El Niño 2015/2016

Impact Analysis

Monthly Outlook

March 2016

Linda Hirons, Nicolas Klingaman

This report has been produced by University of Reading for Evidence on Demand with the assistance of the UK Department for International Development (DFID) contracted through the Climate, Environment, Infrastructure and Livelihoods Professional Evidence and Applied Knowledge Services (CEIL PEAKS) programme, jointly managed by DAI (which incorporates HTSPE Limited) and IMC Worldwide Limited.

The views expressed in the report are entirely those of the author and do not necessarily represent DFID's own views or policies, or those of Evidence on Demand. Comments and discussion on items related to content and opinion should be addressed to the author, via enquiries@evidenceondemand.org

Your feedback helps us ensure the quality and usefulness of all knowledge products. Please email enquiries@evidenceondemand.org and let us know whether or not you have found this material useful; in what ways it has helped build your knowledge base and informed your work; or how it could be improved.

DOI:http://dx.doi.org/10.12774/eod_cr.march2016.hironsletal3

First published March 2016

Contents

SECTION 1 1
Introduction 1
1.1 Update of current event 1
1.2 Forecast Model Data 2
SECTION 2 3
Description of Monthly Outlook Analysis and Tables 3
2.1 Monthly Outlook Analysis 3
2.2 Interpretation of the Forecast Maps 4
2.3 Interpretation of the Impact Tables 4
2.4 Impact, Symbol and Level of Confidence Keys 4
SECTION 3 7
Impact Tables with March 2016 Monthly Outlook 7
Comparison of observed 2015/16 event with historical impacts 7
3.1 Southern Africa 7
3.2 West Africa 7
3.3 East Africa 8
3.4 Central Africa 8
3.5 MENA – Middle East and North Africa 8
3.6 Indonesia 8
3.7 Southeast Asian Peninsular 8
3.8 Southern Asia 8
3.9 Caribbean 9
3.10 British Overseas Territories 9
3.11 Southern Europe 9
3.12 Indian Ocean 9
3.13 Pacific Ocean 9
3.1 Impact Tables 10

List of Annexes

Annex 1 Forecast Maps 20
Annex 2 Detailed Technical Methodology 25

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 observations and seasonal forecast models to give a more detailed 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 an 'Observations and Outlook' row. This consists of observational information for the past seasons of JJA 2015, SON 2015 and DJF 2015/2016, a detailed monthly outlook from 5 modeling centres for Mar 2016 and then longer-term seasonal forecast information from 2 modeling centres for the future seasons of AM 2016 and JJA 2016. The seasonal outlook information is an indication of the average likely conditions for that coming month (or season) and region and is not a definite prediction of weather impacts. There is no seasonal forecast information yet available for Sep-Nov 2016, seasons which include these months are marked by 'X'.

Summary Table of Observations and Outlook Information

<table>
<tr><th rowspan="2">JJA 2015</th><th rowspan="2">SON 2015</th><th rowspan="2">DJF 15/16</th><th colspan="2">MAM 2016</th><th rowspan="2">JJA 2016</th><th rowspan="2">SON 2016</th></tr>
<tr><th>Mar-16</th><th>AM 2016</th></tr>
<tr><td colspan="3" rowspan="2">Observations</td><td colspan="2">Outlook</td><td rowspan="2">X- No information yet</td></tr>
<tr><td>5 Models</td><td>2 Models</td></tr>
</table>

1.1 Update of current event

Strong El Niño conditions continue to be present in the east and central Pacific. However, the peak of this event occurred in November and December 2015, with conditions starting to weaken in January and February 2016. Most models predict that El Niño conditions will continue (although weaker) during January-March 2016 and further weaken transitioning to ENSO-neutral conditions during late spring or early summer (CPC/IRI consensus forecast; A2.2). There is potential after that to transition into La Niña conditions, which are characterised by cooler than normal tropical Pacific sea surface temperatures. Such a transition from strong El Niño conditions to La Niña conditions has been observed in nearly 90% of past El Niño events between 1950 and 2011.

Broadly speaking, global climate impacts of La Niña, especially in the tropics, tend to be opposite to those of El Niño. A full report on the historical impacts of past La Niña events will be available soon.

1.2 Forecast Model Data

The data used to produce the monthly outlook comes from 5 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), the National Centers for Environmental Prediction (NCEP; United States), Météo-France (MetFrance) and the UK Met Office (UKMO). These models were chosen because they are known to be reputable, reliable seasonal forecast models. Data for the extended range outlook is only available from 2 models (NCEP and UKMO). The current tables and maps are based on forecasts made in February 2016. 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 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.

Uncertainty at longer forecast lead times: Due to the chaotic nature of the atmosphere, it is easier to predict what will happen in the near-term over the next month or so than it is to predict what will happen 3 or 6 months from now. Therefore, as the length of the seasonal forecast increases, the level of skill decreases. This means we have higher confidence in the near-term forecasts than in the extended-range forecasts. In addition to this, we have higher confidence in the monthly outlook because information from more models has gone into the monthly outlook (5 models) compared with the extended-range outlook (2 models).

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 metres). 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 'Observations and Outlook' row of the Impact Tables refers to what has already occurred in observations during this el Niño event (JJA 2015, SON 2015 and DJF 2015/2016), what is forecast to occur for the next Monthly Outlook, in this case March 2016, and the extended-range forecast over the following five months (AM 2016 and JJA 2016). The MAM 2016 season is broken down into the monthly outlook (Mar 2016) and extended-range forecast (AM 2016) so that the near-term monthly forecast, in which we have more confidence and more models have contributed, can be seen separately. Boxes in future seasons (Sep-Nov 2016) where there is no information yet available are marked by an 'X'.

The analysis for the outlook part of the Impact Table takes the forecast of rainfall, soil moisture and near-surface temperature for the forecast period and compares it 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.

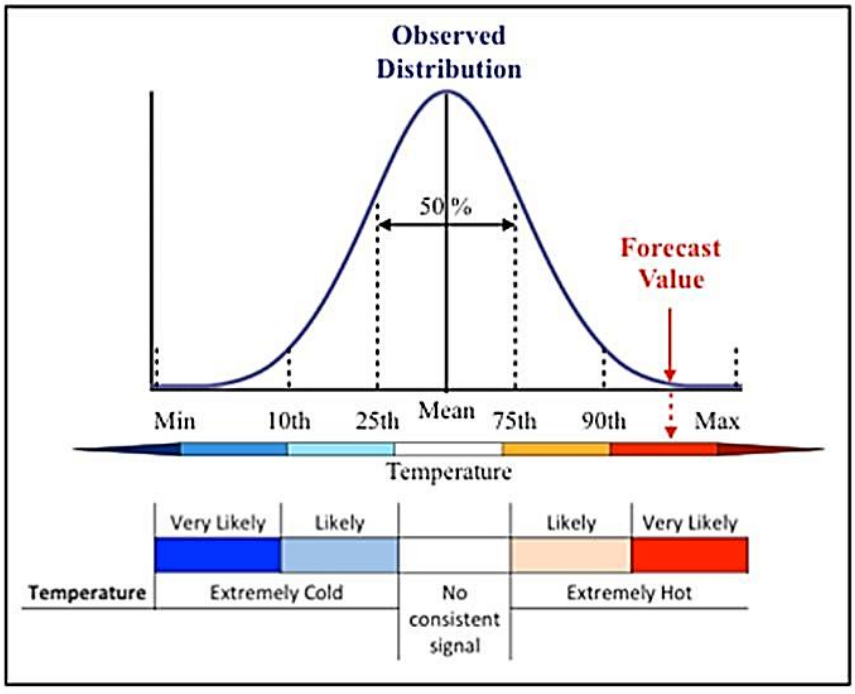


Figure 2.1. Schematic representation of the methodology. This is an example for Temperature comparing the forecast value to the observed distribution. The top colour scales represents that used for Temperature in the Forecast Maps in Annex 1. The bottom colour scale refers to how this links to the colours 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 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 record 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

For each region/country and variable, the Impact Tables are divided into two separate rows. The top row, labeled 'Analysis of Past El Niño Events' refers to the mean impact of past, observed El Niño events that have occurred over the last 35 years. The bottom row, labeled 'Observations and Outlook' refers to what has been happening during this current El Niño event. For past seasons/months, JJA 2015, SON 2015 and DJF 2015/2016, this is information from observations (see section A2.1 for details of the data used). The monthly outlook, in this case March 2016, is the forecast from 5 models (BoM, ECMWF, MetFrance, NCEP, UKMO). The following five months of outlook, AM 2016 and JJA 2016, is the extended-range forecast from 2 models (NCEP, UKMO). The 'X', marks future seasons where there is no forecast information yet available.

