

Plans for Data Assimilation and Cloud-Resolving Modeling Studies in the Tropical West Pacific Region

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ARM Proposal

- Study of Multi-scale Cloud Processes Over the Tropical Western Pacific Using Cloud-resolving Models Constrained by Satellite Data
- PIs: Jimmy Dudhia, Bill Kuo, Andy Heymsfield (NCAR), Ruby Leung (PNNL). Collaborator: G. Mace (U. Utah)
- Funded: 2008-2011

Goals

- Perform Data Assimilation using Ensemble Kalman Filter Method and COSMIC GPS data
- Perform multi-level nested simulations to cloud-resolving scale, and compare with *in situ* microphysics data and satellite cloud data
- Investigate mesoscale clouds in Maritime Continent region (large-scale/local-scale interactions)
- Use WRF as a testbed for GCM parameterizations (e.g. cumulus, radiation schemes)

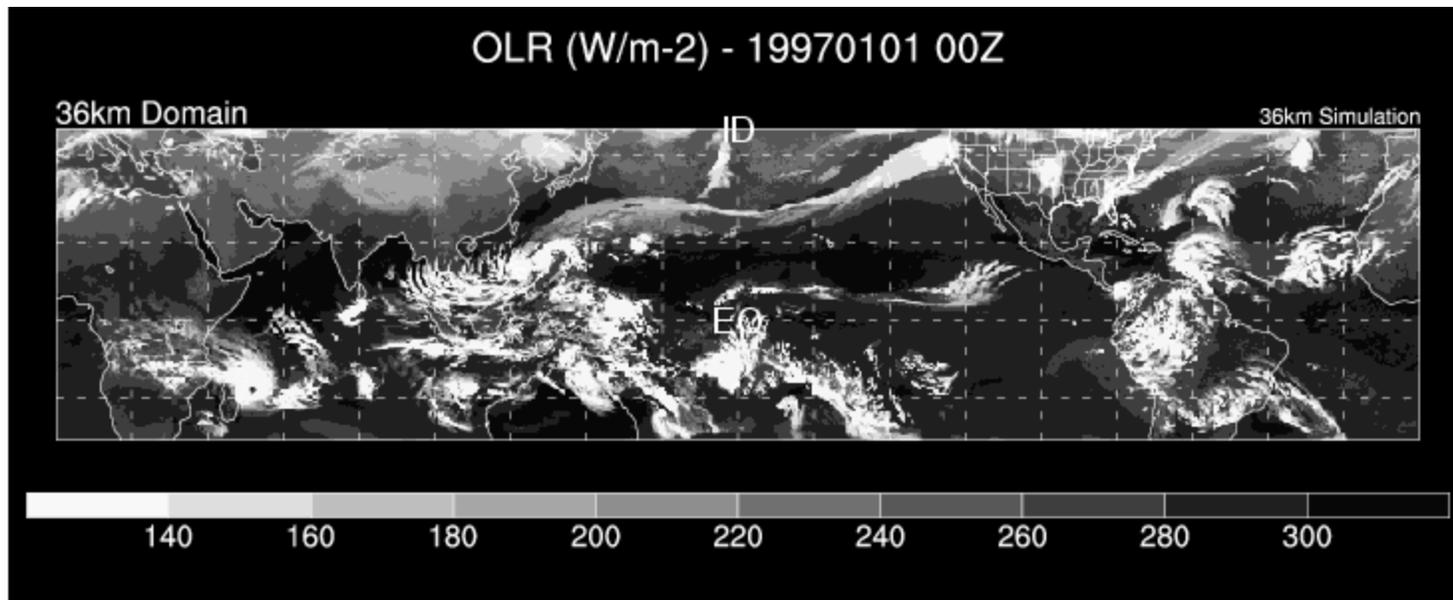
WRF Nested Regional Climate Model (NRCM)

- Features (available in WRF V3.0 or V3.1)
 - Specified time-varying sea-surface temperature, sea ice, vegetation fraction, albedo (3.0)
 - Ocean skin temperature prediction (X. Zheng) (3.1)
 - Physics for long-term simulations
 - CAM radiation (3.0) with CO₂ variation (3.1)
 - Land surface with time-varying deep soil (3.1)
 - Special accumulation outputs for radiative and surface fluxes and precipitation (3.1)
 - Lateral boundary zone suitable for forcing by analyses or CCSM outputs (3.0)

NRCM Applications

- 1996-2000 and 2000-2005 tropical channel model driven by NNRP analysis (36 km with 12 km and 4 km nests over West Pacific, and 12 km nest over Atlantic)
- North America and Atlantic (36 km, 12 km nest over Atlantic) 1995-2005, 2020-2030, 2045-2055 driven by CCSM (ongoing)
- Western U.S. down to 2km driven by NARR analysis and CCSM (ongoing)

Outgoing Longwave Radiation



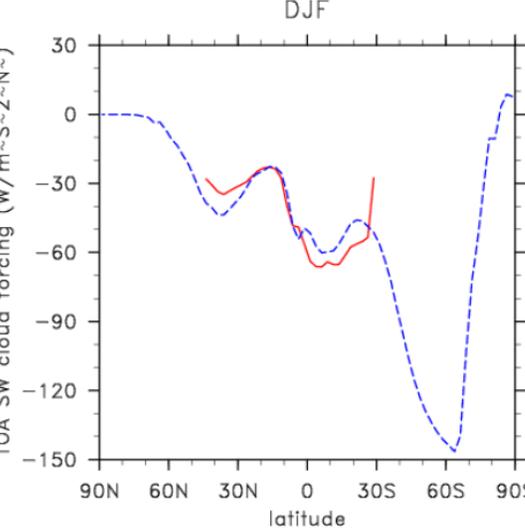
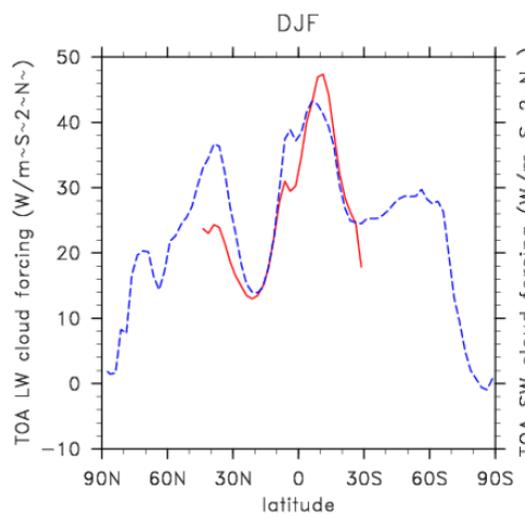
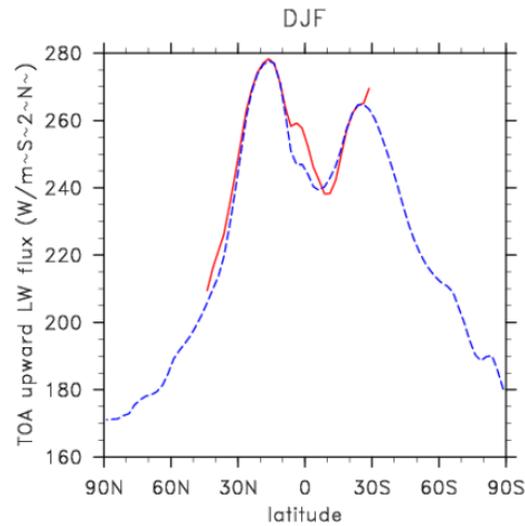
TOA Radiative Fluxes

