Microphysics Complexity and Simulations of Deep Convection

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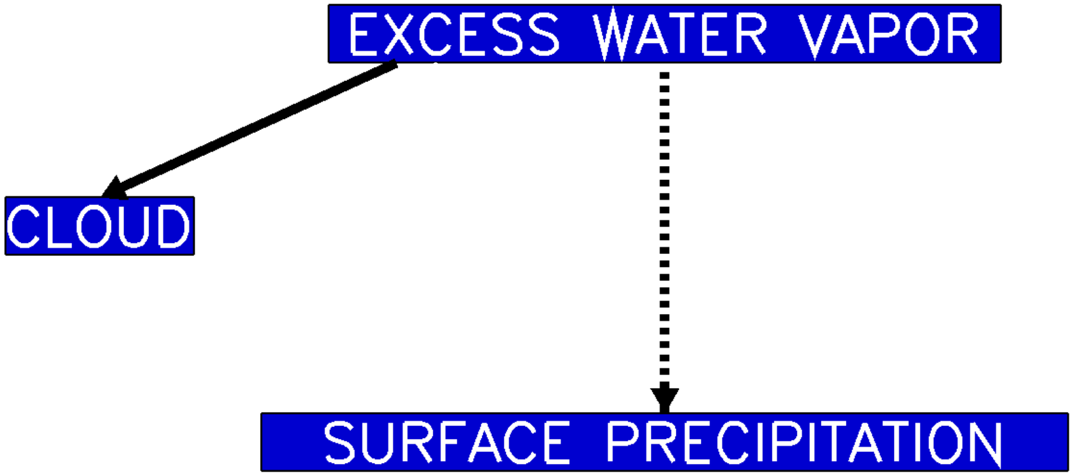
What Level of Complexity is Needed?



Diagnostic precipitation

Large grid spacing (> 4 km):

- **Convection parameterization required**

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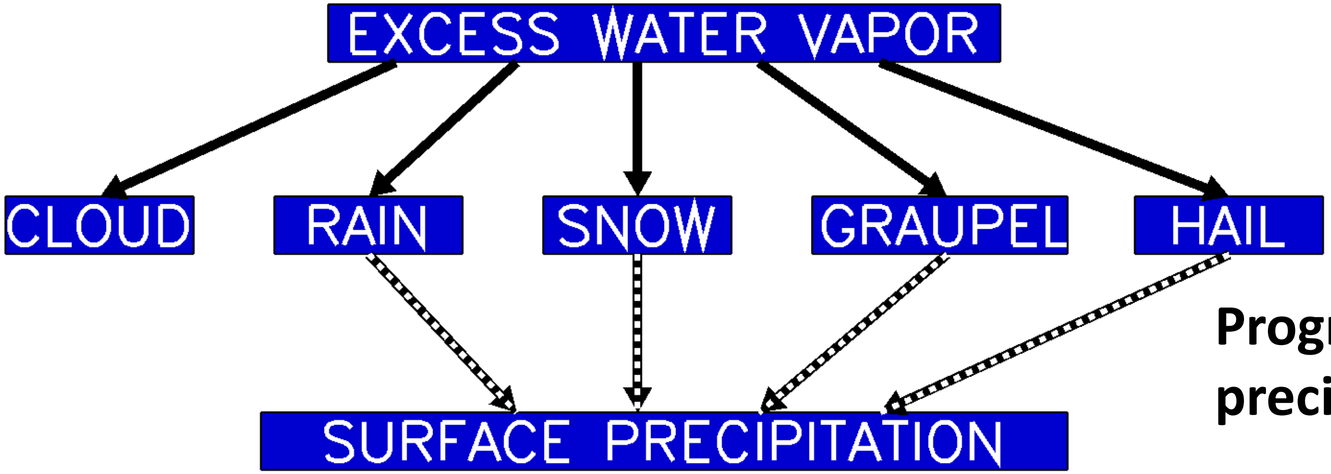

Prognostic precipitation

Large grid spacing (> 4 km):

- **Convection parameterization required**

Small grid spacing (< 4 km):

- **Explicit vertical transport of convective <u>mass</u> and <u>heat</u>**
- **Increased importance of <u>microphysics</u> parameterization**

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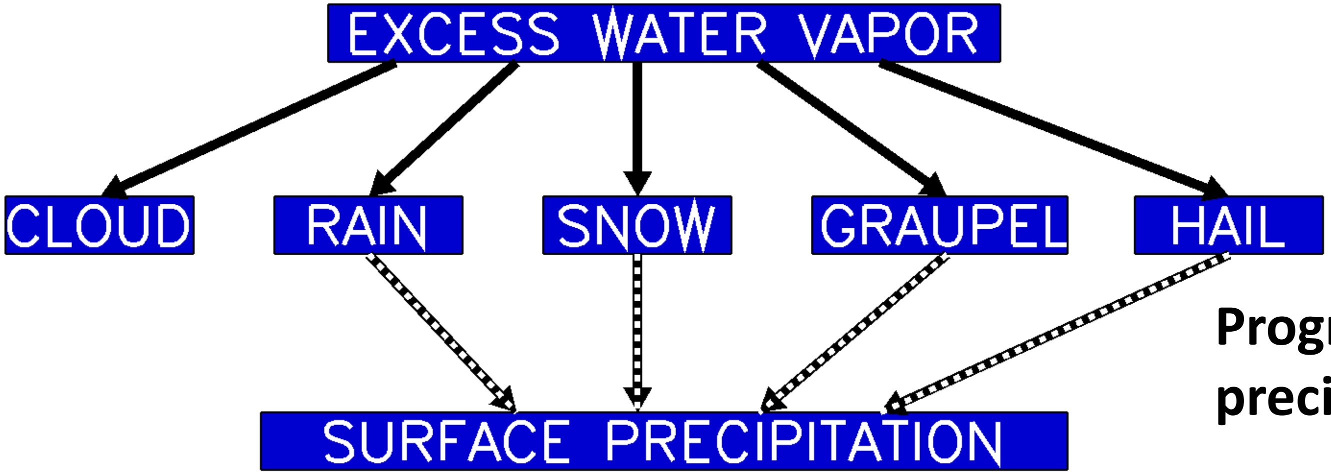

Prognostic precipitation

→ **Sensitivity of simulations to microphysics complexity**

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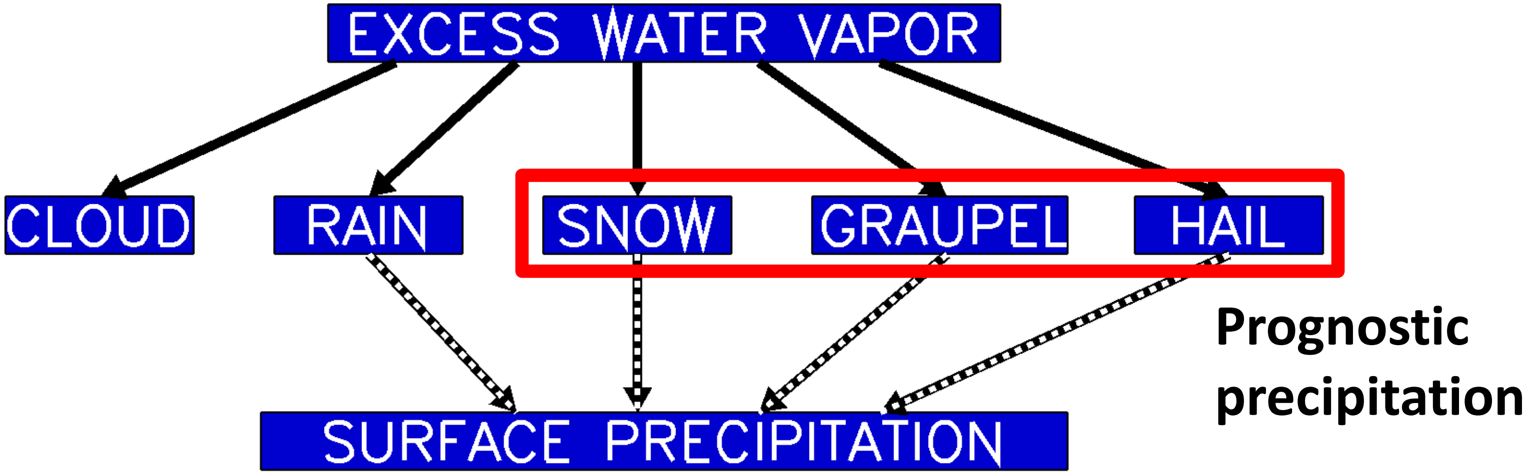

