# Evaluation of Cloud Parameterizations using CAPT

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with:
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**With help from Christian Jakob, Minghua Zhang, the ECMWF (Martin Miller), NCEP**
**And special support from Dave Bader**

- Overview of CAPT strategy and approach
- Examples of diagnosing GCM parameterizations
  - » on the local scale (an ARM site)
  - » on the global scale

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UCRL-PRES-153034

CAPT
CCPP-ARM Parameterization Testbed

# What is CAPT?

## CAPT = CCPP-ARM Parameterization Testbed

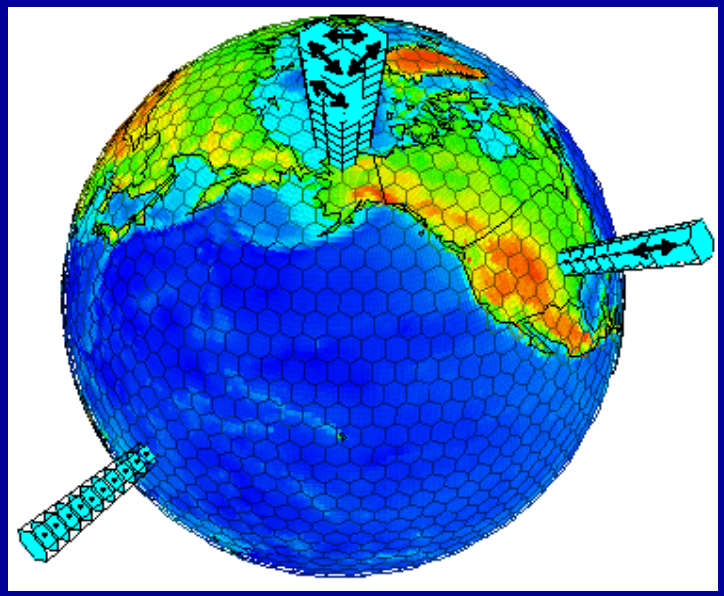
CAPT combines the strengths of two DOE programs with complementary missions:

CCPP *(Climate Change Prediction Program)* Focus on GCM performance

ARM *(Atmospheric Radiation Measurement)* Focus of radiation and cloud processes and their parameterization in GCMs

CAPT provides a flexible user environment for running GCMs in NWP 'forecast' mode:

- > global initialization data sets
- > processed global and local observations
- > high-frequency GCM forecast output
- > diagnostic analysis and visualization tools
- > experienced scientific staff to collaborate with parameterization developers



from Dave Randall

# Why use CAPT approach to test GCM parameterizations?

There are other ways ….

- Climate models with climate simulations
  - Complicated and depend on all aspects of the model;
  - Computationally expensive and time consuming;
  - Not able to link to particular synoptic processes, only statistical comparison
- NWP models with short-range forecasts
  - Parameterizations may not be designed for climate models
  - Model resolutions are much higher than those in climate models
- SCMs/CRMs with specified large-scale forcing *(done in ARM)*
  - Results are highly dependent on quality of large-scale forcing
  - No internal feedback from dynamic processes

*But, running climate models in NWP mode (CAPT)*

- *provides high-frequency NWP analyses*
- *uses more available observations*

  *>> able to link deficiencies with atmospheric processes through case study*
- *allows systematic errors to be identified before multiple errors compensated*
- *…*

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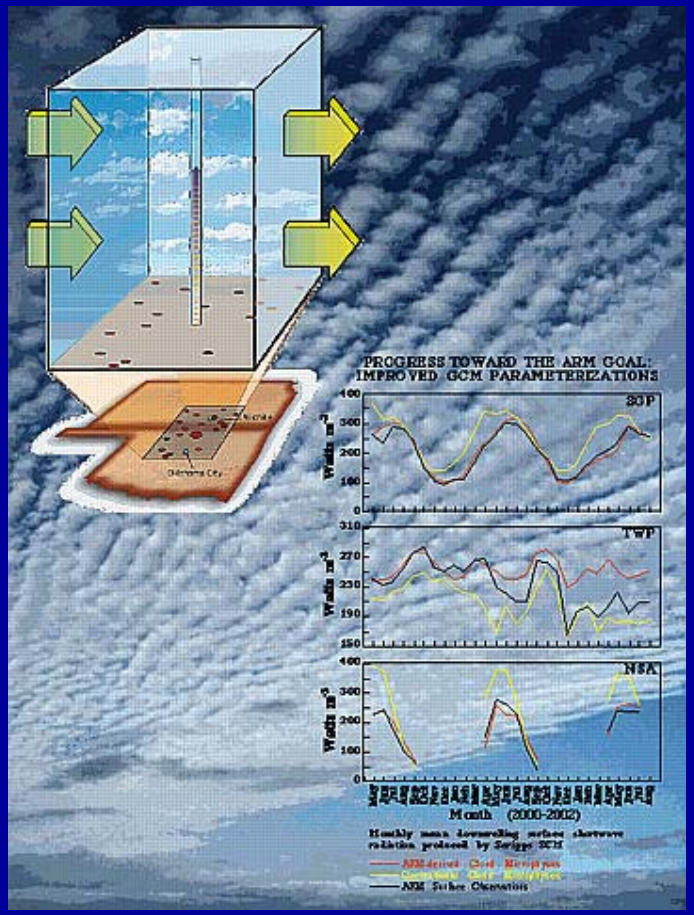
# ARM has used the SGP column data




ARM observations collected during Intensive Operational Periods (IOPs) have been analyzed to provide large-scale forcing for **Single-Column Models** and **Cloud-Resolving Models;**

Detailed cloud and radiation observations have been used to evaluate and improved GCM parameterization performance in different seasons of the year.

