

ISAP 2016,
Yokohama, 12 July 2016

After Paris: Climate Challenge Revisited

Hans Joachim Schellnhuber

*Director, Potsdam Institute for Climate Impact Research (PIK);
Chair, German Advisory Council on Global Change (WBGU)*

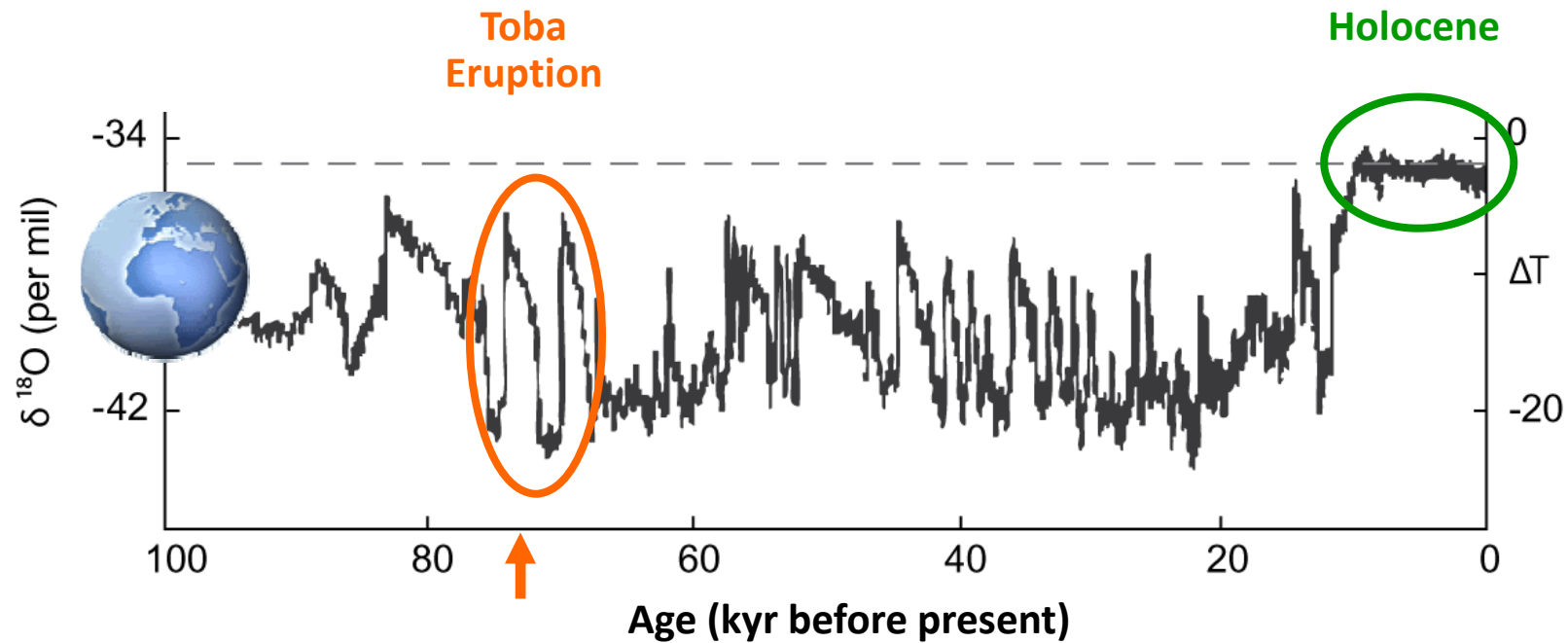


The Blue Marble: New NASA Satellite Image



Image taken by NASA space probe "Lunar Reconnaissance Orbiter" on 12 October 2015

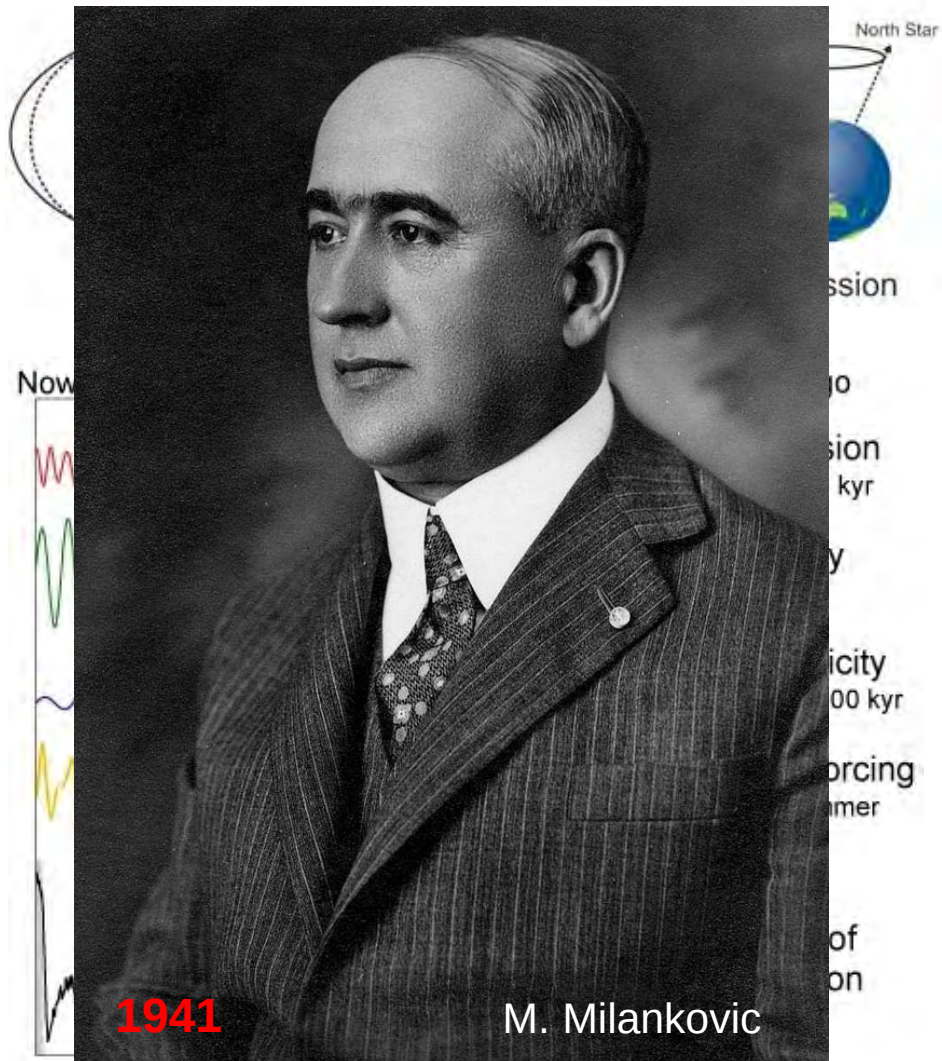
The Holocene: *From Glacial Chaos to Climate Paradise*



Time Series Source: Johan Rockström,
Stockholm Resilience Centre

Why Does the Climate Change at All? Longer-Term Factors:

Milankovic Cycles



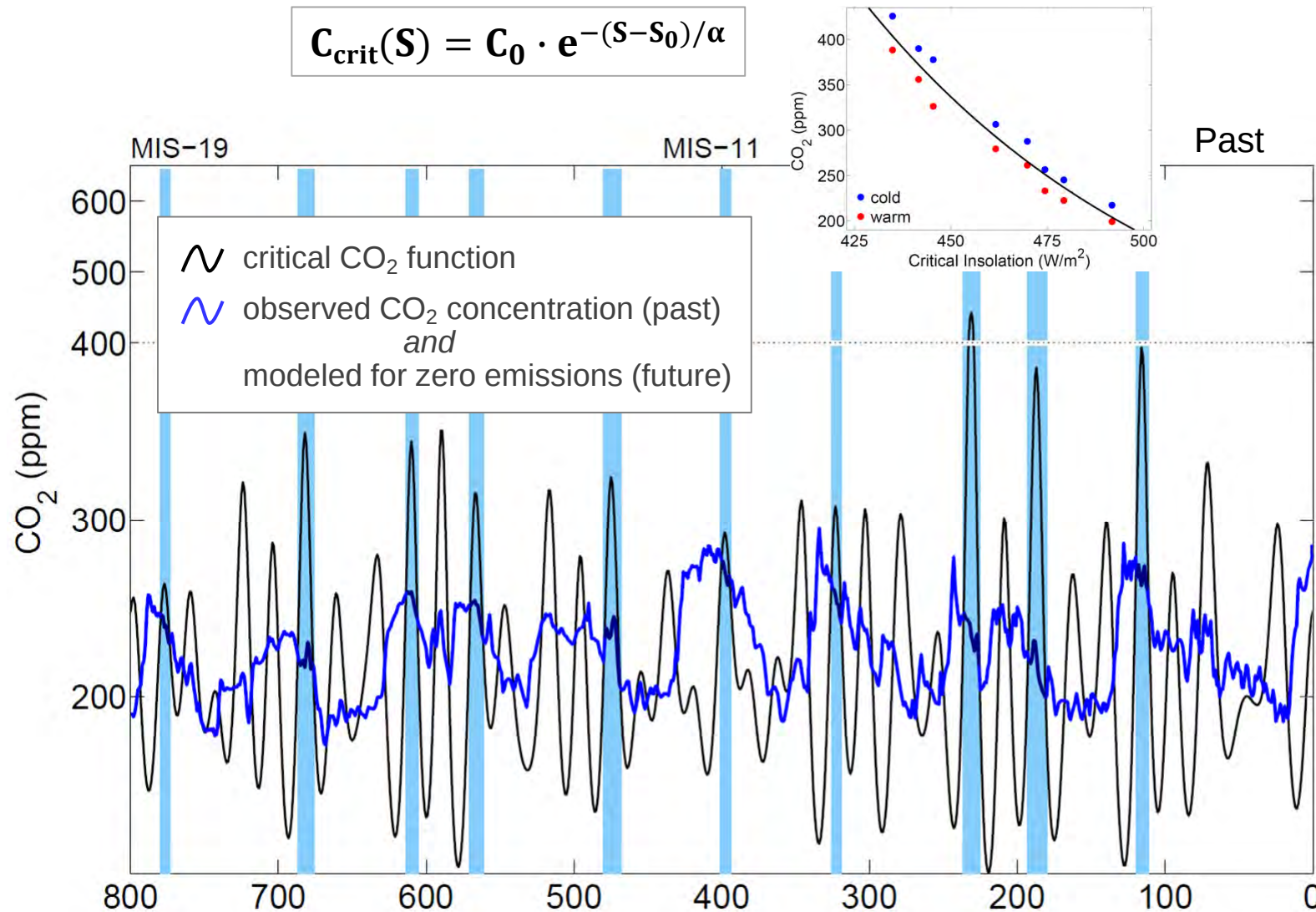
Source: Global Warming Art

The Greenhouse Effect



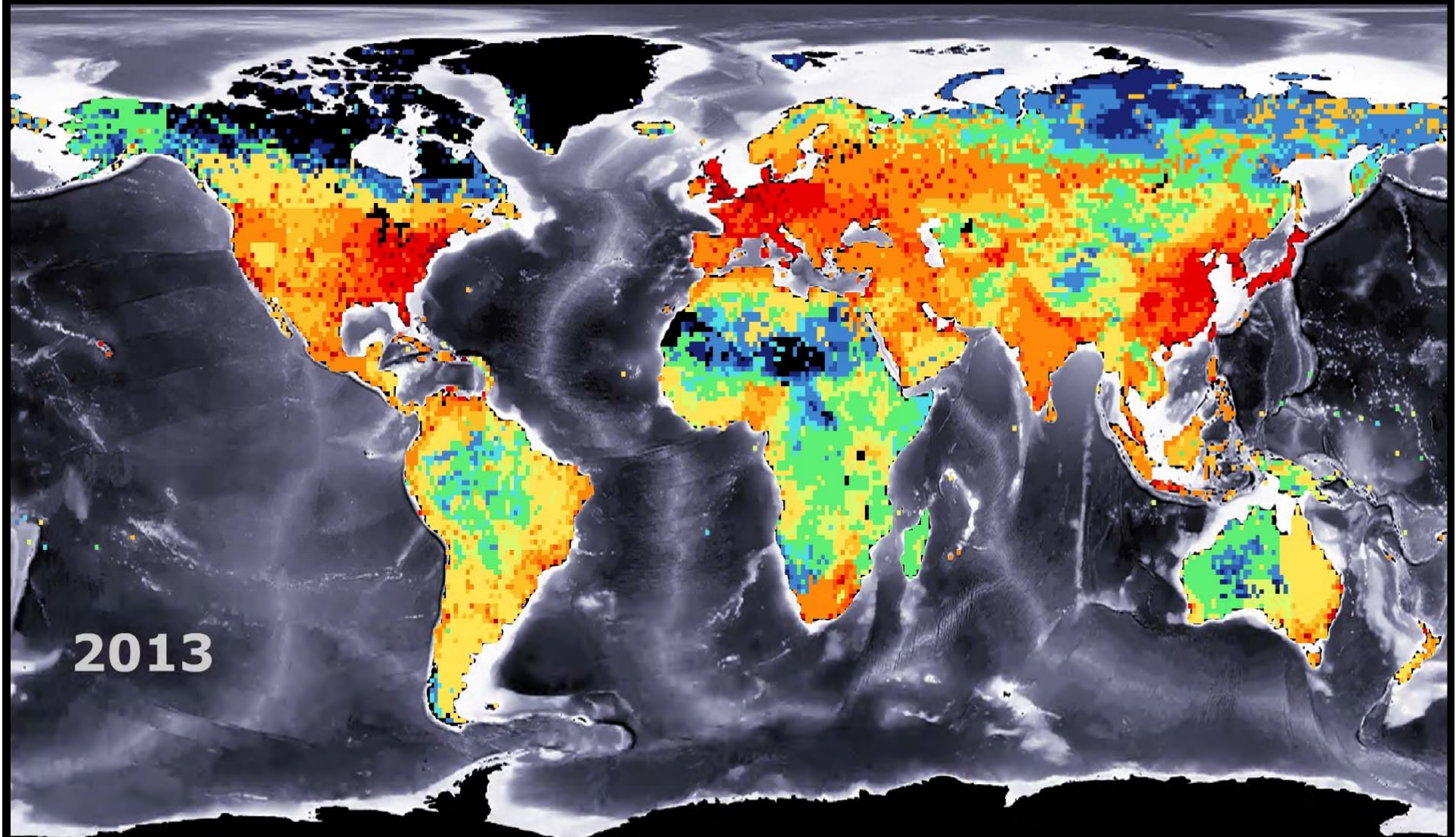
S. Arrhenius

Critical CO₂ Concentration-Insolation Function



Ganopolski, A., Winkelmann, R., Schellnhuber, H.J. (2016): Critical insolation-CO₂ relation for diagnosing past and future glacial inception. Nature

