Predicting ice particle shape evolution in a bulk microphysics scheme

Anders A. Jensen
NCAR RAL

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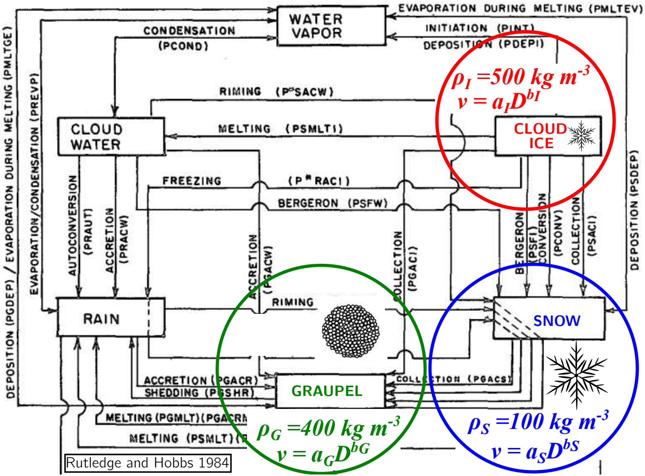
Collaborators: Jerry Harrington
Hugh Morrison, Jason Milbrandt

Ice is complex and difficult to represent in models

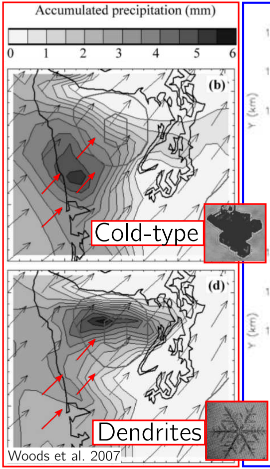
- Ice particles have a vast range of shapes, sizes, densities, fall speeds
- Ice particles can grow by multiple processes (e.g. vapor growth, riming, aggregation)
- Ice is important for precipitation, thermodynamics, radiation

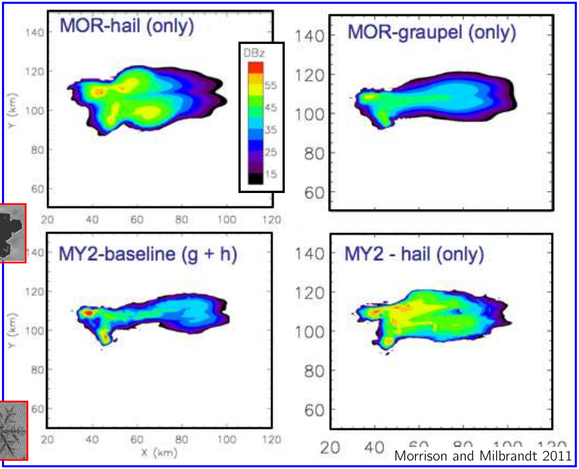
How is the complexity of ice represented in traditional microphysics schemes?



Problem: Conversions between categories are ad-hoc and produce large changes in particle properties

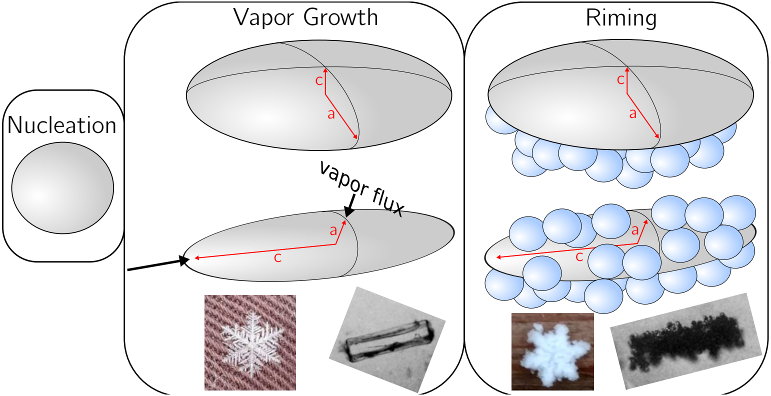
Simulations are sensitive to the choice of ice categories





