Climatology of High Impact Weather

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DHMZ

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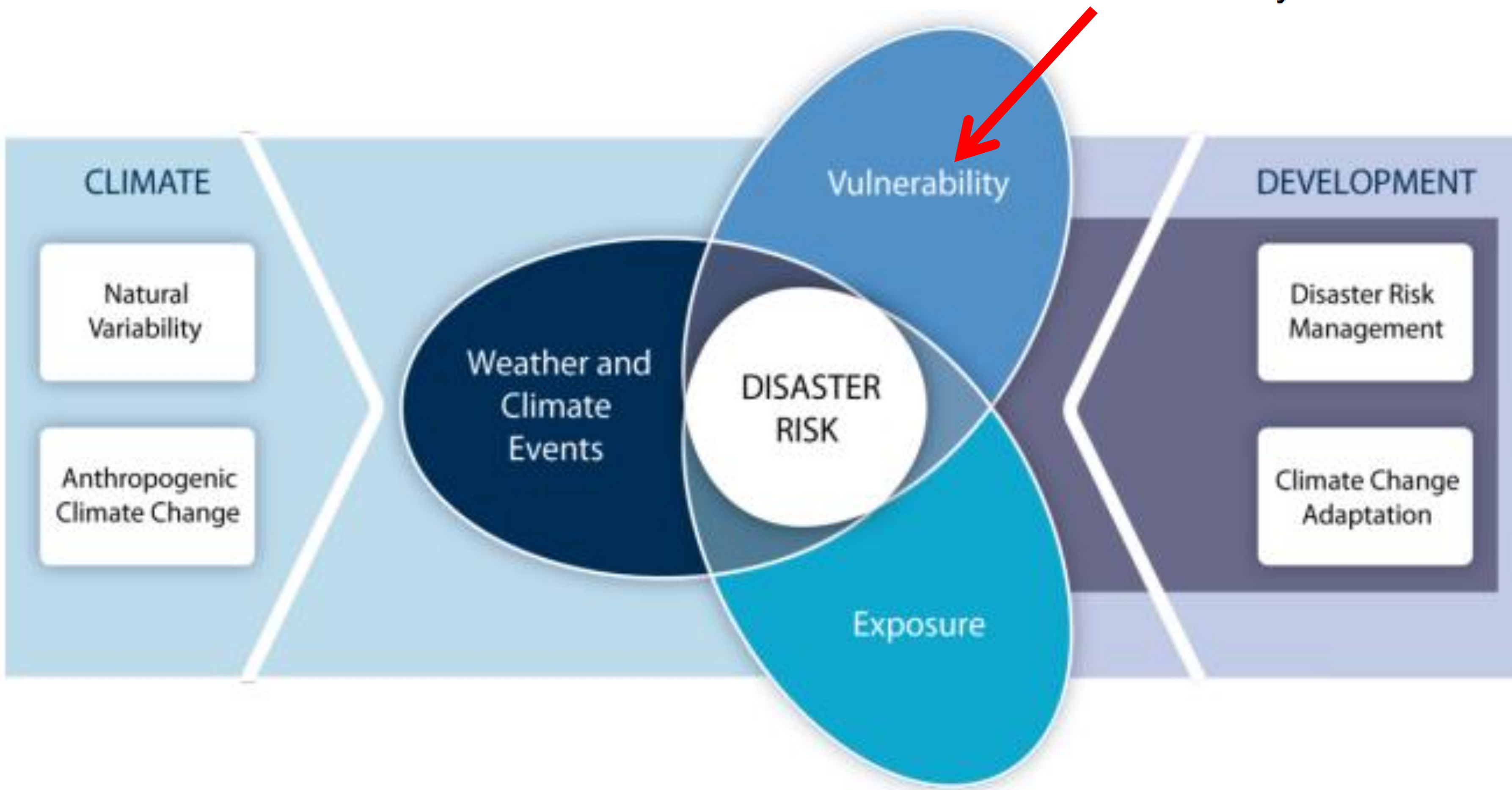
- A changing climate leads to changes in
  1) extreme weather events
  2) extreme climate events
- Impacts from weather and climate events depend on
  1) nature and severity of event
  2) vulnerability
  3) exposure
- **Socioeconomic development** interacts with **natural climate variations** and **human-caused climate change** to influence disaster risk
- Increasing (1) vulnerability, (2) exposure, or (3) severity and frequency of climate events increases **disaster risk**
- For **exposed** and **vulnerable** communities, even **non-extreme** weather and climate events can have **extreme** impacts

IPCC (2012) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* the predisposition of a person or group to be adversely affected



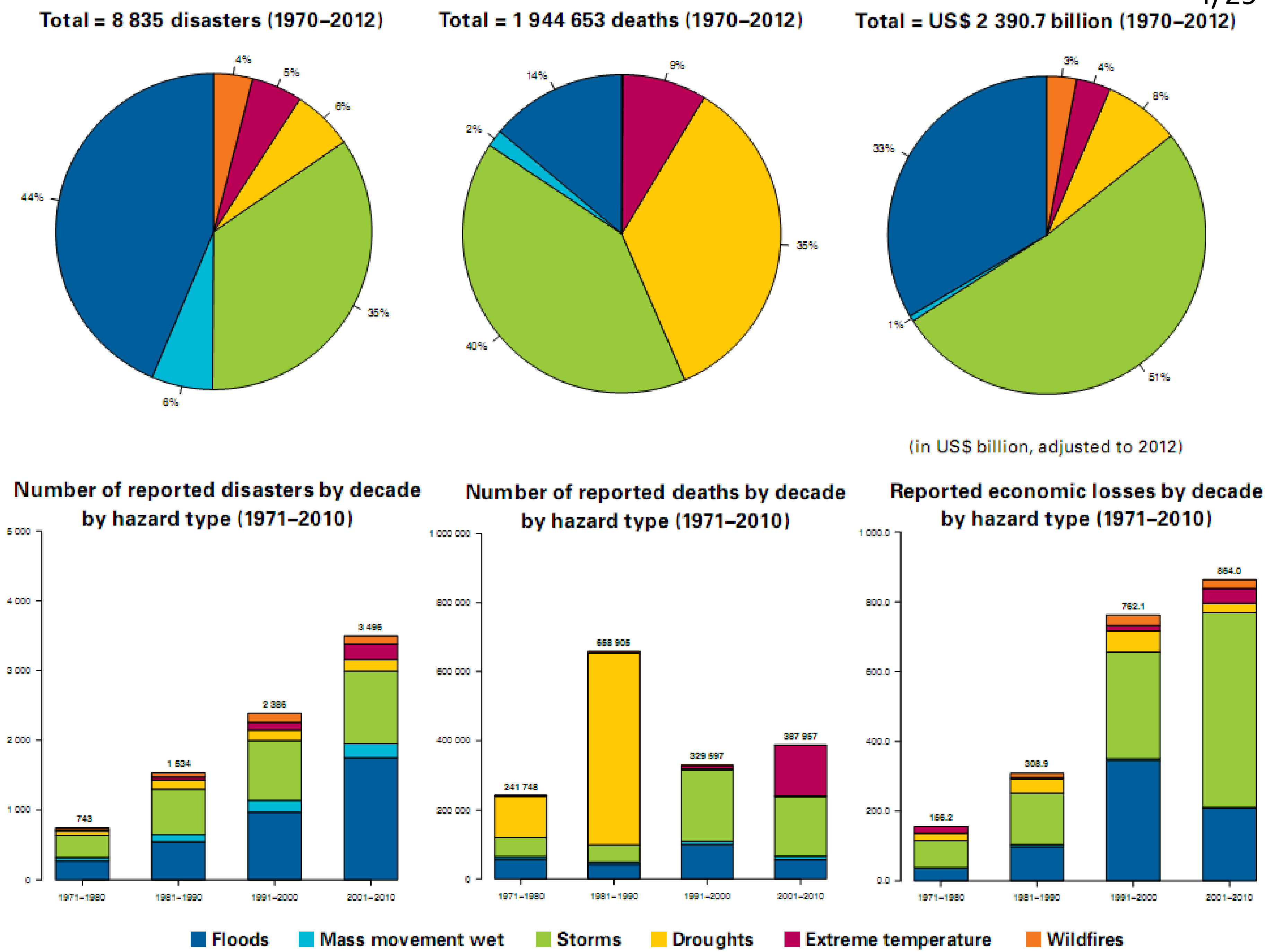
IPCC (2012) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*

Disasters ranked according to reported (a) deaths and (b) economic losses, globally (1970–2012). TC indicates disasters caused by tropical cyclones.

(a)	Disaster type	Year	Country	Number of deaths
1	Drought	1983	Ethiopia	300 000
2	Storm (TC[a])	1970	Bangladesh	300 000
3	Drought	1984	Sudan	150 000
4	Storm (TC[b])	1991	Bangladesh	138 866
5	Storm (*Nargis*)	2008	Myanmar	138 366
6	Drought	1975	Ethiopia	100 000
7	Drought	1983	Mozambique	100 000
8	Extreme temperature	2010	Russian Federation	55 736
9	Flood	1999	Venezuela, Bolivarian Republic of	30 000
10	Flood	1974	Bangladesh	28 700

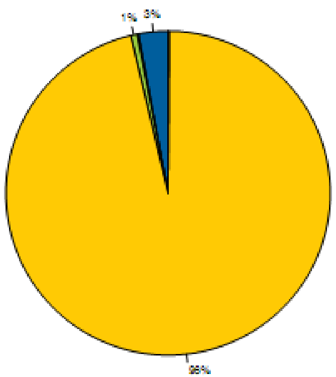
(b)	Disaster type	Year	Country	Economic losses (in US$ billion)
1	Storm (*Katrina*)	2005	United States	146.89
2	Storm (*Sandy*)	2012	United States	50.00
3	Storm (*Andrew*)	1992	United States	43.37
4	Flood	1998	China	42.25
5	Flood	2011	Thailand	40.82
6	Storm (*Ike*)	2008	United States	31.98
7	Flood	1995	Democratic People's Republic of Korea	22.59
8	Extreme temperature	2008	China	22.49
9	Storm (*Ivan*)	2004	United States	21.87
10	Drought	1994	China	21.33

WMO (2014) *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2012)*

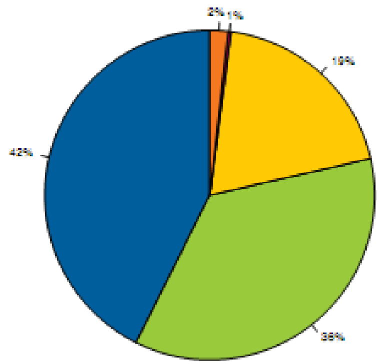

Total = 8 835 disasters (1970–2012)
4%
5%
6%
35%
6%
44%
Total = 1 944 653 deaths (1970–2012)
9%
35%
40%
2%
14%
Total = US$ 2 390.7 billion (1970–2012)
3%
4%
8%
51%
1%
33%
(in US$ billion, adjusted to 2012)
Number of reported disasters by decade by hazard type (1971–2010)
743
1 534
2 386
3 496
Number of reported deaths by decade by hazard type (1971–2010)
241 748
658 905
329 597
387 957
Reported economic losses by decade by hazard type (1971–2010)
156.2
308.9
762.1
864.0
1971–1980
1981–1990
1991–2000
2001–2010
Floods
Mass movement wet
Storms
Droughts
Extreme temperature
Wildfires

Africa

Total = 698 380 deaths (1970–2012)

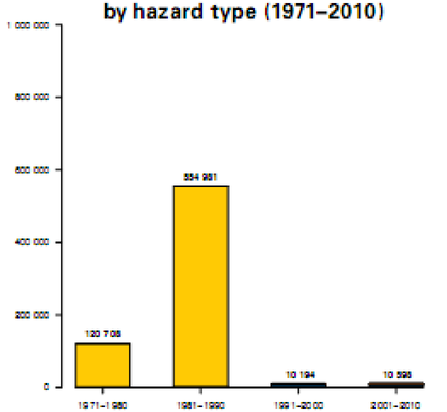


Total = US$ 26.6 billion (1970–2012)

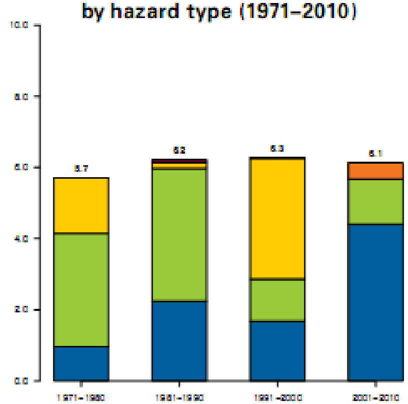


(in US$ billion, adjusted to 2012)

Number of reported deaths by decade by hazard type (1971–2010)



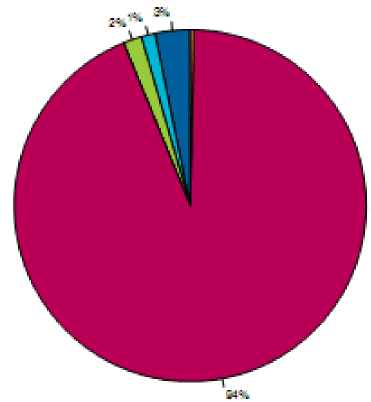
Reported economic losses by decade by hazard type (1971–2010)



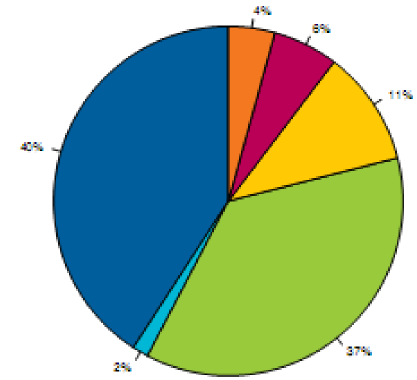
(in US$ billion, adjusted to 2012)

Europe

Total = 149 959 deaths (1970–2012)

