Satellite Meteorology: Past, Present & Future

A Symposium in Celebration of CIMSS Silver Anniversary

Our Roots and Some Reflections

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The GWE

The defining moment for global weather prediction

The three keys:

The global observational system

Data analysis and assimilation

Global numerical prediction

Some Highly Relevant and Ancillary Events that Nurtured Roots Leading to Professor Suomi's Formation of the Cooperative Institute for Meteorological Satellite Studies (CIMSS) in 1980

1957 Exploring the atmosphere's first mile

1959 The radiation balance of the Earth from a satellite

1961 Differential cooling from satellite observations

1963 *Meteorology at Wisconsin: A plan for the future*

1965 SSEC founded

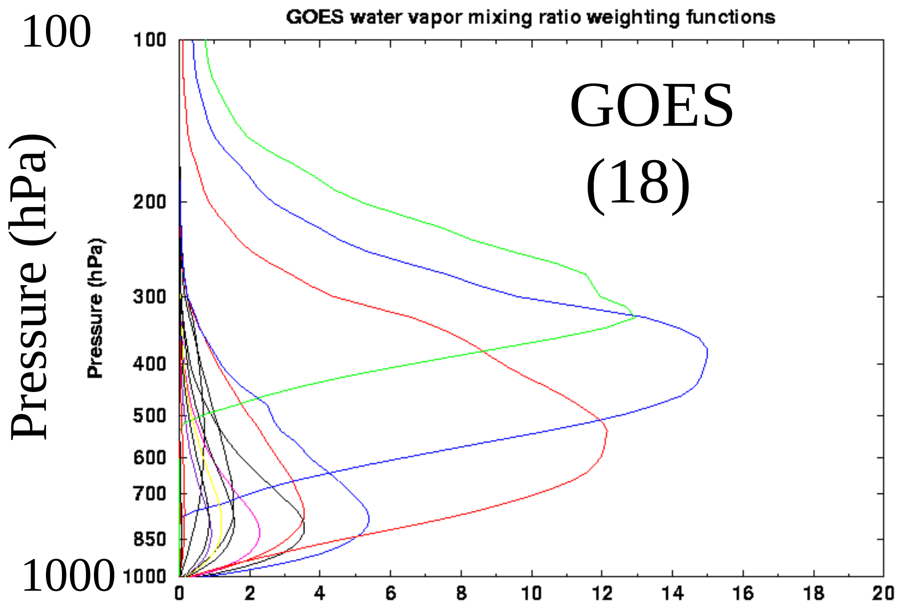
1967 The ATS-III geosynchronous color spin scan camera

