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STRENGTHENING RESILIENCE AND RESPONSE TO CRISES

Department for International Development

EL NIÑO 2018-19: HISTORICAL IMPACT ANALYSIS

OCTOBER 2018

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EXPERT ADVISORY CALL DOWN SERVICE – LOT B

STRENGTHENING RESILIENCE AND RESPONSE TO CRISES

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El Niño 2018-19:
Historical Impact Analysis
(October 2018)

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1. Introduction

International weather forecasting centres agree that El Niño conditions are likely to develop in the Pacific in late autumn 2018. A weak to moderate El Niño event is expected to reach its peak intensity in late 2018 and early 2019. El Niño events are a significant perturbation, or 'kick', to the climate system and can affect weather patterns globally. This report analyses El Niño events over the last 35 years and aims to identify regions where changes in temperature and rainfall are likely. Detailed analysis of El Niño impacts is presented only for DFID countries of interest.

This analysis is based on previous, analogous El Niño events; it is not a prediction for this year. No two El Niño events will be the same – the timing and magnitude of events differs considerably. More importantly, no two El Niño events lead to the same effects; other local physical, social and economic factors lead to event-to-event variations in effects. Therefore, the timings, locations and magnitudes of effects stated in this report should be interpreted with caution; the reader should account for these sources of uncertainty in any preparedness measures.

As of the writing of this report, no El Niño event has formed in 2018. It is important that the information used in this report is used only for planning purposes. Readers should monitor information from national meteorological services for declarations of El Niño conditions.

2. What is El Niño and what do we expect this year?

2.1 Description of El Niño

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 effects 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 occurs when the SSTs in the central and eastern Pacific are substantially warmer than normal (by at least 0.5°C; e.g., 1997-98, 2015-16). Conversely, a La Niña occurs when the SSTs are substantially colder than normal (by at least 0.5°C; e.g., 1988-89, 2011-12). A La Niña often, but not always, follows an El Niño. Neutral conditions refer to the state when SSTs in the equatorial Pacific are close to average (between 0.5°C cooler than average and 0.5°C warmer than average; e.g., 2003-05, 2017-18). Several years of Neutral conditions can persist between La Niña and El Niño events.

El Niño and La Niña events tend to develop between May and August 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 once per 2-7 years.

The Southern Oscillation refers to the atmospheric component of ENSO; it describes the atmospheric pressure and wind patterns that respond to the changes in Pacific SST. For example, during El Niño the low-level winds, which usually blow from east to west in the equatorial Pacific (trade winds), are significantly weakened, or sometimes even reversed.

ENSO has significant effects on global weather and climate (section 3). It is a slowly evolving climate phenomenon, the peak of which often can be predicted months in advance. Therefore, understanding its global effects is crucial in providing early advice and warning to vulnerable regions of the globe.

2.2 Summary of current forecasts

International Research Institute for Climate and Society (IRI)[1]

Approximately 70% of models surveyed predict an El Niño event in 2018-19. The event is likely to develop in November, reaching its peak intensity by January 2019. Of the models predicting an El Niño, approximately 80% predict a weak El Niño event.

The IRI issues a multi-model forecast which consists of 15 dynamical models from leading international forecast centres, as well as eight statistical models. Approximately 75% of models predict an El Niño event in 2018-19. On average, models predict a peak intensity of approximately 0.9°C warming[2] during a period from December 2018 until February 2019. This would be a weak El Niño event. For comparison, the strong 2015-16 El Niño event had a peak intensity of approximately 3.5°C. Dynamical and statistical models give similar forecasts for the 2018-19 event.

European Centre for Medium Range Weather Forecasts (ECMWF)[3]

Weak to moderate El Niño event spread across the central and eastern Pacific, peaking at 1.1°C in early 2019.

The October forecasts from ECMWF anticipate an El Niño event with a peak intensity of 1.1°C between November 2018 and January 2019. The warm SSTs are expected to be spread evenly across the central Pacific and eastern Pacific. This would be a weak to moderate El Niño event. ECMWF run 51 forecasts every month to sample the uncertainty in the developing conditions. Of the 51 October 2018 forecasts:

- Five (~10%) show no El Niño event (less than 0.5°C warming)
- 31 (~60%) predict a weak El Niño event (between 0.5°C and 1.0°C)
- 15 (~30%) predict a moderate El Niño event (between 1.0°C and 2.0°C)

3. Global Impacts

3.1 Scenarios for types of El Niño

The spatial distribution and severity of impacts associated with an El Niño event depend on the ***type*** *(location of the maximum SST anomaly)* and ***strength*** *(magnitude of the SST anomaly)* of the event. El Niño events can be separated into two types; those with the maximum SST anomaly in the East Pacific (EP; Niño3 region[4]) and those with the maximum SST anomaly in

[1] For the current forecast, see: https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/. Forecasts in this document were last updated 11 October 2018.
[2] In the Niño 3.4 region [5°N-5°S, 120°-170°W]
[3] For the current forecast, see: https://www.ecmwf.int/en/forecasts/charts/catalogue/seasonal_system5_public_nino_plumes. Forecasts in this document were last updated 11 October 2018.
[4] Niño 3 region [5°N-5°S, 150°W-90°W]

the Central Pacific (CP; Niño4 region[5]). Combined with the separation between weak and strong events, Figure 3.1 shows a matrix of how the El Niño events over the past 35 years can be characterised. The 2018-19 event is currently forecast to be a weak El Niño in both the EP and CP regions (as indicated in section 2.2).

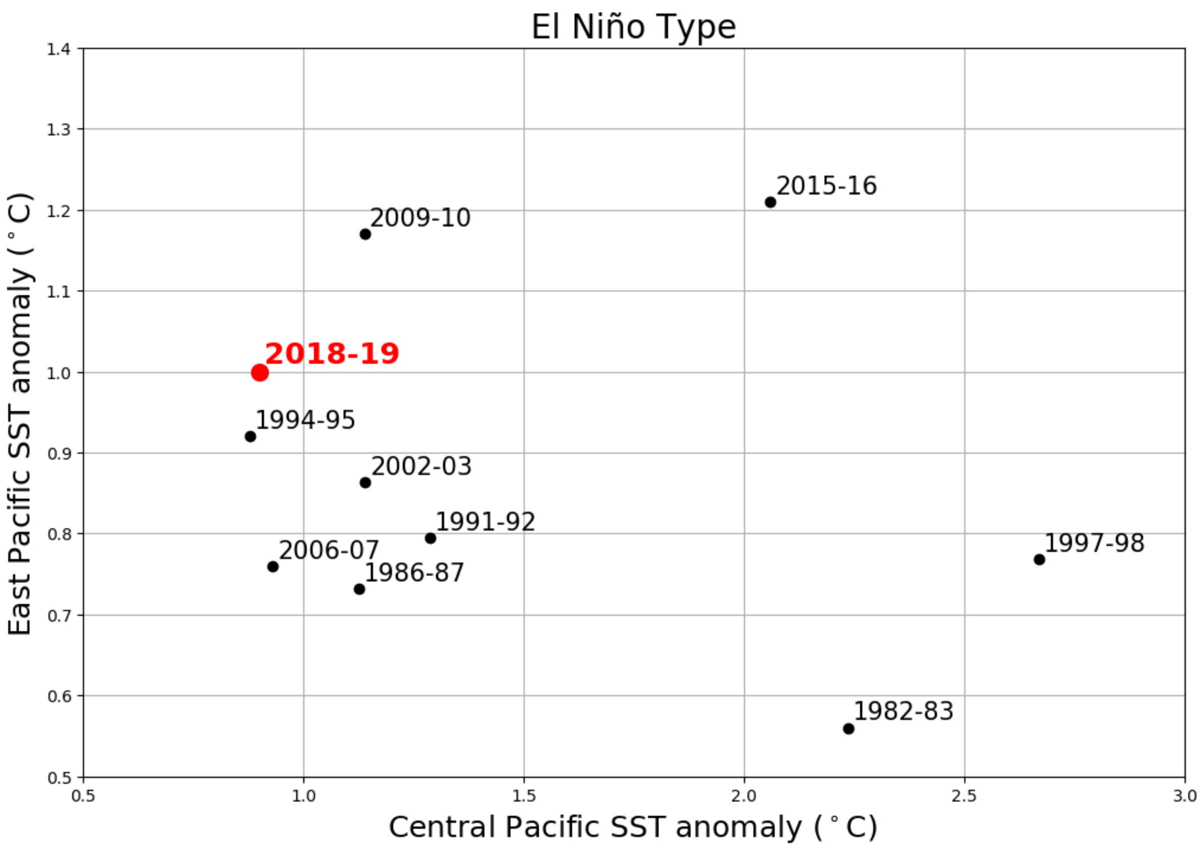


Figure 3.1: The strength and location of previous El Niño events (black). The 2018-19 event (red) is projected to be a weak to moderate event, spread across the East and Central Pacific regions.

