Quantification of climate system responses

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LA, Chapter 10; (C)Las CHs 5, 10, 12, 13,
Response to CO₂ doubling

Transient climate response:
• temperature change during increasing radiative forcing;
• change in global mean surface temperature at CO₂ doubling in a 1% / year scenario. timescale: decade to century

Equilibrium climate sensitivity:
• Temperature response to doubling of CO₂ 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).
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 CO₂ emissions

TCRE is *likely* in the range of 0.8°C to 2.5°C per 1000 PgC
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<th>TAR</th>
<th>AR4</th>
<th>AR5</th>
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<tbody>
<tr>
<td>ECS</td>
<td>Likely range: 1.5 to 4.5°C</td>
<td><em>likely range: 2.0 to 4.5°C</em></td>
<td><em>likely range: 1.5 to 4.5°C</em></td>
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<td>very unlikely &lt;1.5°C</td>
<td>very unlikely &lt;1.0°C</td>
<td>extremely unlikely &lt;1.0°C</td>
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<td>best estimate about 3°C</td>
<td>very unlikely &gt;1.0°C</td>
<td>very unlikely &gt;6.0°C</td>
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<td>very unlikely &gt;3.0°C</td>
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<td>TCR</td>
<td>Model range 1.1 to 3.1°C</td>
<td><em>very likely &gt;1.0°C</em></td>
<td><em>likely range: 1.0 to 2.5°C</em></td>
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<td>very unlikely &gt;3.0°C</td>
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<td>*likely range: 0.8 to 2.5 °C/1000 PgC</td>
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