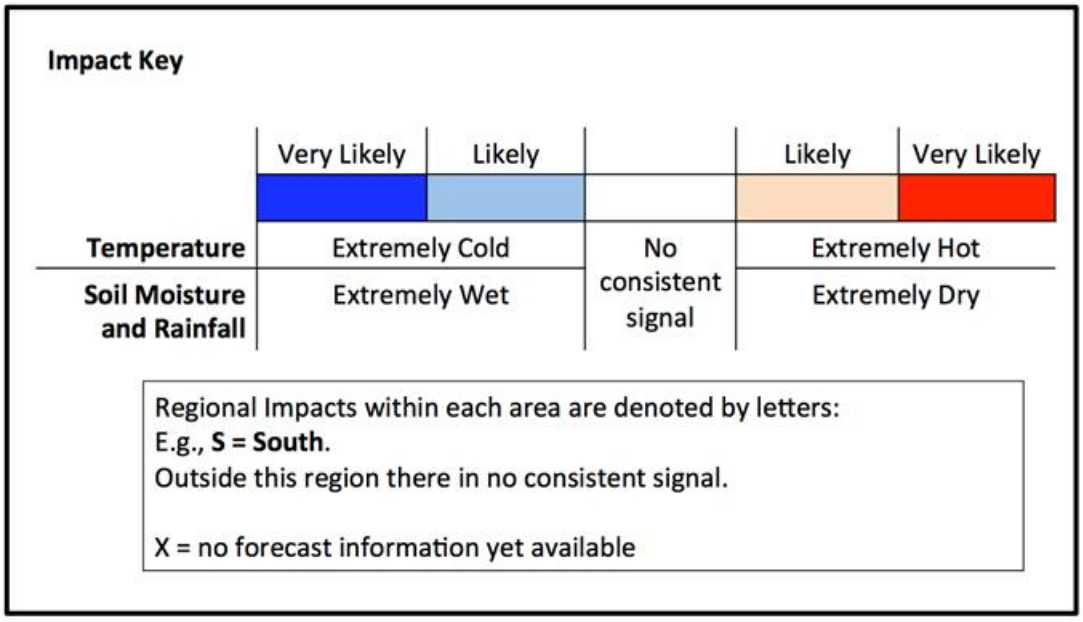
The remainder of the table, the Risk and Evidenced Impacts columns, refers to analysis of past, observed El Niño events over the last 35 years and remains unchanged from previous analysis.

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[1] extremes occurring is shown by the coloured boxes according to the Impact key below. For example, dark blue colours for temperature – corresponding to "Very Likely

[1] Rainfall in the Impact Tables refers to analysis of both Rainfall **and** Soil Moisture.

Extremely Cold" conditions – can be interpreted as extreme[2] 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.



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).

It should be noted that the impacts are not updated with the seasonal forecast data but are the impacts of past El Niño events.

Time evolution of Impacts
It is not possible to break the sector impacts down by season because each event is slightly different and therefore the timing or occurrence of particular impacts can vary considerably. However, in some regions there is a clear distinction between the impacts that occur during the developing phase of El Niño (June– February) and those which occur during the decaying phase of El Niño (March- November of the following year). Where impacts differ significantly between the developing and decaying phases this is made clear in the Risk column of the Impact Tables. For example, in Indonesia, analysis of previous events shows that drought is likely during the developing phase of the El Niño while flooding is likely during the decaying phase after the peak of the event. Where this distinction is appropriate it is

[2] 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.

made clear on the Impact Table by showing sector symbols for the ‘developing’ phase and ‘decaying’ phase separately. If there is no clear distinction between impacts in the developing and decaying phases then the impacts are assumed to occur most strongly during the peak of the El Niño event.

Symbol Key

Analysis of Past El Niño events

Symbol	Description of threat
	Crop productivity
	Water availability
	Flooding
	Drought
	Migration /displacement of people
	Infrastructure
	Economy
	Health
	Food Security

Level of Confidence

	High – well evidenced
	Medium – some evidence
	Potential – possible pathway to impact

Developing –
Phase of El Niño up to and including the peak (June – February).

Decaying –
Phase of El Niño after the peak (March – November of the following year).

SECTION 3

Impact Tables with March 2016 Monthly Outlook

Below are Impact Tables by region. The information is split into (a) 'Analysis of Past El Niño Events' – based on past, observed El Niño events over the last 35 years, and (b) 'Observations and Outlook' – based on current observations of this El Niño event for past seasons and seasonal forecast information for the next 6 months (month 1 from 5 models and months 2-6 from 2 models). The 'X', marks future seasons where there is no forecast information yet available.

Comparison of observed 2015/16 event with historical impacts

Not all El Niño events result in the same meteorological and socio-economic impacts. Furthermore, it is important to remember that the meteorological Impact Tables describe the seasonal mean impact on rainfall and temperature rather than the day-to-day weather events during those months.

A brief description of how the seasonal mean temperature and rainfall of the current 2015/16 event compares with the identified historical risk from past events will be provided below for each region. ***This should not be interpreted as an attribution analysis that identifies which local impacts are a result of the El Niño. Rather, it is a qualitative comparison of the observed 2015/16 event with the identified historical impacts using, where appropriate, local extreme conditions as examples.***

3.1 Southern Africa

Analysis of past El Niño events identified that southern Africa was vulnerable to extreme warm temperatures and dry conditions during the peak of El Niño. The temperatures have indeed been extremely warm with some regions of South Africa, for example, recording record high temperatures[3]. The conditions have been drier than according to the historical risk with many regions experiencing extreme drought; in South Africa, for example, 2015 was the driest year on record[4]. This has resulted in extreme water shortages causing famine and mass migration as well as wildfires in the region.

3.2 West Africa

Analysis of past El Niño events identified that West Africa was vulnerable to warm temperatures and extreme dry conditions during the peak of El Niño. The temperature signal has not matched that of the historical risk and, while it has been dry in the Guinea Coast region of West Africa, the highlighted risk of extreme dry conditions has not occurred.

[3] Durban recorded a record high temperature of 45C compared to the previous record of 43C recorded in Dec 1990. *http://www.weathersa.co.za*

[4] 2015 was the driest year since 1904 when records began. *http://www.weathersa.co.za*

3.3 East Africa

Analysis of past El Niño events identified that eastern Africa was vulnerable to warm temperatures and extreme wet conditions during the peak of El Niño. The conditions have indeed been extremely wet with flooding occurring in, for example, Tanzania, Kenya, Ethiopia and Somalia over the last 3 months. Prior to the El Niño peak regions such as northern Ethiopia experienced extreme drought, which was not an historical risk that was highlighted.

3.4 Central Africa

Analysis of past El Niño events identified that central Africa was potentially vulnerable to warm temperatures and wet conditions during the peak of El Niño, although this risk was less coherent than historical risks identified in other parts of Africa. During the 2015/16 event there has not been a consistent signal in central Africa, although countries such as the Democratic Republic of Congo have experienced some heavy rainfall and flooding during the peak of El Niño in DJF 2015/16.

3.5 MENA – Middle East and North Africa

Analysis of past El Niño events identified that the Middle East and North Africa (MENA) was vulnerable to cold temperatures and wet conditions during the peak of El Niño. In general the MENA region has been warmer and drier than during past historical events although anomalously wet conditions were observed in the Middle East prior to the peak of El Niño[5], which was in agreement with impacts from past El Niño events.

3.6 Indonesia

Analysis of past El Niño events identified that Indonesia was vulnerable to warm, dry conditions during the developing stages of El Niño and warm and wet conditions during the peak of El Niño. These historical risks have materialised with warm dry conditions followed by extreme wet conditions during the El Niño peak[6]. Indonesia is located near to the main El Niño region in the tropical Pacific so we would expect to have more confidence in the 'local' Impact on temperature and rainfall here as compared with 'remote' regions further away such as Europe.

3.7 Southeast Asian Peninsular

Analysis of past El Niño events identified that the Southeast Asian Peninsular was vulnerable to warm temperatures before the El Niño peak and extreme wet conditions during the El Niño peak. The region has indeed been anomalously warm. The wet conditions have materialised in some parts of the region, for example in northern Vietnam as well as in South East China.

