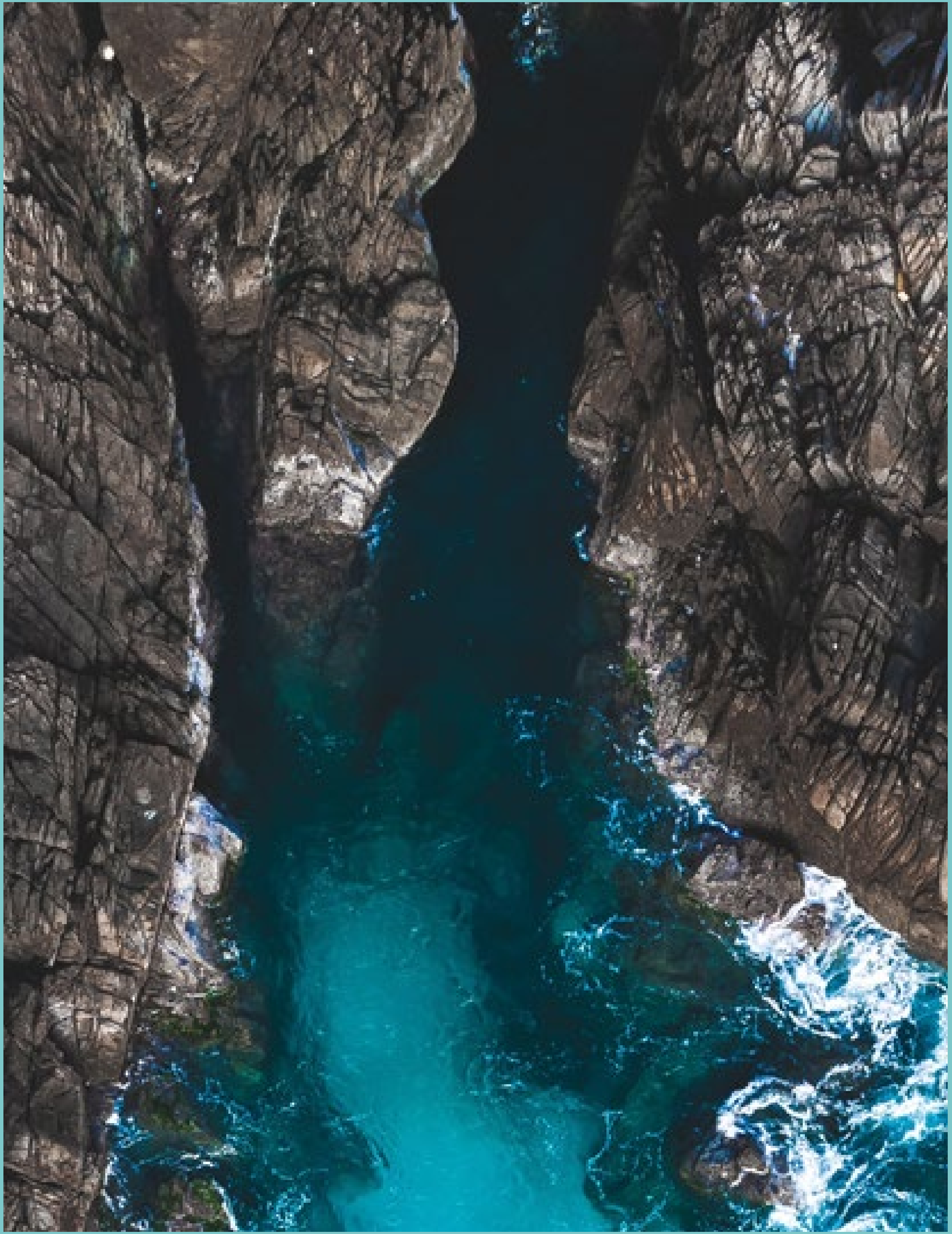


°CMSI

Climate Measurement Standards Initiative

Scenario analysis of climate-related physical risk for buildings and infrastructure: Climate science guidance

TECHNICAL SUMMARY

The Task Force on Climate-Related Financial Disclosures (TCFD) has developed a set of recommendations that companies can use to disclose information about climate risks. The disclosures include physical and transition risks.

