Climate Change Scenario Analysis Report

Endeavour Energy
29 July 2022

Disclaimer and Assumptions

Limitation of Use

This report is intended solely for the information and use of Endeavour Energy in accordance with our letter of engagement of 26th May 2022 and is not intended to be and should not be used by any other person or entity. No other person or entity is entitled to rely, in any manner, or for any purpose, on this report. We do not accept or assume responsibility to anyone other than ***Endeavour Energy*** for our work, for this report, or for any reliance which may be placed on this report by any party other than ***Endeavour Energy***.

Climate scenario analysis (CSA)

This analysis is intended to give insight into the historic and potential future projections of trends and exposures to physical climate hazards across the Endeavour Energy network area leveraging global and regional climate models as referenced in this document. Additional analysis of localised data and orographic conditions may need to be considered at postcode level to understand specific risks related to assets, infrastructure and operations, and inform resilience and adaptation planning decisions.

Climate projections are based on assumptions about future greenhouse gas emissions associated with human activity and other policy choices. Climate projections are not predictions and they do not attempt to predict the timing of meteorological events such as storms, droughts, or El Niños. Projections vary from model to model: the best projection dataset for one location and purpose may not be the best for other situations. Considering a range of projections from multiple models may help you gain a more complete picture of potential future risks. Multiple datasets are used in this report:

- For bushfire weather, extreme heat and extreme rain intensity: Downscaled global climate projections are at a resolution of 5km x 5km and utilize the latest downscaled projections for Australia.
- For storm surge frequency: Global climate projections primarily at a scale of 100km x 100km and utilizing the data from the Fifth phase of the Coupled Model Intercomparison Project are used.
- For extreme wind: regional climate projections at a scale of 50km by 50km are used in addition to peer-reviewed literature focusing on the type of weather systems that contribute to extreme wind conditions. Assessment methodology is explained in the Appendix.

This granularity means that models are a summary of the climate within each grid box and can average out large variations (e.g., a mountain region with high rain adjacent to a coastal region with no rain).

Exposure information highlighting which parts of the network area most at risk are included in this report and can be considered as locations to prioritize future investment decisions made by Endeavour to reduce community exposure and vulnerability associated with maintaining network services. It is possible that regions beyond the Endeavour Network area may experience larger projected changes. Therefore, caution is urged in the interpretation and public disclosure of the results presented within this report regarding network exposure.

Inter-annual variability

Climate is driven by multiple atmospheric processes that vary the temperature and rainfall on annual to decadal timescales, such as El Niño/La Niña cycles. The natural variability in the climate system means that there are wet and dry decades, and some years are hotter than others. We take 20-year averages around each horizon (2050 and 2090) to provide long term climate trends and an indication of climate risk, and this reduces the inter-annual variability signals.

However, it is important to note that the climate system does not change linearly and does not always increase in signals under future climate scenarios. A key example is rainfall – the hydrological cycle is amplified under future climates in various ways and so there are many instances where the trends are larger under a future where the globe aligns with the Paris Agreement, compared to one with no climate action.

Scenarios and horizons

Many climate metrics, particularly acute metrics associated with extreme weather events, are not outputted directly from climate models and are estimated post-modelling by specialised climate research groups. As such, not all scenarios and horizons are available for all metrics.

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Endeavour Energy - Climate Change Scenario Analysis and Financial Impact Report

Executive Summary

Project Overview

Deloitte is supporting Endeavour Energy in understanding the potential financial and economic impact of climate-related risks in their business. This report will outline key findings from Phase 1 and Phase 2.

Project context:

Endeavour Energy is looking to understand the potential financial and economic impact of physical climate change on operations under two hypothetical climate scenarios to inform future conversations, regulatory submissions and business decisions related to network resilience.

Scope:

- Scenario analysis for climate-related risks under scenarios RCP4.5 and RCP8.5*
- Quantification of change in risk and associated financial and economic impacts through a concise, transparent and logical model
- Case studies on implementable network and non-network solutions

Project timeline

Phase	Deliverable
Phase 1: Climate risk identification	Summary of identified risks (Appendix B)
Phase 2: Climate scenario analysis	Scenario analysis identifying hot spots of exposure over time
Phase 3: Financial and economic impact model	Final model including in-model user guide
Phase 4: Impact assessment	Analysis of three case studies of implementable network and non-network solutions

Objectives:

- Understand and where possible, quantify the physical risks and opportunities Endeavour Energy may face under different hypothetical futures, to inform engagement with customers and customer advocates, and the forthcoming Regulatory Report.
- Provide network vulnerability insights articulating consequences for service reliability and motivate increased action and investment in climate adaption initiatives.

* RCP stands for the Representative Concentration Pathways described in detail in the Appendix. RCP4.5 is a scenario where all current targets & pledges are met with global warming of 2°C by 2100. RCP8.5 refers to a world with no climate action and global warming of 4°C by 2100.

CSA | Key findings

Projected changes in five physical climate hazards were assessed for the Endeavour Energy network area across two plausible and distinctive climate scenarios and two time horizons with a summary of the findings for 2090 presented below.

Hazard	High-level Summary	Potential Impacts
Bushfire	Projected changes in bushfire weather conditions are intimately linked to projected changes in extreme heat and rainfall distribution with all scenarios projecting an increase in weather conditions conducive to fires. The top 5 postcodes with the highest future frequency of very high fire weather days under a high emissions scenario by 2090 are 2330, 2753, 2754, 2750 and 2773 with 33 to 46 days/year.	• Increased damage to network assets – in particular timber poles and conductors; • Increased likelihood of reputation or litigation risk due to network fire starts; and • Health impacts on employees due to smoke inhalation.
Extreme Heat	All scenarios project an increase in extreme heat conditions, with larger increases under the high emissions scenarios compared to the low emission scenario, particularly by 2090 where the contrast is considerable. The top 5 postcodes with the highest frequency of hot days over 35°C under a high emissions scenario by 2090 are 2330, 2753, 2754, 2750 and 2773 with 47 to 65 days/year.	• An increase in extreme heat conditions risks increasing failure rates of conductors due to increased demand; • Acceleration of substation, conductor and switch degradation due to current design specifications; and • Heat stress on staff
Flood	Projected changes in flood risk focus on changes in extreme rainfall. Extreme rainfall events are projected to increase across the Endeavour Energy network area with magnitudes varying by scenario and time horizon. The top 5 postcodes with the highest wettest day rainfalls under a high emissions scenario by 2090 are 2527, 2526, 2528, 2529 and 2502 with 234 to 265 mm/day.	• Increased damage to substation and pillars; • Poles are destabilised due to changes in soil integrity; • Impact to communication systems; and • Forced staff down time due to sites being inaccessible.
Storm Surge	Storm surge events are often coincident with weather phenomena such as East Coast Lows and can contribute to coastal inundation due to extreme wave heights that are compounded by sea level rise. The postcodes currently impacted by storm surge events include 2500, 2502, 2505, 2506, 2508, 2515, 2516, 2517, 2525, 2526, 2528, 2529, 2530, 2533, 2534, 2538 and 2539 and represent approximately 12% of Endeavour's asset portfolio (by quantity). By 2090 under a high emission scenario storm surge events at these postcodes are projected to become more frequent occurring annually.	• Damage to substations and pillars due to coastal inundation; • Coastal erosion caused by storm surge damages and exposes assets in low-lying coastal areas; • Corrosion of steel poles due to sea salt encroaching oceans; • Poles are destabilised due to changes in soil integrity; and • Increased moisture in soil, termites and fungus leading to increased timber pole failure.
Extreme Wind	Projected changes in extreme wind are dependent on the type of weather phenomena. East Coast Lows are projected to decrease in frequency but with increases in intensity. The frequency of severe wind days across the Endeavour network area are projected to increase by +1 to +3 days by 2090 under a high emissions scenario.	• Increased winds risk causing vegetation to collide with assets; • Increased wind causing poles and overhead lines to be brought down; and • Phase-to-phase and circuit-to –circuit clashing.

Introduction

Scenarios Demystified

Climate scenarios illustrate what the future might look like under differing degrees of climate change and provide us with a structured way of making strategic choices. They are not predictions about what will happen, but rather hypotheses about what could happen in the short to long term. The outcomes of scenario analysis often vary considerably per region.

