Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
43rd NOAA Annual Climate Diagnostics and Prediction Workshop
Santa Barbara, CA, 23-25 October 2018

Operational Probabilistic Drought Prediction to Improve the Seasonal Drought Outlook

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1. Introduction

We provide a new frame work to forecast drought. At this moment, the CPC/NWS provides users the monthly and seasonal Drought Outlook. There is no estimate of forecast uncertainties. We will use the meteorological drought as an example. We plan to provide users the mean state of meteorological drought based on the Standardized Precipitation Index (SPI) and the probability for drought to occur in the Dx (x=1-4) categories. Users can assess the severity of drought and the likelihood for drought to occur in each category.

2. Data and procedures

The SPI measures the precipitation anomalies. We obtained Precipitation (P) forecasts from lead time one to six months from the North American Multi model ensemble (NMME) in real time. There are total 6 models: NCEP CFSv2, CMC1_CanCM3, CMC2_CanCM4, GFDL Flor , NASA GEOS 5 and NCAR CCSM4. Each model has 10 members so there are 60 members in total.

From P forecasts, we computed SPI6 and expressed SPI6 forecasts in percentiles. The grand mean is the mean of 60 members. We then mapped the mean to a uniform distribution function so forecasts will be between zero to one. The grand mean was verified against the SPI6 computed from the P analysis.

3. Real time probabilistic drought forecasts

The operational probabilistic forecasts have been in operation since June 2018 and continue until present. Figure 1 shows the grand mean and probability for drought to occur in D0 to D4 above categories for December 2018 based on forecasts initialized on 1 December 2018. Figure 1 indicates that drought remained in the Pacific Northwest and the severity was in D0-D1 category. The December 2018 was an El-Nino winter so it was expected to have dryness over the Pacific Northwest and wetness in the southern United States. Individual model also indicates dryness over the PNW and wetness over the Southeast.

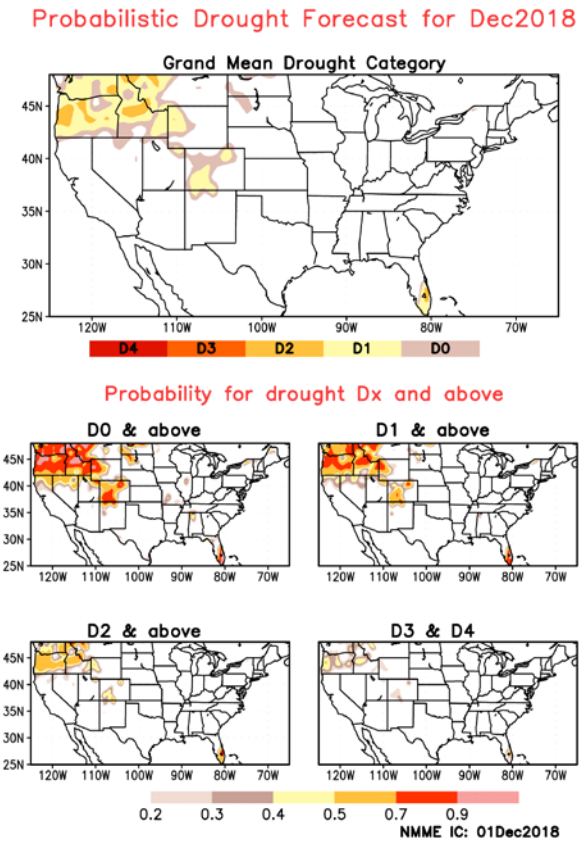

Fig. 1 (a) Probabilistic drought forecasts for lead 1 month for the initial conditions from December 2018. : Grand mean and probability for drought in Dx (x=1 to 4) above categories Contours are given by the color bar.

We have provided forecasters and users probabilistic forecasts since March 2018 and have improved the operation based on comments from forecasters. These forecasts are posted at the CPC web site each month after the forecasts from the NMME are available.

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4. Evaluation of drought occurrence based on SPI6 hindcasts from the NMME

In this section, we used the January SPI6 hindcasts as an example. We obtained P hindcasts from the NMME archive for January from 1982-2010. We computed the SPI6 hindcasts the same way as the real time forecasts. There are total 60 members. The grand mean is the mean of 60 members and then is mapped onto a uniform distribution function. The grand mean was evaluated against the SPI6 computed from the P analysis based on the gridded P data. We used the Spearman's rank correlation for evaluation. The probability for drought occurrence was evaluated using the ranked probability skill score (RPSS) with climatology as the reference state.

