The statistical properties of tropical ice clouds from ground-based ARM radar-lidar observations

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ARM CPWG

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Australian Government
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The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

CSIRO

Motivation

Characterize the tropical ice cloud properties from different radar-lidar observations at different sites :

- to evaluate the variability of these properties along the tropical belt, as a function of large-scale environment, cloud regime, in the vertical, interannual, etc …
- to better understand the cloud / radiation feedback mechanisms
- to provide an observational basis for model evaluation
- to provide a reference to evaluate new spaceborne sensors (A-Train)

Ground-based radar-lidar observations

- ARM Sites : Darwin → 2006/2007 monsoon season
  (other seasons soon for interannual variability)

- AMF Sites : Niamey (West-Africa, 2006 monsoon season)

Mather et al. (2007) and Mace et al. (2006) already documented the Manus and Nauru ARM sites – this study adds up two sites.

Radars are degraded to the same sensitivity in all comparisons
"Ice cloud" and "convective ice" profiles are separated in both datasets

Which methodology ?

Morphological characteristics :

Cloud boundaries, thickness, occurrence, fraction are derived directly from the CloudNet “target categorization” files (www.cloud-net.org).

Microphysical and radiative properties : IWC, α, R_e, N_t

Radar-lidar techniques can only be applied to the common cloud samples, except in the variational technique of Delanoe and Hogan (2007) which provides solutions both for radar-lidar, radar and lidar. We have therefore used primarily this method for our climatology.

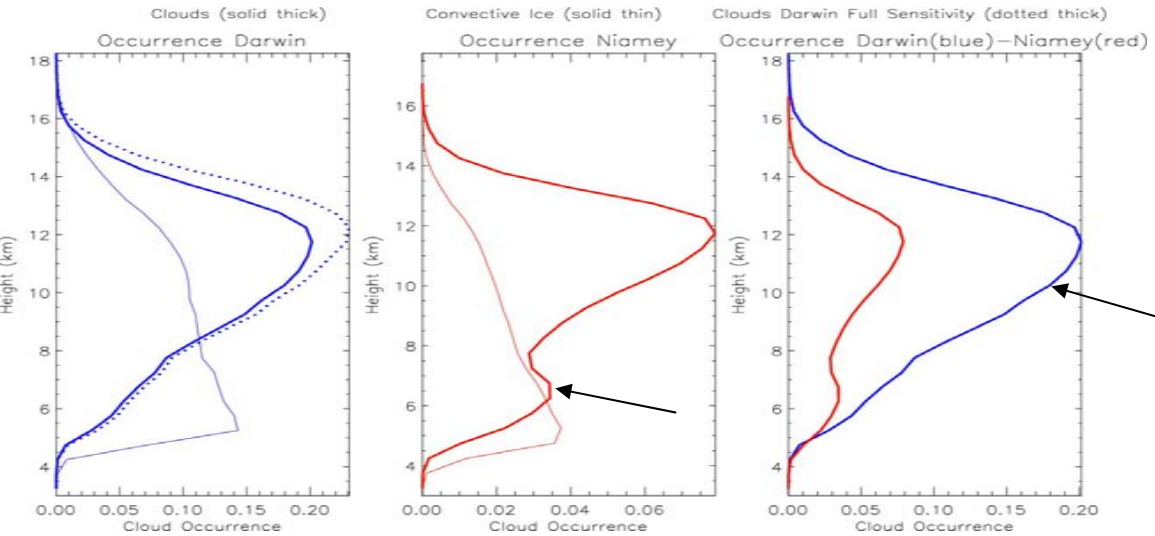
The RadOn radar-only technique of Delanoe et al. (2007) provides additional parameters, such as terminal fall speed and in-cloud vertical air velocity, which are included too (but issues with extinction for now).

In a near future a new method by McFarlane, Comstock, and Wang will be added too. These three methods will be used together to give an error bar due to retrieval techniques.

