Global climate disruption is upon us, we are obliged to react

Jan Hollan

CzechGlobe –
Global change research centre

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.

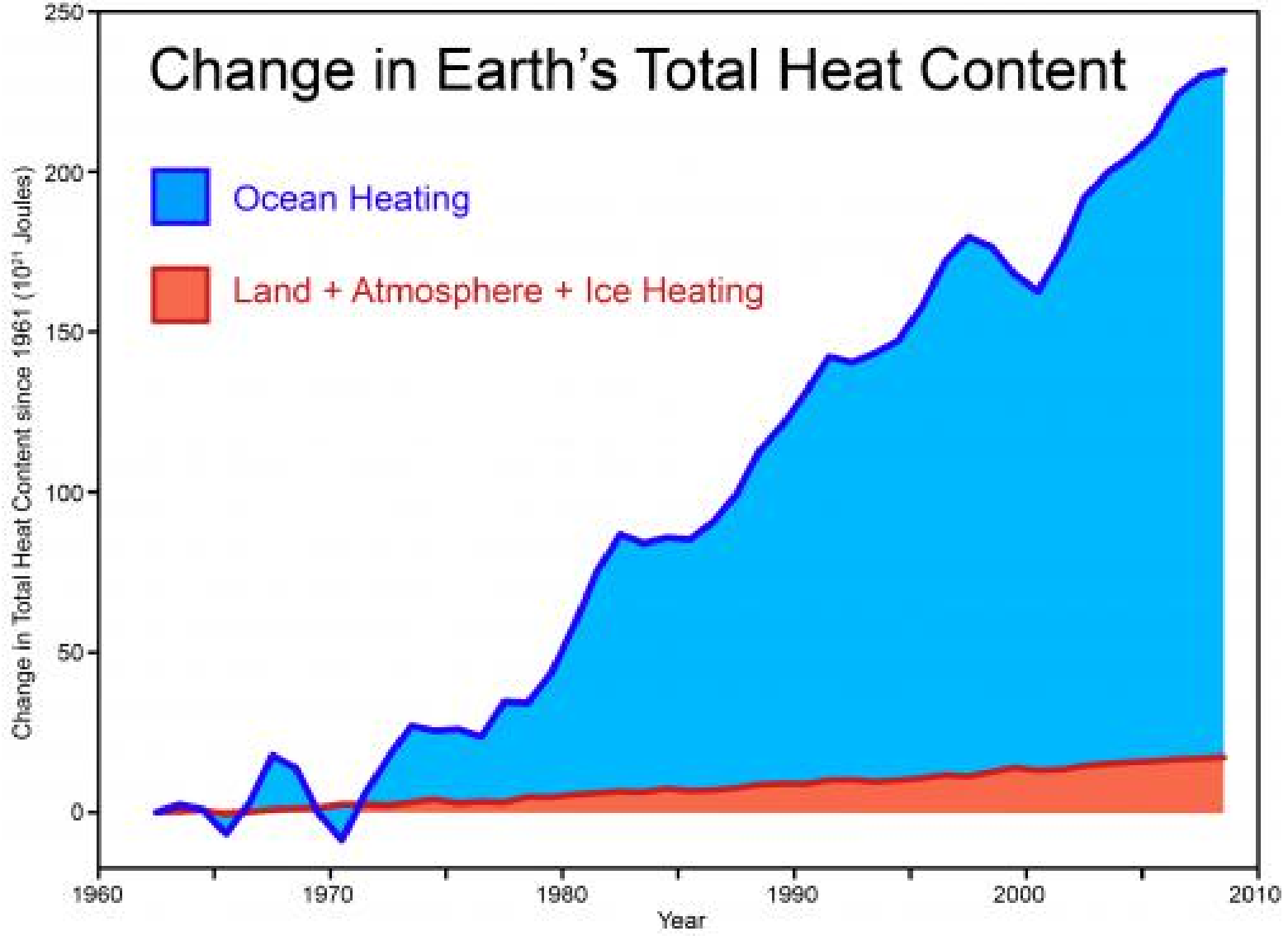
1. Causes

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


Jak člověk přidává uhlík do atmosféry
a jak s tím přestat
ATMOSFÉRA
0,1
SOPEČNÁ ČINNOST
fotosyntéza
3
Severské a některé tropické lesy rostou rychleji
1
ODLESŇOVÁNÍ A DEGRADACE PŮD
VEGETACE
PŮDA
FOTOVOLTAICKÉ PANELY
SOLÁRNÍ KOLEKTORY
VODNÍ ELEKTRÁRNA
BIOMASA
GEOTERMÁLNÍ ENERGIE
10
SPALOVÁNÍ FOSILNÍCH PALIV
JADERNÁ ENERGIE
ŘEKY
příjem oceánů
3
UHLÍ
VĚTRNÁ ELEKTRÁRNA
V ovzduší je přetlak oxidu uhličitého. Ten se rozpouští v oceánu a vede k jeho okyselování
ROPA A ZEMNÍ PLYN
tok uhlíku do atmosféry působený lidmi
tzv. propady uhlíku, následek lidské činnosti
geologický oběh uhlíku
(údaje v gigatunách za rok)
MOŘSKÉ ORGANISMY
0,1
UKLÁDÁNÍ VÁPENCE A ORGANICKÉHO UHLÍKU NA DNO
HLUBOKÝ OCEÁN
0,1
PODSOUVÁNÍ DNA POD ZEMSKOU KŮRU

Enthalpy change of Earth in exajoules

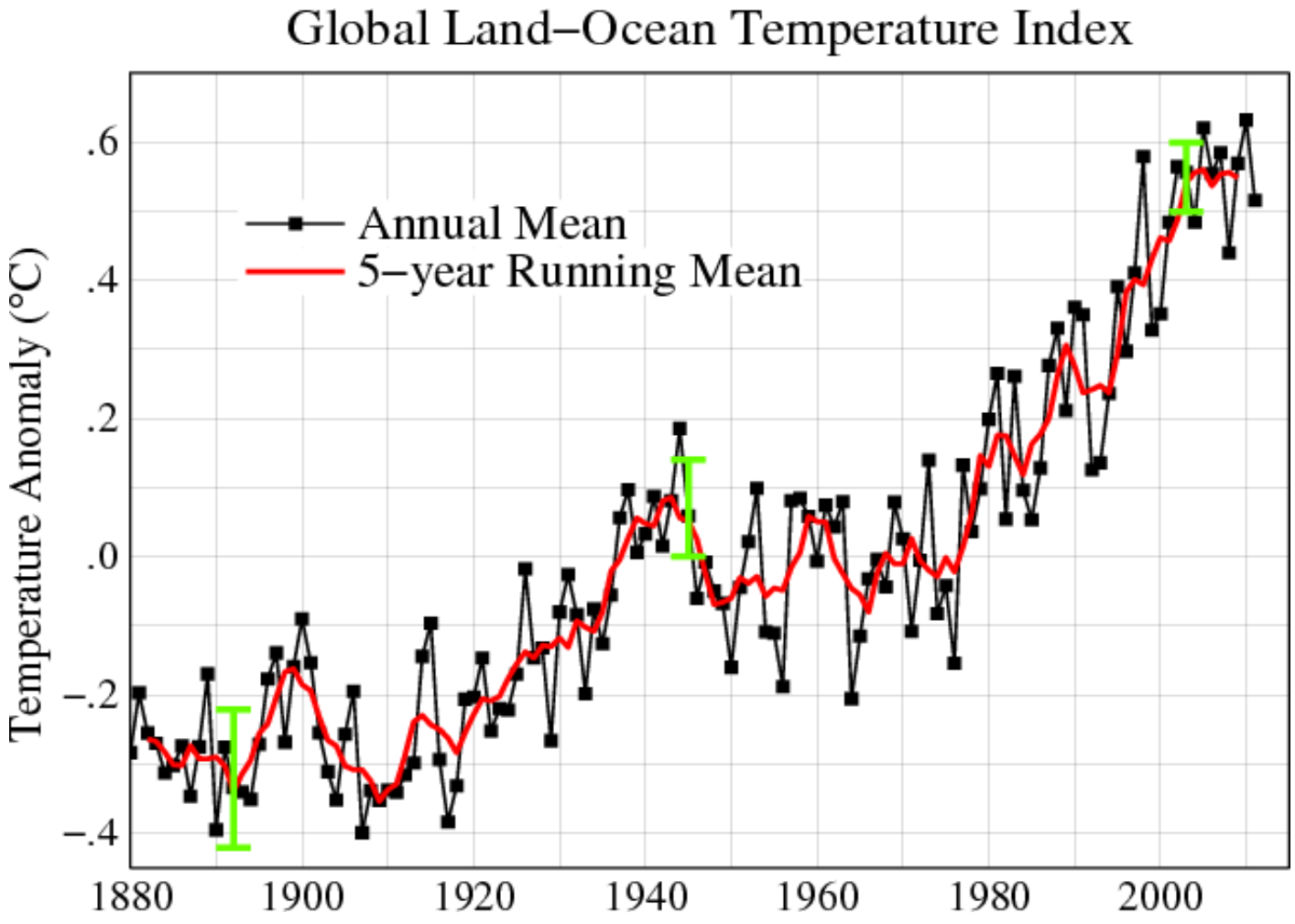
data from Church et al 2011. Figure by John Cook,
http://skepticalscience.com/going-down-the-up-escalator-part-2.html



