La convection profonde vue par le concept C2OMODO d'un tandem de radiomètres micro-ondes


Cumulonimbus cloud over Africa (International Space Station view)

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AMA meeting
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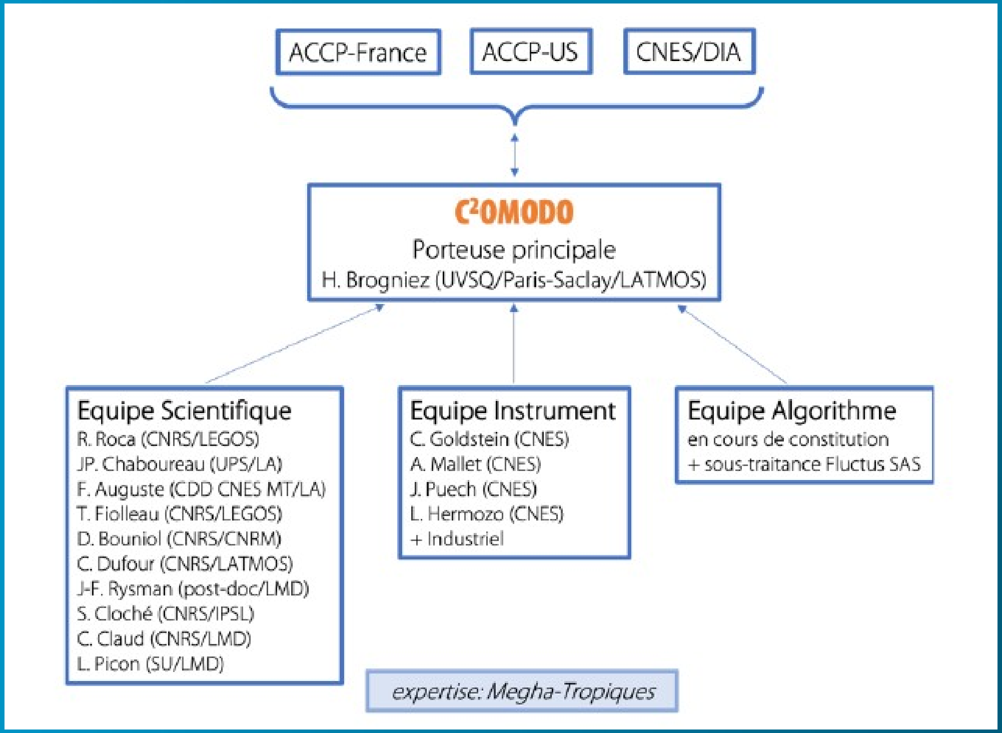
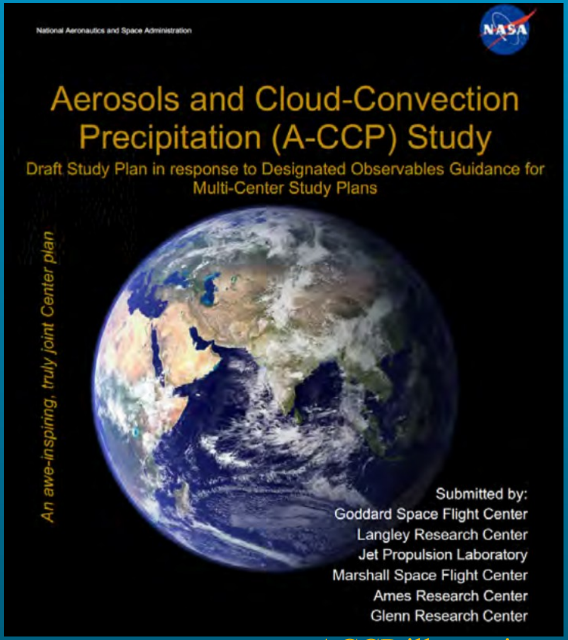
ACCP / C^{2}OMODO

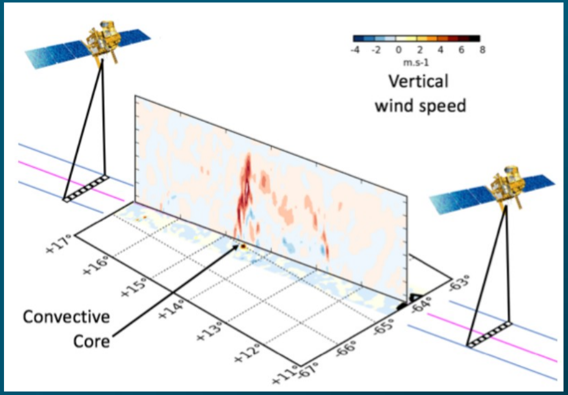
ACCP : Aerosol, Cloud, Convection Precipitation
(Obj. 3: Storm dynamics)