Introduction

Scenarios are rich, data-driven stories about tomorrow that can help organisations make better decisions today. They are not predictions about the future, but rather hypotheses that describe a range of possibilities for the future. In order to be a scenario, they need to be plausible, distinctly different and internally consistent.

Scenarios must be believable and reasonable, describing a future clearly separable from each other, with conditions present within the scenario not mutually exclusive, but able to occur in unison.

The Role of Scenarios

Strategic choice making becomes difficult amidst uncertainty. Scenarios provide companies with a structured way of thinking through and making strategic choices despite the uncertainty.

Using scenarios is like rehearsing the future, and by recognising the warning signs and the drama that is unfolding one can avoid surprises, adapt and act effectively.

Decisions, which have been pre-tested against a range of what fate may offer, are more likely to stand the test of time, produce robust and resilient strategies and create distinct competitive advantage. Ultimately, the result of scenario planning is not a more accurate picture of tomorrow but to inform decisions about the future.

Climate scenario analysis

The climate scenario analysis methodology undertaken across Endeavour's portfolio is summarised below, with limitations, caveats and assumptions, and nomenclature used throughout the report provided and in the Appendix. All data used was from publicly available sources combined with Endeavour internal information.

CLIMATE SCENARIOS

PHYSICAL RISK

High Emission

No Climate Action

4°C Scenario (RCP8.5)

Moderate Emission

Meet Current Targets & Pledges

2°C Scenario (RCP4.5)

TIME HORIZONS

PHYSICAL RISK

2050 as the 20-year average over 2040 to 2059

2090 as the 20-year average over 2080 to 2099

ASSESS HAZARDS, ISSUES AND THEMES

PHYSICAL HAZARDS

- Flood*
- Extreme Heat*
- Bushfire*
- Storm Surge**
- Extreme Wind**

**Data sources are from Electricity Sector Climate Information (ESCI) at 5 km granularity*

***Only available for selected scenarios/horizons and using IPCC AR5 Representative Concentration Pathways.*

Physical Climate Scenario Analysis

CSA | Introduction & Approach

Context

According to the most recent Global Carbon Project report, 40% of global CO_2 emissions associated with fossil fuel extraction in 2020 were attributed to coal. Rapid reductions in greenhouse gas (GHG) emissions are necessary, however some heating is already committed in the system and it will take another 20-30 years to see global temperatures to stabilise. For every incremental increase in GHGs, changes in extremes will continue to become larger.

More frequent and more intense heatwaves, droughts and bushfires are expected to rise in Australia by mid-century due to the 'locked in' impacts of current GHG emissions. Beyond this timeframe, climate extremes are expected to consistently rise unless large-scale mitigation activities are implemented on a global scale.

Prolonged exposure to hotter temperatures, and extreme temperature events such as widespread drought and heatwaves, extreme rainfall events and rising sea levels can damage assets and other critical infrastructure causing periods of extended service disruption, increased insurance costs and a higher risks from post-event litigation.

Endeavour has experienced major impacts from extreme weather events. For example, the 2019-2020 Black Summer bushfires caused extensive damage to Endeavour's network and resulted in emergency costs of $21.8m. In addition, the bushfires impacted Endeavour staff through damages to property and infrastructure, and affected staff wellbeing through poor air quality and risks to health and safety. Thus assessing how climate extremes evolve in the future is important in the mitigation and adaptation of damages and disruptions to operations and personnel.

Key Assumptions

For estimating the projected changes in extreme heat, flood and bushfire weather conditions, the Electricity Sector Climate Information (ESCI) regional climate projection data is used and is available at a 5 km by 5 km spatial resolution. The results presented in this report are the multi-model mean estimate across 7 ESCI climate models, where projected changes outside the ranges indicated in this report are possible. The assessment of storm surge uses data with a spatial resolution of 100 km by 100 km. Extreme wind is assessed using multiple lines of evidence drawing upon peer-reviewed literature and supported by data with a spatial resolution of 50 km by 50 km. Projected changes in storm surge and extreme wind may also be higher than that reported here due to spatial resolution constraints. Further constraints in the analysis are presented in the Appendix.

Quantitative data analysis^:
- Flood
- Extreme Heat
- Bushfire
- Storm Surge
- Extreme Wind Intensity

Qualitative (research-based):
- Extreme Wind Frequency

This work has been designed to understand the implications of future extreme weather impacts on Endeavour's assets only.

Assess projected exposure to climate hazards at 134 postcodes located within the Endeavour network.

Two scenarios have been used in this analysis:

Scenario 1: RCP4.5*

Scenario 2: RCP8.5**

^ Definitions of each metric in Metrics and Data Sources

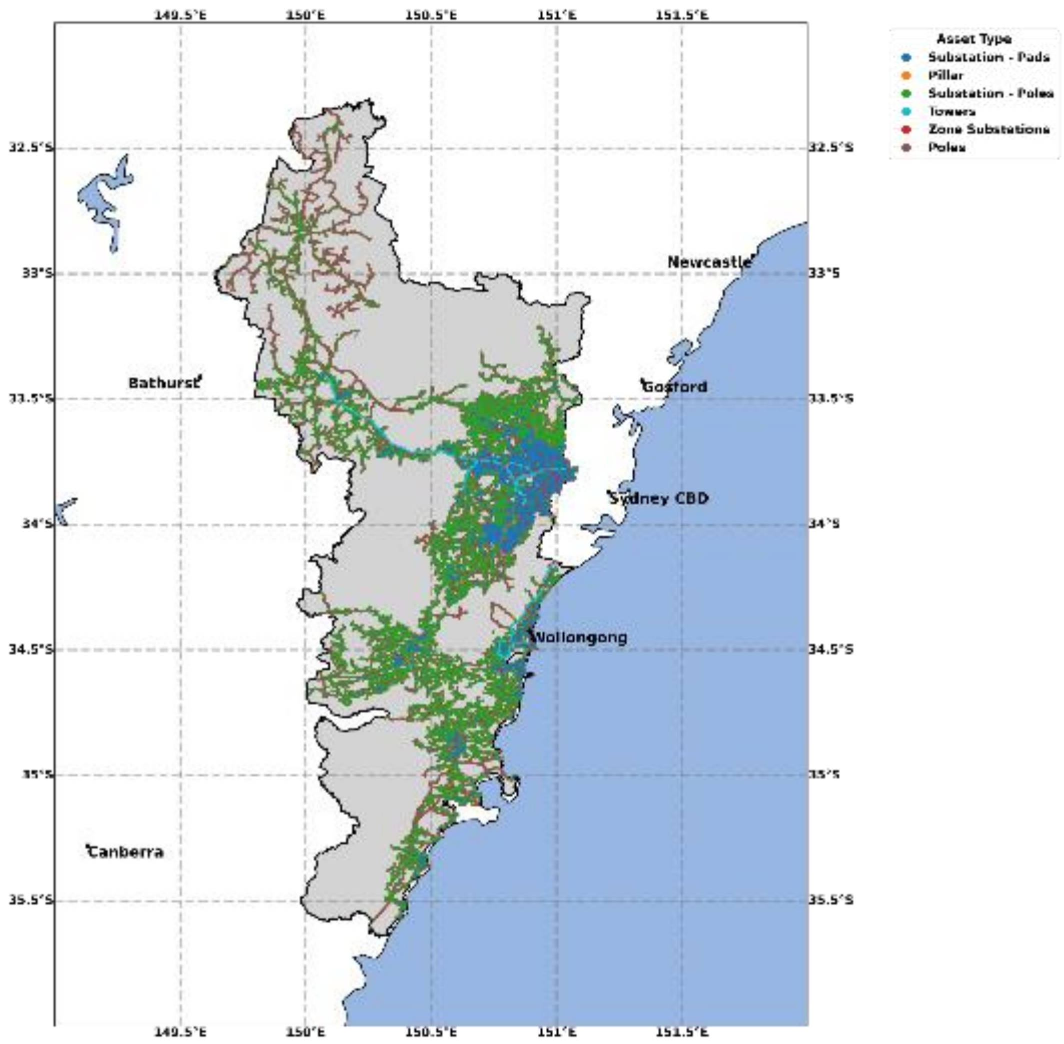
** RCP4.5 is a scenario where all current targets & pledges are met with global warming of 2°C by 2100.*

*** RCP8.5 refers to a world with no climate action and global warming of 4°C by 2100.*

CSA | Endeavour Assets Assessed

A total of 134 postcodes within the Endeavour Energy network area (see right) were assessed according to the geographic coordinates of 817,867 assets including Conductors, Pillars, Poles, Reclosers, Regulators, Substations, Switches and Towers. The greatest density of assets are located in Greater Western Sydney. The same climate hazard datasets are used for all postcodes to facilitate a consistent assessment of projected climate changes across the Endeavour network area.

