CIDs - Climatic Impact-Drivers – Tentative Summary

Since AR5, the attribution to human influence has become possible across a wider range of climate variables and climatic impact-drivers (CIDs).

Climatic impact-drivers (CIDs) are physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems, having impacts on human or ecological systems.

Depending on system tolerance, CIDs and their changes can be detrimental (i.e., hazards in the context of climate change risks), beneficial, neutral, or a mixture of each across interacting system elements, regions and society sectors. Each sector is affected by multiple CIDs, and each CID affects multiple sectors. CID types include Heat and Cold, Wet and Dry, Wind, Snow and Ice, Coastal, and Open Ocean. A range of indices may capture the sector- or application-relevant characteristics of a climatic impact-driver and can reflect exceedances of identified tolerance thresholds. (Sections TS.1.4 and TS.4.3) {12.1–12.3, FAQ 12.1, Glossary}

All regions are projected to experience further increases in hot climatic impact-drivers (CIDs) and decreases in cold CIDs (high confidence). Further decreases are projected in permafrost; snow, glaciers and ice sheets; and lake and Arctic sea ice (medium to high confidence). These changes would be larger at 2°C global warming or above than at 1.5°C (high confidence). For example, extreme heat thresholds relevant to agriculture and health are projected to be exceeded more frequently at higher global warming levels (high confidence).

More CIDs across more regions are projected to change at 2°C and above compared to 1.5°C global warming (high confidence). Region-specific changes include intensification of tropical cyclones and/or extratropical storms (medium confidence), increases in river floods (medium to high confidence), reductions in mean precipitation and increases in aridity (medium to high confidence), and increases in fire weather (medium to high confidence). There is low confidence in most regions in potential future changes in other CIDs, such as hail, ice storms, severe storms, dust storms, heavy snowfall and landslides.

The climatic impact-driver (CID) framework adopted in Chapter 12 allows for assessment of changing climate conditions that are relevant for regional impacts and risk assessment.

Climate change has already altered CID profiles and resulted in shifting magnitude, frequency, duration, seasonality and spatial extent of associated indices (high confidence). A CID can be measured by indices to represent related tolerance thresholds. {12.1–12.3}

The current climate in most regions is already different from the climate of the early or mid-20th century with respect to several CIDs. Climate change has already altered CID profiles and resulted in shifts in the magnitude, frequency, duration, seasonality and spatial extent of associated indices (high confidence). Changes in temperature-related CIDs such as mean temperatures, growing season length, extreme heat and frost have already occurred and many of these changes have been attributed to human activities (medium confidence). Mean temperatures and heat extremes have emerged above natural variability in all land regions (high confidence). In tropical regions, recent past temperature distributions have already shifted to a range different to that of the early 20th century (high confidence). Ocean acidification and deoxygenation have already emerged over most of the global open ocean, as has reduction in Arctic sea ice (high confidence). Using CID index distributions and event probabilities accurately in both current and future risk assessments requires accounting for the climate change-induced shifts in distributions that have already occurred. {12.4, 12.5}

Many global- and regional-scale CIDs, including extremes, have a direct relation to global warming levels (GWLs) and can thus inform the hazard component of 'Representative Key Risks' and 'Reasons for Concern' assessed by AR6 WGII. These include heat, cold, wet and dry hazards, both mean and extremes; cryospheric hazards (snow cover, ice extent, permafrost) and oceanic hazards (marine heatwaves) (high confidence) (Figure TS.6).

Establishing links between specific GWLs with tipping points and irreversible behaviour is challenging due to model uncertainties and lack of observations, but their occurrence cannot be excluded, and their likelihood of occurrence generally increases at greater warming levels (Box TS.1, Section TS.9). {11.2.4, Box 11.2, Cross-Chapter Boxes 11.1 and 12.1}

From Chapter 12: Frequently Asked Questions

FAQ 12.1 | What Is a Climatic Impact-driver (CID)?

