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

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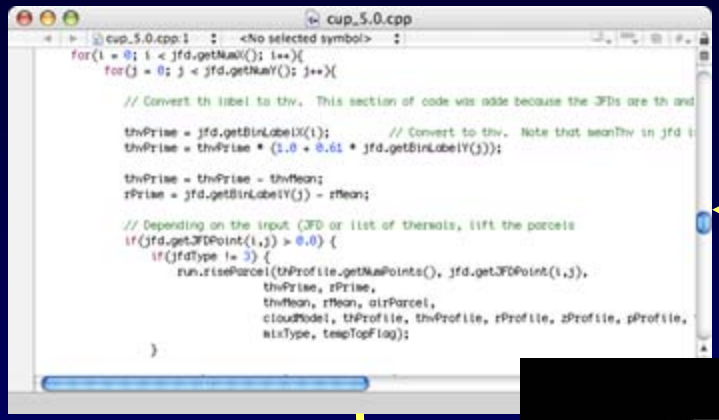
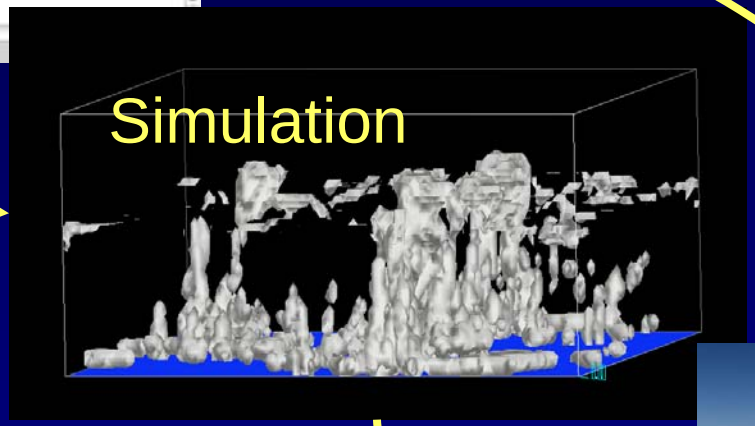
Where are We Going?

Development

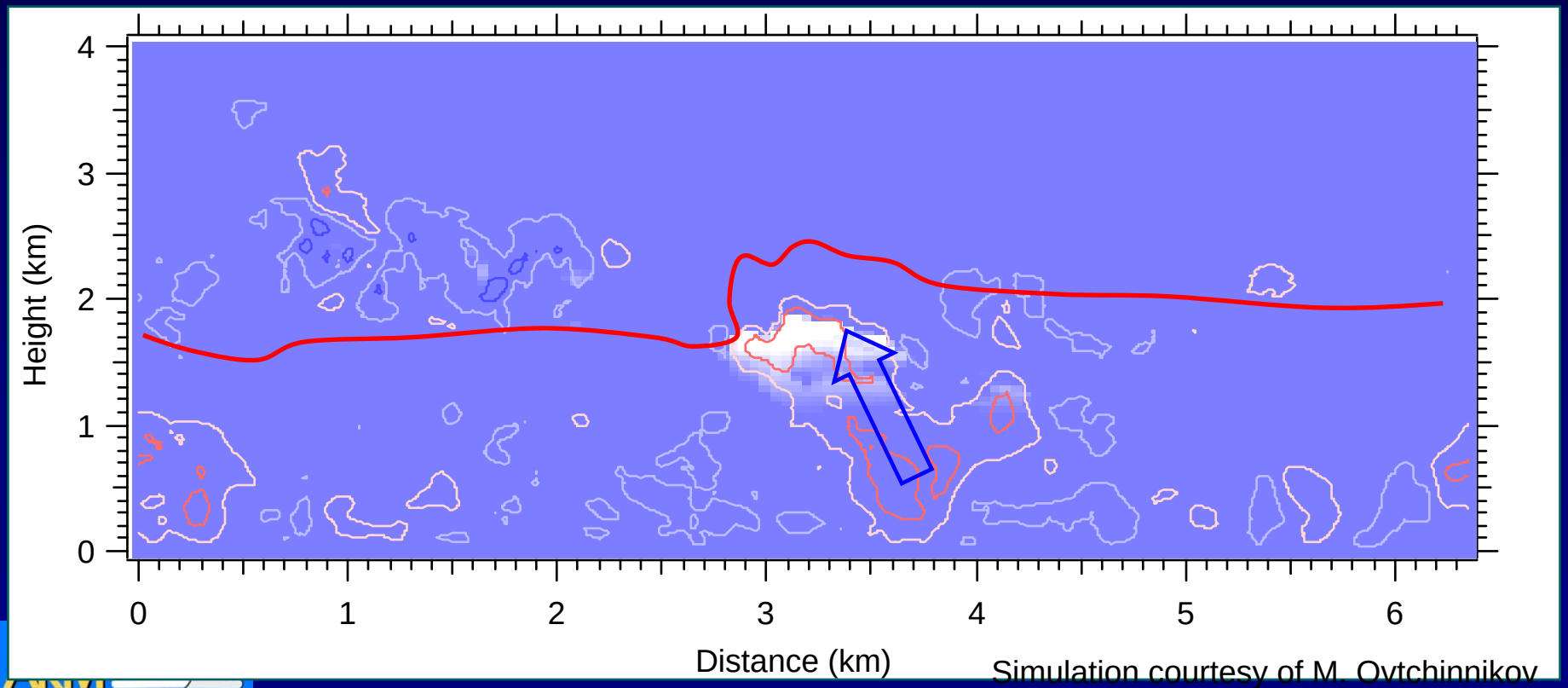




Observations

Development: Coupling Clouds to the Convective Boundary Layer

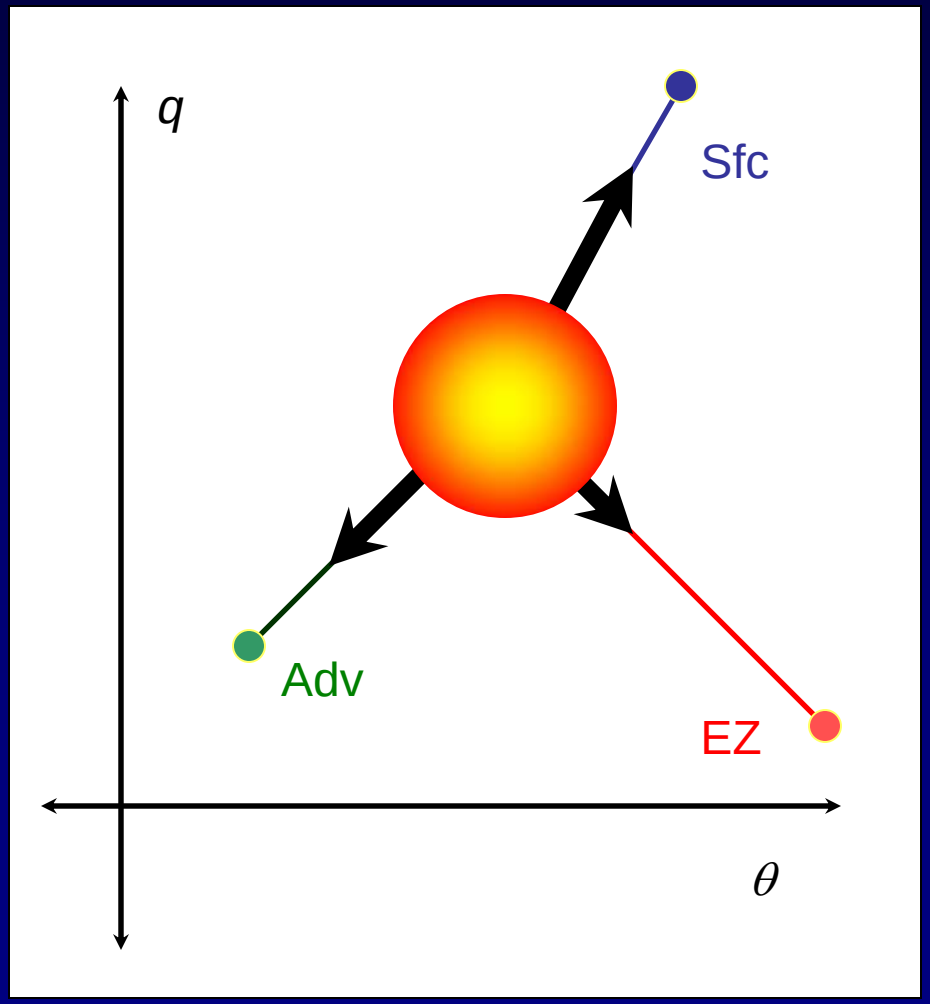
- Shallow cumuli are turbulently coupled to the planetary boundary layer



