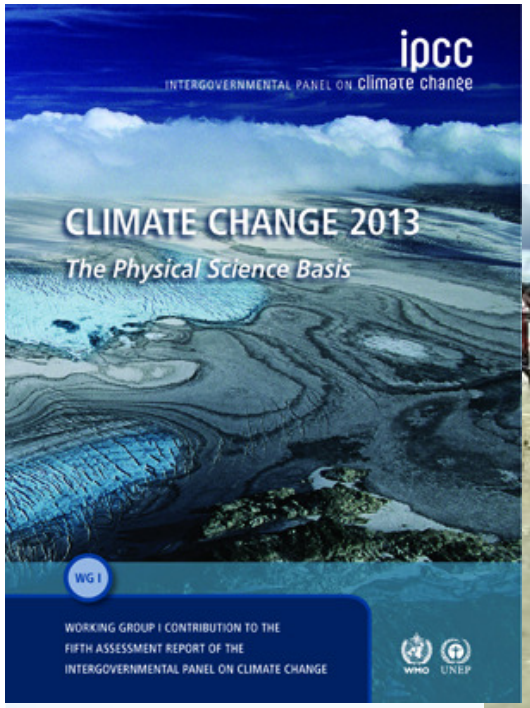
Understanding and Measuring Human Vulnerability to Climate Change

Elena Lioubimtseva, Geography and Planning Department
Environmental Studies Program,
Grand Valley State University,
USA



Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.



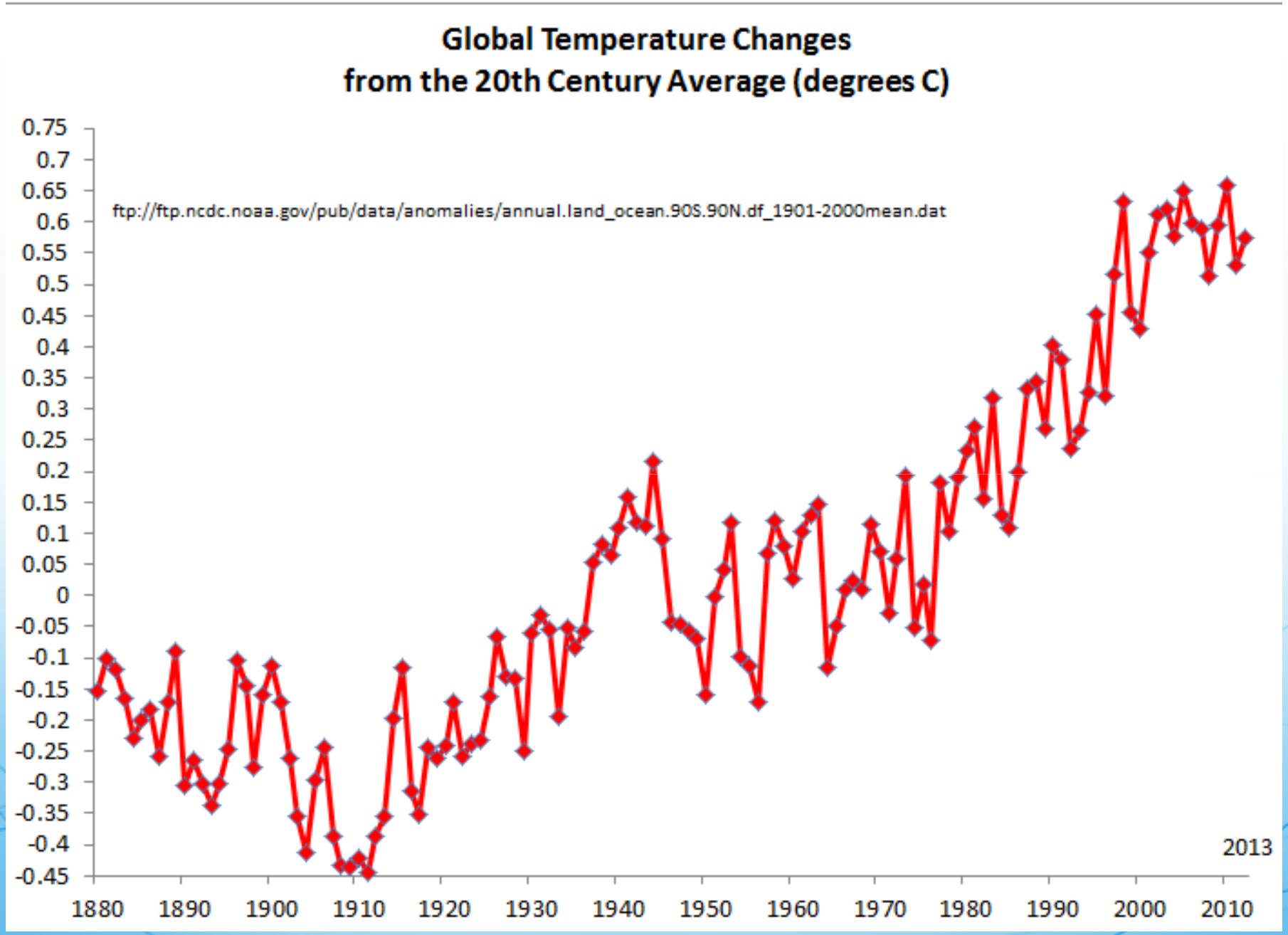
The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of GHGs have increased.



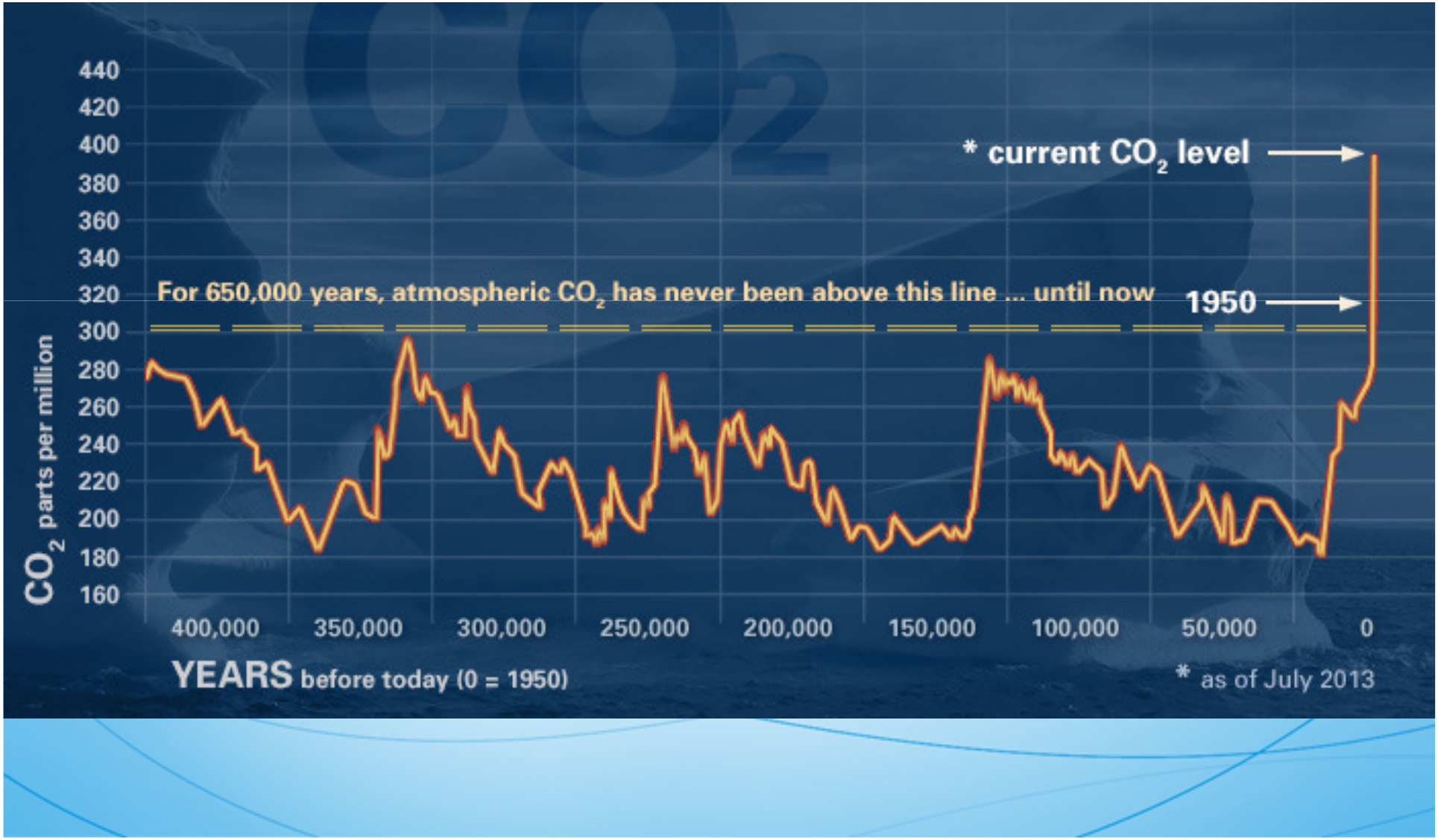
Total radiative forcing is positive, and has led to an uptake of energy by the climate system.

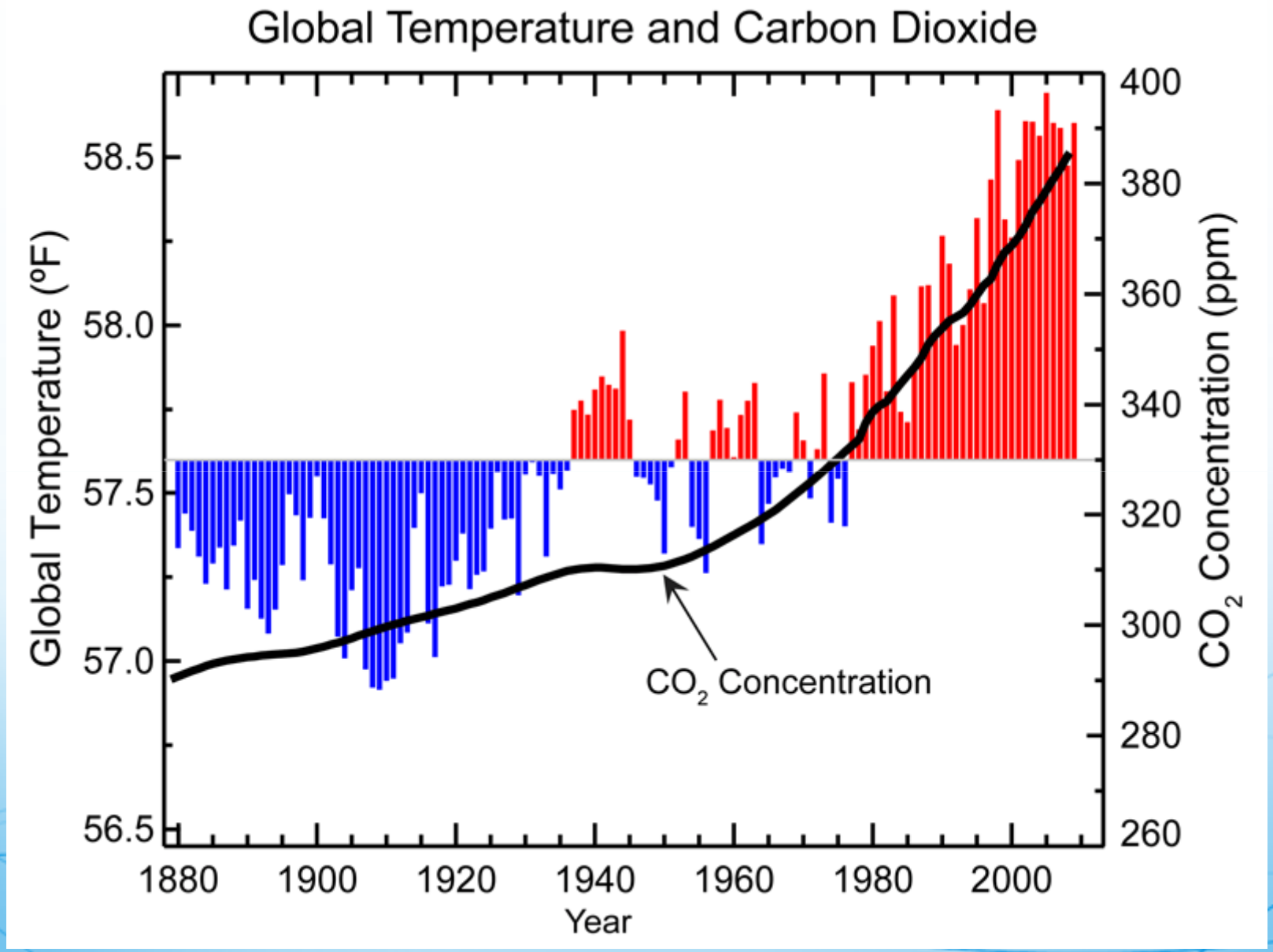


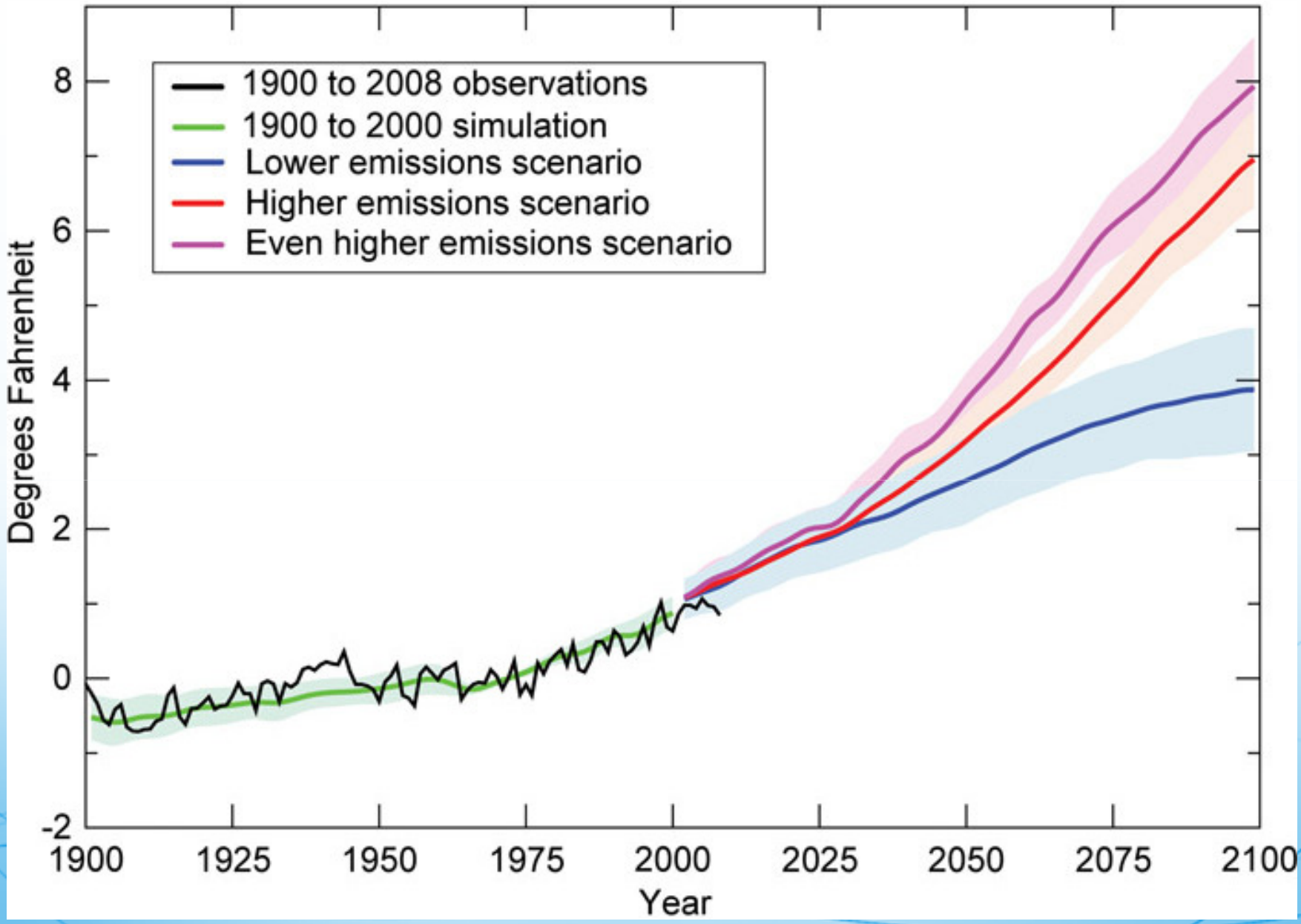
The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO_2 since 1750.

