How to Read and Interpret Model Data and MOS

ATM 211

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Source: http://www.weather.gov/mdl/synop/products.php

MOS (Model Output Statistics) is statistical processing that occurs after a model has been run. This is done in order to adjust for errors or biases of a particular model, or to capture the effects of local terrain (i.e., the Hudson Valley has specific meteorological characteristics that a model might not be able to pick up on due to its horizontal/vertical resolution). MOS, over time, will pick up on these errors and attempt to fix them. You can think of MOS as the model *plus* what the model has learned over time about a specific city or area.

First, let's take a look at **NAM MOS**. Below is NAM MOS from Baltimore, MD (KBWI) from 1200 UTC on April 18, 2022:

```
KBWI   NAM MOS GUIDANCE    4/18/2022  1200 UTC
DT /APR  18/APR  19                /APR  20                /APR  21
HR   18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 06 12
N/X                    37          56          37          62    44
TMP  46 45 43 44 42 39 42 49 52 54 50 46 43 40 44 55 59 60 55 47 49
DPT  35 35 35 37 35 33 33 29 28 25 23 27 28 28 29 30 30 31 33 39 41
CLD  OV OV OV OV OV BK BK BK OV BK SC CL CL CL CL CL CL CL SC BK BK
WDR  10 08 04 34 29 28 26 27 27 28 28 27 27 28 27 30 28 25 16 14 16
WSP  09 17 09 14 10 11 11 16 18 16 11 09 07 06 06 09 06 06 02 01 07
P06       100    71    14     4     3     2     0     0     1  8 12
P12                    85          6          4          2    19
Q06          4     2     0     0     0     0     0     0     0  0  0
Q12                    3          0          0          0       0
T06      5/ 7  4/ 4  0/ 6  0/ 4  0/16  1/10  0/ 3  0/ 1  0/ 0  1/ 3
T12           5/ 7        0/ 6        1/23        1/ 3     1/ 0
POZ   0  1  0  0  0  0  0  0  0  0  0  0  0  2  2  0  0  2  3  0  0
POS   1  0  3  1  7  8 26 13 15 12 13 11 27 28 19  0  0  0  0  0  0
TYP   R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R
SNW                    0                          0                0
CIG   6  4  3  3  4  8  8  8  7  7  7  8  8  8  8  8  8  8  8  8  8
VIS   7  5  4  5  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
OBV   N  N BR BR  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N
```

The first column describes the values to the right. The top shows the station (KWBI), the model (NAM), the date and time.

DT = The day of the month, denoted by the standard three or four letter abbreviation
HR = Hour of the day in UTC time. This is the hour at which the forecast is valid, or if the forecast is valid for a period, the end of the forecast period.
N/X = Nighttime minimum/daytime maximum surface temperatures. In the example above, the low temperature between 00Z-12Z on April 19 in BWI is forecast to be 37. The high temperature from 12Z-00Z (the next period) is 56. The next night's low is 37, and next day's high is 62.
TMP = surface temperature valid at a specific forecast hour.
DPT = surface dewpoint valid at a specific forecast hour.

CLD = forecast categories of total sky cover valid at that hour:
CLD Categories:

```
CL    clear
FW    > 0 to 2 octas of total sky cover
SC    > 2 to 4 octas of total sky cover
BK    > 4 to < 8 octas of total sky cover
OV    8 octas of total sky cover or totally obscured
```

WDR = forecasts of the 10-meter wind direction at the hour, given in tens of degrees. In the example above, at 09Z on April 19, the winds are forecast to be at 280 degrees (westerly).
WSP = forecasts of the 10-meter wind speed at the hour, given in knots. In the BWI example, at 18Z on April 19, the NAM forecasts winds of 18 knots at 270 degrees (westerly).
P06 = probability of precipitation (POP) during a 6-hour period ending at that time. In the BWI example, between 00Z-06Z on April 19, the NAM forecasts a probability of precipitation of 71%.
P12 = POP during a 12-h period ending at that time. From 00Z-12Z on April 19, the NAM forecasts a POP of 85% for BWI.
Q06 = Quantitative precipitation forecast (QPF) category for liquid equivalent precipitation amount during a 6-h period ending at that time:

QPF Categories:

```
0      no precipitation
1     0.01 to 0.09 inches
2     0.10 to 0.24 inches
3     0.25 to 0.49 inches
4     0.50 to 0.99 inches
5     1.00 to 1.99 inches
6     2.00 inches or greater
```

Example: The NAM forecasts category 2 precipitation (0.10 to 0.24 inches) to fall between 00Z-06Z on April 19.

