

# Progress in cloud microphysics

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Earth  
in visible light

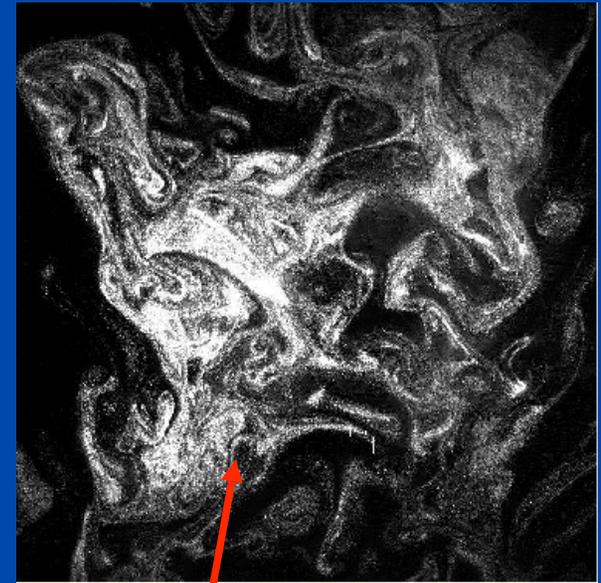


1,000 km

Small cumulus  
clouds



Mixing in laboratory  
cloud chamber



10 cm

...cloud microphysics in action....

## Cloud microphysics is critical in the clouds-in-climate problem:

- *Release of latent heat (condensation, freezing, sublimation).*
- *Formation of precipitation (warm-rain processes, ice physics).*
- *Impact on radiative transfer (sizes of cloud droplets and ice particles are important for cloud albedo).*

## *Long-term goal:*

**Develop and validate cloud microphysics schemes suitable for cloud-system resolving models (and thus for cloud-system-resolving climate models and climate models applying super-parameterization), capable in providing information required by the radiation transfer model (e.g., sizes of cloud and precipitation particles) and responding to the local variability of atmospheric aerosols (e.g., cloud condensation nuclei, ice nuclei) to simulate the so-called “indirect aerosol effects”.**

Morrison, H., and W. W. Grabowski, 2007: Comparison of bulk and bin warm rain microphysics models using a kinematic framework. *J. Atmos. Sci.* (in press).

Morrison, H., and W. W. Grabowski, 2007: Modeling supersaturation and subgrid-scale mixing in a large-eddy model with two-moment bulk warm microphysics. *J. Atmos. Sci.* (submitted).

Morrison, H., and W. W. Grabowski, 2007: A novel approach for representing ice microphysics in models: Description and tests using a kinematic framework. *J. Atmos. Sci.* (submitted).

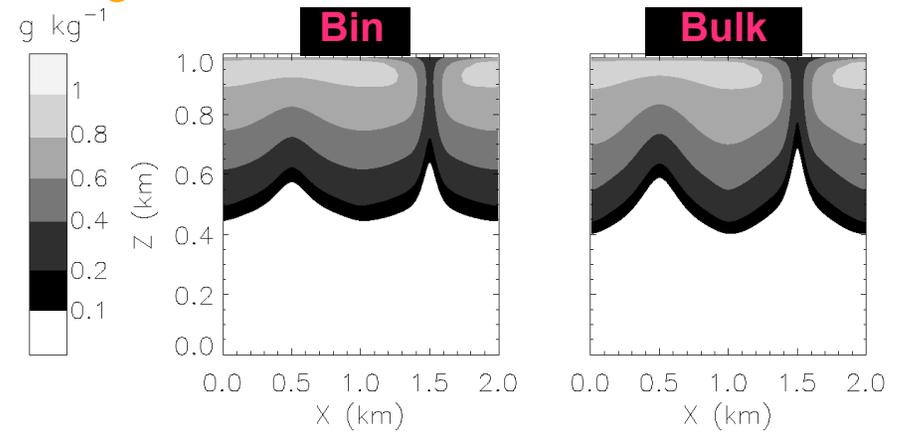
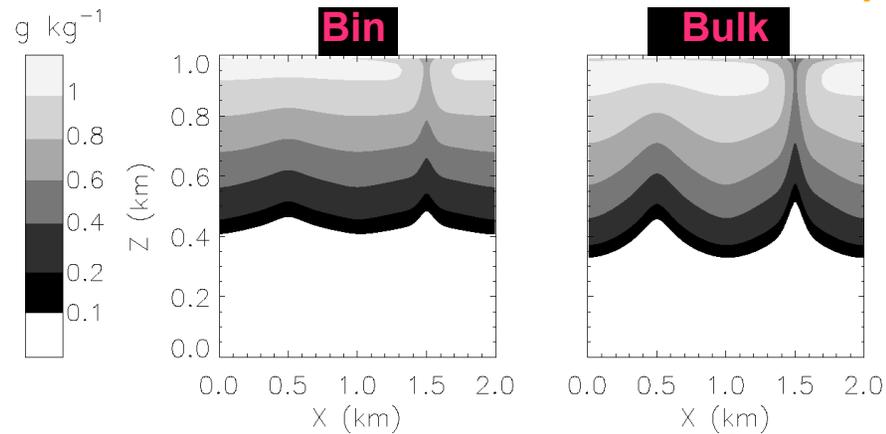
# Results from a kinematic model of drizzling Stratocumulus

