

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



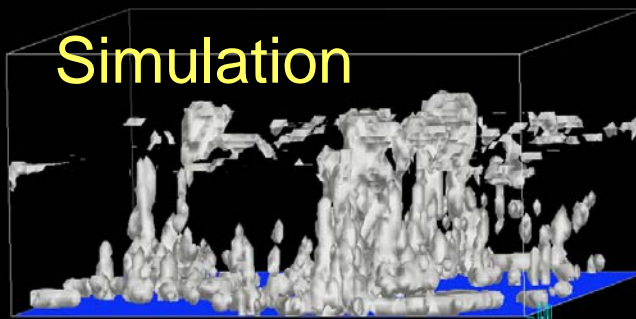
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Evgueni I. Kassianov
Pacific Northwest National Laboratory

Where are We Going?

Development

```
cup_5.0.cpp 1  <No selected symbol> 1  
for(i = 0; i < jfd.getNum(); i++){  
  for(j = 0; j < jfd.getNum(); j++){  
  
    // Convert th label to thv. This section of code was added because the JFDs are th and  
    thPrise = jfd.getBinLabelX(i); // Convert to thv. Note that meanthv in jfd is  
    thPrise = thPrise * (1.0 + 0.61 * jfd.getBinLabelY(j));  
  
    thPrise = thPrise - thflean;  
    rPrise = jfd.getBinLabelY(j) - rflean;  
  
    // Depending on the input (JFD or list of therwals, lift the parcels  
    if(jfd.getJFDPoint(i,j) > 0.0) {  
      if(jfdType != 3) {  
        run.raiseParcel(thProfile.getMePoints(), jfd.getJFDPoint(i,j),  
          thPrise, rPrise,  
          thflean, rflean, airParcel,  
          cloudModel, thProfile, thvProfile, rProfile, zProfile, pProfile,  
          mixType, tempTopFlag);  
      }  
    }  
  }  
}
```

