CLIMATE GUIDANCE SERIES

PRECIPITATION FORECASTS

JUNE 2023

OCHA

centre for humdata

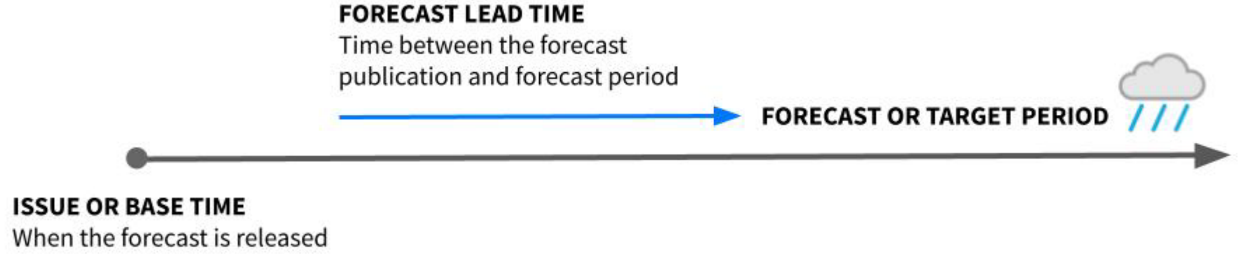
About this series: The climate crisis is intensifying humanitarian emergencies around the world and humanitarians are increasingly having to incorporate climate data and forecasts into their analysis and planning. This guidance series has been developed to help humanitarians to access, analyze and interpret common types of climate and weather data, and to provide a common language for working with meteorological and hydrological services.

Key takeaways

- Precipitation forecasts predict how much it will rain during a period of time in the future.
- Precipitation forecasts can be presented in different ways, such as the total amount of precipitation expected, the likelihood of precipitation occurring, or whether precipitation is expected to be above, below, or near average.
- The accuracy of a precipitation forecast depends on various factors, such as the presence of El Niño or La Niña events, which can have a significant impact on precipitation patterns globally[1].
- Seasonal forecasts offer valuable insights into precipitation patterns over large geographic regions but they may not provide sufficient detail to accurately predict what will happen in smaller areas, such as cities, or during shorter time frames, such as weeks.
- Medium- or short-range forecasts are able to provide more granular and specific information about expected precipitation amounts and patterns in a particular location over a shorter period of time.

What are Precipitation Forecasts?

Precipitation forecasts are predictions of how much it will rain during a specific future period, referred to as the **forecast** or **target period**. The forecast period varies in duration, depending on the type of forecast. For example, the forecast period for a short-range forecast could be a day or week whereas the forecast period for a long-range forecast may be as long as three months. The time between the forecast publication (the **issue** or **base time**) and the forecast period is called the **lead time**[2]. Precipitation forecasts are updated regularly and the updates become more frequent as the forecast period approaches.



[1] El Niño events are associated with a warming of the central and eastern tropical Pacific, while La Niña events are the reverse, with a sustained cooling of these same areas. Both events alter weather around the world https://www.climate.gov/news-features/blogs/enso/how-enso-leads-cascade-global-impacts.

[2] Forecast providers define categories differently. Before using a forecast, always look for the provider's definitions and/or the forecast and issue periods to confirm.

Precipitation forecasts make predictions about the likelihood and/or amount of rainfall and are valuable for a variety of applications. Daily forecasts can help determine whether it's likely to rain during an event, while weekly or monthly forecasts can indicate whether there will be enough rain to begin planting crops. Seasonal forecasts are useful for determining whether the upcoming rainy season will bring more or less rainfall than usual, which can be important for planning potential humanitarian action.

Key Characteristics of Precipitation Forecasts

When selecting a precipitation forecast, it is crucial to consider the forecast's temporal and spatial resolution. Spatial and temporal resolution vary depending on forecast type (e.g., monthly) and provider (e.g., the United Kingdom Meteorological Office). Providers will typically publish the resolutions of their products and information about how well their forecasts perform in historical cases alongside their forecasts. Understanding the level of detail and accuracy provided by different forecast types and providers enables individuals to assess the reliability and applicability of the forecasts for specific temporal and geographic contexts.

Temporal resolution is the shortest unit of time for which the forecast produces a prediction. A seasonal forecast typically has a three-month resolution, whereas a weather forecast might have an hourly resolution. The temporal resolution may coincide with the forecast period, as is the case for seasonal forecasts, or be shorter, as in the case of daily forecasts with an hourly temporal resolution.

Spatial resolution is the smallest unit of space for which the forecast produces a prediction. Visually, a forecast is presented as a grid, which is made up of individual squares called **pixels** (also referred to as grid points or cells). Each pixel represents a discrete area of land. The size of that area is the forecast's spatial resolution. For example, if one pixel covers one hundred square kilometers then the spatial resolution is 10 kilometers. A higher resolution means that a pixel covers more geographic detail over a smaller area, which often comes at the cost of lower temporal resolution or a shorter lead time for the forecast.

When assessing how informative a precipitation forecast will be, there are two considerations to keep in mind:

1. **Forecasts become more detailed as lead times shorten.** To enable forecasting at longer lead times, climate scientists look at large-scale phenomena that evolve slowly. These phenomena make it possible to produce long-term forecasts that track patterns across large geographic areas and over long timescales. As the forecast period draws nearer, more details become available on when and where it is likely to rain. In other words, as the lead times shorten, predictions become more precise at a higher resolution.

2. **Forecasts have greater certainty at shorter lead times.** When lead times are shorter, there is less time for climate and weather systems to change drastically between the forecast publication and the forecast period. While forecasts with longer lead times are inherently more uncertain they still provide actionable information and are a significant improvement over having no information or relying solely on historical data.

When using a precipitation forecast, it is important to remember that conclusions cannot be drawn about rainfall patterns *within* a forecast's temporal and spatial resolution. For example, a seasonal forecast with a three-month temporal resolution cannot provide information on the number of rainy days to expect during that three-month period as this would require a forecast with a one day temporal resolution. Similarly a seasonal forecast with a spatial resolution of 10 kilometers cannot provide information about the expected rainfall for areas smaller than that.

Additionally, it is not advisable to draw conclusions based on a prediction at the level of a single pixel, especially if adjacent pixels indicate variability in the prediction. For instance, if a seasonal forecast predicts above-average rainfall for a pixel at the heart of the city but the pixels covering the rest of the city suggest below-average rainfall, the forecast is less confident in its prediction for the city and may change before it can converge on a reliable prediction. Predictions that are consistent across adjacent pixels signal that a forecast is more confident for that geographic area.

The minimum number of consistent pixels for reliable predictions depends on several factors including geographic location, time of year, and spatial resolution. However, as a rule of thumb, we recommend no less than five consistent pixels for a reliable prediction when using long-range, seasonal, monthly, extended, or sub-seasonal forecasts of a typical spatial resolution (for more details, see the table below). It is always advisable to consult the forecast provider for further guidance.

Types of Precipitation Forecasts

There are three types of precipitation forecasts: seasonal forecasts (1-6 months ahead), sub-seasonal forecasts (approximately 2-6 weeks ahead), and weather forecasts that are medium range (3-15 days ahead) or short range (1 hour to 3 days ahead). More details are provided below.

1. **Seasonal forecasts (1-6 months ahead)** are based on slowly varying, very large-scale climate phenomena such as the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole, which have been shown to impact climate conditions worldwide. Seasonal forecasts are produced by global centers, as well as regional and national meteorological offices, and they provide information on whether an area is more likely to experience above-, near-, or below-normal rainfall over a forecasted period of up to three months. While seasonal forecasts can be used to better understand likely trends over the course of a season, they cannot capture weather extremes such as heavy rain events and dry spells or provide information for specific geographic areas.

2. **Sub-seasonal forecasts (approximately 2-6 weeks ahead)** are high-resolution forecasts that typically cover a time frame ranging from about two to six weeks. Sometimes they are also described as monthly forecasts. Sub-seasonal forecasts help to bridge the information gap between short-term weather forecasts and longer-term seasonal forecasts. However, producing accurate and reliable predictions for this time frame has historically been challenging due to the complex dependency on both local weather conditions and global climate patterns. In recent years, sub-seasonal forecasts have become more reliable and it's where we'll most likely see further improvements in the future.

3. **Weather forecasts that are medium range (3-15 days ahead) and short range (1 hour to 3 days ahead)** often come from national meteorological and hydrological services and typically cover smaller geographic areas at a higher level of temporal detail. They are crucial for responding to sudden onset events such as heavy rainfall or dry spells.

COMPARING PRECIPITATION FORECASTS				
Forecast type	**Seasonal**	**Sub-seasonal[3]**	**Weather (medium range)**	**Weather (short range)**
Lead time	1 to 6 months	2 to 6 weeks	3 to 15 days	1 hour to 3 days
Spatial resolution	100km	75km	50km	10km
Temporal resolution	3 months	1 week	1 day	1 hour
Good for understanding	• Early predictions for rainfall 1-6 months from now. • Cumulative rainfall over the upcoming 1-3 months. • Cumulative rainfall over large-sized areas (typically around 50,000 km^2, roughly the size of Costa Rica). • Whether there is a risk of considerably above- or below-normal rainfall for a region. • Whether there will be enough rain this season to meet the minimal requirement of crops.	• Early predictions for rainfall weeks from now. • Cumulative rainfall over the upcoming 2-4 weeks. • Cumulative rainfall over medium to large-sized areas (typically around 28,000 km^2, roughly the size of Armenia).	• Forecasts for rainfall less than 2 weeks from now. • Cumulative or daily rainfall over the upcoming 3-15 days. • Cumulative rainfall over medium-sized areas (typically around 2,500 km^2, roughly the size of Luxembourg). • Whether there will be a prolonged dry spell in the next 15 days. • Whether a small to medium-sized area is likely to receive more or less rain than another.	• Most certain rainfall forecasts for the next few days or hours. • Rainfall patterns and expected amounts by the day or hour. • Rainfall patterns over specific areas (typically around 100 km^2, roughly the size of Tunis). • Whether a day will be dry or rainy. • Whether a small-sized area is likely to receive more or less rain than another. • Whether it will rain today.
Not good for understanding	• Whether a small geographic area is likely to receive an average amount of rain. • How many days will be rainy. • Whether there will be a dry spell within a rainy season. • How long a rainy season will be. • Whether every month of the season will receive average amounts of rain.	• Whether there will be a 5-day dry spell. • Whether it will rain every day. • Whether the rainfall in the predicted period means it will be a good or poor rainy season. • When a dry spell will end. • How much rain might fall in 3 months. • How much rainfall a small-sized area (less than 28,000 km^2) might receive.	• Whether the current month's or the season's rainfall is likely to be at, below or above average. • How much rainfall might fall 1 or more months from now. • How many dry spells are likely to occur during the rainy season. • Whether the rainy season is likely to start on time.[4]	• Whether the current month's or the season's rainfall is likely to be at, below or above average. • How much rainfall might fall 1 or more months from now. • How many dry spells are likely to occur during the rainy season. • Whether the rainy season is likely to start on time.[3]

[3] Sub-seasonal forecasts are recent products still in research and development. Monthly forecasts can be categorized with seasonal forecasts due to how they are generated.

[4] Rainy season onset is defined specifically for the local context and may require meeting several criteria. A forecast may inform on whether there will be rainfall and when, but is not enough to confirm season onset. For example, a definition might be 'the first day of the wet season is when a wet spell of accumulated rainfall in 3 consecutive days is at least 20 millimeters and there is no dryspell of at least 7 days in the next 21 days'. See more: https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/rain/rainy-seasons.

Interpreting Precipitation Forecasts

Precipitation forecasts differ in their reporting methods for predictions. Some forecasts present predictions as the total amount of rainfall in millimeters, while others indicate whether the precipitation is expected to be above average, average, or below average. Additionally, forecasts may provide information on the expected deviation from the average in terms of millimeters, percentage of average, or using an index.

To determine how a forecast reports its values, you can refer to the methodology report or summary provided by the data provider. These resources offer insights into the specific reporting approach used by the forecast and enable an accurate interpretation of the forecasted values.

ABOUT TERCILE FORECASTS

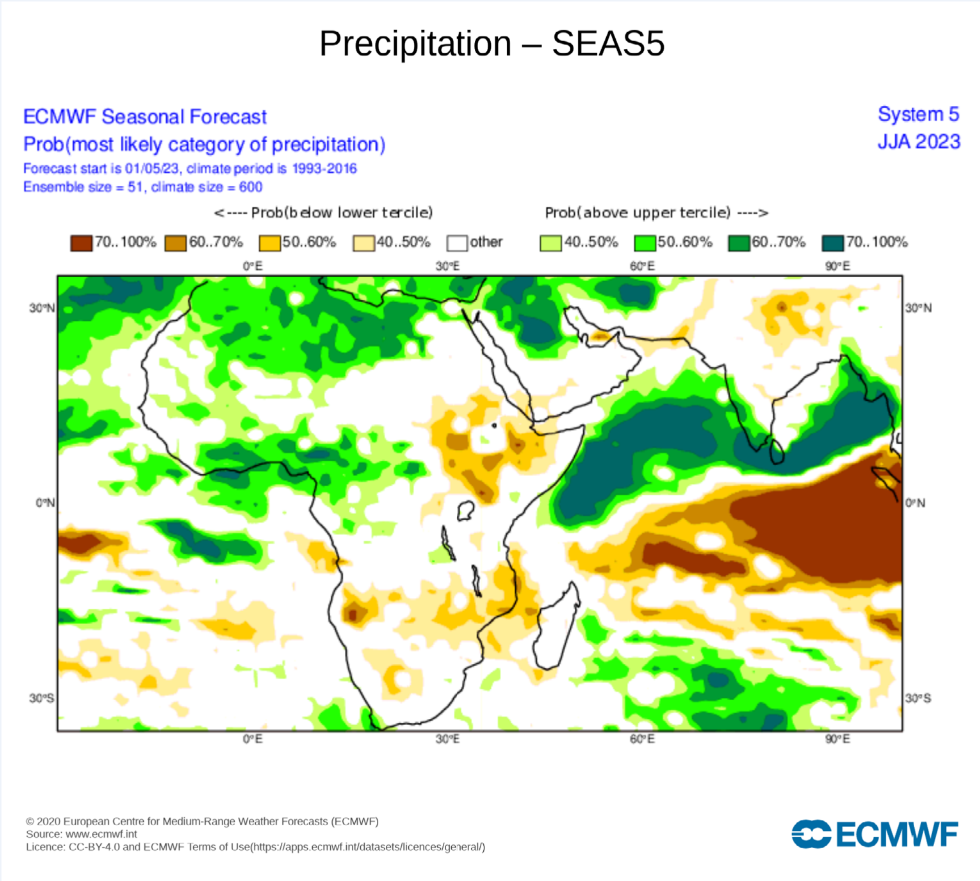
Terciles are a statistical concept used to divide a probability distribution into three equal parts. In the context of climate and weather forecasting, terciles are commonly used to categorize the likelihood of different outcomes for a specific variable, such as temperature or precipitation.

In a tercile seasonal forecast, there are three possible scenarios for rainfall: above average, average or below average. Under normal conditions, each scenario would be expected to occur one-third of the time. Tercile seasonal forecasts evaluate the state of the climate system at a specific point in time and assess the likelihood of each scenario occurring.

When a forecast is issued, it will either report the probability of each scenario or the probability of the most likely scenario. In any case, the combined probabilities of all three scenarios will always add up to 100 percent.The most likely scenario is the category (i.e., above average, average or below average) with the highest probability. The forecast's certainty increases as the probability deviates from 33 percent, which is the likelihood based on chance alone (one scenario occurring out of three possibilities).

Climate science enables forecasts to identify patterns in the climate system that alter the probabilities away from chance. A forecast takes into account multiple pieces of information, each contributing to the likelihood of different scenarios. A probability of 50 percent, indicating a 17 percentage point deviation from chance, signifies that the scenario is significantly more likely to occur. Conversely, a probability of 16 percent, 17 percentage points below chance, indicates that the scenario is significantly less likely.

Although a probability of 50 percent may appear low, it represents a significant departure from chance and suggests multiple reasons to expect that the scenario will occur. Probabilities at 40 percent and above are considered likely scenarios, while probabilities exceeding 55 percent are infrequent and indicate highly confident predictions.



A seasonal forecast released by the ECMWF in May 2023 for the African continent.

The seasonal forecast above from the European Centre for Medium-Range Weather Forecasts (ECMWF) is an example of a forecast where the most-likely scenario by geographic area is being reported using probabilities. In this forecast, the most-likely scenario is expressed as a percentage and visualized as a single color on the map. This forecast was issued in May 2023 and refers to the forecast period between June and August 2023 (JJA 2023, following the first letter of each month). The brown color scale represents below average predictions, while green represents above average predictions. The forecast predicts that some countries in Southern and Eastern Africa will likely receive below average rains during this forecast period with a likelihood of 60+ percent. Parts of Northern and Western Africa, on the other hand, are predicted to receive above average rainfall with the likelihood reaching 60 percent.

Factors to consider when interpreting precipitation forecasts

When interpreting precipitation forecasts, it is important to bear in mind a few general rules and facts that influence how the forecast can be used. However, specific considerations regarding forecast skills may vary depending on the particular application, type of forecasts, and geographical region. It is essential to evaluate these factors on a case-by-case basis.

1. **Forecasts vary in their skill, or accuracy, level.** Forecast skill quantifies the ability of a forecast to accurately reproduce actual observations. Scientists estimate forecast skill by using different statistical indicators. Forecast skill will vary based on the geographic location, the lead time, the presence of an ENSO event, the month of the year, and a number of other factors. In cases where documentation is inaccessible or incomplete, we advise reaching out to the forecast providers for further information. The first time you use a forecast, consult the forecast provider to confirm that its skill is sufficient for your application.

2. **Forecasts evolve over time.** A forecast provides a prediction at a given point in time and is produced based on the information available at that time. The climate system can suddenly or slowly change and the forecast will change with it.

3. **Be aware of the spring predictability barrier.** This refers to the phenomenon where the skill of forecasts is reduced during the spring in the northern hemisphere. This is because during this time the climate system can change rapidly. After May, large climate patterns stabilize and the ability of forecasts to predict improves. This predictability barrier is an active area of scientific research.

4. **Different forecast providers can offer varying predictions.** The more convergence there is between forecasts from different providers, the more confidence there is in the predictions. When forecasts offer conflicting predictions, there is less confidence in individual predictions and more time is needed for more reliable patterns and convergence to emerge.

5. **Forecasts are probabilistic, meaning there is always a chance that something other than the most likely scenario occurs.** Confidence in the predictions is highest when probabilities are very high, the most likely scenario is much more likely than the second most likely scenario, the forecast period is close, or a strong ENSO is present. Sound decisions can be made based on forecasts but their uncertainty is the price we pay for obtaining information about events before they occur. The key to using forecasts effectively is to balance the trade-offs between lead time and the ability to act early while mitigating the risk that a less likely scenario occurs.

Common errors and misconceptions when using forecasts

The following are some of the most common errors and misconceptions that arise when using forecasts, which lead to misunderstandings and ineffective decision-making:

1. A high probability is not the same as certainty. A high probability for the most-likely scenario does not mean that the most-likely scenario will happen. It is important to keep in mind that any of the scenarios could happen.

2. When using seasonal forecast maps that show the likelihood of a scenario (such as the ECMWF map above), the darker colors usually refer to a higher probability for that scenario. A higher probability does not mean a higher amount of total rainfall.

3. Seasonal forecasts do not provide predictions that are granular enough to know what is or is not likely to happen in small geographic areas or during shorter periods of time such as days or weeks.

4. A 'below average season' can still receive heavy rain on certain days or light rain on most days because below average refers to the cumulative amount of rainfall over the entire period. Likewise, an 'above average season' can still mean that there are frequent dry days and prolonged dry spells.

5. Below or above average does not provide an indication of how far from average the total rainfall is expected to be.

6. Above average rainfall does not necessarily mean there is a higher likelihood of flooding.

Resources

- Watch the UK Met Office video series[5] 'Seasonal Forecasts Explained'.
- Learn more about and access IRI's seasonal precipitation forecasts.[6]
- Access ECMWF's seasonal precipitation forecasts.[7]
- Download and process seasonal forecasts using Python code in the Centre's tool AnticiPy.[8]
- Dive deeper into the science behind long-range forecasts.[9]

This guidance was developed by the OCHA Centre for Humanitarian Data[10] with input from Columbia University Climate School[11] International Research Institute for Climate and Society[12], and the United Kingdom Meteorological Office[13].

[5] https://www.youtube.com/watch?v=JdwxIiVqzbQ&list=LL&index=3&t=1s
[6] https://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/
[7] https://charts.ecmwf.int/products/seasonal_system5_standard_rain
[8] https://github.com/OCHA-DAP/ocha-anticipy
[9] https://www.worldclimateservice.com/2021/06/27/long-range-weather-forecast/
[10] https://centre.humdata.org/
[11] https://www.climate.columbia.edu/
[12] https://iri.columbia.edu/
[13] https://www.metoffice.gov.uk/