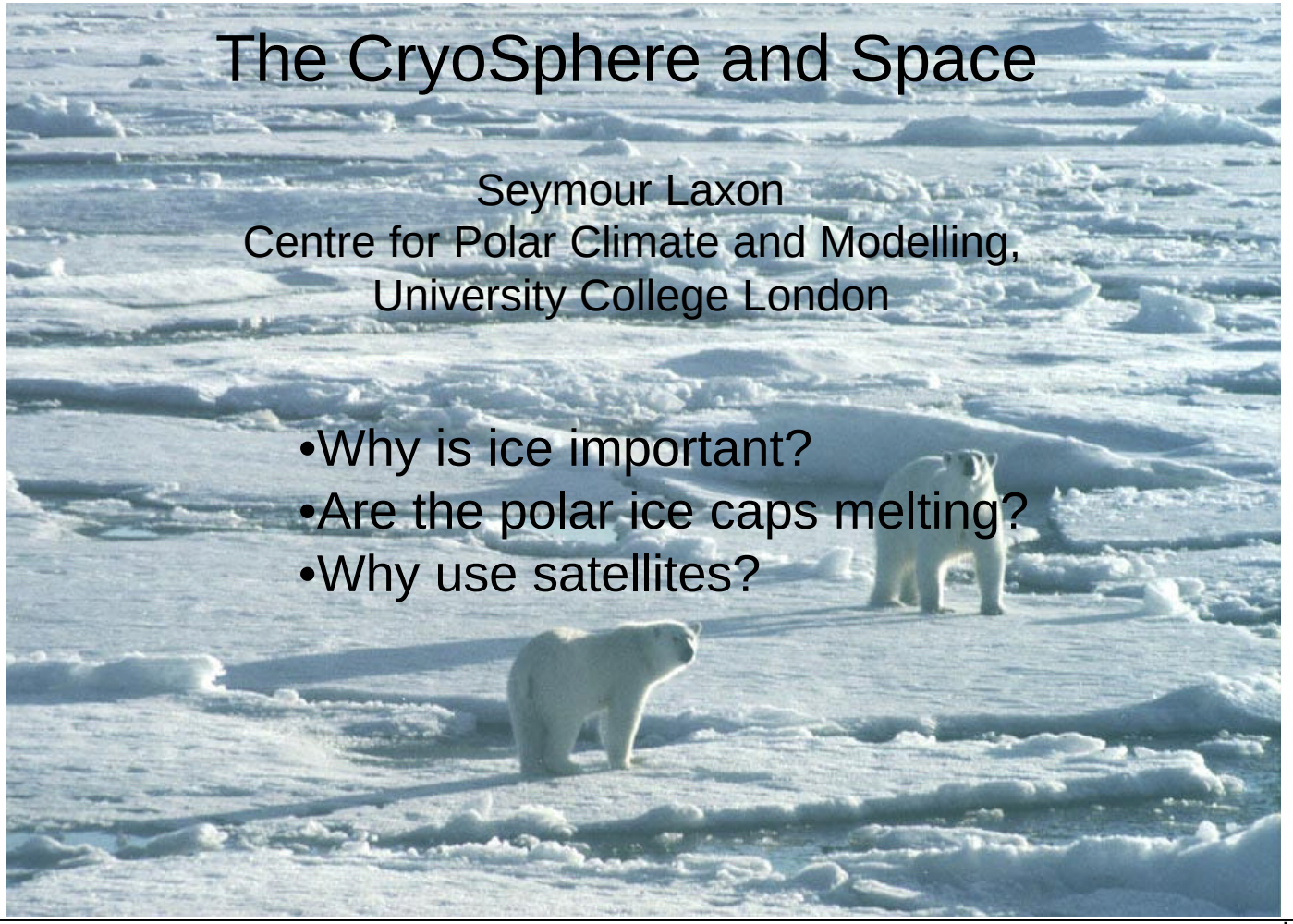
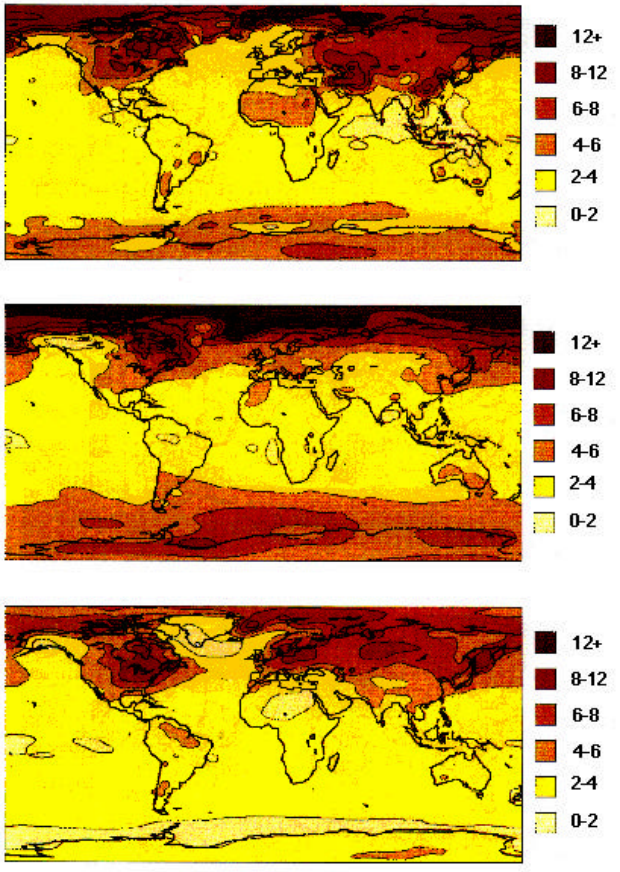


# The CryoSphere and Space

Seymour Laxon
Centre for Polar Climate and Modelling,
University College London

- Why is ice important?
- Are the polar ice caps melting?
- Why use satellites?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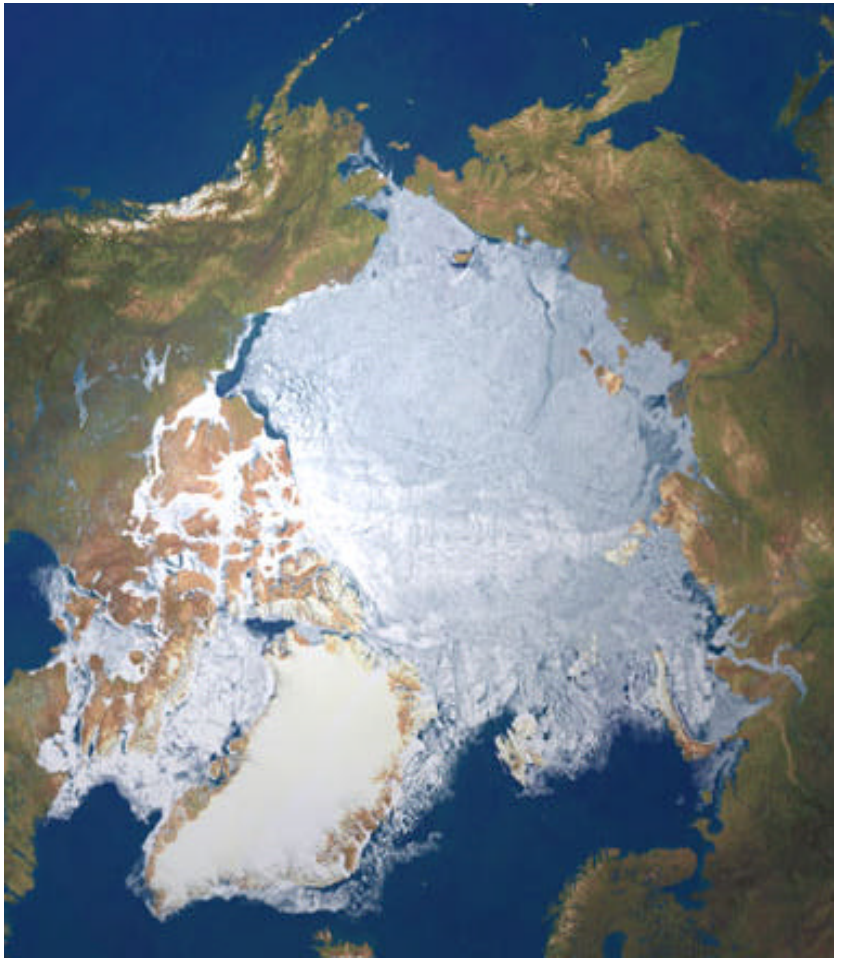
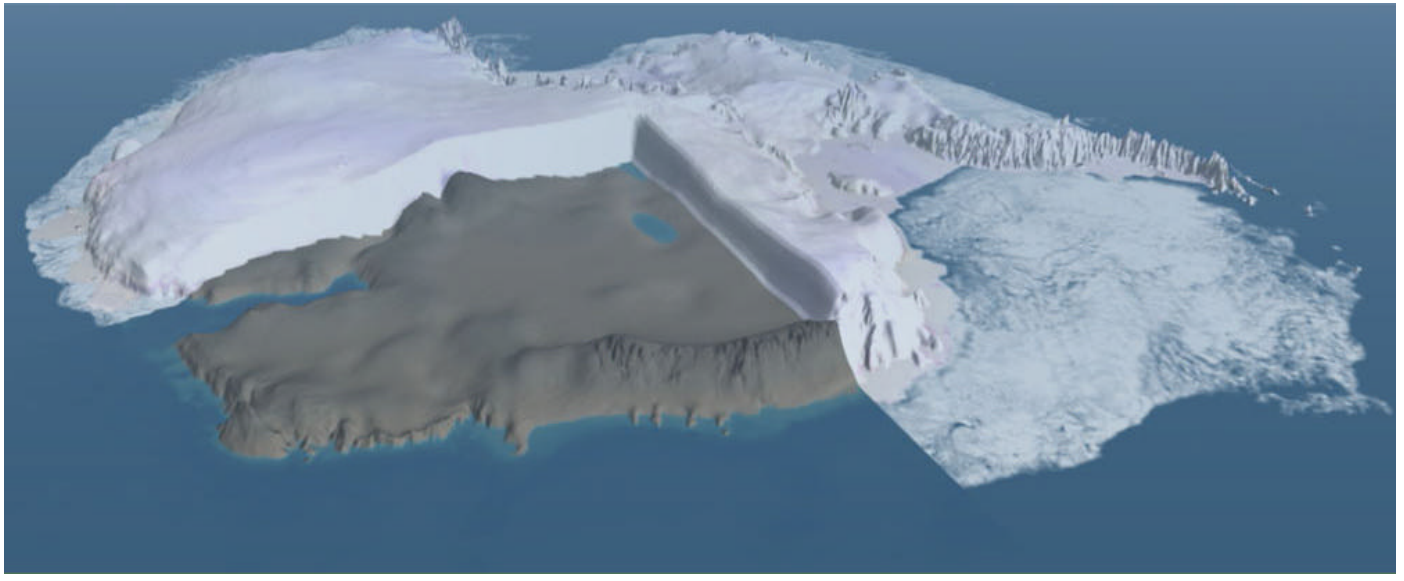
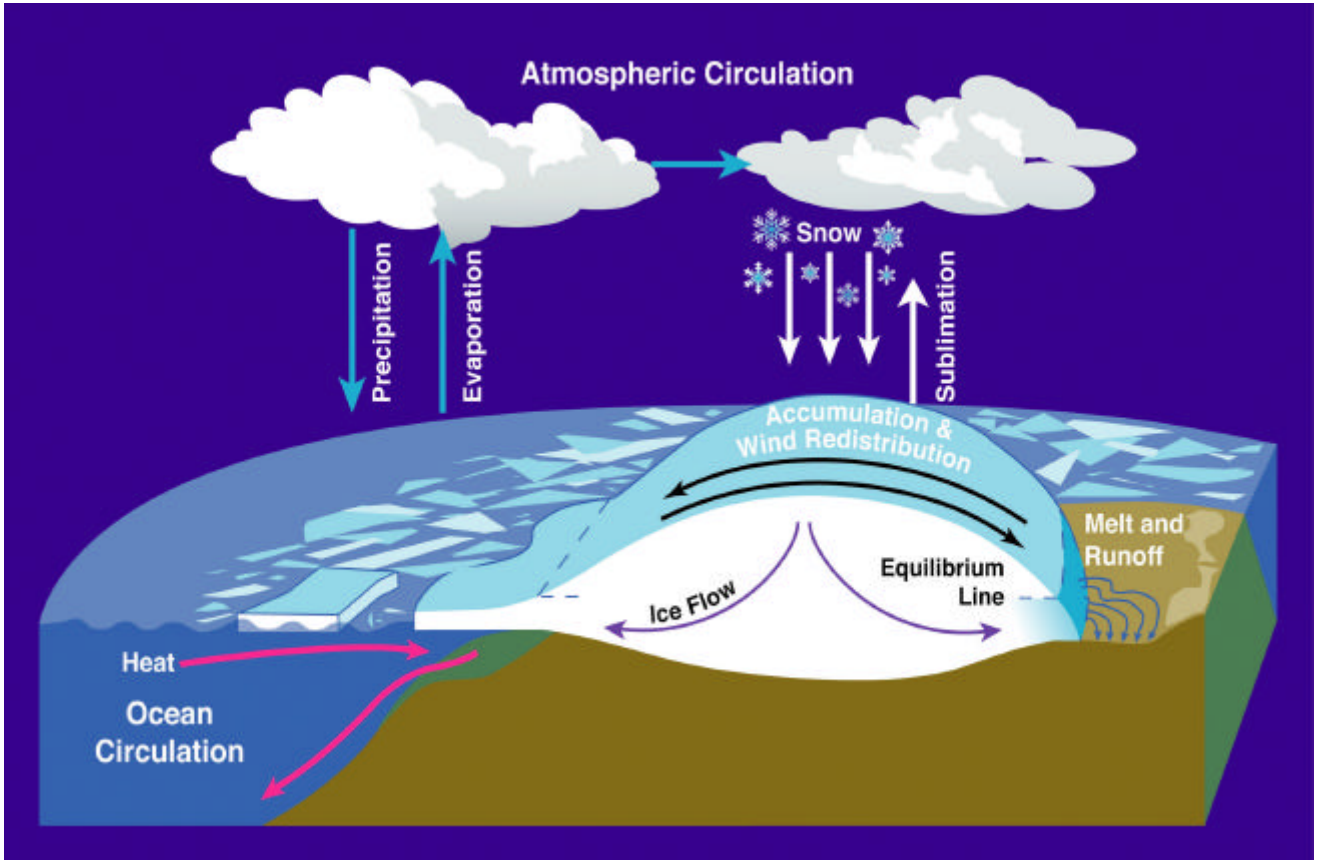


