HIGH-resolution simulations to improve and TUNE boundary-layer cloud parameterizations

Improve the representation of low-levels clouds in atmospheric models
Comparison 1D/LES
Using state-of-the art statistical tools and advanced Monte Carlo radiative models

HIGH-resolution simulations to improve and TUNE boundary-layer cloud parameterizations

To improve cloud dynamics and cloud radiative effects in atmospheric models
Comparison 1D/LES
Using state-of-the art statistical tools and advanced Monte Carlo radiative models

Expectations from the 1st coding sprint (5-7 September 2017):

- Objectives :
  - Exchange informations on the tuning of models
  - Coding sprint in order to better understand the statistical tools and how to apply them to the SCM/LES comparisons
- An occasion for many discussions :
  - Gathering statisticians, climate modelers, parameterization developers, process studies
  - Quite informal
- A collaborative work :
  - Every one should be able to run the SCM version of one of theatmospheric models
  - Identify the different steps
- A pedagogic role:
  - To feel how the tuning tool work
  - To highlight the difficulties & next steps in the project

2nd HIGH-TUNE Coding Sprint Paris, 2-4 May 2018

- A first 2-day coding sprint in September 2017 :
  - learn the tuning tools=> a prototype of tuning tools
  - 1st time of a coding sprint => very stimulating
- The second coding sprint :
  - Some new persons : thatshould know how to run the tools
  - The possibility to use 4 differents models (AROME, ARPEGE-Climat, ARPEGE-PNT, LMDZ)
  - 2 main objectives :
    - About the tuning tools, learn how to:
      - use more complex metrics (/one real) :time series, vertical profiles, 2D
      - Combine several metrics/several cases
    - Start to use those tools to work on specific questions :
      - Compare range of values for the parameters involved in the updraft velocity equation for two different models (AROME & LMDZ)
      - Explore the dependency of the range of parameter values on the metrics used (mean variables or internal variables of the parameterization)
      - Can those tools help in chosing between formulations (closure of PCMT ? And how to do that ?
      - Others ? ….

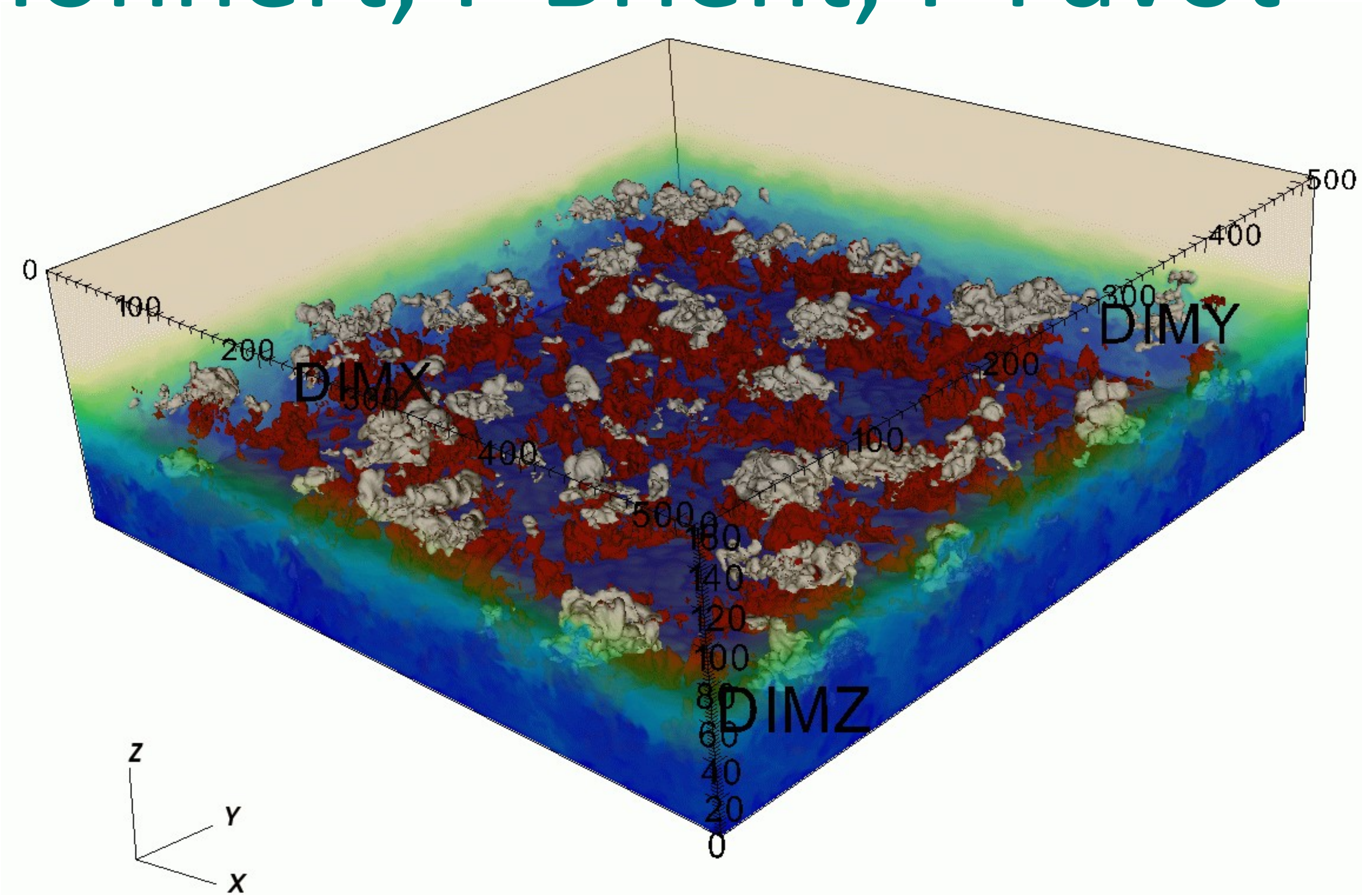
2nd HIGH-TUNE Coding Sprint Paris, 2-4 May 2018

