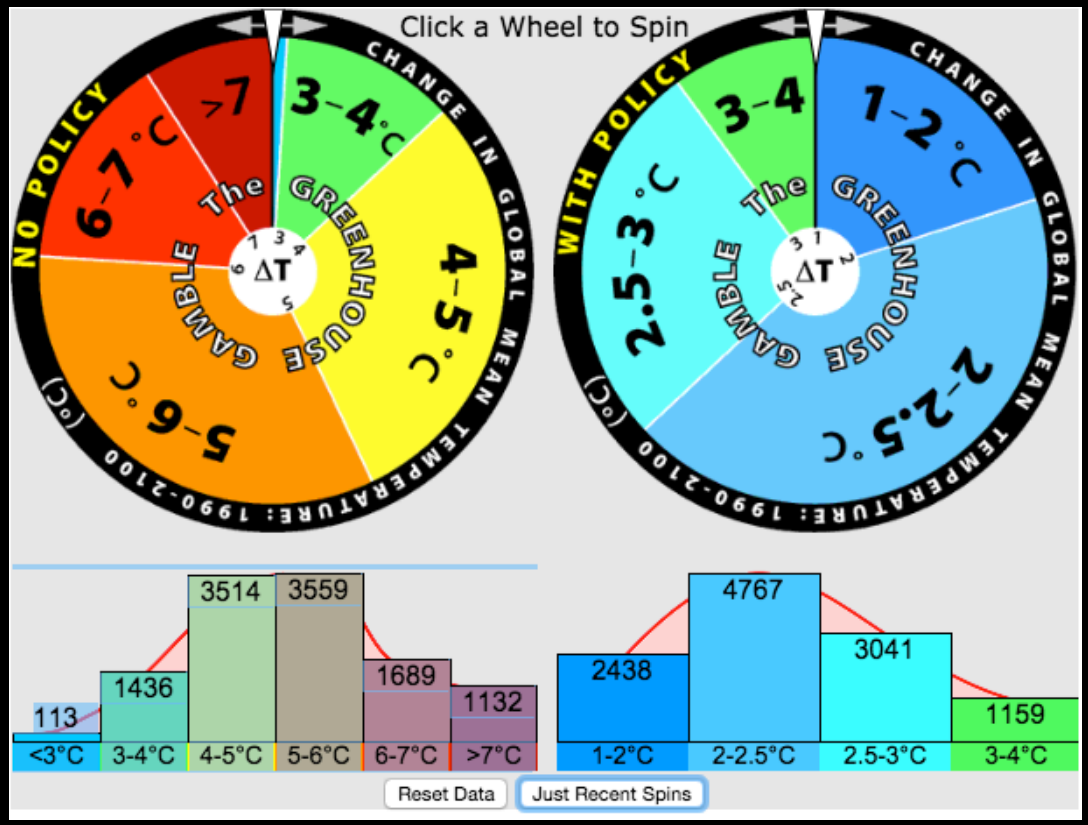
Climate Changes. Do Policies?



Ankur Desai
Dept of Atmospheric & Oceanic Sciences
University of Wisconsin-Madison

Nov 2016. Public Affairs 850

http://www.elephantsinthelivingroom.org/backgrounds/elephant-in-room.jpg

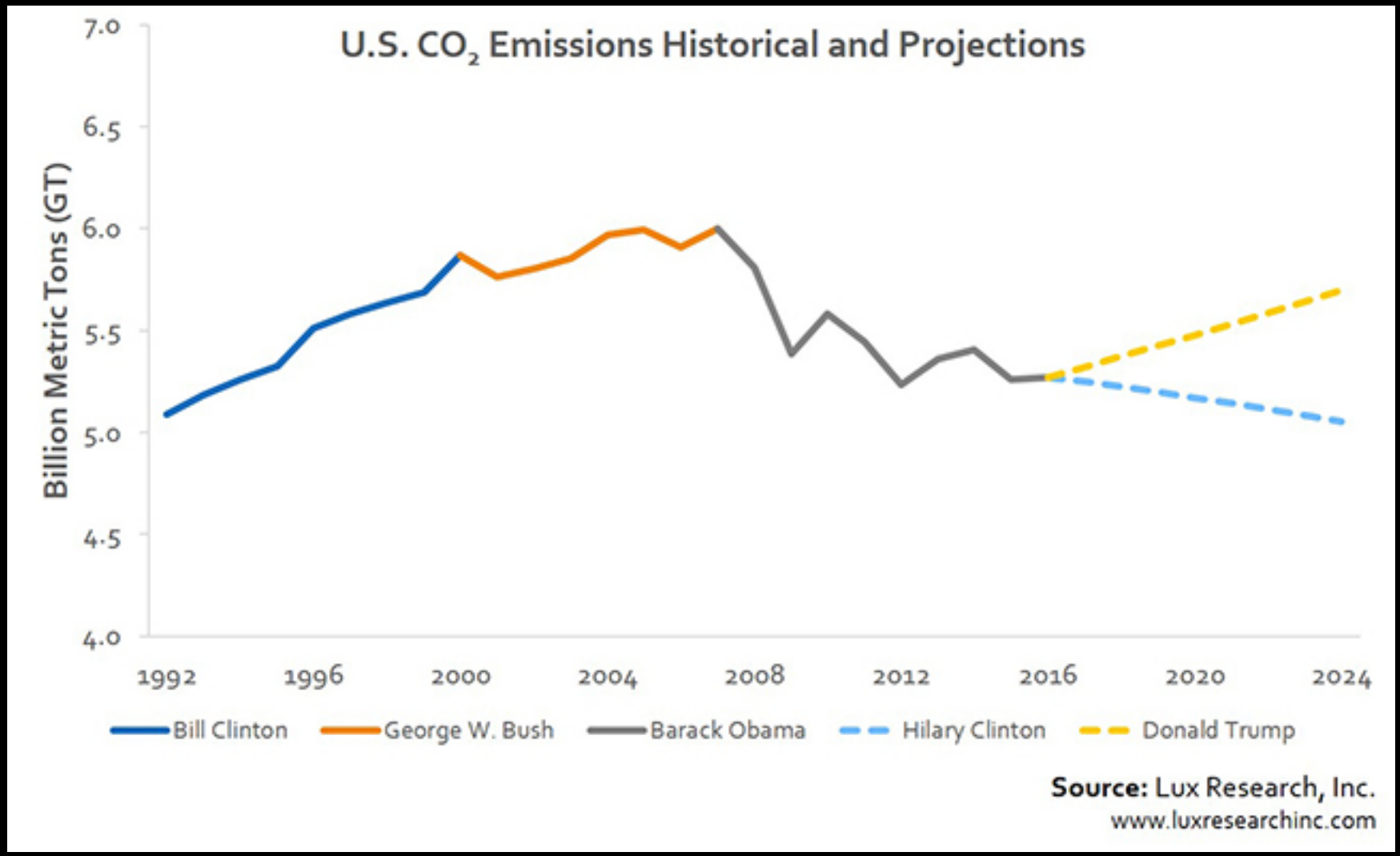
ClimateWire

CLIMATE

Trump Picks Top Climate Skeptic to Lead EPA Transition

Choosing Myron Ebell means Trump plans to drastically reshape climate policies

By Robin Bravender, ClimateWire on September 26, 2016



http://www.vox.com/2016/11/9/13571318/donald-trump-disaster-climate

The Washington Post

Middle East

An epic Middle East heat wave could be global warming's hellish curtain-raiser

By Hugh Naylor August 10 at 4:00 AM

Parts of the United Arab Emirates and Iran experienced a heat index — a measurement that factors in humidity as well as temperature — that soared to 140 degrees in July, and Jiddah, Saudi Arabia, recorded an all-time high temperature of nearly 126 degrees. Southern Morocco's relatively cooler climate suddenly sizzled last month, with temperatures surging to highs between 109 and 116 degrees. In May, record-breaking temperatures in Israel caused a surged of heat-related illnesses.

The 28-year-old engineer at a government-run oil company in Basra said employees were ordered to stay home for several days in the past month. He and his family try not to go outside before 7 p.m.

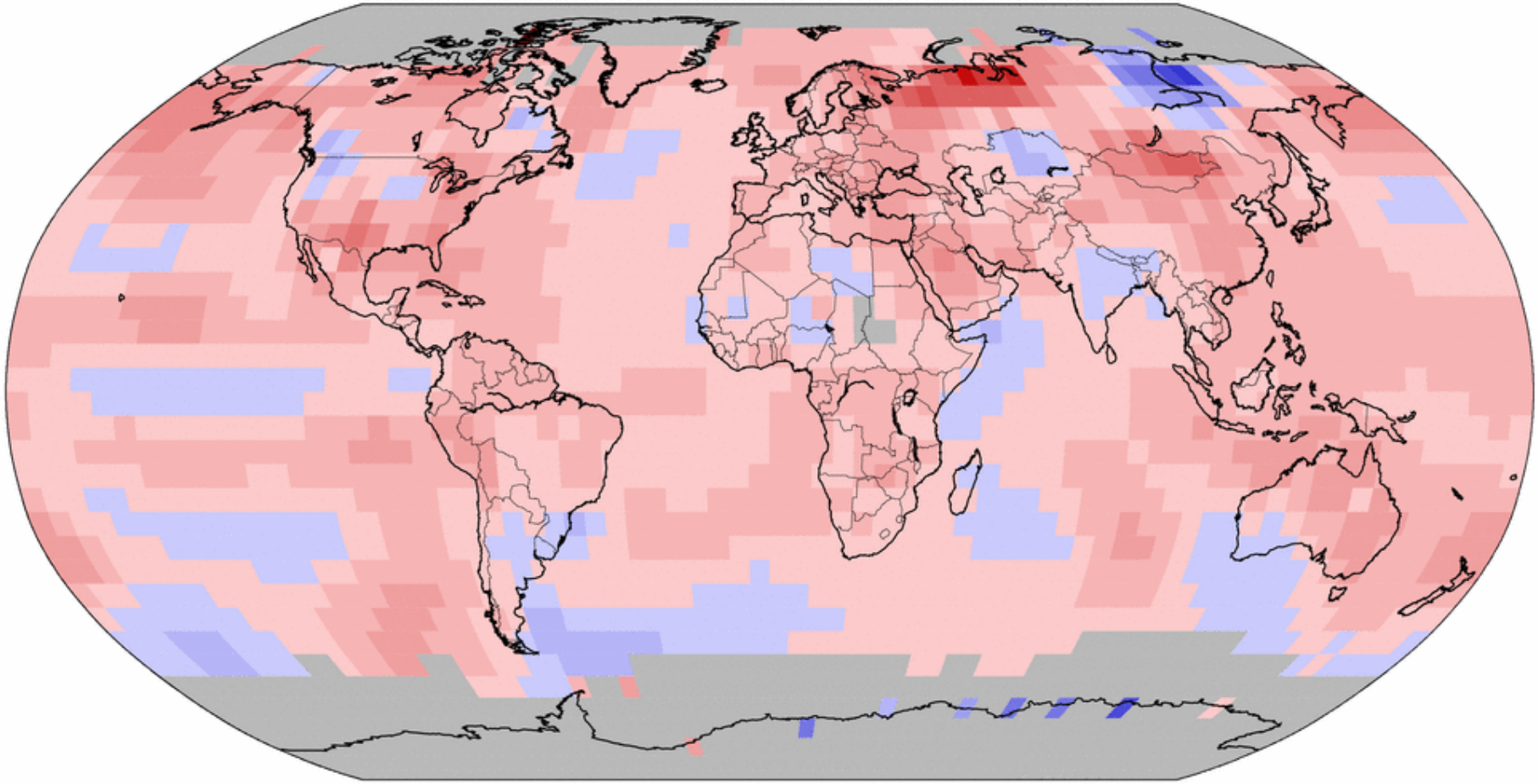
"We're prisoners," Karim said.

Bassem Antoine, an Iraqi economist, said the weather has inflicted serious damage to the country's economy. He estimates that Iraq's gross domestic product — about $230 billion annually — has probably contracted 10 to 20 percent during the summer heat.

Land & Ocean Temperature Departure from Average Jul 2016

(with respect to a 1981–2010 base period)

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



−5 −4 −3 −2 −1 0 1 2 3 4 5

Degrees Celsius

National Centers for Environmental Information
Mon Aug 15 07:11:22 EDT 2016

Please Note: Gray areas represent missing data
Map Projection: Robinson

Flooding of Coast, Caused by Global Warming, Has Already Begun

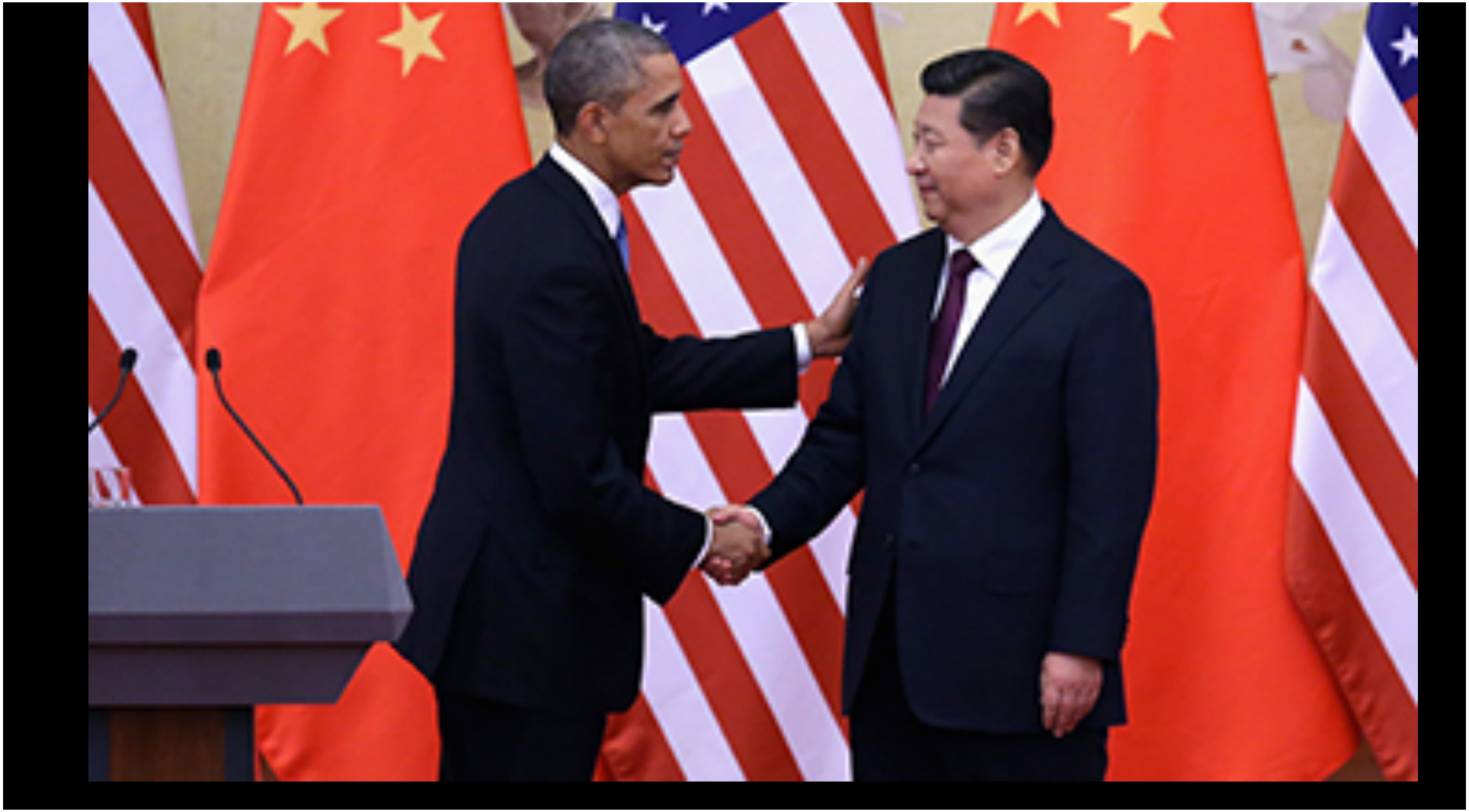
Scientists' warnings that the rise of the sea would eventually imperil the United States' coastline are no longer theoretical.

By JUSTIN GILLIS SEPT. 3, 2016

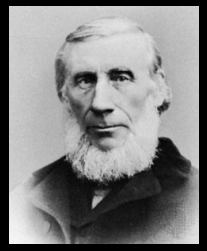
ASIA PACIFIC

Rare Harmony as China and U.S. Commit to Climate Deal

By MARK LANDLER and JANE PERLEZ SEPT. 3, 2016



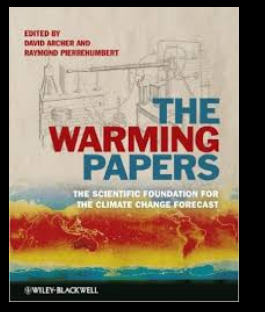
CLIMATE SCIENCE FOR FUTURE POLICYMAKERS

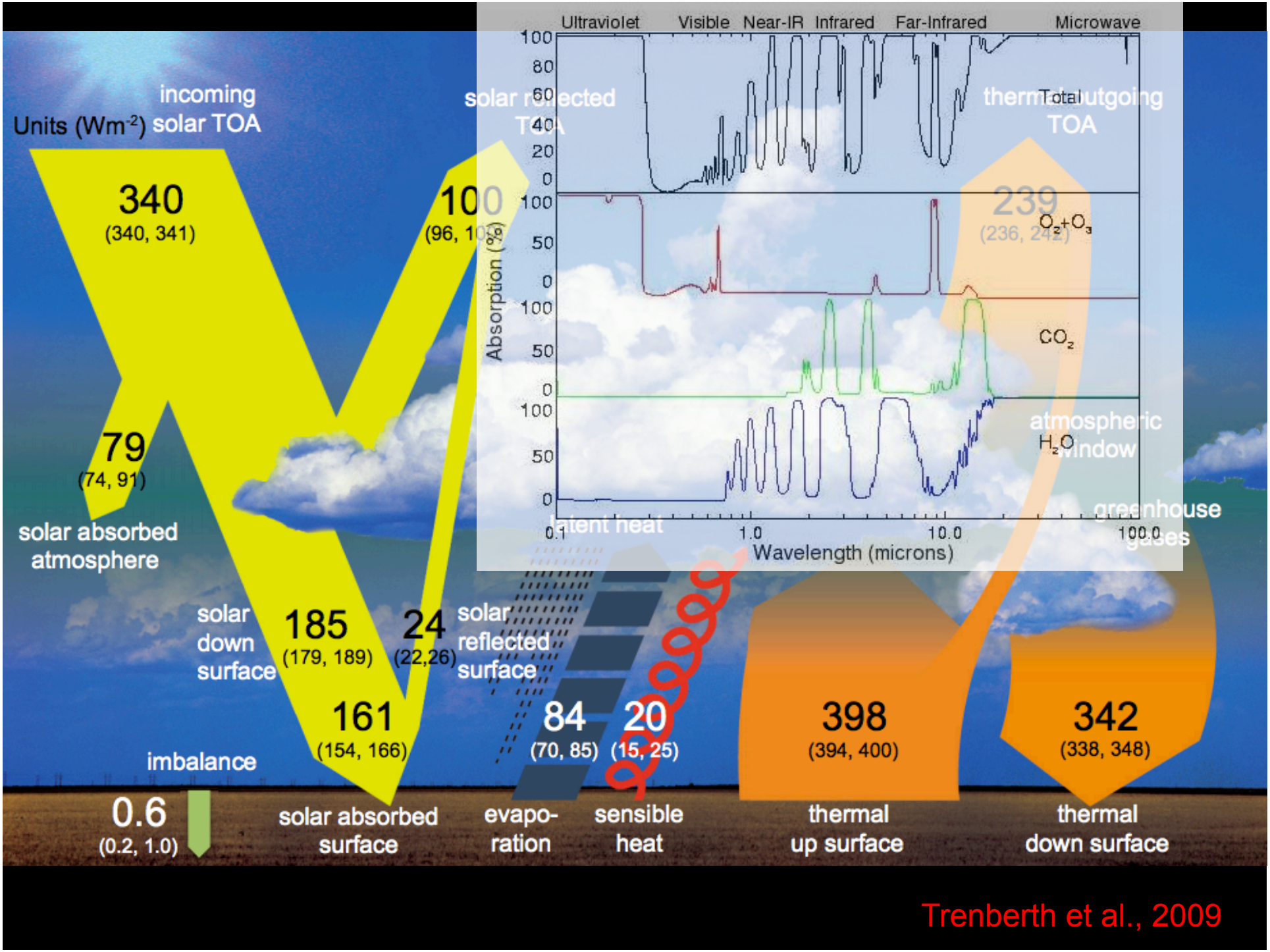


- Planetary (inc. Earth) temperature is determined by interaction of sunlight warming Earth's surface, and "greenhouse" gases that absorb infrared radiation (Fourier 1824, Tyndall 1861)

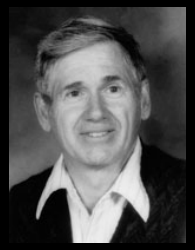
- CO_2 is a greenhouse warming gas and emitted from coal, oil, gas (Arrhenius 1896)

- Oceans can only take up a fraction of CO_2 produced by combustion (Revelle 1957)

