Daily Numerical Weather Prediction with the Global UW Hybrid θ- η Coordinate Model

Todd K. Schaack
Tom H. Zapotocny
Allen J. Lenzen
Donald R. Johnson

Space Science and Engineering Center

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The UW Hybrid θ-η Model

- Developed through modification of the predecessor UW hybrid θ-σ coordinate model

- UW θ-η model - vertical coordinate smoothly varies from terrain following at the earth's surface to isentropic coordinates in the middle to upper troposphere.

- The UW θ-η model retains the excellent transport characteristics of the UW θ-σ model.

UW θ-η Model

1. Grid point model

2. Various horizontal and vertical resolutions

3. Numerics - Piecewise parabolic method (PPM) after
   Colella and Woodward (1994)

4. Time differencing - Forward – backward

5. Physical Parameterizations
   CCM3 package
   McRAS, RAS, Betts-Miller moist convective parameterizations
   NCAR CAM
   NCEP GFS package

6. Filters and Diffusion
   Fourier polar filter (tendencies)
   Fourth order horizontal diffusion

What's New Since the Last Hybrid Coordinate Modeling Workshop?

- **The record of once daily 7-day forecasts extended : March 2002 – September 2006 (Tom Zapotocny)**
- **Validation of numerical models using entropy and energy principles (Donald Johnson)**
- **Incorporation of the NCAR CAM and NCEP GFS physical parameterizations (Allen Lenzen)**
- **Continued development and application of the Real-time Air Quality Modeling System (RAQMS, collaboration with NASA Langley and NOAA) (Brad Pierce)**

ARCPAC/ARCTAS 2008, TexAQS 2006, INTEX 2006
Data assimilation – ozone (column total, 3-d), 3-d CO from OMI, TES, OSIRIS, MLS
- aerosol optical depth (AOD) from MODIS

Climate Simulation with the UW Model

2.8125 latitude-longitude
28 vertical layers
14 isentropic layers, 13 eta layers, 1 sigma layer

14 year simulation
AMIP II SSTs
CCM3 physical parameterizations

Established the capability of the UW hybrid model for
for climate simulation. Schaack et al. 2004 (J. Climate)

UW θ-η Model NWP

Tom Zapotocny's work

Daily 7-day integrations: March 2002 – September 2006

Initialized daily from 00Z NCEP GDAS (plus/minus 3 hour cutoff)
-sigma spectral files

UW model has 37 layers
GFS physics operational – May 2004

Multiple resolutions (0.703 degrees, 0.47 degrees)

Different physical parameterizations

Verification made against GDAS final analysis

Tom's Computer Center

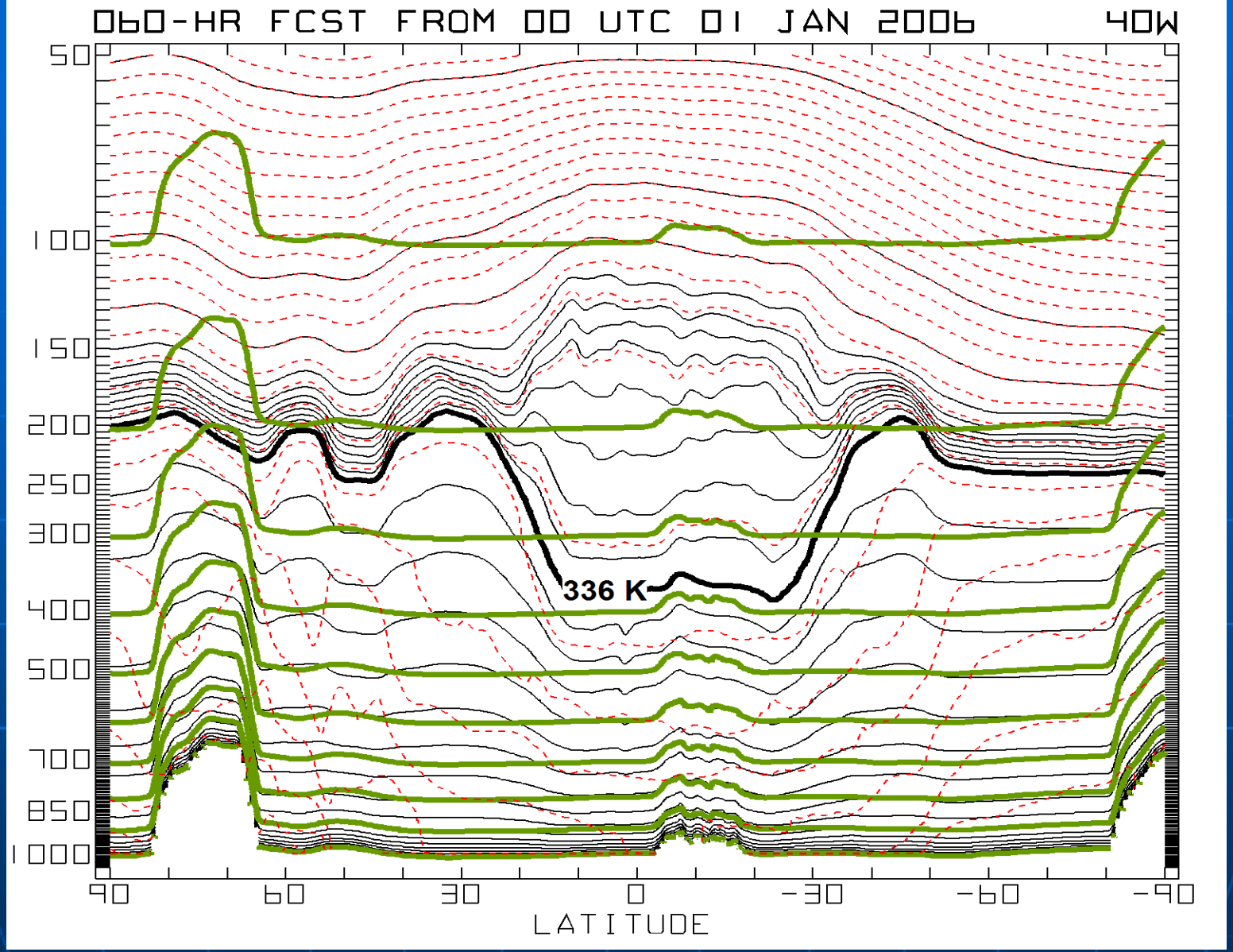
- 7 networked computers at home
- 6 dedicated to running the UW hybrid models

- Dell workstations within our group
- Raptor (SGI workstation)
- NCEP computers

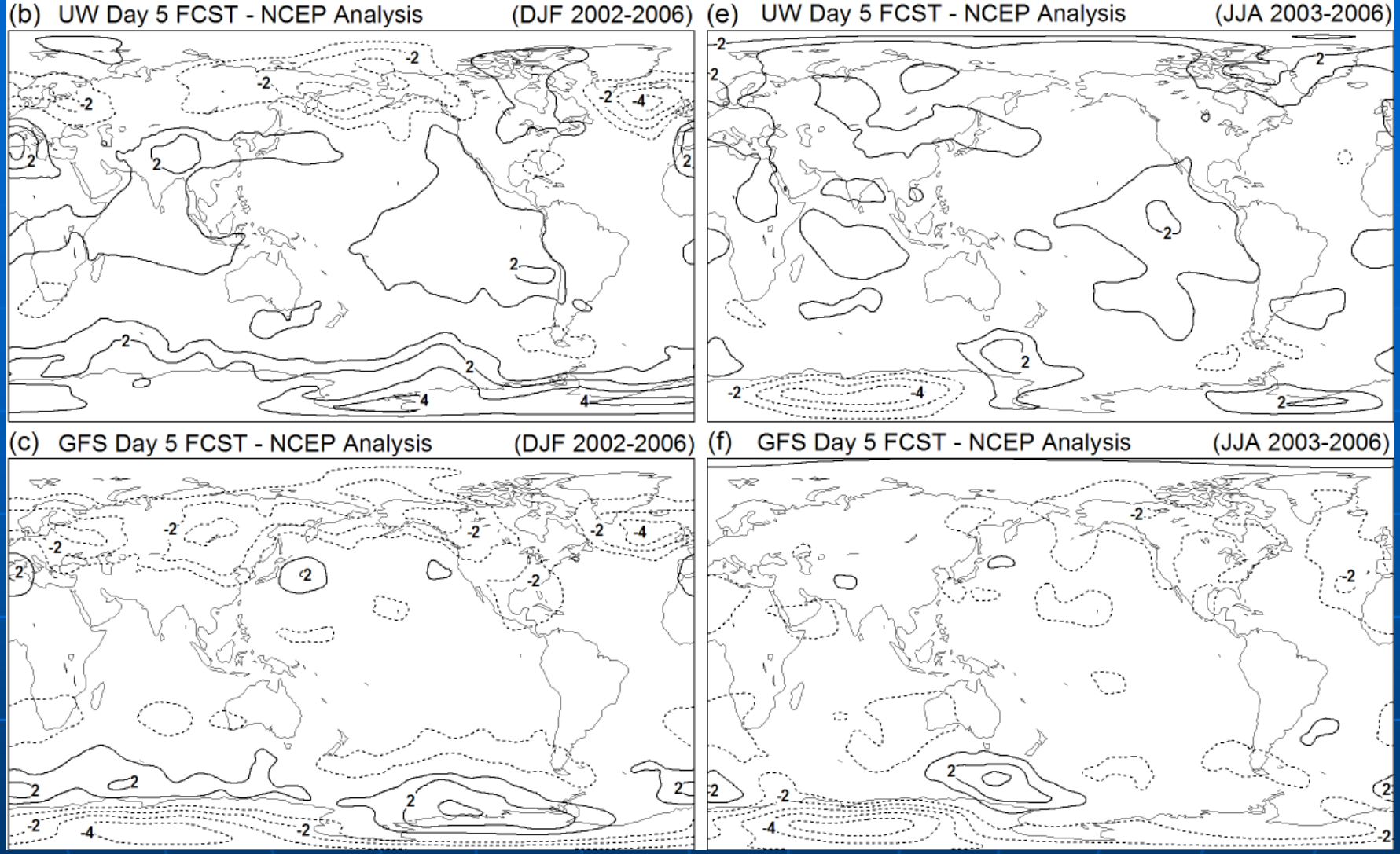
UW θ-η Model NWP (cont)