3.8 Southern Asia

Analysis of past El Niño events showed that the signal in southern Asia was weaker than in other regions, but that conditions were likely to be warmer and slightly wetter than normal during the El Niño development and peak respectively. The region has indeed been warmer than normal, and, although there was some localised heavy rainfall in July and August 2015, the wet conditions during the El Niño peak have not materialised broadly across the region.

---

5 e.g.: wet conditions in Iraq in October 2015 causing flooding.

6 e.g., extreme wet conditions caused flooding and landslides in Indonesia.

3.9 Caribbean

Analysis of past El Niño events identified that the Caribbean and northern South America were vulnerable to extreme warm and dry conditions during El Niño. The region has indeed been extremely warm and dry[7] during the developing stages of El Niño, as predicted from the historical events. During the El Niño peak the northern Caribbean has been wetter than normal, which was not an impact, highlighted in the historical risk analysis.

3.10 British Overseas Territories

Analysis of past El Niño events identified that the northern subtropical Atlantic was vulnerable to colder and wetter than normal conditions during El Niño, while the signal in the southern subtropical Atlantic was less coherent. The Atlantic hurricane season (Jun-Nov 2015) was predicted to be below normal during the 2015 season. However, the 2015 Atlantic hurricane season was close to average[8]; there were 11 named storms, 4 of which were hurricane strength.

3.11 Southern Europe

Analysis of past El Niño events suggested that southern Europe would potentially experience slightly wetter and warmer and wetter conditions during the developing stages and peak of El Niño respectively. However, due to large distance between Europe and the El Niño region in the tropical Pacific, and the fact that these impacts have not been the same in every past El Niño event there was low confidence in these historical risks. During this 2015/16 event the region has been warmer than normal but there has been no consistent signal in the rainfall.

3.12 Indian Ocean

Analysis of past El Niño events identified that the Indian Ocean was vulnerable to wetter than normal conditions during El Niño. During the 2015/16 event the Indian Ocean has been consistently warmer than normal, although this was not a consistent impact identified in all past events, and wetter than normal but as extreme as was predicted from past events.

3.13 Pacific Ocean

Analysis of past El Niño events identified that the central Pacific was vulnerable to extreme warm temperatures and extreme wet conditions during the developing stages and peak of El Niño. These conditions have indeed materialised. The close proximity of Pacific islands to the El Niño region means that we were able to have high confidence that these impacts would occur during the 2015/16 event.

7 Exacerbating the drought conditions in the region leaving many food-insecure.

8 The 1981-2010 average is 12.1 named storms 6.4 of which are hurricane strength.

3.1 Impact Tables

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016 Mar-16	MAM 2016 AM 2016	JJA 2016	SON 2016	Risk	Evidenced Impacts
Southern Africa	Temperature	Analysis of Past El Niño Events		no consistent signal				no consistent signal			Reduced water availability, reduction in crop yields. Increased risk of drought-related humanitarian disaster.
		Observations and Outlook						no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events		no consistent signal					no consistent signal		
		Observations and Outlook	no consistent signal	no consistent signal		no consistent signal		no consistent signal	X		
South Africa	Temperature	Analysis of Past El Niño Events		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.
		Observations and Outlook						no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events		no consistent signal	E	NE			no consistent signal		
		Observations and Outlook	S	no consistent signal		no consistent signal		no consistent signal	X		
Mozambique	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	S			N	S		Drought, and crop failure leading to potential food shortages.
		Observations and Outlook	N	no consistent signal			no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		
		Observations and Outlook		no consistent signal		N		no consistent signal	X		
Malawi	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal				no consistent signal	no consistent signal		Drought affecting crop productivity.
		Observations and Outlook					no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal	no consistent signal			no consistent signal	no consistent signal		
		Observations and Outlook		no consistent signal	S			no consistent signal	X		
Zambia	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	S						Increase water stress, crops vulnerable to drought. Increase East Coast Fever in cattle.
		Observations and Outlook	E				no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	E	E	no consistent signal	no consistent signal	no consistent signal	E		
		Observations and Outlook	no consistent signal	no consistent signal	S	no consistent signal	no consistent signal	no consistent signal	X		
Zimbabwe	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal				no consistent signal			Drought leads to significantly reduced Maize yield.
		Observations and Outlook	no consistent signal				no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal		no consistent signal	no consistent signal		no consistent signal		
		Observations and Outlook	no consistent signal	no consistent signal	E	no consistent signal	no consistent signal	no consistent signal	X		

University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

Table 1 Southern Africa

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
West Africa	Temperature	Analysis of Past El Niño Events		no consistent signal				no consistent signal	no consistent signal		Risk of drought and reduced crop productivity. Drought-related migration leading to increased disease risk.
		Observations and Outlook		no consistent signal	N		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events									
		Observations and Outlook		no consistent signal	S	S	S	S	X		
Nigeria	Temperature	Analysis of Past El Niño Events	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.
		Observations and Outlook	E	no consistent signal	N		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	N	no consistent signal	S			no consistent signal		
		Observations and Outlook	S	no consistent signal	S	N		S	X		
Ghana	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	S			no consistent signal	no consistent signal		Significantly less rain in May-Jun major rains. Reduced water availability and drought.
		Observations and Outlook		no consistent signal	N			no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	S	no consistent signal		S		S	no consistent signal		
		Observations and Outlook	S	no consistent signal	S	S			X		
Sierra Leone	Temperature	Analysis of Past El Niño Events		no consistent signal		no consistent signal	no consistent signal	no consistent signal	no consistent signal		Some risk of drought. Reduced Rice and Maize crop yields.
		Observations and Outlook			no consistent signal		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal		no consistent signal	no consistent signal	no consistent signal	no consistent signal		
		Observations and Outlook		no consistent signal	no consistent signal				X		

University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

Table 2 West Africa

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
East Africa	Temperature	Analysis of Past El Niño Events		no consistent signal					no consistent signal		Risk of flooding causing damage to infrastructure and displacement of people. Increase risk of Rift Valley Fever, Malaria and Cholera.
		Observations and Outlook						no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events				no consistent signal	no consistent signal				
		Observations and Outlook		no consistent signal				no consistent signal	X		
Ethiopia	Temperature	Analysis of Past El Niño Events						no consistent signal	no consistent signal		Risk of flooding causing displacement of people. Increase incidence of Rift Valley Fever, Malaria and Cholera.
		Observations and Outlook			E	NE	E	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	E		no consistent signal	no consistent signal		W		
		Observations and Outlook	N				no consistent signal	no consistent signal	X		
South Sudan	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	SE	SE		no consistent signal	no consistent signal		Flooding affecting infrastructure and access to basic relief for vulnerable people.
		Observations and Outlook					no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal	SE						
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal		no consistent signal	S	X		
Kenya	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	no consistent signal	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.
		Observations and Outlook	no consistent signal		E		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal			no consistent signal	no consistent signal		no consistent signal		
		Observations and Outlook	W	no consistent signal			E	E	X		
Uganda	Temperature	Analysis of Past El Niño Events	no consistent signal	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.
		Observations and Outlook			no consistent signal		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal			no consistent signal	no consistent signal				
		Observations and Outlook		no consistent signal					X		