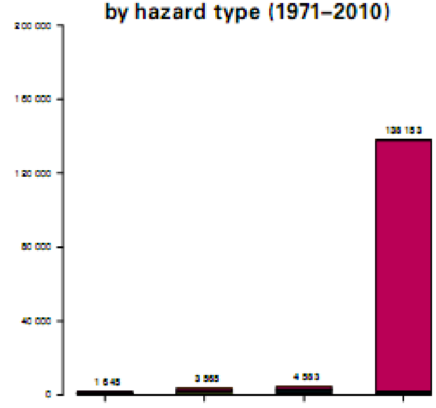


Total = US$ 375.7 billion (1970–2012)

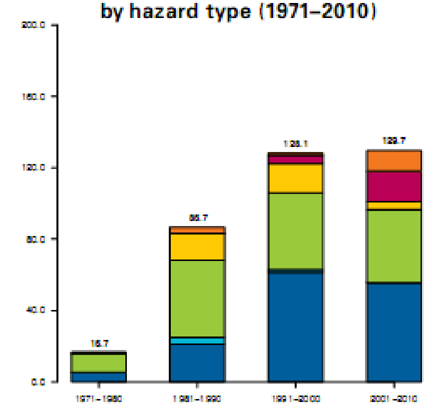


(in US$ billion, adjusted to 2012)

Number of reported deaths by decade by hazard type (1971–2010)

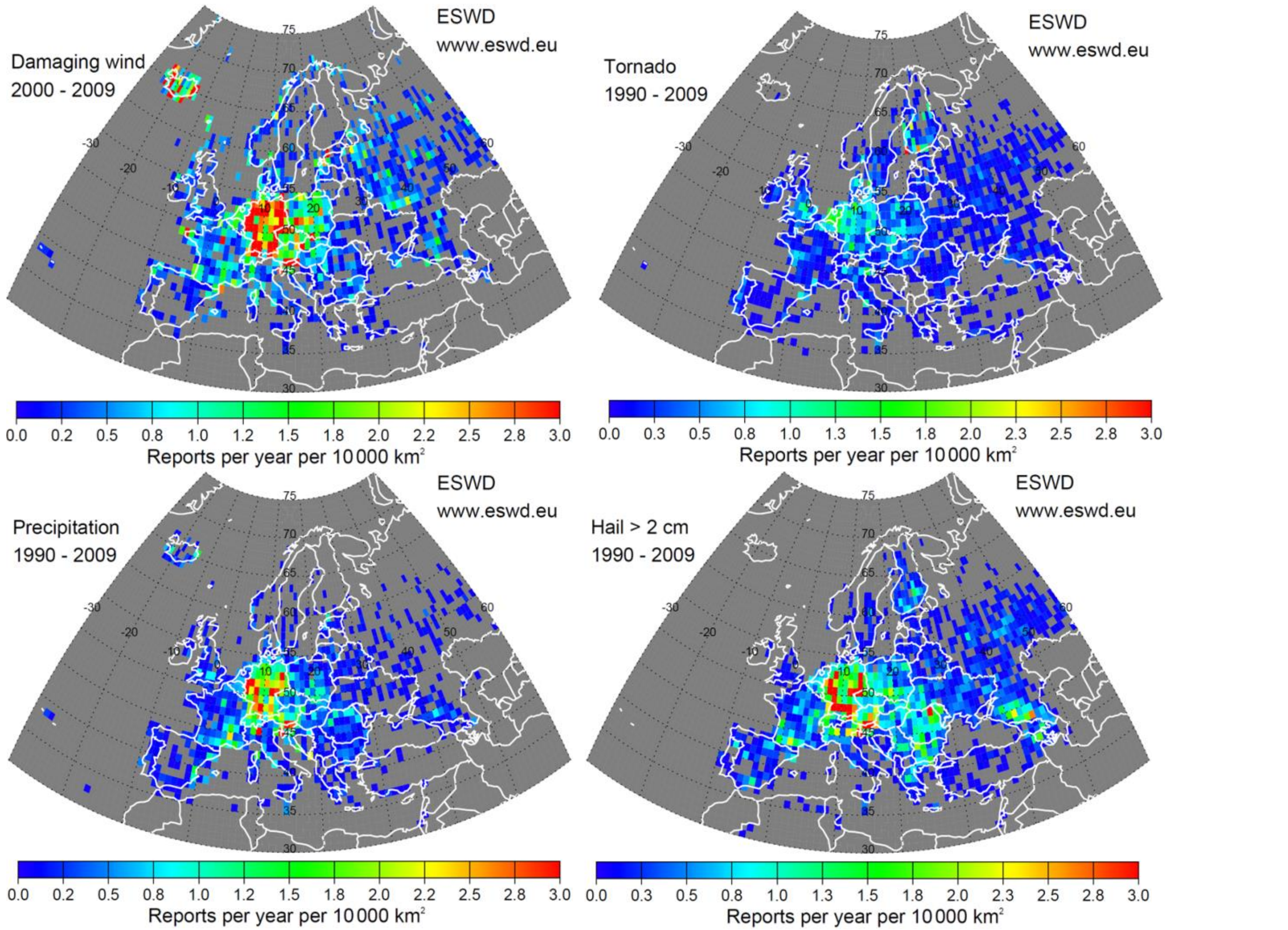


Reported economic losses by decade by hazard type (1971–2010)

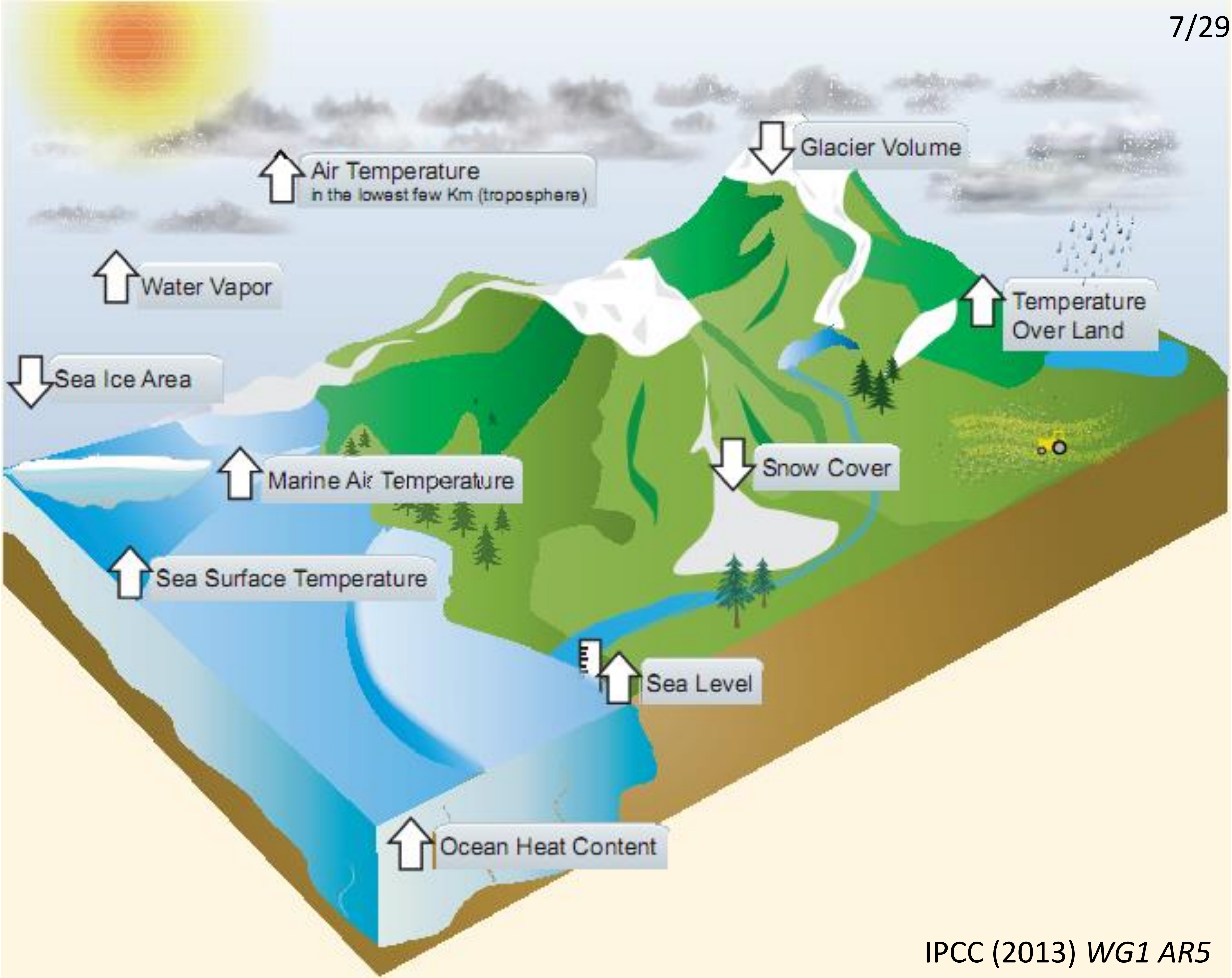


(in US$ billion, adjusted to 2012)

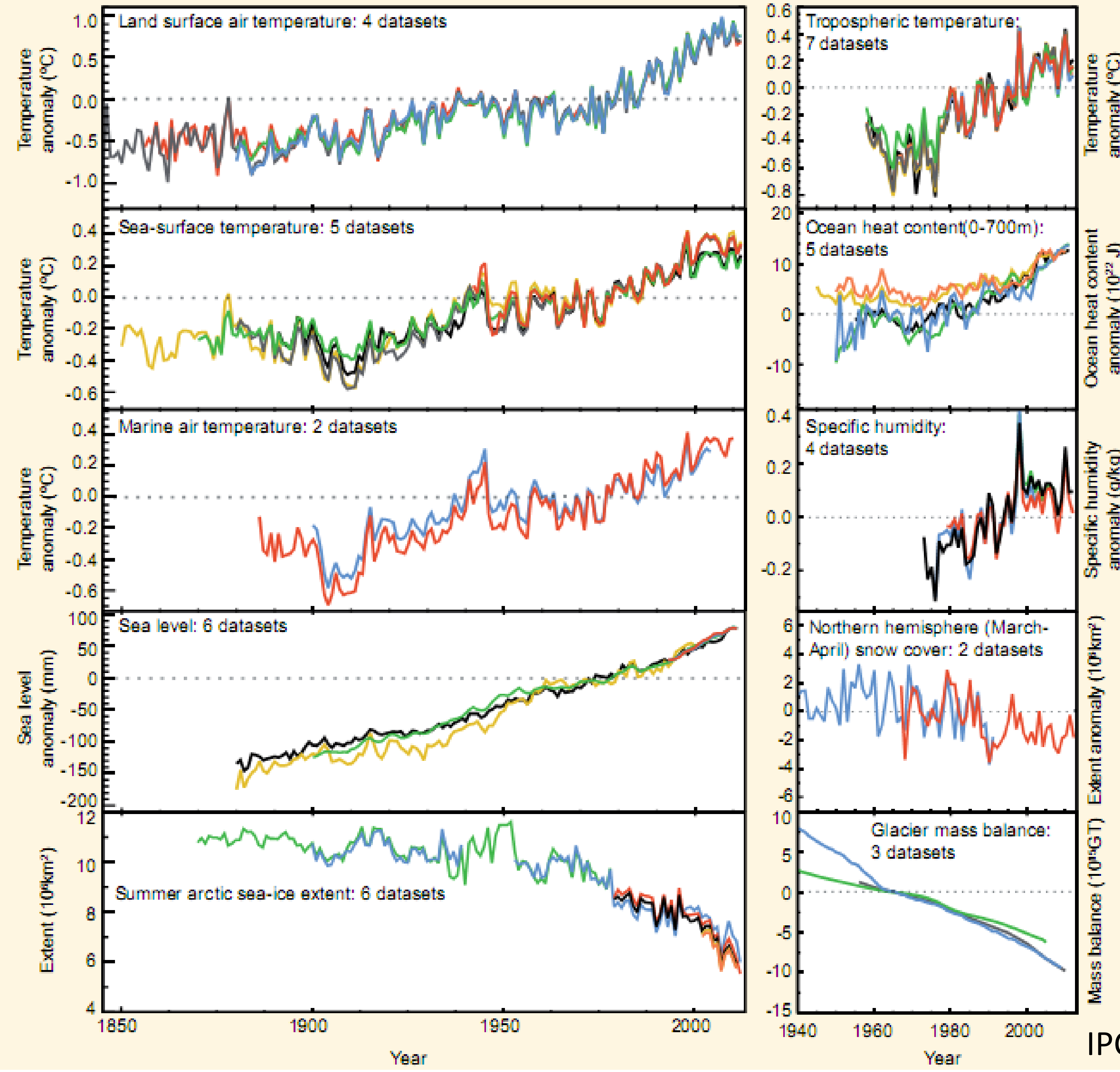
Floods | Mass movement wet | Storms | Droughts | Extreme temperature | Wildfires



Overview of the damaging wind gusts ≥ 25 m/s (a) and tornado (b), heavy precipitation (c) and hail diameter ≥ 2 cm (d) in Europe in the period 1990–2009, except for damaging wind in the period 2000–2009 (prepared by Aloise Holzer; European Severe Weather Database) .



