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A numerical study of thermals as the prototype of moist convection

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Despite the fact that thermals—small, transient air bubbles—are known to be the main convective elements of atmospheric moist convection, current parameterizations are typically based on the steady-plume concept, mostly due to practical and historical reasons. Within the current need for new parameterizations, the thermal conceptual model for convection is one promising path. For example, thermals are highly entraining, albeit weakly damped. This would hardly fit within the typical entraining plume model, but could aid to improve key issues of current convection parameterizations, such as the lack of sensitivity to ambient humidity and the excess of condensate carried to upper levels. Furthermore, the transient nature of thermals would bring an entirely new physical ingredient to convection parameterizations.

The first step towards developing such new parameterizations is to understand the dynamics of thermals. Here we will describe their dynamics based on 2D and 3D cloud resolving simulations of sea-breeze initiated convection using WRF. We analize a large sample of thermals from which we can describe statistics about their size, ascent rate, momentum budget and mixing properties. We will show how these properties define their transient nature, how they are related to each other, and how they evolve as convection deepens. Furthermore we will provide simple relations between buoyancy, vertical velocity and drag forces, which would be crucial for new parameterizations.