To determine the physical risks in a credible and comparable way, Australian companies need reliable information for scenario analyses. The Climate Measurement Standards Initiative (CMSI) is an industry-led collaboration between Australian insurers, banks, scientists, reporting standards professionals, service providers and supporting parties to assist with TCFD reporting. The CMSI is initially developing technical, business and scientific standards for climate-related physical risk to buildings and infrastructure assets.

This is a technical summary of the report 'Scenario analysis of climate-related physical risk for buildings and infrastructure: climate science guidance'. The report, which was independently authored by the Earth Systems and Climate Change Hub of the National Environmental Science Program (NESP), describes methods, scenarios for acute and chronic climate hazards, gaps and needs, and a roadmap for the future.

Methods and scenarios

There are 3 factors that affect uncertainty in future climate scenarios:

1. Ongoing natural climate variability
2. Global socio-economic development and resulting emissions of greenhouse gases and aerosols
3. Regional climate responses to these emissions.

Researchers use multiple lines of evidence to assess observed and projected climate change. Plausible ranges of change and associated confidence ratings are consistent with guidance recommended by the Intergovernmental Panel on Climate Change (IPCC).

Consultation with CMSI participants led to identification of a set of relevant emission scenarios, climate variables and timeframes.

The report outlines two emission scenarios leading to global warming above or below 2°C, consistent with the TCFD recommendations, along with the following time frames: the present; and 10, 30 and 70 years in the future, expressed as the years 2020, 2030, 2050 and 2090.

The ranges of projected changes for climate variables, including changes to extreme weather, from all adequately performing climate model simulations should be considered. Expert judgment can determine whether changes outside the simulated range should also be considered. The range of possibilities for a given global warming scenario should be limited only if the model or the physical change it represents is implausible.

Ongoing natural variability

Climate variability on timescales from minutes to decades affects extreme events such as floods, drought, heatwaves and fires. Large-scale drivers of natural climate variability include the El Niño – Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) and Southern Annular Mode (SAM). ENSO is a coupled ocean-atmosphere process in the Pacific Ocean, with El Niño and La Niña events representing the extreme phases, typically occurring every 4-7 years. The IOD is characterised by changes in sea surface temperatures in the eastern Indian Ocean basin and opposite changes in the west of the basin. SAM is the alternation of atmospheric pressure between the middle and high latitudes.

Emissions of greenhouse gases

Using the lowest and highest international-standard scenarios for atmospheric greenhouse gas concentrations, known as representative concentration pathways (RCPs), provides the range of future climate possibilities, and meets international TCFD guidelines.

RCP2.6 aligns with low emissions and has a 2-in-3 chance of staying below 2°C global warming by the end of the century relative to the preindustrial period (1850-1900). RCP8.5 aligns with high emissions and projects 3-5°C (or more) global warming by the end of the century.

The assumptions underlying each scenario need ongoing assessment over time. For example, a transition away from fossil fuels may make some of the assumptions under RCP8.5 unlikely, or sustained high emissions may make RCP2.6 impossible, at least in the medium term.

Regional climate responses

Regional climate responses to RCP2.6 and RCP8.5 are based on the Coupled Model Inter-comparison Project phase 5 (CMIP5) set of global climate model results used by the IPCC and reported in www.climatechangeinaustralia.gov.au. Researchers have supplemented this work with regional climate modelling done for some state government projects, and applied new insights from the emerging CMIP6 modelling. This work has quantified the range of modelled responses to the emissions scenarios, providing an estimate of the plausible range of climate change. The range of model results includes uncertainty due to imperfect modelling, and efforts to represent deeper uncertainties.

Table 1: Attributes of low and high greenhouse gas emission scenarios

Sector	Carbon dioxide emissions	Likely global SSP*	Global warming relative to 1850-1900**	Transition risk	Physical risk
Low case	Net zero by around 2070 (RCP2.6)	Sustainability (SSP1)	1.3–2.2°C by 2050 0.9–2.4°C by 2090	Higher challenges	Lower challenges
High case	High and accelerating (RCP8.5)	Fossil fueled development (SSP5)	1.8–3.0°C by 2050 3.2–5.4°C by 2090	Lower challenges	Higher challenges

There may be important factors that no models incorporate. The full range of adequately performing models is not a statistical sample of uncertainty, but rather researchers' best estimate of the range of plausible change.

