Changes in Climate Extremes and their Impacts on the Natural Physical Environment

(Ch.3 IPCC SREX, 2011)

Jose A. Marengo
CCST/INPE, Sao Paulo, Brazil

Climate & Development Knowledge Network

Overseas Development Institute

Agulhas Applied Knowledge

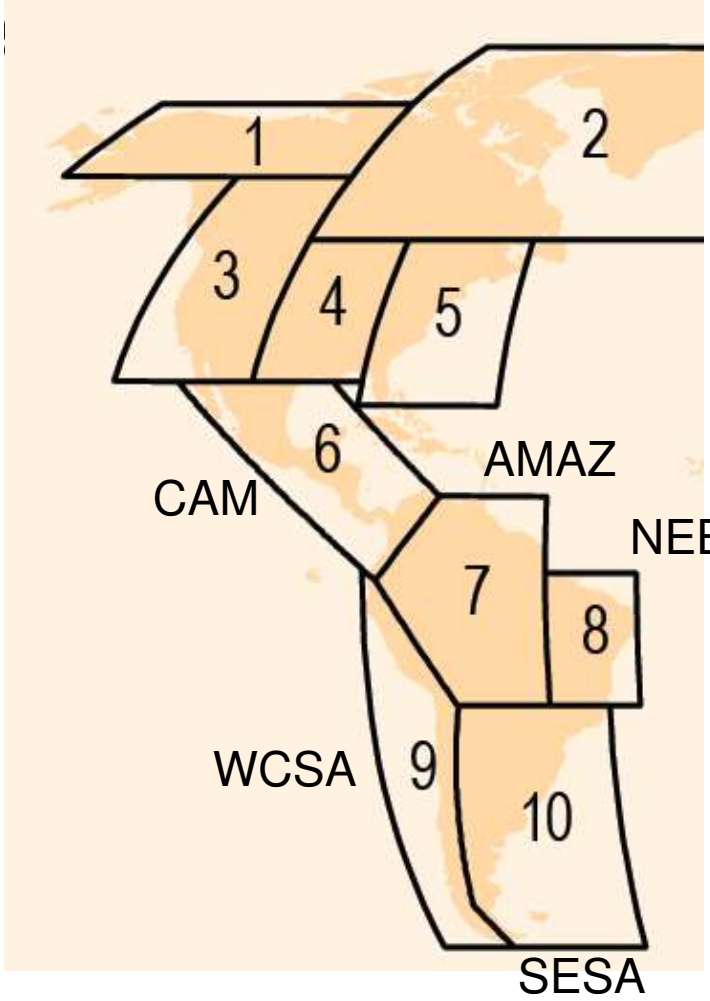
ipcc INTERGOVERNMENTAL PANEL ON climate change

Key messages – observed changes

There is evidence from observations gathered since 1950 of change in some extremes:

- ***Very likely*** **increase in warm days and nights** & **decrease in cold days and nights** on global scale
- ***Likely*** that **more regions have experienced increases** than decreases in **heavy precipitation events**
- ***Likely*** that there has been an increase in **extreme coastal high water** related to increases in mean sea level
- ***Medium confidence*** that some regions of the world have experienced more intense and longer **droughts**, but in some regions droughts have become less frequent, less intense, or shorter
- ***Low confidence*** in any observed long-term (i.e., 40 years or more) increases in **tropical cyclone activity.**The uncertainties in the historical tropical cyclone records→***low confidence*** for the **attribution of any detectable changes in tropical cyclone activity to anthropogenic influences**.

Large-scale, land only, regions used for temperature & precipitation extremes: ➔ More detail than AR4



Key

Symbols

- Increasing trend
- Decreasing trend
- Varying trend
- Inconsistent trend/insufficient evidence
- No or only slight change

Level of confidence in findings

- Low confidence
- Medium confidence
- High confidence

SREX Observations: Temperature and precipitation extremes

Table 1: Observed changes in temperature and precipitation extremes since the 1950s[5]

Table 1 shows observed changes in temperature and precipitation extremes, including dryness in regions of Latin America since 1950, with the period 1961-1990 used as a baseline (see Box 3.1 in Chapter 3 of SREX for more information).