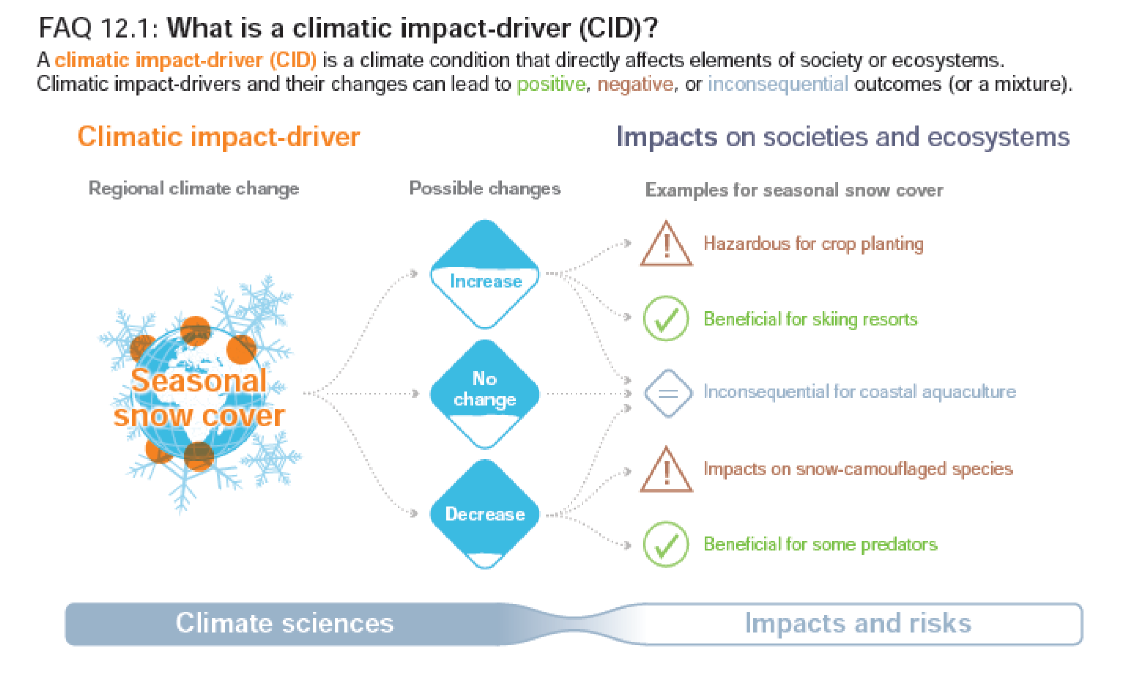
A climatic impact-driver is a physical climate condition that directly affects society or ecosystems. Climatic impact drivers may represent a long-term average condition (such as the average winter temperatures that affect indoor heating requirements), a common event (such as a frost that kills off warm-season plants), or an extreme event (such as a coastal flood that destroys homes). A single climatic impact-driver may lead to detrimental effects for one part of society while benefiting another, while others are not affected at all. A climatic impact-driver (or its change caused by climate change) is therefore not universally hazardous or beneficial, but we refer to it as a 'hazard' when experts determine it is detrimental to a specific system.

Climate change can alter many aspects of the climate system, but efforts to identify impacts and risks usually focus on a smaller set of changes known to affect, or potentially affect, things that society cares about. These climatic impact-drivers (CIDs) are formally defined in this Report as 'physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems. Depending on system tolerance, CIDs and their changes can be detrimental, beneficial, neutral, or a mixture of each across interacting system elements and regions'. Because people, infrastructure and ecosystems interact directly with their immediate environment, climate experts assess CIDs locally and regionally. CIDs may relate to temperature, the water cycle, wind and storms, snow and ice, oceanic and coastal processes or the chemistry and energy balance of the climate system. Future impacts and risk may also be directly affected by factors unrelated to the climate (such as socio-economic development, population growth, or a viral outbreak) that may also alter the vulnerability or exposure of systems.