The climate science report presents projected changes for two categories of climate hazards that can damage buildings and infrastructure:

1. Acute—extreme weather events identified by the CMSI science committee associated with building and infrastructure damage. This includes changes in natural hazards such as tropical cyclones, east coast lows, extreme rainfall, hail, extreme sea level events and fire weather, presented in Table 2 with confidence ratings for RCP2.6 and RCP8.5 for 2030, 2050 and 2090.
2. Chronic—gradually emerging aspects of climate risk, including changes to annual average temperature, rainfall and sea level, time in drought and days over 35°C. Table 3 presents projected changes and confidence ratings for RCP2.6 and RCP8.5 for 2030, 2050 and 2090.

* There is an emerging system of socio-economic pathways (SSPs) that can be related to different RCPs.

** CMIP5 models reported in IPCC (2013), but new generation climate modelling suggests that even greater warming late in the century than cited here can't be ruled out (see Grose et al. 2020).

Projected changes

Acute and chronic climate hazards

Tables 2 and 3 present projected changes in acute and chronic climate hazards, respectively, based on information that is limited in some cases. For each climate variable, the tables list the average in the IPCC baseline period (1986-2005), and the observed change over recent decades. Where possible, the level of attribution to human influence is included (none, weak or strong). Projections are relative to 1986-2005, based on 20-year periods centred on each of 2030 (2020-2039), 2050 (2040-2059) and 2090 (2080-2099).

Projections for RCP2.6 and RCP8.5 are similar for 2030, but generally diverge by 2050 and beyond. The 'central estimate' is based on different lines of evidence and expert judgment, with values in square brackets indicating the 80 per cent likelihood range, and a confidence rating. Qualitative projections are provided where there is low confidence.

The tables present broad estimates for all of Australia or for large regions. Spatial variation occurs for all projections, with models revealing possible values above or below those presented. Confidence ratings, based on IPCC guidance, provide information about whether the range of change is a reliable and complete description.

Table 2: Observed and projected changes in acute climate hazards that present physical risks for Australian buildings and infrastructure. Green boxes show projections for RCP2.6, pink boxes for RCP8.5. Projections have a central estimate and a range of plausible change (based on 10th-90th percentile estimates considering multiple lines of evidence). *Continued overleaf.*

Extreme or hazard	Average in 1986-2005	Observed change (and attribution)	2030	2050	2090	Confidence
Tropical cyclone (TC) frequency in Australian region	10-11 per year	-10% (weak)	East -4% [-8% to 1%]; West -6% [-10% to -2%]	East -4% [-8% to 1%]; West -6% [-10% to -2%]	East -4% [-8% to 1%]; West -6% [-10% to -2%]	Medium
				East -8% [-15% to 2%]; West -12% [-20% to -4%]	East -15% [-25% to 5%]; West -20% [-30% to -10%]	
Category 4-5 TC frequency (relevant for damaging winds)	2-3 per year	Little change (noting large variability) (none)	Little change or small increase	Little change or small increase	Little change or small increase	Low-Medium (for examples of numbers published in previous studies, see Section 3.2 of the Science Report)
				Little change or increase	Little change or increase	