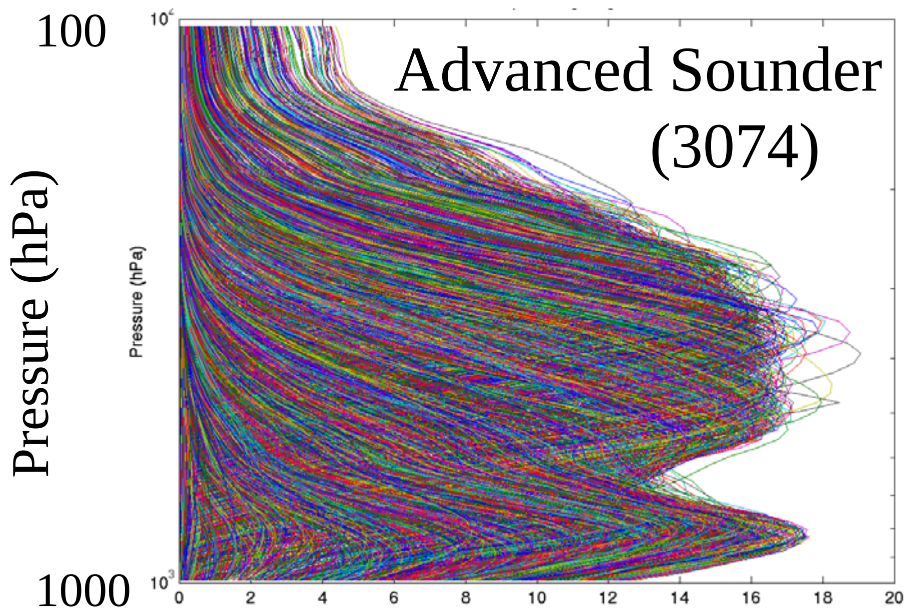
1970's Initiation of GARP

1972 Mc IDAS- The Man-computer Interactive Data Access System

1977 Arrival of NOAA/NESDIS researchers

1997 Bill Smith's surprise announcement of his move to NASA Langley to head the Division of atmospheric sciences

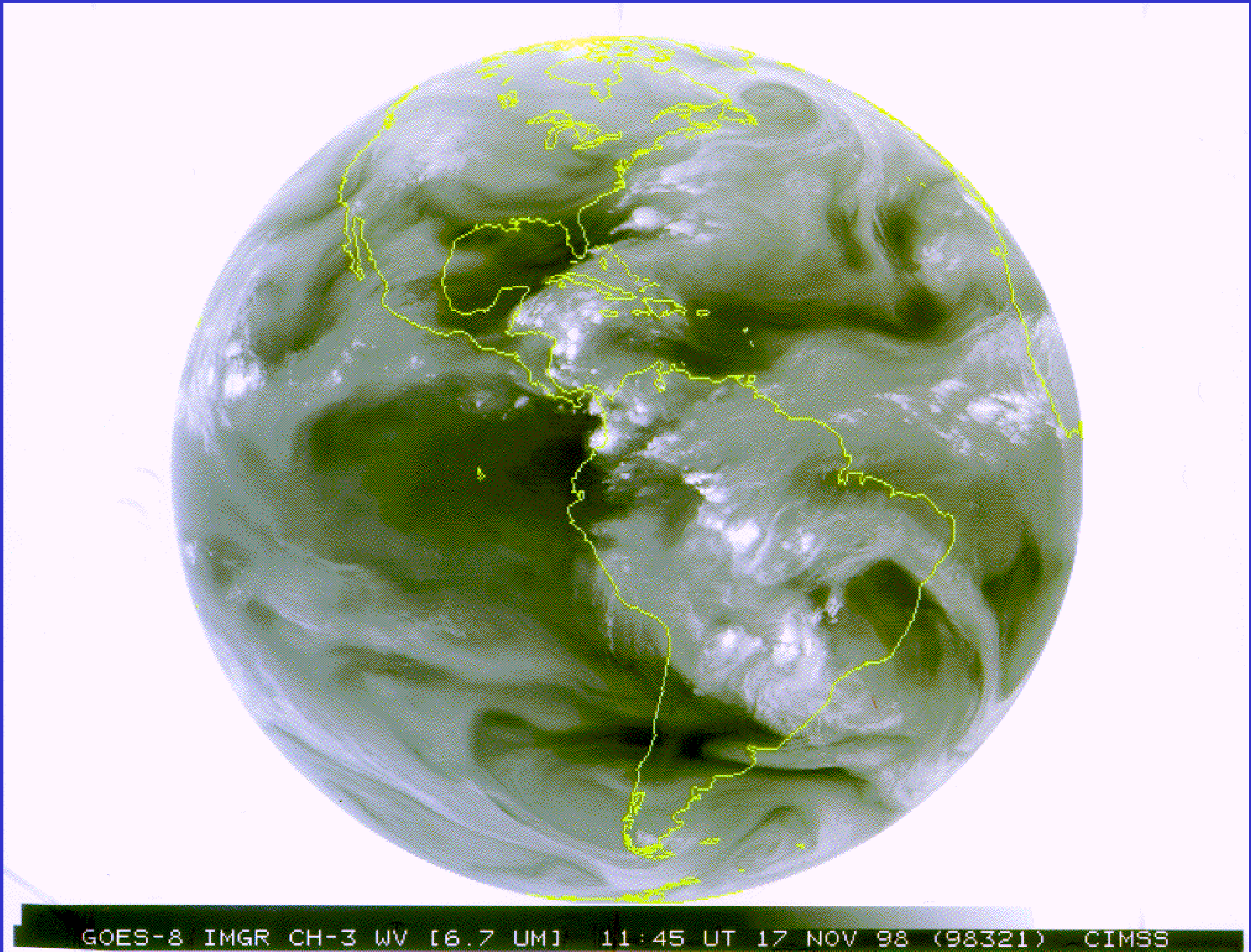




Moisture Weighting Functions

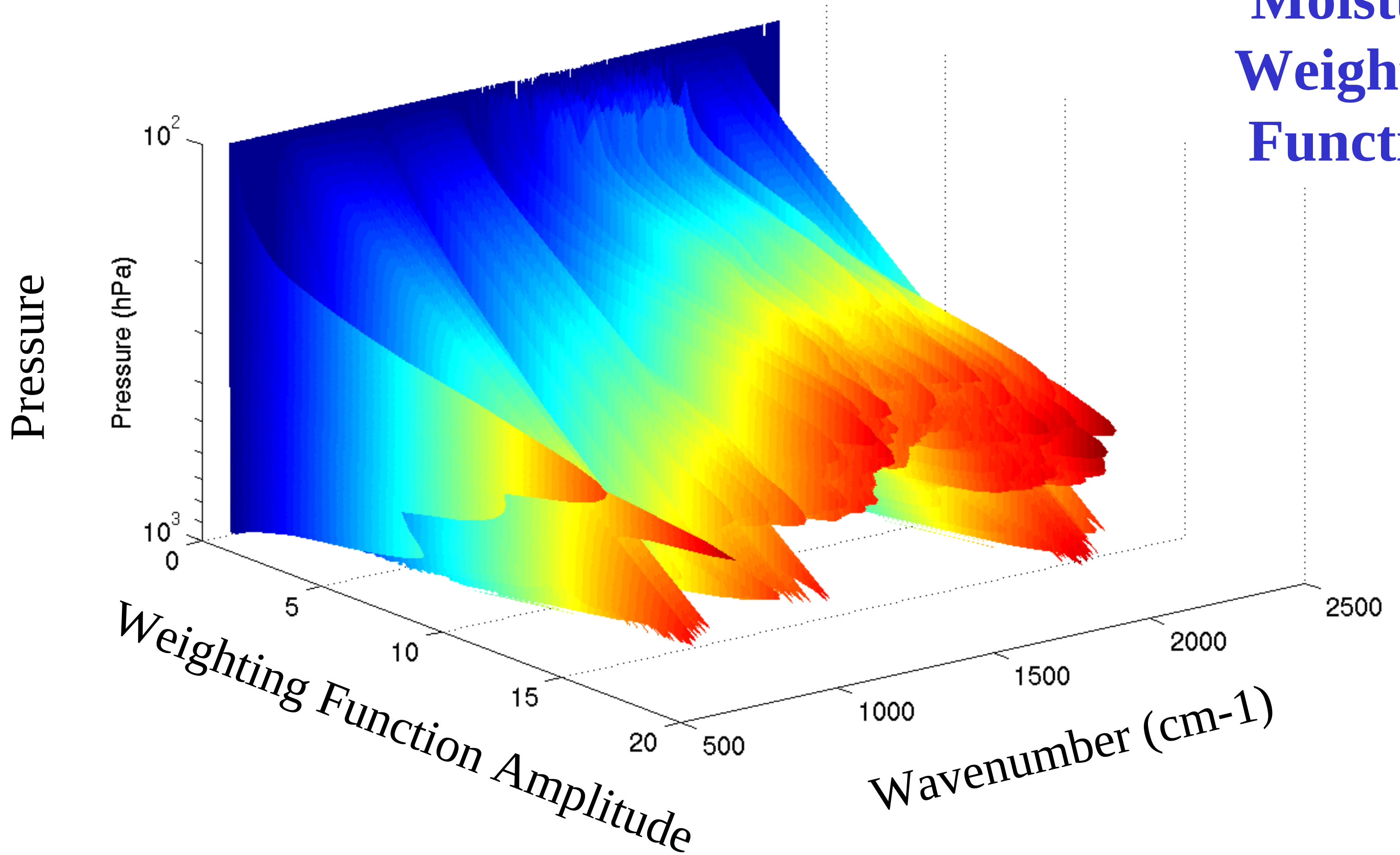
High spectral resolution advanced sounder will have more and sharper weighting functions compared to current GOES sounder. Retrievals will have better vertical resolution.

GOES - 8 Water Vapor (6.7 micron)



These water vapor weighting functions reflect the radiance sensitivity of the specific channels to a water vapor % change at a specific level (equivalent to dR/dlnq scaled by dlnp).

