What does a 1.5°C+ rise in temperatures mean for sea-level rise and associated impacts?

Results from ADJUST1.5

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**Key messages**

- Median projection suggest that annual carbon emissions must be reduced to zero by 2045 for 1.5°C, and by the 2080s for 2.0°C.
- At 1.5°C, sea-levels will keep rising.
- Climate change mitigation can reduce the percentage of impacts avoided (in terms of area and people exposed) by approximately 50% by 2100.
- Temperature stabilization at 1.5°C and 2.0°C lead to similar levels of exposure for flood plain area and population even at 2300.
- However, both have a lower magnitude of sea-level rise and range of uncertainty from a non-mitigation scenario, especially beyond 2100.
- High impact locations include deltas (many south, south-east, east Asia countries) and small island developing States, where there is a need for adaptation. There are further adaptation challenges in cities, where there is a greater emphasis on adaptation planning.
- 1.5°C indicates a significant reduction in ocean acidification and associated ecosystem stress.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Sea-level rise in 2100 (m) 50th [5th-95th percentiles]</th>
<th>Sea-level rise in 2300 (m) 50th [5th-95th percentiles]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5°C</td>
<td>0.40 [0.62-0.62]</td>
<td>1.00 [0.59-1.55]</td>
</tr>
<tr>
<td>2.0°C</td>
<td>0.46 [0.30-0.69]</td>
<td>1.26 [0.74-1.90]</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>0.78 [0.53-1.11]</td>
<td>4.48 [2.76-6.87]</td>
</tr>
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</table>
Sea-levels will keep on rising, even taking account of climate change mitigation. There is no set time period to define impacts.
Warming Acidification & Sea level Projector (WASP): Background

Monte Carlo + history matching:

1. Generate initial set of model runs, and run from 1750 to 2017

2. Test each simulation against observations of:
   - surface warming
   - ocean heat uptake
   - ocean carbon uptake
   - land carbon uptake
   - sea-level rise

3. Extract only the simulations that agree with observations, and make future projections with those (~ 0.03 % of initial runs)
We conducted an observation-constrained estimate of the future carbon budget for 1.5 and 2 °C.

For 1.5°C, we can emit up to **195 to 200 PgC** from 2017.
- **Must reduce the emission-rate to zero during 2040s**

For 2.0°C, we can emit up to **395 to 455 PgC**.
- **Must reduce the emission-rate to zero by the 2080s**
A theoretical approach

- We focused on hitting set temperature targets at different time slices.
- Simulations constrained by **observations** to present day
- Then followed the **INDC**s until 2030, then analysed variations in emissions and subsequently temperature and sea-level rise.
How much will sea-levels rise?

- Mitigating reduces the rate of rise, particularly over centennial timescales.

### Table 1.

<table>
<thead>
<tr>
<th>Time</th>
<th>Climate parameter</th>
<th>AMP1.5</th>
<th>AMP2.0</th>
<th>AMP2.5</th>
<th>AMP3.0</th>
<th>AMP4.5</th>
<th>RCP8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050</td>
<td>Temperature (°C)</td>
<td>1.71(1.44–2.16)</td>
<td>1.76(1.51–2.16)</td>
<td>1.77(1.52–2.16)</td>
<td>1.78(1.53–2.15)</td>
<td>2.26(1.96–2.51)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea-level rise (m)</td>
<td>0.20(0.14–0.29)</td>
<td>0.20(0.14–0.29)</td>
<td>0.20(0.14–0.29)</td>
<td>0.21(0.14–0.29)</td>
<td>0.24(0.17–0.33)</td>
<td></td>
</tr>
<tr>
<td>2100</td>
<td>Temperature (°C)</td>
<td>1.60(1.26–2.33)</td>
<td>2.03(1.72–2.64)</td>
<td>2.30(1.89–2.95)</td>
<td>2.39(1.97–3.15)</td>
<td>2.50(2.05–3.28)</td>
<td>4.93(4.35–5.83)</td>
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<td>0.49(0.32–0.73)</td>
<td>0.50(0.33–0.75)</td>
<td>0.78(0.53–1.11)</td>
</tr>
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<td>2150</td>
<td>Temperature (°C)</td>
<td>1.49(1.19–2.31)</td>
<td>1.97(1.72–2.68)</td>
<td>2.45(2.08–3.08)</td>
<td>2.75(2.24–3.48)</td>
<td>3.04(2.44–4.15)</td>
<td>7.09(6.02–8.92)</td>
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<td>Sea-level rise (m)</td>
<td>0.58(0.35–0.92)</td>
<td>0.69(0.43–1.06)</td>
<td>0.76(0.48–1.17)</td>
<td>0.80(0.51–1.23)</td>
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<td>2200</td>
<td>Temperature (°C)</td>
<td>1.41(1.15–2.10)</td>
<td>1.90(1.66–2.57)</td>
<td>2.41(2.12–3.02)</td>
<td>2.85(2.40–3.49)</td>
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<td>1.22(0.85–2.13)</td>
<td>2.53(1.86–4.44)</td>
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<tr>
<td>2250</td>
<td>Temperature (°C)</td>
<td>1.36(1.13–1.99)</td>
<td>1.83(1.61–2.41)</td>
<td>2.33(2.08–2.88)</td>
<td>2.82(2.48–3.37)</td>
<td>3.71(3.00–4.81)</td>
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What land area and how many people will be exposed to sea-level rise?

The land and people exposed to rising sea-levels (not taking account of adaptation) varies between socio-economic scenarios.

Much land and people are exposed today.

Climate change mitigation can reduce the percentage of impacts avoided by approximately 50% by 2100.

The benefits of mitigation will increase post 2100.
Which countries are most greatly affected?

High impact locations:
- Deltas (many south, south-east, east Asia countries)
- Small island developing States

Adaptation challenges:
- Cities
Surface ocean $\rho$H

- Significant reduction in ocean acidification for 1.5 °C versus greater warming
- Coupled with reduction in ocean warming - reduces associated stress on marine ecosystems
- Calcifying organisms (making shells) particularly at risk for greater $\rho$H change
Key messages

• Median projection suggest that annual carbon emissions must be reduced to zero by 2045 for 1.5°C, and by the 2080s for 2.0°C.
• Sea-level rise won't go away, even at 1.5°C.
• Climate change mitigation can reduce the percentage of impacts avoided (in terms of area and people exposed) by approximately 50% by 2100.
• Temperature stabilization at 1.5°C and 2.0°C lead to similar levels of exposure for flood plain area and population even at 2300.
• However, both have a lower magnitude of sea-level rise and range of uncertainty from a non-mitigation scenario, especially beyond 2100.
• High impact locations include deltas (many south, south-east, east Asia countries) and small island developing States, where there is a need for adaptation. There are further adaptation challenges in cities, where there is a greater emphasis on adaptation planning.
• 1.5°C indicates a significant reduction in ocean acidification and associated ecosystem stress.

Pathways to 1.5 °C and future carbon budget:

Impacts of 1.5 °C (and relative to greater warming):