ACCP illustration

C^{2}MODO : Convective Core Observations through MicrOwave Derivatives in the trOpics
(Tsc. 1 : Convective activity using the ΔBT concept)



C^{2}OMODO illustration

=> Numerical approach of the concept

" a tandem of microwave radiometers boarded in satellite and delayed by one minute "

Means of investigation

Numerical study

Modelling the cloud dynamic
(wind, water mixing ratio ..)

A non-hydrostatic atmospheric model (Meso-NH) combined with a radiative transfer code (RTTOV)

Calculating brightness temperature (BT) change
(Spectral decomposition of 183, 325 and 448 GHz
vapor water band absorption, 50 channels per band)

Meso-NH
mesoscale non-hydrostatic model

Lafore et al., Ann. Geo., 1998
Lac et al., GMD, 2018

of two tropical deep convection cases

A developing storm over an Australian island

HECTOR

6 h - 30 s step
180x100 km² - 1x1km² horizontal step
40 km – stretched 250m vertical step

Hector storm over the Tiwi islands
Dauhut et al., J. Atmos. Sci., 2016

A radiation-convective equilibrium case

RCEMIP

4x15min episodes in 60 days simulation - 30 s step
6000x400 km² - 3x3km² horizontal step
35 km - stretched 500m vertical step

RCEMIP cloud top
Wing et al., GMD, 2018

Introduction of the ΔBT concept

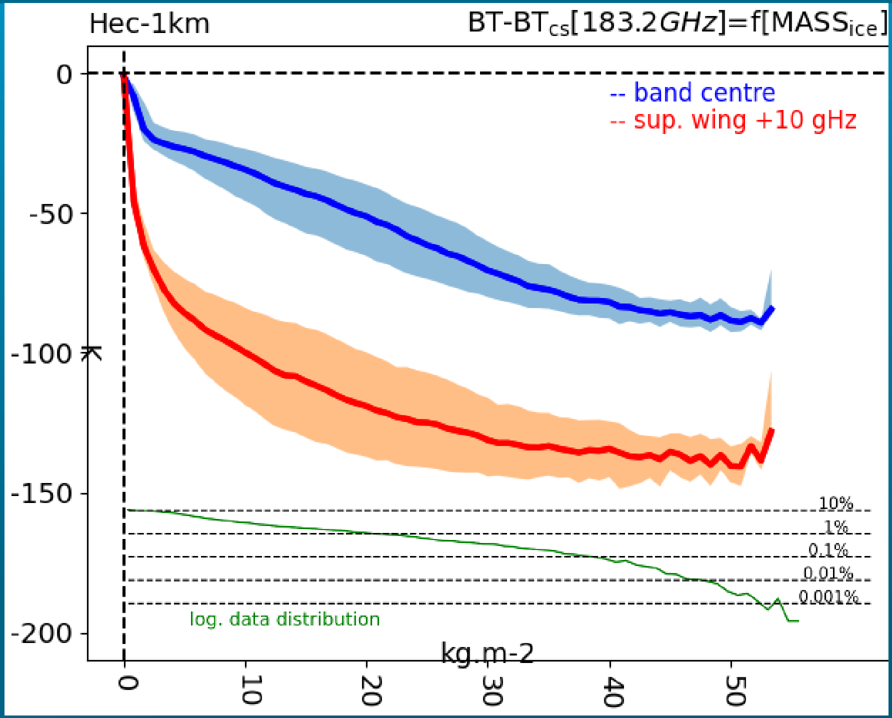
BT depression* vs. Ice Mass content

** The BT depression is defined as the Brightness Temperature difference between cloudy and clear-sky BTs*

The H_20 absorbing band at 183 GHz is sensitive to icy hydrometeors

(similar results for the 325 and 448 GHz bands for the Hector and Rcemip cases)

=> ΔBT strongly depends to the ice evolution



BT depression* vs. Ice Mass Content
(Meso-NH/RTTOV results from the Hector simulation, ~1,7.10^7 pts)

