Climate information relevant for the Energy Sector

This fact sheet presents AR6 Working Group I (WGI) assessments for changes to climate factors connected to responses in energy systems, highlighting climate information and data needs that inform sectoral assessments and further actions for adaptation, mitigation and resilience planning. This WGI fact sheet is focused on the assessment of **climatic variables** (temperature, precipitation, wind, drought, etc.)

Impacts and adaptation *options for energy are assessed in the AR6 WGII Chapter 6.*
Mitigation aspects *are assessed in the AR6 WGIII Chapter 6.*

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HEAT AND COLD

Temperature drives seasonal energy demand (for heating or cooling) and affects biofuel productivity. Heat extremes also affect energy production and distribution (cooling water, transformer capacity, power lines, photovoltaic production), while cold extremes increase heating and electricity demand.

- Trends in mean temperatures and heat extremes have emerged above natural variability in all land regions with *high confidence*.
- It is *virtually certain* that hot extremes (including heatwaves) have become more frequent and more intense across most land regions since the 1950s, while cold extremes (including cold waves) have become less frequent and less severe, with *high confidence* that human-induced climate change is the main driver of these changes. Some recent hot extremes observed over the past decade would have been extremely unlikely to occur without human influence on the climate system. All regions are projected to experience further increases in hot climatic impact-drivers (CIDs) and decreases in cold CIDs (*high confidence*). {12.ES, 12.3, SPM.A.3.1, SPM.C.2.1}

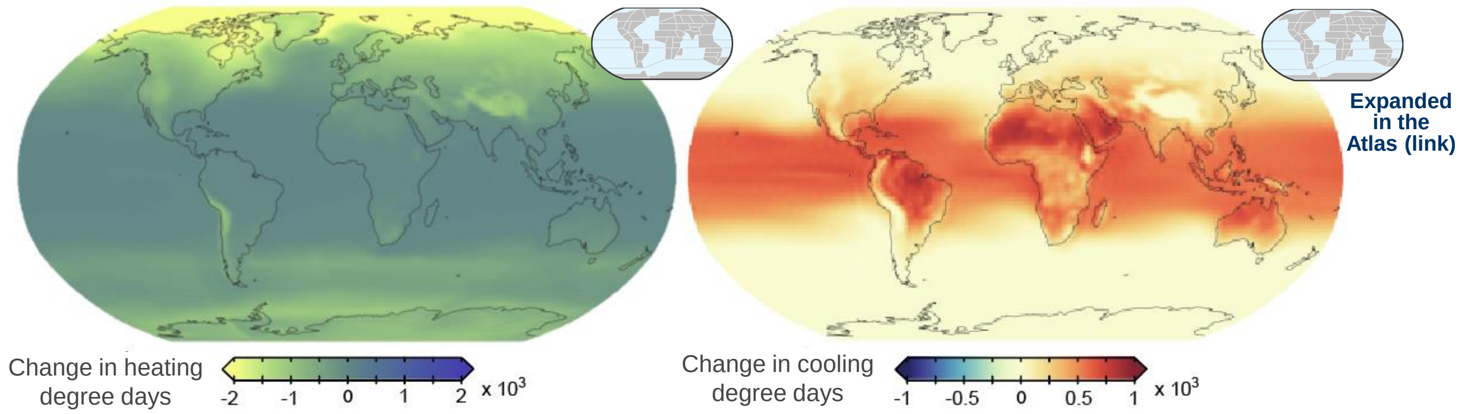

Figure 1: Projected changes, for a 2°C global warming level, of two energy-related climatic impact-drivers: the "Heating Degree Day below 15.5°C" (left) and "Cooling Degree Day above 22°C" (right) indices, relative to pre-industrial. {Interactive Atlas}.

WET AND DRY

- A reduction in water availability, due to increased aridity or hydrological droughts, challenges water supplies needed for hydropower use. Low flow volume and intermittency thresholds also affect thermal power plant cooling. At 2°C global warming and above, the level of confidence in and the magnitude of the change in droughts and mean precipitation increases compared to those at 1.5°C.
- At 2°C, a small number of regions in Africa, Australasia, Europe and North America are projected to be affected by increases in hydrological droughts, and several regions are projected to be affected by increases or decreases in meteorological droughts, with more regions displaying an increase (*medium confidence*).
- The water cycle is projected to intensify in polar regions, leading to more rainfall, higher river flood potential and more intense precipitation (*high confidence*).
- Freshwater supports a range of human activities from irrigation to industrial processes, including the generation of hydroelectricity and the cooling of thermoelectric power plants. Runoff from small glaciers will typically decrease through loss of ice mass, while runoff from large glaciers is *likely* to increase with increasing global warming until glacier mass becomes depleted (*high confidence*). {4.5.1, 8.4.1, 12.3, SPM.C.2.3, SPM.C.2.4}

