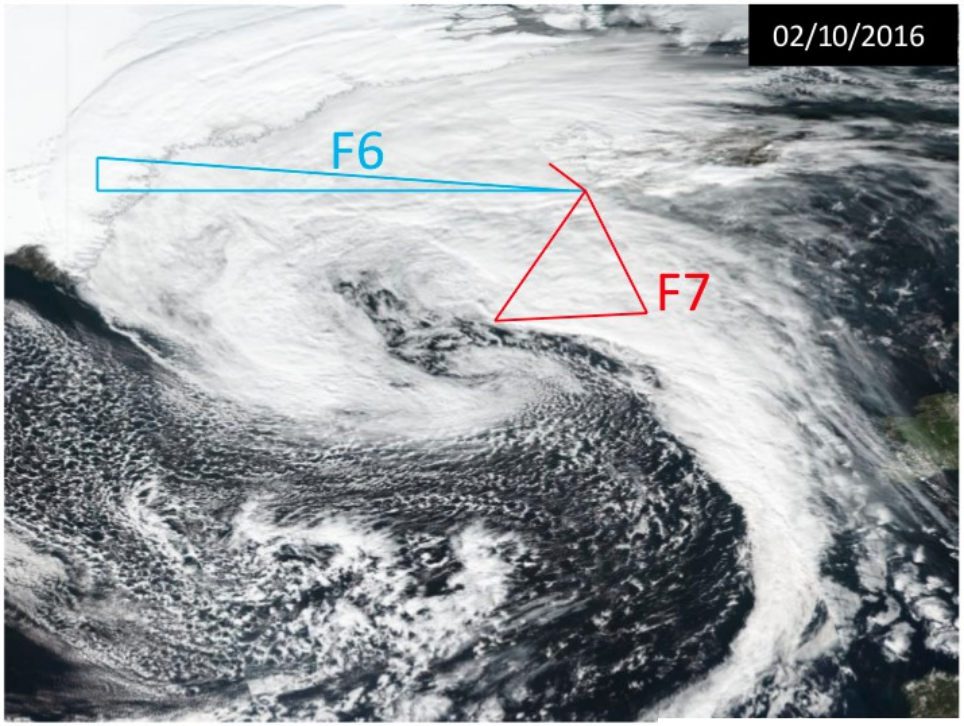
Influence of diabatic processes in warm conveyor belt of the Stalactite Cyclone in Meso-NH simulations and comparison between two microphysical schemes



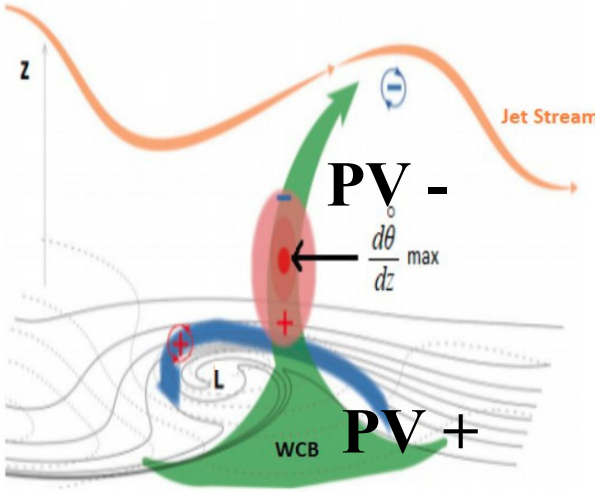
MODIS ***Figure M. Wimmer***

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)

ANR DIP-NAWDEX, Toulouse, 29/01/19

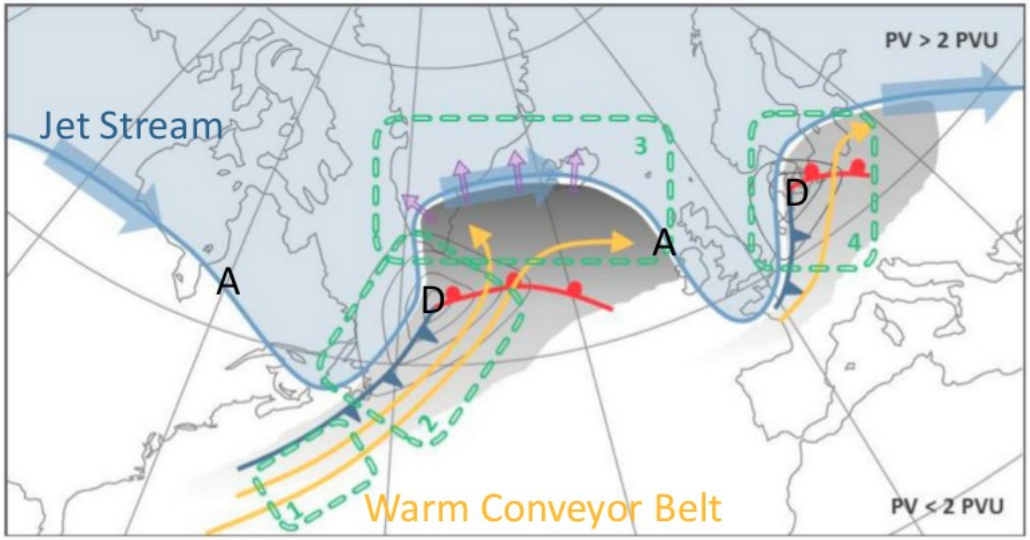
Diabatic processes in warm conveyor belt

- 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)

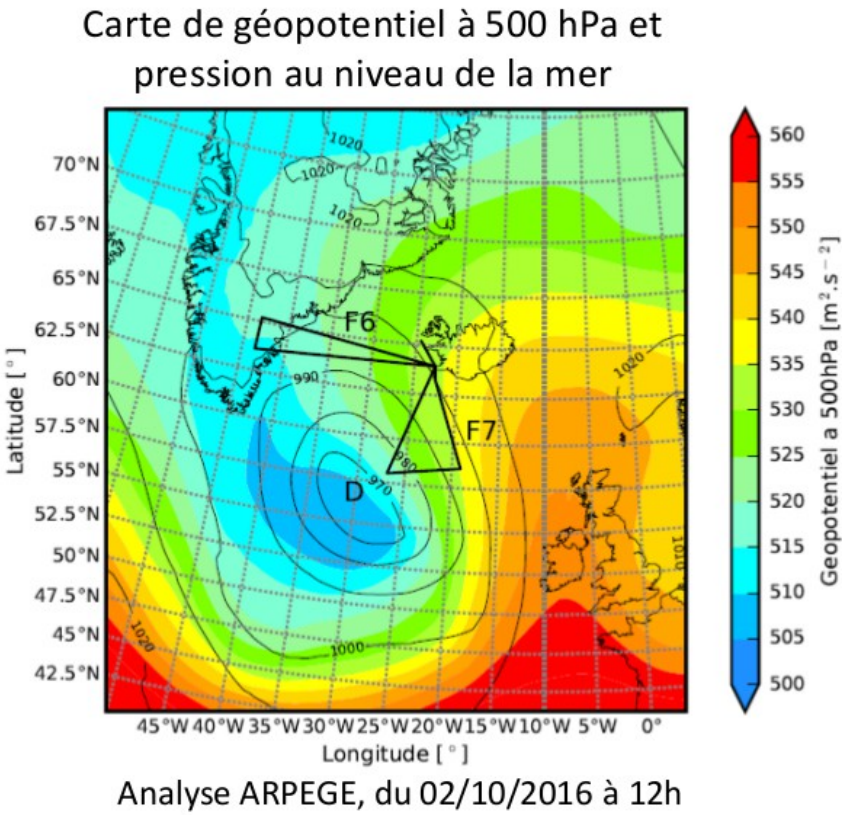
$$\frac{D.PV}{Dt} = \frac{1}{\rho}.(f+\zeta r).\frac{d\theta}{dz}$$

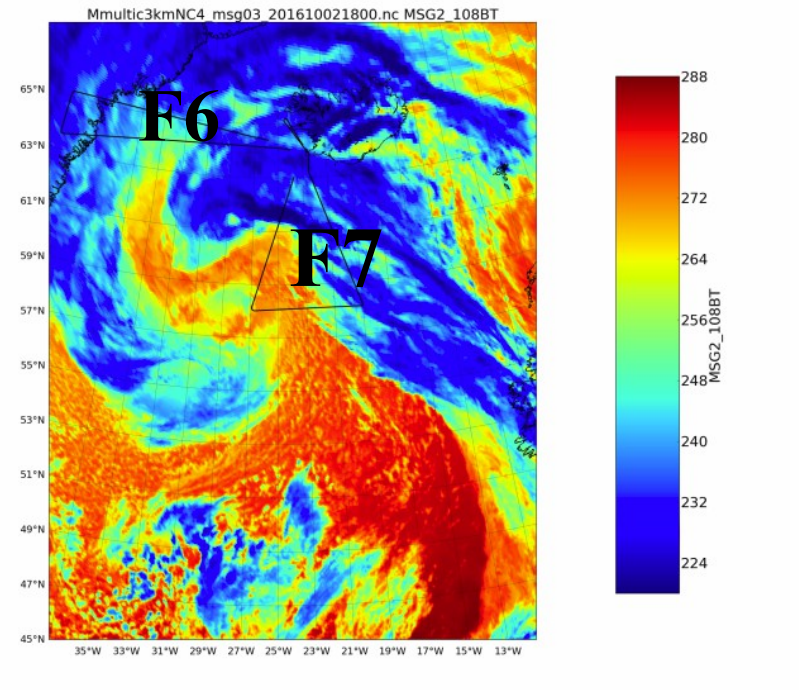


Schäfler et al, 2018

Objectives : Comparison of two distincts microphysical schemes
(→ mixed and ice phase and role of aerosols)
and identification of main diabatic processes in a WCB

