

Recent Progress from the CCPP-ARM Parameterization Testbed (CAPT)

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And special support from Dave Bader



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ARM Science Team, April 3, 2003

UCRL-JC-151905



Goal of this project

Evaluate parameterizations

- – gain insight leading to improved predicted climate
- ***Identify errors very early in the simulation***
 - -- with a eye on reducing long-term systematic errors
- ***Comprehensive evaluation of model changes***
- ***Develop a test bed for parameterizations***



The goal is to develop procedures to run a climate model in a forecast mode

Create a new set of initial files from analysis and model output

- ***Nudging***
- ***Forecast/analysis***

One question remains: how can we determine if the errors are initialization or physics?

We are evaluating the errors of the “perfect analysis” due the initialization process

Motivation – ECMWF philosophy

*“One can have confidence in simulated climate scenarios only if one has confidence in the physical formulations and feed-back loops of the GCMs. A strong case could be made that every GCM should be equipped with a data assimilation system, so that one can diagnose its performance **with field experiment data** and in medium- and extended-range forecasts”*

A.J. Hollingsworth

ECMWF 1999-2009 10-year Plan



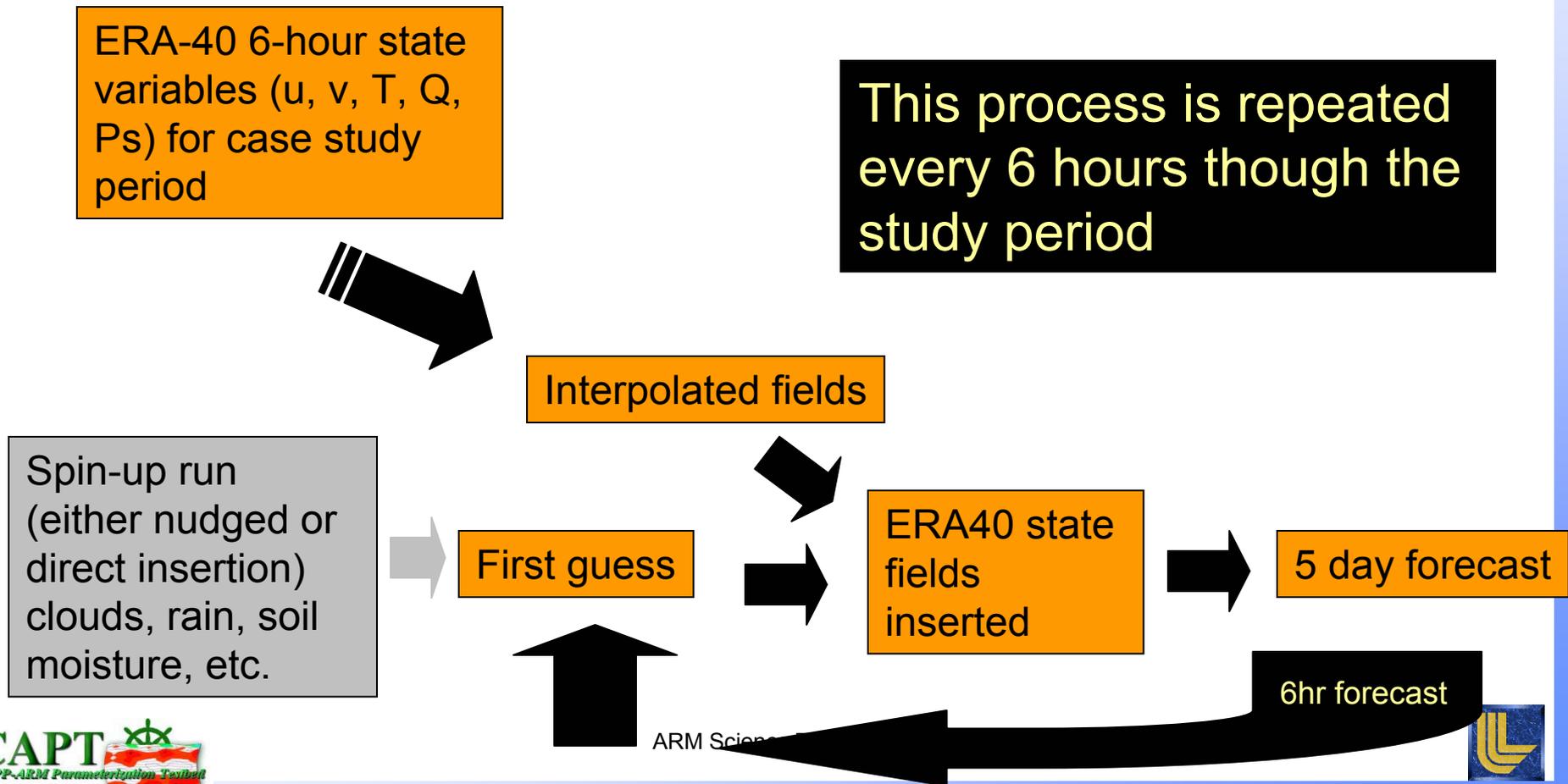
Advantages of NWP

- ***Large scale flow is more likely to be correct***
 - Errors we see are more likely to be errors in parameterizations
- ***Evaluation easier because of perfect time match between observations and model***
 - Eg. ISCCP histogram
- ***Use of observations that are less accessible to climate models***
 - Eg. ARM,
- ***Identify and execute case studies e.g. GCSS***
- ***NWP has metric to measure success.***
 - 500, weather parameters, 2m t, 10m wind, rain, q.

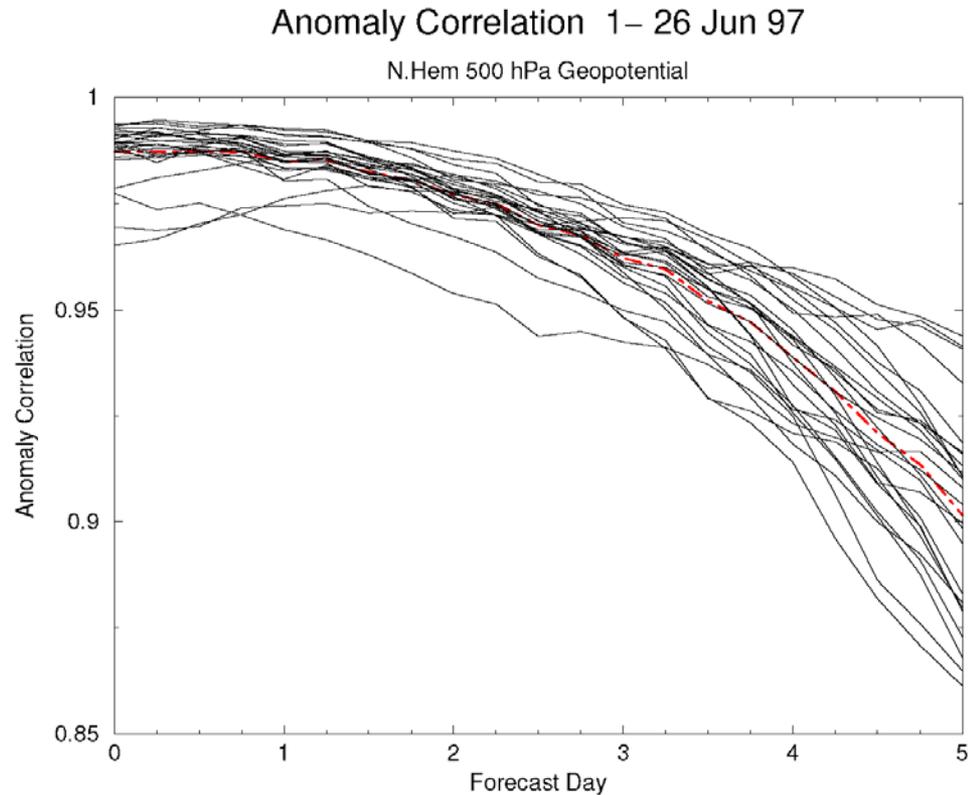


Preliminary studies and results

- Transition from nudging studies to direct insertion forecasts



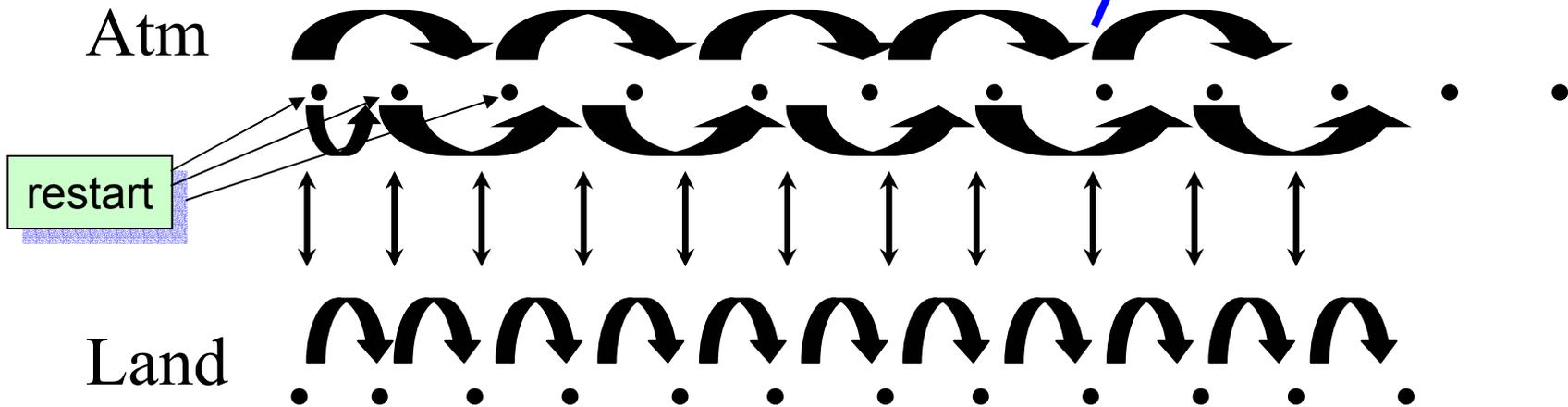
NH anomaly correlations from the direct insertion initializing method are quite acceptable



Initialization: plans and progress

This procedure has been used successfully

Forecast



The hope is that the land will come into some sort of equilibrium with the imposed initialization conditions

Time →

Work in progress

- ***Initialization - special issues of land surface spin-up***
 - CAM2 “perfect model” tests
 - NCEP “perfect initialization” tests
 - CAM2 initialization
 - Nudging
 - Forecast/analysis
- ***Forecasts***
 - 72 hour forecasts initiated every 24 hours
 - Comparison with analysis (or reanalysis)
 - Comparison with ARM and other case studies
- ***Parameterization tests – collaborative efforts with developers***
- ***Climate simulations – model diagnostics***



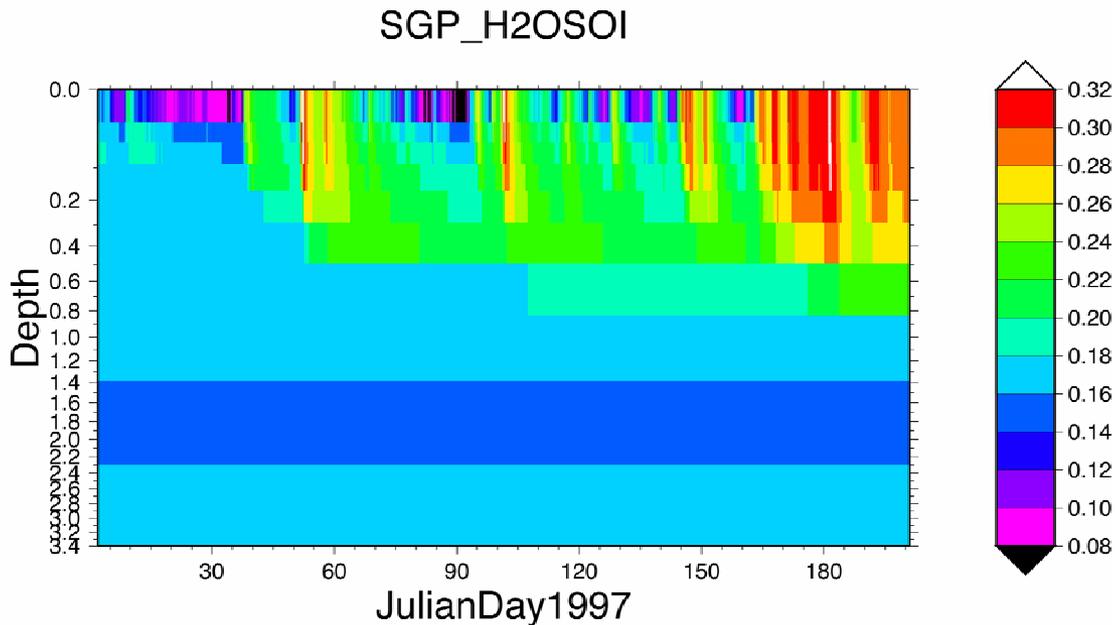
Model initialization

Method testing – every 6 hours

- ***Direct insertion of reanalysis into model ✓***
- ***Nudging the data to reanalysis ✓***
- ***Forecast analysis (add increment) – poor man's data assimilation***
- ***Forecast analysis – Data assimilation***