Extreme or hazard	Average in 1986-2005	Observed change (and attribution)	2030	2050	2090	Confidence
TC location (latitude) with changes noted for southern extent	10-20°S common (30°S less common)	Little change or small poleward expansion (none)	Little change or small poleward expansion	Little change or small poleward expansion Little change or poleward expansion	Little change or small poleward expansion Little change or poleward expansion	Low (for examples of numbers published in previous studies, see Section 3.2 of the Science Report)
East coast low (ECL) frequency	20 per year, with 2-3 intense ECLs per year impacting on land	-10% (but with large variability) (weak)	-10% [-15% to -5%]	-10% [-15% to -5%] -20% [-30% to -10%]	-10% [-15% to -5%] -35% [-50% to -20%]	Medium (Low for summer and High for winter)
Extreme rainfall intensity (considering 20-year return period)	Spatially variable intensity	+10% hourly and +7% daily (but with large variability) (weak)	+10% [5% to 15%] hourly; +7% [4% to 10%] daily	+10% [5% to 15%] hourly; +7% [4% to 10%] daily +20% [10% to 30%] hourly; +15% [8% to 20%] daily	+10% [5% to 15%] hourly; +7% [4% to 10%] daily +35% [15% to 55%] hourly; +25% [15% to 35%] daily	High for direction of change and Medium for magnitude of change
Extreme sea-level events	Spatially variable	Mainly driven by mean sea-level rise: 3 mm/year (strong)	1-in-100-year event becomes an annual event by the end of the century under RCP 2.6 and by mid-century under RCP 8.5			High
Floods	Spatially variable and dependent on flood type	No clear signal	Increase more likely than a decrease for most types of floods; increases very likely for coastal flooding (based on the rate of sea-level rise) and for small-scale flash floods (based on extreme rainfall increases).			Low for large catchments and large floods in general (including river and surface water); High for coastal and flash floods
Large hail (>2.5 cm diameter) frequency in city-scale regions	About 5-10 per year in eastern regions and 0-5 per year elsewhere	No information	Little change, but potential increase in east and poleward shift in features	As for 2030 As for 2030	As for 2030 As for 2030	Low
Extreme fire weather days (exceeding 95th percentile)	About 18 days per year to once every few years	+15% (medium-high)	+20% [+5% to +35%]; East +15% [+0% to +30%]	+20% [+5% to +35%]; East +15% [+0% to +30%] +40% [+10% to +70%]; East +30% [+0% to +60%]	+20% [+5% to +35%]; East +15% [+0% to +30%] +75% [+20% to +130%]; East +55% [+0% to +110%]	High; Medium in east. Low confidence for lightning ignition and fuel load (key risk factors particularly in north and central Australia)

Table 3: Observed and projected changes in chronic climate hazards that present physical risks for Australian buildings and infrastructure. Table details as for Table 1.

Climate variable	Observed change (and attribution)	2030	2050	2090	Confidence
Annual average temperature	Around +1.4°C since 1910 (strong)	+0.6 to 1.4°C	+0.5 to 1.5°C +1.5 to 2.5°C	+0.5 to 1.5°C +2.5 to 5.0°C	Very high
Average sea level	Increased by 3.1 mm/year during 1993–2009 (strong)	+0.07 to 0.2 m	+0.1 to 0.3 m +0.1 to 0.3 m	+0.2 to 0.6 m +0.4 to 1 m	Very high
Average annual rainfall	Decreased 11% in the southeast during April to October for 1999–2018 relative to 1900–98, and decreased 20% in the southwest during May to July since 1970 relative to 1900–69 (strong), with an increase of 10 mm/decade from 1900–2019 in the north (weak)	East: -13 to +5% North: -9 to +4% South: -9 to +2% Rangelands: -10 to +6%	Drier in the south and east, uncertain in the north Drier in the south and east, uncertain in the north		High in southern Australia, Low elsewhere
Time in drought*	Insignificant (weak)	Increase in many regions	No data Significant increase in many regions		High in southern Australia, Low elsewhere
Annual days >35°C#	Increase (strong)	Increases	Increases Large increases		High

* Meteorological drought (rainfall deficits) and soil moisture drought, not accounting for changes to other factors that are included in agricultural, socio-economic and other drought measures

\# There are projections for other threshold temperatures at www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/threshold-calculator/

Warming over Australia is projected to be broadly similar to the global average warming over land, more than the global average warming including oceans, and less than the rapid warming in the Arctic and the large inland regions of North America and Eurasia.

Rainfall is likely to continue decreasing in the south, especially in southwest Australia and during the southern wet season of May-October, similar to other areas in the mid-latitudes such as southwest Africa and southwest South America and the Mediterranean. Rainfall projections for northern Australia are uncertain, due to a wide range of plausible future changes to the monsoon. Regional modelling produces more detail in projections of rainfall around mountain ranges, and for Tasmania and the eastern seaboard.

Regardless of the change in average rainfall, climate change is likely to increase rainfall variability, including an increase in the incidence of short-duration extreme rainfall. This change will affect the reliability of water supply and lead to an increase in flash flooding.