→ **Sensitivity of simulations to microphysics complexity**

- **Number and treatment of ice categories**

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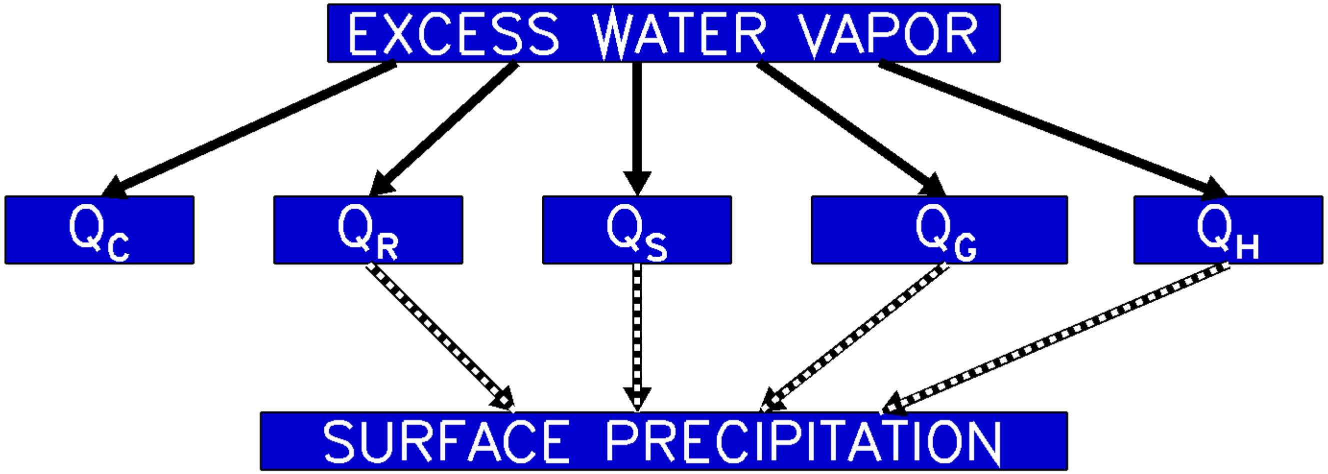

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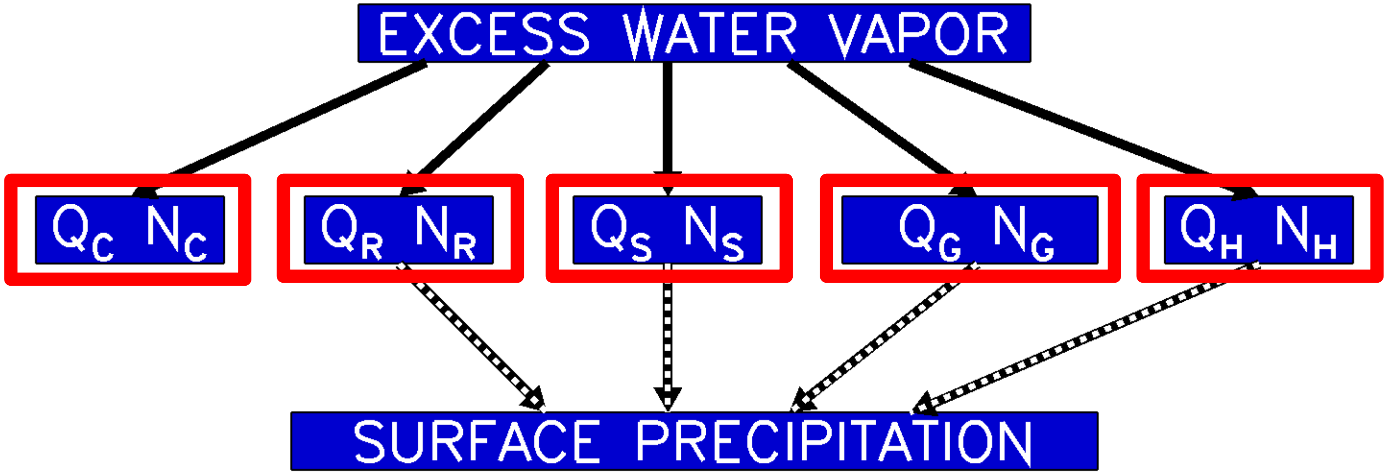

→ Sensitivity of simulations to microphysics complexity

- **Number and treatment of ice categories**
- **Number of predicted moments**

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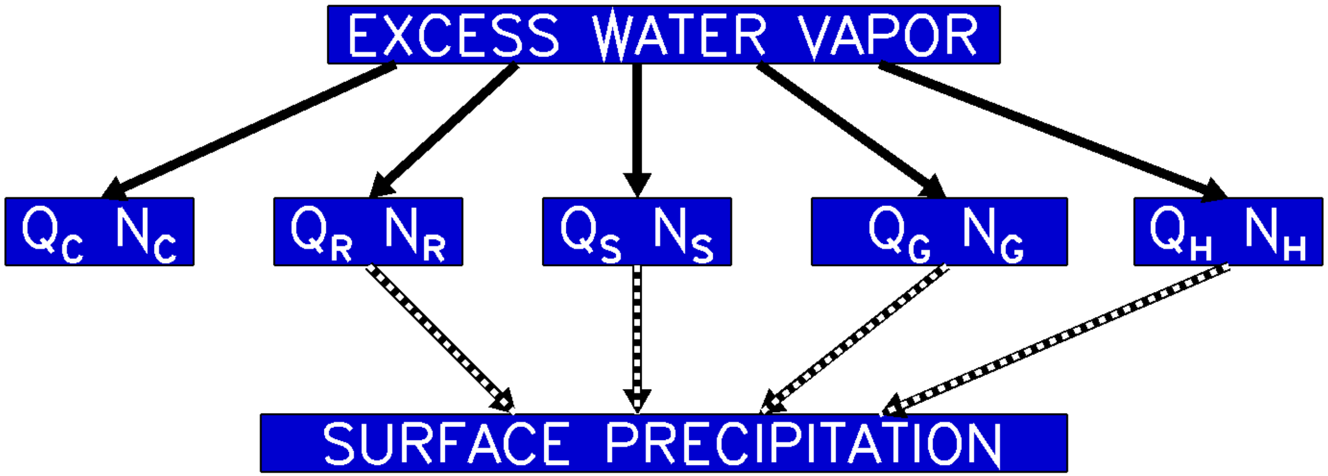