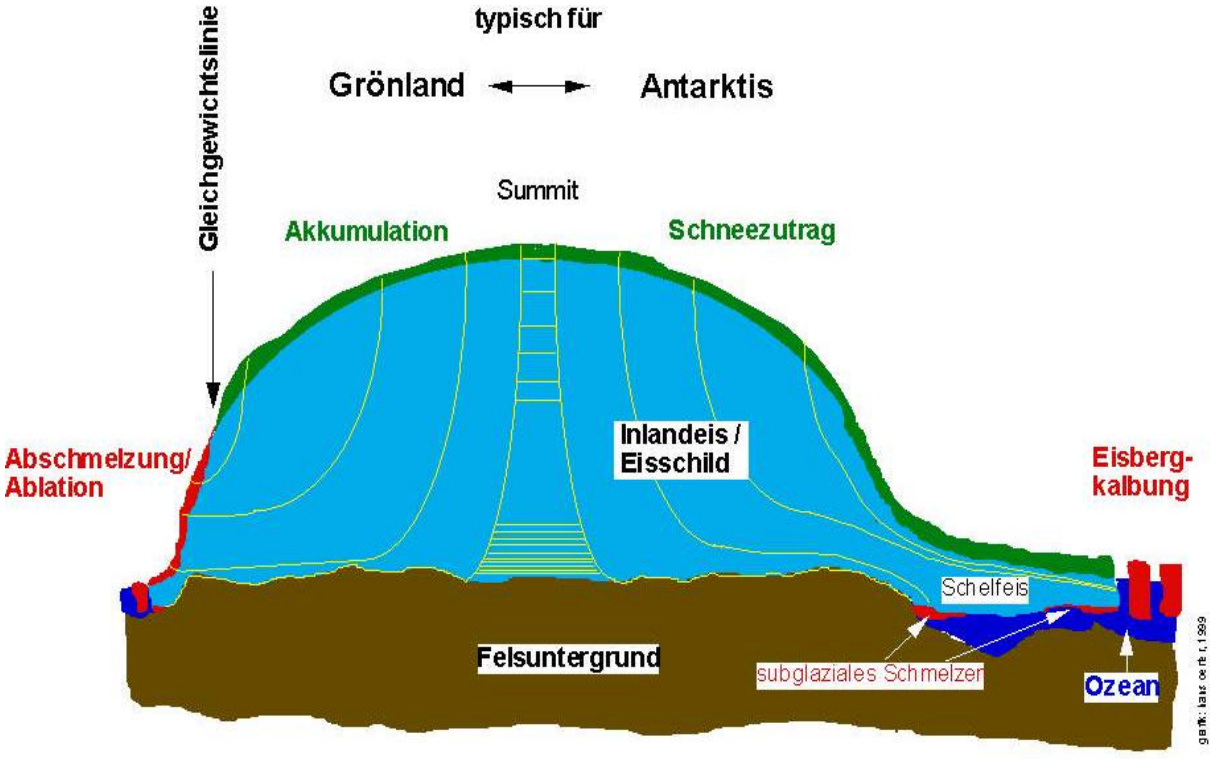


Courtesy Planetary Visions Ltd.

# Ice Sheet Mass Balance



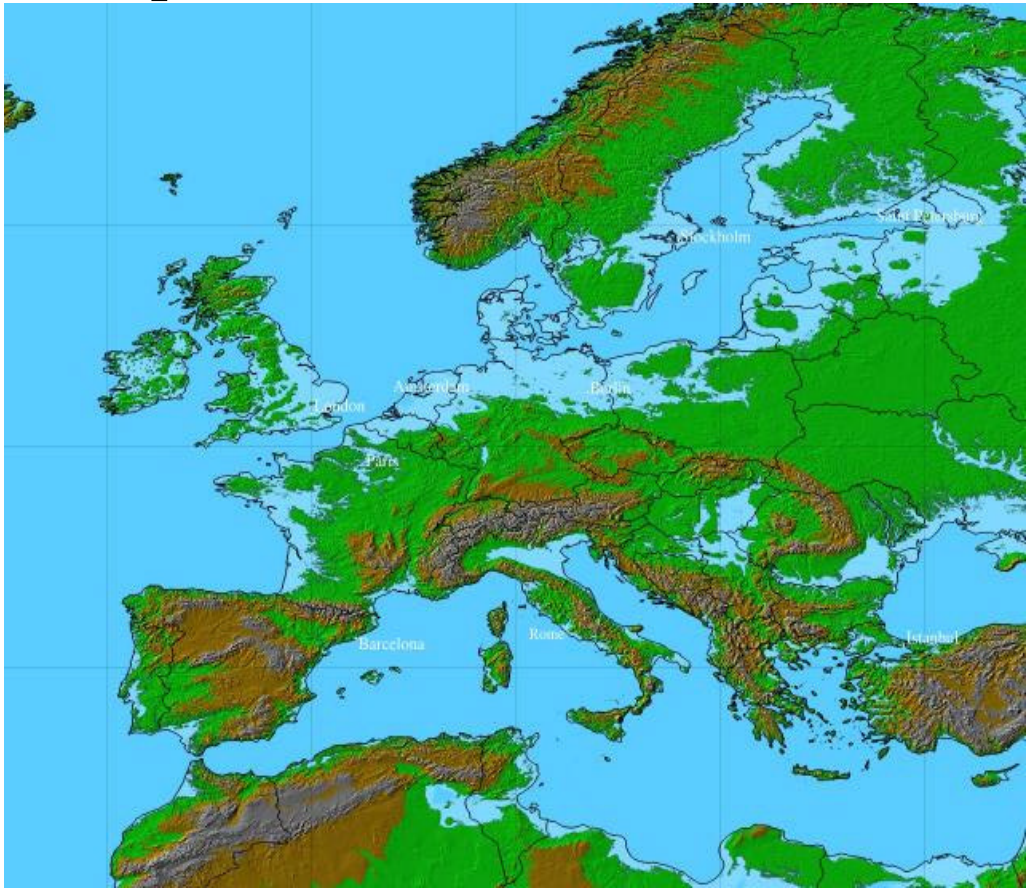
# Ice Sheet Mass Balance -2



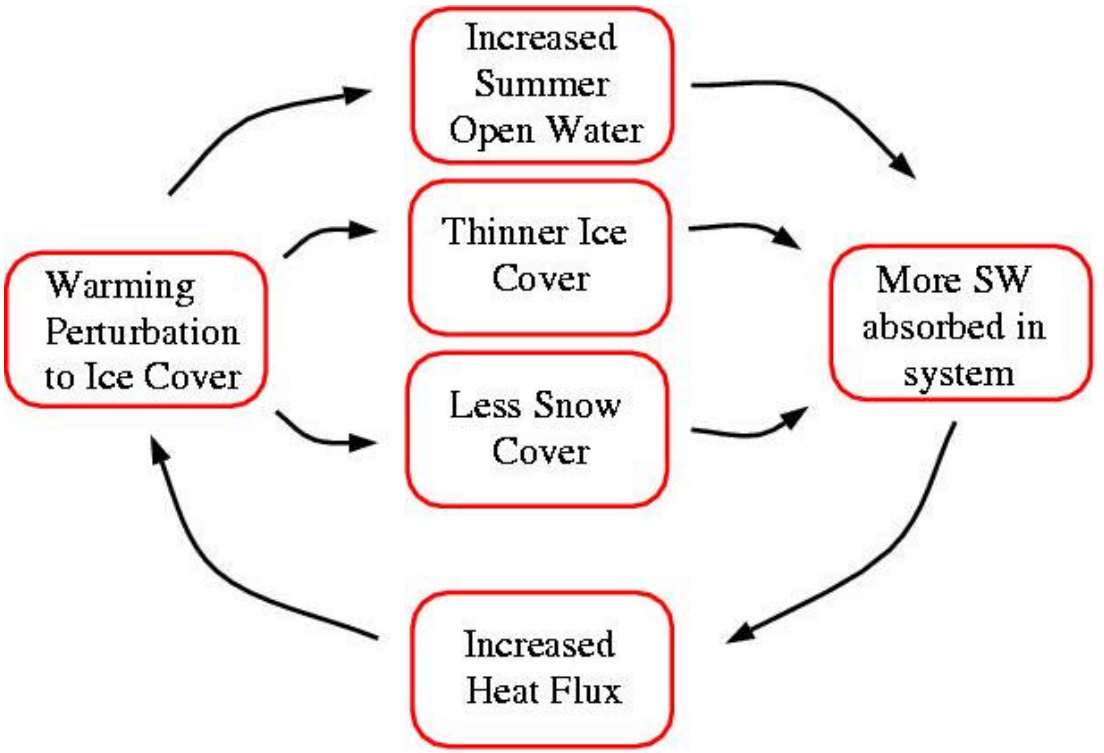
QuickTime™ and a
Silicon Graphics JPEG decompressor
are needed to see this picture.

Courtesy Planetary Visions Ltd.