Projected changes

Internally consistent scenarios for multiple climate hazards

When considering projections for multiple climate hazards, randomly combining the ranges of change for different hazards is not recommended because some combinations may be physically implausible. Internally consistent scenarios should be:

- Physically plausible—the correlations between the variability and change in climate variables should be maintained. To achieve this, CSIRO's climate futures framework can be used, supplemented by other evidence and assessment.
- Representative—they should sample the projected range in general climate represented by average temperature and rainfall change (e.g. hotter and drier vs warmer and wetter), and the hazards and impacts of interest for the specific application.

Researchers have identified 4 internally consistent scenarios for a 20-year period centred on 2050 (2040–2059). (Scenarios for other timeframes can be produced if required.) Projected changes can help inform the development of scenarios of climate extremes for 'stress testing' industry sectors. (The terms 'stress test' and 'scenario' have different meanings to different stakeholders, so must be carefully defined for any application.)

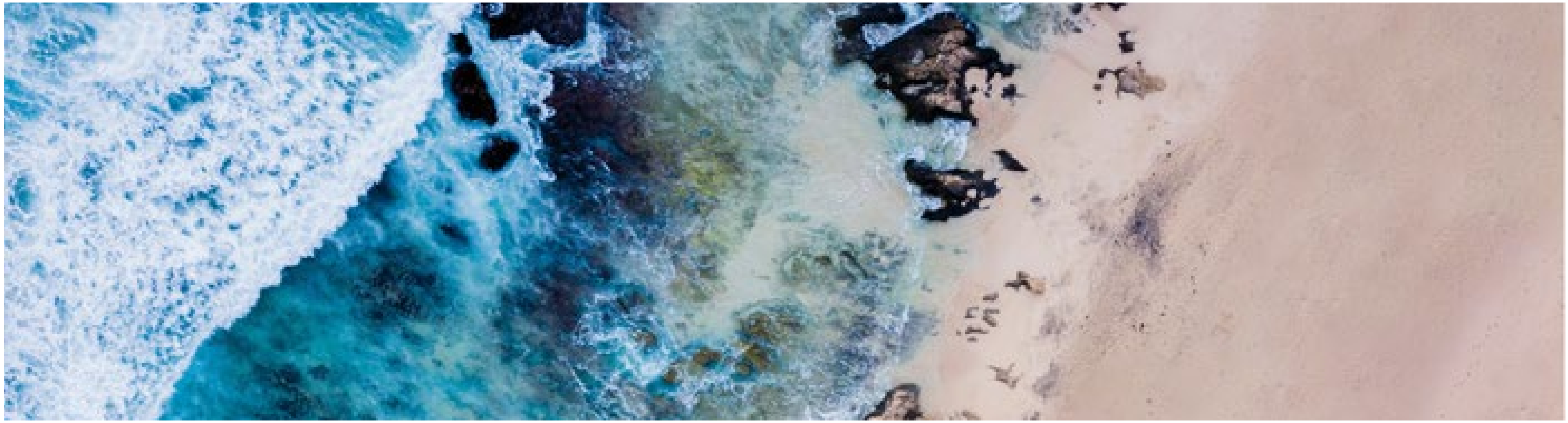
Insights from these projections, supported by other evidence, non-climate knowledge and expert judgement, can provide tests of climate hazard impacts. Specifically, for extreme events that can damage buildings and infrastructure, scenario analyses should include quantitative increases in extreme wind, rainfall, fire weather, large hail and coastal inundation. Scenario analyses can use research on compound extreme events as information emerges.

Gaps and needs

There are several practical limitations to consistent analysis of climate risk for disclosures using the data described here. Some datasets are not publicly available, some are difficult to use, and some are not for commercial use.

Projections for some hazards have wide ranges of plausible changes and low confidence levels. The scientific needs include:

- improved understanding of physical processes associated with climatic hazards, especially bushfires, thunderstorms, floods, hail, tropical cyclones, east coast lows, storm surges and drought
- evaluation of present-day climate model hazard simulations with a focus on extreme hazards that cause damage
- examination of compound events (occurring at the same time or in close succession) and cascading events where one hazard or impact triggers another (e.g. a bushfire triggers water quality and security issues in the months and years following the fire)
- assessment of future changes in extreme weather and climate hazards
- nationally consistent high-resolution projections (rather than the inconsistent high-resolution projections for regional domains currently available), so that regional insights from high-resolution modelling are comparable across the country
- use of up-to-date climate models—projections overwhelmingly use the CMIP3/CMIP5 generation of international models, which are 7-15 years old, but CMIP6 models are now emerging.