Moisture Weighting Functions



UW/CIMSS

The advanced sounder has more and sharper weighting functions

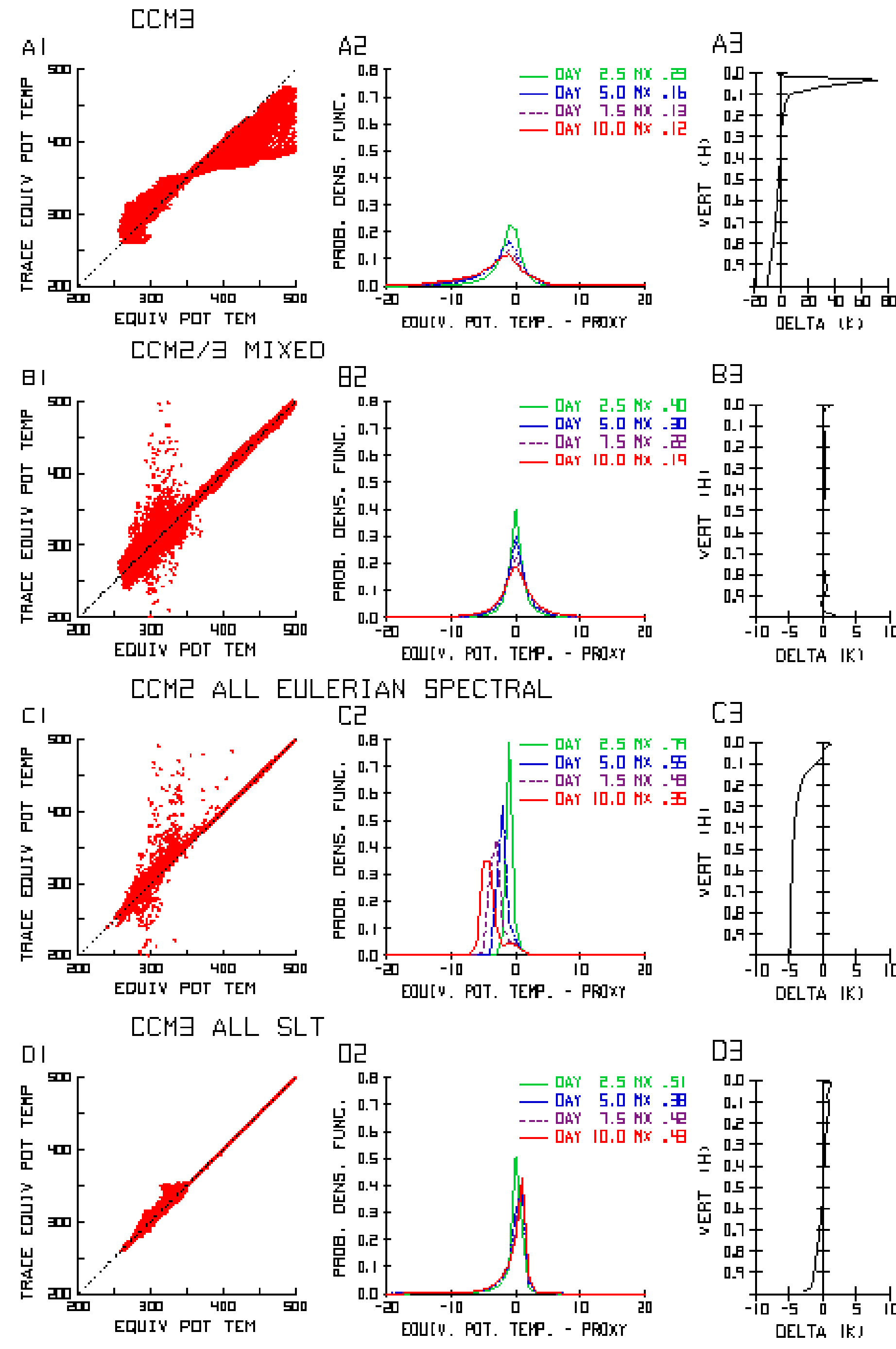
There is a need for critical assessment of the accuracy of models in relation to limitation of prediction of atmospheric hydrological processes

Assessment of Numerical Accuracies for CCM2 and CCM3

Scatter Diagrams for Equivalent Potential Temperature and its trace at Day 10

Empirical Probability Density Functions at Days 2.5, 5.0, 7.5 and 10.0 for Pure Error Differences of Equivalent Potential Temperature and its Trace

Vertical Profiles of Global Areally Averages of Pure Error Differences of Equivalent Potential Temperatue and its Trace



