New England High Resolution Temperature Program (NEHRTP) Project Review Workshop

4-5 May 2004

Boulder, Colorado

Issues affecting the accuracy of 2-m temperature forecasts in NCEP models

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Environmental Modeling Center

General Factors

- **Data assimilation**
  - "Representativeness" of observations
  - L/S dynamic balance vs. mesoscale structure

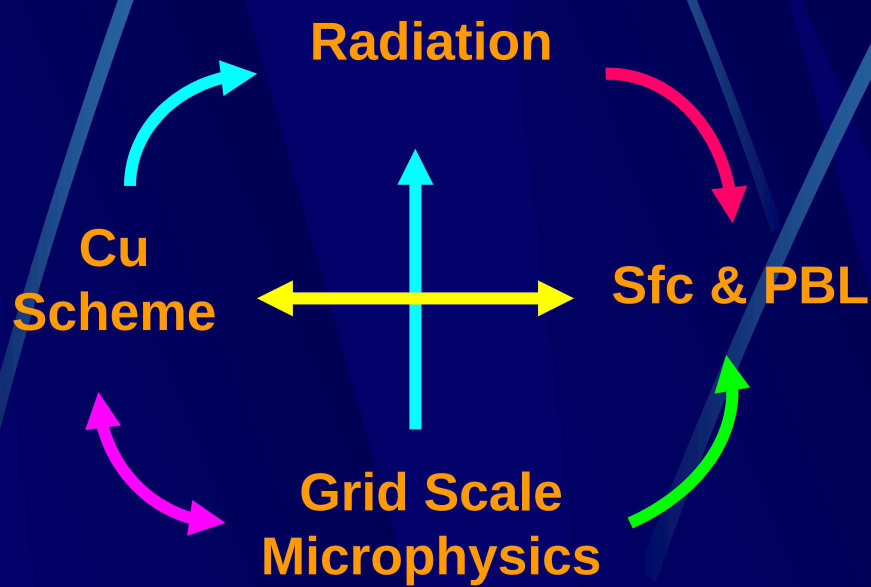
(More on this later when it comes to sfc observs.)

- **Forecast model errors**
  - Initial conditions (data assim + model)
  - Numerics
  - Approximate representations of topography, land surface properties
  - Physical parameterizations – simplified representations of actual atmospheric physics

"THE PHYSICS WHEEL OF PAIN"

(Modified from Jiayu Zhou, NOAA/OST)

Direct Physical Interaction of Clouds



1. Hydrometeor phase, cloud optical properties, cloud fractions, & cloud overlap
2. Precipitation (incl. phase)
3. Subgrid transports, stabilization, detrainment
4. Sfc energy fluxes, LSM
5. Convection, PBL evolution, precipitation

Sources of 2-m Temperature Forecast Errors

- **Back-door cold fronts**
- **Timing of frontal passages**
- **Convective events**
- **Sea breezes and coastal effects**
- **Land surface processes**
  - **Land states (e.g., soil moisture, temperature, many more)**
  - **Surface albedos => midday + diurnal variation**
  - **Errors in input radiation fields => *clouds***
  - **Interactions with PBL (local vs. nonlocal schemes)**