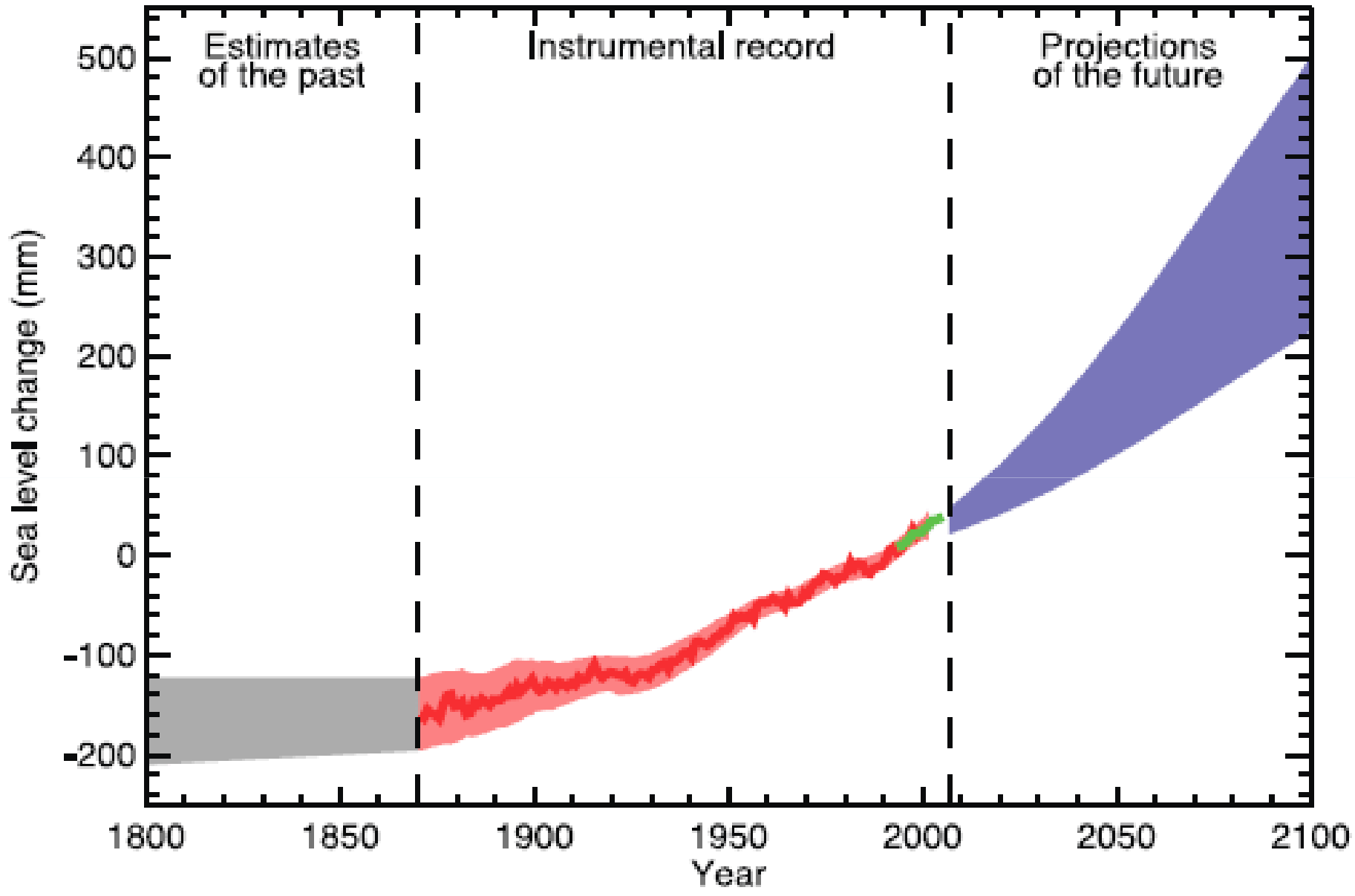

Global Temperature Changes
from the 20th Century Average (degrees C)
ftp://ftp.ncdc.noaa.gov/pub/data/anomalies/annual.land_ocean.90S.90N.df_1901-2000mean.dat
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2013

"Scientific evidence for warming of the climate system is unequivocal."
- Intergovernmental Panel on Climate Change

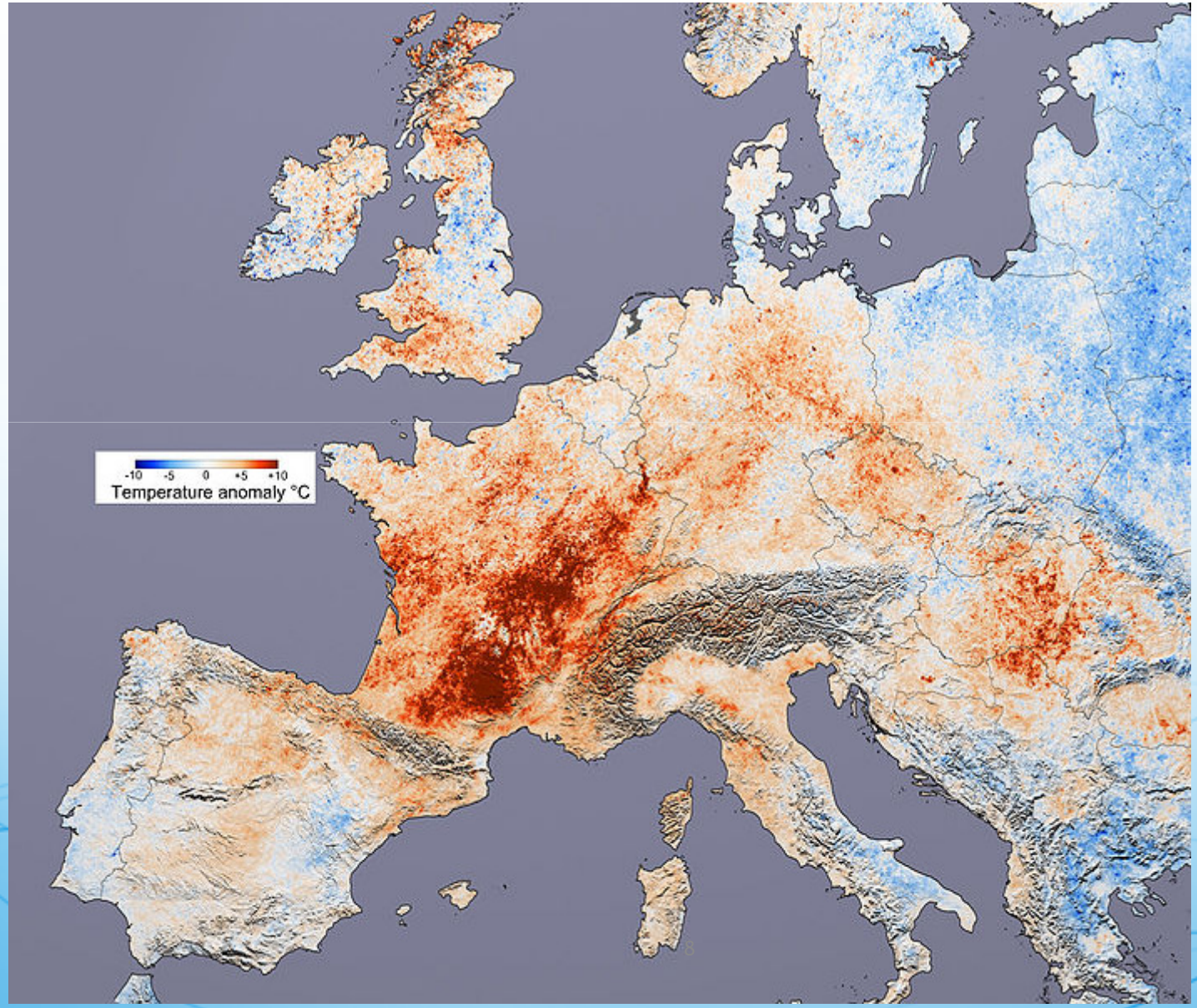



Global Temperature and Carbon Dioxide
Global Temperature (ºF)
58.5
58.0
57.5
57.0
56.5
400
380
360
340
320
300
280
260
CO2 Concentration (ppm)
CO2 Concentration
1880
1900
1920
1940
1960
1980
2000
Year

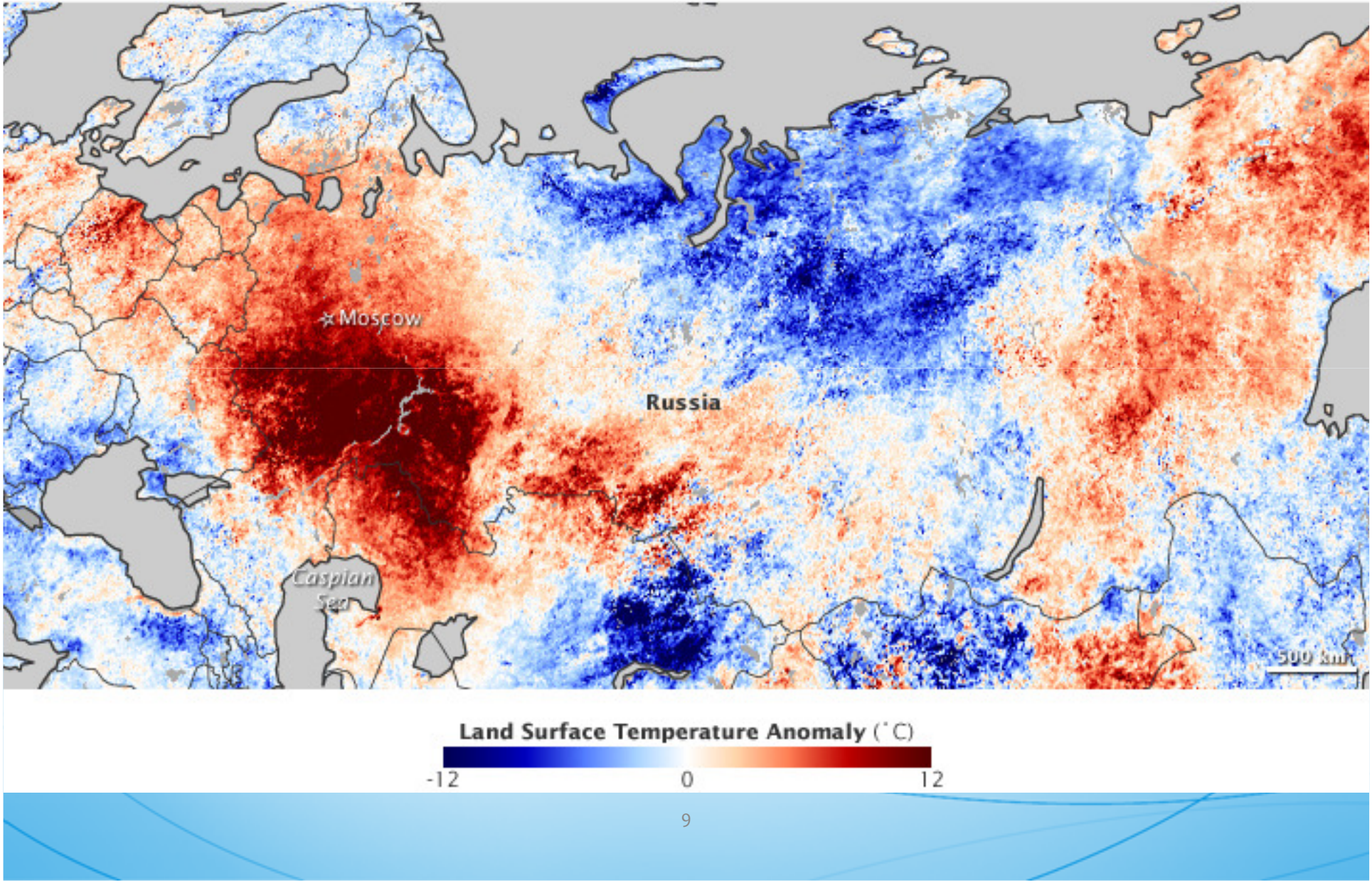

1900 to 2008 observations
1900 to 2000 simulation
Lower emissions scenario
Higher emissions scenario
Even higher emissions scenario
Degrees Fahrenheit
8
6
4
2
0
-2
1900
1925
1950
1975
2000
2025
2050
2075
2100
Year


Estimates of the past
Instrumental record
Projections of the future
Sea level change (mm)
500
400
300
200
100
0
-100
-200
1800
1850
1900
1950
2000
2050
2100
Year

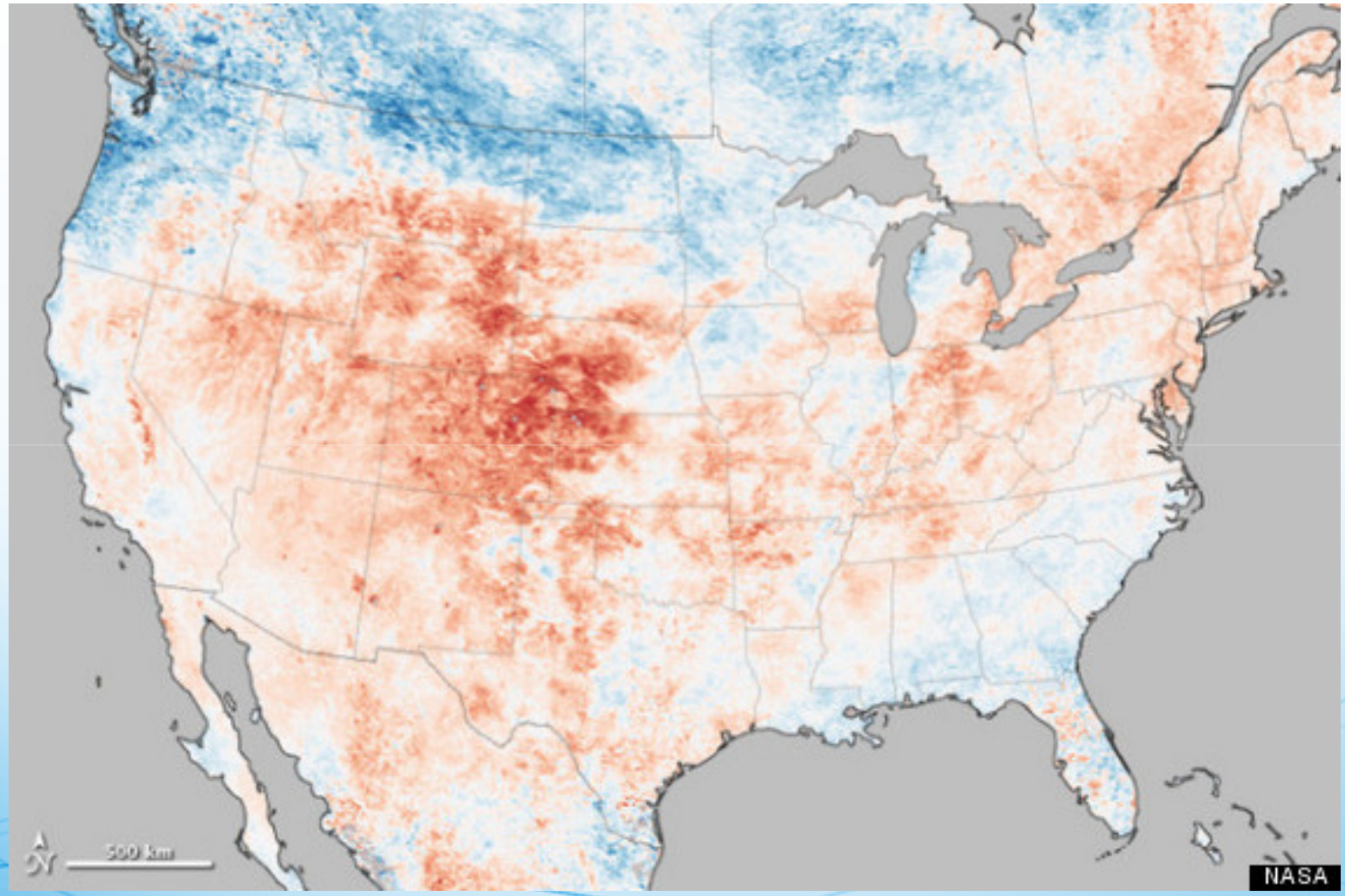
Mean temperature and degrees above average during the 2003 European heat wave, which killed over 70,000 people



