POTSDAM INSTITUTE FOR
CLIMATE IMPACT RESEARCH

The carbon story of mankind
&
deep decarbonisation opportunities

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Leibniz Association

Outline

1. The carbon story of mankind

2. Why should we care?

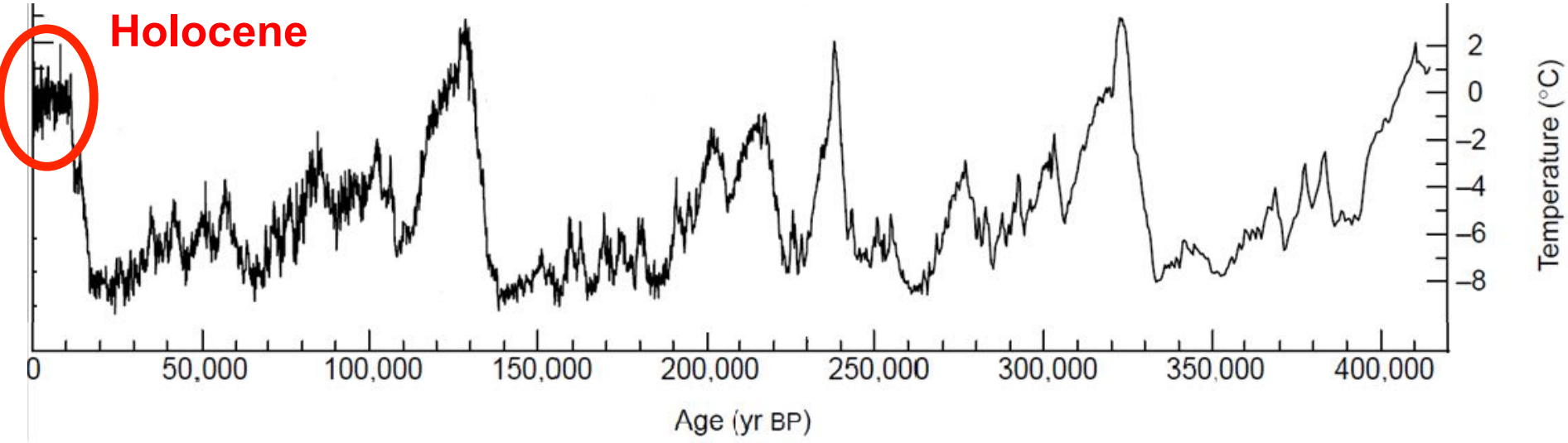
3. How to proceed?

4. Decarbonization

PART 1:
THE CARBON STORY OF MANKIND

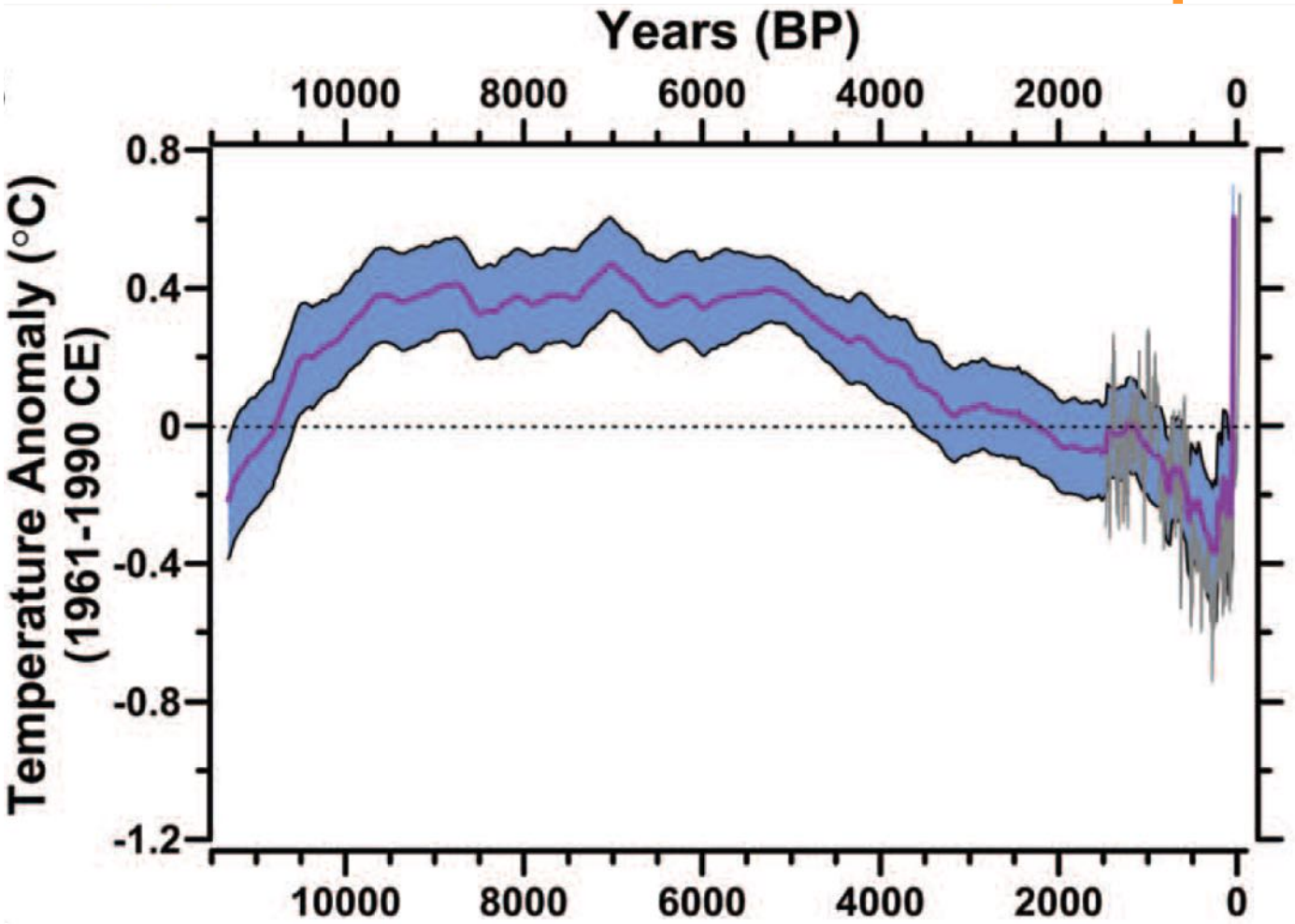
PIK

The climate story of mankind



Source: Petit et al. 1999 (Nature)

Global Reconstruction of Holocene Temperature

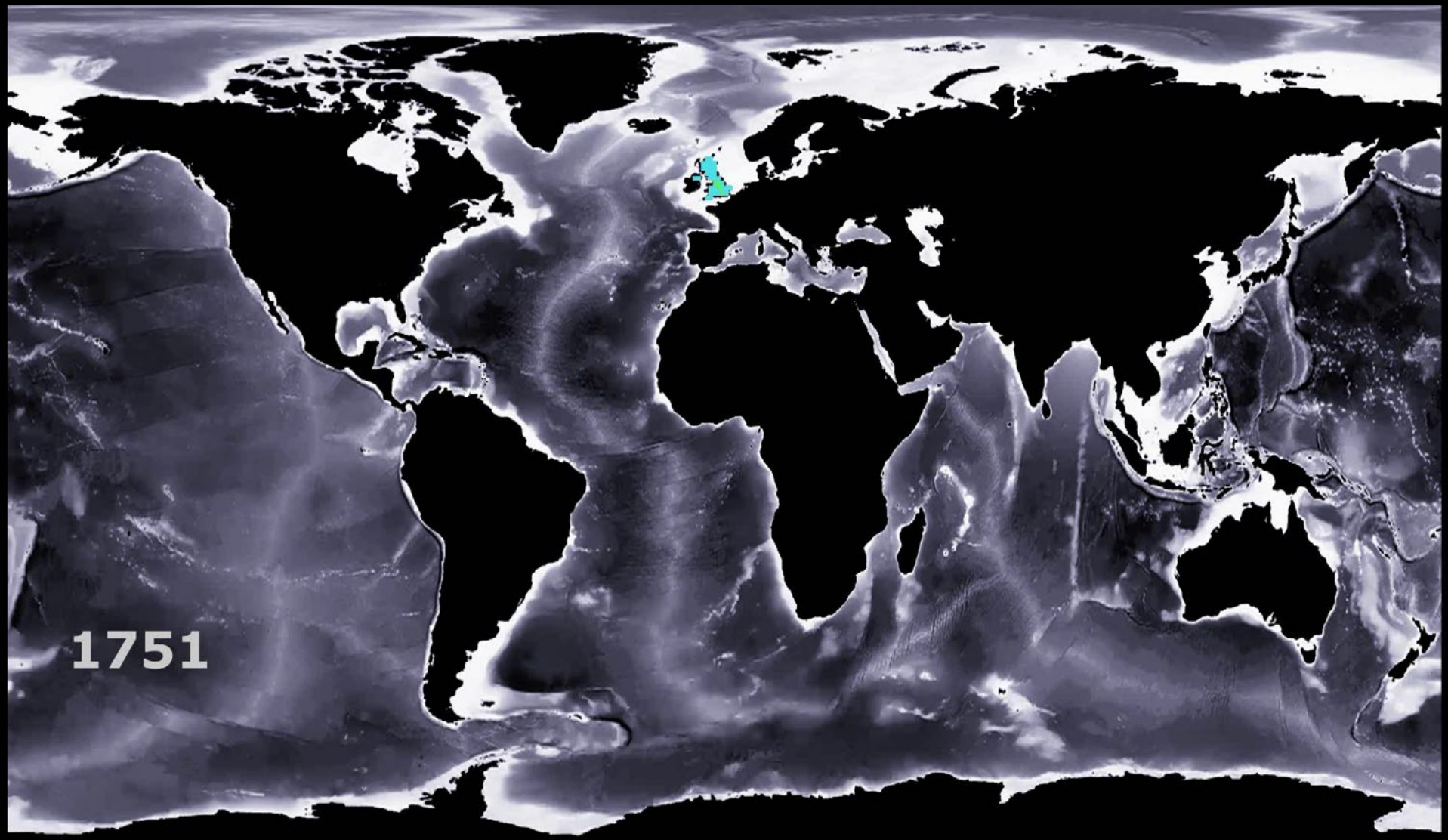


The temperature has been reconstructed with proxy data (mainly from sediment cores) and was calibrated with observational data for the period 1850-1950, where both time series overlap. Anomalies relative to 1961-1990.