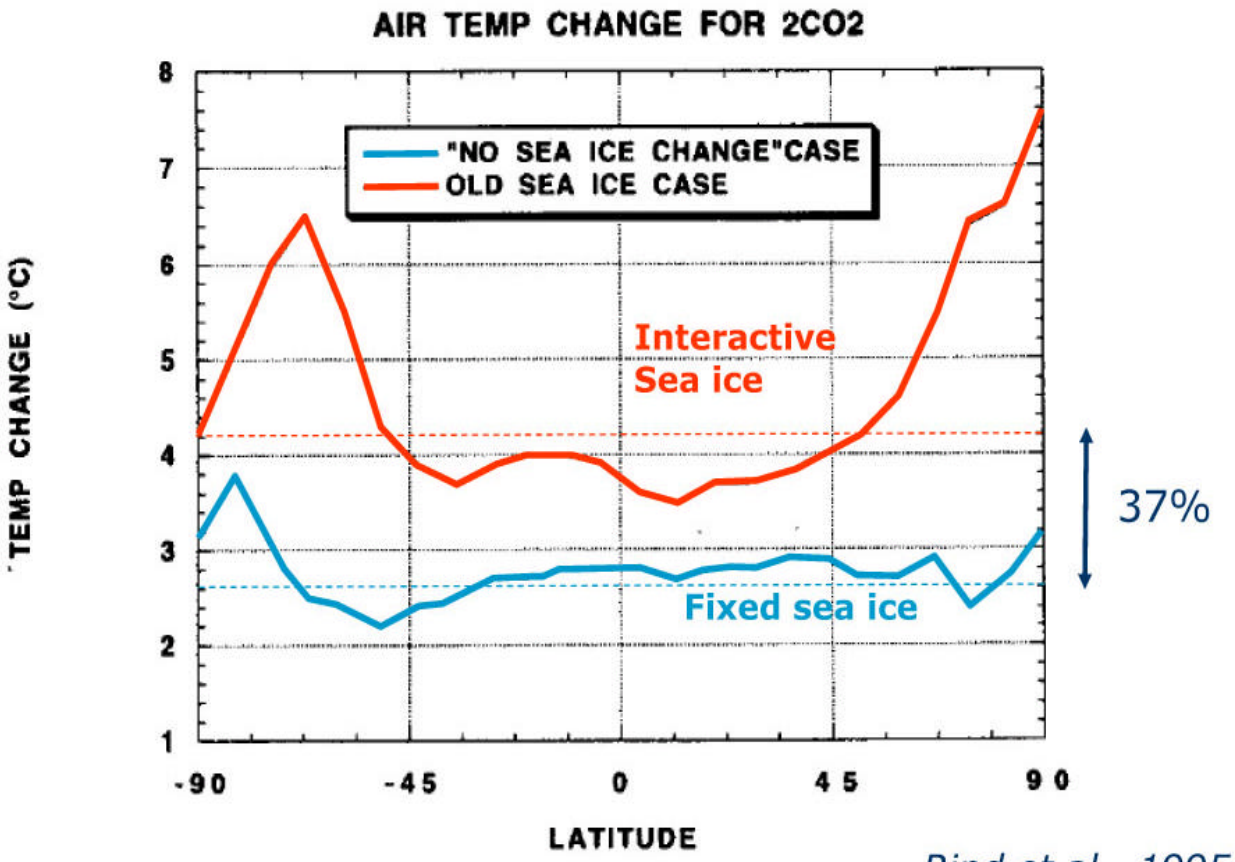
# Europe after a 100m sea level rise



# Sea Ice Feedbacks



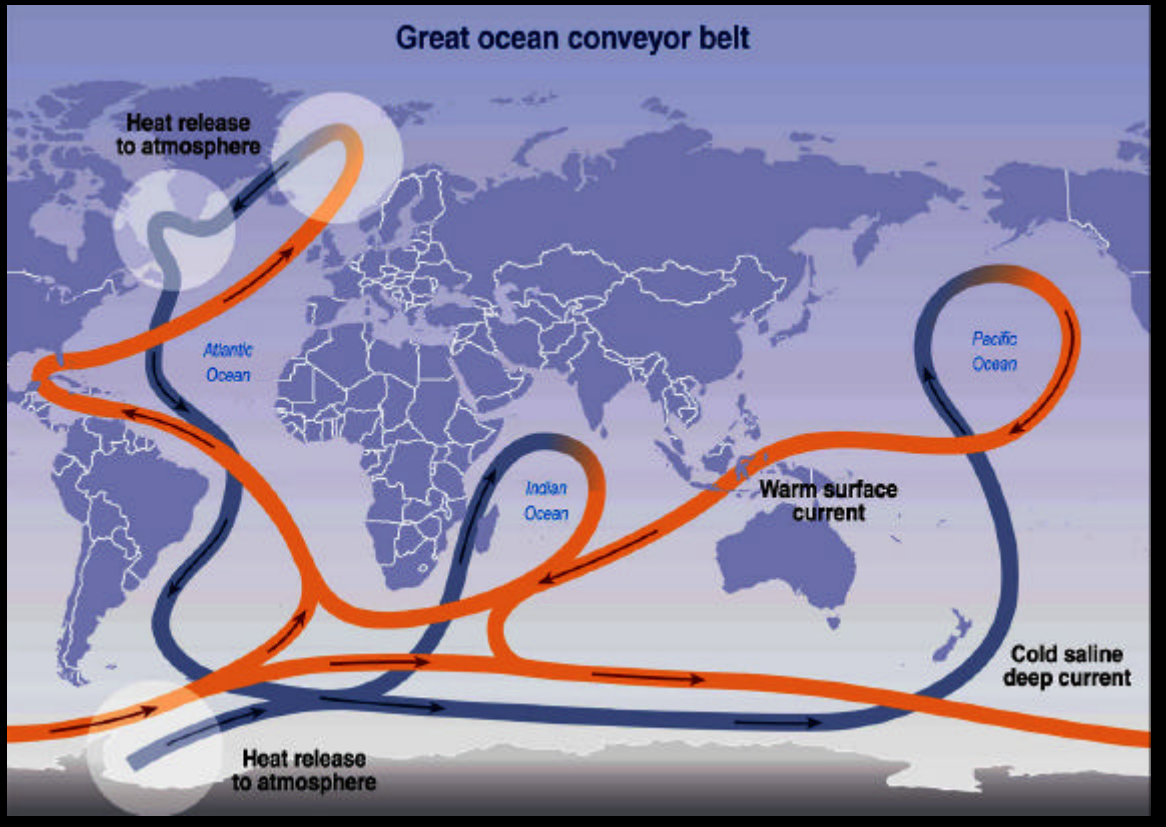

Ice/Albedo Positive Feedback



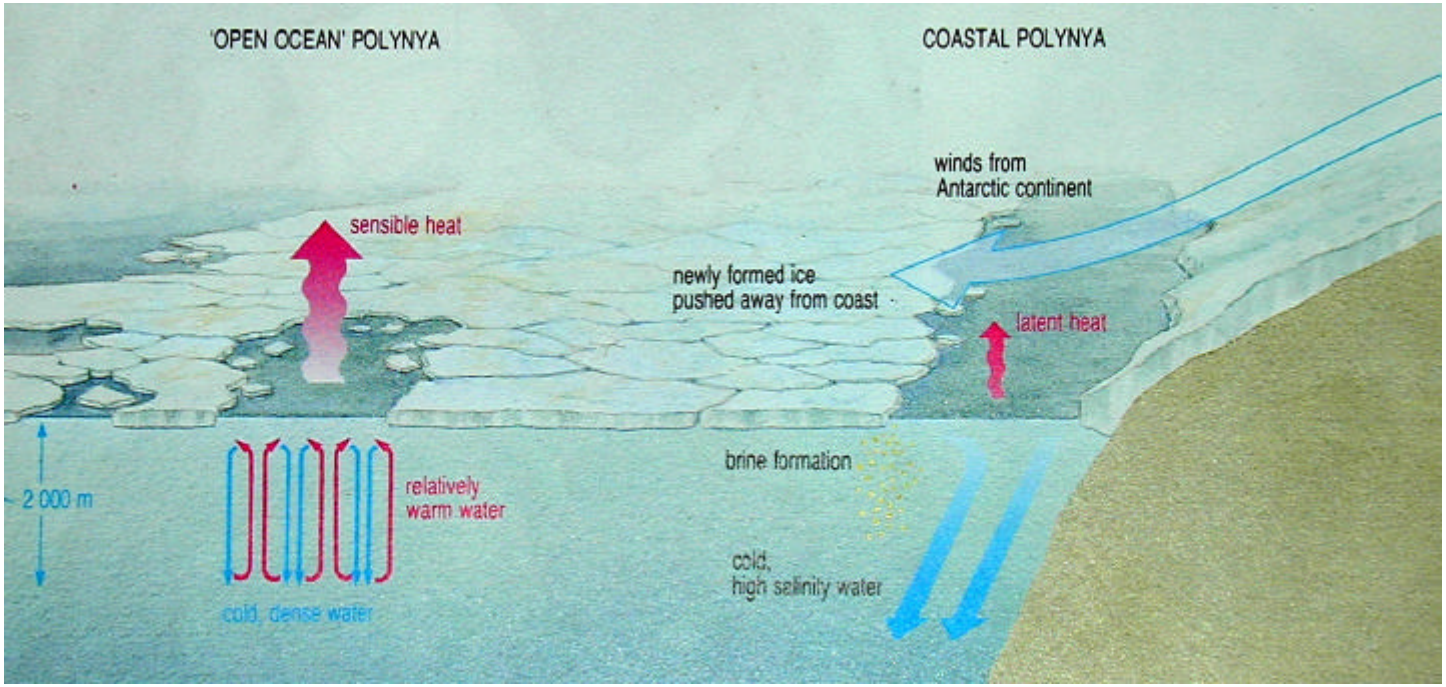

*Rind et al., 1995*

QuickTime™ and a
DV/DVCPRO - NTSC decompressor
are needed to see this picture.

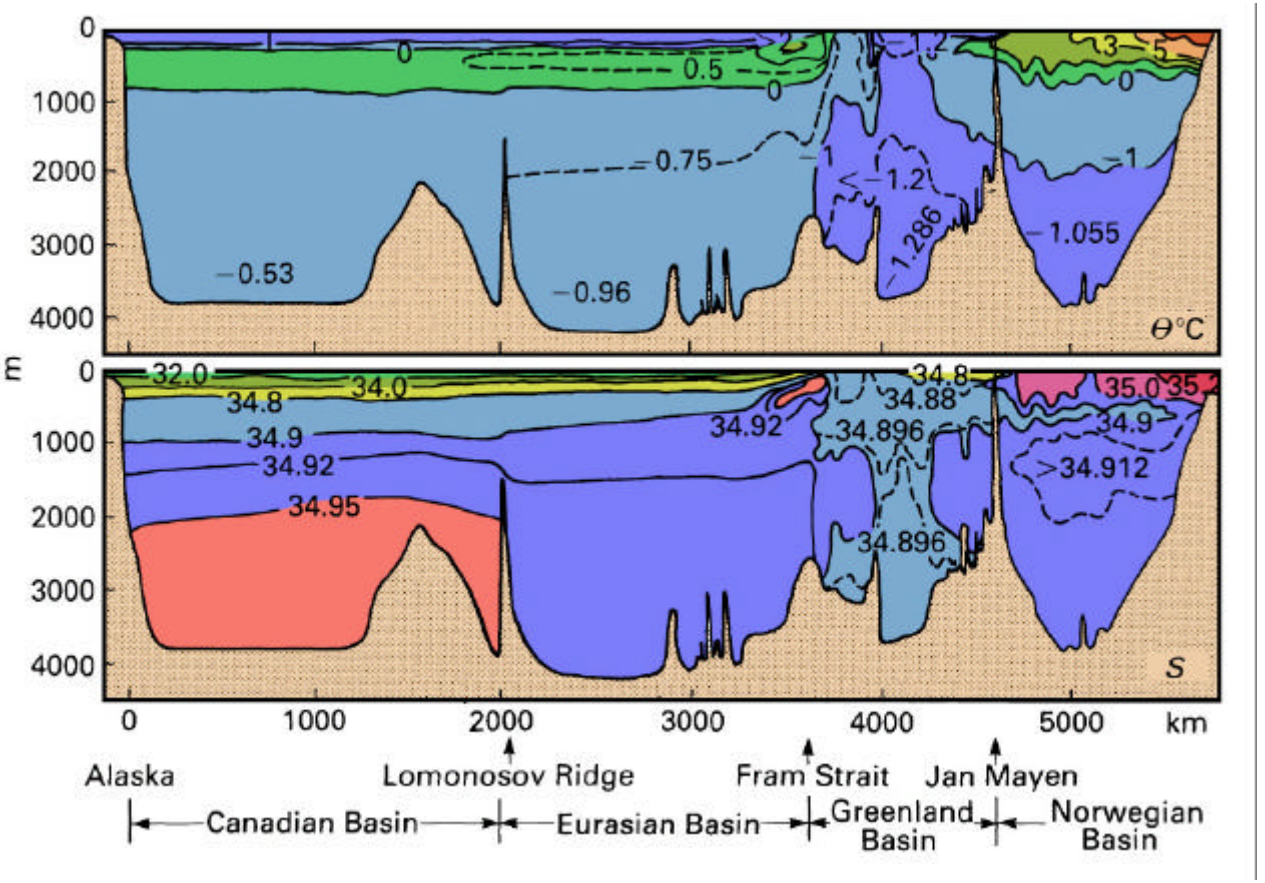



Great ocean conveyor belt
Heat release to atmosphere
Atlantic Ocean
Pacific Ocean
Indian Ocean
Warm surface current
Cold saline deep current
Heat release to atmosphere