Russian Heat Wave, Summer 2010, 56-60000 deaths

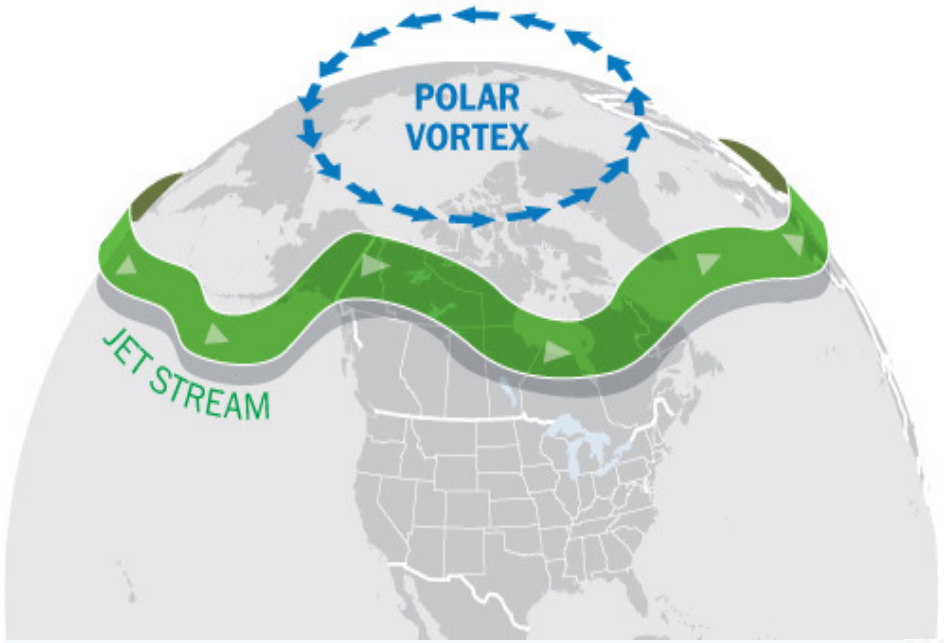


Heat wave in the United States, June 2012



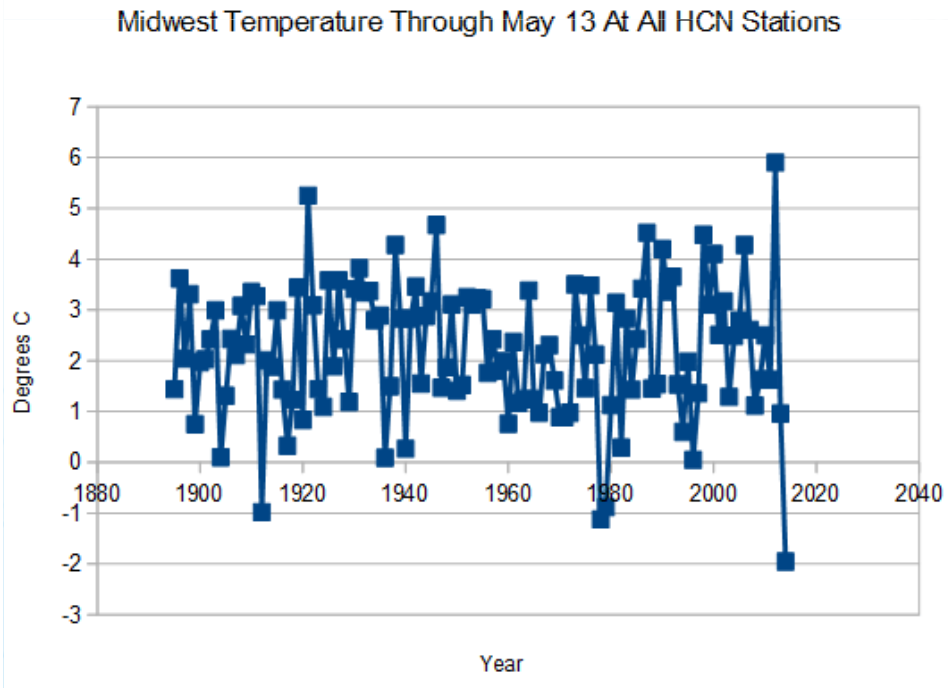


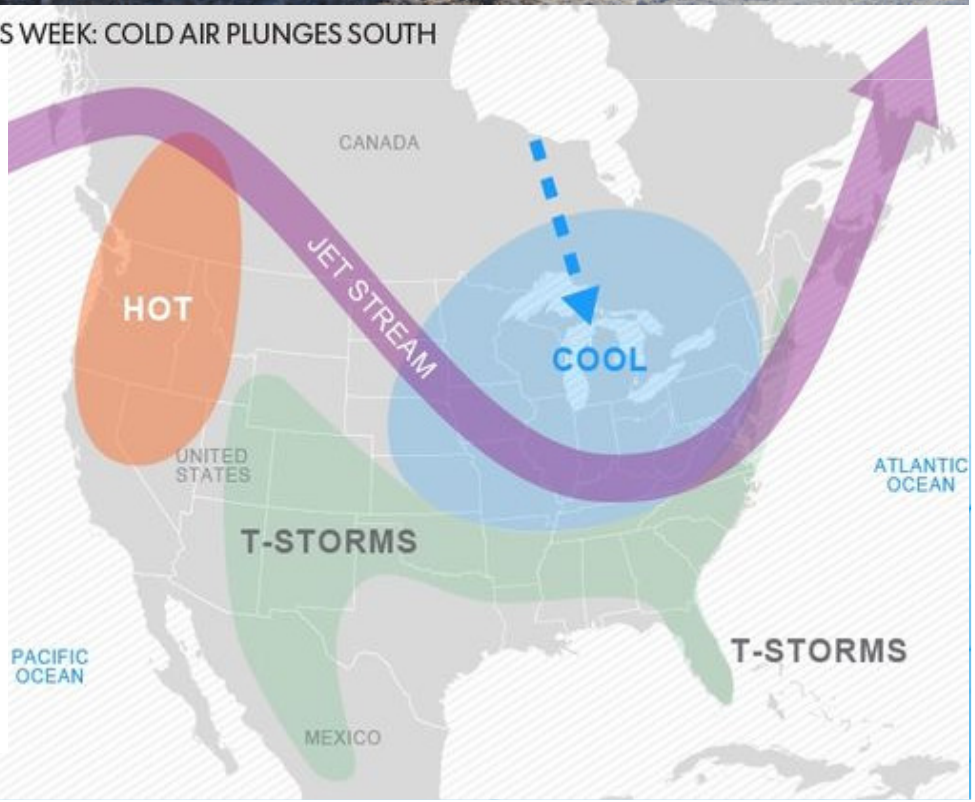
Grand Rapids flooding, Huffington Post, April 2013



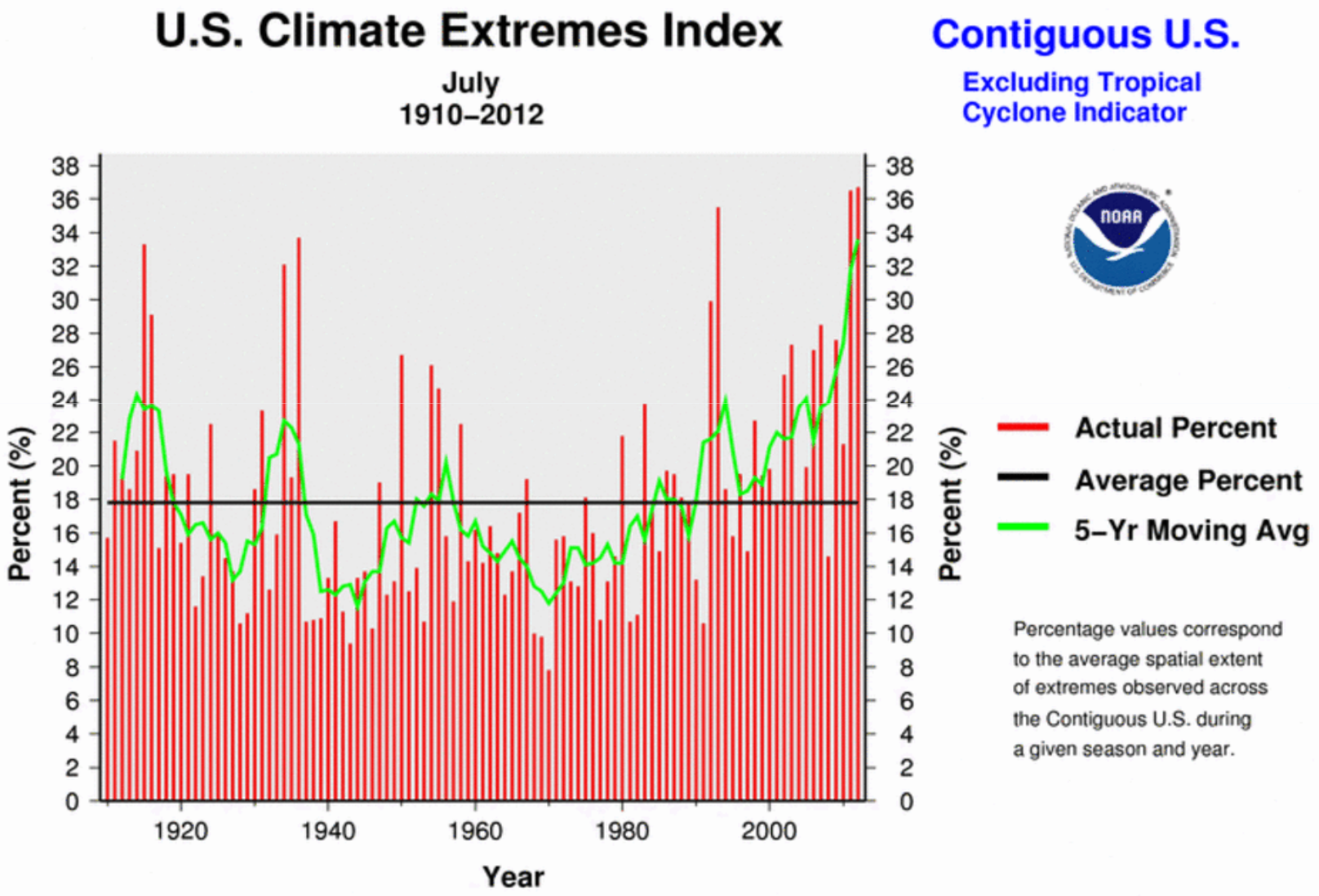


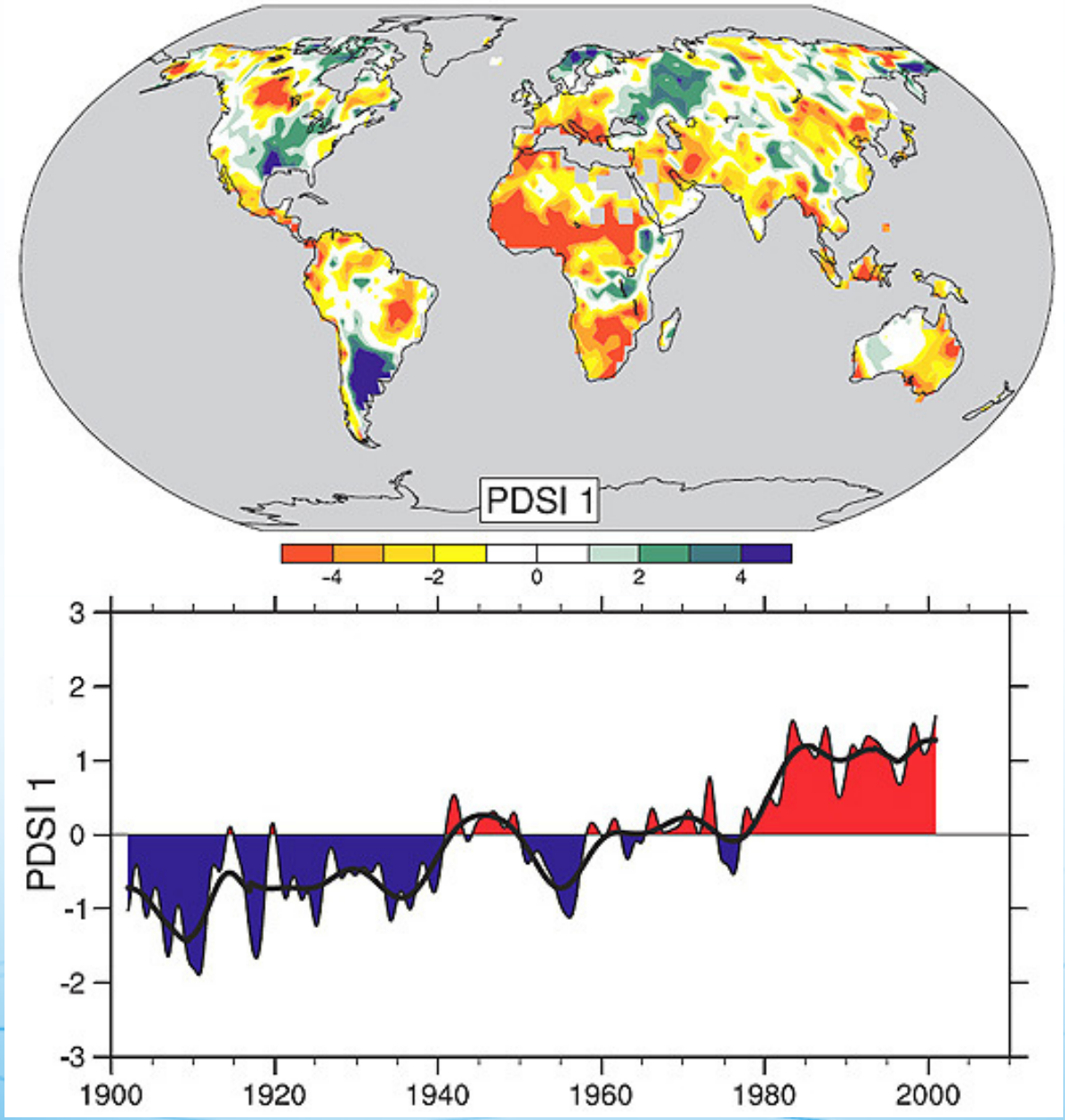
THIS WEEK: COLD AIR PLUNGES SOUTH





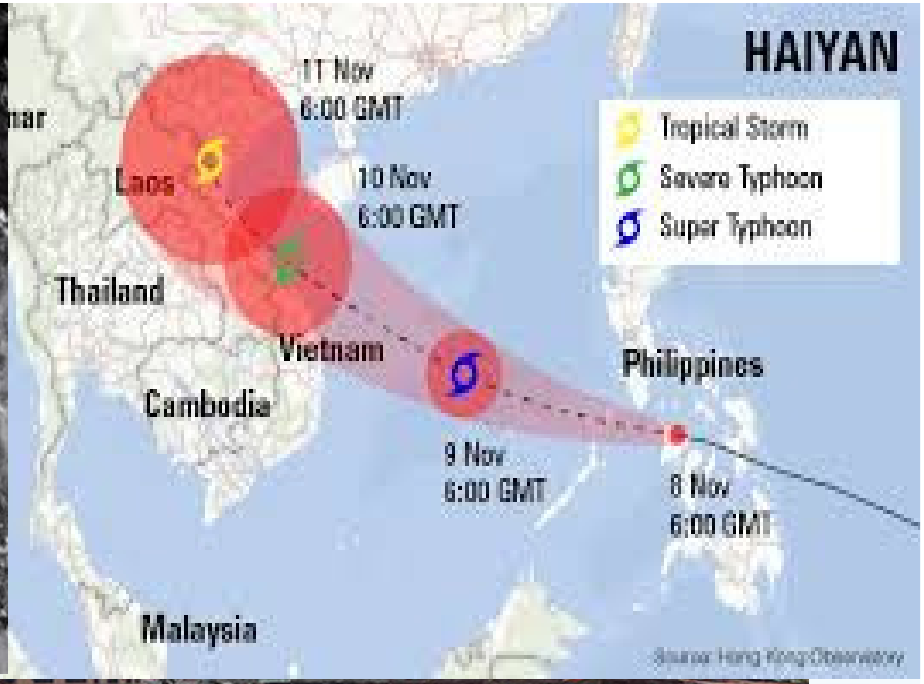



U.S. Climate Extremes Index
July
1910–2012
Contiguous U.S.
Excluding Tropical
Cyclone Indicator
Percent (%)
Year
1920
1940
1960
1980
2000
Actual Percent
Average Percent
5–Yr Moving Avg
Percentage values correspond to the average spatial extent of extremes observed across the Contiguous U.S. during a given season and year.

