

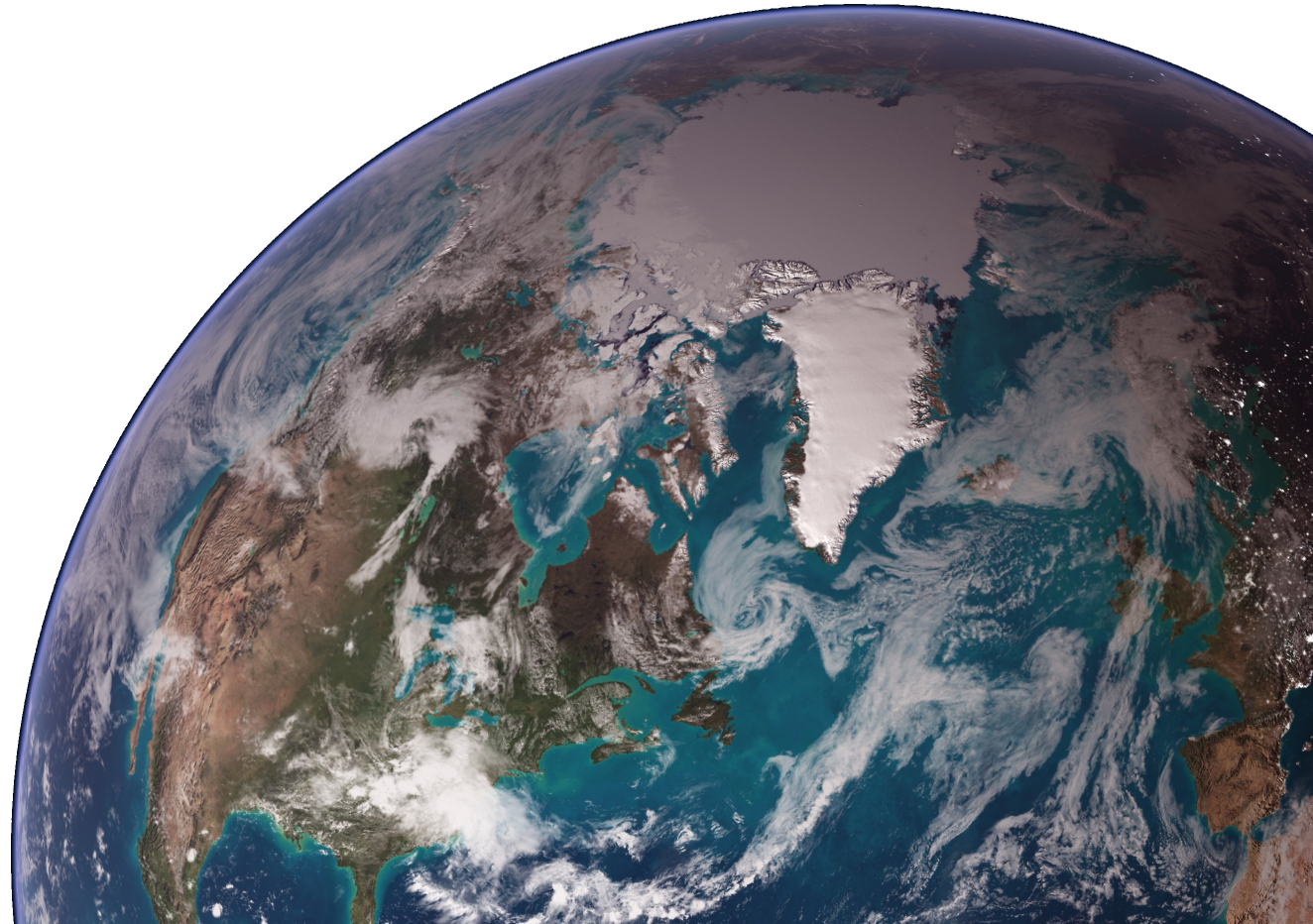


NOAA RESEARCH • ESRL • PHYSICAL SCIENCES DIVISION

Model Studies of Arctic Cloud Processes

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Science Review
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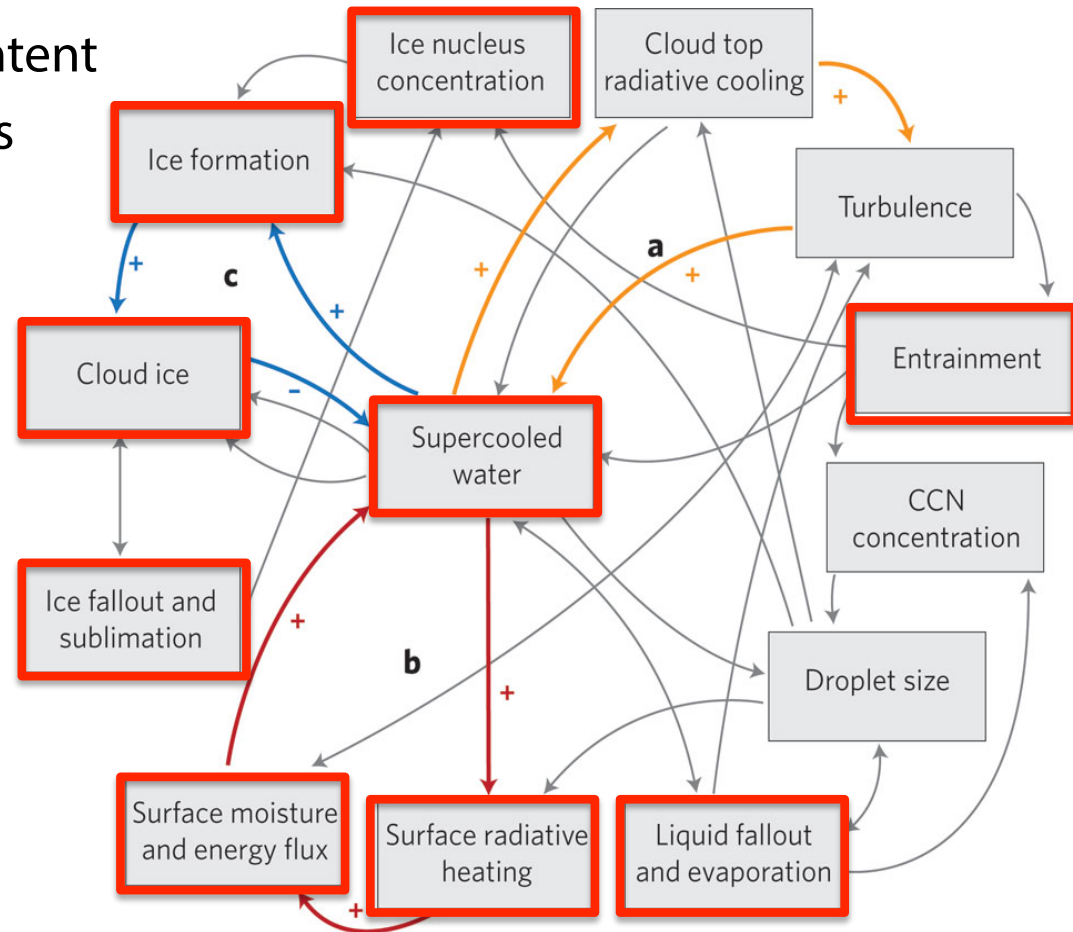
Motivation

- Supercooled liquid in Arctic clouds is ubiquitous (Curry et al. 2000; Intrieri et al. 2002)
- Liquid-bearing clouds play a fundamental role in the surface energy budget and the structure of the boundary layer—net effect in the Arctic is a warming (Curry et al. 1996; Shupe and Intrieri 2004; Morrison and Pinto 2006; Francis and Hunter 2007)
- Models struggle to simulate these cloud systems and sparse measurements limit validation of cloud liquid and ice properties (Prenni et al. 2007; Klein et al. 2009)

Arctic and Subtropical Stratocumulus differ!

