Future of forests in a changing climate

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EUROPEAN UNION

MINISTRY OF EDUCATION, YOUTH AND SPORTS

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INVESTMENTS IN EDUCATION DEVELOPMENT

Forests are long-lived ecosystems tuned to a stable climate

What's that? Little differing statistics from year to year, or decade to decade

- Weather: momentaneous state of the atmosphere
- Climate: statistics of weather *and* of characteristics of hydrosphere and land cover (the *climate system*) over any period – not only averages, but all percentiles of the values and of behaviour of those values in time

Various terms

- global warming (… correct: a trend)
- climate change (… nobody gets worried)

- **global climate disruption** (… illustrative)
- climate crisis (… dtto)
- dramatic climate change (… euphemism)

Global warming
- such a term may be confusing

May appear to be

- uniform over Earth,
- concerning just its temperature,
- gradual
- and maybe harmless

However, the changes are

- not uniform at all,
- concern much more than temperature
- quick compared to adaptation abilities
- and harmfull at many cases and sites

Temperature anomaly is the simplest indicator of change

Apart averages, climate is characterised by extremes, times of occurence, spatial arrangement of

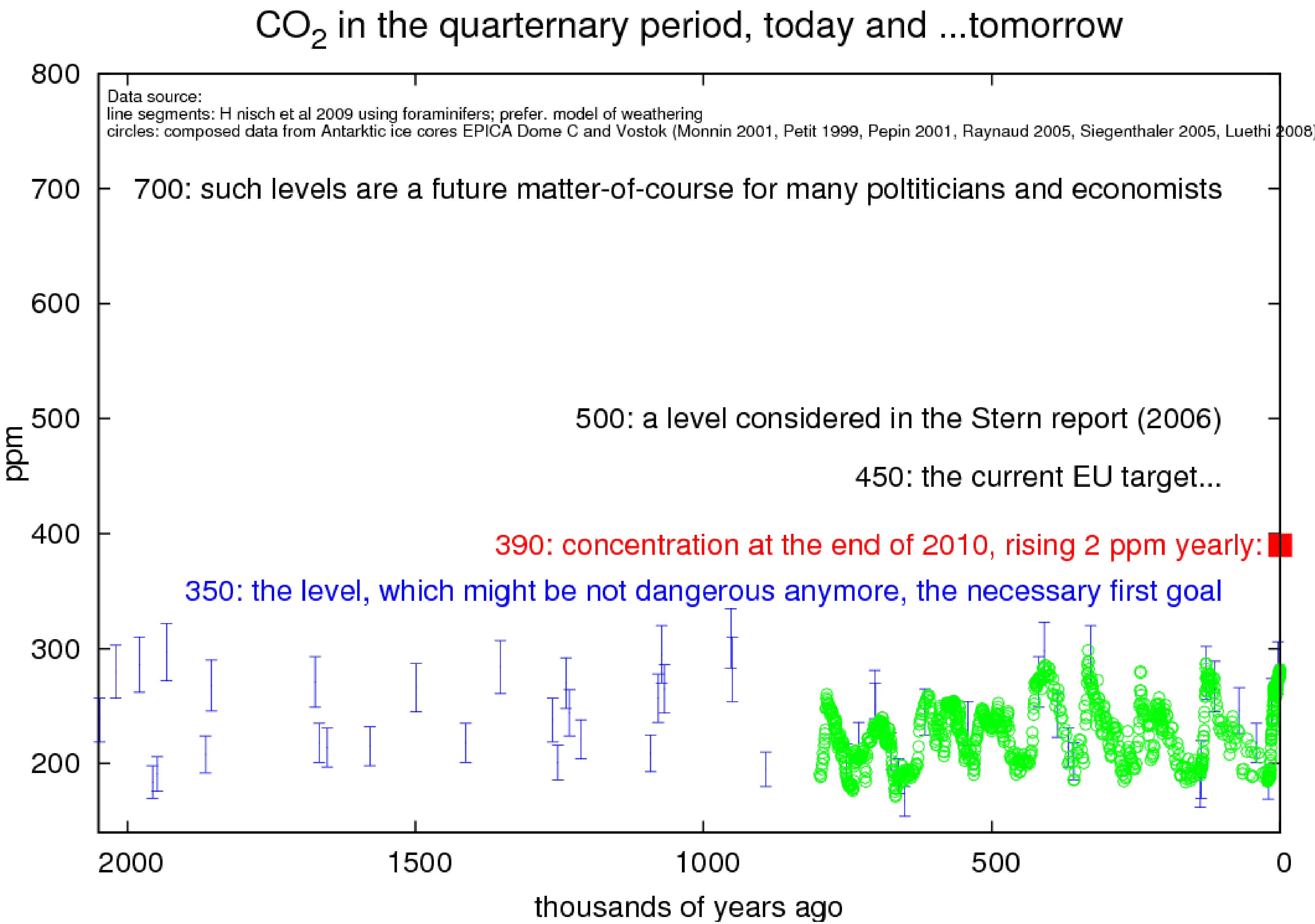
- hot and cold,
- overcast and clear sky,
- humidity and droughts
- snowfall, snow cover and thawing
- breezes, snowstorms, tornados and hurricanes

Climate change means the disruption of the patterns existing up to recently. A small change of the indicator (global departure from past temperatures) implies large changes of occurence of different types of weather.

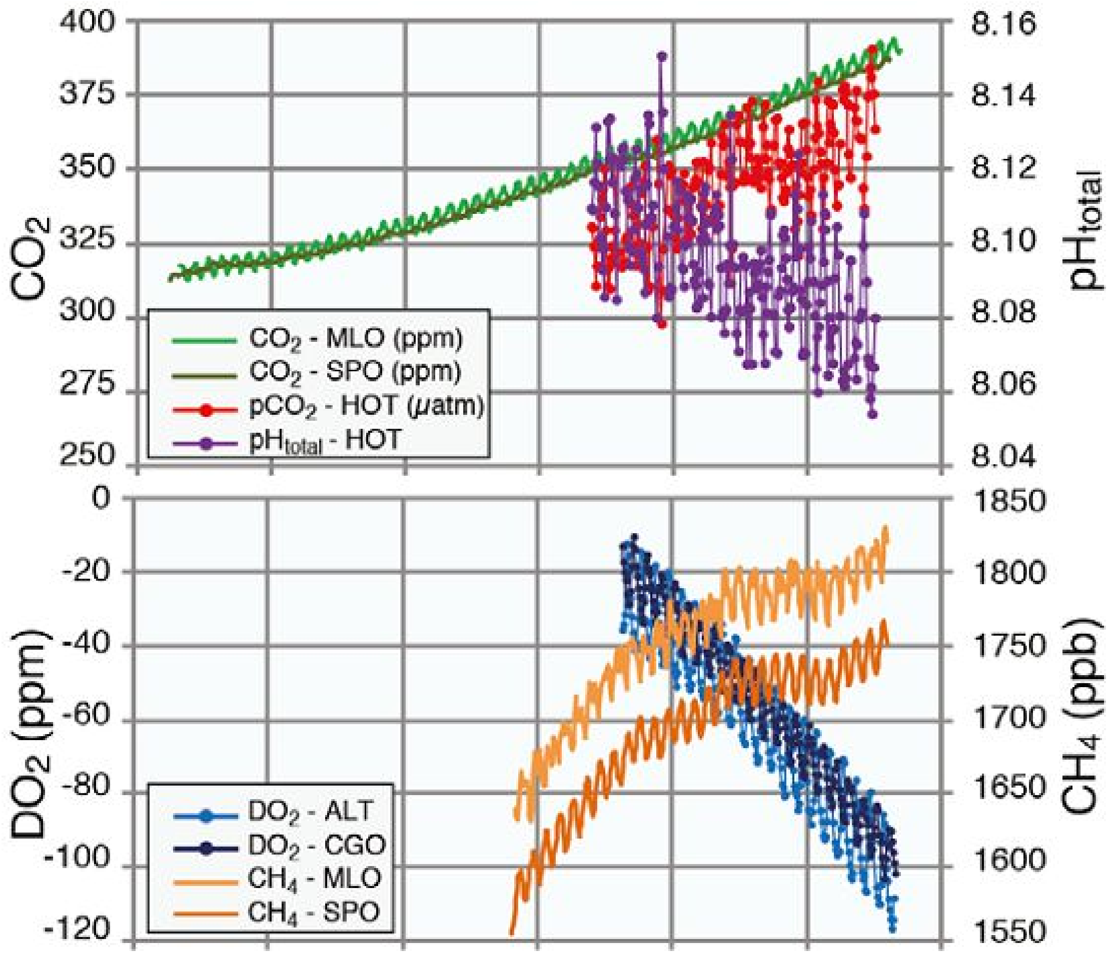
Causes

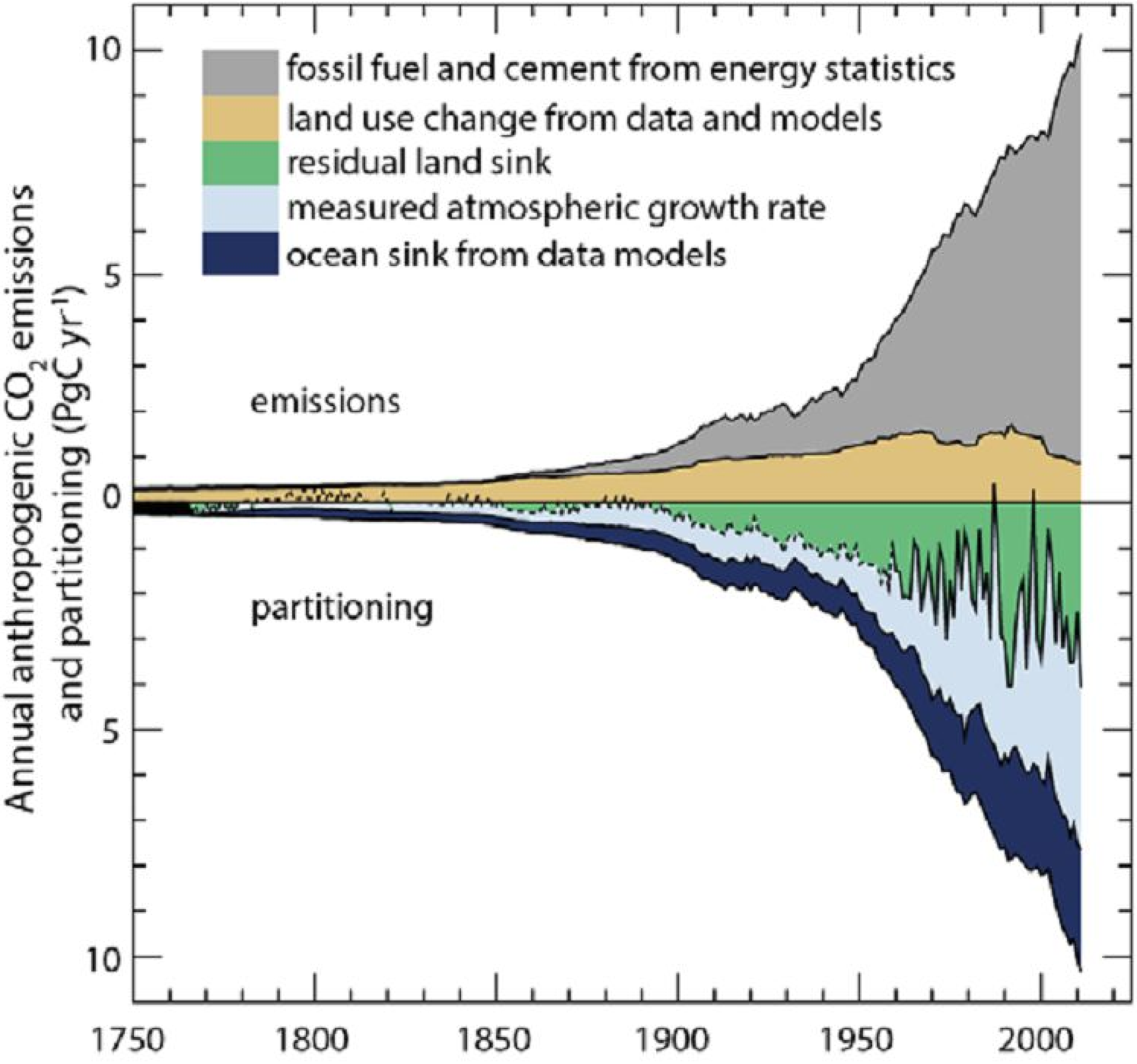
Rising concentrations of greenhouse gases. Their influence is masked by sulphate aerosols quite a lot

Květen 2011: 392,01 ppm


CO2 in the quarternary period, today and ...tomorrow
Data source:
line segments: H nisch et al 2009 using foraminifers; prefer. model of weathering
circles: composed data from Antarktic ice cores EPICA Dome C and Vostok (Monnin 2001, Petit 1999, Pepin 2001, Raynaud 2005, Siegenthaler 2005, Luethi 2008)
700: such levels are a future matter-of-course for many poltiticians and economists
500: a level considered in the Stern report (2006)
450: the current EU target...
390: concentration at the end of 2010, rising 2 ppm yearly:
350: the level, which might be not dangerous anymore, the necessary first goal
ppm
800
700
600
500
400
300
200
2000
1500
1000
500
0
thousands of years ago

(AR5 WG I, figure TS.5, upper 2 graphs)