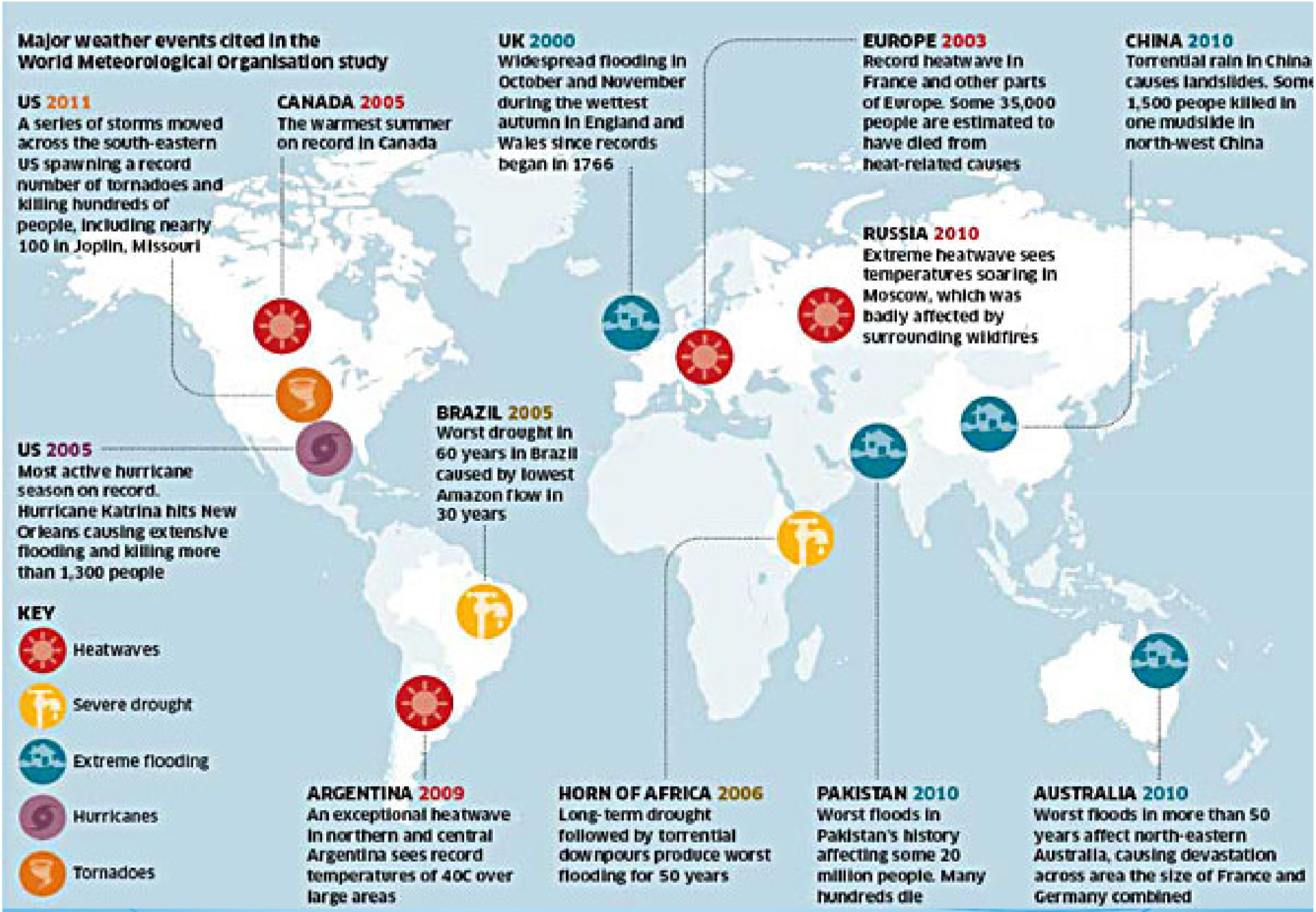


Palmer Drought Severity Index (PDSI) (IPCC, 2007)



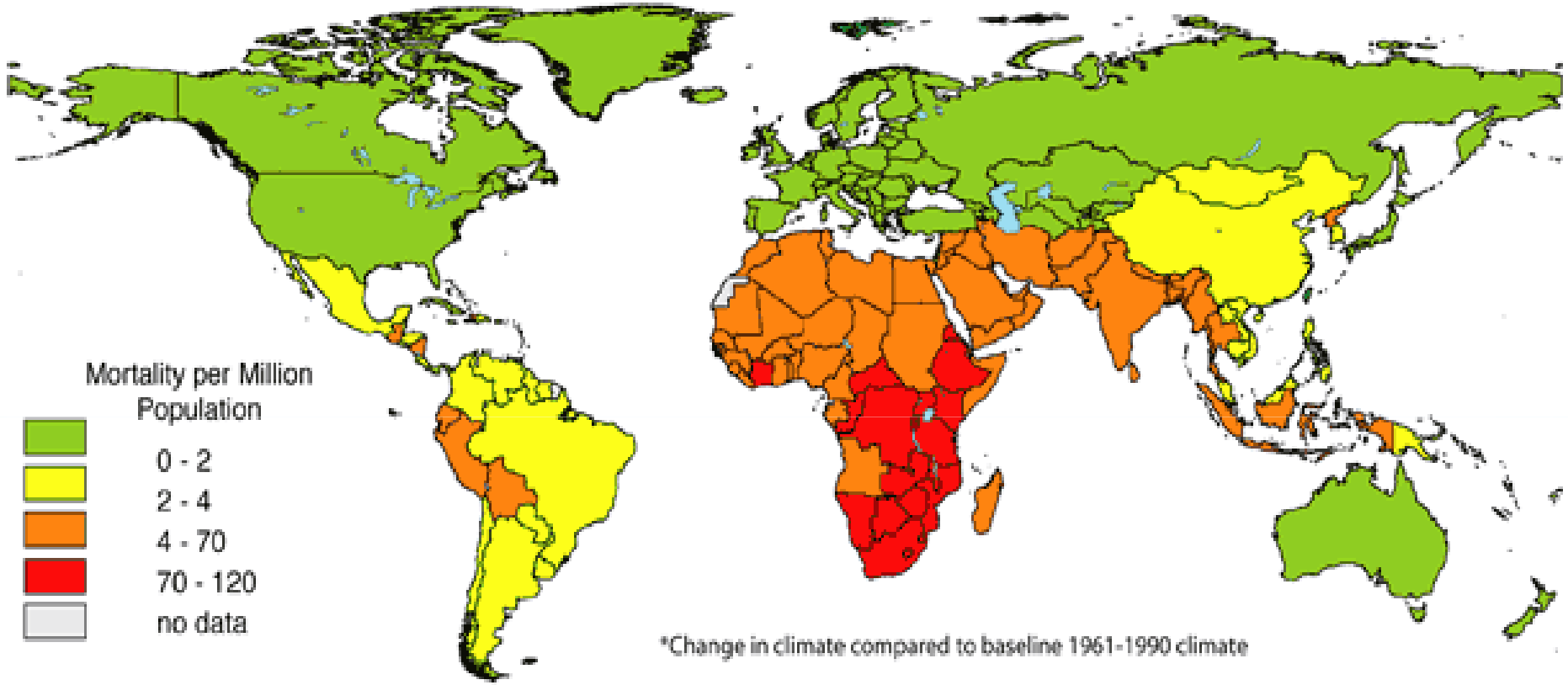

HAIYAN
11 Nov
6:00 GMT
10 Nov
6:00 GMT
9 Nov
6:00 GMT
8 Nov
6:00 GMT
Tropical Storm
Severe Typhoon
Super Typhoon
Laos
Thailand
Vietnam
Cambodia
Philippines
Malaysia
Source: Hong Kong Observatory





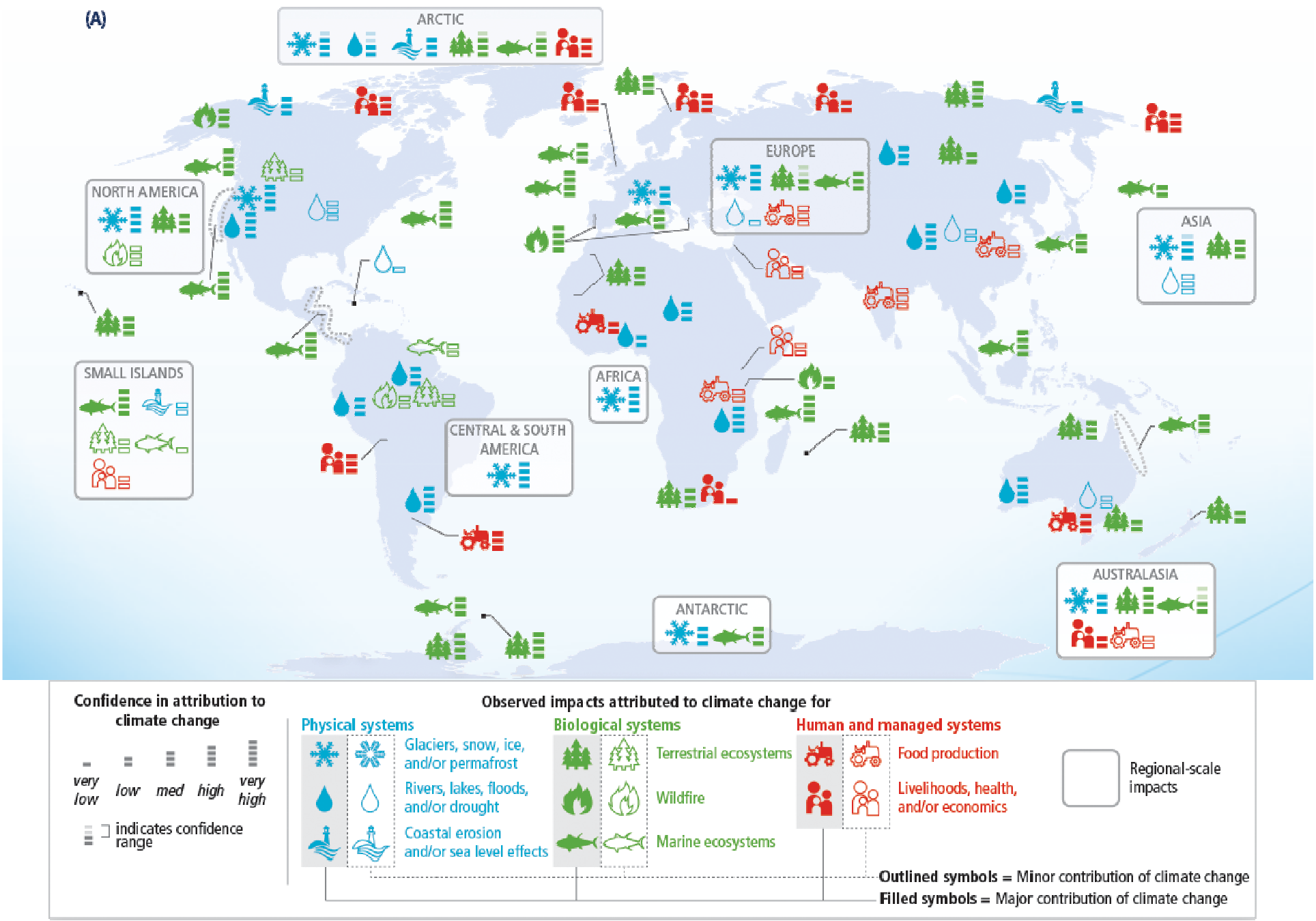
Major Weather Events in the 2000s (Connor, 2011)

Estimated Deaths Attributed to Climate Change in the Year 2000, by Subregion*

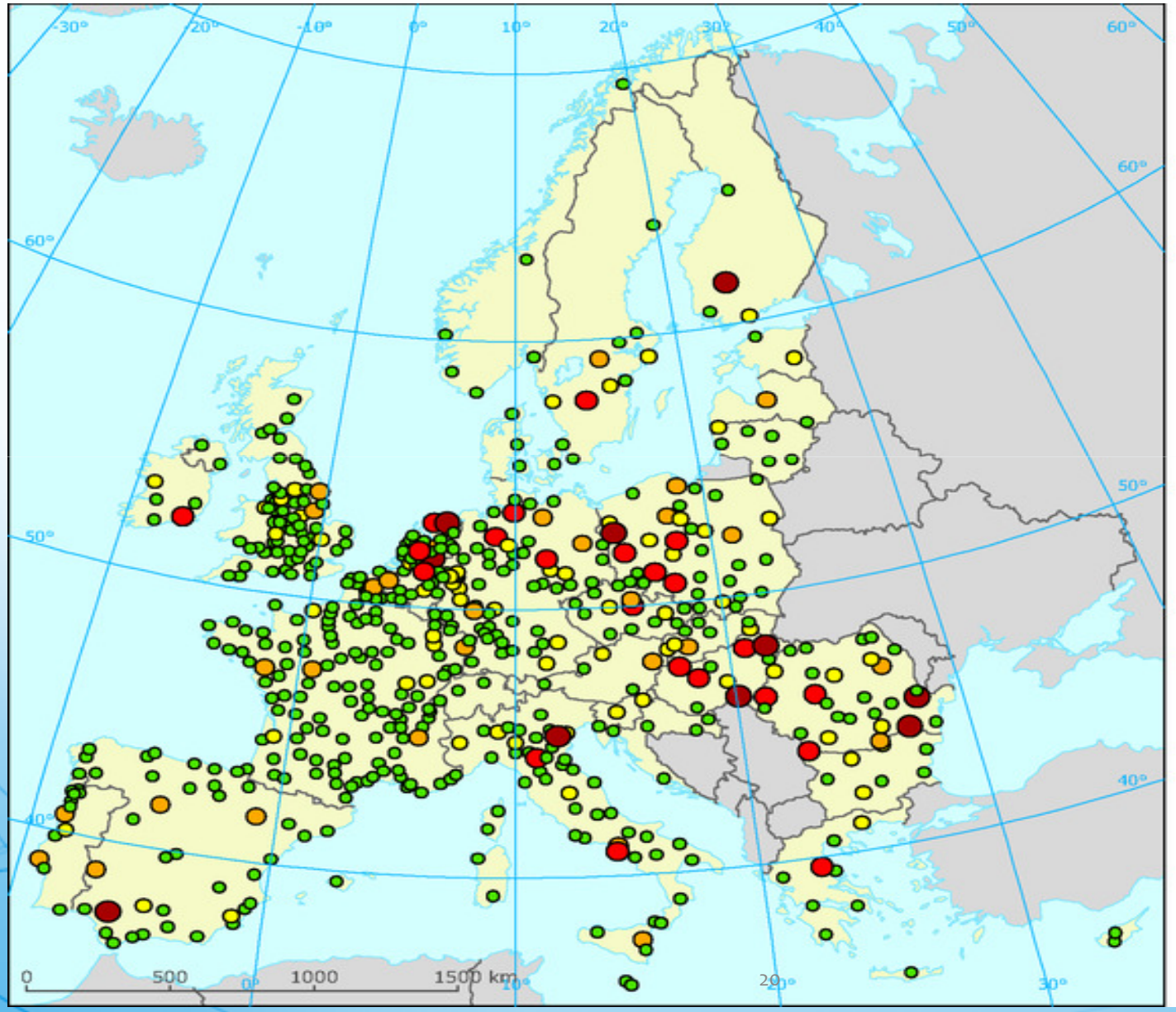


Data Source:
McMichael, JJ, Campbell-Lendrum D, Kovats RS, et al. Global Climate Change. In Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors. M. Ezzati, Lopez, AD, Rodgers A., Murray CJL. Geneva, World Health Organization, 2004

