Pedagogical input of idealized numerical simulations performed by Meso-NH model

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Goals

The objective is to create a human-machine interface that could be used by teachers in practical classes and lectures. The website has to facilitate the study of convection phenomena and to propose various ways of understanding the main processes. It also allows the users to easily work with images created from the research model Meso-NH, which often implies time-consuming simulations. This work is the result of an ENM students project realized by 5 students.

About the website

The ideal case is based upon the sounding proposed by Klemp and Wilhelmson (1978).

To model this case, the French research model Meso-NH *(more information below)* has been used. The obtained outputs allowed to generate the images which appear on the website.

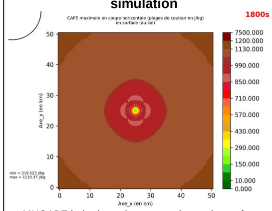
Several parameters are available such as CAPE, CIN, hydrometeors, theta and pressure perturbation, wind, vertical velocities, vorticity…

Various displaying modes are available:
- 2D (horizontal cross section)
- vertical cross sections
- 3D with ground values of another parameter
+ comparison

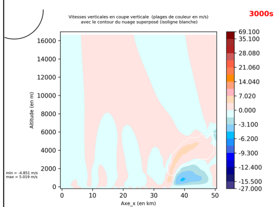
Users are able to modify easily the characteristics of the warm bubble (intensity, altitude, width, depth, moisture) and its environment (temperature, moisture, vertical wind shear, Coriolis force and vertical velocity) but also microphysics scheme to model a convective situation in the "Simulation" section.

In addition, they can choose the "Comparison" page to compare two simulations by changing the intensity of the variable (for example to compare a narrow bubble to a large one).

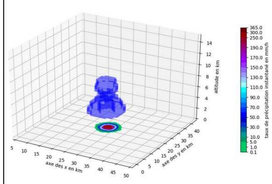
Illustrations about the used reference simulation



MUCAPE in horizontal cross section at the surface (no shear)



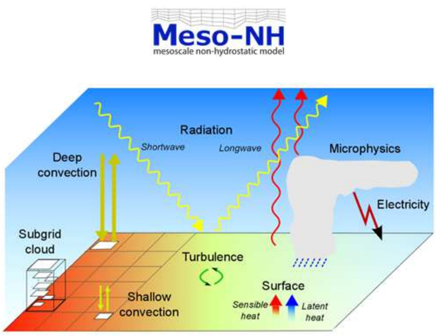
Vertical velocity in vertical cross section with the cloud outline (in white), high unidirectional shear



Cloud Water Ratio (3D) with instantaneous precipitations (2D) superimposed

Meso-NH

Meso-NH (Lafore & al., 1998 ; Lac & al., 2018) is the non-hydrostatic meso-scale atmospheric model of the French research community. It has been jointly developing by the Aerology Laboratory and CNRM-GAME (URA 1357 CNRS/MÉTÉO-FRANCE) for 20 years. It takes in account numerous parametrizations *(as you can see on the scheme)*. The model physics is the same as in AROME for forecast and can deal with scales ranging from large (synoptic) to small (large eddies) scales.



Prospects

In the future, other cases could fill the interface, such as storm splitting (Klemp and Wilhelmson, 1978), supercell (Weisman and Klemp, 1982) or even a QLCS ?

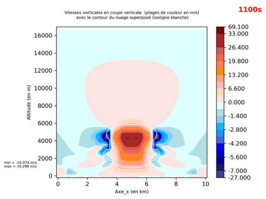
For the moment, this interface is on the Météo-France internal network. Nevertheless, if other organisms are interested in this website, it could be extended on the Internet.

Key questions

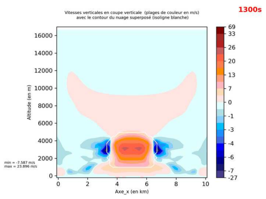
What are the main experiments to illustrate?
What are the most important parameters to study?
How to create a useful interface?

Examples

The influence of the width of the warm bubble can be shown for instance thanks to the vertical velocity or the accumulated precipitations. Students can be asked to compare those parameters with different sizes of warm bubbles.



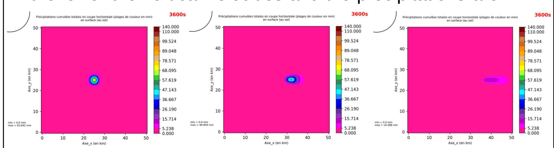
Vertical velocity in vertical cross section of a narrow warm bubble



Vertical velocity in vertical cross section of a wide warm bubble

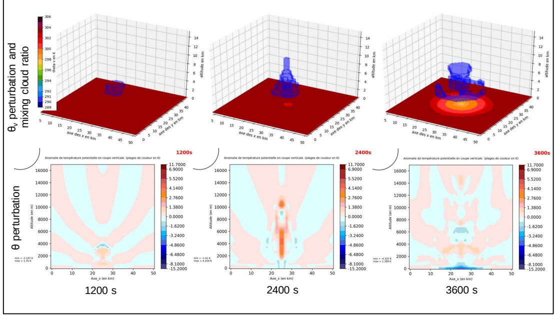
For a narrow warm bubble, the convection starts earlier and is stronger than for a larger bubble.

The impact of the vertical wind shear can be seen on the accumulated precipitations and the Cloud Mixing Ratio. Indeed the students will clearly notice, the more the shear is:
- the larger the shift is
- the lower the vertical velocities and the precipitations are



Accumulated precipitations without wind shear — *Accumulated precipitations with low to moderate unidirectional wind shear* — *Accumulated precipitations with moderate to high unidirectional wind shear*

The life cycle of an isolated cell can be illustrated in various ways:
- with 3D mixing cloud ratio and θ_v it is possible to see the growth of the cloud and in the end, of the cold pool
- with a vertical cross section of θ perturbation, students will be able to analyze physical processes in and around the cloud (condensation, evaporation and the cold pool in the end)
- cloud propagation (isotropic)



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