Integration of the WRF Model into an Existing Climate Modeling System

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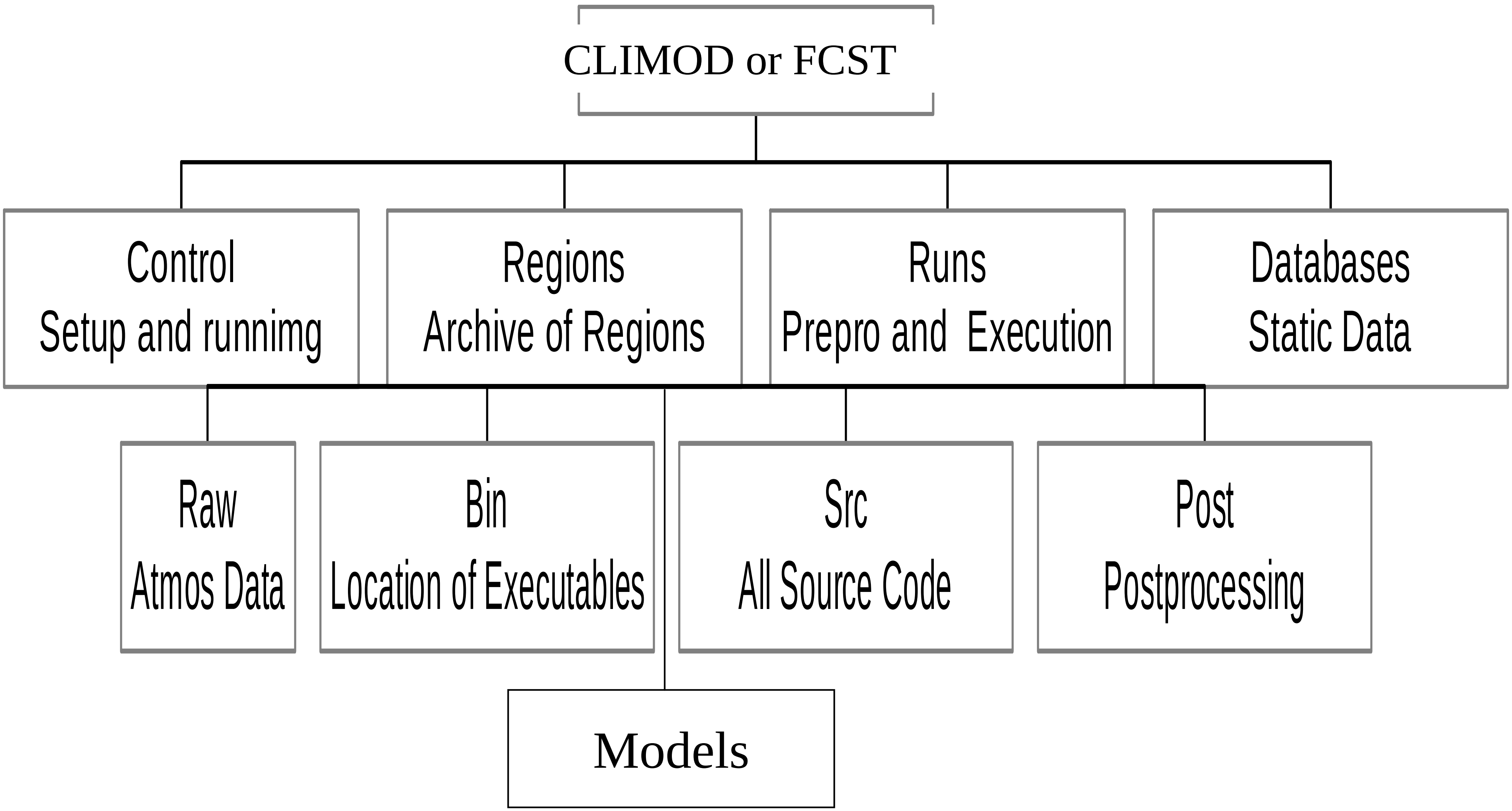
Overview

- System Design
  - Description of the regional modeling system and model configuration
- Quality of Performance
  - Comparison of results using MASS and WRF
    - California
    - Korea
- Computational Performance
  - Comparison of computational speed

Regional Modeling System



Modeling Steps

- Setup up Modeling System (Done Once)
  - Untar modeling system
  - Set paths to data
  - Set environmental variables
  - Compile
- To Run a Specific Region
  - Go to control directory
  - Use a script to select and configure model
    - WRF or MASS, Microphysics, CU Parameterizations
  - Select time period for a climate run or real time for a forecast
  - Select system(s) it will run on

COLO1 (Region)

WRF (Model)

Polar Stereographic
(Projection)

0 (Use same center for all)

40. (Standard Lat)

-105. (Standard Long)

Grid A (Mother Nest)

1 (On/Off)

50 x 50 x 25 (Dimensions)

44.0 (Horz Grid Spacing)

25. (X Lat calib point)

-107. (Y Long calib point)

1. (X Calib Point)

1. (Y calib point)

No IAU

Hydrostatic

Grid B (Child Nest)

1

Grid A (Parent Nest)

20 x 20 x 20

8.0

43.61 (Center B)

-75.69 (Center B)

-99.

-99.

No IAU

Hydrostatic

Grid C (Child Nest)

1

Grid B (Parent Nest)

64 x 64 x 25

4.8

43.62

-75.68

-99.

-99.

IAU

Non-Hydrostatic

Model Configuration Used in Comparisons

Option	MASS	WRF
Microphysics	MASS Level 2: Mixed Phase cloud water and ice, rain and snow, no hail QC(1) = cloud water QC(2) = cloud ice QC(3) = rain QC(4) = snow	WSM 3-class simple ice scheme
Cu Parameterization	Kain - Fritch	Grell-Devenyi ensemble scheme
Radiation Scheme	Longwave radiation - broadband approach of Sasamori, Pielke. Shortwave radiation - formulated after Noilhan and Planton.	Longwave radiation - RRTM scheme Shortwave radiation - Dudhia scheme
Boundary Layer	TKE Scheme - Therry and LaCarrere	TKE Scheme - Mellor-Yamada-Janjic (Eta)
Hydro/Nonhydrostatic	Hydrostatic	Nonhydrostatic
Terrain Data	5 minute global terrain/bathymetry dataset, obtained from NCAR	USGS derived, 30-second data; obtained from NCAR
Terrain Smoothing	No Smoothing	
Land Use	Olson World Ecosystems BATS Land Cover from Global Ecosystems Database CD-ROM 30 minute resolution	24-Category, USGS 30-second data; obtained from NCAR
Soil	soil type database was created from data on the Global Ecosystems Database	FAO Top-Layer 16-category data; obtained from NCAR
SST and Sea Ice	USGS SST Climatology 12 minute resolution	USGS SST Climatology 12 minute resolution
Grid Spacing	40 km	40 km
Vertical Levels	21	21
Grib Data	NCEP-NCAR Reanalysis Data on Sigma Surfaces	NCEP-NCAR Reanalysis Data on Pressure Surfaces
Numerics	Horizontal 3^{rd} order, Vertical 2^{nd} order	Horizontal 5^{th} order, Vertical 3^{rd} order

MASS and WRF configurations used in the California simulations.

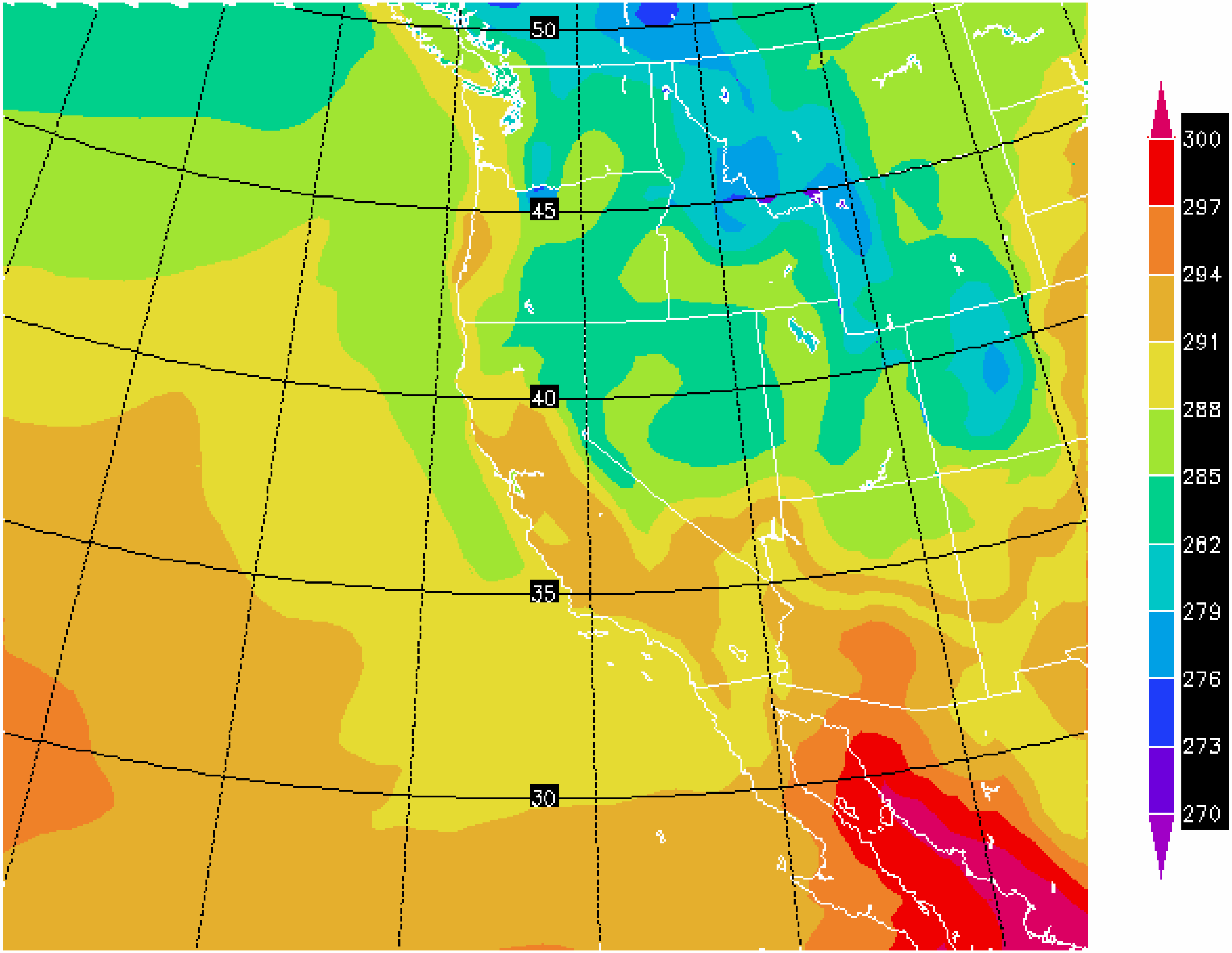
Comparisons Results for California

- Three Periods looked at:
  - Nov-Dec 2001, Mar-Apr 2002, and May-Jun 2002

- Overall patterns were similar with the following trends:
  - 2 m Temperature: WRF slight cold bias
  - 2 m Dewpoint: MASS had significantly lower dewpoints
  - 10 m Wind: MASS higher wind speed, most notable over water.
  - Surface Pressure: Reasonable agreement
  - 500 mb Height Fields: MASS exhibited stronger gradients.