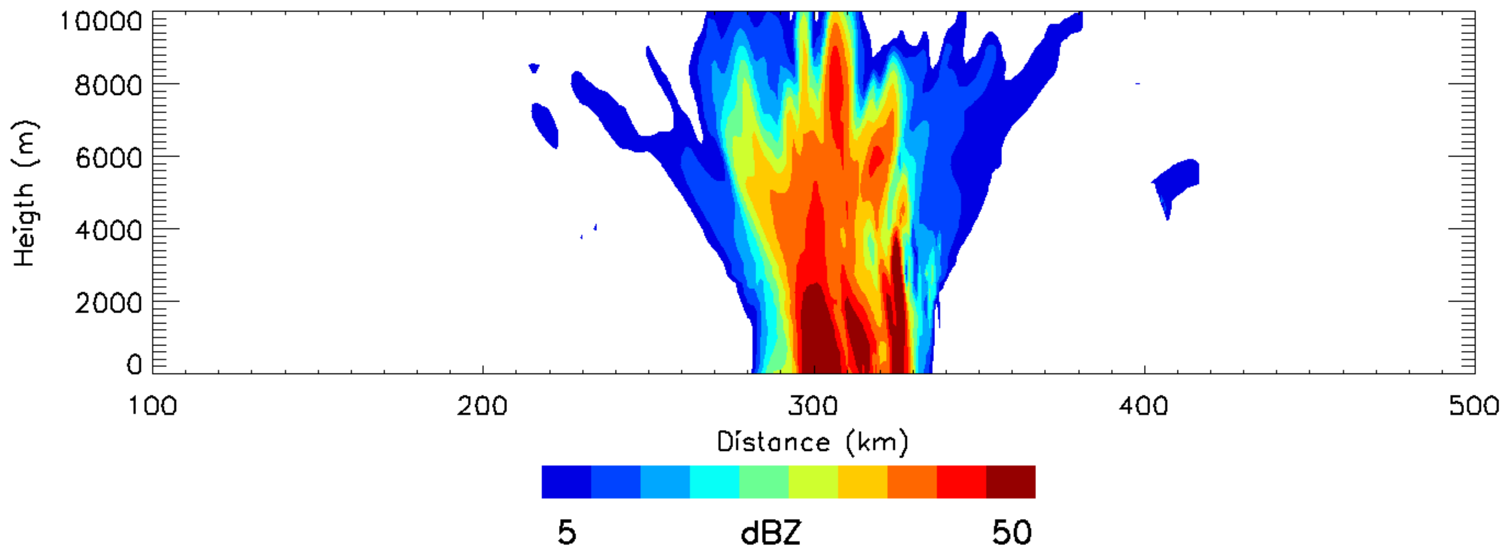
→ **Sensitivity of simulations to microphysics complexity**

- **Number and treatment of ice categories**
- **Number of predicted moments**

→ **Why difference between equally complex models?**

- **Morrison versus Milbrandt 2-Moment schemes**

Methods



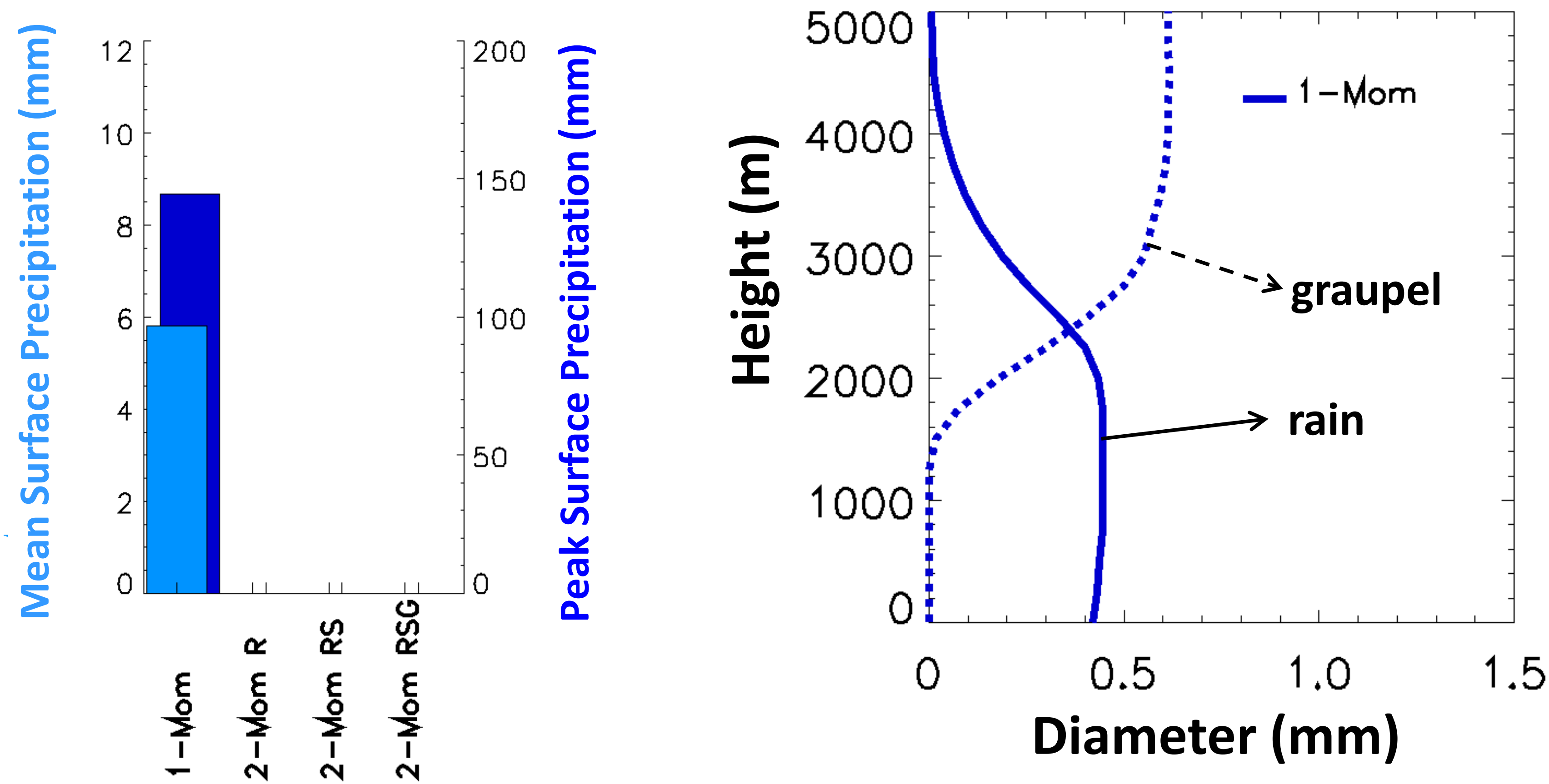
WRF 2-D idealized squall line simulations

- Large number of sensitivity experiments
- 1 km grid spacing
- Idealized setup (no radiation or BL processes)
- Sensitivity of <u>surface precipitation</u> to microphysics complexity

Number of predicted moments

Precipitation extremes sensitive to <u>\# predicted moments</u>

- large drops: faster fallout and less evaporation



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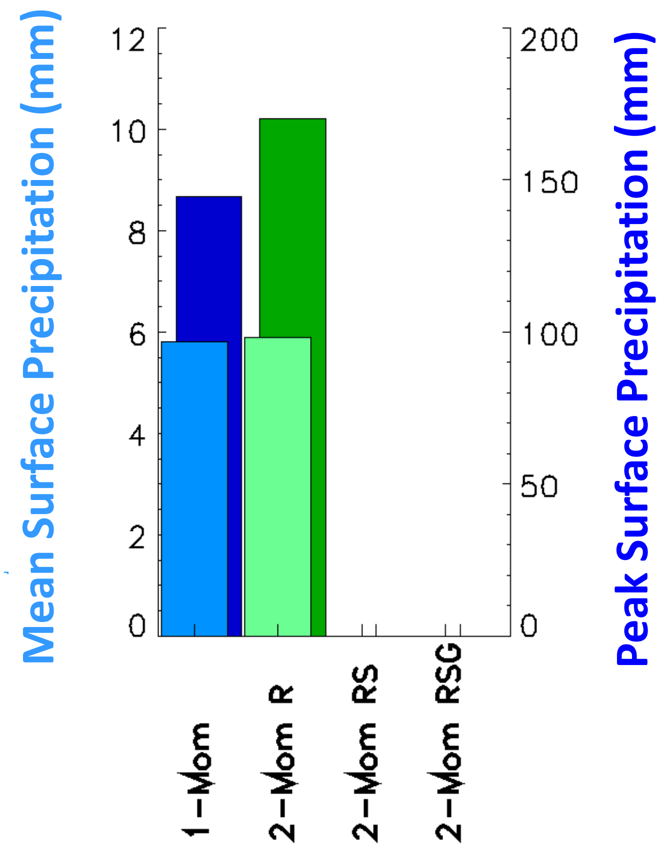