Region and Sub-region	Trends in maximum temperature (warm and cold days)[6]	Trends in minimum temperature (warm and cold nights)[7]	Trends in the heat waves/warm spells[8]	Trends in heavy precipitation (rain, snow)[9]	Trends in dryness and drought[10]
Amazon	Insufficient evidence to identify a significant trend	Insufficient evidence to identify a significant trend	Insufficient evidence	Increase in many areas, decrease in a few areas	Decrease in dryness for much of the region. Some opposite trends and inconsistencies
Northeastern Brazil	Increases in the number of warm days	Increases in the number of warm nights	Insufficient evidence	Increases in many areas, decreases in a few areas	Varying and inconsistent trends
Southeastern South America	Spatially varying trends (increases in some areas decreases in others)	Increases in number of warm nights (decreases in number of cold nights)	Spatially varying trends (increases in some areas, decreases in others)	Increases in northern areas Insufficient evidence in southern areas	Varying and inconsistent trends
West Coast South America	Spatially varying trends (increases in some areas decreases in others)	Increases in number of warm nights (decrease in number of cold nights)	Insufficient evidence	Increases in some areas, decreases in others	Varying and inconsistent trends
Central America and Mexico	Increases in the number of warm days, decreases in the number of cold days	Increases in number of warm nights (decrease in number of cold nights)	Spatially varying trends (increases in some areas, decreases in others)	Increases in many areas, decreases in few areas	Varying and inconsistent trends

SREX Projections: Temperature and precipitation extremes

Table 2: Projected changes in temperature and precipitation extremes at the end of 21st century[11]

Table 2 shows projected changes in temperature and precipitation extremes, including dryness in Latin America. The projections are for the period 2071-2100 (compared with 1961-1990) or 2080-2100 (compared with 1980-2000) and are based on GCM and RCM[12] outputs run under the A2/A1B emissions scenario.

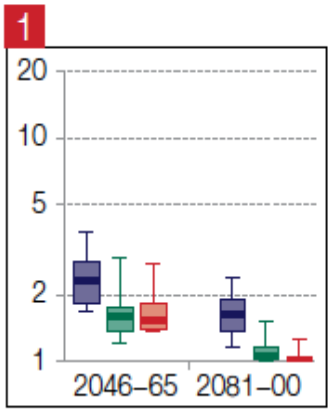
Region and Sub-region	Trends in maximum temperature (the frequency of warm and cold days)[13]	Trends in minimum temperature (the frequency of warm and cold nights)[14]	Trends in the heat waves/warm spells[15]	Trends in heavy precipitation (rain, snow)[16]	Trends in dryness and drought[17]
Amazon	Warm days *likely* to increase (cold days *likely* decrease)	Very *likely* increase in warm nights (*likely* decrease in cold nights)	*Likely* more frequent and longer heat waves and warm spells	Tendency for increases in heavy precipitation events	Inconsistent trends
Northeastern Brazil	Warm days *likely* to increase (cold days *likely* decrease)	*Likely* increase in warm nights (*likely* decrease in cold nights)	*Likely* more frequent and longer heat waves and warm spells in some studies. Non-significant signal in others	Slight or no change	Increase in dryness
Southeastern South America	Warm days *likely* to increase (cold days *likely* decrease)	Very *likely* increase in warm nights (*likely* decrease in cold nights)	Tendency for more frequent and longer heat waves and warm spells	Increases in northern areas Insufficient evidence in southern areas	Inconsistent trends
West Coast South America	Warm days *likely* to increase (cold days *likely* decrease)	*Likely* increase in warm nights (*likely* decrease in cold nights)	*Likely* more frequent and longer heat waves and warm spells	Increases in tropics Insufficient evidence in extratropics	Varying and inconsistent trends
Central America and Mexico	Warm days *likely* to increase (cold days *likely* decrease)	*Likely* increase in warm nights (*likely* decrease in cold nights)	*Likely* more frequent, longer and/or more intense heat waves/warm spells in most of the region	Inconsistent trends	Increase in dryness in Central America and Mexico, with less confidence in trend in extreme South of region

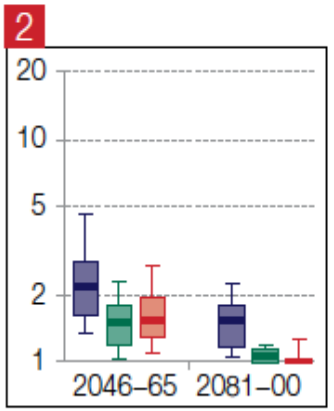
SREX Projections: Return Periods-Temperature extremes