Maps produced by the Center for Sustainability and the Global Environment (SAGE)


(A)
ARCTIC
NORTH AMERICA
EUROPE
ASIA
SMALL ISLANDS
AFRICA
CENTRAL & SOUTH AMERICA
AUSTRALASIA
ANTARCTIC
Confidence in attribution to climate change
very low
low
med
high
very high
indicates confidence range
Observed impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods, and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildfire
Marine ecosystems
Human and managed systems
Food production
Livelihoods, health, and/or economics
Regional-scale impacts
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change

Climate change impacts — exposure to flood risk under the climate change scenario A2



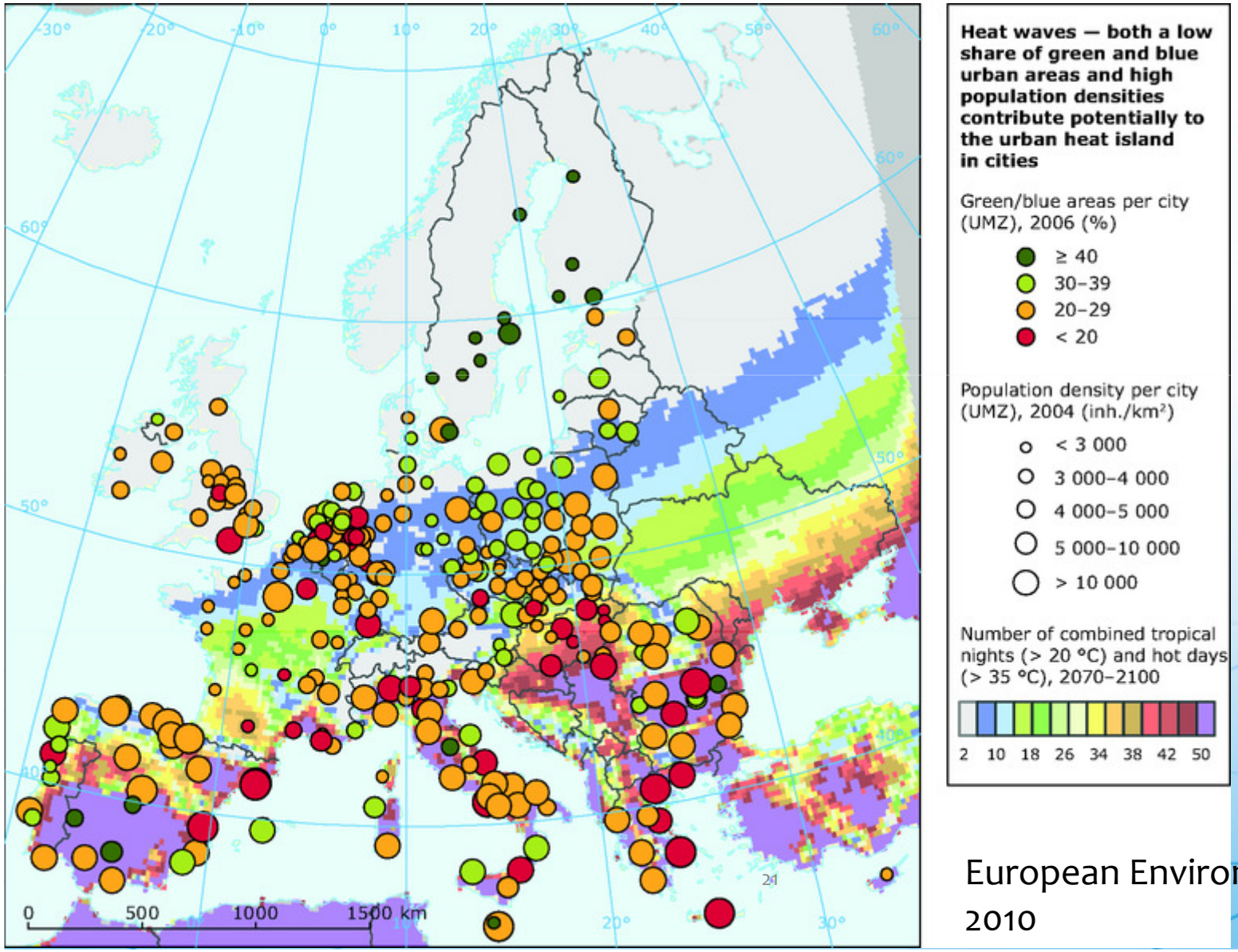
Flood risk in European cities

Portion of urban land exposed to potential floods under climate change scenario A2 (high emission)

- < 3 %
- 3 %–6 %
- 6 %–10 %
- 10 %–20 %
- > 20 %

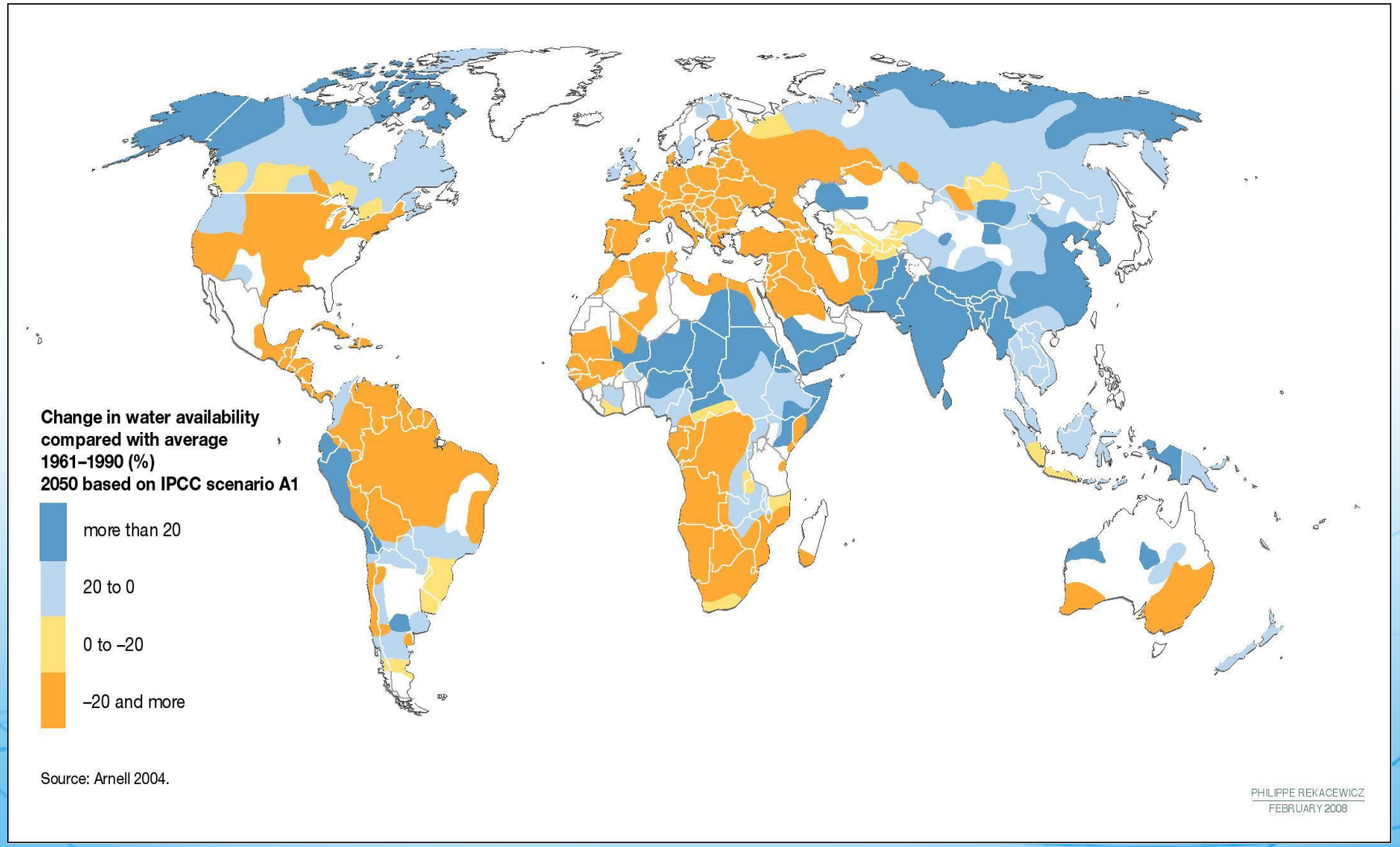
European Environmental Agency, 2010

Heat waves — both a low share of green and blue urban areas and high population densities can contribute to the urban heat island effect in cities



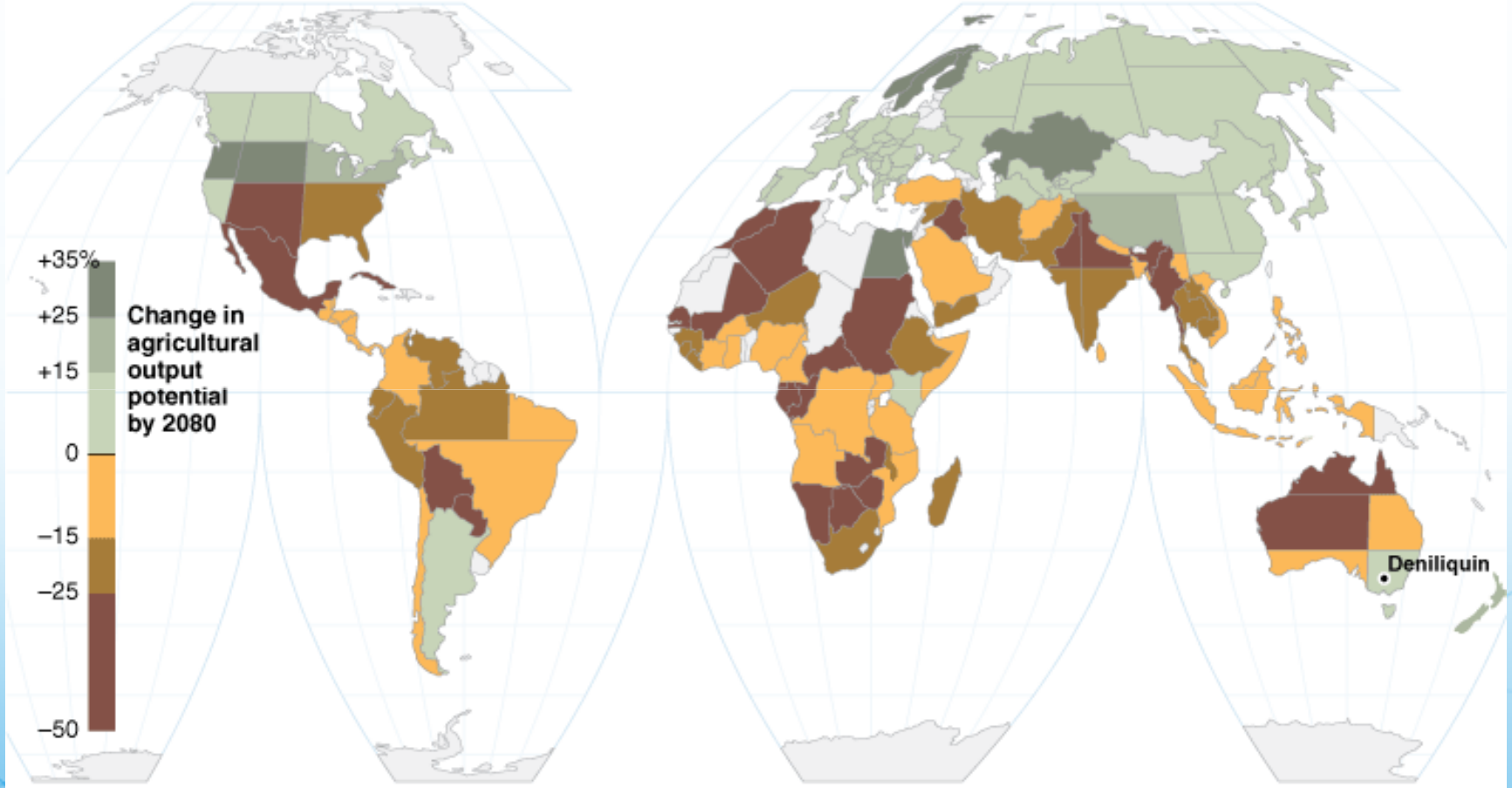
European Environmental Agency, 2010

Changes in water availability



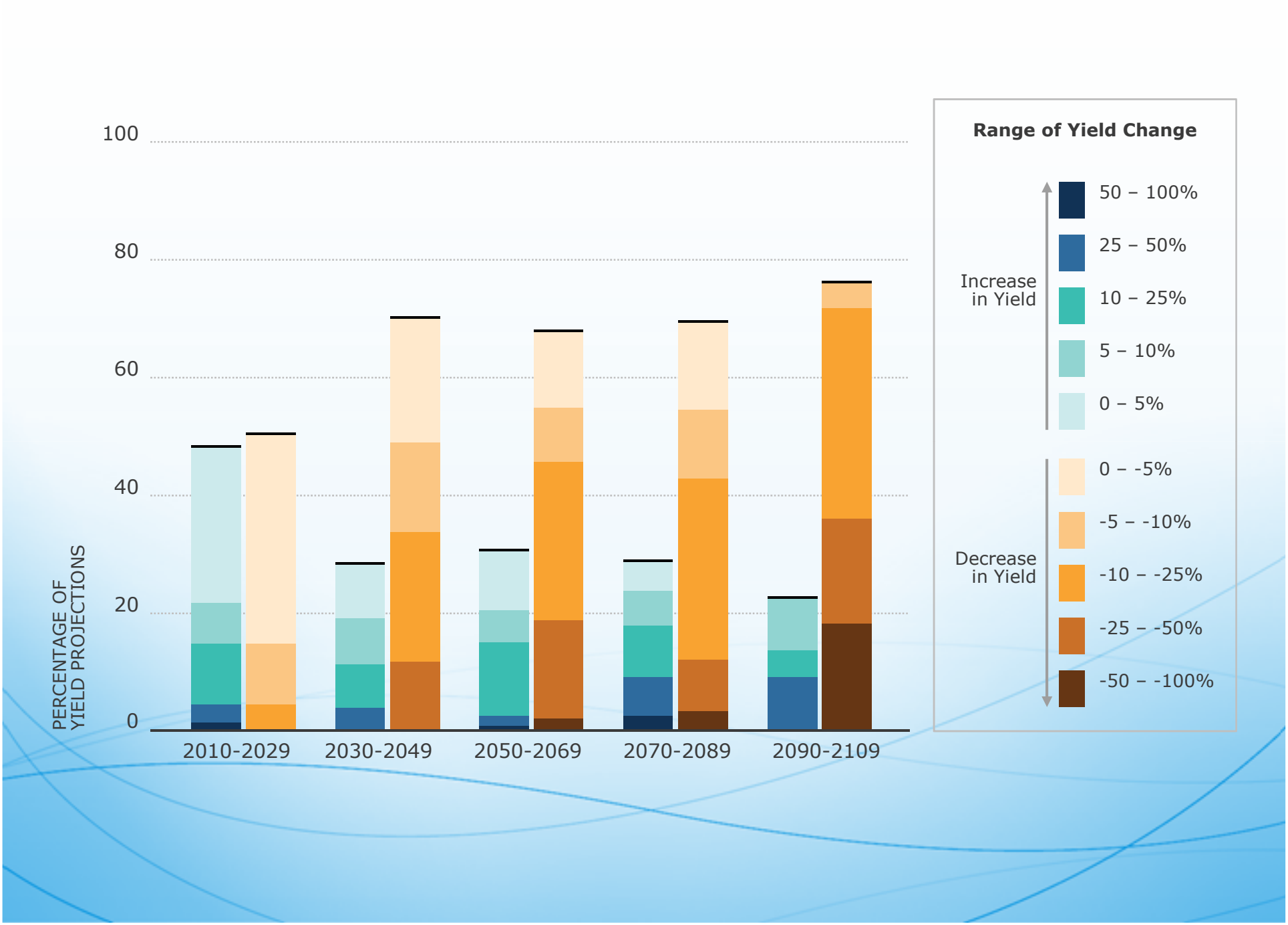
Farming in a Warmer World

Crop forecasts show that some countries farther from the Equator could benefit from a warmer world, but others would be worse off by 2080 if global warming were to proceed unchecked. Long-range forecasts vary widely; the following is a synthesis of available forecasts by country or region.



