### Welcome to our NWS Boston/Norton Webinar! Weather Models 101

















### Check our Webinar page for the latest schedule! www.weather.gov/boston/ webinars



Recorded webinars are on our YouTube Channel! YouTube.com/NWSBoston



#### Join our email list for new webinar dates! Email Joseph.Dellicarpini@noaa.gov to be added.

# Presenters



### Joe Dellicarpini Science and Operations Officer



### Bryce Williams Meteorologist

# Weather Models 101



Numerical weather prediction involves the use of mathematical models of the atmosphere to predict the weather.

### 213,000 Trillion calculations per second!

The roots of numerical weather prediction can be traced back to the work of Vilhelm Bjerknes, a Norwegian physicist who has been called the father of modern meteorology.

In 1904, he published a paper suggesting that it would be possible to forecast the weather by solving a system of nonlinear partial differential equations.



Vilhelm Bjerknes

A British mathematician, Lewis Fry Richardson, spent three years developing Bjerknes's techniques to solve these equations.

Armed with no more than a slide rule and a table of logarithms, and working among the World War I battlefields of France where he was a member of an ambulance unit, Richardson computed a prediction for the change in pressure at a single point over a six-hour period.

The calculation took him six weeks, and the prediction turned out to be completely unrealistic, but his efforts were a glimpse into the future of weather forecasting.

| "Primitive" Weather Forecasting Equations   |
|---|
| p = a R T [deal Cap Law (Remation of State)   |
| $\frac{\partial u}{\partial t} = \eta v - \frac{\partial \Phi}{\partial r} - c_p \theta \frac{\partial \pi}{\partial r} - z \frac{\partial u}{\partial r} - \frac{\partial (\frac{u+v^2}{2})}{\partial r}$  |
| $\vec{\sigma} = \nabla (\vec{F}_{b} / )$ Mustavia Grand Law of Mation $\Delta p = -\rho g \Delta z$ Meridianal Wind:  |
| $u_{h} = 2 \left( \frac{n}{m} \right)^{\text{Newon's Second Ldw of Moduli }} \frac{(PGA)_{v}}{\vec{E}} = g \qquad \frac{\partial v}{\partial t} = -\eta \frac{u}{v} - \frac{\partial \Phi}{\partial y} - c_{p} \frac{\partial \pi}{\partial y} - z \frac{\partial v}{\partial \sigma} - \frac{\partial (\frac{u^{2}+u}{2})}{\partial y}$  |
| $\vec{a}_{v} = \sum \left( \frac{T_{v}}{m} \right) = \left( \vec{P} \vec{G} \vec{A} \right)_{v} - \vec{g}  \stackrel{\text{Temperature:}}{\overset{Temperature:}}{\overset{Temperature:}}{$ |
| Hydrostatic Law (Obtained from the Equation of Vertical Motion) $\partial t = \partial t + \partial x + \partial y + \partial z$<br>Precipitable water:   |
| $\Delta T = \Delta q/c_p + (1/\rho)\Delta p \text{ First Law of Thermodynamics} \qquad \qquad \frac{\delta W}{\partial t} = u\frac{\partial W}{\partial x} + v\frac{\partial W}{\partial y} + w\frac{\partial W}{\partial z}$   |
| $(1/\rho)\Delta\rho/\Delta t = -DIV$ Pressure thickness:  |
| Conservation of Mass Applied to the Atmosphere (Equation of Continuity) $\frac{\partial}{\partial t}\frac{\partial p}{\partial \sigma} = u\frac{\partial}{\partial x}x\frac{\partial p}{\partial \sigma} + v\frac{\partial}{\partial y}y\frac{\partial p}{\partial \sigma} + w\frac{\partial}{\partial z}z\frac{\partial p}{\partial \sigma}$   |
| $\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} + \omega\left(\frac{\partial T}{\partial p} + \frac{RT}{pc_p}\right) = \frac{J}{c_p} \qquad \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \omega}{\partial p} = 0 \qquad 0 = -\frac{\partial \phi}{\partial p} - \frac{RT}{p}$  |

Richardson foresaw a "forecast factory," where he calculated that 64,000 human "computers," each responsible for a small part of the globe, would be needed to keep "pace with the weather" in order to predict weather conditions.

They would be housed in a circular hall like a theater, with galleries going around the room and a map painted on the walls and ceiling. A conductor located in the center of the hall would coordinate the calculations using colored lights.



John von Neumann, the developer of that first computer (called the ENIAC), recognized that the problem of weather forecasting was a natural for his computing machinery.

In 1948, he assembled a group of theoretical meteorologists at the Institute of Advanced Study in Princeton, New Jersey. The group was headed by Jule Charney, who had done extensive work on developing a simplified, filtered system of equations for weather forecasting. His group constructed a successful mathematical model of the atmosphere and demonstrated the feasibility of numerical weather prediction.



The first one-day, nonlinear weather prediction was made in April, 1950.

Its completion required the round-the-clock services of the modelers, and, because of several ENIAC breakdowns, more than 24 hours to execute.

However, this first forecast was successful in proving to the meteorological community that numerical weather prediction was feasible.



By 1954, both modeling capability and computer power had advanced to a point where the possibility of real-time operational numerical weather prediction was under active consideration in Europe and the United States.

On July 1, 1954, the Joint Numerical Weather Prediction Unit (JNWPU) was organized, staffed, and funded by the U.S. Weather Bureau, the U.S. Air Force, and the U.S. Navy.

This new unit was given the mission to apply emerging computer technology to the operational production of weather forecasts.



Fred Shuman (left) and Otha Fuller, circa 1955 at the IBM 701. The 701 was the first computer used by the JNWPU to produce operational numerical weather prediction.

A progression of more and more powerful computers procured by the National Weather Service throughout the 1960s and 1970s as well as increasing sources of data—particularly from weather satellites—allowed the expansion of both the domains and the number of models run.

Increases were also made in the number of vertical levels and the horizontal resolution of the models. A three-layer hemispheric model was introduced in 1962 and a six-layer primitive equation model appeared in 1966. Additional atmospheric layers allowed more accurate forecasts of winds and temperature, resulting in better prediction of storm motion.



# What Are Weather Models?

#### Model Does the Math For Us

- Initial Conditions
- Runs Equations
- Graphical Output

Global models typically run 4 times a day

Models have different resolutions, initial conditions, parameterizations, and schemes that make output differ.





National Weather Service - Boston, MA



Each model is run for a specific area, in order to focus on certain weather features

**<u>Clobal models:</u>** entire globe or hemisphere

**Regional models:** smaller sections, like countries (U.S.)

Mesoscale models: even smaller sections, like parts of the country (Northeast)



#### **Global models:**

Focus on larger scale features such as jet streams, tropical cyclones, and others that affect a large portion of the globe.

The input initializes regional models, in order to give them a "starting point" for a forecast, and also feeds climate models which provide forecasts out several weeks in time.



#### **Regional models:**

Able to provide more detail with larger scale systems such as winter storms, tropical cyclones, and severe weather.

The input initializes mesoscale models, in order to give them a "starting point" for a forecast.



#### Mesoscale models:

Able to provide more detail with smaller scale systems such as rain/snow lines, supercells, and sea breezes,

They are typically run at least once per hour and can provide forecasts at very high resolution.



