Cirrus Production by a Mesoscale Convective System Sampled During TWP-ICE: Analysis via Water Budget Equations

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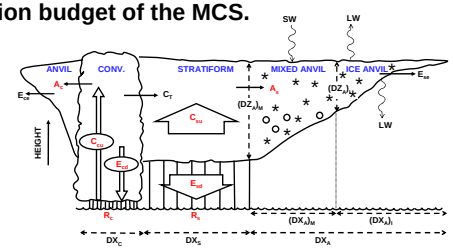
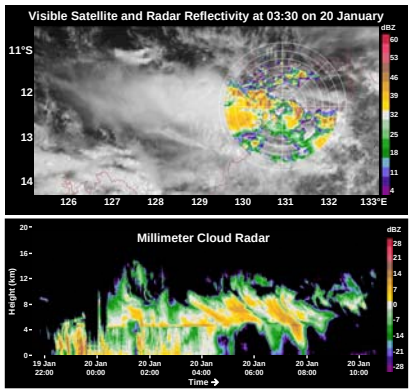
Introduction

This study computes certain elements of the water budget of a MCS observed during the Tropical Warm Pool-International Cloud Experiment (TWP-ICE). The precipitation efficiency can help relate global maps of precipitation to maps of global anvil coverage, and the amount of cirrus produced by the system affects the radiation budget of the MCS.



$$C_{cu} = R_c + E_{cd} + A_c + C_T$$
$$C_T + C_{su} = R_s + E_{sd} + A_s$$

MCS Overview



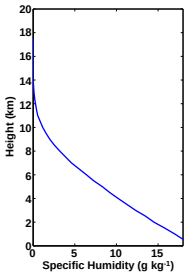
- A large MCS moved toward the north over the radar sites on 19-20 January 2006
- MCS was mainly leading convective precipitation and trailing stratiform
- Anvil blown off toward the WNW by upper-level winds
- Total precipitation area coverage of storm uncertain: between 1 and 2 times the actual radar area coverage

Condensation and Evaporation

- Humidity profile computed from Darwin radiosonde
- Vertical velocity profiles of updrafts and downdrafts in the convective and stratiform regions computed from dual-Doppler radar data
- Condensation and evaporation terms calculated from the following equations:

$$C = -A\tau \int_{z_b}^{z_t} \rho w_u \frac{dq}{dz} dz$$

$$E = A\tau \int_{z_b}^{z_t} \rho w_d \frac{dq}{dz} dz$$



Results over radar domain:

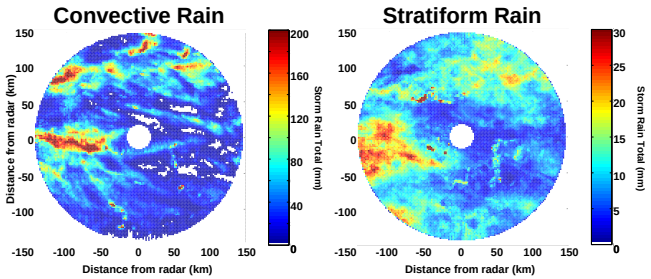
C_{cu}=3.3627×10^{13} kg

E_{cd}=1.8498×10^{13} kg

C_{su}=2.7560×10^{13} kg

E_{sd}=3.8781×10^{13} kg

Precipitation



- Convective/stratiform maps computed from radar data
- Maps applied to reflectivity data to give convective and stratiform rain totals in the radar domain

Results over radar domain:

R_c=2.8586×10^{12} kg

R_s=6.7226×10^{11} kg

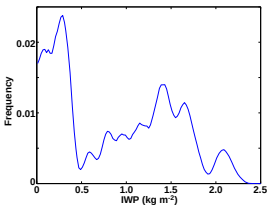
$R=R_c+R_s$=3.5208×10^{12} kg

Summary and Future Work

- Anvil mass is approximately 10% of the total rain precipitated out by the system in the radar domain
- Errors in MMCR data amplify in calculations of anvil mass
- Next steps: Extend to another MCS (23-24 Jan)
  Determine error bars on calculations
  Extend to other tropical regions

Anvil

- Ice water content (IWC) calculated for anvil seen by MMCR via a Z-IWC relationship: IWC=0.097Z$^{0.59}$
- Histogram of ice water path (IWP) calculated for the anvil; applied to the area covered by anvil in the satellite to get the mass of total anvil (A_c+A_s)
- MMCR sensitivity was low during TWP-ICE, resulting in underestimation of IWC in anvil and thus total anvil mass
- Some anvil will not be accounted for as it evaporates



Results of anvil from satellite/MMCR method:

A_c+A_s=3.3244×10^{11} kg

Results of anvil as a residual of other terms:

$A_c+A_s=C_{cu}+C_{su}-E_{cd}-E_{sd}-R_c-R_s$
between 3.077×10^{11} kg and 6.154 ×10^{11} kg
(for areas between 1 and 2 times the radar area coverage)

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