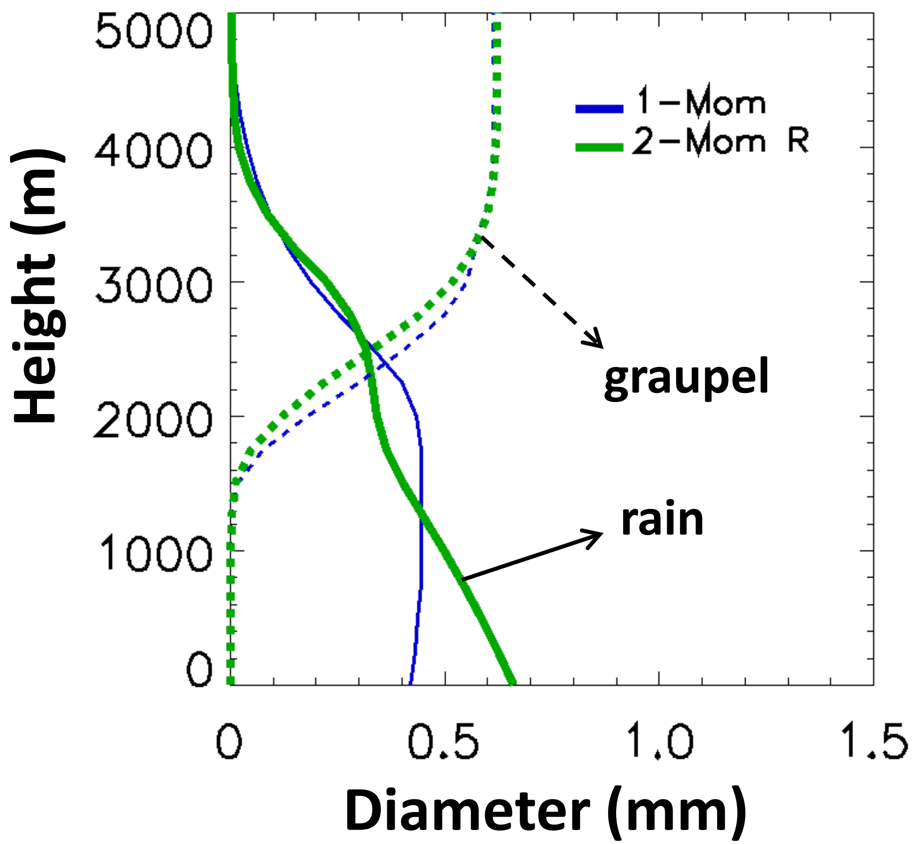

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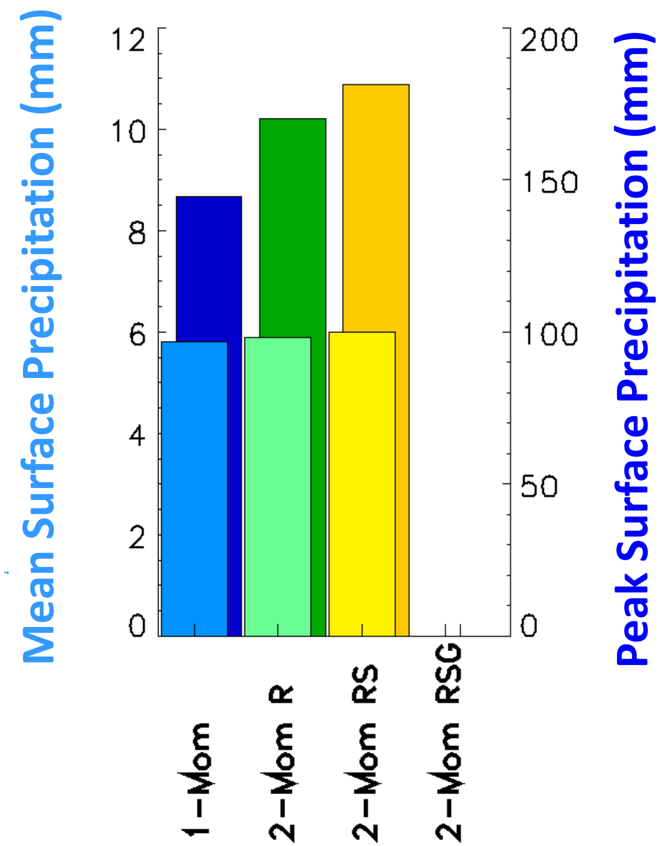