02/10/2016 - NAWDEX CAMPAIGN





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

Flights : F6 - 09:30 → 11:30

F7 – 13:00 → 16:00

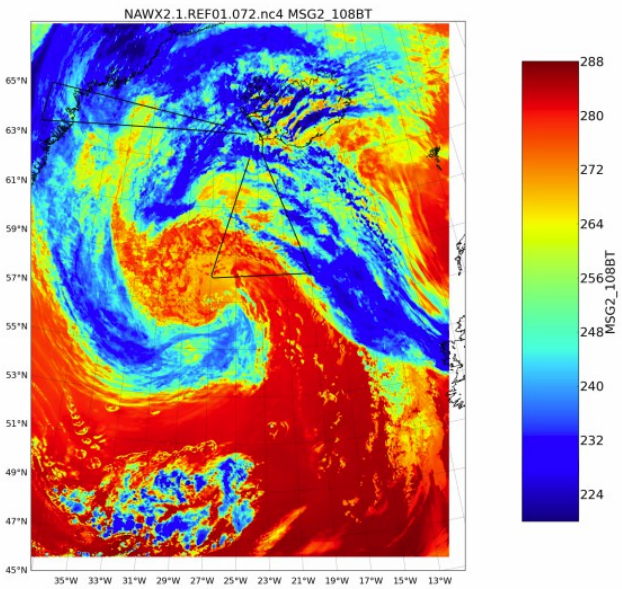
RASTA embedded (Zdb, vent)

+ F6 : Dropsondes (P,T,U,RH)

02/10/2016 - SIMULATION

- **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
  Z → 56 verticals levels ~[0-20]km

Meteosat brightness temperature at 10.8µm at 18:00



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

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

MICROPHYSICS SCHEMES

ICE3

LIMA

Droplet, rain, graupel, snow, ice

One moment (r)

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

➡ **Aerosol dependency with LIMA**
→ Simulation LIMA : aerosols loading *homogeneous* in space and configuration « comparable » to ICE3
Differencies in passage from a specy to an other

Ice supersaturation

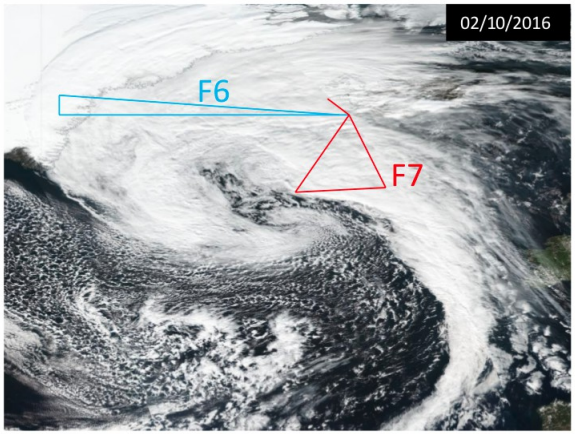
Equilibrium humidity Ice/Liquid : Linear temperature function between 0°C and -20°C

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)

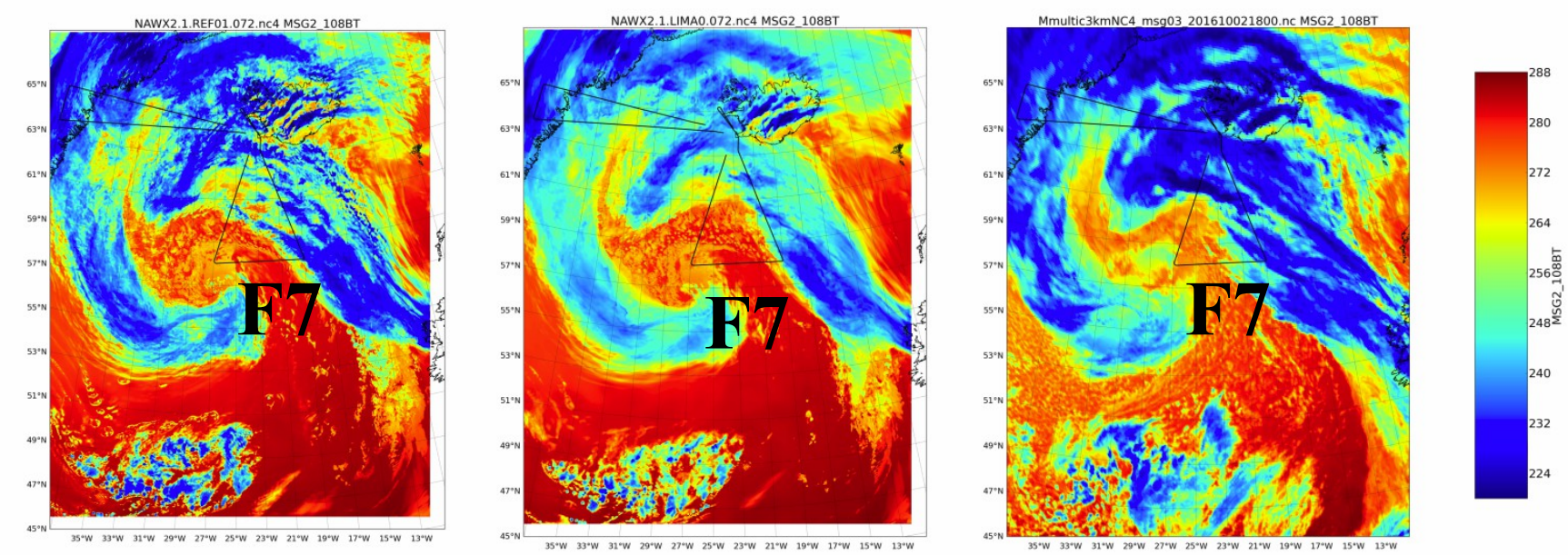
Influence of diabatic processes in warm conveyor belt of the Stalactite Cyclone in Meso-NH simulations and comparison between two microphysical schemes

00 – Cas and simulation presentation
0 – Differences ICE3/LIMA
1 – Comparisons with observations
2 – Comparisons at larger scale
3 – Explaining larger scale with WCB (lagrangian view point)
4 - Conclusions



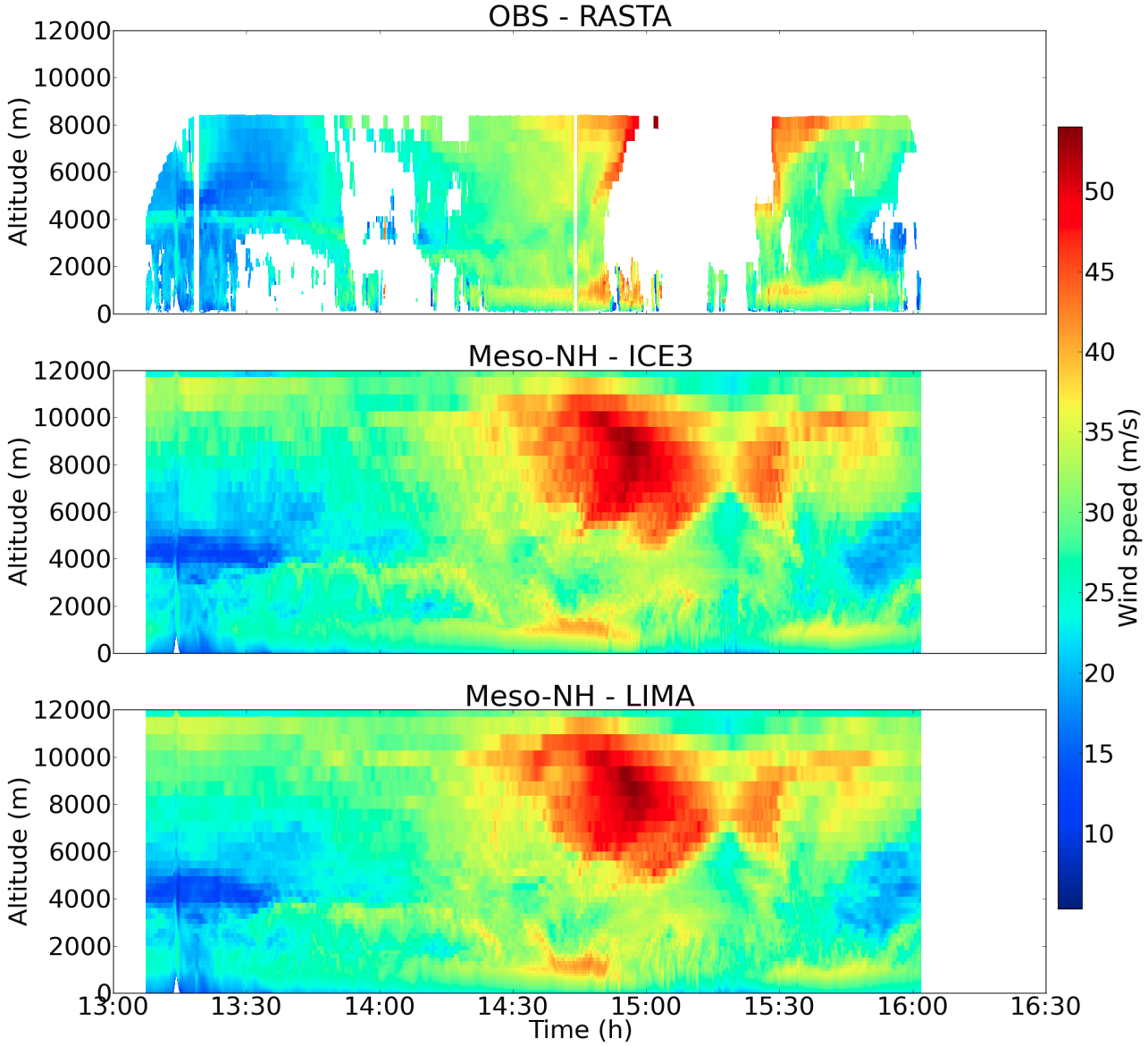
Meteosat, brightness temperature 10.8 µm, 18:00: Clouds top