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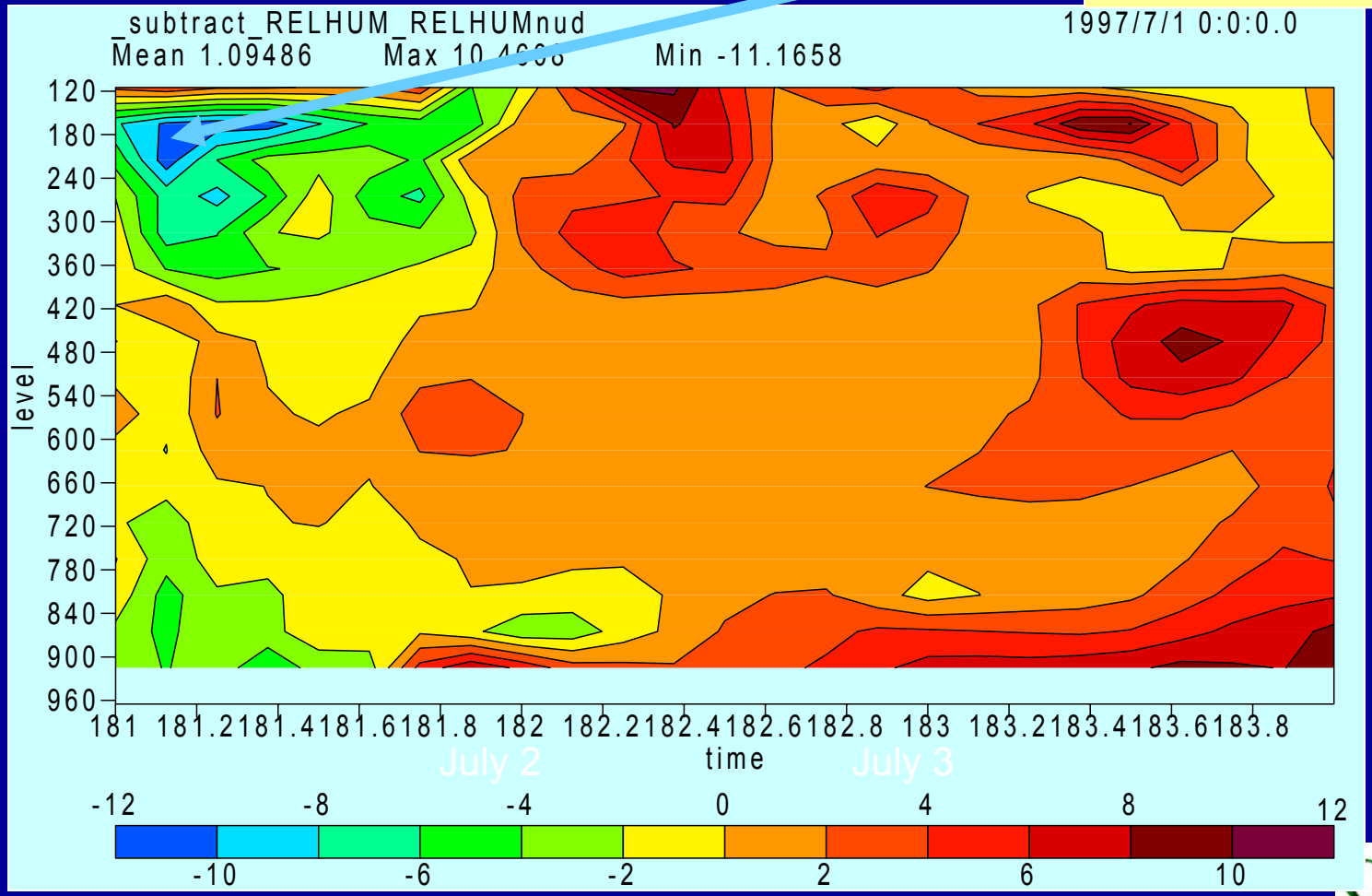
# The effect of different initialization