- ✧ Mixed-phase
 - ✧ Ice formation limits liquid content
- ✧ Persistence of decoupled systems
- ✧ Humidity inversions
- ✧ Cloud extending into inversions
- ✧ Weaker inversions
- ✧ Weaker mean subsidence

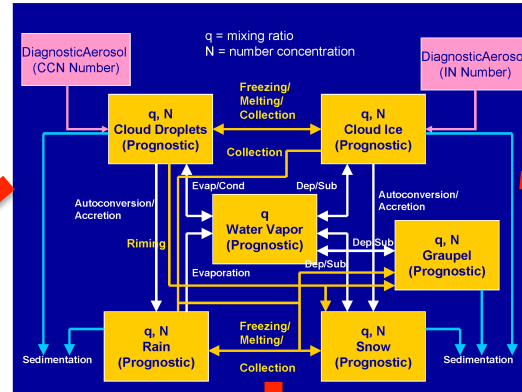
How do these unique properties determine the persistence of Arctic mixed-phase stratocumulus?



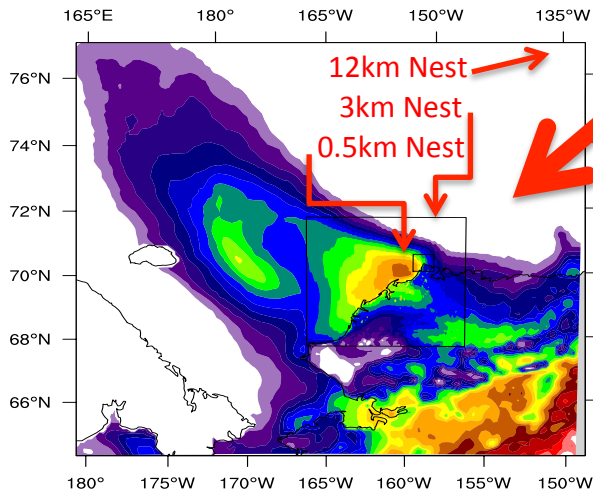
Morrison et al. (2011)

