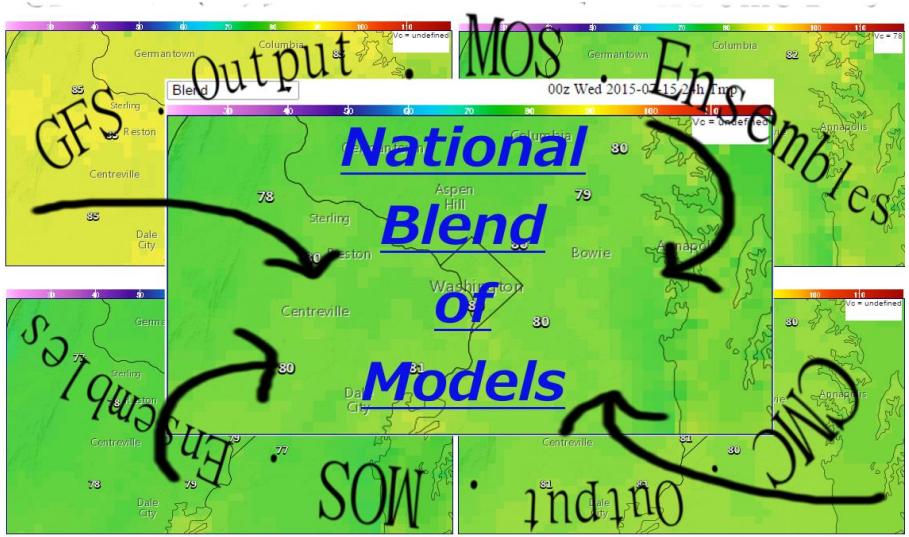
National Blend of Models v3.2: DAS



Jeff Craven, David Rudack, and Robert James
NOAA/NWS/OSTI/MDL/SMB

SAWS 8 Jun 7, 2019

Outline

- NBM Digital Aviation Services products
- NWP components and expert weights
- Techniques and Verification
- Example products
- Potential future probabilistic capabilities

Outline

- **NBM Digital Aviation Services products**
- NWP components and expert weights
- Techniques and verification
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Suite of 65 NBM products produced

31 different NWP and MOS inputs from 5 different centers {NCEP, CMC (Canada), FNMOC (Navy), ECMWF, BoM Australia}

Temperature	Moisture	Precipitation	Wind	Winter	Fire Weather	Aviation	Marine
Temperature (Temp)	Relative Humidity (RH)	QPF 1 hour	10-m wind	Snow Amount, 1 hour	Haines Index	Sky Cover	Sig Wave Height
MaxT	MaxRH	QPF 6 hour	10-m wind gust	Snow Amount, 6 hour	Fosberg Index	Ceiling	Freezing Spray
MinT	MinRH	QPF 12 hour	30-m wind	Snow Amount, 24 hour	Solar Radiation	Visibility	Sea Ice Concentration
Apparent Temp	Dew Point Temperature	QPF 24 hour	80-m wind	Ice Amount, 1 hour	Mixing Height	Lowest Cloud Base	PMSL
Water Temp		Precipitation Duration		Ice Amount, 6 hour	Transport Wind	Echo Tops	
		PoP01		Ice Amount, 24 hour	Ventilation Rate	VIL	
		PoP06		Conditional Probability of Snow	Prob Dry Thunder 3 hour	Max Hourly Reflectivity	
		PoP12		Conditional Probability of Rain		LLWS Speed	
		Predominant Weather		Conditional Probability of Sleet		LLWS Height	
				Conditional Probability of Freezing Rain		Elrod CATurb	
				Conditional Probability Refreeze Sleet		MtnWaveTurb	
				Probability of Ice Present		MUCAPE	
				Max Wet Bulb Temp Aloft		Prob Thunder 1 hour	
				PosEWarmLayer (Bourgouin)		Prob Thunder 3 hour	
				NegEColdLayer (Bourgouin)		Prob Thunder 12 hour	
				SnowLevel			
				SnowLiquidRatio			

NBM runs every hour

- Just like LAMP and HRRR/RAP
- Time of Day notation: 12z NBM does not have any 12z guidance in it
- 12z NBM (example) has 11z GLMP, 10z HRRR and RAP, 06z NAMNest, etc

NBM v3.2 Aviation core elements

- 10-m wind speed and direction
- 10-m wind gust (top of hour)
- Sky Cover
- Ceiling
- Visibility
- Lowest Cloud Base (Cloud Base Primary)

NOTE: All at 2.5km resolution in CONUS

NBM v3.2 Aviation - others

- LLWS Speed and Direction
- LLWS Height
- 30-m and 80-m wind speed
- Echo Tops
- Max Hourly Reflectivity
- VIL
- Elrod Index Turbulence (300-400 mb)
- Low Level Mountain Wave Turbulence
- Prob Thunder 1, 3, and 12 hour

NBM v3.2 Aviation - even more

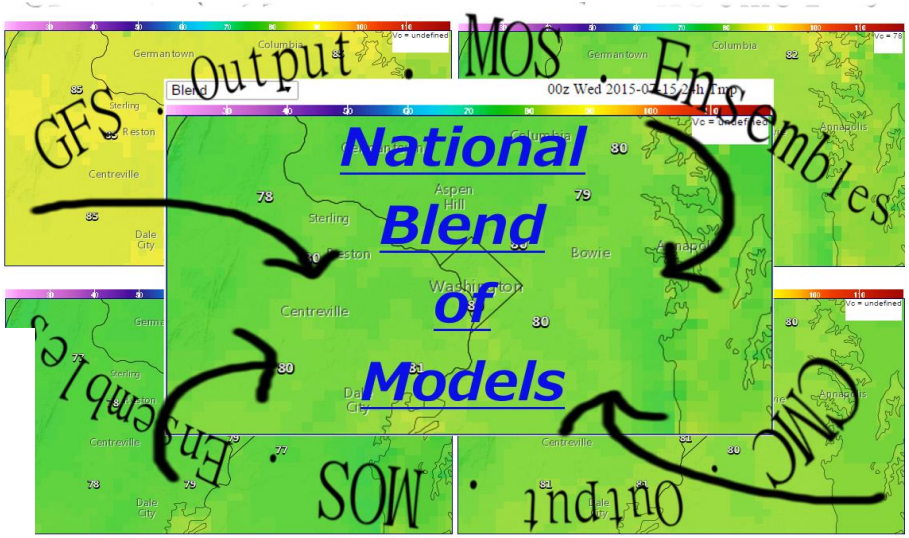
- SBCAPE (Surface based)
- Snow Level (0.5C Wet Bulb height AGL)
- SnowAmt01
- IceAmt01
- QPF01
- Prob Snow, Freezing Rain, Sleet
- Predominant Weather

Outline

- NBM Digital Aviation Services products
- **NWP components and expert weights**
- Techniques and verification
- Example products
- Potential future probabilistic capabilities

Ceiling/Visibility/Lowest Cloud Base

NWP components and expert weights



Ceiling CONUS

9 total inputs: 6 DMO, 3 MOS

NWP Weight (%) in forecast hour

	1-16	17-34	35-36	37-46	47-58	59-79	80+
HRRR	15						
HRRRX	5	20					
GMLP-Meld	50	50	50				
HiResW ARW	5	5	5	10			
HiResW NMMB	5	5	5	10			
HiResW Mem2	5	5	5	10			
NAMH	5	5	10	15	25		
GMOS GFS	5	5	12	27	37	50	50
GMOS NAML	5	5	13	28	38	50	50
	100	**100**	**100**	**100**	**100**	**100**	**100**

Lowest Cloud Base CONUS
(AKA Cloud Base Primary)

16 total inputs: 6 DMO, 10 RH blend

NWP Weight (%) in forecast hour

	1-16	17-19	20-34	35-36	37-46	47-58	59-79	80+
HRRR	25							
HRRRX	5	25	25					
HiResW ARW	5	5	5	10	10			
HiResW NMMB	5	5	5	10	10			
HiResW Mem2	5	5	5	15	15			
NAMH	10	10	10	15	15	20		
Blend from RH method	45	50	50	50	50	80	100	100
	100	**100**	**100**	**100**	**100**	**100**	**100**	**100**

RH Blend method components (per WFO GGW and CRGMAT)

NWP Weight (%) in forecast hour

Model	1-16	17-19	20-34	35-37	38-46	47-58	59-82	83,84
HRRR	40							
RAP	5	5						
HRRRX	10	40	40					
RAPX	5	5	5	10				
WRF-ARW	7	9	9	15	15			
NEMS-NMMB	5	6	6	10	10			
WRF_MEM2	8	10	10	15	15			
NAMH	10	15	20	30	35	45		
NAML	5	5	5	10	10	15	40	
GFS FV3	5	5	5	10	15	40	60	100
	100	**100**	**100**	**100**	**100**	**100**	**100**	**100**

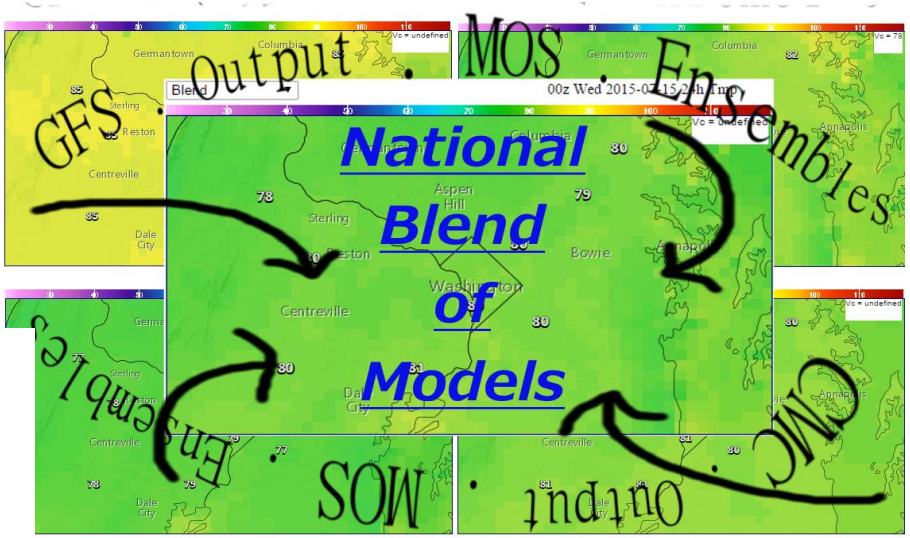
Visibility CONUS

10 total inputs: 7 DMO, 3 MOS

NWP	Weight (%) in forecast hour						
	1-16	17-34	35-36	37-46	47-58	59-79	80+
HRRR	15						
HRRRX	5	20					
GMLP-Meld	50	50	50				
HiResW ARW	5	5	5	10			
HiResW NMMB	5	5	5	10			
HiResW Mem2	5	5	5	10			
NAMH	5	5	10	15	25		
GFS FV3	0	0	5	5	10	15	15
GMOS GFS	5	5	10	25	32	42	42
GMOS NAML	5	5	10	25	33	43	43
	100	**100**	**100**	**100**	**100**	**100**	**100**

Probability of Thunderstorms: 1 hour, 3 hour, and 12 hour

NWP components and expert weights



25% 15 min

Probability of Thunderstorm

- Expert Weights Prob Thunder 3, 12

Short-range through 84 hours:
50% SREF (67% currently) - developed by SPC
20% ECMWF MOS
15% GFS MOS (33% currently)
15% NAM MOS

Extended-range after 84 hours:
55% ECMWF MOS
45% GFS MOS (100% currently)

- Expert Weights Prob Thunder 1

1-36 hour:
50% GLMP
50% SREF (100% currently) - developed by SPC

Outline

- NBM Digital Aviation Services products
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- **Techniques and verification**
- Example products
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Techniques and verification issues

- LLWS technique
- Wind speed and gust (URMA vs METAR issue) verification issues

NBM Algorithm for Calculating Low Level Wind Shear (LLWS) Speed, Height, and Direction

1. Leverage the individual model inputs of the U and V components at: Surface, 500 ft (interpolated from Surface and 1000 ft), 1000 ft, 1500 ft (interpolated from Surface and 1000 ft), 2000 ft

2. Calculate the wind speed at each height and determine the wind speed differences between ***all*** possible layers: (a) [Surface-500 ft], (b) [Surface-1500 ft], (c) [Surface-2000 ft], (d) [500-1000 ft], (e) [500-1500 ft], (f) [500-2000 ft], (g) [1000-1500 ft], (h) [1000-2000 ft], (i) [1500-2000 ft]

3. The models for any particular layer whose wind speed differences are less than 30 knots are ignored in the calculations for (4), (5), and (6).