Vision for climate science and projections

Improvements to weather and climate data, information and services are needed to support the goal of a resilient financial services sector that embeds climate change understanding into rigorous institutional level assessment and disclosure of risk.

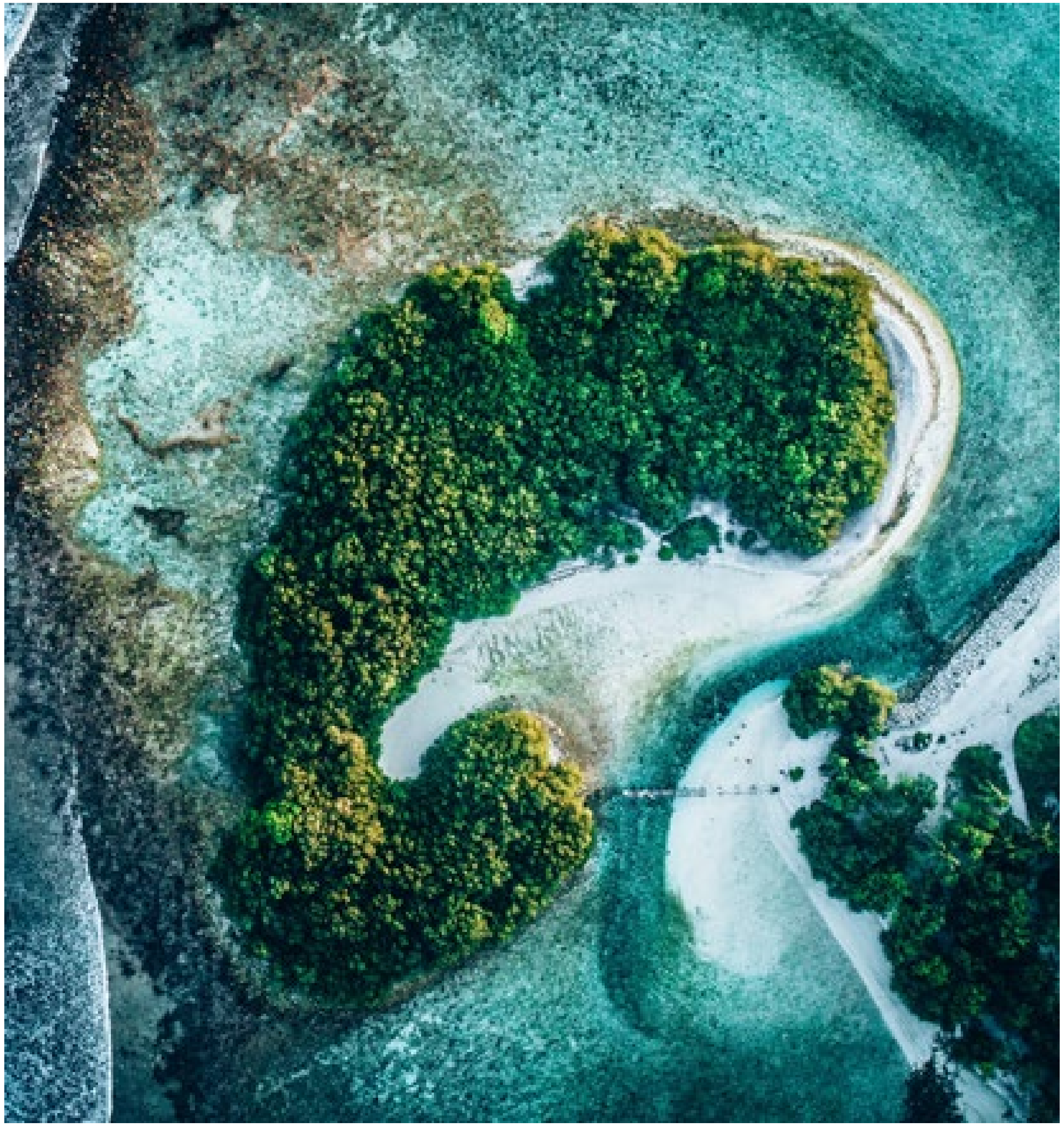
For climate science and projections, the ideal is a comprehensive, fully evaluated set of high-resolution climate projections that can depict all the relevant hazards and phenomena of interest (including their extremes) with high confidence and narrow ranges of spread in projected change, with a full description of natural variability. Information would be available at spatial and temporal scales relevant to assessing climate risks, extending from the present for 100 years.