Arctic Model Toolbox

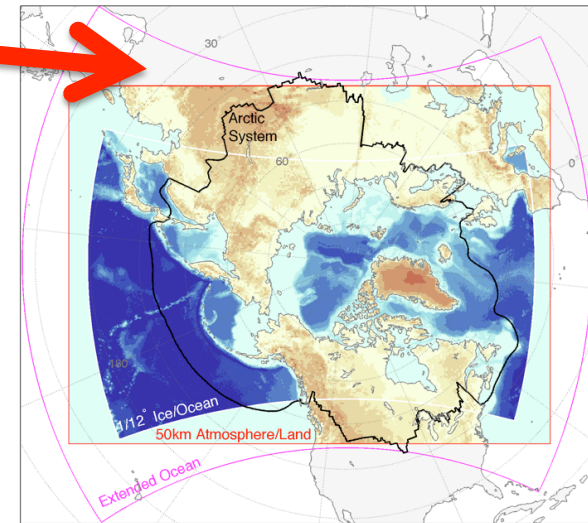
Morrison Two-Moment Microphysics



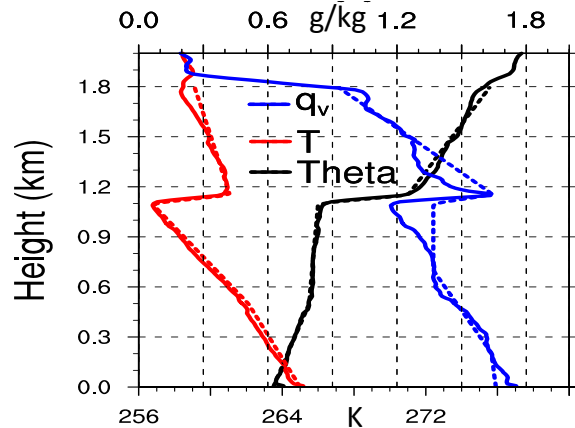
WRF Nested Limited-Area Model



Regional Arctic System Model



WRF-LES Model

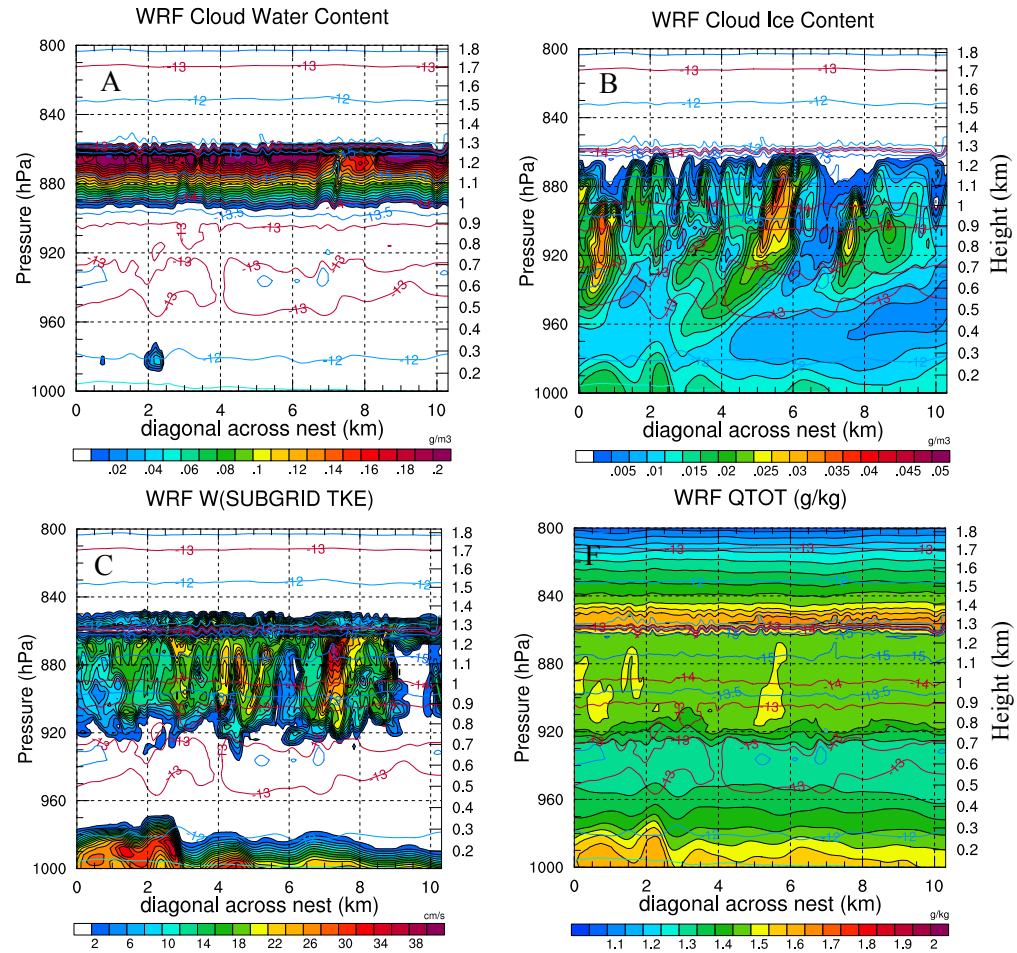


Filling Conceptual Gaps

Focus on:

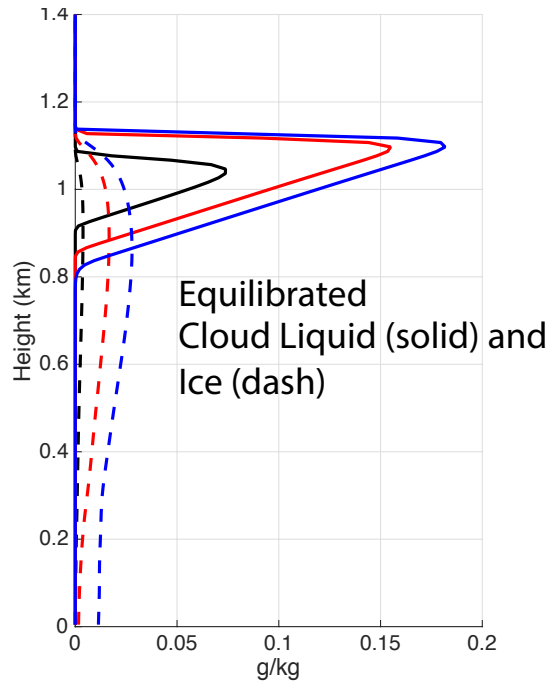
- 1) Maintenance of decoupled cloud systems
- 2) Processes that determine phase-partitioning

