

Climate Change and the Antarctic: What Next?

SCAR Lecture 2nd May 2007 Delhi

Chris Rapley

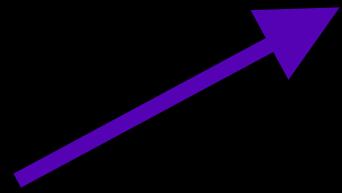
President of SCAR

Member ICSU-WMO Joint Committee for the IPY 2007-2008

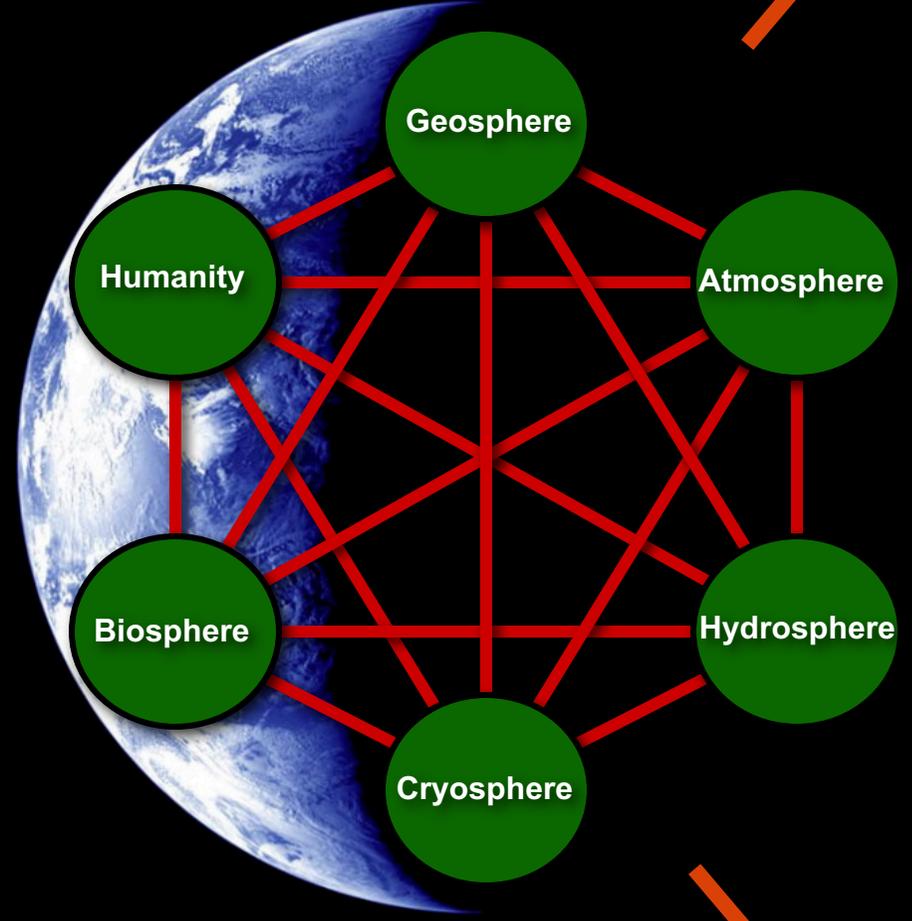
Director British Antarctic Survey



Earth System



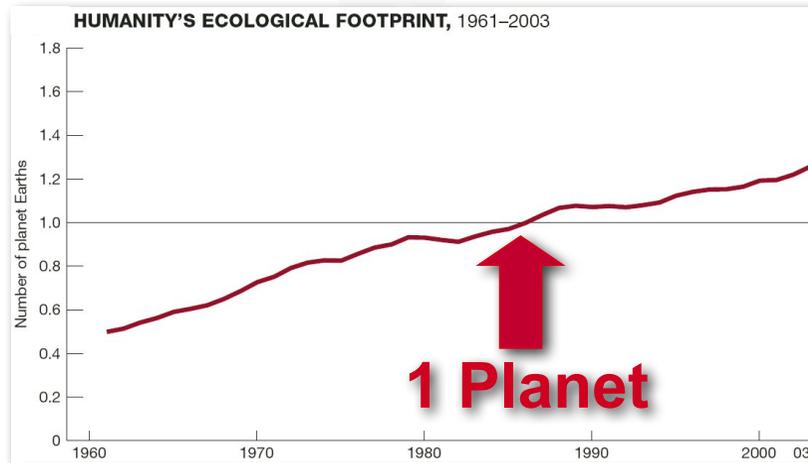
Other
Astronomical



Earth System

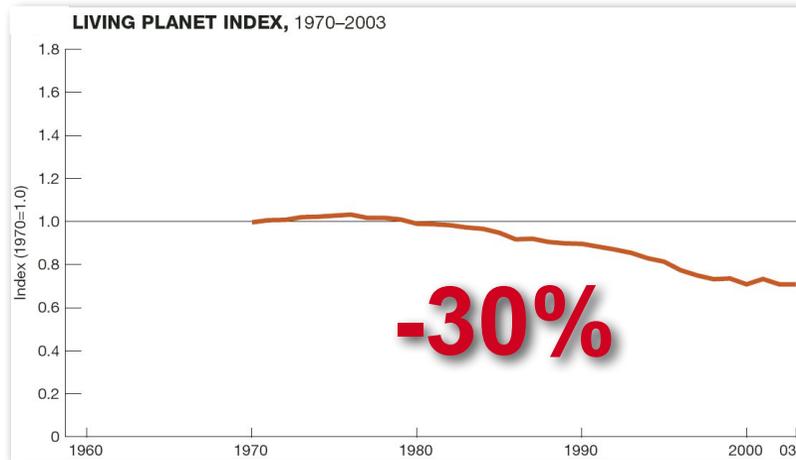
- Most complex in the Universe
- Energised by Sun
- Functions as integrated whole
- Vast range of scales
- No User's Manual
- Finite - No Spares!
- Provides "Ecosystem Services" Essential for Life
- "Unhealthy State" - Driven by Humans

Human Footprint



Human Ecological Footprint

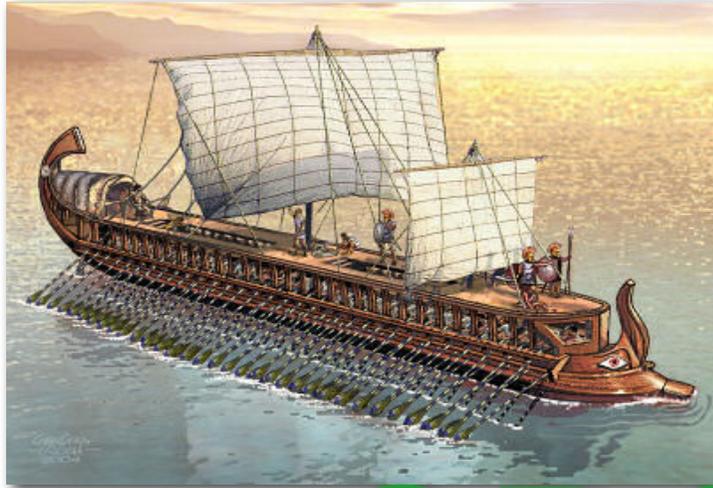
Area of biologically productive land and water needed to provide ecological resources and services used by humanity



Living Planet Index

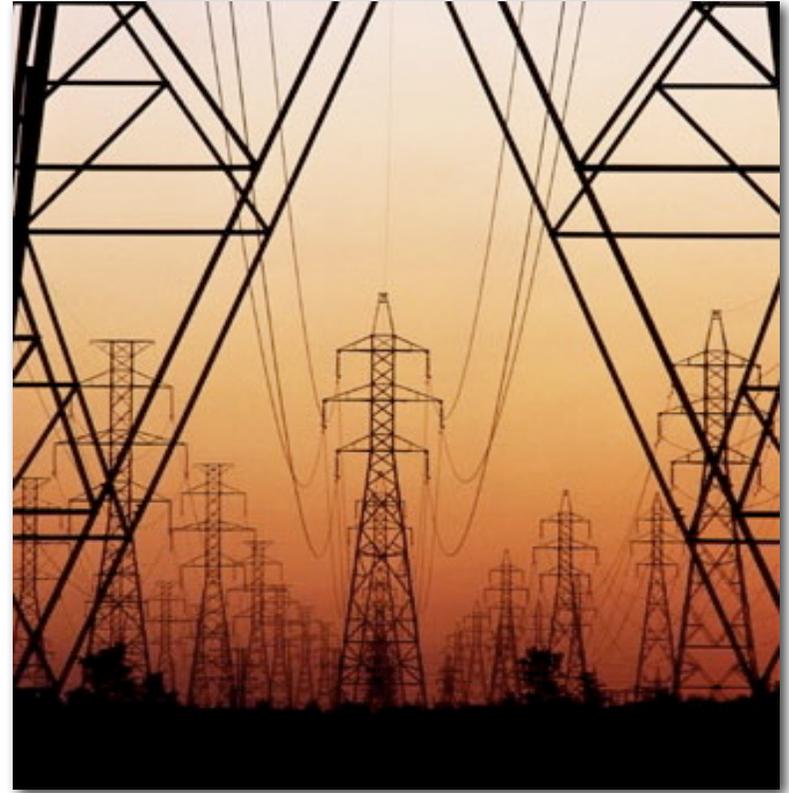
Based on populations of 1313 vertebrate species worldwide