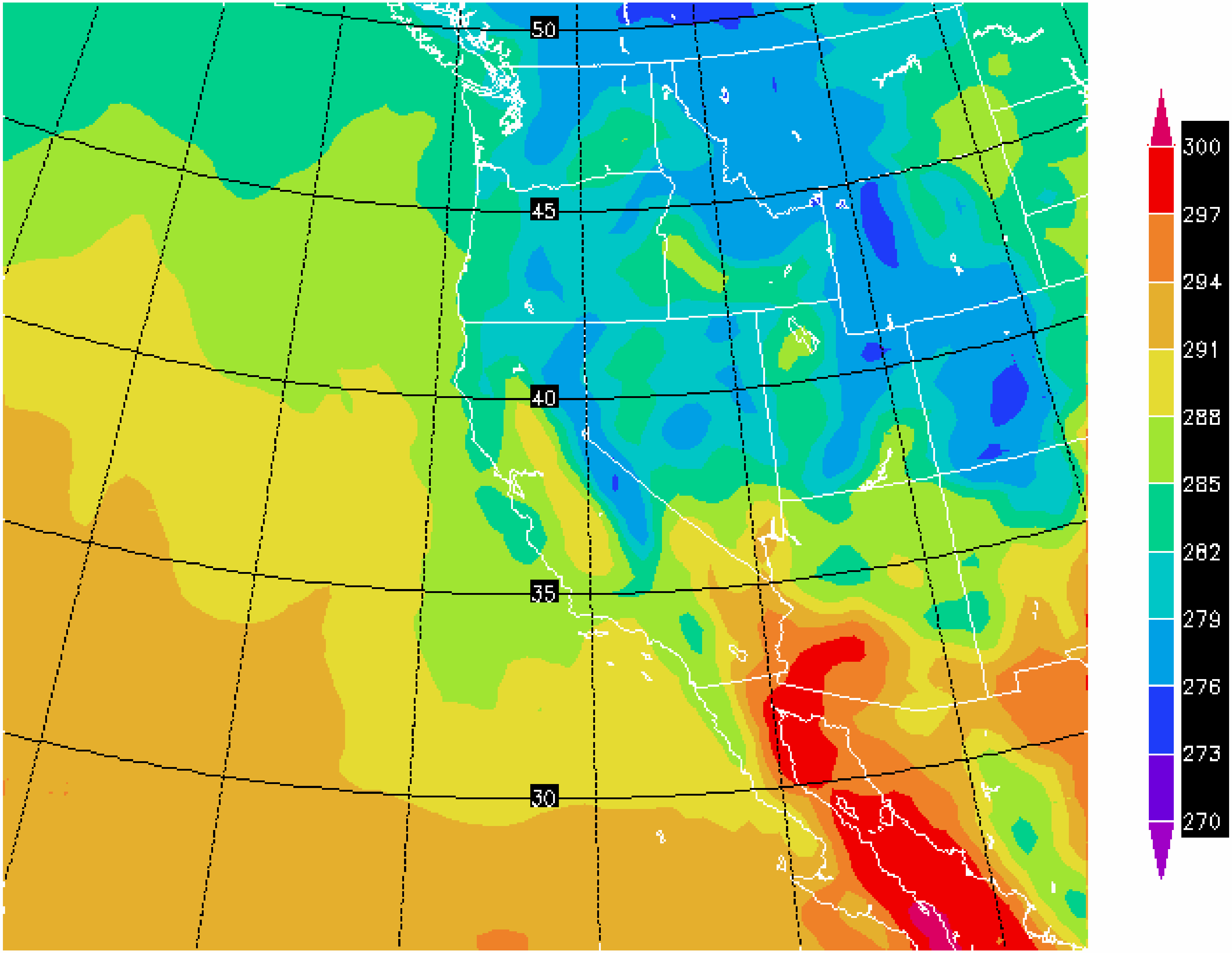
MASS 2m Temp K

All Hours November - Decemeber 2001

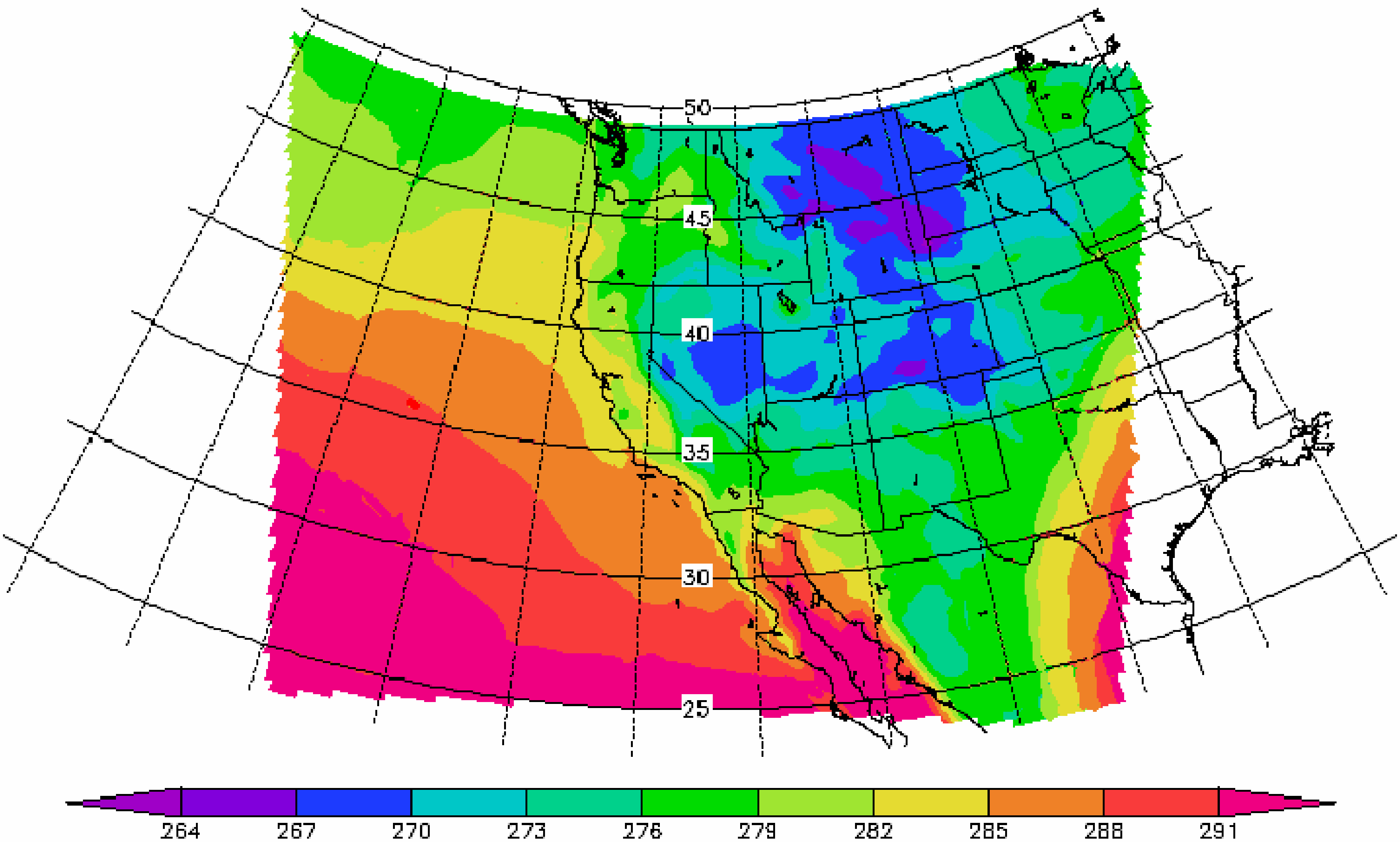


WRF 2m Temp K

All Hours November - Decemeber 2001

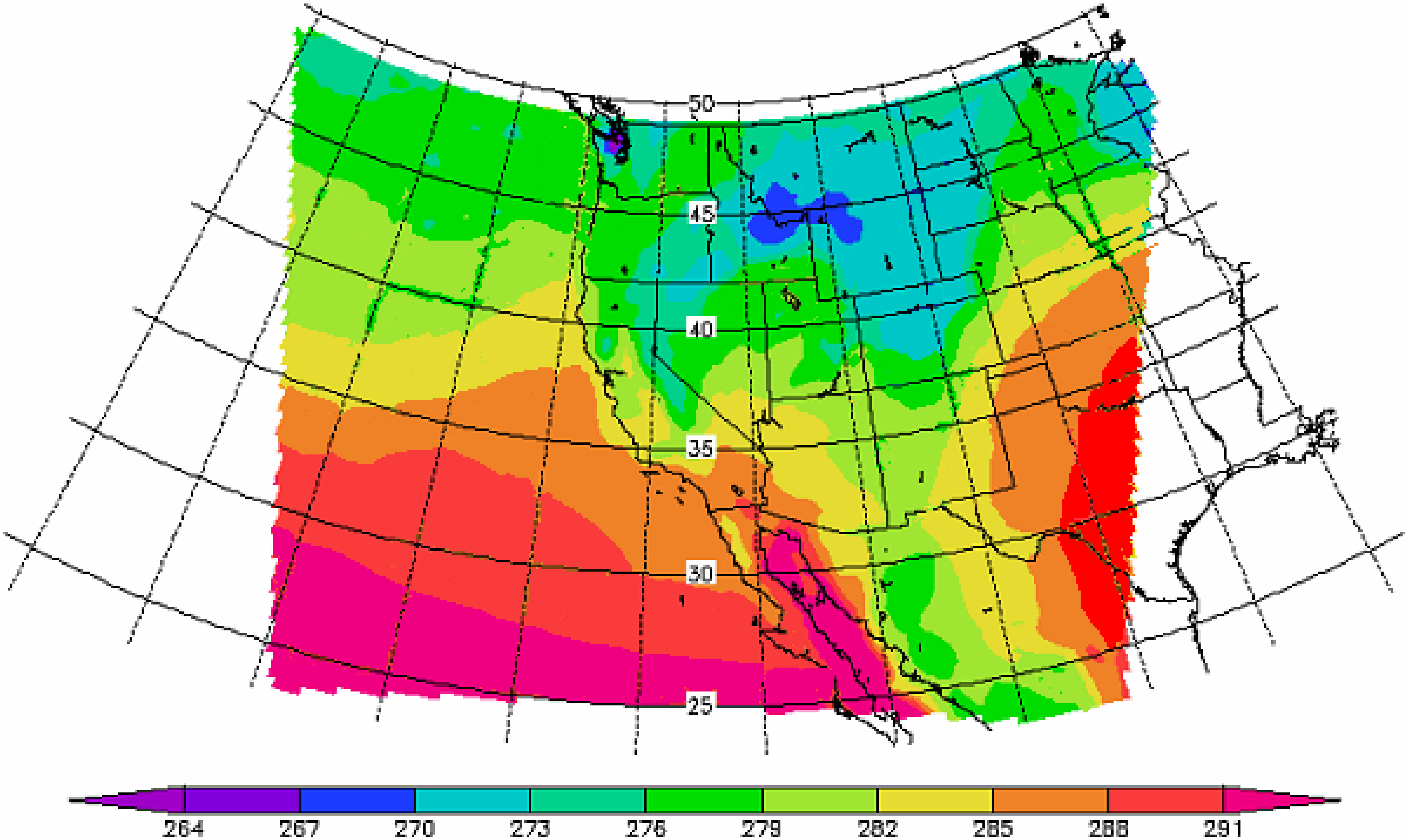


