La Niña 2016/2017 Historical Impact Analysis

Linda Hirons and Nicholas Klingaman

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SECTION 1

Introduction

El Niño conditions developed in the tropical Pacific during the latter half of 2015, peaking in December 2015 as one of the strongest El Niño events on record, comparable with the 1997-98 "El Niño of the century". Conditions in the tropical Pacific are forecast to return to normal over the coming months (section 3), with the potential to transition into La Niña conditions (section 2.2, 3) during 2016-17. If this was to occur it would act as a further strong perturbation, or 'kick', to the climate system and lead to further significant socio-economic impacts affecting many sectors such as infrastructure, agriculture, health and energy. This report analyses La Niña events over the last 37 years of the satellite era (1979-present) and aims to identify regions where there is an increased likelihood of impacts occurring.

It is important to note that this analysis is based on past analogous events and is not a prediction for this year. No two La Niña events will be the same – the timing and magnitude of events differs considerably (Figures 1 and 2). More importantly, no two La Niña events lead to the same impacts – other local physical and social factors come into play. Therefore, the exact timings, locations and magnitudes of impacts should be interpreted with caution and this should be accounted for in any preparedness measures that are taken.

SECTION 2

What are El Niño and La Niña and what can we expect this year?

2.1 Description of El Niño and La Niña

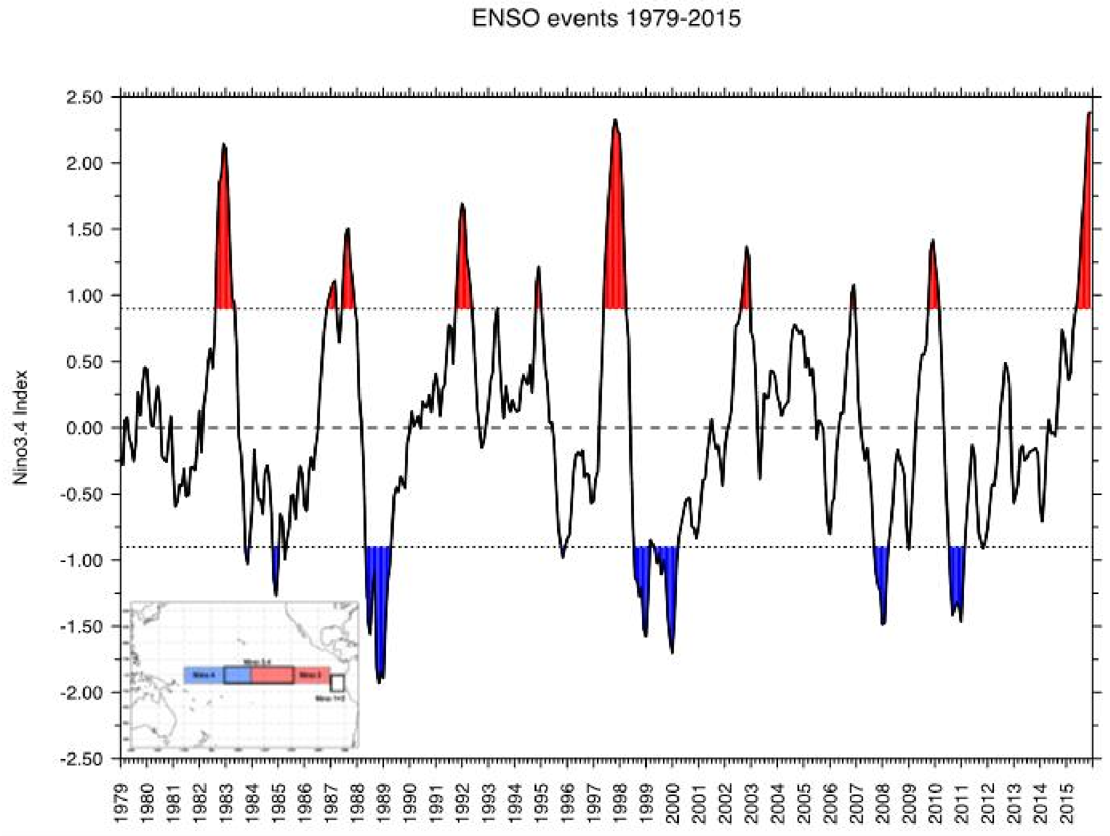
The El Niño-Southern Oscillation (ENSO) is one of the most important phenomena in the Earth's climate system. It describes the year-to-year variations in ocean temperatures in the tropical Pacific. These variations influence weather patterns in the tropics but also have impacts on a global scale.

ENSO has three states - El Niño, La Niña and Neutral - described by the cycle between above and below normal sea-surface temperatures (SSTs) in the equatorial central and eastern Pacific. An El Niño state occurs when the SSTs in the central and eastern Pacific are substantially warmer than normal (red shading in Figure 1; e.g., 1997-98). Conversely, a La Niña state occurs when the SSTs are substantially colder than normal (blue shading in Figure 1; e.g., 1988-89). La Niña conditions often, but not always, follow El Niño conditions (Figure 1 and 2). Neutral conditions refer to the state when neither El Niño nor La Niña is occurring and the SSTs in the equatorial Pacific are close to average (e.g., 2003-05). Several years of Neutral conditions can persist between La Niña and El Niño events.

El Niño and La Niña events tend to develop between April and June and tend to reach their maximum strength (or peak) during December to February. An event typically persists for 9-12 months and typically recurs approximately every 2-7 years (see Figure 1 for recent events from 1979-2015).

ENSO has significant impacts on global weather and climate (section 4). It is a slowly evolving climate phenomenon, the peak of which can be predicted months in advance. Therefore, understanding its global impacts is crucial in providing early advice and warning to regions of the globe likely to be vulnerable to those impacts.

Figure 1: *Observed ENSO events defined by SST anomalies in the Niño 3.4 region (see insert)[1] in the Pacific. The dotted line shows ± one standard deviation from the mean used to define El Niño and La Niña events. El Niño events, associated with warmer-than-normal SSTs in the Pacific, are shown in red (1982-83, 1986-87, 1991-92, 1994-95, 1997-98, 2002, 2006, 2009-10, 2015-16). La Niña events, associated with colder-than-normal SSTs in the Pacific are shown in blue (1983, 1984-85, 1988-89, 1995, 1998-99, 1999-2000, 2007-08, 2010-11).*



2.2 Do all El Niño events transition into La Niña events?

As is clear from Figure 1, strong La Niña conditions (blue shading) often, but not always, follow strong El Niño conditions (red shading). Between 1950 and 2015 three quarters of El Niño events were followed by La Niña conditions[2]. Figure 3 shows the progression of the last 8 strong El Niño events in the satellite era (1979-present). 6 out of the 8 events transition into La Niña conditions the following year.

The strongest amplitude El Niño events do not necessarily lead to the strongest amplitude La Niña events; for example, the strongest La Niña on record followed the 1987-88 El Niño, which was only of moderate amplitude (blue line, Figure 2). Conversely, one of the strongest El Niños on record in 1987-88 led to a very weak La Niña event the following year (red line, Figure 2). After the El Niño events in 1992 (orange line, Figure 2) and 2003 (green line, Figure 2), the central and eastern Pacific returned to neutral conditions rather than transitioning into a La Niña state.

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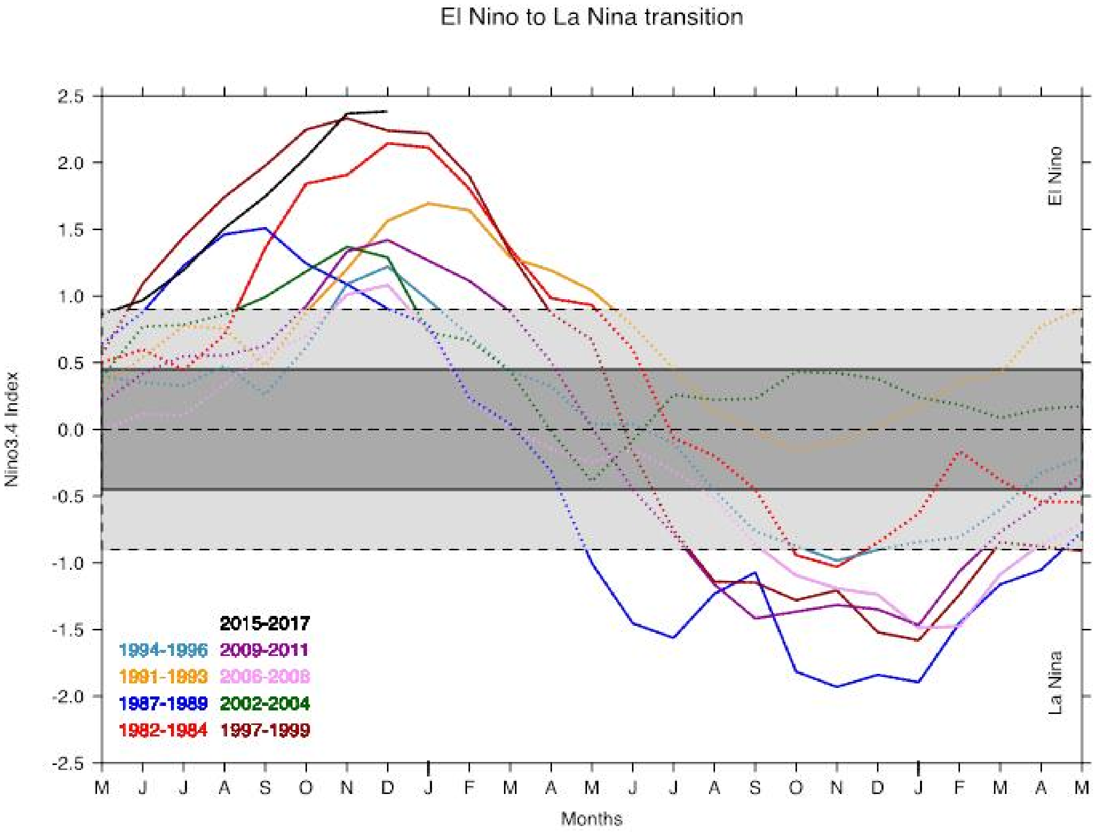
[1] The Niño 3.4 region in the Pacific is defined as [5°N-5°S, 120°-170°W], and is the most commonly used index to measure ENSO.

[2] There were 12 strong El Niño events between 1950-2015 of which 3 didn’t transition into La Niña conditions. Here strong events are defined as at least one standard deviation from the mean Niño 3.4 index using Extended Reconstructed SST (ERSST) version 4 data from the National Oceanic and Atmospheric Administration (NOAA).

Figure 2: *Transition of El Niño events from 1979-2015 defined by SST in the Niño 3.4 region in the Pacific. Solid lines of positive Niño 3.4 index (top of plot; above grey region) represent El Niño conditions. Solid lines of negative Niño 3.4 index (bottom of plot; below grey region) represent La Niña conditions. The dashed lines (within the grey regions) show neutral conditions in the Pacific.*



6 out of the 8 El Niño events since 1979 have transitioned to La Niña conditions.

SECTION 3

Monitoring: Summary of current forecasts

To understand the context of the potential meteorological and socio-economic impacts, it is important to monitor the weakening El Niño and potential transition to La Niña conditions in the Pacific. There are many modeling centres around the world doing exactly this. Below is a summary of the current forecasts of ENSO over the coming months. The International Research Institute for Climate and Society (IRI; section 3.1) provides a multi-model forecast which consists of 15 dynamical models[3] and 8 statistical models[4]. This forecast gives an idea of whether different types of models from different modelling centres agree what will happen over the coming months and seasons. One of the IRI dynamical models known to be more accurate is the European Centre for Medium Range Weather Forecasts (ECMWF) model. Therefore, the current ensemble forecast from ECMWF is also summarised below (section 3.2).

3.1 International Research Institute for Climate and Society (IRI)

El Niño conditions are forecast to continue in the first half of 2016, although SST anomalies are currently weakening, having peaked in Nov-Dec 2015. The El Niño is forecast to dissipate to neutral conditions by late spring or early summer 2016 with a possible transition into La Niña conditions forecast in Autumn 2016.

On average, the models are predicting that the El Niño conditions will continue to weaken towards neutral conditions, with a change from positive to negative SST anomalies in the Pacific occurring during Jun-Aug 2016. On average, the dynamical models predict a transition into La Niña conditions occurring in Sep-Nov 2016; the statistical models also predict a transition to La Niña conditions but that it will occur slightly later in Oct-Dec 2016.

On average, the models predict that neutral conditions are more likely than El Niño conditions by May-Jul 2016 and that La Niña conditions are more likely than neutral conditions from Aug-Oct 2016.

One of the more accurate dynamical models included in the IRI forecast is the ECMWF model. It is predicting that El Niño conditions will weaken over the next 5 months and that SST anomalies in the Pacific will become weakly negative in Jun-Aug 2016 (-0.2 degrees).

3.2 European Centre for Medium Range Weather Forecasts (ECMWF)

El Niño has peaked and will weaken to neutral conditions by late spring or early summer with the potential of transitioning to La Niña conditions.

ECMWF runs 51 forecasts every month to sample the uncertainty in the developing conditions. All the February forecasts anticipate a weakening of the warm SST anomalies in

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[3] A dynamical model is a complex mathematical model made up of physical equations that model motion in the atmosphere and ocean.

[4] A statistical model is a simple model based on statistical relationships or predictors that have been observed in the real world.

the central and eastern Pacific towards neutral conditions. All 51 February forecasts show neutral or La Niña conditions by August 2016 in the Niño 3.4 region. In the Niño 3 region in the eastern Pacific[5] 8 (~16%) forecasts predict continued weak El Niño conditions by August 2016, 8 (~16%) predict a transition into La Niña conditions by August 2016 and the remaining 35 forecasts (~68%) are predicting neutral conditions by August 2016 in the eastern Pacific.