Simulation courtesy of M. Ovtchinnikov

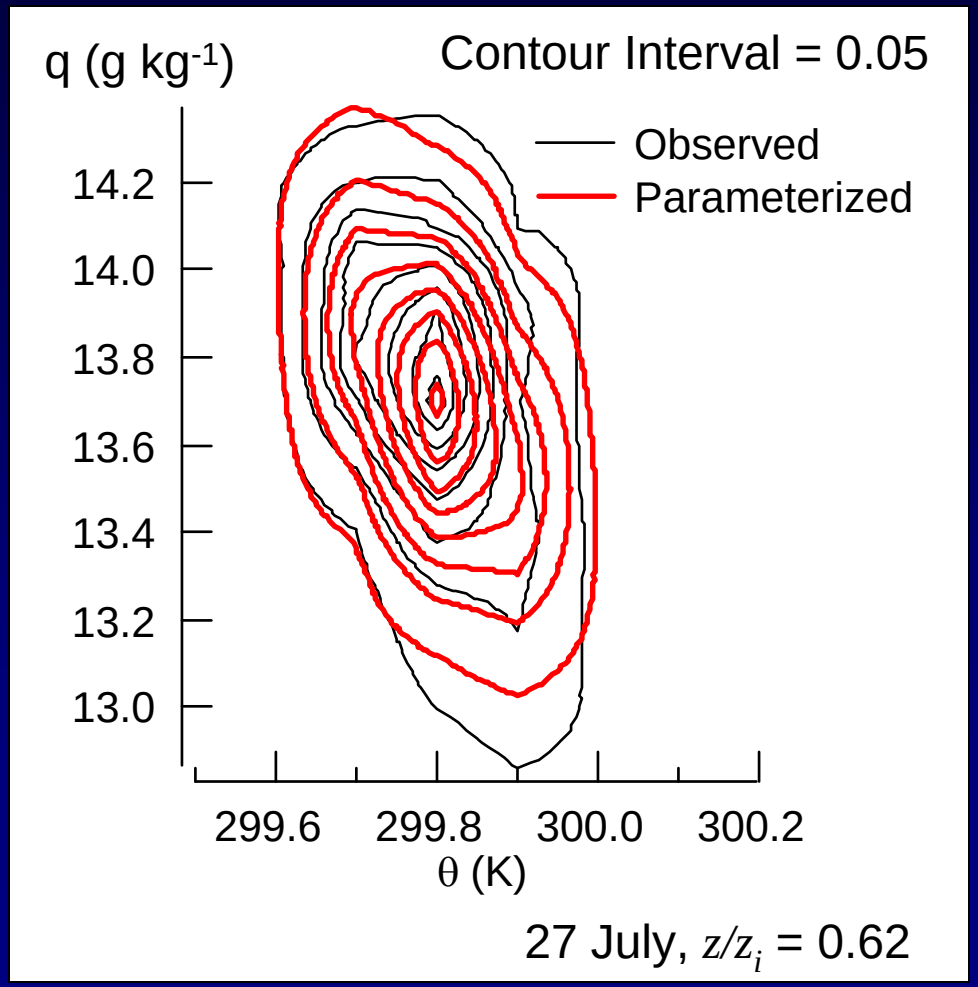
Development: Coupling Clouds to the Convective Boundary Layer

- Parameterization should represent this coupling
- The Cumulus Potential (CuP) scheme is one way
  - Accounts for sub-grid variability of the parcel temperature and humidity using a mixing diagram approach
  - Can be used with any boundary-layer parameterization

