Large-Scale 3-D Cloud Ice Water Features Determined by Combining Satellite and Surface Measurements during TWP-ICE

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Motivation

• **LARGE-SCALE** cloud water distribution is needed to
  – derive advective tendency terms for forcing single-column models
  – validate GCMs/CRMs that have grid scale of tens ~ hundreds km
  – understand the microphysical evolution of / the interaction among different cloud cells

• Surface radar observation (MMCR) is a point measurement, do not provide the area coverage required for the above studies
Objectives & Works Done

- The advantage of combining surface and satellite obs.
  - *surface*: better cloud vertical structural measurements;
  - *satellite*: better areal coverage
- Ice water retrieval method:  
  - MMCR + Satellites + Surface Met Obs.
- Validation:
  - Time series
  - Mean vertical structure
  - Histograms
- Ice water over 10°×10° area centered Darwin
  - Mean distribution
  - vs. cloud temperature
  - vs. SGP March 2000
Ice Water Retrieval Flow Chart

MMCR \rightarrow iwc profiles
MWR \rightarrow Iwp
ECMWF \rightarrow p, T, q, ...

RT model simulations

a-priori database
iwc \leftarrow T b's

DDA simulations - nonspherical scattering

IR cloud top height

AMSU-B MW data

Bayesian retrieval procedure

Point Measurements

Areal Measurements

iwp & 3-D iwc within 10° x 10° area surrounding TWP site
Primary data source

• Radar – MMCR
  – 35 GHz (8.6 mm)
  – Vertical pointing
  – Reflectivity&Doppler
  – Data from surface to 20 km ALT
  – Continuous observation

• Satellite – AMSU-B
  – 89, 150, 183.3±1, 183.3±3, 183.3±7 GHz
  – 16 km resolution at nadir, ~2000 km swath width, cross scan
  – Twice daily coverage per satellite (During TWP-ICE 4 NOAA satellites)

Now, focusing on TWP-ICE IOP
TWPICE  (Point View to 3D View)
Horizontal IWP Distribution
- TWP-ICE & SGP 32k

TWP-ICE 40-Day Mean

SGP-32k 30-Day Mean
Comparison with MMCR (TWP-ICE)  
- IWP Time Series

Radar:  
dBZ $\rightarrow$ IWC $\rightarrow$ IWP

Satellite:  
TB $\rightarrow$ IWC&IWP  
0.5 Deg. Ave.
Comparison with MMCR
- IWP PDF

TWP-ICE (40 Days)

SGP-32k (31 Days)
Comparison with MMCR (TWP-ICE)
- Mean IWC Profiles & Frequency of Occurrence
  (40 Days)

Mean IWC Profiles

Frequency

IWC (x 10^{-3} \text{ g m}^{-2})

Altitude (km)

Frequency of Occurrence (%)
Comparison with MMCR
– TWP-ICE

For 40 days of all co-incident radar-satellite observations

Compare Radar and Satellite
Radar: Average of 1 hours
Satellite: Average of 0.5 degree (60 km) radius
Error Bars: Standard Deviation within averaged profiles/pixels
Comparison with MMCR
- IWC Time-Height Cross-Section

Satellite

MMCR
Comparison with SGP-32k
- Mean IWC Profiles

TWP-ICE (40 days)

SGP-32k (30 Days)

Altitude (km)

IWC (x 10^{-3} \text{ g m}^{-2})

Satellite
Radar
IWP vs. Cloud Height
- TWP-ICE & SGP-32k

TWP-ICE 40-Day 10° x 10°

SGP-32k 30-Day 10° x 10°
Data Status

- Ver.1 of IWP/IWC retrievals available for entire TWP-ICE period, 10x10 deg. centered at Darwin. Downloadable from http://cirrus.met.fsu.edu/data/armdownload.html
- Continued Validation/Improvement, Will archive as PI-product (March 2000 SGP data have been archived)
- Want to know needs from modeling group.
- Please use our data. email me: liug@met.fsu.edu
Objectives & Approach

**Objectives**

By combining surface radar and satellite data, we derive
- Ice water path over a large area (10° x 10°)
- Vertical ice water content distribution over a large area
- The above two combined is 3-D ice water content distribution
  - Can be used to calculate ice water advection terms for single column model inputs

**Approach**

- Surface radar (MMCR) provides detailed, high-quality characteristics of ice water content vertical distribution
- Satellite (NOAA AMSU-B/MHS) provides broad horizontal coverage
- Use surface radar data to generate database for satellite retrievals, use satellite data to broaden the area coverage
  - From point-measurement to area measurement