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Climate Risks and 2°C

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Overview

Part 1: Article 2 Context

Part 2: Impacts on Ecosystems, Food Production and Sustainable Development

Part 3: Climate System Risks

Article 2 UNFCCC

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"The ultimate objective of this Convention .. is to achieve...stabilization of greenhouse gas concentrations in the atmosphere at a level that would **prevent dangerous anthropogenic interference** with the climate system. 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**."

Policy Context European Union

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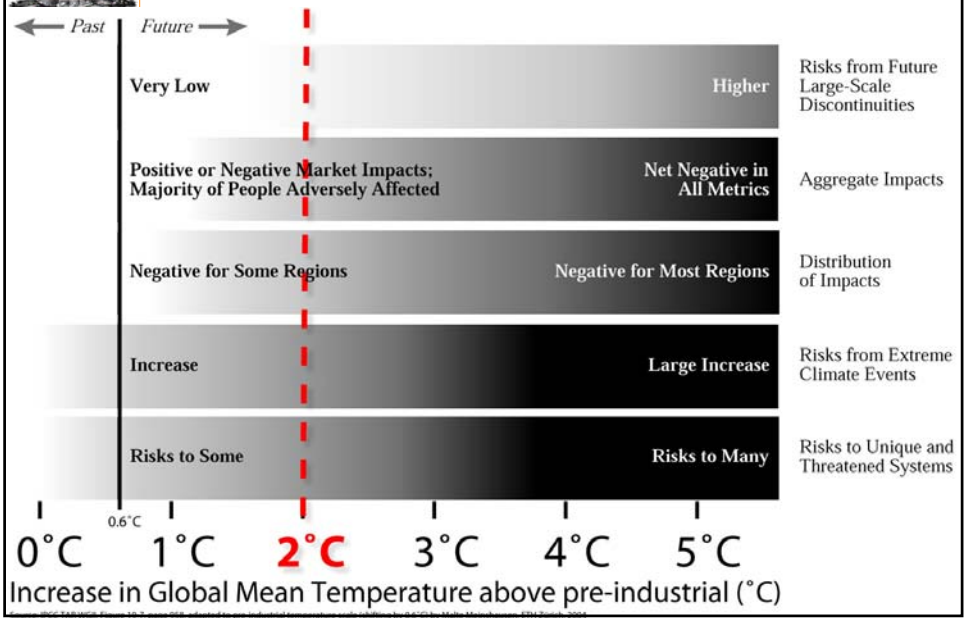
- *"[...] the Council believes that global average temperatures* ***should not exceed 2 degrees above pre-industrial level*** *[...]"* (1939th Council meeting, Luxembourg, 25 June 1996)
- *"REAFFIRMS that, with a view to meeting the ultimate objective of the United Nations Framework Convention on Climate Change [...] to prevent dangerous anthropogenic interference with the climate system, overall global annual mean surface temperature increase* ***should not exceed 2°C above pre-industrial levels*** *in order to limit high risks, including irreversible impacts of climate change; RECOGNISES that 2°C would already imply significant impacts on ecosystems and water resources [...]"* (2610th Council Meeting, Luxembourg, 14 October 2004 Council 2004, 25-26 March 2004)

Reasons for Concern (IPCC TAR WGII)



Assessing Impacts vs Temperature

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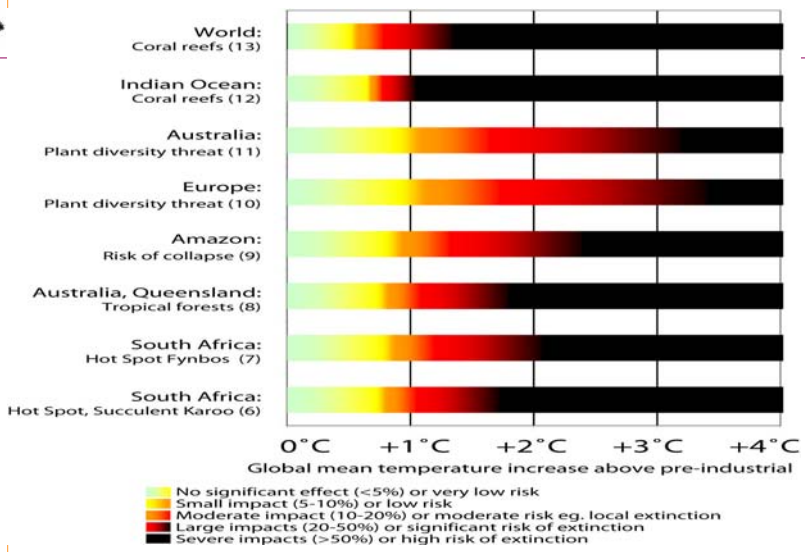
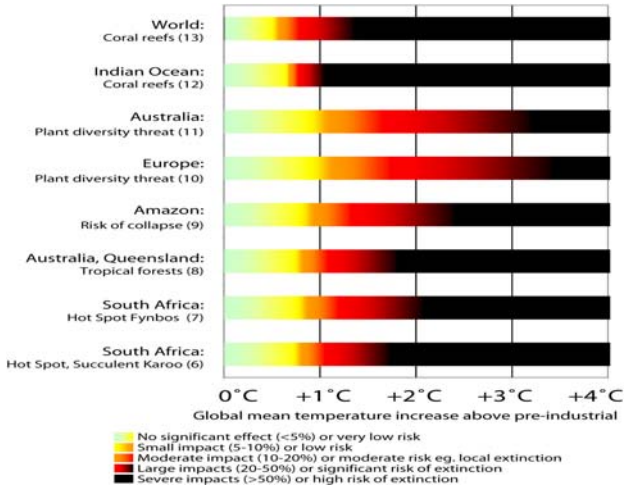
- Analysis of literature included in the TAR and into 2004
  - Peer reviewed literature
  - Analysed for robustness
  - Effects placed on a common temperature scale of global mean increase wrt 1861-1890
- Comparison with other assessments