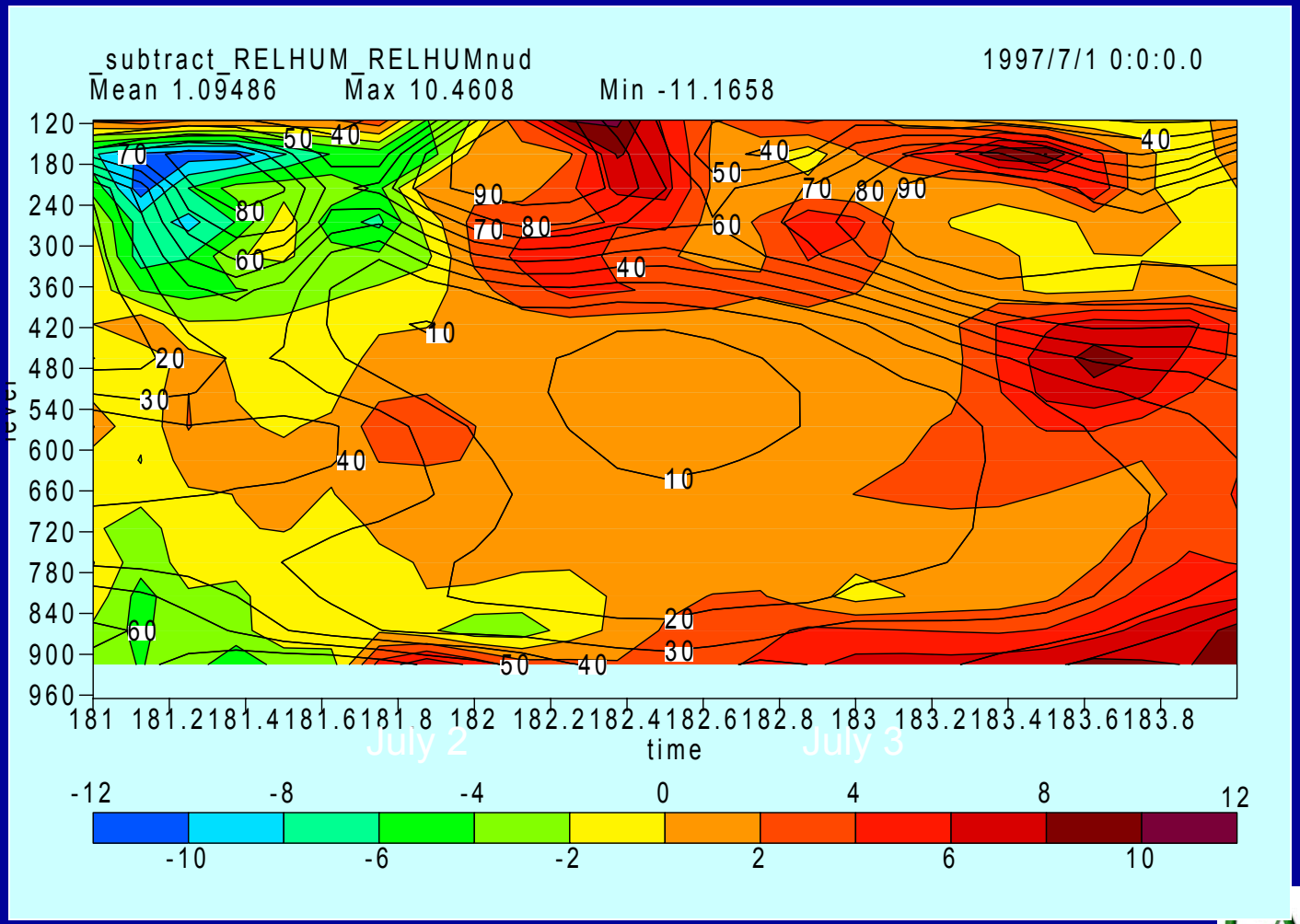
*Direct insertion minus nudging for RH*

Direct insertion of the analysis starts out drier than nudging

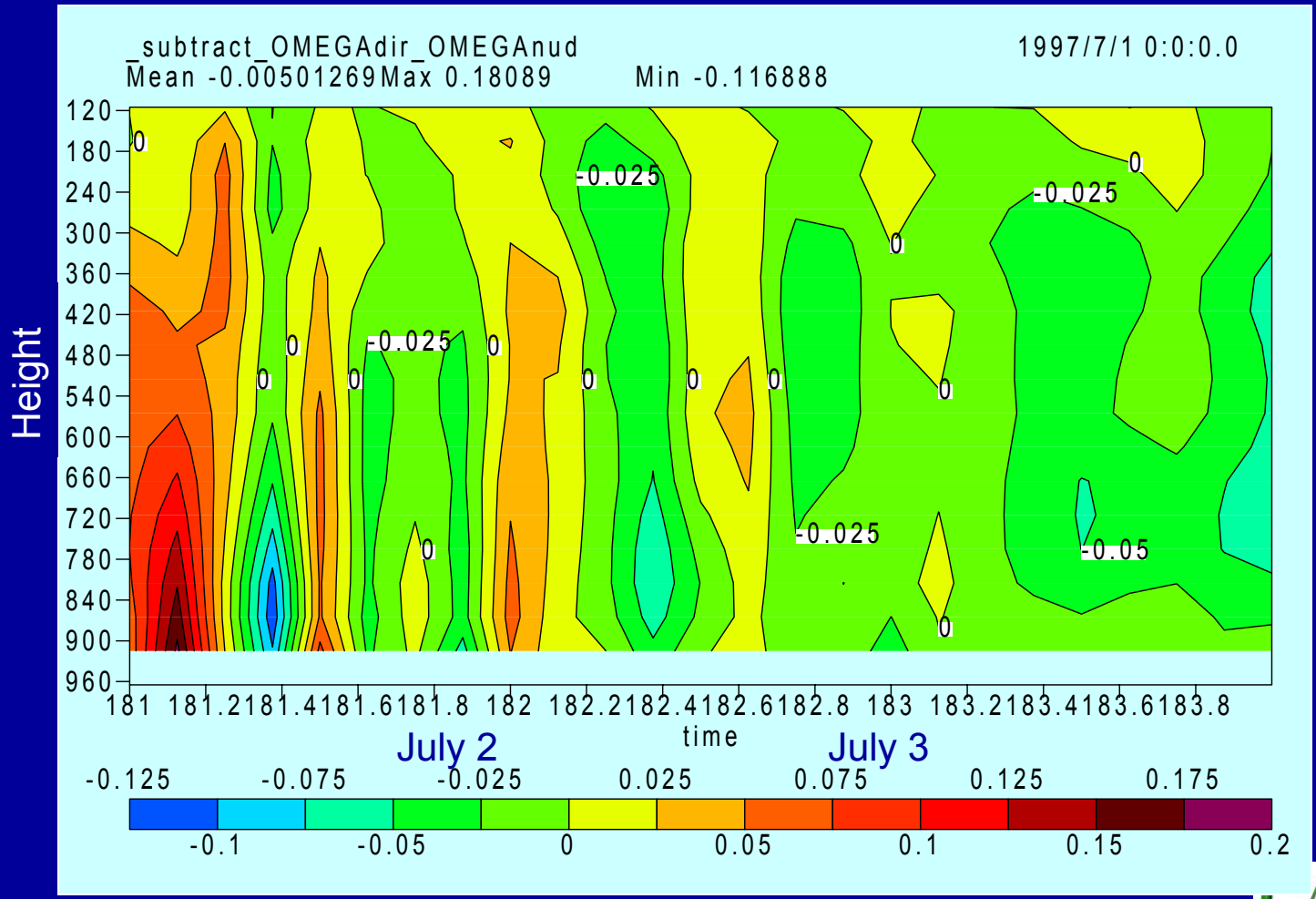


# Differences are small compared overall forecast RH

(color contours for differences are from -12% to +12%)
solid lines are for forecast RH (from 0 to 100%



# Direct insertion minus nudging vertical velocity shows methods converge after 2 days



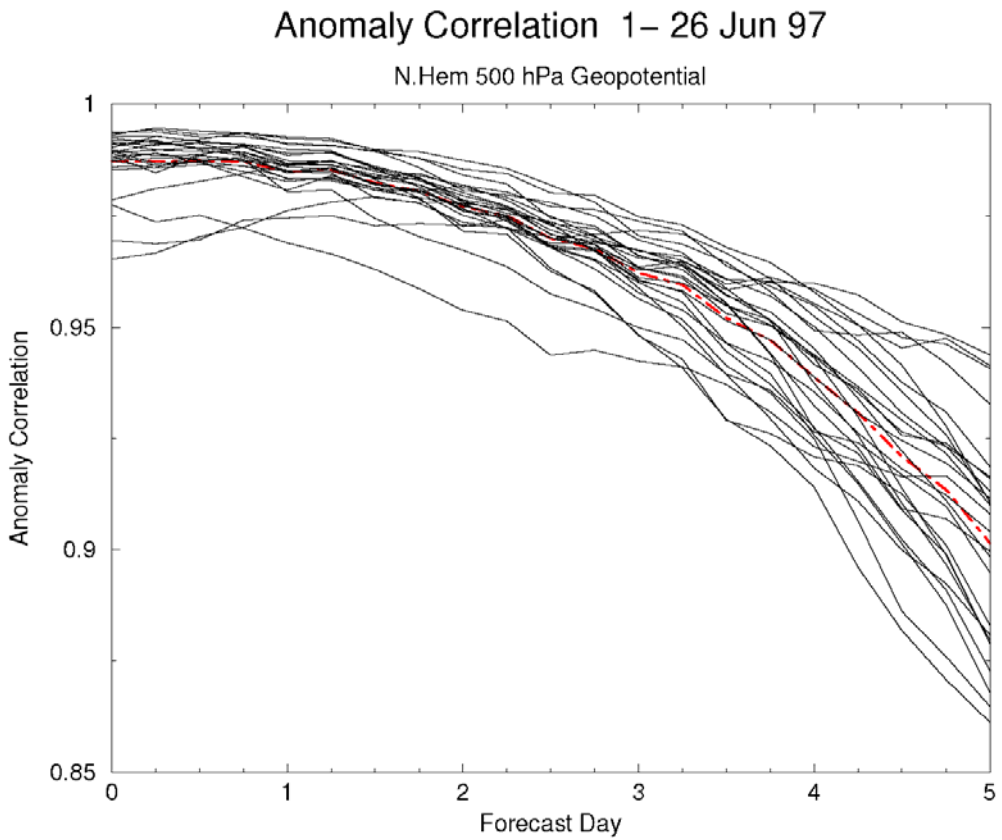
# 60-day experiment with CAM2

>> series of 5-day forecasts begun every 6 hours

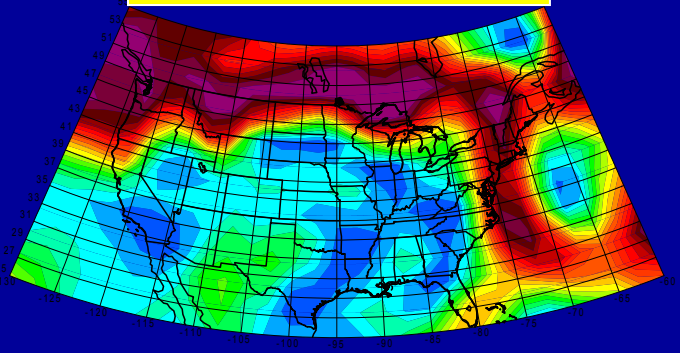
>> model initialized by direct insertion of interpolated ERA-40 reanalysis state variables

