Stephen H. Schneider*

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Professor, Department of Biology
Senior Fellow, Woods Institute for the Environment

Stanford University

Climate Change Policy– Expecting the "Unimaginable Surprises" and Actions to Consider

Climate Change, Natural Resources and Coastal Management
A workshop on the Coastal Ecosystems of CA, OR, and WA
Friday, January 30, 2009
10:00AM-10:30AM

***[Website for more info: climatechange.net.]**

Is the Science “Settled”?

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-Well-established components

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-Competing Explanations

Is The Science “Settled”?

-Well-established components

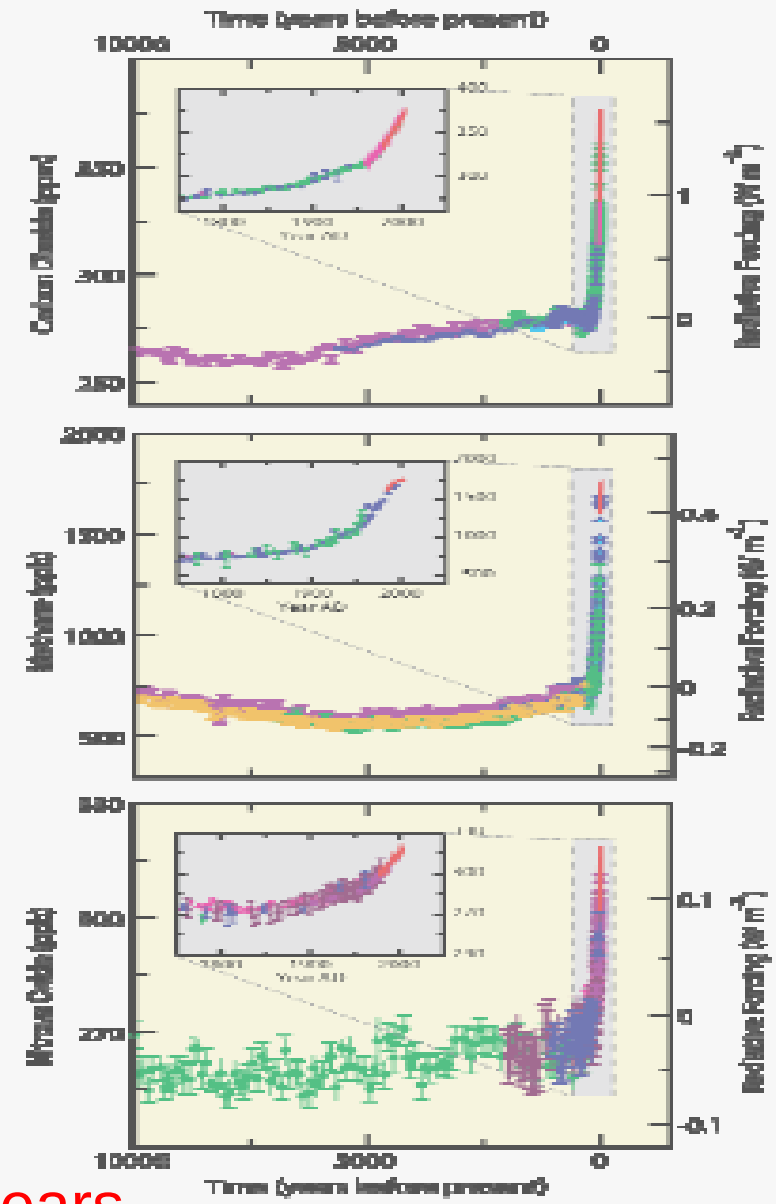
-Competing Explanations

-Speculative components

CO2

CH4

N2O



10,000 Years

Figure 2.4. Atmospheric concentrations of carbon dioxide, methane and nitrous oxide over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (lines). The corresponding radiative forcings are shown on the right hand axes of the large panels. [WGI Figure SPM-1]

Global Warming is Happening NOW:

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level (see Figure SPM-3). {3.2, 4.2, 5.5}."

IPCC, Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report, February, 2007

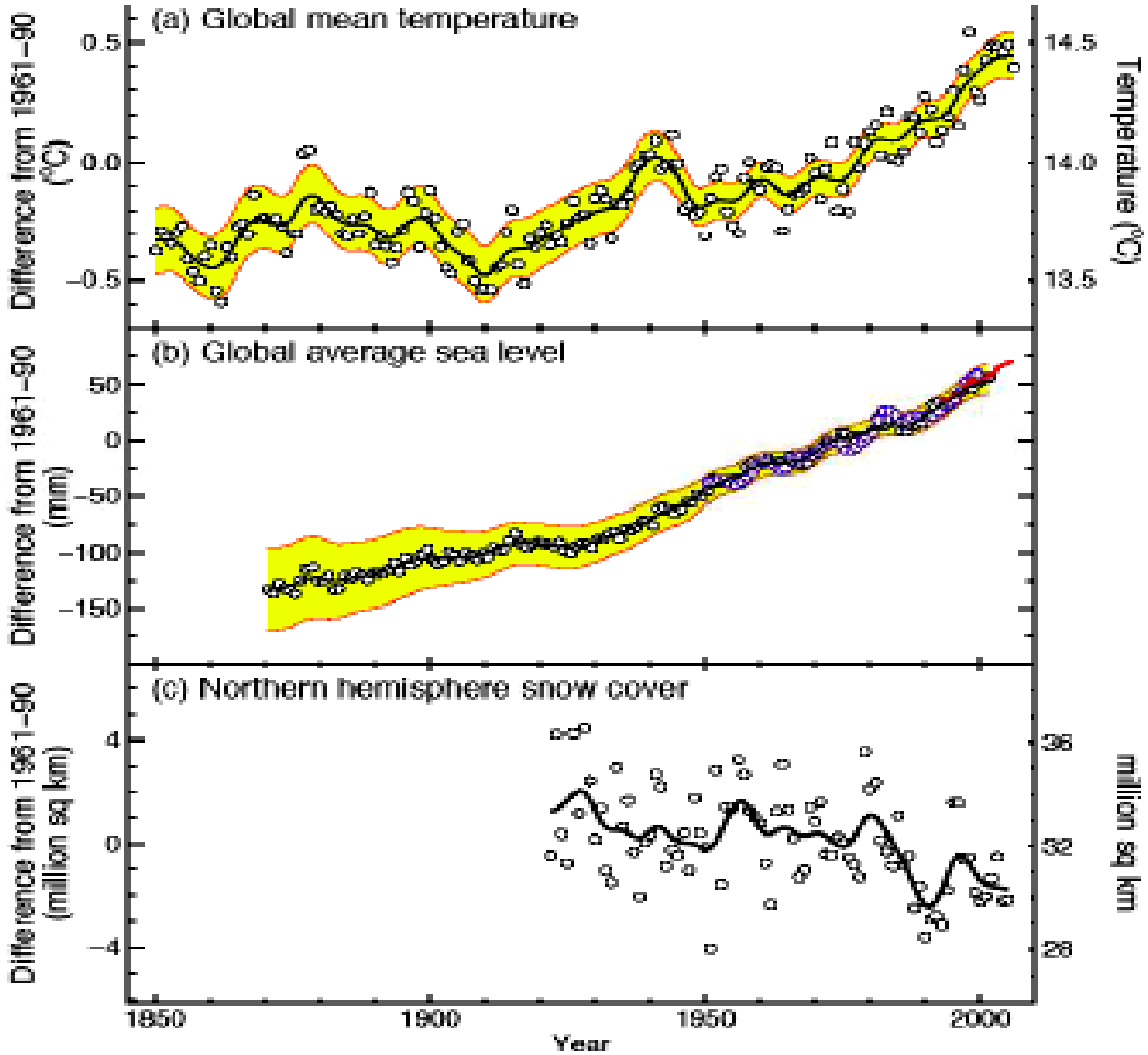
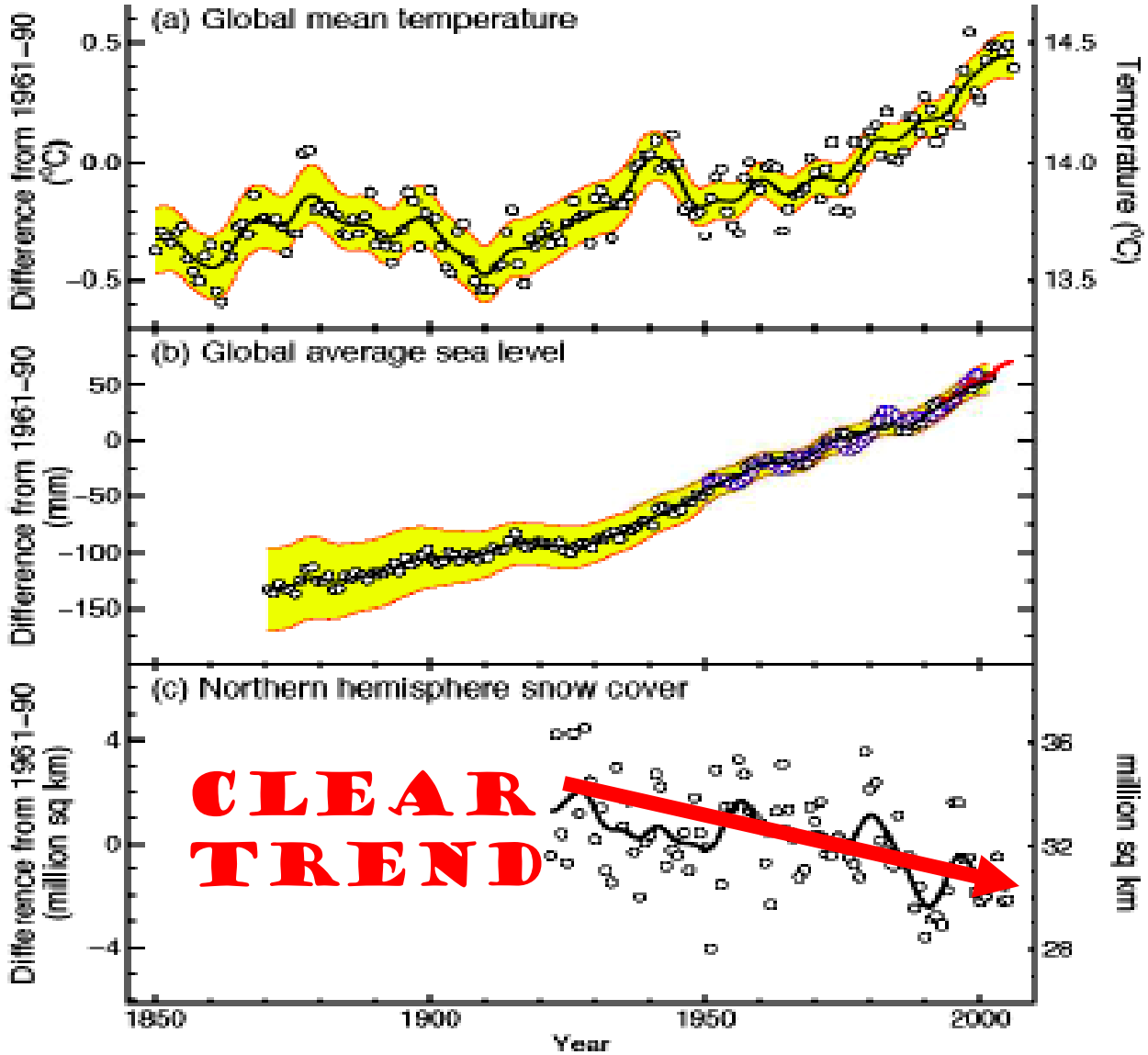


Figure 1.1. Changes in global mean temperature, sea level, and snow cover area. Panel (a) shows global mean temperatures as annual values (open circles) and a smoothed curve (black line) with uncertainty in the smoothed curve shown by the yellow shaded area. Panel (b) shows global mean sea level from tide gauge data (circles) and recent satellite measurements (red line). Panel (c) shows April Northern Hemisphere snow cover area each year (circles) with smoothed values (black line). [WGI Figure SPM-3]



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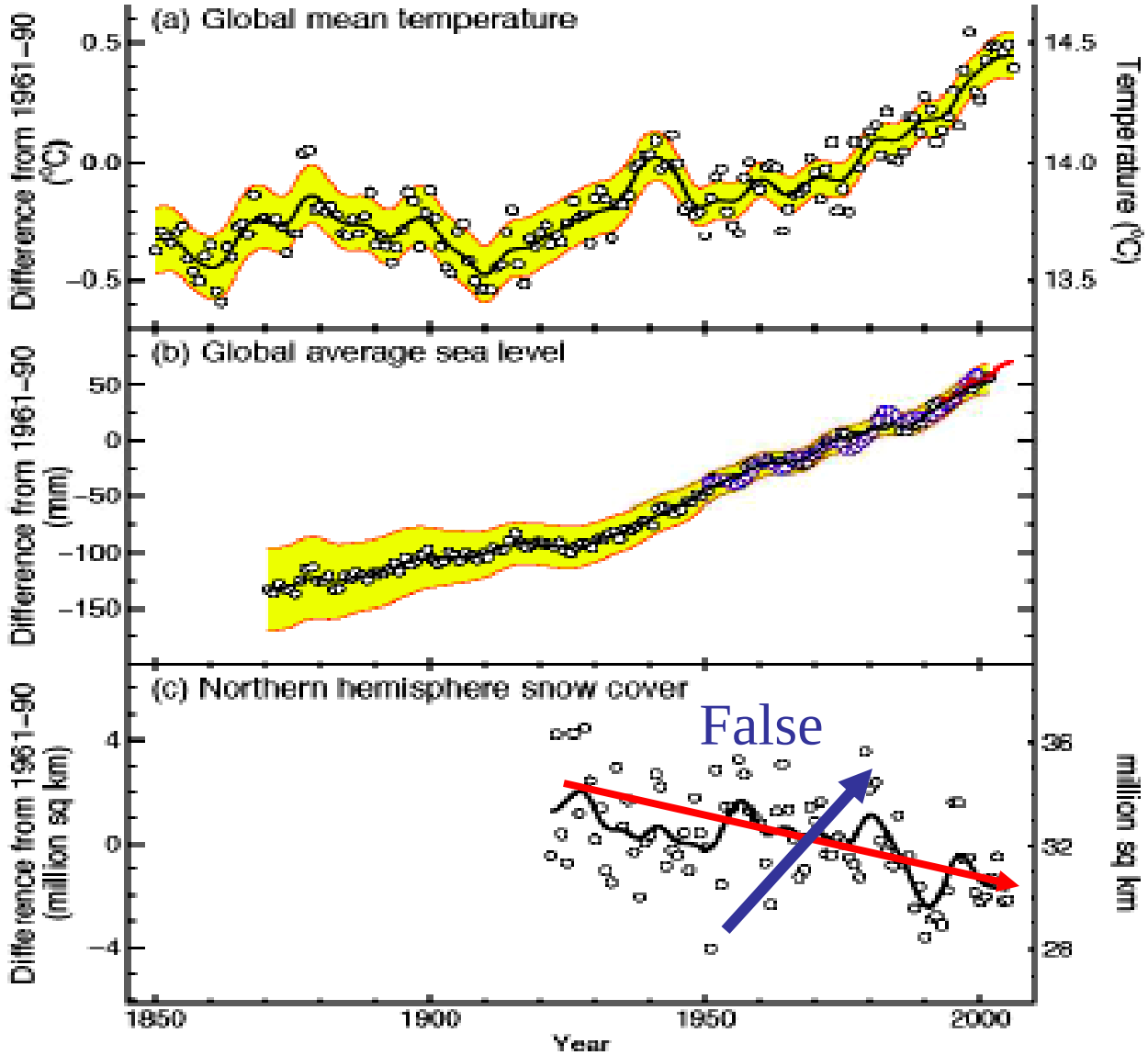

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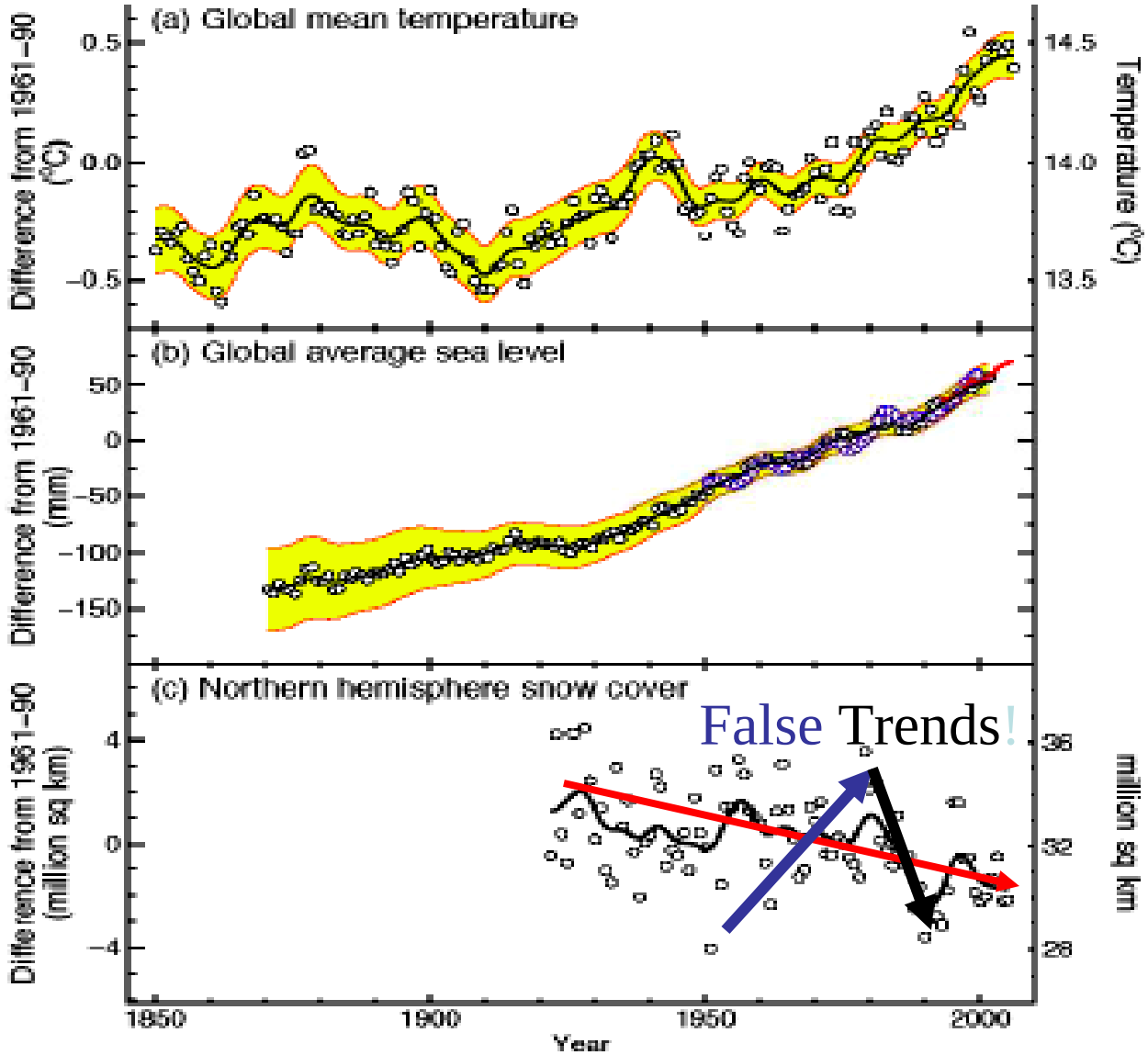