Scientific Tasks 2020-2022

- data building : **atmospheric and radiative model interface & simulations**
- data analysis : **examine the relationships between radiometric & icy cloud dynamic variables**

Reduction of the problem in time and space

First approach

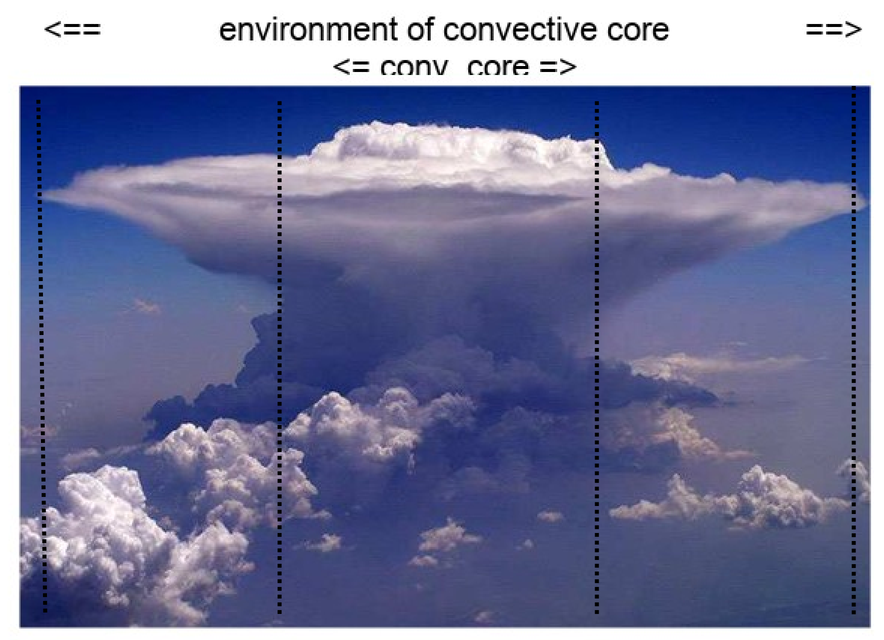
Convective cores during their growing phase (6 for Rcemip, 6 for Hector)

Two dynamic variables are investigated:
- Ice Mass Content (IMC)
- Ice Mass Flux (IMF)

$$IMC = \int_z \rho r_I dz$$

$$IMF = z_{ref}^{-1} \Delta_h^{-2} \int_z \int_{S_h} \rho r_I w dS_h dz$$

Simulation	Localisation zone i/j	CC i/j	Temps (Durée)	Sommet (km)	Eau solide ($kg.m^{-2}$)	Indice CC
RCEMIP	i1336-1346 / j34-44	i5 / j5	H1412(+15min)	10	18	A
RCEMIP	i1365-1375 / j55-65	i6 / j5	H1412(+15min)	11	28	B
RCEMIP	i1257-1267 / j11-21	i5 / j5	H1414(+15min)	12	25	C
RCEMIP	i1375-1385 / j58-68	i5 / j5	H1414(+15min)	13	35	D
RCEMIP	i1374-1384 / j71-81	i5 / j5	H1412(+15min)	13	30	E
RCEMIP	i1266-1276 / j57-67	i8 / j3	H1414(+15min)	14	30	F
HECTOR	i90-110 / j50-70	i10 / j10	1h45min (+1h)	09	12	G
HECTOR	i38-48 / j51-61	i5 / j5	2h15min (+1h)	10	11	H
HECTOR	i57-77 / j17-37	i6 / j10	2h15min (+1h)	12	19	I
HECTOR	i115-125 / j45-55	i6 / j6	2h30min (+1h)	13	20	J
HECTOR	i125-135 / j55-65	i5 / j4	2h30min (+1h)	13	24	K
HECTOR	i58-68 / j50-60	i4 / j3	3h15min (+1h)	16	40	L



Next steps with extensions to

=> Convective Cell (CC) : core + its environnement

=> Full datasets : growing and collapsing CCs

(Rcemip ~ 7,5.10^5 pts ; Hector ~ 5,6.10^5 pts)

Other dynamic variables (E_p, E_k, V_{air} ..)