>> results saved every 3 hours

*Northern Hemisphere 500 mb height anomaly correlations using the direct insertion method are quite acceptable*

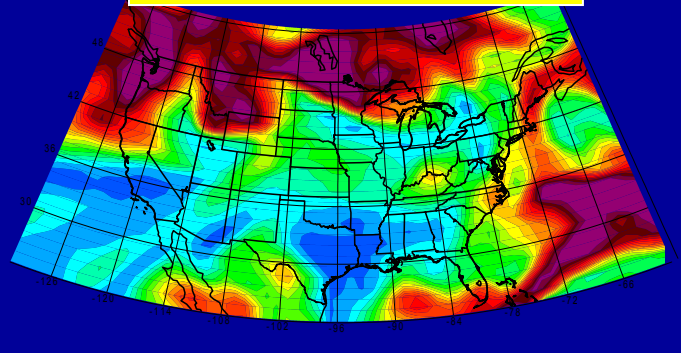


ERA40 reanalysis



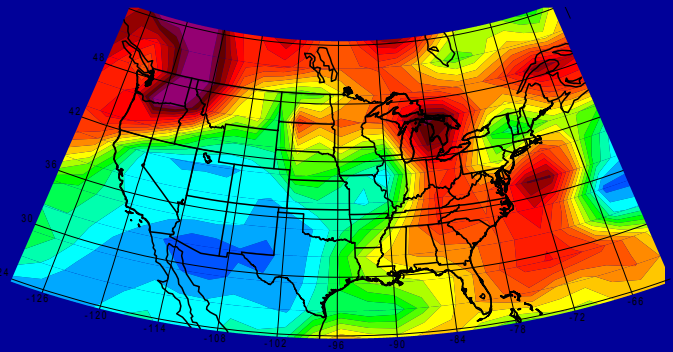
0Z July 3, 1997

NCEP RH forecast



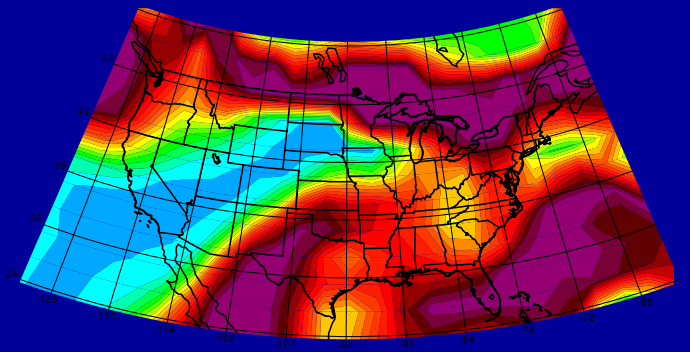
0Z July 3, 1997

CAM2 initial data for forecast



0Z July 1, 1997

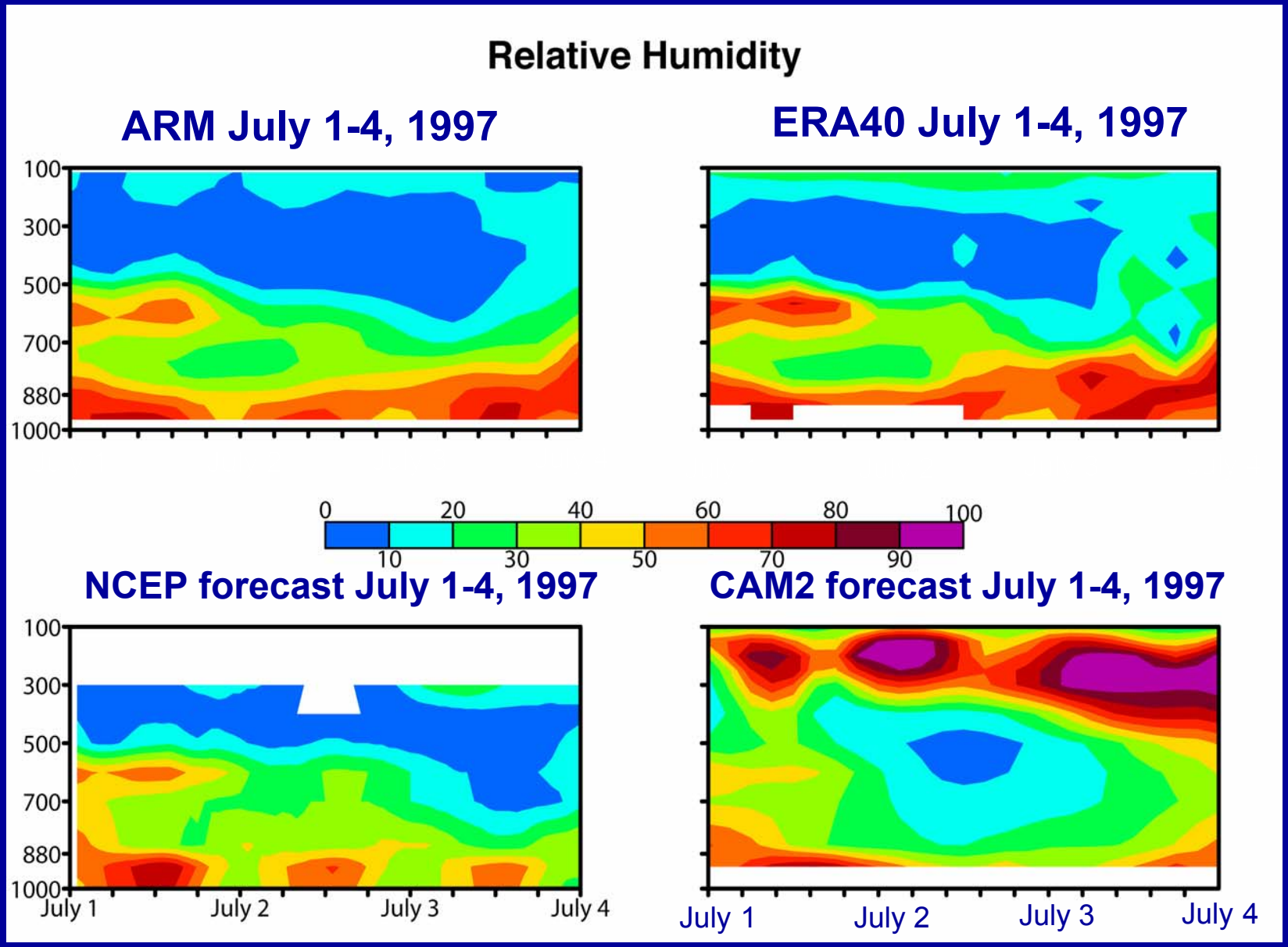
CAM2 forecast



0Z July 3, 1997

**300 mb RH**

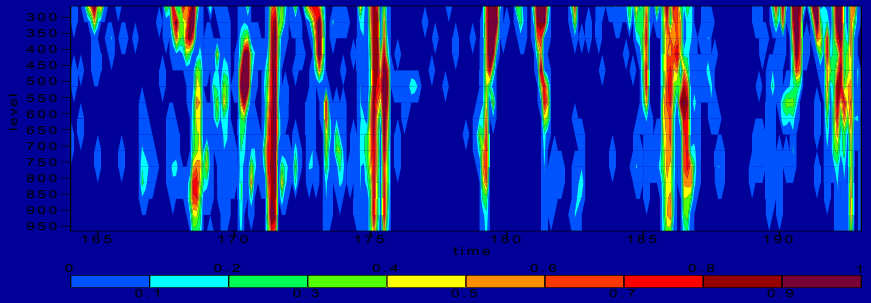