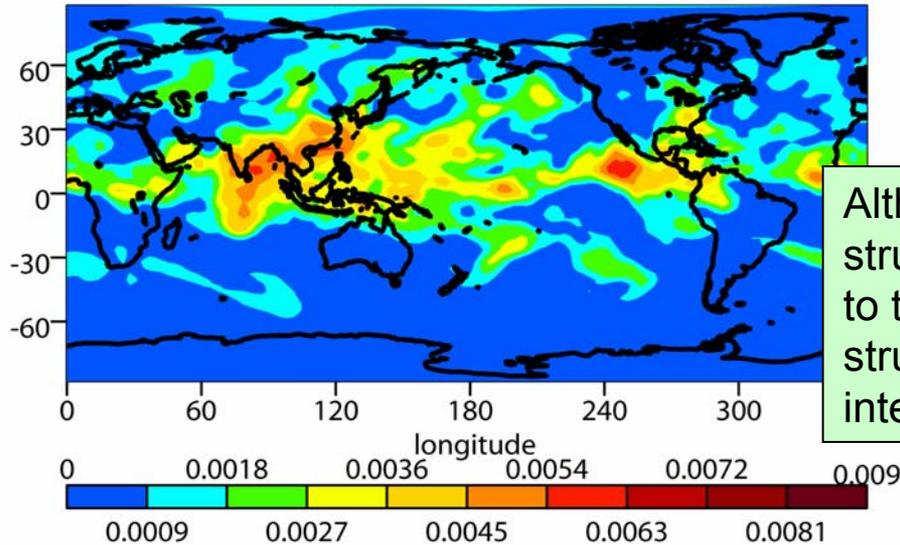
Soil moisture and rainfall during the 6-month spin-up



Because the surface cannot be initialized separately from the atmosphere, a minimum 6 month spin-up was required

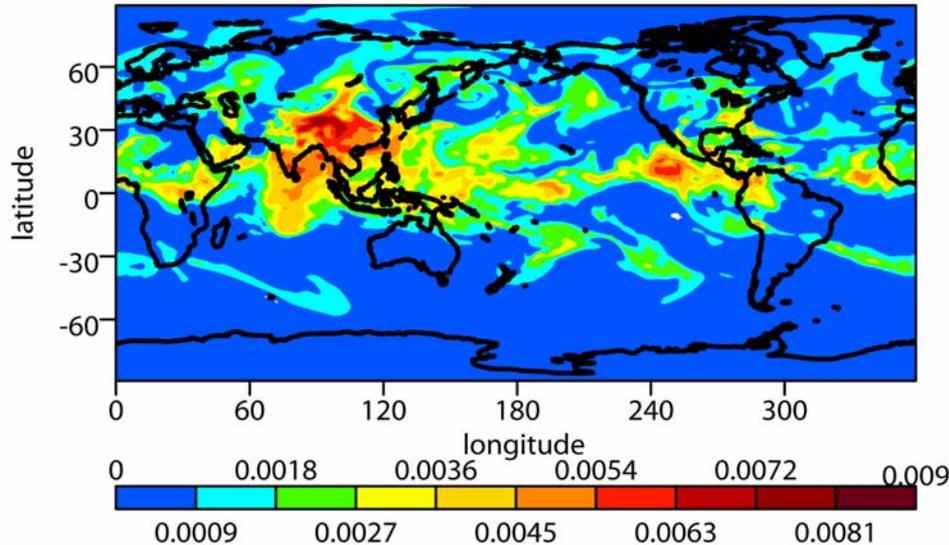
Q at 500 hPa

CAM2 initialized
by ERA40

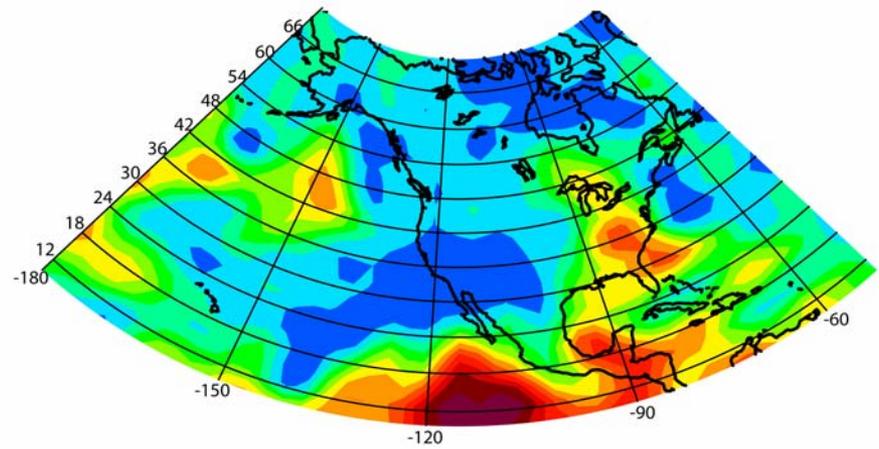
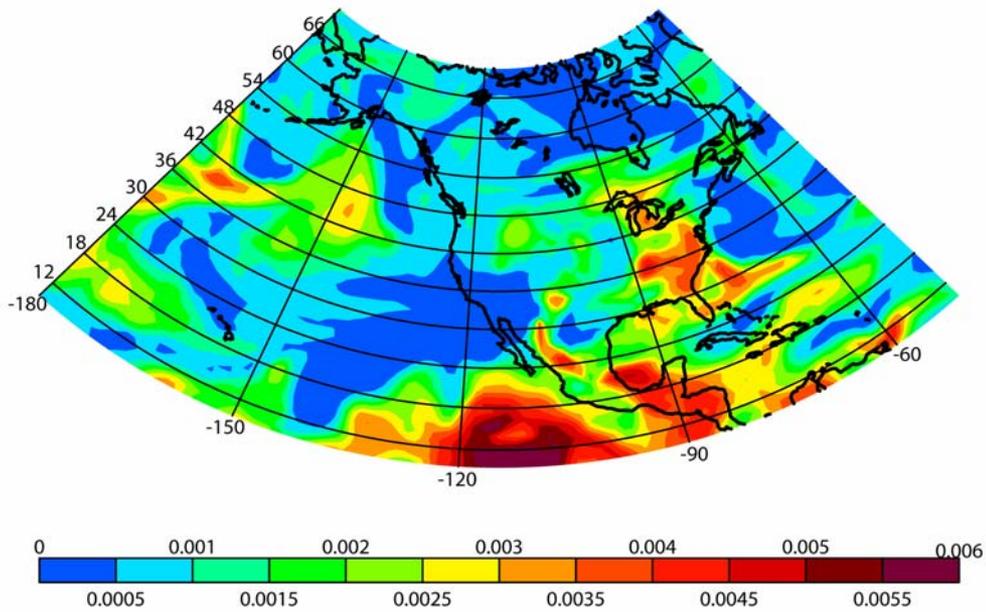


Although the general structure of the field is close to the reanalysis, the fine structure is lost after interpolation

ERA40



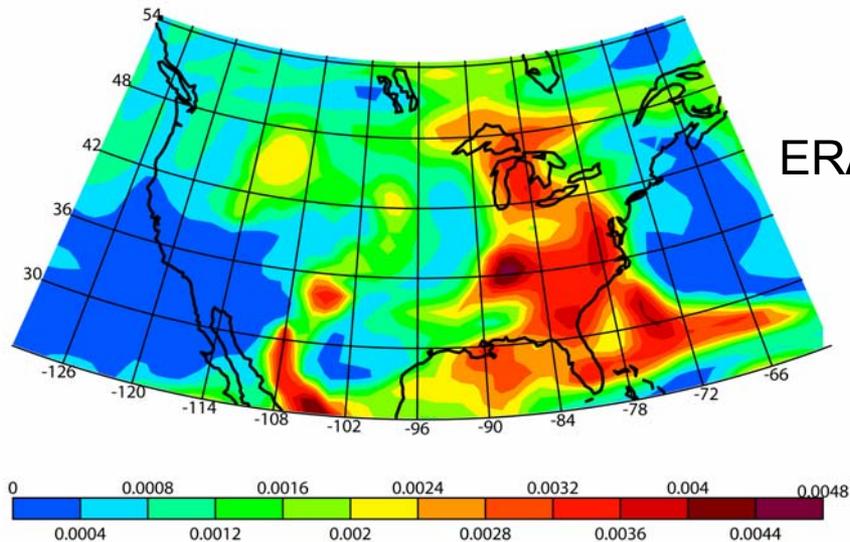
Interpolation



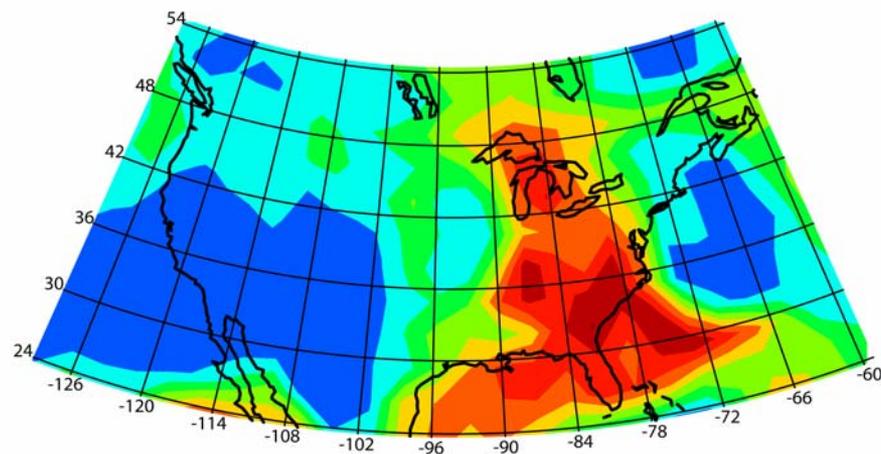
Interpolating the ERA40 grid to the CAM2 results in some loss of detail

July 1, 1997

ERA40 T170 Q AT 500 MB

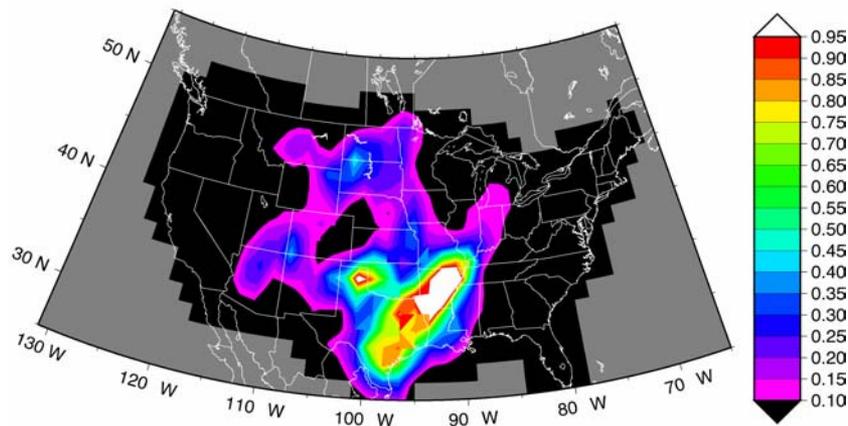


CAM2 initial state from
ERA40 after interpolation

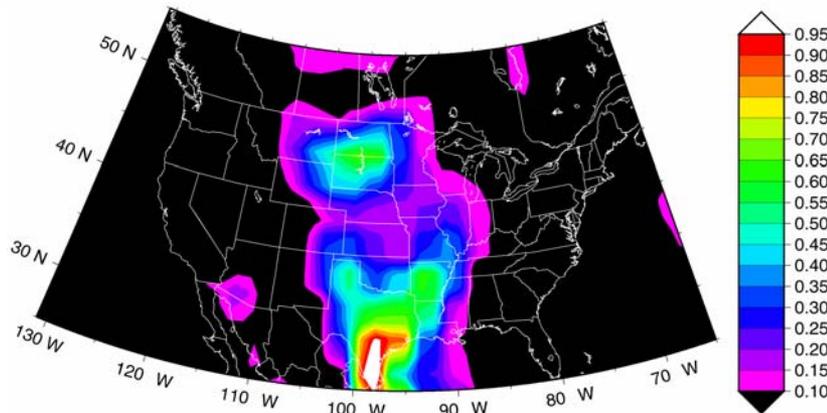


US precipitation rate averaged over 72 hour forecast compared with surface observations