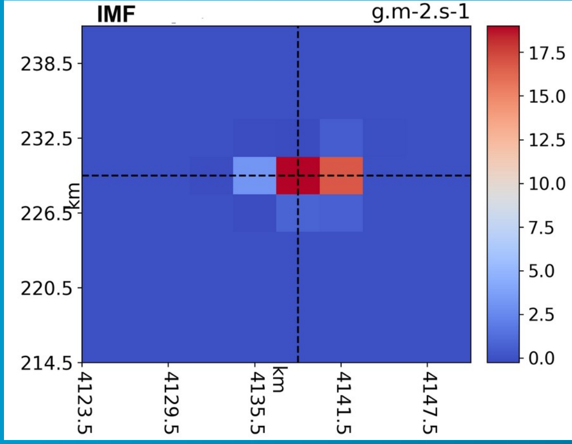
Growing convective cell Rcemip CC-E at t_0

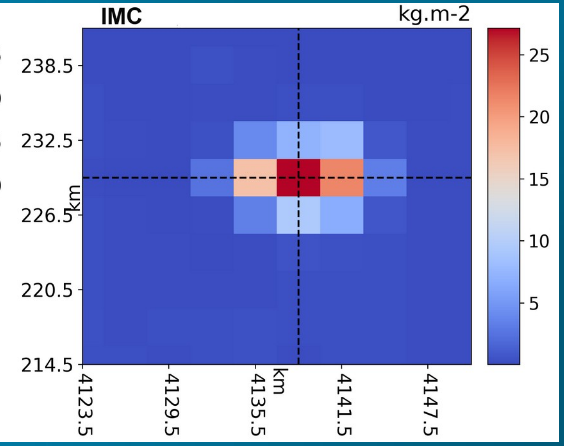
CC-E core at (i=4138 km, j=230 km, t_0~58 days) illustrated by the black dashed lines

IMF > 0 when IMC increases and BT decreases

Dynamic variables :

Ice mass flux and content

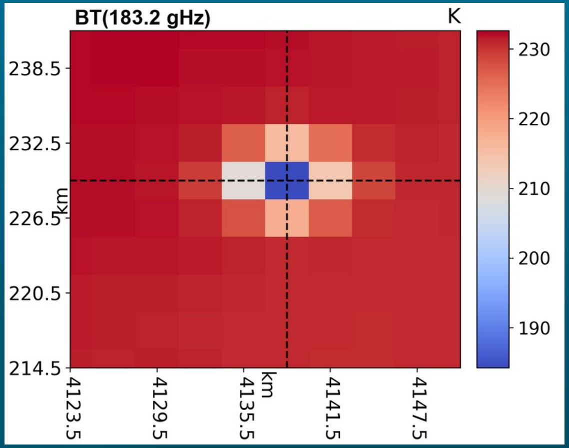




Horizontal maps after vertical integration

Radiometric variable :