TOA Upward LW

TOA LW Cloud Forcing

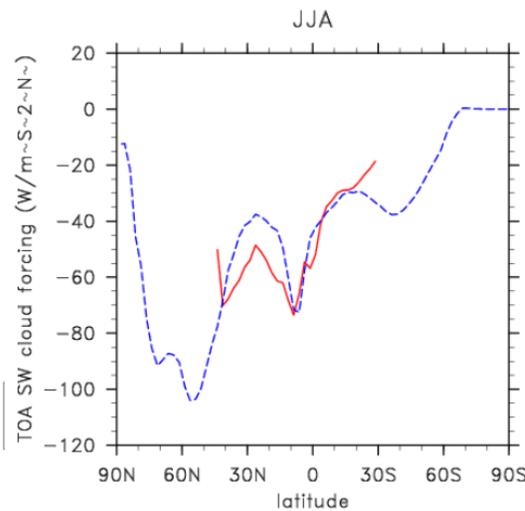
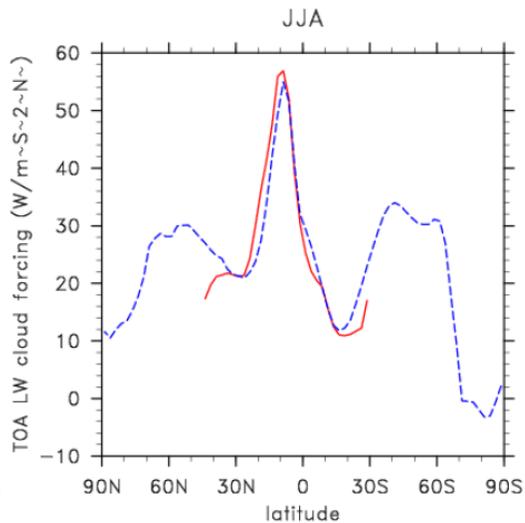
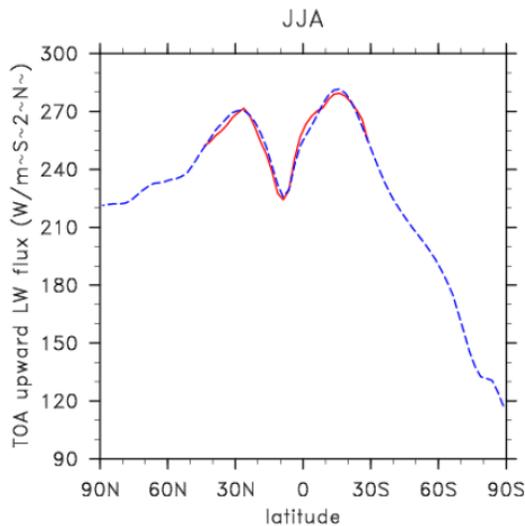
TOA SW Cloud Forcing

DJF



--- CERES
--- wrfoutd01

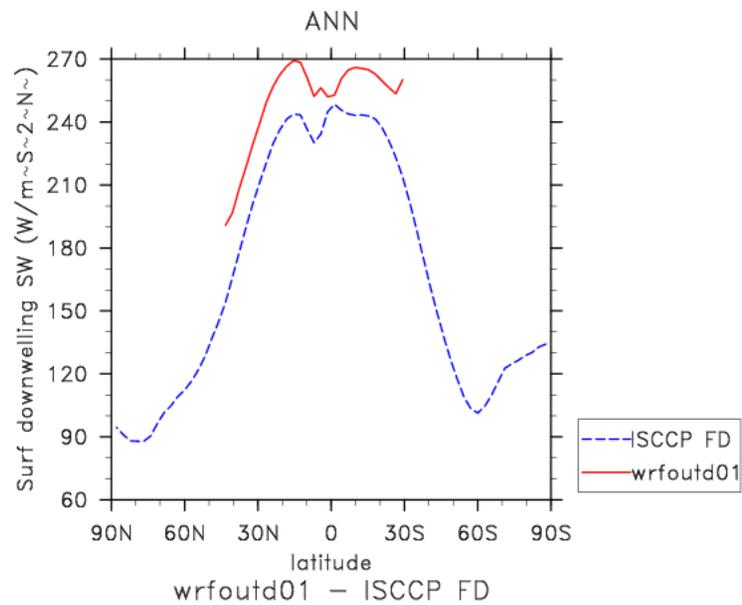
JJA



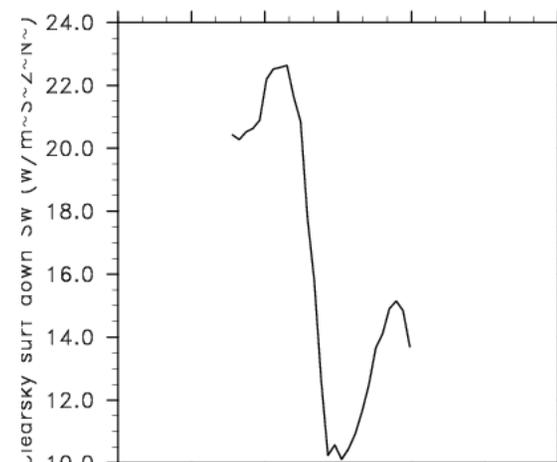
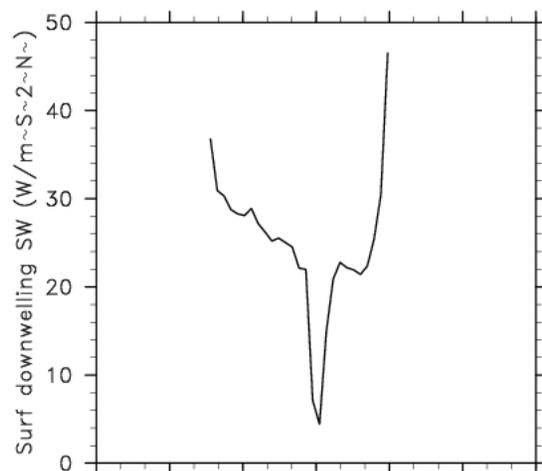
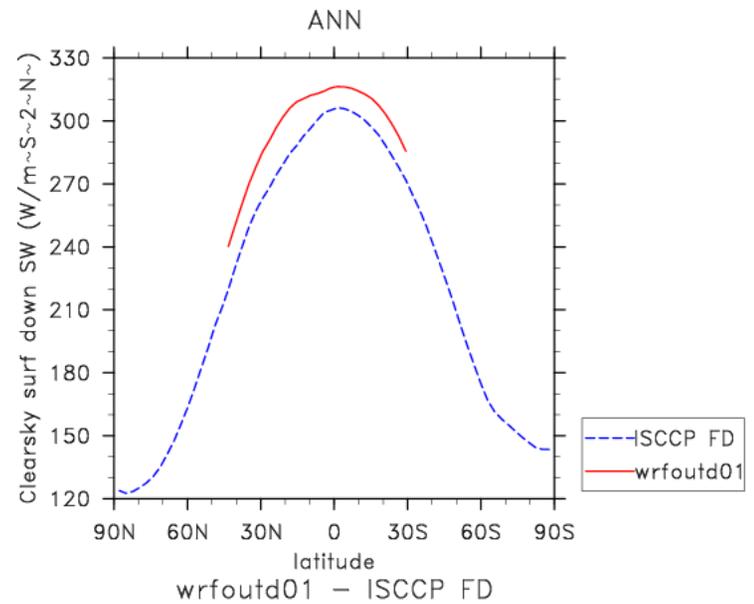
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Surface Radiative Fluxes