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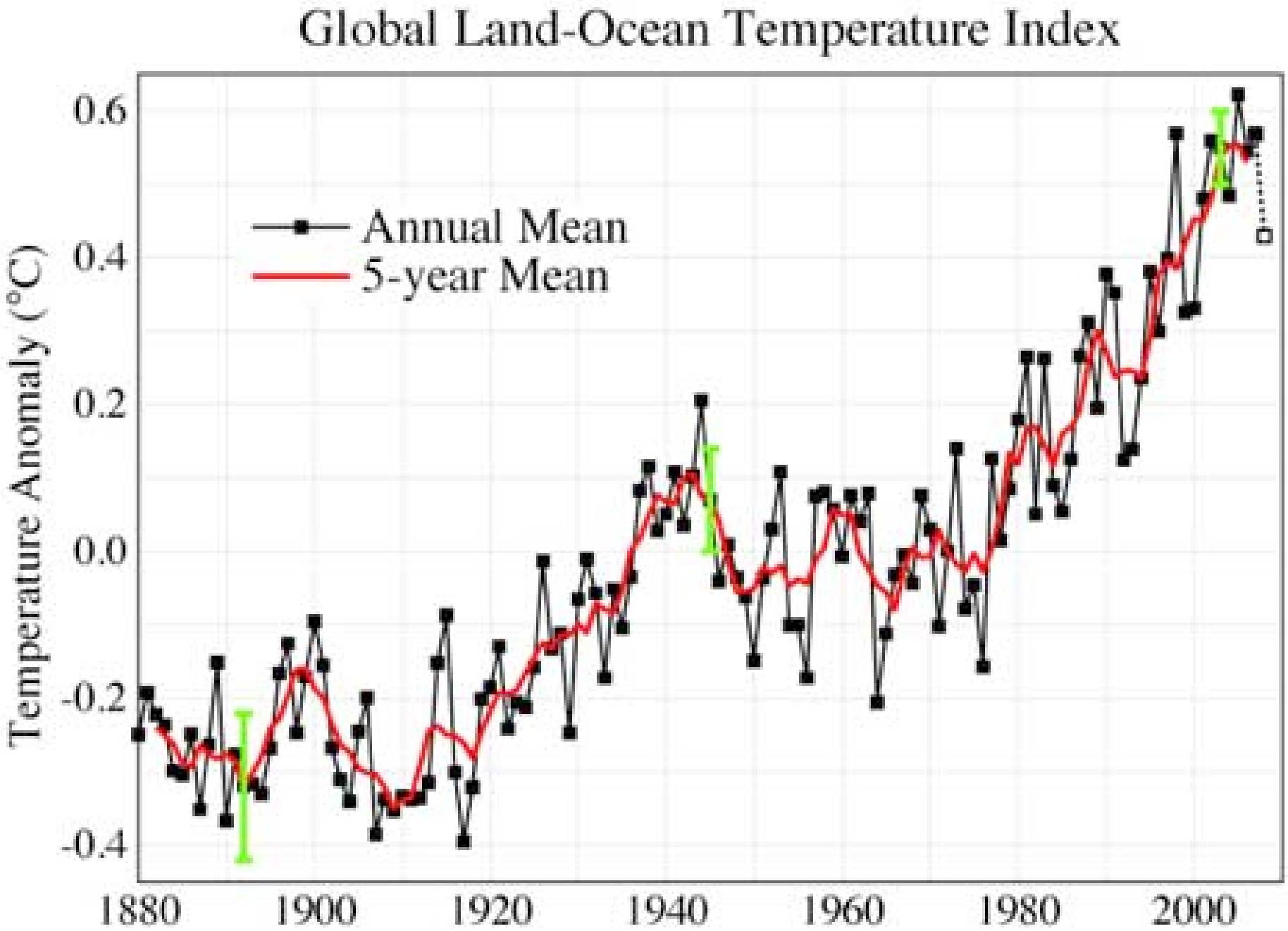
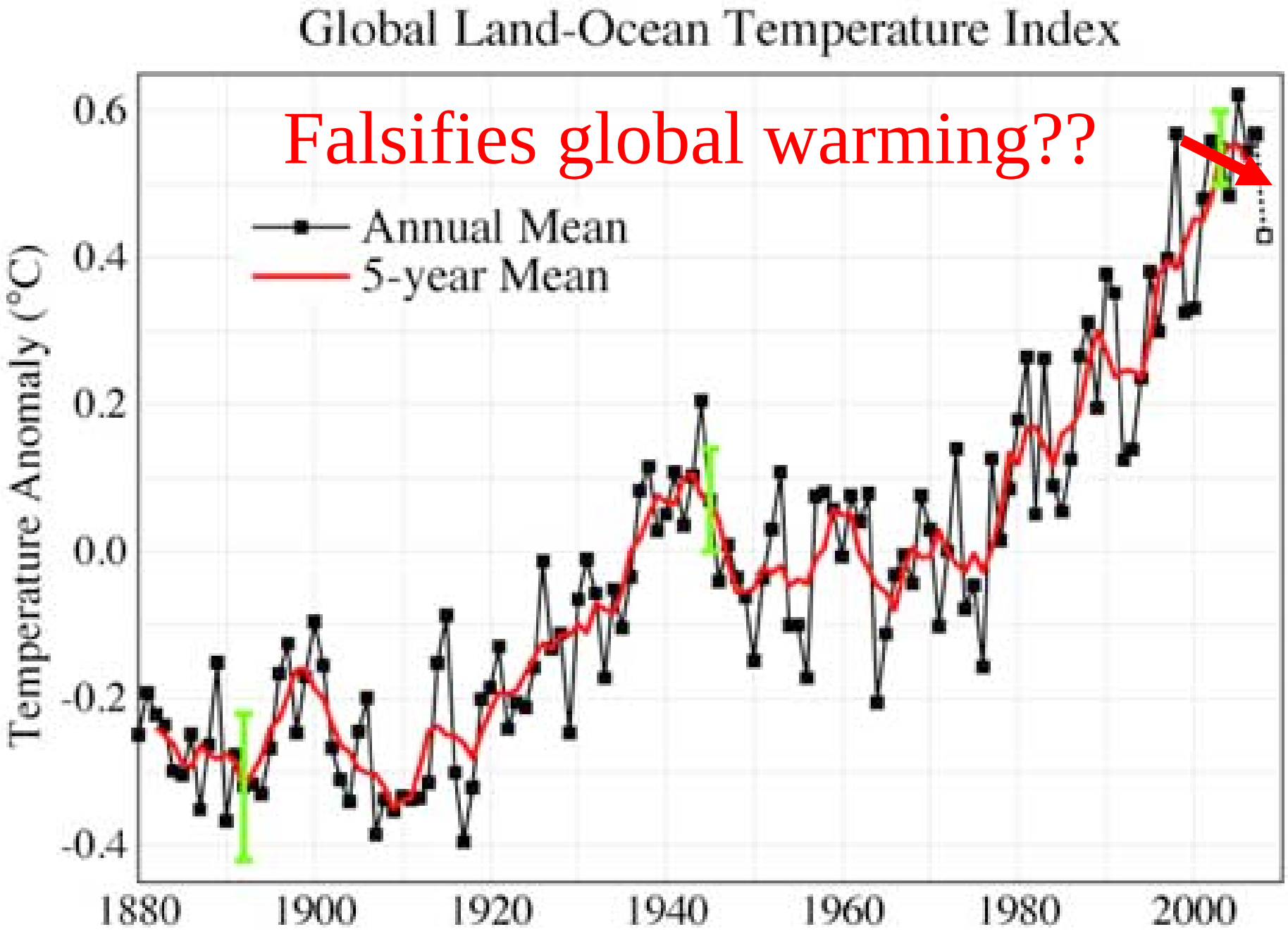

Global Land-Ocean Temperature Index
Annual Mean
5-year Mean
Temperature Anomaly (°C)
0.6
0.4
0.2
0.0
-0.2
-0.4
1880
1900
1920
1940
1960
1980
2000


Global Land-Ocean Temperature Index
Falsifies global warming??
Annual Mean
5-year Mean
Temperature Anomaly (°C)
0.6
0.4
0.2
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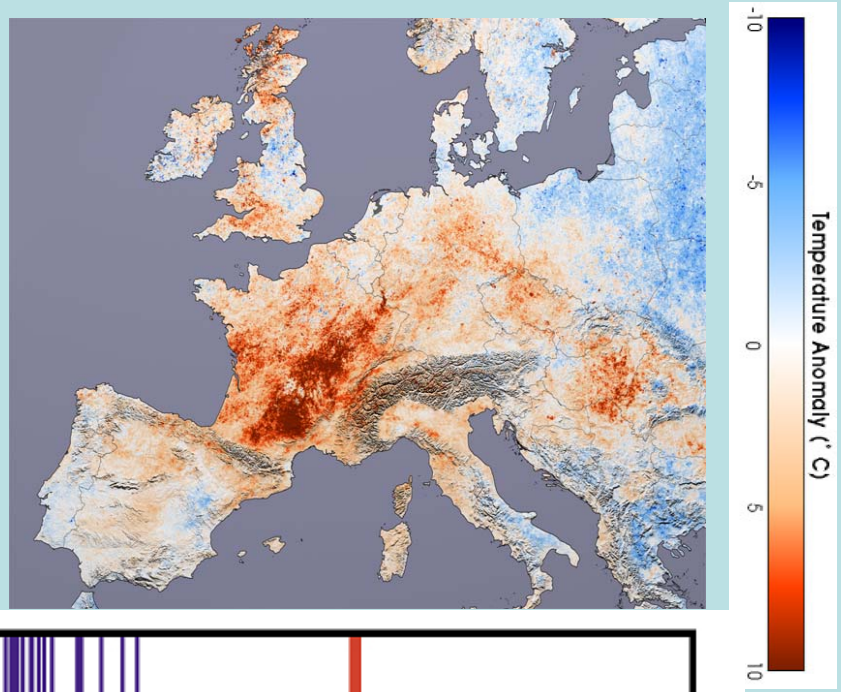
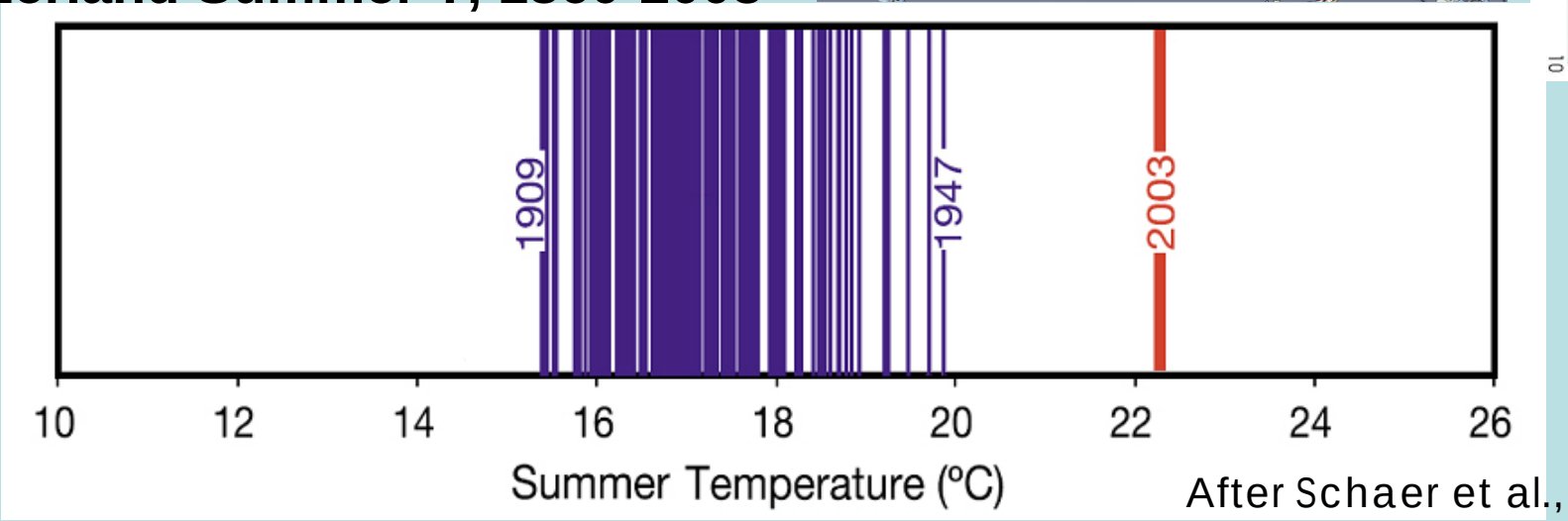
Extreme Events: Heat

