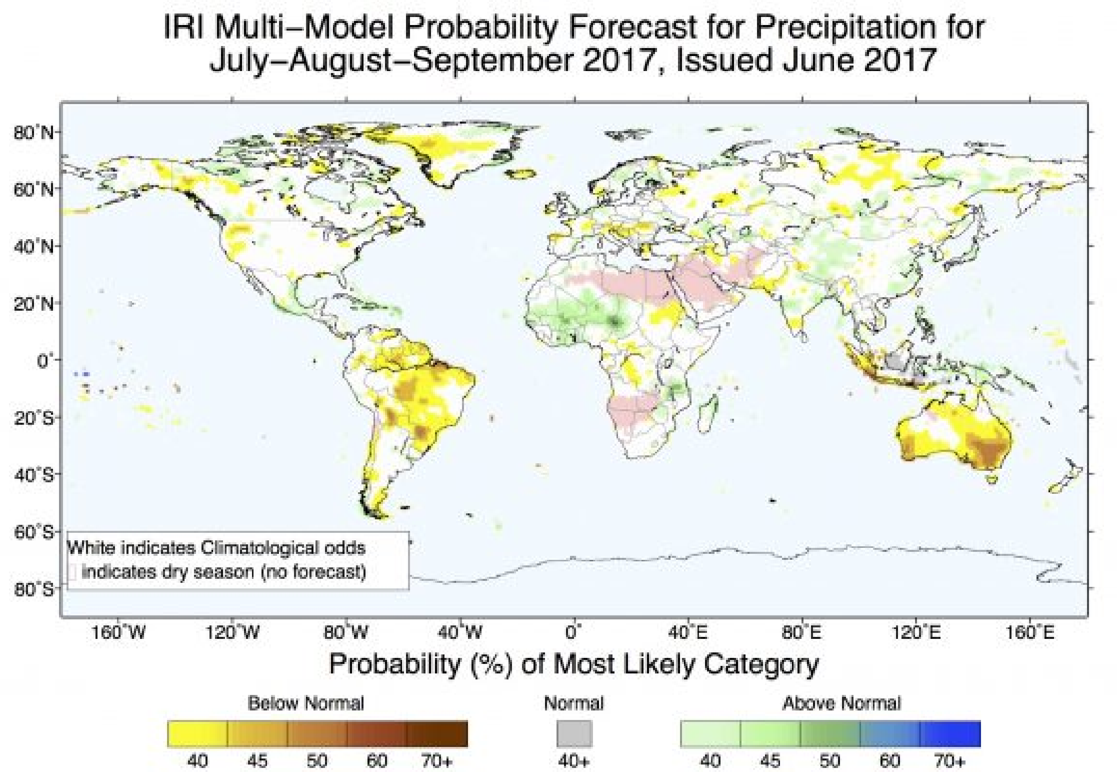
What's in the forecast and how do we know?

July 13 2017, by Renee Cho, Earth Institute, Columbia University



Here's what the global temperature and rainfall conditions for the rest of this year are expected to be. The Earth Institute's International Research Institute for Climate and Society's (IRI) probabilistic outlooks for temperature and precipitation are updated monthly for six months into the future. The forecasts call for warmer than normal temperatures for portions of Africa, Australia, South America, south-central or southwestern Asia, southeastern Europe, the United States and Greenland. The likelihood of above average temperatures is highest for Greenland and northern North America. Cooler than normal temperatures are projected for northern and northwestern North America and portions of northern Asia. Southern Africa could see cooler temperatures in the August to October season.

According to IRI, however, there is no such thing as a strictly right or wrong probabilistic forecast. If there is a 75 percent chance of above-average temperature, but the temperature ends up being below average, this doesn't mean the forecast is wrong, because a 75 percent chance of above-average temperature also allows for a 25 percent chance of average or below-average temperature.

The Met Office, the U.K.'s national weather service, predicts that the 2017 global average temperature will be from 0.63 °C to 0.87 °C warmer than the long-term (1961-1990) average temperature of 14.0 °C.

"You see a lot of warm anomalies," said Adam Sobel, professor in the Department of Applied Physics and Applied Mathematics at Columbia University and Lamont-Doherty Earth Observatory, and director of the Columbia Initiative on Extreme Weather and Climate. "But because an anomaly is a difference from an average that's defined by the last 20 or 30 years, it's almost always warmer than that now because of global warming. So when you look at the temperature maps, you see warm over most of the globe—you don't see much cool, and that, to some extent, is just the climate change signal which is mixed in there."