ICE3 LIMA OBS



➡ Cloud structure very similar
WCB (LIMA/ICE3) more at the east than obs
LIMA clouds lower in altitude

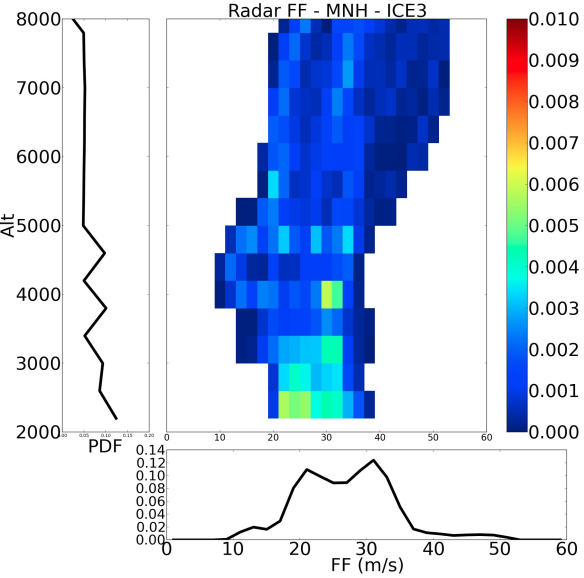
WIND SPEED - F7

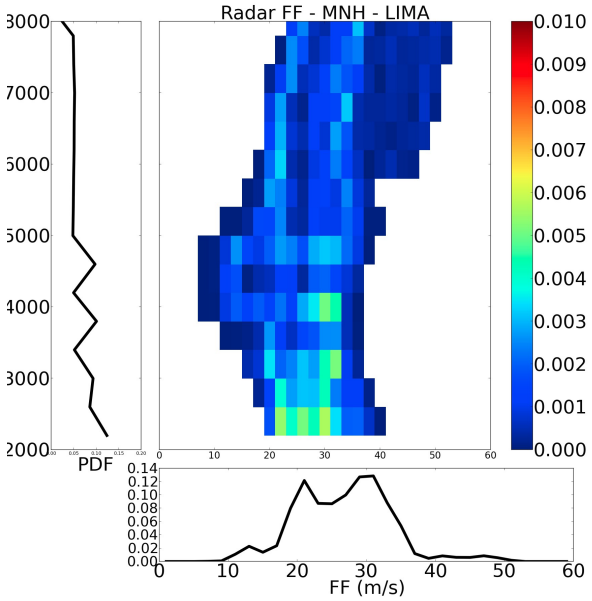


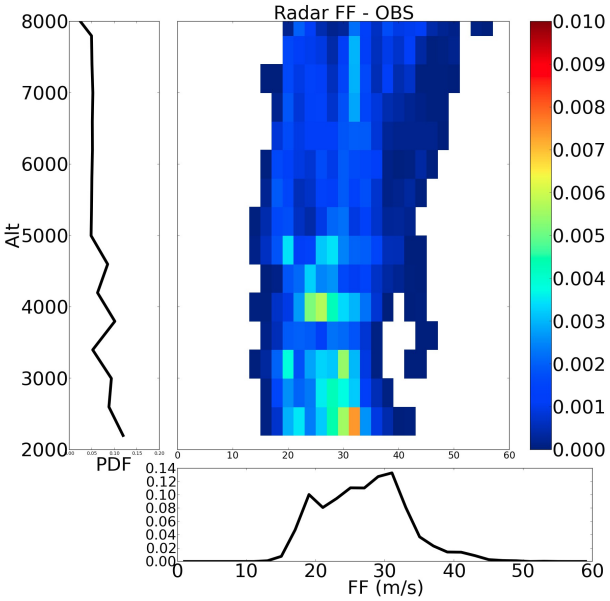
➡ ICE3/LIMA, very similar horizontal wind speed and structure

WIND SPEED – F7 (ONLY RADAR AREA) – BIVARIATE PDF

ICE3 LIMA OBS





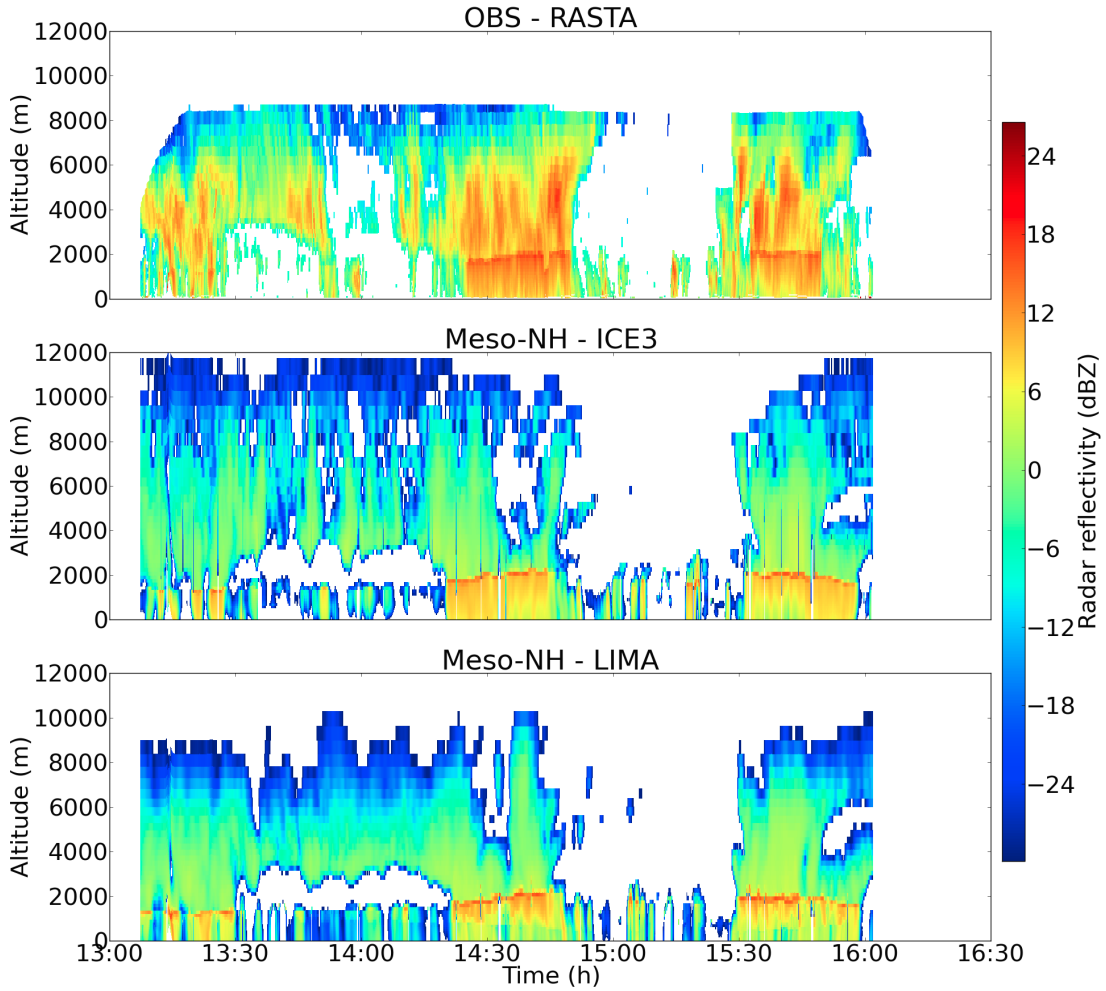


➡ Close verticale profile ICE3/LIMA/OBS
ICE3/LIMA, lower wind speed (4000-6000m)
, less strong wind

+Dropsondes F6: Very good agreement

➡ Good dynamical representation (on F7)

RADAR REFLECTIVITY



-Very close structure (ICE3 less diffuse, may be due to the subgrid condensation scheme)