Simulation



Observations

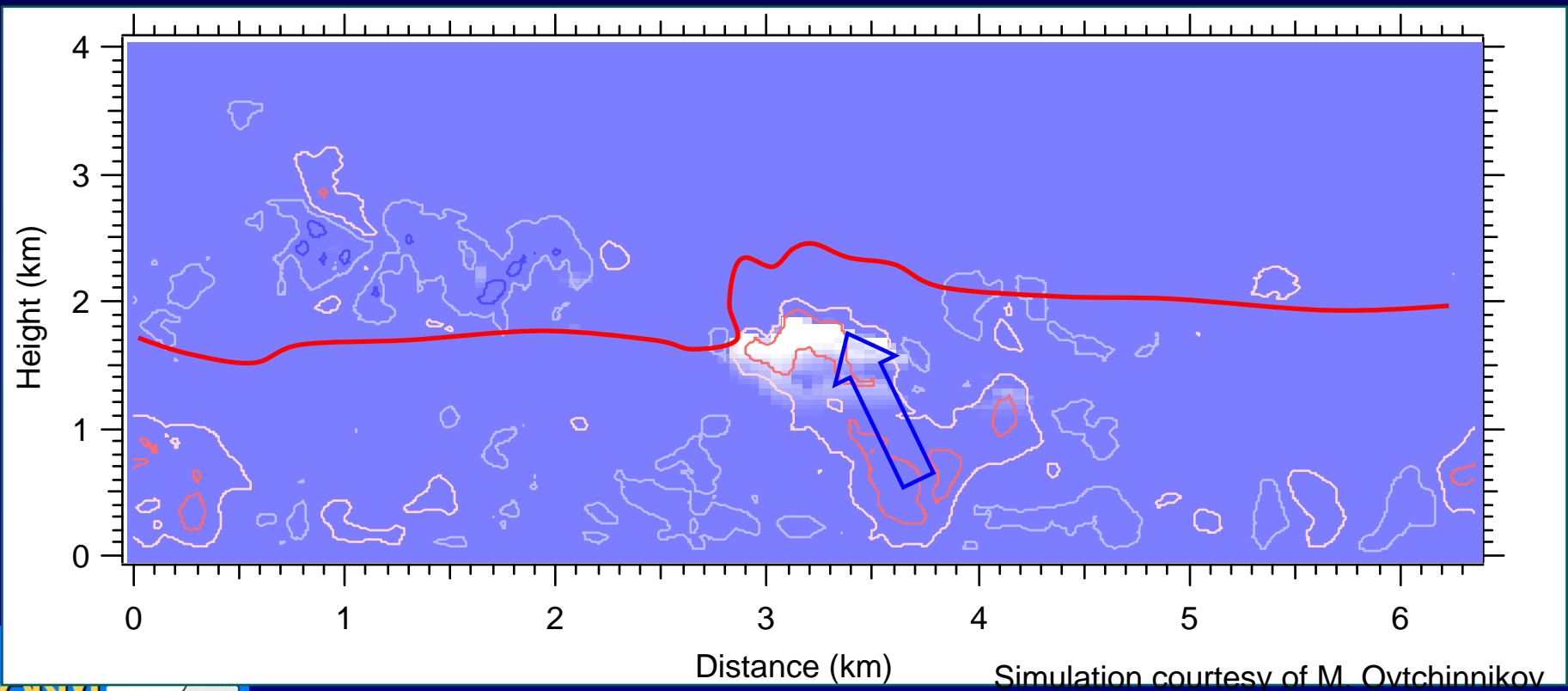


Evaluation



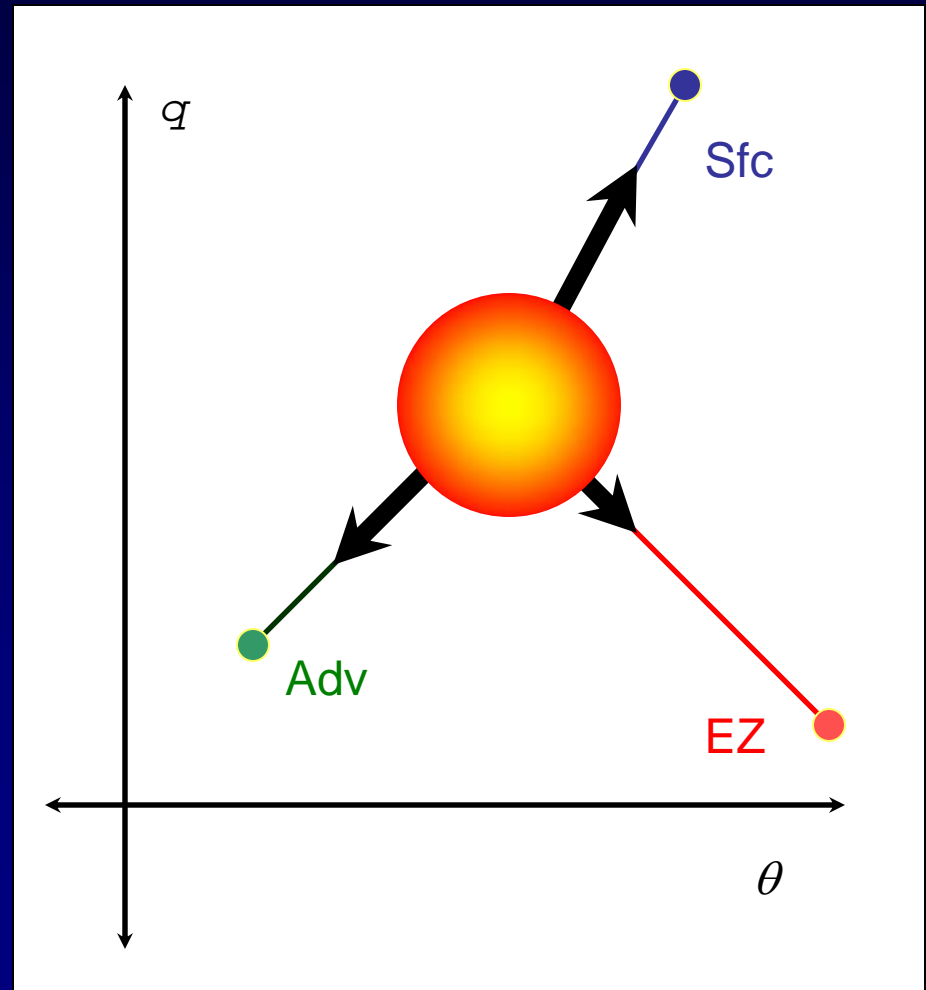
Development: Coupling Clouds to the Convective Boundary Layer

- Shallow cumuli are turbulently coupled to the planetary boundary layer



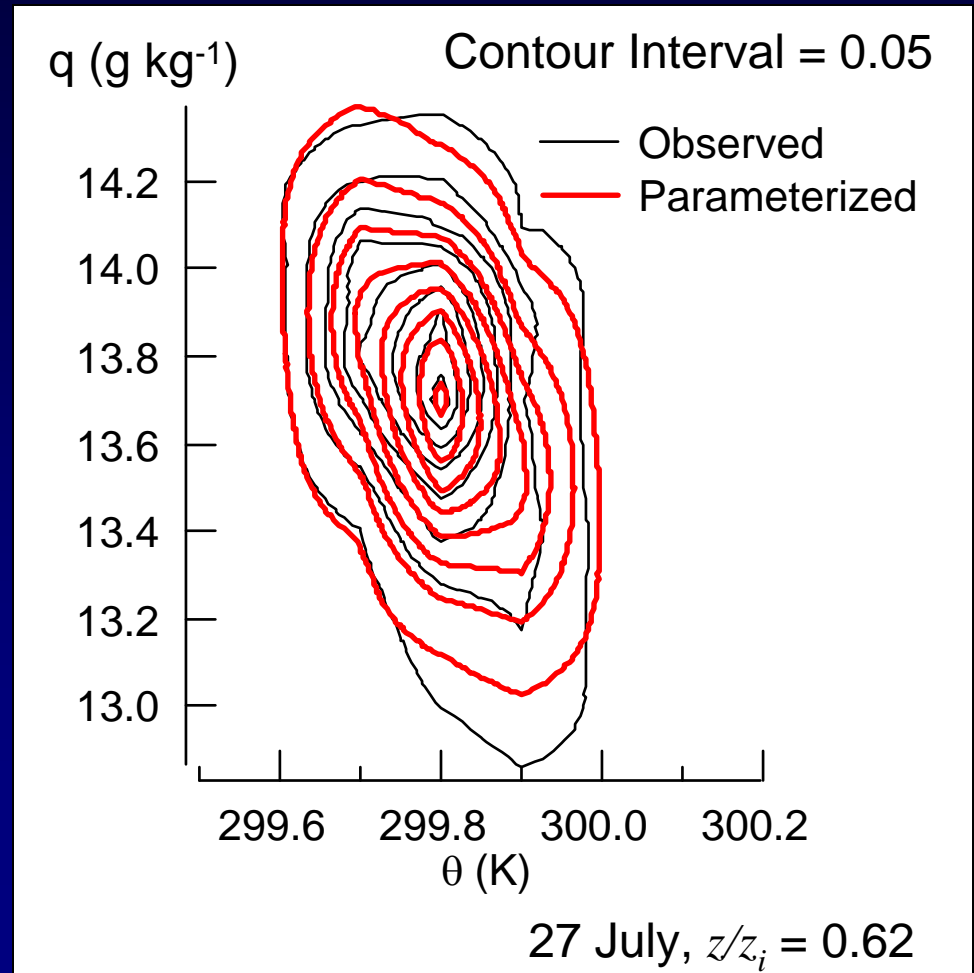
Development: Coupling Clouds to the Convective Boundary Layer

