Climate Change and their Impacts

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Introduction to Climate Change

Learning Objectives

At the end of this module, participants will be able to

- Describe the science behind climate change;
- Know about natural and human-induced climate change; and
- Describe the impacts of climate change.

Weather vs. Climate

Weather

The state of atmosphere at a given time and place measured in terms of variables that include temperature, precipitation, cloudiness, humidity, air pressure and wind.

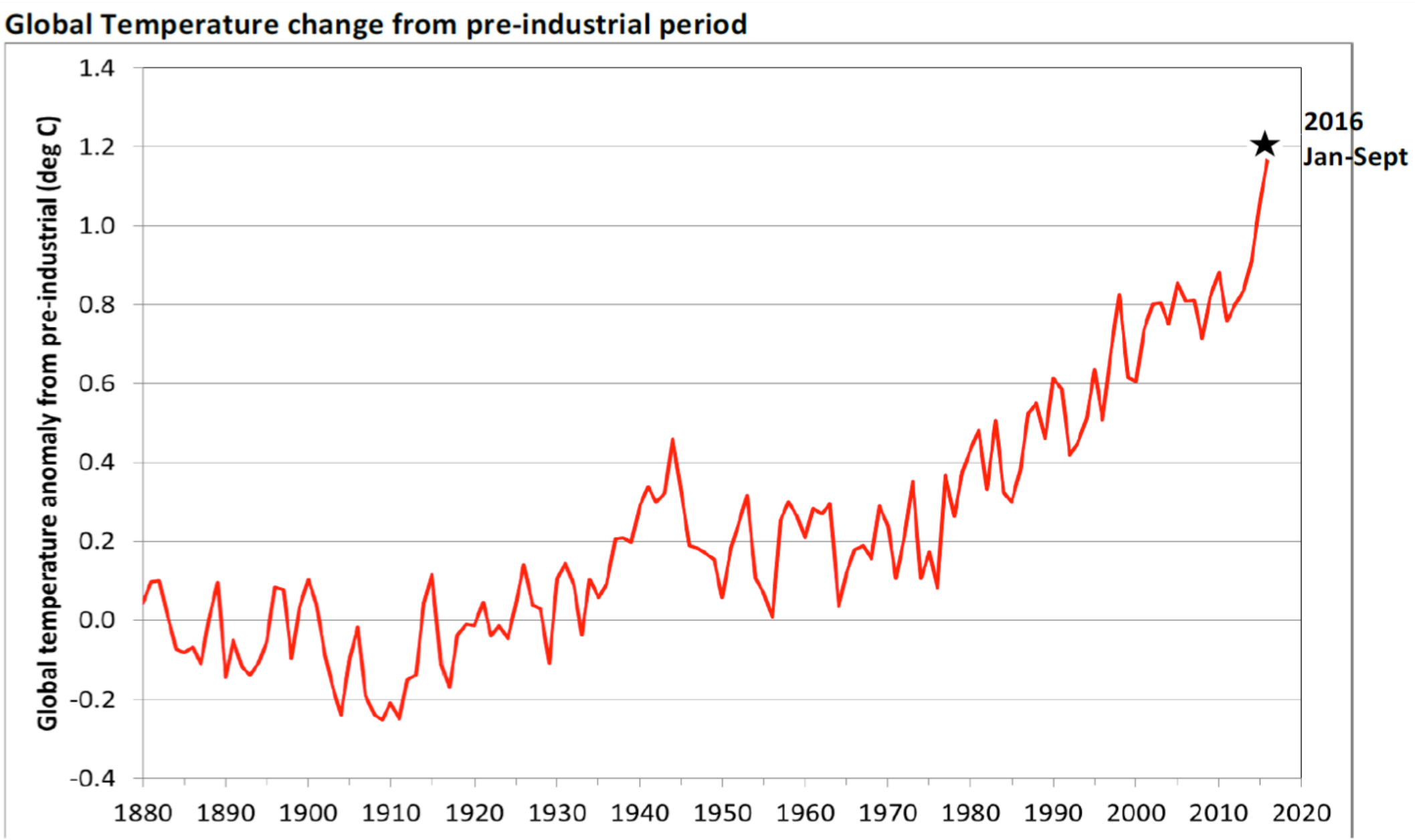
Climate

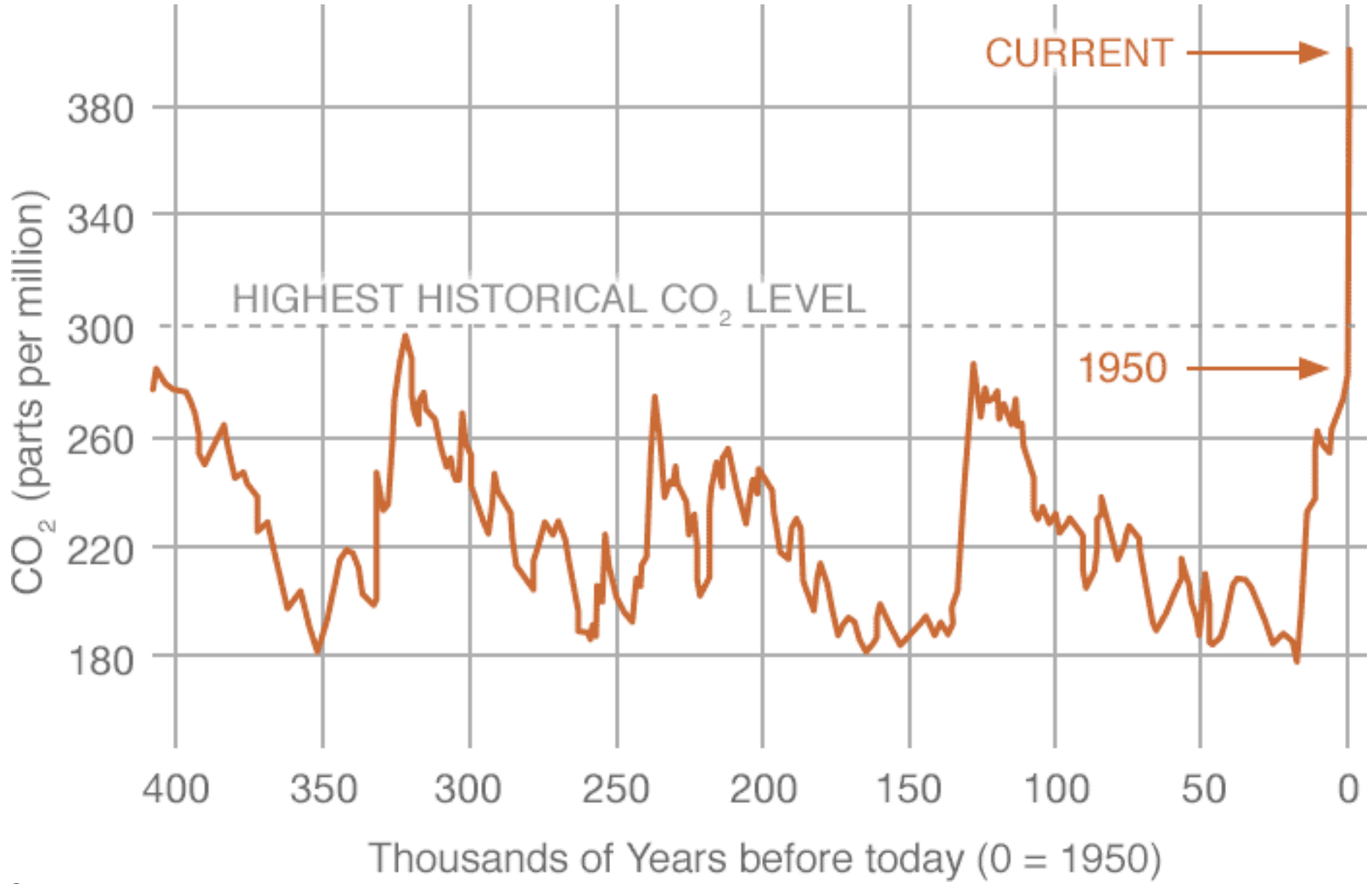
The long-term average of conditions in the atmosphere described by statistics, such as means and extremes