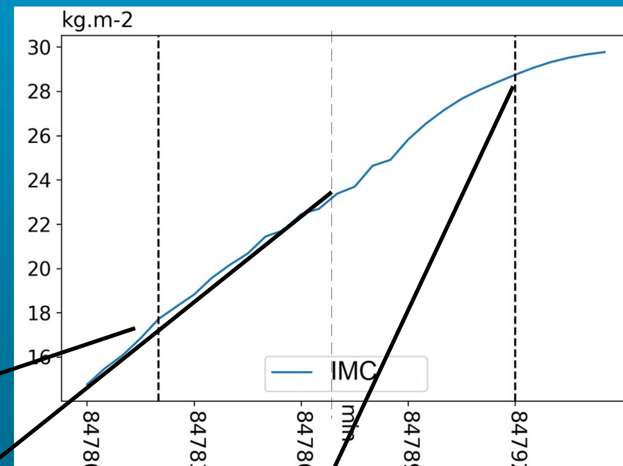
BT at 183 GHz



Horizontal map

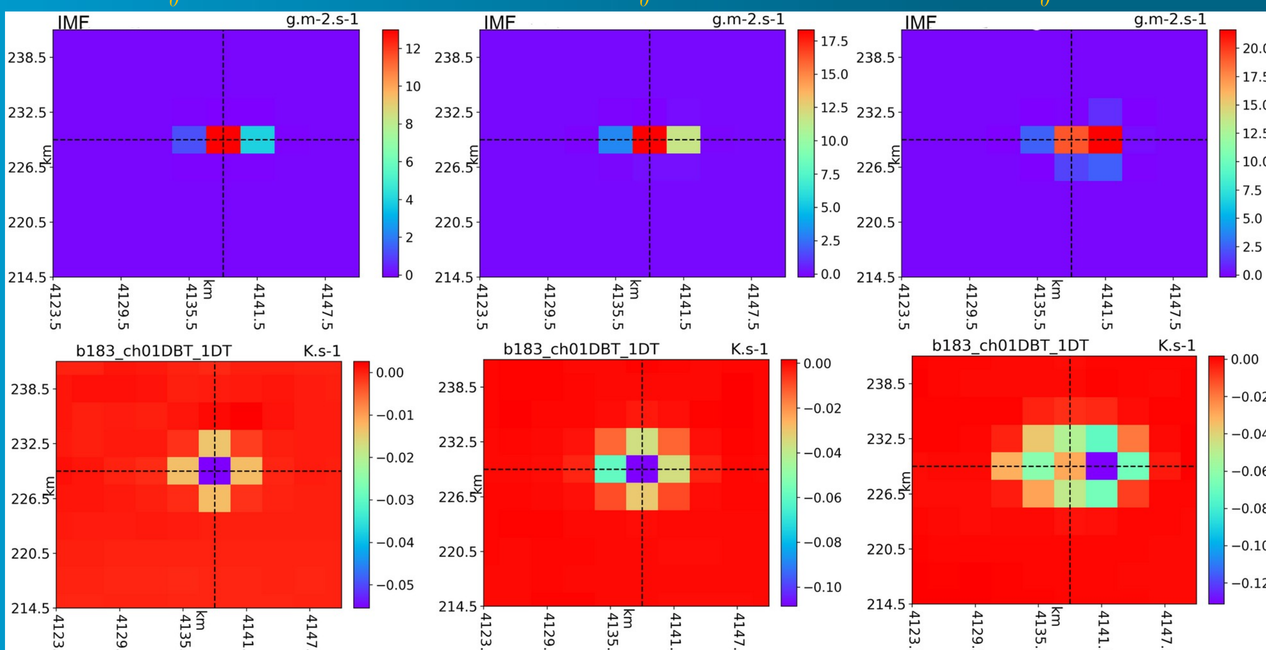
Time evolution of the deep convection

Results for the CC-E core



IMC during 10 min at the CC-E core

t_0 -5min *t_0* *t_0 + 5 min*

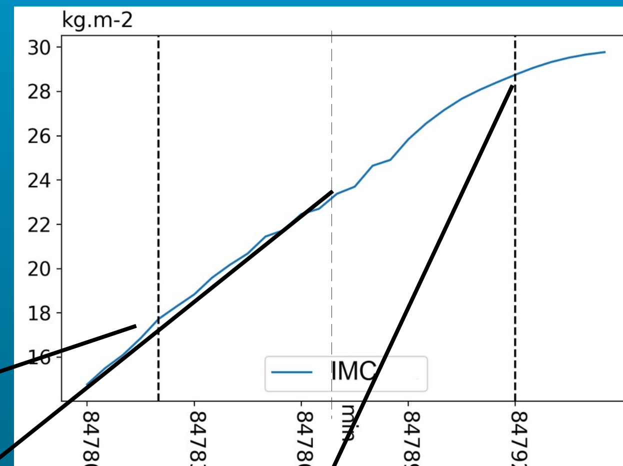


IMF and dBTdt at 183 GHz for three times (CC-E)