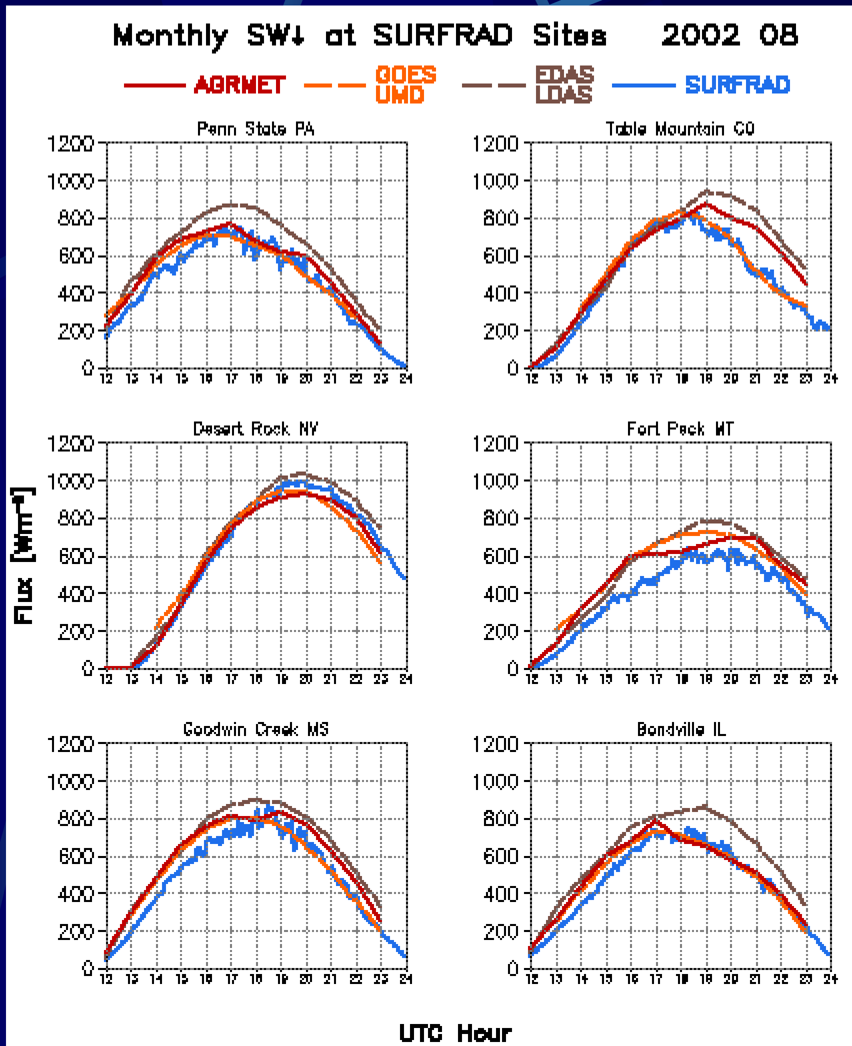
Eta Model Cloud, Radiation Biases

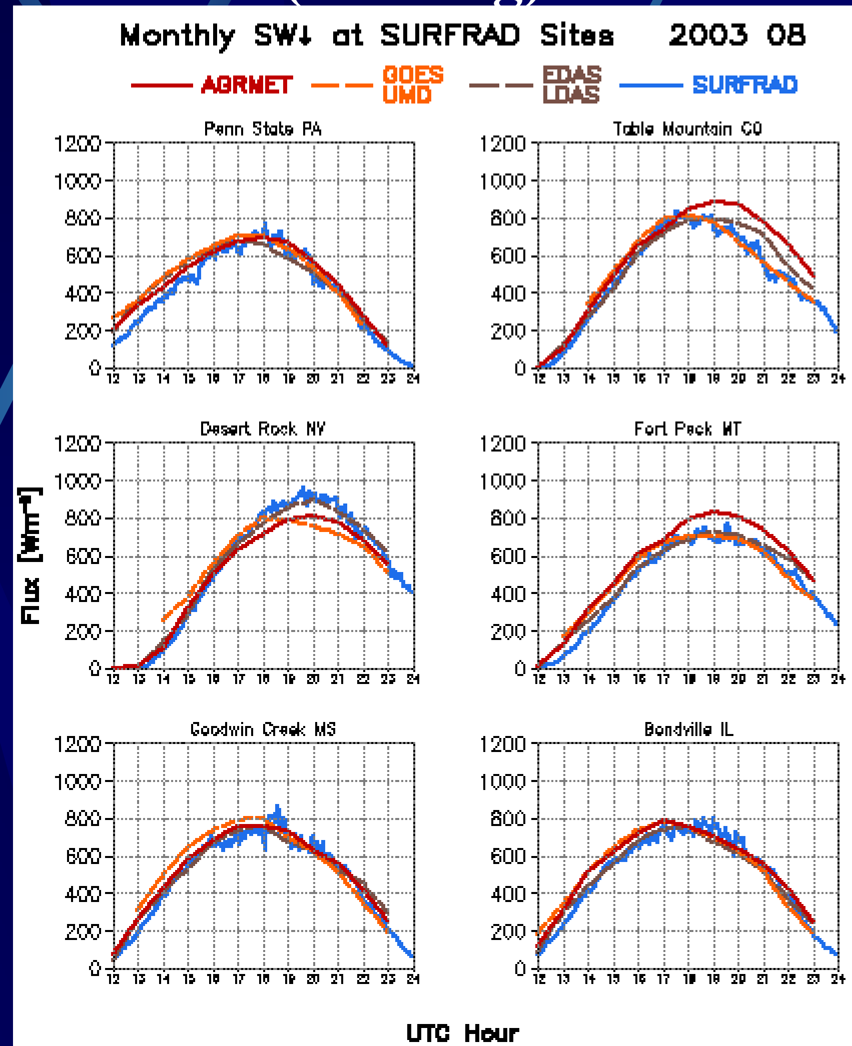
- High bias in incoming surface solar insolation
- Low bias in downwelling surface longwave radiation

(Based on ETL's studies over NE, extended to rest of US using SURFRAD observations by Meng & Mitchell)

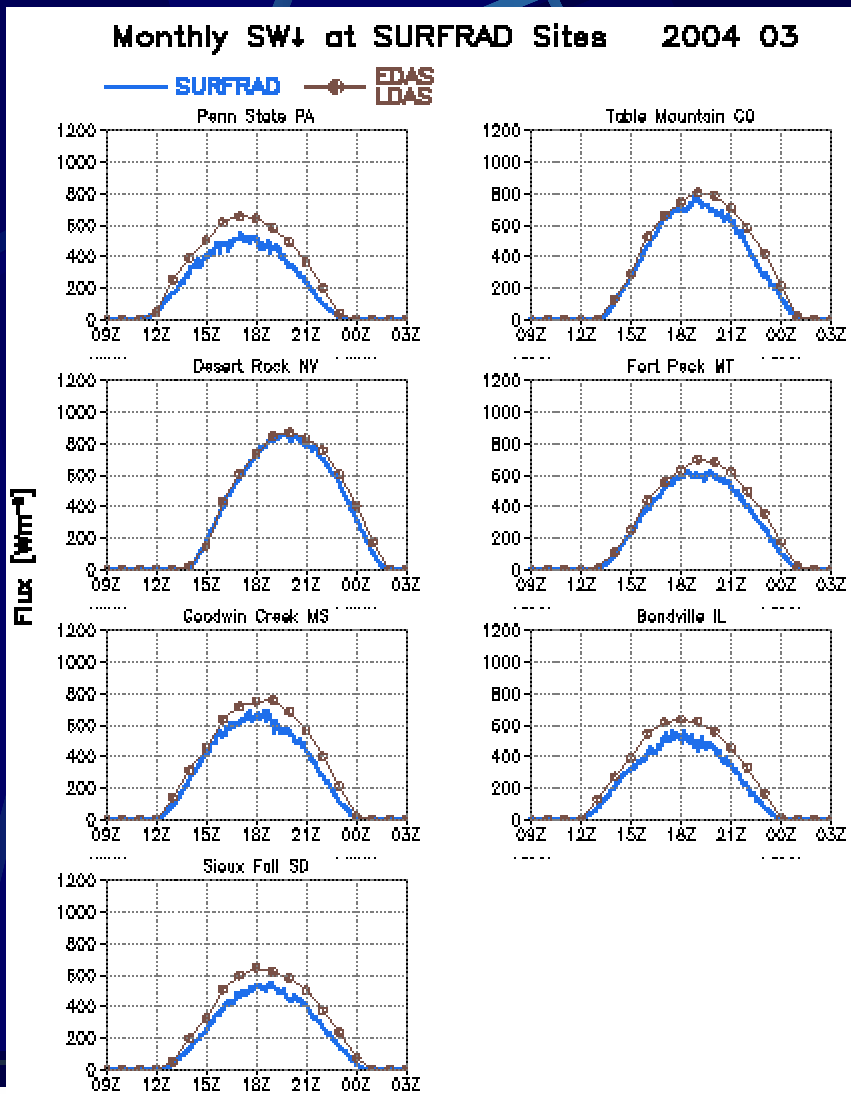
- Binary grid-scale cloudiness – predominately either clear or completely overcast
- Shallow convection that is too aggressive and too extensive in time and space