CPC_1997-4-3-0-1997-4-6-0



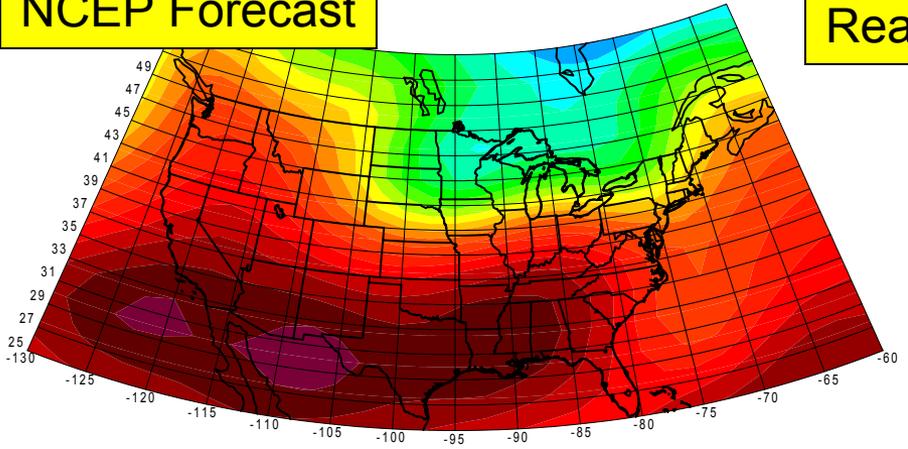
CAM_Nudged_1997-4-3-0-1997-4-6-0



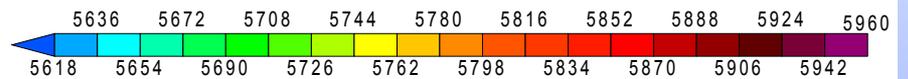
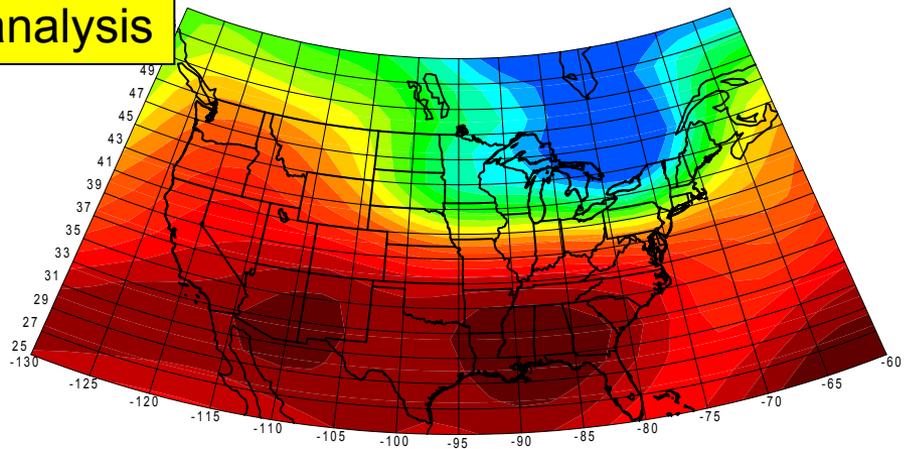
Forecast after initialization
using nudging

For this case, the CAM2 produces a reasonable 2-day forecast of 500mb heights

NCEP Forecast

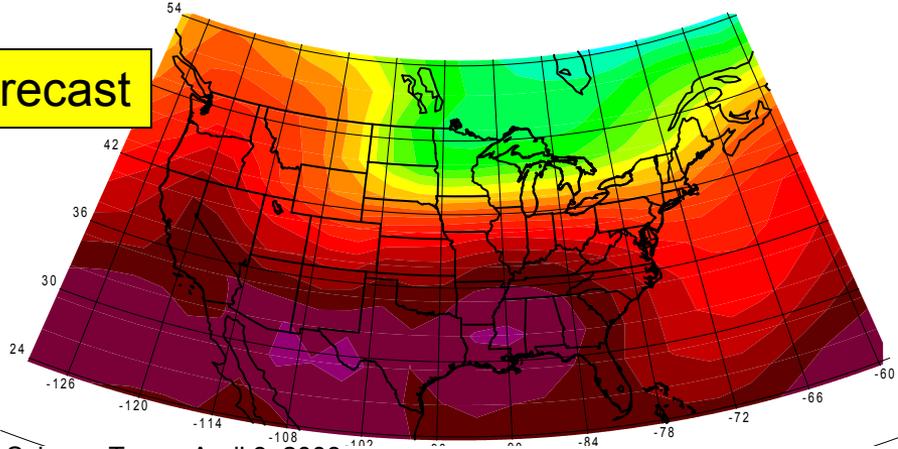


Reanalysis



0Z July 3, 1997

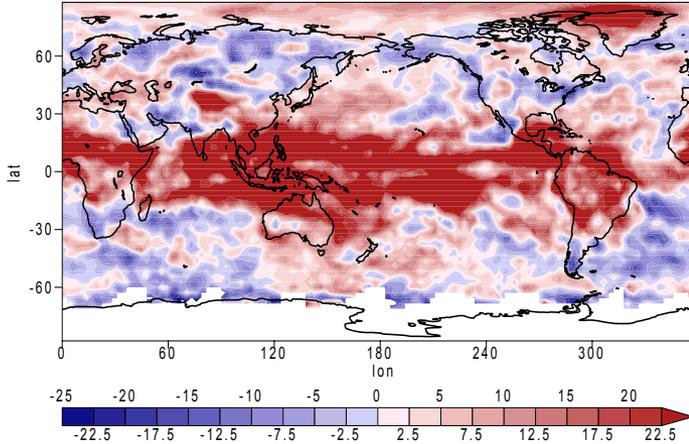
CAM2 forecast



For example, using the ISCCP simulator, we can look in detail at some of the CAM2 cloud biases

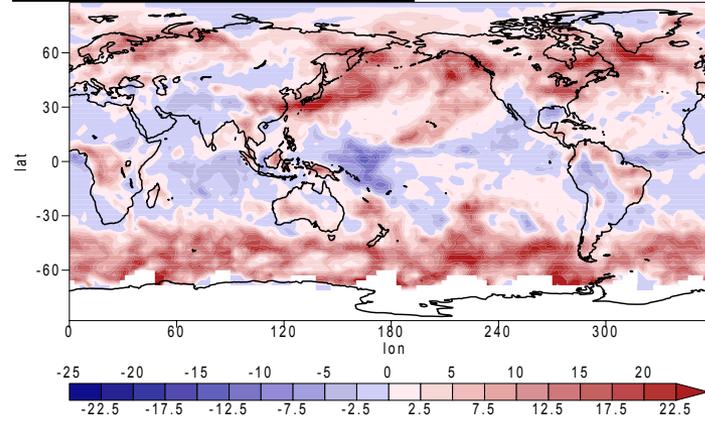
Cirrus

_subtract_cirrus_cam2_cirrus_isccp
Mean 9.79508 Max 66.4631 Min -50.7692



Deep convection

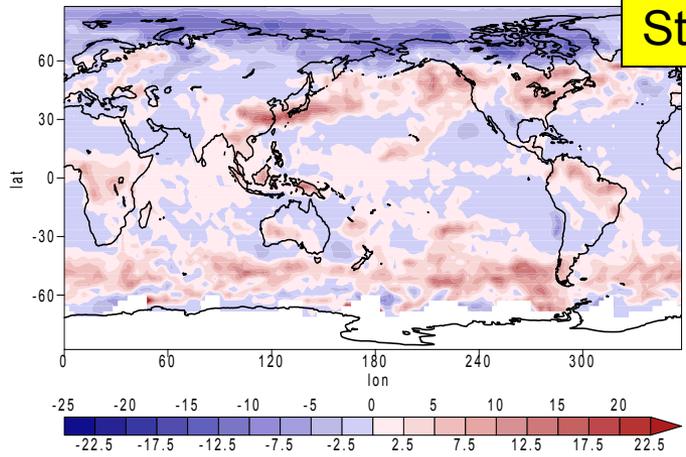
section
3756



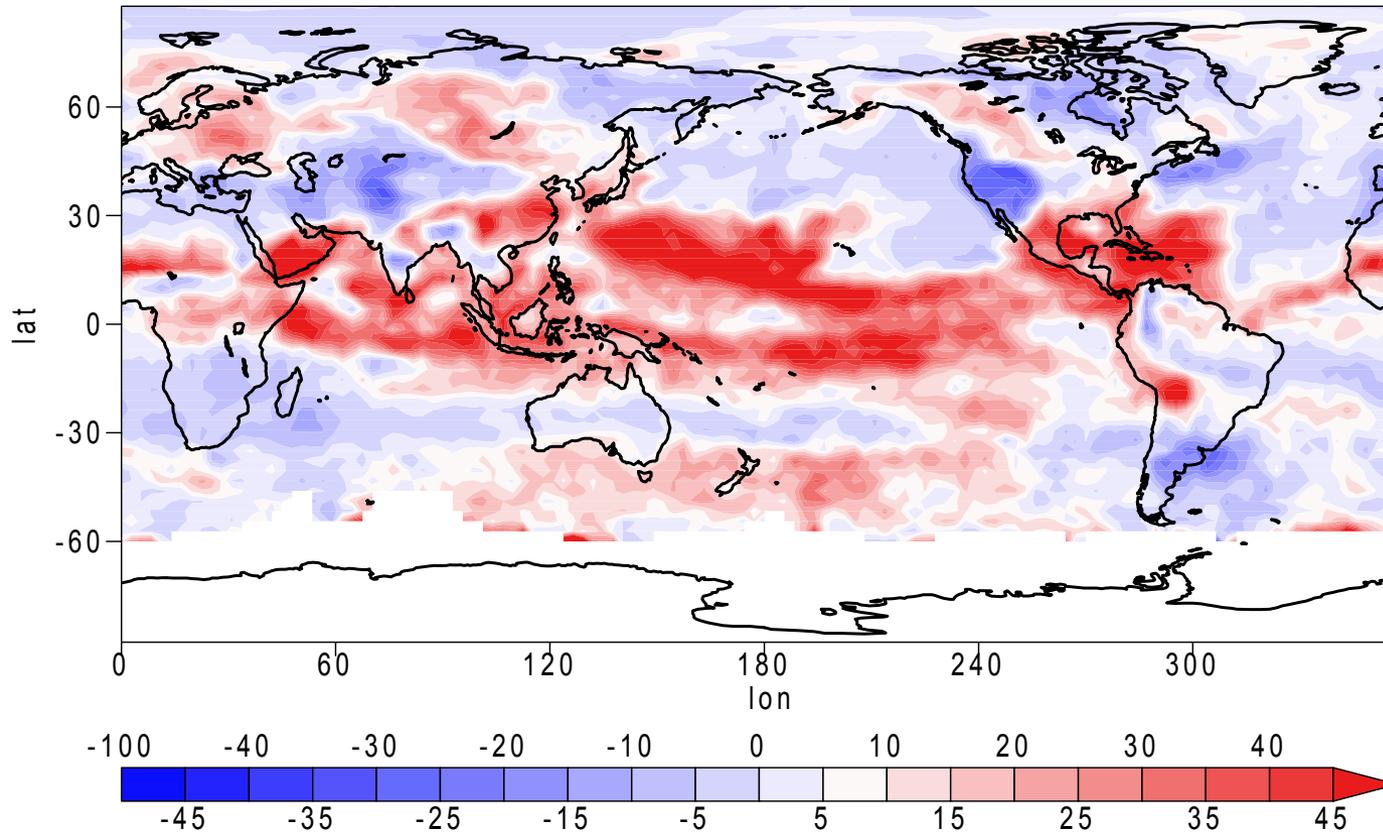
April average difference between the model and ISCCP