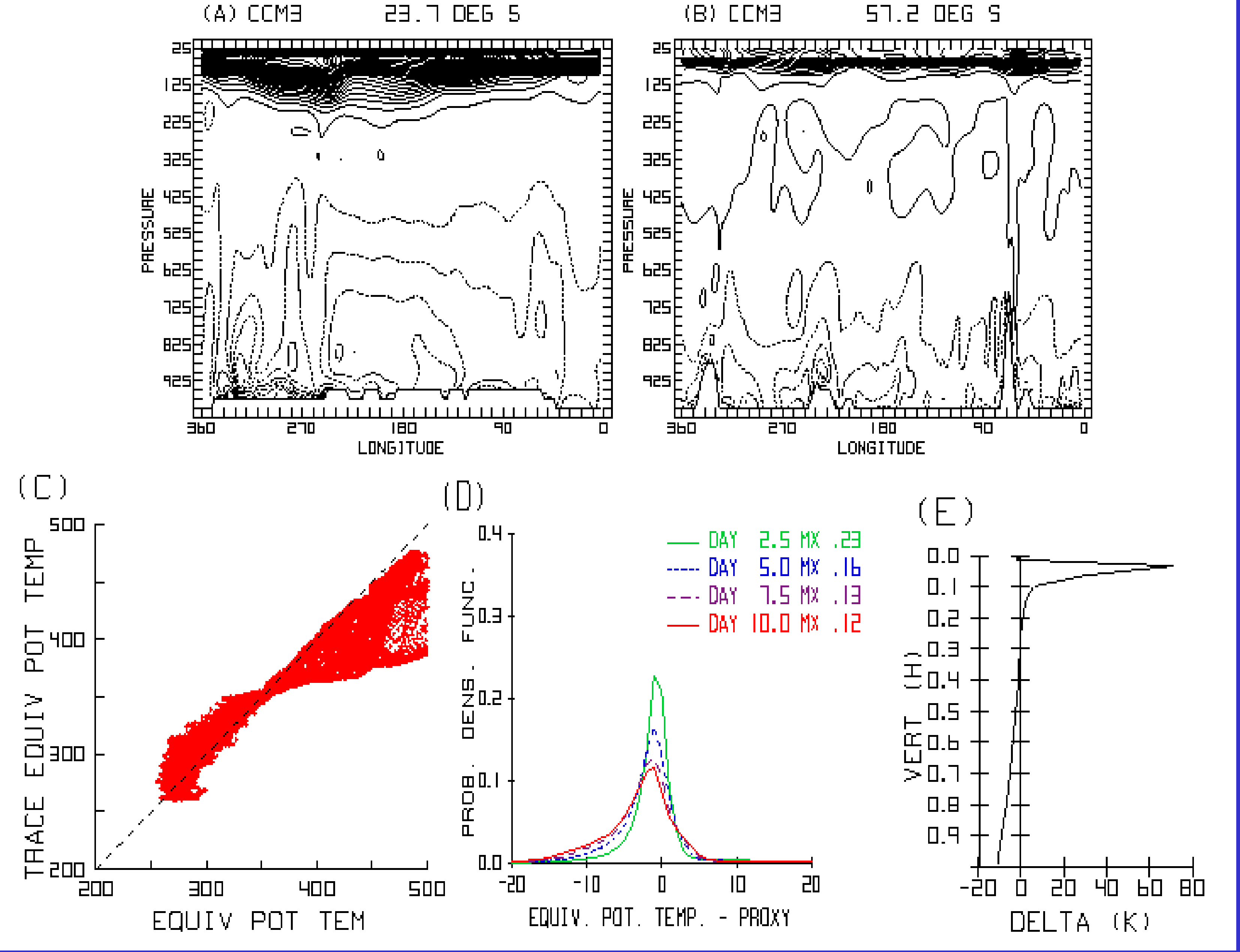
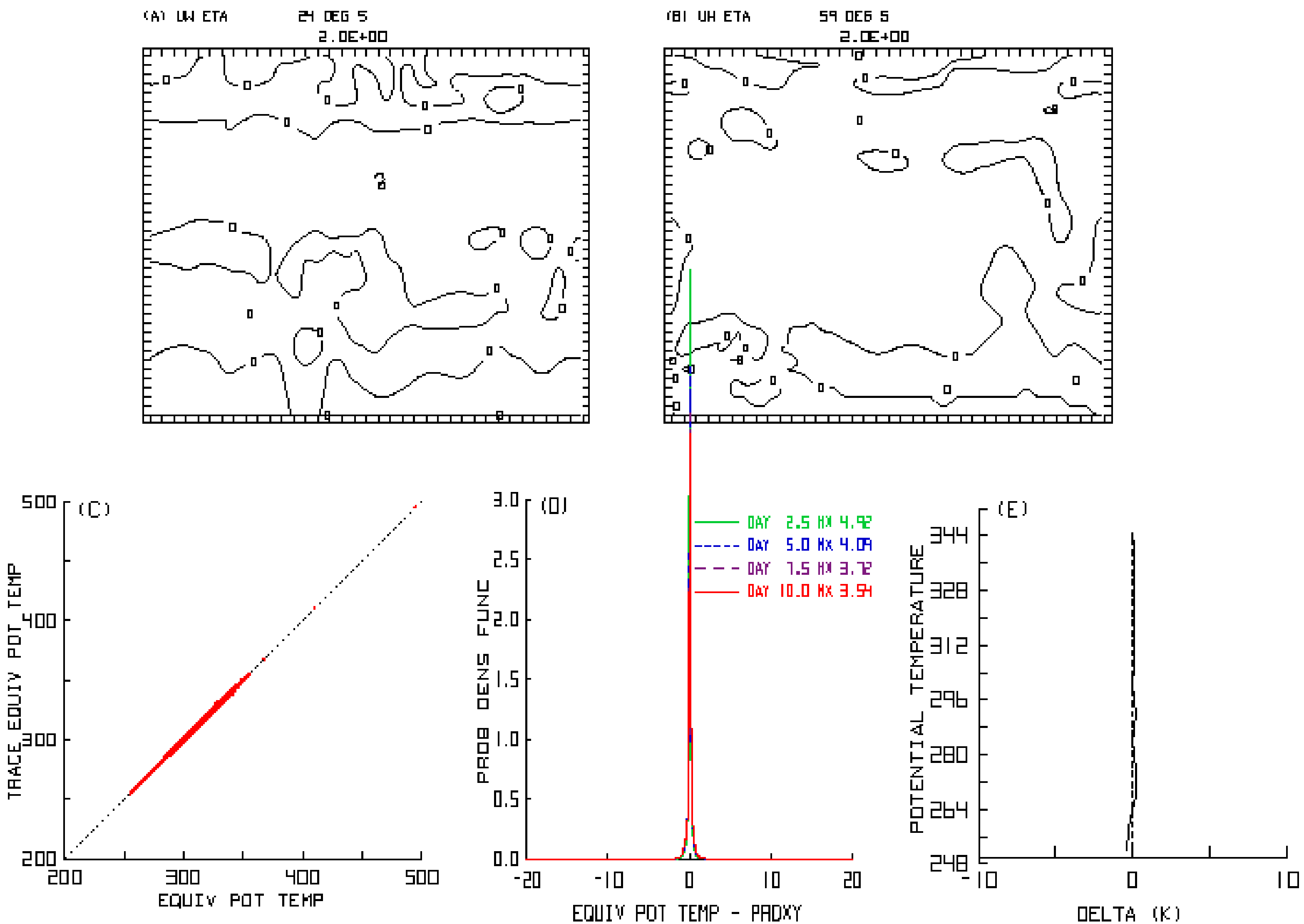


