El Niño 2015/2016

Impact Analysis

Monthly Outlook

November 2015

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SECTION 1

Introduction

During the summer and autumn 2015, El Niño conditions in the east and central Pacific have strengthened, disrupting weather patterns throughout the tropics and into the mid-latitudes. For example, rainfall during this summer's Indian monsoon was approximately 15% below normal. The continued strong El Niño conditions have the potential to trigger damaging impacts (e.g., droughts, famines, floods), particularly in less-developed tropical countries, which would require a swift and effective humanitarian response to mitigate damage to life and property (e.g., health, migration, infrastructure). This analysis uses key climatic variables (temperature, soil moisture and precipitation – see section 1.1) as measures to monitor the ongoing risk of these potentially damaging impacts.

The previous 2015-2016 El Niño Impact Analysis was based on observations over the past 35 years and produced Impact Tables showing the likelihood and severity of the impacts on temperature and rainfall by season. The current report is an extension of this work providing information from seasonal forecast models to give a more detailed monthly outlook of the potential near-term impacts of the current El Niño conditions by region. This information has been added to the Impact Tables in the form of a monthly outlook column. This monthly outlook is an indication of the average likely conditions for that month and region and is not a definite prediction of weather impacts.

1.1 Forecast Model Data

The data used to produce the Monthly Outlook column comes from 4 seasonal forecast models. The models used in this analysis are the Bureau of Meteorology (BoM; Australia), the European Centre for Medium Range Weather Forecasts (ECMWF; Europe, based in UK), Météo-France (MetFrance; France) and the National Centers for Environmental Prediction (NCEP; United States). These models were chosen because they are known to be reputable, reliable seasonal forecast models and their forecast data was publically available as part of the S2S (Sub-seasonal to Seasonal) forecast database. The current tables and maps are based on forecasts made in October 2015. The length and frequency of the forecast data available differs between modeling centres, the details of these different data are described in section A2.1 of Annex 2.

Seasonal forecasts: The chaotic nature of the atmosphere means that it is hard to predict exactly what will happen 1-2 months in advance. There are some aspects of the global weather and climate system that are more predictable than others and it is because of these that we are able to make seasonal forecasts. Such forecasts are able to show what is more or less likely to occur, but acknowledge that other outcomes are possible.

Data variables:
Precipitation: In the report and tables this is referred to as rainfall but in fact encompasses any form of water, liquid or solid, falling from the sky. The seasonal forecasts are compared to observations from the Global Precipitation Climatology Project (GPCP) from 1979-2014.
Soil Moisture: This is the moisture content in the soil over the top 20cm. The seasonal forecasts are compared to the global ECMWF Reanalysis (ERA-Interim/Land) of land-surface parameters from 1979-2010.

Temperature: This is the near-surface temperature (2 metre). The seasonal forecasts are compared to the global ECMWF Reanalysis (ERA-Interim) from 1979-2014.