Note: These figures assume that crops grow faster because of higher levels of carbon dioxide in the air. But some scientists say that the actual effects of global warming could be worse than shown here, because the benefits of extra carbon dioxide may not appear if crops lack proper rainfall, proper soil and clean air.

Source: "Global Warming and Agriculture: Impact Estimates by Country," by William R. Cline, Peterson Institute, 2007.


100
80
60
40
20
0
PERCENTAGE OF YIELD PROJECTIONS
2010-2029
2030-2049
2050-2069
2070-2089
2090-2109
Range of Yield Change
Increase in Yield
50 – 100%
25 – 50%
10 – 25%
5 – 10%
0 – 5%
Decrease in Yield
0 – -5%
-5 – -10%
-10 – -25%
-25 – -50%
-50 – -100%

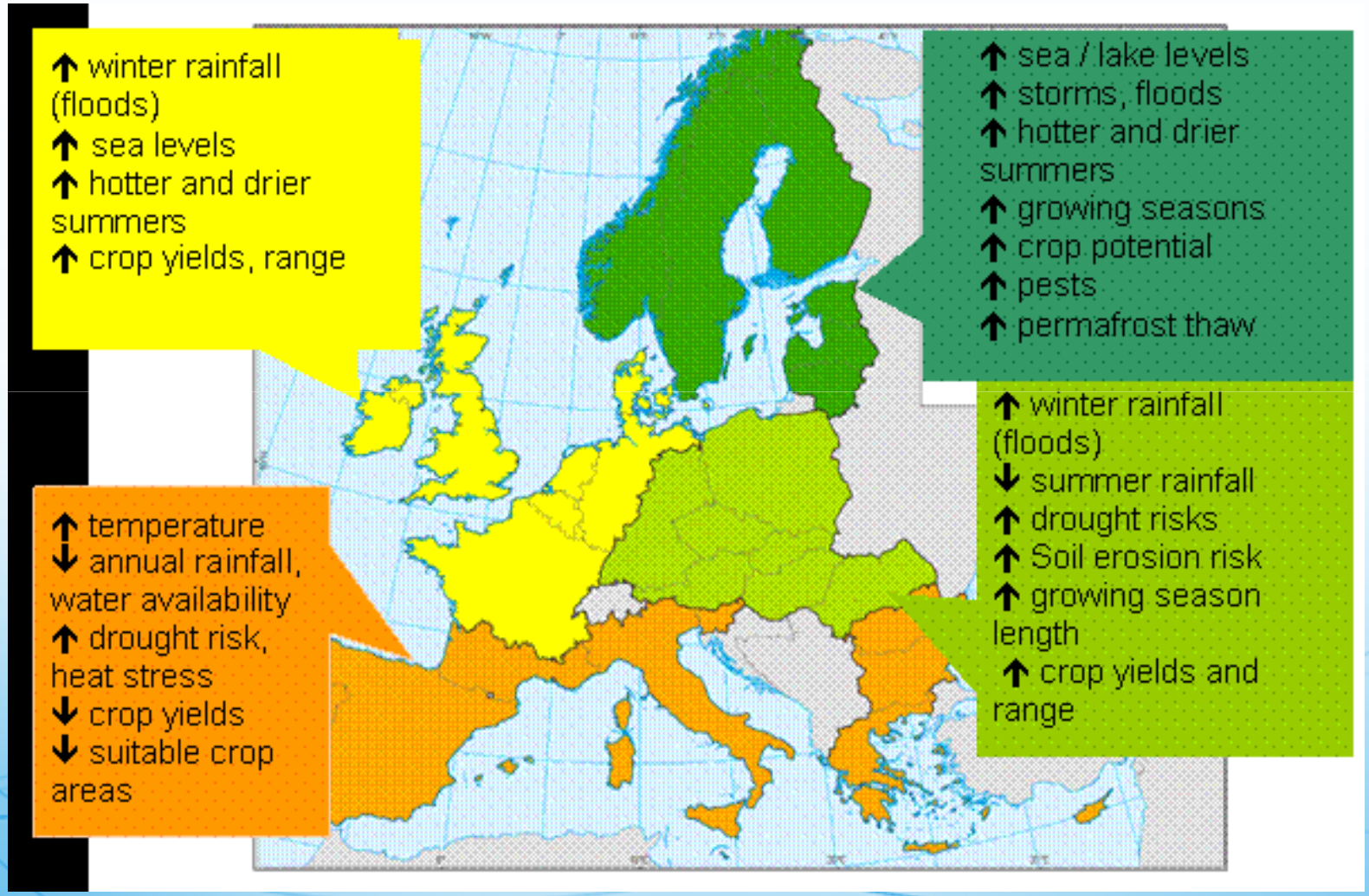
Grain productivity is likely to benefit from

* warmer winters,
* longer growing season,
* less frosts and possibly
* Possibly CO_2 fertilization and water-use efficiency increase caused by CO_2.

Grain productivity is threatened by

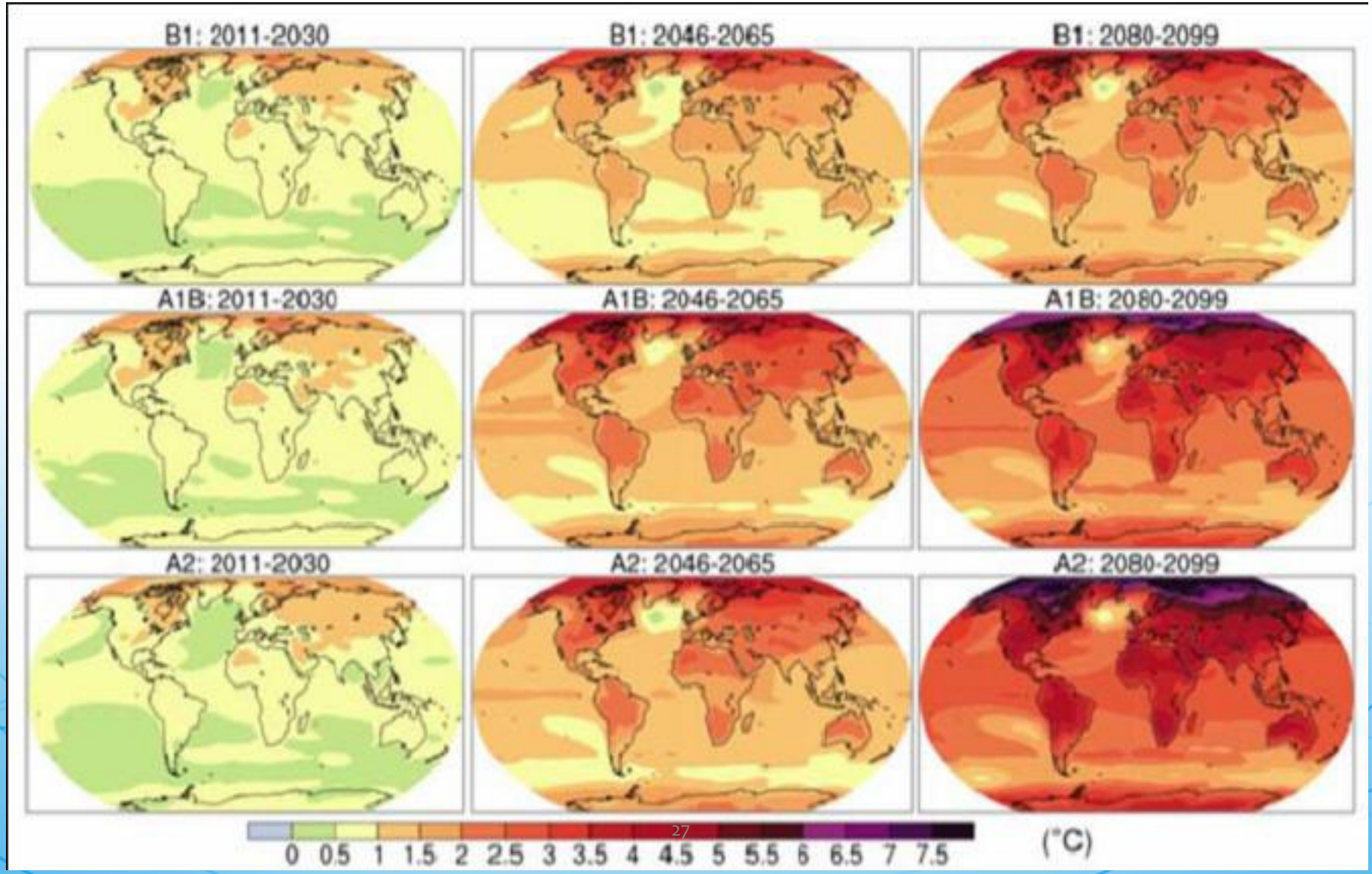
* increase in summer temperatures and PET,
* decrease in summer precipitation and soil moisture
* possibly increase in fall precipitation.
* more frequent and longer droughts,
* possibly more crops diseases and pest infestations.

Projected impacts from climate change in different EU regions

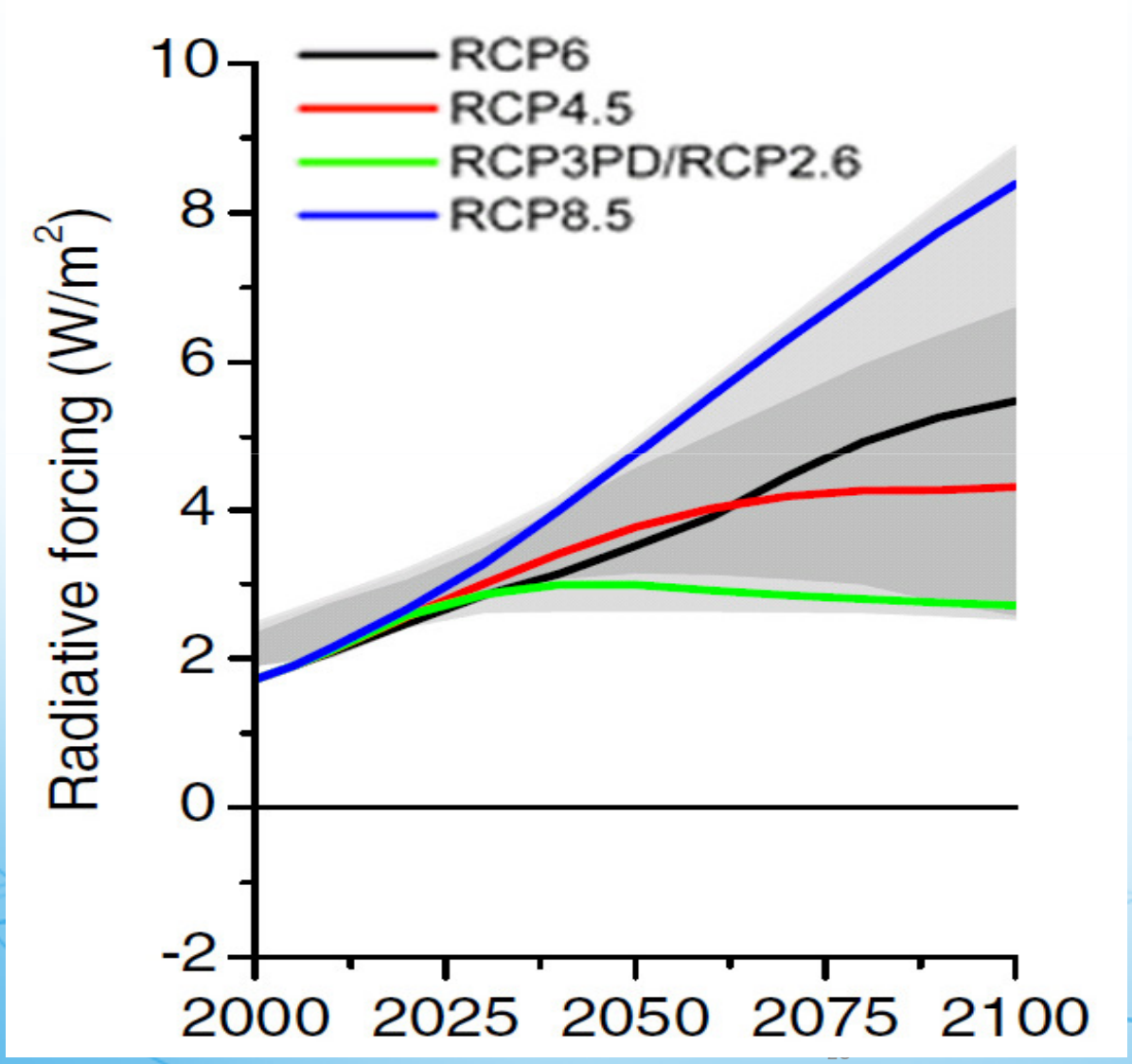


Adapting to climate change: the European Union must prepare for the impacts to come
European Commission - IP/09/519 01/04/2009

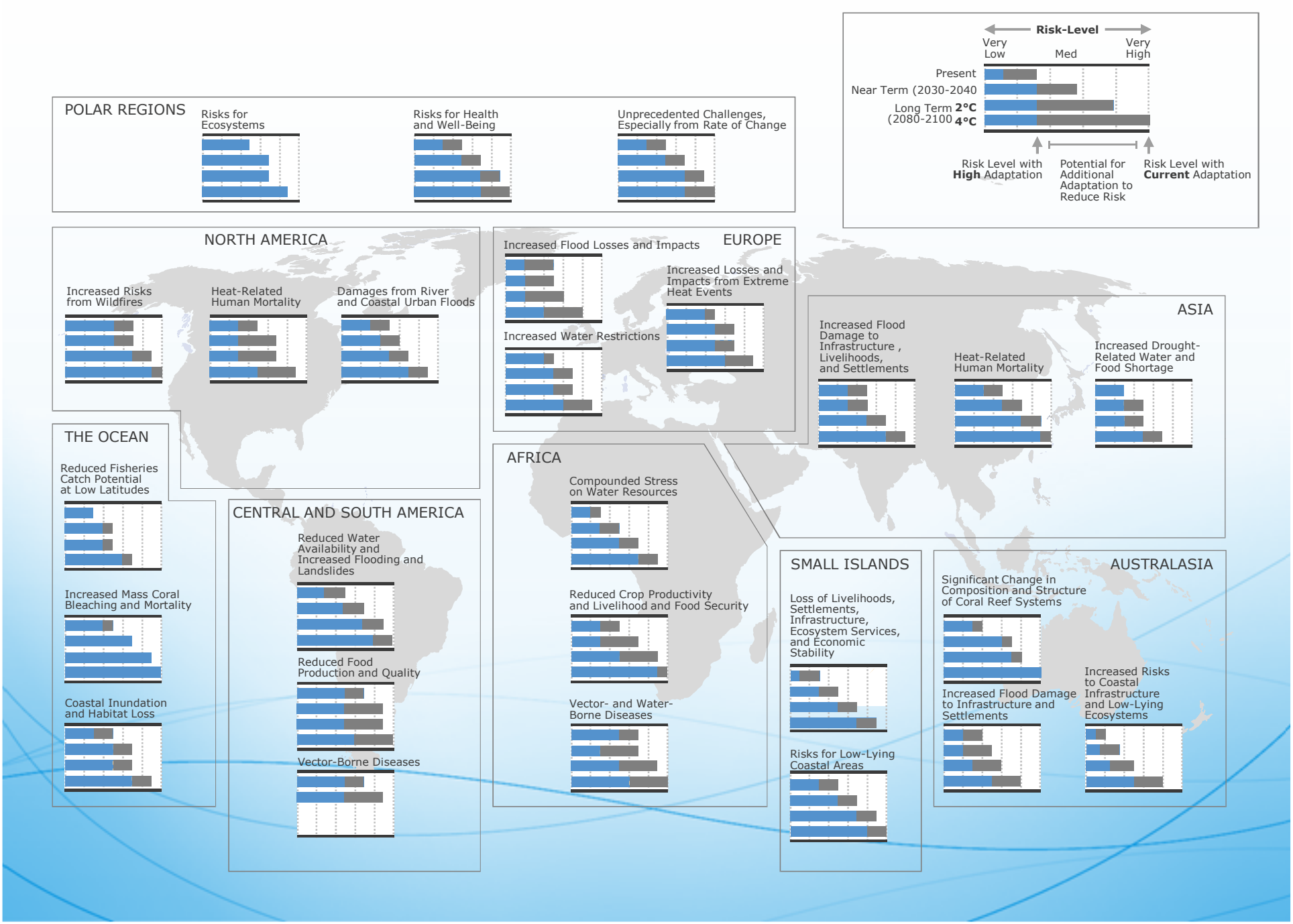
Multi-AOGCM mean of surface air temperature anomalies (mean base years: 1980-1999)