# Comparison of ARM, ECMWF ERA 40 Reanalysis, NCEP R2 forecast, and CAM2 at the ARM SGP site



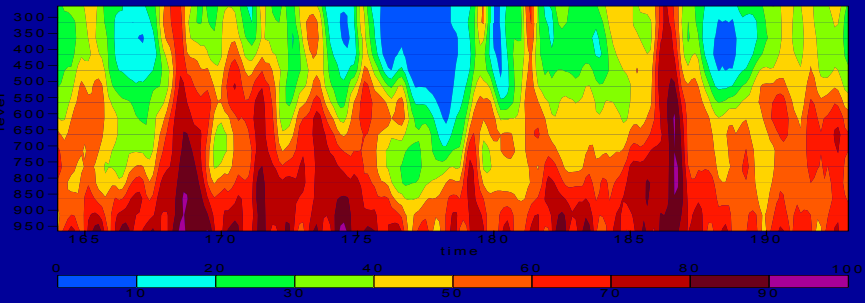
# How can we compare model clouds with observations?

*30 days at ARM SGP site in Summer 1997*

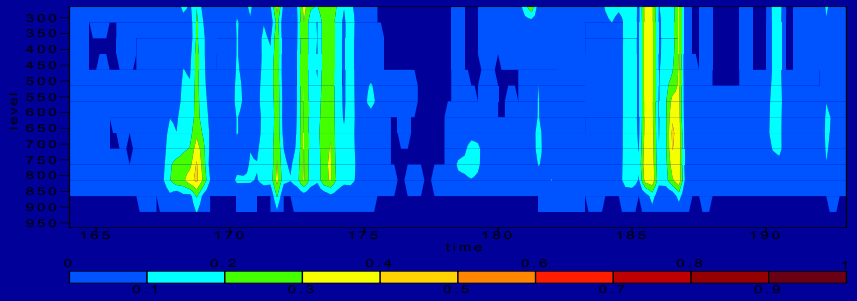
ARM Cloud Fraction (0 – 1.0)



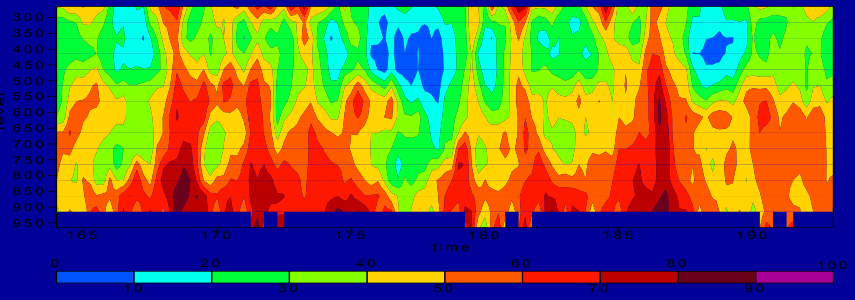

ARM Relative Humidity (%)



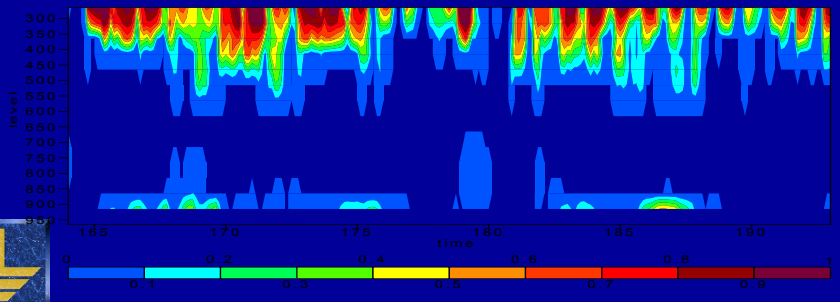

R2 Cloud Fraction (0 – 1.0)



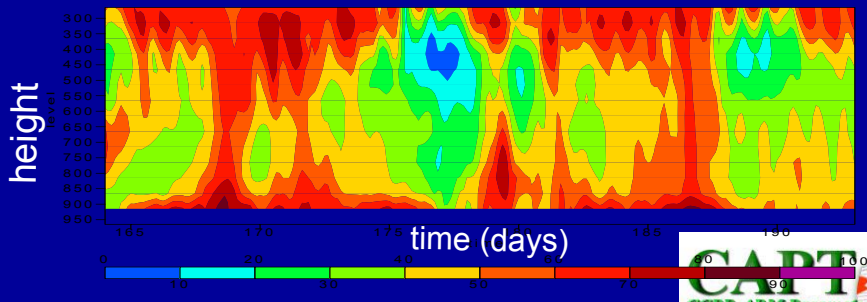

R2 Relative Humidity (%)




CAM Cloud Fraction (0 – 1.0)




CAM Relative Humidity (%)