3.2 Global changes in probability of seasonal extremes

Figures 3.2 and 3.3 show regions where seasonal extremes of temperature and precipitation are likely during the developing and peak stages of an El Niño event (Figure 3.2) and the decaying stage of an El Niño event (Figure 3.3). For simplicity, the figures combine several seasons into one diagram and use smoothed spatial data. Greater seasonal and regional detail is available is the figures in Annex A at the end of this report. This analysis is based on six observed similar El Niño events (i.e., weak events in both the EP and CP regions) over the last 35 years. Extremes here are defined as being in the top (or bottom) 25% of the observed record at that location.

[5] Niño 4 region [5°N-5°S, 160°E-150°W].

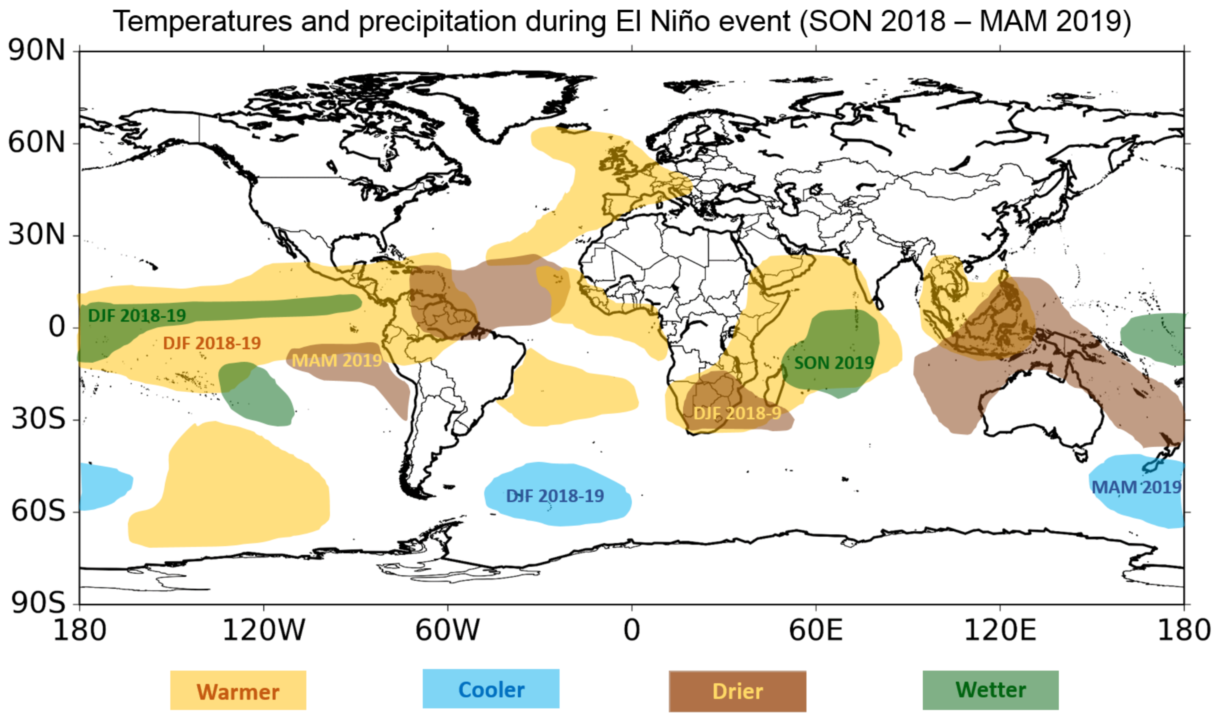


Figure 3.2: Regions where seasonal extremes of temperatures and rainfall are likely during a 2018-19 El Niño event, based on analysis of six historical similar El Niño events. This map combines data for September through March during the peak of an El Niño (i.e., corresponding to September 2018 – March 2019). Where extremes are likely only in one season, that season is labelled inside the shaded region. Regions without a label have likely changes in extremes throughout the period.

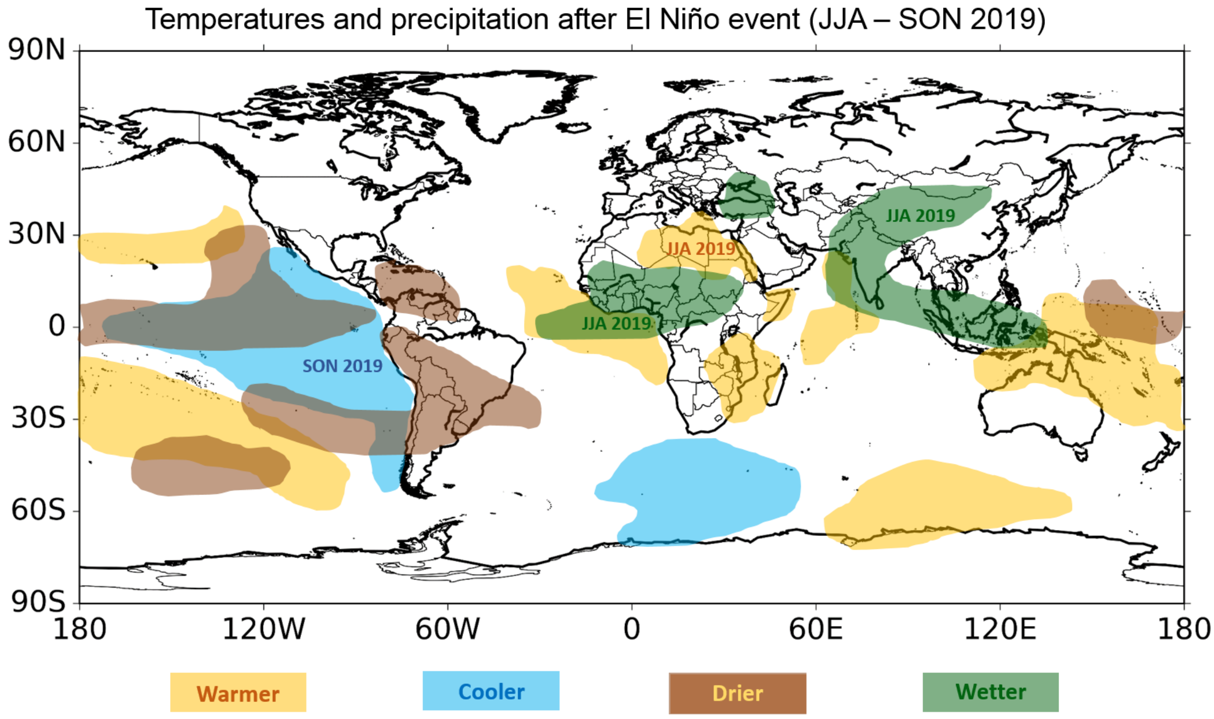


Figure 3.3: Regions where seasonal extremes of temperatures and rainfall are likely after a 2018-19 El Niño event, based on analysis of six historical similar El Niño events This map combines data for June through November after the peak of an El Niño (i.e., corresponding to June-November 2019). Where extremes are likely only in one season, that season is labelled inside the shaded region. Regions without a label have likely changes in extremes throughout the period.

The known links with El Niño conditions for upcoming seasons are summarised below.

November 2018 – May 2019

- Wetter and warmer than normal in the central and eastern equatorial Pacific.
- Drier than normal conditions over northern Australia, Indonesia, the Philippines, northern South America, the Caribbean and southern Africa.
- Warmer than normal conditions across southeastern Asia, southern and eastern Africa, central America and southeastern Brazil.

June – September 2019

- Wetter than normal conditions in western Africa, southern Asia, Indonesia and parts of the Middle East.
- Drier than normal conditions across most of South America and the Caribbean.
- Warmer than normal conditions across the Middle East, southern Africa and northern Australia.
- Cooler than normal conditions across the eastern Pacific.

4. Impacts by Region and Country

4.1 Introduction

Evidence from past weak EP and CP El Niño events has been used to determine the probability of temperature, soil moisture and rainfall extremes during the 2018-19 event in DFID high priority regions and countries (Table 4.1) over the next five seasons (Annex 1: Table A1.1). Reference keys for understanding the meteorological and socio-economic impact information are shown in Table 4.2. These keys can be used to interpret the regional summary Impact Table (Table 4.3), as well as the country-level Impact Tables for each region (Tables 4.4 – 4.14).