ISDAC- North Slope of Alaska April 2008



(Solomon, Shupe, Persson, Morrison 2011)

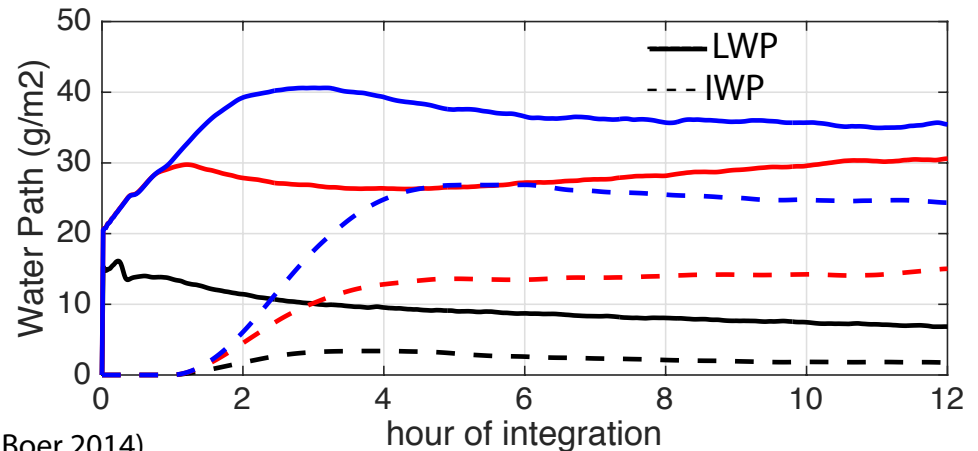
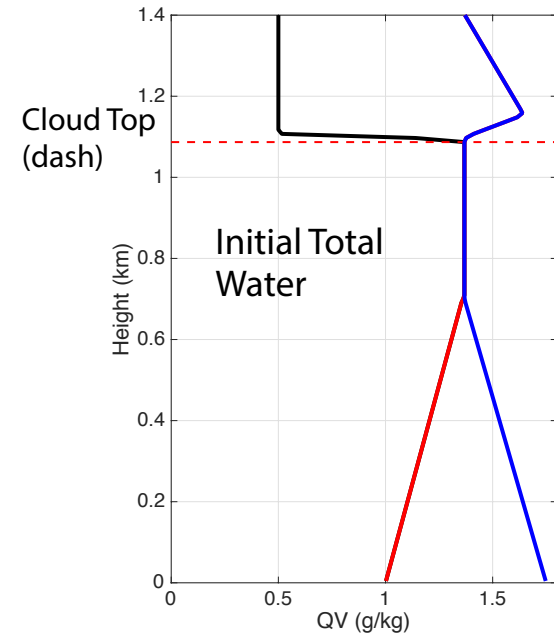
Maintenance of Decoupled Cloud Systems



