

Final MM5 Modeling Evaluation: 36 km and 12 km Results

Susan Kemball-Cook, Yiqin Jia, Chris Emery and Ralph Morris,
ENVIRON Corporation Int., Novato, CA

Zion Wang and Gail Tonnesen
University of California, Riverside

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Overview

- **Brief history of development of 2002 36 km /12 km MM5 fields to support CMAQ visibility modeling**
- **Evaluation of 36 km grid MM5 performance; comparison to 36 km runs from other RPOs**
 - surface T, q, winds
 - precipitation
 - upper air
- **Evaluation of 12 km grid MM5 performance**
 - surface T, q, winds
 - precipitation
- **Summary and conclusion**

Project History

**WRAP Run 0
2003**



**WRAP Run 5
2004**



**New WRAP Run
2005**

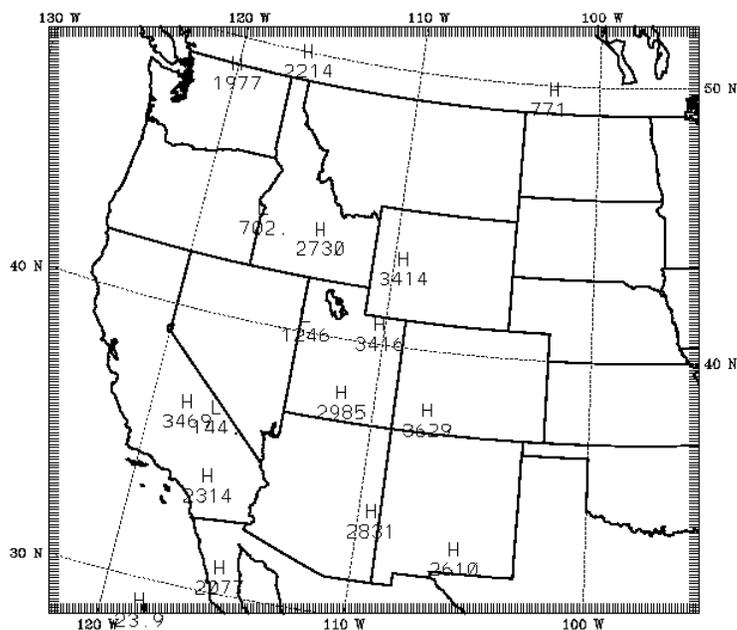
- **Performance issues in region and time of year critical for WRAP visibility modeling**
 - Strong wet, cold bias in WRAP region in summer
 - Underestimated diurnal surface T cycle amplitude
 - Associated with excessive rainfall
- **Some improvement, but still too much precipitation and humidity in the desert southwest**
 - Changed cumulus scheme, soil moisture nudging
 - Extensive sensitivity testing lead to new 36 km and 12 km configurations
- **Significant improvement in fields at 36 km and 12 km**
 - Better simulation of summer T, q, winds at the surface
 - Better simulation of rainfall and upper air structure

Model Setup for CENRAP, VISTAS, WRAP_0 and new WRAP 36 km 2002 Runs

- All use National RPO 36 km Grid, 164 x 128 x 34
- Lambert Conformal Projection
- Pleim-Xiu LSM / ACM PBL
- RRTM Longwave and Dudhia Shortwave

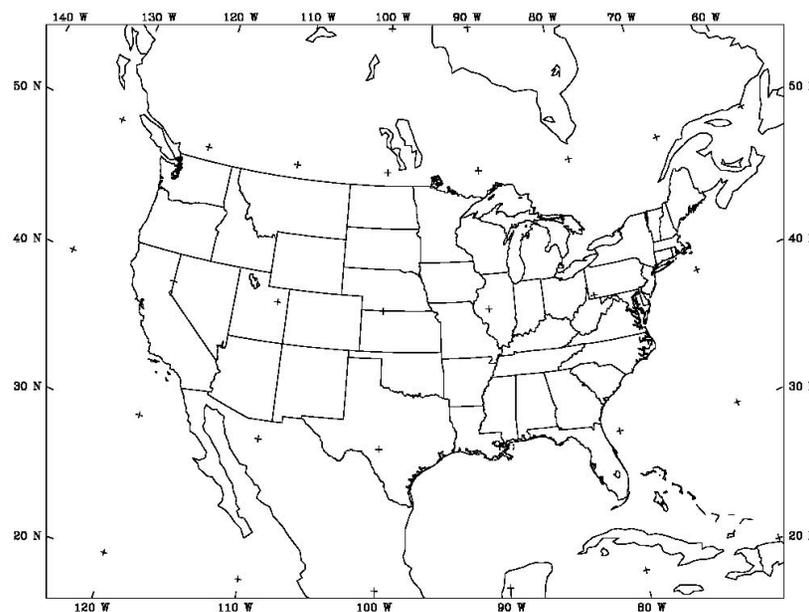
MM5 Modeling Domains for 2002 Annual Run

12 km



Domain Setup, WRAP 2002
CONTOUR FROM 50000. TO 50000. CONTOUR INTERVAL OF 50000. PT(3,3)=-0.10000E-02

36 km MAP OF DOMAIN 1 (NON-EXPANDED)



Model Setup for CENRAP, WRAP, and VISTAS 36 km 2002 Runs (continued)

Physics Options Differences

	CENRAP	VISTAS	WRAP_0	New WRAP
Cumulus Convection	Kain-Fritsch II	Kain-Fritsch II	Kain-Fritsch I	Betts-Miller
Moist Physics	Reisner I	Reisner I	Reisner II	Reisner II
Analysis Nudging at Surface	U/V Soil q	U/V Soil q	U/V/T/Q Soil q	U/V
Analysis Nudging Aloft	U/V/T/Q	U/V/T/Q	U/V/T/Q	U/V/T/Q
Surface Obs Nudging				U/V

Method for Evaluating MM5 Runs

For WRAP, CENRAP, and VISTAS runs, we examine:

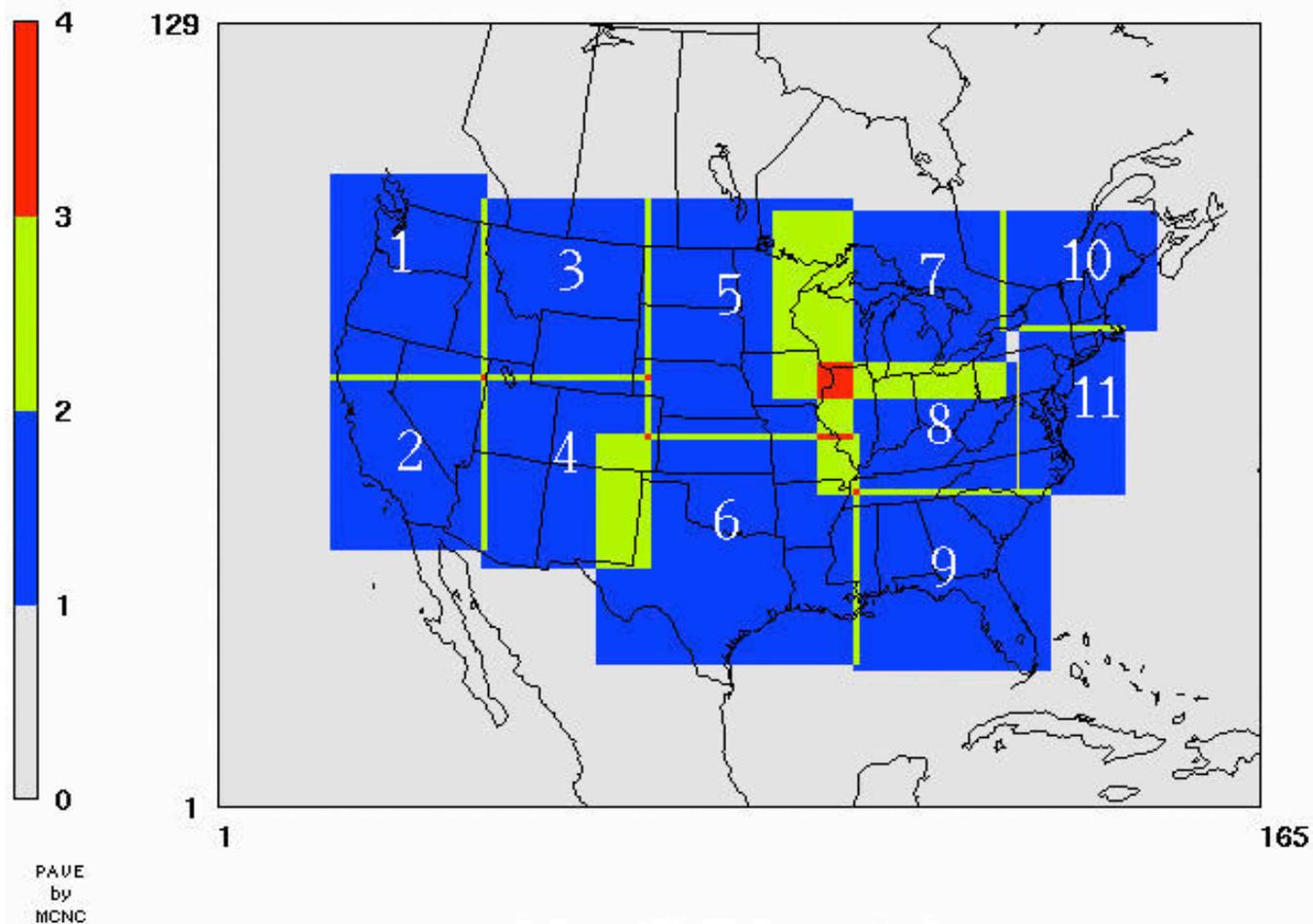
- **Surface statistics for wind, temperature, and humidity**
- **Upper air soundings of temperature, dew point, and winds**
- **Precipitation**

and compare with observations.