SFC Downward SW

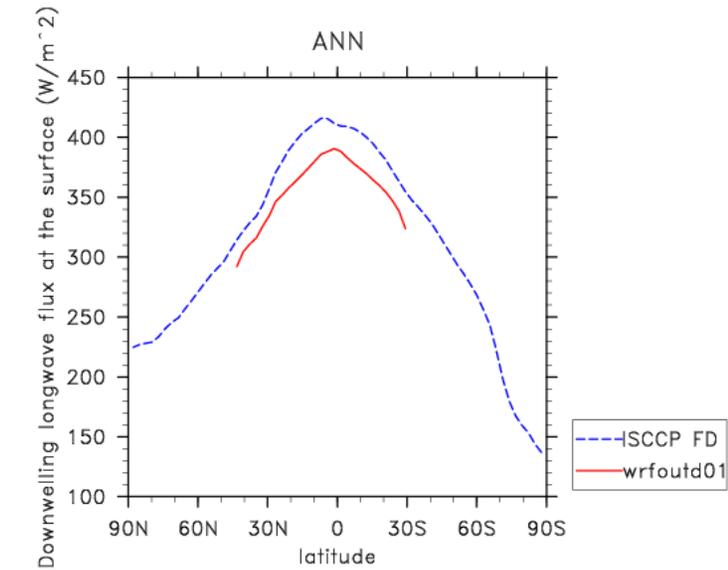


SFC Clearsky Downward SW

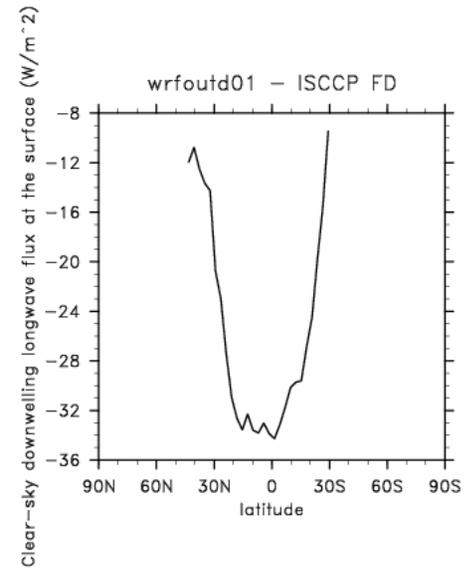
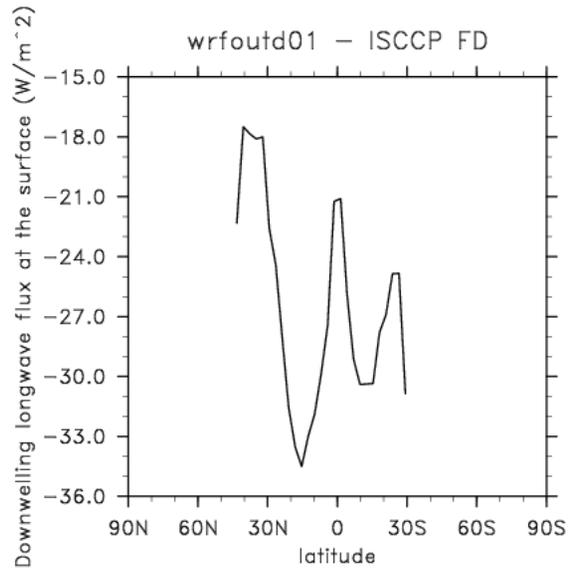
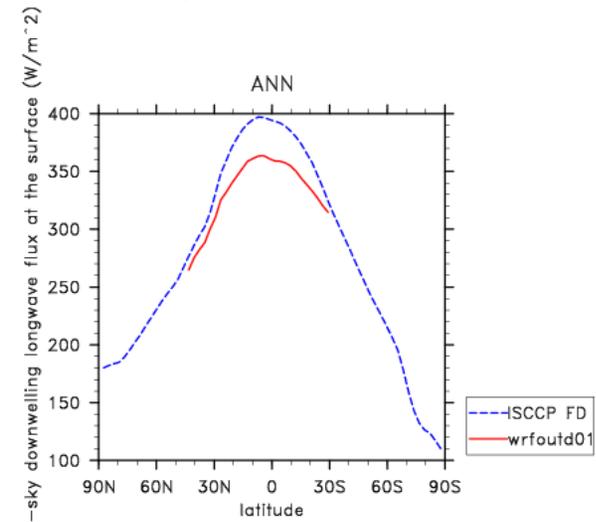


Surface Radiative Fluxes

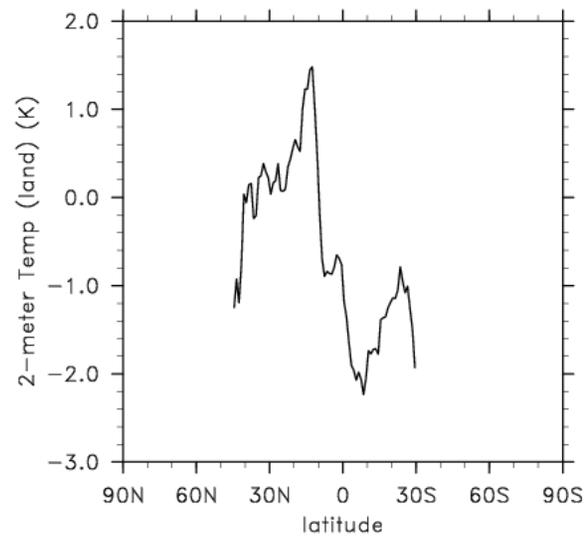
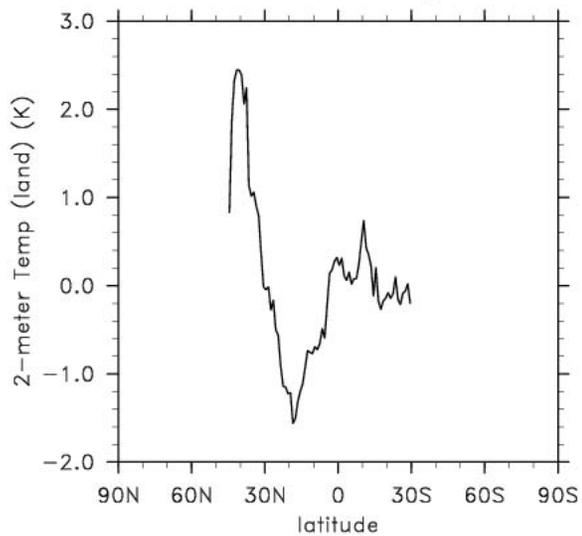
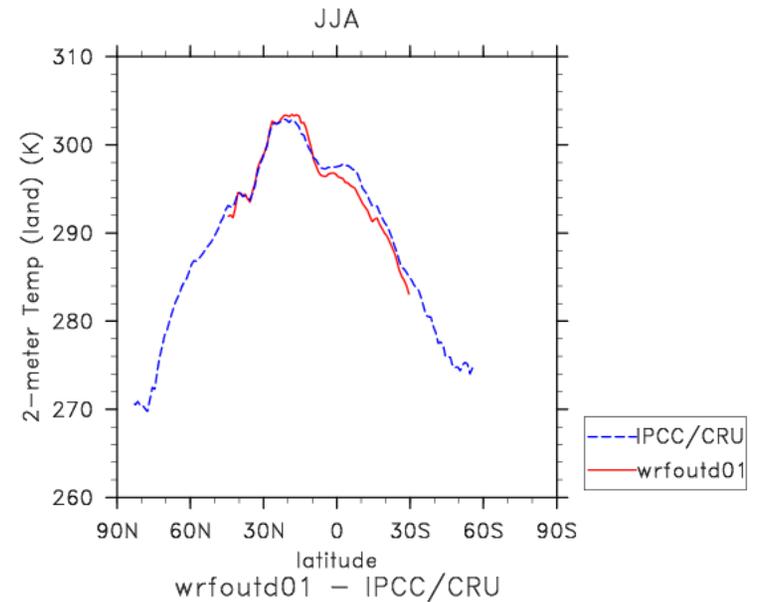
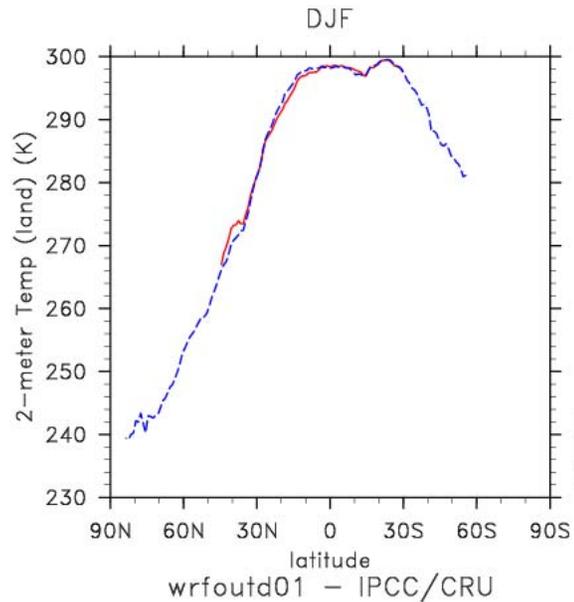
SFC Downward LW



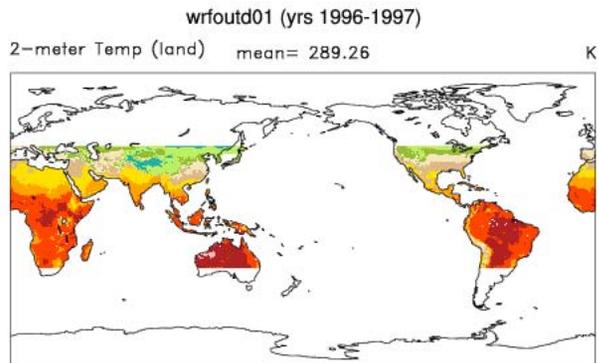
SFC Clearsky Downward LW



2m Temperature (Land)