### **Model Resolution**



• Higher resolution = greater precision (more grid boxes over a given area)

- A higher resolution model has a smaller grid size and can forecast smaller-scale features better than a lower resolution model
- A 12km model (NAM) is lower resolution than a 2 or 3 km model (HRRR)

# **Model Output**

#### Maps

#### MOS (Model Output Statistics)

- Developed by the NWS in 1965 and forecasts first issued from it in 1968.
- Given its long history and continuous improvement, it is still one of the most valuable forecast tools
- Consistently performs better than "raw" model guidance

|   | MAN/ -  | EVT  | DL   | 1.00   | T.T.1.   |   |  |   |  |   |   |   |   |   |  |   |  |  |   |   |   |   |
|---|---|--|--|--|--|---|--|---|--|---|---|---|---|---|--|---|--|--|---|---|---|---|
|   | MAVI  | EXI  | BUI  | LLE  | ITN  |   |  | _   |  |   |   |   |   |   |  |   |  |  |   |   |   |   |
|   | KPVD  | KPVD GFS MOS GUIDANCE 1/04   |  |  |  |   |  |   |  |   |   | 22  | 060   | 30 1  | JIC  |   |  |  |   |   |   |   |
|   | DT /  | JAN  | 4  | 4  |  | 121   | AN   | 5   |  |   |   |   |   | 121   | AN   | 6   |  |  |   |   | 1   |   |
|   | HR  | 12   | 15   | 18   | 21   | 00  | 03   | 06  | 09   | 12  | 15  | 18  | 21  | 00  | 03   | 06  | 09   | 12   | 15  | 18  | 00  | 06  |
|   | X/N   |  |  |  |  | 32  |  |   |  | 25  |   |   |   | 50  |  |   |  | 35   |   |   | 40  |   |
|   | TMP   | 16   | 24   | 31   | 30   | 27  | 26   | 27  | 29   | 32  | 44  | 46  | 46  | 45  | 45   | 44  | 40   | 36   | 36  | 39  | 33  | 28  |
|   | DPT   | 1  | -1   | 1  | 6  | 13  | 16   | 19  | 23   | 28  | 37  | 40  | 40  | 39  | 37   | 34  | 30   | 26   | 20  | 18  | 20  | 20  |
|   | CLD   | CL   | CL   | CL   | EW   | CL  | CL   | SC  | ov   | ov  | OV  | OV  | ov  | ov  | ov   | BK  | CL   | FW   | FW  | SC  | ov  | OV  |
|   | WDR   | 33   | 33   | 25   | 21   | 21  | 21   | 21  | 20   | 20  | 18  | 18  | 18  | 21  | 23   | 23  | 25   | 27   | 29  | 28  | 23  | 05  |
|   | WSP   | 06   | 96   | 05   | 07   | 01  | 01   | 01  | 06   | 07  | 10  | 14  | 14  | 12  | 09   | 08  | 10   | 10   | 12  | 08  | 03  | 03  |
|   | PAG   | 00   | 00   | 0  | 0,   | 04  | 04   | 04  | 00   | a   | 10  | 30  | 14  | 01  | 05   | 17  | 10   | 1  | 12  | 6   | 7   | 7   |
|   | P10   |  |  | 0  |  | 0   |  | 0   |  | 0   |   | 50  |   | 04  |  | 1/  |  | 10   |   | U   | 0   | /   |
|   | P12   |  |  | 0  |  | 0   |  | 0   |  | 0   |   | 0   |   | 94  |  | 0   |  | 10   |   | 0   | 0   | 0   |
|   | 000   |  |  | 0  |  | 0   |  | 0   |  | 0   |   | 0   |   | 2   |  | 0   |  | 0  |   | 0   | 0   | 0   |
|   | Q12   |  |  |  |  | 0   |  |   |  | 0   |   |   |   | 3   |  |   |  | 0  |   |   | 0   |   |
|   | 106   |  | 0  | / 1  | 0,   | 0   | 0,   | 10  | 0,   | / 3   | 0   | 13  | 3,  | /10   | 0,   | /13   | Ø,   | /12  | 0   | 6   | 0,  | 0   |
|   | T12   |  |  |  |  |   | 0,   | 10  |  |   | 0   | / 4   |   |   | 3,   | /19   |  |  | 0   | /12   | 1,  | 4   |
|   | POZ   | 1  | 1  | 0  | 1  | 2   | 0  | 1   | 1  | 4   | 4   | 1   | 0   | 1   | 0  | 0   | 0  | 0  | 0   | 0   | 1   | 0   |
|   | POS   | 96   | 99:  | 100  | 99   | 93  | 97   | 69  | 57   | 37  | 14  | 1   | 0   | 0   | 9  | 17  | 27   | 56   | 84  | 78  | 85  | 79  |
|   | TYP   | S  | S  | S  | S  | S   | S  | S   | S  | R   | R   | R   | R   | R   | R  | R   | R  | S  | S   | S   | S   | S   |
|   | SNW   |  |  |  |  |   |  |   |  | 0   |   |   |   |   |  |   |  | 0  |   |   |   |   |
|   | CIG   | 8  | 8  | 8  | 8  | 8   | 8  | 8   | 8  | 6   | 5   | 4   | 3   | 3   | 8  | 8   | 8  | 8  | 8   | 8   | 8   | 7   |
|   | VIS   | 7  | 7  | 7  | 7  | 7   | 7  | 7   | 7  | 7   | 7   | 5   | 2   | 5   | 7  | 7   | 7  | 7  | 7   | 7   | 7   | 7   |
|   | OBV   | N  | N  | N  | N  | N   | N  | N   | N  | N   | N   | H7  | FG  | BR  | N  | N   | N  | N  | N   | N   | N   | N   |
|   |   |  |  |  |  |   |  |   |  |   |   |   |   |   |  |   |  |  |   |   |   |   |
|   |   |  |  |  |  |   |  |   |  |   |   |   |   |   |  |   |  |  |   |   |   |   |
|   | MET T   | EXT  | BUI  | LLE  | TIN  |   |  |   |  |   |   |   |   |   |  |   |  |  |   |   |   |   |
| 1 | MET T   | EXT  | BUI  | MOS  | TIN<br>5 GL  | JID   |  | E   | 1  | /04   | /20   | 22  | 120   | 30 1  | лтс  |   |  |  |   |   |   |   |
| 2 | MET T<br>KPVD   |  | BUI  | MO:  | TIN<br>S GU  | JID   | ANCI   | E   | 1,   | /04   | /20:  | 22  | 12(<br>AN   | 00 I  | лтс  |   |  |  |   | /1/   | AN  | 7   |
|   | MET T<br>KPVD<br>DT /<br>HR   | EXT<br>JAN   | BUI<br>NAM   | MO:<br>4/3/  | TIN<br>S GU<br>AN<br>03  | JID/<br>5<br>96   | ANCI   | E<br>12   | 1,   | /04   | /20:  | 22<br>/J  | 120<br>AN<br>03   | 00 I<br>6<br>96   | JTC<br>09  | 12  | 15   | 18   | 21  | /3/   | AN  | 7   |
|   | MET T<br>KPVD<br>DT /<br>HR   | EXT<br>JAN<br>18   | BUI<br>NAM   | MO:<br>4/J/<br>00  | TIN<br>S GU<br>AN<br>Ø3  | JID/<br>5<br>06   | ANCI<br>09   | 12<br>25  | 1,<br>15   | /04,<br>18  | /20:<br>21  | 22<br>/J<br>00<br>54  | 12(<br>AN<br>03   | 00 I<br>6<br>06   | лтс<br>09  | 12  | 15   | 18   | 21  | /]/   | AN<br>06  | 7 12 28   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP   | EXT<br>JAN<br>18   | BUI<br>VAM<br>21   | LLE<br>MO:<br>4/J/<br>00   | TIN<br>S GU<br>AN<br>03  | JID/<br>5<br>06   | ANCI<br>09   | 12<br>25<br>34  | 1,<br>15   | /04, 18   | /20:<br>21  | 22<br>/J/<br>00<br>54   | 120<br>AN<br>03   | 00 I<br>6<br>06   | JTC<br>09  | 12<br>35  | 15   | 18   | 21  | /J/<br>00<br>44<br>34   | AN<br>06  | 7<br>12<br>28   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT  | EXT<br>JAN<br>18<br>31   | BUI<br>VAM<br>21<br>31   | LLE<br>MO:<br>4/J/<br>00<br>26<br>7  | TIN<br>5 GU<br>03<br>26  | JID<br>5<br>06<br>26  | 09<br>29   | 12<br>25<br>34  | 1,<br>15<br>45   | /04<br>18<br>51   | /20:<br>21<br>51  | 22<br>/J<br>00<br>54<br>49  | 120<br>AN<br>03<br>46<br>41   | 00 1<br>6<br>06<br>44   | UTC<br>09<br>40  | 12<br>35<br>37  | 15<br>38   | 18<br>42   | 21<br>40  | /J/<br>00<br>44<br>34   | AN<br>06<br>31  | 7<br>12<br>28<br>31   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT  | EXT<br>JAN<br>18<br>31<br>2  | BUI<br>VAM<br>21<br>31<br>4<br>EW  | LLE<br>MO<br>4/J/<br>00<br>26<br>7   | TIN<br>5 GU<br>03<br>26<br>11  | JID<br>5<br>06<br>26<br>16  | 09<br>29<br>22   | 12<br>25<br>34<br>29  | 1,<br>15<br>45<br>36   | /04<br>18<br>51<br>41   | 20:<br>21<br>51<br>42   | 22<br>/J<br>00<br>54<br>49<br>42  | 120<br>AN<br>03<br>46<br>41   | 00 0<br>06<br>44<br>36  | UTC<br>09<br>40<br>31  | 12<br>35<br>37<br>25  | 15<br>38<br>18   | 18<br>42<br>16   | 21<br>40<br>15  | /J/<br>00<br>44<br>34<br>16   | AN<br>06<br>31<br>23  | 7<br>12<br>28<br>31<br>25<br>0V   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD   | EXT<br>JAN<br>18<br>31<br>2<br>CL  | BUI<br>VAM<br>21<br>31<br>4<br>FW  | LLE<br>MO:<br>4/J/<br>00<br>26<br>7<br>CL  | TIN<br>S GU<br>AN<br>03<br>26<br>11<br>CL  | JID/<br>5<br>06<br>26<br>16<br>CL   | 09<br>29<br>22<br>0V   | 12<br>25<br>34<br>29<br>0V  | 1,<br>15<br>45<br>36<br>0V   | /04<br>18<br>51<br>41<br>0V   | 20:<br>21<br>51<br>42<br>0V   | 22<br>/J<br>00<br>54<br>49<br>42<br>0V  | 120<br>AN<br>03<br>46<br>41<br>OV   | 00 0<br>06<br>44<br>36<br>0V  | JTC<br>09<br>40<br>31<br>CL                                      | 12<br>35<br>37<br>25<br>50  | 15<br>38<br>18<br>FW   | 18<br>42<br>16<br>50   | 21<br>40<br>15<br>5C  | /J/<br>00<br>44<br>34<br>16<br>BK   | AN<br>06<br>31<br>23<br>0V  | 7<br>12<br>28<br>31<br>25<br>0V   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR  | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20  | LLE<br>MO:<br>4/J/<br>00<br>26<br>7<br>CL<br>20  | TIN<br>5 GU<br>03<br>26<br>11<br>CL<br>21  | JID<br>5<br>06<br>26<br>16<br>CL<br>20  | 09<br>29<br>22<br>0V<br>20   | 12<br>25<br>34<br>29<br>0V<br>20  | 1,<br>15<br>45<br>36<br>0V<br>19   | /04<br>18<br>51<br>41<br>0V<br>17   | 202<br>21<br>51<br>42<br>0V<br>18   | 22<br>/J<br>00<br>54<br>49<br>42<br>0V<br>20  | 120<br>AN<br>03<br>46<br>41<br>0V<br>23   | 00<br>06<br>44<br>36<br>0V<br>25  | JTC<br>09<br>40<br>31<br>CL<br>25                                | 12<br>35<br>37<br>25<br>50<br>26  | 15<br>38<br>18<br>FW<br>28   | 18<br>42<br>16<br>50<br>27   | 21<br>40<br>15<br>5C<br>27  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27   | AN<br>06<br>31<br>23<br>0V<br>35  | 7<br>12<br>28<br>31<br>25<br>0V<br>03   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP   | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05  | LLE<br>M09<br>4/J/<br>00<br>26<br>7<br>CL<br>20<br>04  | TIN<br>S GU<br>03<br>26<br>11<br>CL<br>21<br>03  | JID<br>5<br>06<br>26<br>16<br>CL<br>20<br>05  | ANCI<br>09<br>29<br>22<br>0V<br>20<br>05                                 | 12<br>25<br>34<br>29<br>0V<br>20<br>07  | 1,<br>15<br>45<br>36<br>0V<br>19<br>09                                     | /04,<br>18<br>51<br>41<br>0V<br>17<br>16  | 202<br>21<br>51<br>42<br>0V<br>18<br>16                                       | 22<br>/J<br>00<br>54<br>49<br>42<br>0V<br>20<br>11  | 120<br>03<br>46<br>41<br>0V<br>23<br>09   | 00<br>06<br>44<br>36<br>0V<br>25<br>09  | 09<br>40<br>31<br>CL<br>25<br>09                                 | 12<br>35<br>37<br>25<br>5C<br>26<br>09  | 15<br>38<br>18<br>FW<br>28<br>12                                   | 18<br>42<br>16<br>50<br>27<br>10   | 21<br>40<br>15<br>5C<br>27<br>08  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04   | AN<br>06<br>31<br>23<br>0V<br>35<br>02  | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06  | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05  | LLE<br>M0:<br>4/J/<br>00<br>26<br>7<br>CL<br>20<br>04<br>0   | TIN<br>S GU<br>03<br>26<br>11<br>CL<br>21<br>03  | JID<br>5<br>06<br>26<br>16<br>CL<br>20<br>05<br>0   | 09<br>29<br>22<br>0V<br>20<br>05   | 12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07  | 1,<br>15<br>45<br>36<br>0V<br>19<br>09                                     | /04<br>18<br>51<br>41<br>0V<br>17<br>16<br>31   | 202<br>21<br>51<br>42<br>0V<br>18<br>16                                       | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83   | 120<br>03<br>46<br>41<br>0V<br>23<br>09   | 00 1<br>6<br>06<br>44<br>36<br>0V<br>25<br>09<br>17                                   | 09<br>40<br>31<br>CL<br>25<br>09                                 | 12<br>35<br>37<br>25<br>5C<br>26<br>09<br>6   | 15<br>38<br>18<br>FW<br>28<br>12                                   | 18<br>42<br>16<br>5C<br>27<br>10<br>8  | 21<br>40<br>15<br>5C<br>27<br>08  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10   | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10  | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12   | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05  | LLE<br>MO:<br>4/J)<br>00<br>26<br>7<br>CL<br>20<br>04<br>0   | TIN<br>5 GU<br>03<br>26<br>11<br>CL<br>21<br>03  | JID/<br>5<br>06<br>16<br>16<br>CL<br>20<br>05<br>0  | 09<br>29<br>22<br>0V<br>20<br>05   | E<br>12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07<br>0<br>1   | 1,<br>15<br>45<br>36<br>0V<br>19<br>09                                     | /04,<br>18<br>51<br>41<br>0V<br>17<br>16<br>31  | /20.<br>21<br>51<br>42<br>0V<br>18<br>16                                      | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83   | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09   | 00 1<br>6<br>06<br>44<br>36<br>0V<br>25<br>09<br>17                                   | 09<br>40<br>31<br>CL<br>25<br>09                                 | 12<br>35<br>37<br>25<br>5C<br>26<br>09<br>6<br>17   | 15<br>38<br>18<br>FW<br>28<br>12                                   | 18<br>42<br>16<br>5C<br>27<br>10<br>8  | 21<br>40<br>15<br>5C<br>27<br>08  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10   | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10  | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22   |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06  | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05  | LLE<br>MO:<br>4/J/<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0  | TIN<br>5 GU<br>03<br>26<br>11<br>CL<br>21<br>03  | JID,<br>5<br>06<br>26<br>16<br>CL<br>20<br>05<br>0<br>0<br>0<br>0   | 09<br>29<br>22<br>0V<br>20<br>05   | 12<br>25<br>34<br>29<br>0V<br>20<br>07<br>0<br>1<br>0   | 1,<br>15<br>36<br>0V<br>19<br>09   | /04,<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0                                     | /20:<br>21<br>51<br>42<br>0V<br>18<br>16                                      | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2  | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09   | 00 1<br>6<br>06<br>44<br>36<br>0V<br>25<br>09<br>17                                   | 09<br>40<br>31<br>CL<br>25<br>09                                 | 12<br>35<br>37<br>25<br>26<br>09<br>6<br>17<br>0  | 15<br>38<br>18<br>FW<br>28<br>12                                   | 18<br>42<br>16<br>5C<br>27<br>10<br>8  | 21<br>40<br>15<br>5C<br>27<br>08  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>10<br>0  | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0                                       | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0  |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12   | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05  | LLE<br>MO<br>4/JJ<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0   | TIN<br>S GU<br>03<br>26<br>11<br>CL<br>21<br>03  | JID<br>5<br>06<br>16<br>CL<br>20<br>05<br>0<br>0  | 09<br>29<br>22<br>0V<br>20<br>05   | 12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07<br>07<br>0<br>0<br>1<br>0<br>0   | 1,<br>15<br>36<br>0V<br>19<br>09   | /04<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0                                      | /20:<br>21<br>51<br>42<br>0V<br>18<br>16                                      | 22<br>/J.