- <u>Thursday morning</u> :
  - Available LES and standardization (Fleur Couvreux & Marie-Pierre Lefebvre, 20min)
  - Available shared scripts : (Frédéric Hourdin, 30 min)
  - Status of new developments on the statistical tools (Daniel Williamson & Vicroria Volodina, 1hour)
  - Discussion on the work content and organization for the coming days

- <u>Thursday afternoon</u> :
  - Work on codes + identified questions
- <u>Friday morning :</u>
  - Debriefing from yesterday afternoon + work
- <u>Friday afternoon</u> :
  - On the evolution of the shared htune scripts
  - On the next priorities in terms of parameterizations
  - On the coordination/collaboration with Exeter
  - From 1D to 3D

Status of LES simulations

F Couvreux, N Villefranque, R Honnert, F Brient, F Favot



LES: strengths/weaknesses

The Pros:

- Realistic reproduction of thermals, cumulus,...
- Consistent 3D fields of various variables => complete overview of an object + access to variables difficult to measure
- Mainly resolved
- Controled simulation conditions => sensitivity tests
- Virtual lab

The Cons :

- **Still a model with parameterizations ; have limits for numerics, microphysics, stable layers, radiation.**..
- Costly but more affordable with increasing computing facility
- Very simple interaction with the large-scale

1D/LES comparison, a useful framework :

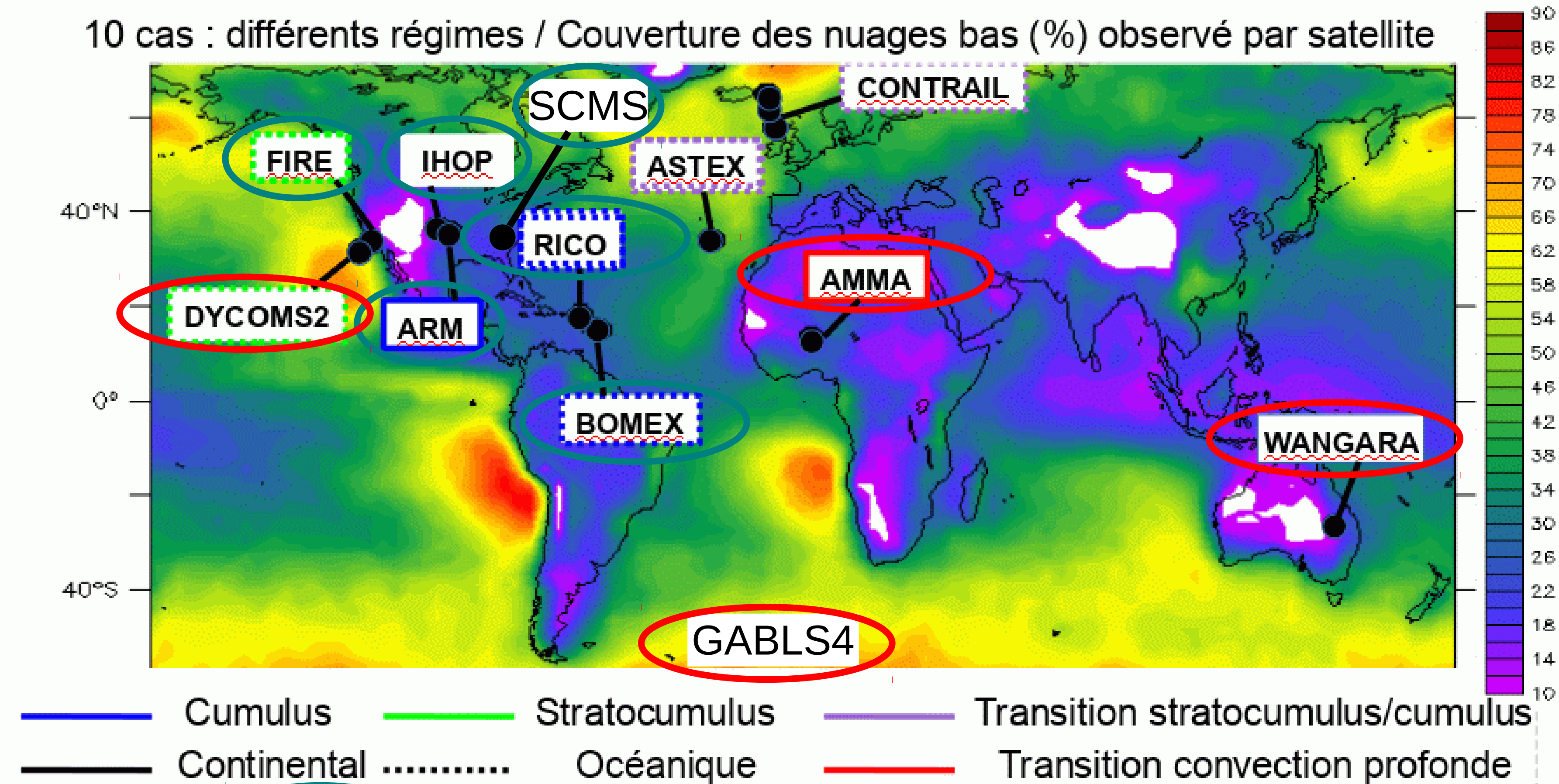
- Exactly the same forcing (initial, lateral conditions & large-scale forcings) => direct comparison
- No interaction with the large-scale dynamics => focus on the parameterizations
- Can realise the same sensitivity tests
- Possibility to derive parameterization-oriented diagnostics from the LES to
  - Test formulation
  - Evaluate the parameterization