- **Anomaly Correlation (AC)**
- **RMS error**
- **Bias**
- **Height, specific humidity, wind**

AC scores computed on 2.5 degree grid and computed using NCEP maintained algorithms

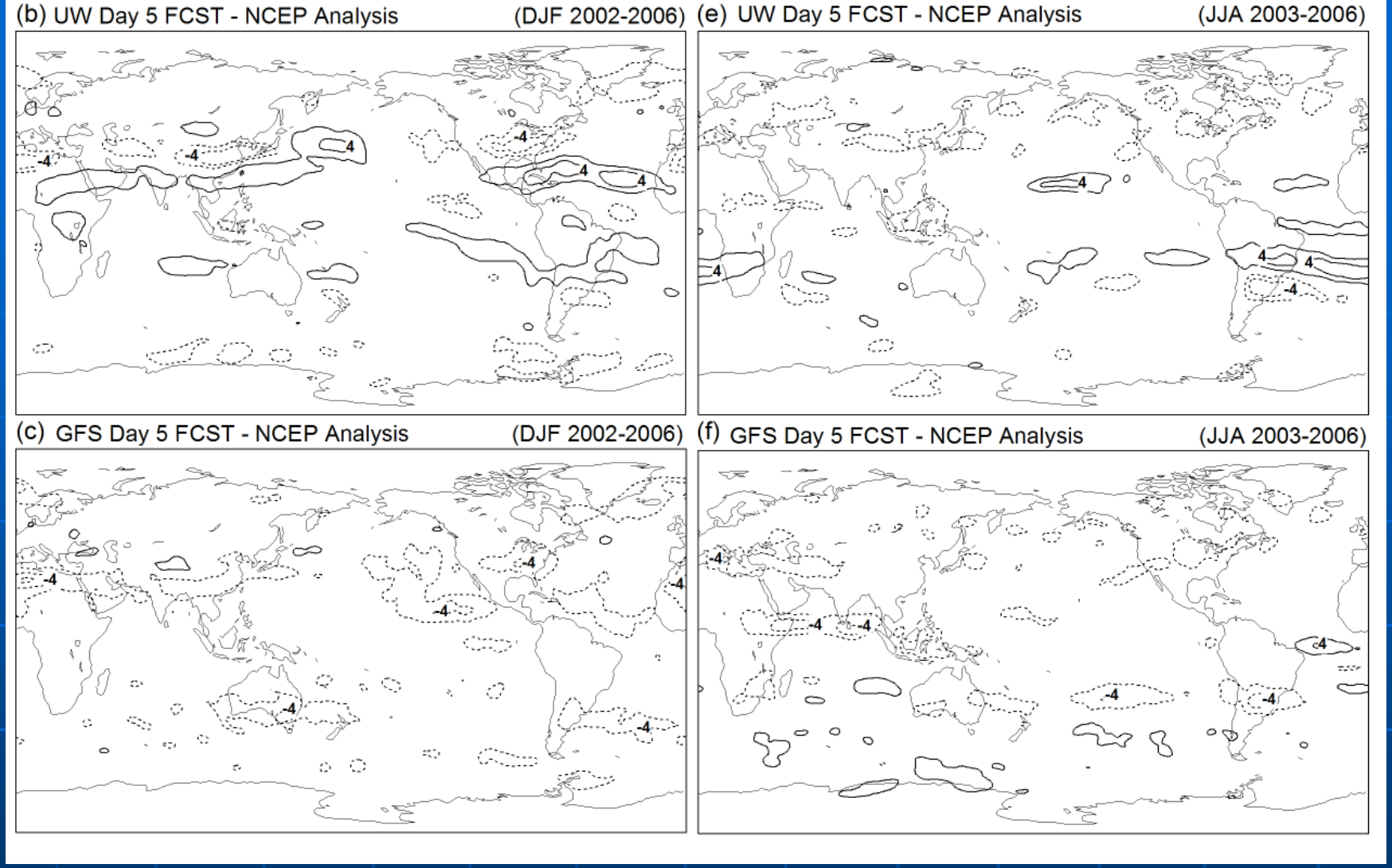


North-south cross section along 40° W, 00Z January 1, 2006
UW model (black), isentropes (red), sigma (green)

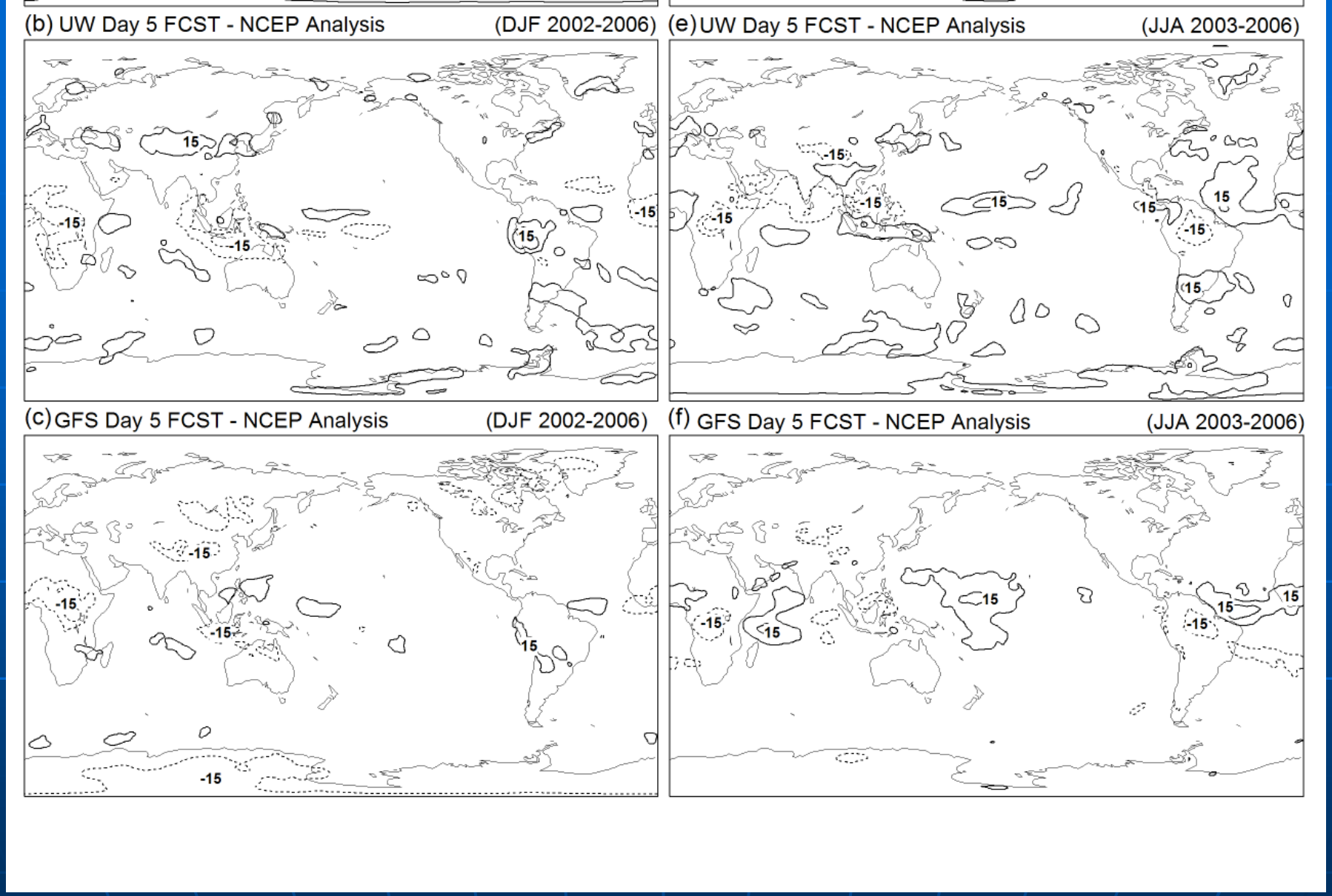


DJF **JJA**

The mean error of 500mb geopotential heights (dm) for 5 day forecasts for DJF and JJA 2003-2006 from the UW (top) and GFS (bottom) models.

