Initial Evaluation of the Cumulus Potential Scheme at the ACRF SGP Site

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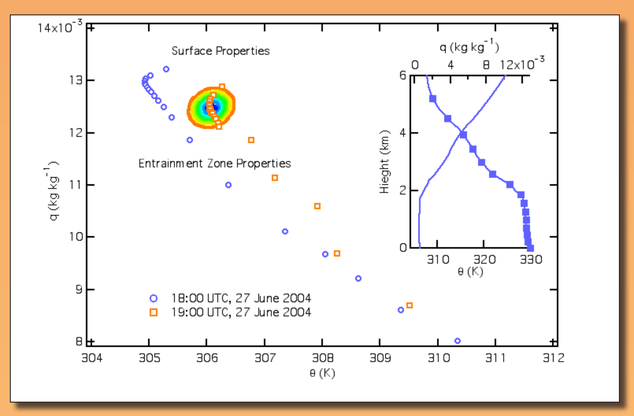
1. Motivation

Shallow clouds are poorly predicted by current global and regional scale models. A new parameterization has been developed that links the boundary-layer turbulence and the shallow clouds.

2. The CuP Parameterization

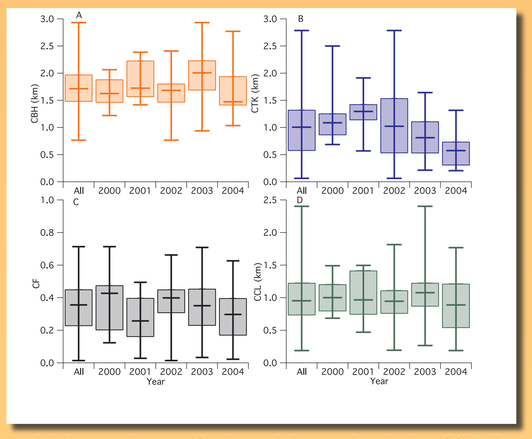
- The Cumulus Potential (CuP) parameterization uses Probability Density Functions (PDFs) of temperature and moisture to represent the subgrid scale processes (Berg and Stull 2005).
- PDFs represent the range of parcel properties within the grid box.
- PDFs are mixtures of air from the surface, the mixed layer, and the entrainment zone at the boundary-layer top.



Mixing diagram of water vapor mixing ratio (q) and potential temperature (θ) computed from WRF output at 18:00 and 19:00 UTC on 27 June, 2004. Colored contours show the PDF computed from the surface, mixed layer and entrainment zone properties (Berg and Stull 2004).

3. New Cloud Climatology

- Computed for the summers (May-August) 2000 through 2004 (Berg and Kassianov 2008).
- Uses ARSCL VAP, Total Sky Imager, and radar wind profiler.

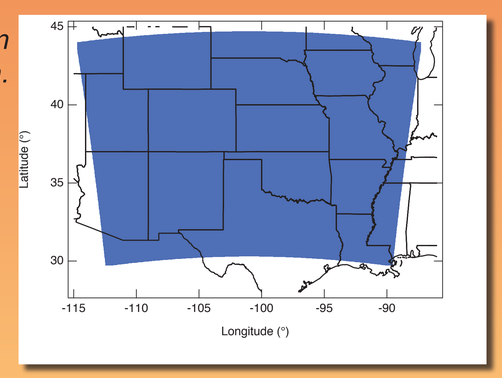


Box and whisker plots of cloud-base height (CBH; A), cloud thickness (CTK; B), cloud fraction (CF, C), and cloud-chord length (CCL; D) computed for the summers of 2000 through 2004. Solid line within the box indicates the median, the box indicates the 75th and 25th percentile, and the error bars indicate the maximum and minimum.

4. Implementation in WRF

- The CuP scheme was implemented in the standard Kain-Fritsch scheme (Kain and Fritsch 1990; Kain 2004).
- The trigger function has been replaced by PDFs.
- Domain: 131 x 131 x 45, 12 km grid spacing
- Physics: Thompson microphysics,
  CAM radiation,
  Noah land surface model,
  YSU PBL

WRF simulation domain.



Issues related to cloud fraction

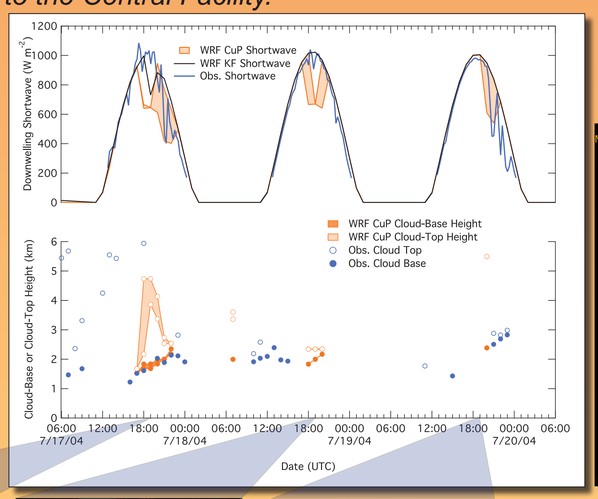
Parametrization calling order in WRF leads to the premature evaporation of shallow clouds!