MEAN 2m Dewpoint



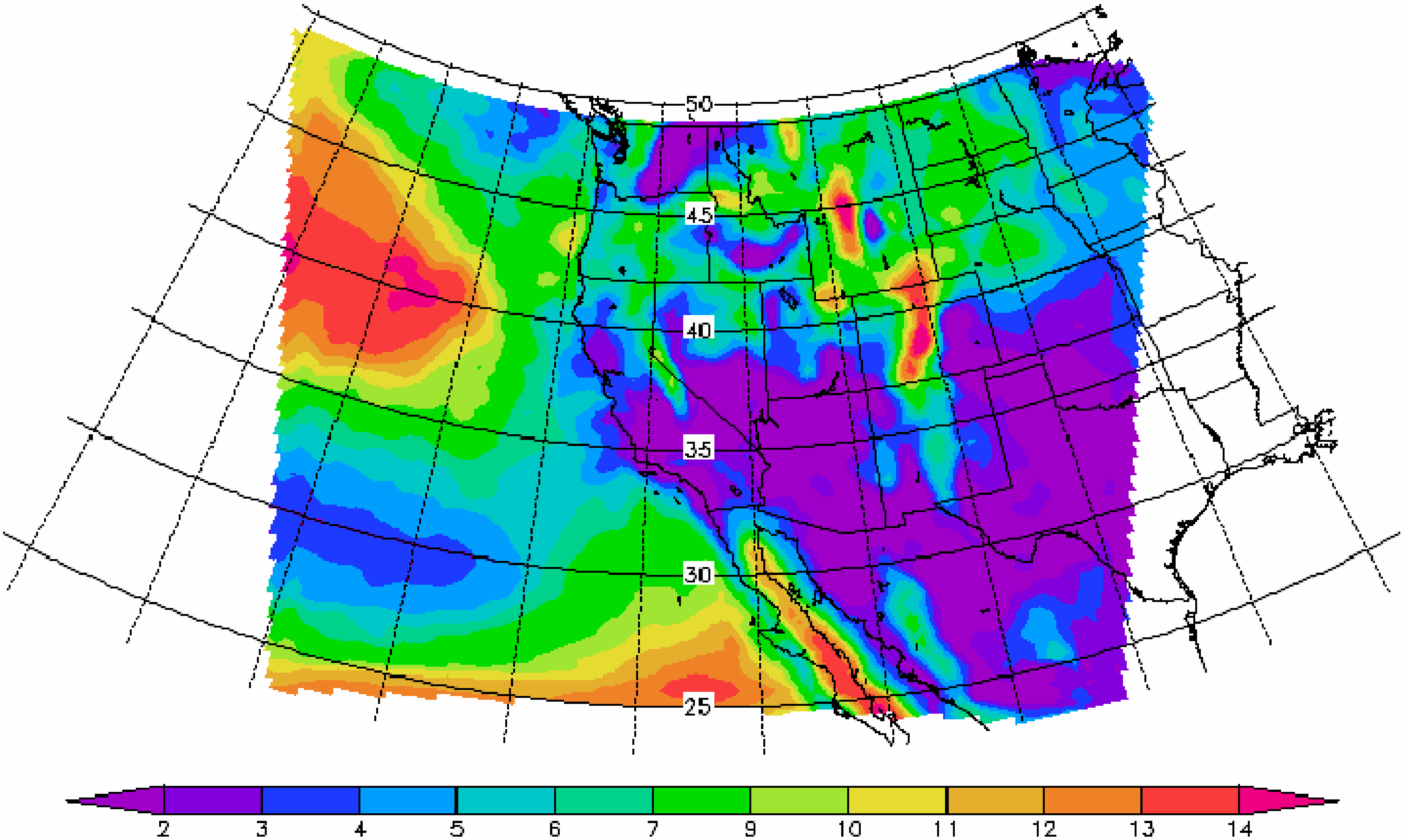
MASS: Nov - Dec 2001

MEAN 2m Dewpoint

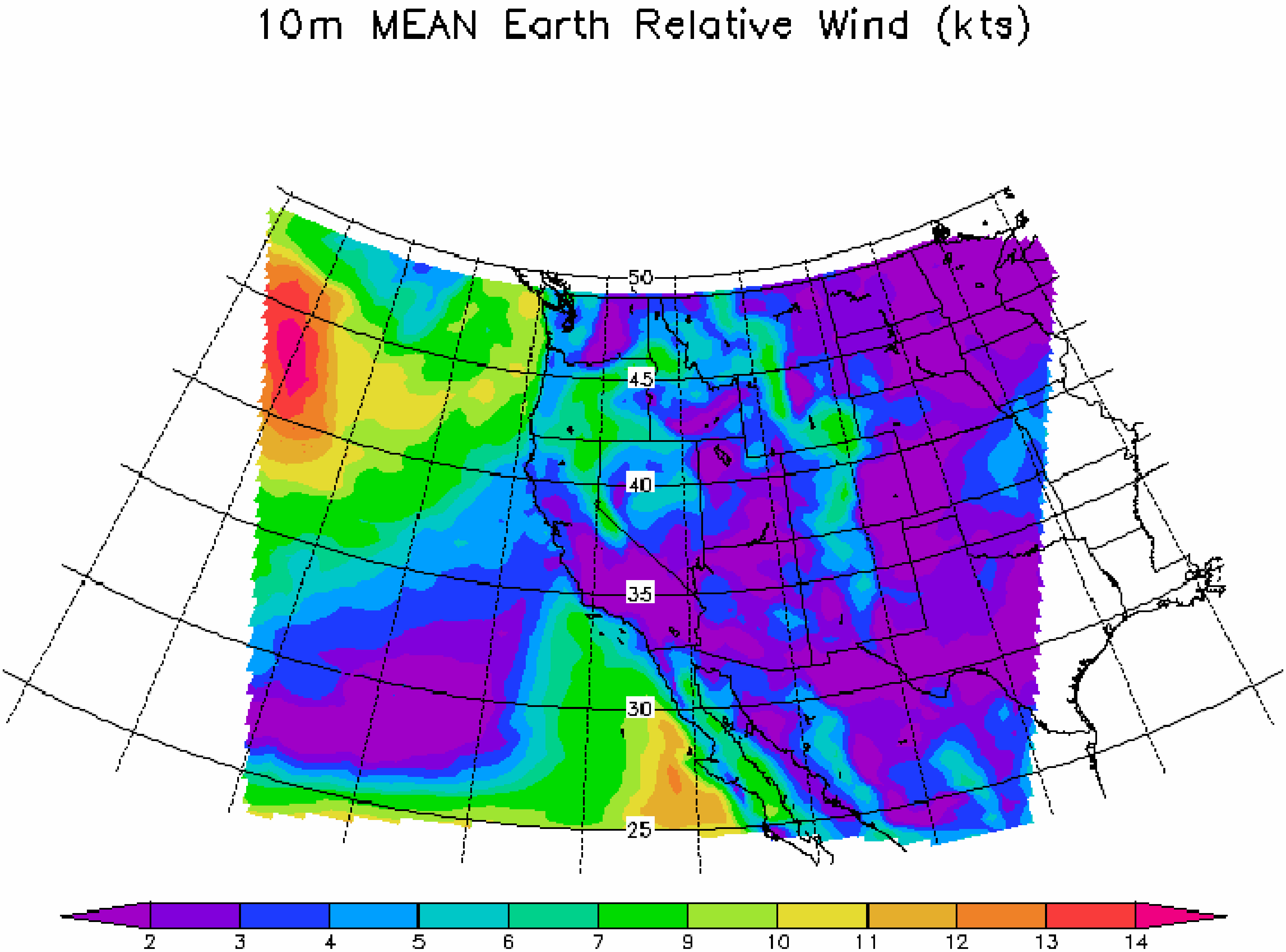


WRF: Nov - Dec 2001

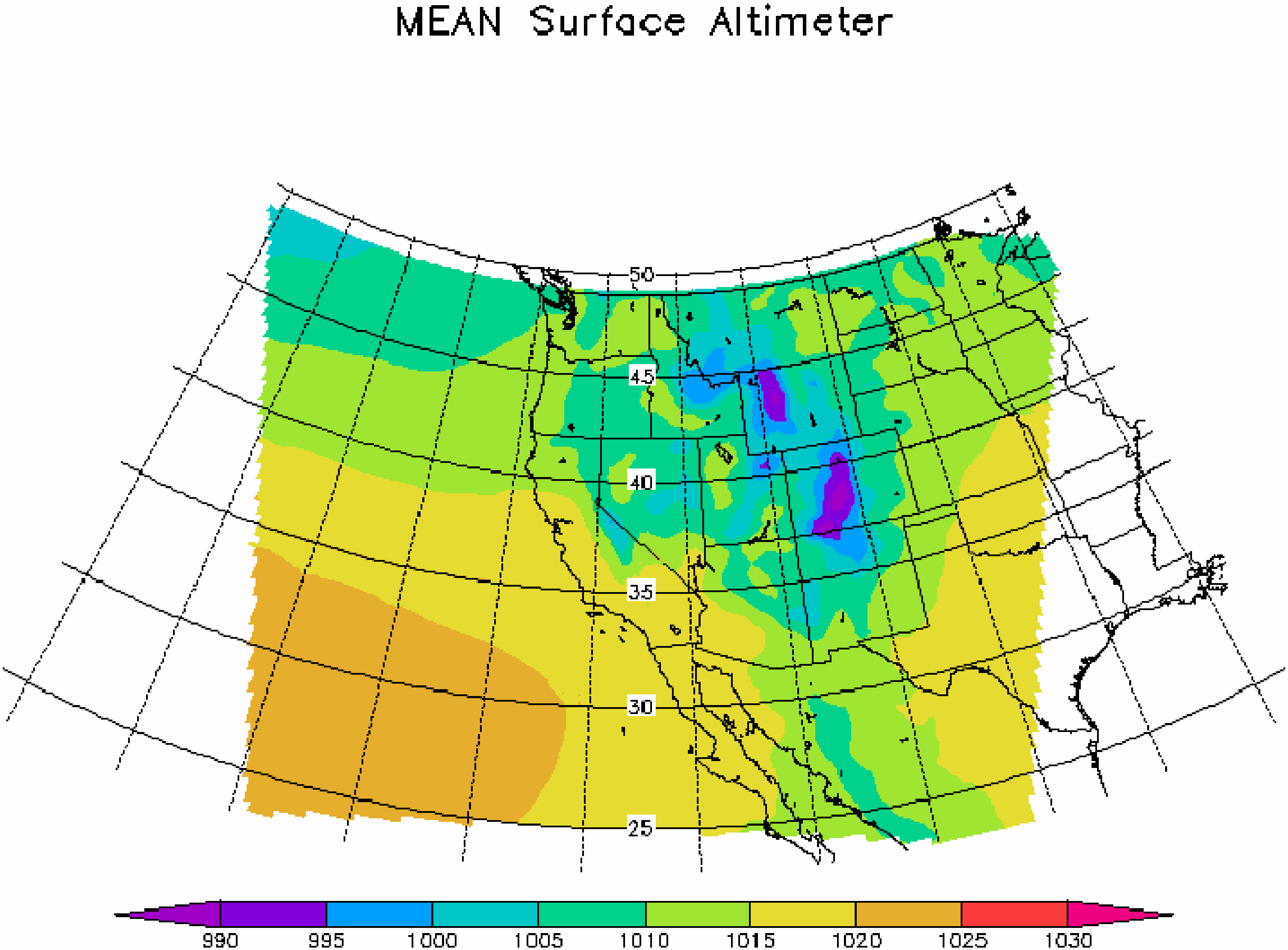
10m MEAN Earth Relative Wind (kts)