- 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

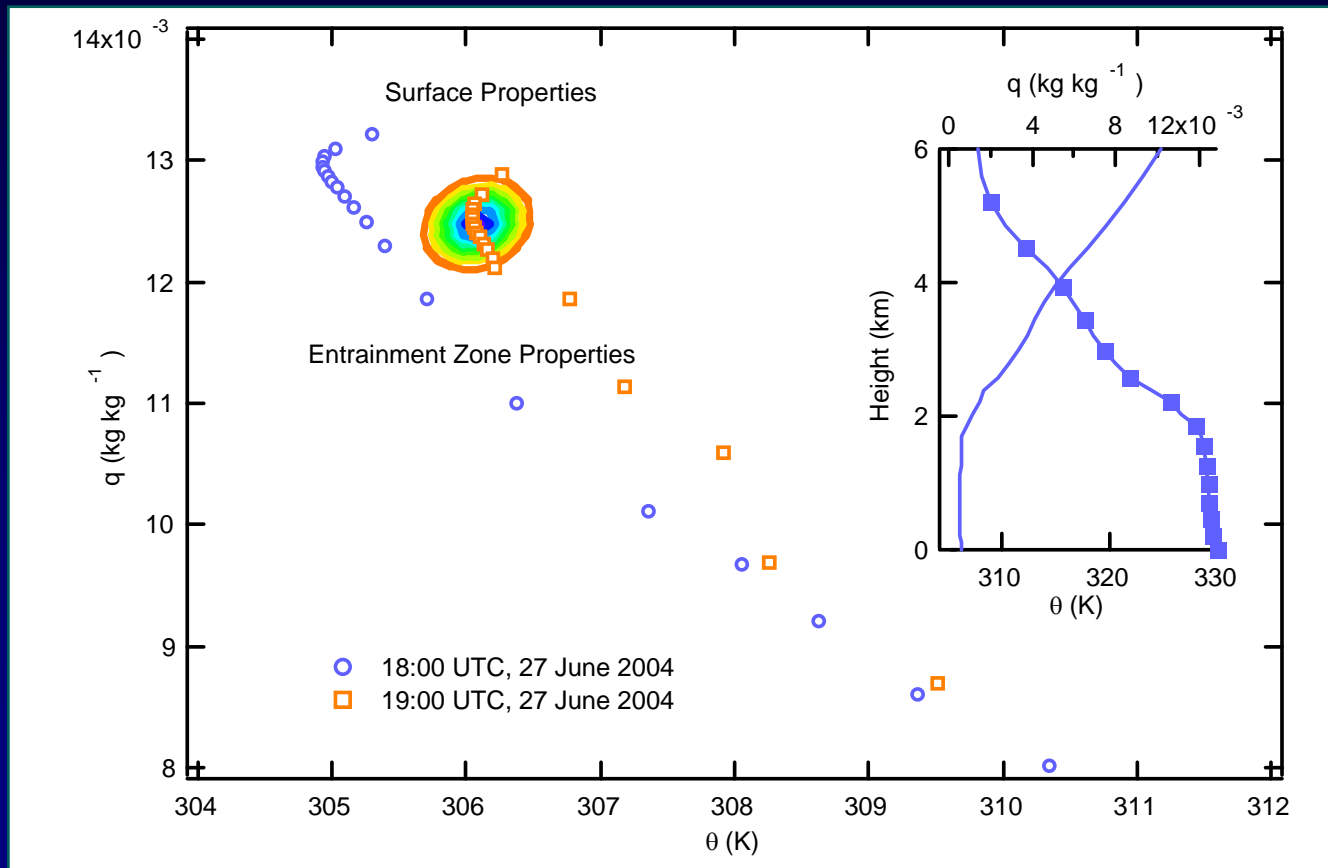


Development: Sample Distribution

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

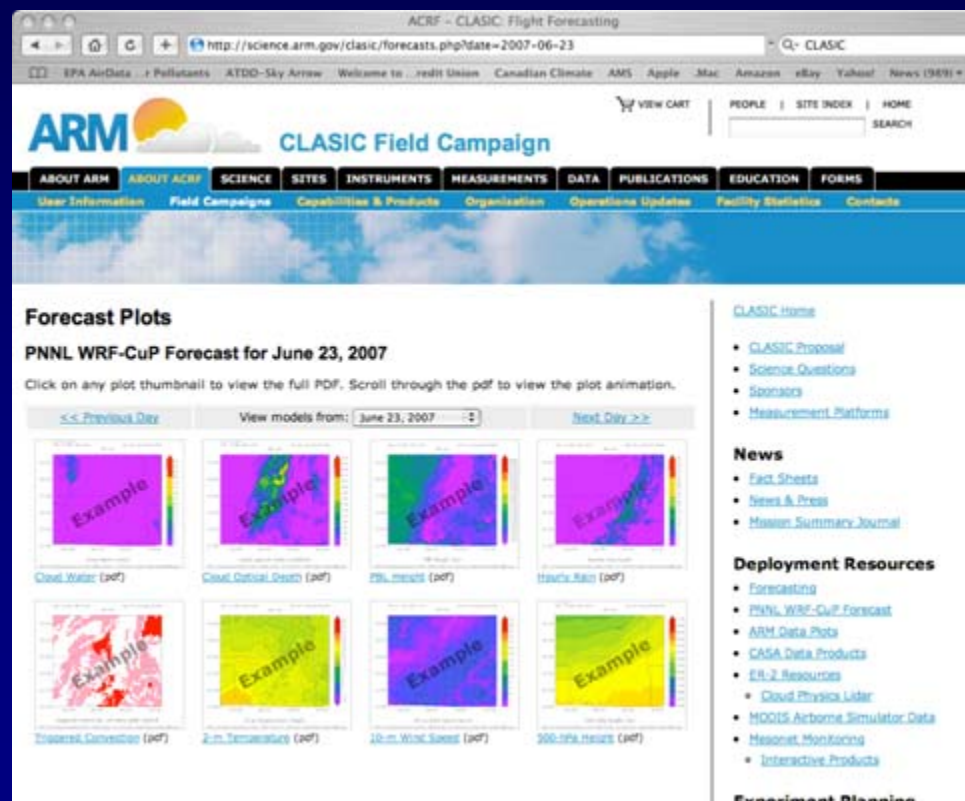


Development: Coupling Clouds to the Convective Boundary Layer



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

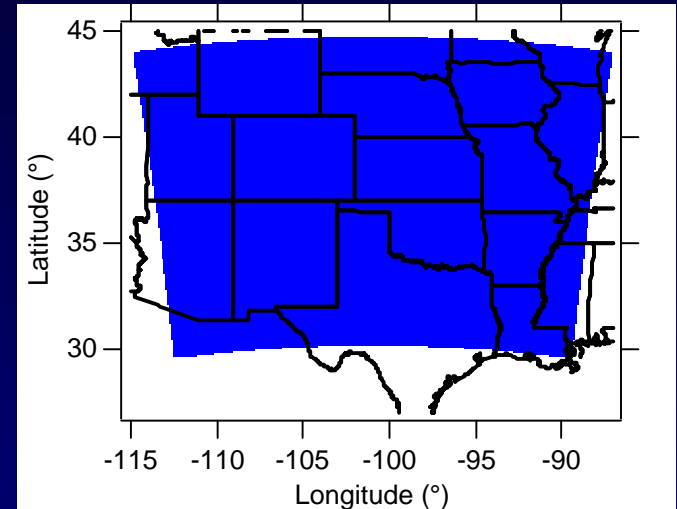


Simulation: WRF Setup