The C-Story of Human Civilization



2013

Cumulative human carbon dioxide emissions [Mt C]

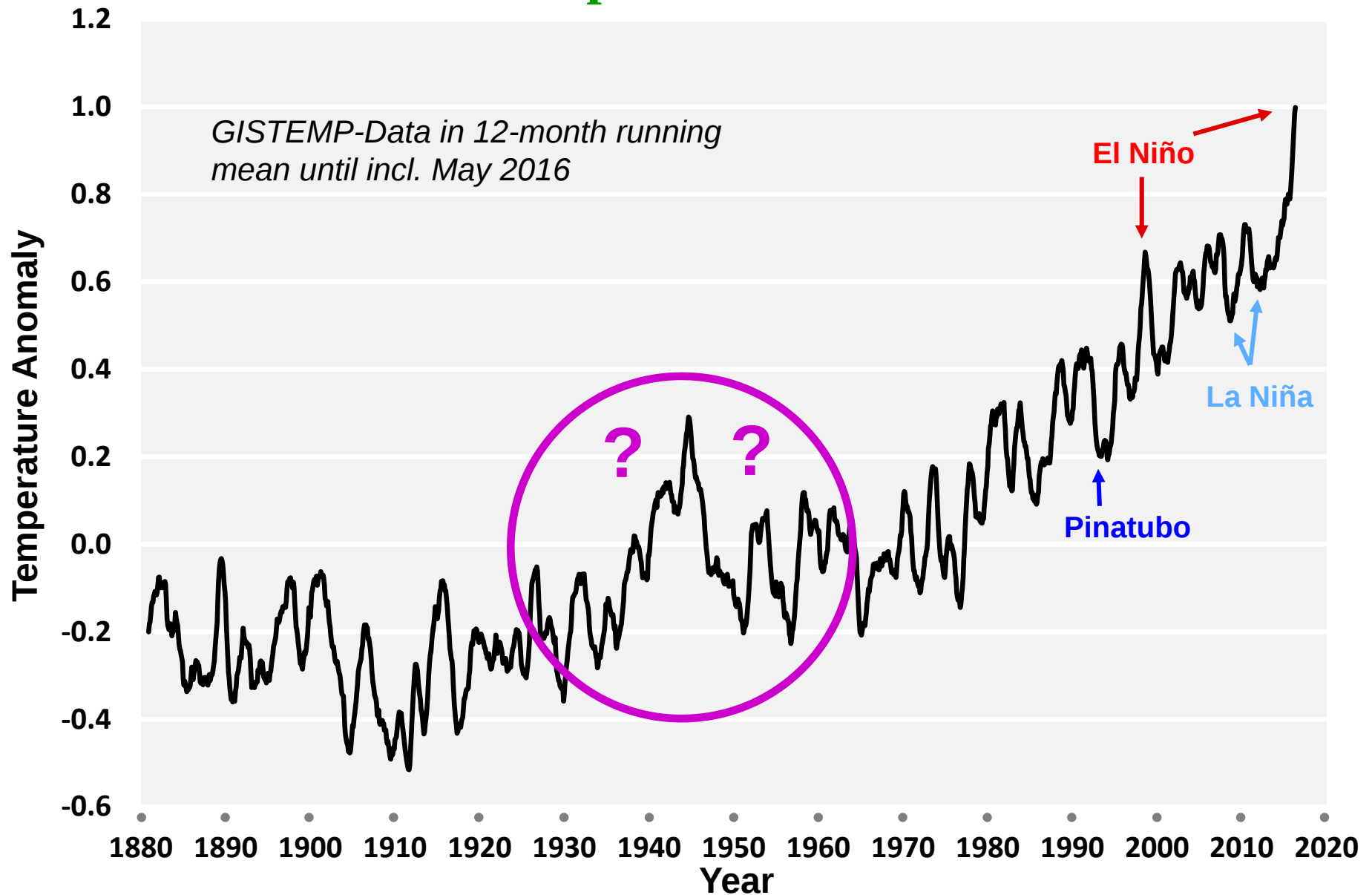


Data Source: CDIAC 2016 (Andres, R.J., T.A. Boden, and G. Marland. 2016)

Bathymetry: NASA, Earth Observatory

Animation: PIK 2016

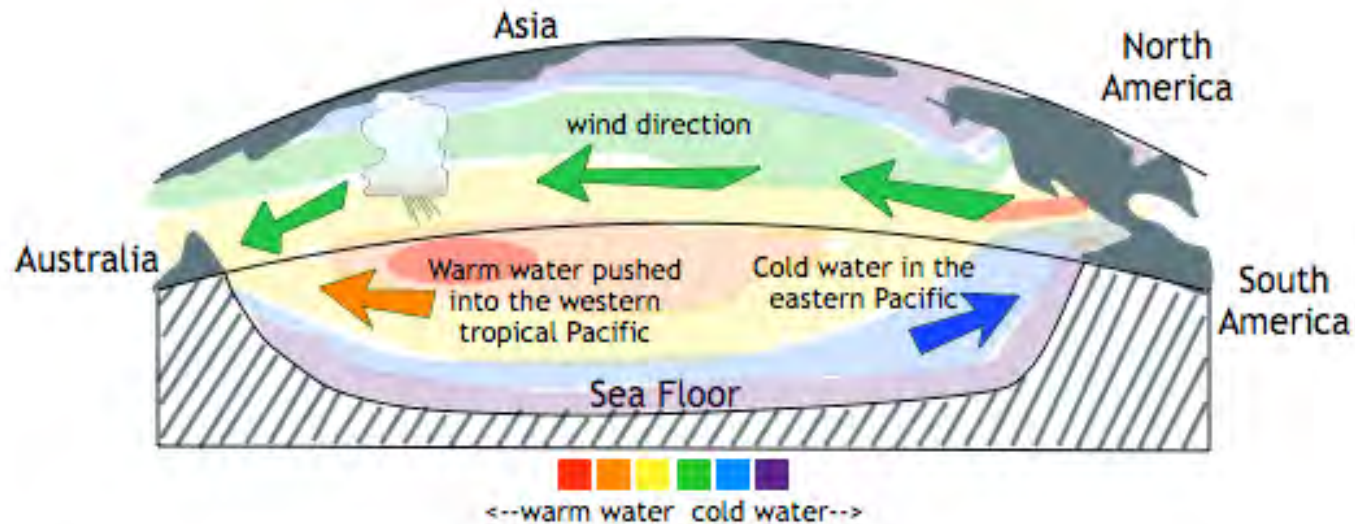
Global Temperature since 1880



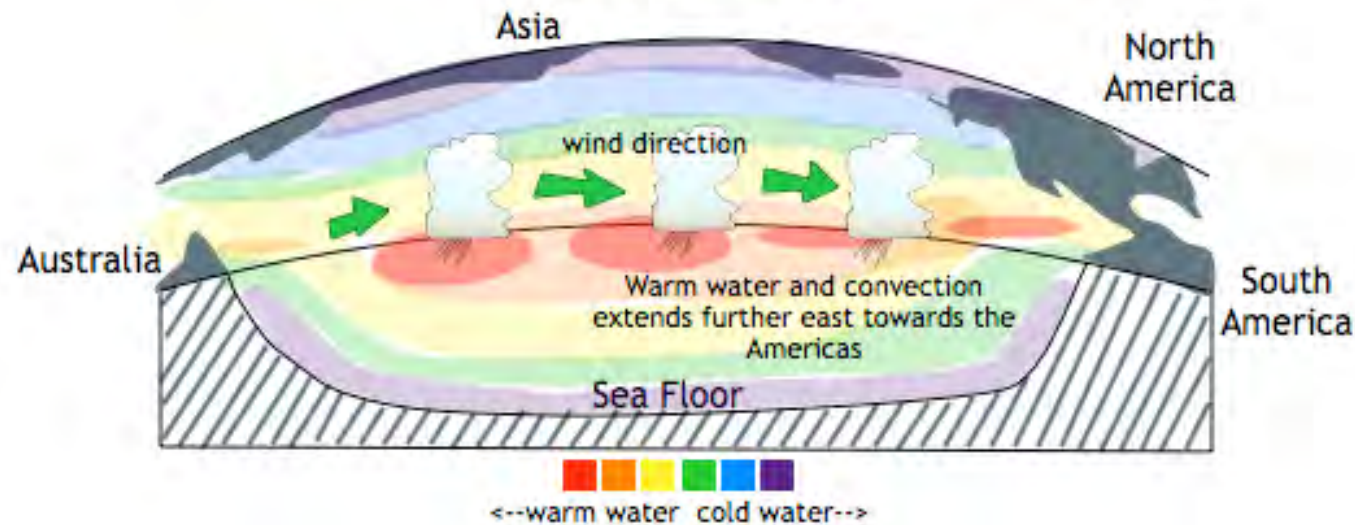
Data source: GISS Surface Temperature Analysis (GISTEMP), <http://data.giss.nasa.gov/gistemp/>