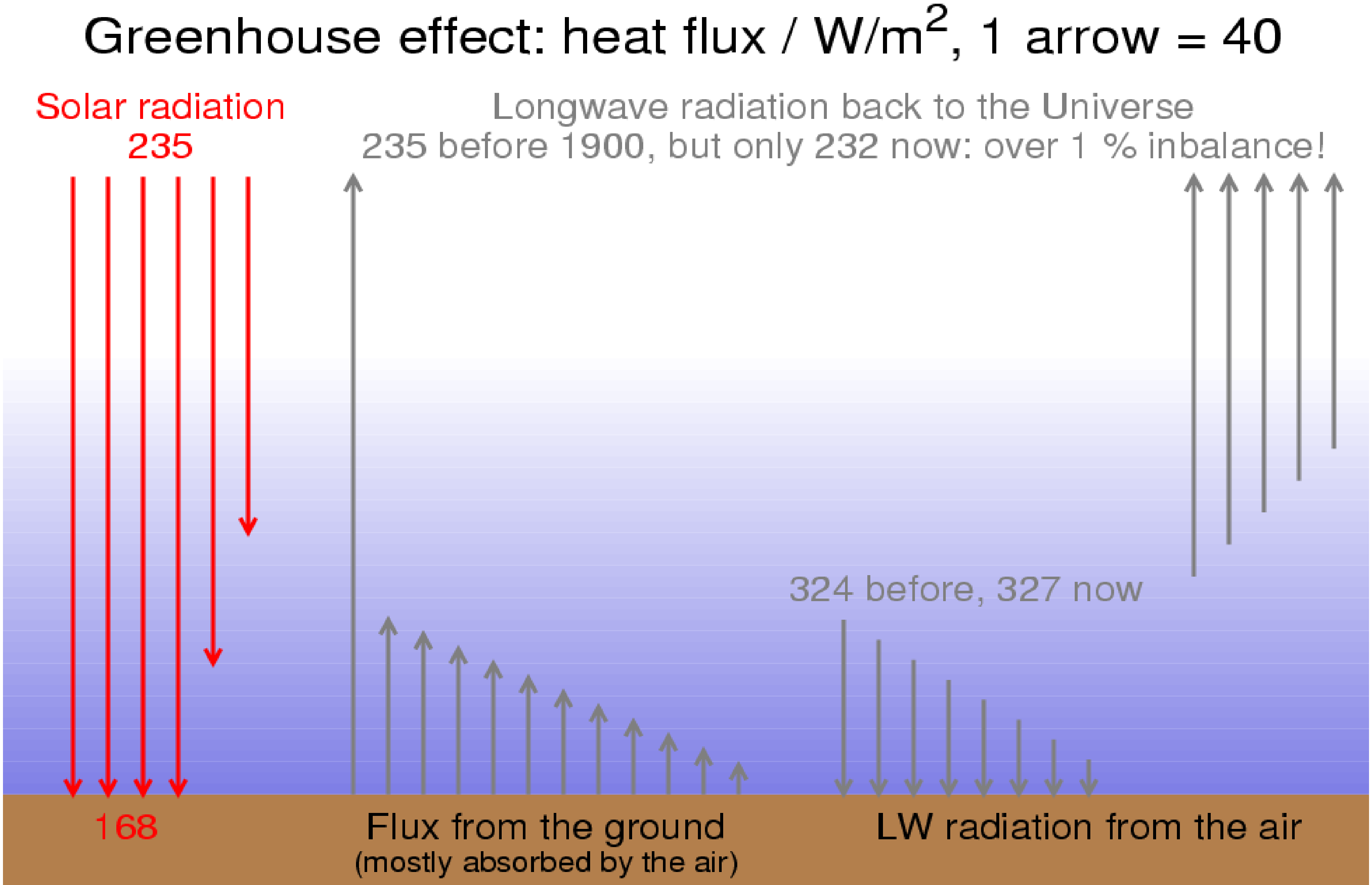




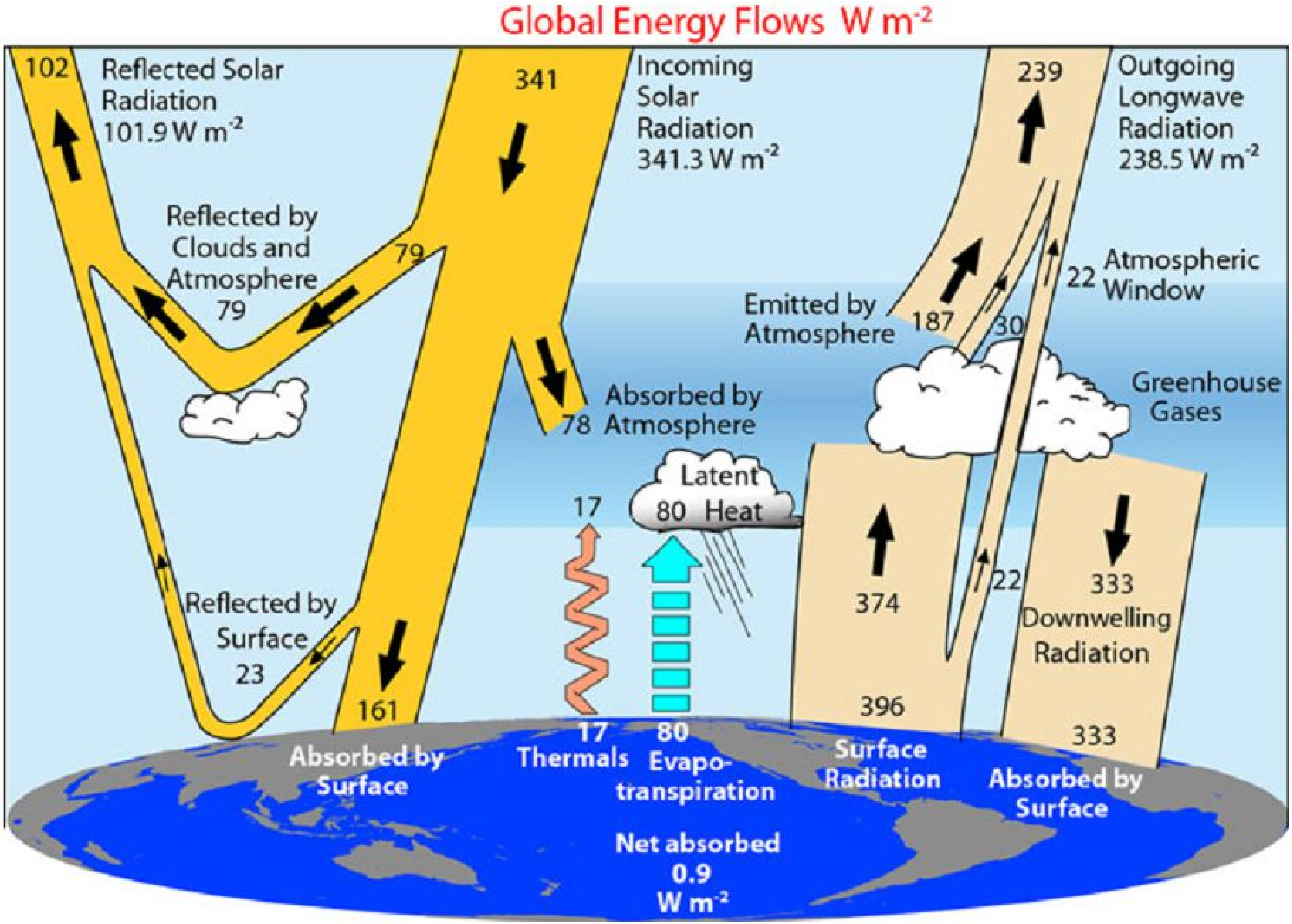
fossil fuel and cement from energy statistics
land use change from data and models
residual land sink
measured atmospheric growth rate
ocean sink from data models
emissions
partitioning
Annual anthropogenic CO_2 emissions and partitioning ($PgC\ yr^{-1}$)
10
5
0
5
10
1750
1800
1850
1900
1950
2000

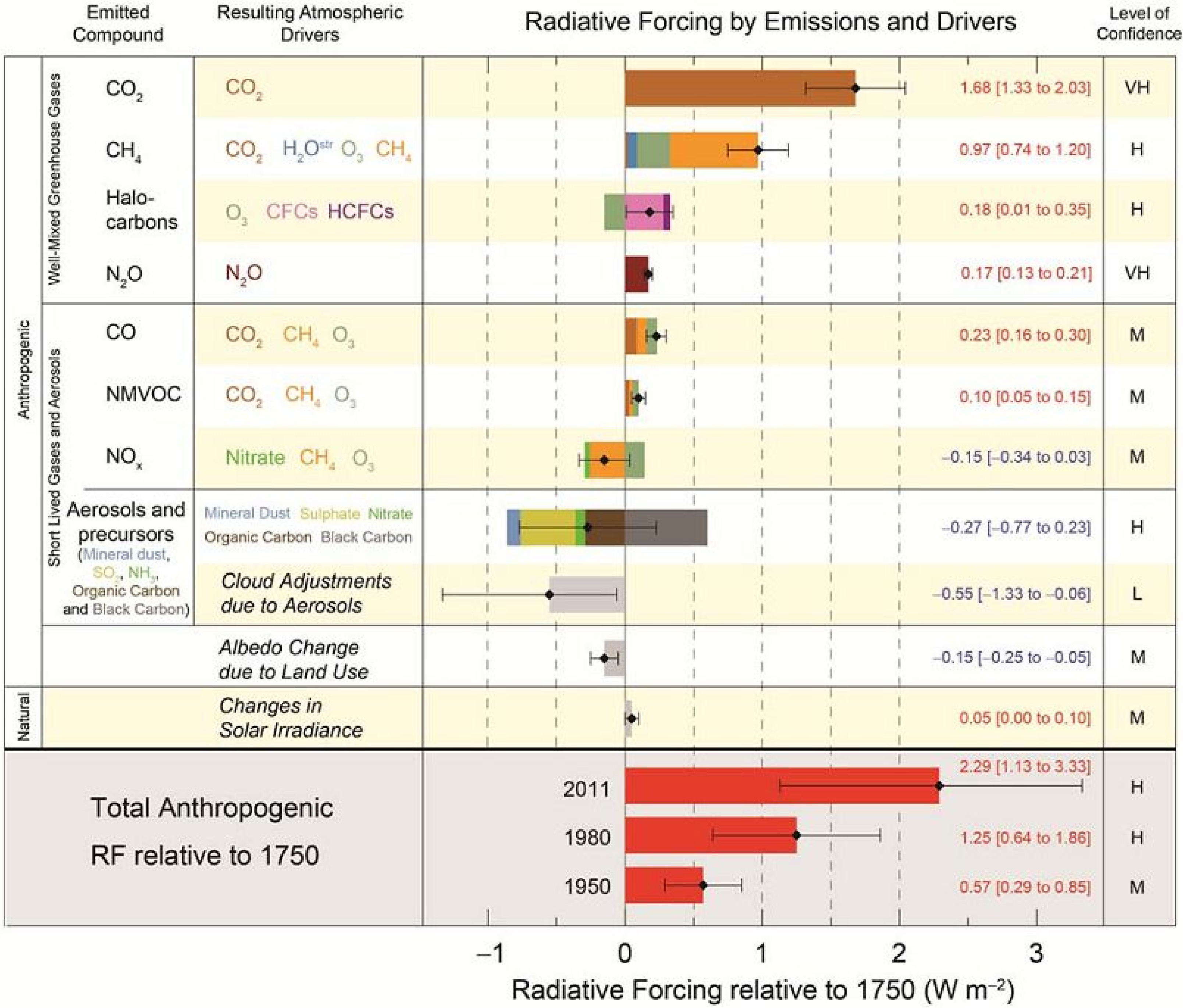
zdroj: Veronica

RF with no cooling aerosols added



2000-2005 (CERES Period); K. E. Trenberth a J. T. Fasullo 2011

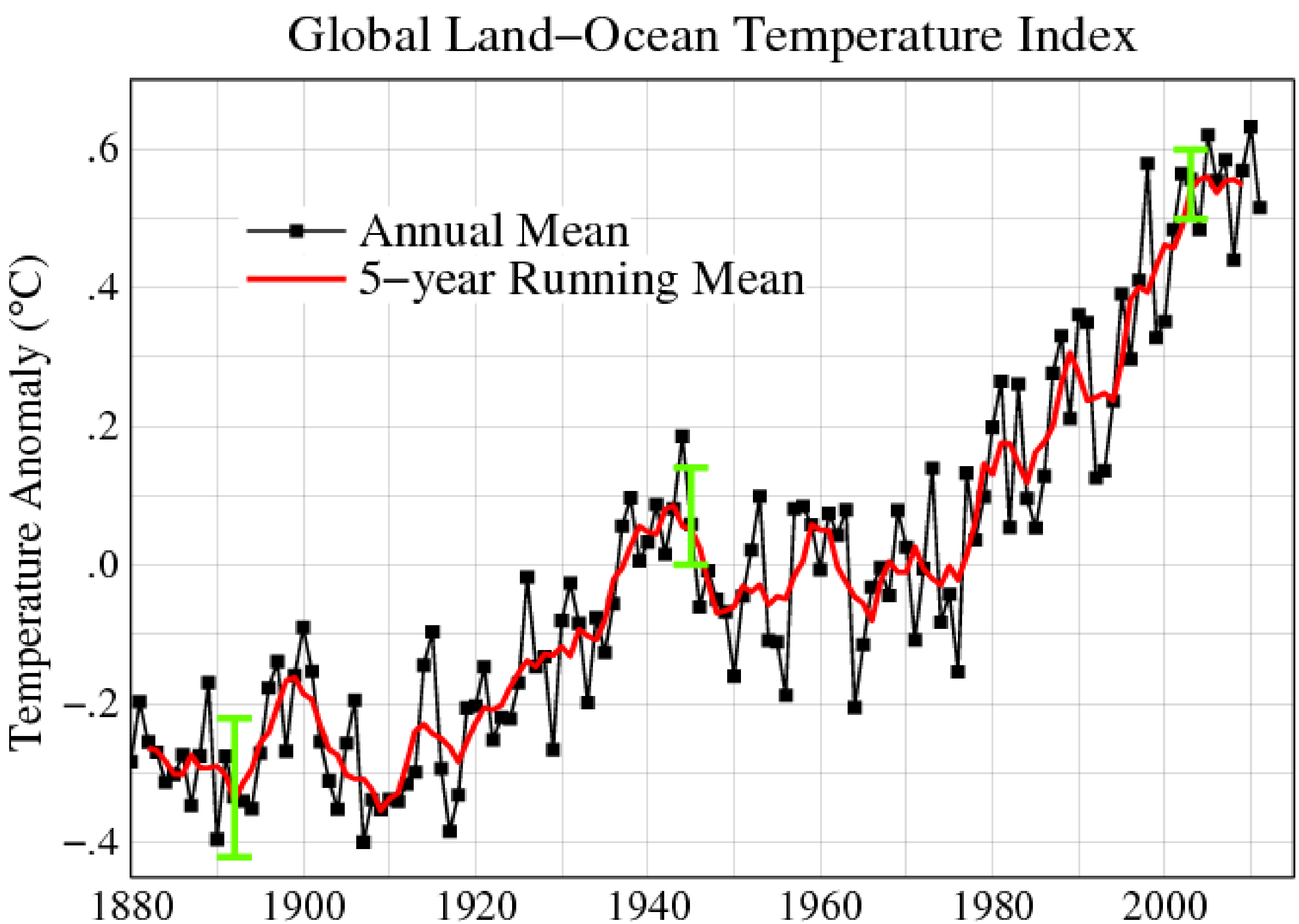




Emitted Compound
Resulting Atmospheric Drivers
Radiative Forcing by Emissions and Drivers
Level of Confidence
Anthropogenic
Well-Mixed Greenhouse Gases
Short Lived Gases and Aerosols
Natural
CO2
CH4
Halo-carbons
N2O
CO
NMVOC
NOx
Aerosols and precursors (Mineral dust, SO2, NH3, Organic Carbon and Black Carbon)
CO2 H2Ostr O3 CH4
O3 CFCs HCFCs
CO2 CH4 O3
Nitrate CH4 O3
Mineral Dust Sulphate Nitrate Organic Carbon Black Carbon
Cloud Adjustments due to Aerosols
Albedo Change due to Land Use
Changes in Solar Irradiance
1.68 [1.33 to 2.03] VH
0.97 [0.74 to 1.20] H
0.18 [0.01 to 0.35] H
0.17 [0.13 to 0.21] VH
0.23 [0.16 to 0.30] M
0.10 [0.05 to 0.15] M
−0.15 [−0.34 to 0.03] M
−0.27 [−0.77 to 0.23] H
−0.55 [−1.33 to −0.06] L
−0.15 [−0.25 to −0.05] M
0.05 [0.00 to 0.10] M
Total Anthropogenic RF relative to 1750
2011 2.29 [1.13 to 3.33] H
1980 1.25 [0.64 to 1.86] H
1950 0.57 [0.29 to 0.85] M
−1 0 1 2 3
Radiative Forcing relative to 1750 (W m−2)

Earth warms up

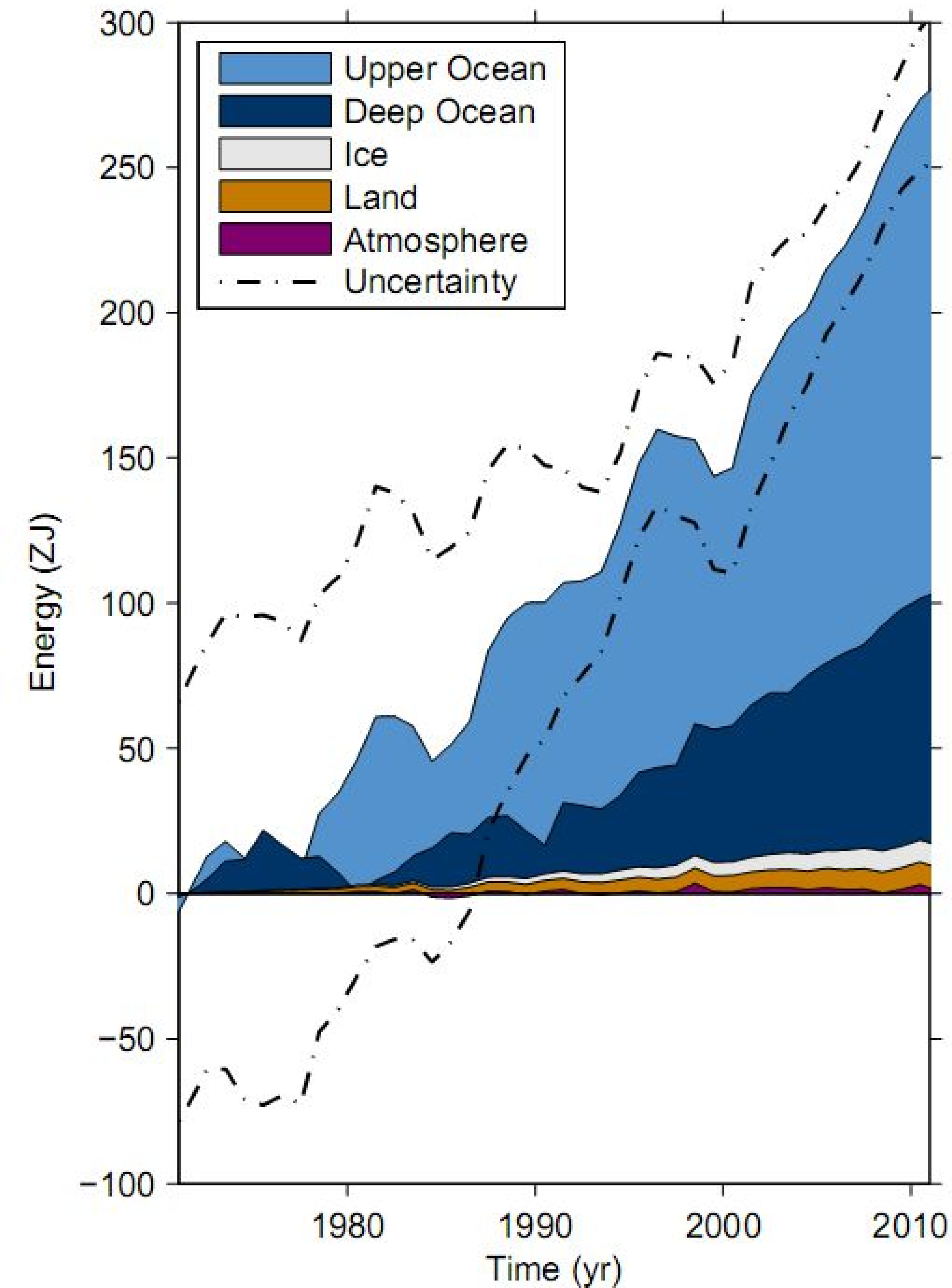
90-ies used to be the warmest decade on record, this millenium is still warmer.:
http://data.giss.nasa.gov/gistemp/graphs_v3/