Subdomains for Model Evaluation

Metstat Subdomains

National Grid Projection



1 = Pacific NW

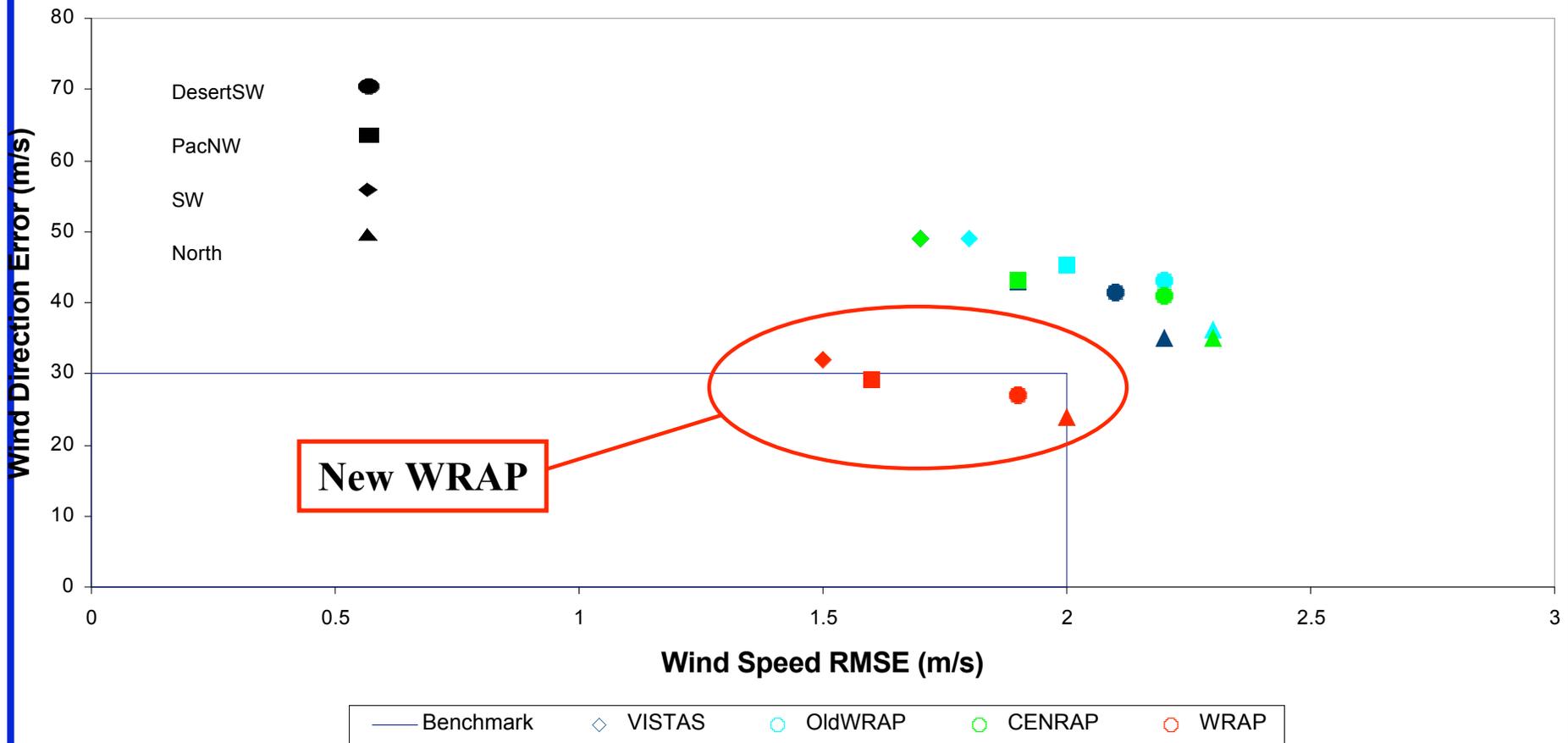
2 = SW

3 = North

4 = Desert SW

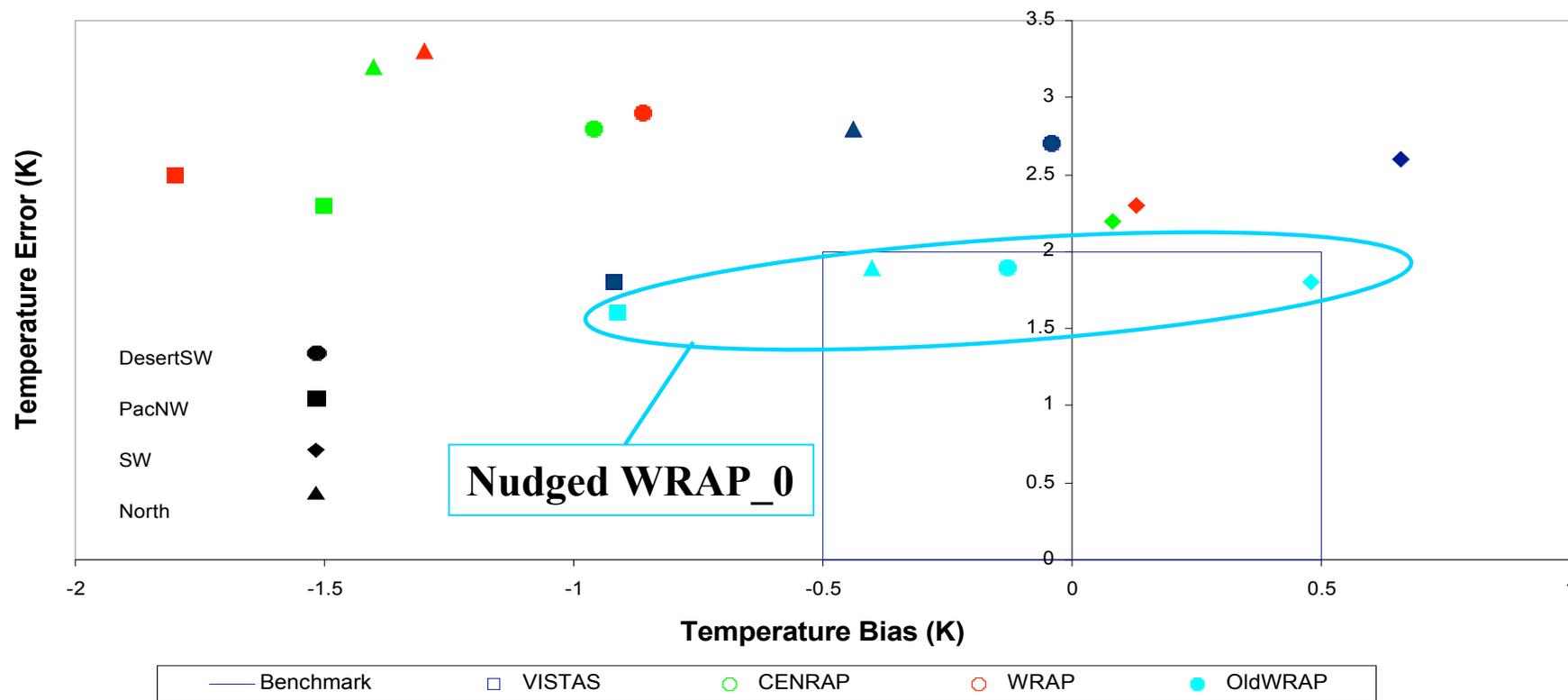
January Wind Performance in WRAP Subregions

CENRAP / VISTAS / WRAP January Wind Performance Comparison Over the Western U.S.