Asset Type	Asset Sub Class	Number of Assets	Number of Postcodes
Conductors	TOTAL	**361,614**	133
	HV	73,217	131
	LV	276,977	132
	TR	11,420	115
Pillars	LVPILL	112,570	127
Poles	TOTAL	**306,873**	133
	Composite	66	8
	Concrete	23,470	117
	Steel	2,278	110
	Treated	180,213	133
	Unknown	6,332	122
	Untreated	94,514	132
Reclosers	RECLOSER	648	89
Regulators	Regulators	99	31
Substation - Pads	SWGEARHV	12,445	123
Substation - Poles	TOTAL	**19,404**	130
	DSPOLE1	19,398	130
	DSPOLE2	6	2
Switches	LBS	3,020	120
Towers	TOWER	886	50
Zone Substations	TOTAL	**308**	97
	TRANSUB	48	23
	ZONESUB	260	95
Grand Total		**817,867**	**134**



Above: Endeavour Energy network and asset distribution as at 2022.

CSA | Metrics & Data Sources

The physical climate hazards assessed, available climate scenarios, horizons including data sources and granularity are detailed below. The climate hazards selected are based on best available data from credible sources, in order to provide the most robust projections of physical climate risk for the postcode regions within Endeavour's network area. Further information on the data assumptions, statistical methods and likelihood calculations are provided in the Appendix.

Physical Hazard	Climate Metric	Metric Description	Unit	Data Granularity	Horizons*	Scenarios	Data Source
Bushfire	Very High Fire Days	Number of days annually where the Forest Fire Danger Index exceeds 25 (very high rating)	days	5 km	2050 and 2090	• Moderate (RCP4.5) • High (RCP8.5)	ESCI
Extreme Heat	Extreme Heat	Number of days annually over 35°C	days	5 km	2050 and 2090	• Moderate (RCP4.5) • High (RCP8.5)	ESCI
Flood	Extreme Wet Intensity**	1-in-20yr wettest day rainfall	mm/day	5 km	2050 and 2090	• Moderate (RCP4.5) • High (RCP8.5)	ESCI
Storm Surge	1-in-100yr storm surge event	Return period of a 1-in-100yr extreme sea level event that includes storm surge	years	100 km	2050 and 2090	• Moderate (SSP2-4.5) • High (SSP5-8.5)	Vousdoukas et al. (2018)
Extreme Wind Frequency***	East Coast Low Frequency	Historical and future days per year where an East Coast Low occurs	%	~250 km	2050 and 2090	• Moderate (RCP4.5) • High (RCP8.5)	Dowdy et al. 2019
Extreme Wind Intensity***	Extreme Wind Intensity	Annual maximum of the daily maximum wind speed gust	km/hr	50 km	2050 and 2090	• Moderate (RCP4.5) • High (RCP8.5)	Evans et al. 2020 and Nishant et al. 2021

* 2050 refers to the 20 year average across the period 2040 to 2059 and 2090 refers to the 20 year average across the period 2080 to 2099.

** Note that multiple factors can influence flood risk, including terrain and the built environment. With climate change, it is assumed that changes in extreme rainfall are the primary driver of future flood risk.

*** Projected changes in extreme wind are dependent on the type of weather event where it is recommended to evaluate this hazard according to changes in the frequency or intensity of that event that indirectly capture extreme wind conditions. East Coast Lows (ECLs) are most relevant for the Endeavour network area and are assessed in this report to characterise changes in extreme wind frequency. Data used to characterise projected changes in extreme wind intensity have been validated against observations with a summary provided in the Appendix.

CSA | Bushfire

Context & Potential Impacts

Rising temperatures are associated with increases in the frequency of very hot days, heatwaves (consecutive days of extreme hot temperatures) and drought conditions (Herold et al., 2021). A warming climate with drier conditions is likely to provide the physical conditions for more frequent and severe risks of bushfire events.

The 2017-19 drought saw substantially reduced rainfall levels across much of eastern Australia and led to the unprecedented 2019-20 Black Summer bushfire season that dramatically increased particulate pollution, with impacts to health, transport and infrastructure (BoM, 2020). As of May 2020 the total insurance loss attributed to the bushfires nationwide was $2.3bn with over 38,000 claims (ICA, 2021).

Bushfires can cause the physical destruction and/or extensive structural damage to Endeavour's assets resulting in the interruption of network electricity supply. Fallen trees can also disrupt transport routes and interfere with site access resulting in an inability to access the assets for repairs and extend the network outage. Network crews and subcontractors undertaking repair works are also at risk of health impacts from smoke inhalation.

Historical Impact on Endeavour's Network

The 2019-20 Black Summer bushfires caused widespread damage to Endeavour's network with 5 work orders raised for different regions in the network affected by these fires including Wollondilly LGA, Colo, Blue Mountains and the Southern region.

- 24,958 m of LVABC cable and 45,593 m of bare conductors replaced and 6,305 assets were replaced including 160 concrete and 196 timber poles and 13 pole substations
- 77,851 customers interrupted, with a total of 96,377,462 customer minutes interrupted
- $22,068,352 total cost, with 31% of these costs associated with labour costs and 41% with material costs

Future Climate Projections

Projected changes in the frequency of very high fire weather days are greatest under a high emissions scenario, with larger increases in magnitude at more distant time horizons of +5 to +18 additional days by 2090 in contrast to +2 to +10 additional days by 2050. The most at risk areas to projected increases in extreme fire days are located in the northern section of Endeavour's Network particularly in less developed areas close to National Parks.

What it means for Endeavour: Projected increases in the frequency of very high fire weather days increases the risk of fire damage to Endeavour's assets and the likelihood of network supply interruptions occurring. This is likely to impact Endeavour through increased insurance costs, post-event litigation, and health impacts to outdoor workers (i.e. heat stress and breathing difficulties associated with poor air quality).

CSA | Bushfire

Insights into Current & Future Exposure

Current Exposure:

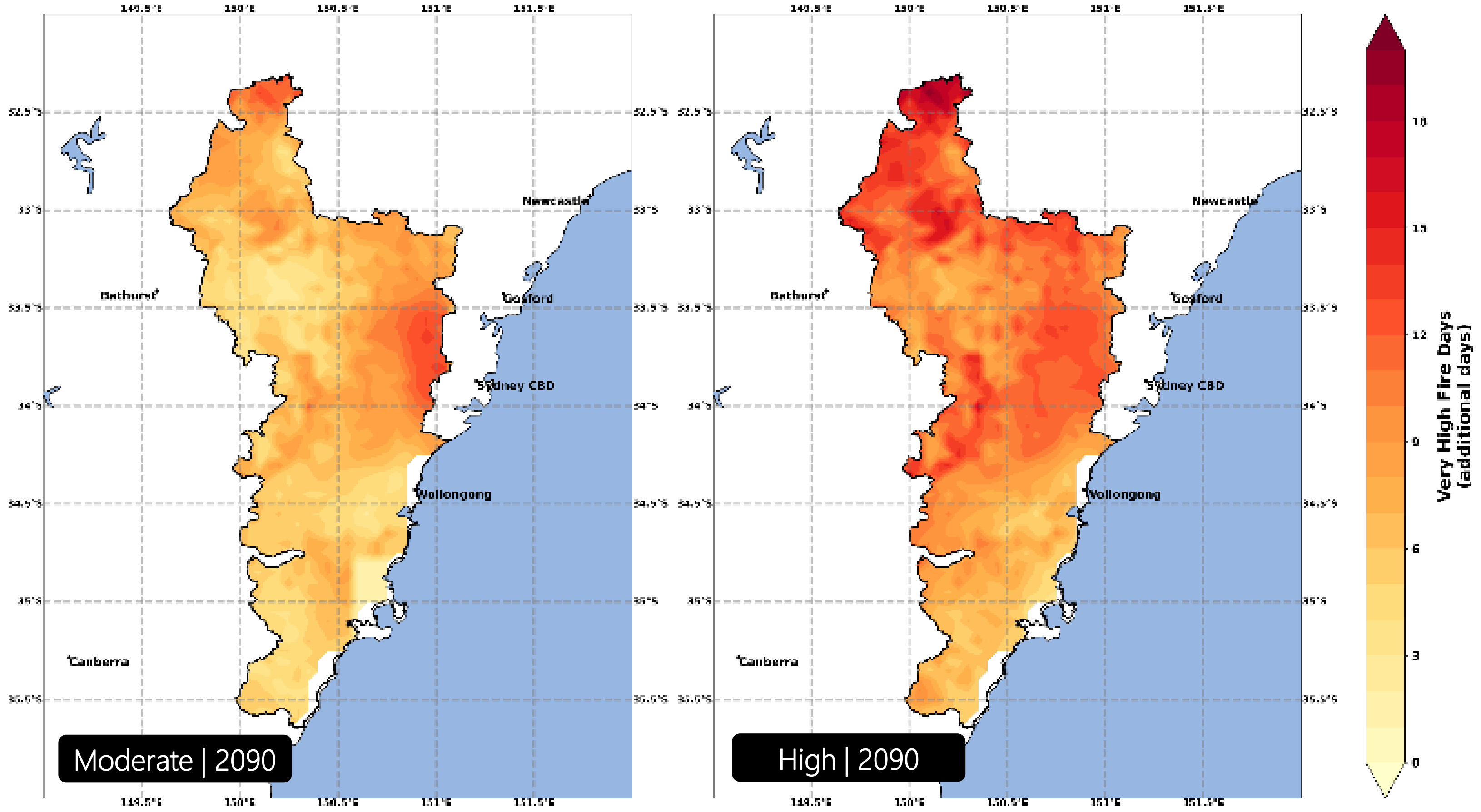
- For the period 1986-2005, Endeavour has experienced an average of 13 very high fire weather days per year with a range of 3 to 39 days across the network area.
- Historically, the top 5 postcodes with at least 20 very high fire weather days per year are 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2750 (Jamisontown) and 2773 (Glenbrook).

Future Exposure under a Moderate Emissions Scenario:

- Very high fire weather days are projected to increase by up to +8 days by 2050 and +1 to +13 days by 2090.
- The top 5 postcodes with the highest future frequency of very high fire weather days (31 to 41 days/year) by 2090 are 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2765 (Oakville) and 2756 (Wilberforce).
- The postcodes with the largest projected increase of very high fire weather days with at least +13 additional days by 2090 are 2124 (Parramatta), 2150 (Parramatta), 2151 (North Paramatta), 2152 (Northmead) and 2115 (Ermington).

Future Exposure under a High Emissions Scenario:

- Very high fire weather days are projected to increase by +2 to +10 days by 2050 and +5 to +18 days by 2090.
- The top 5 postcodes with the highest future frequency of very high fire weather days (33 to 46 days/year) by 2090 are 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2750 (Jamisontown) and 2773 (Glenbrook).
- The postcodes with the largest projected increase of very high fire weather days (+13 to +18 additional days) by 2090 are 2330 (Camberwell), 2795 (Sunny Corner), 2753 (Richmond), 2754 (North Richmond) and 2580 (Middle Arm).



Above: Additional days with very high bushfire weather conditions by 2090 under moderate (left) and high (right) emissions scenarios compared to 1986-2005. Additional figures in Appendix.

CSA | Extreme Heat

Context & Potential Impacts

Rising temperatures are associated with increases in the frequency of very hot days, heatwaves (consecutive days of extreme hot temperatures) and drought conditions (Herold et al., 2021). Temperature extremes tend to increase the demand for electricity while reducing network capacity, increasing the potential for blackouts (Chang et al., 2020). Direct impacts to Endeavour's assets include reduced transformer capacity and lifespan, increased conductor sag and reduced transmission line capacity.

Extreme heat has been known to influence human health and worker safety and productivity adversely. In built up areas, urban heating can exacerbate the impacts of increasing temperatures, particularly on hot days and during heatwaves (Hirsch et al., 2021).

Historical Impact on Endeavour's Network

While historical heatwaves have not directly impacted the network infrastructure, these events have caused switches to fail and noted an increase in electricity demand.

- In the 2021 financial year, 13,526 customers were impacted by switch failures on 93 separate occasions.
- The majority of these incidents occurred in the Western Suburbs of Sydney, which are particularly vulnerable to hot days given the regions geographic location.

Future Climate Projections

Projected changes in the frequency of hot days over 35°C are greatest under a high emissions scenario, with larger increases in magnitude at more distant time horizons of +5 to +44 additional days by 2090 in contrast to +2 to +18 additional days by 2050. The most at risk areas to projected increases in hot days over 35°C are located in across the central and northern regions of Endeavour's Network particularly across the urban areas of Western Sydney.

What it means for Endeavour: Projected increases in extreme heat conditions increase the risk of damage network supply interruptions occurring. This is likely to impact Endeavour through increased insurance costs, post-event litigation arising from unplanned outages affecting vulnerable customers, and health impacts to outdoor workers (i.e. heat stress).

CSA | Extreme Heat

Insights into Current & Future Exposure

Current Exposure:

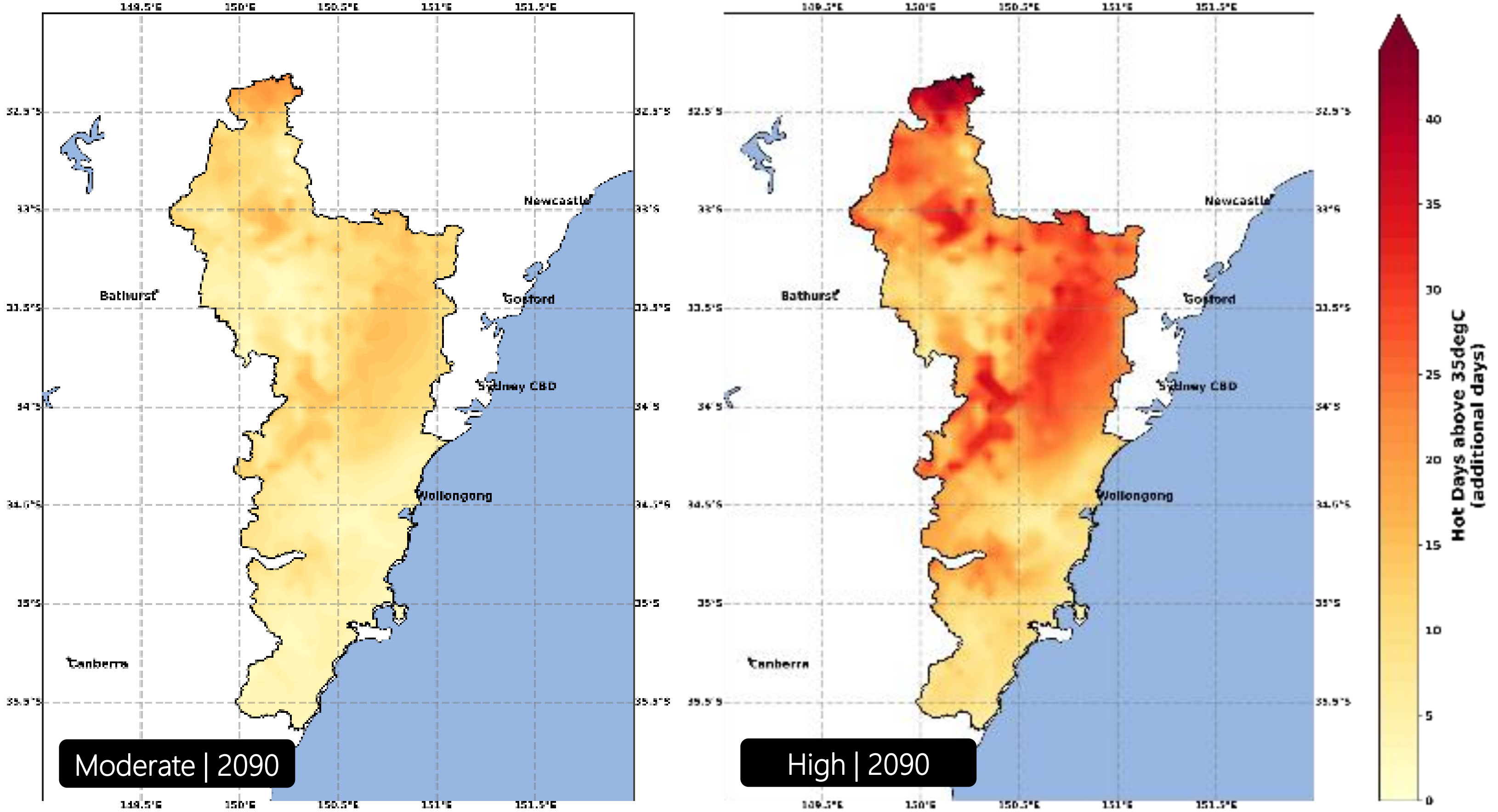
- For the period 1986-2005, Endeavour's has experienced an average of 7 hot days over 35°C per year, with the number of extreme heat days ranging from 0 to 30 days per year across the network area.
- Historically, the top 5 postcodes with at least 14 hot days over 35°C per year 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2750 (Jamisontown) and 2773 (Glenbrook).