_subtract_stratuscam_stratus
Mean 0.758114 Max 49 Min -15.9791

Stratus

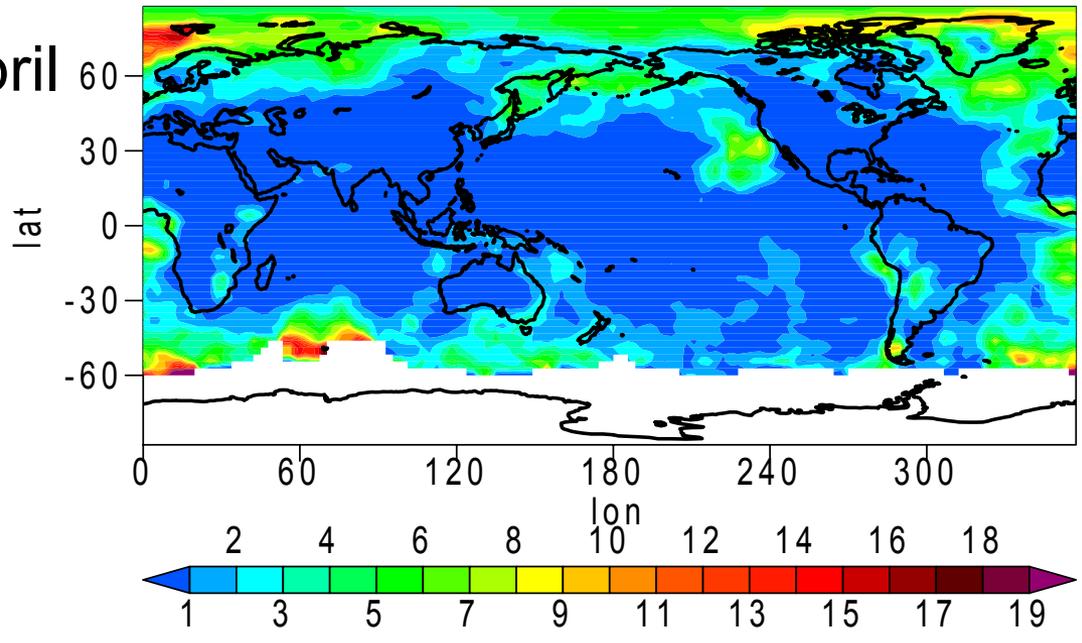


_subtract_cirrus_cam2_cirrus_isccp
Mean 10.7798 Max 99 Min -41

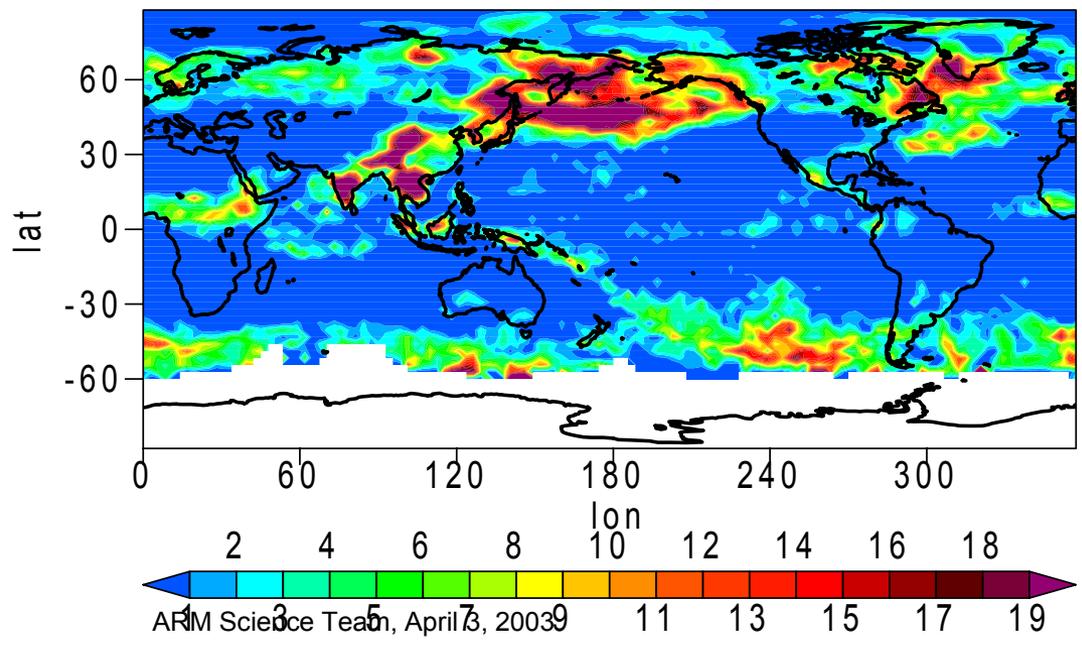


Stratus clouds for April

ISCCP

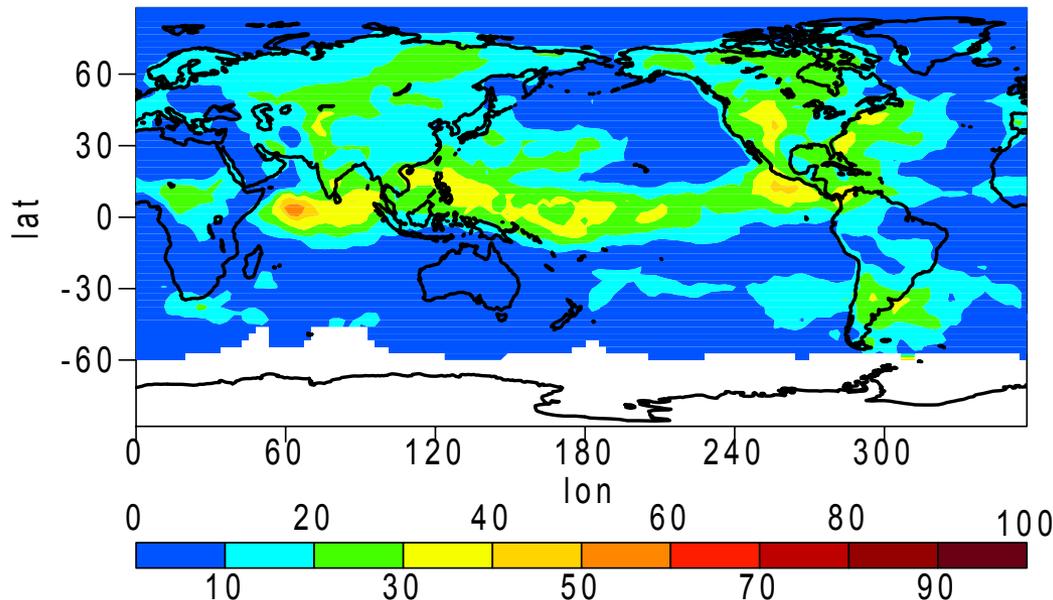


CAM2

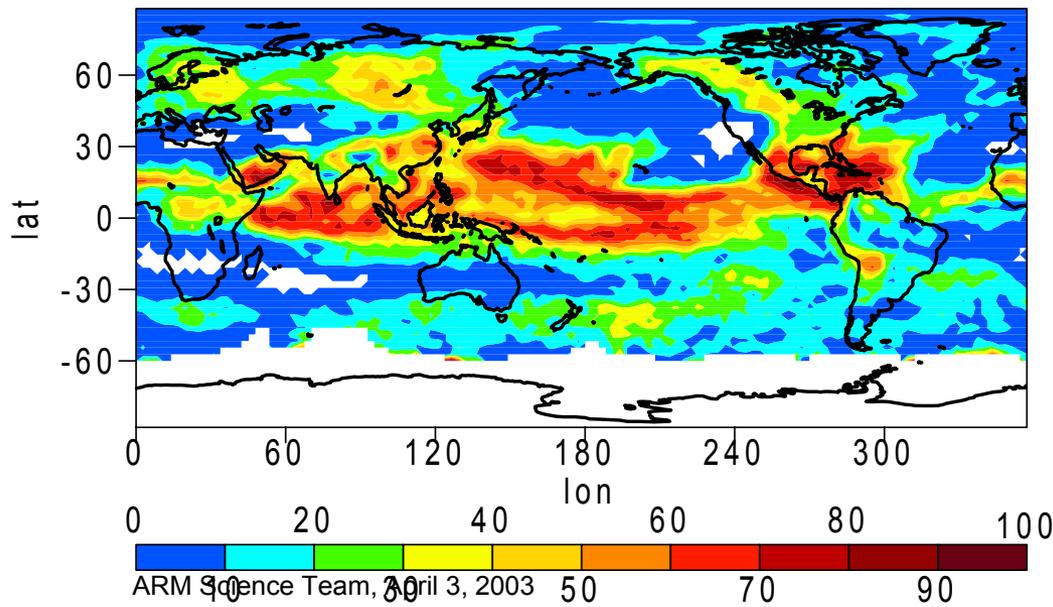


Monthly averaged cirrus clouds

ISCCP for July 1997



CAM2 cirrus clouds from the ISCCP simulator for July (initialized July 1997)