Warmest years

2010
2005
2007
1998
2009
2002
2003
2006
2011
2001
2004

~ 0.8 ^{o}C: global temperature increase within 100 years



Increase of enthalpy of the Earth

(AR5 WG I, Box 3.1, Figure 1)

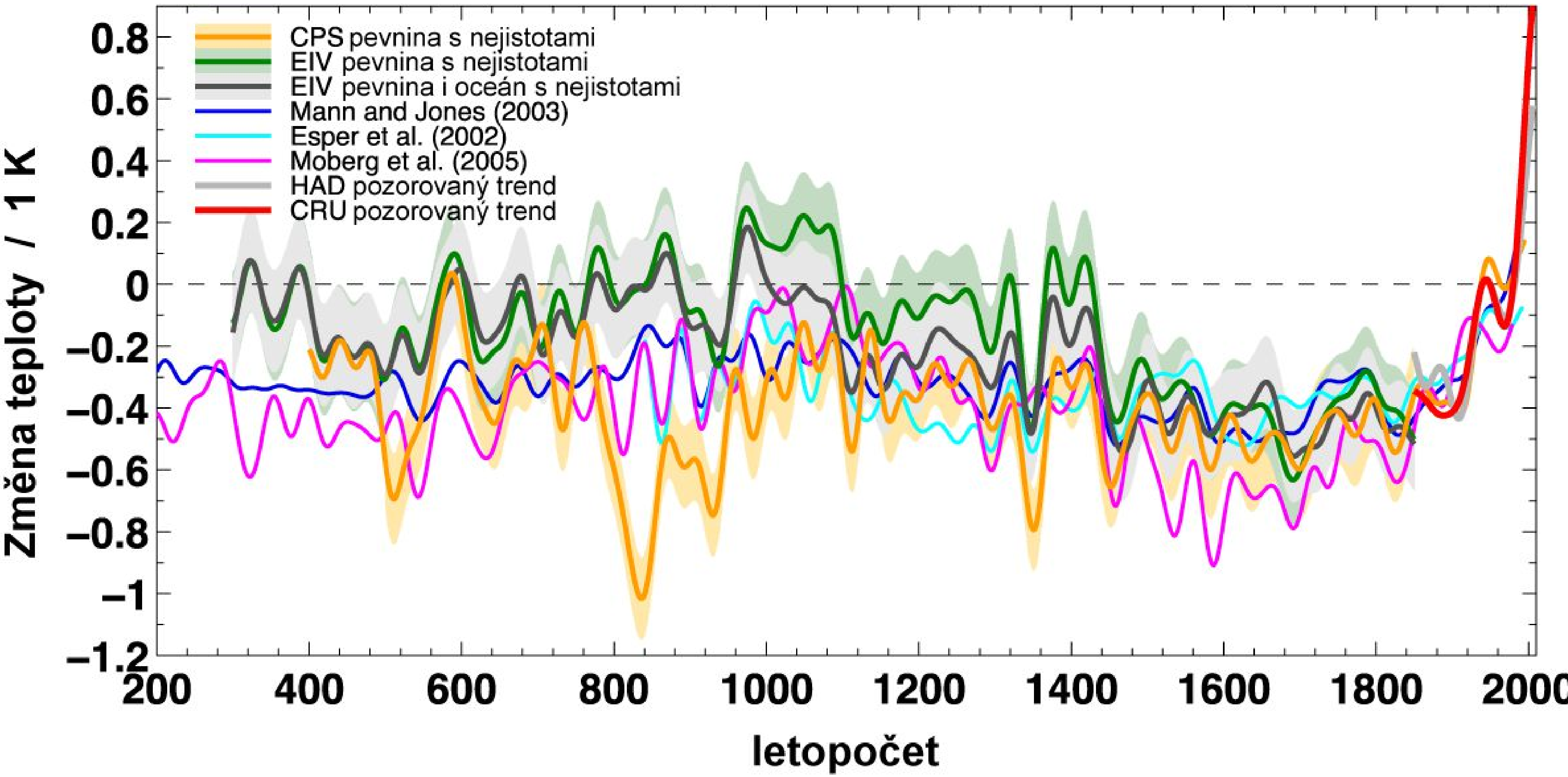


Figure 19: Rekonstrukce změn teploty severní polokoule od roku 200 (zdroj: **Kodaňská diagnóza**)

United Nations
Framework Convention on Climate Change
(1992)

Aim:

to stabilize greenhouse gas concentrations...

"…at a level that would prevent dangerous anthropogenic interference with the climate system."

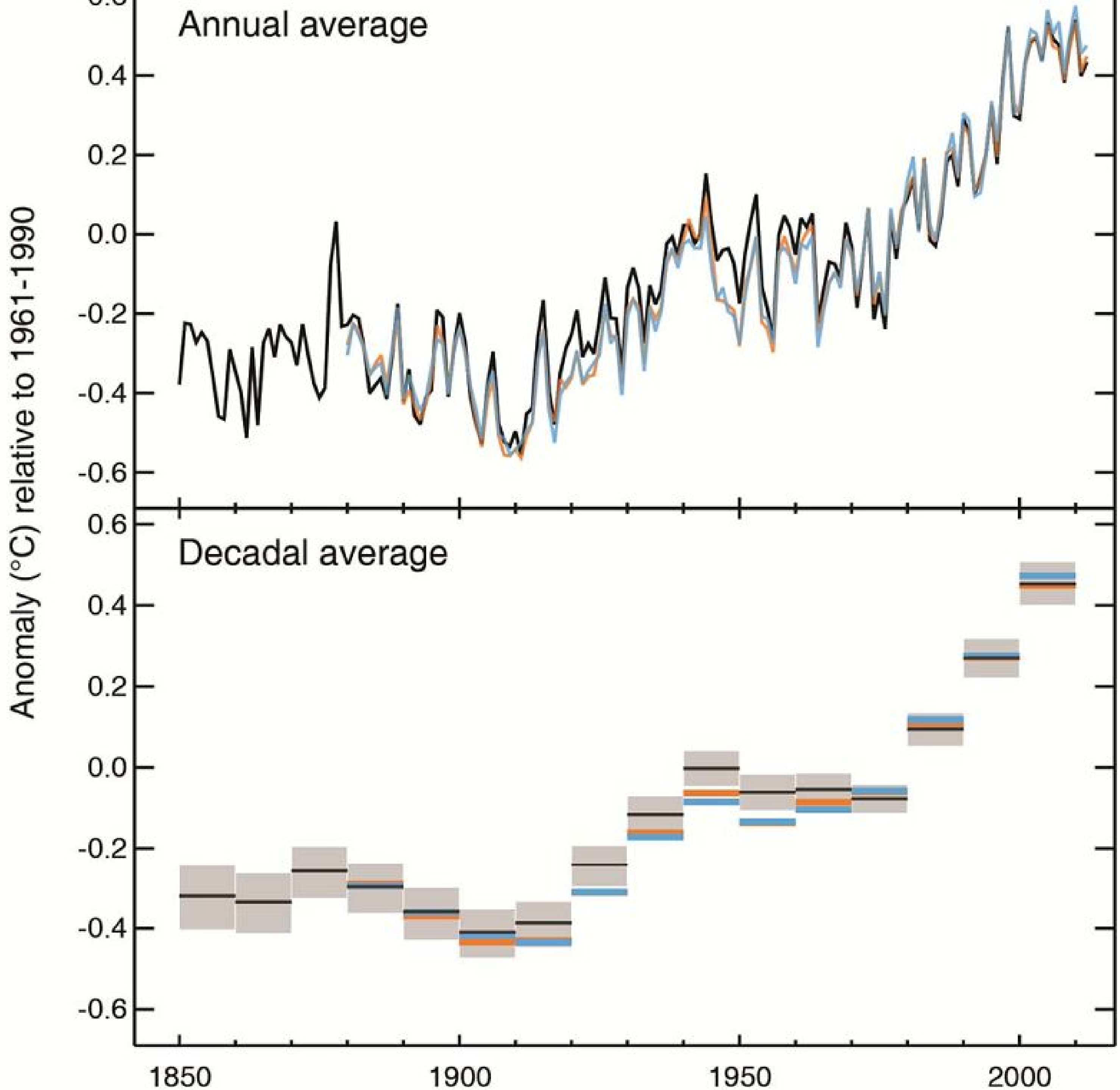
Differing terms

- dangerous interference into the climate system
- dangerous climate change

Causing a disbalance of thermal fluxes absorbed by the Earth and emitted by it is an interference already

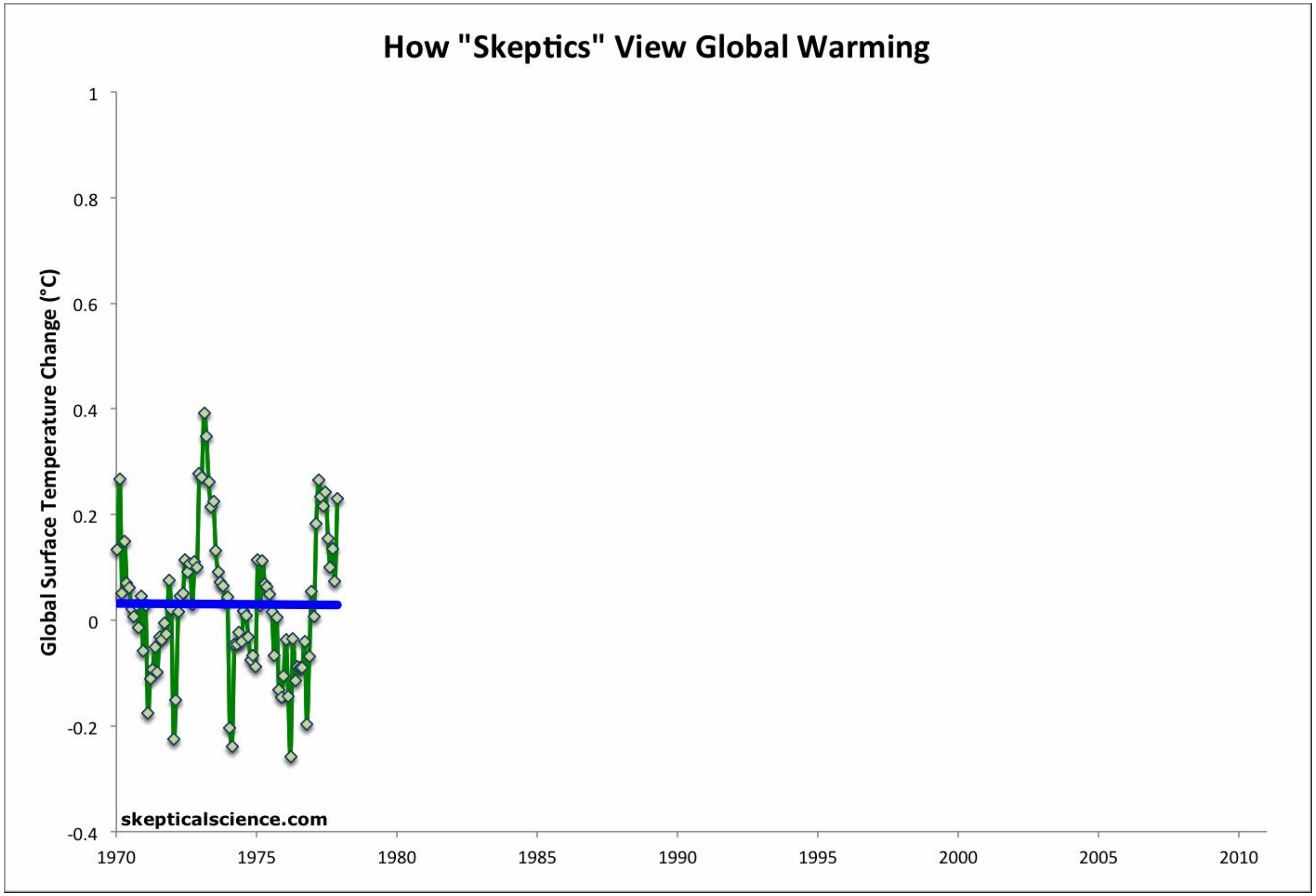
Thermal surplus of almost 1 W/m^2 is dangerous. It changed the climate already and will change it further on