2. Manifestations

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/

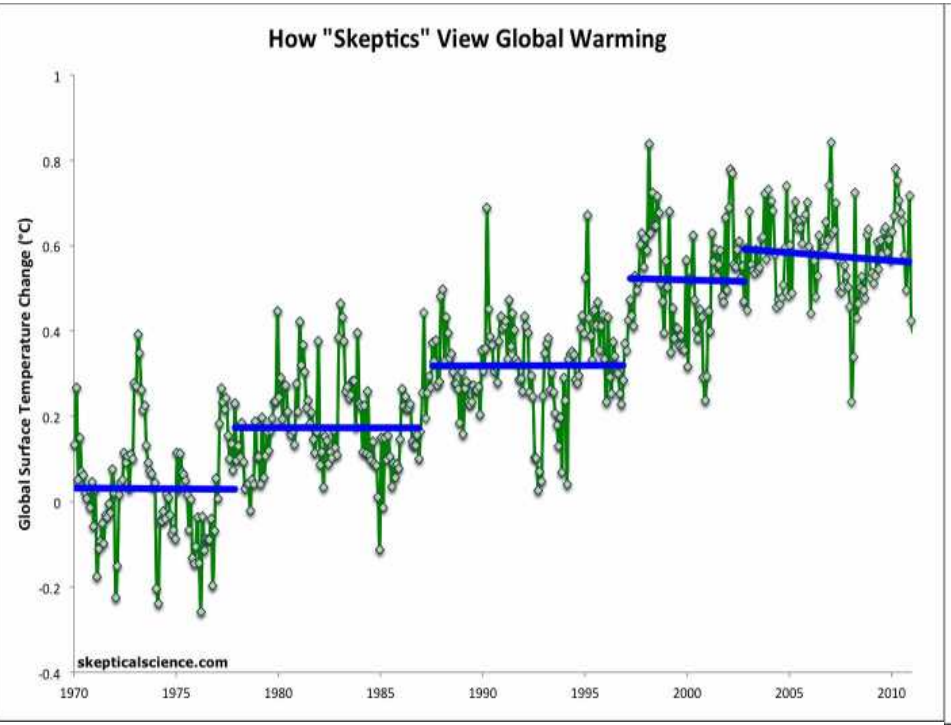


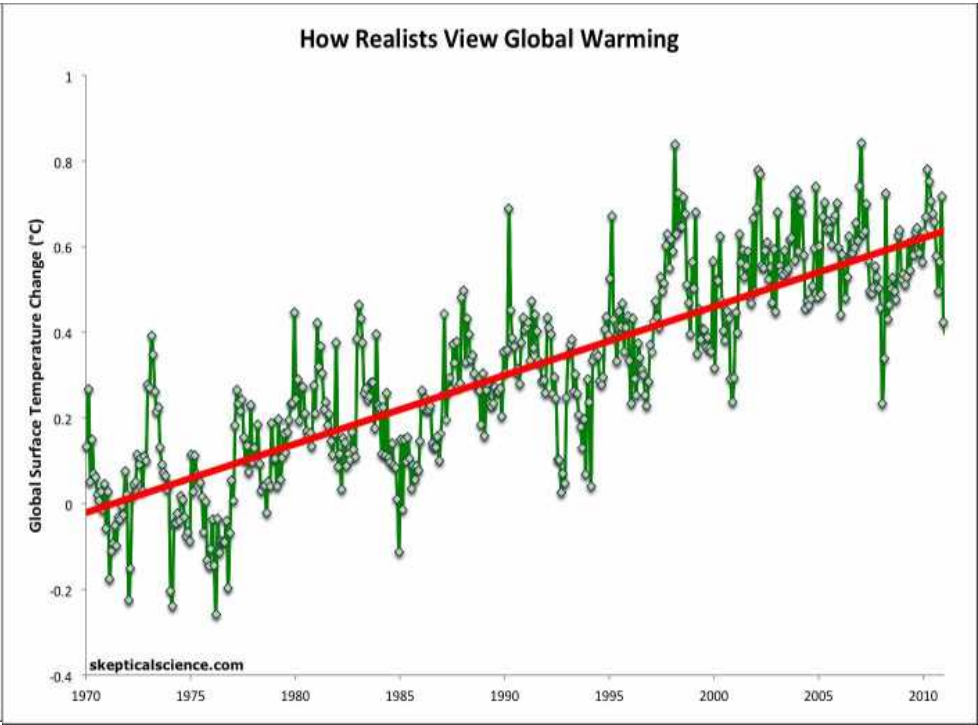
Warmest years

2010
2005
2007
1998
2009
2002
2003
2006
2011
2001
2004

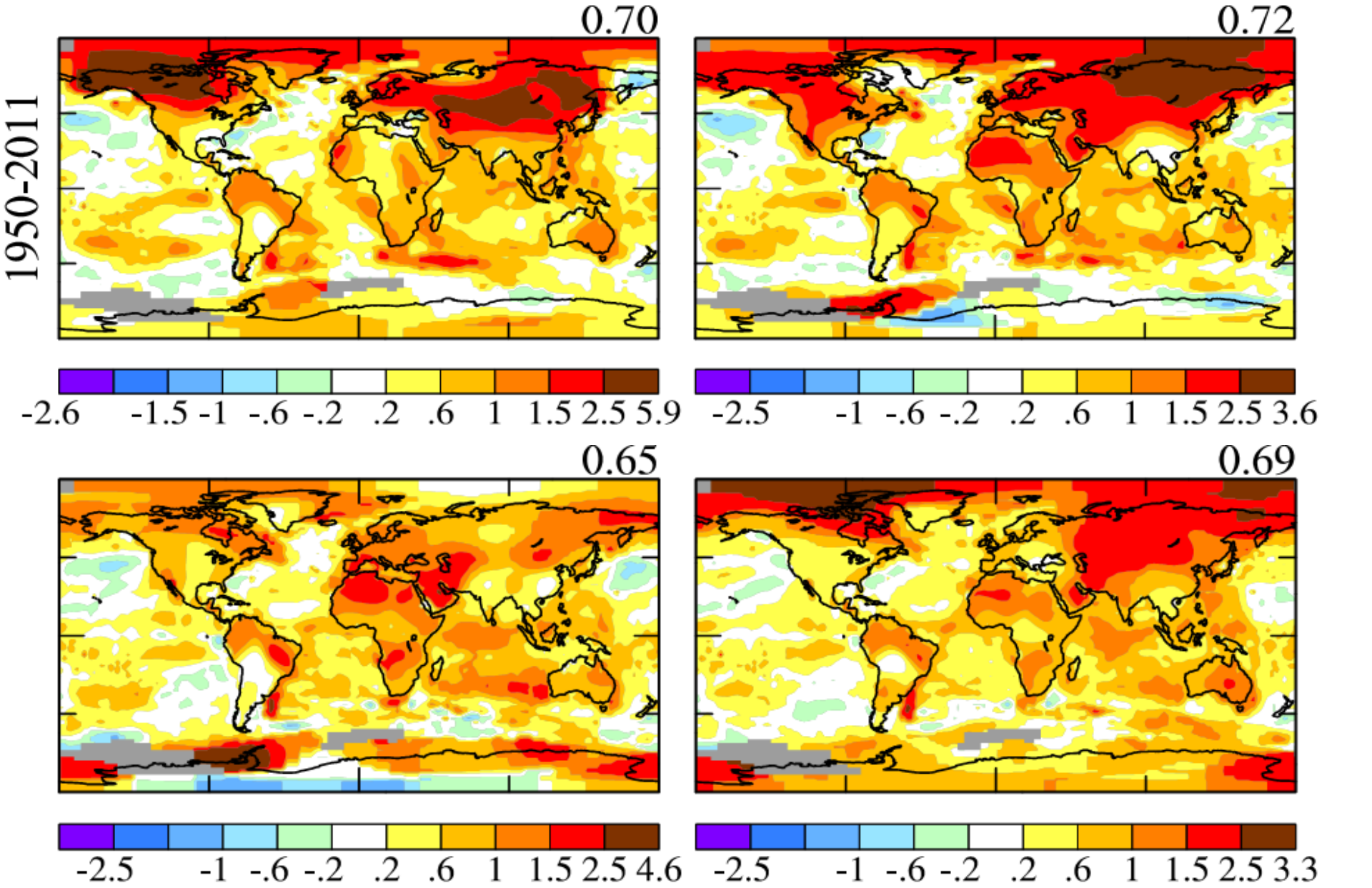
~ 0.8 °C: globální zvýšení teploty za poslední století

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 (samotný animovaný graf pak viz http://www.skepticalscience.com/pics/NCDC_Escalator.gif)

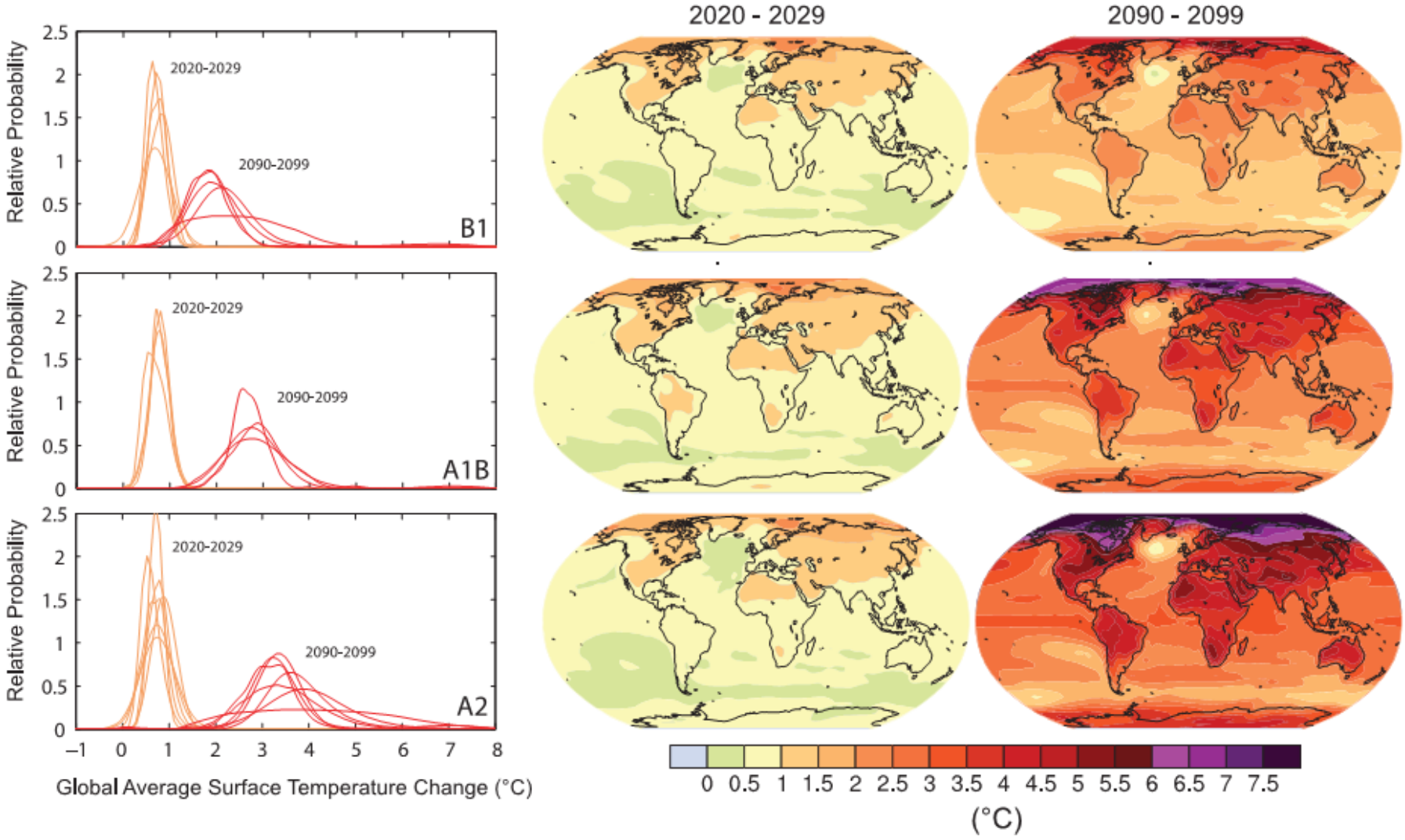




Temperature change since 1950 for 3-month periods, taken as seasons of northern hemisphere: winter (Dec, Jan, Feb), spring, summer and fall.
http://data.giss.nasa.gov/gistemp/



