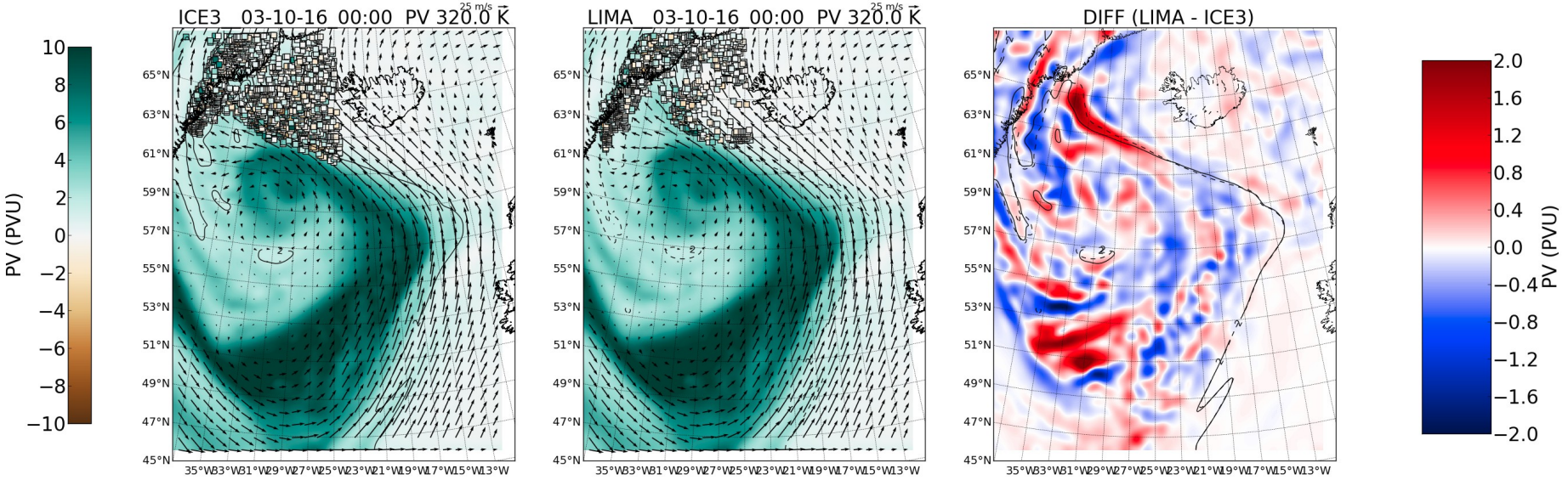
LIMA



WCB : 1 719

Impact on **altitude anticyclone** – PV at isentrope 320 K – 03/10/16 - 00:00

ICE3 LIMA LIMA-ICE3



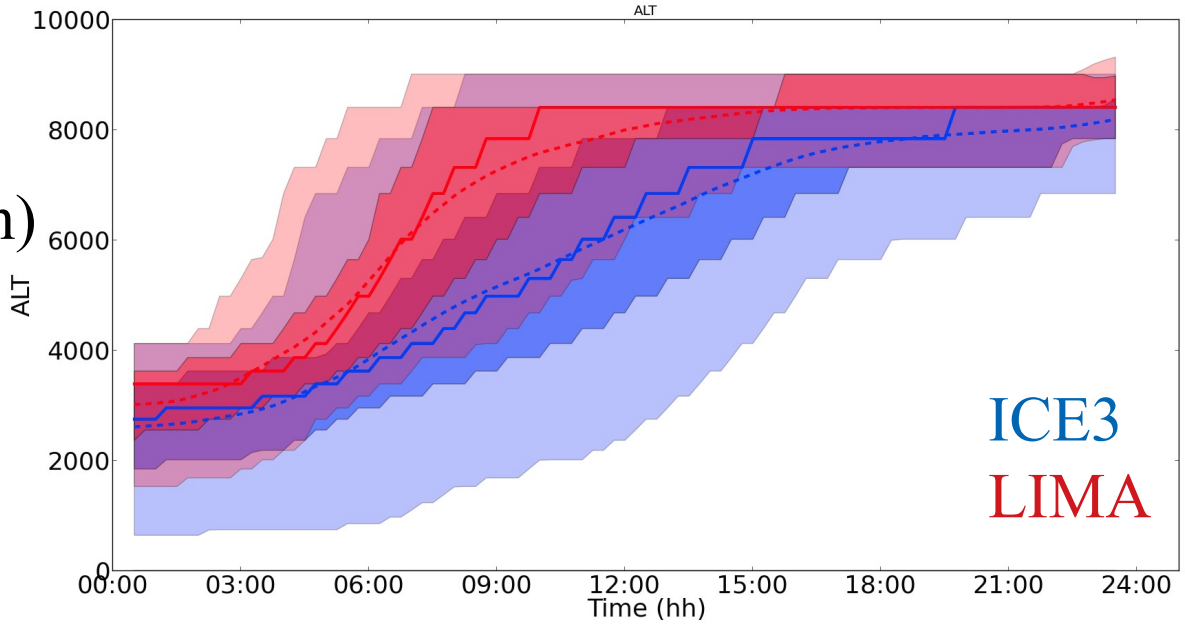
2PVU ICE3

2PVU LIMA

➡ **LIMA** less intersection with isentrope 320K, **WCB less active**
Less reinforcement of the altitude anticyclone