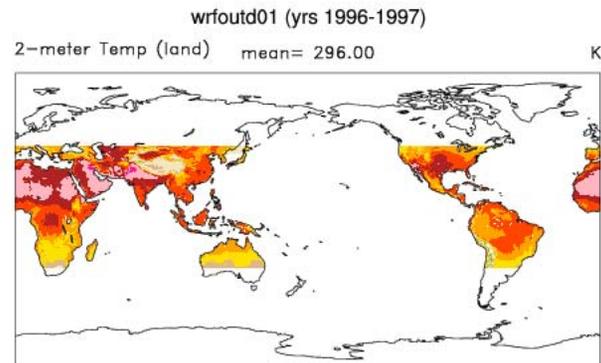
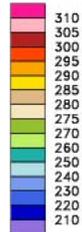


2m Temperature (Land)



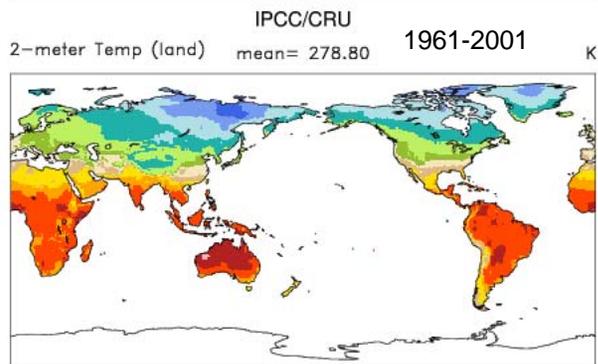
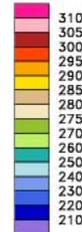
DJF

Min = 248.49 Max = 306.01

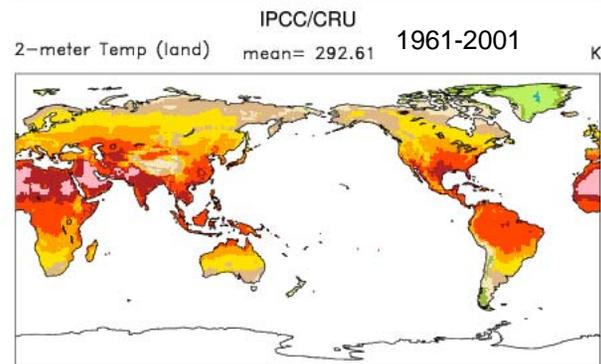
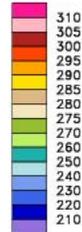


JJA

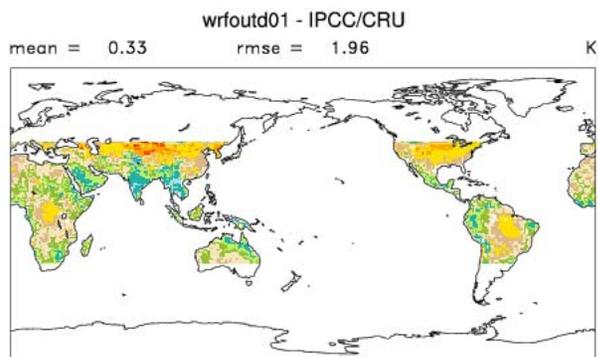
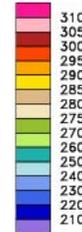
Min = 262.81 Max = 311.91



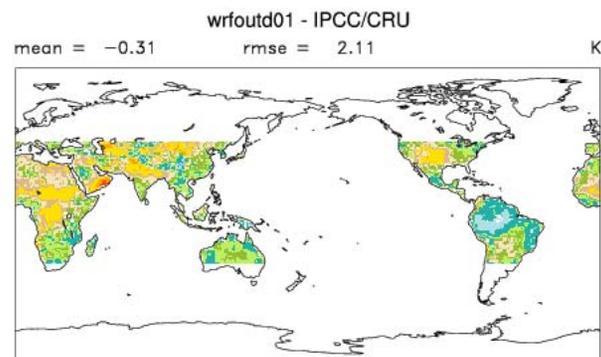
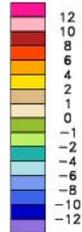
Min = 223.80 Max = 305.78



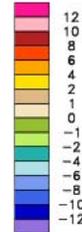
Min = 259.58 Max = 309.35



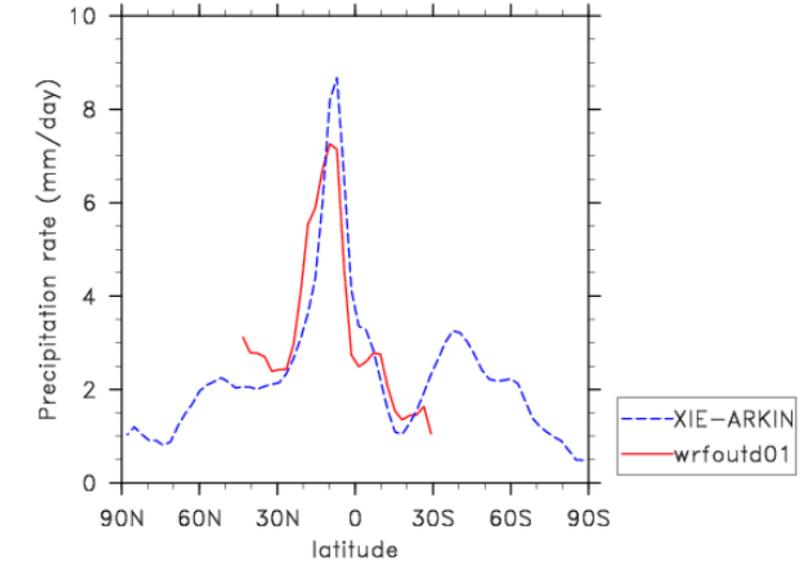
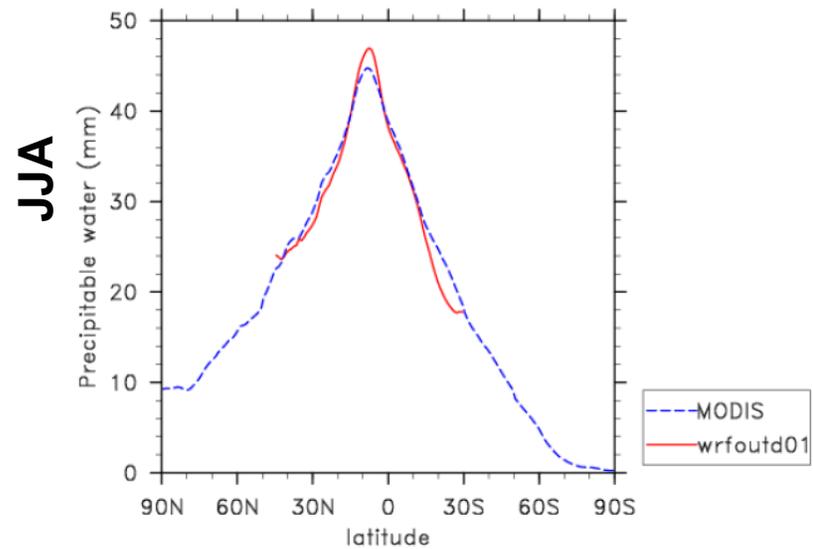
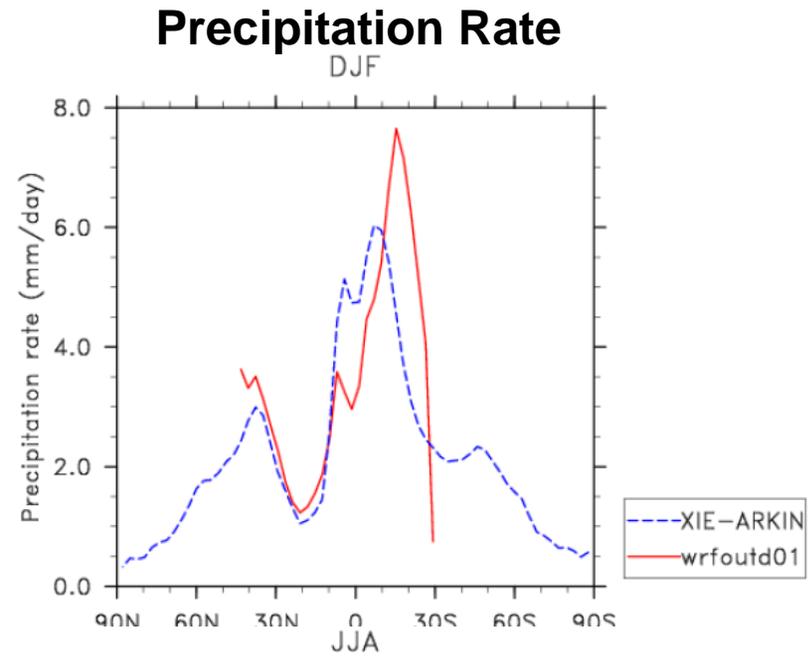
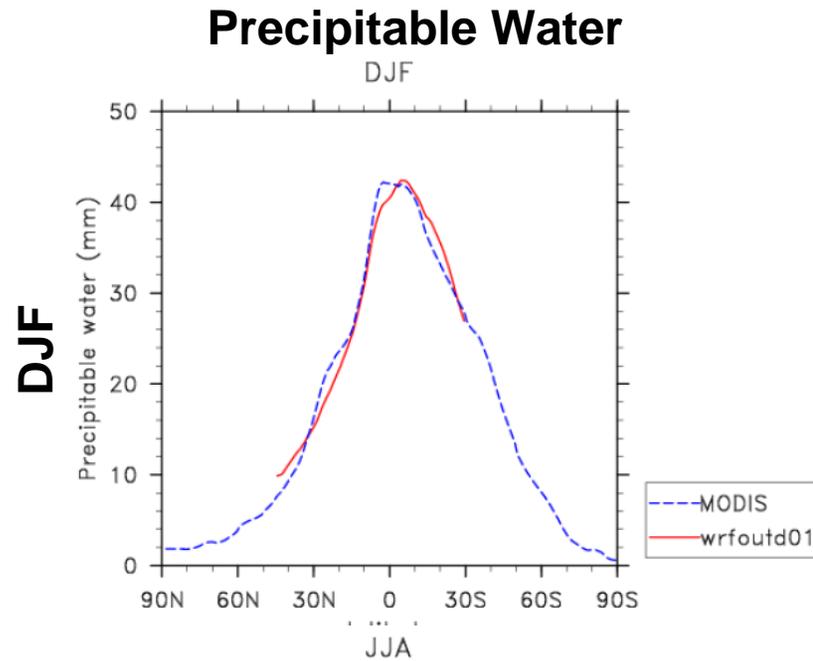
Min = -10.47 Max = 8.73