The needs for the tuning tool

- A reference = LES
  +
- An uncertainty around this reference

- Different ways of estimating this uncertainty :
  - Use of reference set-up of different LES models
  - **Use several LES from the same model**

The different cases

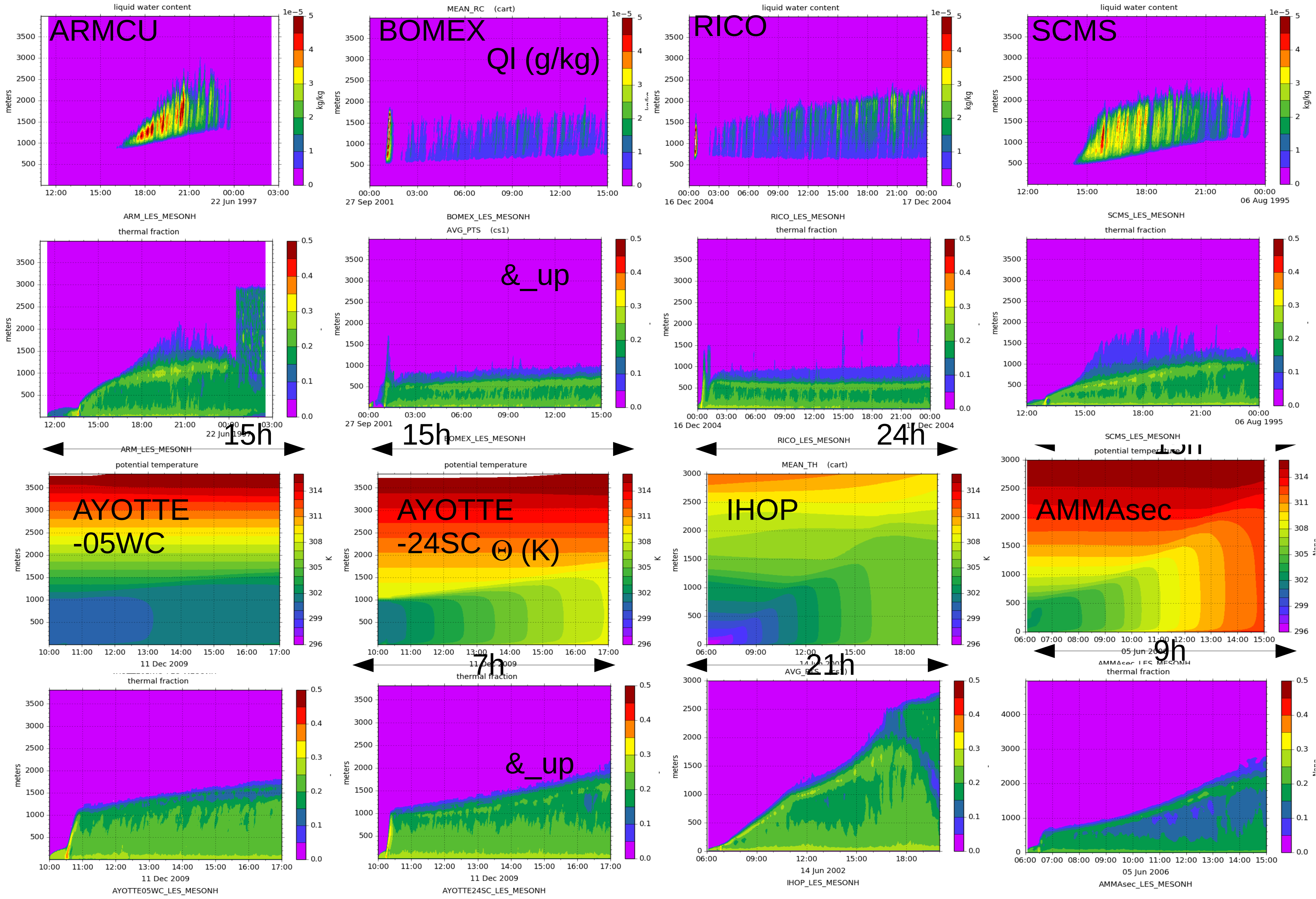


+ idealized cases : AYOTTE (constant surface fluxes + different inversion strengths, no moisture)

