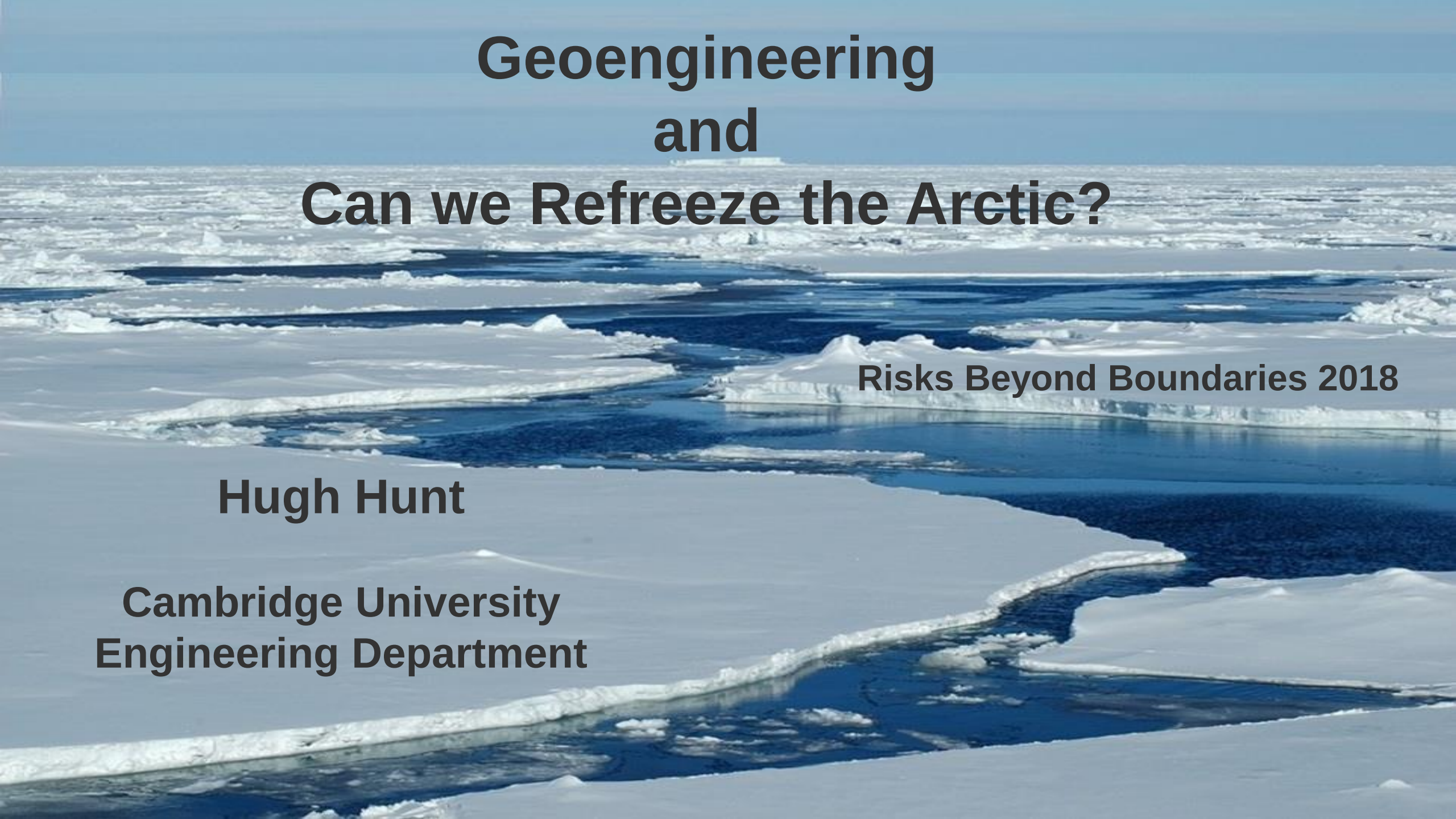


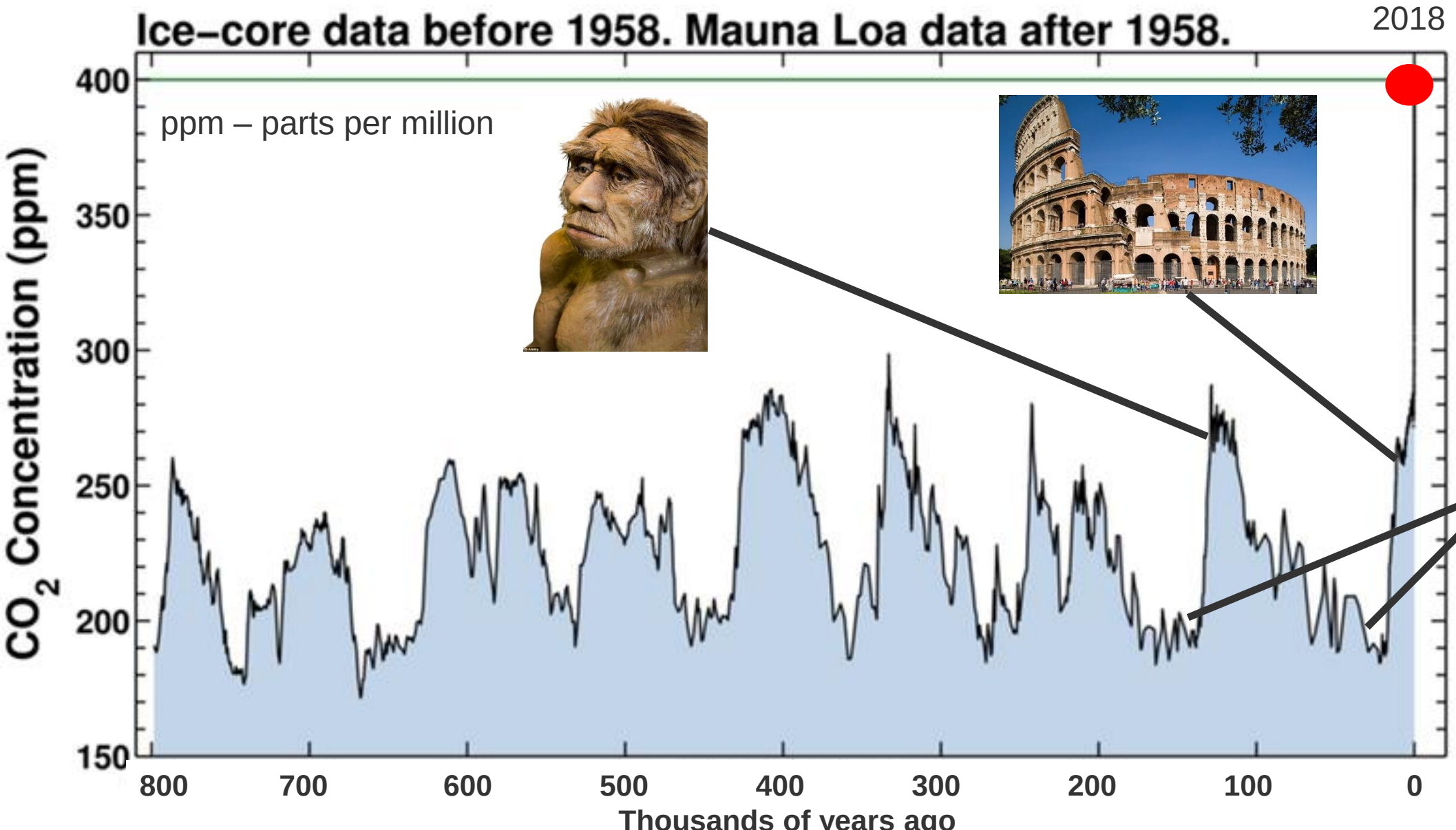
Geoengineering and Can we Refreeze the Arctic?