Fig. 3. Same as Fig. 2 except for CCM3 running at T42 horizontal resolution.

UW Hybrid θ-η Model



Results from Analysis of Variance Globally for the Difference of Equivalent Potential Temperature Minus its Trace (θ_e-tθ_e) and three components at day 10

CCM2 and CCM3

	$S_G(\delta^*)$	$S_G(\hat{\delta}^*)$	$S_G(\hat{\hat{\delta}})$	$S_G(\delta)$
CCM3	37.45 (6.12)	195.77 (13.99)	0.02 (.15)	233.24 (15.27)
CCM3/2	27.88 (5.28)	0.09 (0.30)	0.03 (0.16)	28.00 (5.29)
CM2(all spectral)	10.83 (3.29)	2.12 (1.46)	15.03 (3.88)	27.98 (5.29)
CCM3(all semi-Lagrangian)	3.41 (1.85)	0.64 (0.79)	0.03 (0.16)	4.08 (2.02)

CCM3

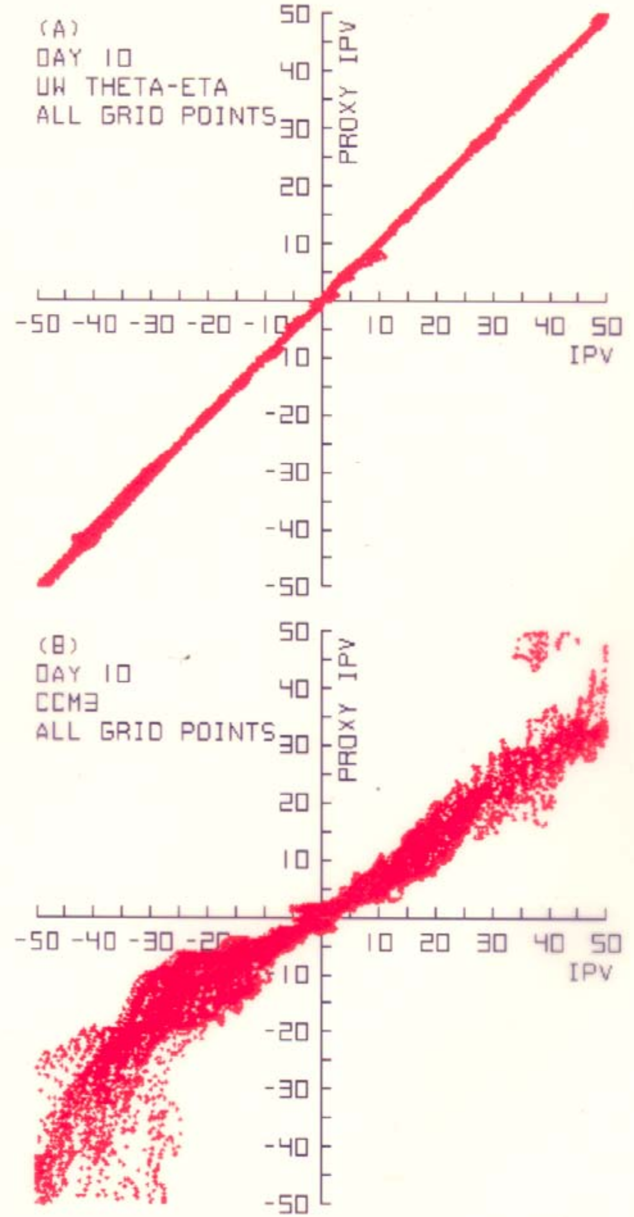
CCM3 Standard	37.45 (6.12)	195.77 (13.99)	0.02 (.15)	233.24 (15.27)
CCM3 Modified	5.93 (2.44)	0.25 (.50)	0.01 (.09)	6.19 (2.49)

