

What is Sub-Seasonal to Seasonal (S2S) Forecasting?

Everyday decisions are made based on weather forecasts for various time ranges within 14 days (short-term), but **sub-seasonal to seasonal (S2S) forecasts** (longer-term climate forecasts for 2 weeks to 12 months from now) are greatly needed by decision makers in water resources, energy and agriculture. According to the National Academy of Science in 2016, S2S forecasts will become more widely used in the future.

The “skill,” or accuracy, of S2S forecasts varies with season, region, and variable (temperature, precipitation). They are also dependent on how far in advance one is forecasting (figure 1). Each type of forecast (short-term, sub-seasonal, and seasonal) makes the best use of knowledge of how the atmosphere works and the latest atmospheric, oceanic, and land surface conditions. S2S forecasts are different than short-term weather forecasts. They are limited by the above factors as well as the chaotic nature of the atmosphere-ocean-land system. Given these uncertainties, S2S forecasts are given in terms of probabilities rather than as forecasts for specific weather events.

S2S forecasts include information from computer models based on our current understanding of the atmosphere, ocean and land system, and from statistical methods linked to historical observations.

Mid-November Precipitation Forecast Skill for All December to Februarys from 1995-2016

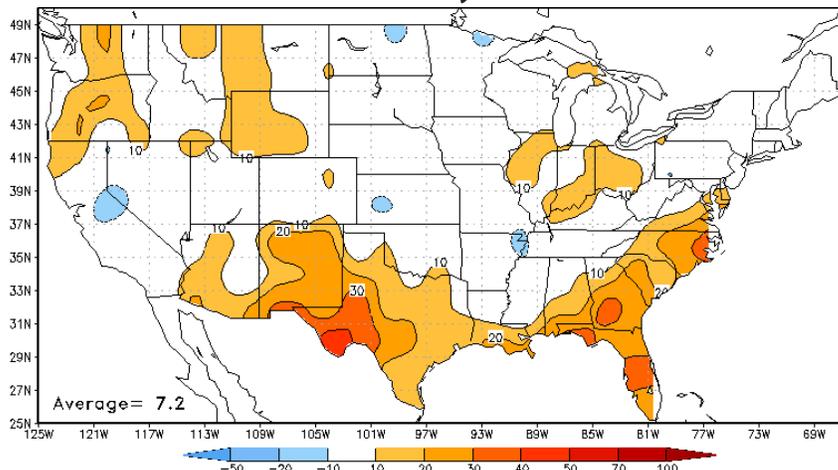


Figure 2. Heidke skill scores show low skill (whites and blues) for December-Februarys from 1995 to 2016, more so in precipitation (shown) forecasts than temperature.

Source: <http://www.cpc.ncep.noaa.gov/products/verification/summary/index>.

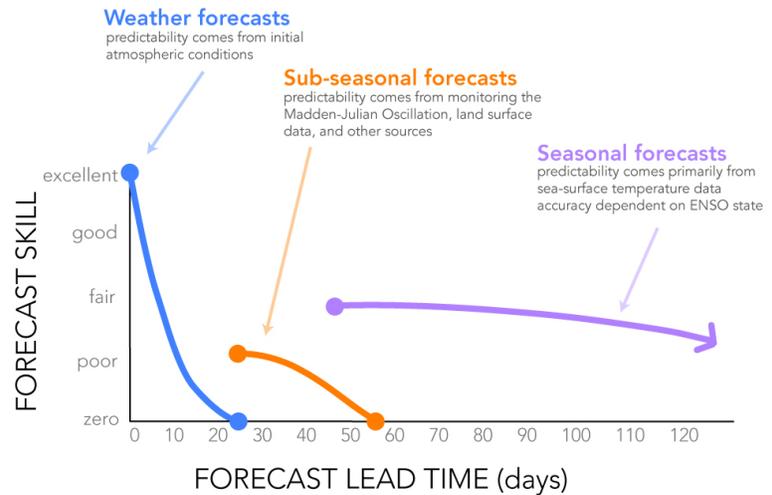


Figure 1. Different type of forecast skill by type of forecast (weather, sub-seasonal, seasonal) which depends on how far out (or lead time) the forecast is for.

Source: <http://iri.columbia.edu/news/qa-subseasonal-prediction-project/>

FORECAST PERFORMANCE

Forecast **skill** is a gauge of the performance of a forecast relative to a given standard. Often, the standard used is the long-term (30-year) average - called the climatology - of temperature or precipitation. Thus, skill scores measure the improvement of the forecast over a solely climatological forecast. NOAA's Climate Prediction Center (CPC) uses the Heidke skill score (figure 2), comparing how often the forecast category correctly match the observed category, over and above the number of correct “hits” expected by chance alone. A score of 0 means that the forecast was not better than what would be expected by chance. A score of 100 depicts a perfect forecast and a score of -50 depicts a perfectly wrong forecast. For example, California and Nevada are shown (figure 2) to have low forecast skill in precipitation as do many other regions of the United States.