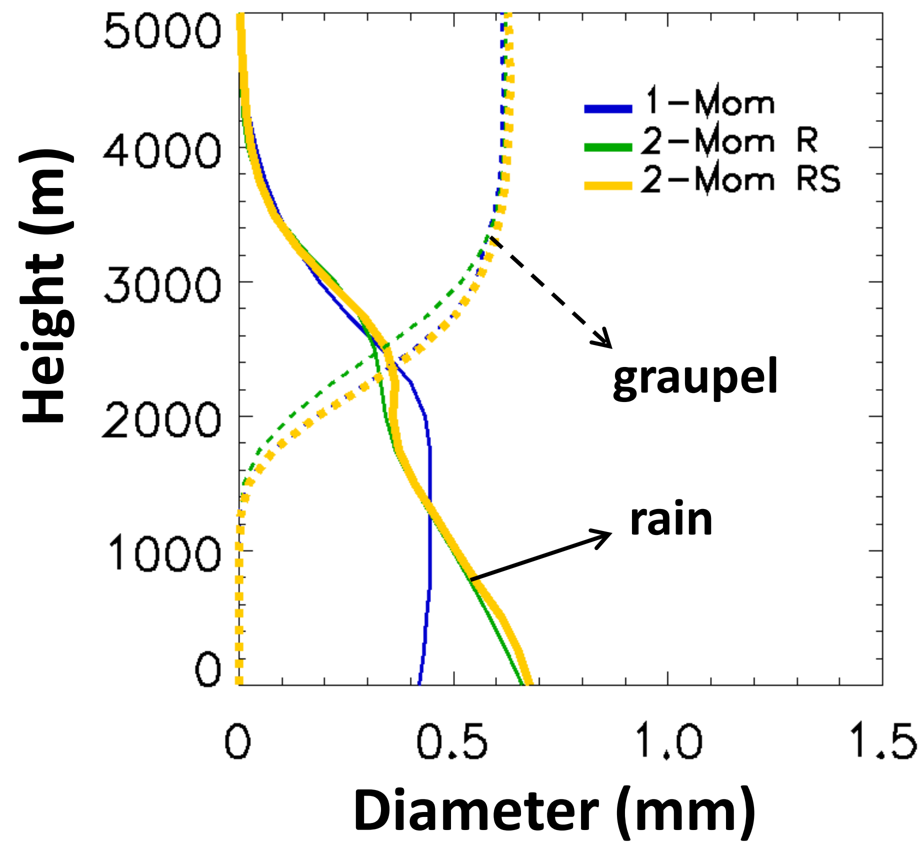

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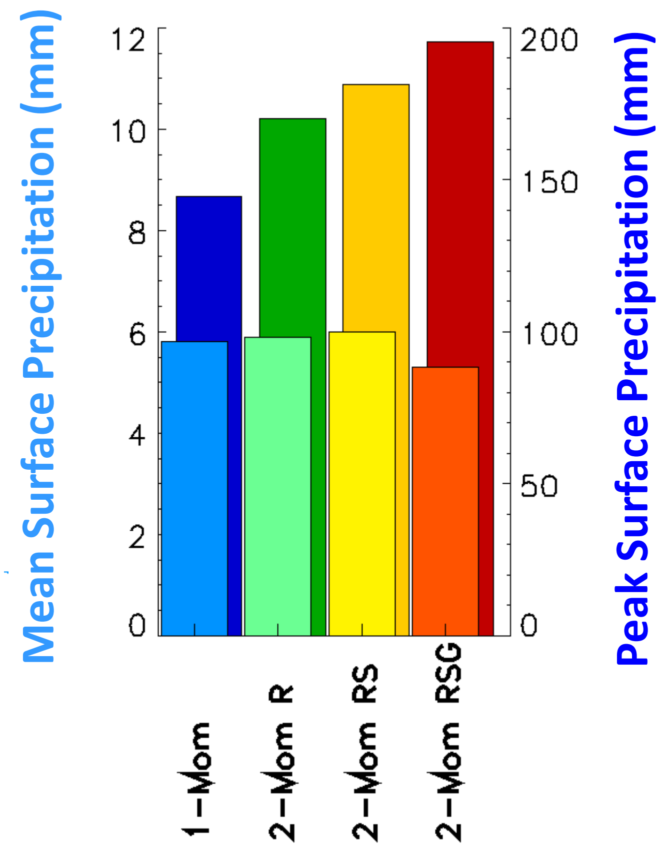
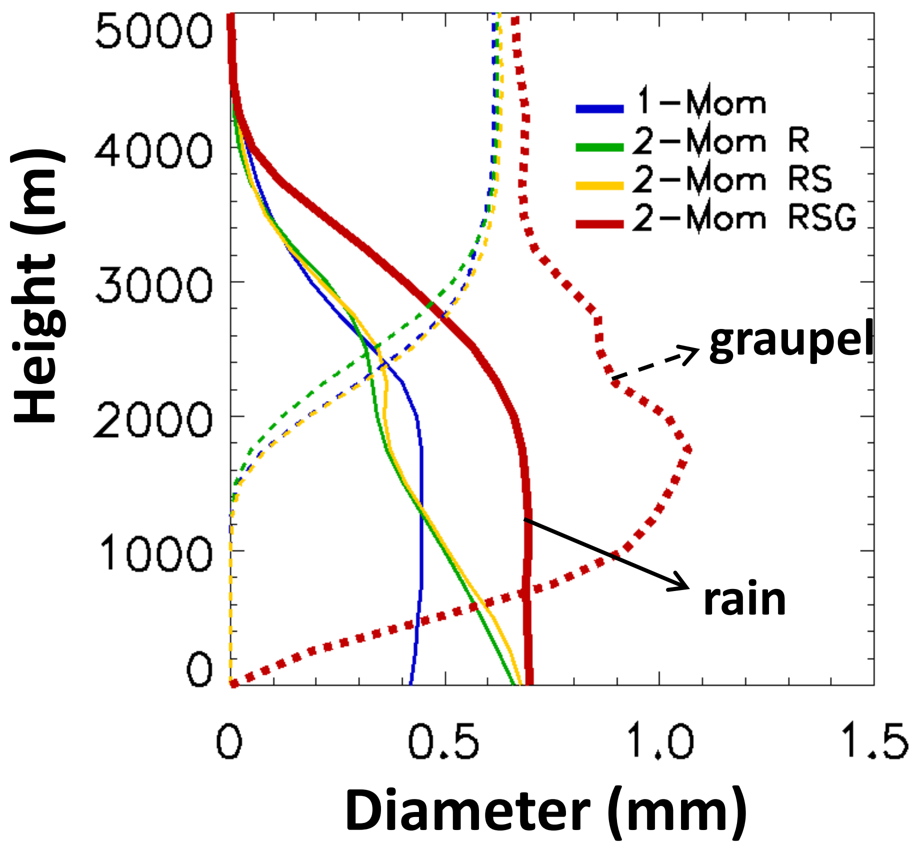
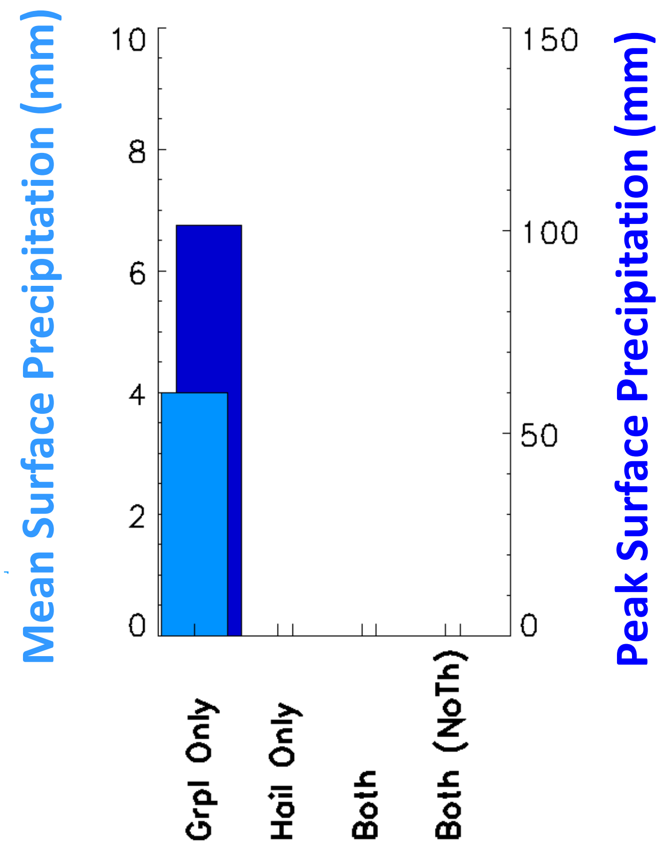