IPCC (2013) *WG1 AR5*



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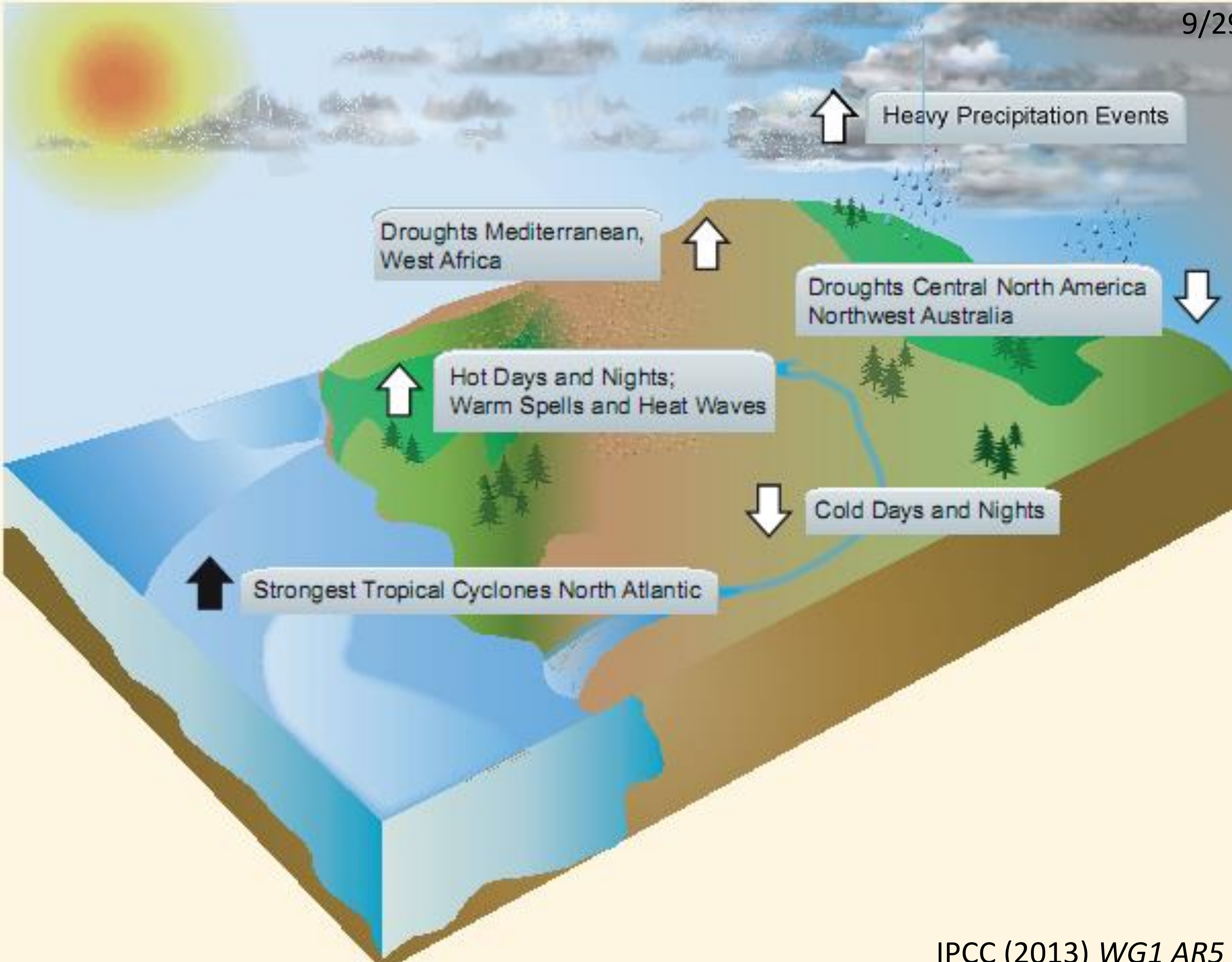
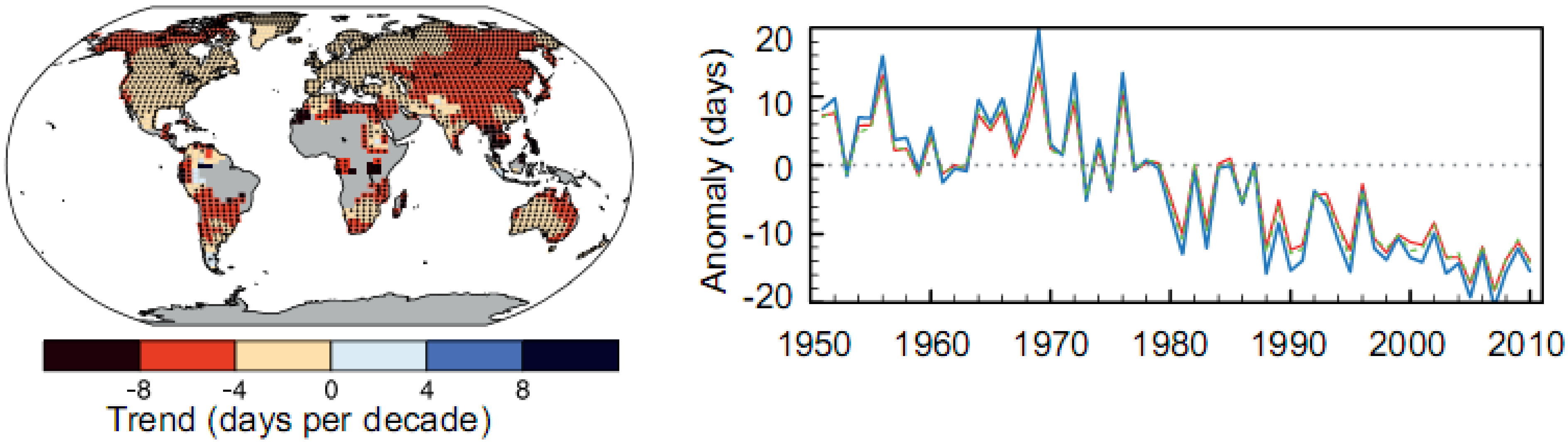
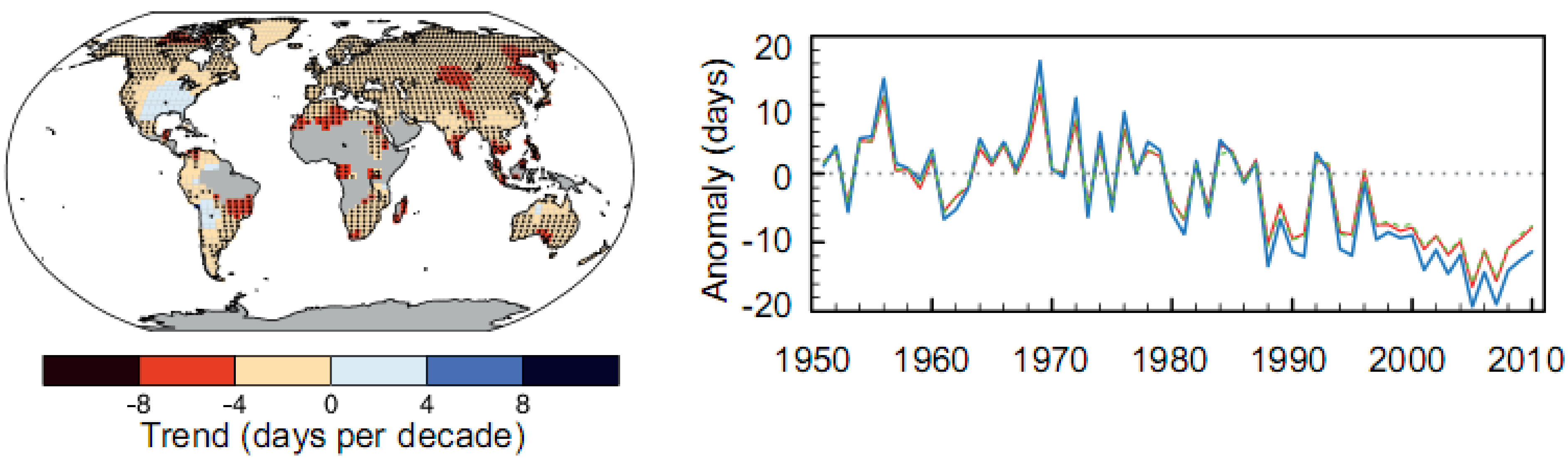


IPCC (2013) *WG1 AR5*

(a) Cold Nights (TN10p)



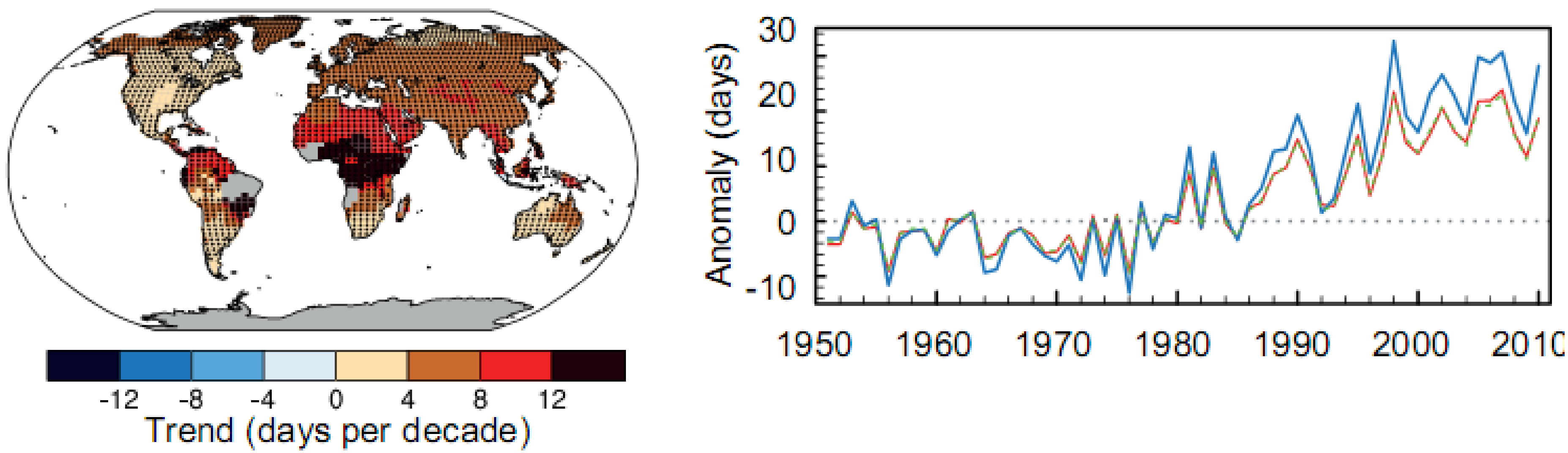
(b) Cold Days (TX10p)



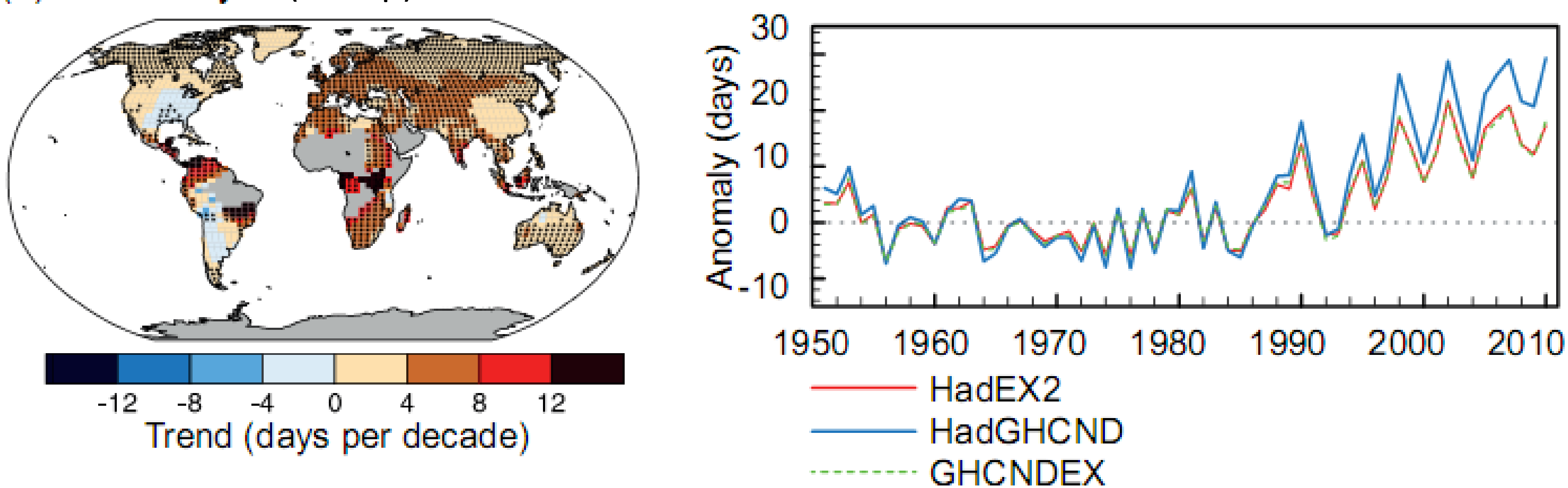
Period: 1951-2010

Fig. 2.32 from IPCC (2013) *WG1 AR5*

(c) Warm Nights (TX10p)



(d) Warm Days (TX90p)



