# ACCESSING AND USING CLIMATE DATA AND INFORMATION IN FRAGILE, DATA-POOR STATES

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### Accessing and Using Climate Data and Information in Fragile, Data-Poor States

### May 2015

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Cover photo credit: UN Photo/Fardin Waezi

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# ACRONYMS

| | |
|---|---|
| ACMAD | African Center of Meteorological Application for Development |
| APCC | Asia-Pacific Economic Cooperation (APEC) Climate Centre |
| ASEAN | Association of Southeast Asian Nations |
| AVHRR | Advanced Very High Resolution Radiometer |
| CHIRPS | Climate Hazards Group InfraRed Precipitation with Station |
| CPC | Climate Prediction Center |
| CMAP | CPC Merged Analysis of Precipitation |
| CMORPH | CPC MORPHing technique |
| ENACTS | Enhancing National Climate Services |
| EVI | Enhanced Vegetation Index |
| GPCP | Global Precipitation Climatology Project |
| GPC | Global Producing Centres |
| IPCC | Intergovernmental Panel on Climate Change |
| IISD | International Institute for Sustainable Development |
| IRI | International Research Institute for Climate and Society (Columbia University) |
| LST | land-surface temperature |
| MODIS | Moderate Resolution Imaging Spectroradiometer |
| NASA | National Aeronautics and Space Administration |
| NCAR | National Center for Atmospheric Research |
| NDVI | Normalized Difference Vegetation Index |
| NMS | national meteorological service |
| NOAA | National Oceanic and Atmospheric Administration |
| RCC | Regional Climate Centre |
| RCOF | Regional Climate Outlook Forum |
| RFE | African Rainfall Estimate |
| TRMM | Tropical Rainfall Measurement Mission |
| WMO | World Meteorological Organization |

# 1.0 INTRODUCTION

The vulnerability of populations in fragile states to weather and climate variability is typically much higher than in other countries. These countries, and their populations, face a higher exposure to climate change as a result of their geography. They are also over-reliant on climate-dependent sectors of the economy, particularly rain-fed agriculture, and their histories of violence, poverty and weak governance serve to undermine resilience and capacities to respond to climate risks (Brown & Crawford, 2009). As such, climate change poses a significant challenge to the transition of fragile states toward peace and stability. In order to address and reduce the risk that climate change and variability may pose to a fragile state's population and to peacebuilding progress, policy-makers and peacebuilding practitioners must be able to access, understand and use information on the local, national and global climate. However, it is within these fragile contexts that climate information is often the weakest, if it exists at all.

This report will provide peacebuilding practitioners with guidance for accessing and using climate data and information in fragile contexts. Section 2 describes some of the challenges to generating, accessing and understanding climate information in contexts of state fragility. Section 3 introduces the types of climate information relevant to national and international peacebuilding practitioners operating in fragile contexts, while also outlining key definitions and terms. Section 4 provides a review of relevant and accessible climate data, and describes how those data are generated. Section 5 addresses how climate information can be effectively used in a peacebuilding context, and Section 6 highlights some of the immediate priorities and sequencing needs for fragile states attempting to rebuild their national capacities to generate climate information. The report concludes in Section 7 with closing remarks.

Photo credit: UN Photo/Marco Dormino

## 2.0 CLIMATE INFORMATION IN FRAGILE STATES

Within fragile states, access to climate information is usually weak at best. In many fragile states, weather stations have been damaged during conflict or have ceased to function due to neglect or a lack of resources, and the technical staff required to operate them have fled or been killed in the conflict. Investments—both domestic and external—in such physical resources have dried up, and the training programs required to build up domestic capacities are often suspended due to the violence. Most of the countries at the top of the Fund for Peace's most recent Fragile States Index[1] have very few meteorological stations reporting to the global community (see Table 1, presented in contrast to the number of stations in Germany, the United States, and the United Kingdom).

The impacts of violence on data generation can be dramatic. In Afghanistan, the Taliban banned weather forecasting upon seizing power in 1996; for them, forecasting was considered a form of sorcery, so they fired the country's 600 or so meteorologists, destroyed the offices of the Afghan Meteorological Authority and burned all of the country's extensive climate data archives (Dokoupil, 2015). Similarly, Figure 1 illustrates the precipitous decline in data-gathering capacities in Rwanda following the 1994 genocide: from 100 reporting rain gauge stations in 1990, to nearly none in 1995.

The lack of availability of climate information affects not only government policy-makers and the resident populations, but is also a critical problem for national, regional and international aid agencies and other organizations that are actively engaged in or planning relief, peacebuilding, recovery and development activities in the fragile states. Designing and implementing peacebuilding interventions on the basis of poor or faulty climate information can threaten the sustainability and efficiency of these interventions, and can undermine their chances at success.

Peacebuilding practitioners working in contexts of state fragility will require climate data at a number of different timescales in order to design and implement appropriate and sustainable interventions. Information on current conditions and short-term forecasts can influence immediate response and relief operations, while longer-term forecasts and threat assessments can feed into preparedness planning, such as decisions on where to locate refugee camps or access water sources. Planning further into the future, peacebuilding practitioners can use climate change scenarios to help ensure that decisions made today—on water, infrastructure, livelihoods, and so on—are not undermined by long-term climate trends down the road (World Meteorological Organization [WMO], n.d.). Unfortunately for many practitioners, climate data may not be readily available or accessible.

**TABLE 1. NUMBER OF REPORTING WEATHER STATIONS FOR FRAGILE STATES. MOST FRAGILE STATES DO NOT HAVE CONTINUOUS REPORTING OVER THE MOST RECENT 30-YEAR PERIOD**

| Country | Number of stations | Station Density (stations/10,000 km$^2$) |
|---|---|---|
| Afghanistan | 45 | .689 |
| Chad | 15 | .116 |
| Central African Republic | 14 | .225 |
| Congo D.R. | 46 | .196 |
| Haiti | 4 | 1.441 |
| Pakistan | 36 | .447 |
| Somalia | 16 | .259 |
| South Sudan* | 4 | .065 |
| Sudan | 24 | .127 |
| Yemen | 25 | .473 |
| | | |
| Germany | 166 | 4.547 |
| United States | 3795 | 3.849 |
| United Kingdom | 161 | 6.608 |

* *University of Bergen* http://www.uib.no/en/news/70998/improving-weather-forecasting-east-africa

*Source: National Center for Atmospheric Research (NCAR) (2015).*

[1] Available at http://ffp.statesindex.org

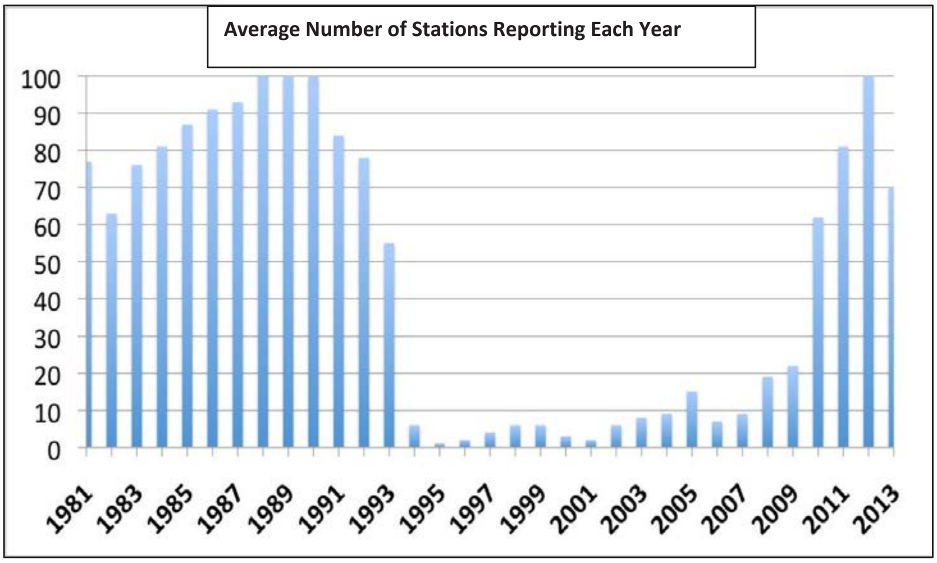



**FIGURE 1. NUMBER OF RAIN GAUGE STATIONS IN RWANDA FROM 1981 TO 2013, SHOWING THE REDUCTION IN NUMBER SOON AFTER THE GENOCIDE**

*Source: Rwanda Meteorological Agency plot by IRI*

Overcoming this lack of climate data is challenging, but not impossible. Even when there is no functioning or operational meteorological service provider in the fragile state in question, a range of potentially useful climate information is available from a variety of sources. Satellites and models may be able to fill some of these climate data gaps. Satellites have been transmitting climate and environmental data since 1979, and the development of online platforms to access such data, coupled with drastic increases in temporal and spatial resolution, have more recently led to their widespread, cost-effective availability.

The types of climate data available to peacebuilding practitioners will be the focus of the next section.

# 3.0 INTRODUCTION TO CLIMATE INFORMATION

Peacebuilding practitioners operating in fragile contexts often face what seems to be a dearth of reliable, locally generated information on climate variability and change. The information that a practitioner needs is not necessarily self-evident, and much of the information that is available may be difficult to access, understand, and use. However there are a number of climate and environmental datasets available to practitioners for understanding and managing climate-related risks in fragile contexts; they just have to know what they are looking for, where to access it, and how to interpret it.