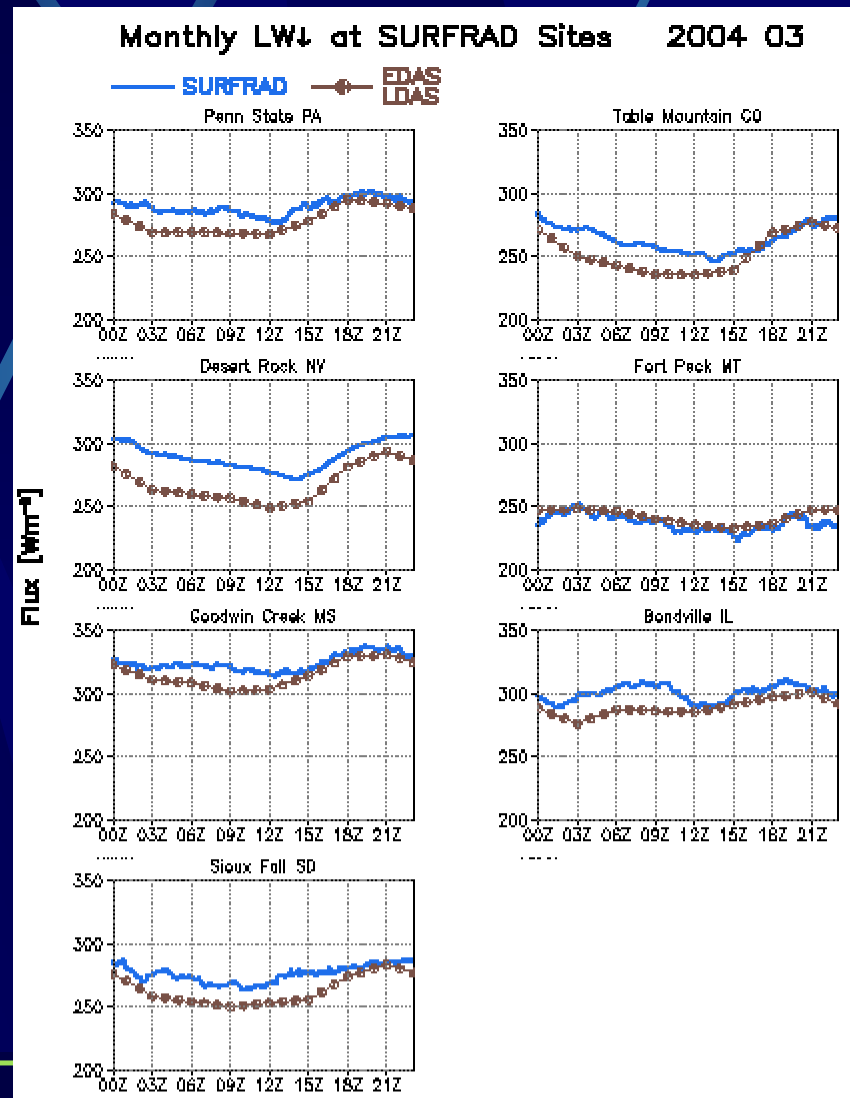
Aug 02 (left) vs. Aug 03
SURFRAD Verification (J. Meng)





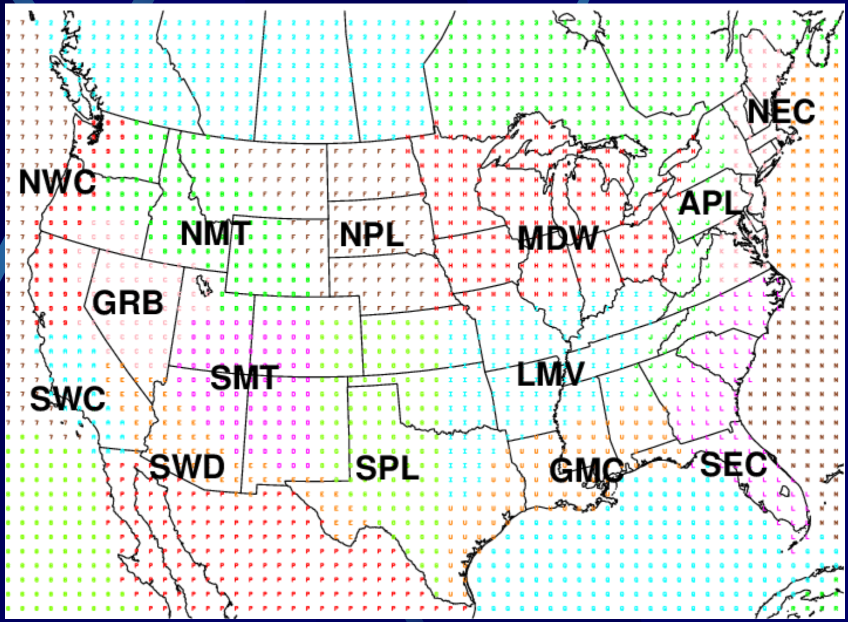
March 04 SW↓ and LW↓ SURFRAD Verification (J. Meng)





Near-Surface Forecast Verification Statistics

➢ Near-surface verification (2-m T & RH, 10-m winds) over New England can be viewed here (Mike Ek)



➢ Steady improvement in 2-m T forecasts over New England over the past 2-3 years

➢ Larger forecast biases over other parts of the US (e.g., SPL, SWC)

