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Simulating airborne 'snow walls' of Antarctica using CRYOWRF v1.0

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When a well-developed, high velocity katabatic flow draining down the ice sheet of Antarctica reaches the coast, it experiences an abrupt and rapid transition due to change in slope resulting in formation of a hydraulic jump. A remarkable manifestation of the hydraulic jump, given the 'right' surface conditions, is the large-scale entrainment and convergence of blowing snow particles within the hydraulic jump. This can result in formation of 100-1000 m high, highly localized 'walls' of snow in the air in an otherwise cloud-free sky.

Recent work by Vignon et al. (2020) has described in detail, the mechanisms resulting in the formation of hydraulic jumps and excitation of gravity waves during a particularly notable event at the Dumont d'Urville (DDU) station in August 2017. They used a combination of satellite images, mesoscale simulations with WRF and station measurements (including Micro Rain Radars) in their study, notably relying on the snow wall for diagnosing and quantifying the hydraulic jump in satellite images. On the other hand, relatively less importance was given towards the surface snow processes including the transport of snow particles in the wall.

In this presentation, we present results from simulations done using the recently developed CRYOWRF v1.0 to recreate the August 2017 episode at DDU and explicitly simulate the formation and the dynamics of the snow wall itself. CRYOWRF enhances the standard WRF model with the state-of-the-art surface snow modelling scheme SNOWPACK as well as a completely new blowing snow scheme. SNOWPACK essentially acts as a land surface model for the WRF atmospheric model, thus making a quantum leap over the existing snow cover models in WRF. Since SNOWPACK is a grain-scale snow model, it allows for the proper formulation of boundary conditions for simulating blowing snow dynamics.

Results show the formation of the snow wall due to large scale entrainment over a wide area of the ice sheet, the mass balance of the snow wall within the hydraulic jump and finally, the destruction of the snow wall and the ultimate fate of all the entrained snow. We also show results for the influence of the snow wall on the local surface radiation at DDU. Overall, we test the capabilities of CRYOWRF to simulate such a complex phenomenon and highlight possible applications now feasible due the tight coupling of an advanced snow cover model and a multi-scale, non-hydrostatic atmospheric flow solver.

Reference:

Vignon, Étienne, Ghislain Picard, Claudio Durán-Alarcón, Simon P. Alexander, Hubert Gallée, and Alexis Berne. " Gravity Wave Excitation during the Coastal Transition of an Extreme Katabatic Flow in Antarctica". *Journal of the Atmospheric Sciences* 77.4 (2020): 1295-1312. <>.