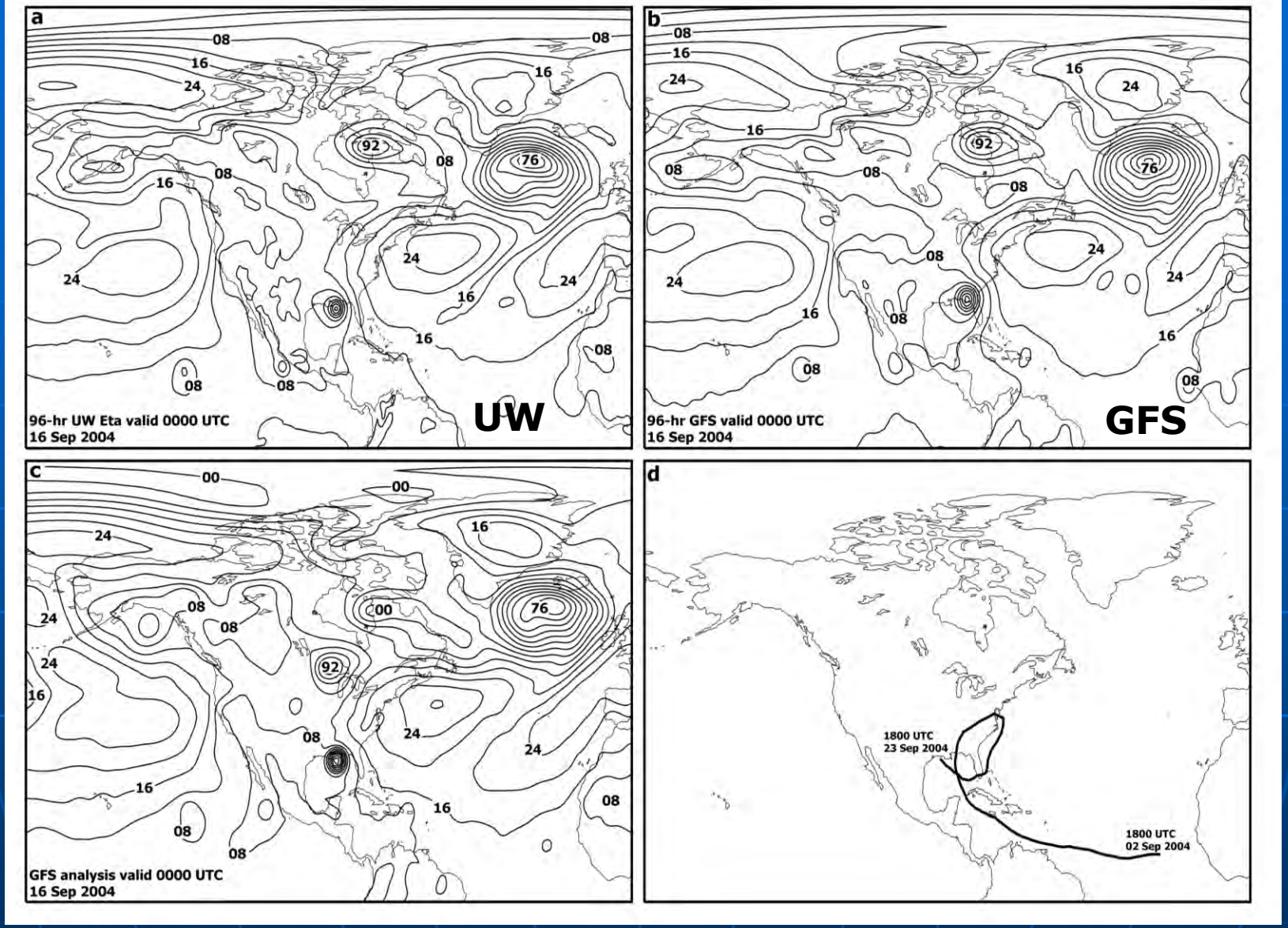


The mean error of 250mb isotachs (ms^{-1}) for 5 day forecasts for DJF and JJA 2003-2006 from the UW (top) and GFS (bottom) models

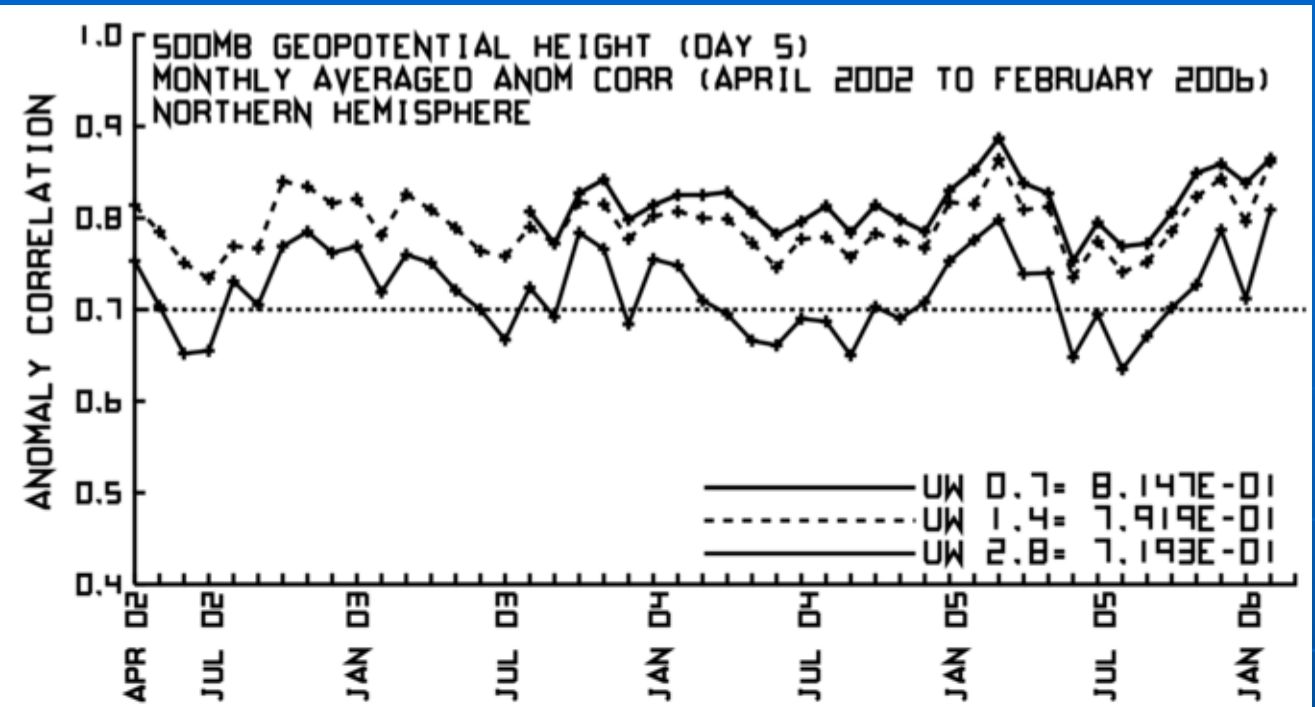


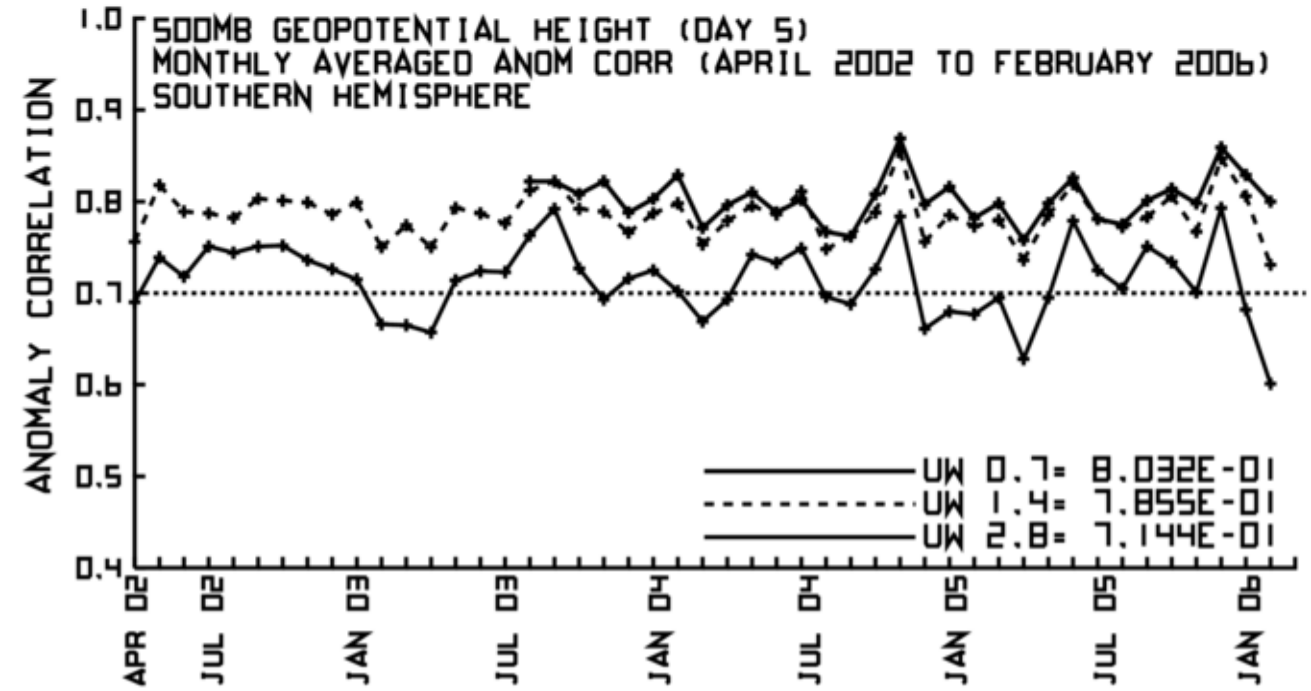
DJF **JJA**

The mean error of 300 mb relative humidity (%) for 5 day forecasts for DJF and JJA 2003-2006 from the UW (top) and GFS (bottom) models



Distributions of mean sea-level pressure (mb) from a 96 hour forecast of the UW (top left) and GFS (top right) models. Both were initialized at 00Z September 12, 2004. GDAS analysis is in the bottom left.