Ecosystems



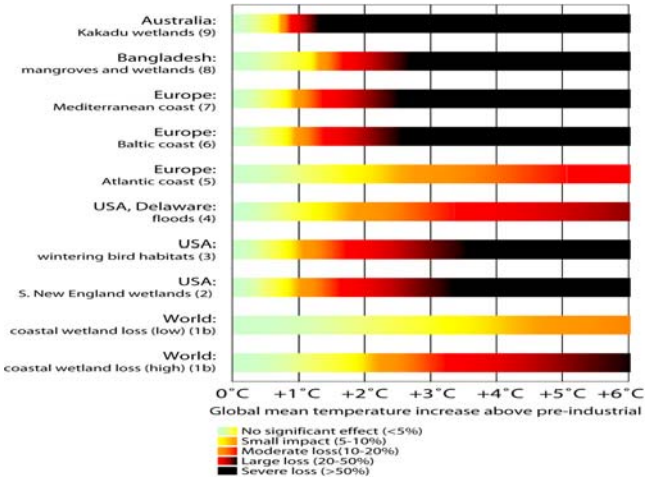
Source: Hare, W. L. (2003). Assessment of Knowledge on Impacts of Climate Change – Contribution to the Specification of Art. 2 of the UNFCCC. http://www.wbgu.de/wbgu_sn2003_ex01.pdf.

Ecosystems



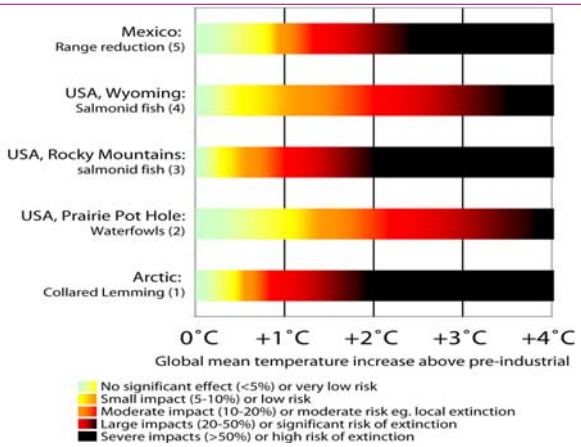
Source: Hare, W. L. (2003). Assessment of Knowledge on Impacts of Climate Change – Contribution to the Specification of Art. 2 of the UNFCCC. http://www.wbgu.de/wbgu_sn2003_ex01.pdf.

Coastal Wetlands



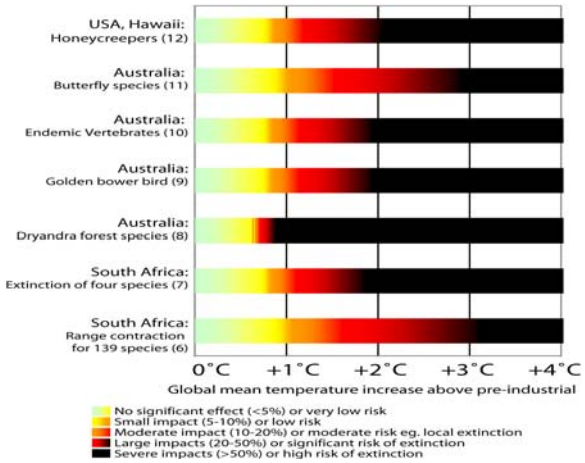
Source: Hare, W. L. (2003). Assessment of Knowledge on Impacts of Climate Change – Contribution to the Specification of Art. 2 of the UNFCCC. http://www.wbgu.de/wbgu_sn2003_ex01.pdf.