PIK

Source: Marcott et al. 2013 (Science)

The C-Story of Human Civilization

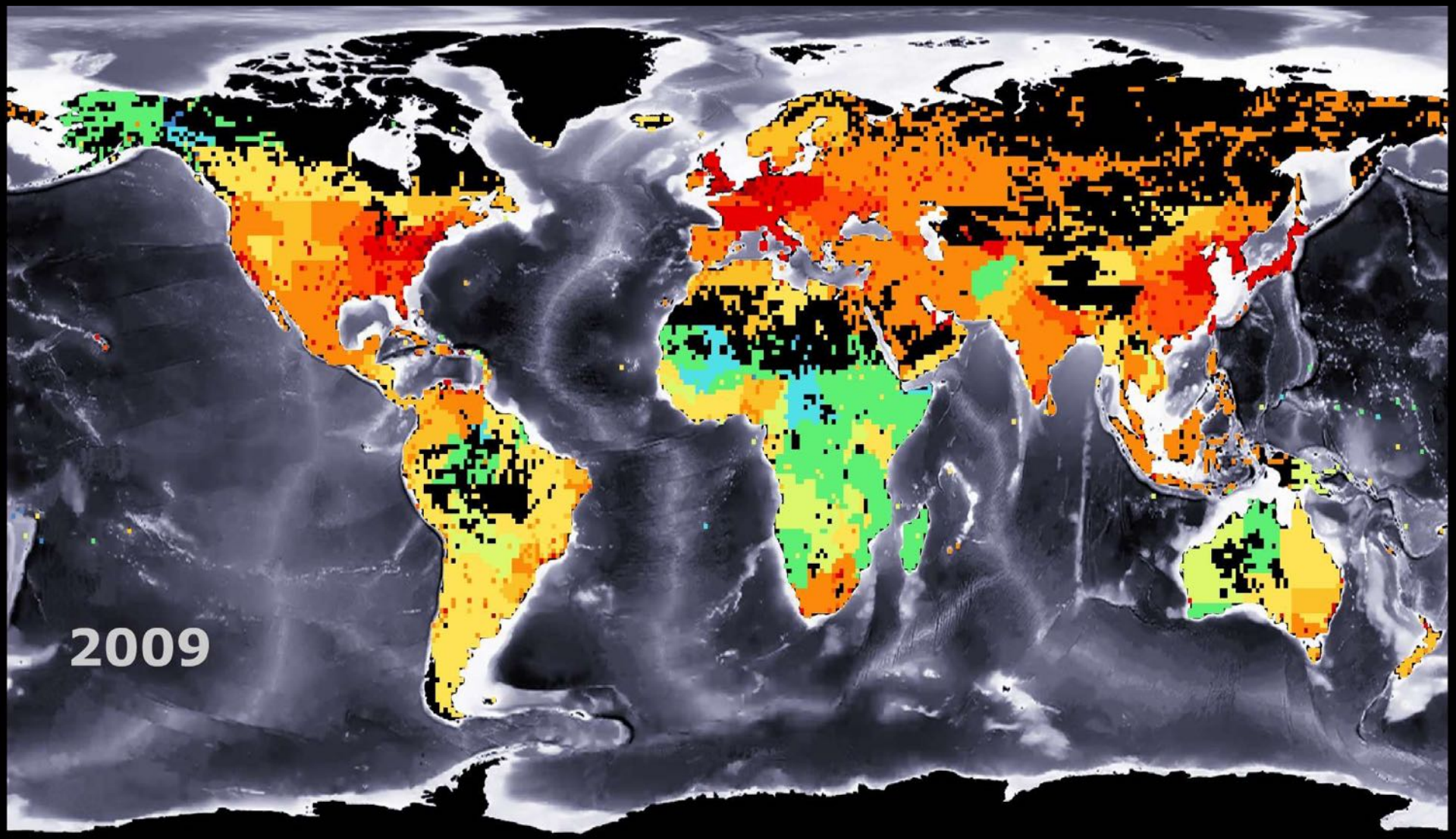


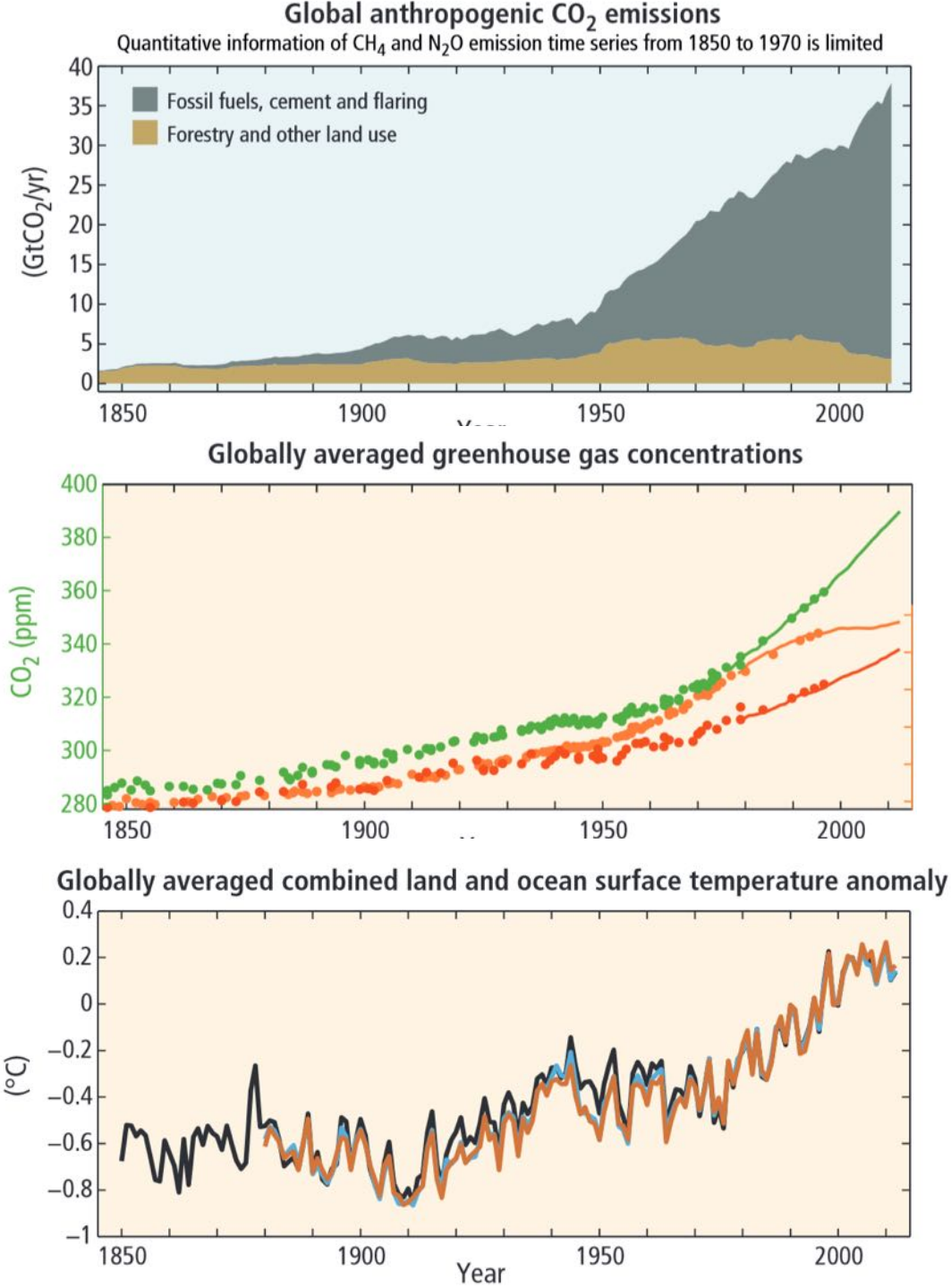
Cumulative human carbon dioxide emissions [Mt C]