ORGANIC

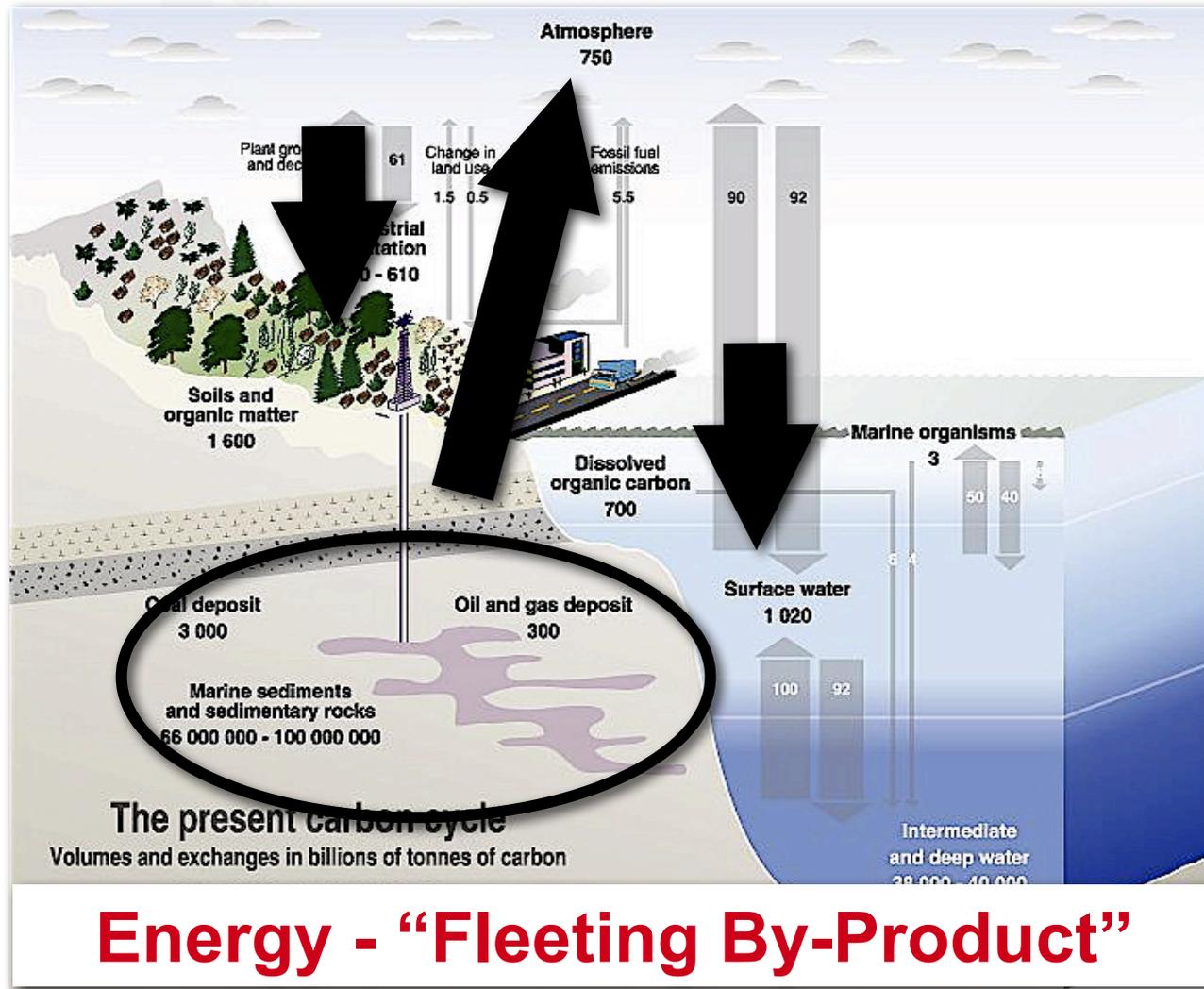




FOSSIL



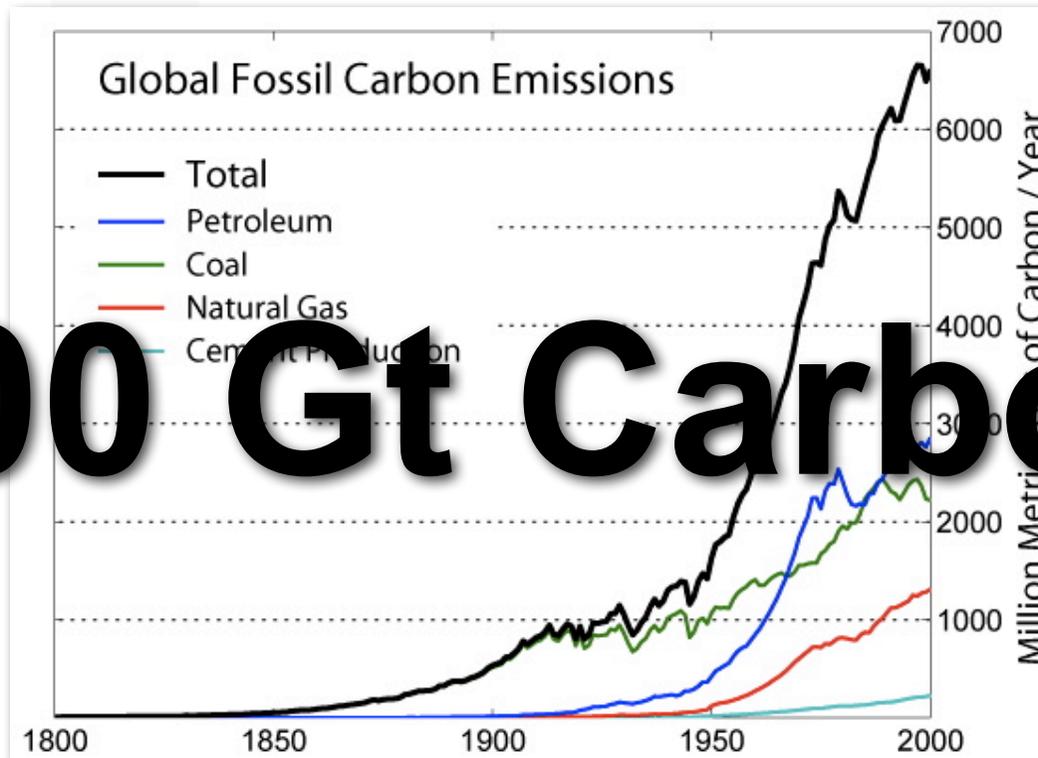
Carbon Reservoirs & Transfers



Energy - "Fleeting By-Product"

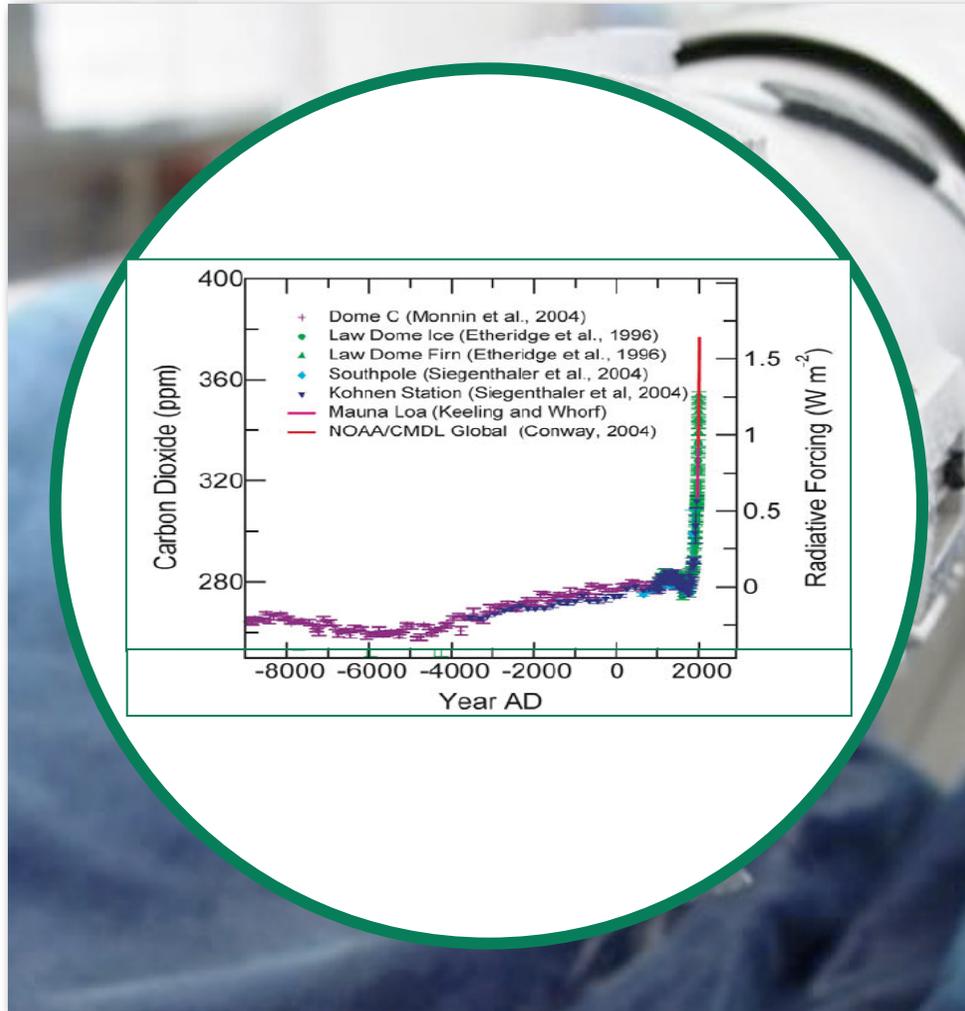


Carbon Emissions

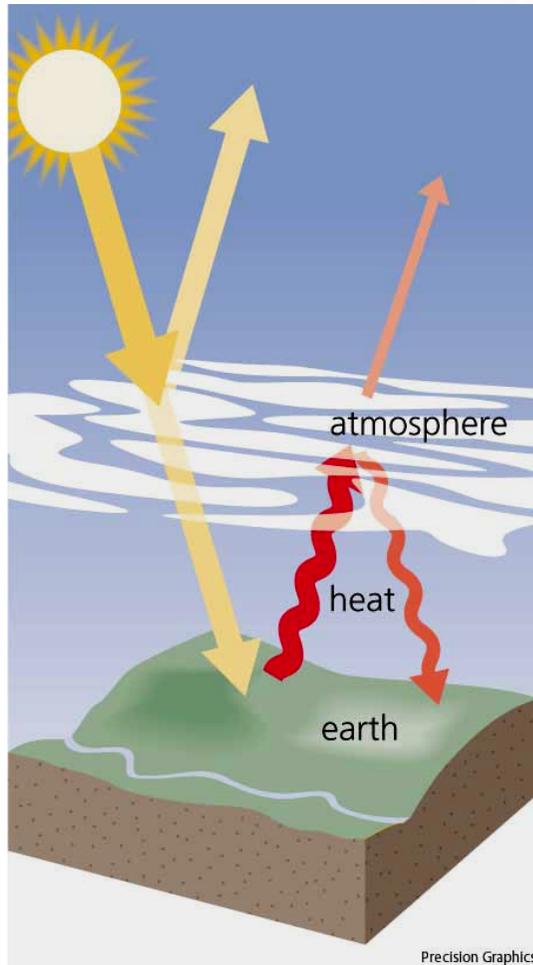


500 Gt Carbon

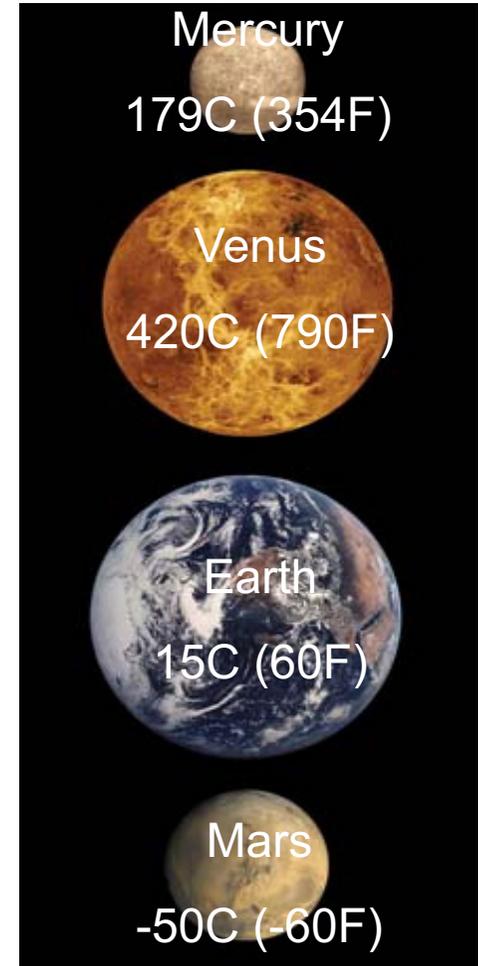
Transforming the Atmosphere



Greenhouse Effect



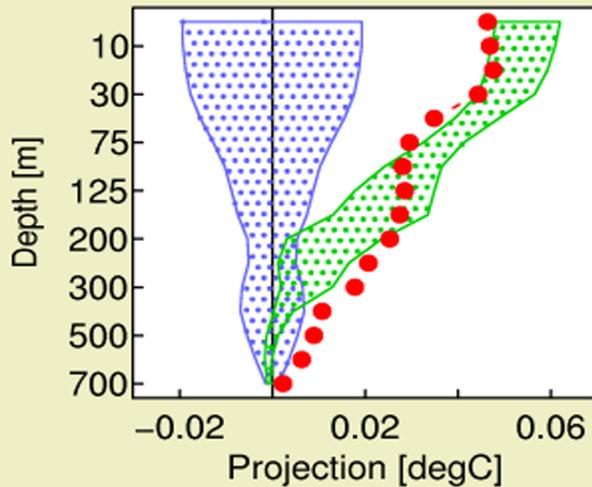
- **C19th physics**
- **Verified by data from Mars, Venus & Mercury**
- **Surface would be frozen over! Without it**
- **30°C warmer**
- **So a “good thing”**
- **Adding CO₂ increases greenhouse effect directly**
- **And by increasing water-vapour content**
- **System currently out of balance by $\sim 1.5\text{W/m}^2$**