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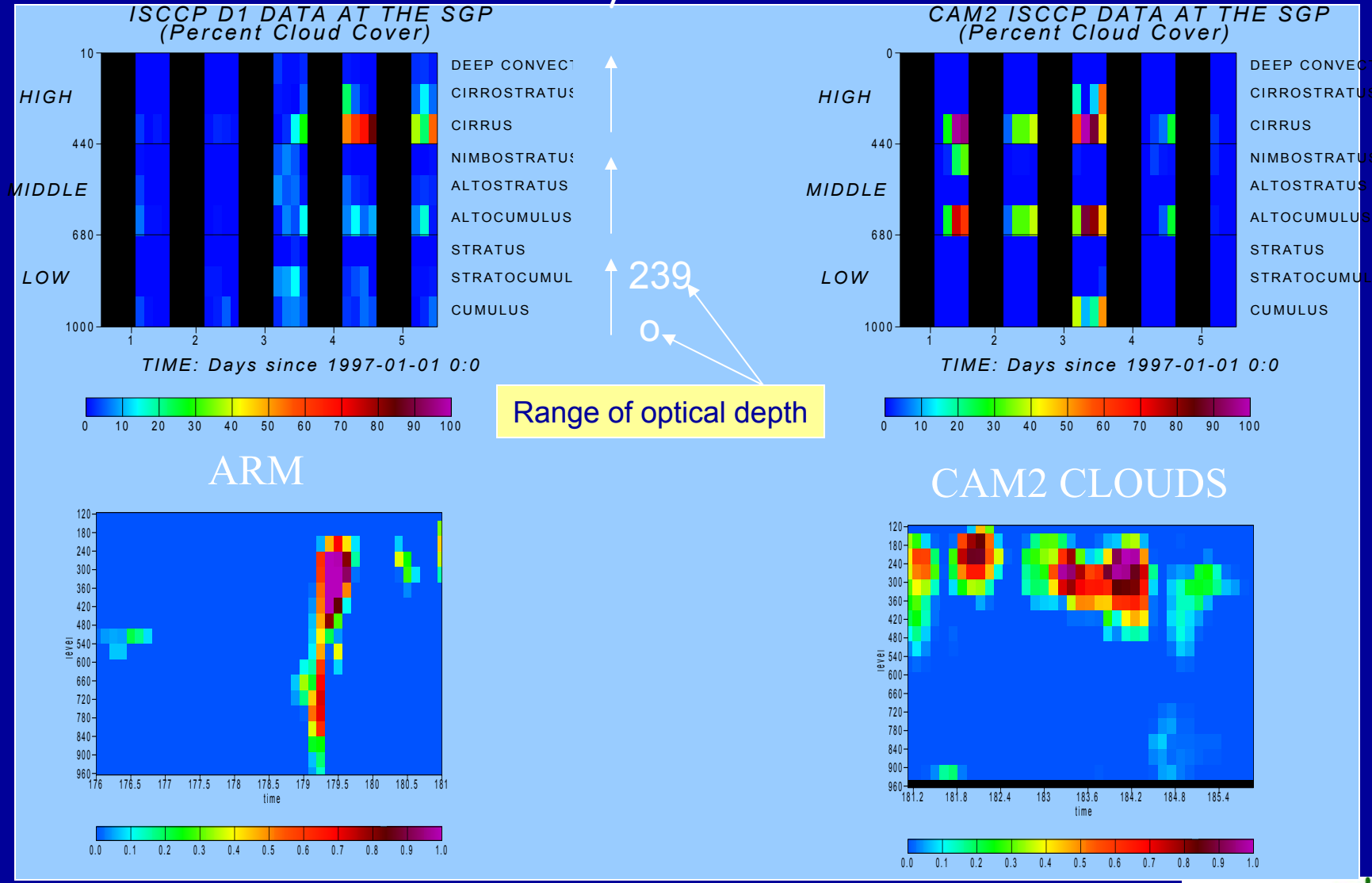
# Jerry's turn

# Evaluating clouds over the *SGP* and other sites

## ISCCP D1 data

## July 1-4 1997

## ISCCP simulator



# CAPT will also be useful in analysis of global systematic errors

For example:

- One concern is the persistence of a double ITCZ in the CAM2 (and many other models)
- CAPT may contribute to understanding mechanisms responsible for persistence
- Data from the ARM TWP will also be important for early times in forecast (24-48 hours)

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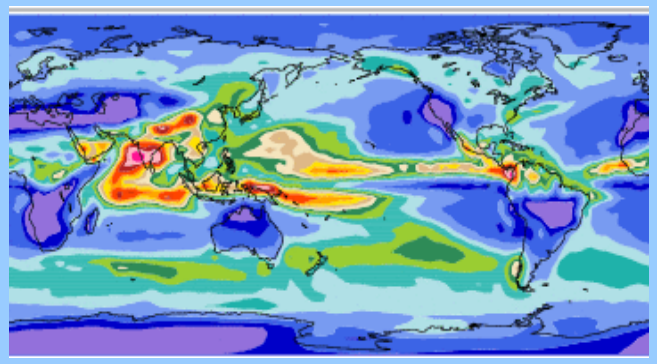
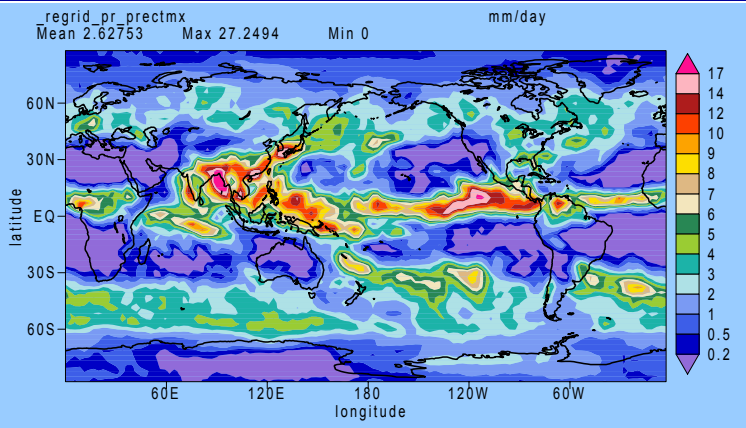
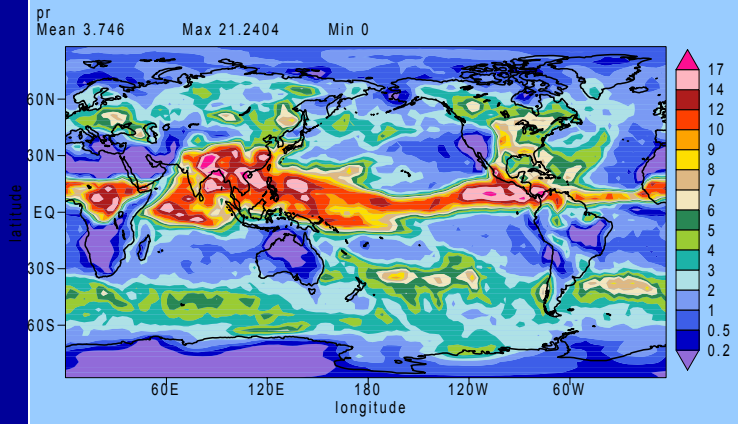
## CAM2 JJA climatology



