Assessing Scientific Knowledge About Climate Change

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6 October 2011

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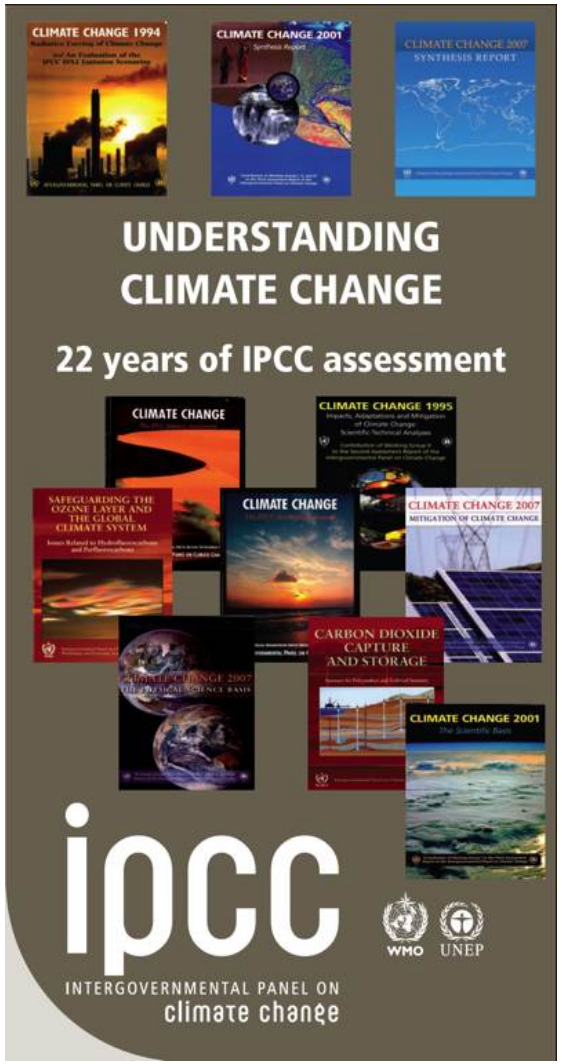
Talk Outline



- Concept of Assessment
- IPCC Fourth Assessment (AR4)
- Some developing areas since 2006-7
  - Recent observations
  - Extreme events
  - Polar ice sheets and sea level
  - Ocean acidification
  - Geoengineering
  - “Metrics” for non-CO_2 greenhouse gases
  - The “trillionth tonne”
  - New scenarios - RCPs
- Special Report on Renewables (2010)
- IPCC Fifth Assessment (AR5)

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Some thoughts about assessment

- Chapter expert teams
  - Nomination / selection
  - Spread of expertise
  - Review editors
- Assess the literature (Journals where possible)
- Look for multiple lines of evidence
- “Policy relevant, not policy prescriptive”
  - Confidence / uncertainty assessment
- Reviews of assessment drafts
- Final approval / acceptance - ownership

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Some Key Findings from the Fourth Assessment

- Warming of the climate system is unequivocal …
- "Very likely" attribution of most of last 50yrs global warming to anthropogenic ghgs..
- " Likely" attribution of last 50 yrs warming over individual continents to human activity.
- New global projections for SRES marker scenarios. Best estimates range from 1.8 to 4.0°C by 2100 depending on emissions.
- Sea level projections for SRES marker scenarios 18-59 cm by 2090s cf 1990, "excluding future rapid dynamical changes in ice flow", but no upper bound or best estimate.
- Equilibrium climate sensitivity likely to be in the range 2°C to 4.5°C, best estimate about 3°C.

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More Key Findings from the Fourth Assessment

- Many natural systems being affected by climate change, especially by temperature change.
- More information on projected impacts - table shows some substantial for even 1.5°C cf late 20th C.
- Substantial economic potential & technical options to reduce projected growth rate of ghg emissions.
- Assessed scenarios to limit eventual ΔT to 2 to 2.4°C above pre-industrial have 50-85% emission reduction by 2050 (cf 2000) and further thereafter. “Stabilisation” CO2-eq concentrations 440-490 ppm.

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Criticisms after the AR4

- Three Working Groups, around 3000 pages total
- Paragraph in Asia Chapter of WG2 about Himalayan Glaciers incorrect.
- Number wrong in WG2 regarding area of Holland below sea level
- Media / web claims of several other "errors"

Netherlands analysis[1] of regional impacts statements: *Overall the summary conclusions are considered well founded and none were found to contain any significant errors.*

Sunday Times published correction and apology[2] for asserting that IPCC Amazon statement was "Bogus"

IAC Review: "…the IPCC assessment process has been successful overall"

IAC Review: " … The IPCC must continue to adapt to … changing conditions in order to continue serving society well in the future".

Key conclusions robust - but improvements to processes & procedures desirable

1. http://www.pbl.nl/images/500216002_tcm61-48119.pdf
2. http://www.thesundaytimes.co.uk/sto/news/article196428.ece

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Science Developments since IPCC 2007

- Still warm: 15 of the 16 warmest years globally in the instrumental record have occurred during the period 1995-2010
- Sea level rise has continued
- End-of-summer Arctic sea ice extent has remained low
- Both Greenland and Antarctica losing (grounded) ice overall
- Growing knowledge + concern about dynamic ice processes / instabilities that could speed up loss of ice from Greenland, West Antarctic ice sheets
- Anthropogenic CO_2 emissions have been tracking towards the upper side of the IPCC scenario range, except 2009.
- Emerging issues: Ocean acidification; Geoengineering

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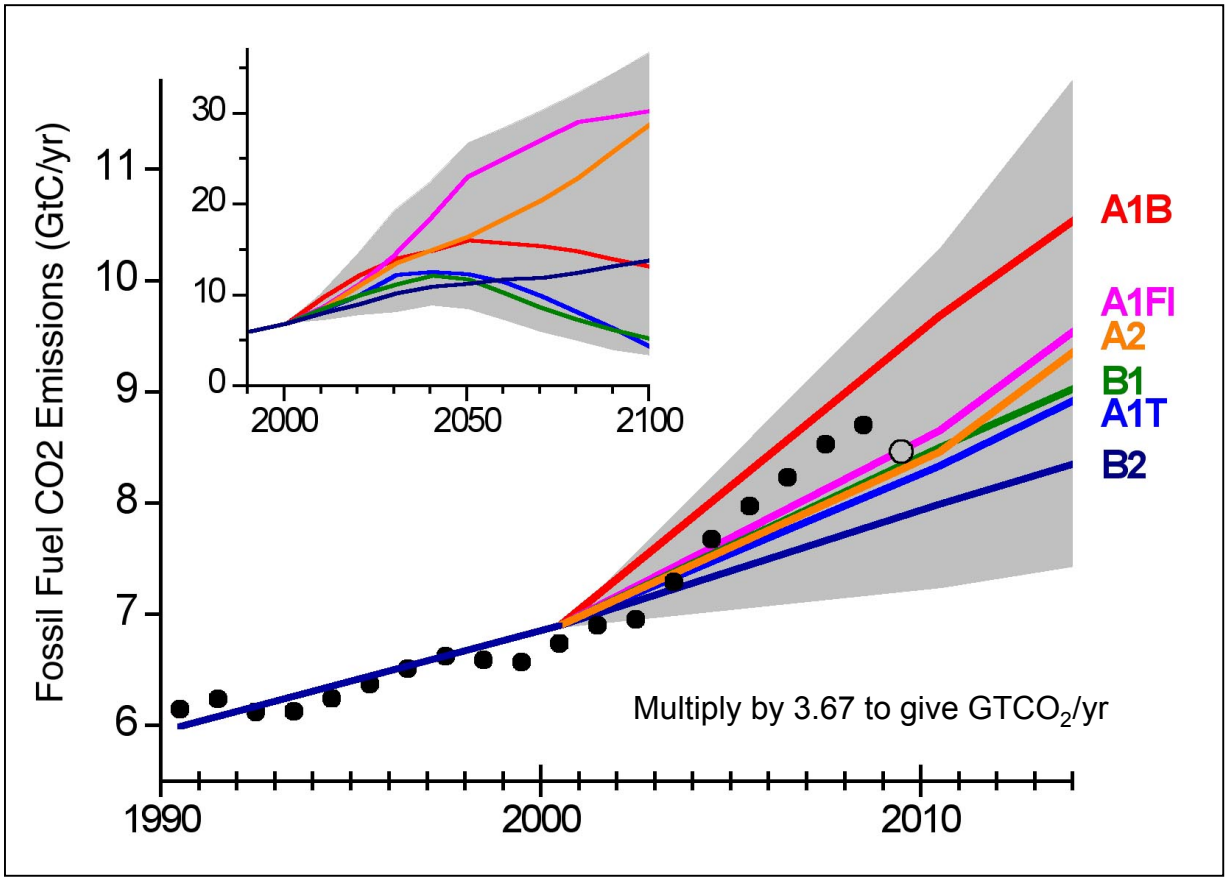
Actuals vs Projections - Emissions