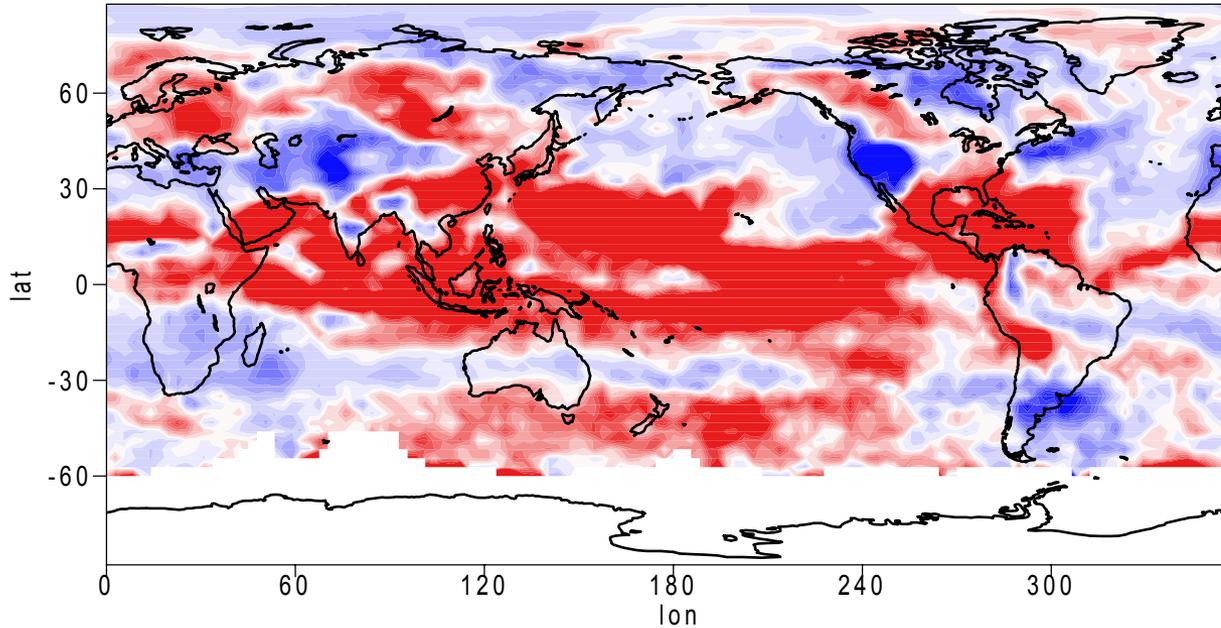
CAM2 minus ISCCP

_subtract_cirrus_cam2_cirrus_isccp

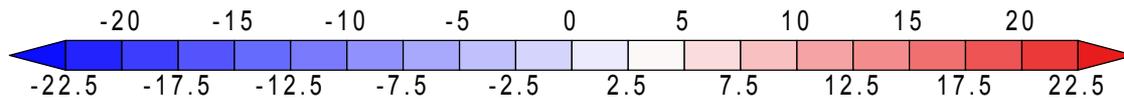
Mean 10.7798

Max 99

Min -41

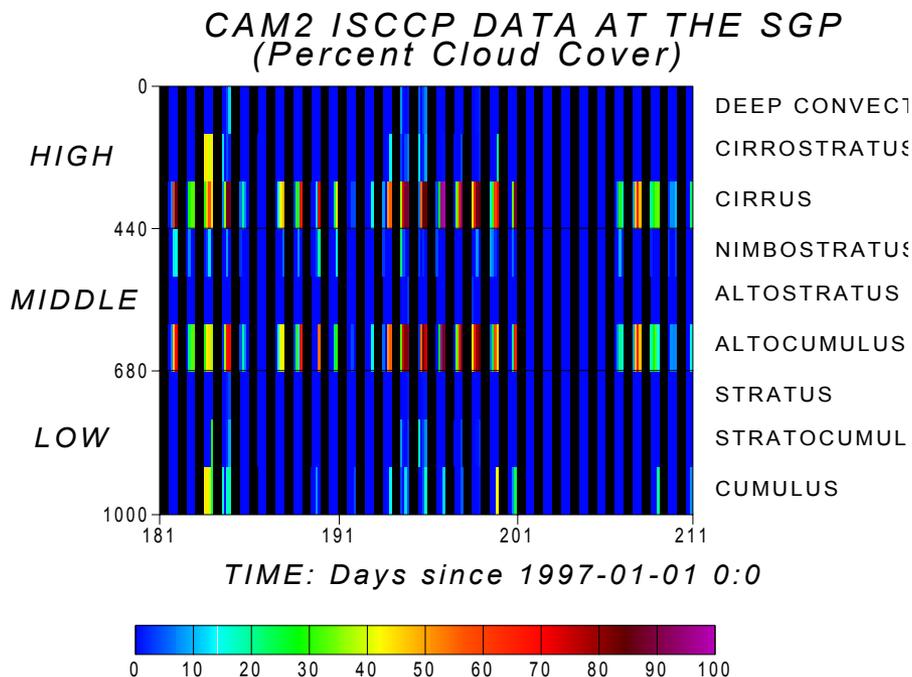


July average cirrus clouds

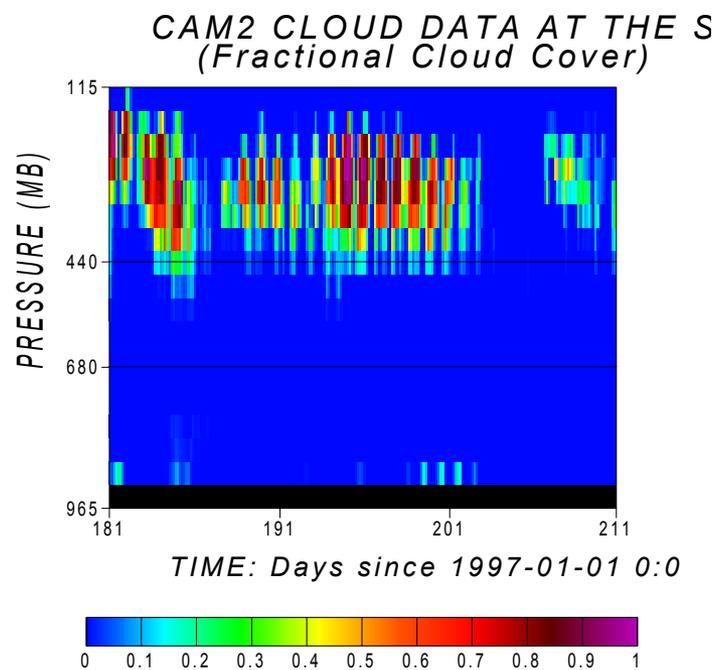


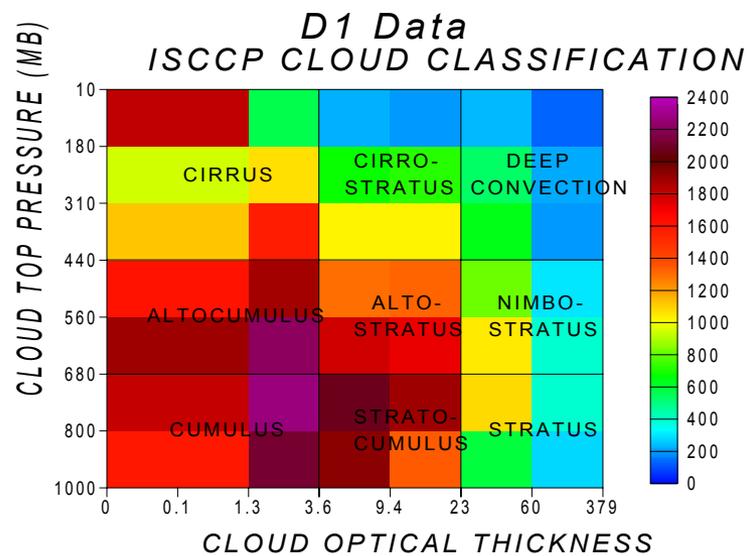
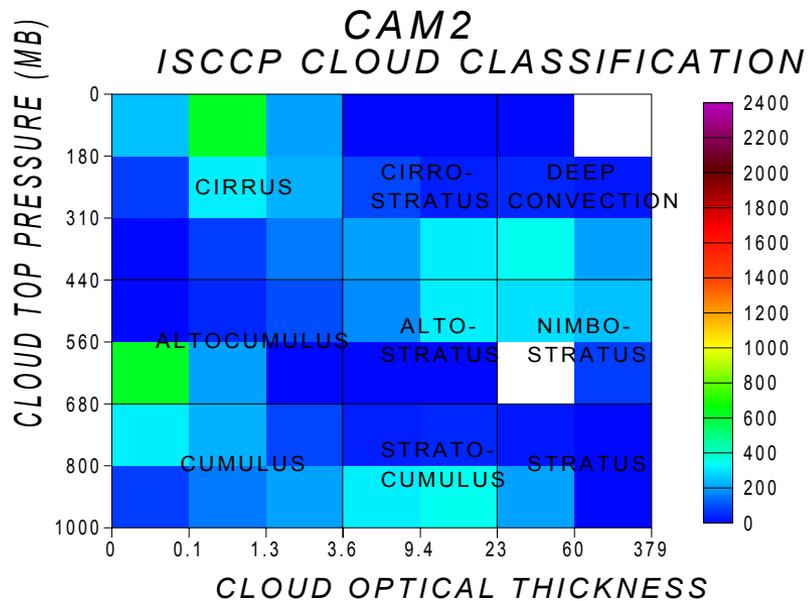
In the first of a series of tests at the ARM SGP, the ISCCP simulator clouds correspond to the models calculated clouds

CAM2 ISCCP Simulator for July, 1997

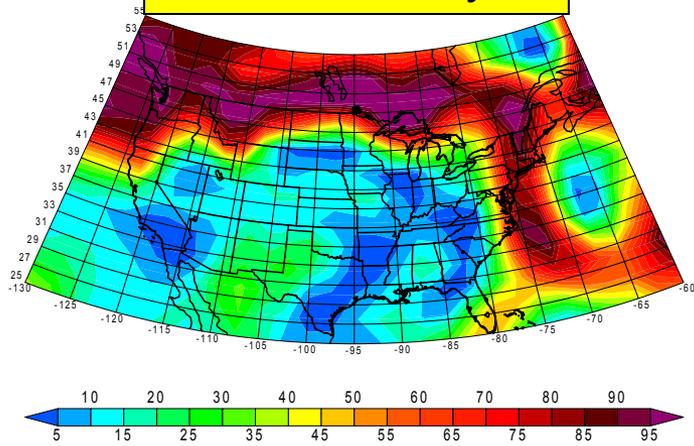


CAM2 produced clouds for July 1997



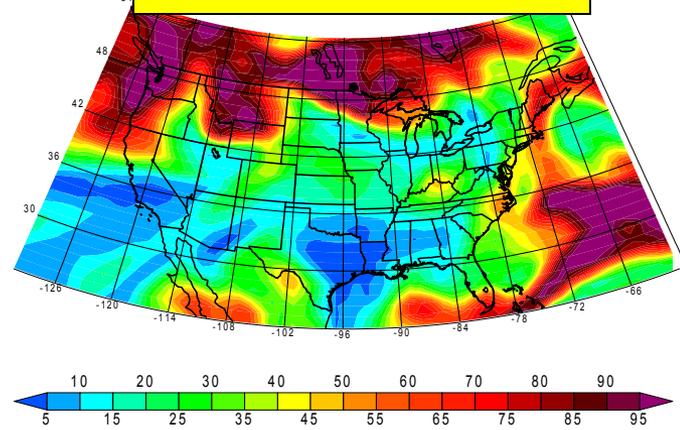


ERA40 reanalysis



0Z July 3, 1997

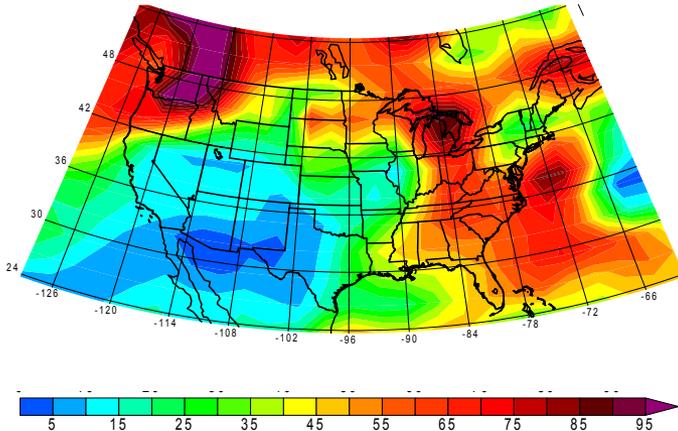
NCEP RH forecast



0Z July 3, 1997

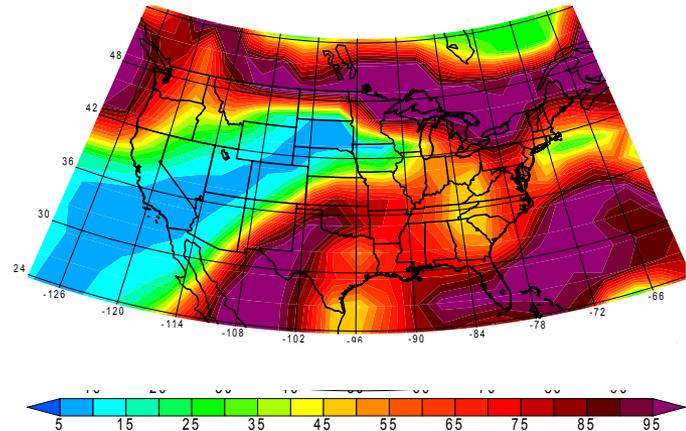
300 mb RH

CAM2 initial data for forecast



0Z July 1, 1997

CAM2 forecast

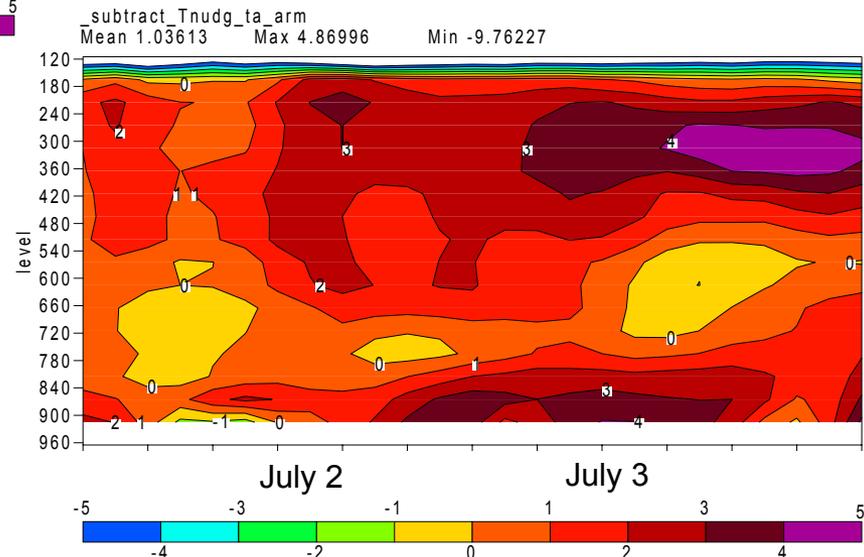
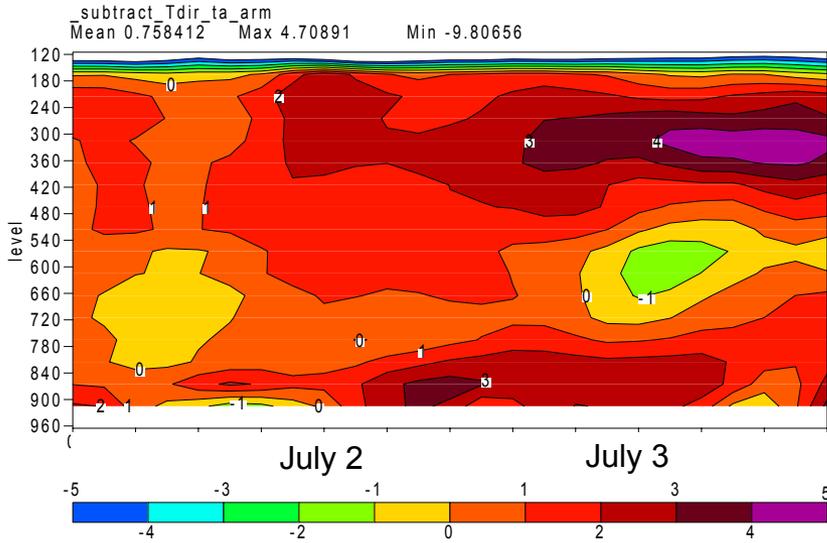