CIDs capture important characteristics of the average climate and both common and extreme events that shape society and nature (see FAQ 12.2). Some CIDs focus on aspects of the average climate (such as the seasonal progression of temperature and precipitation, average winds or the chemistry of the ocean) that determine, for example, species distribution, farming systems, the location of tourist resorts, the availability of water resources and the expected heating and cooling needs for buildings in an average year. CIDs also include common episodic events that are particularly important to systems, such as thaw events that can trigger the development of plants in spring, cold spells that are important for fruit crop chill requirements, or frost events that eliminate summer vegetation as winter sets in. Finally, CIDs include many extreme events connected to impacts such as hailstorms that damage vehicles, coastal floods that destroy shoreline property, tornadoes that damage infrastructure, droughts that increase competition for water resources, and heatwaves that can strain the health of outdoor labourers.

Many aspects of our daily lives, businesses and natural systems depend on weather and climate, and there is great interest in anticipating the impacts of climate change on the things we care about. To meet these needs, scientists engage with companies and authorities to provide climate services – meaningful and possibly actionable climate information designed to assist decision-making. Climate science and services can focus on CIDs that substantially disrupt systems to support broader risk management approaches. A single CID change can have dramatically different implications for different sectors or even elements of the same sector, so engagement between climate scientists and stakeholders is important to contextualize the climate changes that will come. Climate services responding to planning and optimization of an activity can focus on more gradual changes in operating climate conditions.

FAQ 12.1 (continued)



FAQ 12.1, Figure 1 | A single climatic impact-driver can affect ecosystems and society in different ways. A variety of impacts from the same climatic impact-driver change, illustrated with the example of regional seasonal snow cover.

Figure 1 tracks example outcomes of seasonal snow cover changes that connect climate science to the need for mitigation, adaptation and regional risk management. The length of the season with snow on the ground is just one of many regional climate conditions that may change in the future, and it becomes a CID because there are many elements of society and ecosystems that rely on an expected seasonality of snow cover. Climate scientists and climate service providers examining human-driven climate change may identify different regions where the length of the season with snow cover could increase, decrease, or stay relatively unaffected. In each region, change in seasonal snow cover may affect different systems in beneficial or detrimental ways (in the latter case, changing seasonal snow cover would be a ‘hazard’), although systems such as coastal aquaculture remain relatively unaffected. The changing profile of benefits and hazards connected to these changes in the seasonal snow cover CID affects the profile of impacts, risks and benefits that stakeholders in the region will grapple with in response to climate change.