Period: 1951-2010

Fig. 2.32 from IPCC (2013) *WG1 AR5*

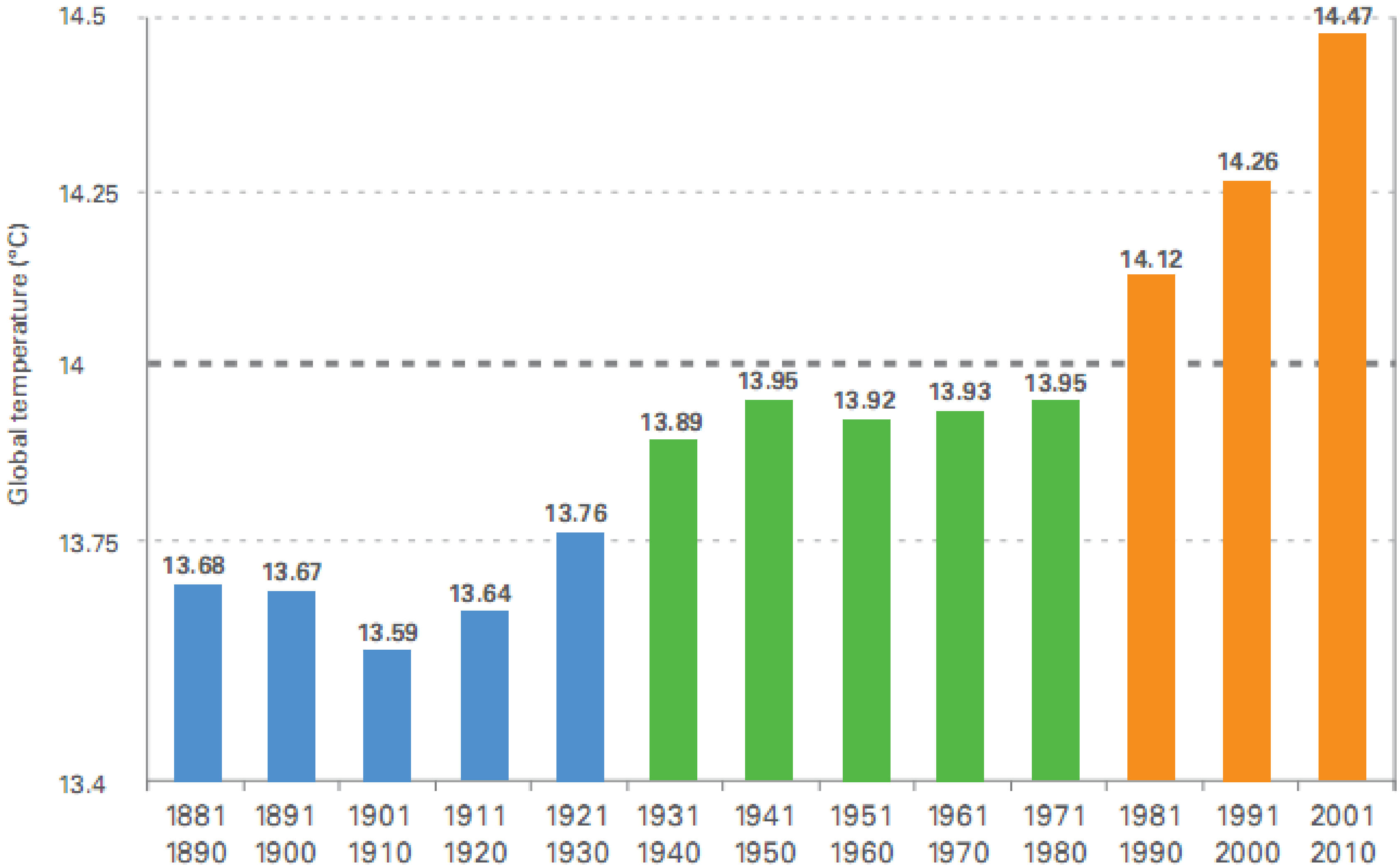
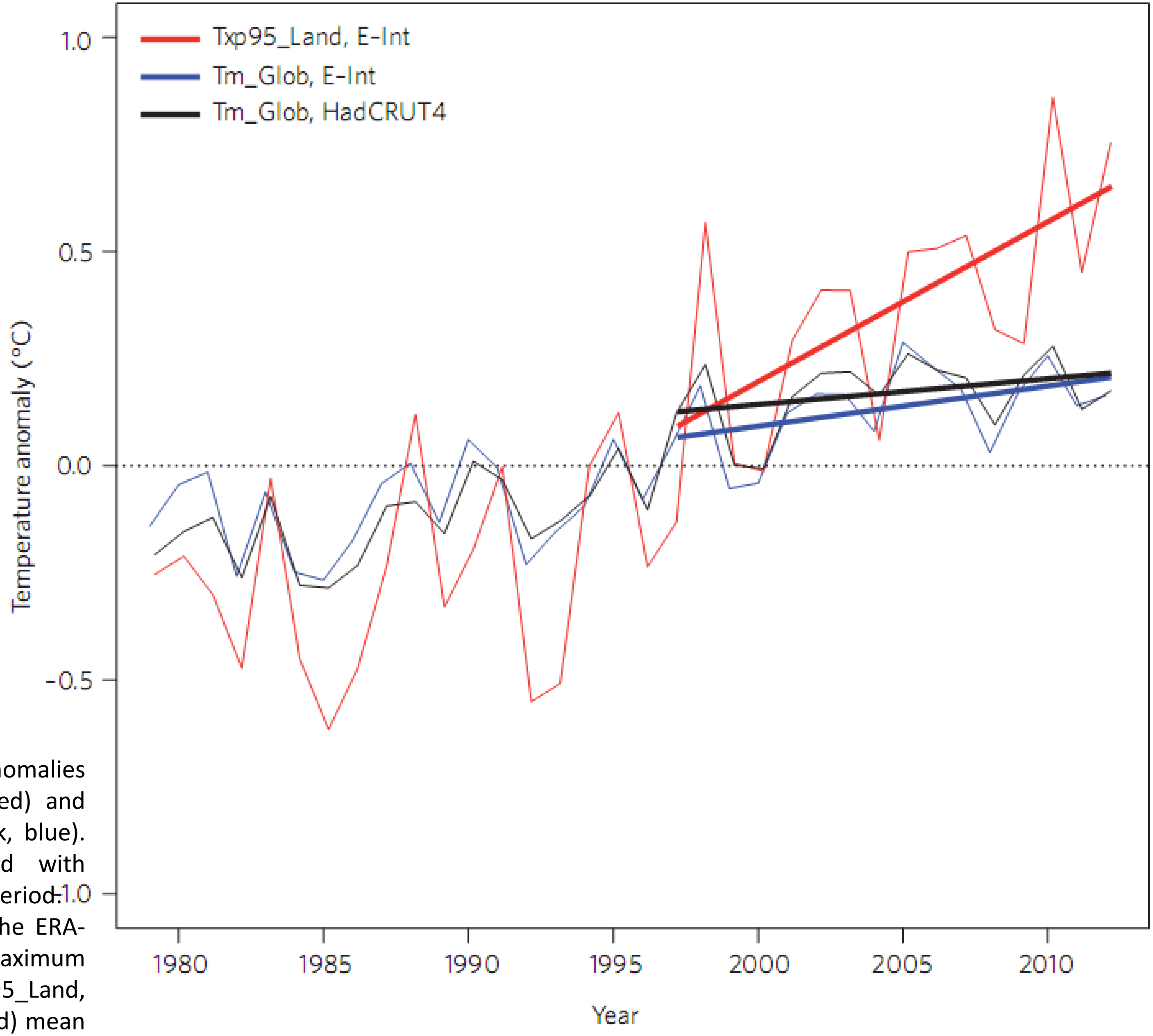


Fig. 1 Decadal global combined surface-air temperature over land and sea-surface temperature (°C) obtained from the average over the three independent datasets maintained by HadCRU, NOAA-NCDC and NASA-GISS. The horizontal grey line indicates the long-term average value (14.0°C) computed based on the 1961–1990 base period.

WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*



Time series of temperature anomalies for hot extremes over land (red) and global mean temperature (black, blue). The anomalies are computed with respect to the 1979–2010 time period. The time series are based on the ERA-Interim 95th percentile of the maximum temperature over land (Txp95_Land, red) and the global (ocean + land) mean temperature (Tm_Glob) in ERA-Interim (blue) and HadCRUT4 (black).

Fig. 2 from Seneviratne et al. (2014) *Nature Climate Change*

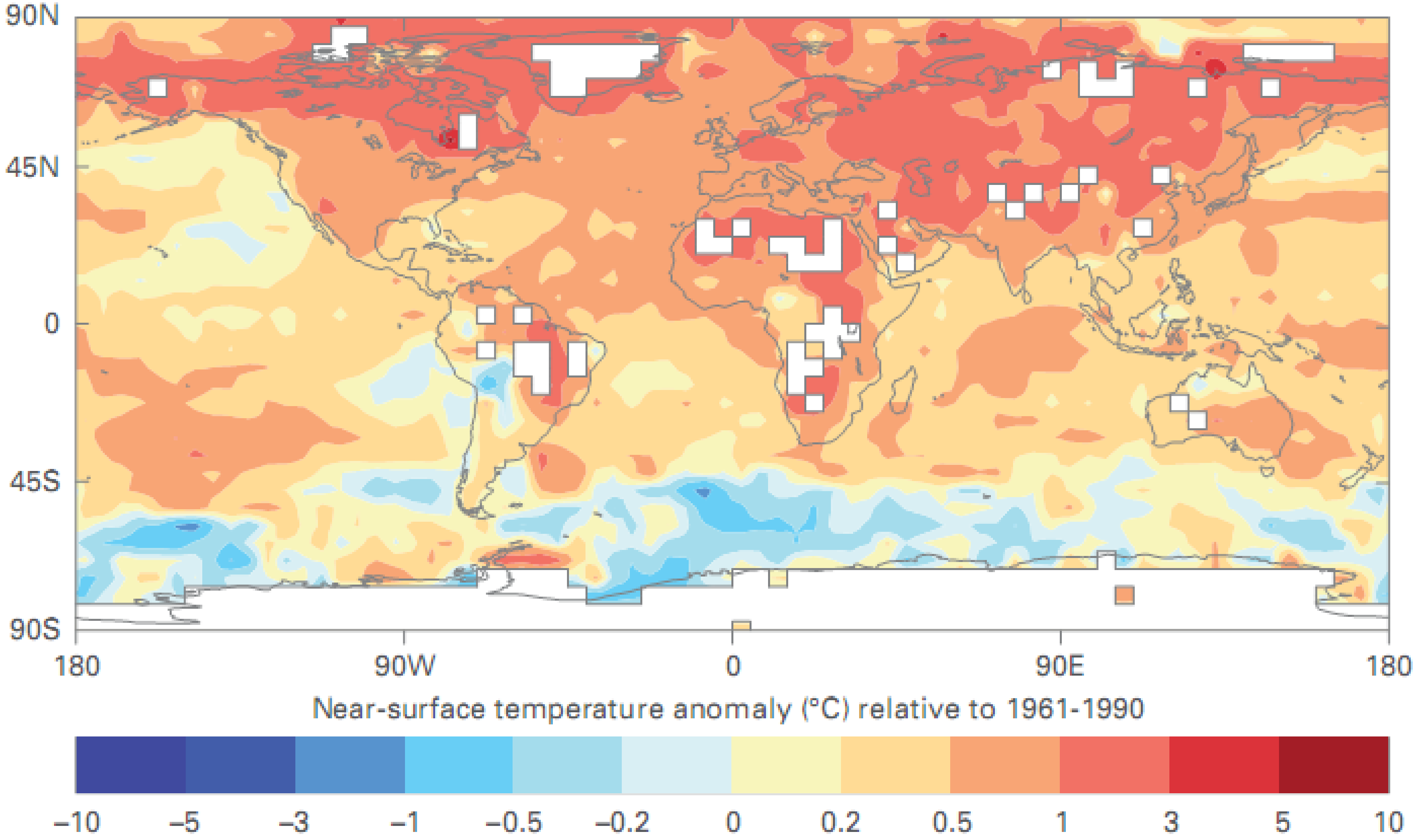


Fig. 6 Global combined surface air temperature over land and sea-surface temperature anomaly (°C) for 2001–2010, relative to 1961–1990 base period. Grid areas without suffcient data are left blank (source: HadCRU).

WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

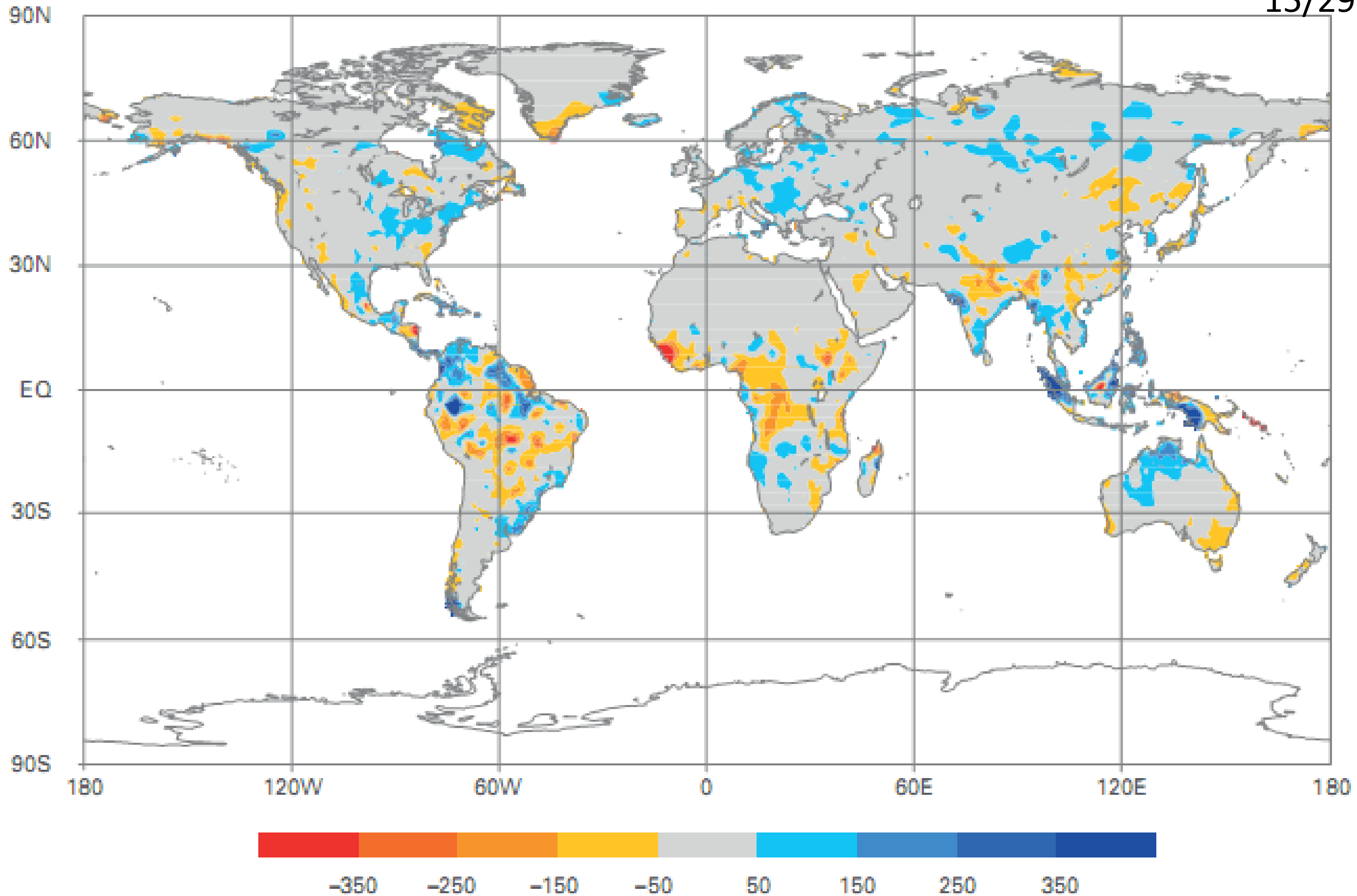


Fig. 10 Decadal precipitation anomalies for global land areas for 2001–2010; gridded 1° raingauge-based analysis as normalized departures in mm/year from averages computed using 1951–2000 base period (source: GPCC-DWD)