0.001 0.01 0.1 1 10 100 1000

Data Source: CDIAC 2012 (Andres, R.J., T.A. Boden, and G. Marland. 2012) Bathymetry: NASA, Earth Observatory Animation: PIK 2013

The C-Story of Human Civilization

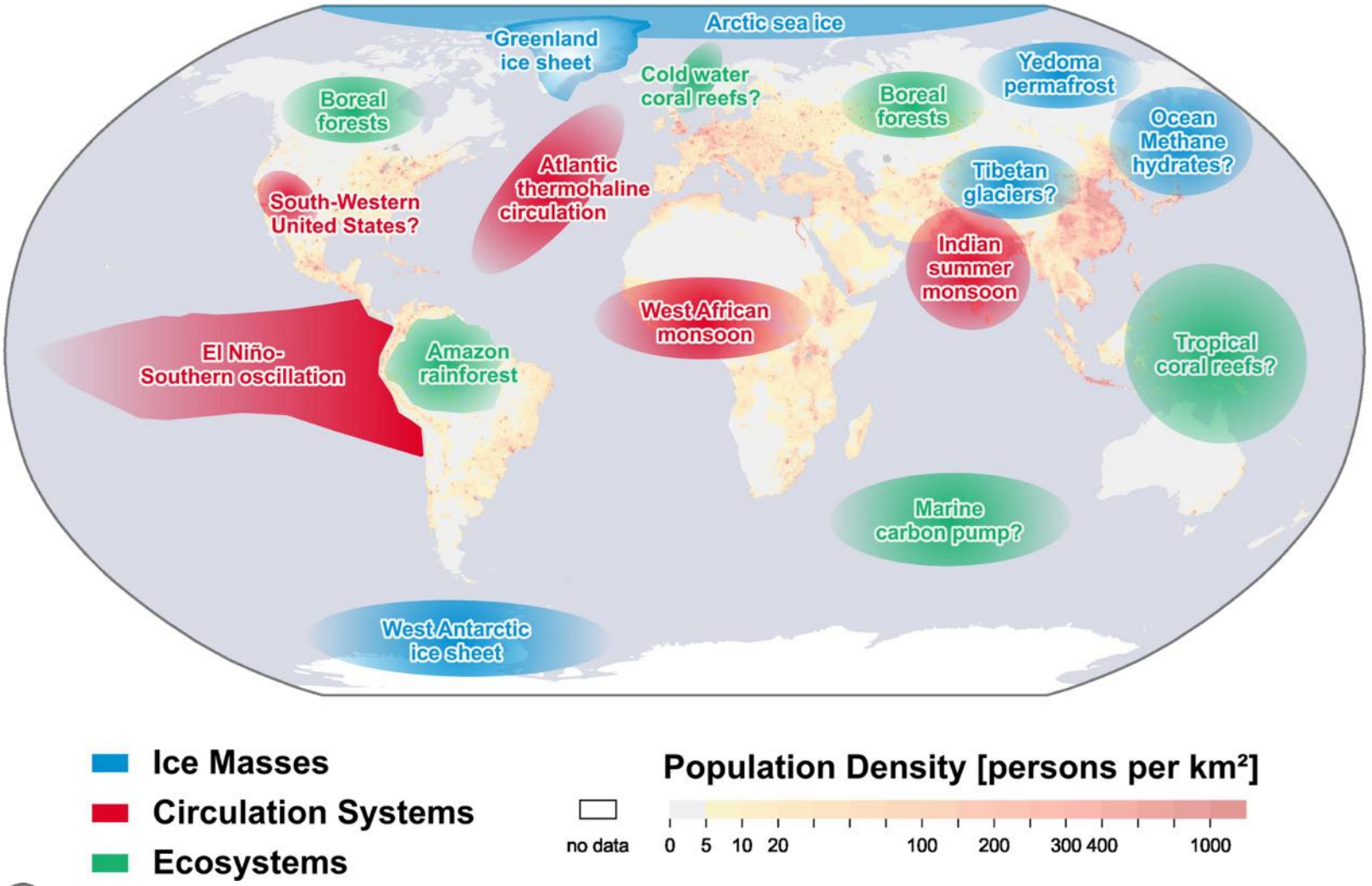




Source: IPCC AR5, Synthesis Reposrt

PART 2:
WHY SHOULD WE CARE?

Tipping Elements in the Earth System



Source: PIK, after Lenton et al. 2008 (PNAS)

Expected impacts

Impact	Effect
Vegetation shifts	Impacts on agriculture / biodiversity
Sea level rise	Coastal cities endangered displacement of humans
Changing precipitation melting snow and ice	Water resources
Ocean acidification	Risks for marine ecosystems, fisheries
More extreme events: droughts, floodings, storms, etc.	Threaten human lives destruction of infrastructure

PIK

Climate change impacts today

CNN Regions » Africa | Americas | Asia | China | Europe | Middle East | World International Edition + menu