- 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

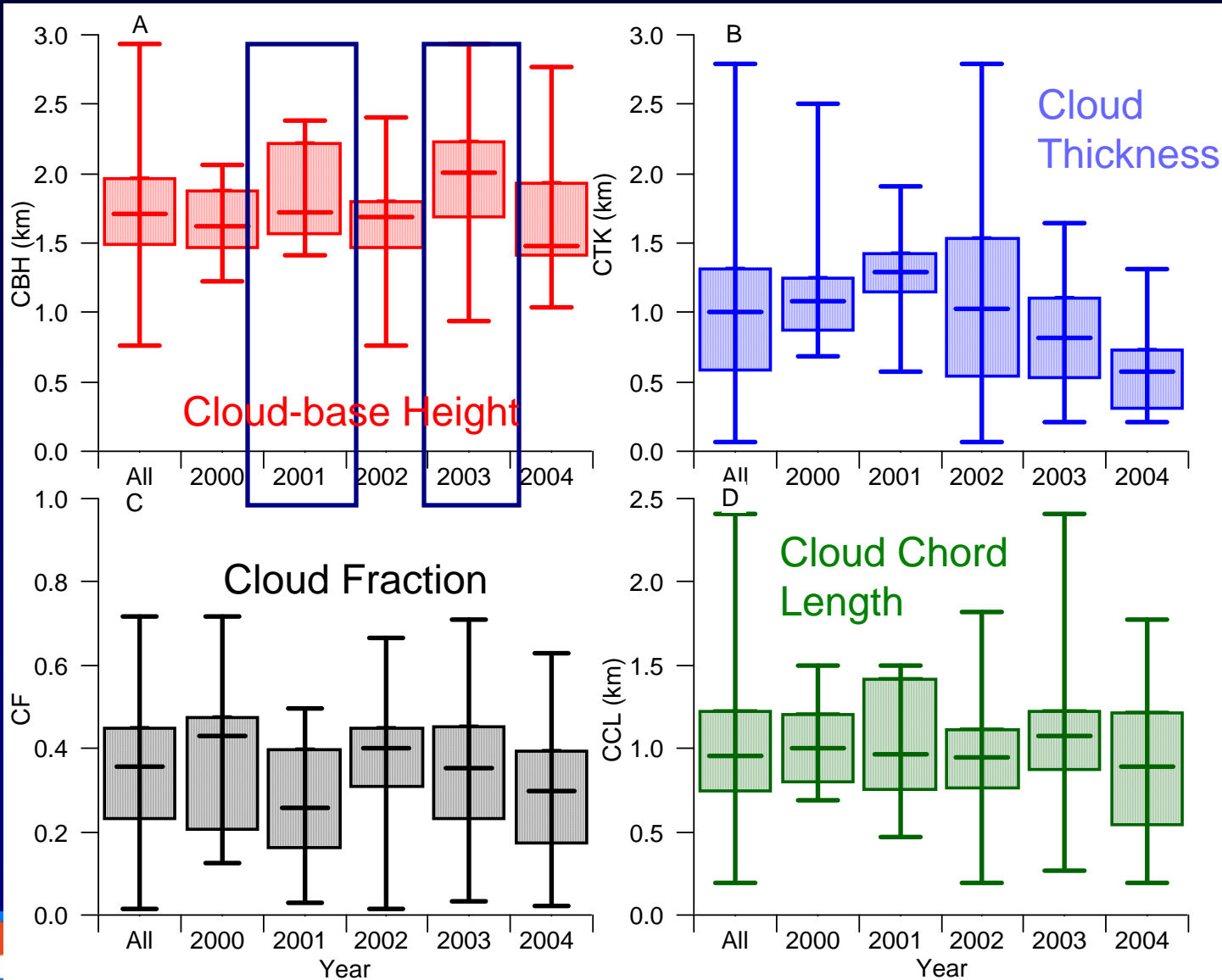
- Domain
 - 131 x 131 x 45
 - 12 km horizontal grid spacing
- Simulations have been started for a season (summer of 2004)
 - Boundary conditions from NARR
 - Reinitialize daily with 12 hr overlap.
 - Cycle soil moisture and cloud fields to minimize spin-up error
- Physics
 - Microphysics: Lin et al. 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