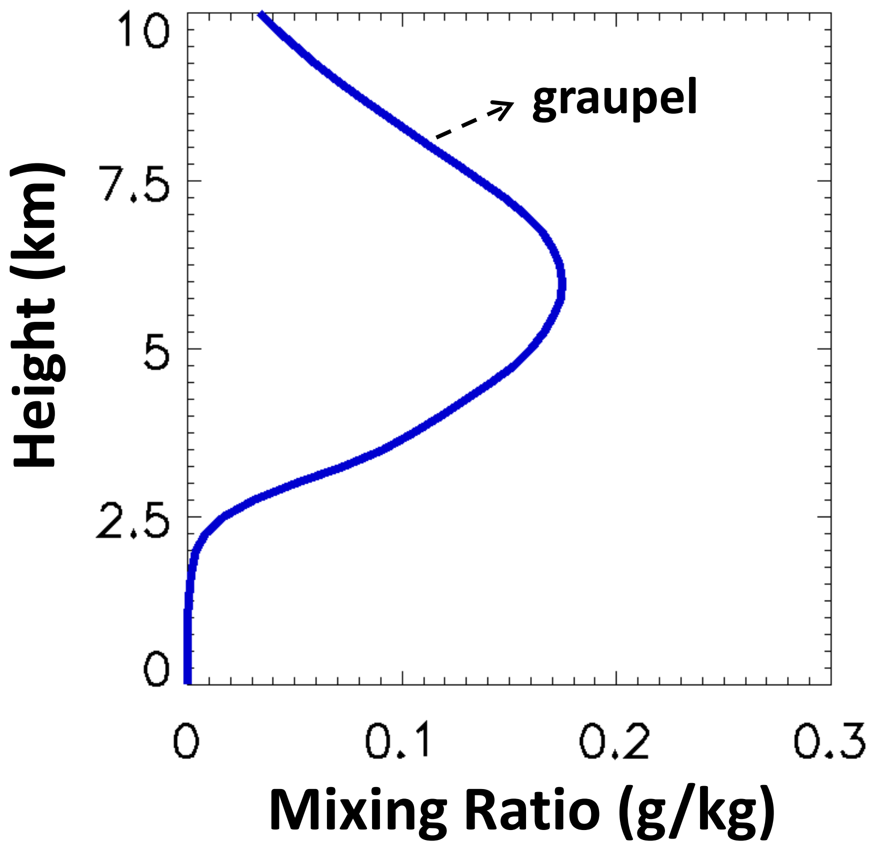


Number of ice categories

Precipitation extremes sensitive to <u>nature of precipitating ice</u>

→ graupel, hail or both





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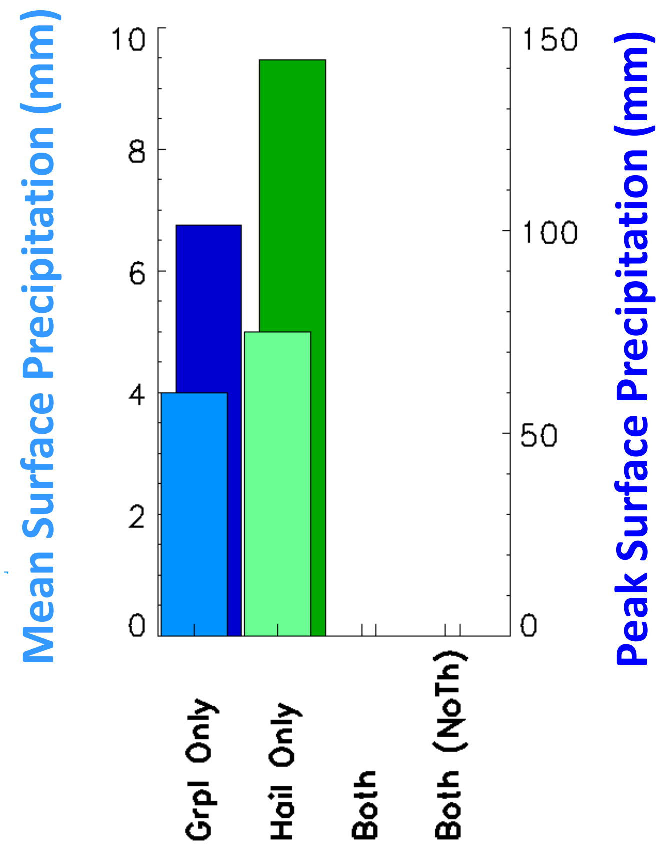
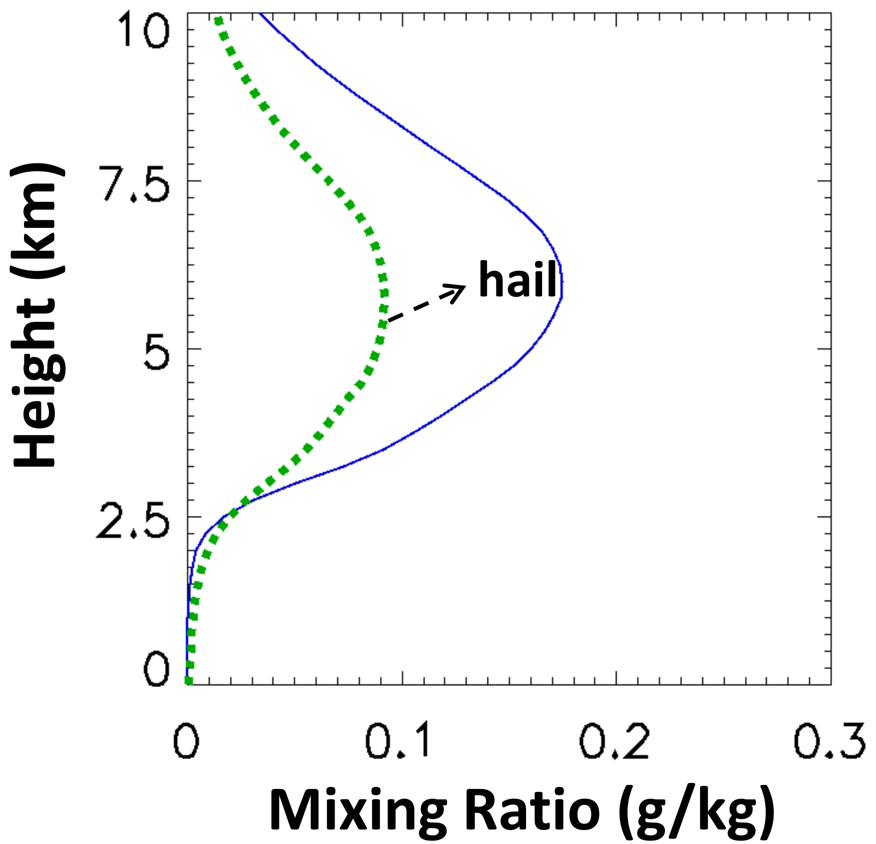
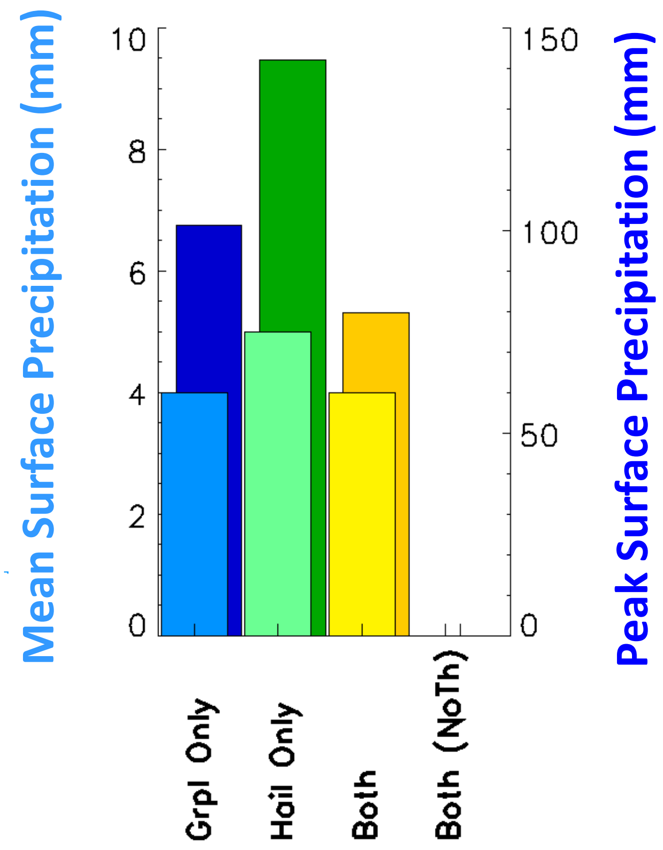
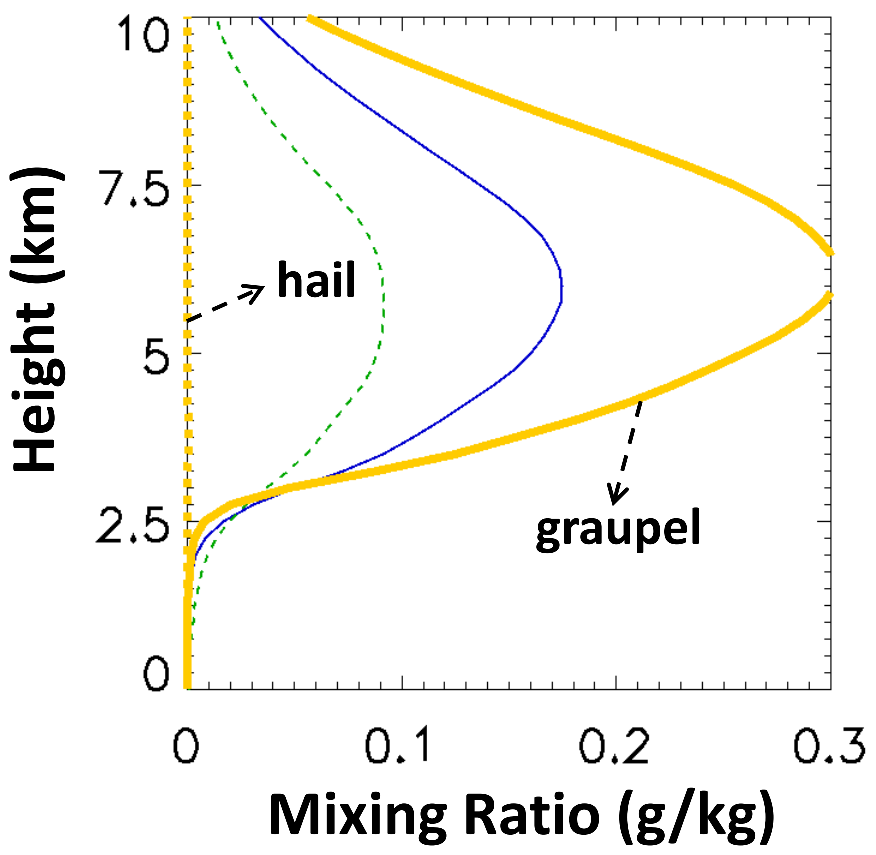