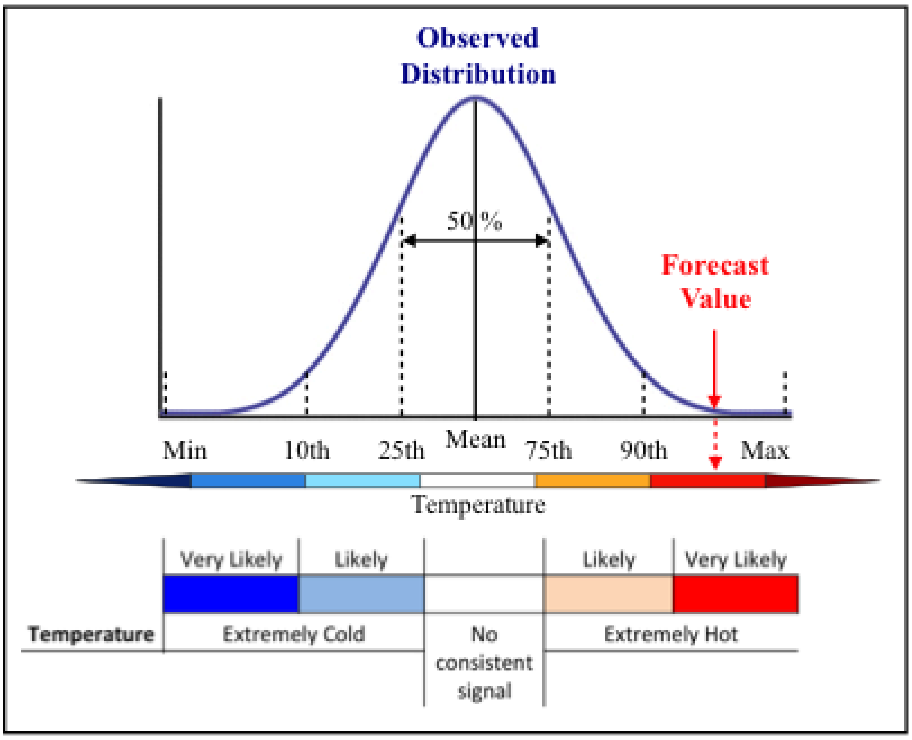
SECTION 2

Description of monthly outlook analysis and tables

2.1 Monthly Outlook Analysis

The Monthly Outlook column of the Impact Tables refers to the consensus of impacts over the next 1-2 months[1] from the 5 forecast models. To do this the forecast of rainfall, soil moisture and near-surface temperature for the coming 1-2 months are compared with the observed distribution of the same period over the past 35 years. This method of comparing the forecast to the observations is explained schematically in Figure 2.1 and more technical details of this method are described in section A2.2.

Figure 2.1. Schematic representation of the methodology. This is an example for Temperature comparing the forecast value to the observed distribution. The top colour scale represents that used for Temperature in the Forecast Maps in Annex 1. The bottom colour scale refers to how this links to the colours used in the impact tables. See the description of this 'worked example' in the text in section 2.



If the forecast value lies within the middle 50% of the observed distribution (i.e. between the 25th and the 75th percentile) then there is no deviation from normal conditions predicted and these regions are left white in the Forecast Maps (see Annex 1) and labeled 'no consistent signal' in the Impact Tables. If, as the example in Figure 2.1 shows, the forecast value is

[1] The forecast length differs between modeling centres, see section A2.1 for details.

above the 90th percentile of the observed distribution it will be coloured red in the temperature maps in Annex 1. An assessment will be made about whether this is a consistent signal across the models. If it is both a strong signal (above the 90th percentile) and robust across the forecast models then it will appear as dark red in the Impact Tables referring to "Very Likely Extremely Hot".

If either the signal is weaker (e.g., only above the 75th percentile), or the signal is not consistent across all the model forecasts, then this would appear in the Impact Tables as only a "Likely" signal rather than a "Very Likely" signal.

2.2 Interpretation of the Forecast Maps

- The Forecast Maps (Annex 1) are designed to put the current seasonal forecast in the context of the observed records over the past 35 years, by comparing to the same period in observations (see Figure 2.1).
- In the **temperature** maps, regions coloured in orange or red indicate areas where it is forecast to be warm or very warm compared with previous observations of that period. Blue regions show areas where it is forecast to be cold or very cold compared to the normal for that period.
- In the **rainfall and soil moisture** maps, regions coloured blue show areas where it is forecast to be wet or very wet compared with previous observations of that period. Brown regions show areas where it is forecast to be dry or very dry compared to the normal for that period.

2.3 Interpretation of the Impact Tables

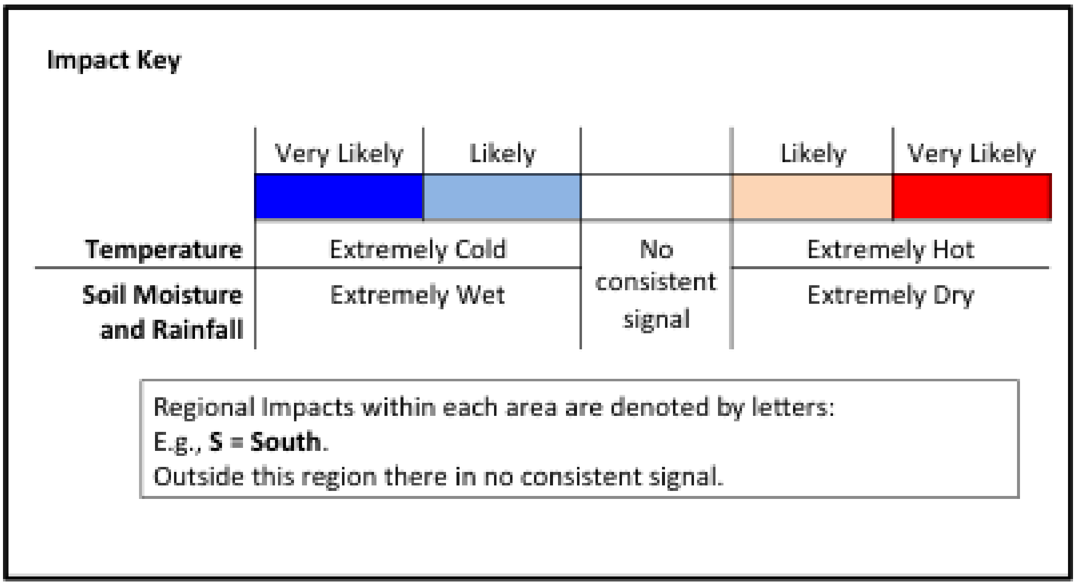
The Monthly Outlook part of the Impact Tables is shown in the Monthly Outlook column labeled "Monthly Outlook". This represents the summary of the forecast impact from the 5 models over the next 1-2 months. The remainder of the table, including other seasons and the Risk and Evidenced Impacts columns, refers to analysis of past, observed El Niño events over the last 35 years and remains unchanged from previous analysis.