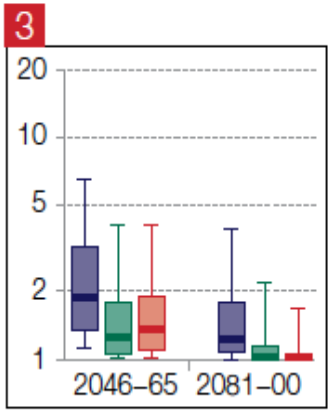
Figure 2: Projected return period (in years) of late 20th century 20-year return values of annual maximum (a) of the daily maximum temperature; and (b) 24-hour precipitation rates

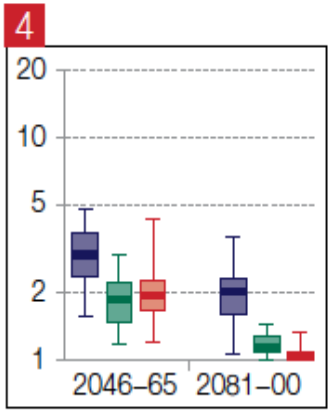
(a) Temperature

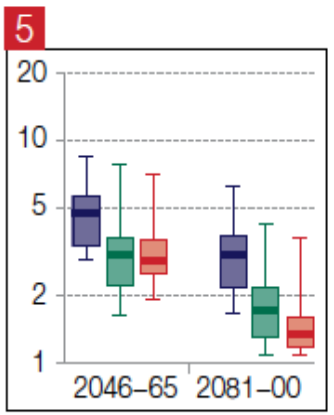
These graphs show how often the hottest day in the last 20 years of the 20th century will be experienced by the middle and end of the 21st century. These are shown under three different emissions scenarios: B1, A1B and A2.[18] For example, in N.E. Brazil, the hottest day experienced in the last 20 years at the end of the 20th century will happen annually or biannually by the end of the 21st century. So what are now considered temperature extremes will become much more like 'normal' temperatures in 70 years' time.



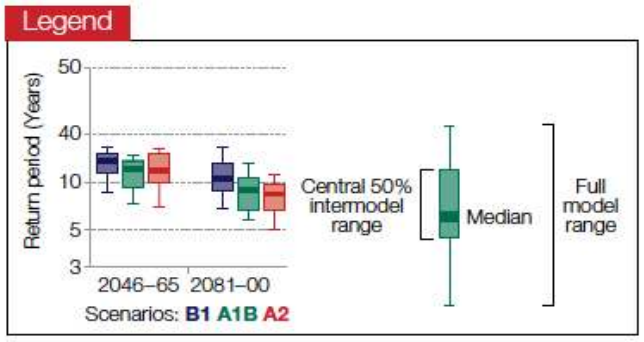








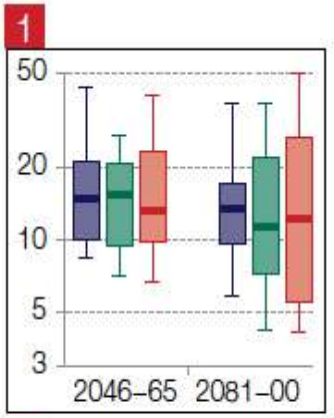
Legend

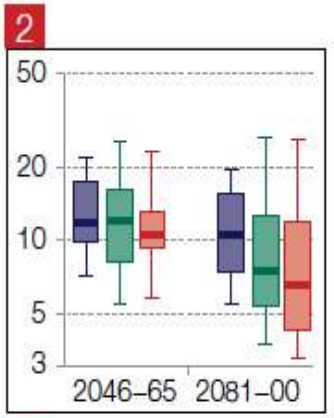


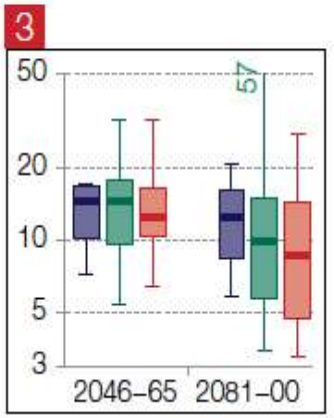
SREX Projections: Return Periods-Precipitation extremes