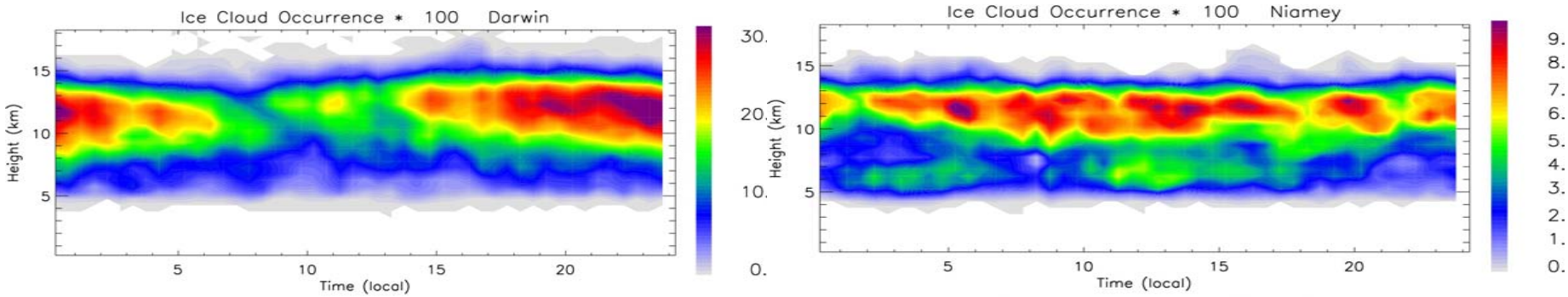
Heating rates and radiative fluxes :

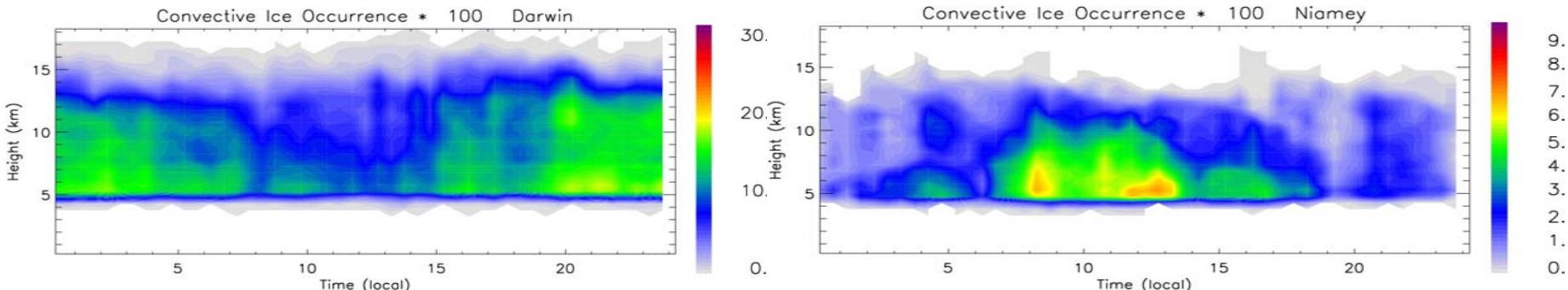
Next planned step of this work (PNNL)