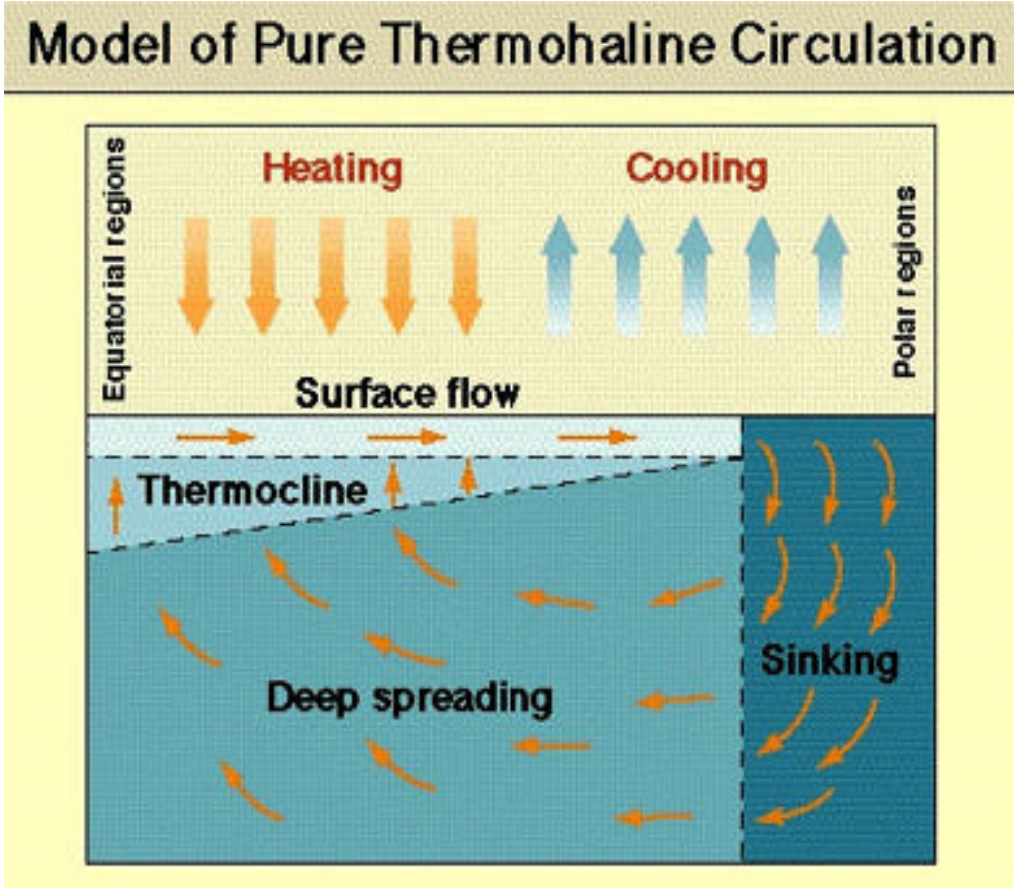
IPCC, 2


'OPEN OCEAN' POLYNYA
COASTAL POLYNYA
winds from
Antarctic continent
sensible heat
newly formed ice
pushed away from coast
latent heat
brine formation
2 000 m
relatively
warm water
cold, dense water
cold,
high salinity water

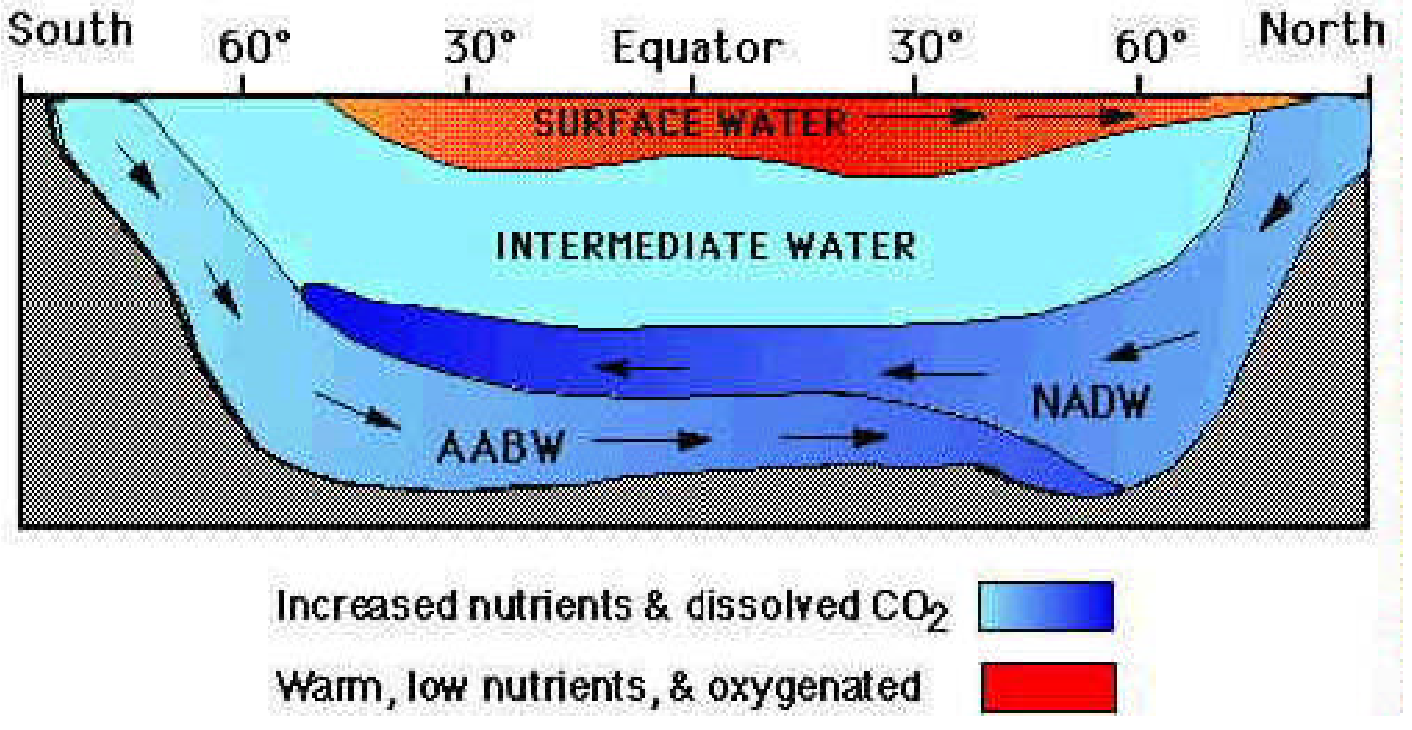
# Arctic Ocean Stratification



# Arctic Ocean Stratification



# Atlantic Ocean Thermohaline Circulation



Guide to climate change

Global warning? ▸ In Depth

Climate forecast | Greenhouse effect | Carbon cycle | Feedback effects | Gulf Stream

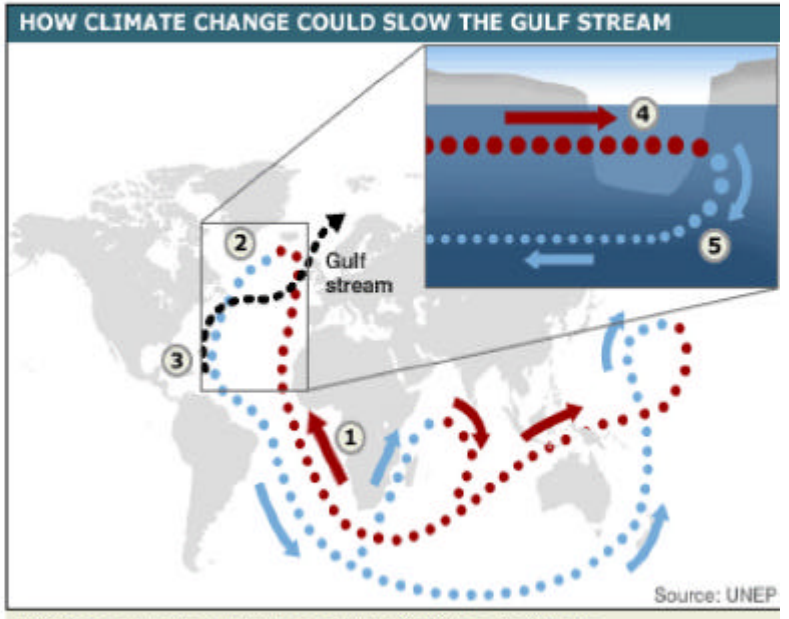
## Gulf Stream

Dramatic temperature shifts have happened in the past, driven partly by changes in a major ocean current.

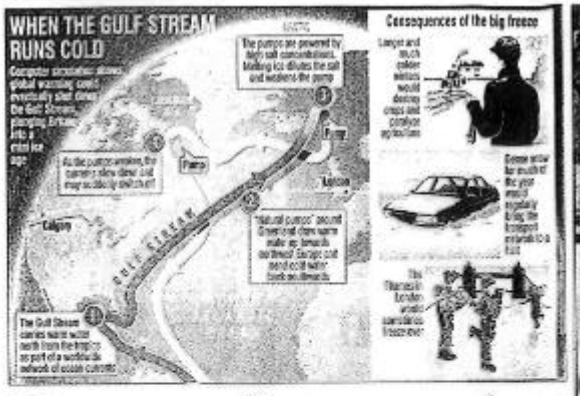
The "ocean conveyor belt" drives the Gulf Stream that warms Europe. Scientists are exploring whether climate change might slow or shut it down – a scenario considered "low probability, high impact".

Current predictions suggest that the Gulf Stream will be weakened, but that overall warming will balance out the cooling this causes.

BBC NEWS




**1** Surface currents carry warm, salty water from the tropics.
**2** The water cools, its density increases and it sinks to the deep ocean.
**3** The cold water flows back to the equator, driving the "ocean conveyor" which in turn contributes to the Gulf Stream that warms northern Europe.
**4** As ice melts, freshwater dilutes the warm salty water from the tropics.
**5** The water becomes less dense so does not sink as fast, weakening the "conveyor" and therefore the Gulf Stream.




# Europe faces an ice age as world warms

by Steve Farrar Science Correspondent

The big chill: the melting of Arctic ice could halt the Gulf Stream that warms Britain

# Bank may 'export' jobs to Bombay

by Paul Nuki
Consumer Affairs Editor

YOUR bank account may soon be run from the streets of Bombay. Lloyds TSB, one of Britain's biggest banks, is considering "exporting" thousands of jobs to India.

The move, which would result in many of the bank's 15m customers having their accounts administered remotely by low-paid but highly skilled "clerks" 4,500 miles from Britain, will anger unions and worry ministers.

Management experts say it could spark a wave of service industry job losses with banks, insurance, travel and telecommunications companies following the path British manufacturers took in the 1980s.

"The potential for job losses is frightening," said Peter Mulder, an expert in outsourcing at Arthur Andersen, one of Britain's largest management consultancies. Lloyds TSB, whose chairman, Sir Brian Pitman, is known to support outsourcing back-office jobs to such countries as India, is understood to be examining the potential to base an Internet banking operation in Bombay.

It recently sent two senior executives there to examine the possibility of such a move and has held meetings with management consultants which specialise in advising on such operations.

India is now seen ideal base because it has a booming information technology industry and a well-educated population.

British Airways and American Express are already running administrative operations in India.

Last week Lloyds TSB confirmed it had met management consultants for "blue sky" talks on the issue, but had "no plans" to outsource business to India.

BBC NEWS UK EDITION

WATCH/LISTEN TO BBC NEWS



Last Updated: Thursday, 13 November, 2003, 11:31 GMT

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# Warming could bring colder UK winters

By Penny Palmer
BBC Horizon

**Britain could be heading for a "big freeze" if global warming switches off an important ocean current in the Atlantic, some scientists say.**

Britain is kept relatively mild in the winter by the warm air blanket brought to us from the tropics by a branch of the Gulf Stream.

We could be heading for much colder winters

But if global warming continues to melt major ice sheets, that supply of warm air could come to an abrupt end, according to a number of experts.

The Gulf Stream relies on a sensitive "conveyer belt" action, which could be "switched off" - quite suddenly - if it becomes diluted by fresh water from the melting ice-sheets, they claim.

Dr Terry Joyce, an oceanographer from Woods Hole Oceanographic Institute, US, believes there is a 50% chance of a sudden climate change happening in the next 100 years.