<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2                                       | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09   | 6<br>06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0                                      | 09<br>40<br>31<br>CL<br>25<br>09                                 | 12<br>35<br>37<br>25<br>SC<br>26<br>09<br>6<br>17<br>0                                    | 15<br>38<br>18<br>FW<br>28<br>12                                   | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0   | 21<br>40<br>15<br>5C<br>27<br>08  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>10<br>0  | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0                                       | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>22<br>0<br>0                                     |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12<br>T06  | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05  | LLE <sup>*</sup><br>MO<br>4/JJ<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>0<br>0  | TIN<br>S GU<br>03<br>26<br>11<br>CL<br>21<br>03  | JID/<br>5<br>06<br>16<br>16<br>20<br>05<br>0<br>0<br>0<br>0<br>0<br>0   | ANCI<br>09<br>29<br>22<br>0V<br>20<br>05                                 | 12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07<br>07<br>0<br>1<br>0<br>0<br>7<br>0  | 1,<br>15<br>36<br>0V<br>19<br>09   | /04<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1                               | /20:<br>21<br>51<br>42<br>0V<br>18<br>16                                      | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>/ 6                                | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09   | 00 1<br>06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0<br>( 6                            | 09<br>40<br>31<br>CL<br>25<br>09                                 | 12<br>35<br>37<br>25<br>26<br>09<br>6<br>17<br>0<br>0<br>( 8                              | 15<br>38<br>18<br>FW<br>28<br>12                                   | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0<br>/ 2                                  | 21<br>40<br>15<br>5C<br>27<br>08  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>10<br>0<br>(0  | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0<br>0                                  | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>0<br>1                                 |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12<br>T06<br>T12   | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>05                                  | LLE<br>MO<br>4/J/<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>0<br>/ 0   | TIN<br>S GU<br>03<br>26<br>11<br>CL<br>21<br>03<br>0,<br>0,<br>0,  | JID/<br>5<br>06<br>16<br>CL<br>20<br>05<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0   | 09<br>29<br>22<br>0V<br>20<br>05   | 12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07<br>07<br>0<br>1<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7   | 1,<br>15<br>36<br>0V<br>19<br>09   | /04<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>/ 1                        | /20:<br>21<br>51<br>42<br>0V<br>18<br>16                                      | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>/ 6                                | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,                               | 00 1<br>06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0<br>/ 6<br>/14                     | 09<br>40<br>31<br>CL<br>25<br>09                                 | 12<br>35<br>37<br>25<br>26<br>09<br>6<br>17<br>0<br>0<br>( 8                              | 15<br>38<br>FW<br>28<br>12<br>0,<br>0,                             | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8                           | 21<br>40<br>15<br>5C<br>27<br>08  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>00<br>00<br>00                                       | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0<br>0,<br>7                            | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>0<br>1                                 |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WDP<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12<br>T06<br>T12<br>P0Z                                     | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05                                  | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>0,<br>0,                            | LLE <sup>*</sup><br>MO!<br>4/J/<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>4<br>0<br>0<br>/ 0<br>3  | TIN<br>S GU<br>03<br>26<br>11<br>CL<br>21<br>03<br>0,<br>0,<br>0,<br>6   | JID/<br>5<br>06<br>16<br>CL<br>20<br>05<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0                  | ANCI<br>09<br>29<br>22<br>0V<br>20<br>05<br>0,<br>20<br>0,               | E<br>12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07<br>0<br>1<br>0<br>07<br>0<br>7<br>0<br>0<br>7<br>0<br>7<br>0<br>7<br>0<br>7<br>0  | 1,<br>15<br>36<br>0V<br>19<br>09<br>0,<br>0,<br>3                          | /04,<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>/ 1<br>2                  | /20:<br>21<br>51<br>42<br>0V<br>18<br>16                                      | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>2<br>/ 6                           | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,<br>0                          | 00 1<br>6<br>06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0<br>/ 6<br>/14<br>0           | 09<br>40<br>31<br>CL<br>25<br>09<br>0,                           | 12<br>35<br>37<br>25<br>5C<br>26<br>09<br>6<br>17<br>0<br>0<br>( 8<br>0                   | 15<br>38<br>FW<br>28<br>12<br>0,<br>0,<br>0                        | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8<br>1                      | 21<br>40<br>15<br>5C<br>27<br>08<br>0,  | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>10<br>0<br>0,<br>0<br>2                              | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0,<br>7<br>0                            | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>0<br>/ 1<br>1                          |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12<br>T06<br>T12<br>P0Z<br>P05   | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05<br>1<br>99:                      | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>05<br>0,<br>05                      | LLE <sup>*</sup><br>MO<br>4/JJ<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>3<br>97                     | TIN<br>5 GU<br>03<br>26<br>11<br>CL<br>21<br>03<br>0,<br>0,<br>6<br>84   | JID/<br>5<br>06<br>26<br>16<br>CL<br>20<br>05<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>8<br>58  | 09<br>29<br>22<br>0V<br>20<br>05<br>0,<br>20<br>0,<br>240                | 12<br>25<br>34<br>29<br>0V<br>20<br>07<br>0<br>1<br>0<br>0<br>20<br>07<br>0<br>20<br>07<br>0<br>20<br>07<br>0<br>20<br>07<br>0<br>20<br>07<br>0<br>20<br>07<br>0<br>20<br>07<br>0<br>20<br>0<br>20<br>0<br>20<br>20<br>20<br>20<br>20<br>20<br>20<br>20<br>20   | 1,<br>15<br>36<br>0V<br>19<br>09<br>0,<br>0,<br>3<br>8                     | /04,<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>/ 1<br>2<br>1             | /20:<br>21<br>51<br>42<br>0V<br>18<br>16<br>1,<br>0<br>2                      | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>/ 6<br>1<br>0                      | 12(<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,<br>0<br>6                     | 00 1<br>6<br>06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0<br>/ 6<br>/ 14<br>0<br>9     | 09<br>40<br>31<br>CL<br>25<br>09<br>0,<br>0,<br>36               | 12<br>35<br>37<br>25<br>5C<br>26<br>09<br>6<br>17<br>0<br>0<br>(<br>8<br>0<br>52          | 15<br>38<br>FW<br>28<br>12<br>0,<br>0,<br>0<br>82                  | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8<br>1<br>91                | 21<br>40<br>15<br>5C<br>27<br>08<br>0,<br>0<br>79                               | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>00<br>00<br>2<br>89                                  | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0,<br>7<br>0<br>74                      | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>(1<br>1<br>77                          |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WDP<br>Q06<br>Q12<br>T06<br>T12<br>Q06<br>Q12<br>T06<br>T12<br>POZ<br>POS<br>TYP                              | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05<br>1<br>99:<br>5                 | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>0,<br>00<br>100<br>S                | LLE <sup>*</sup><br>MO<br>4/JJ<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>4<br>0<br>0<br>7<br>0<br>97<br>5  | TIN<br>5 GU<br>03<br>26<br>11<br>CL<br>21<br>03<br>0,<br>0,<br>6<br>84<br>5  | JID/<br>5<br>06<br>26<br>16<br>CL<br>20<br>05<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>8<br>58<br>58<br>5                    | 09<br>29<br>22<br>0V<br>20<br>05<br>0,<br>20<br>05<br>0,<br>2<br>40<br>R | 12<br>25<br>34<br>29<br>0V<br>20<br>07<br>0<br>1<br>0<br>0<br>20<br>07<br>0<br>20<br>07<br>0<br>20<br>0<br>7<br>0<br>20<br>0<br>7<br>0<br>7   | 1,<br>15<br>36<br>0V<br>19<br>09<br>0,<br>0,<br>3<br>8<br>R                | /04<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>/ 1<br>2<br>1<br>R         | /20:<br>21<br>51<br>42<br>0V<br>18<br>16<br>1,<br>0<br>2<br>R                 | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>/ 6<br>1<br>0<br>R                 | 12(<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,<br>0<br>6<br>R                | 00 1<br>6<br>06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0<br>(14<br>0<br>9<br>R        | 09<br>40<br>31<br>CL<br>25<br>09<br>0,<br>0,<br>0<br>36<br>R     | 12<br>35<br>37<br>25<br>5C<br>09<br>6<br>17<br>0<br>0<br>8<br>0<br>52<br>5                | 15<br>38<br>18<br>FW<br>28<br>12<br>0,<br>0,<br>0,<br>82<br>5      | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8<br>1<br>91<br>5           | 21<br>40<br>15<br>5C<br>27<br>08<br>0,<br>0<br>79<br>5                          | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>00,<br>0,<br>2<br>89<br>5                            | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0,<br>7<br>0<br>74<br>S                 | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>(<br>1<br>1<br>77<br>5                 |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12<br>T06<br>C12<br>P02<br>T02<br>F02<br>T12<br>P05<br>TYP<br>SNW                | EXT<br>JAN<br>18<br>31<br>25<br>05<br>1<br>999:<br>5                           | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>0,<br>0,<br>0<br>100<br>S           | LLE <sup>-</sup><br>MO!<br>4/J)<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>4<br>0<br>0<br>4<br>0<br>0<br>4<br>0<br>0<br>5<br>5                          | TIN<br>S GU<br>AN<br>03<br>26<br>11<br>CL<br>21<br>03<br>0,<br>0,<br>6<br>84<br>S  | JID/<br>5<br>06<br>16<br>20<br>05<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>8<br>58<br>5<br>8<br>5                  | ANCI<br>09<br>22<br>0V<br>20<br>05<br>0,<br>2<br>40<br>R                 | E<br>12<br>25<br>34<br>29<br>0V<br>20<br>07<br>0<br>07<br>0<br>0<br>1<br>0<br>0<br>20<br>07<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>0<br>7<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0 | 1,<br>15<br>36<br>0V<br>19<br>09<br>0,<br>0,<br>3<br>8<br>R                | /04<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>2<br>1<br>R                | /20:<br>21<br>51<br>42<br>0V<br>18<br>16<br>1,<br>0<br>2<br>R                 | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>2<br>/ 6<br>1<br>0<br>R            | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,<br>0<br>6<br>R                | 00 1<br>6 06<br>44<br>36 0V<br>25 09<br>17<br>0<br>/ 14<br>0<br>9 R                   | 09<br>40<br>31<br>CL<br>25<br>09<br>0,<br>0<br>36<br>R           | 12<br>35<br>37<br>25<br>5C<br>09<br>6<br>17<br>0<br>0<br>7<br>8<br>0<br>52<br>5<br>0      | 15<br>38<br>18<br>FW<br>28<br>12<br>0,<br>0,<br>0<br>82<br>5       | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8<br>1<br>91<br>5           | 21<br>40<br>15<br>SC<br>27<br>08<br>0,<br>0<br>79<br>S                          | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>0<br>0<br>0<br>0<br>2<br>89<br>5                     | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0<br>0<br>7<br>0<br>74<br>5             | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>7<br>1<br>77<br>5<br>1                 |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12<br>T06<br>T12<br>P02<br>P02<br>P02<br>P05<br>SNW<br>CLG                       | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05<br>1<br>999:<br>5<br>8           | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>05<br>0,<br>00<br>100<br>5<br>8     | LLE <sup>-</sup><br>MO!