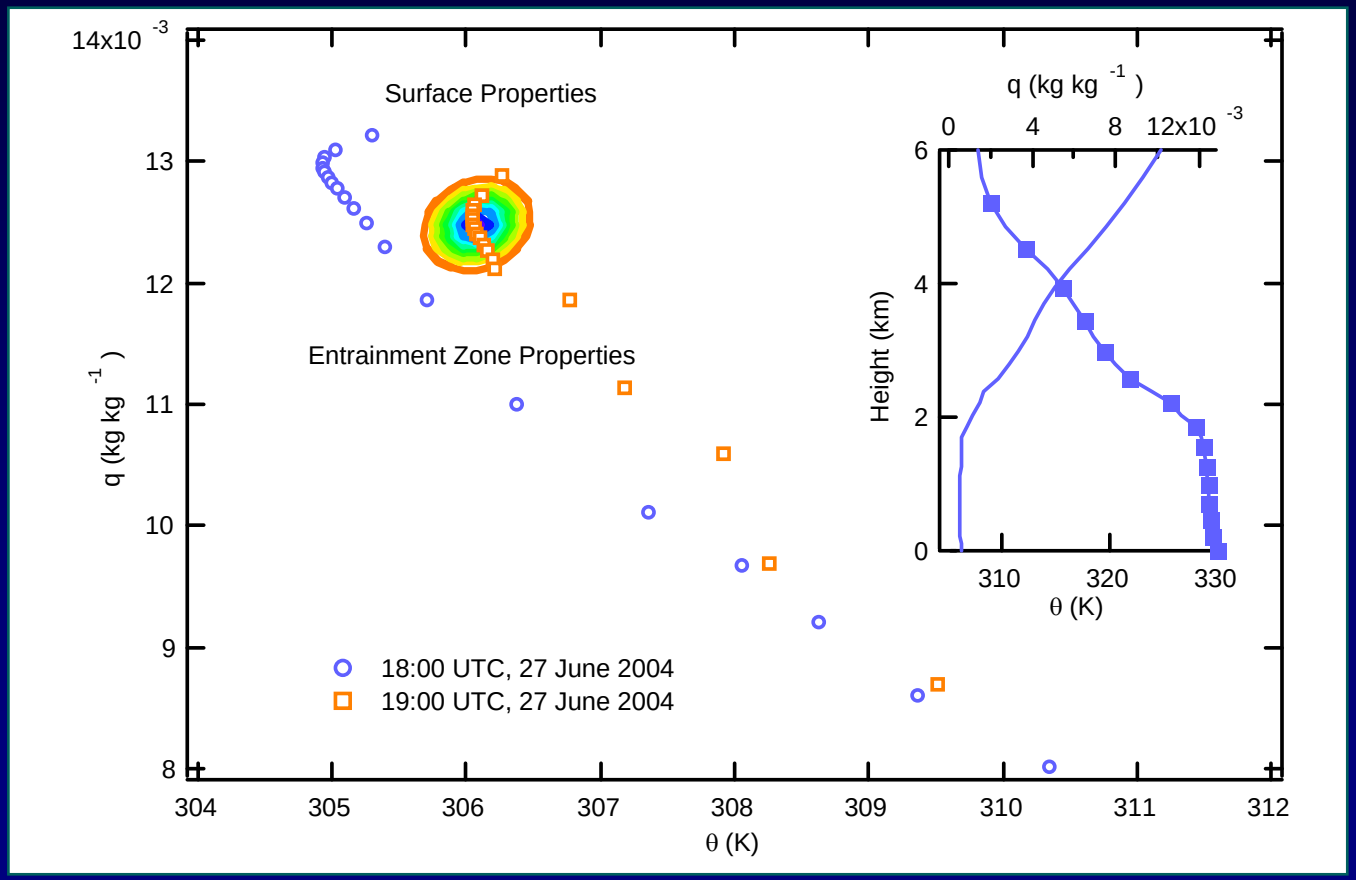


Development: Sample Distribution

- Data collected during BLX96
- Used methods described by Berg and Stull (2004) to parameterize Joint Probability Density Functions (JPDFs)



Development: Coupling Clouds to the Convective Boundary Layer



Simulation: Modeling Strategy

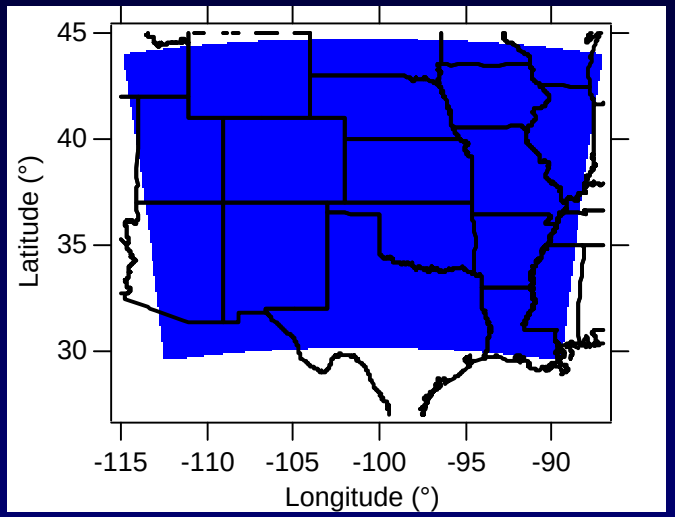
- Weather Research and Forecast (WRF) model
- Why WRF?
  - Relevant for regional scale modeling and downscaling
  - Allows for easy case study analysis
  - Support for CLASIC

Simulation: WRF Setup

- Kain-Fritsch cumulus scheme
  - Entraining-detraining cloud model
  - Has been modified to include shallow clouds
  - Uses ad hoc temperature perturbation for parcels
- Control simulations
  - Standard KF
  - WRF KF
- Experimental simulations
  - Use JPDFs based on thermodynamic profile
  - WRF CuP
- Goal: Run simulations for a season or seasons

Simulation: WRF Setup

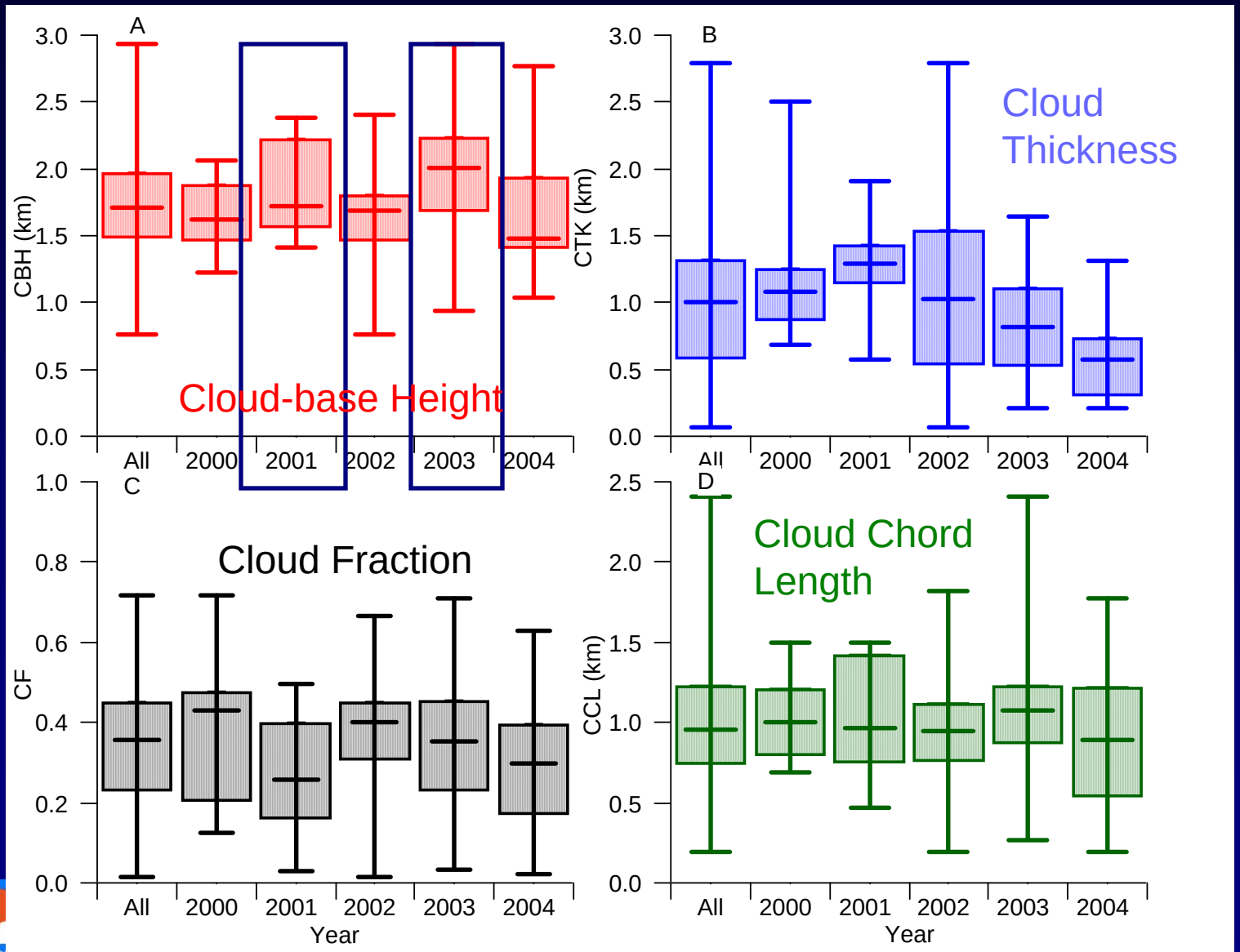
- Domain
  - 131 x 131 x 45
  - 12 km horizontal grid spacing
- Simulations have been started for a season (summer of 2004)
  - Boundary conditions from NARR
  - Reinitialize daily with 12 hr overlap.
  - Cycle soil moisture and cloud fields to minimize spin-up error
- Physics
  - Microphysics: Lin et al. or Thompson
  - Radiation: CAM shortwave and longwave
  - Surface Layer: MM5 surface layer (based on Monin-Obukov)
  - Land Surface: Noah land surface model
  - PBL: YSU
  - Cumulus: Kain-Fritsch