(Morrison and Grabowski JAS in press)

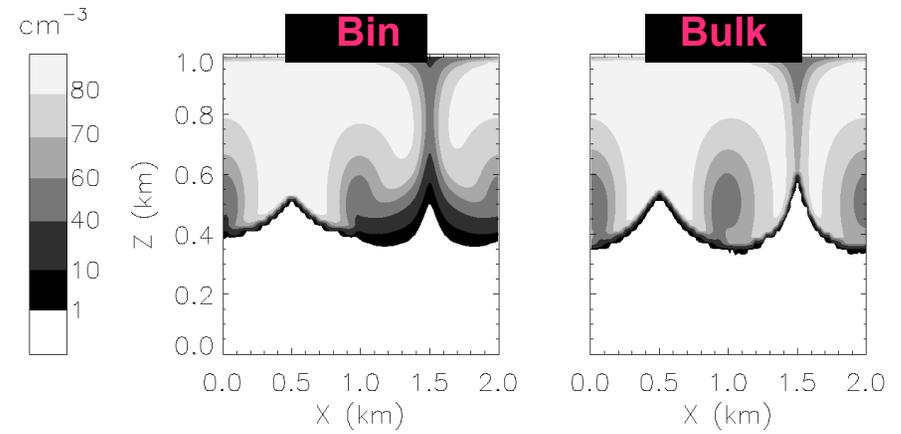
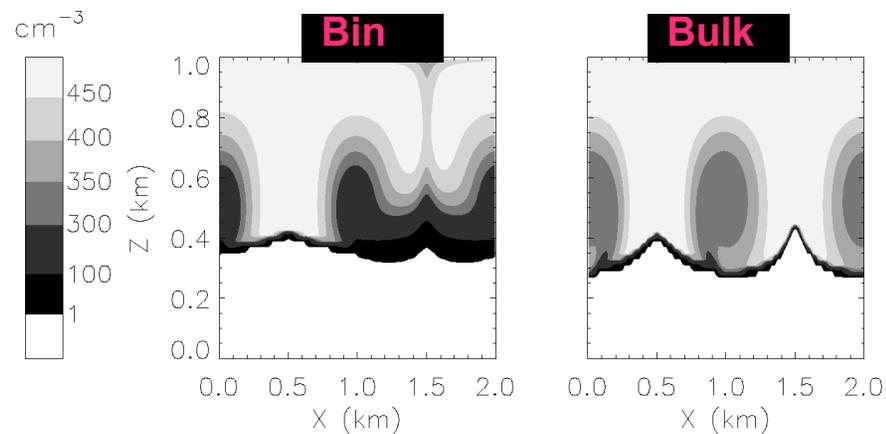
**POLLUTED**

**PRISTINE**

**Droplet Mixing Ratio**



**Droplet Concentration**



# *Novel approach to modeling ice processes:*

A two-moment three-variable ice scheme:

$$\frac{\partial N}{\partial t} + \frac{1}{\rho_a} \nabla \cdot [\rho_a (\mathbf{u} - V_N \mathbf{k}) N] = \mathcal{F}_N$$

Number concentration of ice crystals,  $N$

$$\frac{\partial q_{dep}}{\partial t} + \frac{1}{\rho_a} \nabla \cdot [\rho_a (\mathbf{u} - V_q \mathbf{k}) q_{dep}] = \mathcal{F}_{q_{dep}}$$