El Niño

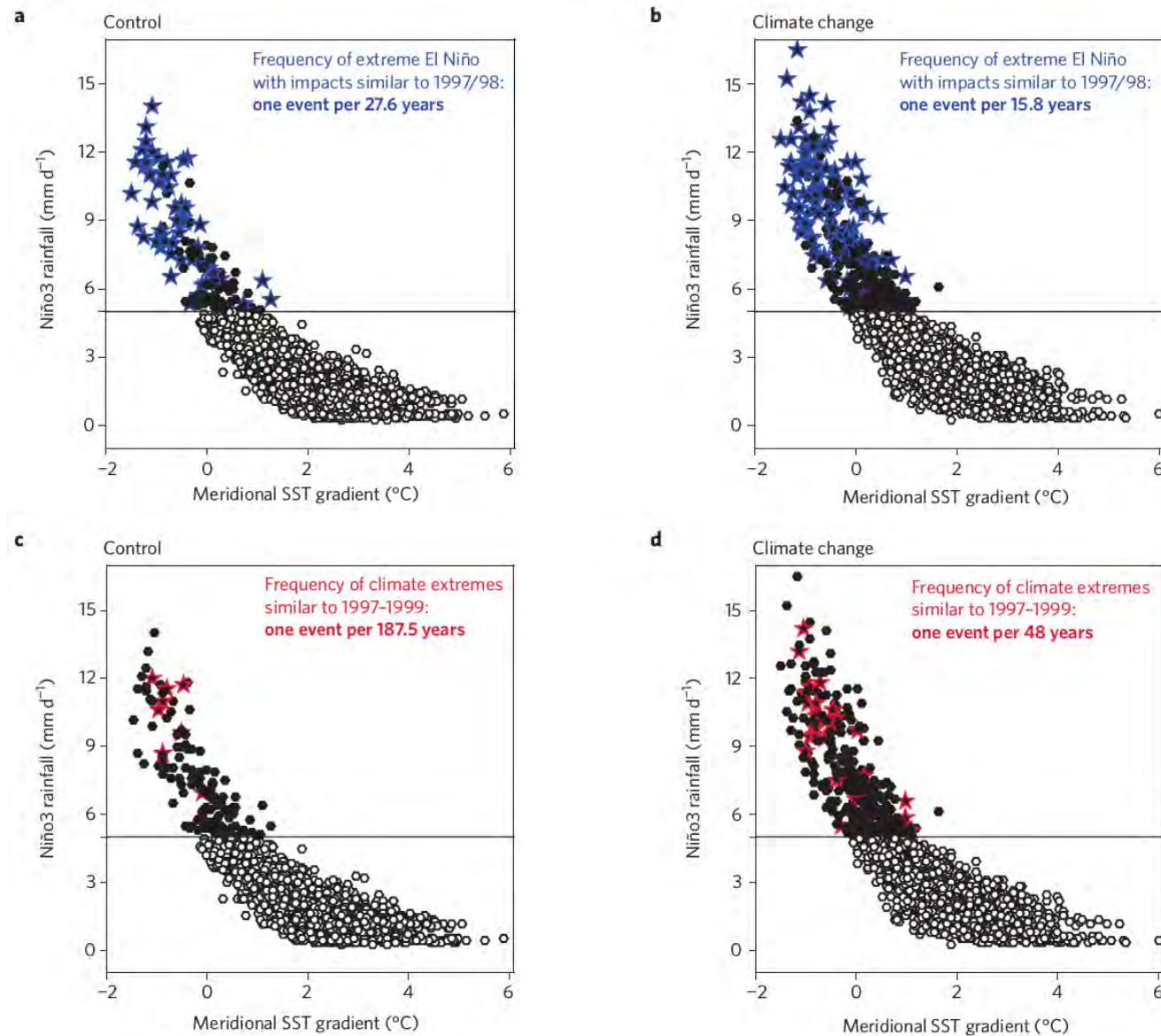
NORMAL CONDITIONS



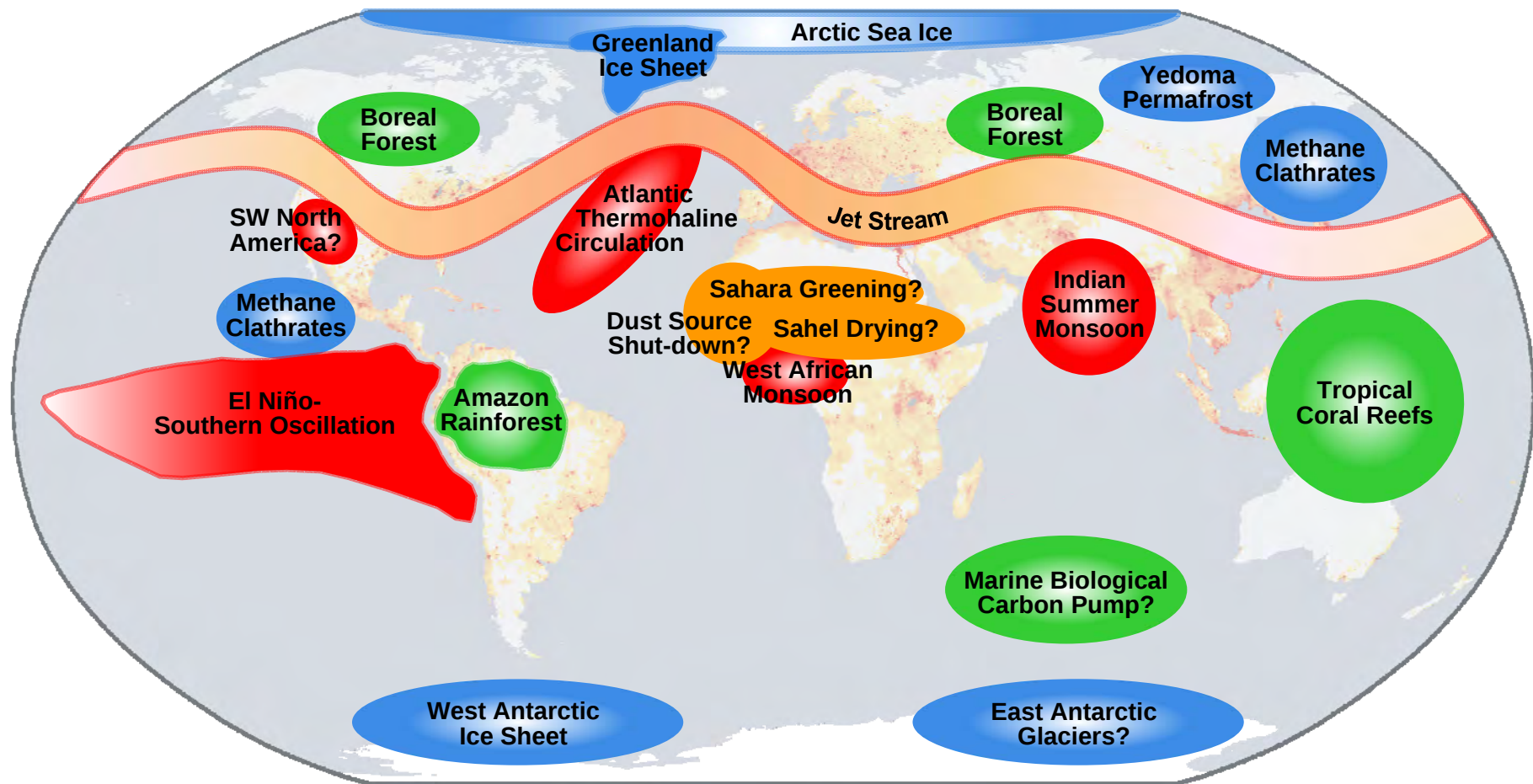
EL NINO CONDITIONS



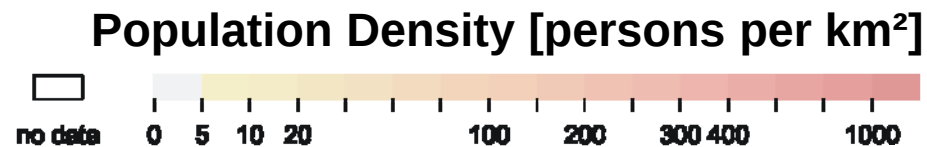
Increased Occurrence of Extreme El Niño and La Niña Events Under Greenhouse Warming



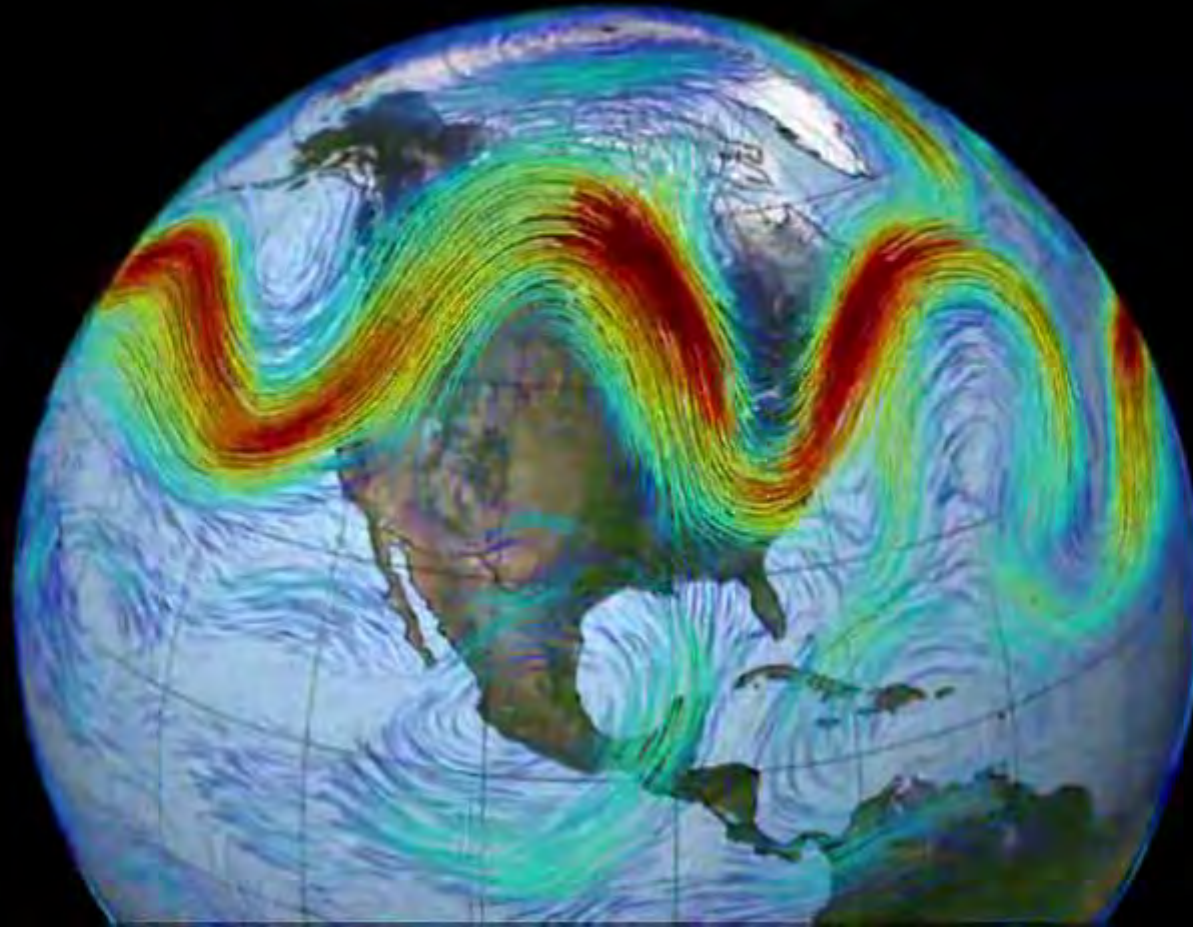
Looming Risks: Tipping Elements in the Earth System



- Cryosphere Entities
- Circulation Patterns
- Biosphere Components



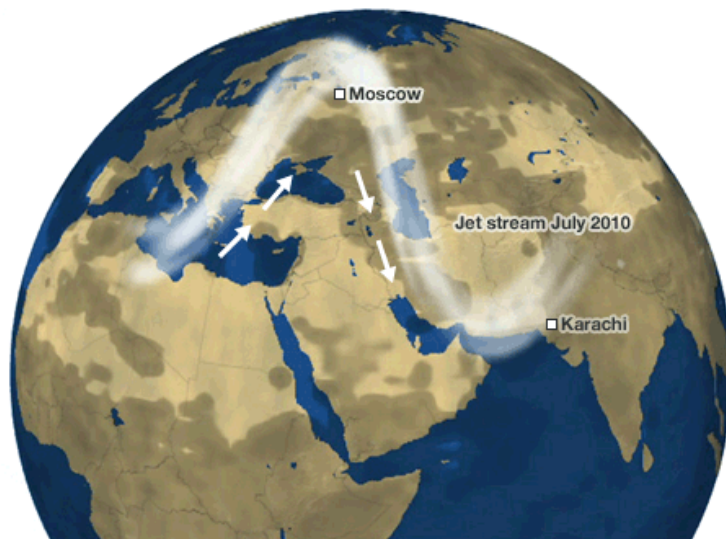
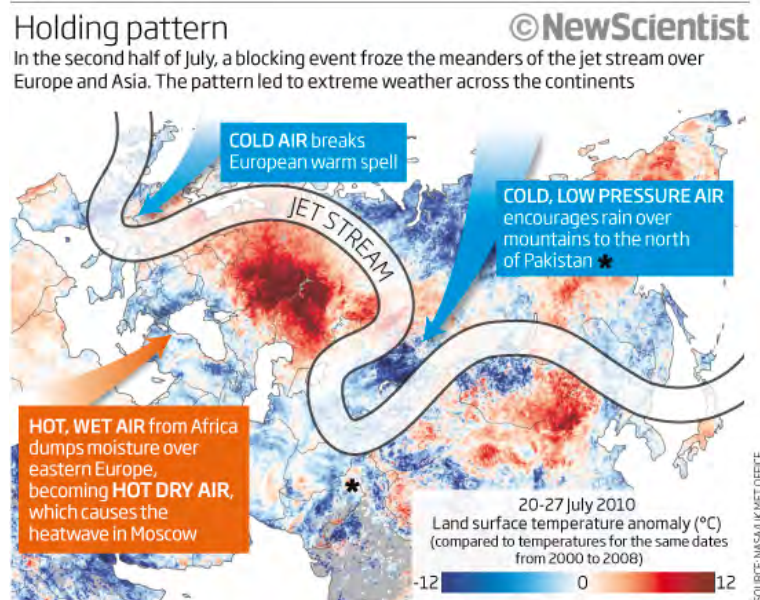
Meandering of the Jetstream