This is consistent with the IRI forecasts above that predict that the transition to La Niña conditions will occur later in the year.

Current observations[6] of the heat content in the upper Pacific Ocean show that it has been decreasing considerably since November 2015. This observational information matches the forecasts described above: that the Pacific is currently transitioning to neutral conditions.

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[5] See insert in Figure 1 for definition of all Niño regions.

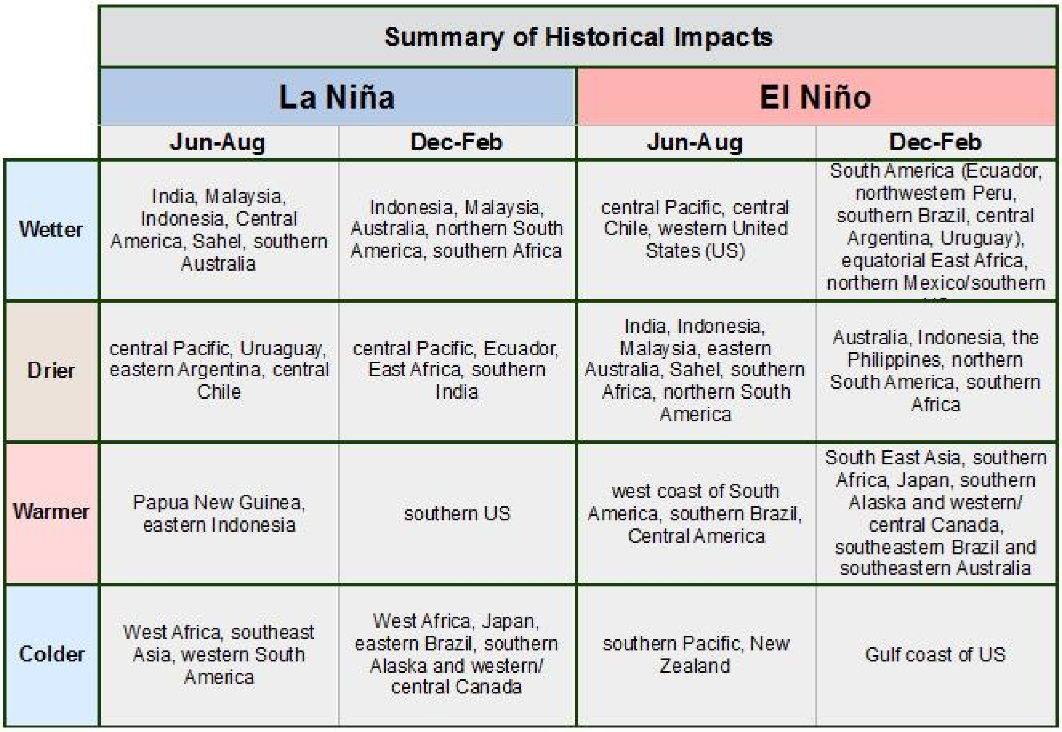
[6] from the NCEP (National Centre of Environmental Prediction) Global Ocean Data Assimilation System (GODAS). *http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_update/heat-last-year.gif*

SECTION 4

Global Impacts of La Niña

4.1 Summary of historical global impacts of La Niña

La Niña conditions (colder than normal conditions in the tropical Pacific) are known to shift global patterns of rainfall and temperature. In general, the global impacts of La Niña can be thought of as opposite to those of El Niño. The known historical global patterns of temperature (colder and warmer than normal) and rainfall (wetter and drier than normal) with La Niña conditions are summarised in Table 1 below for two seasons (Jun-Aug) and (Dec-Feb). These are compared with the historical global impacts of El Niño.



	Summary of Historical Impacts			
	La Niña		**El Niño**	
	Jun-Aug	**Dec-Feb**	**Jun-Aug**	**Dec-Feb**
Wetter	India, Malaysia, Indonesia, Central America, Sahel, southern Australia	Indonesia, Malaysia, Australia, northern South America, southern Africa	central Pacific, central Chile, western United States (US)	South America (Ecuador, northwestern Peru, southern Brazil, central Argentina, Uruguay), equatorial East Africa, northern Mexico/southern
Drier	central Pacific, Uruaguay, eastern Argentina, central Chile	central Pacific, Ecuador, East Africa, southern India	India, Indonesia, Malaysia, eastern Australia, Sahel, southern Africa, northern South America	Australia, Indonesia, the Philippines, northern South America, southern Africa
Warmer	Papua New Guinea, eastern Indonesia	southern US	west coast of South America, southern Brazil, Central America	South East Asia, southern Africa, Japan, southern Alaska and western/ central Canada, southeastern Brazil and southeastern Australia
Colder	West Africa, southeast Asia, western South America	West Africa, Japan, eastern Brazil, southern Alaska and western/ central Canada	southern Pacific, New Zealand	Gulf coast of US

Table 1 Summary of historical global impact of La Niña and El Niño during Jun-Aug and Dec-Feb seasons.

4.2 Global changes in probability of extremes

Figures 4.2 and 4.3 show the probability of changes of extremes in temperature, precipitation and soil moisture during March – November (Figure 4.2) and December – August (Figure 4.3) of an average La Niña event. This analysis is based on 8 observed La Niña events over the last 37 years (1979-present). Extremes here are defined as being in the top (or bottom) 25% of the observed record at that location. ***The maps in Figures 4.2 and 4.3 show where impacts occur and how important they are to that region.*** More detailed, zoomed in maps of Africa (p 18-20), southern Asia (p 21-23) and the Middle East and Northern Africa (MENA; p 24-26) can be found in the supplementary material (SM1).

Figure 4.2: *Global change in the probability of extremes in temperature, precipitation and soil moisture from March-November 2016. Composites are based on averages of 8 observed events over the last 35 years. Colours show the change in the probability of the upper (or lower) quartile during La Niña (e.g., light yellow shows extreme warm temperatures in the upper quartile of the observed record being 1.5-2 times more likely during La Niña).* ***Zoomed in maps are available in the supplementary material (SM1).***

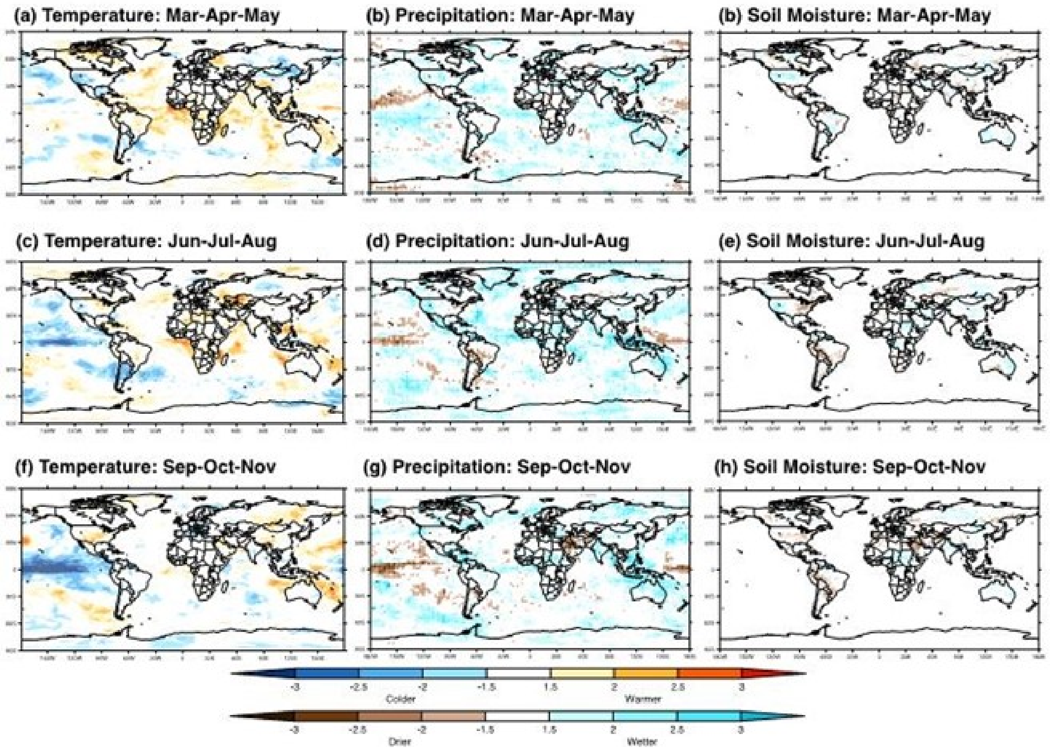
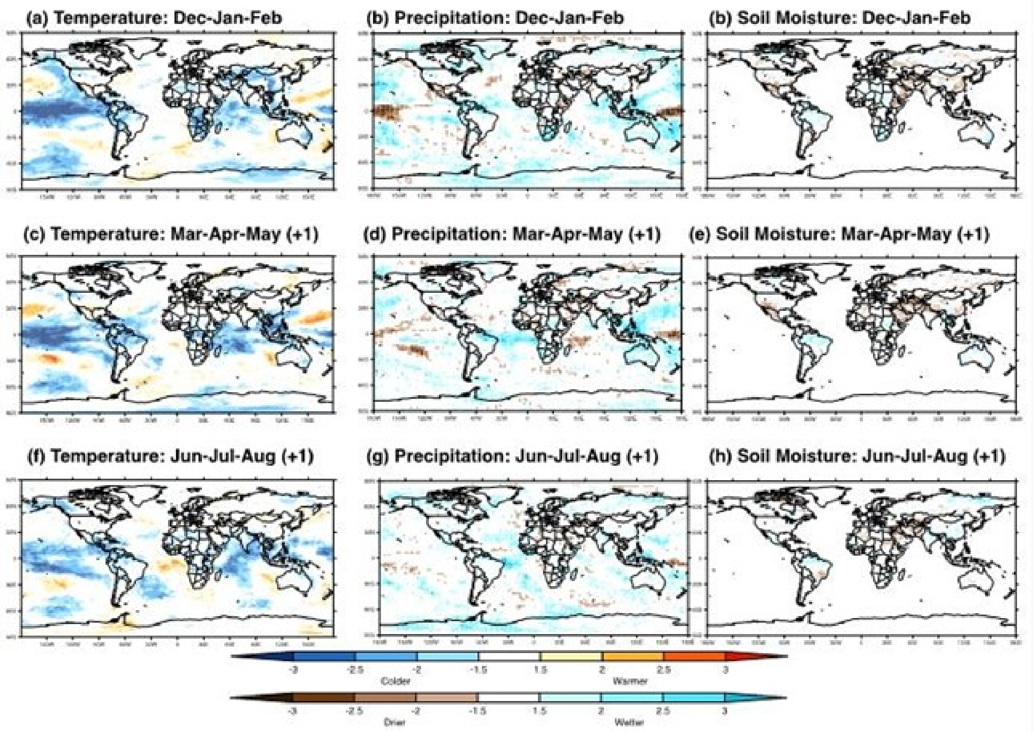


Figure 4.3: *As Figure 4.2, but for December 2015-August 2016.* ***Zoomed in maps available in SM1.***



SECTION 5

Impact Tables

5.1 Introduction

Evidence from past La Niña events has been used to determine the probability of temperature, soil moisture and rainfall extremes during the 2016-17 event in different DFID high priority regions and countries (Table 5.1) over the next 6 seasons (Mar-May 2016, Jun-Aug 2016, Sep-Nov 2016, Dec-Feb 2016/17, Mar-May 2017, Jun-Aug 2017).

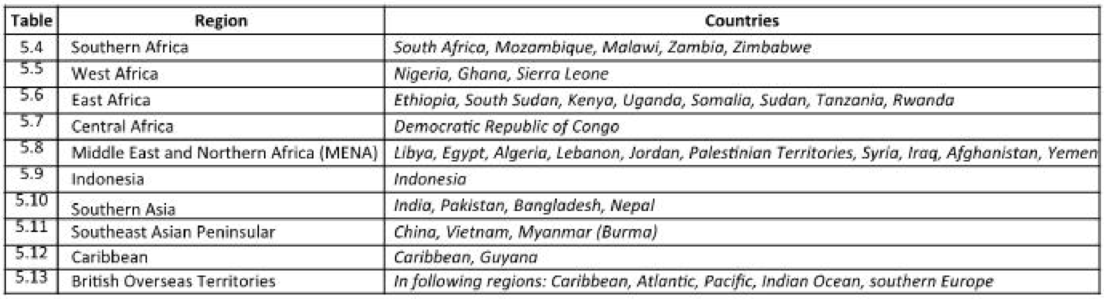


Table	Region	Countries
5.4	Southern Africa	*South Africa, Mozambique, Malawi, Zambia, Zimbabwe*
5.5	West Africa	*Nigeria, Ghana, Sierra Leone*
5.6	East Africa	*Ethiopia, South Sudan, Kenya, Uganda, Somalia, Sudan, Tanzania, Rwanda*
5.7	Central Africa	*Democratic Republic of Congo*
5.8	Middle East and Northern Africa (MENA)	*Libya, Egypt, Algeria, Lebanon, Jordan, Palestinian Territories, Syria, Iraq, Afghanistan, Yemen*
5.9	Indonesia	*Indonesia*
5.10	Southern Asia	*India, Pakistan, Bangladesh, Nepal*
5.11	Southeast Asian Peninsular	*China, Vietnam, Myanmar (Burma)*
5.12	Caribbean	*Caribbean, Guyana*
5.13	British Overseas Territories	*In following regions: Caribbean, Atlantic, Pacific, Indian Ocean, southern Europe*

Table 5.1: Summary of regions and countries covered in the Impact Tables.