Q12 = QPF category for liquid equivalent precipitation amount during a 12-h period ending at the indicated time. The categories are the same as above.
T06 = probability of thunderstorms/conditional probability of severe thunderstorms during the 6-hr period ending at the indicated time. BWI Example: There is a 4% chance of thunderstorms between 00Z-06Z on April 19, and a 4% chance of severe thunderstorms in the same time frame (4/4).
T12 = probability of thunderstorms/conditional probability of severe thunderstorms during the 12-hr period ending at the indicated time.
POZ, **POS**, and **TYP**: We'll explore these in more detail when we analyze GFS MOS.
SNW = snow fall categorical forecasts during a 24-h period ending at the indicated time:

Snowfall Categories:

```
0      no snow or a trace expected
1     > a trace to 2 inches
2     2 to 4 inches
4     4 to 6 inches
6     6 to 8 inches
8     >= 8 inches
```

CIG = ceiling height categorical forecasts at the hour.

CIG Categories:

```
1  less than 200 feet;
2  200 to 400 feet;
3  500 to 900 feet;
4  1000 to 3000 feet;
5  3100 to 6500 feet;
6  6000 to 12,000 feet;
7  greater than 12,000 feet;
8  clear skies
9  no forecast available.
```

VIS = visibility categorical forecasts at the hour.

Visibility Categories:

```
1   < 1/2 miles
2   1/2 - < 1 miles
3   1 - < 2 miles
4   2 - < 3 miles
5   3 - 5 miles
6   6 miles
7   > 6 miles
```

OBV = obstruction to vision categorical forecasts at the hour.

Obstruction to Visibility Symbols:

```
N     none of the following
HZ    haze, smoke, dust
BR    mist (fog with visibility >= 5/8 mile)
FG    fog or ground fog (visibility < 5/8 mile)
BL    blowing dust, sand, snow
```

Next, let's look at **GFS MOS**. We'll look at the GFS MOS from 06Z on April 18, 2022 for Watertown, New York (KART):

```
KART   GFS MOS GUIDANCE    4/18/2022  0600 UTC
DT /APR  18       /APR  19                /APR  20                /
HR   12 15 18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 00 06
X/N               59          35          45          33       49
TMP  34 51 57 58 50 43 40 39 38 41 41 40 41 41 38 36 37 42 46 42 38
DPT  22 22 22 22 27 30 32 31 31 30 31 32 30 31 30 28 28 27 27 28 26
CLD  CL CL CL OV OV OV OV OV OV OV OV OV OV OV OV OV SC SC SC CL SC
WDR  07 07 09 10 17 12 09 09 01 26 24 24 23 24 25 26 26 26 25 17 11
WSP  02 05 07 08 10 09 09 05 04 05 09 09 11 12 12 15 13 13 12 03 07
P06         0     18     87     95     86     66     61     23      2  2  5
P12               30          100         92          61       5
Q06         0      0      3      4      2      1      1      0      0  0  0
Q12               0           5           2           1       0
T06       0/ 0 10/ 0  4/ 0  2/ 0  8/ 0 10/ 0  0/ 0  3/ 0  2/ 0  0/ 0
T12                  10/ 3       11/ 0       14/ 2       5/ 3  4/ 0
POZ   6  4  3  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  1  1
POS  94 52 17 16 36 65 77 84 85 87 72 58 59 72 75 79 79 68 54 20 10
TYP   S  S  R  R  R  S  S  S  S  S  S  S  S  S  S  S  S  S  S  R  R
SNW                           0                       1
CIG   8  8  8  8  6  3  3  3  3  3  4  3  3  4  5  5  6  8  8  8  8
VIS   7  7  7  7  7  4  4  5  3  4  4  5  4  5  7  7  7  7  7  7  7
OBV   N  N  N  N  N  N  N  N BR BR  N  N BR HZ  N  N  N  N  N  N  N
```

The three variables we didn't analyze from the NAM are below:

POZ = Conditional probability of freezing precipitation (sleet or freezing rain) occurring at the hour.
POS = Conditional probability of snow occurring at the hour.
TYP = Conditional precipitation type at the hour. (R = Rain, S = Snow, Z = Freezing Precip.) Notice how the expected precipitation type changes from rain to snow throughout the forecast period for Watertown. Precipitation types are conditional, and only are significant if precipitation is actually falling. These are derived from model soundings.

