Guidance Sheet No. 1: Introduction to Climate Change

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1. What is climate change?

Climate change refers to a large-scale, long-term shift in the planet's weather patterns and average temperatures (MetOffice, www.metoffice.gov.uk).

- Observation of the climate system since the 1950s highlights the global warming of ocean and atmosphere, the increase of greenhouse gases, the rise of sea level, and the diminishing of snow and ice amounts.
- A few examples of climate change:
    - Global temperature as risen by 1°C since 1850.
    - Global increase of average precipitation (some regions observe a decrease)
    - Increase of intensity, duration and frequency of extreme events (e.g. heat waves, storm, heavy rainfall)
    - Between 1901 and 2010, the increase of the global mean sea level was about 0.19m due to ice melting and thermal expansion and about 0.08m between 1993 and 2018.

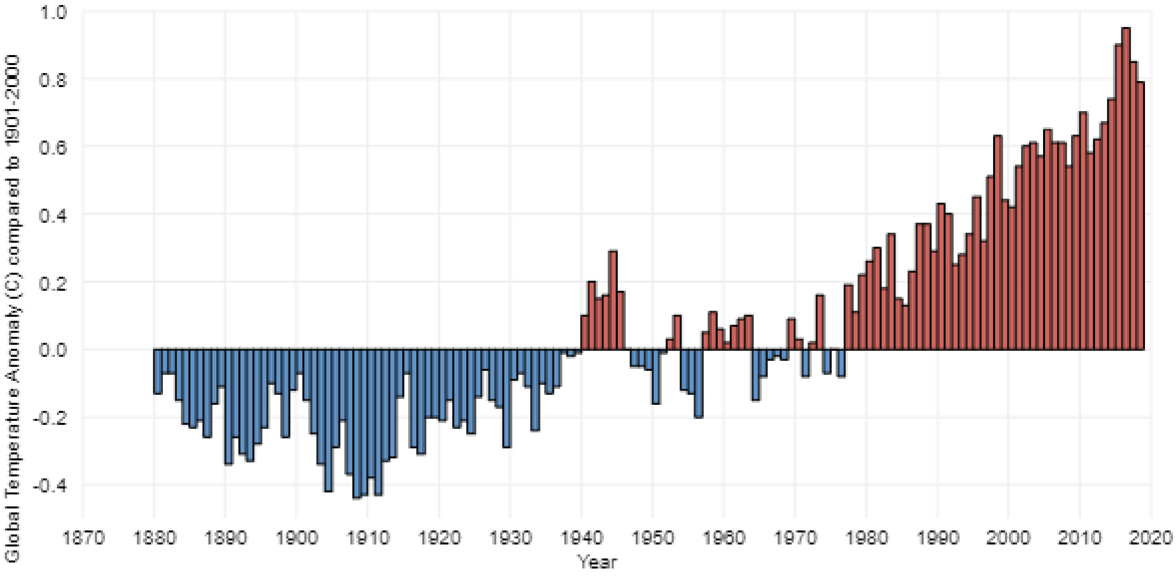

Figure 1 - History of global surface temperature since 1880, from NOAA (www.climate.gov)

The graph shows average annual global temperatures since 1880 compared to the long-term average (1901-2000). The zero line represents the long-term average temperature for the whole planet; blue and red bars show the difference above or below average for each year.