To make this clear, the parts of the table relating to past El Niño events are shown by the grey stippling.

2.4 Impact, Symbol and Level of Confidence Keys

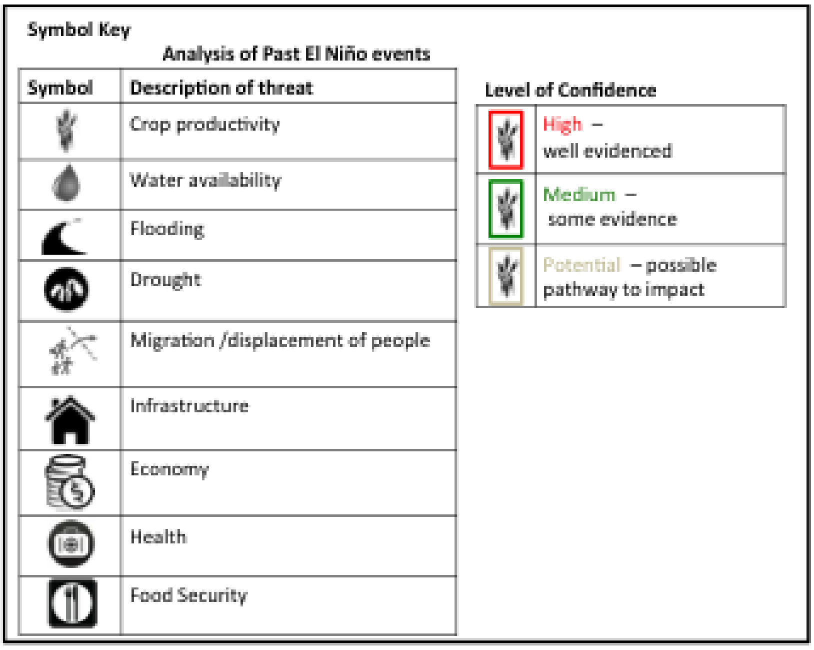
Meteorological Analysis
As in previous analysis, for each country or region, the **likelihood** of temperature and rainfall[2] extremes occurring is shown by the coloured boxes according to the Impact key below. For example, dark blue stippled colours for temperature – corresponding to "Very Likely Extremely Cold" conditions – can be interpreted as extreme[3] cold conditions in that season, in that country, as being at least twice as likely to occur during El Niño. If the impact is limited to a particular region of that country then that region is represented in that box (e.g., S referring to South) and there is no consistent signal in the rest of that region or country.

[2] Rainfall in the Impact Tables refers to analysis of both Rainfall **and** Soil Moisture.
[3] In the grey dotted boxes extreme refers to an event being in the upper or lower quartile - the bottom or top 25% of the observed record for that country for that season.



Impact Analysis
An extensive **literature search** has been carried out. Scientific literature has been reviewed using the science direct, web of knowledge and google scholar databases. Grey literature and media reports were also analysed (e.g., NGO reports). In addition specific case study details were analysed using databases of past natural disasters (e.g., EM-DAT – International Disaster Database).

Potential **socio-economic impacts** that were identified in the literature search have been categorized by sector e.g., 'Food Security' and 'Health'. The evidenced impacts, based on past events, are summarised using sector symbols (see the Symbol key below). The uncertainty of the impact in these sectors is represented by the coloured borders around the symbols: red, green and beige correspond to high, medium and potential impacts respectively (see Level of Confidence key below).



SECTION 3

Impact tables with November 2015 Monthly Outlook

Below are Impact Tables by region. The Monthly Outlook for November 2015 is shown in the Monthly Outlook column. The remainder of the table refers to analysis of past, observed El Niño events over the last 35 years and is indicated by the grey stippling.