Number of ice categories

Precipitation extremes sensitive to <u># ice categories</u>, but....





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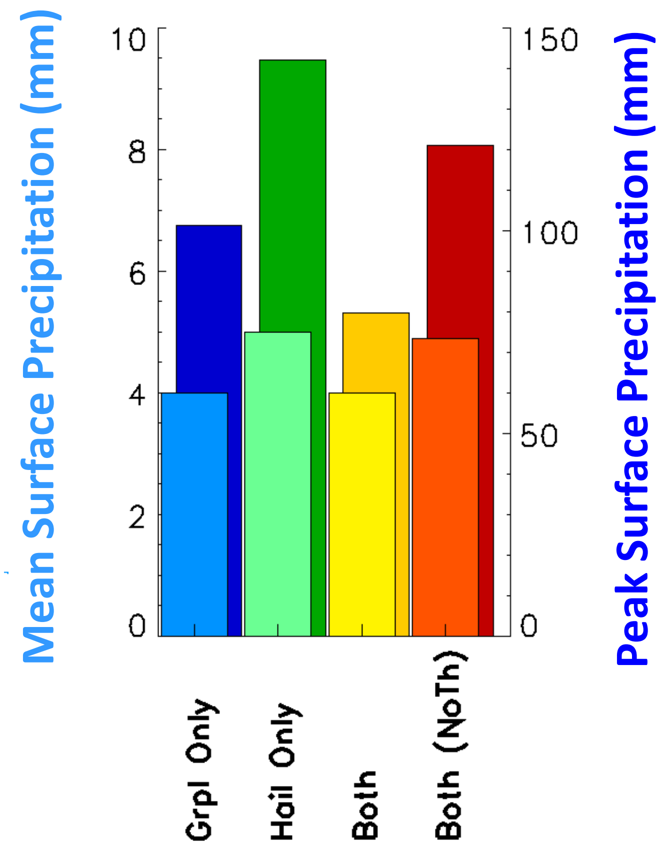
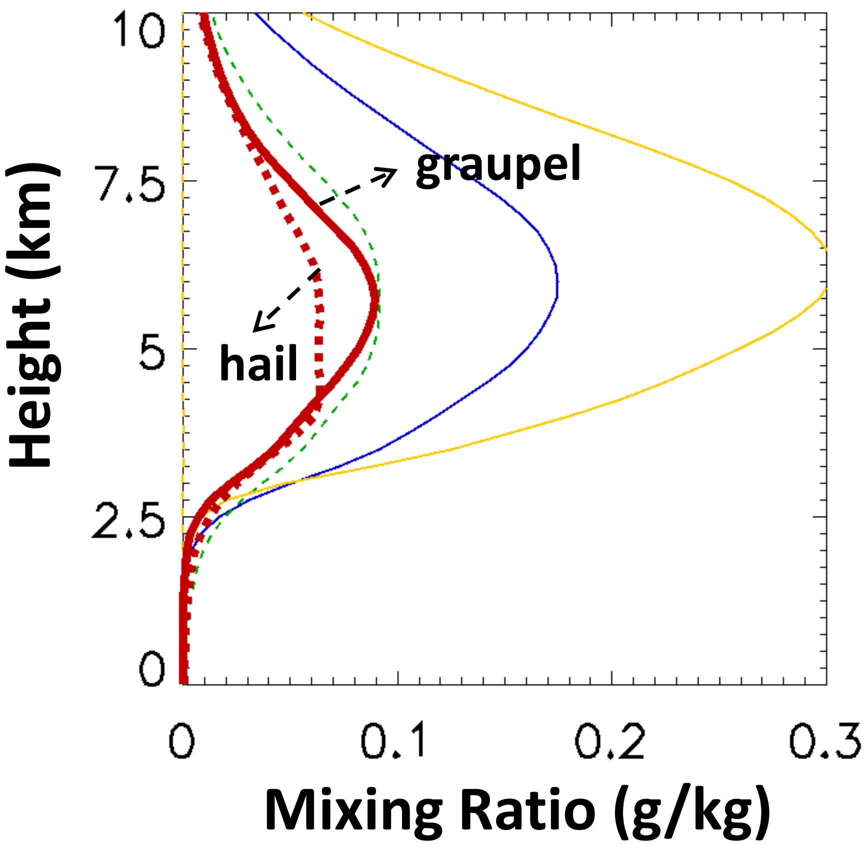
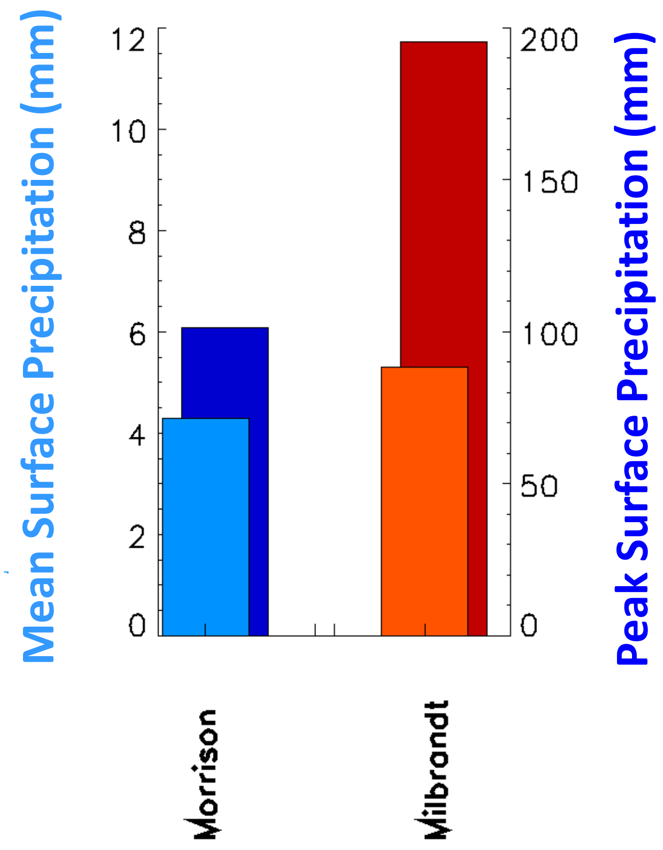
→ also to unphysical thresholds