This section introduces the basic concepts of climate data and the types of information that will be most useful to those operating in contexts of state fragility, before moving on in the next section to some of the resources available to the public for accessing local, national and regional climate data. Please see Box 1 for some key definitions.

The most useful types of climate data for peacebuilding practitioners are precipitation (rainfall, snow, hail), temperature, vegetation, wind and humidity, although there are others that may be better suited for a specific decision. For each type of climate data, practitioners may need to consider:

1. **Historical information:** Data on past conditions and trends can be used for mapping hazards, assessing trends, identifying relationships with historical impacts (such as disease outbreaks and food insecurity), and providing a reference against which to compare current and anticipated conditions. Historical data can also be used for identifying the seasonality of climate, which can, for example, be important information for understanding the monthly distribution shifts of disease-carrying vectors, or identifying likely cropping cycles.
2. **Current information**: Data on current and recent conditions can be useful for indicating whether potentially impactful weather and climate events, such as severe storms, have recently occurred, or are under way, such as droughts.
3. **Prospective information**: Forecasts, projections, and scenarios are useful for anticipating climate hazards, for planning humanitarian operations, and for longer-term recovery and development planning.

Inevitably, the proper use of such information is fraught with difficulties in fragile states, because of disruptions to the network of observations and operational climate services, as well as the lack of human resources in these contexts to generate and understand such information. But even in fragile states, climate information can be of value if its limitations are known and made explicit and climate-sensitive decisions are addressed appropriately.

## 3.1 HISTORICAL INFORMATION

Historical climate information consists of data records of past climate. In anticipating potential climate impacts, it is helpful to consider which timescale might be most relevant for the intended decision. Different timescales will allow users to place their climate analysis within the context of climate change, climate variability, and inter-annual variability.

### BOX 1: CLIMATE DATA DEFINITIONS

**Weather** is the state of the atmosphere as it is experienced at any given moment and location. It is usually defined in terms of temperature, humidity, precipitation (a general term that includes rain, snow, sleet and hail), and wind. Weather conditions tend to be organized into distinct features known as weather systems.

**Weather systems** are patterns of weather that can vary in duration and spatial extent. They can be very localized and short-lived, such as severe thunderstorms and tornadoes; they can also be larger-scale storms such as tropical cyclones or prolonged dry and sunny weather.

**Climate** is often described as the average weather conditions over a period of a few weeks or more at a specific location. In fact, the climate is best described not only by the average, but also by other measures describing climate variability, including the extremes. The long-term climate average for a specific location and time of the year is referred to as the climatology of the region and the period of interest. The climatology is typically calculated using data for a continuous 30-year period known as the Standard Climate Normal.

The **climate system** consists of separate components of the Earth that interact to influence the climate of a region. While the atmosphere is the most important component, oceans and lakes (the hydrosphere), the land surface (lithosphere and biosphere), and ice and snow cover (the cryosphere) also have important effects.

**Climate change**, according to the Intergovernmental Panel on Climate Change (IPCC), refers to "a change in the state of the climate that can be identified . . . by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC, 2013, p. 126).

**Climate variability** refers to "variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability)" (IPCC, 2013, p. 1451).

An example is shown in Figure 2, which indicates how rainfall in the Sahel region of Africa has changed over the last 100 years. From this figure, it is possible to gauge the following three components of climate variability:

1. *Inter-annual (red line)*: how climate can shift from year to year. Just as the weather today can differ considerably from that of yesterday, so the climate this year can be very different from last year. In fact, in nearly all places, the difference in rainfall from one year to the next is much larger than any changes that might be expected from climate change. The largest part of climate variability that will need to be managed by practitioners occurs at timescales of approximately 1 to 10 years—particularly when considering rainfall.

2. *Decadal (blue line)*: how climate can shift over periods of about 10 to 30 years. In some parts of the globe there may be clusters of wet or dry years, possibly resulting in prolonged periods of drought or flooding. For example, the drought that the Sahel experienced during the 1970s and 1980s is clearly noted by the dip in the blue line, while a recovery to more normal levels of rainfall is visible from the mid-1980s to around 2010. This component of climate variability can be very important in adaptation planning: it is possible that short-term climate trends (perhaps over the coming 5 to 10 years) could be inconsistent with the long-term trend. For example, it is possible for an area to experience a period of a few years of steady or slowly cooling temperatures even if a strong warming trend is anticipated over the next century. Similarly, strong recent warming trends may be much faster than trends that can be expected for the coming decades.

3. *Long-term trend (black line)*: how climate can shift over the long term (beyond 30 years). The most important contributor at this timescale is the impact from climate change. Here, the long-term trend shows a decrease of rainfall over 100 years. However long-term trends are much more evident in temperatures than in rainfall, and are likely to be less relevant to those working in fragile contexts.

## 3.2 CURRENT INFORMATION

Current climate information involves assessments of current and recent conditions and the comparison of these conditions to the historical climate. While current data are most accurate when attained from weather stations, access to such data can be challenging even in countries with fully functioning meteorological services. Satellite data are an alternative, and can be accessed online in near real-time from most locations, including from most fragile states.[2]

Monitoring products can be presented in a wide variety of formats, usually differing in timescale and in how the recent observations are compared with the historical background. Commonly used timescales include information for the previous 10 days, the previous month, or the previous three-month period. The value of current climate information is found in its ability to inform on what is happening now, but it should be noted that this could be done in different ways; the best way will depend on the decision that is being made. In addition to using the absolute value of the climate variable in question (for example, today's rainfall amount), it is often the case that the deviation of the current value from the historical record (referred to as the climatology), is equally if not more important.

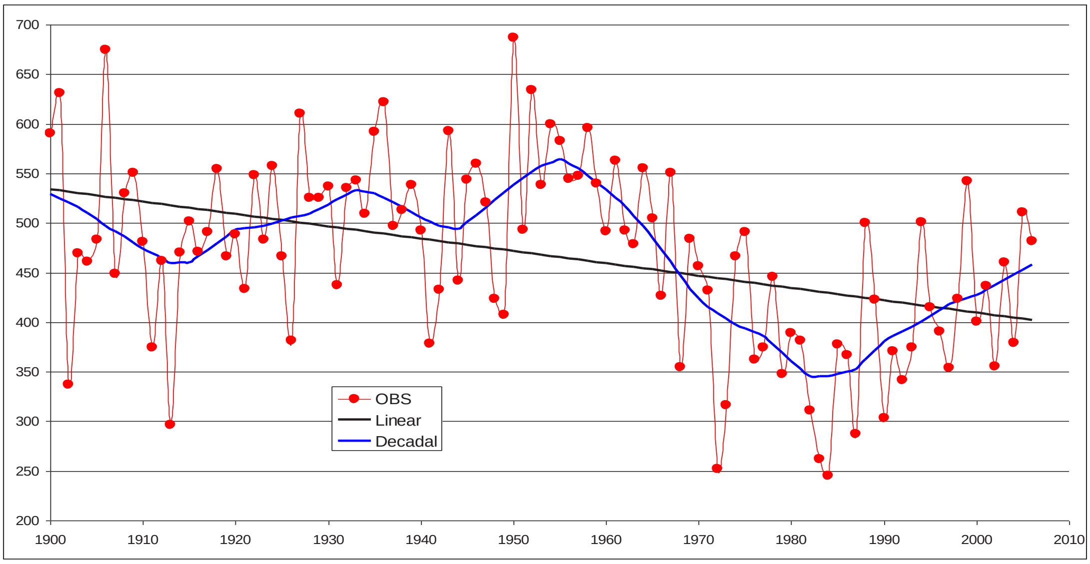



**FIGURE 2. OBSERVED ANNUAL RAINFALL IN THE SAHEL OVER 1900–2006**

*Source: Giannini, Saravanan, & Chang (2003).*

[2] Some climate and environmental information could be derived from satellite data provided free of charge by NOAA and NASA (See Annex 1 for links on how to access this data).

One of the most commonly used methods for assessing how the current climate deviates from "normal" is to create an anomaly by subtracting the historical average from the value in question. For example, the average rainfall for 21–31 January from 1980 to 2010 (say 135 mm) can be subtracted from the total for 21–31 January 2015 (say 200 mm) to create a positive "anomaly" of 65 mm (see Figure 3). It could then be determined that rainfall for 21–31 January 2015 was 65 mm above average. However climate anomalies are presented, monitoring is an important step in the identification of the early onset of severe conditions, especially of slow-onset hazards such as droughts. In combination with forecasting, monitoring can provide advanced warning of imminent hazardous conditions.

Figure 3 depicts rainfall anomalies over Africa. On the map, brown colouring indicates areas with below-average rainfall (negative anomalies) for the period January 21 to 31, 2015; and blue colouring indicates above-average rainfall (positive anomalies) for the same period. The darker the colour, the greater the anomaly. For more information on climate anomalies, please see Box 2.