5.2 Description of Impact Tables

The Impacts of La Niña on the countries listed in Table 5.1 can be broken down into (a) the Meteorological Impact: the likely impact on the meteorological variables of temperature, soil moisture and rainfall, and (b) the Socio-economic Impact: the evidenced impact that such changes in meteorological variables will have on different sectors. The Meteorological Impacts are shown by the colours in the Impact Tables (see Table 5.2 for full explanation) and the Socio-economic Impacts are represented by colour coded sector symbols (see Table 5.3 for full explanation). These keys can be used to interpret the Impact Tables for each region (Tables 5.4 – 5.13). More detail on the methodology used for the Meteorological and Socio-economic analysis is given below.

(a) Meteorological Impact Analysis

For each country or region, the **likelihood** of temperature and rainfall[7] extremes occurring is shown by the coloured boxes according to the Impact key below (Table 5.2). For example, dark blue colours for temperature – corresponding to “Very Likely Extremely Cold” conditions – can be interpreted as extreme[8] cold conditions in that season, in that country, as being at least twice as likely to occur during La Niña. 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. If there is no consistent signal across that country at all, even regionally, then this is labelled in the tables as ‘no consistent signal’.

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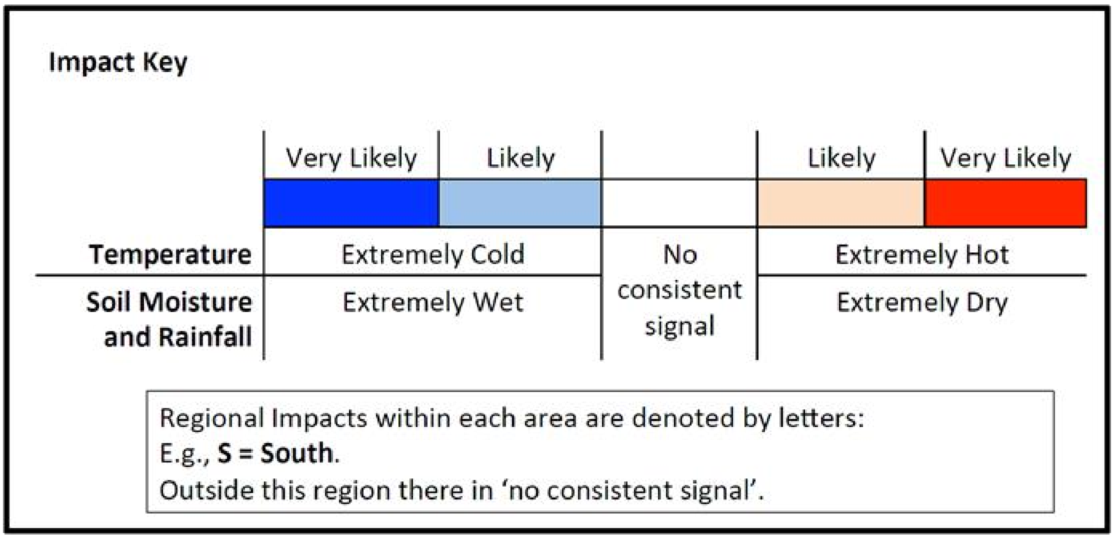
[7] Rainfall in the Impact Tables refers to analysis of both Rainfall **and** Soil Moisture.

[8] 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 Key

	Very Likely	Likely		Likely	Very Likely
	🟦	🟦	⬜	🟧	🟥
Temperature	Extremely Cold		No consistent signal	Extremely Hot	
Soil Moisture and Rainfall	Extremely Wet			Extremely Dry	

Regional Impacts within each area are denoted by letters:
E.g., **S = South.**
Outside this region there in 'no consistent signal'.

Table 5.2: Key for meteorological impacts of temperature, soil moisture and rainfall.

(b) Socio-economic Impact Analysis

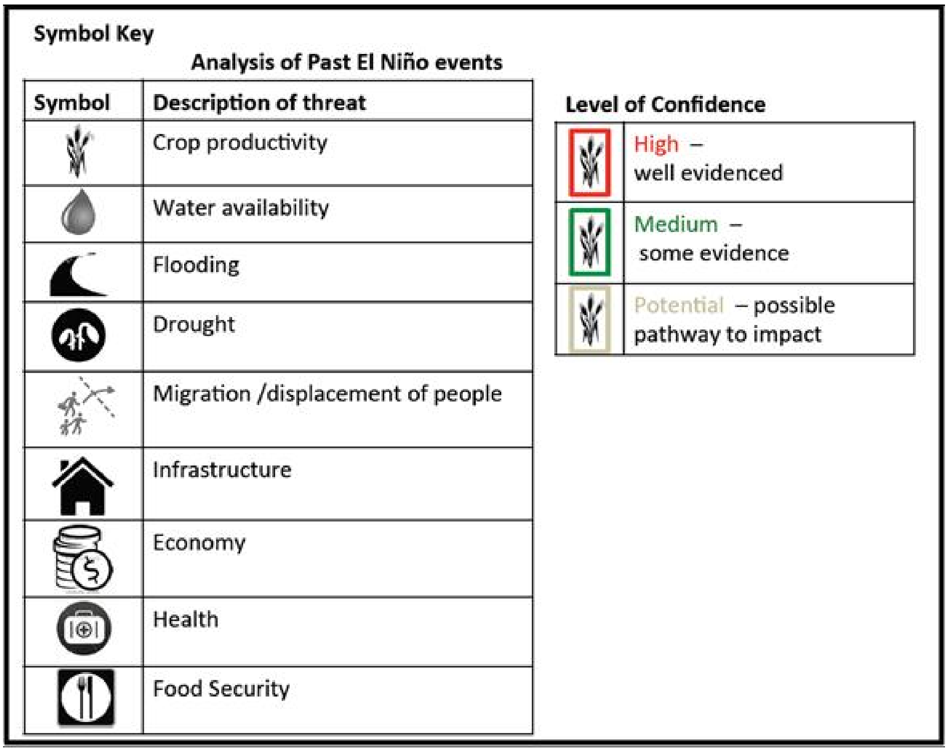
An extensive **literature search** has been carried out. Scientific literature has been reviewed using the *science direct, web of knowledge* and *google scholar* databases. Grey literature and media reports were also analysed *(e.g., NGO reports)*. In addition, specific case study details were analysed 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 in Table 5.3 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 in Table 5.3 below). A full list of the referenced literature used to evidence the socio-economic impacts is provided in the supplementary material (SM2).

5.3 Time evolution of Impacts

It is not possible to break the sector impacts down by season because there is not sufficient scientific understanding or evidence to do so. Furthermore, each event is slightly different and therefore the timing or occurrence of particular impacts can vary considerably.

The developing phase of La Niña (March-November) can also, in most but not all cases, be thought of as the transitioning from El Niño to La Niña. Therefore, impacts during the developing phase of La Niña may be similar to impacts during the decaying phase of El Niño. This will be especially true in the MAM 2016 season when the decaying strong El Niño event will have the largest influence.



Symbol Key

Analysis of Past El Niño events

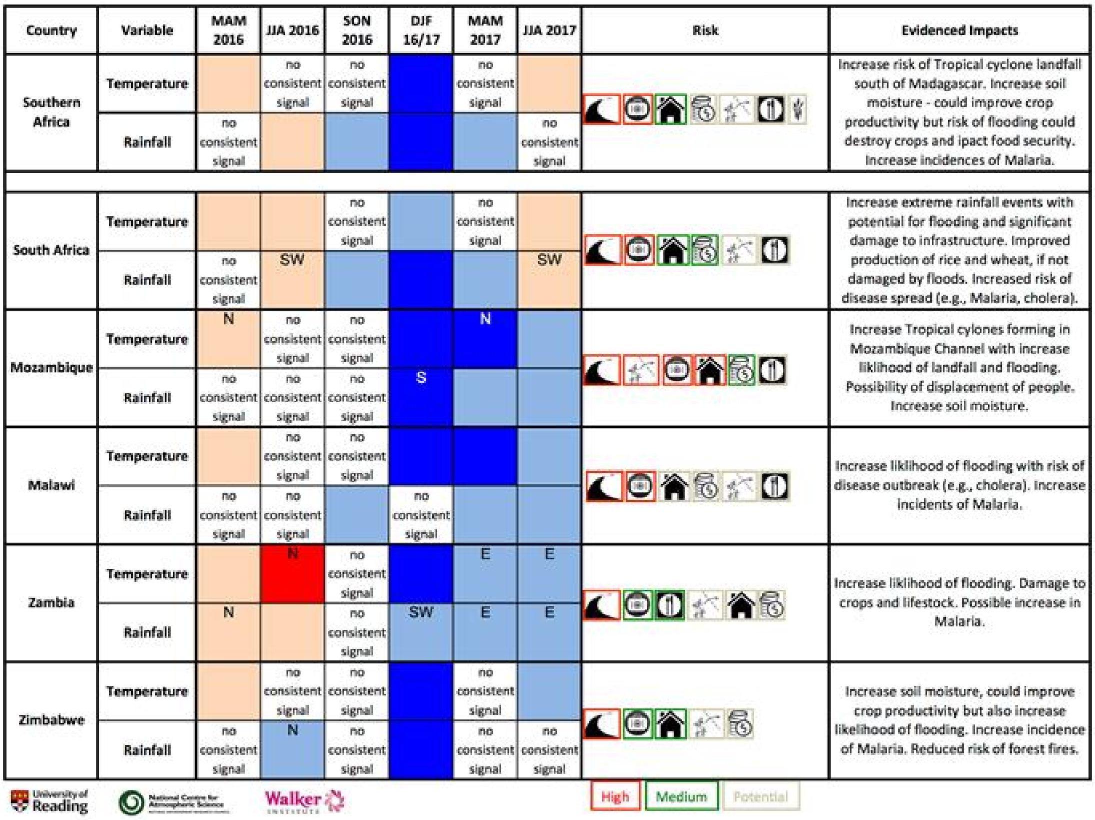
Symbol	Description of threat
	Crop productivity
	Water availability
	Flooding
	Drought
	Migration /displacement of people
	Infrastructure
	Economy
	Health
	Food Security

Level of Confidence

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

Table 5.3: Key for socio-economic impacts by sector and level of confidence.

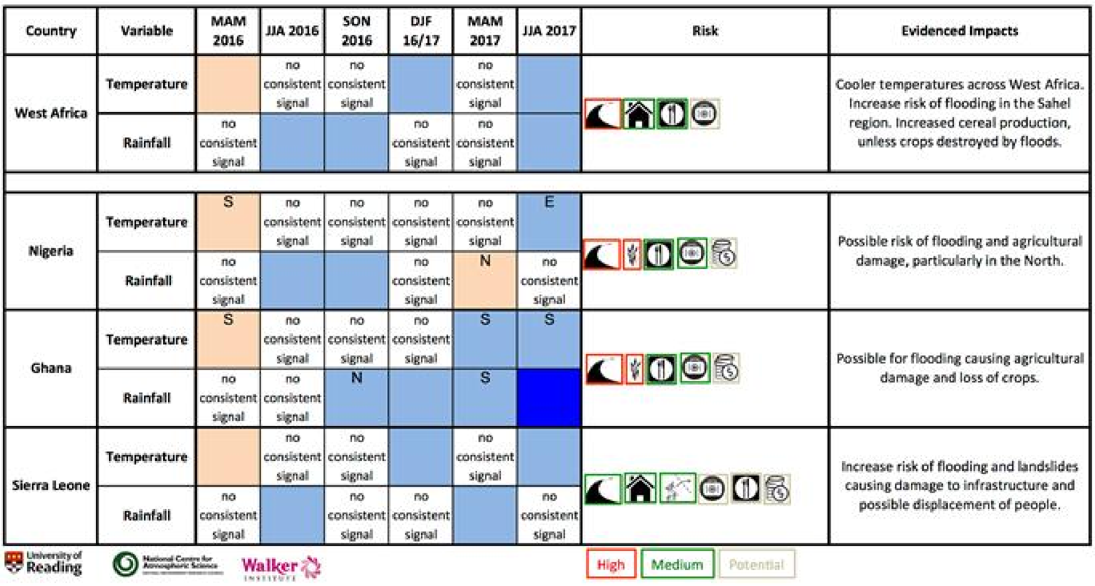
5.4 Southern Africa



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Southern Africa	Temperature		no consistent signal	no consistent signal		no consistent signal			Increase risk of Tropical cyclone landfall south of Madagascar. Increase soil moisture - could improve crop productivity but risk of flooding could destroy crops and ipact food security. Increase incidences of Malaria.
	Rainfall	no consistent signal					no consistent signal		
South Africa	Temperature			no consistent signal		no consistent signal			Increase extreme rainfall events with potential for flooding and significant damage to infrastructure. Improved production of rice and wheat, if not damaged by floods. Increased risk of disease spread (e.g., Malaria, cholera).
	Rainfall	no consistent signal	SW				SW		
Mozambique	Temperature	N	no consistent signal	no consistent signal		N			Increase Tropical cylones forming in Mozambique Channel with increase liklihood of landfall and flooding. Possibility of displacement of people. Increase soil moisture.
	Rainfall	no consistent signal	no consistent signal	no consistent signal	S				
Malawi	Temperature		no consistent signal	no consistent signal					Increase liklihood of flooding with risk of disease outbreak (e.g., cholera). Increase incidents of Malaria.
	Rainfall	no consistent signal	no consistent signal		no consistent signal				
Zambia	Temperature		N	no consistent signal		E	E		Increase liklihood of flooding. Damage to crops and lifestock. Possible increase in Malaria.
	Rainfall	N		no consistent signal	SW	E	E		
Zimbabwe	Temperature		no consistent signal	no consistent signal		no consistent signal			Increase soil moisture, could improve crop productivity but also increase likelihood of flooding. Increase incidence of Malaria. Reduced risk of forest fires.
	Rainfall	no consistent signal	N	no consistent signal		no consistent signal	no consistent signal		

