# The Difference Between Thin and Thick Fair-weather Shallow Cumulus Inferred from ARM Observations over the Southern Great Plains

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## Introduction

Shallow cumulus clouds occur very often during summertime over large areas at Southern Great Plains. On some days one observes only forced clouds whereas on other days active clouds are present either alone or in combination with forced clouds. (Fig. 1)

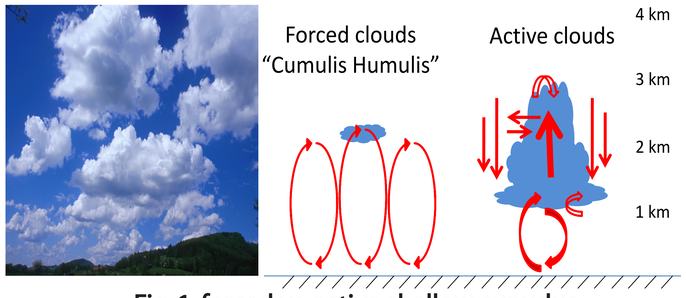


Fig. 1: forced vs. active shallow cumulus

We expect that dynamic and thermodynamic cloud properties to be different between forced and active clouds. We use 13 years (1997-2009) of ACRF SGP observations of daytime shallow cumulus to ask the following questions:

1. How different are cloud properties and their radiative impacts between days with "thin" versus "thick" clouds?
2. How do environmental conditions differ between days with thin and thick clouds and do the differences provide any clues as to what controls the vertical extent of shallow cumuli?

### Case Selection Criteria (Fig.2)

1. No precipitation
2. Boundary layer development under 4 km
3. Gradually rising cloud base
4. Diurnally varying cloud fraction and thickness
5. Less affected by previous night conditions
6. Not or less affected by other weather phenomena

### Data Used for case selection

1. ABRFC precipitation 2. ARSCL cloud data 3. Satellite Images (NASA Langley Minnis Group) 4. Total Sky Imager images 5. Shallow cumulus index (2000-2007) (Berg and Kassianov, 2008)

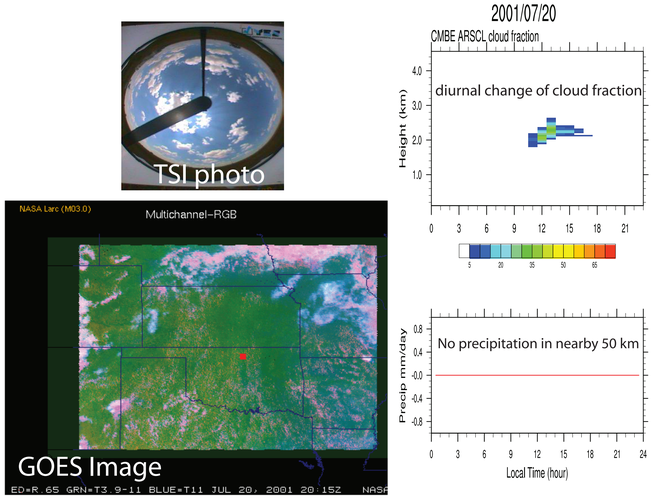


Fig. 2: An example of fair-weather shallow cumulus day

## Comparing cloud properties and their radiative impacts

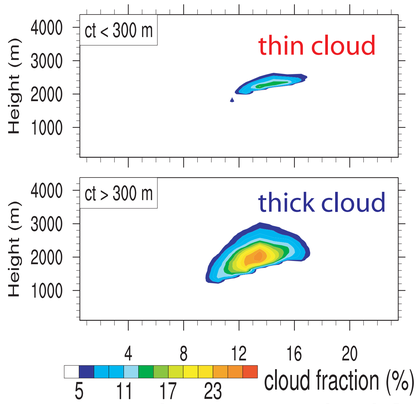


Fig. 3: Diurnal composite cloud fraction. Composites are based on daily mean cloud thickness (ct>300 or ct<300) of the lowest-level cloud as determined from 10 sec ARSCL data