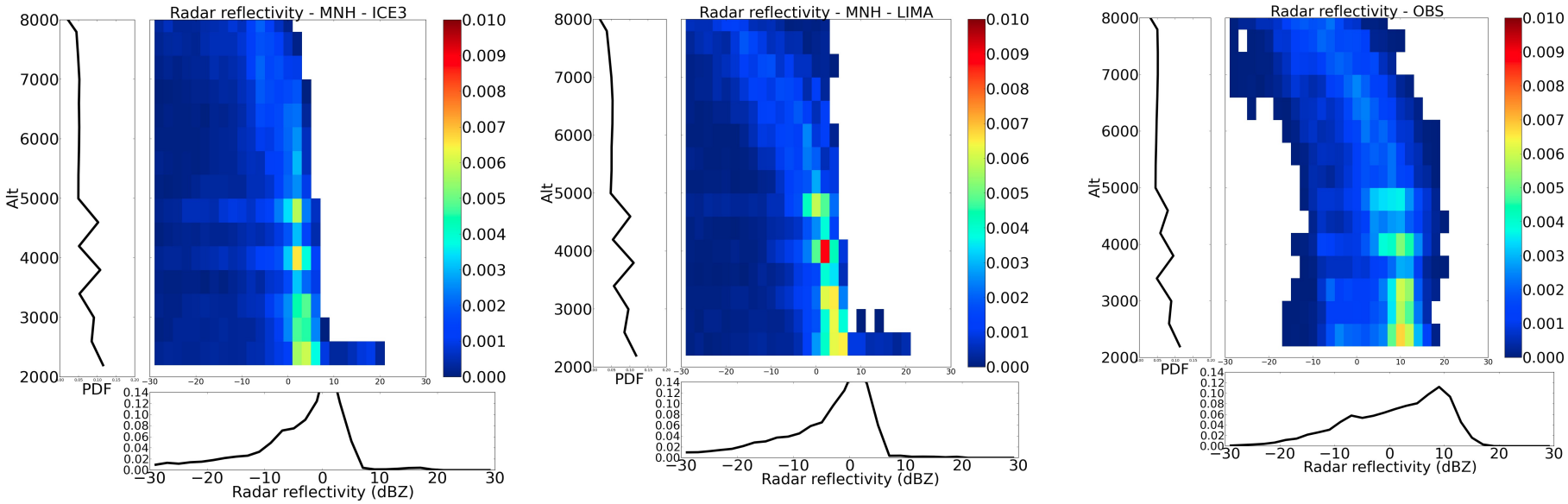
-Melting area similar

-Strong Z understimation (but new radar similator more physic should ↗ Z)

-LIMA clouds lower (as Satellite)

RADAR REFLECTIVITY – F7 – BIVARIATE PDF

ICE3 LIMA OBS



-Shift between models and obs

-PDF radar reflectivity : Different repartition in intensity

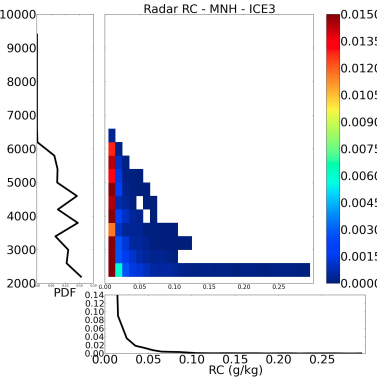
-PDF alt : Repartition similar in altitude (suggest a good repartition of species)

-LIMA less strong reflectivity in altitude compare to ICE3

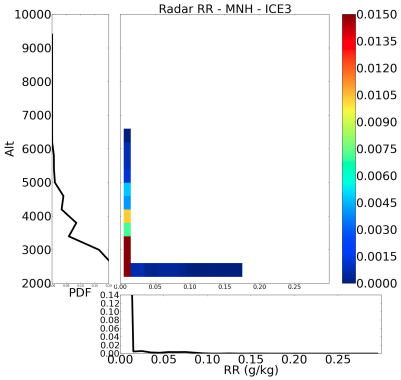
-LIMA profile closer to the obs (same on HyMex campaign)

MICROPHYSICS SPECIES (MIXING RATIO)

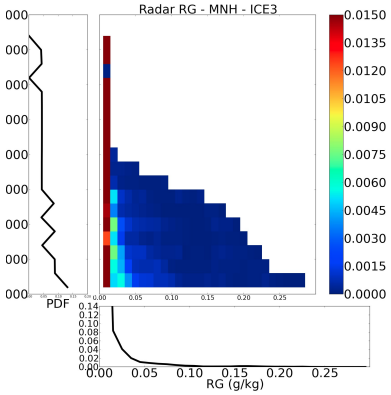
ICE3



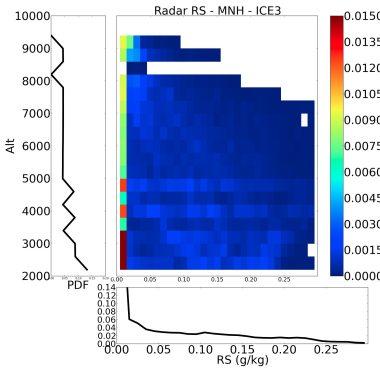
Droplets



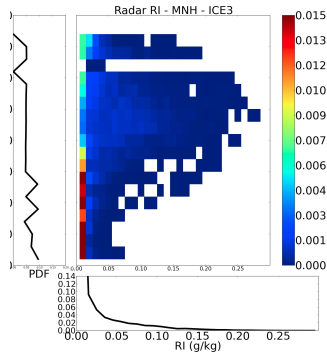
Rain



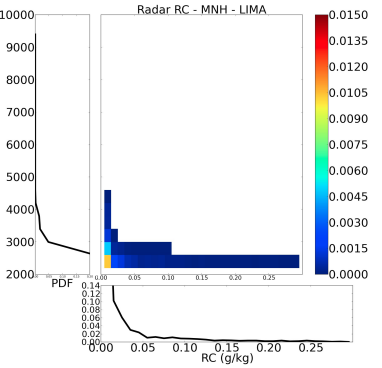
Graupel

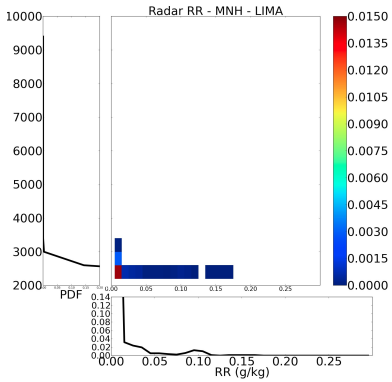


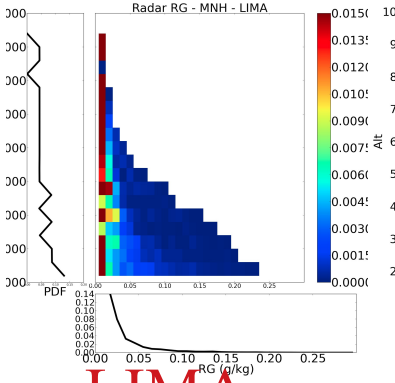
Snow

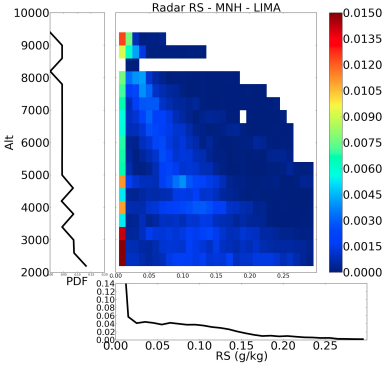


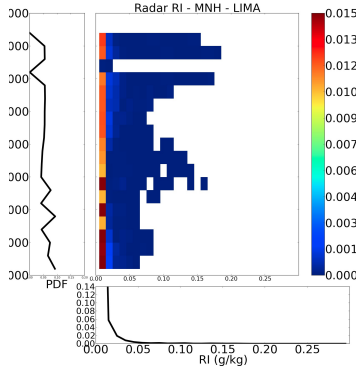
Ice











LIMA

→ LIMA, Droplets at lower level and higher values for rain

Lower strong values for graupel

More snow at every level (**profil of Z**)

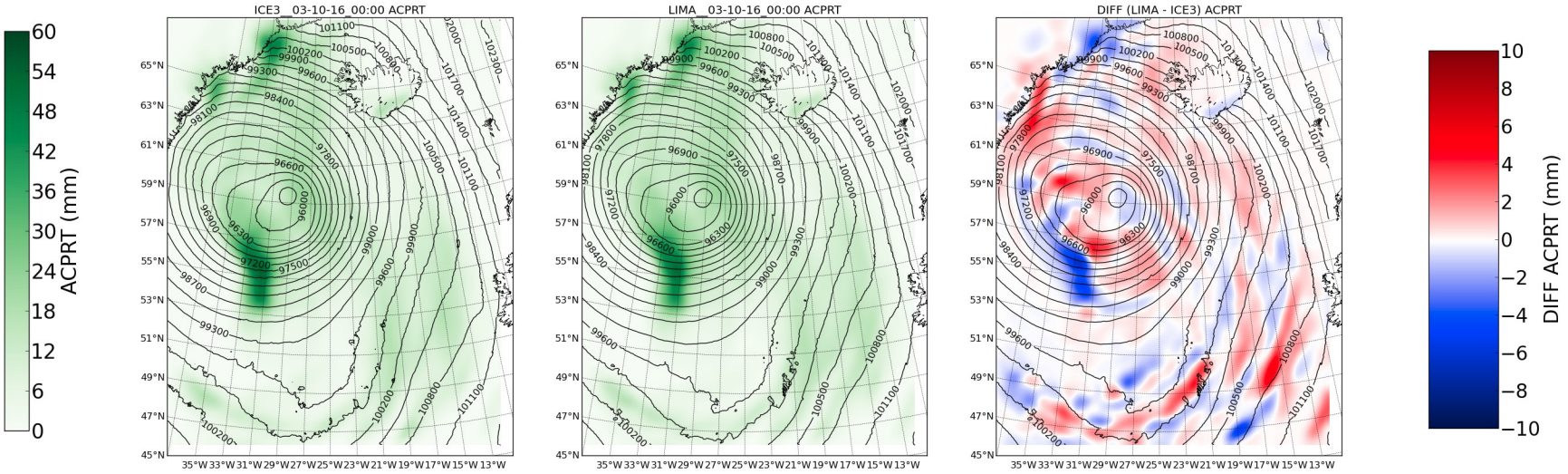
<u>Less ice</u>, in altitude also (Satellite profile, RADAR)