<br>4/J/<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>4<br>0<br>0<br>4<br>0<br>0<br>4<br>0<br>0<br>4<br>0<br>0<br>7<br>5<br>5<br>8 | TIN<br>S GU<br>AN<br>26<br>11<br>CL<br>21<br>03<br>0,<br>0,<br>6<br>84<br>S<br>8   | JID/<br>5<br>06<br>16<br>CL<br>20<br>05<br>0<br>0<br>0<br>0<br>0<br>8<br>58<br>58<br>58<br>58<br>58   | ANCI<br>09<br>29<br>22<br>0V<br>20<br>05<br>0,<br>2<br>40<br>R<br>5      | E<br>12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07<br>0<br>07<br>0<br>0<br>0<br>07<br>0<br>0<br>0<br>20<br>07<br>0<br>0<br>0<br>7<br>0<br>0<br>0<br>7<br>0<br>0<br>5   | 1,<br>15<br>36<br>0V<br>19<br>09<br>0,<br>0,<br>3<br>8<br>R                | /04,<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>/ 1<br>2<br>1<br>R<br>R   | /20:<br>21<br>51<br>42<br>0V<br>18<br>16<br>1,<br>0<br>2<br>R<br>3            | 22<br>/J,<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>/ 6<br>1<br>0<br>R<br>3            | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,<br>0<br>6<br>R                | 00 1<br>6 06<br>44<br>36 0V<br>25 09<br>17<br>0<br>/ 6<br>/ 14<br>0<br>9 R<br>8       | 09<br>40<br>31<br>CL<br>25<br>09<br>0,<br>0<br>36<br>R<br>8      | 12<br>35<br>37<br>25<br>5C<br>26<br>09<br>6<br>17<br>0<br>0<br>52<br>5<br>0<br>8          | 15<br>38<br>FW<br>28<br>12<br>0,<br>0,<br>0,<br>82<br>5<br>8       | 18<br>42<br>16<br>5C<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8<br>1<br>91<br>5<br>8      | 21<br>40<br>15<br>5C<br>27<br>08<br>0,<br>0<br>79<br>5<br>8                     | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>00<br>0<br>2<br>89<br>5<br>8                         | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0<br>,<br>7<br>0<br>74<br>5<br>8        | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>7<br>1<br>77<br>5<br>1<br>6            |
|   | MET T<br>KPVD<br>DT /<br>HR<br>N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WDP<br>P06<br>P12<br>Q06<br>Q12<br>T06<br>T12<br>P02<br>P05<br>TYP<br>P05<br>SNW<br>CIG<br>VIS                | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05<br>1<br>999:<br>5<br>8<br>7      | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>05<br>0,<br>0<br>100<br>5<br>8<br>7 | LLE <sup>-</sup><br>MO:<br>4/J)<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0      | TIN<br>S GU<br>AN<br>03<br>26<br>11<br>CL<br>21<br>03<br>0,<br>0,<br>6<br>84<br>S<br>84<br>S<br>7  | JID/<br>5<br>06<br>16<br>CL<br>20<br>05<br>0<br>0<br>0<br>0<br>8<br>58<br>58<br>58<br>5<br>8<br>7   | ANCI<br>09<br>22<br>0V<br>20<br>05<br>0,<br>2<br>40<br>R<br>5<br>7       | E<br>12<br>25<br>34<br>29<br>0V<br>20<br>07<br>0<br>07<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0  | 1,<br>15<br>45<br>36<br>0V<br>19<br>09<br>0,<br>0,<br>38<br>R<br>57        | /04,<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>2<br>1<br>R<br>4<br>5     | /20:<br>21<br>51<br>42<br>0V<br>18<br>16<br>1,<br>0<br>2<br>R<br>3<br>4       | 22<br>/J.<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>/ 6<br>1<br>0<br>R<br>3<br>4       | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,<br>0<br>6<br>R<br>6<br>7      | 00 1<br>6 06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0<br>/ 14<br>0<br>9 R<br>8<br>7   | 09<br>40<br>31<br>CL<br>25<br>09<br>0,<br>0<br>36<br>R<br>8<br>7 | 12<br>35<br>37<br>25<br>26<br>09<br>6<br>17<br>0<br>0<br>8<br>0<br>52<br>5<br>0<br>8<br>7 | 15<br>38<br>FW<br>28<br>12<br>0,<br>0,<br>0,<br>82<br>5<br>8<br>7  | 18<br>42<br>16<br>SC<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8<br>1<br>91<br>5<br>8<br>7 | 21<br>40<br>15<br>5C<br>27<br>08<br>0,<br>0<br>79<br>5<br>8<br>7                | /J/<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>0<br>0<br>0<br>2<br>89<br>5<br>8<br>7                | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0,<br>7<br>0,<br>74<br>5<br>8<br>7      | 7<br>12<br>28<br>31<br>25<br>0V<br>03<br>08<br>22<br>22<br>0<br>0<br>7<br>1<br>1<br>77<br>5<br>1<br>6<br>7  |
|   | MET T KPVD<br>DT /<br>HR N/X<br>TMP<br>DPT<br>CLD<br>WDR<br>WSP<br>P06<br>P12<br>Q06<br>Q12<br>T06<br>Q12<br>T06<br>T12<br>P02<br>P02<br>F05<br>T12<br>P02<br>SNW<br>CIG<br>VIS | EXT<br>JAN<br>18<br>31<br>2<br>CL<br>25<br>05<br>1<br>999:<br>5<br>8<br>7<br>№ | BUI<br>VAM<br>21<br>31<br>4<br>FW<br>20<br>05<br>0,<br>00<br>100<br>5<br>8<br>7<br>N | LLE<br>MO:<br>4/J/<br>00<br>26<br>7<br>CL<br>20<br>04<br>0<br>0<br>20<br>04<br>0<br>0<br>0<br>3<br>97<br>5<br>8<br>7<br>N                                    | CL<br>21<br>03<br>03<br>03<br>03<br>03<br>03<br>03<br>04<br>03<br>03<br>04<br>03<br>03<br>04<br>03<br>03<br>04<br>03<br>04<br>03<br>03<br>04<br>03<br>03<br>04<br>03<br>03<br>04<br>03<br>03<br>04<br>03<br>04<br>03<br>04<br>04<br>04<br>04<br>04<br>04<br>04<br>04<br>04<br>04<br>04<br>04<br>04 | JID/<br>5 06<br>16<br>CL<br>20<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>8<br>58<br>5<br>8<br>7<br>N | ANCI<br>09<br>22<br>0V<br>20<br>05<br>0,<br>2<br>40<br>R<br>5<br>7<br>M  | E<br>12<br>25<br>34<br>29<br>0V<br>20<br>07<br>07<br>0<br>1<br>0<br>0<br>0<br>7<br>0<br>0<br>1<br>0<br>0<br>7<br>0<br>0<br>1<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>0<br>7<br>0<br>7   | 1,<br>15<br>36<br>0V<br>19<br>09<br>0,<br>0,<br>3<br>8<br>R<br>5<br>7<br>N | /04<br>18<br>51<br>41<br>0V<br>17<br>16<br>31<br>0<br>/ 1<br>2<br>1<br>R<br>4<br>5<br>N | /20:<br>21<br>51<br>42<br>0V<br>18<br>16<br>1,<br>0<br>2<br>R<br>3<br>4<br>BP | 22<br>/J.<br>00<br>54<br>49<br>42<br>0V<br>20<br>11<br>83<br>83<br>2<br>2<br>/ 6<br>1<br>0<br>R<br>3<br>4<br>BR | 120<br>AN<br>03<br>46<br>41<br>0V<br>23<br>09<br>0,<br>1,<br>0<br>6<br>R<br>6<br>7<br>N | 00 1<br>6 06<br>44<br>36<br>0V<br>25<br>09<br>17<br>0<br>/ 14<br>0<br>9 R<br>8<br>7 № | 09<br>40<br>31<br>25<br>09<br>0,<br>0<br>36<br>R<br>8<br>7<br>N  | 12<br>35<br>37<br>25<br>26<br>09<br>6<br>17<br>0<br>0<br>8<br>0<br>52<br>5<br>0<br>8<br>7 | 15<br>38<br>FW<br>28<br>12<br>0,<br>0,<br>0,<br>82<br>5<br>87<br>7 | 18<br>42<br>16<br>SC<br>27<br>10<br>8<br>0<br>/ 2<br>/ 8<br>1<br>91<br>5<br>8<br>7 | 21<br>40<br>15<br>5C<br>27<br>08<br>0,<br>0<br>79<br>5<br>8<br>7<br>7<br>8<br>7 | /J)<br>00<br>44<br>34<br>16<br>BK<br>27<br>04<br>10<br>0<br>0<br>0<br>0<br>0<br>2<br>89<br>5<br>8<br>7<br>№ | AN<br>06<br>31<br>23<br>0V<br>35<br>02<br>10<br>0,<br>7<br>0,<br>74<br>5<br>8<br>7<br>N | 7<br>12<br>28<br>31<br>25<br>00V<br>03<br>08<br>22<br>22<br>0<br>0<br>7<br>1<br>77<br>5<br>1<br>6<br>7<br>N |

# **Global Models - GFS and ECMWF**

500mb Absolute Vorticity (s-') | Height (gpm) | College of DuPage NEXLAB

18Z GFS | F045 Valid: 15Z SAT DEC 05 2020

500mb RH (%) | Streamlines | College of DuPage NEXLAB

CMWF | F066 Valid: 12Z SUN DEC 06 2020





- Forecasts 384 Hours (16 Days)
- Resolution: 13 km (8 miles) horizontal, 64 vertical levels
- Country/Organization: U.S. NOAA, NCEP

- Forecasts 240 Hours (10 days)
- Resolution: 9 km horizontal (5.5 miles), 91 vertical levels
- NCEP Country/Organization: European Centre for Medium-Range Weather Forecasting

# **Global Models - Canadian and UKMET**



- Forecasts 240 Hours (10 days)
- Resolution: 15 km horizontal (9 miles), 84 vertical levels
- Country/Organization: Environment and Climate Change Canada National V



- Forecasts 144 Hours (6 days)
- Resolution: 10 km horizontal (6 miles), 70 vertical levels
- nt and 
  Country/Organization: United Kingdom
  National Weather Servid Meteorological Agency

# **Other Models - NAM and 3km NAM**

925mb Isotachs (kts) | Geopotential Height (gpm) | College of DuPage NEXLAB

NAM | F006 Valid: 12Z MON SEP 27 2021



- Forecasts 84 hours (3.5 days)
- Resolution: 12 km horizontal (7.5 miles), 60 vertical levels
- Country/Organization: U.S. NOAA, NCEP



- Forecasts 60 hours (2.5 days)
- Resolution: 3 km horizontal (2 miles), 70 vertical levels
- Country/Organization: U.S. NOAA, NCEP

# **Other Models - RAP and HRRR**



- Forecasts 36 hours
- Resolution: 13 km horizontal (8 miles), 50 vertical levels
- Country/Organization: U.S. NOAA, NCEP

- Forecasts 36 hours
- Resolution: 3 km horizontal (2 miles), 50 vertical levels
- Country/Organization: U.S. NOAA, NCEP

#### **Ensembles**

Ensemble Forecast Systems (EFS) use initial condition sensitivity, model estimates and errors, or both, to tease out potential forecast outcomes.



| WFO BOX Table Jan 4, 2022 00Z Run |     |     |             |             |             |             |            |             |             |             |            |  |  |
|-----------------------------------|-----|-----|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|------------|--|--|
|                                   |     |     | Z           | Ι           | U           | V           | <u>WSP</u> | <u>SLP</u>  | Q           | <u>PW</u>   | <u>IVT</u> |  |  |
| 0                                 | Tue | 00Z | -2.1        | <u>1.6</u>  | <u>-3.4</u> | <u>-3.0</u> | <u>2.9</u> | <u>-1.9</u> | <u>3.0</u>  | 2.7         | <u>3.8</u> |  |  |
| 6                                 | 4th | 06Z | -1.2        | <u>1.5</u>  | -1.3        | <u>-3.0</u> | <u>2.6</u> | <u>-1.0</u> | <u>-1.1</u> | <u>-1.1</u> | 0.5        |  |  |
| 12                                |     | 12Z | <u>1.0</u>  | <u>-1.4</u> | <u>1.1</u>  | -1.9        | <u>1.2</u> | <u>1.1</u>  | <u>-1.1</u> | <u>-1.1</u> | 0.0        |  |  |
| 18                                |     | 18Z | <u>1.1</u>  | -1.6        | <u>1.4</u>  | <u>-1.6</u> | <u>1.2</u> | <u>1.1</u>  | <u>-1.2</u> | <u>-1.1</u> | <u>0.3</u> |  |  |
| 24                                | Wed | 00Z | <u>1.2</u>  | <u>-2.1</u> | <u>1.6</u>  | <u>1.1</u>  | <u>1.4</u> | <u>1.2</u>  | <u>-1.1</u> | <u>-1.1</u> | 0.6        |  |  |
| 30                                | 5th | 06Z | <u>1.2</u>  | <u>-2.2</u> | <u>1.4</u>  | <u>2.5</u>  | <u>1.7</u> | <u>1.2</u>  | <u>-1.0</u> | -0.9        | 0.5        |  |  |
| 36                                |     | 12Z | <u>1.0</u>  | <u>-2.1</u> | <u>1.4</u>  | <u>2.8</u>  | <u>2.4</u> | <u>0.9</u>  | <u>1.1</u>  | -0.4        | 0.6        |  |  |
| 42                                |     | 18Z | -1.0        | -2.0        | <u>1.4</u>  | <u>2.9</u>  | 2.3        | <u>-1.3</u> | <u>1.8</u>  | <u>1.1</u>  | 2.0        |  |  |
| 48                                | Thu | 00Z | -1.4        | <u>2.0</u>  | <u>1.6</u>  | <u>2.7</u>  | 2.6        | <u>-1.7</u> | <u>2.5</u>  | 1.8         | <u>3.2</u> |  |  |
| 54                                | 6th | 06Z | <u>-1.5</u> | <u>1.8</u>  | <u>2.2</u>  | <u>2.7</u>  | <u>2.5</u> | <u>-1.5</u> | <u>1.7</u>  | <u>1.7</u>  | <u>2.6</u> |  |  |
| 60                                |     | 12Z | <u>-1.1</u> | <u>1.3</u>  | <u>2.2</u>  | <u>1.9</u>  | <u>2.4</u> | <u>-1.2</u> | 1.1         | <u>-0.8</u> | <u>0.6</u> |  |  |
| 66                                |     | 18Z | -1.1        | -0.7        | 2.0         | <u>1.2</u>  | <u>1.9</u> | -0.7        | <u>1.1</u>  | -0.7        | 0.1        |  |  |
| 72                                | Fri | 00Z | -1.0        | -0.7        | <u>1.5</u>  | <u>1.7</u>  | <u>1.6</u> | -0.6        | 0.8         | -0.4        | 0.2        |  |  |
| 78                                | 7th | 06Z | <u>-1.3</u> | 0.8         | <u>1.4</u>  | <u>2.1</u>  | 1.7        | <u>-1.3</u> | 0.9         | 0.6         | 1.0        |  |  |
| 84                                |     | 12Z | <u>-1.8</u> | <u>1.5</u>  | -1.5        | <u>2.3</u>  | <u>1.6</u> | <u>-1.7</u> | 1.5         | <u>1.3</u>  | 1.9        |  |  |
| 90                                |     | 18Z | -2.0        | 1.8         | -2.0        | 2.1         | 2.0        | -2.0        | -0.9        | -0.9        | 0.9        |  |  |



### **Ensembles**

Each member of the ensemble has a unique representation in the range or "envelope" of outcomes.