NASA

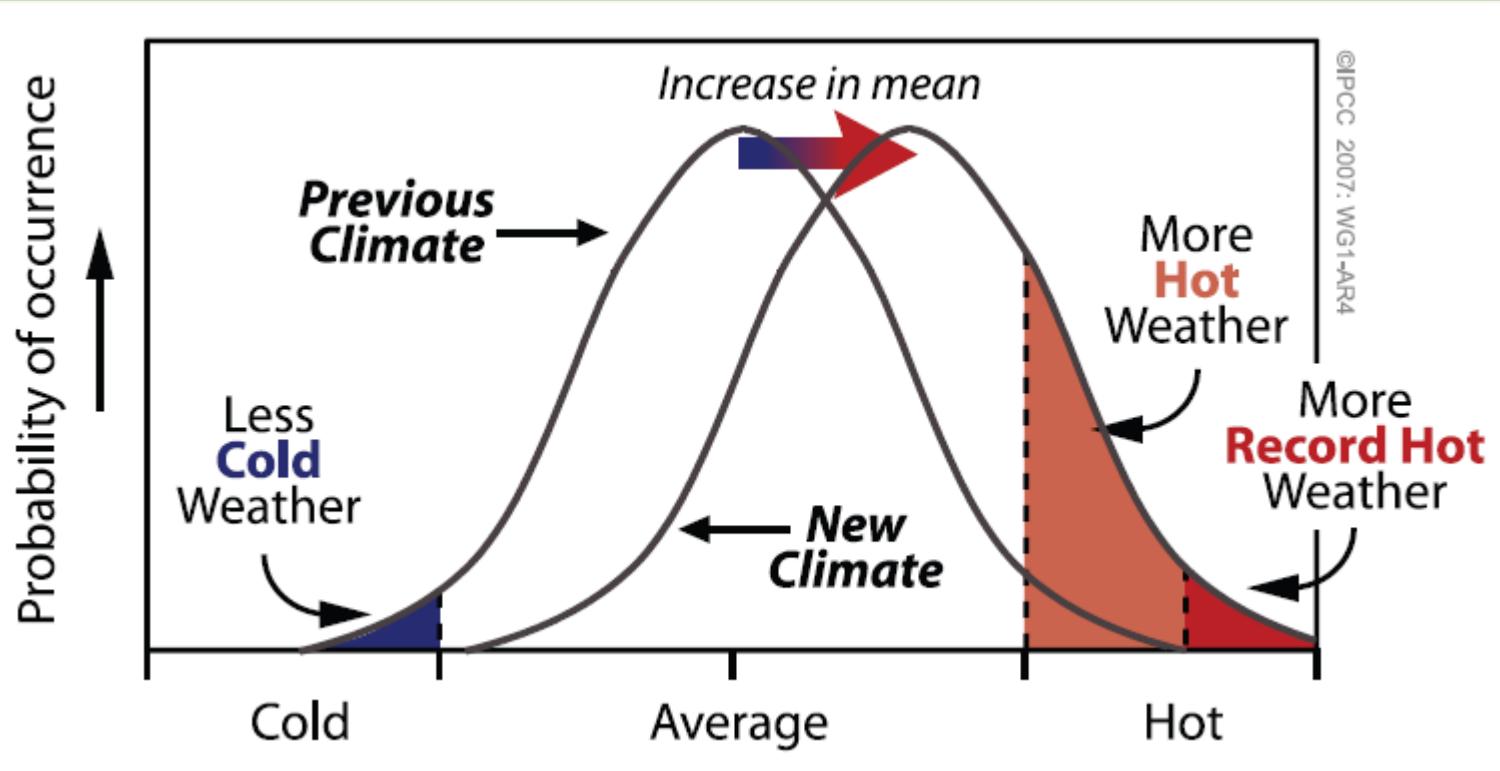


Switzerland Summer T, 1860-2003



After Schaer et al., 2004

Extreme Events: Heat



IPCC, 2007

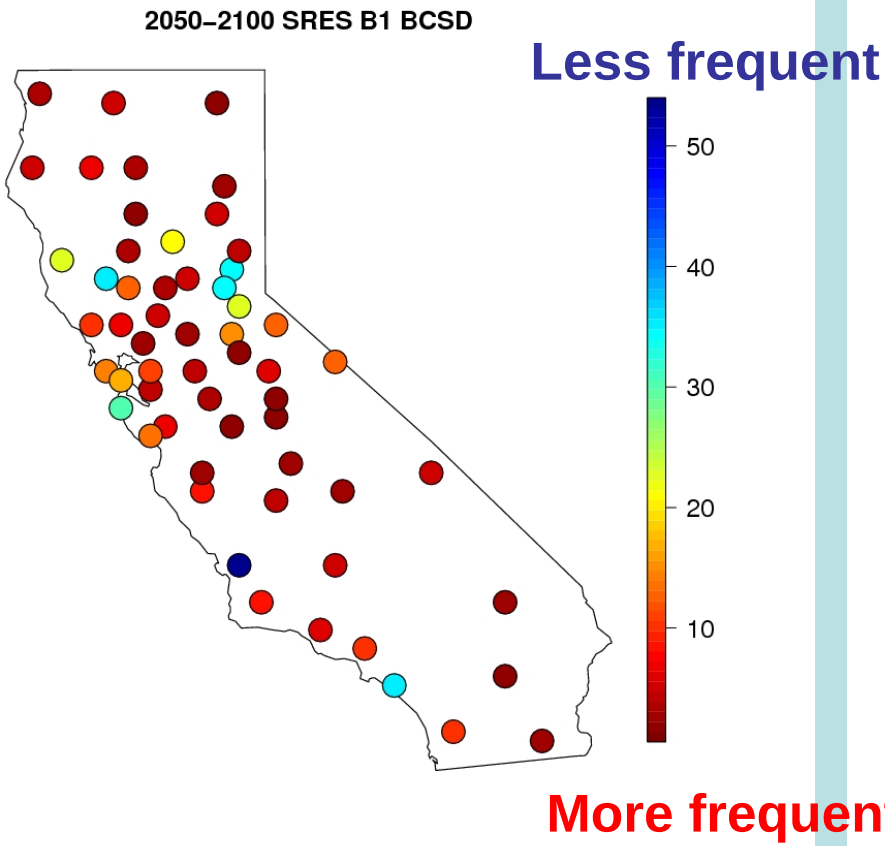
FOR
CALIFORNIA'S
FUTURE

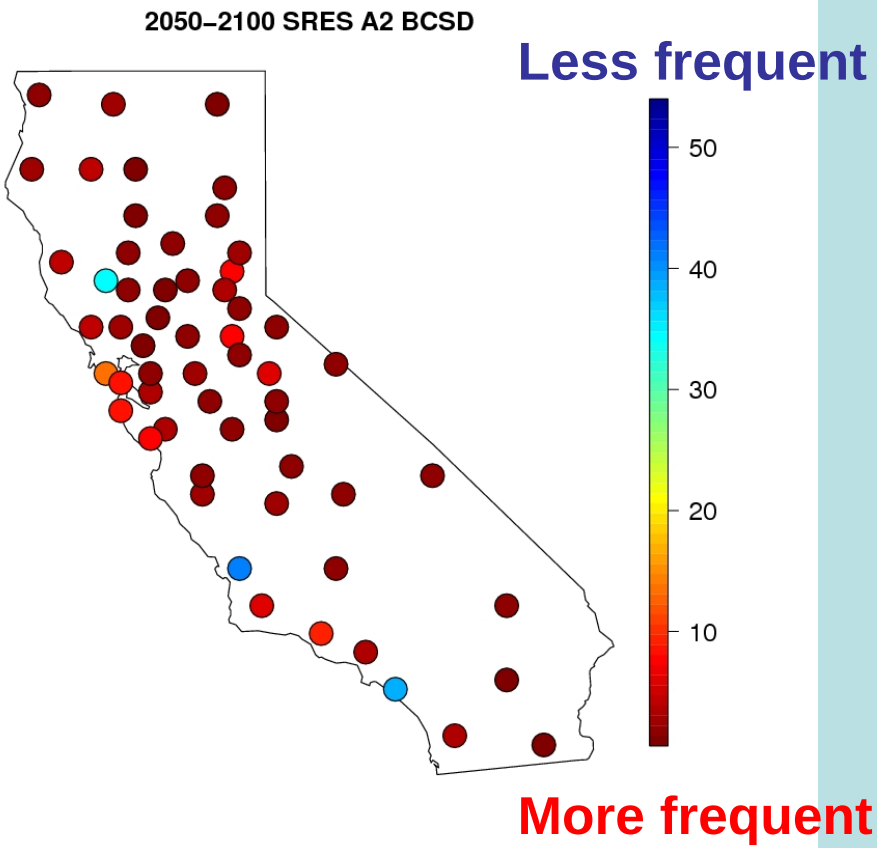
Governor of California:
80% reduction in emissions
by 2050

Motivating Issues For A *Sustainability Agenda* For California on Climate Change

Extreme Events: Heat

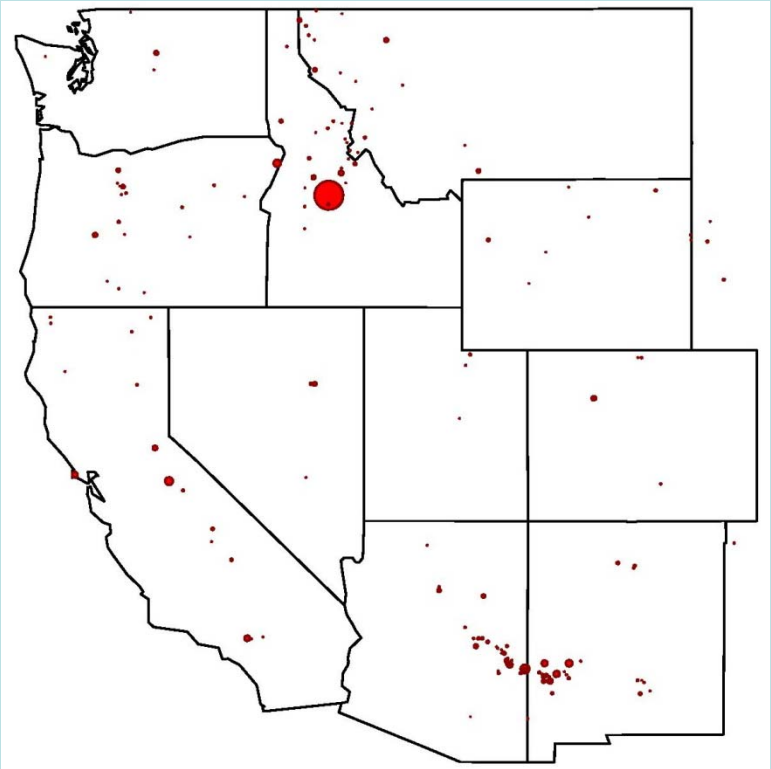
Projected 2050-2100 Return Period (in Years) of Current 100-Year Return Level
3-Day Mean Tmax





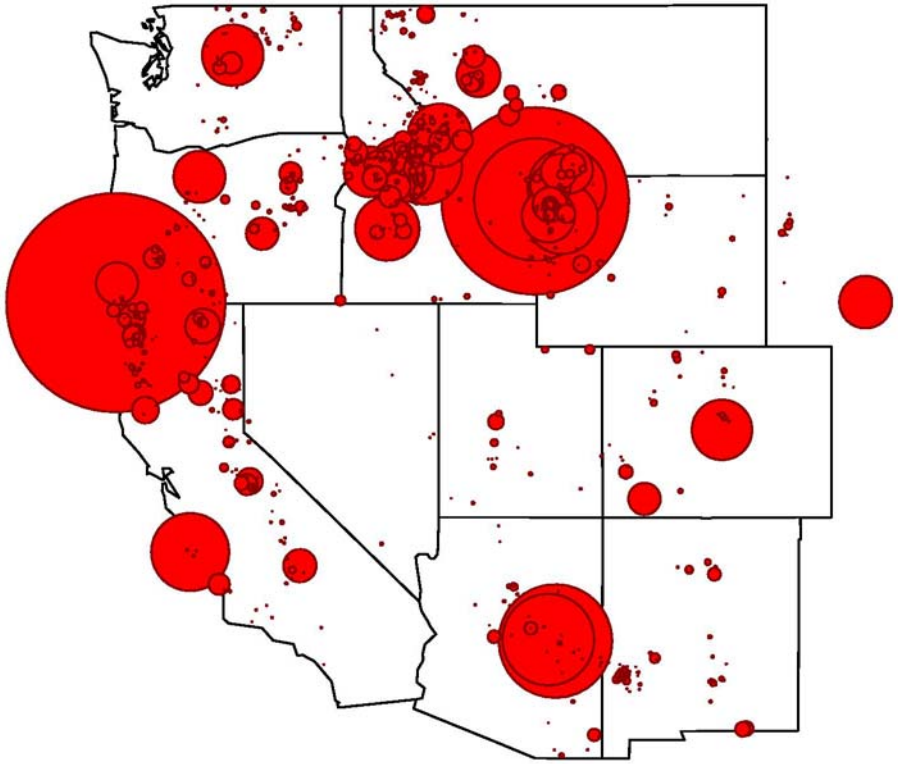
Extreme Events: Wildfires

Fewer, smaller fires



Late Snowmelt Years

More, larger fires

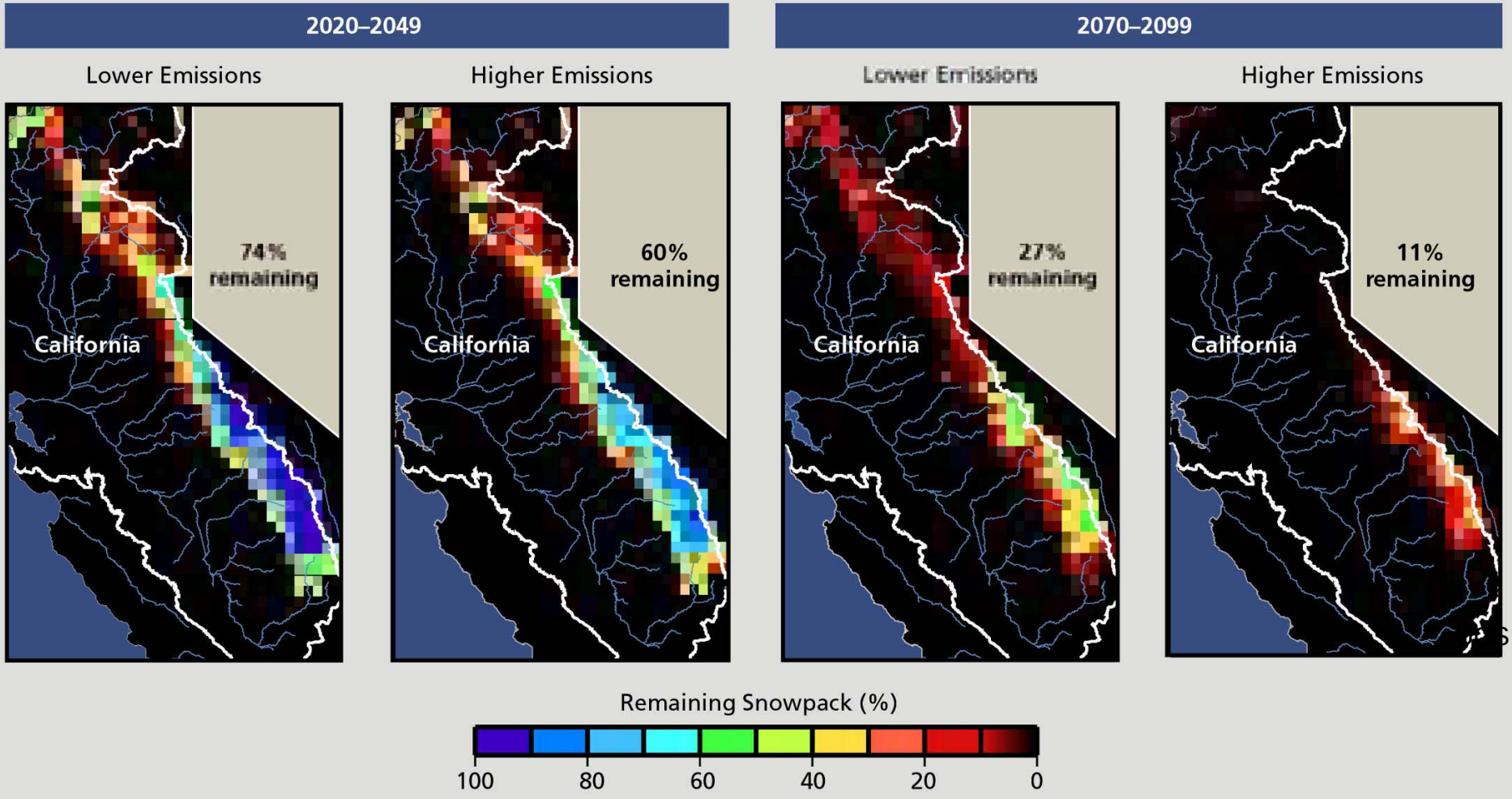


Early Snowmelt Years

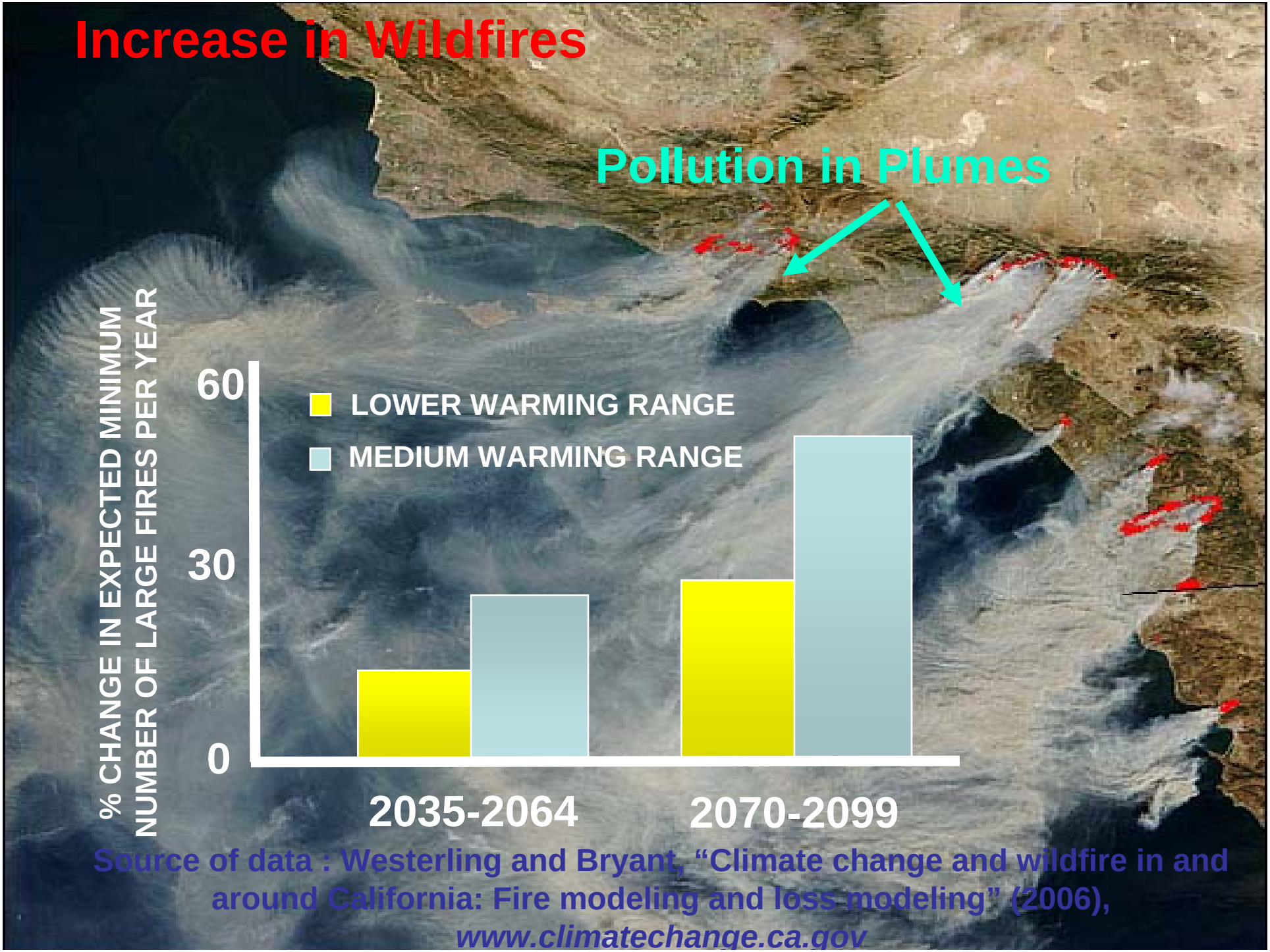
Westerling

Diminishing Sierra Snowpack

Percentage Remaining, Relative to 1961-1990



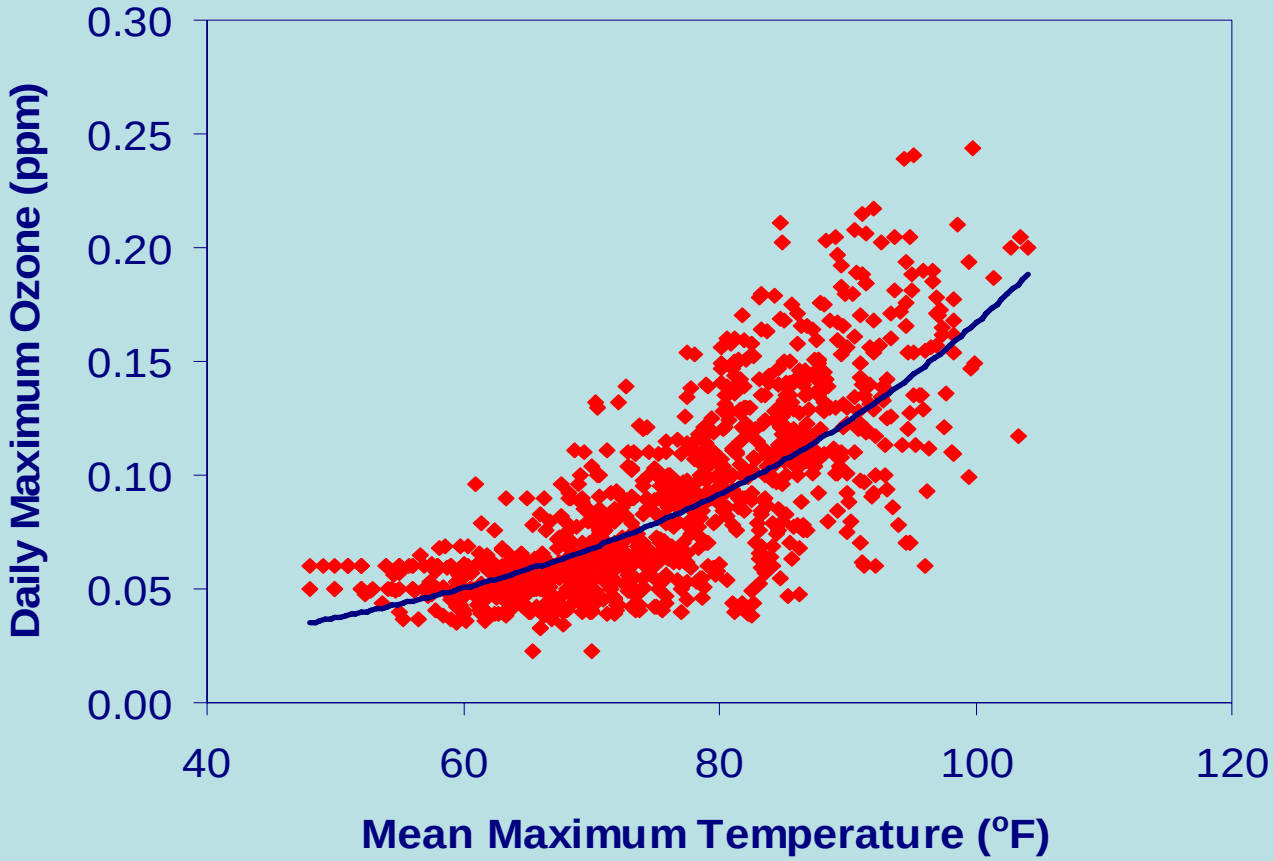
Increase in Wildfires



Source of data : Westerling and Bryant, "Climate change and wildfire in and around California: Fire modeling and loss modeling" (2006), *www.climatechange.ca.gov*