→ Lower LIMA's reflectivity in altitude may be due to less ice production

→ Different species warm and cold repartition (microphysics and radiation), **impact on dynamic ?**

PRECIPITATIONS 24H

ICE3 LIMA LIMA-ICE3

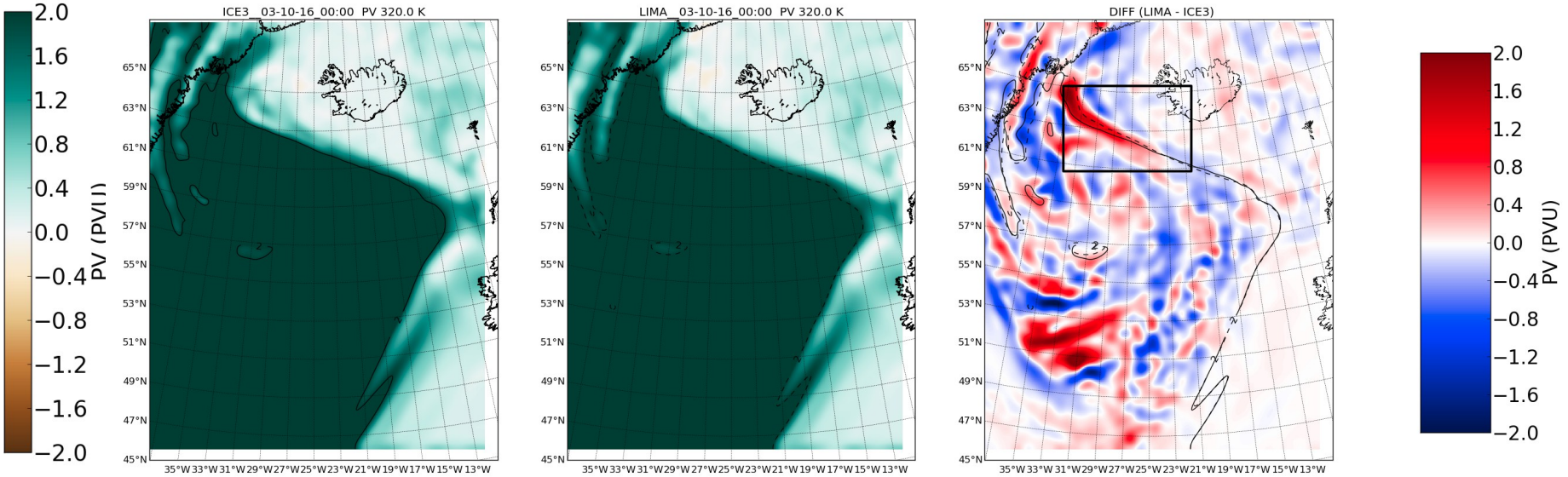


Isolines Psea (03/10/16 00h)

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

ALTITUDE ANTICYCLONE – 320 K – 03/10/16 - 00:00

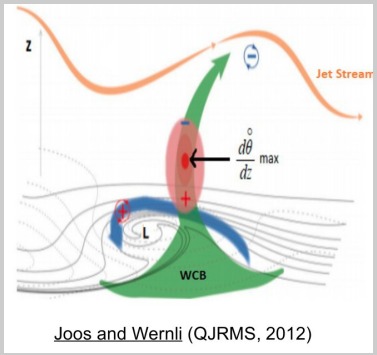
ICE3 LIMA LIMA-ICE3



Isolines Psea (03/10/16 00h)

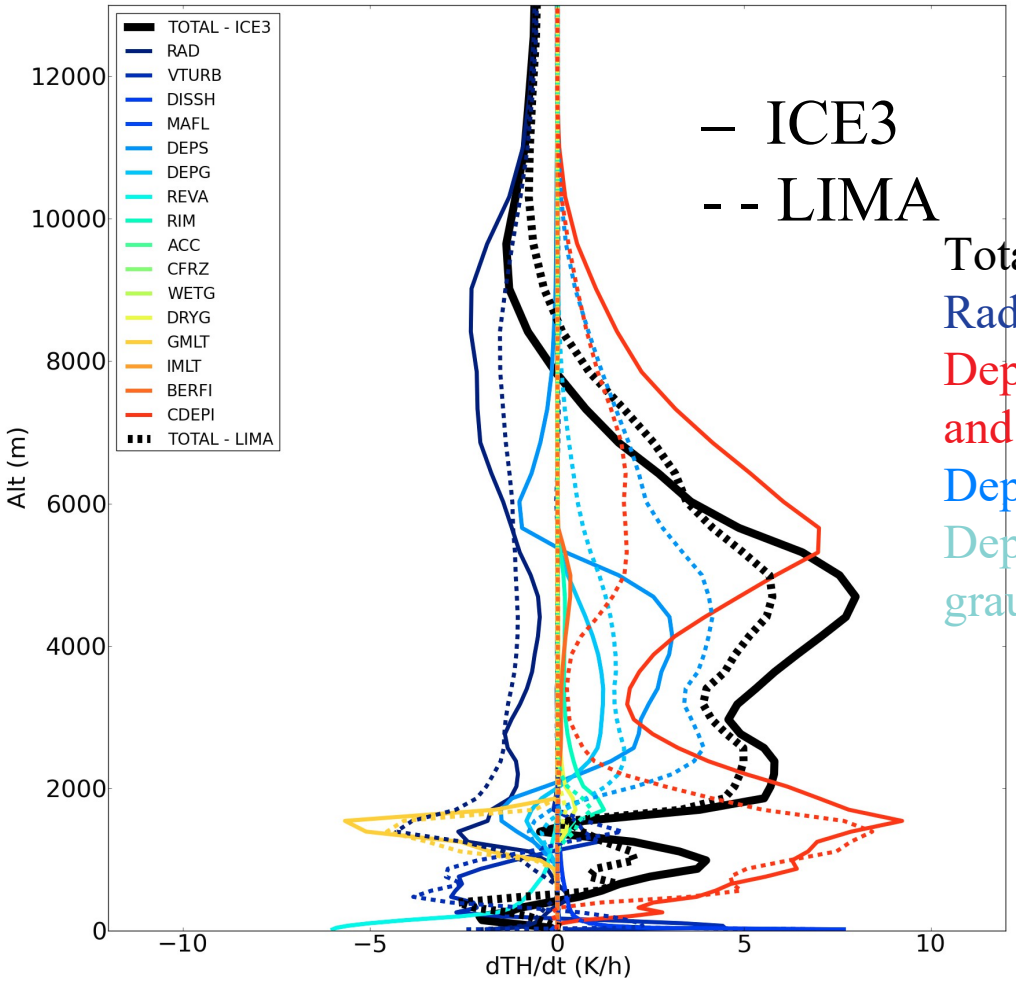
➡ LIMA 2PVU east shift (2°)

EULERIAN APPROACH - TEMPERATURE BUDGET



Joos and Wernli (QJRMS, 2012)

$$\frac{D.PV}{Dt} = \frac{1}{\rho}.(f+\zeta r).\frac{d\dot{\theta}}{dz}$$



Total
Radiation
Deposition on ice and droplets
Deposition on snow
Deposition on graupel

→ **DIPOLE of dTH/dt**

→ On that box at that time, ICE3 more negative DPV/Dt above 4000m

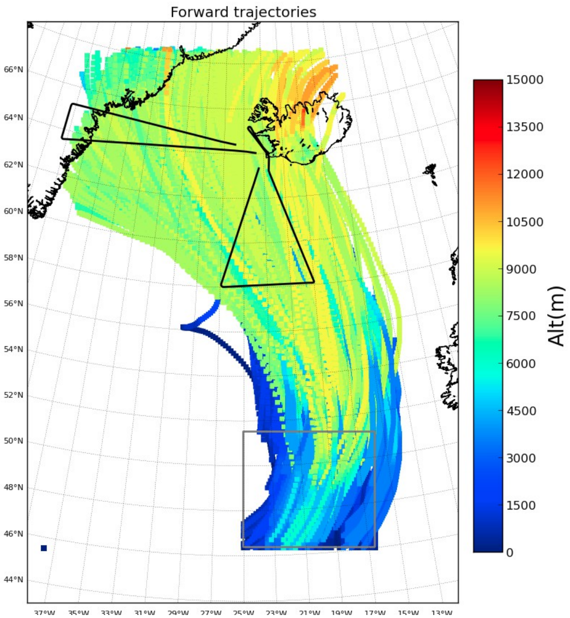
→ LIMA : more deposition and snow and graupel
ICE3 : more deposition on ice

→ 'Compensation' radiation/ice deposition (no snow radiation in model → LIMA less radiation?)