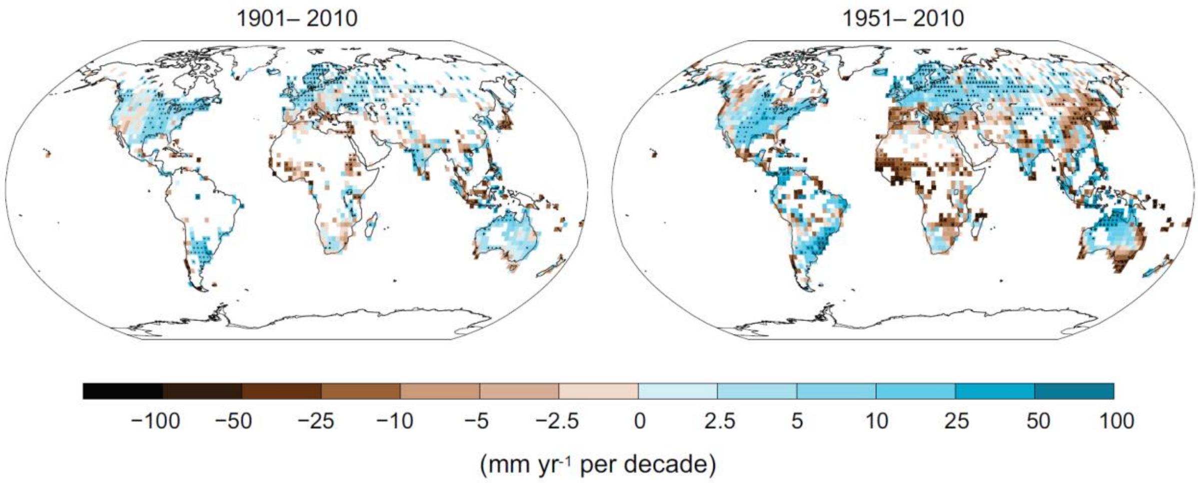

Figure 2 - Observed change in annual precipitation over land (IPCC, 2016)

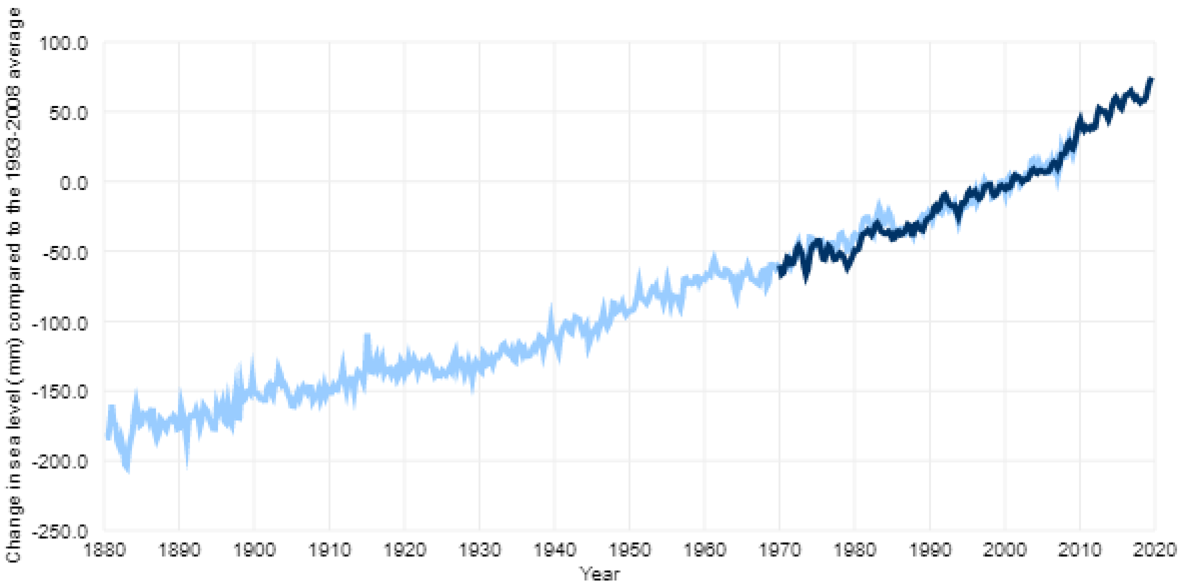

Figure 3 – Global sea level since 1880, from NOAA (www.climate.gov)

The light blue line shows seasonal (3-month) sea level estimates from Church and White (2011). The darker line is based on University of Hawaii Fast Delivery sea level data.

2. Impacts of climate change

- Climate change has a direct impact on coastal ecosystem. Fauna and flora see their environment evolve, impact their capacity to grow, reproduce or survive and can force them to migrate.
- Coastal erosion is increased by sea level rise but also by the higher frequency of extreme weather events and oblige the coastal habitats to migrate landward.
- Precipitation distributions are modified and therefore increase flooding or drought.