Figure 2 shows the Spearman's rank correlation coefficient for January initial conditions from lead one to 4 months. The skill is higher in the central United States for both grand mean and RPSS because winter is their dry season. The skill decreases as the lead time increases. For most places, the forecasts are skillful up to lead 3 months. The skill of the SPI forecasts comes from initial conditions because the P forecasts from the NMME are unskillful after one month. After 3 months, the impact of initial conditions diminishes and forecasts are no longer skillful. Because the CPC issues monthly and seasonal forecasts, the SPI6 forecasts can still provide useful guidance to forecasters.

The forecasts for July have similar level of skill except the Southwest. Because the NMME is not able to forecast the intensity and evolution of the North American Monsoon rainfall, the SPI6 forecast skill over the Southwest is overall low.

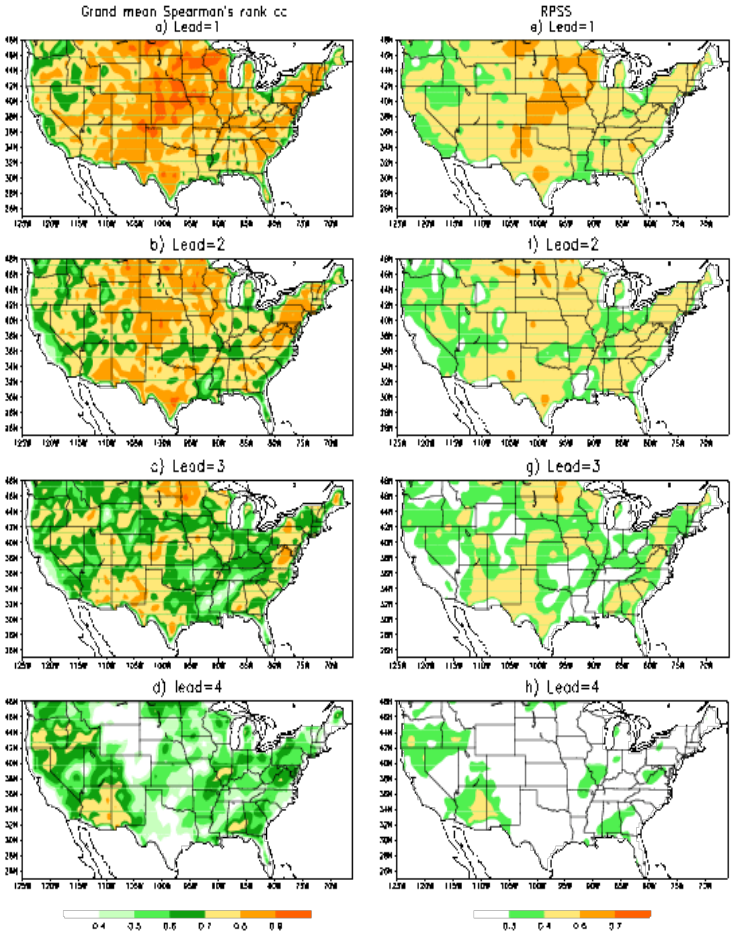

Fig. 2 Spearman's rank correlation for January initial conditions from (a) lead one month, (b) lead two months, (c) lead 3 months and (d) lead 4 months. Shading values are given by the color bar. White areas indicate that the forecast is un-skillful with the correlation less than 0.37, (e)-(h) same as (a)-(d) but for RPSS.

5. Future research plan

a) In order to provide forecasters the probabilistic drought forecast information quickly, we focused on the real time forecasts first. We will continue to provide forecasters probabilistic drought forecasts from lead one to 3 months and put forecasts on the web site.

b) We will continue to assess skill of SPI6 forecasts for other months. We will obtain the P hindcasts from the NMME archive from lead one to six months for forecasts initialized from all other months from 1982-2010. We will compute the grand mean and probabilistic drought categories and evaluate them against the SPI from the P analysis. We will evaluate hindcasts using the Spearmen's rank correlation and the RPSS.

c) Indication of forecast skill

We noticed that skillful set of forecasts has smaller spread among members. We will quantify the relationship between skill and spread. We will examine the relationship between spread and the reliability of forecasts.