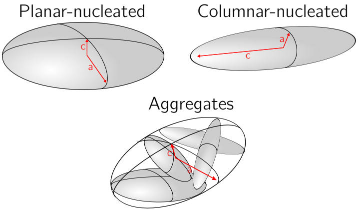
- **Vapor-grown habit properties can impact precipitation**
- **Rimed-ice properties can influence storm characteristics**

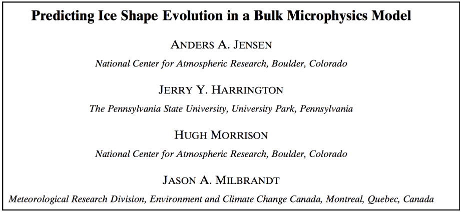
Modeling ice particles as spheroids



- **Growth processes act along two axes**
- **Ice particle properties (mass, shape, density, fall speed, maximum diameter) evolve continuously**

The bulk microphysics scheme





Predicting Ice Shape Evolution in a Bulk Microphysics Model

ANDERS A. JENSEN

National Center for Atmospheric Research, Boulder, Colorado

JERRY Y. HARRINGTON

The Pennsylvania State University, University Park, Pennsylvania

HUGH MORRISON

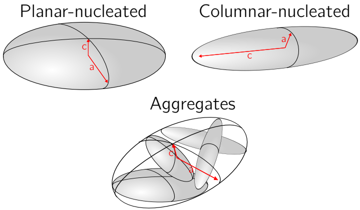
National Center for Atmospheric Research, Boulder, Colorado

JASON A. MILBRANDT

Meteorological Research Division, Environment and Climate Change Canada, Montreal, Quebec, Canada

- Based on the adaptive habit (AHAB) vapor-growth method

The bulk microphysics scheme



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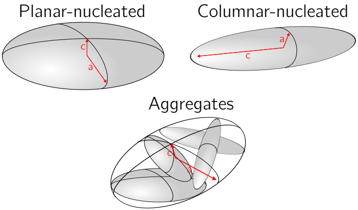
- Based on the adaptive habit (AHAB) vapor-growth method
- Called the Ice Spheroids Habit Model with Aspect-ratio Evolution (ISHMAEL)

The bulk microphysics scheme



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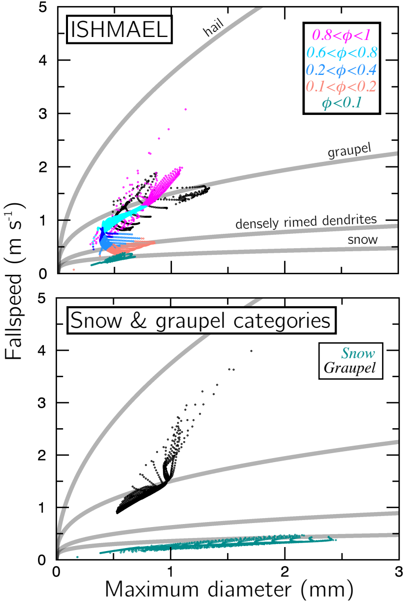
- Based on the adaptive habit (AHAB) vapor-growth method
- Called the Ice Spheroids Habit Model with Aspect-ratio Evolution (ISHMAEL)
- Four advected variables for each ice species (mass, number, volume, volume x aspect ratio mixing ratios)

Impact of predicting ice particle shape evolution



- Compared to the traditional approach ISHMAEL produces partially rimed ice
- ISHMAEL fills in the fall speed-size parameter space between unrimed and rimed ice (more variability in particle fall speeds)
- We expect these differences in fall speeds to impact the spatial distribution of precipitation in certain cases

WRF 3D Squall Line Case (dx = 1 km)

Microphysical Characteristics of Squall-Line Stratiform Precipitation and Transition Zones Simulated Using an Ice Particle Property-Evolving Model

ANDERS A. JENSEN

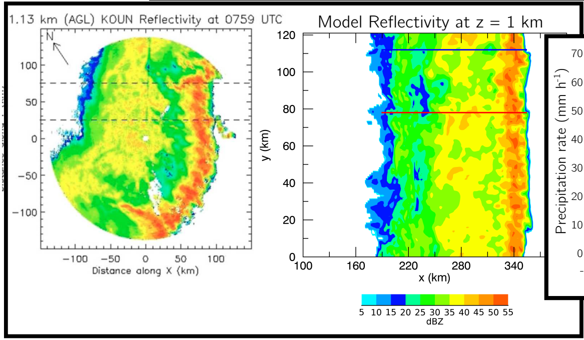
National Center for Atmospheric Research, Boulder, Colorado