Species I



Source: Hare, W. L. (2003). Assessment of Knowledge on Impacts of Climate Change – Contribution to the Specification of Art. 2 of the UNFCCC. http://www.wbgu.de/wbgu_sn2003_ex01.pdf.

Species II



Source: Hare, W. L. (2003). Assessment of Knowledge on Impacts of Climate Change – Contribution to the Specification of Art. 2 of the UNFCCC. http://www.wbgu.de/wbgu_sn2003_ex01.pdf.

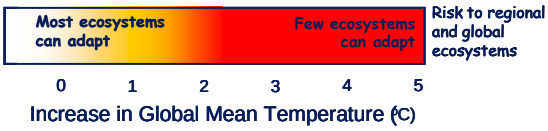
Ecosystems and Article 2

- Analysis indicates that many ecosystems vulnerable to substantial damage at or above 1.5-2.0°C warming range.
- Other analyses tend to confirm this:

European Climate Forum Symposium Beijing China

- ▲ 1.5-2.0°C warming above pre-industrial
  - Australian ecosystems - parts of the Great Barrier Reef, the Alpine region of south eastern Australia and endemic fauna and flora in the wet tropics of North East Queensland
- http://www.european-climate-forum.net/pdf/ECF_beijing_results.pdf

Leemans and Eickhout (2004)



Food Production and Sustainable Development

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- Millions at Risk (Parry et al., 2001)
- Analysis of literature
- European Climate Forum Symposium, Beijing China

Millions at Risk (Parry et al., 2001)

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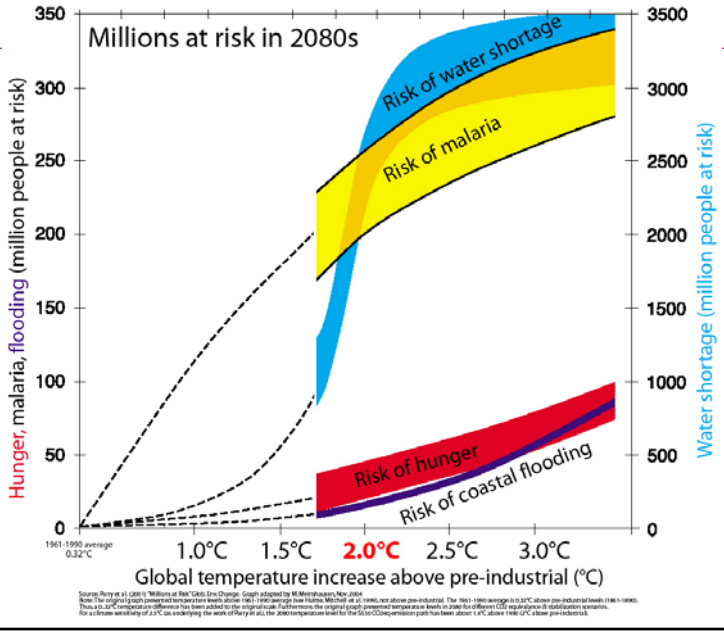

European Climate Symposium, Beijing China -Food

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- ▲ 2-2.5°C above pre-industrial
  - Significant regional risks to food production, with varying degrees of severity - South Asia, southern Africa and parts of Russia.
- ▲ Above 2-2.5°C above pre-industrial
  - Risks grow in China, Africa, South Asia and Russia
  - Risks in China severe if CO_2 fertilization of crops is low but small to modest if CO_2 fertilization is high.

See www.european-climate-forum.net

Aggregated global monetary damage functions as a percentage of world GDP

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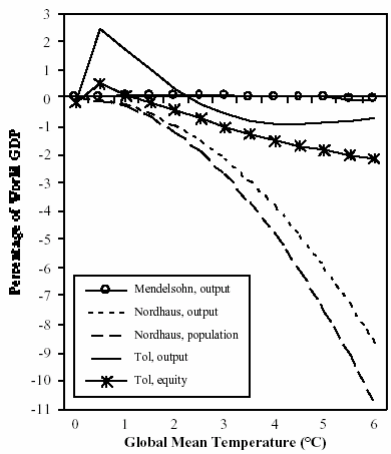

IPCC TAR
WGII
Chapter 19,
Figure 19-4

Economic Damages

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1°C A significant number of developing countries likely to experience net losses as high as a few % of GDP.

2°C Net adverse effects developing countries few to several % GDP.

> 2°C likelihood of net damages globally increases

Several developing regions 3-5% GDP loss 2.5-3°C

- Africa seems to be consistently amongst the regions with high to very high projected damages.