Manifestations

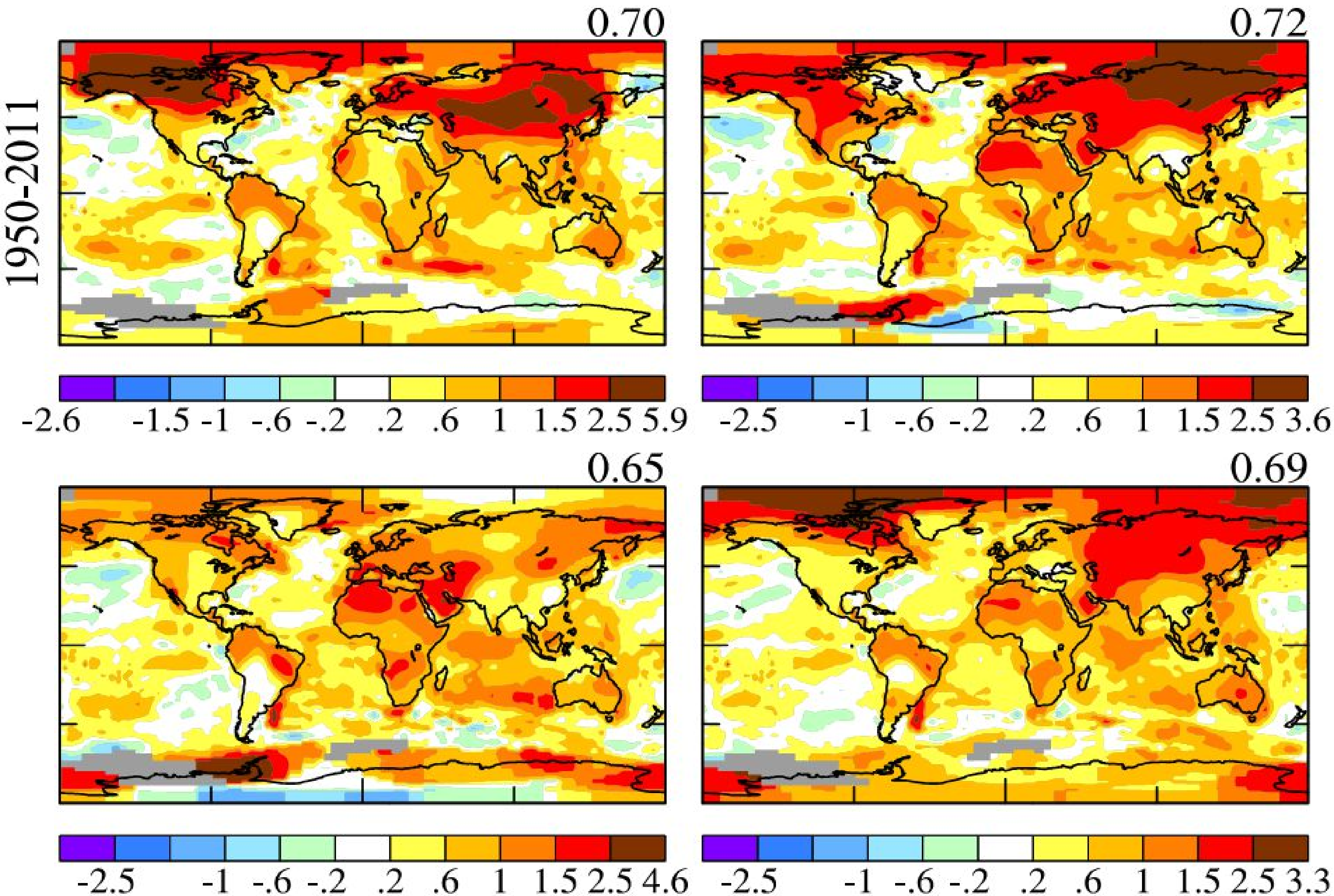


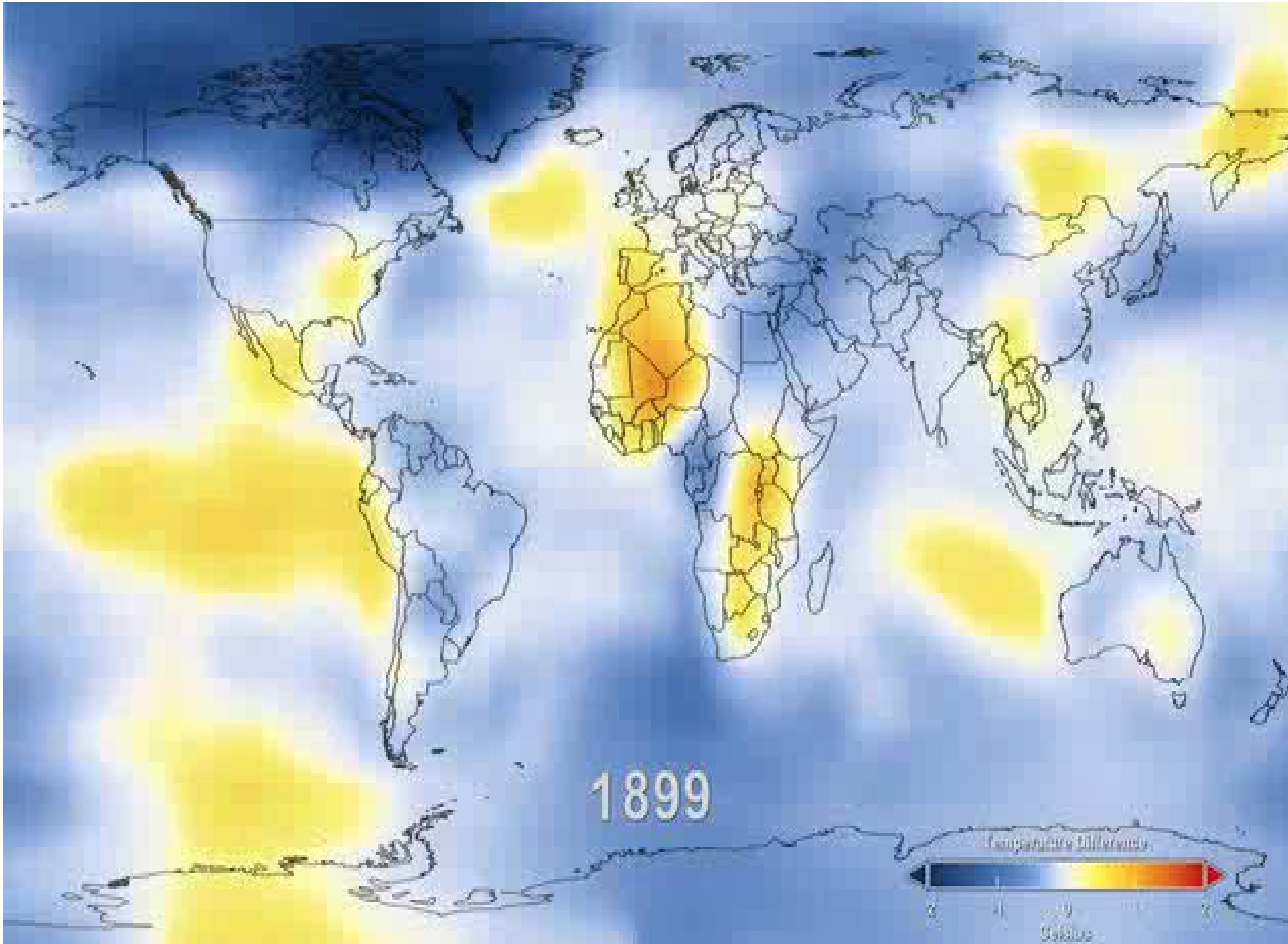
Annual average
Decadal average
Anomaly (°C) relative to 1961-1990
0.4
0.2
0.0
-0.2
-0.4
-0.6
0.6
1850
1900
1950
2000

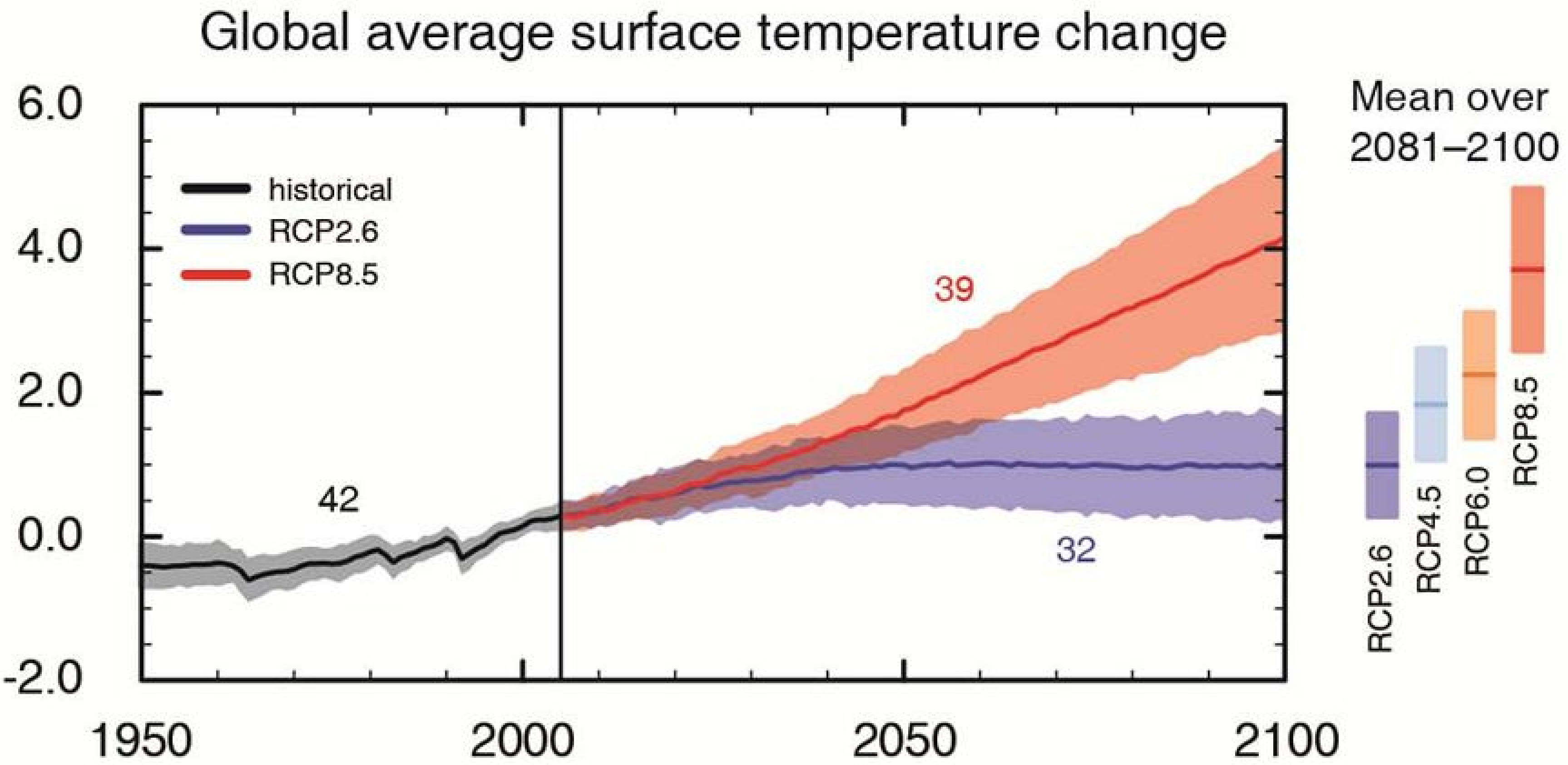
Krátkodobé trendy ochlazování 1970/01 až 77/11, dtto až 86/11, 87/09 až 96/11, 97/03 až 2002/10, 2002/10 až 2011/12 (modře) a trend 42 let oteplování (leden 1970 až prosinec 2011, červeně) dle dat pro oceán i pevninu NOAA NCDC. Zdroj: Dana Nuccitelli, http://www.skepticalscience.com/still-going-down-the-up-escalator.html



Temperature change from 1950 for 3-month seasons – as NH winter (Dec, Jan, Feb), spring, summer, autumn. Source: http://data.giss.nasa.gov/gistemp/

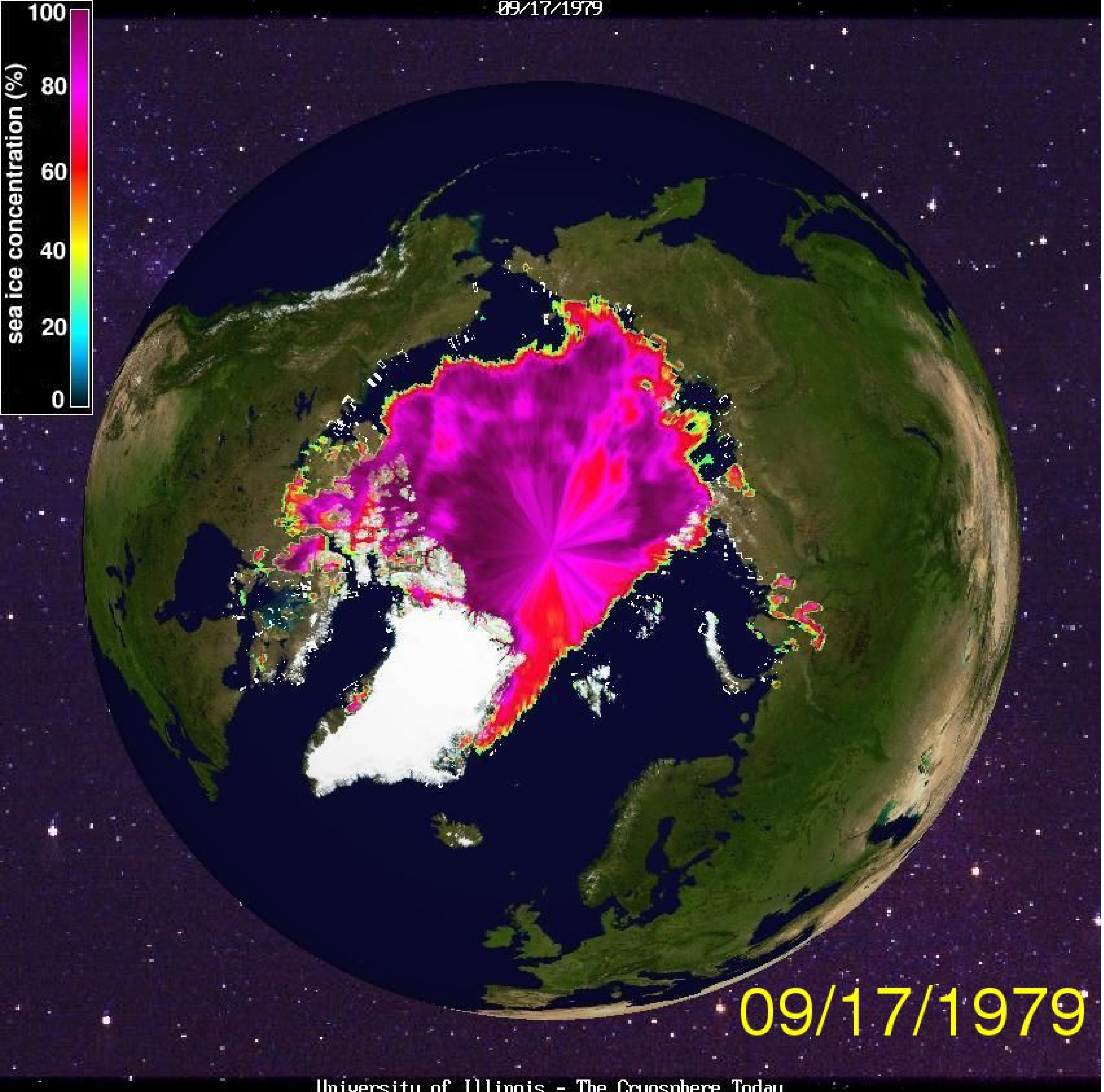



1899


Global average surface temperature change
Mean over 2081–2100
6.0
4.0
2.0
0.0
-2.0
historical
RCP2.6
RCP8.5
39
42
32
1950
2000
2050
2100
RCP2.6
RCP4.5
RCP6.0
RCP8.5