Greenland ice melt off to record early start

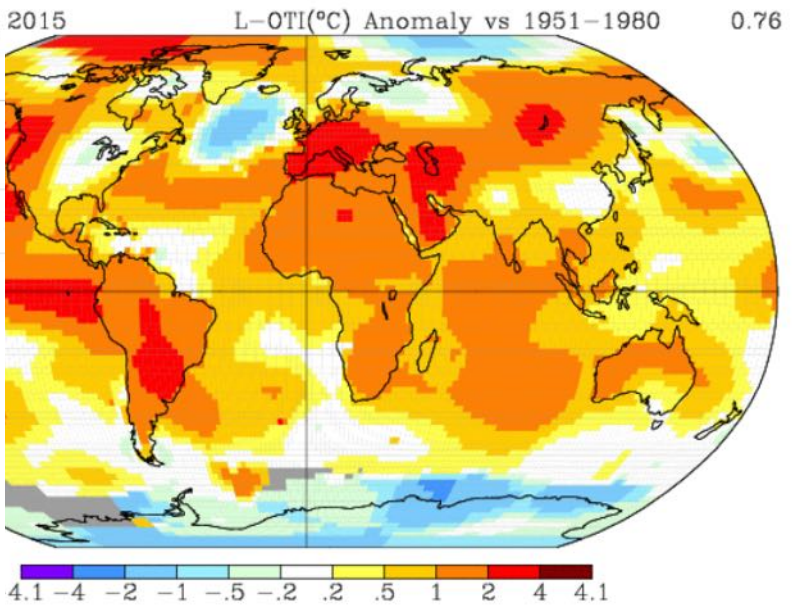
By Michael Pearson, CNN

Updated 1637 GMT (2337 HKT) April 15, 2016

The Washington Post

The summer of 2015 was Earth's hottest on record, multiple datasets show

By Jason Samenow September 17, 2015



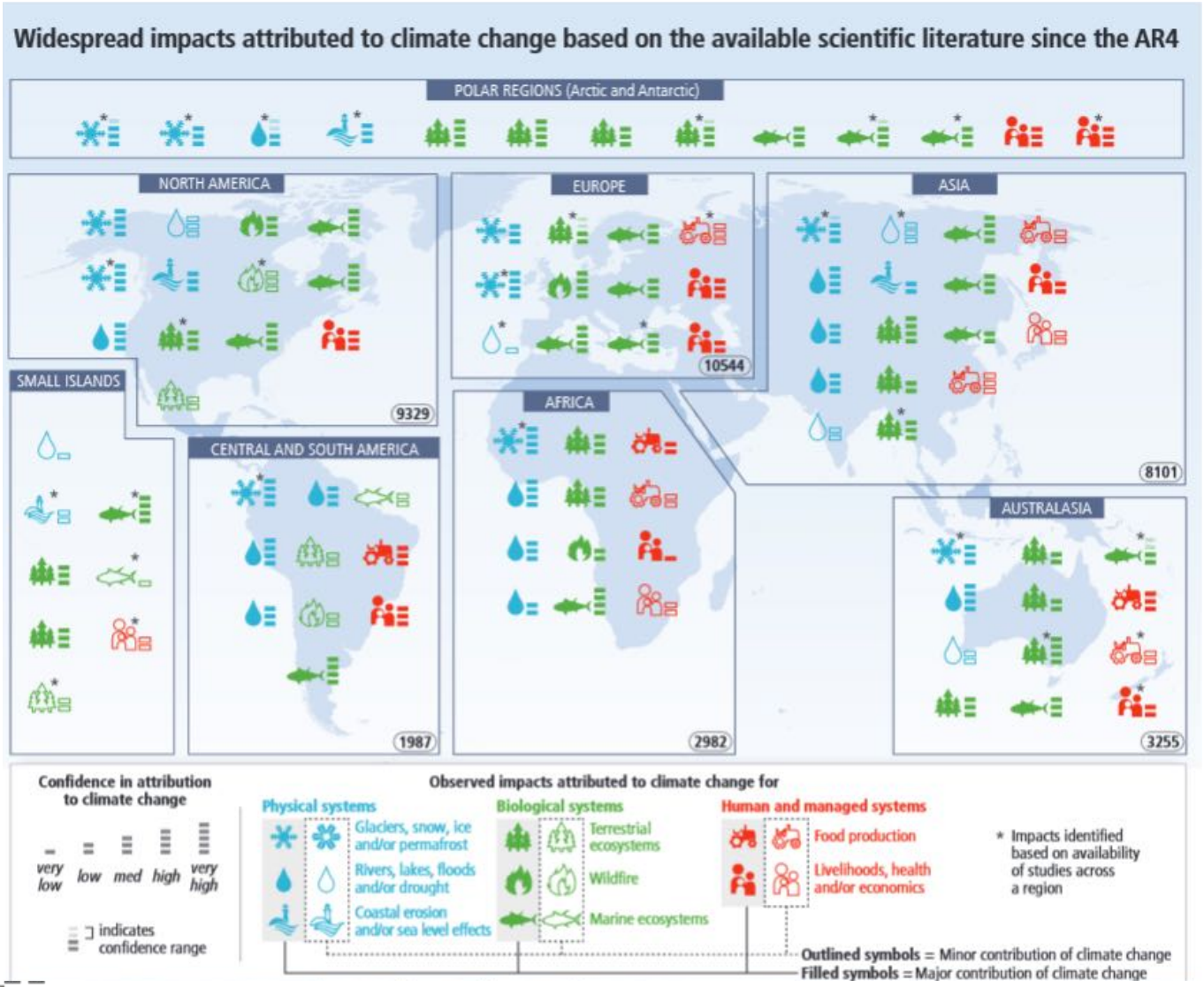
SEARCH The New York Times

Climate-Related Death of Coral Around World Alarms Scientists

By MICHELLE INNIS APRIL 9, 2016

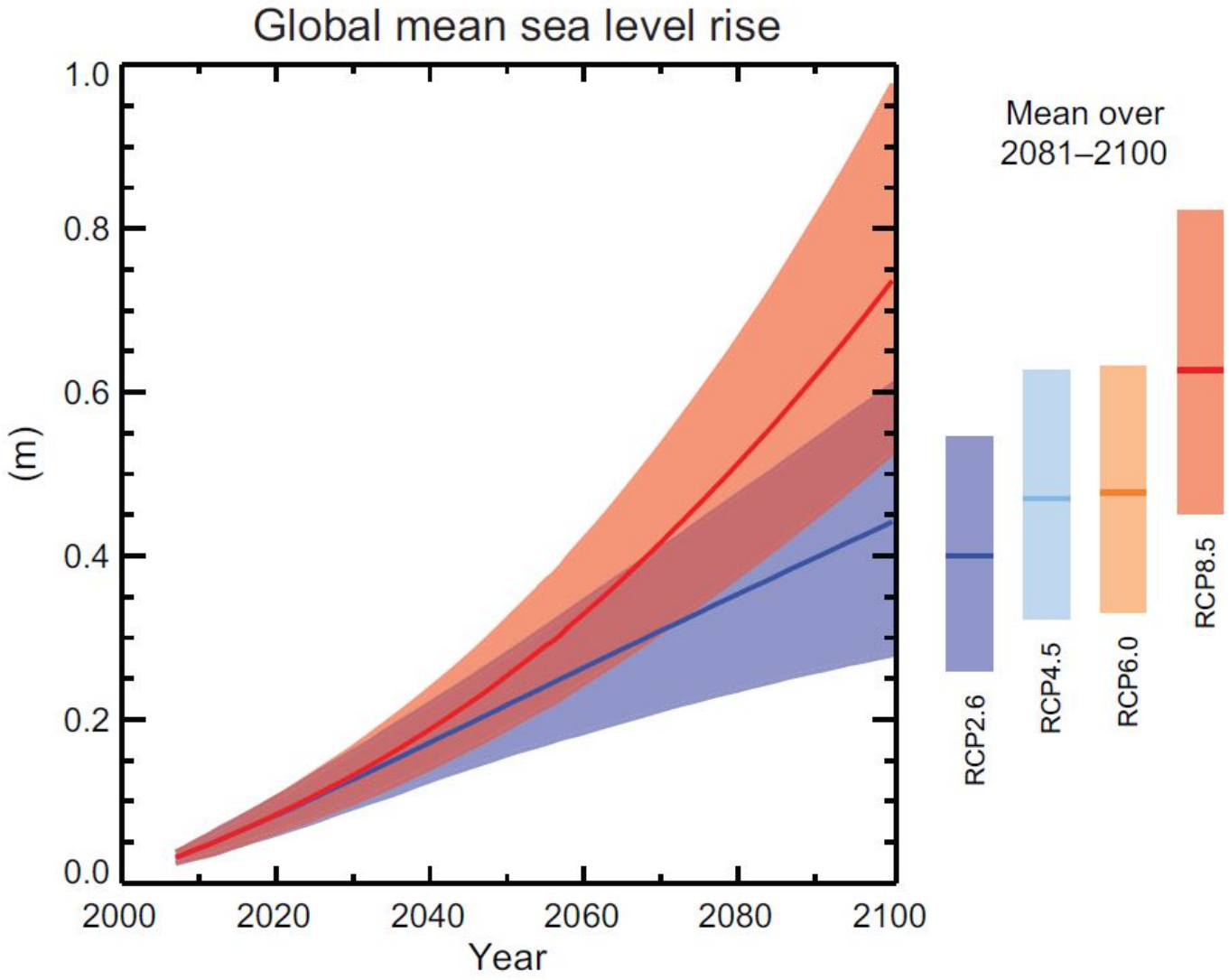
A turtle swimming over bleached coral near Heron Island, in the southern Great Barrier Reef.
XL Catlin Seaview Survey

Observed impacts



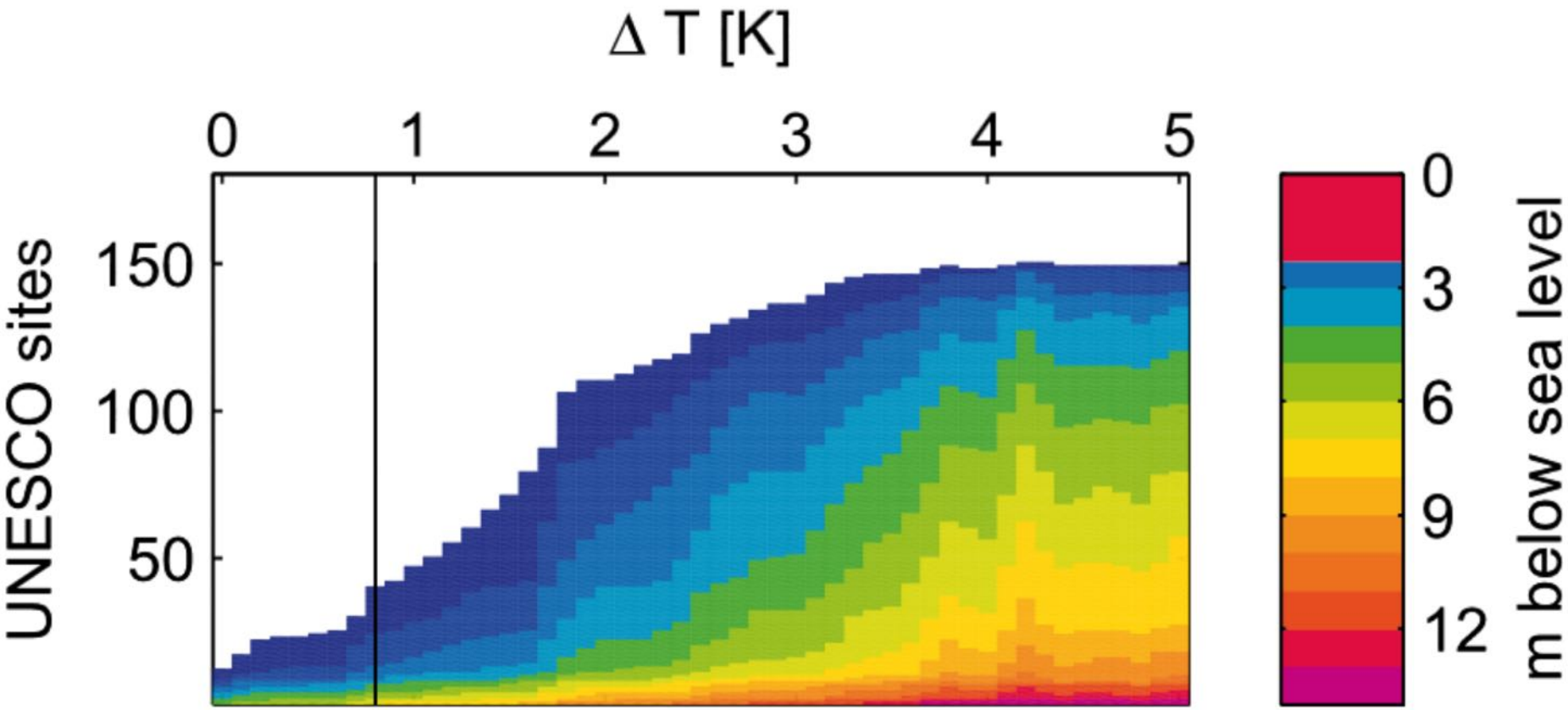
Source: IPCC AR5, Synthesis Report

Sea level rise in the 21st century



Source: IPCC AR5, WG1 SPM

UNESCO world heritage



Number of cultural UNESCO world heritage sites impacted by SLR, and depth of the sites below sea level, as a function of ΔT

Source: Marzeion and Levermann, ERL (2014)

Venice in 1000 years

Source: http://choices.climatecentral.org

PART 3:
HOW TO PROCEED?