Table 4.1: ***Regions and Countries for Impact Tables***

Table Number	***Region***	***Countries***
4.5	*Southern Africa*	*South Africa, Mozambique, Malawi, Zambia, Zimbabwe, Madagascar*
4.6	*West Africa*	*Nigeria, Ghana, Sierra Leone, Liberia, Cameroon, Mali*
4.7	*East Africa*	*Ethiopia, South Sudan, Kenya, Uganda, Somalia, Sudan, Tanzania, Rwanda*
4.8	*Central Africa*	*Democratic Republic of Congo, Chad, Niger*
4.9	*Middle East and Northern Africa (MENA)*	*Libya, Egypt, Algeria, Jordan, Palestinian Territories, Syria, Iraq, Yemen, Morocco, Tunisia, Turkey, Eritrea, Mauritania*
4.10	*Southeast Asian Maritime Continent*	*Indonesia, Papua New Guinea*
4.11	*South Asia*	*India, Pakistan, Bangladesh, Nepal*
4.12	*Southeast Asian Peninsula*	*China, Vietnam, Myanmar*
4.13	*Central Asia*	*Afghanistan, Tajikistan, Kyrgyzstan*
4.14	*Caribbean*	*Haiti, Guyana, Caribbean Overseas Territories*
4.15	*British Overseas Territories*	*Atlantic (non-Caribbean), Pacific, Indian Ocean*

4.2 Description of Impact Tables.

For each country or region, the ***likelihood*** of temperature and rainfall extremes occurring over the next five seasons is shown by the coloured boxes, according to the Impact Key in Table 4.2.

For example, dark blue colours for temperature – corresponding to “Very Likely Extremely Cold” conditions – can be interpreted as extreme[6] cold conditions in that season, in that country as being at least twice as likely to occur during El Niño. The evidenced impacts are summarised using sector symbols, the uncertainty of the impact in these sectors are represented by the coloured borders around the symbols: red, green and beige correspond to high, medium and potential impacts respectively (see Table 4.2).

A full description of the methodology and referenced literature is provided in a separate technical report available on request.

[6] Extreme here 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.

Table 4.2: ***Impact, Symbol and Level of Confidence Keys***

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.

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 4.3: ***Season abbreviations used in Impact Tables***

Season	Months
SON 2018	September 2018, October 2018, November 2018
DJF 18/19	December 2018, January 2019, February 2019
MAM 2019	March 2019, April 2019, May 2019
JJA 2019	June 2019, July 2019, August 2019
SON 2019	September 2019, October 2019, November 2019

4.3 Regional summary

*Table 4.4: **Regional summaries** of temperature and rainfall anomalies, risk to impact sectors and evidenced impacts.*

Region	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
Southern Africa	Temp							Reduced water availability, reduction in crop yields. Increased risk of drought-related disasters.
	Rainfall							
West Africa	Temp							Enhanced risk of drought and reduced crop productivity. Drought-related migration leading to increased disease risk.
	Rainfall							
East Africa	Temp							Risk of flooding causing damage to infrastructure and displacement of people. Increased risk of Rift Valley Fever, malaria and cholera.
	Rainfall							
Central Africa	Temp							Potential risk to food security from flooding. Increased risk of water-borne disease.
	Rainfall							
Middle East and North Africa	Temp							Potential for flooding during El Niño developing stage. Potential for drought during decaying stage. Reduced crop productivity.
	Rainfall							
Central Asia	Temp							Increased risk of flooding in autumn and winter in Afghanistan. Other regions have no consistent effects of El Niño.
	Rainfall							
Southeast Asian Maritime Continent	Temp						2018-19:	Drought during El Niño developing stage. Reduced crop productivity. Threat of

	Rainfall						2019-20:	forest fires with health-related impacts. Flooding and landslides during decaying stage with risk of increased Dengue fever.
South Asia	Temp						2018-19:	During El Niño developing stage: below normal monsoon rainfall, drought risk and reduced crop productivity. Potential for flooding following peak with increased cholera and malaria risk.
	Rainfall						2019-20:	
Southeast Asian peninsula	Temp							Increased risk of drought and forest fires. Reduced crop productivity.
	Rainfall							
Caribbean (including British Overseas Territories)	Temp						2018-19:	Risk of drought and reduced water availability during developing stage. Potential for flooding in decaying stage, with increased risk of Dengue fever.
	Rainfall						2019-20:	
British Overseas Territories (non-Caribbean)	Temp							Increased risk of flooding during El Niño peak in Pacific islands. Increased hurricane activity near Atlantic islands.
	Rainfall							

4.4 Southern Africa

Previous El Niño events have resulted in drought and crop failure, particularly reduced Maize yields, which have led to food shortages.

Table 4.5: ***Southern Africa***

Region	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
South Africa	Temp							Increase water stress, reduction in crop yields (e.g., Maize, soybean). Below normal instances of Malaria.
	Rainfall							
Mozambique	Temp							Drought and crop failure leading to potential food shortages.
	Rainfall							
Malawi	Temp							Drought affecting crop productivity
	Rainfall							
Zambia	Temp							Increase in water stress, crops vulnerable to drought. Increase in East Coast Fever in cattle.
	Rainfall							
Zimbabwe	Temp							Drought leads to significantly reduced maize yield.
	Rainfall							
Madagascar	Temp							Drought risk to crop production.
	Rainfall							

4.5 West Africa

Previous El Niño events have led to drought conditions with reduced crop productivity and the displacement of people. Drought-forced migration has increased the risk of spreading infectious disease.

Table 4.6: ***West Africa***

Region	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
Nigeria	Temp							Drought results in reduced maize yields. Drought-related migration increases risk of spreading infectious disease.
	Rainfall							
Ghana	Temp							Reduced water availability and drought.
	Rainfall							
Sierra Leone	Temp							Slightly enhanced risk of drought and reduced maize yields.
	Rainfall							
Liberia	Temp							Reduced rainfall during El Niño event to reduced crop productivity.
	Rainfall							
Cameroon	Temp							Slightly enhanced risk of drought and reduced crop yields.
	Rainfall							
Mali	Temp							Slightly enhanced risk of drought and reduced crop yields.
	Rainfall							

4.6 East Africa

Previous El Niño events have led to significant flooding causing damage to infrastructure and the displacement of people. Flooding has led to an increased risk of Rift Valley Fever epidemics and malaria and cholera outbreaks.

Table 4.7: ***East Africa***

Region	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
Ethiopia	Temp							Risk of flooding causing displacement of people. Increased incidence of Rift Valley Fever, malaria and cholera.
	Rainfall							
South Sudan	Temp							Flooding damages infrastructure and restricts access to basic relief.
	Rainfall							
Kenya	Temp							Flooding restricts access to food. Increased risk of Rift Valley Fever, malaria and cholera.
	Rainfall							
Uganda	Temp							Increased risk of heavy rainfall during wet season causing flooding.
	Rainfall							
Somalia	Temp							Persistent heavy rain causes risk bank collapse and flooding. Increased risk of Rift Valley Fever.
	Rainfall							
Sudan	Temp							Flooding and mudslides in summer following El Niño displaces people and restrict access to food.
	Rainfall							
Tanzania	Temp							Decreased crop productivity from warm temperatures. Increased risk of Rift Valley Fever.
	Rainfall							
Rwanda	Temp							No consistent impact of past El Niño events of this type.
	Rainfall							

4.7 Central Africa

Previous El Niño events have led to flooding with damage to infrastructure and increased risk of Rift Valley Fever epidemics.

Table 4.8: ***Central Africa***

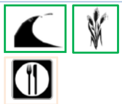
Country	**Field**	**SON 2018**	**DJF 18-19**	**MAM 2019**	**JJA 2019**	**SON 2019**	**Risk**	**Evidenced impacts**
Democratic Republic of Congo	Temp							*Lack of established literature to make assessment*
	Rainfall							
Chad	Temp							Persistent heavy rainfall may cause flooding and increase risk of water-borne disease.
	Rainfall							
Niger	Temp							Heavy rainfall may increase risk of water-borne disease.
	Rainfall							

4.8 Middle East and Northern Africa (MENA)

Previous El Niño events have led to flooding, with significant damage to infrastructure. In the year after previous El Niño events, dry conditions have led to drought, reduced water availability and reduced crop productivity.

Table 4.9: ***Middle East and Northern Africa (MENA)***

Country	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
Libya	Temp							*Lack of established literature to make assessment*
	Rainfall							
Egypt	Temp							Enhanced risk of flooding. Reduced maize and wheat yields.
	Rainfall							
Algeria	Temp							Reduced crop productivity. Increased risk of drought.
	Rainfall							
Lebanon	Temp							Flooding and high winds during autumn and winter. Disruption to power supplies.
	Rainfall							
Jordan	Temp							Flooding during autumn and winter.
	Rainfall							
Palestinian Territories	Temp							*Lack of established literature to make assessment*
	Rainfall							
Syria	Temp							Flooding during autumn and winter.
	Rainfall							
Iraq	Temp							Flooding during autumn and winter. Risk to infrastructure and displacement of people.
	Rainfall							
Yemen	Temp							Potential risk to crops from warm temperatures.
	Rainfall							
Morocco	Temp							No consistent impact of past El Niño events of this type.
	Rainfall							
Tunisia	Temp							Risks to crop yields and food security from warm and dry conditions.
	Rainfall							
Turkey	Temp							Heavy rainfall may cause flooding in autumn and winter.
	Rainfall							

Eritrea	Temp							Risk to crops from warm temperatures and flooding. Heavy rainfall damages infrastructure and displaces people.
	Rainfall							
Mauritania	Temp							Risk to crops from warm temperatures and flooding during El Niño developing stage.
	Rainfall							

4.9 Southeast Asian Maritime Continent

Previous El Niño events have been associated with significant drought, which has led to reduced crop production and increased threat of significant forest fires. In the year following previous El Niño events, extremely wet conditions have caused flooding and landslides and led to increased risk of Dengue Fever.

