Enhancing Seasonal Drought Prediction Capabilities for the US and the Globe Using the National Multi-Model Ensemble
Progress Report

1. General Information

Project Title: Enhancing Seasonal Drought Prediction Capabilities for the US and the Globe Using the National Multi-Model Ensemble

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2. Main goals of the project, as outlined in the funded proposal

- The overall goal of the proposed work is to enhance real-time, seasonal drought assessment and prediction capabilities for the US and globally through the use of the NMME.

This goal will be met by addressing the following objectives:

- Identify and correct systematic biases in the NMME precipitation forecasts.
- Combine observations with downscaled NMME forecasts to generate probabilistic predictions of multiple drought indicators at multiple lead times for the US.
- Combine near real-time observations with NMME forecasts to generate probabilistic forecasts of multiple drought indicators globally.
- Develop Web-based, interactive tools for the display of the probabilistic, NMME seasonal drought forecasts for the U.S. and the globe.

3. Results and accomplishments

3a. Bias-corrected NMME precipitation forecasts incorporated into operational SPI forecasts at CPC

Following bias adjustment, the NMME precipitation forecasts were merged with observed precipitation conditions to generate forecasts of the standardized precipitation index (SPI) for different accumulation periods and lead times across the U.S. A Web-based tool for displaying the SPI forecasts was developed at NOAA CPC, where users can examine the multi-model ensemble results, or display forecast from individual models separately. These forecasts are now routinely produced and are available for CPC forecasters working on the monthly and seasonal drought outlooks.

These tools are located here:
http://www.cpc.ncep.noaa.gov/products/Drought/Monitoring/spi_outlooks_12.shtml

A sample display is shown below in Figure 1.

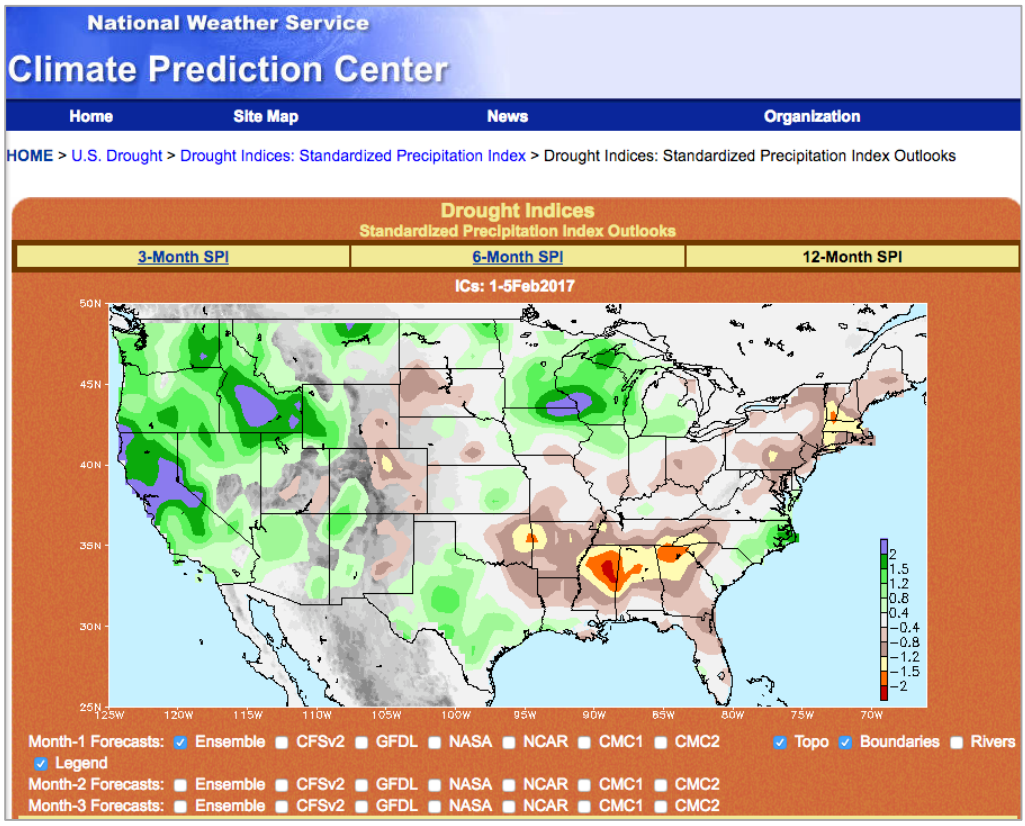

Figure 1. *Display of a best estimate forecast of the 12-month SPI on the CPC website.*

3b. Forecast skill assessment identifies the critical need for improved, real-time precipitation monitoring products

An important diagnostic analysis undertaken was to evaluate changes in skill of the SPI forecasts when NMME precipitation was merged with different observed precipitation datasets. Comparing the skill of SPI forecasts between those based on "historical" datasets (e.g., with more data inputs) versus those available in near real-time indicated substantial differences in SPI forecast skill in many parts of the globe. This result clearly indicates that, in the short term, improved monthly to seasonal drought forecasts will depend as much on improved precipitation monitoring products as improvements in model forecast skill. This important finding was reported in an article published in the Journal of Hydrometeorology.