The Paris agreement

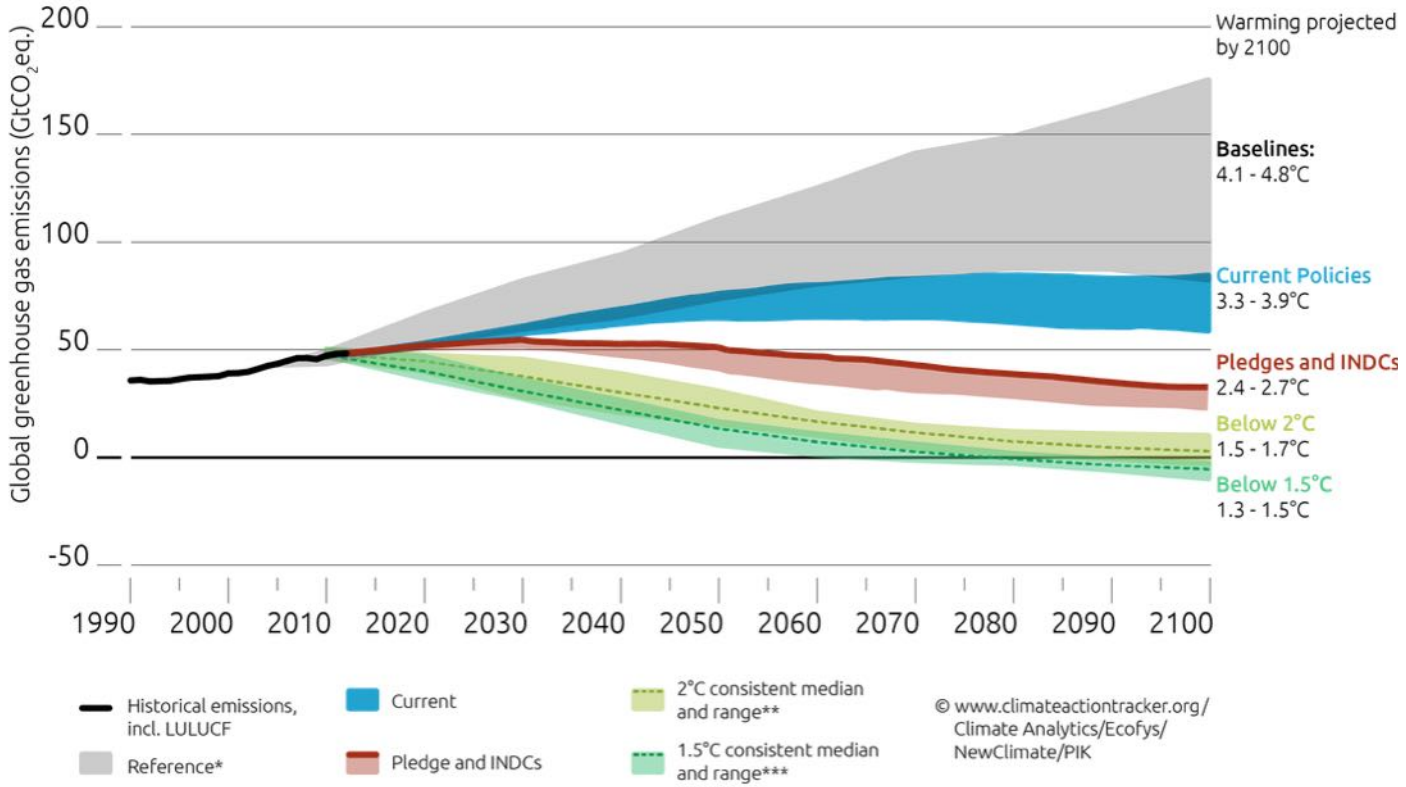
- Temperature increase **well below 2°** above pre-industrial levels
- **Balance** between anthropogenic emissions by **sources and removals** by sinks of greenhouse gases in the second half of this century
- Developed countries provide **USD 100 billion** per year
- NDCs to progress over time

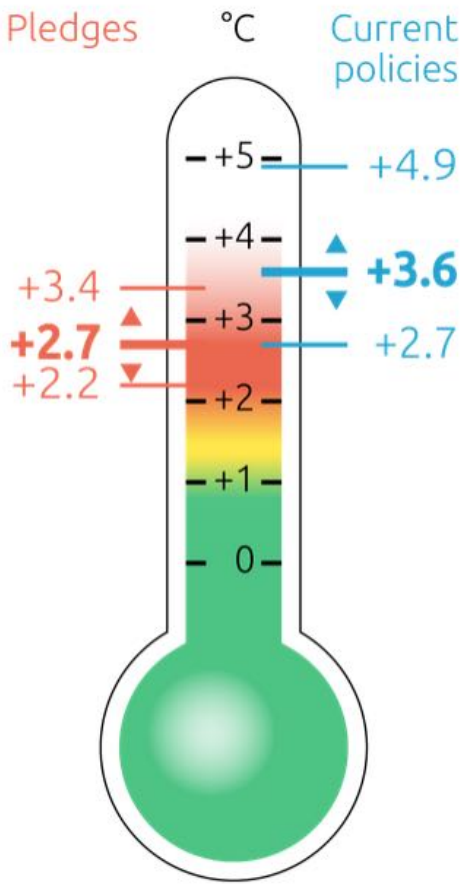
Pope Francis‘ encyclical on climate change

"It is urgent to develop policies to reduce emissions of carbon dioxide and highly polluting gases"

Pope Francis

Current policies and pledges





PIK

Source:

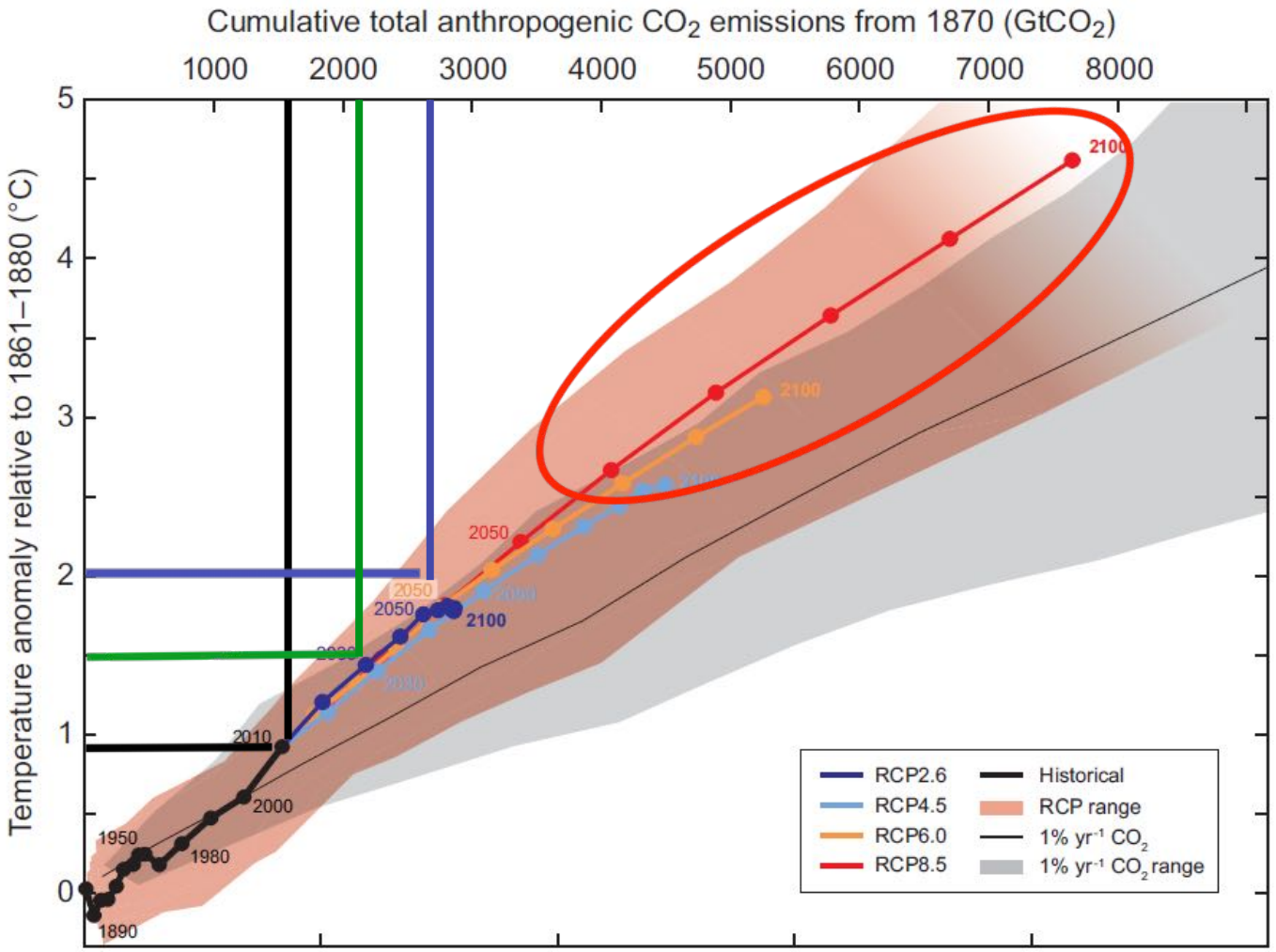
Global cumulative CO_2 budget

Today

1.5°~ 500 Gt

2° ~ 1000 Gt

3 – 5°~
4000 - 8000 Gt

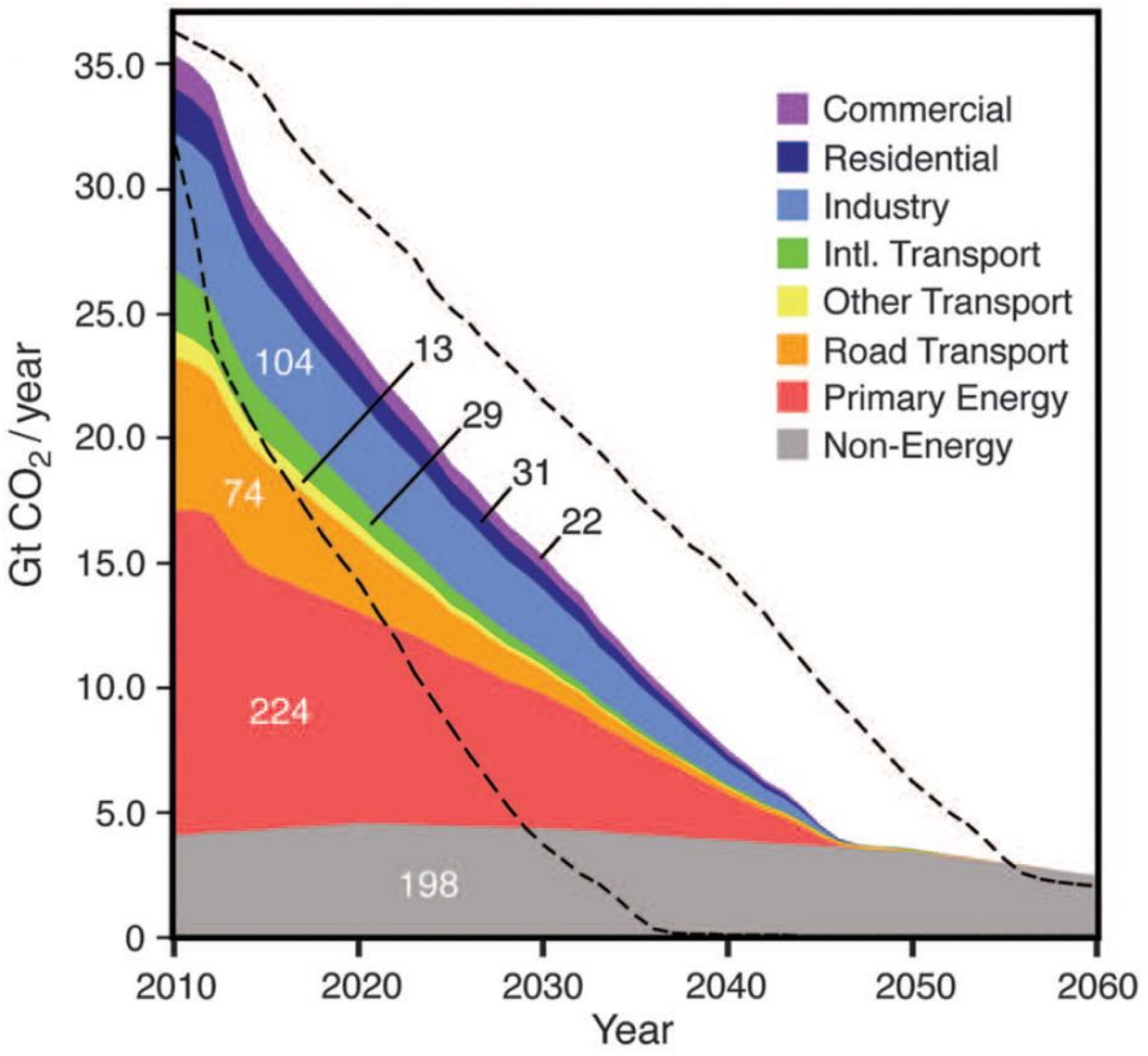


Source: IPCC AR5, WG1 SPM

Emissions from existing infrastructure

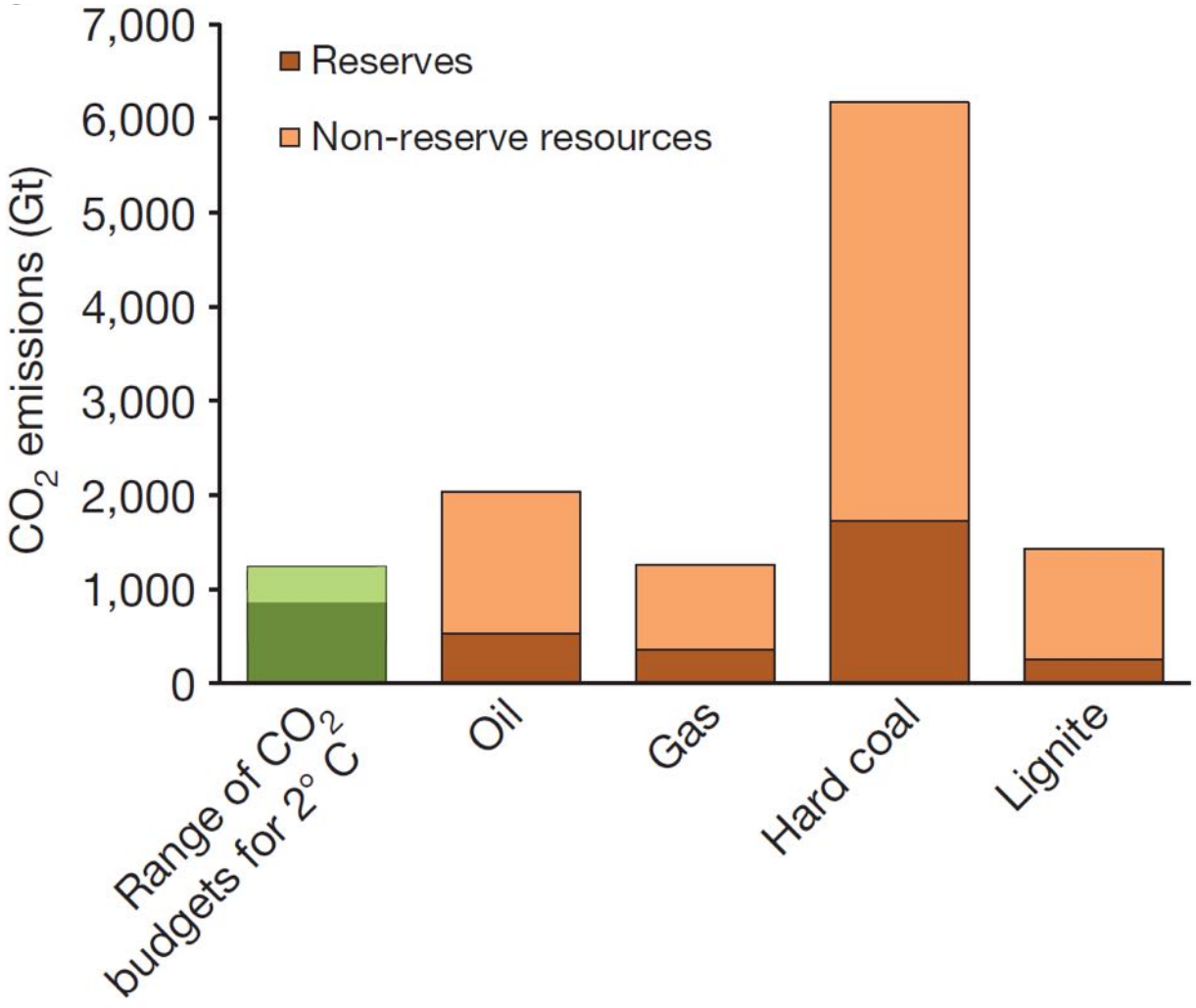
500 Gt CO_2 to be emitted from existing infrastructure 2010 – 2060

+ 200 Gt CO_2 non-energy emissions (e.g. cement production, land cover change)



Source: Davis et al., 2010 (Science)