NBM Algorithm for Calculating Low Level Wind Shear (LLWS) Speed, Height, and Direction

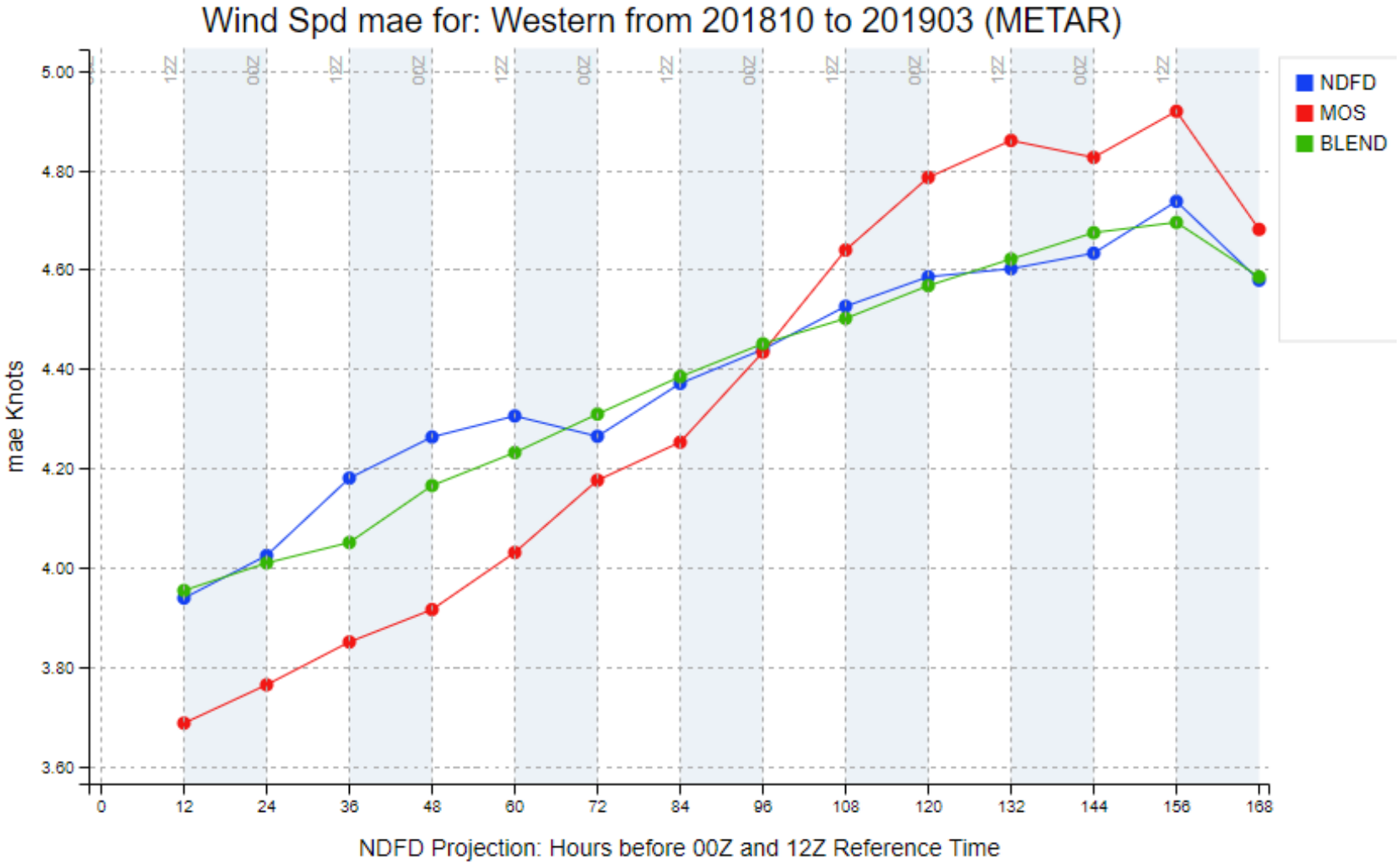
4. Normalize all wind speed shear values (for those models that indicate wind shear at any given level) so that the relative wind speed shear magnitudes between layers with different thicknesses can be compared.

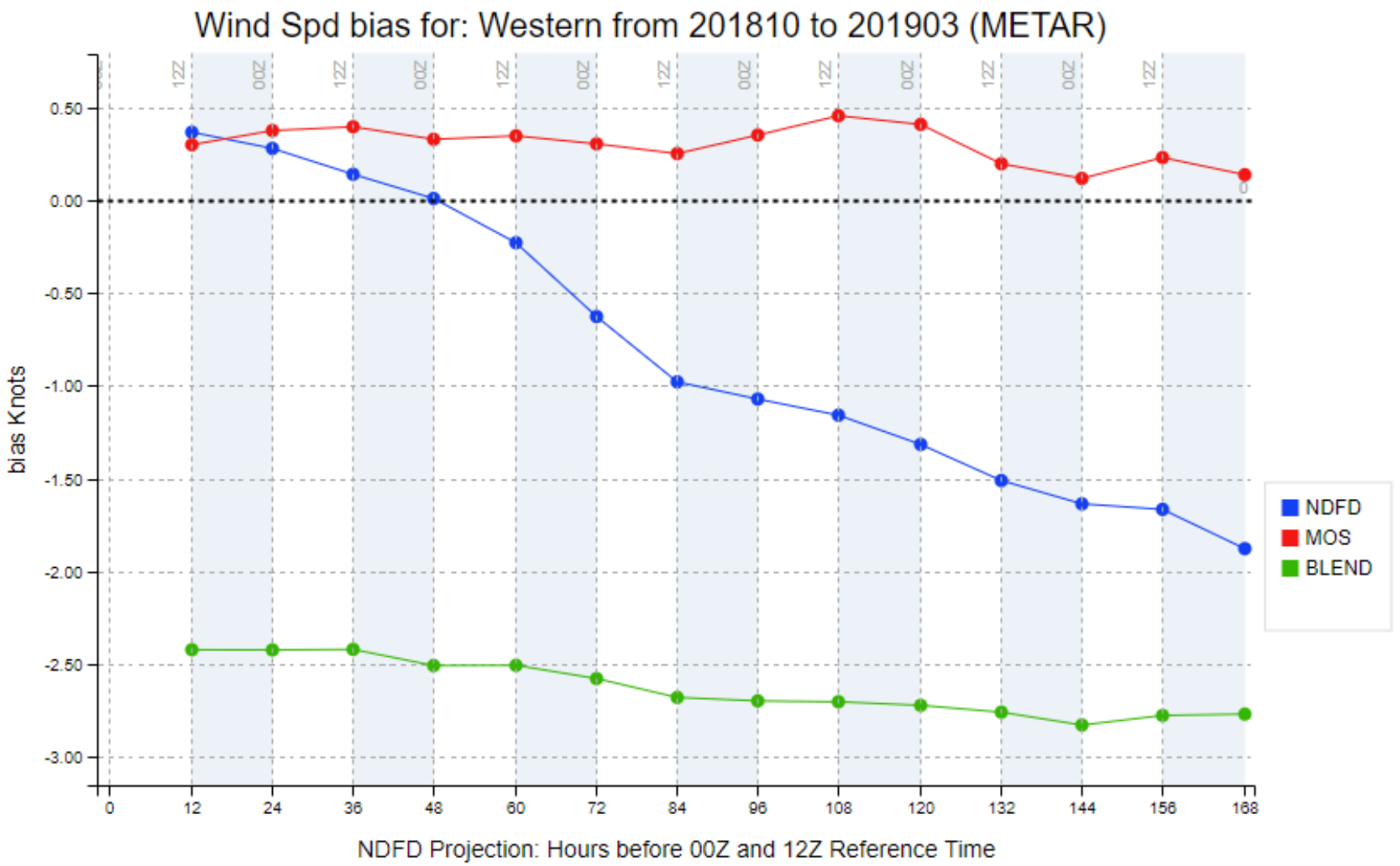
5. Tabulate which model has the greatest wind speed shear for any given layer and assign the wind speed found at the ***top*** of that layer as the LLWS Speed. The LLWS height is simply assigned to the ***top*** of this layer.

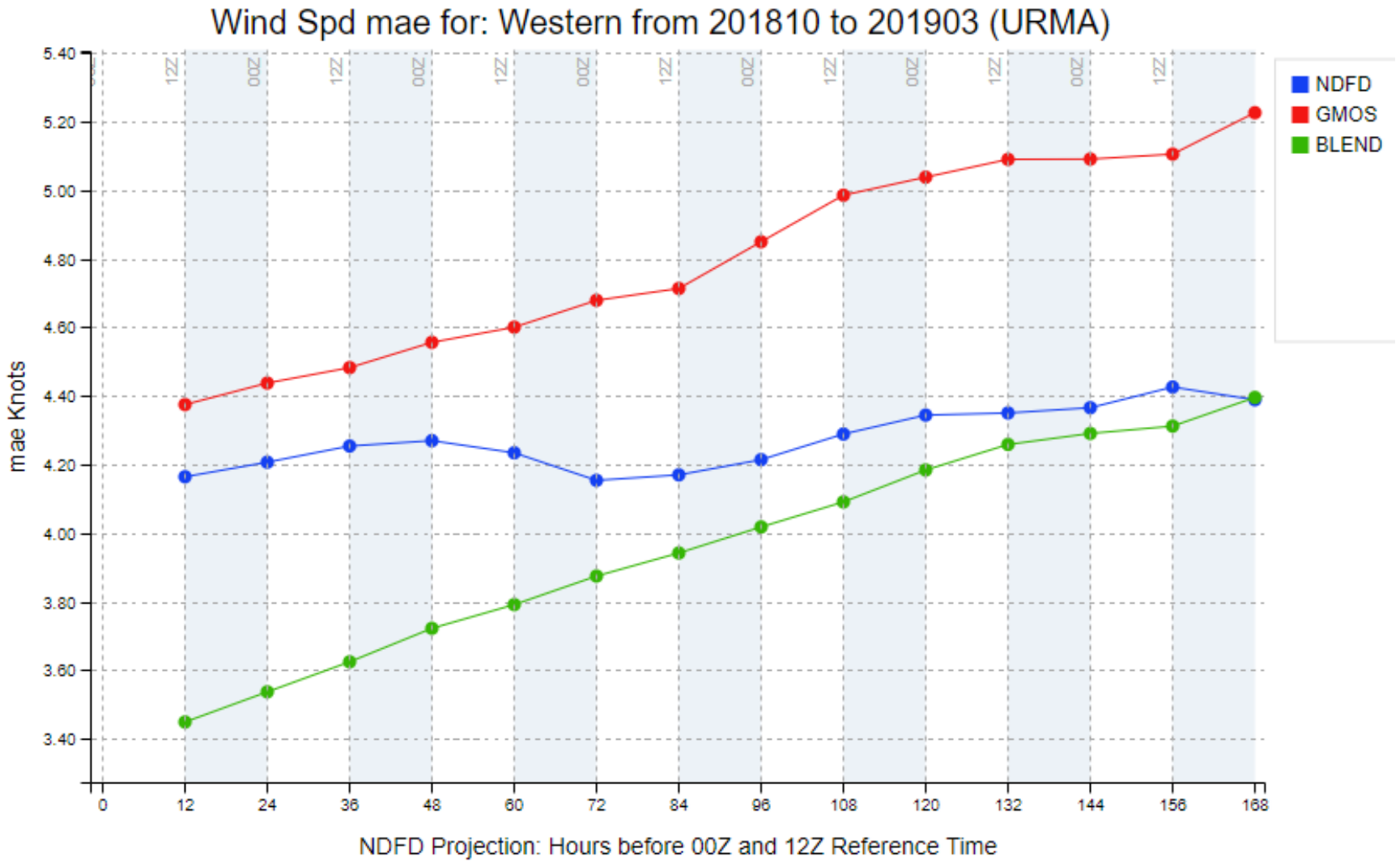
6. Use that model's U- and V- component (at the ***top*** of that layer that exhibits the greatest LLWS in (5)) to calculate LLWS direction.

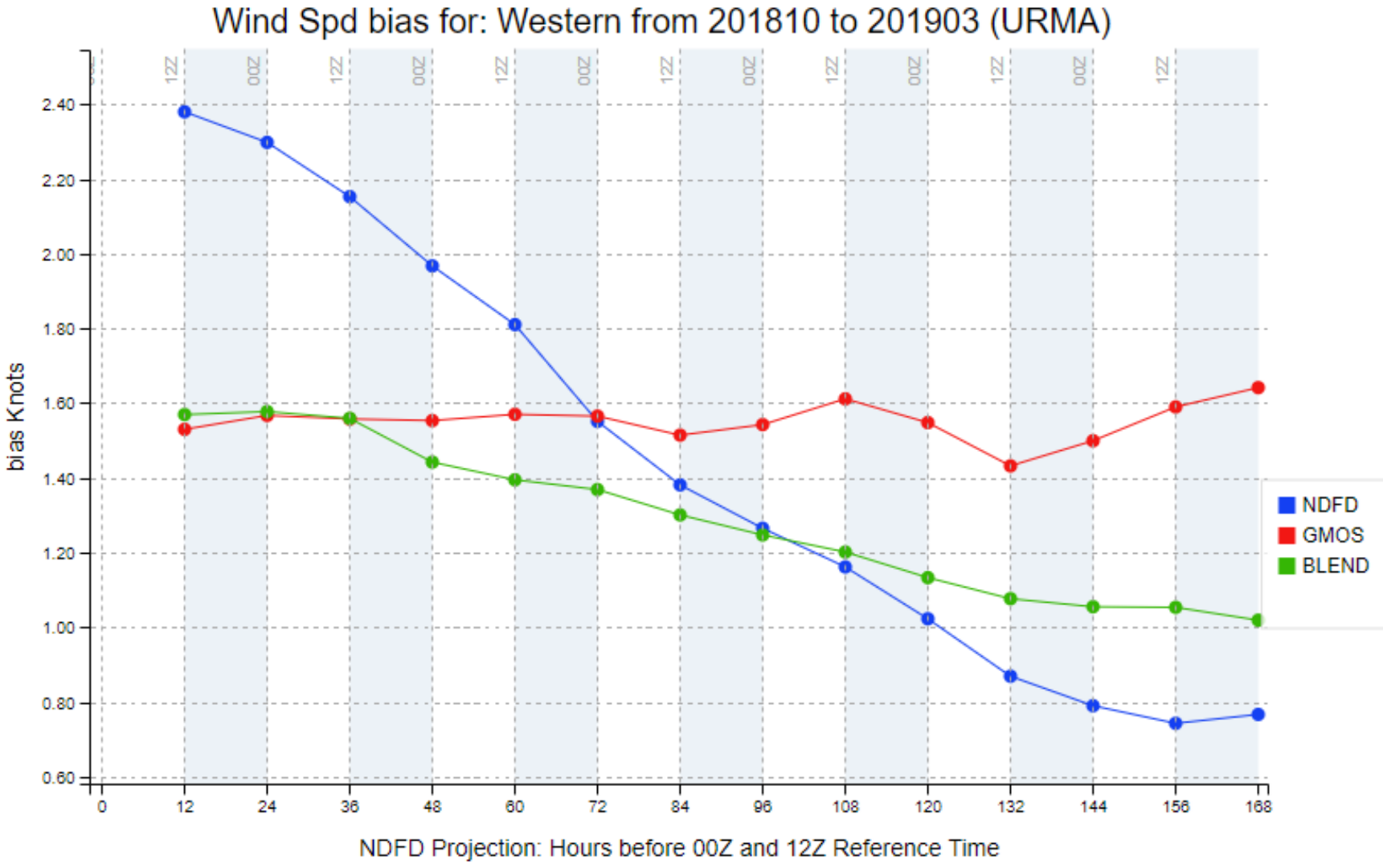
Pronounced bias of NBM versus METARs

- NBM tuned to URMA, not METARs
- URMA has a wind speed low bias versus METARs, and so does NBM
- URMA has a wind gust high bias versus METARs, and so does NBM
- Therefore, the NBM gust factors tend to be higher than what you would normally expect (1.3 for marine, 1.5 to 2.0 for land). NBM are frequently 2.0 to 3.0+


Wind Spd mae for: Western from 201810 to 201903 (METAR)
mae Knots
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
NDFD Projection: Hours before 00Z and 12Z Reference Time
NDFD
MOS
BLEND