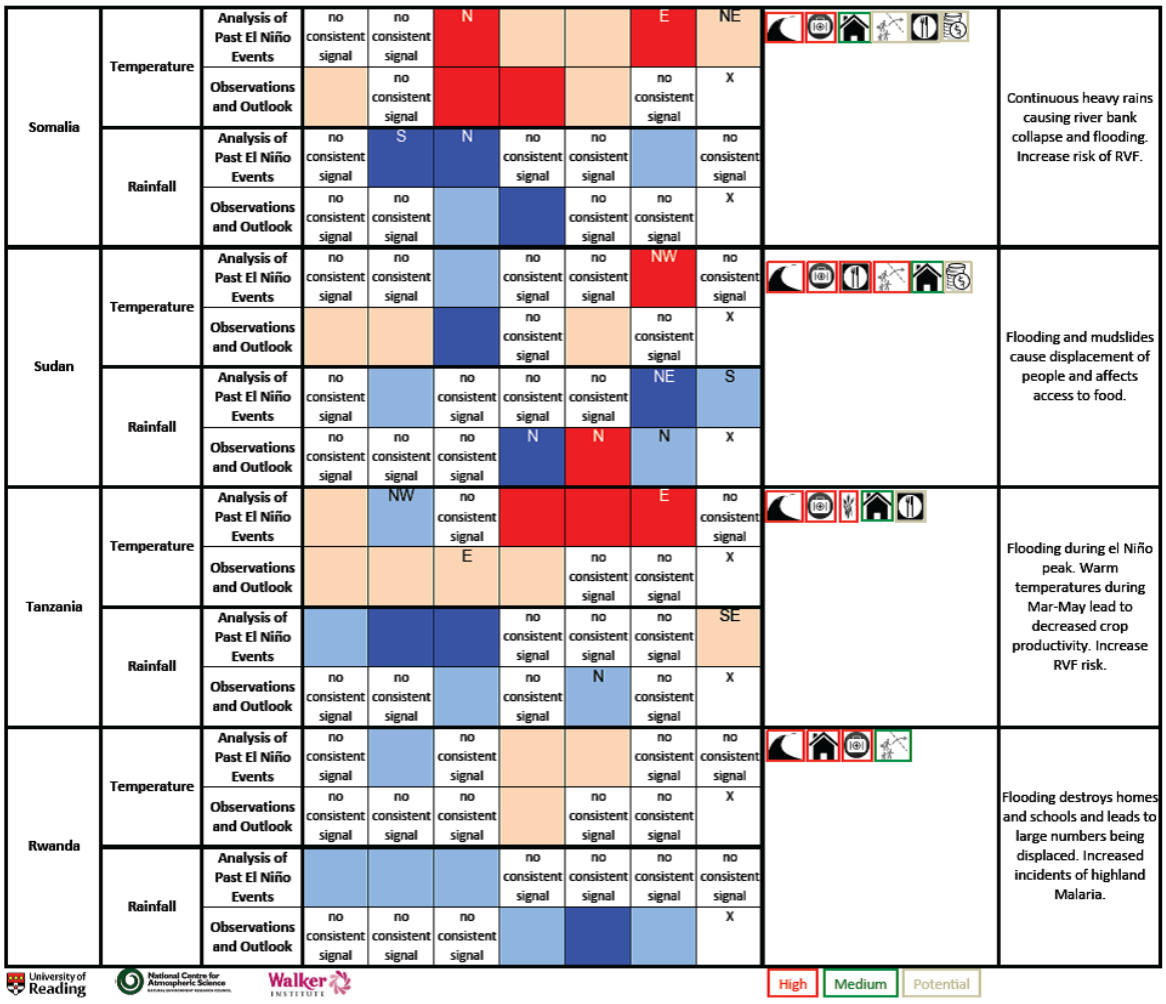


Table 3 East Africa

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016 Mar-16	MAM 2016 AM 2016	JJA 2016	SON 2016	Risk	Evidenced Impacts
Central Africa	Temperature	Analysis of Past El Niño Events	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.
		Observations and Outlook			no consistent signal		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events				no consistent signal	no consistent signal		no consistent signal		
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	X		
Democratic Republic of Congo	Temperature	Analysis of Past El Niño Events	no consistent signal	S				no consistent signal	no consistent signal		
		Observations and Outlook			no consistent signal		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	SE	no consistent signal	no consistent signal	no consistent signal	no consistent signal	S	N		
		Observations and Outlook	NW	no consistent signal	no consistent signal	no consistent signal	E	no consistent signal	X		

University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

Table 4 Central Africa

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
MENA	Temperature	Analysis of Past El Niño Events		no consistent signal		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.
		Observations and Outlook	no consistent signal	no consistent signal		no consistent signal	no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal								
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal			no consistent signal	X		
Libya	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	no consistent signal			W	no consistent signal		
		Observations and Outlook	no consistent signal		S	no consistent signal	no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal		no consistent signal	no consistent signal	no consistent signal		N		
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal	no consistent signal		no consistent signal	X		
Egypt	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	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.
		Observations and Outlook			S	no consistent signal	no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal		N	N		E	N		
		Observations and Outlook	no consistent signal		no consistent signal	S			X		
Algeria	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal		no consistent signal	no consistent signal	S	no consistent signal		Affected by reduced crop productivity and drought.
		Observations and Outlook	no consistent signal				no consistent signal		X		
	Rainfall	Analysis of Past El Niño Events	W	E	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		
		Observations and Outlook	S	no consistent signal	no consistent signal	no consistent signal	SE	W	X		
Lebanon	Temperature	Analysis of Past El Niño Events		no consistent signal	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.
		Observations and Outlook	no consistent signal		no consistent signal		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal								
		Observations and Outlook	no consistent signal		no consistent signal	no consistent signal			X		
Jordan	Temperature	Analysis of Past El Niño Events	E	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		Flash flooding experienced before el Niño peak.
		Observations and Outlook	no consistent signal		no consistent signal		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal								
		Observations and Outlook	no consistent signal		no consistent signal	no consistent signal			X		