Some relevant Figures

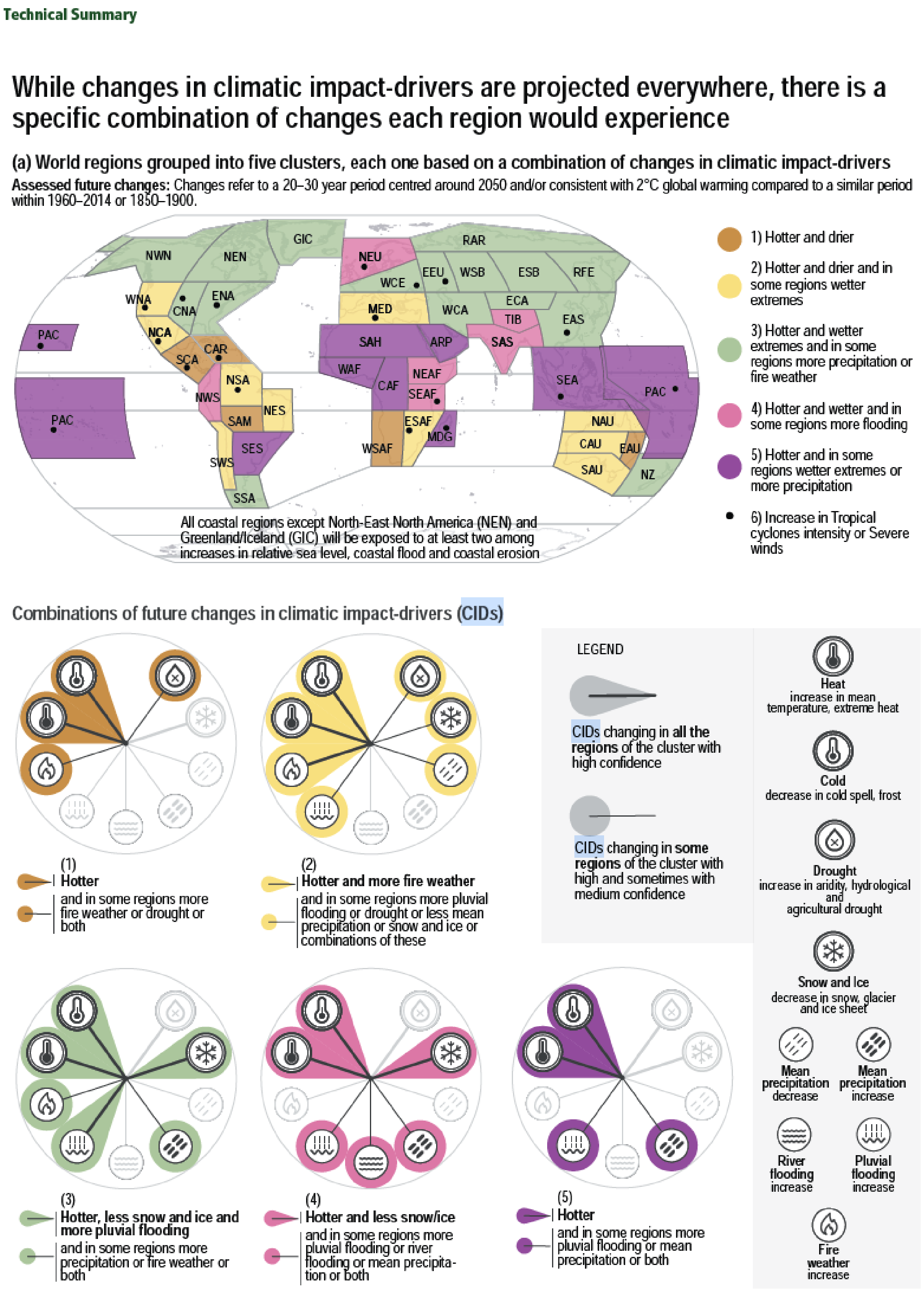