Min = -12.21 Max = 7.46



Precipitable Water/Precipitation



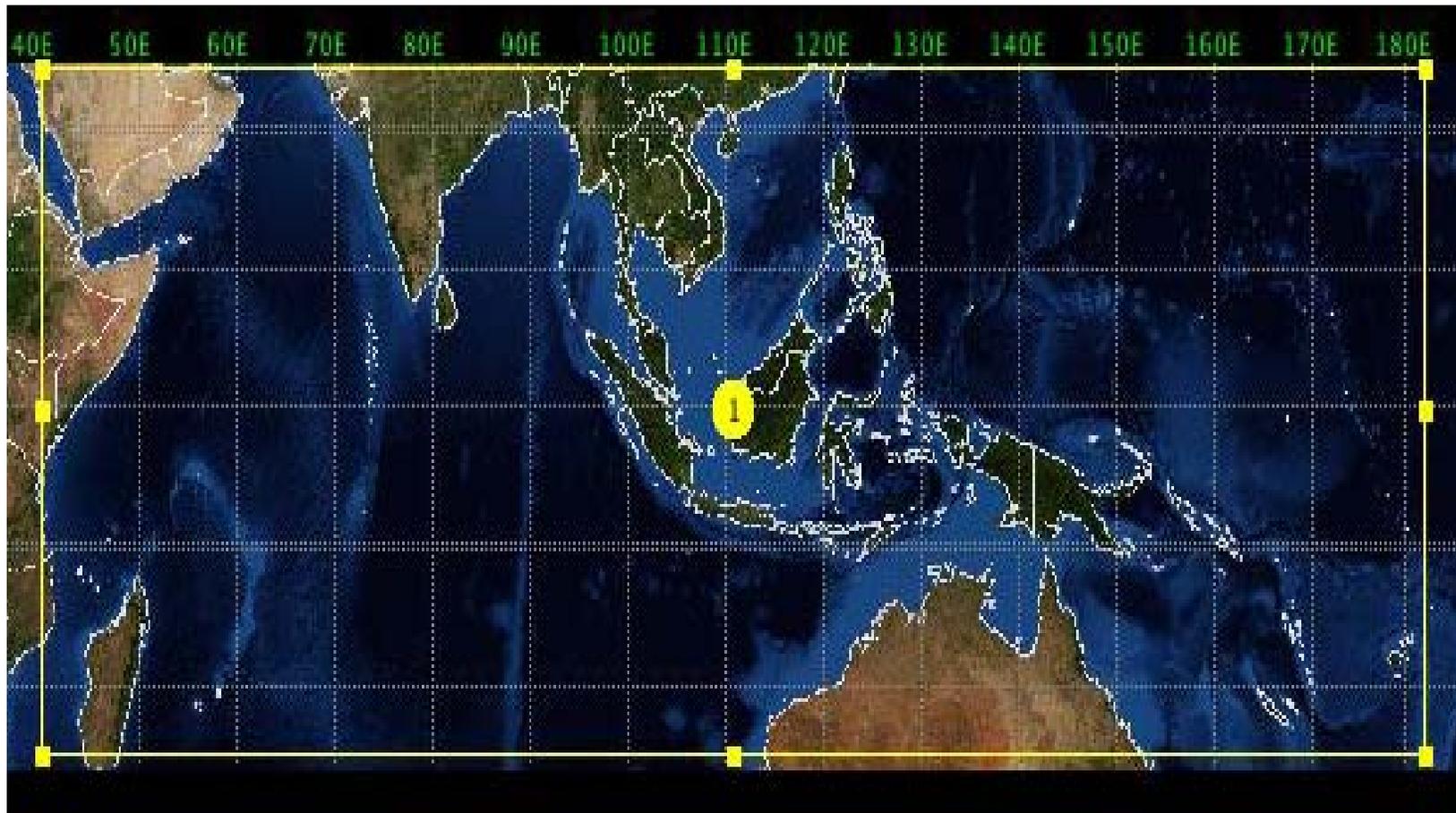
Data Assimilation

- Goal is to provide an ARM-specific mesoscale analysis using advanced data assimilation techniques and data sources
- 36 km analysis of the ARM TWP area
- Expertise at NCAR in the DART group

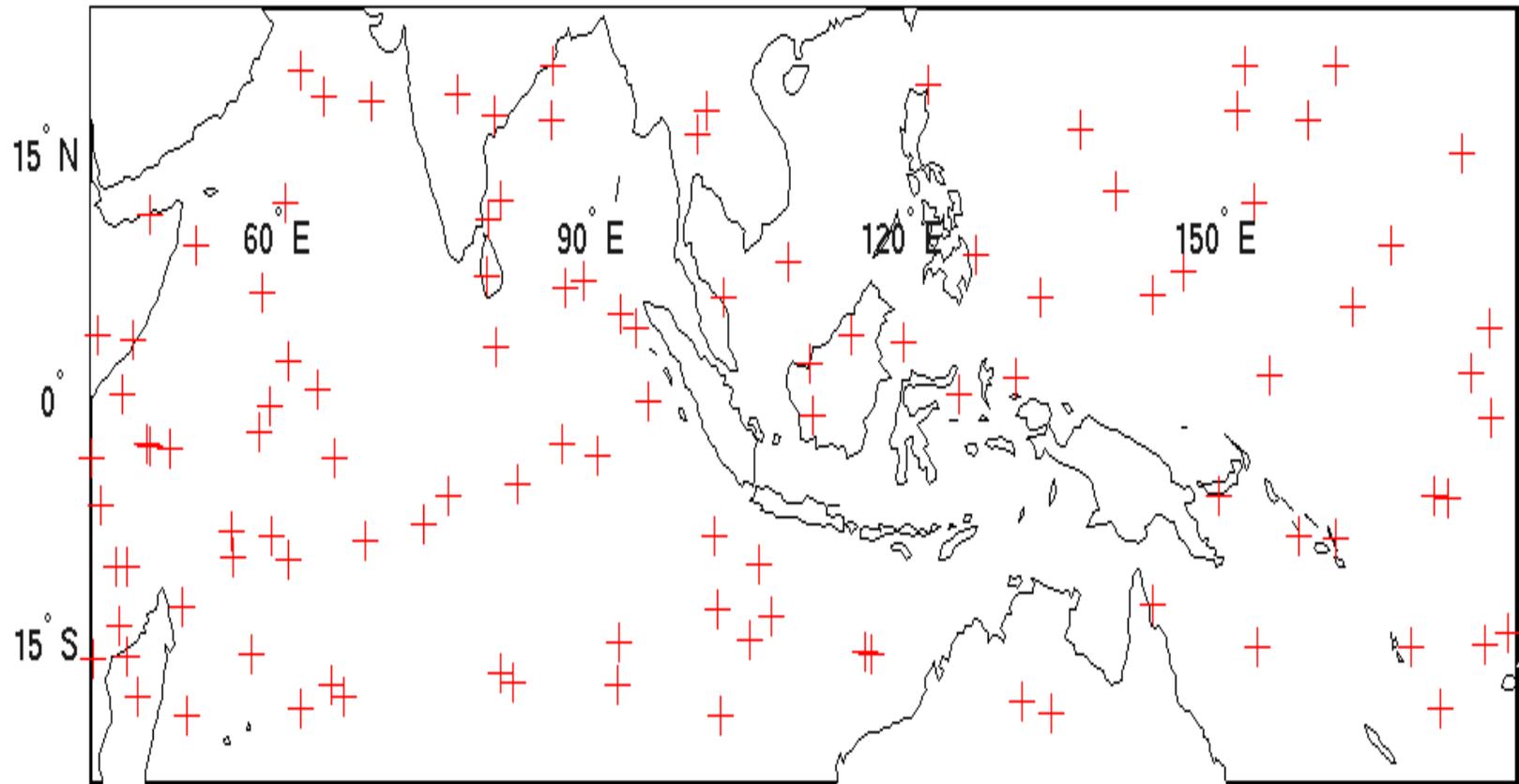
Features of WRF/DART ensemble analysis system