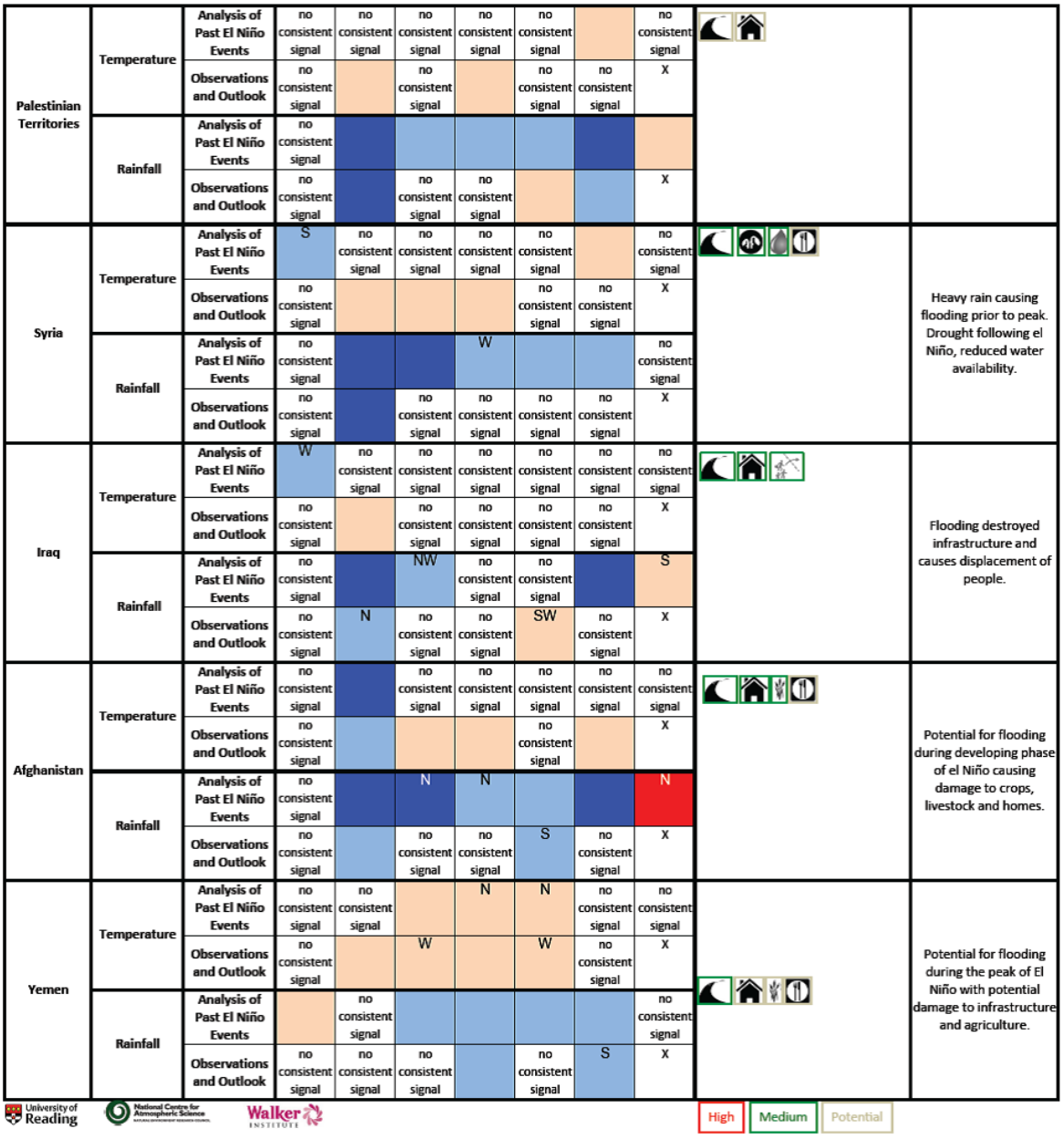


Table 5 MENA – Middle East and North Africa

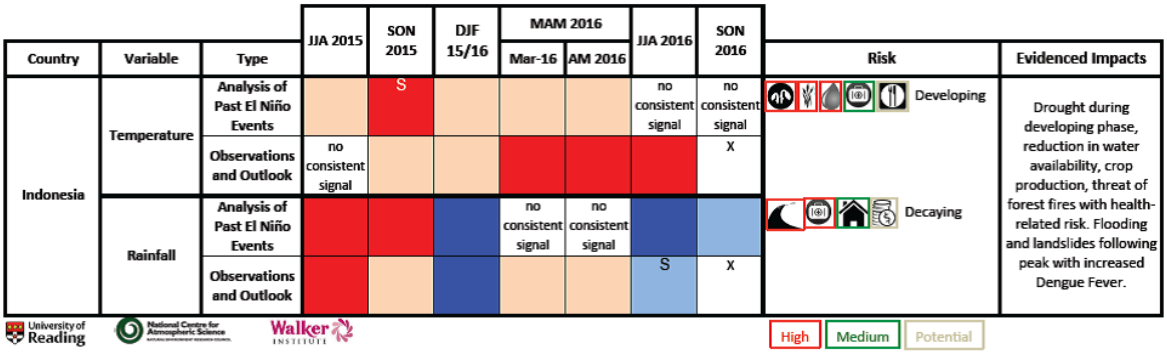


Table 6 Indonesia

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
Southeast Asian Peninsular	Temperature	Analysis of Past El Niño Events	no consistent signal		no consistent signal						Increased risk of drought and forest fires. Reduced crop productivity.
		Observations and Outlook			no consistent signal				X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal				no consistent signal	no consistent signal		
		Observations and Outlook		no consistent signal					X		
China	Temperature	Analysis of Past El Niño Events	SE	no consistent signal	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.
		Observations and Outlook	no consistent signal	S	no consistent signal	W	SE		X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	SE	SE	N		SE	N		
		Observations and Outlook	no consistent signal	S	SE	S		no consistent signal	X		
Vietnam	Temperature	Analysis of Past El Niño Events	no consistent signal			no consistent signal	no consistent signal	N			Increase incidences of forest fire and smoke-related deaths.
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal				X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal	N			N	no consistent signal		
		Observations and Outlook			N				X		
Myanmar (Burma)	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	no consistent signal	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.
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal	no consistent signal	S	S	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	no consistent signal	no consistent signal	S		no consistent signal	NW		
		Observations and Outlook	no consistent signal		no consistent signal	no consistent signal	S	S	X		

University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

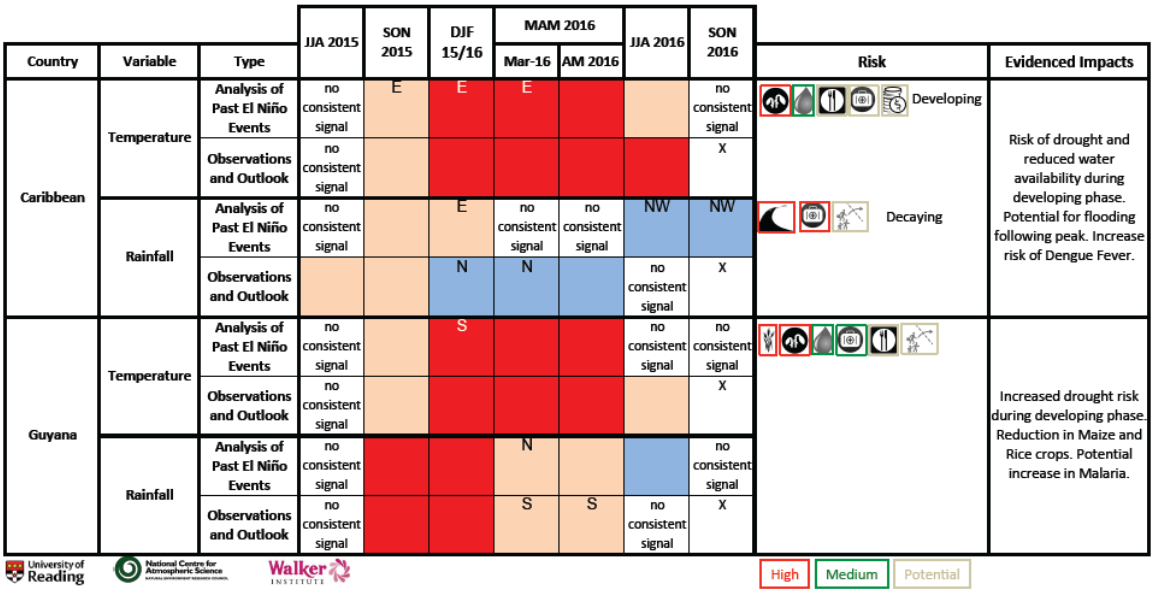
Table 7 Southeast Asian Peninsular

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
Southern Asia	Temperature	Analysis of Past El Niño Events		no consistent signal	no consistent signal	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.
		Observations and Outlook						no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events		no consistent signal		no consistent signal	no consistent signal	no consistent signal		Decaying	
		Observations and Outlook		no consistent signal	no consistent signal		no consistent signal	no consistent signal	X		
India	Temperature	Analysis of Past El Niño Events	N	S	no consistent signal	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.
		Observations and Outlook	S		N	S	S	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	N	no consistent signal		no consistent signal	no consistent signal	S			
		Observations and Outlook	SW		no consistent signal		no consistent signal		X		
Pakistan	Temperature	Analysis of Past El Niño Events			no consistent signal	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.
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal		no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	N			no consistent signal	no consistent signal		NE		
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	X		
Bangladesh	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal		no consistent signal	no consistent signal	no consistent signal			Drought risk in developing phase. Increase Cholera risk after peak.
		Observations and Outlook	no consistent signal			no consistent signal	no consistent signal		X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal		no consistent signal			no consistent signal			
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal			no consistent signal	X		
Nepal	Temperature	Analysis of Past El Niño Events	no consistent signal		no consistent signal	no consistent signal	no consistent signal	no consistent signal			
		Observations and Outlook					no consistent signal		X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal		no consistent signal	no consistent signal	no consistent signal	no consistent signal			
		Observations and Outlook	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	X		

University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

Table 8 Southern Asia

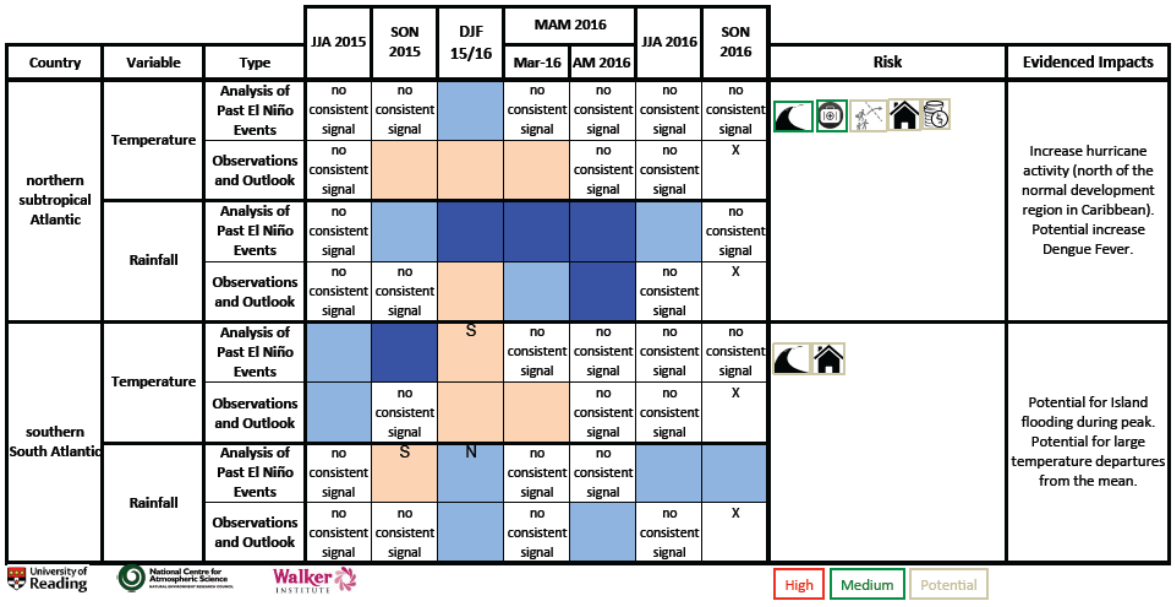


Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
Caribbean	Temperature	Analysis of Past El Niño Events	no consistent signal	E	E	E			no consistent signal	Developing	Risk of drought and reduced water availability during developing phase. Potential for flooding following peak. Increase risk of Dengue Fever.
		Observations and Outlook	no consistent signal						X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal		E	no consistent signal	no consistent signal	NW	NW	Decaying	
		Observations and Outlook			N	N		no consistent signal	X		
Guyana	Temperature	Analysis of Past El Niño Events	no consistent signal		S			no consistent signal	no consistent signal		Increased drought risk during developing phase. Reduction in Maize and Rice crops. Potential increase in Malaria.
		Observations and Outlook	no consistent signal						X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal			N			no consistent signal		
		Observations and Outlook	no consistent signal			S	S	no consistent signal	X		