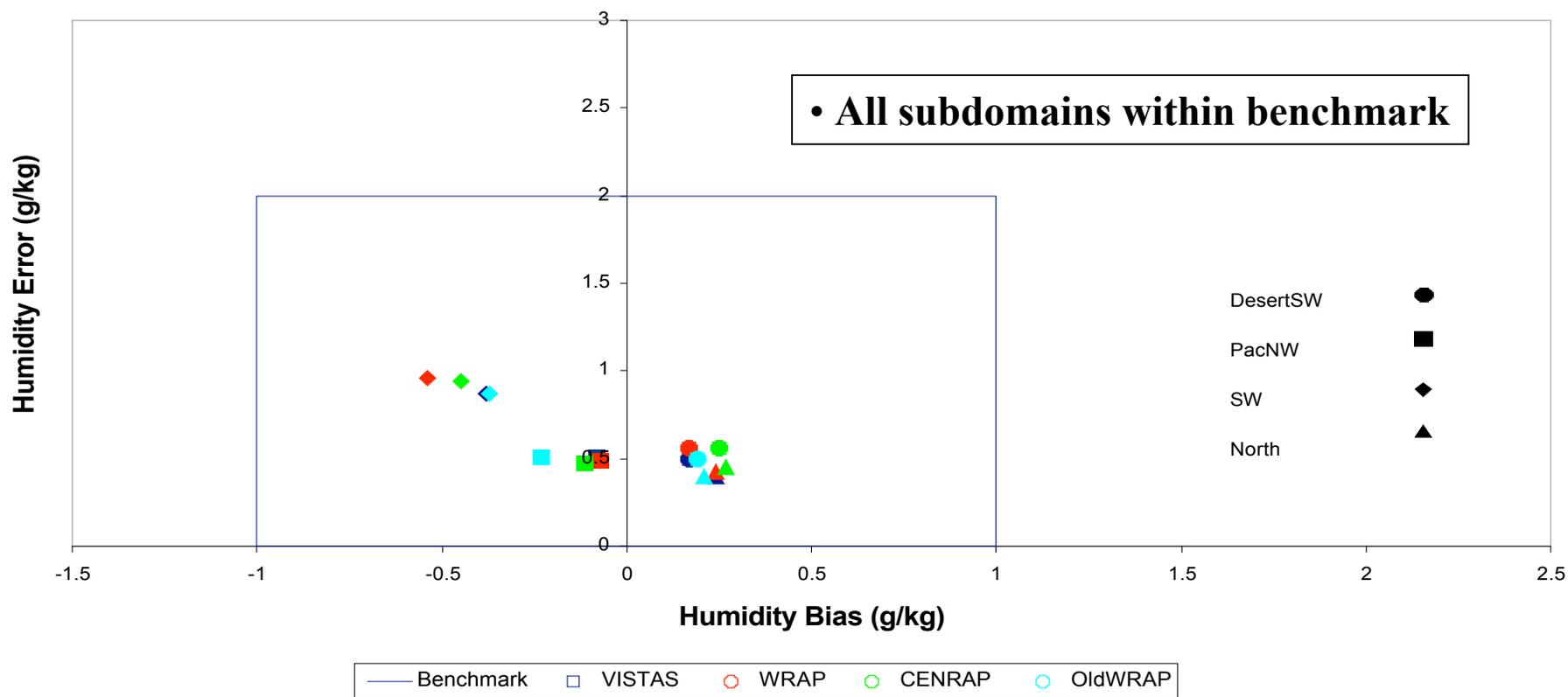


January Temperature Performance in WRAP Subregions

CENRAP / VISTAS / WRAP January Temperature Performance Comparison Over Western U.S.

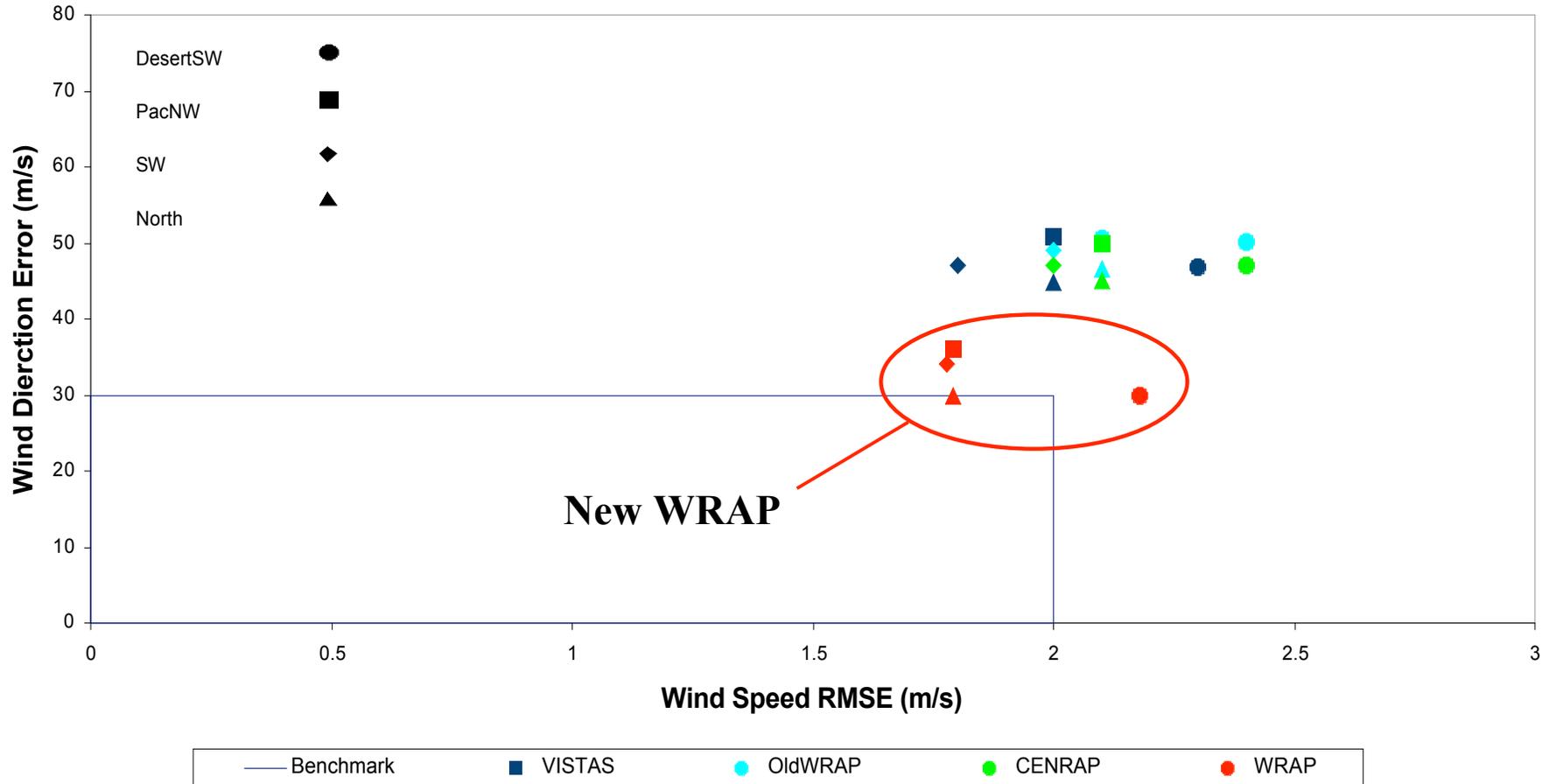


CENRAP / VISTAS / WRAP January Humidity Performance Comparison Over the Western U.S.