Animation

NASA Goddard Space Flight Center

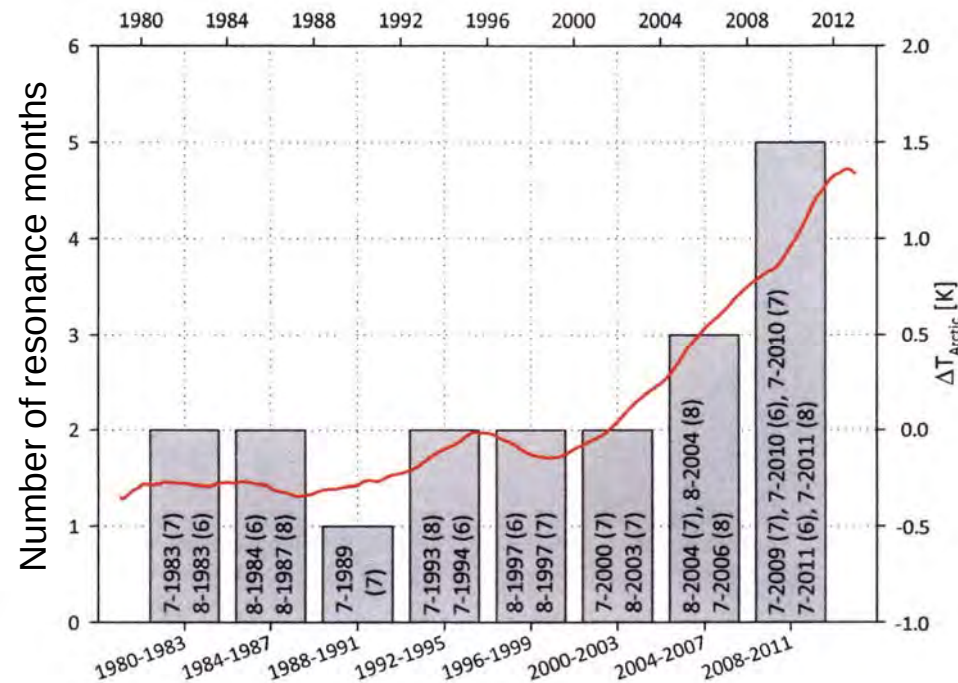
Synchronicity of Extreme Events



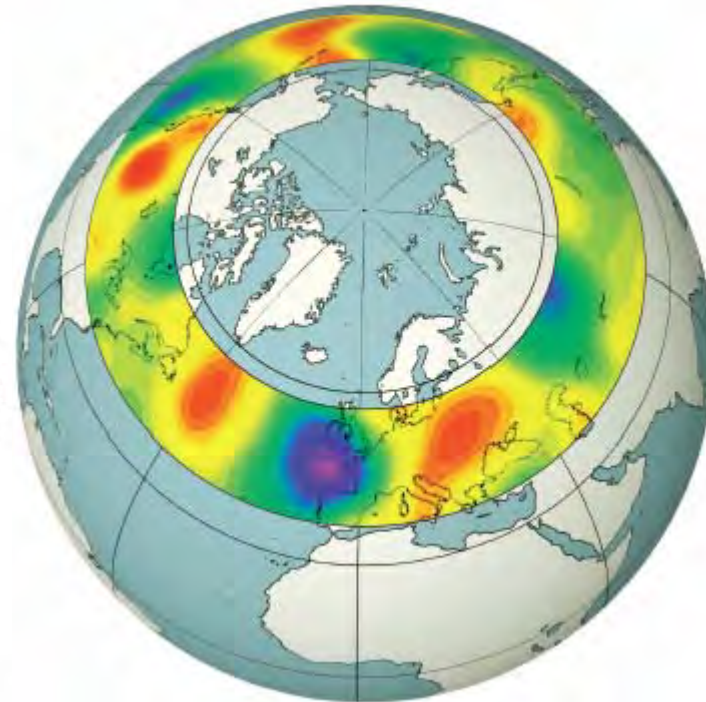
Source: bbc.co.uk



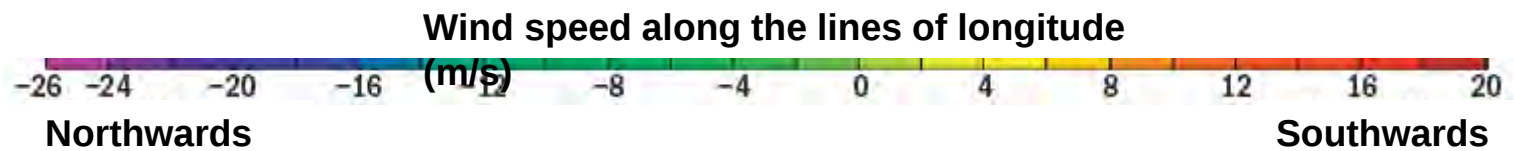
Quasi-Resonance of Planetary Waves



Coumou et al. 2014

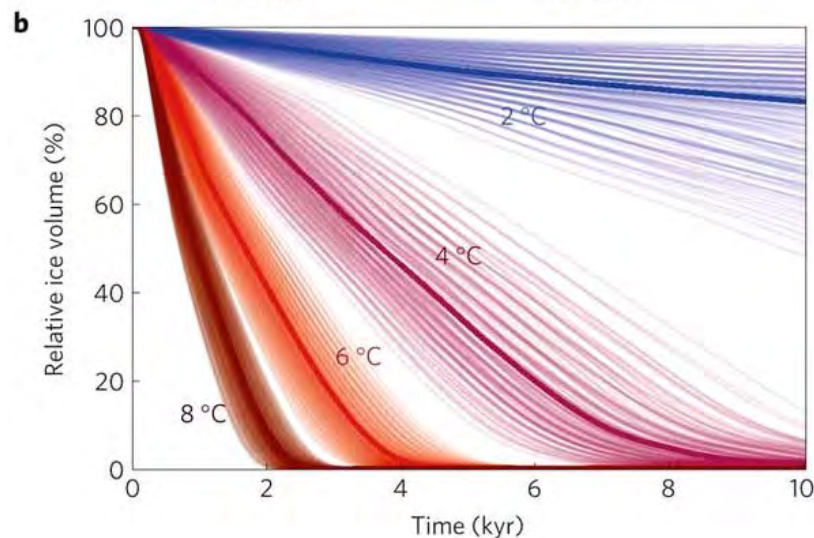
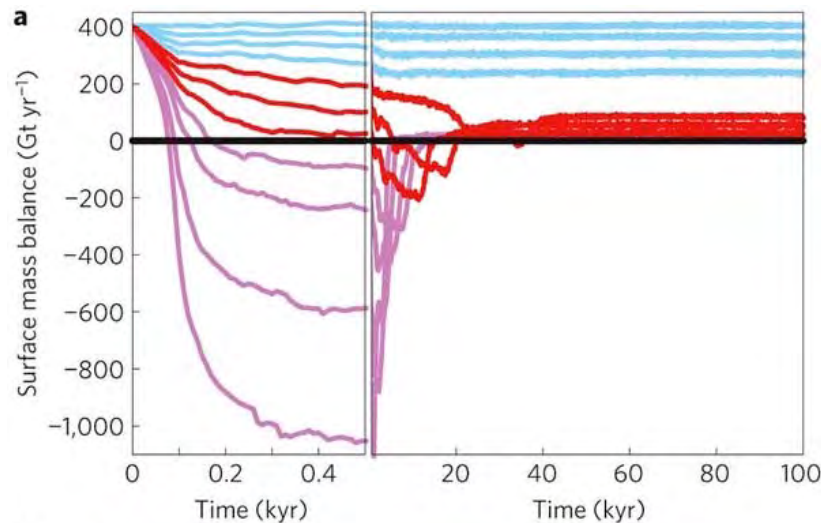


Extreme: May 2013

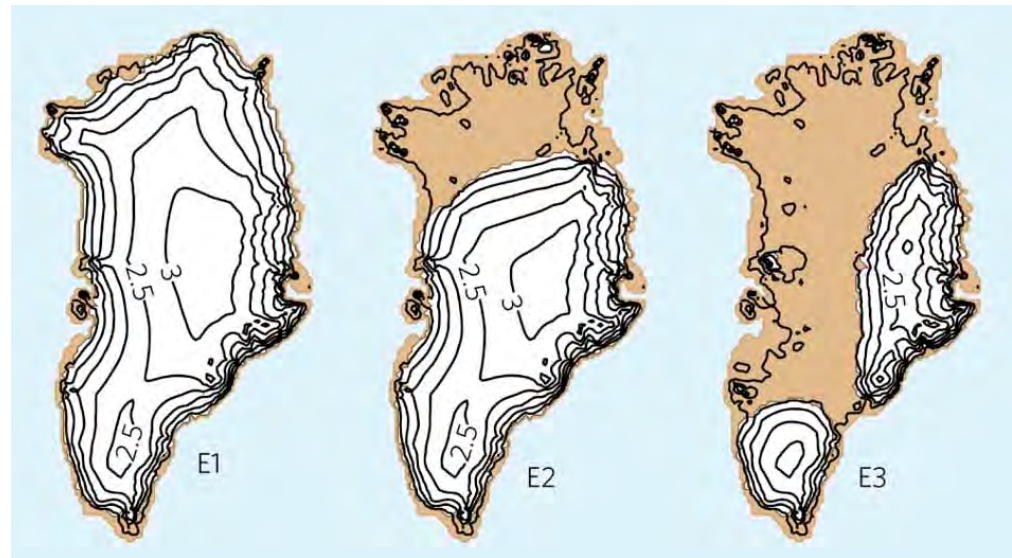


Data source: PIK/Stefan Rahmstorf;
Illustration: Focus 2013, No. 28/13

Irreversible Loss of Greenland Ice-Sheet Could Start with 1.6°C Temperature Rise Relative to Preindustrial



Transient GIS evolution



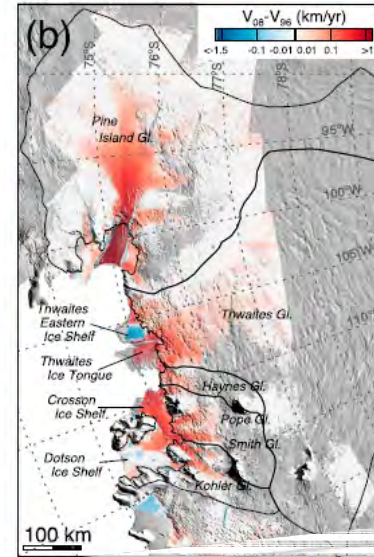
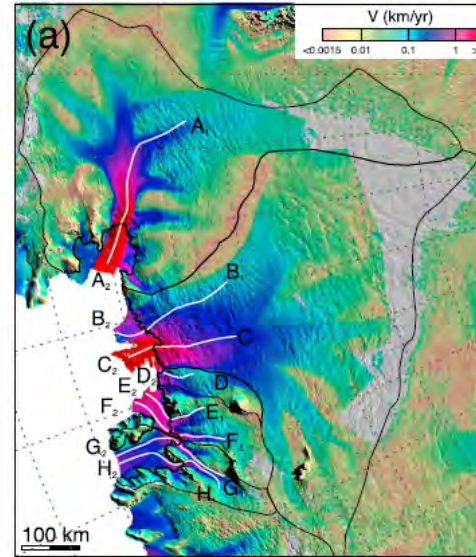
Equilibrium states of the GIS

The Die is Cast!

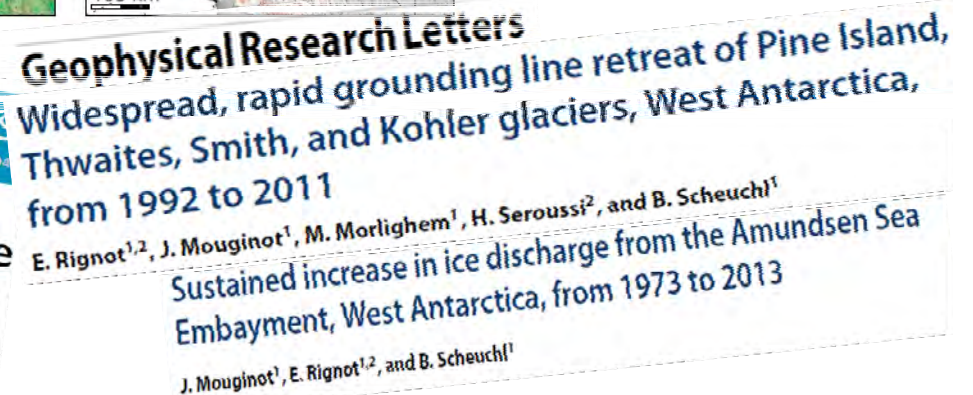
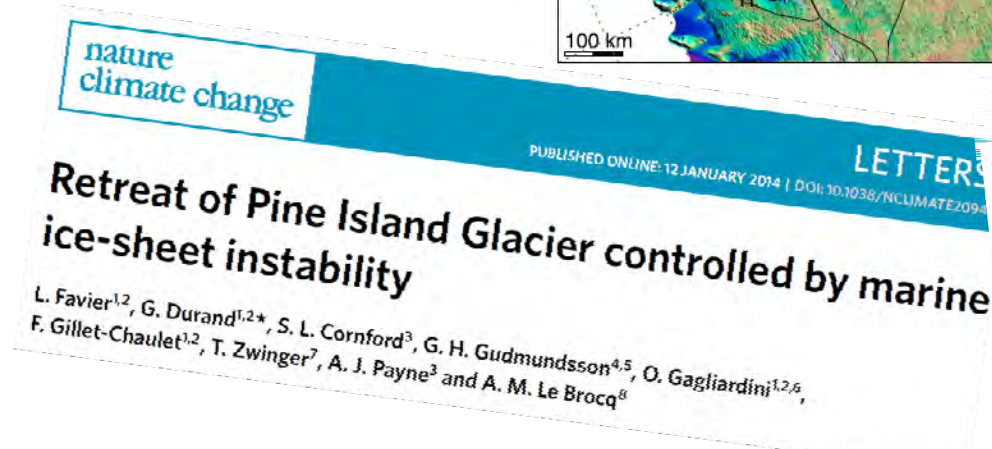


ca. 1.2 and 3.3 m
Sea-Level Equivalent, resp.

Ice-Flow Speed →

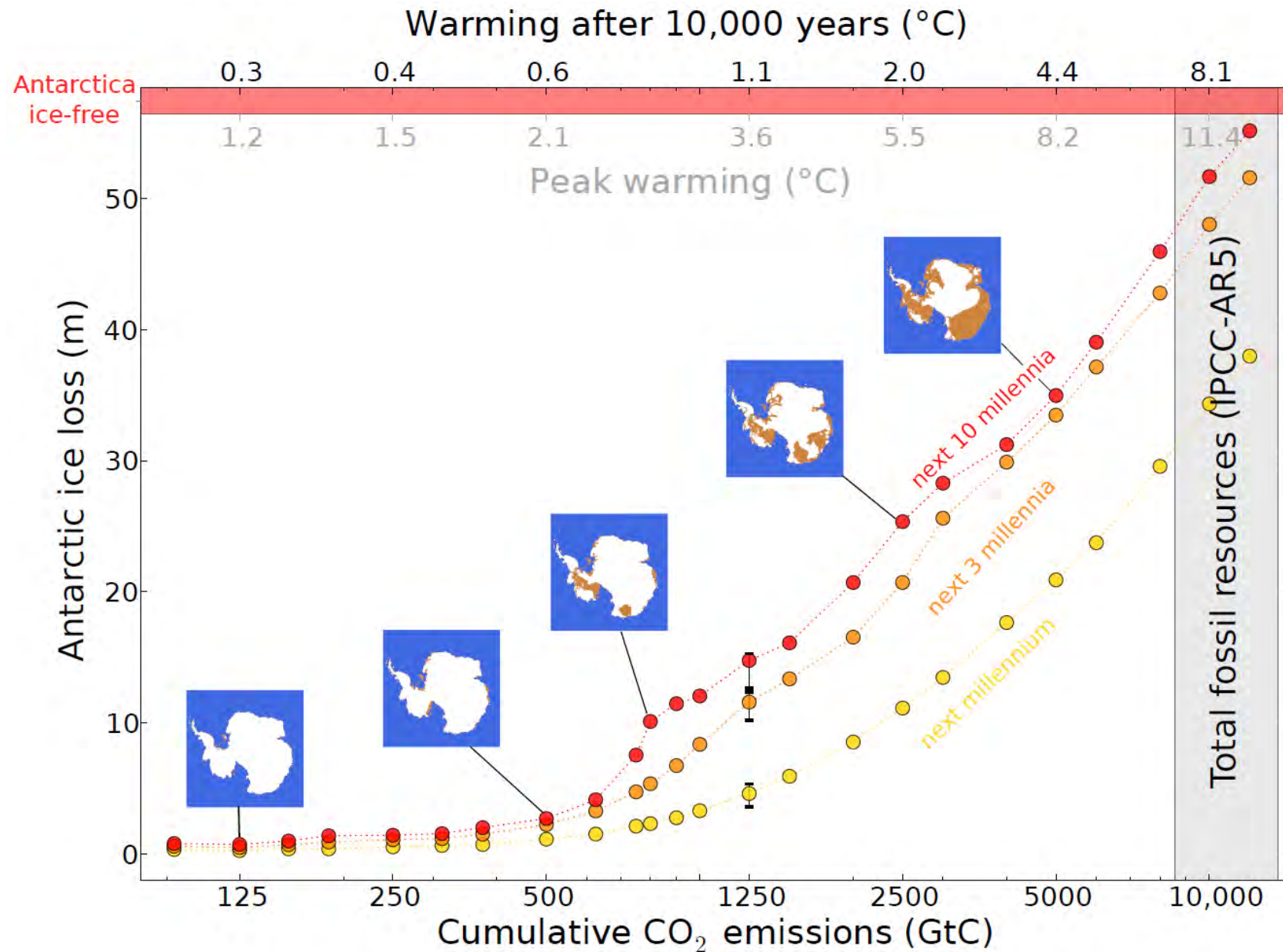


← Acceleration
of Ice Flow



Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica
Ian Joughin *et al.*
Science **344**, 735 (2014);
DOI: 10.1126/science.1249055