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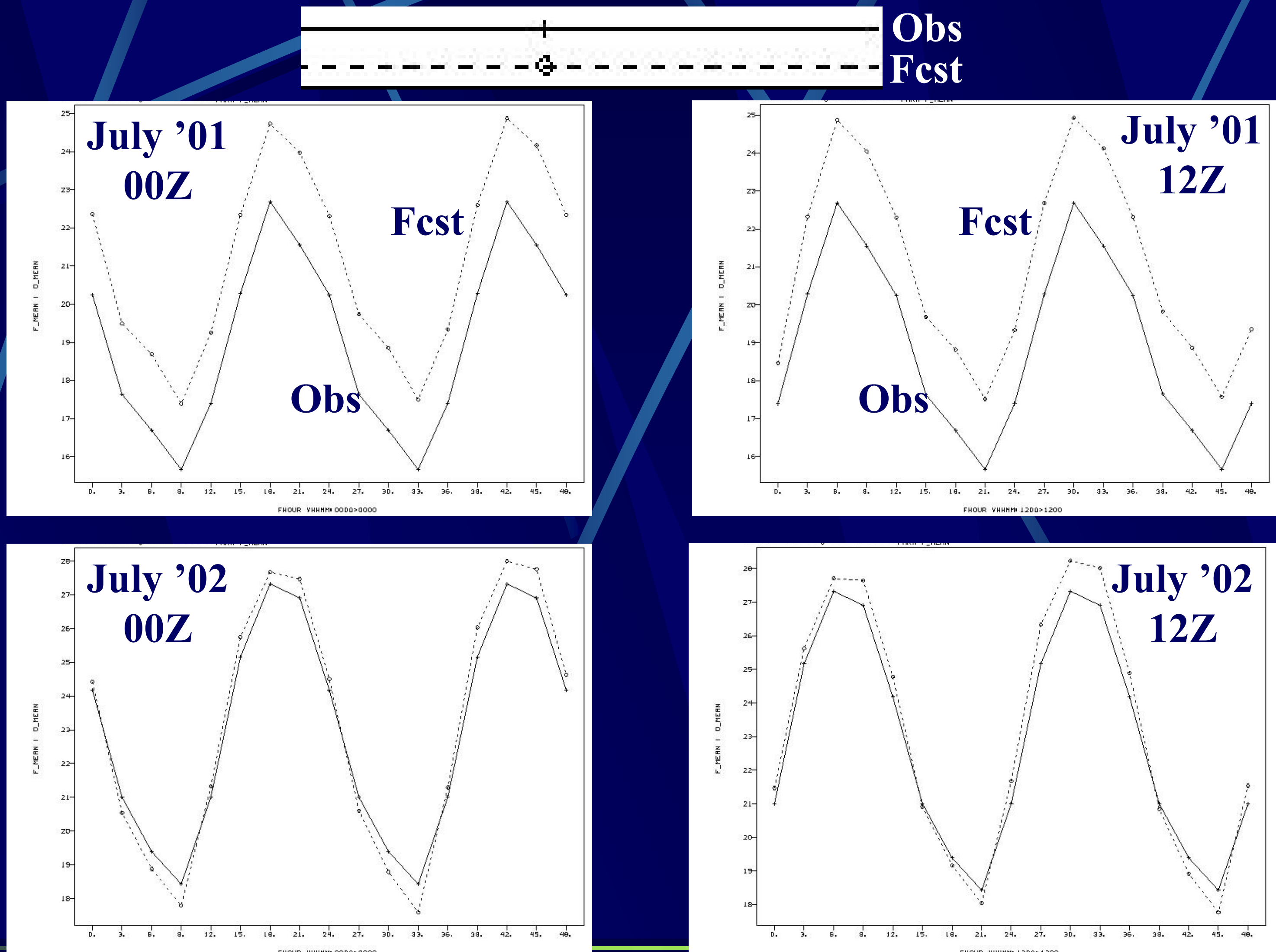
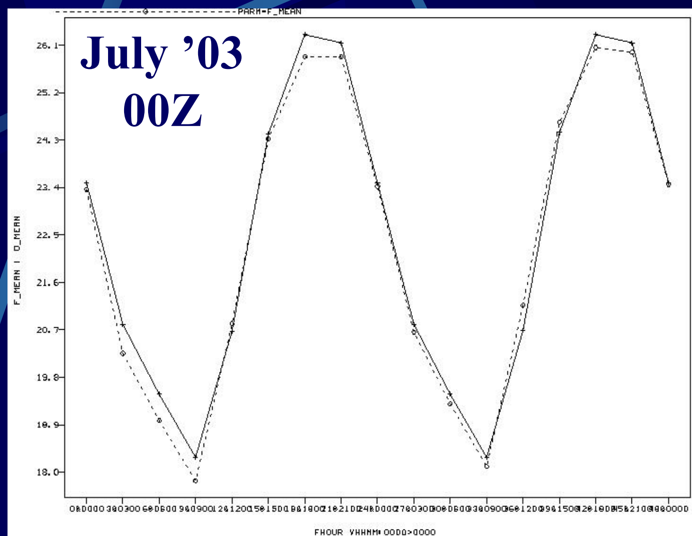
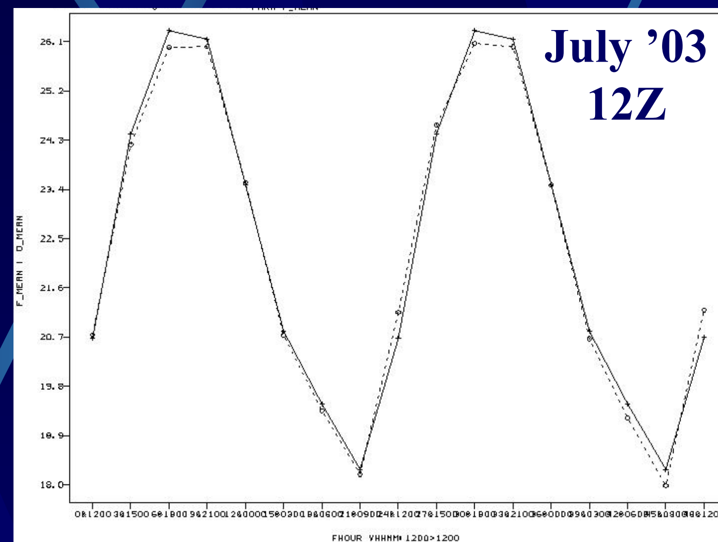
Average Diurnal Cycle Verif over NE

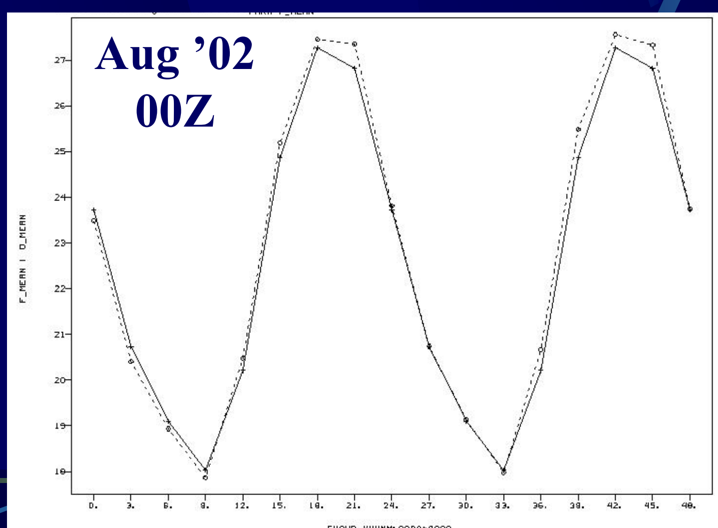


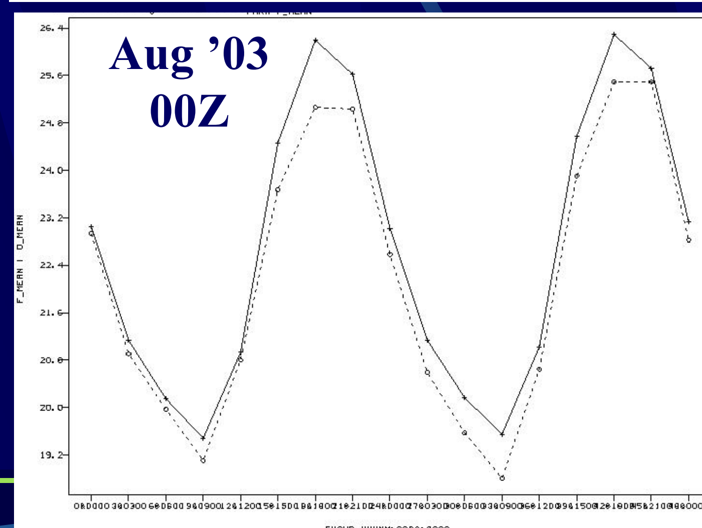
Average Diurnal Cycle Verif over NE

Obs
Fcst









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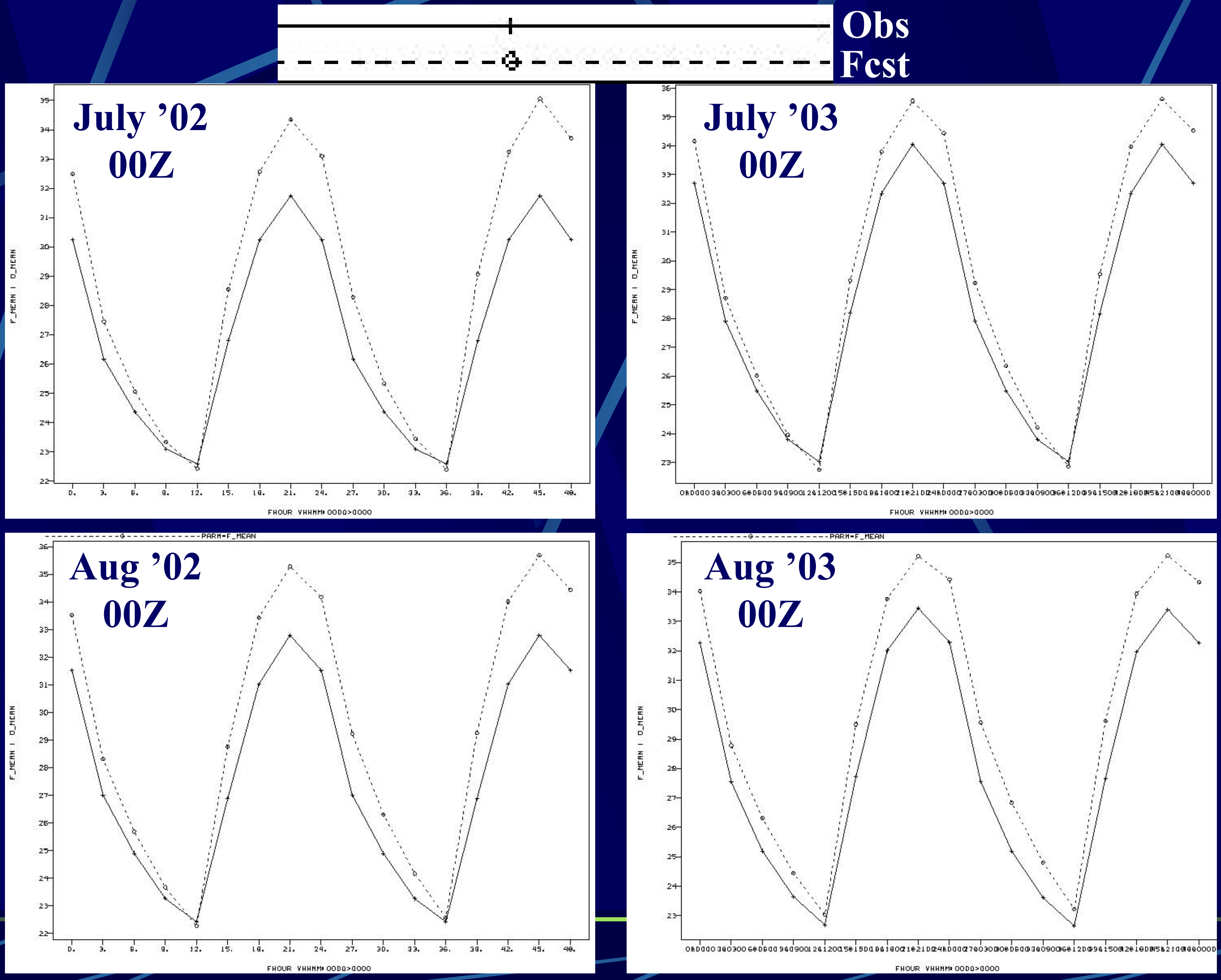
Average Diurnal Cycle Verif over SPL



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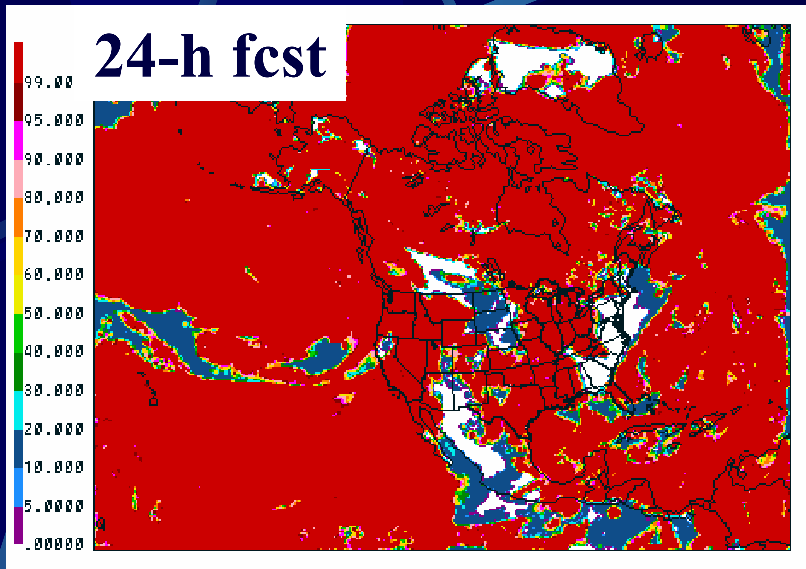
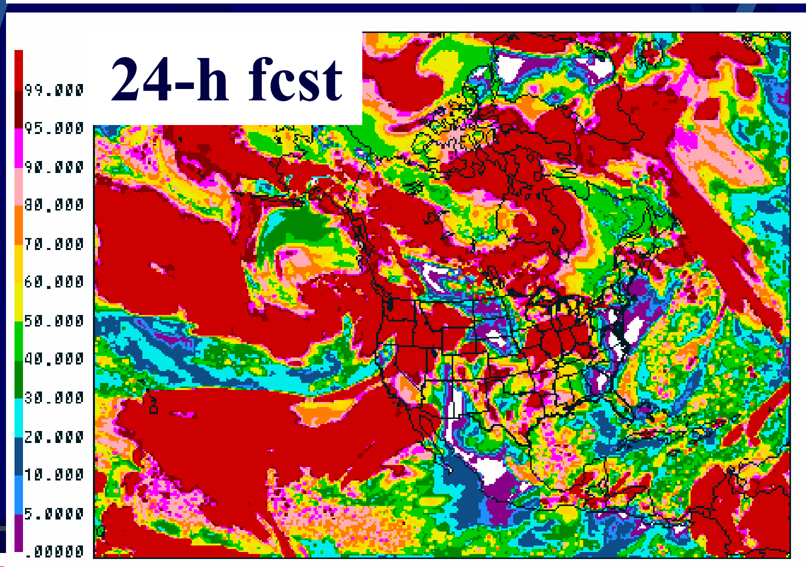
Total Cloud Cover

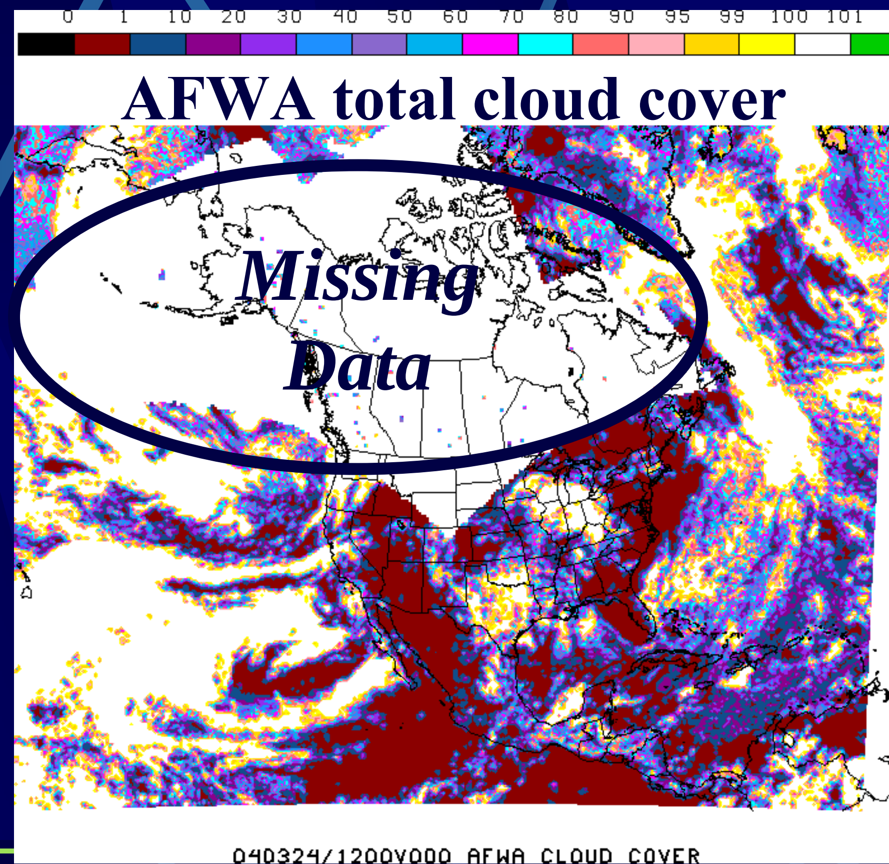
Operational



Experimental



All valid at
12Z 24 Mar '04



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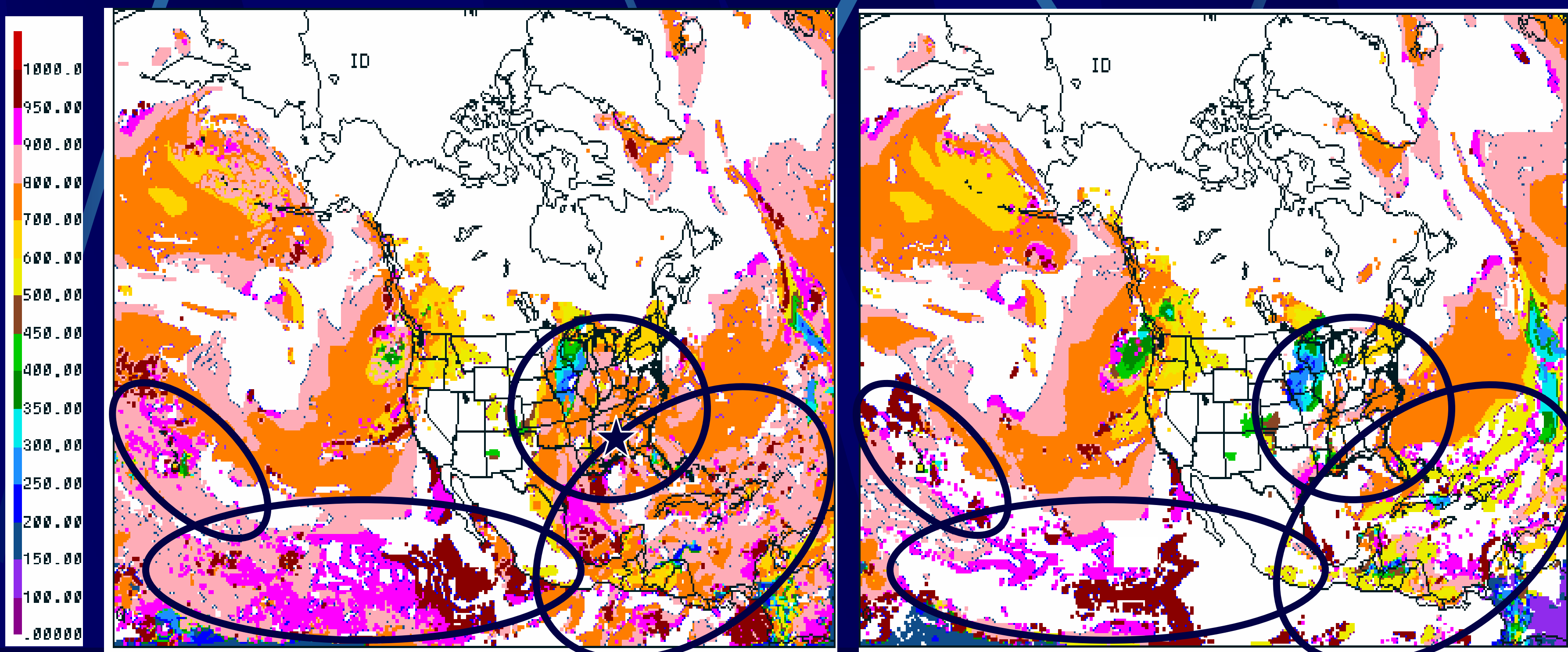
Shallow Convection

60-h fcsts of convective cloud-top pressure (hPa) valid at 00Z 26 March 2004

Old shallow Cu scheme | **New shallow Cu scheme**



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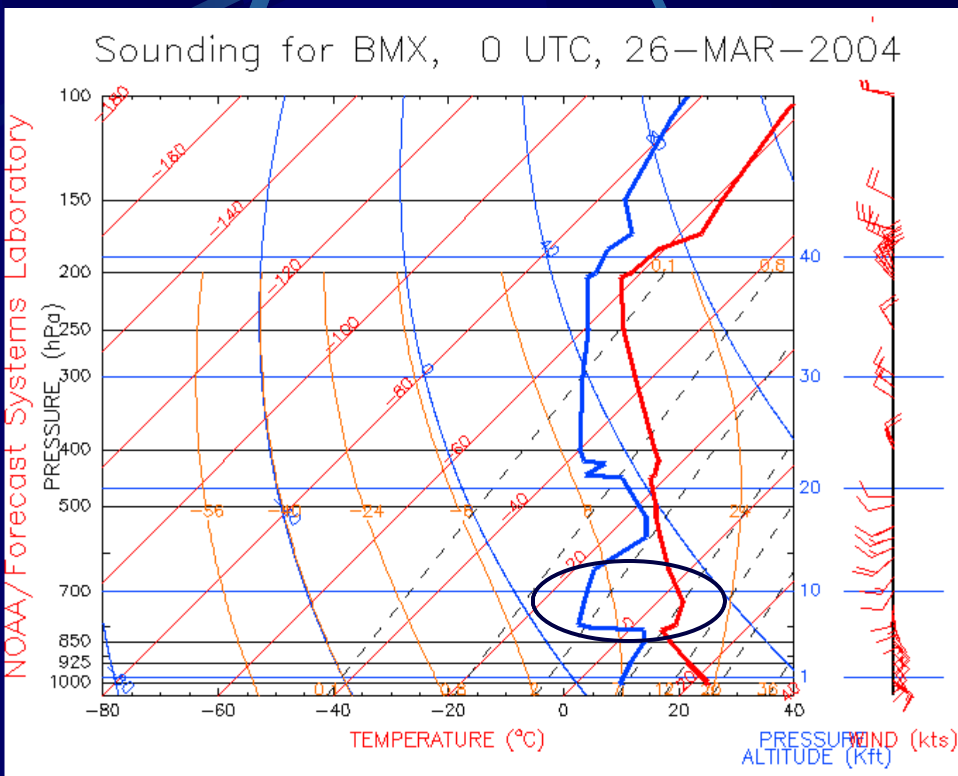
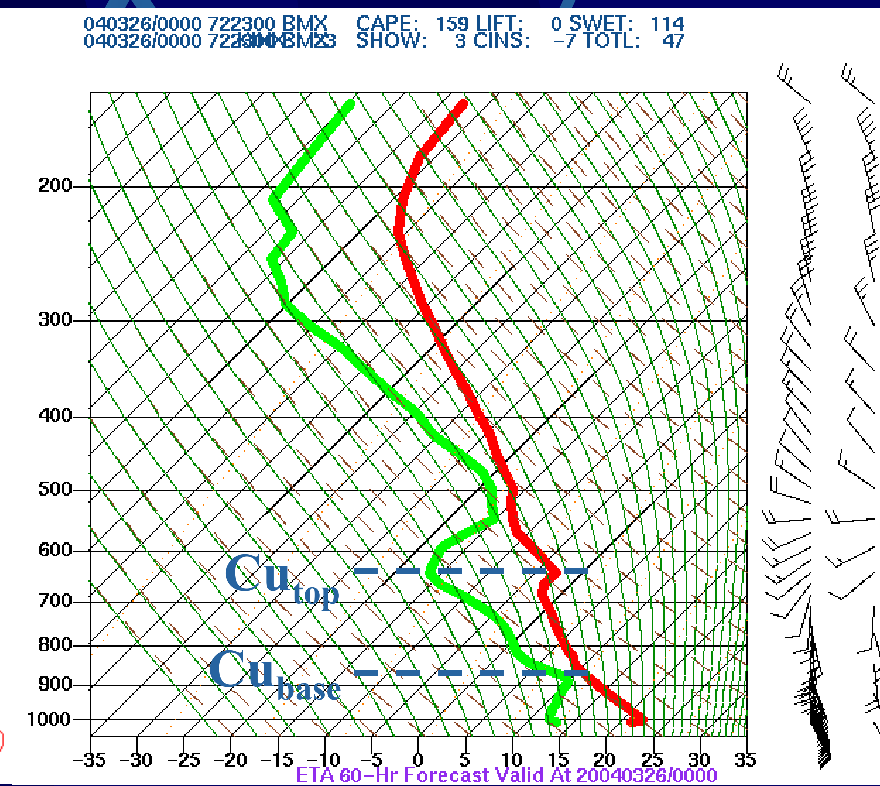
Impact of Eta Shallow Convection on Forecast Soundings

Observed (FSL)



60-h fcst 12-km Eta



Birmingham, AL (Shelby airport)

Plans for Final Set of Eta Changes

- **Major upgrade to Noah LSM**
  - Make consistent with what's in the WRF
  - Higher latent heat fluxes from the surface ⇒ should help increase low-level cloud amounts
- **GFS solar radiation package**
  - Monthly 5-degree aerosol tables
  - Less surface solar radiation below low clouds
- **Revised cloud optical properties**
  - Large increase in partial cloudiness from convective and grid-scale clouds
  - Increased longwave emissivities for ice
- **Revised shallow convection**
  - Cloud top based more on parcel theory
  - Includes small amt of cloud-top entrainment (5%)

Challenges and Caveats

- Similar changes last fall were not implemented because cold-season cold biases were worse, especially at higher latitudes
- Becoming increasingly difficult to implement changes that lead to "across the board" improvements due to "wheel of pain"

  … *Thou shalt not degrade QPF* ….
- Must evaluate from cold-season and warm-season parallel retrospectives
- With WRF looming, moratorium for IBM upgrade, & limited throughput on current system will probably have time only for "one good shot"

Steps to Resume Assimilation of Surface Observations

- Removed from EDAS in Sept '03
  - Improved forecasts (originally found from RR)
- Near-term strategy
  - Limited assimilation of surface observations into EDAS using a 2D analysis at the lowest model level => targeted for final Eta changes in late summer or early fall
  - Start testing assimilating mesonet data into the 2D analysis => can be put into operations after final Eta changes

Assimilation of Surface Obs (cont.)

- **Longer-term strategy**
  - Approximate timing with WRF replacing Eta in North American guidance (end of FY05)
  - Transfer lessons learned from Utah ADAS into the WRF GSI (grid-point statistical interpolation)
  - More emphasis in future developments on assimilating surface observations into NCEP's operational WRF model - likely to be the NMM (Nonhydrostatic Mesoscale Model)

Path(s) to Operational NCEP Models

- **Direct physical and meteorological validation**
  - SW↑↓ , LW↑↓ , latent & sensible heat fluxes, PBL heights, T, RH, winds, etc. at the surface
  - Evaluating observed cloud properties against forecasted fields, *taking into account the assumptions and simplifications in the models*
    - Convective vs. stratiform (grid scale), cloud fractions (at least total), LWP and IWP, cloud bases and tops
    - Simple aspects of particle spectra
      - r_{eff} for cloud water, cloud ice, snow, and rain
      - Characteristic size spectra of snow, rain + onset of drizzle
  - Profiling capability puts surface observations in context of PBL, atmospheric profiles

Path(s) to NCEP Models (cont.)

- Monthly evaluations ⇒ identify model biases
- Select case studies
  - Small sources of error from initial conditions
  - Larger-scale pattern accurately predicted
  - Not affected by convective QPF
  - Errors possessing temporal (at least 1-2 h) & spatial ($8\Delta x$) continuity
- Can observations give some sense of expected uncertainty from modeling systems (i.e., data assimilation and forecast models)? Balance between deterministic & probabilistic approaches?
- Evaluate satellite radiances & retrievals used for improved verification of & assimilation into NWP models (JCSDA)?