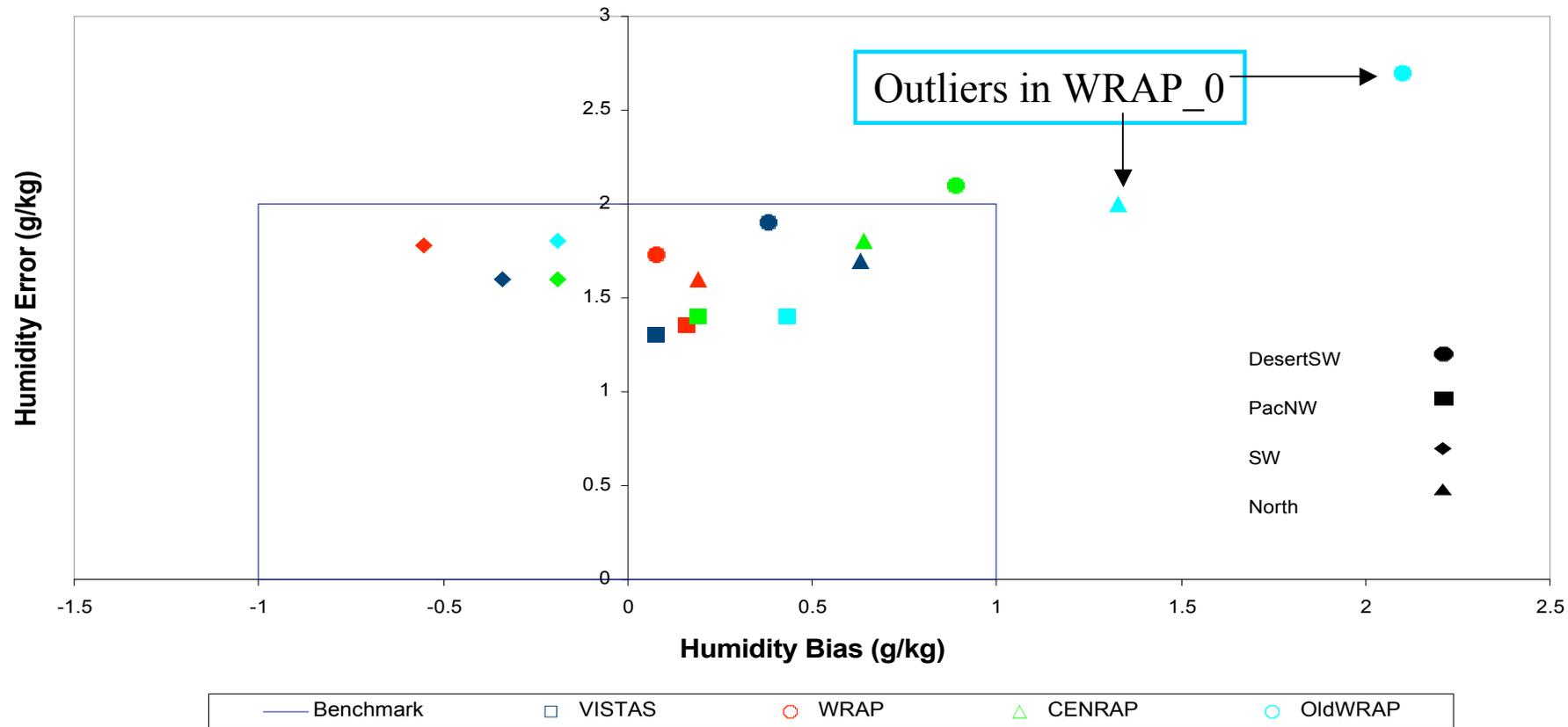
July Wind Performance in WRAP Subregions

CENRAP / VISTAS / WRAP July Wind Performance Comparison Over the Western U.S.



July Humidity Performance in WRAP Subregions

CENRAP / VISTAS / WRAP July Humidity Performance Comparison Over the Western U.S.



Summary of Surface Performance of New 36 km WRAP Run

- **Surface wind performance improved significantly throughout the year due to observational nudging of surface winds.**
- **Wind and humidity within or near benchmarks for all months and subdomains.**
- **Wet, cold bias reduced in the North and DesertSW subdomains in the summer months.**
- **Better simulation of diurnal cycle in temperature in summer.**
- **Some degradation in winter temperature performance because surface analysis nudging not done in new WRAP run.**

Method for Evaluating Precipitation Performance

- For each model run, calculate the total MM5 precipitation for each hourly output time:

$$\text{Total Precip} = \text{Convective Precip} + \text{Large-Scale Precip}$$

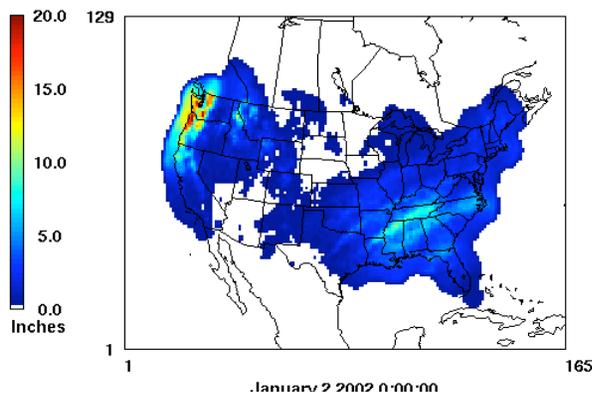
and sum over a month to obtain a total monthly precipitation amount.

- Compare with CPC 0.25x0.25 degree gridded precipitation analysis.

January Total Precipitation Comparison

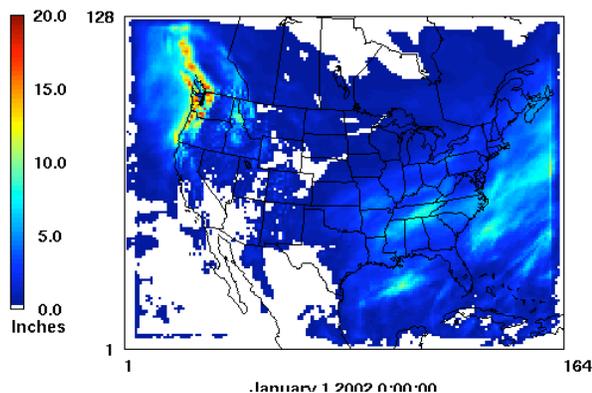
CPC Observed Precipitation

January 2-31, 2002



MM5 Total Precipitation: WRAP

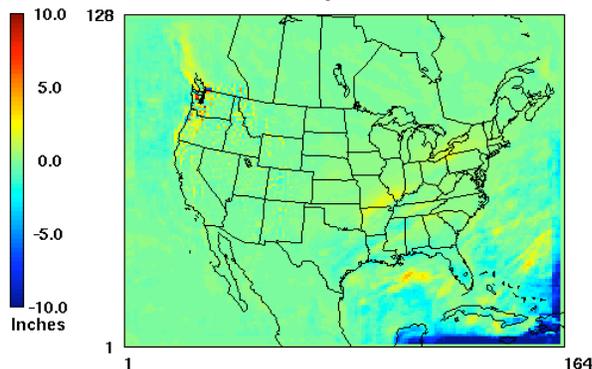
January 2-31, 2002



← WRAP Final

MM5 Total Precipitation Difference

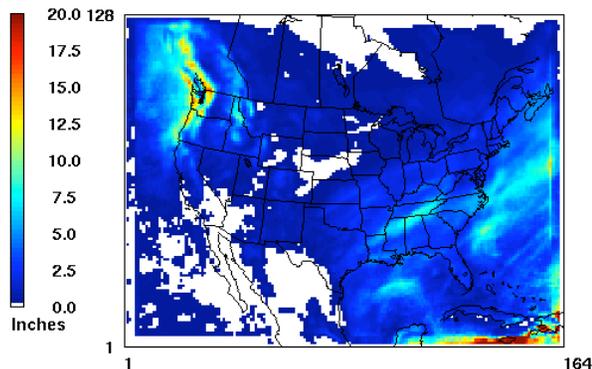
New WRAP Run - Old WRAP Run
January 2-31, 2002



January 1, 2002 0:00:00
Min=-46.0 at (147,3), Max= 10.3 at (28,96)

MM5 Total Precipitation: WRAP Run 0

January 2-31, 2002



January 1, 2002 0:00:00
Min= 0.0 at (1,1), Max= 46.7 at (147,3)

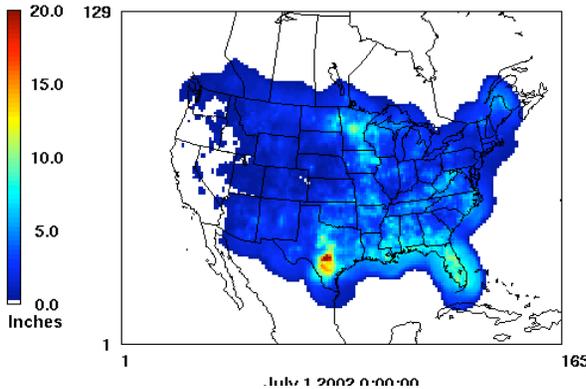
- MM5 predicts January rainfall with good skill
- Increased rainfall over pacNW in new WRAP
- Improves surface q in the pacNW