Sea Level Commitment from Antarctic Ice Loss



The Paris Agreement

Nations Unies

Conférence sur les Changements Climatiques 2015

COP21/CMP11

Paris France



Bildquelle: <https://www.wmo.int/media/>

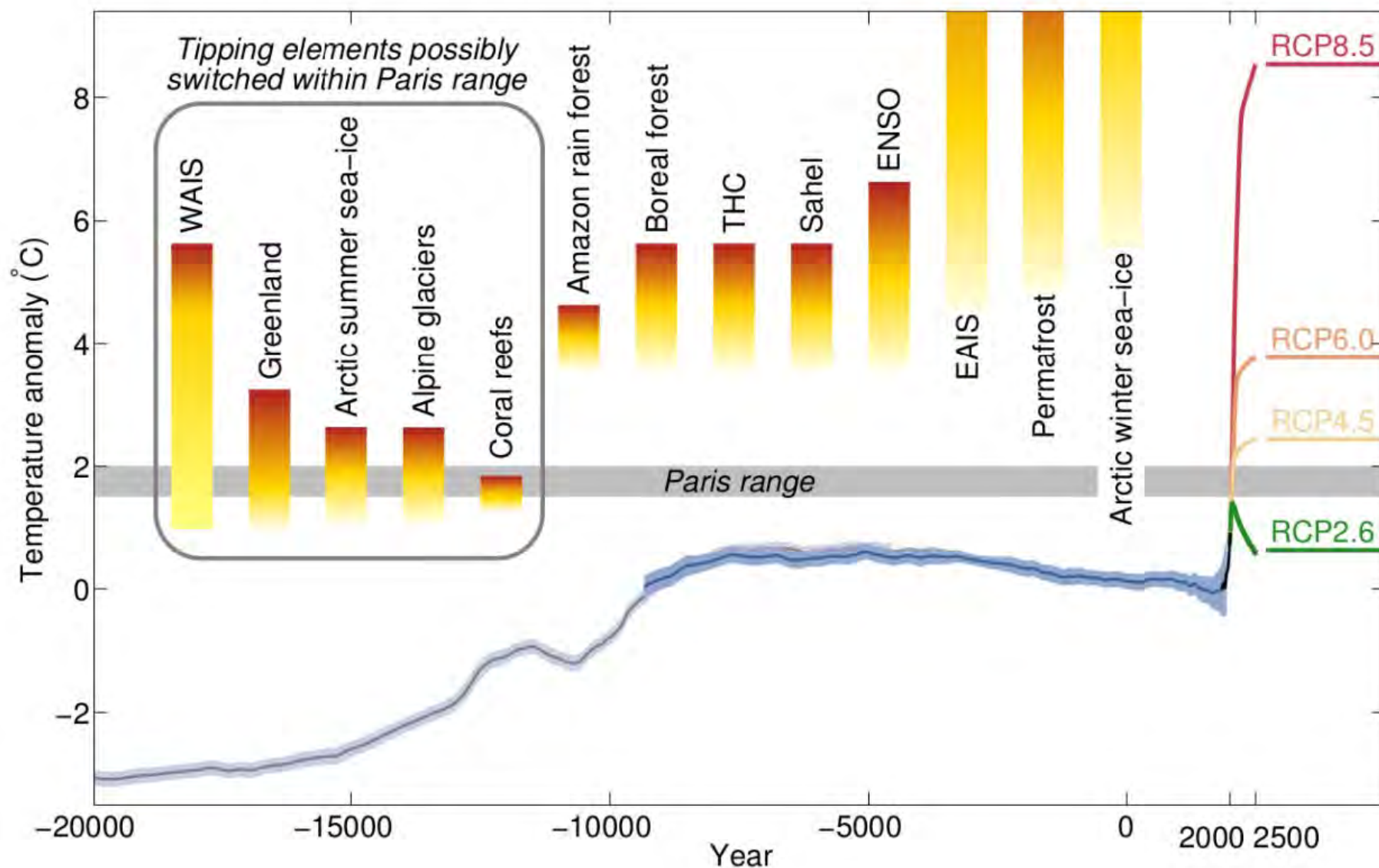
Limiting global
warming “**well
below**”
2 degrees Celsius

Net-zero emissions
of greenhouse gases by
mid-21st century

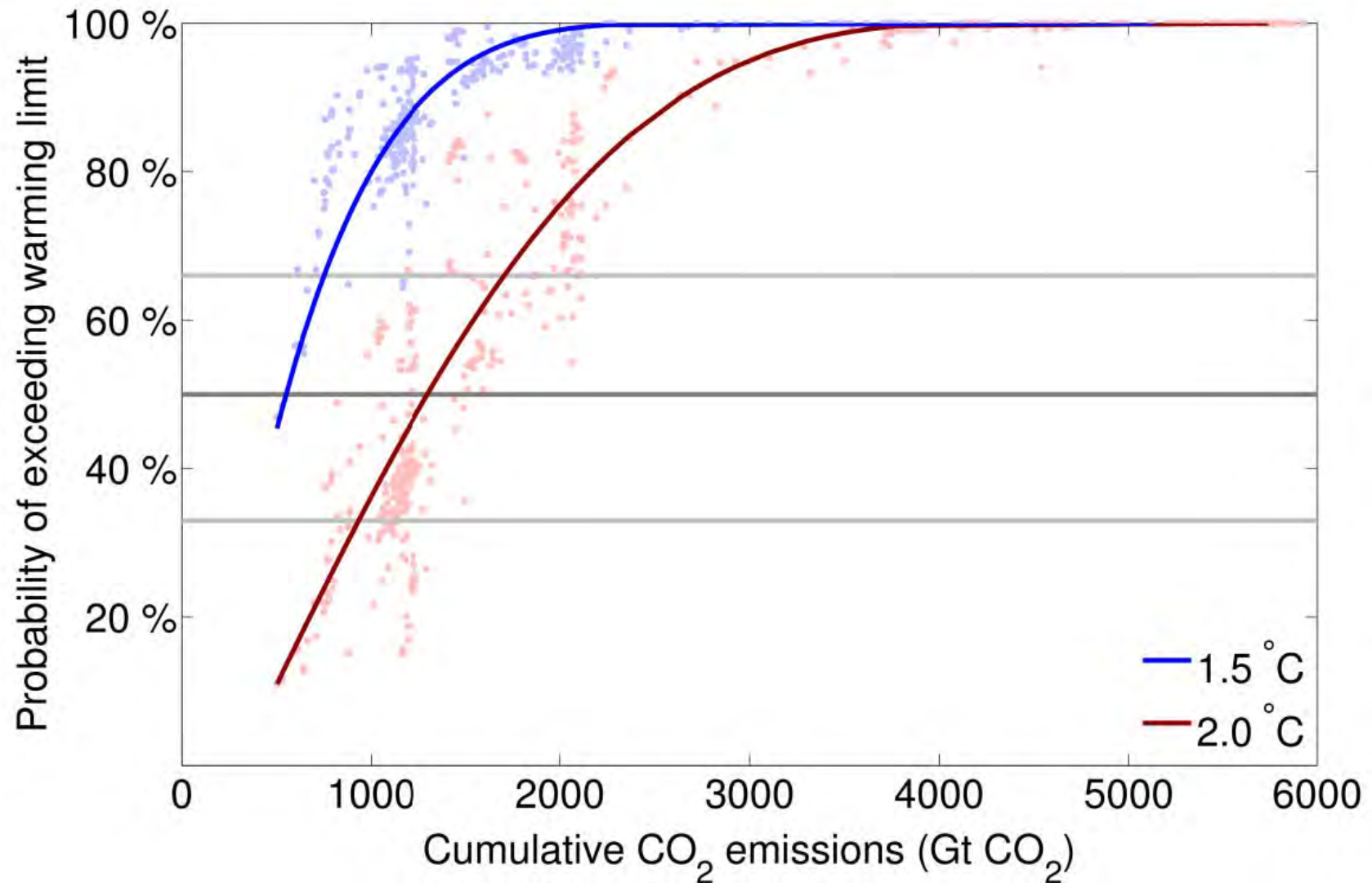
National emission targets
regularly reviewed and
tightened