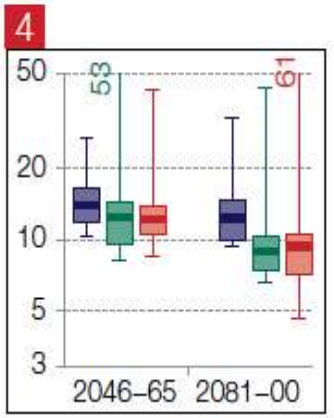
(b) Precipitation

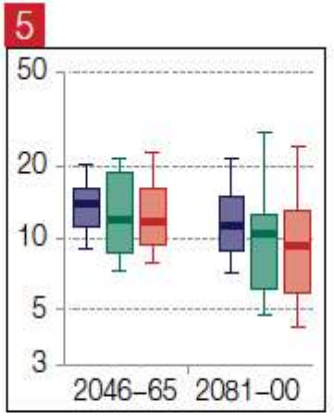
These graphs show how often the wettest day in the last 20 years of the 20th century will be experienced by the middle and end of the 21st century. These are shown under three different emissions scenarios: B1, A1B and A2.[19] For example, in N.E. Brazil, the wettest day experienced in the last 20 years at the end of the 20th century will happen more like every 10 years by the end of the 21st century depending on which emissions scenario is followed.



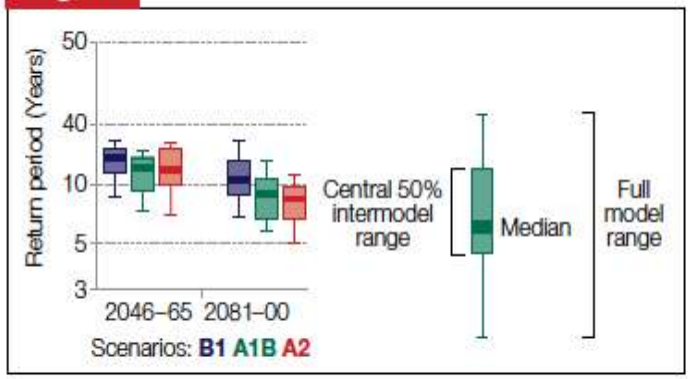








Legend



Key messages–Phenomena Related to Weather and Climate Extremes

		Observed Changes (since 1950)	Attribution of Observed Changes	Projected Changes (up to 2100) with Respect to Late 20th Century
Phenomena Related to Weather and Climate Extremes	**Monsoons** (Section 3.4.1)	*Low confidence* in trends because of insufficient evidence.	*Low confidence* due to insufficient evidence.	*Low confidence* in projected changes in monsoons, because of insufficient agreement between climate models.
	El Niño and other Modes of Variability (Sections 3.4.2 and 3.4.3)	*Medium confidence* in past trends toward more frequent central equatorial Pacific El Niño-Southern Oscillation (ENSO) events. Insufficient evidence for more specific statements on ENSO trends. *Likely* trends in Southern Annular Mode (SAM).	*Likely* anthropogenic influence on identified trends in SAM.[1] Anthropogenic influence on trends in North Atlantic Oscillation (NAO) are *about as likely as not*. No attribution of changes in ENSO.	*Low confidence* in projections of changes in behavior of ENSO and other modes of variability because of insufficient agreement of model projections.
	Tropical Cyclones (Section 3.4.4)	*Low confidence* that any observed long-term (i.e., 40 years or more) increases in tropical cyclone activity are robust, after accounting for past changes in observing capabilities.	*Low confidence* in attribution of any detectable changes in tropical cyclone activity to anthropogenic influences (due to uncertainties in historical tropical cyclones record, incomplete understanding of physical mechanisms, and degree of tropical cyclone variability).	*Likely* decrease or no change in frequency of tropical cyclones. *Likely* increase in mean maximum wind speed, but possibly not in all basins. *Likely* increase in heavy rainfall associated with tropical cyclones.
	Extratropical Cyclones (Section 3.4.5)	*Likely* poleward shift in extratropical cyclones. *Low confidence* in regional changes in intensity.	*Medium confidence* in an anthropogenic influence on poleward shift.	*Likely* impacts on regional cyclone activity but *low confidence* in detailed regional projections due to only partial representation of relevant processes in current models. *Medium confidence* in a reduction in the numbers of mid-latitude storms. *Medium confidence* in projected poleward shift of mid-latitude storm tracks.