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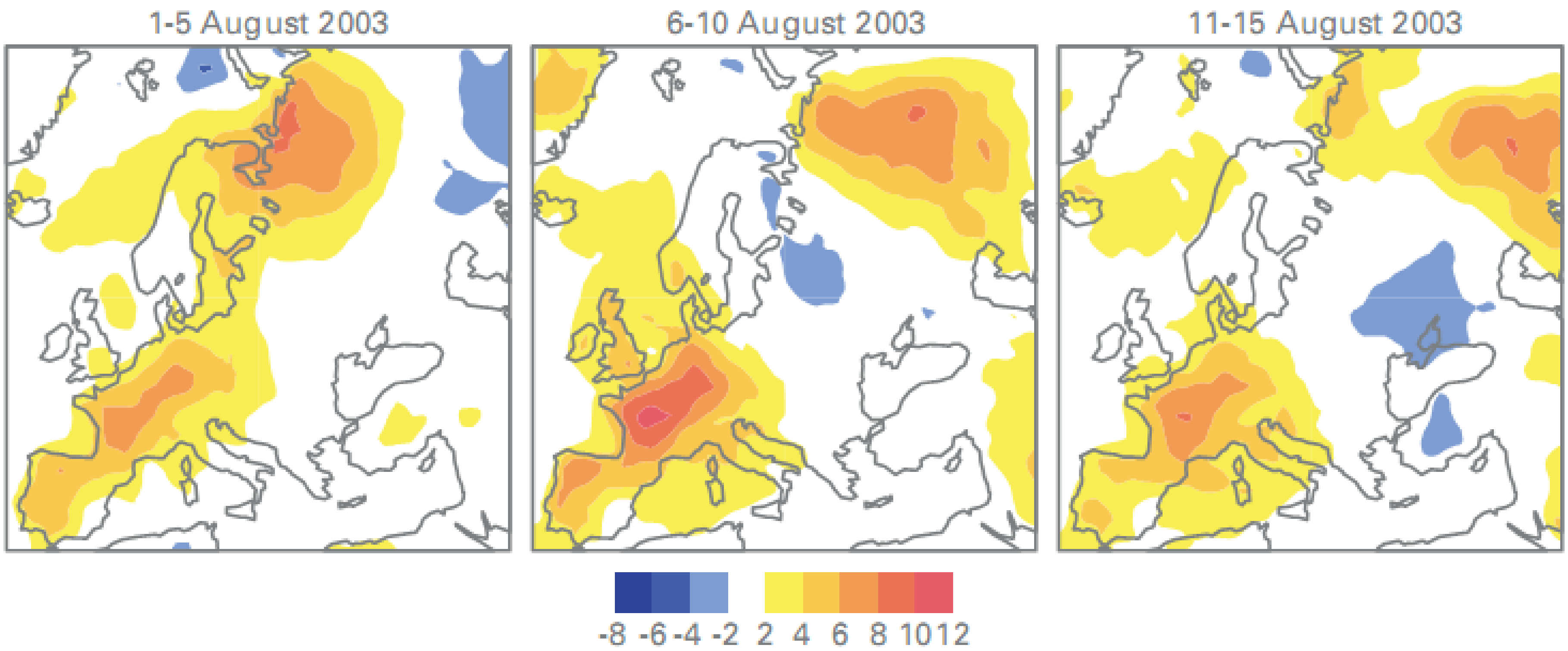


Fig. 23 Five-day mean surface air-temperature anomaly (°C) for August 2003, relative to 1981–2010 from the ERA- Interim reanalysis (source: ECMWF)

The number of deaths compared with normal summer conditions revealed a total of more than 66 700 excess deaths that were attributed to the heatwave. The 2003 heatwave affected France and Italy most with a loss of nearly US$ 4.5 billion each, followed by Germany with nearly US$ 1.7 billion.

WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

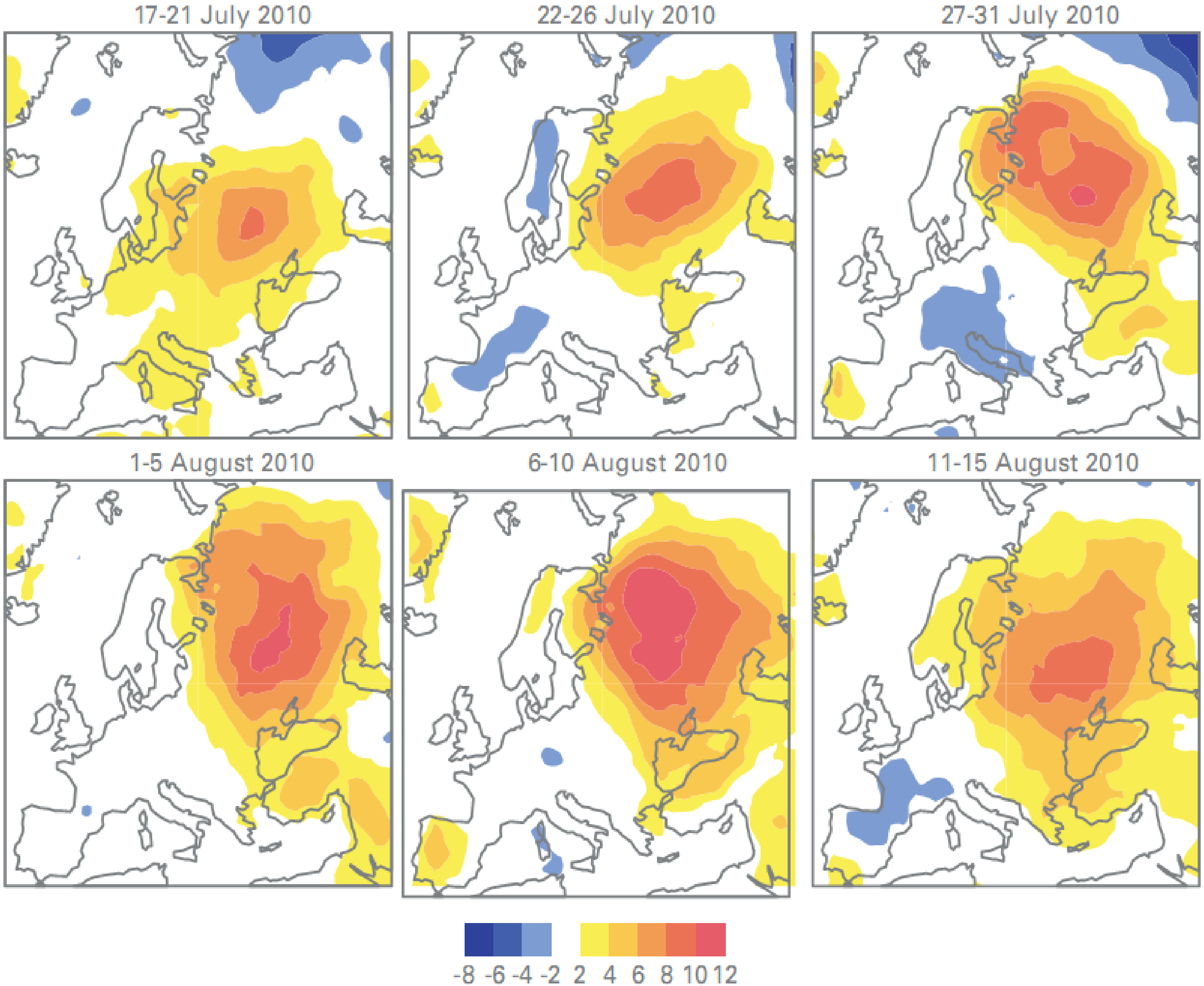


Fig. 24 Five-day mean surface air-temperature anomaly (°C) for July and August 2010, relative to 1981–2010 from the ERA-Interim reanalysis (source: ECMWF).

The extreme heatwave of 2010 caused more than 55 000 excess deaths. Over 20 per cent of crops growing on some 9 million hectares of farmland were destroyed. There were more than 600 wildfires and some 950 forest fires in 18 regions at the beginning of August, with thousands of people made homeless. The wildfires are listed as the costliest natural disaster of the country since 1900, with an estimated economic damage of US$ 1.8 billion.

WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

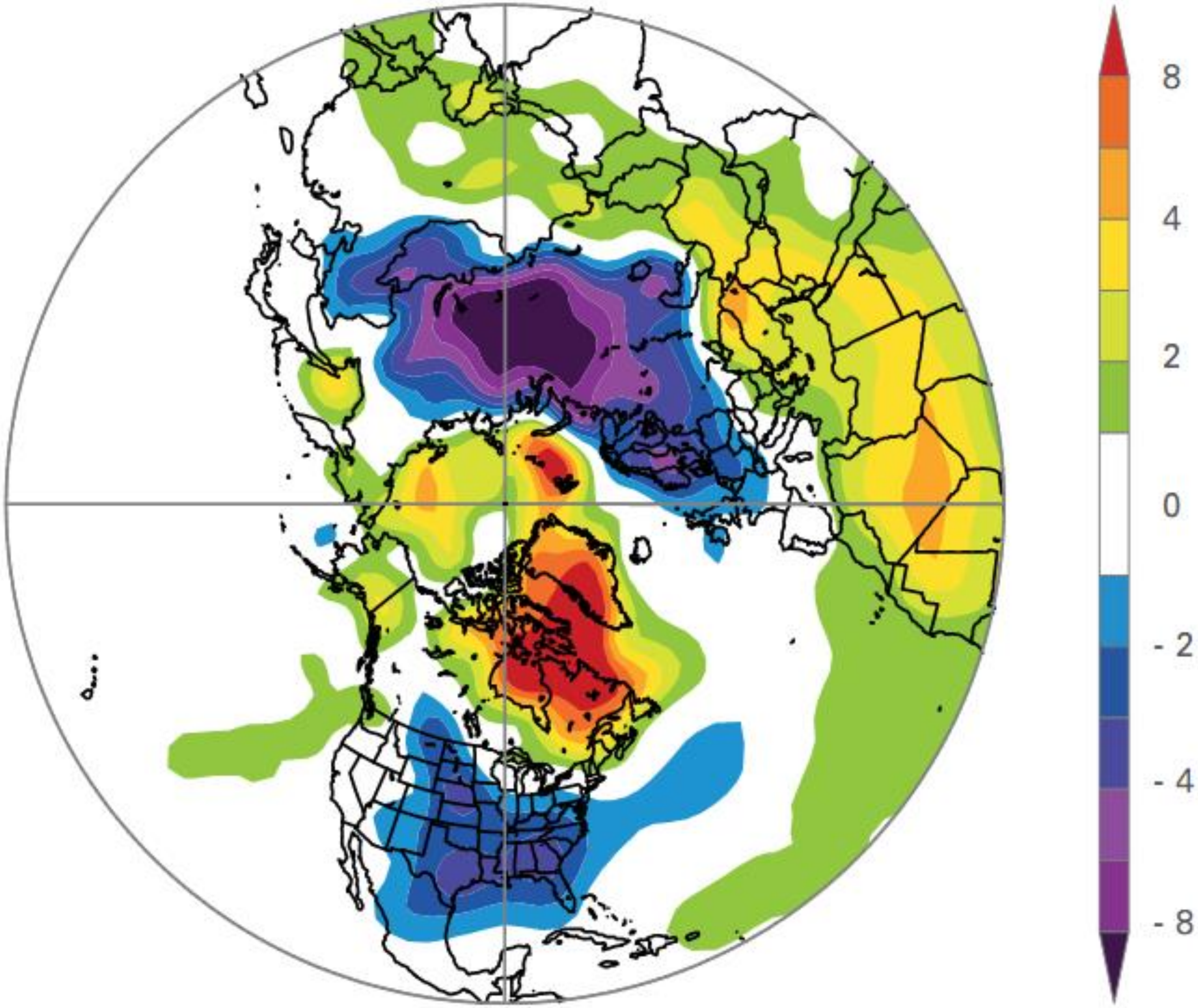
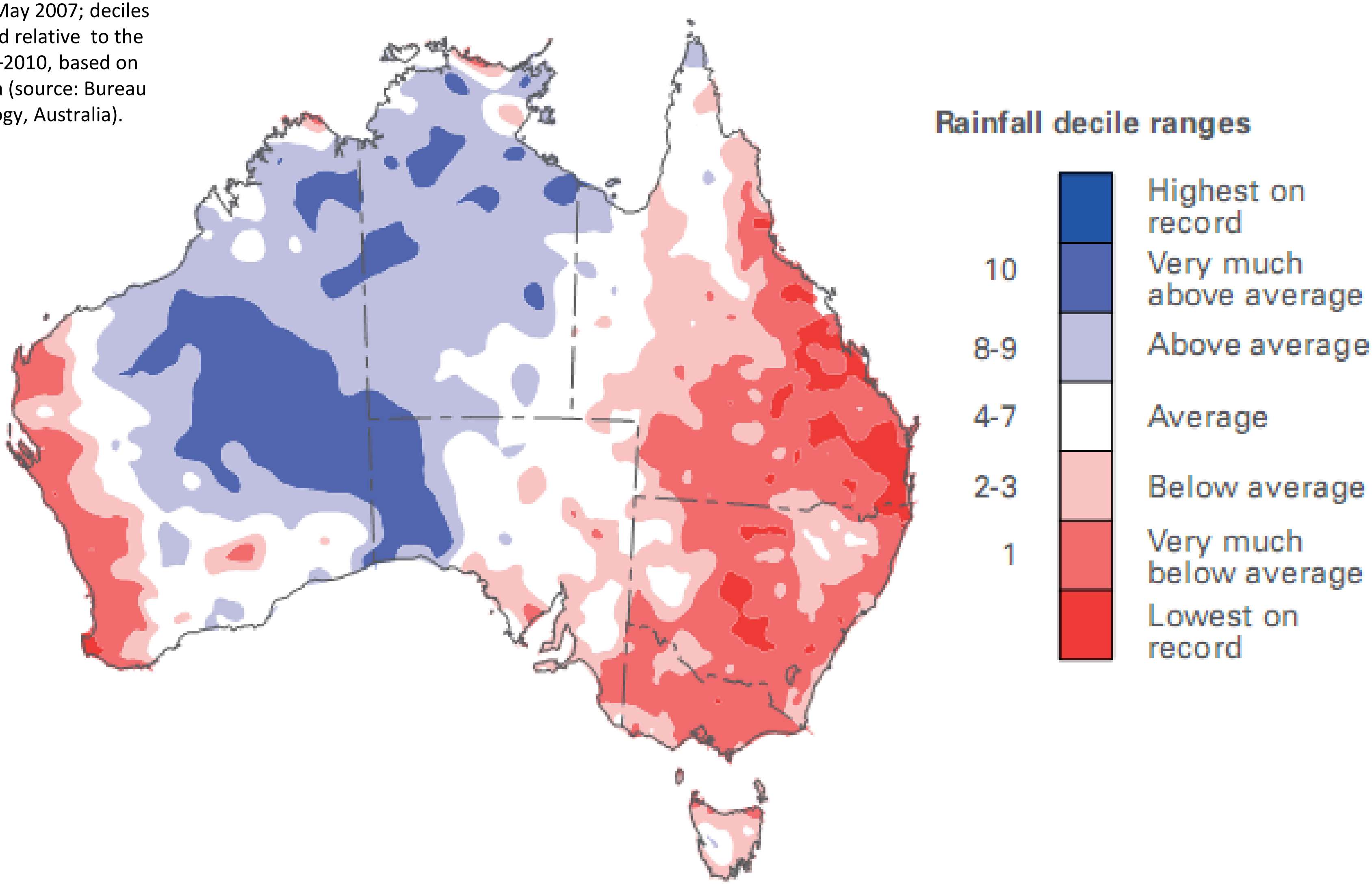