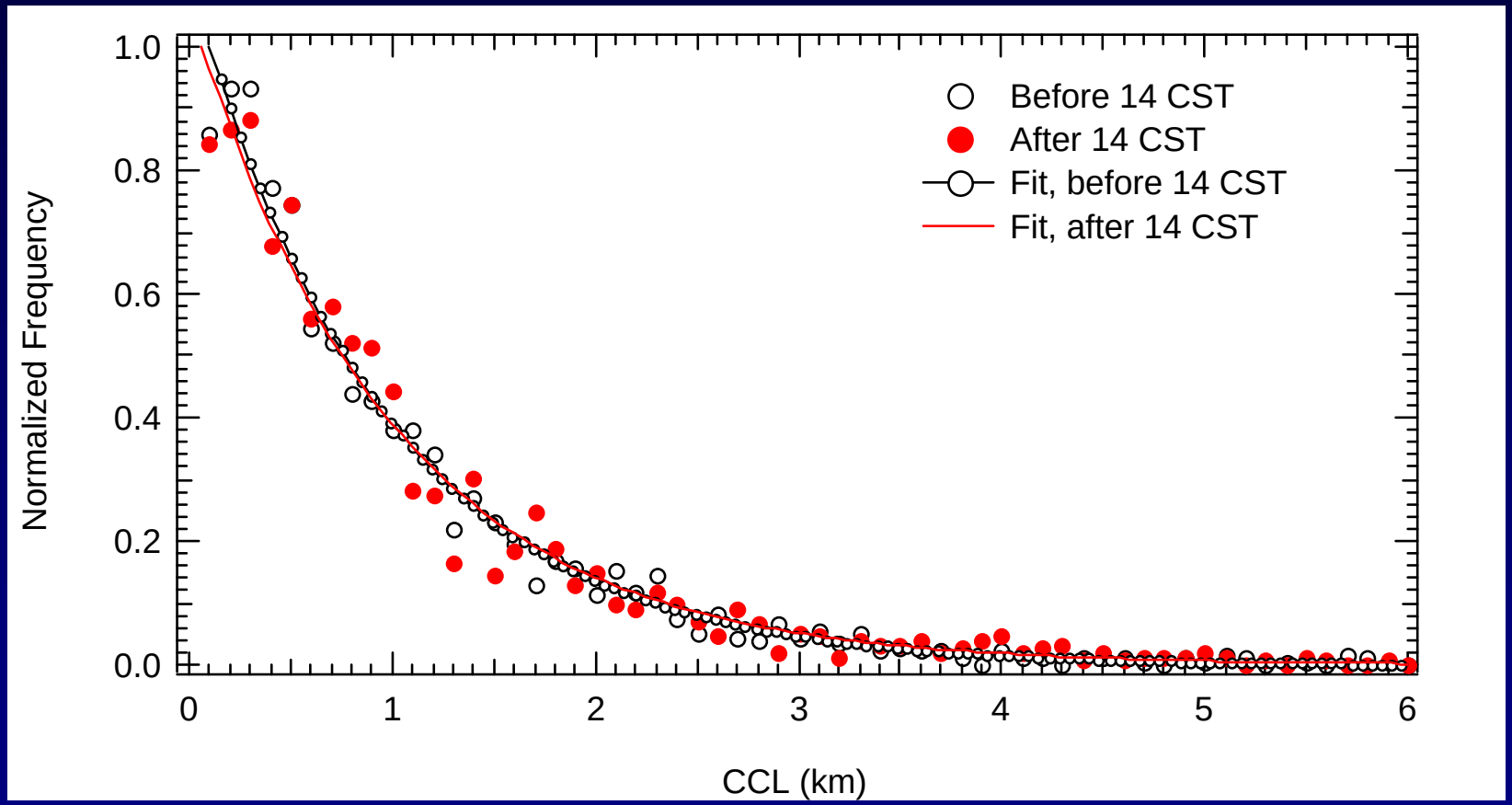
Evaluation: New Data Sets

- Need long-term data sets for proper evaluation of new parameterizations
- A new climatology of shallow Cumuli has been developed (Berg and Kassianov 2008)
  - ARSCL VAP
  - Wind profiler
  - TSI
  - Five summers, 2000-2004