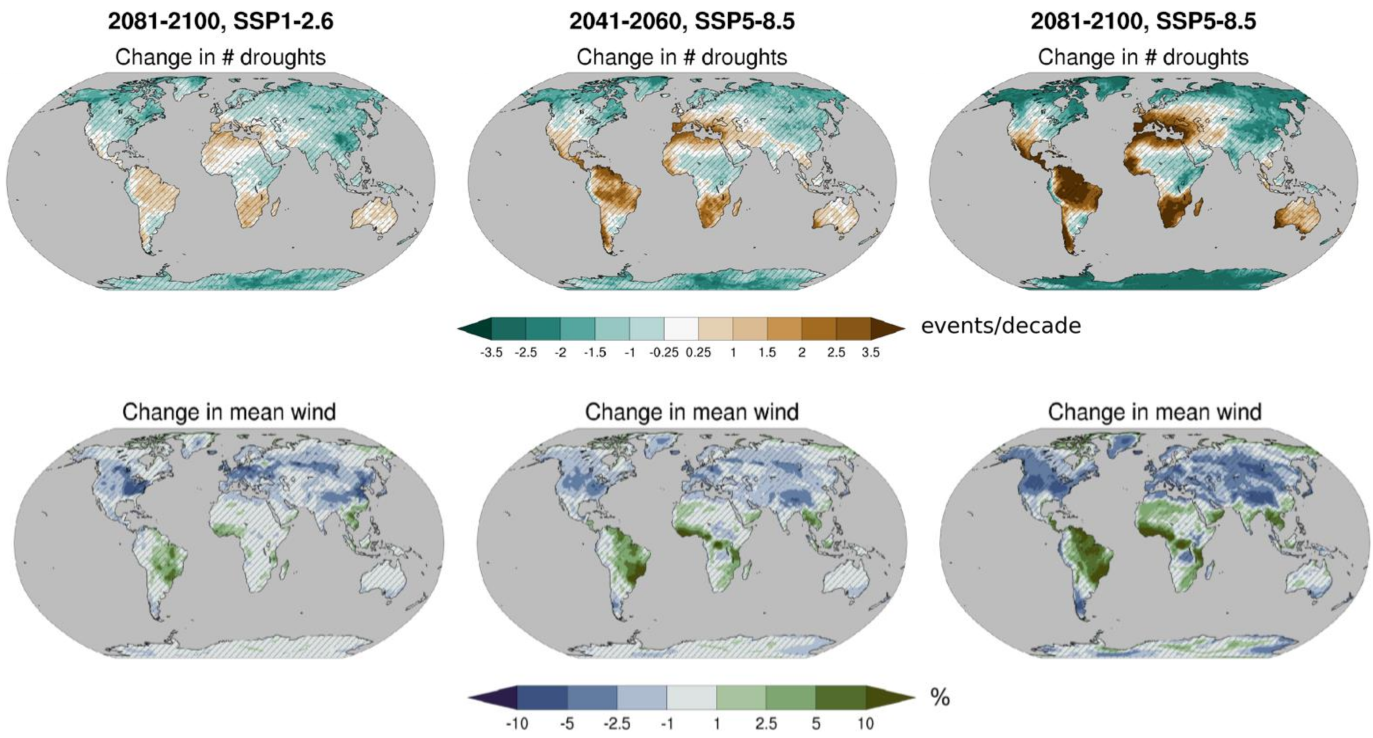

Figure 2: From Figure 12.4, the number of negative precipitation anomaly 4 events per decade using the 6-month Standardized Precipitation Index. For more information on the simple approach for confidence, please refer to the Cross-Chapter Box Atlas.1. See Annex VI for details of indices.

WIND

- Changes to wind density also modify a region's wind and wave renewable energy endowment (Figure 2).
- Since the 1970s, near-surface winds have *likely* weakened over land. Over the oceans, near-surface winds *likely* strengthened over 1980–2000, but divergent estimates lead to *low confidence* in the sign of change thereafter.
- Mean winds are projected to slightly decrease by 2050 over much of Europe, Asia, and Western North America, and increase in many parts of South America except Patagonia, West and South Africa and Eastern Mediterranean (*medium to high confidence*). Severe storms particularly threaten energy infrastructure. Photovoltaic panels can lose energy production efficiency with dust accumulation. Severe storms are expected to have a decreasing frequency but increasing intensity over the Mediterranean, most of North America, and an increasing frequency over most of Europe (*medium confidence*).
- Tropical cyclones are expected to increase in intensity despite a decrease in frequency in most tropical regions (*medium confidence*). {11.7.1, 12.3}

COASTAL

- Coastal floods may threaten energy infrastructures located in the coastal zone. Due to relative sea level rise, extreme sea level events that occurred once per century in the recent past are projected to occur at least annually at between one fifth and one third of all tide gauge locations by 2050 and at more than half of all tide gauge locations by 2100 (*high confidence*). The highest increases in extreme sea level are projected to occur in Western North America, North-Western South America, South-Western South America, Central Africa, South Eastern Africa, West Southern Africa, Southern Australia, New Zealand (*medium confidence*). {SPM.C.2.5, 12.4}

RADIATION

- Changes in cloud cover and surface solar radiation affect solar energy resources. Surface radiation (balance of net shortwave, longwave and ultraviolet) has undergone decadal variations in past observations, which are mostly responding to the increase and decrease of aerosols. In future conditions, under a 2°C warming, radiation is expected to increase over North Africa, South Africa, Southern Europe, East Asia, the Amazon Basin, the Northern part of South America, Southern and Eastern USA. and decrease over the Sahara, North-East Africa and West Africa (*medium confidence*), Northern Europe, North-Western North America. {12.3, 12.4}