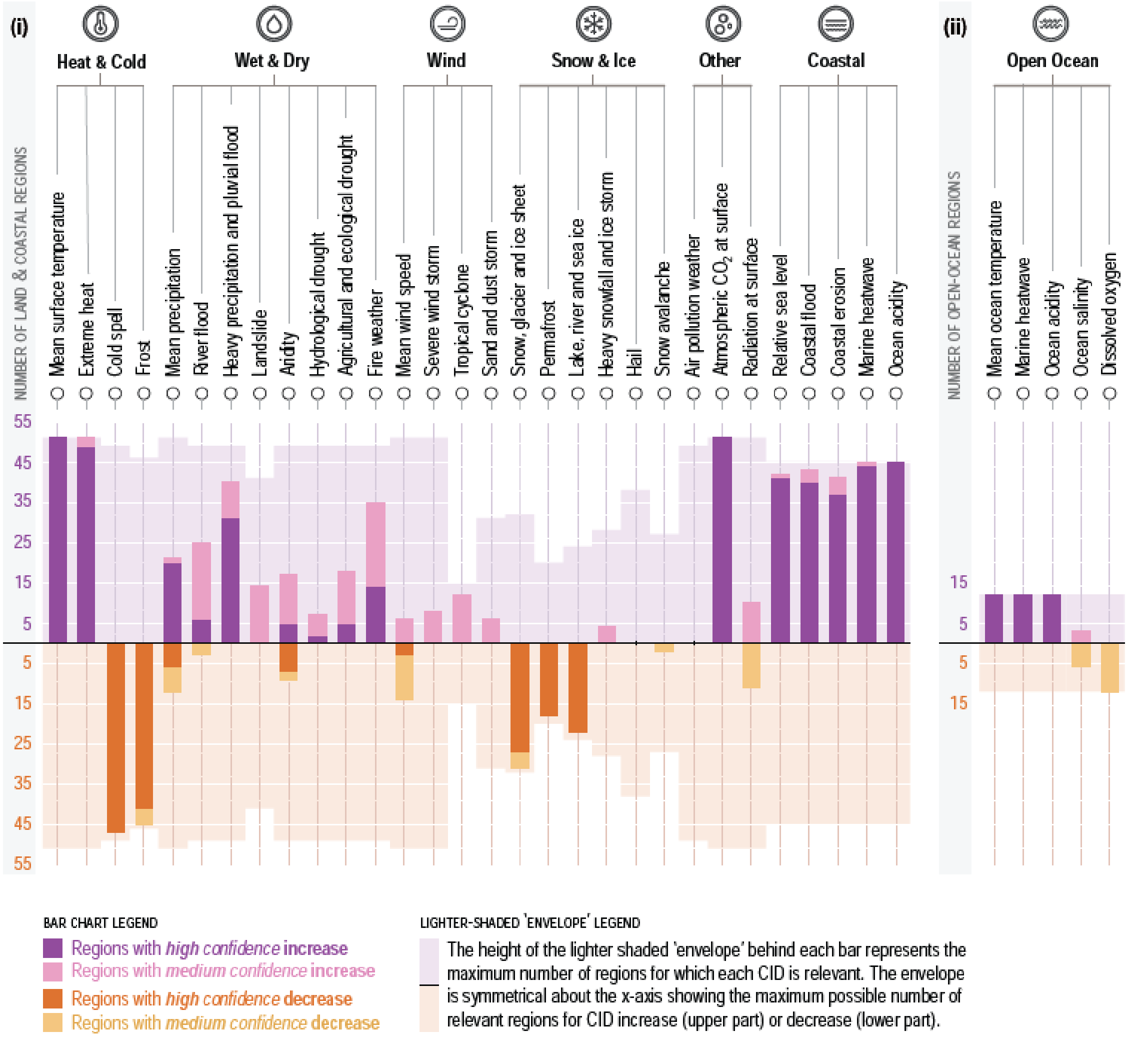