Future Exposure under a Moderate Emissions Scenario:

- Hot days over 35°C are projected to increase by +1 to +13 days by 2050 and +2 to +21 days by 2090.
- The top 5 postcodes with the highest frequency of hot days over 35°C (29 to 42 days/year) by 2090 are 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2750 (Jamisontown) and 2773 (Glenbrook).
- The postcodes with the largest projected increase of hot days over 35°C (+15 to +21 additional days) by 2090 are 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2750 (Jamisontown) and 2773 (Glenbrook).

Future Exposure under a High Emissions Scenario:

- Hot days per year over 35°C are projected to increase by +2 to +18 days by 2050 and +5 to +44 days by 2090.
- The top 5 postcodes with the highest frequency of hot days over 35°C (47 to 65 days/year) by 2090 are 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2750 (Jamisontown) and 2773 (Glenbrook).
- The postcodes with the largest projected increase of hot days over 35°C (+33 to +44 additional days) by 2090 are 2330 (Camberwell), 2753 (Richmond), 2754 (North Richmond), 2750 (Jamisontown) and 2773 (Glenbrook).



Above: Additional hot days over 35°C by 2090 under moderate (left) and high (right) emissions scenarios compared to 1986-2005. Additional figures in Appendix.

CSA |Flood

Context & Potential Impacts

Extreme rainfall and associated flooding events are often caused by weather phenomena such as thunderstorms, frontal systems, tropical cyclones and east coast lows. There is a large degree of natural variability in the drivers of these phenomena, such as El Niño Southern Oscillation (ENSO). Climate change is expected to intensify short duration rainfall extremes and lead to an increase in the large-scale atmospheric conditions that are conducive to thunderstorm development. This is likely to increase the frequency and magnitude of flood events.

Rainfall extremes increase the potential for flood risks and mudslides that can cause extensive structural damage to Endeavour's assets and interrupt network electricity supply. Flooding can also disrupt transport routes and interfere with site access resulting in an inability to access the assets for repairs and extend the network outage. This presents both a financial and regulatory risk to Endeavour Energy.

Historical Impact on Endeavour's Network

Previous flood events have caused widespread damage and outages to Endeavour's network with damages associated with the March 2021 flood event include:

- 2,145 m of LVABC cable and 1,206 m of bare conductors replaced and 476 assets were replaced, with most of these being insulators, 4 pole substations and 2 padmount transformers
- 17,521 customers interrupted, with a total of 5,199,582 customer minutes interrupted
- $1,074,937 total cost, with 48% of these costs associated with labour costs and 23% with material costs

Future Climate Projections

Projected changes in the intensity of extreme rainfall are greatest under a high emissions scenario of -4 to +49 mm/day by 2050 and -4 to +56 mm/day by 2090. There is some variability across the Endeavour Network with projected decreases concentrated in the Blue Mountains region under both scenarios by 2050 and elsewhere projected increases. The most at risk areas to projected increases in extreme rainfall intensity are located on the coast, particularly around Wollongong and Port Kembla.

What it means for Endeavour: Projected increases in extreme rainfall increase the potential for flooding, particularly when catchments are already saturated from successive events. Extreme rainfall and the resulting flooding can cause extensive structural damage to assets, interrupt network electricity supply and contribute to potential delays to in resuming network service should site access be impeded.

CSA |Flood

Insights into Current & Future Exposure

Current Exposure:

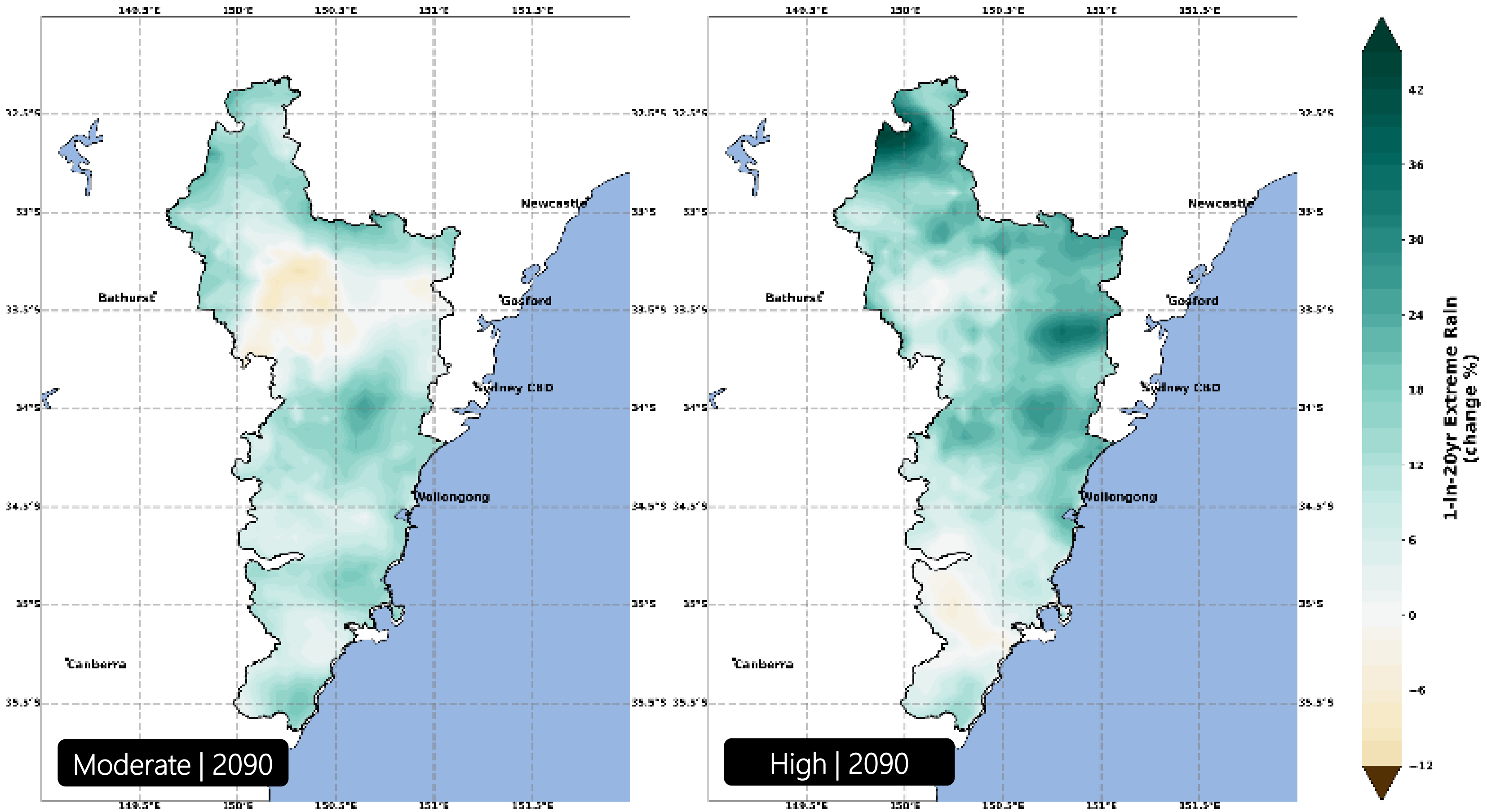
- For the period 1986-2005, the Endeavour network has experienced an average wettest day rainfall intensity of 158 mm/day for a 1-in-20yr event, and a range of 72 to 233 mm/day across the Endeavour network area.
- Historically, the 5 highest 1-in-20yr wettest day rainfall amounts are located in postcodes 2527 (Tullimbar), 2526 (Cordeux Heights), 2528 (Warilla), 2529 (Flinders) and 2535 (Berry).