Surface darkening

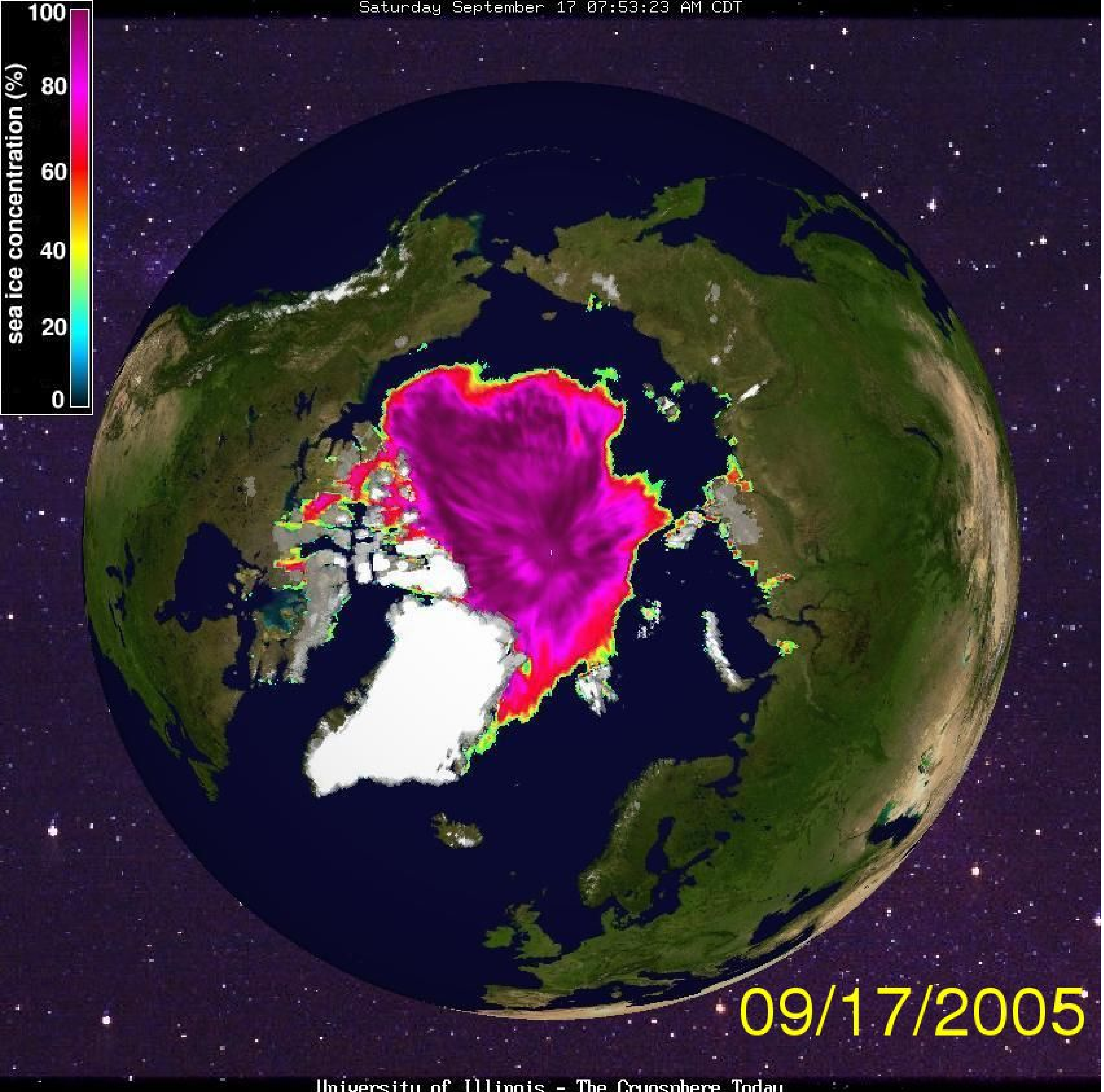
a strong amplifying feedback



1979

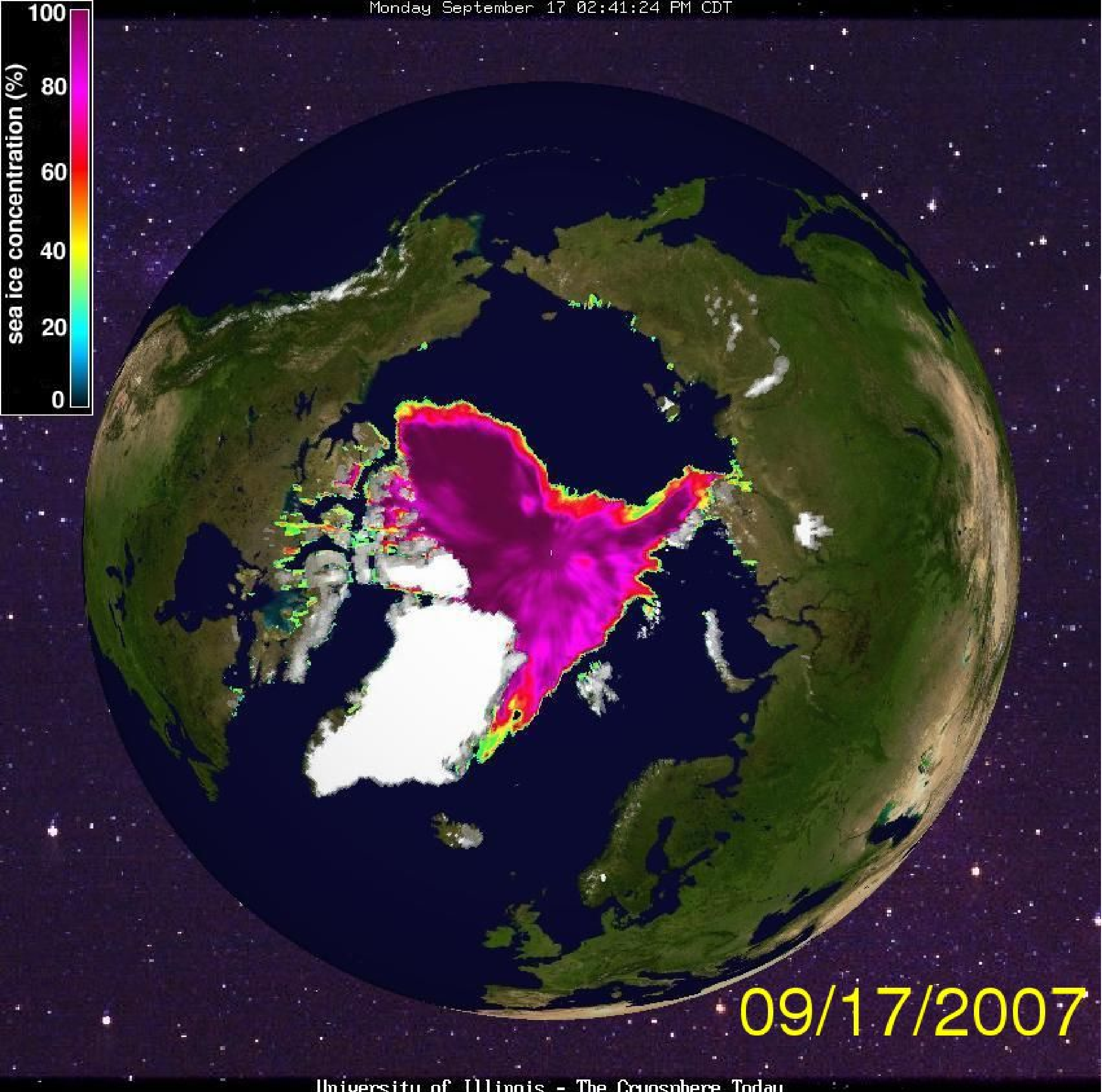
17. září

Arktický mořský led



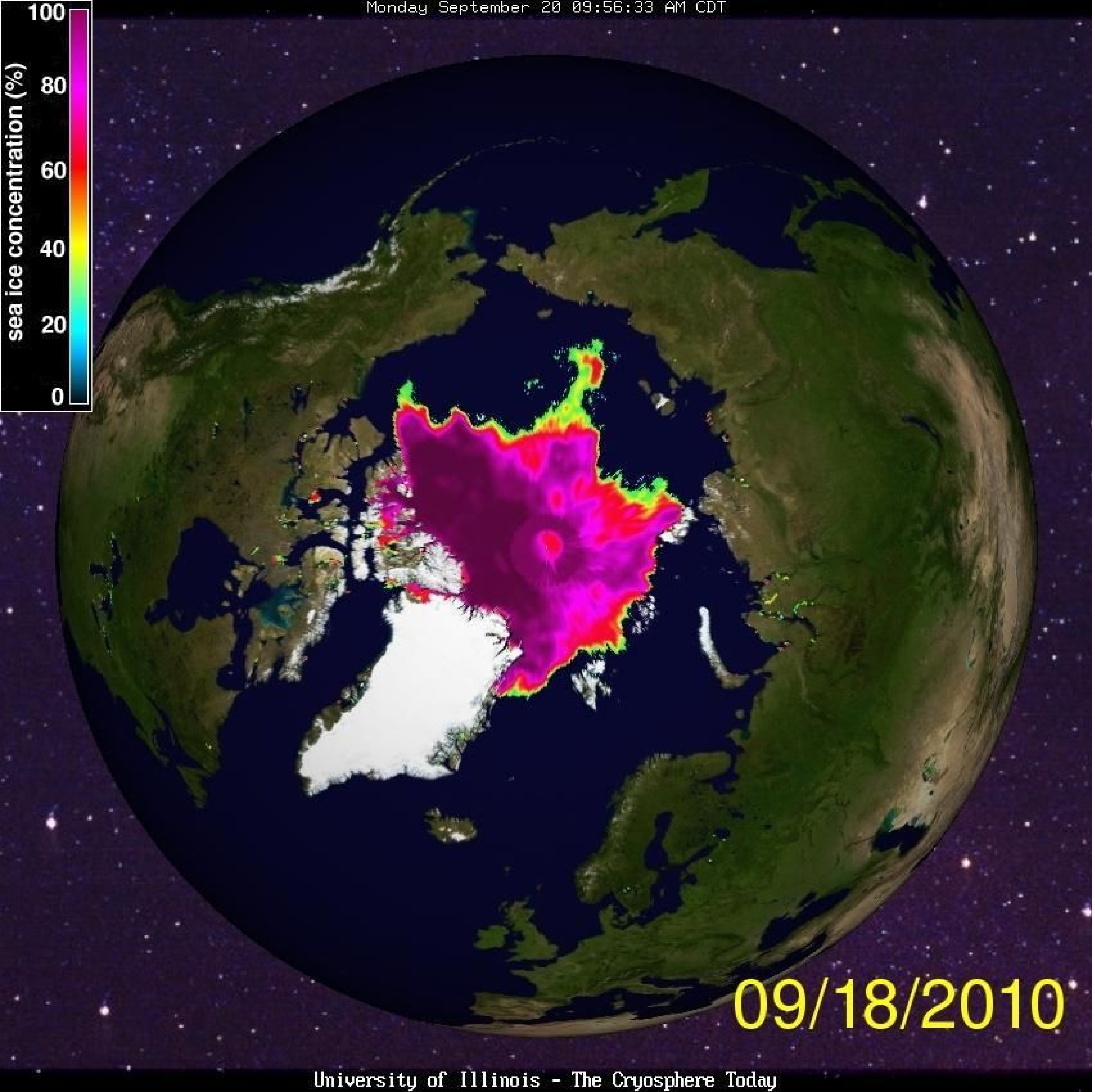
2005
17. září

Arktický mořský led



2007
17. září

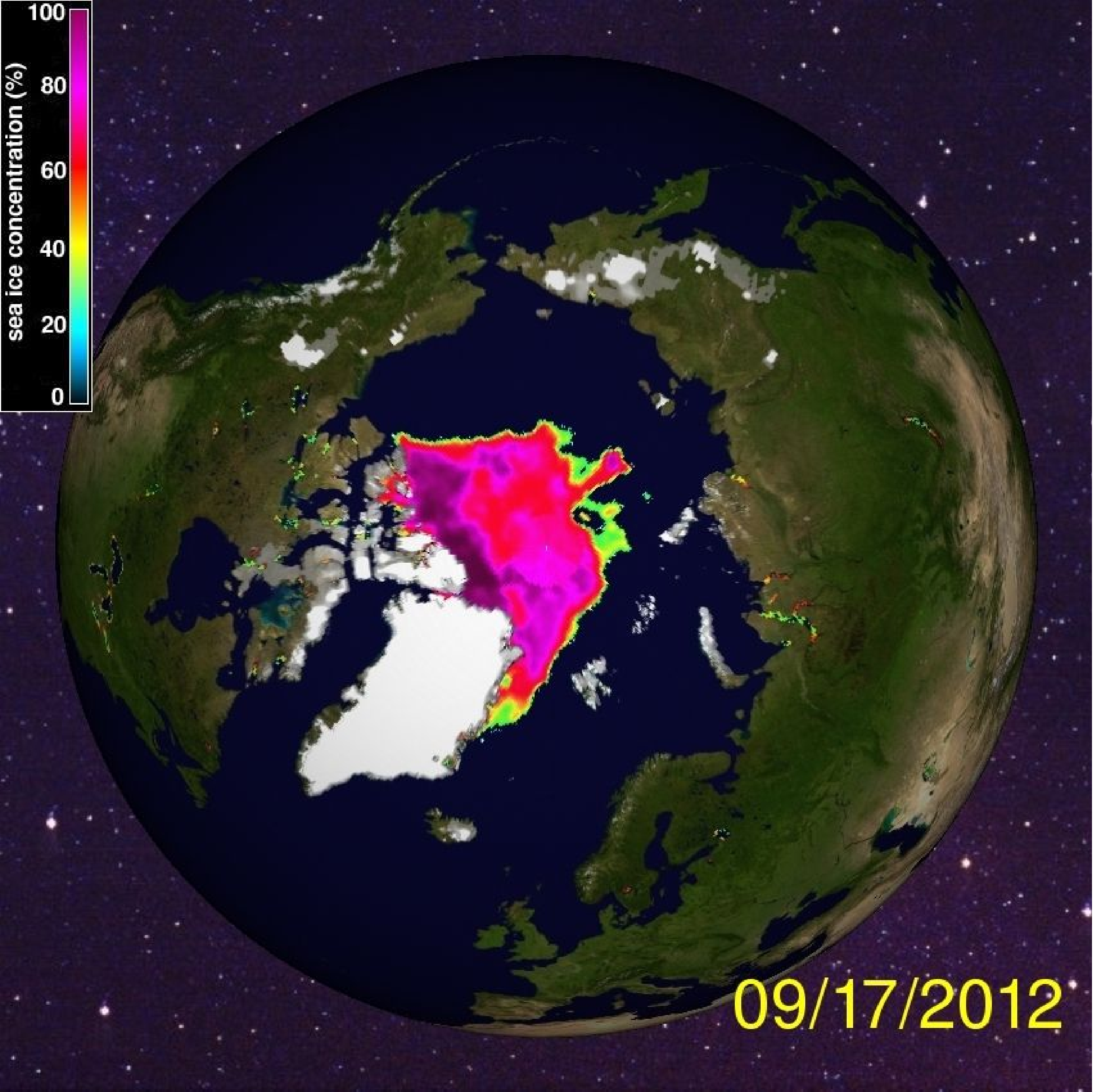
Arktický mořský led



2010

18. září

Arktický mořský led

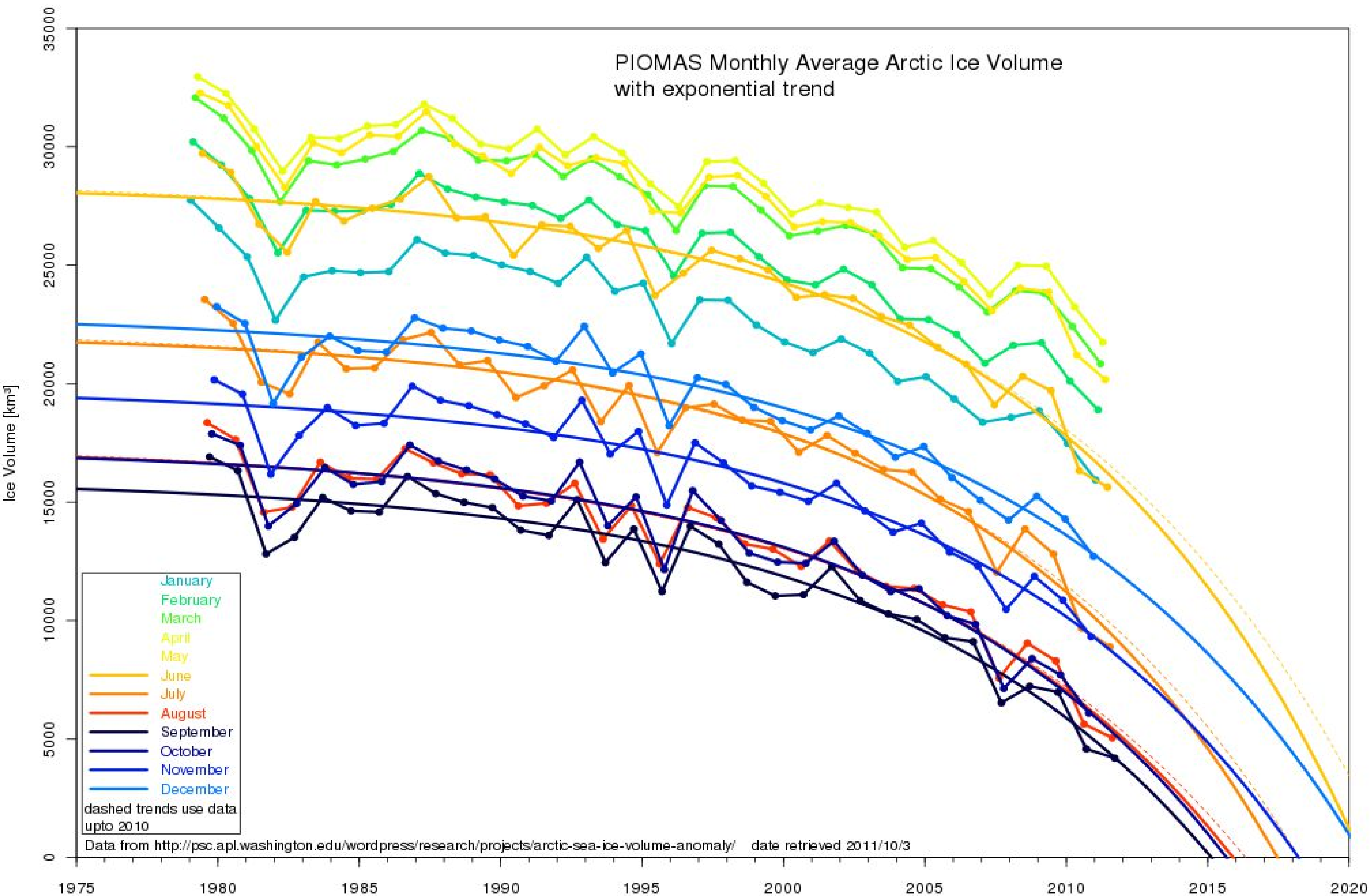


2012

17. září

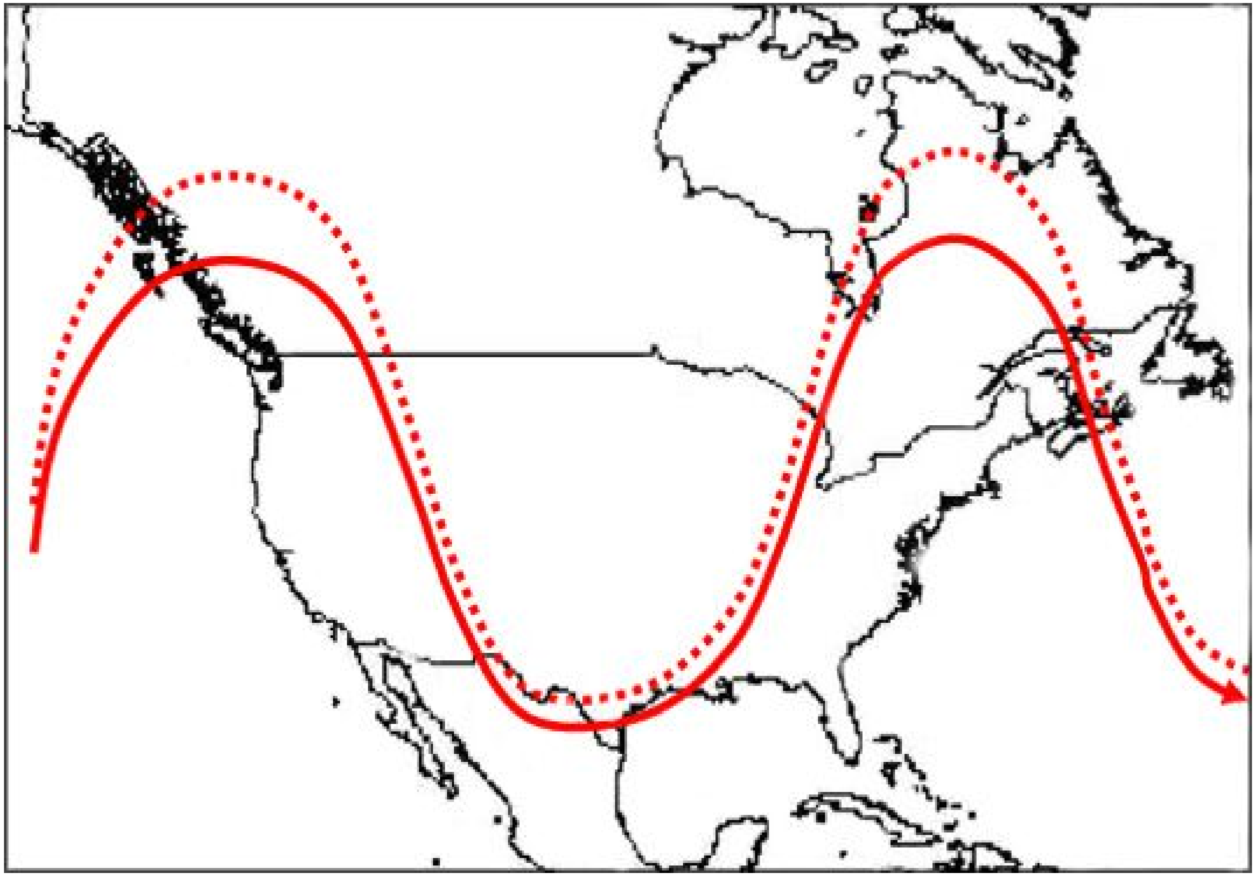
Arktický mořský led

Arctic sea ice volume is declining exponentially



Warmer Arctic => slower jet stream with larger (Rossby) waves, shifting more slowly (Jennifer Francis, 2012)

Francis, J. A. and S. J. Vavrus (2012), Evidence linking Arctic amplification to extreme weather in mid-latitudes, Geophys. Res. Lett., 39, L06801, doi:10.1029/2012GL051000.

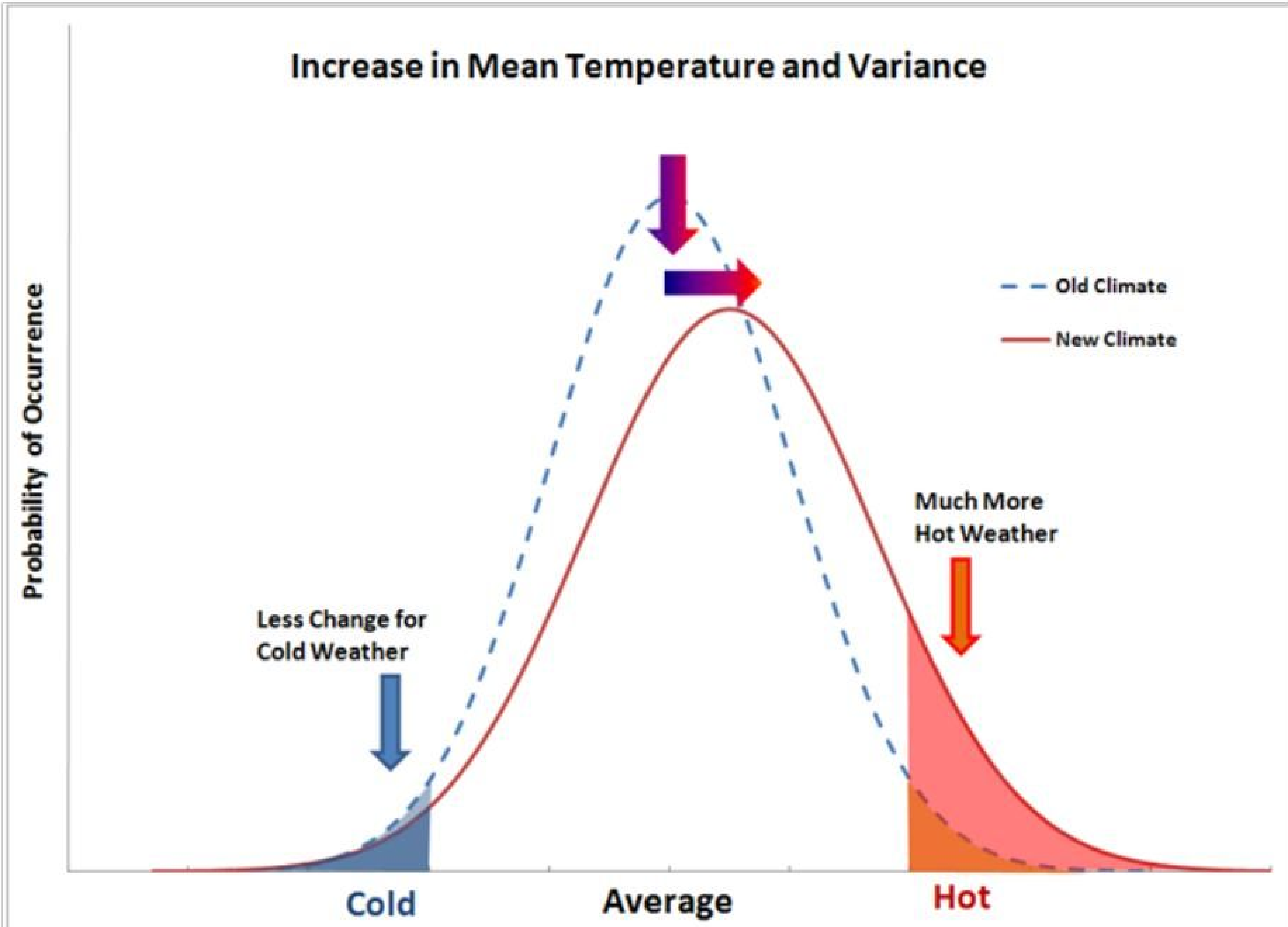