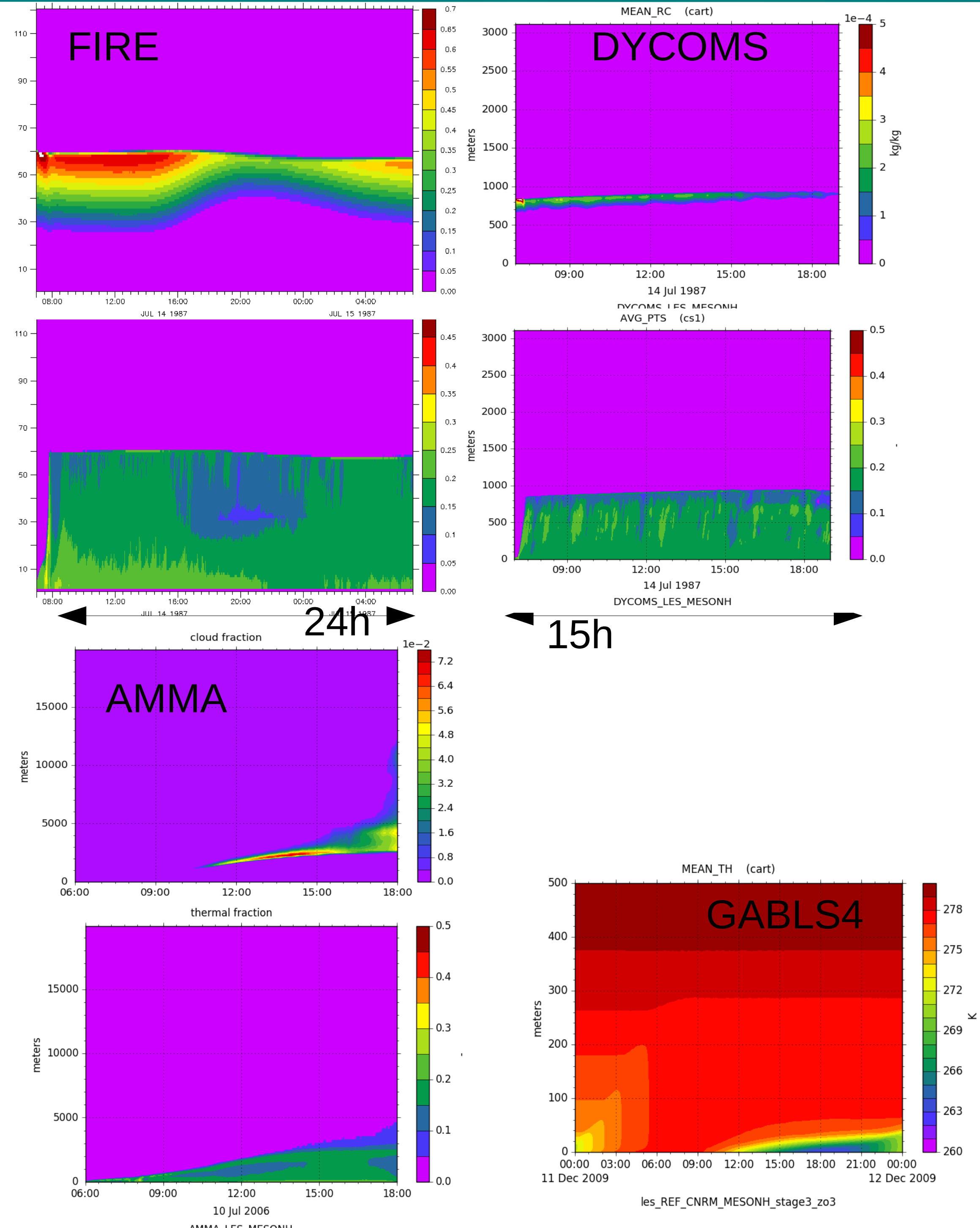
Reference LES available
Reference LES +sensitivity tests available

Cases of clear boundary layer, cumulus, stratocumus, transition from stratocumulus to cumulus, transition to deep convection, stable boundary layer

The different cases



The different cases



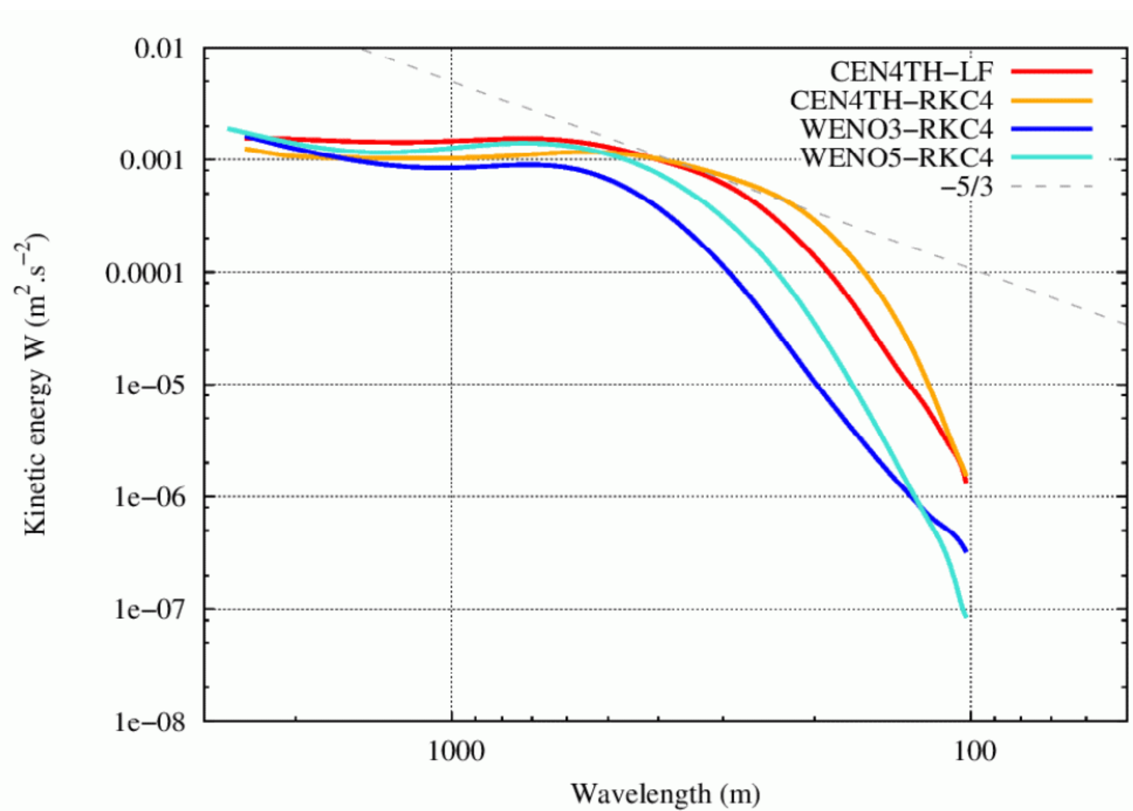
The transition cases from stratocumulus to cumulus => still to be done