Climate Change

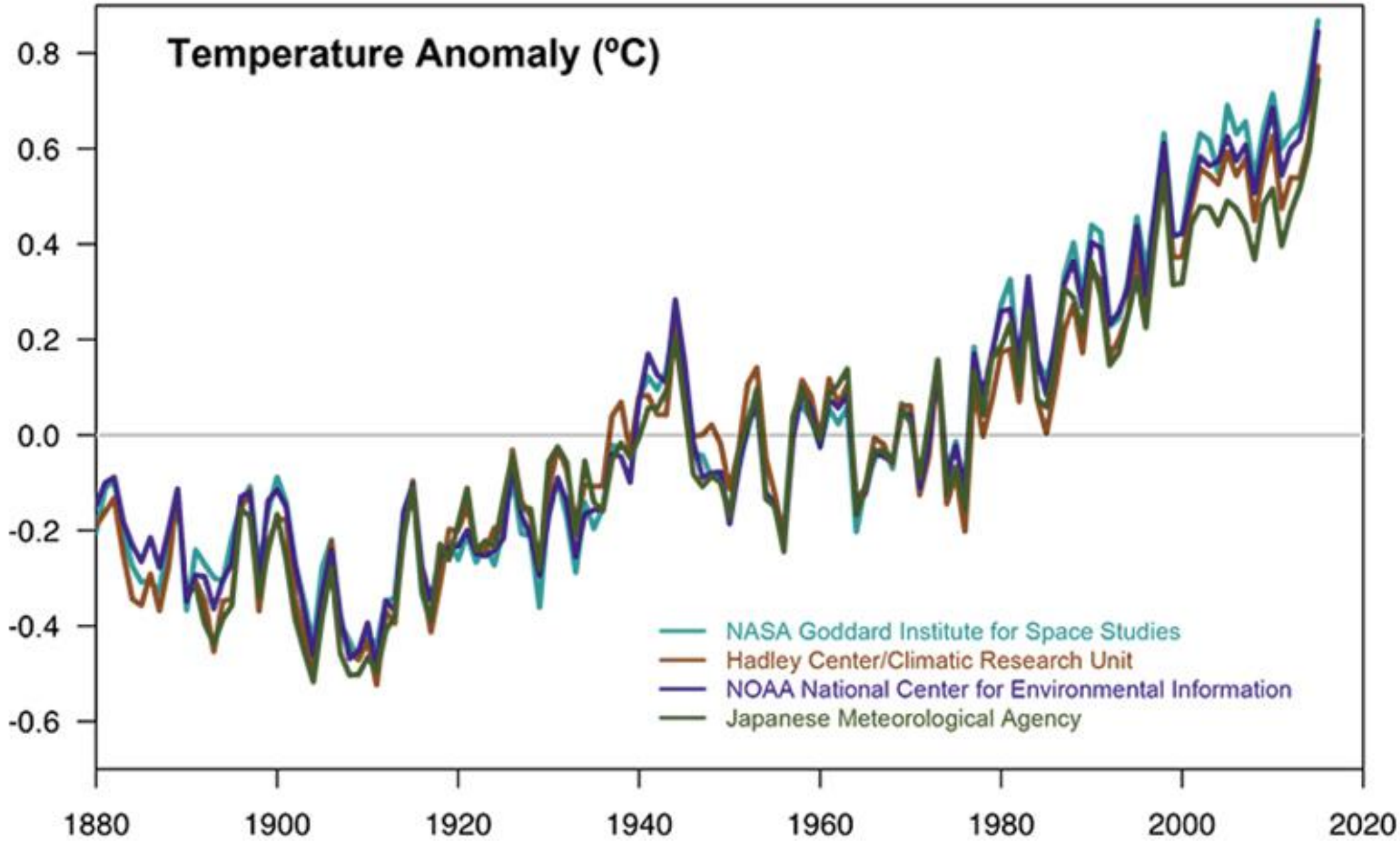
Climate Change is defined as statistically significant variation in either mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).

Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use (**IPCC, 2001**).


Global Temperature change from pre-industrial period
Global temperature anomaly from pre-industrial (deg C)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2016
Jan-Sept


CURRENT
HIGHEST HISTORICAL CO_2 LEVEL
1950
380
340
300
260
220
180
CO_2 (parts per million)
400
350
300
250
200
150
100
50
0
Thousands of Years before today (0 = 1950)

Source: NASA


Temperature Anomaly (ºC)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1880
1900
1920
1940
1960
1980
2000
2020
NASA Goddard Institute for Space Studies
Hadley Center/Climatic Research Unit
NOAA National Center for Environmental Information
Japanese Meteorological Agency

Climate Change (NOAA Definition)

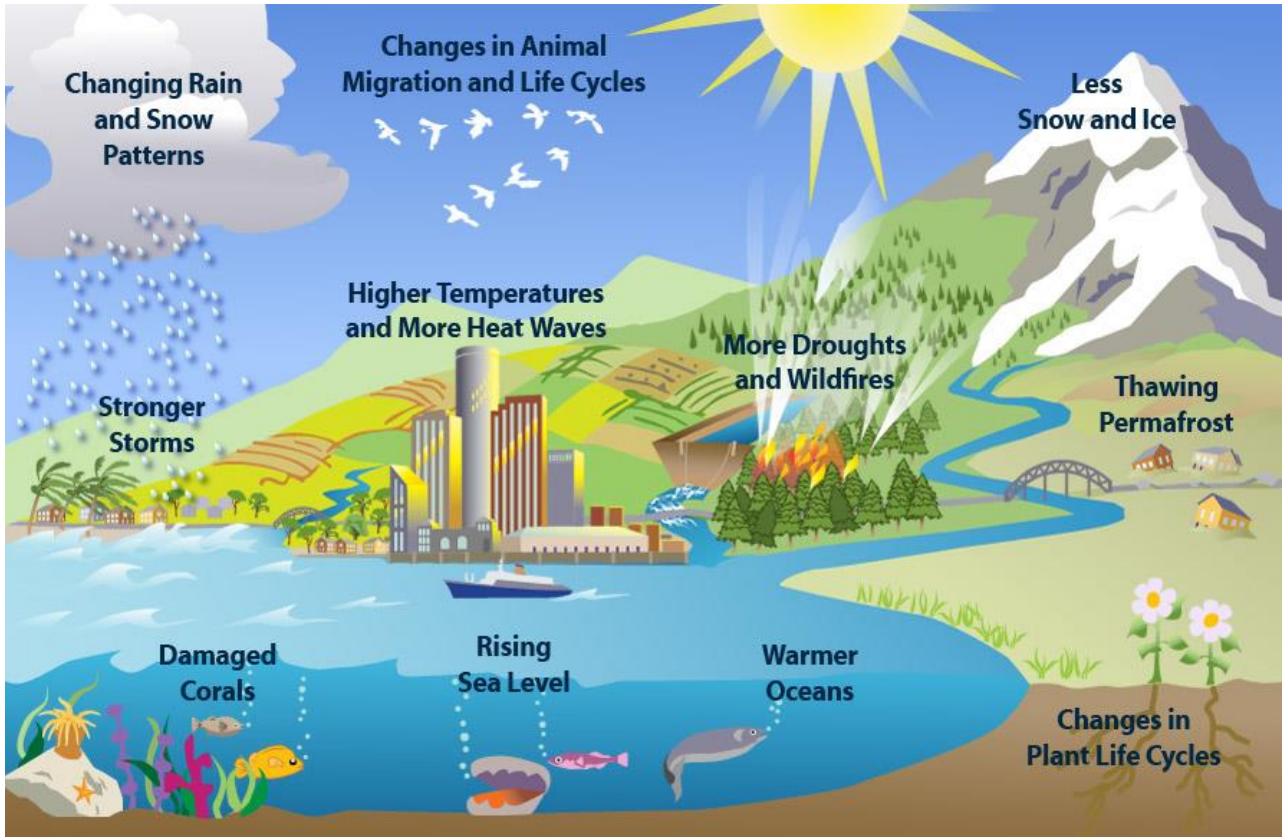
Climate change is a long-term shift in the statistics of the weather (including its averages).

For example, it could show up as a change in climate normal's (expected average values for temperature and precipitation) for a given place and time of year, from one decade to the next.

Why is the Climate Changing??

Natural Variability

Climate change is a normal part of the Earth's natural variability, which is related to interactions among the atmosphere, ocean, and land, as well as changes in the amount of solar radiation reaching the earth.



US Environment Protection Agency

Human Induced Change

Greenhouse Gases

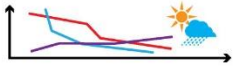
- Carbon dioxide (CO_2) and water vapor (H_2O), trap heat in the atmosphere causing a greenhouse effects
- Burning of fossil fuels, like oil, coal, and natural gas is adding CO_2 to the atmosphere.

The **AR4 of the Intergovernmental Panel on Climate Change (IPCC)** concludes, "that most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

CLIMATE CHANGE

The negative impacts of climate change on the environment and human beings by the end of the 21st century, unless we do all we can to reduce greenhouse gas emissions.

The average temperature on Earth has risen by 0.85 °C in the last 130 years. Temperatures have never been warmer at any time in the last 1400 years. 11 of the first 14 years of the 21st century have been the warmest years since records began, with 2014 setting an absolute record.



Rising temperatures change the balance in all natural systems on Earth: glaciers and permafrost are melting; the level of the world ocean is rising; floods, droughts and hurricanes are happening more frequently; the weather is becoming increasingly unpredictable.

2 billion people
2050

By 2050, as many as two billion people will be affected by floods and other natural disasters caused by climate change, increase of population, deforestation and the rising level of the world ocean.

1/3 of the world population

A third of the world population live in the coastal areas within less than 100 km from the sea. These people will be especially affected by the rising sea level, increased salinization of agricultural lands, as well as more frequent storms and floodings.