Finally, we'll examine the **GFS's medium-range MOS**. The highs and lows (N/X) will be identical to the 12Z GFS MOS, since this is just the long-range version. So, this is really only useful in making medium-range (3-7 day) forecasts.

The GFSX MOS below is from 1200Z April 12, 2019 for Fond du Lac, Wisconsin (KFLD)

KFLD	GFSX	MOS	GUIDANCE		4/12/2019		1200	UTC								
FHR	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	
	SAT	13	SUN	14	MON	15	TUE	16	WED	17	THU	18	FRI	19	SAT	CLIMO
N/X	33	48	31	46	28	52	40	60	47	66	50	59	41	50	36	36 56
TMP	34	45	34	41	32	47	43	54	50	61	52	53	43	46	38	
DPT	25	23	26	24	25	30	36	42	42	47	48	43	37	32	31	
CLD	OV	OV	OV	OV	PC	PC	OV	OV	OV	OV	OV	OV	OV	OV	OV	
WND	14	13	8	14	11	10	10	11	13	12	12	17	19	23	15	
P12	22	13	9	24	9	7	34	33	51	48	60	67	49	33	23999999	
P24		22		24		16		40		69		78		61		999
Q12	0	0	0	0	0	0	0	1	2	3	4	4				
Q24		0		0		0		0		3		6				
T12	2	3	3	2	0	2	5	4	26	21	29	23	14	4	6	
T24			3		2		7		26		43		36		13	
PZP	0	0	0	0	2	1	0	0	1	0	1	2	1	0	2	
PSN	60	73	39	37	45	32	2	0	1	3	4	0	4	8	26	
PRS	37	22	29	32	33	18	7	1	3	4	2	3	5	21	20	
TYP	S	S	RS	RS	RS	RS	R	R	R	R	R	R	R	R	R	
SNW		0		0		0		0		0		0				

FHR = Forecast hour, i.e. how many hours from the model run time
N/X = Nighttime min (N) / Daytime max (X) temperatures
TMP = Temperature valid at a specific forecast hour
DPT = Dewpoint valid at a specific forecast hour
WND = maximum sustained surface wind (in knots) during a 12-h period
P12 = 12-hr probability of precipitation (POP) ending at that forecast time.
P24 = 24-hr POP ending at that forecast time. The example above has a 43% probability of precipitation (POP) in the 12-hour period from 12Z Sat-00Z on Sunday, and a 100% POP for the 24-hour period from 00Z Sat-00Z Sunday.
Q12 = 12-hr quantitative precipitation forecast (QPF) ending at that forecast time (see the QPF chart in the NAM MOS description for details)
Q24 = 24-hr QPF ending at that forecast time
T12 = 12-hr probability of thunderstorm ending at that forecast time.
T24 = 24-hr probability of thunderstorm for the 1200-1200 UTC time period ending at that forecast time. The example above for Albany has a 13% chance of a thunderstorm between 12Z Friday, April 3 and 12Z Saturday, April 4.
PZP, PSN, PRS = Probability of frozen precip., snow, and rain, respectively
TYP = Most likely precipitation type
SNW = snowfall categorical forecasts during a 24-h period ending at the indicated time. (9 = missing)

Now, we'll look at data that has been extrapolated directly from the model (no MOS). Both the **EXTNAM** and **EXTGFS** look similar, so we'll just go through the **EXTNAM**. The following is a forecast extrapolated from the 12Z April 1, 2009 NAM for Jacksonville, FL:

Station: JAX Lat: 30.50 Lon: -81.68 Elev: 10 Closest grid pt: 25.1 km.
Initialization Time: 09-04-01 1200 UTC