Risks Beyond Boundaries 2018

Hugh Hunt

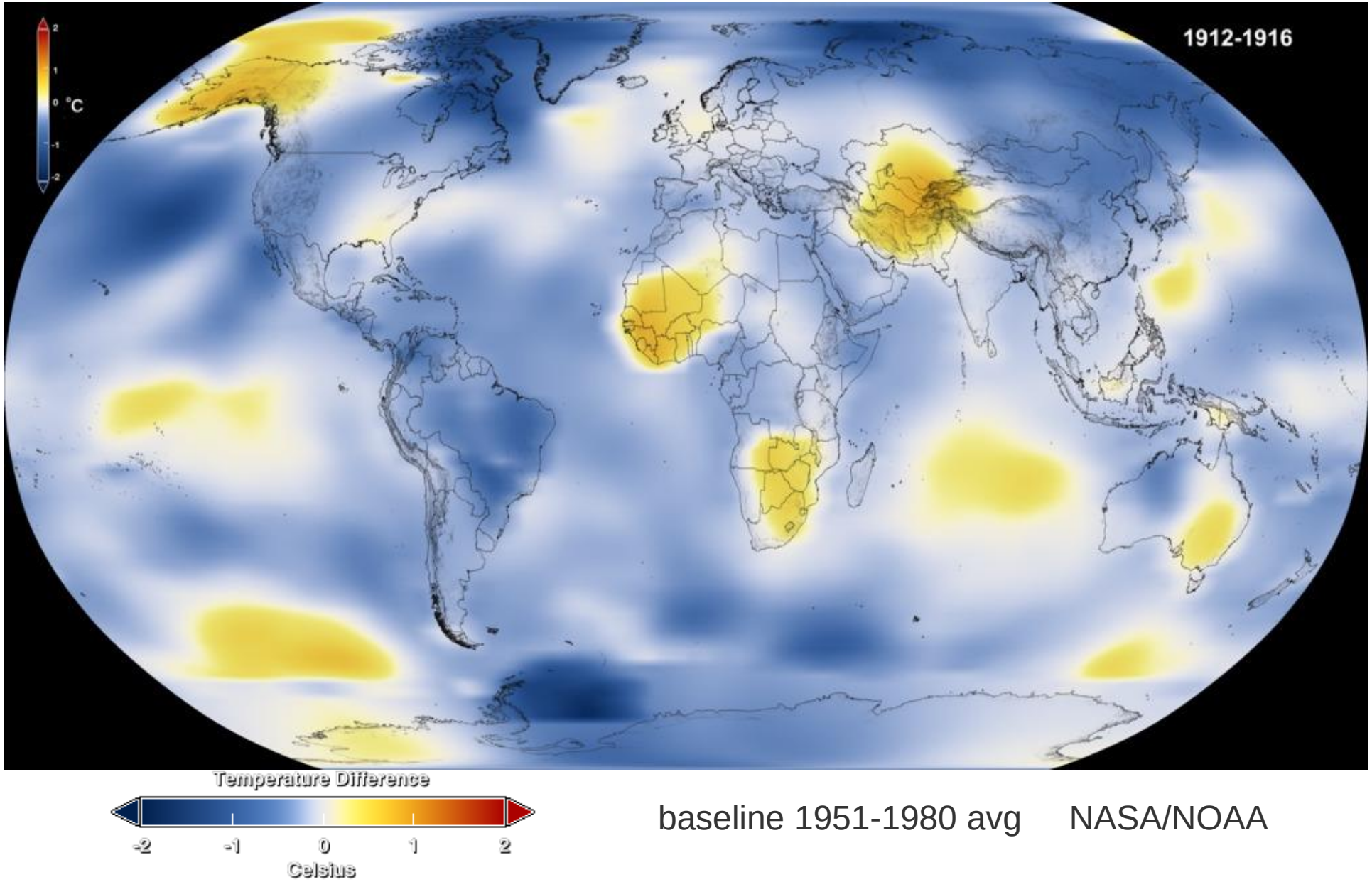
Cambridge University
Engineering Department