Sustainable Development: A Climate Poverty Trap?

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- Climate change can cause a poverty trap
- Recurring natural disasters can undermine development

Conclusions – 2°C Warming

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- Threatens many tens of millions with increased risk of hunger, hundreds of millions with increased Malaria risk, millions with increased flooding and billions with risk of water shortage.
  - Damages fall largely on the poorest and developing countries
- Risk of major ice sheet responses with commitments to many metres of sea level rise over several centuries.
  - Ensuing sea level rise threatens large populations everywhere and particularly in developing countries
- Threate of major ecosystem damages from the Arctic and Antarctic to the tropics
  - Loss of forests and species will affect the lives of all with economic costs falling disproportionately on the poor and developing countries

Risks of Non Linear and Abrupt Changes

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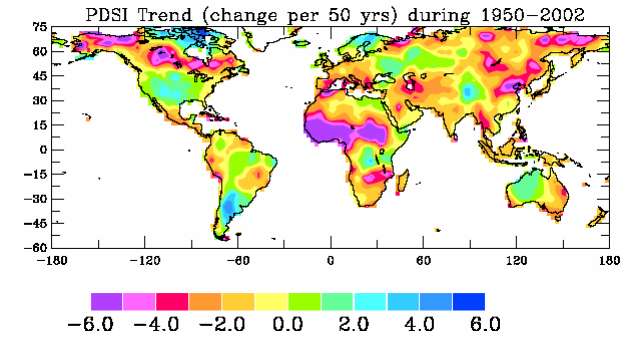
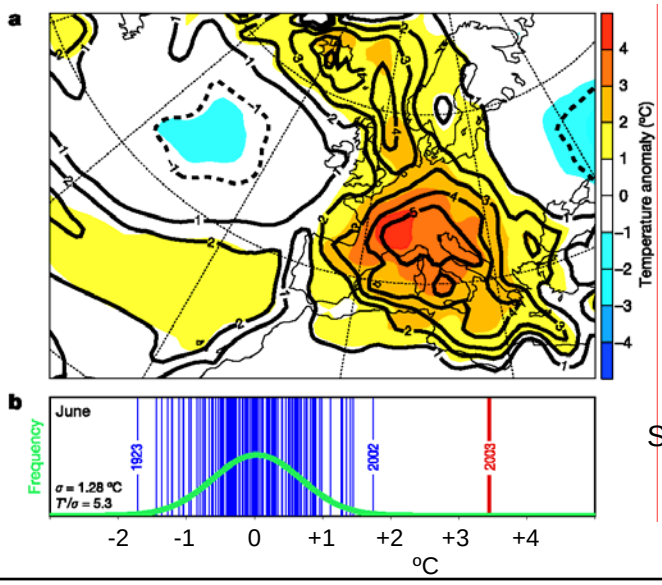
- Carbon Cycle feedbacks
- Ocean thermohaline circulation
- Ice Sheet decay or disintegration
- Changes in Extreme Events Frequency and Severity
  - Increased drought
  - Hurricanes
  - Shift towards El Nino mode of climate as the world warms?
  - Increased Monsoon variability

Increasing drought trend



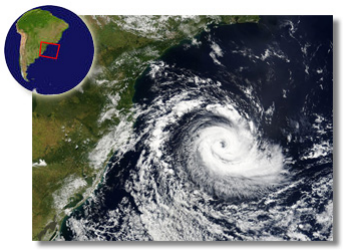
A Global Data Set of Palmer Drought Severity Index for 1870-2002: Relationship with Soil Moisture and Effects of Surface Warming
Aiguo Dai, Kevin E. Trenberth, and Taotao Qian
National Center for Atmospheric Research$, Boulder, Colorado, USA
Submitted to *J. Hydrometeorology,* February 12, 2004

European Summer 2003

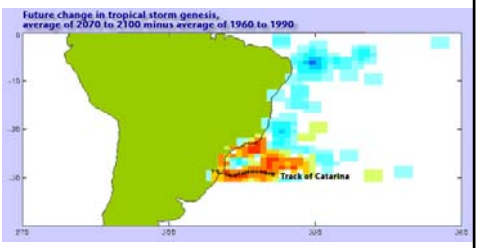


Schär et al. 2004

Hurricanes



Tropical cyclone Catarina off Southern Brazil, 26 March 2004. The first hurricane recorded in the South Atlantic.