Precipitation is predicted to be below normal in northern and central South America until September with northern South America expected to receive less precipitation from August through December. Chances for below normal precipitation are also expected for parts of Australia through November; below normal precipitation is predicted for southern and western Indonesia through October, and for central Africa from September through December. Slightly above normal precipitation is forecast for western Africa through October, and some of northern Asia from September to December.

2017 will likely be a neutral year for El Niño and its counterpart La Niña. El Niño is a complex and naturally occurring weather pattern that results every two to seven years when Pacific Ocean temperatures near the equator vary from the norm; La Niña, which often occurs about a year after El Niño, is an intensification of the normal pattern. The cycling of the two phases is called El Niño Southern Oscillation (ENSO).

During an El Niño year, the normal trade winds that blow east to west across the Pacific around the equator weaken or break down. The warm water that is usually pushed towards the western Pacific by the winds washes back across, accumulating on the east side of the Pacific from California to Chile, causing rain and storms. El Niño can affect weather around the world by influencing high and low pressure systems, winds and precipitation, and pushing global temperatures higher. 2015 and 2016 set records for global high temperatures because they were El Niño years.

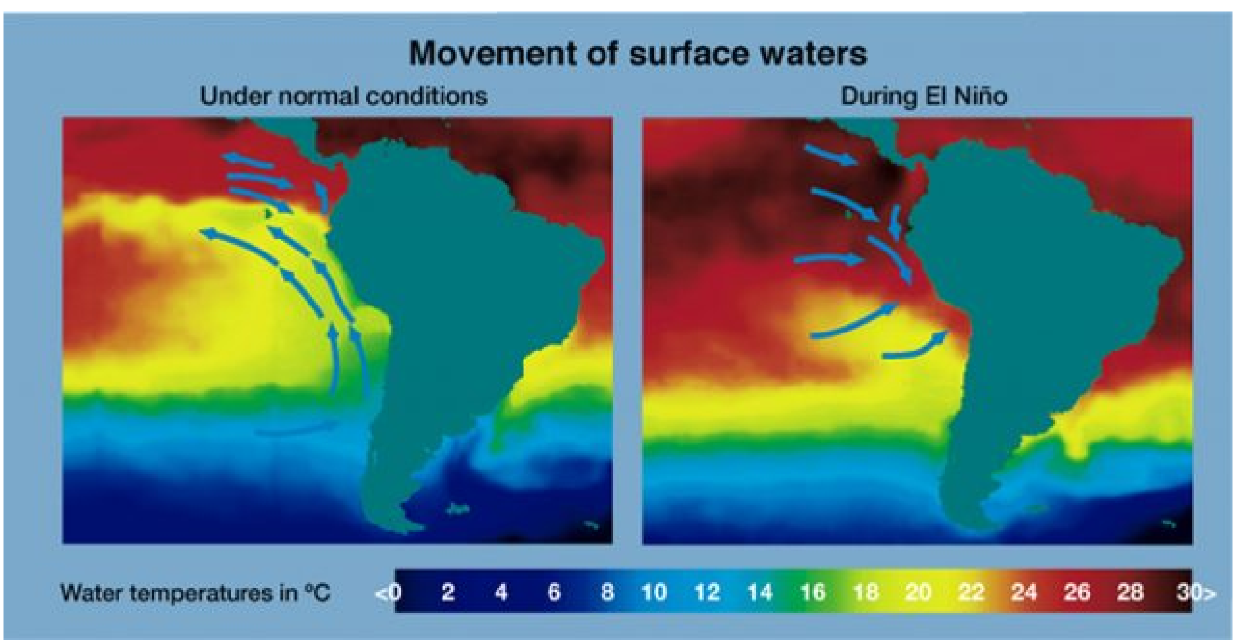
IRI, which was established in 1996 after Mark Cane and Stephen Zebiak of Lamont-Doherty invented ENSO forecasting, predicts that ENSO will remain in its neutral state through the rest of the year. The likelihood of El Niño conditions developing never exceeds 45 percent according to the latest forecast (IRI's ENSO forecasts, which it produces with the National Oceanic and Atmospheric Administration, are updated each month.). Probabilities for a La Niña are less than 10 percent. During ENSO-neutral periods, ocean temperatures, tropical rainfall patterns, and atmospheric winds over the equatorial Pacific Ocean remain around the long-term average.