floods

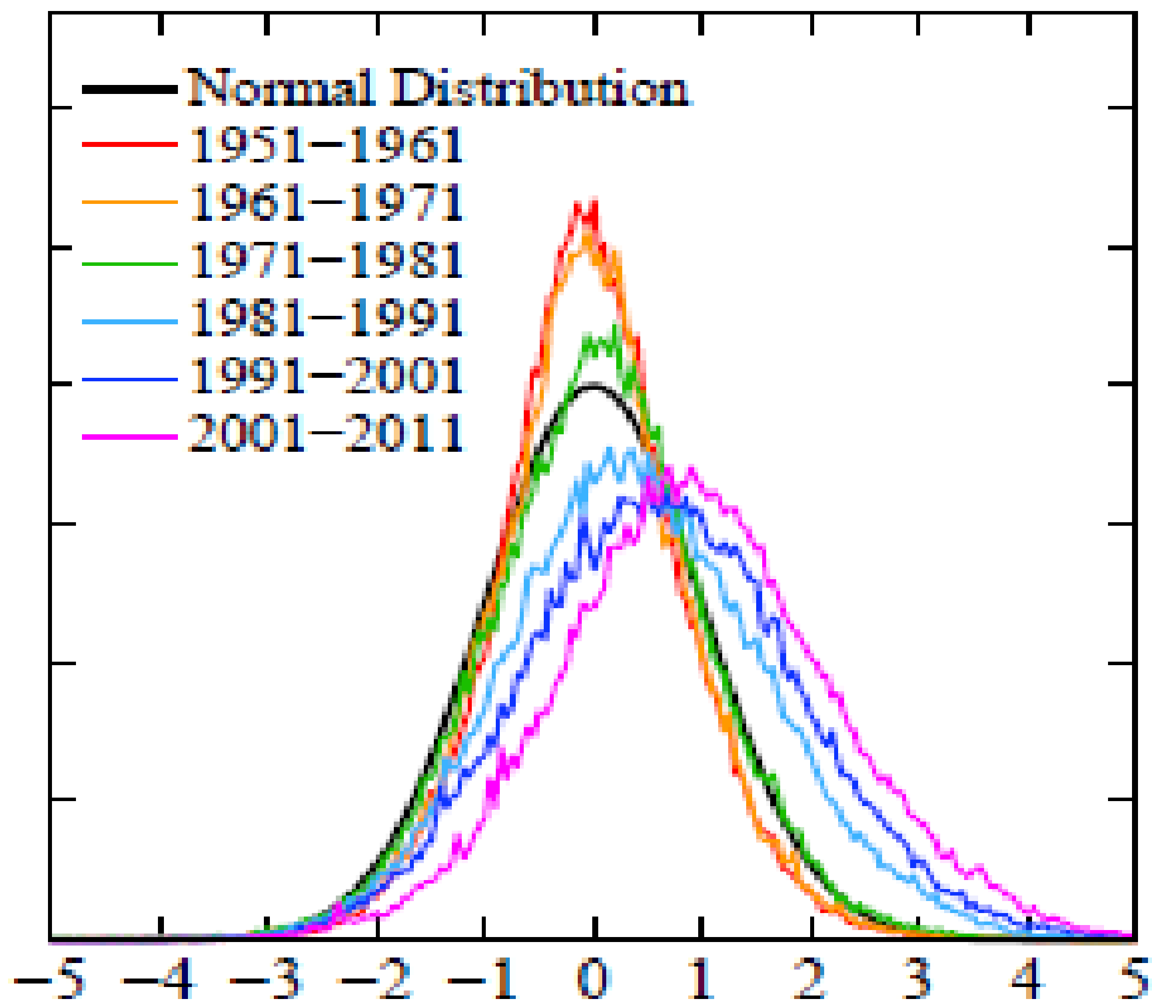
Risks:
Extreme events

Warmer air can hold more water (~7%/°C)

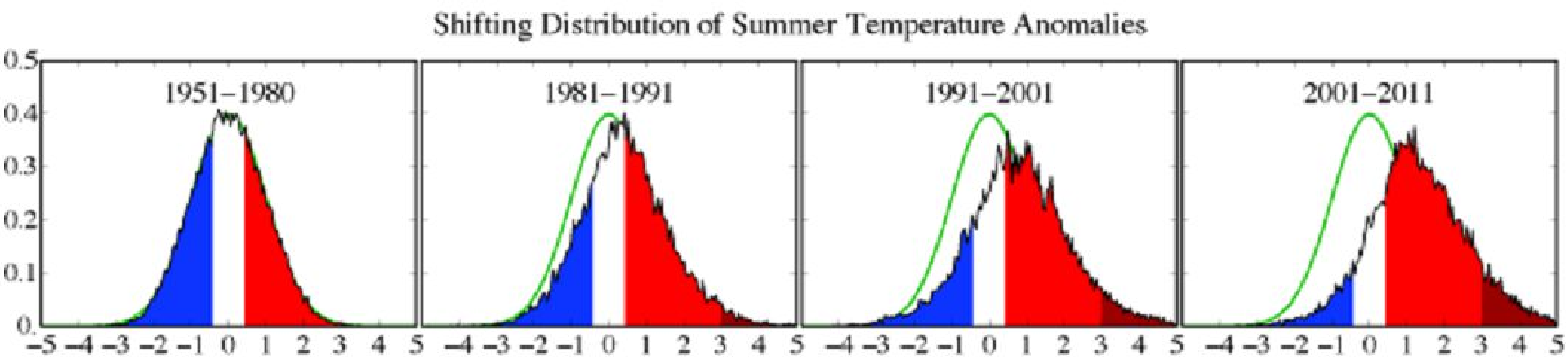
- More rainpours
  - flash floods
  - droughts


Increase in Mean Temperature and Variance
Probability of Occurrence
Old Climate
New Climate
Much More
Hot Weather
Less Change for
Cold Weather
Cold
Average
Hot

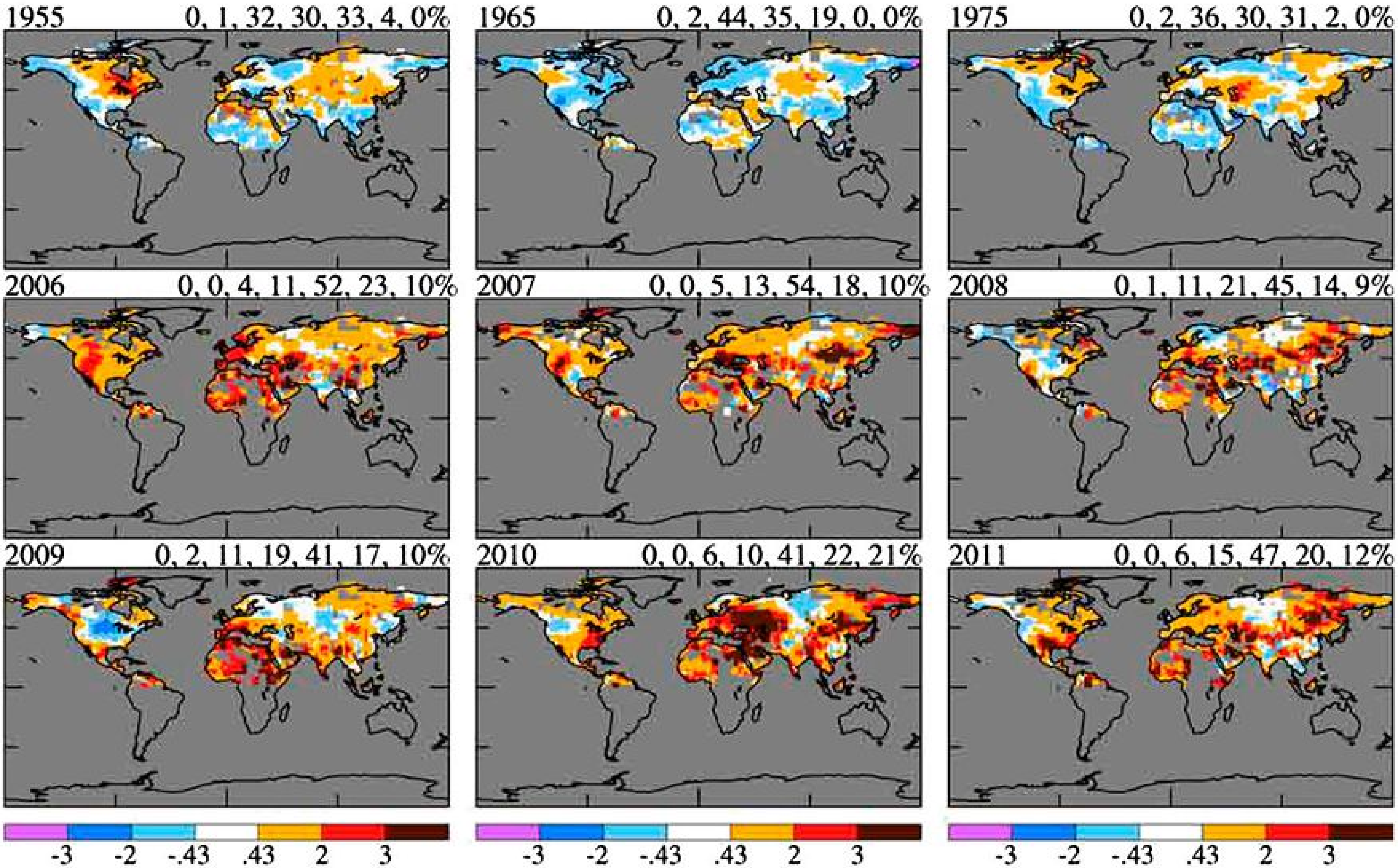
Frequency of occurence (Y axis) of local temperature anomalies. Horizontal axis gives the temperature anomaly divided by standard deviation for a given site, as valid during 1951-1980. The area below each curve is the same. Source: James Hansen, M. Sato and R. Ruedy: Public Perceptions of Climate Change and the New Climate Dice



The problem: >3-sigma extremes, 4-sigma ones hapenning sometimes already, 5-sigma ahead...