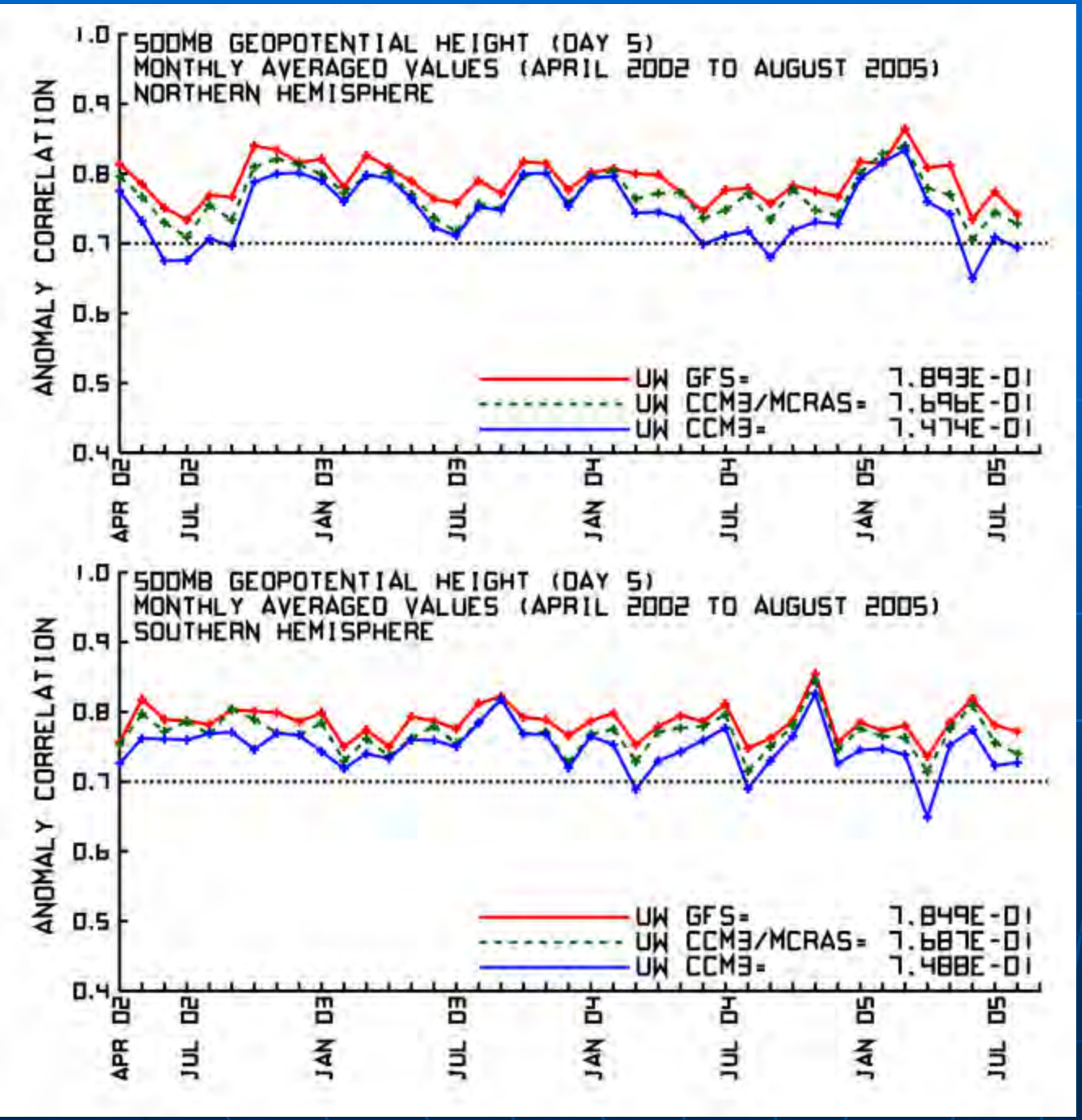


500 mb geopotential height AC scores for the UW hybrid model.

2.8°, 1.4°, 0.7° horizontal resolution
37 vertical layers

NH

SH



500 mb geopotential height AC scores.

UW hybrid model with CCM3, CCM3/McRAS and GFS physical parameterizations

37 vertical layers

NH

SH

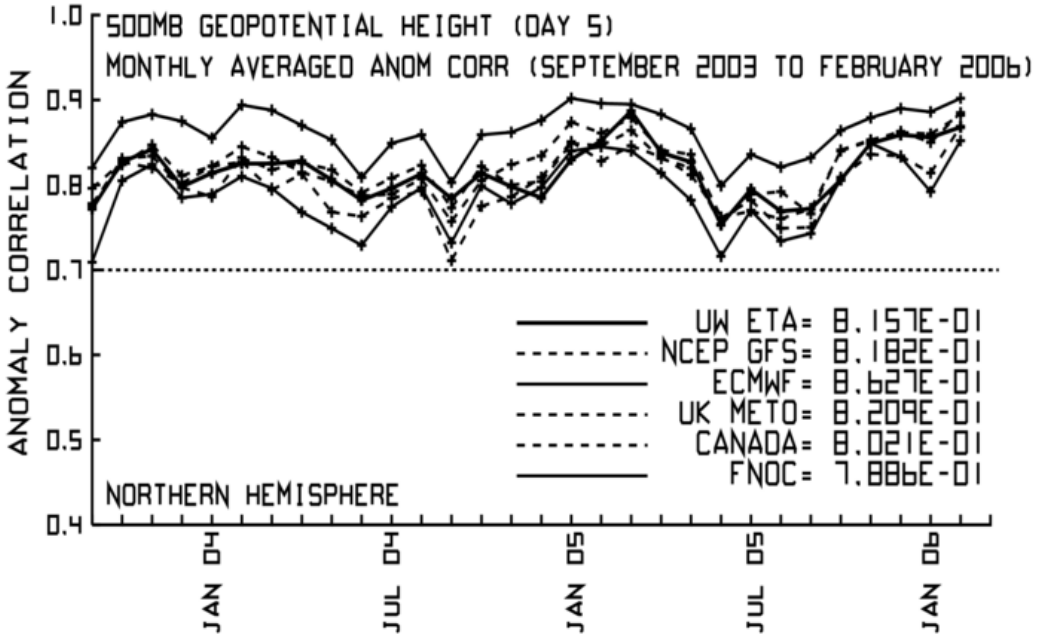
Specific humidity at 300 mb
Day 5

April 2004 | July 2004 | October 2004

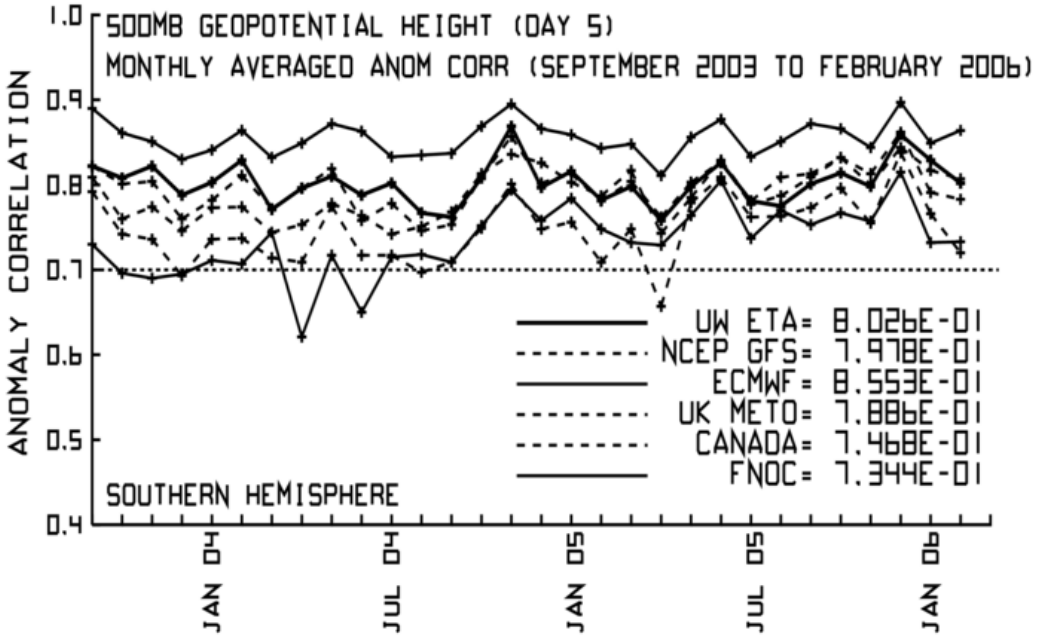
UW Hybrid isentropic coordinate model compared to UW sigma coordinate model