High Medium Potential

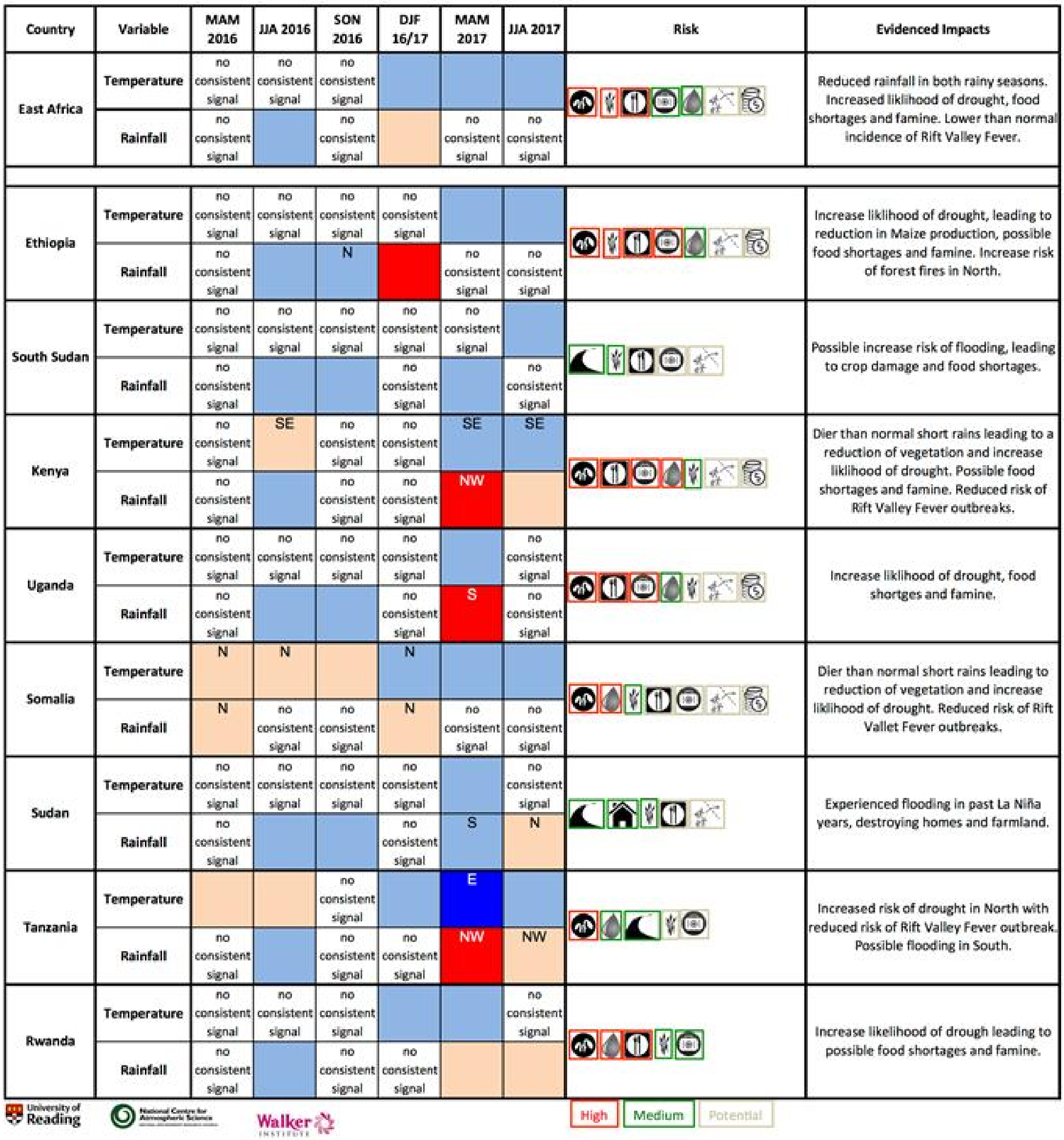
5.5 West Africa



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
West Africa	Temperature	🟧	no consistent signal	no consistent signal	🟦	no consistent signal	🟦		Cooler temperatures across West Africa. Increase risk of flooding in the Sahel region. Increased cereal production, unless crops destroyed by floods.
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	no consistent signal	🟦		
Nigeria	Temperature	🟧 S	no consistent signal	no consistent signal	no consistent signal	no consistent signal	🟦 E		Possible risk of flooding and agricultural damage, particularly in the North.
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	🟧 N	no consistent signal		
Ghana	Temperature	🟧 S	no consistent signal	no consistent signal	no consistent signal	🟦 S	🟦 S		Possible for flooding causing agricultural damage and loss of crops.
	Rainfall	no consistent signal	no consistent signal	🟦 N	🟦	🟦 S	■		
Sierra Leone	Temperature	🟧	no consistent signal	no consistent signal	🟦	no consistent signal	🟦		Increase risk of flooding and landslides causing damage to infrastructure and possible displacement of people.
	Rainfall	no consistent signal	🟦	no consistent signal	no consistent signal	🟦	no consistent signal		

High Medium Potential

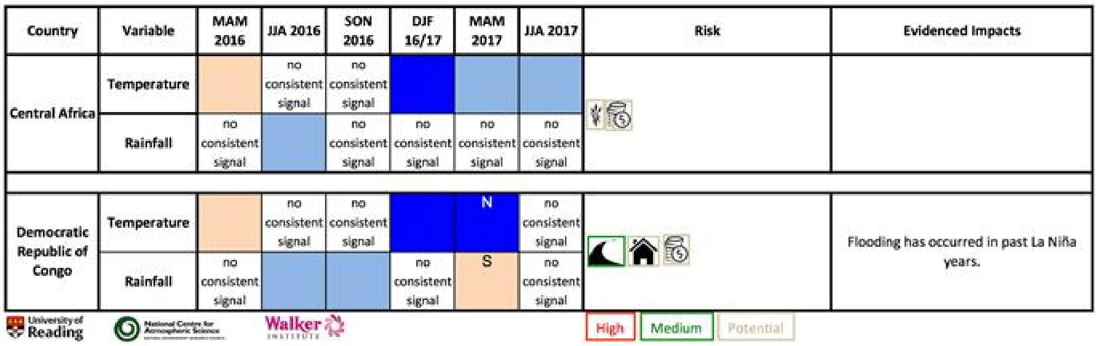
5.6 East Africa



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
East Africa	Temperature	no consistent signal	no consistent signal	no consistent signal	🟦	🟦	🟦		Reduced rainfall in both rainy seasons. Increased liklihood of drought, food shortages and famine. Lower than normal incidence of Rift Valley Fever.
	Rainfall	no consistent signal	🟦	no consistent signal	🟧	no consistent signal	no consistent signal		
Ethiopia	Temperature	no consistent signal	no consistent signal	no consistent signal	no consistent signal	🟦	🟦		Increase liklihood of drought, leading to reduction in Maize production, possible food shortages and famine. Increase risk of forest fires in North.
	Rainfall	no consistent signal	🟦	🟦 N	🟥	no consistent signal	no consistent signal		
South Sudan	Temperature	no consistent signal	no consistent signal	no consistent signal	no consistent signal	no consistent signal	🟦		Possible increase risk of flooding, leading to crop damage and food shortages.
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	🟦	no consistent signal		
Kenya	Temperature	no consistent signal	🟧 SE	no consistent signal	no consistent signal	🟦 SE	🟦 SE		Dier than normal short rains leading to a reduction of vegetation and increase liklihood of drought. Possible food shortages and famine. Reduced risk of Rift Valley Fever outbreaks.
	Rainfall	no consistent signal	🟦	no consistent signal	no consistent signal	🟥 NW	🟧		
Uganda	Temperature	no consistent signal	no consistent signal	no consistent signal	no consistent signal	🟦	no consistent signal		Increase liklihood of drought, food shortges and famine.
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	🟥 S	no consistent signal		
Somalia	Temperature	🟧 N	🟧 N	🟧	🟦 N	🟦	🟦		Dier than normal short rains leading to reduction of vegetation and increase liklihood of drought. Reduced risk of Rift Vallet Fever outbreaks.
	Rainfall	🟧 N	no consistent signal	no consistent signal	🟧 N	no consistent signal	no consistent signal		
Sudan	Temperature	no consistent signal	no consistent signal	no consistent signal	no consistent signal	🟦	no consistent signal		Experienced flooding in past La Niña years, destroying homes and farmland.
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	🟦 S	🟧 N		
Tanzania	Temperature	🟧	🟧	no consistent signal	🟦	■ E	🟦		Increased risk of drought in North with reduced risk of Rift Valley Fever outbreak. Possible flooding in South.
	Rainfall	no consistent signal	🟦	no consistent signal	no consistent signal	🟥 NW	🟧 NW		
Rwanda	Temperature	no consistent signal	no consistent signal	no consistent signal	🟦	🟦	no consistent signal		Increase likelihood of drough leading to possible food shortages and famine.
	Rainfall	no consistent signal	🟦	no consistent signal	no consistent signal	🟧	🟧		

High Medium Potential

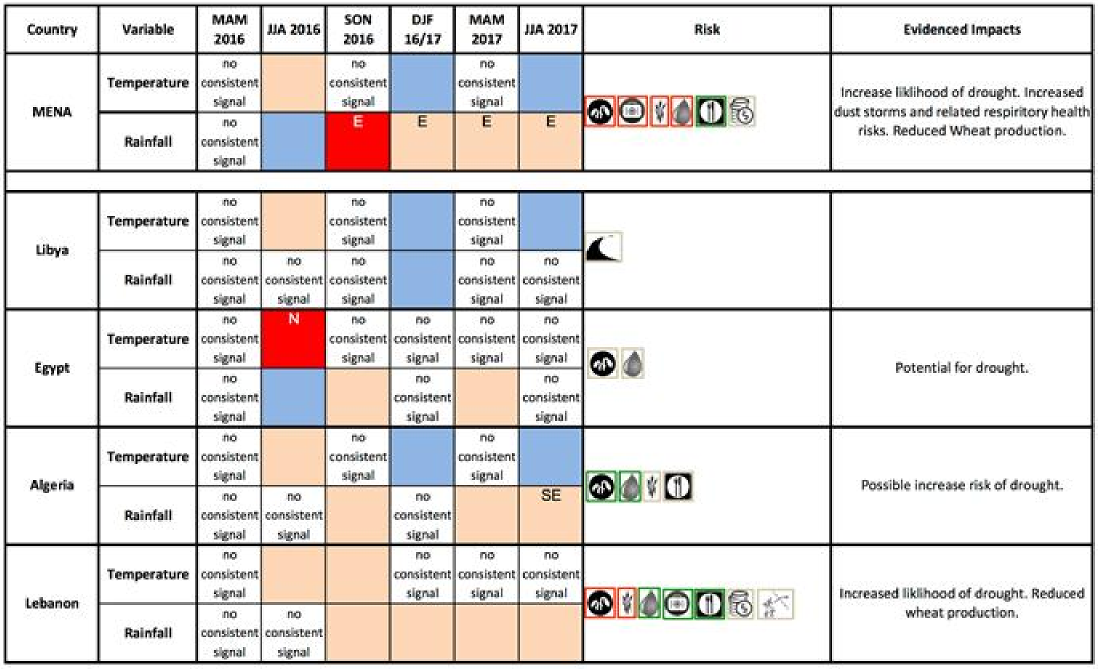
5.7 Central Africa

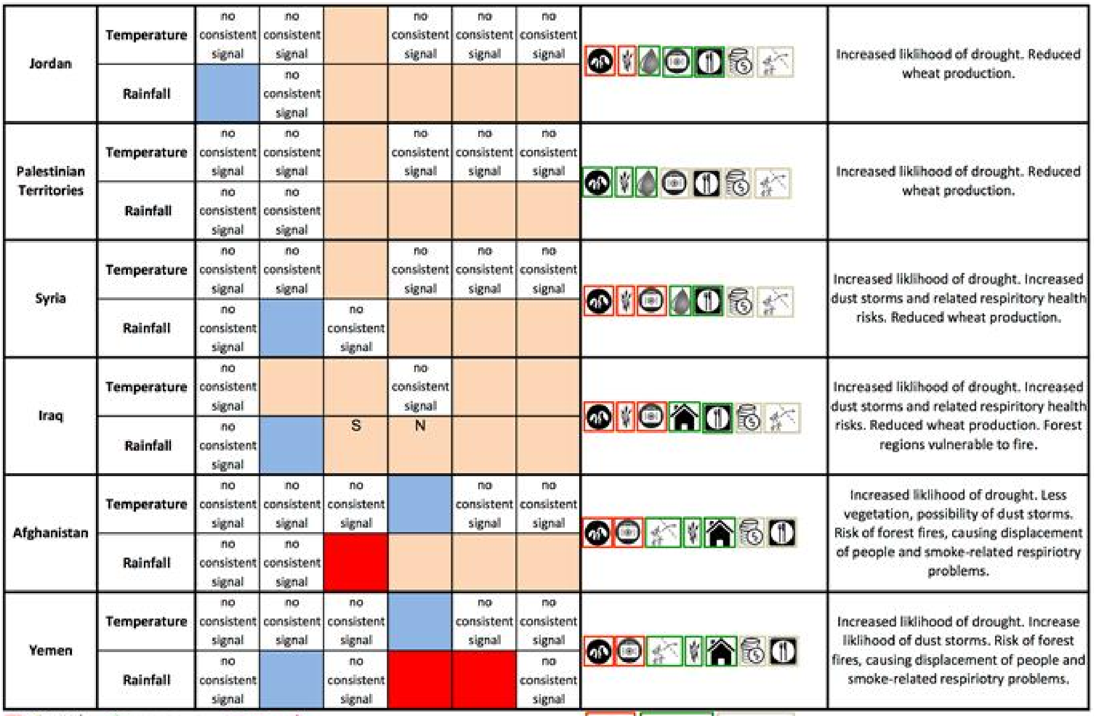


Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Central Africa	Temperature	🟧	no consistent signal	no consistent signal	■	🟦	🟦		
	Rainfall	no consistent signal	🟦	no consistent signal	no consistent signal	no consistent signal	no consistent signal		
Democratic Republic of Congo	Temperature	🟧	no consistent signal	no consistent signal	■	■ N	no consistent signal		Flooding has occurred in past La Niña years.
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	🟧 S	no consistent signal		