Developed
countries provide
100 billion USD
per year between
2020-2025

Tipping Points Related to 2°C-Guardrail



Likelihood of Exceeding the 1.5°C and 2°C Global Warming Limits



**Summary for
Policy-Makers**

WBGU
German Advisory Council on Global Change

**World in Transition
A Social Contract for
Sustainability**

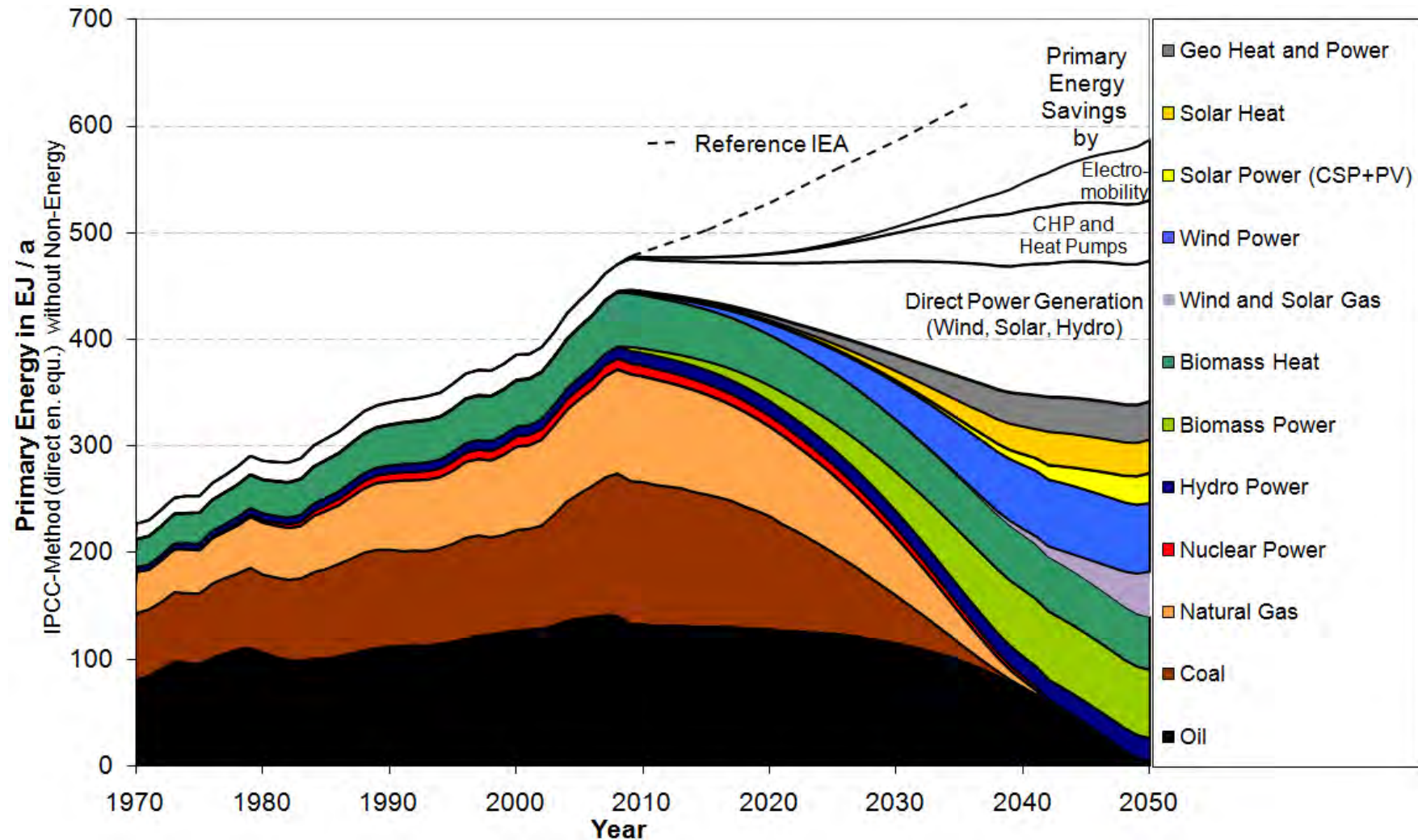


**„Die
Große
Transformation“**

WGBU 2011

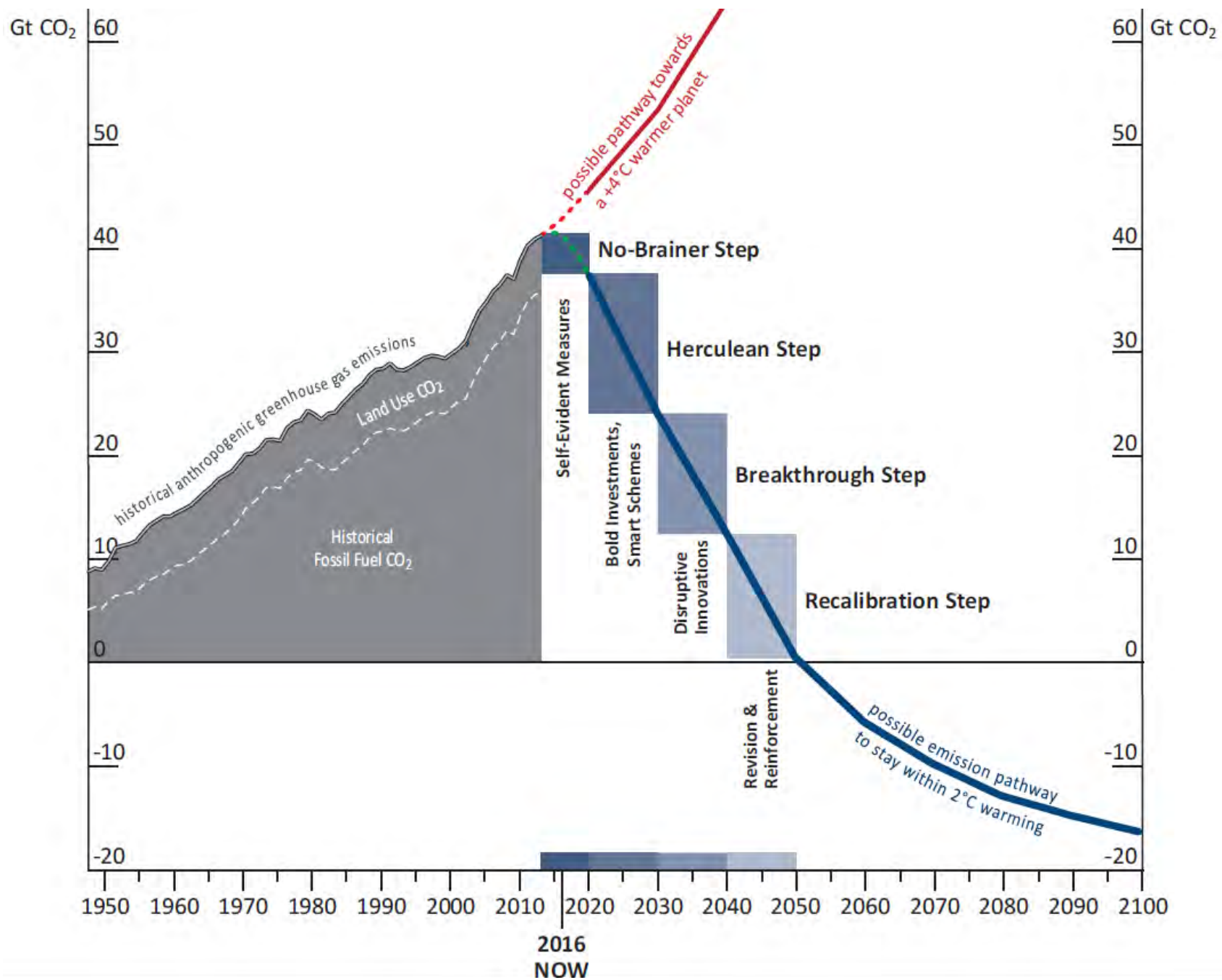
WBGU Vision of Global Energy Revolution

Development of the primary energy demand between 1970 and 2050



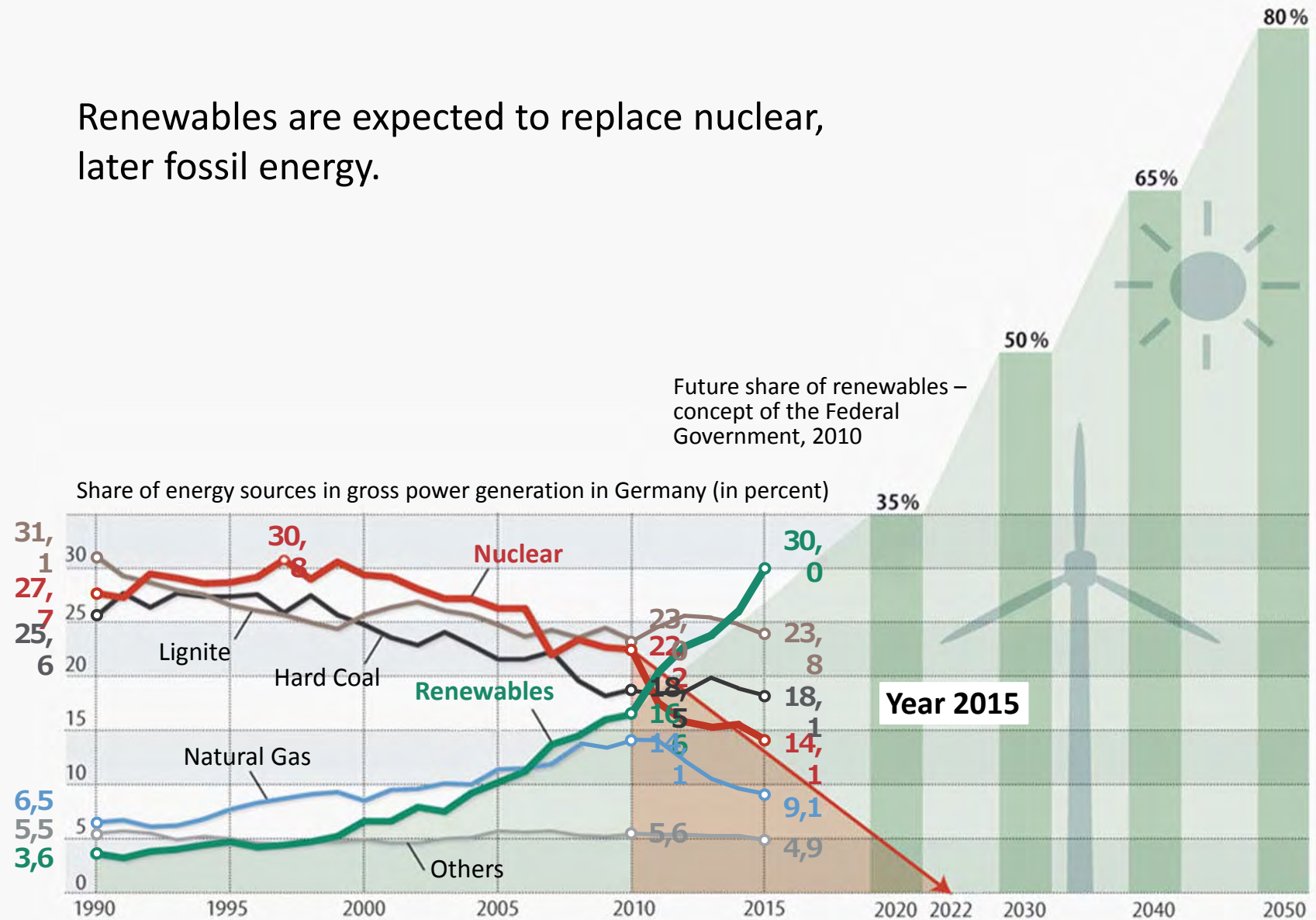
Source: WBGU 2011

Down the Carbon Staircase!?



“Energiewende“ in Germany

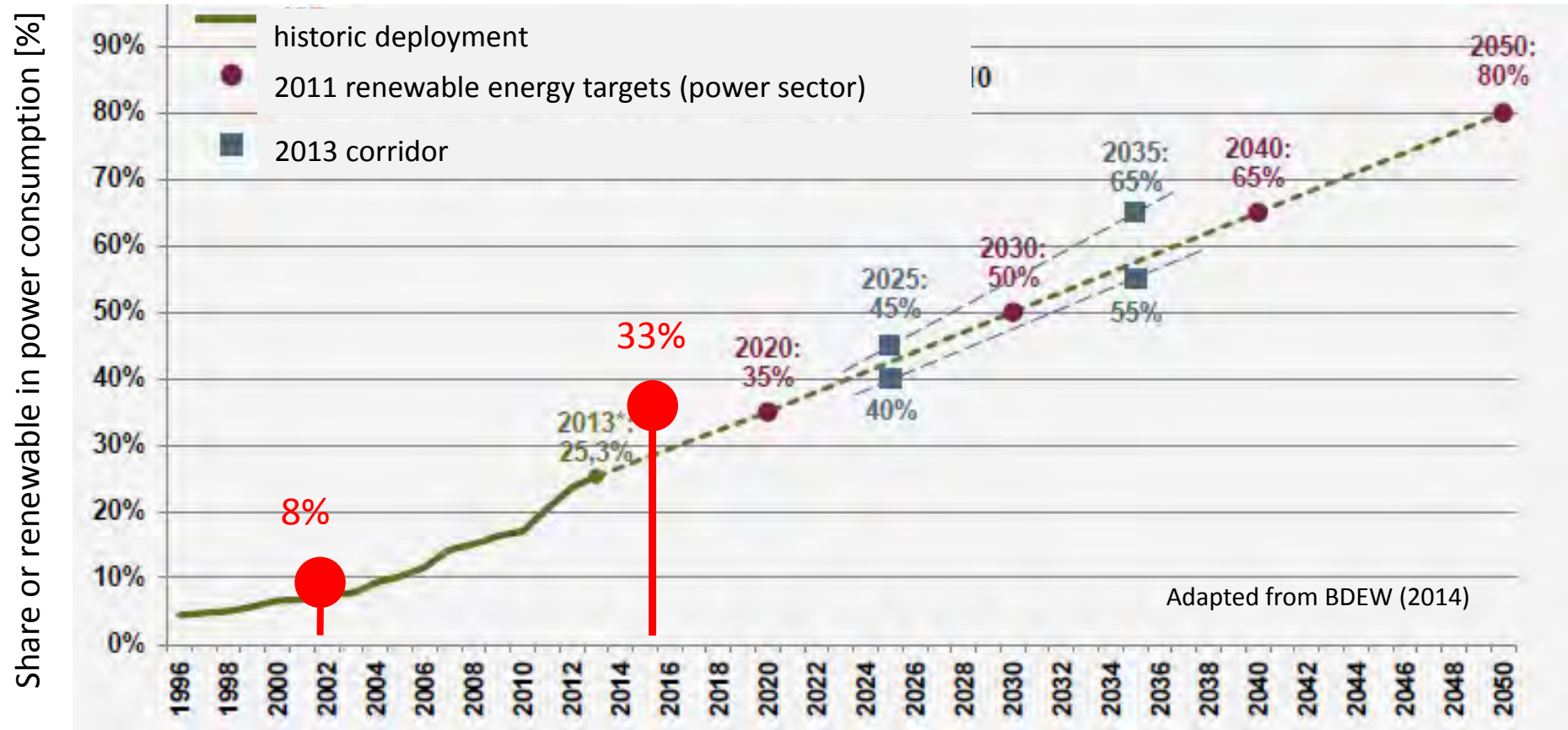
Renewables are expected to replace nuclear, later fossil energy.



Quellen: Bundesregierung; Bundesumweltministerium; Umweltbundesamt; Statistisches Bundesamt; Statistische Landesämter; Bundesanstalt für Geowissenschaften und Rohstoffe; Deutsche Energie-Agentur (dena); eigene Berechnungen
Aktualisierung 2016 durch PIK nach Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), Arbeitsgemeinschaft Energiebilanzen

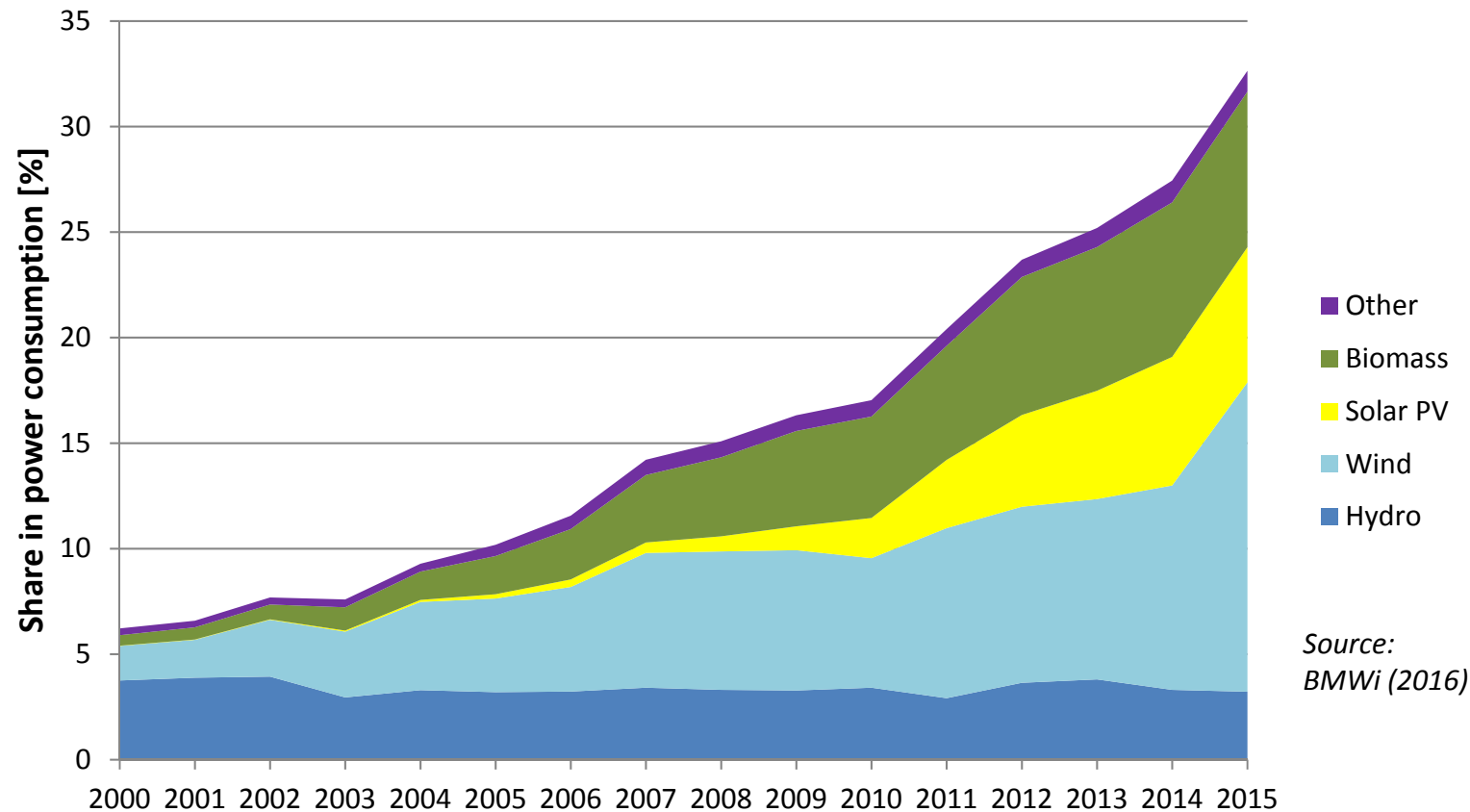
FAZ, June 2011; updated 2016

Renewable Power Deployment Has (Over)-Delivered



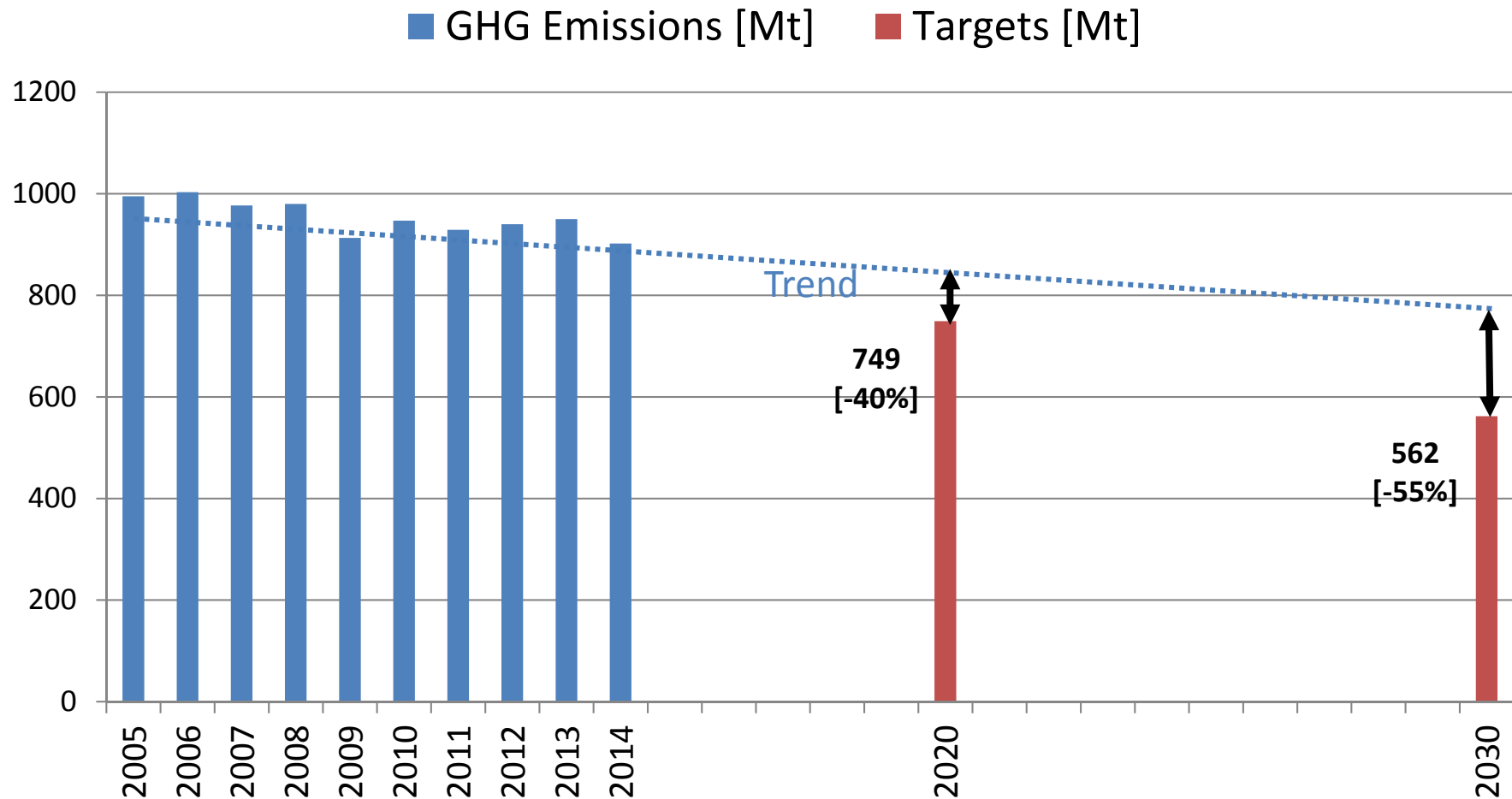
- Share of renewables increased by 25 percentage points in 13 years (33% in 2015)
- Main driver: Feed-in tariff (EEG) since 2000
- High costs a concern, but reductions expected from auctioning from 2017 on