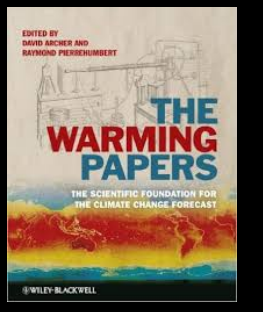


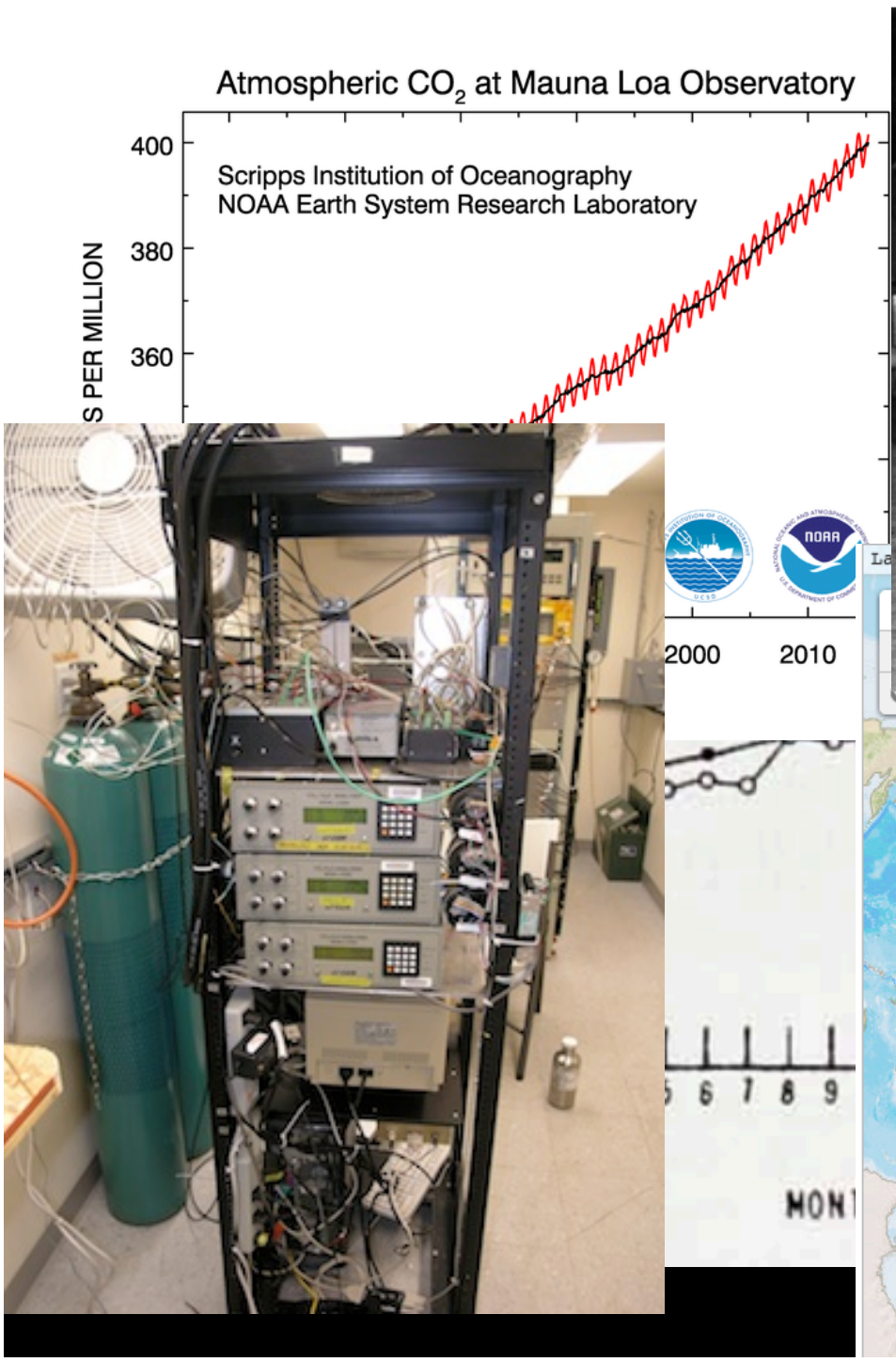


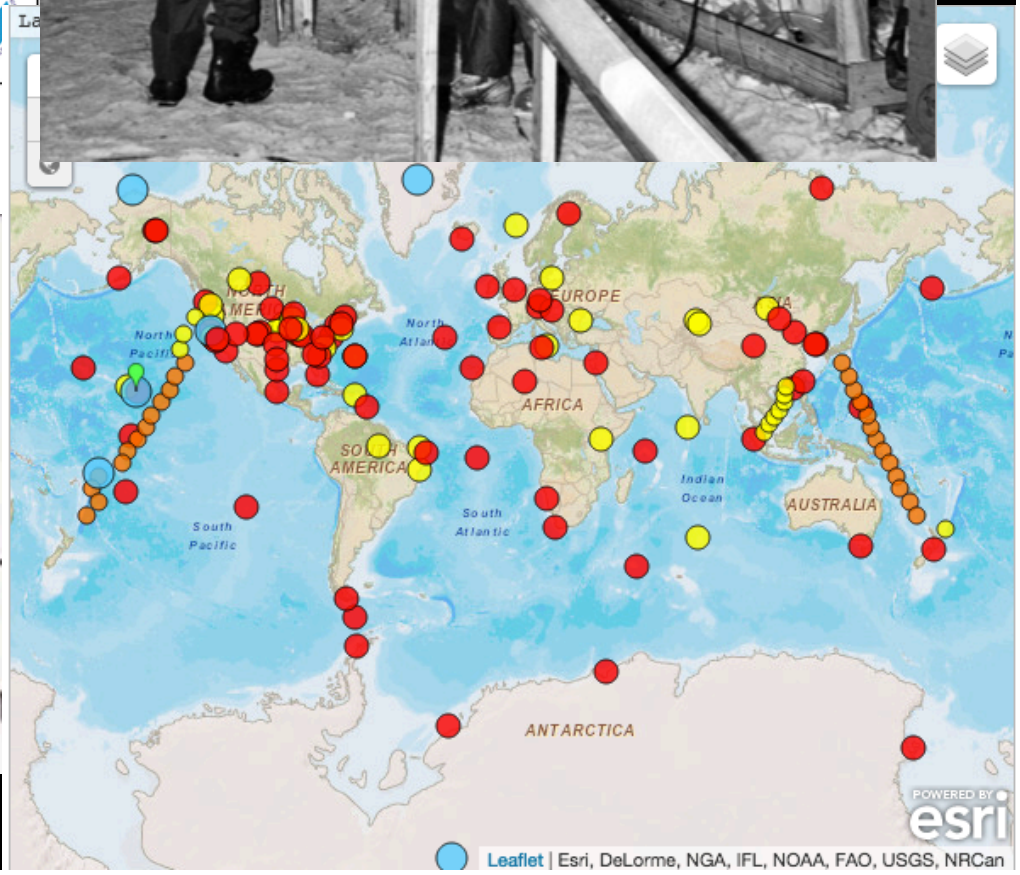
Trenberth et al., 2009

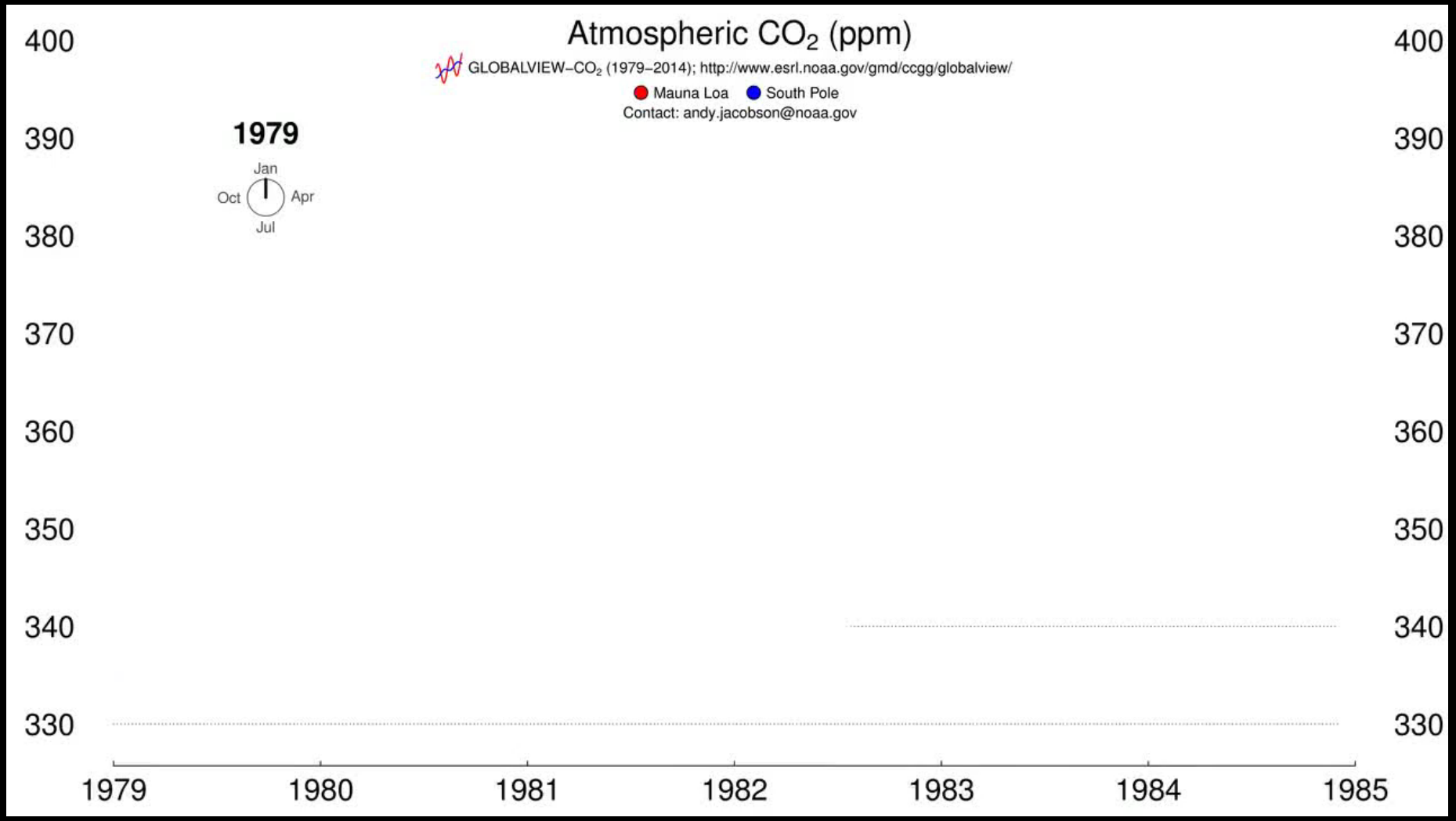


- Atmospheric CO_2 increasing ~ 2 ppm/yr from fossil fuel combustion, with 50% going into land and ocean sinks (Keeling 1960, Tans 1990)
- Short and long term observed warming patterns are linked to greenhouse gases (Callendar 1938, Mann 1999)
- Significant warming in the 20th century is mostly explained by atmospheric CO_2 (Manabe 1967, Hansen 1984)

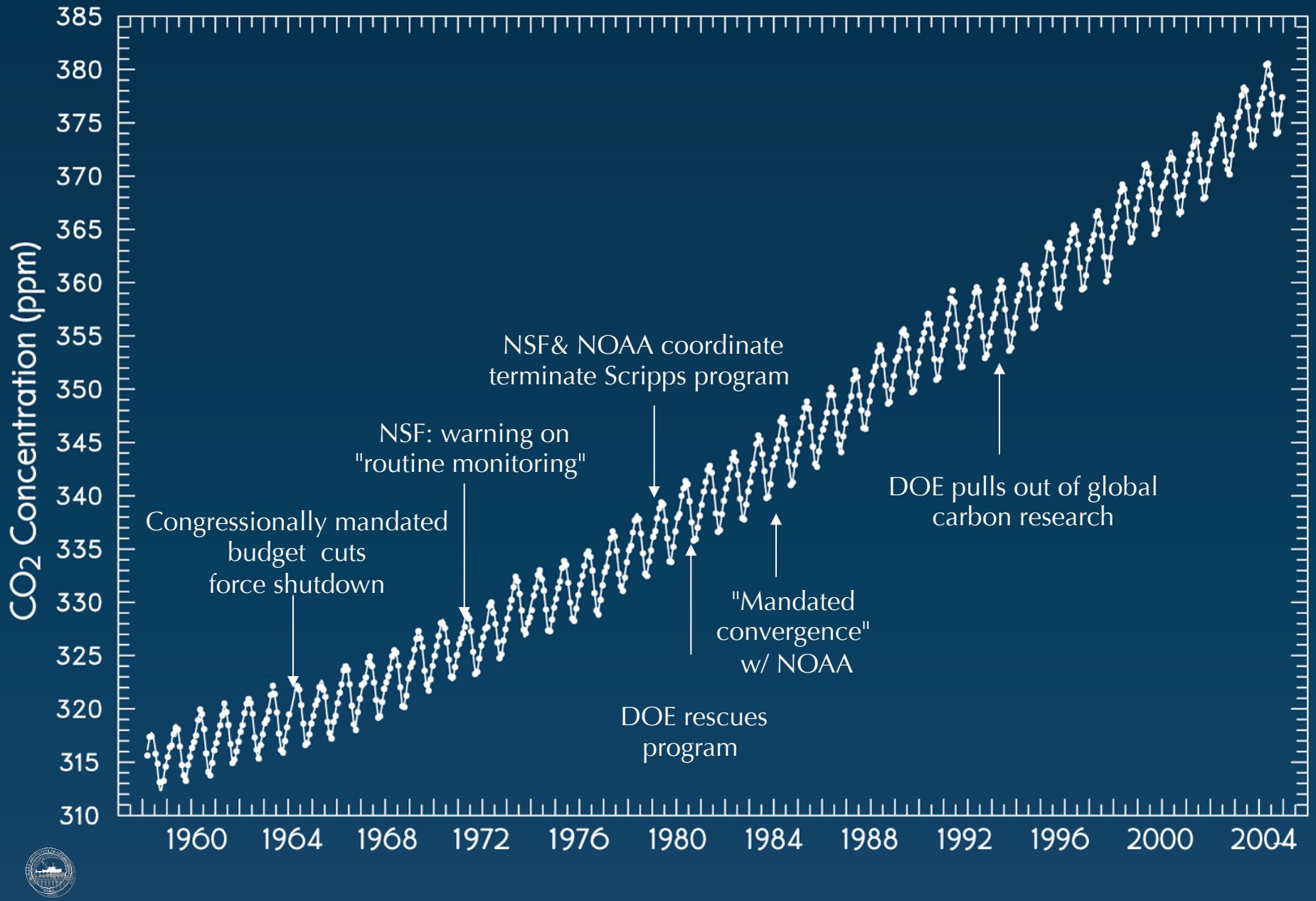



Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
400
380
360
S PER MILLION
2000
2010
MON

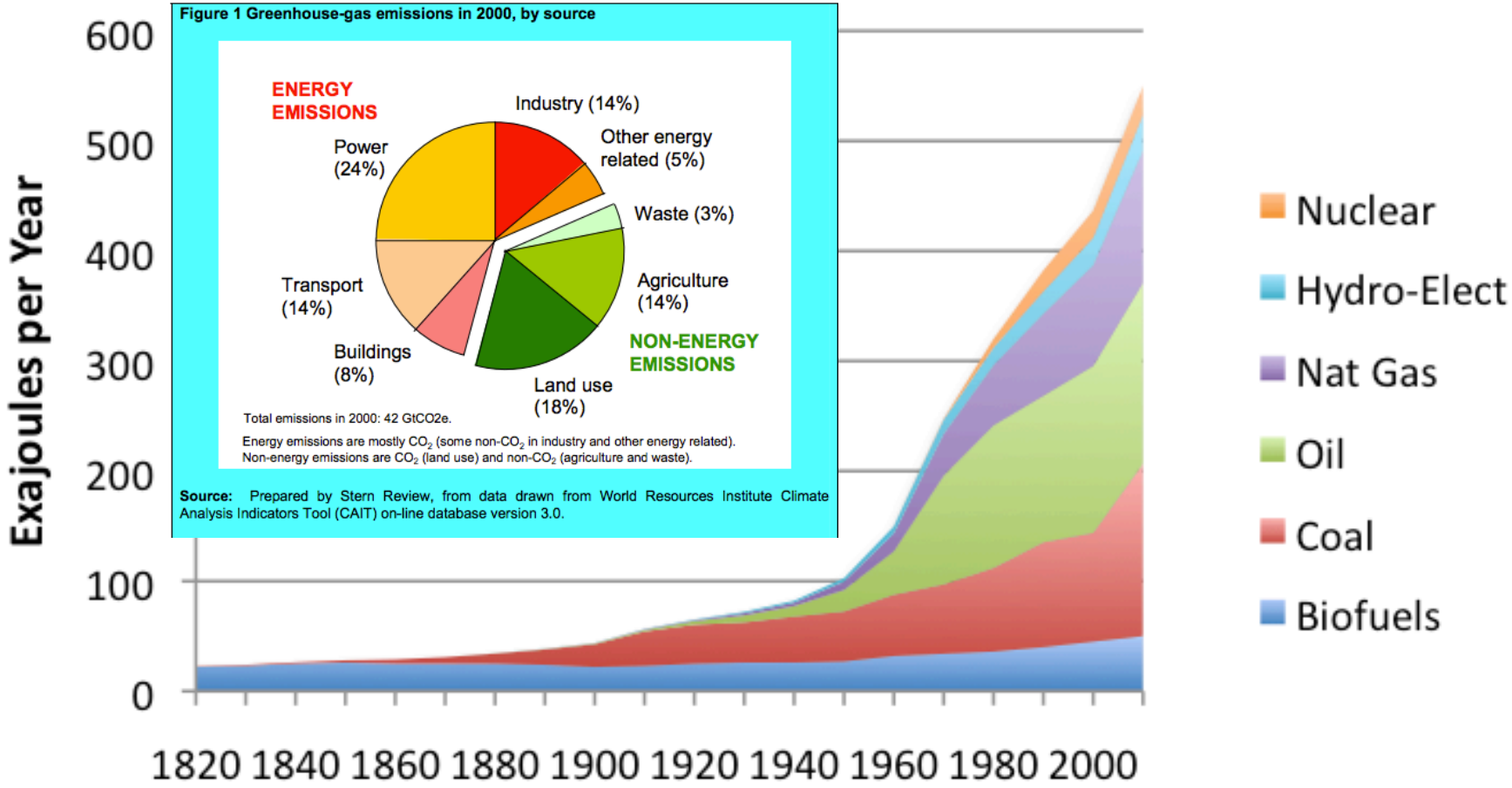

EUROPE
AFRICA
AUSTRALIA
ANTARCTICA
Indian Ocean
South Pacific
South Atlantic
Leaflet | Esri, DeLorme, NGA, IFL, NOAA, FAO, USGS, NRCan


Atmospheric CO_2 (ppm)
GLOBALVIEW–CO_2 (1979–2014); http://www.esrl.noaa.gov/gmd/ccgg/globalview/
Mauna Loa
South Pole
Contact: andy.jacobson@noaa.gov
1979
Jan
Oct
Apr
Jul
400
390
380
370
360
350
340
330
1979
1980
1981
1982
1983
1984
1985

Mauna Loa Record



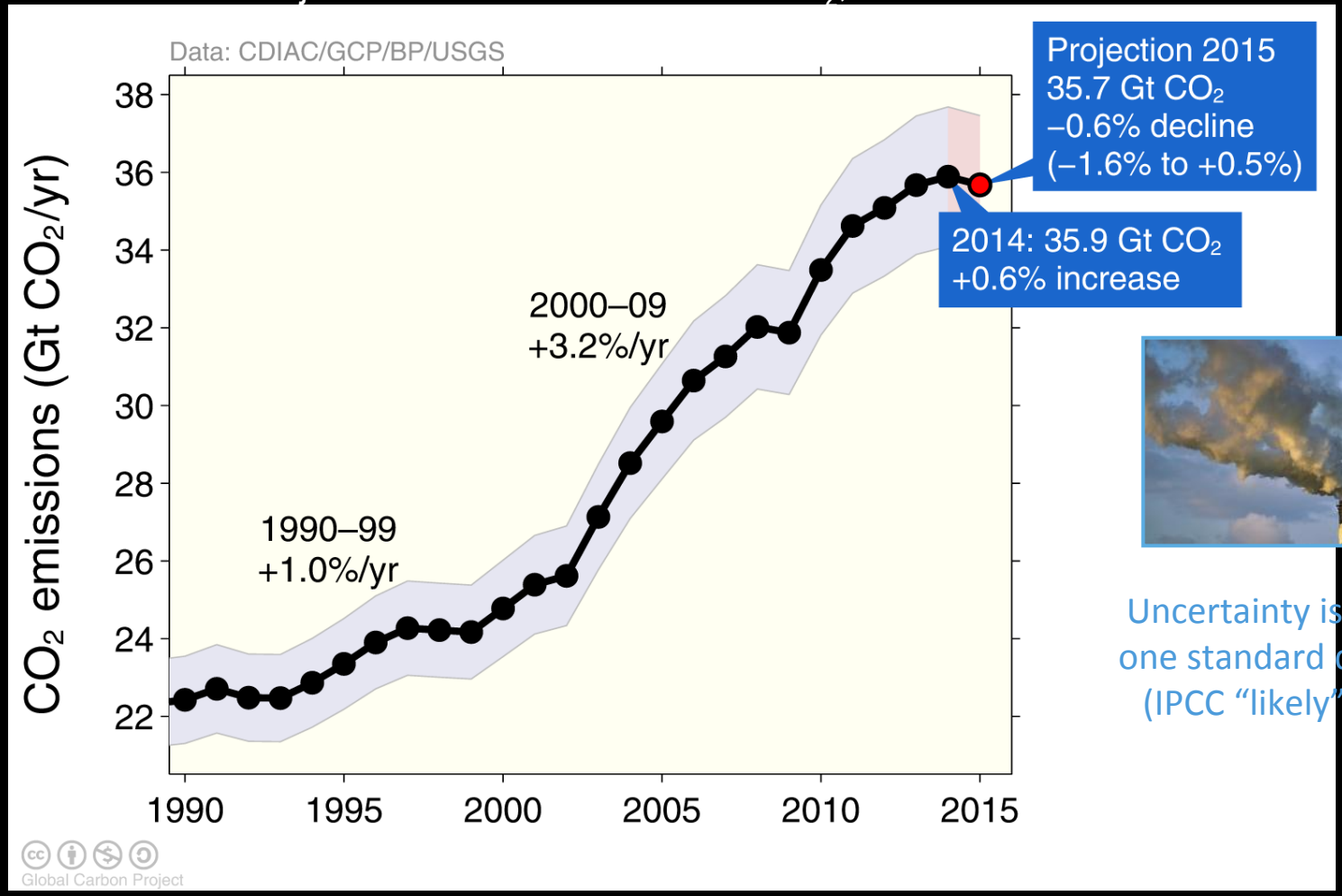
World Energy Consumption



Emissions from fossil fuel use and industry

Global emissions from fossil fuel and industry: 35.9 ± 1.8 $GtCO_2$ in 2014, 60% over 1990