3.1 Southern Africa

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
Southern Africa	**Temperature**	no consistent signal			no consistent signal			Reduced water availability, reduction in crop yields. Increased risk of drought-related humanitarian disaster.
	Rainfall	no consistent signal				no consistent signal		
South Africa	**Temperature**	no consistent signal		E	no consistent signal	no consistent signal		Increase water stress, reduction in crop yields (e.g., Maize and Soybean). Below normal instances of Malaria.
	Rainfall	no consistent signal	E	NE		no consistent signal		
Mozambique	**Temperature**	no consistent signal	S		N	S		Drought, and crop failure leading to potential food shortages.
	Rainfall	NE	no consistent signal	no consistent signal	no consistent signal	no consistent signal		
Malawi	**Temperature**	no consistent signal			no consistent signal	no consistent signal		Drought affecting crop productivity.
	Rainfall	N	no consistent signal		no consistent signal	no consistent signal		
Zambia	**Temperature**	no consistent signal	S					Increase water stress, crops vulnerable to drought. Increase East Coast Fever in cattle.
	Rainfall	NE	E	no consistent signal	no consistent signal	E		
Zimbabwe	**Temperature**	no consistent signal			no consistent signal			Drought leads to significantly reduced Maize yield.
	Rainfall	no consistent signal		no consistent signal		no consistent signal		

High | Medium | Potential

3.2 West Africa

Country	Variable	Monthly Outlook Nov-15	Analysis of Past El Niño Events: DJF 15/16	MAM 2016	JJA 2016	SON 2016	Risk	Evidenced Impacts
West Africa	Temperature	no consistent signal			no consistent signal	no consistent signal		Risk of drought and reduced crop productivity. Drought-related migration leading to increased disease risk.
	Rainfall	no consistent signal						
Nigeria	Temperature	no consistent signal	no consistent signal	S	no consistent signal	no consistent signal		Drought results in reduced Maize yields. Drought-related migration increases risk of spreading infectious disease.
	Rainfall		no consistent signal	S		no consistent signal		
Ghana	Temperature	no consistent signal	S		no consistent signal	no consistent signal		Significantly less rain in May-Jun major rains. Reduced water availability and drought.
	Rainfall	no consistent signal		S	S	no consistent signal		
Sierra Leone	Temperature	no consistent signal		no consistent signal	no consistent signal	no consistent signal		Some risk of drought. Reduced Rice and Maize crop yields.
	Rainfall	no consistent signal		no consistent signal	no consistent signal	no consistent signal		

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High   Medium   Potential

3.3 East Africa

Country	Variable	Monthly Outlook Nov-15	Analysis of Past El Niño Events: DJF 15/16	MAM 2016	JJA 2016	SON 2016	Risk	Evidenced Impacts
East Africa	Temperature					no consistent signal		Risk of flooding causing damage to infrastructure and displacement of people. Increase risk of Rift Valley Fever, Malaria and Cholera.
	Rainfall			no consistent signal				
Ethiopia	Temperature	W			no consistent signal	no consistent signal		Risk of flooding causing displacement of people. Increase incidence of Rift Valley Fever, Malaria and Cholera.
	Rainfall			no consistent signal		W		
South Sudan	Temperature	no consistent signal	SE	SE	no consistent signal	no consistent signal		Flooding affecting infrastructure and access to basic relief for vulnerable people.
	Rainfall		SE					
Kenya	Temperature		no consistent signal	no consistent signal	no consistent signal	no consistent signal		Flooding affecting access to food. Increase risk of Rift Valley Fever, Malaria and diarrhoea.
	Rainfall			no consistent signal		no consistent signal		
Uganda	Temperature	no consistent signal	no consistent signal		no consistent signal	no consistent signal		Significant displacement of people following flooding and landslides. Increase risk of Cholera and highland Malaria.
	Rainfall			no consistent signal				
Somalia	Temperature		N		E	NE		Continuous heavy rains causing river bank collapse and flooding. Increase risk of RVF.
	Rainfall		N	no consistent signal		no consistent signal		
Sudan	Temperature	no consistent signal		no consistent signal	NW	no consistent signal		Flooding and mudslides cause displacement of people and affects access to food.
	Rainfall	S	no consistent signal	no consistent signal	NE	S		