From Manning et al, Nature Geoscience, June 2010

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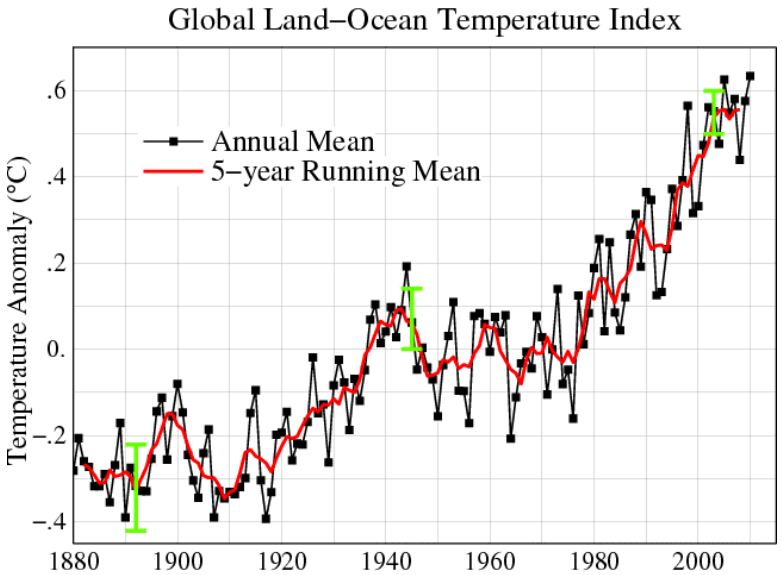
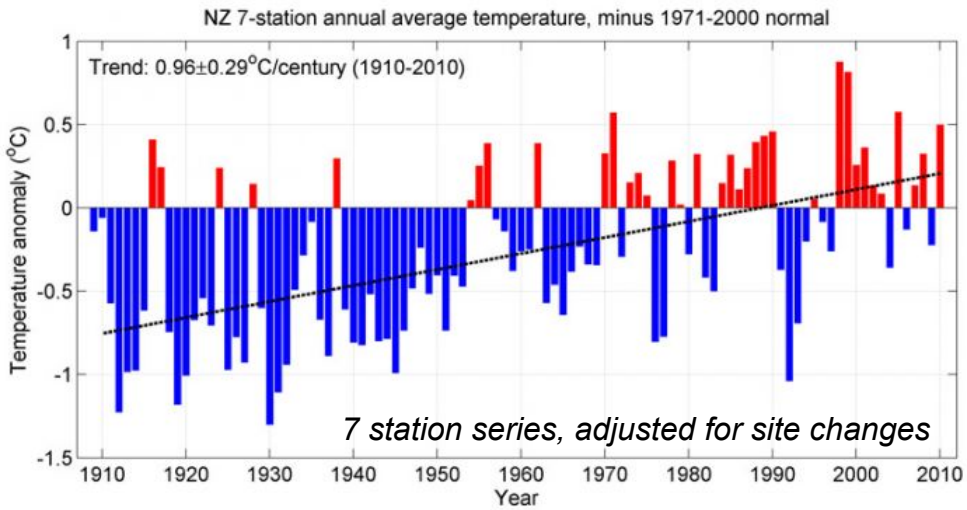
Global and Local Temperature Changes



The Globe (1880-2010)

Source http://data.giss.nasa.gov/gistemp/graphs/

NZ (1909-2010)



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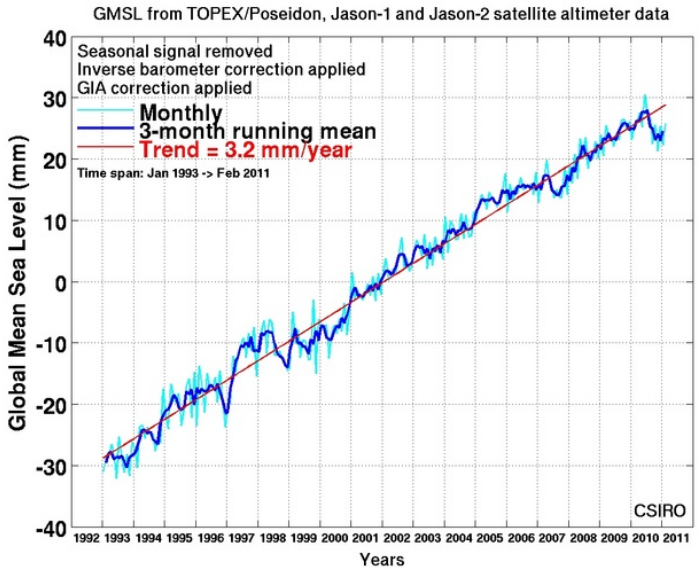
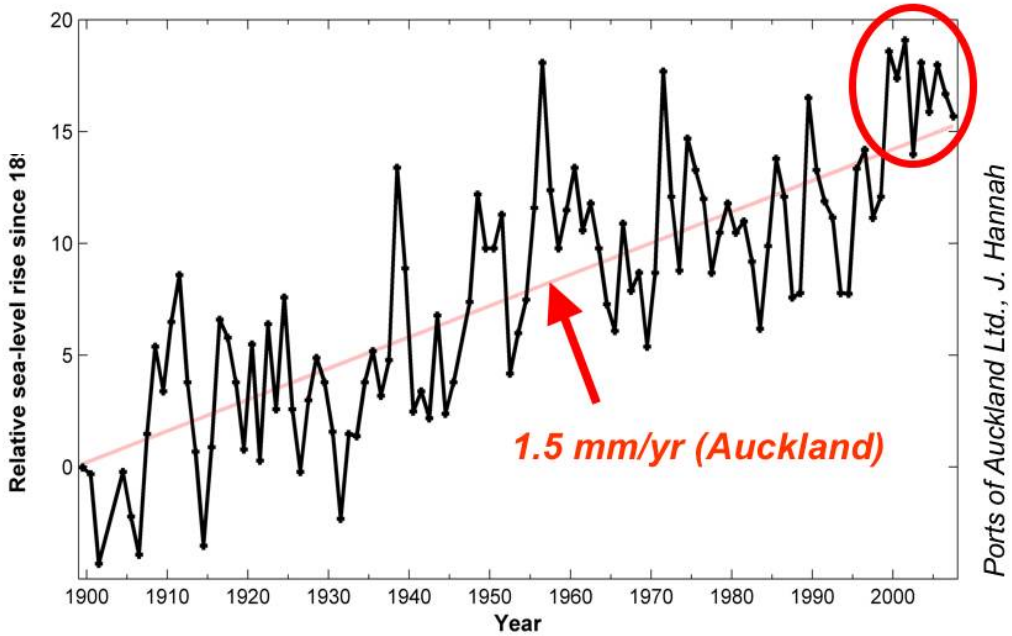
Global and Local Sea Level Changes



Global (1900-2010)

Auckland (1900-2007)



