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Temporal evolution of rain drops' velocities in a turbulent wind field

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It is commonly assumed that a rain drop falls vertically at a speed equal to its so called "terminal fall velocity" which has been determined both empirically and theoretically by equating the net gravity force with the drag force due to the fact the drop is moving in the atmosphere. This velocity depends on the size of the drop, usually characterized by its equivolumic diameter.

In this investigation we study the temporal evolution of the velocity of a rain drop falling through turbulent wind field. The equation governing a rain drop motion relates the acceleration to the forces of gravity and buoyancy along with the drag force. The latter depends non-linearly on the instantaneous relative velocity between the drop and the local wind. The whole complexity of the resulting behaviour arises from this feature. In this work, the drag force is expressed in a standard way with the help of a drag coefficient, which is itself determined according to a Reynolds number. It should be mentioned that in this initial work, the strong assumption that the drops remain spherical in their fall is made. It is well known that its not true for drops greater than typically 1-2 mm which tend to become oblate, and potential effects on the results will be discussed.

An explicit numerical scheme is implemented to solve this equation for 3+1D turbulent wind field to study the temporal evolution of the velocities as well as the trajectories of rain drops over few hundreds of meters. The variations in both space and time of the wind field are simulated with the help of a Universal Multifractals which are a framework that has been widely used to characterize and simulate geophysical fields extremely variable over a wide range of scales such as wind.

Temporal multifractal analysis are then carried out on the simulated drop velocity, which enables to characterize the behaviour of drops according to their size, and notably a scale below which turbulent eddies have a limited impact on their motion. Finally the consequences of these findings on rainfall remote sensing with radars are briefly discussed.