Table 4.10: ***Indonesia***

Country	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
Indonesia	Temp						2018-19:  2019-20: 	Drought during developing phase with reduced water availability, reduced crop production, increased threat of forest fires with health-related risk. Flooding and landslides in year after El Niño, with increased risk of Dengue fever.
	Rainfall							
Papua New Guinea	Temp						2018-19:  2019-20: 	Enhanced risk of drought during developing phase with reduced water availability. Flooding and landsides in year after El Niño, with increased risk of water-borne disease.
	Rainfall							

4.10 Southern Asia

Previous El Niño events have been associated with warm temperatures and below normal monsoon rainfall in the region, leading to drought and reduced crop productivity. In the year following El Niño, extreme wet conditions have led to an increase in cholera and malaria outbreaks in the region.

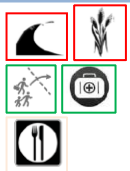
Table 4.11: ***Southern Asia***

Country	**Field**	**SON 2018**	**DJF 18-19**	**MAM 2019**	**JJA 2019**	**SON 2019**	**Risk**	**Evidenced impacts**
India	Temp							Slow onset of monsoon rains in developing El Niño stage. Potential flooding in year after El Niño.
	Rainfall							
Pakistan	Temp							Drought likely in northern regions. Increased risk of malaria epidemics in year after El Niño.
	Rainfall							
Bangladesh	Temp							Drought risk in developing El Niño stage. Increase in cholera risk in year after El Niño.
	Rainfall							
Nepal	Temp							*Lack of established literature to make assessment*
	Rainfall							

4.11 Southeast Asian Peninsula

In previous years, extremely warm and dry conditions have resulted in drought and forest fires and reduced crop productivity.

Table 4.12: ***Southeast Asian Peninsula***

Country	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
China	Temp							Flooding resulting in displacement of people. Increase in risk of dysentery in eastern China.
	Rainfall							
Vietnam	Temp							Increased risk of forest fire and smoke-related deaths.
	Rainfall							
Myanmar	Temp							Moderate drought and reduced maize and rice crops. Increased risk of cholera and malaria.
	Rainfall							

4.12 Central Asia

Previous El Niño events have had relatively little effect on Central Asia, although there is an increased risk of flooding in Afghanistan.

*Table 4.13: **Central Asia***

Country	**Field**	**SON 2018**	**DJF 18-19**	**MAM 2019**	**JJA 2019**	**SON 2019**	**Risk**	**Evidenced impacts**
Afghanistan	Temp							Increased risk of flooding in winter during El Niño and in following summer. Risk to crops, livestock and homes.
	Rainfall							
Tajikistan	Temp							Little previous impact of El Niño events of this type.
	Rainfall							
Kyrgyzstan	Temp							Little previous impact of El Niño events of this type.
	Rainfall							

4.13 Caribbean (including British Overseas Territories)

During the developing phase and peak of El Niño, from September 2018 to May 2019, the Eastern Caribbean – Haiti, Dominican Republic, Puerto Rico, US Virgin Islands, St. Maarten, and Barbados – is very likely to be warmer than normal and likely to be drier than normal. In previous events, this has resulted in drought.

Following the peak of El Niño, from June 2019 to November 2019, the North Western Caribbean – Cuba, Bahamas and Jamaica – is likely to be wetter than normal. In previous El Niño events, this has caused flooding in previous events can increase the risk of Dengue Fever.

Hurricane Season

The Caribbean hurricane season runs from June – November. El Niño suppresses hurricane activity in the Atlantic Basin. Over most of the Caribbean, this will likely result in fewer hurricanes making landfall (e.g., Cuba, Bahamas, Jamaica) at the end of the 2018 hurricane season. In past La Niña events, a significantly higher number of hurricanes made landfall over the Caribbean. This will be of interest if any El Niño event in 2018-19 transitions to La Niña conditions in summer 2019.

Table 4.14: ***Caribbean***

Country	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
Haiti	Temp						2018-19: 2019-20:	Risk of drought and reduced water availability during developing El Niño stage. Potential for flooding in year after El Niño, with increased risk of Dengue fever.
	Rainfall							
Guyana	Temp							Increased drought risk during developing stage. Reduced maize and rice yields. Possible increase in malaria in year after El Niño.
	Rainfall							
Caribbean Overseas Territories	Temp						2018-19: 2019-20:	Risk of drought and reduced water availability during El Niño developing stage. Flooding risk in year after El Niño, with increased risk of water-borne disease and possible displacement of people.
	Rainfall							

4.14 Non-Caribbean British Overseas Territories

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****]*

Northern Subtropical Atlantic (Bermuda)

The Atlantic hurricane season in general is forecast to be below normal in 2018. However, in the northern subtropical Atlantic, north of the main development region in the Caribbean, El Niño conditions would favour higher than average hurricane activity during October and November 2018.

South Atlantic (Falkland Islands, South Georgia and the South Sandwich Islands, British Antarctic Territories)

During the developing phase of El Niño from September to November the Antarctic Peninsula and Islands to the north are likely to be colder than normal. During the peak of El Niño the Antarctic Peninsula is likely to be warmer than normal. There is some indication that the British Antarctic Territories are likely to be drier, especially during the developing phase of El Niño from September to November. However, there is low confidence in the potential impacts of El Niño this far away from the tropics.

Southern Tropical Atlantic (St Helena and dependencies- Ascension Island, Tristan da Cunha)

There is no coherence in the impacts of El Niño across the tropical Atlantic south of the equator.

Pacific – *[Pitcairn Islands]*

The equatorial Central and East Pacific are likely to experience warm and wet conditions during the peak of El Niño. Dry extremes are likely to occur across the Maritime Continent and in the tropical, off-equatorial West Pacific during the peak. The Pitcairn Islands lie in the South Pacific Convergence Zone (SPCZ), which is likely to be wetter than normal during September 2018 – February 2019. This could increase the risk of flooding with potential damage to infrastructure.

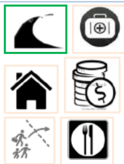
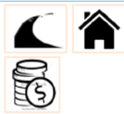
Indian Ocean – *[British Indian Ocean Territory]*

Based on past events, wet conditions are likely in the central Indian Ocean during September to November 2018, as well as during from March to August 2019. This could potentially lead to flooding and damaged infrastructure on islands in the central Indian Ocean.

Southern Europe – *[Gibraltar]*

There is no consistent effect of El Niño on southern Europe.

Table 4.15: ***British Overseas Territories***

Region	Field	SON 2018	DJF 18-19	MAM 2019	JJA 2019	SON 2019	Risk	Evidenced impacts
Northern subtropical Atlantic	Temp							Increase in hurricane activity. Potential increase in Dengue fever.
	Rainfall							
Southern subtropical Atlantic	Temp							Potential for island flooding during El Niño peak.
	Rainfall							
Central Pacific	Temp							Potential for island flooding during El Niño peak.
	Rainfall							
Central Indian Ocean	Temp							*Lack of established literature to make assessment*
	Rainfall							
Southern Europe	Temp							Little previous impact of El Niño events of this type.
	Rainfall							

Section 5: Sources of Uncertainty

There are several key sources of uncertainty to consider

in interpreting this report:

1. There is uncertainty over *whether an El Niño will form*. Although El Niño conditions are likely (70% chance; see Section 2), it remains possible (30% chance) that no El Niño will form. However, substantial temperature and rainfall anomalies can happen in many of these countries even in non-El Niño years, due to other climate influences such as the Indian Ocean Dipole.

2. If an El Niño does form, there is uncertainty over *the timing of the event*. November 2018 is the most likely month, but it is possible that El Niño could develop in October, or not until December. El Niño events are unlikely to form after December.

3. If an El Niño does form, there is uncertainty over *the intensity of the event*. A weak El Niño (ocean surface temperature anomalies less than 1.0°C) is most likely, but a moderate event is also possible.

4. If an El Niño does form, there is uncertainty over *how long after formation the effects would develop*. The temperature and precipitation response to El Niño is not immediate, but likely involves a lag of at least one month, possibly more in regions that are more remote from the Pacific (e.g., Africa).

5. If a weak El Niño does form, there is uncertainty over *the strength of the effects on temperature and precipitation*. A weak El Niño does not necessarily mean a weak effect on temperature and precipitation. For example, Figures 5.1-5.3 below show the relationship between El Niño and accumulated rainfall during the major wet seasons in South Africa, Indonesia and Ethiopia. In South Africa and Indonesia, El Niño events (warmer than average Niño 3.4 SSTs; the right side of the diagram in Figs. 5.1-5.3) are linked to dry conditions, but rainfall has also been below normal during La Niña events (colder than average Niño 3.4 SSTs; the left side of the diagrams) and neutral conditions (Niño 3.4 SSTs close to average; in the middle of the diagrams). Although there is a relationship between the strength of the El Niño event and the degree to which rainfall is below normal, there have been weak and strong El Niño events with similar rainfall. In Ethiopia, the relationship with El Niño is less clear. The relationship between El Niño and enhanced October-December rainfall is due mainly to several strong El Niño events; without these events, there would be no significant relationship to rainfall.