1. Ensemble estimated forecast error covariance aimed at mesoscale and convective-scale in tropics
2. Correlations of moist variables with other analysis variables included
3. Use of GPS RO data down to surface to get moisture information

Domain of the mesoscale analysis



Availability of COSMIC RO data 2007 Dec 2, 111 RO profiles



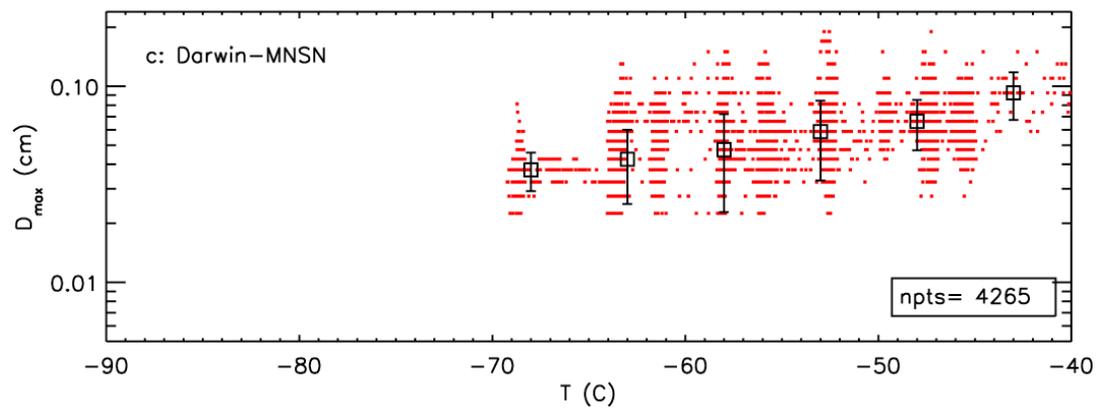
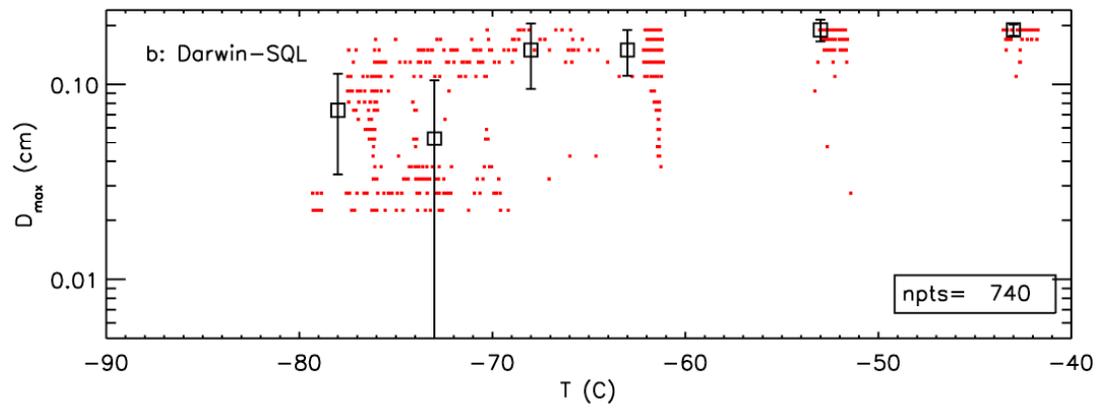
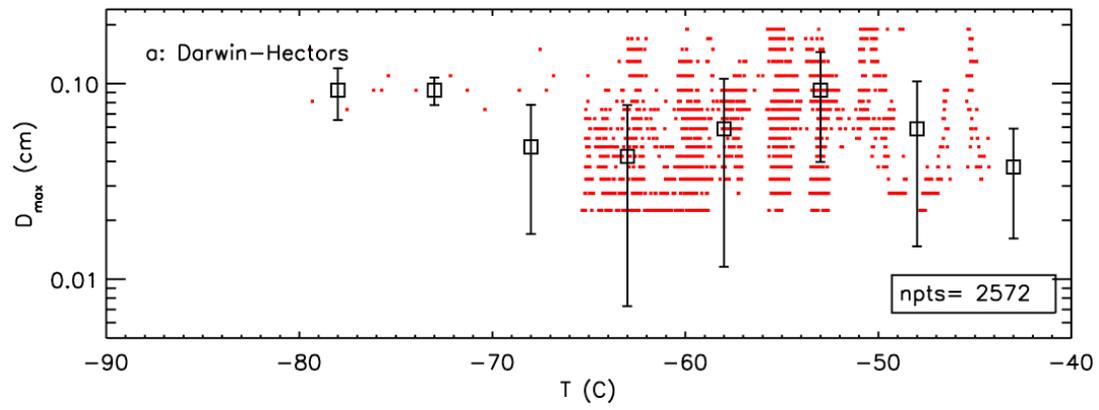
Microphysical Observations

- Goal is to validate or improve microphysics representations in models, especially ice clouds where the greatest uncertainty still exists
- This in turn would improve in both mesoscale and global models
 - Radiative properties
 - Cloud distributions
- Some results from ACTIVE in the TWP-ICE period