- Drought as well as heat waves are also impacted by the increase of greenhouse gas.
- Coastal infrastructures take more damage as the frequency of extreme weather events increases. Coastlines can also be less protected by reefs as the sea level rise makes them less efficient to dissipate wave energy.
- Extreme weather events impact sediment quantity, composition and transport and so the way they should be managed.
- Risk assessment on coastal infrastructures is usually based on records of extreme events. For example, coastal buffer zones are decided by erosion risks, coastal floodplains by river flood frequency and extent, building are designed to take a certain amount of physical impacts, coastal protections are designed for a certain tide range and significant wave heights. With climate change, past events are no longer enough to estimate future risks.
- Climate has a direct impact on economies:
    - Fishery and aquaculture productivity
    - Coastal tourism
    - Infrastructure damage
    - Operating time of industries with climate thresholds (e.g. downtime due to high temperature).
- Due to their coastal location, ports are directly impacted by climate change: flooding of infrastructures, need to adapt assets to sea level rise, change in operating time due to weather conditions (see Guidance Sheet 2, Climate Impacts on Ports and Harbours).

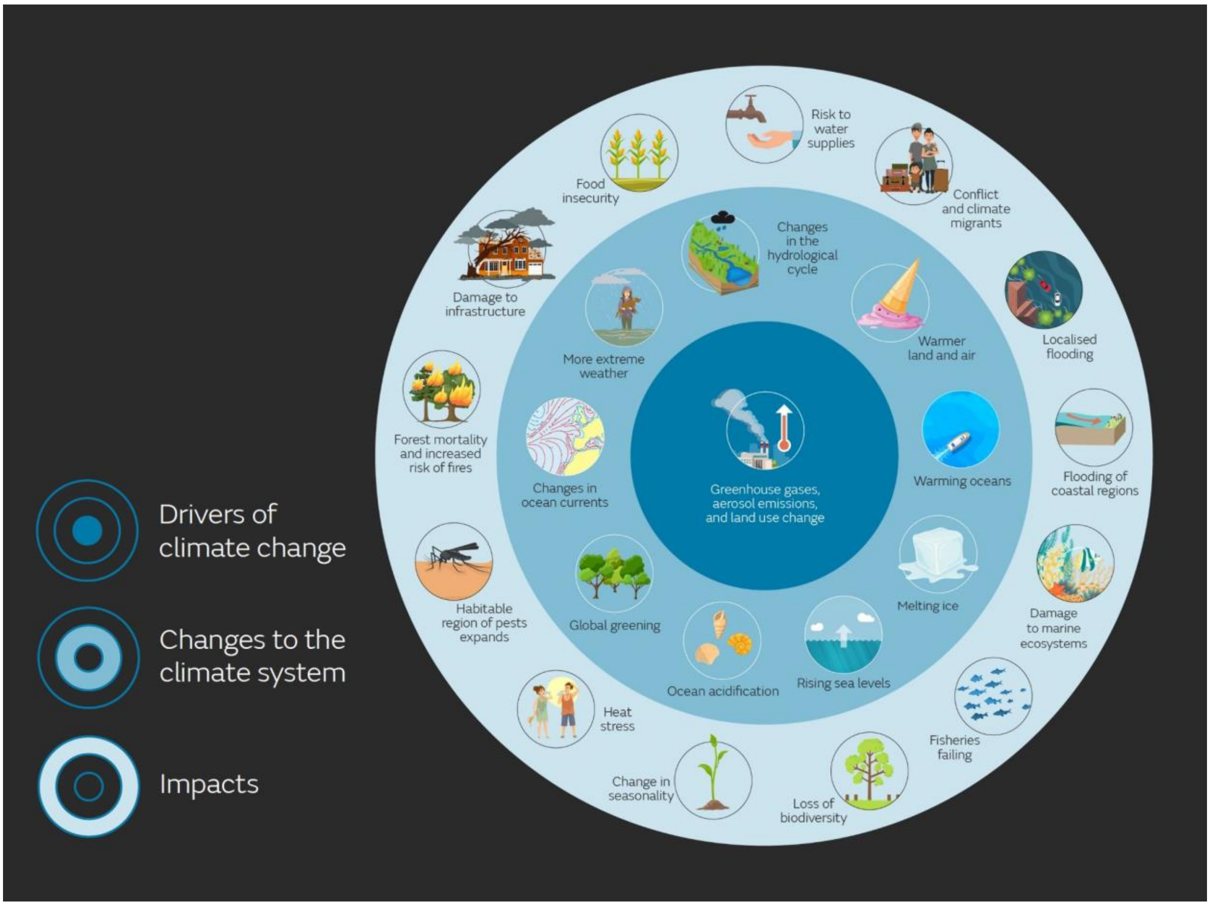

Figure 4 - Drivers and impacts of climate change (from MetOffice)