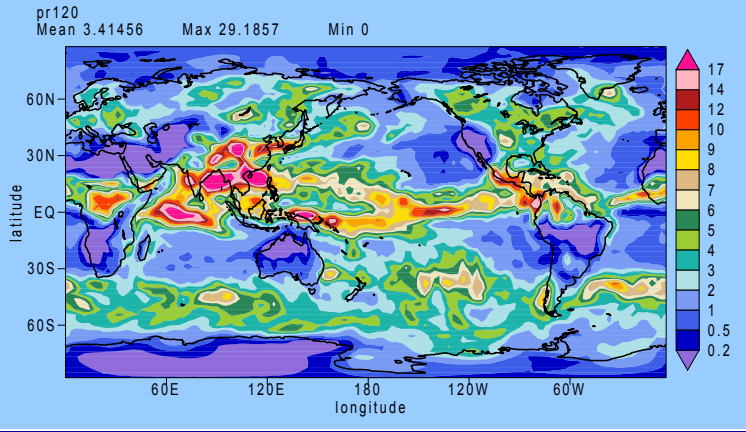
## GPCP June-July 1997 precipitation




## Forecast at 24 hours




## CAM2 forecast at day 5 (120 hours) Ensemble of 60 forecast*




*There is some indication that the systematic errors in the CAM2 climatology can be detected in day 5 or earlier forecasts

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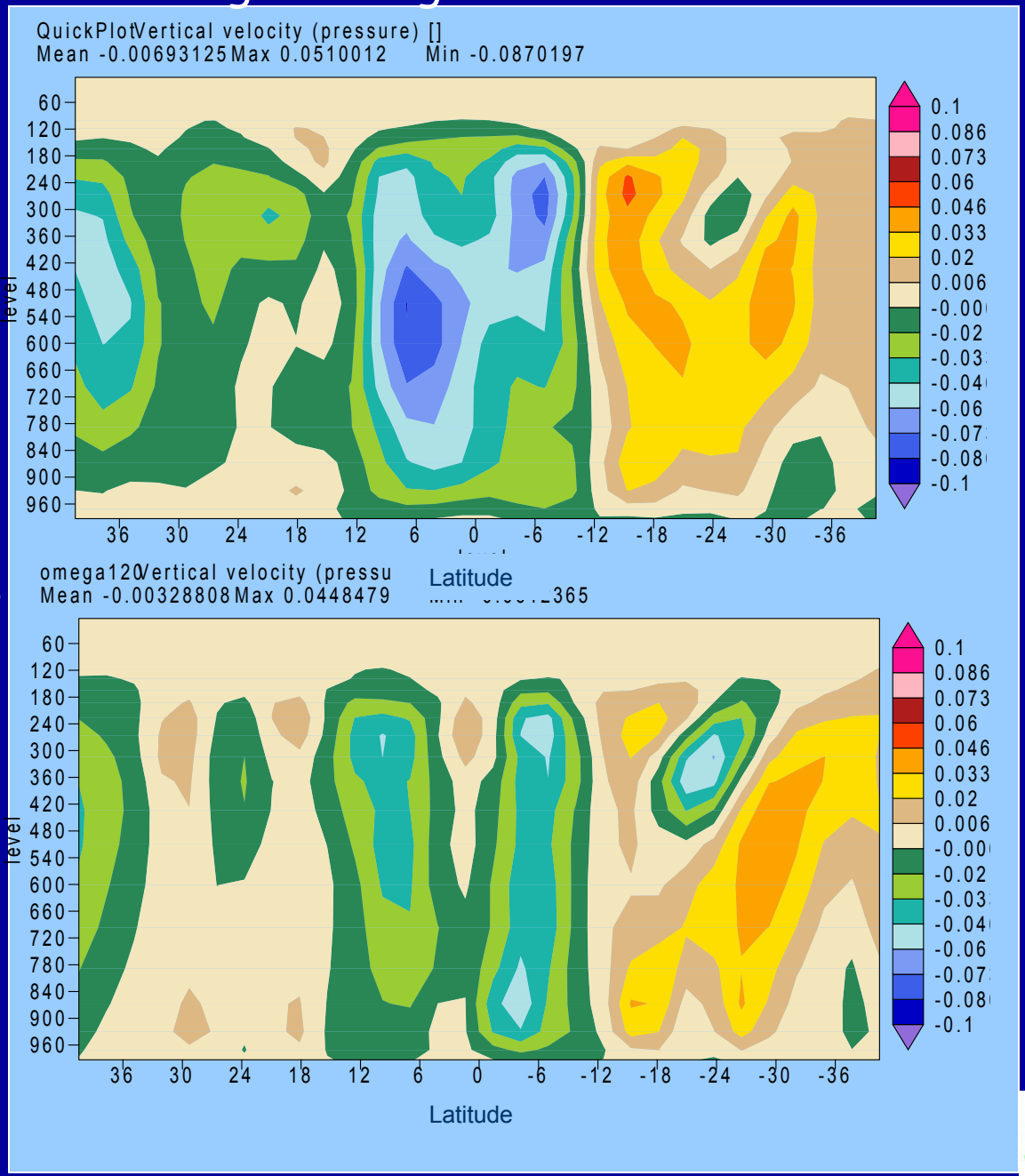
# Latitude-height Omega at the international dateline