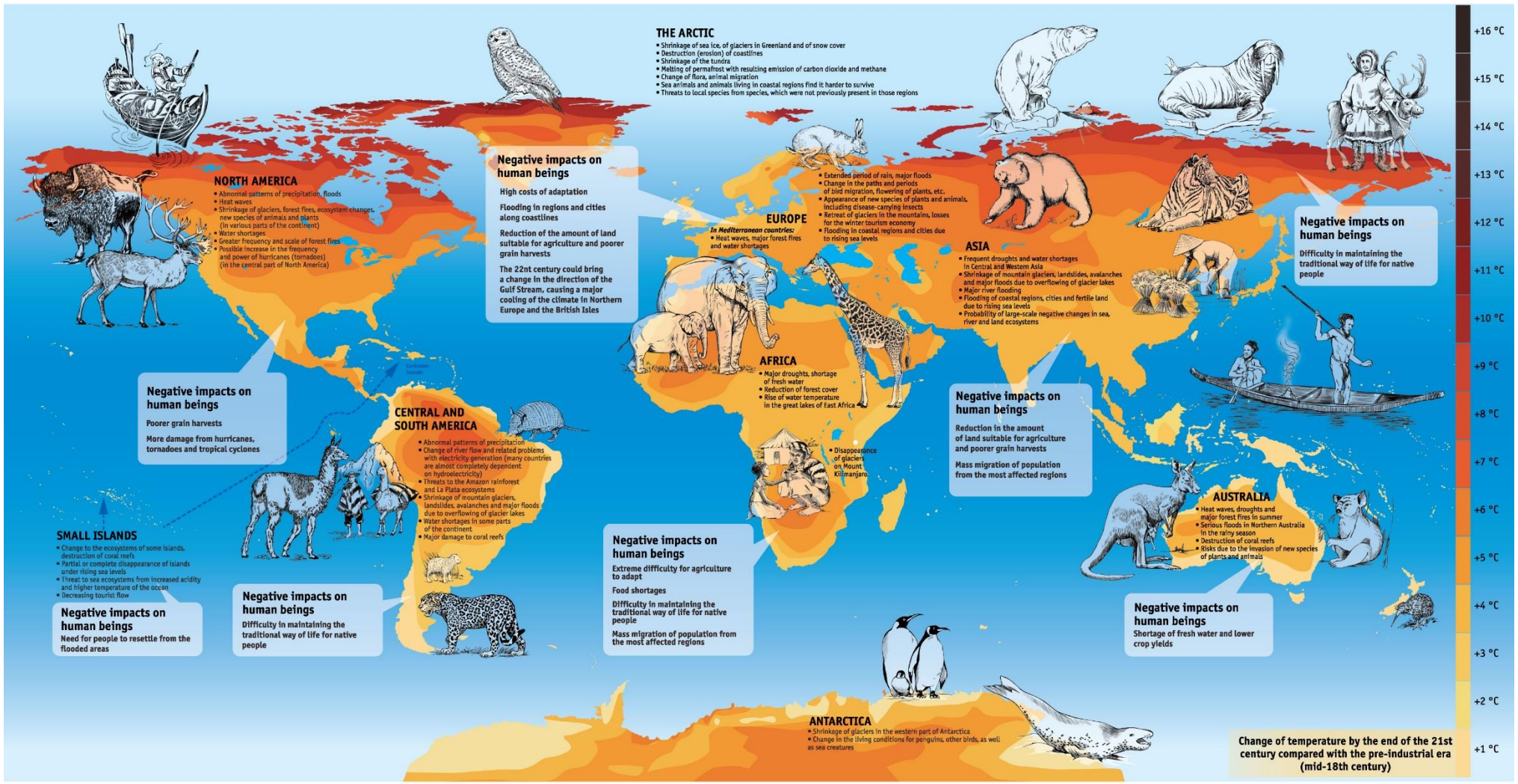
1.8 billion

Climate change will accelerate the melting of glaciers, change cycles and amounts of precipitation, and alter seasonal flow in rivers. As a result, 1.8 billion people will live in a water scarce environment by 2080.

2 °C = $ 100 billion

Measures to adapt the world population to a rise of the temperature on Earth by just 2 °C will cost 70–100 billion US dollars every year.

Burning of fossil fuels, rapid development of transport and deforestation have led to a record increase in concentrations of greenhouse gases in the atmosphere, which have not occurred on Earth for at least the last 800,000 years. Since the Industrial Revolution (mid-18th century), the levels of carbon dioxide (CO_2) have risen by 40%, of methane (CH_4) by 120% and of nitrous oxide (N_2O) by 20%.



The map is based on the findings of the Fourth and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC), data of the United Nations Development Programme and the United Kingdom's Met Office.

Climate Box

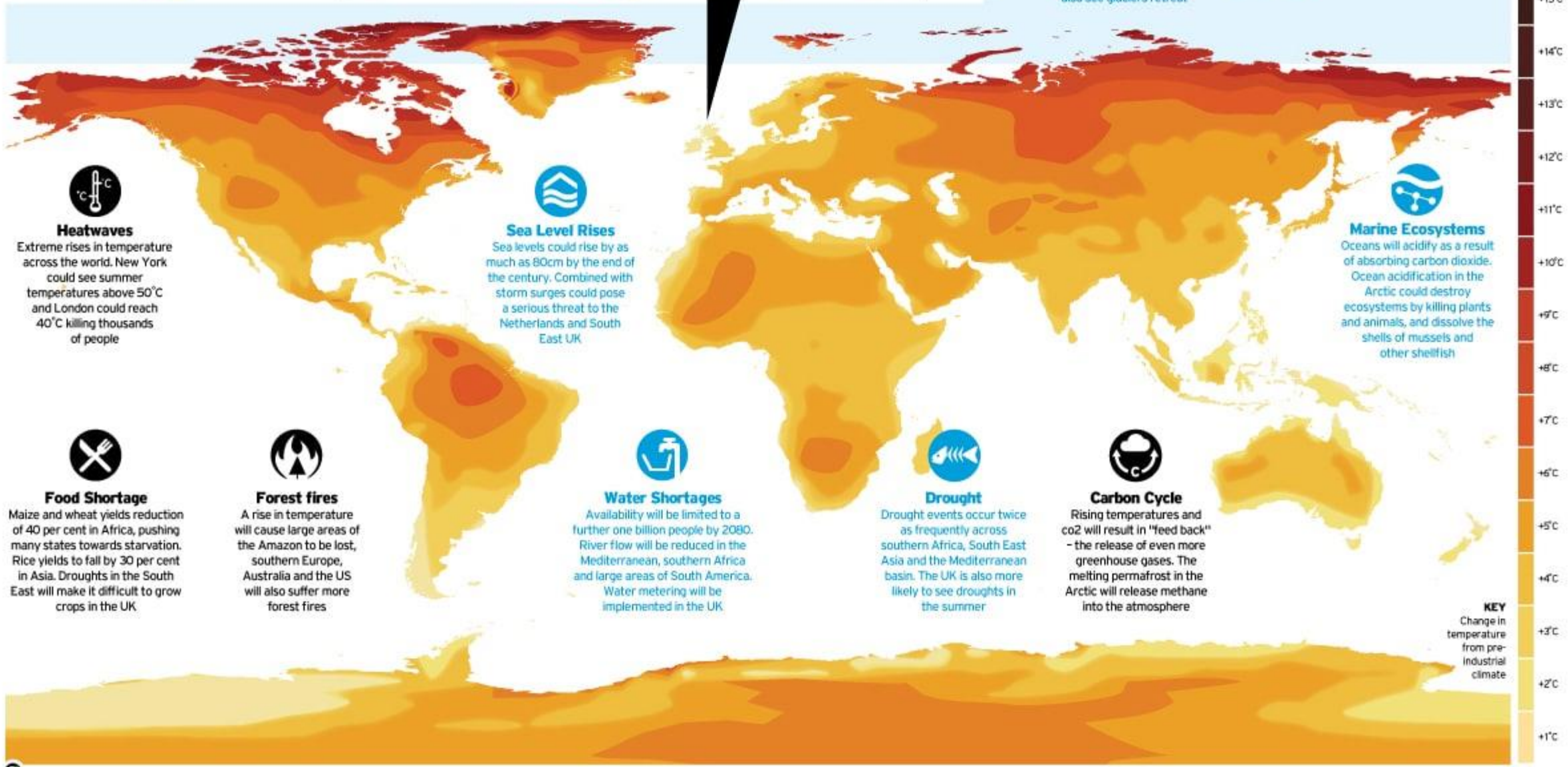
CLIMATE DESTABILISATION

The average temperature rise across the globe 4°C

The arctic rise will be as much as 16°C

Coastal areas of Britain and New Zealand will see temperatures rise by 2°C

Affects on the UK



Heatwaves
Extreme rises in temperature across the world. New York could see summer temperatures above 50°C and London could reach 40°C killing thousands of people

Sea Level Rises
Sea levels could rise by as much as 80cm by the end of the century. Combined with storm surges could pose a serious threat to the Netherlands and South East UK

Melting Glaciers
Himalayan glaciers will be significantly reduced by 2050 putting the water source of billions of people at risk. South America and the Alps will also see glaciers retreat

Marine Ecosystems
Oceans will acidify as a result of absorbing carbon dioxide. Ocean acidification in the Arctic could destroy ecosystems by killing plants and animals, and dissolve the shells of mussels and other shellfish

Food Shortage
Maize and wheat yields reduction of 40 per cent in Africa, pushing many states towards starvation. Rice yields to fall by 30 per cent in Asia. Droughts in the South East will make it difficult to grow crops in the UK

Forest fires
A rise in temperature will cause large areas of the Amazon to be lost, southern Europe, Australia and the US will also suffer more forest fires

Water Shortages
Availability will be limited to a further one billion people by 2080. River flow will be reduced in the Mediterranean, southern Africa and large areas of South America. Water metering will be implemented in the UK