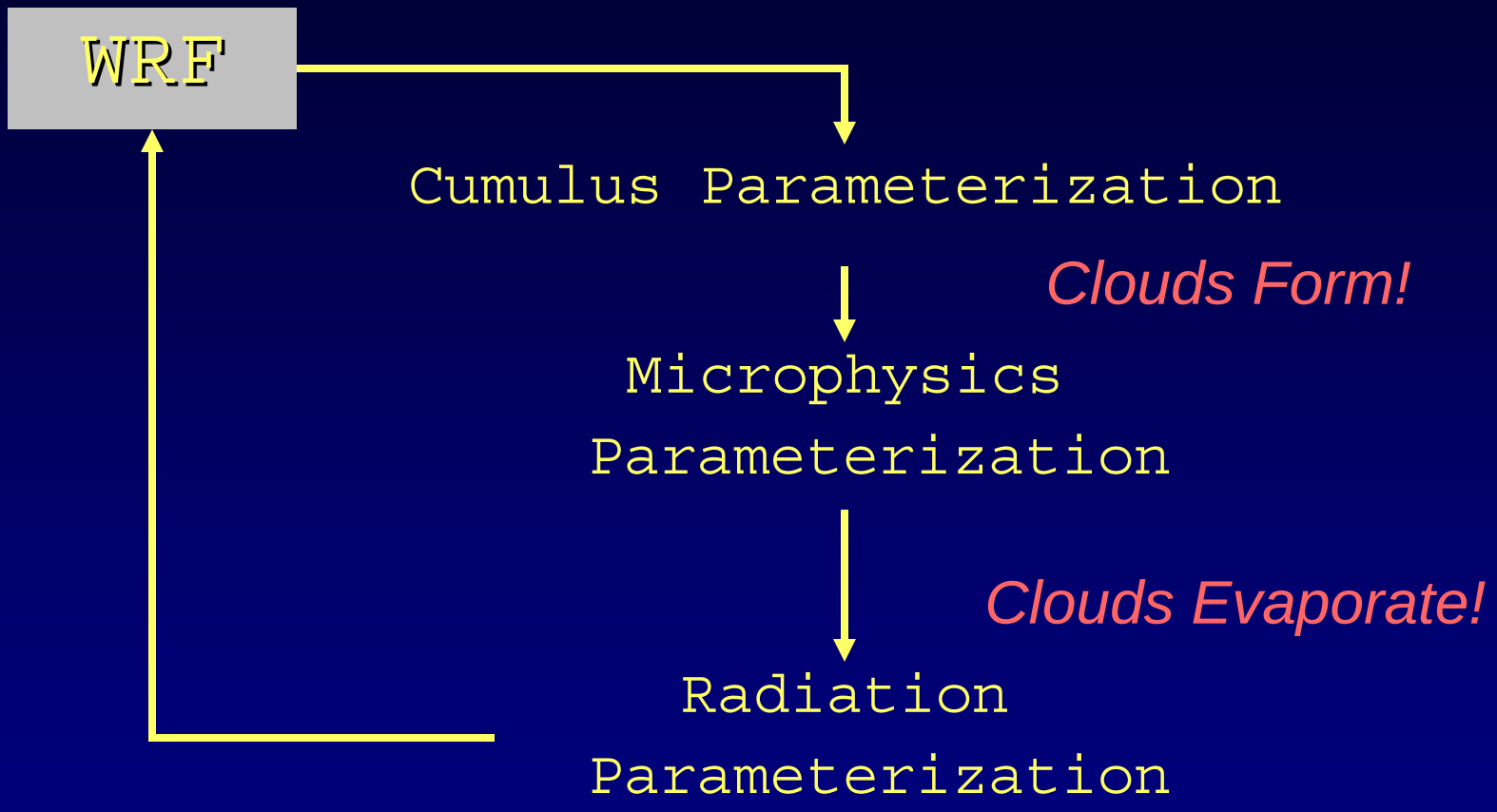
Evaluation: Cloud Properties



Evaluation: Cloud Chord Lengths

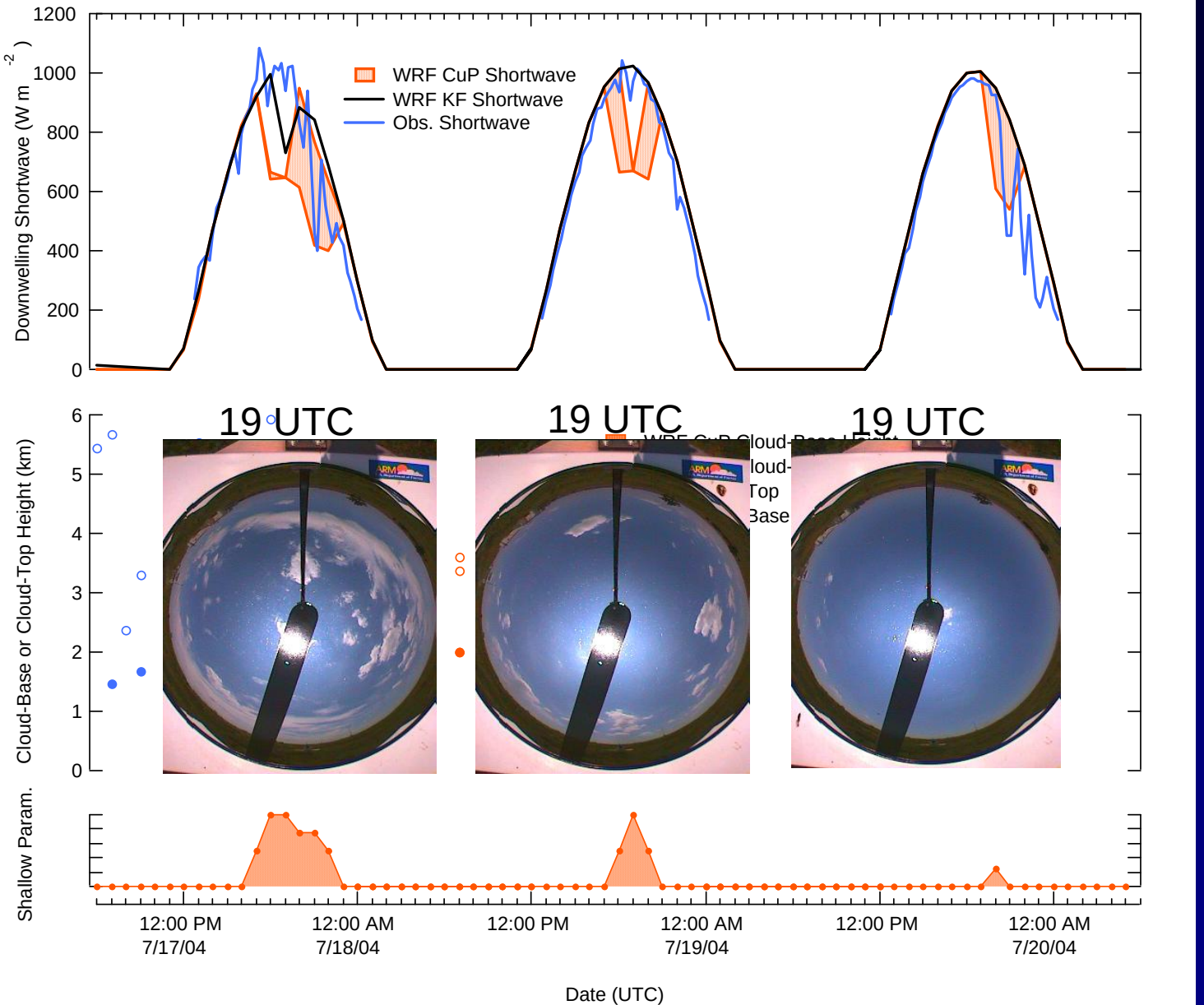


Evaluation: Shortcomings

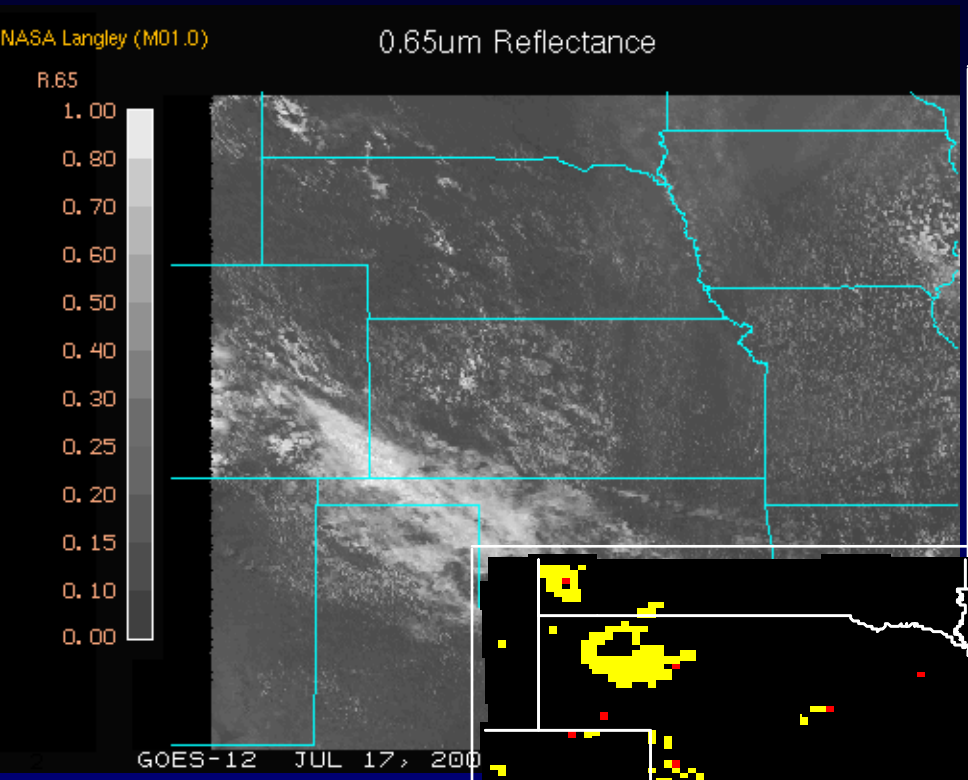


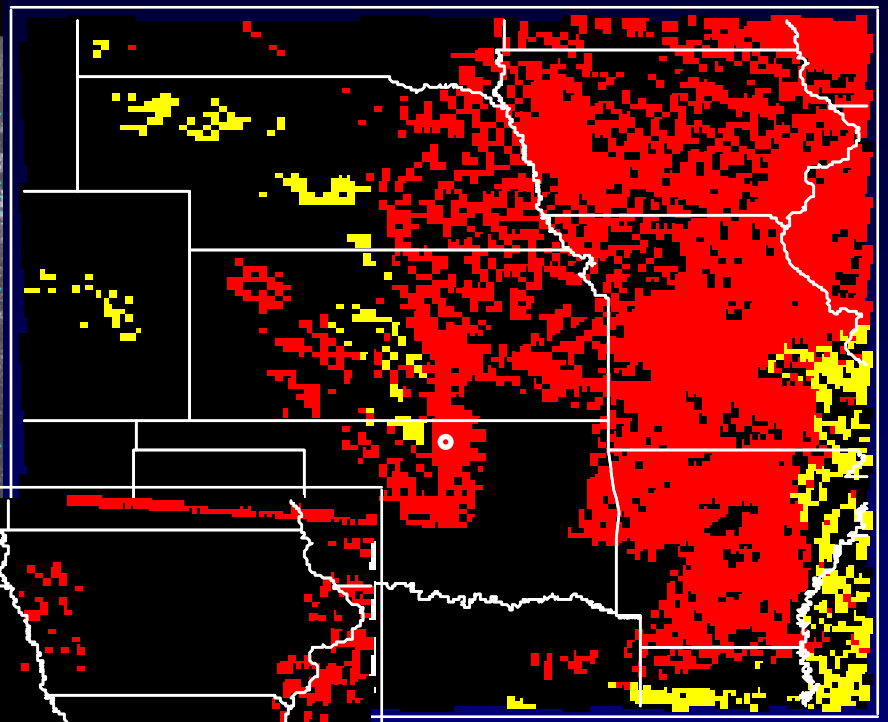
Solution: Prescribe cloud fraction