Frequency of Ice Cloud Occurrence



Similar profiles but very large difference



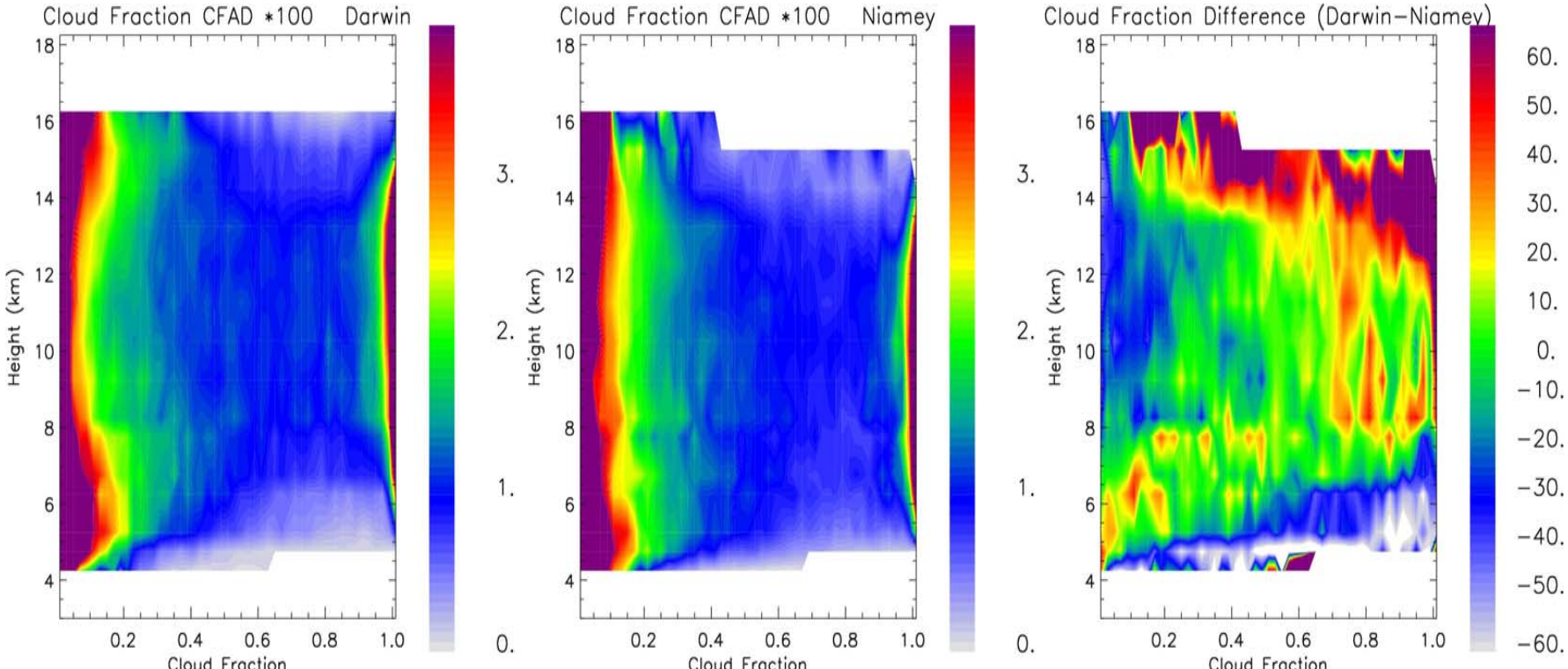


Ice Cloud Fraction

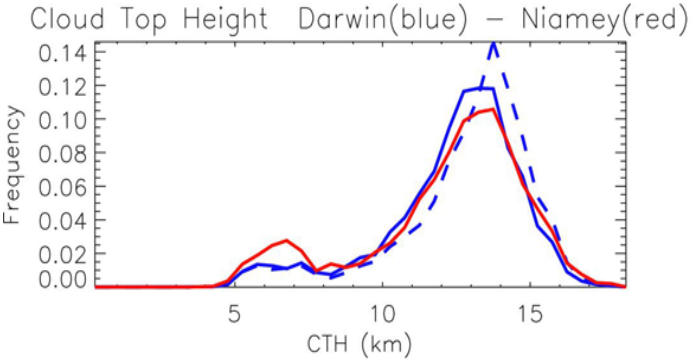
Cloud fraction corresponds to the UM model (12 km horizontal, 50 vertical levels) which will be used for regional Australian forecast from January 2009

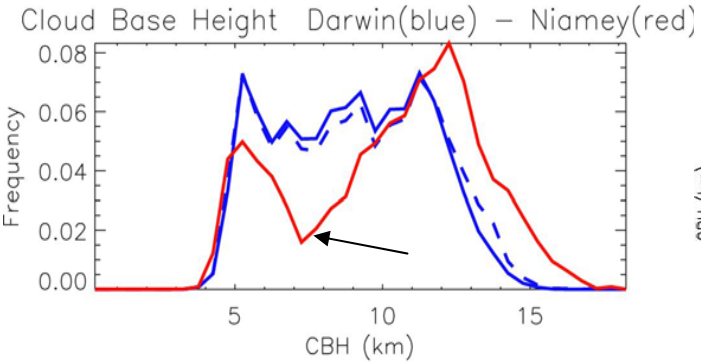
Both sites are characterized by similar cloud fraction distributions (0.05 to 0.3 / 0.9 to 1)
Main differences are in the upper-levels (more high CFs in Darwin cirrus)
and above melting layer (more small CFs in Darwin)