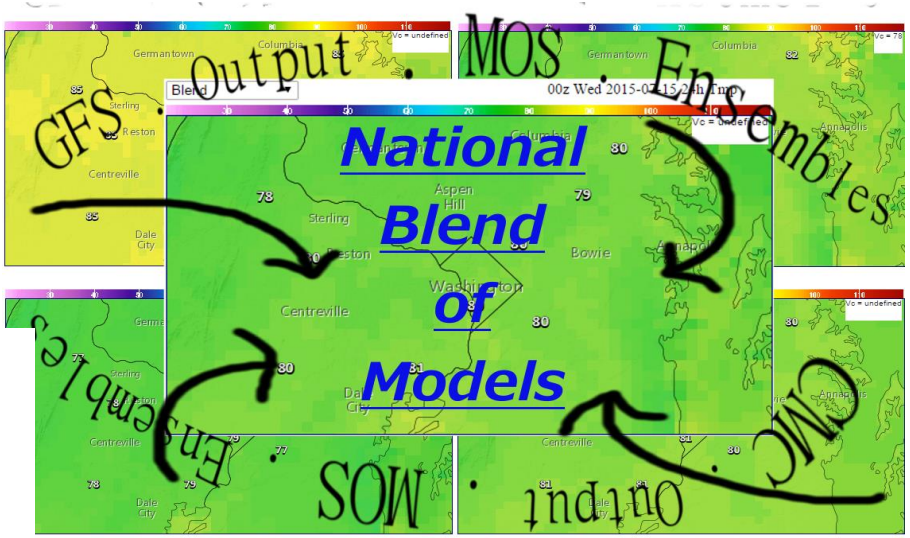

Wind Spd bias for: Western from 201810 to 201903 (METAR)
bias Knots
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
NDFD Projection: Hours before 00Z and 12Z Reference Time
NDFD
MOS
BLEND


Wind Spd mae for: Western from 201810 to 201903 (URMA)
mae Knots
5.40
5.20
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
3.40
12Z
00Z
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
NDFD Projection: Hours before 00Z and 12Z Reference Time
NDFD
GMOS
BLEND

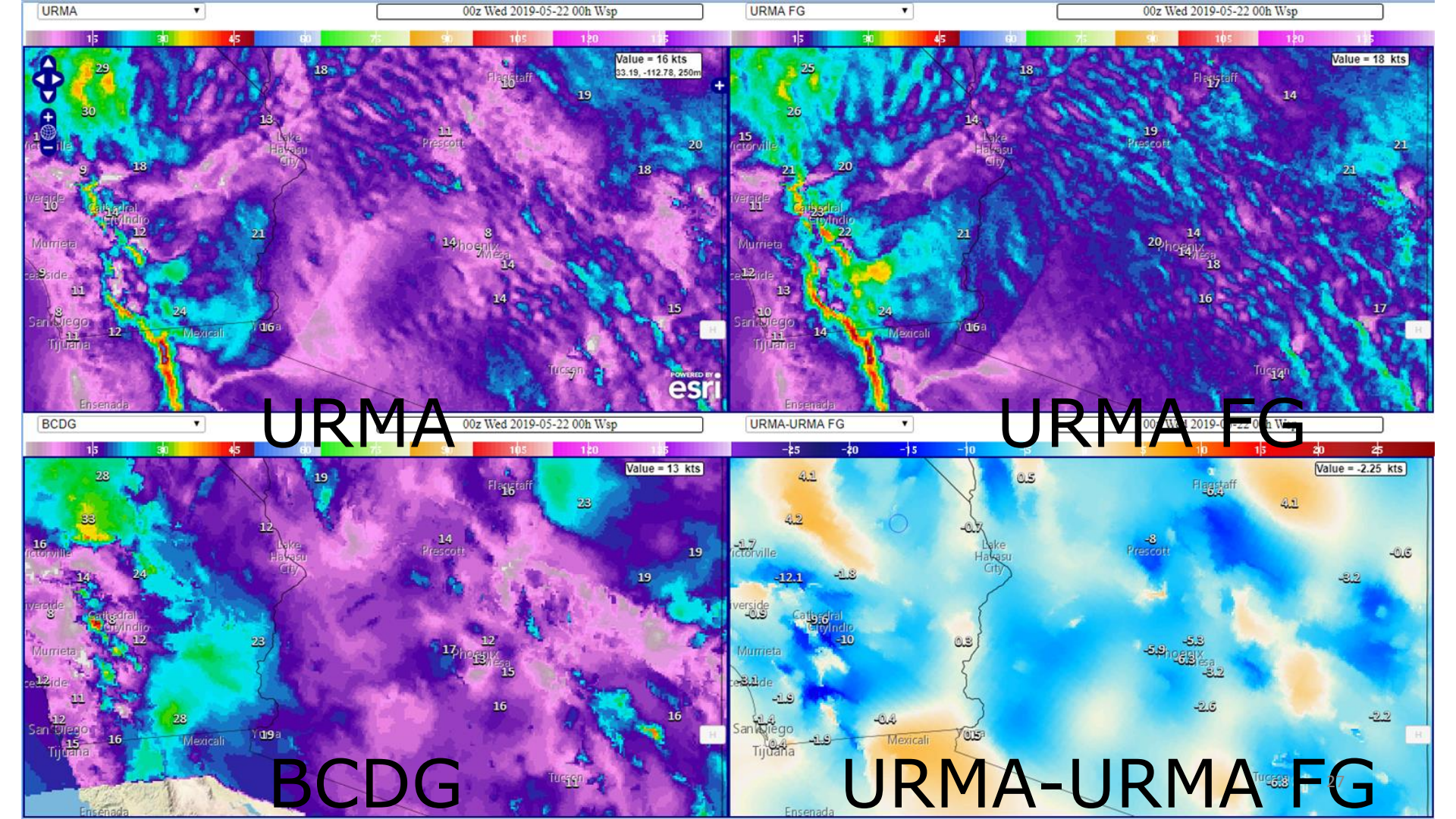

Wind Spd bias for: Western from 201810 to 201903 (URMA)
bias Knots
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
12Z
00Z
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
NDFD Projection: Hours before 00Z and 12Z Reference Time
NDFD
GMOS
BLEND

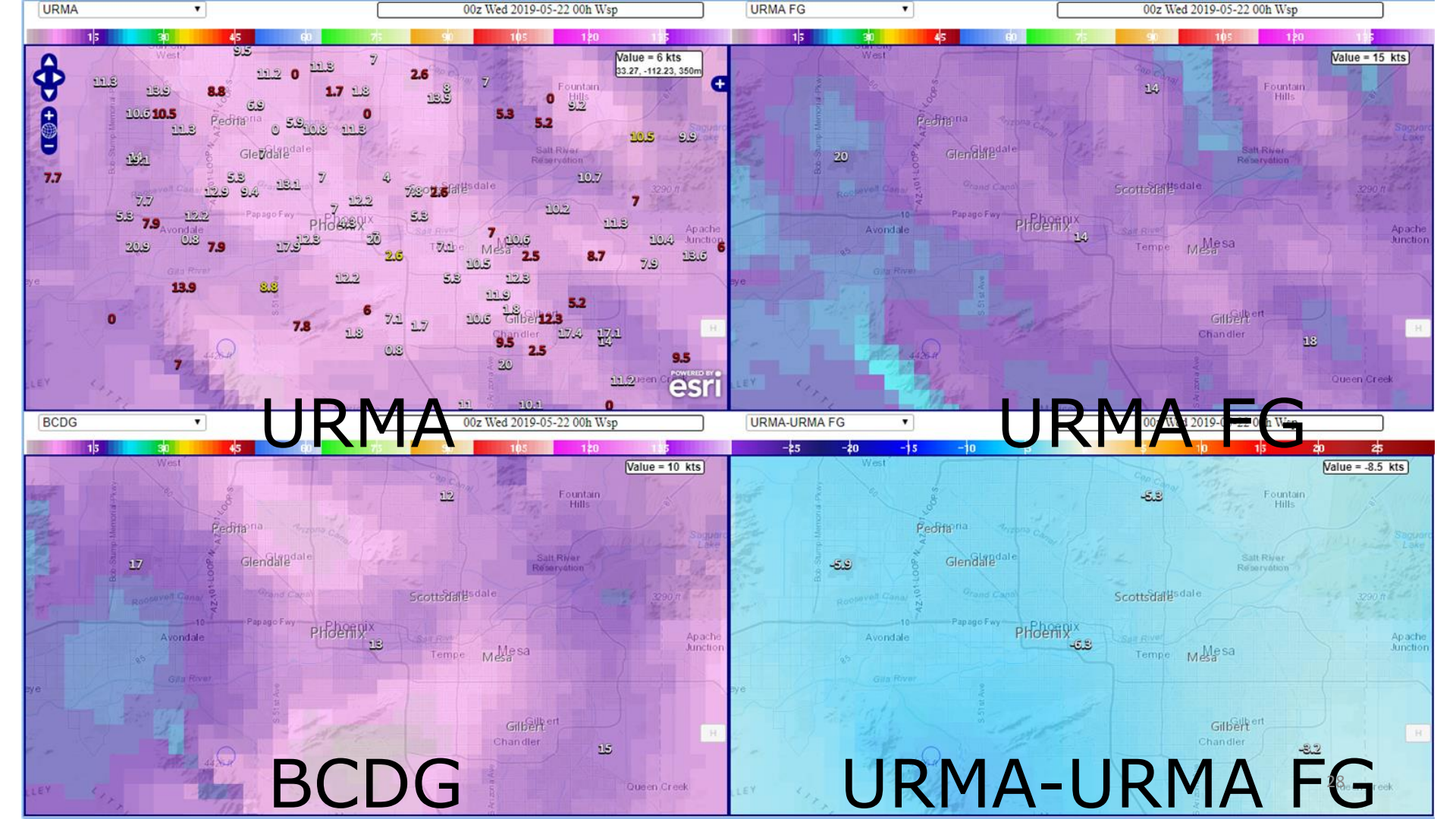
Case study of METAR vs URMA in Phoenix area 00z May 22, 2019

METAR at KPHX 20 knots, URMA 7 knots



50% 10 min


URMA
00z Wed 2019-05-22 00h Wsp
Value = 16 kts
URMA FG
00z Wed 2019-05-22 00h Wsp
Value = 18 kts
BCDG
00z Wed 2019-05-22 00h Wsp
Value = 13 kts
URMA-URMA FG
Value = -2.25 kts
Flagstaff
Lake Havasu City
Prescott
Phoenix
Mesa
Cathedral City
Indio
Murrieta
Mexicali
Tijuana
San Diego
Tucson
Ensenada
POWERED BY esri


URMA
00z Wed 2019-05-22 00h Wsp
Value = 6 kts
33.27, -112.23, 350m
URMA FG
00z Wed 2019-05-22 00h Wsp
Value = 15 kts
BCDG
00z Wed 2019-05-22 00h Wsp
Value = 10 kts
URMA-URMA FG
Value = -8.5 kts
Pedria
Glendale
Phoenix
Avondale
Scottsdale
Tempe
Mesa
Chandler
Gilbert
Fountain Hills
Salt River Reservation
Apache Junction
Queen Creek
POWERED BY esri

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- NBM Digital Aviation Services products
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NBM Text Products

1. **NBH** (NBM **H**ourly) to 24 hours (like LAMP)
2. **NBS** (NBM **S**hort Range) to 72 hours (like MET/MAV)
3. **NBE** (NBM **E**xtended Range) to 192 hours (like MEX)
4. **NBX** (NBM E**x**tra-Extended Range) 204-264 hours
5. **NBP** (NBM **P**robability) to 228 hours

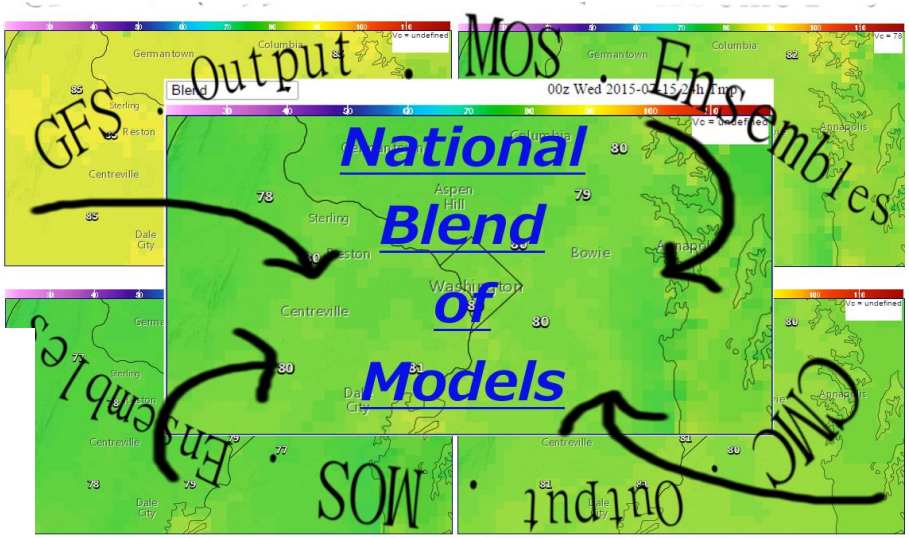
NBH example from KAVX (Catalina Island CA)