500 mb geopotential height AC scores

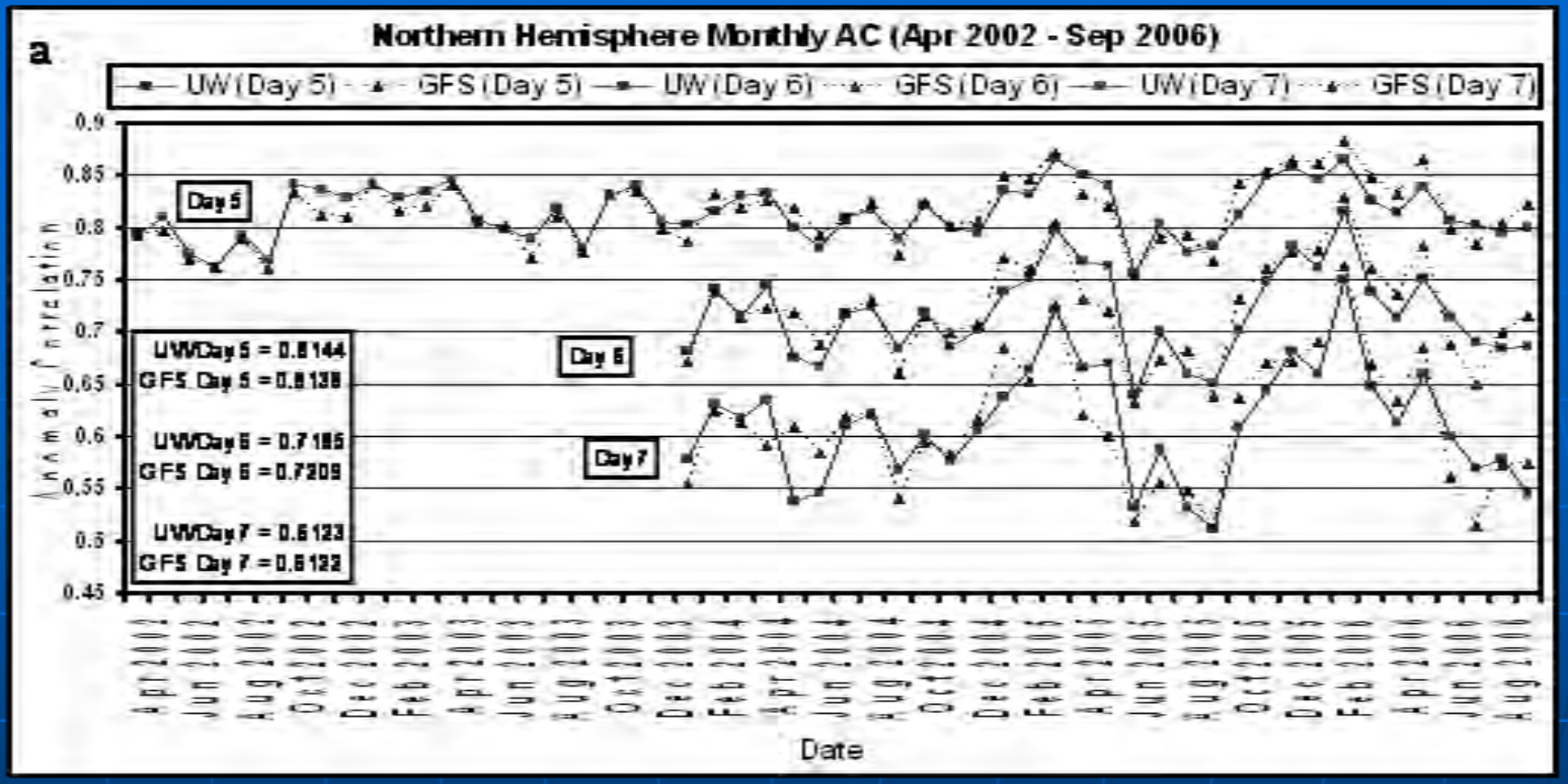
UW hybrid
GFS
ECMWF
UK Met
Canada
FNOC



NH

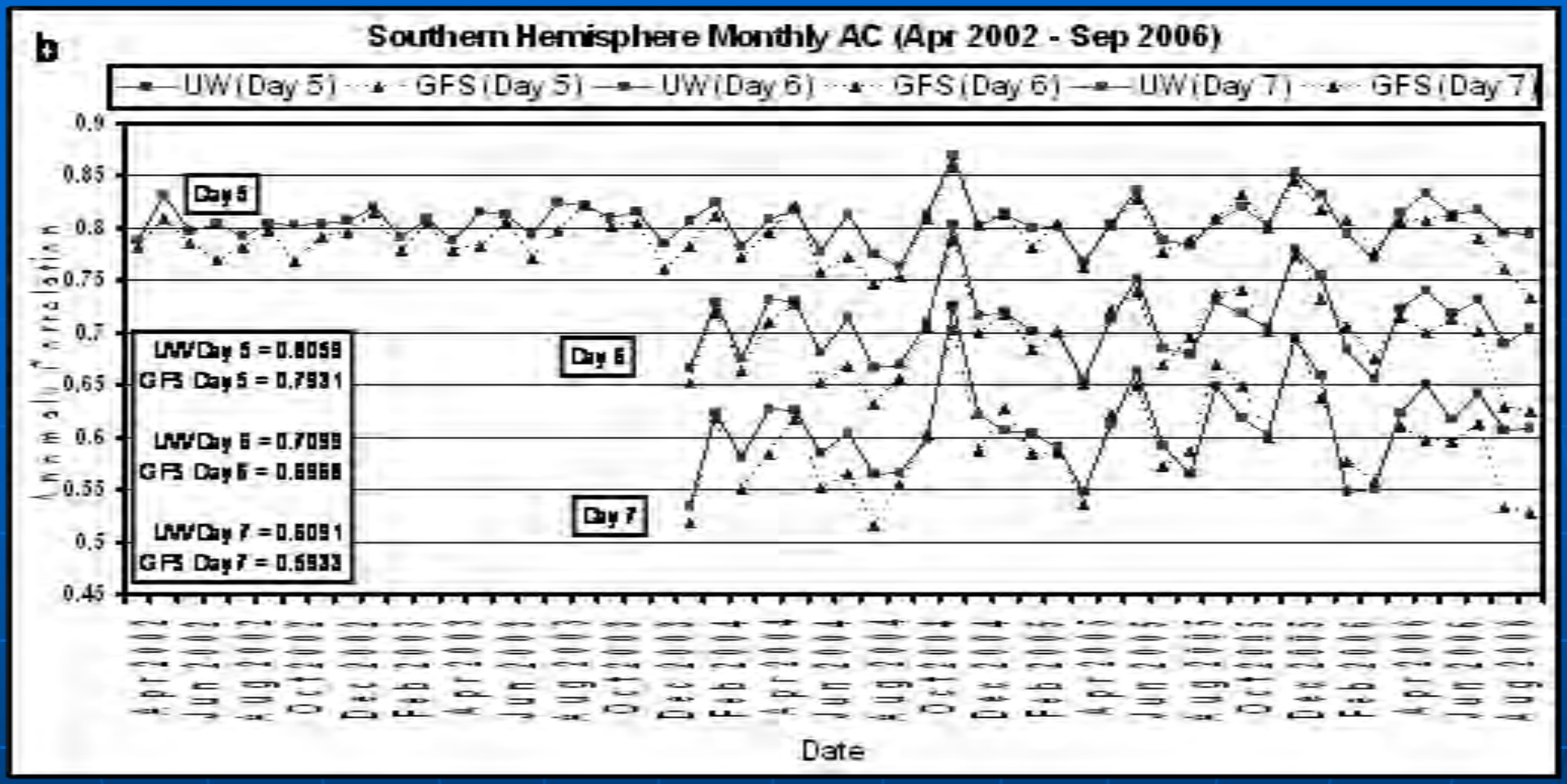


SH



NH 500 mb geopotential height AC scores for days 5, 6 and 7.

	day 5	day 6	day 7
UW hybrid model	0.814	0.719	0.612
GFS	0.814	0.721	0.612



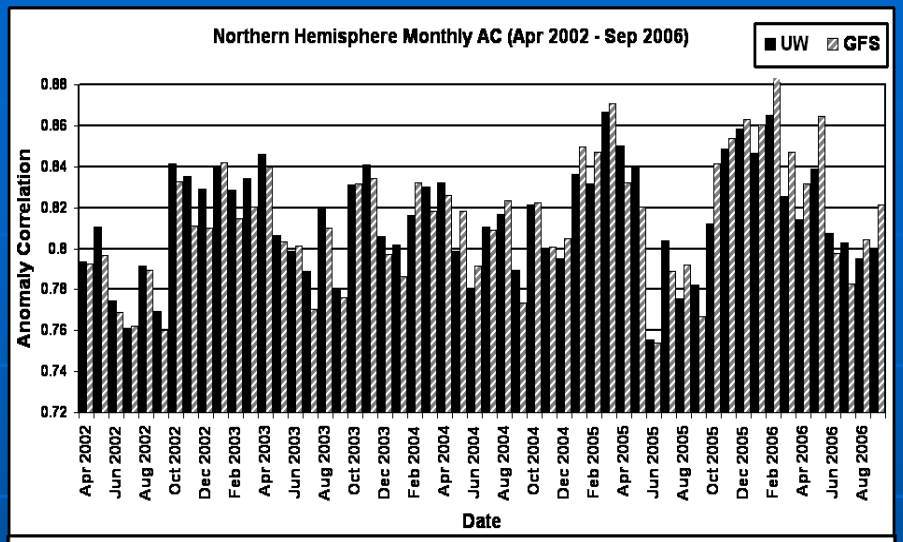
SH 500 mb geopotential height AC scores for days 5, 6 and 7.

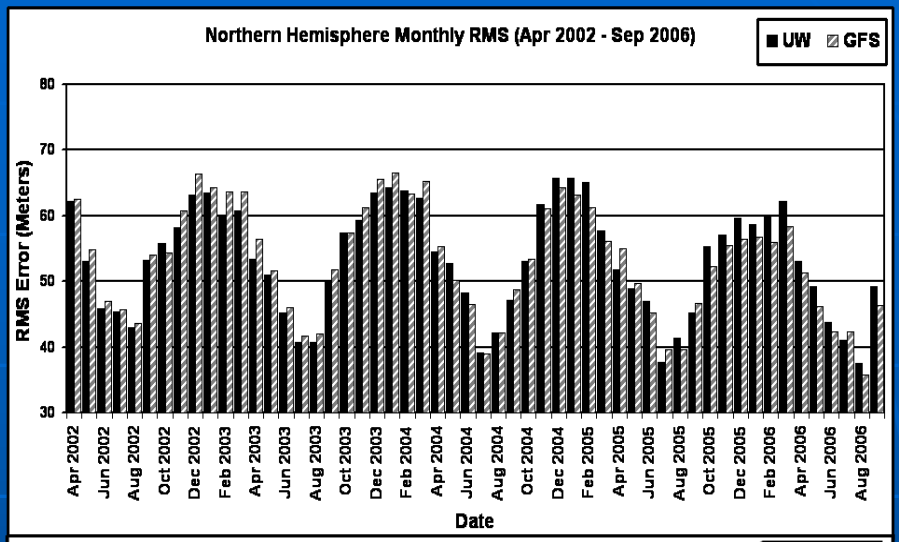
	day 5	day 6	day 7
UW hybrid model	**0.801**	**0.709**	**0.609**
GFS	**0.793**	**0.697**	**0.593**

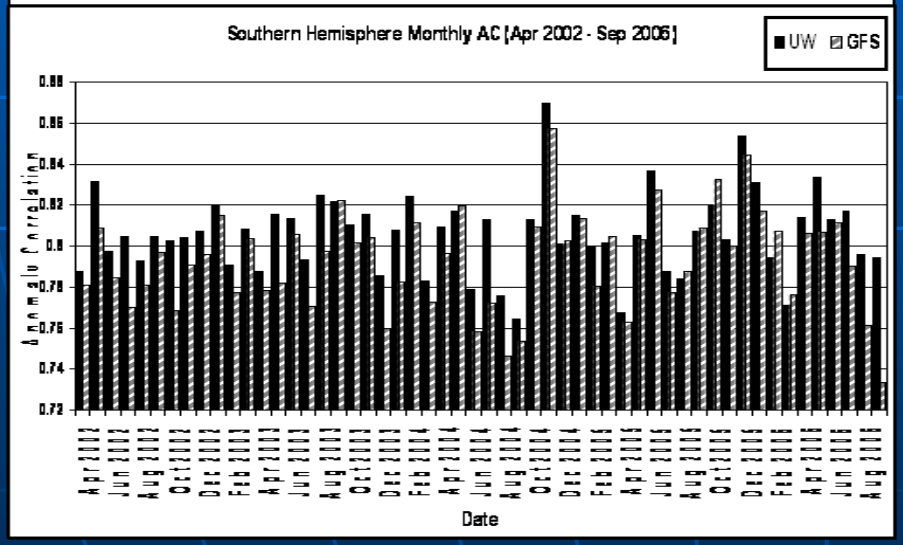
Monthly Averaged 500mb day 5 AC and RMS Errors

