Statistical Post-Processing in MDL

NCEP Model Review

December 12, 2007

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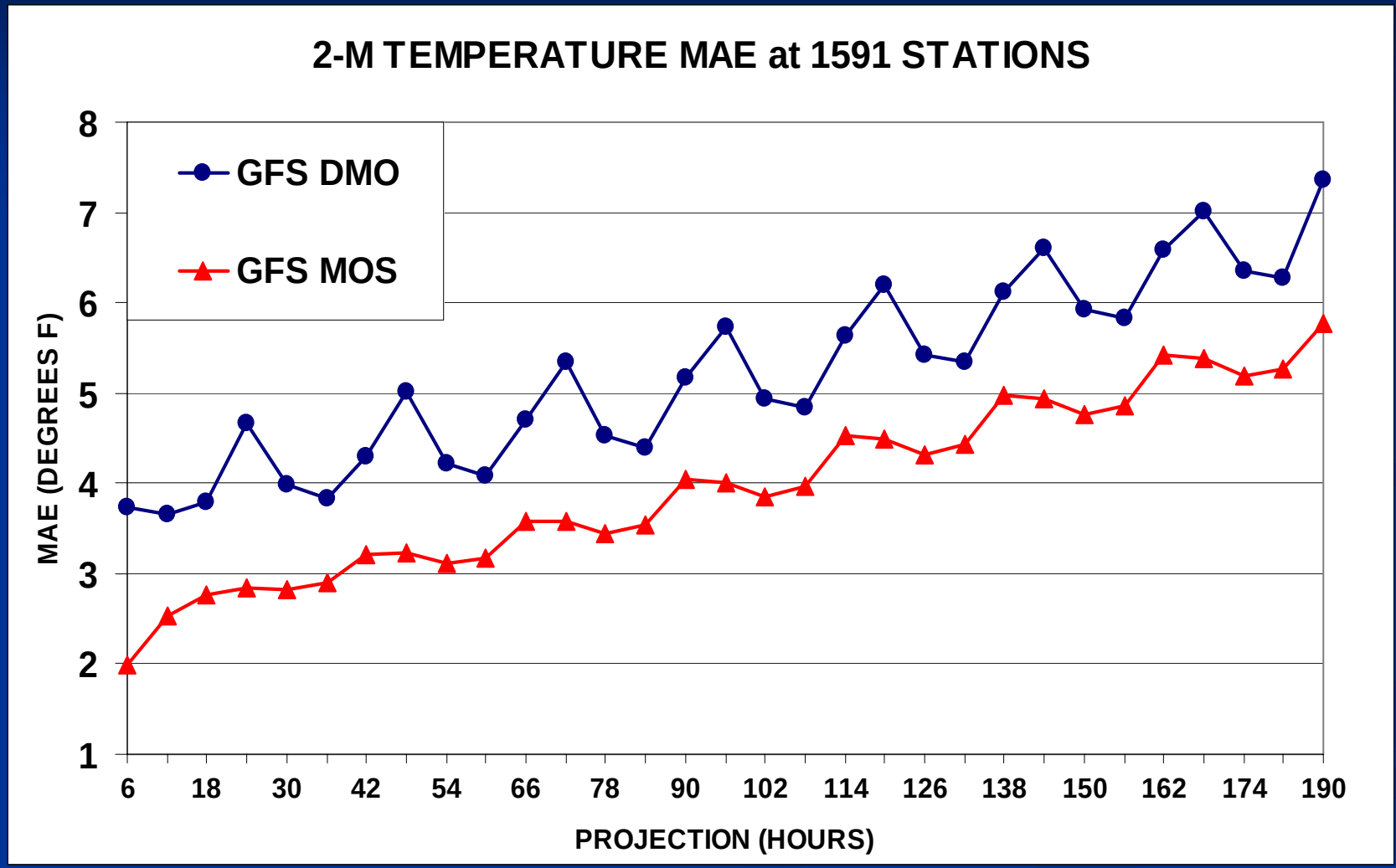
Why do statistical post-processing?

- Add value to direct model output (DMO)
  - Remove model bias
- Produce guidance for surface-based sensible weather elements
- Downscale to finer resolution of NDFD grids
- Produce station-specific guidance (i.e. for TAFs)
- Provide reliable probabilistic guidance
- Interpret ensemble forecast systems

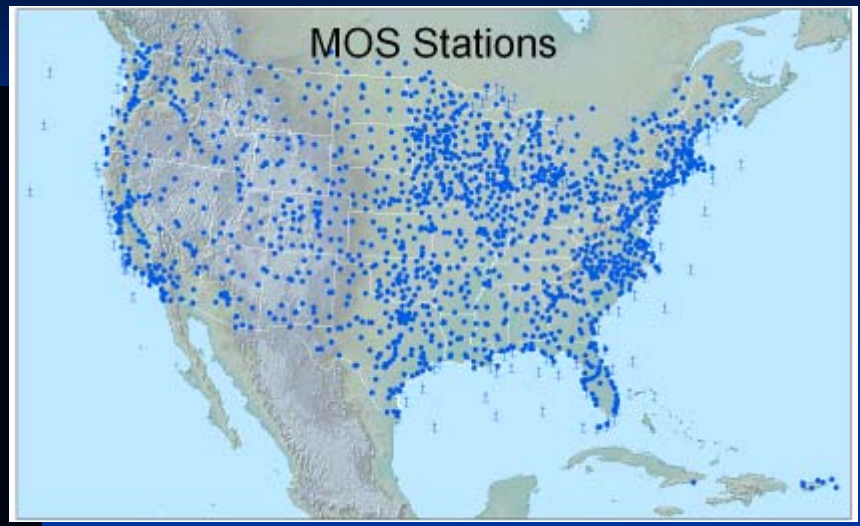
Temperature Verification - 0000 UTC
GFS MOS vs. GFS DMO



April 2004 through May 2006

Station-based MOS Products

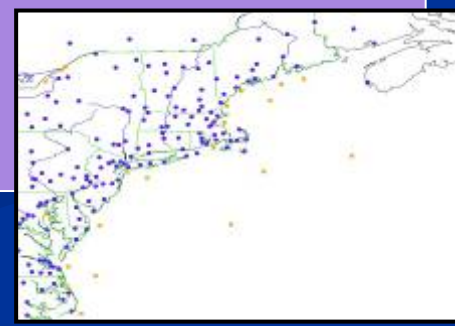
```
GFSX MOS (MEX)
KBWI GFSX MOS GUIDANCE 4/24/2007 1200 UTC
   WED 25|THU 26|FRI 27|SAT 28|SUN 29|MON 30|TUE 01|WED CLIMO
N/X 51 65| 50 60| 53 75| 57 71| 50 70| 47 71| 48 72| 53 47 69
TMP 55 58| 52 56| 56 68| 60 62| 55 62| 54 63| 54 65| 58
DPT 46 48| 47 51| 55 56| 54 49| 46 44| 45 46| 46 46| 51
WND  4  6|  7 11|  9 13|  7 10|  9 17| 10 18|  9 17|  7
P12 21 72| 64 40| 77 56| 51 22| 20 13| 18 17|  7 17| 24 26 24
P24    72|    80|    92|    65|    25|    19|    21| 37
Q12  0  2|  1  1|  3  2|  2  0|  0  0|  0  0|      |
Q24     2|     2|     3|     2|     0|     0|      |
T12  6 14|  9  5| 22 37| 15  5|  6  5|  6 11|  8  9|  9
T24      |   15 |   22 |   47 |    9 |   11 |   11 | 12
```



- GFS-based through 7 days
- Eta-based through 84 hours
- NGM-based through 60 hours

```
44004  GFS MOS GUIDANCE   11/22/2005  1200 UTC
DT  /NOV 22/NOV 23                  /NOV 24                  /NOV 25
HR   18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 03 06
TMP  58 53 49 49 50 48 46 44 44 45 47 48 51 54 56 60 62 61 59 51 47
WD   23 25 27 28 28 29 29 28 28 27 27 25 22 22 22 23 23 23 24 27 28
WS   33 31 29 25 23 22 24 25 23 18 14 12 14 19 26 29 30 29 29 28 24
WS10 36 34 31 26 25 24 26 27 25 19 15 13 15 21 28 31 32 31 31 30 26

DT  /NOV 25         /
HR   09 12 15 18 21 00
TMP  45 45 45 47 47 47
WD   29 29 28 30 29 34
WS   18 15 10 10 13 12
WS10 20 16 11 11 14 13
```