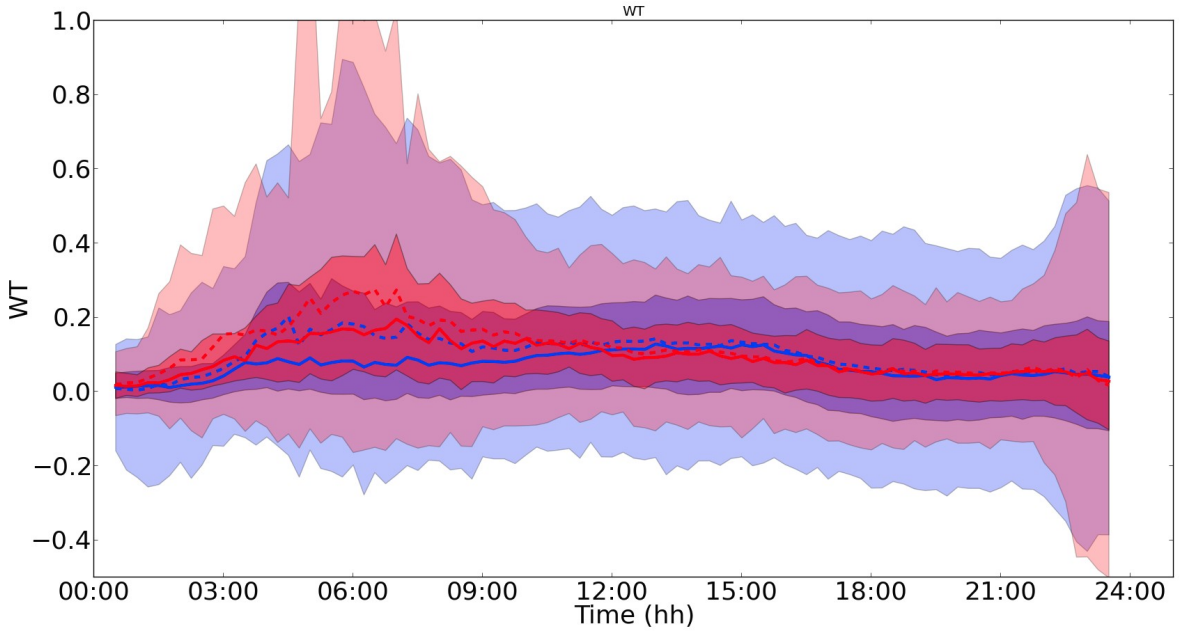
Temporal evolution – **Altitude and vertical velocities**

Altitude (m)

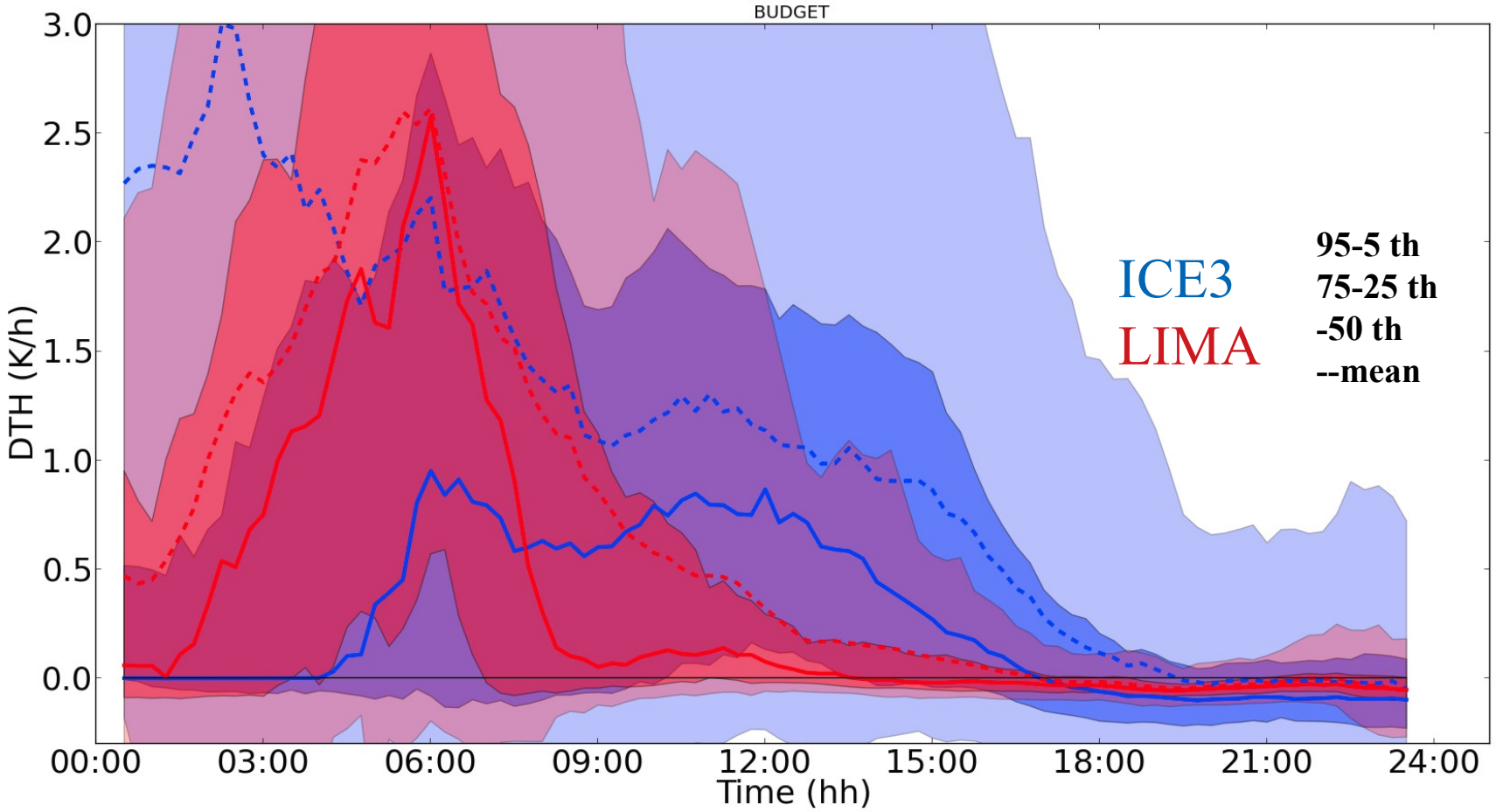


95-5 th
75-25 th
-50 th
--mean

W (m/s)