PARAMETER/TIME	000	006	012	018	024	030	036	042	048
DAY / HOUR	01/12	01/18	02/00	02/06	02/12	02/18	03/00	03/06	03/12
TEMPS									
2 M (F)									
850 MB (C)	13	13	13	14	14	14	14	15	14
700 MB (C)	3	4	4	5	5	5	5	6	6
500 MB (C)	-10	-11	-10	-11	-11	-10	-10	-10	-11
1000-500 THCK	564	565	565	567	567	568	568	568	568
MOISTURE									
2 M DEW POINT (F)									
850 MB DP(C)/RH	11/86	10/80	12/90	12/89	11/84	12/92	11/84	12/86	13/91
700 MB DP(C)/RH	1/92	1/81	2/91	3/85	3/92	3/86	3/87	2/78	-6/39 -
500 MB DP(C)/RH	-10/99	-11/96	-11/96	-12/91	-13/89	-11/94	-11/92	-18/55	-39/08 -
PRCPABLE WTR (IN)									
CONV PRECIP (IN)	0.12	0.02	0.04	0.21	0.16	0.17	0.07	0.00	
6HR TOTAL PRECIP	0.40	0.11	0.10	0.26	0.32	0.26	0.17	0.02	
12HR TOTAL PRECIP		0.51		0.36		0.59		0.19	
WIND DD/FFF (Kts)									
10 M									
850 MB	25/022	25/021	21/015	21/025	24/026	21/033	22/049	24/040	24/044
700 MB	25/034	26/027	23/032	25/029	24/022	22/043	24/052	25/049	24/053
500 MB	26/048	26/044	26/045	26/060	26/049	25/064	25/067	25/062	26/061
250 MB	27/070	26/080	27/100	26/093	25/071	26/082	24/068	24/094	25/083
PRESS/HEIGHTS									
MSL PRESSURE	1014.2	1016.2	1013.3	1013.1	1010.7	1009.1	1006.5	1005.7	1004.4
850 MB HGT	150	152	150	150	149	147	145	144	143
700 MB HGT	311	313	311	311	310	308	306	306	305
500 MB HGT	576	579	577	578	576	575	574	573	572
250 MB HGT	1073	1076	1073	1075	1073	1075	1073	1069	1066
VERTICAL VEL (uB/S)									
850 MB	-40	-36	-26	22	-4	69	-19	-23	-2
700 MB	22	-13	17	17	8	116	-39	-20	-24
500 MB	62	38	73	15	40	89	31	26	19
CONVECTION PARAMS									
LIFT INX SFC									
LIFT INX 4LYR									
CAPE SFC	0	0	37	86	438	459	281	620	856
CAPE 4LYR									
CIN SFC	-56	-131	-126	-70	-40	-17	-13	-18	-13
CIN 4LYR									
HELICITY (0-3 KM)									

The first line tells us the station, time of the model run, as well as the location of the station. Notice that the "**closest grid point**" is 25.1 km away. This tells us that the station is a distance away from the nearest grid point, which could make the data somewhat askew.

DAY / HOUR tells us the day of the month and time of the day for each piece of data (02/06 is 06Z on the 2nd of April, in this case).

The **TEMPS** section shows temperatures at various levels of the troposphere in degrees Celsius. 2 meter (surface) temperatures will appear for EXTGFS, not EXTNAM. The 1000-500 mb thickness, in decameters is also shown for each forecast time. Notice how the 850 mb temperatures increase as the 1000-500 mb thickness increases, which shouldn't be surprising.

MOISTURE tells us the dewpoint (Celsius) and relative humidity at various levels in the tropopause. At 12Z on the 2nd, the NAM forecasts an 850-mb dewpoint of 11° C, with a relative humidity of 84%.

This section also shows forecast 6-hourly and 12-hourly precipitation, as well as how much of the precipitation is "convective" (precipitation resulting from instability in the atmosphere). These amounts are in inches. Between 00Z-12Z on the 2nd, the NAM forecasts 0.36" of precipitation, and between 06Z-12Z, the NAM forecasts 0.26".

The **WIND** section displays wind speed and direction at various levels of the troposphere (Example: At 00Z on April 3, the 250-mb winds are forecast to be 68 knots at 240 degrees).

The **PRES/HEIGHTS** section displays sea level pressure in millibars, and heights at various pressure levels in decameters.

For now, don't worry about the **vertical velocity** and **convection parameters**.