MASS: Nov - Dec 2001

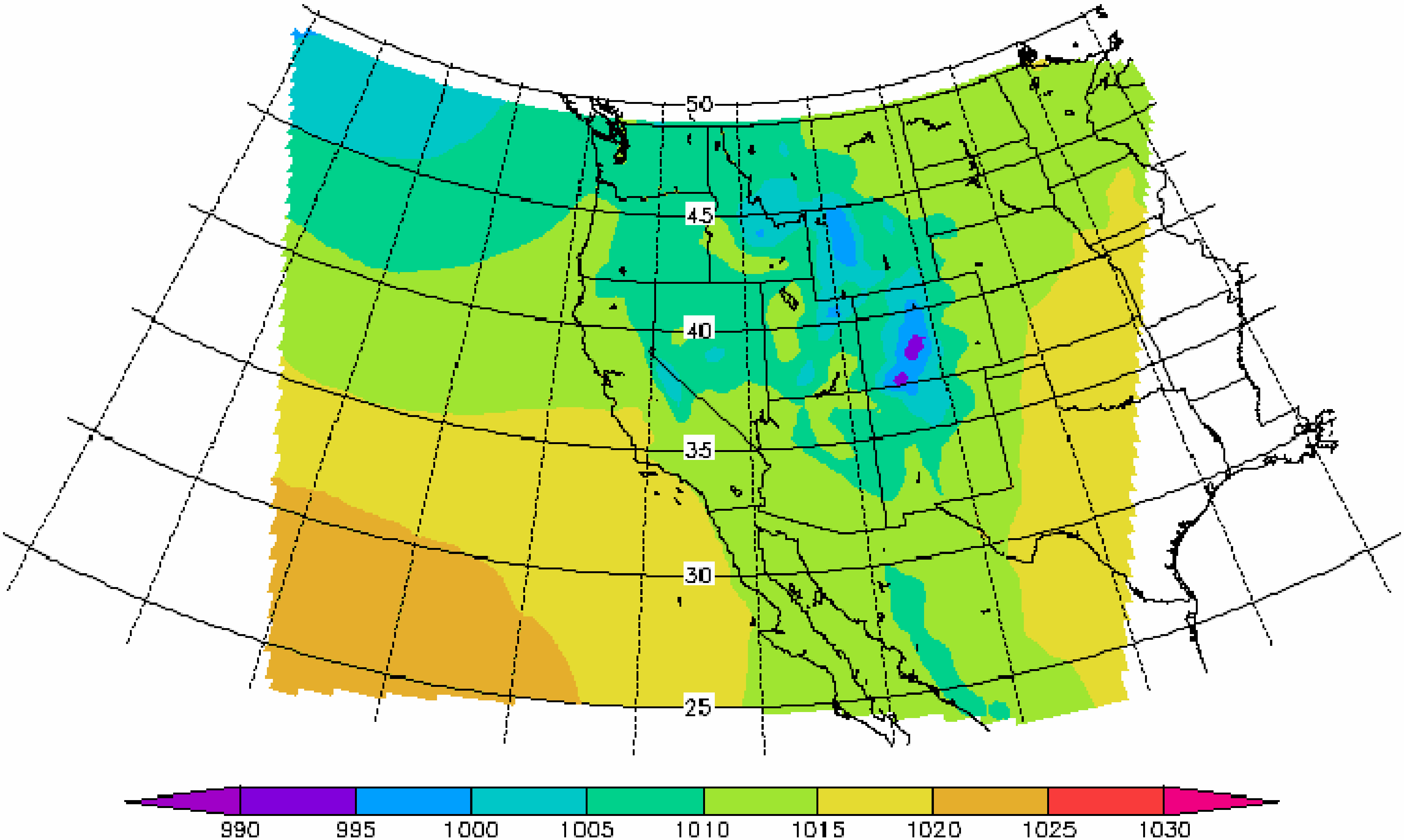


WRF: Nov - Dec 2001



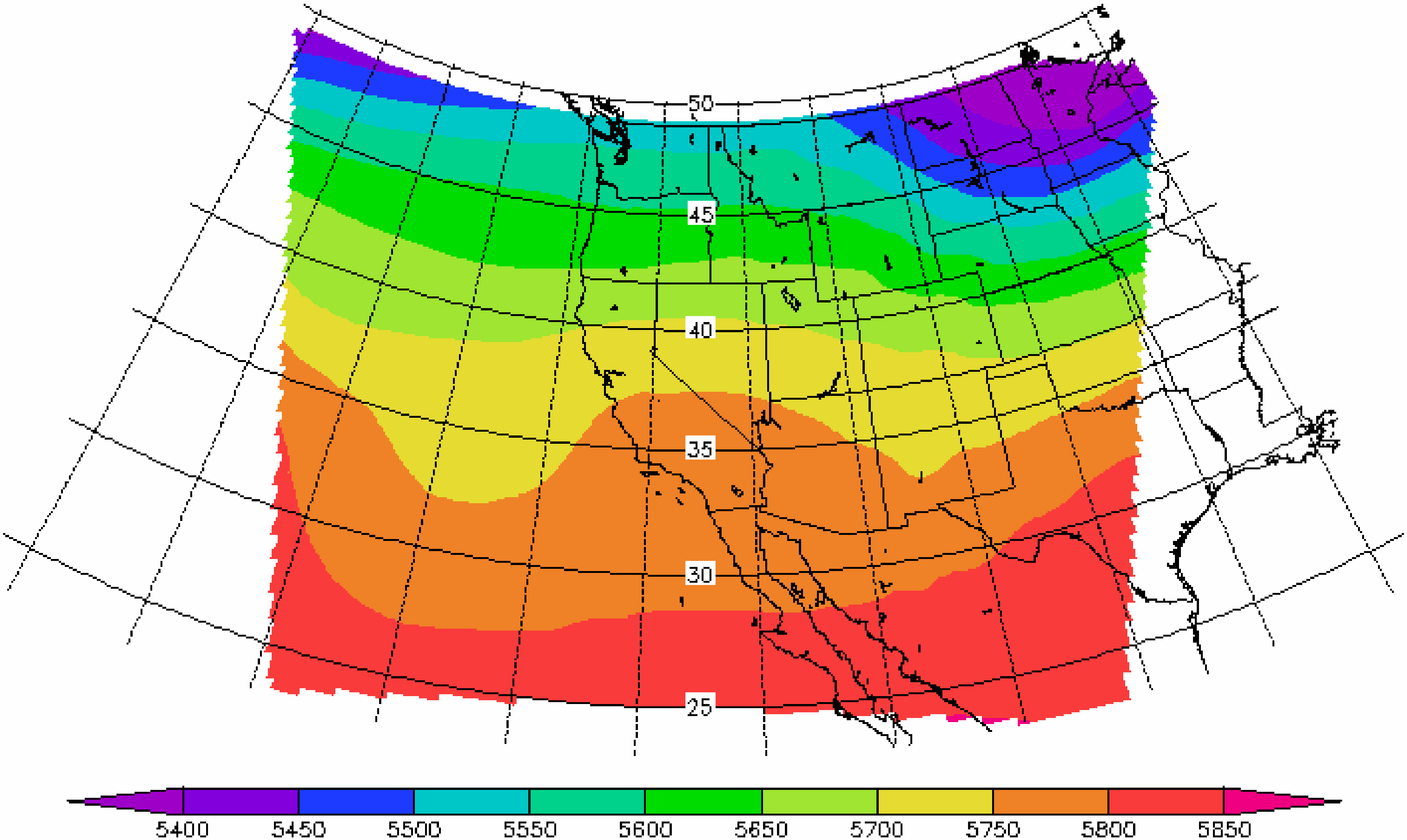
MASS: Nov - Dec 2001

MEAN Surface Altimeter

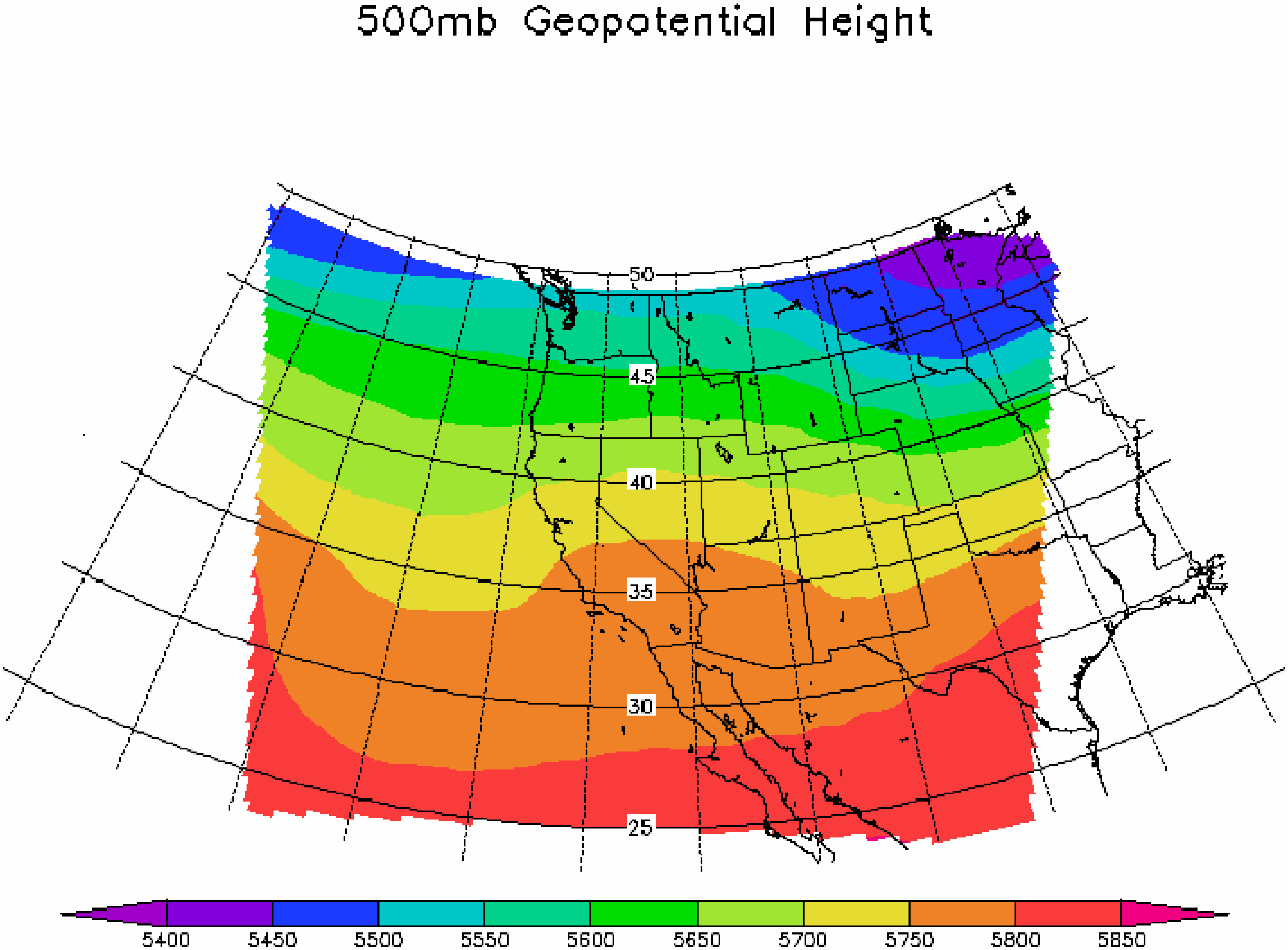


WRF: Nov - Dec 2001

500mb Geopotential Height



MASS: Nov - Dec 2001



WRF: Nov - Dec 2001

California Point Comparison

METAR Station Comparison Sites

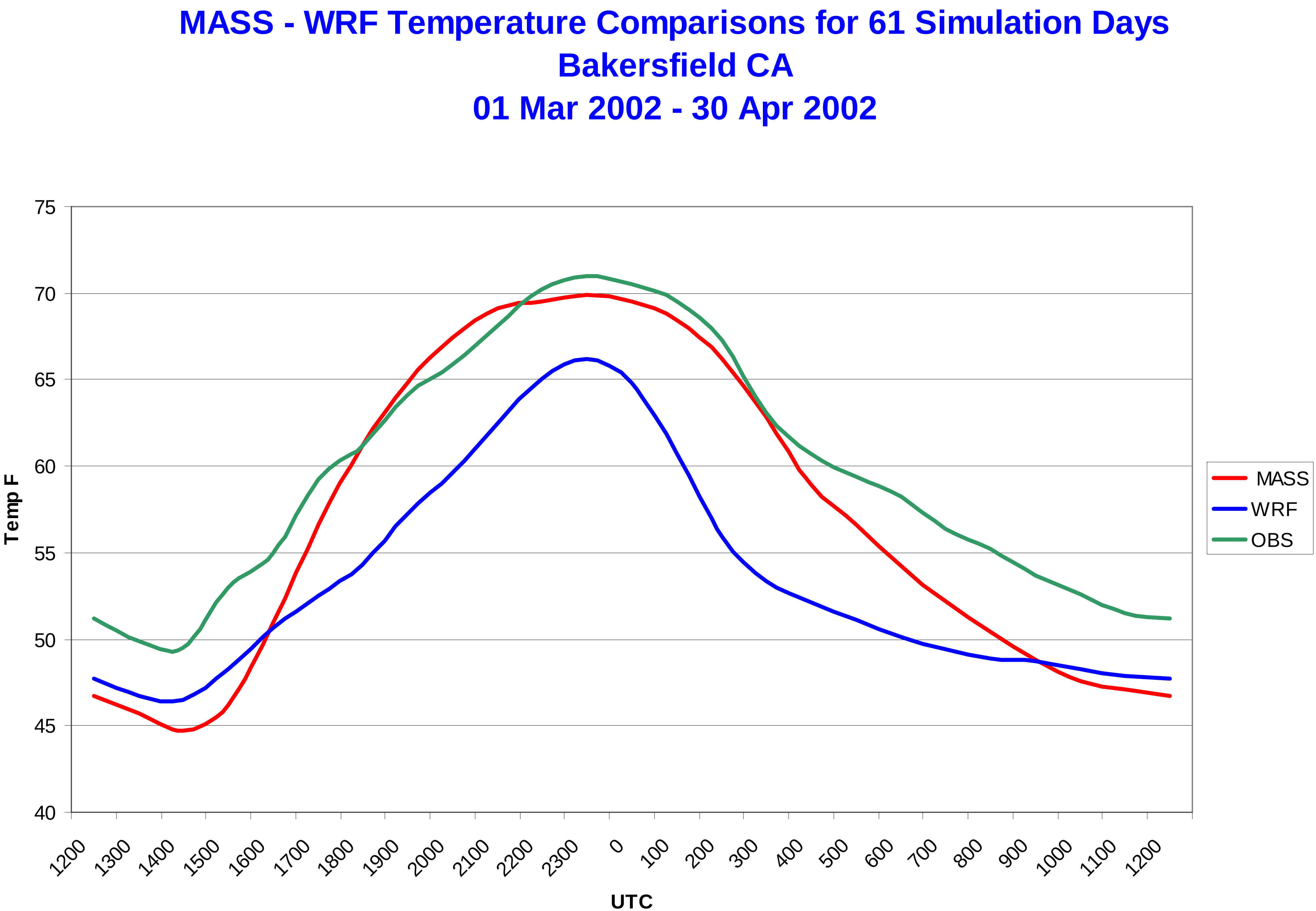
Station	Lat	Lon	Elevation (meters)			Roughness (cm)	
	North	West	Measured	MASS	WRF	MASS	WRF
Bakersfield (BFL)	35.43	119.06	154.5	508.3	635.8	10.0	10.0
Fresno (FAT)	36.78	119.72	102.4	383.0	213.1	10.0	10.0
Las Angeles (LAX)	33.94	118.40	38.4	236.6	164.9	75.0	50.0
Palm Springs(KPSP)	33.83	116.51	145.4	904.9	742.7	7.0	10.0
Redding (RDD)	40.51	122.29	153.0	715.2	539.2	175.0	50.0
Riverside (RIV)	33.88	117.26	468.0	706.6	853.4	55.0	10.0
Sacramento (SAC)	38.51	121.49	7.3	117.4	56.5	30.0	10.0
San Diego (SAN)	32.73	117.19	5.0	206.5	407.4	0.1	10.0
San Francisco (SFO)	37.62	122.37	4	98.7	103.3	0.1	10.0
Lake Tahoe (TVL)	38.89	120.00	1909.3	1831.1	1886.9	175.0	50.0

Mean value comparisons for surface pressure and temperature between MASS, WRF, and METAR observations for November-December 2001.

Station	Pressure (mb)					Temperature (°F)				
	OBS	MASS		WRF		OBS	MASS		WRF	
	Value	Value	% Diff	Value	% Diff	Value	Value	% Diff	Value	% Diff
BFL	1019.2	1020.1	0.09%	1017.1	-0.21%	52.6	52.1	-0.95%	48.9	-7.03%
FAT	1019.7	1020.1	0.04%	1018.3	-0.14%	51.1	51.4	0.59%	50.8	-0.59%
LAX	1018.0	1019.5	0.15%	1017.8	-0.02%	57.6	58.8	2.08%	55.4	-3.82%
PSP	1016.9	1019.6	0.27%	1016.4	-0.05%	61.1	51.0	-16.53%	51.0	-16.53%
RDD	1018.2	1019.7	0.15%	1015.1	-0.30%	49.1	43.4	-11.61%	45.4	-7.54%
RIV	1018.1	1019.7	0.16%	1016.1	-0.20%	53.3	52.5	-1.50%	48.8	-8.44%
SAC	1018.7	1019.6	0.09%	1017.1	-0.16%	54.4	53.8	-1.10%	51.3	-5.70%
SAN	1018.5	1019.2	0.07%	1017.3	-0.12%	57.7	58.8	1.91%	53.4	-7.45%
SFO	1018.8	1020.0	0.12%	1017.2	-0.16%	54.1	54.4	0.55%	52.5	-2.96%
TVL	1019.0	1020.9	0.19%	1007.0	-1.18%	31.9	35.9	12.54%	33.0	3.45%
Avg. Total Difference		MASS: 0.13%		WRF: 0.25%			MASS: 4.94%		WRF: 6.35%	

Mean value comparisons for dewpoint and 10m wind between MASS, WRF, and METAR observations for November-December 2001.

Station	Dewpoint (℉)					Wind Speed (m/s)				
	OBS	MASS		WRF		OBS	MASS		WRF	
	Value	Value	% Diff	Value	% Diff	Value	Value	% Diff	Value	% Diff
BFL	44.8	32.0	-28.57%	37.7	-15.85%	2.1	3.2	52.38%	2.9	38.10%
FAT	44.9	32.2	-28.29%	42.4	-5.57%	2.0	3.0	50.00%	2.1	5.00%
LAX	46.2	38.0	-17.75%	43.4	-6.06%	2.8	3.0	7.14%	2.1	-25.00%
PSP	34.0	28.0	-17.65%	31.5	-7.35%	2.4	3.4	41.67%	3.6	50.00%
RDD	41.8	34.4	-17.70%	38.4	-8.13%	2.6	3.0	15.38%	3.4	30.77%
RIV	38.5	30.5	-20.78%	33.5	-12.99%	2.1	3.3	57.14%	3.2	52.38%
SAC	47.9	38.0	-20.67%	44.0	-8.14%	2.7	3.1	14.81%	3.5	29.63%
SAN	49.1	42.7	-13.03%	40.9	-16.70%	2.1	2.7	28.57%	2.8	33.33%
SFO	48.8	47.0	-3.69%	46.6	-4.51%	3.5	4.4	25.71%	3.2	-8.57%
TVL	22.9	25.8	12.66%	27.2	18.78%	2.5	3.1	24.00%	5.5	120.00%
Avg. Total Difference		MASS: 18.08%		WRF: 10.41%			MASS: 31.68%		WRF: 39.28%	


MASS - WRF Temperature Comparisons for 61 Simulation Days
Bakersfield CA
01 Mar 2002 - 30 Apr 2002
Temp F
75
70
65
60
55
50
45
40
1200
1300
1400
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1600
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2200
2300
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100
200
300
400
500
600
700
800
900
1000
1100
1200
UTC
MASS
WRF
OBS

Wind Tower Comparison

Mean wind speed comparisons between MASS and WRF for three wind towers, November-December 2001.

	Mean Wind Speed (m/s)		
Wind Tower	**OBS**	**MASS**	**WRF**
San Gorgonio Pass	6.30	7.07	5.90
Altamont Pass 427	5.42	4.39	3.93
Altamont Pass 438	9.51	8.50	7.92