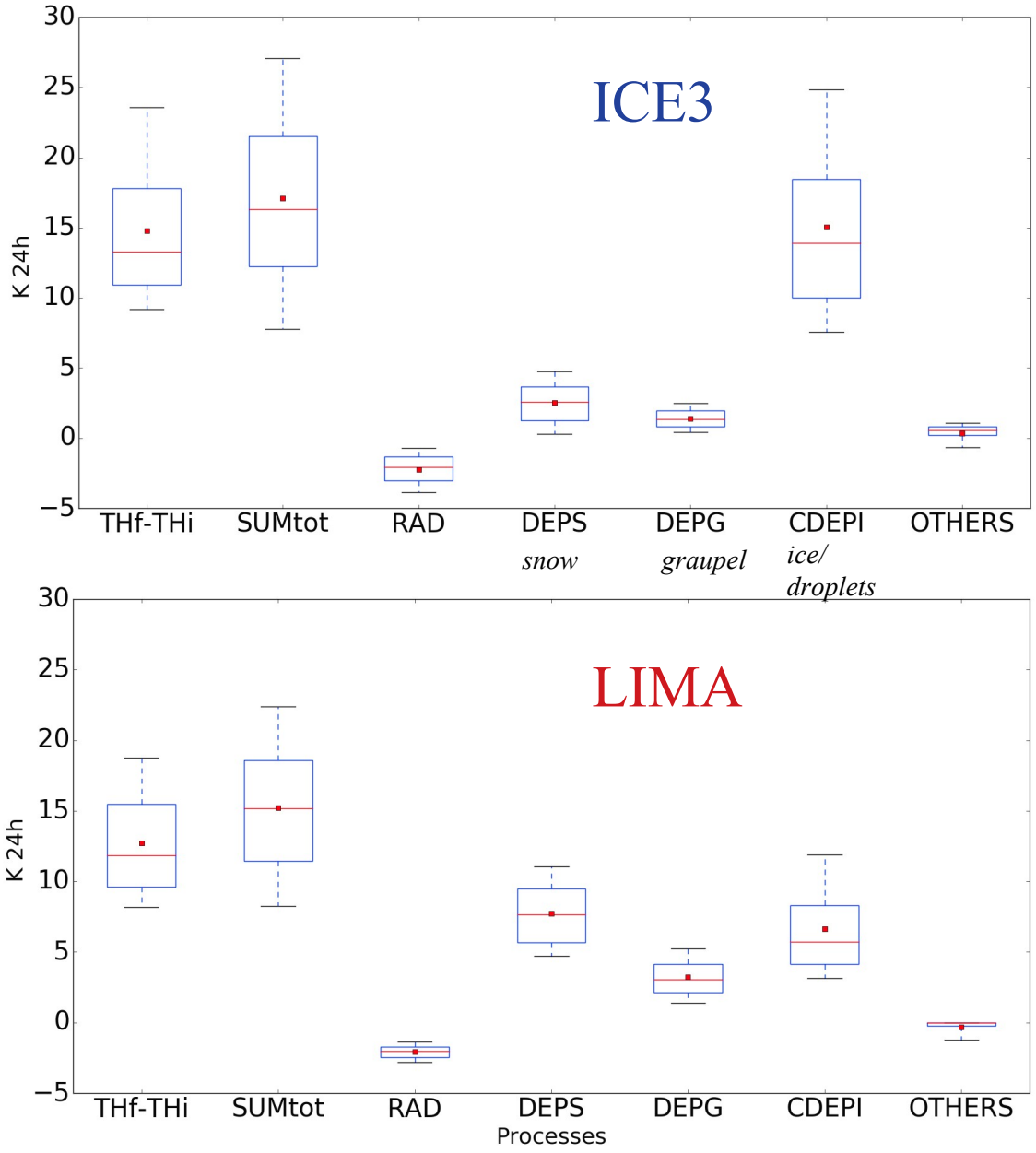
Temporal evolution – **Potential temperature budget**



➡ Two peaks of latent heat release

Second peak which may help to ascent more trajectories **less intense with LIMA**

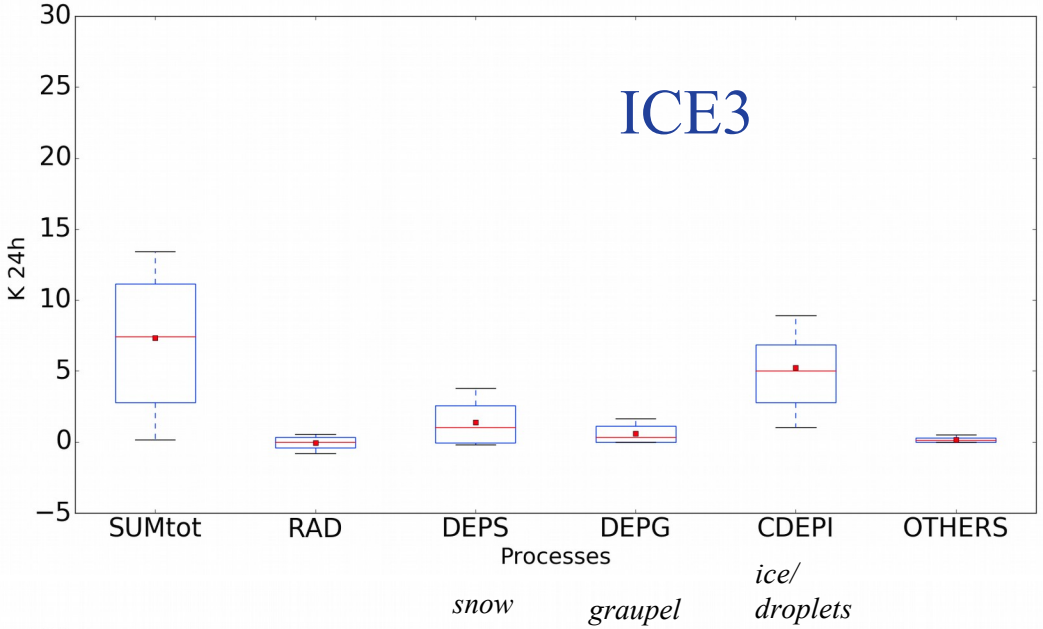
Main diabatic processes (4/16), DTH/Dt : 00-24h

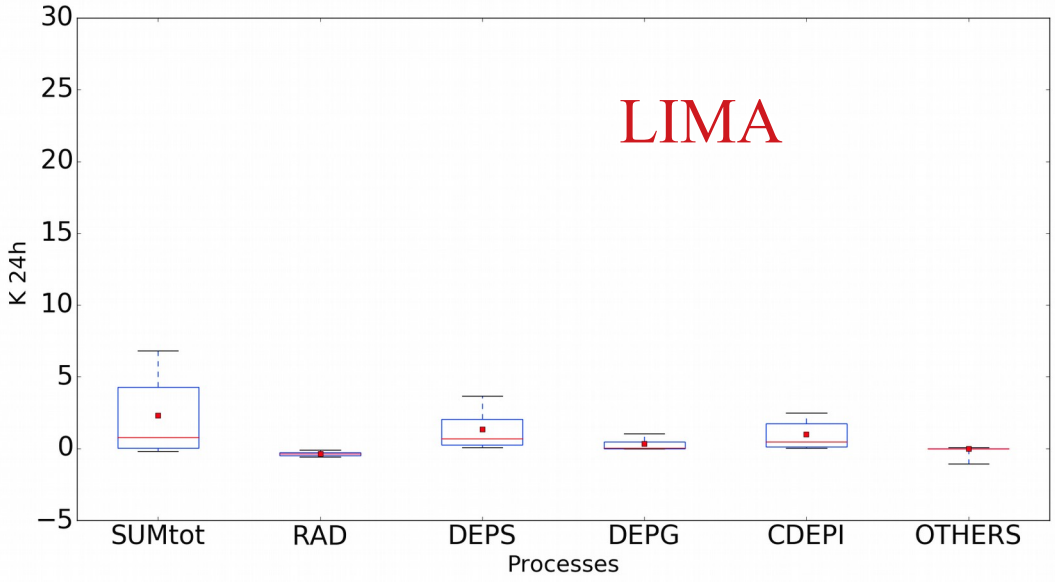


→ **Same main processes but different importances** :