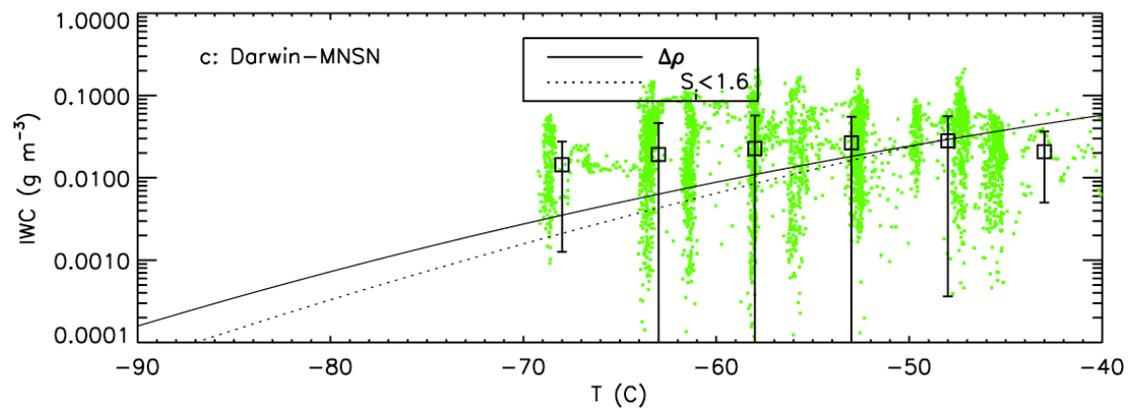
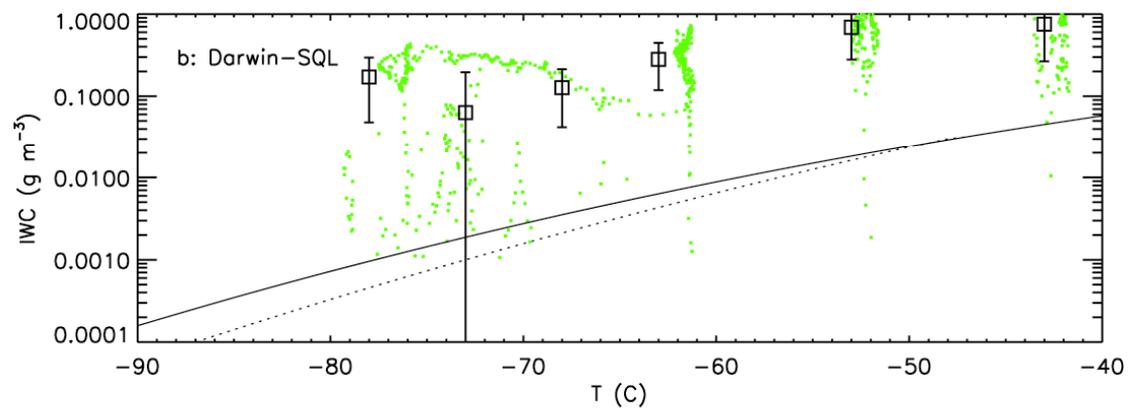
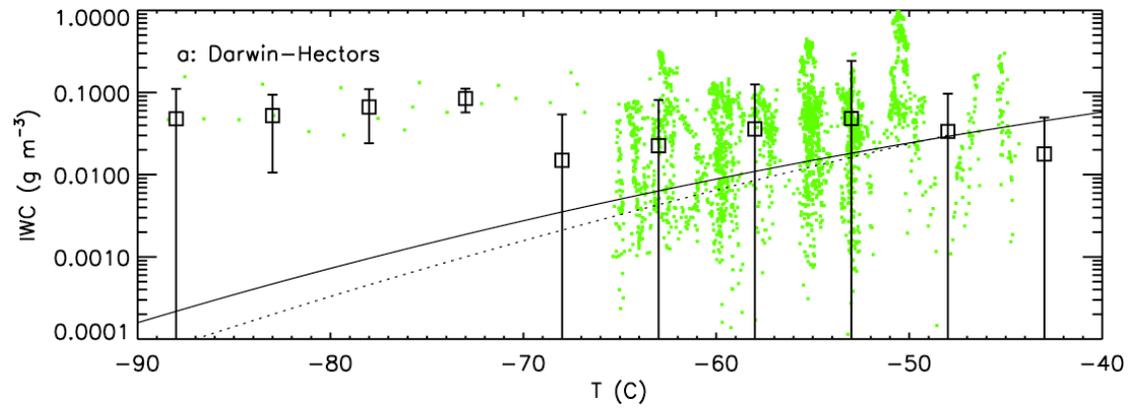
**MICROPHYSICAL OBSERVATIONS
In ACTIVE/TWP ICE**

(Heymsfield, Bansemer)

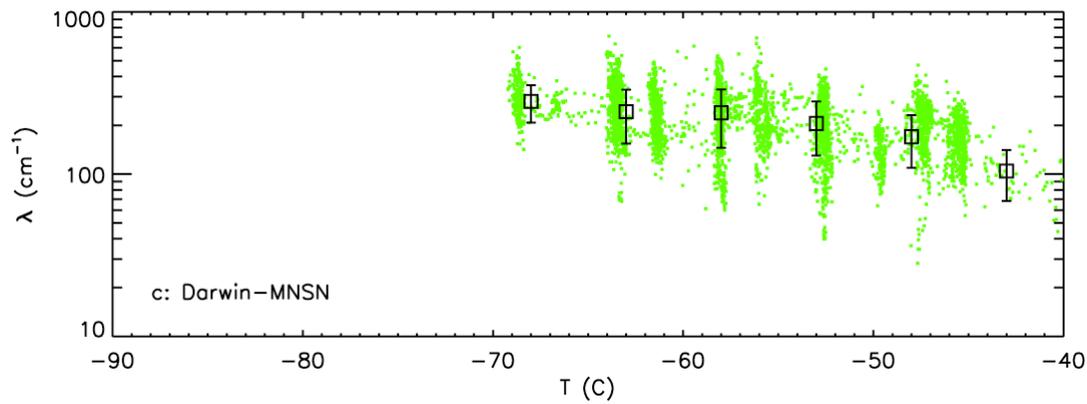
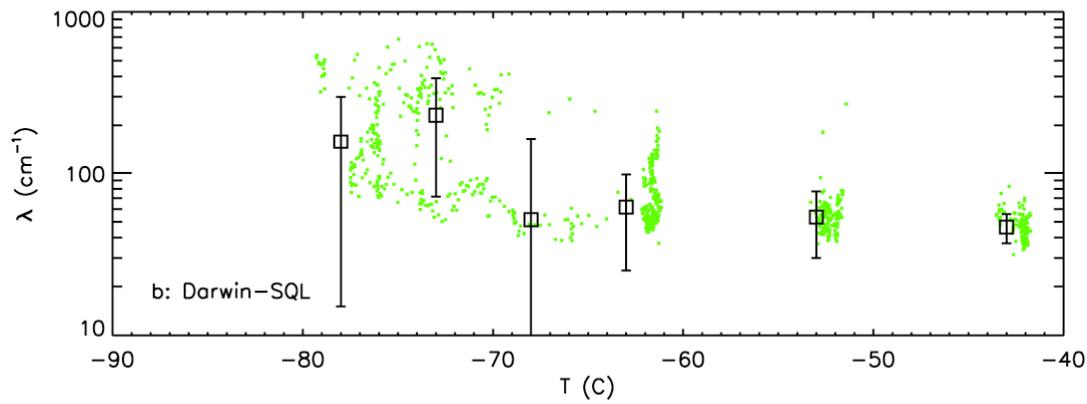
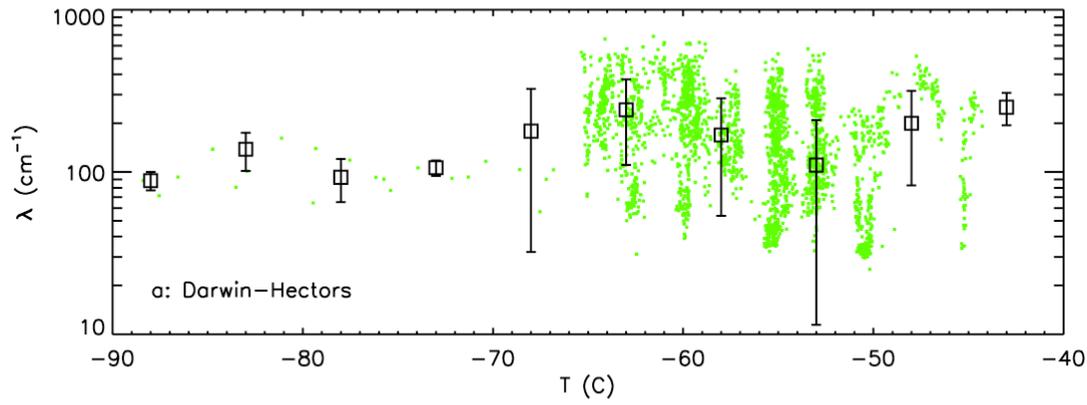
Maximum Dimension