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High   Medium   Potential

3.4 Central Africa

Country	Variable	Monthly Outlook: Nov-15	Analysis of Past El Niño Events: DJF 15/16	MAM 2016	JJA 2016	SON 2016	Risk	Evidenced Impacts
Central Africa	Temperature	no consistent signal			no consistent signal	no consistent signal		Flooding during developing phase. Increased Rift Valley Fever risk. Reduced crop productivity during hot temperatures in decaying phase.
	Rainfall			no consistent signal		no consistent signal		
Democratic Republic of Congo	Temperature	no consistent signal			no consistent signal	no consistent signal		
	Rainfall	E	no consistent signal	no consistent signal	S	N		
Tanzania	Temperature	no consistent signal	no consistent signal		E	no consistent signal		Flooding during el Niño peak. Warm temperatures during Mar-May lead to decreased crop productivity. Increase RVF risk.
	Rainfall			no consistent signal	no consistent signal	SE		
Rwanda	Temperature	no consistent signal	no consistent signal		no consistent signal	no consistent signal		Flooding destroys homes and schools and leads to large numbers being displaced. Increased incidents of highland Malaria.
	Rainfall			no consistent signal	no consistent signal	no consistent signal		

High | Medium | Potential

3.5 MENA – Middle East and North Africa

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
MENA	**Temperature**	no consistent signal		no consistent signal		no consistent signal		Potential for flooding before el Niño peak. Potential for drought following peak, resulting in reduced crop productivity.
	Rainfall							
Libya	**Temperature**	no consistent signal	no consistent signal		W	no consistent signal		
	Rainfall	no consistent signal	no consistent signal	no consistent signal		N		
Egypt	**Temperature**	no consistent signal	no consistent signal	no consistent signal	SW	no consistent signal		Agricultural land and houses flooded during el Niño peak. Reduction in Maize and Wheat crop yields.
	Rainfall		N	N	E	N		
Algeria	**Temperature**	no consistent signal		no consistent signal	S	no consistent signal		Affected by reduced crop productivity and drought.
	Rainfall	S	no consistent signal	no consistent signal	no consistent signal	no consistent signal		
Lebanon	**Temperature**	no consistent signal	no consistent signal	no consistent signal		no consistent signal		Flooding and high winds during el Niño peak destroys infrastructure and disrupts power.
	Rainfall							
Jordan	**Temperature**	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		Flash flooding experienced before el Niño peak.
	Rainfall		no consistent signal					
Palestinian Territories	**Temperature**	no consistent signal	no consistent signal	no consistent signal		no consistent signal		
	Rainfall							
Syria	**Temperature**	no consistent signal	no consistent signal	no consistent signal		no consistent signal		Heavy rain causing flooding prior to peak. Drought following el Niño, reduced water availability.
	Rainfall	no consistent signal		W		no consistent signal		
Iraq	**Temperature**	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		Flooding destroyed infrastructure and causes displacement of people.
	Rainfall	no consistent signal	NW	no consistent signal		S		
Afghanistan	**Temperature**	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		Potential for flooding during developing phase of el Niño causing damage to crops, livestock and homes.
	Rainfall		N	N		N		

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High | Medium | Potential

3.6 Indonesia

Country	Variable	Monthly Outlook Nov-15	Analysis of Past El Niño Events DJF 15/16	MAM 2016	JJA 2016	SON 2016	Risk	Evidenced Impacts
Indonesia	Temperature	N			no consistent signal	no consistent signal	Developing	Drought during developing phase, reduction in water availability, crop production, threat of forest fires with health-related risk. Flooding and landslides following peak with increased Dengue Fever.
	Rainfall			no consistent signal			Decaying	

High Medium Potential

3.7 Southeast Asian Peninsular

Country	Variable	Monthly Outlook Nov-15	Analysis of Past El Niño Events DJF 15/16	MAM 2016	JJA 2016	SON 2016	Risk	Evidenced Impacts
Southeast Asian Peninsular	Temperature		no consistent signal					Increased risk of drought and forest fires. Reduced crop productivity.
	Rainfall				no consistent signal	no consistent signal		
China	Temperature	S	no consistent signal	NW	no consistent signal	no consistent signal		Flooding resulting in displacement of people. Reduction in Maize crop productivity. Increase risk of dysentery in east.
	Rainfall		SE	N	SE	N		
Vietnam	Temperature			no consistent signal	N			Increase incidences of forest fire and smoke-related deaths.
	Rainfall	no consistent signal	N		N	no consistent signal		
Myanmar (Burma)	Temperature	S	no consistent signal	no consistent signal		no consistent signal		Affected by moderate drought and reduction in Maize and Rice crops. Increase risk of Cholera and Malaria.
	Rainfall		no consistent signal	S	no consistent signal	NW		