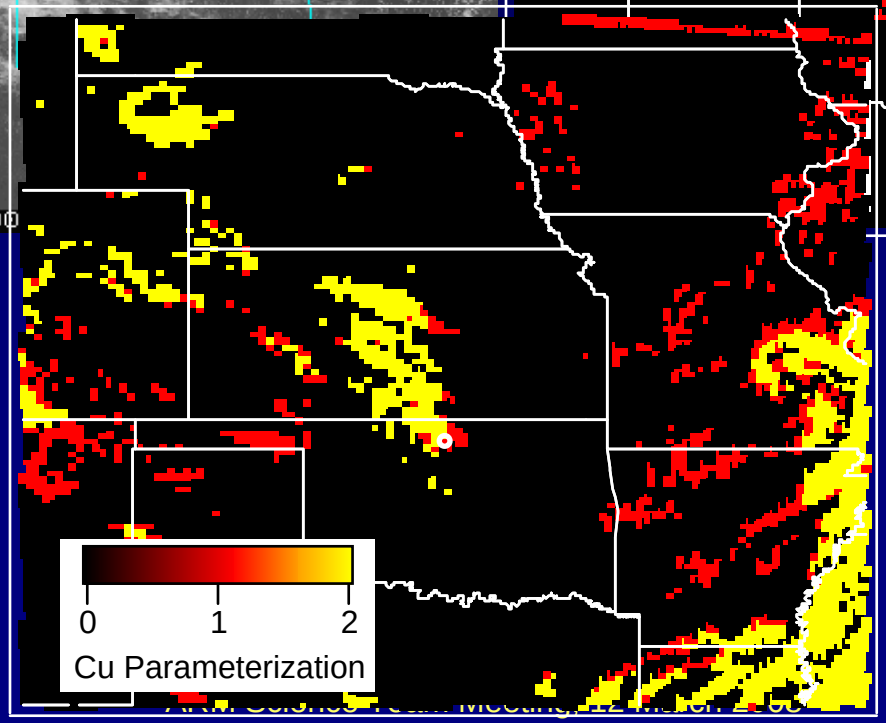
Evaluation: Downwelling Shortwave



Evaluation: Shallow Clouds







WRF KF

WRF CuP

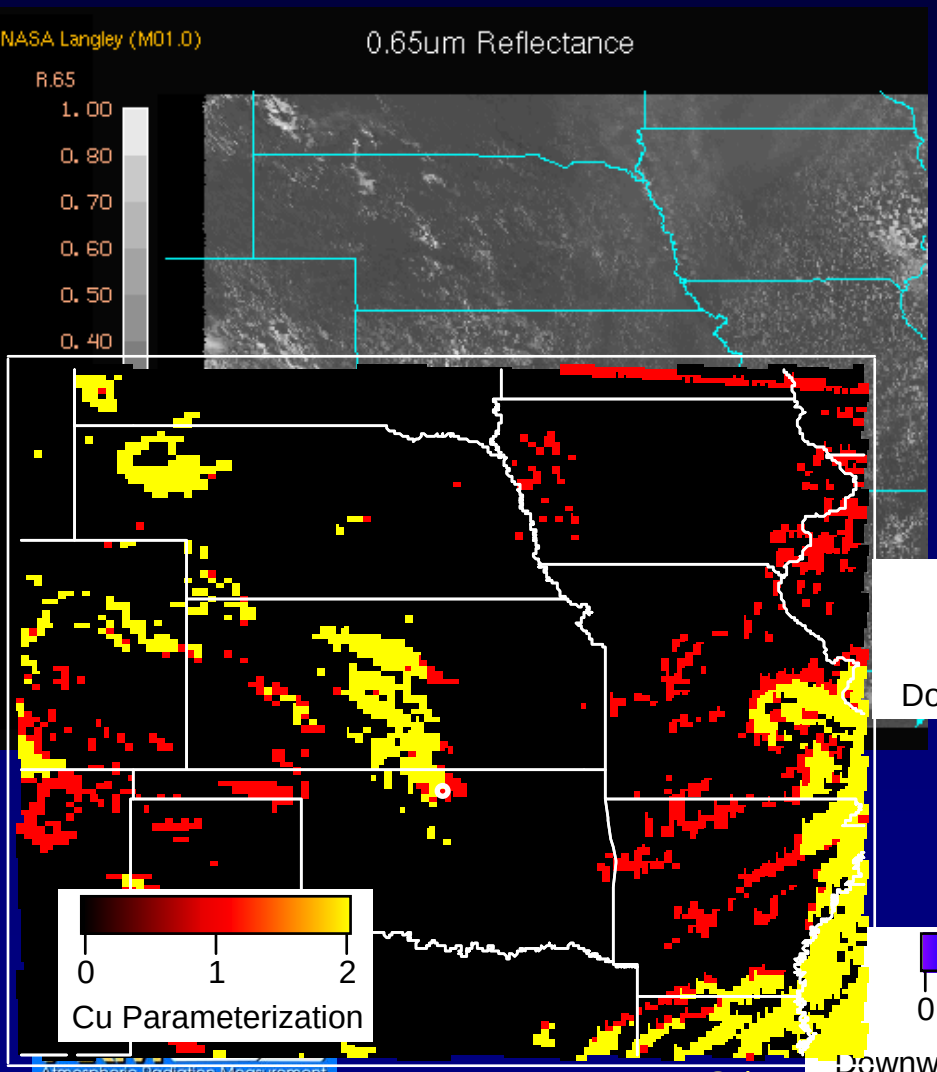
0 = None

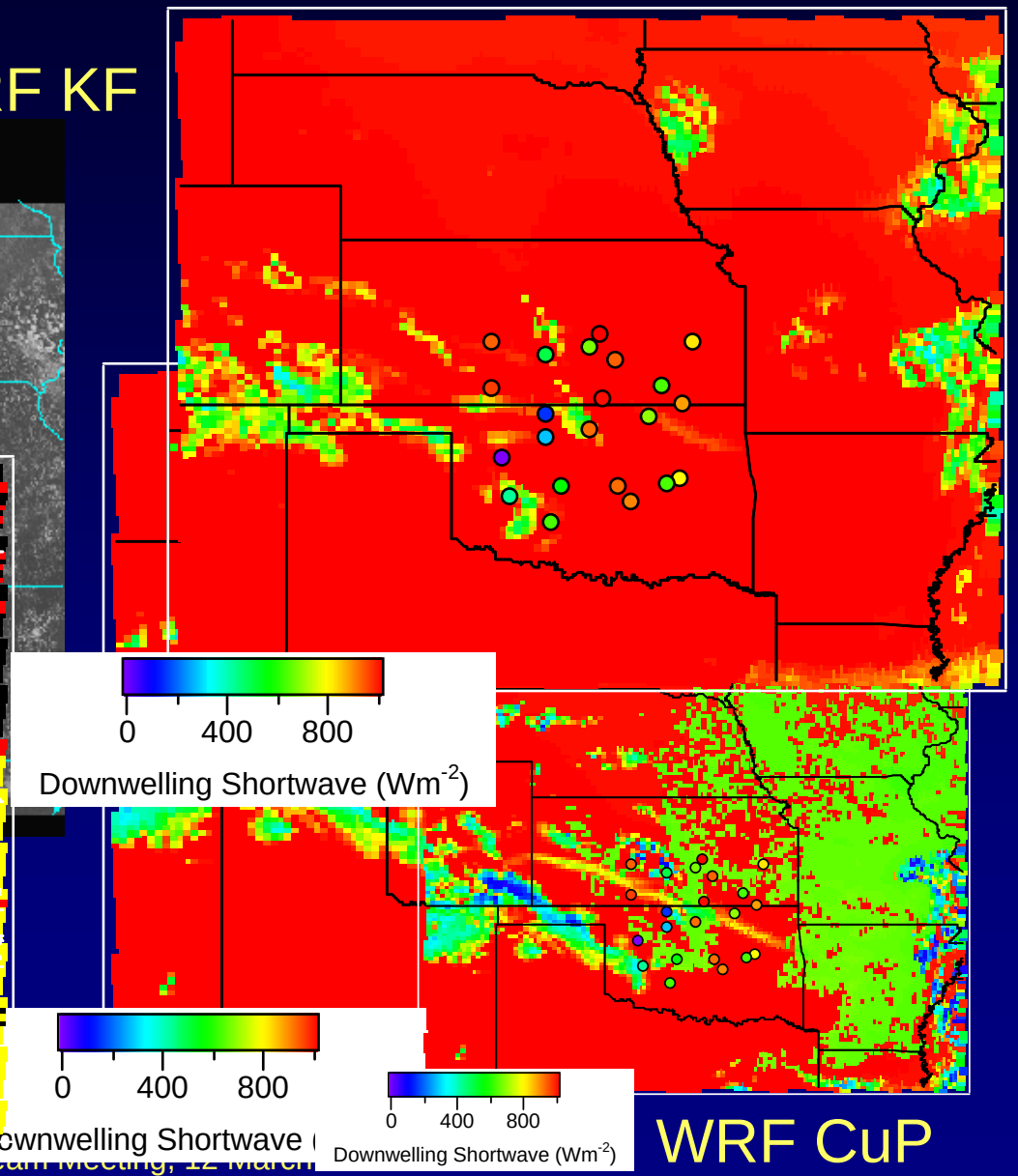
1 = Shallow

2 = Deep

Evaluation: Shortwave Radiation