The different sensitivities

- The reference set-up : Dx=25m(cumulus)/50m (clear BL) ; Dz=25m ; microphysics=ICE3 ; turbulence=DEAR ; Domain=6.4km/10km ; Advection (wind): centered discretization of 4th order

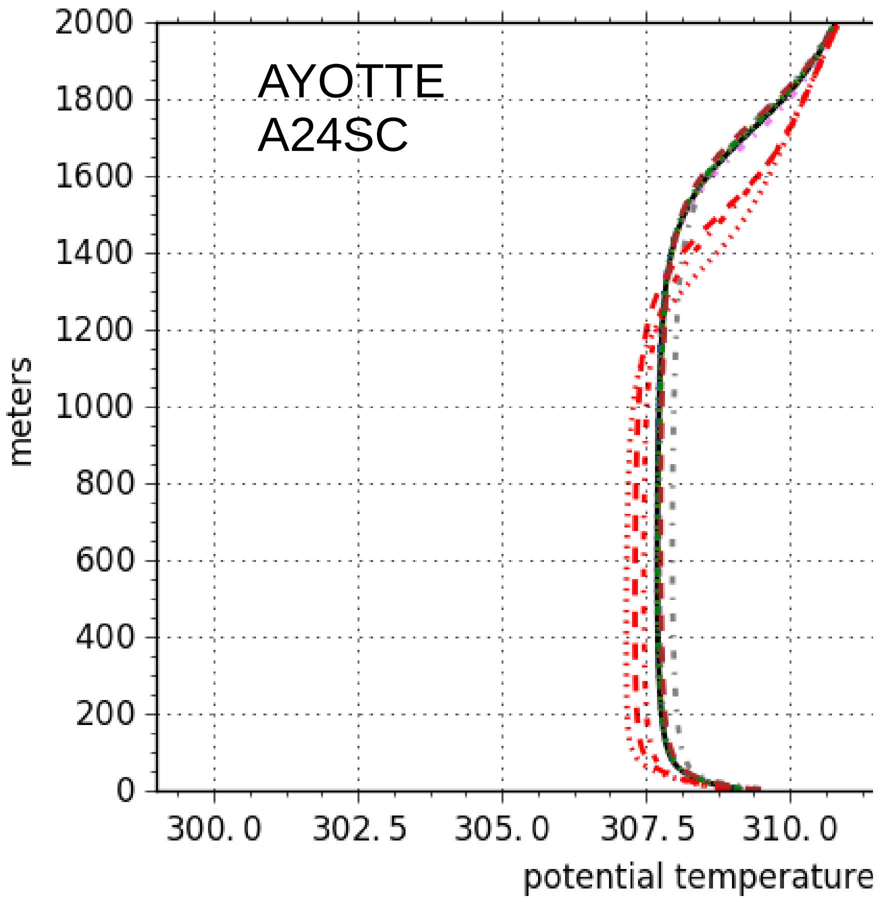
Sensitivities to :

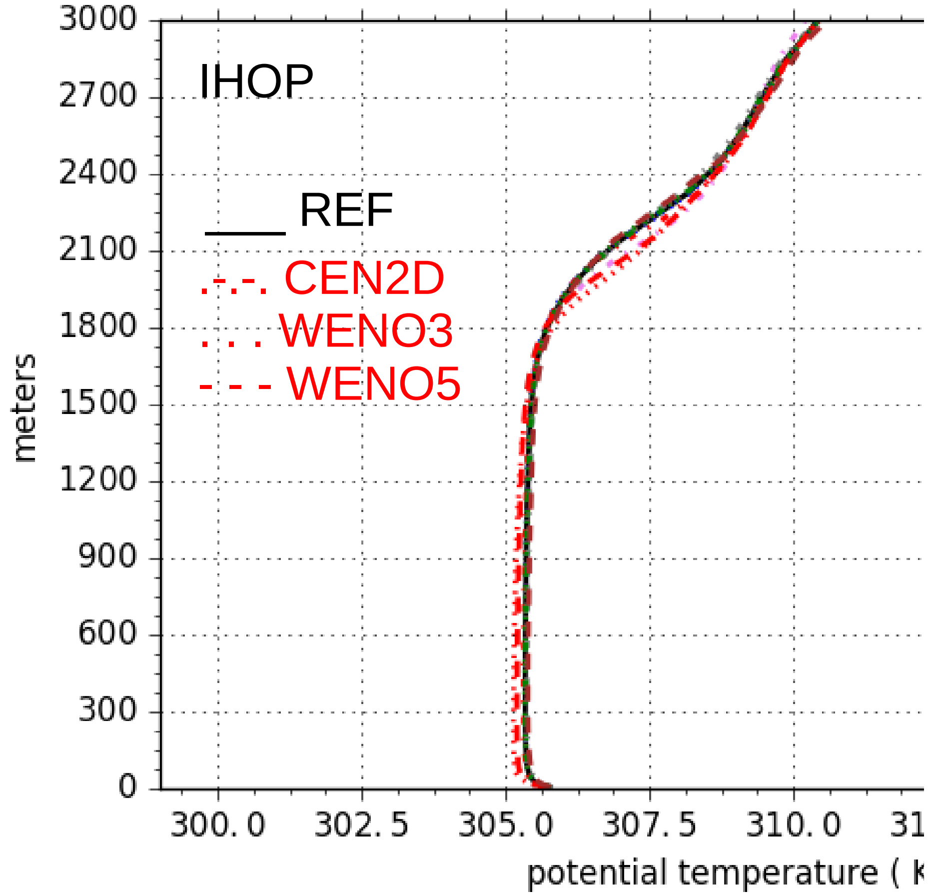
- the white noise introduced at the beginning of the simulation (0.01, 0.1, 0.5 K)
- the resolution horizontal & vertical
- the strength of the numerical diffusion
- the size of the domain 12km/ 20km
- the microphysics (2nd moment, only saturation adjustement, subgrid condensation allowed)
- the turbulence (change of the length scale formulation)
- the advection scheme : Centered 2nd order ; WENO3 (Wieighted Essentially Non Oscillatory Discretization of 3rd order ; WENO5