← WRAP Run 0

July Total Precipitation Comparison

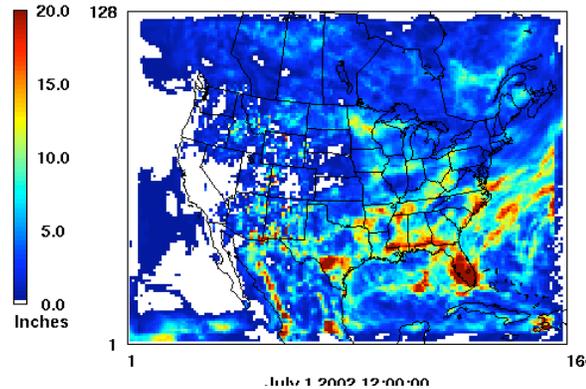
CPC Observed Precipitation

July 1-31, 2002



MM5 Total Precipitation: WRAP

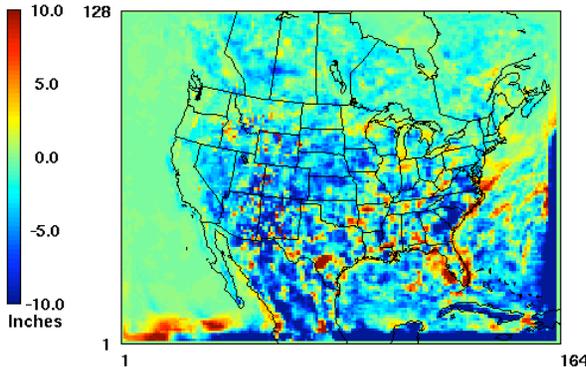
July 1-31, 2002



← WRAP Final

MM5 Total Precipitation Difference

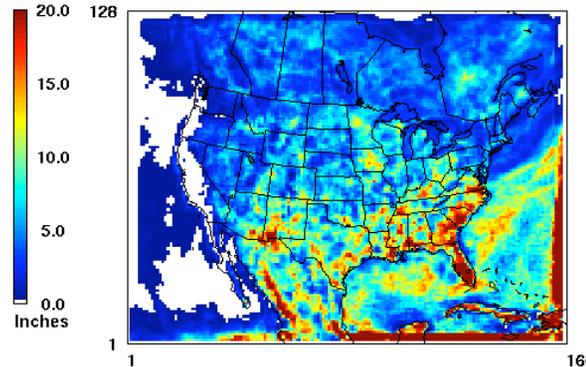
New WRAP Run - Old WRAP Run
July 1-31, 2002



July 1, 2002 12:00:00
Min=-92.8 at (163,8), Max= 31.7 at (130,25)

MM5 Total Precipitation: WRAP Run 0

July 1-31, 2002



July 1, 2002 12:00:00
Min= 0.0 at (1,1), Max= 94.8 at (163,8)

← WRAP Run 0

- Improvement in new WRAP over WRAP_0
- Improves surface q in the desertSW and North
- Betts-Miller scheme
 - smaller convecting area
 - cells more intense

Summary of Precipitation Comparison

- In winter, both WRAP runs showed considerable skill in reproducing the observed precipitation field.
- The new WRAP run produces more rainfall in the mountains along the west coast, bringing it into closer agreement with obs.
- In July, rainfall is over predicted over most of the U.S. as a result of excessive convective rainfall. This precip bias is consistent with the wet bias in the METSTAT surface humidity statistics.
- The over prediction of rainfall in the southwestern U.S. is smallest in the new WRAP run, which has a different type of cumulus scheme than the other three runs.

Summary of 36 km Upper Air Evaluation

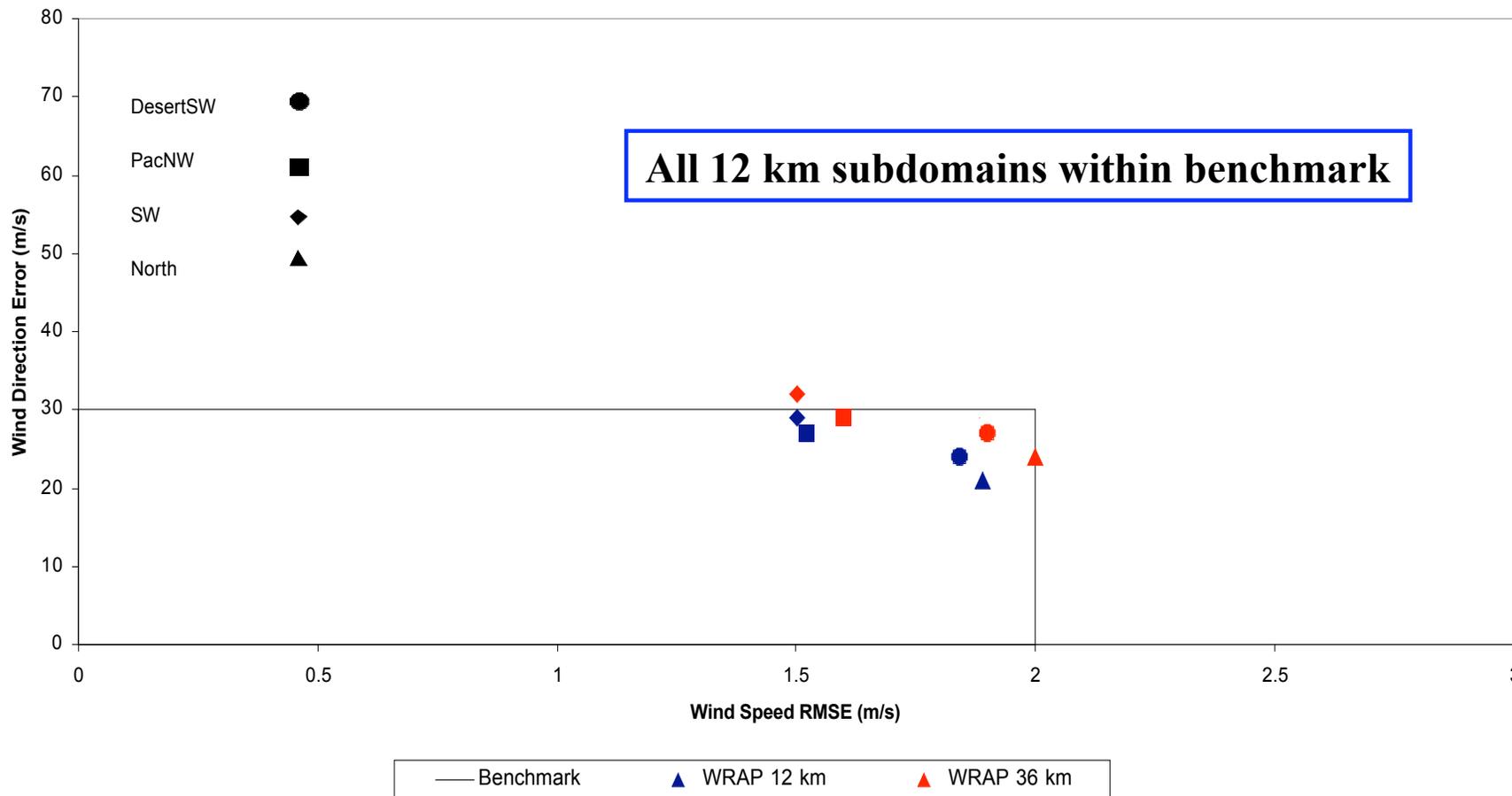
- Inversion strength frequently underestimated in WRAP_0 – better in new WRAP.
- For July soundings with a deep, convecting boundary layer, WRAP_0 frequently missed the observed temperature inversion at the top of the PBL; the new WRAP run showed some improvement.
- New WRAP run tended to produce profiles of temp and dew point indicating that the atmosphere was close to or at saturation near the PBL top inversion during active convection.
- The new WRAP run had a more accurate surface pressure than WRAP_0. Unclear what caused this improvement.
- New WRAP had better dew point profile, but slightly degraded surface temperature relative to WRAP_0. Surface nudging.