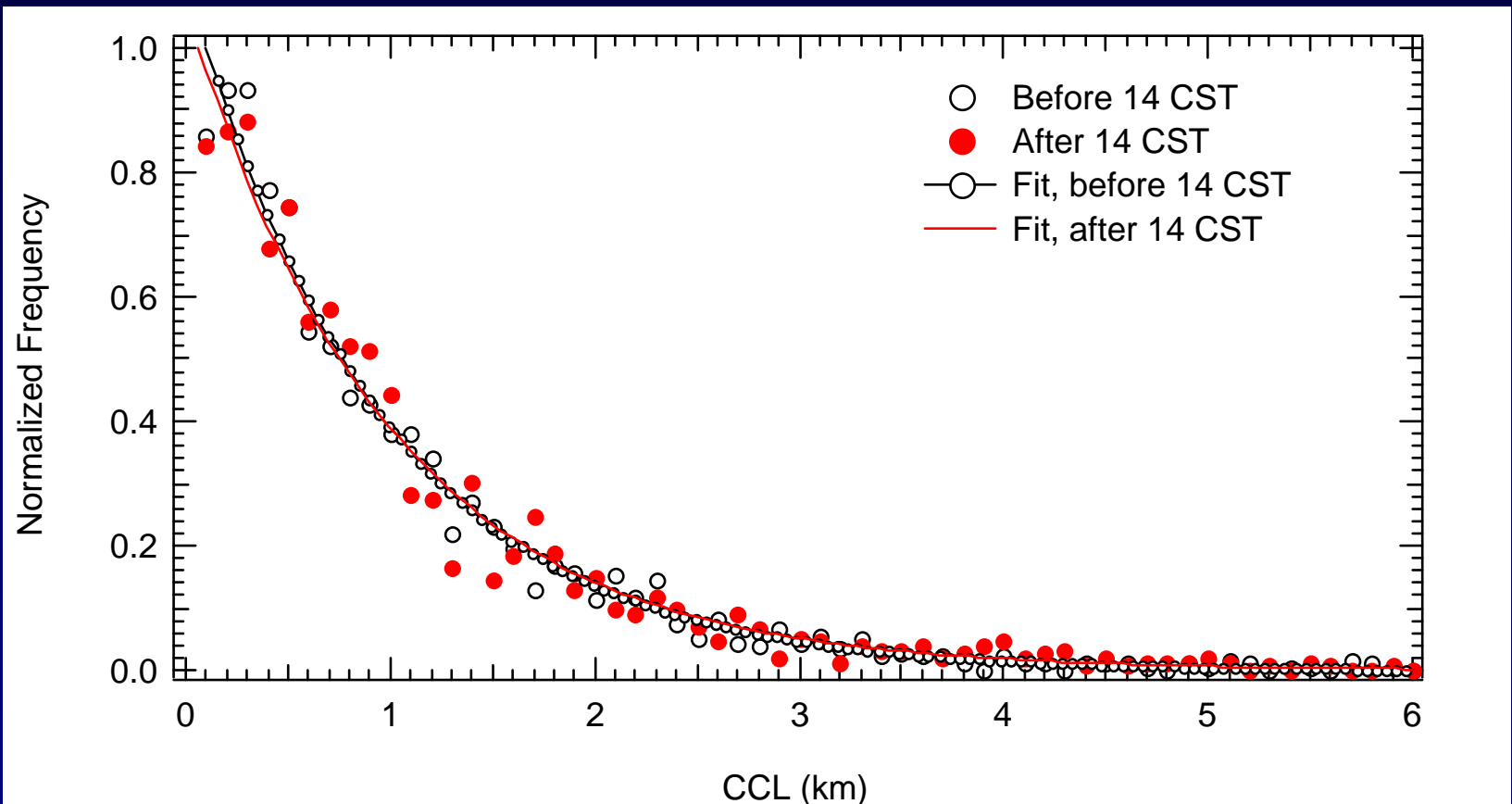
Evaluation: New Data Sets

- 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

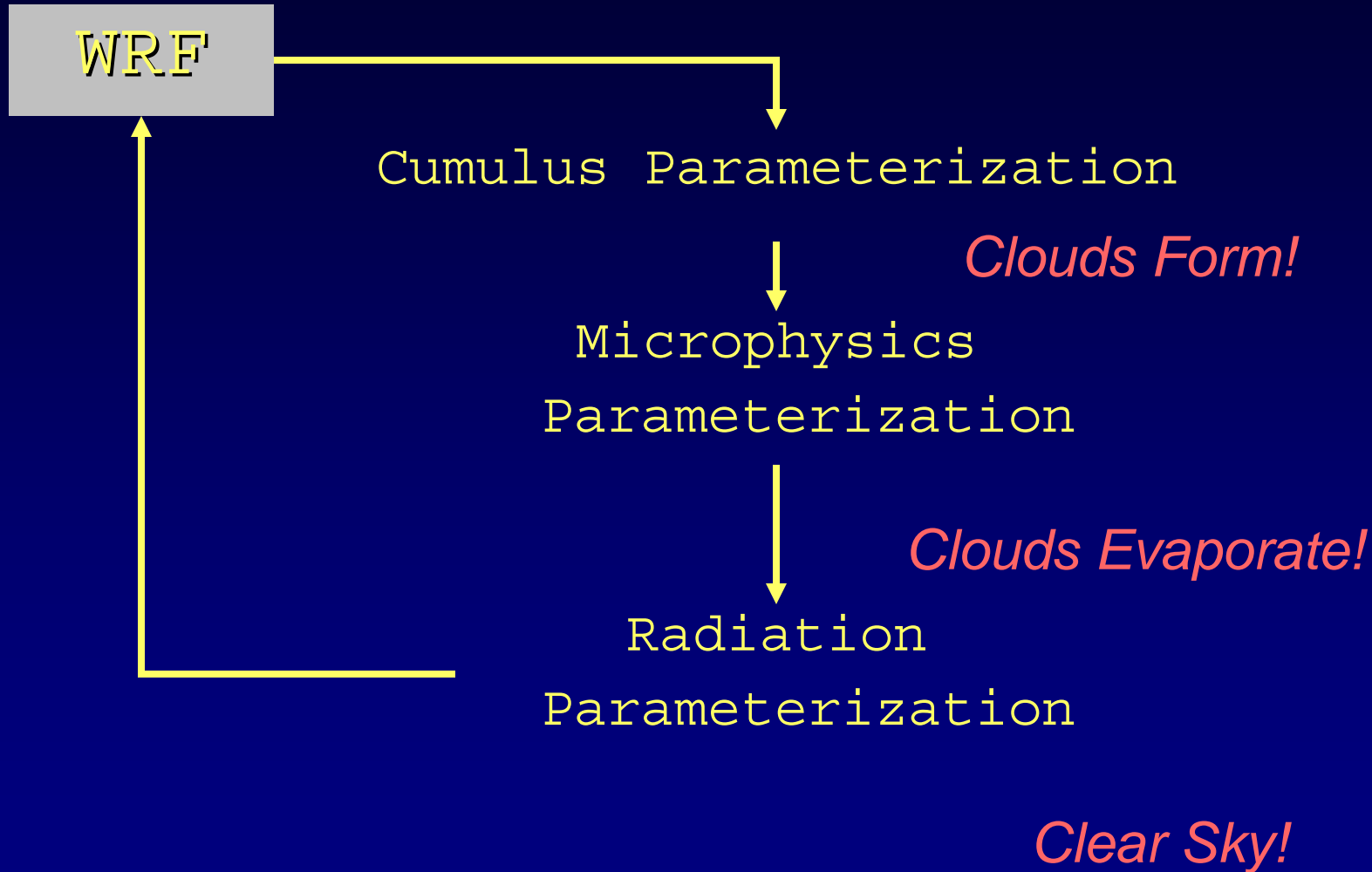
Evaluation: Cloud Properties