- Radiation
- Deposition on snow
- Deposition on graupel
- **Deposition on ice** and droplets

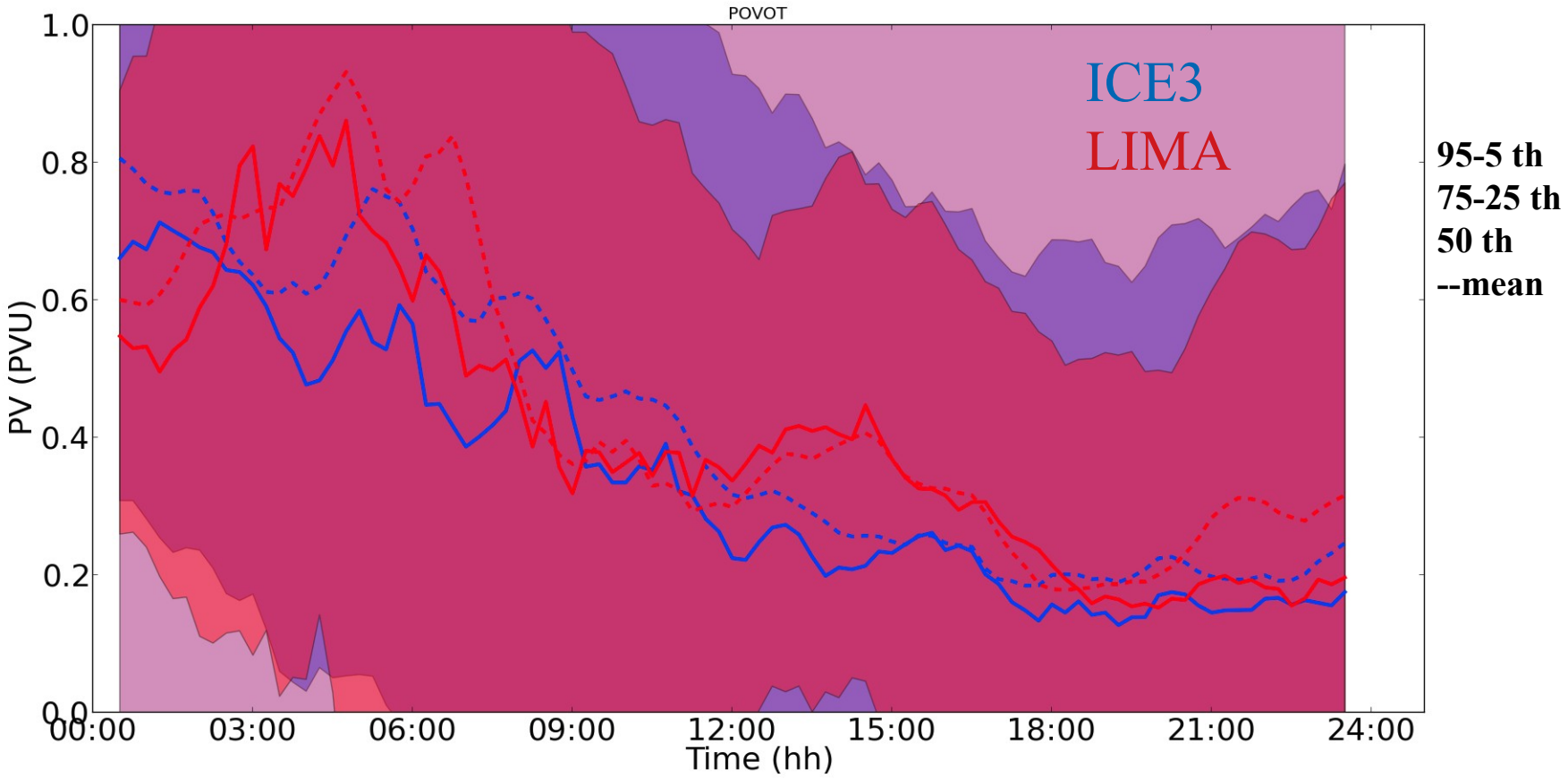
Main diabatic processes (4/16), DTH/Dt : Second peak – 09:16h





➡ Second peak with ICE3 due to **deposition on ice**

Temporal evolution – **Potential vorticity**



➡ LIMA higher PV after 24h (0.1 PVU)

CONCLUSION

➡ **Comparisons** of two simulations with **two distincts microphysical schemes** of the **Stalactite Cyclone**

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→ After 24h, **LIMA 2° NE shift** compare to ICE3 for the 2PVU isoline at 320 K

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→ **LIMA seems to produce less ascent due to deposition on ice at higher altitude**
Same dominant processes for both : Ice and droplets deposition, snow deposition, graupel deposition and radiation with different repartition

→ **LIMA produces less ice than ICE3** on the whole domain and on F7

→ Comparison with reflectivities observed : - Both shift on intensity
- LIMA shape closer to the obs
- ICE3 intensity in altitude closer to the obs

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➡ **Intensities of the WCB seems to differ due to the ice production and subsequent vapor deposition**
But small impact on upper level after 24h

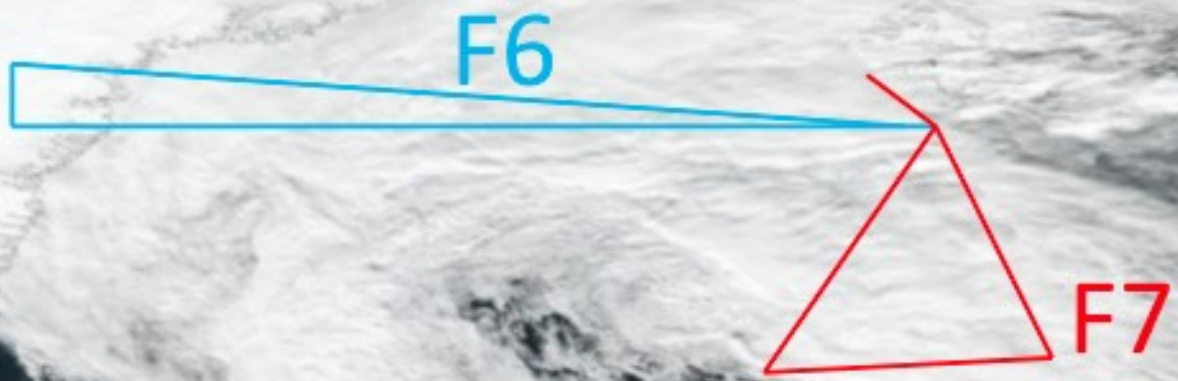
PERSPECTIVES

→ Equivalent study on a case with a less intense warm conveyor belt
To have weaker impact of synoptic flow

Any case suggestions ?

