Kinematic Modeling Study of the Re-Organization of Snowfall beneath Cloud-top Generating Cells in Mid latitude Cyclones using a 3-Dimensional Deformation Wind Field

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Objectives

This study aims to assess the impacts of deformation flow on the re-organization of falling ice particles using a kinematic model with a 3-D deformation field.

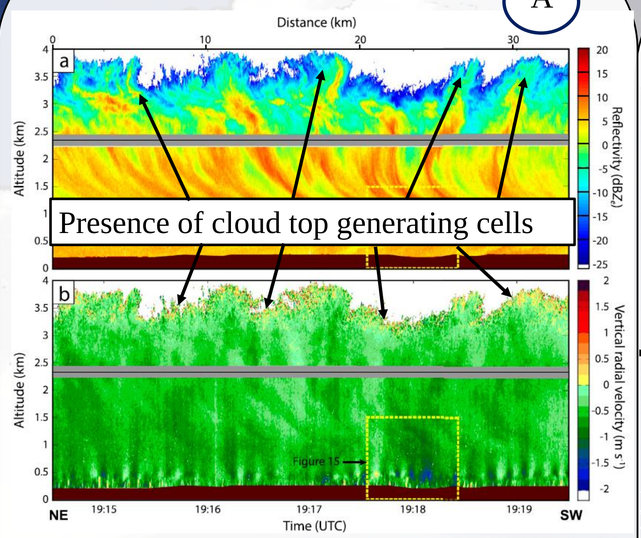
Methodology

A stretching deformation flow field, constant with height, is implemented into the model using a 500 x 200 x 10 km grid in X, Y, and Z respectively. Clusters of ice particles representing generating cells (see F) are placed in rows atop the grid and fall through the depth of the grid. Initial cluster arrangement is based on Keeler et al. (2017) (see C2). For each experiment, clusters are given a residence time, $T = H/V_T$, where H is the cloud depth and V_T is the particle terminal velocity, to fall through deformation flow of either 1×10^{-4} s^{-1} or 2×10^{-4} s^{-1} and the stretching of the initial ice field and shape of distribution after falling through the grid is analyzed.

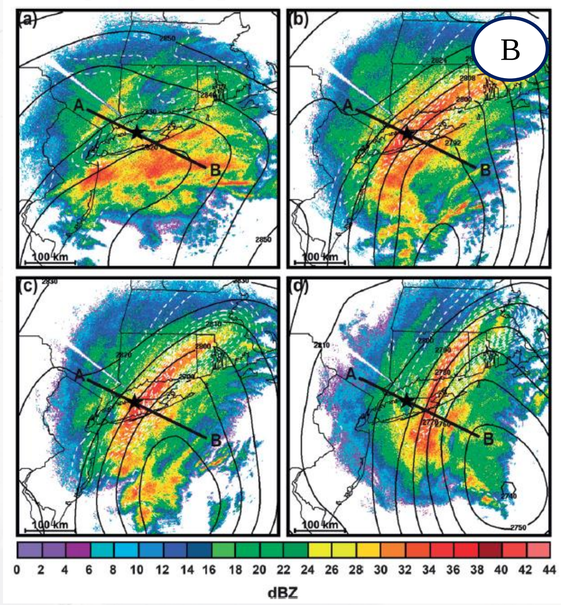
Additional Information:

I will be happy to show you additional aspects of this study on my laptop, and discuss two additional studies we are pursuing regarding this question. Future research will incorporate data from an IMPACTS event to understand role of kinematics in organizing snowfall in a real storm environment.