Renewable Power Mix in Detail



- Considerable increase in particular of fluctuating renewables (solar, wind)
- Integration a concern, but **not yet a challenge**

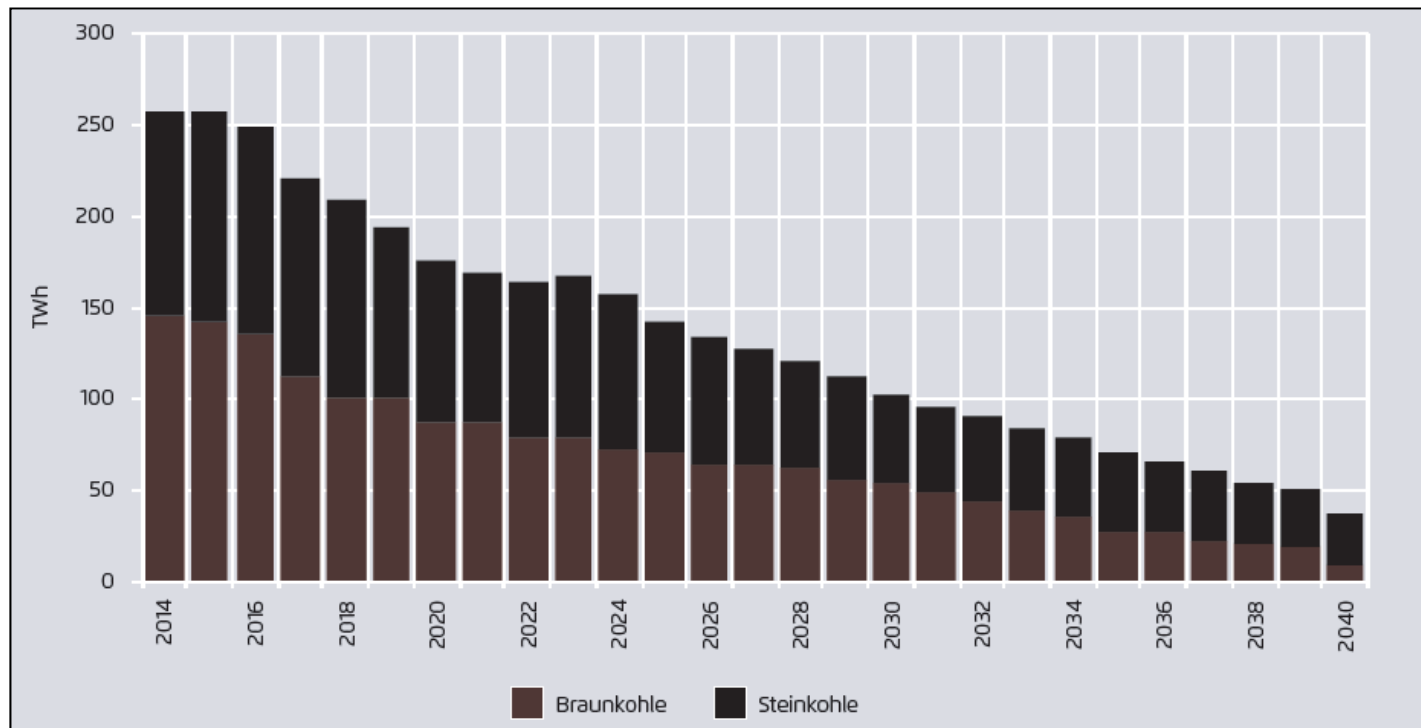
Not on Track With Climate Targets



- According to Government projections (BMUB 2014) GHG emission reduction in 2020 only ~33% (target: -40% / 740 Mt)
- Even larger gap for 2030 target (-55% / 562 Mt)

Coal Phase-Out in Response?

- Coal-phase out until 2040 proposed to reduce GHG emissions in power sector



Source: Agora
Energiewende (2015)

- Part of proposed “catalog of climate measures for 2050”, but unclear if endorsed by Government

„The Great Transformation“, Reloaded 2016

DER SPIEGEL 26/2016



Große Transformation



Klima Mit einem Plan zum Umbau der Industriegesellschaft setzen die SPD-Minister Hendricks und Gabriel die Kanzlerin unter Druck. Wer ist der bessere Koalitionspartner für die Grünen?

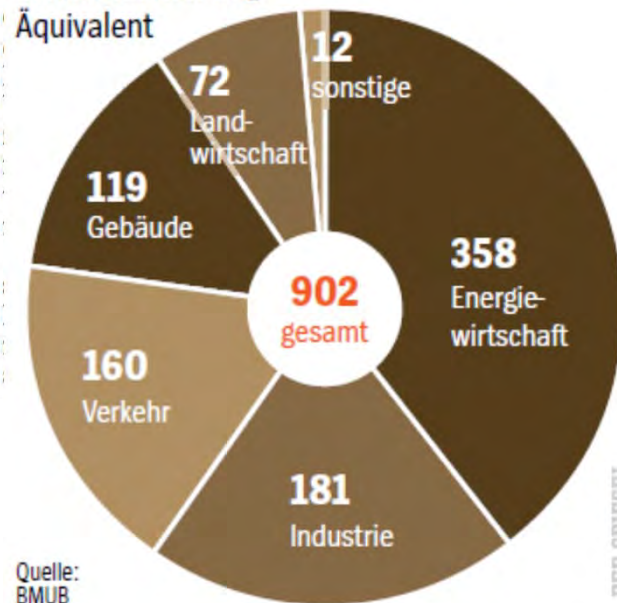
Wenn die Kanzlerin in diesen Tagen öffentlich auftritt, gibt sie gern die Mutmacherin. Von einem „großen Auftrag“ spricht Angela Merkel dann, von „ehrgeizigen Zielen“ sowie der Zusage, dass „wir als Deutsche weiter mit gutem Beispiel vorangehen wollen“. So oder so ähnlich ist sie derzeit zu vernehmen, ganz gleich, ob sie in Peking zum Ehrendoktor ernannt wird oder in Düsseldorf auf dem Deutschen Sparkasentag spricht.

Ein neues „Wir schaffen das“ ist ihre Lösung, nur dass es diesmal nicht um Europas Flüchtlingskrise, sondern um ein anderes bedeutendes Thema geht: den Kampf gegen die Erderwärmung, dem sich die in-

ternationale Staatengemeinschaft auf ihrem historischen Gipfel Ende vorigen Jahres in Paris verpflichtet hat. Einen „großen Erfolg“ nennt das die Kanzlerin, der nun „intensiv umgesetzt werden“ müsse.

Die Gelegenheit ist gekommen. Auf Merkels Schreibtisch liegt ein gut 60 Seiten starkes Papier ihrer Minister Barbara Hendricks (Umwelt) und Sigmar Gabriel (Wirtschaft), das die Konsequenzen der Pariser Beschlüsse für Deutschland ausbuchstabiert. Wochenlang haben die beiden Sozialdemokraten über Maßnahmen gestritten, die das Klimaversprechen von Paris mit den wirtschaftlichen Realitäten einer exportstarken Industriegesellschaft in Einklang bringen sollen.

Emission von Treibhausgasen
nach Verursachern, in Deutschland 2014
in Mio. Tonnen CO₂-
Äquivalent



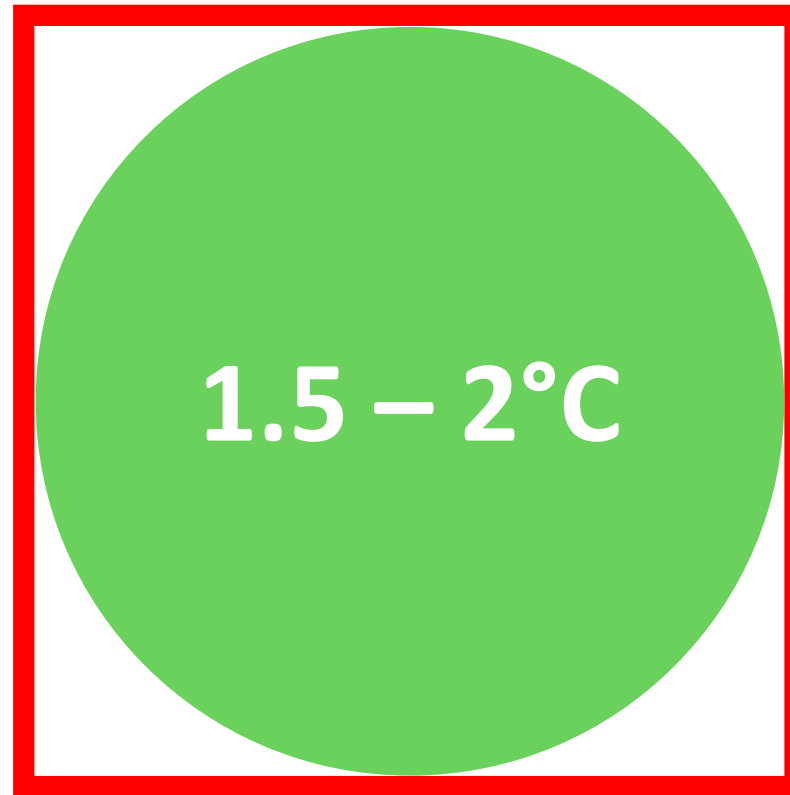
I-Squaring the Climate Circle

Innovation

(Multifolding
Pertinent
RD&D)

Infrastructure

(Carbon -
neutral/negative
Construction)



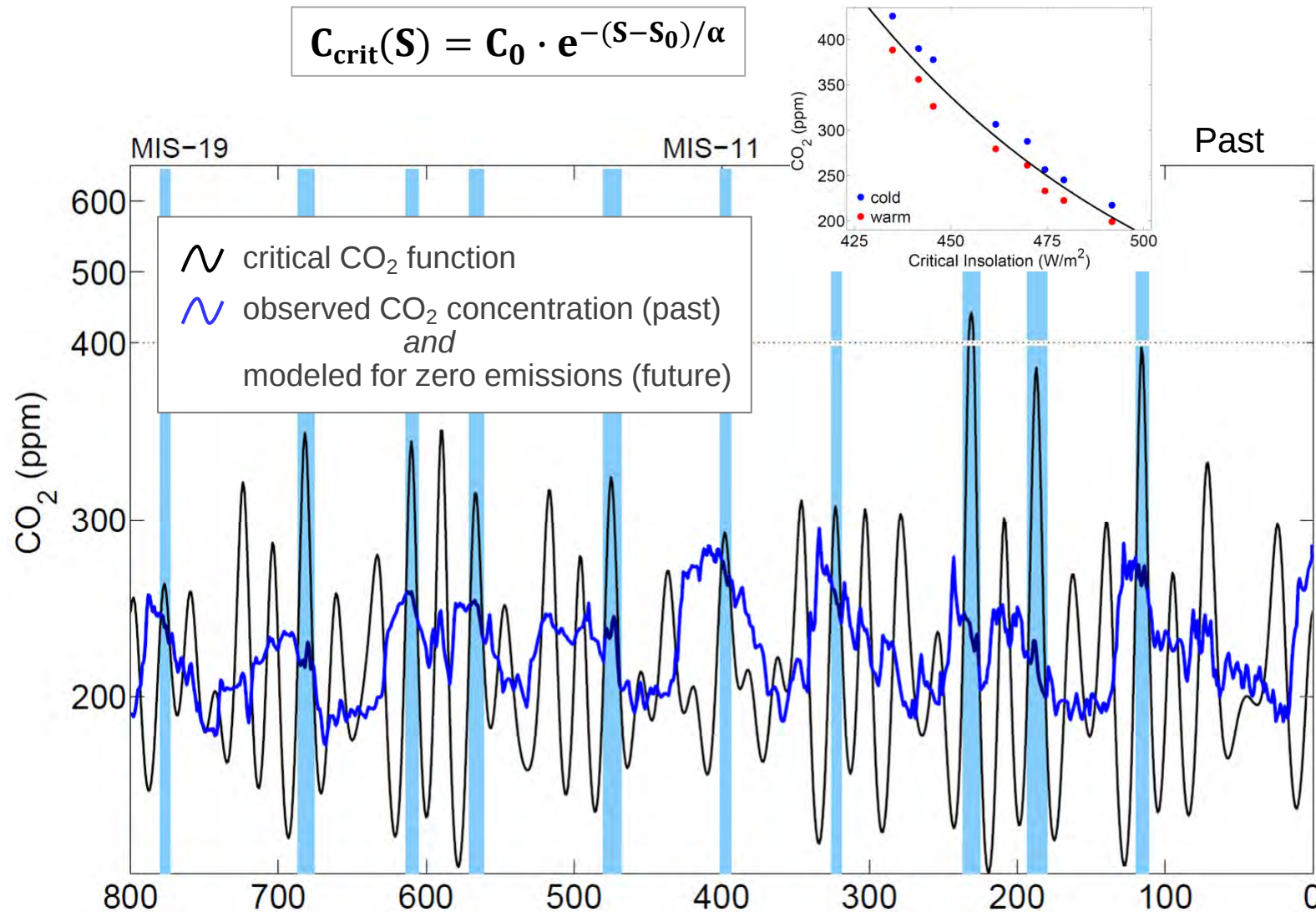
Investment

(National
Transformation
Funds)

Inheritance

(Paying back
Externality
Debts)