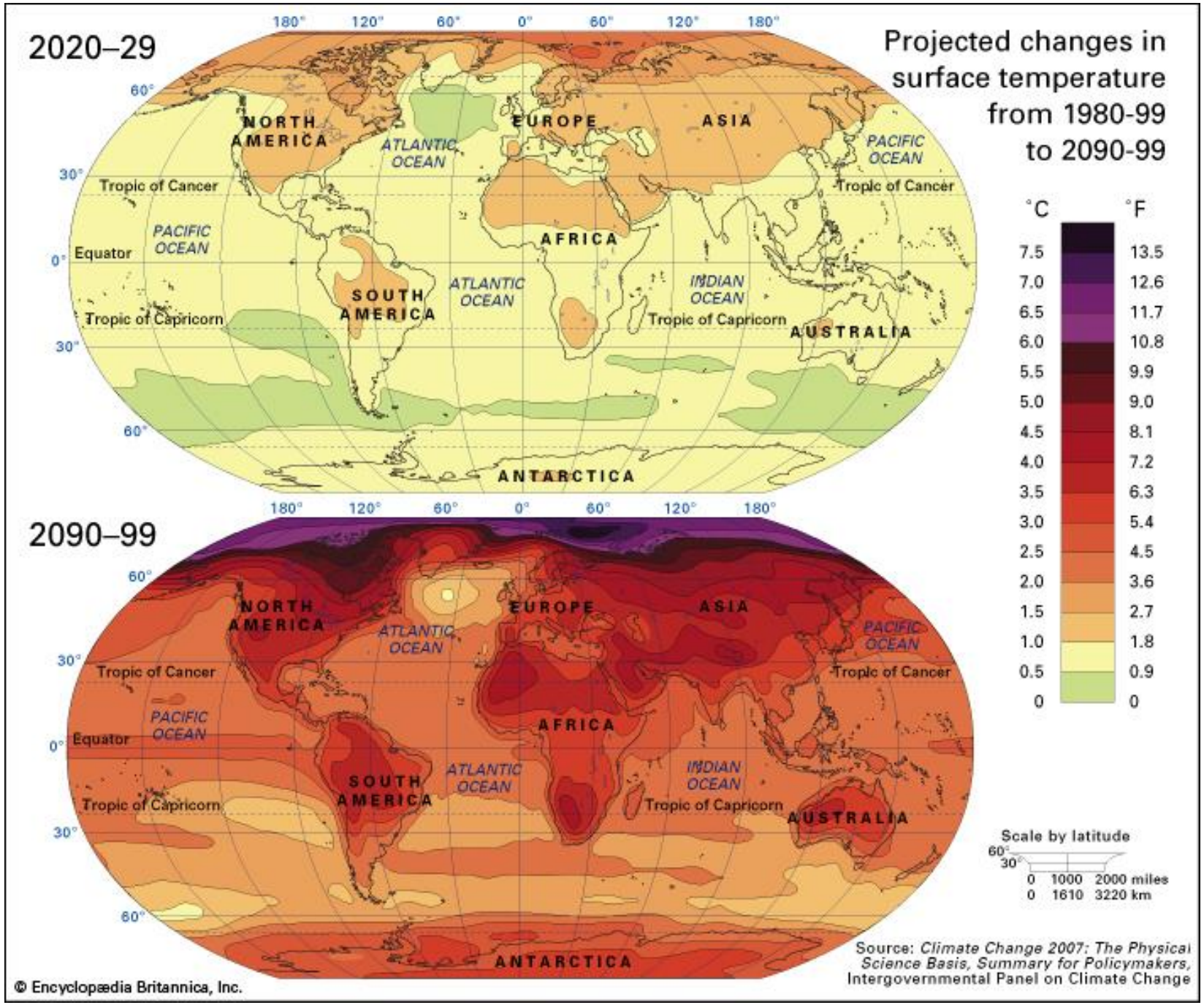
Drought
Drought events occur twice as frequently across southern Africa, South East Asia and the Mediterranean basin. The UK is also more likely to see droughts in the summer

Carbon Cycle
Rising temperatures and co2 will result in "feed back" – the release of even more greenhouse gases. The melting permafrost in the Arctic will release methane into the atmosphere

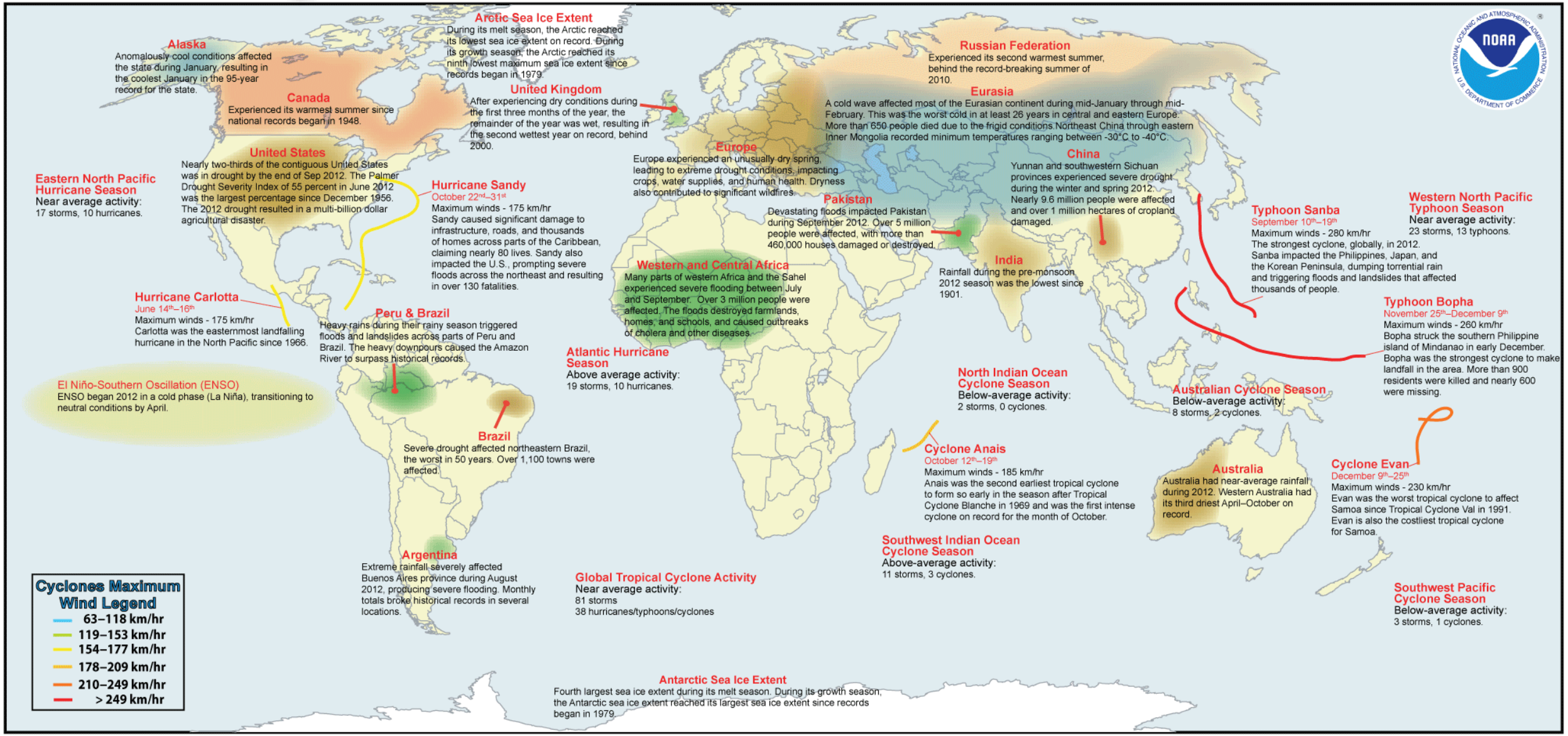
KEY
Change in temperature from pre-industrial climate