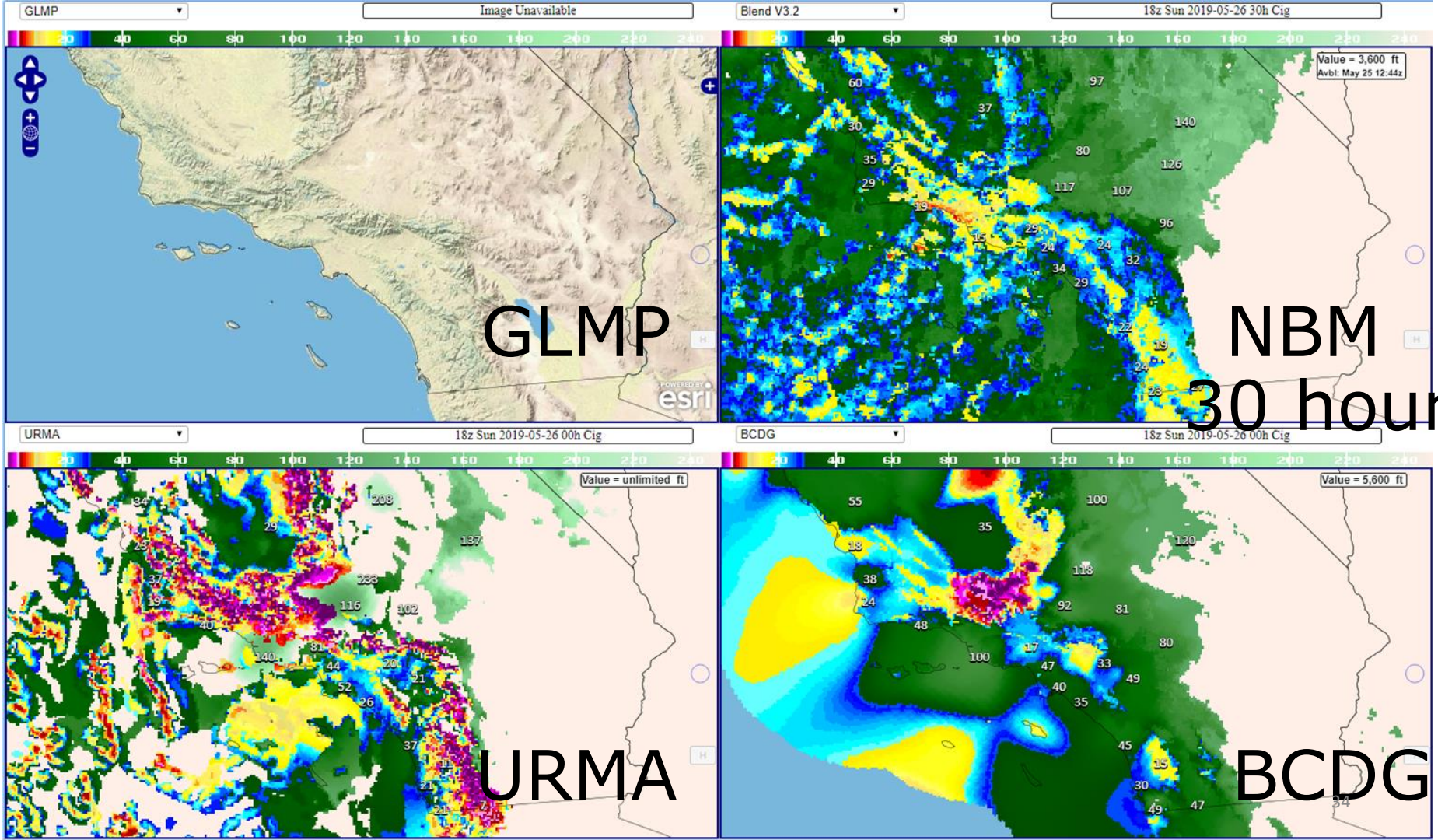
```
KAVX   NBM V3.2 NBH GUIDANCE    6/06/2019  1000 UTC
UTC  11 12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11
TMP  54 54 54 55 56 57 59 60 61 62 62 62 61 60 59 57 55 55 55 55 55 55 55 54 54
DPT  53 53 53 54 55 55 56 57 57 57 57 57 57 56 56 56 55 54 54 54 54 54 54 54 53
SKY  81 82 83 82 78 74 71 67 56 44 37 48 52 49 50 54 62 63 65 67 65 66 69 73 75
WDR  33 36  4  5  6  8  9 25 27 26 25 25 25 25 25 25 25 24 23 18 17 14 14 14 14
WSP   1  1  1  1  2  2  2  2  3  3  4  4  4  4  4  3  3  3  2  2  2  1  1  1  2
GST   3  3  3  3  4  4  4  3  4  5  6  6  6  6  5  5  5  4  4  3  3  3  3  3  3
P01   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
P06                       0                       1                       2
Q01   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
DUR                                               0
T01   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
PZR   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
PSN   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
PPL   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
PRA 100100100100100100100100100100100100100100100100100100100100100100100100
S01   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
SLV 110109109108108107106107107108109109110110110110111109108105102 99 98 99100
I01   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
CIG   2  2  3  3  4  4 21 7088888888888888888888888  3  3  3  3  3  3  3  3  3
VIS  10 20  9 20 20 20 40 70 80 40 70 80 80 80 40 30 30 30 30 30 30 20 30 20 20
LCB   2  2  2  2  2  2  3 35 45 26  3  2  2  2  3  1  2  2  2  2  2  2  2  2  2
MHT  10 11 11 11 11 12 12 14 16 16 16 16 15 16 15 15 13 13 12 13 11 11 13 15 15
TWD   7 14  9 13 14 27 28 22 24 26 24 24 24 26 24 23 22 23 22 15 18 15 18 18 18
TWS   2  3  3  2  2  3  3  3  4  5  6  6  6  6  5  4  4  4  4  3  4  4  4  4  4
HID                       4                       4                       4
SOL   0  0  1 80180330500690860900910830690530320160 50 30 20 20  0  8  0  0  0
```

NBS example from KSLC (Salt Lake City) UT

```
KSLC     NBM V3.2 NBS GUIDANCE    6/07/2019  0800 UTC
DT /JUNE  7       /JUNE  8                  /JUNE  9                  /JUNE 10
UTC  12 15 18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 03 06
FHR  04 07 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70
X/N              80             49             63             44             70
TMP  62 70 75 76 75 62 55 52 49 53 57 60 61 55 51 47 45 55 63 67 68 62 55
DPT  50 49 47 45 45 44 40 36 34 33 29 27 25 30 33 33 33 32 28 30 32 37 39
SKY  17 11 25 61 71 62 65 57 51 44 11  6  4  7 11 16 30 18 14  7 12 16 18
WDR  15 19 26 30 33 33 34 34 35 34 32 32 33 35  4  5  6  2 34 33 33 35  6
WSP   4  7 10  9  9 13  7  6  4  5  7  8  7  4  4  3  3  3  5  7  7  4  4
GST   9 14 19 18 16 24 16 14  9 10 11 13 12  9  6  6  5  7  9 12 12  7  5
P06         4    14    33    10     6     2     0     0     0     0     0
P12              17          33           6           0           0
Q06         0     0     0     0     0     0     0     0     0     0     0
Q12              0           0           0           0           0
DUR              0           0           0           0           0
T03   5  2  4  8 15  9  3  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0
T12              20          10           1           0           0
PZR   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
PSN   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
PPL   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
PRA 100100100100100100100100100100100100100100100100100100100100100100
S06         0     0     0     0     0     0     0     0     0     0     0
SLV 118112110118117113 81 64 62 63 65 67 68 70 68 65 64 65 73 82 87 89 87
I06         0     0     0     0     0     0     0     0     0     0     0
CIG 888888888220260 90100 8088888888888888888888888888888888888888888888
VIS 170140200250270200200220220130130130130110110120120110110110110110110
LCB 100110210160180 70 80 80100 90999999999999 902302002309999992402402l0
MHT   5 18 50 49 44 28 30 15 17 51 71 69 56  5  5  5  5 30 52 47 30  5  5
TWD  17 18 22 23 28 33 34 36 36 34 32 28 32 36  2  4  1 36 36 35 35  2  8
TWS   7 10 16 14 11 21 12  8  6 10  9  9 10  6  5  6  6  7  8  8  8  4  5
HID         4     6     4     3     3     4     4     4     4     5     5
SOL  20440880840500 40  4  0 20430890998680220 50  0 50220690998690220 50
```

Ceiling SoCal
18z Sunday May 26, 2019



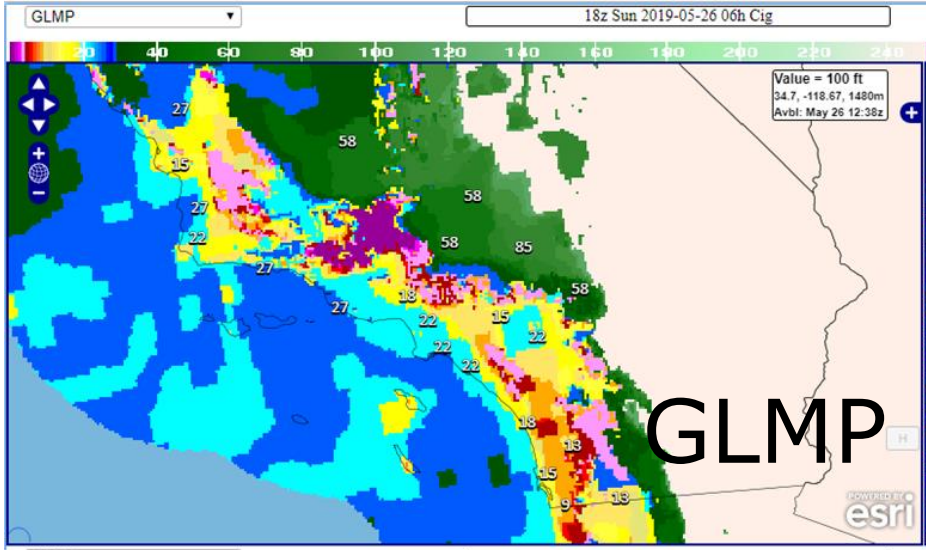

GLMP
Image Unavailable
Blend V3.2
18z Sun 2019-05-26 30h Cig
Value = 3,600 ft
Avbl: May 25 12:44z
GLMP
NBM
30 hour
URMA
18z Sun 2019-05-26 00h Cig
BCDG
18z Sun 2019-05-26 00h Cig
Value = unlimited ft
Value = 5,600 ft
URMA
BCDG

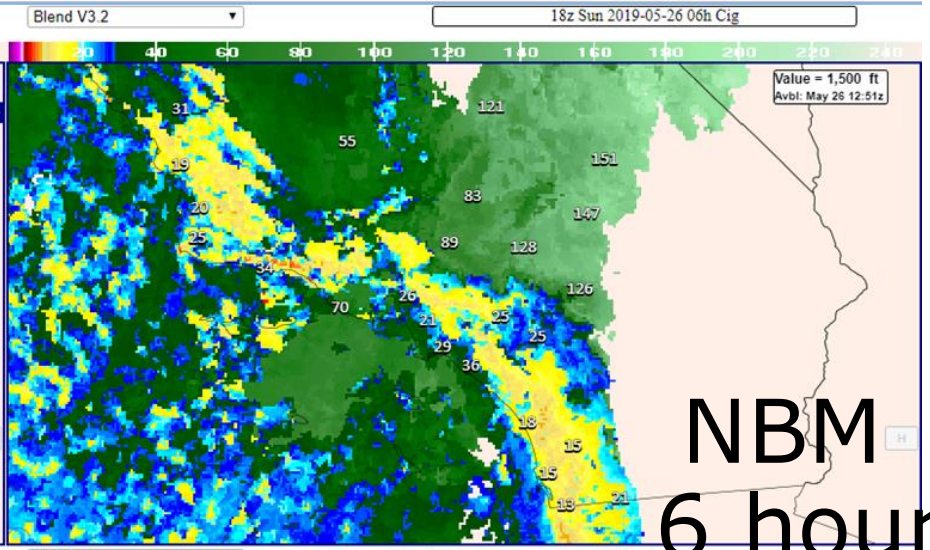
GLMP

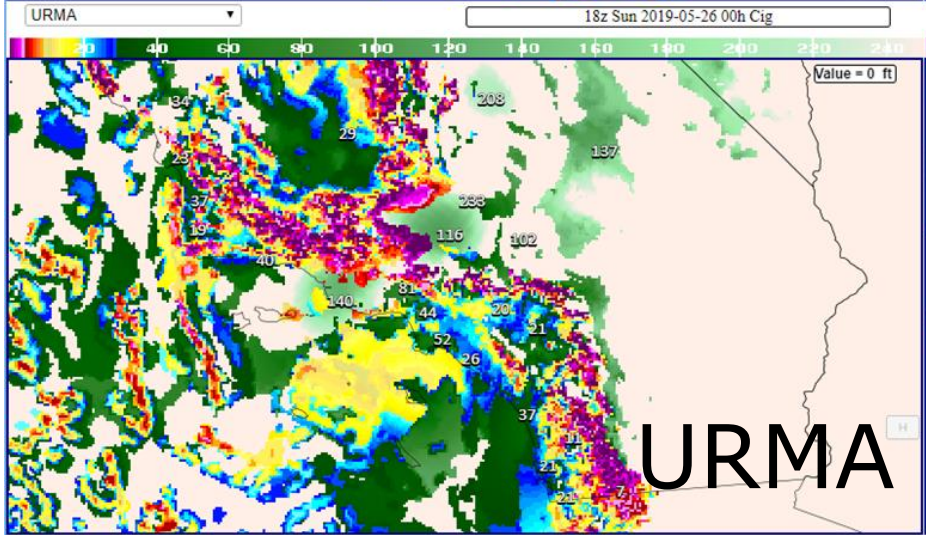
NBM
18 hour

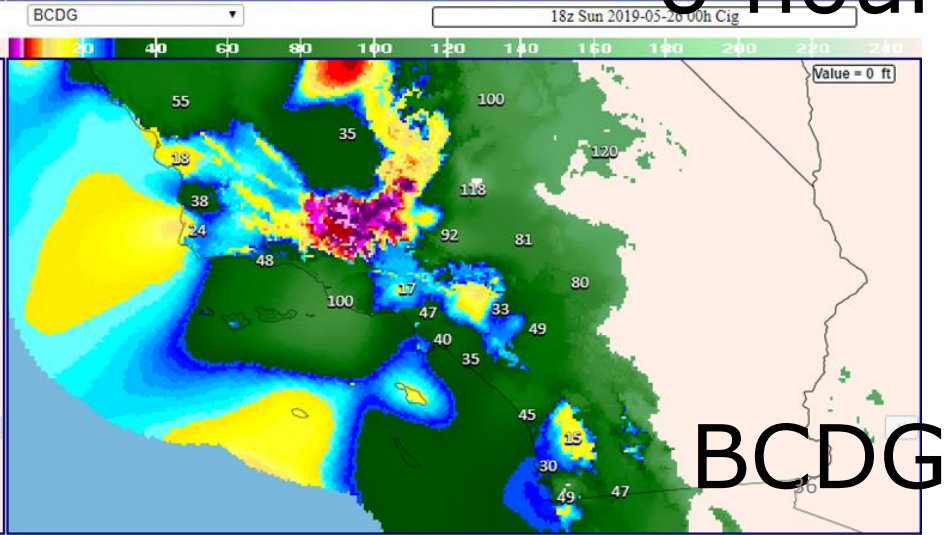
URMA

BCDG

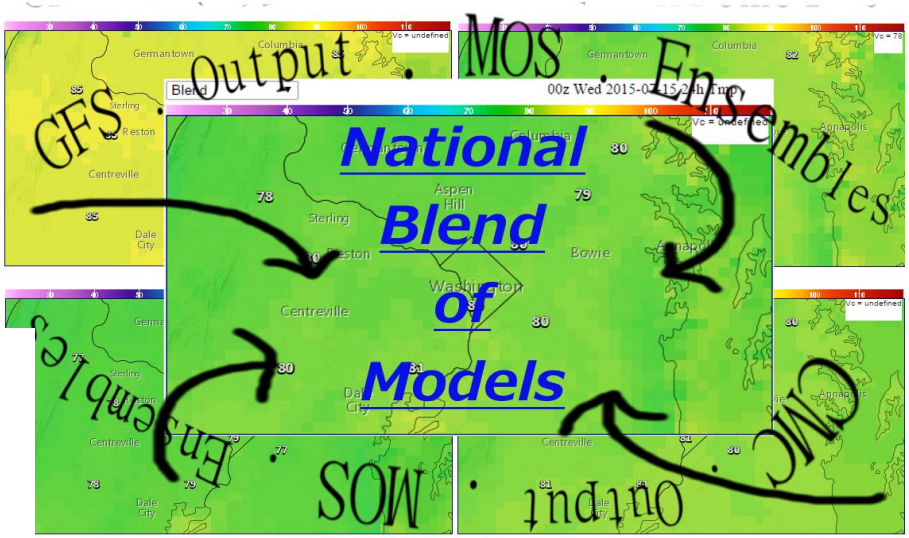

GLMP
18z Sun 2019-05-26 06h Cig
Value = 100 ft
34.7, -118.67, 1480m
Avbl: May 26 12:36z
GLMP

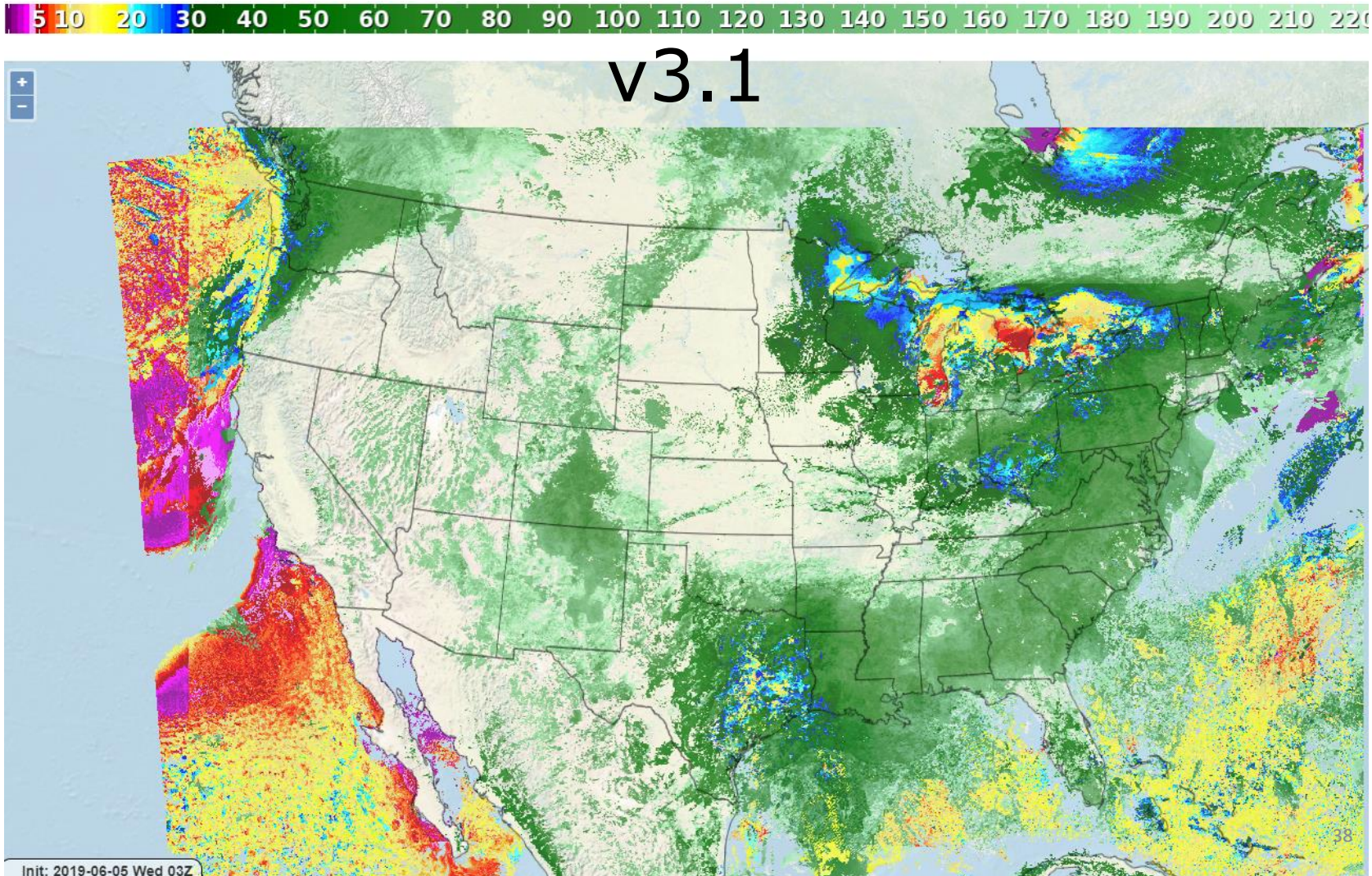

Blend V3.2
18z Sun 2019-05-26 06h Cig
Value = 1,500 ft
Avbl: May 26 12:51z
NBM
6 hour

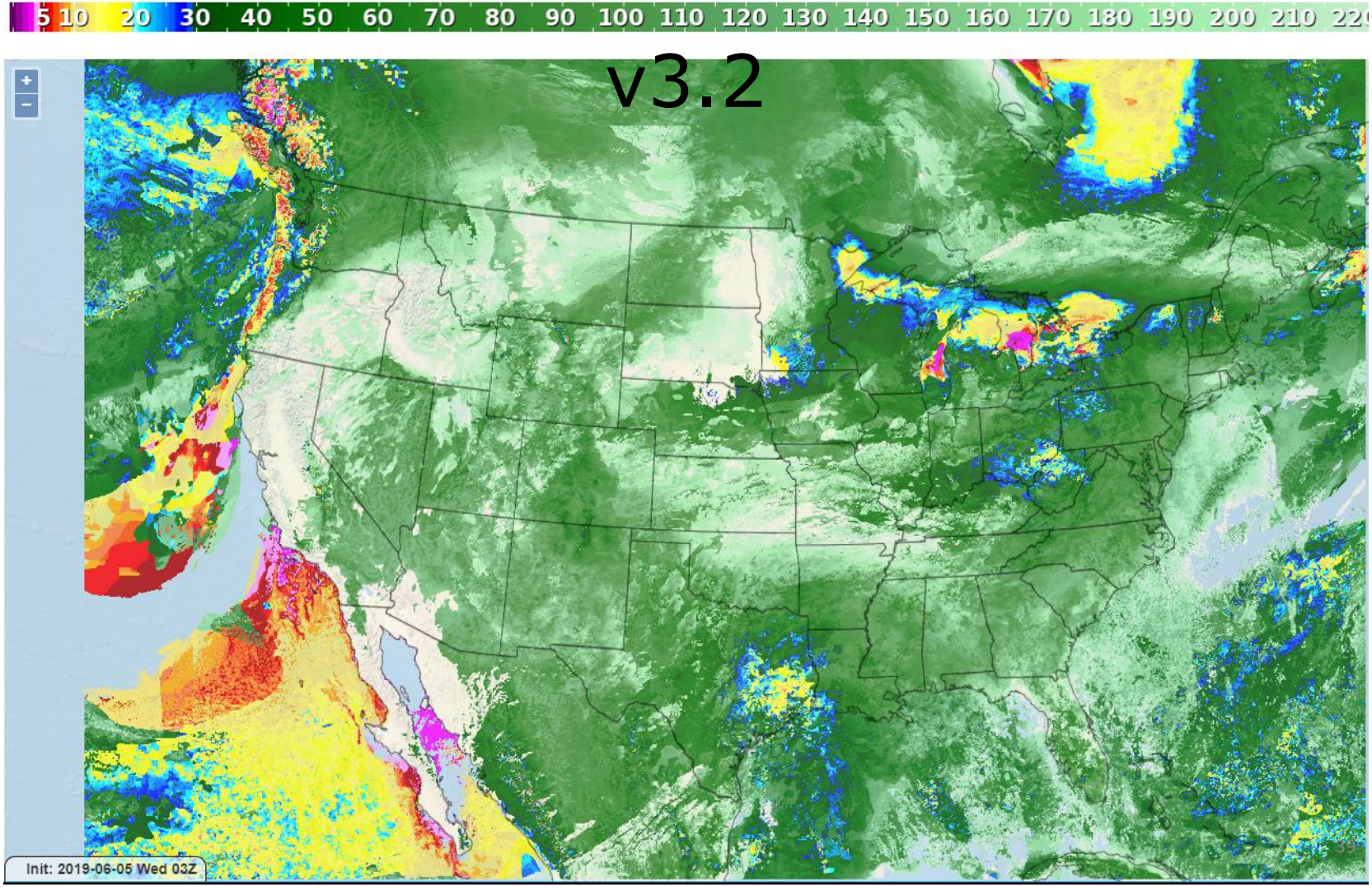

URMA
18z Sun 2019-05-26 00h Cig
Value = 0 ft
URMA


BCDG
18z Sun 2019-05-26 00h Cig
Value = 0 ft
BCDG

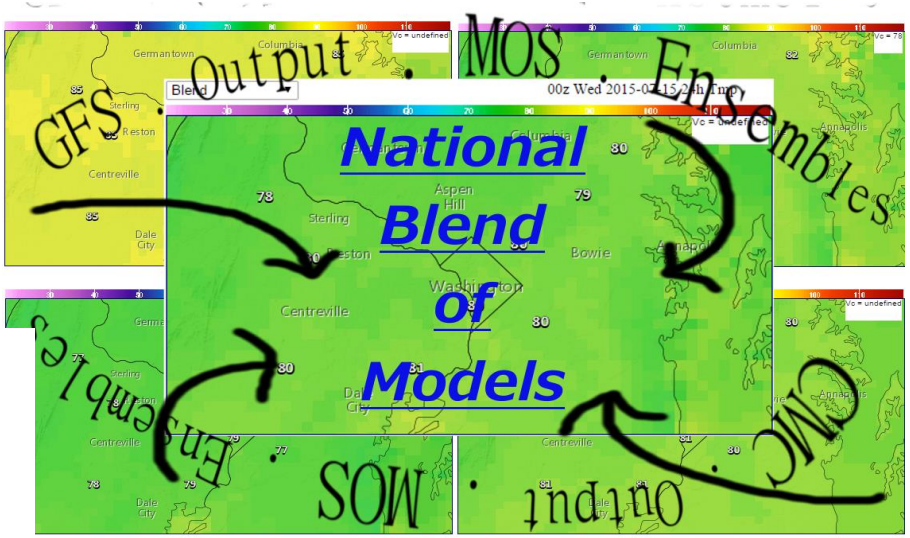
Lowest Cloud Base: v3.1 vs v3.2
21z (18 hour forecast) Jun 5, 2019




5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
v3.1
Init: 2019-06-05 Wed 03Z


5 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
v3.2
Init: 2019-06-05 Wed 03Z

