Comparison of Convective Anvil and Isolated Cirrus Cloud Properties and Radiative Forcing over the SGP through an Integrated Analysis of NEXRAD, GOES, and MMCR Data

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Objective

1. Develop an objective classification technique to identify Deep Convective Systems (DCS) and separate their rain core, connected anvil with isolated cirrus clouds using merged radar and GOES observations
2. Compare microphysical properties and radiative impact between DCS anvil and isolated cirrus cloud over the mid-latitudes

Dataset

NEXRAD Q2 Product (NSSL)

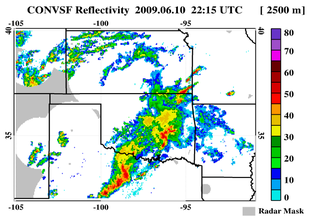
- 3D Mosaic reflectivity over the SGP region (8×15°)

GOES Cloud Product (NASA Langley)

- Pixel-level cloud property retrievals

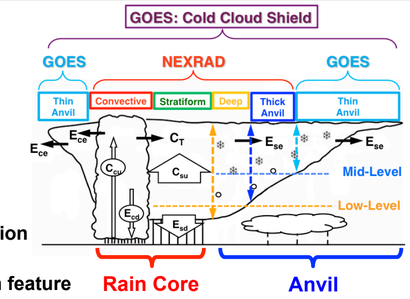
Time Period: 2009-2010 Summers - JJA (6 months)

Cirrus microphysics Retrieval from MMCR (Min Deng)



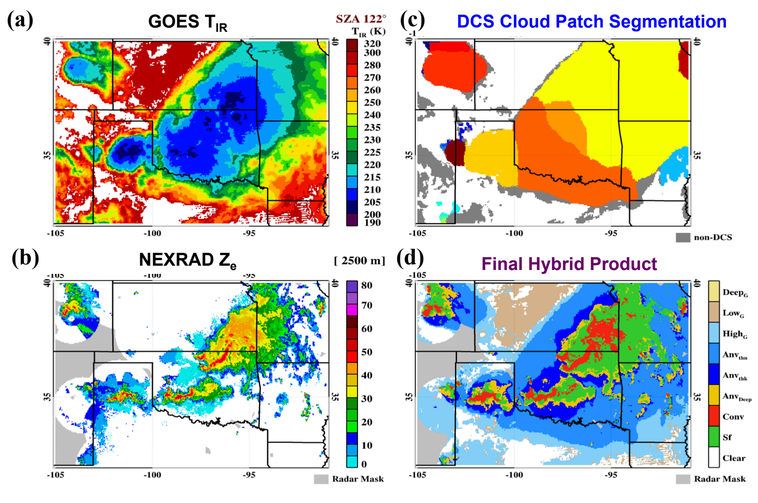
Hybrid Classification

- Segment cloud patch using GOES T_{IR}
- Examine NEXRAD rain feature within each patch to identify DCS (b, c)
- Combine radar classification with GOES cloud product for final product

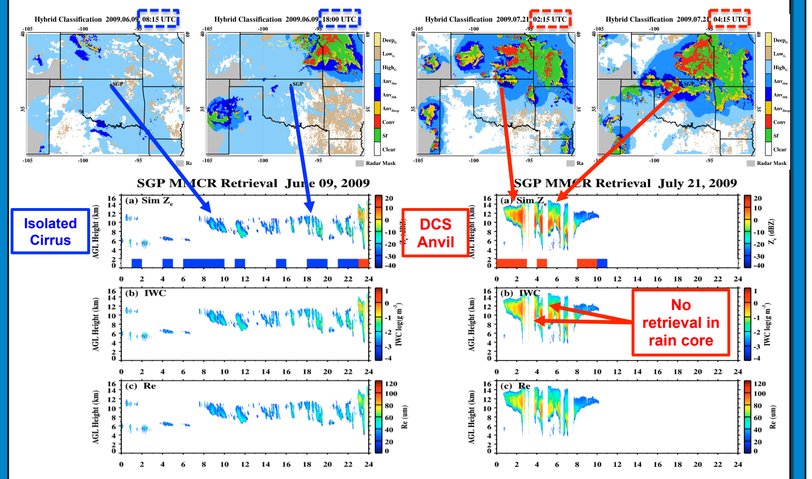


Use Hybrid Mask to define:

- **DCS anvil:** still attached to convection
- **Isolated cirrus:** high cloud patch (z_t > 6 km, z_b > 3 km) without rain feature