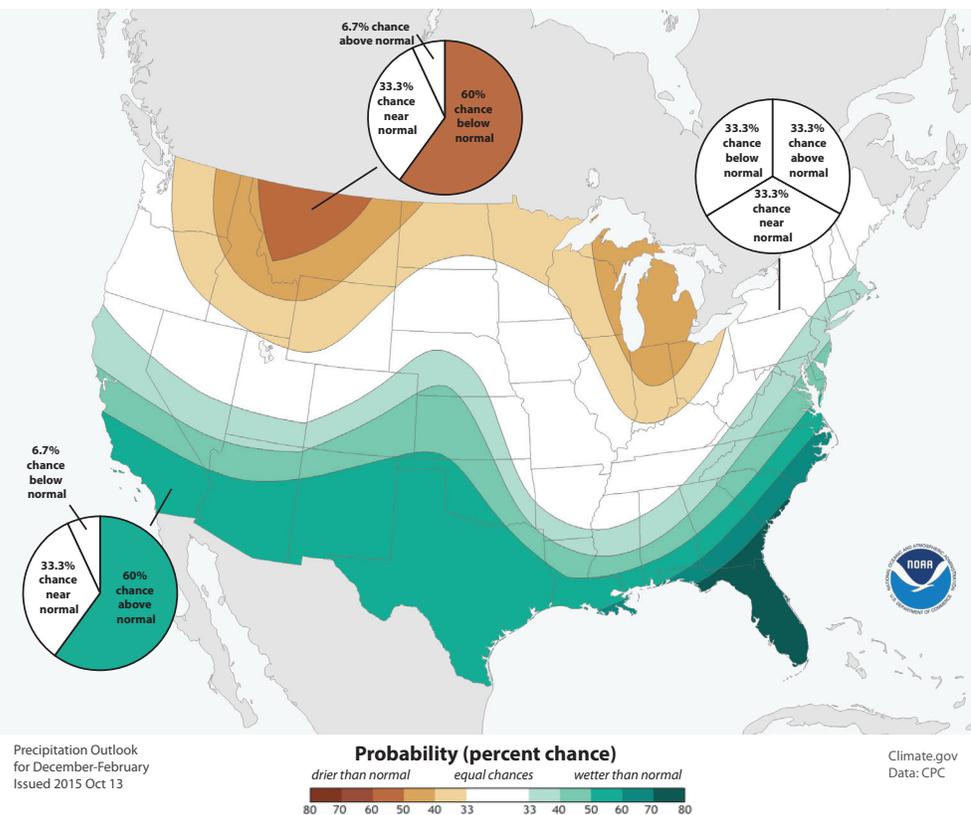


Figure 3. National precipitation outlook for December 2015 to February 2016, issued on October 15, 2015. Colors indicate the odds of the most favored category (i.e. above-, near-, or below-average) for seasonal total precipitation. White indicates equal chances for any outcome—above-, below-, or near-average precipitation—not a prediction of “normal” seasonal total precipitation. Map by NOAA Climate.gov (<https://www.climate.gov/news-features/videos/2015-16-winter-outlook>), based on data from the Climate Prediction Center.

NOAA Climate Prediction Center (CPC) Suite of Official Forecasts can be found at <http://www.cpc.ncep.noaa.gov/products/predictions/>

Understanding NOAA Climate Prediction Center S2S Forecasts

S2S forecasts are made by several federal programs and universities, each encompassing different methods and skill. A widely used set of S2S forecasts are NOAA’s Climate Prediction Center (CPC) color shaded maps of extended range outlooks (for example, 6-10 or 8-14 days to 1 month) and longer lead time (up to 12.5 months) outlooks for 3-month time periods. There is a shift in forecast skill as one moves across time scales from the extended range outlooks to the 3-month outlook as shown in figure 1. Although the color shading indicates the probability of above- or below-average temperature or precipitation, the forecasts do not indicate how much above or below average (i.e. how extreme) a forecast period might be.

How are these forecast likelihoods displayed on CPC maps determined? NOAA’s seasonal forecasts start with the assumption that for any summer or winter, there are three possible climate outcomes: temperature or precipitation that is above normal (upper third of the 1981-2010 record), near normal (middle third), or below normal (lower third). Without looking at the current forecast, at a given location each category has equal chances of occurring, and together they must add up to 100%. Thus the default probability for each outcome is 33.3%.

Determining how the odds shift to favor above or below normal conditions is controlled by a number of factors such as the

status of large scale climate factors (e.g. ENSO), statistical forecast tools and the characteristics of the output from dynamical models. For example in the forecast for December 2015 to February 2016 made in (or issued in) October 2015 (figure 3), a wetter-than-normal Southwest US was anticipated, with drier than average conditions in the Northwest US. The consistent and nearly unanimous model predictions for a wetter than normal season in Southern California contributed significantly to CPC forecasters setting the odds at a 60% chance of wetter than normal conditions. That left a 40% chance of near normal or below normal precipitation. Forecasters divided this remaining fraction (40%) by holding the chances for near-normal conditions at the default (equal chances) 33.3% leaving 6.7% as the probability of the least favored category, for this example being below normal precipitation. S. California was then color shaded to match the more favored category, here being wetter than normal precipitation. CPC does the same types of maps for temperature using this same approach.

When the odds of above or below normal are very high (70% or more) such that the remaining fraction is smaller than 33.3%, forecasters set a minimum 3.3% chance for the opposite outcome, and assign the larger portion of the remainder to the near-normal outcome. This prevents the least-favored category from being assigned an impossible negative value.

- **CNAP**, the California Nevada Applications Program, is a NOAA RISA team conducting applied climate research that is inspired by and useful to decision makers in the region. cnap.ucsd.edu
- The **National Weather Service** is tasked with providing weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy. weather.gov
- **NIDIS**, National Integrated Drought Information System, works with federal, state, tribal and local partners to improve drought early warning, preparedness, and response to impacts. drought.gov
- **CW3E**, Center for Western Weather and Water Extremes, provides science to support effective policy on extreme weather and water events. cw3e.ucsd.edu
- Thank you to **California Department of Water Resources and NOAA’s Climate Prediction Center** for suggestions and revisions to this document.