Jun-Jul-Aug Hot & Cold Areas over N.H. Land excluding Greenland

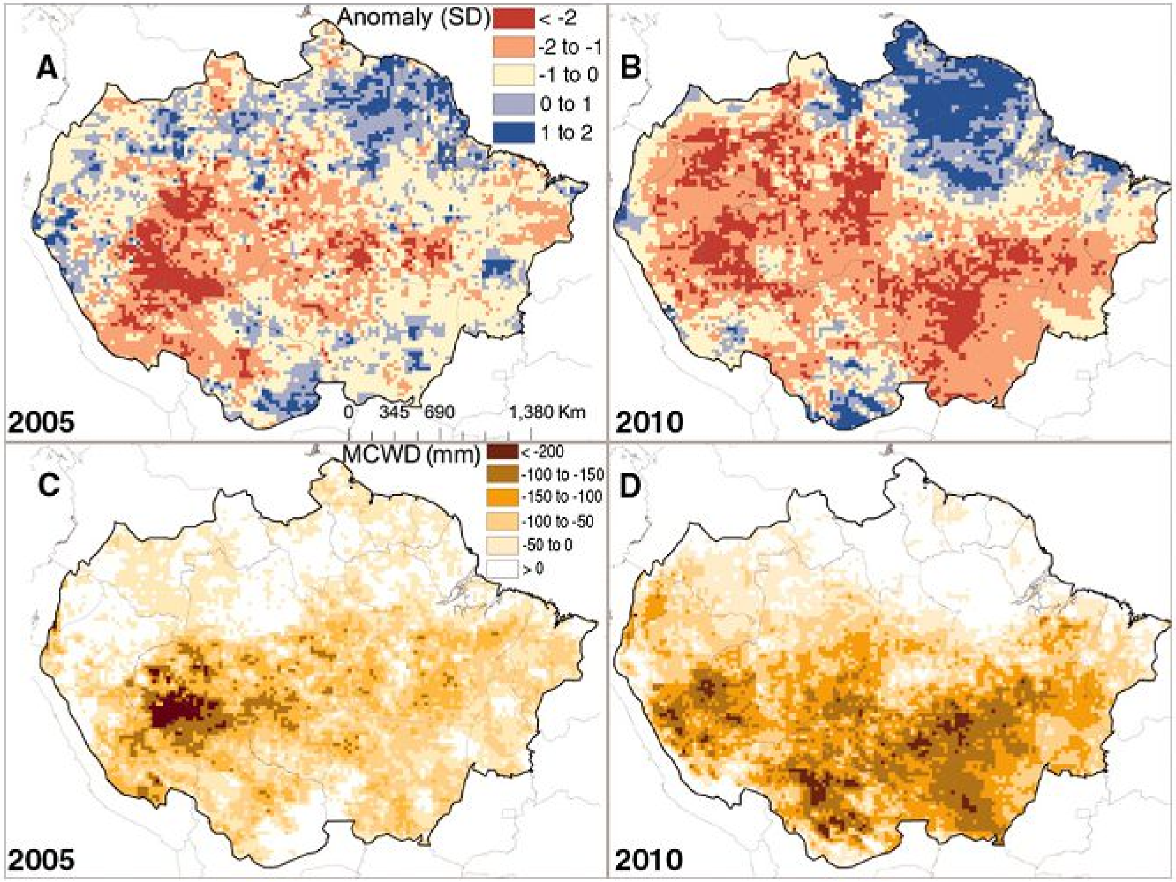


Wild fires in Greece, August 2007

Source: spiegel.de

Amazon – from carbon sink to carbon source?

- the 2005 & 2010 droughts



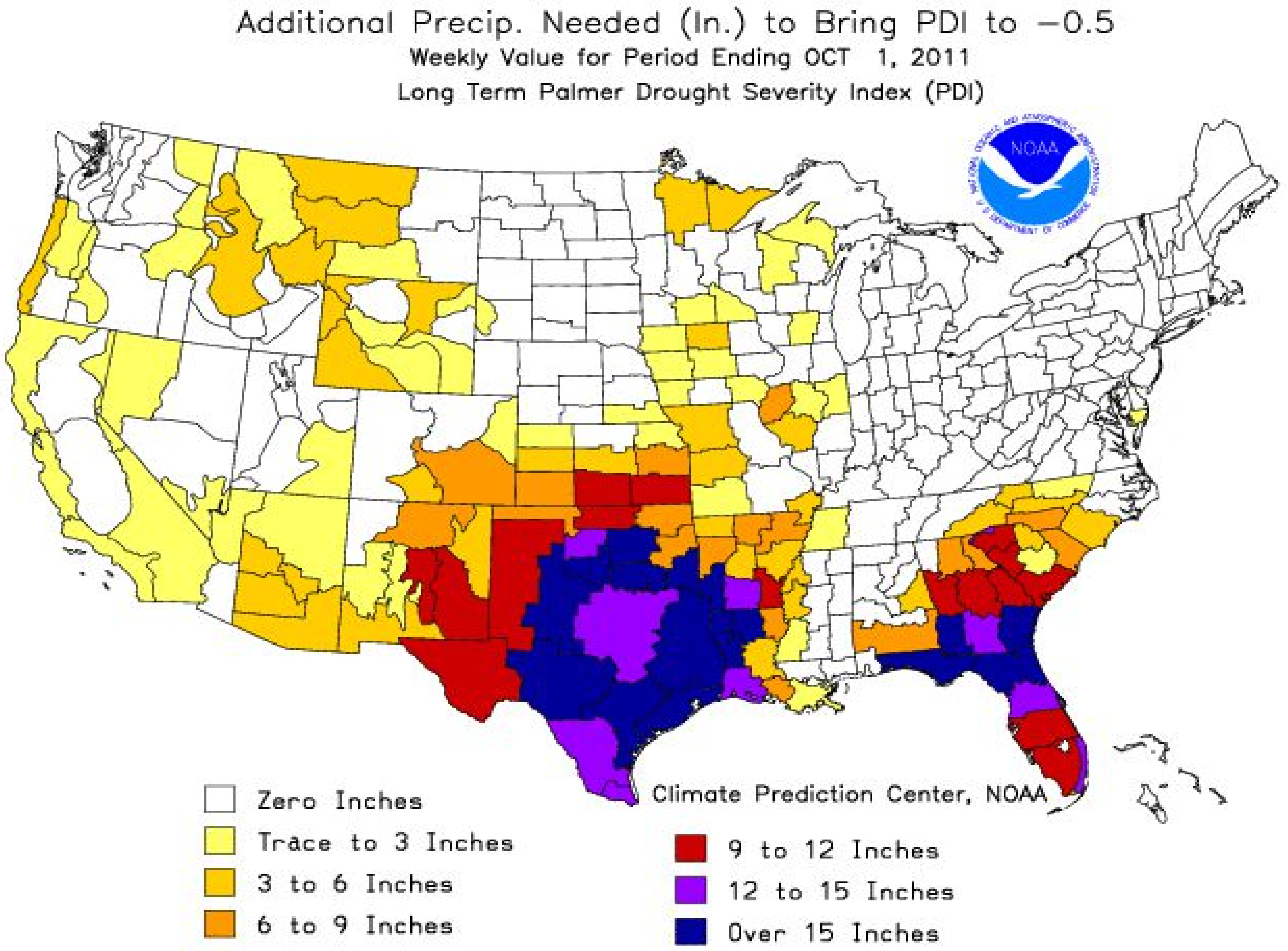
A & B = anomaly of dry season rainfall from decadal mean

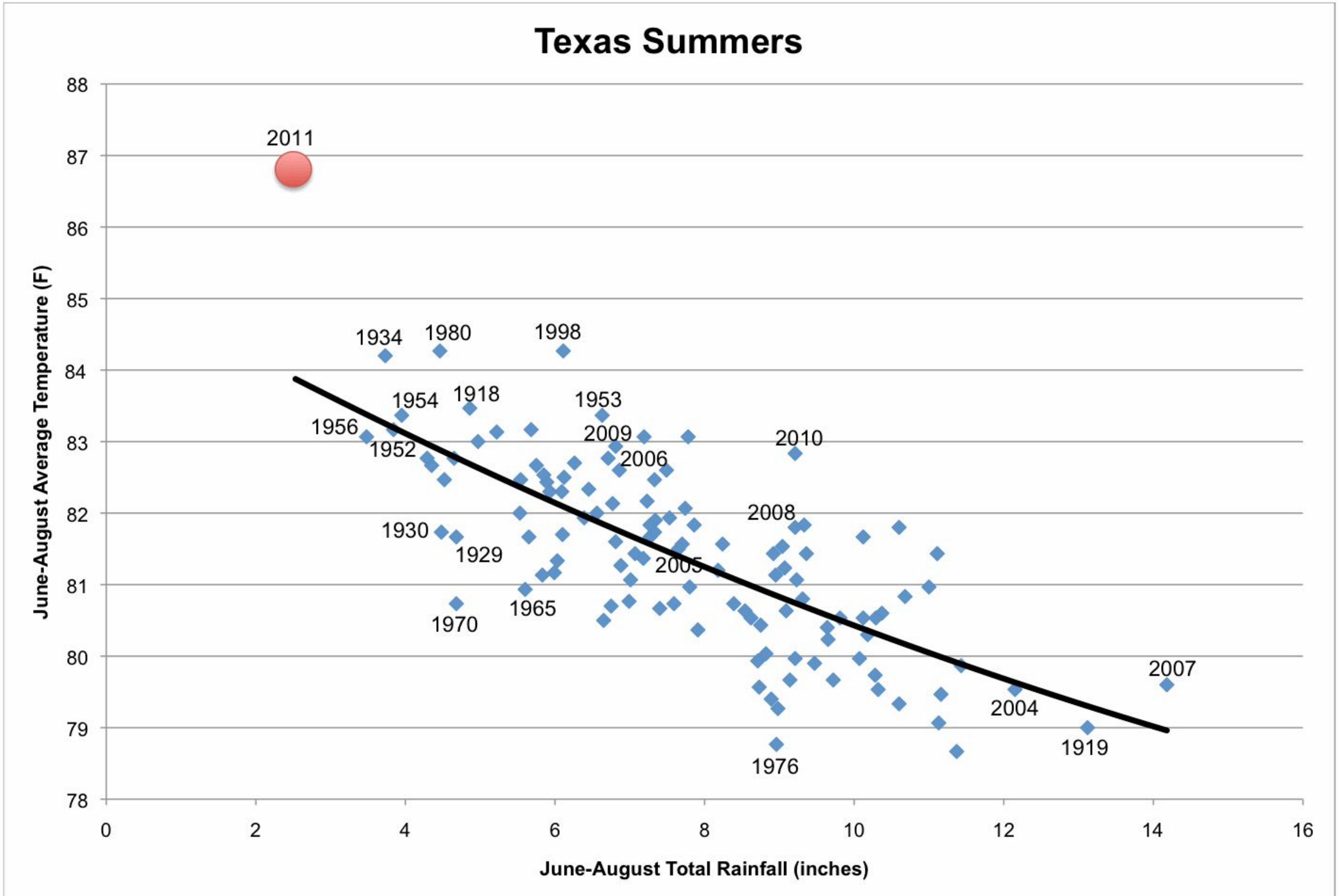
C & D = maximum climatological water deficit from decadal mean

2010 emissions release due to drought may have been in excess of 5 billion tonnes CO_2

= US total annual fossil-fuel emissions

Source: The 2010 Amazon Drought, Lewis et al, University of Leeds, Science, February 2011


Additional Precip. Needed (In.) to Bring PDI to -0.5
Weekly Value for Period Ending OCT 1, 2011
Long Term Palmer Drought Severity Index (PDI)
NOAA
Zero Inches
Trace to 3 Inches
3 to 6 Inches
6 to 9 Inches
9 to 12 Inches
12 to 15 Inches
Over 15 Inches
Climate Prediction Center, NOAA



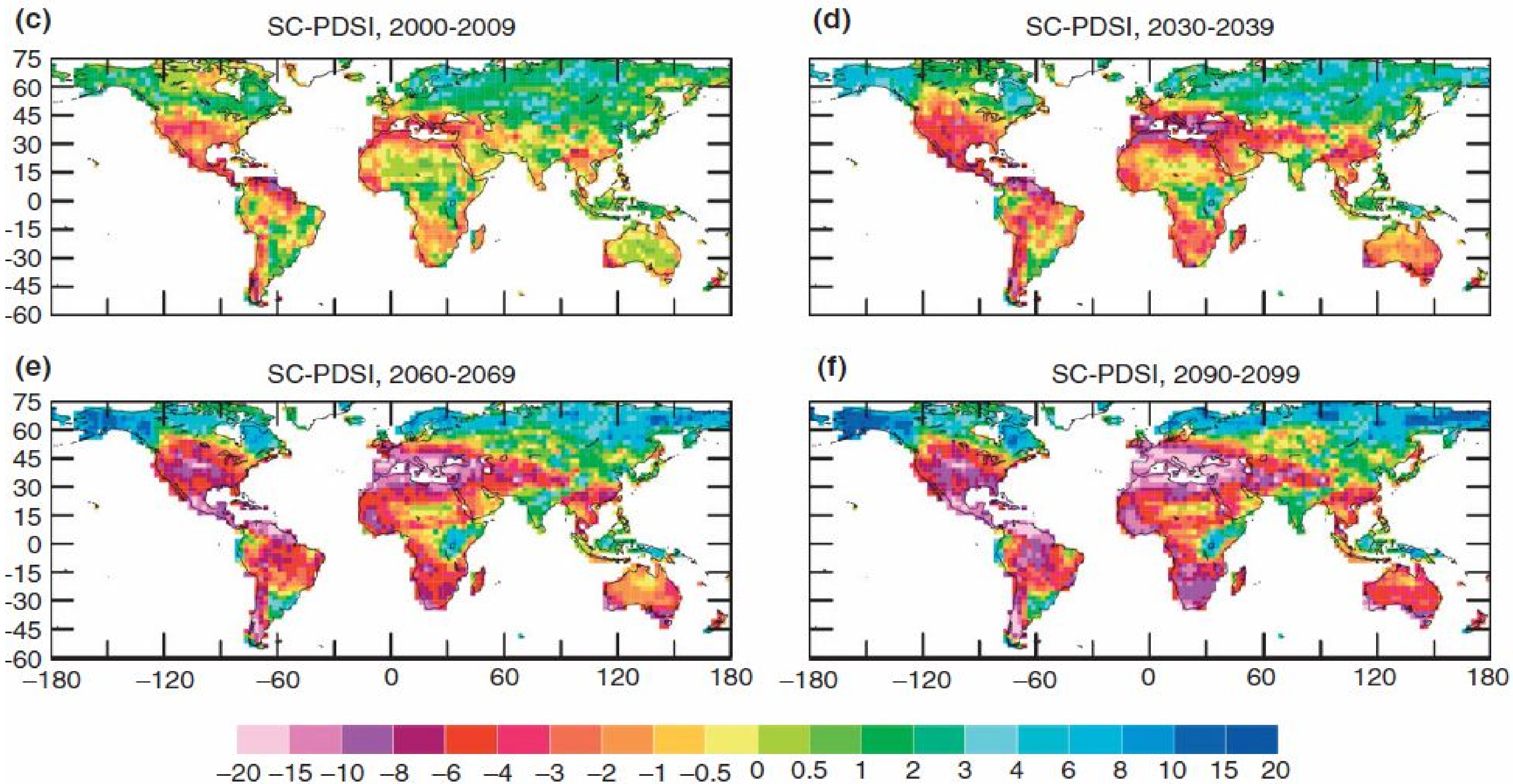
Texas Summers
June-August Average Temperature (F)
June-August Total Rainfall (inches)
88
87
86
85
84
83
82
81
80
79
78
0
2
4
6
8
10
12
14
16
2011
1934
1980
1998
1954
1918
1953
1956
2009
1952
2006
2010
2008
1930
1929
2005
1965
1970
2007
2004
1919
1976