University of Reading · National Centre for Atmospheric Science · Walker Institute

High · Medium · Potential

Table 9 Caribbean



Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
northern subtropical Atlantic	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal		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.
		Observations and Outlook	no consistent signal				no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal						no consistent signal		
		Observations and Outlook	no consistent signal	no consistent signal				no consistent signal	X		
southern South Atlantic	Temperature	Analysis of Past El Niño Events			S	no consistent signal	no consistent signal	no consistent signal	no consistent signal		Potential for Island flooding during peak. Potential for large temperature departures from the mean.
		Observations and Outlook		no consistent signal			no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal	S	N	no consistent signal	no consistent signal				
		Observations and Outlook	no consistent signal	no consistent signal		no consistent signal		no consistent signal	X		

University of Reading · National Centre for Atmospheric Science · Walker Institute

High · Medium · Potential

Table 10 British Overseas Territories

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
Southern Europe	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal		no consistent signal	no consistent signal	no consistent signal	no consistent signal		
		Observations and Outlook		no consistent signal			no consistent signal	no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events			no consistent signal	no consistent signal	no consistent signal		no consistent signal		
		Observations and Outlook	no consistent signal	no consistent signal		no consistent signal	no consistent signal	no consistent signal	X		

University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

Table 11 Southern Europe

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
Central Indian Ocean	Temperature	Analysis of Past El Niño Events	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal		
		Observations and Outlook						no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal		no consistent signal				no consistent signal		
		Observations and Outlook	no consistent signal					no consistent signal	X		

University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

Table 12 Indian Ocean

Country	Variable	Type	JJA 2015	SON 2015	DJF 15/16	MAM 2016		JJA 2016	SON 2016	Risk	Evidenced Impacts
						Mar-16	AM 2016				
Central Pacific	Temperature	Analysis of Past El Niño Events						no consistent signal	no consistent signal		Increase risk of flooding during the peak for Islands in the South Pacific Convergence.
		Observations and Outlook						no consistent signal	X		
	Rainfall	Analysis of Past El Niño Events	no consistent signal			no consistent signal	no consistent signal	no consistent signal	no consistent signal		
		Observations and Outlook						no consistent signal	X		

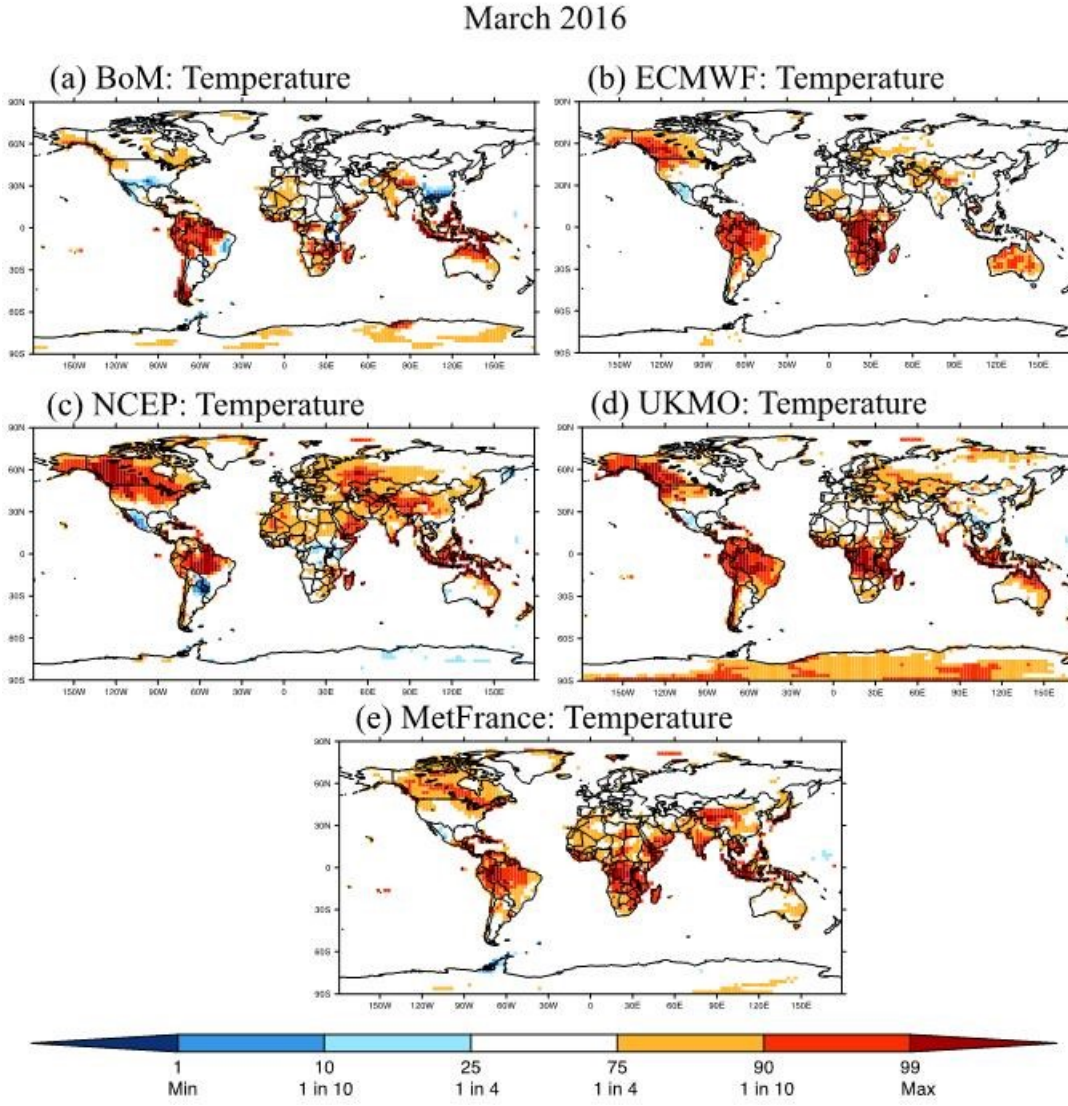
University of Reading | National Centre for Atmospheric Science | Walker Institute

High | Medium | Potential

Table 13 Pacific Ocean

Annex 1 Forecast Maps

Figure A1.1 Forecast percentile maps for the 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 February 2016 and are compared to the observations for the period from March 1st 2016 to the end of the forecast (see section A2.1 for exact details for each model).



EVIDENCE ON DEMAND
CLIMATE & ENVIRONMENT
INFRASTRUCTURE | LIVELIHOODS

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 February 2016 and are compared to the observations for the period from March 1st 2016 to the end of the forecast (see section A2.1 for exact details for each model).