- Projection for 2015: 35.7 ± 1.8 $GtCO_2$, 59% over 1990

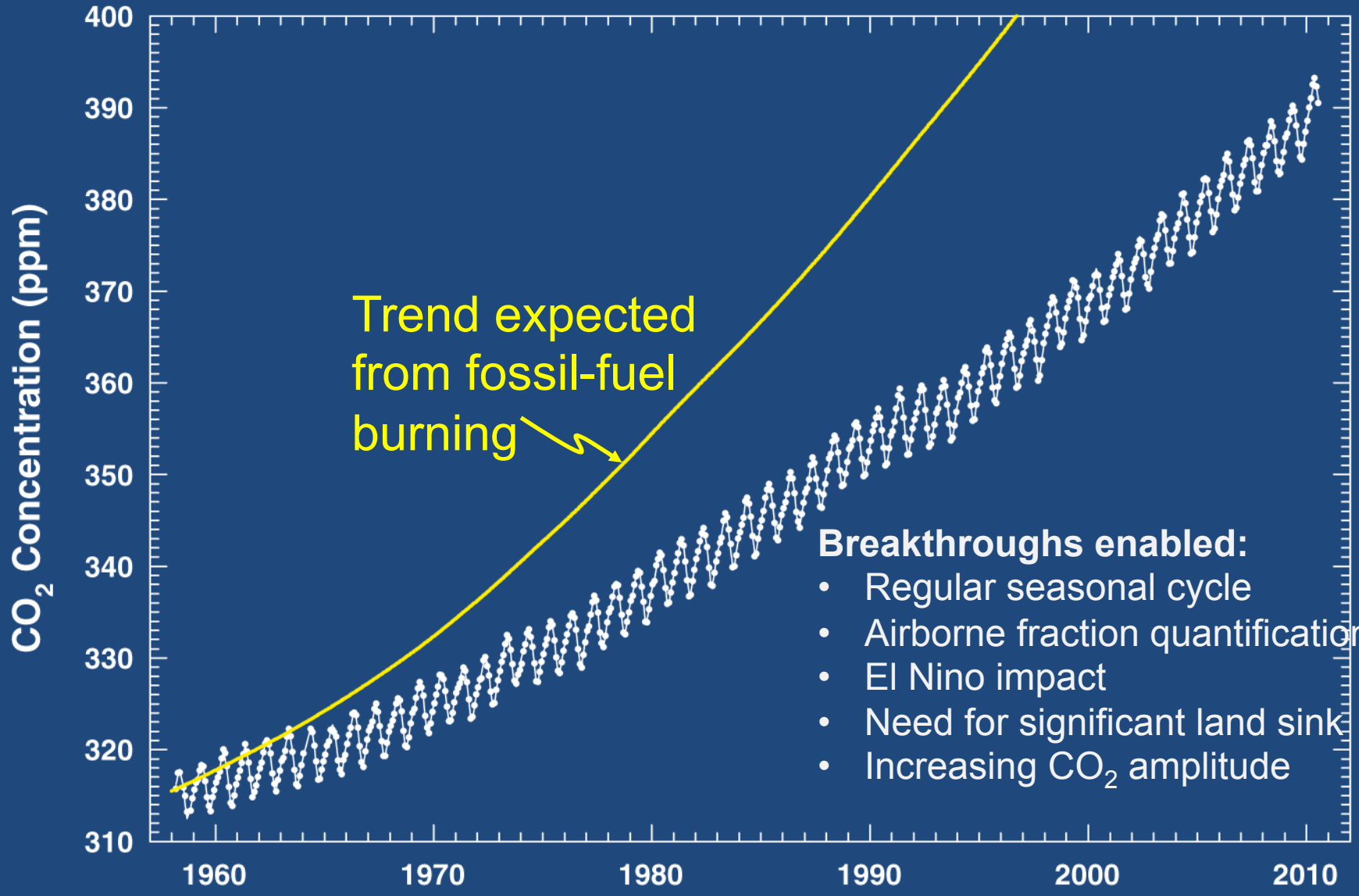


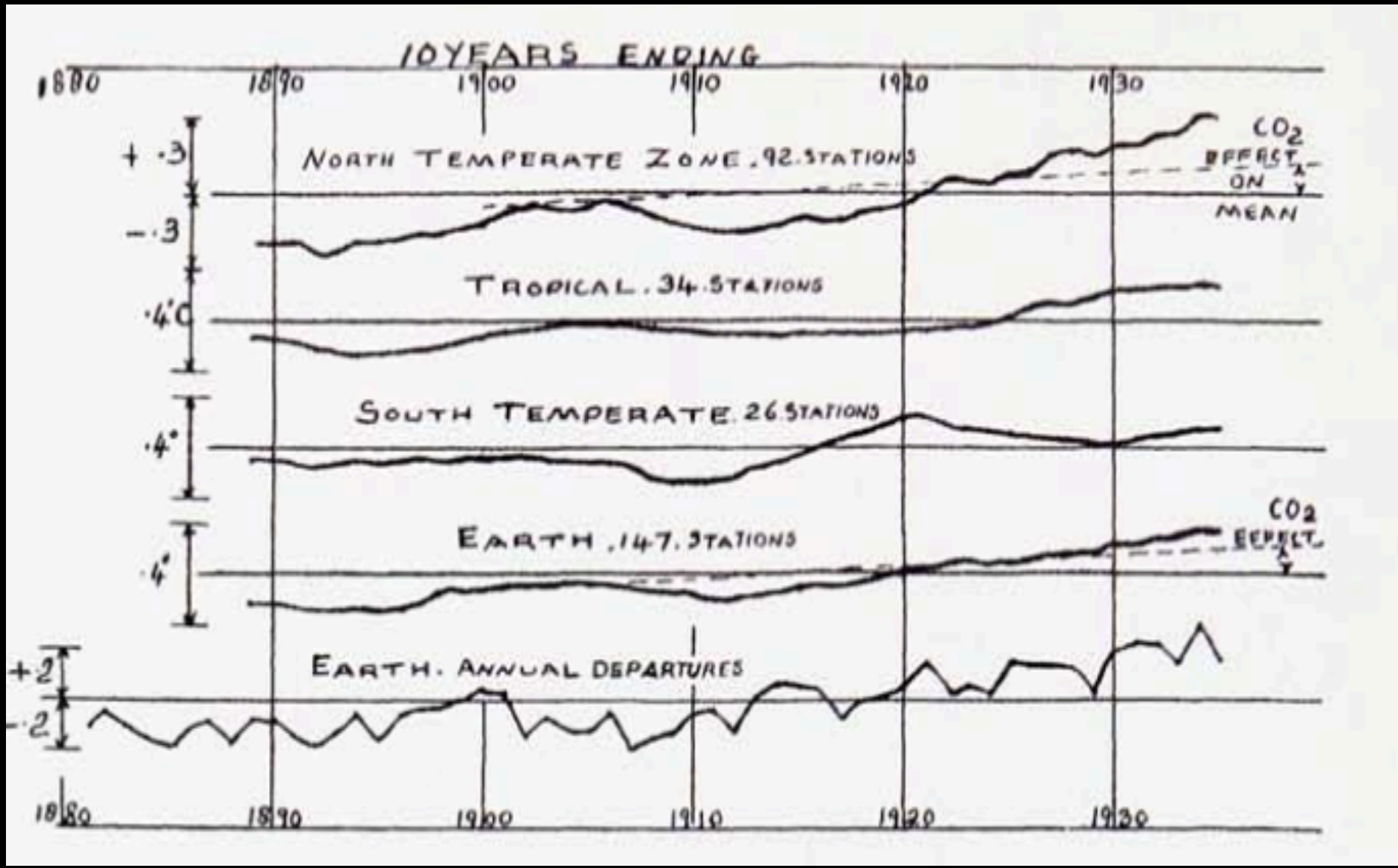
Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

Estimates for 2012, 2013, 2014, and 2015 are preliminary

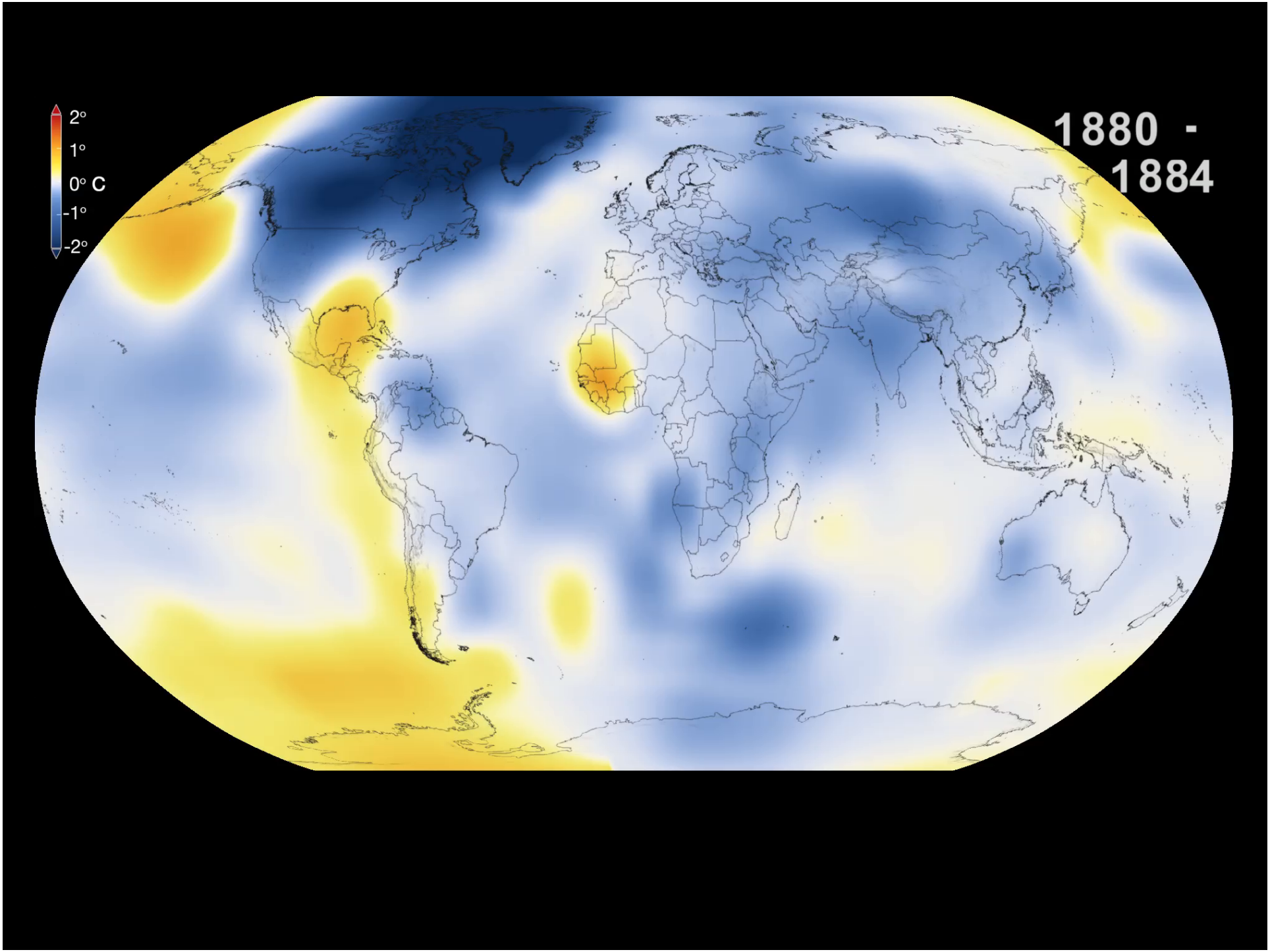
Source: CDIAC; Le Quéré et al 2015; Global Carbon Budget 2015