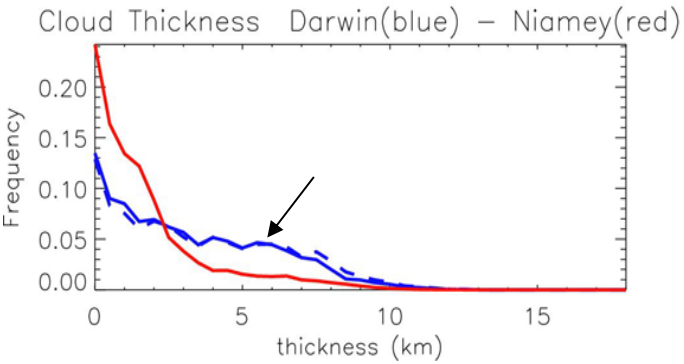
A large-scale model should be able to reproduce that

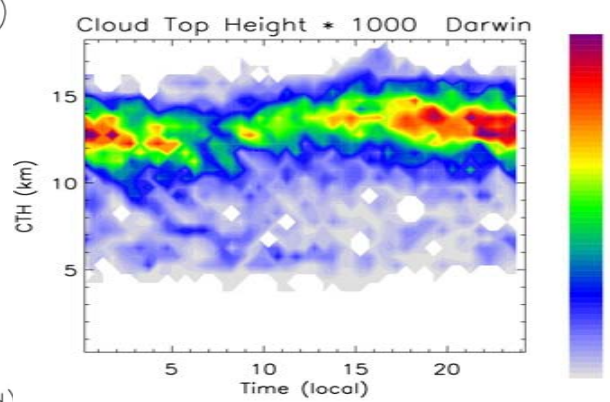


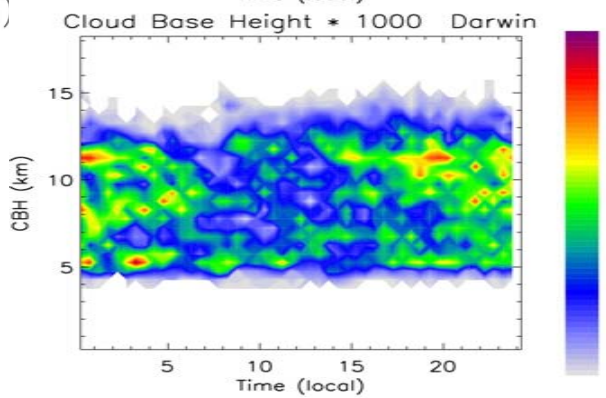
Ice Cloud Top Height, Base, Thickness

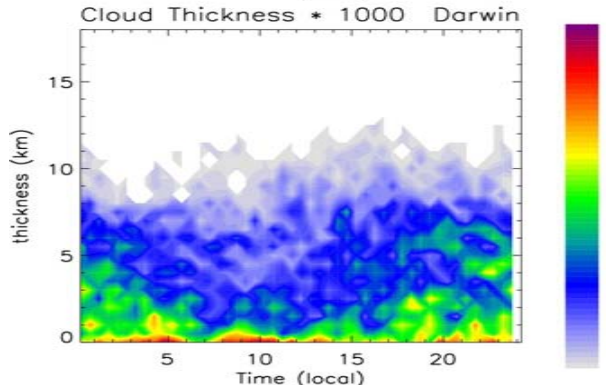


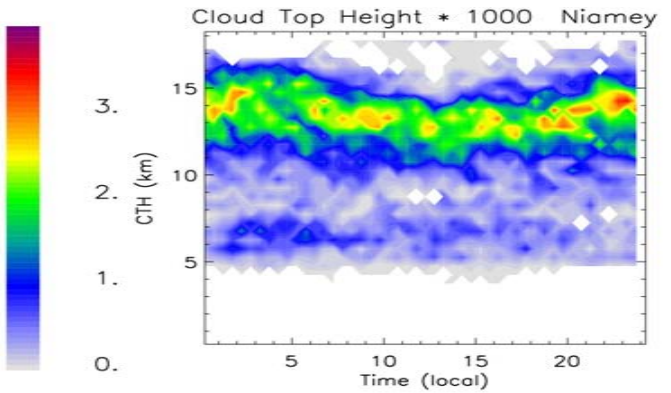


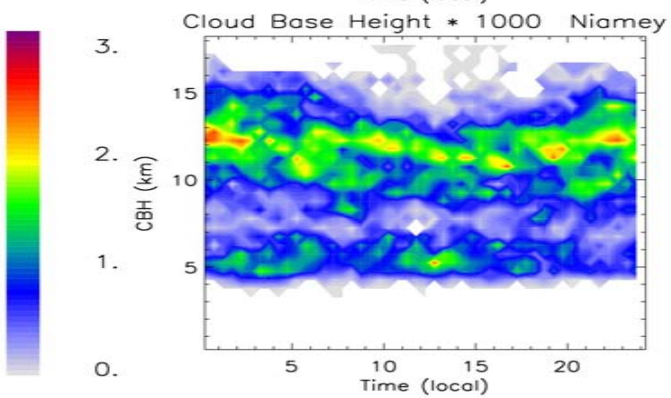


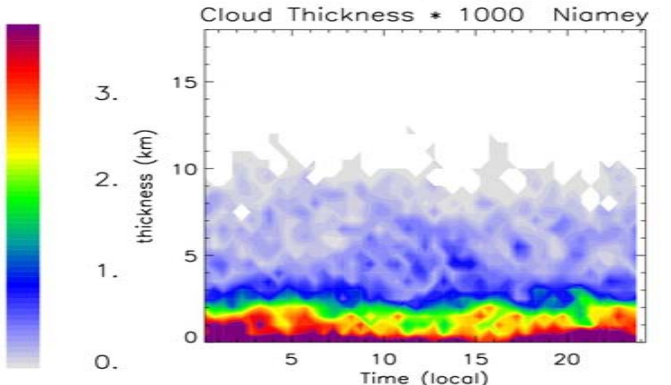




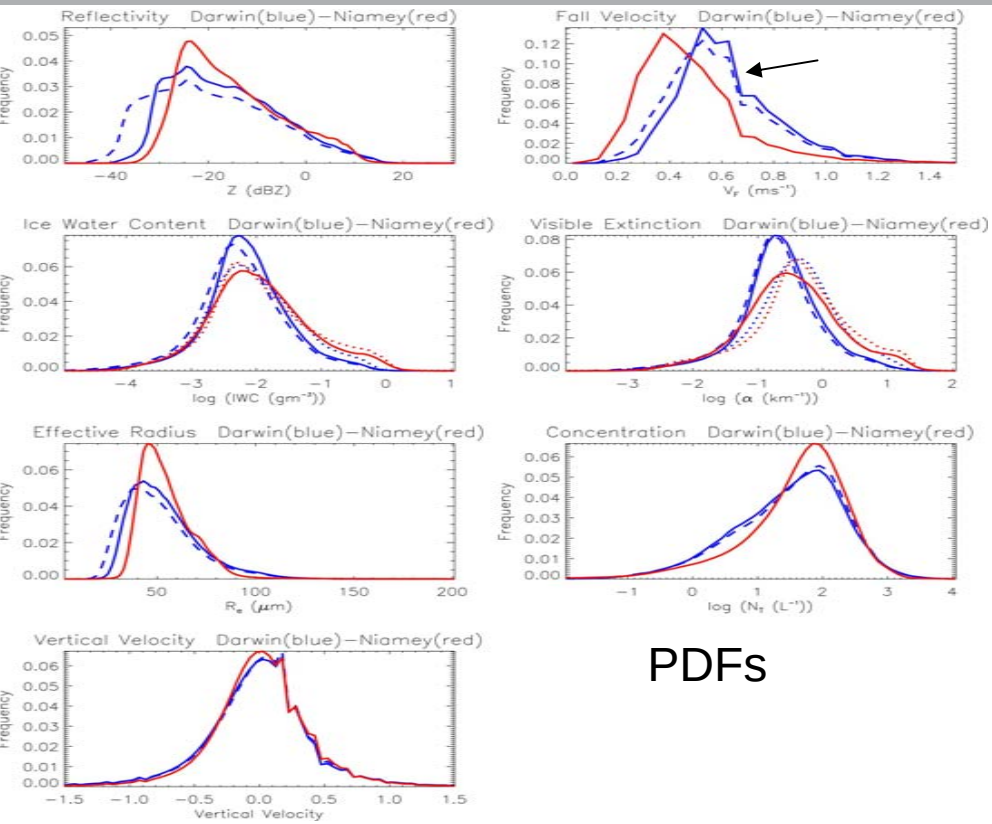




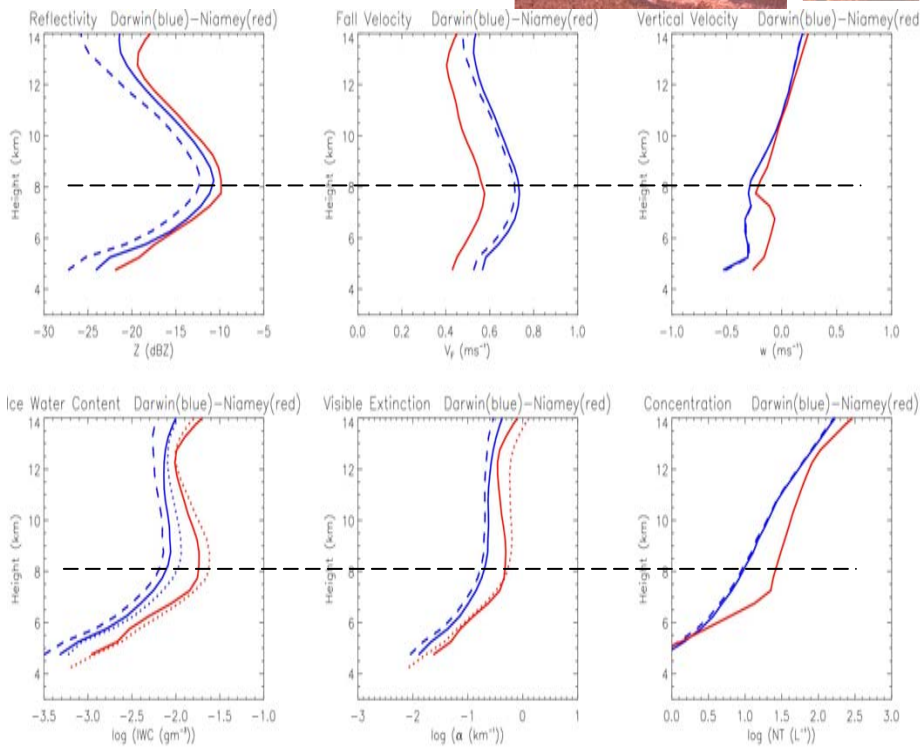




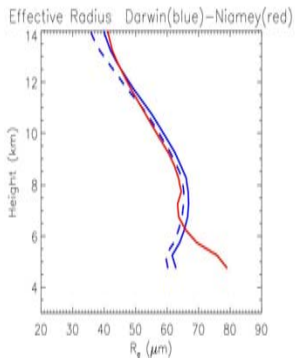
Microphysical Properties



PDFs



Mean Vertical Profiles



Microphysical processes - Two regions
From top to 8 km – aggregation dominating
From 8 km to Melting Layer – sublimation dominating

Darwin vs Niamey : ice clouds over Niamey consist of smaller-sized particles but in much larger concentrations, thereby carrying more ice water and producing more visible extinction than the ice clouds over Darwin. Heating rates ?

Perspectives

- Add up RadOn and McFarlane/Comstock/Wang results
- Evaluate the cloud retrievals using Proteus (McFarquhar) and Egrett (Heymsfield) in-situ observations over Darwin during TWP-ICE
- Compute heating rates and radiative fluxes using different RTMs (PNNL)
- Evaluate the 2B-CWC and 2B-CWC-RVOD products from CloudSat
- New project starting to evaluate the representation of clouds in the UM model over Australia using ARM TWP sites and CloudSat / CALIPSO

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Thank you

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