Spectra of w² averaged from 100m to 1000m, FIRE (LES, Dx=50m) Lac et al, 2018

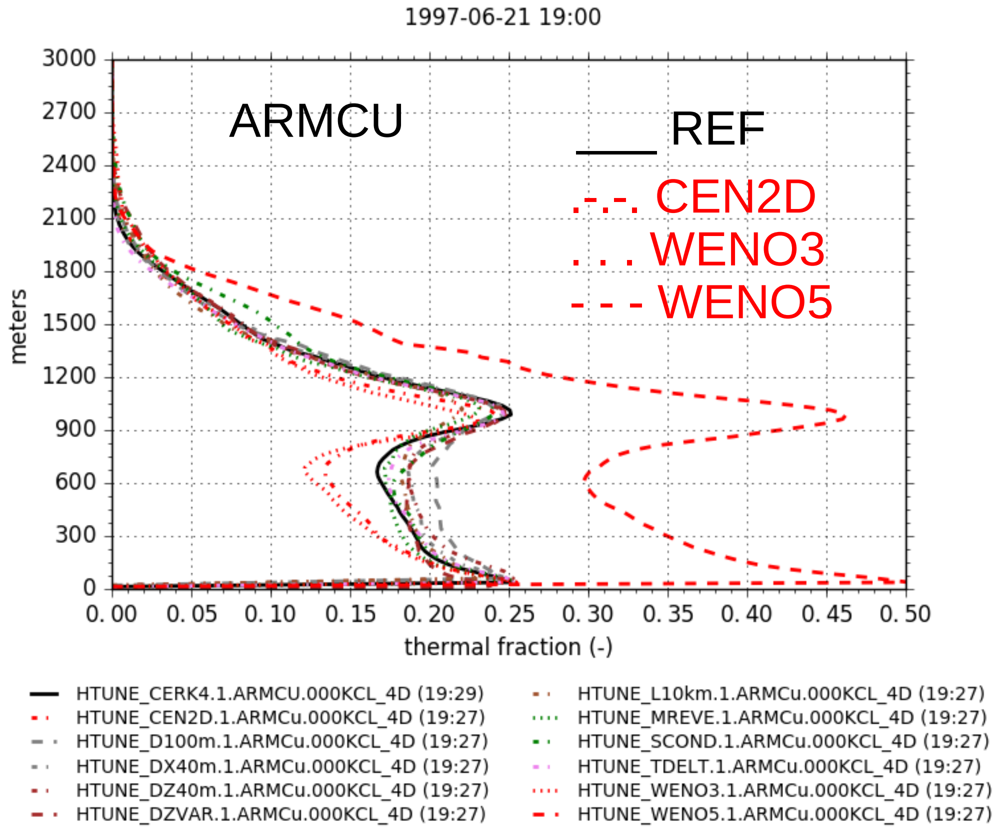
Impact of advection scheme on mean variable