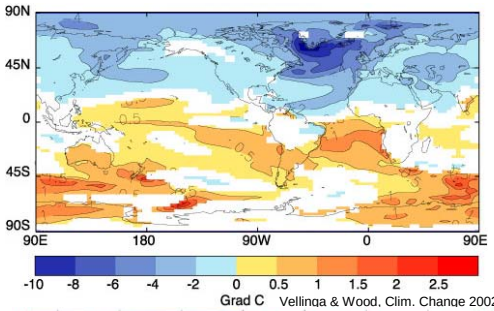


2004:

- First hurricane in South Atlantic
- First time Florida hit by 4 hurricanes in one season
- First time Japan hit by 10 typhoons in one season

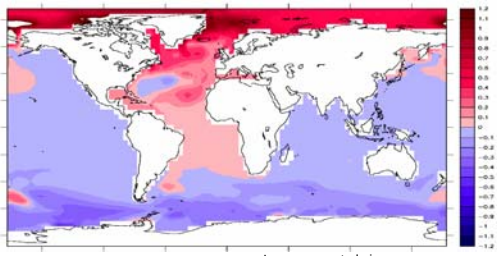
Effects of Atlantic Circulation Breakdown

Temperature Change



Vellinga & Wood, Clim. Change 2002

Sea Level Change



Levermann et al., in press

What do experts think?

- In-depth interviews with 12 experts:
- Four of the experts see 5% risk already at 2 °C warming
- Four of the experts see 50% risk exceeded at 4-5 °C warming

Amazon dieback risk

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- Serious risk with large consequences for biodiversity and climate system
  - Cowling et al (2003):
    - find that there is threshold "at which tropical ecosystems exceed their capacity for internal/external feedback effects compensating of the deleterious effects of warming on tropical plants,"
    - speculate that the climate system is very close to this threshold at present
  - Other results confirm this

Hadley Centre: Amazon projections

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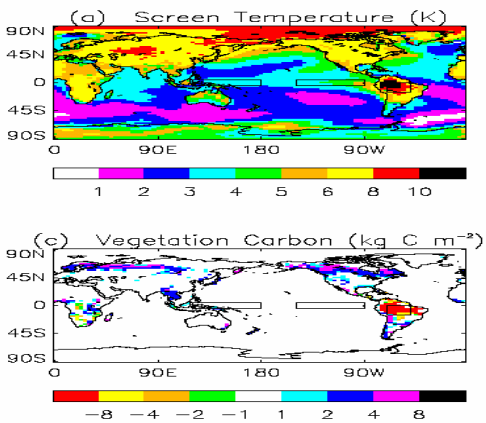
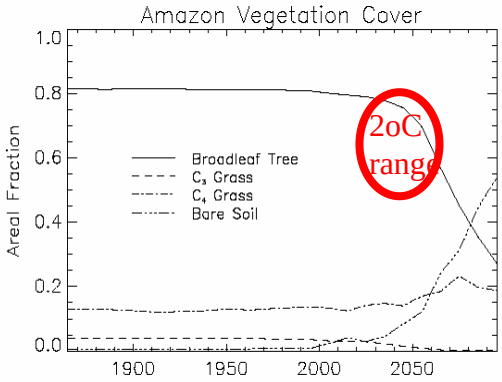


Cox, P.M, Betts, R.A et al (2003) "Amazon Dieback under climate-carbon cycle projections for the 21st century" submitted to Theoretical and Applied Climatology.

Hadley Centre: Amazon projections



Cox, P.M, Betts, R.A et al (2003) "Amazon Dieback under climate-carbon cycle projections for the 21st century" submitted to Theoretical and Applied Climatology.

Ice sheets and the climate system

- Greenland holds (6-7 metres of sea level)
  - Thermal viability limit may be quite close to present temperatures
  - Does not have risk of collapse but future decay rate could approach 0.5m/century
- West Antarctic Ice Sheet (5-6 metres)
  - Thought to be unstable with possibility of catastrophic disintegration – metre or more per century disintegration rates are plausible
  - Thermal viability limit for fringing ice shelves could be approached or committed to this century
- East Antarctic Ice Sheet (55m)
  - Thought to to be stable but there are some concerns in relation to coupled effects of WAIS collapse or ice shelf collapse

Ice sheets and sea level rise risks

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- IPCC TAR Assessment for 21st century
  - Greenland decays and Antarctica grows with close to zero net effect on sea level
  - In the longer term significant sea level rise contribution expected
- Since the TAR
  - Mass balance of West Antarctic Ice Sheet and Greenland found to be negative
  - East Antarctic Ice Sheet close to zero