New WRAP 12 km Run Configuration

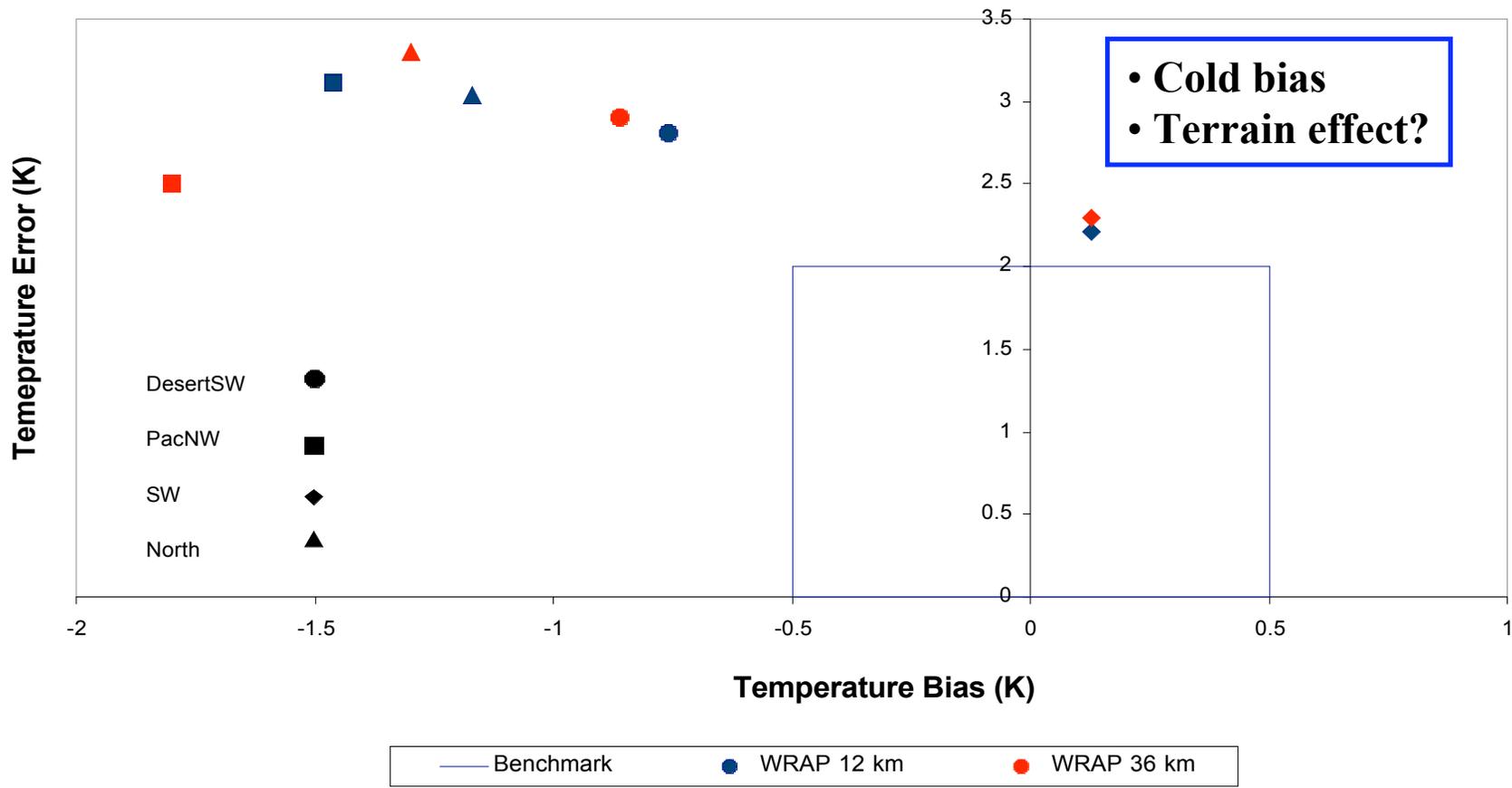
LSM	PBL	Cumulus	Microphysics	Analysis FDDA		Obs FDDA
				3D	Surface	
Pleim-Xiu	ACM	None	Reisner II	W/T/q	W	W

12 km configuration identical to 36 km grid, except for cumulus scheme

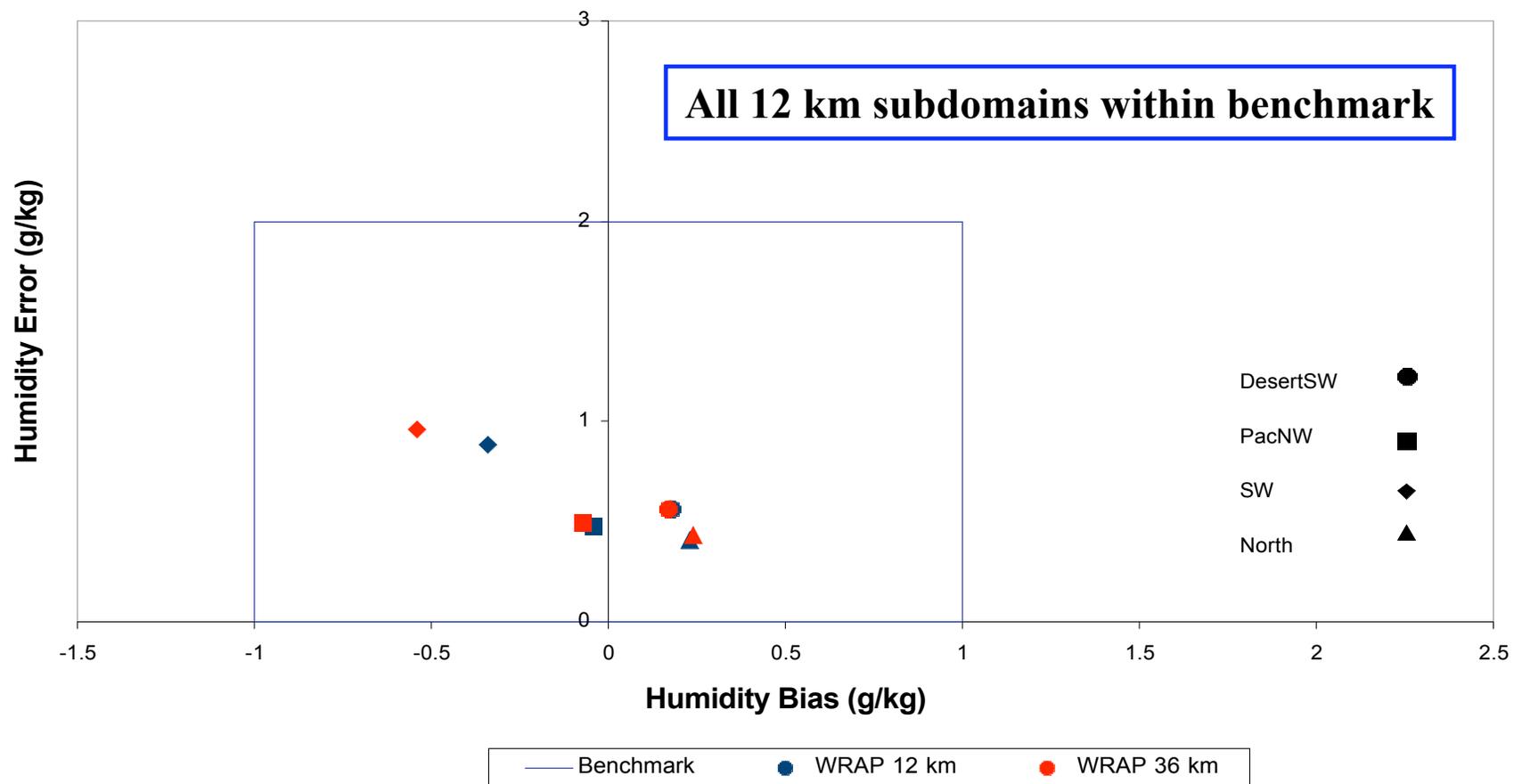
WRAP 12/36 km January Wind Performance Comparison



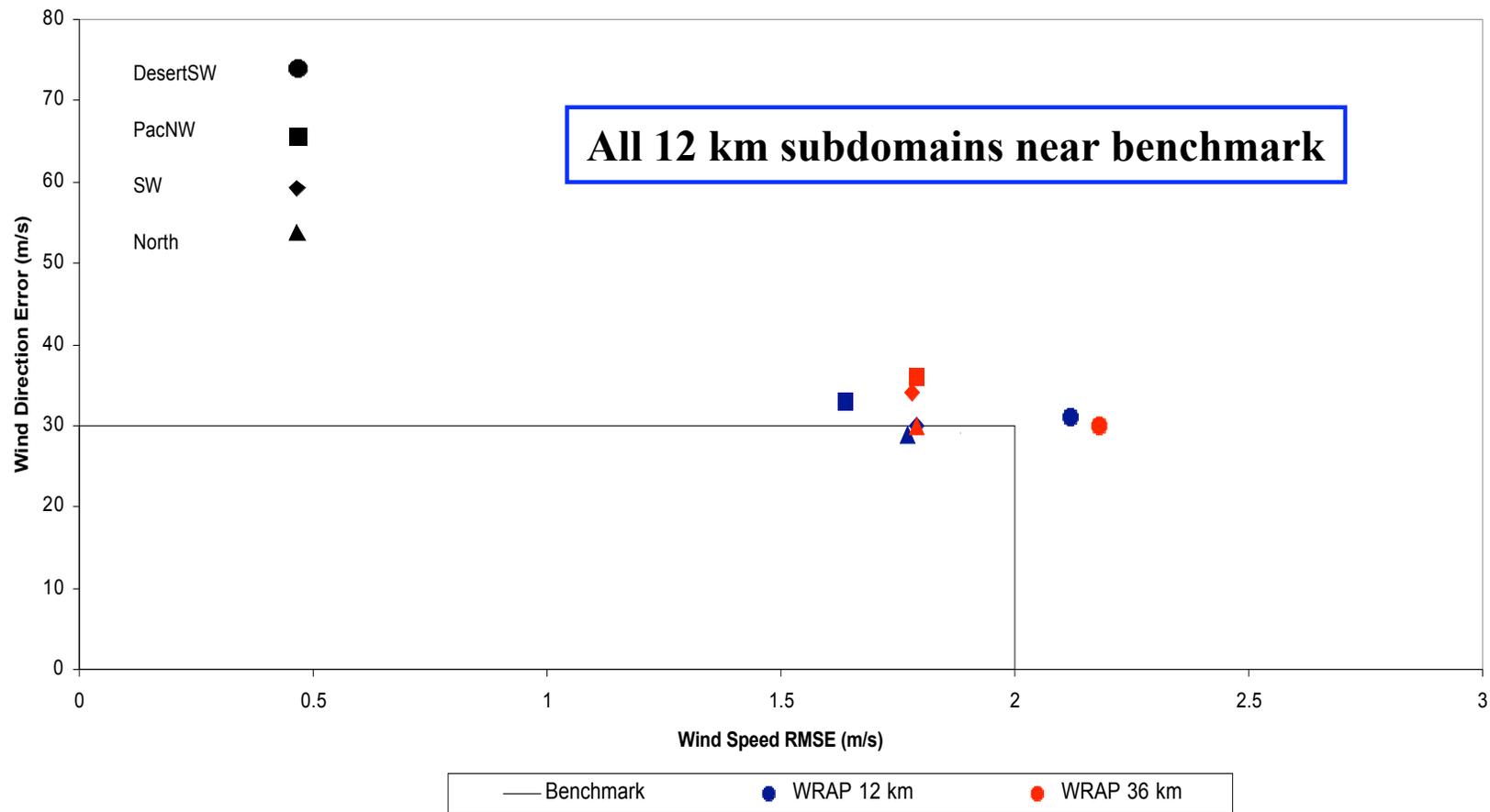
WRAP 12/36 km January Temperature Performance Comparison