High Medium Potential

3.8 Southern Asia

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
Southern Asia	Temperature		no consistent signal	no consistent signal		no consistent signal	Developing	Below normal monsoon rainfall, drought risk and reduced crop productivity during developing phase. Potential for flooding following peak with increased Cholera and Malaria risk.
	Rainfall			no consistent signal	no consistent signal		Decaying	
India	Temperature		no consistent signal	no consistent signal	W	no consistent signal		Slow onset of monsoon in developing phase, drought risk and reduced Soybean crops. Increased water availability and reduced rice crop failure in south.
	Rainfall	N		no consistent signal	S			
Pakistan	Temperature		no consistent signal	no consistent signal	no consistent signal	no consistent signal		Affected by drought in North. Increased risk of Malaria epidemics after el Niño peak.
	Rainfall			no consistent signal		NE		
Bangladesh	Temperature			no consistent signal	no consistent signal			Drought risk in developing phase. Increase Cholera risk after peak.
	Rainfall	no consistent signal	no consistent signal		no consistent signal			
Nepal	Temperature		no consistent signal	no consistent signal	no consistent signal			
	Rainfall		no consistent signal	no consistent signal	no consistent signal			

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High | Medium | Potential

3.9 Caribbean

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
Caribbean	Temperature		E	E		no consistent signal	Developing	Risk of drought and reduced water availability during developing phase. Potential for flooding following peak. Increase risk of Dengue Fever.
	Rainfall	S	E	no consistent signal	NW	NW	Decaying	
Guyana	Temperature		S		no consistent signal	no consistent signal		Increased drought risk during developing phase. Reduction in Maize and Rice crops. Potential increase in Malaria.
	Rainfall			N		no consistent signal		

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High | Medium | Potential

3.10 British Overseas Territories

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
northern subtropical Atlantic	Temperature	no consistent signal		no consistent signal	no consistent signal	no consistent signal		Increase hurricane activity (north of the normal development region in Caribbean). Potential increase Dengue Fever.
	Rainfall	no consistent signal				no consistent signal		
southern South Atlantic	Temperature	no consistent signal	S	no consistent signal	no consistent signal	no consistent signal		Potential for Island flooding during peak. Potential for large temperature departures from the mean.
	Rainfall		N	no consistent signal				

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High | Medium | Potential

3.11 Southern Europe

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
Southern Europe	Temperature	no consistent signal		no consistent signal	no consistent signal	no consistent signal		
	Rainfall	no consistent signal	no consistent signal	no consistent signal		no consistent signal		

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High | Medium | Potential

3.12 Indian Ocean

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
Central Indian Ocean	Temperature	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		
	Rainfall		no consistent signal			no consistent signal		

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High | Medium | Potential

3.13 Pacific Ocean

		Monthly Outlook	Analysis of Past El Niño Events					
Country	**Variable**	**Nov-15**	**DJF 15/16**	**MAM 2016**	**JJA 2016**	**SON 2016**	**Risk**	**Evidenced Impacts**
Central Pacific	Temperature				no consistent signal	no consistent signal		Increase risk of flooding during the peak for Islands in the South Pacific Convergence.
	Rainfall			no consistent signal	no consistent signal	no consistent signal		

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High | Medium | Potential

Annex 1 Forecast Maps

Figure A1.1 Forecast percentile maps for Temperature. Blue colours show areas likely to be colder than normal, red colours show areas likely to be warmer (see explanation in section 2.1-2.2). These maps are based on forecasts from 8th (with the exception of (d) which is 1st) October 2015 and are compared to the observations for the period from October 29 2015 to the end of the forecast (see section A2.1).