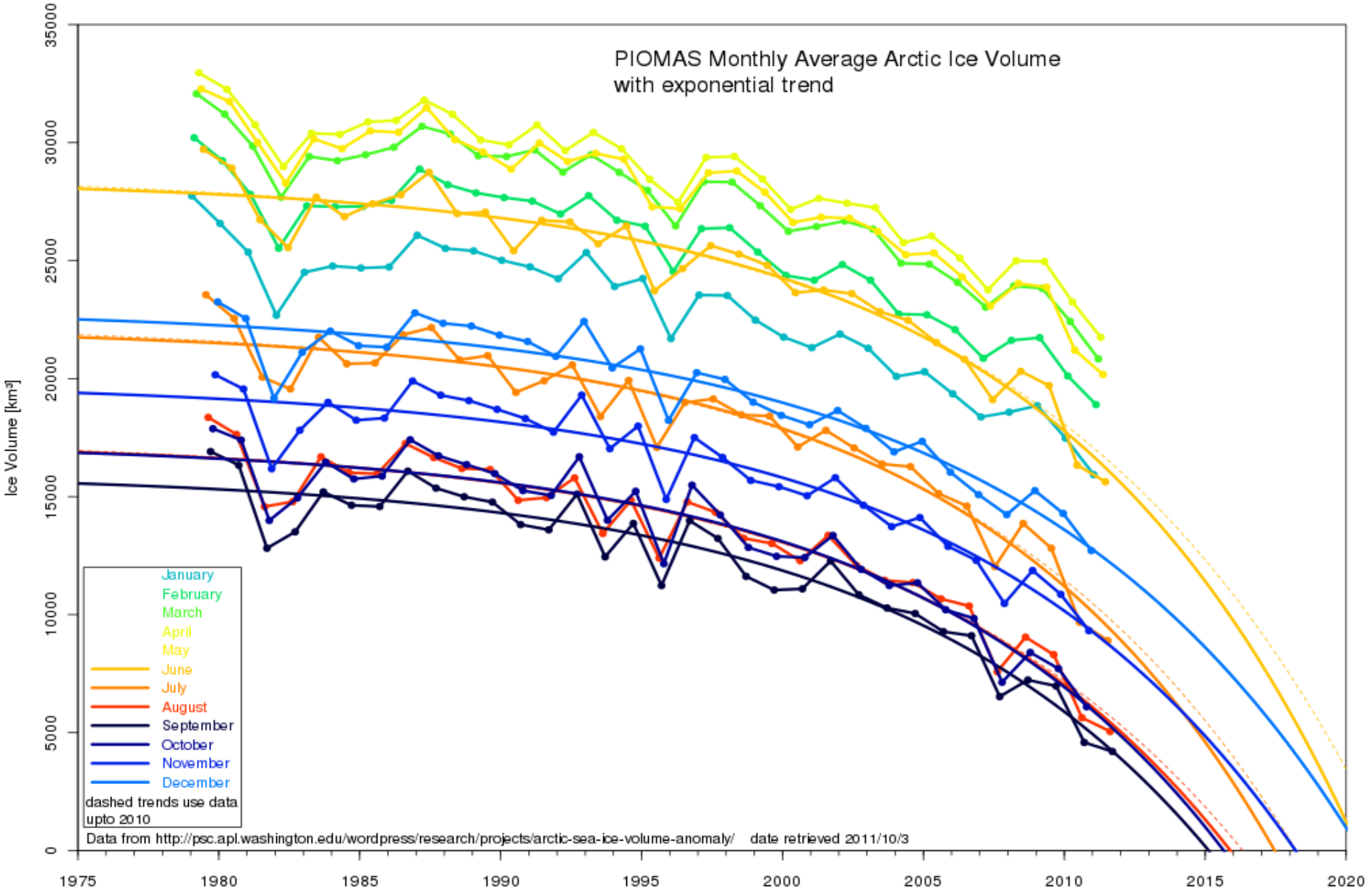
Projections of Surface Temperatures

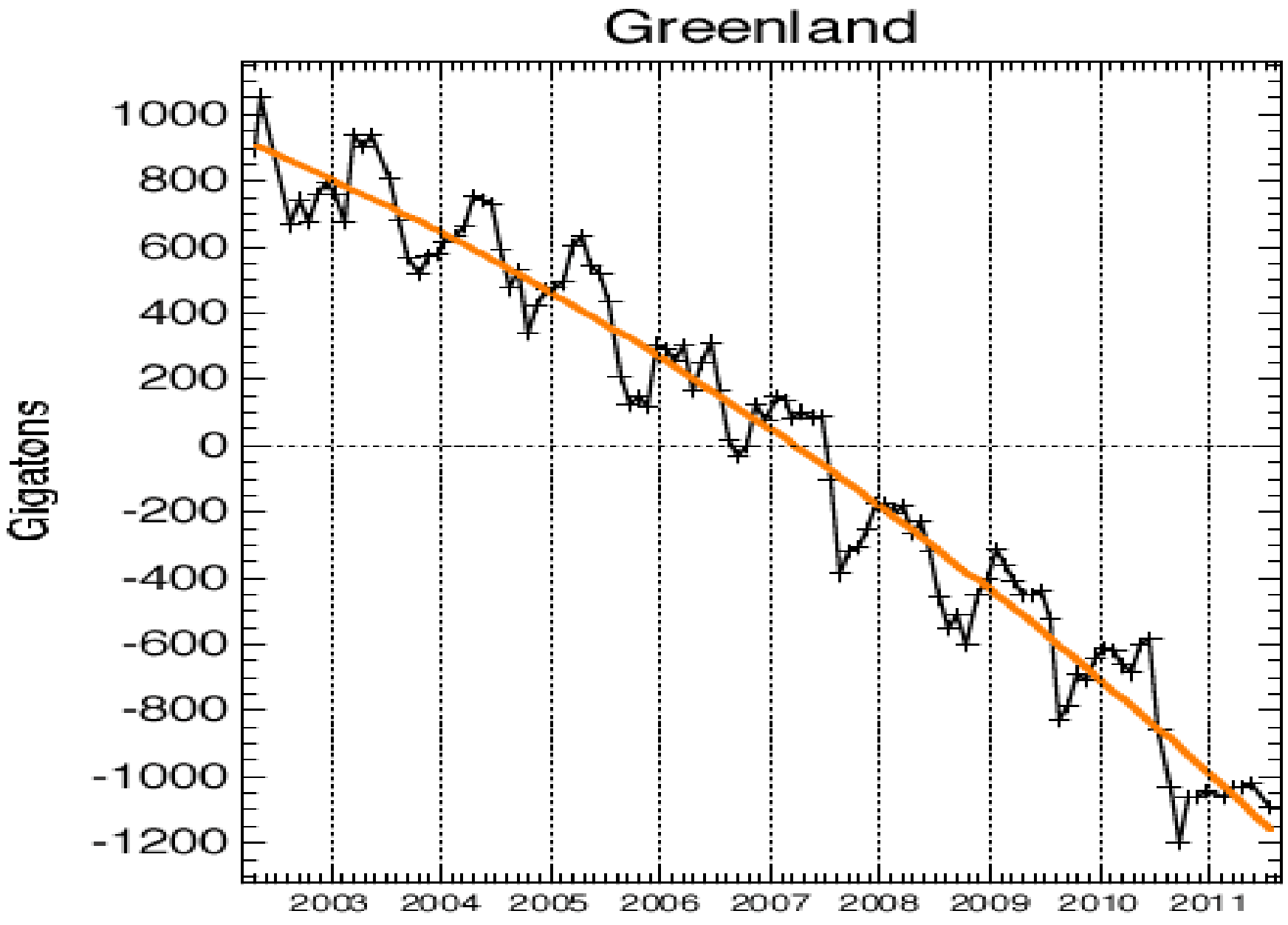


Surface darkening

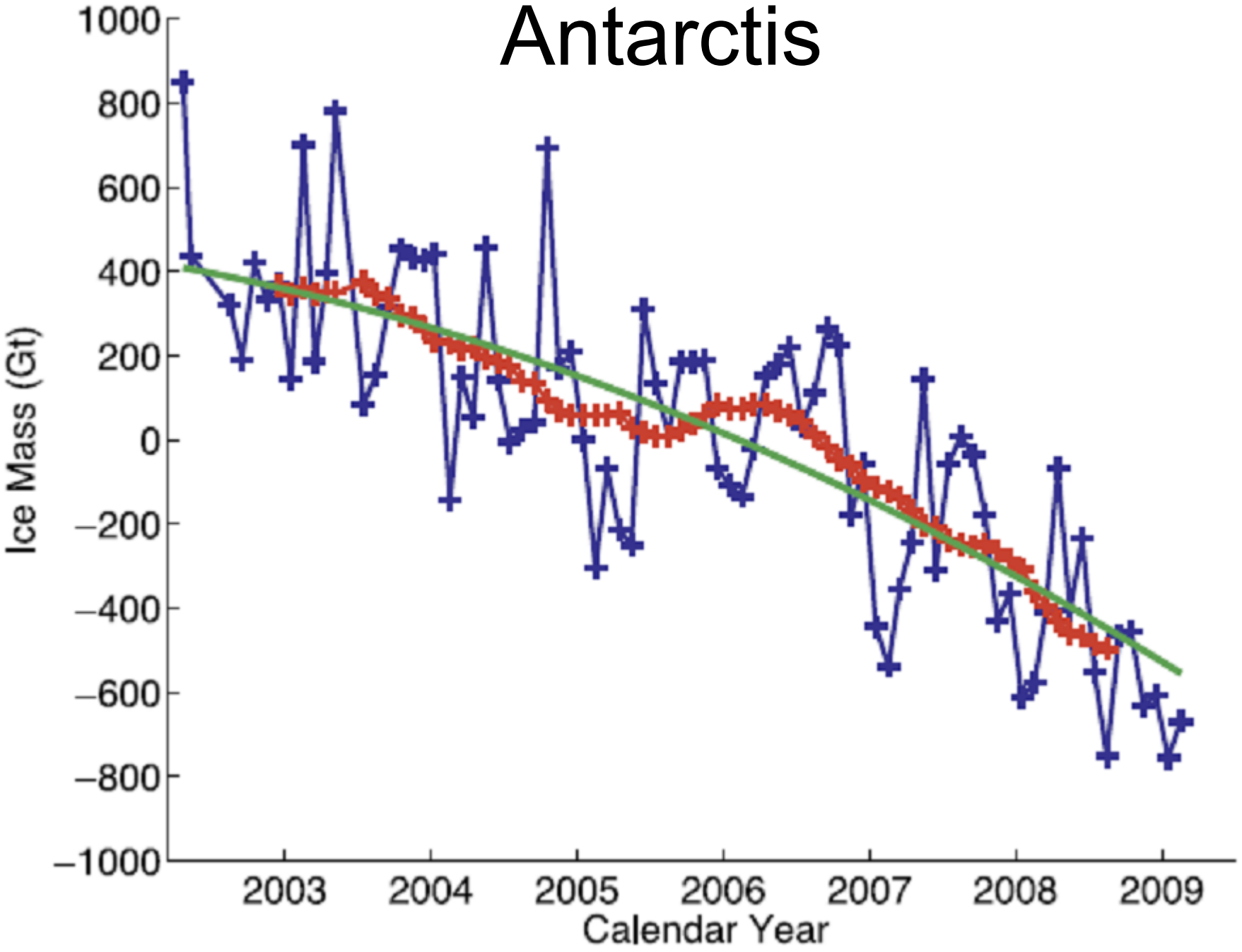
a strong amplifying feedback

Arctic sea ice volume declines exponencially

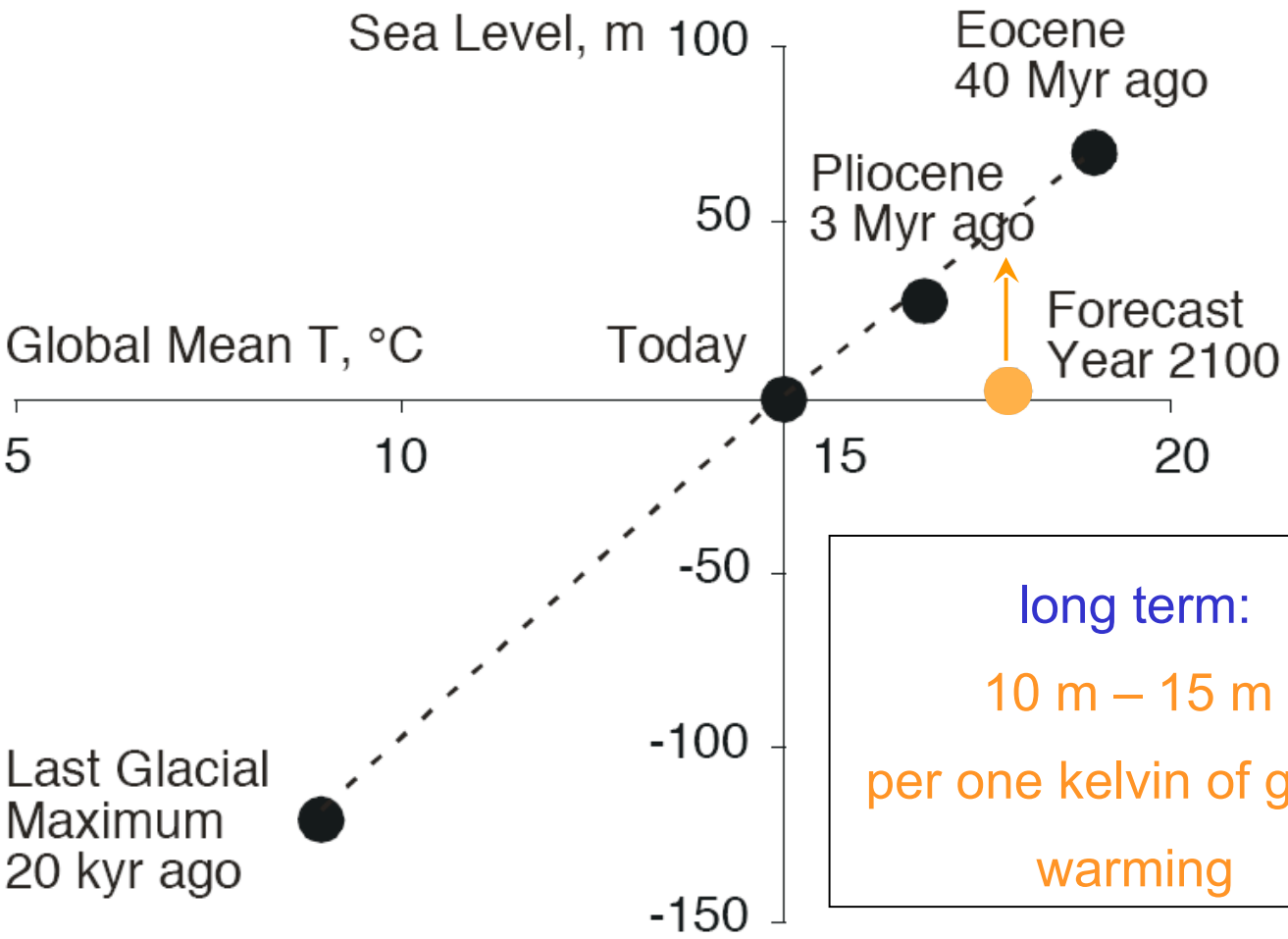



Greenland
Gigatons
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
2003
2004
2005
2006
2007
2008
2009
2010
2011

Antarctis


1000
800
600
400
200
0
−200
−400
−600
−800
−1000
Ice Mass (Gt)
2003
2004
2005
2006
2007
2008
2009
Calendar Year