0Z July 3, 1997



Temperature forecasts from both initialization procedures show some skill

Direct insertion minus ARM Observations

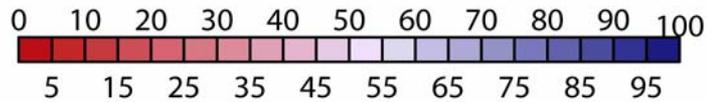
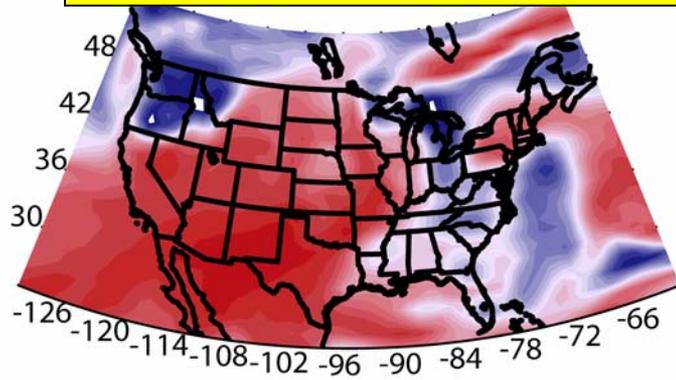


Nudging minus ARM Observations

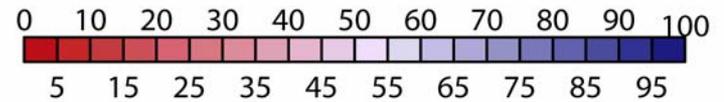
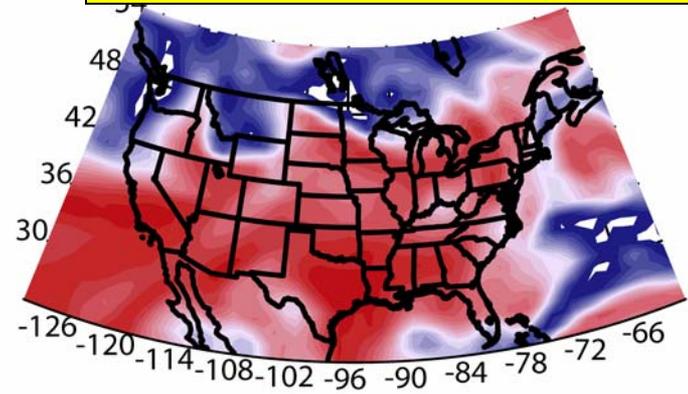
ARM Science Team, April 3, 2003

300 mb RH

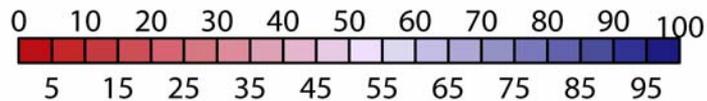
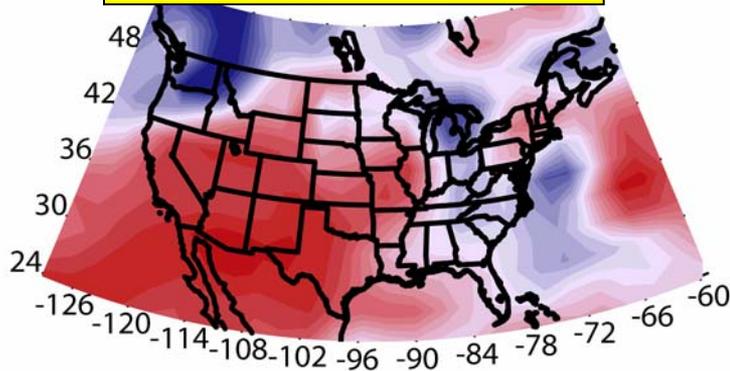
Day 1 ECMWF Reanalysis



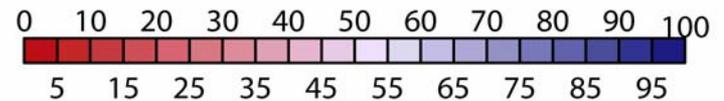
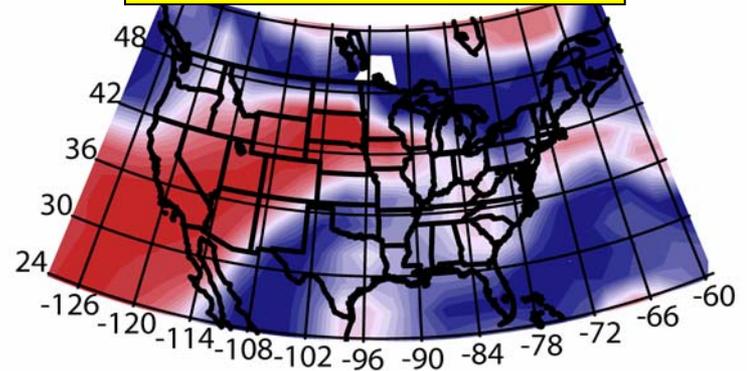
Day 2 ECMWF Reanalysis



Day 2 NCEP forecast



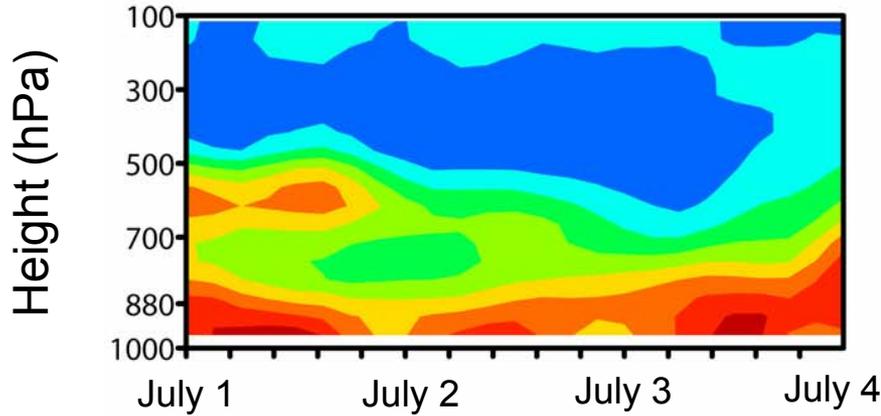
Day 2 CAM2 forecast



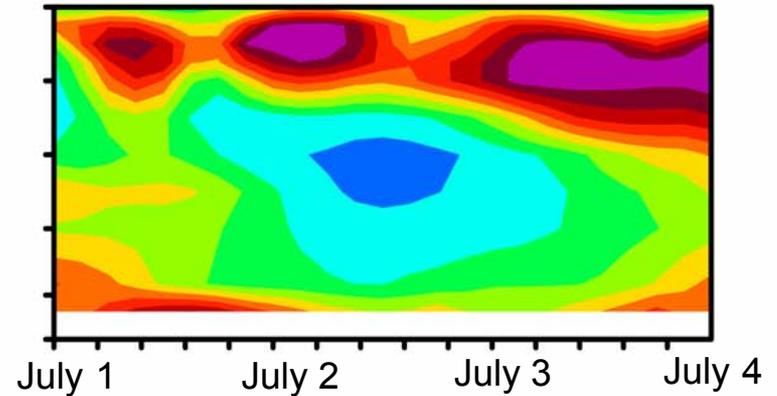
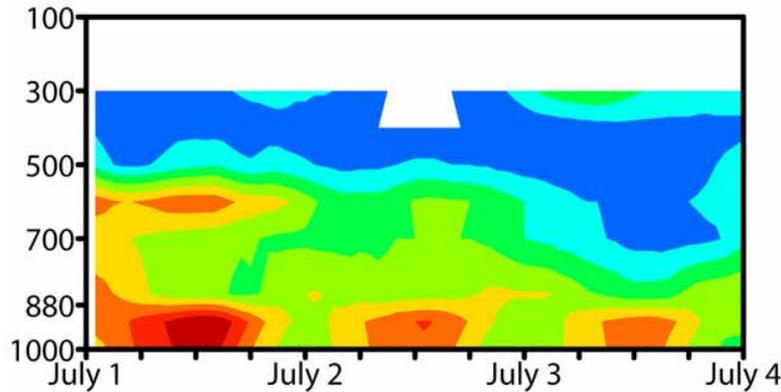
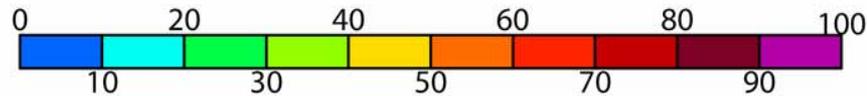
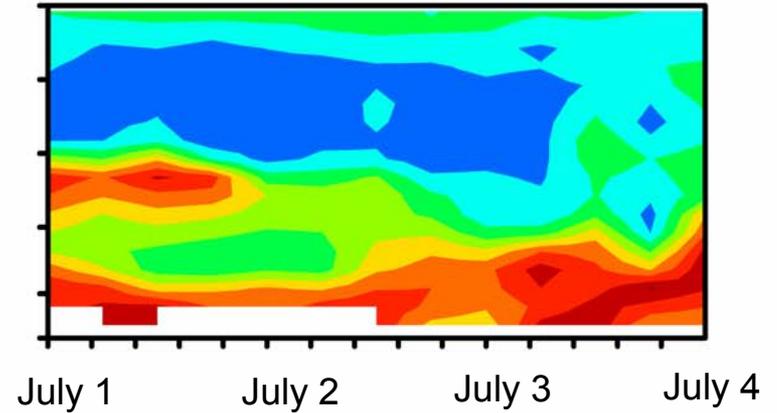
Comparison of ARM, the ECMWF ERA 40 Reanalysis, NCEP R2 forecast, and CAM2 at the SGP site