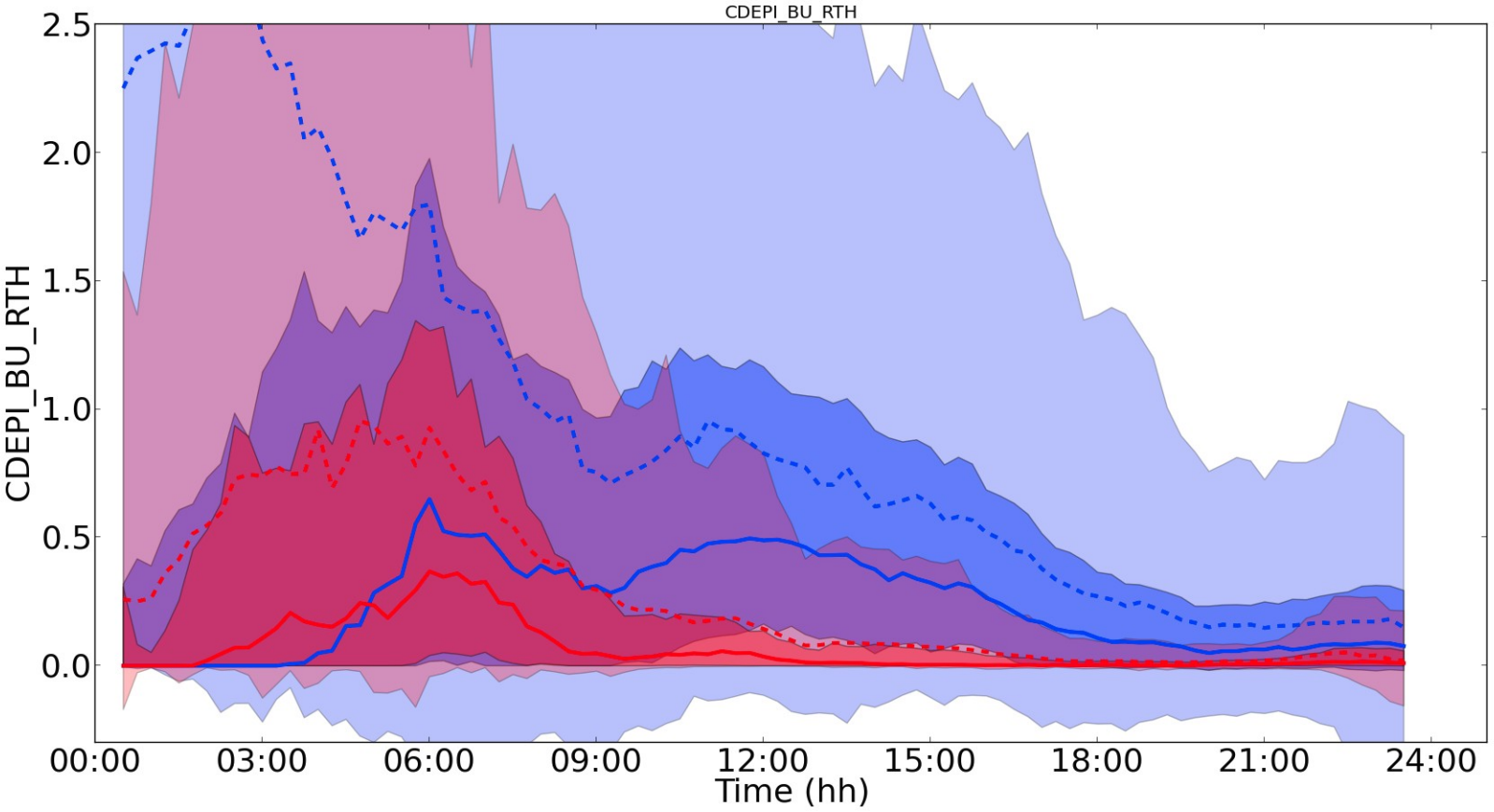
→ Test on physics (including terminal fall speed of snow should impact reflectivities) and aerosols concentration with LIMA on this other case (negligeable impact on Stalactite cyclone)

Any other tests suggestions ?

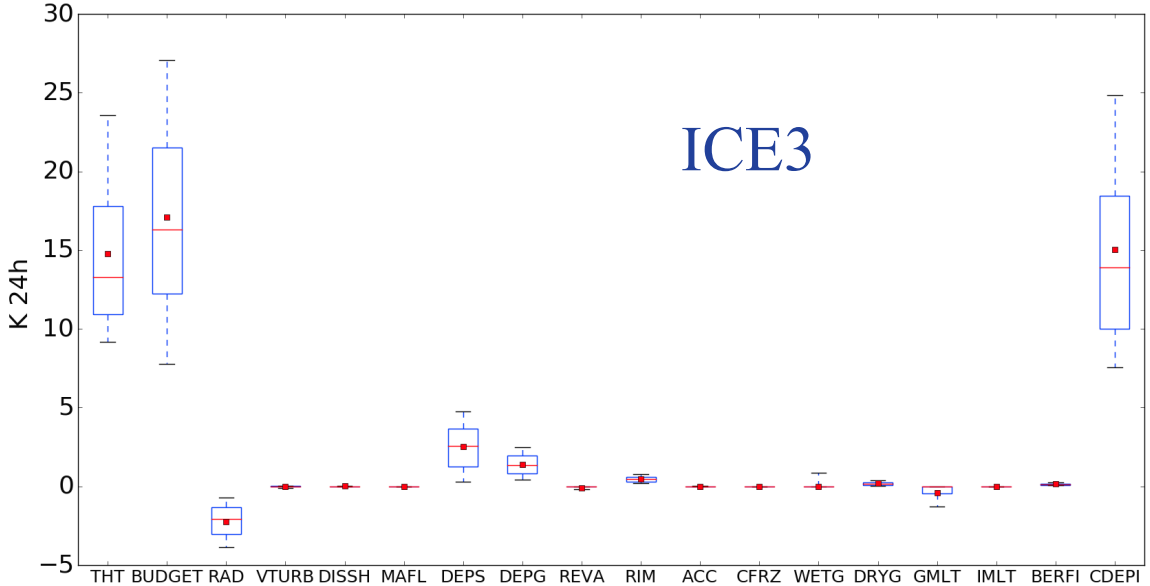


Thank you for your attention

Questions ?


