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A simplified microphysics model to assess the impact of gravity waves on homogeneous ice nucleation in the tropical tropopause layer

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We present first results aiming at understanding the impact of gravity waves on homogeneous ice nucleation in a simplified microphysics set-up. We use a 1D model of homogeneous ice nucleation, growth, sedimentation, and mixing due to wind shear. This model describes the evolution of ice crystals number and mass with 36 bins of size, after freezing on particles of ammonium sulfate. 420 supersaturated air parcels of 20m thickness and 200m length, distributed in a 7 columns grid, are simulated simultaneously, allowing exchanges of ice crystals between the air masses by sedimentation and horizontal mixing.

A first simple set-up represents the large-scale ascending motion of air parcels in the tropics, with a vertical speed of 0.5 mm/s. Air parcels follow a typical tropical temperature profile, between 16400 and 17700 m of altitude. The maximum of nucleated ice crystals is found just below the cold point and nucleation occurs in a layer of 400m, whereas sedimented ice crystals are found down to the bottom of the columns of air masses, showing that the width of cirrus clouds is different from the nucleation layer. The majority of nucleated ice crystals is small enough to be carried up with the air parcels. Yet the fall streaks of a few bigger crystals deplete the humidity of air parcels beneath, preventing new nucleation events from happening. We find that more than half of the total ice mass in air parcels is from the sedimented crystals only, even though they represent less than a third of the number of crystals counted in our system. These few crystals are responsible for more than half of the diminution of the humidity within the air parcels.

A second experiment is designed to take into account smaller scale perturbations induced by gravity waves, by coupling the microphysics model with lagrangian temperature measurements from superpressure balloons of the first Stratéole-2 campaign. Gravity waves are found to create more nucleation events, in time and at all altitude levels of our experiment, expanding the nucleation layer up to one kilometer. The larger cooling rates create more small crystals, but the growth of ice is slowed down by the waves's warming phases and the decreased humidity from more nucleation events. Furthermore, gravity waves prevent the biggest ice crystals from appearing. Last, the addition of gravity waves removes on average less humidity from the air

parcels than the sedimentation of ice crystals nucleated during the slow unperturbed ascent.