=> First step : need to detect the location of deep convection

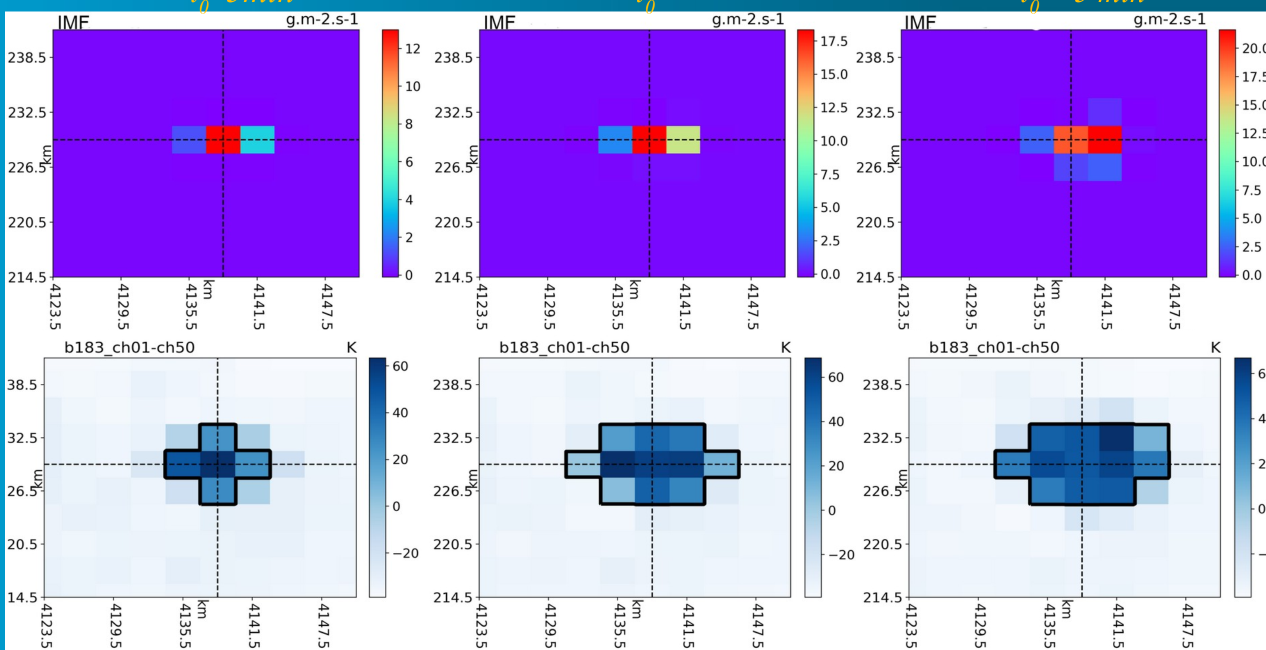
Detection of the deep convection

Results for the CC-E core



IMC during 10 min at the CC-E core

t_0 -5min *t_0* *t_0 + 5 min*



Deep convection criterion
Rysman et al., QJRMS, 2016

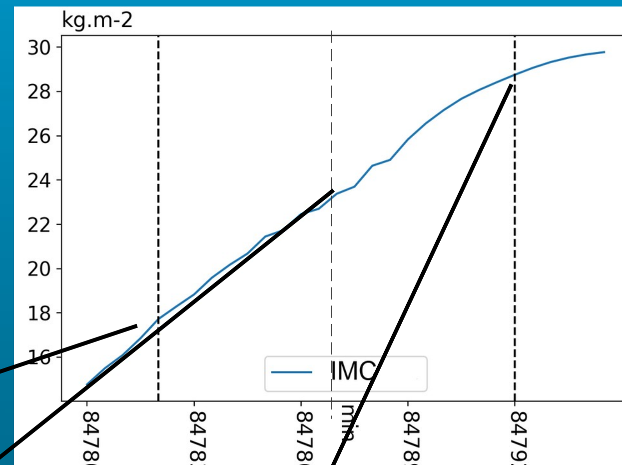
BT_{cent}-BT_{wing} ~ 0 K at 183 GHz

=> difference of location between IMF and the criterion

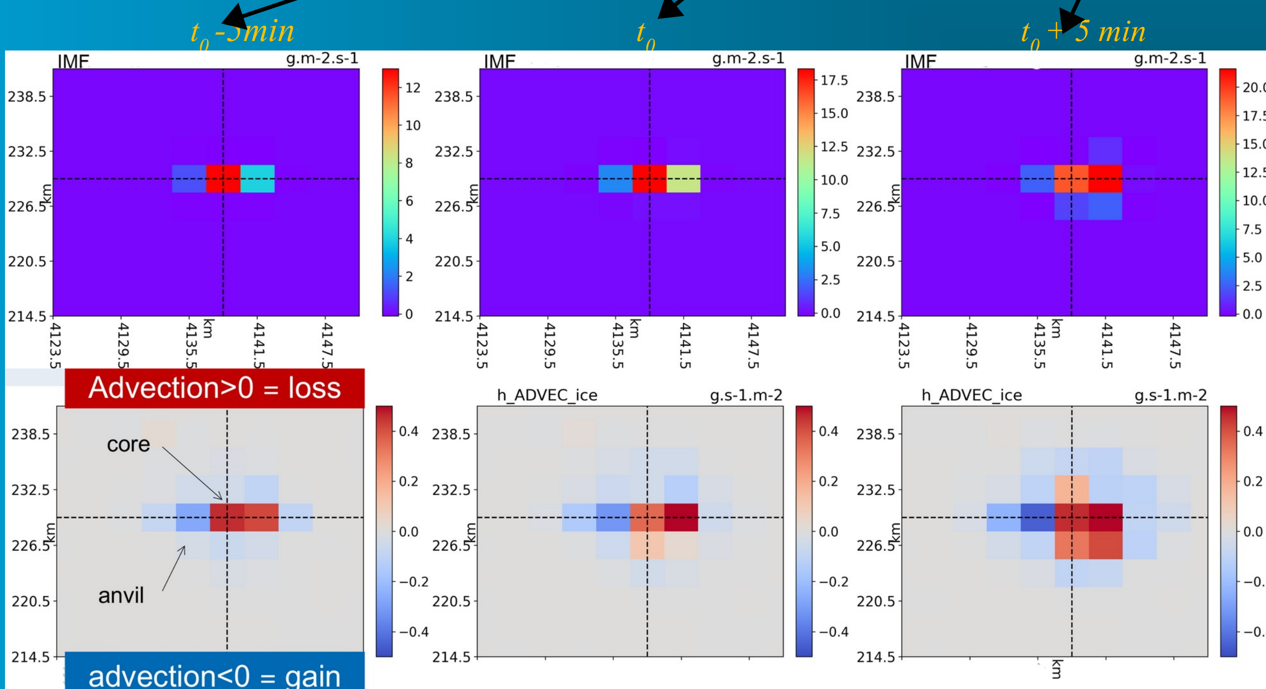
IMF and BT_{cent}-BT_{wing} at 183 GHz for three times (CC-E)

Limitation of the detection criterion