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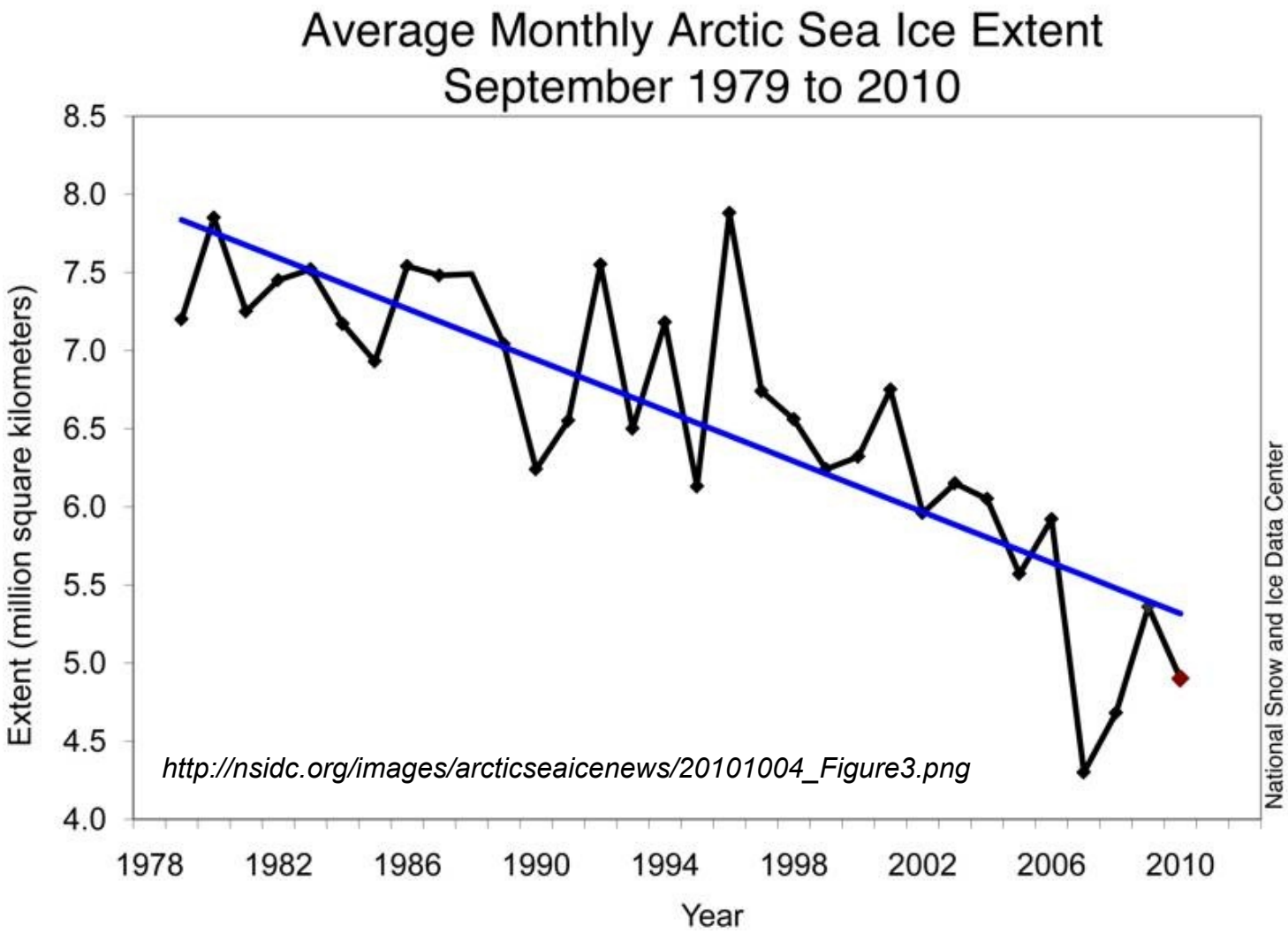
Recent global changes - Arctic sea ice



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Extreme Events

IPCC Special Report on “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation” due November 2011

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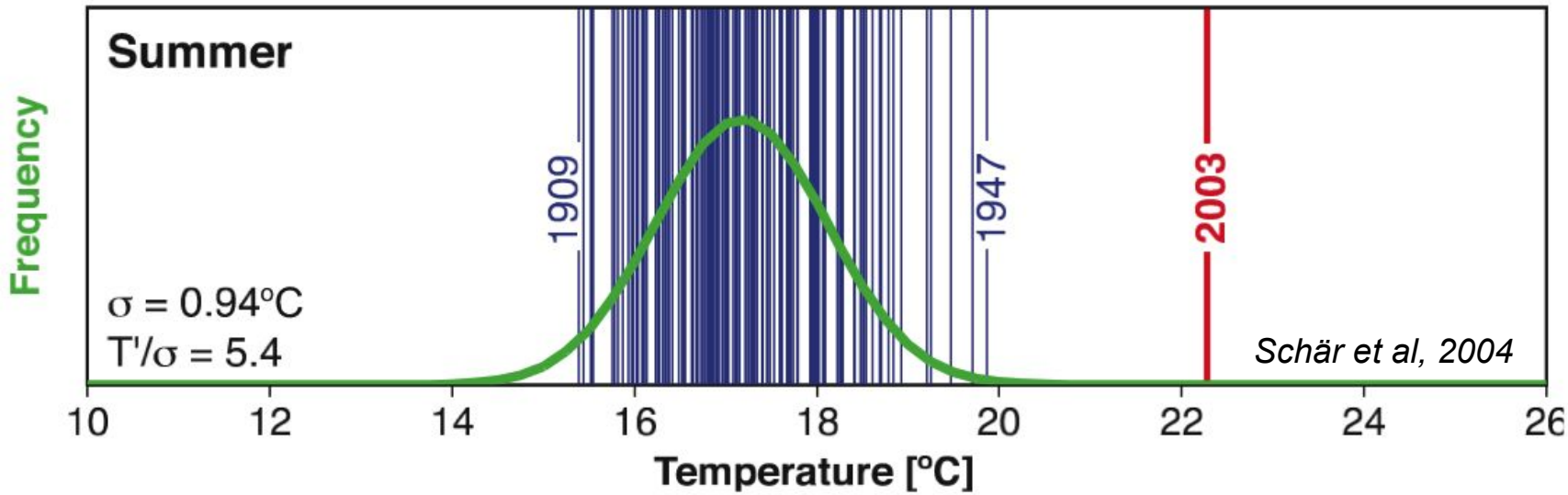
Can individual extreme events be explained by greenhouse warming ?



- Active field of research. Generally frame in terms of probabilities under 'historical" climate, shift in probability under changed climate (from model runs) - "changing the odds"
- Interest in recent events, e.g. 2003 European summer temperatures; cold 2009/10 winter in parts of N Hem; Australian drought/ bushfires, …
- "No computer simulation can conclusively attribute a given snowstorm or flood to global warming. But with a combination of climate models, weather observations and a good dose of probability theory scientists may be able to determine how climate warming changes the odds." *Schiermeier, Nature, Feb 2011*

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Recent papers on intense rainfall / flood and global warming

- Pall et al, Nature, Feb 2011: Damaging floods in 2000 in England and Wales. Ran thousands of high-resolution seasonal forecasts simulations with or without the effect of greenhouse gases.
- Found " the increase in risk of occurrence of floods in England and Wales in autumn 2000 that is attributable to twentieth-century anthropogenic greenhouse gas emissions is very likely (nine out of ten cases) to be more than 20%, and likely (two out of three cases) to be more than 90%…"

- Min et al, Nature, Feb 2011: Showed increases in heavy precipitation that have been observed over much of the Northern Hemisphere over the past several decades correspond with changes in extreme precipitation predicted with climate models when those models are influenced by historical changes in greenhouse gases, but cannot be explained just by their estimates of internal climate variability.

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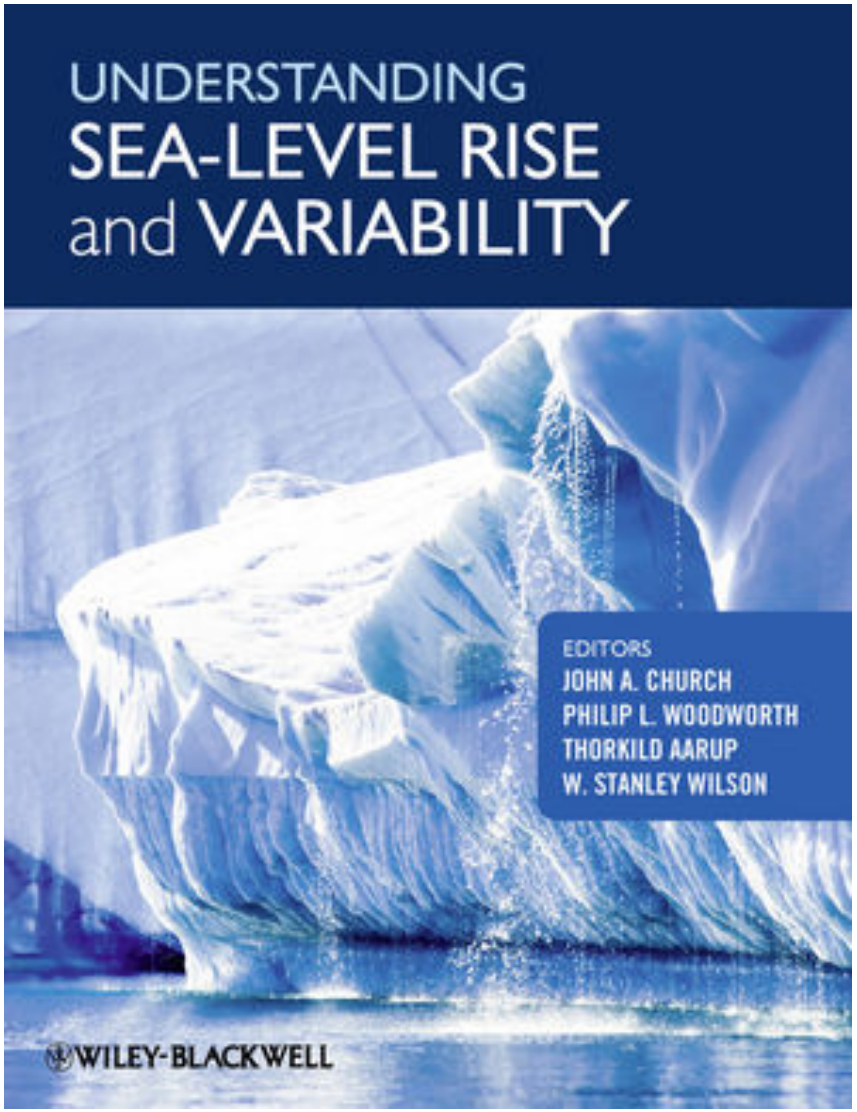
Sea Level Rise



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Sea Level Rise - Contributions

Table 13.1 Contributions to sea-level rise for the period 1961 to 2003, from Domingues et al. (2008).

Contribution	Amount of rise
Ocean thermal expansion for the upper 700 m	0.5 ± 0.1 mm/year
Ocean thermal expansion below 700 m	0.2 ± 0.1 mm/year
Glaciers and ice caps	0.5 ± 0.2 mm/year
Greenland Ice Sheet	0.1 ± 0.1 mm/year
Antarctic Ice Sheet	0.2 ± 0.4 mm/year
Sum of contributions	1.5 ± 0.4 mm/year
Observed sea-level rise	1.6 ± 0.2 mm/year

From: Church et al (Eds), Understanding Sea Level Rise and Variability. Wiley-Blackwell, 2010.

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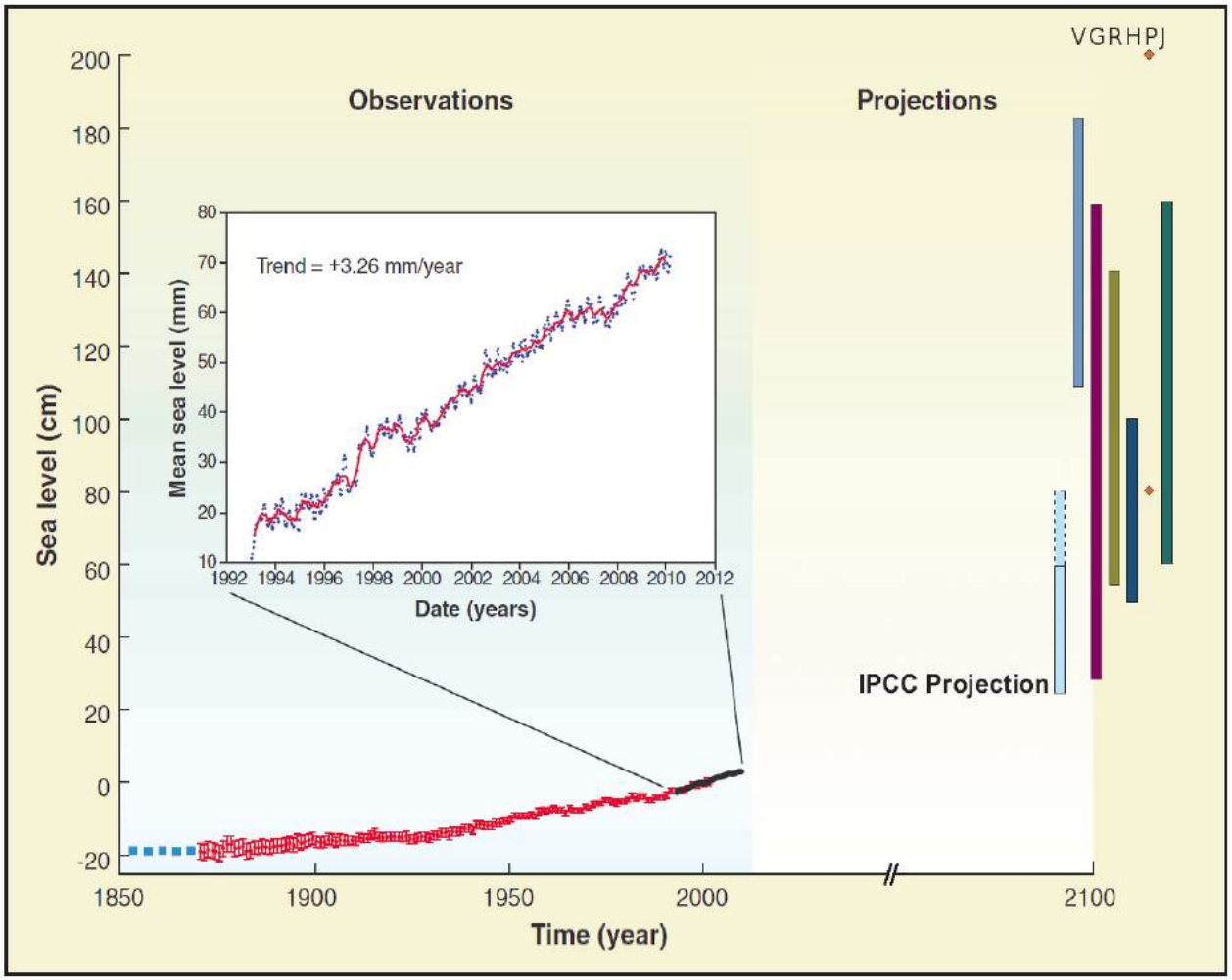
Sea Level Rise - Projections



From: Sea Level Rise - Emerging Issues. RSNZ, Sept 2010

Projections from: IPCC (no upper bound), Vermeer, Grinstead, Rahmstorf, Horton, Pfeffer, Jevrejeva

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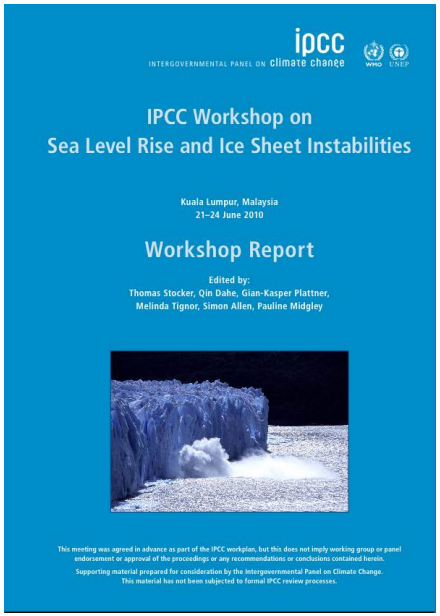
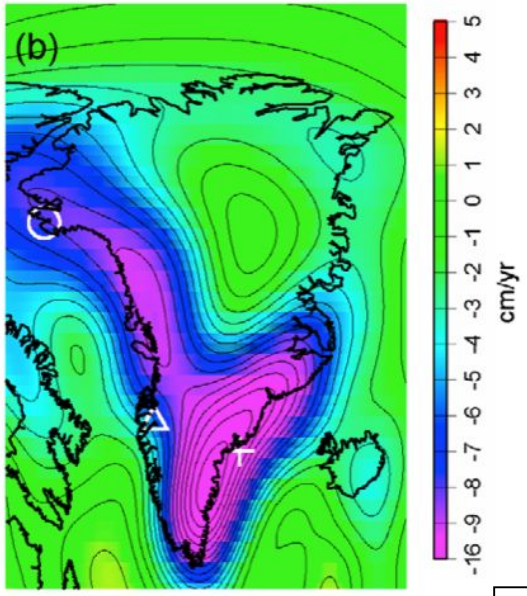
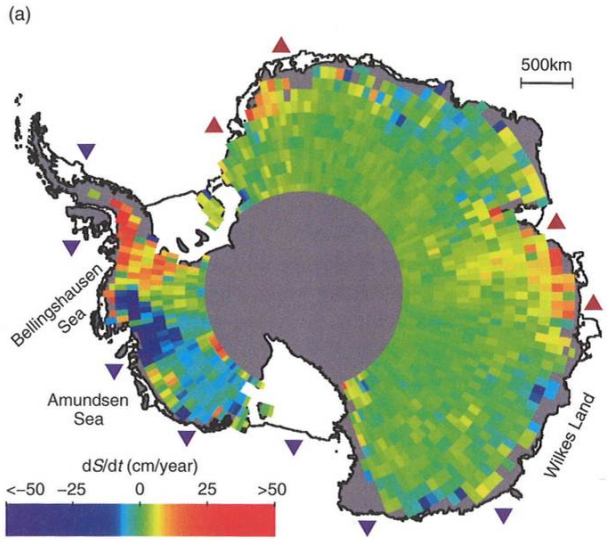
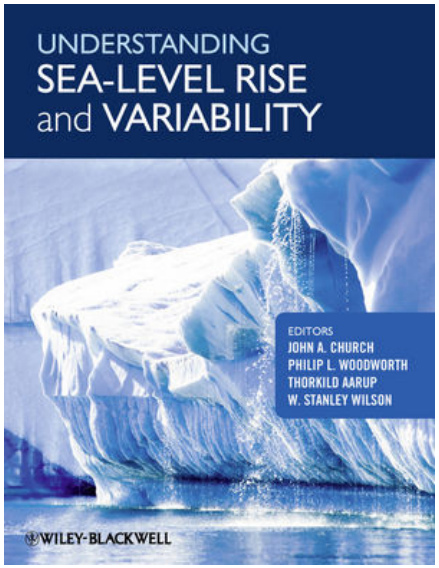
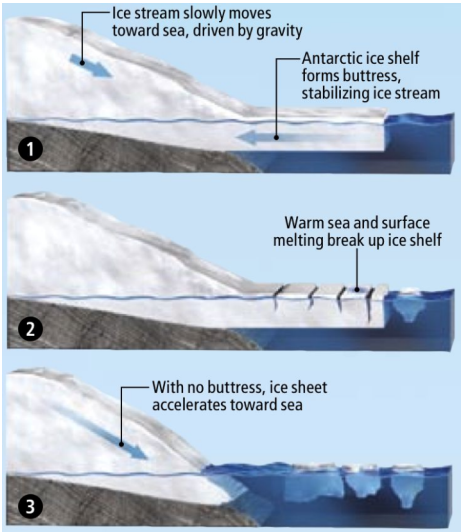
Very active research field - watch AR5!

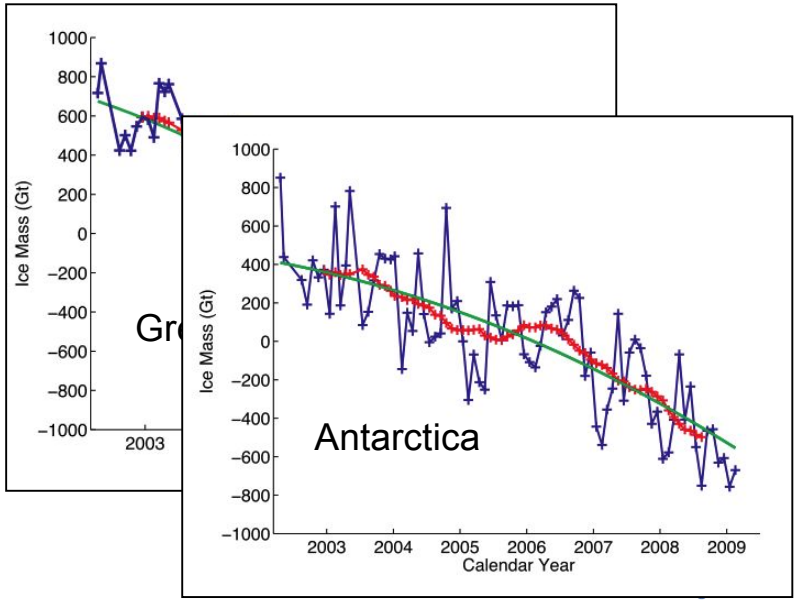




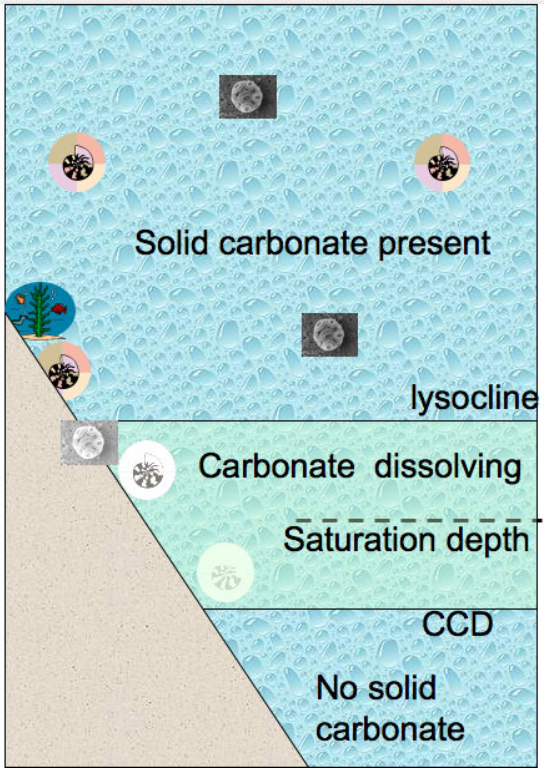








Ocean Acidification



Carbonate solubility increases with lower temperature and at higher pressure

- Rising atmospheric CO_2 reduces ocean pH and changes seawater carbonate chemistry
- The "ocean acidification" rate will accelerate over this century unless CO_2 emissions are curbed substantially
- Lowering of calcium carbonate saturation states impacts shell-forming marine organisms e.g. some plankton, molluscs, echinoderms, corals
- Many calcifying species exhibit reduced calcification and growth rates in Lab experiments under high-CO_2 experiments
- The potential for marine organisms to adapt to increasing CO_2, and broader implications for ocean ecosystems are not well known
- Ocean pH has varied in the past but paleo-events may be only imperfect analogs to current conditions.

Summarised from Feely et al, Ann Rev Marine Science, Jan 2009

IPCC Ocean Acidification Expert Workshop Report Due Out Soon

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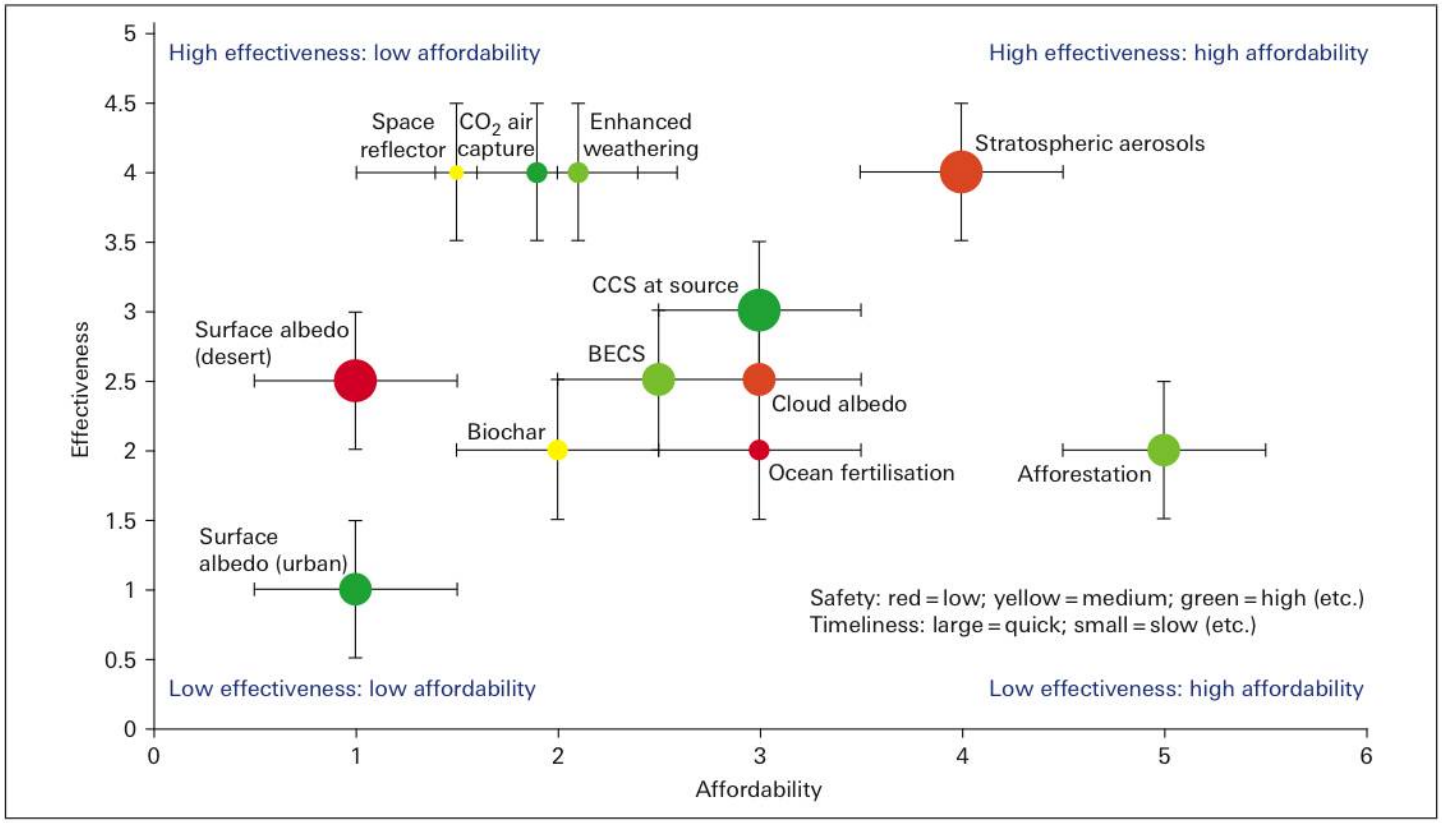
Geoengineering



Geoengineering the climate: Science, governance and uncertainty. Royal Society, September 2009

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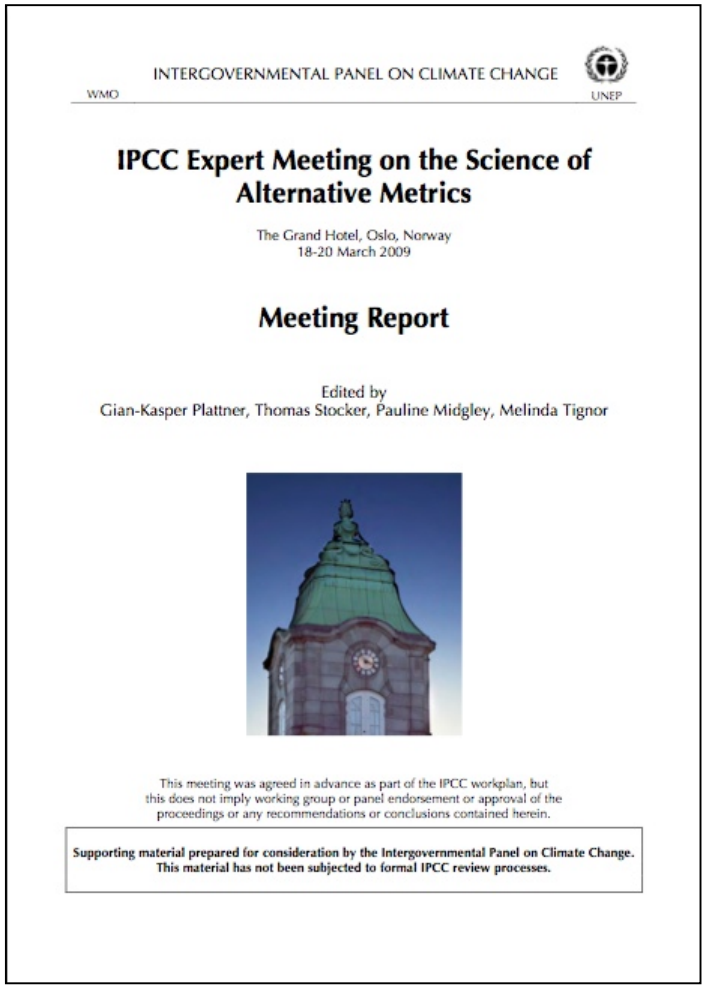
Metrics for non-CO_2 greenhouse gases



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

IPCC Expert Meeting on the Science of Alternative Metrics

The Grand Hotel, Oslo, Norway
18-20 March 2009

Meeting Report

Edited by
Gian-Kasper Plattner, Thomas Stocker, Pauline Midgley, Melinda Tignor

This meeting was agreed in advance as part of the IPCC workplan, but this does not imply working group or panel endorsement or approval of the proceedings or any recommendations or conclusions contained herein.

Supporting material prepared for consideration by the Intergovernmental Panel on Climate Change. This material has not been subjected to formal IPCC review processes.

"The effectiveness of the use of a given metric depends on the primary policy goal, for example to limit the long term temperature change, limit rates of change, avoid particular impacts, and balance costs and benefits. The GWP was not designed with a particular policy goal in mind. Depending on the specific policy goal or goals, alternative metrics may be preferable"

Methane	20 years	100 years
GWP	72	25
GTP	46	5

GWPs from IPCC AR4 WG1; GTPs from Shine 2005 (EBM GTP)

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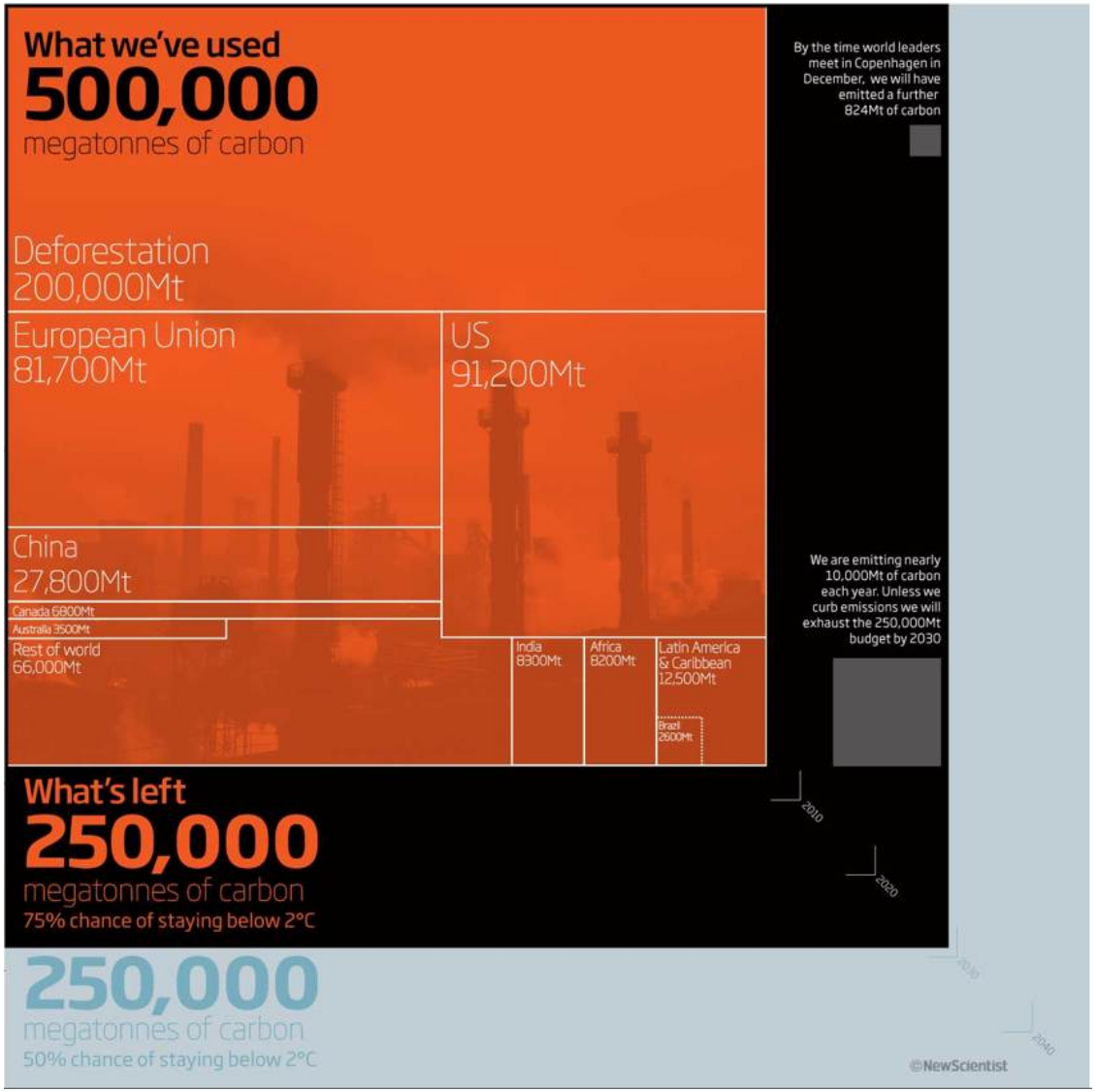
Cumulative Emissions - "The Trillionth Tonne"



From New Scientist, 4 Nov 2009

Brahic and Pearce, New Scientist, Nov 2009

For more details see: Allen, Frame et al, Nature, April 2009: Warming caused by cumulative carbon emissions towards the trillionth tonne; also Climate Stabilization Targets - Emissions, Concentrations and Impacts over Decades to Millenia. National Research Council of the National Accademies, USA, 2011

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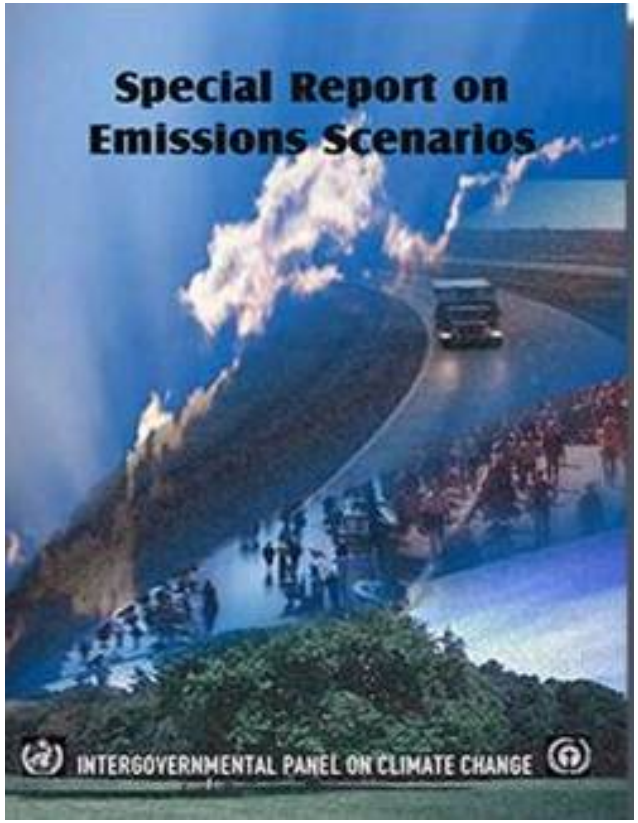
Work on New Scenarios - In Progress



2001

TOWARDS NEW SCENARIOS FOR ANALYSIS OF EMISSIONS, CLIMATE CHANGE, IMPACTS, AND RESPONSE STRATEGIES

IPCC EXPERT MEETING REPORT

19–21 September, 2007
Noordwijkerhout, The Netherlands

Supporting material prepared for consideration by the Intergovernmental Panel on Climate Change. This material has not been subjected to formal IPCC review processes. This expert meeting was agreed in advance as part of the IPCC work plan, but this does not imply working group or panel endorsement or approval of this report or any recommendations or conclusions contained herein.

The report has been subjected to an expert peer review process and revised accordingly. A collation of the comments received is available on the IPCC website (http://www.ipcc.ch/ipccreports/supporting-material.htm).

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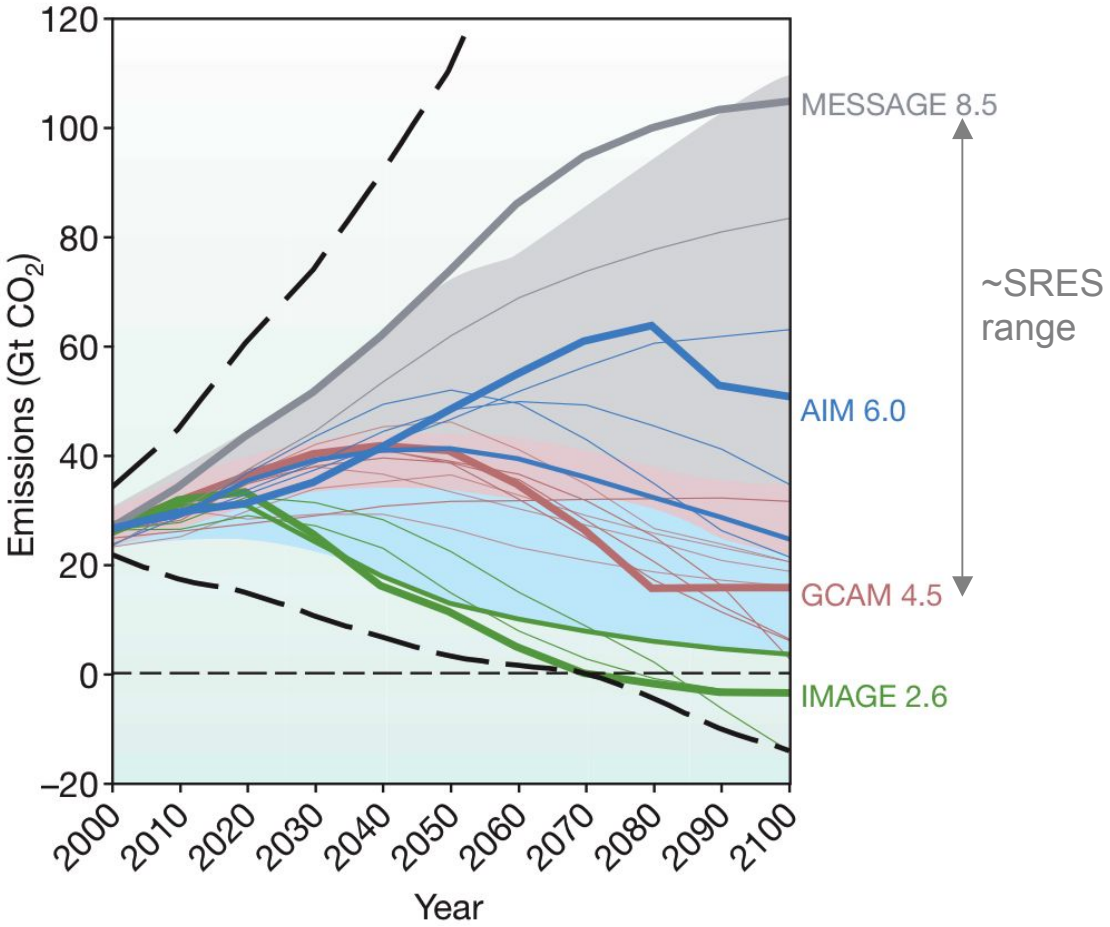
Representative Concentration Pathways (RCPs)



Moss et al, Nature, Feb2010

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Scenario approach for IPCC AR5
(RCPs - Representative Concentration Pathways)

Name	Concentration (p.p.m.)	Pathway
RCP8.5	>1,370 CO_2-equiv in 2100	Rising
RCP6.0	~850 CO_2-equiv (at stabilization after 2100)	Stabilization without overshoot
RCP4.5	~650 CO_2-equiv (at stabilization after 2100)	Stabilization without overshoot
RCP2.6	Peak at ~490 CO_2-equiv before 2100 & then declines	Peak and decline

Extracted from Moss et al, Nature, Feb2010

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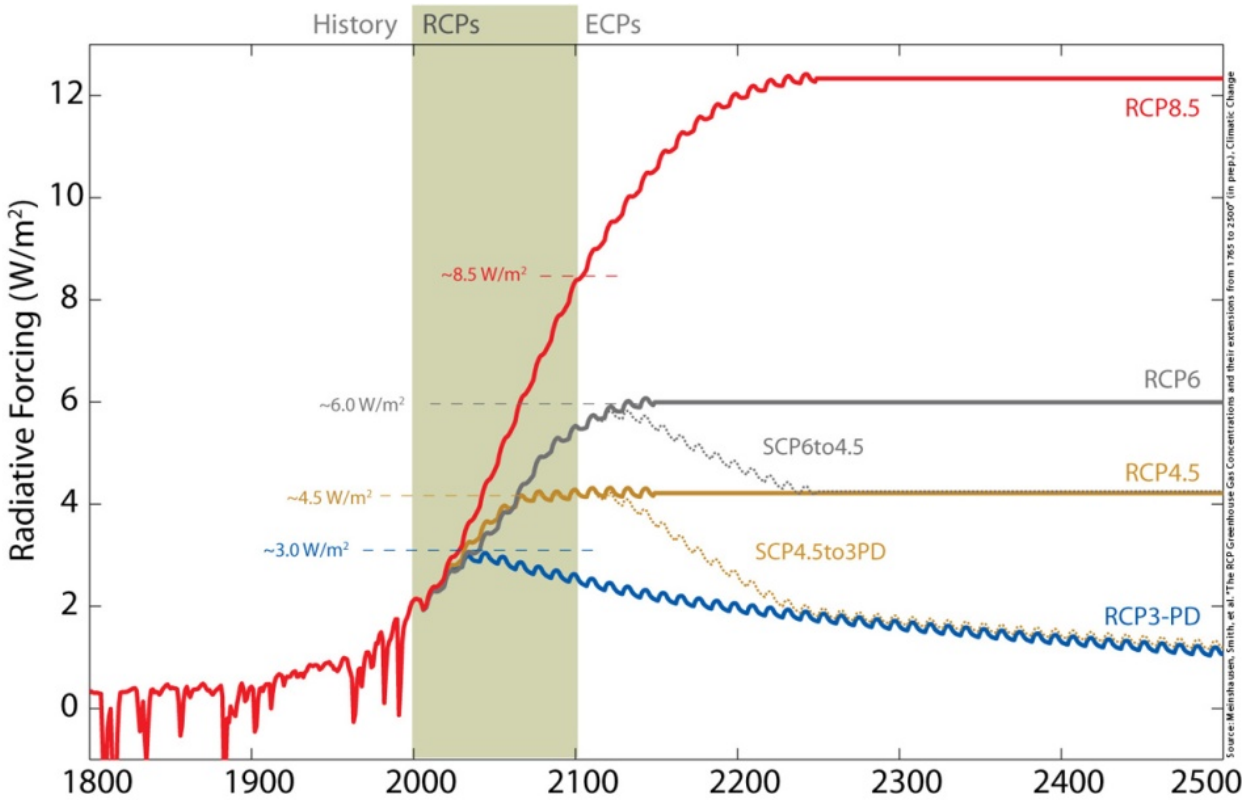
Also “what if” simulations further into future



http://www.pik-potsdam.de/%7Emmalte/rcps/graphics/RadiativeForcingRCPs.jpg

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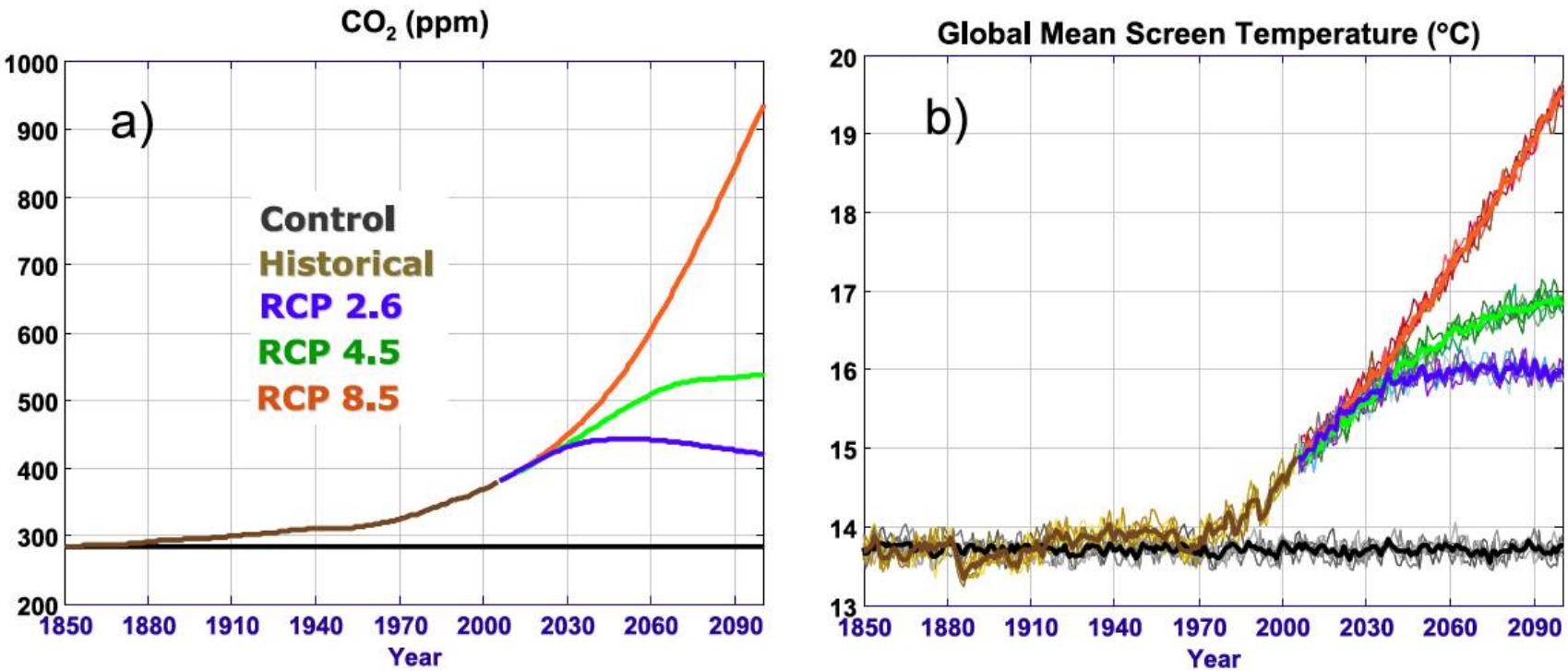
RCPs - Some Initial Results



From Arora et al, Geophys Res Letters March 2011

Arora et al conclude: "The results of this study suggest that limiting warming to roughly 2°C by the end of this century is unlikely since it requires an immediate ramp down of emissions followed by ongoing carbon sequestration in the second half of this century"

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IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation

SPM approved and report accepted
Abu Dhabi May 2011

- Technical chapters: bioenergy, direct solar, geothermal, hydropower, ocean energy, wind energy: Existing use, potential, technology, costs, impacts, ghg implications, developments, …
- Big Picture: Reviews over 160 existing scenarios on possible penetration of renewables by 2050, alongside environmental and social implications.
- Presently RE accounts for 12.9% of the global energy supply.
- RE becomes dominant low-carbon energy supply option by 2050 in majority of scenarios, has large potential to mitigate greenhouse gas emissions.
- Scenarios do not indicate an obvious single dominant RE technology at a global level.
- Under most scenarios, increasing the share of RE in the energy mix will require policies to stimulate changes in the energy system, including additional policies to attract investment in technologies and infrastructure

http://srren.ipcc-wg3.de/report

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Planned timing of relevant IPCC reports

- SRREN Special Report on Renewable Energy Sources and Climate Change Mitigation. May 2011. (Completed).
- SREX Special Report on “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation”. Nov 2011
- Fifth Assessment Report.
  - WG1 Physical Science Basis - Sept 2013.
  - WG2 Impacts/Adaptation/Vulnerability - March 2014.
  - WG3 Mitigation - April 2014.
  - SYR Synthesis - October 2014

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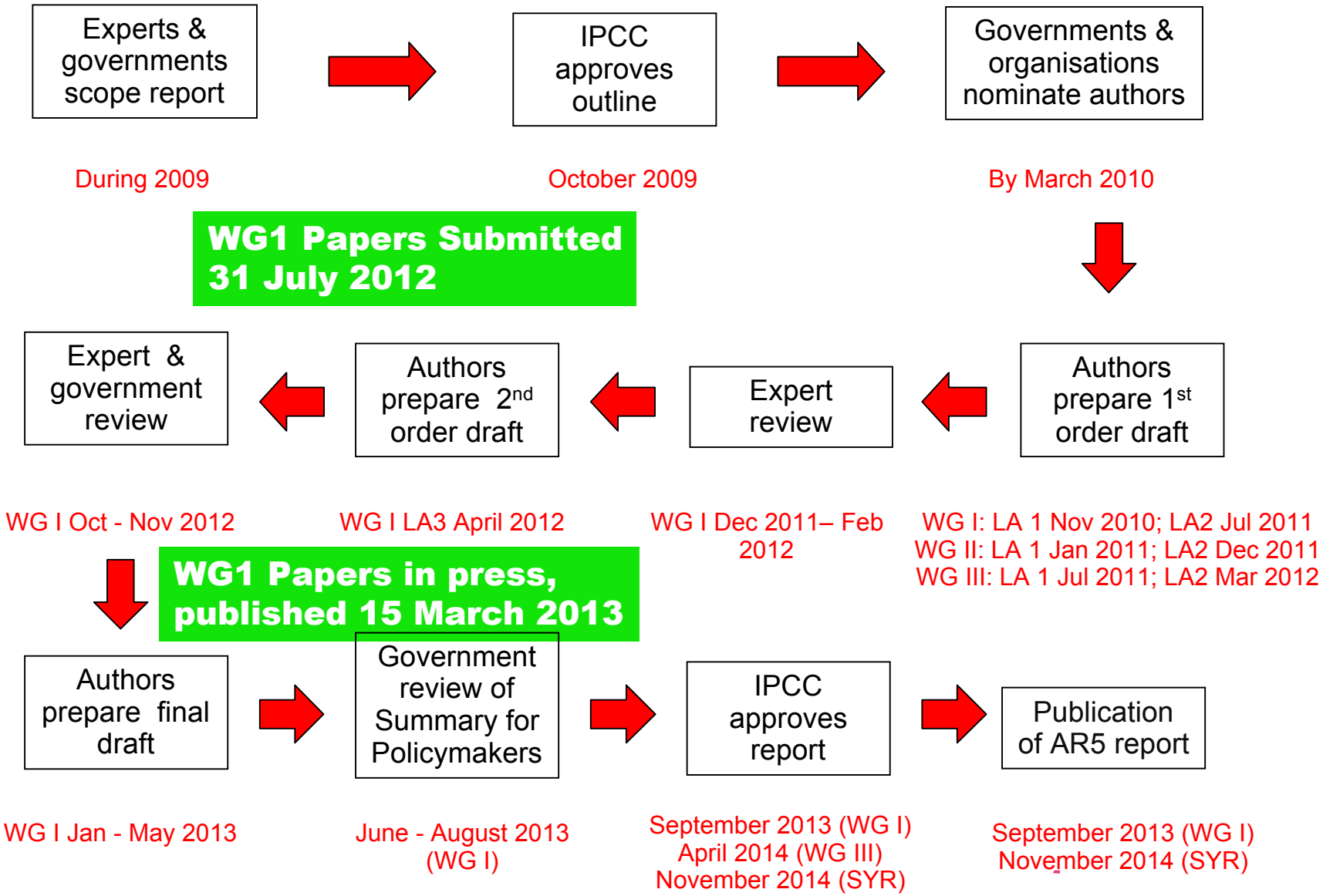
The AR5 timeline …



Summary

- Assessments assist many groups and activities: Government policymakers, regional planning, industry, researchers, the public, …
- Key goal: be relevant but not “policy prescriptive”.
- Multiple peer review processes (scientists and governments) key to robustness, credibility, and ownership
- Contributions of people like you through publishing your research, and participating in expert review of assessment drafts are vital