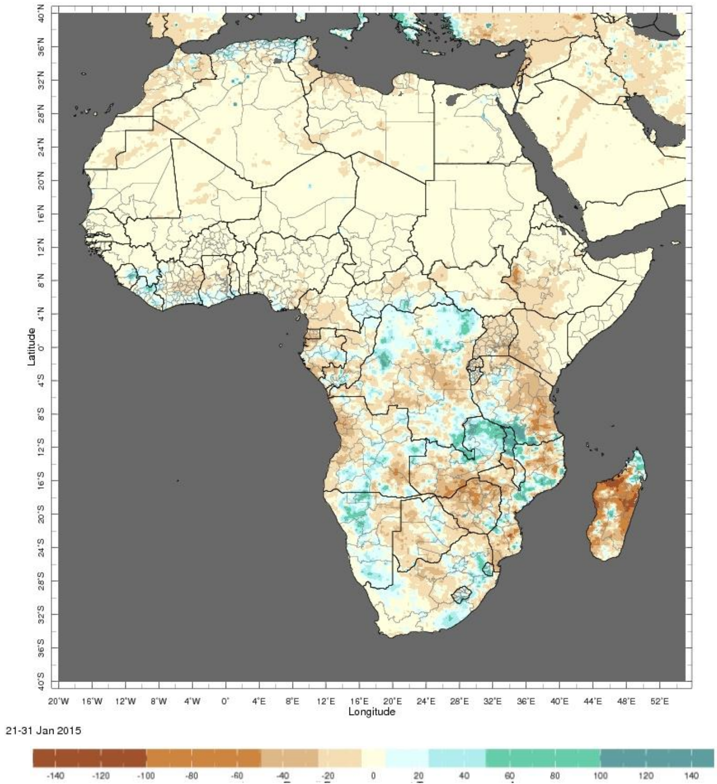



**FIGURE 3. RAINFALL ANOMALIES OVER AFRICA**

*Source: IRI Data Library (n.d.).*[3]

## 3.3 PROSPECTIVE INFORMATION

Prospective climate information includes predictions and projections of future climate and weather conditions and trends. **Forecasts, predictions, outlooks, projections** and **scenarios** are all statements about the expected or possible weather or climate conditions in the future. For each of these statements there is an associated:

- ***Timescale***: The length of period for which the forecast applies. For example, if the forecast is for June–August 2015, the timescale is three months.
- **Lead time**: The time between when the forecast is issued and the beginning of the period for which the forecast is made, regardless of the timescale. For example, a one-month forecast issued on 1 May for June has a lead time of one month, as does a forecast for June–August if issued on the same date.
- **Target period**: The actual period for which the forecast applies, and is a function of the lead time and the timescale. The target period can be specified by specific times and dates (for example, a forecast for June–August 2015). Typical timescales and lead times of different types of prospective information are given in Table 2.

**BOX 2: CLIMATE ANOMALIES**

*Climate anomalies*—the difference in climate between two time periods—can be expressed in different ways.

*Percent of average*: Divide the observed rainfall by the average rainfall, and then express the result as a percentage. For example, if 200 mm of rainfall is received in a given period when, on average, rainfall is 135 mm, the region received almost 50 per cent more rain than typically falls during that time of year. When compared to anomalies, percentages may be easier to understand, but they can still be misleading. For example, in months or seasons that are typically dry, even a small amount of extra rainfall can translate into a large percentage change:[4] an area that receives 15 mm of rain, but typically receives only 5 mm of rain, would be receiving 300 per cent of its average rainfall, but 15 mm is not much rain by almost any standards, and is unlikely to have major impacts. In contrast, if an area that typically receives 500 mm instead receives 300 per cent of its average rainfall, the results are likely to be devastating.

*Categories* are defined in terms of their historical frequency rather than in comparison to the average. The categories are defined by thresholds, which set upper and lower limits to the category. The thresholds may be defined in terms of the proportion of years in the historical record that had less rain, or colder temperatures. For example, in seasonal forecasting three categories are commonly defined so that each category typically occurs once in every three years. In this case, "below-normal" is defined so that historically one third of years had less rainfall than the upper limit for this category.

[3] Available at http://iridl.ldeo.columbia.edu/maproom/Health/Regional/Africa/Malaria/RED/index.html

[4] This percentage option is not applicable for temperature.

### TABLE 2. TYPICAL TIMESCALES AND LEAD TIMES FOR DIFFERENT "FORECAST TYPE" (USED GENERICALLY FOR ALL TYPES OF PROSPECTIVE CLIMATE INFORMATION)

| Forecast type | Timescale | Lead time |
|---|---|---|
| Intra-seasonal | <3 months | <3 months |
| Seasonal | 3 or 4 months | <9 months |
| Annual | 1 year | <1 month |
| Multi-year | <5 years | <1 year |
| Decadal | <10 years | <1 year |
| Short-range | <30 years | <1 year |
| Climate change | 10 years | >30 years |

*Predictability* is the extent to which the weather and climate can be predicted beyond a minimum level of accuracy and precision. In general, the predictability of the weather and climate decreases as the amount of advanced notice ("lead time") increases. However, there are also important differences in predictability from place to place and at different times of the year. Taking seasonal forecasts as an example, predictability is generally higher in the tropics than in the mid-latitudes (Figure 4), whereas for weather forecasts the opposite is true—weather forecasts are generally more accurate in the mid-latitudes than in the tropics.

**Forecasts** and **predictions**[5] are specific statements about the expected conditions either for the immediate future, or for lead times of up to about one year. A weather forecast provides information for a specific weather system or condition at a specific place and time. In contrast, a climate forecast indicates only the general weather conditions over the target period. For example, a seasonal rainfall forecast (sometimes called an **outlook**) typically describes the total rainfall over the next three or four months, but does not indicate when the rain might fall within that season.

Similarly, while weather forecasts are usually location-specific, most climate forecasts are represented as area averages, with areas typically of the order of 10,000 $km^2$ or larger. Nevertheless, many national meteorological services do produce seasonal forecasts that are location-specific.

Forecasts are used as the basis for issuing alerts for immediate or imminent weather conditions, information that can be of great value in humanitarian contexts. The specifications for issuing formal alerts for hazardous climate conditions are still being formulated by the World Meteorological Organization (WMO), although many countries and regions have developed their own formal drought alert systems. The following categories of alerts are used for severe weather events and for droughts:

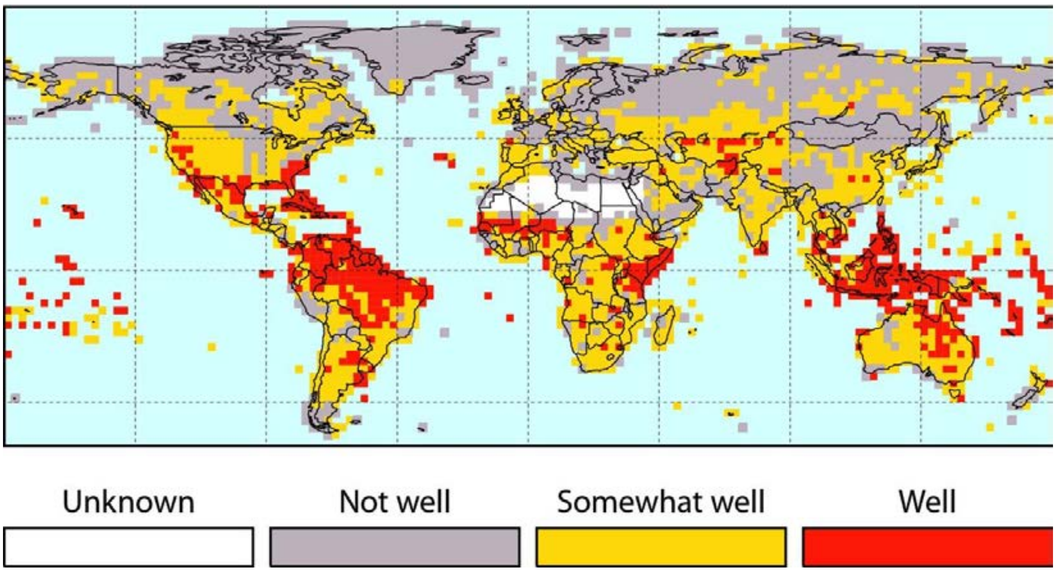



FIGURE 4. ESTIMATES OF HOW PREDICTABLE THE CLIMATE IS AT SEASONAL TIMESCALES.
THE ESTIMATES ARE BASED UPON HOW WELL THE IRI'S SEASONAL CLIMATE FORECASTS HAVE PREDICTED THREE-MONTH RAINFALL TOTALS.

*Source: Hellmuth, Mason, Vaughan, van Aalst & Choularton (2011).*

[5] Some scientists prefer to use "prediction" to refer to the output of a model, and "forecast" for the interpreted output that is actually released to the public. However, there is no consistent distinction between the two terms.

- **Advisories** are issued to inform the public of a weather event that may cause inconvenience, but not serious threat to life or damage to property. These are issued when hazardous conditions are imminent or occurring.
- **Watches** are used to inform the public of potentially severe conditions that may have substantial impacts, although the exact time, location and intensity may not yet be determined. They are meant to create awareness, which is very helpful should the threat develop.
- **Warnings** are issued when the threat of severe weather conditions is imminent. Warnings should give a specific time, intensity and spatial range of an event. They are meant to incite a sense of imminent danger and to promote action.

Projections are a longer-term concept; they are statements or model outputs far enough into the future that it is not possible to give an accurate quantitative estimate of the uncertainty in the outcome. Climate "projections" apply to timescales on the order of a few years to about one or two decades. Decadal projections are still largely an area of research.

Finally, climate scenarios (Box 3) are possible weather or climate conditions that might be expected to occur if corresponding assumptions about greenhouse and other climate change-related gases are met. Climate scenarios apply to multi-decadal (including climate change) timescales, and so are beyond the planning horizons of most decision makers, although they can be useful for advocacy around questions of mitigation against climate change.

**How Are Predictions Made?** Weather forecasts are made by modelling how the current weather is expected to evolve given our knowledge of the physics of how the atmosphere behaves. Using a wide range of observations, including from weather stations, balloons, satellites and airplanes, an estimate of the current state of the atmosphere over the whole globe is made. However, without perfect models and exact estimates of the current weather, it is impossible to accurately predict individual weather systems more than about seven days into the future. Even beyond about two or three days errors can be large, and it is advisable to generate a set, or ensemble, of forecasts to see how sensitive the forecast is to the initial errors.

When forecasting beyond about two weeks it becomes important to consider how other parts of the climate system might affect future weather conditions. In particular, when predicting the next few months, sea-surface temperatures can have an important effect. The strongest influence is from El Niño and La Niña,[6] although sea-surface temperatures in other areas can also be important. These effects can be predicted in different ways. For example, in a scenario where El Niño has developed, a peacebuilding practitioner will want to know if it will have any effect on rainfall. They can ask the following questions:

- In the past, has rainfall been unusual when El Niño conditions have occurred? This approach requires good historical data, but is relatively easy to compute. These statistical models are in fairly wide use, and are an important input to some of the Regional Climate Outlook Forums (see below).

### BOX 3: IPCC REPORTS AND CLIMATE CHANGE SCENARIOS

The IPCC[7] (see Box 2) is an intergovernmental scientific body that provides comprehensive assessments of current scientific, technical and socioeconomic information worldwide about the risk of climate change caused by human activity, its potential environmental and socioeconomic consequences, and possible options for adapting to these consequences or mitigating the effects. It publishes a variety of periodic and occasional reports that review the scientific literature in order to provide technical guidance to the United Nations Framework Convention on Climate Change. IPCC reports include:

**Assessment Reports**: Comprehensive reviews of the latest scientific evidence for climate change, projections for the future, assessments of impacts of such changes, and options for mitigation and adaptation. They are published every five to seven years; the latest report (2013) is the Fifth Assessment.[8]

**Special Reports**: Occasional publications on specific topics, as requested by governments. Examples of important special reports are:

- *Special Report on Emissions Scenarios*,[9] published in 2000, which defines scenarios of future emissions of greenhouses gases and sulphur dioxide. Four families of emissions are defined based on assumptions about economic growth, population expansion, technological development, and international collaboration:

| Scenario | Economy | Population | Development | Collaboration |
|---|---|---|---|---|
| A1 | global, rapid | peaks 2050 | Rapid | strong |
| A2 | regional, rapid | continuous | Rapid | weak |
| B1 | ecologically friendly, rapid | peaks 2050 | resource-efficient | strong |
| B2 | intermediate | slow | Slow | weak |

- *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*[10], published in 2012, which reviews the evidence for changes in extreme weather and climate events, and provides guidance on how to manage expected future changes in extremes.

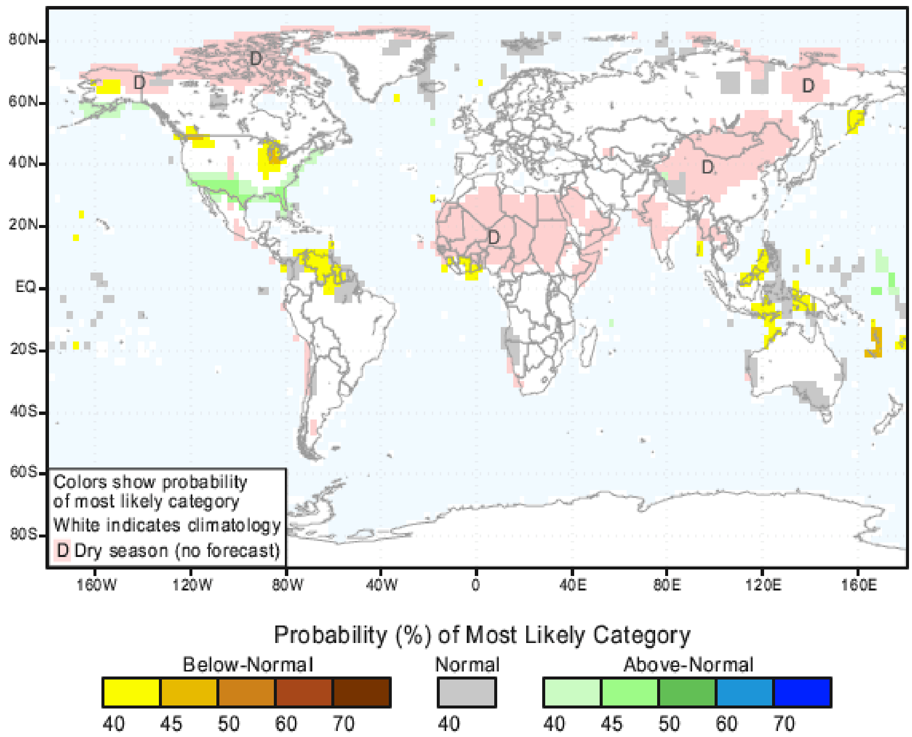
[6] El Niño refers to an unusually hot central and eastern equatorial Pacific Ocean; La Niña refers to an unusually cold central and eastern equatorial Pacific Ocean.
[7] http://www.ipcc.ch/
[8] https://www.ipcc.ch/report/ar5/
[9] https://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=0
[10] https://www.ipcc.ch/report/srex/

- How might *this* El Niño affect rainfall? A large ensemble of forecasts are made for the next few months using models that are very similar to those used for forecasting the weather. If many of these forecasts indicate unusual rainfall, it suggests that this El Niño may have an important effect on rainfall. These models are run by some of the larger forecasting centres around the world, a few of which make the outputs available to the general public (see below).

Weather and climate forecasts typically are issued in one of three formats:

- A specific value: These so-called **deterministic** forecasts show only one possible outcome with no corresponding information about possible errors in the forecast. For example, a forecast for 10 mm of rainfall in Nairobi on 5 January 2015. Climate forecasts are not typically presented deterministically because of the large uncertainties involved.
- A range of values: The range or **interval** indicates an explicit upper and lower limit between which the actual value is expected to occur. For example, the IPCC concludes that the average surface temperature of the Earth is likely to increase by between 0.3 and 4.8°C by the end of the 21st century (and across a range of emissions scenarios), relative to 1986–2005 (IPCC 2013). Prediction intervals are often displayed as plumes.
- One or more probabilities: These **probabilistic** forecasts show the probability or probabilities of one or more discrete outcomes or categories occurring (see Box 2). Probabilistic formats are commonly used in seasonal forecasts (see Figure 5), including the consensus products from Regional Climate Outlook Forums, where it is standard to define three equally probable categories ("below-normal", "normal", and "above-normal").[11]

In general, there is a significant gap in many countries between the timescales of routinely available weather and climate information. In most cases weather forecast information is available only for the next few days at best, while the most immediate climate forecasts are likely to be for the coming three months. Thus, intra-seasonal information is generally not easily accessible. However, many centres do issue forecasts for the coming month, or at least generate them to produce the seasonal forecasts. Decadal projections are still largely a new area of research, and are not widely available. The Met Office in the United Kingdom is producing experimental decadal predictions, but much work still needs to be done to improve them and to identify whether they currently provide any usable information. Longer-term scenarios for climate change, profiled in Box 3 above, are available through the IPCC.




**IRI SEASONAL FORECAST AS AN EXAMPLE OF A PROBABILISTIC FORECAST. THE MAP SHOWS, AT EACH GRID CELL, THE PROBABILITY OF ONLY THE MOST LIKELY OUTCOME.**

*Source: IRI (2014)*

[11] Five categories (e.g., UK Met Office), and two categories (e.g., Australian Bureau of Meteorology) are also used but are less common.

# 4.0 ACCESSING CLIMATE INFORMATION

Climate information is generated by a number of global, regional and national stakeholders, some of whose efforts are profiled below. Whether the public can access the climate data presented in the previous section will depend on the policies of the stakeholders involved in funding, producing, processing and storing the data.

It is important to note that while many datasets are available for free online, access may be limited by the national policies governing data sharing. Furthermore, in many areas where data can be accessed freely and the desired dataset is available for free, online connectivity and network strength may be a significant hindrance for the user. Moreover, while some data can be easily processed in simple spreadsheets, many calculations and analyses may require the use of more complex software and require a high user skill level, which may also affect the usability of data in fragile states. Nevertheless, there are a number of accessible databases providing data on rainfall, temperature and vegetation cover, which are outlined below and in Annex 2 of this report.

## 4.1 GENERATION OF CLIMATE DATA

The generation of climate data at the local and national levels is typically the responsibility of a country's national meteorological service (NMS). NMS offices are mandated to continuously generate and disseminate weather and climate data from across a country's territory, as well as develop and issue forecasts and warnings. Generating these data requires functioning, well-maintained and well-distributed physical infrastructure (such as weather stations and rainfall gauges), as well as capacities within the NMS for analyzing climate data and using it to model future conditions. Information about current and recent conditions is best obtained using automatic weather stations that can transmit measurements to the NMS in real time; data from manual stations can often take weeks or even months to reach the NMS office. Once generated, climate information should be publicly disseminated to ensure that it is integrated into responses for affected populations and sectors (including health, transport, agriculture and industry). The knock-on effects of strong climate data and analysis capabilities will include improved management of water resources and disaster risks.

The government is not the sole source of local and national climate data and information in a country. The information generated by an NMS can be complemented by additional data from universities, or even the private sector; companies working in the country may keep their own climate records for business purposes. Likewise, at the local level, civil society organizations such as farmers associations and conservation organizations may keep records of historical temperatures and rainfall measures, information which may be useful to peacebuilding practitioners in the absence of government-generated data. Local leaders themselves could also be a viable source of qualitative historical data; practitioners can get at least a narrative of past climate trends and current changes from those who have lived in their area of operations for an extended period. In all of these cases, however, the data may not have been collected according to international standards and so caution should be exercised, especially when looking for long-term trends and changes.

The WMO has begun to establish a climate forecasting infrastructure, in which a number of global, regional and national centres run climate prediction systems that adhere to a fixed production cycle, generate a standard set of prediction products, and routinely exchange and disseminate predictions and related information in an operational environment similar to that in place for weather forecasting, albeit on longer production cycles. Currently this infrastructure applies only to seasonal forecasts, but there are plans to extend the system to cover all other timescales for which climate prediction information can be supplied. The structure for seasonal timescales involves a network of information providers at global, regional and national scales. These elements are discussed below.

There is a designated network of Global Producing Centres (GPCs) for Long-Range Forecasts that make and distribute global seasonal forecasts. The current GPCs, designated by the WMO, are shown in Figure 6.

At a regional level, the WMO is encouraging the establishment of a number of **Regional Climate Centres** (RCCs)[12] that will generate and deliver more regionally focused, high-resolution predictions, information and products, including regional climate watch bulletins. The aim is for RCCs to assist WMO members in a given region or a defined sub-region to deliver better climate services and products, and to strengthen their capacities to meet national climate information needs. RCCs are also encouraged to contribute to climate change projections, non-operational data services, capacity building, and research and development activities.[13]

WMO has also, since 1997, facilitated the establishment of the **Regional Climate Outlook Forums** (RCOF) as multistakeholder mechanisms engaging national, regional and international climate experts, sectoral practitioners and policy-makers. RCOFs seek to reach agreement among participants on current and expected seasonal conditions and to deliver a range of regional climate monitoring and outlook products. Using a

[12] http://www.wmo.int/pages/prog/wcp/wcasp/RCCs.html

[13] The establishment of RCCs has lagged behind that of GPCs, and so there are currently only a few RCCs already designated, and several in various stages of the development process. However, the WMO is actively working to ensure that all regions are served by one or more RCCs or RCC networks, and a number of demonstration and pilot initiatives have formally been launched. For the latest status on RCCs see the WMO's RCC Implementation Overview http://www.wmo.int/pages/prog/wcp/wcasp/


**FIGURE 6. CURRENT DISTRIBUTION OF GLOBAL PRODUCING CENTRES FOR LONG-RANGE FORECASTS.**

*Source: WMO*[14]

predominantly consensus-based approach, the RCOFs have an overarching responsibility to produce and disseminate an assessment of the regional climate for the upcoming season. The forums bring together national, regional, and international climate experts to produce regional climate outlooks based on input from NMSs, regional institutions, RCCs, and GPCs. They also facilitate enhanced feedback from the users to climate scientists, and catalyse the development of user-specific products. They review impediments to the use of climate information, share successful lessons regarding applications of past products, and enhance sector-specific applications. As such, they can help respond to the important challenge of understanding and using climate data, as well as contribute to building the much-needed technical skills in fragile countries.

There are other international climate centres that cooperate closely with WMO structures and programs, but not as formally as GPCs or RCCs. These include the IRI[15] and the APEC Climate Centre (APCC).[16] Such centres carry out similar functions to those of WMO GPCs and RCCs and deliver a wide range of climate products and services online; for example, IRI provides seasonal forecasts every month for the next three to six months on a global and continental scale (see Annex 2 and 3 for further details on global and regional sources of climate data).

## 4.2 ACCESSING BY SOURCE OF DATA

Climate data and information—whether station- or satellite-generated—can increasingly be accessed freely online; for a list of online resources, please see Annex 1. Practitioners without online access, or who require more spatially-specific data, may be able to obtain them in person from the country's NMS office. However, this is dependent on both national access-to-information laws and on whether reliable data has been generated and archived.

Station data can typically be obtained from a country's national meteorological service. Depending on the quality control processes performed by the NMS, these data may be of high or low quality. However, station data are not always available free of charge. Some of the station data provided by the NMS is freely available through the Global Telecommunication System. These data can also be accessed from outside the country (e.g., via the IRI Data Library[17]).

To address the spatial and temporal gaps in climate data as well as the lack of quality-controlled data, approaches are being developed based on the idea of "merging" station data with satellite and modelled data. Some of these methods are taking advantage of working with climate scientists and meteorologists in both fragile and more stable states to develop a platform in which the now-quality-improved data can be accessed, manipulated and integrated into the programs of national-level stakeholders and international partners, from inside the country and abroad.

Satellites provide raw data that are continuously archived. In order for decision maker to access, visualize or manipulate these data, an interface is necessary. In many cases the raw data may be free, but not all interfaces allow free access to their archived data. It should be noted that satellites cannot measure rainfall; correct measurement of rainfall can only be made through rain gauges. Satellite rainfall estimates try to convert radiation measurements into precipitation information.

Sources for satellite-generated climate data are varied, and a selection is provided below, with further details—including

[14] http://www.wmo.int/pages/prog/wcp/wcasp/clips/producers_forecasts.html RCCImplementationOverview.html
[15] http://iri.columbia.edu
[16] http://www.apcc21.net/en/
[17] http://iridl.ldeo.columbia.edu

web addresses—provided in Annex 1. The following are likely to be the most useful of the freely available satellite-based estimates of precipitation:

- *Global Precipitation Climatology Project (GPCP)* combines satellite and station data. The monthly data extend from 1979 onwards, while the daily product is from 1996 to present. This product has a low spatial resolution, but is of interest when creating long time series to understand trends in past precipitation.[18]
- *Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP)* combines satellite and station data.[19] This product is very similar to the GPCP but has some differences due to different algorithms used to estimate the precipitation.
- *CPC MORPHing technique (CMORPH)* provides global precipitation estimates at very high spatial and temporal resolution.[20] This product is suitable for real-time monitoring of rainfall, provided a long history is not required, as data are only available from December 2002.
- *Tropical Rainfall Measurement Mission (TRMM)* provides estimates of precipitation in the tropics. Monthly aggregates improve the quality of the data. They are available from January 1998, but there is a delay of about a month or more in updating the data. The product is of good quality if high spatial detail is required and real-time information is not critical.[21]
- *African Rainfall Estimate (RFE)* combines satellite and station data specifically for Africa. The data are available from January 2001 and is useful for high spatial resolution but not for daily observations.[22]
- *The Enhancing National Climate Services (ENACTS)* program combines all available rain gauge data from the National Meteorology Agencies of Ethiopia, Tanzania, Madagascar, and Rwanda with satellite data for the last 30 years with high spatial resolution.[23] Similarly, the *Climate Hazards Group InfraRed Precipitation with Station* (CHIRPS) data are produced by the University of California Santa Barbara using the same technique developed to create the ENACTS data but using fewer rain gauges.[24] However, CHIRPS is produced at a higher spatial resolution than ENACTS.

For temperature-based data, the following dataset is recommended:

- *Land-Surface Temperature (LST)* provides land-surface temperature estimates for Africa and South America. The data are available from July 2002 for Africa, and from March 2000 for South America. Separate estimates for daytime and nighttime temperatures are available. Maximum and minimum air temperature estimates can be derived from the land-surface temperatures.

Finally, practitioners can access data on vegetation cover through the following sources:

- *Global Normalized Difference Vegetation Index (NDVI)* is available from 1981 to 2006. The dataset has been shown to be valid in representing vegetation patterns in certain regions (but not everywhere) and should be used with caution.
- *TERRA-MODIS Normalized Difference Vegetation Index (NDVI)* and Enhanced Vegetation Index (EVI) are available for 16-day periods from April 2000 at 250 m resolution. The NDVI is an updated extension to the Global NDVI. The EVI is another index used to estimate vegetation which can complement the NDVI.

Despite progress in making satellite data available, challenges remain: in fragile states, there is often a lack of technical capacities to interpret climate data and to communicate it—in an appropriate format—to potential users, including peacebuilding practitioners. There is a need to build up these capacities in fragile states, as well as for data providers to think about how to deliver their information in a format that is conducive to interpretation and understanding by a non-technical audience of decision makers. Using climate data will be the focus of the next section.

Photo credit: UN Photo/Albert González Farran

[18] GPCP provides global monthly 2.5° and daily 1° rainfall estimates.
[19] CMAP provides products at a spatial resolution of 2.5° with five-day and monthly aggregations since 1979.
[20] CMORPH provides precipitation analyses at 8 km spatial resolution and 30 min temporal resolution.
[21] TRMM provides precipitation data at 0.25°.
[22] RFE has an 11km spatial resolution and a 10-day temporal resolution.
[23] ENACTS uses a spatial resolution of 10 km and 10-day and monthly products are available for the last 30 years. They can be accessed via the websites listed in Annex I. The approach is now being considered for expansion into other countries in Kenya, Uganda, and West Africa.
[24] The CHIRPS data cover the African continent at 5 km on daily basis for the last 30 years, and at 5 km every 10 days and on monthly basis for the entire globe. The data are available via the IRI Data Library at: http://iridl.ldeo.columbia.edu/SOURCES/.UCSB/.CHIRPS/.v1p8/.

# 5.0 USING CLIMATE DATA

Climate and environmental information is most useful if it can be integrated into the decision-making process. To be most effective, peacebuilding practitioners should use climate data at an appropriate timescale to their needs. Immediate relief and response operations from peacebuilding practitioners—interventions such as emergency food distribution and health care provision—can draw on weather-based data to support their decision making: watches, warnings and alerts, forecasts, and threat assessments covering current conditions and extending out a few weeks will be most helpful in ensuring that the negative impacts of weather conditions on on-going operations are minimized.

For medium-term preparedness planning, practitioners should start to look beyond current weather conditions to the data on climate variability, specifically the climate variability outlook and predictions for the coming months, seasons and years. Integrating these medium-term climate considerations into decision making on, for example, the location of camps for displaced populations or programs supporting the establishment of natural resource-based livelihoods, will help to minimize the chances that these decisions are undermined by climatic forces over time, and will increase their resilience. A climate-induced collapse in local livelihoods could, for example, have a detrimental effect on peacebuilding, whereas the integration of climate resilience into livelihood strategies in part through the use of climate data—a focus on using drought-resistant crops in agricultural livelihoods in an area expected to become hotter and drier, for example—could reduce the vulnerability of local communities to longer-term climate trends.

As peacebuilding practitioners transition from immediate humanitarian responses to longer-term development programming, including the rehabilitation and restoration of damaged or destroyed infrastructure, there is a need to integrate climate risks into their work to ensure that it is resilient to longer-term climatic forces. This will require consideration of yearly and decadal climate change projects, as well as longer-term climate change scenarios. The uncertainty associated with these long-term forecasts will increase with time, but it is nevertheless important to consider possible climate futures when making decisions with long-term implications.

The relationship between climate data and humanitarian planning horizons is illustrated in Figure 7 below.

Integrating climate data into decision-making processes in fragile states will require an understanding of the operating context and of the ways in which weather and climate interact with livelihoods and conflict dynamics. This should include an analysis of the causes, effects, actors and dynamics that contribute to the country's fragility, and an identification of how current weather and forecasted climate trends—knowledge based on available climate data—may influence or exacerbate the drivers of fragility today and in the future. Integrating climate information into conflict analyses will help practitioners form a better understanding of the current and potential conflict dynamics in their operating contexts, and to respond accordingly.

### EXAMPLE OF CLIMATE ANALYSIS WITH MALARIA DATA

IRI developed a climate risk map in Eritrea that illustrates the relationship between climate and malaria. From the risk analysis, the researchers could identify the incidence of malaria across the country, and they linked regional variations to climatic factors, such as regional gradients of temperature and precipitation. This demonstrated link between climate and health risk then allows for a host of possible response measures on different time scales, including: a review of climate forecasts to anticipate possible outbreaks; the establishment of an early warning system to monitor climate factors that influence the development of mosquitos, including precipitation and temperature; and an assessment of existing vulnerabilities to the disease among the local population. The use of historical and medium-term climate data allows for the development of a much more effective strategy to respond to possible outbreaks.

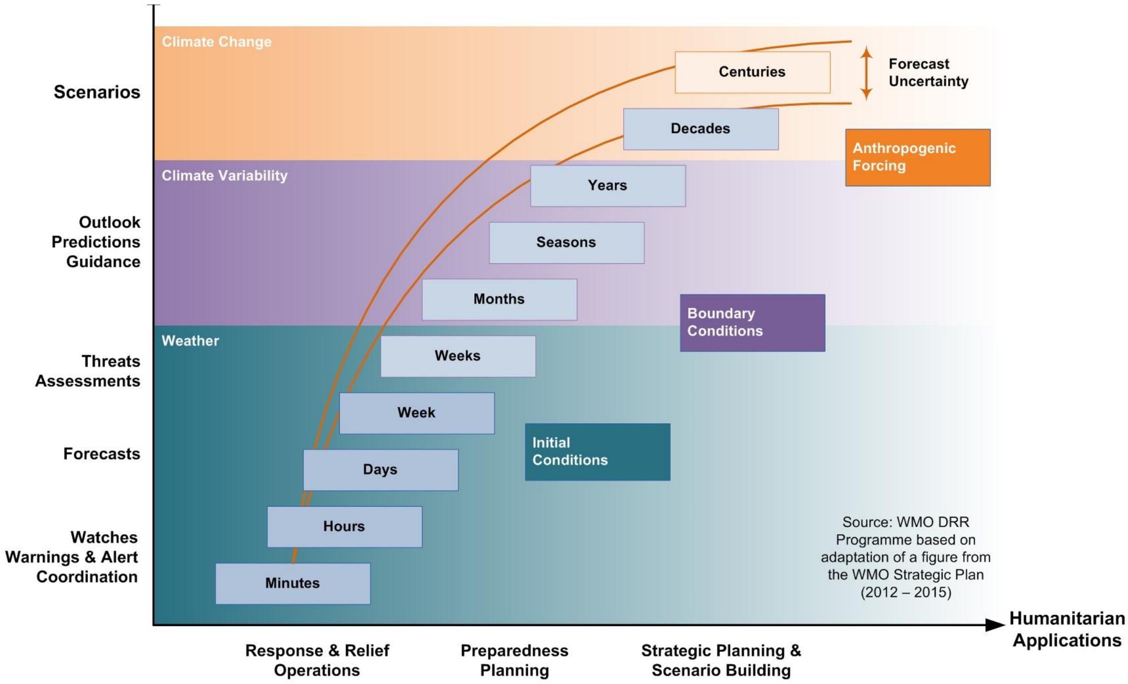



**FIGURE 7. SCHEMATIC DIAGRAM SHOWING THE RELATIONSHIP OF CLIMATE DATA PRODUCTS, FROM WEATHER TO CLIMATE TIMEFRAMES, AND HUMANITARIAN APPLICATIONS, FROM RESPONSE AND RELIEF OPERATIONS TO STRATEGIC PLANNING AND SCENARIO BUILDING**

*Source: Adapted from WMO (n.d.).*

Photo credit: UN Photo/Albert González Farran

# 6.0 PRIORITIES FOR FRAGILE STATES

In fragile states, the greatest challenges will be to access climate information from the National Meteorology Services. Weather stations are often damaged during conflict or non-existent due to weak governance and investment; human resources and research capacities are depleted due to the breakdown of institutions and violence; and investments from outside are minimal due to high risks. Some climatic and environmental information can be accessed through remotely sensed products and international agencies, but the challenge will remain on how to access reliable data generated in-country. Rebuilding a fragile state's NMS, including its network of weather stations, is crucial to supporting development, disaster risk management and early warning systems.

There is a need for donors, international aid agencies and national peacebuilding and development organizations to work with the NMS office to rebuild the climate station network, to gather and restore what historical data is available, and to invest in capacity building to ensure that the technical skills required to generate, understand and use climate data are in place. In Haiti, a number of technical staff perished in the 2010 earthquake, the NMS offices were destroyed, and the already limited number of weather stations prior to the earthquake were extensively damaged. After years of instability and then the earthquake, the WMO identified climate data priorities as: the need to replace technical capacities at the NMS; the provision of a safe work environment for the NMS; and strengthening the NMS's observation, forecasting and information dissemination capacities (WMO, 2010).

In Sierra Leone, much of the country's meteorological infrastructure was destroyed during the lengthy civil war. During the peacebuilding phase, the United Nations Development Programme and the United Kingdom's Met Office partnered to help rebuild the national network and to establish the Sierra Leone Met Department as a genuine weather forecasting service provider for the national government (Met Office, 2012). The process undertaken by the three partners to rebuild Sierra Leone's national climate station network is broadly applicable to other fragile states facing a similar circumstances (Met Office, 2012):

1. Site selection: Using extensive knowledge of observation networks and WMO guidelines, identify the most appropriate sites of climate stations and agree on how these sites can be best prepared for weather and climate monitoring.
2. System design and procurement: The stations will then have to be designed for the local context and procured. Automatic weather stations are ideal.
3. Training: A comprehensive capacity-building program will have to be offered to the technical staff of the NMS in the operation and maintenance of the new station network.
4. Installation: For Sierra Leone, this involved the initial installation of new stations as part of the training program, followed by the supervised installation of new stations by national government staff.

Once the country has restored its ability to generate and analyze weather and climate data, this information will have to be disseminated to the public so that it can be integrated into planning and decision-making processes. Increasingly, this is done online, which will require the design and support of a user-friendly website capable of hosting the information. There may also be a need to digitize historical information, should it exist, to ensure that historical information is accessible to a broad audience. Online efforts should be complemented with hard copies of climate information, accessible at the NMS office for those unable to access the data online.

Photo credit: UN Photo/Albert González Farran

## 7.0 CONCLUSIONS

Understanding and interpreting data and information on climate change is not typically within the remit of peacebuilding practitioners working in contexts of state fragility. For them, immediate humanitarian needs often understandably trump concerns about long-term environmental change. There is an increasing need, however, for these practitioners to integrate climate risks and considerations into their work; extreme weather events are becoming more frequent in many parts of the globe, while decisions made in the peacebuilding phase—decisions pertaining to the access to, control of, and use of climate-related resources like freshwater, productive land, and forests—can have both immediate and long-term impacts on livelihoods and well-being. Integrating climate risks and considerations into peacebuilding decisions, approaches, programs and projects can greatly increase their chances of long-term, sustainable success. But to do so requires an understanding of how the local and national climate is changing, and this understanding must be built upon consistent, high-quality climate data.