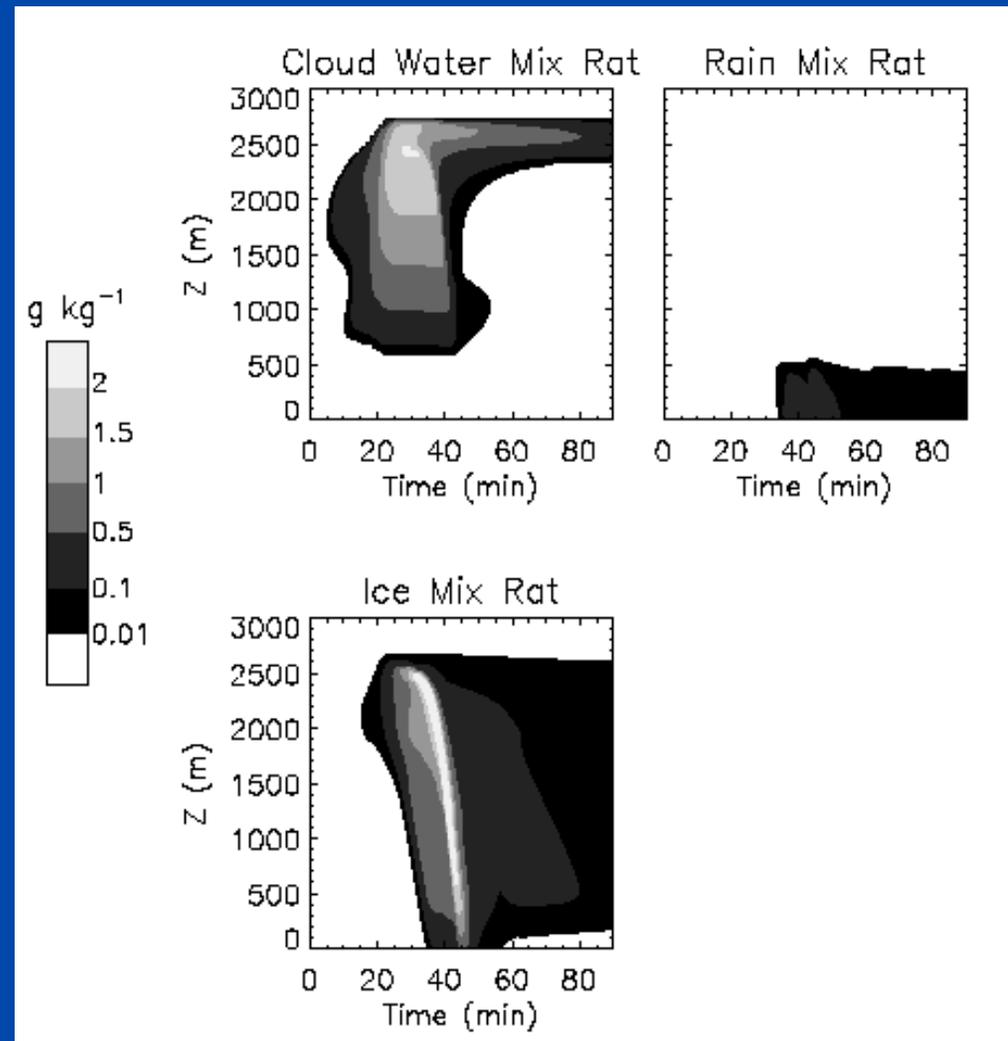
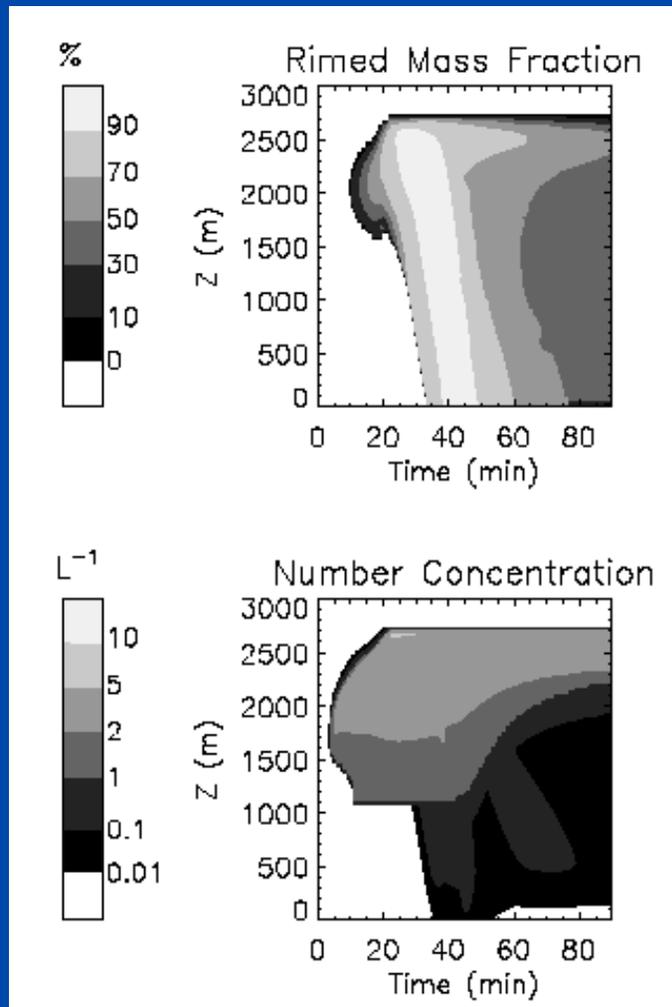
Mixing ratio of ice mass grown by diffusion of water vapor,  $q_{dep}$

$$\frac{\partial q_{rim}}{\partial t} + \frac{1}{\rho_a} \nabla \cdot [\rho_a (\mathbf{u} - V_q \mathbf{k}) q_{rim}] = \mathcal{F}_{q_{rim}}$$

Mixing ratio of ice mass grown by riming (accretion of liquid water),  $q_{rim}$

**Morrison and Grabowski 2007 (submitted)**

Example of results:  
evolutions of horizontal  
maximum at each level



Morrison and Grabowski 2007 (submitted)