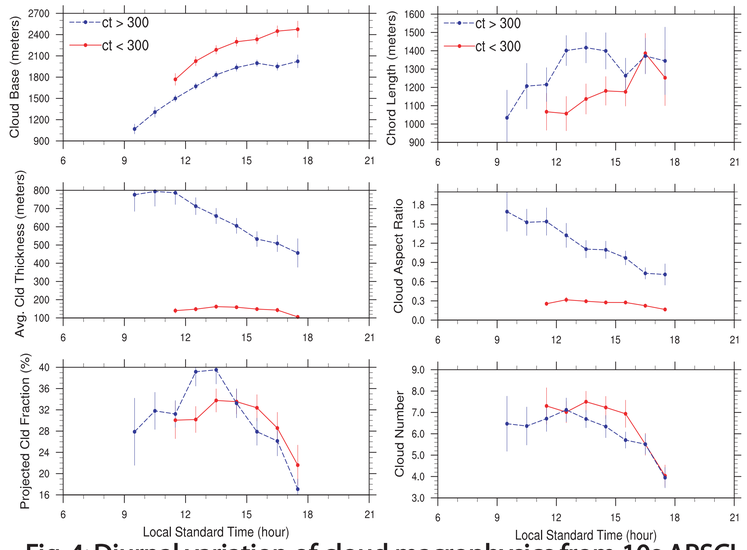


Fig. 4: Diurnal variation of cloud macrophysics from 10s ARSCL

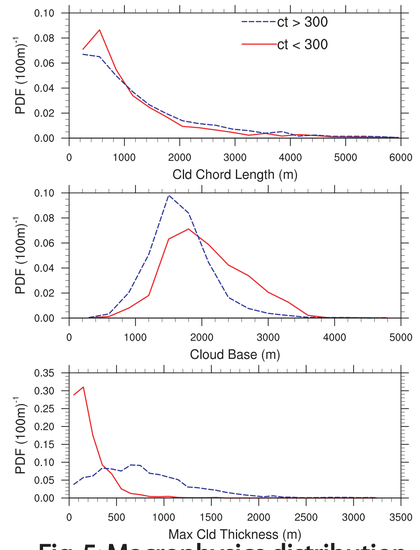


Fig. 5: Macrophysics distribution

MWRRET time-mean LWP composite shows a surprisingly small difference between thick and thin cloud days. Consistent with the LWP, the difference in downward shortwave is also surprisingly small. Based on cloud depth and LWP, rough estimate liquid water contents of 0.33 g m-3 for thin days and 0.15 g m-3 for thick days. Are these correct? If they are correct, is this the result of greater mixing in the thicker cloud days?