Critical CO₂ Concentration-Insolation Function



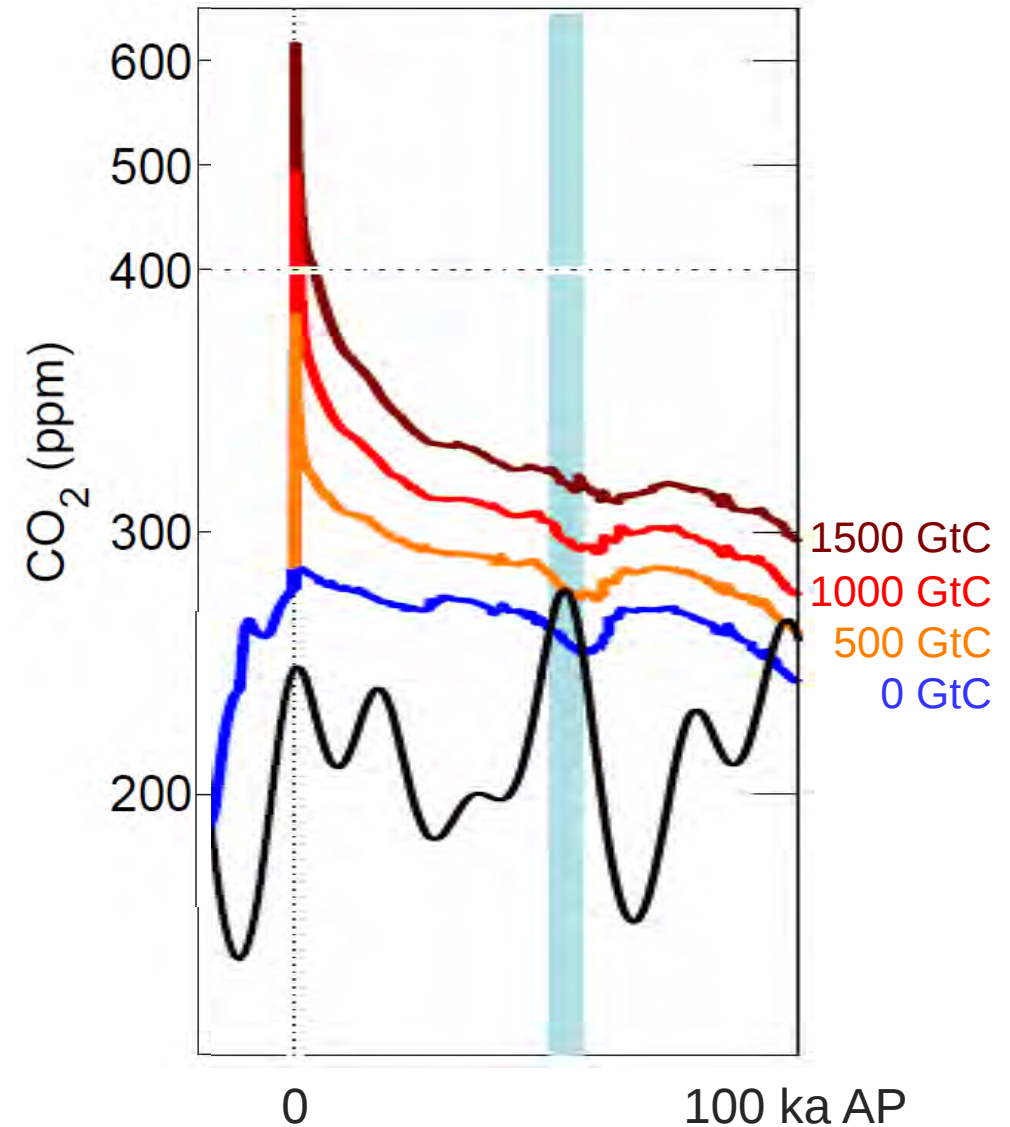
Ganopolski, A., Winkelmann, R., Schellnhuber, H.J. (2016): Critical insolation-CO₂ relation for diagnosing past and future glacial inception. Nature

Critical CO₂ Concentration-Insolation Function

$$C_{\text{crit}}(S) = C_0 \cdot e^{-(S-S_0)/\alpha}$$

$\blacktriangledown$ critical CO₂ function
 $\color{blue}\blacktriangledown$ observed CO₂ concentration (past)
and
modeled for zero emissions (future)

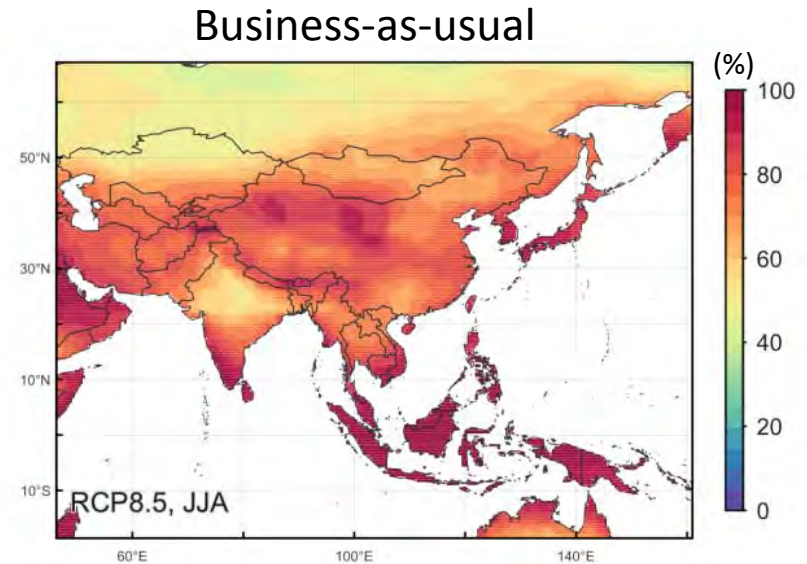
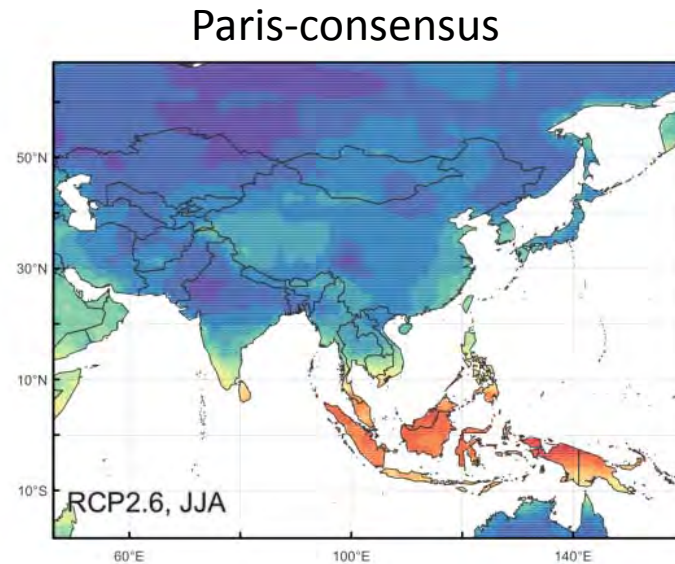
Anthropogenic carbon
injection so far: ≈ 500 Gt



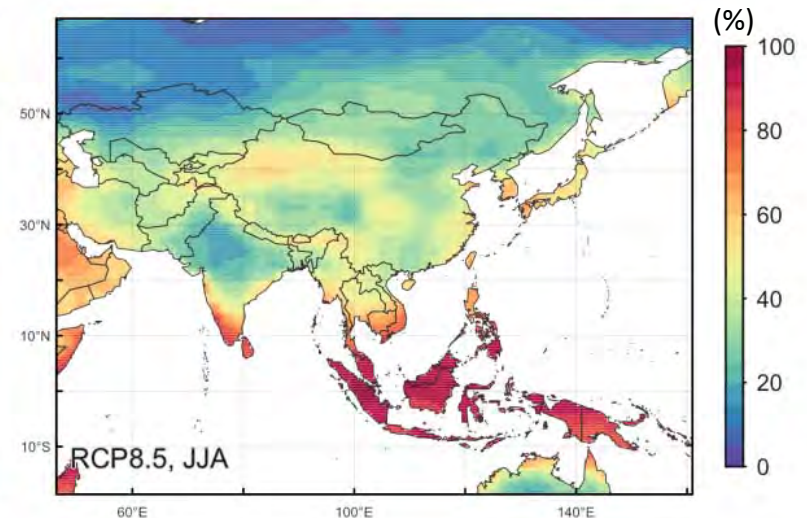
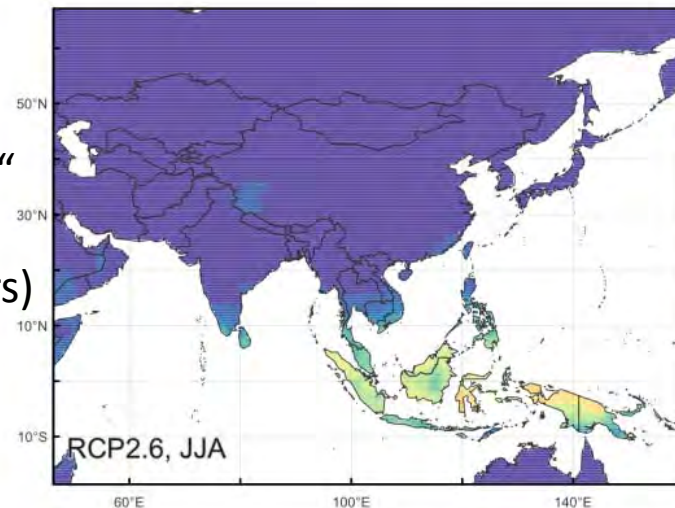
Summer Heat Extremes

Shift Regions into New Climate Regimes

“Unusual”
3-sigma events
(1 in 740 years)



“Unprecedented”
5-sigma events
(1 in > 3 mio years)



Data source: ISI-MIP database (Warszawski et al. 2014, PNAS)

Heat Records Could Make Gulf Region Uninhabitable

nature
climate change

LETTERS

PUBLISHED ONLINE: 26 OCTOBER 2015 | DOI: 10.1038/NCLIMATE2833

Future temperature in southwest Asia projected to exceed a threshold for human adaptability

Jeremy S. Pal^{1,2} and Elfatih A. B. Eltahir^{2*}

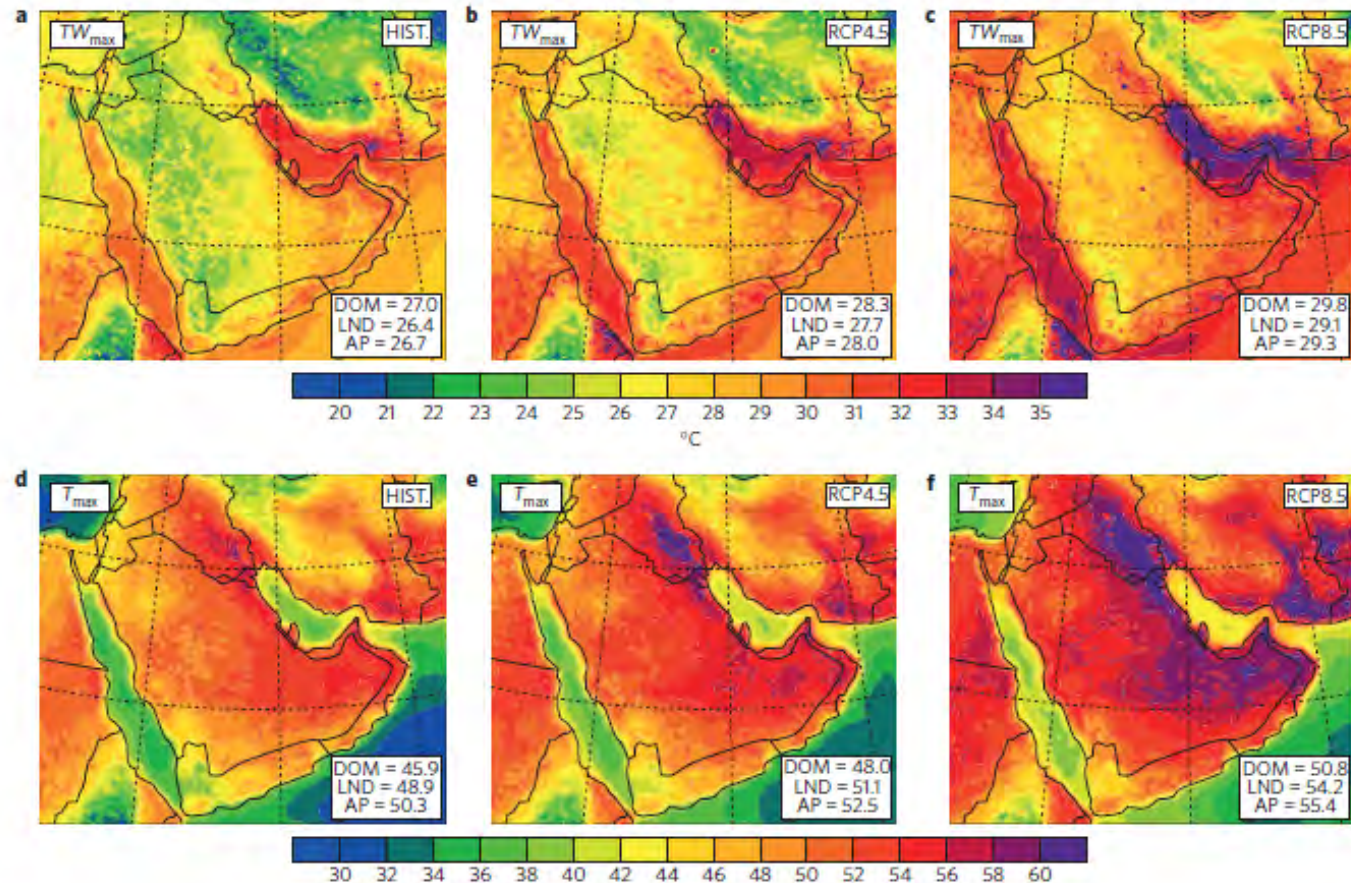


Figure 1 | Spatial distributions of extreme wet bulb temperature and extreme temperature. a–f, Ensemble average of the 30-year maximum TW_{max} (a–c) and T_{max} (d–f) temperatures for each GHG scenario: historical (a,d), RCP4.5 (b,e) and RCP8.5 (c,f). Averages for the domain excluding the buffer zone (DOM), land excluding the buffer zone (LND) and the Arabian Peninsula (AP) are indicated in each plot. TW_{max} and T_{max} are the maximum daily values averaged over a 6-h window.