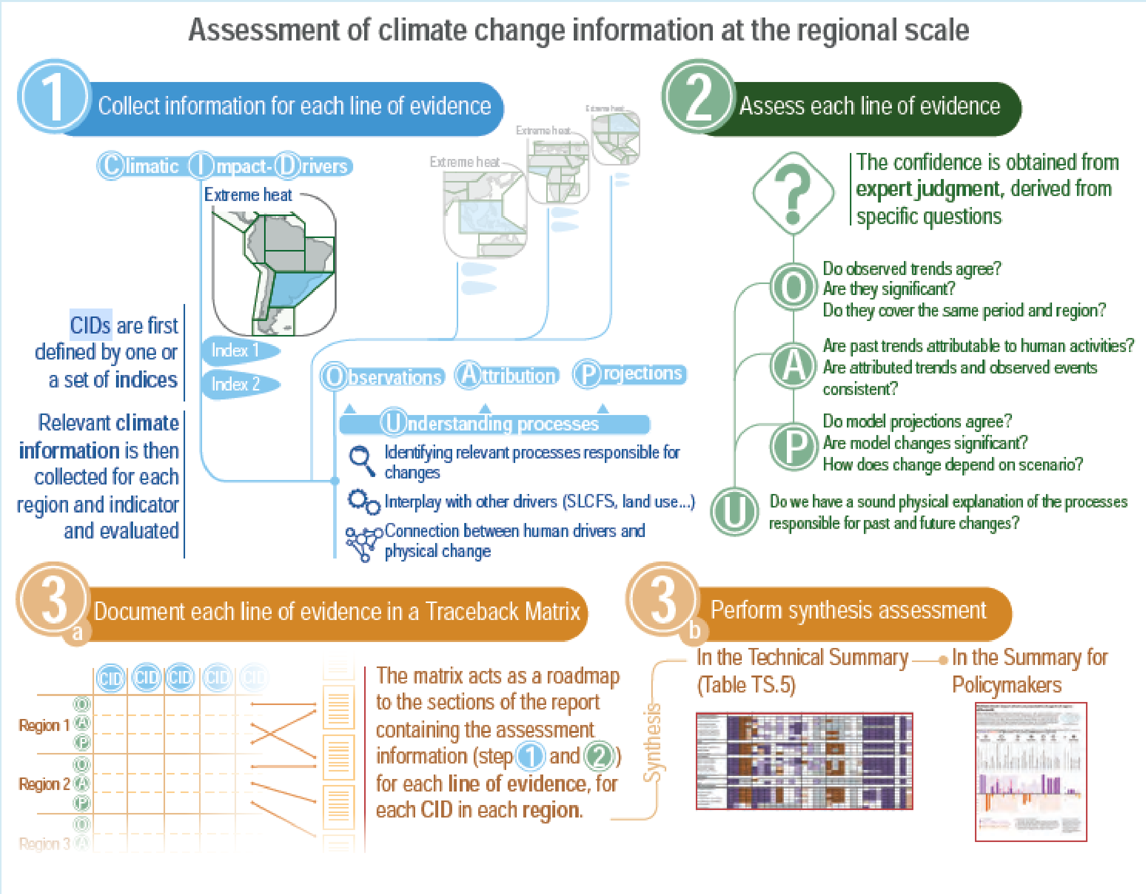
Figure TS.22 | Synthesis of the geographical distribution of climatic impact-drivers changes (a) and the number of AR6 WGI reference regions where they are projected to change (b).