SEE ALSO:
- Global warming 'could melt Arctic'
  19 Feb 01 | Sci/Tech
- Ocean drift disruption may chill Europe
  25 Nov 99 | Sci/Tech

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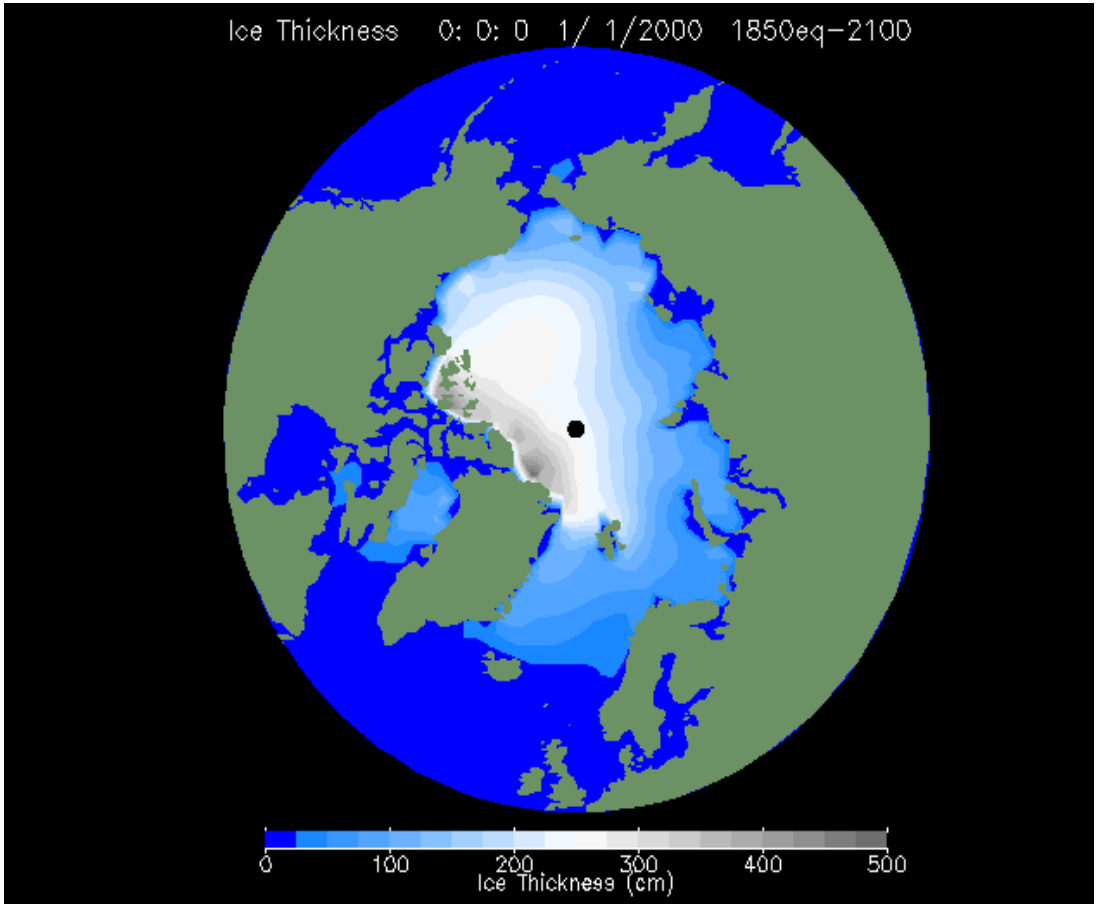
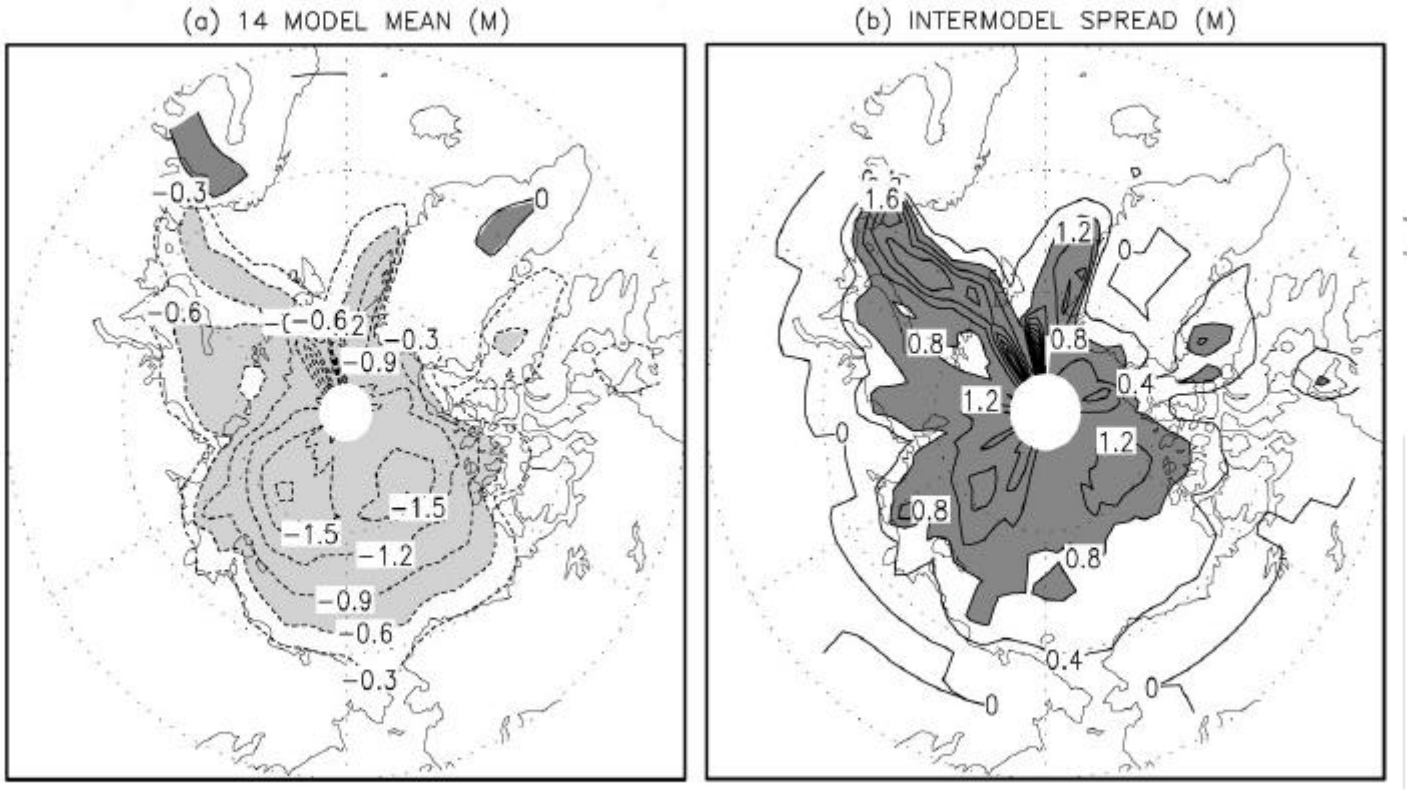
# Predicted change sea ice cover 2080



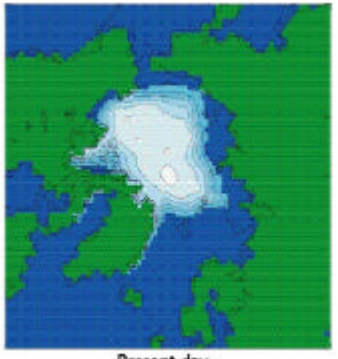
CMIP2 ANNUAL MEAN SEA ICE THICKNESS (SIT)
2XCO2 (YEARS 61–80)–CONTROL (YEARS 1–80)

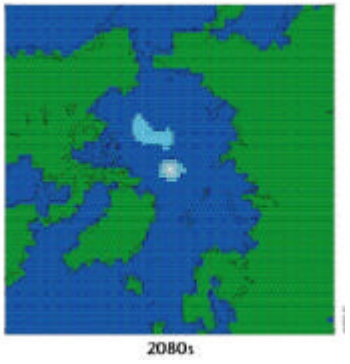


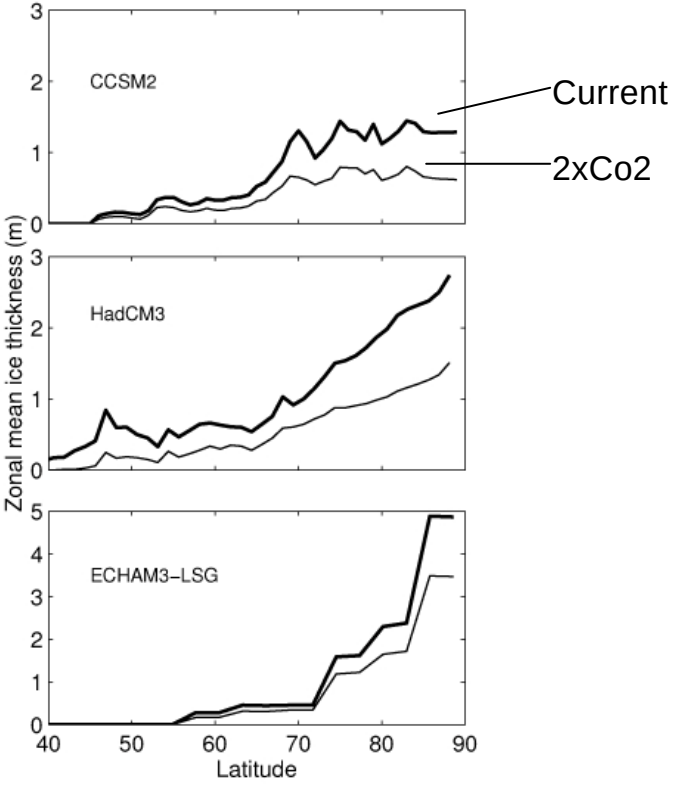

HU ET AL.: ARCTIC SEA ICE AND CLIMATE CHANGES

# GCM Predictions of Arctic Ice

HADCM3
Sea Ice




[Bitz and Roe, J. Climate, in Press]

electronic Telegraph Science

# Sea levels may rise in wake of giant iceberg

**Roger Highfield assesses the implications of a warmer Antarctic revealed this week by satellite pictures**

THE CONTINENT of Antarctica will never be the same again. Satellite images released this week revealed the disintegration of an ice-shelf and the calving of a giant iceberg, roughly the size of Oxfordshire, that dramatically alter the outline of the frozen continent.

The black and white images from a weather satellite, relayed to Cambridge from the British Antarctic Survey's ice base at Rothera, confirm that recent warming of the Antarctic Peninsula is having a major impact on ice sheets in the region. As more ice melts, global sea levels could rise.

The regional climate has warmed by 2.5¡C since the 1940s, the greatest average change in temperature anywhere on the surface of the planet. Though climatologists say that this is consistent with the effects of warming, they add that such upheavals are a normal feature of the evolution of Antarctica's ice shelves.

The shelves shed around 2,020,000,000,000 tons each year but gain a similar amount from snowfall on the continent.

The Electronic Telegraph Wednesday 13 December 1995 World News

electronic Telegraph World News

# Global warming theory is now alarming fact, say scientists

## By Bruce Johnston in Rome

GLOBAL warming is no longer theory but a fact; it is largely attributable to man and threatens to worsen significantly in the next century, with serious health implications, a United Nations-sponsored report says.

The Second Assessment Report, presented in Rome yesterday by experts on the Inter-governmental Panel on Climate Change, forecasts a grim future. This is based on findings recorded since a first report was drawn up in 1990 for the Earth Summit in Rio de Janeiro.

Unless we stop burning combustible materials, the experts warn, we can expect average global temperatures to continue to rise at an even greater rate than the half-a-degree centigrade increase which scientists say they can prove occurred this century.

Over the next 100 years, temperatures are expected to go up by between one and 3.5 degrees - more than the total increase over the past 10,000 years.

Sea levels, which rose by 10-25 cm this century, could rise by another four times. The frequency of climatic extremes already experienced this century is likely to increase.


# Royal Geographical Society: Professor pours cold water on flood idea

## By Robert Uhlig, Technology Correspondent

THE commonly-held belief that global warming will lead to melting of polar ice-caps and worldwide flooding because of rising sea levels was disputed yesterday by the vice-president of the Royal Geographical Society at its annual conference in Glasgow.

Prof David Sugden, of Edinburgh University, suggested that if global temperatures rise, the East Antarctic Ice Sheet - which accounts for two-thirds of the Antarctic's surface - will get larger because of increased snowfall due to the higher temperatures.

For more than 10 years scientists have speculated as to whether the East Antarctic Ice Sheet disappeared in the Pliocene period, three million years ago.

Many scientists see the Pliocene as an analogy for the future, as the average temperature of the world then was a few degrees warmer than it is now.

International News
Thursday 13 November 1997

Electronic Telegraph
Issue 983

[redacted]

# World 'may be on brink of ice age'

**By Roger Highfield, Science Editor**

External Links

- MIT Centre for Global Climate Change Science
- National Institute for Global Environmental Change
- Climate Crisis - Greenpeace

**EVIDENCE that the world's climate may be poised for another ice age has come from studies of ocean sediments published today.**

**However, the scientists who made the find, reported in the journal Nature, say it is difficult to estimate how carbon dioxide emissions linked to global warming are influencing the recurring pattern of ice ages.**

**The analysis of sediments from near Bermuda suggests that the last warm "inter-glacial" period stretched from about 118,000 to 127,000 years ago.**

**The first author, Dr Jess Adkins of the Massachusetts Institute of Technology, pointed out that the present warm period - the Holocene - has been stable for around 9,000 years.**

Given that the last interglacial period lasted around 9,000 years, the time may be ripe for another ice age. "The global climate system seems to be poised at one of **these thresholds," he said. "This would be the logical conclusion if there were no**

EVENING STANDARD
Tues 7/12/99.