ipcc
INTERGOVERNMENTAL PANEL ON climate change

Key messages–Impacts on Physical Environment

		Observed Changes (since 1950)	Attribution of Observed Changes	Projected Changes (up to 2100) with Respect to Late 20th Century
Impacts on Physical Environment	**Droughts** (Section 3.5.1)	*Medium confidence* that some regions of the world have experienced more intense and longer droughts, in particular in southern Europe and West Africa, but opposite trends also exist. [Regional details in Table 3-2]	*Medium confidence* that anthropogenic influence has contributed to some observed changes in drought patterns. *Low confidence* in attribution of changes in drought at the level of single regions due to inconsistent or insufficient evidence.	*Medium confidence* in projected increase in duration and intensity of droughts in some regions of the world, including southern Europe and the Mediterranean region, central Europe, central North America, Central America and Mexico, northeast Brazil, and southern Africa. Overall *low confidence* elsewhere because of insufficient agreement of projections. [Regional details in Table 3-3]
	Floods (Section 3.5.2)	Limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of floods at regional scale. Furthermore, there is low agreement in this evidence, and thus overall *low confidence* at the global scale regarding even the sign of these changes. *High confidence* in trend toward earlier occurrence of spring peak river flows in snowmelt- and glacier-fed rivers.	*Low confidence* that anthropogenic warming has affected the magnitude or frequency of floods at a global scale. *Medium confidence* to *high confidence* in anthropogenic influence on changes in some components of the water cycle (precipitation, snowmelt) affecting floods.	*Low confidence* in global projections of changes in flood magnitude and frequency because of insufficient evidence. *Medium confidence* (based on physical reasoning) that projected increases in heavy precipitation would contribute to rain-generated local flooding in some catchments or regions. *Very likely* earlier spring peak flows in snowmelt- and glacier-fed rivers.
Impacts on Physical Environment (Continued)	**Extreme Sea Level and Coastal Impacts** (Sections 3.5.3, 3.5.4, and 3.5.5)	*Likely* increase in extreme coastal high water worldwide related to increases in mean sea level in the late 20th century.	*Likely* anthropogenic influence via mean sea level contributions.	*Very likely* that mean sea level rise will contribute to upward trends in extreme coastal high water levels. *High confidence* that locations currently experiencing coastal erosion and inundation will continue to do so due to increasing sea level, in the absence of changes in other contributing factors.
	Other Physical Impacts (Sections 3.5.6, 3.5.7, and 3.5.8)	*Low confidence* in global trends in large landslides in some regions. *Likely* increased thawing of permafrost with *likely* resultant physical impacts.	*Likely* anthropogenic influence on thawing of permafrost. *Low confidence* of other anthropogenic influences because of insufficient evidence for trends in other physical impacts in cold regions.	*High confidence* that changes in heat waves, glacial retreat, and/or permafrost degradation will affect high mountain phenomena such as slope instabilities, mass movements, and glacial lake outburst floods. *High confidence* that changes in heavy precipitation will affect landslides in some regions. *Low confidence* in projected future changes in dust activity.

Key messages – projected changes

- *Virtually certain* that increases in the frequency and magnitude of **warm daily temperature extremes** and decreases in **cold extremes** will occur

- *Likely* that the frequency of **heavy precipitation** or the proportion of total rainfall from heavy falls will increase over many areas

- *Medium confidence* that **droughts** will intensify in some seasons and areas

- *Very likely* that mean sea level rise will contribute to upward trends in extreme **coastal high water levels**

- There is *low confidence* in projections of changes in **tropical cyclone** genesis, location, tracks, duration, or areas of impact. It is likely that **tropical cyclone** related rainfall rates will increase with greenhouse warming

- **SREX: Significantly expanded information compared to AR4 in particular on regional scale. Limitations to provide information at higher resolutions (data coverage, model uncertainties, resolution)**

- **Level of certainty in projection strongly depends on the considered extreme, region and season (e.g. uncertainties in extreme rainfall and tropical cyclones→attribution to human causes)**