Evaluation: Cloud Chord Lengths



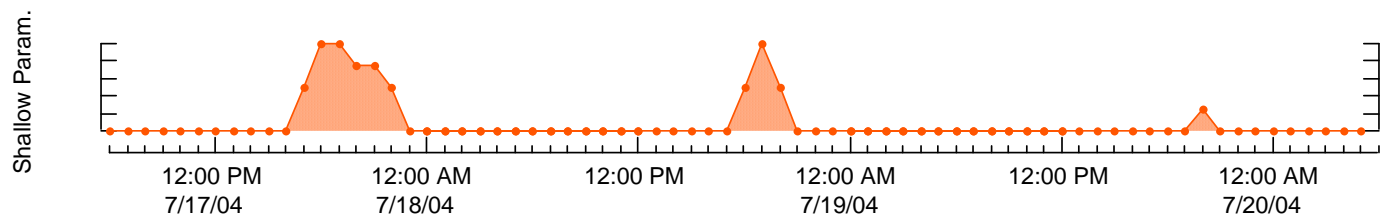
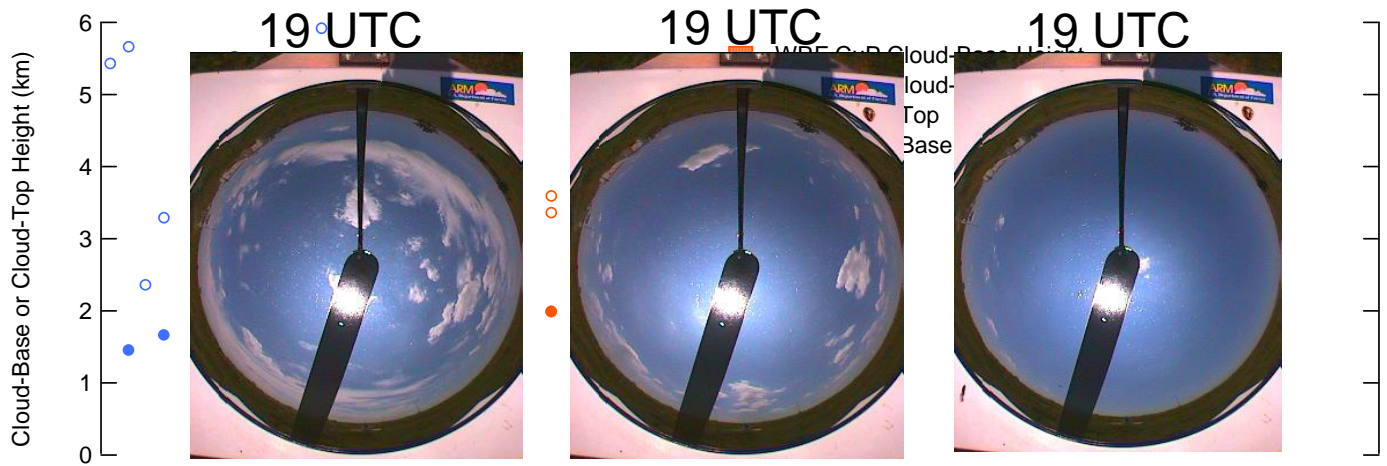
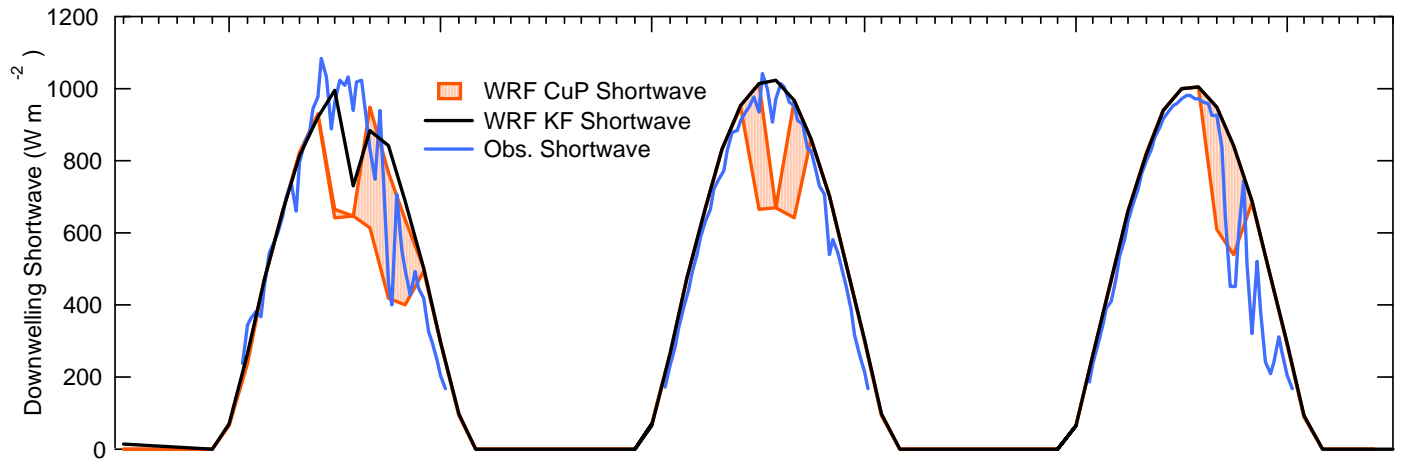
Evaluation: Shortcomings