CDEPI_BU_RTH
CDEPI_BU_RTH
2.5
2.0
1.5
1.0
0.5
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
24:00
Time (hh)

Diabatic processes, **DTH/Dt : 00-24h**



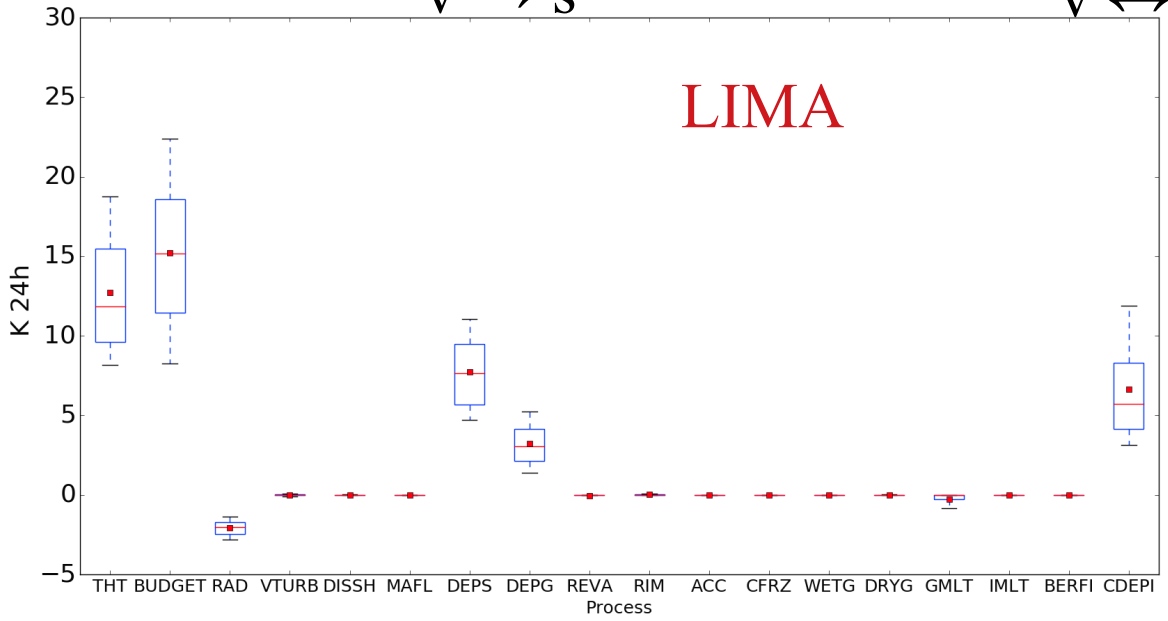
rad

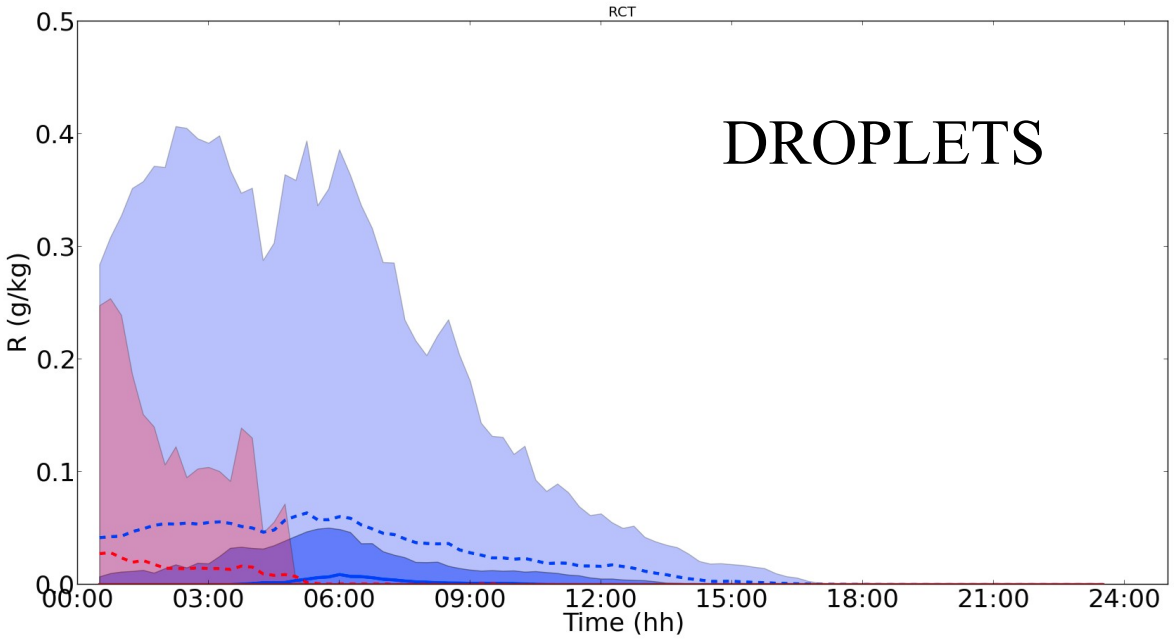
v → g

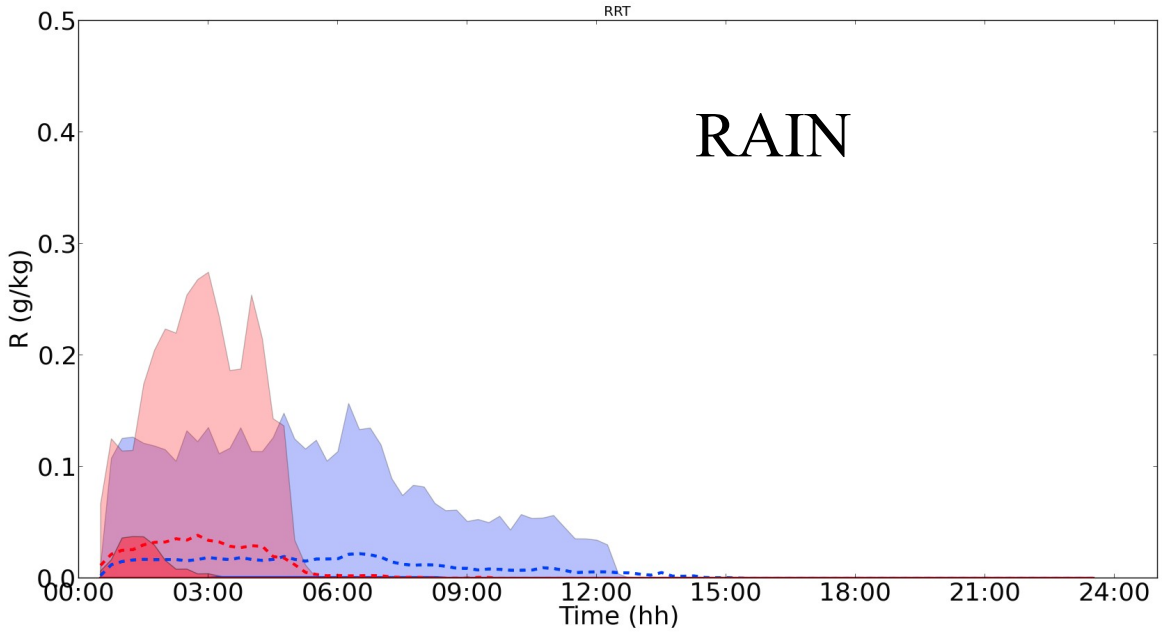
v ↔ d

v → s

v ↔ i




RCT
DROPLETS
R (g/kg)
0.5
0.4
0.3
0.2
0.1
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
24:00
Time (hh)


RRT
RAIN
R (g/kg)
0.5
0.4
0.3
0.2
0.1
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06:00
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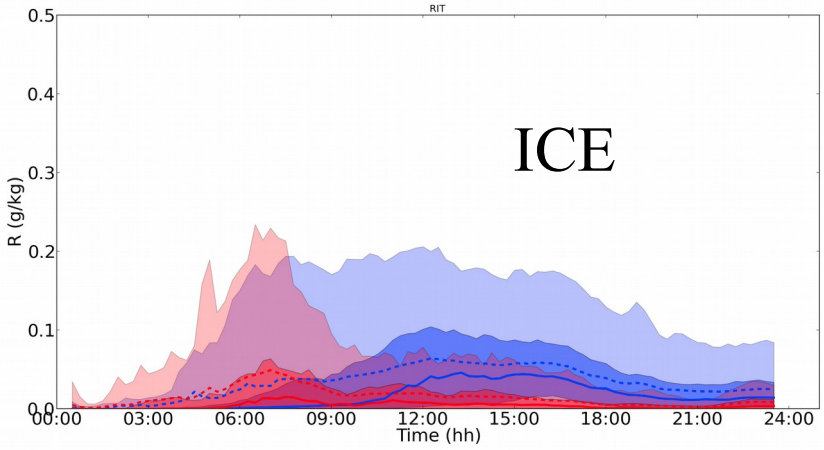
15:00
18:00
21:00
24:00