News & City

# South-East 'under water in 200 years'

*by Tim Barlass*

Sea levels could rise by 70 metres within 200 years, leaving London and much of lowland Britain under water, according to new research into the melting of polar ice sheets.

Continued global warming would mean that our near descendants would never know most of Kent, East Anglia, Hampshire and Oxfordshire. The South-East would become a seascape broken only by the emerging islands of the Chilterns, the North and South Downs and the Weald.

**Today's Top News**

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- Leg amputee gets £600,000 pay-out
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Last Updated: Wednesday, 28 July, 2004, 13:53 GMT 14:53 UK

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# Greenland ice-melt 'speeding up'

By David Shukman
BBC environment and science correspondent in Greenland

First you hear a savage cracking sound, next the rolling crash of thunder.

Then as the icebergs rip away from the margin of the ice-sheet they plunge into the grey waters of the Atlantic with a roar that echoes around the mountains.

Nothing prepares you for the sheer scale and drama of events in this forbidding terrain and all the signs are that the changes at work here are gathering pace.

The only way to reach the ice-sheet is by helicopter - a spectacular flight through remote fjords and the jagged blue-white rubble of the ice.

In some places, the ice is melting one metre a month

WATCH AND LISTEN

**The BBC's David Shukman**
"The rate of melting is far beyond what normally happens in summer"

VIDEO

Global warning? In Depth

**Animated guide**
Find out why the Gulf Stream might slow and how the greenhouse effect works

KEY STORIES

- Sea engulfing Alaskan village
- Southern Spain 'dust bowl' threat
- Maldives: Paradise soon to be lost

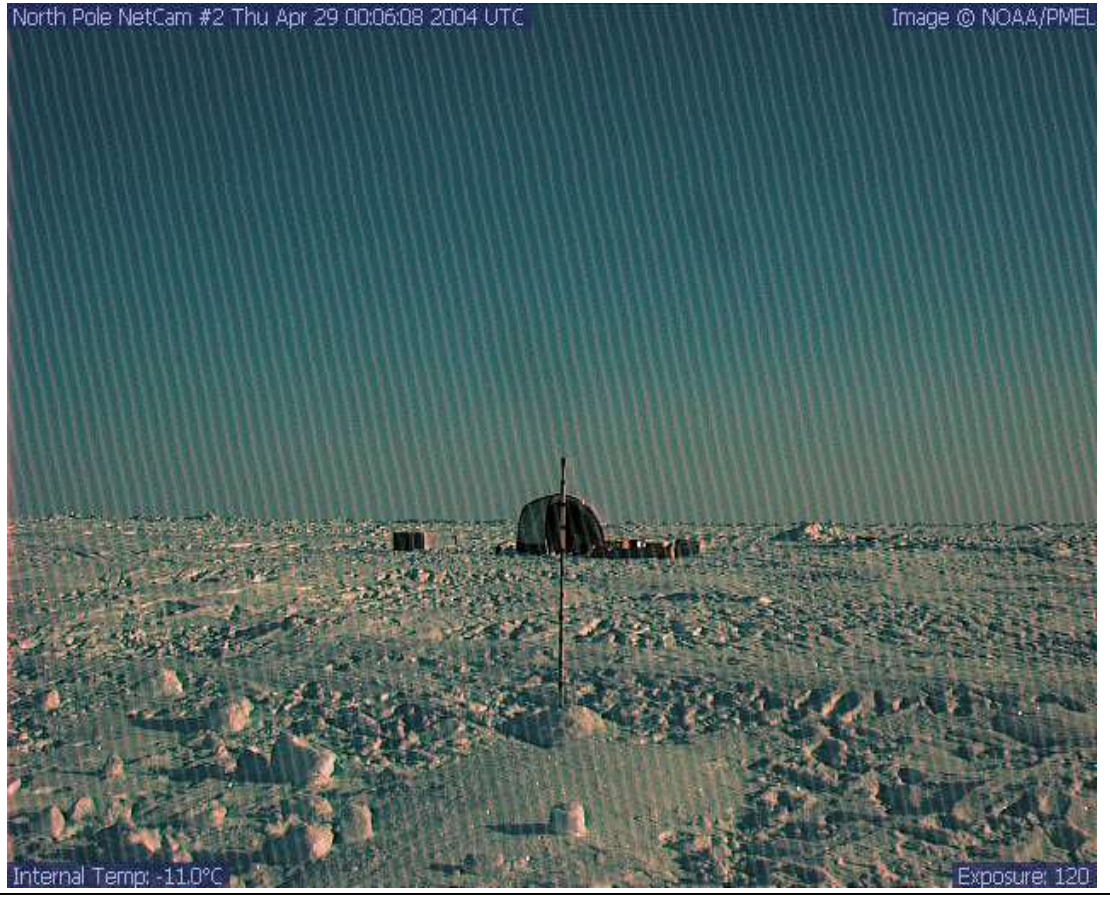
BACKGROUND

- Q&A: Climate change
- Q&A: The Kyoto Protocol
- Climate: What science can tell us
- The big greenhouse gas emitters

# Why is the picture so confusing?

- **Interactions of the cryosphere with the climate are very complex**
- **The polar regions are very large but inhospitable and so are very poorly observed**
- **Models of the cryosphere are poorly constrained and therefore contain many uncertainties**