Solution: Prescribe cloud fraction

ARM Science Team Meeting, 12 March 2008

Evaluation: Downwelling Shortwave



Date (UTC)

Evaluation: Shallow Clouds

NASA Langley (M01.0)

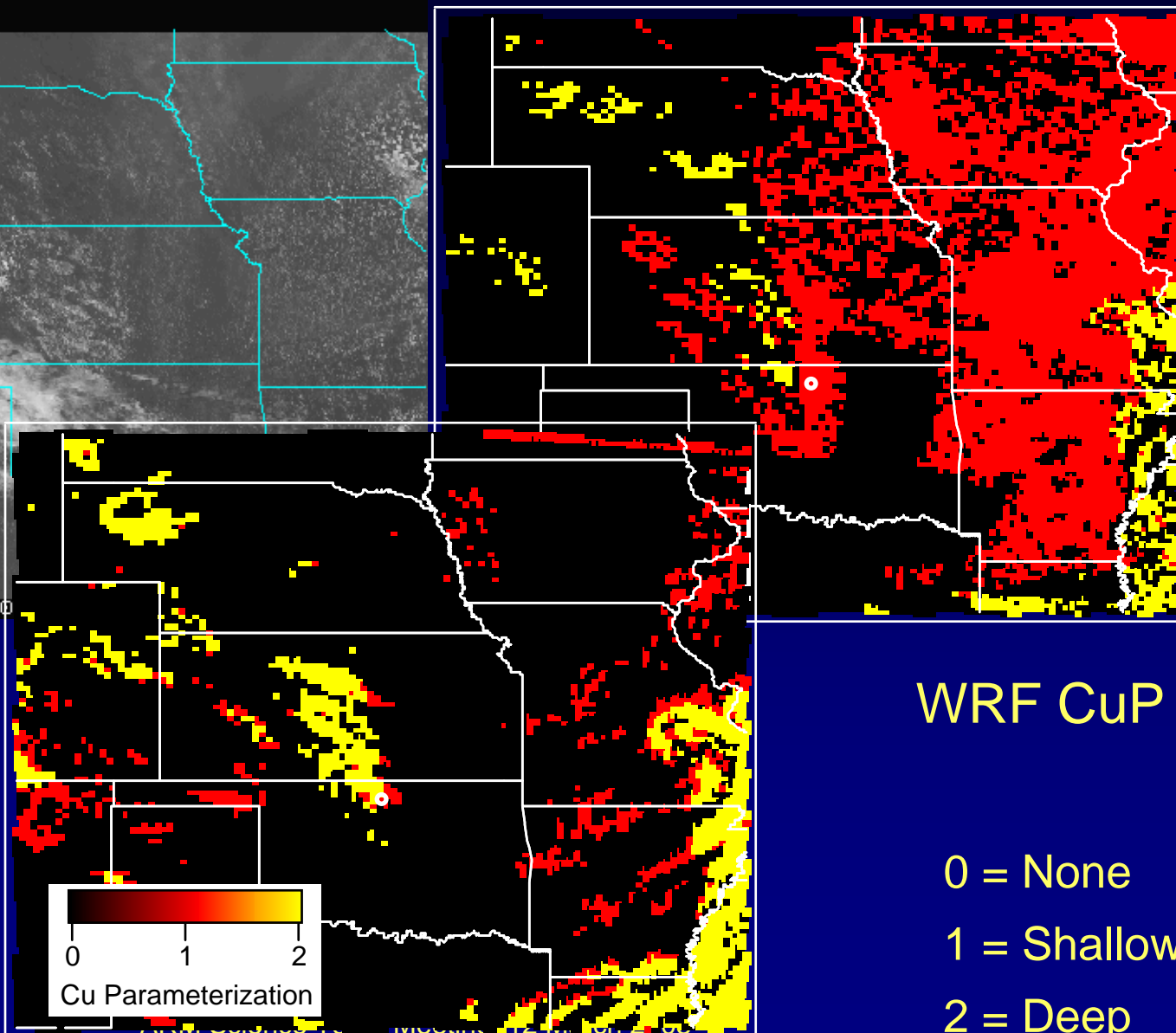
0.65um Reflectance

R.65

1.00
0.80
0.70
0.60
0.50
0.40
0.30
0.25
0.20
0.15
0.10
0.00

GOES-12 JUL 17, 2000

WRF KF



WRF CuP

0 = None

1 = Shallow

2 = Deep

Evaluation: Shortwave Radiation

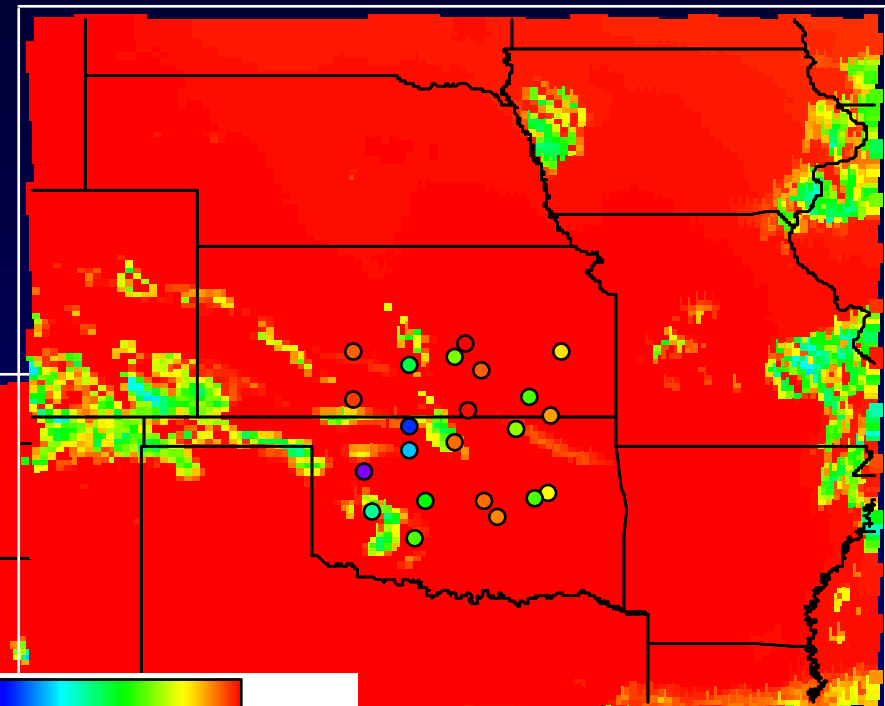
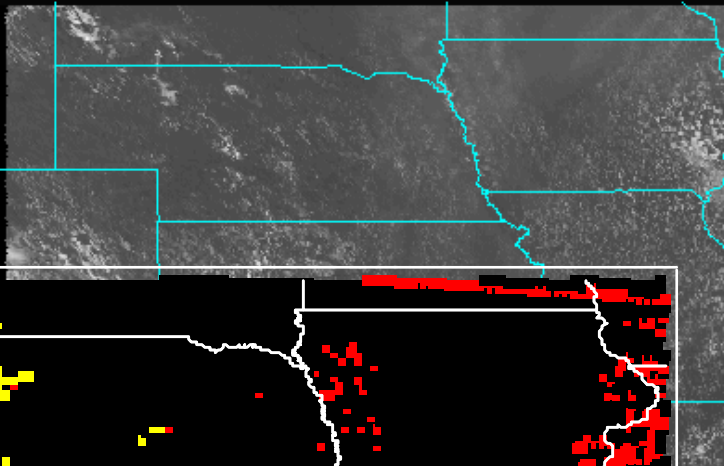
WRF KF

NASA Langley (M01.0)

0.65um Reflectance

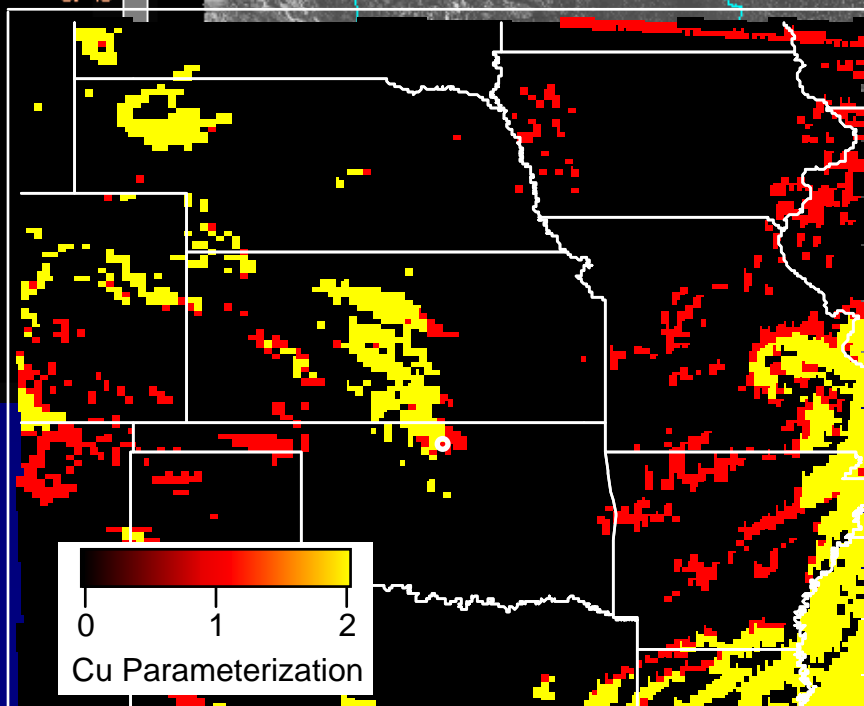
R.65

1.00
0.80
0.70
0.60
0.50
0.40



Downwelling Shortwave (Wm^{-2})

0 400 800



0 1 2

Cu Parameterization

Downwelling Shortwave

0 400 800

Downwelling Shortwave (Wm^{-2})