3c. Diagnostic analysis of NMME precipitation forecasts in the context of their ability to capture observed decadal drought variability in the western U.S.

A study was undertaken to see the extent to which the coupled climate models in the NMME were able to capture an observed shift towards increased drought occurrence in the western U.S. beginning in the late 1990s. This assessment was carried out at different forecast lead times to examine how the decadal signal present in sea surface temperature (SST) conditions decayed at longer leads. The models were found to be able to capture the observed decadal shift, though weakening with lead time as the model SST field drifted from observed conditions. The results were reported in an article published in the Journal of Climate, and emphasize some of the challenges in making decadal predictions.

3d. Development of global SPI predictions and Web-based display tools

While work at the CPC focused on the development of drought indicator forecasts for the U.S., the IRI and University of Maine focused on related forecasts for the global domain. An immediate challenge was to identify what observational precipitation dataset would be used for this purpose, having global coverage and available in near real time. After some experimentation, it was decided that the CPC "gauge and outgoing longwave radiation blend" (GOB) product would be used. These data go back to 1979 for global land areas. Bias corrected NMME precipitation forecasts were then merged with the observations to generate probabilistic SPI forecasts ate different lead times. A set of interactive, Web-based analysis and prediction tools were developed based on the observations alone (for monitoring purposes), and the NMME forecasts. The full probability density function for different SPI indices is generated by

this methodology, which can be “sliced” in different ways. For example, users can display the probability of the SPI being below a user-specified threshold value at a given lead time. Conversely, users can select a probability of non-exceedance and display what the associated SPI value would be. For example, if a user selects a probability of non-exceedance of 10%, then the display will show the value of the SPI that has only a 10% chance of being lower.

The analysis and display tools developed at the IRI required more effort and resources than anticipated over the last several months of the project. As such, remaining resources identified in the May 2017 progress report were largely devoted to this effort rather than the completion of a study on the NMME performance during major El Nino events, including 2015-16 in particular and the reporting of those results in a peer-reviewed paper.

The SPI analysis and prediction tools are available to the public and are located here: http://iridl.ldeo.columbia.edu/maproom/Global/Drought/Global/index.html and are also available via the North American Drought Portal: https://www.drought.gov/nadm/content/forecasts

Examples of the analysis and prediction tools display are shown in Figures 2 and 3, respectively.

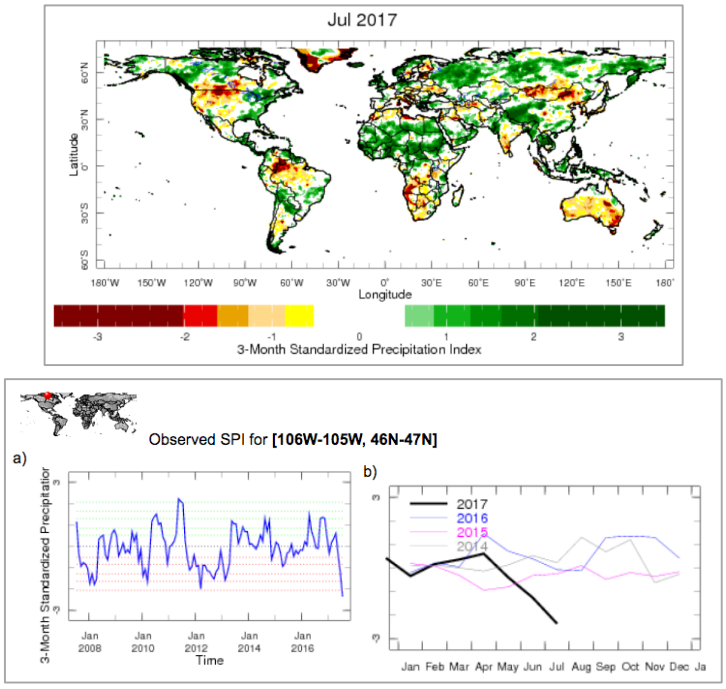

Figure 2. *Top panel shows a global plot of the 3-month SPI for the end of July 2017. Bottom panel shows time series information for a user-specified location in North Dakota (red pin in upper-left). Users can also zoom in to any region of the domain, overlay additional political boundaries, etc.*