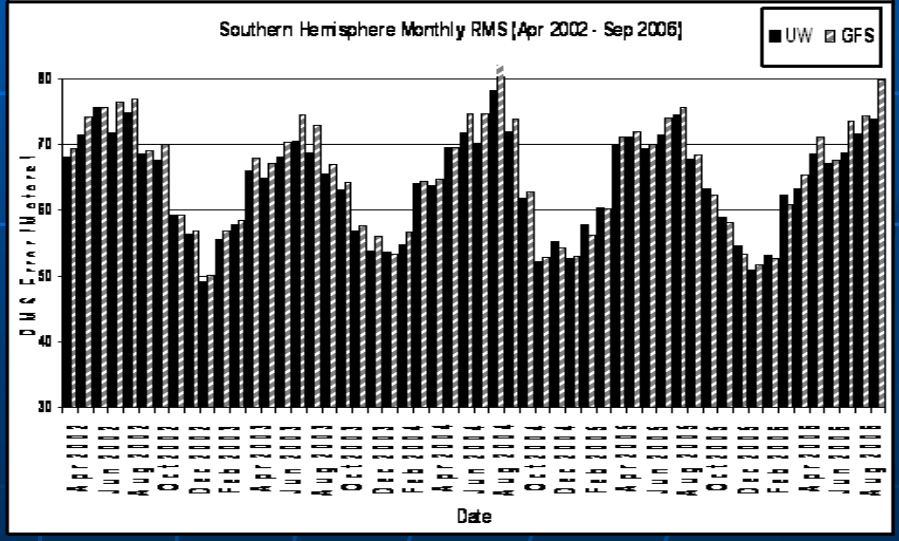
NH

SH



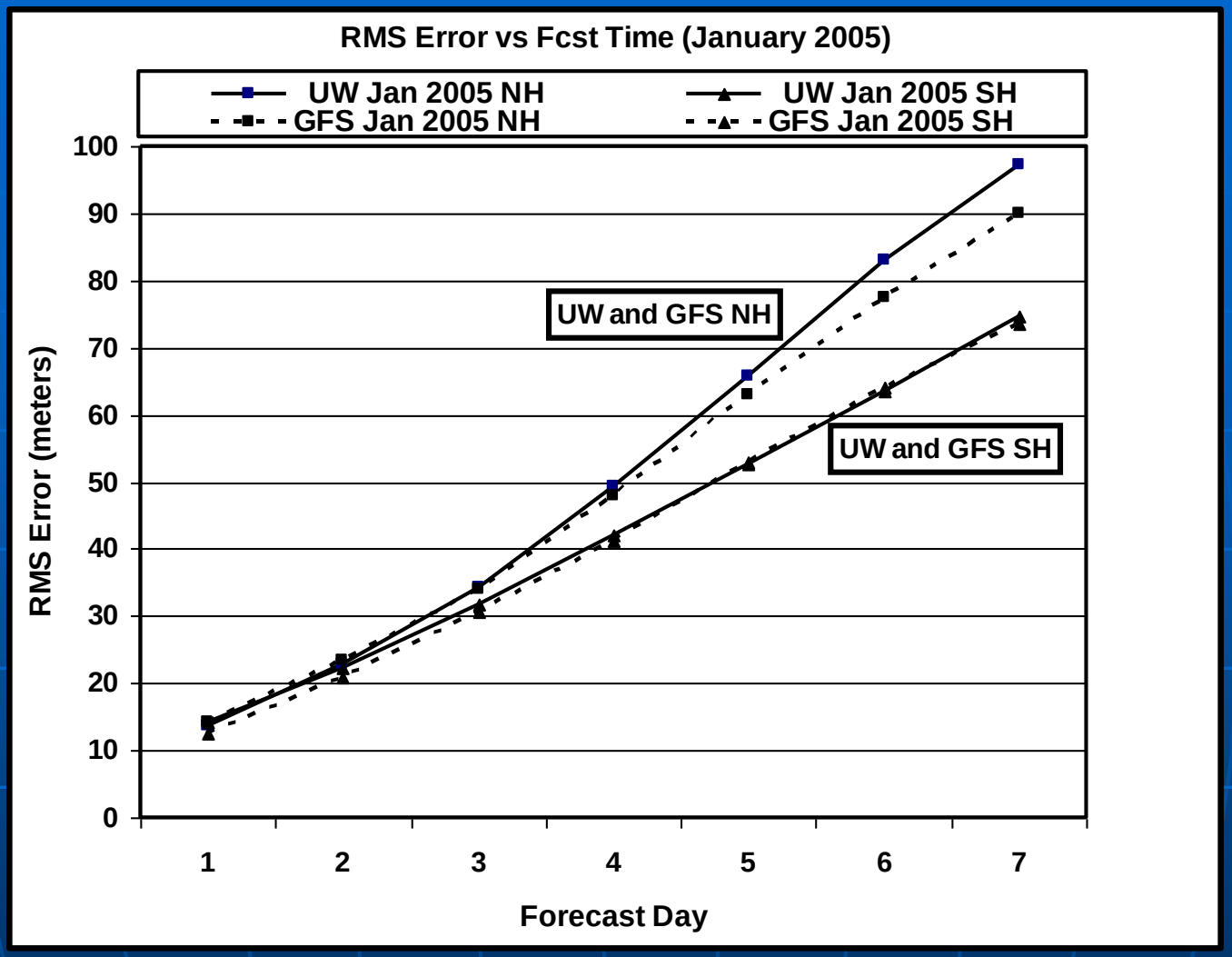




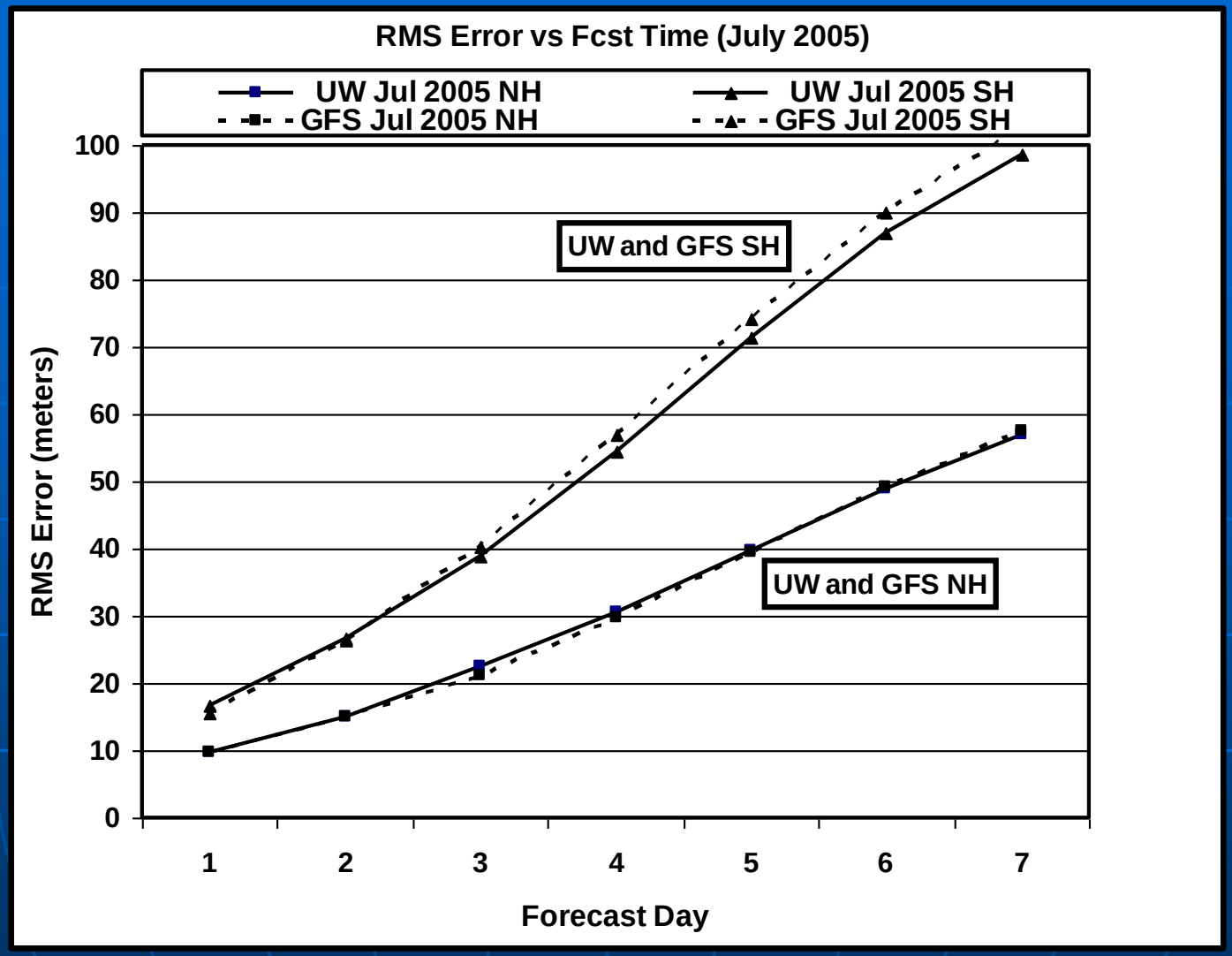


AC

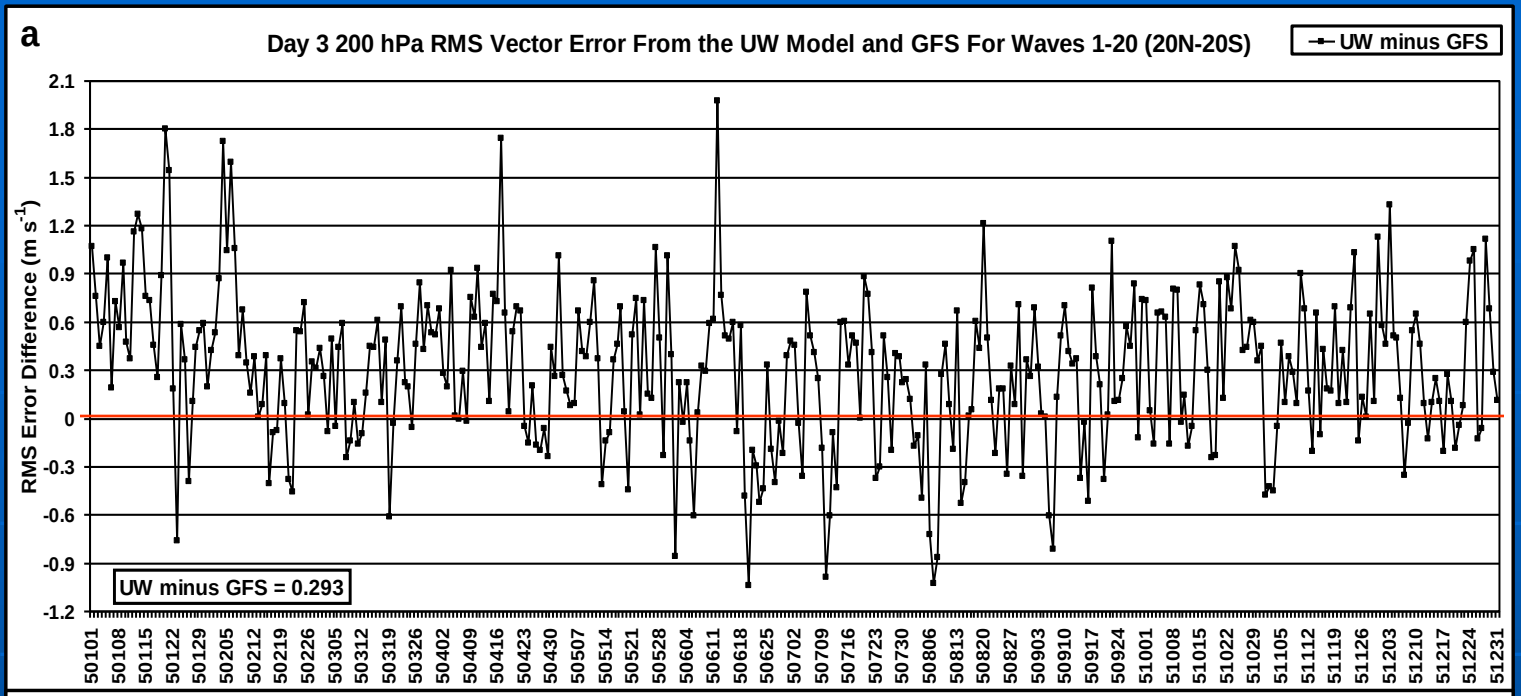
RMSE (m)