0 400 800

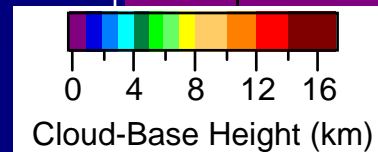
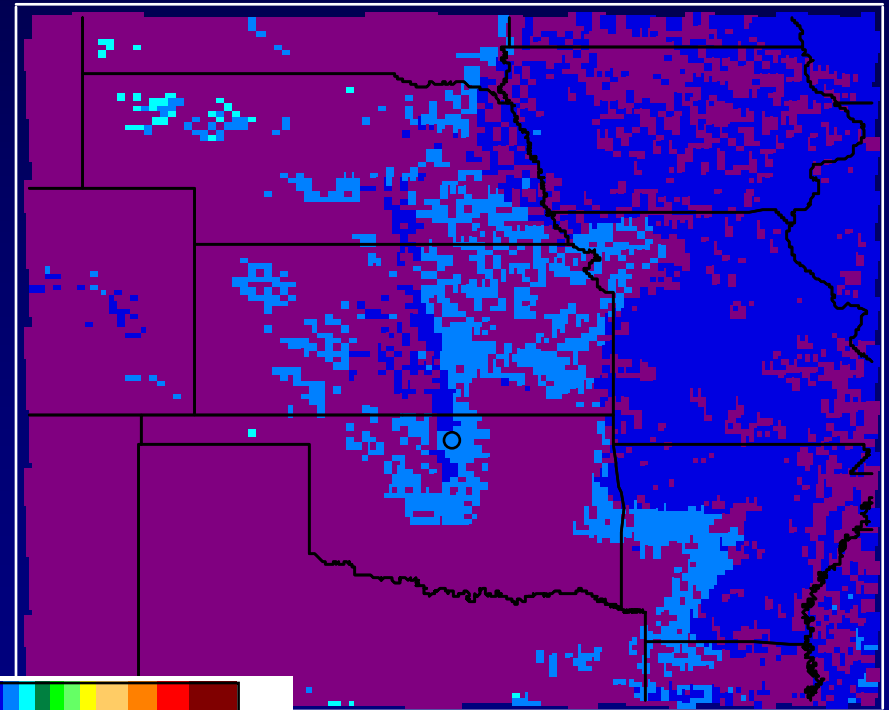
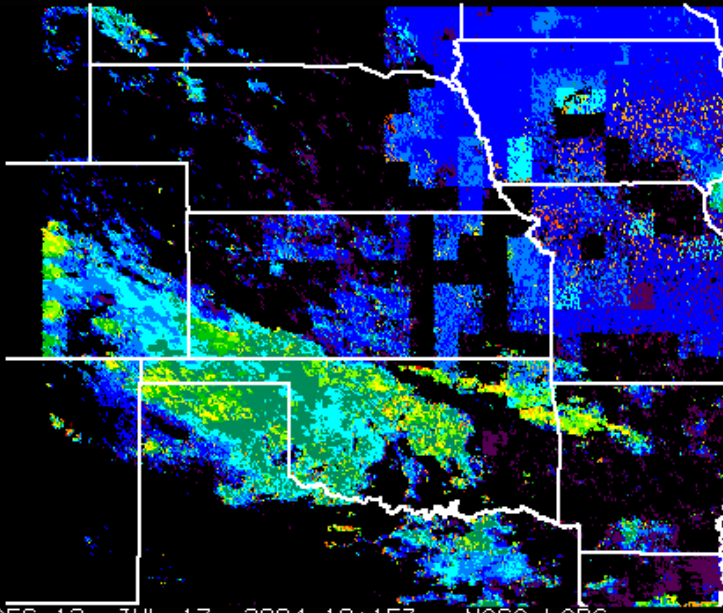
WRF CuP

Evaluation: Cloud-Base Height

NASA Langley (M01.0)

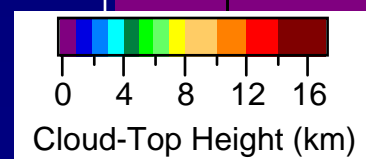
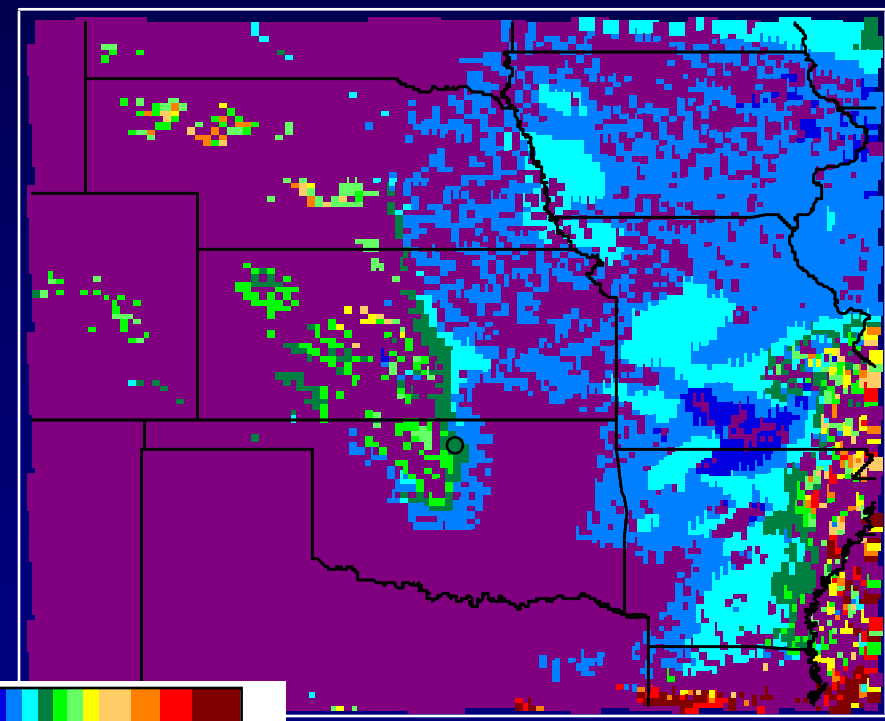
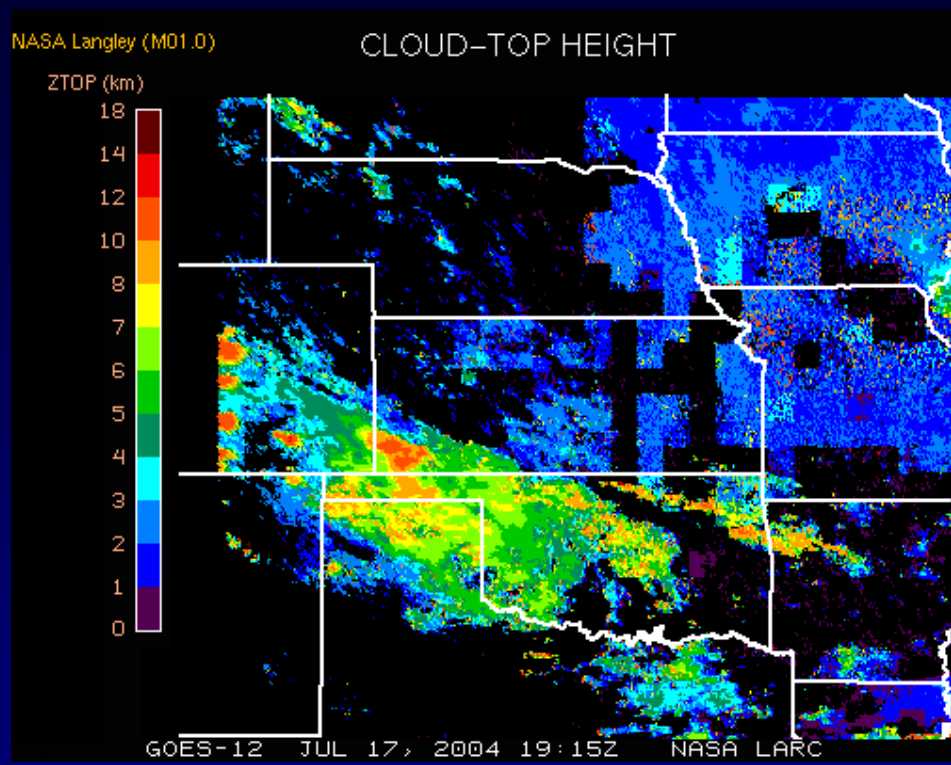
CLOUD-BASE HEIGHT

ZBOT (km)



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