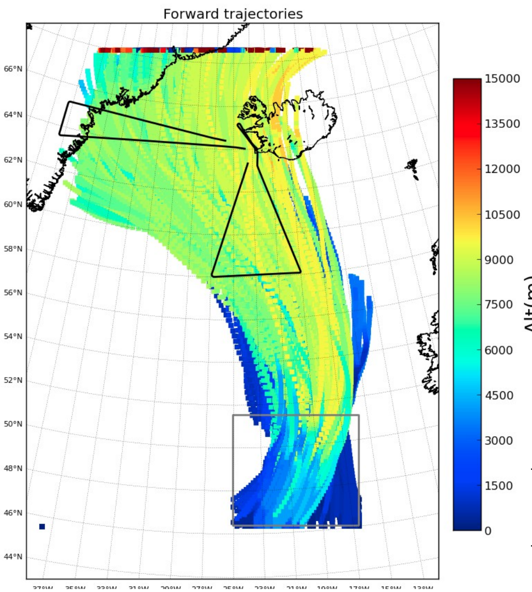
But lagrangian issue ...

WCBs (300hPa elevation in 24h, Jood and Wernli, 2012)
FORWARD TRAJECTORIES : 22 440

ICE3

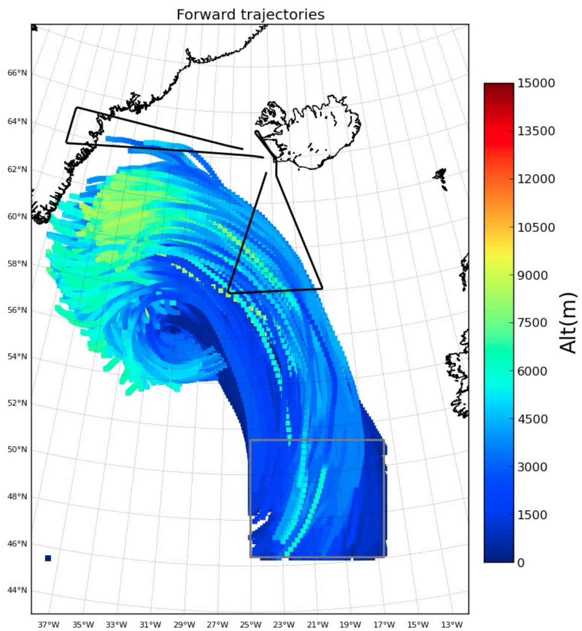


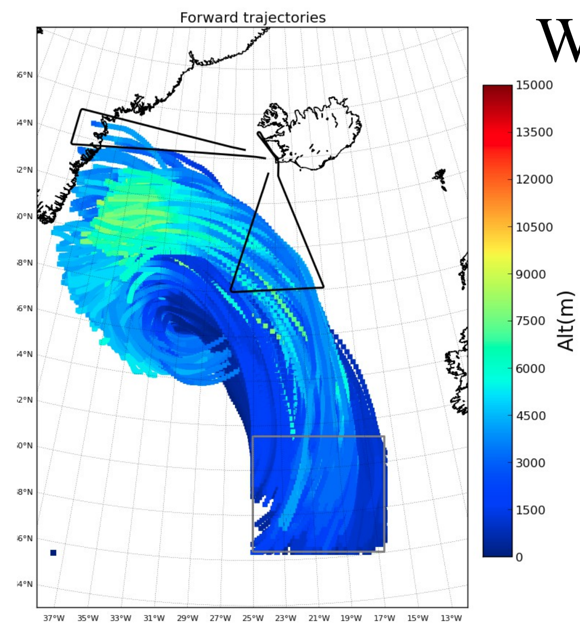
LIMA



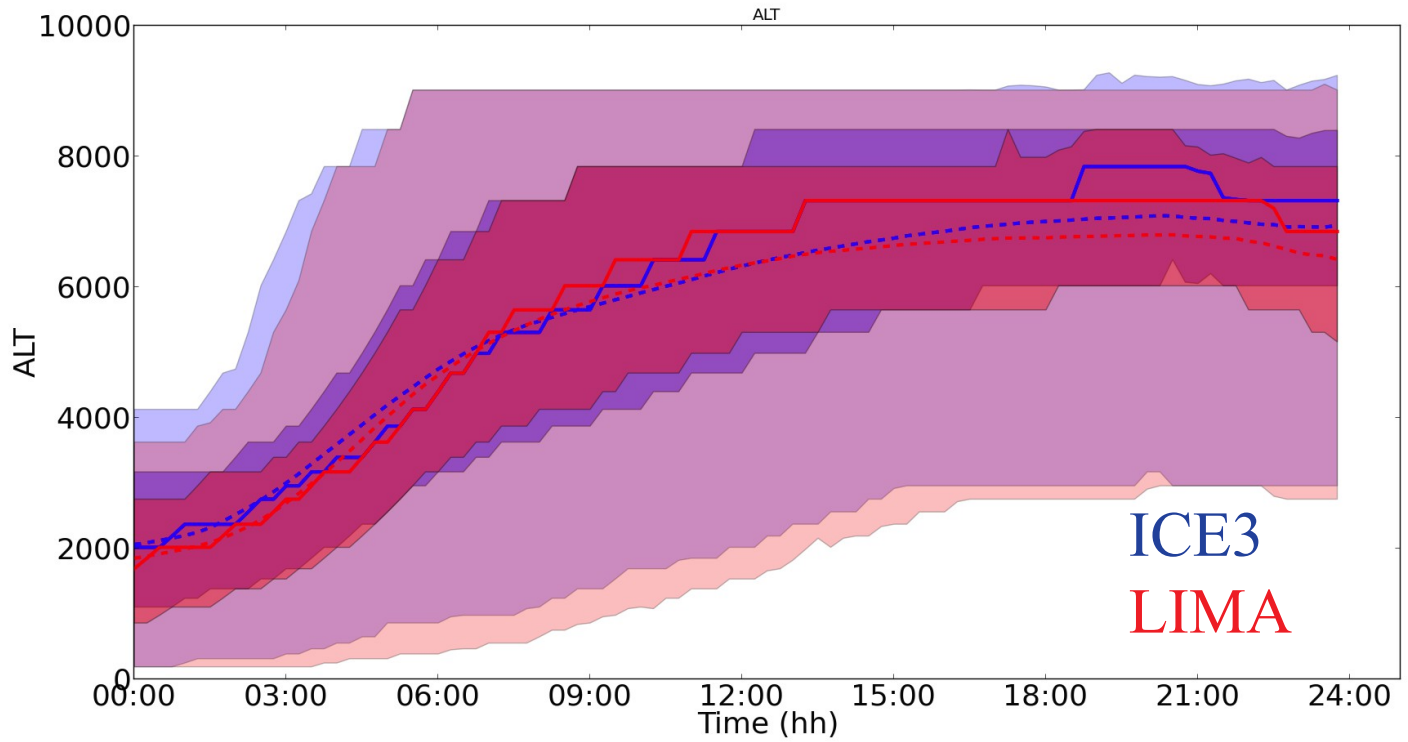
WCB : 4777
WCBA : **3120**
WCBC : 1657

WCB : 3504
WCBA : **2387**
WCBC : 1117





WCB anticyclonique ALTITUDE EVOLUTION



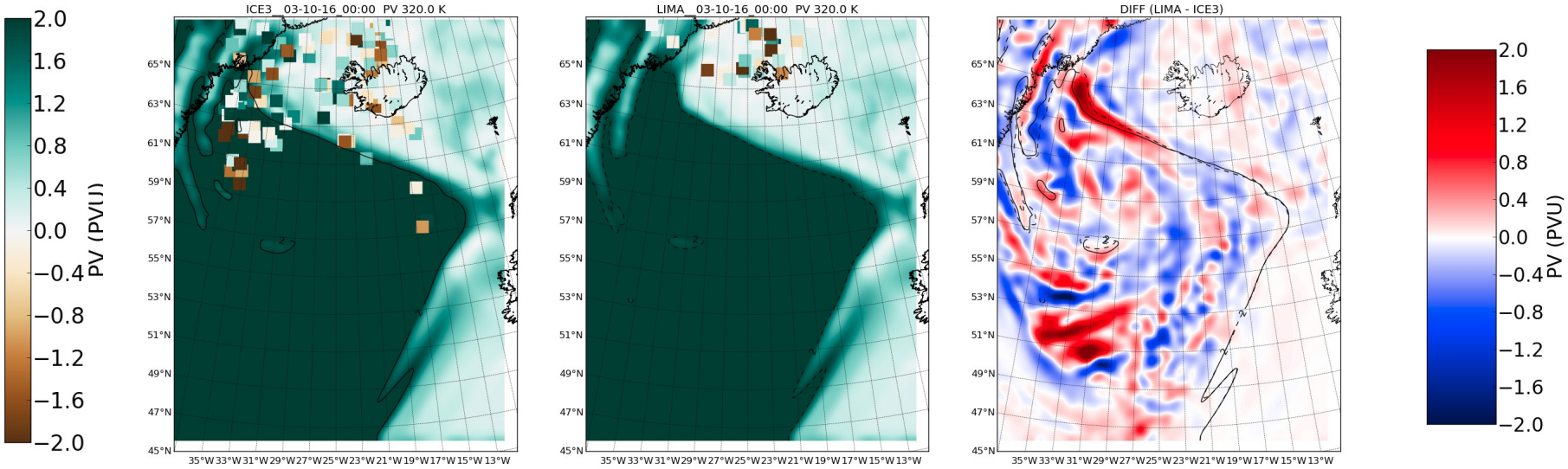
95-5 th
75-25 th
50 th
--mean

➡ LIMA ascension faster until 12:00 then slower
LIMA WCB altitude lower at final (coherent RADAR, satellite)