6. If an El Niño does form, there is uncertainty over the *interactions with other regional and global phenomena*. These interactions may alter the temperature and precipitation effects of the El Niño event. For instance, a positive Indian Ocean Dipole event[7] often, but not always, coincides with an El Niño. The Indian Ocean Dipole influences rainfall in East Africa, Indonesia and South Asia. In fact, the Indian Ocean Dipole has a

[7] Warmer than normal sea-surface temperatures in the western Indian Ocean, and colder than normal sea-surface temperatures in the eastern Indian Ocean

stronger effect on East African rainfall than El Niño. It is essential to monitor these other phenomena, together with El Niño, when planning mitigation strategies.

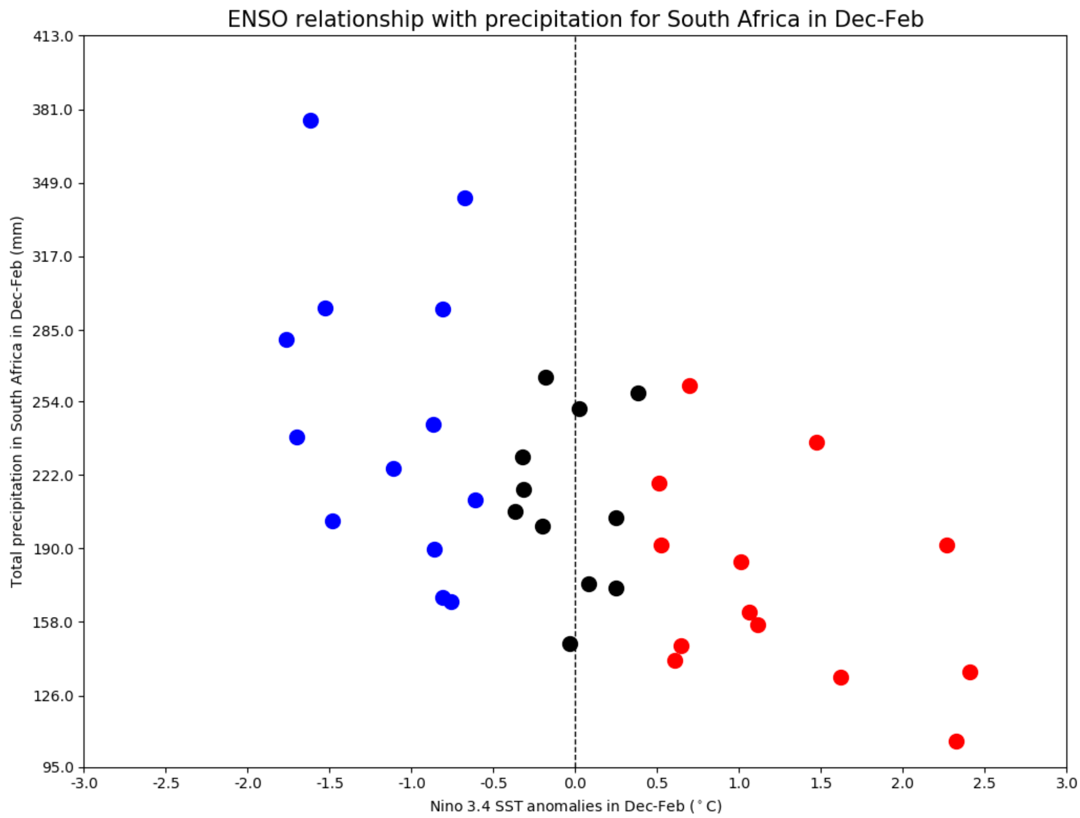


Figure 5.1: Relationship between Niño 3.4 SST anomalies and December-February accumulated rainfall in South Africa, using Global Precipitation Climatology Product precipitation data and National Oceanic and Atmospheric Administration Niño 3.4 data for 1979-2016. Each dot represents one year. El Niño events (red dots) refer to Niño 3.4 SST anomalies warmer than 0.5°C; La Niña events (blue dots) refer to Niño 3.4 SST anomalies colder than -0.5°C. Neutral years are shown with black dots.

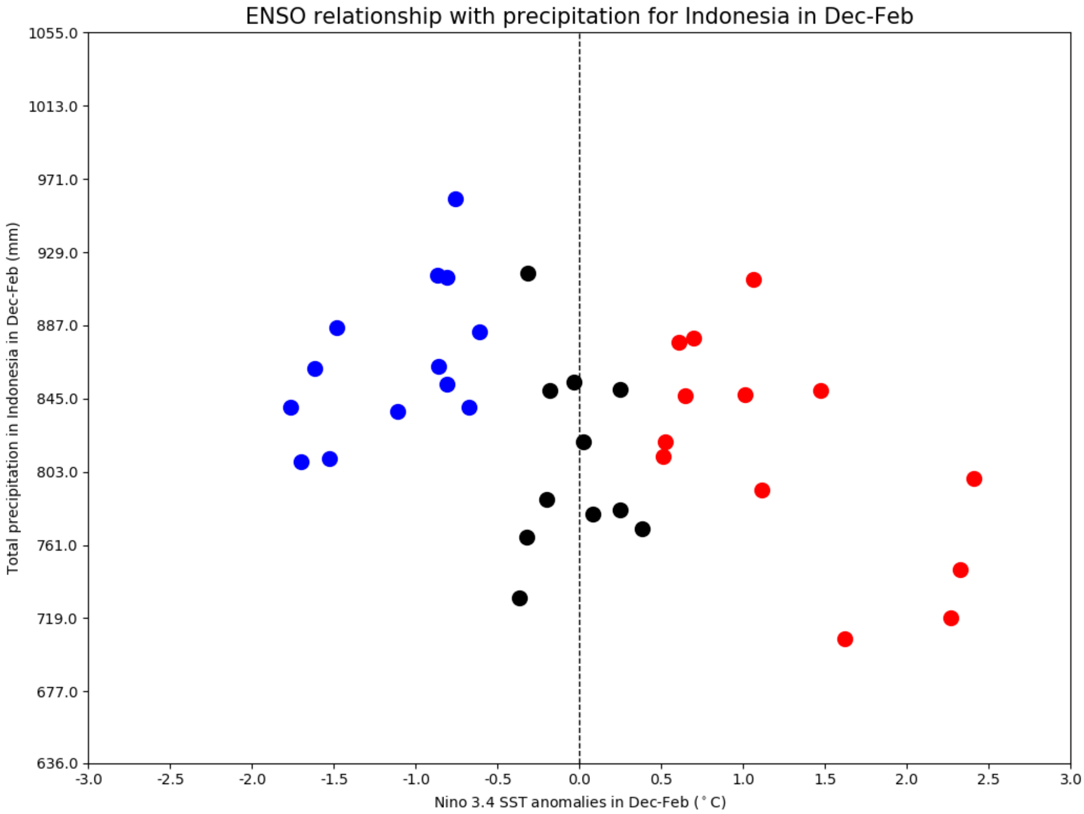


Figure 5.2: The relationship between Niño 3.4 SST anomalies and December-February accumulated rainfall in Indonesia, using the same data as in Fig. 5.1 for 1979-2016. Each dot represents one year. El Niño events (red dots) refer to Niño 3.4 SST anomalies warmer than 0.5◦C; La Niña events (blue dots) refer to Niño 3.4 SST anomalies colder than -0.5◦C. Neutral years are shown with black dots.