Recent Sea Level Changes: Satellite Altimetry

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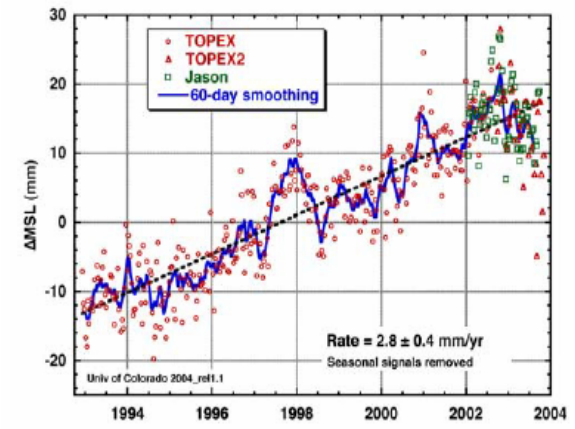

Cazenave, A., and R. S. Nerem (2004), Present-day sea level change: Observations and causes, Rev. Geophys., 42,

Ice sheet contribution to recent sea level rise

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Ice Sheet	Sea level rise contribution last decade mm/yr
Greenland (Rignot and Thomas 2002)	0.13
WAIS (Rignot and Thomas 2002)	0.16
Antarctic Peninsula (Rignot et al 2004) since 2002 collapse of Larsen B (Larsen A ice streams not quantified)	0.07
EAIS (Rignot and Thomas 2002)	-0.07
Patagonia (Rignot et al. 2003)	0.10
Total contribution	0.39

Hare and Oppenheimer (2004) "Climate system risks: Ice sheet instability or decay and sea level rise" presentation to ECF Symposium Beijing China

Melting of Ice over Greenland

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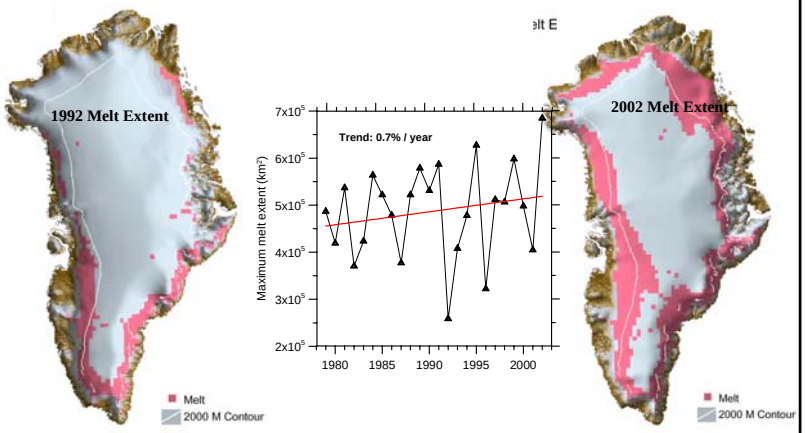
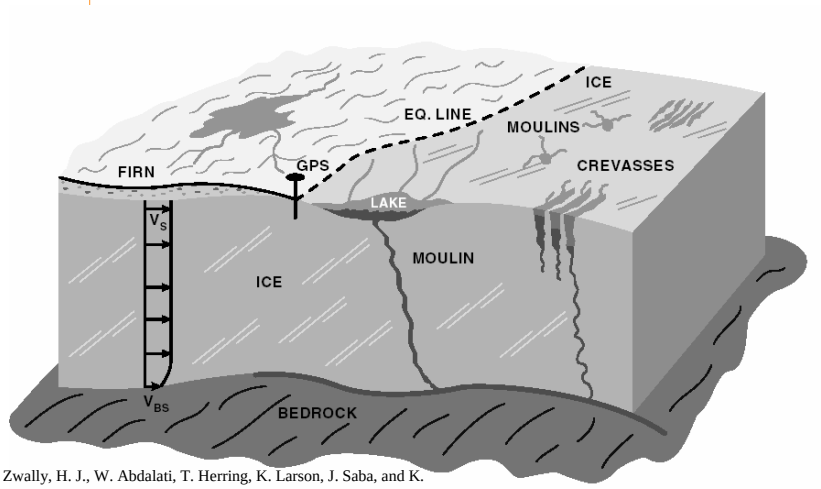


Greenland ice sheet melt area increased on average by 16% from 1979 to 2002.
The smallest melt extent was observed after the Mt. Pinatubo eruption in 1992

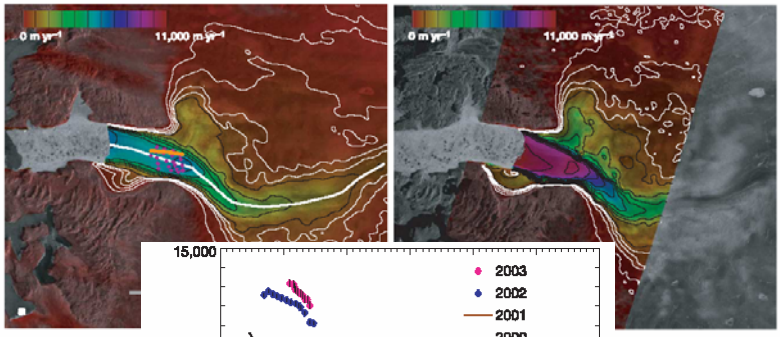
Data from Konrad Steffen and Russell Huff, University of Colorado

Surface Meltwater feedback to Ice Stream Flow



Zwally, H. J., W. Abdalati, T. Herring, K. Larson, J. Saba, and K. Steffen (2002). "Surface Melt-Induced Acceleration of Greenland Ice-Sheet Flow." Science **297**(5579): 218-222.