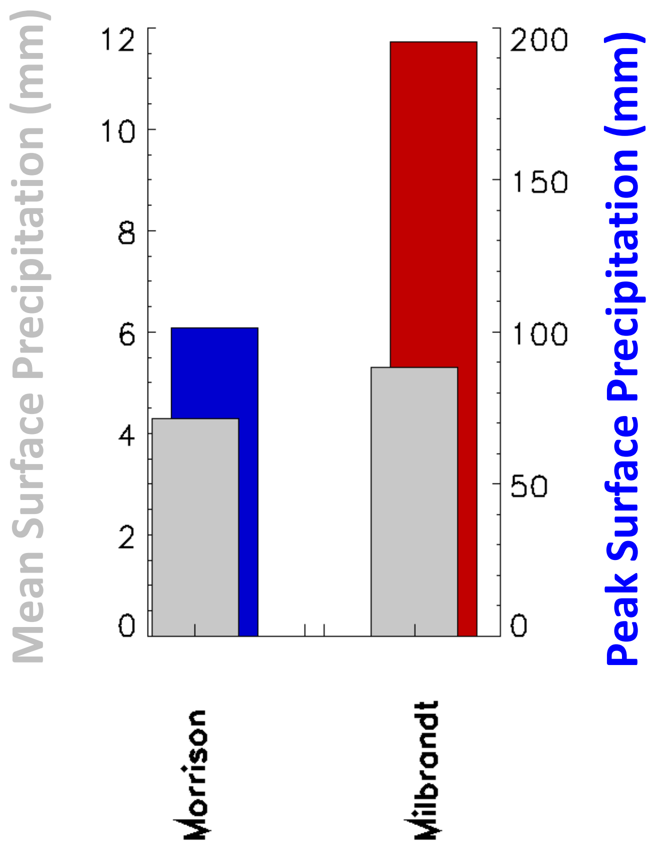
Differences Morrison - Milbrandt

Morrison et al. (2009) versus **Milbrandt and Yau (2005)**

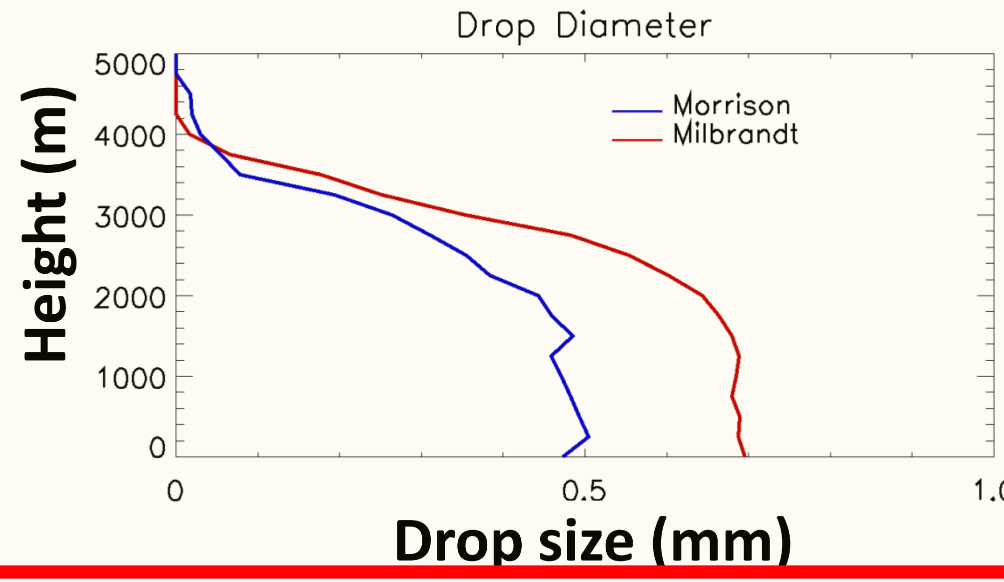


→ **Equally complex schemes, yet <u>large</u> differences**

Differences Morrison - Milbrandt



Peak precipitation: drop breakup



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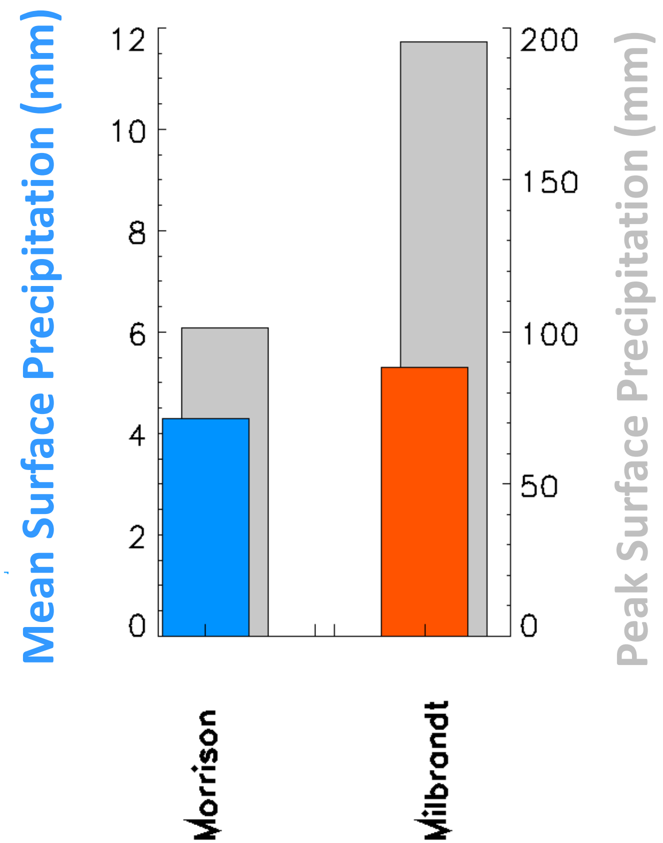

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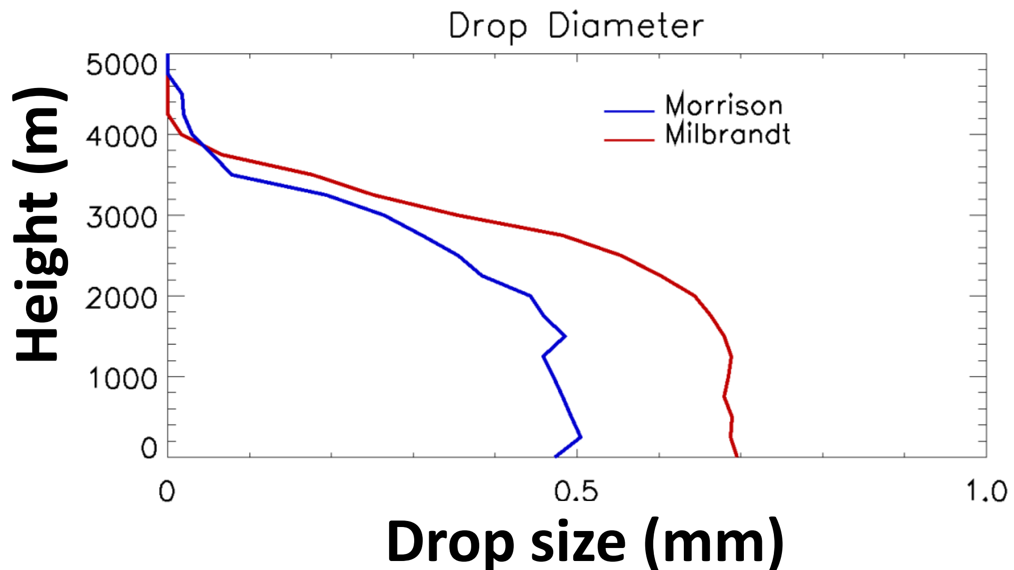

Mean precipitation: graupel sublimation

- **Morrison:** Large return of graupel to vapor → **Low Precipitation Efficiency**
- **Milbrandt:** No return of graupel to vapor → **High Precipitation Efficiency**

Conclusions – What complexity is needed?

- **Precipitation extremes: number moments of *all* hydrometeors, nature of precipitating ice and raindrop breakup**

Size sorting, drop sizes and evaporation determine extremes

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- ***Next, bring in Atmospheric Radiation Measurement observations:***

  Midlatitude Continental Convective Clouds Experiment (MC^3E), NEXRAD, Disdrometers