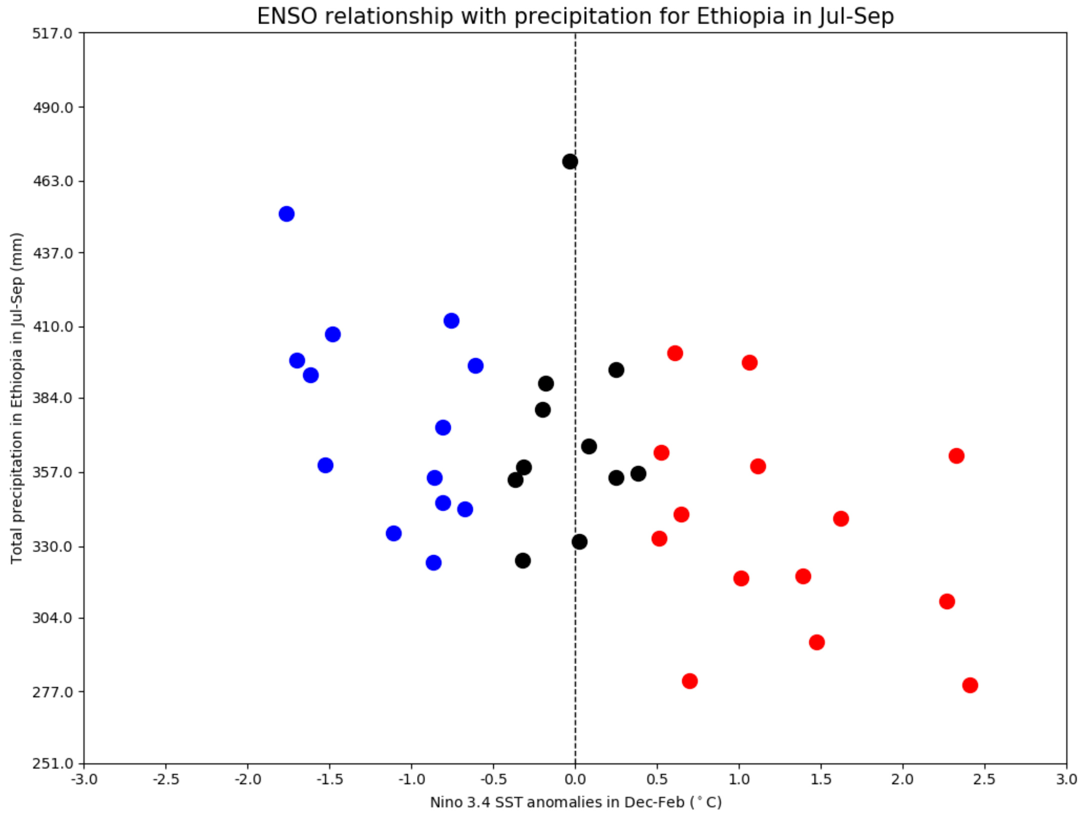
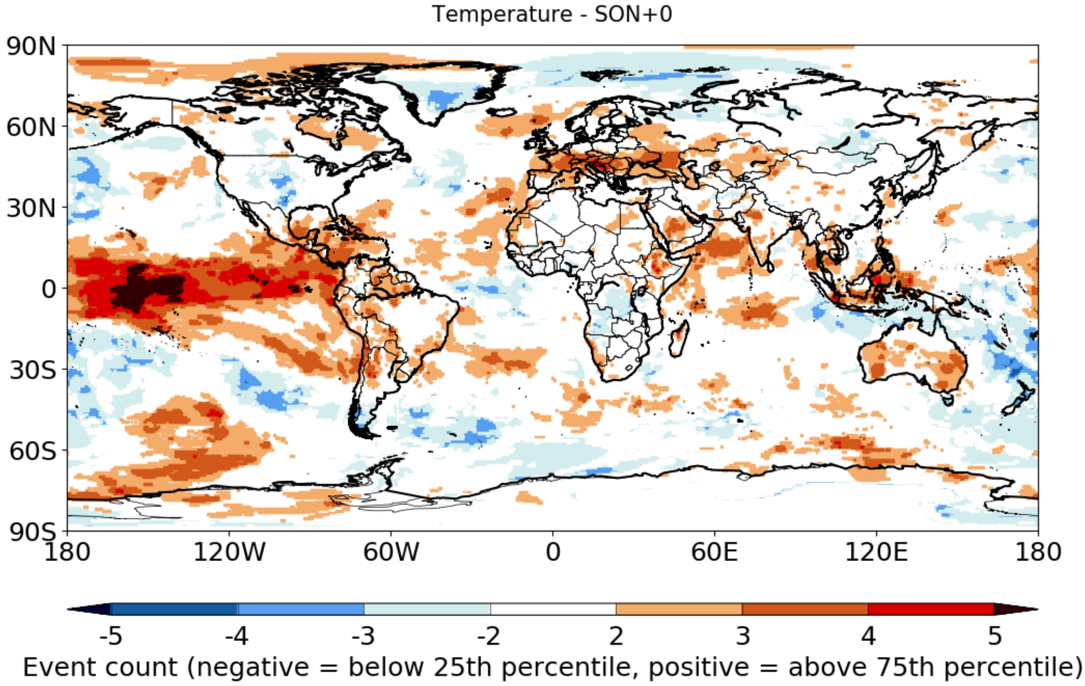


Figure 5.3: The relationship between Niño 3.4 SST anomalies and July-September accumulated rainfall in Ethiopia, using the same data as in Fig. 5.1 for 1979-2016. Each dot represents one year. El Niño events refer to Niño 3.4 SST anomalies warmer than 0.5°C; La Niña events refer to Niño 3.4 SST anomalies colder than -0.5°C. El Niño events (red dots) refer to Niño 3.4 SST anomalies warmer than 0.5°C; La Niña events (blue dots) refer to Niño 3.4 SST anomalies colder than -0.5°C. Neutral years are shown with black dots.

Annex A: Detailed changes in the likelihood of seasonal temperature and rainfall extremes

Figures A.1 to A.6 show the probability of changes of extremes in temperature, precipitation during the developing (Sep-Nov), peak (Dec-Feb) and decaying (Mar-Nov) phases of an El Niño event. This analysis is based on six observed similar El Niño events (i.e., weak events in both the EP and CP regions) over the last 35 years. Extremes here are defined as being in the top (or bottom) 25% of the observed record at that location. These maps supplement the simplified representations of these changes in Figures 3.2 and 3.3.



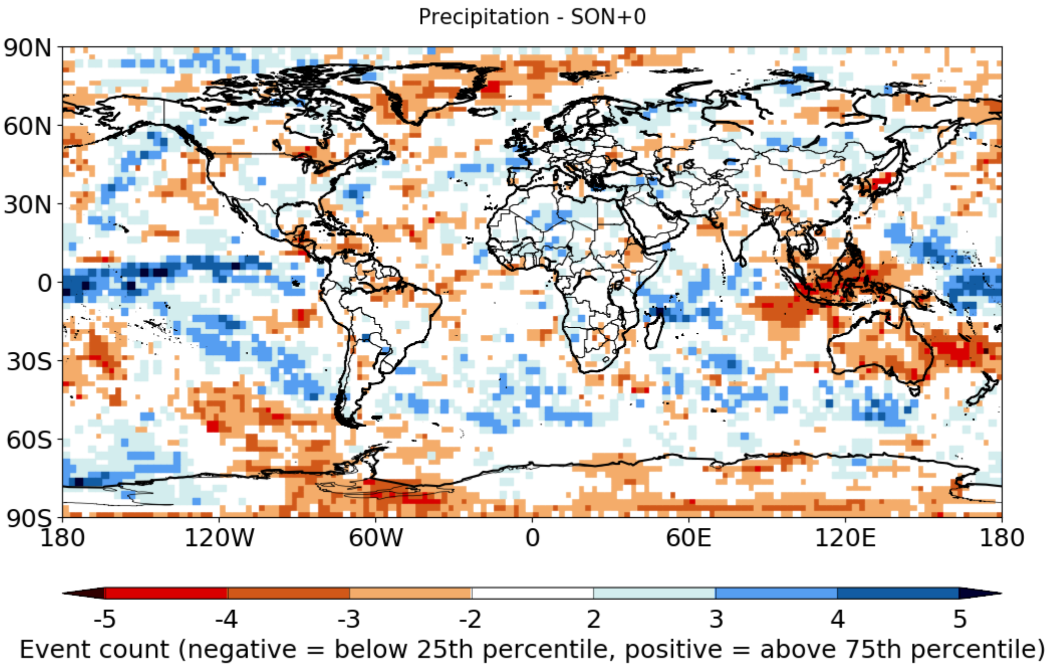
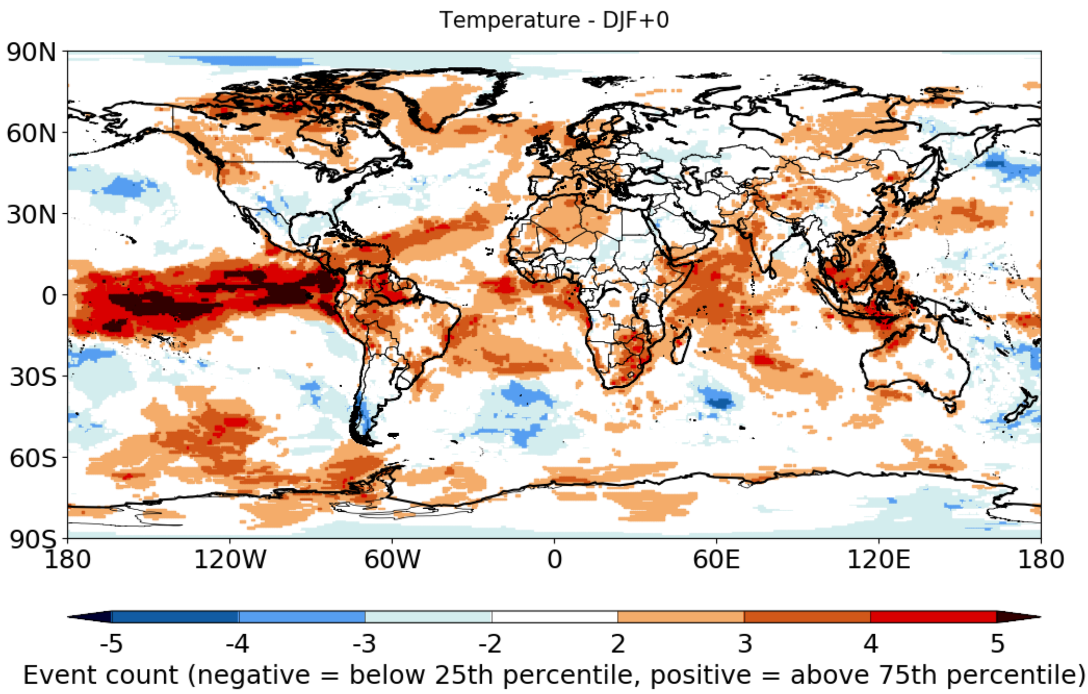