Forecast Mode

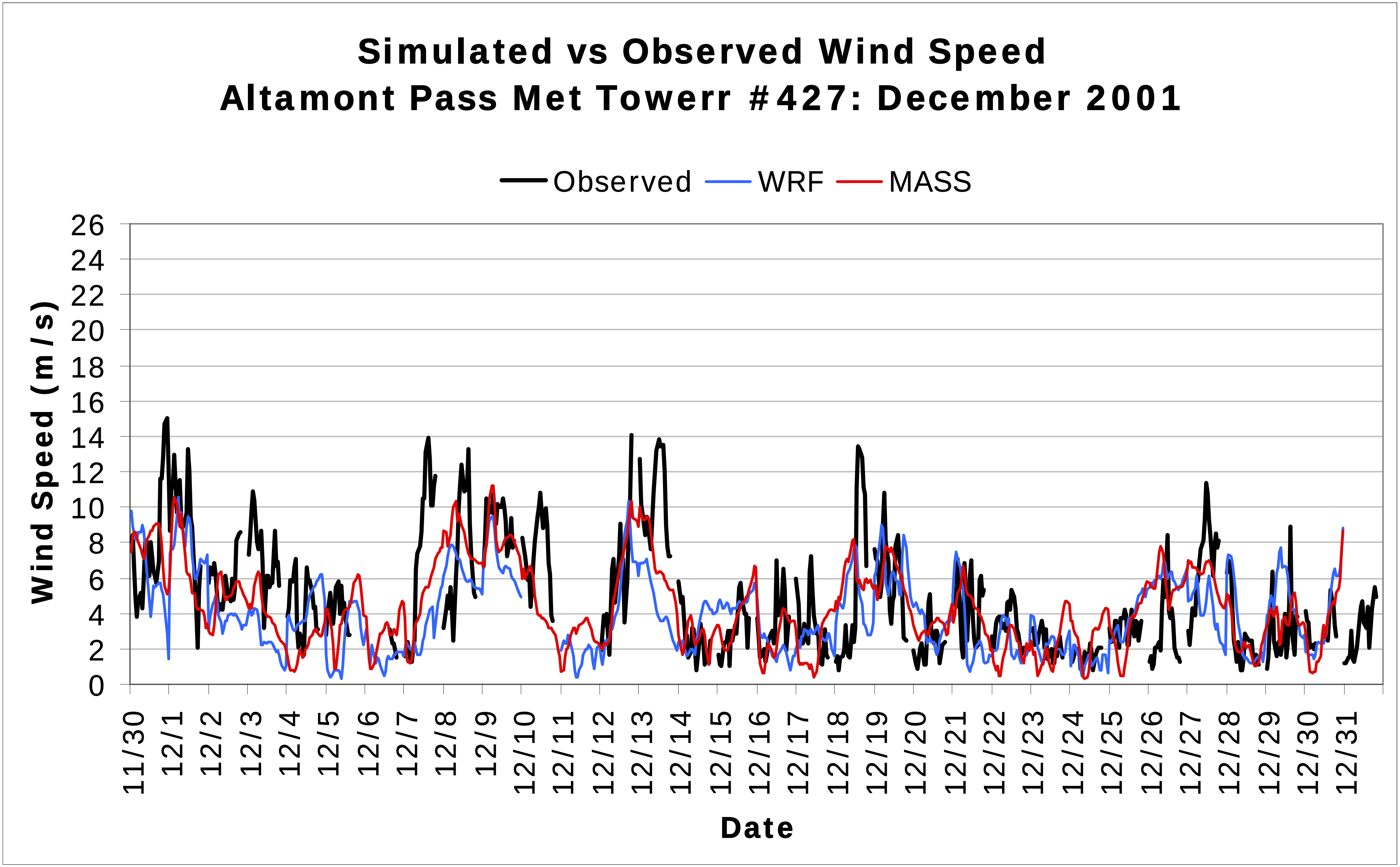
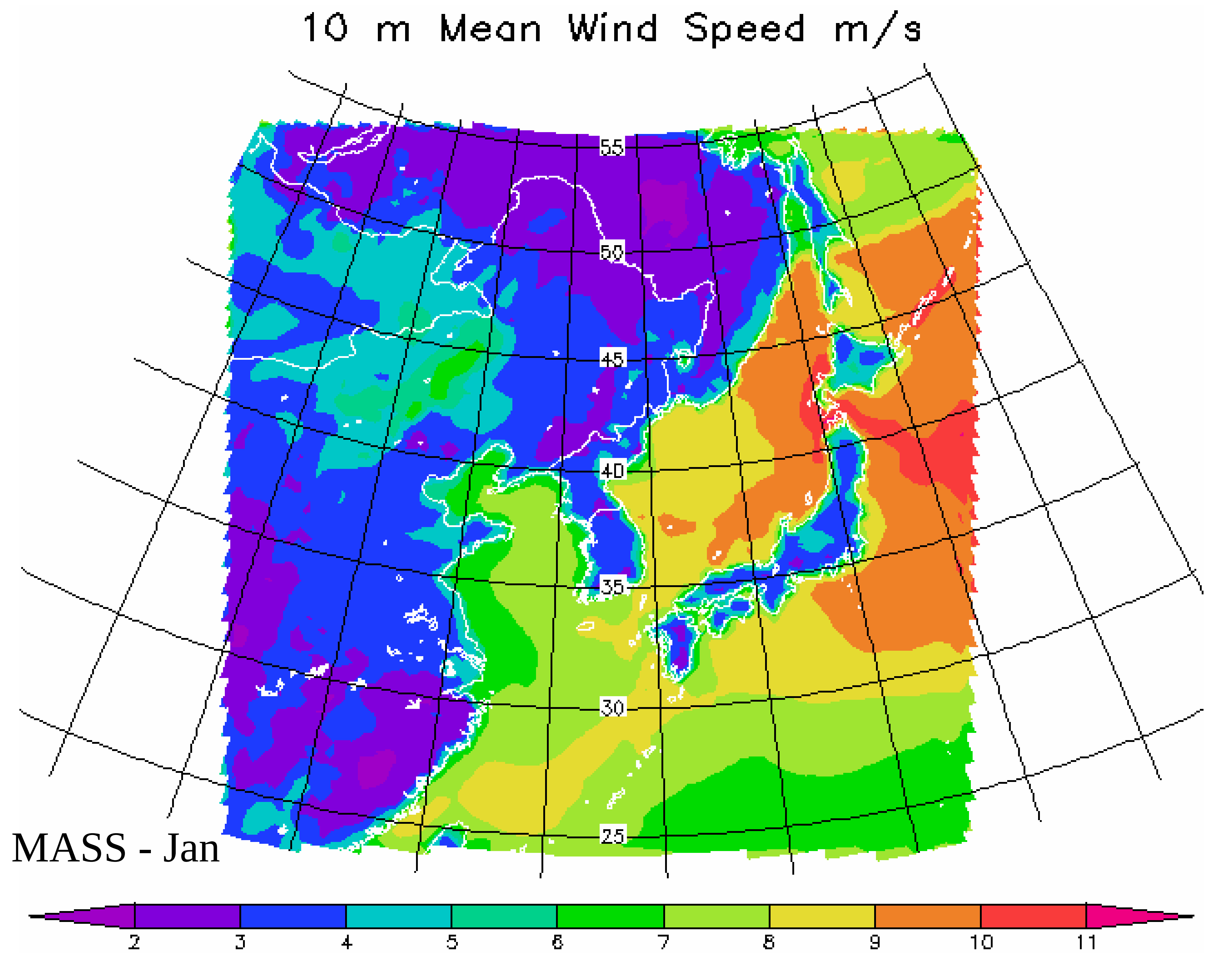


Figure 3.

Comparison Results for Korea

- Periods looked at:
  - All Januarys 1987-96 and all Julys 1987-96
  - Results show similar trends to the California analysis.
- More focus on seasonal differences and extreme value point comparisons
  - Performance was similar for each season
  - Extreme values for ten-year period were captured quite well by WRF


10 m Mean Wind Speed m/s
55
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35
30
25
MASS - Jan
2
3
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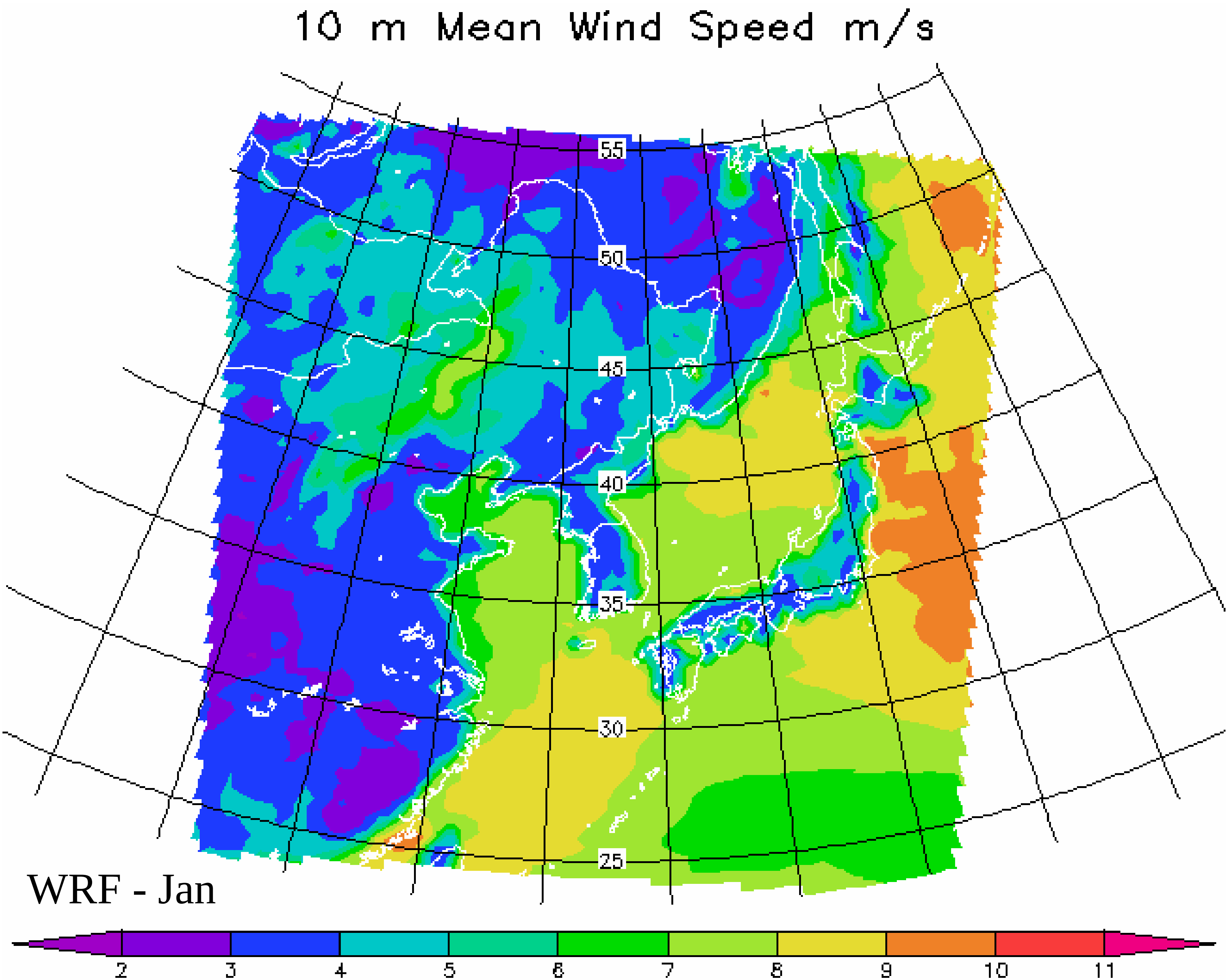
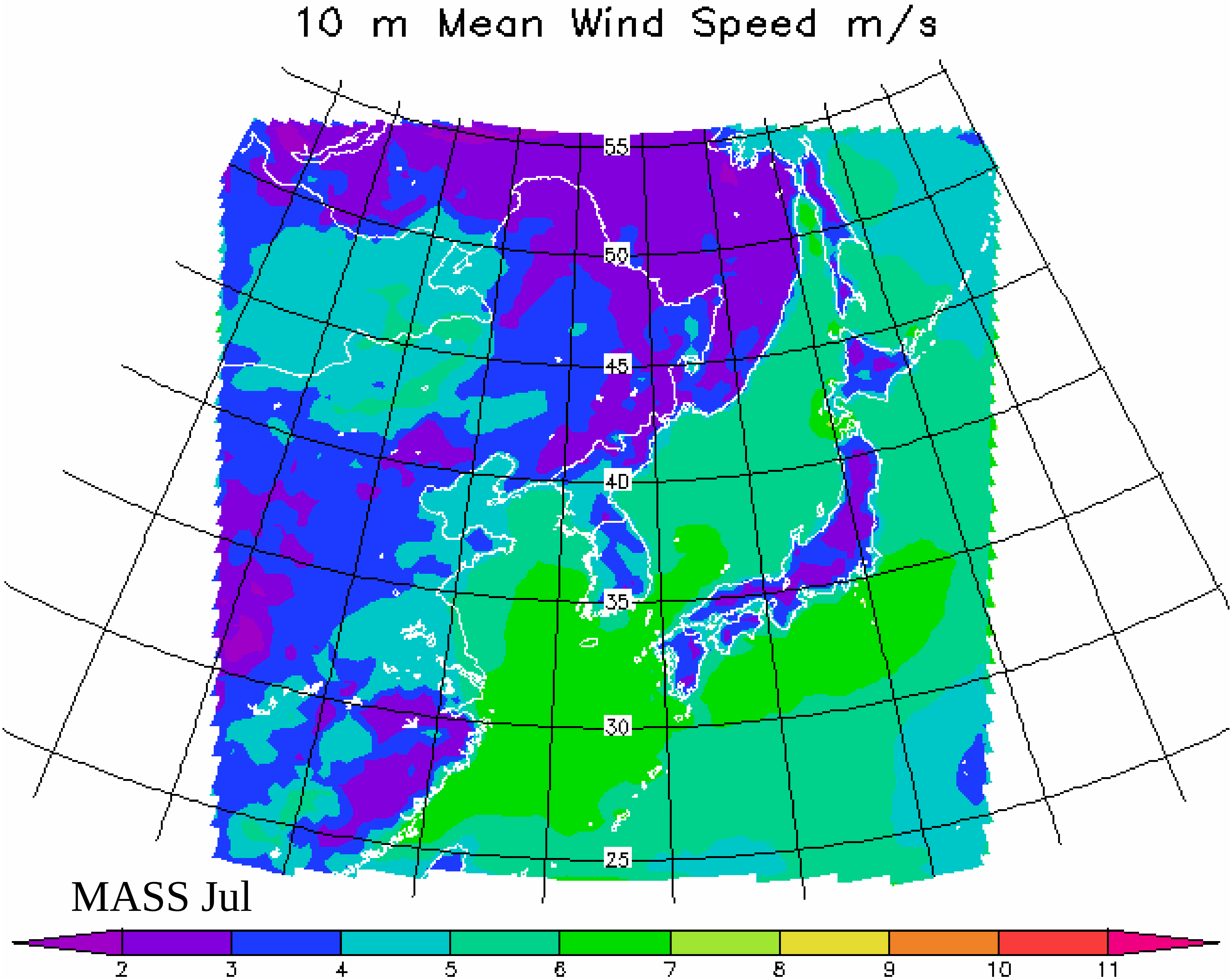
11



WRF - Jan


10 m Mean Wind Speed m/s
55
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25
MASS Jul
2
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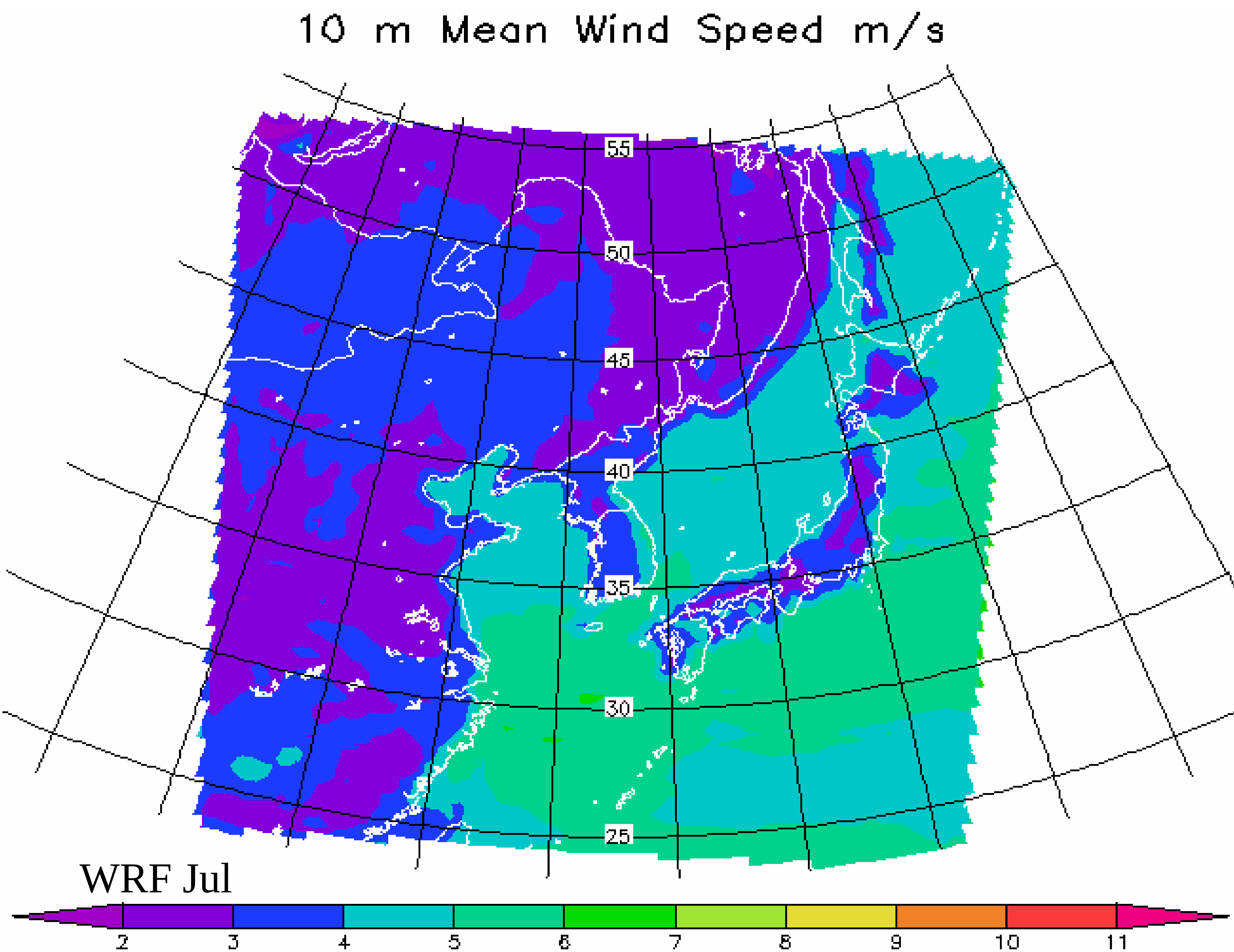
10 m Mean Wind Speed m/s
55
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WRF Jul
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Korea Points

Station			Lat	Lon	Elevation (meters)		
Number	**ICAO**	**Location**	**(W)**	**(E)**	**Measured**	**MASS**	**WRF**
470080	**CHO**	**Chongjin, N. KO**	41.47	129.49	43.0	35.6	283.8
471180	**KNH**	**Hoengsong, S. KO**	37.26	127.57	100.9	373.8	396.7
471220	**KSO**	**Osan, S. KO**	37.05	12702	11.9	42.0	102.2
471390	**KTH**	**Pohang, S. KO**	35.59	12925	20.1	122.3	121.0

METAR station locations used in the Korea comparisons.

January

Stat.	Pressure (mb)			Temperature (°F)			Dewpoint (°F)			Wind Speed (m/s)		
	OBS	**MASS**	**WRF**	**OBS**	**MASS**	**WRF**	**OBS**	**MASS**	**WRF**	**OBS**	**MASS**	**WRF**
CHO	1021.2	1020.1	1017.8	18.3	20.1	19.9	8.8	3.0	4.7	3.9	7.2	4.9
KNH	1021.7	1022.1	1018.3	24.1	23.4	20.8	14.9	10.2	12.4	2.0	3.0	2.1
KSO	1024.0	1025.5	1022.8	26.8	26.9	25.4	16.1	14.3	15.4	3.4	5.8	2.7
KTH	1026.9	1027.6	1026.4	34.1	33.0	31.0	19.0	15.7	18.5	6.4	10.4	9.6

Ten year, mean-value comparisons for surface pressure, temperature, dewpoint and 10m wind-speeds among MASS, WRF, and METAR observations for *January*, 1987-1996.

July

Stat.	Pressure (mb)			Temperature (°F)			Dewpoint (°F)			Wind Speed (m/s)		
	OBS	**MASS**	**WRF**	**OBS**	**MASS**	**WRF**	**OBS**	**MASS**	**WRF**	**OBS**	**MASS**	**WRF**
CHO	1007.2	1007.9	1005.1	70.1	73.4	72.2	64.8	60.4	62.4	2.6	3.0	3.4
KNH	1008.1	1008.7	1006.1	76.8	75.5	74.7	68.2	65.5	66.5	2.3	3.3	3.2
KSO	1006.7	1007.6	1005.8	78.1	78.8	76.3	70.0	65.0	68.0	3.7	5.1	3.5
KTH	1008.5	1009.2	1007.3	77.3	78.6	73.4	71.1	66.7	70.9	4.1	8.2	6.8

Ten year, mean-value comparisons for surface pressure, temperature, dewpoint and 10m wind-speeds between MASS, WRF, and METAR observations for *July*, 1987-1996.

Extreme Value Comparison

Station	Month	Temperature Max/Min (°F)			Max Wind Speed (m/s)		
		OBS	MASS	WRF	OBS	MASS	WRF
CHO	Jan	47/-6	45/-7	47/-2	38	32	30
CHO	Jul	93/49	90/47	91/50	25	18	22
KNH	Jan	65/-21	58/-23	61/-25	38	40	43
KNH	Jul	106/60	102/57	103/60	27	30	32
KSO	Jan	56/-16	54/-6	55/-8	38	37	34
KSO	Jul	97/55	107/59	102/42	47	32	47
KTH	Jan	68/3	63/0	64/-2	44	38	40
KTH	Jul	100/50	104/47	109/46	40	30	36

Extrema comparisons of surface temperature and wind-speed among MASS, WRF, and METAR observations between 1987 and 1996.

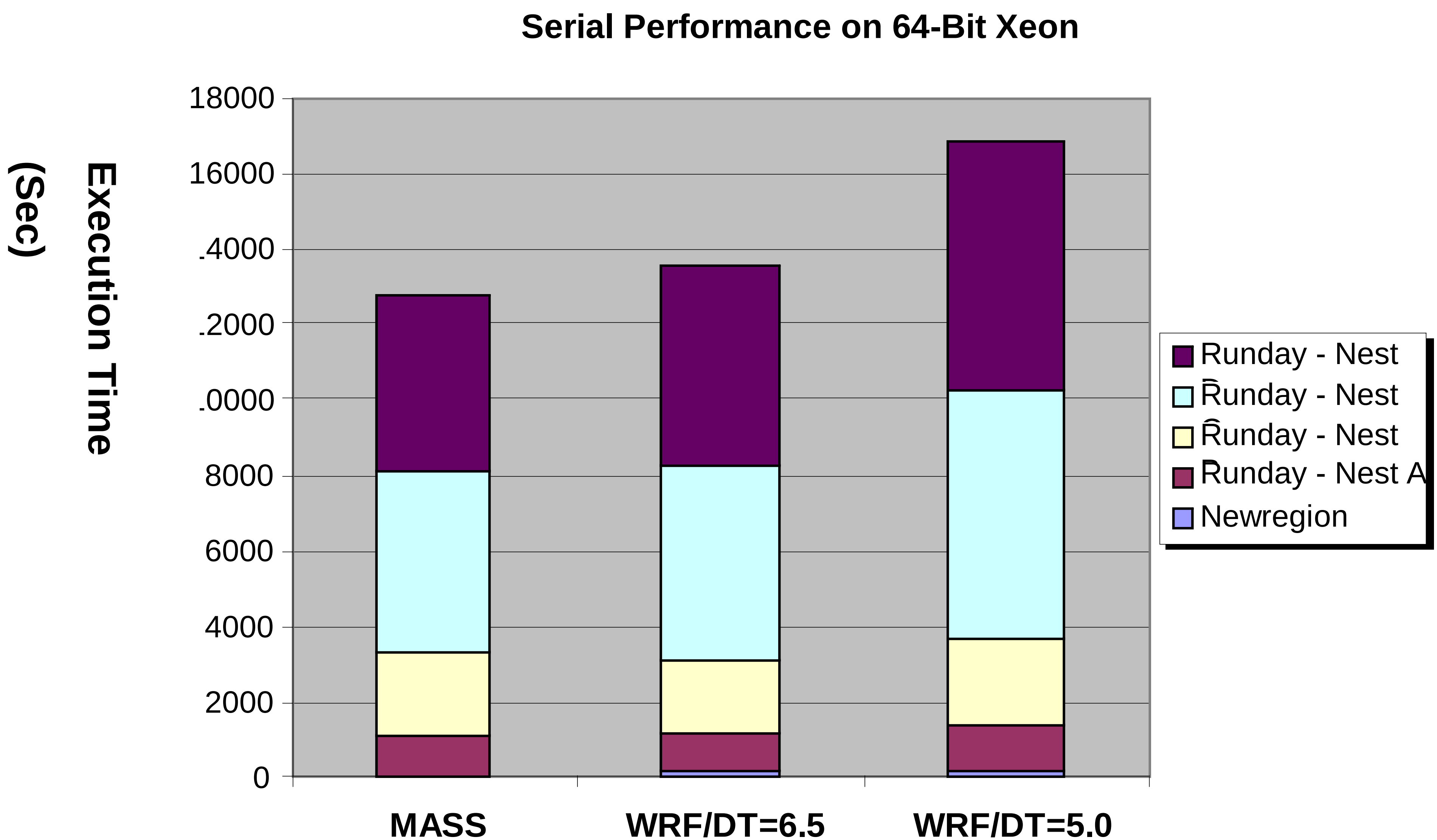
Computational Performance Comparison

To quantify the application performance of the WRF and MASS models, a set of execution timings were obtained using the geometry configuration of the California region presented previously. This configuration consisted of four nests and the mesh sizing information for each nest.

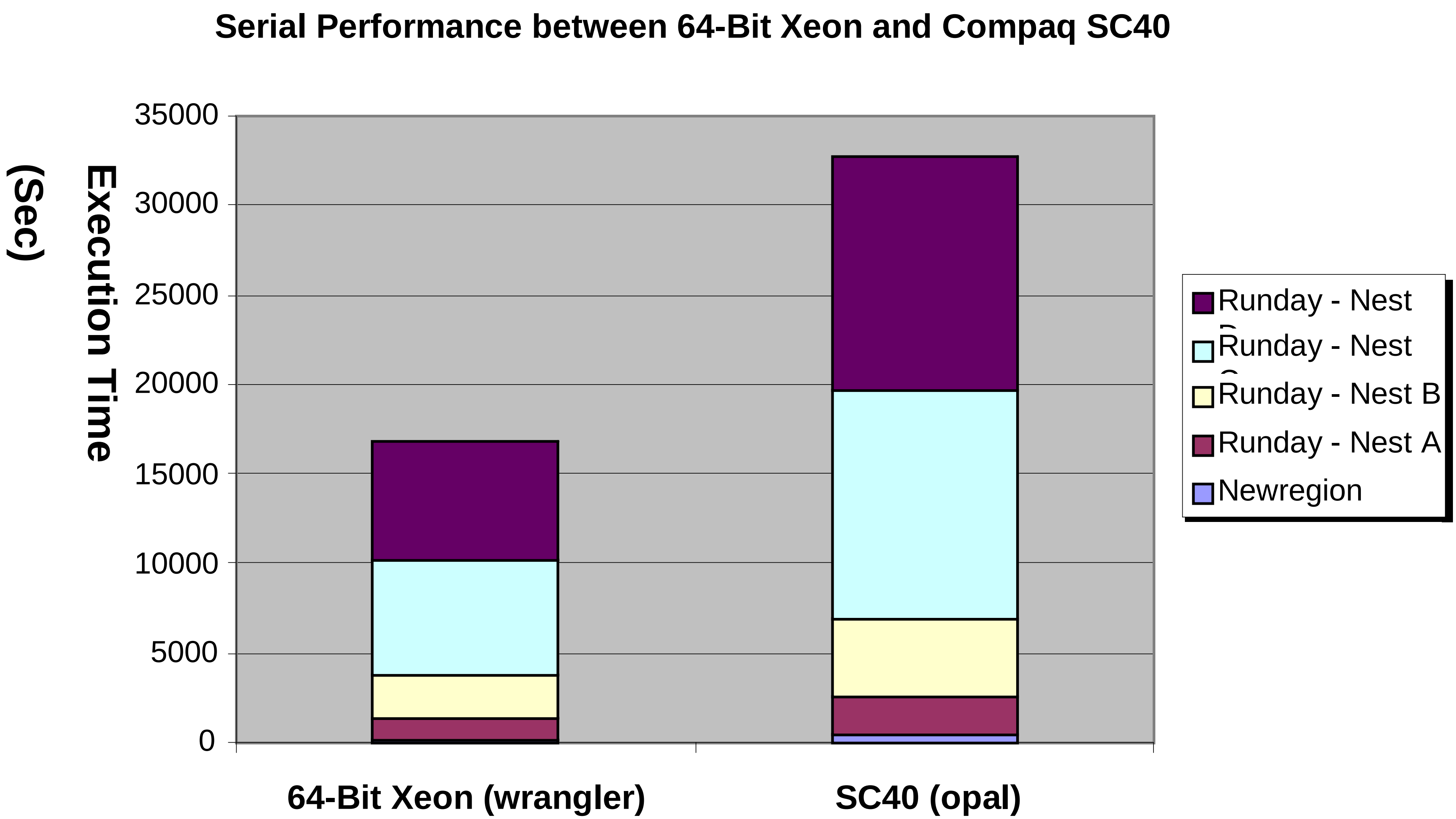
Grid Parameter	Nest A	Nest B	Nest C	Nest D
Mesh Sizing	100 x 80 x 25	100 x 80 x 25	80 x 80 x 25	80 x 80 x 25
Mesh Resolution	40 km	15 km	4 km	4 km

Grid sizing information for each of the four nests used to obtain application performance measurements.

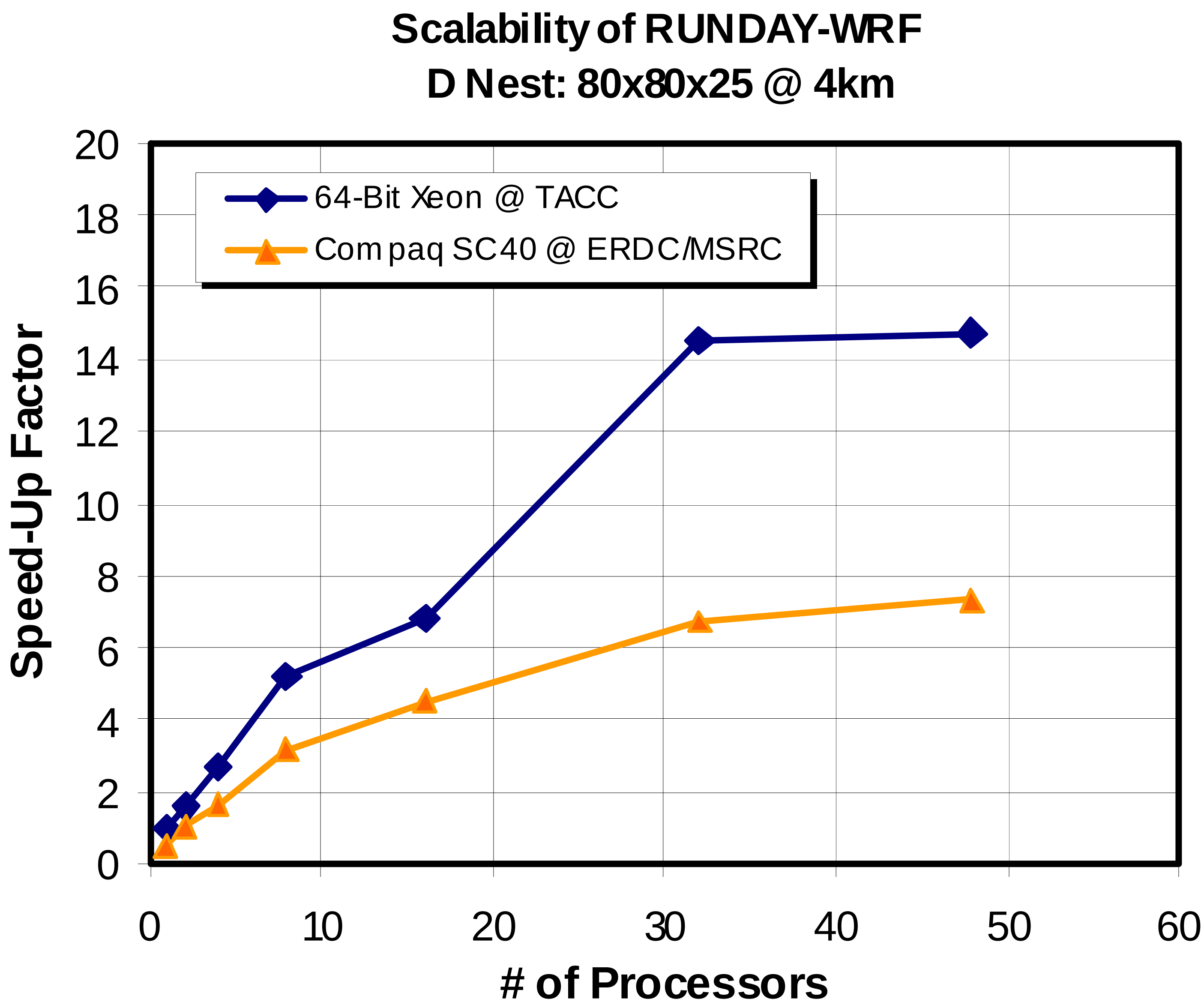
Serial performance comparisons for a 24-hour forecast between the MASS and WRF models.



Serial performance between 64-Bit Xeon and Compaq SC40



Speed-up factors using the WRF model from a 24-hour forecast on the TACC 64-Bit Xeon cluster and the Compaq SC40 at ERDC.



Conclusions

- System Design -
  - Designed for easy setup and running
- Quality of Output
  - 2 Meter Temperature patterns: similar WRF slight cold bias
  - 2m Mean Dewpoint: patterns similar, however MASS had lower dewpoints (up to 5 - 10 K) especially over the mountains
  - 10m Mean Wind: MASS showed a trend of higher wind speed, most notable over water.
  - Surface Pressure: Reasonable agreement but with more significant quantitative differences in warmer months
  - 500 mb Height Fields: Overall patterns were very similar, however MASS exhibited stronger gradients
- Computational Performance
  - WRF very Comparable to MASS
  - WRF has advantage of being designed for parallel processing

WRF Users Forum

http://tornado.meso.com/wrf_forum

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Forum Goal & Purpose

- The goal of the site is to facilitate communication and solve problems among the WRF user group community by allowing users to:
  - Share WRF experiences
  - Post questions and comments concerning WRF
  - Involve the entire WRF community to help solve problems concerning the WRF.

How to Access the Forum

- Go to:

  http://tornado.meso.com/wrf_forum

- Or access through WRF Home page

  http://wrf-model.org/index.php

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THE WEATHER RESEARCH & FORECASTING MODEL

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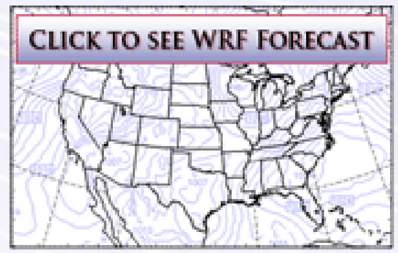
About the Weather Research & Forecasting Model



The Weather Research and Forecasting (WRF) Model is a next-generation mesocale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. WRF is suitable for a broad spectrum of applications across scales ranging from meters to thousands of kilometers.

The effort to develop WRF has been a collaborative partnership, principally among the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (the National Centers for Environmental Prediction (NCEP) and the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, Oklahoma University, and the Federal Aviation Administration (FAA). WRF allows researchers the ability to conduct simulations reflecting either real data or idealized configurations. WRF provides operational forecasting a model that is flexible and efficient computationally, while

Events & Announcements

Complete details at: Events

Title: 2005 Joint WRF/MM5 User's Workshop
Type of Event: workshop
Start Date: 06 - 27 - 2005
End Date: 06 - 30 - 2005

Title: WRF Tutorial
Type of Event: tutorial
Start Date: 07 - 25 - 2005
End Date: 07 - 29 - 2005

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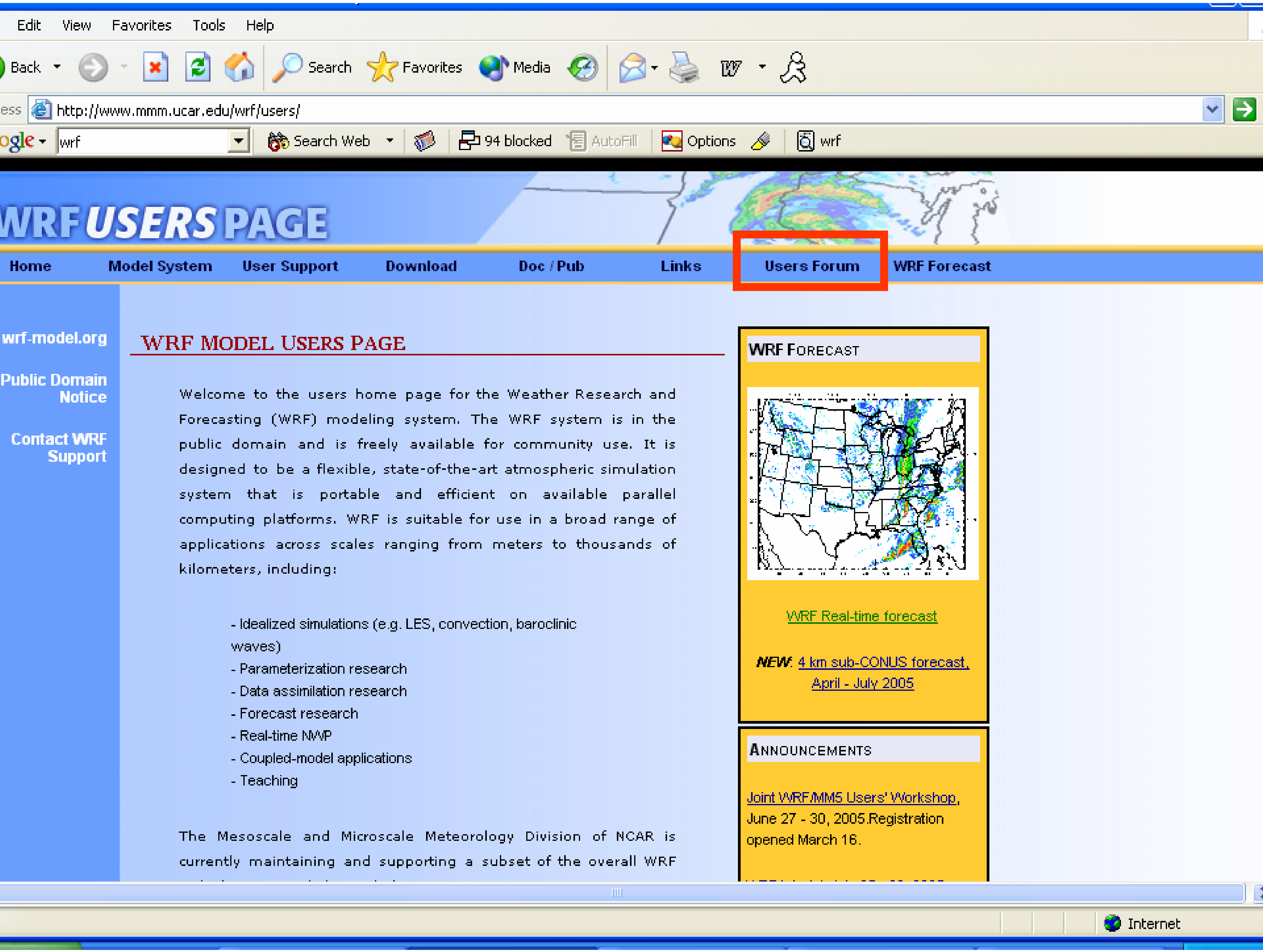
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http://www.mmm.ucar.edu/wrf/users/
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Options
wrf
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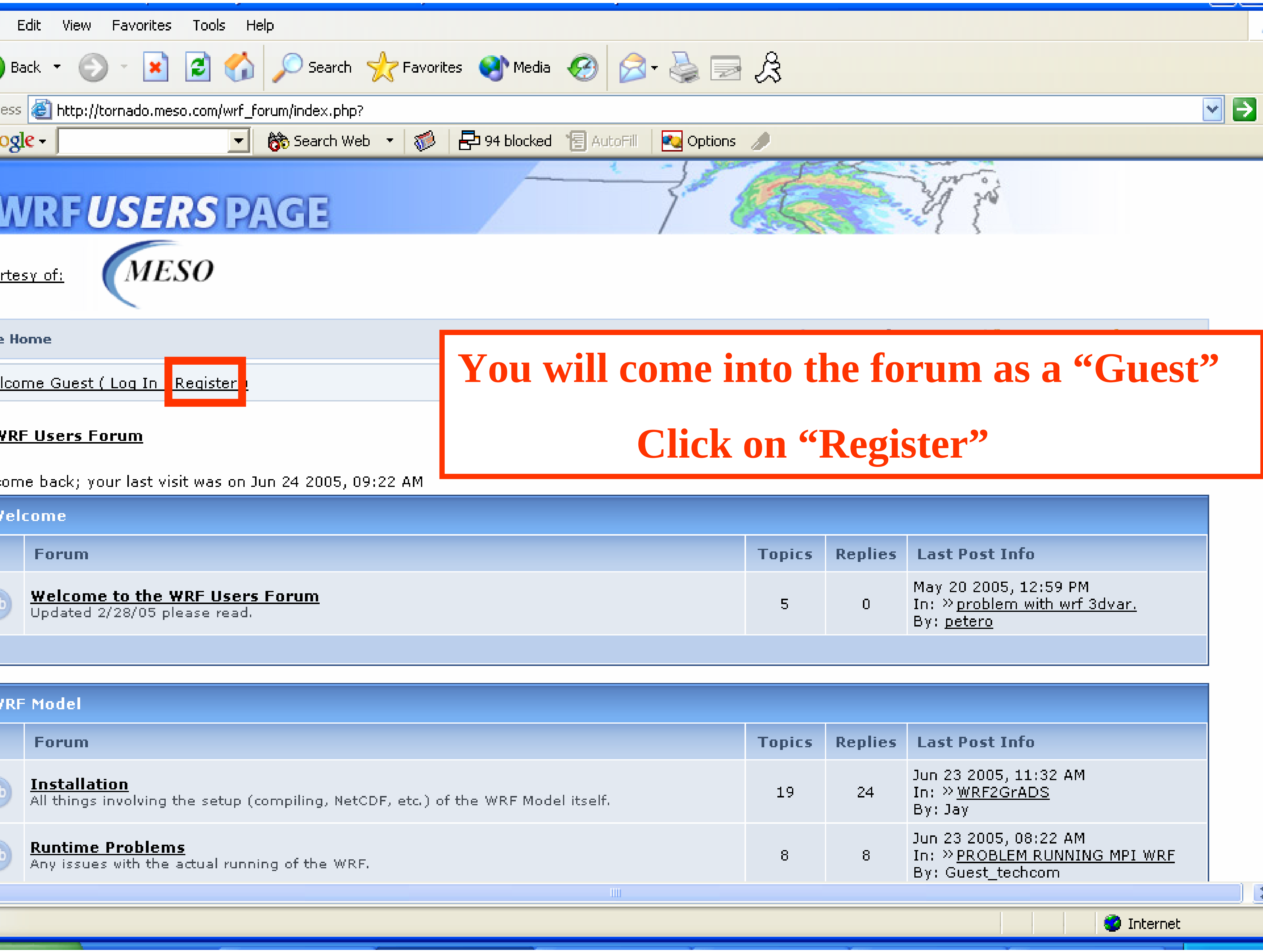
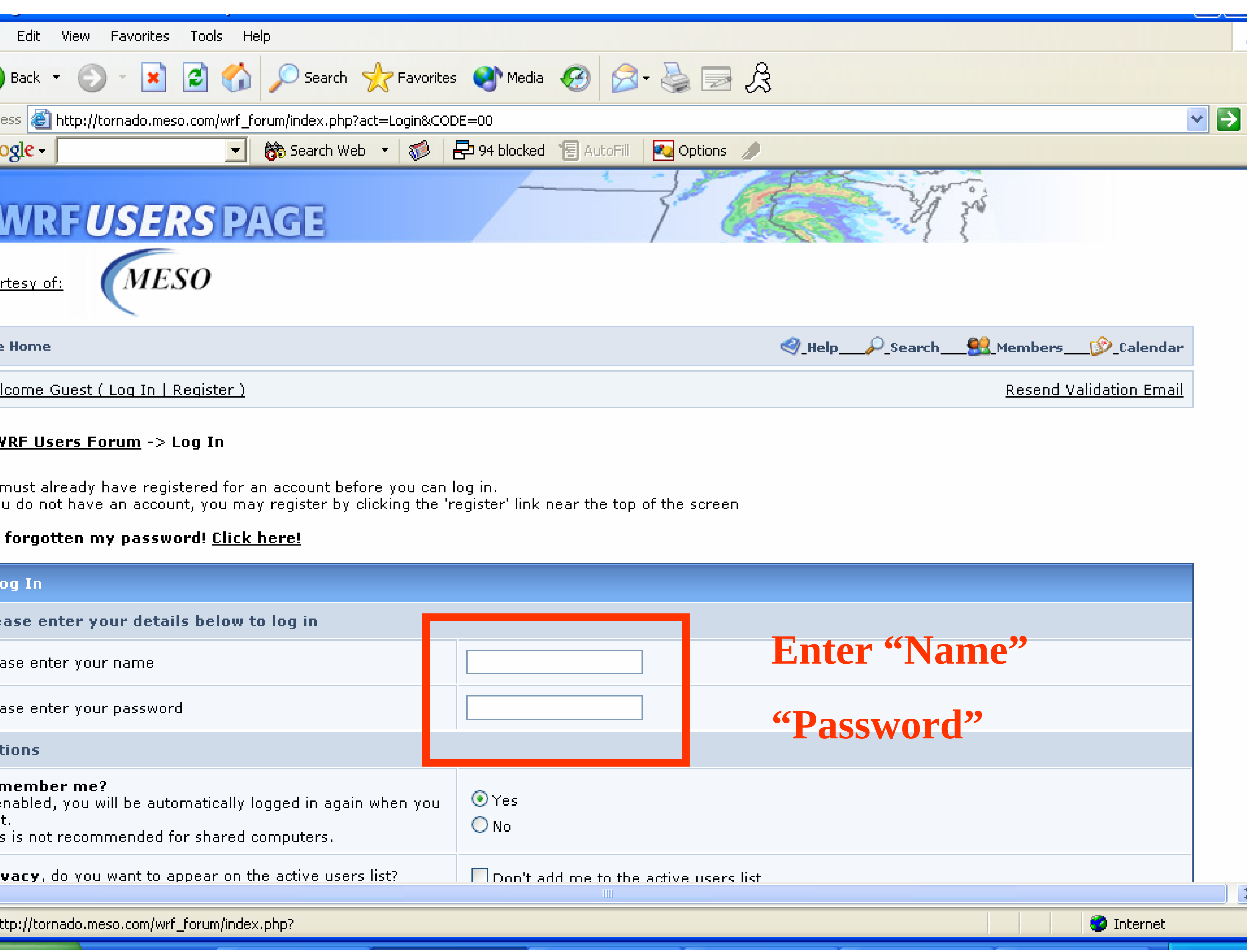
WRF MODEL USERS PAGE
Welcome to the users home page for the Weather Research and Forecasting (WRF) modeling system. The WRF system is in the public domain and is freely available for community use. It is designed to be a flexible, state-of-the-art atmospheric simulation system that is portable and efficient on available parallel computing platforms. WRF is suitable for use in a broad range of applications across scales ranging from meters to thousands of kilometers, including:
- Idealized simulations (e.g. LES, convection, baroclinic waves)
- Parameterization research
- Data assimilation research
- Forecast research
- Real-time NWP
- Coupled-model applications
- Teaching
The Mesoscale and Microscale Meteorology Division of NCAR is currently maintaining and supporting a subset of the overall WRF
WRF FORECAST
WRF Real-time forecast
NEW: 4 km sub-CONUS forecast, April - July 2005
ANNOUNCEMENTS
Joint WRF/MM5 Users' Workshop, June 27 - 30, 2005.Registration opened March 16.
Internet

You will come into the forum as a "Guest"

Click on "Register"

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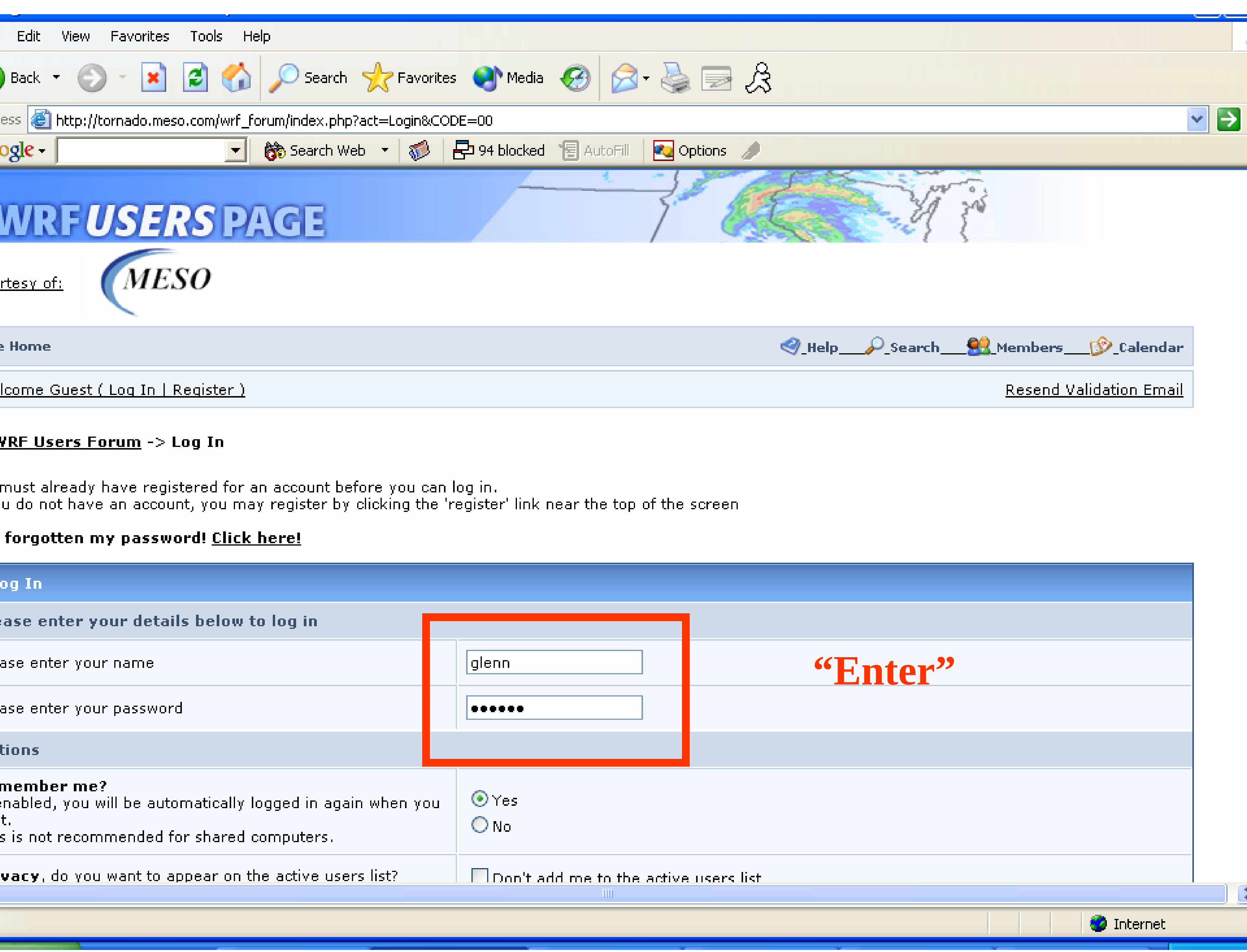
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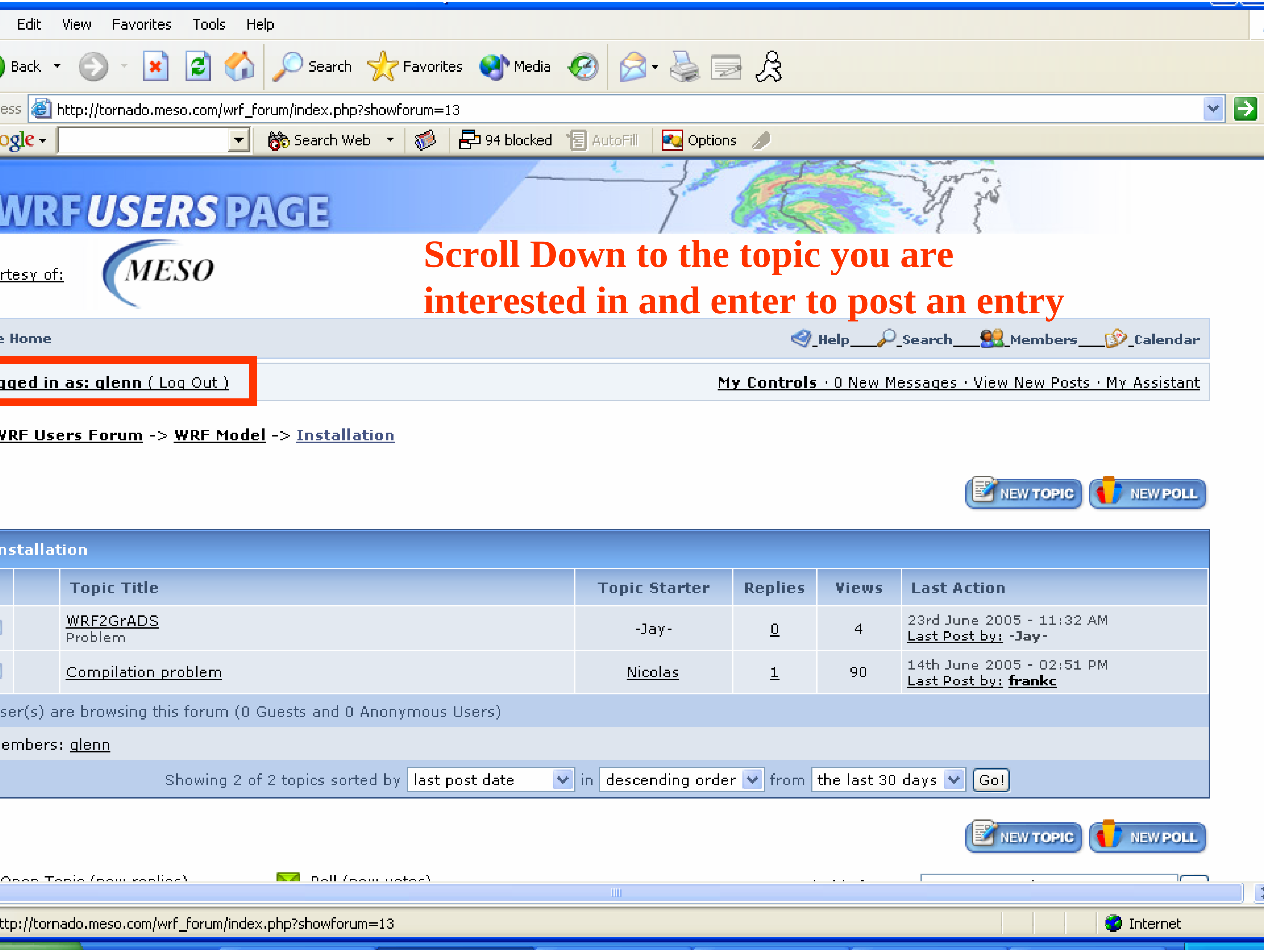
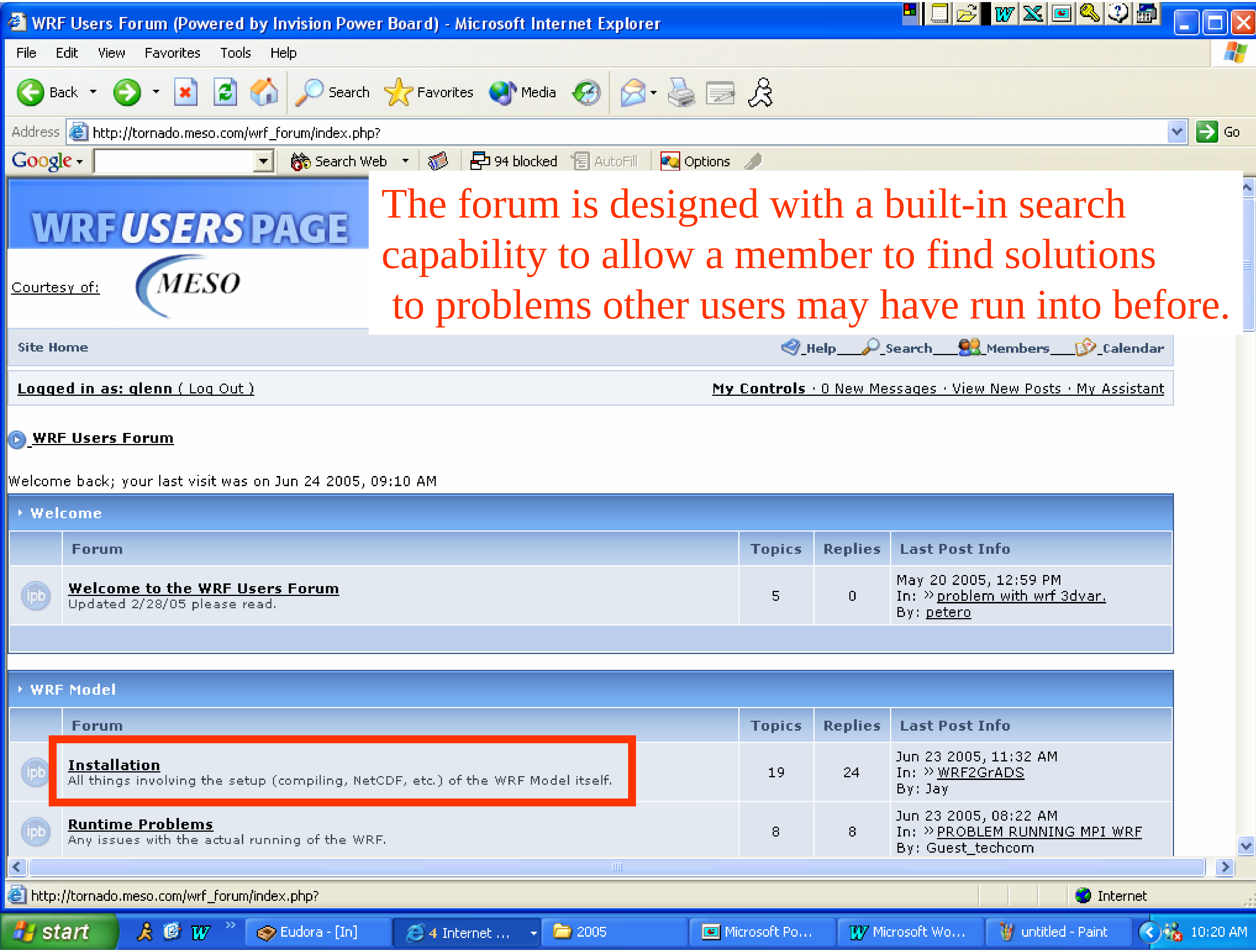
Scroll Down to the topic you are interested in and enter to post an entry



The forum is designed with a built-in search capability to allow a member to find solutions to problems other users may have run into before.



WRF Users Forum

http://tornado.meso.com/wrf_forum

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