+16°C
+15°C
+14°C
+13°C
+12°C
+11°C
+10°C
+9°C
+8°C
+7°C
+6°C
+5°C
+4°C
+3°C
+2°C
+1°C

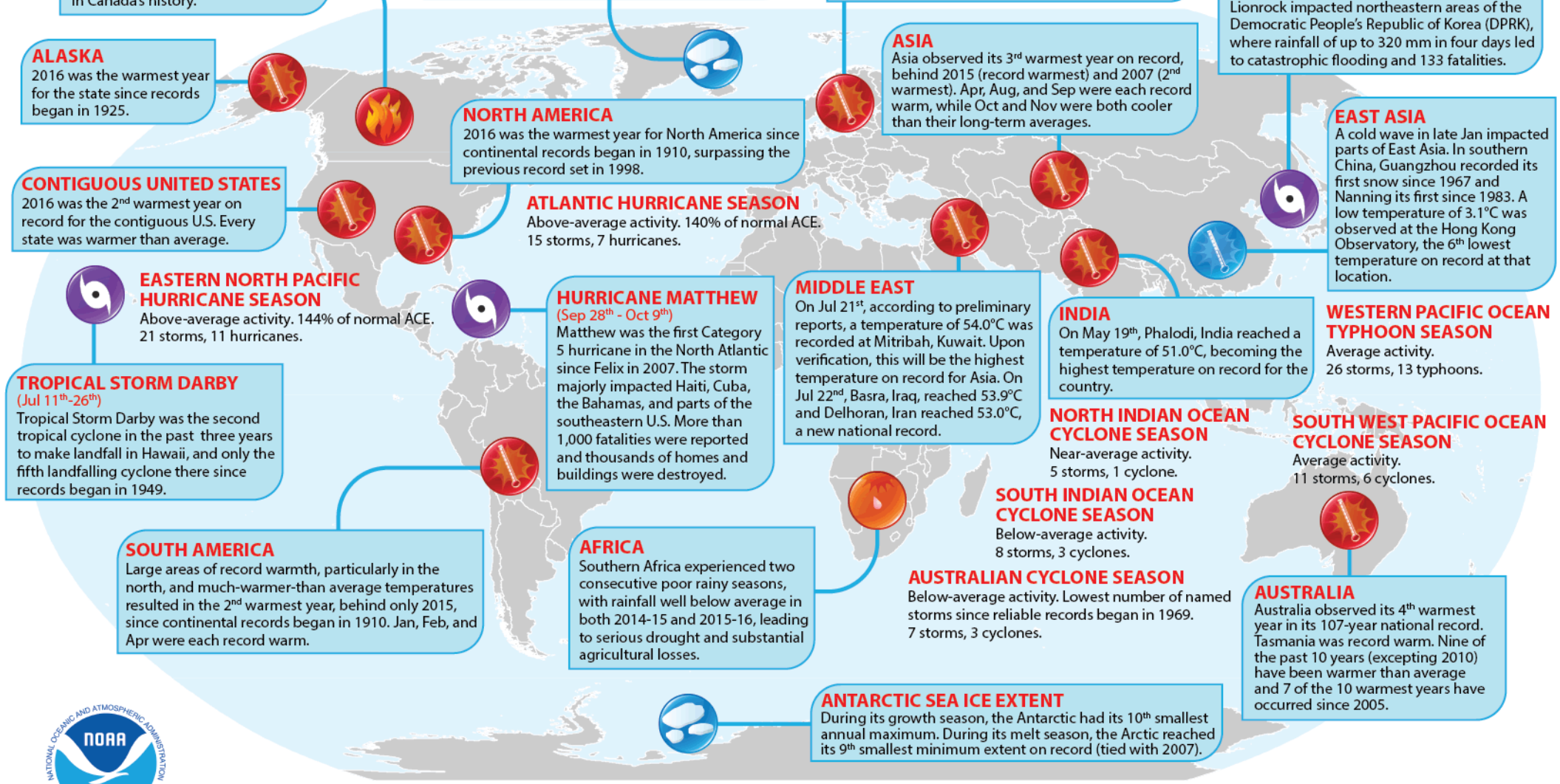
SOURCE MET OFFICE AND HM GOVERNMENT


2020–29
Projected changes in surface temperature from 1980-99 to 2090-99
180° 120° 60° 0° 60° 120° 180°
60°
30°
0°
30°
60°
NORTH AMERICA
EUROPE
ASIA
ATLANTIC OCEAN
PACIFIC OCEAN
Tropic of Cancer
Equator
AFRICA
SOUTH AMERICA
INDIAN OCEAN
Tropic of Capricorn
AUSTRALIA
ANTARCTICA
°C
°F
7.5 13.5
7.0 12.6
6.5 11.7
6.0 10.8
5.5 9.9
5.0 9.0
4.5 8.1
4.0 7.2
3.5 6.3
3.0 5.4
2.5 4.5
2.0 3.6
1.5 2.7
1.0 1.8
0.5 0.9
0 0
2090–99
Scale by latitude
60°
30°
0 1000 2000 miles
0 1610 3220 km
Source: Climate Change 2007: The Physical Science Basis, Summary for Policymakers, Intergovernmental Panel on Climate Change
© Encyclopædia Britannica, Inc.

2012 Significant Climate Anomalies and Events



Selected Significant Climate Anomalies and Events in 2016



CANADA
A wildfire destroyed large parts of Fort McMurray (Alberta) in early May and became the costliest natural disaster in Canada's history.

ARCTIC SEA ICE EXTENT
During its growth season, the Arctic had its smallest annual maximum extent for the second year in a row. During its melt season, the Arctic reached its 2nd smallest minimum extent on record (tied with 2007).

EUROPE
Europe experienced its 3rd warmest year, behind only 2014 (record warm) and 2015 (2nd warmest), making the past three years the three warmest in the 107-year continental record. The average winter (Dec 2015–Feb 2016) temperature was record high.

TYPHOON LIONROCK
(Aug 16th-31st)
Lionrock impacted northeastern areas of the Democratic People's Republic of Korea (DPRK), where rainfall of up to 320 mm in four days led to catastrophic flooding and 133 fatalities.

ALASKA
2016 was the warmest year for the state since records began in 1925.

ASIA
Asia observed its 3rd warmest year on record, behind 2015 (record warmest) and 2007 (2nd warmest). Apr, Aug, and Sep were each record warm, while Oct and Nov were both cooler than their long-term averages.

NORTH AMERICA
2016 was the warmest year for North America since continental records began in 1910, surpassing the previous record set in 1998.

EAST ASIA
A cold wave in late Jan impacted parts of East Asia. In southern China, Guangzhou recorded its first snow since 1967 and Nanning its first since 1983. A low temperature of 3.1°C was observed at the Hong Kong Observatory, the 6th lowest temperature on record at that location.

CONTIGUOUS UNITED STATES
2016 was the 2nd warmest year on record for the contiguous U.S. Every state was warmer than average.

ATLANTIC HURRICANE SEASON
Above-average activity. 140% of normal ACE.
15 storms, 7 hurricanes.

EASTERN NORTH PACIFIC HURRICANE SEASON
Above-average activity. 144% of normal ACE.
21 storms, 11 hurricanes.

HURRICANE MATTHEW
(Sep 28th - Oct 9th)
Matthew was the first Category 5 hurricane in the North Atlantic since Felix in 2007. The storm majorly impacted Haiti, Cuba, the Bahamas, and parts of the southeastern U.S. More than 1,000 fatalities were reported and thousands of homes and buildings were destroyed.

MIDDLE EAST
On Jul 21st, according to preliminary reports, a temperature of 54.0°C was recorded at Mitribah, Kuwait. Upon verification, this will be the highest temperature on record for Asia. On Jul 22nd, Basra, Iraq, reached 53.9°C and Delhoran, Iran reached 53.0°C, a new national record.

INDIA
On May 19th, Phalodi, India reached a temperature of 51.0°C, becoming the highest temperature on record for the country.

WESTERN PACIFIC OCEAN TYPHOON SEASON
Average activity.
26 storms, 13 typhoons.

TROPICAL STORM DARBY
(Jul 11th-26th)
Tropical Storm Darby was the second tropical cyclone in the past three years to make landfall in Hawaii, and only the fifth landfalling cyclone there since records began in 1949.

NORTH INDIAN OCEAN CYCLONE SEASON
Near-average activity.
5 storms, 1 cyclone.

SOUTH WEST PACIFIC OCEAN CYCLONE SEASON
Average activity.
11 storms, 6 cyclones.

SOUTH INDIAN OCEAN CYCLONE SEASON
Below-average activity.
8 storms, 3 cyclones.

SOUTH AMERICA
Large areas of record warmth, particularly in the north, and much-warmer-than average temperatures resulted in the 2nd warmest year, behind only 2015, since continental records began in 1910. Jan, Feb, and Apr were each record warm.

AFRICA
Southern Africa experienced two consecutive poor rainy seasons, with rainfall well below average in both 2014-15 and 2015-16, leading to serious drought and substantial agricultural losses.

AUSTRALIAN CYCLONE SEASON
Below-average activity. Lowest number of named storms since reliable records began in 1969.
7 storms, 3 cyclones.

AUSTRALIA
Australia observed its 4th warmest year in its 107-year national record. Tasmania was record warm. Nine of the past 10 years (excepting 2010) have been warmer than average and 7 of the 10 warmest years have occurred since 2005.

ANTARCTIC SEA ICE EXTENT
During its growth season, the Antarctic had its 10th smallest annual maximum. During its melt season, the Arctic reached its 9th smallest minimum extent on record (tied with 2007).

Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports and international partners. For more information please visit: http://www.ncdc.noaa.gov/sotc

Climate Variability & Climate Change

What is the Climate System?

Consists of five major components:

- The atmosphere
- The hydrosphere
- The cryosphere
- Land surface
- The biosphere

The climate system is continually changing due to the interactions between the components as well as external factors such as volcanic eruptions or solar variations and human-induced factors such as changes to the atmosphere and changes in land use. (**WMO**)

What is Climate Variability?

Variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events.