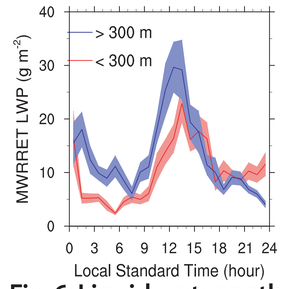


Fig. 6: Liquid water path

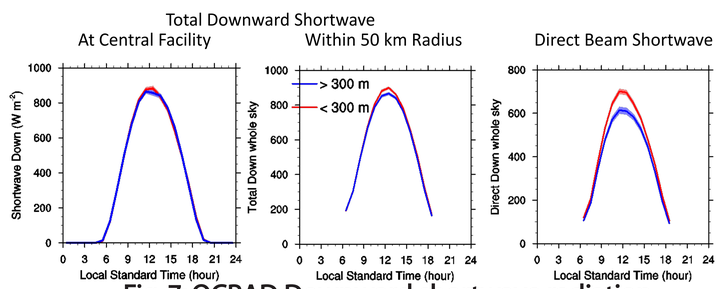


Fig. 7: QCRAD Downward shortwave radiation

## Comparing Environmental conditions

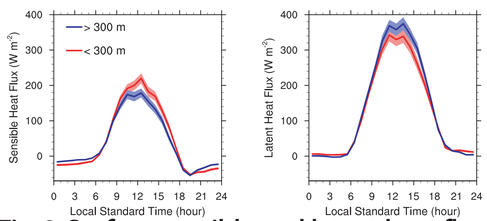


Fig. 8: Surface sensible and latent heat flux

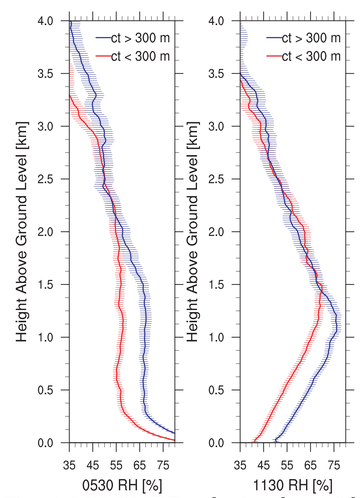


Fig. 9: LSSONDE relative humidity

Relative humidity is higher on days with thicker clouds. While greater relative humidity may explain the earlier onset and lower cloud base, the physical mechanism for greater cloud thickness is not yet clear.

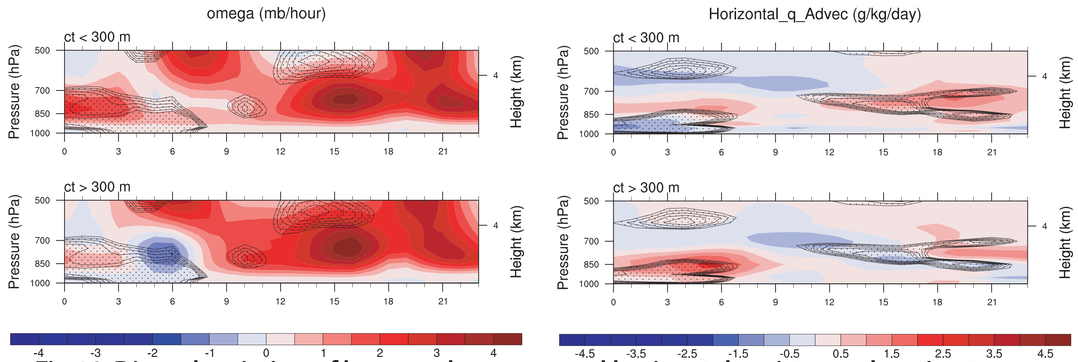


Fig. 10: Diurnal variation of large-scale omega and horizontal moisture advection tendency at SGP region from long-term continuous forcing data (99% sig. level in stipple)

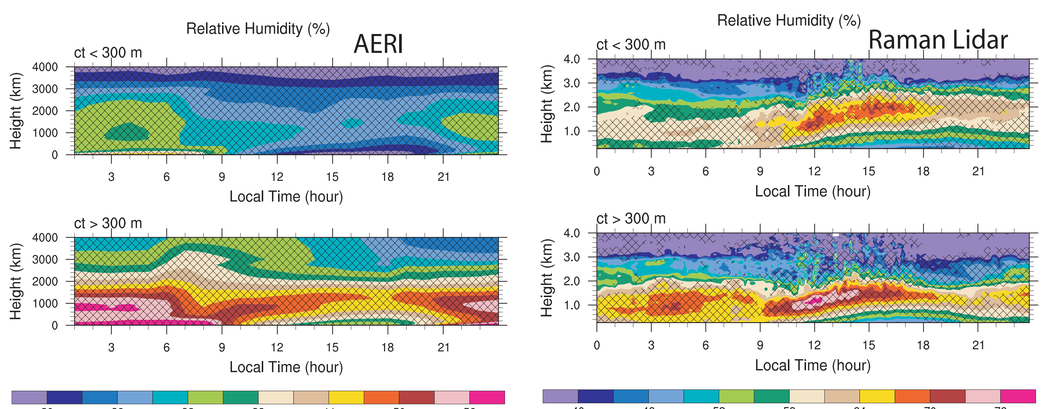


Fig. 11: Diurnal variation of relative humidity from continuous measurement (99% sig. level in cross)

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