Up and down - 1 million years of CO_2



Five-Year Global Temperature Anomalies

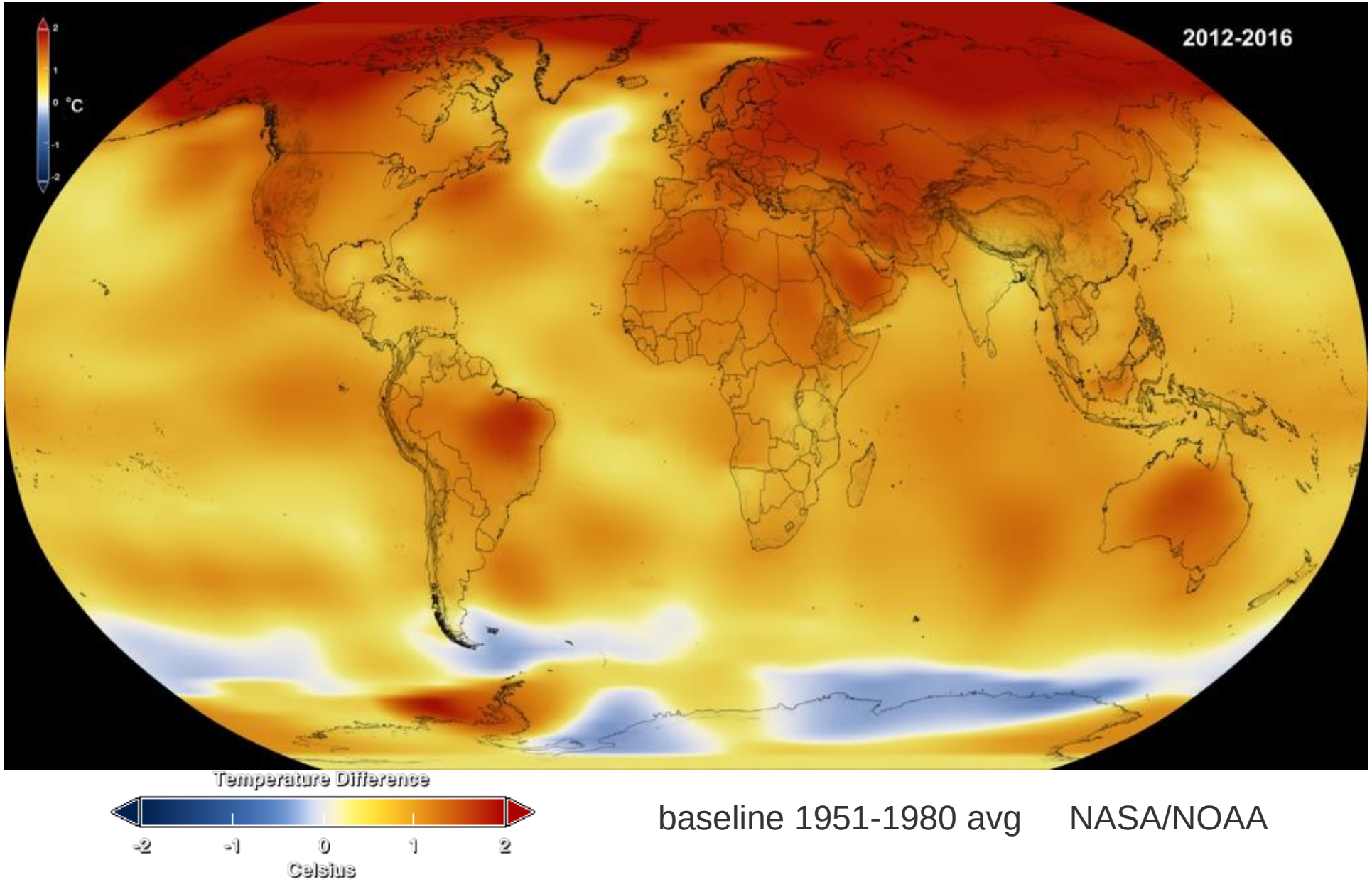
1912-1916



baseline 1951-1980 avg NASA/NOAA

Five-Year Global Temperature Anomalies

2012-2016



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The Arctic problem: Summer ice will vanish before 2025

Arctic ice yielding to open water, albedo (reflectivity) drops from 0.6 to 0.1

Albedo loss from summer ice has the same warming effect as past 25 years of CO_2 emissions.

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If it melts → sea-le

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Arctic Ocean is shallow, surface warming extends to seabed, melts permafrost, triggers release of methane.

Methane is 20-80 times more potent a GHG as CO_2

Greenland ice shelf holds 2million km^3 of ice.
If it melts → sea-level rise of 7.2m

Ice-free arctic will alter jet stream patterns and ocean
climate

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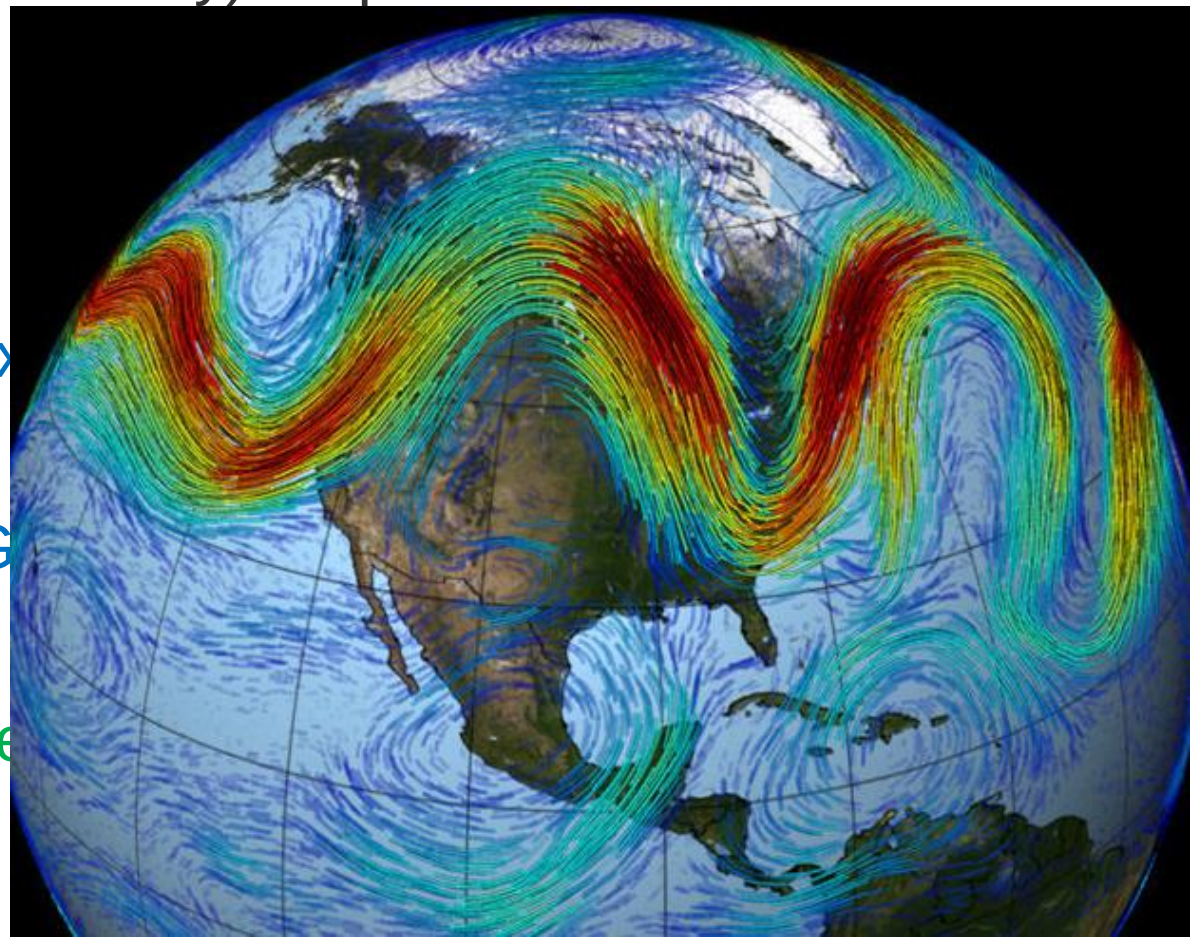


Ice-free arctic will alter jet stream patterns and ocean circulations → changes in climate

Arrival in Sydney – how much CO_2 is my fair share?

Imagine that each white suitcase contains 20kg of CO_2

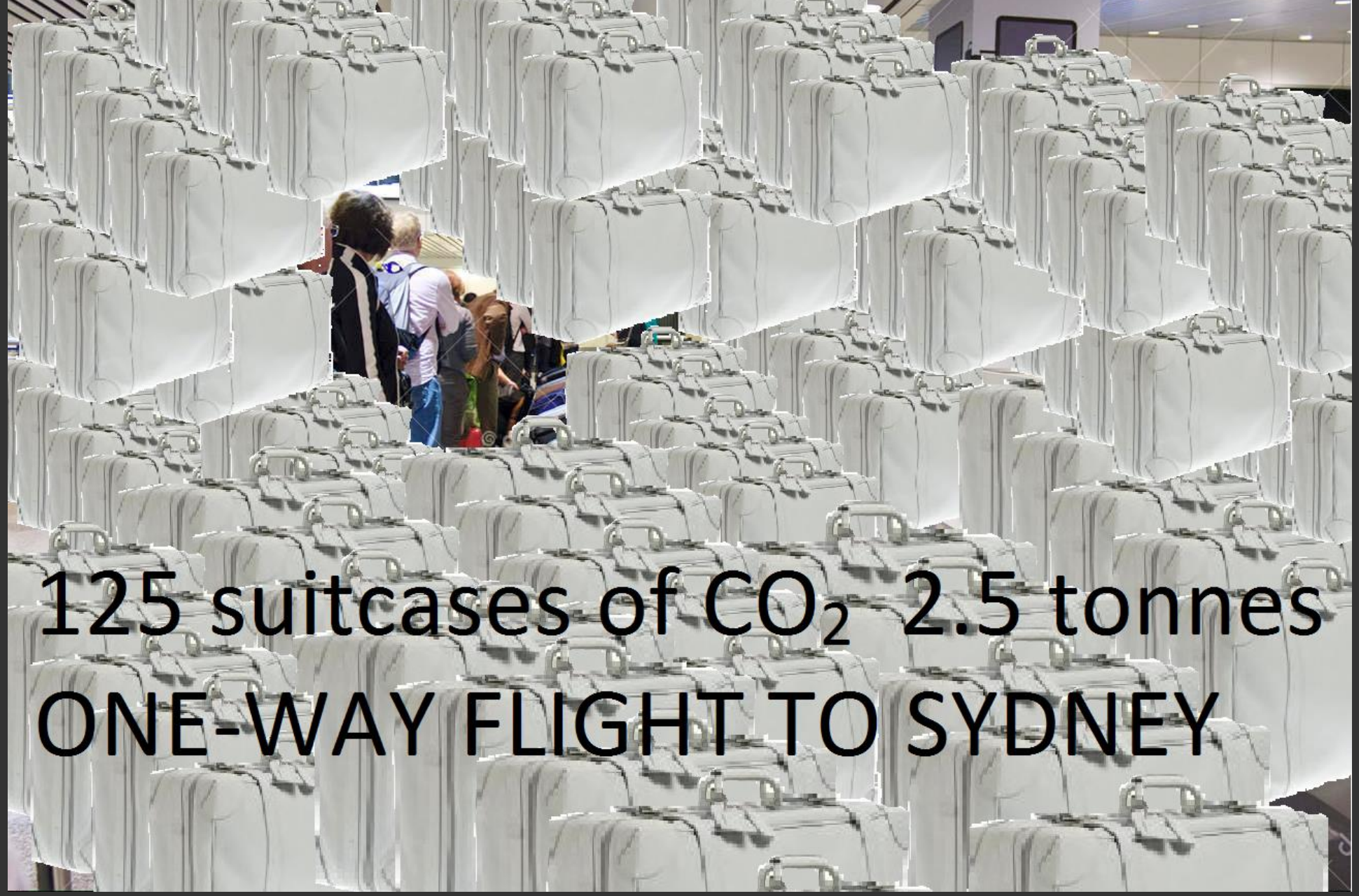
A Boeing 747 burns fuel at 4kg per second

to Sydney is a 20 hour flight

There are 350 passengers

1kg fuel generates 3kg CO_2 (carbon + oxygen from air)

$N_{suitcases} = 4 \times 3 \times 20 \times 3600 / 350 / 20 =$???



My share of CO_2 for a flight to Sydney is 2.5 tonnes

OK – so what are our options ?

GEOENGINEERING – active control of climate

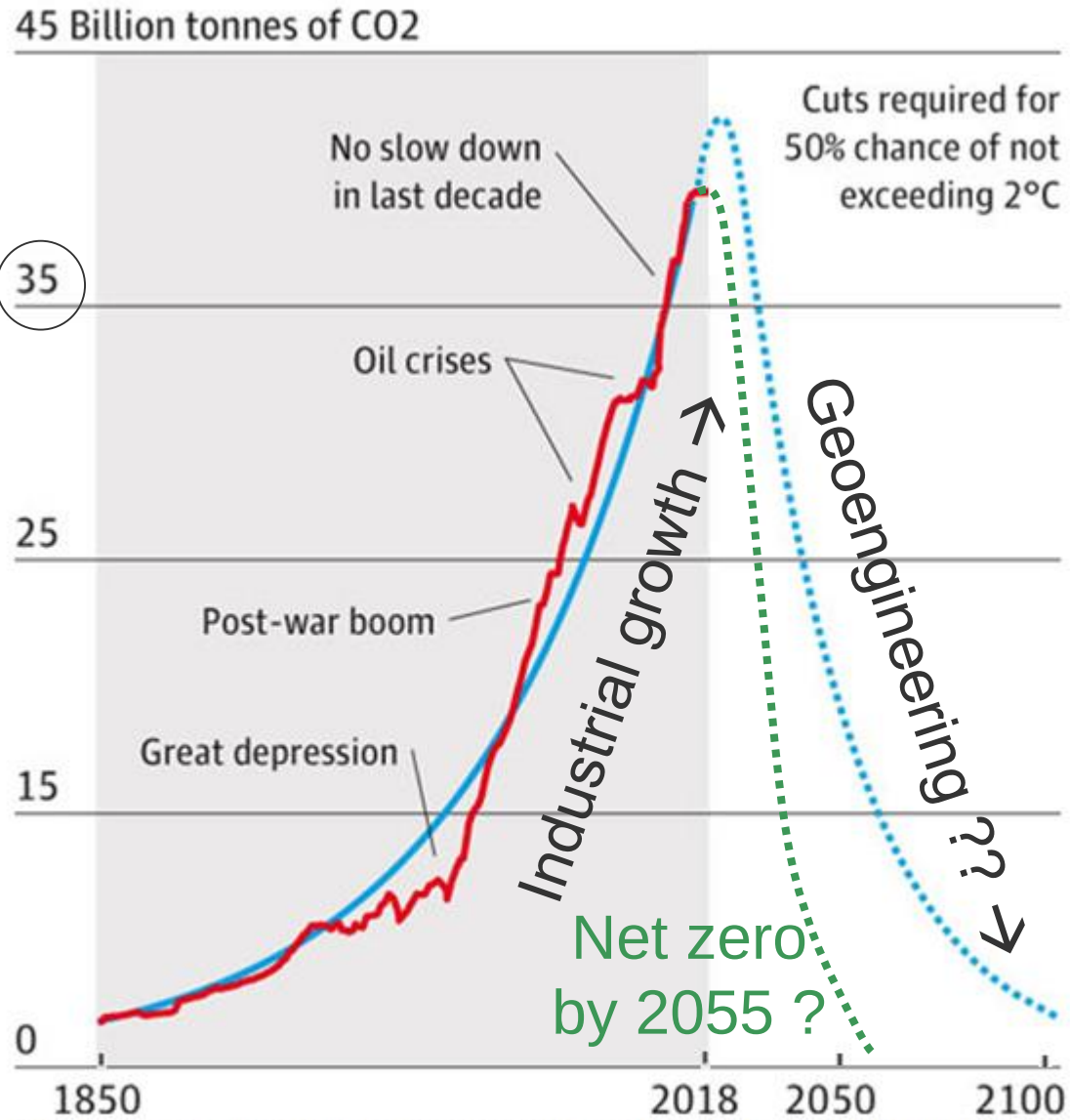
35 billion tonnes/year

World pop = 7billion

Global average
5 tonnes/person/yr

Return flight to Melbourne
5 tonnes/person

My trash:
500kg/yr ?



CO2 emissions since 1850 (red); exponential growth (blue); cuts to hit climate target (dashed). Photograph: guardian.co.uk

GEOENGINEERING – active control of climate

What is Geoengineering?

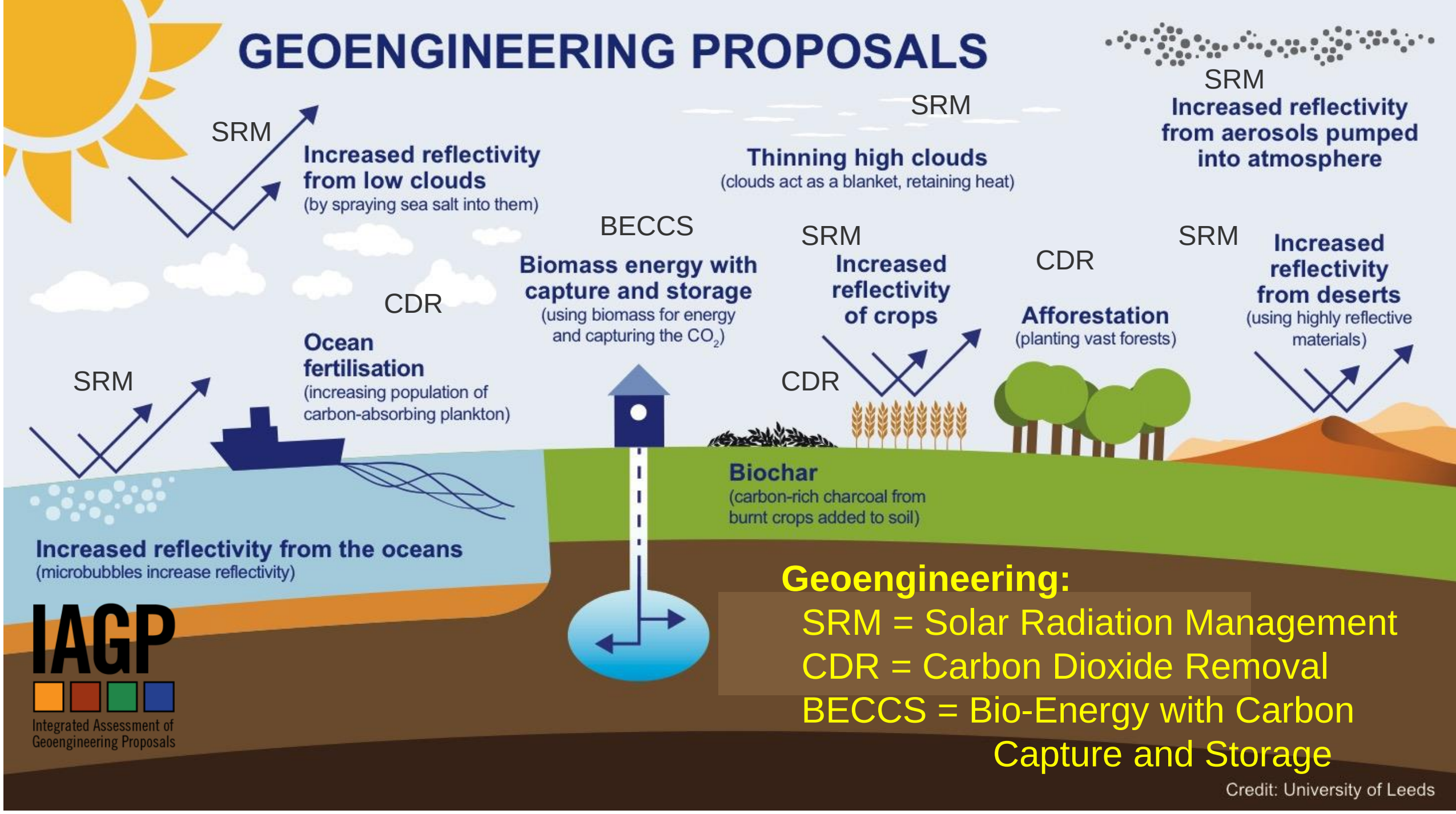
Active and intentional modification of the climate

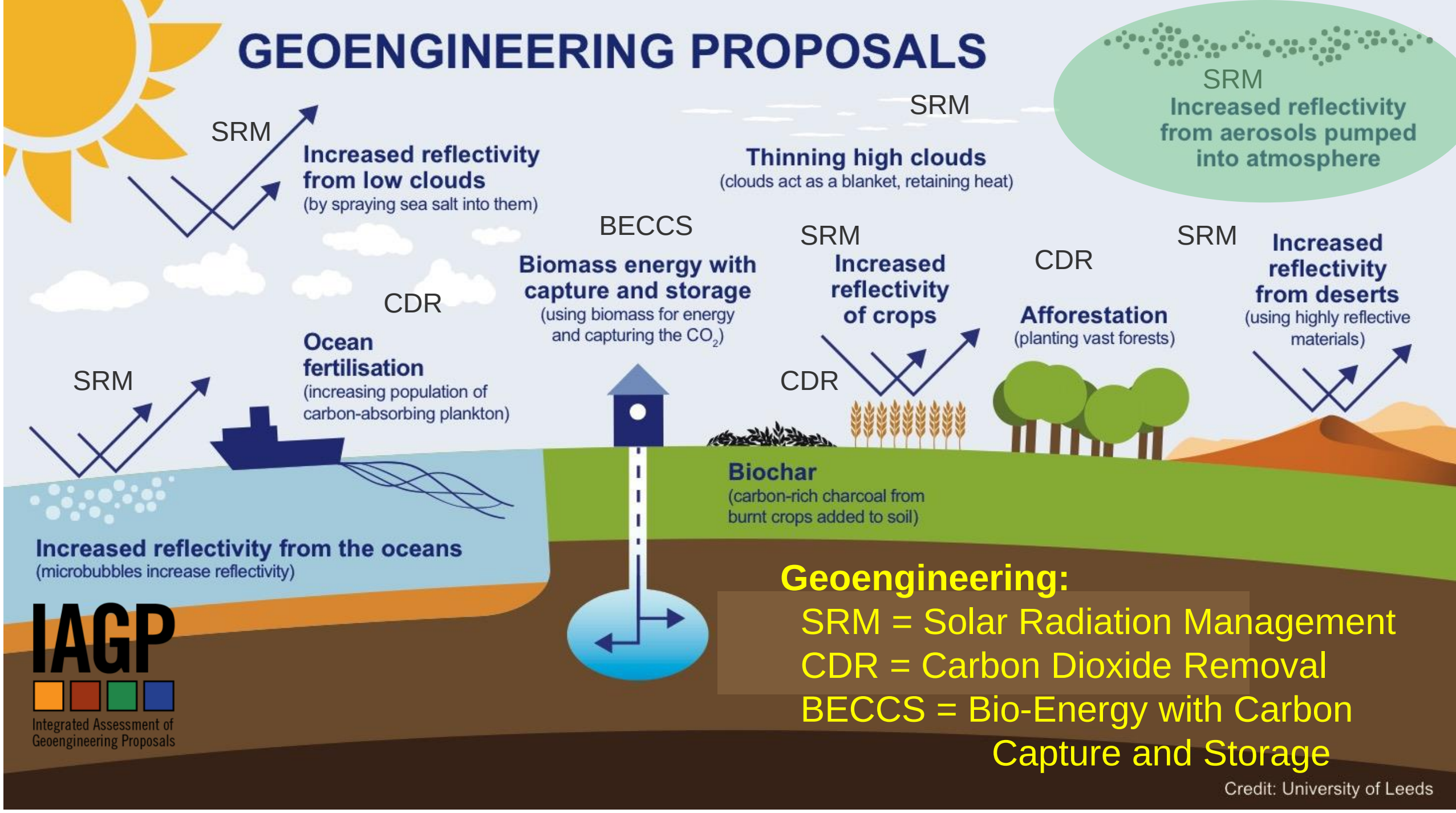
SRM: Solar Radiation Management

reflect sunlight — easy

CDR: Carbon Dioxide Removal

suck out CO_2 — hard


GEOENGINEERING PROPOSALS
SRM
Increased reflectivity from low clouds
(by spraying sea salt into them)
SRM
Thinning high clouds
(clouds act as a blanket, retaining heat)
SRM
Increased reflectivity from aerosols pumped into atmosphere
BECCS
Biomass energy with capture and storage
(using biomass for energy and capturing the CO_2)
CDR
Ocean fertilisation
(increasing population of carbon-absorbing plankton)
SRM
Increased reflectivity of crops
CDR
CDR
Afforestation
(planting vast forests)
SRM
Increased reflectivity from deserts
(using highly reflective materials)
SRM
Increased reflectivity from the oceans
(microbubbles increase reflectivity)
Biochar
(carbon-rich charcoal from burnt crops added to soil)
IAGP
Integrated Assessment of Geoengineering Proposals
Geoengineering:
SRM = Solar Radiation Management
CDR = Carbon Dioxide Removal
BECCS = Bio-Energy with Carbon Capture and Storage
Credit: University of Leeds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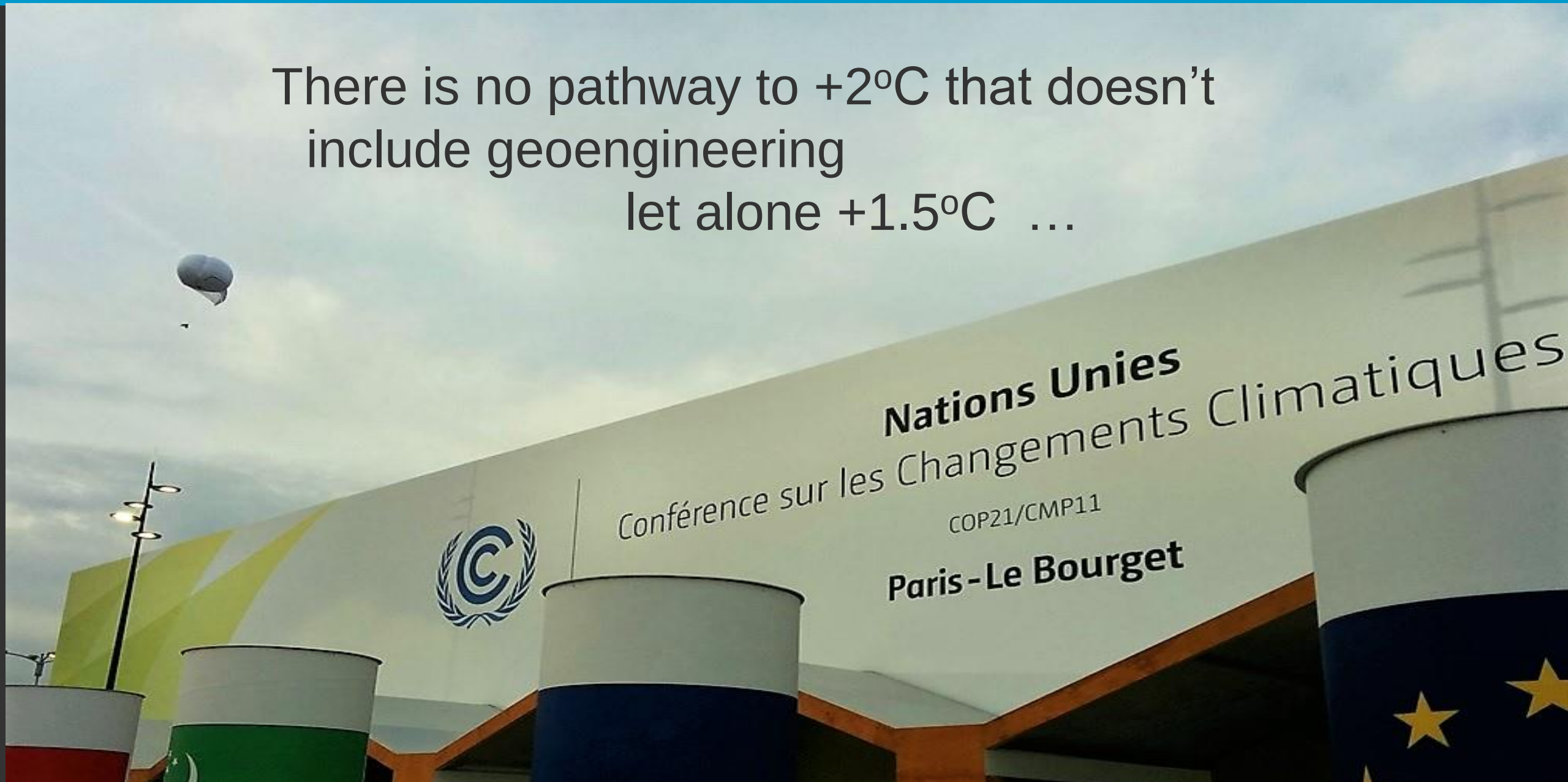
COP21 in Paris has legitimized geoengineering

There is no pathway to +2°C that doesn't include geoengineering

let alone +1.5°C …



SRM – eruption of Mt Pinatubo, 1991

August 30, 1984

August 8, 1991

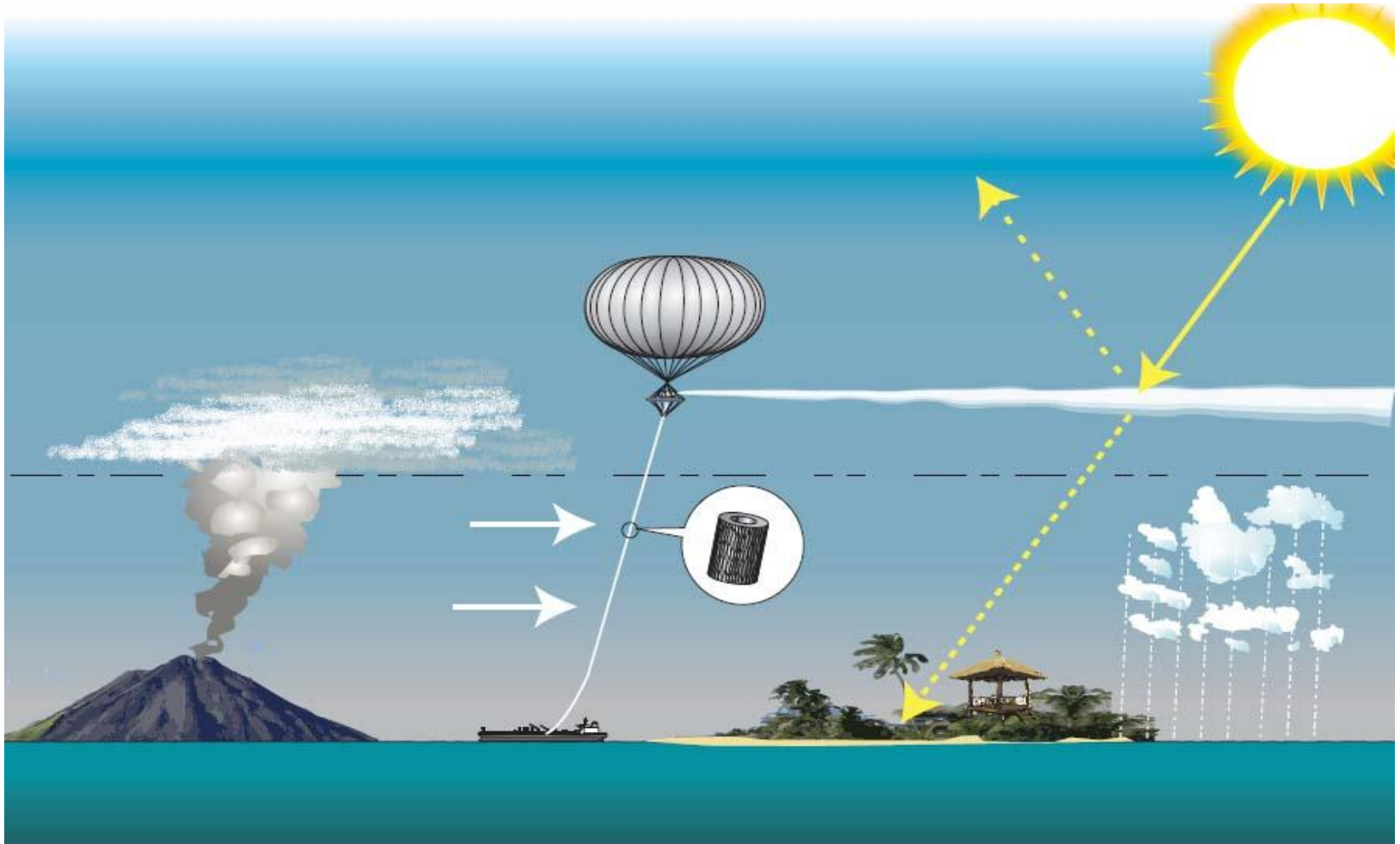
SPICE

SPICE: aerosol delivery system for 2°C cooling

Stratospheric **P**article **I**njection for **C**limate **E**ngineering

Tethered balloon – height 20km

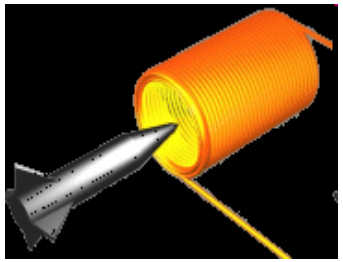
maybe 10 balloons worldwide each delivering 30kg/s of aerosol

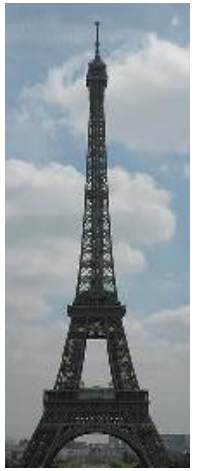


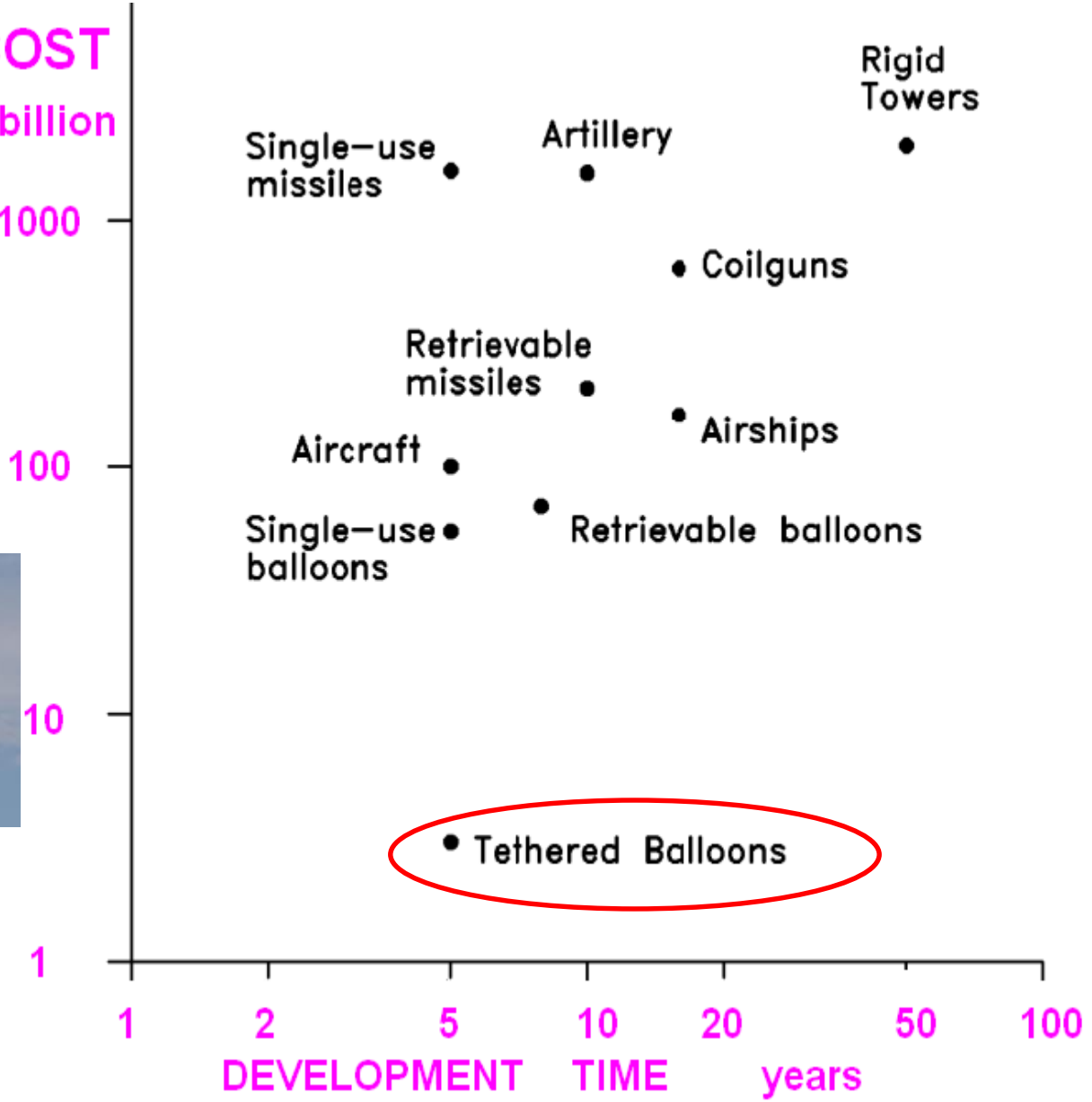
OPTIONS:

- Aircraft
- Airships
- Missiles
- Artillery
- Towers
- Tethered balloons

Particle delivery – costs & timescales (target: 10 million tonnes per year)







SPICE “cancelled” ? Controversial?

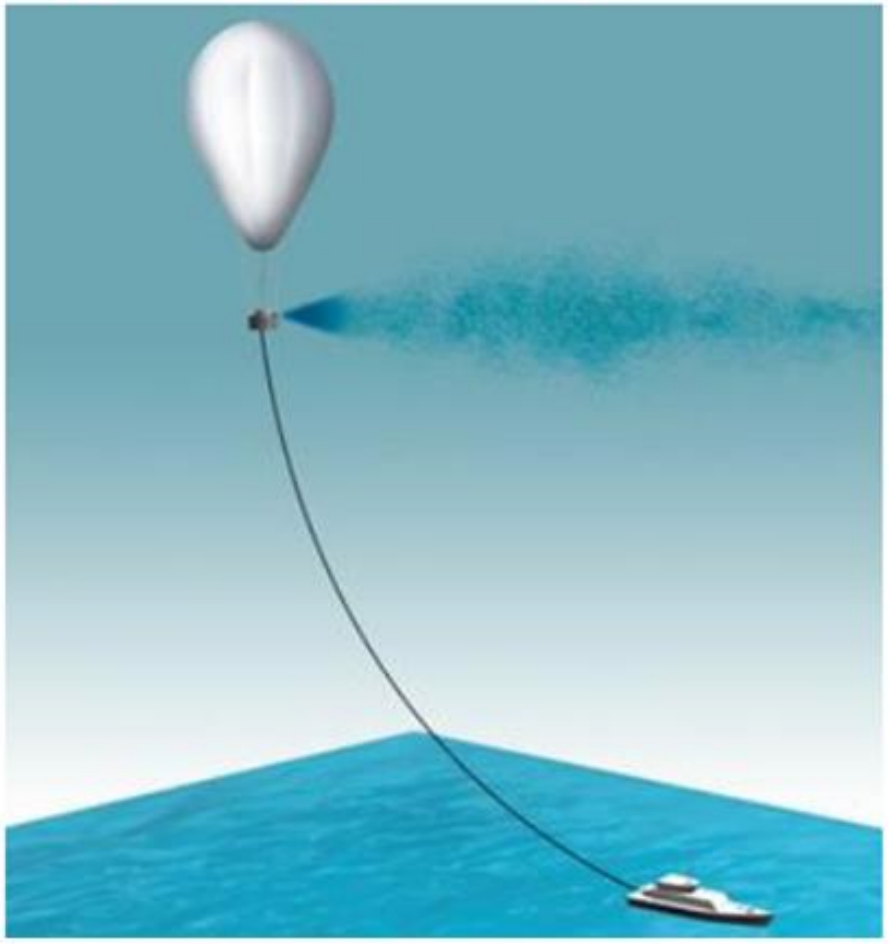
NewScientist **Environment**

search New Scientist Go » Log

Controversial geoengineering field test cancelled

PRINT SEND SHARE

17:30 22 May 2012 by **Michael Marshall**



THE balloon will not go up. A controversial geoengineering field test has been cancelled after the lead scientist learned of a patent on the technology held by several of his collaborators.

The Stratospheric Particle Injection for Climate Engineering (SPICE) project, run by researchers at three UK universities, is investigating cooling the planet by releasing aerosol particles into the stratosphere. The field test would have tested the feasibility of the delivery system – a hose lofted by a balloon – by pumping out water spray at an altitude of 1 kilometre.

In October 2011 the field test was postponed for six months, after an oversight panel decided more public engagement was needed.

Now lead scientist Matthew Watson at the University of Bristol, has cancelled it altogether.

At issue was a patent on the technology, filed in 2009 by independent consultant engineer Peter Davidson. Watson only learned of the patent late last year.

What is controversial about geoengineering?

- Ethics
  we shouldn't go messing with the planet
- Governance
  who's hand will be on the thermostat?
- Legality
  how would we react to unilateral deployment?
- Public perception
  this will let the Fossil-fuel industry off the hook

What is controversial about geoengineering?

- What materials?

  H_2SO_4 Sulphuric acid

  TiO_2 Sunscreen

  SiO_2 Sand

- Research

  do we allow *any* outdoor experiments?

- Unintended consequences

  what if we screw it up?

- Termination

  if we start will we ever stop?

What is controversial about geoengineering?

- Cost

  geoengineering is cheap compared with other solutions

- Timescale

  the Arctic will soon be summer-ice free

- Political expediency

  is SRM the only way to meet the Paris 2^{o}C target?

Conclusions

Can we refreeze the Arctic?	Yes (SPICE)
Should we refreeze the Arctic?	Yes
Will we refreeze the Arctic?	No
If the Arctic melts:	
can we deal with rise of Methane?	Maybe (SUGGR)
can we handle sea level rise?	Hmmm

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Thank you!
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