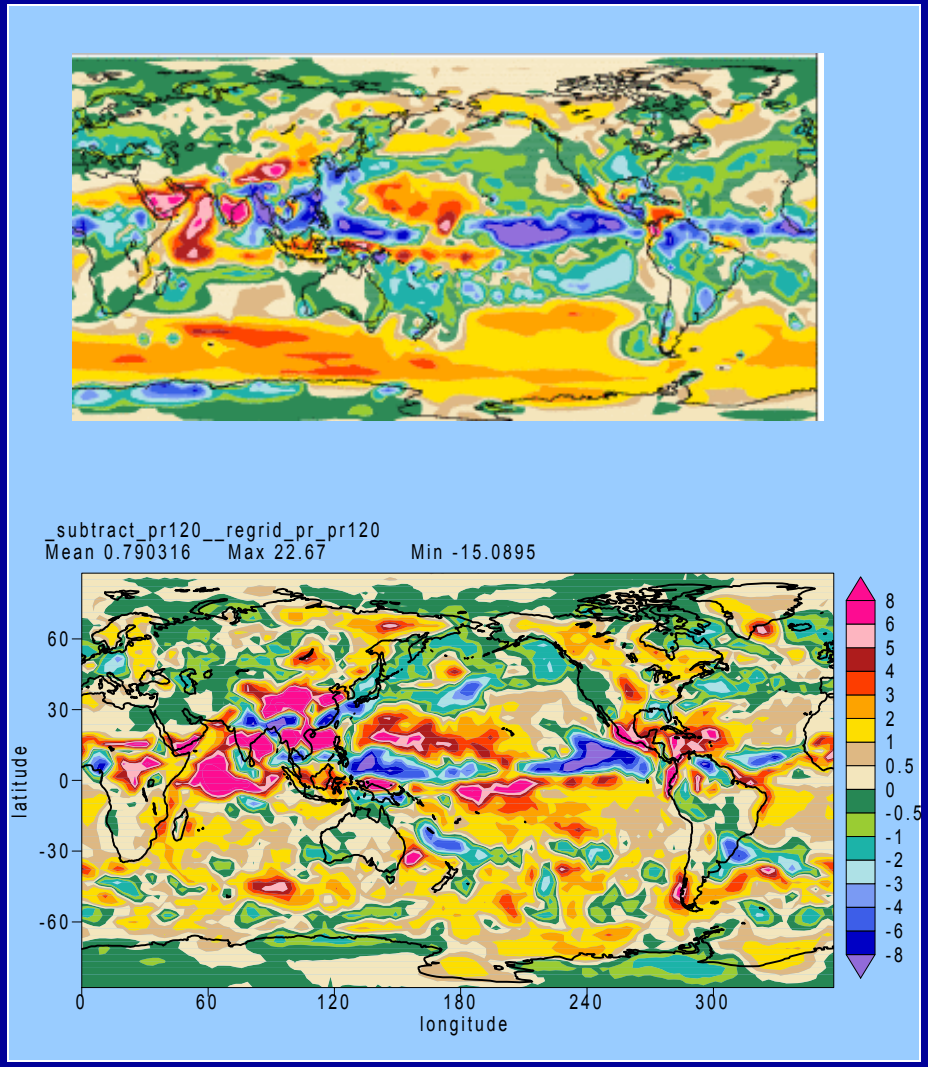
24 hours

Ensemble averages

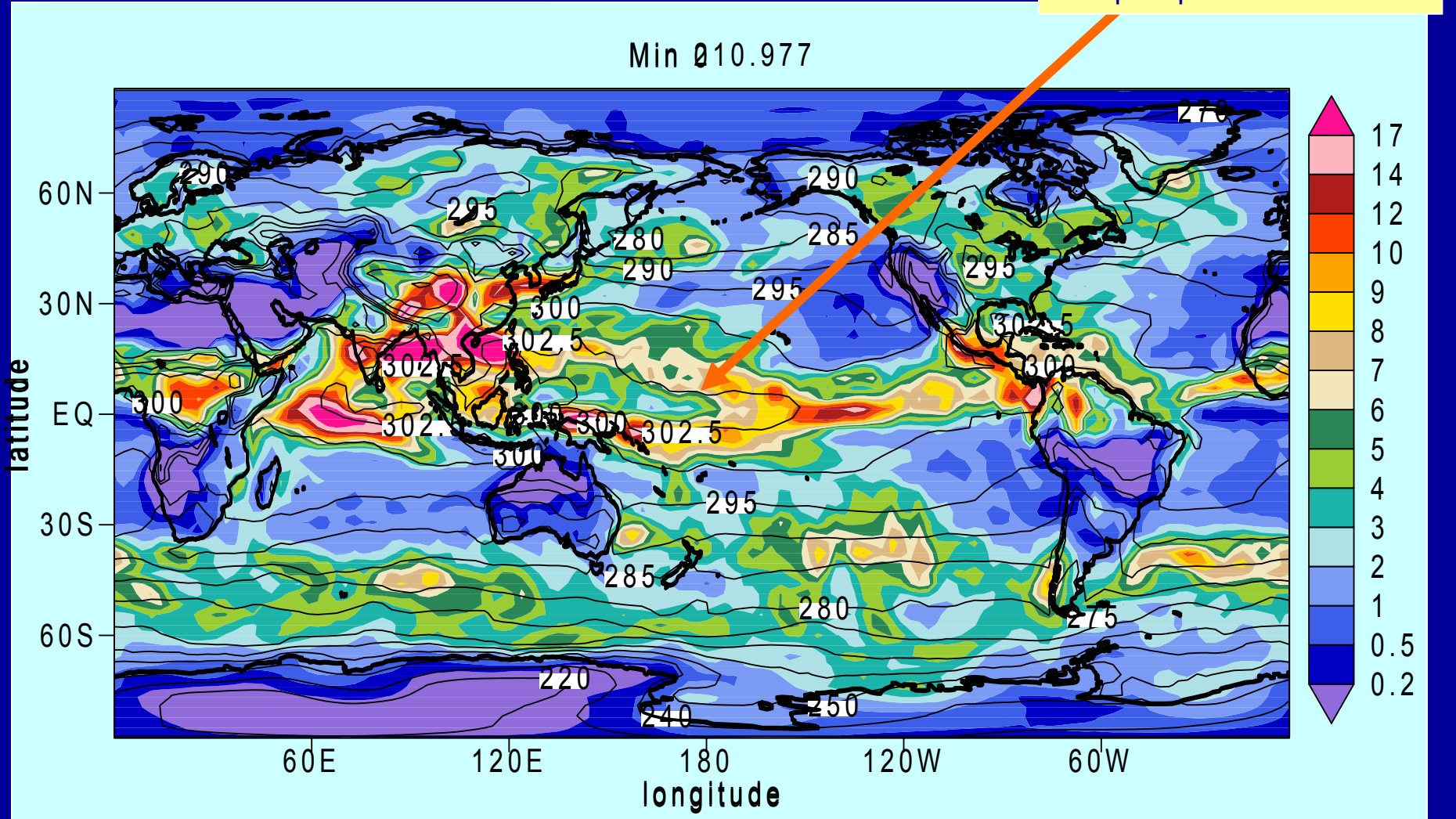
120 hours



# Precipitations errors from the 5-day forecast ensemble are somewhat similar to the errors in climatology



# Day 5 ensemble forecast with SST's superimposed



# CAPT collaborations

- Dave Randall
- Minghua Zhang
- Leo Donner
- Chris Bretherton
- Guang Zhang
- Shaocheng Xie
- Steve Ghan

# Data issues

- So far - for two cases we have more than one terabyte of data
- Plan to distribute the data to collaborators via mechanisms like the Live Access Server - Earth System Grid
- Still working on issues for distributing the test bed itself

# Case studies

- ARM/GCSS Case 3 complete with CAM2
- ARM/GCSS Case 4 in progress
- Short study of double ITCZ for upcoming workshop

# Summary

- CAPT – a test bed to help improve model parameterizations by analyzing their behavior in an NWP mode
- Successfully implemented direct insertion of reanalysis products into CAM2
- Forecasts in areas with extensive observations (ARM) suggest it may be possible to determine causes of some model deficiencies in short-term (5-day) forecasts.
- Analysis of some global scale systematic errors suggest they form at very early times and can be analyzed in detail using CAPT
- We are prepared to initiate testing Super Parameterization in late June 2003

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