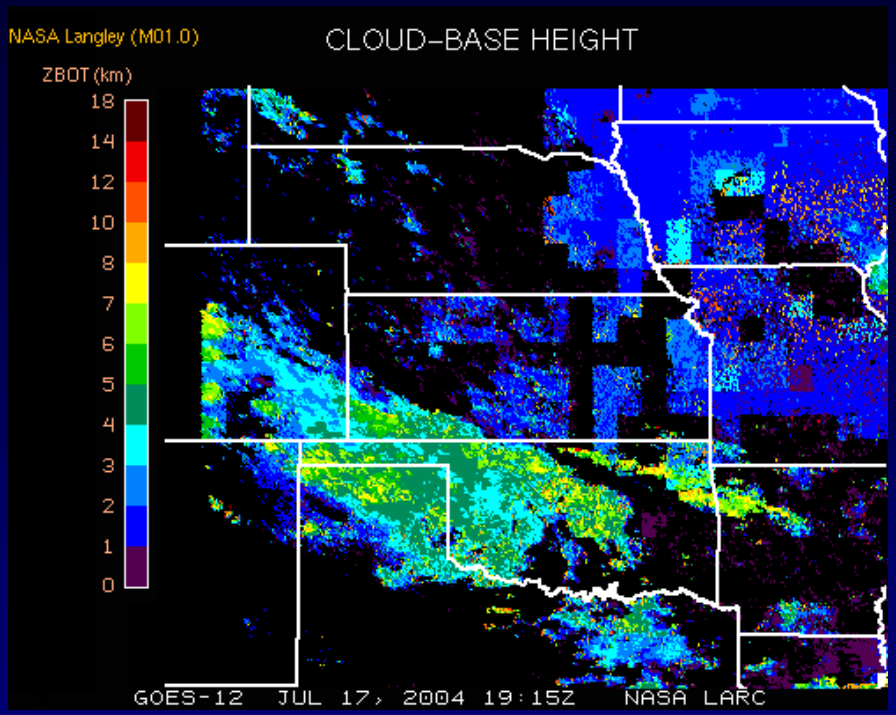
WRF KF

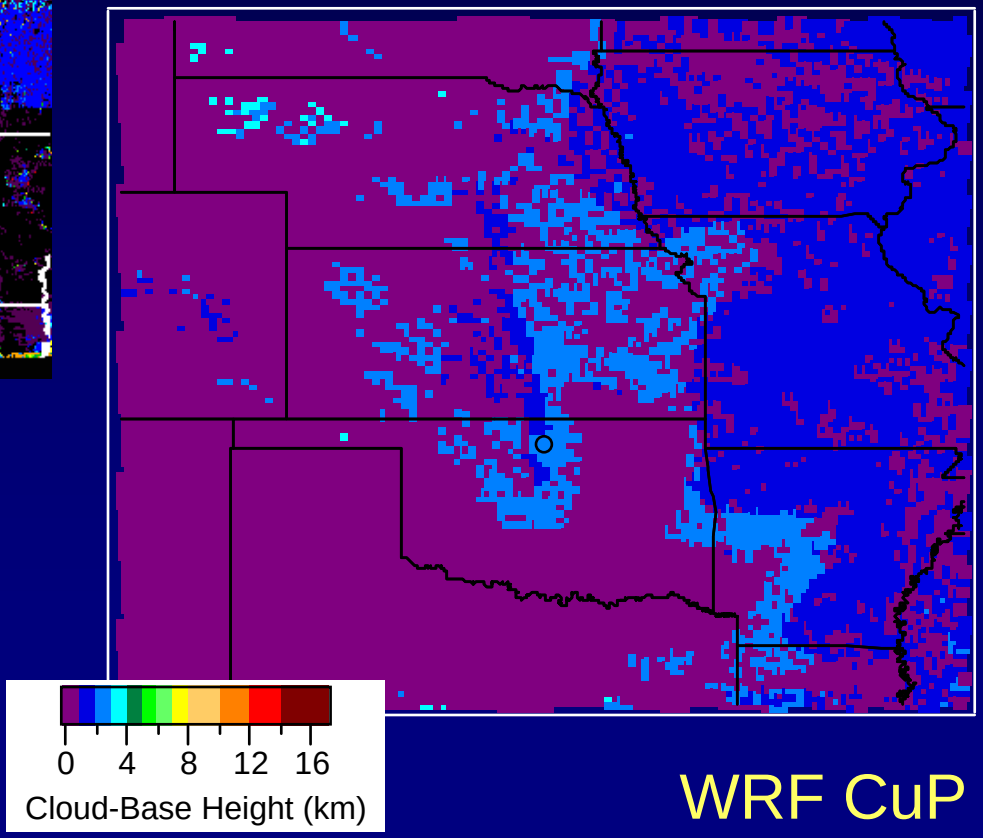




WRF CuP

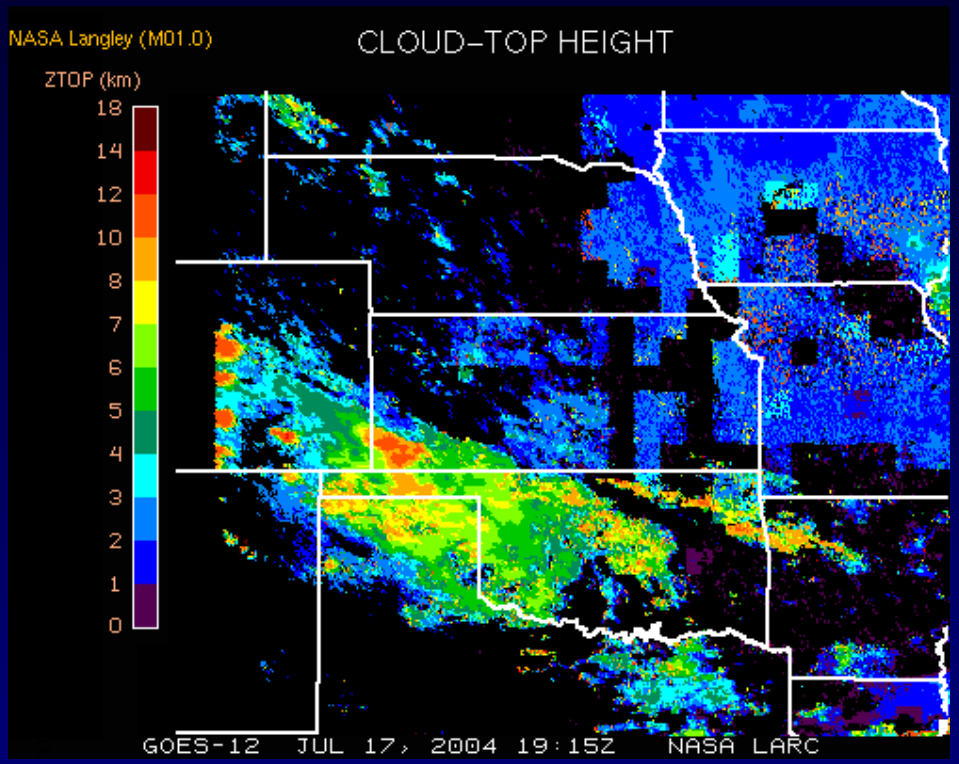
Evaluation: Cloud-Base Height

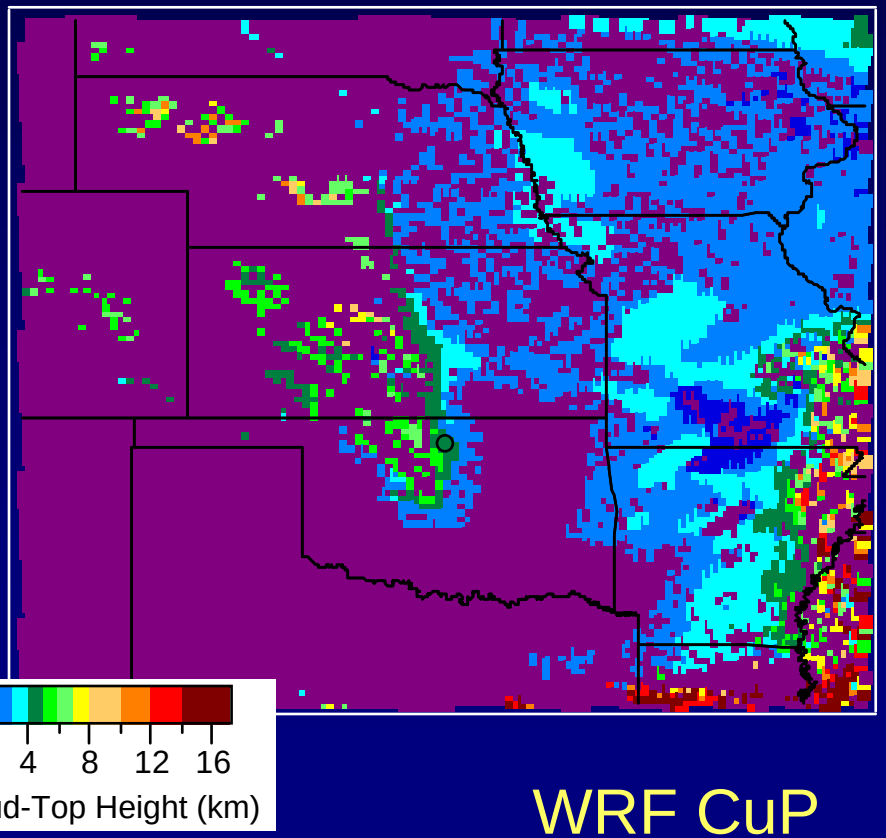




WRF CuP

Evaluation: Cloud-Top Height





WRF CuP

Conclusions

- WRF CuP has been used to simulate periods of the summer of 2004
  - Errors associated with cloud fraction
  - A new set of seasonal simulations are underway
- Case study results presented here
  - Improved coverage of shallow cumuli
  - Improved simulation of downwelling shortwave
  - Atmospheric chemistry