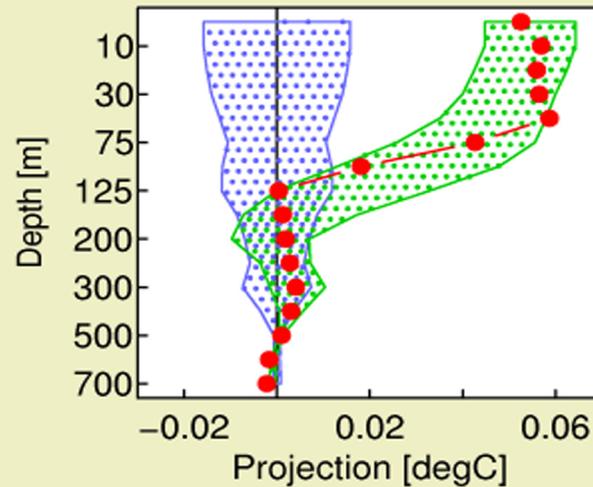
Global Warming of the World's Oceans

(T.P. Barnett, et al 2005)

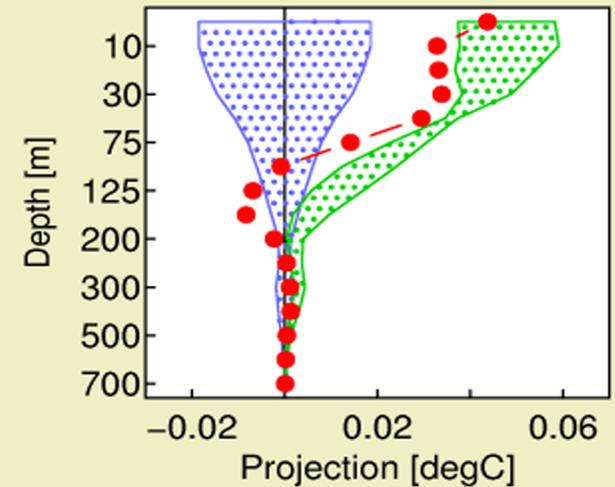
North Atlantic



North Indian



North Pacific



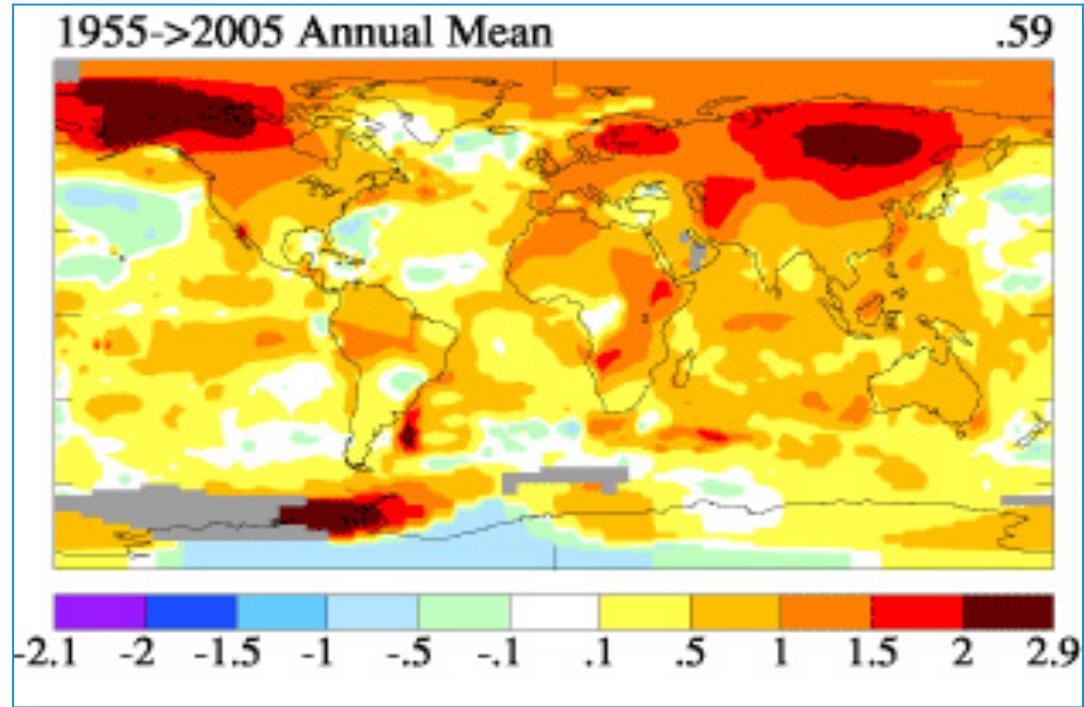
Key: No Anthropogenic Forcing (Blue)

With Anthropogenic Forcing (Green)

Observational Data (Red)