Drought severity index

(extreme drought starts by red)

(22 models using SRES A1B emissions pth)

(Dai, 2010: Drought under global warming: a review)



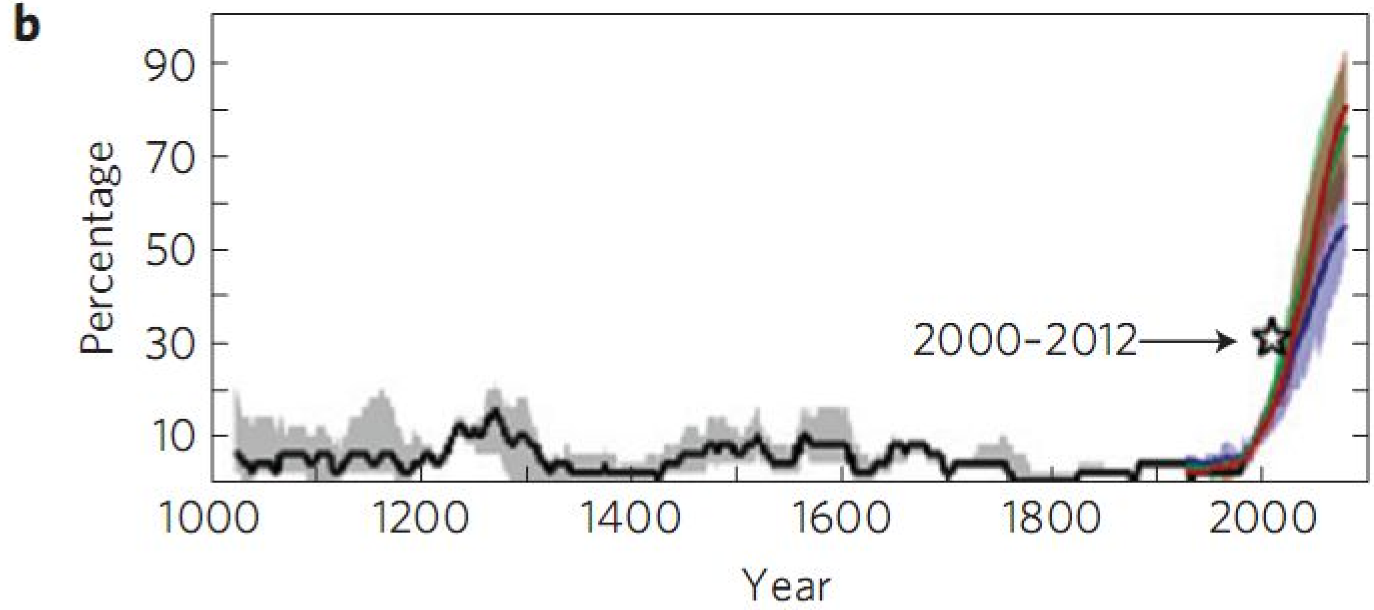
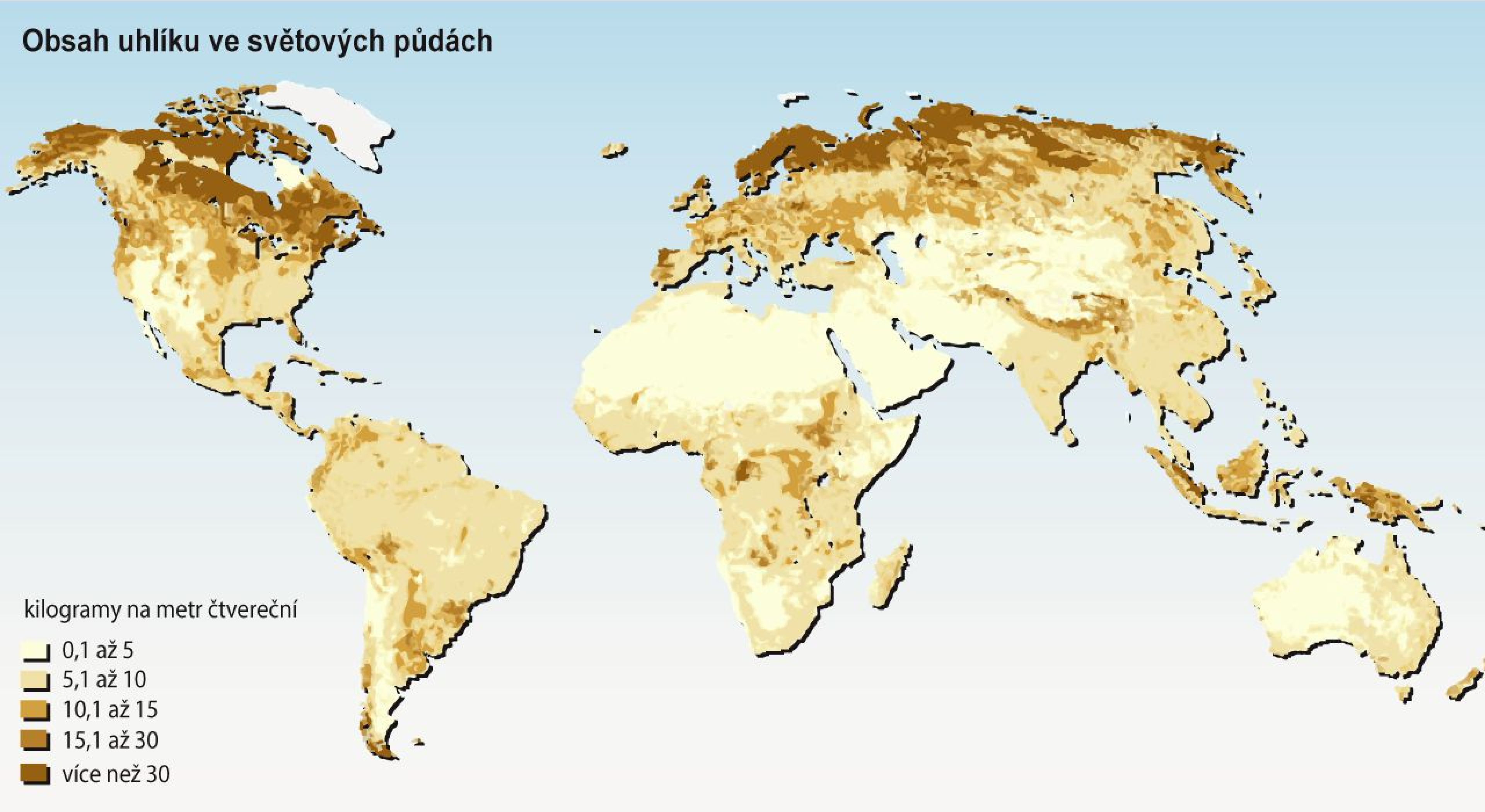


Figure 5 | Extreme drought stress. a, Cumulative distribution functions of tree-ring derived FDSI during AD 1000–2007 (black) and model-projected FDSI during AD 2000–2100 for the A2 (red), A1B (green) and B1 (blue) emissions scenarios. Brown line: mean FDSI during the most extreme half of the 1572–1587 megadrought. **b**, Fifty-year running frequency of annual FDSI values more negative than the mean FDSI during the most negative half of the years during the 1572–1587 megadrought. The colours in **b** represent the same as in **a**. Shaded areas: 95% confidence ranges for tree-ring-derived values and inner-quartile values for model ensemble projections.

Forest damage not only by fires due to drought, but by insects too


Obsah uhlíku ve světových půdách
kilogramy na metr čtvereční
0,1 až 5
5,1 až 10
10,1 až 15
15,1 až 30
více než 30

What to do?

We have to think in a centenial timeframe – which forests could survive, which might be resilient

But, too: We have to cease oxidating fossil carbon

And begin to store it again in the Earth – in soils mainly

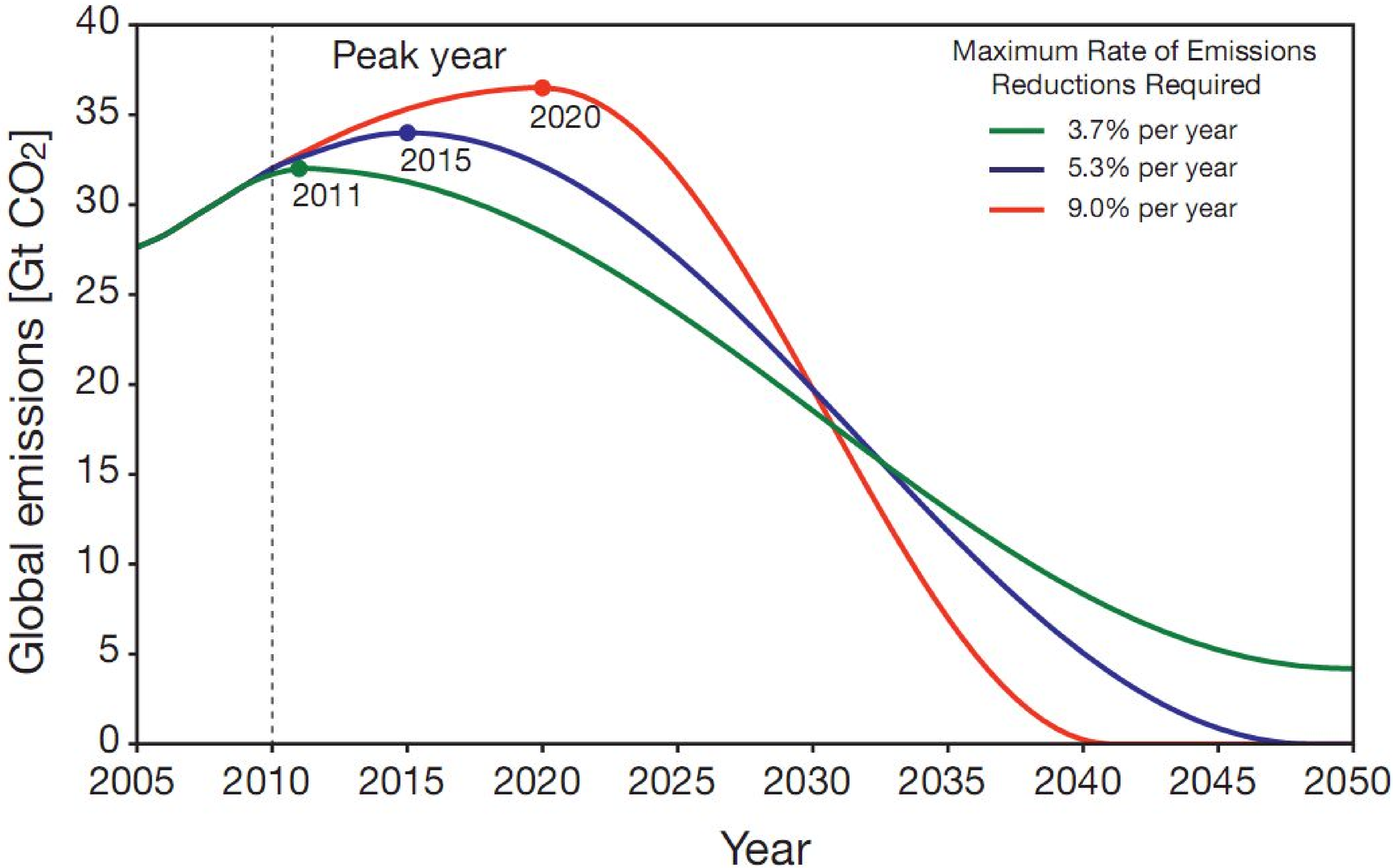


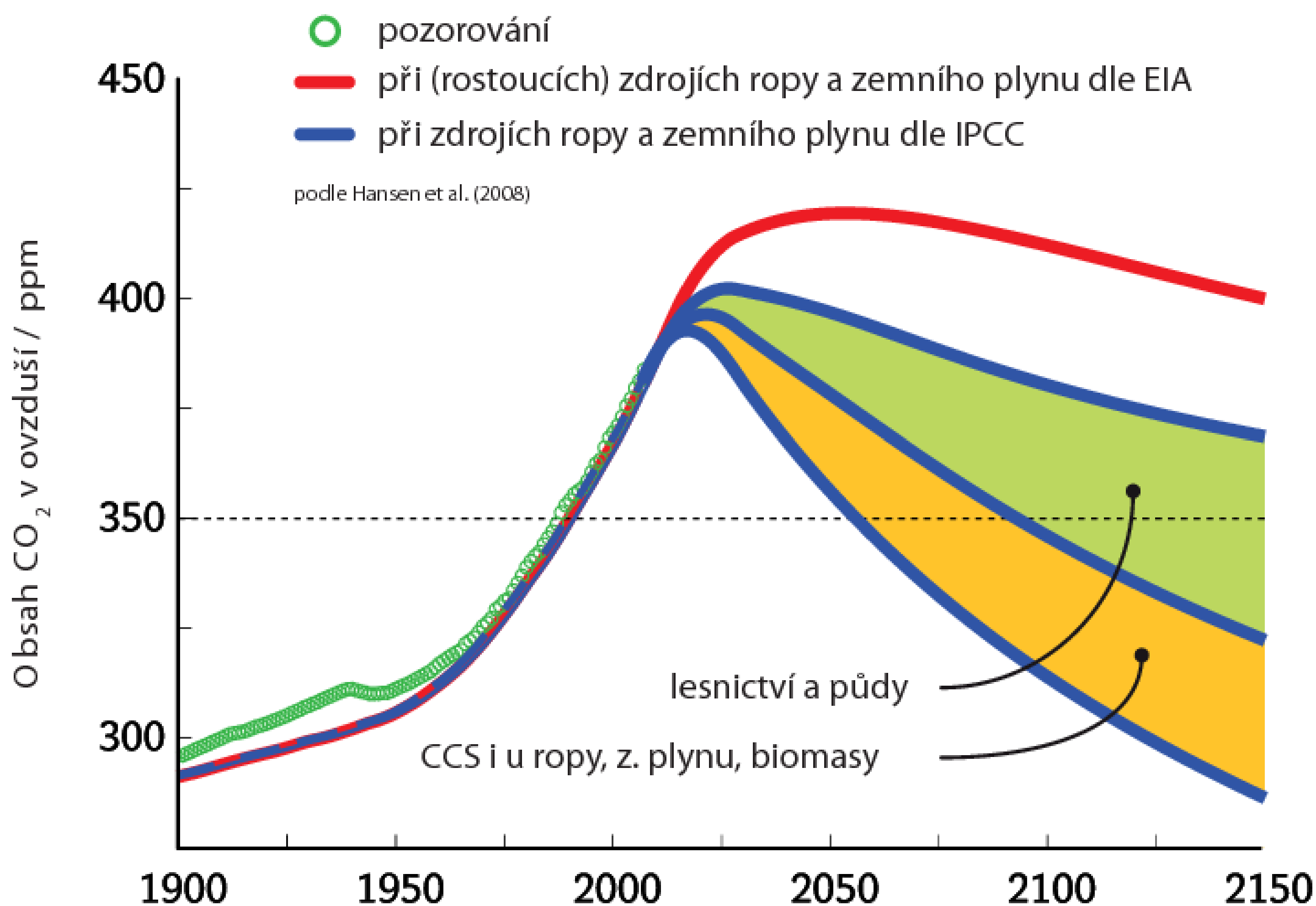
Figure 22: Emission paths providing a 67 % chance to remain below 2 K warming

Target CO_2

< 350 ppm

To save the planet in a state in which civilisation appeared

Climate Solutions: we have the technology!



pozorování
při (rostoucích) zdrojích ropy a zemního plynu dle EIA
při zdrojích ropy a zemního plynu dle IPCC
podle Hansen et al. (2008)
Obsah CO_2 v ovzduší / ppm
450
400
350
300
lesnictví a půdy
CCS i u ropy, z. plynu, biomasy
1900
1950
2000
2050
2100
2150

References

http://amper.ped.muni.cz/gw

www.ipcc.ch

http://skepticalscience.com/

www.zerocarbonbritain.org

Sources of figures and texts

Alexander Ač

James Hansen, NASA Goddard Institute for Space Studies

NASA JPL

Kevin Trenberth, National Center for Atmoshperic Research

John Wahr

John Cook

Ian Dunlop

Yvonna Gailly

Anders Levermann, Potsdam-Institut für Klimafolgenforschung (PIK)

Intergovernmental Panel on Climate Change (IPCC)

The Copenhagen Diagnosis, 2009

John Holdren

Jan Hollan

and some other (see figure captions)