UW Hybrid Model

UW $\theta-\sigma$	0.70(0.84)	0.23(0.48)	0.13(0.35)	1.05 (1.03)
UW $\theta-\eta$	0.12 (0.35)	0.01 (.10)	0.03 (.16)	0.16 (0.40)

Units of variance are the square of Kelvin temperature (K^2). Units of quantity in parenthesis as the square root of the variance (standard deviation) are Kelvin temperature ($\pm$ K).

Scatter diagrams of IPV versus trace of IPV at Day 10 at all grid points within the global domains of the UW theta-eta model and CCM 3



Caratheodory'statement of the Second Law (Sommerfeld 1950)

"In the neighborhood of every state which can be reached reversible , there exists states which cannot be reached along a reversible adiabatic path, or in other words, which can only be reached irreversible or which cannot be reached at all."

Is Caratheodory's statement of the Second Law relevant to modeling of the climate state? If so, are there robust means to assess the accuracies of model in appropriately simulating reversibility, or alternatively to avoid adjacent states that should not be reached by irreversible processes?

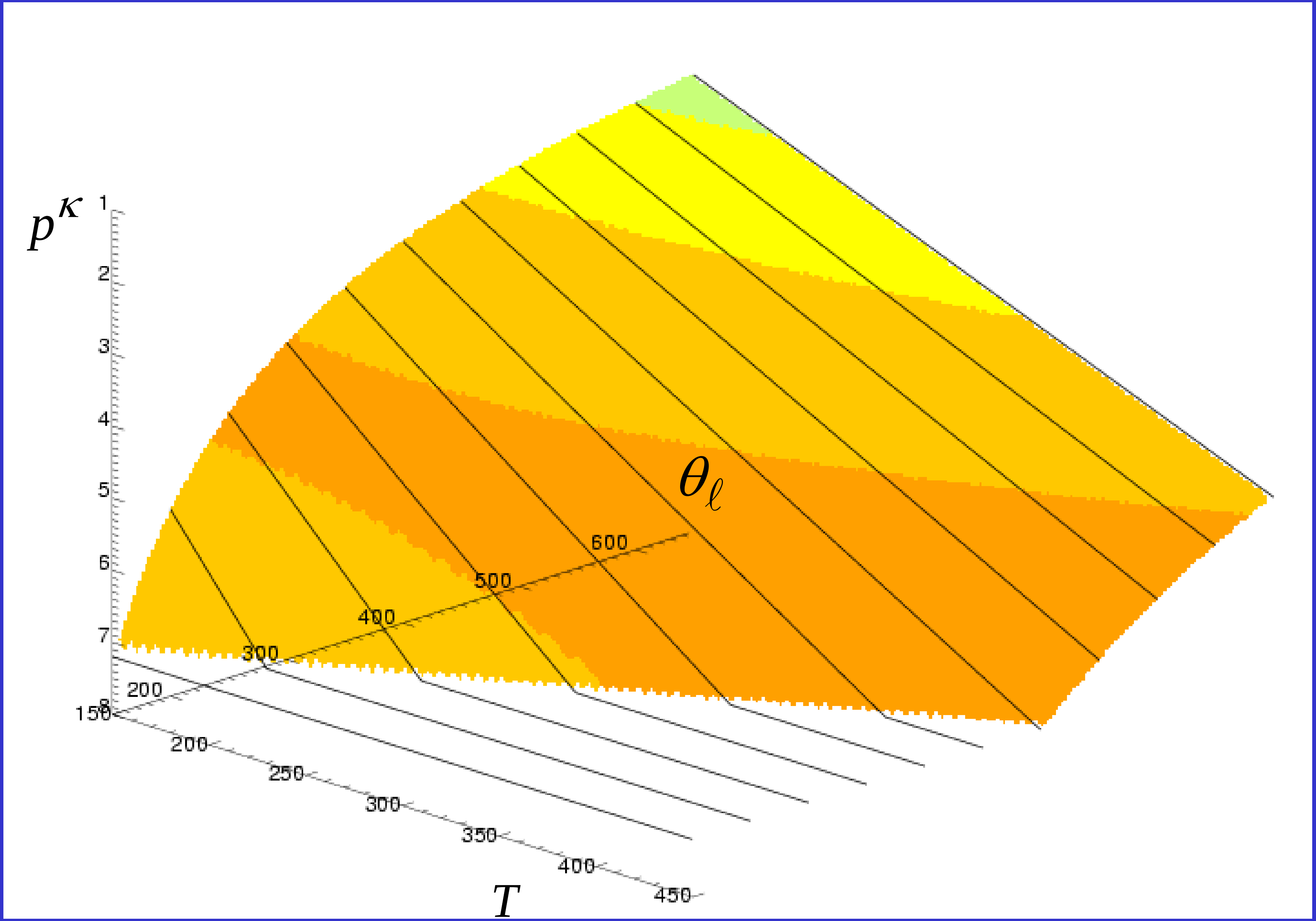
In Born's (1949) own words (lecture delivered in 1948), Carathéordory's postulate simply states "that there exist adiabatically inaccessible states in any vicinity of a given state." Chandrasekhar (1939) states that Carathéodory's theory is not merely "an elegant approach to thermodynamics but is the only physically correct approach to the Second Law". "The logical rigor and beauty of Carathéodory's theory may be regarded as an example of the standard of perfection which should be demanded eventually of any physical theory, including the theory of stellar structure."