Future Exposure under a Moderate Emissions Scenario:

- The wettest day rainfall for a 1-in-20yr event is projected to change by -15 to +31 mm/day by 2050 and by -11 to +31 mm/day by 2090. This represents a change to the historic wettest day rainfall of -10% to +27% by 2050 and -9% to +27% by 2090.
- The 5 highest wettest day rainfalls (+230 to +252 mm/day) by 2090 are located in postcodes 2526 (Cordeux Heights), 2527 (Tullimbar), 2529 (Flinders), 2528 (Warilla) and 2505 (Port Kembla).
- The postcodes with the largest projected increase of wettest day rainfall (+29 to +31 mm/day) by 2090 are located in 2541 (Bomaderry), 2570 (Camden), 2529 (Flinders), 2526 (Cordeux Heights) and 2538 (Milton).

Future Exposure under a High Emissions Scenario:

- The wettest day rainfall for a 1-in-20yr event is projected to change by -4 to +49 mm/day by 2050 and by -4 to +56 mm/day by 2090. This represents a change to the historic wettest day rainfall of -5% to +30% by 2050 and -4% to +39% by 2090.
- The 5 highest wettest day rainfalls (+234 to +265 mm/day) by 2090 are located in postcodes 2527 (Tullimbar), 2526 (Cordeux Heights), 2528 (Warilla), 2529 (Flinders) and 2502 (Primbee).
- The postcodes with the largest projected increase in wettest day rainfall (+46 to +56 mm/day) by 2090 are located in 2508 (Stanwell Park), 2515 (Wombarra), 2159 (Cabramatta), 2529 (Flinders) and 2528 (Warilla).



Above: Projected change in the 1-in-20yr wettest day rainfall (mm/day) by 2050 for moderate (left) and high (right) emissions scenarios compared to 1986-2005. Additional figures in Appendix.

CSA |Storm Surge

Context & Potential Impacts

Climate change is leading to rising sea levels and greater storm intensity, [increasing the risk of flooding for coastal infrastructure](), including coastal postcodes within the Endeavour network. The most damaging events are likely to arise when inland flooding, storm surges and high tides occur concurrently. This has the potential to impact Endeavour's coastal assets through direct flooding of substations and control rooms, corrosion from salt water damage, inability to access facilities for repairs and interruptions to network supply.

Storm surge events are often coincident with weather phenomena and can contribute to coastal inundation due to extreme wave heights that are compounded by sea level rise. Typical weather events across the Endeavour network area includes East Coast Lows which can affect the broader region further inland by bringing heavy rainfall and strong winds. Across coastal locations, the current 1-in-100 year extreme sea level events are projected to become more frequent.

Insights into Current & Future Exposure

Current Exposure:

- The coastal region of Endeavour's network currently experiences an average storm surge height of 2.11 m for a 1-in-100 year event (i.e., 1% chance of occurring annually).
- The postcodes impacted by storm surge events include 2500 (Coniston), 2502 (Primbee), 2505 (Port Kembla), 2506 (Berkeley), 2508 (Stanwell Park), 2515 (Wombarra), 2516 (Bulli), 2517 (Woonona), 2525 (Figtree), 2526 (Cordeux Heights), 2528 (Warilla), 2529 (Flinders), 2530 (Cleveland), 2533 (Jerrara), 2534 (Willow Vale), 2538 (Milton) and 2539 (Bendalong). Assets located within these postcode areas account for approximately 12% of the total assets maintained by Endeavour.

Future Exposure under a Moderate Emissions Scenario:

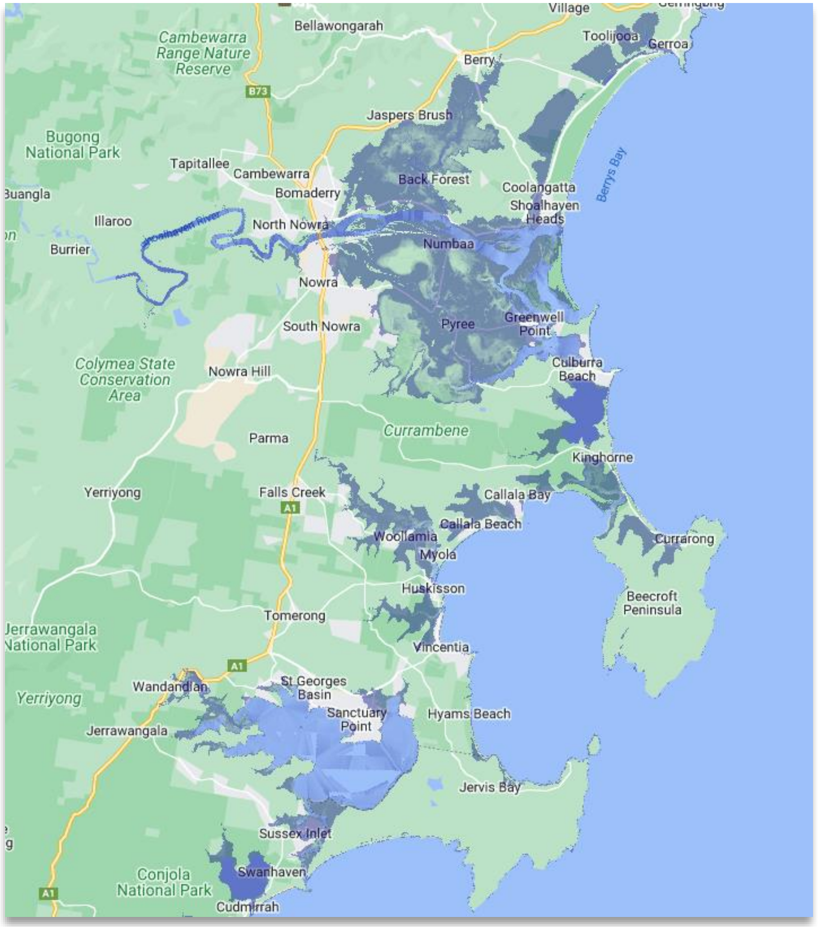
- The current 1-in-100yr storm surge event (1% AEP) is projected to become more frequent and become a 1-in-37yr event (a 2.7% AEP) by 2050 and an annual event by 2090.

Future Exposure under a High Emissions Scenario:

- The current 1-in-100yr storm surge event (1% AEP) is projected to become more frequent and become a 1-in-13yr event (a 7.7% AEP) by 2050 and an annual event by 2090.

- An **extreme sea level event** is the sum of storm surge, extreme wave height and mean sea level. This metric is the future return period of the present day (1986-2014) 1-in-100yr extreme sea level event.
- **AEP** refers to Annual Exceedance Probability. A 1-in-100 year event has a 1% AEP, that is, a 1% chance of occurrence in any year.

What it means for Endeavour: Projected increases in coastal inundation arising from storm surge events and sea level rise may damage coastal assets (e.g. padmount and zone substation equipment), reduce the useful life of assets through saltwater corrosion and interrupt network supply.



Above: Projected sea level rise and coastal inundation in the Shoalhaven LGA by 2100 under a high emissions scenario. Source: [Coastal Risk]().

CSA |Extreme Wind Frequency

Context & Potential Impacts

Extreme wind speeds are typically caused by either convective (e.g. tornados and thunderstorms) or large-scale (e.g. tropical cyclones and east coast lows) weather events. Assessment of projected changes in extreme winds are typically dependent on changes to the intensity or duration of the associated weather event (DPIE, 2020). East Coast Lows (ECLs) are the most relevant weather event for south-east Australia, including the Endeavour network area.

ECLs are intense low-pressure systems that often have severe impacts on the Australian east coast, increasing the risk of extreme winds, lightning and rainfall. ECLs can result in extreme wind speeds, with a 3-second wind gust of 170.6 km/h (the second strongest wind gust on record in NSW) at Nobbys Head in 1974.