- Deviations of climatic statistics over a given period of time (e.g. a month, season or year) when compared to long-term statistics for the same calendar period;

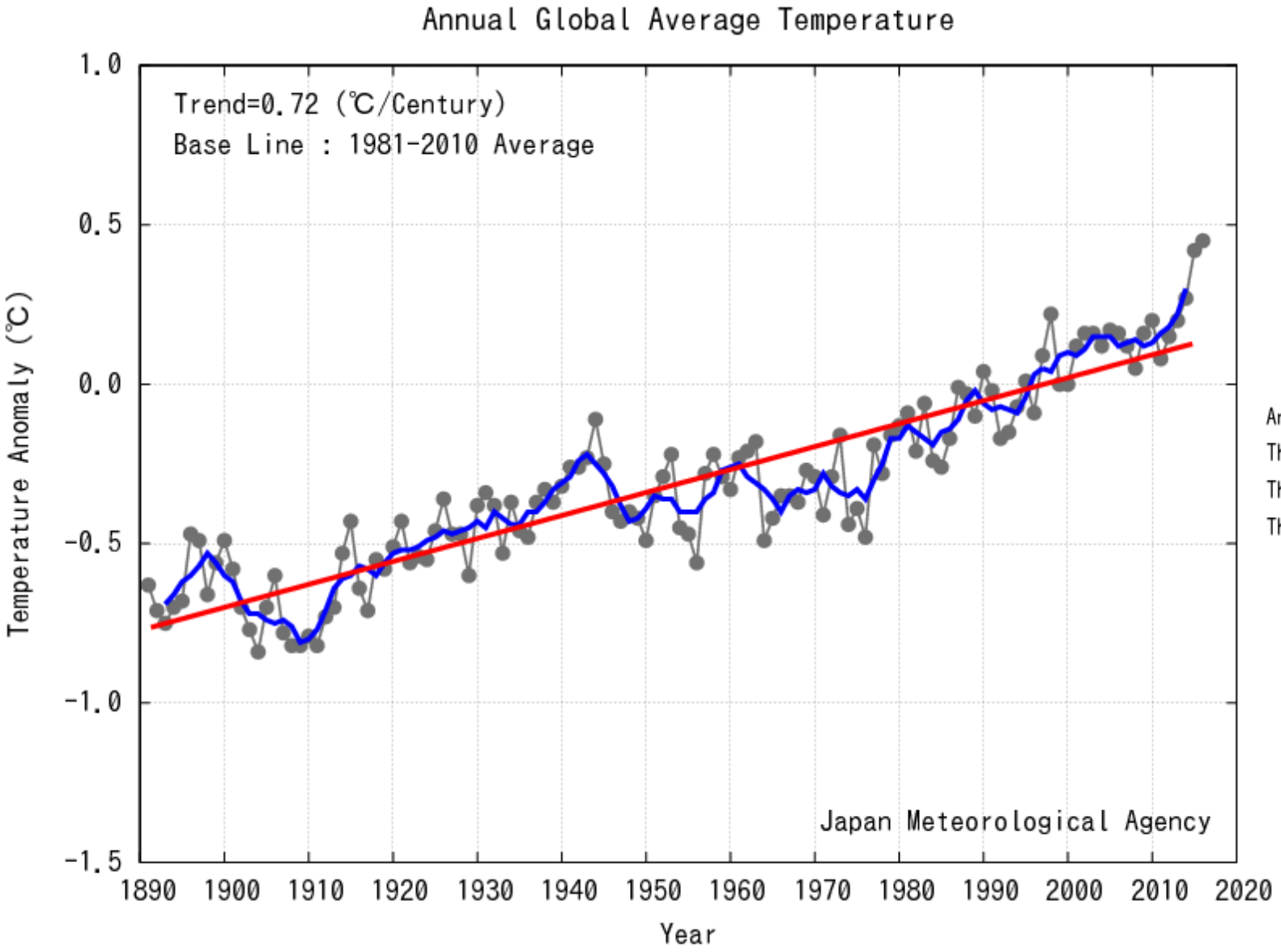
- Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external factors (external variability).

What is the difference between Climate Variability and Climate Change?

Climate variability looks at changes that occur within smaller timeframes, such as a month, a season or a year, and climate change considers changes that occur over a longer period of time, typically over decades or longer.

A key difference between climate variability and change is in persistence of "anomalous" conditions - when events that used to be rare occur more frequently, or vice-versa.

(**WMO**)



Anomalies are deviation from baseline (1981-2010 Average).
The black thin line indicates surface temperature anomaly of each year.
The blue line indicates their 5-year running mean.
The red line indicates the long-term linear trend.

Source: https://ds.data.jma.go.jp/tcc/tcc/products/gwp/temp/fig/an_wld.png

Global Temperature Anomalies from 1880 to 2012

Source: NASA

Consequences of Climate Change

Present Consequences

Global climate change has already had observable effects on the environment.

- Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner.
- Past predictions by scientists are now occurring: loss of sea ice, accelerated sea level rise and longer, more intense heat waves.

(NASA Vital Signs of the Planet)

Future Consequences

- Change will continue through this century and beyond;
- Temperatures will continue to rise;
- Variations in crop growing season;
- Changes in precipitation patterns;
- More droughts and heat waves;
- Sea level will rise 1-4 feet by 2100.

(NASA Vital Signs of the Planet)

What Changes Climate??

What changes have been observed so far in climate?

- Warming of global climate is now unequivocal;
  - Impacts includes, increasing air and ocean temperatures, widespread melting of snow and ice, and rising sea levels;
  - Most of the increase in global temperature observed over the past fifty years is very likely due to human emissions of greenhouse gases.

Source: https://www.eea.europa.eu/themes/climate/faq/how-is-climate-changing-and-how-has-it-changed-in-the-past

How has climate changed?

Past climate has varied enormously on a variety of time-scales;

Past records demonstrate that global climate is sensitive to small but persistent influences;

Global average temperatures have increased over the past century;

Changes consistent with an increase in global temperature have been observed in many other components of the climate system.

Source: https://www.science.org.au/learning/general-audience/science-booklets-0/science-climate-change/2-how-has-climate-changed

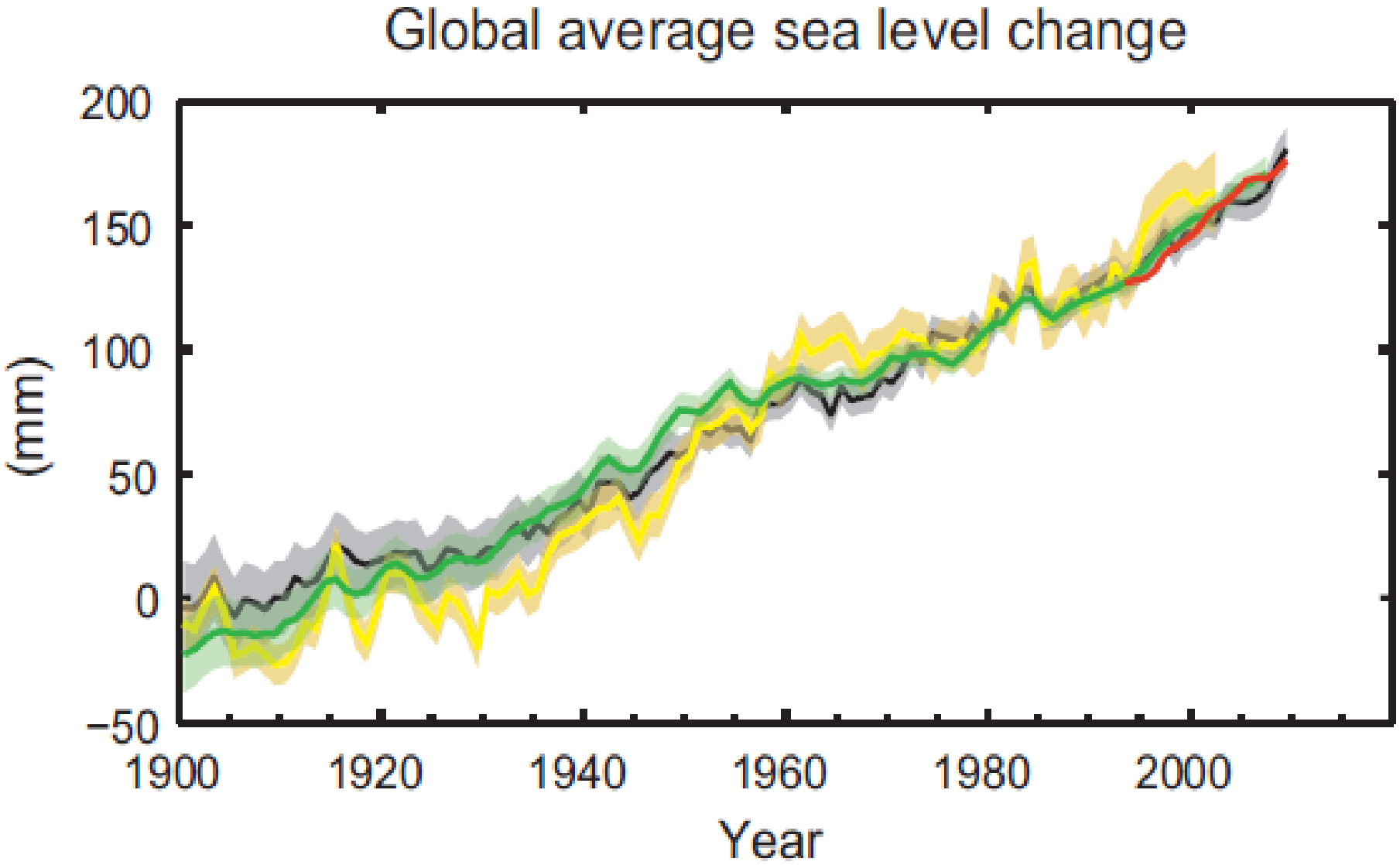
10 Indicators Our Climate is Changing

1. **AIR TEMPERATURES OVER LAND ARE INCREASING**
2. **AIR TEMPERATURES OVER OCEANS ARE INCREASING.**
3. **ARCTIC SEA ICE IS DECREASING.**
4. **GLACIERS ARE MELTING**
5. **SEA LEVELS ARE RISING.**
6. **HUMIDITY IS INCREASING**
7. **OCEAN HEAT CONTENT IS INCREASING**
8. **SEA SURFACE TEMPERATURE IS INCREASING**
9. **SNOW IS DECREASING**
10. **EARTH'S LOWER ATMOSPHERE TEMPERATURE IS INCREASING.**