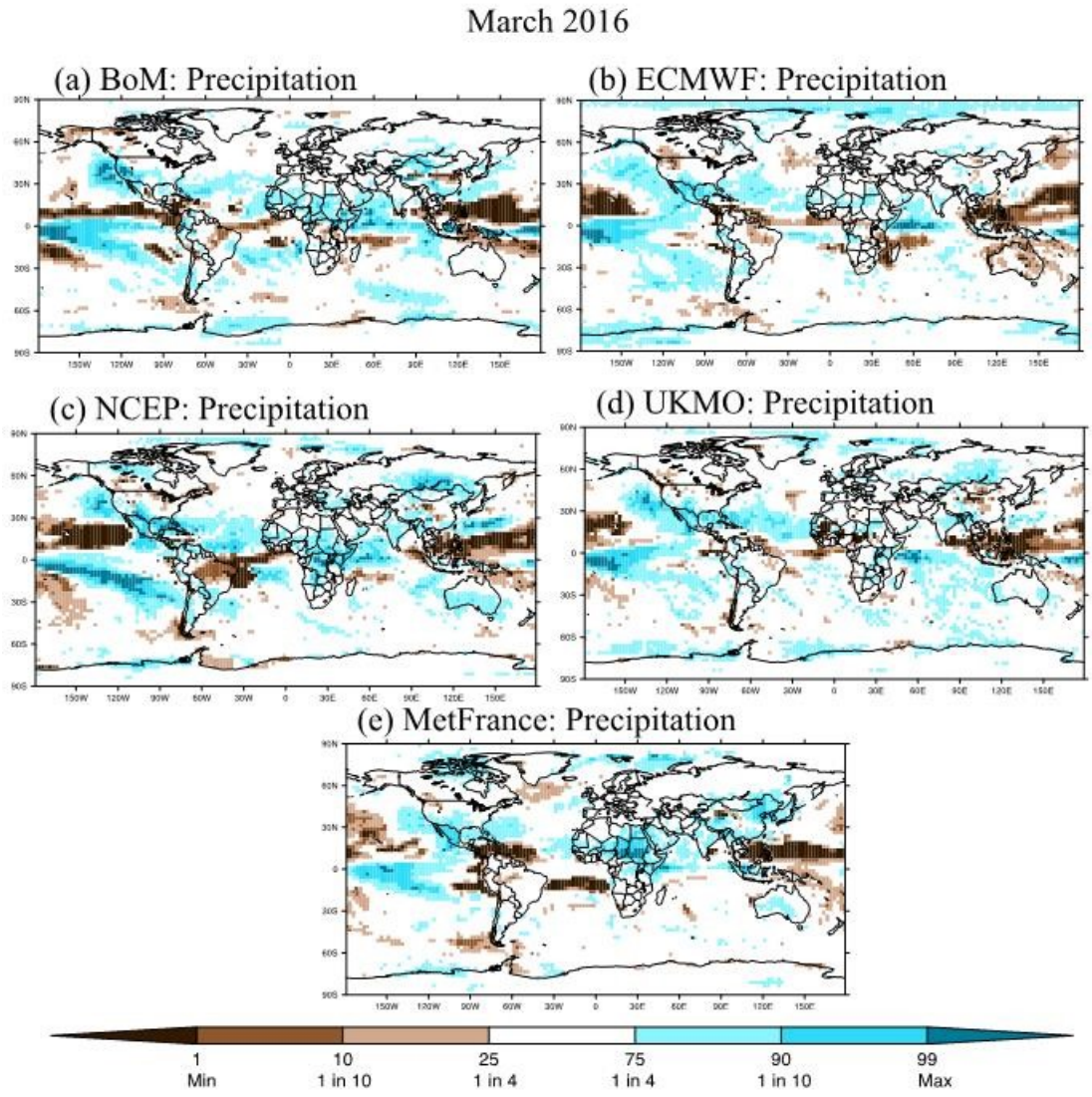
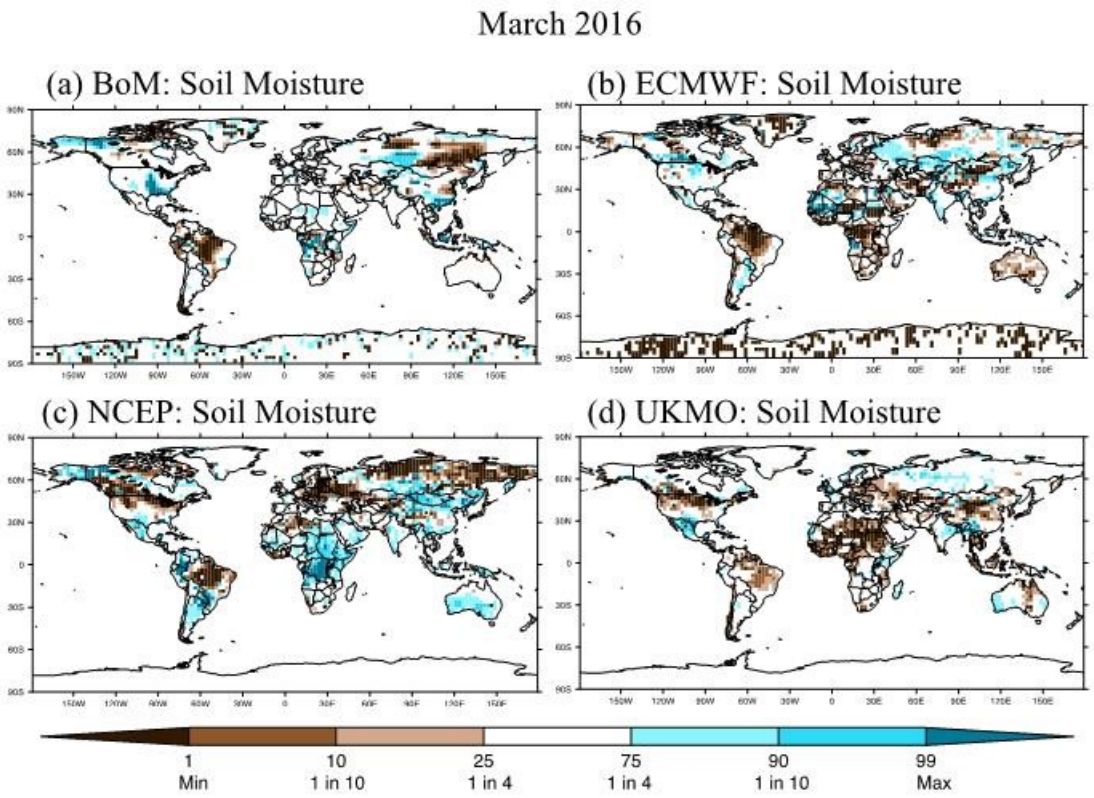


Figure A1.3 Forecast percentile maps for Soil Moisture. Blue colours show areas likely to be wetter than normal, brown colours show areas likely to be drier (see explanation in section 2.1-2.2). These maps are based on forecasts from February 2016 and are compared to the observations for the period from March 1st 2016 to the end of the forecast (see section A2.1 for exact details for each model).



EVIDENCE ON DEMAND
CLIMATE & ENVIRONMENT
INFRASTRUCTURE | LIVELIHOODS

Figure A1.4: As Figures A1.1-A1.3, but forecast percentile maps for Temperature, Rainfall and Soil Moisture from NCEP and UKMO for April –May 2016 (months 2-3 of the extended-range forecast).