Severe convective winds are extreme wind gusts that are typically associated with multiple weather events, including thunderstorms and east coast lows. They are commonly defined as 3-second average wind speeds at a height of 10m that exceed 25 m/s. Severe convective wind days are projected to increase under climate change (Brown and Dowdy, 2021).

Risks associated with extreme wind include direct damage to assets (e.g. poles, transmission towers and overhead power lines) from high wind loads and damage from debris (such as vegetation) that is blown into the air and collides with assets. The associated damage can interrupt network supply and threaten the integrity of wind generation that is sensitive to destructive gusts.

Insights into Current & Future Exposure

Current Exposure:

- The east coast of Australia has historically (1970-2006) experienced an average of 22 east coast low events per year, occurring across an average of 36 days per year (Dowdy et al. 2019).
- Historically (1979-2018), the Endeavour Network area experienced 38 to 44 days/year with severe convective winds.

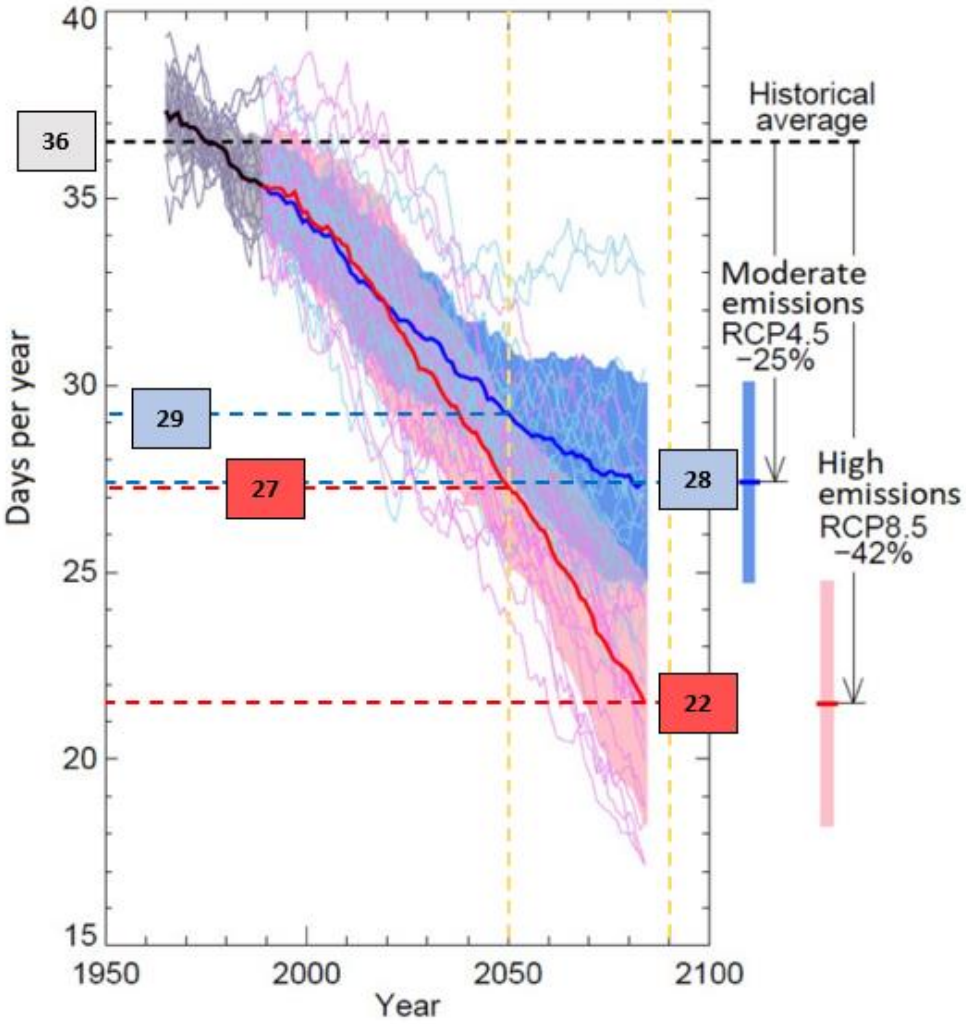
Future Exposure under a Moderate Emissions Scenario:

- The frequency of ECLs is projected to decrease to 27 to 31 days/year by 2050 and 25 to 30 days/year by 2090, but with potential increases to their intensity and associated extreme wind speeds.

Future Exposure under a High Emissions Scenario:

- The frequency of ECLs is projected to decrease to 25 to 29 days/year by 2050 and 18 to 25 days/year by 2090, but with potential increases to their intensity and associated severe weather impacts.
- The frequency of severe convective wind days across the Endeavour network area are projected to increase by +1 to +3 days by 2090.

What it means for Endeavour: Climate change is expected to increase Endeavour's exposure to extreme winds and is likely to lead to increasing costs associated with damage to assets, interruptions to network supply and increased insurance premiums.



Above: Future value in East Coast Low frequency under moderate and high emissions scenarios. *Source:* *Dowdy et al. 2019*

CSA | Extreme Wind Intensity

Insights into Current & Future Exposure

Current Exposure:

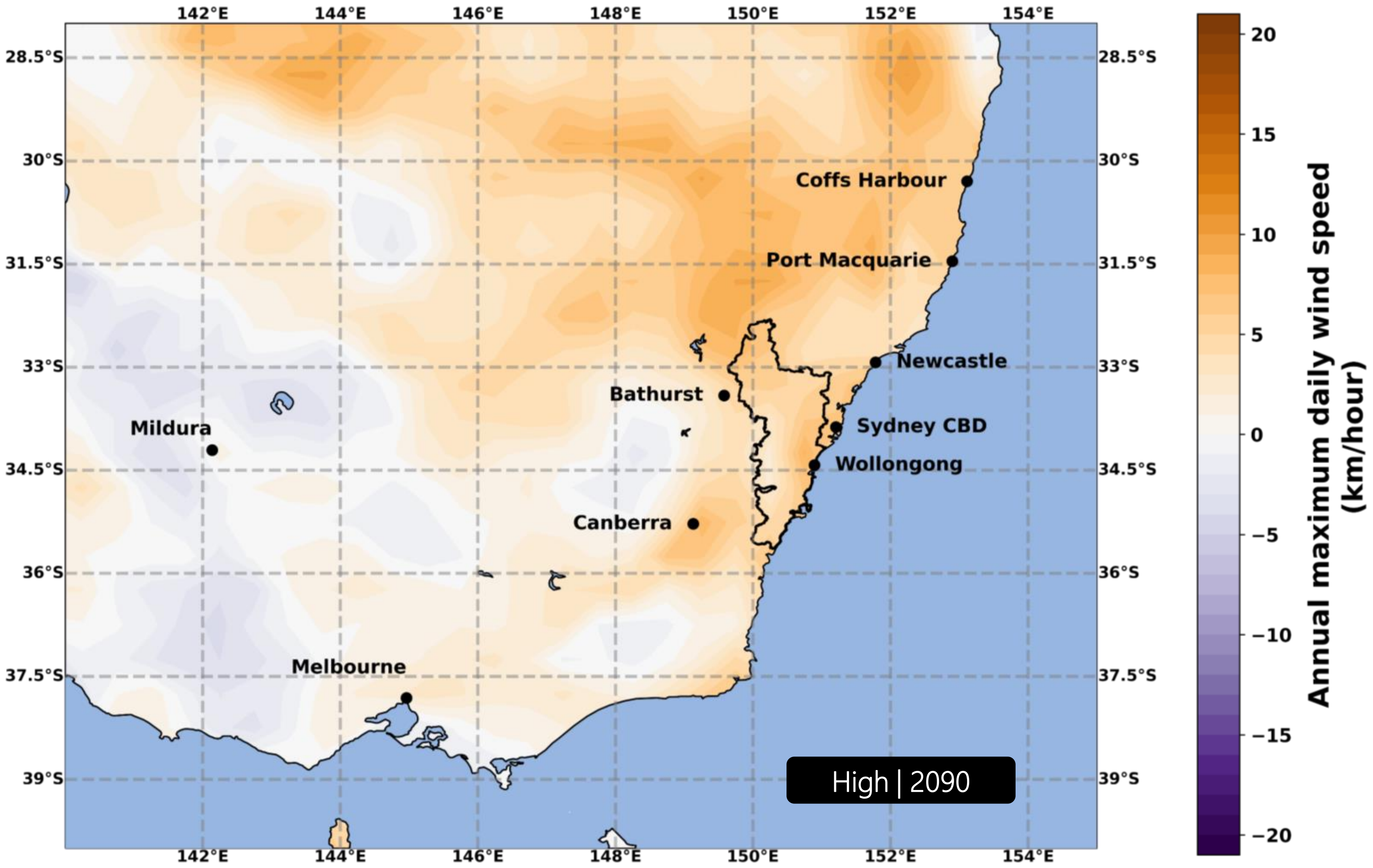
- For the period 1986-2005, the Endeavour network has experienced annual maximum daily wind speeds of 25.6 to 70.0 km/hour across the Endeavour network area.
- Historically, the highest annual maximum daily wind speeds have occurred across the south-east of the Endeavour network area (Shoalhaven and Batemans Bay).