High Medium Potential

5.8 Middle East and Northern Africa (MENA)

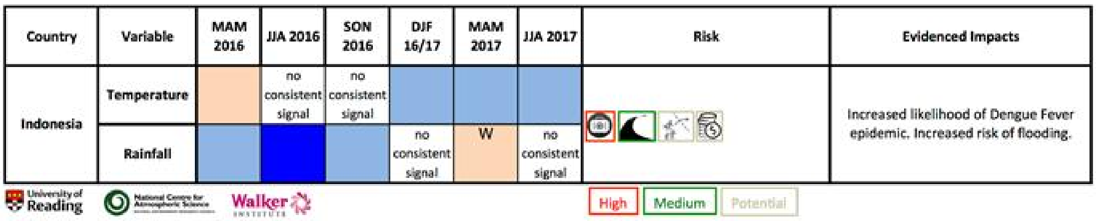




Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
MENA	Temperature	no consistent signal	🟧	no consistent signal	🟦	no consistent signal	🟦		Increase liklihood of drought. Increased dust storms and related respiritory health risks. Reduced Wheat production.
	Rainfall	no consistent signal	🟦	🟥 E	🟧 E	🟧 E	🟧 E		
Libya	Temperature	no consistent signal	🟧	no consistent signal	🟦	no consistent signal	🟦		
	Rainfall	no consistent signal	no consistent signal	no consistent signal	🟦	no consistent signal	no consistent signal		
Egypt	Temperature	no consistent signal	🟥 N	no consistent signal	no consistent signal	no consistent signal	no consistent signal		Potential for drought.
	Rainfall	no consistent signal	🟦	🟧	no consistent signal	🟧	no consistent signal		
Algeria	Temperature	no consistent signal	🟧	no consistent signal	🟦	no consistent signal	🟦		Possible increase risk of drought.
	Rainfall	no consistent signal	no consistent signal	🟧	no consistent signal	🟧	🟧 SE		
Lebanon	Temperature	no consistent signal	🟧	🟧	no consistent signal	no consistent signal	no consistent signal		Increased liklihood of drought. Reduced wheat production.
	Rainfall	no consistent signal	no consistent signal	🟧	🟧	🟧	🟧		
Jordan	Temperature	no consistent signal	no consistent signal	🟧	no consistent signal	no consistent signal	no consistent signal		Increased liklihood of drought. Reduced wheat production.
	Rainfall	🟦	no consistent signal	🟧	🟧	🟧	🟧		
Palestinian Territories	Temperature	no consistent signal	no consistent signal	🟧	no consistent signal	no consistent signal	no consistent signal		Increased liklihood of drought. Reduced wheat production.
	Rainfall	no consistent signal	no consistent signal	🟧	🟧	🟧	🟧		
Syria	Temperature	no consistent signal	no consistent signal	🟧	no consistent signal	no consistent signal	no consistent signal		Increased liklihood of drought. Increased dust storms and related respiritory health risks. Reduced wheat production.
	Rainfall	no consistent signal	🟦	no consistent signal	🟧	🟧	🟧		
Iraq	Temperature	no consistent signal	🟧	🟧	no consistent signal	🟧	🟧		Increased liklihood of drought. Increased dust storms and related respiritory health risks. Reduced wheat production. Forest regions vulnerable to fire.
	Rainfall	no consistent signal	🟦	🟧 S	🟧 N	🟧	🟧		
Afghanistan	Temperature	no consistent signal	no consistent signal	no consistent signal	🟦	no consistent signal	no consistent signal		Increased liklihood of drought. Less vegetation, possibility of dust storms. Risk of forest fires, causing displacement of people and smoke-related respiriotry problems.
	Rainfall	no consistent signal	no consistent signal	🟥	🟧	🟧	🟧		
Yemen	Temperature	no consistent signal	no consistent signal	no consistent signal	🟦	no consistent signal	no consistent signal		Increased liklihood of drought. Increase liklihood of dust storms. Risk of forest fires, causing displacement of people and smoke-related respiriotry problems.
	Rainfall	no consistent signal	🟦	no consistent signal	🟥	🟥	no consistent signal		

High | Medium | Potential

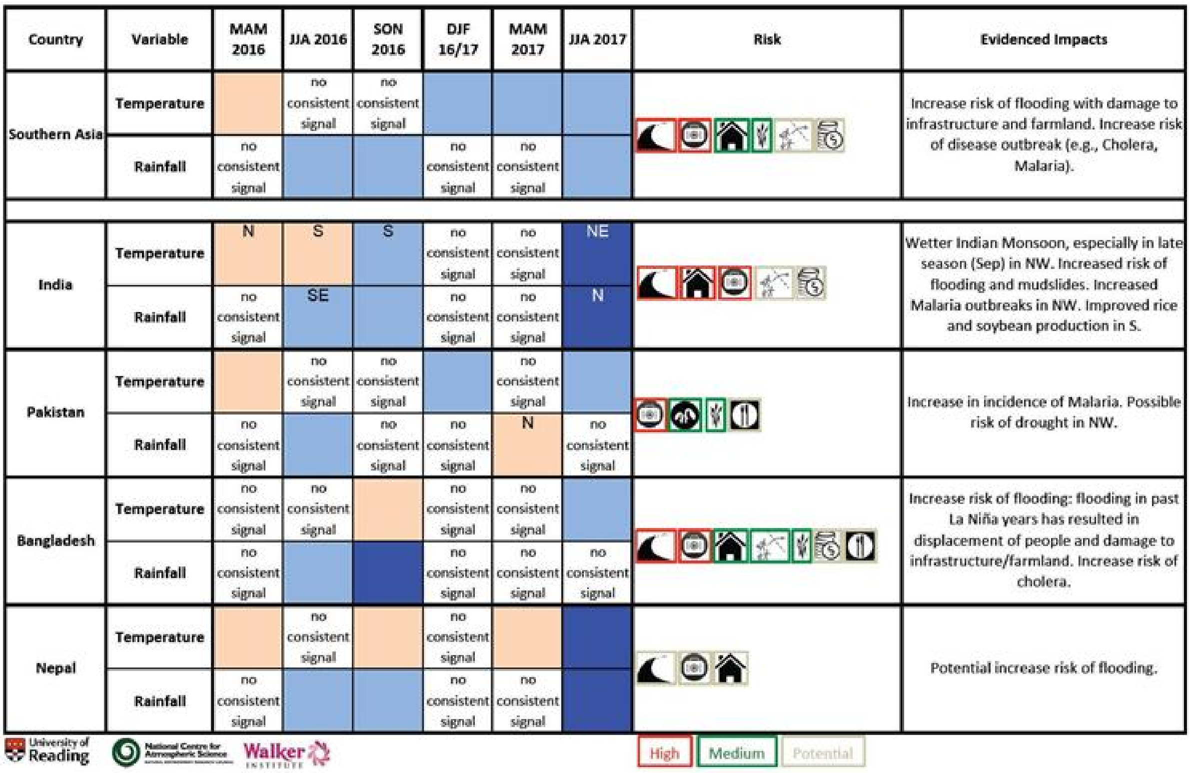
5.9 Indonesia



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Indonesia	Temperature	🟧	no consistent signal	no consistent signal	🟦	🟦	🟦		Increased likelihood of Dengue Fever epidemic. Increased risk of flooding.
	Rainfall	🟦	■	🟦	no consistent signal	W	no consistent signal		

High Medium Potential

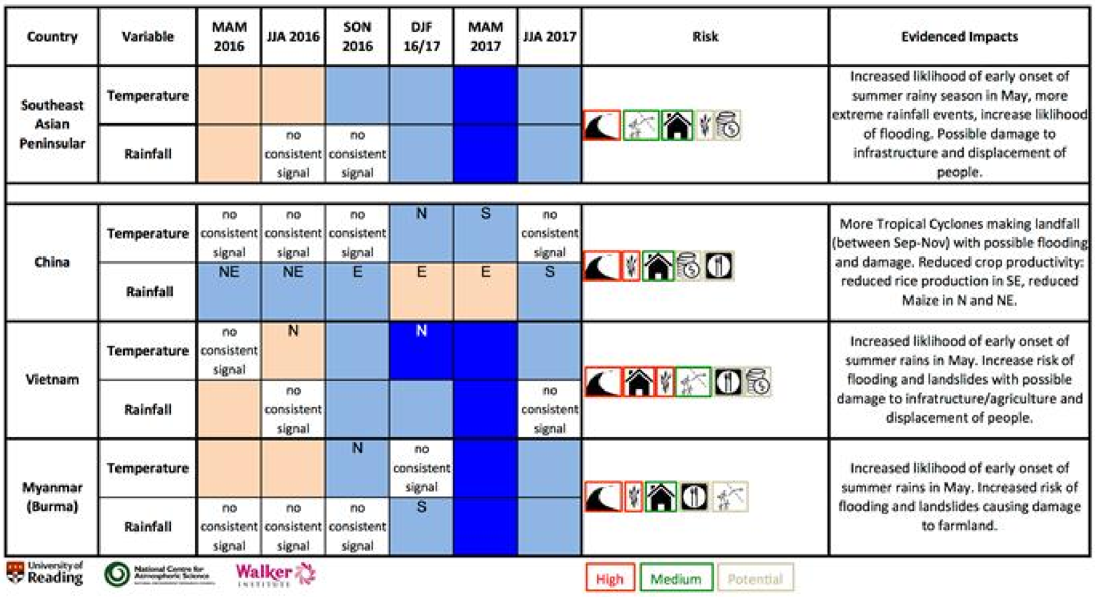
5.10 Southern Asia



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Southern Asia	Temperature	🟧	no consistent signal	no consistent signal	🟦	🟦	🟦		Increase risk of flooding with damage to infrastructure and farmland. Increase risk of disease outbreak (e.g., Cholera, Malaria).
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	no consistent signal	🟦		
India	Temperature	N	S	S	no consistent signal	no consistent signal	NE		Wetter Indian Monsoon, especially in late season (Sep) in NW. Increased risk of flooding and mudslides. Increased Malaria outbreaks in NW. Improved rice and soybean production in S.
	Rainfall	no consistent signal	SE	🟦	no consistent signal	no consistent signal	N		
Pakistan	Temperature	🟧	no consistent signal	no consistent signal	🟦	no consistent signal	🟦		Increase in incidence of Malaria. Possible risk of drought in NW.
	Rainfall	no consistent signal	🟦	no consistent signal	no consistent signal	N	no consistent signal		
Bangladesh	Temperature	no consistent signal	no consistent signal	🟧	no consistent signal	no consistent signal	🟦		Increase risk of flooding: flooding in past La Niña years has resulted in displacement of people and damage to infrastructure/farmland. Increase risk of cholera.
	Rainfall	no consistent signal	🟦	■	no consistent signal	no consistent signal	no consistent signal		
Nepal	Temperature	🟧	no consistent signal	🟧	no consistent signal	🟧	■		Potential increase risk of flooding.
	Rainfall	no consistent signal	🟦	🟦	no consistent signal	no consistent signal	■		