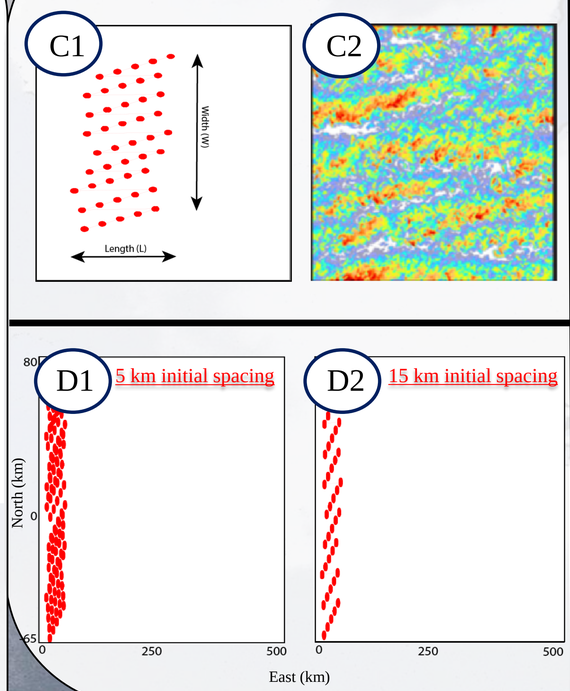
Previous Work



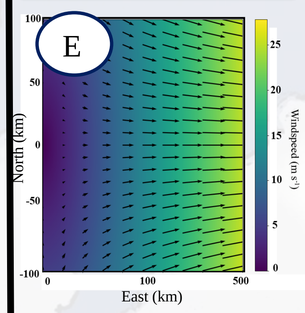
Previous work has studied cloud-top generating cells as shown in "A" from Rauber et al. (2015) above and linear near-surface banded features as shown in "B" below, from Stark et al. (2013). However, little work has been done to show the relationship between the two. This work, while preliminary, attempts to bridge this gap.



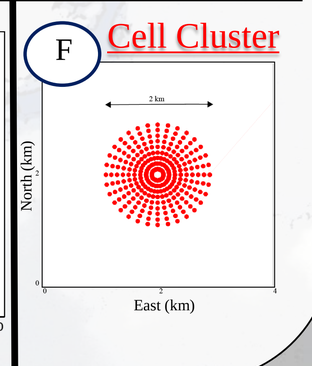
Initial Cluster Arrangements



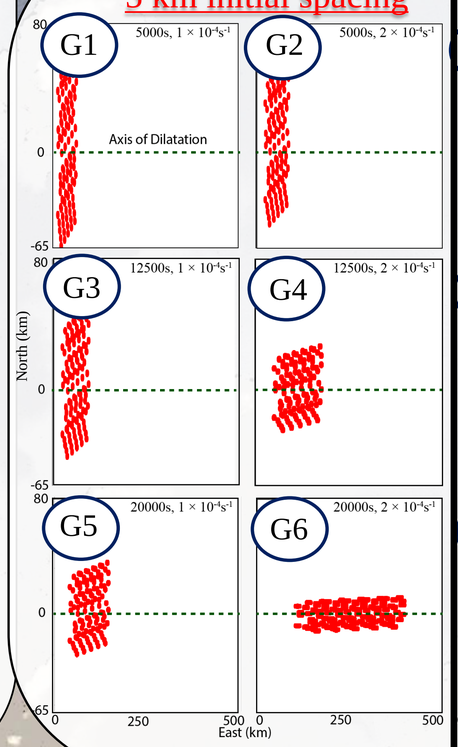
Deformation Flow



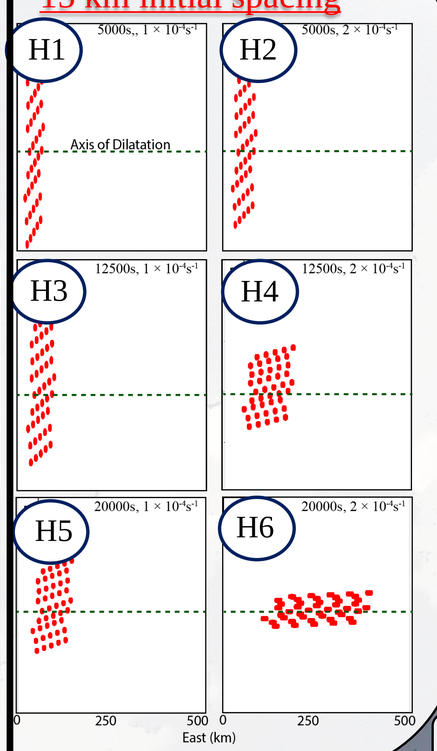
Cell Cluster



Surface Distributions 5 km initial spacing



Surface Distributions 15 km initial spacing



Discussion

The initial cluster row arrangements in "C1" were based on a study by Keeler et al. 2017 in "C2" where generating cells organized into lines with wind shear. The initial ice fields with 5 km spacing (D1) and 15 km spacing (D2) between cluster rows were subject to deformation flow in "E". An example of one cell cluster of ice particles is shown in "F" with each red dot signifying one ice particle. Surface distributions shown in "G6" and "H6" were subject to the maximum deformation and residence time. They stretched most along the axis of dilatation with "G6" showing a congealed shape with cluster row spacing of 406 m while "H6" was more porous with cluster row spacing of 1,759 m. The other distributions are more diffuse with the least stretching in "G1" and "H1" under minimum deformation and residence time. For all experiments, as residence time and deformation increased, stretching along the axis of dilatation increased, contraction normal to the axis of dilatation increased, and spacing in between cluster rows decreased.

This work was funded by the NASA Earth Venture Suborbital-3 (EVS-3) program under grant NASA 80NSSC19K0355 (IMPACTS). All data is publicly available in the NASA EOSDID GHRC Archive: http://dx.doi.org/10.5067/IMPACTS/DATA101