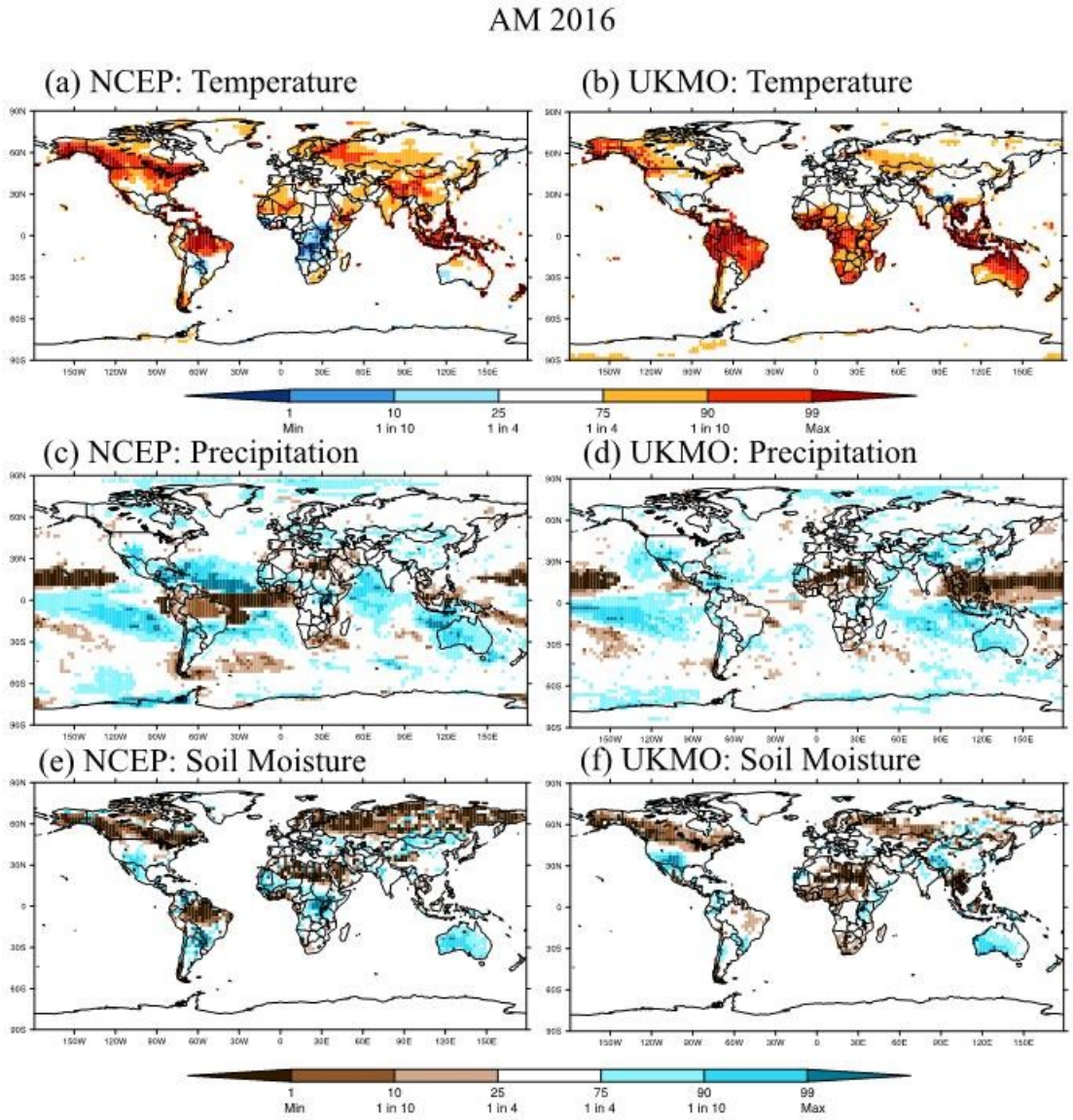
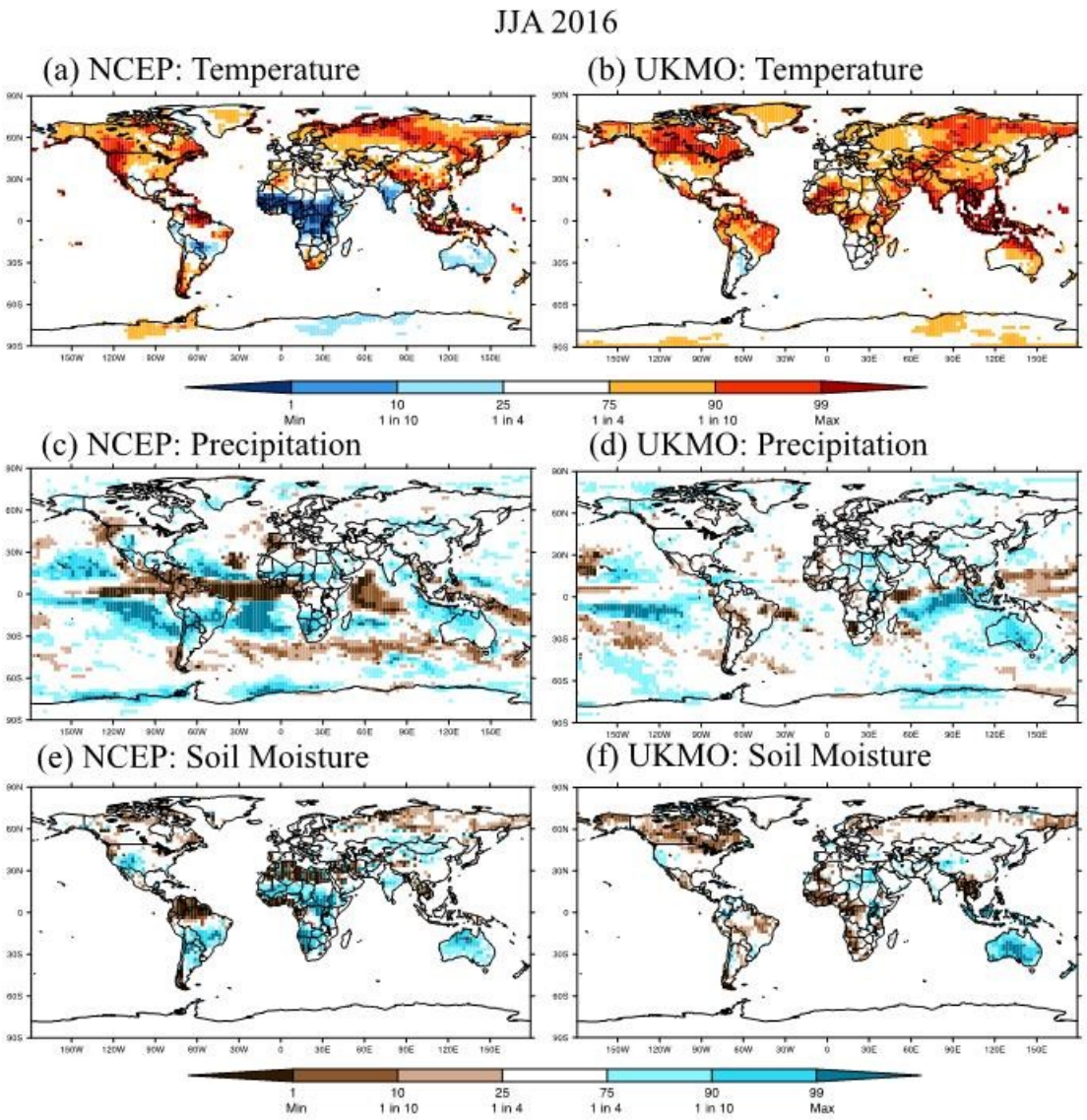


Figure A1.5: As Figures A1.1-A1.3, but forecast percentile maps for Temperature, Rainfall and Soil Moisture from NCEP and UKMO for June-August 2016 (month 4-6 of the extended-range forecast).



EVIDENCE ON DEMAND
CLIMATE & ENVIRONMENT
INFRASTRUCTURE | LIVELIHOODS

Annex 2 Detailed Technical Methodology

A2.1: Data

The current tables are based on forecasts made in January 2016. 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, spilt by those models from which only the monthly forecast data is available (BoM, ECMWF and MetFrance) and those which have an extended-range forecast available for the next 6 months (NCEP, UKMO).

Monthly forecast data:

BoM forecasts are updated twice per week and run for 60 days. The forecasts are bias-corrected using hindcasts for 1st February with 33 ensemble members for the period from 1981-2013.
Current forecast start date: 31st January 2016 with 33 ensemble members.

ECMWF forecasts are updated twice per week and run for 46-days. The forecasts are bias-corrected using hindcasts for 1st February 2016 with 11 ensemble members for the period from 1996-2015.
Current forecast start date: 1st February 2016 with 51 ensemble members.

MetFrance forecasts are updated once per month and run for 60-days. The forecasts are bias-corrected using hindcasts for 1st February 2016 with 15 ensemble members for the period from 1993-2014.
Current forecast start date: 1st February 2016 with 51 ensemble members.

Extended-range seasonal forecast data:

NCEP : The hindcast period available, from which the forecast anomalies are calculated, is 1982-2010. For the hindcast, there is one start date (15th February 2016), with 4 ensemble members per day.
Current forecast period is 15th February 2016 – 20th February 2016 with 7 ensemble members per day for 6 days (total 42 ensemble members).

UKMO: The hindcast period, from which the forecast anomalies are calculated, is 1996-2009. For the hindcast, there are five start dates (17th, 25th February 2016 and 1st, 9th March 2016), with 2 ensemble members per start date.
Current forecast period is 11th – 21st February 2016 with 2 ensemble members per day for 10 days (total 20 ensemble members).

Observational data for past seasons:

Observational data was used to analyse what has been observed over previous seasons (JJA 2015, SON 2015 and DJF 2015/16). For Rainfall monthly data from the Global Precipitation Climatology Project (GPCP), Climate Prediction Centre Merged Analysis of Precipitation (CMAP) and Global Historical Climatology Network (GHCN) was used. For Temperature monthly data from GHCN and the Hadley Centre of the UK Met Office Climate Research Unit (HadCRUT) was used. These were compared with Rainfall, Temperature and Soil Moisture from the NCEP/NCAR Reanalysis.

A2.2 Methodology

To produce the forecast outlook information 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[9]. 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 have been used to make the final tables and maps. Only forecast information from 1st March 2016 onwards is shown on the monthly outlook maps. For example, for BoM forecasts - with a start date of 31st January- only information from March 1st onwards is used to create the forecast map shown in A1.1-A1.3.

CPC/IRI consensus forecast: http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/

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