Extreme Events: Air Pollution

Hotter Days Lead to More Smog



South Coast Air Basin

Ozone Levels

(1996-1999)

Our Changing Climate: Assessing the Risks to California (2006), *www.climatechange.ca.gov*. Source: Air Resources Board, 2000

Wine Grape Quality

Temperature Impacts

	1961-1990
	Current Conditions
Wine Country	Optimal (mid)
Cool Coastal	Optimal (low)
Northern Central Valley	Marginal

Wine Country (Sonoma, Napa Counties)
Cool Coastal (Mendocino, Monterey Counties)
Northern Central Valley (San Joaquin, Sacramento Counties)

Decreasing Wine Grape Quality

Temperature Impacts

	1961-1990	2070-2099		
	Current Conditions	Lower Emissions (B1)		
		PCM	HadCM3	
Wine Country	Optimal (mid)	Impaired	Marginal	
Cool Coastal	Optimal (low)	Optimal (mid-high)	Optimal (mid-high)	
Northern Central Valley	Marginal	Impaired	Impaired	

Wine Country (Sonoma, Napa Counties)
Cool Coastal (Mendocino, Monterey Counties)
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Decreasing Wine Grape Quality

Temperature Impacts

	1961-1990	2070-2099			
	Current Conditions	Lower Emissions (B1)		Higher Emissions (A1fi)	
		PCM	HadCM3	PCM	HadCM3
Wine Country	Optimal (mid)	Impaired	Marginal	Impared	Impaired
Cool Coastal	Optimal (low)	Optimal (mid-high)	Optimal (mid-high)	Optimal (high)	Impaired
Northern Central Valley	Marginal	Impaired	Impaired	Impaired	Impaired

Wine Country (Sonoma, Napa Counties)
Cool Coastal (Mendocino, Monterey Counties)
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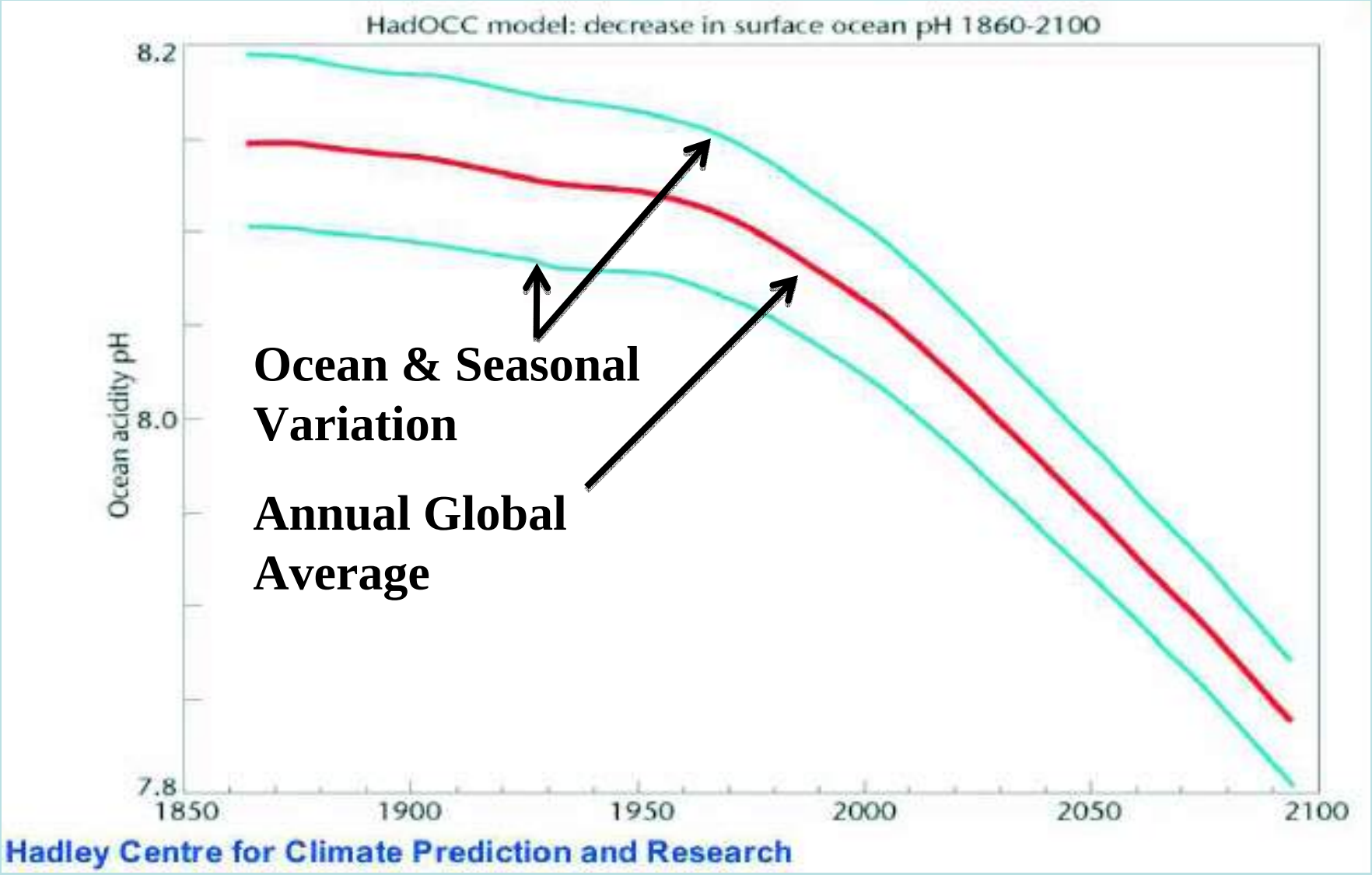
Ocean Acidification



Article 2 of the UN Framework Convention on Climate Change (UNFCCC) states that: "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The Framework Convention on Climate Change further suggests that "Such a level should be achieved within a time frame sufficient

- **to allow ecosystems to adapt naturally to climate change,**
- **to ensure that food production is not threatened and**
- **to enable economic development to proceed in a sustainable manner."**

Vulnerability

Vulnerability (potential for harm)

Function of:

- **Exposure**
- **Sensitivity**
- **Adaptation capacity**

Vulnerability

Vulnerability (potential for harm)

Function of:

- **Exposure (Climate Dynamics)**
- **Sensitivity (Mix, Natural and Social Issues)**
- **Adaptation capacity (Largely Social Issues—Except for Ecosystems)**

IPCC Approved Outline: Key Vulnerabilities Chapter

Preventing DAI: Dangerous Anthropogenic Interference

Key Impacts &Vulnerabilities

Mitigation & Adaptation Strategies

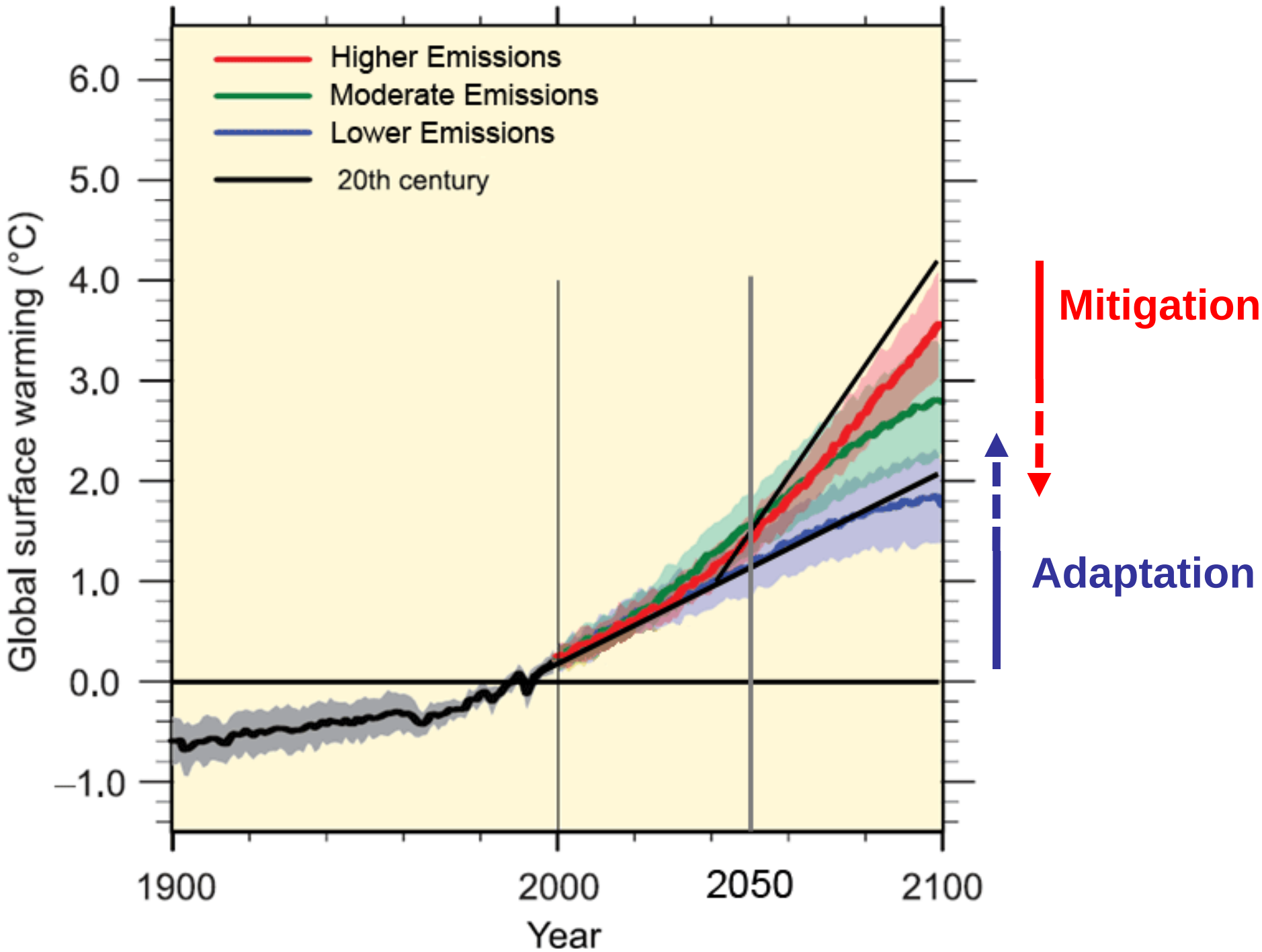
Avoiding Irreversibilities

Priorities for Research

Key Vulnerabilities (Criteria)

- Magnitude
- Timing
- Irreversibility
- Adaptation potential
- Distribution
- Likelihood
- “Importance”

No single metric can adequately capture the diversity of key vulnerabilities, nor determine their ranking.


Higher Emissions
Moderate Emissions
Lower Emissions
20th century
Global surface warming (°C)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
–1.0
1900
2000
2050
2100
Year
Mitigation
Adaptation

Adaptation and Mitigation are Complements, not Trade-offs!

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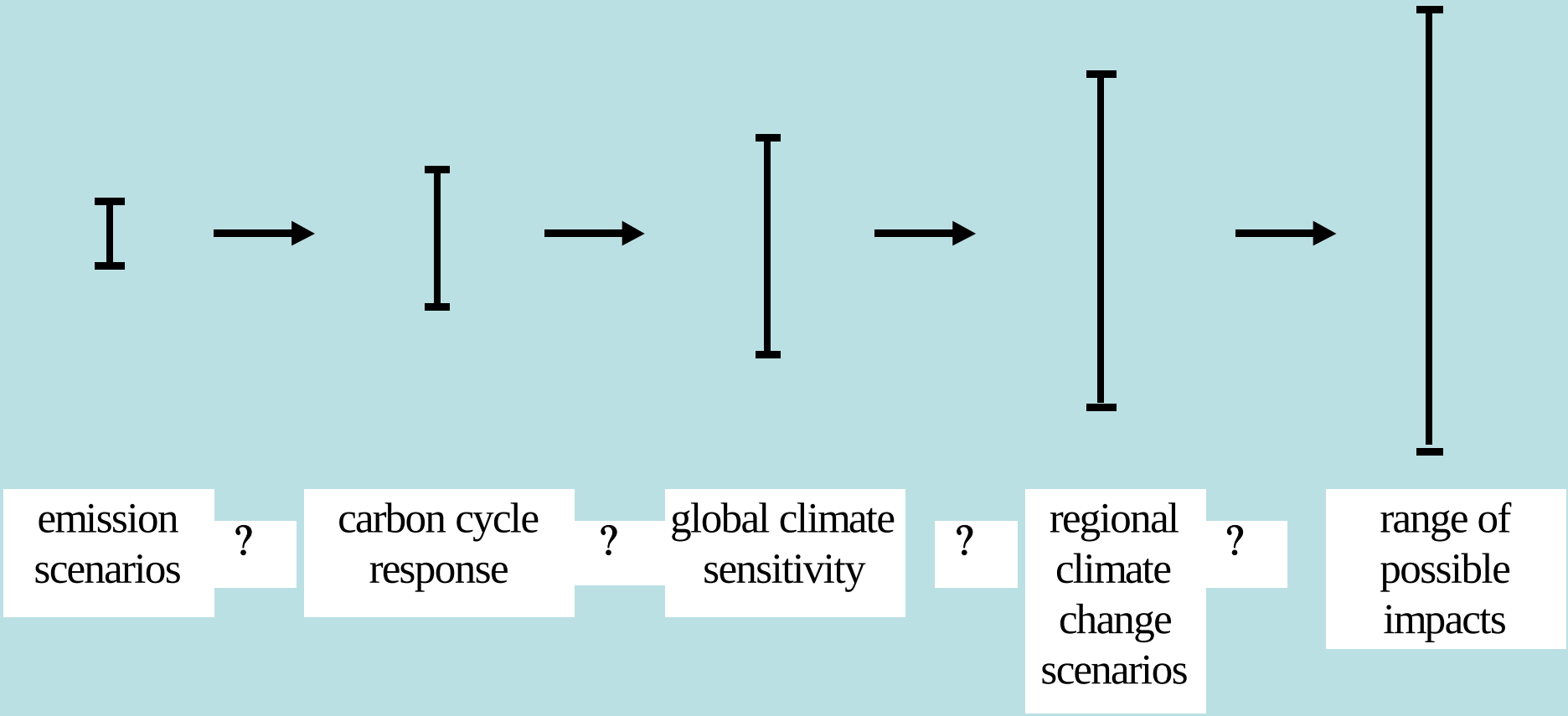
-**Adaptation to unavoidable climate changes**

Adaptation and Mitigation are Complements, not Trade-offs!