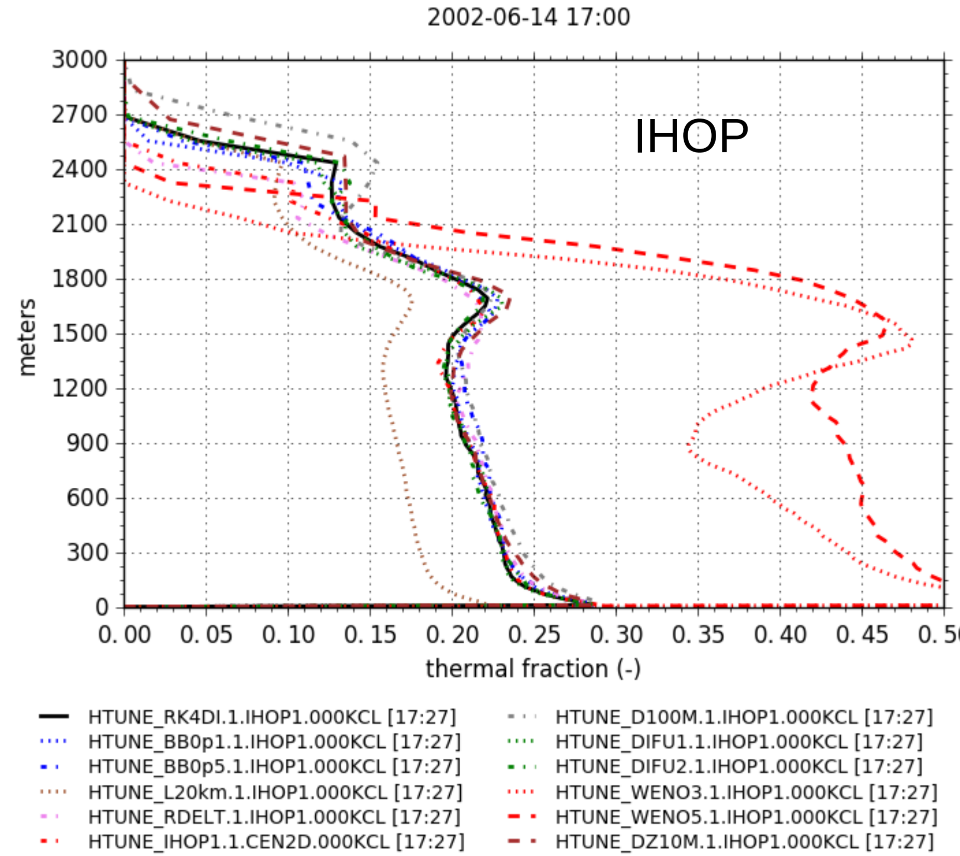




WENO3 : smallest boundary-layer ; WENO5=CEN2D in a lesser extent
WENO3 & CEN2D almost no entrainment (wth<0 at the BL top)
=> recommended advection scheme CEN4TH +RK4 (as in the reference)

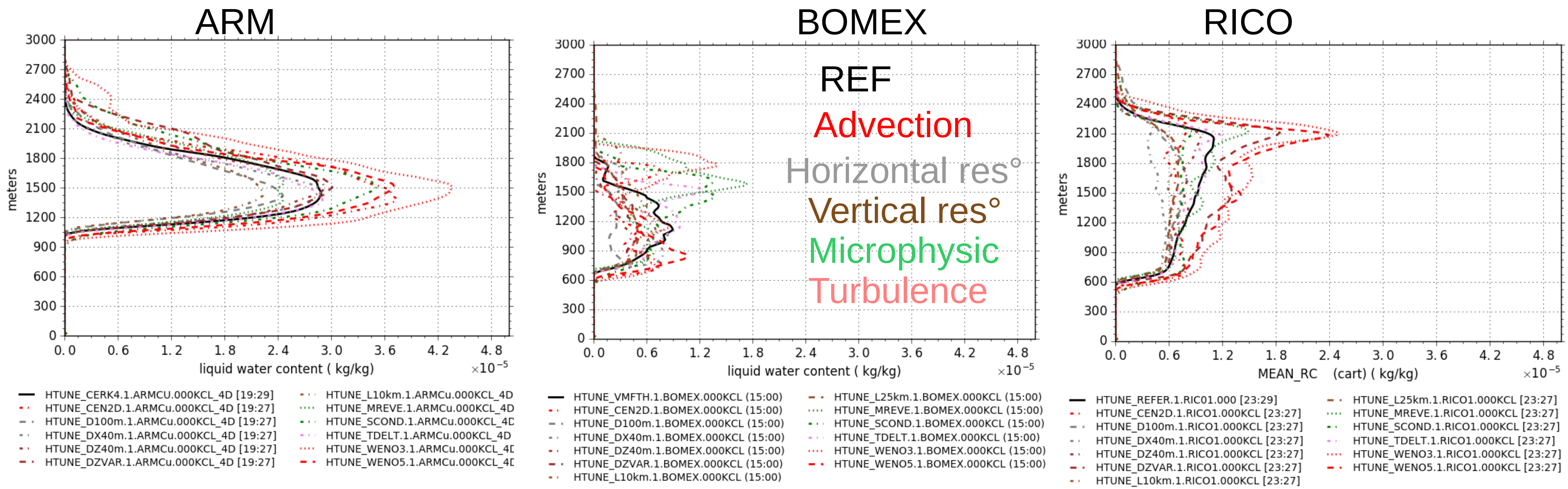
Impact of advection scheme on diagnostic (&u)





WENO5 : much larger fraction (related to the diffusion?)
=> not sure to keep the sensitivity to the advection scheme ? In particular for Parameterization oriented diagnostics ?

Sensitivity on cloud content



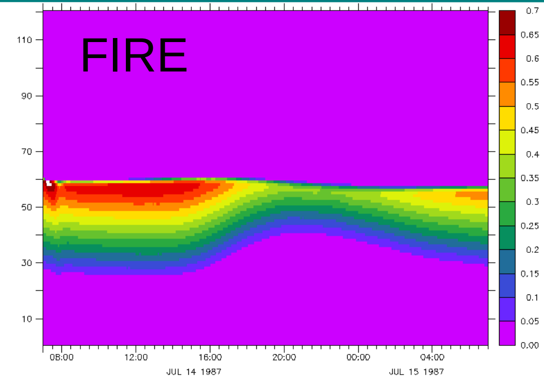
Horizontal res° : 100 m slightly less ql / 25m (~ no change at 40m)
Vertical res° : 40m/25m slightly more ql but not systematic
Larger domain : less ql
Turbulence : no very sensitive
Microphysic : subgrid cond° => more ql / saturation adjustement (= no prec°) no syst. effect

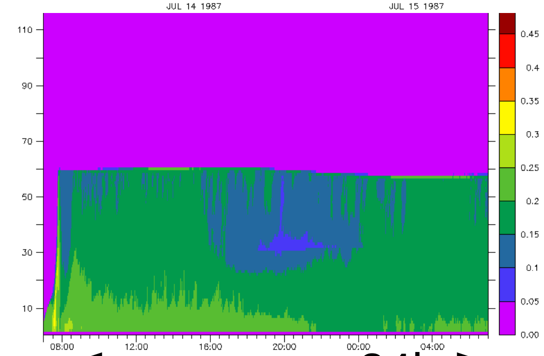
Conclusions

- Already available :
  - Reference LES simulations for all cases except ASTEX
  - Sensitivity simulations to be done : Wangara, other Ayotte cases, DYCOMS, ASTEX, AMMAsec, AMMAdeep