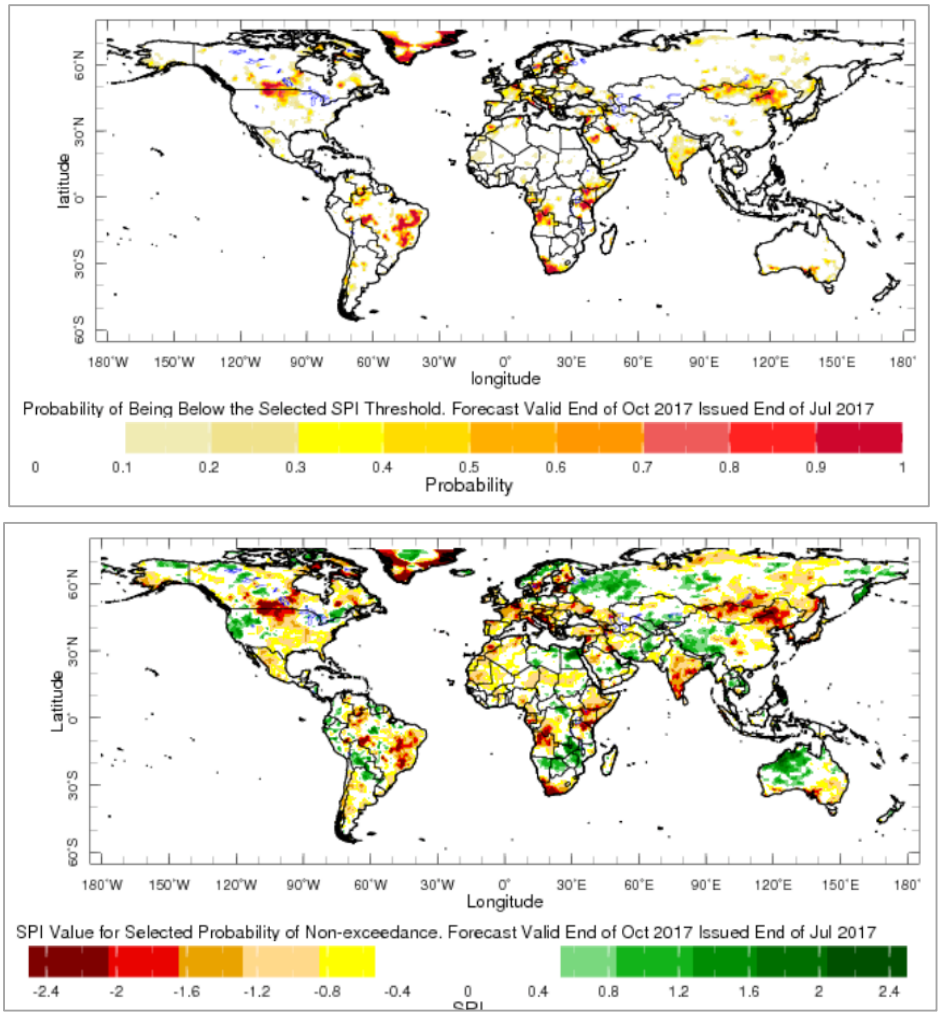

Figure 3. *Top panel shows the probability of the 12-month SPI being < -1 at the end of October 2017 based on a forecast issued at the end of July 2017. Bottom panel shows the 12-month SPI value associated with a 10% non-exceedance level valid the same forecast time as top plot.*

4. Highlights of Accomplishments

- Evaluated the sensitivity of seasonal SPI forecast skill to the integrity of the *observational* data used.
- Completed bias-corrected NMME precipitation forecasts and merged with observations to generate operational SPI forecasts at the CPC.
- Completed diagnostic analyses examining the ability of the NMME to capture observed decadal drought variability in the western U.S.
- Completed the development of display tools for drought analysis and prediction in the global domain.

5. Transitions to Applications

The tools developed under this project have not been formally transitioned to operations, but are available on a near real-time basis.

6. Publications from the Project

- Mo. K.C., and B. Lyon, 2015: Global Prediction of the Standardized Precipitation Index Using the NMME. *J. Hydrometeor.*, **16**, 1409-1424.

- Barnston, A.G., and B. Lyon, 2016: Does the NMME Capture a Recent Decadal Shift Toward Increasing Drought Occurrence in the Western US? *J. Climate,* **29**, 561-581.

- Seager, R., M. Hoerling, S. Schubert, H. Wang, B. Lyon, A. Kumar, J. Nakamura, and N. Henderson, 2014: Causes and Predictability of the 2011 to 2014 California Drought. *NOAA Climate Program Office, Drought Task Force Report, 42pp.*

- Seager, R., M. Hoerling, S. Schubert, H. Wang, B. Lyon, A. Kumar, J. Nakamura, and N. Henderson, 2015: Causes of the 2011 to 2014 California Drought. *J. Climate*, **28**, 6997-7024.

7. PI Contact Information

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8. Budget for Coming Year

The project is now completed, with this its final report.

9. Future Work

The project is now completed, with this its final report.