(b) Number of land & coastal regions (i) and **open-ocean regions** (ii) where each **climatic impact-driver** (CID) is projected to increase or decrease with ***high** confidence* (dark shade) or ***medium** confidence* (light shade)



Climatic impact-drivers (CIDs) are physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems. Depending on system tolerance, CIDs and their changes can be detrimental, beneficial, neutral, or a mixture of each across interacting system elements and regions. The CIDs are grouped into seven types, which are summarized under the icons in sub-panels (i) and (ii). All regions are projected to experience changes in at least 5 CIDs. Almost all (96%) are projected to experience changes in at least 10 CIDs and half in at least 15 CIDs. For many CID changes, there is wide geographical variation, and so each region is projected to experience a specific set of CID changes. Each bar in the chart represents a specific geographical set of changes that can be explored in the WGI Interactive Atlas.

Figure TS.22 | Synthesis of the geographical distribution of climatic impact-drivers changes and the number of AR6 WGI reference regions where they are projected to change.



Cross-Chapter Box 10.3, Figure 1 | Schematic illustration of the process to derive the assessment of regional climate change information based on a distillation process of multiple lines of evidence taken from observed trends, attribution of trends or events, climate model projections, and physical understanding.

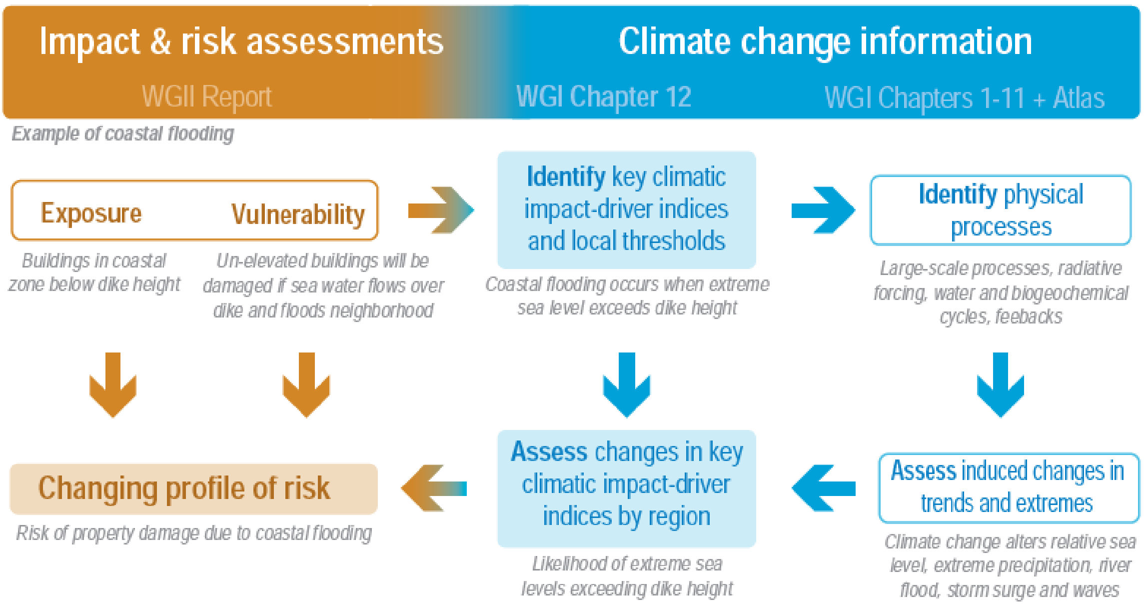


Figure 12.1 | Schematic diagram showing the use of climate change information (AR6 WGI chapters) for typical impacts or risk assessment (AR6 WGII chapters) and the role of Chapter 12, via an illustration of the assessment of property damage or loss in a particular region when extreme sea level exceeds dike height.

Table 12.1 | Overview of the main climatic impact-driver (CID) types and related CID categories with a short description and their link to other chapters where the underlying climatic phenomenon and its associated essential climate variables are assessed and described.