Solution: Prescribe cloud fraction & mass for radiation

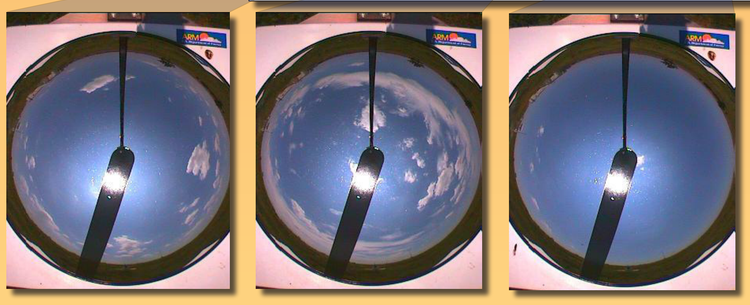
5. Case Studies Results

- Simulations for 17, 18, 19 July 2004
- Control simulations made with standard KF scheme (WRF KF)
- Experimental simulations made with CuP scheme (WRF CuP)
- Shallow clouds predicted by WRF CuP at grid points near the Central Facility
- Cloud properties are consistent with climatology

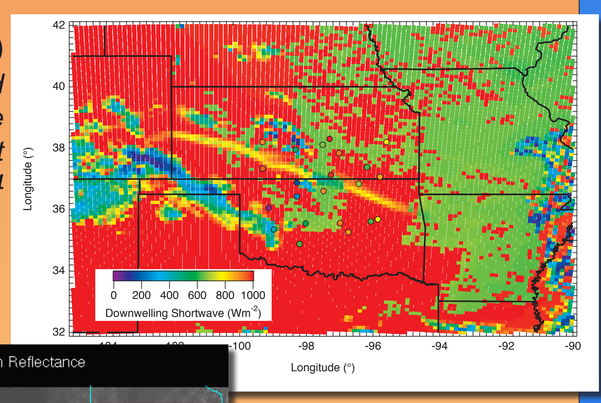
Time series of WRF CuP predicted (orange), WRF KF predicted (black) and observed (blue) downwelling shortwave radition (top); WRF CuP predicted (orange) and observed (black) cloud-base and cloud-top height (middle). Shading indicates range of values of the four grid points closest to the Central Facility.

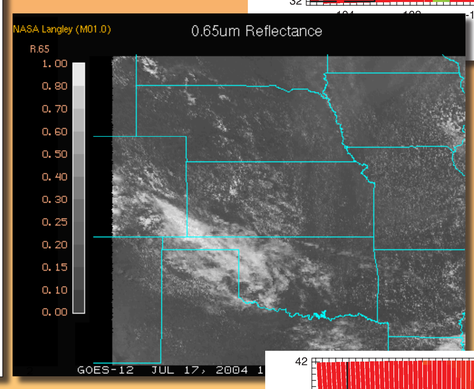


TSI images for 19 UTC on 17, 18, and 19 July, 2004



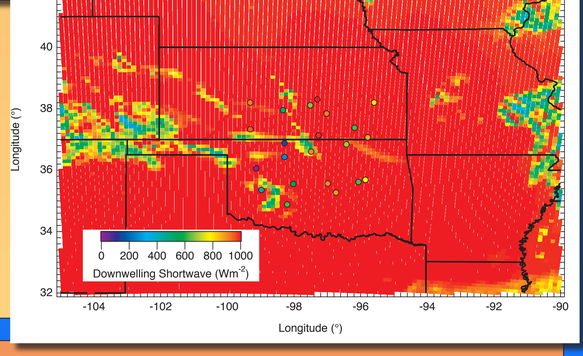
WRF CuP (shading) and observed downwelling shortwave radiation (circles) at 19 UTC, 17 July 2004





Observed reflectance at 19:15 UTC, 17 July 2004 (image courtesy of NASA LARC)

WRF KF (shading) and observed downwelling shortwave radiation (circles) at 19 UTC, 17 July 2004



6. Results

- CuP parameterization has been linked with WRF.
- Simulations with the new scheme have increased amounts of shallow clouds.
- Cloud-base height and cloud-top height are consistent with climatology.

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