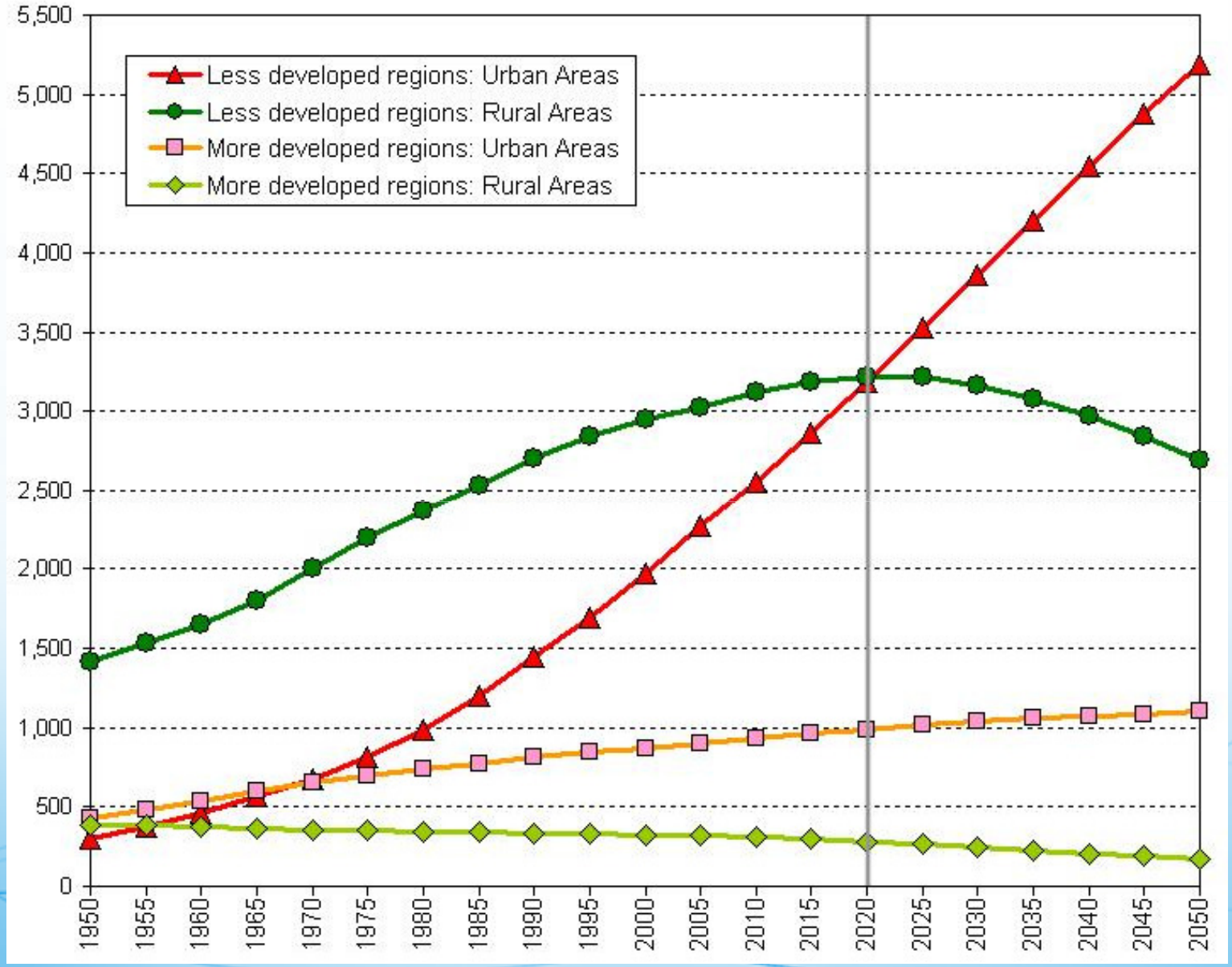


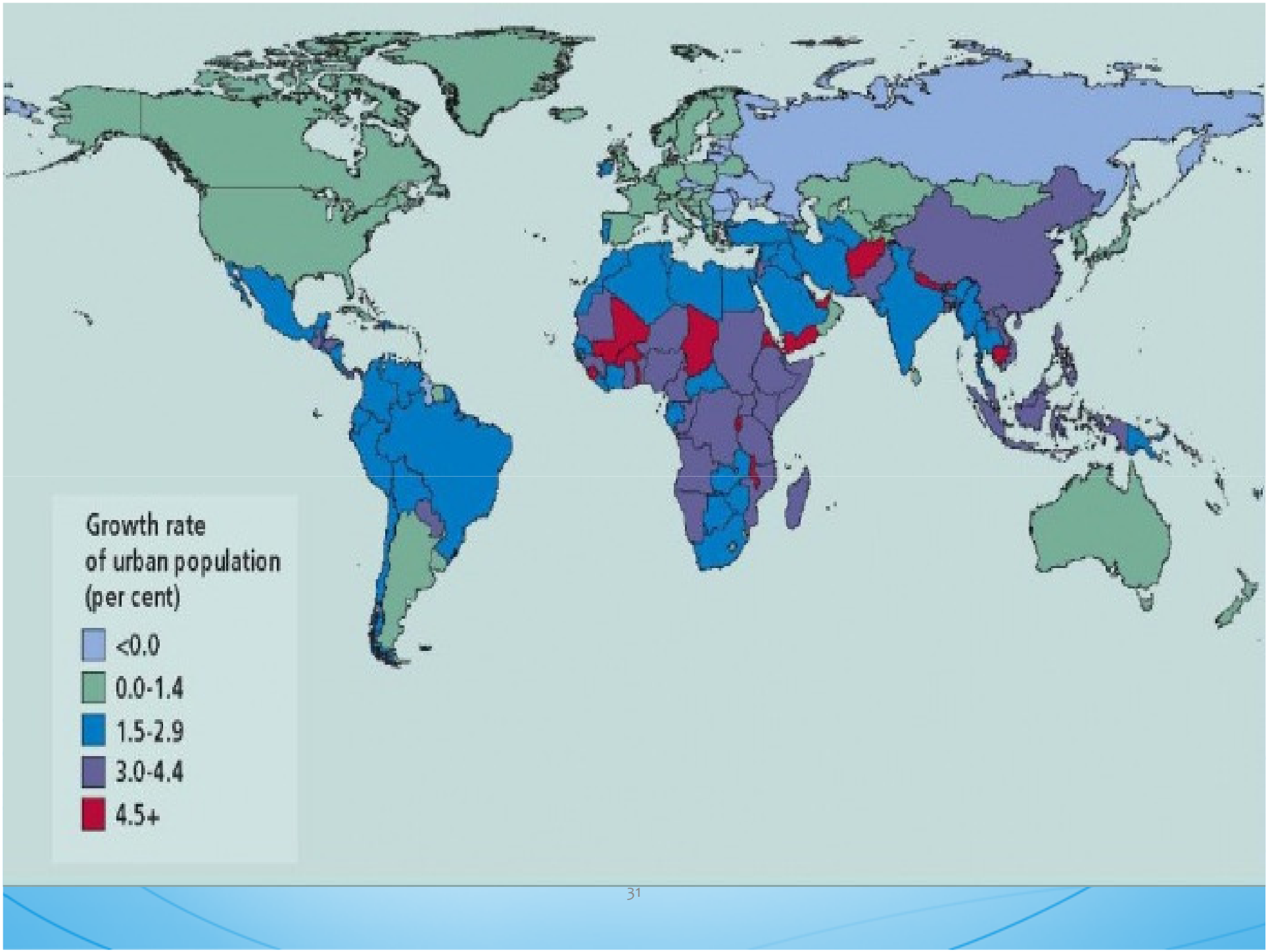
Radiative Forcing of the Representative Concentration Pathways

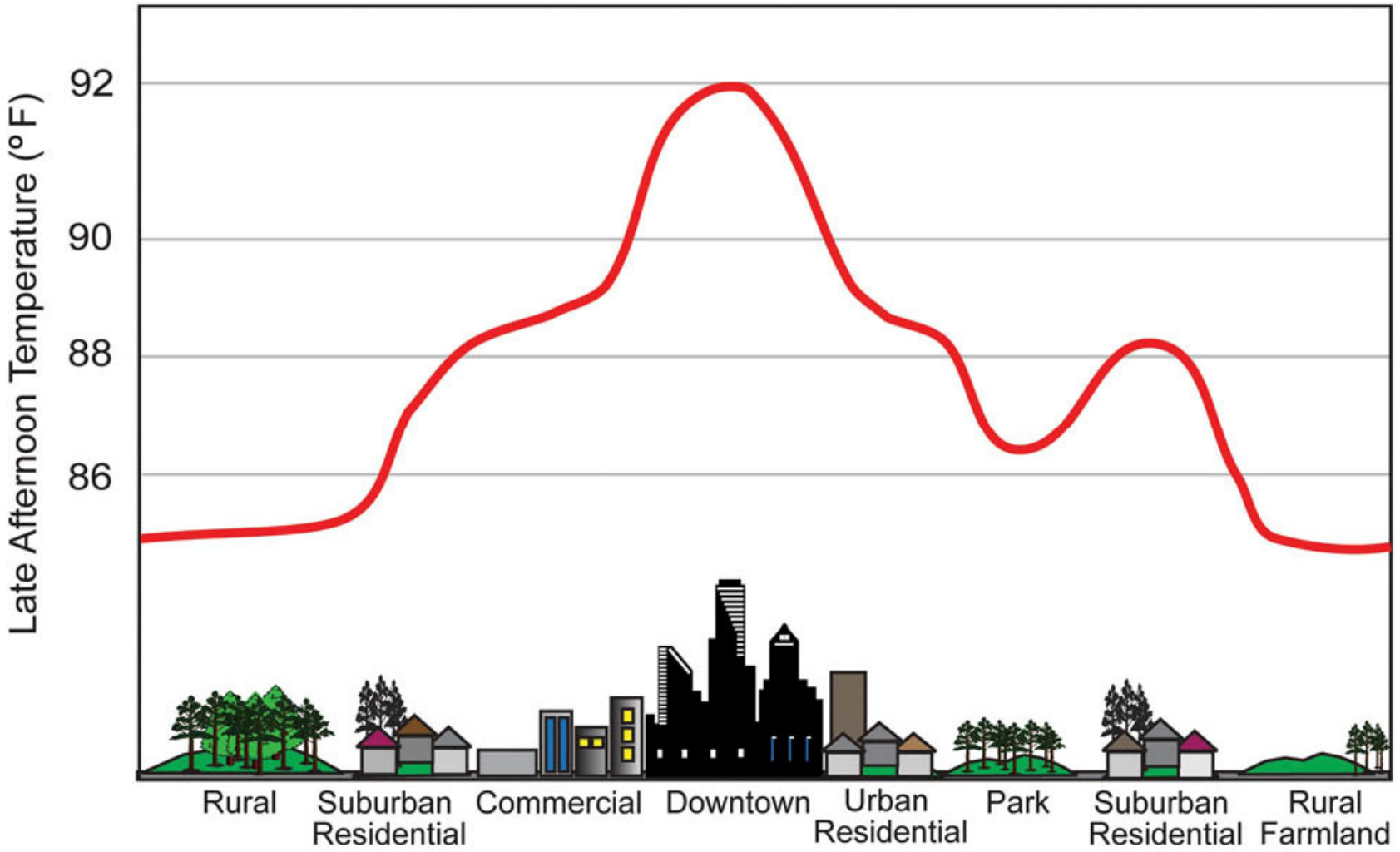


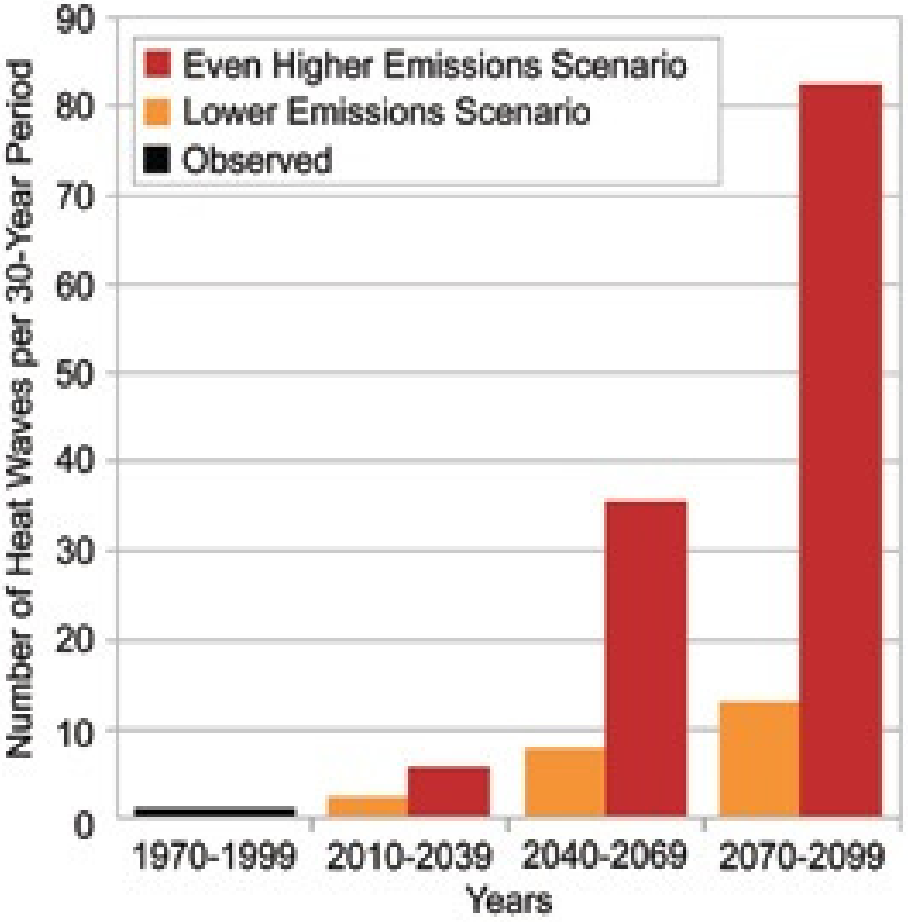
From van Vuuren et al (2011) The Representative Concentration Pathways: An Overview. Climatic Change, 109 (1-2), 5-31.


Risk-Level
Very Low
Med
Very High
Present
Near Term (2030-2040
Long Term (2080-2100
2°C
4°C
Risk Level with High Adaptation
Potential for Additional Adaptation to Reduce Risk
Risk Level with Current Adaptation
POLAR REGIONS
Risks for Ecosystems
Risks for Health and Well-Being
Unprecedented Challenges, Especially from Rate of Change
NORTH AMERICA
Increased Risks from Wildfires
Heat-Related Human Mortality
Damages from River and Coastal Urban Floods
EUROPE
Increased Flood Losses and Impacts
Increased Losses and Impacts from Extreme Heat Events
Increased Water Restrictions
ASIA
Increased Flood Damage to Infrastructure , Livelihoods, and Settlements
Heat-Related Human Mortality
Increased Drought-Related Water and Food Shortage
THE OCEAN
Reduced Fisheries Catch Potential at Low Latitudes
Increased Mass Coral Bleaching and Mortality
Coastal Inundation and Habitat Loss
CENTRAL AND SOUTH AMERICA
Reduced Water Availability and Increased Flooding and Landslides
Reduced Food Production and Quality
Vector-Borne Diseases
AFRICA
Compounded Stress on Water Resources
Reduced Crop Productivity and Livelihood and Food Security
Vector- and Water-Borne Diseases
SMALL ISLANDS
Loss of Livelihoods, Settlements, Infrastructure, Ecosystem Services, and Economic Stability
Risks for Low-Lying Coastal Areas
AUSTRALASIA
Significant Change in Composition and Structure of Coral Reef Systems
Increased Flood Damage to Infrastructure and Settlements
Increased Risks to Coastal Infrastructure and Low-Lying Ecosystems

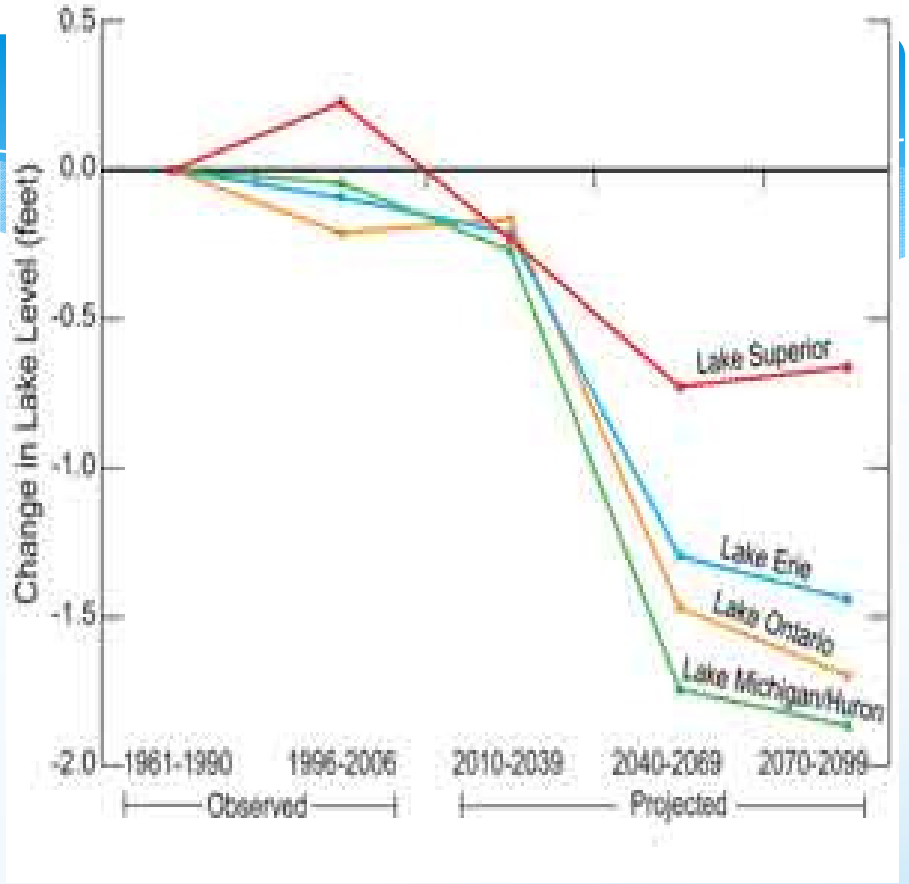

Less developed regions: Urban Areas
Less developed regions: Rural Areas
More developed regions: Urban Areas
More developed regions: Rural Areas
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050


Growth rate
of urban population
(per cent)
<0.0
0.0-1.4
1.5-2.9
3.0-4.4
4.5+


Late Afternoon Temperature (°F)
92
90
88
86
Rural
Suburban Residential
Commercial
Downtown
Urban Residential
Park
Suburban Residential
Rural Farmland



Number of 1995-like Chicago Heat Waves. Under the lower emissions scenarios, 1995-like heat waves are projected to occur approximately once every three years. Under the higher scenarios, heat waves are projected to occur on average, three times per year. Source: USGCRP (2009)



Projected changes in the level of the Great Lakes by end of the century.
Source: USGCRP (2009)



This Envisat image covering the area east of Moscow shows several large smoke plumes originating from burning peat fields and forest fires. Source: ESA



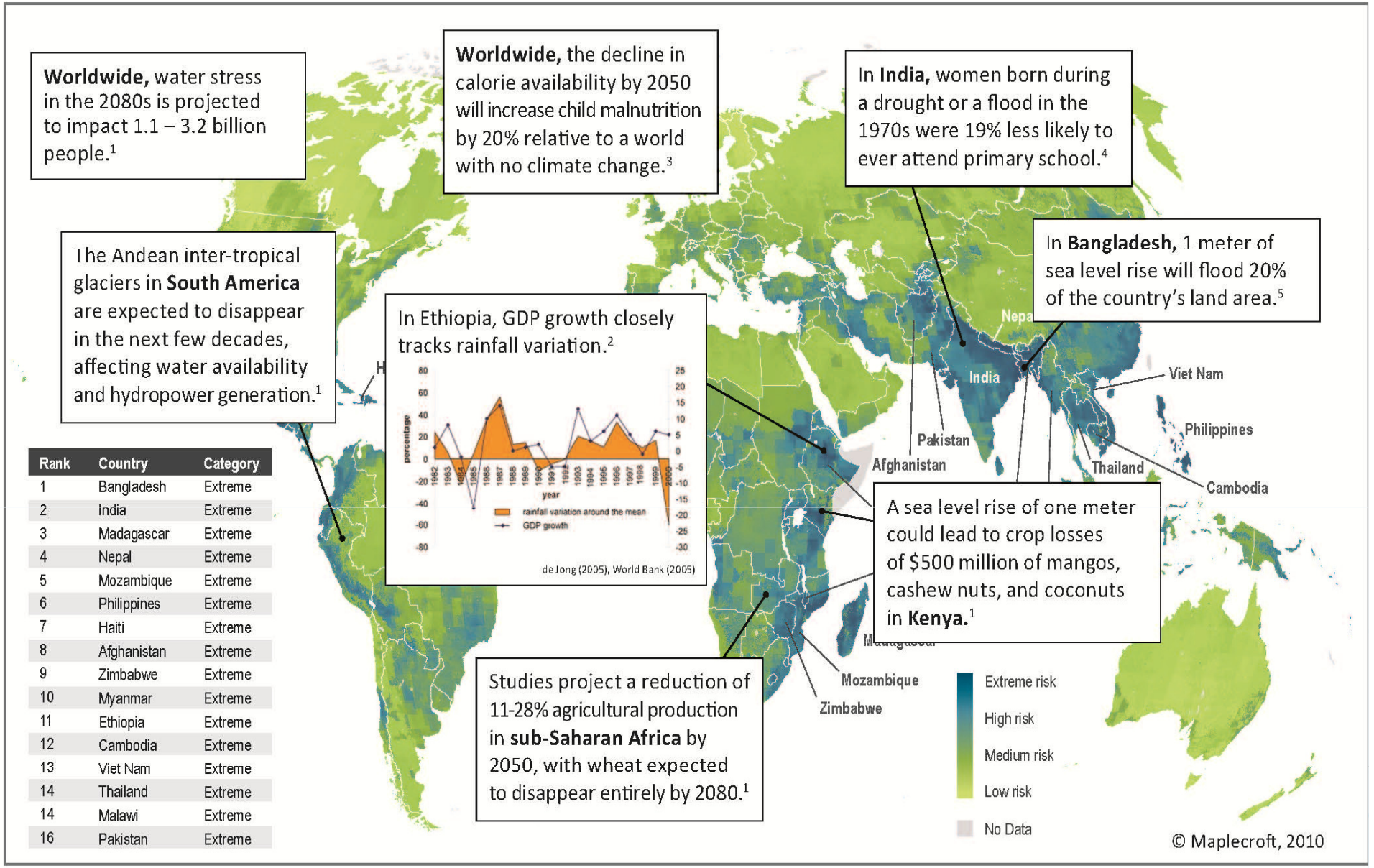
(Left) Street in Moscow, June 17th, 2010, 20:22 PM. (Right) August 7th, 2010, 17:05 PM



Floods in Copenhagen, July 2011
Image © Risager , EEA

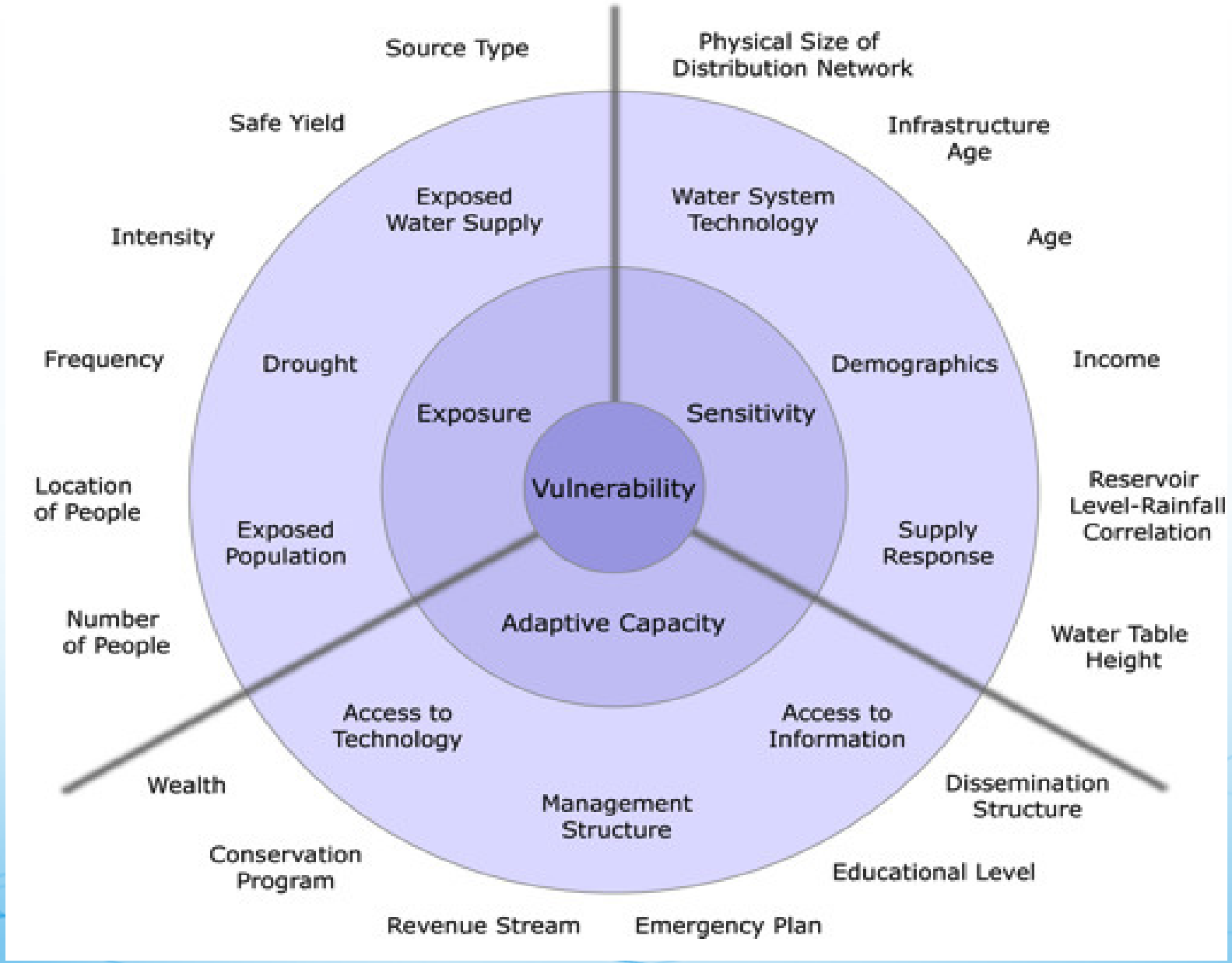


Flooded streets in New Orleans after Hurricane Katrina in 2005.
Source: FEMA (2005)



Rank	Country	Category
1	Bangladesh	Extreme
2	India	Extreme
3	Madagascar	Extreme
4	Nepal	Extreme
5	Mozambique	Extreme
6	Philippines	Extreme
7	Haiti	Extreme
8	Afghanistan	Extreme
9	Zimbabwe	Extreme
10	Myanmar	Extreme
11	Ethiopia	Extreme
12	Cambodia	Extreme
13	Viet Nam	Extreme
14	Thailand	Extreme
14	Malawi	Extreme
16	Pakistan	Extreme

Map reference: Maplecroft, 2010: Climate change vulnerability map. Vulnerability index combines risk of exposure, degree of sensitivity, and ability of a country to adjust to stresses. [1]Intergovernmental Panel on Climate Change, Working Group II: *Climate Change 2007 – Impact, Adaptation and Vulnerability.* [2]World Bank, 2006: *Ethiopia: Managing Water Resources to Maximize Sustainable Growth.* [3]International Flood Policy Research Institute, 2009: *Climate Change: Impact on Agriculture and Costs of Adaptation.* [4]United Nations Development Program: *Human Development Report 2007/2008: Fighting Climate Change: Human solidarity in a divided world.* [5]World Bank, 2000: *Bangladesh: Climate Change and Sustainable Development.* Report no. 21104 BD, Dhaka.



Polsky, Neff, and Yarnal (2007). Building comparable global change vulnerability assessments: The Vulnerability Scoping Diagram. [*Global Environmental Change 17*](), *472-485*

Thematic dimensions of vulnerability

* **Social:** refers e.g. to human welfare including mental and physical health, both at an individual and collective level.
* **Economic:** related to potential financial damage and/or disruption of productive capacity.
* **Physical:** refers to the condition of physical assets including built-up areas, infrastructure and open spaces that can be affected by natural hazards. This dimension depicts locations in susceptible areas and deficiencies in the resistance of the exposed elements.
* **Cultural:** related to the meanings placed on artifacts, customs, habitual practices and natural or urban landscapes.
* **Environmental:** refers to all ecological and bio-physical systems and their different functions.
* **Institutional:** refers to both organizational form and function as well as guiding legal and cultural rules .

(Adapted from Methods for the Improvement of Vulnerability Assessment in Europe. Generic conceptual framework for vulnerability measurement, EC DG Environment 2012)

Indicators	Sector	Exposure	Sensitivity	Adaptive capacity
Impacts of the global climate change	Water availability	Distance from water sources Population density and distribution Surface runoff	Population demographics and wealth Ground water depth and quality	Financial resources Access to technology National and international water regulation
	Food and agriculture	Population occupation and location Proximity to water resources Terrain and landscape	Agricultural crops and livestock species Irrigation techniques Wealth National and international land-use and water regulations	Financial resources Access to agricultural machinery Modern irrigation techniques chemicals
	Human health	Distance from mosquito breeding grounds Water quality	Population demographics Wealth Type of dwelling	National health care infrastructure Education Access to information Emergency management

Indicators	Sector	Exposure	Sensitivity	Adaptive capacity
Regional land-use and land-cover changes and related hydrometeorological changes	Water availability	Population density and distribution Distance from water supply	Irrigation and water supply infrastructure Land management practices Population demographics Water mineralization	Financial resources Water treatment technology
	Food security	Population density and distribution Terrain Soils Food vs. non-food crop ratio Livestock density and distribution	Food crops livestock land management and irrigation techniques and infrastructure food market flexibility regional land-use policy	Access to education, information, funding, drought resistant seeds, drip irrigation Machinery Availability of affordable food imports
	Human health	Population density and pattern distance from malaria endemic areas size of areas affected by malaria Water contamination by pollutants and bacteria	Population demographics (gender, age) Occupation Dwelling Income Education Equality	Access to health care Mosquito spraying Drainage improvement Water treatment and sanitation measures