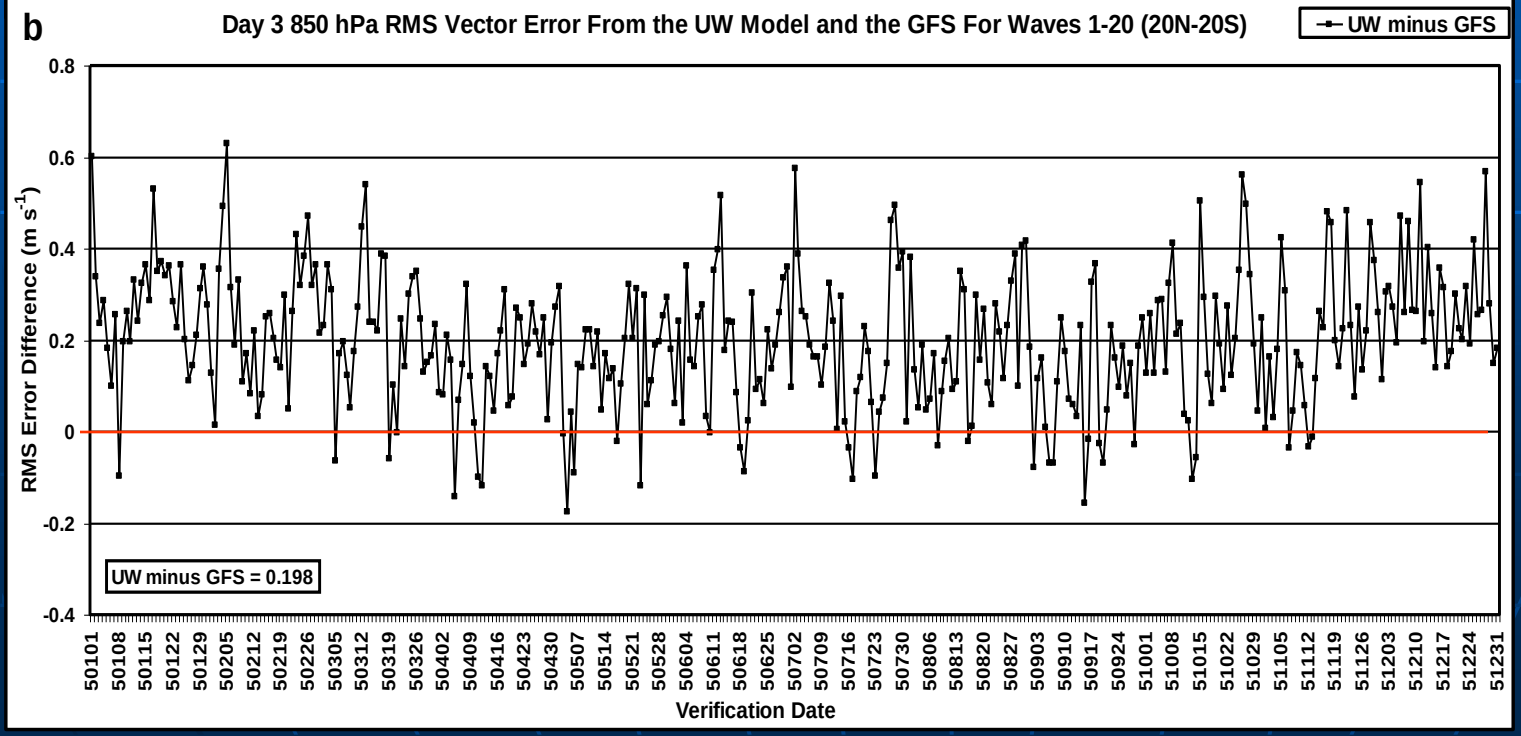


January 2005 500 mb RMS error growth (m) by day for the UW hybrid and GFS models.



July 2005 500 mb RMS error growth (m) by day for the UW hybrid and GFS models.