Now consider that each of the variables may be defined as a Lagrangian and/or a replicate property to be simulated as trace constituents. For example, the corresponding Lagrangian properties of potential temperature in conjunction with appropriate transport relations may be determined as a function of

$$\theta_{\ell}(T, T_o, p, p_o^{\kappa}, \theta_o)$$

In the case of equivalent potential temperature, additional initial value information is required regarding water substances and specification of moist processes.

2-D Surface of Admissible T and p^κ as a function of θ_L



The Linear Expansion of the Lagragian Pure Error Difference

Through addition and subtraction, the Lagrangian estimate of the change of potential temperature expressed as a linear combination of the four distinct definitions for potential temperatures , is given by

$$\Delta(\theta_\ell, \theta_{\ell_o}) = (\theta - \theta_o) + (\theta_\ell - \theta) + (\theta_o - \theta_{\ell_o})$$

Components of Uncertainties

$$\delta(\theta_\ell, \theta) = \theta_o[(\theta_o / \theta_{\ell_o}) - 1] + \Delta(\theta, \theta_o)[(\theta_o / \theta_{\ell_o}) - 1]$$

10 day Component Variance and RMS differences of Potential Temps- initial day 15 Dec. 1998,

		$(\theta_L - \theta_{L0})$	$(\theta - \theta_o)$	$(\theta_L - \theta)$	$(\theta_o - \theta_{L0})$
UW θ-η Model, 14 theta, 14 eta layer					
CCM3 No Physics	2.1825 deg	1.12 (1.06)	0.02 (0.14)	0.28 (0.53)	0.28 (0.53)
CCM3 Physics	2.1825 deg	130.52 (11.43)	115.37 (10.74)	1.79 (1.34)	1.82 (1.35)
NCEP No Physics	2.1825 deg	0.97 (0.99)	0.00 (0.07)	0.24 (0.49)	0.24 (0.49)
NCEP Physics	2.1825 deg	276.40 (16.63)	205.47 (14.33)	6.22 (2.49)	5.96 (2.44)
NCEP Physics	0.70 deg	114.17 (10.69)	74.21 (8.61)	3.38 (1.84)	3.14 (1.77)
XXXXXXXXXXXXXXXXX					
NCAR FV, 26 layers, 2x2.5 deg					
CAM3 NO PHYS		6.93 (2.63)	1.00 (1.00)	1.54 (1.24)	1.53 (1.24)
CAM3 PHYS		210.97 (14.53)	156.99 (12.53)	6.52 (2.55)	6.18 (2.49)
xXXXXXXXXXXXXXXXXXXX					

30 day Component Variance and RMS differences of Potential Temps- initial day 15 Dec. 1998,

UW Model, CCM3 Physics, 14 theta, 14 eta layer

	$(\theta_L - \theta_{L0})$	$(\theta - \theta_o)$	$(\theta_L - \theta)$	$(\theta_o - \theta_{L0})$
UW θ-η Model , 2.1825 deg	477.52 (21.85)	402.89 (20.07)	8.27 (2.88)	9.17 (3.03)
UW Sigma Model, 2.1825 deg	1752.90 (41.87)	661.55 (25.72)	181.95 (13.49)	118.11 (10.87)

“Challenges in Remote Sensing and Modeling of Hydrologic Processes in Weather Prediction and Climate”

The observation and modeling of water vapor, cloudiness, precipitation and other hygrologic processes for weather prediction and climate continue to pose unusually difficult challenge. Future progress depends critically upon understanding current limitations in both observational systems and models, assessing strategies to overcome these limitations, and undertaking studies to isolate an optimum course of action.

The End