"ENSO is the most predictable signal in the climate system," said Sobel, "If it's ENSO neutral, there can still be other things in the climate system that could make for predictable anomalies, but none of them are as powerful as ENSO, so it tends to be a kind of unexciting forecast, which is what you see now."

In the U.S., the outlook through September from the National Oceanic and Atmospheric Administration's (NOAA) Climate Prediction Center is for above normal temperatures for much of the continental U.S. and Alaska. The places most likely to see warmer than average temperatures are the Northeast, parts of the Gulf Coast and Florida, the Southwest and southwest Alaska and the Aleutian Islands. Parts of central U.S. may see normal temperatures due in part to moisture in the soil. The northern Great Plains, western Gulf Coast and southwest Alaska and the Aleutians have a slight chance of more precipitation than usual. During the fall and winter, neutral ENSO conditions will likely keep temperatures and precipitation in the average range.

In May, NOAA predicted that there is a 45 percent chance for an above normal and a 20 percent chance of a below normal Atlantic hurricane season. Through November 30, forecasters say there is a 70 percent chance of 11 to 17 names storms (winds 39 mph or more), five to nine of which could become hurricanes (winds 74 mph or more), with two to four becoming major hurricanes (winds 111 mph or more). Average seasons usually bring 12 named storms with six hurricanes and three major hurricanes. El Niño and the wind shear that accompanies it usually keep hurricanes in check, so a neutral ENSO suggests the possibility of more hurricane activity.

NOAA is also predicting an 80 percent chance of near or above normal hurricane activity in the eastern and central Pacific, with a 70 percent chance of 14 to 20 named storms, including six to 11 hurricanes of which three to seven will be major hurricanes. NOAA's hurricane outlook will be updated in early August. According to Sobel, however, not too many decision makers depend on the hurricane forecast because they don't forecast landfall.



As of April 2017, 570 tornados had been reported in the U.S., close to 100 more than average. By June, the end of "tornado season" (though tornadoes have occurred in every month in the U.S.), the number of tornados had almost doubled, with NOAA preliminarily reporting 1076 tornadoes.

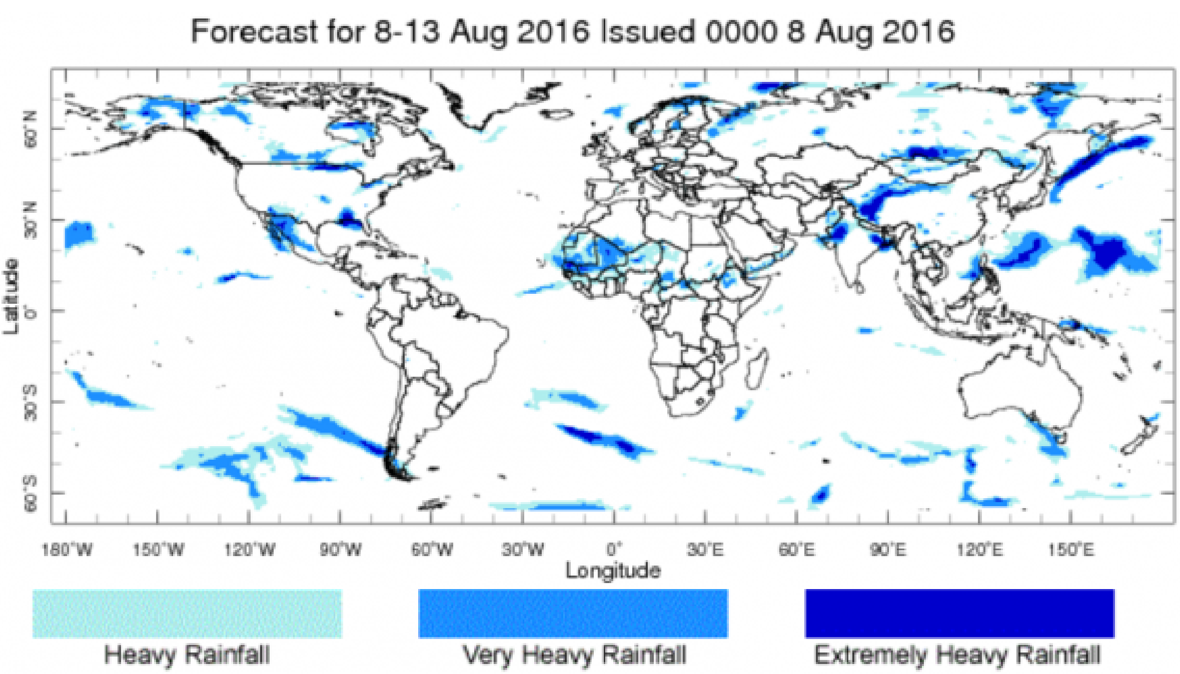
"We don't have explicit forecasts of extreme events that come with a high degree of confidence for lead times further out than the weather forecast," said Sobel. "The influences on the climate system that are predictable are the things that move slowly, like the ocean. What you're predicting are some slow components of the system, but extreme events depend very much on the fast moving components— they always result from a confluence of factors and a lot of those factors are not predictable far in advance. But things like ENSO do affect the probability of some kind of extreme events and we do have a little bit of skill at that and we can get better at it."