ALTITUDE ANTICYCLONE – 320 K – 03/10/16 - 00:00

Intersection with forward trajectories (19H-24H)

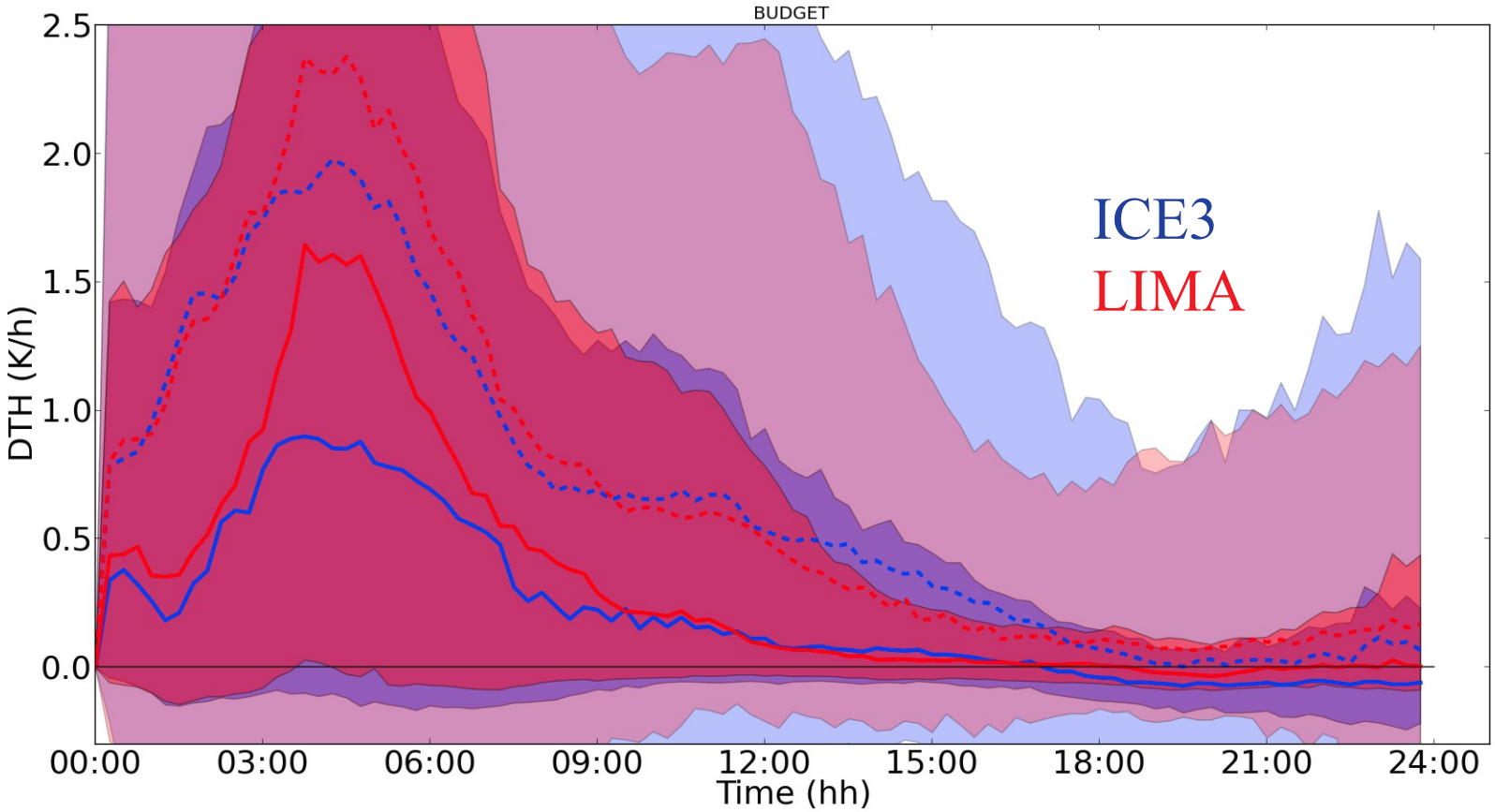
ICE3 LIMA LIMA-ICE3



➡ ICE3 more intersection with isentrope 320K, WCB more active
Reinforcement of the altitude anticyclone

WCB sampled not representative of WCB crossing the isentrope 320K
But still LIMA's WCB less high than ICE3

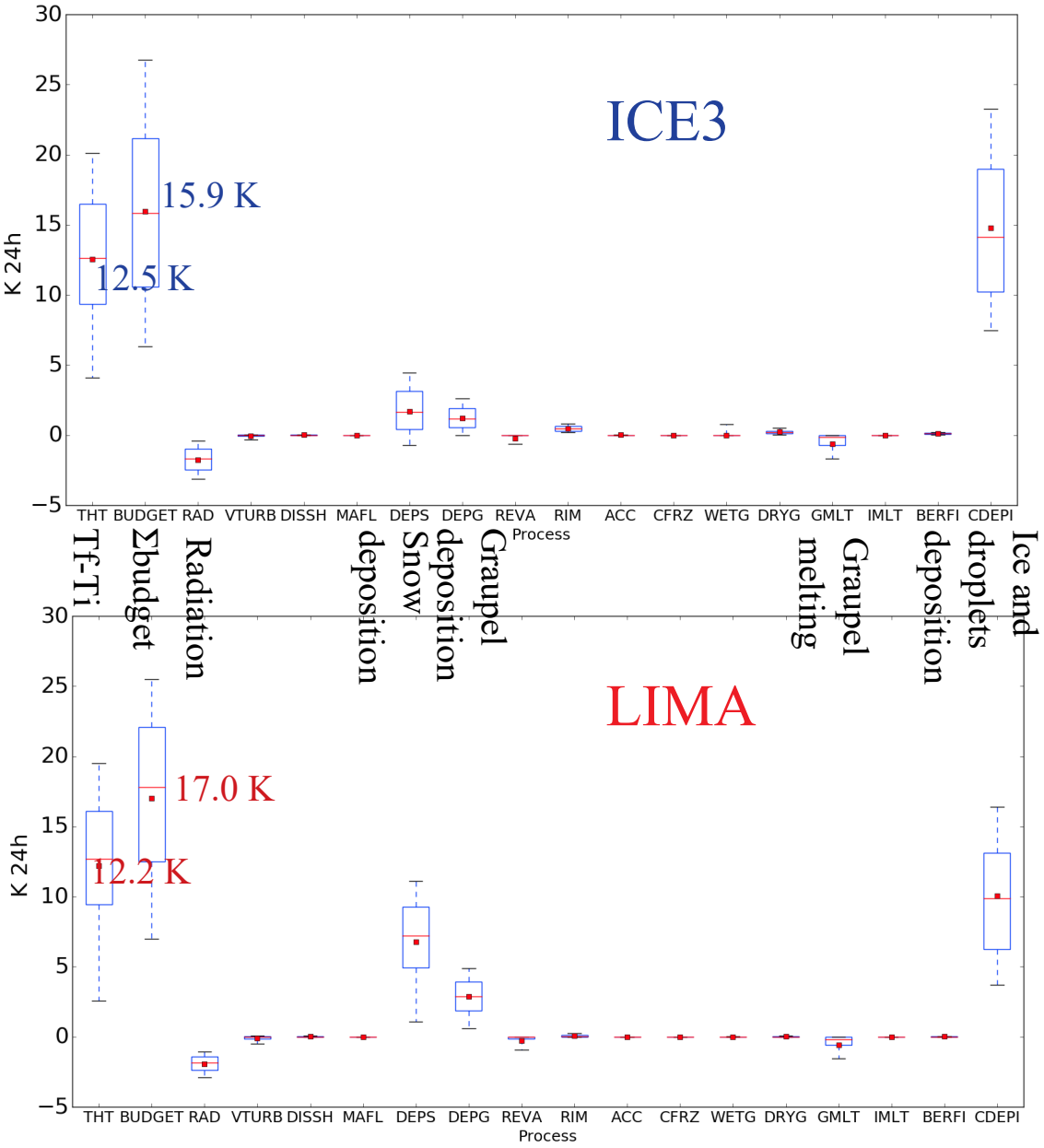
WCB anticylonique - LATENT HEAT RELEASE EVOLUTION



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

➡ LIMA more latent heat release
After ~17:00, ICE3 more cooling (more radiation, more deposition on ice and less deposition on snow)
Does not explain higher ICE3 WCB (lagrangian issue …?)