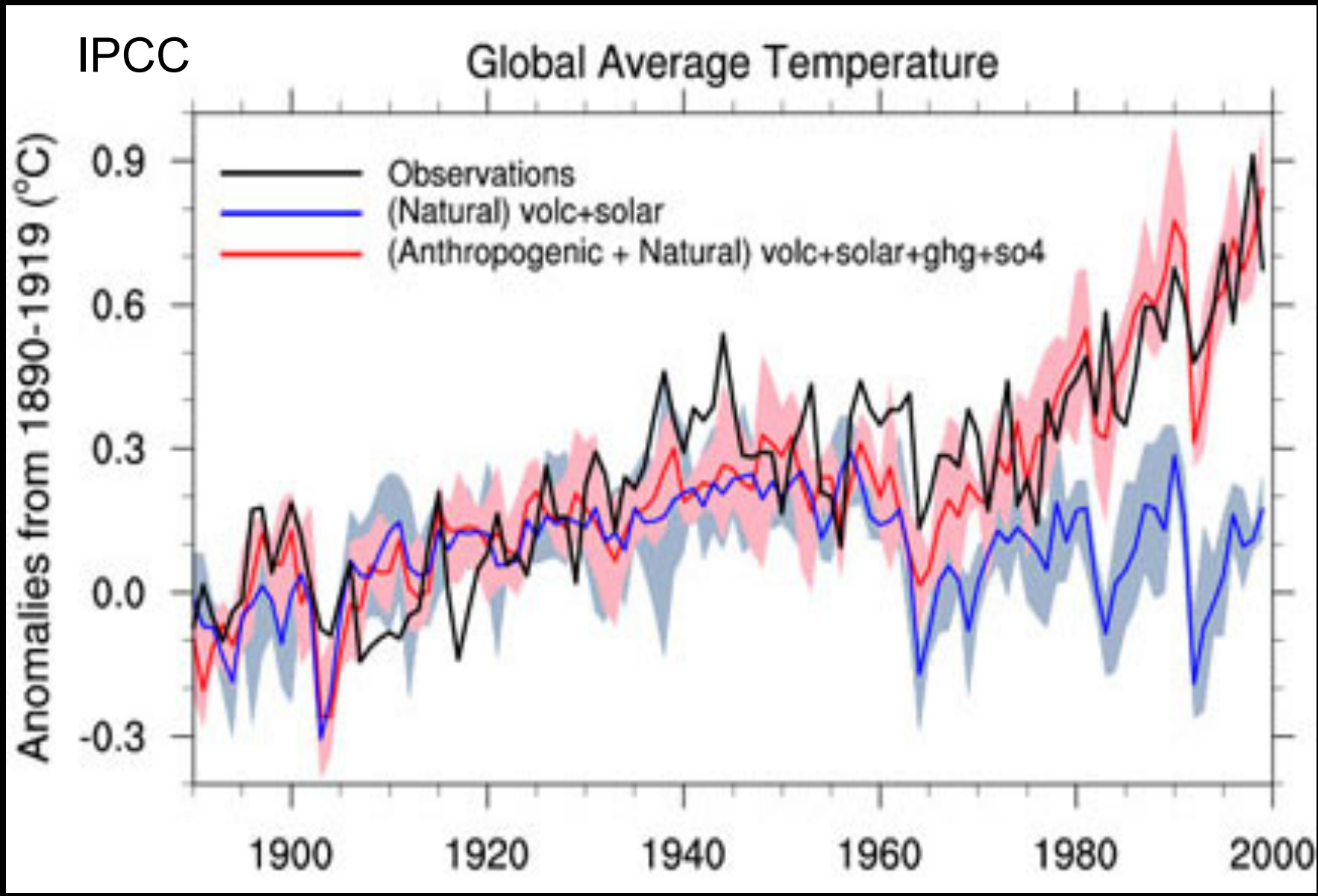
Atmospheric CO_2 records

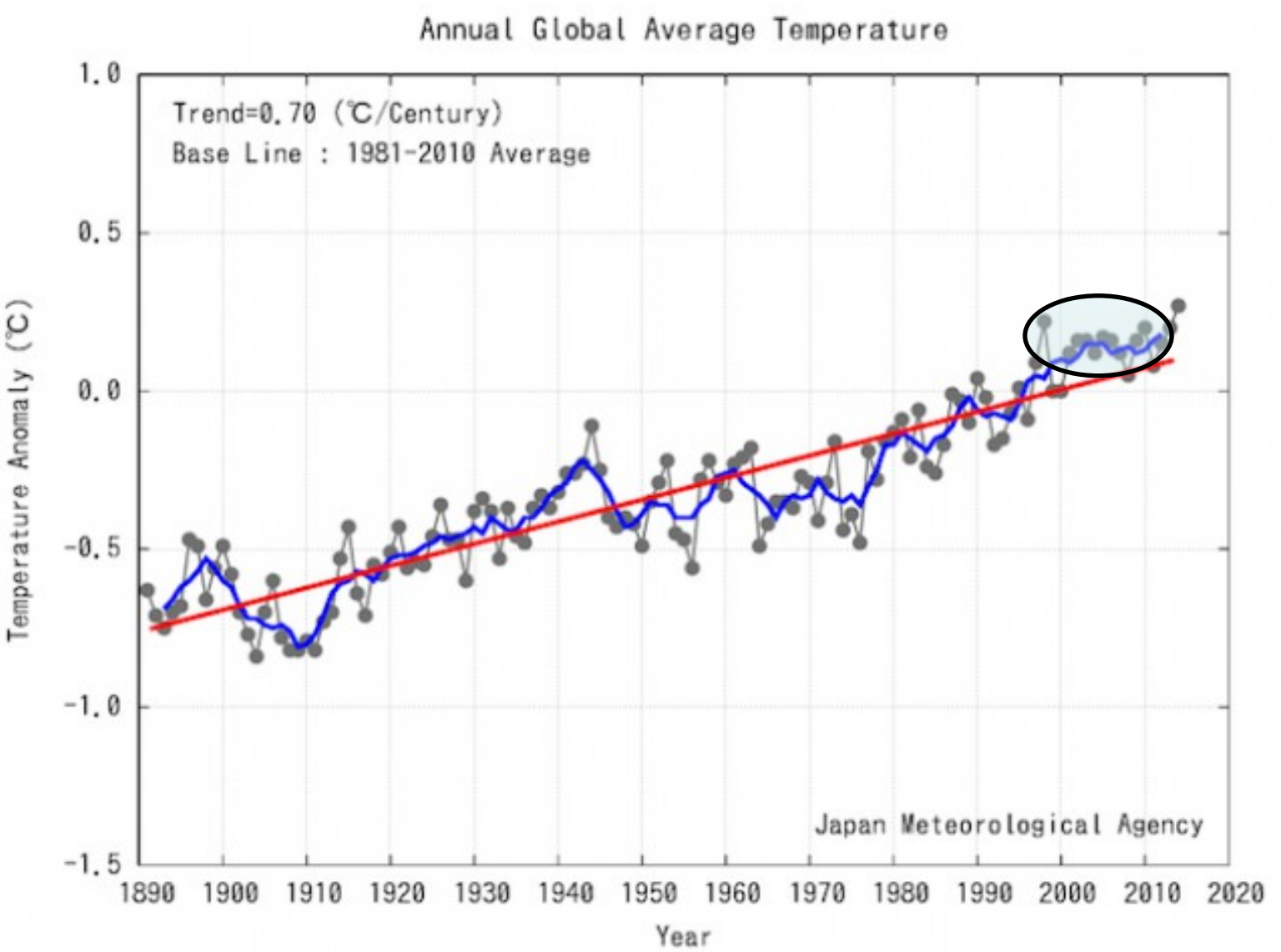




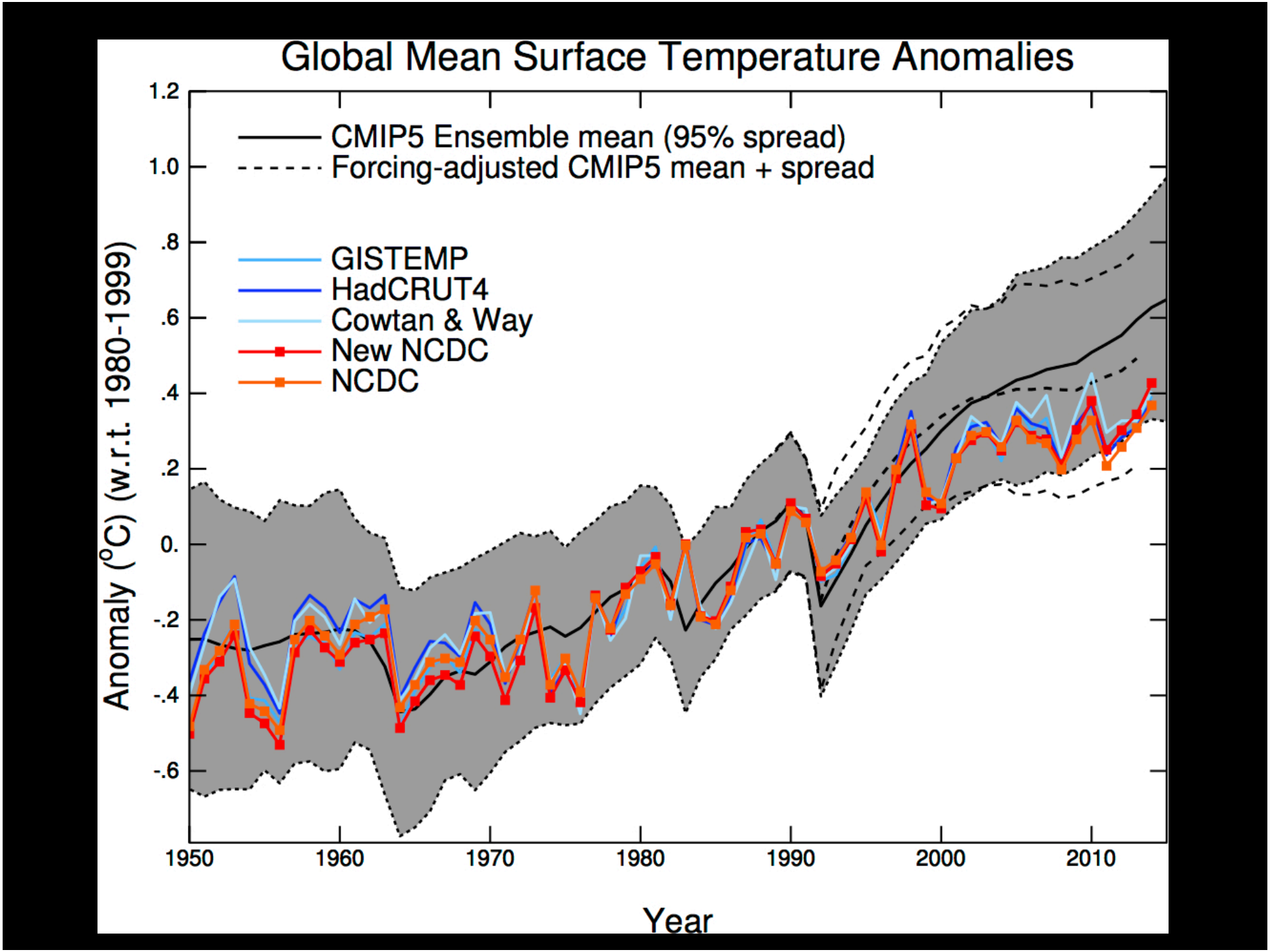
Callendar, 1938

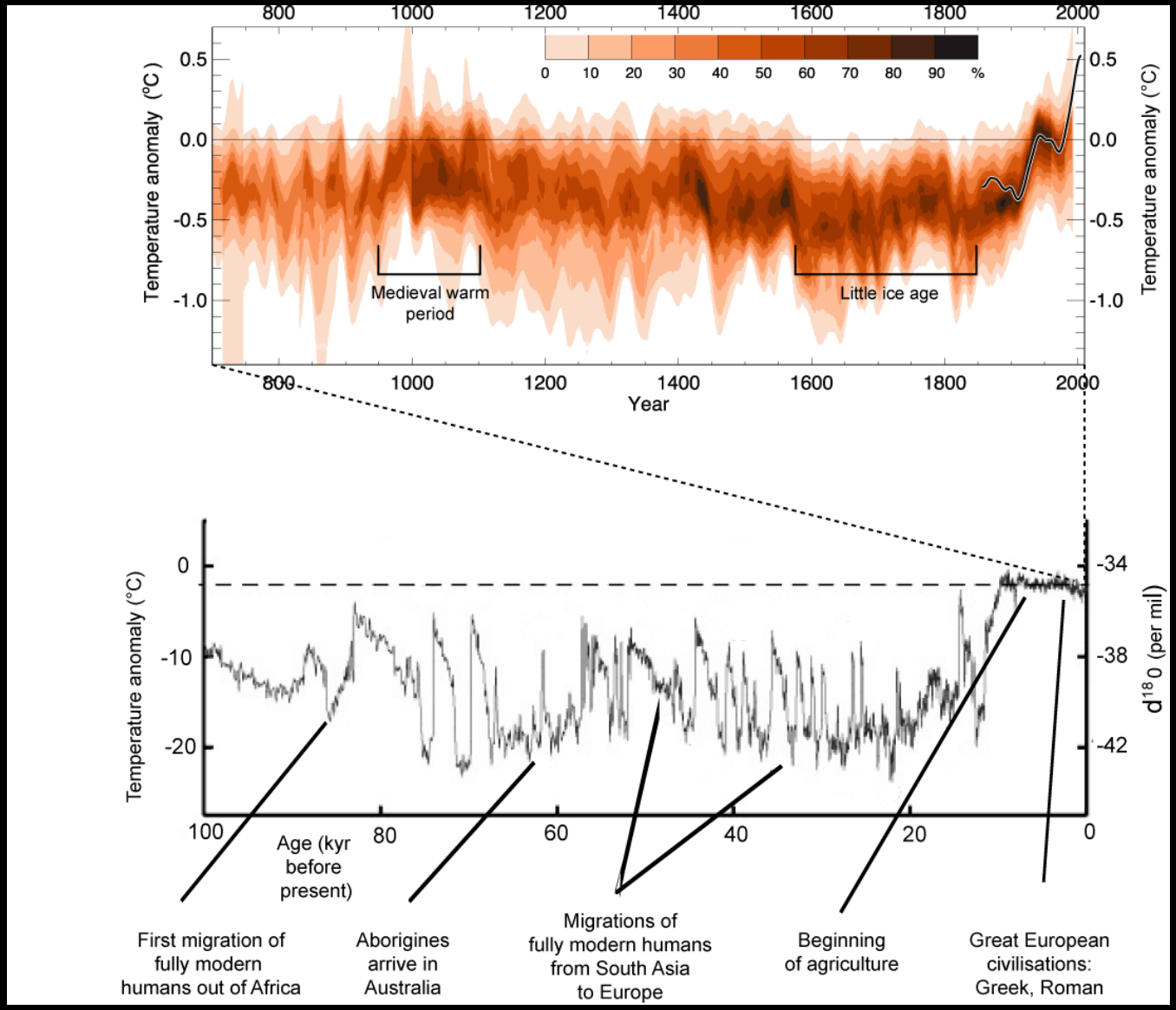

2°
1°
0° C
-1°
-2°
1880 -
1884


IPCC
Global Average Temperature
Anomalies from 1890-1919 (°C)
0.9
0.6
0.3
0.0
-0.3
Observations
(Natural) volc+solar
(Anthropogenic + Natural) volc+solar+ghg+so4
1900
1920
1940
1960
1980
2000



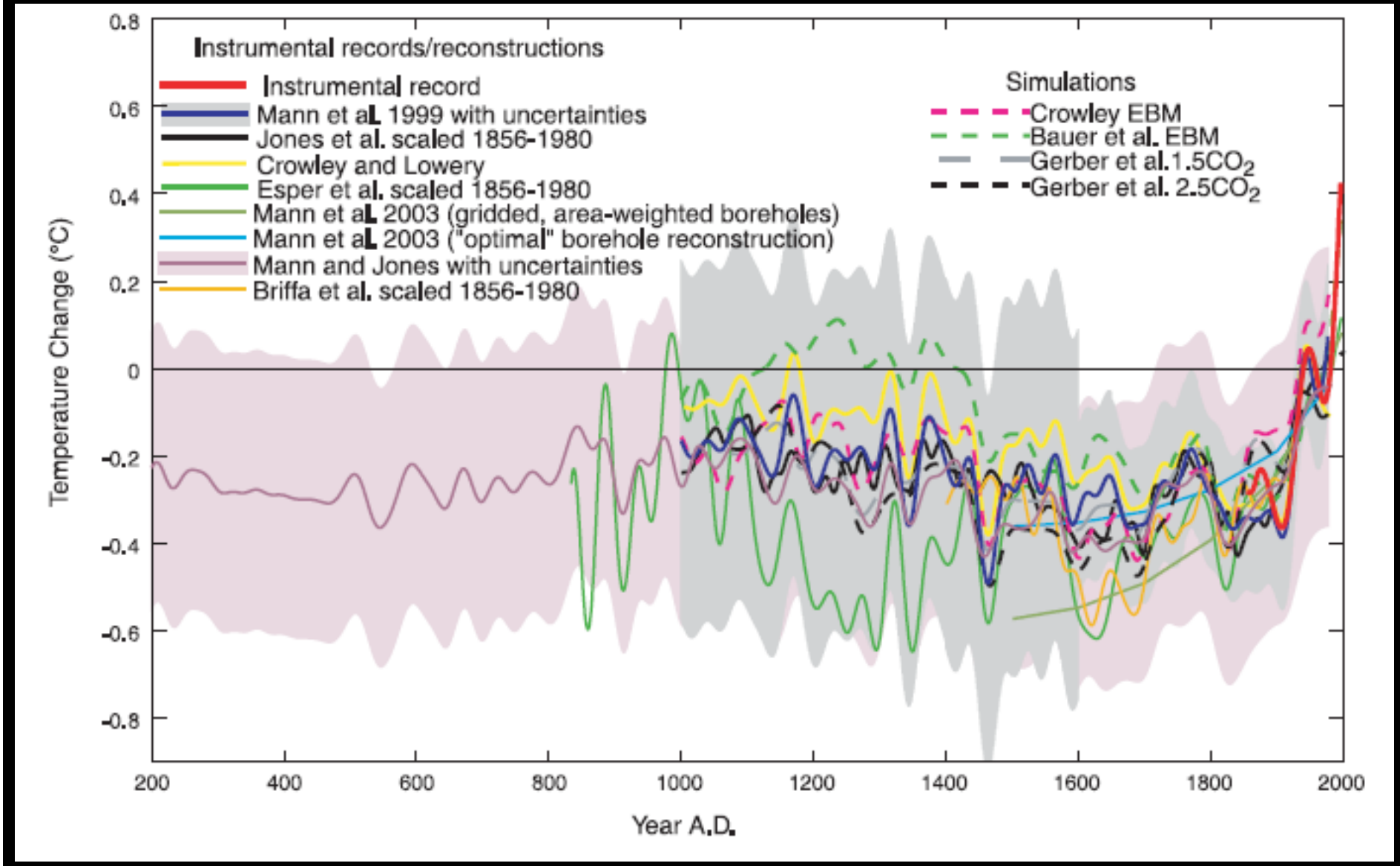
Anonalies are deviation fron baseline (1981-2010 Average).
The black thin line indicates surface temperature anomaly of each year.
The blue line indicates their 5-year running mean.
The red line indicates the long-tern linear trend.


Global Mean Surface Temperature Anomalies
CMIP5 Ensemble mean (95% spread)
Forcing-adjusted CMIP5 mean + spread
GISTEMP
HadCRUT4
Cowtan & Way
New NCDC
NCDC
Anomaly (°C) (w.r.t. 1980-1999)
1.2
1.0
.8
.6
.4
.2
0.
-.2
-.4
-.6
1950
1960
1970
1980
1990
2000
2010
Year



9/1/11

Chapin et al., 2011

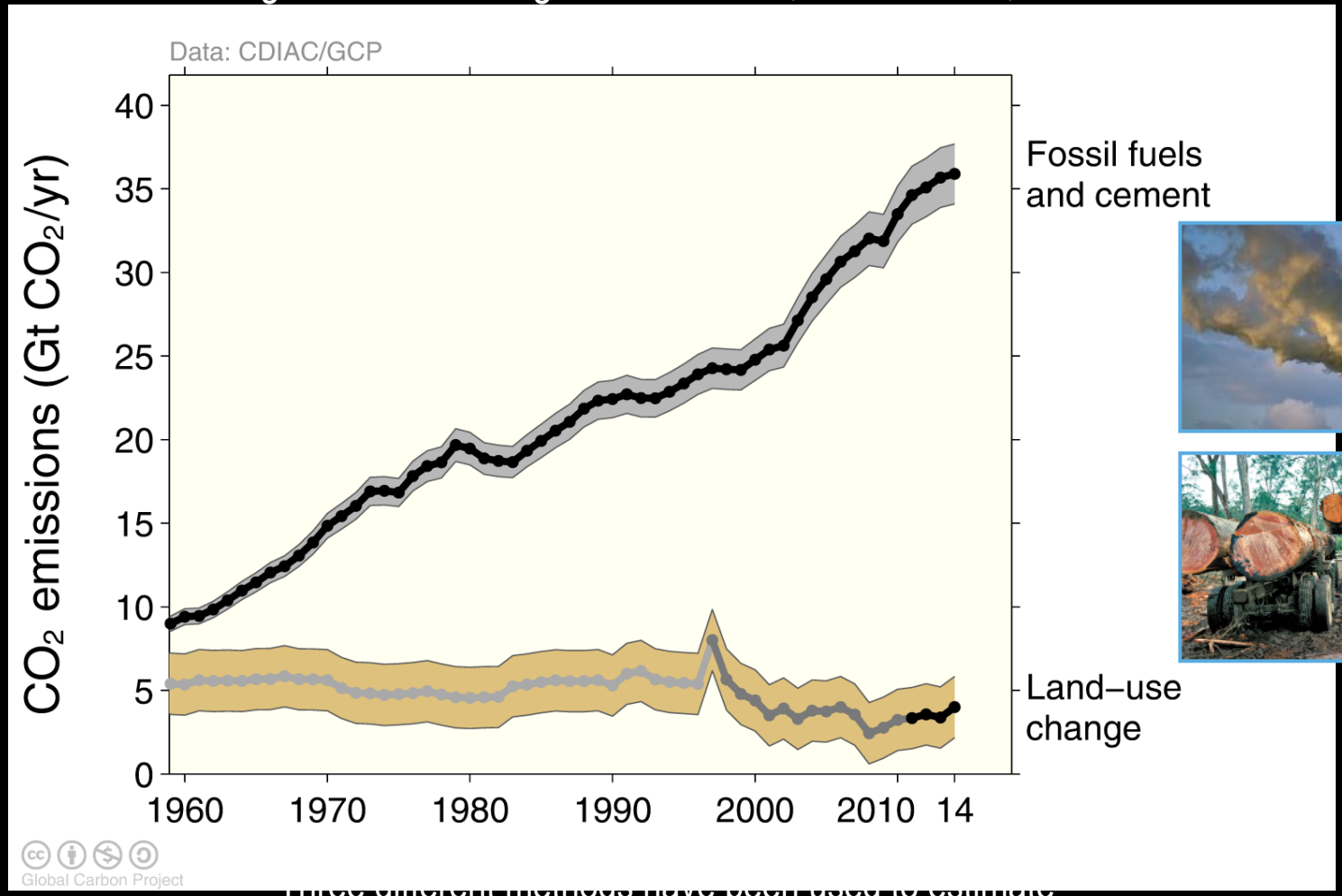


Mann et al., 2003, EOS

- US per capita fossil fuel emissions exceed most of the world (DOE, GCP). China total emissions now exceeds the US (IEA).
- Climate projections show a 3 C +/- 1.5 C response to doubling of CO_2 by 2100 with the primary uncertainty in range of emissions (IPCC 1990, 1995, 2001, 2007, 2013)
- Modest warming (0-2 C) creates both winners and losers; warming above 2C or 550 ppm, losers > winners; warming above 4C, mostly losers (WMO, ExxonMobil, Stern Review, World Bank, NCA, WICCI, DOD 1979-present)

Total global emissions

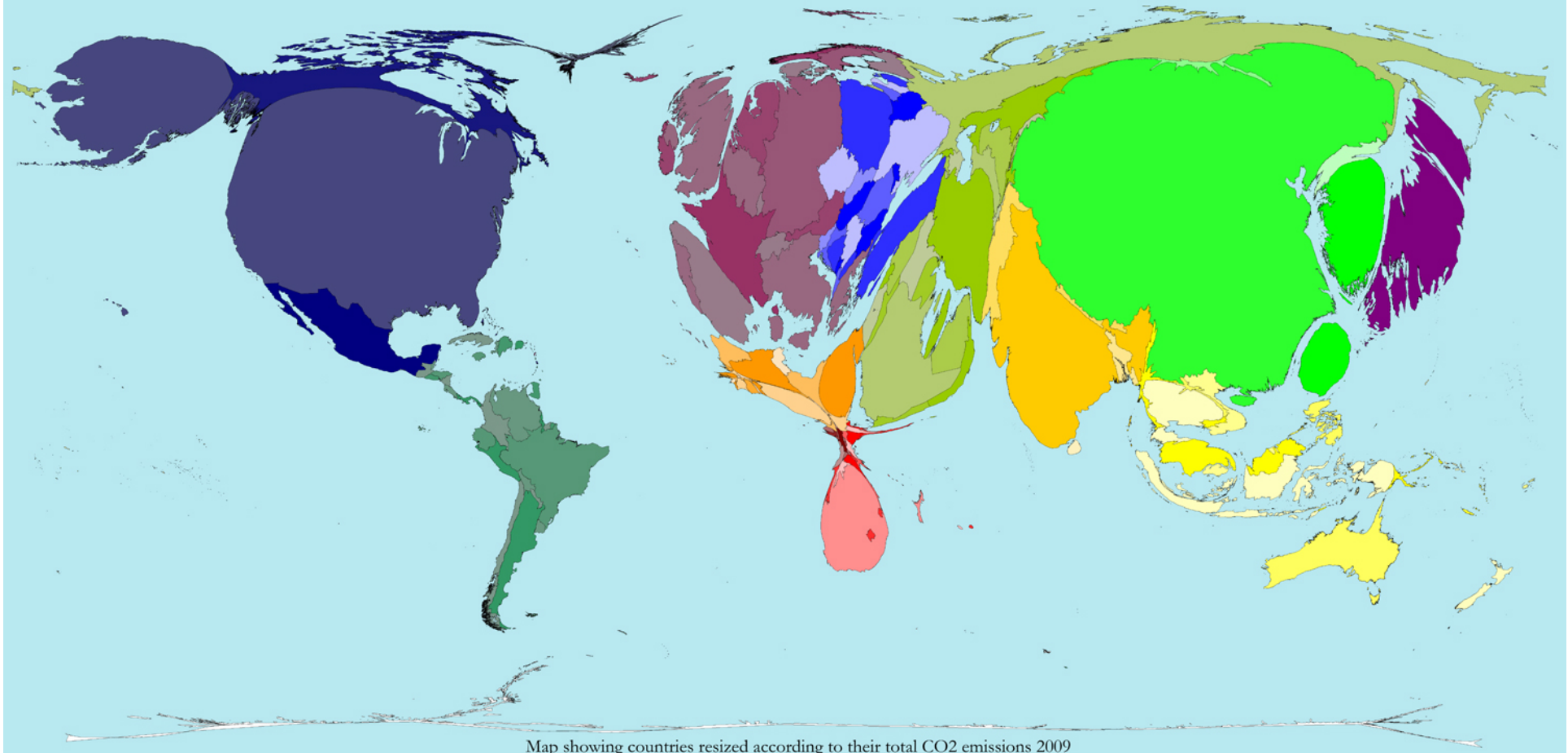
Total global emissions: 39.9 ± 3.8 $GtCO_2$ in 2014, 44% over 1990
Percentage land-use change: 36% in 1960, 19% in 1990, 10% in 2014



Three different methods have been used to estimate land-use change emissions, indicated here by different shades of grey

Source: CDIAC; Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2015; Global Carbon Budget 2015