Past changes of sea level

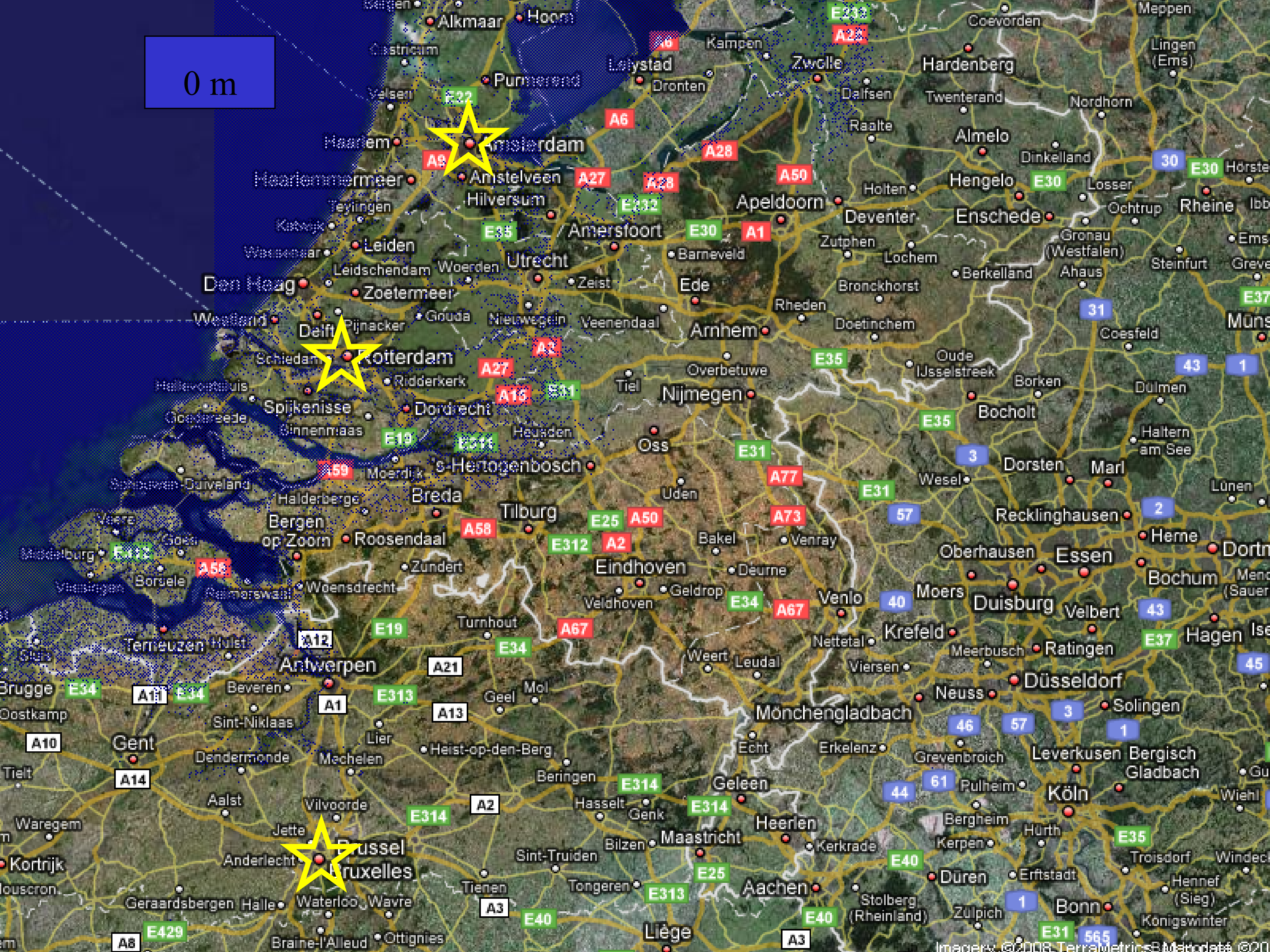


long term:

10 m – 15 m

per one kelvin of global warming

Archer & Brovkin, 2008


0 m
Alkmaar
Hoorn
Purmerend
Lelystad
Dronten
Kampen
Zwolle
Hardenberg
Coevorden
Meppen
Haarlem
Amsterdam
Amstelveen
Haarlemmermeer
Hilversum
Amersfoort
Apeldoorn
Deventer
Enschede
Hengelo
Almelo
Leiden
Den Haag
Zoetermeer
Utrecht
Woerden
Gouda
Delft
Rotterdam
Schiedam
Spijkenisse
Dordrecht
Ridderkerk
Nieuwegein
Veenendaal
Ede
Arnhem
Nijmegen
Oss
's-Hertogenbosch
Breda
Tilburg
Eindhoven
Roosendaal
Bergen op Zoom
Middelburg
Vlissingen
Terneuzen
Antwerpen
Brugge
Gent
Mechelen
Brussel
Bruxelles
Waterloo
Wavre
Leuven
Kortrijk
Aalst
Hasselt
Maastricht
Heerlen
Aachen
Liège
Venlo
Krefeld
Duisburg
Essen
Oberhausen
Bochum
Düsseldorf
Mönchengladbach
Neuss
Solingen
Köln
Leverkusen
Bonn
Düren
Münster
Bocholt
Dorsten
Recklinghausen
Hagen
Imagery ©2008 TerraMetrics, Map data ©20


1 m
Alkmaar
Hoorn
Purmerend
Lelystad
Kampen
Zwolle
Coevorden
Hardenberg
Meppen
Haarlem
Amsterdam
Amstelveen
Hilversum
Haarlemmermeer
Leiden
Den Haag
Zoetermeer
Utrecht
Amersfoort
Zeist
Barneveld
Apeldoorn
Deventer
Zutphen
Lochem
Raalte
Twenterand
Almelo
Hengelo
Enschede
Nordhorn
Dinkelland
Losser
Ochtrup
Rheine
Gronau (Westfalen)
Ahaus
Steinfurt
Westland
Rotterdam
Schiedam
Spijkenisse
Dordrecht
Veenendaal
Ede
Arnhem
Rheden
Bronckhorst
Doetinchem
Berkelland
Oude IJsselstreek
Borken
Coesfeld
Dülmen
Overbetuwe
Nijmegen
Tiel
Bocholt
Oss
Breda
Tilburg
Roosendaal
's-Hertogenbosch
Uden
Wesel
Dorsten
Marl
Haltern am See
Recklinghausen
Herne
Lünen
Bakel
Venray
Oberhausen
Essen
Bochum
Eindhoven
Veldhoven
Geldrop
Deurne
Venlo
Moers
Duisburg
Velbert
Hagen
Zundert
Woensdrecht
Turnhout
Krefeld
Ratingen
Meerbusch
Nettetal
Weert
Leudal
Viersen
Düsseldorf
Neuss
Solingen
Antwerpen
Beveren
Sint-Niklaas
Brugge
Oostkamp
Gent
Dendermonde
Mechelen
Lier
Geel
Mol
Heist-op-den-Berg
Beringen
Mönchengladbach
Erkelenz
Grevenbroich
Leverkusen
Bergisch Gladbach
Pulheim
Köln
Bergheim
Kerpen
Hürth
Wiehl
Echt
Geleen
Hasselt
Genk
Aalst
Vilvoorde
Jette
Anderlecht
Brussel
Bruxelles
Waregem
Kortrijk
Geraardsbergen
Halle
Waterloo
Wavre
Tienen
Sint-Truiden
Bilzen
Maastricht
Heerlen
Kerkrade
Tongeren
Aachen
Stolberg (Rheinland)
Düren
Erftstadt
Troisdorf
Hennef (Sieg)
Bonn
Zülpich
Königswinter
Liège
Braine-l'Alleud
Ottignies
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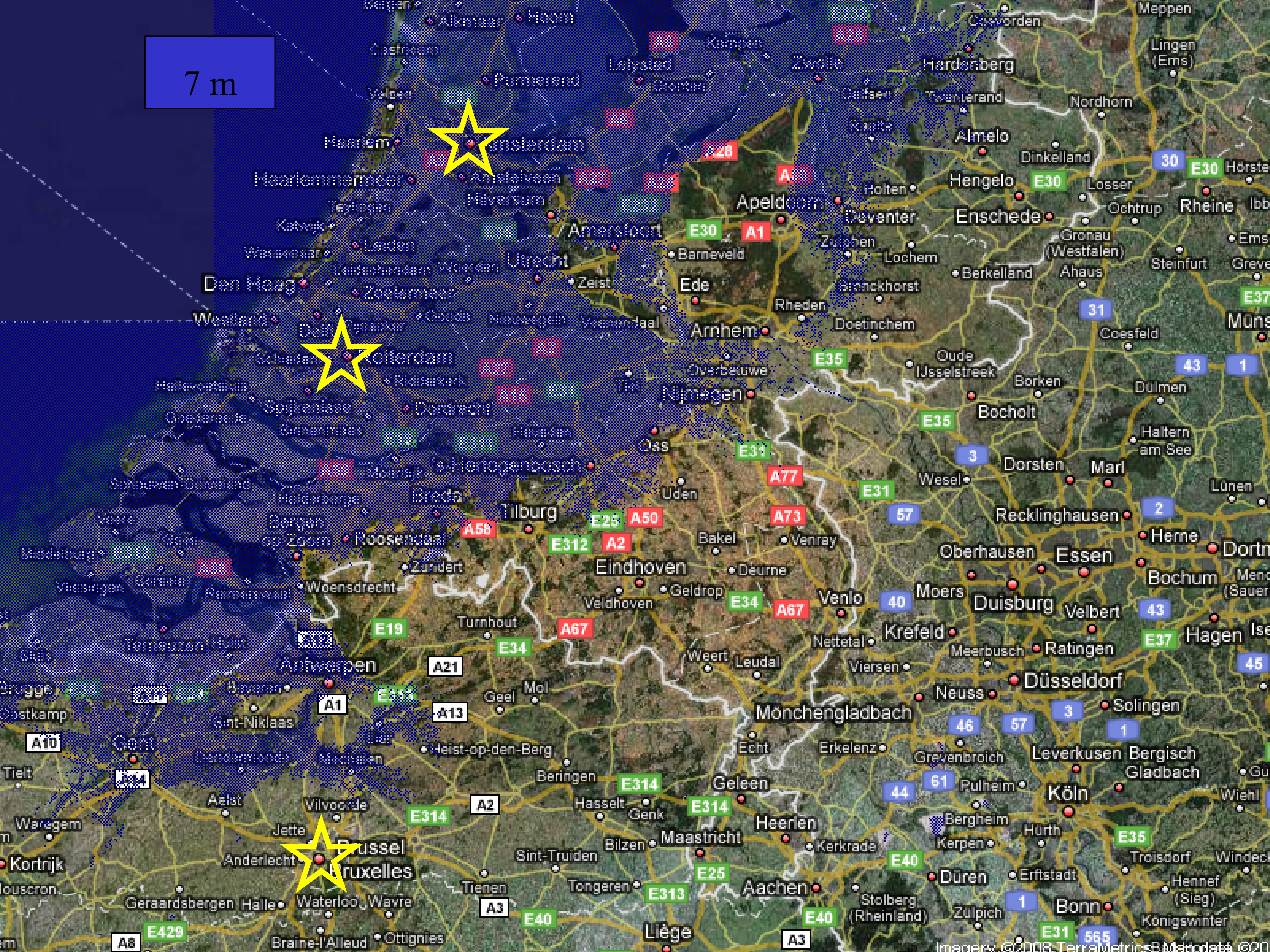
7 m
Alkmaar
Hoorn
Purmerend
Lelystad
Zwolle
Hardenberg
Meppen
Amsterdam
Amstelveen
Hilversum
Haarlem
Haarlemmermeer
Leiden
Den Haag
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Utrecht
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Amersfoort
Barneveld
Apeldoorn
Deventer
Zutphen
Lochem
Almelo
Hengelo
Enschede
Dinkelland
Losser
Nordhorn
Rheine
Ede
Rheden
Arnhem
Doetinchem
Oude IJsselstreek
Rotterdam
Dordrecht
Spijkenisse
Nijmegen
Overbetuwe
Oss
's-Hertogenbosch
Breda
Tilburg
Roosendaal
Bergen op Zoom
Zundert
Woensdrecht
Uden
Bakel
Venray
Eindhoven
Geldrop
Veldhoven
Deurne
Venlo
Weert
Leudal
Borken
Bocholt
Dorsten
Marl
Wesel
Recklinghausen
Herne
Oberhausen
Essen
Bochum
Moers
Duisburg
Velbert
Krefeld
Meerbusch
Ratingen
Hagen
Nettetal
Viersen
Düsseldorf
Neuss
Mönchengladbach
Solingen
Echt
Erkelenz
Grevenbroich
Leverkusen
Bergisch Gladbach
Pulheim
Köln
Bergheim
Kerpen
Hürth
Turnhout
Geel
Mol
Antwerpen
Gent
Aalst
Vilvoorde
Jette
Brussel
Bruxelles
Anderlecht
Halle
Waterloo
Wavre
Braine-l'Alleud
Ottignies
Geraardsbergen
Waregem
Kortrijk
Beringen
Heist-op-den-Berg
Hasselt
Genk
Sint-Truiden
Bilzen
Maastricht
Tienen
Tongeren
Geleen
Heerlen
Kerkrade
Aachen
Liège
Stolberg (Rheinland)
Düren
Zülpich
Erftstadt
Bonn
Hennef (Sieg)
Troisdorf
Königswinter
Imagery ©2008 TerraMetrics

13 m

Holland cows prepared to global warming

©Bill Hare

Adaptation limits?