Relative Humidity

ARM July 1-4, 1997



ERA40 July 1-4, 1997

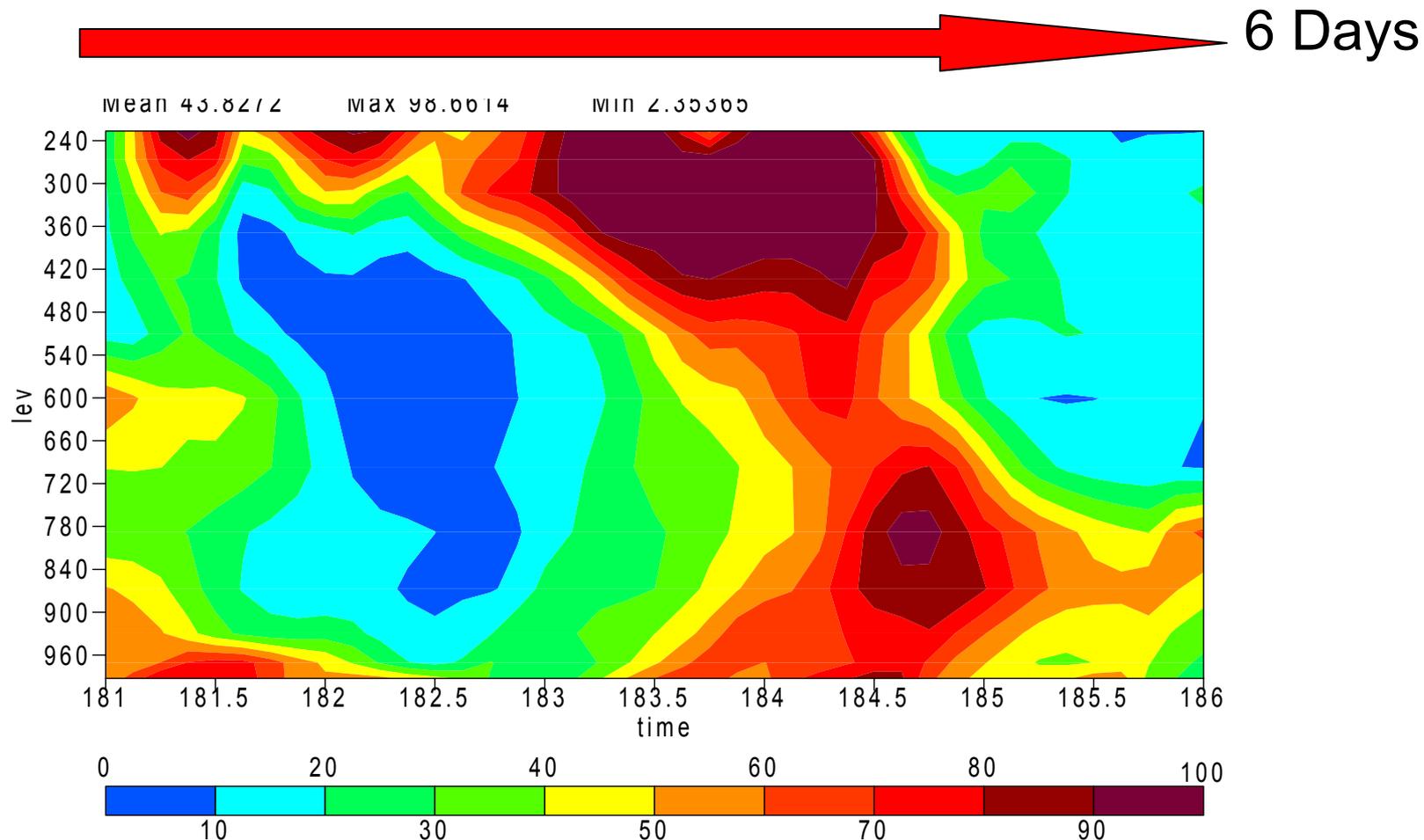


NCEP forecast July 1-4, 1997

CAM2 forecast July 1-4, 1997



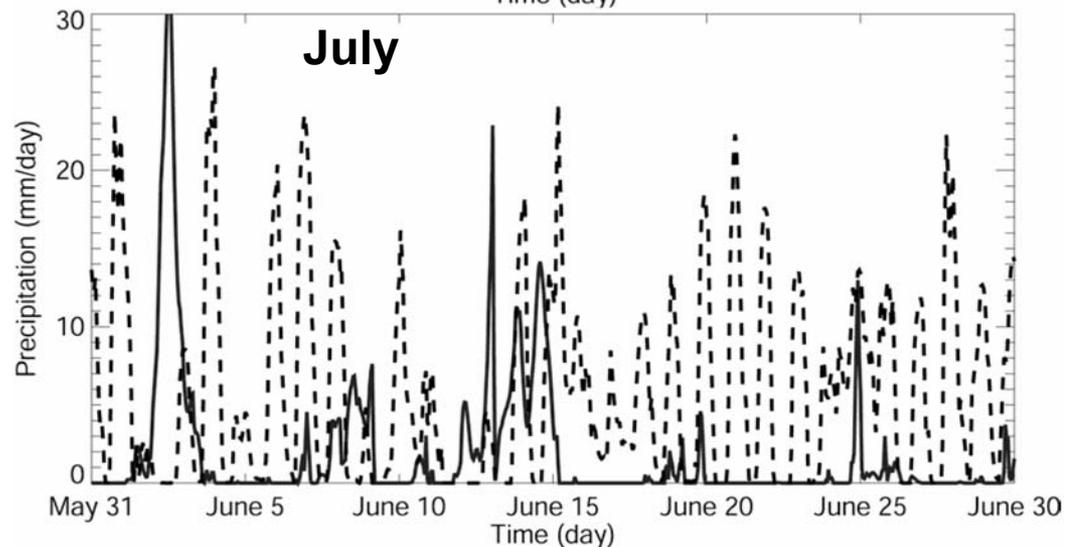
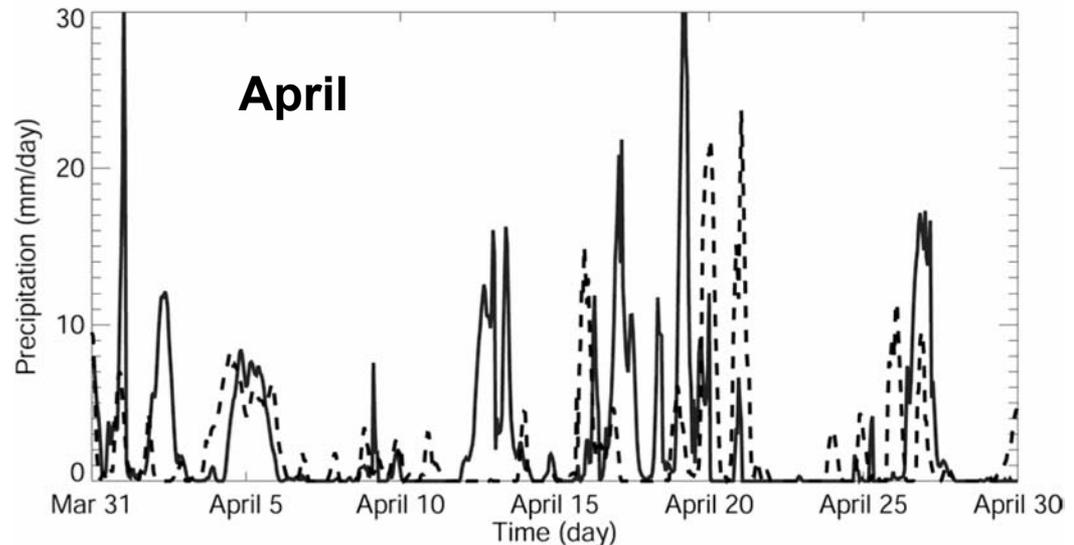
It appears that a longer forecast may bring some surprises



Guang Zhang is testing a new closure to the Z-M convection scheme in CCM3 (soon to be implemented in CAM2)

Problem: the Z-M scheme produces excessive convective precipitation at the SGP in July