Results for the CC-E core



IMC during 10 min at the CC-E core



The horizontal advection spreads the ice around the core

=> BT_{cent}-BT_{wing} ~ 0 K at 183 GHz strongly depends to IMC but does not inform about the processes of IMC evolution

IMF and ice advection for three times (CC-E)

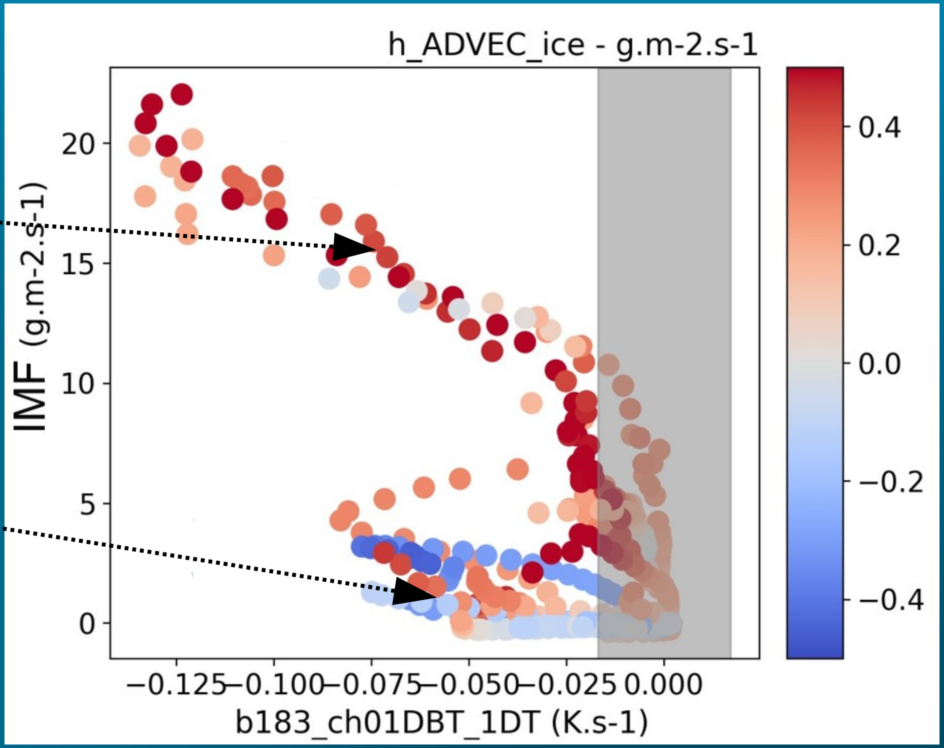
Relationship between IMF and ΔBT

Application to Rcemip CCs

Near-linear relationship between IMF and ΔBT in the core

This relationship is altered by processes like the horizontal advection of ice

(*Similar results for Hector simulation*)