Speedup of Jakobshavn Glacier, Greenland



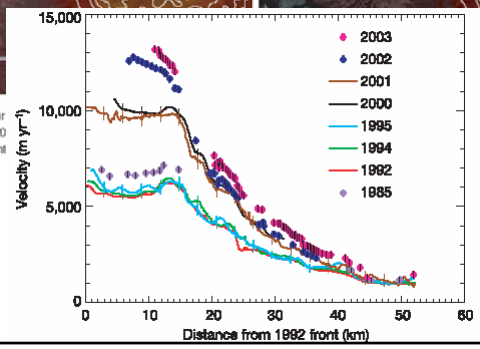


Figure 1 Ice-flow speed as colour February 1992 (**a**) and October 20 thin black lines at 1,000 m yr^{-1} int

ation of the profile plotted in Fig. 2. The 97 (orange line) and 1985 (purple

Antarctic Ice Sheet – Ice streams and ice shelves

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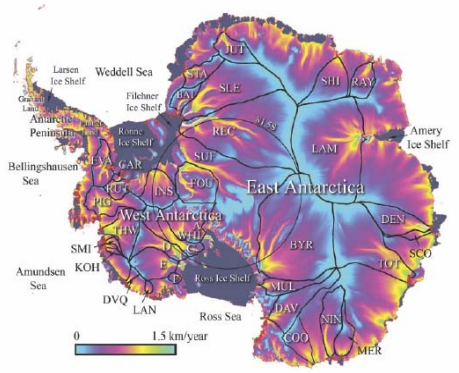
Newly discovered fast and complex ice streams extending deep into the continental interior challenge the assumption that the interior of the ice sheet is relatively stable and inactive



Rignot, E., and R. H. Thomas (2002). "Mass Balance of Polar Ice Sheets." Science 297(5586): 1502-1506.

Ice streams

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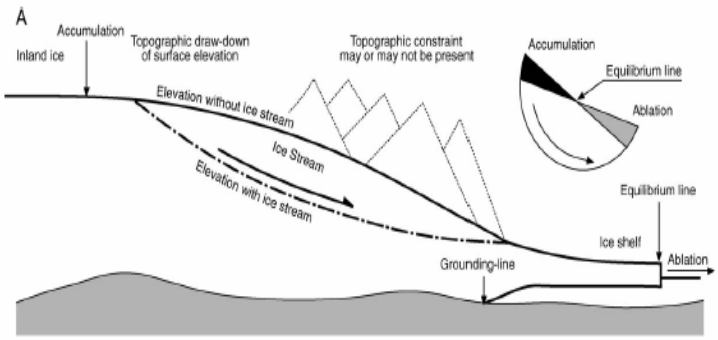
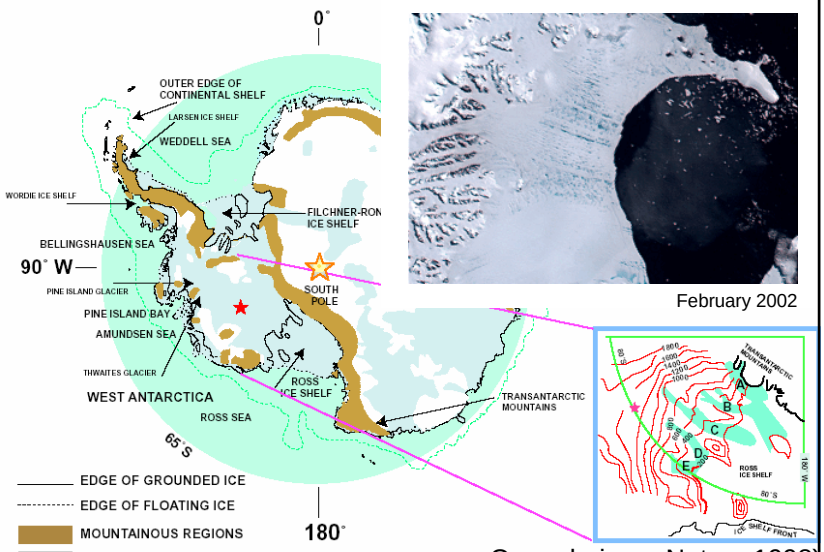


West Antarctic Ice Sheet



February 2002

Oppenheimer, Nature 1998)

Why is the WAIS thought to be unstable?