-**Adaptation to unavoidable climate changes**

-**Mitigation of changes that are too difficult to adapt to**

Top ➔ Down ➔



Cascade of Uncertainties

NEED NEW PARADIGM:

Not just top down—linear cascade

NEED NEW PARADIGM:

Not just top down—linear cascade

but bottom up: regional, sectoral and groups' vulnerability analysis mapped to top down analyses

Characterization of Climate Problem:

*Potential For Significant Risks

*Deep Uncertainties

*Normative Judgments

*”Optimal” Solutions Tenuous

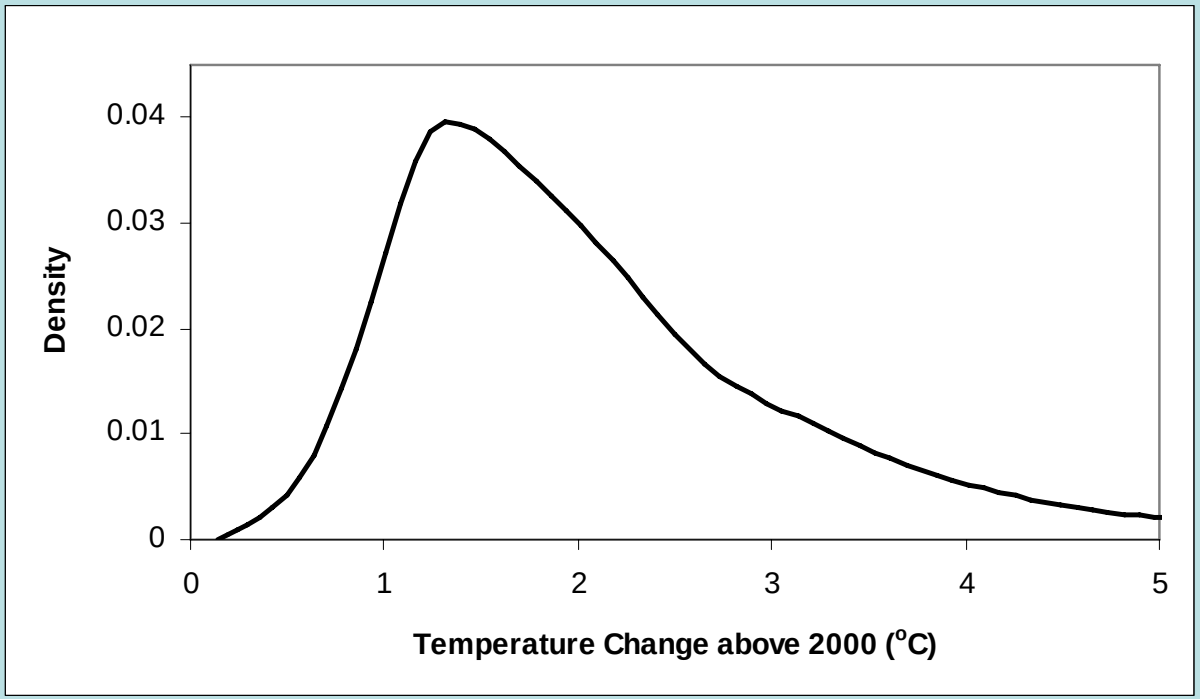
****

➔”Risk/Management Framework

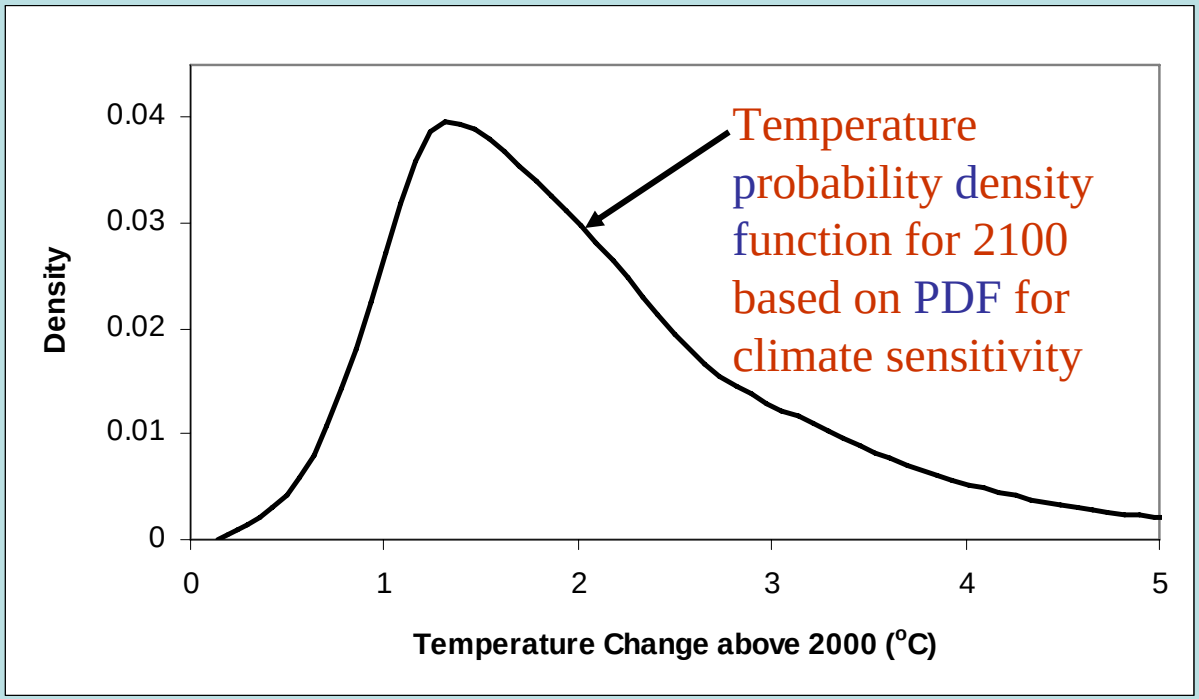
Risk Management Requires PDFs

Climate Uncertainty

Climate Uncertainty

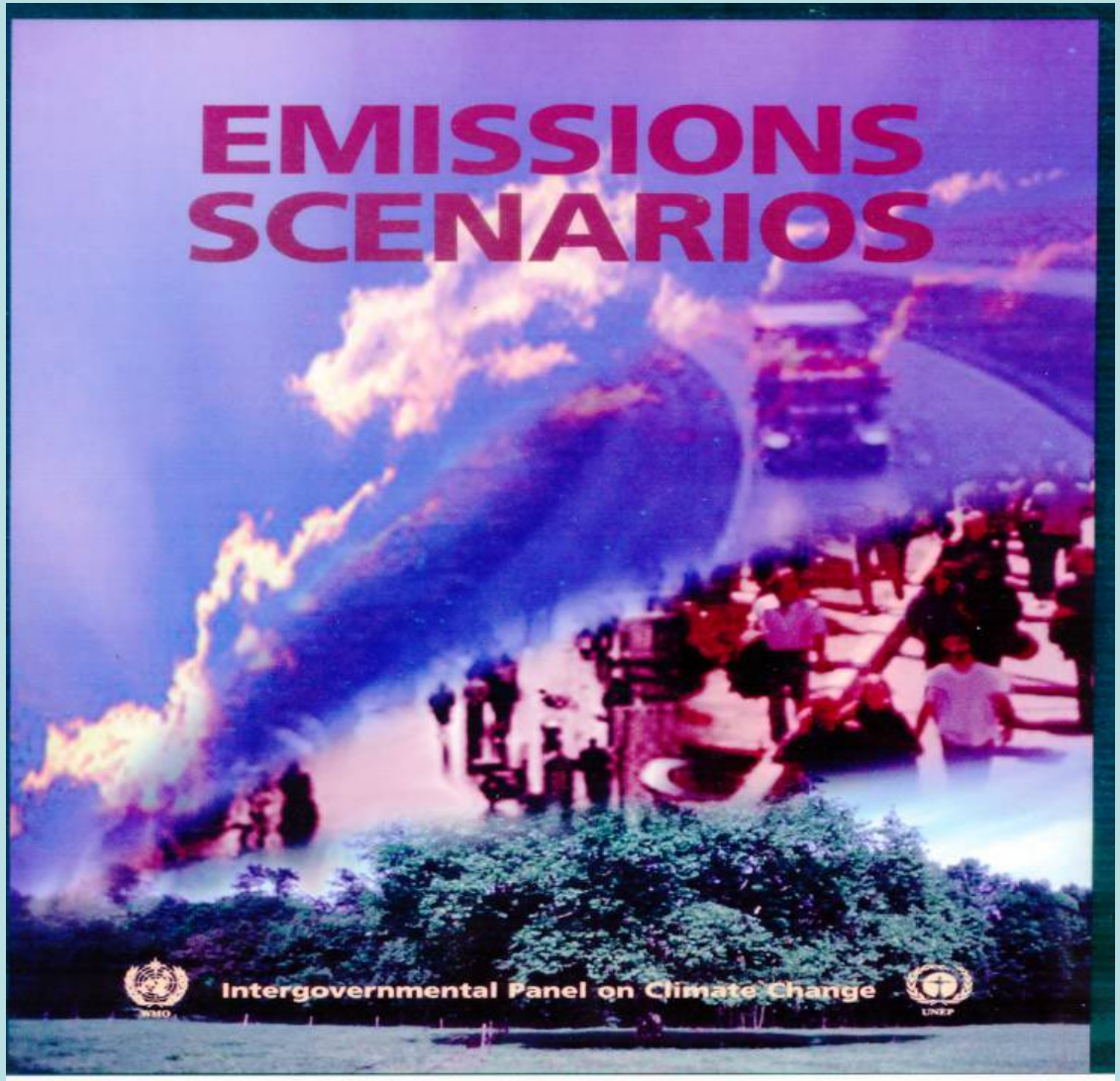


Climate Uncertainty



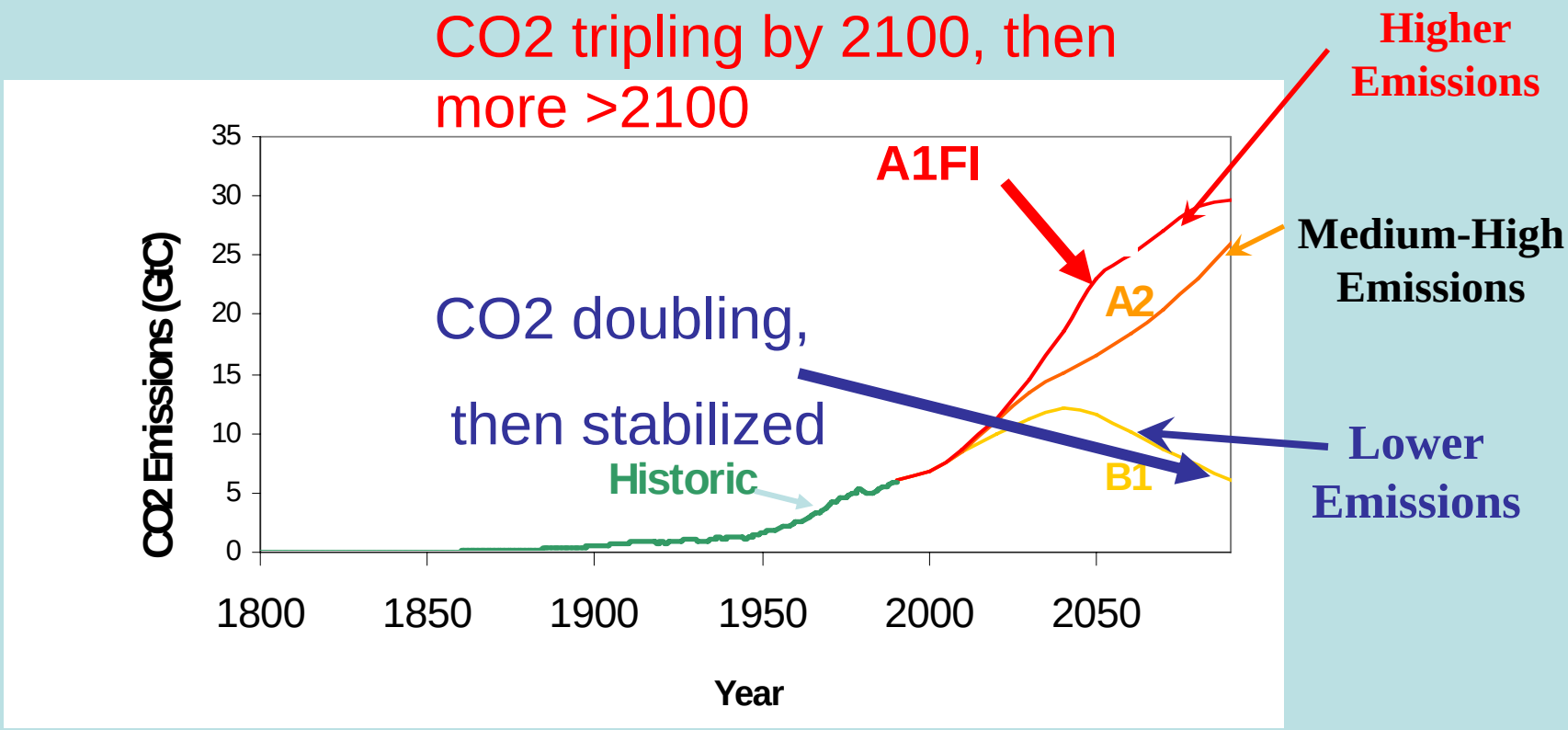
Most sensible decision paradigm?: Risk-management.

The role of the scientific community
#1: Provide climate change scenarios



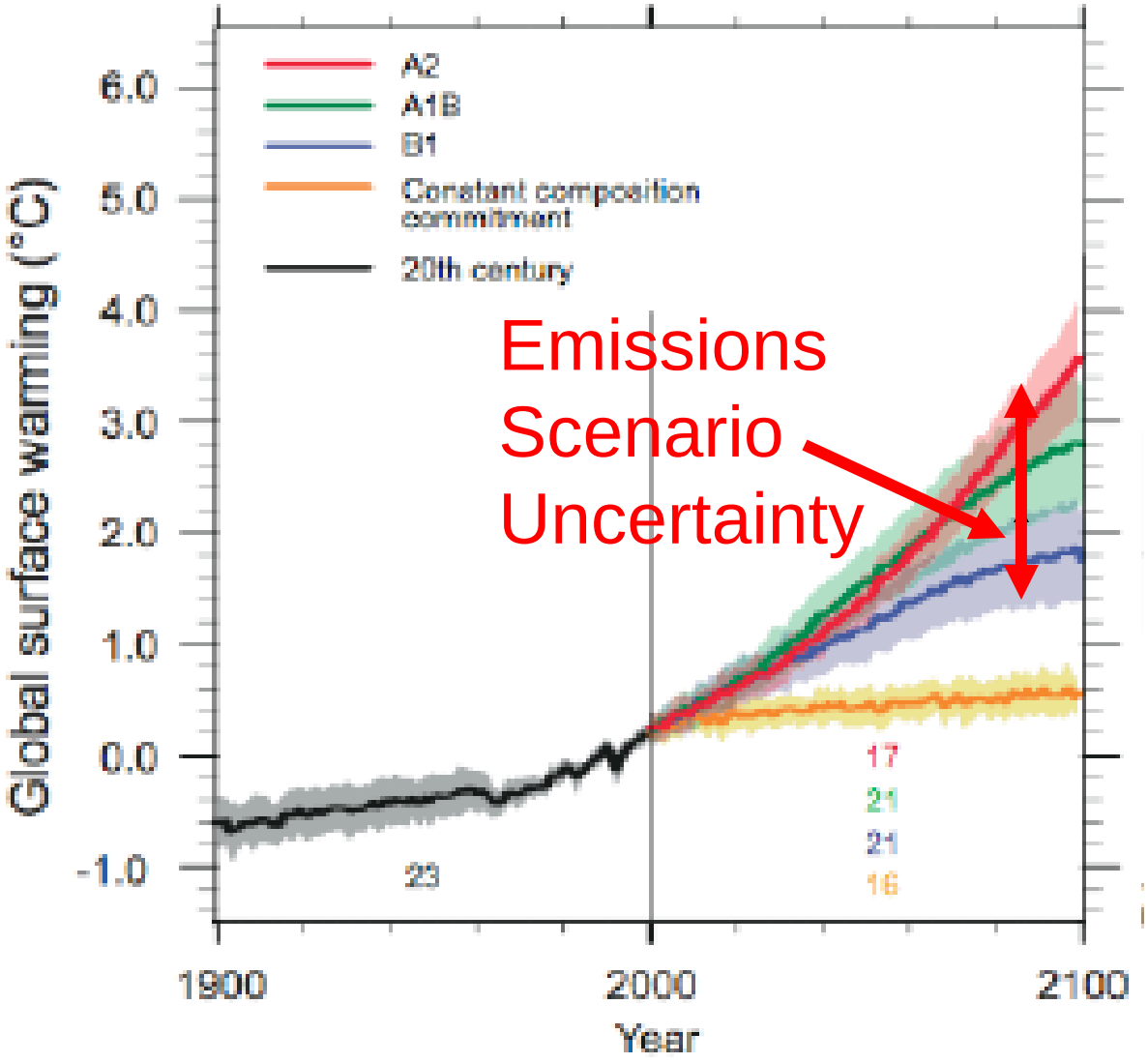
The IPCC's Special Report on Emissions Scenarios (SRES) - 2000

We can Choose our Emissions Future (Intergovernmental Panel on Climate Change Emission Scenarios)



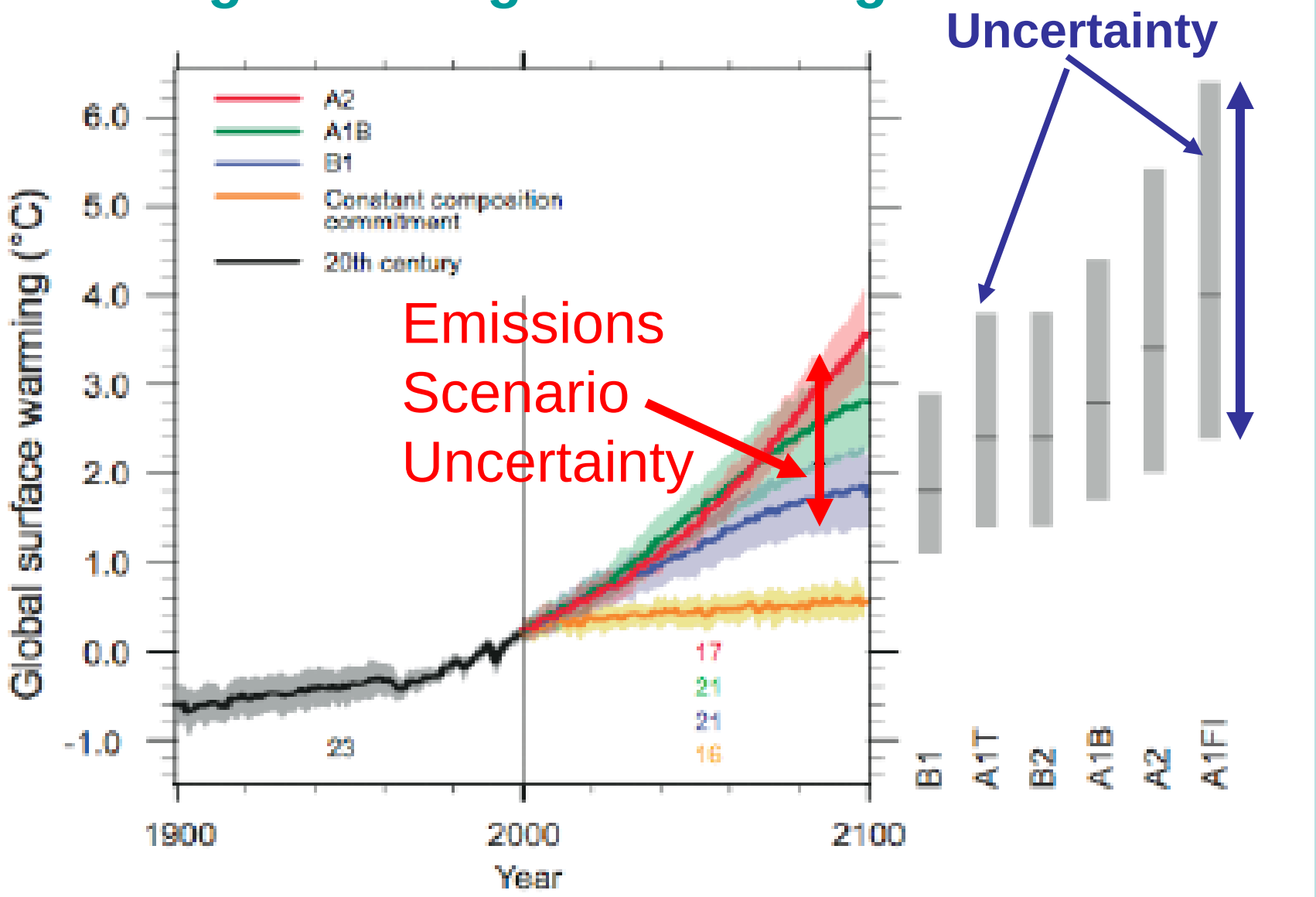
Just fossil fuel emissions shown in graphic.