Source: NOAA

Observations of Climate Change

Direct Observations



From IPCC Assessment Report (AR5) (2014)

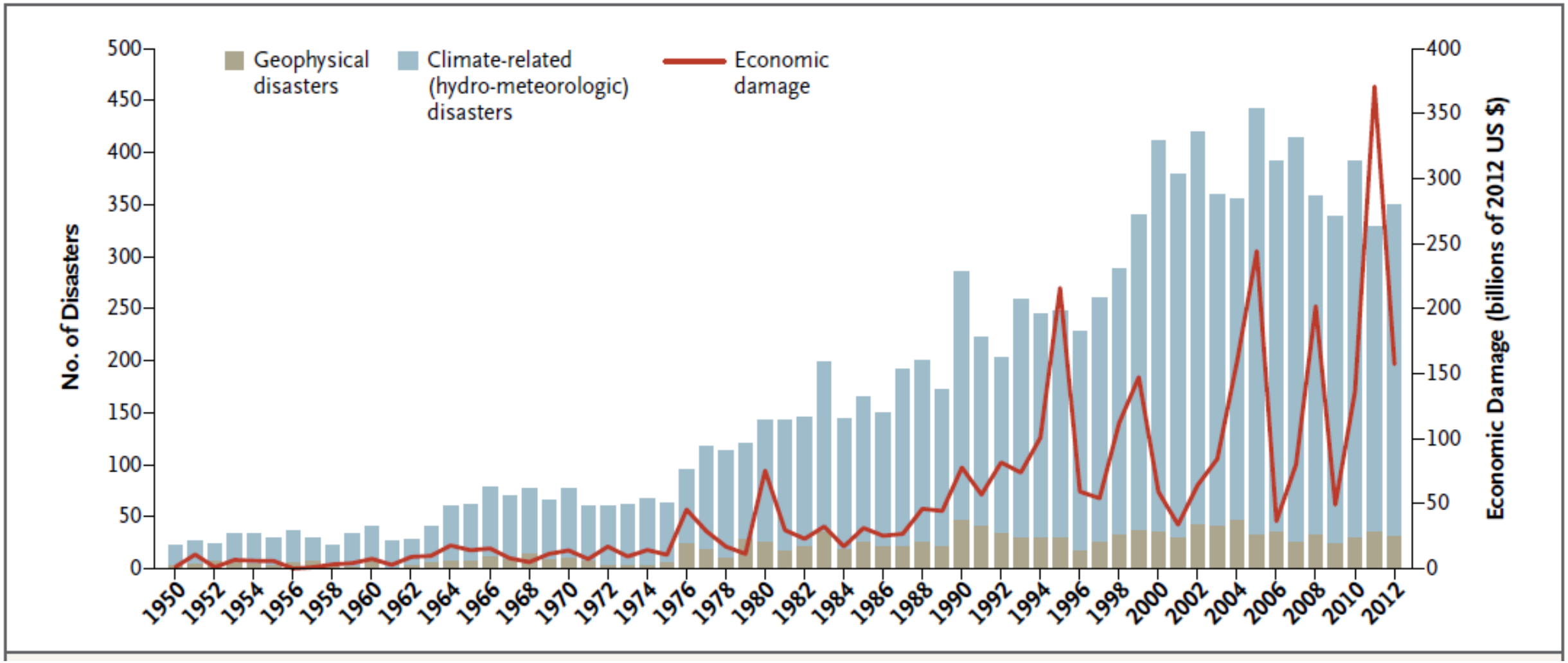
Mount Kilimanjaro

Feb. 17, 1993

Feb. 21, 2000

Credit: ***Jim Williams, NASA GSFC Scientific Visualization Studio, Landsat 7 Science Team***

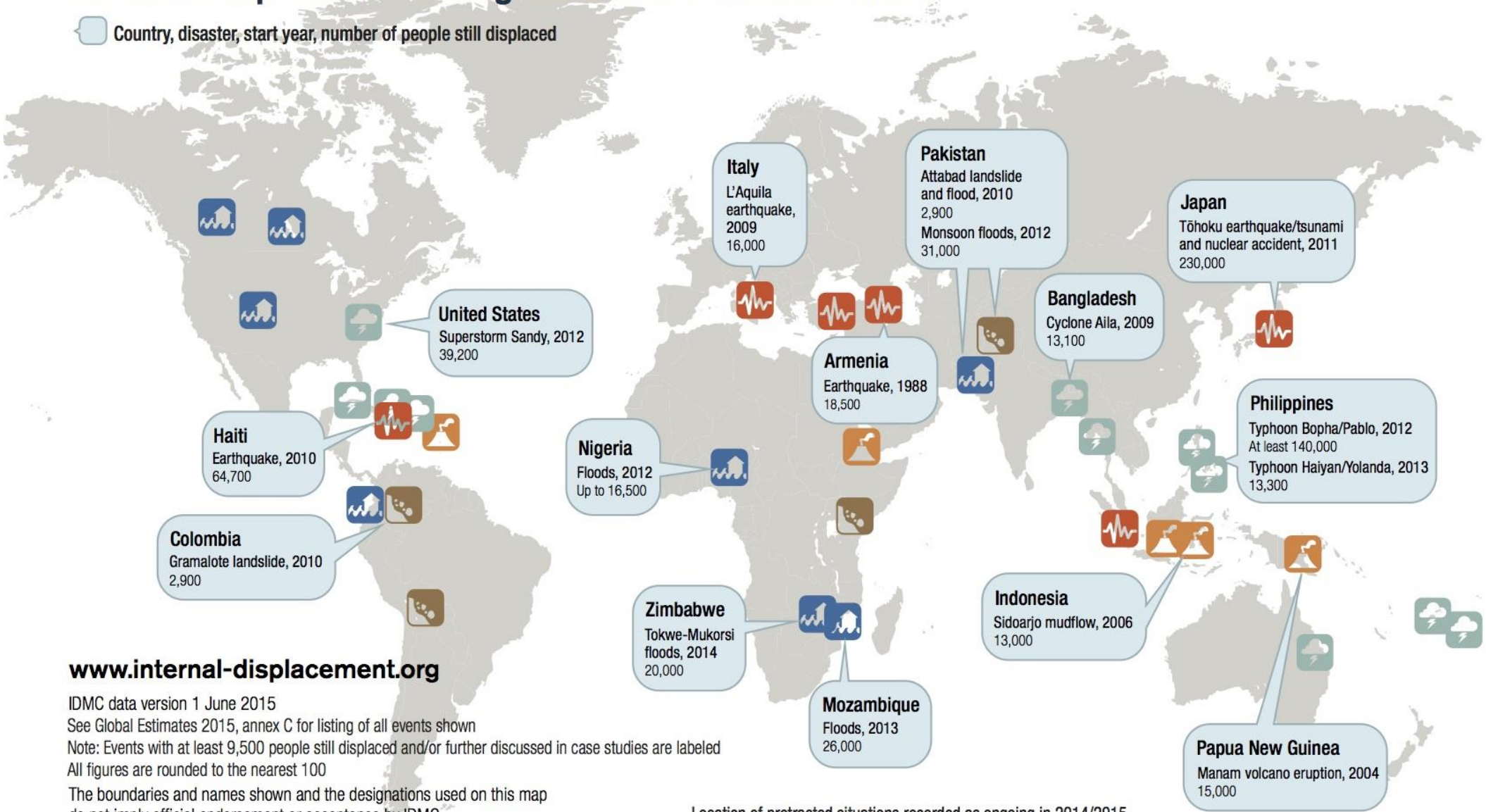
Climate related Disasters on the Increase…