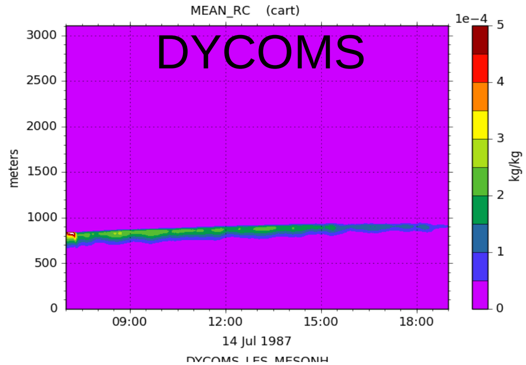
- Preliminary results on sensitivity :
  - Largest sensitivity = advection scheme but CEN4TH recommended ; notably large impact on thermal coverage fraction
  - Other sensitivity on the same range : microphysics, resolution, domain, num° diffusion
  - Turbulence & white noise : less impact

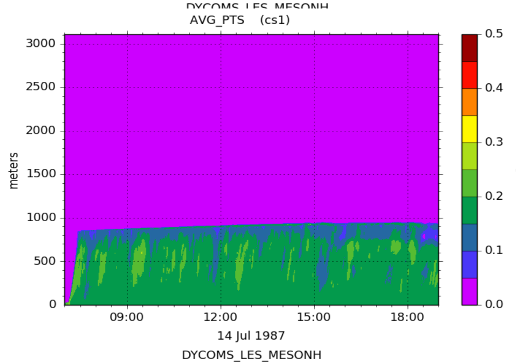
The different cases





24h





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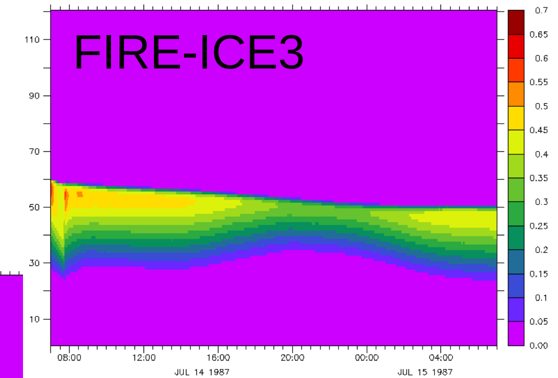

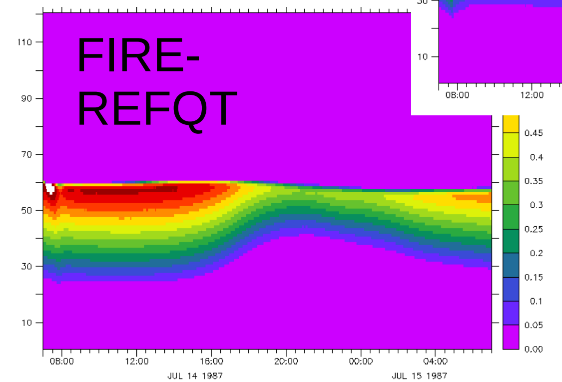

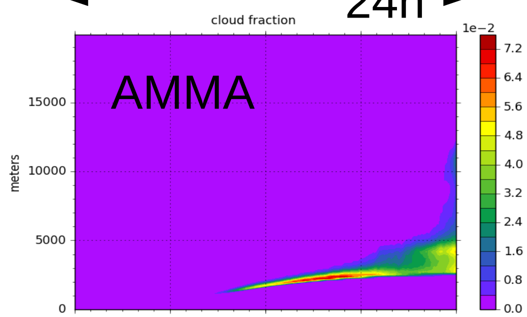

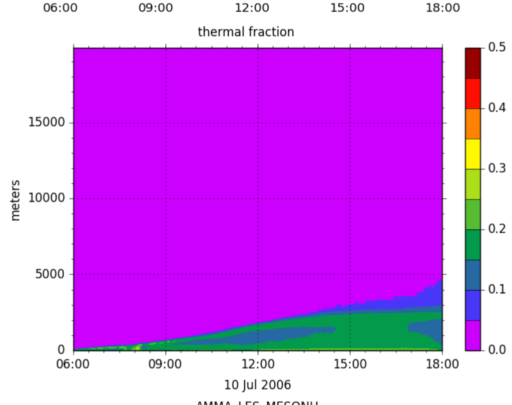

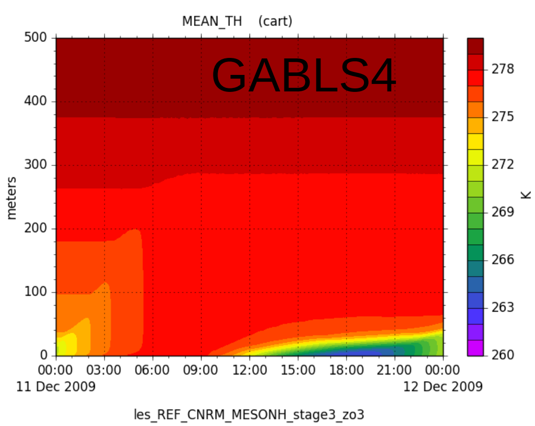

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