Calculating The Range of Warming

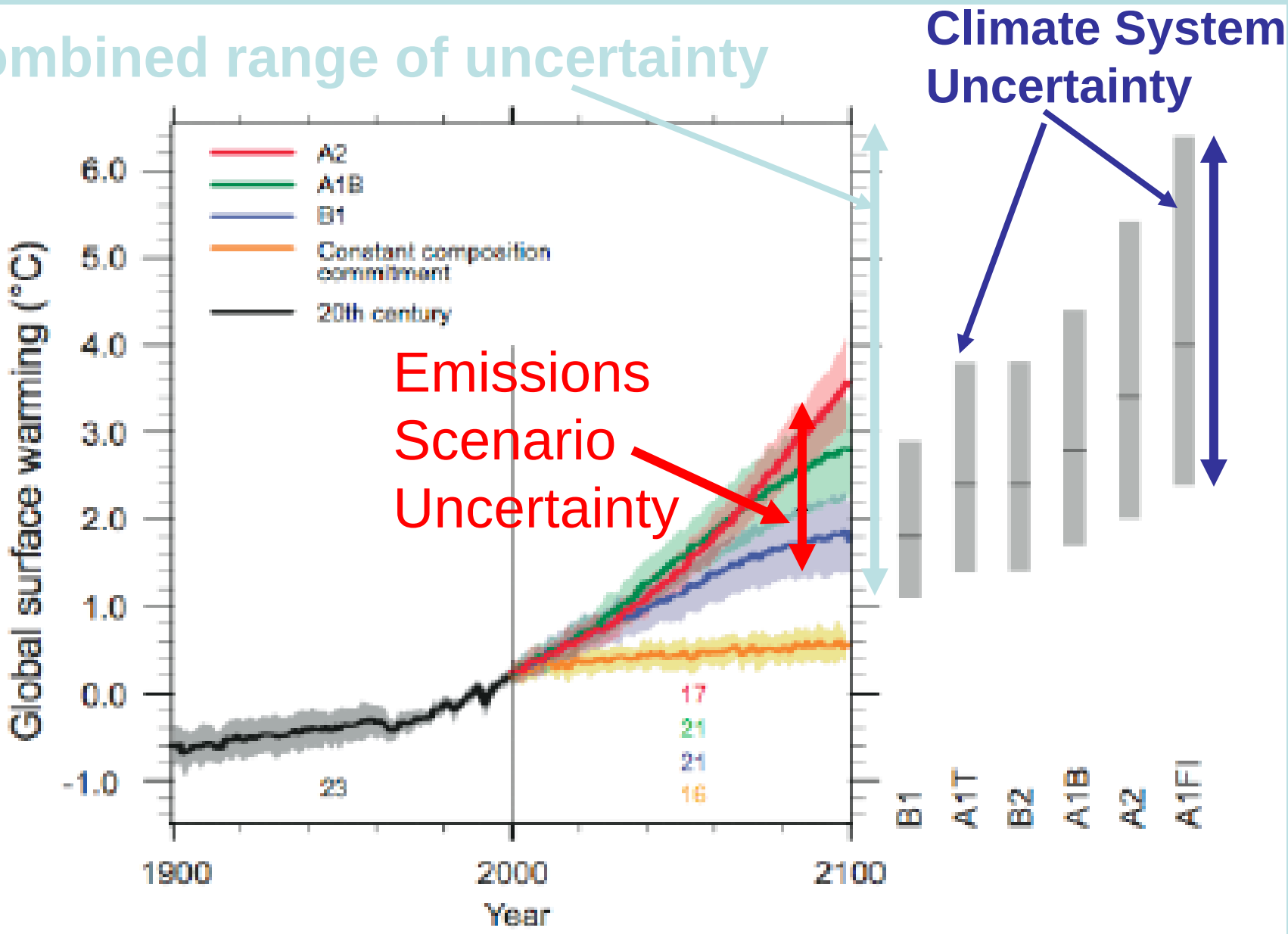


Source: IPCC, WG 1, AR4, 2007

Calculating The Range of Warming



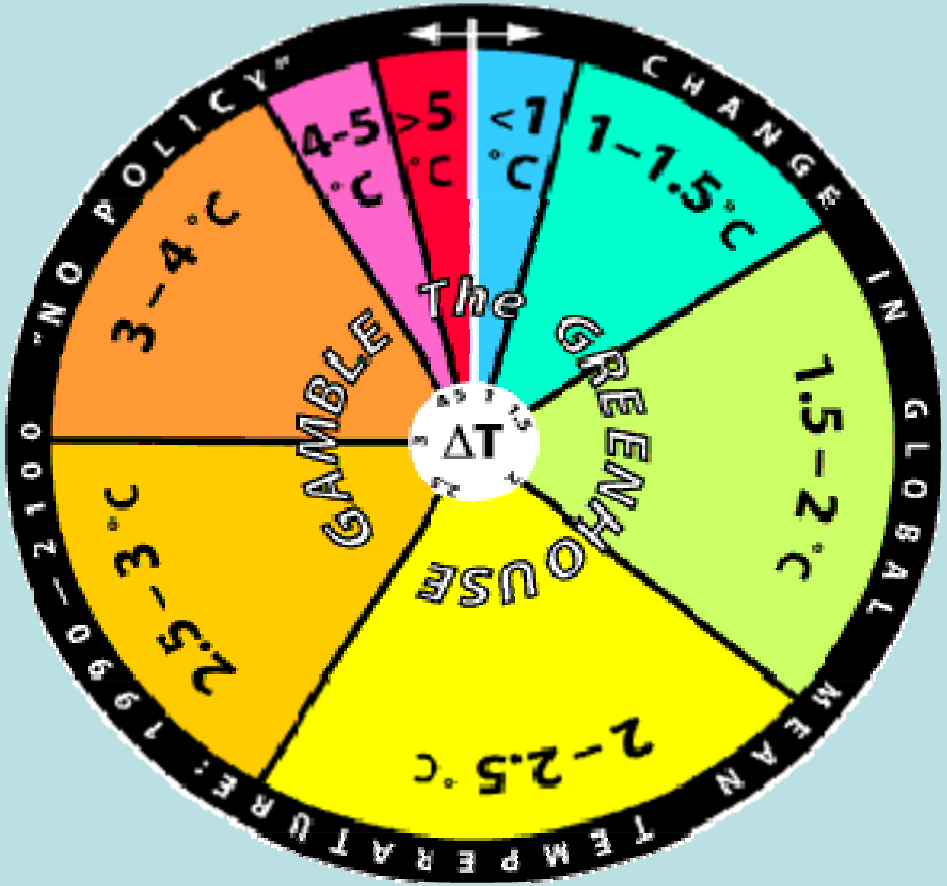
Source: IPCC, WG 1, AR4, 2007



Source: IPCC, WG 1, AR4, 2007

The great “greenhouse gamble”…

<1°C	(4.1%; 1 in 24 odds)
1 to 1.5°C	(11.4%; 1 in 9 odds)
1.5 to 2°C	(20.6%; 1 in 5 odds)
2 to 2.5°C	(22.5%; 1 in 4 odds)
2.5 to 3°C	(16.8%; 1 in 6 odds)
3 to 4°C	(16.2%; 1 in 6 odds)
4 to 5°C	(4.6%; 1 in 22 odds)
>5°C	(3.8%; 1 in 26 odds)



Source: MIT Joint Program on the Science and Policy of Climate Change

Little adaptive capacity

<1°C	(4.1%; 1 in 24 odds)
1 to 1.5°C	(11.4%; 1 in 9 odds)
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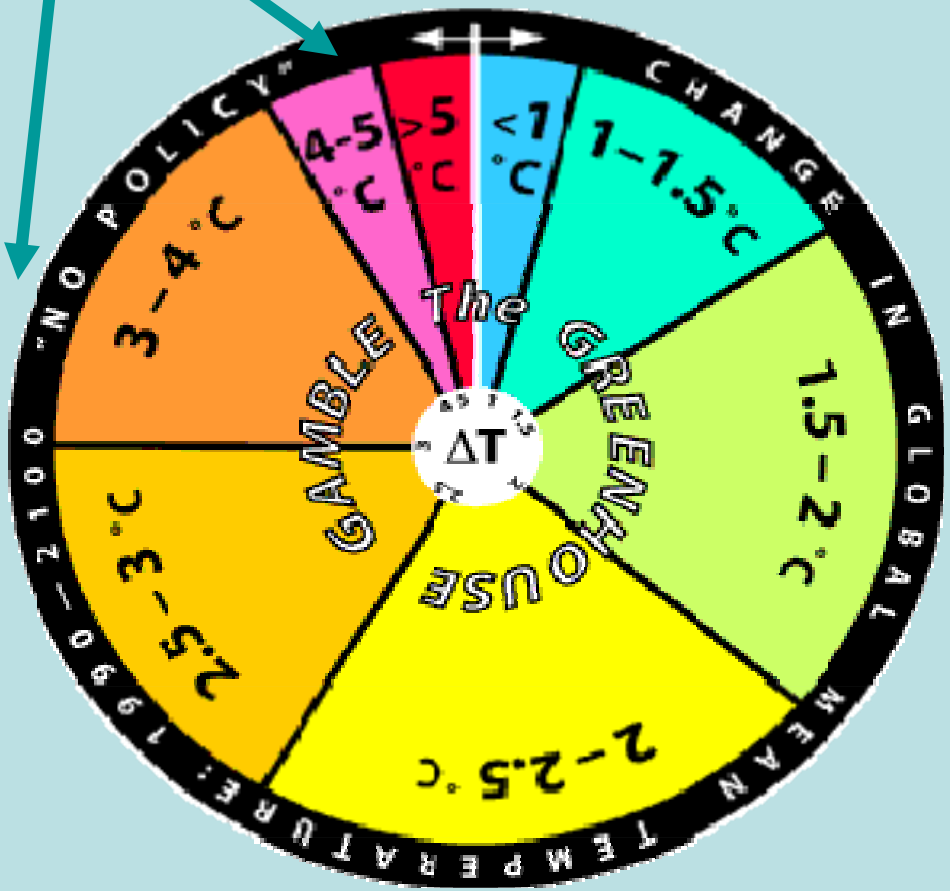

Source: MIT Joint Program on the Science and Policy of Climate Change

Little adaptive capacity

Some adaptive capacity

<1°C	(4.1%; 1 in 24 odds)
1 to 1.5°C	(11.4%; 1 in 9 odds)
1.5 to 2°C	(20.6%; 1 in 5 odds)
2 to 2.5°C	(22.5%; 1 in 4 odds)
2.5 to 3°C	(16.8%; 1 in 6 odds)
3 to 4°C	(16.2%; 1 in 6 odds)
4 to 5°C	(4.6%; 1 in 22 odds)
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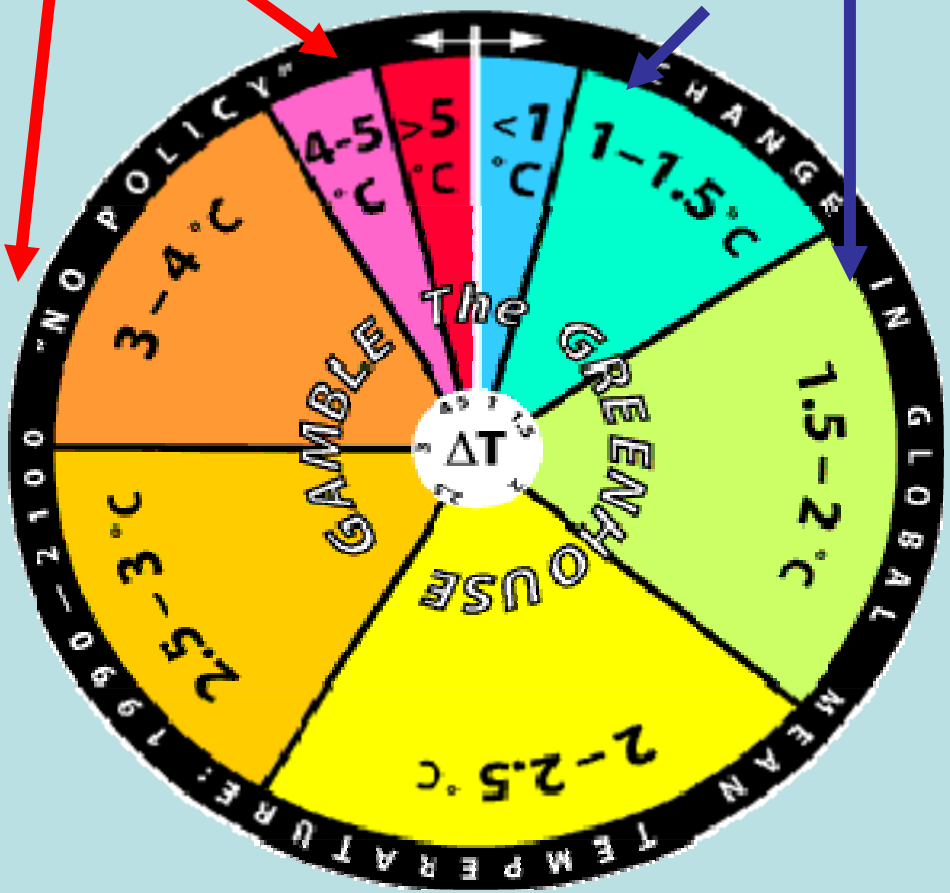

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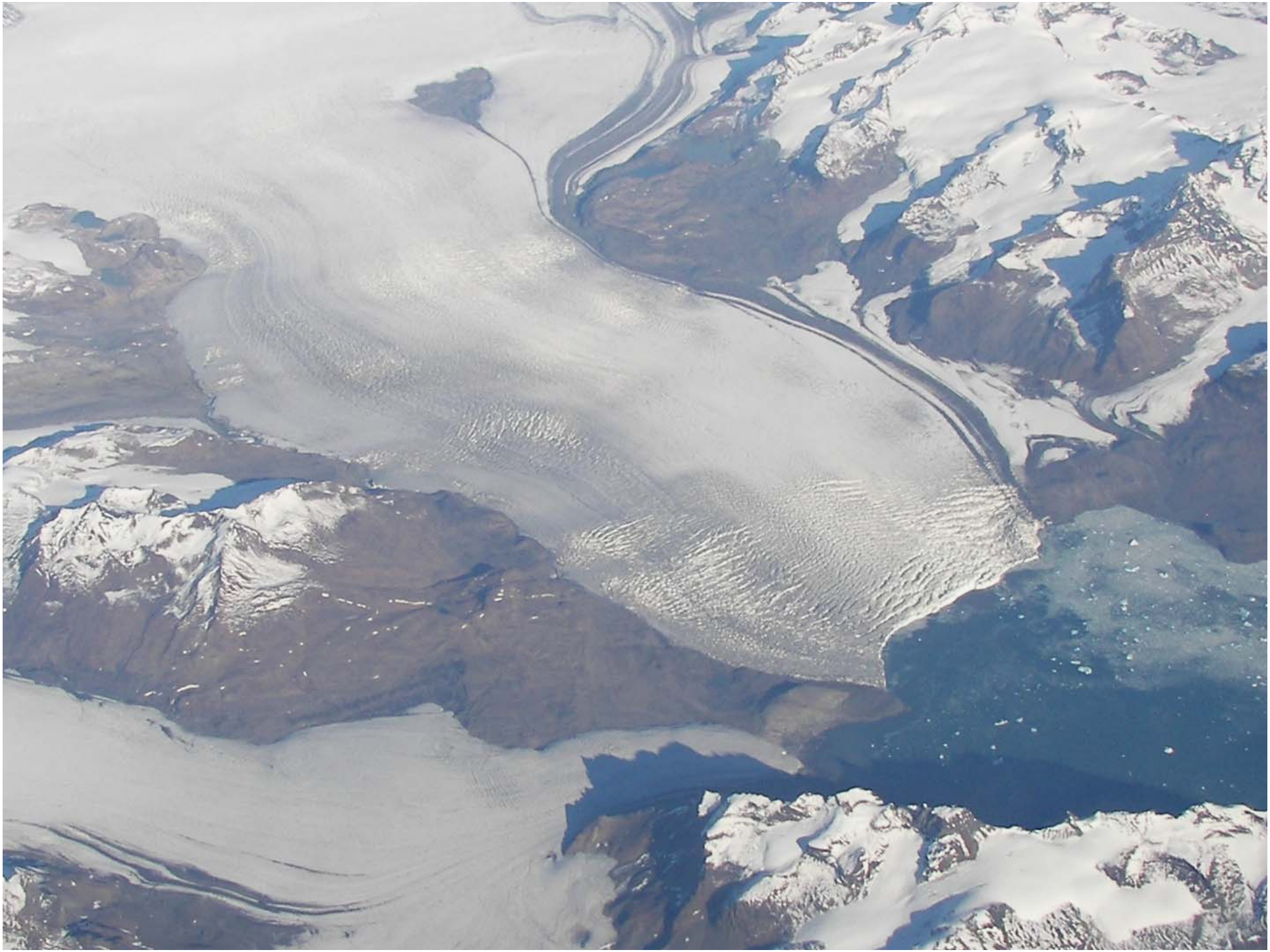
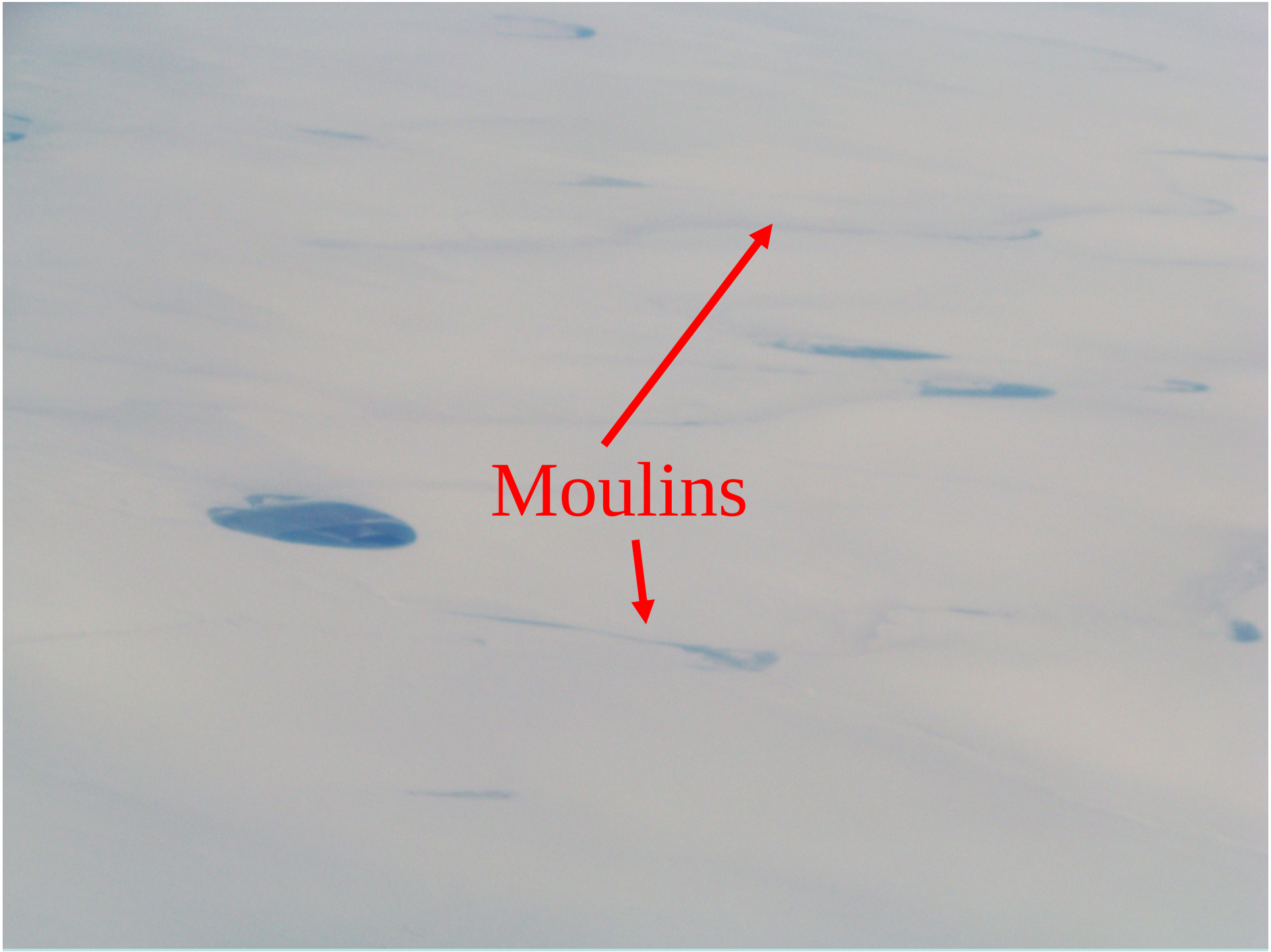