Oceans are damaged a lot already

and their state deteriorates further due to :

- acidification by surplus CO_2 from the air

  (pH got down by 0.1 on average, i.e., free protons are one third more numerous; apart from carbonaceous shell organisms it harms fish reproduction)
- warming
- oxygen deficit (anoxia) due to its increased consumption and diminished mixing

(see http://www.stateoftheocean.org/)

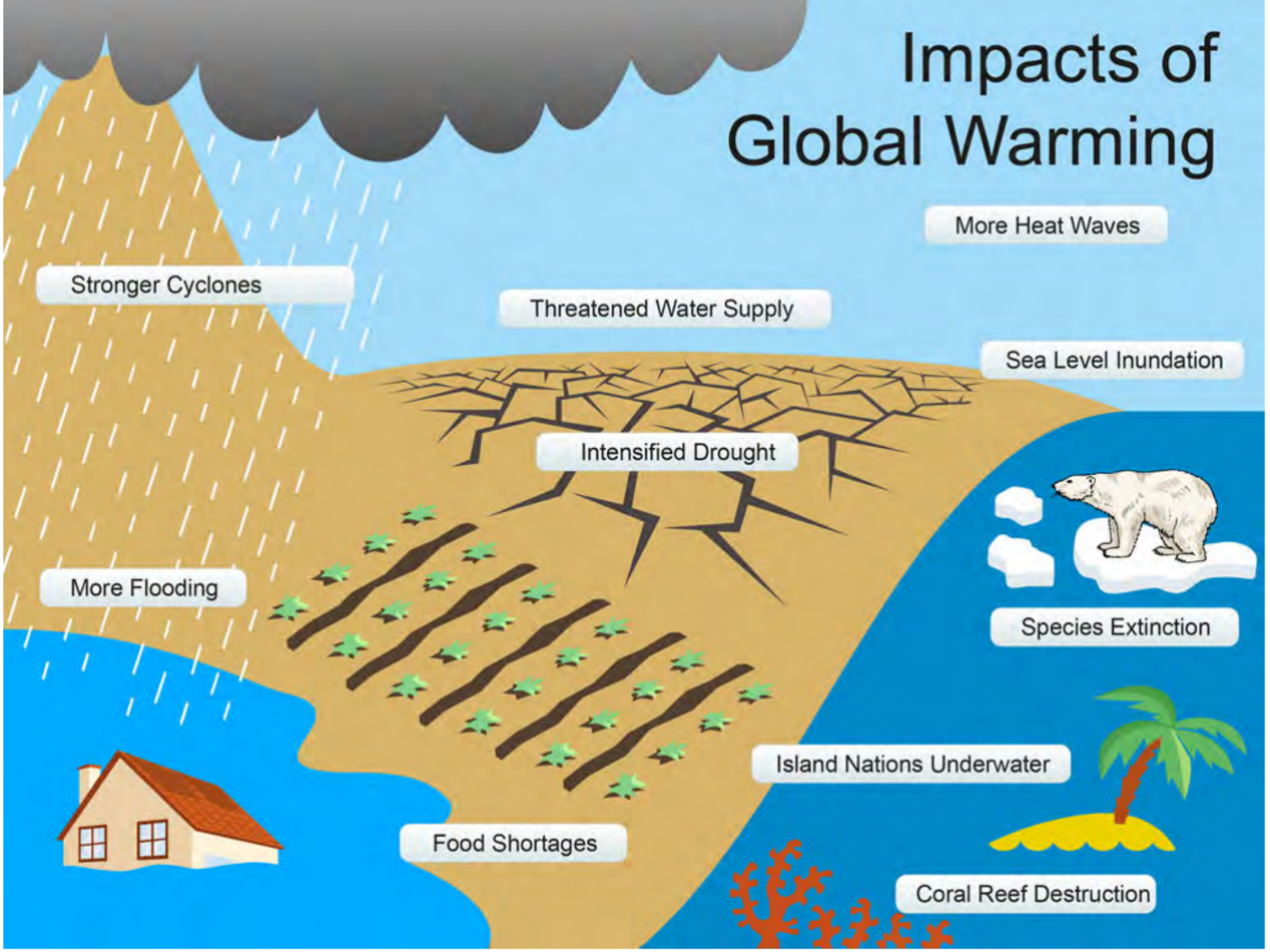
floods

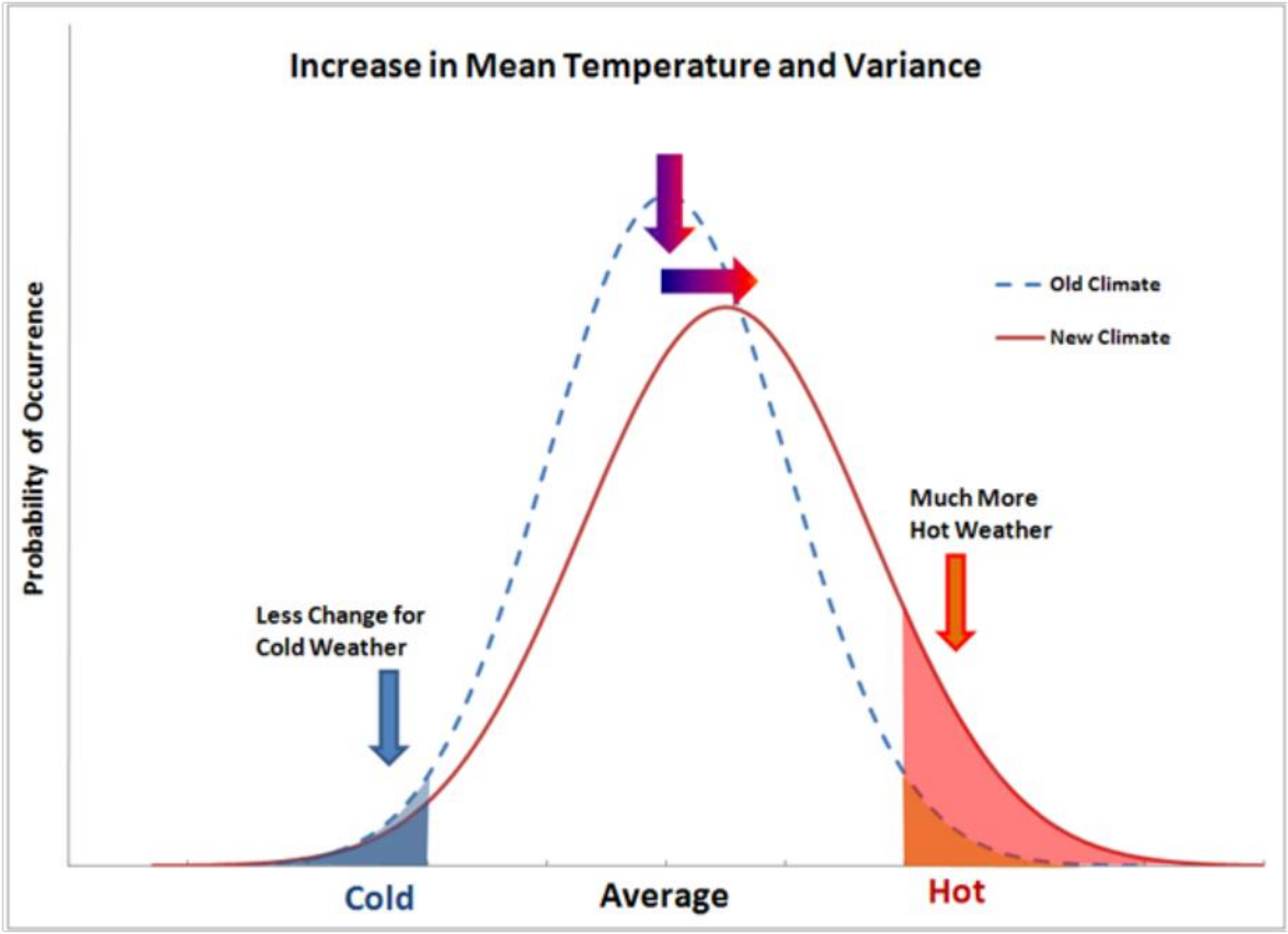
Risks:
Extreme events

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

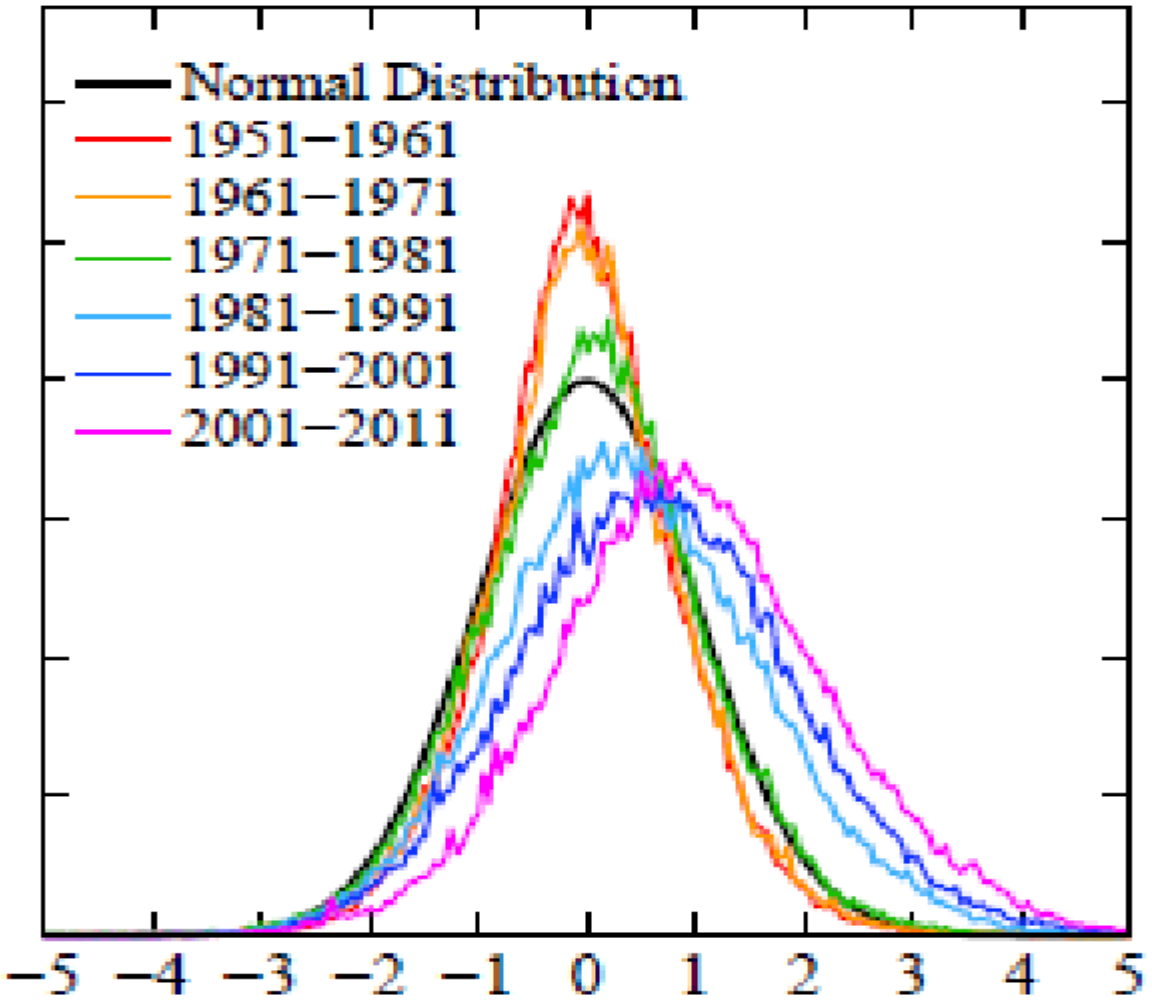
- More rainpours
  - flash floods
  - droughts