Time (hh)


RIT
ICE
R (g/kg)
0.5
0.4
0.3
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00:00
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06:00
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12:00
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18:00
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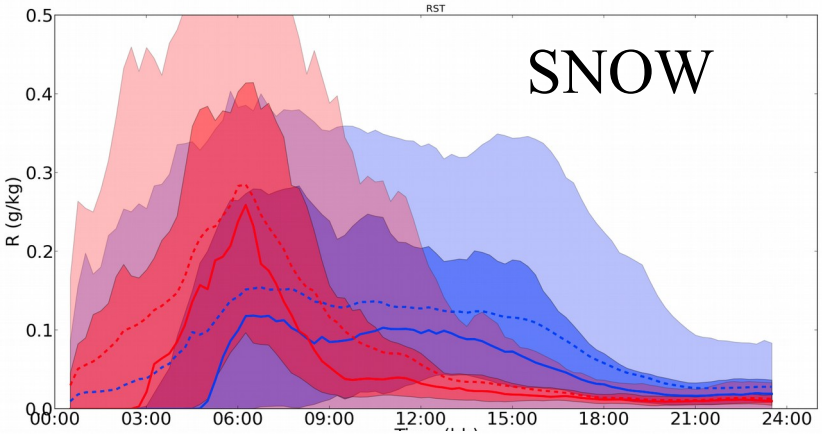
24:00
Time (hh)


RST
SNOW
R (g/kg)
0.5
0.4
0.3
0.2
0.1
0.0
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03:00
06:00
09:00
12:00
15:00
18:00
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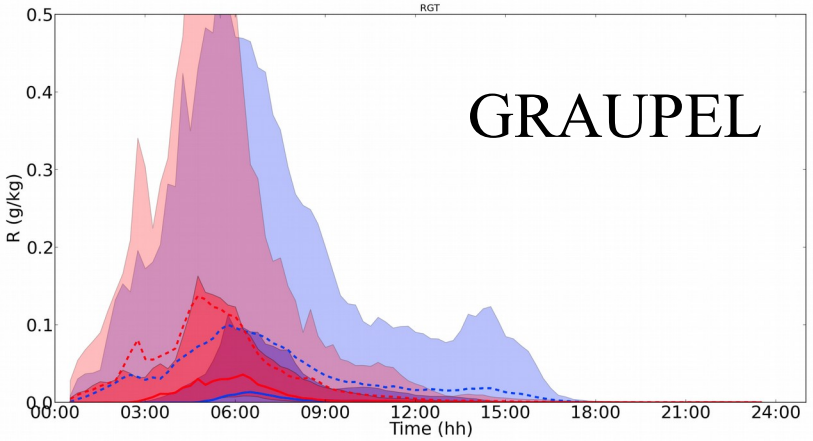
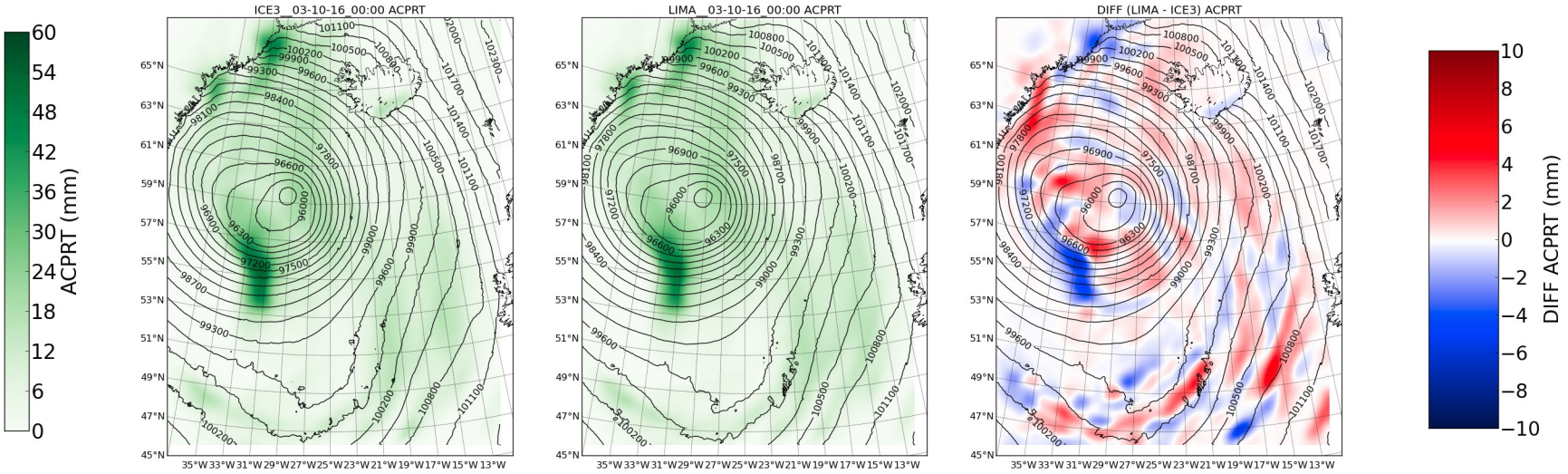