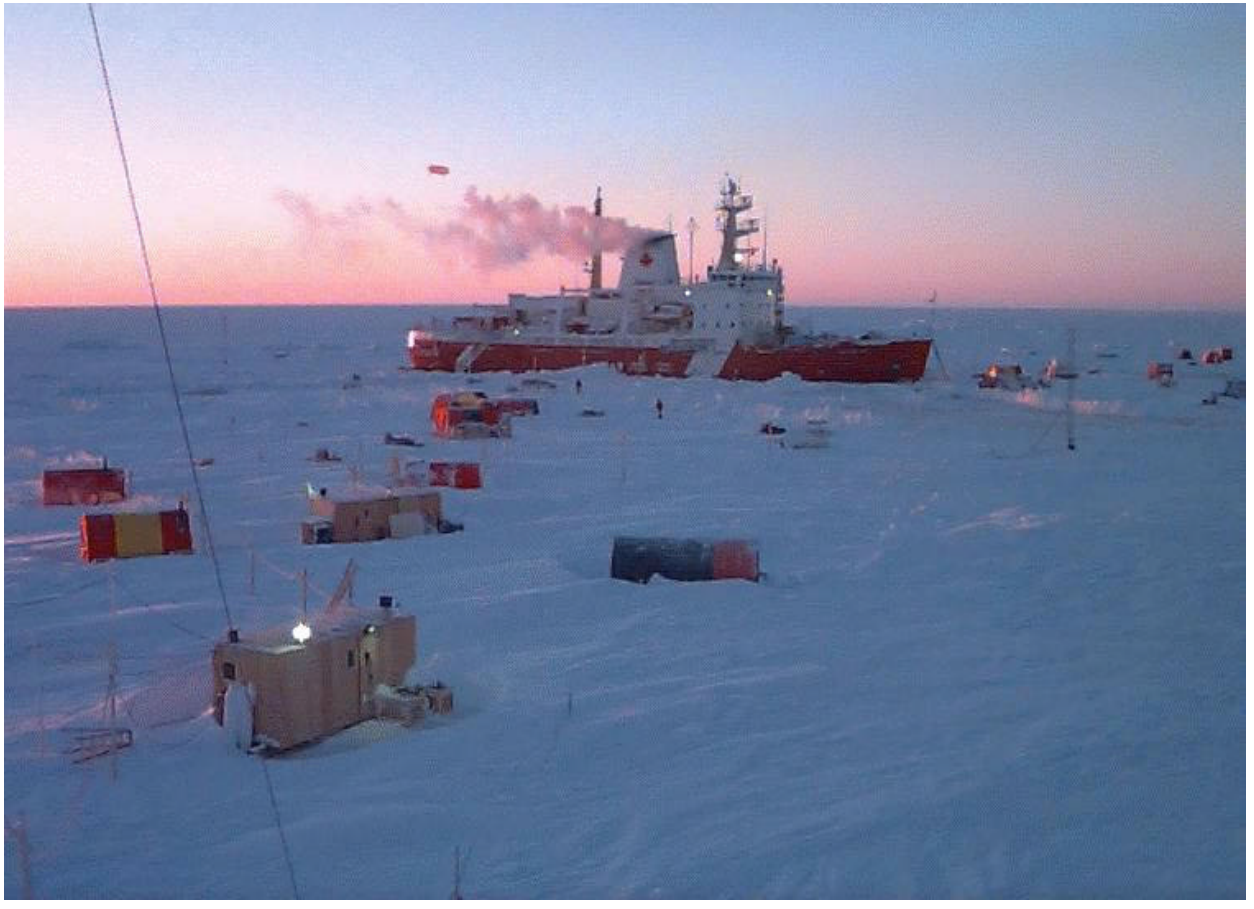
# Live from the North Pole



# Live from the North Pole

# October

# November



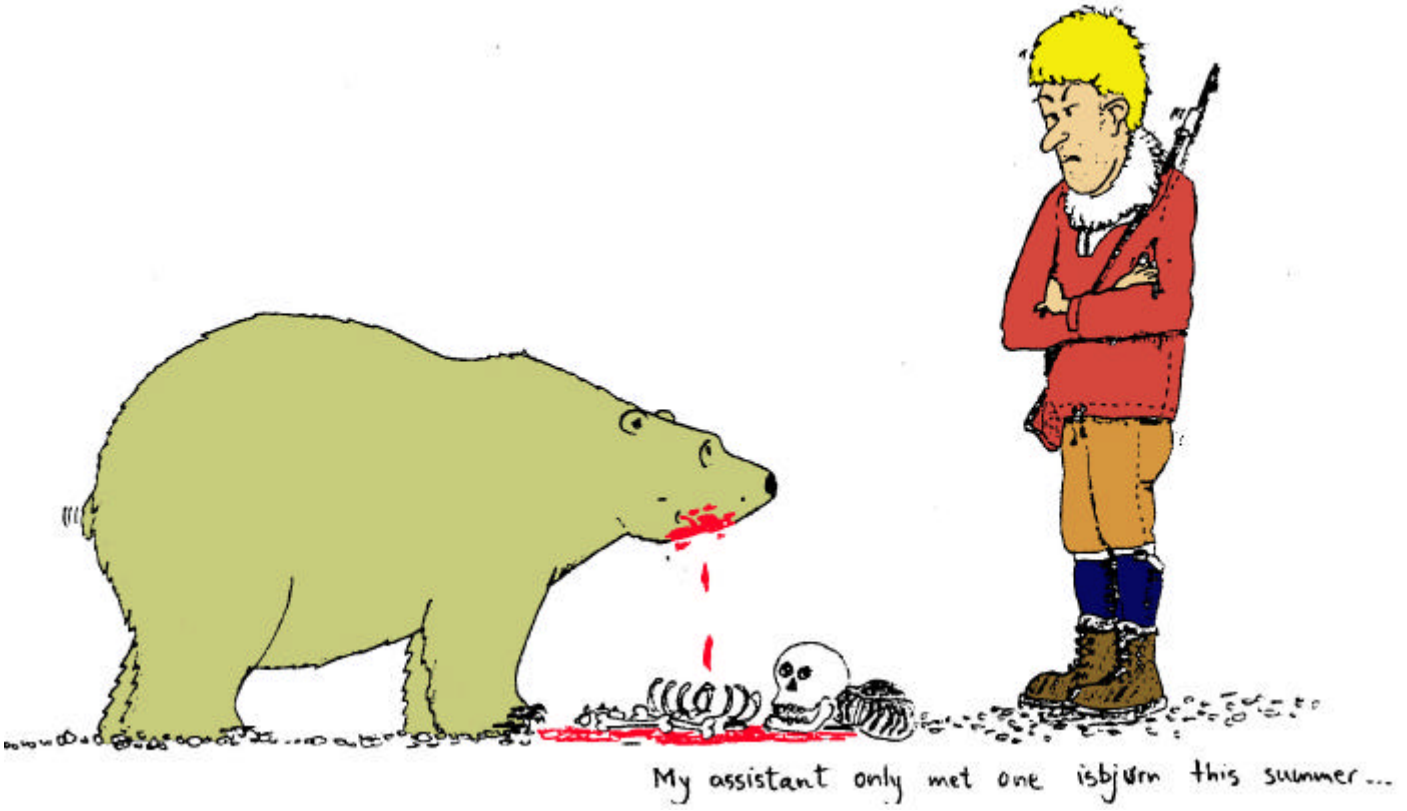
# December

# The Dangers of Working at the Poles

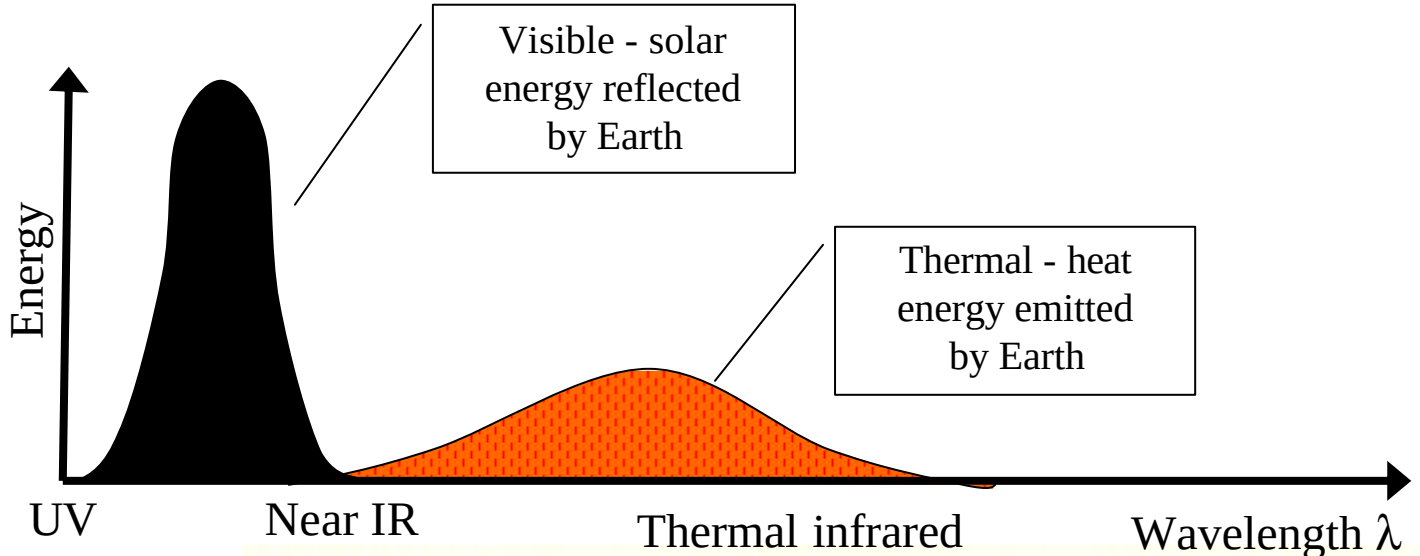
QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

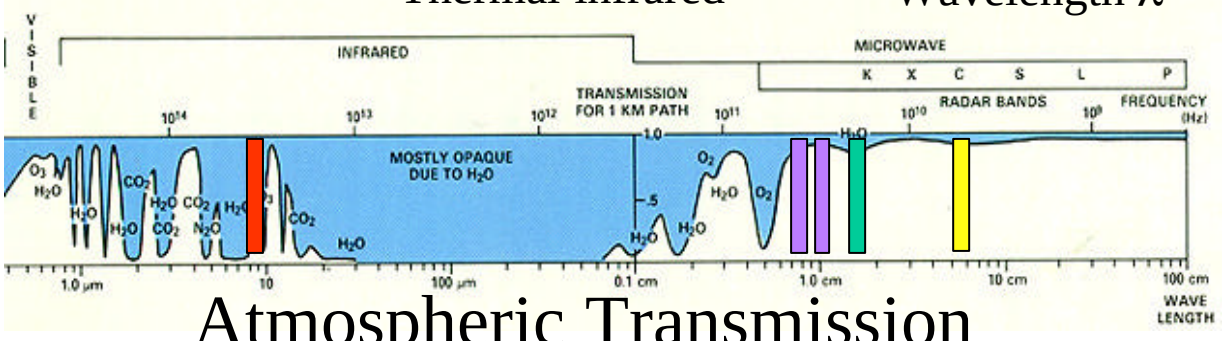


# The Dangers of Working at the Poles

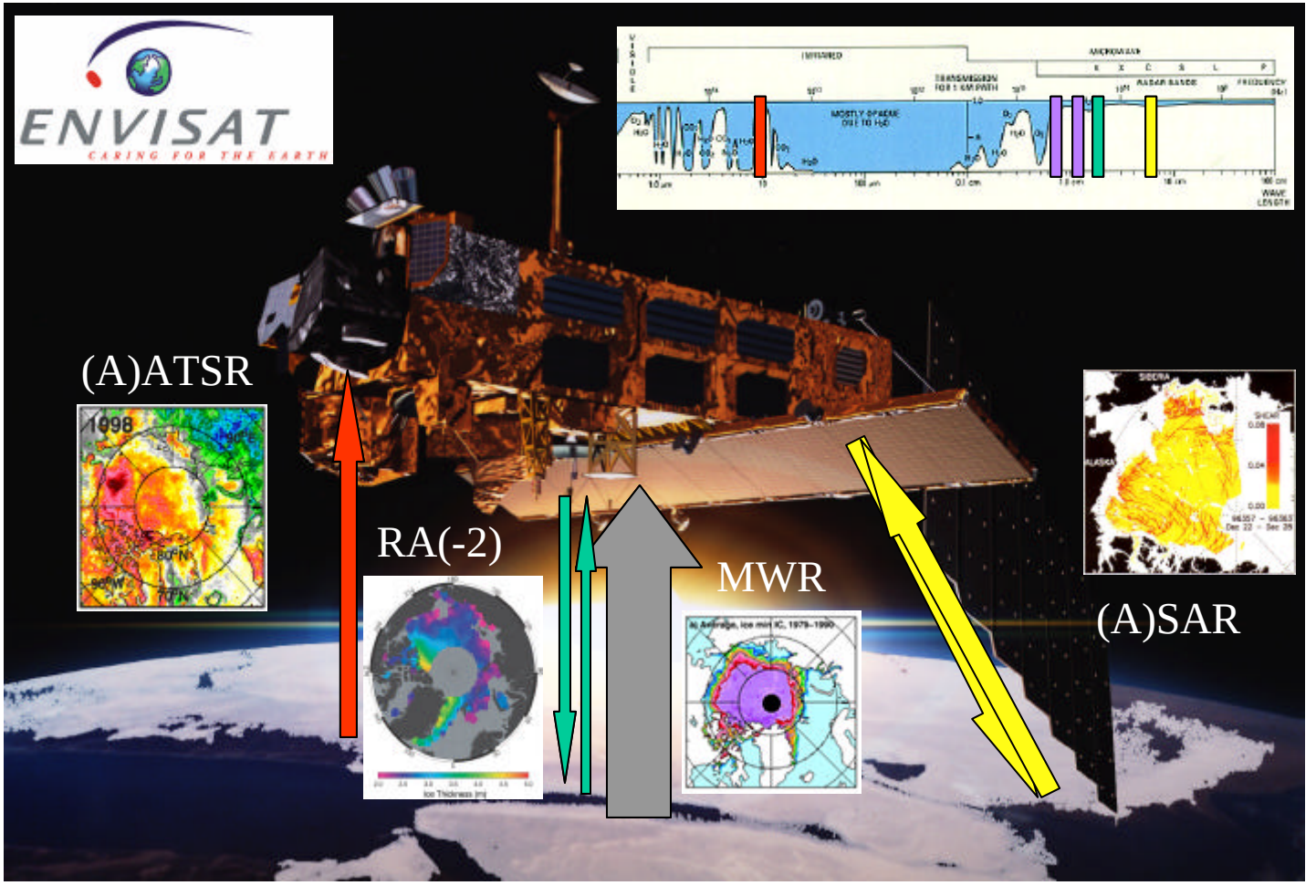


# Solar & Terrestrial Emission




Atmospheric Transmission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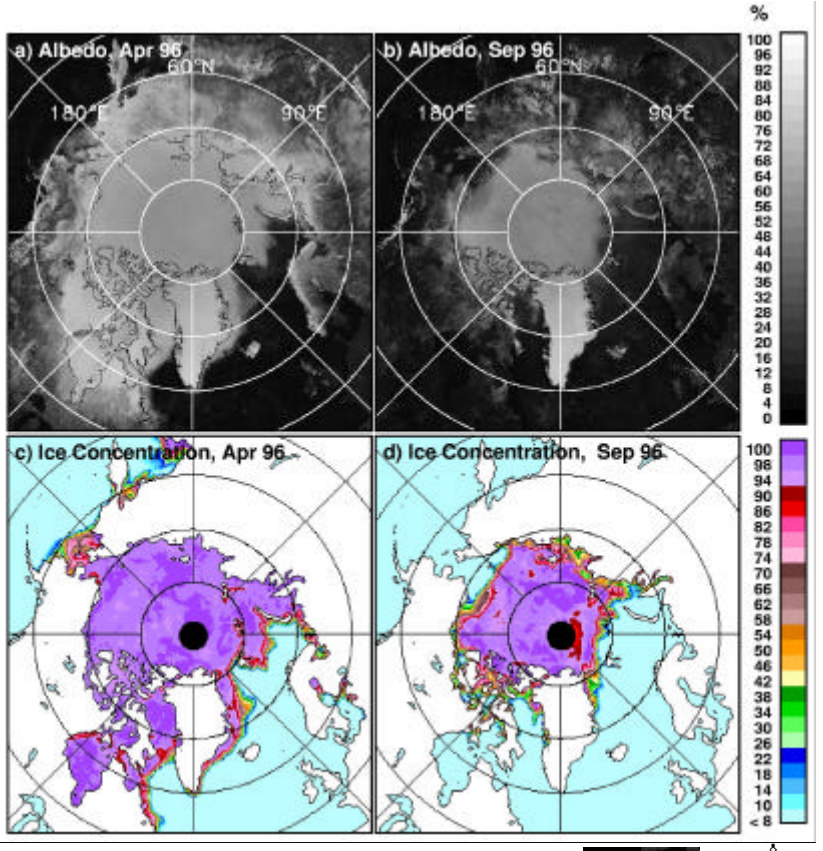
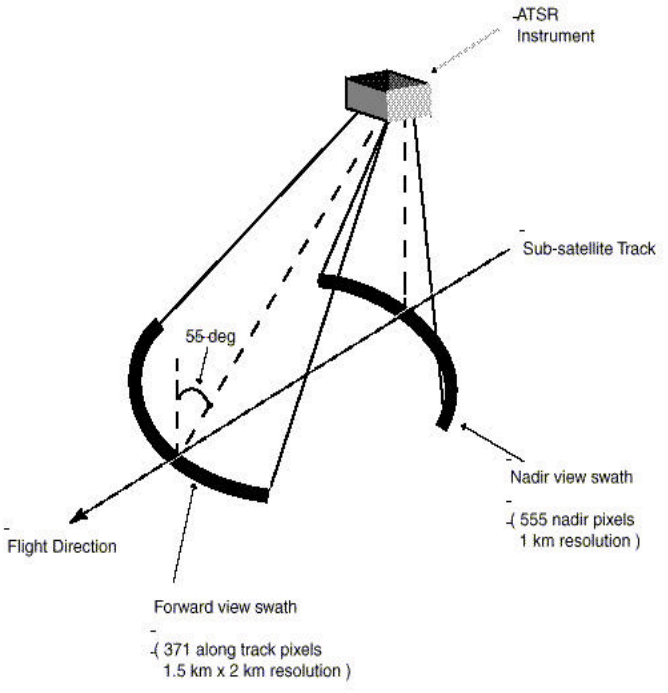
CARING FOR THE EARTH
(A)ATSR
1998
RA(-2)
MWR
(A)SAR

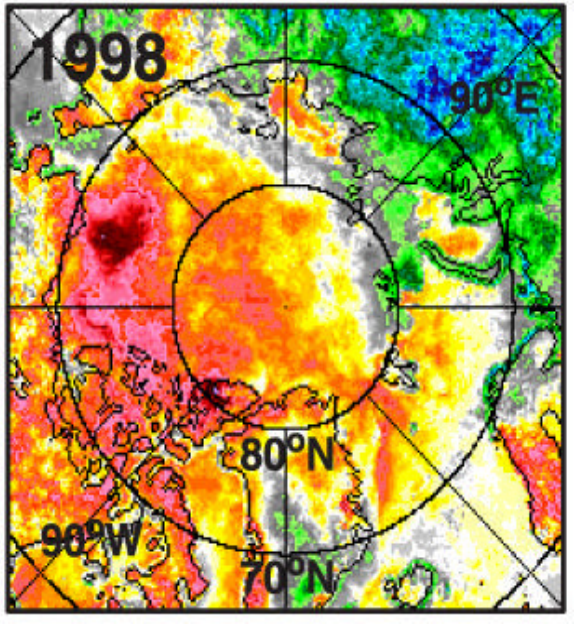
# Sea Ice Cover in the NH using visible and passive microwave data