GREENLAND
ATLANTIC

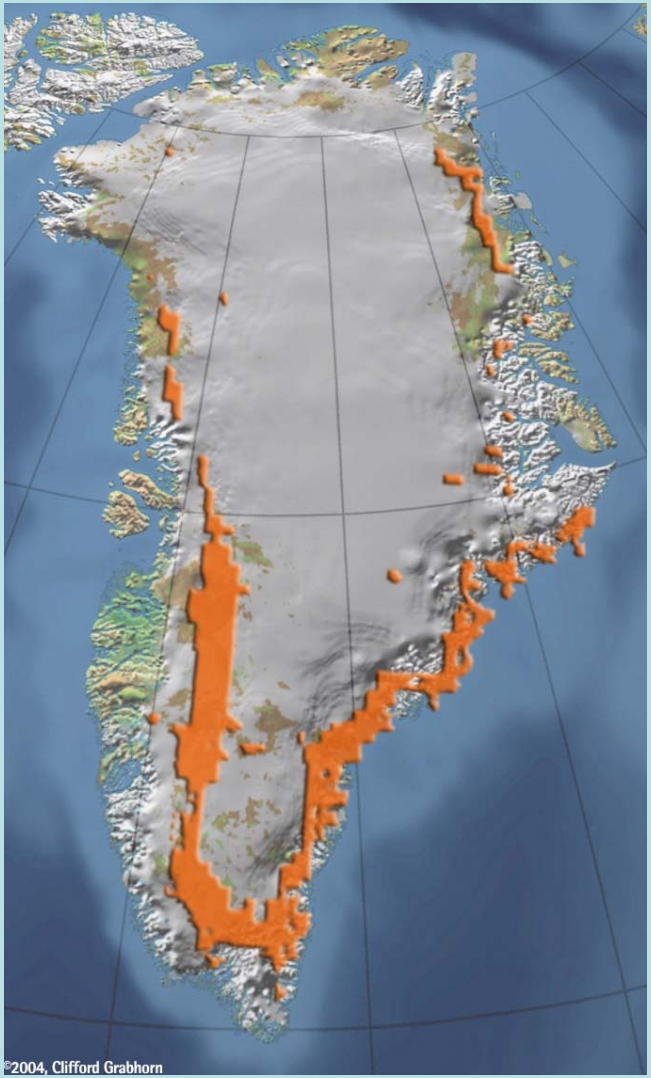
TUNUMILU NUNA
ALLANNGUTSAALIUGAQ
Nationalparken i
Nord- og Østgrønland
KITAA
VESTGRØNLAND
ØSTGRØNLAND
KONG CHRISTIAN IX LAND
KONG FREDERIK IX LAND
DRONNING INGRID LAND
KONG FREDERIK VI KYST
Qaasuitsup Killeqarfia Avannarleq
Nordlige Polarkreds
66° 33' 00" N
Nuugaatsiaq
Illorsuit
Niaqornat
Maarmorilik
Ukkusissat
Saattut
UUMMANNAQ
Ikerasak
Qaarsut
Qeqertarsuatsiaq
Hareøen
Nuussuaq
Qullissat
QEQERTARSUAQ DISKO
Saqqaq
Qeqertaq
Kangerluk
Diskofjord
Arktisk Station
QEQERTARSUAQ GODHAVN
Oqaatsut
Rodebay
Ilimanaq
Claushavn
ILULISSAT JAKOBSHAVN
Kitsissuarsuit
Hunde Ejlande
AASIAAT EGEDESMINDE
Akunnaaq
QASIGIANNGUIT CHRISTIANSHÅB
Ikamiut
KANGAATSIAQ
Ikerasaarsuk
Niaqornaarsuk
Iginniarfik
Attu
SISIMIUT OLSTEINSBORG
Sarfannguit
Kangerlussuaq
Søndre Strømfjord - BW 8
Itilleq
Sarfartooq/Paradisdalen
Kangaamiut
MANIITSOQ SUKKERTOPPEN
Apussuit
Napasoq
Atammik
Toqqusaq Banke
Ivisaartoq
NUUK GODTHÅB
Kapisillit
Fyllas Banke
Utoqqarmiut Kangerluarsunnguat
Kangerluarsoruseq
Qeqertarsuatsiaat
Danas Banke
J.A.D. Jensen Nunatakker
PAAMIUT FREDERIKSHÅB
Narsalik
Arsuk
IVITTUUT
NARSAQ
Qassimiut
QAQORTOQ JULIANEHÅB
Alluitsup Paa
NANORTALIK
Narsaq Kujalleq
Narsarmijit
Narsarsuaq - BW 1
Kangeq
Qulleq
Avaqqat
Kap Cort Adelaer
Tordenskjold Banke
Kap Møsting
Kap Molkte
Imaarsivik
Saqqisikuik
Skjoldungen
Timmiarmiut
Ikermiit
Umiiviip Kimmut Kangera
Kap Poul Løvenøm
Umiivik
Kap Møsting
Dannebrog Ø
Pikiullit
Tiniteqilaaq
Ikkatteq
Isortoq
TASIILAQ AMMASSALIK
Kulusuk
Kuummiit
Sermiligaaq
Leif Ø
Mont Forel
Kronprins Frederik Bjerge
IRMINGER HAVET

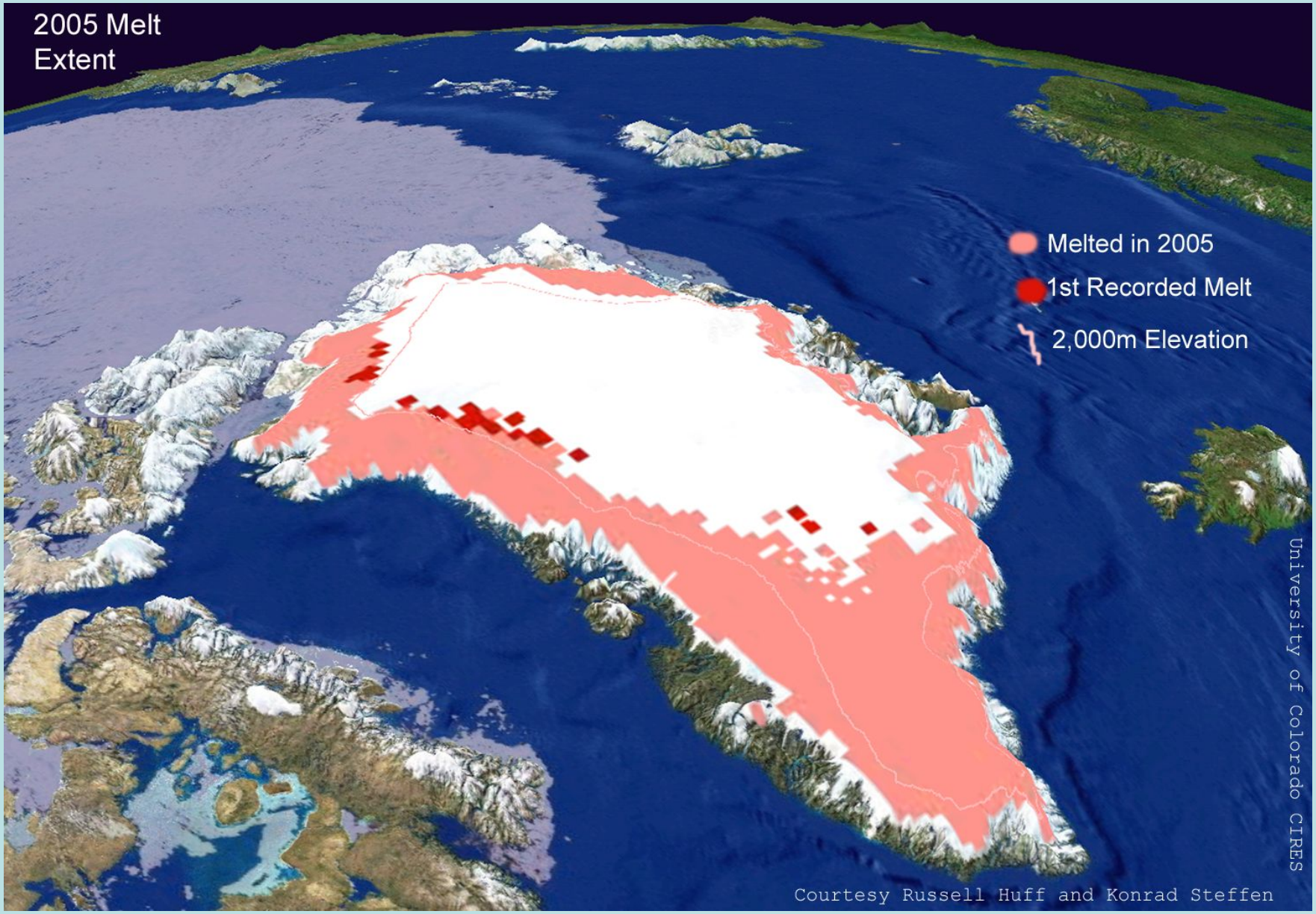

Moulins

Source: Roger Braithwaite, University of Manchester (UK)

A.BEHAR/NASA

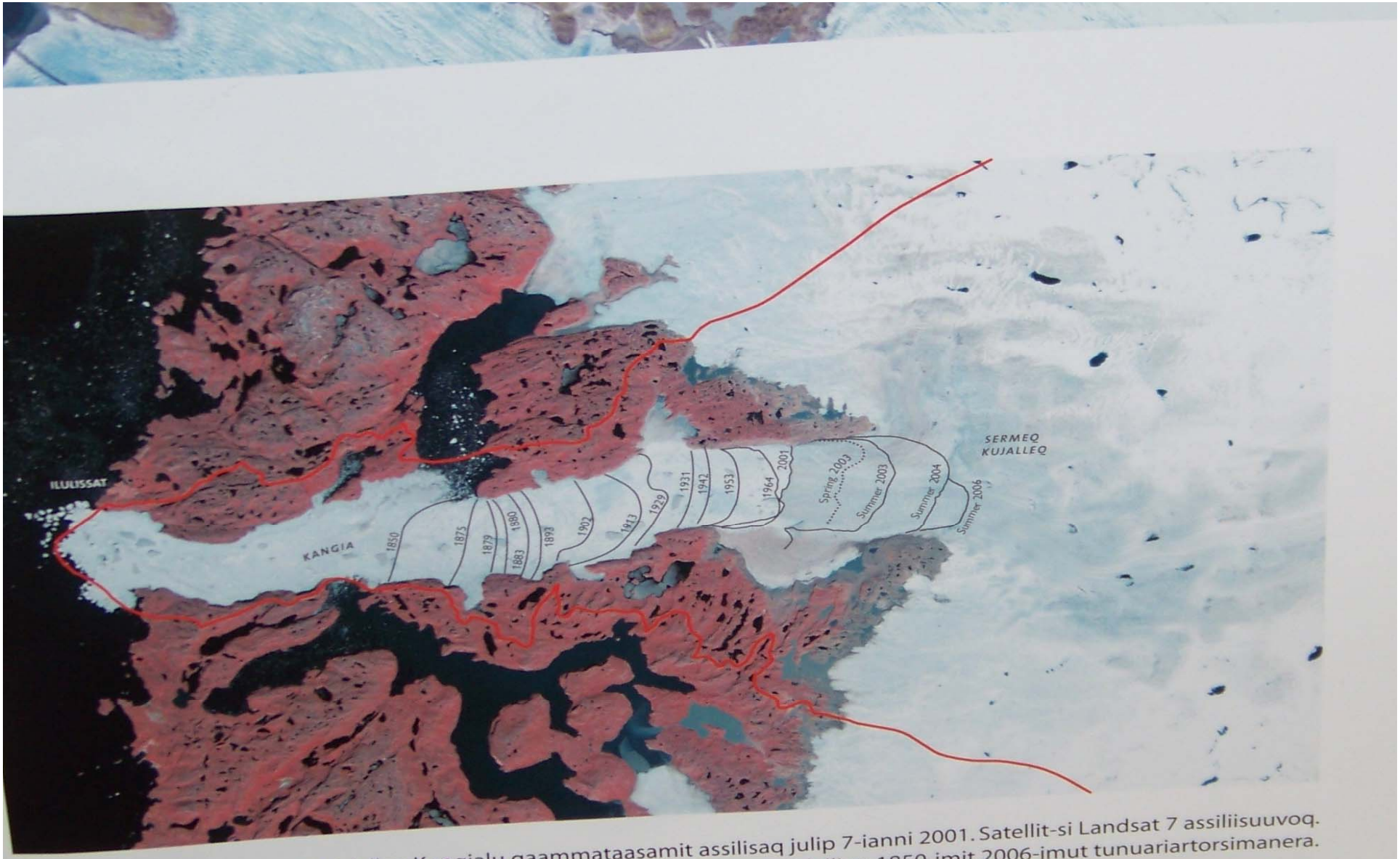
Greenland Ice Melt, 1992 vs. 2002




2005 Melt
Extent
Melted in 2005
1st Recorded Melt
2,000m Elevation
University of Colorado CIRES
Courtesy Russell Huff and Konrad Steffen

TUNUMILU NUNA
ALLANNGUTSAALIUGAQ
Nationalparken i
Nord- og Østgrønland
KITAA
VESTGRØNLAND
ØSTGRØNLAND
QEQERTARSUAQ
DISKO
QEQERTARSUAQ
GODHAVN
ILULISSAT
JAKOBSHAVN
AASIAAT
EGEDESMINDE
KANGAATSIAQ
KONG FREDERIK IX
LAND
SISIMIUT
OLSTEINSBORG
DRONNING
INGRID
LAND
Qaasuitsup Killeqarfia Avannarleq
Nordlige Polarkreds
66° 33' 00" N
KONG CHRISTIAN IX LAND
KONG FREDERIK VI KYST
NUUK
GODTHÅB
PAAMIUT
FREDERIKSHÅB
NARSAQ
QAQORTOQ
JULIANEHÅB
NANORTALIK
IRMINGER
HAVET

In Illulissat, Greenland, 2008



Sermeq Kujalleq Kangialu qaammataasamit assilisaq julip 7-ianni 2001. Satellit-si Landsat 7 assiliisuuvoq.
Sermeq Kujalliup 1850-imit 2006-imut tunuariartorsimanera.

Satellitbillede af Sermeq Kujalleq og Kangia fra 7. juli 2001. Data er fra Landsat 7 satelliten.
Udviklingen i fronten af Sermeq Kujalleq fra 1850 til 2006.

