Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Quantification of climate system responses

Gabriele Hegerl

Nathan Gillett, Jonathan Gregory, Reto Knutti, Pierre Friedlingstein, Myles Allen, Valerie Masson Delmotte, Michael Schulz and Tim Osborn, Peter Stott

LA, Chapter 10; (C)Las CHs 5, 10, 12, 13,

© Yann Arthus-Bertrand / Altitude

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

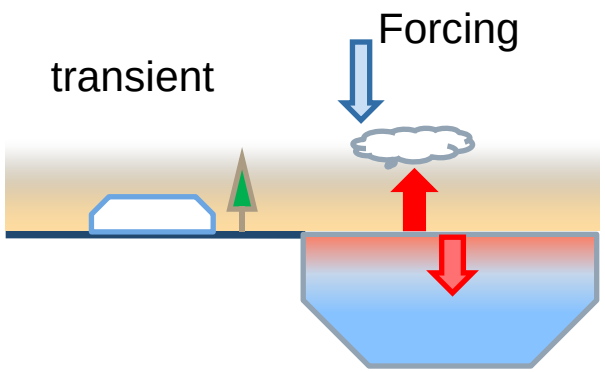
Response to CO_2 doubling

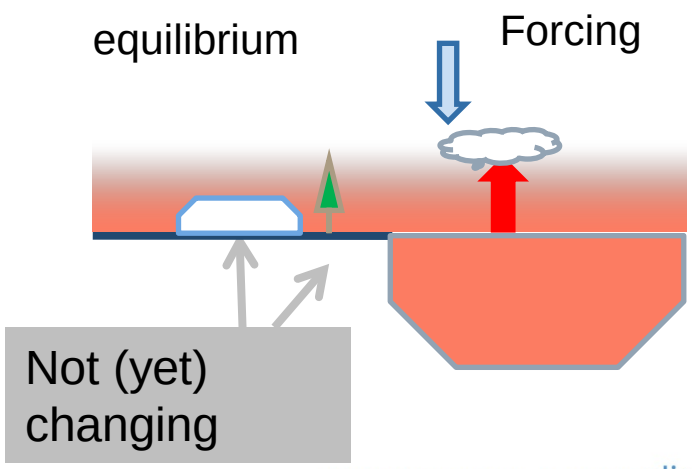
Transient climate response:

- temperature change during increasing radiative forcing;
- change in global mean surface temperature at CO_2 doubling in a 1% / year scenario. timescale: decade to century

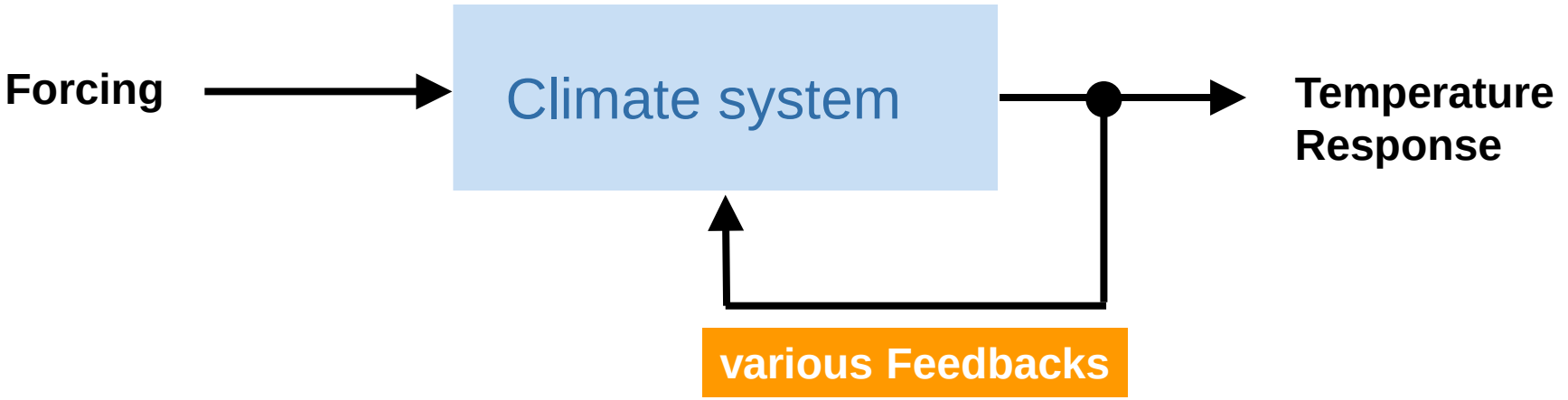
Equilibrium climate sensitivity:

- Temperature response to doubling of CO_2 doubling in equilibrium; century to millennium
- Determined by atmospheric feedbacks





Atmospheric feedbacks to warming



- **Combined water vapour and lapse rate feedback** *extremely likely* positive
- **Cloud feedback** important for spread in models *'likely'* positive
- **Albedo Feedback**: *'likely'* positive

Total Feedback: positive *(very high confidence)*

Supporting that equilibrium climate sensitivity extremely likely >1

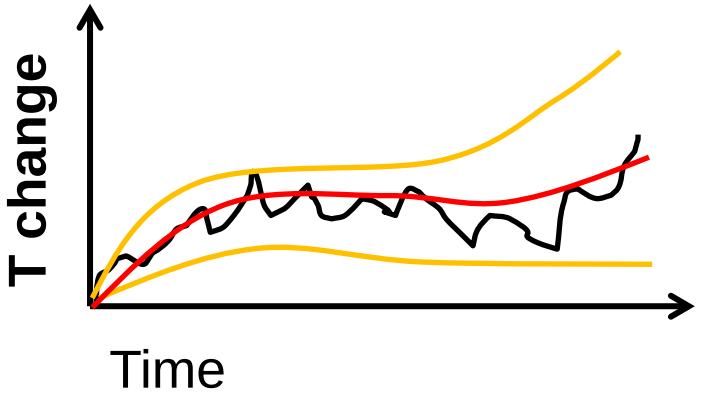
Estimating Equilibrium Climate Sensitivity and Transient Climate Response

- CMIP5 range
- Model ensembles evaluated against mean climate

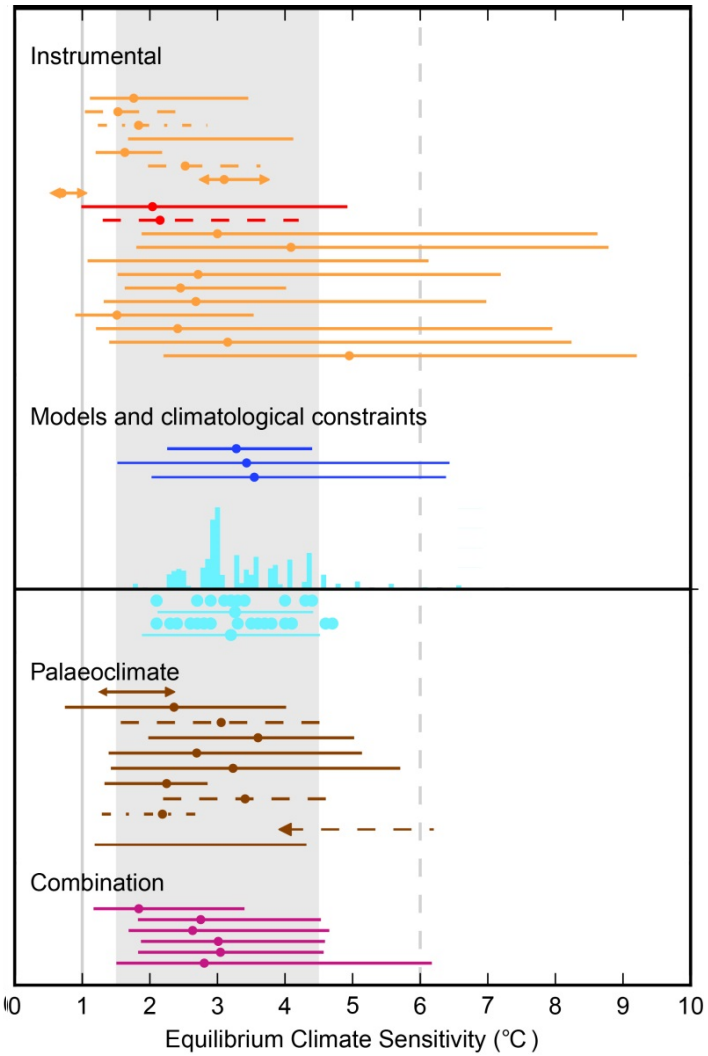
Estimates based on observed warming use

- energy balance arguments
- simple **models** fitted to data

Influenced by climate variability (particularly most likely value)



