CAPT – Summary and Plans

CCPP – ARM Parameterization Testbed

Atmospheric Radiation Measurement Program

Climate Change Prediction Program

Participants: Jim Boyle (LLNL), Mike Fiorino (LLNL), Jay Hnilo (LLNL), Steve Klein (LLNL), Jerry Olson (NCAR), Tom Phillips (LLNL), Jerry Potter (LLNL), Dave Williamson (NCAR), Shaocheng Xie (LLNL)

CAPT GOALS

- Provide diagnostic assessment of clouds, radiation, and moist processes for climate models run in NWP mode principally using data from ARM field sites
- Develop diagnostic tools that are of use in assessing the impacts of new parameterizations on the simulations of climate models run in NWP mode

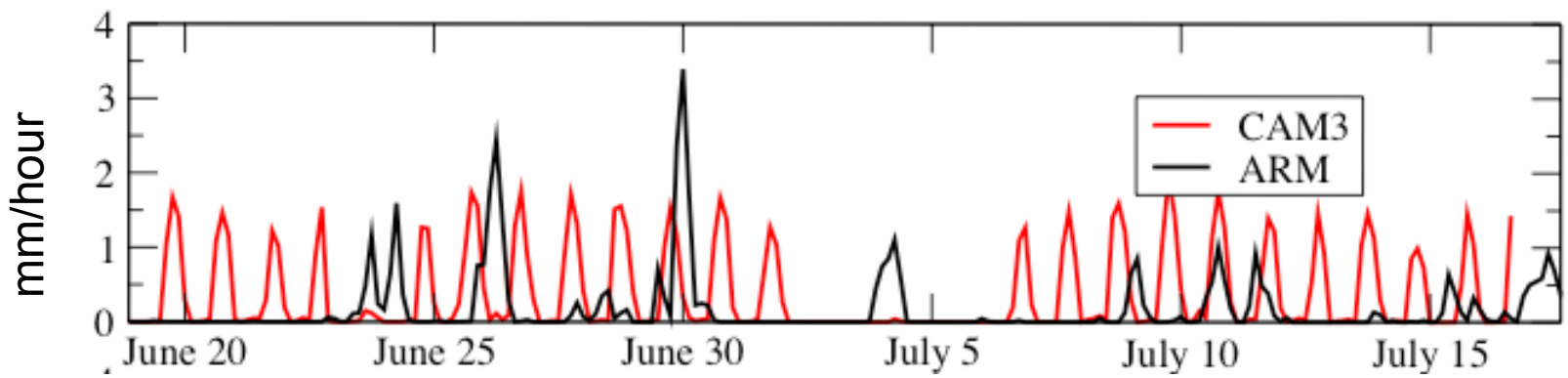
Accomplishments in past year

- 4 Publications
  - Boyle et al., Phillips et al., Xie et al., Williamson et al.
- Migrated from NCAR CAM2 to CAM3
  - Performed one year of forecasts (2000)
  - Demonstrated ability to run Finite Volume core
- Have done initial GFDL AM2 forecasts
- Developed a relationship with one parameterization developer - Guang Zhang (UCSD)

CAM2 vs. CAM3

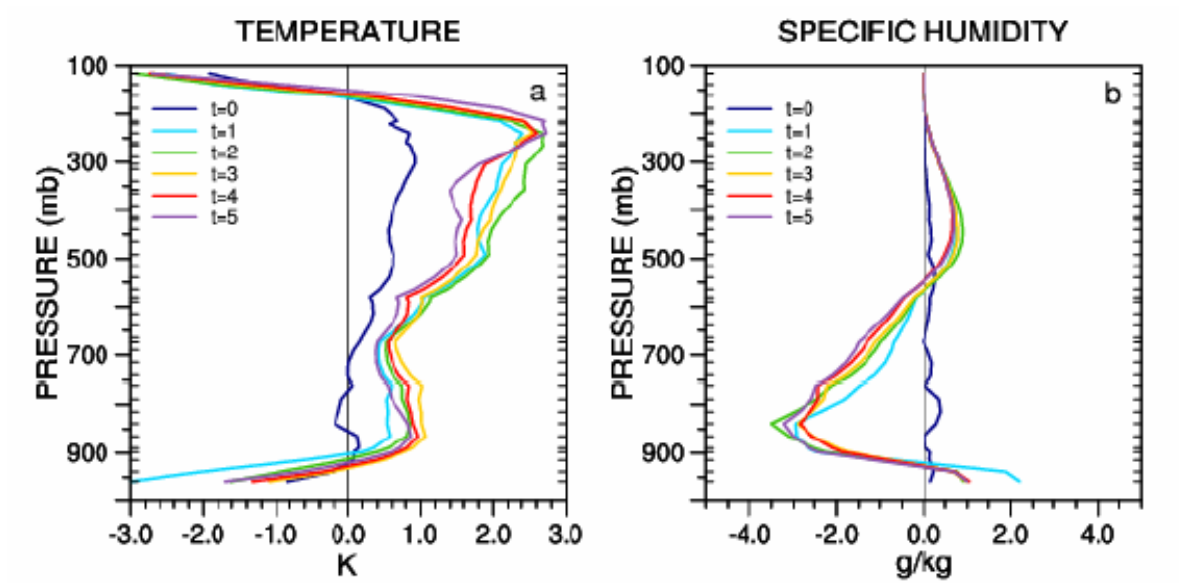
Evaluation at the ARM Oklahoma site for short-range forecasts of the June/July 1997 Intensive Observing Period

Surface precipitation – 12 to 36 hours

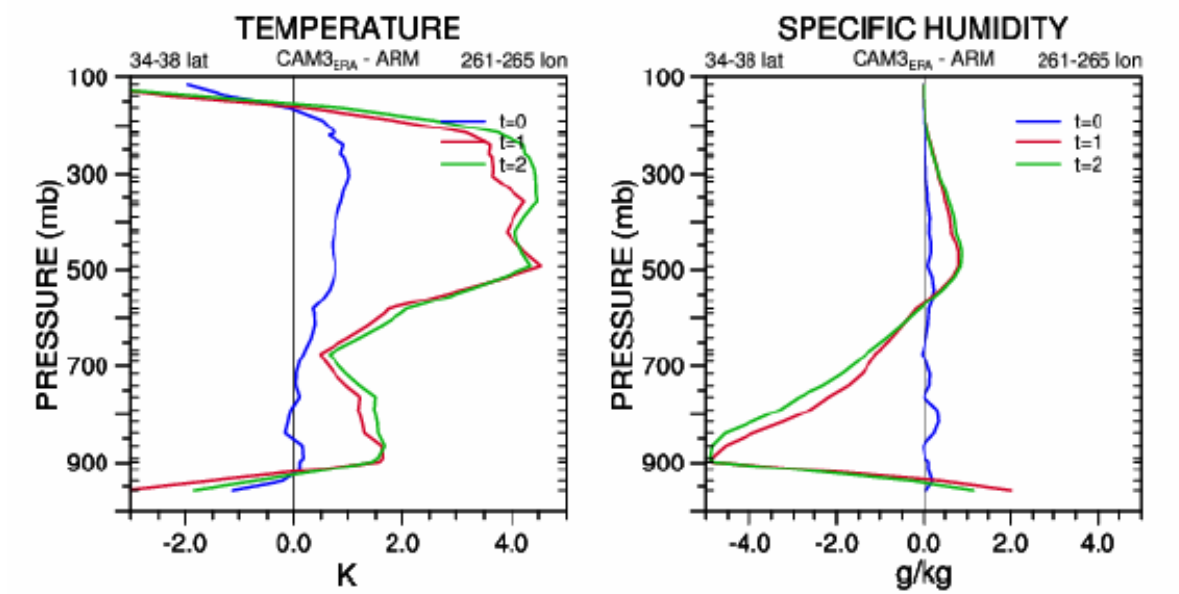


Temperature and water vapor errors

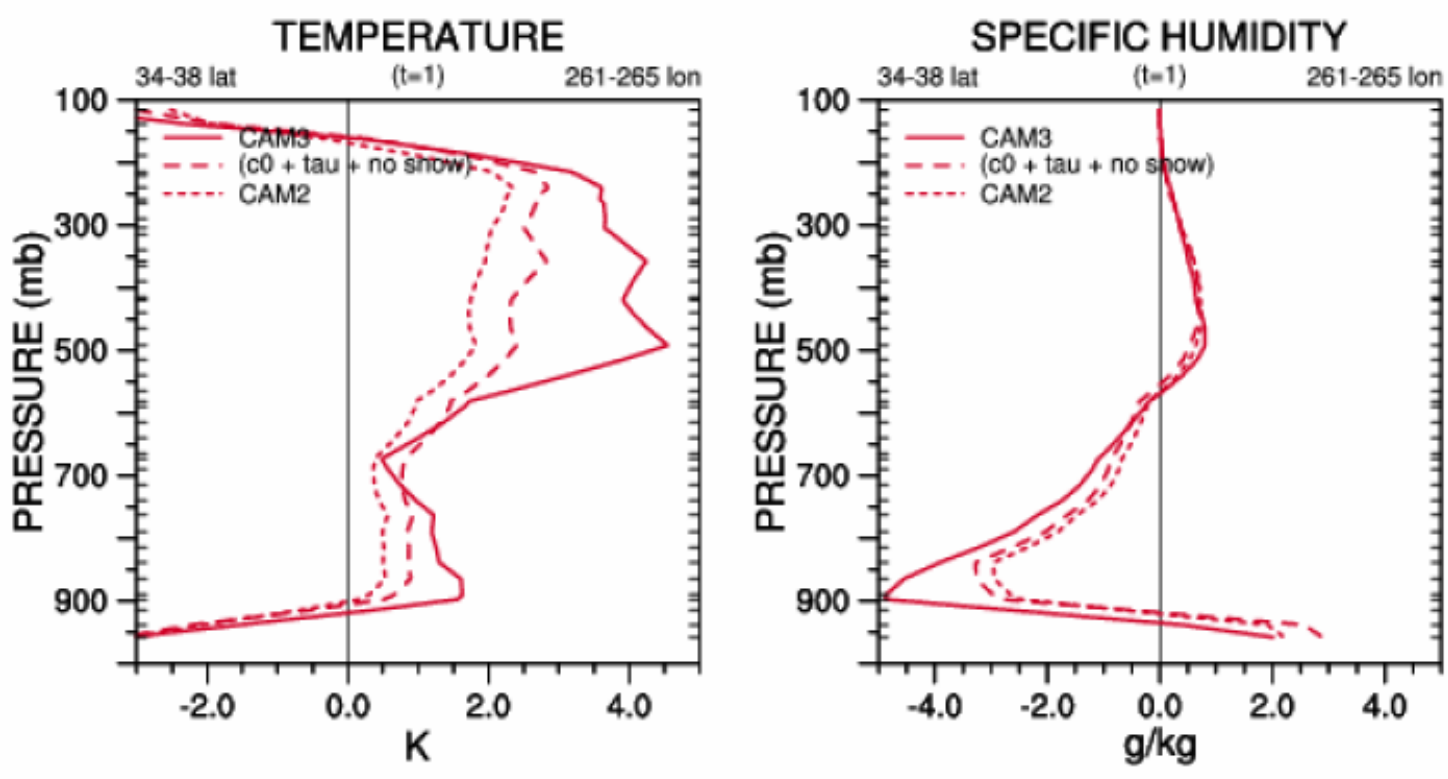
CAM2



CAM3



Attribution of differences

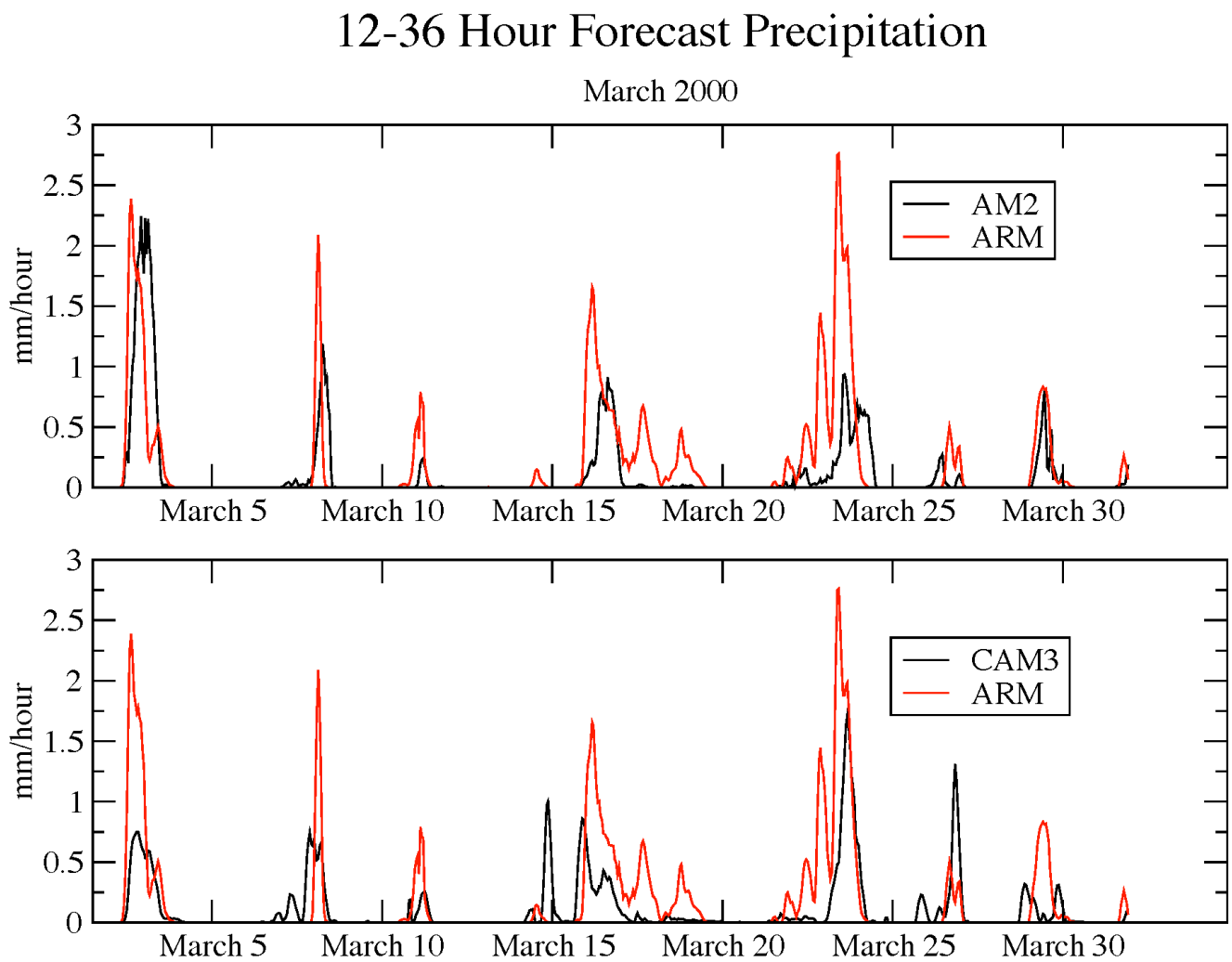


Changes in the convection parameterization explain most of the differences.

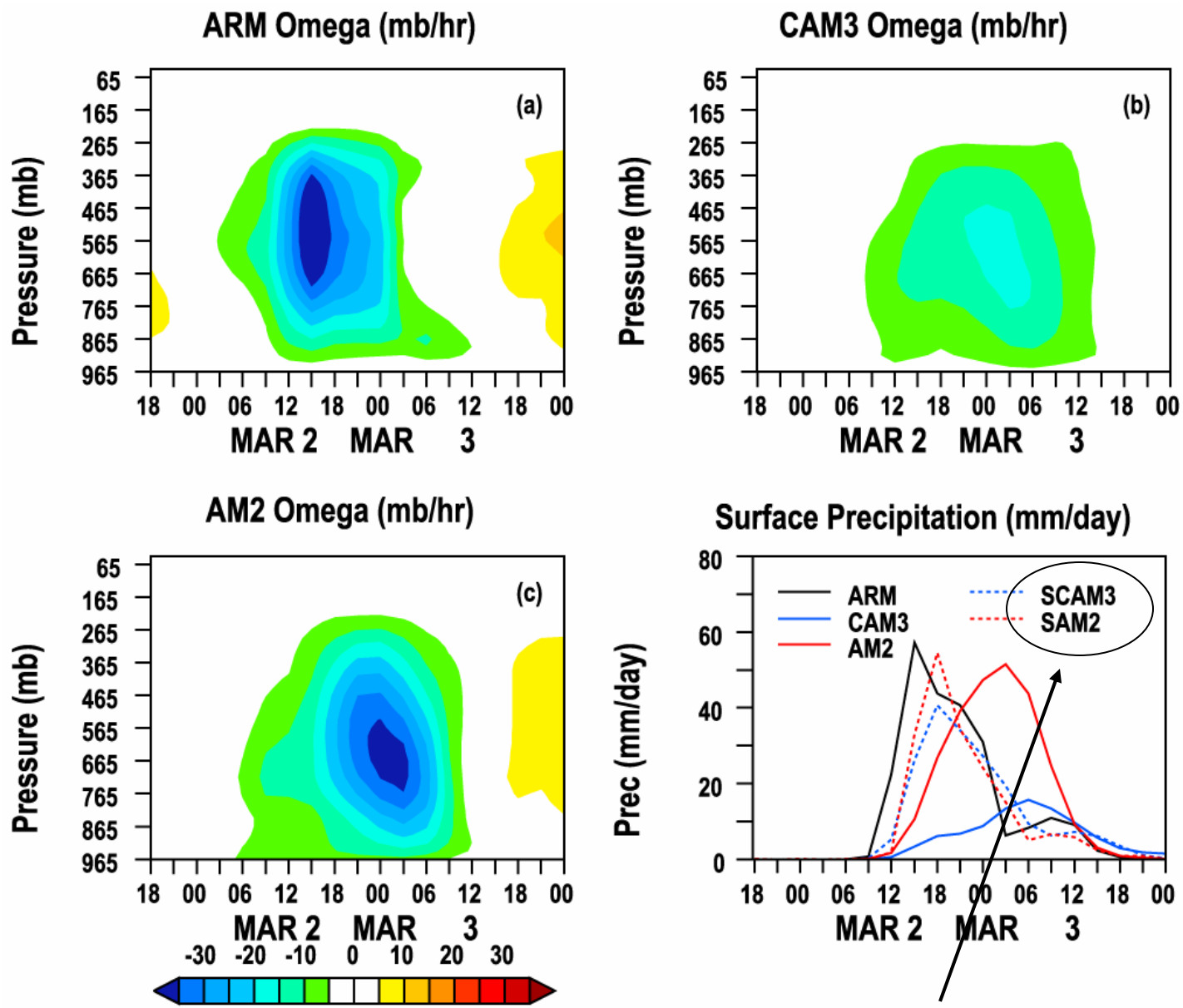
- *c0* = conversion rate of convective condensate to precipitation (increased)
- *tau* = time scale for CAPE adjustment (shortened)
- *no snow* = frozen condensate in convection scheme was added

Addition of GFDL AM2 model

Evaluation at the ARM Oklahoma site for short-range forecasts of the March 2000 Intensive Observing Period



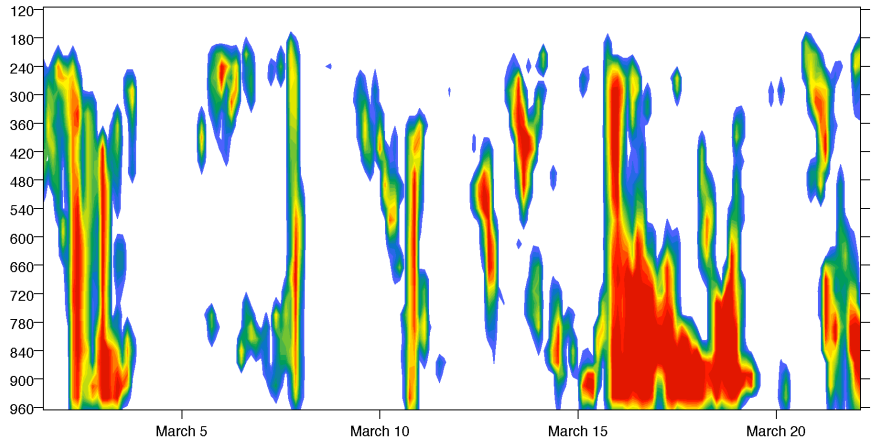
Simulation of vertical motion and surface precipitation for the March 2-3, 2000 storm



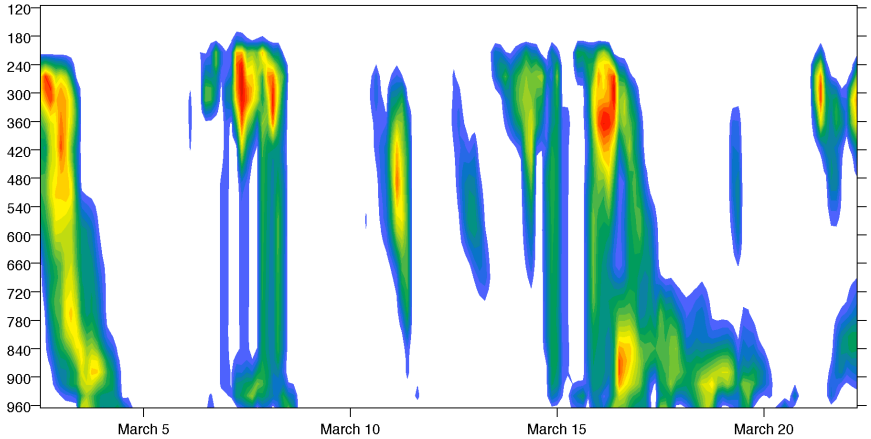
Single Column Models (SCMs)

Cloud Fraction during the March 2000 IOP

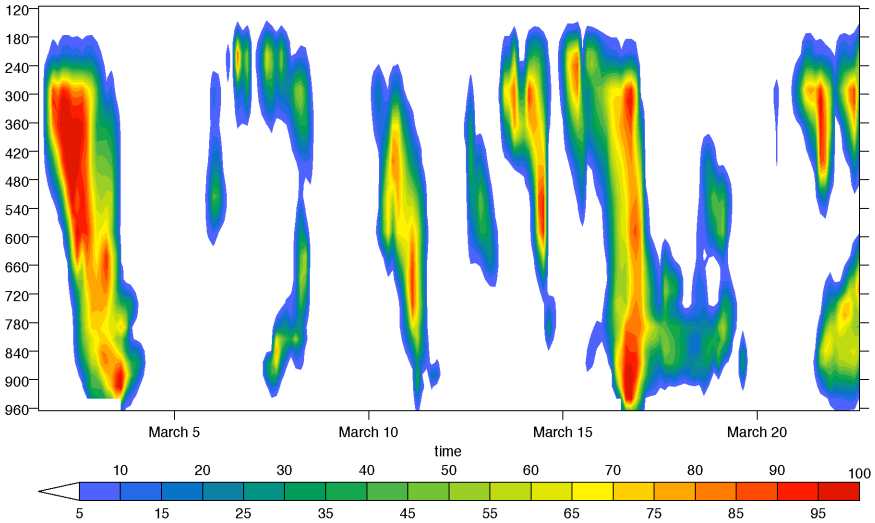
ARM Cloud Radar



NCAR CAM3



GFDL AM2



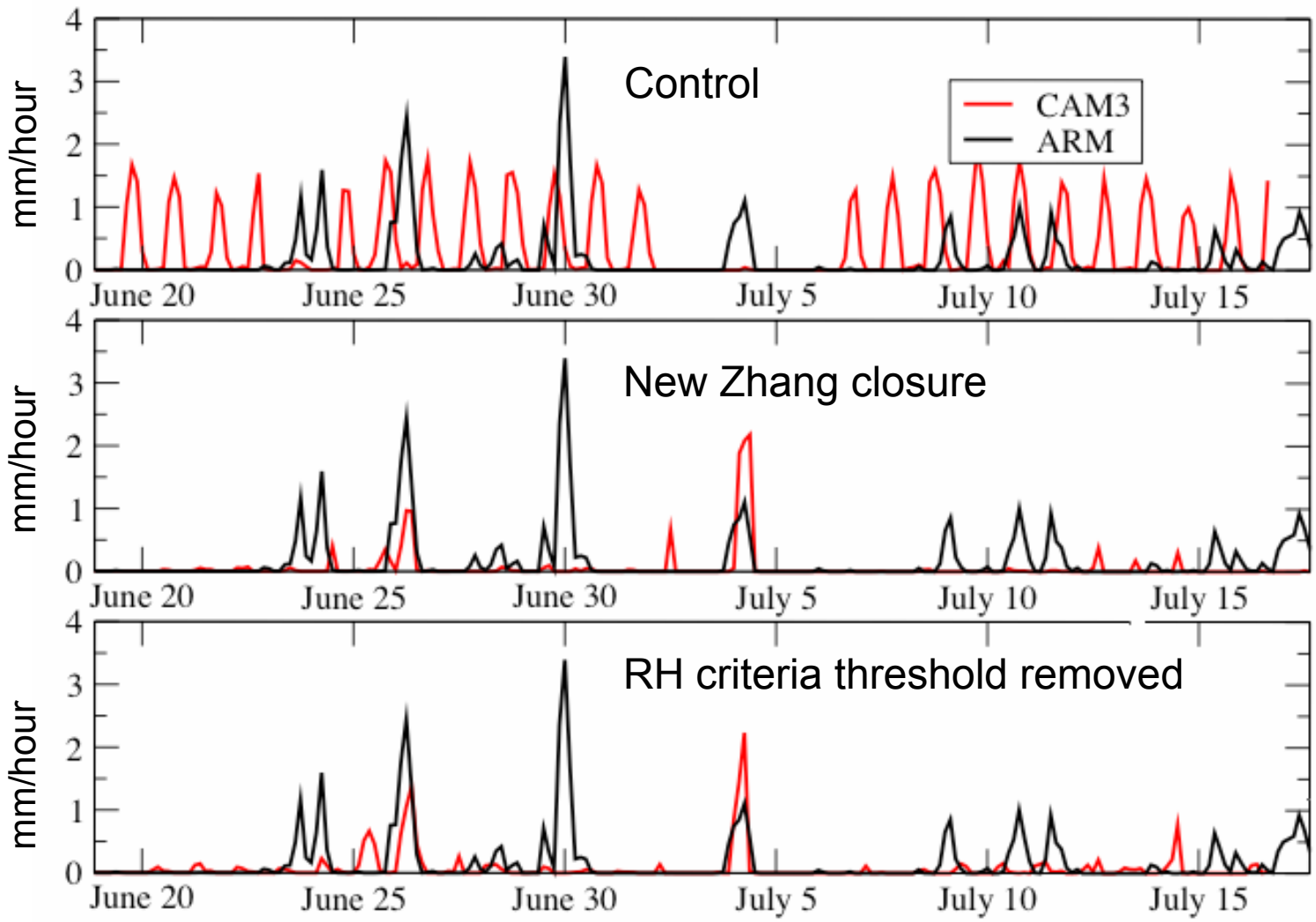
Test of modifications to Zhang-McFarlane convection scheme (Zhang and Mu 2005)

- Modified closure:
  instead of CAPE/tau, use:

$$M_b = \frac{1}{F} \max\left\{ \left(\frac{\partial \mathrm{CAPE}_e}{\partial t} \right)_{ls}, 0 \right\},$$

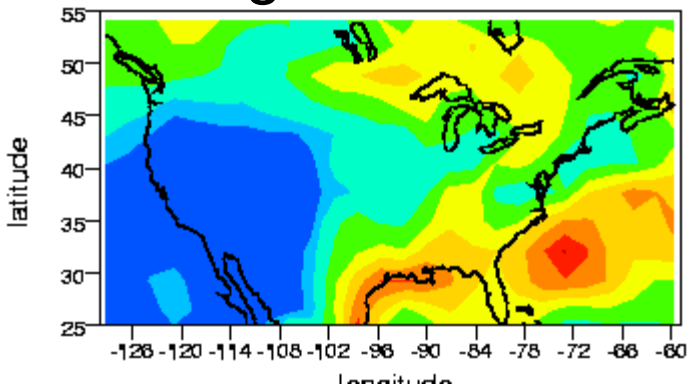
- Relative humidity threshold for level from which parcels are lifted (RHcrit = 80%)
- Parcels may originate from any layer of the atmosphere instead of only in the planetary boundary layer (PBL)

Simulation of Oklahoma precipitation during the June/July 1997 IOP

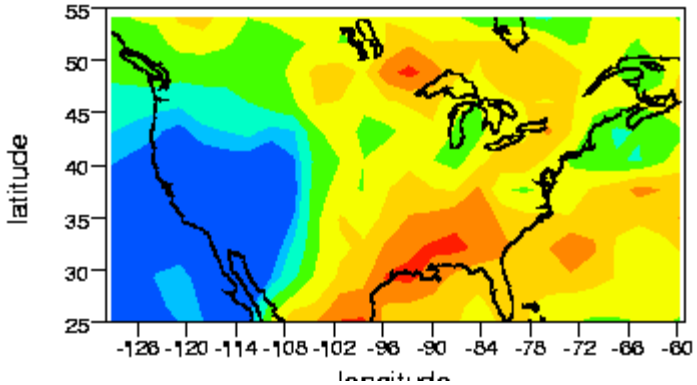


First day accumulated precipitation during the June/July 1997 IOP

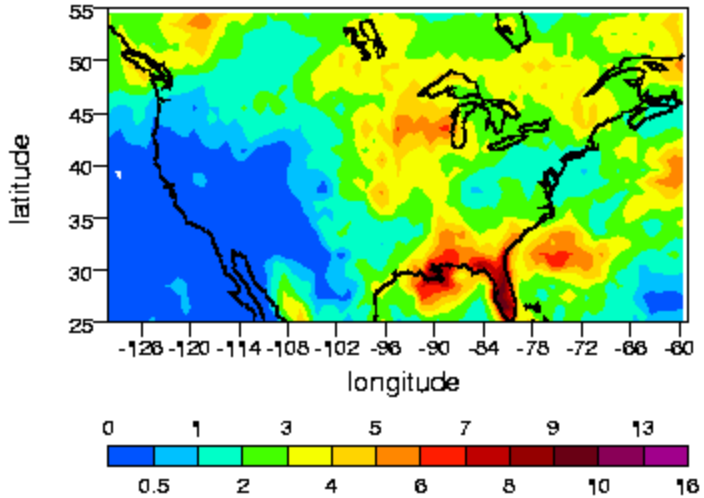
Zhang modifications



No RHcrit threshold



GPCP Observations



mm/day

CAPT Plans

1. Deep convection case development
   - New oceanic convection case: TOGA-COARE
   - Further work on summertime land convection case
2. Assessment of model clouds with cloud radar data
   - ARM Oklahoma site and CloudSat

1. TOGA-COARE Convection

- We want another case to test the simulation of atmospheric convection
  - TOGA-COARE was a field experiment in the West Pacific Warm Pool which observed several phases of the Madden-Julian Oscillation between November 1992 and February 1993
- Because this is also the current GEWEX Cloud System Study (GCSS) case, this affords us the opportunity to evaluate the simulation of atmospheric convection in comparison to other models which are also run in NWP mode from ERA40 analyses
- This is a challenging case – the transition from suppressed to active conditions is difficult for models to do well

Possible Activities for TOGA-COARE

- Simulations of climate models in NWP mode to be compared to Single Column Model simulations driven with 2 observational analyses (Johnson and Zhang)
- Can evaluate the dynamical forcing in comparison with ERA40 and the two analyses
- Sensitivity studies
  - Spectral dynamics versus finite volume
  - Resolution: T42 versus T85
  - Convection formulations: Zhang modifications, Xie modification, Emanuel
  - Impact of X. Wu cumulus momentum transport
  - Impact of Bretherton PBL scheme (and vertical resolution)
  - GFDL AM2 simulations: Relaxed-Arakawa-Schubert versus Donner convection

TOGA-COARE goals

- Assess and understand differences between simulations of the heating/moistening profiles in different phases of the MJO
- Evaluate the simulation of surface fluxes and surface wind speed in relation to phases of the MJO
- Evaluate the radiation simulation in different phases of the MJO

Possible activities centered on the summertime land convection case

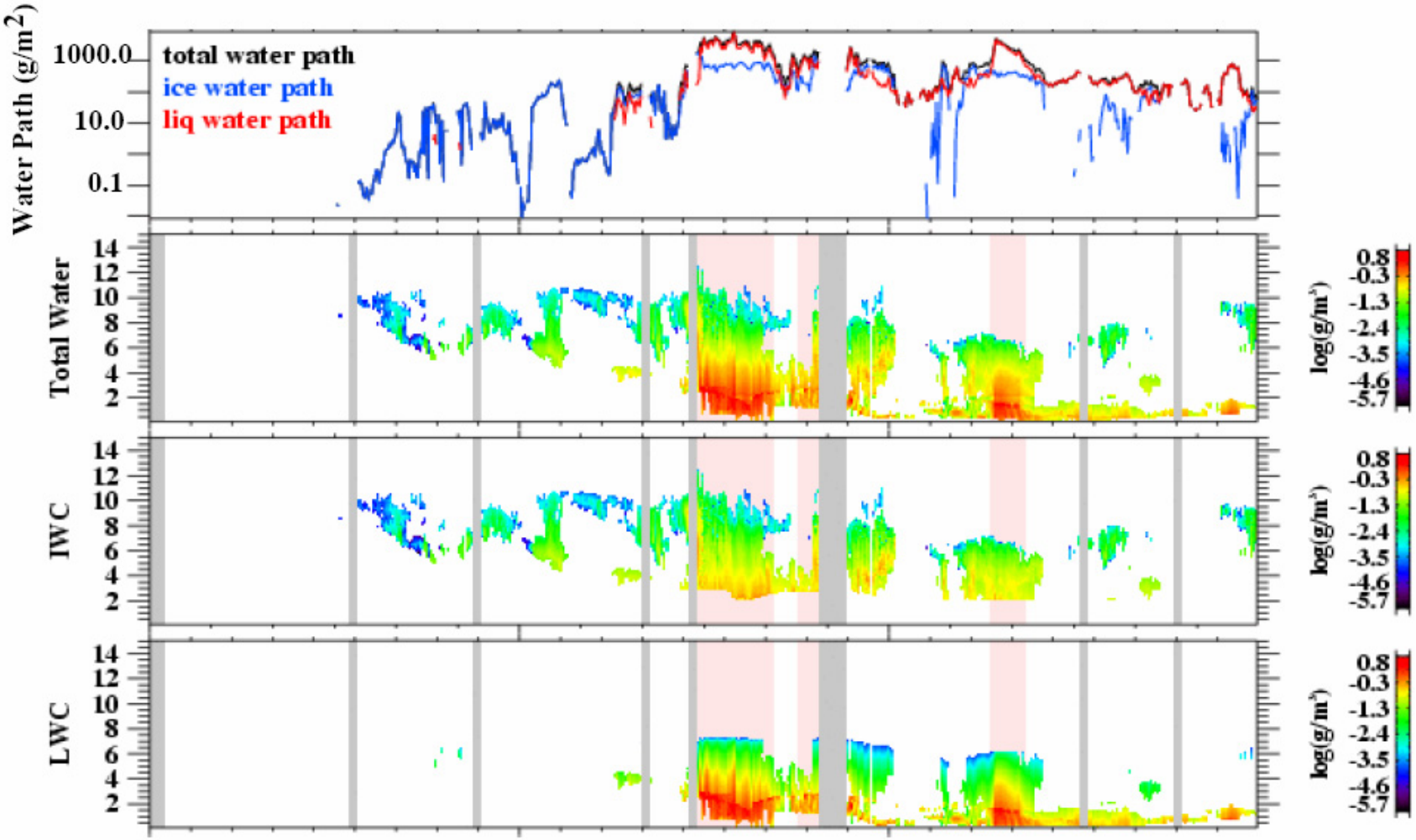
- Broader perspective on simulations
  - How do events propagate horizontally in model simulations?
  - Is there a difference in the CAPT integrations between events which are generated locally over Oklahoma versus those that result from horizontal propagation?
  - How well is the low level jet simulated?
- Further contrast of SCM and CAPT simulations
  - How well are the large-scale tendencies simulated?
  - Which differences are crucial for incorrect simulations of these forcings?
  - How well are surface fluxes simulated?
- Further sensitivity studies
  - Impact of horizontal resolution
  - Impact of Bretherton boundary layer formulation
  - Impact of X. Wu cumulus momentum transport
  - Impact of alternate cumulus parameterizations (Emanuel or Donner)

2. Assessment of clouds with cloud radar data

Why cloud radar data?

- Cloud radar data gives the vertical extent of clouds – satellites don't really do this
- Well-developed algorithms have been developed which retrieve the cloud microphysics (e.g. ice and liquid water contents, effective particle sizes)

Collaboration with Jay Mace (U. Utah)



March 2-3, 2000 (Mace et al., JGR submitted)

Considerations for comparing to cloud radar data

- Cloud radar data provides difficult sampling issues, thus we need many forecasts
  - We have run the NCAR CAM3 for a full year (2000) and we will run the GFDL AM2 for the same period
- We can run SCM simulations for the years 1999-2001 for the ARM Oklahoma site to contrast with the CAPT simulations

Cloud Property Analysis Goals

- Analyze clouds in terms of meteorologic context
  - Stratify analysis into dominant cloud types
  - Relate variations of clouds within a class to variations in dynamics and thermodynamics (e.g. assess the depence of ice water content on temperature and vertical velocity)
- Can contrast simulations of CAM3 and AM2
  - Why is the ice water path much greater in AM2 than it is in CAM3? Different cloud thicknesses or cloud water contents?
- Assess clouds with ISCCP satellite data using the ISCCP simulator embedded in the models
- Initial focus on cold season clouds
  - The models simulate cloud occurrence more reliably in these situations

CloudSat extension

- CloudSat will be launched within the next few months
- CloudSat will be the first research satellite to carry a cloud radar
  - This is like a ‘flying ARM site’
- We will run the NCAR model for the period of the CloudSat satellite and extract columns of the model at the places and times of satellite overpasses
  - We need analysis data for post-2001 periods. We are pursuing the operational NCEP analyses
- We will collaborate with Jay Mace (U. Utah) on the analysis and interpretation of CloudSat data

Other Potential Periods of Interest

- ARM field experiment MPACE = Mixed-Phase Arctic Cloud Experiment
  - Took place at the ARM site in Northern Alaska in October 2004
- AMMA = African Monsoon Multi-disciplinary Analysis
  - Will occur in West Africa in 2006
- ARM field experiment TWP-ICE = Tropical Warm Pool – International Cloud Experiment
  - Will occur in January 2006 in Darwin Australia to study oceanic monsoon convection

THE END