CID Type	CID Category	Brief Description	Physical Description of Phenomena
Heat and Cold	Mean air temperature	Mean surface air temperature and its diurnal and seasonal cycles.	Chapters 2, 3, 4 and Atlas
	Extreme heat	Episodic high surface air temperature events potentially exacerbated by humidity.	Chapter 11
	Cold spell	Episodic cold surface air temperature events potentially exacerbated by wind.	Chapter 11
	Frost	Freeze and thaw events near the land surface and their seasonality.	Chapter 12
Wet and Dry	Mean precipitation	Mean precipitation and its diurnal and seasonal cycles.	Chapters 2, 8 and Atlas
	River flood	Episodic high water levels in streams and rivers driven by basin runoff and the expected seasonal cycle of flooding.	Chapters 8 and 11
	Heavy precipitation and pluvial flood	High rates of precipitation and resulting episodic, localized flooding of streams and flat lands.	Chapter 11
	Landslide	Ground and atmospheric conditions that lead to geological mass movements, including landslide, mudslide and rockfall.	Chapter 12
	Aridity	Mean conditions of precipitation and evapotranspiration compared to potential atmospheric and surface water demand, resulting in low mean surface water, low soil moisture and/or low relative humidity.	Chapters 8, 11 and Atlas
	Hydrological drought	Episodic combination of runoff deficit and evaporative demand that affects surface water or groundwater availability.	Chapters 8 and 11
	Agricultural and ecological drought	Episodic combination of soil moisture supply deficit and atmospheric demand requirements that challenges the vegetation's ability to meet its water needs for transpiration and growth. *Note: 'agricultural' vs. 'ecological' term depends on affected biome.*	Chapters 8 and 11
	Fire weather	Weather conditions conducive to triggering and sustaining wildfires, usually based on a set of indicators and combinations of indicators including temperature, soil moisture, humidity and wind. Fire weather does not include the presence or absence of fuel load. *Note: distinct from wildfire occurrence and area burned.*	Chapters 11 and 12
Wind	Mean wind speed	Mean wind speeds and transport patterns and their diurnal and seasonal cycles.	Chapters 2 and 12
	Severe wind storm	Episodic severe storms including extratropical cyclone wind storms, thunderstorms, wind gusts, derechos and tornadoes.	Chapters 11 and 12
	Tropical cyclone	Strong, rotating storm originating over tropical oceans accompanied by high winds, rainfall and storm surges.	Chapter 11
	Sand and dust storm	Storms causing the transport of soil and fine dust particles.	Chapters 8 and 12
Snow and Ice	Snow, glacier and ice sheet	Snowpack seasonality and characteristics of glaciers and ice sheets including calving events and meltwater.	Chapters 2, 9 and Atlas
	Permafrost	Permanently frozen deep soil layers, their ice characteristics, and the characteristics of seasonally frozen soils above.	Chapters 2 and 9
	Lake, river and sea ice	The seasonality and characteristics of ice formations on the ocean and freshwater bodies of water.	Chapters 2 and 9
	Heavy snowfall and ice storm	High snowfall and ice storm events including freezing rain and rain-on-snow conditions.	Chapters 11 and 12
	Hail	Storms producing solid hailstones.	Chapters 11 and 12
	Snow avalanche	Cryospheric mass movements and the conditions of collapsing snowpack.	Chapter 12
Coastal	Relative sea level	The local mean sea surface height relative to the local solid surface.	Chapter 9
	Coastal flood	Flooding driven by episodic high coastal water levels that result from a combination of relative sea level rise, tides, storm surge and wave setup.	Chapters 9 and 12
	Coastal erosion	Long term or episodic change in shoreline position caused by relative sea level rise, nearshore currents, waves and storm surge.	Chapter 12
Open Ocean	Mean ocean temperature	Mean temperature profile of ocean through the seasons, including heat content at different depths and associated stratification.	Chapters 2 and 9
	Marine heatwave	Episodic extreme ocean temperatures.	Chapters 9 and 12
	Ocean acidity	Profile of ocean water pH levels and accompanying concentrations of carbonate and bicarbonate ions.	Chapter 5
	Ocean salinity	Profile of ocean salinity and associated seasonal stratification. *Note: distinct from salinization of freshwater resources.*	Chapters 2 and 5
	Dissolved oxygen	Profile of ocean water dissolved oxygen and episodic low oxygen events.	Chapter 5
Other	Air pollution weather	Atmospheric conditions that increase the likelihood of high particulate matter or ozone concentrations or chemical processes generating air pollutants. *Note: distinct from aerosol emissions or air pollution concentrations themselves.*	Chapter 6
	Atmospheric CO_2 at surface	Concentration of atmospheric carbon dioxide (CO_2) at the surface. *Note: distinct from overall radiative effect of CO_2 as greenhouse gas.*	Chapter 5
	Radiation at surface	Balance of net shortwave, longwave and ultraviolet radiation at the Earth's surface and their diurnal and seasonal patterns.	Chapter 7

Direct link to relevant chapters and figures:

https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf#page=74

https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf#page=137

Cross-Chapter Box 1.3 | Risk Framing in IPCC AR6:
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf#page=217

https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf#page=1452

Entire Chapter 12:
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FullReport_small.pdf#page=1784

(printed pages: 1, 74-76, 137-161, 217-219, 1452-1455, 1784-1893)