Impacts of Global Warming




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

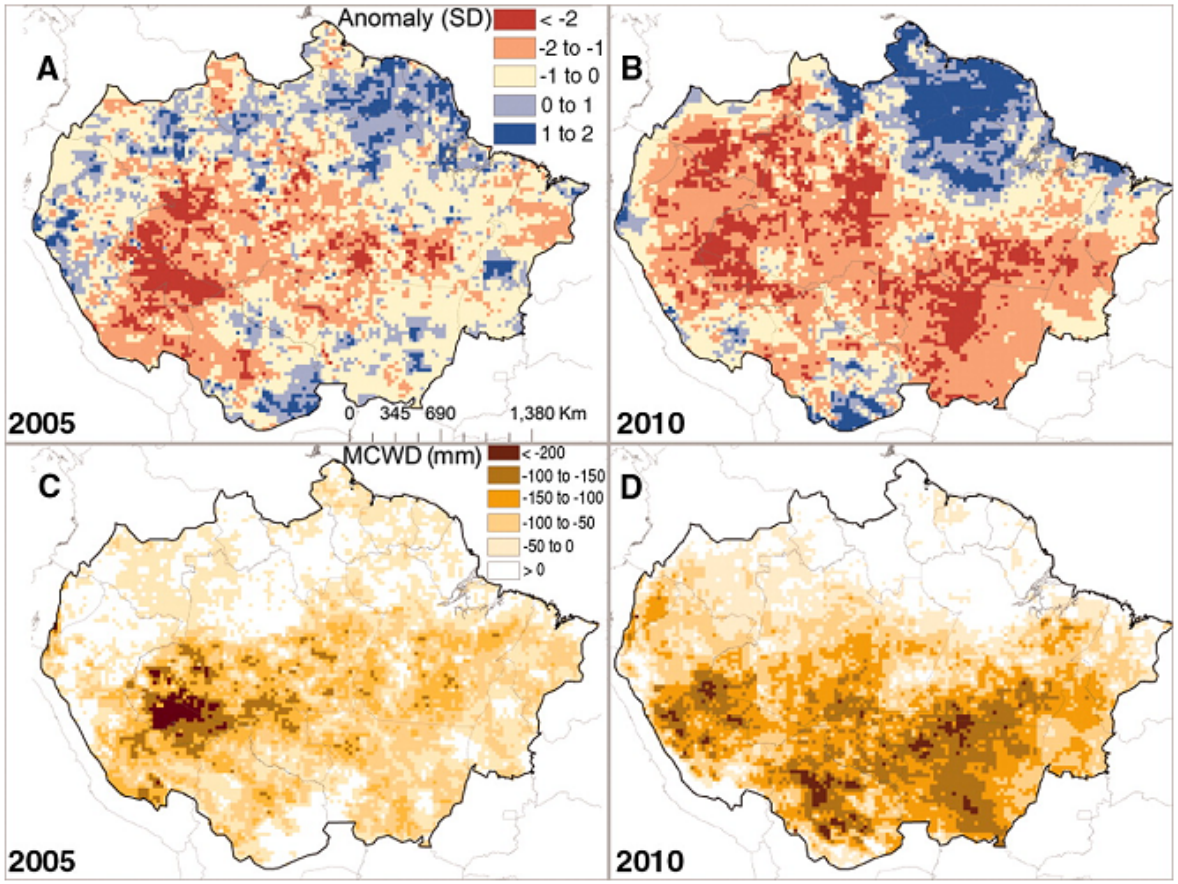


Wild fires in Greece, August 2007

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

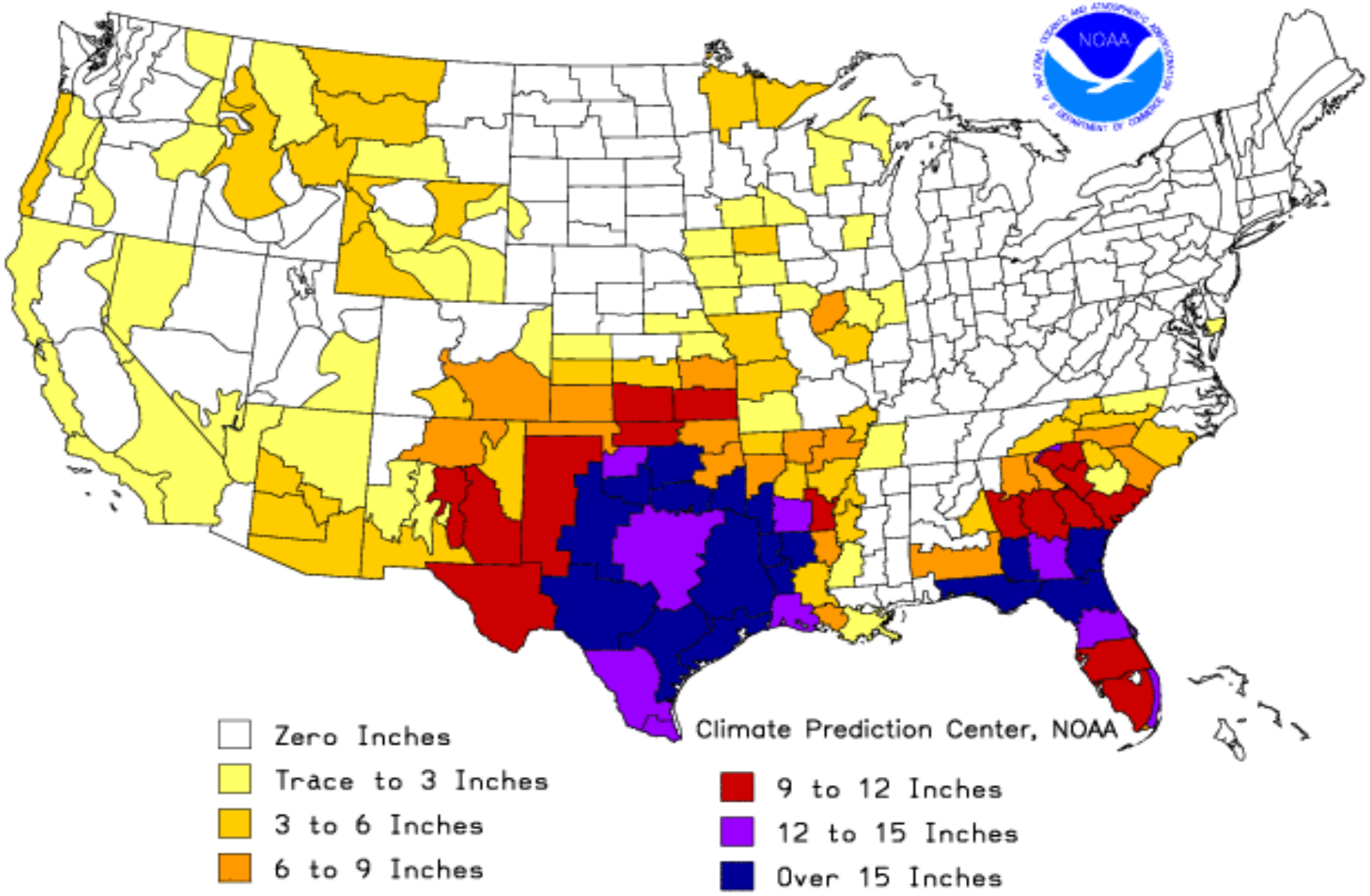
= US total annual fossil-fuel emissions

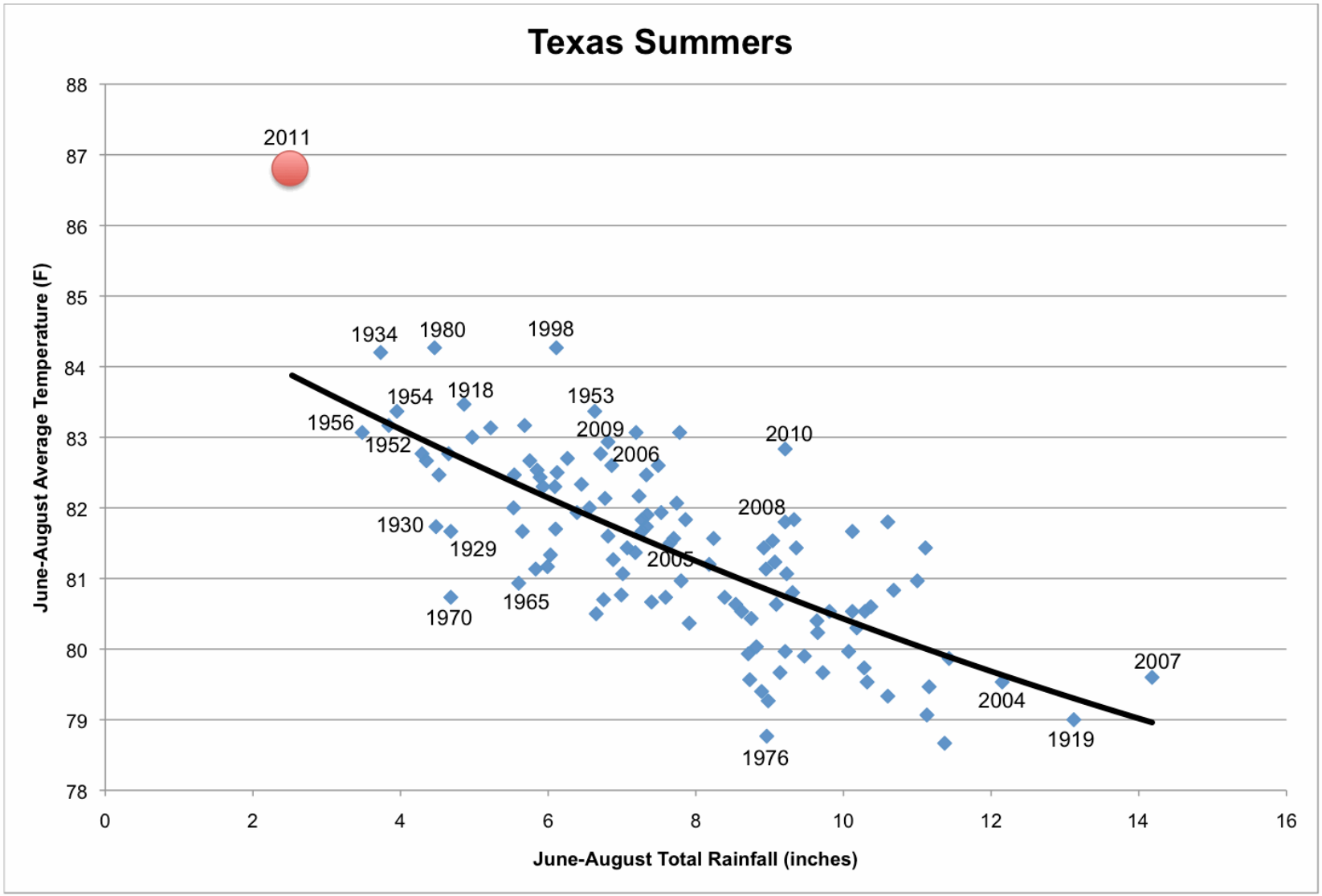
Source: The 2010 Amazon Drought, Lewis et al, University of Leeds, Science, February 2011

Additional Precip. Needed (In.) to Bring PDI to −0.5

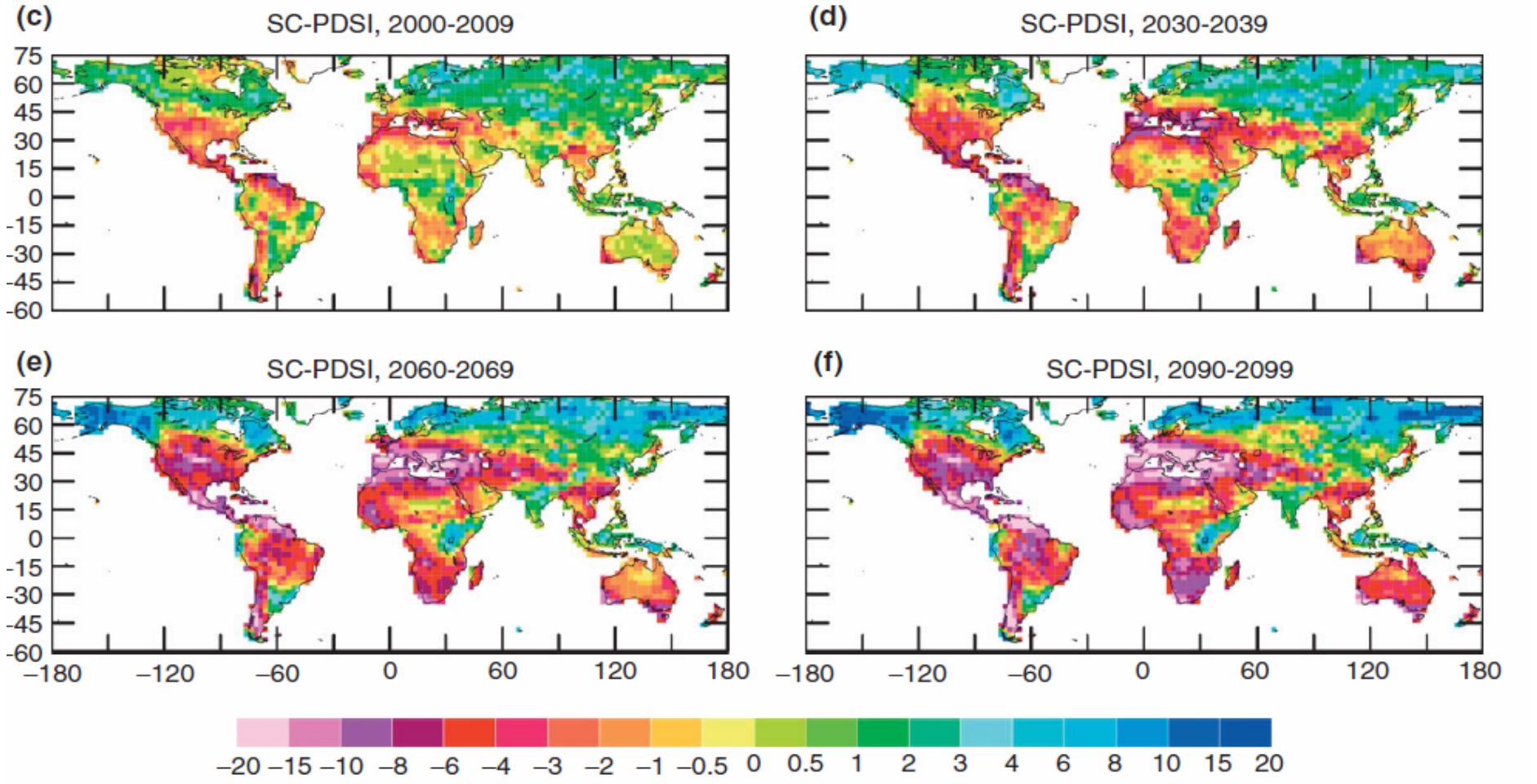
Weekly Value for Period Ending OCT 1, 2011

Long Term Palmer Drought Severity Index (PDI)




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
2010
1952
2006
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)



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."

Dangerous changes?