Unburnable fossil fuels

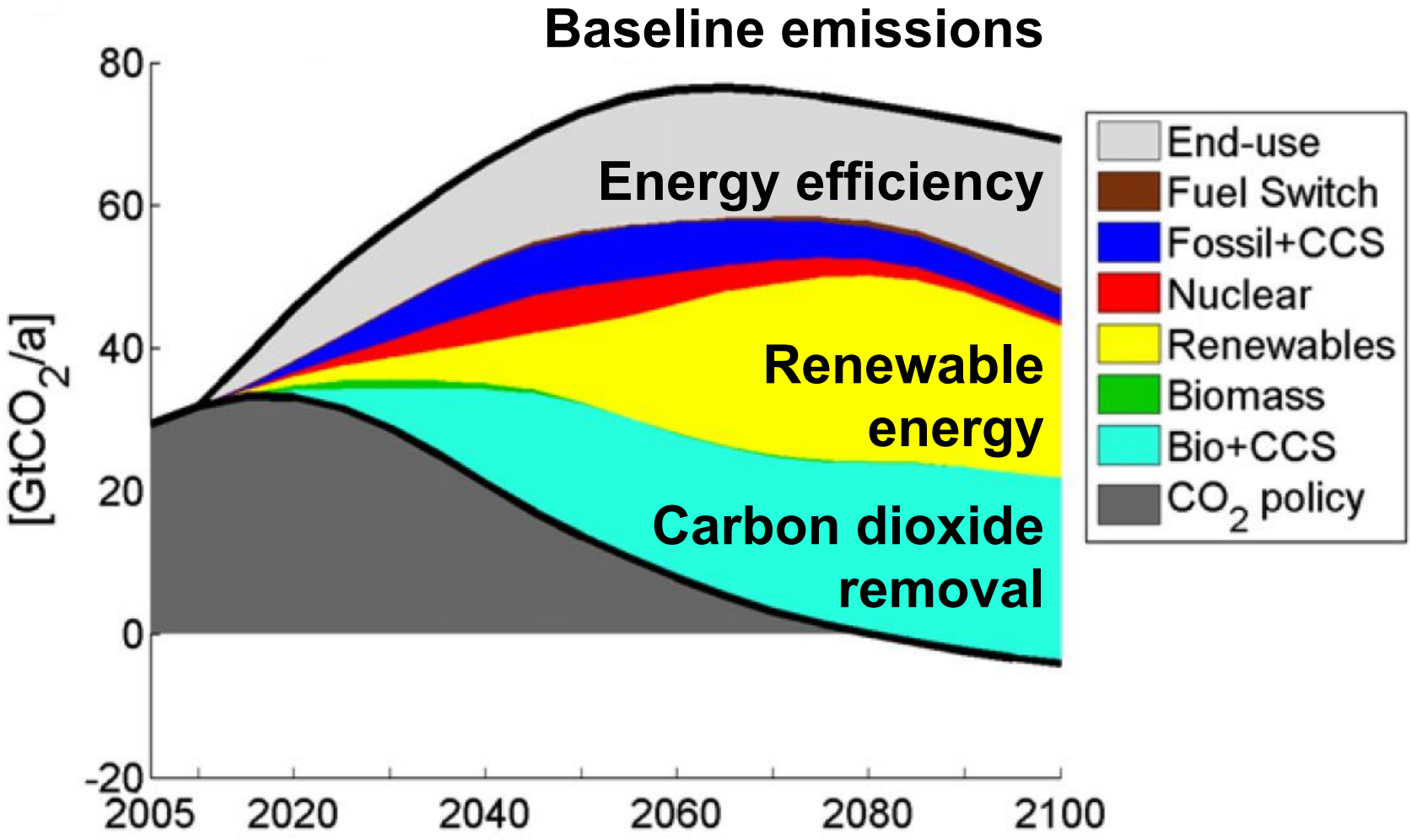


Reserves that have to stay underground until 2050 to reach 2°

- 80% coal (90% w/o CCS)
- 50% gas
- 33% oil

Source: McGlade & Ekins, 2015 (*Nature*)

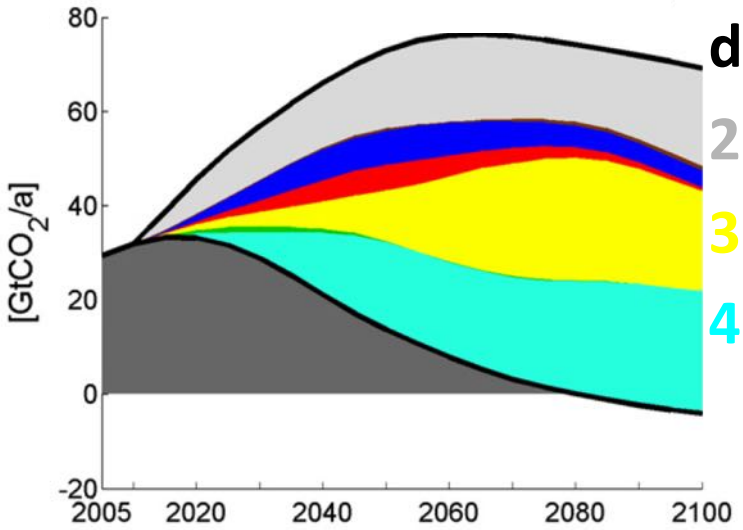
Emissions gap to 2°



Source: Luderer et al. 2012 (Energy Economics)

PART 4: DECARBONIZATION

Main decarbonization opportunities



1. Socio – economic development

2. Energy efficiency

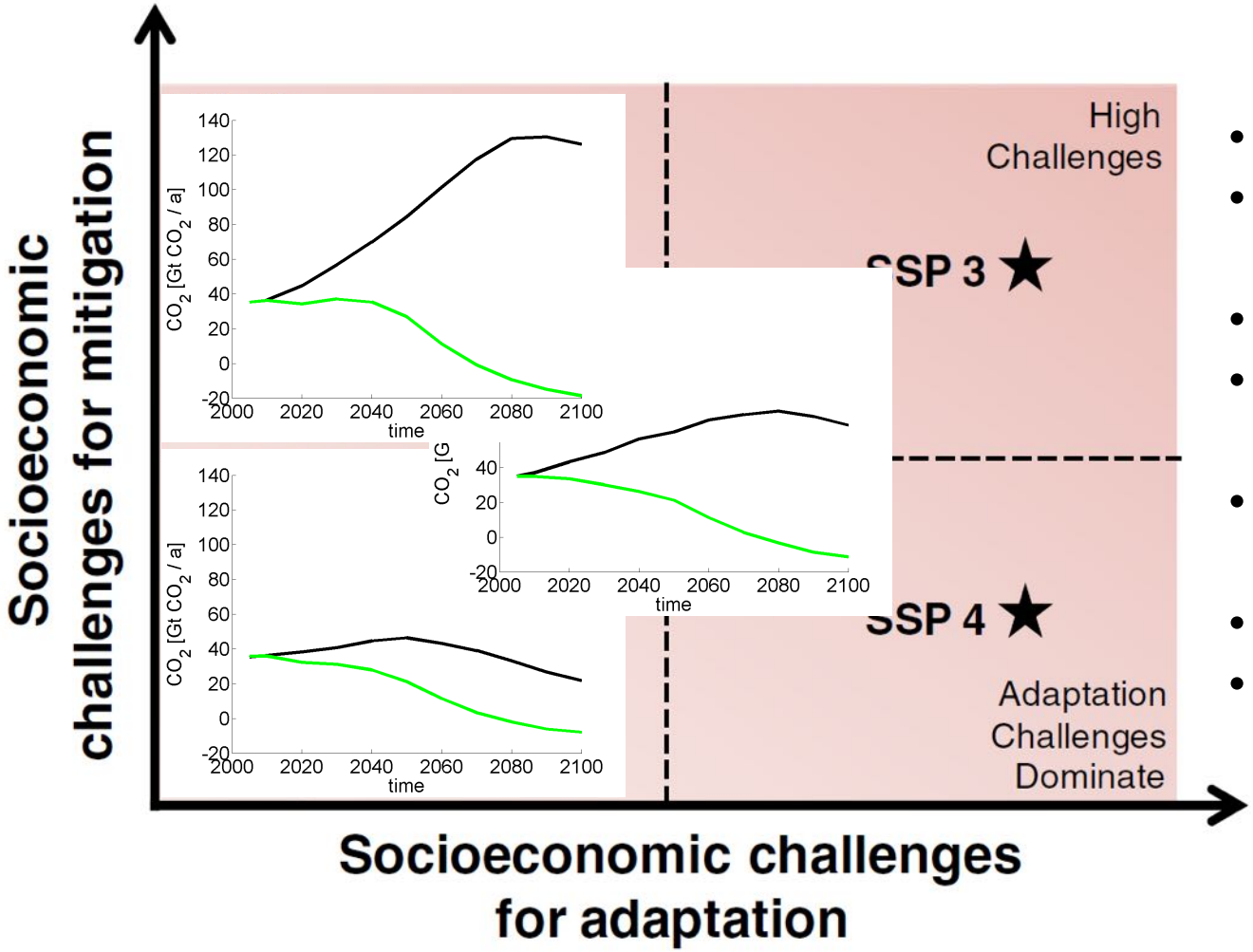
3. Renewable energy

4. Carbon dioxide removal

Kaya identity: Population * (GDP / Population) * (Energy / GDP) * (CO_2 / Energy) = CO_2 Emissions

Source: Luderer et al. 2012 (Energy Economics)

Shared Socio-economic Pathways (SSPs)



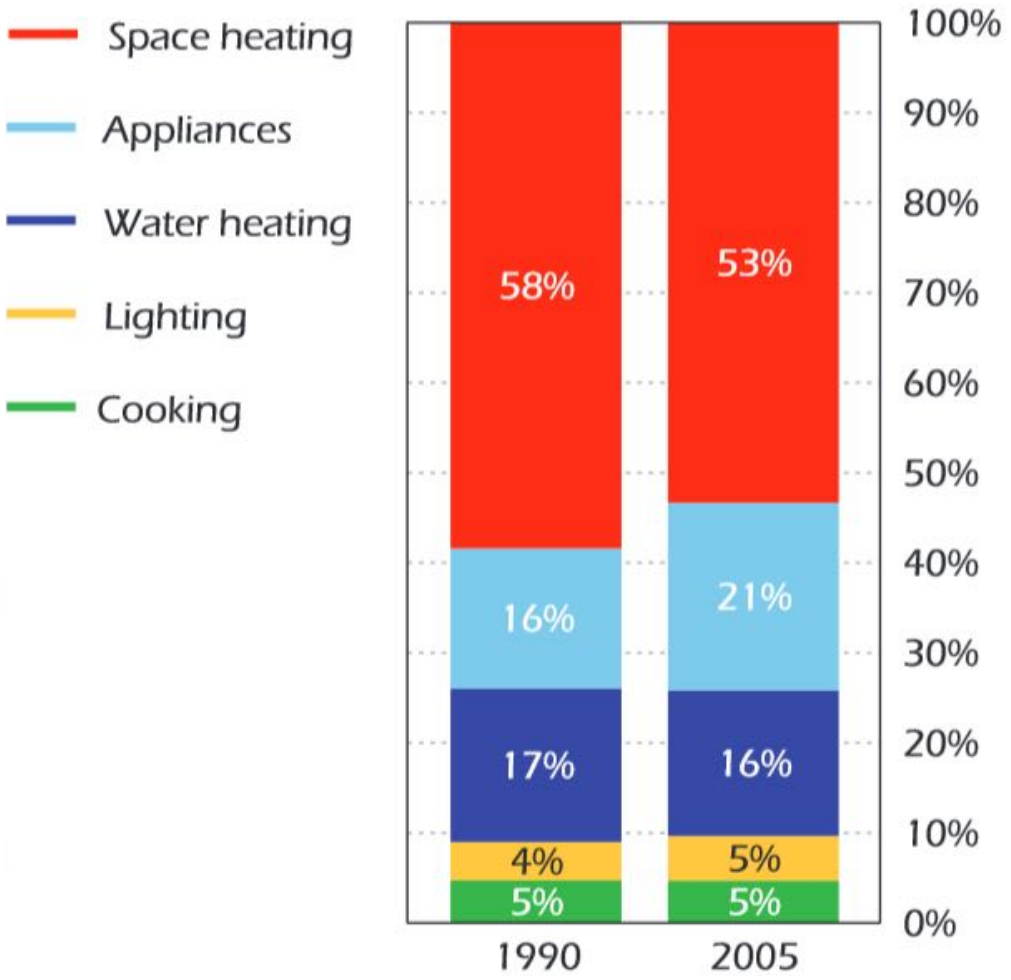
- Demographics
- Economic development
- Resources
- Technological development
- Institutional changes
- Life styles
- …

Challenge depends on socio-economic development

Source: O'Neill et al. 2014 (Climatic Change)

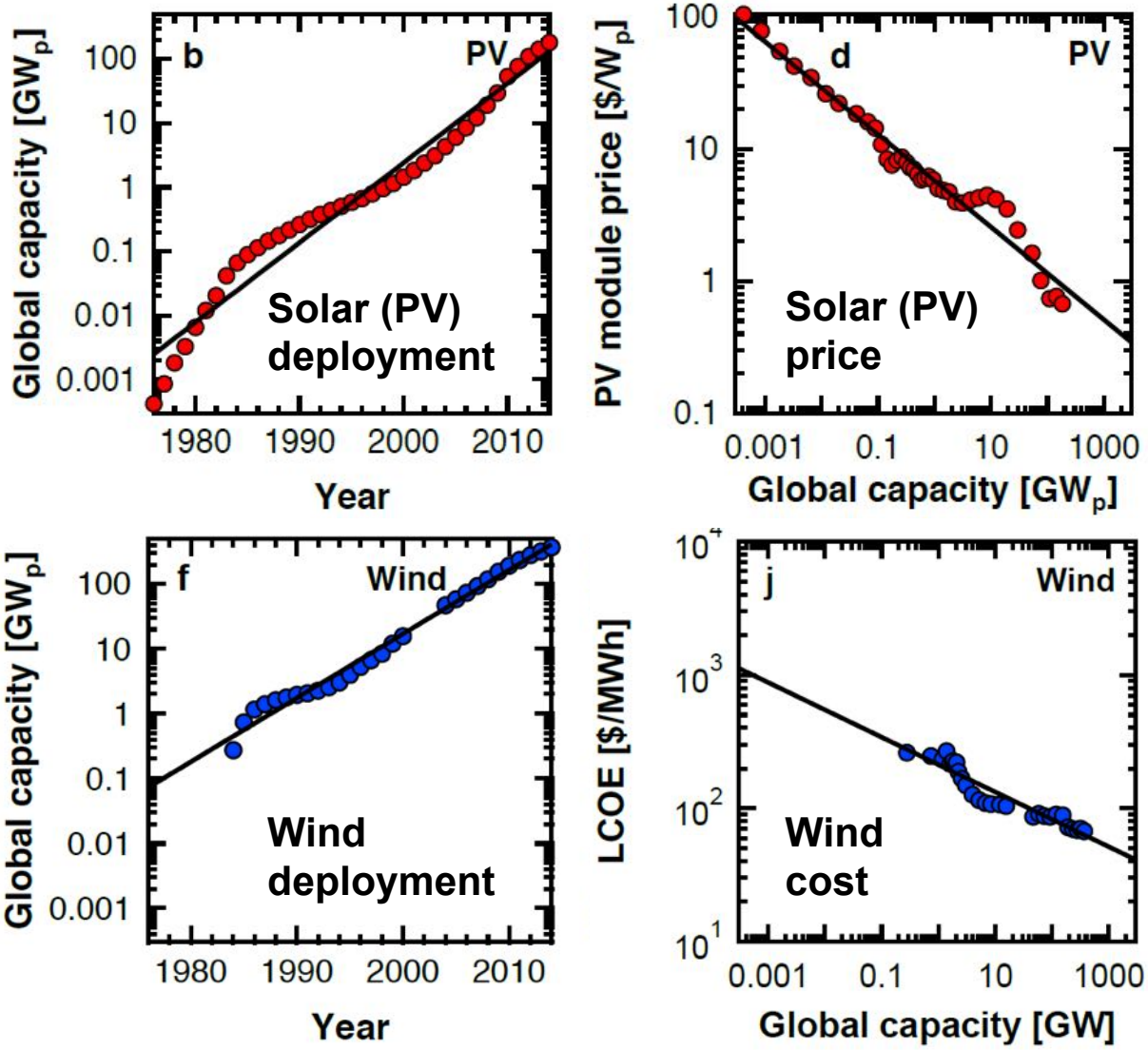
Energy efficiency

- Industry
- Transport
  - Hybrid / electric cars
  - More efficient enginges
  - Smaller cars
  - Public transport
- Households
  - Buildings insulation
  - More efficient appliances



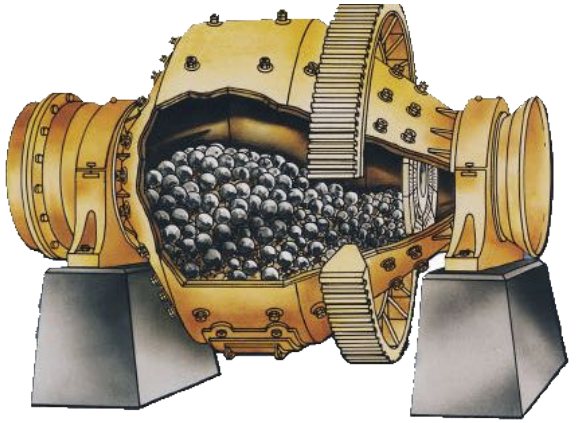
Source: OECD/IEA 2008, Worldwide trends in energy use and efficiency

Renewable energy



Source: Trancik J & McNerney J. MIT 2015

Carbon dioxide removal technologies



CDR technologies have diverse characteristics

Technology	CDR potential	Costs	Energy require-ments	Side Effects
Afforestation	200 – 700 Gt CO_2 (Tavoni & Socolow, 2013, Climatic Change)	Low	Low	Land competition
BECCS	200 EJ/yr → ≈15 Gt CO_2/yr	Medium	Low	Land competition, geological storage, water demand
Direct air capture	Limited by storage capacity	High	High	Geological storage, chemical substances, water demand
Enhanced weathering of rocks	unclear	Medium	Medium	Trace metals, environmental costs of mining Nutrient supply

Summary

Key decarbonization opportunities:

1. **Energy efficiency**
2. **Renewable energy**
3. **Carbon dioxide removal**

- **Availability of CDR does not reduce the need for short-term mitigation**
- **Delay of stringent mitigation**
  → exceed budget
  → choice between large-scale deployment of CDR and acceptance of higher climate change impacts