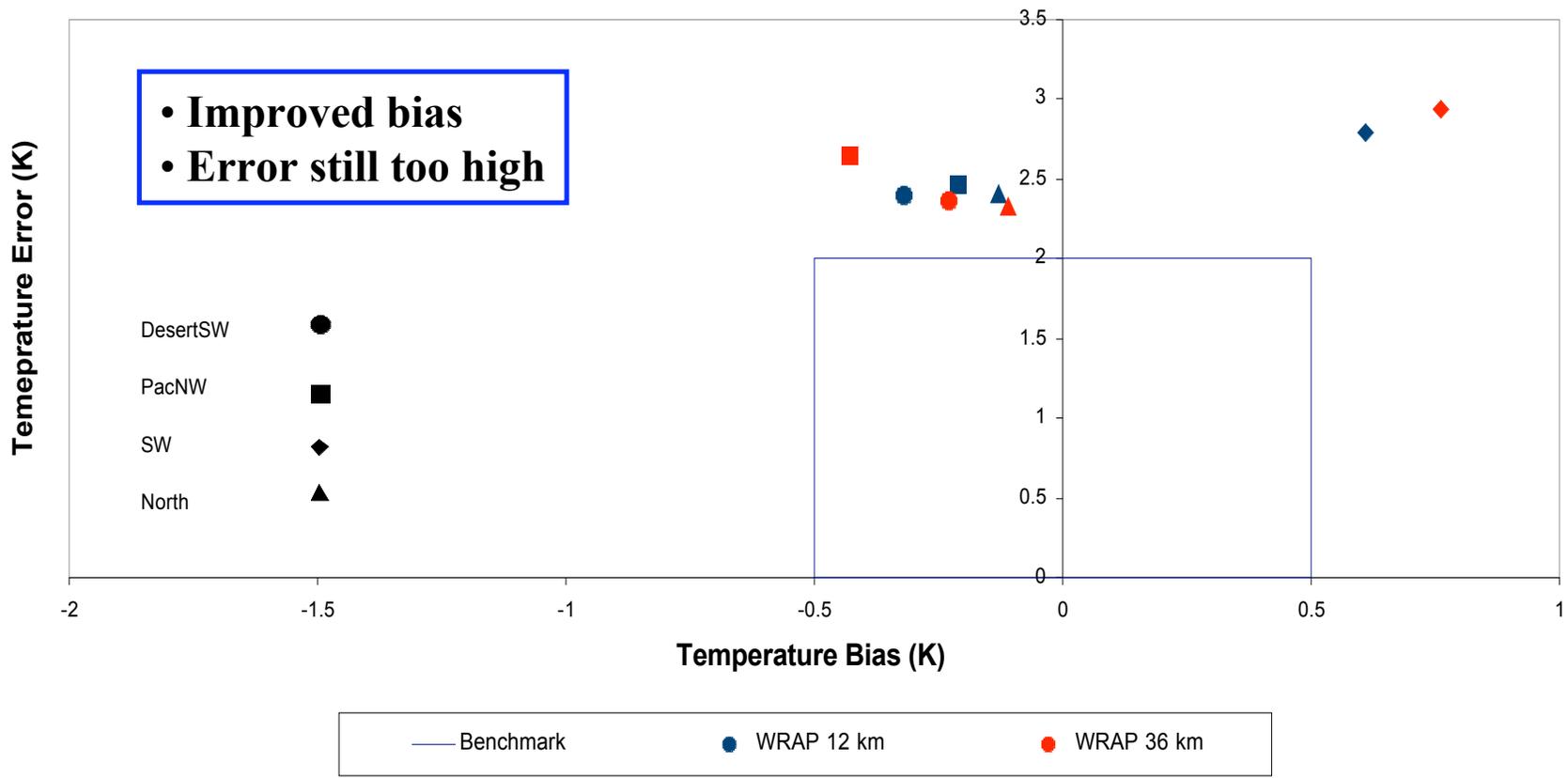
WRAP 12/36 km January Humidity Performance Comparison



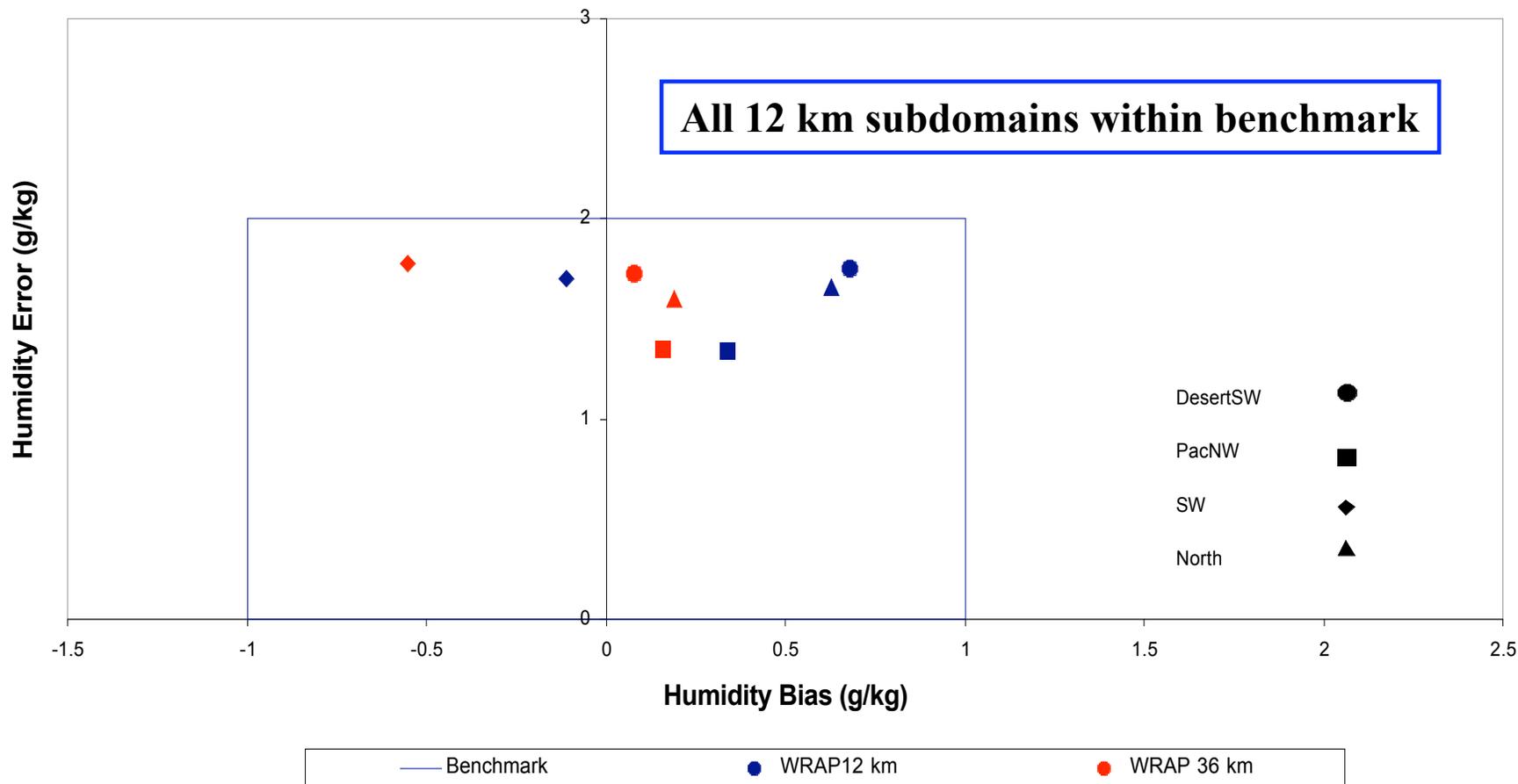
WRAP 12/36 km July Wind Performance Comparison



