Atmospheric CO$_2$ concentration
Atmospheric CO\textsubscript{2} over the last 800,000 years

- 2100 Higher Emissions Scenario\textsuperscript{91}
- 2100 Lower Emissions Scenario\textsuperscript{91}
- 2008 Observed

U.S. Global Change Research Program: Lüthi et al.; Tans; IIASA2
A Progression of Understanding: Greater and Greater Certainty in Attribution

AR1 (1990): “unequivocal detection not likely for a decade”


AR3 (2001): “most of the warming of the past 50 years is likely (odds 2 out of 3) due to human activities”

AR4 (2007): “most of the warming is very likely (odds 9 out of 10) due to greenhouse gases”

AR5 (2013) «It is extremely likely (odds 95 out of 100) that human influence has been the dominant cause... »
Most CMIP5 runs are based on the concentrations, but emissions-driven runs are available for RCP 8.5

AR5, chapter 12. WGI- Adopted version / subject to final copyedit
Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 for all scenarios (IPCC 2013, Fig. SPM.7a).
Adapted from: International Geosphere Biosphere Programme Report no.6, Global Changes of the Past, July 1988
18-20000 years ago (Last Glacial Maximum)

With permission from Dr. S. Joussaume, in « Climat d’hier à demain », CNRS éditions.
Today, with +4-5°C globally

With permission from Dr. S. Joussaume, in « Climat d’hier à demain », CNRS éditions.
We have a choice.
Projected Change in Precipitation

Change in average precipitation (1986–2005 to 2081–2100)
AR5 WGI Regional Atlas

- Addition to previous reports
- > 70 pages of maps, for RCP4.5 only: temperature and precipitation changes (winter & summer average climate, including model uncertainties)
- Other RCPs & seasons will be available as suppl. material later
Regional Atlas - «Central Europe», summer temp.

Median of multi-model distribution, average temp change JJA, 2081-2100

°C / 1985-2005
North Europe - Map of temperature changes: 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)
Regional Atlas - «Central Europe», precipitation

Median of multi-model distribution, average over October-March, 2081-2100

Matching : change < present day variability for 20 years periods)
North Europe - Map of precipitation changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)
## Extreme weather and climate events

<table>
<thead>
<tr>
<th>Phenomenon and direction of trend</th>
<th>Assessment that changes occurred (typically since 1950 unless otherwise indicated)</th>
<th>Assessment of a human contribution to observed changes</th>
<th>Likelihood of further changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmer and/or fewer cold days and nights over most land areas</td>
<td>Very likely</td>
<td>Very likely</td>
<td>Likely</td>
</tr>
<tr>
<td>Warmer and/or more frequent hot days and nights over most land areas</td>
<td>Very likely</td>
<td>Very likely</td>
<td>Likely</td>
</tr>
<tr>
<td>Warm spells/heat waves. Frequency and/or duration increases over most land areas</td>
<td>Medium confidence on a global scale Likely in large parts of Europe, Asia and Australia</td>
<td>Likely</td>
<td>Not formally assessed</td>
</tr>
<tr>
<td>Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation</td>
<td>Likely more land areas with increases than decreases</td>
<td>Medium confidence</td>
<td>Likely over many land areas</td>
</tr>
<tr>
<td>Increases in intensity and/or duration of drought</td>
<td>Low confidence on a global scale Likely changes in some regions</td>
<td>Low confidence</td>
<td>Low confidence</td>
</tr>
<tr>
<td>Increases in intense tropical cyclone activity</td>
<td>Low confidence in long term (centennial) changes Virtually certain in North Atlantic since 1970</td>
<td>Low confidence</td>
<td>Low confidence</td>
</tr>
<tr>
<td>Increased incidence and/or magnitude of extreme high sea level</td>
<td>Likely (since 1970)</td>
<td>Likely</td>
<td>Likely</td>
</tr>
</tbody>
</table>
Since 1950, extreme hot days and heavy precipitation have become more common.

There is evidence that anthropogenic influences, including increasing atmospheric greenhouse gas concentrations, have changed these extremes.
Changes in Extremes: Storms in North Atlantic

Since the 1970s, it is *virtually certain* that the frequency and intensity of storms in the North Atlantic has increased although the reasons for this increase are debated...
Ocean Acidification, for RCP 8.5 (orange) & RCP2.6 (blue)
Oceans are Acidifying Fast ..........

Changes in pH over the last 25 million years

- It is happening now, at a speed and to a level not experienced by marine organisms for about 60 million years
- Mass extinctions linked to previous ocean acidification events
- Takes 10,000’ s of years to recover

Turley et al. 2006

“Today is a rare event in the history of the World”

Slide courtesy of Carol Turley, PML
RCP2.6 (2081-2100), *likely* range: 26 to 55 cm

RCP8.5 (in 2100), *likely* range: 52 to 98 cm
Cumulative emissions of CO₂ largely determine global mean surface warming by the late 21st century and beyond.
Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.
Limiting warming to *likely* less than 2°C since 1861-1880 requires cumulative CO$_2$ emissions to stay below 1000 GtC. Until 2011, over 50% of this amount has been emitted.

Accounting for other forcings, the upper amount of cumulative CO$_2$ emissions is 800 GtC; over 60% have been emitted by 2011.
We have a choice.
Compatible fossil fuel emissions simulated by the CMIP5 models for the four RCP scenarios.
Conclusion:
IPCC is eager to continue serving the climate and sustainable development process, with policy relevance, without being policy-prescriptive.
Useful links:

- www.ipcc.ch: IPCC
- www.climatechange2013.org: IPCC WGI AR5
- www.climate.be/vanyp: my slides and other documents
- www.skepticalscience.com: excellent responses to contrarians arguments
- On Twitter: @JPvanYpersele