High Medium Potential

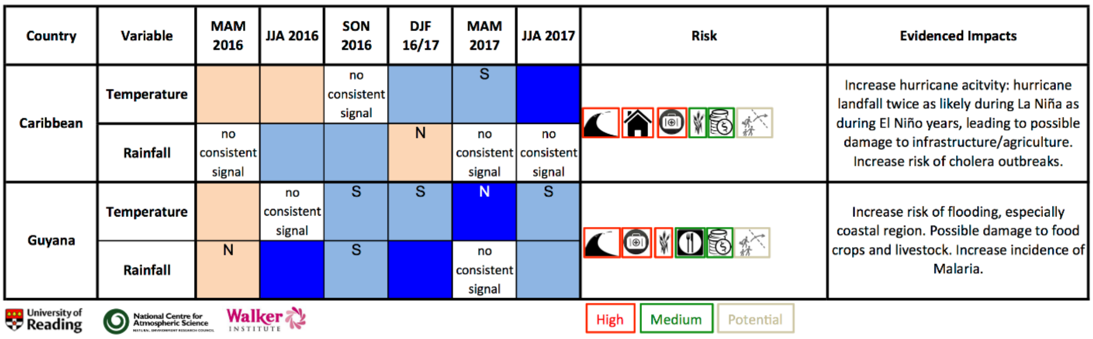
5.11 Southeast Asian Peninsular



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Southeast Asian Peninsular	Temperature	🟧	🟧	🟦	🟦	■	🟦		Increased liklihood of early onset of summer rainy season in May, more extreme rainfall events, increase liklihood of flooding. Possible damage to infrastructure and displacement of people.
	Rainfall	🟧	no consistent signal	no consistent signal	🟦	■	🟦		
China	Temperature	no consistent signal	no consistent signal	no consistent signal	🟦 N	🟦 S	no consistent signal		More Tropical Cyclones making landfall (between Sep-Nov) with possible flooding and damage. Reduced crop productivity: reduced rice production in SE, reduced Maize in N and NE.
	Rainfall	🟦 NE	🟦 NE	🟦 E	🟧 E	🟧 E	🟦 S		
Vietnam	Temperature	no consistent signal	🟧 N	🟦	■ N	■	🟦		Increased liklihood of early onset of summer rains in May. Increase risk of flooding and landslides with possible damage to infratructure/agriculture and displacement of people.
	Rainfall	🟧	no consistent signal	🟦	🟦	■	no consistent signal		
Myanmar (Burma)	Temperature	🟧	🟧	🟦 N	no consistent signal	■	🟦		Increased liklihood of early onset of summer rains in May. Increased risk of flooding and landslides causing damage to farmland.
	Rainfall	no consistent signal	no consistent signal	no consistent signal	🟦 S	■	🟦		

High Medium Potential

5.12 Caribbean

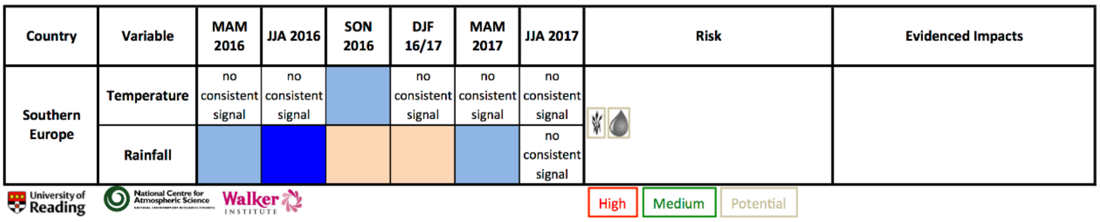


Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Caribbean	Temperature	🟧	🟧	no consistent signal	🟦	🟦 S	■		Increase hurricane acitvity: hurricane landfall twice as likely during La Niña as during El Niño years, leading to possible damage to infrastructure/agriculture. Increase risk of cholera outbreaks.
	Rainfall	no consistent signal	🟦	🟦	🟧 N	no consistent signal	no consistent signal		
Guyana	Temperature	🟧	no consistent signal	🟦 S	🟦 S	■ N	🟦 S		Increase risk of flooding, especially coastal region. Possible damage to food crops and livestock. Increase incidence of Malaria.
	Rainfall	🟧 N	■	🟦 S	■	no consistent signal	🟦		

High Medium Potential

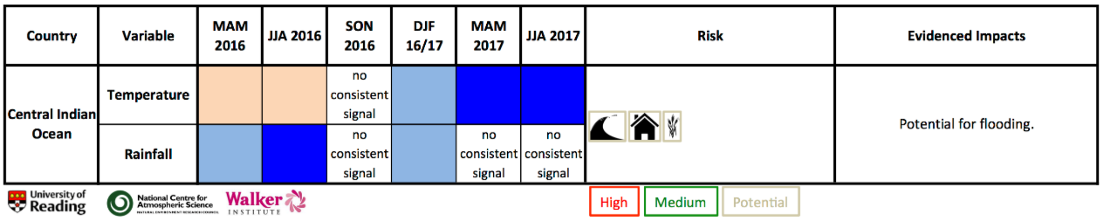
5.13 British Overseas Territories

***Caribbean** – [Anguilla, Montserrat, British Virgin Islands, – **East**], [Cayman Islands, Turks and Caicos Islands – **North**].*
***Atlantic** – [Bermuda – **northern subtropical**], [St Helena and dependencies- Ascension Island, Tristan da Cunha – **southern tropical**], [Falkland Islands, South Georgia and the South Sandwich Islands, British Antarctic Territories – **South**].*
***Pacific –** [Pitcairn Islands]*
***Indian Ocean –** [British Indian Ocean Territory]*
***Southern Europe –** [Gibraltar]*



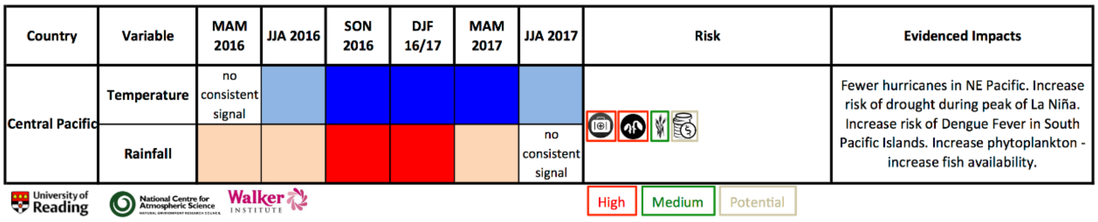
Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Southern Europe	Temperature	no consistent signal	no consistent signal	🟦	no consistent signal	no consistent signal	no consistent signal		
	Rainfall	🟦	■	🟧	🟧	🟦	no consistent signal		

High Medium Potential



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Central Indian Ocean	Temperature	🟧	🟧	no consistent signal	▨	🟦	🟦		Potential for flooding.
	Rainfall	▨	🟦	no consistent signal	▨	no consistent signal	no consistent signal		

High Medium Potential



Country	Variable	MAM 2016	JJA 2016	SON 2016	DJF 16/17	MAM 2017	JJA 2017	Risk	Evidenced Impacts
Central Pacific	Temperature	no consistent signal	▨	🟦	🟦	🟦	▨		Fewer hurricanes in NE Pacific. Increase risk of drought during peak of La Niña. Increase risk of Dengue Fever in South Pacific Islands. Increase phytoplankton - increase fish availability.
	Rainfall	🟧	🟧	🟥	🟥	🟧	no consistent signal		

High Medium Potential

Supplementary Material

SM1: Extra Impact Maps

Regional impact maps showing the change in the probability of extremes of temperature, rainfall and soil moisture across Africa (SM1.1-SM1.3), Asia (SM1.4-SM1.6) and the Middle East and Northern Africa (MENA; SM1.7-SM1.9). *These regional impact maps are the same as the global maps in the report above but for focused regions.*

Figure SM1.1: *Change in the probability of extremes in temperature across Africa for the seasons Mar-May 2016 (MAM), Jun-Aug 2016 (JJA), Sep-Nov 2016 (SON), Dec-Feb 16/17 (DJF), Mar-May 2017 (MAM1), Jun-Aug 2017 (JJA1). Composites are based on averages of 8 observed events over the last 37 years. Colours show the change in the probability of the upper (or lower) quartile (e.g., light yellow refers to extreme warm temperatures in the upper quartile of the observed record being 1.5-2 times more likely during a La Niña).* ***These maps show where impacts occur and how important they are to that region.***

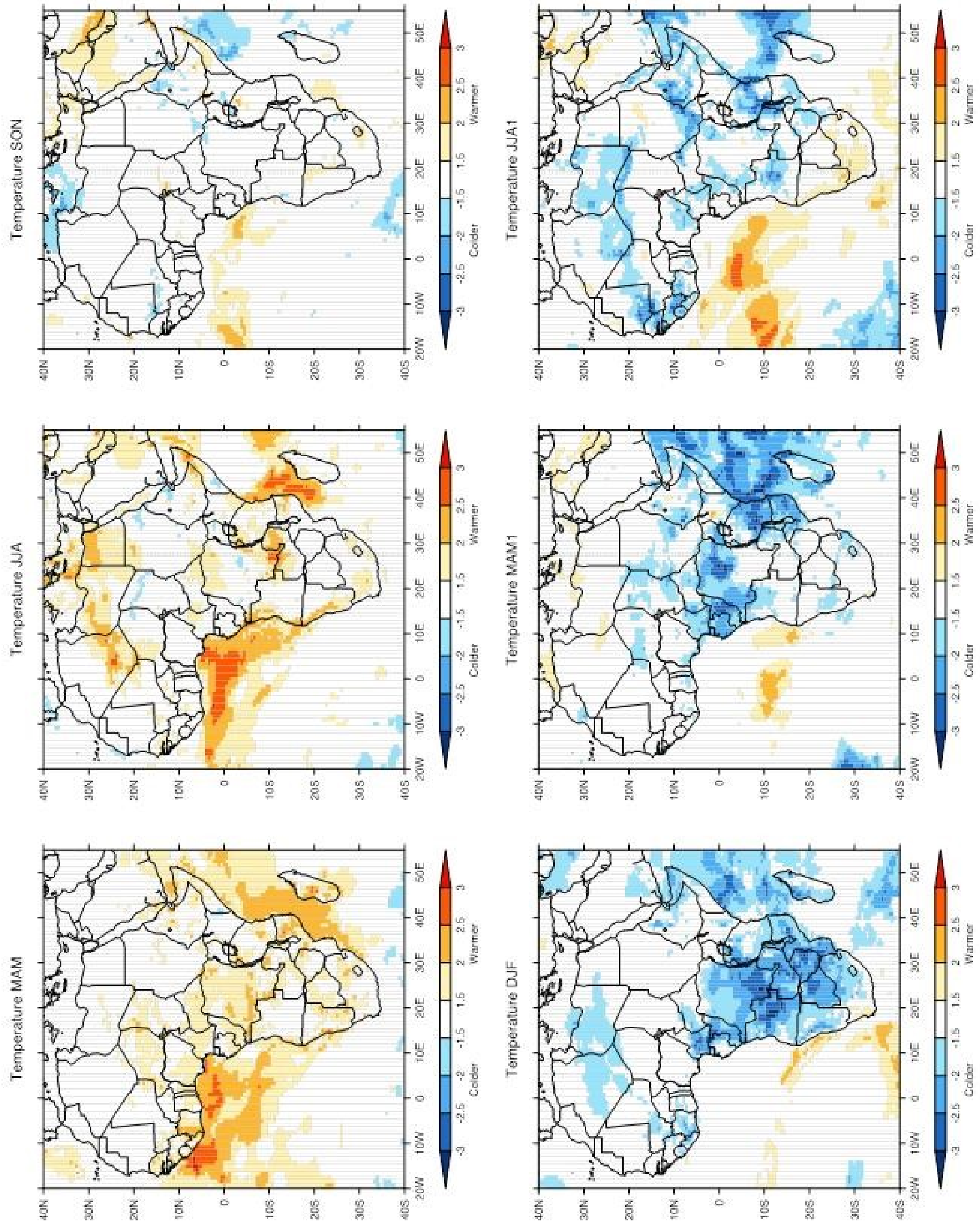


***Figure SM1.2:** As Figure SM1.1, but for extremes in rainfall across Africa.*
These maps show where impacts occur and how important they are to that region.

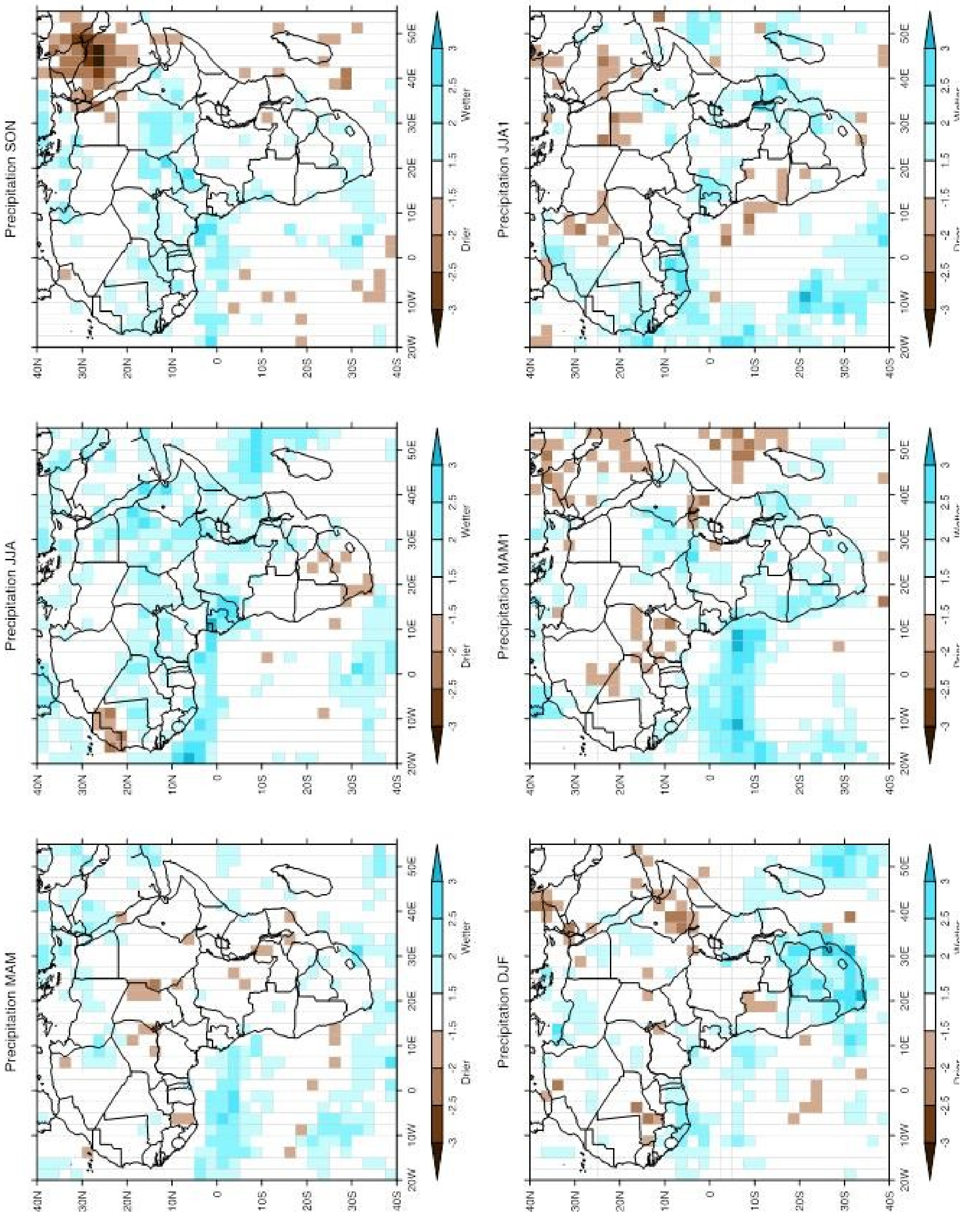


***Figure SM1.3**: As Figure SM1.1, but for extremes in soil moisture across Africa.*
These maps show where impacts occur and how important they are to that region.