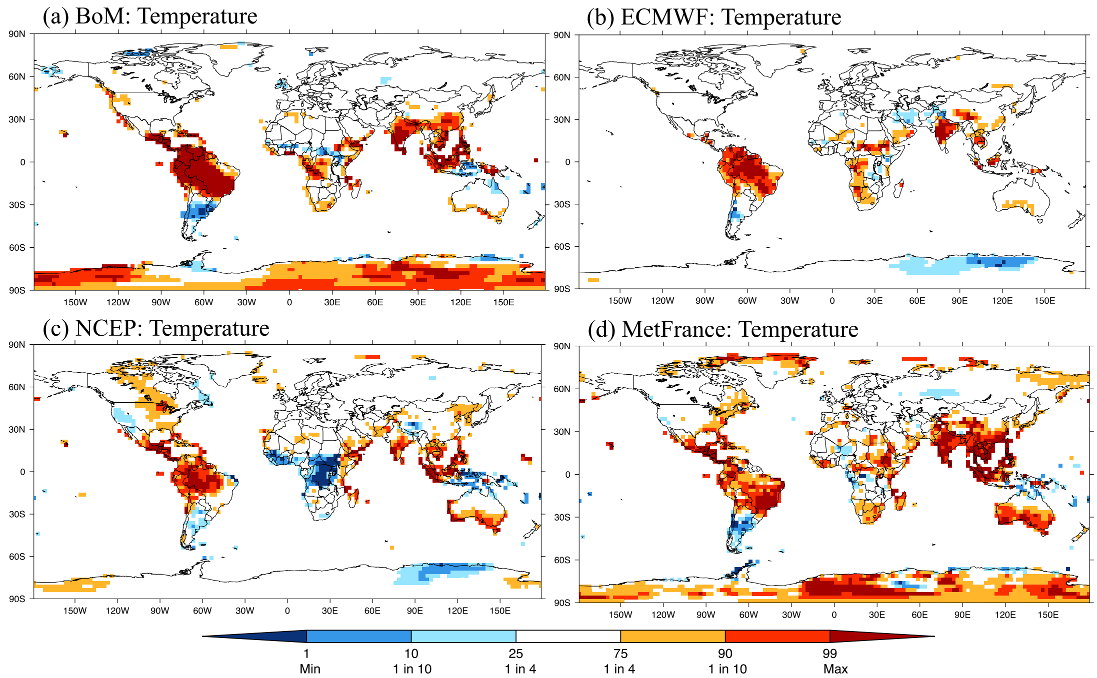


Figure A1.2 Forecast percentile maps for Rainfall. Blue colours show areas likely to be wetter than normal, brown colours show areas likely to be drier (see explanation in section 2.1-2.2). These maps are based on forecasts from 8th (with the exception of (d) which is 1st) October 2015 and are compared to the observations for the period from October 29 2015 to the end of the forecast (see section A2.1).

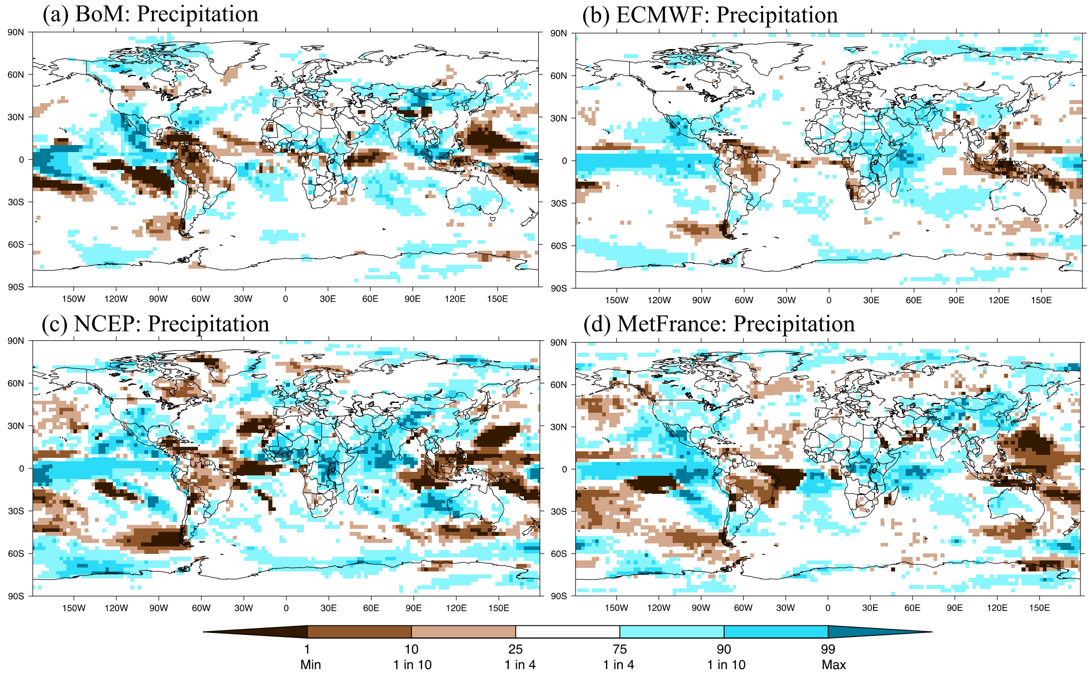
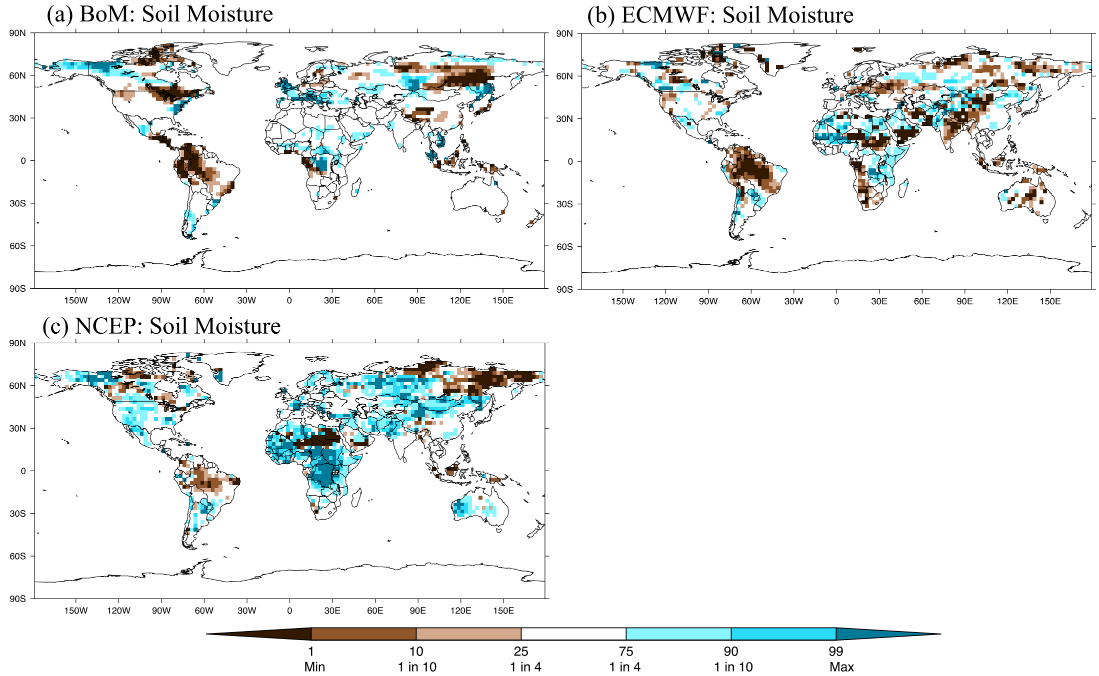