Figure A.1: Global change in the probability of extremes in temperature (top) and precipitation (bottom) during the ***developing phase of a weak EP & CP El Niño*** *event from September-November. Composites are based on 6*

EP & CP events over the last 35 years. Colours show the number of events that temperature was in the upper (or lower) quartile during the developing EP & CP event (e.g., light orange refers to extreme warm temperatures in the upper quartile of the observed record being 1.5-2 times more likely during weak EP & CP El Niño). ***This shows where impacts occur and how consistent they are in that region.***



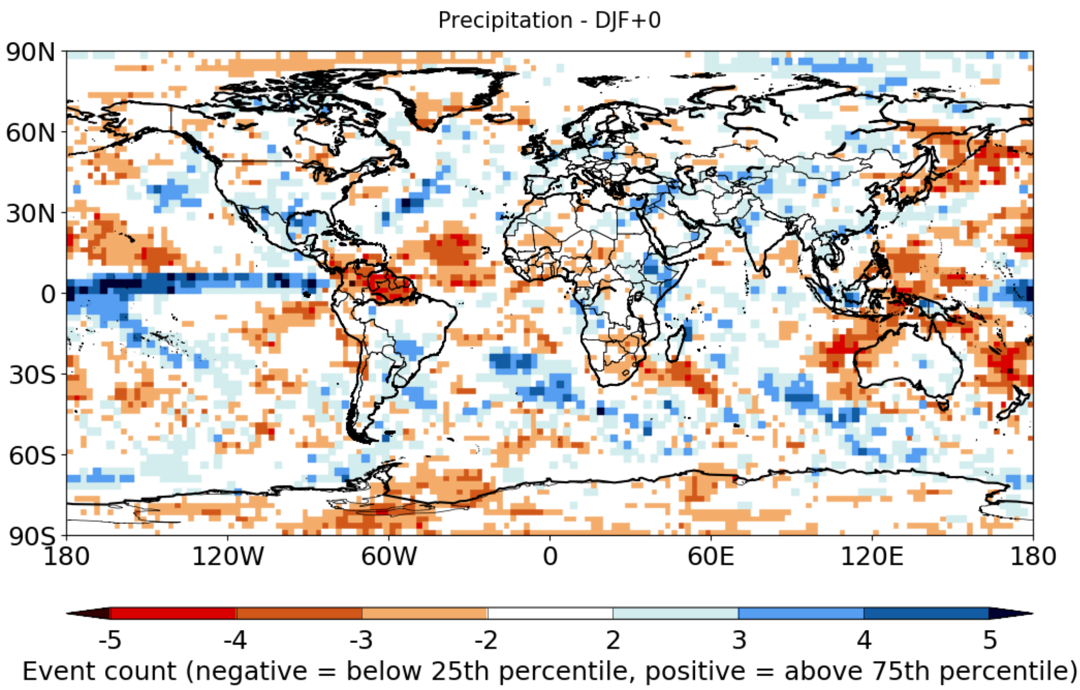


Figure A.2: As in Figure A.1, but for December to February during the peak of an El Niño event. ***This shows where impacts occur and how consistent they are in that region.***

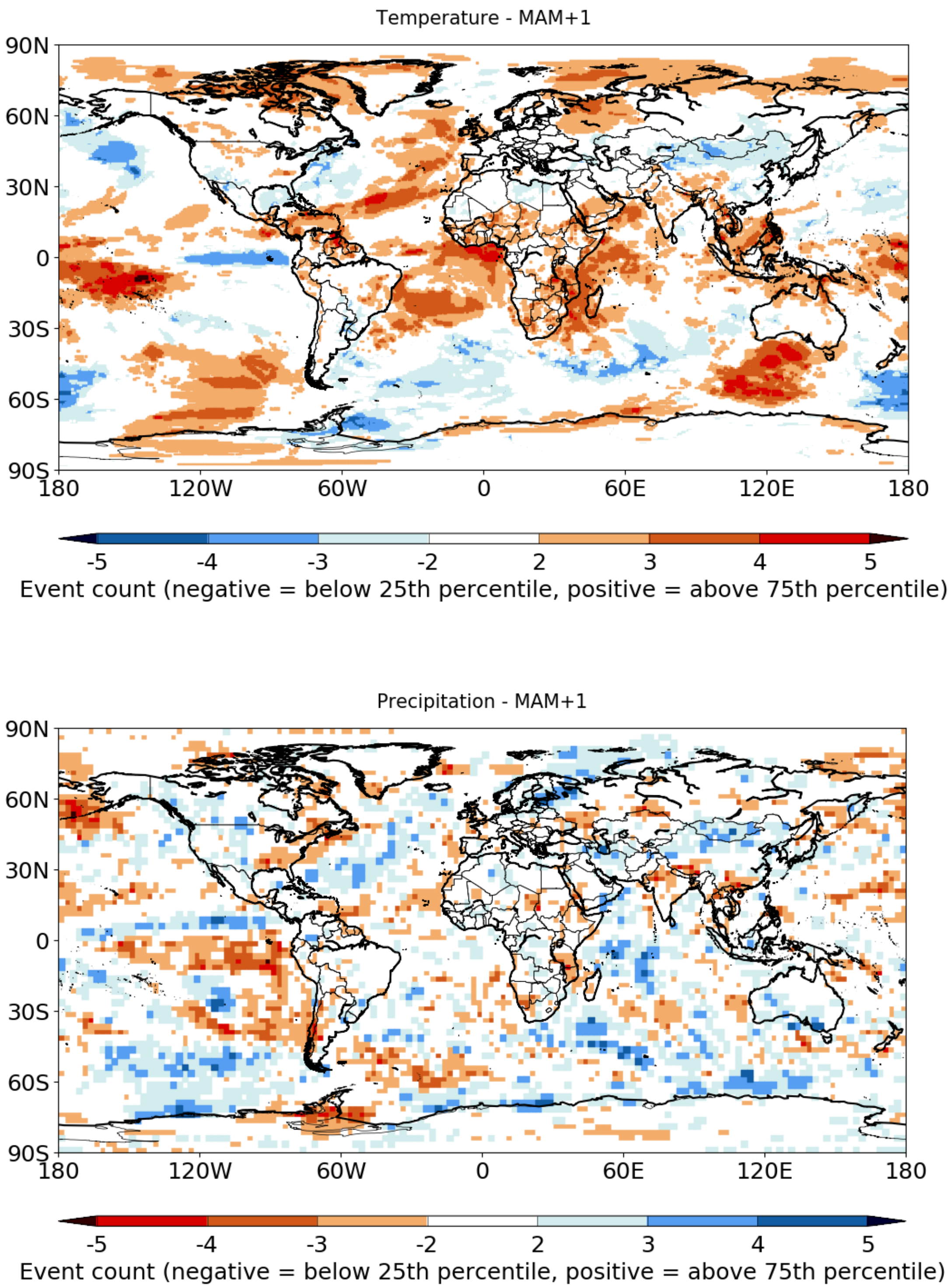
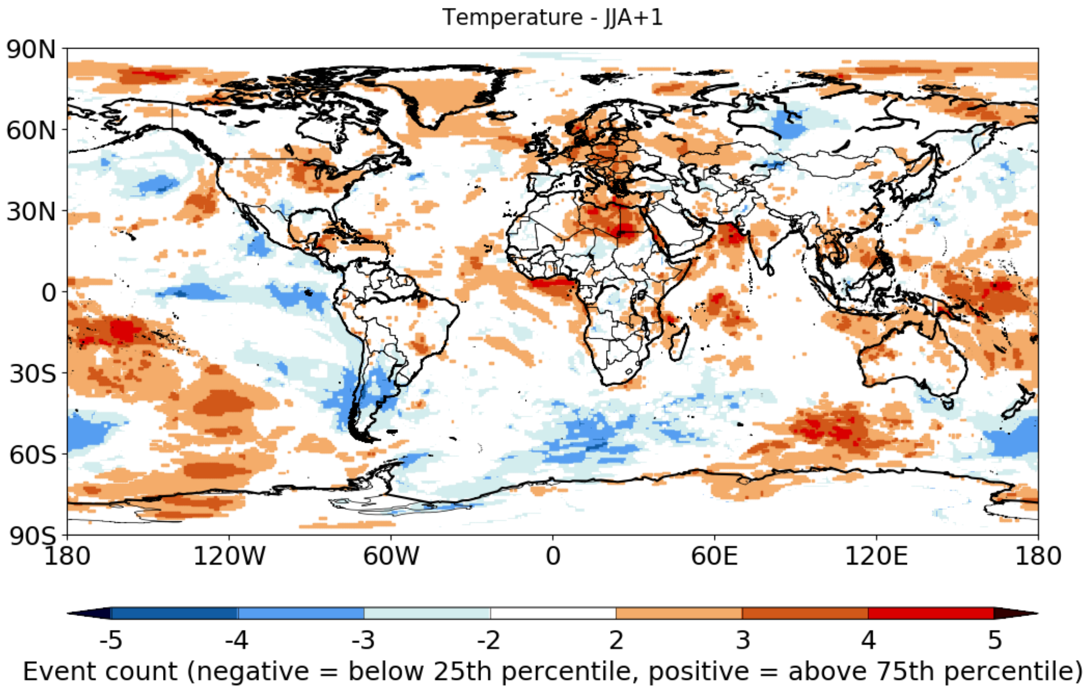


