Evaluating and Constraining Cirrus Parameterizations in GCMs with SPartICus Observations

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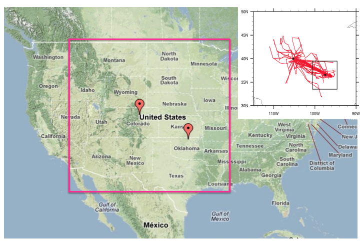
Objectives

- ▶ Understand ice nucleation mechanisms and the role of updraft velocity in the formation of northern hemisphere mid-latitude cirrus.
- ▶ Evaluate and constrain ice microphysics parameterizations in Community Atmosphere Model (CAM5) using SPartICus observations.

SPartICus: Small Particles in Cirrus Jan-June 2010



Routine aircraft in situ measurements in cirrus over ARM SGP and along NASA A-Train orbit

Cloud Microphysics in CAM5

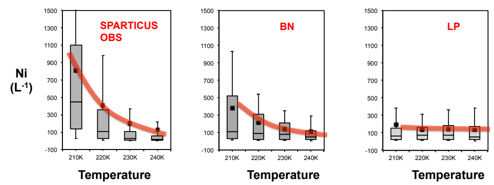
▶ **Two-moment stratiform microphysics**

- ➢Prognostic '*cloud mass*' and '*cloud droplet number*' (Γ-function size distributions)
- ➢Diagnostic 'precipitation mass' and 'precipitation droplet number'
- ➢Droplet and ice nucleation links to aerosols
- ➢Ice supersaturation and explicit vapor deposition
- ➢Other ice microphysics processes: autoconversion, accretion, sedimentation, sublimation, melting, etc.

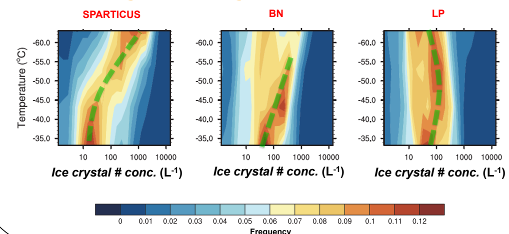
Ice Nucleation in CAM5

- ▶ ***Liu and Penner (2005):*** considers the competition between homogeneous (HOM) and heterogeneous nucleation (HET) (hereafter **LP**). LP-HET uses classical nucleation theory (CNT).
- ▶ ***Barahona and Nenes (2009)***: developed a framework that can use different heterogeneous ice nuclei (IN) spectra (CFDC measured IN; CNT), and consider the competition of HOM and HET (hereafter **BN**). BN-HET uses Phillips et al. (2008) from CFDC.

Ice Crystal Number Concentration (Ni)



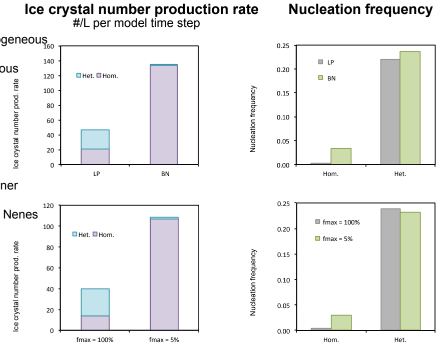
Probability Density Function of Ni & T



Ice Nucleation Mechanisms

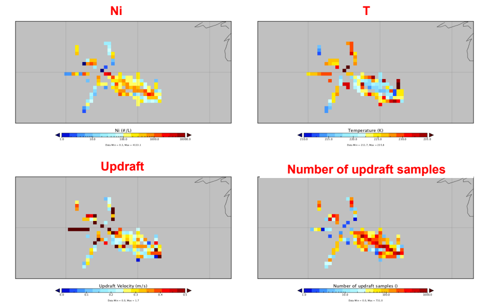
HOM: homogeneous
HET: Heterogeneous

LP: Liu and Penner
BN: Barahona & Nenes

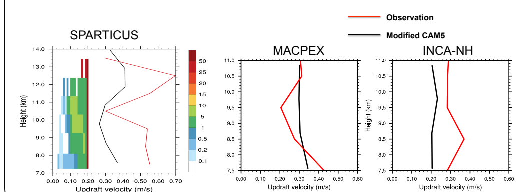


Sensitivity tests (lower panel) using BN parameterization with different maximum freezing ratios for heterogeneous nucleation (f_{max}=100% and 5%)

Correlation between Ni, Updraft Velocity and T during SPartICus



Evaluating CAM5 Updraft Velocity in Cirrus with Observations



In-cirrus condition : Ni > 0.1 L^{-1}, T<-37°C

Conclusions

- ▶Both the ice nucleation mechanism and vertical updraft play key roles in determining ice crystal number density in cirrus during SPartICus.
- ▶It is likely that homogeneous nucleation dominates ice nucleation in cirrus clouds at T < -40 C over SGP site during the SPartICus.
- ▶SPartICus updraft velocity data provide useful constrains for CAM5 parameterization. The too low updrafts in CAM5 may influence the frequency occurrence of high ice crystal number and relationship of ice crystal number with temperature.