3. Qualifying and quantifying climate uncertainty

- Qualifying and quantifying the climate uncertainty is very important as decision makers develop policy based on climate projections. We need to quantify uncertainty at regional and local to predict impacts of climate change.
- Because of the complexity of the climate models, any slight change in initial forcing can make future projection very different.
- Processes have different scale of prediction after which they lose memory of initial condition. Here are a few examples of predictable time scales:
  - Cumulus convection: hours
  - El Niño Southern Oscillation: seasonal to interannual
  - Deep ocean circulations: multidecadal to centennial
- Anthropogenic forcing was first thought as an external forcing of the system but as human react and adapt to climate change, it needs to be fully integrated to the system and make it more complex.
- With these uncertainties on climate predictions, a statistical approach can be taken, generating a range of future climate conditions with a certain probability to occur.

- Moreover, some regions have complex forcing (e.g. in topography, land use, pollutants) that cannot be accurately reproduce as a global scale, making the downscaling of climate models in these regions more uncertain.
- For these reasons, climate projections have been defined as climate response assuming a future forcing scenario.
- Scenarios, which represent the greenhouse gas emission by human activities in the future, are also uncertain as we cannot say which pathway we will follow. It can be one of the four RCPs (Representative Concentrations Pathways, see Climate modelling guidance), but it could be something different.
- Comparing results for two periods of time is also difficult due to the natural variability. For example, during two periods of time the number of El Nino event can be different and therefore it will have an impact on the global average temperature.
- As scenario and natural uncertainty is always be present, having models with better resolution does not necessarily mean more accuracy.
- When using a climate model, we need to remember that they do not predict the future, but they give a good basis to study possible impacts at regional scale.

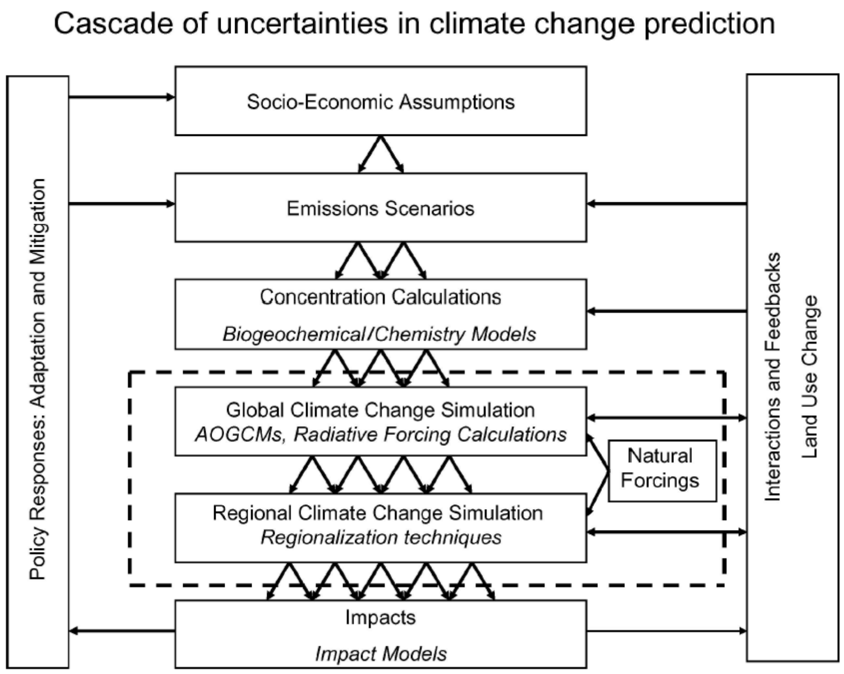

Figure 5 - Cascade of uncertainties in a climate change prediction. The dashed line encompasses the climate simulation segment of the cascade (from Giorgi, 2005)

Sources

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- https://coastadapt.com.au/learn-about-climate-change
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