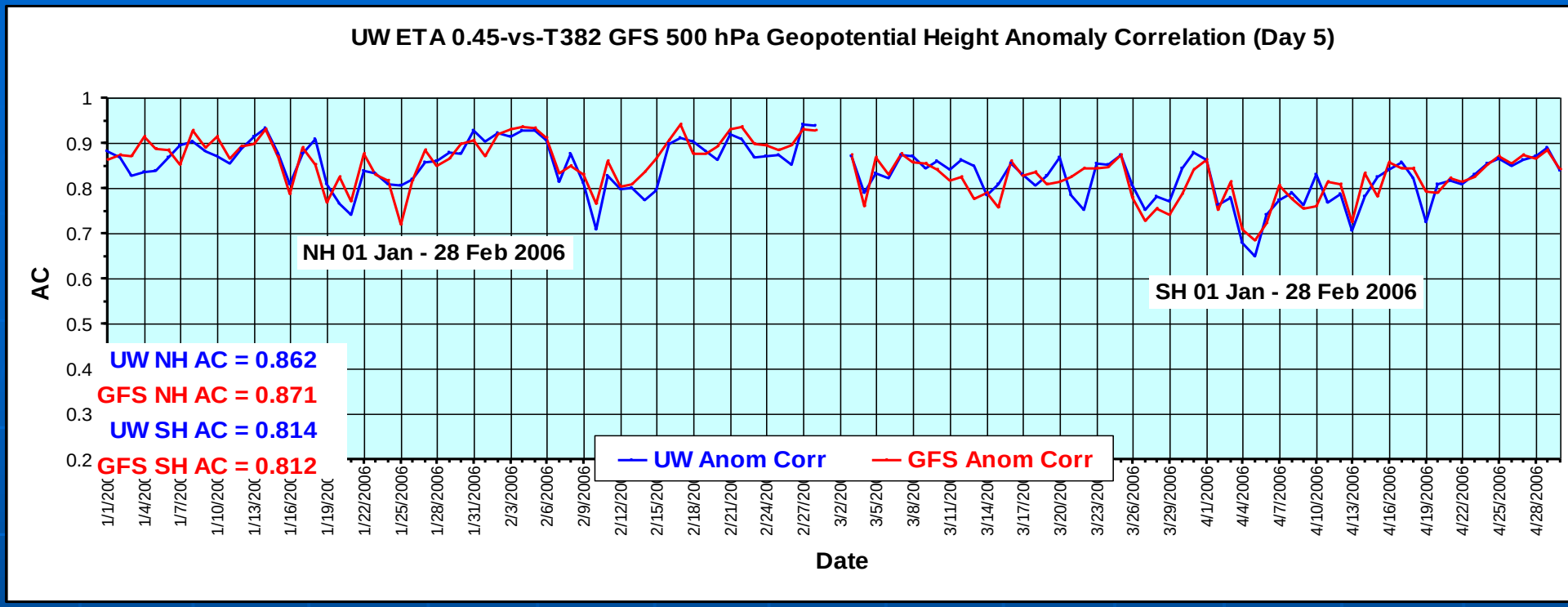


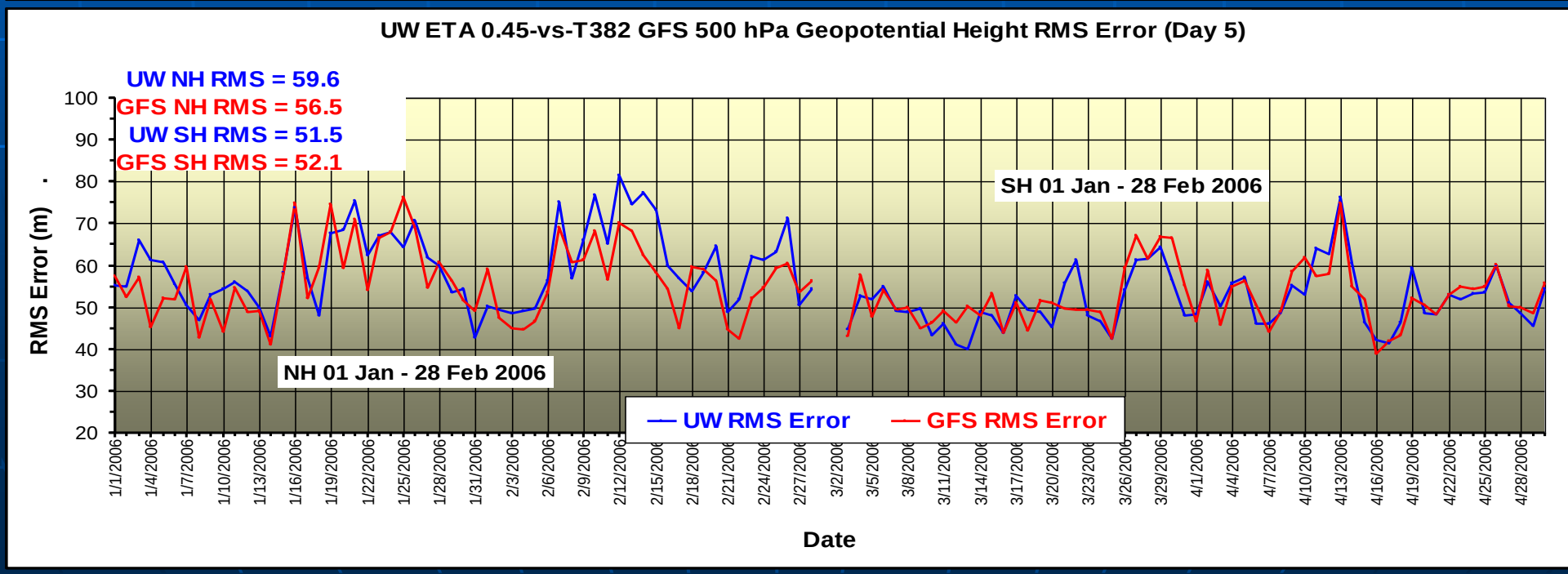


RMS Vector Wind Error 20N – 20S (ms^{-1})

200 mb

850 mb

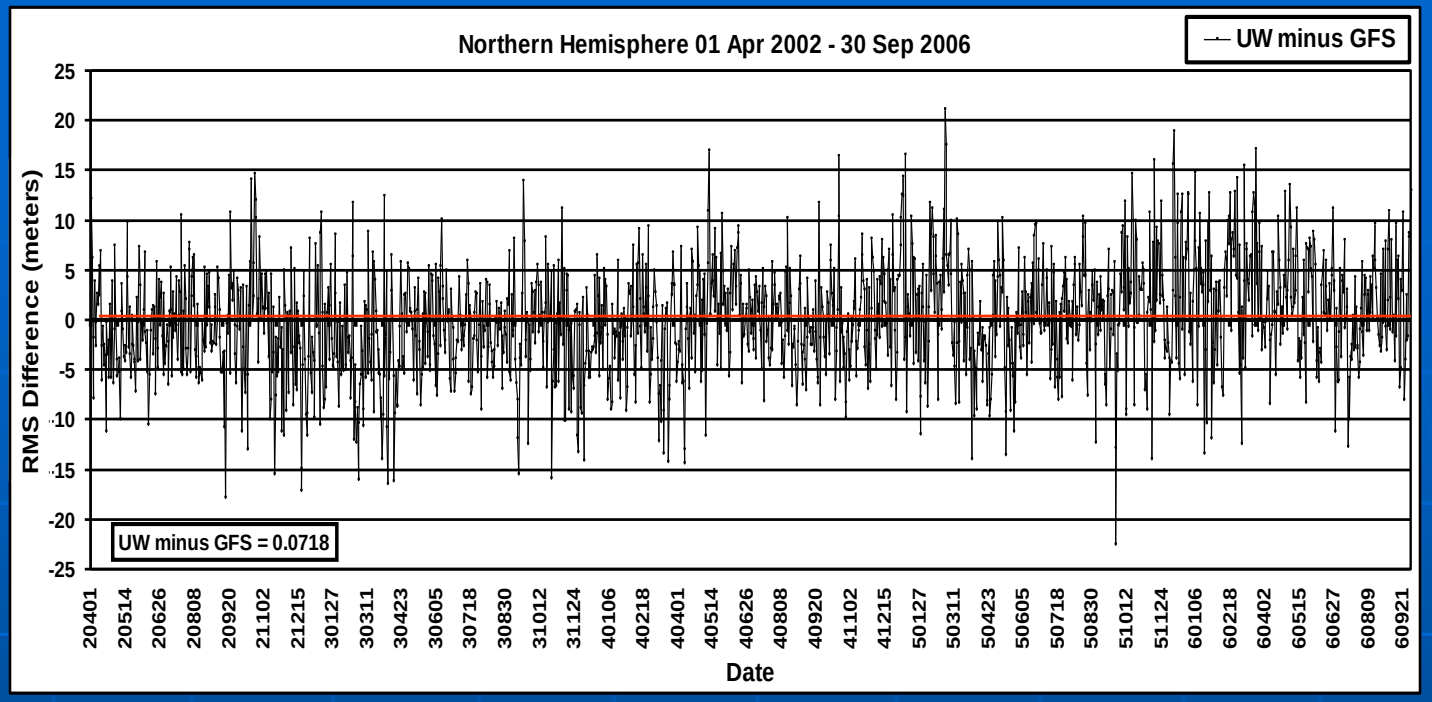

UW ETA 0.45-vs-T382 GFS 500 hPa Geopotential Height Anomaly Correlation (Day 5)
AC
NH 01 Jan - 28 Feb 2006
SH 01 Jan - 28 Feb 2006
UW NH AC = 0.862
GFS NH AC = 0.871
UW SH AC = 0.814
GFS SH AC = 0.812
UW Anom Corr
GFS Anom Corr
Date

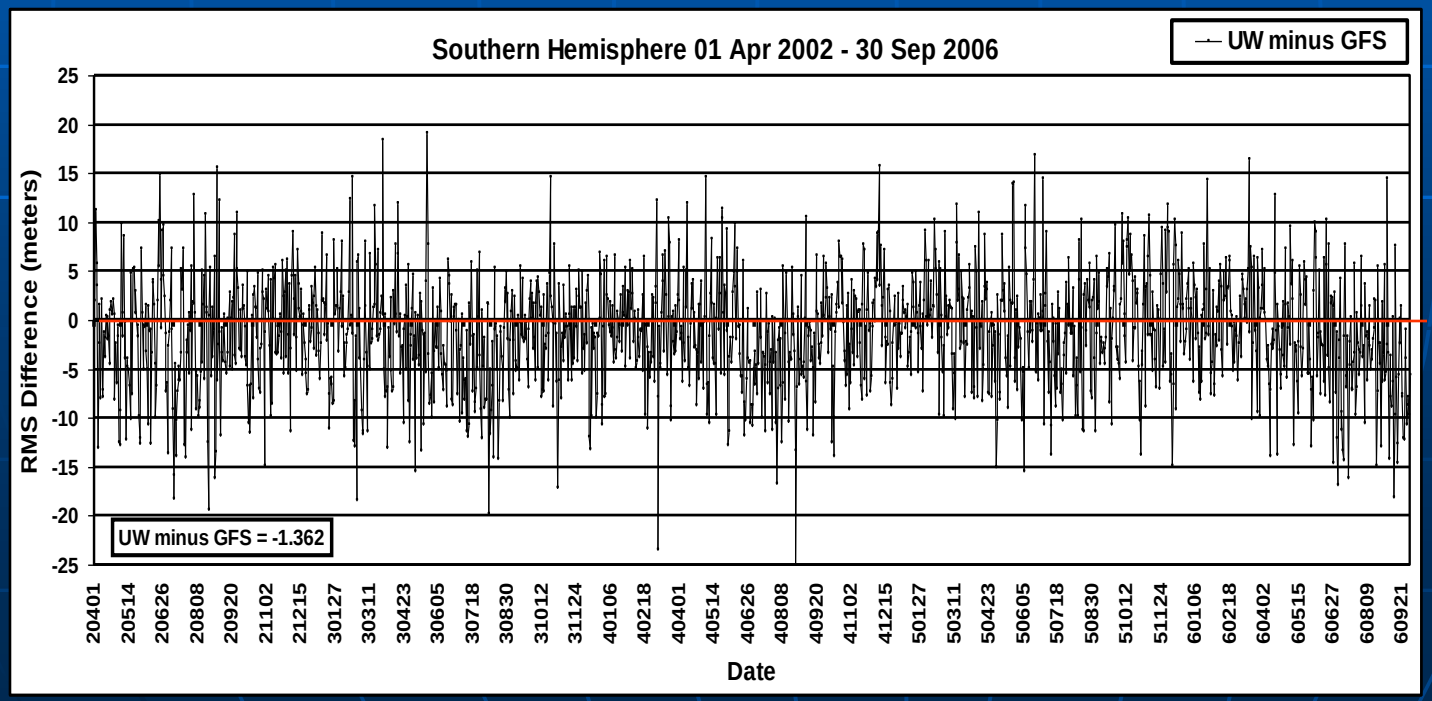

UW ETA 0.45-vs-T382 GFS 500 hPa Geopotential Height RMS Error (Day 5)
RMS Error (m)
UW NH RMS = 59.6
GFS NH RMS = 56.5
UW SH RMS = 51.5
GFS SH RMS = 52.1
NH 01 Jan - 28 Feb 2006
SH 01 Jan - 28 Feb 2006
UW RMS Error
GFS RMS Error
Date

Conclusions:

These results establish the credibility of the UW θ- η model for medium ranged numerical weather prediction.

These results along with those of the RUC, and the success of RAQMS for meteorological and chemical forecasting and those of Schaack et al (2004) for climate simulation establish the credibility of numerical prediction/simulation with hybrid isentropic coordinate models over all time scales.





500 mb height RMSE difference (m) UW-GFS

NH=0.07

SH=-1.36

Tom's Data Archive

- 00Z NCEP GFS analyses since 2002 (~1500 days @ 340 Mb/day)
- 4 times daily GFS analyses during part of 2004 and nearly all of 2006 for RAQMS field experiments
- Copies of data to his home and to SSEC
- Hundreds of CDs and DVDs full of NCEP GFS analyses and UW model output