Equilibrium climate sensitivity estimates



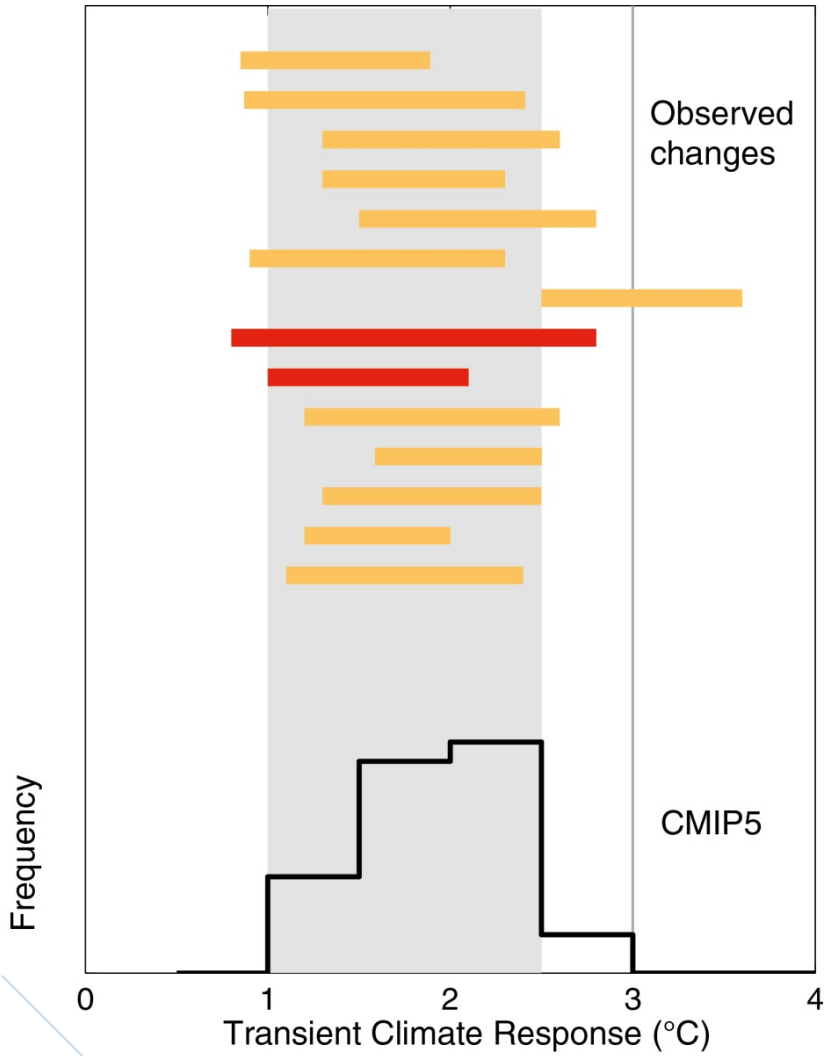
Likely range supported by all lines of evidence

Model fit to observed warming **in lower part of *likely* range**; model estimates constrained by mean climate in **upper part of the *likely* range**)
=> No best estimate possible

ECS is

- *likely* in the range 1.5°C to 4.5°C (high confidence)
- *extremely unlikely* less than 1°C (high confidence)
- *very unlikely* greater than 6°C (medium confidence).

Transient Climate Response: more relevant for next century



The transient climate response (TCR) is *likely* in the range of 1.0°C to 2.5°C (*high confidence*) and *extremely unlikely* greater than 3°C

⇒ tightening of upper limit compared to earlier estimates,

⇒ slight downward adjustment of lower limit

What has changed compared to earlier results?

Charney range 1979: 2 climate models

AR5: Multiple lines of evidence (paleo, observed climate change, modelling, feedback analysis) support 'likely' range of 1.5 to 4.5 **=> high confidence**

Since AR4:

- Longer record (surface temperature, ocean heat content)
- Less negative aerosol forcing based on improved estimates
- reduced recent warming rate
- methodological changes (prior assumptions)

Transient climate response to cumulative carbon emissions (TCRE)

- Relates transient response of the climate system to cumulative carbon emissions
- global mean surface temperature change per 1000 PgC emitted to the atmosphere

Evidence:
- warming attributable to greenhouse gas increases
- Observed airborne fraction of anthropogenic CO_2 emissions

TCRE is *likely* in the range of 0.8°C to 2.5°C per 1000 PgC

	TAR	AR4	AR5
ECS	Likely range: 1.5 to 4.5°C	*likely* range: 2.0 to 4.5°C *very unlikely* <1.5°C – best estimate about 3°C	***likely* range:** **1.5 to 4.5°C** ***extremely unlikely*** **<1.0°C** ***very unlikely*** **>6.0°C** –
TCR	Model range 1.1 to 3.1°C	*very likely* >1.0°C *very unlikely* >3.0°C	***likely* range:** **1.0 to 2.5°C** ***extremely unlikely*** **>3.0°C**
TCRE			***likely* range:** **0.8 to 2.5 °C/1000 PgC**

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

© Yann Arthus-Bertrand / Altitude

Further Information

www.climatechange2013.org

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP