NATIONAL WEATHER SERVICE PRODUCT DESCRIPTION DOCUMENT (PDD)

TYPE: Experimental Forecast Product
DATE: April 1, 2015

Experimental Forecast Product – Probability of Exceedance Forecast for Precipitation and Snowfall

Feedback Period: April 1, 2015 – March 31, 2016

Part I - Mission Connection

A. Product / Service Description: The NWS Multi-Format Forecast Information Web Page provides for a customer-based approach in delivering NWS high resolution (5 km grid) forecast information in a variety of formats on demand. One of these formats is the Hourly Weather Graph which provides a time-series graph of forecast elements so the user can see how the weather changes with time. This service enhancement adds the probability of exceedance for specific rainfall amount thresholds (0.10, 0.25, 0.50 and 1.00 inch) and snowfall amount thresholds (0.1, 1, 3, 6 and 12 inches) to the list of selectable elements for display by the user.

B. Purpose/Intended Use: Enhancement of the Hourly Weather Graph format to provide access to forecast probabilities for rainfall and snowfall exceeding specific thresholds. The NWS has historically provided the probability of precipitation (PoP) for 12 hour time periods which is the chance that the occurrence of rainfall will equal or exceed 0.01 inch or more at the selected location. This service enhancement provides the probability that rainfall or snowfall will exceed additional (higher) threshold amounts. Potential users of this enhancement would be in construction, agriculture, water management, outdoor planning, media, academia and the general public. For example, workers pouring concrete often need to know what is the chance of rainfall exceeding 0.10 inches, since rainfall above 0.10 would hamper or damage their work. Therefore, they would be able to display the probability of rainfall above the threshold of 0.10.

C. Audience: The current audience for the forecast information web page consists of the customers and partners in the areas of emergency management, construction, agriculture, water management, outdoor planning, media, academia, and many others.

D. Presentation Format: The web grid point forecasts are presented for display as HTML in text, hourly weather graph, and digital/tabular format. This enhancement only applies to the hourly weather graph format. Forecasts can be viewed using a web browser and the user selects a location of interest by “left-clicking” on the map. Select “Hourly Weather Graph” from the “Additional Forecast & Information” section in the lower right of the page.

This page will then display a timeline of the forecast weather element that have been selected (check box selection) at the top of the page. This enhancement adds selection and display capabilities for probabilistic forecasts of precipitation and snowfall. Selections can be made for the probability of exceedance for specific thresholds of 0.10, 0.25, 0.50 and/or 1.00 inch for precipitation, and 0.1, 1, 3, 6 and/or 12 inches for snowfall. These threshold values may be

selected for 3, 6, 12 and 24-hour time periods. If selected, a timeline graphic will be displayed showing these forecasts through time.

A sample of the home page from which the initial selection is made can be found at http://forecast.weather.gov/MapClick.php?site=eax&zmx=1&zmy=1&map.x=127&map.y=148&FcstType=graphical

E. Feedback Method – Feedback is encouraged and may be sent through an online survey at

http://www.weather.gov/survey/nws-survey.php?code=pefps

For assistance, please contact:
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Part II – Technical Description

A. Format and Science Basis

Format: New experimental probabilistic quantitative precipitation forecasts (PQPF) probability of exceedance forecasts are available for the following thresholds: 0.10, 0.25, 0.50 and 1.00. Thresholds are derived from the probability of precipitation and quantitative precipitation forecast elements with exceedance values available for 3, 6, 12 and/or 24-hour periods. Users can select which forecast weather elements to display on the graphic by clicking on/off the check box next to the element label.

A sample of the hourly weather graphic web display can be found at:
http://forecast.weather.gov/MapClick.php?site=eax&zmx=1&zmy=1&map.x=127&map.y=148&FcstType=graphical.

Science Basis: Probabilistic quantitative precipitation forecasts (PQPF) and quantitative snowfall (PSnow) provide our best estimate of the chance that any given location will receive an amount of rain/snow that exceeds a certain threshold value. Our regular "probability of precipitation" (PoP) forecast is the unconditional probability that a location will receive an amount of rain/melted snow that equals or exceeds 0.01 inches. The PQPF/PSnow is similar, except it is computed for the probability to exceed higher amounts (e.g., 1.00 inches of rain or 6.0 inches of snow).

The PQPF/PSnow is derived from the probability of precipitation (PoP) forecasts and our quantitative precipitation/snowfall forecast (QPF/SnowAmt). For the purpose of the calculations, the standard QPF/SnowAmt, which is an unconditional value, is converted to a conditional value by dividing it by the PoP. The resulting QPF/SnowAmt is then an amount that is conditional upon the occurrence of rain/snow at any specific location. Although this seems to be a subtle difference, it is very important.

The PQPF/PSnow is based on the climatological distribution of precipitation, which very closely matches a linear combination of low order gamma distributions. Generally speaking, this combined distribution indicates that the probability of receiving larger rainfall/snowfall amounts decreases nearly exponentially as the amounts get larger.
The probabilty density function is:

f(x,a,b) = C(a=1) • (1/b) • e-x/b + C(a=2) • (x/b2) • e-x/b + C(a=3) • (x2/2b3) • e-x/b

where b=μ/a, μ is the conditional QPF/SnowAmt, or mean expected rainfall/snowfall amount given that precipitation occurs at the specified location, a is the gamma order and C(PoP,a) is a weighting function.

Each term of this equation can be integrated from any rainfall/snowfall threshold value x, to infinity to determine the probability to exceed that value x and recombined using a PoP based weighting fnction. After integrating, the conditional probability to exceed an amount x is given by:

cPOE(x) = C(a=1) • e-x/μ + C(a=2) • (2x/μ + 1) • e-2x/μ + C(a=3) • 1/2 • (9x2/μ2 + 6x/μ + 2) • e-3x/μ

C(PoP,a) = max(1-abs(2 + tanh(pi/60 • (PoP-60)) - a), 0)

However, it is more useful to provide the unconditional probability to exceed the specified amounts. The cPOE(x) is simply multiplied by the probability of precipitation (PoP) at any location to determine the unconditional probability to exceed the amount x. For simplicity, the unconditional probability of exceedance will be denoted by "POE."

POE(x) = (PoP) • cPOE(x)

Rainfall Example: Assume the forecast QPF (unconditional) is 0.80 inches and the PoP is 70% and we are interested in the probability of exceeding 1.00 inch. The conditional QPF is (0.80)/(0.70) or approximately 1.14 which is now the value μ. The result is:

cPOE(1) = 0.50 = 50%.

Since there is only a 70% chance of rain, the final, unconditional chance to exceed one inch of rain at a location is:

POE(1) = (0.70)• (0.50) = 0.35 = 35.0%.

Snowfall Example: Assume the forecast SnowAmt (unconditional) is 3.7 inches and the PoP is 80% and we are interested in the probability of exceeding 6.0 inches. The conditional SnowAmt is (3.7)/(0.80) or approximately 4.62 which is now the value μ. The result is:

cPOE(6) = 0.256 = 25.6%.

Since there is only a 80% chance of snow, the final, unconditional chance to exceed six inches of snow at a location is:

POE(6) = (0.80)• (0.256) = 0.205 = 20.5%.

The probability distribution can also be used to calculate a minimum and maximum value for the specified time periods. The minimum value is defined to be the 15th percentile (85% chance of exceeding this value - which also corresponds to the threshold for "categorical" precipitation - PoP >= 80%). The maximum value is defined to be the 95th percentile (5% chance of exceeding this value).

B. **Availability**: Updates to grid point forecasts are made once an hour from the existing GFE database. These updates are generally available at quarter past every hour.

C. **Additional information**: These results are very similar to those of Donald L. Jorgensen, William H. Klein, and Charles F. Roberts, *Conditional Probabilities of Precipitation Amounts in the Conterminous United States*, ESSA Technical Memorandum WBTM TDL 18, Weather Bureau Office of Systems Development Techiques Development Laboratory, Silver Spring, MD., March 1969. Questions regarding this method may be directed to Steve Amburn, Science and Operations Officer (Steve.Amburn@noaa.gov) at the National Weather Service in Tulsa (918-832-4115).