Species extinction

esp. polarn and alpine
unsustainable migration speeds

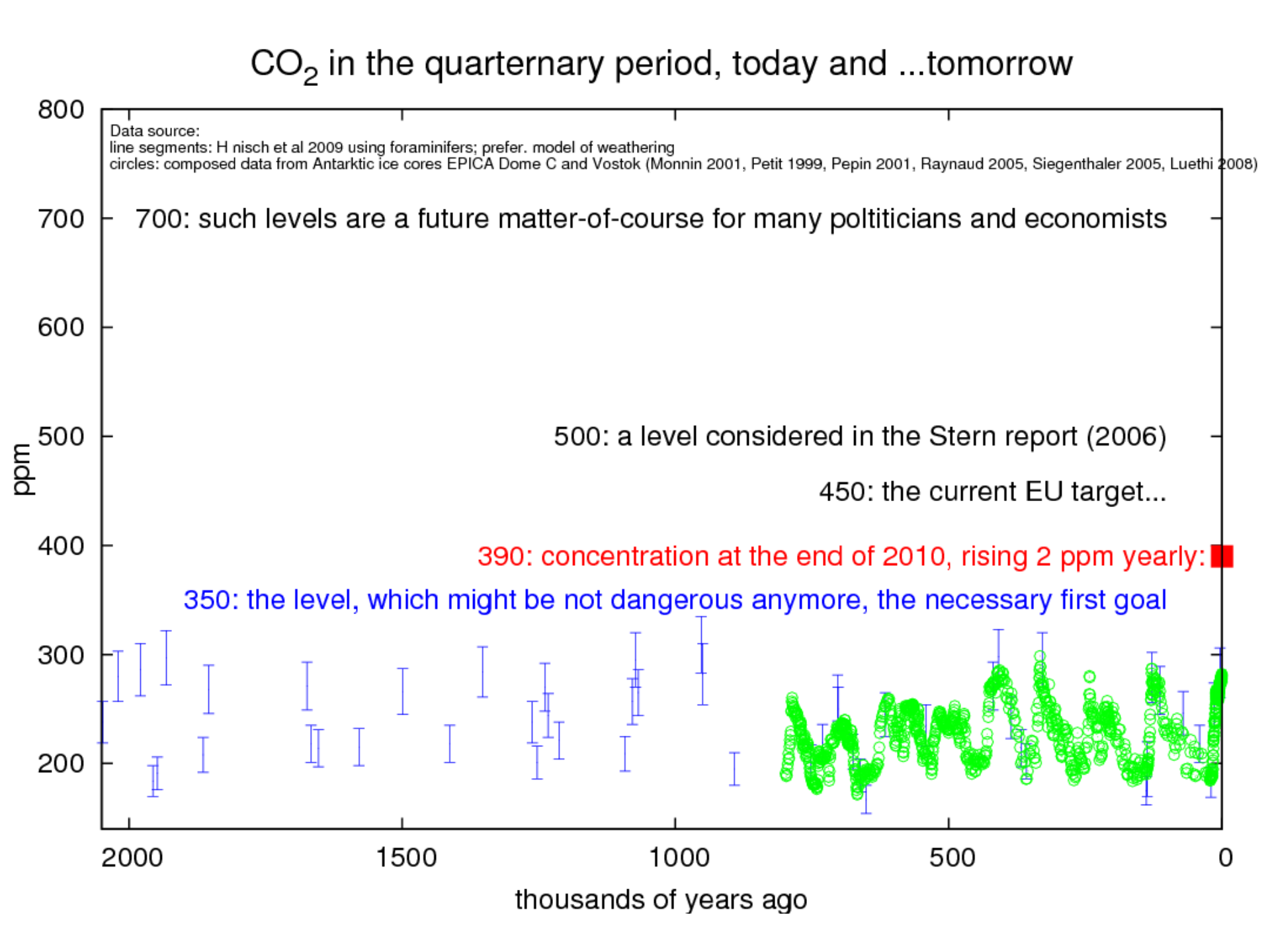
Ice sheet disruption: sea level

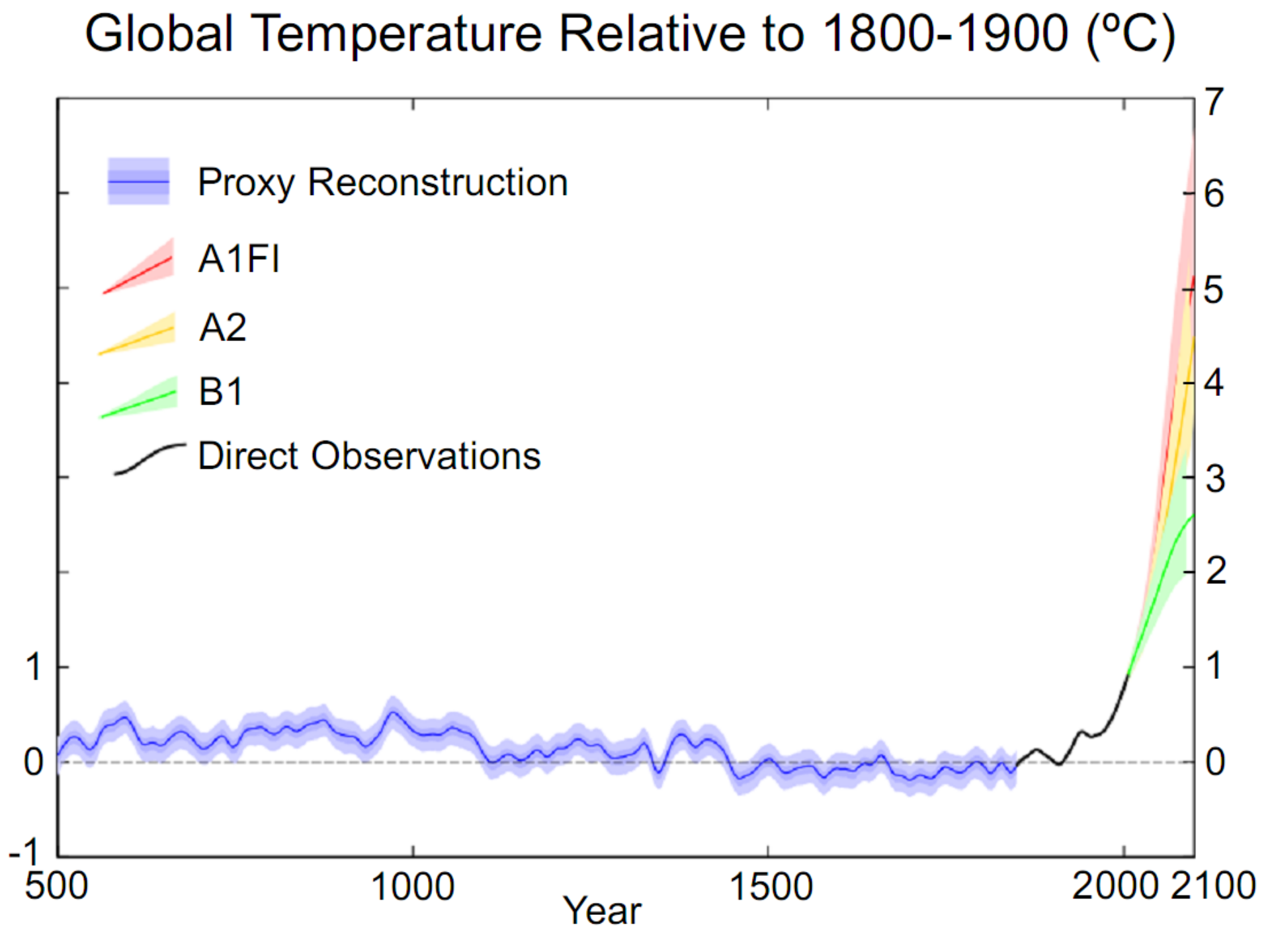
Regionalní climate disruptions

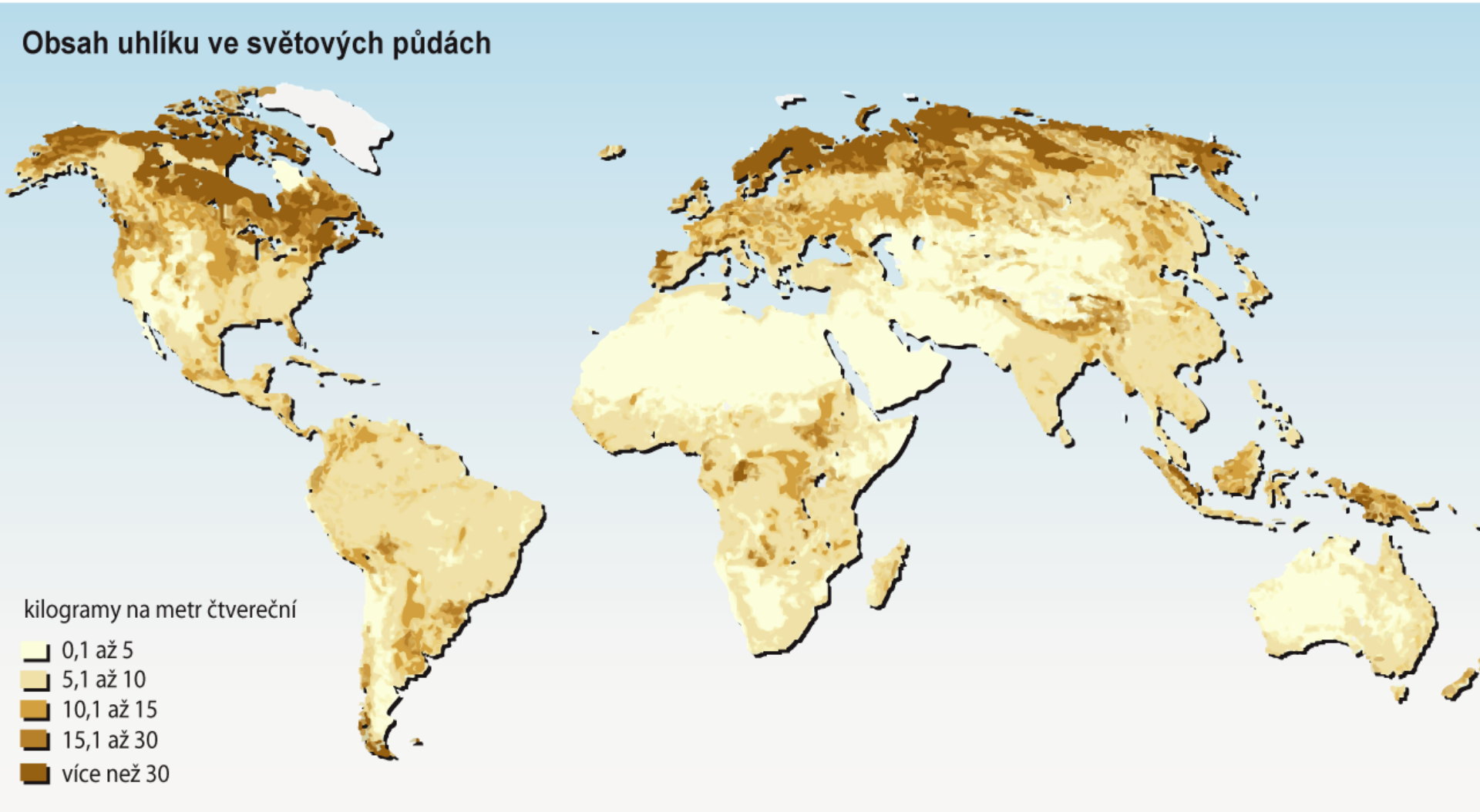
extreme events more frequent
vegetation zones shifts / water scarcity