WRAP 12/36 km July Temperature Performance Comparison



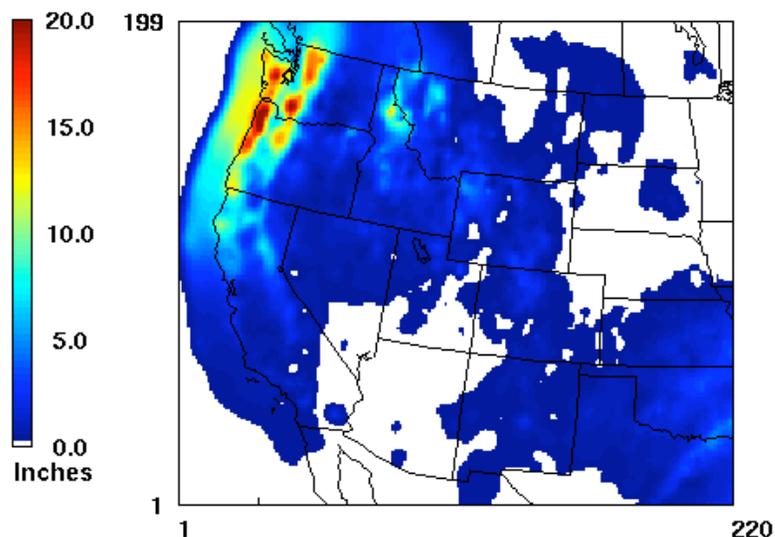
WRAP 12/36 km July Humidity Performance Comparison



January 12 km Run Total Precipitation Comparison

CPC Observed Precipitation

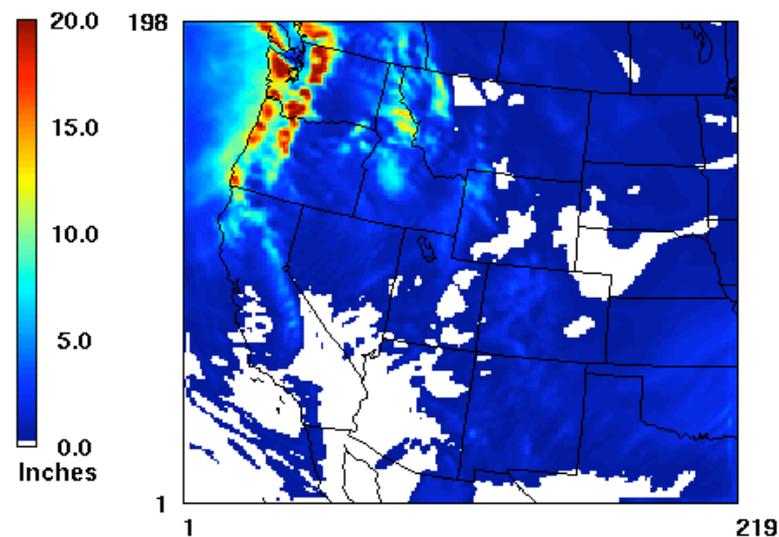
January 2-31, 2002
WRAP 12 km Grid



January 2, 2002 0:00:00
Min= 0.0 at (1,1), Max= 22.6 at (35,161)

MM5 Total Precipitation: WRAP

January 2-31, 2002
12 km Grid

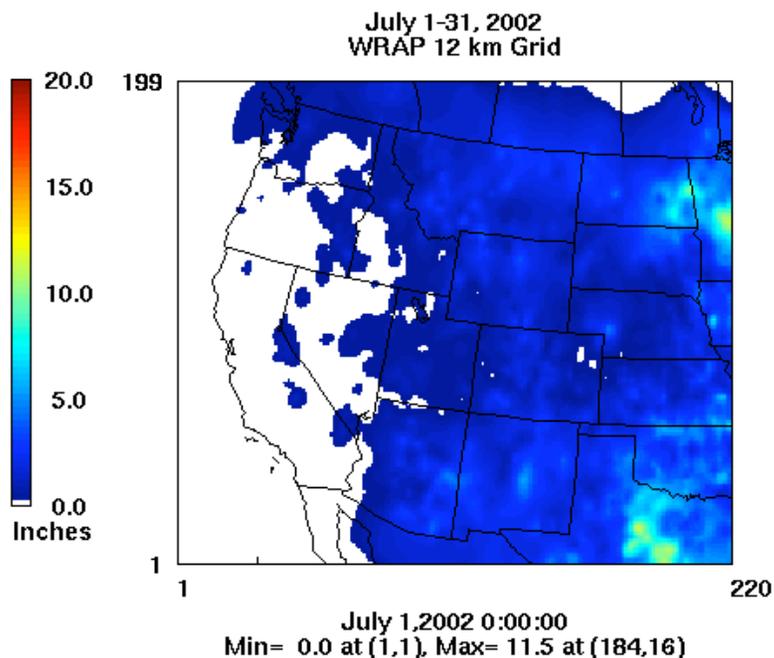


January 1, 2002 0:00:00
Min= 0.0 at (67,48), Max= 27.1 at (40,178)

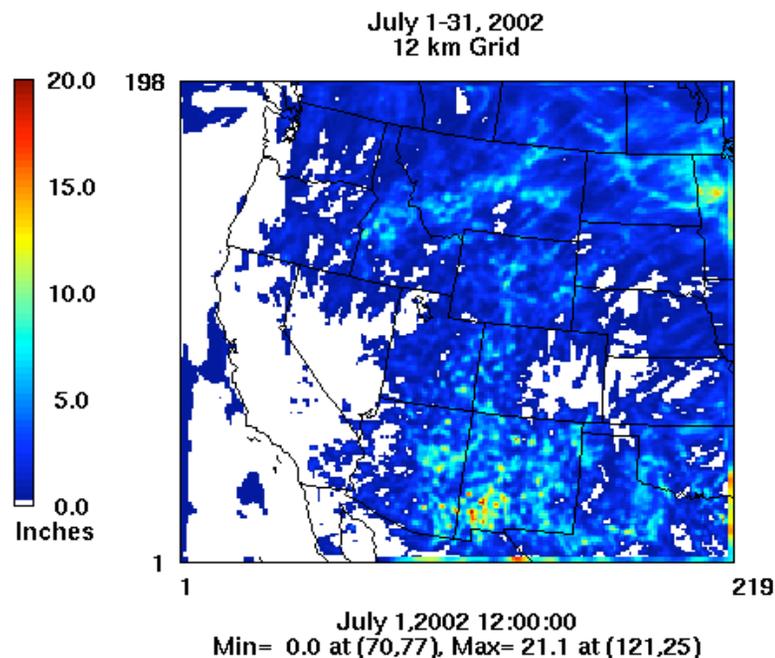
- Precipitation predicted with good skill overall
- Overprediction in North subdomain
- Rainfall too intense in parts of pacNW subdomain

July 12 km Run Total Precipitation Comparison

CPC Observed Precipitation



MM5 Total Precipitation: WRAP



- Widespread over prediction of rainfall—no cumulus parameterization
- MM5 precipitation field more detailed than coarse CPC dataset
- General pattern OK

Summary of 12 km Results

- **12 km run is within or near performance benchmarks for surface wind and humidity over the annual cycle of 2002.**
- **Surface temperature generally falls outside the bias benchmark. It is possible that this is due to terrain resolution effects.**
- **The new 12 km WRAP run has been significantly improved in terms of its surface performance relative to the WRAP_0 12 km run.**
- **Improvement in summer rainfall and surface humidity performance in the WRAP region reduces biases of original 12 km run.**

Conclusions

- **The new 36 km and 12 km WRAP runs represent a significant improvement in performance over the original WRAP_0 run.**
- **At both 12 km and 36 km resolutions, the new WRAP 2002 MM5 simulation produced results that are generally within the range of meteorological model results that have been used in the past for air quality applications.**
- **It is therefore reasonable to proceed with their use as inputs for future CMAQ visibility modeling.**