Rcemip CCs (cores + environments) : IMF vs dBTdt at 183GHz

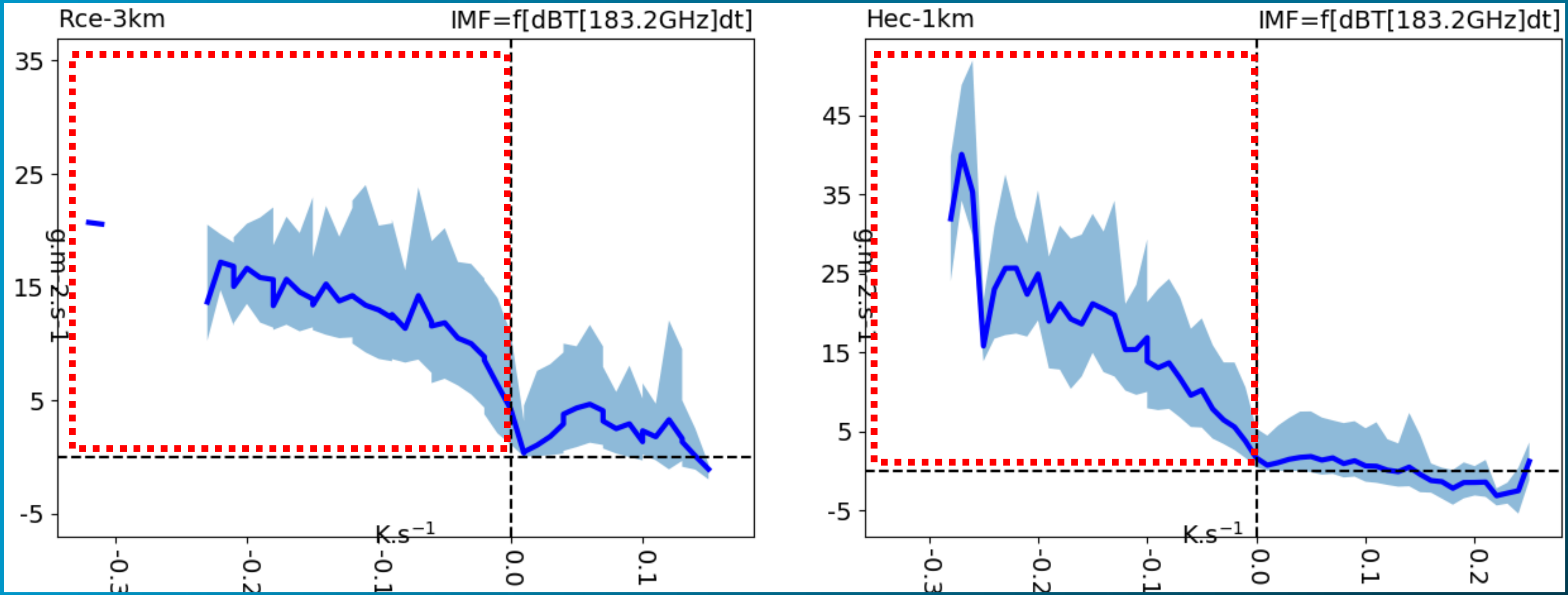
Relationship between IMF and ΔBT

Application to the full datasets

After selecting the convective cells (deep convection criterion), using the minimum BT in space to select only the cores

A second criterion to mainly select the locations where the vertical advection is important

=> dBTdr > 0
r is the horizontal radial distance to the core



Rcemip-3km (~ 1,5.10⁵ pts) Hector-1km (~1,1.10⁵ pts)

Median Q_1 and Q_2, Q_3 quartiles for IMF vs dBTdt at 183GHz

Conclusions

How icy cloud dynamics is related to ΔBT ?

A part of the icy cloud dynamics can be retrieved from the C²OMODO concept

Detection steps

- A criterion of deep convection (BT difference between wing and center at 183 GHz)

- A criterion of minimum BT in space separates the core from the CC environment

Relationships between icy cloud dynamic variables and ΔBT

- The time-derivative ice mass content (IMC) strongly depends to ΔBT in the convective cells

- The ice mass flux (IMF) offers promising scores in the growing phase of convective cores

THAT'S ALL !