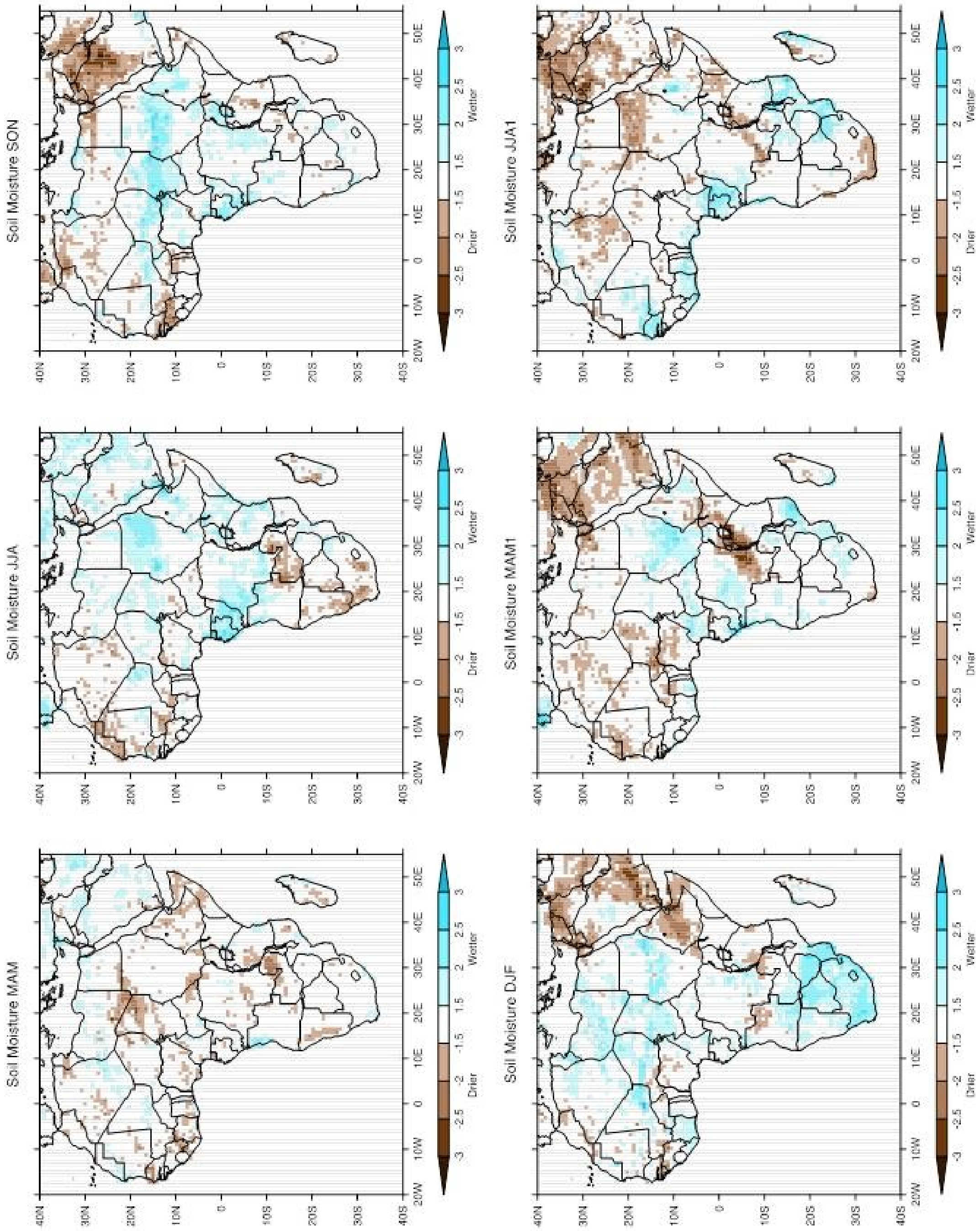


Figure SM1.4: *As Figure SM1.1, but for extremes in temperature across Asia.*
These maps show where impacts occur and how important they are to that region.

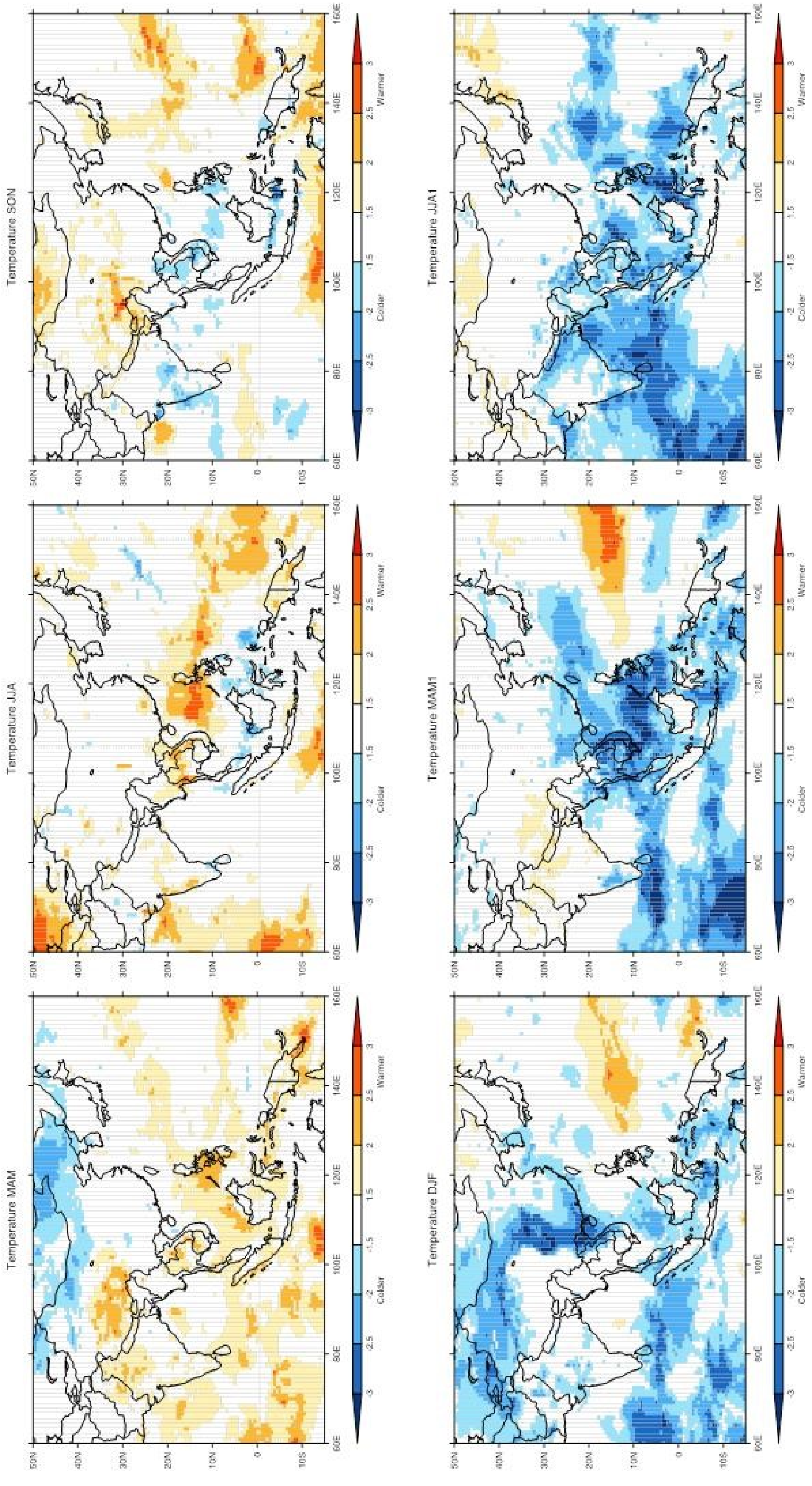


Figure SM1.5: *As Figure SM1.1, but for extremes in rainfall across Asia.*
These maps show where impacts occur and how important they are to that region.

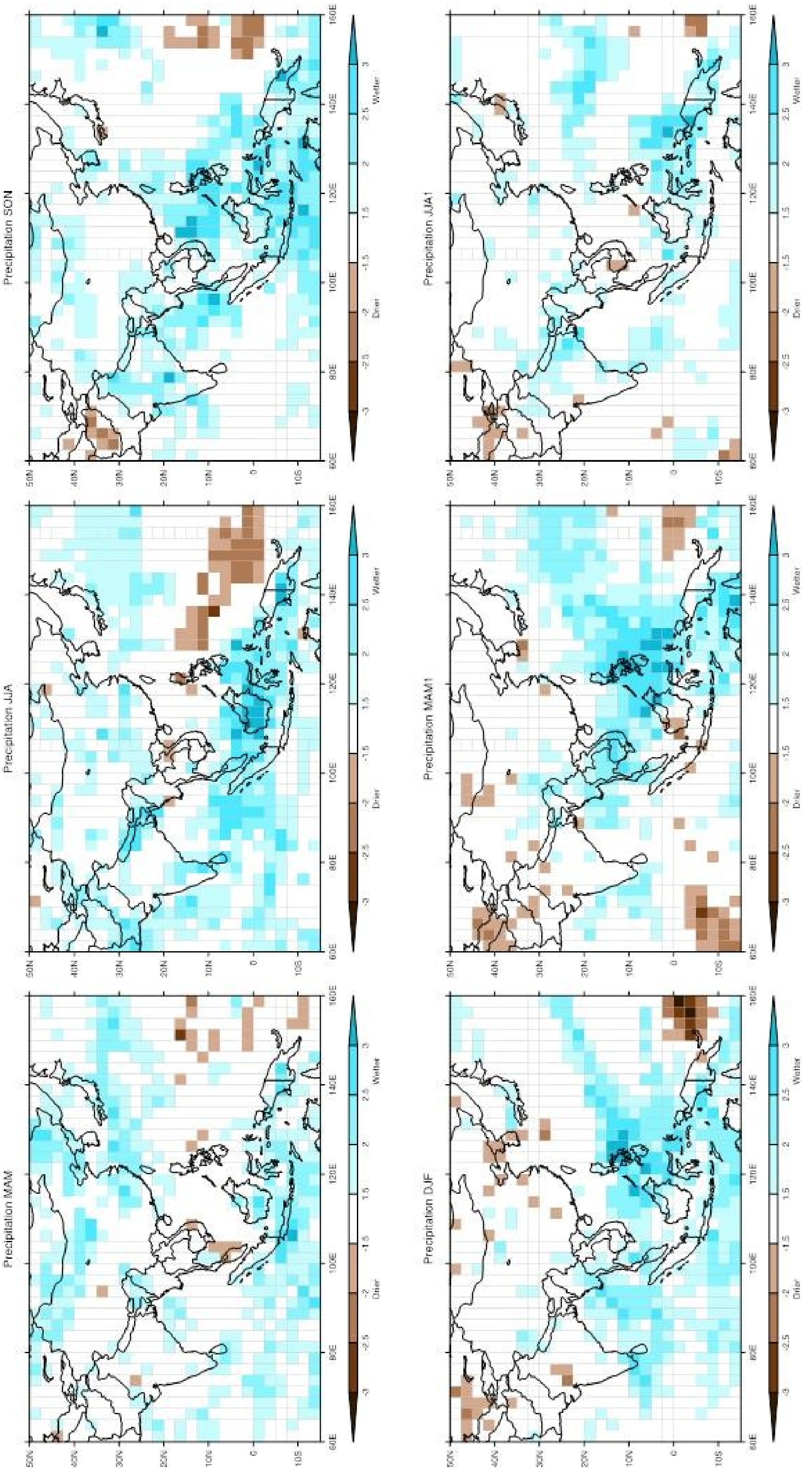
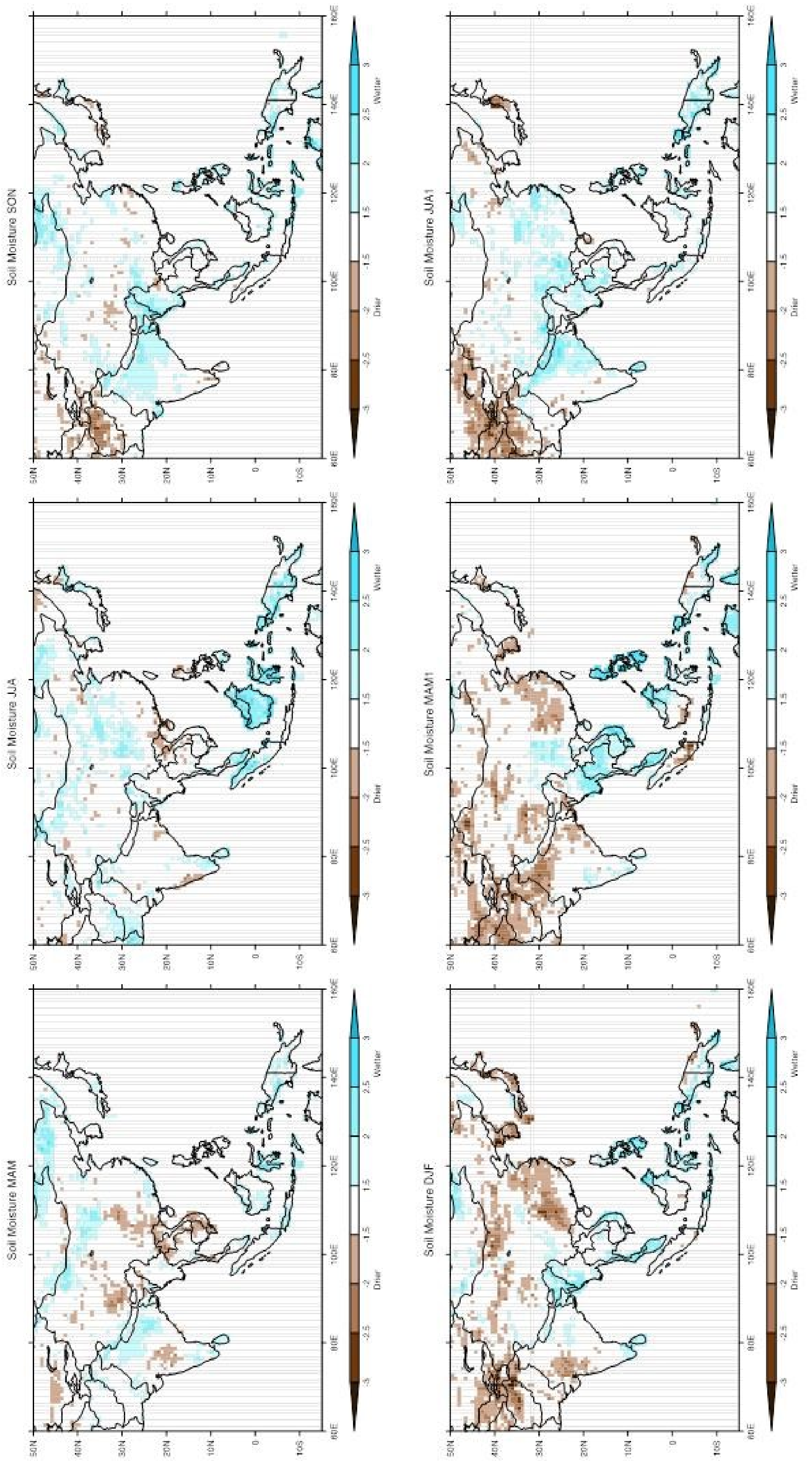