Figure A1.3 Forecast percentile maps for Soil Moisture. Blue colours show areas likely to be wetter than normal, brown colours show areas likely to be drier (see explanation in section 2.1-2.2). These maps are based on forecasts from 8th (with the exception of (d) which is 1st) October 2015 and are compared to the observations for the period from October 29 2015 to the end of the forecast (see section A2.1).



Annex 2 Detailed Technical Methodology

A2.1: Model Data

The current tables are based on forecasts made in October 2015. The length and frequency of the forecast data available, as well as the climatological period available to calculate the anomalies from, differ between centres. These differences are summarised below.

> ***BoM*** forecasts are updated twice per week and run for 60 days. The hindcast period available, from which the forecast anomalies are calculated, is 1981-2013.
> *Current forecast: 8th October forecast ends on 7th December 2015.*
>
> ***ECMWF*** forecasts are updated twice per week and run for 46days. The hindcast period available, from which the forecast anomalies are calculated, is 1995-2014.
> *Current forecast: 8th October forecast ends on 22nd November 2015.*
>
> ***MetFrance*** forecasts are run once per month for 60 days. The hindcast period available, from which the forecast anomalies are calculated, is 1994-2014.
> *Current forecast: 1st October forecast ends on 30th November 2015.*
>
> ***NCEP*** forecasts are run every day for 44 days. The hindcast period available, from which the forecast anomalies are calculated, is 1999-2010.
> *Current forecast: 8th October forecast ends on 20th November 2015.*

A2.2 Methodology

To produce the forecast column in the impact table the forecast anomaly, defined as the difference from that model's own climatological value at that location for the hindcast period available (see section A2.1 for details for each model), is compared to the distribution of observed anomalies for the same period as the forecast[4]. To make this comparison at each longitude and latitude between observations and the models, each data were interpolated onto a common 2.5 x 2.5 degree grid using a bilinear interpolation method.

This is a method of understanding where the forecast anomalies fall compared with the observed distribution of anomalies. This method is described schematically in the main report in Figure 2.1 with a worked example.

Forecast Period covered: The most up-to-date forecasts available will be made to the final tables and maps. Only forecast information from the 'future' (at the time of analysis) is shown in the maps. For example, the analysis for the forecast maps was carried out on 29th October so forecast information from 29th October to the end date of the forecast (which differs for different centres) was used to create the current maps.

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[4] Note, this is a slightly different period in observations depending on the model.