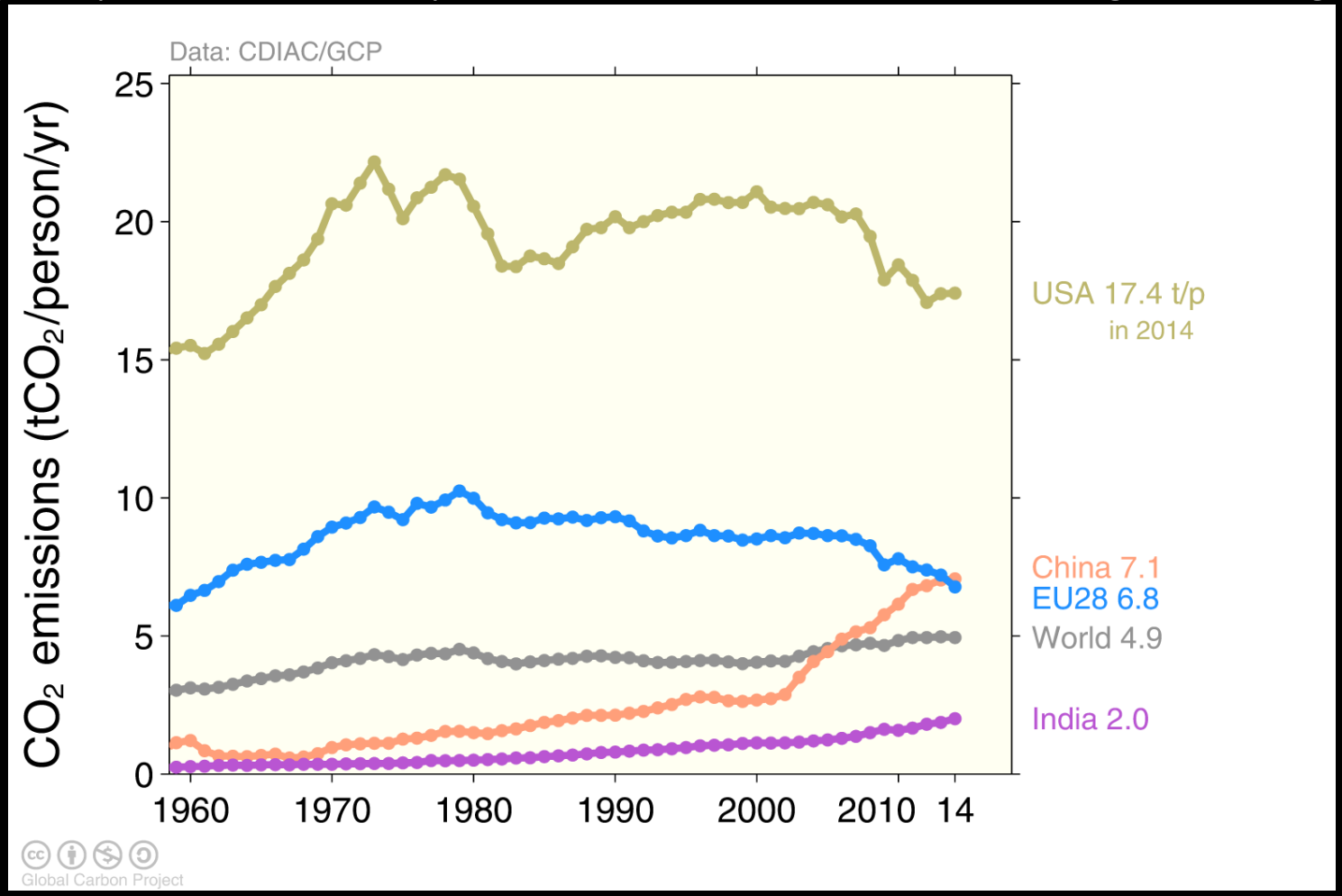
Global CO_2 Emissions



Map showing countries resized according to their total CO2 emissions 2009
Data Sources: IWR (2009) & UNFCC (2007)
Map created by Benjamin Hennig, Sasi Research Group, University of Sheffield - www.viewsoftheworld.net

Top fossil fuel emitters (per capita)

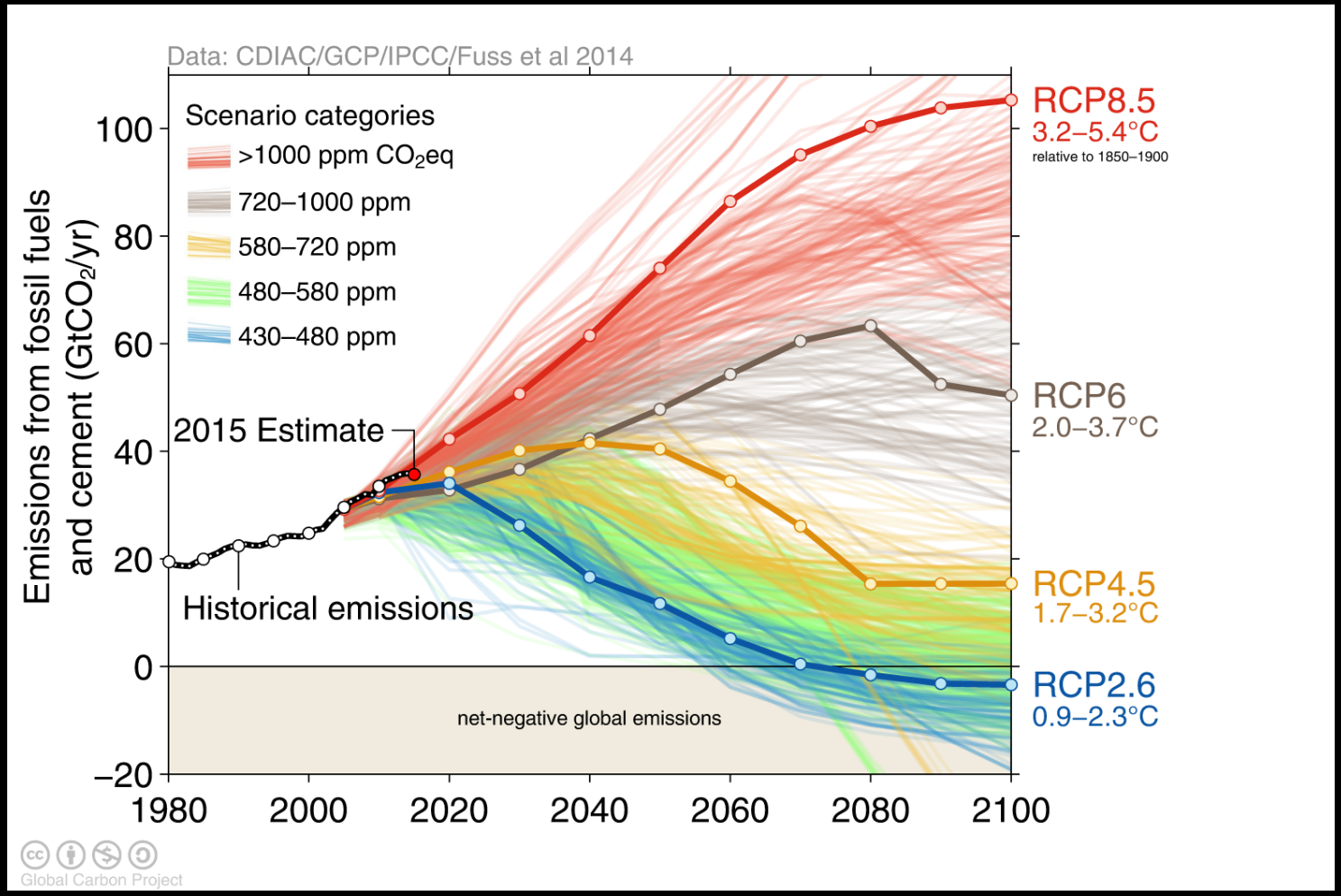
Countries have a broad range of per capita emissions reflecting their national circumstances China's per capita emissions have passed the EU28 and are 43% above the global average



Source: CDIAC; Le Quéré et al 2015; Global Carbon Budget 2015

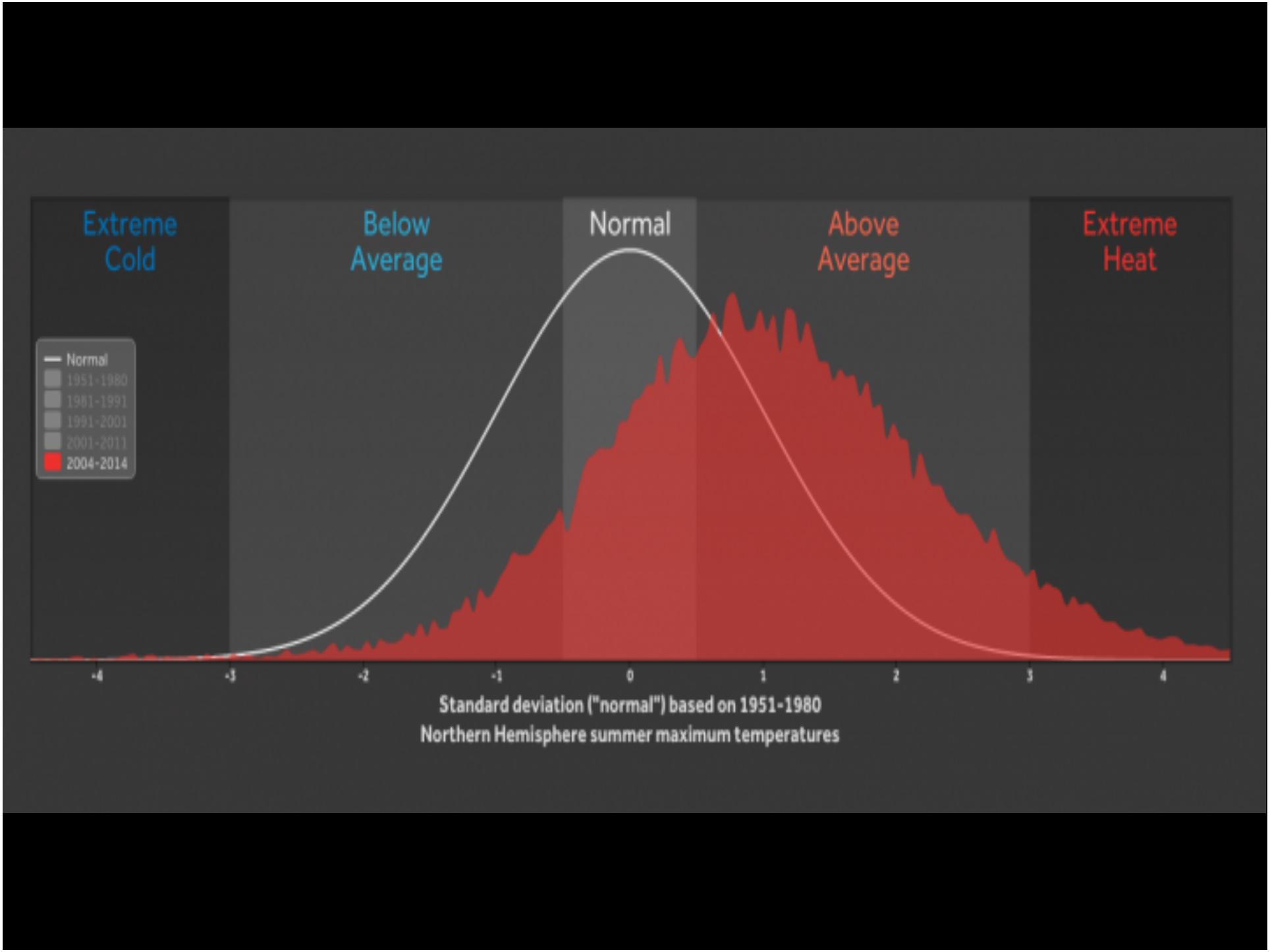
Observed emissions and emissions scenarios

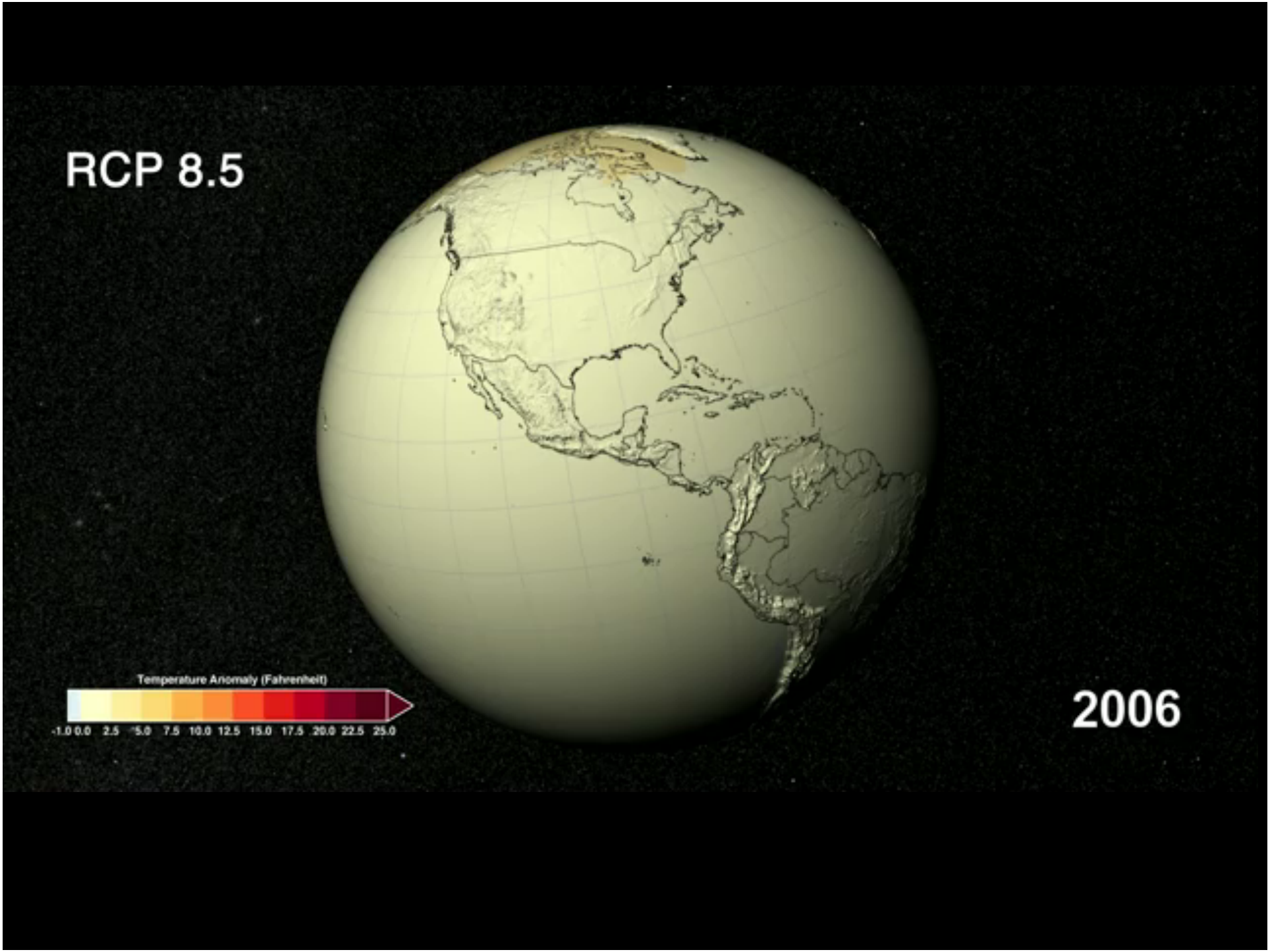
The emission pledges submitted to the Paris climate summit avoid the worst effects of climate change (red), most studies suggest a likely temperature increase of about 3°C (brown)

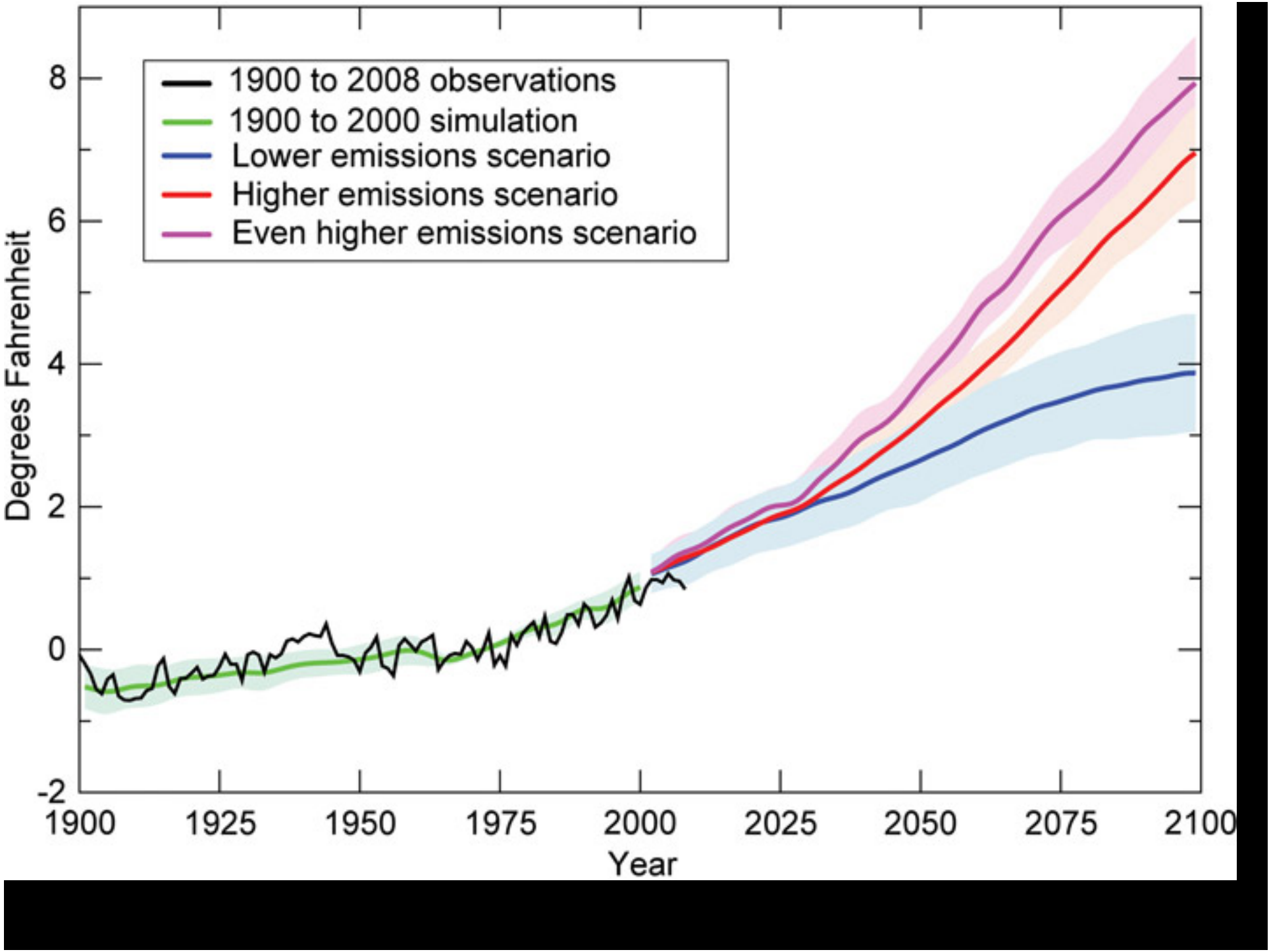


Over 1000 scenarios from the IPCC Fifth Assessment Report are shown

Source: Fuss et al 2014; CDIAC; Global Carbon Budget 2015


Extreme Cold
Below Average
Normal
Above Average
Extreme Heat
Normal
1951-1980
1981-1991
1991-2001
2001-2011
2004-2014
-4
-3
-2
-1
0
1
2
3
4
Standard deviation ("normal") based on 1951-1980
Northern Hemisphere summer maximum temperatures


RCP 8.5
Temperature Anomaly (Fahrenheit)
<1.0 0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0
2006


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

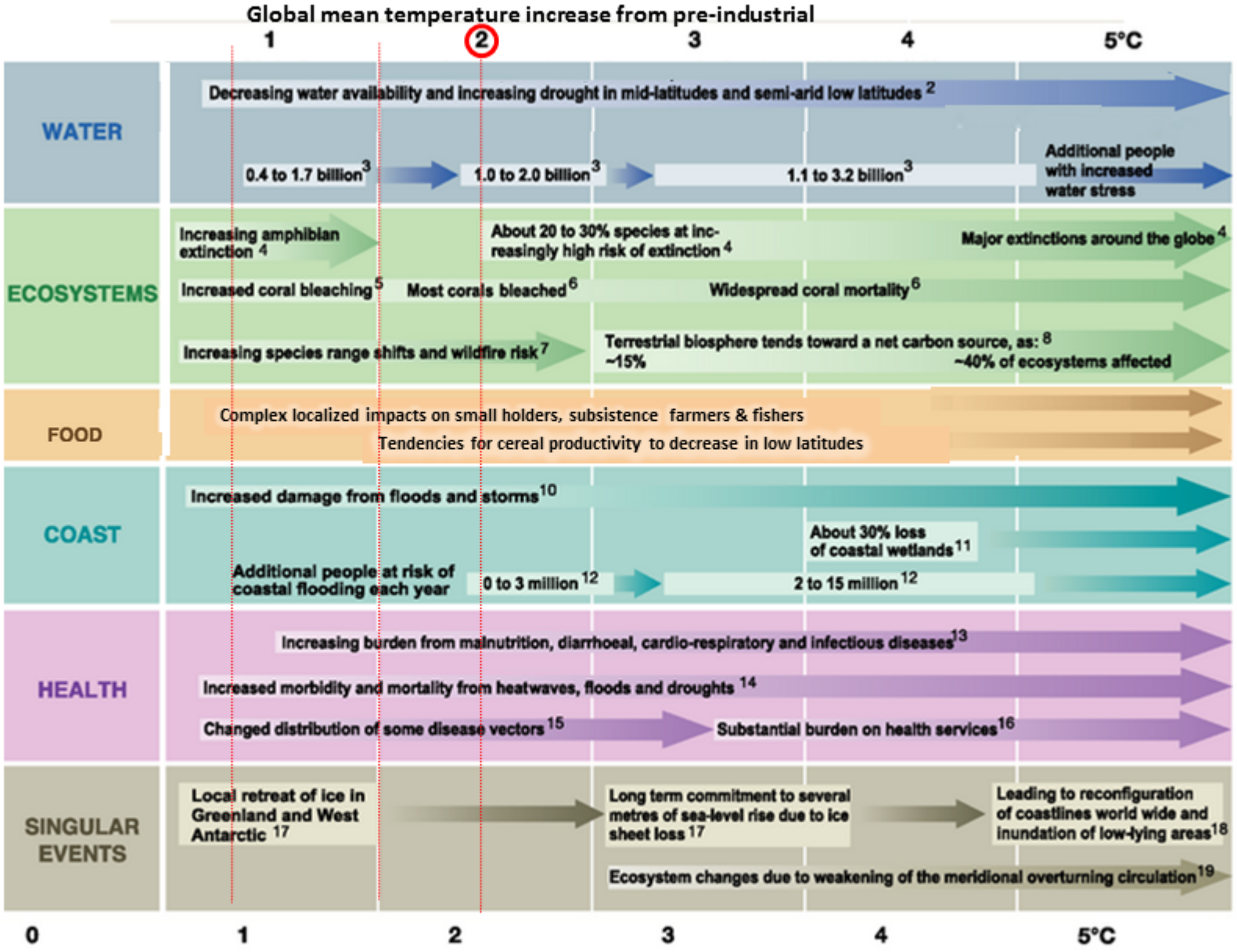
IPCC 2007 AR4 TS.4.3 Magnitudes of ADVERSE impacts for varying amounts of climate change

IPCC quotes in blue. Impacts start where text box begins. Edges of boxes and placing of text indicate the range of temperature change to which the impacts relate.

The impact chart omitted extreme weather events, that increase most impacts The SPM impact chart was identical except it omitted the singular events

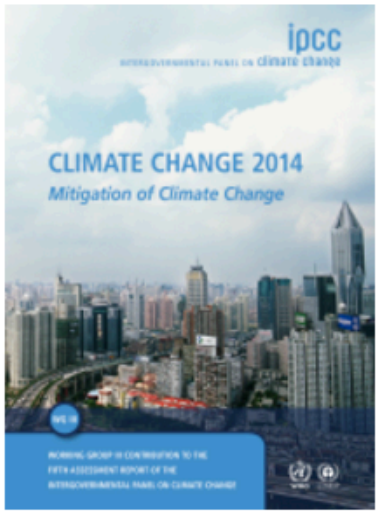
.

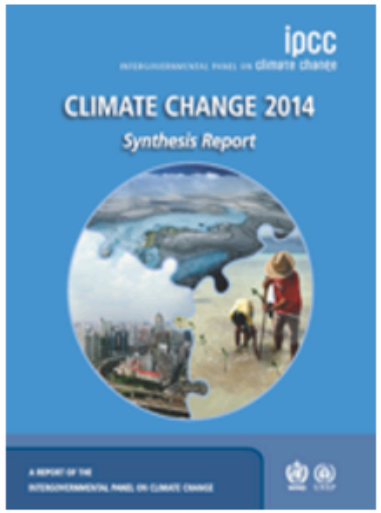
Estimates are for the 2020s, 2050s and 2080s, (used by he IPCC Data Distribution Centre) and for the 2090s.
Note that equilibrium temperatures would not be reached until decades or centuries after greenhouse gas stabilisation.

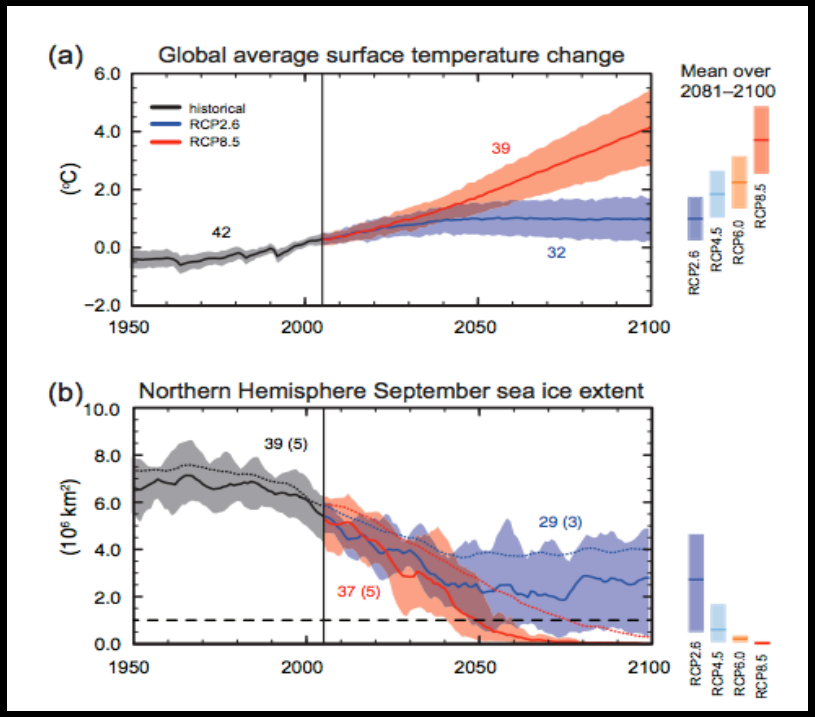


UNFCCC objective quoted in AR4 ...'prevent dangerous ...interference with the climate system....within a time frame sufficient to allow ecosystems to adapt naturally to climate change, and to ensure that food production is not threatened'

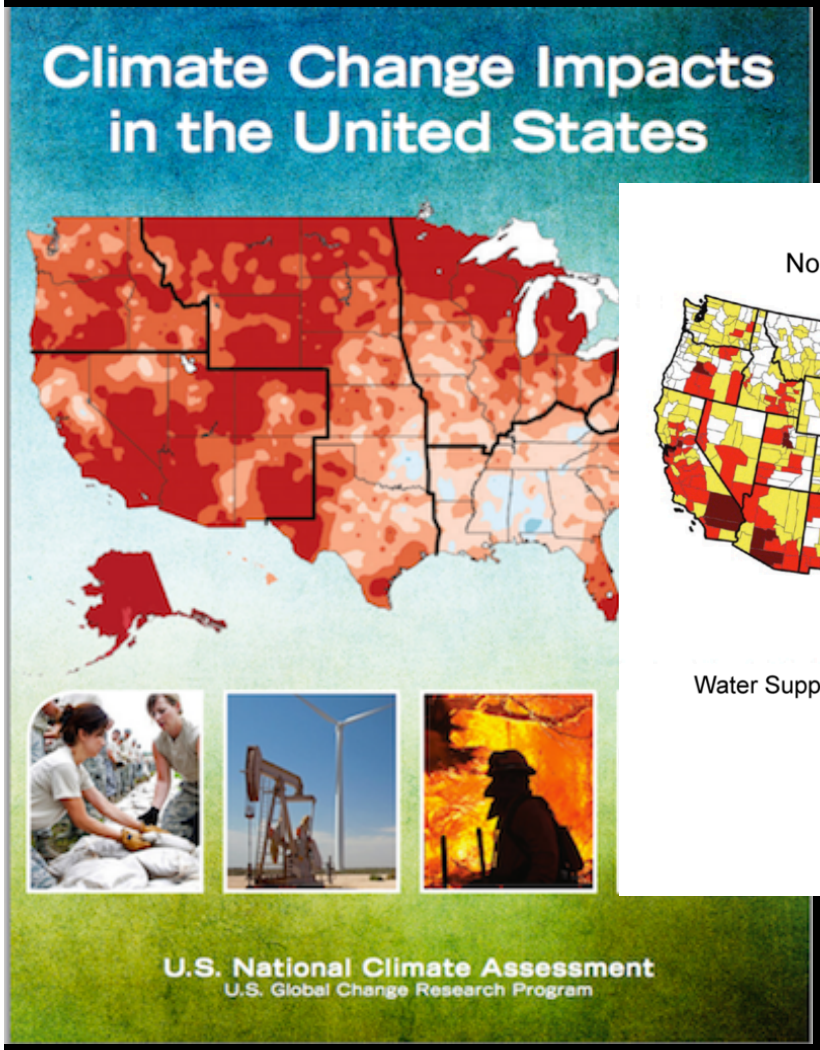
Peter Carter

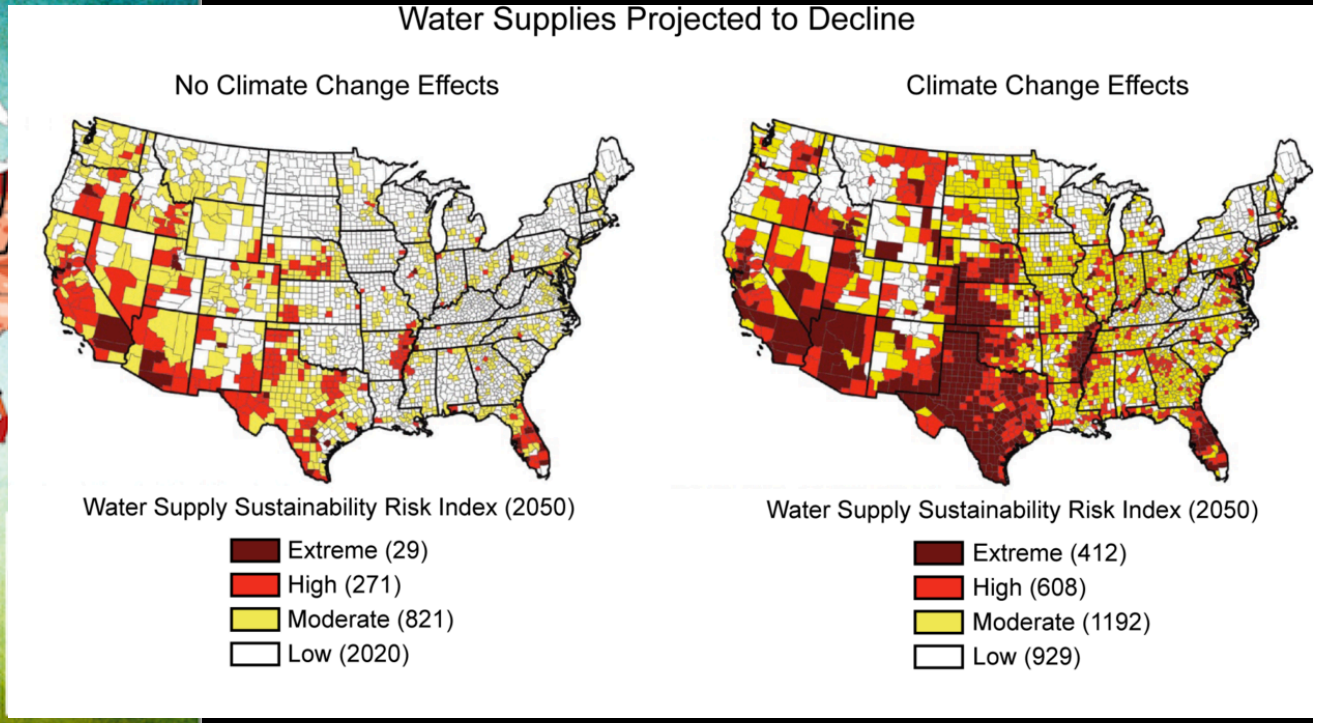






https://www.ipcc.ch/report/ar5/

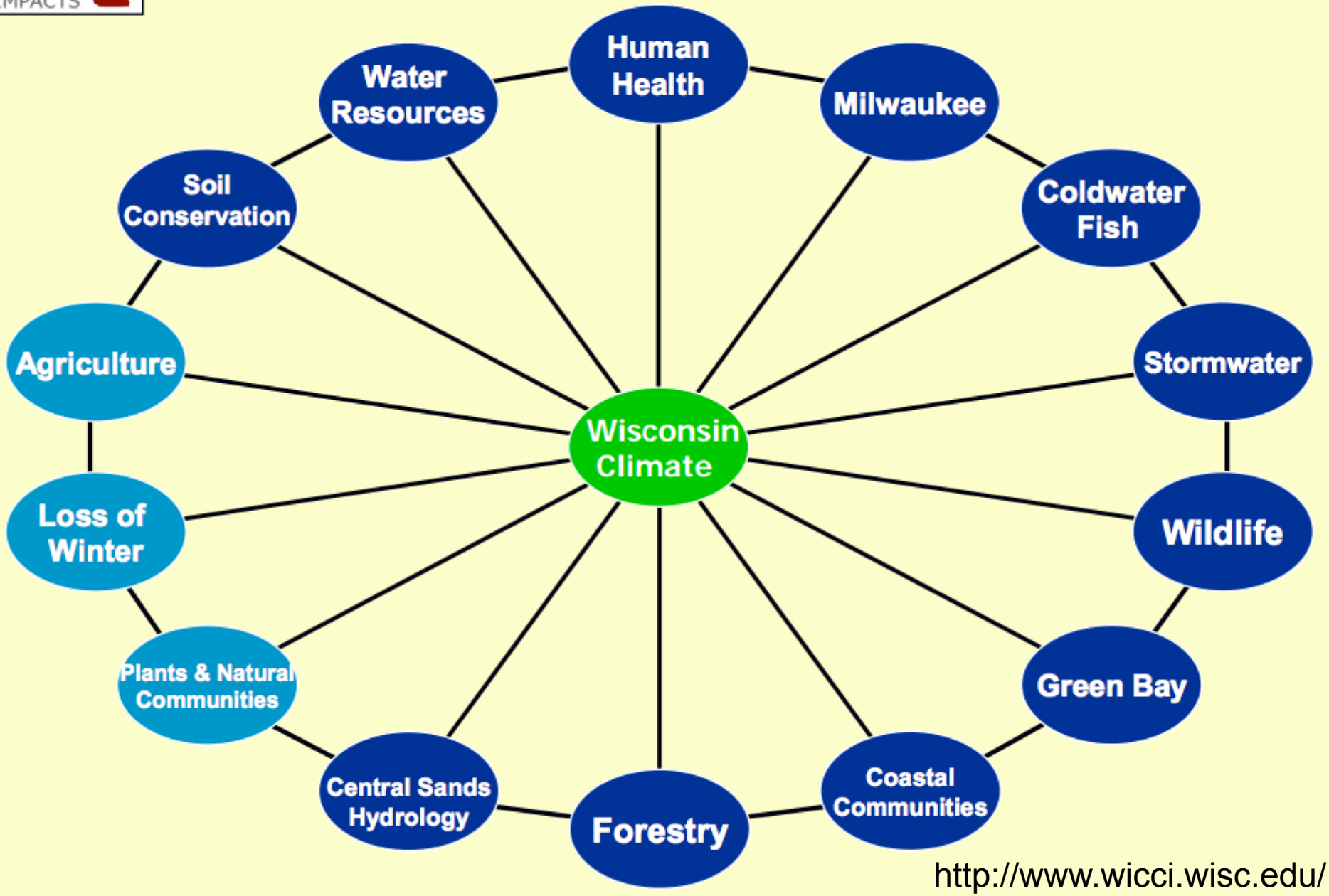




http://nca2014.globalchange.gov/

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

Current & Developing Working Groups



http://www.wicci.wisc.edu/

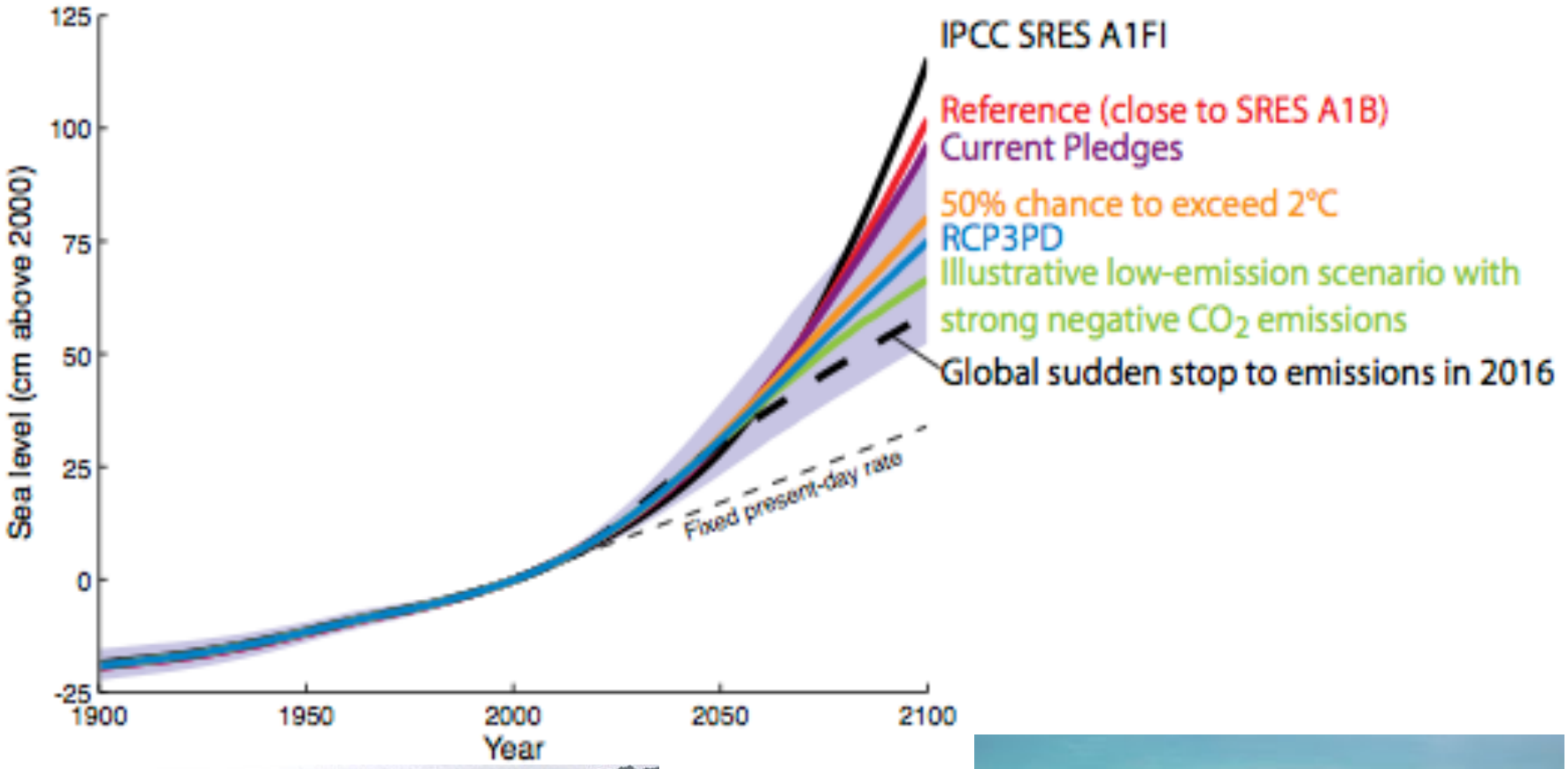
What Are The Options?

- Adaptation

- Mitigation

What Are The Options?

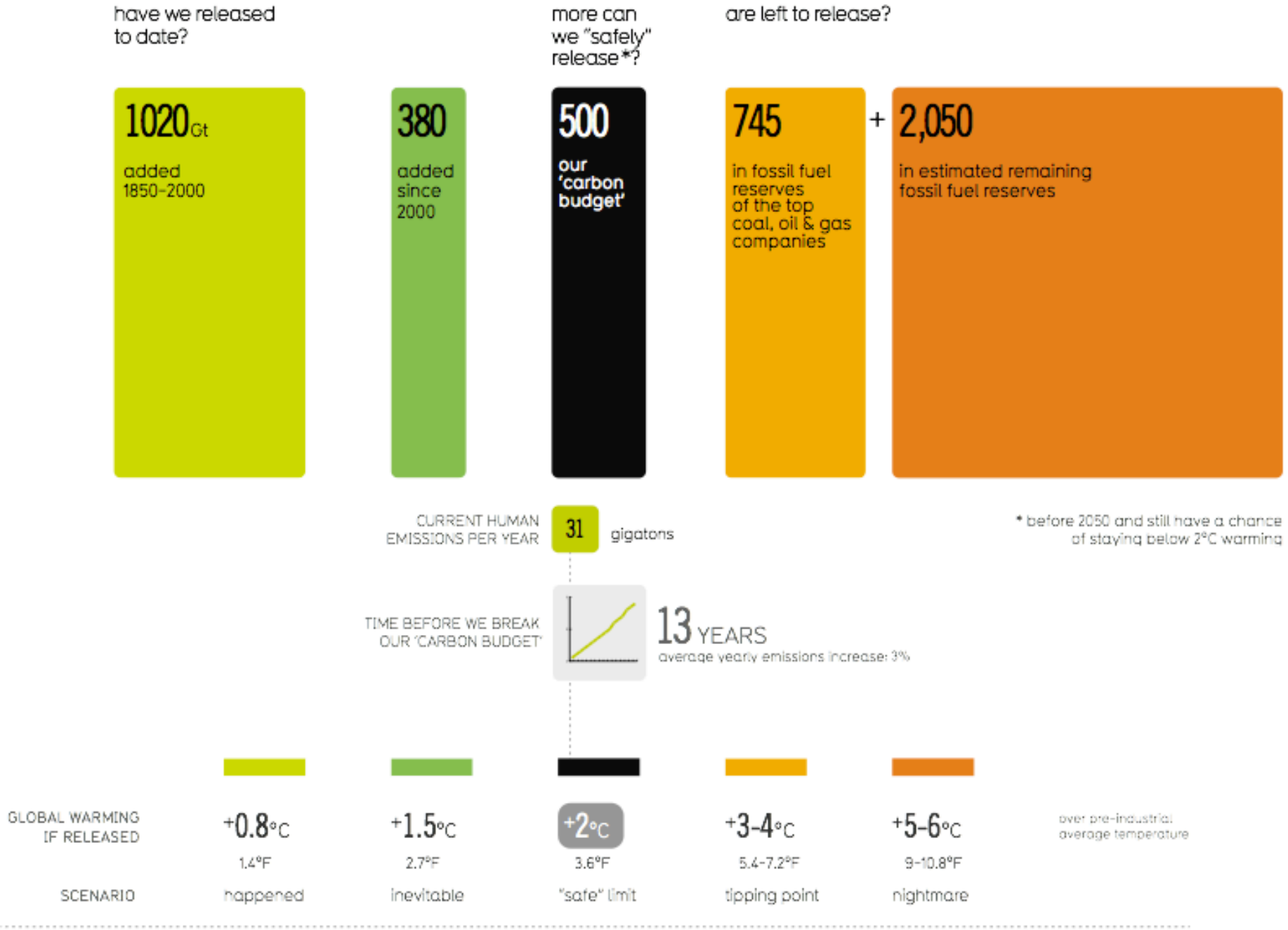
- Adaptation
  - Economic/political (relocation, tech transfer, payments for damages, reduce poverty, educate)
  - Technological (resilient tech, seawalls, genetic hybrids, cure malaria, colonize new planet)
- Mitigation



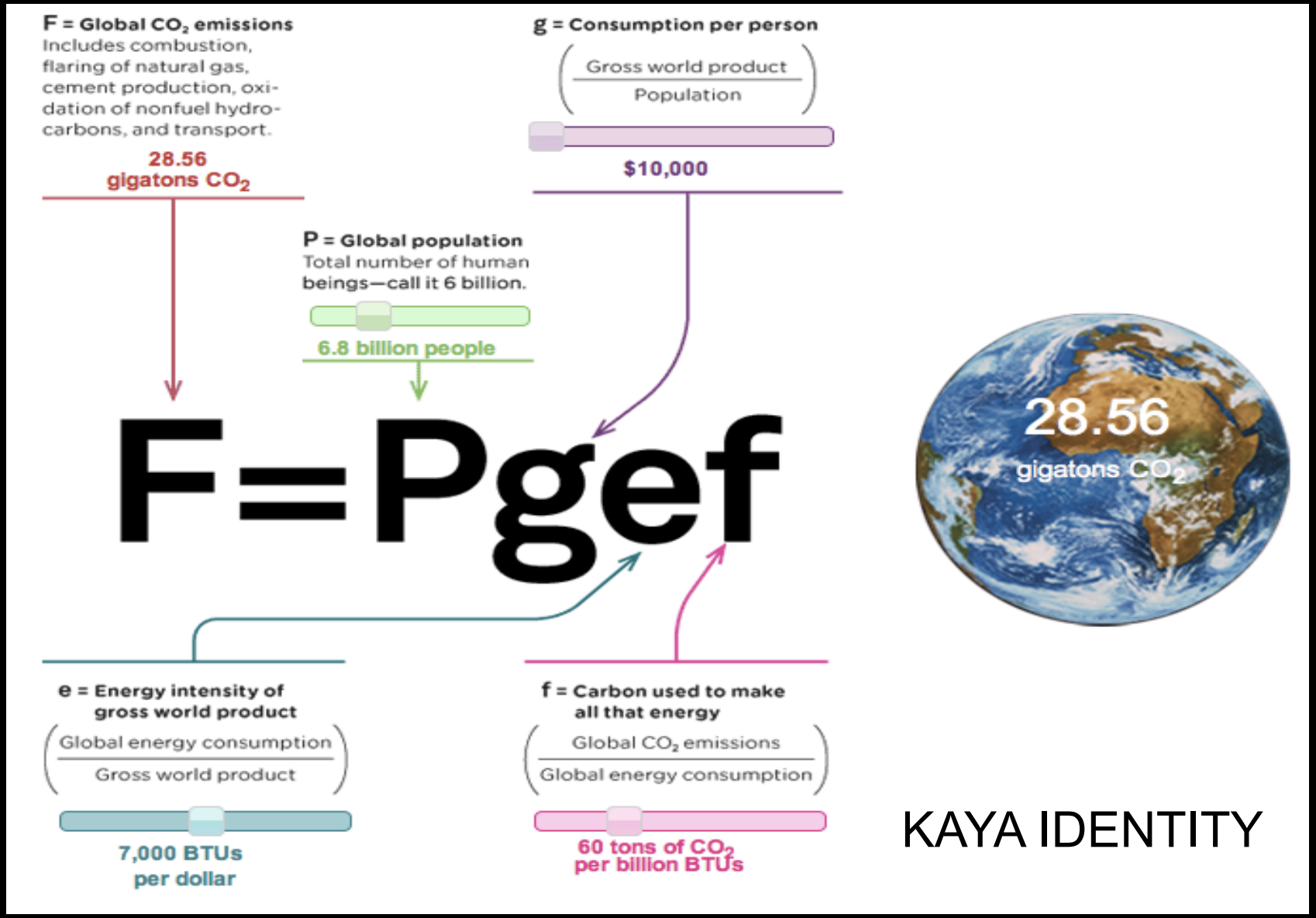
Maarten van Aalst / World Bank

What Are The Options?

- Adaptation
  - Economic/political (relocation, tech transfer, payments for damages, reduce poverty, educate)
  - Technological (resilient tech, seawalls, genetic hybrids, cure malaria, colonize new planet)
- Mitigation
  - Economic (taxes, cap and trade, R&D)
  - Regulatory (treaties, bans, compacts, fuel/energy standards, public transit, voluntary agreements)
  - Societal (sustainable development, education)
  - Technological (CO_2 capture, geoengineering, green tech, alternative energy, energy efficiency)

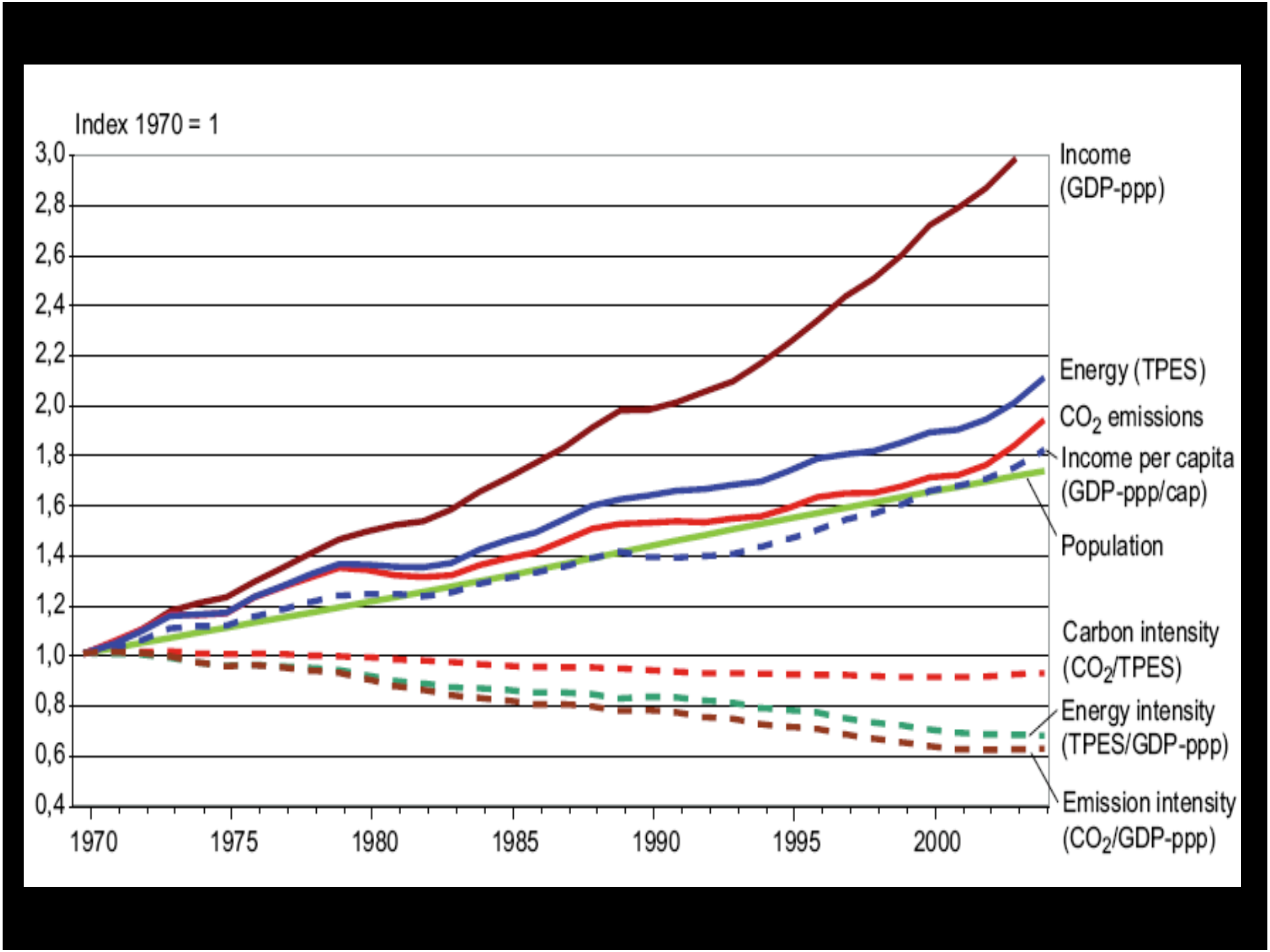


http://www.informationisbeautiful.net/2012/how-many-gigatons-of-co2/



KAYA IDENTITY

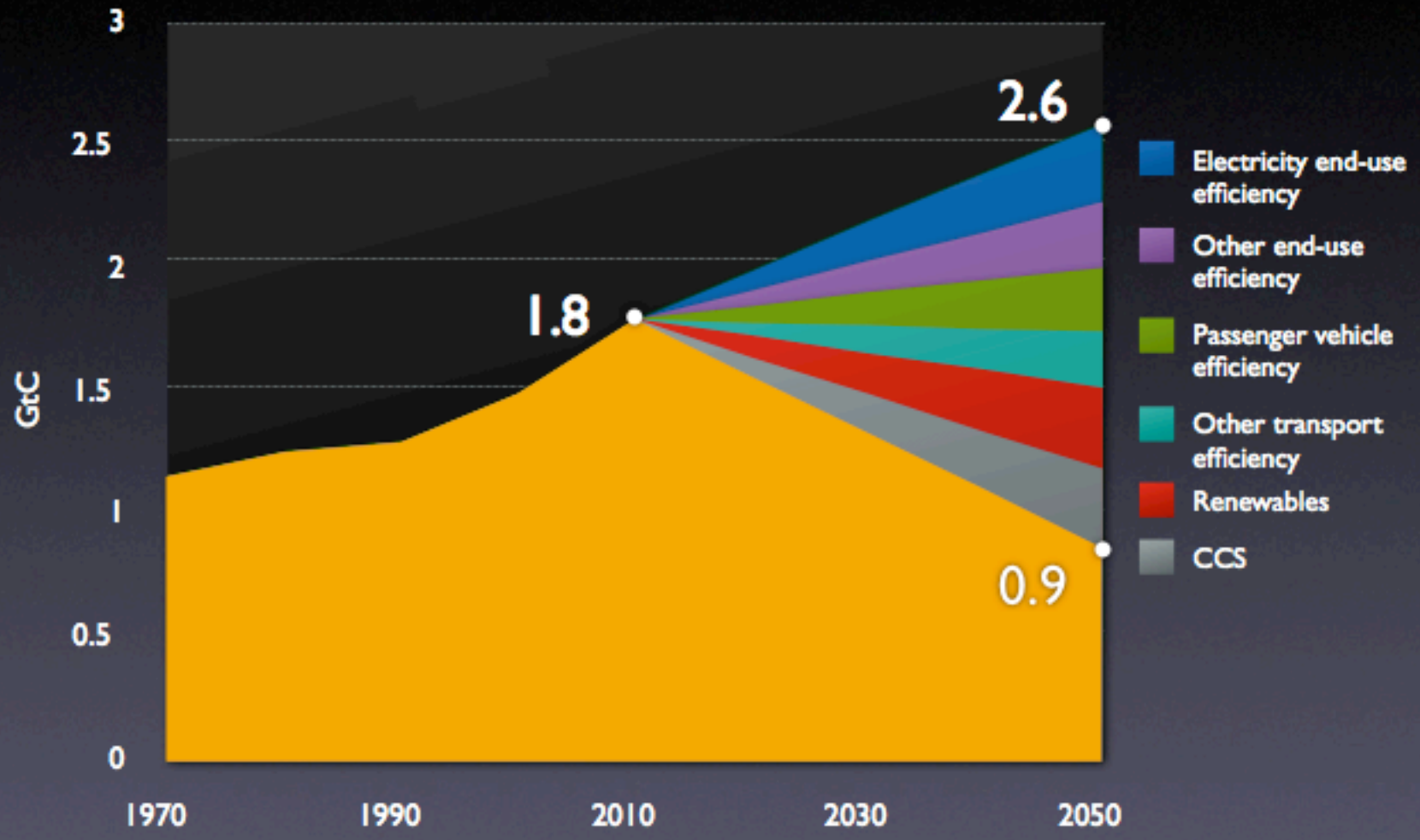
http://climatemodels.uchicago.edu/kaya/


Index 1970 = 1
3,0
2,8
2,6
2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
1970
1975
1980
1985
1990
1995
2000
Income (GDP-ppp)
Energy (TPES)
CO2 emissions
Income per capita (GDP-ppp/cap)
Population
Carbon intensity (CO2/TPES)
Energy intensity (TPES/GDP-ppp)
Emission intensity (CO2/GDP-ppp)

U.S. Emissions

After Pacala and Socolow, 2004;
ARI CarBen3 Spreadsheet

- Carbon Capture & Storage



Why is climate policy so hard?

1990

SO, THIS CLIMATE CHANGE THING COULD BE A PROBLEM...

1995

CLIMATE CHANGE: DEFINITELY A PROBLEM.

2001

YEP, WE SHOULD REALLY BE GETTING ON WITH SORTING THIS OUT PRETTY SOON...

2007

LOOK, SORRY TO SOUND LIKE A BROKEN RECORD HERE...

2013

WE REALLY HAVE CHECKED AND WE'RE NOT MAKING THIS UP.

2019

IS THIS THING ON?

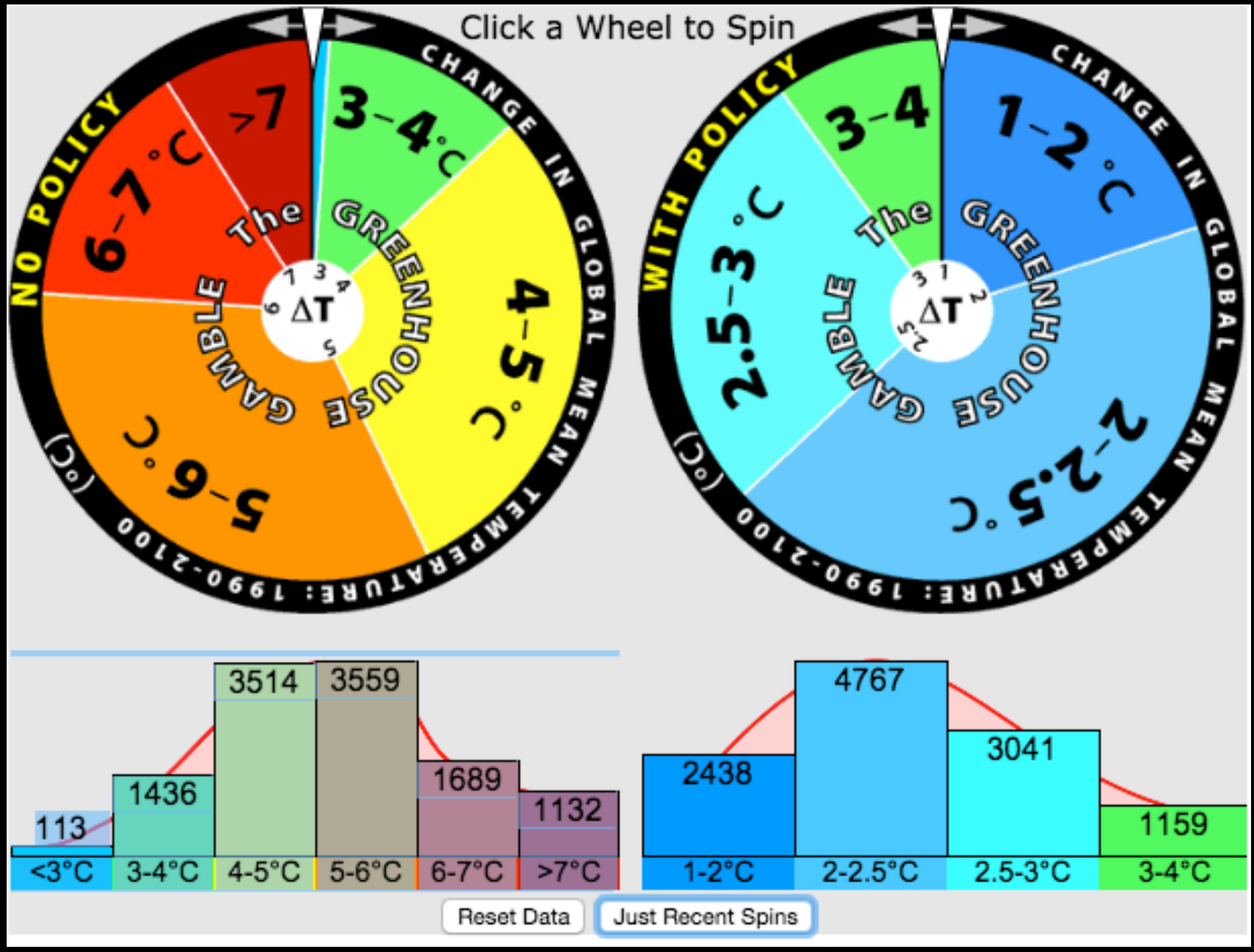
TAP TAP TAP

KUDELKA. 28/9/13

- “I am not a scientist myself, but my best assessment of the data is that the world is getting warmer, that human activity contributes to that warming, and that policymakers should therefore consider the risk of negative consequences.”

  – Sept. 2012

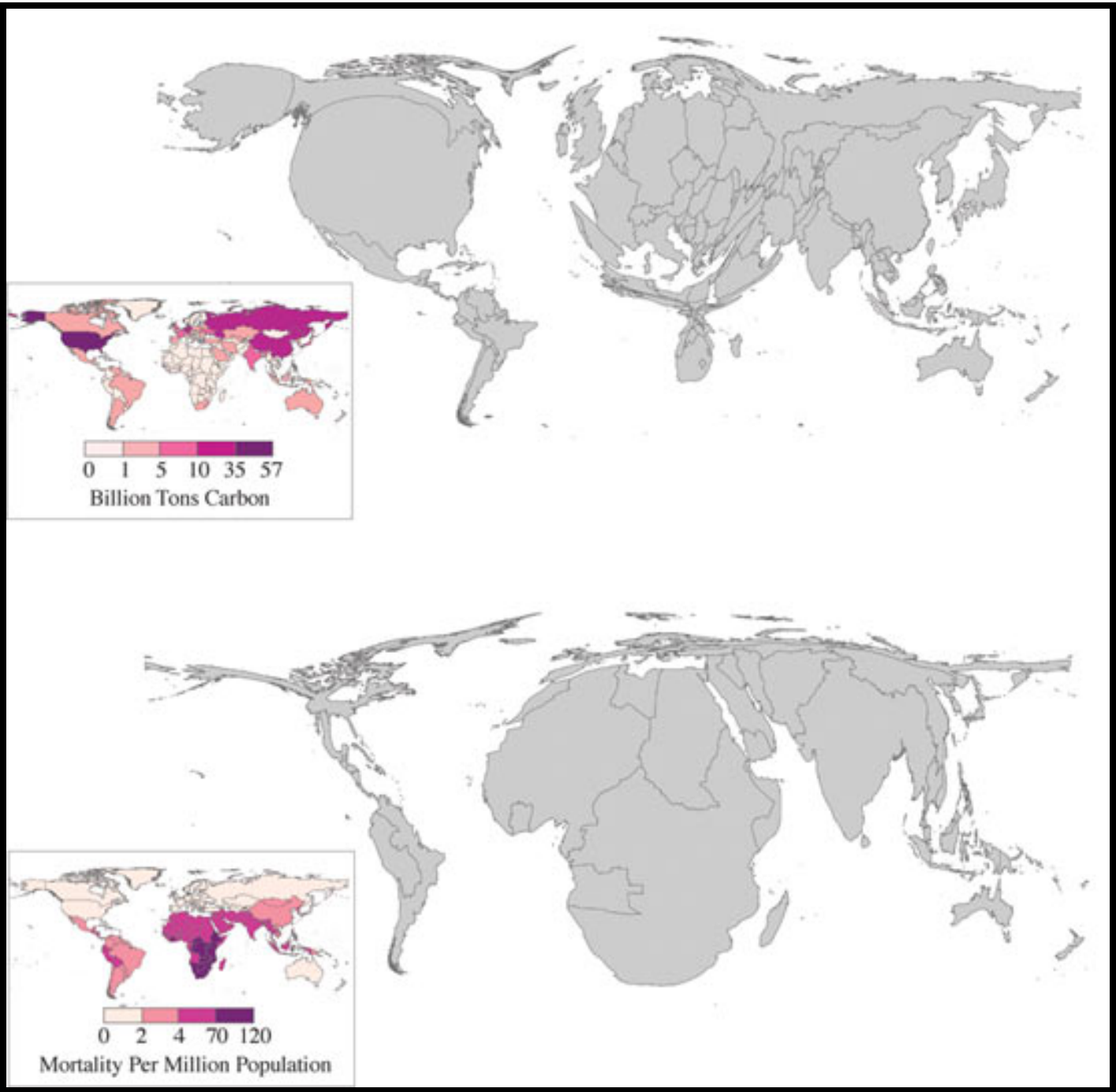
http://www.sciencedebate.org/debate12/

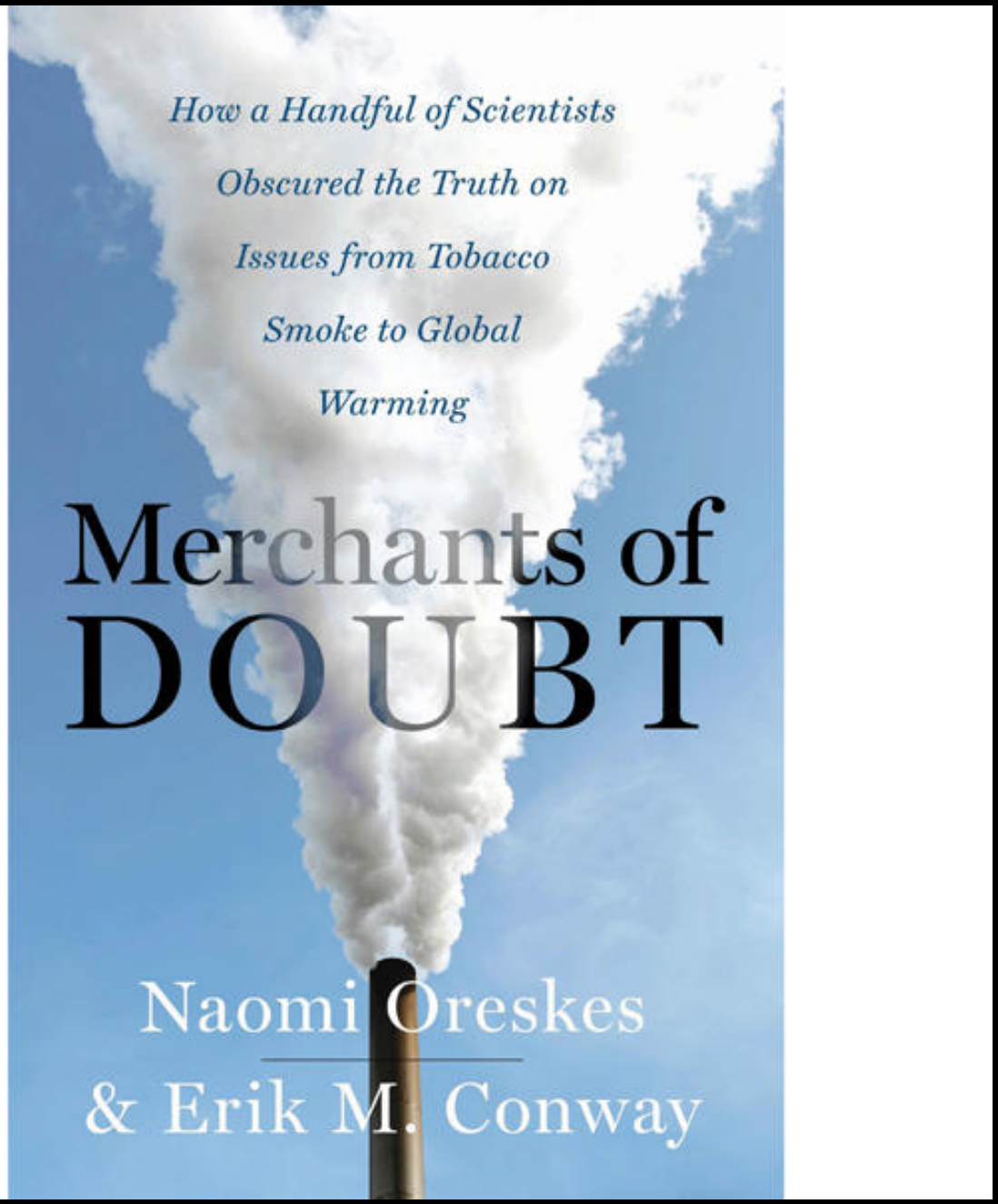


http://globalchange.mit.edu/focus-areas/uncertainty/gamble

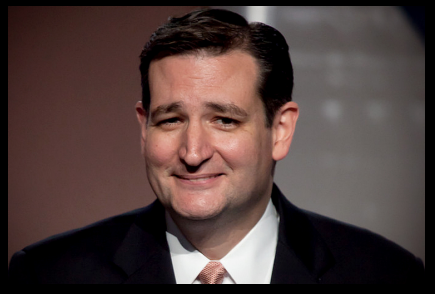
- “Higher temperatures and less-predictable weather would hurt poor farmers, most of whom live on the edge and can be devastated by a single bad crop. […] It would be a terrible injustice to let climate change undo any of the past half-century’s progress against poverty and disease—and doubly unfair because the people who will be hurt the most are the ones doing the least to cause the problem.”

Linkedin.com


0 1 5 10 35 57
Billion Tons Carbon
0 2 4 70 120
Mortality Per Million Population

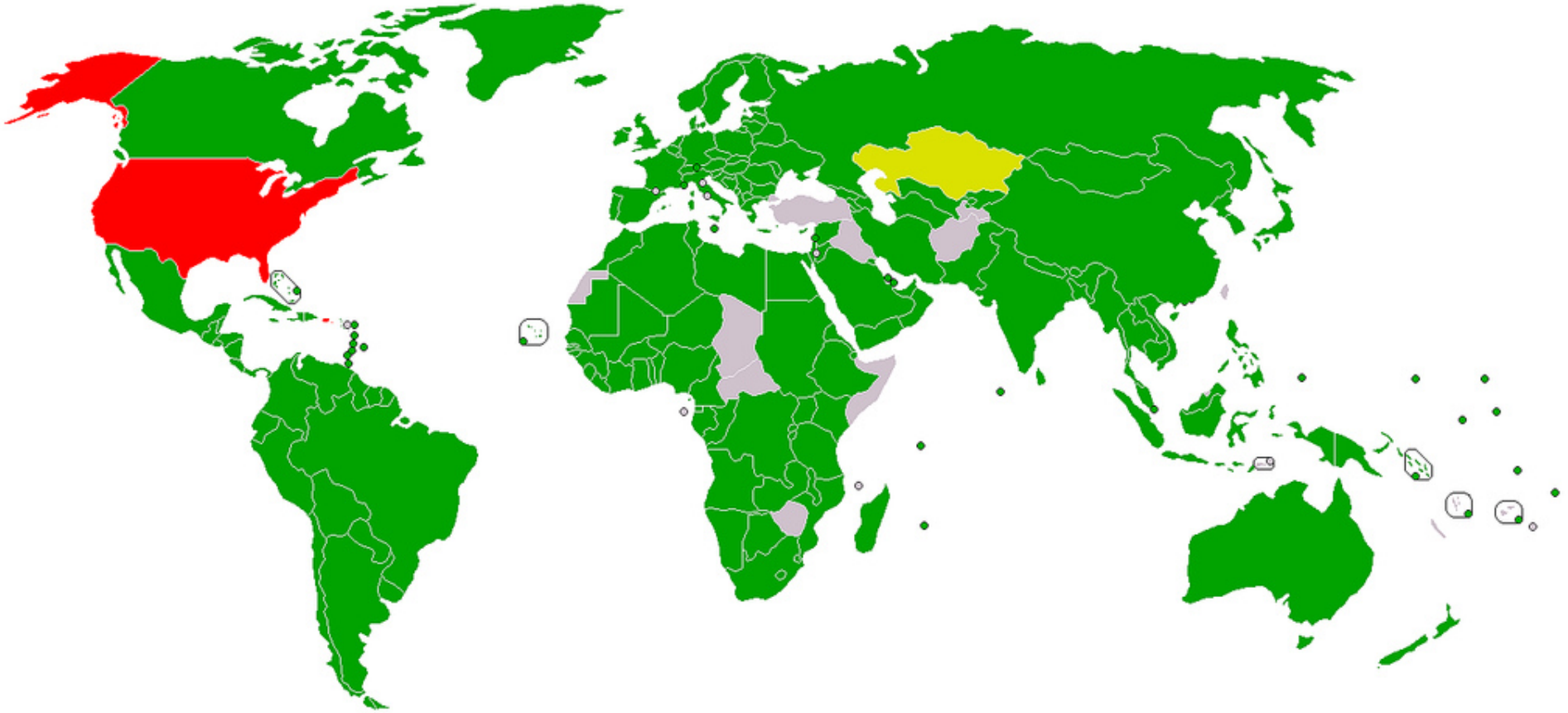

How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming
Merchants of DOUBT
Naomi Oreskes
& Erik M. Conway

- “If you look at global warming alarmists, they don't like to look at the actual facts and the data. The satellite data demonstrate that there has been no significant warming whatsoever for 17 years. […] I read this morning a Newsweek article from the 1970s talking about global cooling. And it said the science is clear, it is overwhelming, we are in a major cooling period... Now, the data proved to be not backing up that theory. So then all the advocates of global cooling suddenly shifted to global warming […] and the **solution interestingly enough was the exact same solution -- government control of the energy sector and every aspect of our lives.**”



Washington Post, 2 Aug 2015

UNFCCC and Kyoto Protocol and the Paris Agreement

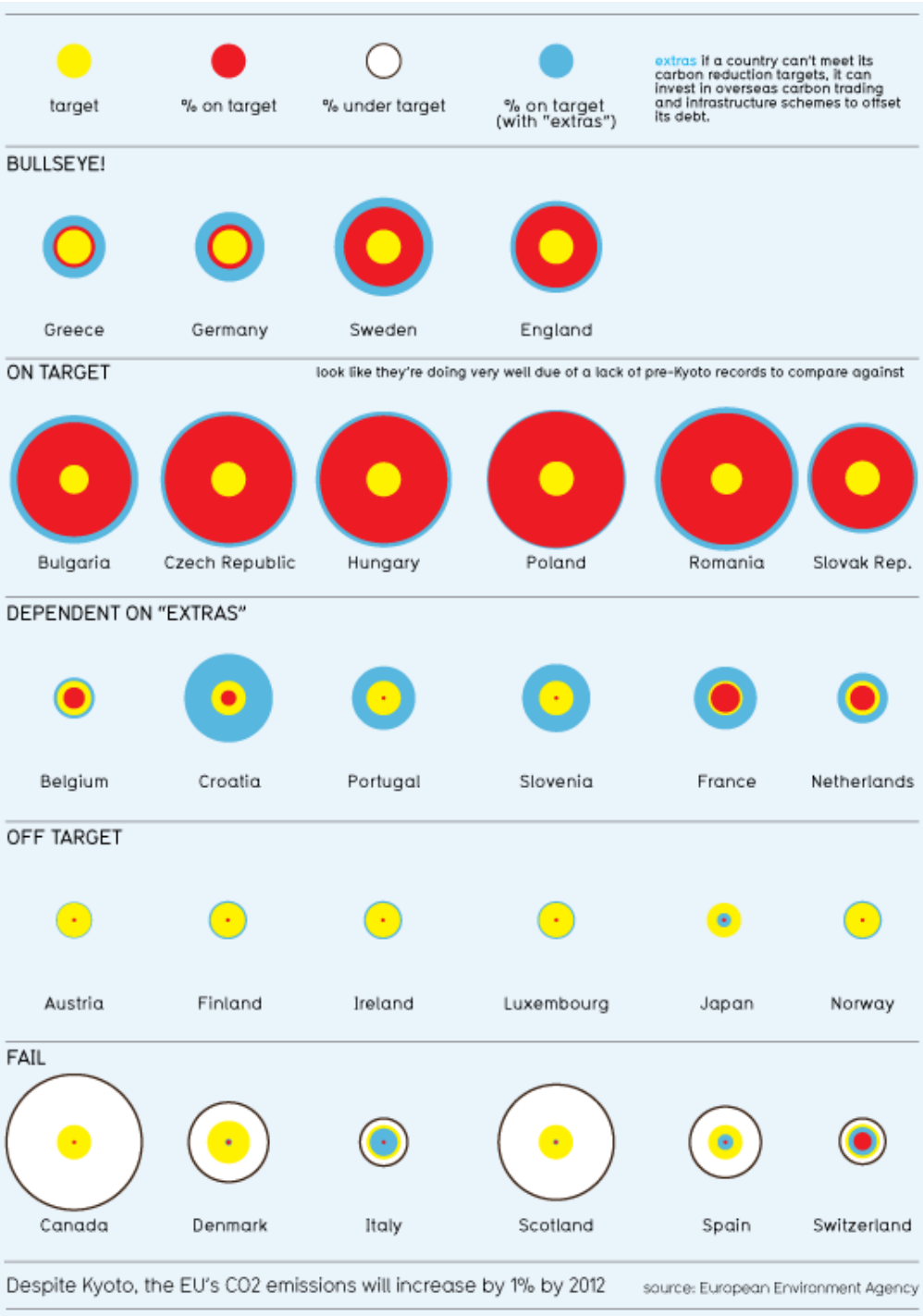


Signed and Ratified

Signed with intent to Ratify

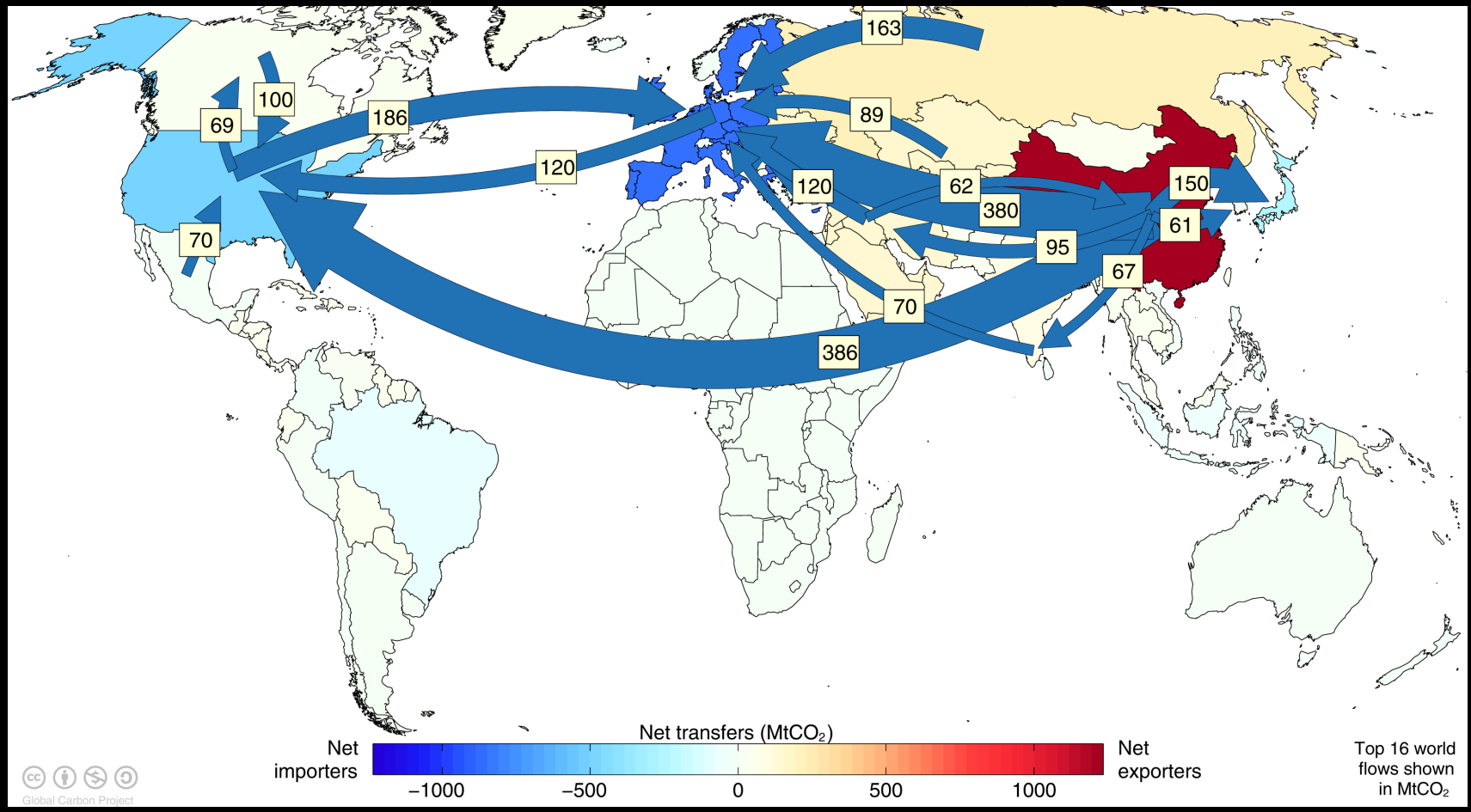
Signed with no intent to Ratify

Non-Signatory



Major flows from production to consumption

Flows from location of generation of emissions to location of consumption of goods and services

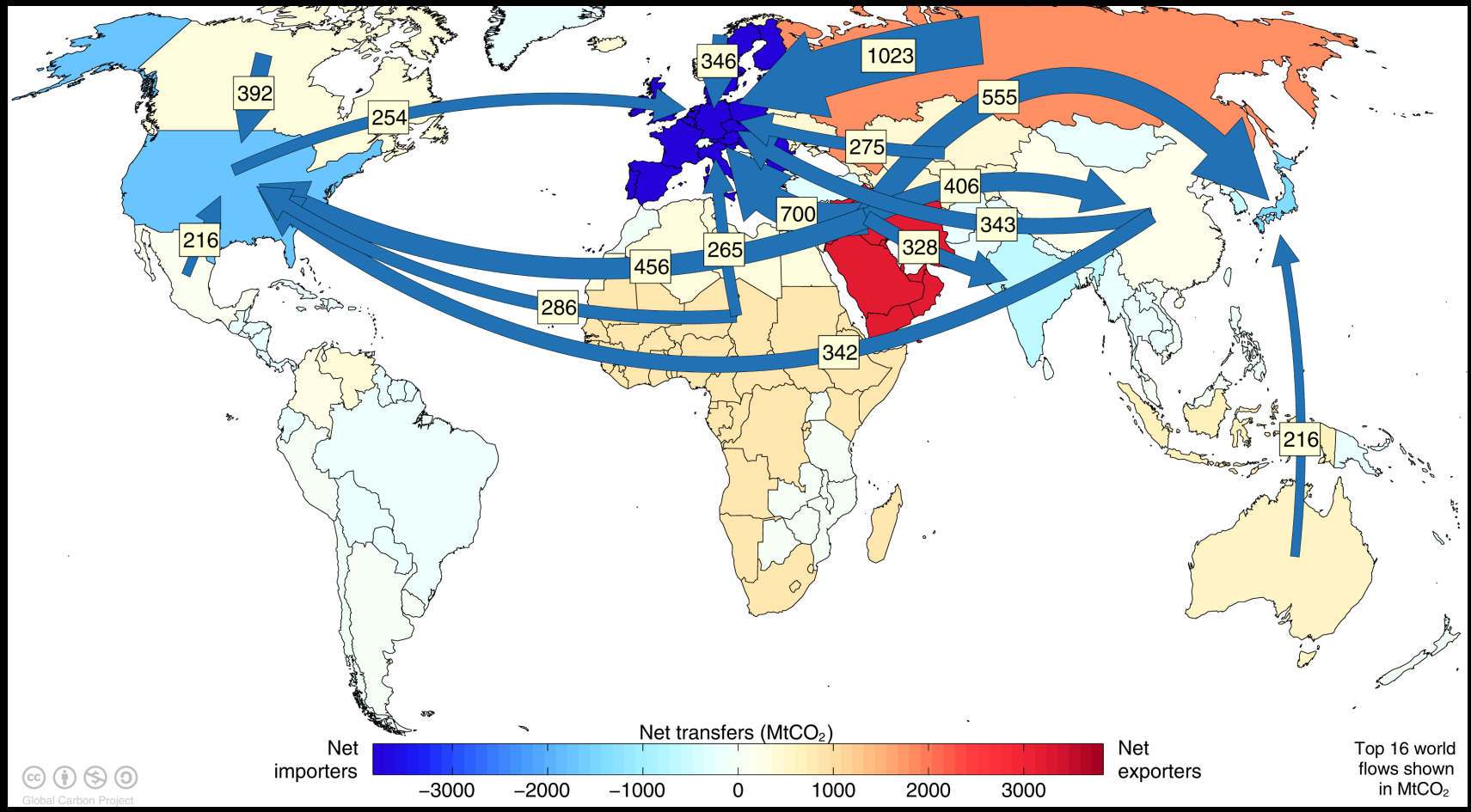


Values for 2011. EU is treated as one region. Units: $MtCO_2$

Source: Peters et al 2012

Major flows from extraction to consumption

Flows from location of fossil fuel extraction to location of consumption of goods and services



Values for 2011. EU is treated as one region. Units: $MtCO_2$

Source: Andrew et al 2013

Paris

- Refocuses goal on temperature below 2 C limit (global emissions will need to peak in <20 years, sources must balance sinks by 2050)
- Lets countries determines their contribution
- $100 billion fund for developing countries
- Is set to be in force, now that > 55% of emissions included in ratified countries*
- Compliance and monitoring will be a key challenge

The future?

- Climate scientists will continue to refine projections of future change and impacts in response to emissions and/or policy
- Global treaty progress will likely be slow, but there are successes in deforestation reduction, developing country support, and renewal energy infrastructure
- Bi- or Multi- lateral agreements (e.g., US-China) and within country “energy arms race” may end up having the biggest bang for buck
- Fossil fuel reserves are getting scarcer, but not running out anytime soon. Given lags in climate response, some level of adaptation is inevitable
- The US election just threw a really big monkey-wrench into the whole thing

DISCUSSION?