… stable *holocene* climate enabled settlement and civilisation

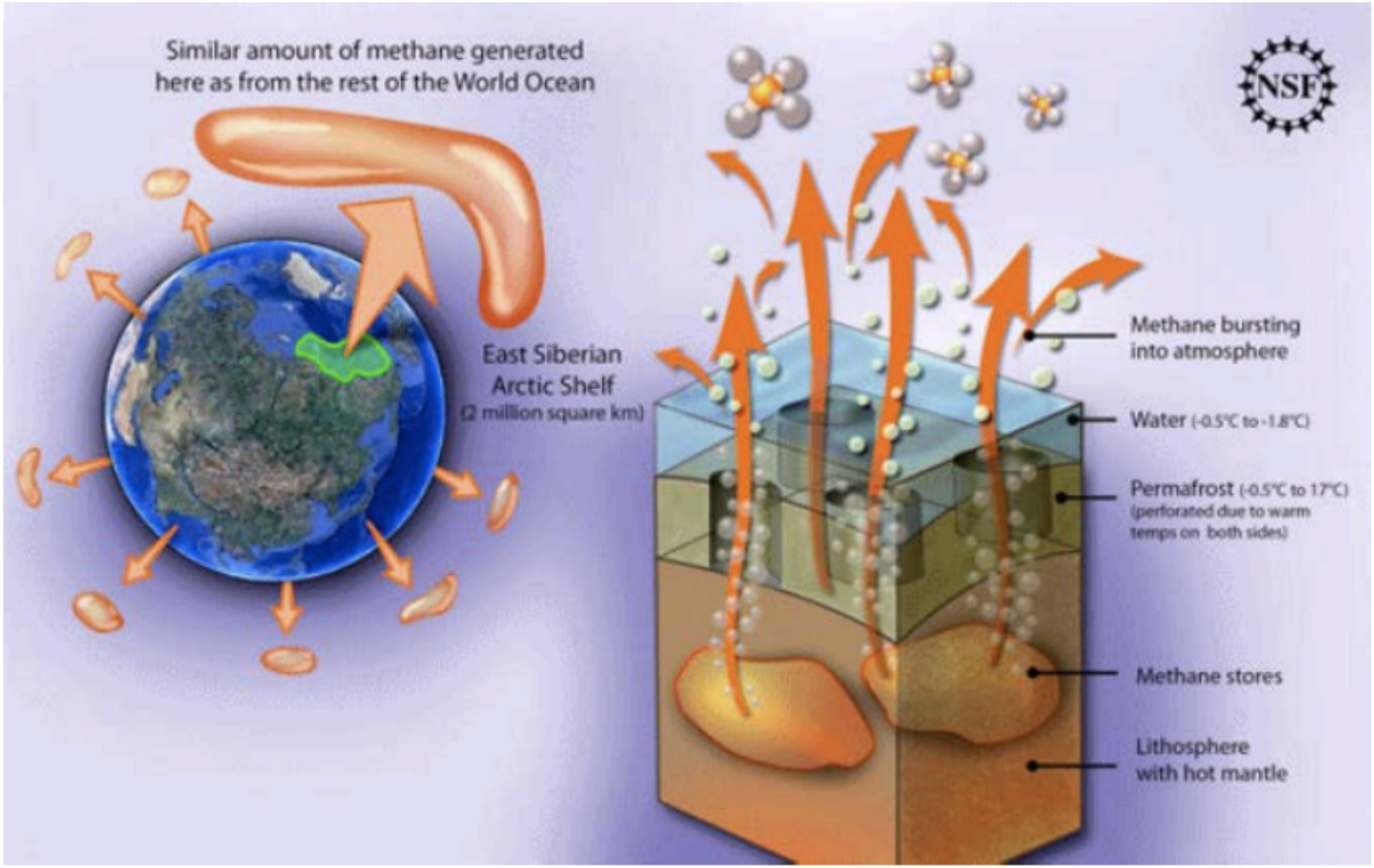
… loss of stability in *anthropocene* – loss of habitability of many regions and of Earth ability to feed us


CO_2 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


Global Temperature Relative to 1800-1900 (ºC)
Proxy Reconstruction
A1FI
A2
B1
Direct Observations
7
6
5
4
3
2
1
0
-1
500
1000
1500
2000
2100
Year


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

Arctic Methane Emissions



Recent evidence shows that methane emissions are increasing from Arctic permafrost and seabed clathrates

Source: US National Science Foundation &
http://climateprogress.org/2010/03/04/science-nsf-tundra-permafrost-methane-east-siberian-arctic-shelf-venting/

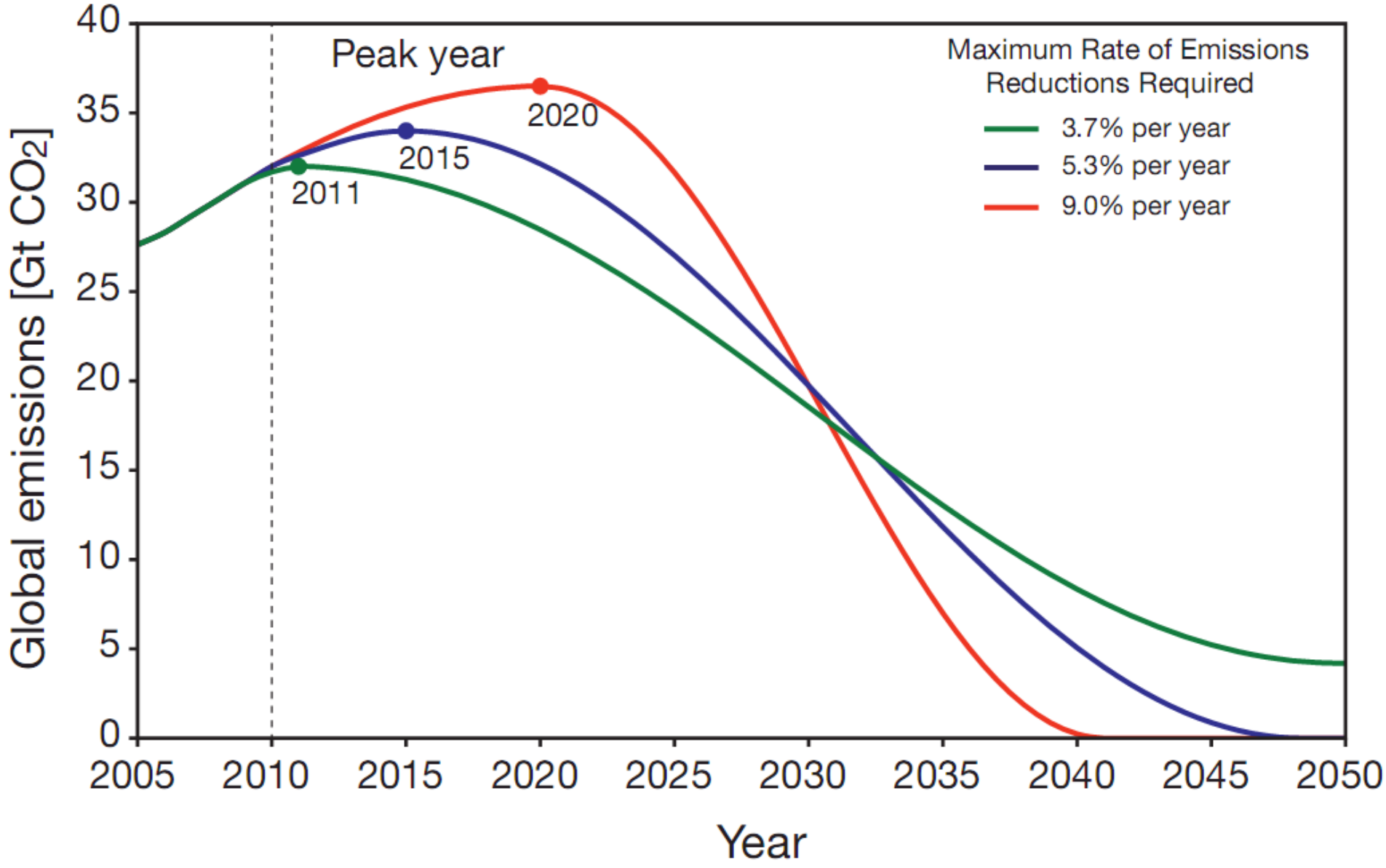


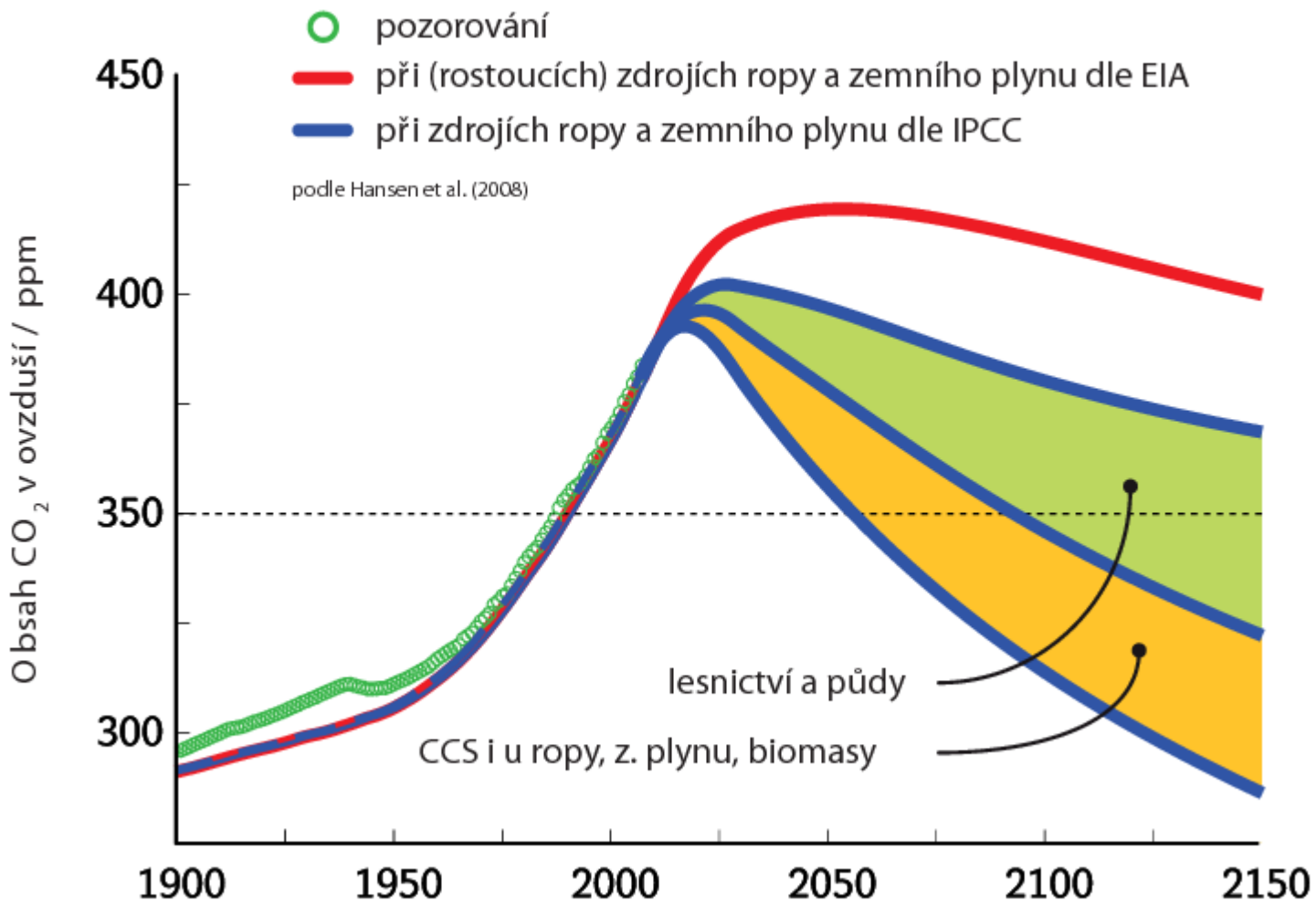
Figure 22: Emission paths providing a 67 % chance to remain below 2 K warming

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
1900
1950
2000
2050
2100
2150
lesnictví a půdy
CCS i u ropy, z. plynu, biomasy

The goal to reduce CO_2 below 350 ppm

Technically achievable

(but not in a „business-as-usual“ case)

When coal use will be abandoned soon

(long lifetime of CO_2 in the air)
(we have to stop construction of new coal power plants, if they don't capture and store CO_2)

The challenge

We can still avoid damaging the world we have inherited

(and have a cleaner planet and useful jobs)

We have to find, soon, a way how to live without fossil fuels…

Why not now?

Reducing emissions of fossil carbon and man-made production of methane and black carbon is the only safe and sure tool to slow down global warming

The latter 2 are easier and help quickly, but carbon determines the fate of the life on Earth

To achieve it, fossil carbon dug from Earth is to get a price.

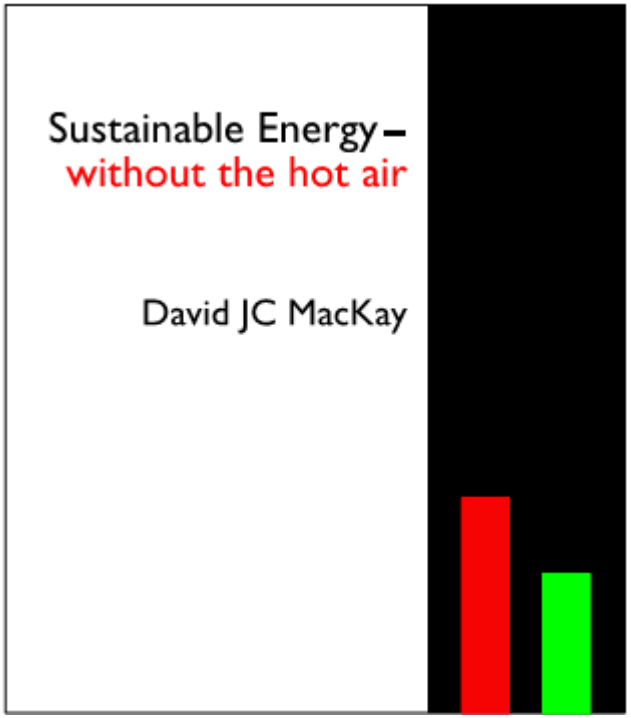
Expressed as CO2, starting from some10 $/t and rising to some 300 $/t over years

(road fuel tax in EU *is* 200 $/t, no problem)

Hansen's fee and dividend way would make it feasible

Pricing carbon would help to reduce our level of consuption, which is unsustainable

All investments should aim at mitigation, helping adaptation if possible



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