Figure A.3: As in Figure A.1, but from March to May following a weak EP & CP El Niño event. ***This shows where impacts occur and how consistent they are in that region.***



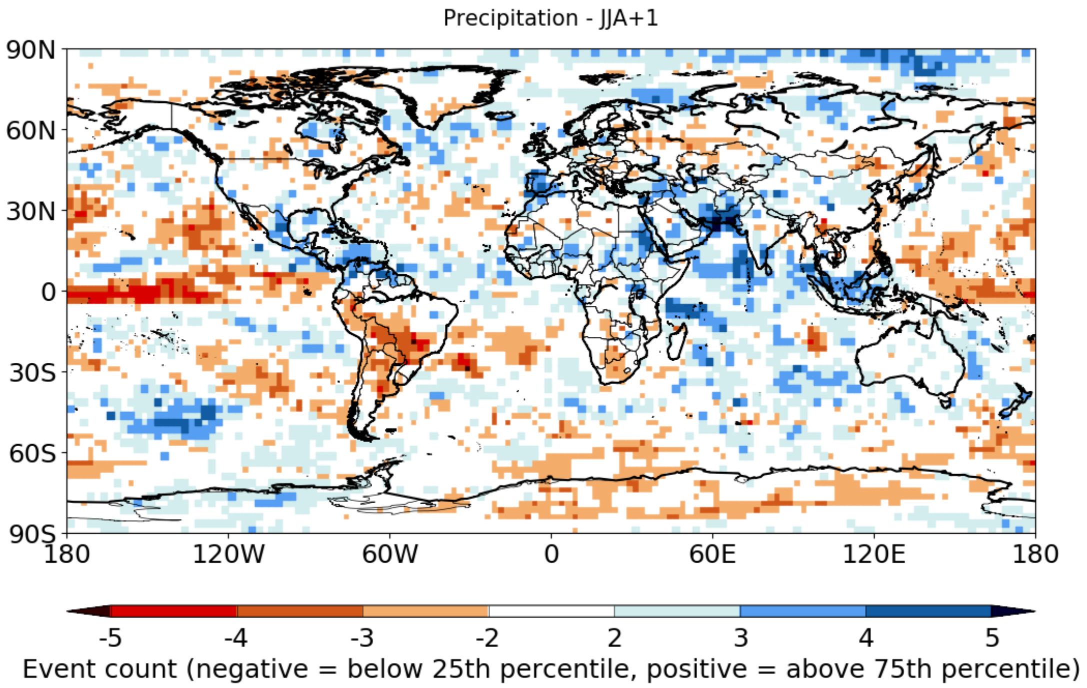
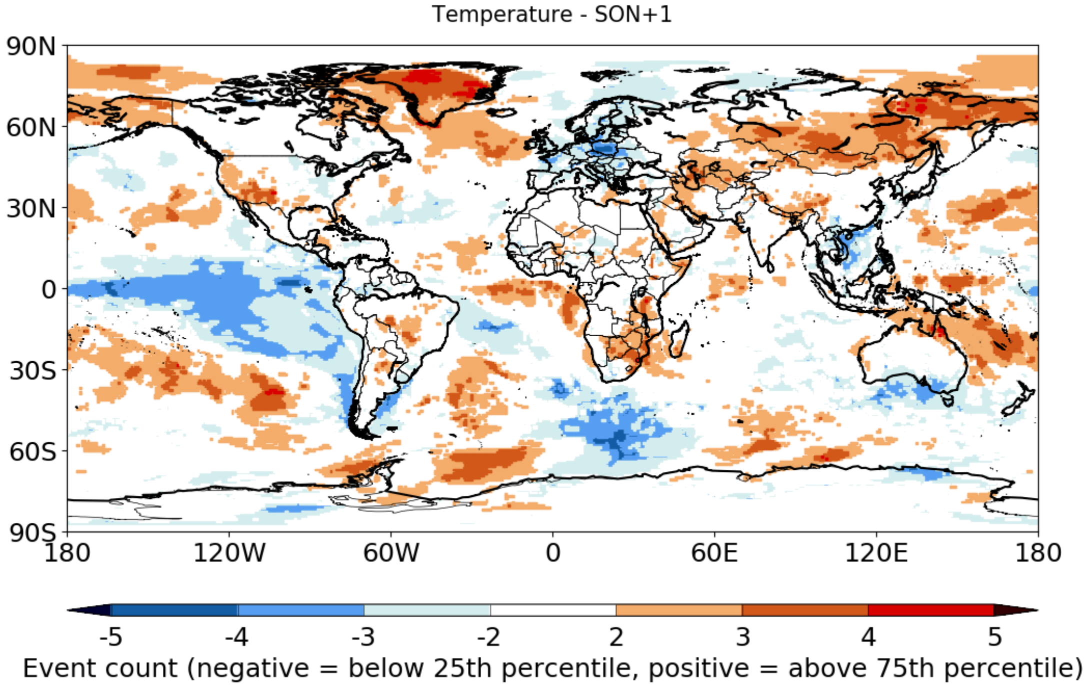


Figure A.4: As in Figure A.1, but for the decaying phase of a weak EP & CP El Niño from June to August. ***This shows where impacts occur and how consistent they are in that region.***



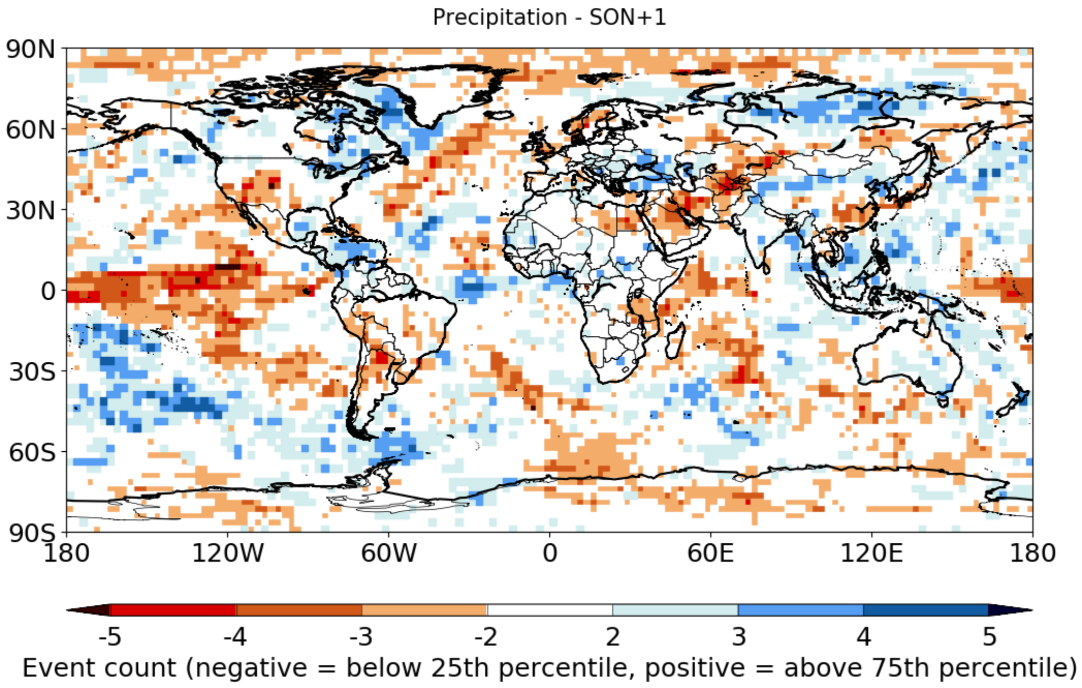


Figure A.5. As in Figure A.1, but for the September to November after a weak EP & CP El Niño. ***This shows where impacts occur and how consistent they are in that region.***