- **Visible channels provide direct measurement of surface albedo and ice cover but coverage is limited by clouds and darkness.**
- **Passive microwave data provides day/night almost all weather coverage.**



# Sea Ice Temperature from thermal readiometry

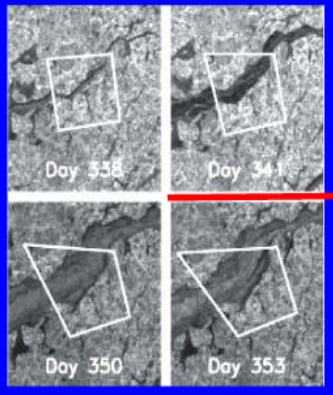


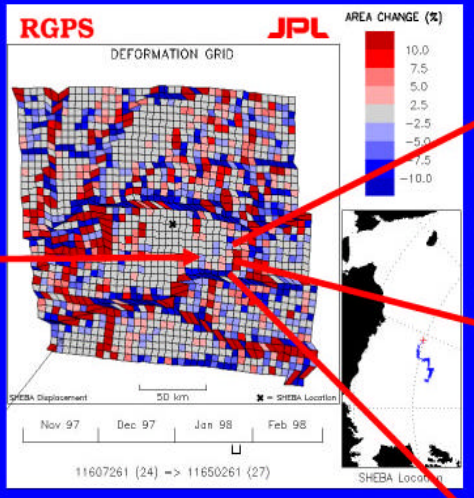



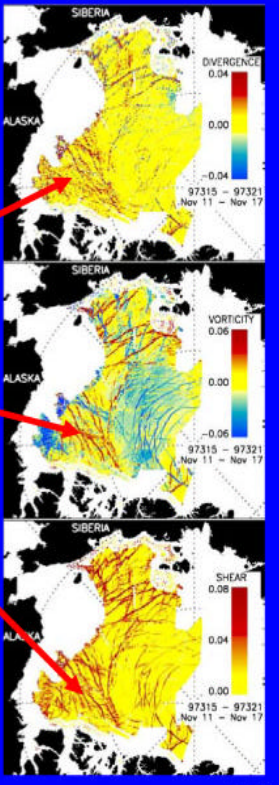
# Kwok

# Lagrangian Observations of Ice Motion and Deformation: RGPS

3-day sampling

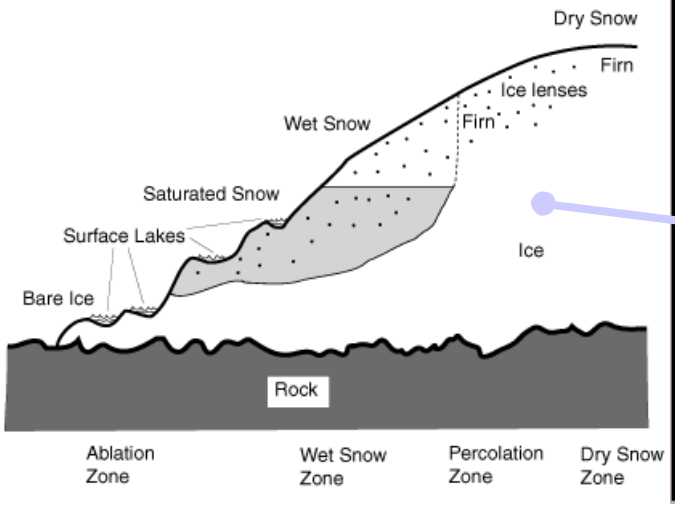


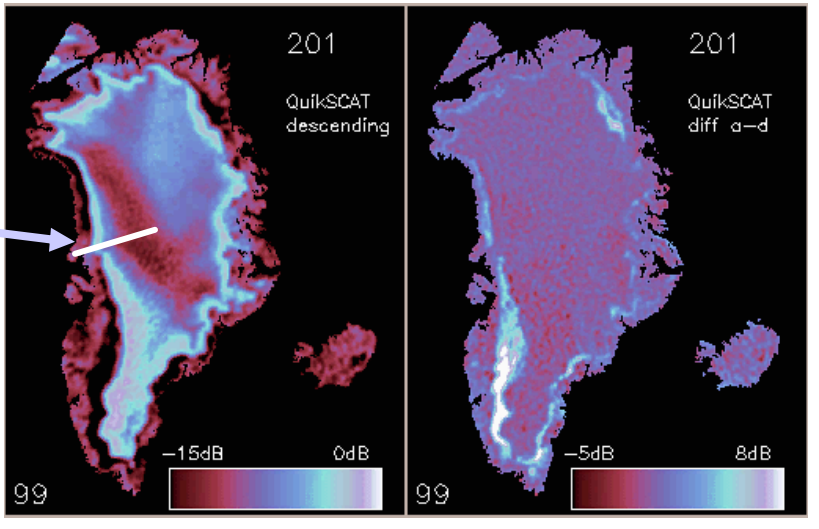



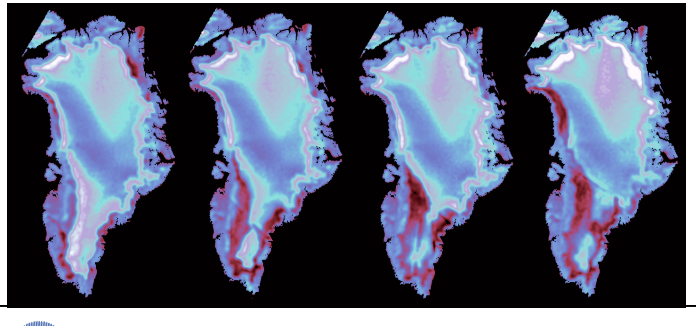




$10^1$ km → $10^2$ km → $10^3$ km

# Greenland Summer Melt



**Liquid water in snow and firn changes the radar backscatter which can then be used to map the extent of the summer melt**

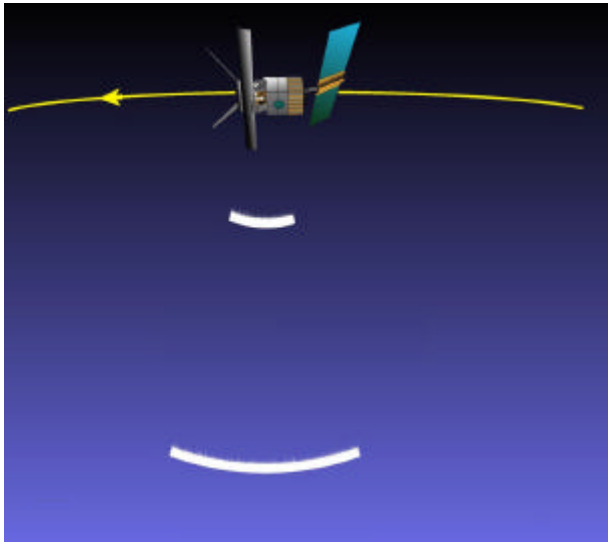
****Albedo & Energy Balance**

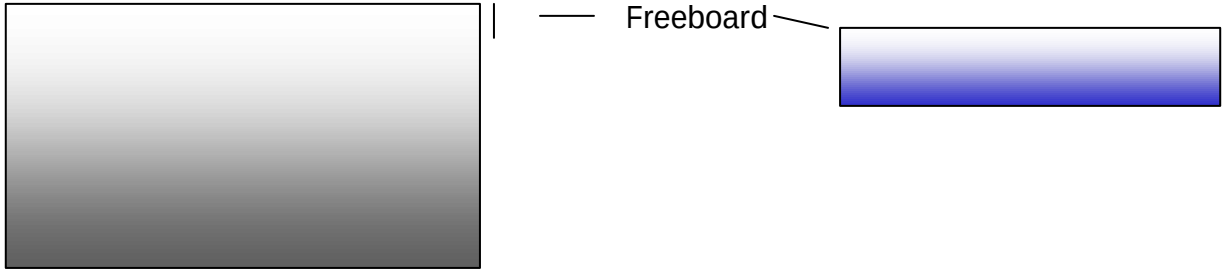
# Satellite Altimetry

QuickTime™ and a
H.263 decompressor
are needed to see this picture.

# Satellite Altimetry - Measurement Principle

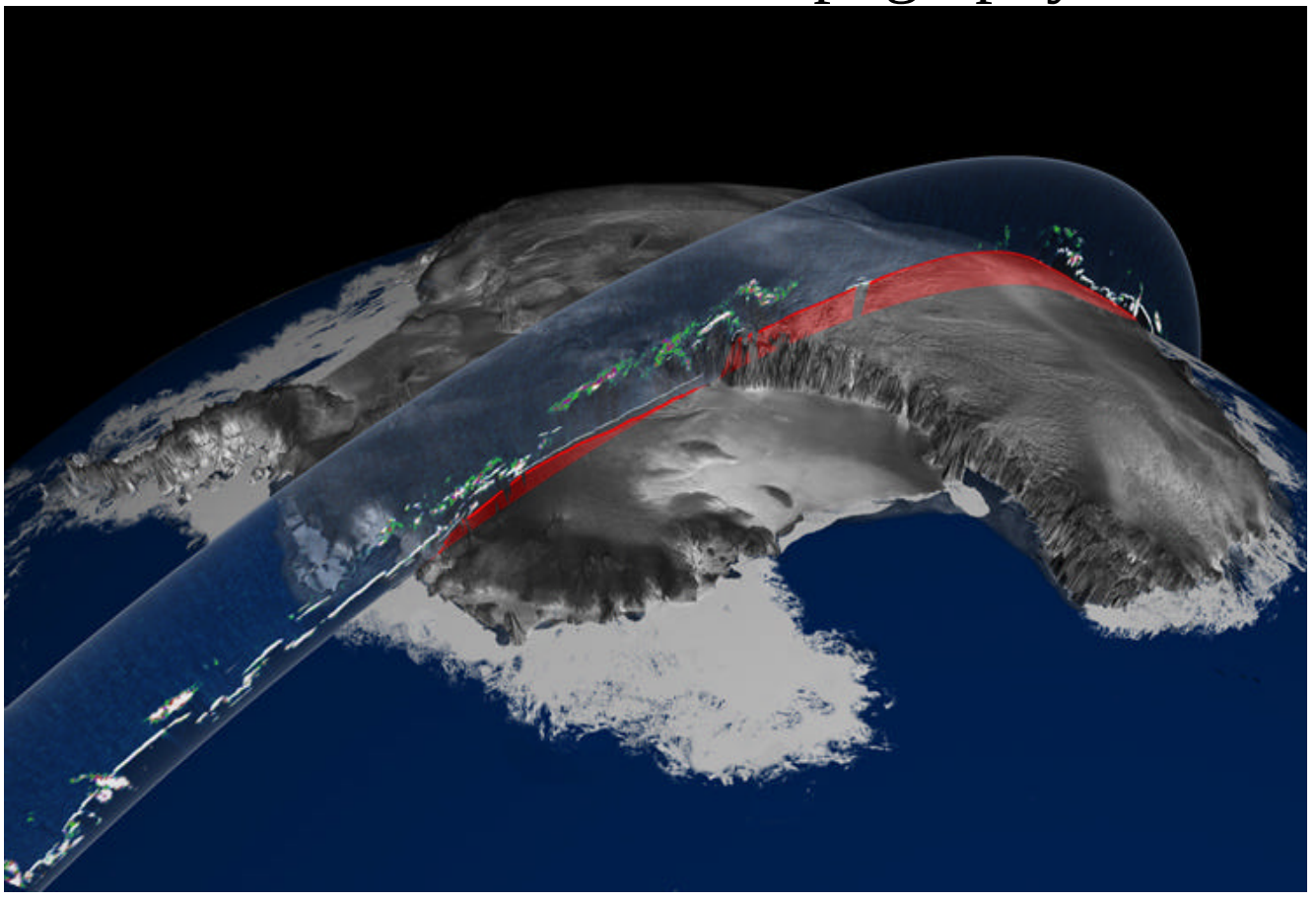
$$h = \frac{ct}{2}$$

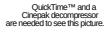




# ICESat

# ICESat Antarctic Topography






Courtesy
Tom Agnew