Source: Original Data from the EM-DAT International Disaster Database

Protracted displacement following disasters worldwide in 2014/2015

Country, disaster, start year, number of people still displaced



www.internal-displacement.org

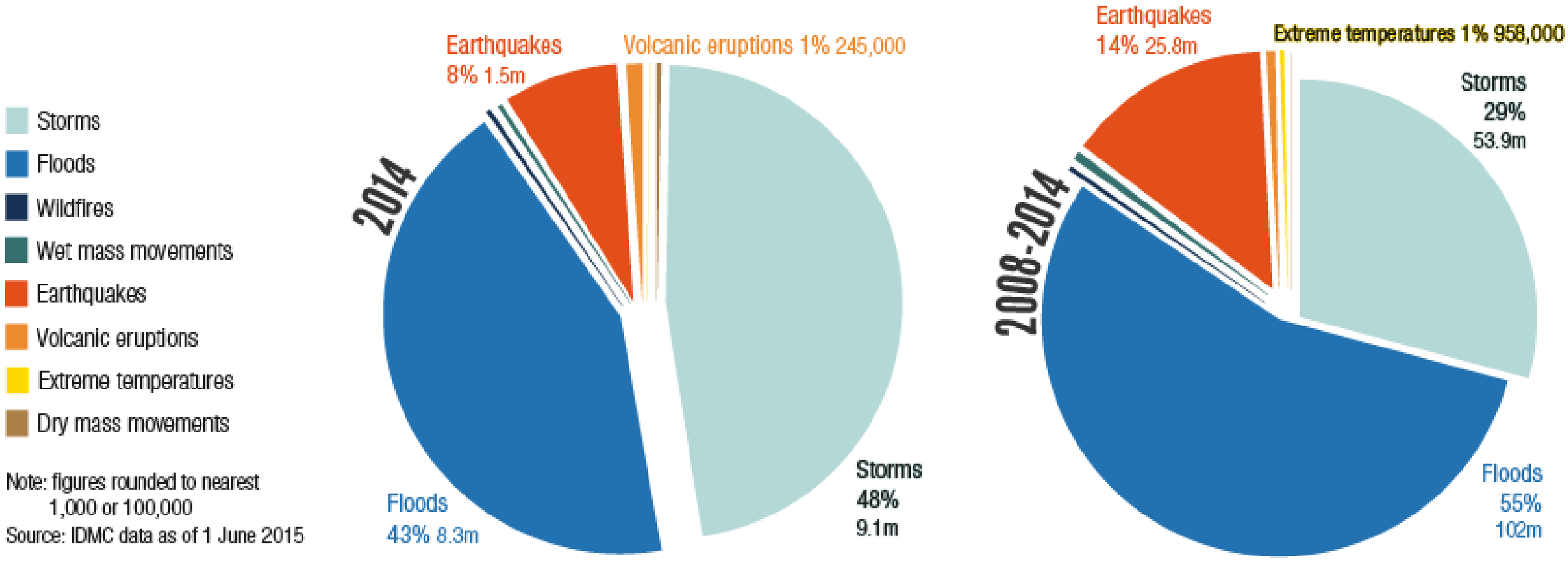
IDMC data version 1 June 2015
See Global Estimates 2015, annex C for listing of all events shown
Note: Events with at least 9,500 people still displaced and/or further discussed in case studies are labeled
All figures are rounded to the nearest 100

Location of protracted situations recorded as ongoing in 2014/2015

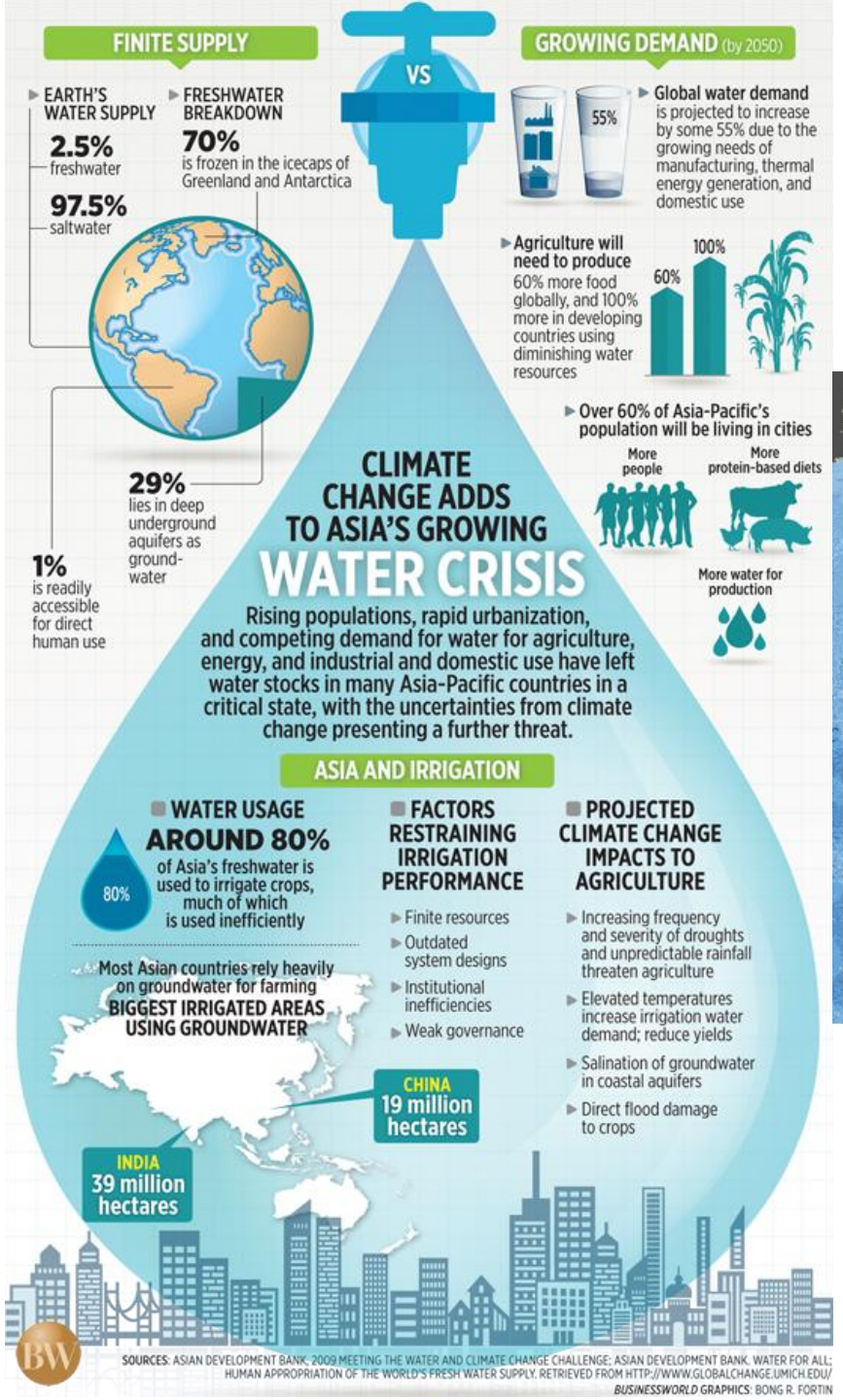
Floods · Landslide · Volcanic eruption
Earthquake · Storm

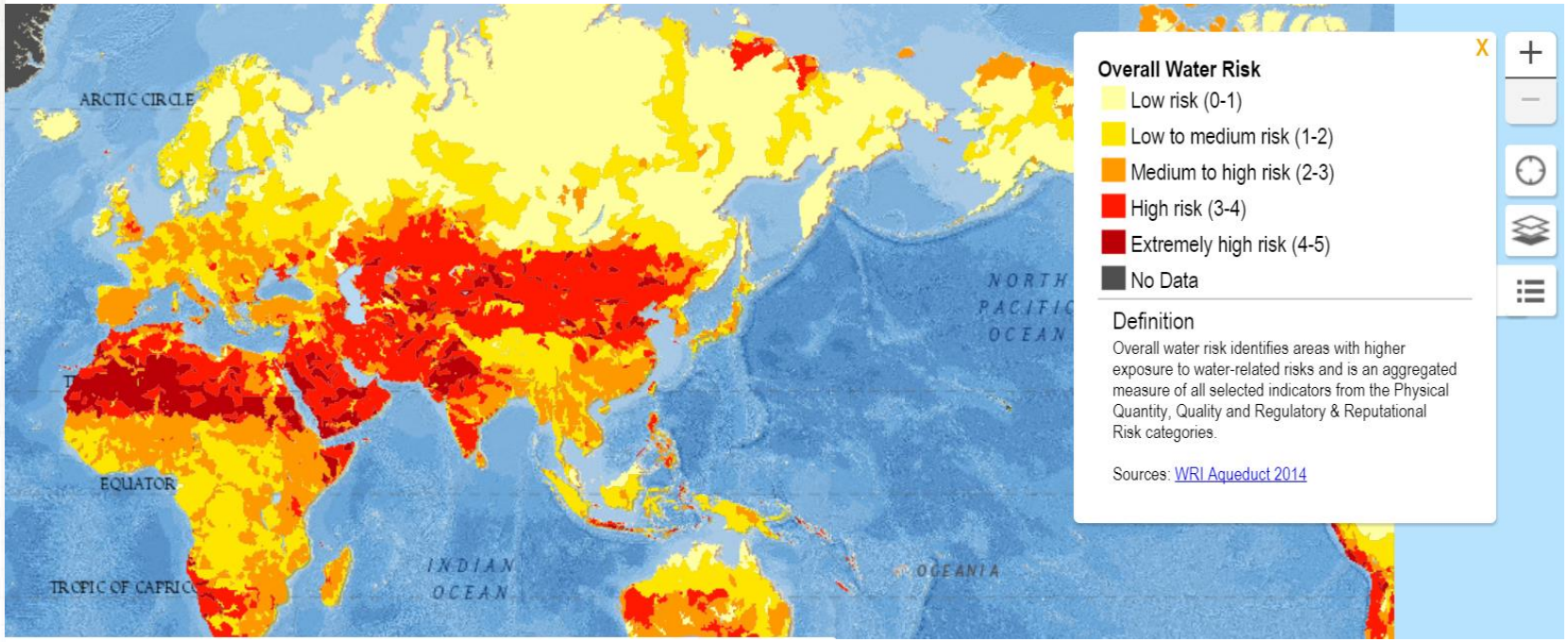
iDMC internal displacement monitoring centre
NRC NORWEGIAN REFUGEE COUNCIL

Global displacement by type of hazard



What's Happening in Asia?





The Impacts of Climate Change

Thank You