Observed Sounding

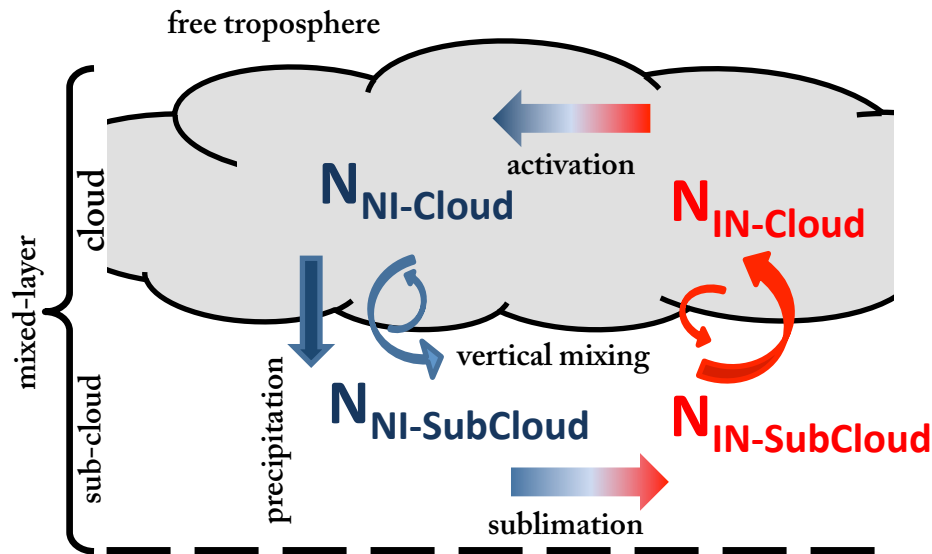
Reduced Water Vapor Below Cloud

Reduced Water Vapor Above and Below Cloud

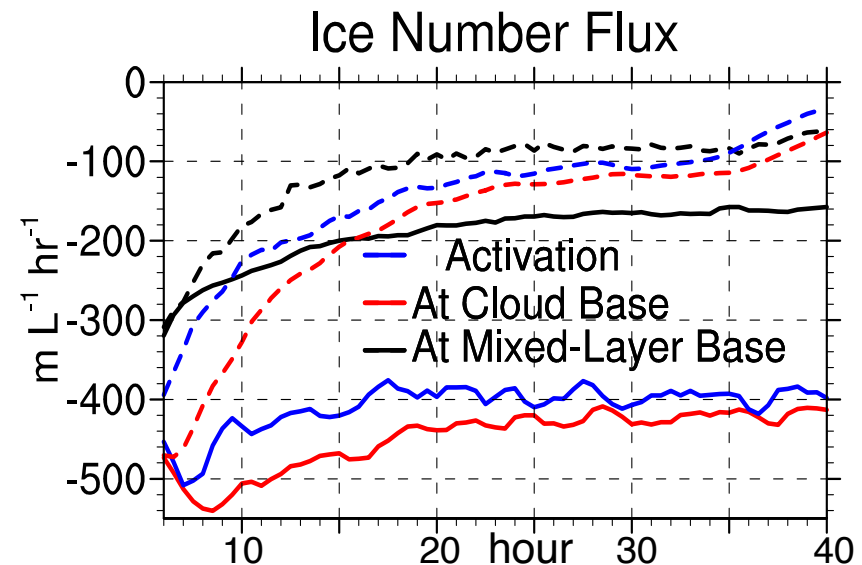
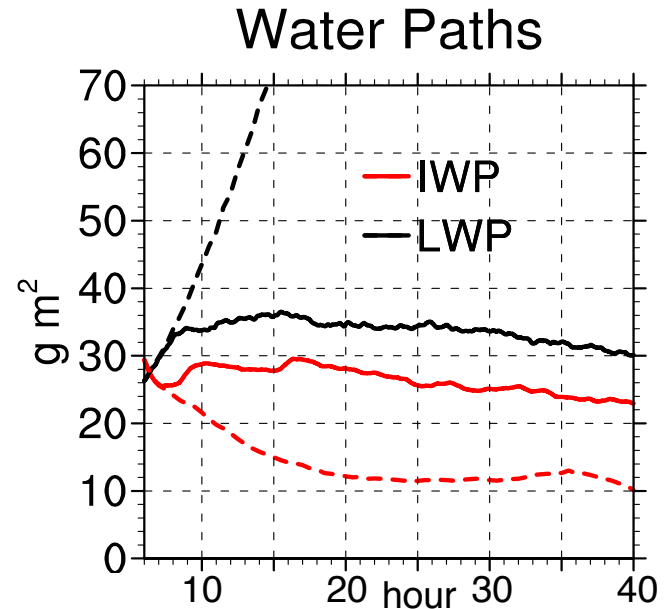


(Solomon, Shupe, Persson, Morrison, Yamaguchi, Caldwell, de Boer 2014)

Maintenance of Phase-Partitioning between Cloud Liquid and Ice— Recycling of Ice Nuclei



(Solomon, Feingold, Shupe 2015)



Current Priorities

- Continue investigations to fill conceptual gaps –
Through model-observation collaborations
- Apply new understanding of Arctic cloud
feedbacks to the coupled system – Extreme melt
events, sea ice melt back and freeze up
- Improve simulations of Arctic climate -- Through
collaborations with the Regional Arctic System
Model team and NOAA sea ice forecasting