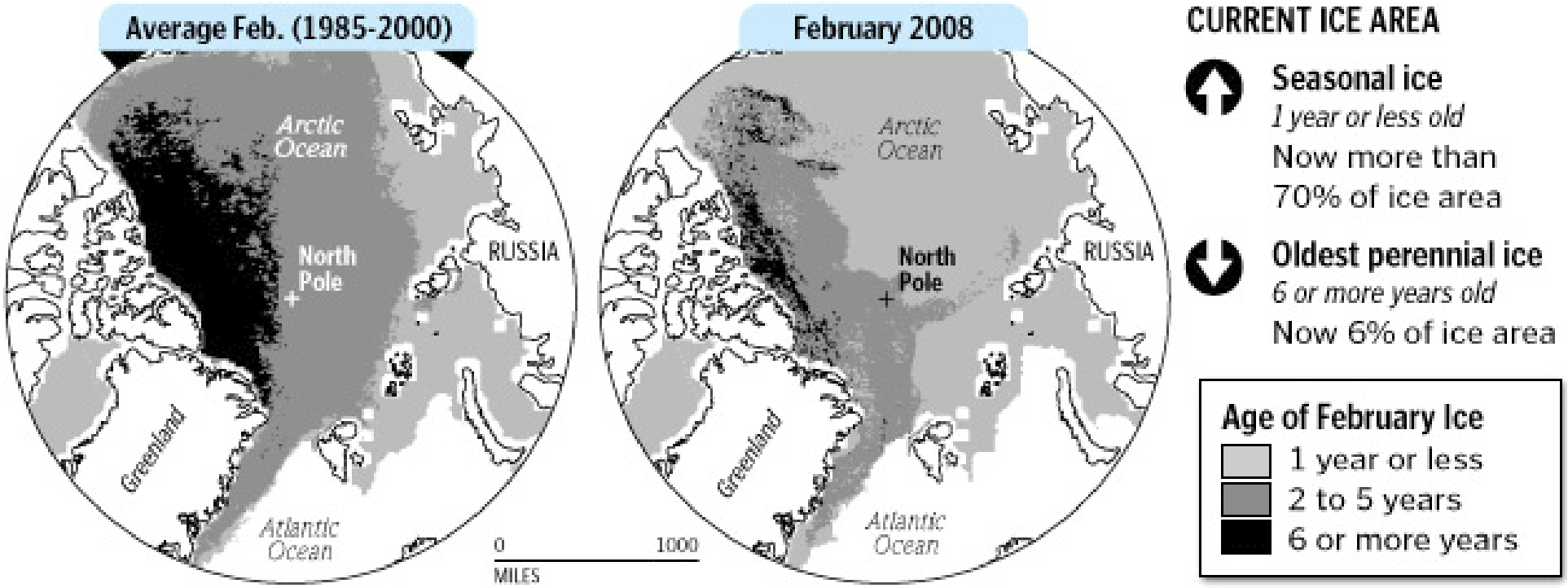
Satellite image of Sermeq Kujalleq and Kangia from July 7, 2001. Data from Landsat 7 satellite.
The development of the front of Sermeq Kujalleq between 1850 and 2006.

Graphic:

http://www.washingtonpost.com/wp-dyn/content/article/2008/03/18/AR2008031802903.html

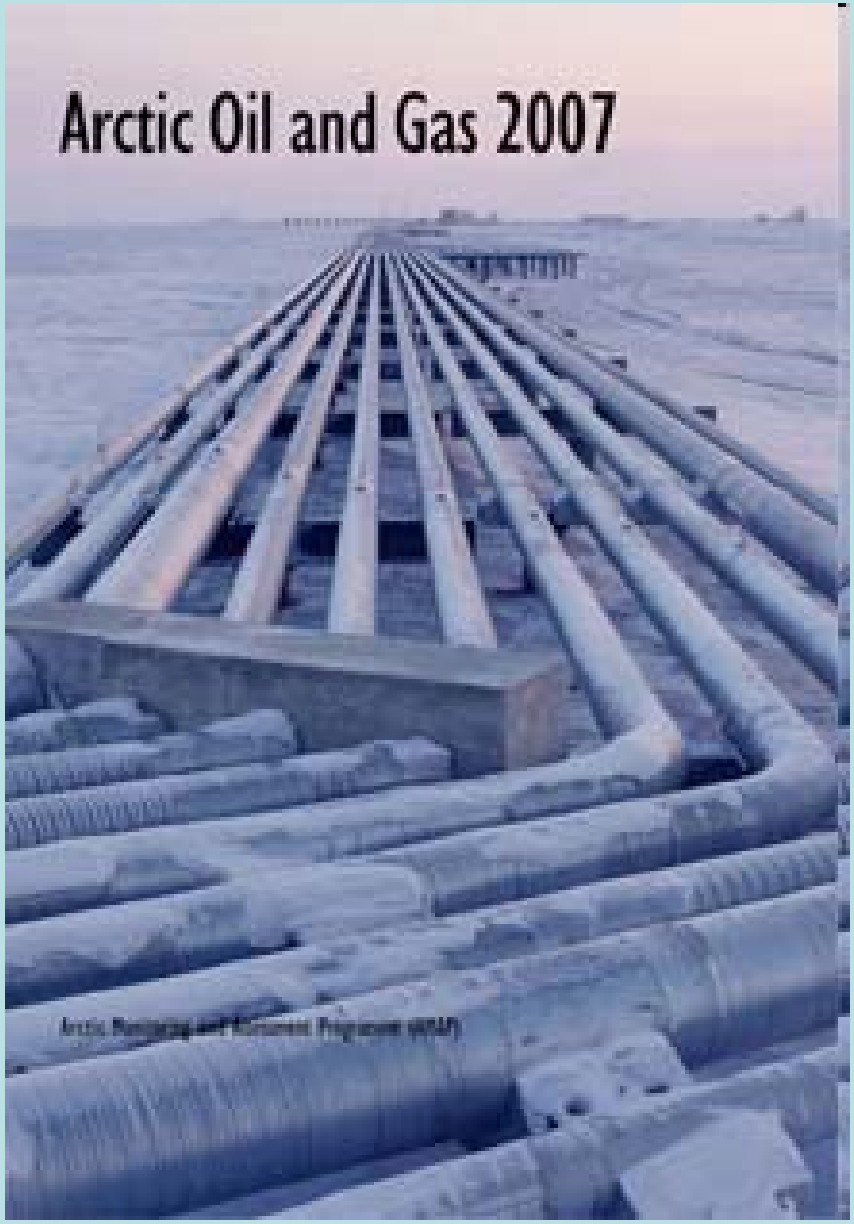
Thinner and Newer

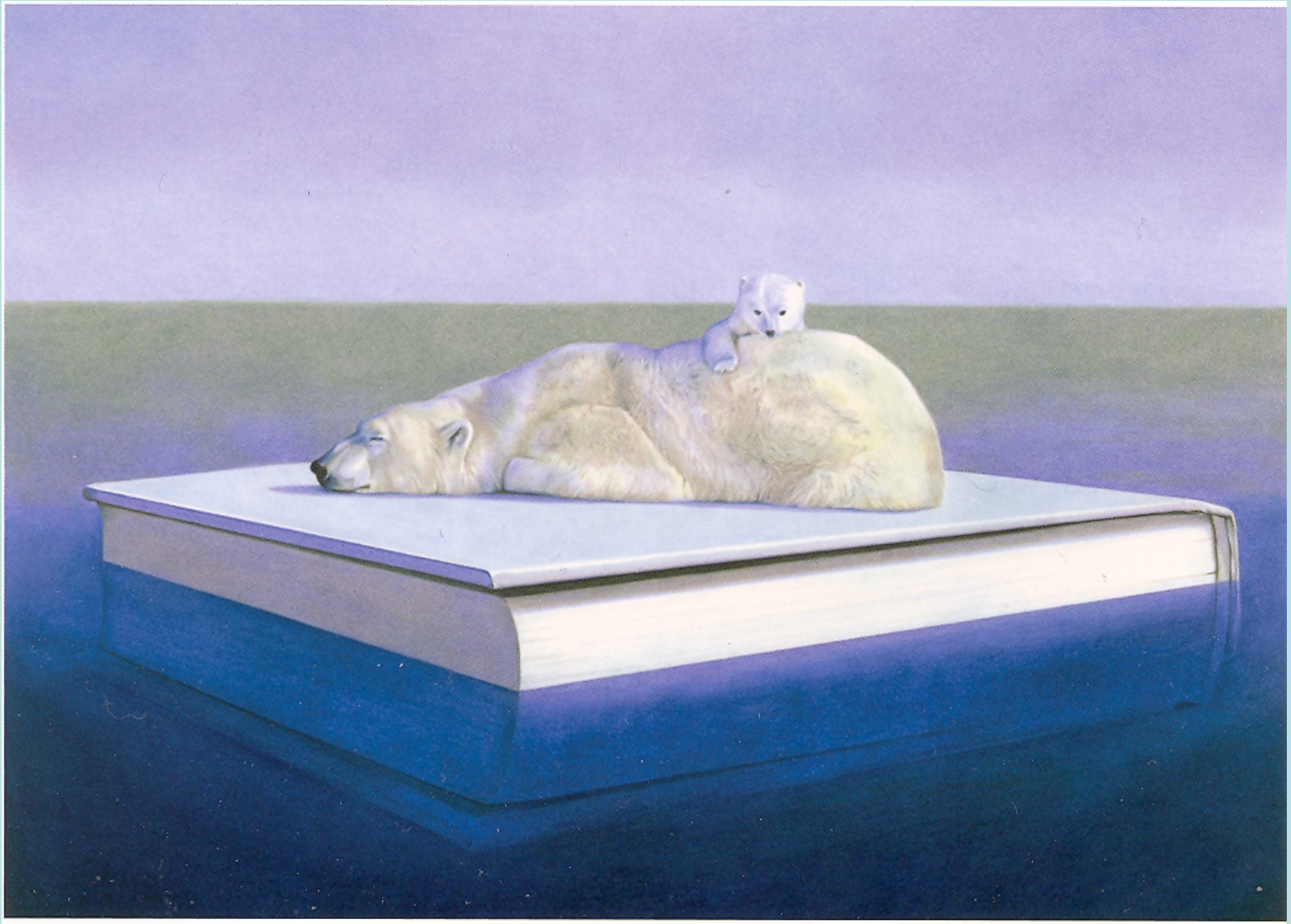
A cool Arctic winter has brought sea ice back to broad expanses that melted clear during last summer's unusual warmth. However, the amount of thick "perennial ice" has declined sharply across the Arctic, and climate experts say that global warming is the cause.



Indigenous Leaders deliver strong messages to the Arctic Council:

"The politics of the Arctic are no longer the politics of the people, but they are the politics of oil."





"PASSAGE 2" DON SIMON 2006

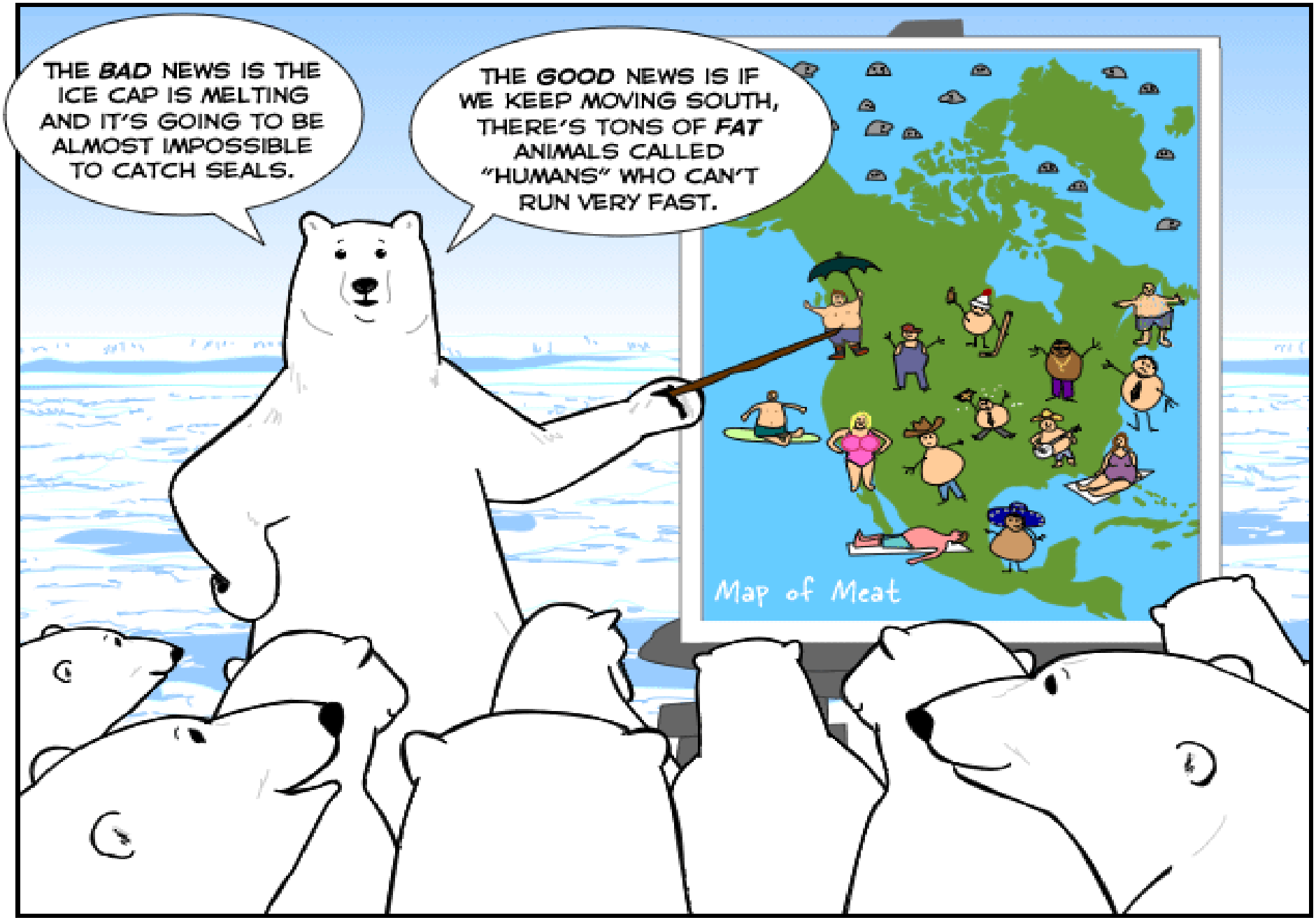
The “Real” Cause of Global Warming

CAUTION

The “Real” Cause of Global Warming

Victims As Villains

by Nitrozac & Snaggy



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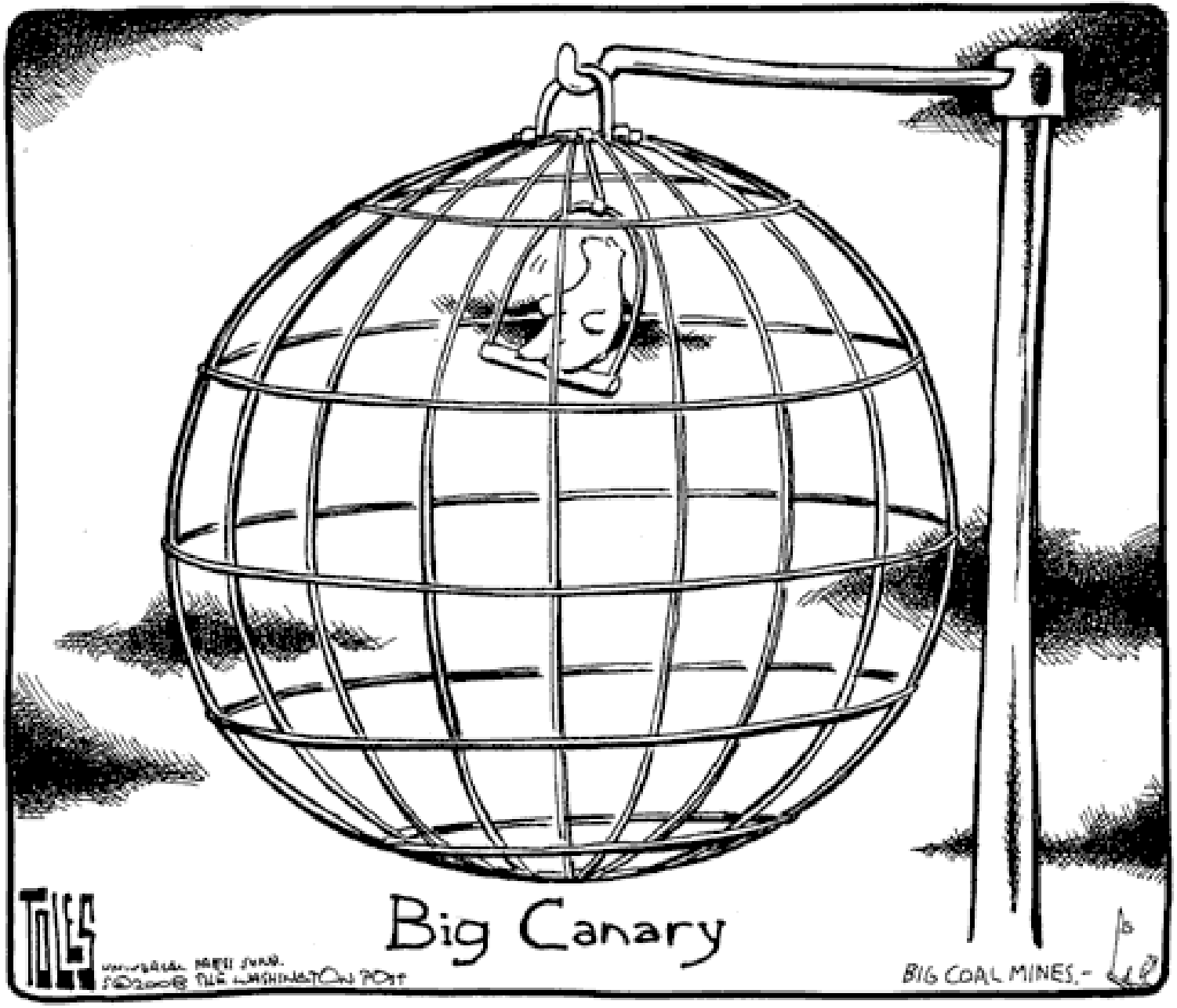

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Questions???

Comments??