IWC Distribution

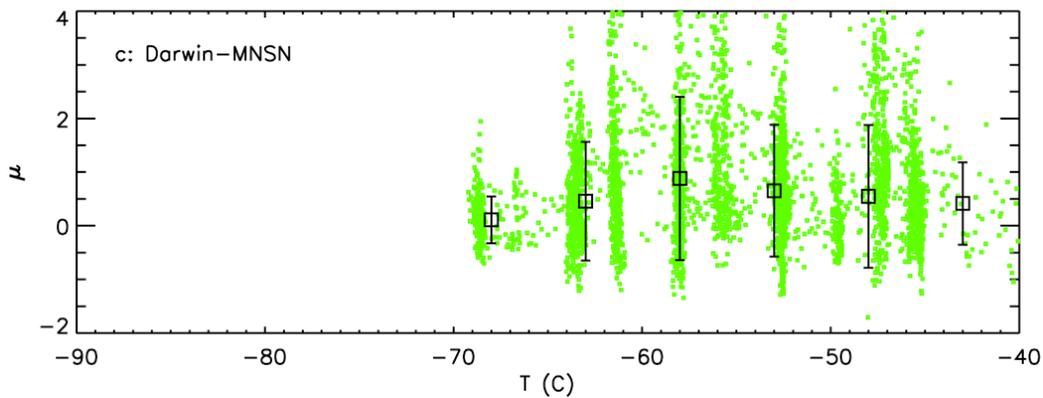
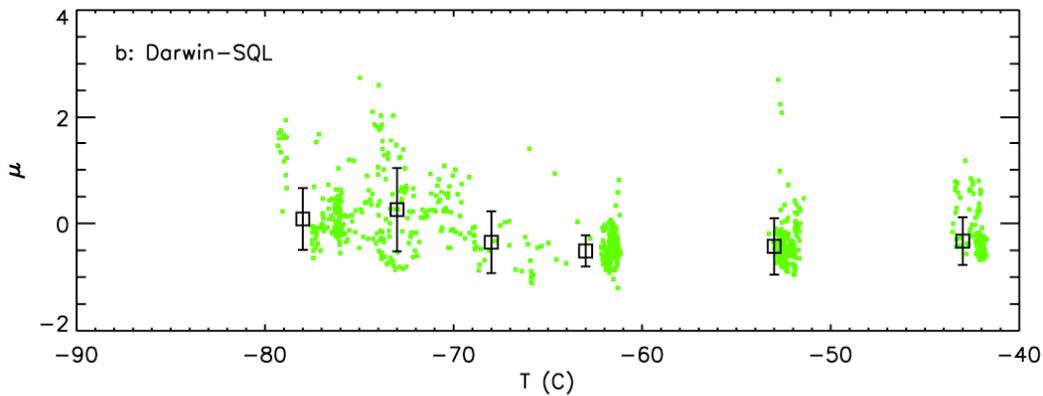
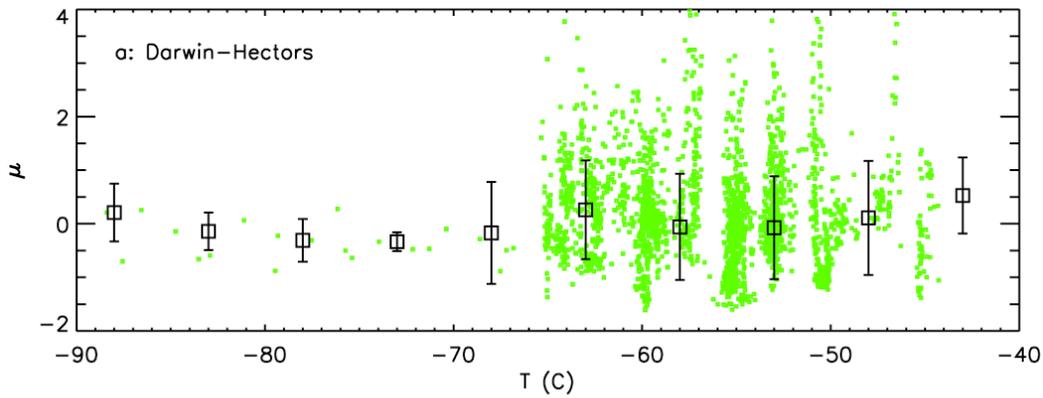


PSD Slope



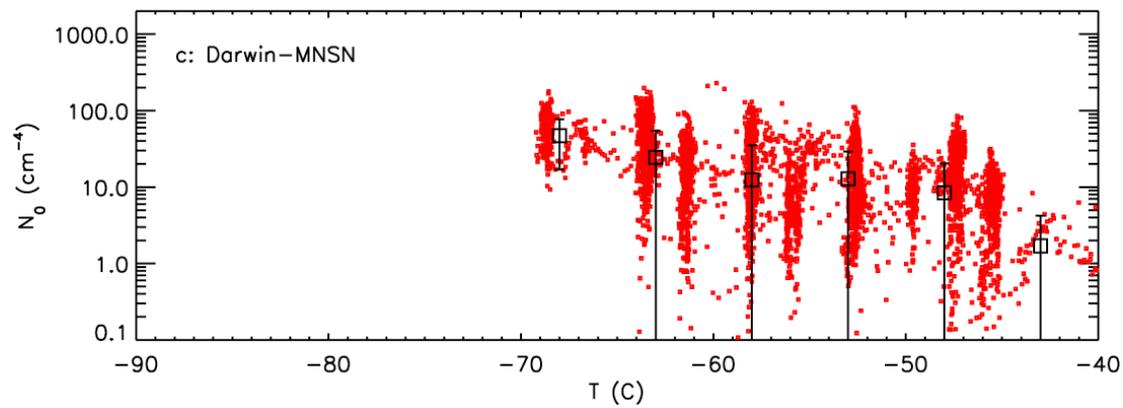
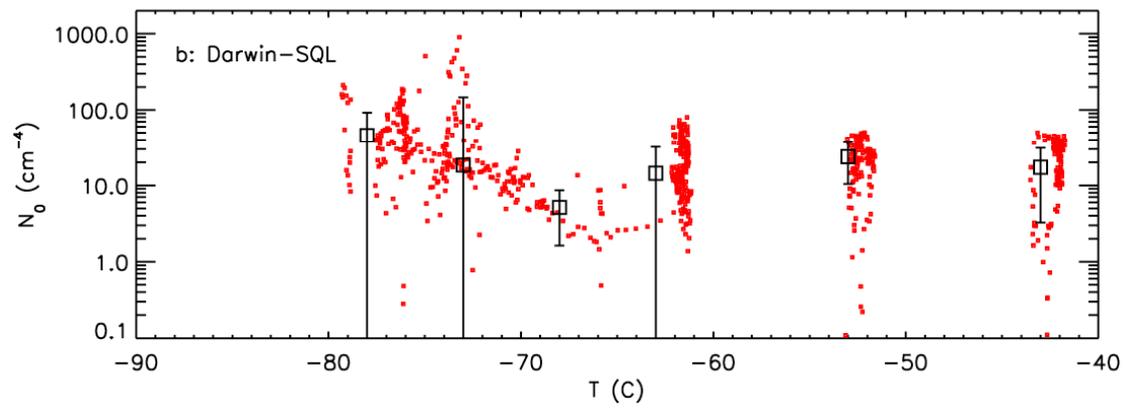
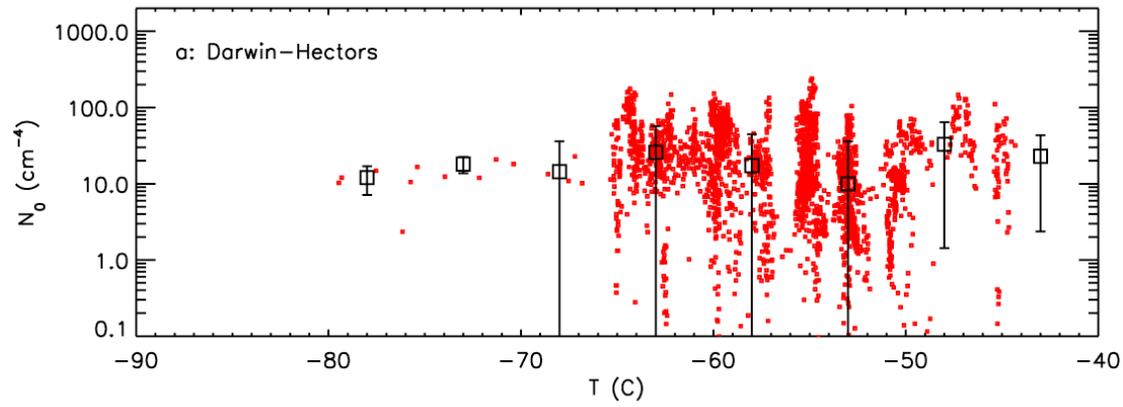
$$N(D) = N_0 D^\mu e^{-\lambda D}$$

PSD Dispersion



The dispersion values are near 0, so that exponential PSD's are Useful in representing these PSD's. The next figure shows N_0 values assuming exponentials

PSD N_0 Exponential



Microphysics Schemes

- Most schemes separate snow and ice and rimed particles
- Nature has no such clear ice categories so interpretation in terms of model parameters is not straightforward
- Work is ongoing to represent ice size distributions more realistically based on observations (Morrison, Field, etc.)

Radiative Properties

- Sizes of particles are critical to radiative properties
- Cloud extent also determined by fall speeds and microphysical process rates, which therefore indirectly affect radiative properties
- A goal is to improve radiative behavior via more realistic microphysics