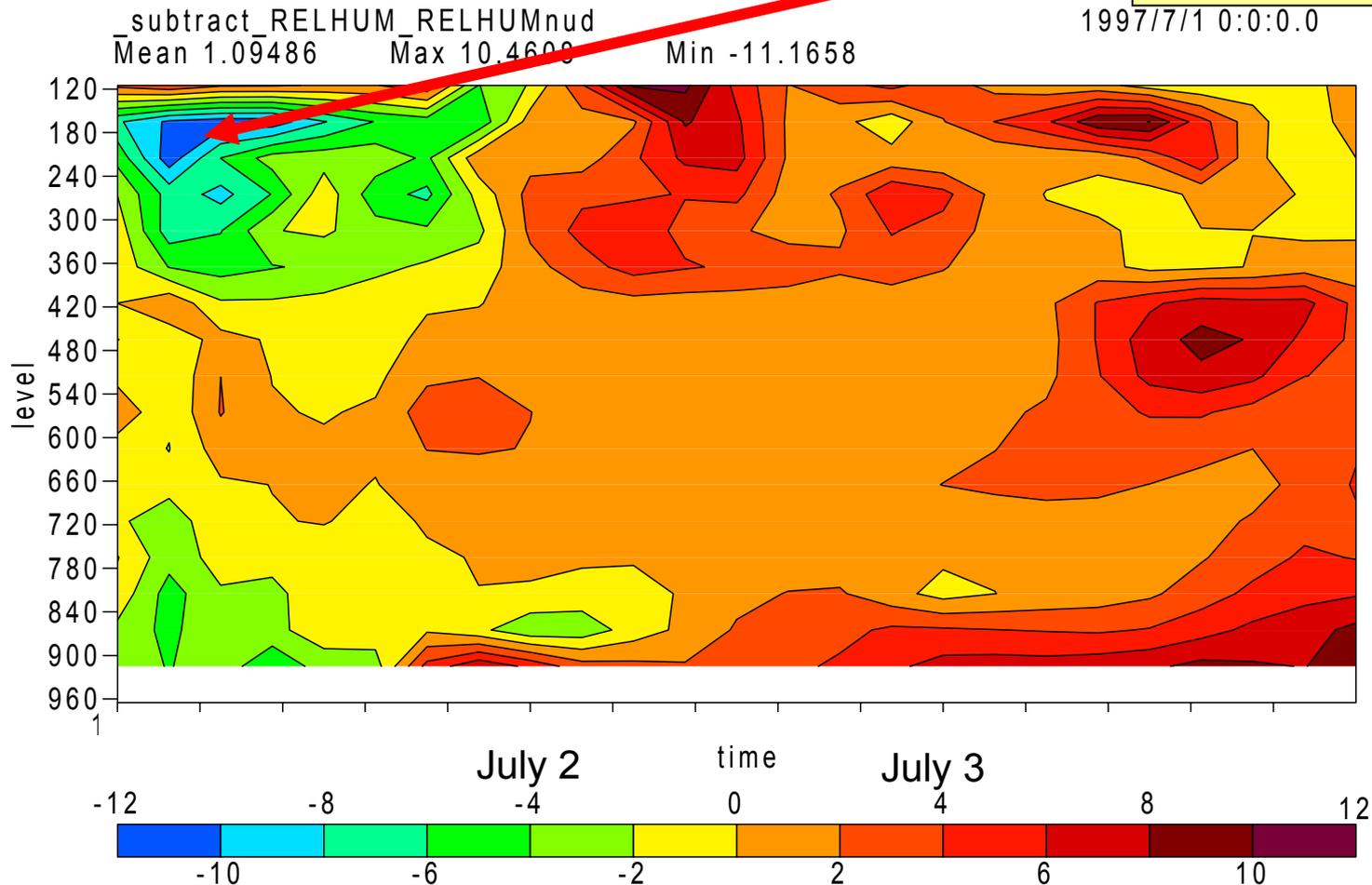
----- Original
———— New closure



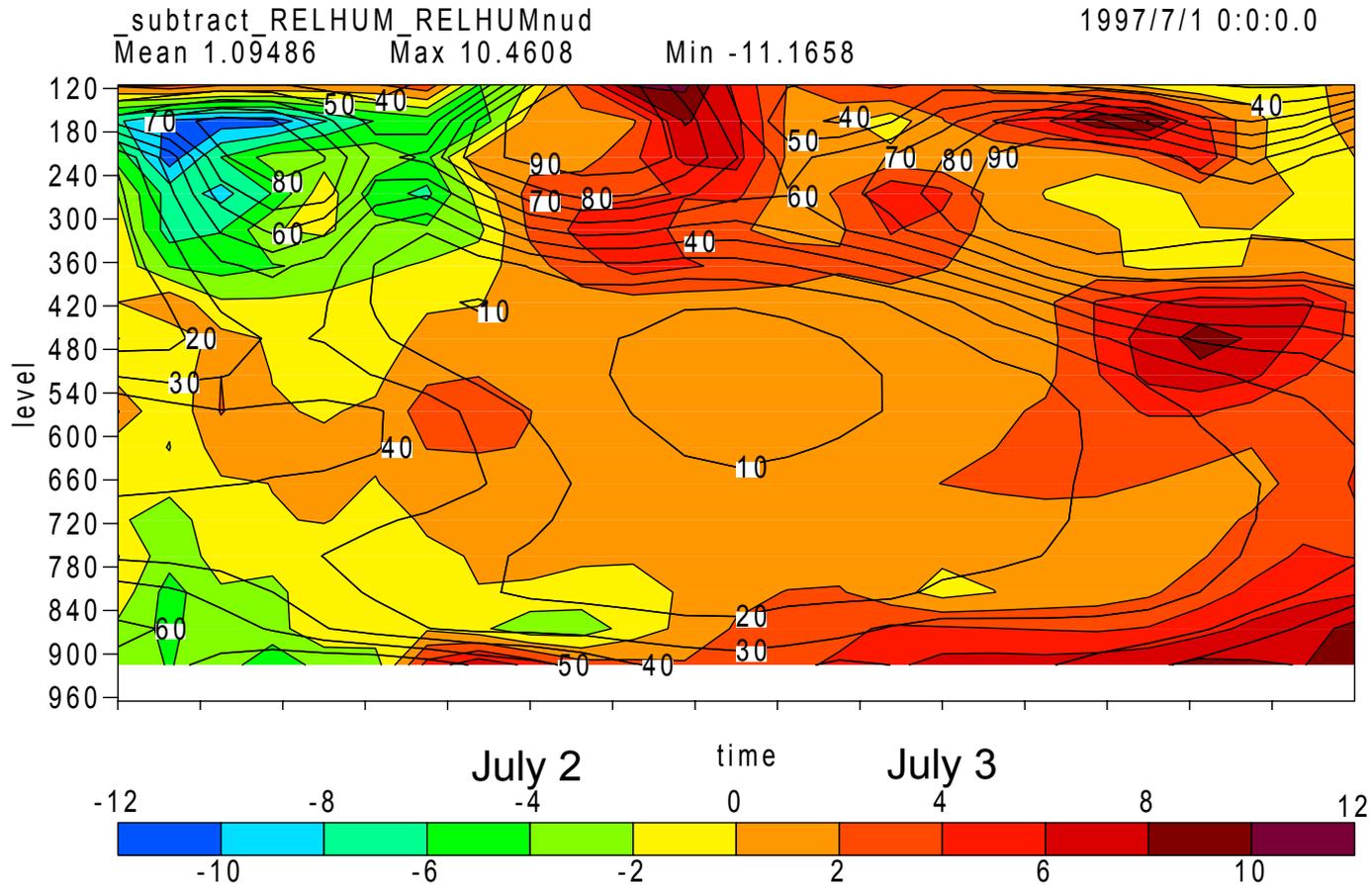
The effect of different initialization

Direct insertion of the analysis starts out drier than nudging

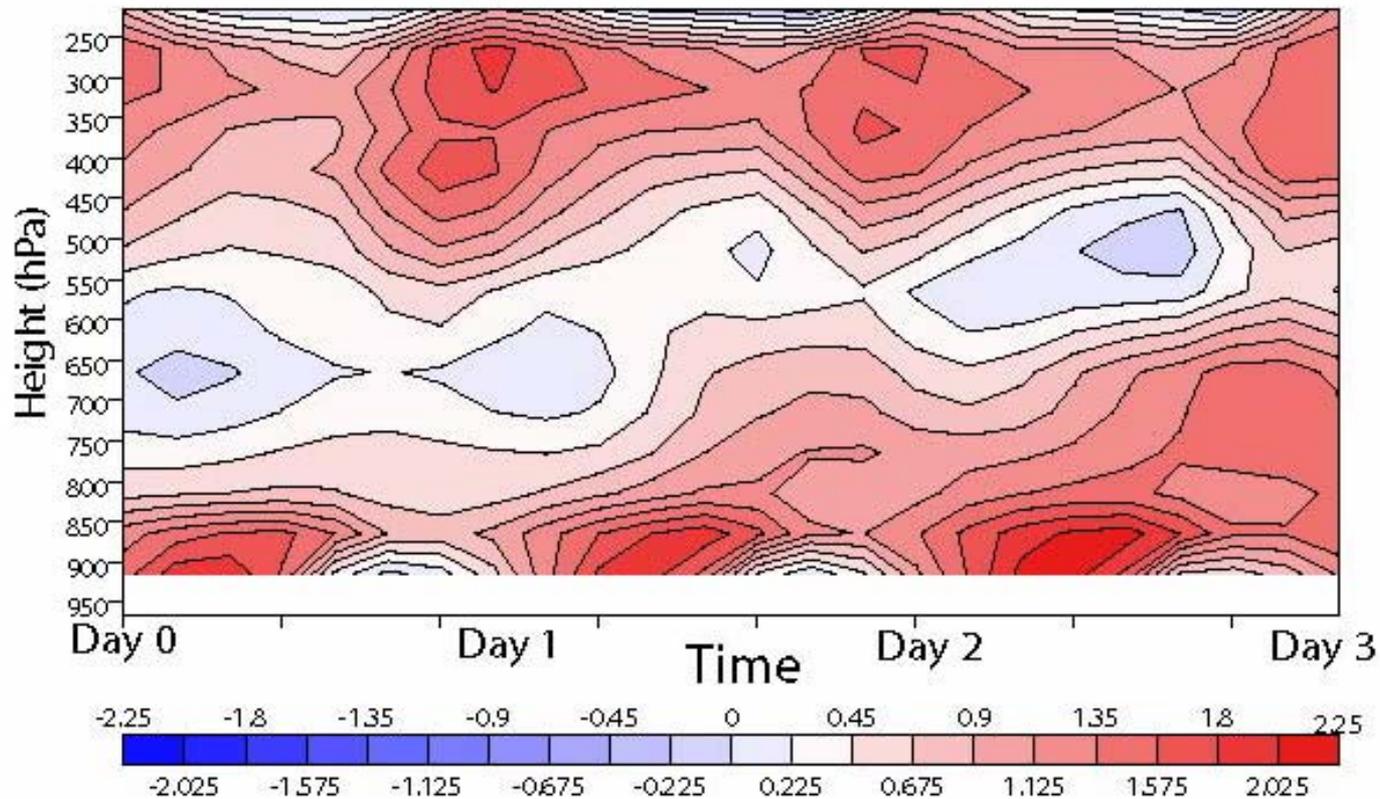
Direct insertion minus nudging



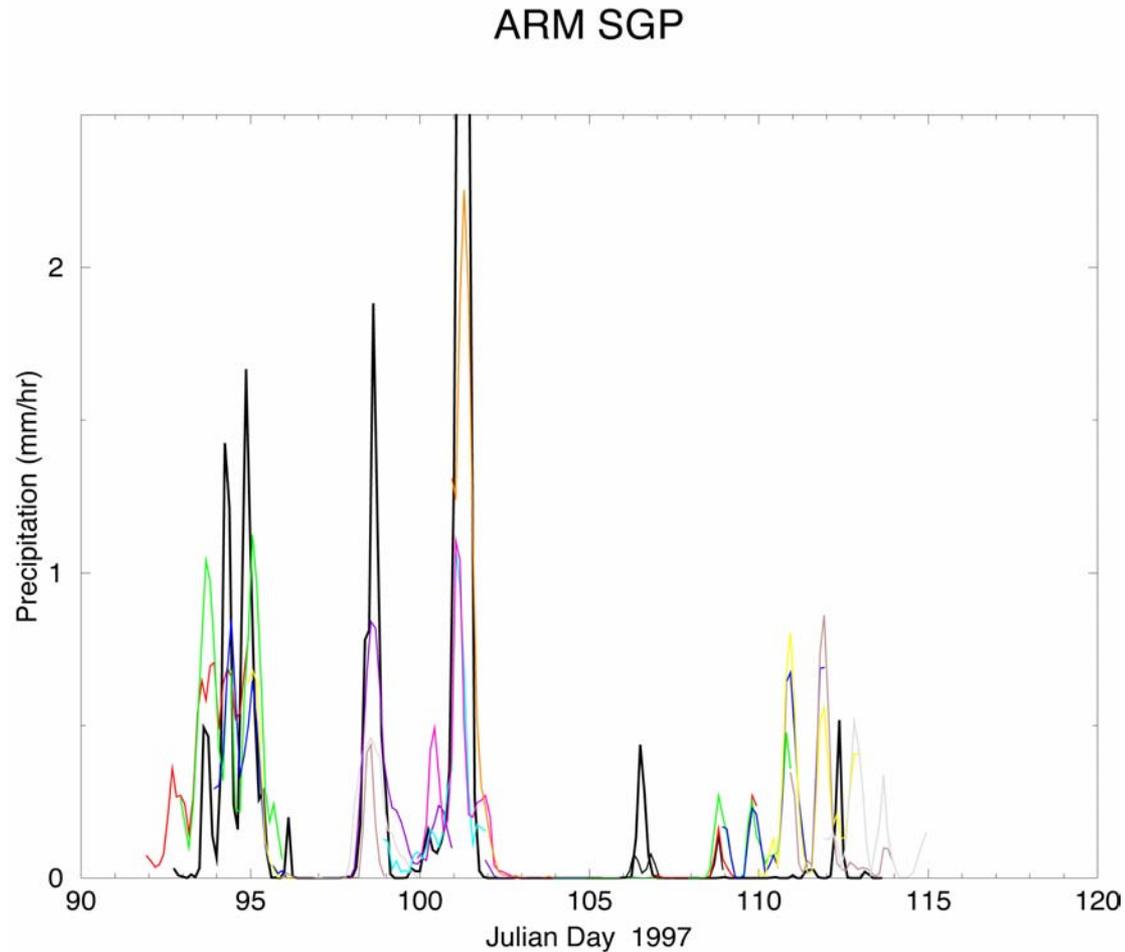
Difference are small compared overall forecast RH



Ensemble of 3-day forecasts from CAM2 minus ARM observed temperature for early July 1997



Series of 72 hour forecasts compared with ARM for the April 1997 IOP



ARM Science Team, April 3, 2003

Parameterization development partners

- ***Guang Zhang (SIO)***
- ***Leo Donner***
- ***Chris Bretherton***
- ***Minghua Zhang***
- ***Shaocheng Xie***
- ***Wei Chung Wang (SUNY Albany)***
- ***Dave Randall***
- ***Steve Ghan***

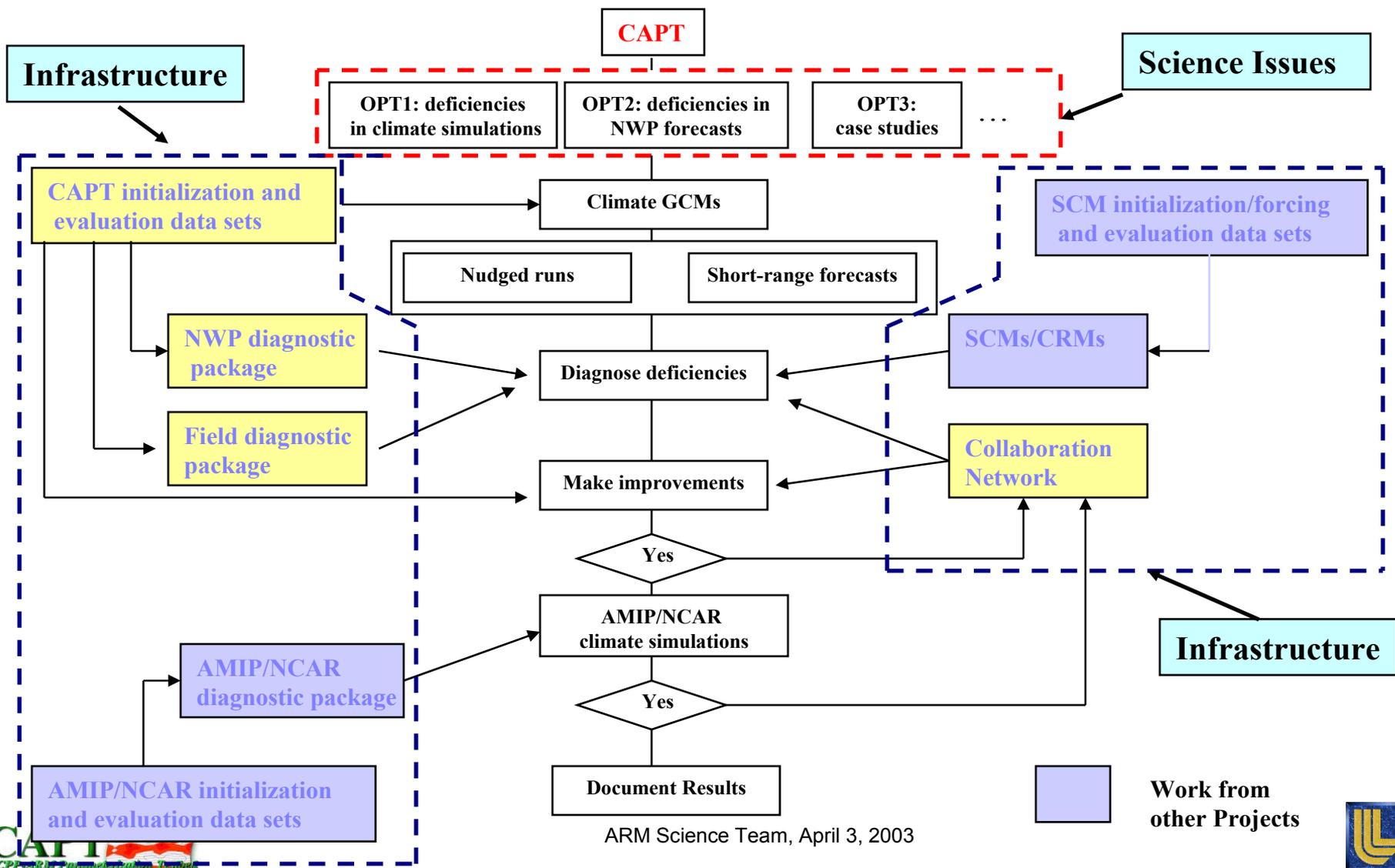


Summary

- *Running climate models in NWP mode*
- *Initialize the model with analyses*
- *Identify errors*
- *Series of forecasts – looking particularly in regions where observation are plentiful*
- *Bring ARM data to GCMs*
- *Test Improved parameterizations*
- *Model experimentation – climate simulations*



The CAPT Diagnostic Protocol



ARM Science Team, April 3, 2003



SCM 72h forecast: Diurnal Cycle -- Precipitation