>90% of increased heat storage goes into the oceans

Warming - Amplification at Poles



Hansen *et al.*, 2005

“Ice-Albedo” feedback in areas covered with ice and snow



**IPCC Fourth Assessment Report
Climate Change 2007 : The Physical Science
Basis – Summary for Policy Makers**

**Atmospheric GHG concentrations far exceed
levels of last 650,000y as a result of human
emissions**

**Warming of the climate system is
“Unequivocal”**

**Climate forcing primarily Human (x10 solar)
Agreed by Delegates of 113 nations
Conservative?**



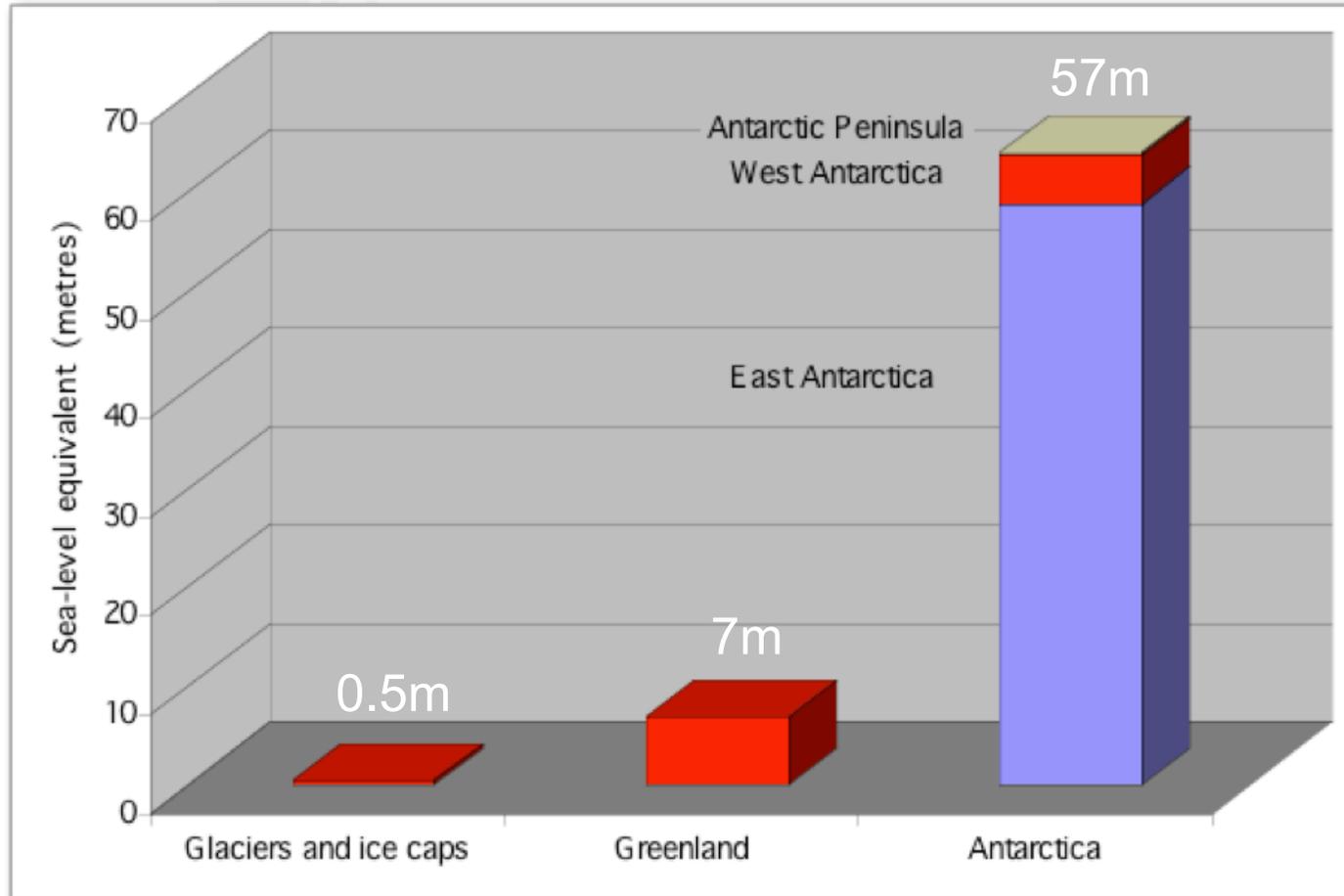


In a Warmer World Ice Retreats





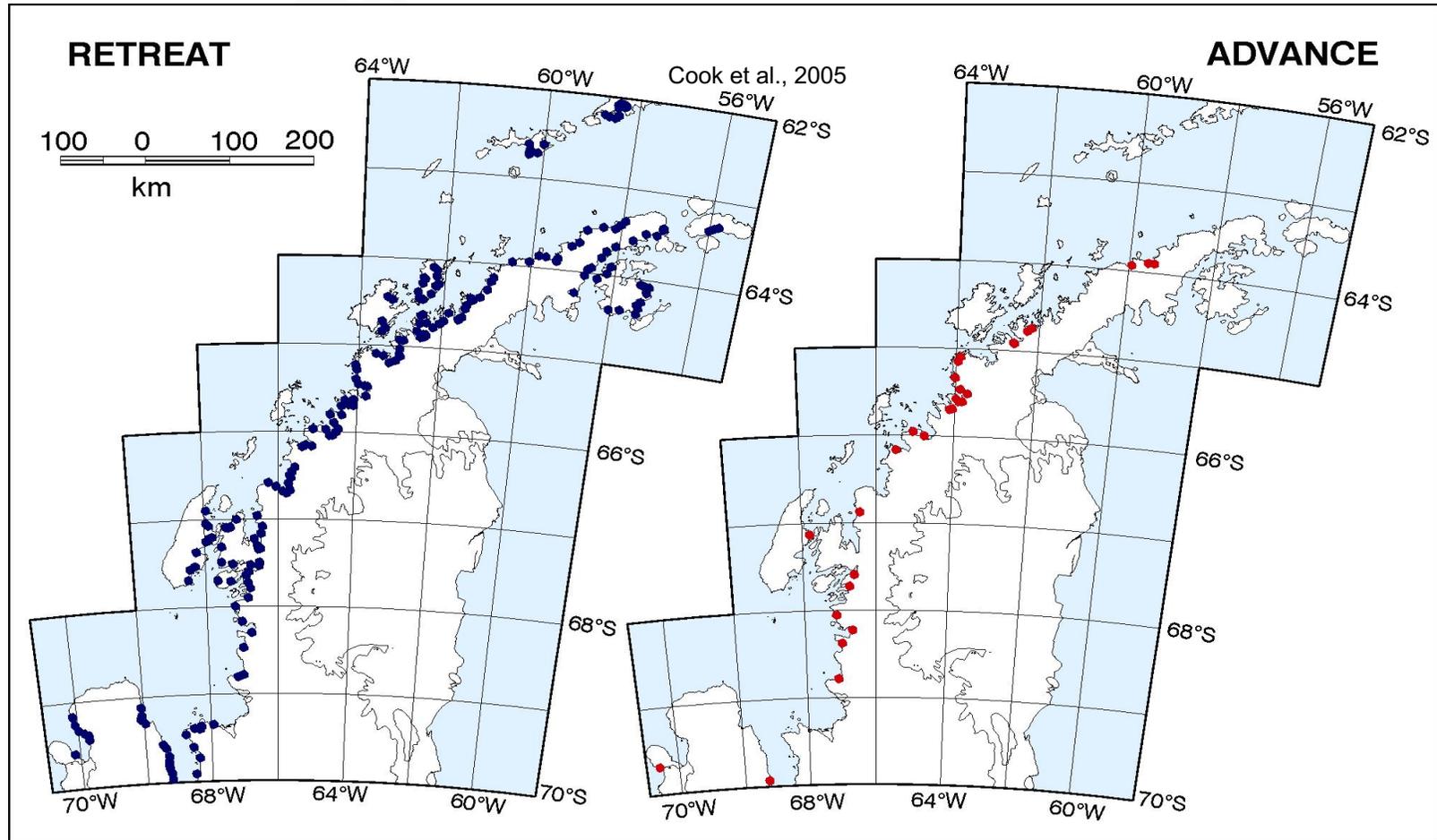
Sea Level Rise Potential



Antarctica



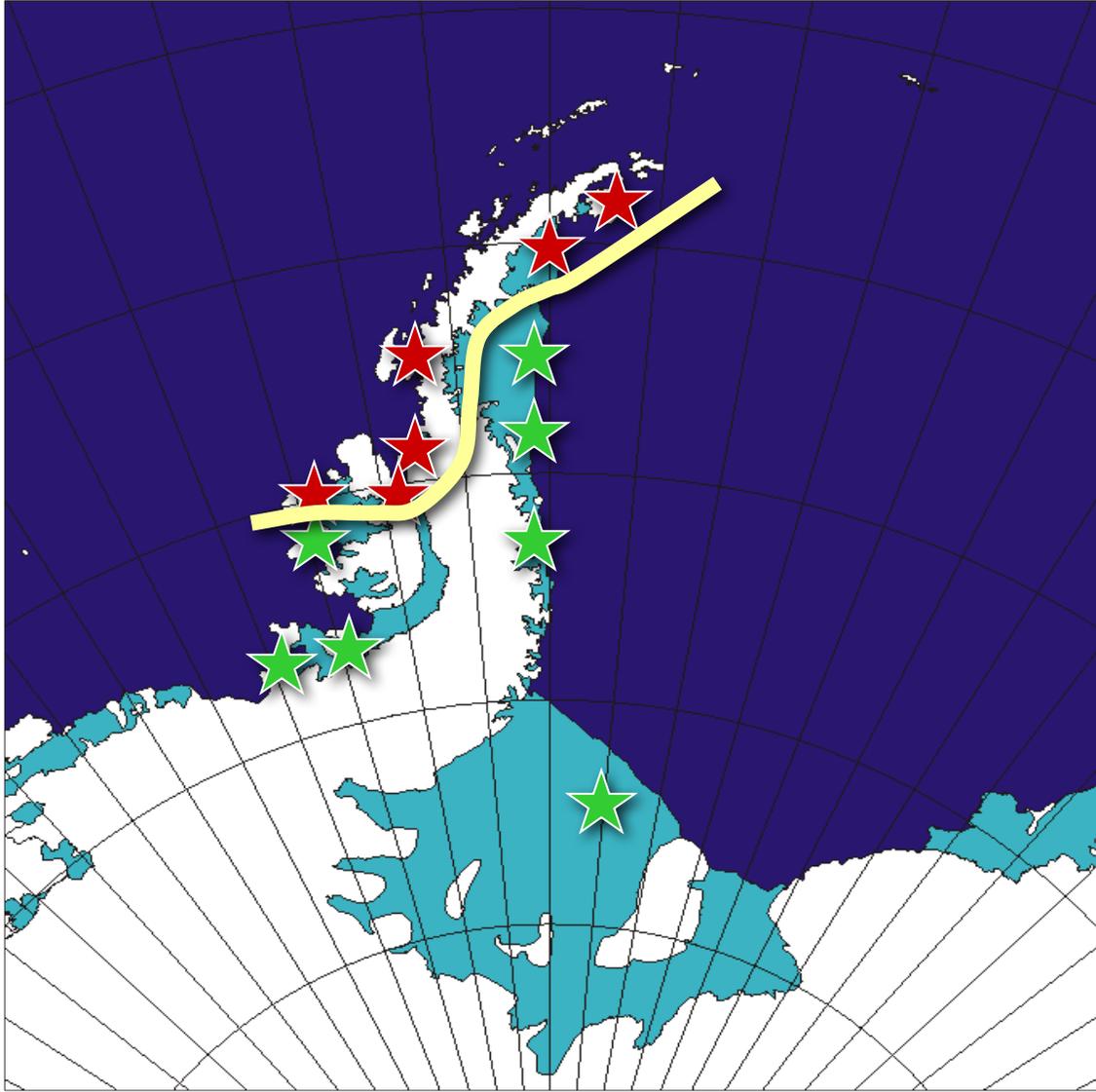
Antarctic Peninsula Glacier Responses



244 glaciers : 87% have retreated over last 50y

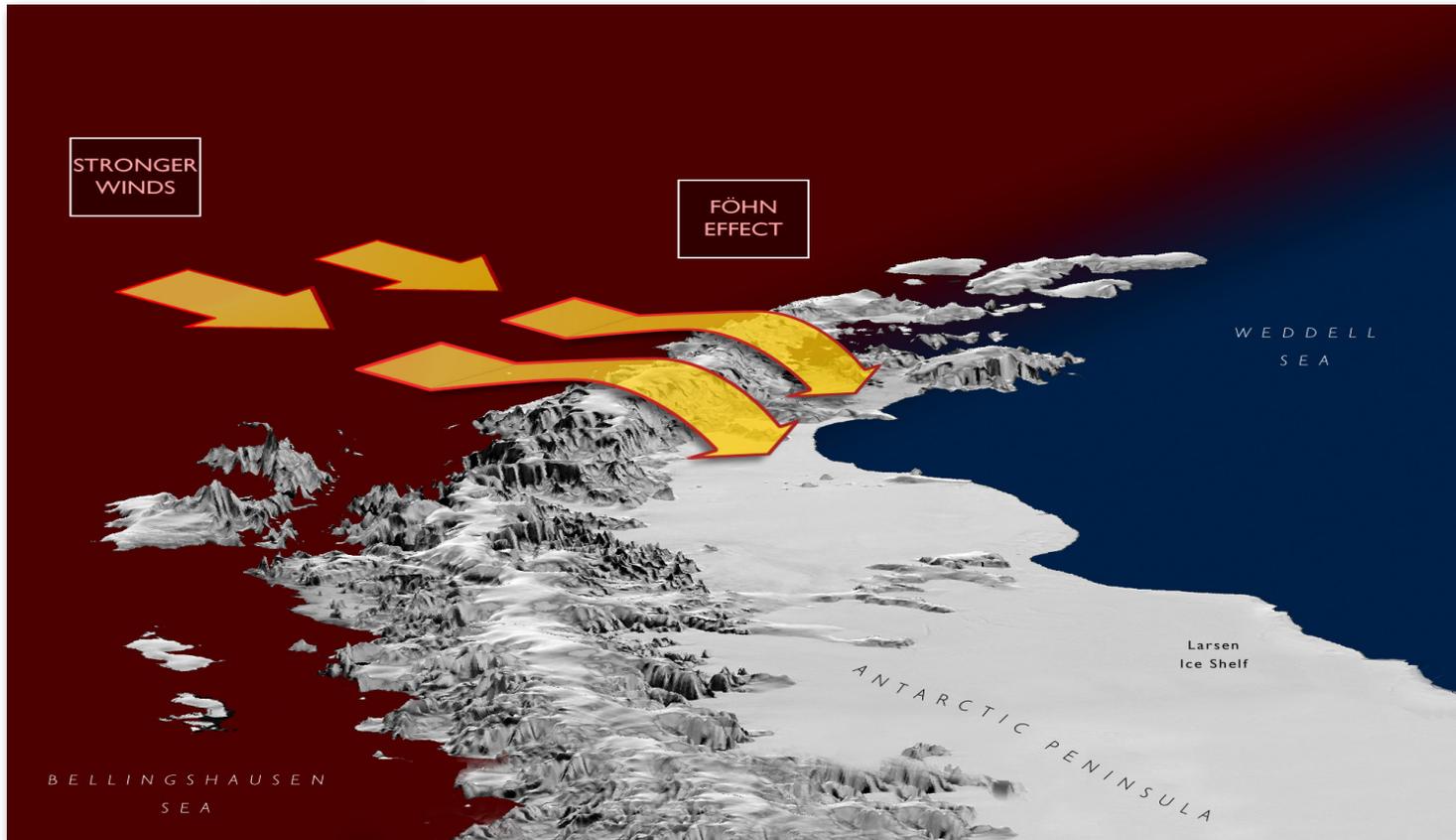


Antarctic Peninsula Ice Shelf Disintegrations



- Summer surface melting the key
- Northern ones absent 3-5ky ago
- Larsen B in place for 10(s)ky

Peninsula Warming and Ice Shelf Break-Up



Attributes progressive wave of warming to human-induced enhanced greenhouse effect and ozone hole

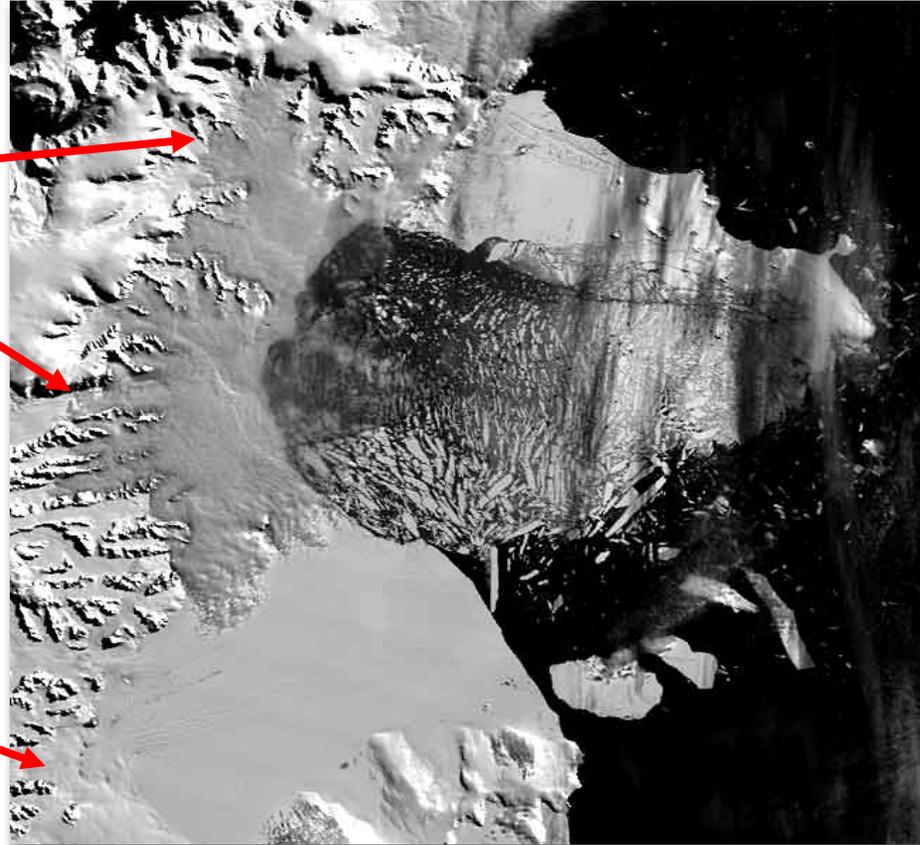
Marshall et al (2006)



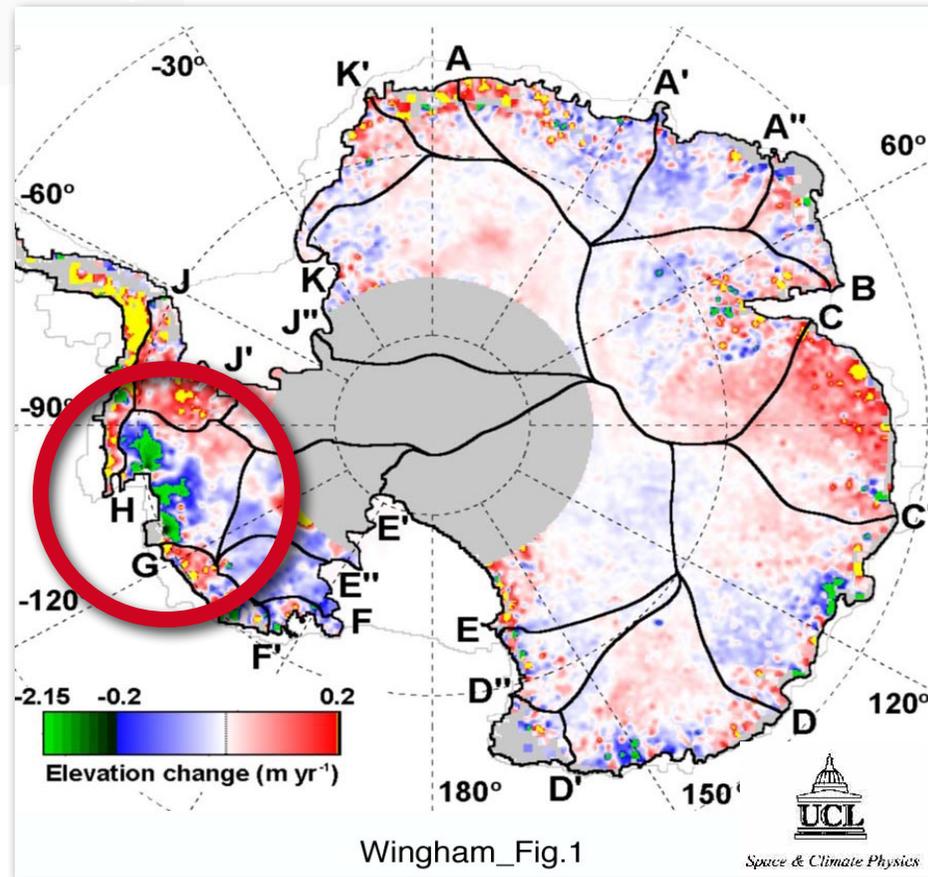
Larsen B Collapse

**Glaciers
accelerated**

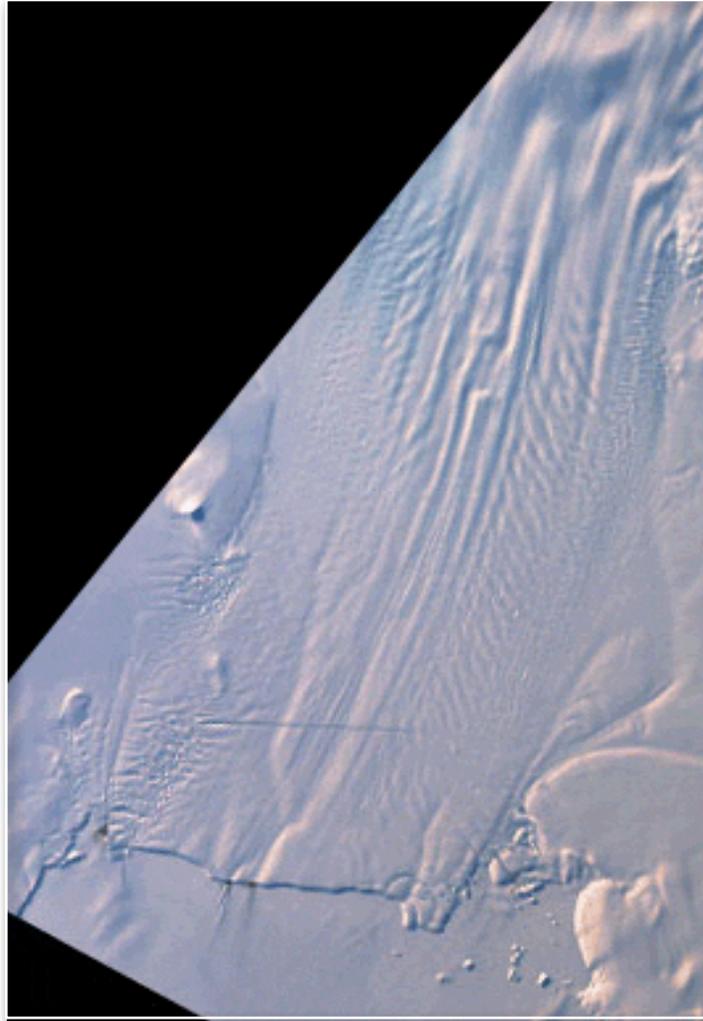
**Glacier
stable**



Antarctic Mass Balance



West Antarctic Ice Sheet Iceberg Calving

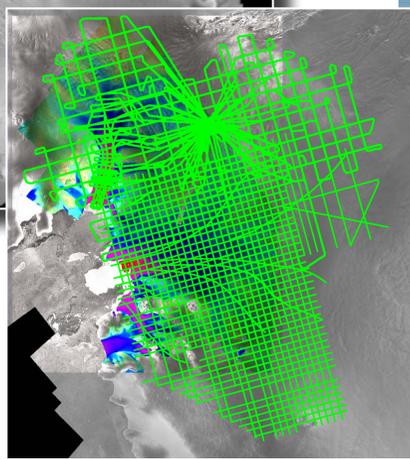
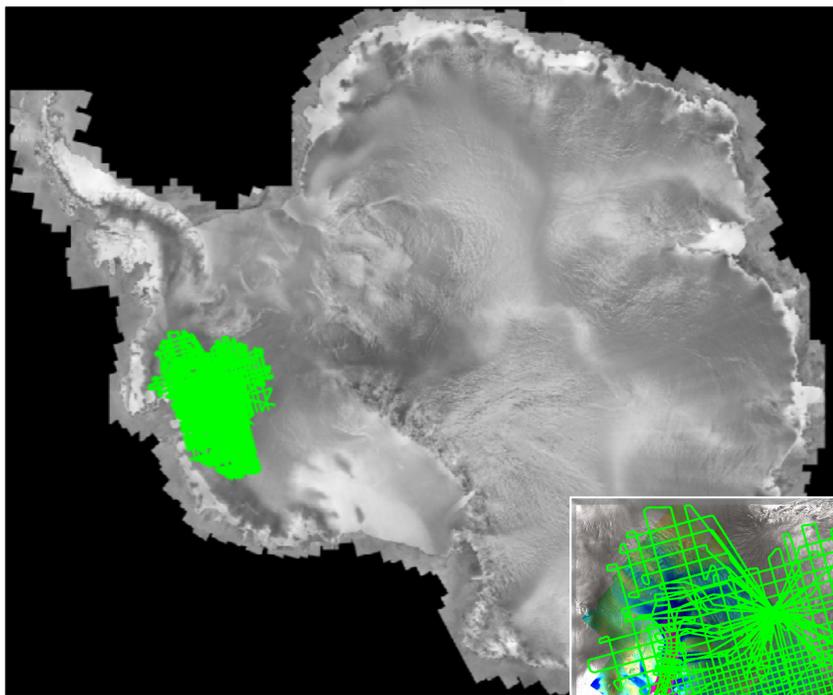


Marine Ice Sheet

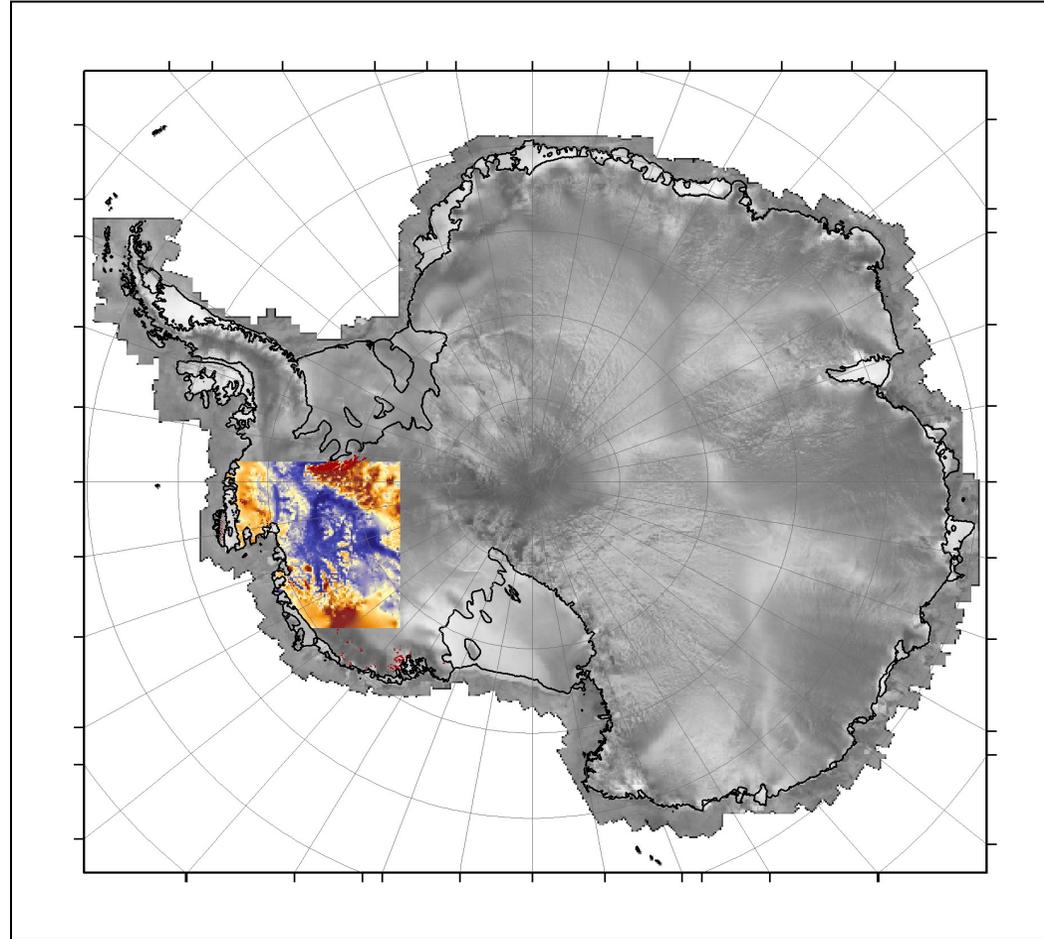
How Much?

How Quickly?

2005 Survey by BAS and U. Texas

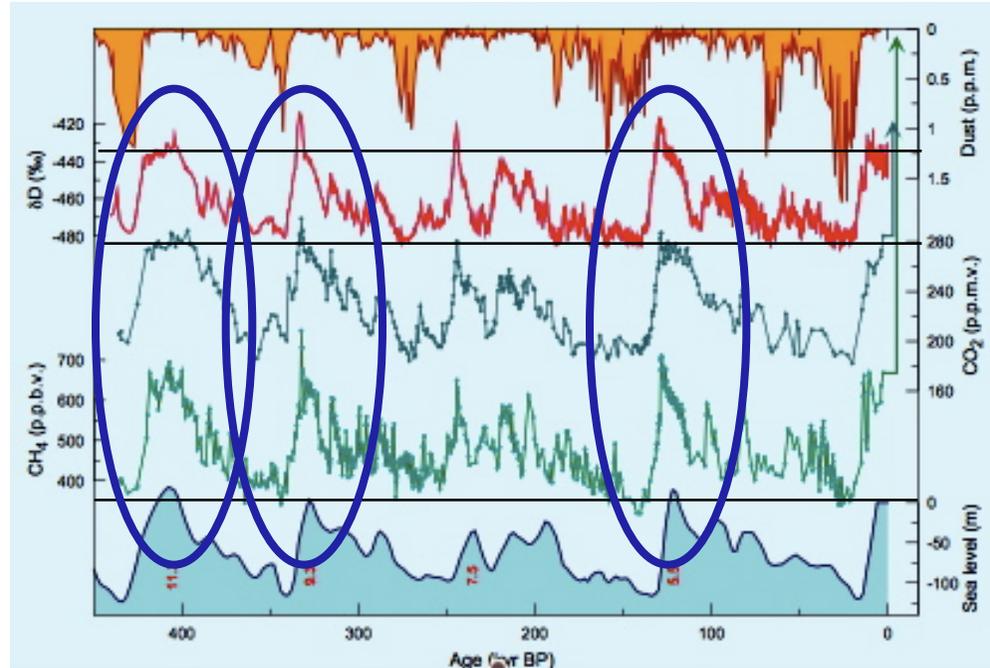


How Much?



Ice accessible for discharge ~1.5m msl equivalent

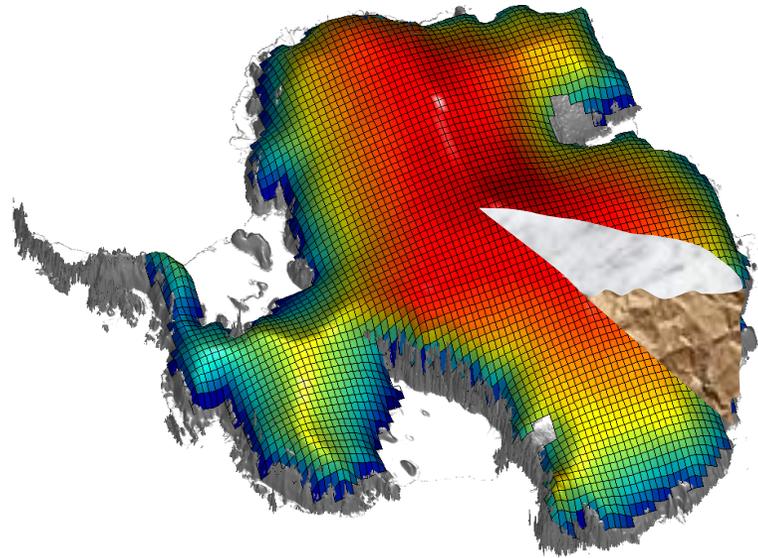
The View from the Past



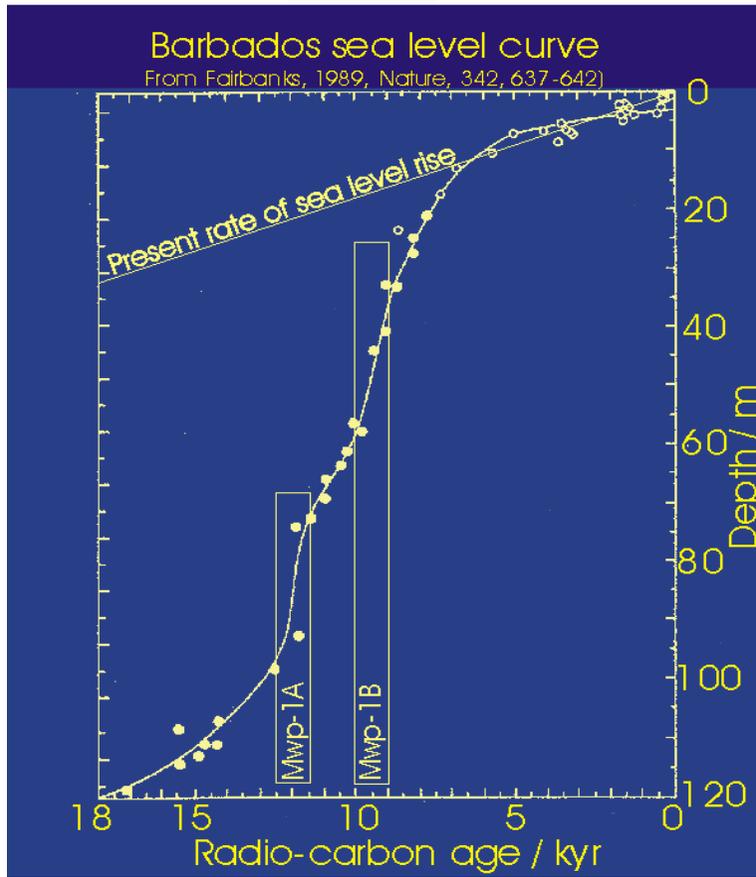
Sea Level 4-6m higher during the last Interglacial

How Quickly?

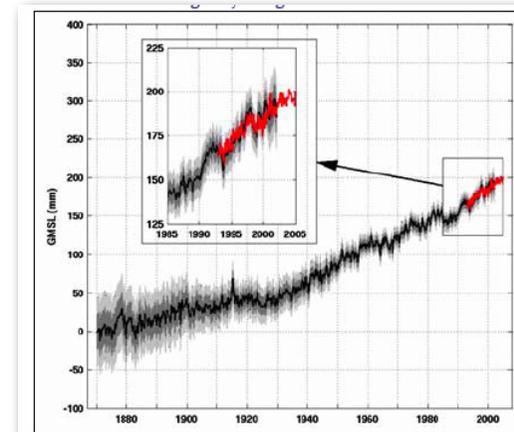
- Numerical ice sheet models cannot predict:
 - *Ice dynamics not included*
 - *Numerical stability problems near grounding line*



Sea Level Rise since Last Glacial Maximum



- 9k years at $\sim 10\text{mm/y}$
- two bursts at $\sim 20\text{mm/y}$ or greater
- last 3ky - 0.1 to 0.2mm/y
- since 1900 1.8mm/y
- last decade $\sim 3\text{mm/y}$



International Polar Year 2007-2008



How Long will London Survive?



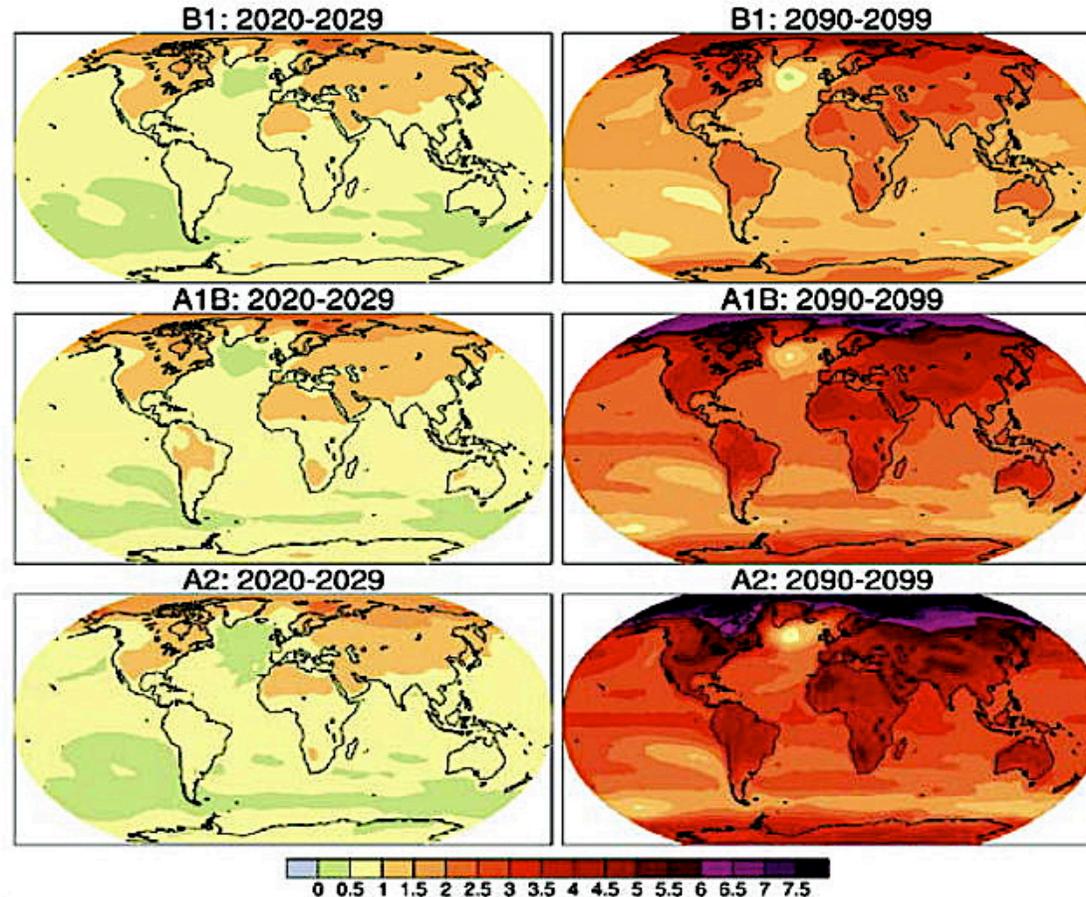
Estimated bill for one flood : £30bn = 2%GDP

Is This The Future?





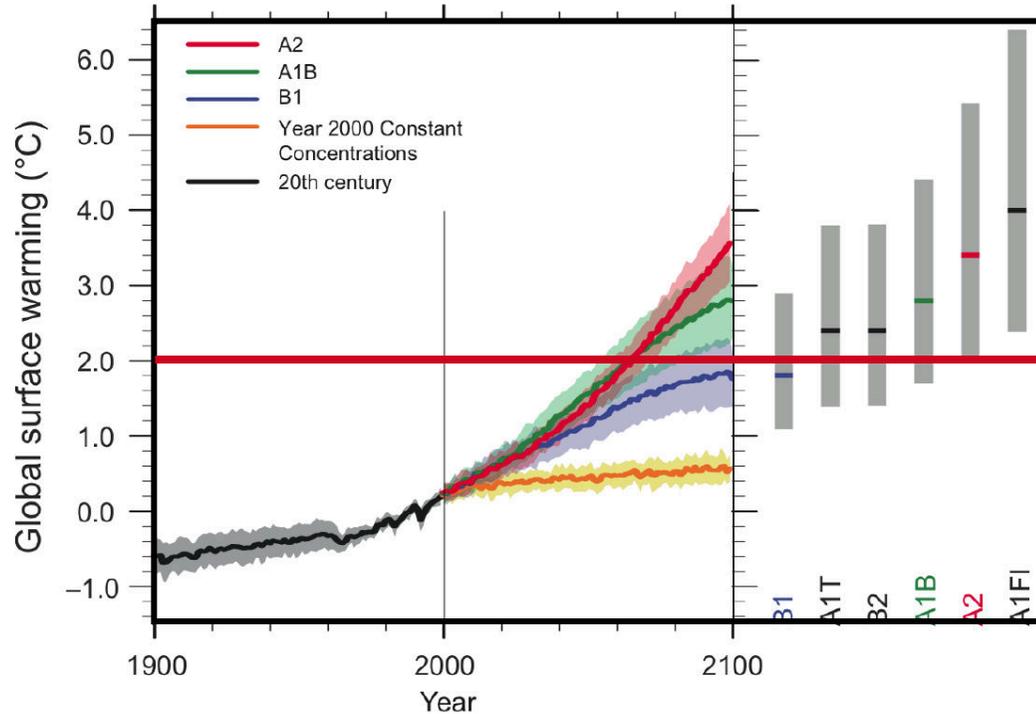
IPCC Temperature Projections



3 scenarios – 2 epochs

IPCC Temperature Projections II

Multi-model Averages and Assessed Ranges for Surface Warming



“Safe” Limit of 2°C?

Equivalent to 450ppm



CO₂ concentration, temperature, and sea level continue to rise long after emissions are reduced

Magnitude of response

Time taken to reach equilibrium

CO₂ emissions peak
0 to 100 years

Key factor determining stabilisation level is total amount of carbon emitted

To achieve 450ppm we humans are permitted ~500Gt and a long-term ongoing rate of ~2Gt/y