Visibility NrnCal
12z Sunday May 19, 2019



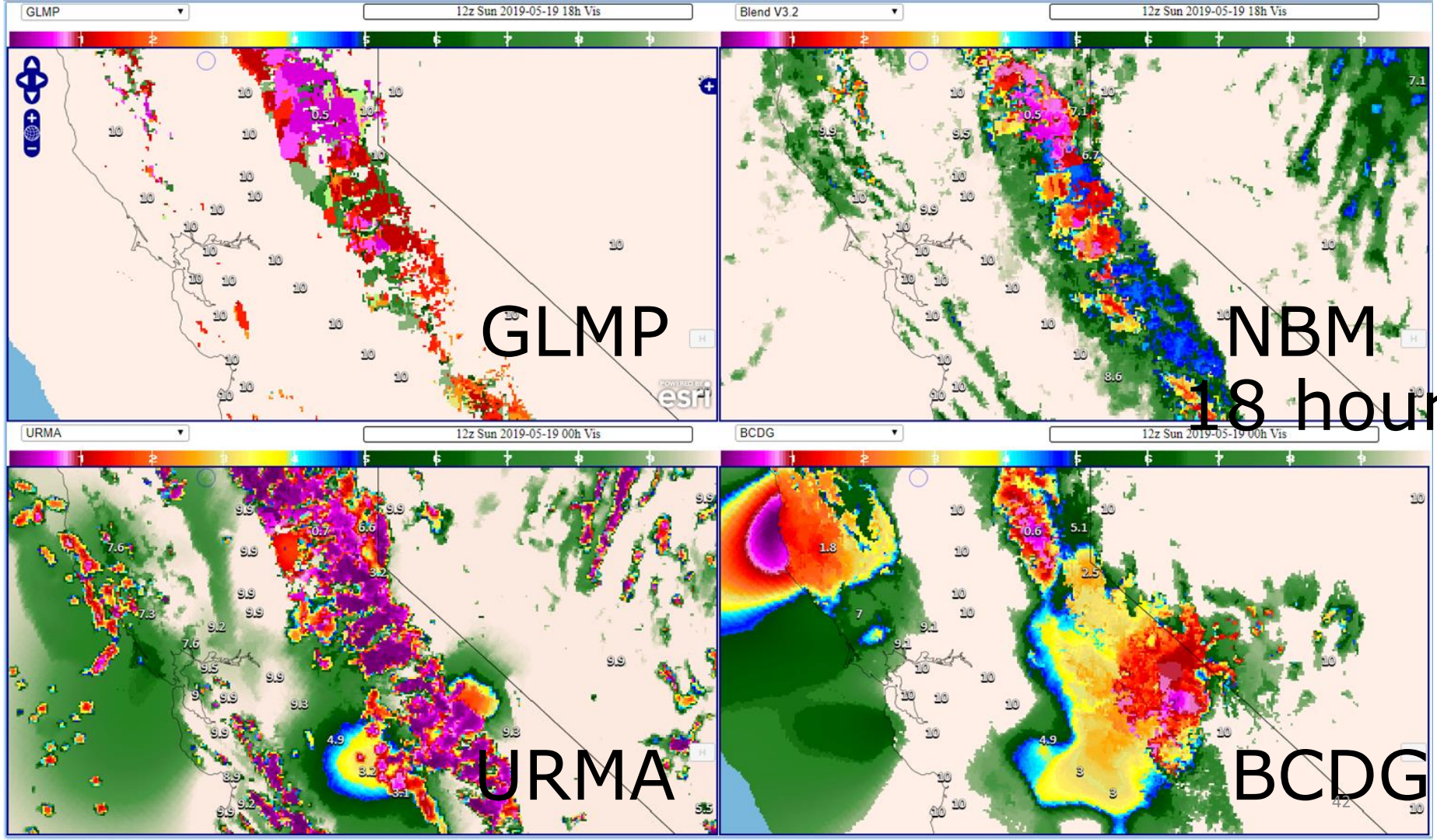
75% 5 min

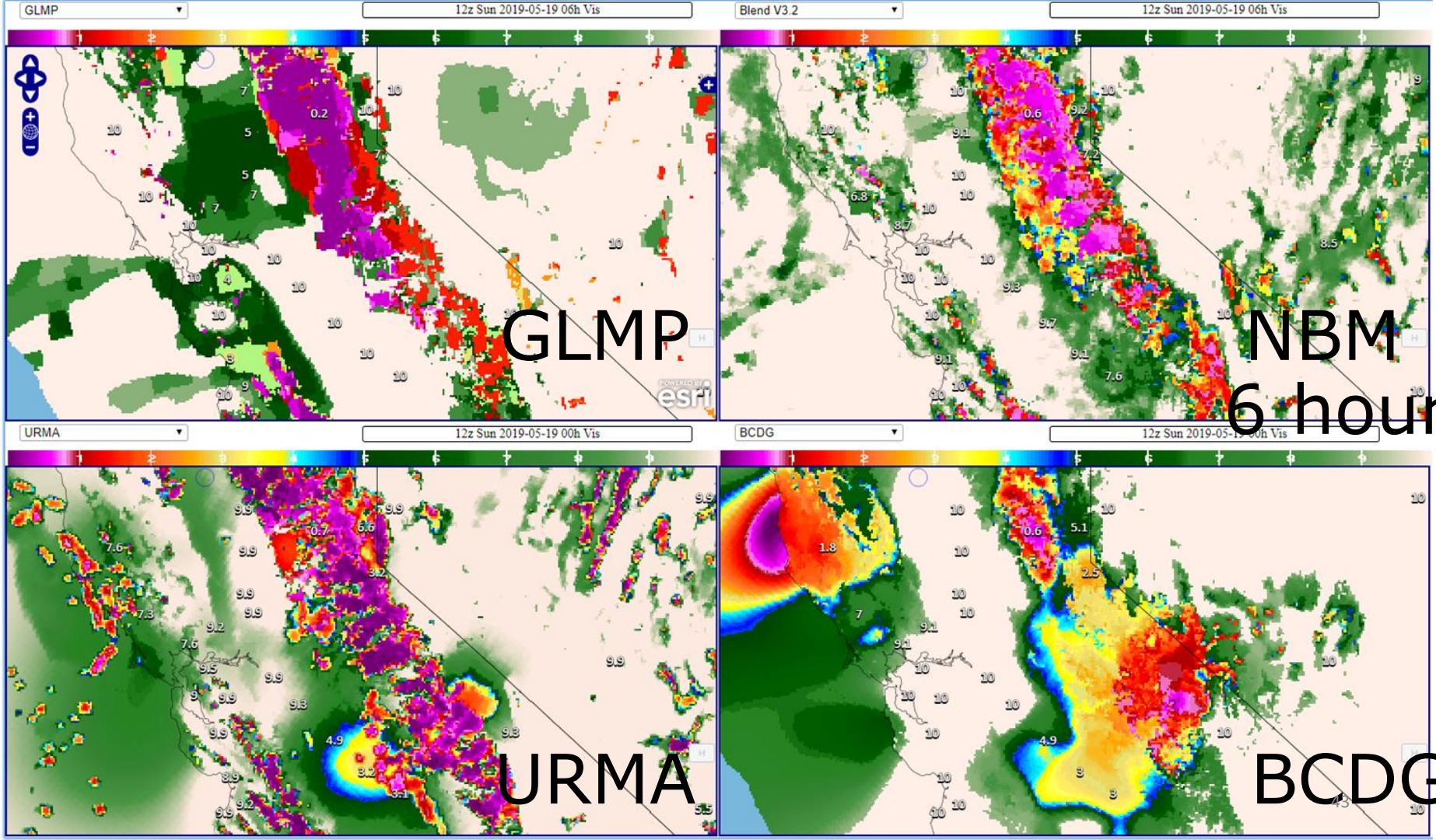
GLMP

NBM
30 hour

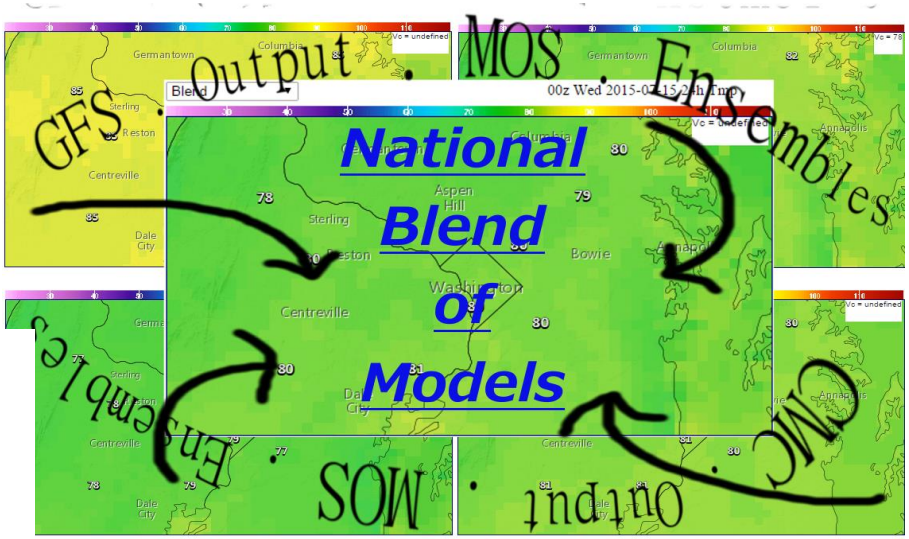
URMA

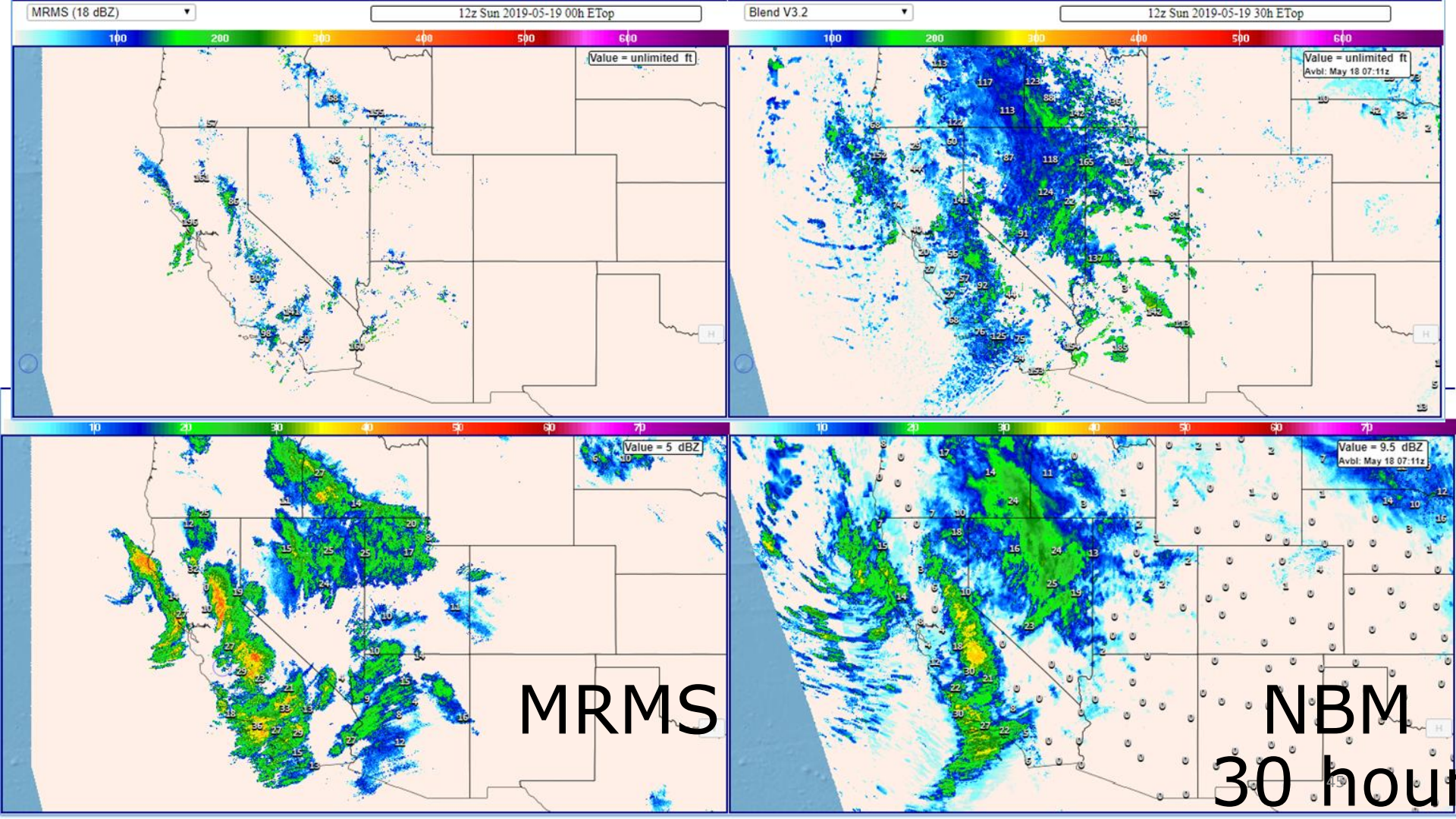
BCDG

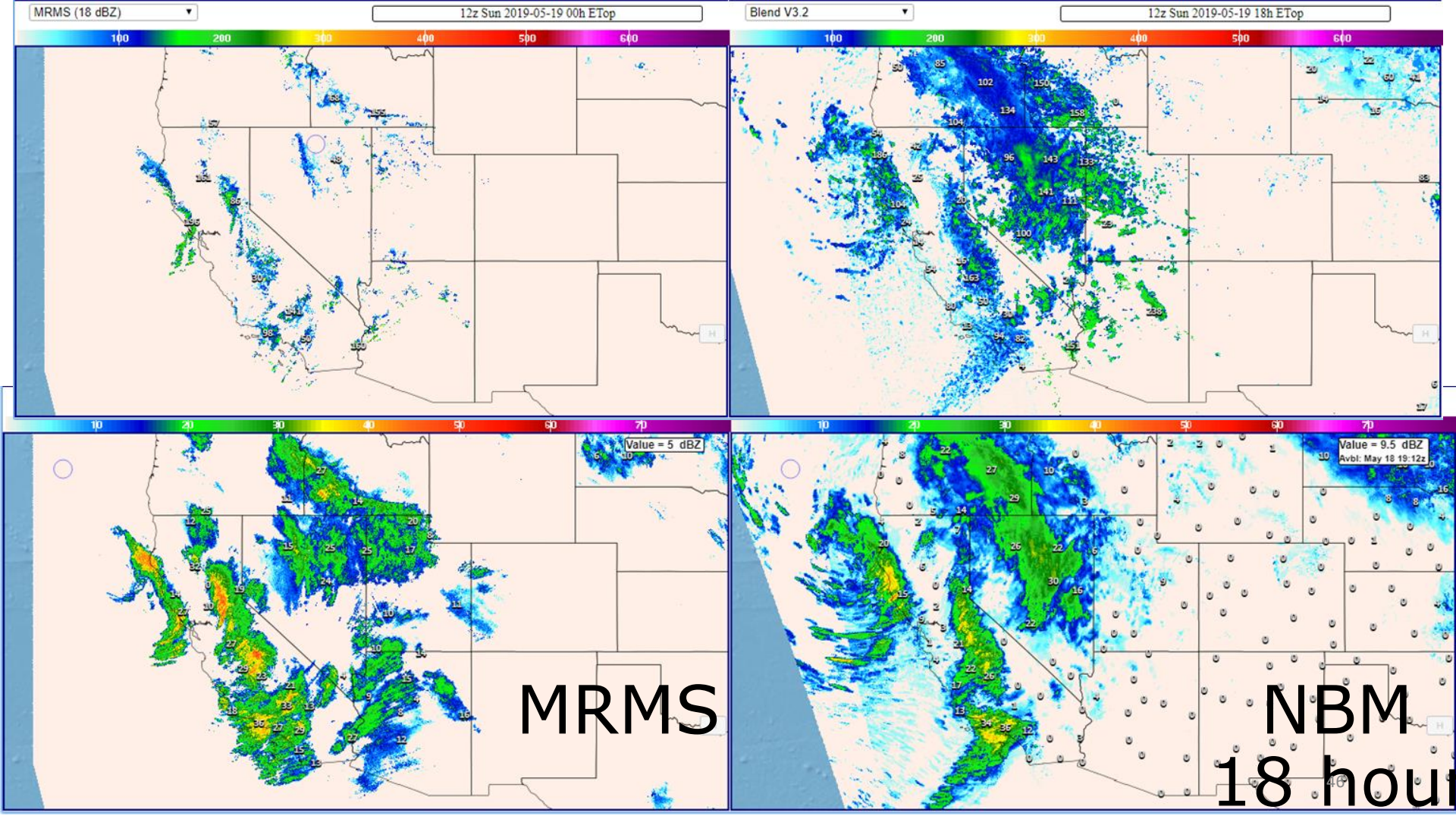

GLMP
12z Sun 2019-05-19 18h Vis
Blend V3.2
12z Sun 2019-05-19 18h Vis
GLMP
NBM
18 hour
URMA
12z Sun 2019-05-19 00h Vis
BCDG
12z Sun 2019-05-19 00h Vis
URMA
BCDG

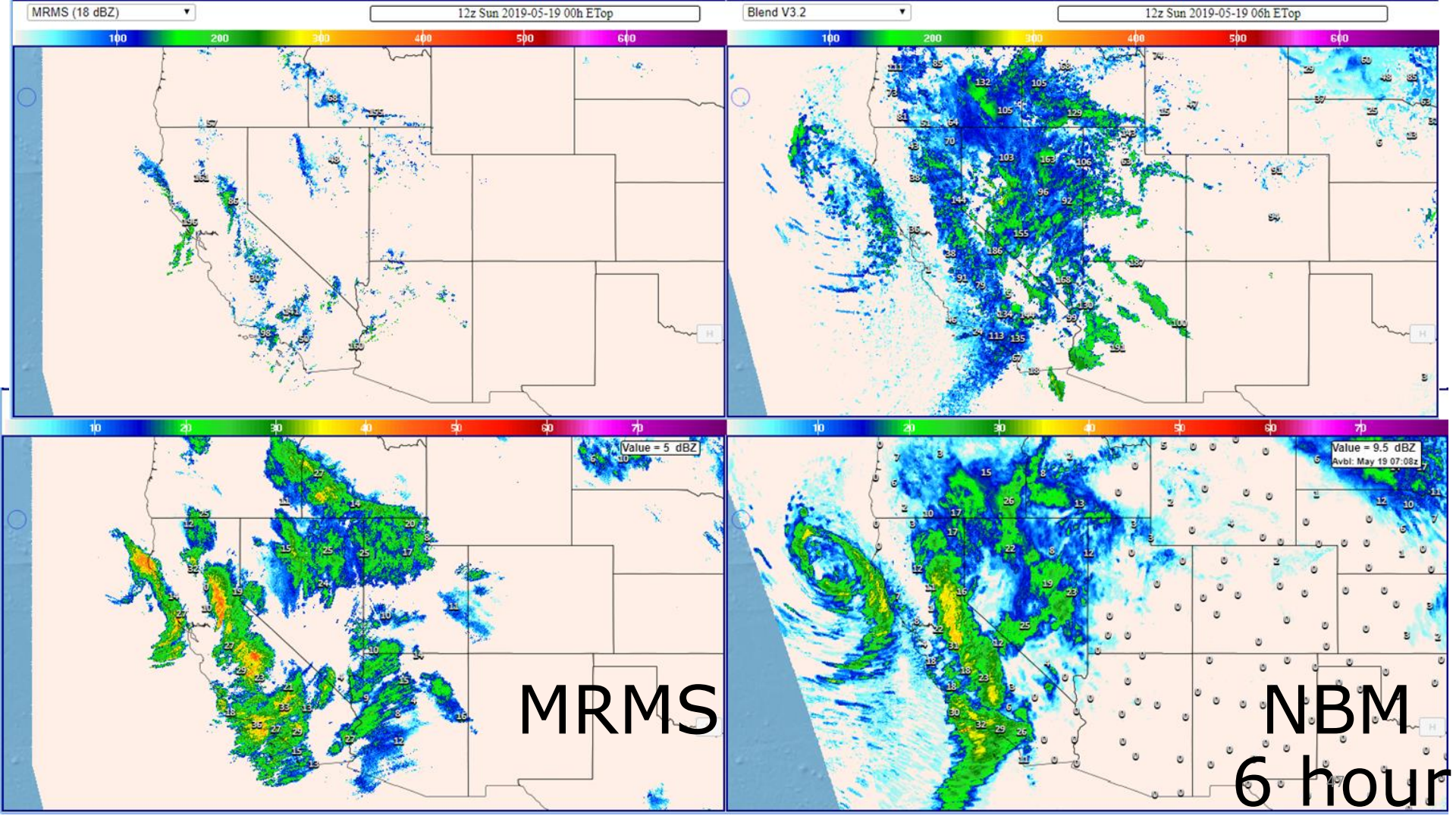

GLMP
12z Sun 2019-05-19 06h Vis
GLMP
Blend V3.2
12z Sun 2019-05-19 06h Vis
NBM
6 hour
URMA
12z Sun 2019-05-19 00h Vis
URMA
BCDG
12z Sun 2019-05-19 00h Vis
BCDG

Echo Tops/Max Hourly Reflectivity
12z Sunday May 19, 2019

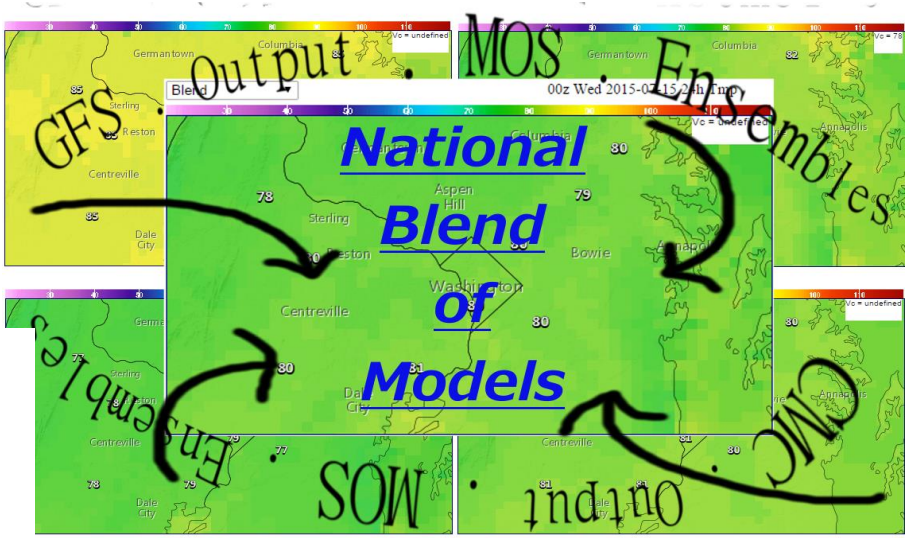


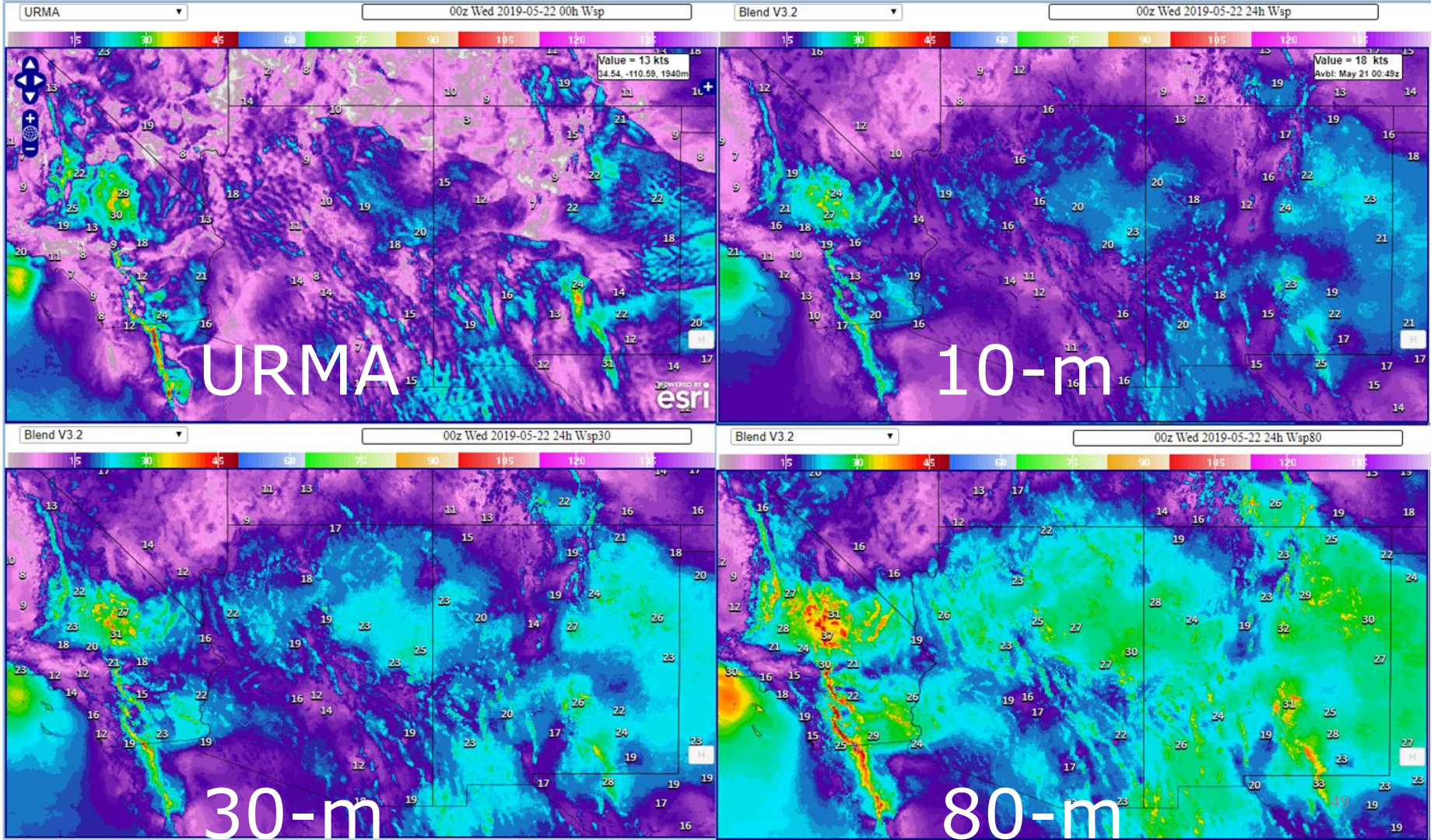

MRMS (18 dBZ)
12z Sun 2019-05-19 00h ETop
Value = unlimited ft
Blend V3.2
12z Sun 2019-05-19 30h ETop
Value = unlimited ft
Avbl: May 18 07:11z
Value = 5 dBZ
MRMS
Value = 9.5 dBZ
Avbl: May 18 07:11z
NBM
30 hour


MRMS (18 dBZ)
12z Sun 2019-05-19 00h ETop
Blend V3.2
12z Sun 2019-05-19 18h ETop
100 200 300 400 500 600
10 20 30 40 50 60 70
Value = 5 dBZ
Value = 9.5 dBZ
Avbl: May 18 19:12z
MRMS
NBM
18 hour

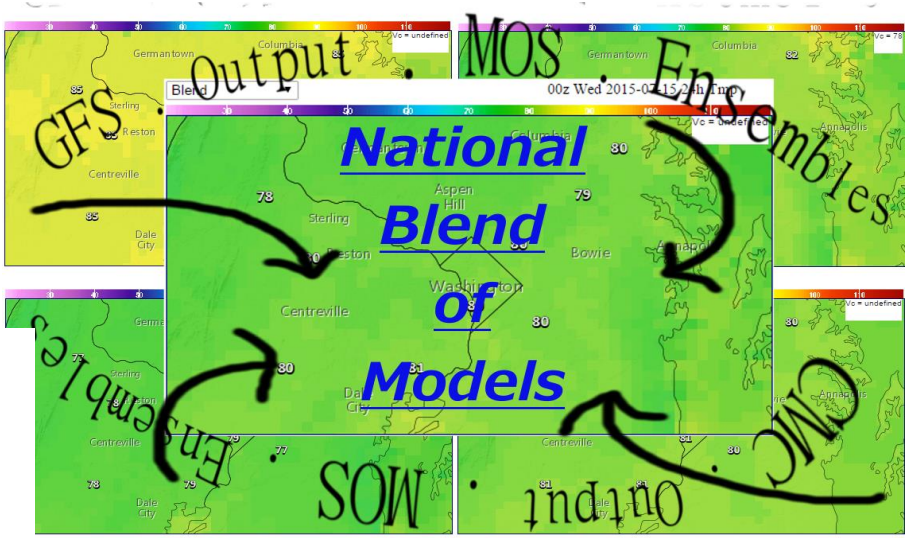

MRMS (18 dBZ)
12z Sun 2019-05-19 00h ETop
Blend V3.2
12z Sun 2019-05-19 06h ETop
Value = 5 dBZ
Value = 9.5 dBZ
Avbl: May 19 07:08z
MRMS
NBM
6 hour

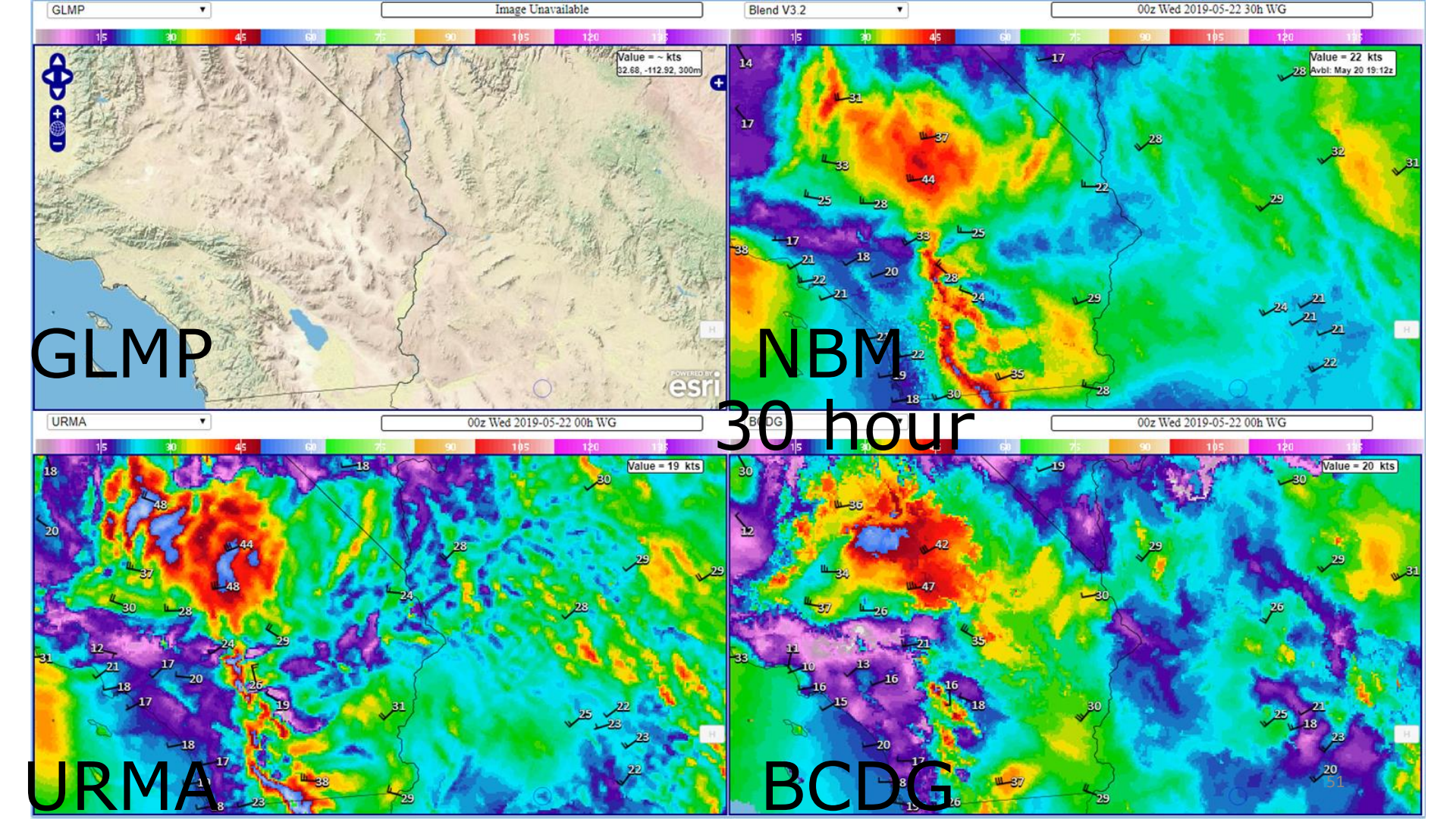
Wind 10-m, 30-m, 80-m wind speed
24 hour forecast
00z Wednesday May 22, 2019

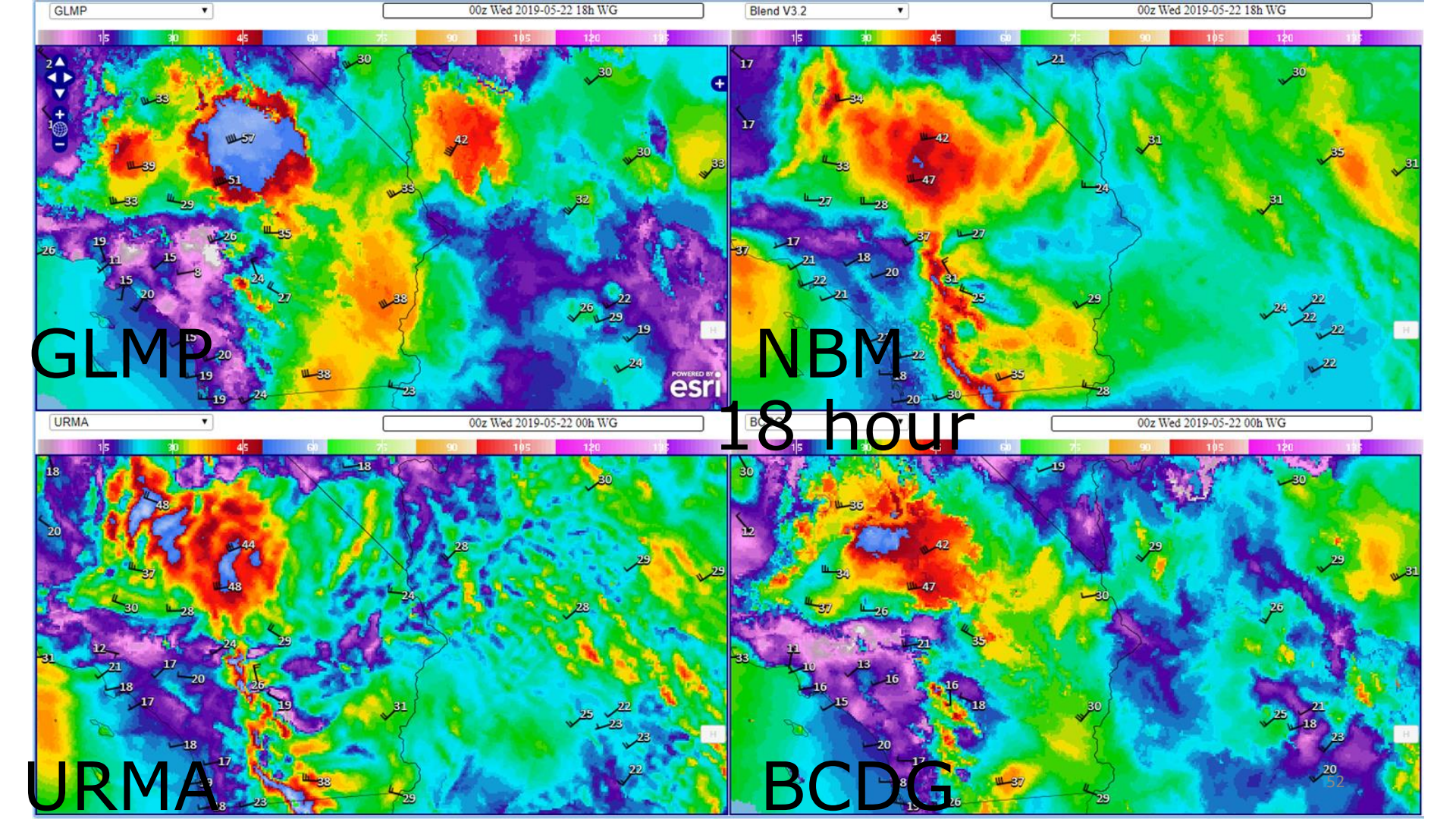


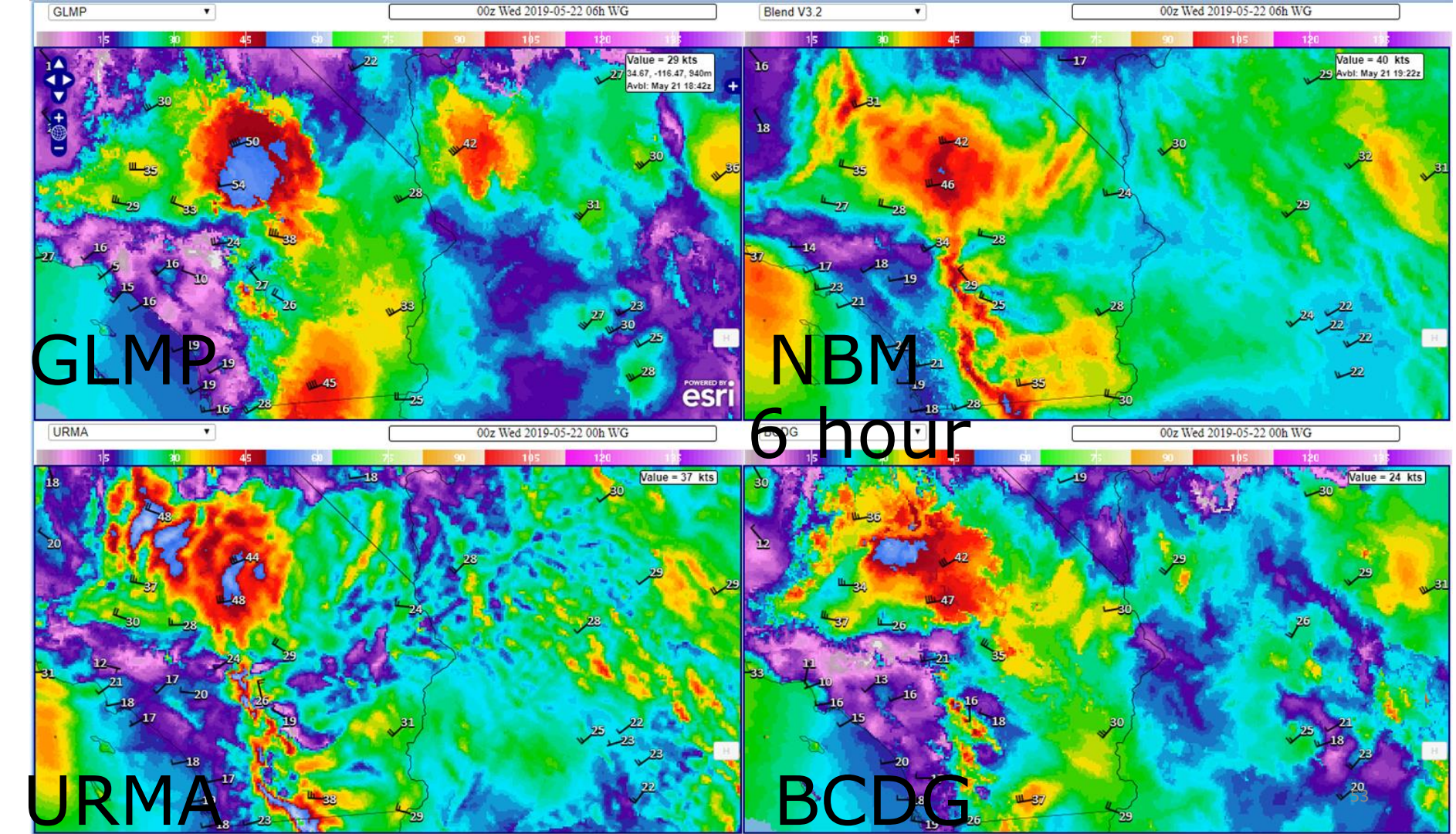

URMA
00z Wed 2019-05-22 00h Wsp
Value = 13 kts
34.54, -110.59, 1940m
URMA
Blend V3.2
00z Wed 2019-05-22 24h Wsp
Value = 18 kts
Avbl: May 21 00:49z
10-m
Blend V3.2
00z Wed 2019-05-22 24h Wsp30
30-m
Blend V3.2
00z Wed 2019-05-22 24h Wsp80
80-m

Wind Gust
00z Wednesday May 22, 2019



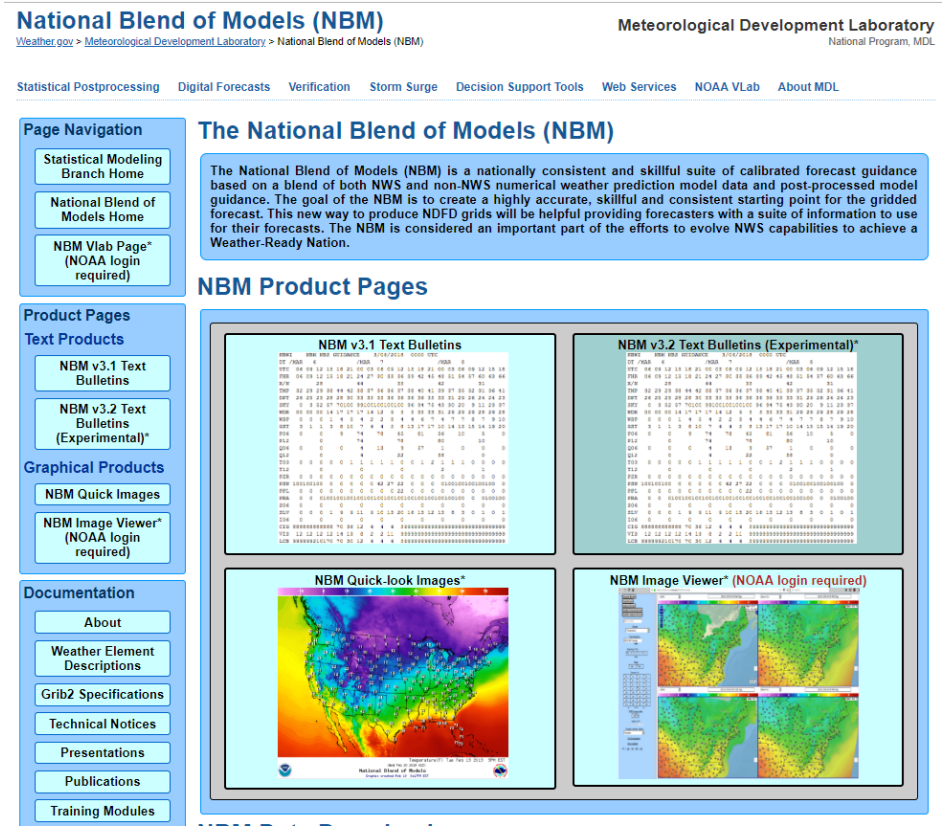

GLMP
Image Unavailable
Value = ~ kts
32.68, -112.92, 300m
NBM
Blend V3.2
00z Wed 2019-05-22 30h WG
Value = 22 kts
Avbl: May 20 19:12z
30 hour
URMA
00z Wed 2019-05-22 00h WG
Value = 19 kts
BCDG
00z Wed 2019-05-22 00h WG
Value = 20 kts


GLMP
00z Wed 2019-05-22 18h WG
Blend V3.2
00z Wed 2019-05-22 18h WG
GLMP
NBM
18 hour
URMA
00z Wed 2019-05-22 00h WG
00z Wed 2019-05-22 00h WG
URMA
BCDG
POWERED BY esri


GLMP
00z Wed 2019-05-22 06h WG
Value = 29 kts
34.67, -116.47, 940m
Avbl: May 21 18:42z
POWERED BY esri
NBM
Blend V3.2
00z Wed 2019-05-22 06h WG
Value = 40 kts
Avbl: May 21 19:22z
6 hour
URMA
00z Wed 2019-05-22 00h WG
Value = 37 kts
BCDG
00z Wed 2019-05-22 00h WG
Value = 24 kts

NBM Home Page

- https://www.weather.gov/mdl/nbm_home
- https://blend.mdl.nws.noaa.gov/

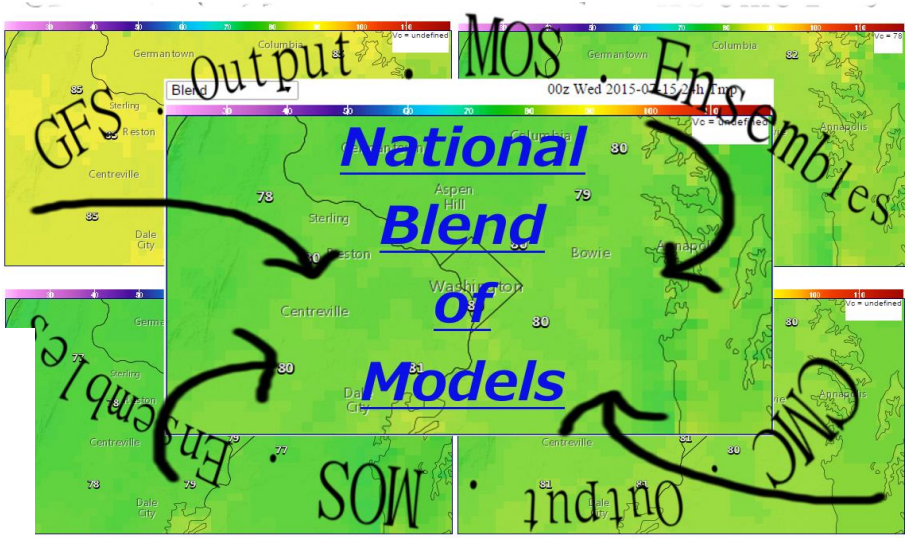


Outline

- NBM Digital Aviation Services products
- NWP components and expert weights
- Techniques and verification
- Example products
- **Potential future probabilistic capabilities**

Probabilistic Aviation Forecasts

- Probability of VLIFR, LIFR, IFR, MVFR:
  - Ceiling
  - Visibility
  - Combined
- Probability of exceedance for wind speeds and wind gusts
- Probability of runway usage based on wind speed and direction
- Probability of LLWS, Icing, turbulence

Thanks for your kind attention!

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