Fig. 28. Northern hemisphere winter 2009/2010 temperature anomaly in °C for December–January–February at 1 000 hPa based on NCEP-NCAR reanalysis, with 1981–2010 as reference period (source: NOAA, ESRL-PSD)

The cold spells in late January caused at least 450 casualties in Europe.

WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

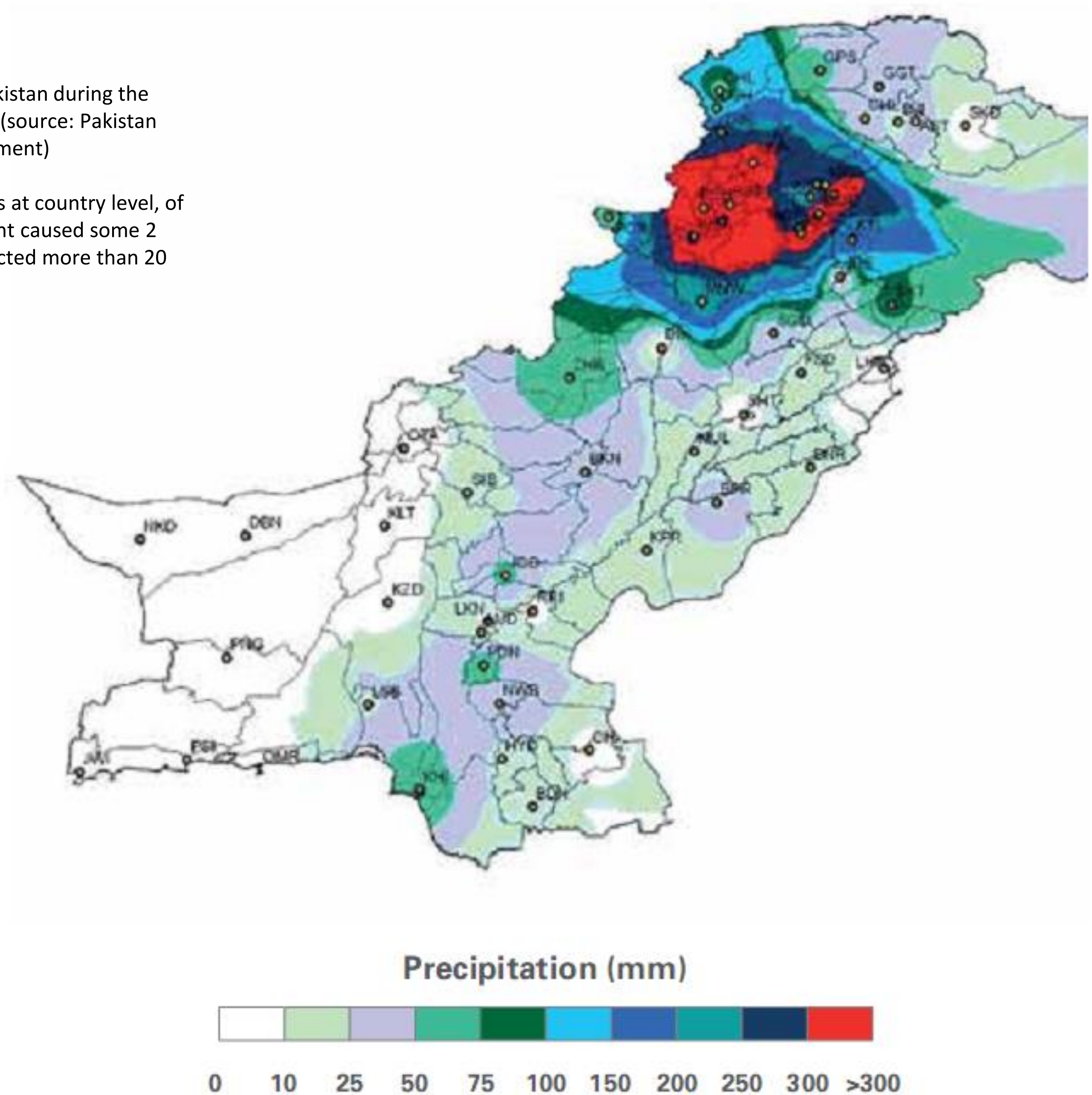
Fig. 33 Australian rainfall deciles for the period 1 June 2001 to 31 May 2007; deciles are calculated relative to the period 1900–2010, based on gridded data (source: Bureau of Meteorology, Australia).



WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

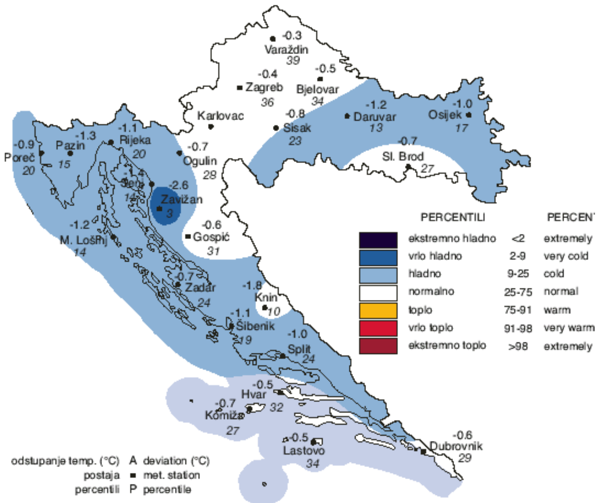
Fig. 31. Rainfall over Pakistan during the period 26–29 July 2010 (source: Pakistan Meteorological Department)

Economic damage costs at country level, of US$ 9.5 billion. The event caused some 2 000 casualties and affected more than 20 million people.

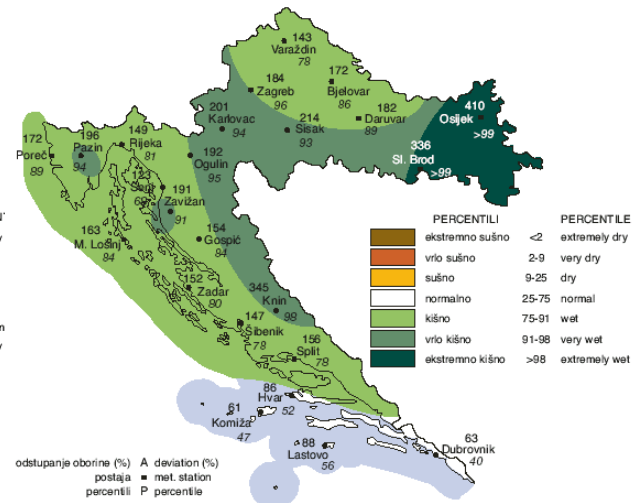


WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

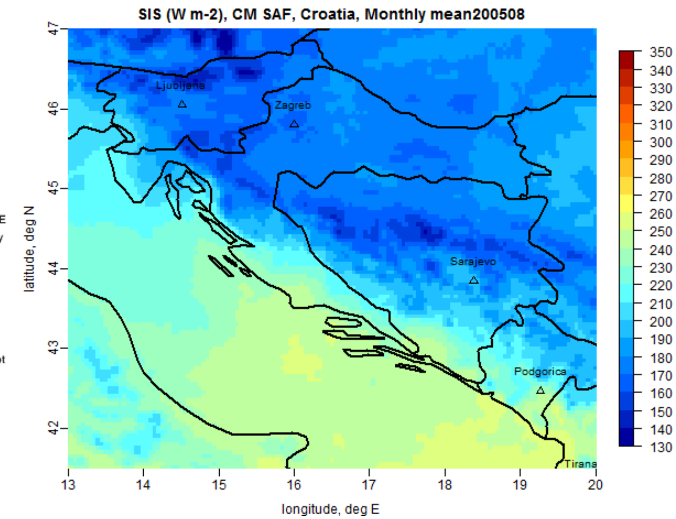
Negative/positive anomalies in CMSAF SIS are indicators of extremely cold/warm air temperature conditions (Fig. 1 / Fig 2)



1 a



1 b



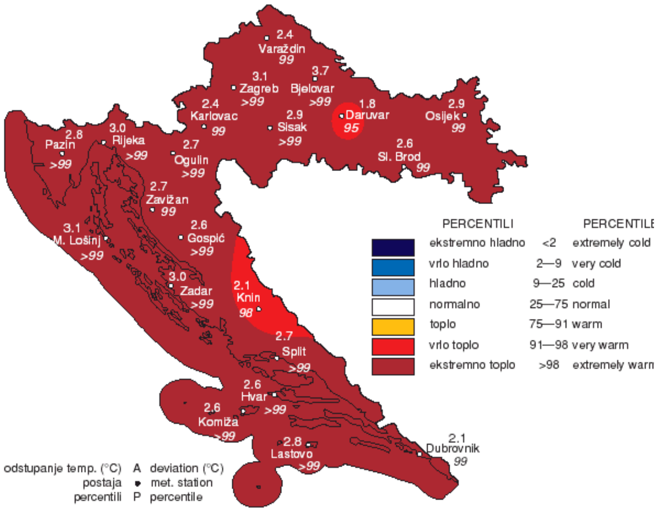
1 c

Figure 1: August 2005. Largest negative anomaly of SIS (-58.8 Wm-2) (Fig. 7 c) from the average for that month (Period: 1983-2011) was connected with cold (Fig. 7 a) and wet (Fig. 7 b) weather conditions in Croatia. In ground data for the period 2004-2014 this was the third largest negative August anomaly, followed by those in 2006 and 2007 (Fig. 6).

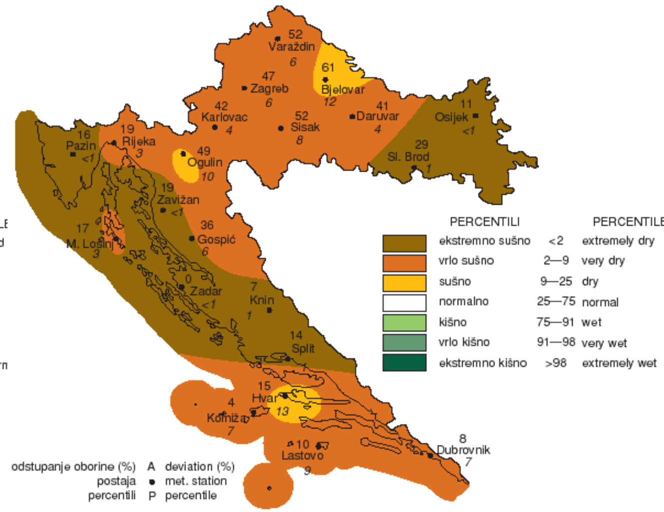
SIS MVIRI DataSet (1983-2005), spatial resolution 0.03°
SIS SEVIRI DataSet (2005-2011), spatial resolution 0.05°

Melita Perčec Tadić, Renata Sokol Jurković: Estimation and validation of hourly surface incoming shortwave radiation using in situ and satellite data . GEOENV2014, Paris.

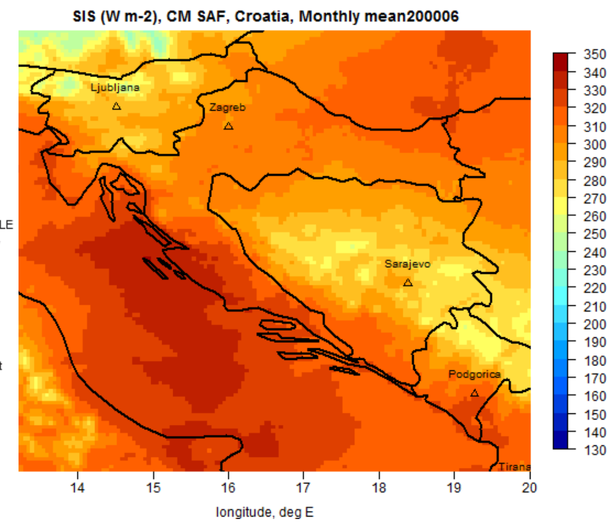
Negative/positive anomalies in CMSAF SIS are indicators of extremely cold/warm air temperature conditions (Fig. 1 / Fig 2)



2 a



2 c



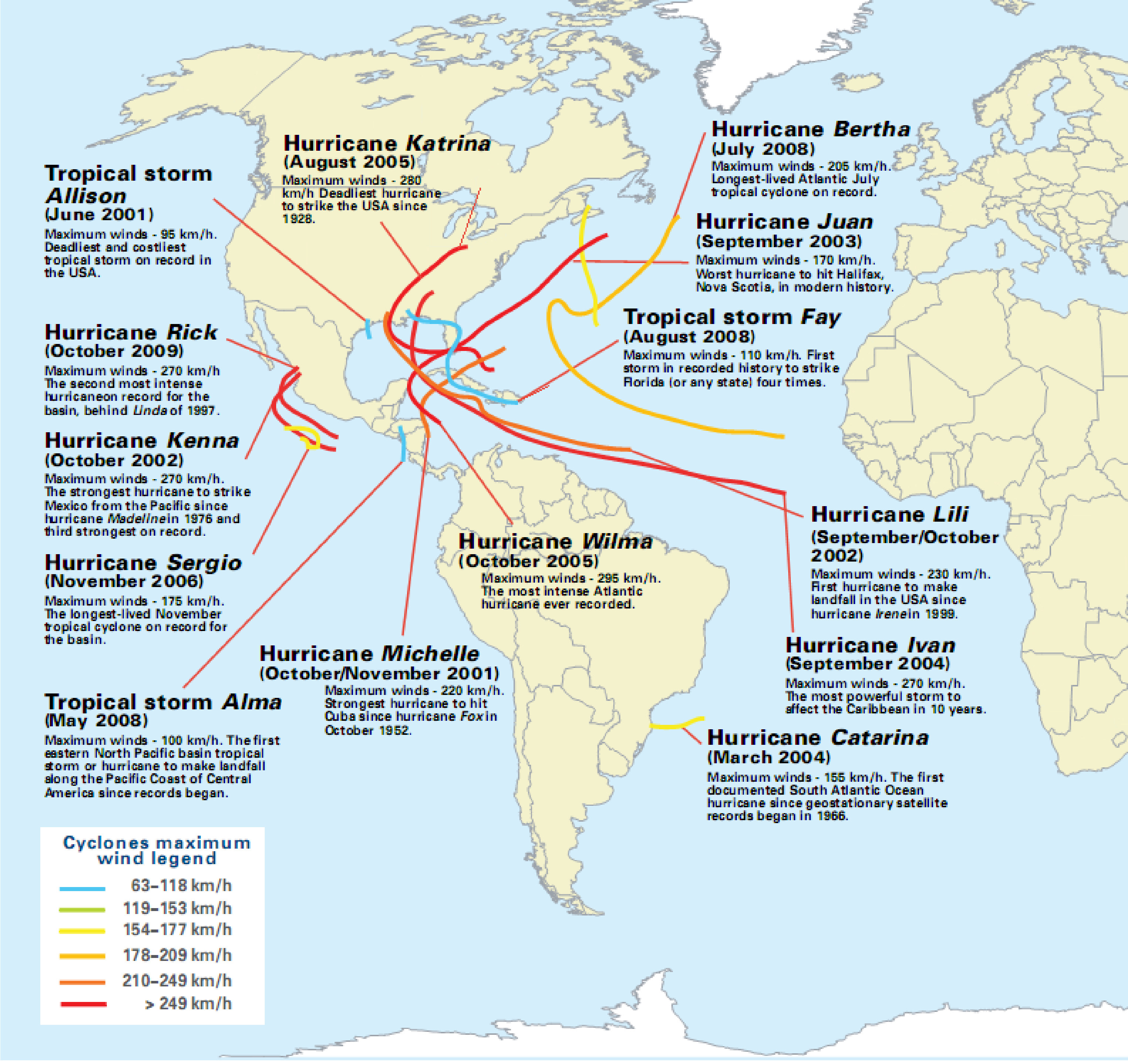
2 b

Figure 2: June 2000. Second largest positive anomaly of SIS (50.4 Wm-2) (Fig. 8 c) from the average for that month (Period: 1983-2011) was connected with warm (Fig. 8 a) and dry (Fig. 8 b) weather conditions. The ground irradiance data were not available for this year. The larges positive anomaly in CMSAF SIS was in April 2007 that was visible also in ground SIS data.

SIS MVIRI DataSet (1983-2005), spatial resolution 0.03°
SIS SEVIRI DataSet (2005-2011), spatial resolution 0.05°

Melita Perčec Tadić, Renata Sokol Jurković: Estimation and validation of hourly surface incoming shortwave radiation using in situ and satellite data . GEOENV2014, Paris.

Fig. 37 Most signifcant tropical cyclones recorded during 2001–2010 (source: NOAA-NCDC).



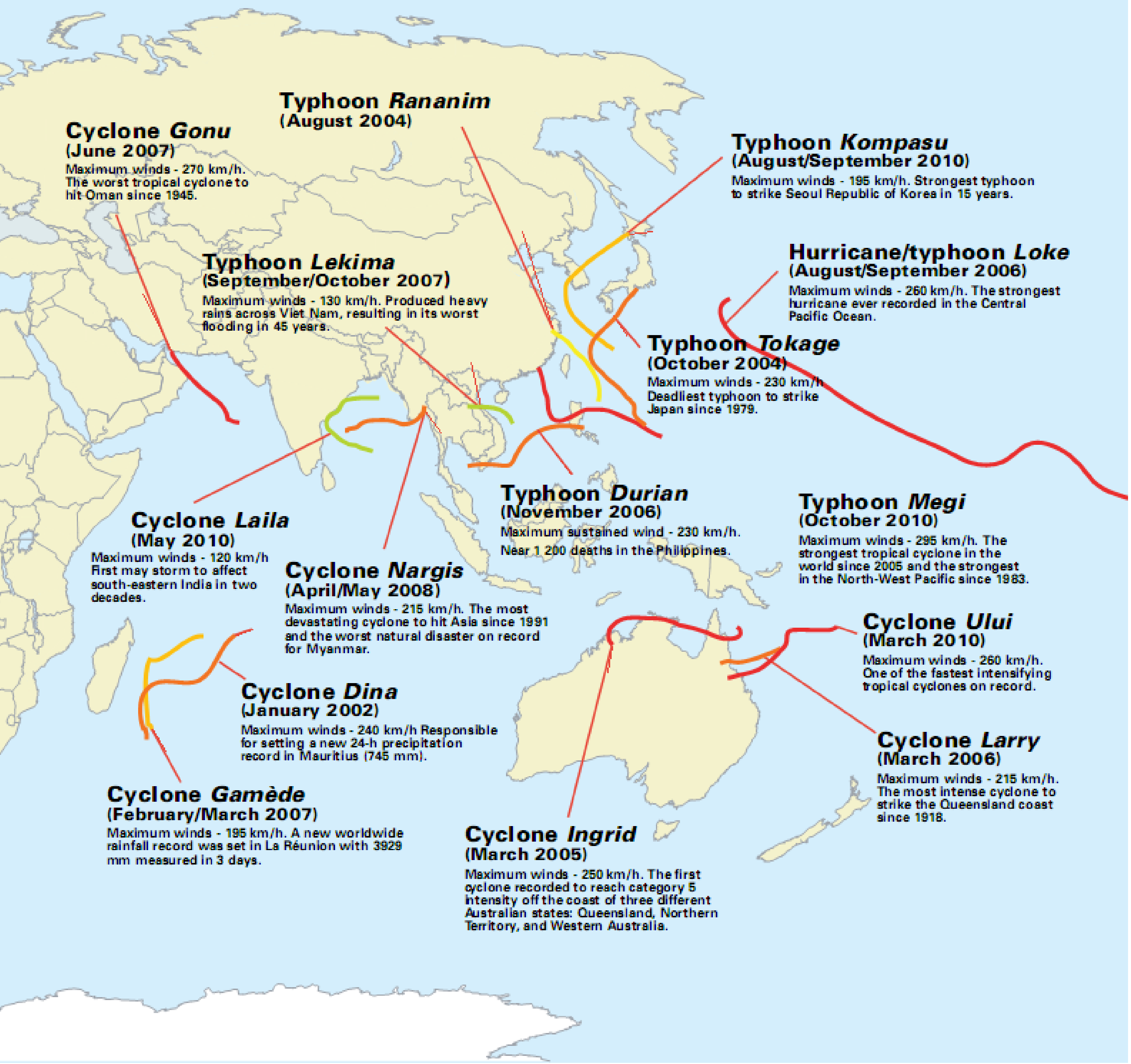


Fig. 37 Most signifcant tropical cyclones recorded during 2001–2010 (source: NOAA-NCDC).

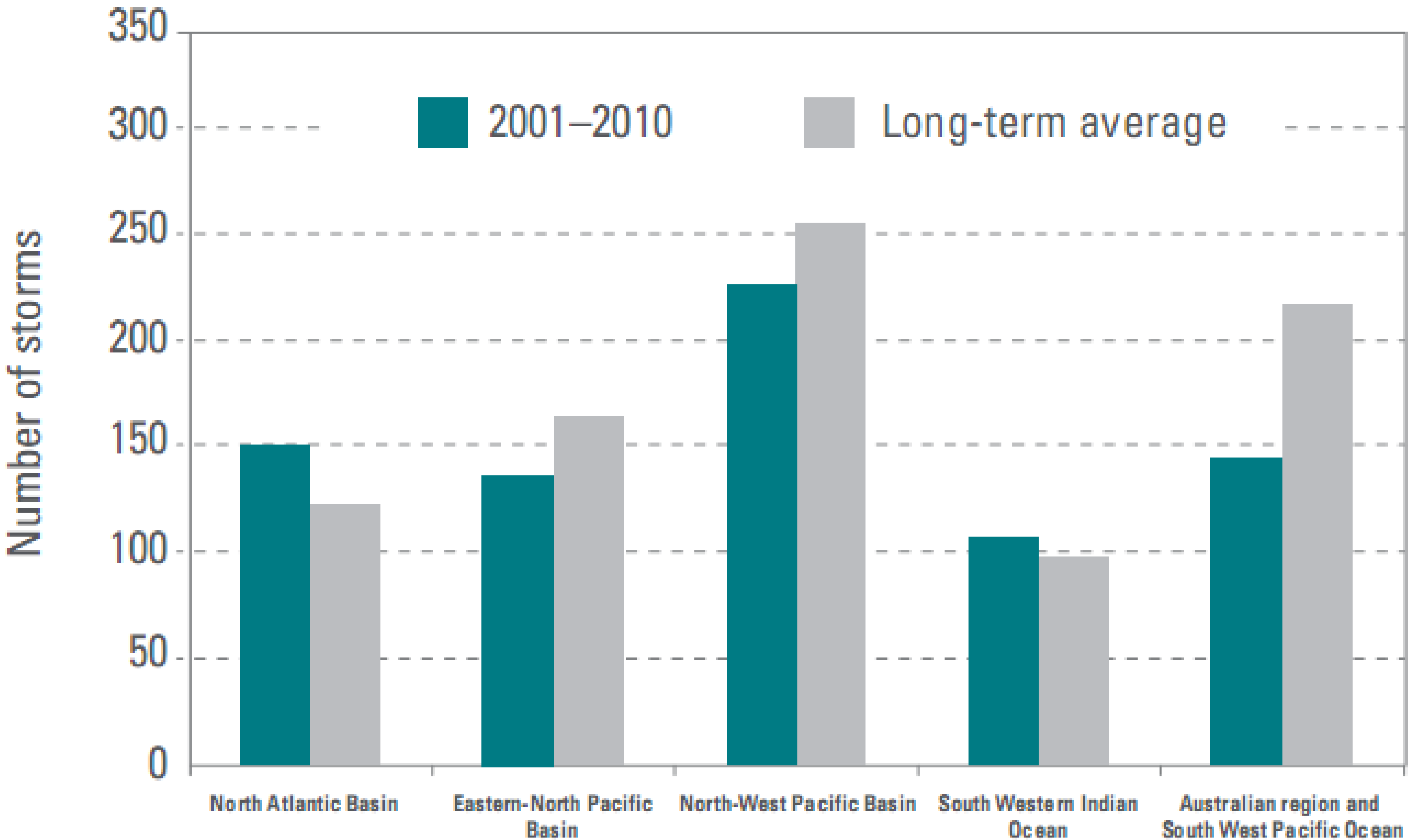


Fig. 38 Total number of named tropical storms during 2001–2010 by basin compared to the long-term average of the 1981–2010 base period (data source: NOAA-NCDC)

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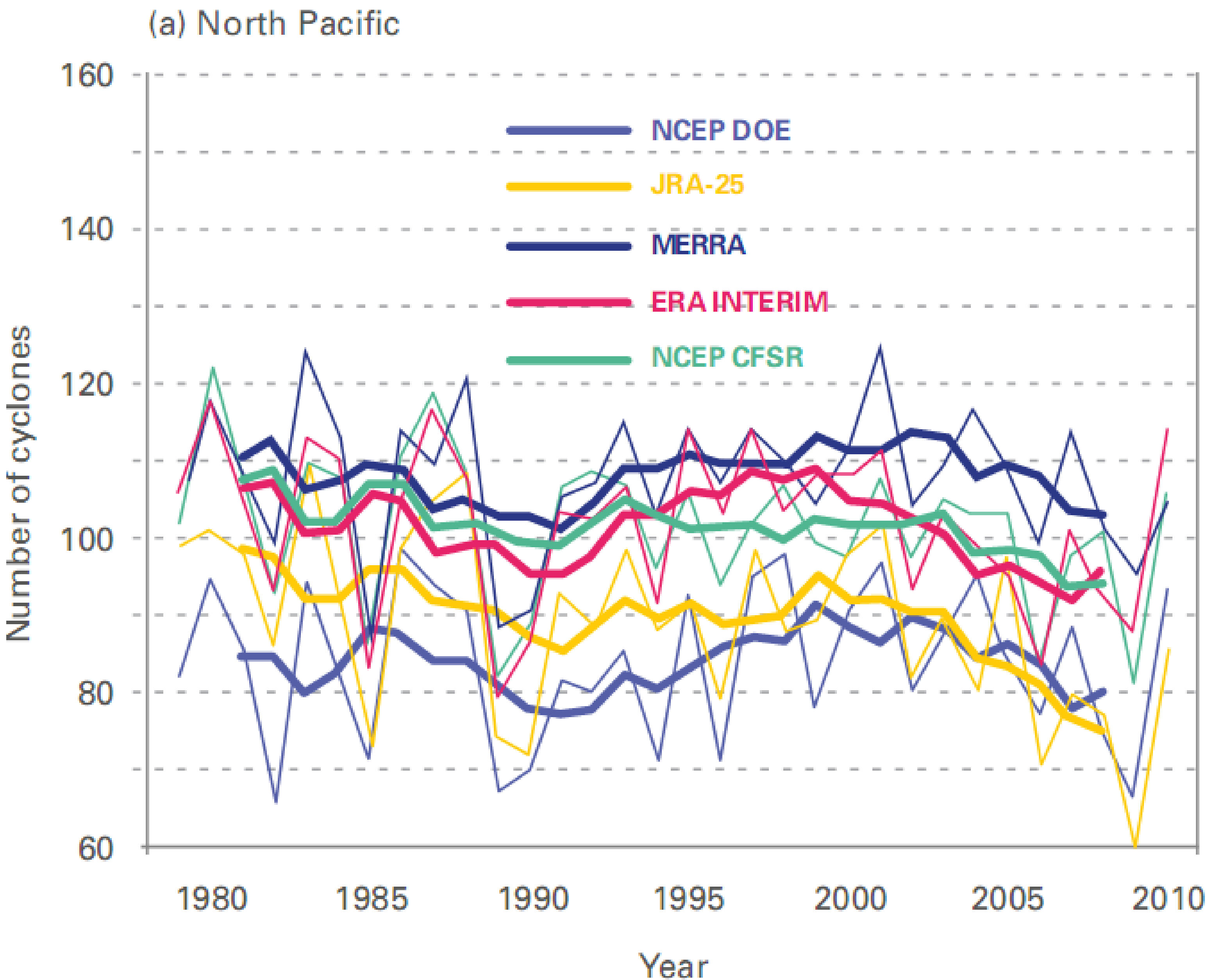


Fig. 45 Time series of the number of deep extra-tropical cyclones (atmospheric pressure at the surface smaller than 980 hPa): (a) North Pacifc; (b) North Atlantic

WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

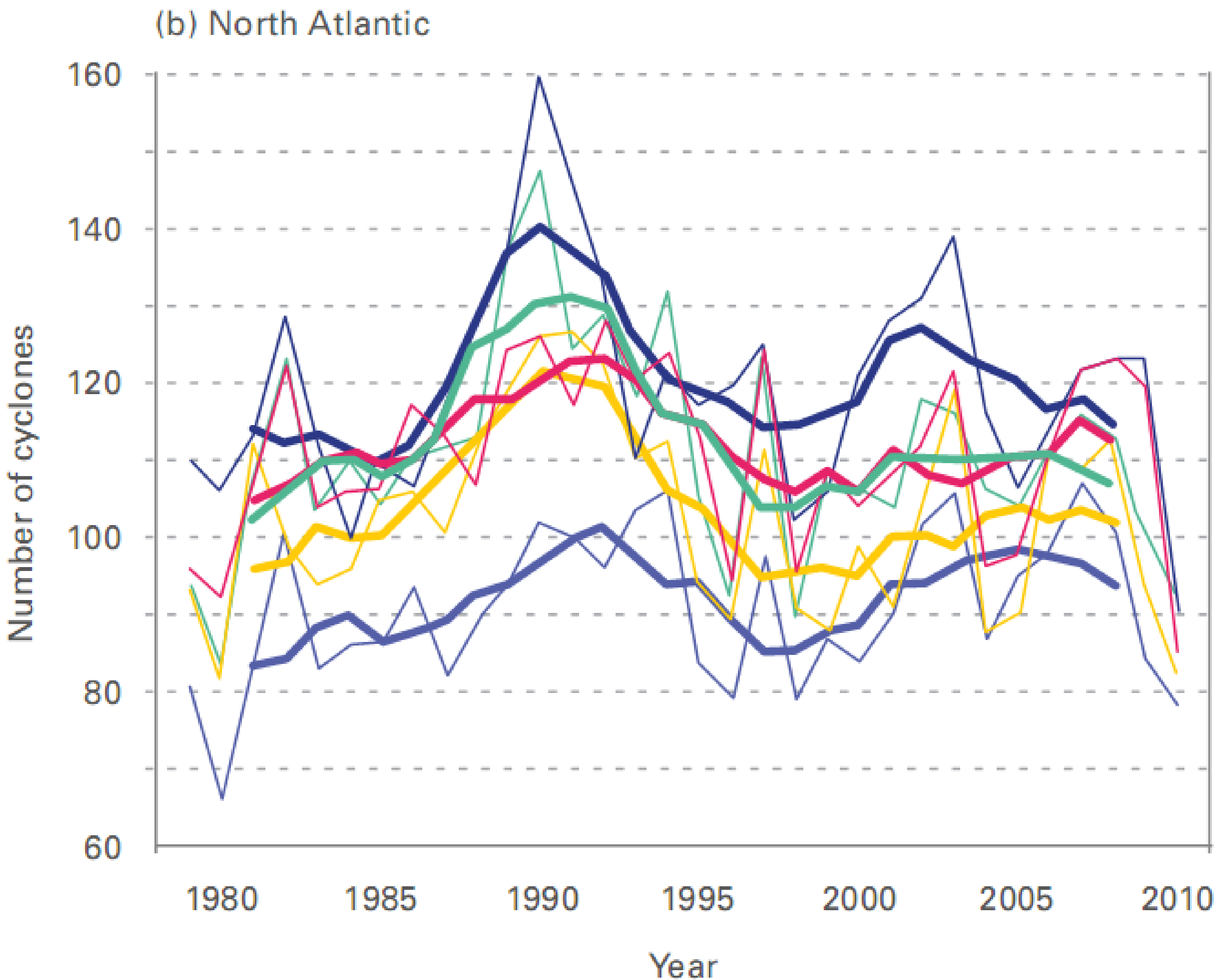
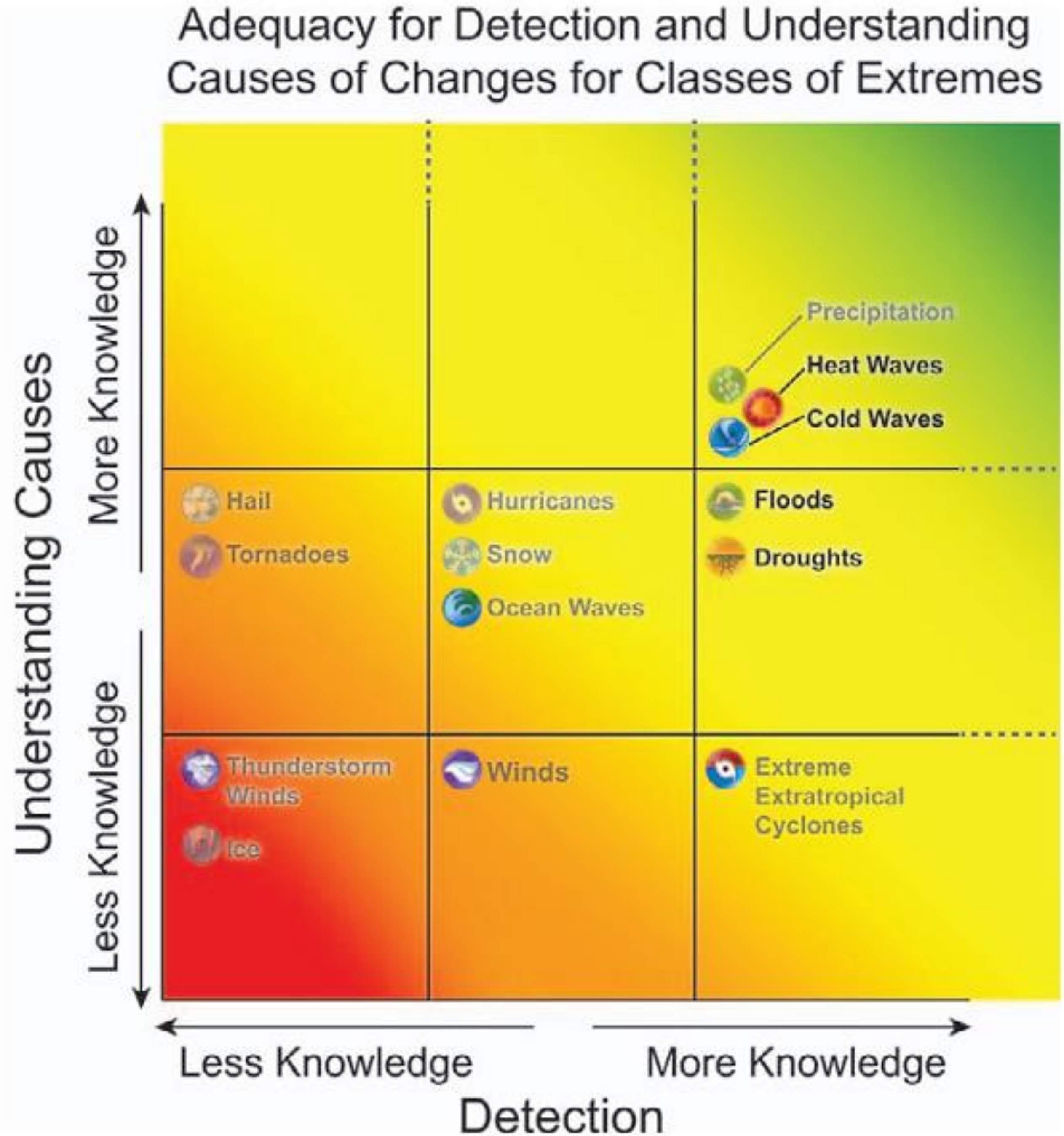


Fig. 45 Time series of the number of deep extra-tropical cyclones (atmospheric pressure at the surface smaller than 980 hPa): (a) North Pacifc; (b) North Atlantic

WMO (2013) *The Global Climate 2001–2010: A Decade of Climate Extremes*

Detection and attribution of changes in extremes depend on both scientists' physical understanding of the factors that not just cause a particular extreme but would cause the intensity or frequency of that extreme to change over time and the quality and quantity of the data. The x axis refers to the adequacy of data to detect trends, while the y axis refers to scientific understanding of what causes those trends. The dashed lines on the right side and top of the graph imply that the knowledge about the phenomena is not complete.



Peterson et al. (2013) *BAMS*

Changes in Phenomenon	Uncertainty in observed changes (since about the mid-20th century)			Uncertainty in projected changes (up to 2100)		
IPCC Assessment Report	TAR	AR4	SREX	TAR	AR4	SREX
Higher maximum temperatures and more hot days	*Likely* over nearly all land areas	*Very Likely* over most land areas	*Very Likely* at a global scale	*Very Likely* over nearly all land areas	*Virtually Certain* over most land areas	*Virtually Certain* at a global scale
Higher minimum temperatures, fewer cold days	*Very Likely* over nearly all land areas	*Very Likely* over most land areas	*Very Likely* at a global scale	*Very Likely* over nearly all land areas	*Virtually Certain* over most land areas	*Virtually Certain* at a global scale
Warm spells/heat waves. frequency, length or intensity increases	-	*Likely* over most land areas	*Medium Confidence* in many regions	-	*Very Likely* over most land areas	*Very Likely* over most land areas
Precipitation extremes	*Likely*[1], over many Northern Hemisphere mid- to high latitude land areas	*Likely*[2] over most areas	*Likely*[3]	*Very Likely*[1] over many areas	*Very Likely*[2]	*Likely*[2,4] in many land areas of the globe
Droughts or dryness	*Likely*[5], in a few areas	*Likely*[6], in many regions since 1970s	*Medium Confidence* in more intense and longer droughts in some regions , but some opposite trend exists	*Likely*[5], over most mid-latitude continental interiors (Lack of consistent projections in other areas)	*Likely*[6]	*Medium Confidence*[7] that droughts will intensify in some seasons and areas; Overall *low confidence* elsewhere
Changes in tropical cyclone activity (i.e. intensity, frequency, duration)	Not Observed[8], in the few analyses available	*Likely*[9], in some regions since 1970	*Low confidence*[10]	*Likely*[8], over some areas	*Likely*[9]	*Likely*[11]
Increase in extreme sea level (excludes tsunamis)	-	*Likely*	*Likely*[12]	-	*Likely*	*Very Likely*[13]

Term*	Likelihood of the Outcome
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability

Term*	Likelihood of the Outcome
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

IPCC (2013) *WG1 AR5*