DIABATIC PROCESSES, DTH/Dt : 00-24h



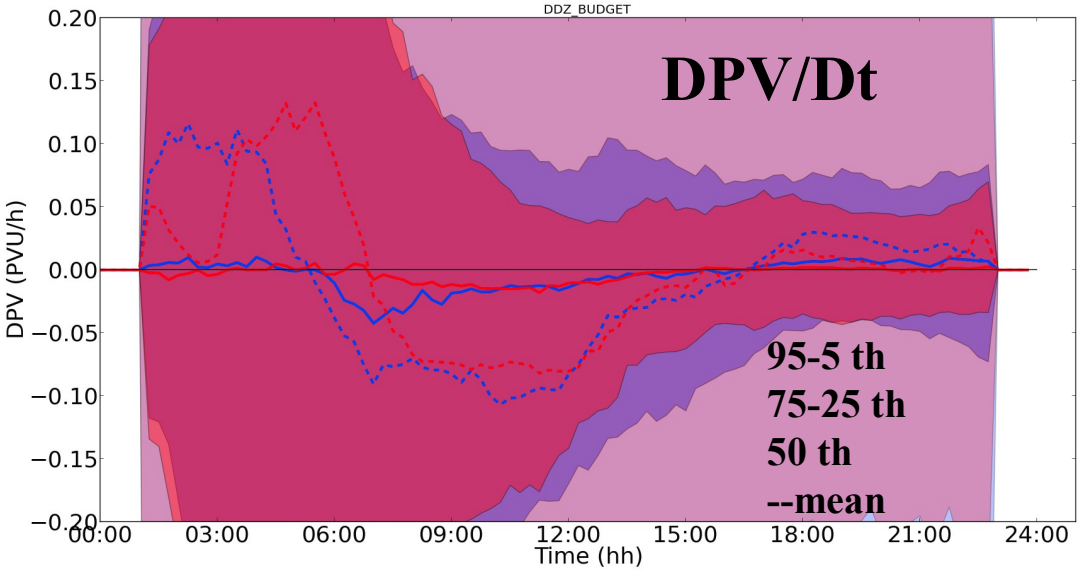
→Differences between Sum budget and delta(Tf-Ti)

→ Same processes but different importance :

Radiation, deposition on snow, deposition on graupel, graupel melting, deposition on ice and droplets

→ LIMA more heating due to snow deposition

WCB anticylonique : PV EVOLUTION

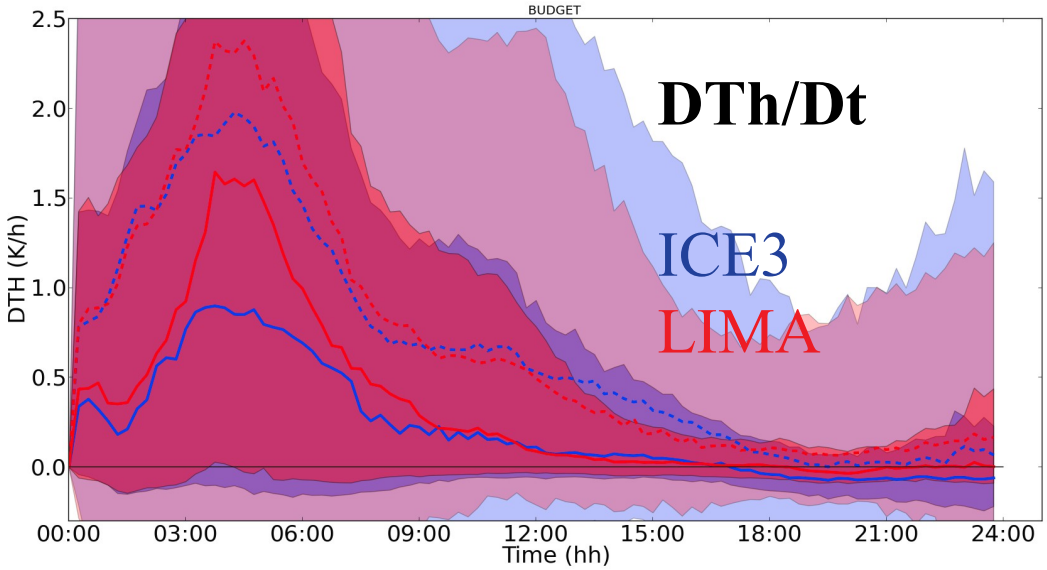


→ ICE3 : DPV/Dt positive when DTh/Dt increase

DPV/Dt negative when DTh/Dt decrease

→ LIMA ~1 hour shift

Stronger heating source above ?



→ ~17:00 both PV increase (Heating source higher?)

↳ Then, to explain PV shift at the tropopause, backward trajectories from isentrope 320K

CONCLUSION

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

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

→ ICE3/LIMA : **Good dynamical representation** F6/F7
→ **LIMA clouds lower than ICE3** (Satellite and RADAR) which is closer to the OBS (Satellite)
→ **LIMA 2° east shift** for the 2PVU isolignes at the 320 K level

→ Lower **reflectivities** for the two simulations : **LIMA profile closer to the OBS**
→ **LIMA** produces **less ice and more snow**

→ **LIMA's WCB less active** in number and at 320K and less ascent
But subit more heating due to snow deposition

→ Dominant processes : Ice and droplets deposition, snow deposition, graupel deposition and radiation

→ **Differences in ascent occurs in the last 12h** (above 6 000 m)

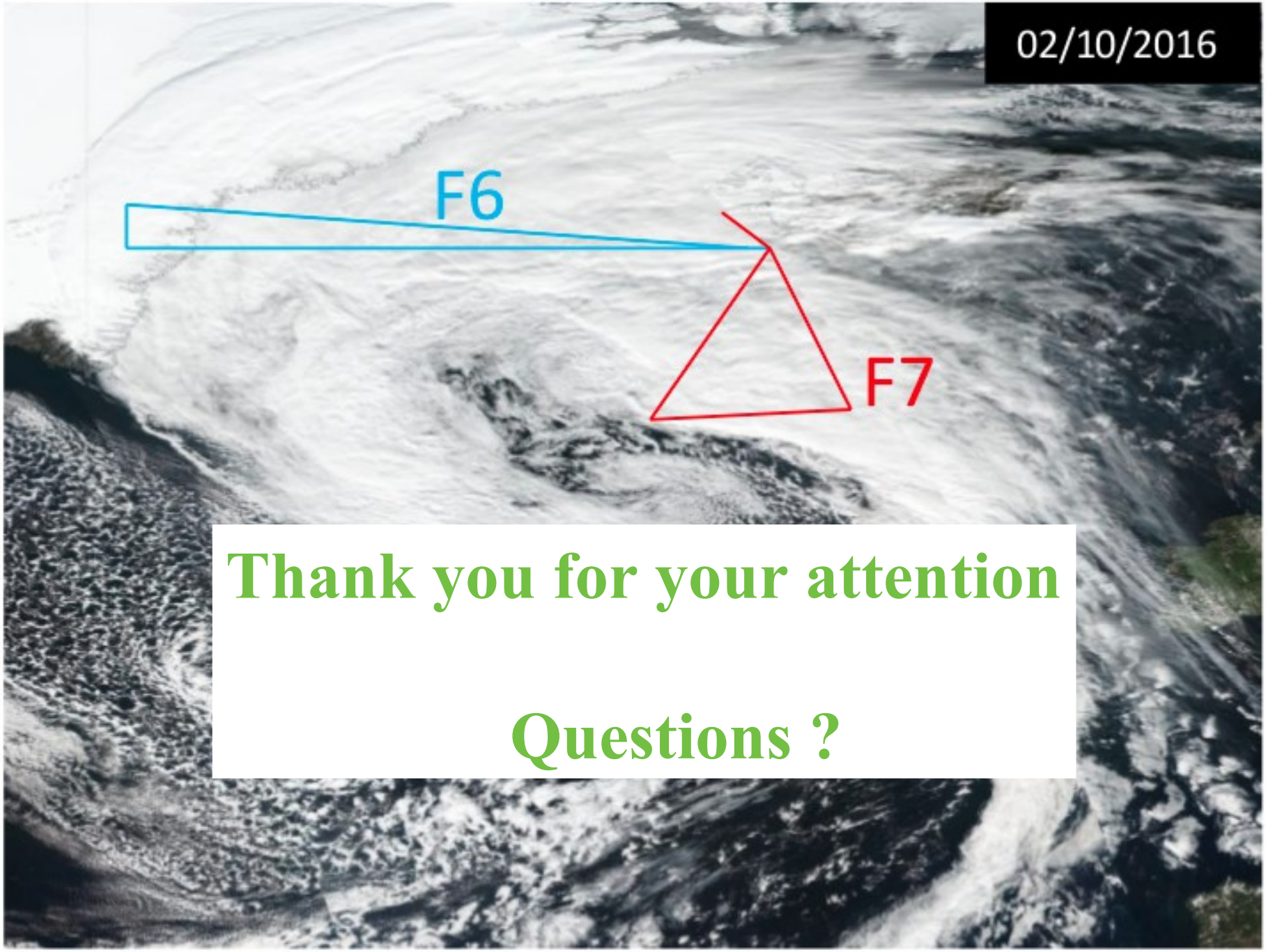
→ **Tests on aerosols and physics (to produce more ice)** have been performed with no significant impact on dynamic

PERSPECTIVES

→ Backwards trajectories from 320 K level to explain PV shift and altitude differences

→ Vertical transect to localise maximum heating and cooling area

→ Equivalent study on an other case to define


02/10/2016
F6
F7
Thank you for your attention
Questions ?

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