RGT
GRAUPEL
R (g/kg)
0.5
0.4
0.3
0.2
0.1
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
24:00
Time (hh)

PRECIPITATIONS 24H

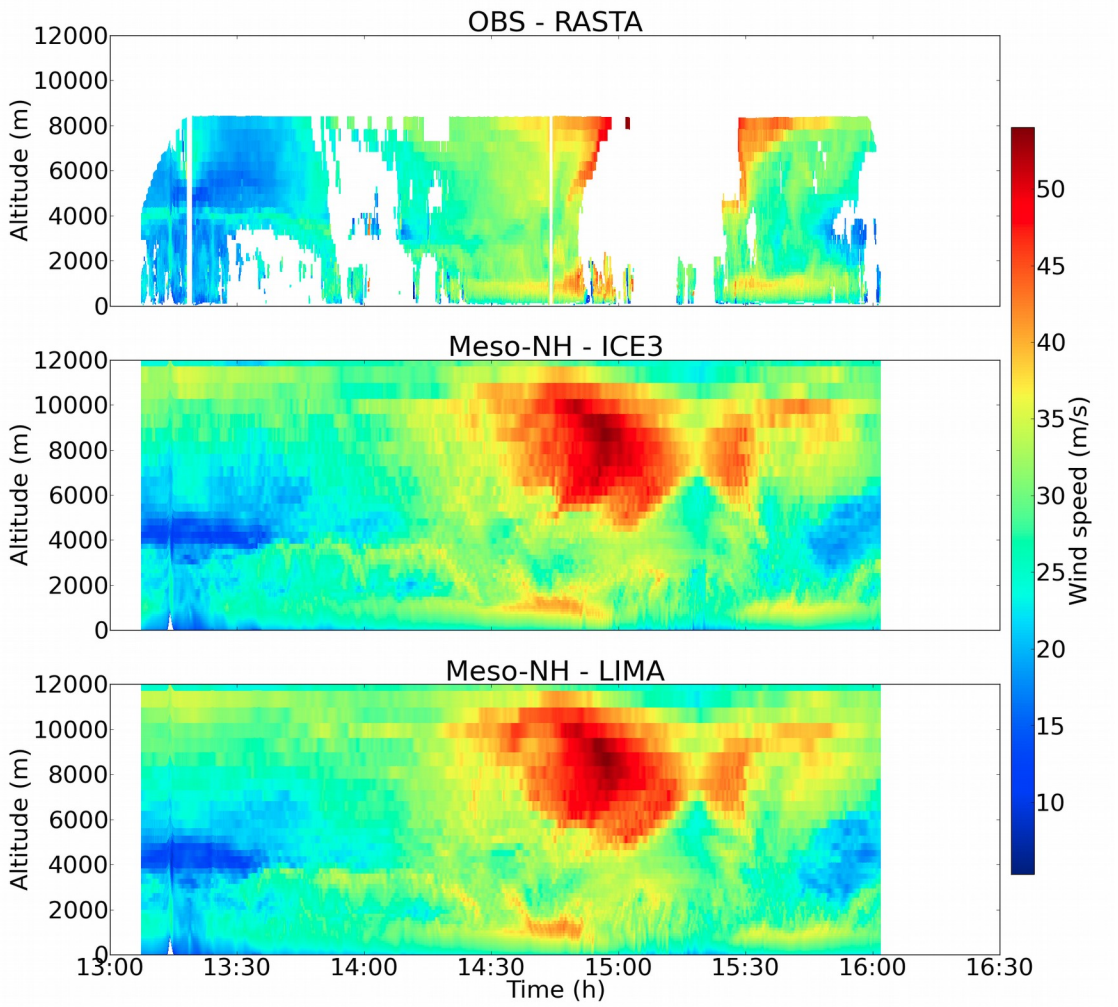
ICE3 LIMA LIMA-ICE3



Isolines Psea (03/10/16 00h)

➡ Digging and structure similar
LIMA more precipitation (+1.8%) (more rain species)

Wind speed - F7



➡ **Slight shift** with observation (also on satellite data)
But **correct dynamical representation**

ICE3/LIMA, very **similar** horizontal wind speed and structure

Test effectués sur LIMA :

-Tests aux aérosols :

-CCN 100 (CCN 300)

-CCN 1000 (CCN 300)

-IFN 1000 (IFN 10 000)

-IFN 100000 (IFN 10 000)

-Concentration de CCN constante en altitude

-→Plus de glace ?

-Threshold diameter entre la glace et la neige pour LIMA, fixé à 125 µm, mais pourrait atteindre 250 µm selon Zhang, 2014

-Production secondaire de cristaux de glace

-Deff constant pour le rayonnement