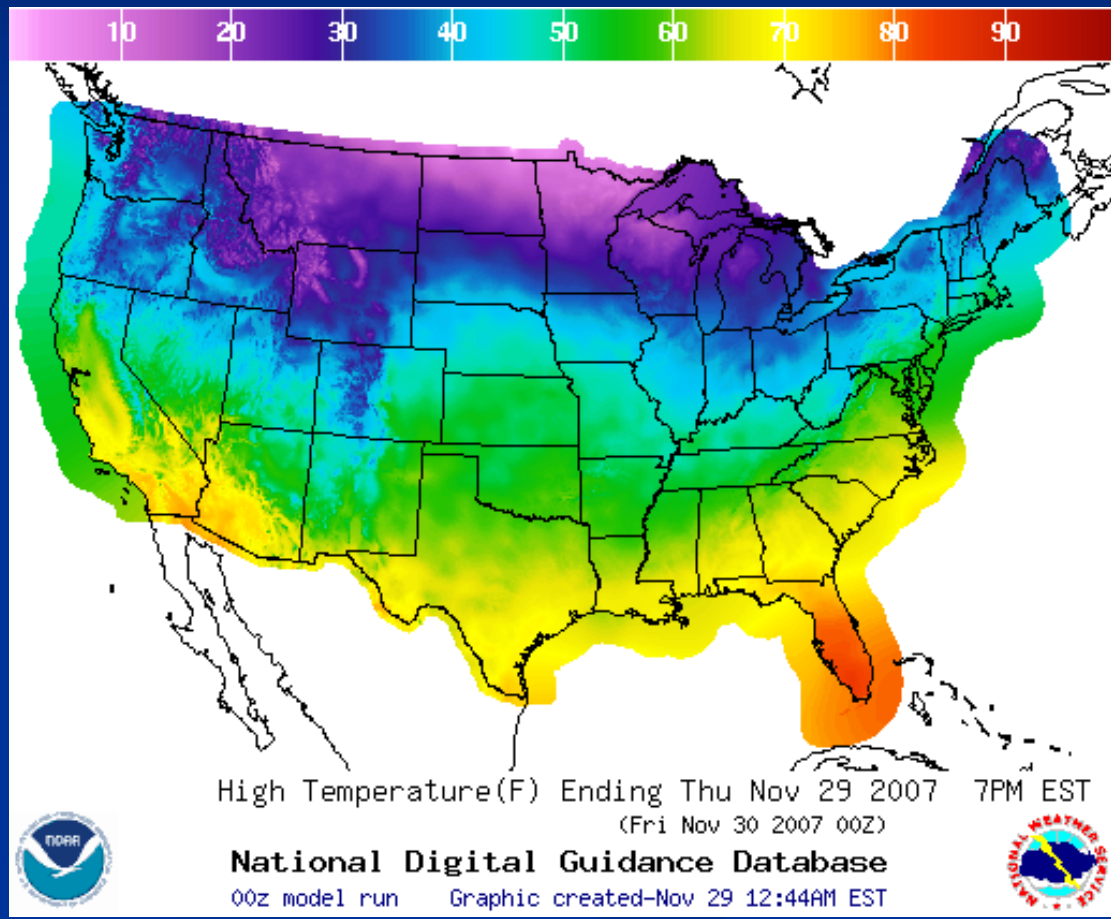


GFS-based Gridded MOS Guidance for the CONUS (5km grid)

Guidance available out to 192 hours

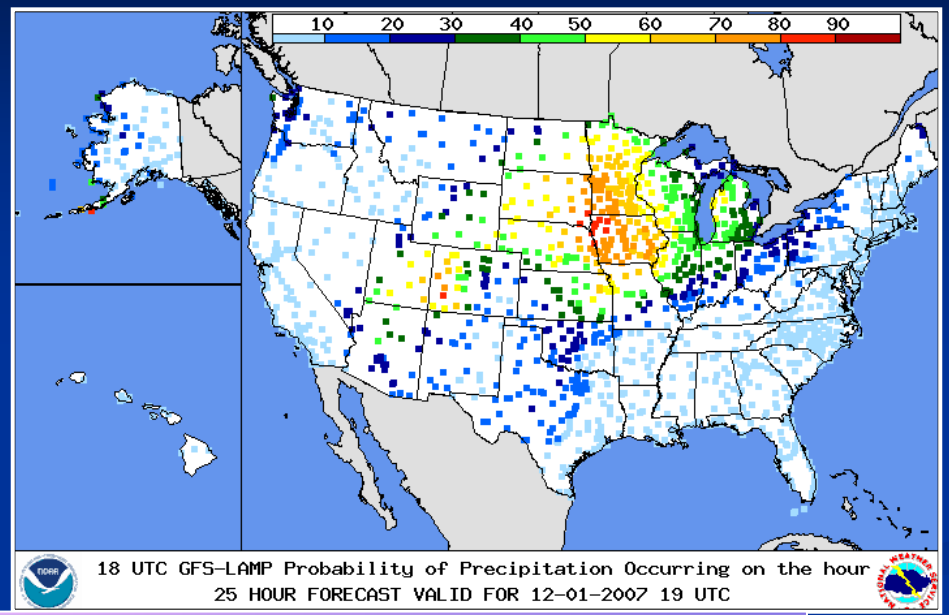
Current Elements:

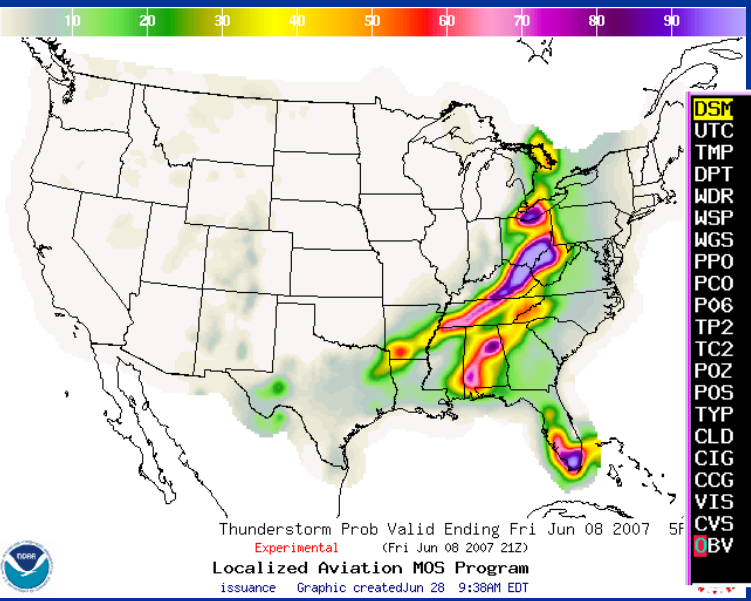
- Surface Temperature
- Dew Point
- Max/Min Temperature
- Wind Speed/Direction
- Wind Gusts
- Probability of Precipitation
- Precipitation Amount
- Opaque Sky Cover
- Snowfall Amount
- Relative Humidity
- Probability of Thunderstorms



LAMP Products

- LAMP acts as an update to MOS guidance
- goes out 25 hours in 1 hour projections
- Station Guidance (~1600 stations)
  - all elements; CONUS, Alaska, Hawaii, Puerto Rico
- Gridded Guidance (20 km)
  - Thunderstorms; CONUS
- 12 cycles operational; 24 cycles by early 2009





DSM GFS LAMP GUIDANCE 11/30/2007 1800 UTC

UTC	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
TMP	27	28	28	27	25	23	23	23	24	24	24	24	24	25	25	26	27	28	27	27	28	30	32	33	34
DPT	2	2	2	2	2	2	3	5	6	7	8	9	10	11	12	14	16	18	18	20	22	24	26	28	32
WDR	33	33	33	35	02	06	09	10	11	12	12	12	12	12	11	11	11	11	11	11	12	12	12	12	12
WSP	10	09	08	07	05	04	05	05	05	06	07	07	08	09	09	11	13	15	15	16	17	16	16	15	17
WGS	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	24	23	23	22	24
PPO	0	0	0	0	0	0	0	1	1	2	3	3	10	17	22	28	33	36	44	51	58	64	69	72	73
PCO	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
P06						0						0						24					100		
TP2			0	0	0	0	0	0		0		0		1		1		1		0		1		1	
TC2			N	N	N	N	N	N		N		N		N		N		N		N		N		N	
POZ	1	1	1	1	1	2	3	3	3	3	3	3	4	2	3	13	25	26	28	26	26	24	22	22	19
POS	98	99	99	99	99	98	97	97	97	97	97	97	97	98	97	81	59	47	42	40	38	32	31	30	27
TYP	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	Z	Z	Z	Z	Z	Z	Z	Z	Z
CLD	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	B													
CIG	8	8	8	8	8	8	8	8	8	8	8														
CCG	7	6	6	7	6	7	7	6	7	7															
VIS	7	7	7	7	7	7	7	7	7	7															
CVS	7	7	7	7	7	7	7	7	7	7															
OBV	N	N	N	N	N	N	N	N	N	N															

Post-processing Ensemble Systems

the here and now…

- MOS equations (from previous development) applied to individual ensemble members

Text 1: MENBOI

File Edit Options Version Tools Scripts Products Help

AFOS Browser | Load History | WMO Search | Enter Editor | Accum | Update Obs | Clear

AFOS Cmd: WMO TTAAii CCCC: AWIPS ID:

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KBOI   ENSEMBLE MOS GUIDANCE   11/30/2007  0000 UTC 43.57 -116.22
FHR  24| 36  48| 60  72| 84  96|108 120|132 144|156 168|180 192
FRI  30| SAT 01| SUN 02| MON 03| TUE 04| WED 05| THU 06| FRI 07 CLIMO
X/N
GFS  34| 22  33| 24  39| 34  47| 35  48| 34  47| 32  42| 30  40 25 40
AVG  33| 22  33| 26  40| 31  43| 31  43| 29  43| 30  43| 30  41
STD   1|  0   0|  2   2|  3   2|  2   1|  1   1|  1   2|  1   3
HI   37| 24  35| 30  44| 37  47| 37  48| 34  47| 34  48| 34  46
LOW  32| 22  32| 21  32| 24  37| 28  41| 26  41| 28  40| 26  35
P12
GFS   8|  2   3|  4  30| 36  11| 23  21| 33  31| 19  22| 24  22 26 28
AVG  13| 14  17| 14  27| 29  17| 25  33| 31  30| 22  22| 23  23
STD   7|  3   3|  3   8|  7   8|  7   6|  3   2|  4   2|  4   2
HI   33| 18  21| 21  42| 46  37| 41  40| 40  32| 35  31| 29  28
LOW   8|  2   3|  4  14| 17   6| 13  21| 27  24| 18  20| 18  19
P24
GFS    |     4|     30|     40|     35|     50|     28|     38    41
AVG 999|999  21|999  39|999  31|999  42|999  40|999  30|999  35
STD   0|  0   4|  0   8|  0   6|  0   6|  0   7|  0   5|  0   5
HI  999|999  29|999  57|999  46|999  51|999  54|999  46|999  45
LOW 999|999   4|999  24|999  18|999  27|999  27|999  25|999  29
Q12
GFS   0|  0   0|  0   0|  1   0|  0   0|  1   1|  0     |
AVG   0|  0   0|  0   0|  0   0|  0   0|  0   0|  0 999|
STD   0|  0   0|  0   0|  0   0|  0   0|  0   0|  0   0|
HI    0|  0   0|  0   1|  2   1|  2   1|  2   1|  1 999|
LOW   0|  0   0|  0   0|  0   0|  0   0|  0   0|  0 999|
PZP
GFS   0|  0   1|  0   1|  3   2|  4   2|  0   1|  1   1|  1   1   1
AVG   0|  0   0|  0   2|  9   6| 17   8|  0   1|  1   1|  1   0
STD   0|  0   0|  0   3| 15  10| 18   8|  0   0|  0   0|  0   0
HI    0|  0   2|  0  13| 56  40| 70  34|  1   1|  1   2|  1   1
LOW   0|  0   0|  0   1|  0   0|  1   0|  0   1|  1   1|  1   0
PSN
GFS  80| 76  70| 70  67| 35  18| 12  10|  7  13| 13  36| 30  39
AVG  76| 73  68| 68  67| 44  29| 20  22| 18  21| 18  32| 25  28
STD   6|  2   1|  3   6|  7  12| 10   8|  7   5|  4   8|  7   6
HI   80| 76  71| 72  80| 65  65| 49  42| 34  36| 29  44| 35  39
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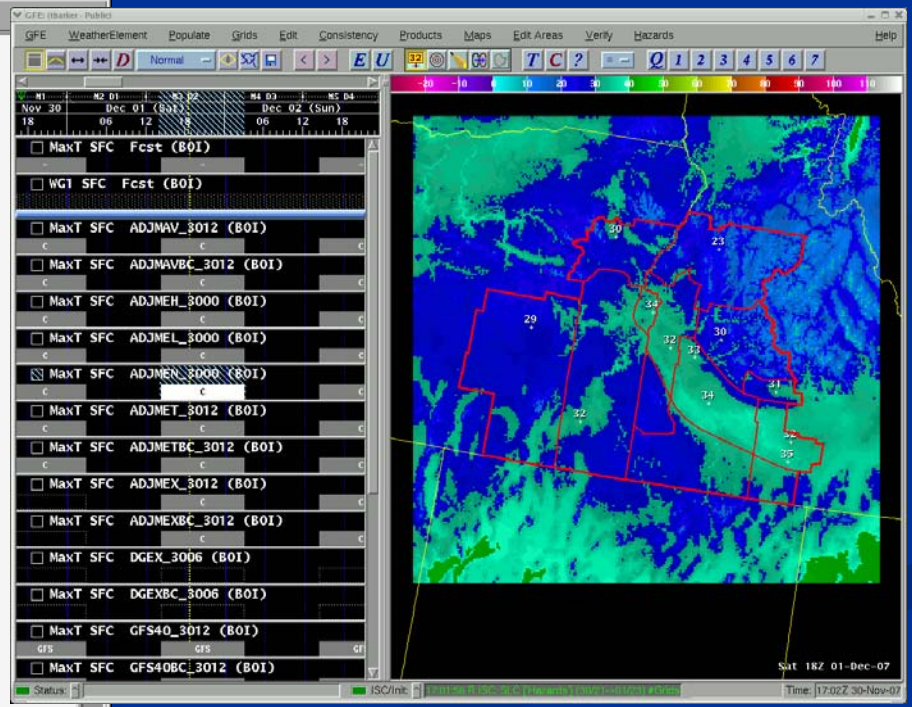


2007 MOS Implementations

http://www.weather.gov/mdl/synop/changes.htm

- GFS station-based MOS
  - April 2007:
    - Added precipitation guidance to Pacific MOS package
  - June 2007:
    - Changed from total sky to opaque cloud cover
  - September 2007:
    - Updated climatic normals available in extended-range message
    - Completed addition of stations

2007 MOS Implementations

http://www.weather.gov/mdl/synop/changes.htm

- GFS-based Gridded MOS
  - June 5, 2007:
    - Added elements QPF, snowfall amount, wind gust and sky cover
    - New analysis code with modified analysis settings including ensembling of station data
    - Expanded extent of forecast output
  - December 18, 2007:
    - Upgrades in response to user feedback:
      - Modified land/water designations
      - New precipitation amount analysis scheme
      - Removed erroneous stations

2007 LAMP Implementations

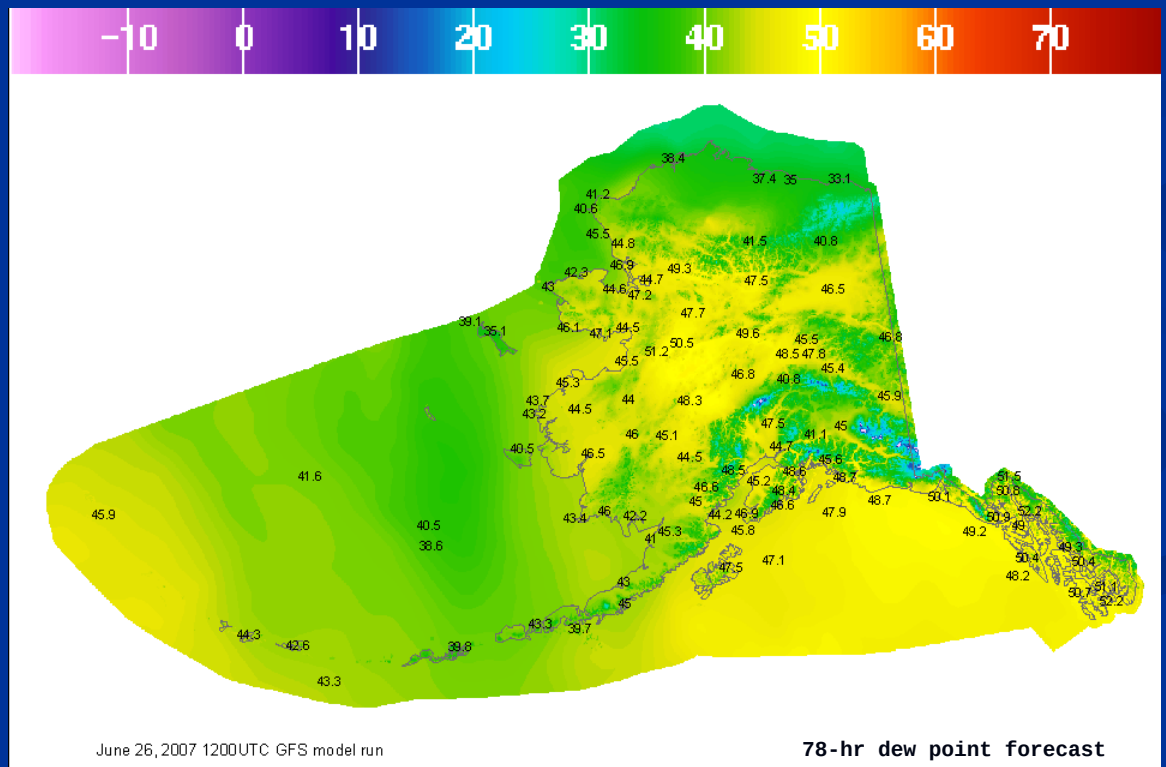
http://www.nws.noaa.gov/mdl/gfslamp/docs/changes.shtml

- Increased from 4 cycles to 12
  - May 2007 – added 0000/0600/1200/1800 UTC
  - September 2007 – added 0400/0500/1000/1100 UTC

Available LAMP cycles (UTC) as of December 2007

Planned 2008 Implementations

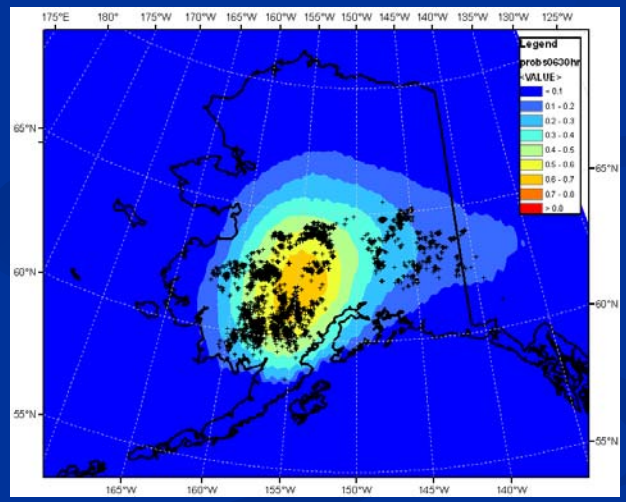
- GFS-based Gridded MOS for Alaska (3km grid)
  - Initial grids February 28, 2008 (temp, dewpt, max/min)
  - Slated for availability in AWIPS OB8.3
  - More elements added as they become available



Planned Implementations

- Removal of NGM LAMP from web/NWS ftp server
  - January 15, 2008
  - Removed from AWIPS as of OB8.1

- GFS-based probability of thunderstorm guidance for Alaska
  - May 2008
  - Added to MAV/MEX bulletins and gridded MOS



- GFS-based MOS temperature and dew point guidance for Pacific sites
  - Summer 2008

Planned 2008 Implementations

- Add more cycles of LAMP
  - 0100, 0700, 1300, 1900 UTC – March 2008
  - Remaining 8 cycles – July 2008, Winter 2009
- Prototype 2.5 km CONUS gridded MOS grids available for evaluation
  - Summer 2008
- High-resolution precipitation amount guidance based on Stage 4 precip estimates
  - Summer/Fall 2008
- Removal of NGM MOS
  - Fall 2009

Proposed Eta MOS Replacement

“Classic” Eta MOS

KORD ETA MOS GUIDANCE 9/27/2007 1200 UTC

DT	/SEPT 27						/SEPT 28						/SEPT 29						/SEPT 30		
HR	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	06	12
N/X							50				72				50				78		57
TMP	67	69	64	60	56	53	52	64	70	70	65	58	55	53	53	65	74	77	71	61	58
DPT	54	52	51	50	48	46	46	48	45	44	44	47	47	47	48	50	49	49	51	55	53
CLD	OV	BK	SC	SC	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	FW
WDR	23	27	30	30	29	28	30	32	33	34	06	11	16	17	17	18	18	19	17	19	20
WSP	09	10	08	06	05	05	04	07	08	07	06	02	02	02	04	08	09	10	08	08	08
P06		19		3		6		1		0		0		1		3		3		8	10
P12						6				1				1				6			12
Q06			0		0		0		0		0		0		0		0		0	0	0
Q12						0				0				0				0			0
T06		1/ 0		9/ 7		0/ 0		0/ 7		0/ 0		0/ 1		0/ 0		0/ 8		2/ 0	999/99		
T12				9/ 7				0/ 7				0/ 1				0/ 8		999/99			
SNW						0								0							0
CIG	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
VIS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
OBV	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

- All Eta model input
- All elements use Eta-based equations

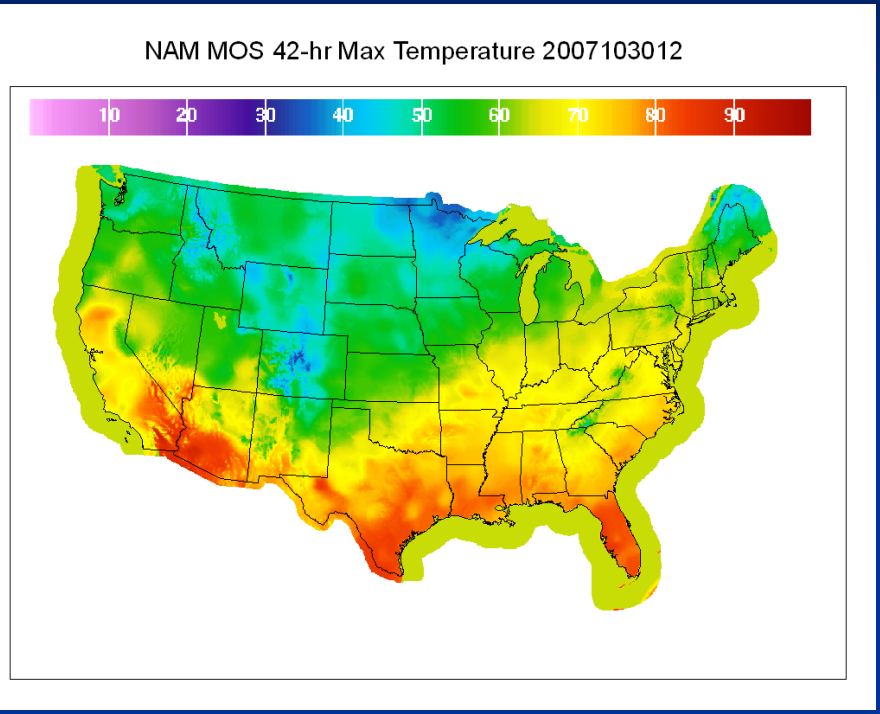
Hybrid Prototype “NAM MOS”

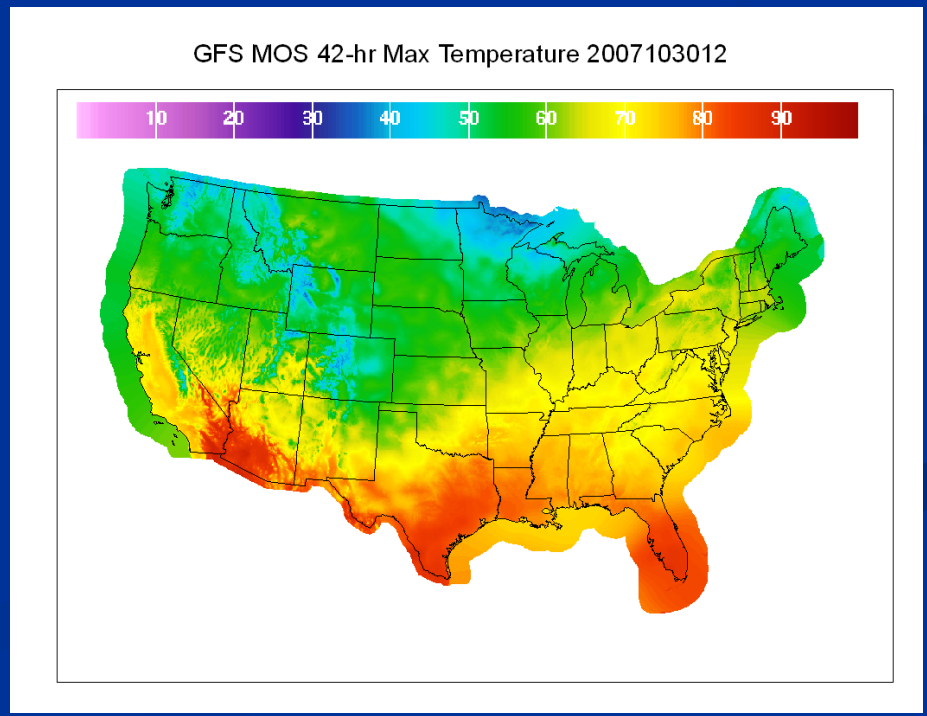
KORD NMM MOS GUIDANCE 9/27/2007 1200 UTC

DT	/SEPT 27						/SEPT 28						/SEPT 29						/SEPT 30		
HR	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	06	12
N/X							51				74				49				76		58
TMP	67	65	62	60	57	52	52	63	71	73	69	59	53	51	50	63	72	76	73	60	58
DPT	54	53	53	51	49	48	48	48	47	45	45	47	47	47	48	50	50	50	51	52	55
CLD	OV	OV	SC	FW	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	FW	FW
WDR	23	27	30	30	29	28	30	32	33	34	06	11	16	17	17	18	18	19	17	19	20
WSP	09	10	08	06	05	05	04	07	08	07	06	02	02	02	04	08	09	10	08	08	08
P06		19		3		2		1		1		0		0		3		5		8	10
P12						3				1				0				7			14
Q06			0		0		0		0		0		0		0		0		0	0	0
Q12						0				0				0				0			0
T06		1/ 0		6/ 1		0/ 0		0/ 3		0/ 0		0/ 0		0/ 0		0/ 1		4/ 0	999/99		
T12				6/ 1				0/ 3				0/ 0				0/ 1		999/99			
SNW						0								0							0
CIG	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
VIS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
OBV	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

- All NMM model input
- Redeveloped elements use new NMM-based equations
- Other elements use older Eta-based equations applied to NMM

Prototype gridded NAM MOS





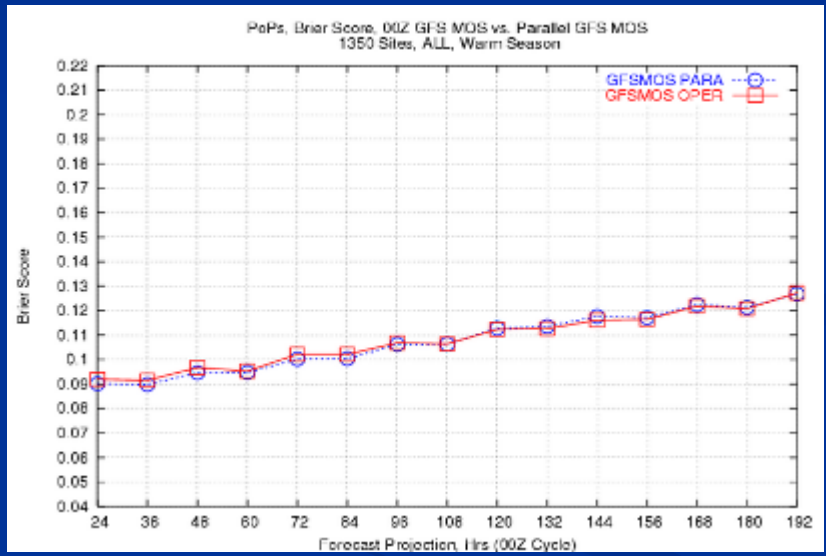
Verification Work in MDL

- **Monthly Point Forecast Verification**
  - Verify max/min, 12-h POP, dew point, temp, wind speed/direction and sky cover using METAR observations at 1000 stations in the CONUS
  - Comparative verification of NDFD, point MOS, gridded MOS and HPC
- **Monthly Gridded Verification**
  - Compare NDFD to RTMA
  - Verify surface temperature, dew point and wind speed
  - Plan to add DNG, GMOS and HPC guidance
- **Other projects**
  - Verification of NAEFS bias-corrected forecasts, NDFD, GMOS, and point MOS using the RTMA and METAR observations

Collaboration

- Share data, promote common file standards (GRIB2)

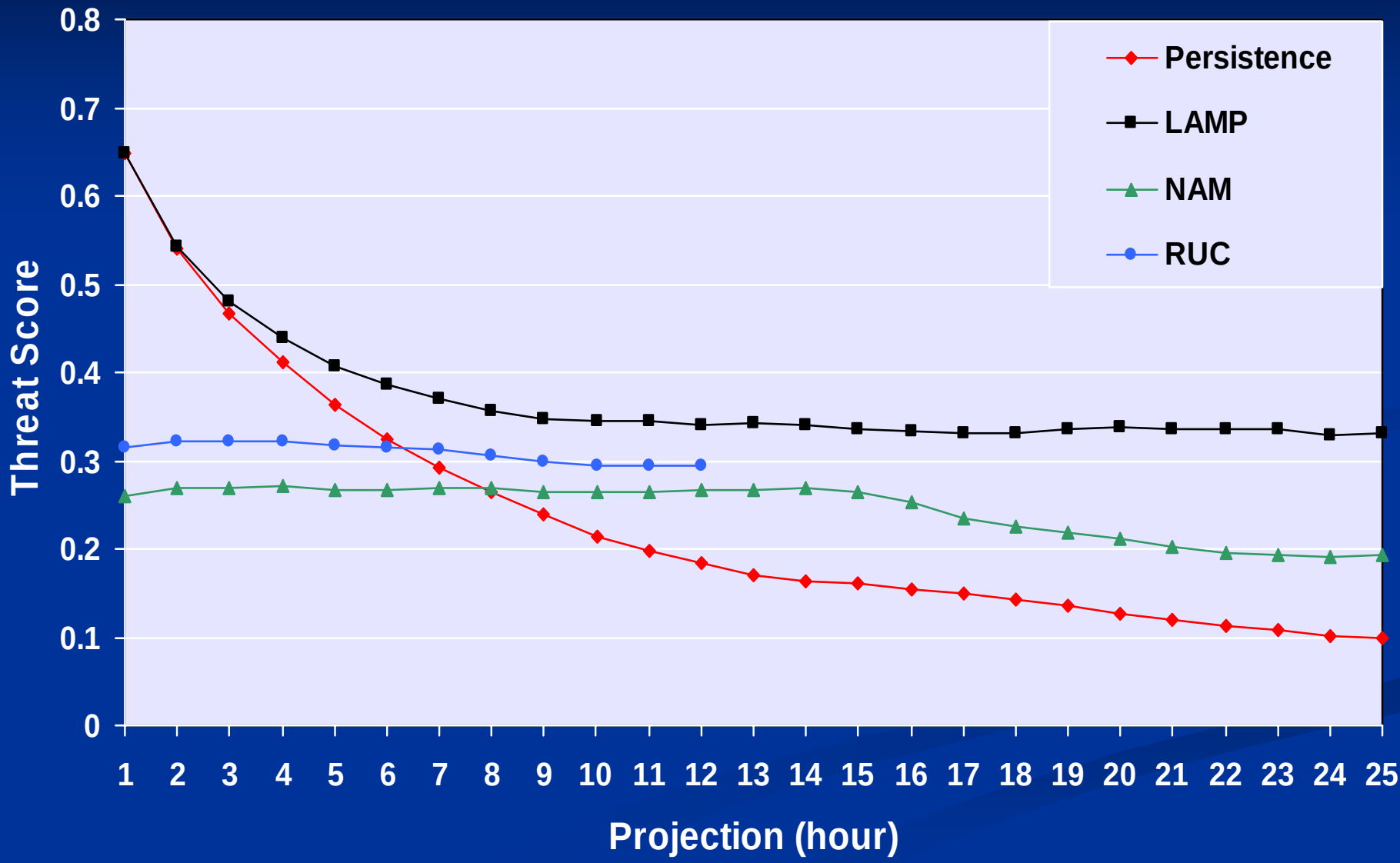
- Product Evaluations
  - Additional human experts examine model output, assisting in checkout



  - Evaluations of downscaled products

Ceiling Height Verification for 0000 UTC

Threat of Ceiling Height < 1000 Feet

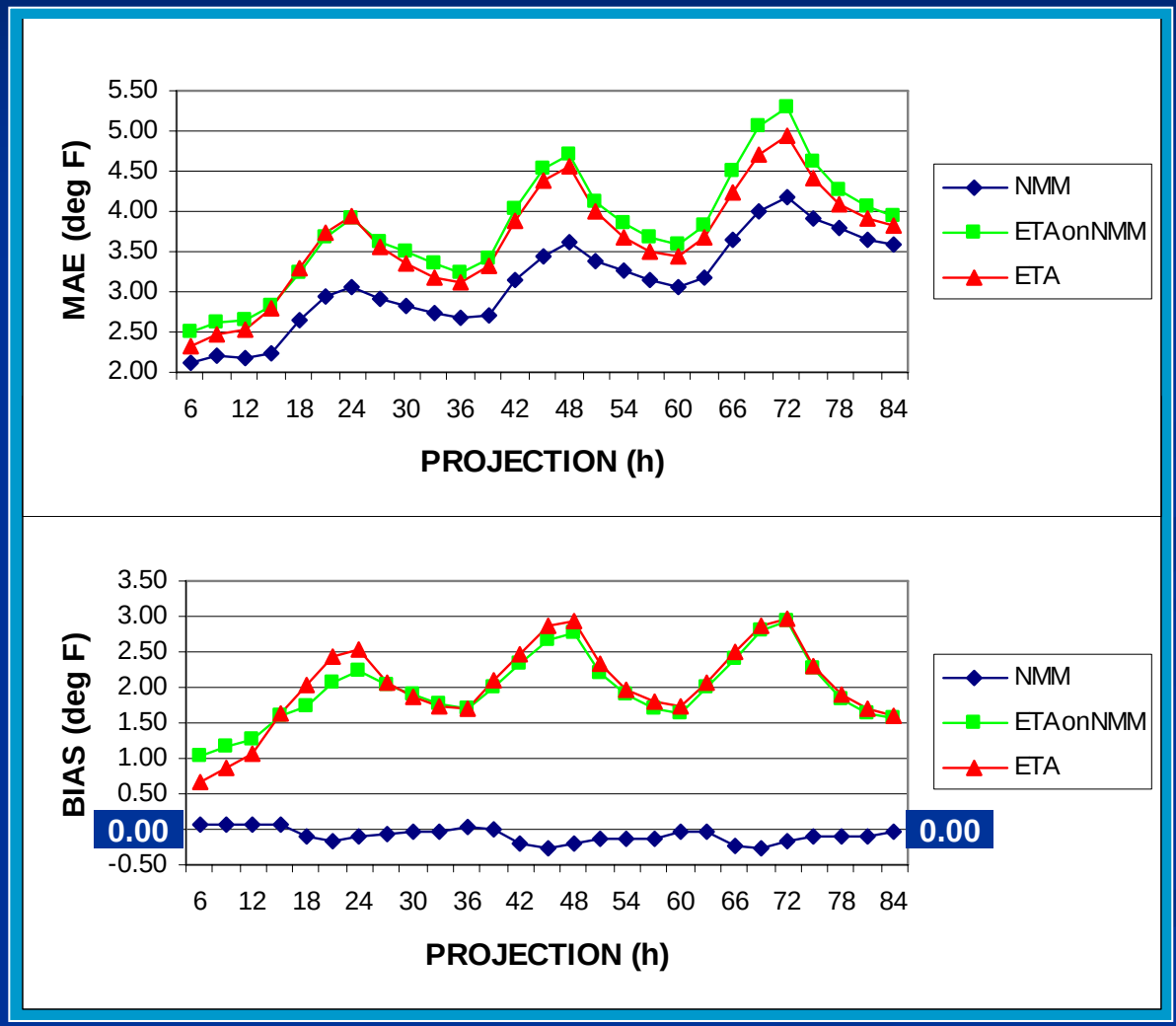


October 2006 – March 2007; CONUS; 1462 Stations

Retrospective Runs

- Minimize time lag between significant model changes and availability of quality guidance
- Minimum of 2 years preferable
- NMM development work shows promise for small-sample development

NAM / Eta MOS Dewpoint Comparison

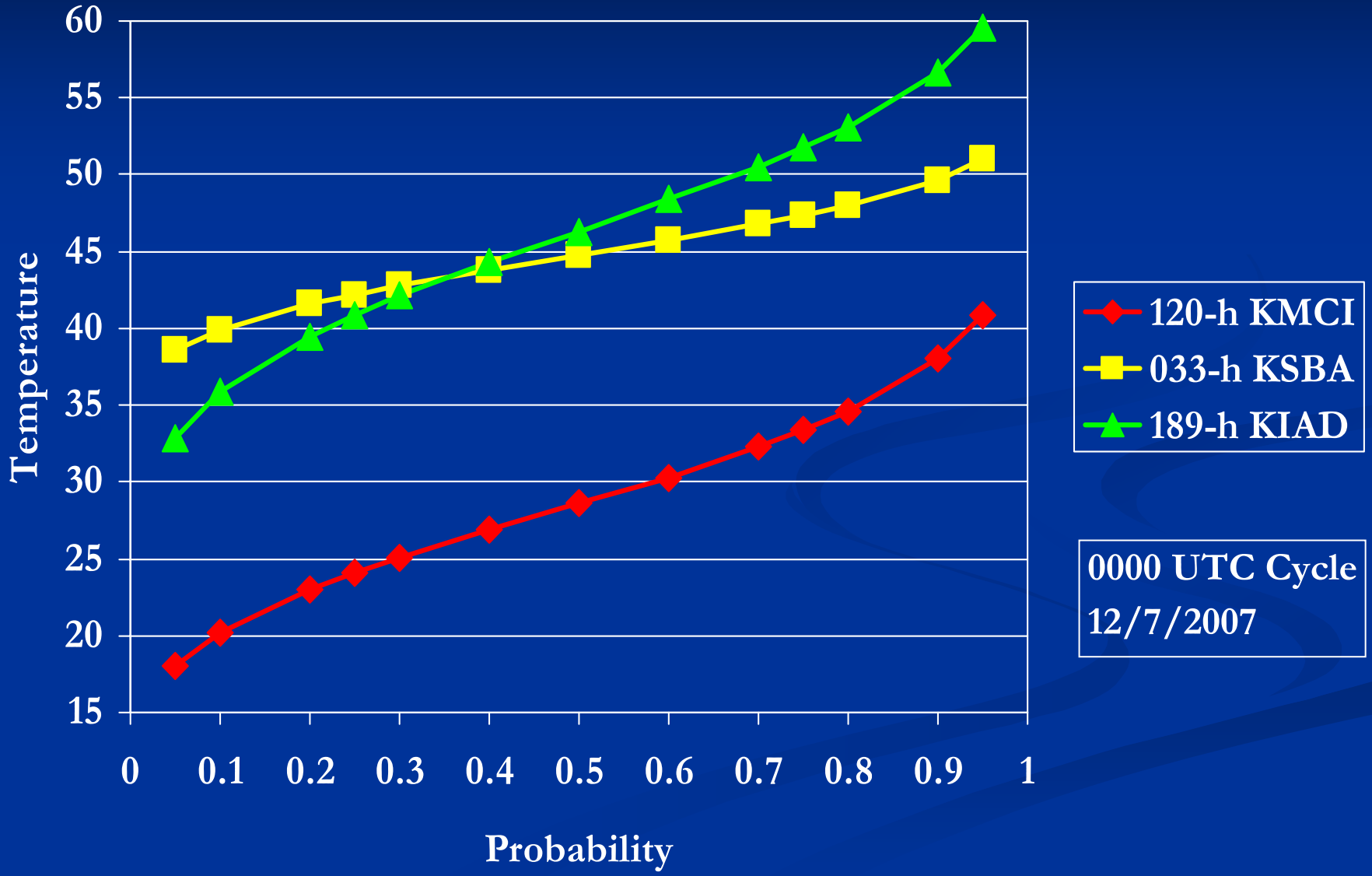


Jul 15-31, 2006 and May 1-15, 2007

Overview

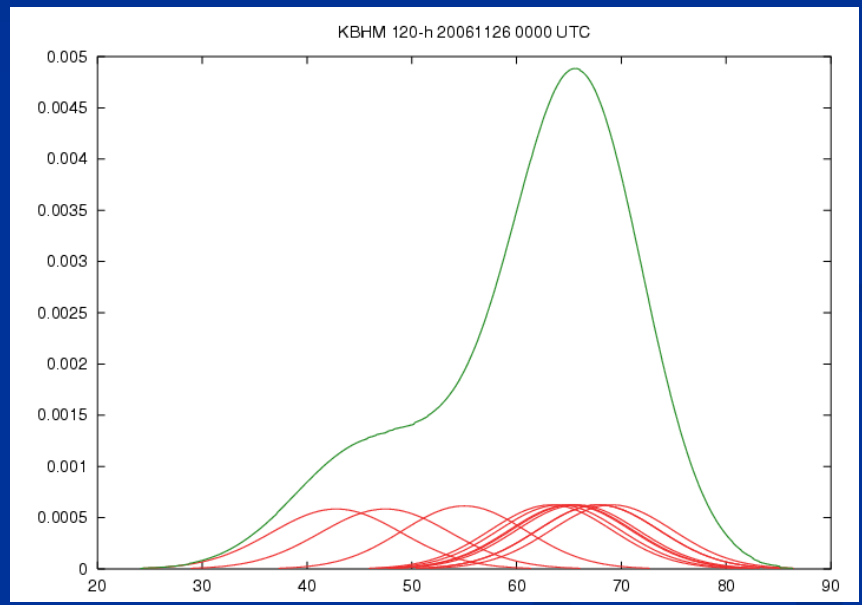
- Goal: Provide probabilistic guidance for all surface weather variables in gridded form in the National Digital Guidance Database (NDGD).
- Model data from NCEP's Global Ensemble Forecast System (GEFS)
- Same stations and time projections as GFS MOS.
- Weather Elements to date:
  - Temperature
  - Dew Point
  - Maximum Temperature
  - Minimum Temperature

Sample Temperature Forecasts

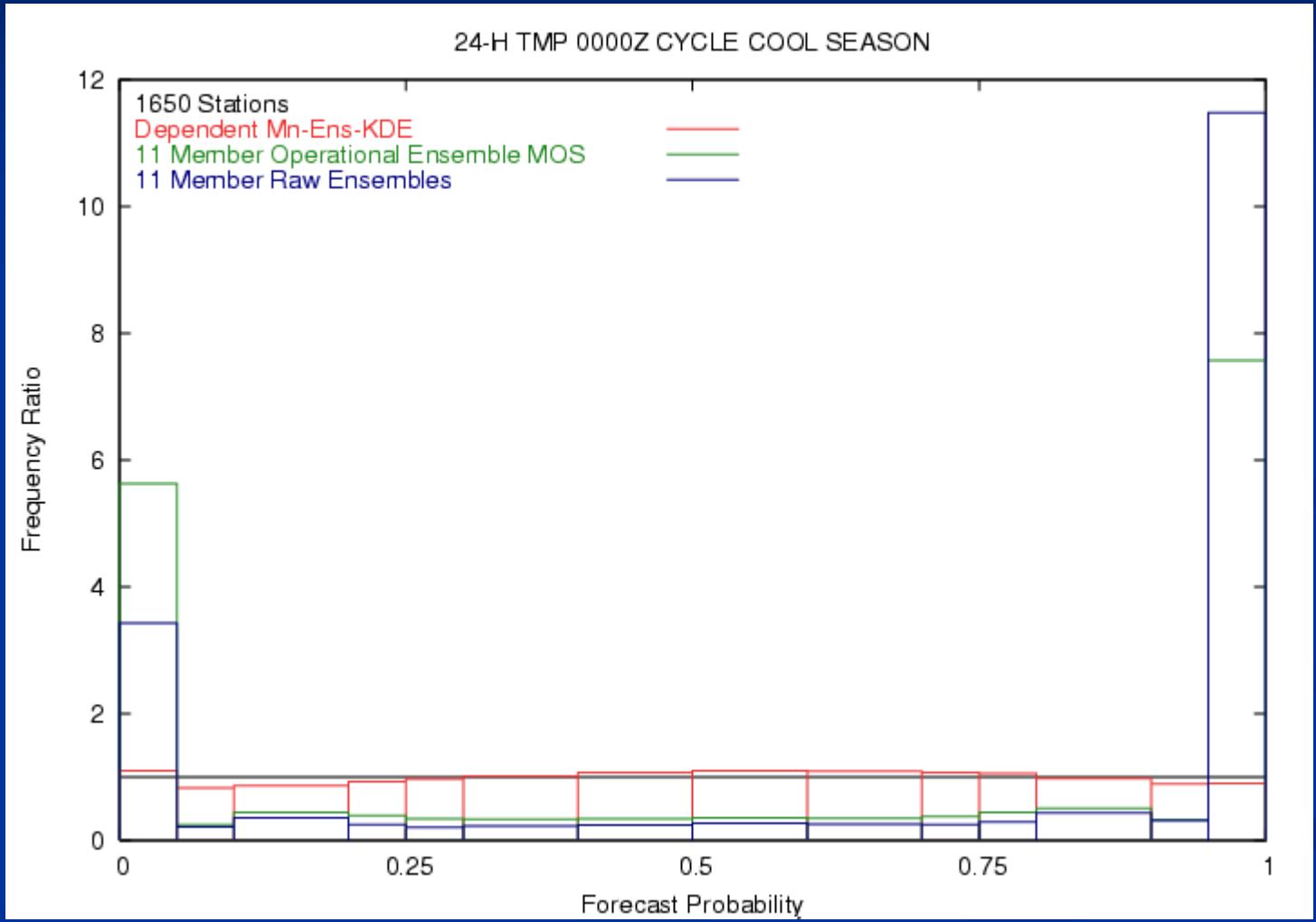


Technique

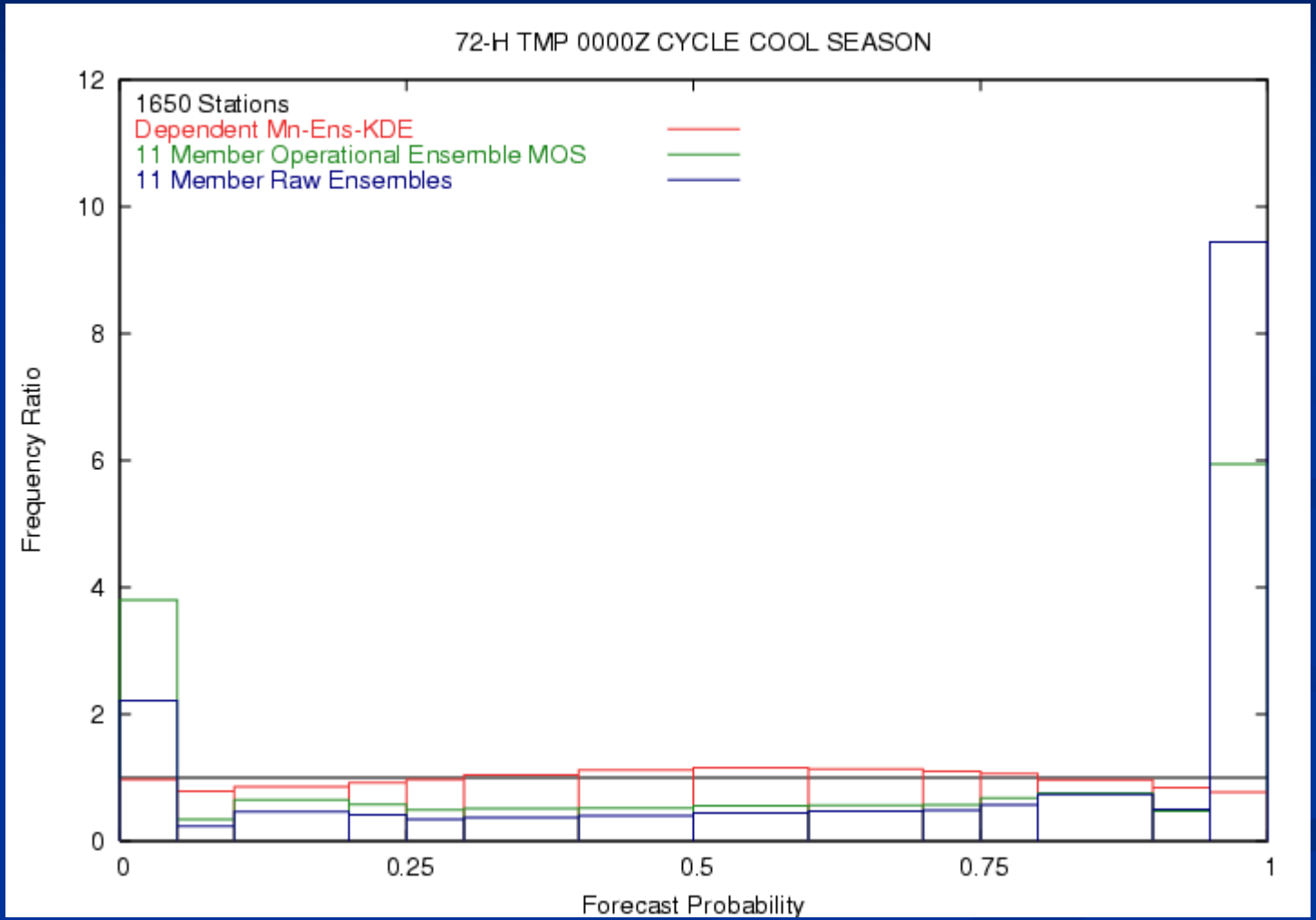
- Use linear regression framework to assess uncertainty.
- Develop MOS equations using ensemble mean.
- Apply MOS equations to each ensemble member.
- Use Kernel Density Estimation to create probability distribution.
- Adjust spread.



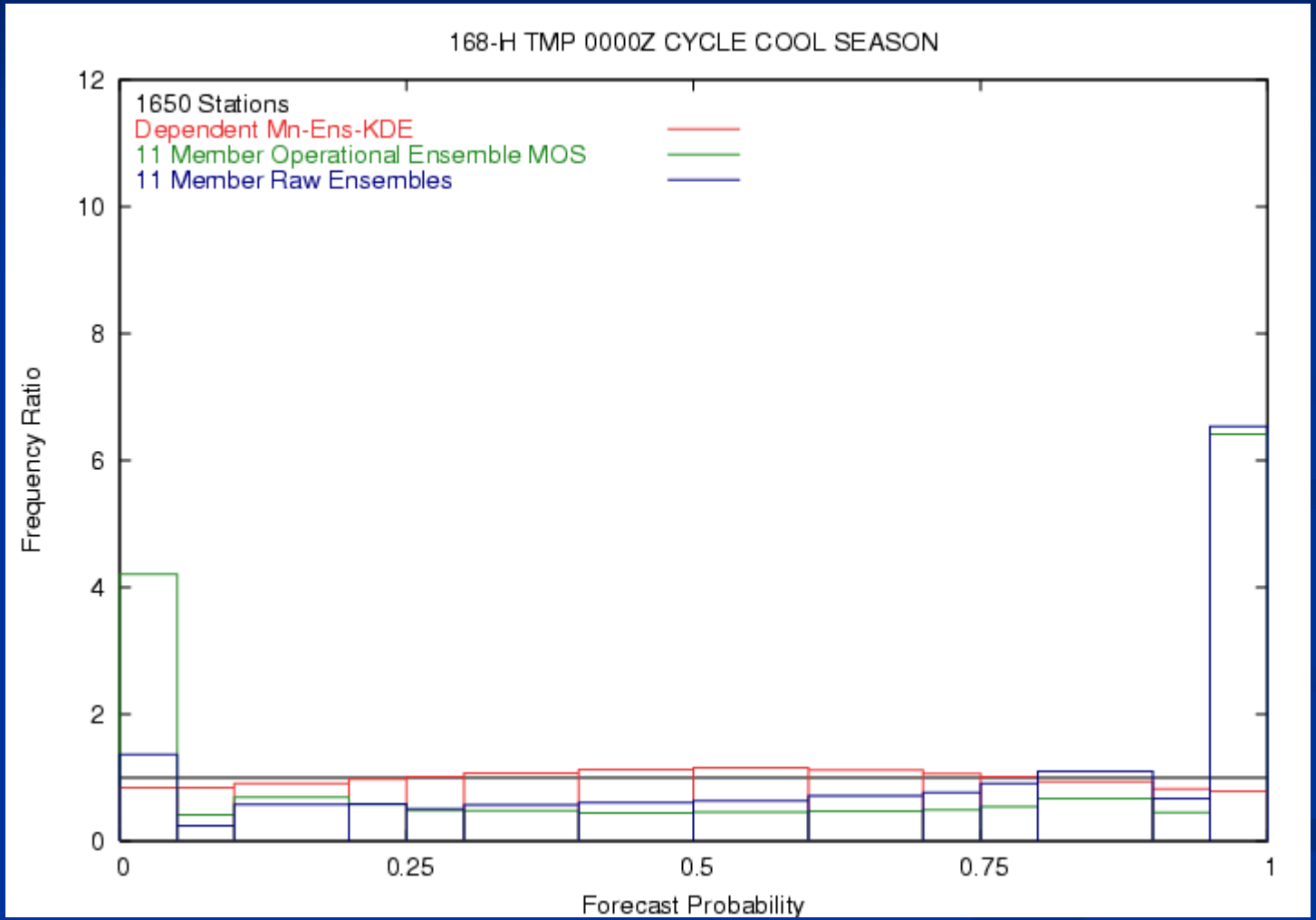
Results—Reliability (Day 1)



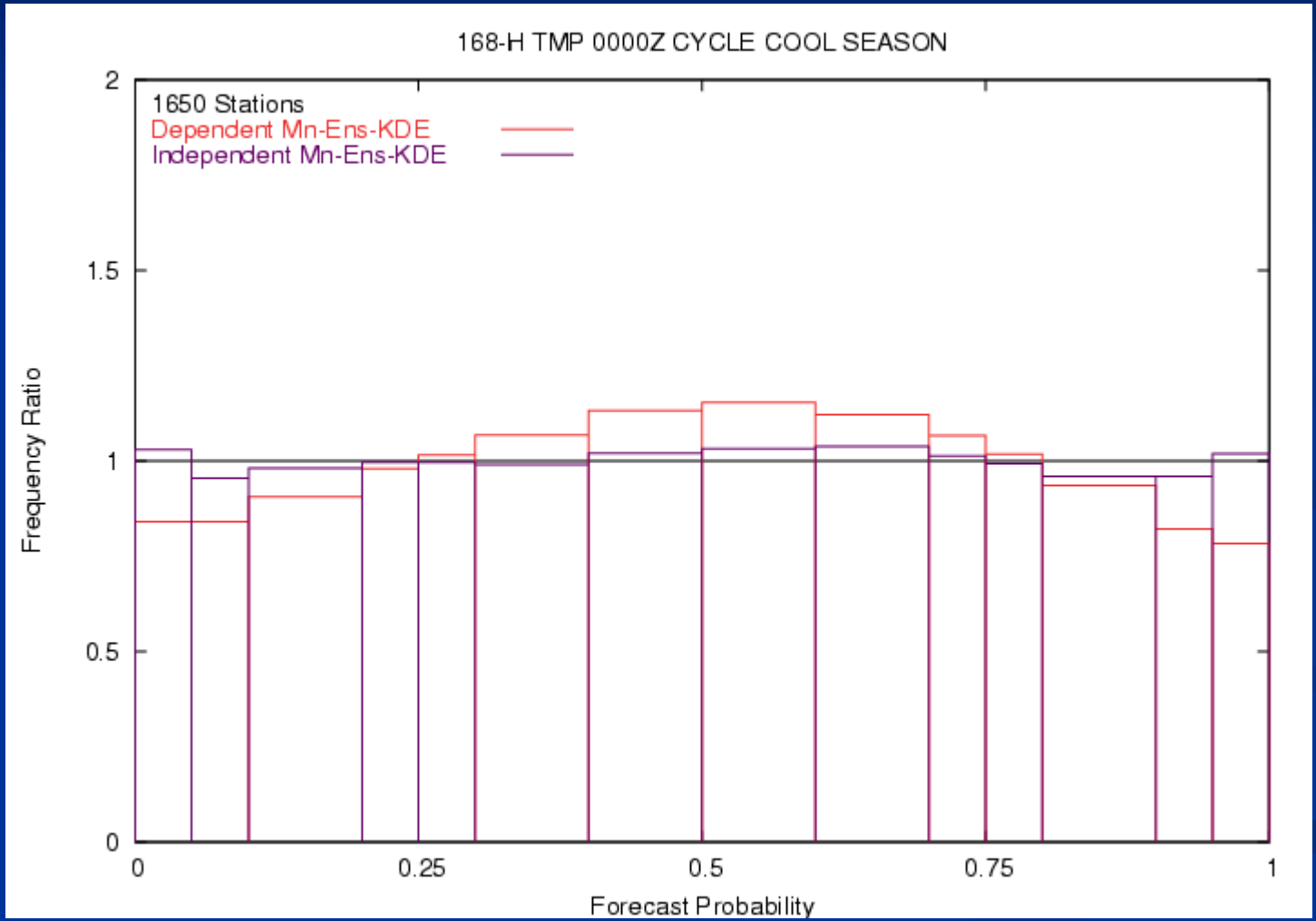
Results—Reliability (Day 3)