Ensembles are especially useful in forecasting the probability of high-impact events, and clustering of members around two or more forecast outcomes.



### **Global Ensembles**

GFS: 31 members

ECMWF: 50 members

Canadian: 20 members



### High Resolution Ensembles

SREF: 26 members

HREF: 10 members



### Warn On Forecast System

Uses output from high-resolution ensembles and models to provide severe weather guidance in real time



SSCRAM Statistical Severe Convective Risk Assessment Model

Similarly, uses output from HRRR to provide severe weather guidance in real time



### National Blend of Models

A nationally consistent and skillful suite of calibrated forecast guidance based on a blend of both National Weather Service and external numerical weather prediction model data and post-processed model guidance.

#### \_\_\_\_\_

A highly accurate, skillful and consistent starting point for the gridded forecast.

Probabilistic and bias-corrected weather elements across several service areas.

Providing forecasters with a suite of information to use for their forecasts.

#### 

An important part of the efforts to evolve NWS capabilities to achieve a Weather-Ready Nation.

### **NBM** Inputs

WRF MEM2 WRF ARW RAP RAPX HRRR HRRRX **GFS GMOS** NAM GMOS **EKDMOS/BMOS** GLMP WW3D (0.5) WW3E (0.5) WW3D-Regional GLW HWRF HMON wTCM

GEFS GFS NAM-Parent SREF NAM-Nest **NEMS NMMB** WRF ARW CMC GDPS CMC RDPS CMC REPS CMC GEPS ECMWFD **ECMWFE** NAVGEMD NAVGEME FNMOC ACCESS-G

NOAA

Canadian Meteorological Centre

- European Centre for Medium-Range Weather Forecasts
- U.S. Navy Fleet Numerical Meteorology and Oceanography Center

Australia Bureau of Meteorology











#### NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

### The Future of Modeling: Unified Forecast System

ATMOSP

NOAA

| NPS Modeling<br>System               | Current<br>Version      | Q3<br>FY 20 | Q4<br>FY 20       | Q1<br>FY 21      | Q2<br>FY 21 | Q3<br>FY 21 | Q4FY21-Q3FY22<br>Moratorium | Q4<br>FY 22   | Q1<br>FY 23 | Q2<br>FY 23 | Q3<br>FY 23 | Q4<br>FY 23 | Q1<br>FY 24        | Q2<br>FY 24   | Q3<br>FY 24        | Q4<br>FY 24 | Q1<br>FY 25        | Q2<br>FY25 | Q3<br>FY25 | UFS<br>Application              |
|--------------------------------------|-------------------------|-------------|-------------------|------------------|-------------|-------------|-----------------------------|---------------|-------------|-------------|-------------|-------------|--------------------|---------------|--------------------|-------------|--------------------|------------|------------|---------------------------------|
| Global Weather &<br>Global Analysis  | GFS/<br>GDASv15         |             |                   |                  | GFSv16      | GFSv16.1    |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            |                                 |
| Global Waves                         | GWMv3                   |             |                   |                  |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            |                                 |
| Global Weather<br>Ensembles          | GEFSv11                 |             |                   |                  |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            | Range                           |
| Global Wave<br>Ensembles             | GWESv3                  |             | GEFSv12           |                  |             |             |                             |               |             |             |             |             |                    |               | GFSv17/<br>GEFSv13 |             |                    |            |            | (weather,<br>Marine,            |
| Global Aerosols                      | NGAC v2                 |             |                   |                  |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            | Cryosphere)                     |
| Short-Range Regional<br>Ensembles    | SREFv7                  |             |                   | <u> </u>         |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            |                                 |
| Global Ocean & Sea-Ice               | RTOFSv1.2               |             |                   | RTOFSv2          |             |             |                             |               |             |             | RTOFSv3     |             |                    |               |                    |             |                    |            |            | UFS                             |
| Global Ocean Analysis                | GODASv2                 |             |                   |                  |             |             |                             |               |             |             | GODASv3     |             |                    |               | <u> </u>           |             |                    |            |            | Subseasonal                     |
| Seasonal Climate                     | CDAS/<br>CFSv2          |             |                   |                  |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    | SFSv1      |            | UFS Seasonal                    |
| Regional Hurricane 1                 | HWRFv12                 |             | HWRFv13           |                  |             |             |                             |               |             |             | HATCH       |             |                    |               | HATELO             |             |                    |            | HATCHO     |                                 |
| Regional Hurricane 2                 | HMONv2                  | HMONv3      |                   |                  |             |             |                             |               |             |             | HAFSVI      |             |                    |               | HAF SV2            |             |                    |            | HAF5V3     | UPS Hurricane                   |
| Regional High<br>Resolution CAM 1    | HiRes<br>Window v7      |             |                   |                  |             | HIRESWv8    |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            |                                 |
| Regional High<br>Resolution CAM 2    | NAM nests/<br>Fire Wxv4 |             |                   |                  |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            |                                 |
| Regional High<br>Resolution CAM 3    | RAPv4/<br>HRRRv3        |             |                   | RAPv5/<br>HRRRv4 |             |             |                             |               |             |             |             | RRFSv1      |                    |               |                    | RRESv2      |                    |            |            | UFS                             |
| Regional HiRes CAM<br>Ensemble       | HREFv2                  |             |                   |                  |             | HREFv3      |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            | Regional HiRes                  |
| Regional Mesoscale<br>Weather        | NAMv4                   |             |                   |                  |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            | Air Quality                     |
| Regional Air Quality                 | CMAQv5                  |             |                   |                  |             | CMAQv6      |                             |               |             |             |             |             |                    |               |                    |             |                    |            |            |                                 |
| Regional Surface<br>Weather Analysis | RTMA/<br>URMA v2.7      |             | RTMA/UR<br>MAv2.8 |                  |             |             |                             |               |             |             |             |             | 3DRTMA/<br>URMA v3 |               |                    |             | 3DRTMA/<br>URMA v4 |            |            | UFS<br>Analysis                 |
| Atmospheric Transport & Dispersion   | HySPLITv7               |             |                   |                  |             |             |                             | HySPLIT<br>v8 |             |             |             |             |                    | HySPLIT<br>v9 |                    |             |                    |            |            | UFS Air Quality<br>& Dispersion |
| Coastal & Regional                   | NWPSv1.2                |             |                   |                  | NWPSv1.3    |             |                             |               |             | NWPSv1.4    |             |             |                    |               |                    | RWPSv1      |                    |            |            | UFS Coastal                     |
| Great Lakes                          | GLWUv3.4                |             |                   |                  |             |             |                             | GLWUv4        |             |             |             |             |                    |               |                    | GLWUv5      |                    |            |            | UFS Lakes                       |
| Regional Hydrology                   | NWMv2                   |             |                   |                  | NWMv2.1     |             |                             |               |             |             | NWMv3       |             |                    |               |                    |             |                    |            |            | UFS Hydrology                   |
| Space Weather 1                      | WAM/IPEv1               |             |                   |                  |             | WAM/IPEv1   |                             |               |             |             |             |             |                    |               |                    |             |                    | WAM/IPEv2  |            | UFS Space                       |
| Space Weather 2                      | ENLILv1                 |             |                   |                  |             |             |                             |               |             |             |             |             |                    |               |                    |             |                    | THE LYZ    |            | Weather                         |

### Join Us For "Weather Models 202" Tuesday, March 1 Precipitation Type and Snowfall