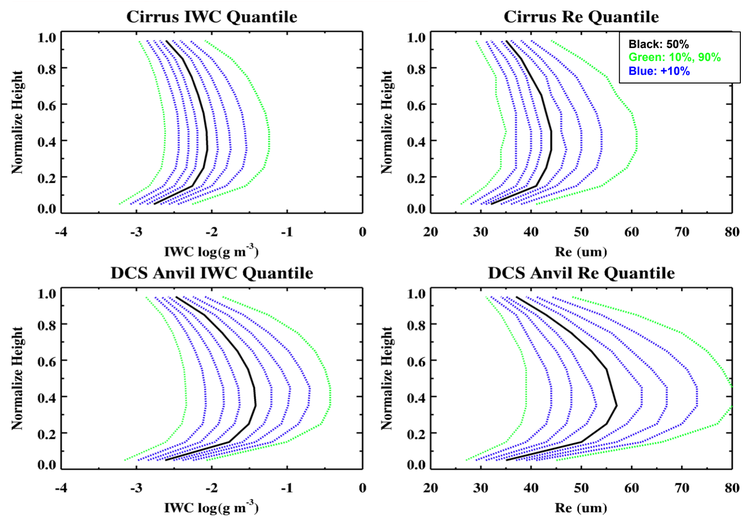


Separate DCS Anvil with Isolated Cirrus



- MMCR cirrus retrieval (Deng & Mace 2006)
  - Use 3 Doppler radar moments to retrieve cirrus microphysics and mean air vertical motion
- Hourly Hybrid Classification near SGP site is used to separate DCS anvil from isolated cirrus
  - Assume cloud type is consistent within an hour
- IWC, R_e statistics are computed in JJA 2009

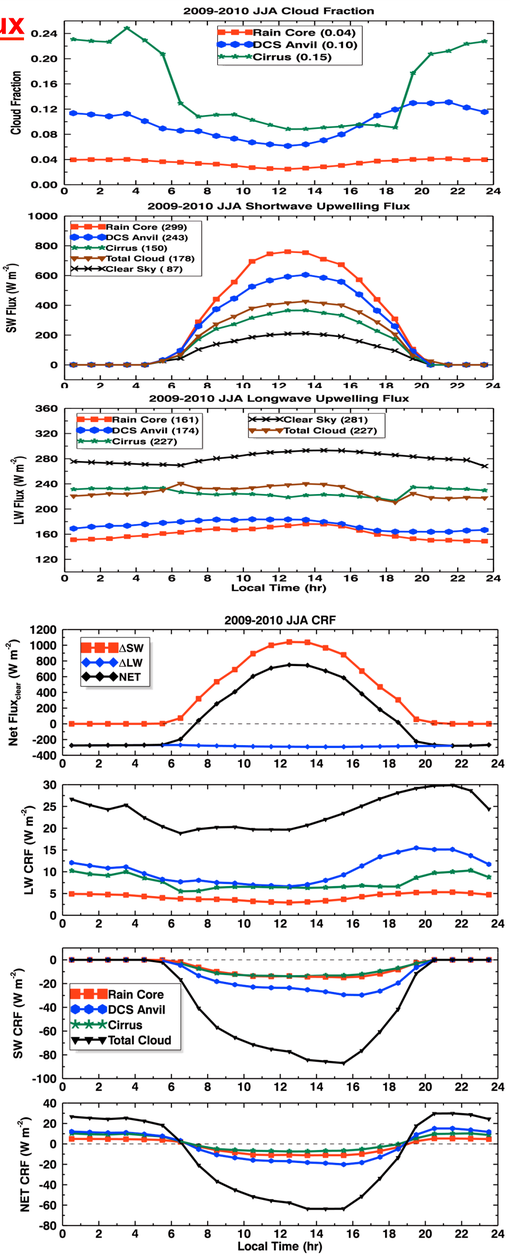
Microphysics Comparison



- **Single layer cloud**, normalized height (z_b: 0, z_t: 1)
- Anvil IWC, R_e:
  - Values consistently higher than cirrus, variance is also larger
- Peak values around 0.3 above cloud base
- Near cloud base sublimation causes decrease of IWC, R_e
- Expect higher radiative heating/cooling rate from anvil
- DCS Anvil could have stronger turbulence, need to further estimate uncertainty

Cloud Fraction and TOA Flux

- There is strong diurnal cycle in **DCS anvil** (dips at local noon, peaks at early evening), but the diurnal cycle of **DCS rain core** fraction is relatively weak.
- Significant difference in **cirrus** cloud fraction due to different day/night GOES retrieval methods.
- TOA SW upwelling flux from **DCS anvil** is 56 Wm^{-2} lower than **rain core**, but is 93 Wm^{-2} higher than **isolated cirrus.**
- OLR from **DCS anvil** is 13 Wm^{-2} higher than **rain core**, but is 53 Wm^{-2} less than **isolated cirrus.** Diurnal problem in **cirrus** ➔ mean LW CRF error of ~3 Wm^{-2}



CRFs weighted by CFs

	SW	LW	NET
Total Cloud	-35.5	23.8	-11.8
Rain Core	-6.3	4.2	-2.1
DCS Anvil	-12.1	10.4	-1.8
Cirrus	-6.1	7.7	1.6

Units: W m^{-2}

CRF Contribution

	SW	LW	NET
Total Cloud	-35.5	23.8	-11.8
Rain Core	18%	18%	18%
DCS Anvil	34%	44%	38%
Cirrus	17%	32%	23%

Rain Core = Convective + Stratiform rain
DCS Anvil = Deep + Thick + Thin Anvil

Summary

1) Hybrid classification can identify DCS clouds, separate rain cores from non-precipitating anvil and isolated cirrus clouds.
2) DCS anvils have noticeably higher IWC and larger particle size than isolated cirrus clouds, as well as larger variances.
3) During summer months over the SGP, total clouds have -11.8 Wm^{-2} net cooling effect, where DCS anvil (isolated cirrus) contributes 34% (17%) in SW CRF, 44% (32%) in LW CRF, and 38% (23%) in NET CRF.
4) Hybrid method provides ground work for studying mid-latitude DCS life cycle (where NEXRAD + GOES available).