Unfortunately for many practitioners operating in fragile states, such data are often not readily available. In many of these countries, weather stations have been damaged during conflict or have ceased to function. National meteorological services can be understaffed or non-operational. When local data exist, they are often inaccessible or inconsistent. In addition, peacebuilding practitioners themselves are often not trained to interpret and use climate data; even when climate data are accessible to a fragile state audience, practitioners may not know how to usefully integrate them into their decision-making processes.

This report has tried to bridge this gap by providing guidance for peacebuilding practitioners on how to access and use climate data and information in fragile contexts. It has introduced basic concepts relating to climate science, and has identified a number of free, accessible climate data sources that offer information on climate change and variability in fragile states. There are advantages and disadvantages to these different types of dataset, and understanding their strengths and limitations is an important step to using them effectively. Practitioners are advised to work with climate experts when possible on the use and interpretation of data; there are no simple rules to facilitate the proper interpretation of the climate data.

In the absence of a functioning national meteorological service and a corresponding dearth of locally generated climate data, there are considerable challenges to integrating climate information into decision making. But it is not impossible: a range of potentially useful climate information is available from a variety of sources. Integrating this information into peacebuilding programming can help practitioners operating in fragile states ensure that their interventions are successful and sustainable.

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# ANNEX 1: ACCESSING CLIMATE DATA

| Type of data | Source | Web address | How to use the data |
|---|---|---|---|
| Ground station | International Research Institute on Climate and Society (IRI) | http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCDC/.GHCN/.v2beta/ | |
| | | Precipitation data | |
| Satellite | Rainfall Estimated from Food Early Warning Systems Network through IRI Data Library | http://iridl.ldeo.columbia.edu/maproom/Health/Regional/Africa/Malaria/MEWS/index.html | It provides data as well as an analysis tool which allows its users to analyze time-series anomalies and download the results in one click (see Figure 3) |
| Satellite | Global Precipitation Climatology Project (GPCP) from the National Aeronautics and Space Administration (NASA) | http://precip.gsfc.nasa.gov/gpcp_v2_comb.html<br>http://iridl.ldeo.columbia.edu/SOURCES/.NASA/.GPCP/.V1DD/<br>Daily data at 1o spatial resolution, which is around 100 km at the equator:<br>http://iridl.ldeo.columbia.edu/SOURCES/.NASA/.GPCP/.V2/.satellite-gauge/ | Global monthly 2.5o and daily 1o rainfall estimates.<br>The monthly data extends from 1979 to current, while the daily product is from 1996 to present.<br>It combines the precipitation information available from different microwave sensors Special Sensor Microwave/Imager data from the Defence Meteorological Satellite Program (United States) and the infrared from geostationary satellites and secondarily from polar orbiting satellites. The gauge data are assembled and analyzed by the Global Precipitation Climatology Centre. |
| Satellite | CPC Merged Analysis of Precipitation (CMAP), from the National Oceanographic and Atmospheric Administration (NOAA) Climate Prediction Centre (CPC) | http://www.esrl.noaa.gov/psd/data/gridded/data.cmap.html<br>http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP/.CPC/.Merged_Analysis/ | Global precipitation at a spatial resolution of 2.5o with pentad (five-day) and monthly aggregations since 1979. Useful for trend analysis in the past.<br>Produces global precipitation in which observations from rain gauges are merged with precipitation estimates from several satellite-based algorithms and is very similar to that of GPCP. |
| Satellite | CPC MORPHing technique (CMORPH) of the NOAA-CPC | http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html<br>http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP/.CPC/.CMORPH/ | Global precipitation analyses at very high spatial (8 km) and temporal (30 minute) resolutions, updated every day in almost real-time making it a good candidate for real-time monitoring of rainfall. Data are available starting from December 2002.<br>It uses precipitation estimates that have been derived from low orbiter satellite microwave observations exclusively, and whose features are transported via spatial propagation information that is obtained entirely from geostationary satellite IR data. |
| Satellite | Tropical Rainfall Measurement Mission (TRMM) from NASA and the National Aeronautics and Japan Aerospace Exploration Agency | http://precip.gsfc.nasa.gov/trmm_comb.html<br>http://iridl.ldeo.columbia.edu/SOURCES/.NASA/.GES-DAAC/.TRMM_L3/.TRMM_3B42/.v7/.daily/.precipitation/ | The data sets cover the period January 1998—Sept 2014 (with about a month delay) at 0.25 deg. This product is of good quality and high temporal spatial resolution.<br>It aims to improve the quantitative knowledge of the 3-dimensional distribution of precipitation in the tropics. TRMM has a passive microwave radiometer, the first active space-borne Precipitation Radar, and a Visible-Infrared Scanner, plus other instruments. It optimally merges microwave and IR rain estimates to produce three-hourly precipitation fields at quarter degree spatial resolution. Then the three-hourly products are aggregated to monthly and merged with gauge data over land to produce the best-estimated monthly precipitation field. |
| Satellite | African Rainfall Estimation (RFE) of the NOAA-CPC | http://www.cpc.ncep.noaa.gov/products/fews/RFE2.0_desc.html<br>http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP/.CPC/.FEWS/ | Specific for Africa, it provides accurate rainfall totals, and is assumed to be the true rainfall near each station. The product is available at 11 km spatial resolution on daily and 10-day basis and is operationally used for Food Early Warning System and for Malaria Early Warning System.<br>RFE2 uses microwave estimates in addition to continuing the use of cloud top temperature and station rainfall data that formed the basis of RFE1. Meteosat geostationary satellite infrared data are acquired in 30-minute intervals, and areas depicting cloud top temperatures of less than 235K are used to estimate convective rainfall. |

| Type of data | Source | Web address | How to use the data |
|---|---|---|---|
| | | **Temperature data** | |
| Satellite | Land-Surface Temperature (LST) from MODI* (Aqua and Terra) | http://iridl.ldeo.columbia.edu/SOURCES/.USGS/.LandDAAC/.MODIS/.1km/.8day/.version_005/<br>Africa: http://iridl.ldeo.columbia.edu/SOURCES/.USGS/.LandDAAC/.MODIS/.1km/.8day/.version_005/.Aqua/<br>South America: http://iridl.ldeo.columbia.edu/SOURCES/.USGS/.LandDAAC/.MODIS/.1km/.8day/.version_005/.Terra/ | For Africa and South America, the spatial resolution is 1km and temporal resolution eight days. Maps are available for daytime and nighttime images.<br>Data available from July 2002 to present for Africa and from March 2000 to present for South America. The data consist of eight-day composite land-surface temperature maps of continental Africa (derived from the MODIS sensor on-board Aqua satellite) and map of South America (derived from the MODIS sensor on-board Terra satellite). |
| | MODIS Land-Surface Temperature (LST) | Minimum air temperature: http://iridl.ldeo.columbia.edu/maproom/Health/Regional/Africa/Malaria/LSTmin/index.html<br>Maximum air temperature: http://iridl.ldeo.columbia.edu/maproom/Health/Regional/Africa/Malaria/TMR/index.html | It provides a good estimation of the minimum and maximum air temperature inferred from that minimum LST. |
| | | **Vegetation cover and water bodies data** | |
| Satellite | MODIS Normalized Difference Vegetation Index | http://iridl.ldeo.columbia.edu/maproom/Health/Regional/Africa/Malaria/NDVI/index.html?sregion=.EAF | |
| Satellite | MODIS Enhanced Vegetation Index | http://iridl.ldeo.columbia.edu/maproom/Health/Regional/Africa/Malaria/NDVI/index.html?sregion=.EAF&var=EVI | |
| Satellite | MODIS Reflectance for monitoring water bodies and bare soils | http://iridl.ldeo.columbia.edu/maproom/Health/Regional/Africa/Malaria/NDVI/index.html?sregion=.EAF&var=reflectance | |
| Satellite | Global Normalized Difference Vegetation Index (NDVI) of the NOAA-AVHRR | http://glcf.umd.edu/data/gimms/<br>http://iridl.ldeo.columbia.edu/SOURCES/.UMD/.GLCF/.GIMMS/.NDVIg/.global/.ndvi/ | The GIMMS (Global Inventory Modelling and Mapping Studies) data set is a normalized difference vegetation index (NDVI) product available for a 25-year period spanning from 1981 to 2006 at 8 km spatial resolution, every 15 days.<br>The data set is derived from imagery obtained from the Advanced Very High Resolution Radiometer (AVHRR) instrument on-board the NOAA satellite series 7, 9, 11, 14, 16 and 17. This is an NDVI dataset that has been corrected for calibration, view geometry, volcanic aerosols, and other effects not related to vegetation change. |
| Satellite | Vegetation indices from TERRA-MODIS and single channels (blue-red-NIR-SWIR) of the NOAA-AVHRR** | http://iridl.ldeo.columbia.edu/SOURCES/.USGS/.LandDAAC/.MODIS/<br>http://iridl.ldeo.columbia.edu/maproom/index.html | It provides consistent, spatial and temporal comparisons of global vegetation conditions that can be used to monitor photosynthetic activity. The data are available at 250 m spatial resolution every 16 days from April 2000 to present.<br>Two MODIS (Moderate Resolution Imaging Spectroradiometer) VIs, the normalized difference vegetation index (NDVI) and the enhanced vegetation index (EVI), are produced globally over land at 16-day compositing periods. Whereas the NDVI is chlorophyll-sensitive, the EVI is more responsive to canopy structural variations, including leaf area index, canopy type, plant physiognomy, and canopy architecture. The two vegetation indices complement each other in global vegetation studies and improve upon the detection of vegetation changes and extraction of canopy biophysical parameters. |
| | | **Regional and global seasonal forecasts** | |
| Forecast | IRI for precipitation forecasts | http://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/ | The user can query the website for forecasts issued any month since 1997 for a target season of three months at the global scale or for a specific region (e.g., Africa, Asia, Australia, Europe, Middle East, North America, Pacific Islands, South America). |
| Forecast | IRI for temperature forecasts | http://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/ | |