- Marine character bed below sea level and sloping inwards towards interior
- Ice shelves buttress or hold back the main ice streams
- Collapse of the ice shelves could cause ice stream acceleration
- Mercer (1967) “uniquely vulnerable and unstable body of ice” and that its disintegration could be “rapid, perhaps even catastrophic”

Ice shelf collapse and ice stream response

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- Observations of ice stream response
  - Larsen A collapse has led to rapid retreat of the grounded ice streams that drained into it on the north eastern Antarctic peninsula and is contributing to sea level rise (De Angelis and Skvarca 2003)
  - Larsen B collapse in 2000 has led to a loss of grounded ice and is raising sea level 0.07mm/yr.(Rignot et al GRL 2004)
- Implications for WAIS
  - Provides support for ice shelf collapse theory of ice stream acceleration

The Weak Underbelly of the WAIS

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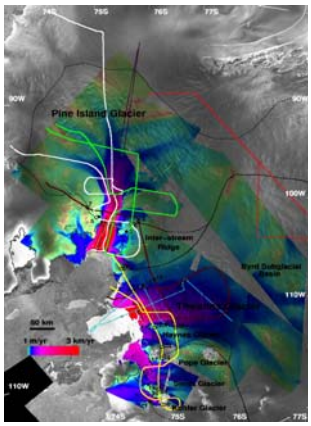
- Amundsen sea sector very vulnerable.
- Has a negative mass balance (Rignot and Thomas 2002)
- Recent observations show discharge accelerating & equivalent to about 10% of the global rate of sea level rise (Thomas et al 2004)
- Acceleration is thought likely to continue



WAIS Danger Points

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- Ice shelf collapse: At what temperature would this occur?
- 2-4.5oC warming

Sea level rises 3-5 meters by 2300 for 3°C

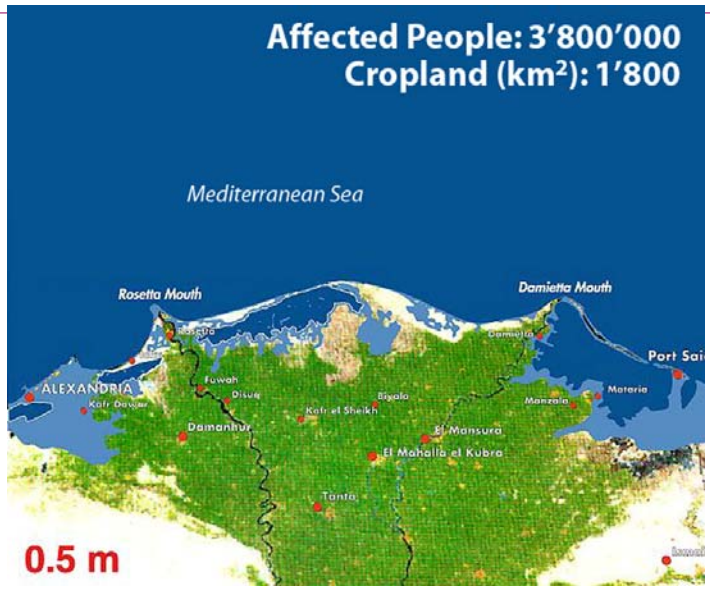
Source: Rahmstorf, S., C. Jaeger (2004)

- 3°C → dangerous interference
- *"Even a stabilisation target of 2ºC cannot necessarily be considered "safe" in terms of the sea level rise caused"*

+ Antarctica	1.0 - 2.0 m	Estimate based on WAIS decay over 900-1800 years
+ Greenland	0.9 - 1.8 m	Lower: IPCC TAR Upper: doubled
+ Glaciers	0.4 m	IPCC TAR, assumed 80% loss of total
Thermal expansion	0.4 - 0.9 m	IPCC TAR, not fully considering THC
Total	**2.7 - 5.1 m**	

...and increasing further from there

Potential Impact of Sea Level Rise: Nile Delta



Source: Otto Simonett, UNEP/GRID Geneva, Prof. G.Sestini, Florence, Remote Sensing Center, Cairo, DERCAE Wüstenschutzatlas

Key Points on Climate System Risks

- Serious risks for high-impact, non-linear or irreversible responses in the climate system exist for global mean warming of 2-3°C above pre-industrial levels.
- Even a global mean temperature rise below 2°C cannot be considered 'safe', given the large uncertainty in some of the thresholds.