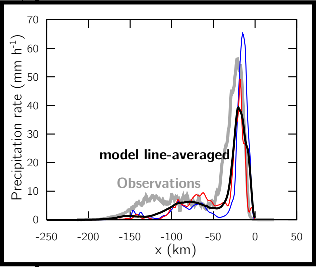
JERRY Y. HARRINGTON

The Pennsylvania State University, University Park, Pennsylvania

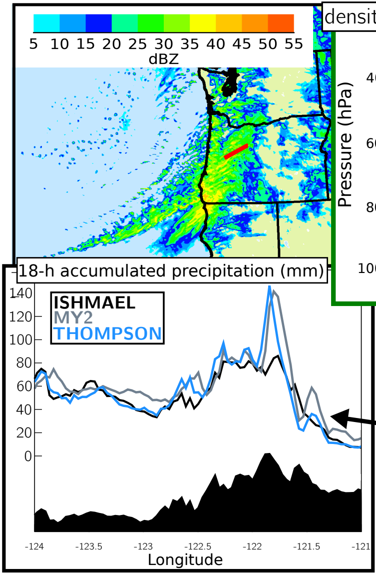
HUGH MORRISON

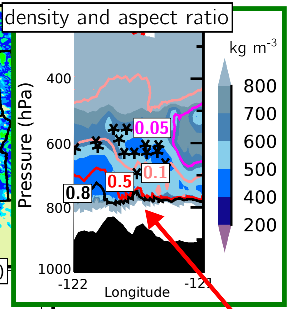
National Center for Atmospheric Research, Boulder, Colorado

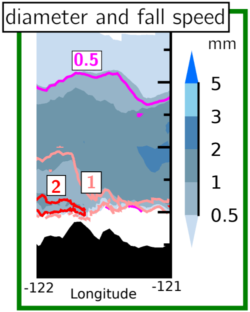




IMPROVE-2 Orographic Precipitation Case (dx = 3 km)



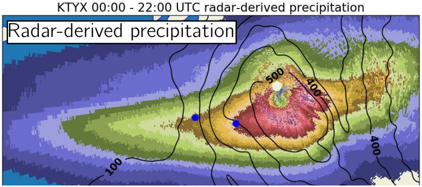


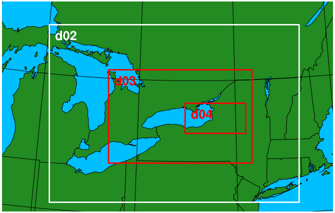


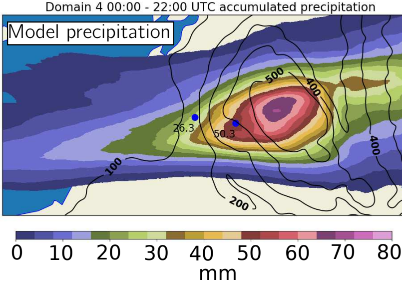
Ice particles sort by aspect ratio

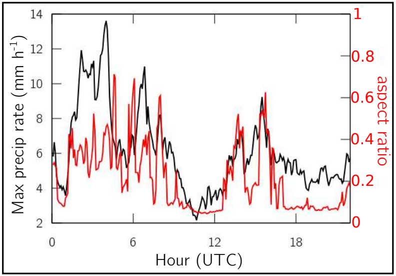
Precipitation decreases more continuously on the leeward side of the Cascades compared to traditional schemes

Jensen et al. 2018 (in review)









Higher maximum precipitation rates occur concurrently with more isometric ice particles

Conclusions and future applications of ISHMAEL

A method to predict ice particle shape evolution in a bulk microphysics scheme has been developed, is ready-ish for release in WRF, and has been/can be used to:

- Study the impact of predicting ice particle shape evolution (partial riming) on ice particle fall speeds and thus precipitation and cloud lifetime
- Better constrain microphysical growth processes (e.g. riming, rime splintering, hail growth) using observations such as dual-polarization radar
- Improve cloud-radiation coupling