** Moderate Resolution Imaging Spectroradiometer.*
*** Advanced Very High Resolution Radiometer*

# ANNEX 2: GLOBAL CLIMATE DATA CENTRES

| Contact details for Global Producing Centres and other global seasonal forecasting centres | |
|---|---|
| Bureau of Meteorology, Australia | http://www.bom.gov.au/climate/ahead/ |
| Beijing Climate Center, China Meteorological Administration | http://bcc.cma.gov.cn |
| Climate Prediction Center of the NOAA | http://www.cpc.ncep.noaa.gov/ |
| European Centre for Medium-range Weather Forecasts | http://www.ecmwf.int/en/forecasts |
| Tokyo Climate Center, Japan Meteorological Agency | http://ds.data.jma.go.jp/gmd/tcc/tcc/index.html |
| Korean Meteorological Administration | http://www.kma.go.kr/ |
| Météo-France | http://www.meteo.fr |
| Met Office (United Kingdom) | http://www.metoffice.gov.uk/research/seasonal/ |
| Canadian Meteorological Centre | http://www.weatheroffice.gc.ca/saisons/GPC_Montreal_e.html |
| South African Weather Service | http://www.weathersa.co.za/ |
| Hydrometeorological Centre of Russia | http://wmc.meteoinfo.ru/season |
| Centro de Previsão de Tempo e Estudos Climáticos, Brazil | http://clima1.cptec.inpe.br/gpc/ |
| Contact details for Lead Centres (LCs) of Global Producing Centres | |
| LC for Long-Range Forecast Multi-Model Ensemble | http://www.wmolc.org/ |
| LC for Long-Range Forecast Verification System | http://www.bom.gov.au/wmo/lrfvs/ |
| *Contact details for other centres producing global seasonal forecast information* | |
| IRI | http://portal.iri.columbia.edu/ |
| APCC | http://www.apcc21.org/eng/html/hapcc030000.html |

## ANNEX 3: REGIONAL CLIMATE OUTLOOK FORUMS

| Acronym | Full name | Countries | Organizer | URL | Seasons |
|---|---|---|---|---|---|
| ASEANCOF | ASEAN Climate Outlook Forum | Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam | Meteorological Service of Singapore | http://www.weather.gov.sg/wip/web/ASMC/ASEANCOF | JJA<br>DJF |
| CACOF | Central America Climate Outlook Forum | Belize, Costa Rica, Guatemala, Honduras, El Salvador, Nicaragua, Panamá | Comité Regional de Recursos Hidráulicos | https://www.facebook.com/recursoshidricos.org?fref=nf | MJJ<br>ASO<br>DJF |
| CariCOF | Caribbean Climate Outlook Forum | Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Virgin Islands, Cayman Islands, Cuba, Curacao, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Montserrat, Puerto Rico, St Kitts and Nevis, St Lucia, St Maarten, St Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands | Caribbean Institute for Meteorology and Hydrology | http://www.cimh.edu.bb/?p=precipoutlook | JAS<br>DJF |
| EASCOF | East Asian Winter Climate Outlook Forum | China, Japan, Mongolia, South Korea | Tokyo Climate Center of Japan Meteorological Agency | http://ds.data.jma.go.jp/tcc/tcc/library/EASCOF/index.html | DJF |
| FOCRAII | Forum on Regional Climate Modelling, Assessment and Prediction for Regional Association II (Asia) | Afghanistan, Bahrain, Bangladesh, Bhutan, Cambodia, China, Hong Kong, India, Indonesia, Iran, Iraq, Japan, Kazakhstan, Kuwait, Kyrgyzstan, Laos, Macao, Maldives, Mongolia, Myanmar, Nepal, North Korea, Oman, Pakistan, Qatar, Russia, Saudi Arabia, South Korea, Sri Lanka, Thailand, United Arab Emirates, Uzbekistan, Vietnam, Yemen | Beijing Climate Center of China Meteorological Association; State Foreign Experts Affairs of China and WMO Training Center Nanjing | http://bcc.cma.gov.cn/channel.php?channelId=70 | JJA |
| GHACOF | Greater Horn of Africa Climate Outlook Forum | Burundi, Djibouti, Eritrea, Ethiopia, Rwanda, Somalia, South Sudan, Sudan, Tanzania, Uganda | Inter-Governmental Authority on Development Climate Prediction and Application Centre | http://www.icpac.net/products/reports/ghacof/ghacof.html | MAM<br>JAS<br>SOND |
| ICU | Island Climate Update | American Samoa, Australia, Cook Islands, Fiji, French Polynesia, Kiribati, New Caledonia, New Zealand, Niue, Papua New Guinea, Pitcairn Island, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna | National Institute of Water and Atmospheric Research | http://www.niwa.co.nz/climate/icu | All three-month seasons |
| MEDCOF | Mediterranean Climate Outlook Forum | Algeria, Egypt, France, Italy, Libya, Malta, Morocco, Portugal, Spain, Tunisia, Turkey ** | Agencia Estatal de Meteorología | http://medcof.aemet.es/Medcof/home.html | JJA<br>DJF |
| NEACOF | North Eurasian Climate Outlook Forum | Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan | North Eurasian Climate Centre | http://neacc.meteoinfo.ru/neacc/north-eurasian-climate-outlook-forum | Various |
| PICOF | Pacific Island Climate Outlook Forum | Cook Islands, Fiji, Kiribati, Niue, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu | Australian Bureau of Meteorology | http://www.bom.gov.au/cosppac/comp/ocof/ | All three-month seasons |
| PRESAC | PRÉvisions Saisonnières en Afrique Centrale | Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon | African Center of Meteorological Application for Development (ACMAD) | http://www.acmad.net/new/ | OND |
| PRESAGG | PRÉvisions Saisonnières en Afrique pour les pays du Golfe Guinée | Benin, Cameroon, Côte d'Ivoire, Equatorial Guinea, Ghana, Guinea, Guinea Bissau, Liberia, Nigeria, Sierra Leone, Togo | ACMAD | http://www.acmad.net/new/ | MAM<br>AMJ |
| PRESANORD | PRÉvisions Saisonnières en Afrique du Nord | Algeria, Egypt, Libya, Morocco, Tunisia | ACMAD | http://www.acmad.net/new/ | FMA or MAM<br>DJF |

| Acronym | Full name | Countries | Organizer | URL | Seasons |
|---|---|---|---|---|---|
| PRESAO | PRÉvisions Saisonnières en Afrique de l'Ouest | Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, The Gambia, Togo | ACMAD | http://www.acmad.net/new/ | JAS |
| PRESASS | PRÉvisions Saisonnières en Afrique de Soudan et Sahel | Benin, Burkina Faso, Central African Republic, Chad, Côte d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, The Gambia, Togo | ACMAD | http://www.acmad.net/new/ | JJA<br>JAS |
| SARCOF | Southern African Regional Climate Outlook Forum | Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe | Southern African Development Community Climate Services Centre | http://www.sadc.int/news-events/newsletters/climate-outlook/ | OND<br>JFM |
| SASCOF | South Asian Climate Outlook Forum | Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka | India Meteorological Department | http://www.imdpune.gov.in/climateoutlook/cli_index.html | JJAS |
| SEACOF | South East Asian Climate Outlook Forum | See ASEANCOF | | | |
| SEECOF | South East Europe Climate Outlook Forum | Albania, Armenia, Azerbaijan, Bosnia, Bulgaria, Croatia, Cyprus, Former Yugoslav Republic of Macedonia, Georgia, Greece, Hungary, Israel, Moldova, Montenegro, Rumania, Slovenia, Serbia, Turkey | South East European Virtual Climate Change Center | http://www.seevccc.rs/?p=7 | JJA<br>DJF |
| SSACOF | Southeast of South America Climate Outlook Forum | Argentina, Brazil, Paraguay and Uruguay | Servicio Meteorológico Nacional (Argentina), Instituto Nacional de Meteorologia (Brazil), Dirección de Meteorología e Hidrología (Paraguay), Dirección Nacional de Meteorología (Uruguay) | http://www.crc-sas.org/es/prevision_foro.php | JFM<br>AMJ<br>JAS<br>OND |
| SWIOCOF | Southwest Indian Ocean Climate Outlook Forum | Comores, Madagascar, Mauritius, Mayotte, Mozambique, Reunion, Seychelles, Tanzania | ACMAD | http://www.acmad.net/new/ | DJFMA |
| WCSACOF | West Coast of South America Climate Outlook Forum | Bolivia, Chile, Colombia, Ecuador, Peru, Venezuela | Centro Internacional para la Investigación del Fenómeno de El Niño | http://www.ciifen.org/index.php?option=com_content&view=category&layout=blog&id=76&Itemid=91&lang=en | DJF |

** Many of the Forums produce updated forecasts for rolling three-month seasons.*
*** The final list of countries has not been settled.*

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