Figure SM1.6: *As Figure SM1.1, but for extremes in soil moisture across Asia.*
These maps show where impacts occur and how important they are to that region.



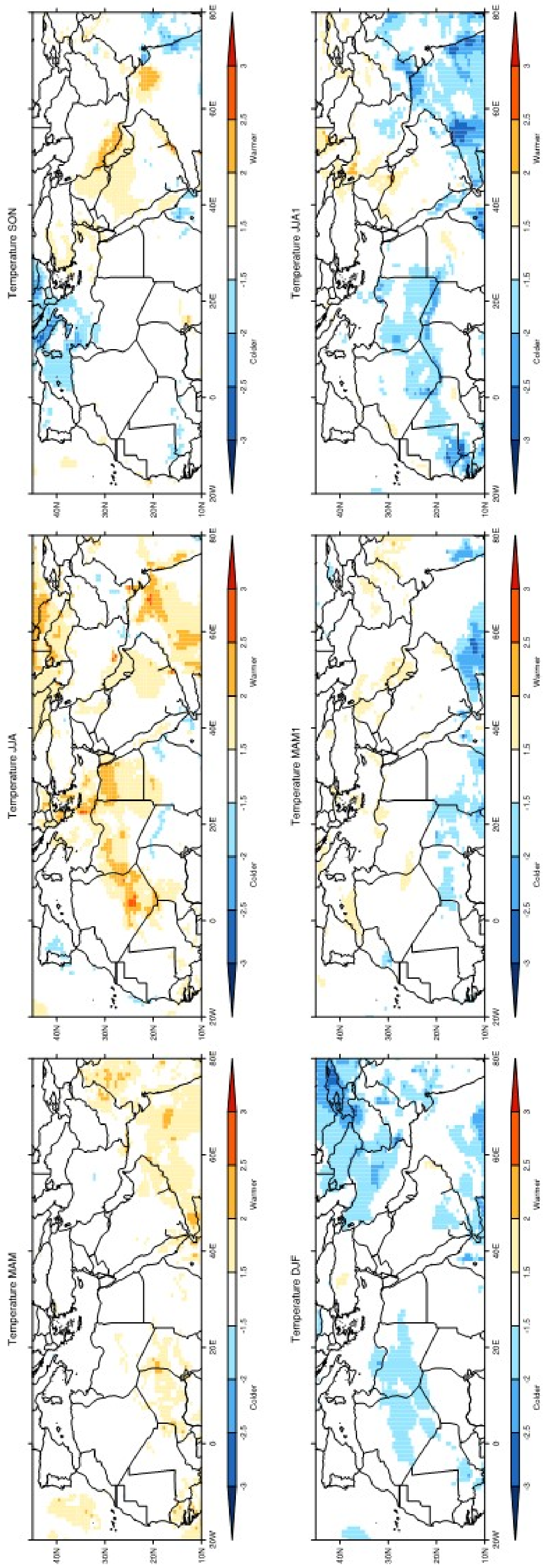


Figure SM1.7**: As Figure SM1.1, but for extremes in temperature across the Middle East and North Africa (MENA). **These maps show where impacts occur and how important they are to that region.

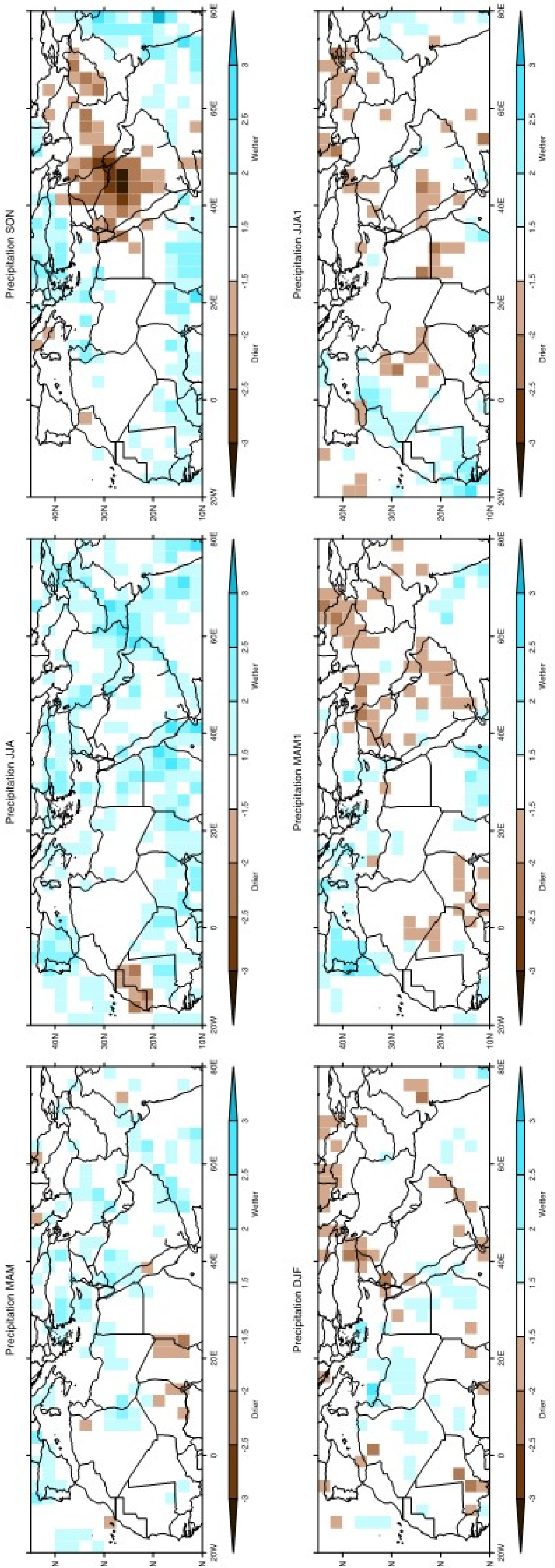


Figure SM1.8: *As Figure SM1.1, but for extremes in rainfall across the Middle East and North Africa (MENA).* ***These maps show where impacts occur and how important they are to that region.***

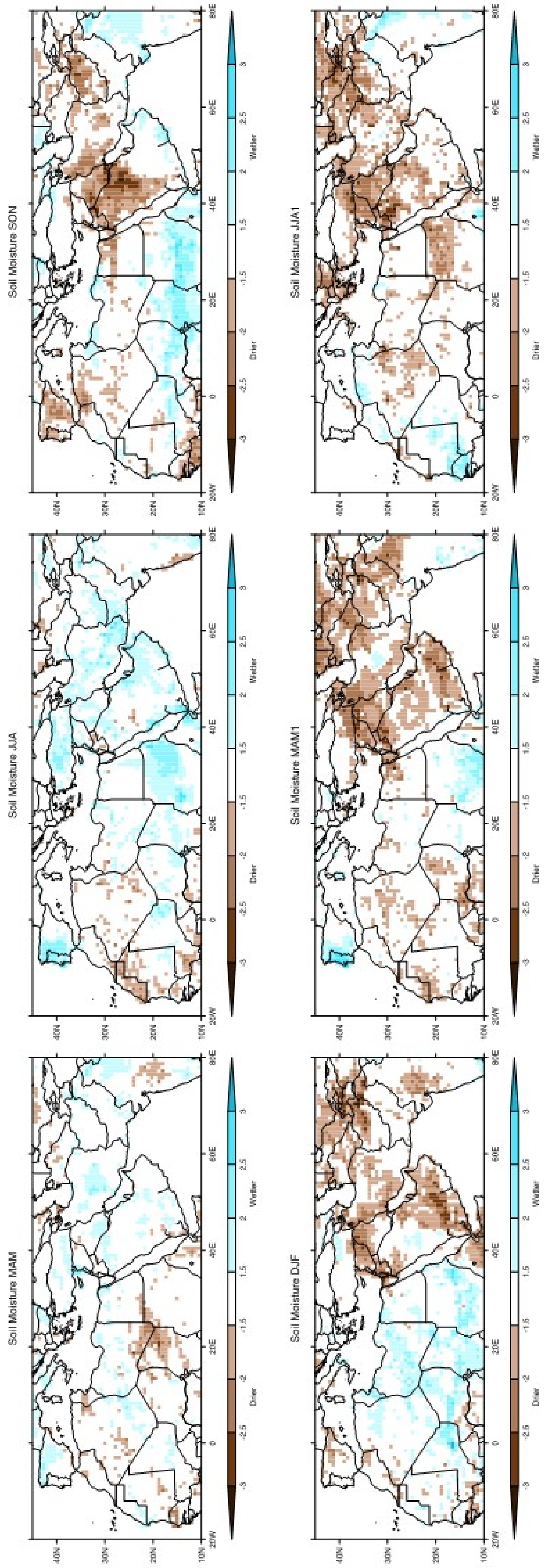


Figure SM1.9**: As Figure SM1.1, but for extremes in soil moisture across the Middle East and North Africa (MENA). **These maps show where impacts occur and how important they are to that region.

SM2: References

Websites: *Current conditions or forecasts, Impacts, Databases of past Hazards, Example NGO reports.*

Monitoring - current conditions or forecasts:

http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/

http://www.ecmwf.int/en/forecasts/charts/seasonal/nino-plumes-public-charts-long-range-forecast?time=2016020100,0,2016020100&nino_area=3&forecast_type_and_skill_measure=plumes

https://www.climate.gov/news-features/department/enso-blog

http://www.cpc.ncep.noaa.gov
Impacts:

http://earthobservatory.nasa.gov/Features/LaNina/la_nina_2.php

https://www.climate.gov/news-features/blogs/enso/impacts-el-niño-and-la-niña-hurricane-season

Databases of past Hazards:

http://floodobservatory.colorado.edu/Archives/index.html

http://www.emdat.be/database

http://reliefweb.int

Examples of NGO websites used for grey literature searches:

http://www.care-international.org
e.g.: *http://www.care-international.org/files/files/publications/Climate-Change-In-Search-of-Shelter-2009.pdf*

http://www.wfp.org
e.g.: http://www.wfp.org/news/news-release/emergency-hub-ecuador-airlifts-food-flood-victims-bolivia

http://reliefweb.int
e.g.: *http://reliefweb.int/report/mozambique/mozambique-la-nina-triggers-record-number-cyclones*

http://www.who.int
e.g.: http://www.who.int/globalchange/summary/en/index4.html

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e.g.: *http://www.fao.org/3/a-i4251e.pdf*

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