Ideally, detailed data will be available for parameters including:

- tropical cyclones: frequency, intensity, duration, location, peak wind speeds, rainfall intensity, latitude of maximum intensity, area of gale-force winds, storm surge intensity and frequency
- extreme east coast lows: frequency, intensity, duration, location, peak wind speeds, rainfall intensity, latitude of maximum intensity, area of gale-force winds, storm surge intensity and frequency
- sea-level rise: average and extreme events
- extreme rainfall: frequency, intensity, duration, location, annual maximum 1-day total, 20-year maximum 1-day total, area exceeding X mm over 1 day, annual maximum 3-day total, 20-year maximum 3-day total, area exceeding Y mm over 3 days
- flood: intensity, frequency, duration and area
- extreme hail: frequency, duration and location of hail over 2.5 cm diameter
- extreme fire: frequency, duration and location including fire weather, fuel and ignition
- extreme heat: frequency, duration and location of days over 35, 40 and 45°C (or other sector-relevant thresholds)
- drought: frequency, duration and location.

The vision for climate science and projections includes achievements in a range of areas, including improvements in observations (and derived high-quality gridded data sets such as for wind speed), advances in climate process research, corresponding advances in climate models and projections, delivery of user-focussed climate services, strong international engagement in science and adaptation, and enhanced national coordination and funding of climate research and services.*

* See NCSAC (2019) *Climate Science for Australia's Future*.



Roadmap for achieving the vision

Achieving the CMSI vision requires investment in short-term actions (next 1-3 years) and longer-term actions (next 10 years). These actions should be consistent with those in *Climate Science for Australia's Future* (NCSAC 2019), which has a broader remit.

Short-term actions

- Collect feedback on CMSI guidelines and update them, including the use of the most recent climate observations and projections.
- Compile and quality-check observations of climate hazards, including their extremes.
- Evaluate present-day simulations of extreme climate hazards.
- Analyse future changes in extreme climate hazards.
- Analyse recent compound events.
- Perform CORDEX-CMIP6 regional climate projections for Australia.
- Implement climate services supporting uptake of hazard projections in impact assessment, planning and action.

Longer-term actions

- Improve observation systems for extreme climatic hazards.
- Improve understanding and modelling of extreme climatic hazards.
- Assess likely future changes in compound events.

Copyright © Climate-KIC Australia. Climate-KIC Australia is a registered trademark of Climate-KIC Australia Ltd (ABN 95616047744). The information contained herein is subject to change without notice. Climate-KIC Australia shall not be liable for technical or editorial errors or omissions contained herein. All other rights are reserved.

Climate-KIC Australia as the convenor of the Climate Measurement Standards Initiative advises that the information contained in this publication comprises general statements. Readers should note that the report is not intended to provide legal advice, accounting or auditing advice, or express an opinion of any kind on the disclosures that companies may need to make to comply with their obligations under the Corporations Act 2001 and other applicable corporations, prudential and securities regulations, nor to comply with applicable accounting standards. In all cases, users of the Guidelines should form an independent view regarding the information and variables that should be considered and disclosed in order to provide a true and fair view of their company's financial performance, position and prospects.

CMSI

The CMSI is being coordinated by Climate-KIC Australia, and a group of industry partners, these include: QBE, Suncorp, IAG, RACQ, NAB, Westpac, Commonwealth Bank, HSBC Australia, Munich Re, Swiss Re, Leadenhall CP, MinterEllison and Investor Group on Climate Change. The National Environmental Science Program Earth Systems and Climate Change Hub developed the Scientific Guidance. Technical support has been provided by the Institute for Sustainable Futures, UTS.