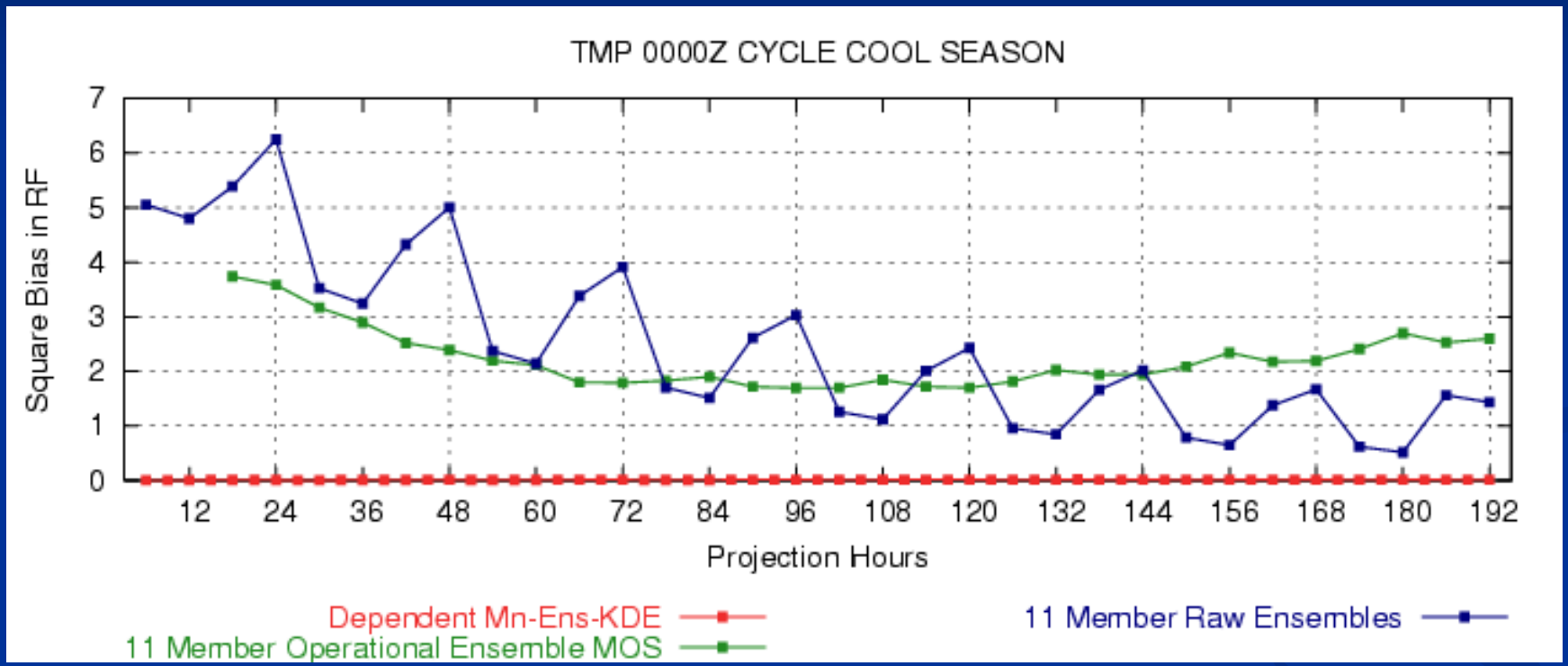
Results—Reliability (Day 7)



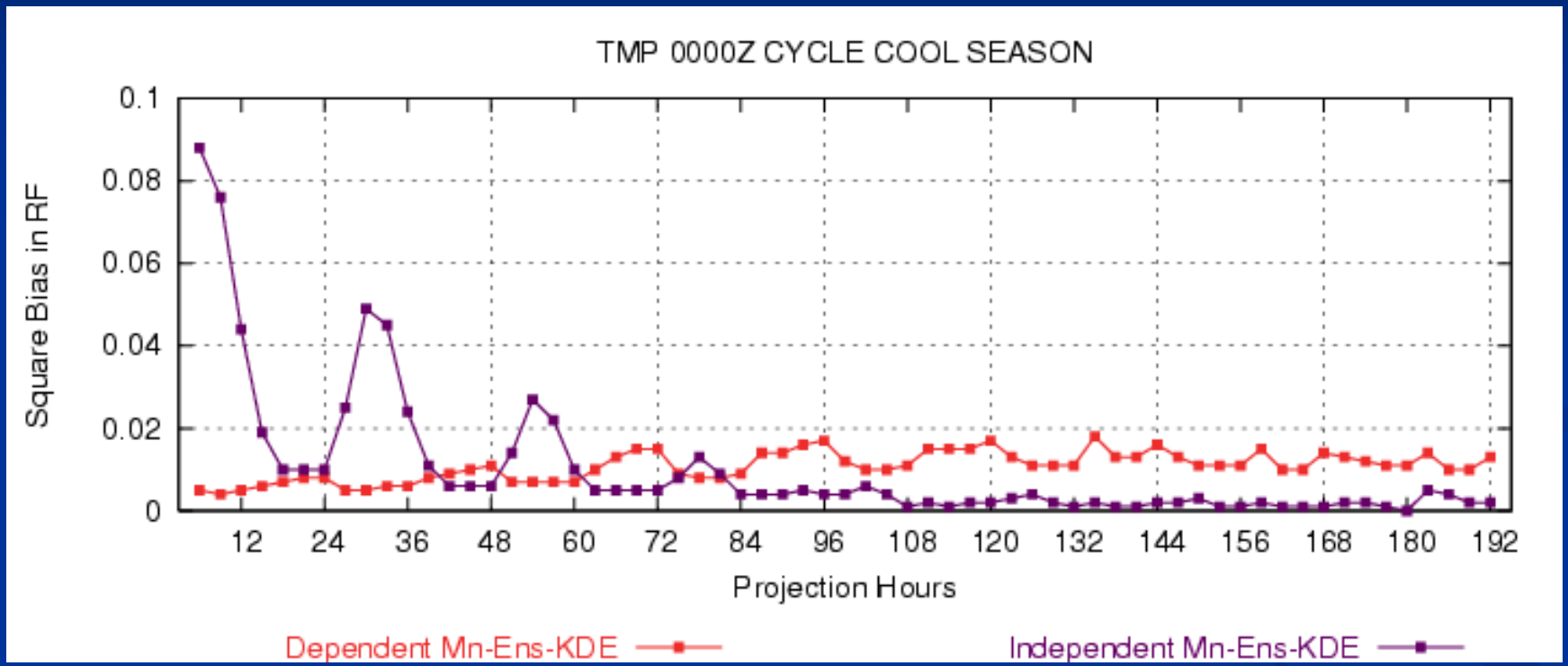
Results—Reliability (Dep. vs Ind.)



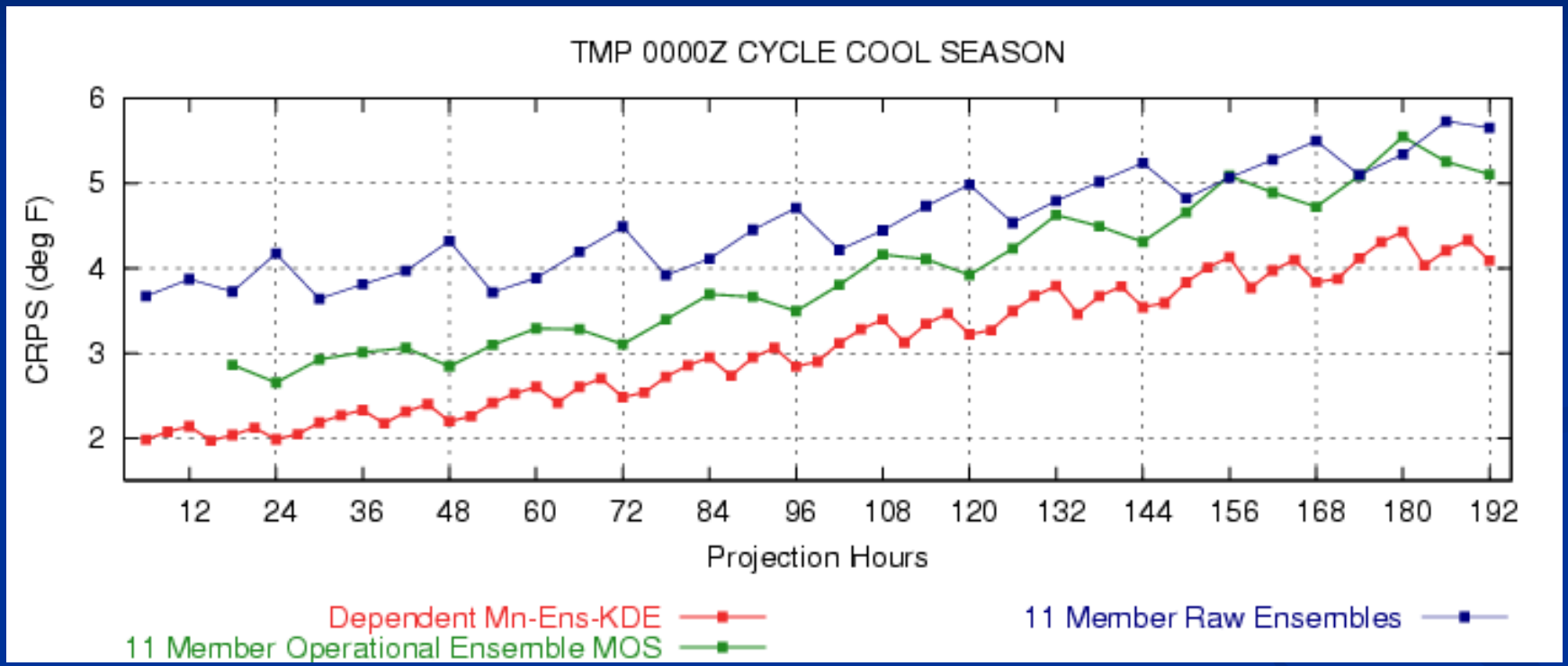
Results—Reliability



Results—Reliability (Dep. vs Ind.)



Results—Accuracy



Results—Accuracy (Dep. vs. Ind.)