Nachiketa Acharya, a statistical climatologist at IRI, explained that while in reality climate largely results from the constant interaction of ocean and atmosphere, older climate models could not always integrate the two. Before this year, scientists would run an ocean model first, then take input from the ocean model and enter it into the atmosphere model to generate a forecast.

In April, Acharya began working with a new one-tiered system model that mimics the real atmosphere, coupling the ocean and atmosphere in a continuous process. IRI's new forecasts are based on NOAA's North American Multi-Model Ensemble Project (NMME) that incorporates data from nine coupled climate models from various U.S. institutions and Environment and Climate Change Canada.

"IRI does not run any climate models in house now," said Acharya, "Instead we are getting all the models from the NMME centers. We are calculating the probabilities for rainfall, temperature and ENSO based on data from those advanced coupled models, and making forecasts for the upcoming four overlapping three-month periods."

To test and refine the reliability of their climate prediction methodology, IRI scientists set up hindcasts. They make a pretend set of forecasts for past years without using the real historical data then calculate the differences between their hindcasts and the actual climate of the past. Repeating the process up to the present time enables them to improve the accuracy of their models.



Red Cross 2016 rainfall forecast

Up until recently, forecasting for the interim between weather forecasts (which predict up to two weeks in the future) and seasonable forecasts (which predict several months into the future) had been difficult to do. But climate scientists are getting better at modeling oscillations in tropical weather, snow cover at certain times of year and other weather phenomena that influence weather at two to four week intervals.

In December 2016, IRI and the Initiative on Extreme Weather and Climate organized a conference on the efforts to offer probabilities for weather in between the time frame of weather forecasts and seasonal forecasts, called subseasonal to seasonal forecasting. The S2S Prediction Project, chaired by IRI senior research scientist Andrew Robertson, is an international effort involving the World Climate Research Program and the World Weather Research Program, both of which are sponsored by the World Meteorological Organization. With a tagline of "bridging the gap between weather and climate," the project's goal is to improve subseasonal to seasonal forecasting skill and promote its application.

"There are many applications for all these forecasts," said Acharya. "IRI has a strong collaboration with the African countries and South Asian countries where they actually use our forecasts to make their agriculture management [decisions]. And they're used for hydrological practice in the U.S., Indonesia, Chile and other countries. Also for the forest fires in Indonesia—if you know that the next season will be very dry with high temperatures, there is a high chance of forest fires. We also have a close collaboration with the Red Cross Climate Centre, which uses our forecast for its early warning system because we give a global forecast. If staff there know there is a high chance of flood some place, they are ready for it."

Traditional forecasts offer probabilities that precipitation or temperatures within a certain time frame will fall in one of three categories: above-normal, below-normal or near normal, but they don't indicate how far above or below normal the impacts are expected to be.

"When we work with stakeholders," said Acharya, "It's not always helpful to give only three categories of forecast—above-normal, below-normal and near normal. For an early warning system, they really need forecasts for the extreme categories." That's why IRI developed what it calls flexible temperature and precipitation forecasts. These determine the probability that temperature or rainfall will go beyond a specific percentile in the average range of a region.

Acharya explained how the flexible forecasts can be used, "For example, since I'm from India, I'm interested in the monsoons. I can look at the map of India and put in any higher value of rainfall in a certain place, because I'm looking for extremes. If I put it in, I will get the probability of getting that higher value of rainfall over three months falling on that specific region."

It is challenging to verify forecasts because they are given as probabilities and thus always contain some inherent uncertainty. However, since 1997 when IRI began predicting precipitation and temperature, it has demonstrated a strong track record of skillful forecasting.

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