Could be worse if terrestrial and marine sinks weaken

Later = Harder

Sea-level rise due to ice melting:
several millennia

Sea-level rise due to thermal expansion:
centuries to millennia

Temperature stabilization:
a few centuries

CO₂ stabilization:
100 to 300 years

CO₂ emissions

Today 100 years

1,000 years

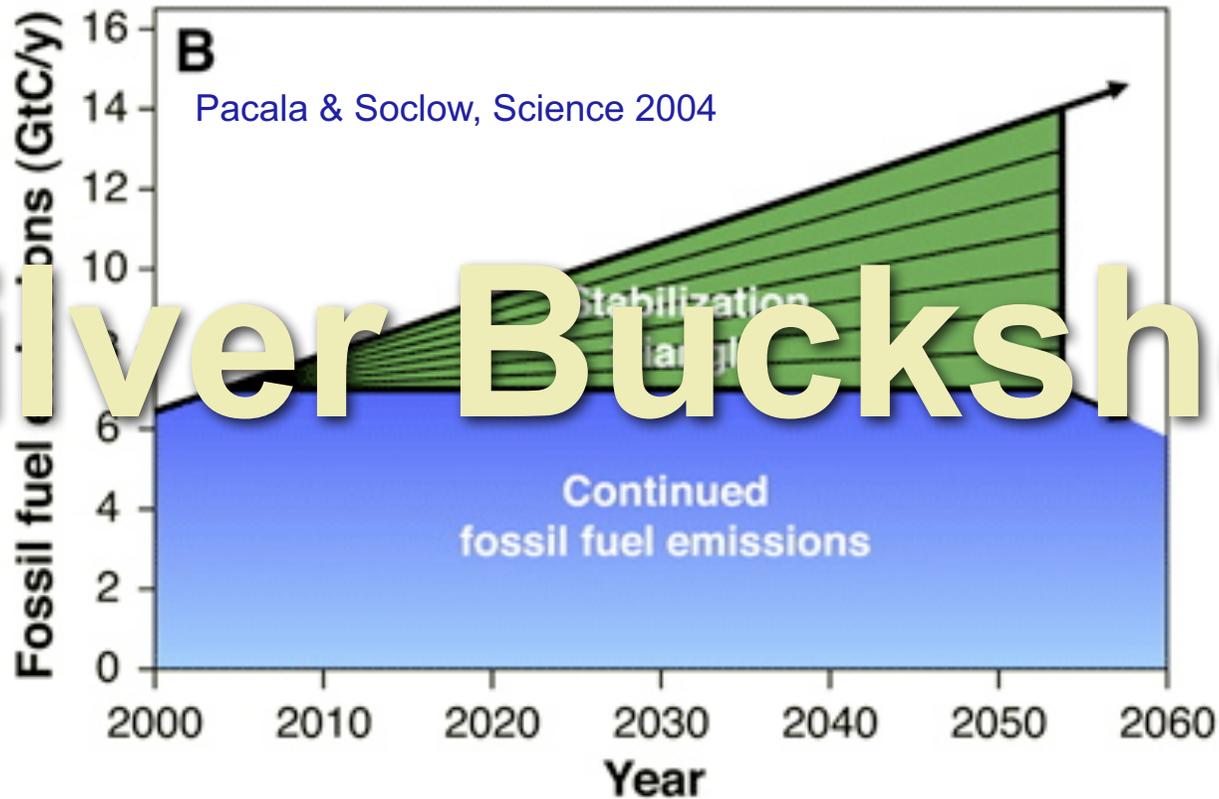
Decarbonising Humankind

IPCC

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



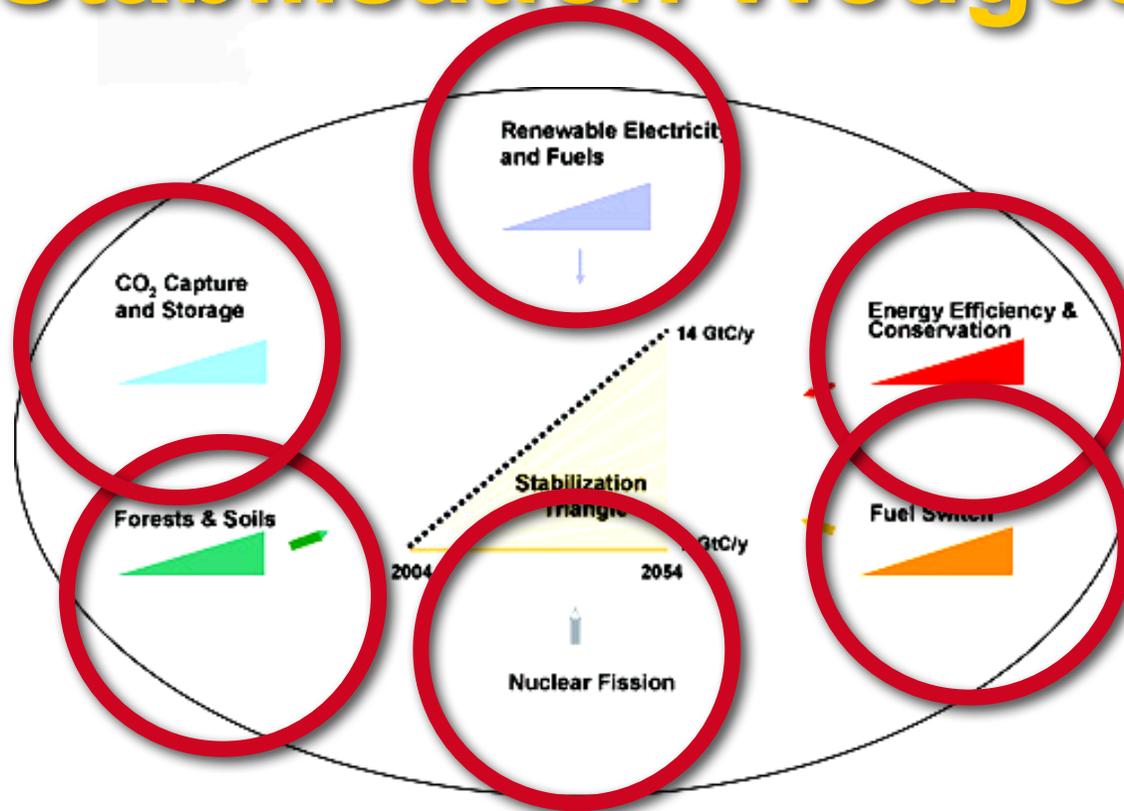
Wedge Approach



Silver Buckshot



Stabilisation Wedges

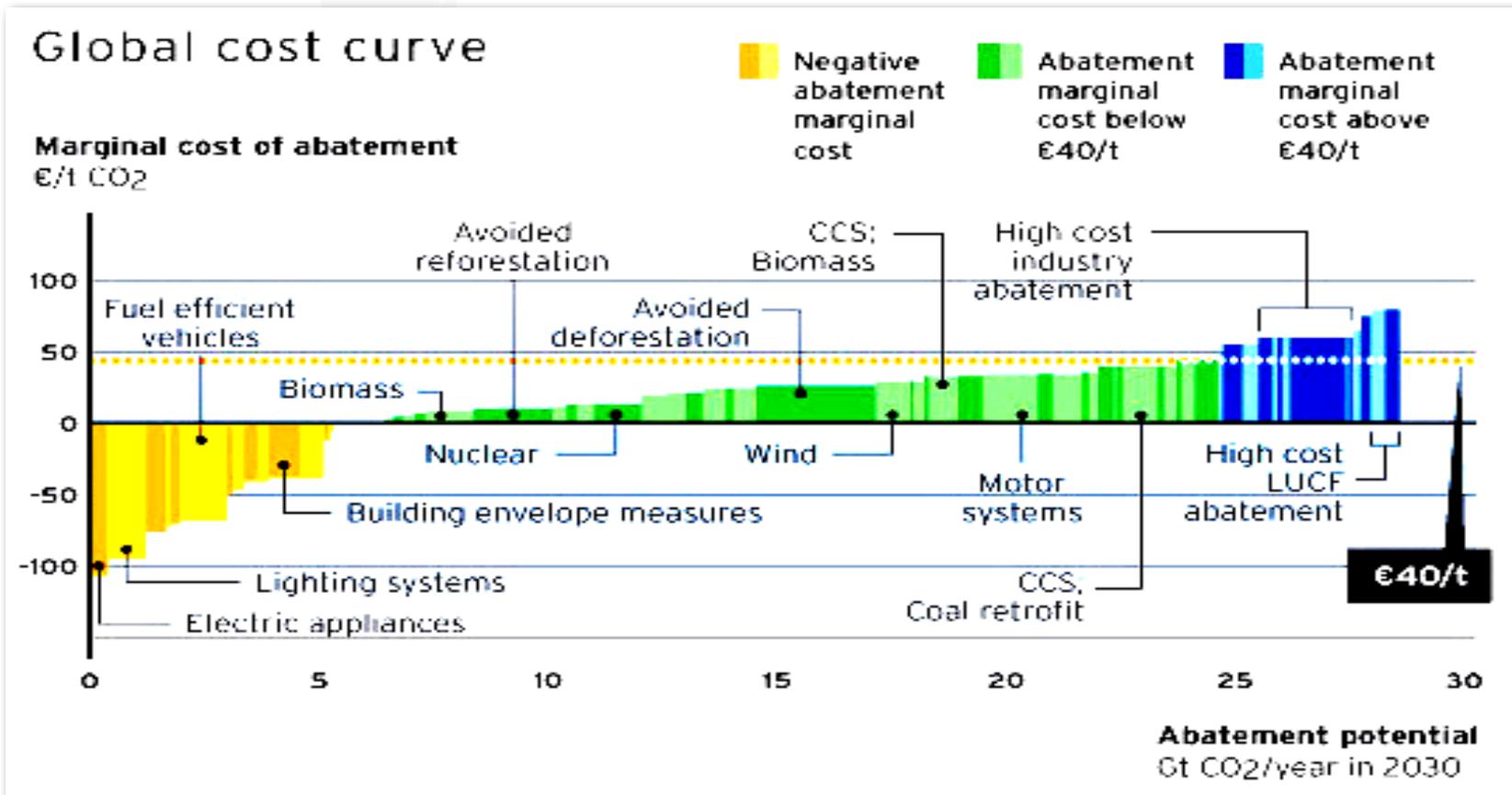


Each Wedge represents 1Gt carbon emissions

Seven wedges needed to stabilise global emissions at current levels by 2050



Techno-Optimists



e.g. Vattenfall Report





Wedge Costs

- **1.5TW nuclear (5% 2050 total) ~ \$1Tn**
- **4TW wind (8×10^5 5Mw units) ~ \$4Tn**
- **2bn cars 30→60mpg ~ \$2Tn**

- **World GDP (2005) = \$60Tn**
- **Stern: 1% GDP investment now (\$0.6Tn/y) to prevent subsequent 20% economic downturn**

- **Investment in oil infrastructure to meet projected USA BAU needs ~\$3-5Tn**
- **Iraq war cost to USA to date ~ \$0.4Tn**



Additional Wedges

- **Food**
 - on average takes 25cal fossil fuel energy to produce 1cal protein
 - effectively eat oil
 - vegetarian products use 10-30 times less energy, 100-200 times less water, and ~7 times less land area
 - currently 2bn meat eaters, 4bn vegetarians
- **People**
 - fertility rates strongly correlate with contraceptive use
 - latent demand
 - average per capita emissions = 1.3t
 - avoid 800m average humans by 2050
 - or 5 times fewer high per capita emitters or 3 times more low emitters
 - cost = \$3bn

An absent human has NO footprint

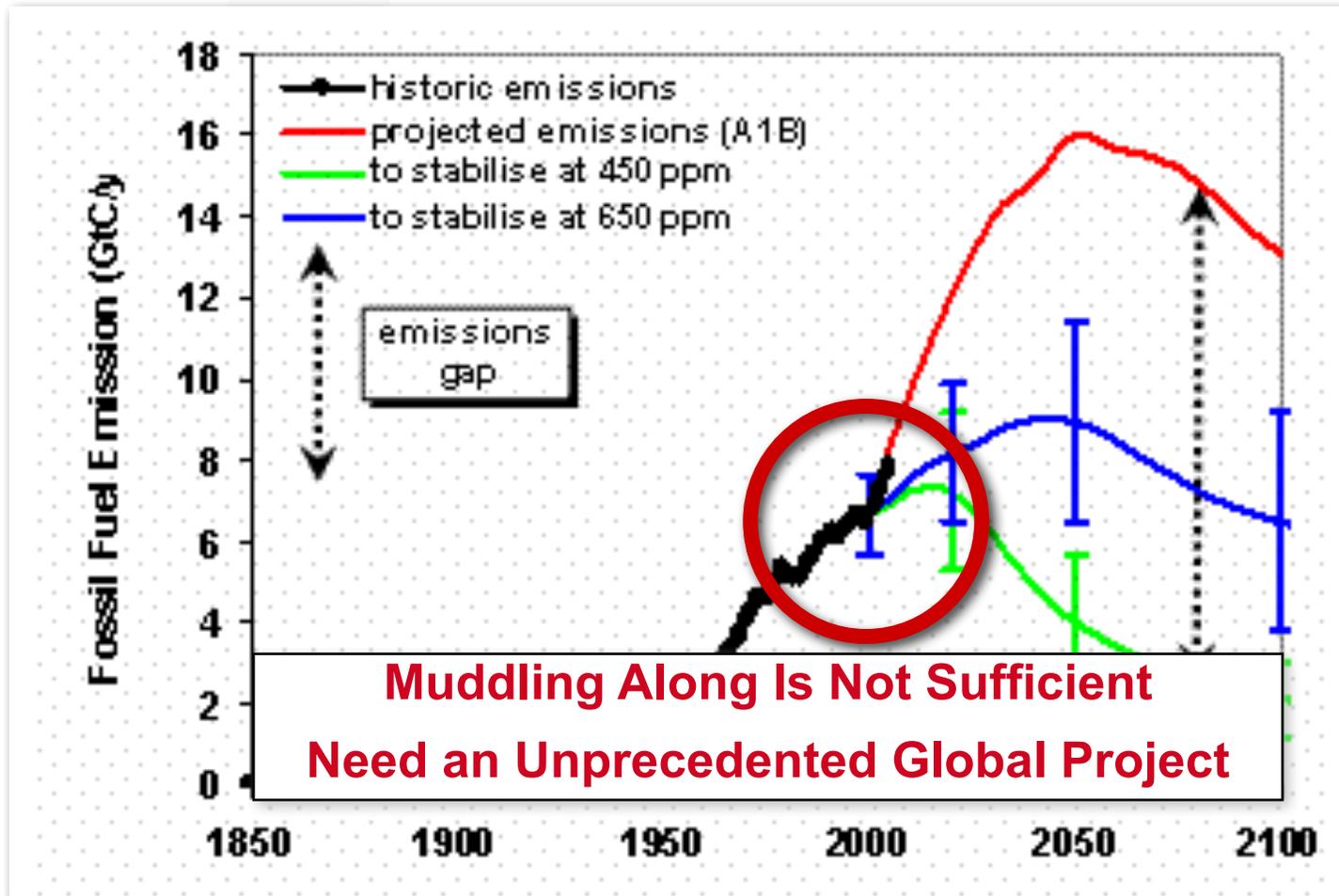


**Better to keep the Carbon in the Ground -
Regulate Extraction!**

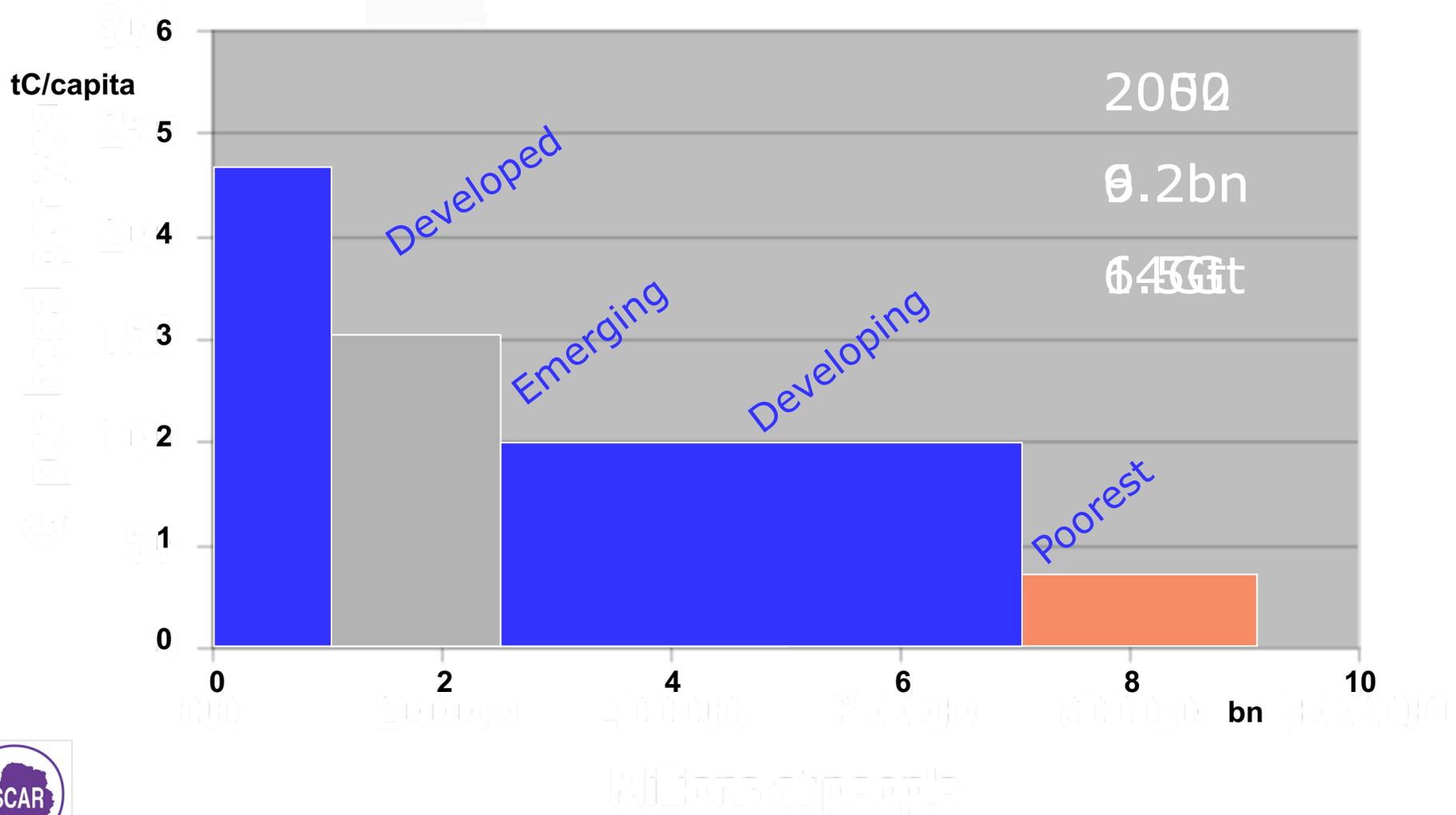
Suck it out of the air & Put it Back!



The Problem



People and Emissions



Unprecedented Challenge

- Evidence of problem complex & technical
- Impacts are distant in time & space
- *Homo Urbanus* insulated from nature
- Inertia in demography, societal infrastructure and behaviour
- Strong vested interests threatened
- Significant issues of sharing between developed and developing world
- Mismatch between nature of problem and the jurisdiction, capabilities and motivation of existing institutions



Leadership Required

- **Clear Vision of Destination**
- **Credible Plan of How to Get There**
- **(and what to do afterwards!)**
- **Integrity**
- **Commitment, Dynamism, Determination**
- **Persuasiveness**
- **Ability to build and cohere collective international partnership at Global Scale**





The Great Test

Previously in human affairs physical strength and aggression rewarded

This time success will depend on intelligent co-operative action for the global common good

The ATS provides a Model



They are here Already



If the Earth were only a few feet in diameter, floating a few feet above a field somewhere, people would come from everywhere to marvel at it. ... they would declare it as sacred because it was the only one, and they would protect it so that it would not be hurt.

Joe Miller





“Our problems are man made, therefore they may be solved by man”

John F Kennedy