Future Exposure under a Moderate Emissions Scenario:

- Annual maximum daily wind speeds are projected to change by -3.0 to +5.8 km/hour by 2050 and by +0.8 to +8.5 km/hour by 2090. This represents a change from the historic annual maximum daily wind speeds of -5% to +11% by 2050 and +3% to +16% by 2090.
- By 2090, annual maximum daily wind speeds have projected values that range from 26.5 to 73.5 km/hour, with the highest speeds located across the south coast section of the Endeavour network area (Shoalhaven and Batemans Bay). The largest projected increase (+8.5 km/hour) in the annual maximum daily wind speed relative to the 1986-2005 average occurs across the north-east region of the Endeavour network area.

Future Exposure under a High Emissions Scenario:

- Annual maximum daily wind speeds are projected to change by -3.0 to +3.5 km/hour by 2050 and by +0.2 to +8.2 km/hour by 2090. This represents a change from the historic annual maximum daily wind speeds of -5% to +7% by 2050 and +1% to +16% by 2090.
- By 2090, annual maximum daily wind speeds have projected values that range from 26.1 to 75.6 km/hour by 2090 with the highest speeds occurring across the south of the Endeavour network area (Shoalhaven and Batemans Bay). The largest projected increase (+8.1 km/hour) in the annual maximum daily wind speed relative to the 1986-2005 average occurs across the north-east region of the Endeavour network area.



Above: Projected change in the annual maximum daily wind speed (km/hour) by 2090 for a high emissions scenario compared to 1986-2005. Additional figures in Appendix.

Appendices

Appendix A: Climate Scenario Analysis

CSA | Understanding physical climate scenarios

Motivation to explore future physical climate risk

The global average temperature has risen around 1°C since the late 19th century, primarily due to human activity. At the present warming rate, global temperatures may likely reach 1.5°C around 2040. This warming means the Earth is more sensitive to climate extreme events, and that these extremes occur more frequently, intensely and are more volatile. The Earth is already experiencing unprecedented climate extreme events numerous times a year, regardless of future scenarios. Impacts from extremes "will exceed the limits of resilience and adaptation of ecosystems and people, leading to unavoidable loss and damage".

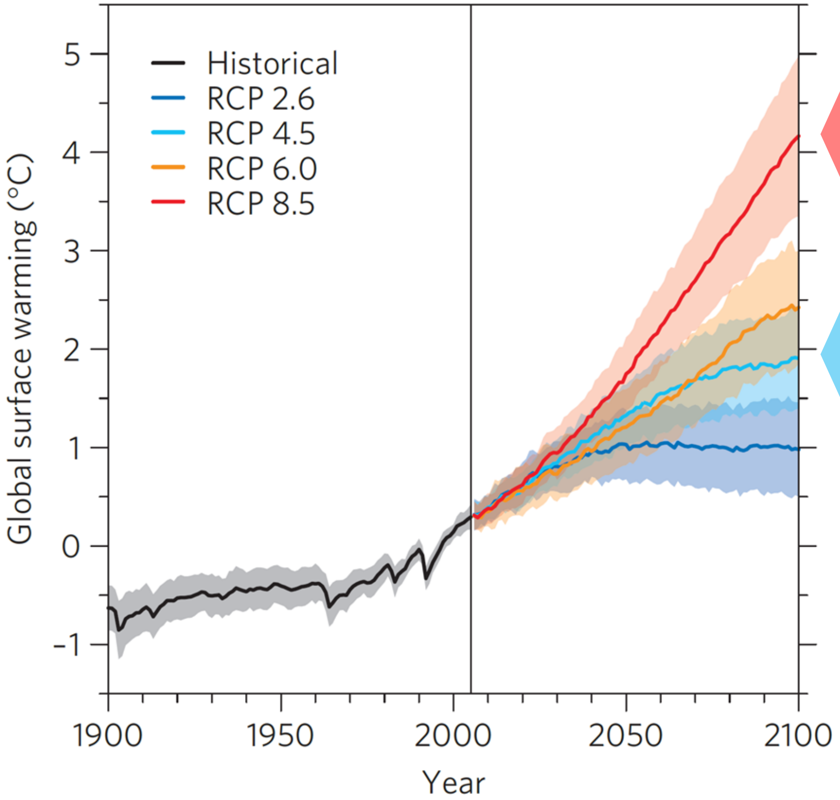
What are the Representative Concentration Pathways?

The four future Representative Concentration Pathways (RCPs) used for understanding changes in physical climate risks stem from the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5), published in 2013. The RCPs describe the top-of-the-atmosphere energy imbalance, associated with warming of the planet Earth. These climate scenarios are named RCP2.6, RCP4.5, RCP6.0 and RCP8.5. The RCP4.5 and RCP8.5 scenarios are used for assessment in this report.

Which climate scenario is most likely?

The RCP climate scenarios represent plausible futures. They are NOT predictions and are NOT accompanied by a likelihood rating. The RCPs are a tool to help decision makers understand the breadth of plausible physical risks. Long term physical climate risk is dependent on transition pathways and choices such as policy, market trends, technology, legalities and decarbonisation on a global scale. COVID-19 reduced some greenhouse gas concentrations (e.g., carbon dioxide), but no more than year-to-year variability, meaning that greenhouse gas emissions are still rising.

Two climate scenarios used in this report



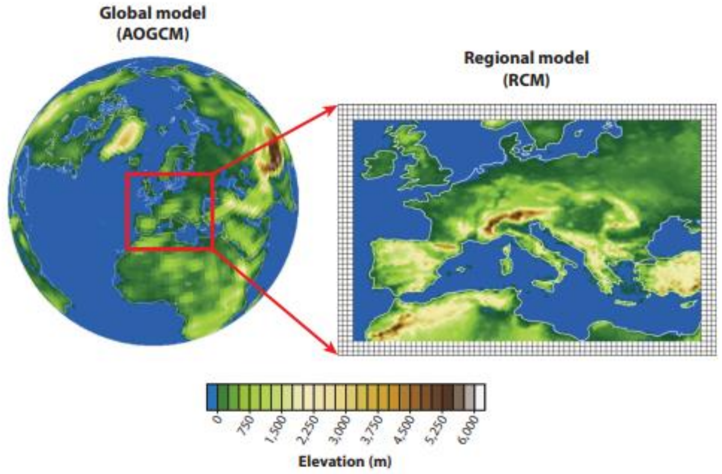
RCP8.5 High emissions scenario
With no climate action and global warming of 4°C by 2100

RCP4.5 Moderate emissions scenario
Strong mitigation with global warming of 2°C by 2100

Above: Multi-model mean (line) and spread (shading) for IPCC AR5 climate models.
Source: Knutti and Sedlackek (2012)

CSA | What is a Climate Model?

Both Global Climate Models (GCMs) and Regional Climate Models (RCMs) are four-dimensional (latitude, longitude, time and height) representations of the climate system at every point in time over a region for the past, present and future.



Credit: F. Giorgi and W. J. Gutowski, Annual Reviews

Why are Climate Models needed?

- Filling gaps in our measurement
- Helping us understand why a climate process occurs
- Provide estimations which we can not measure (e.g., winds)

How do Regional Climate Models differ from Global Climate Models?

- Provide more granular detail than is currently possible with a Global Climate Model (GCM)
- RCMs simulate a region (e.g. Australia) while GCM simulations have global coverage
- To run over a region, RCMs need to know what the conditions are at the boundary of the regional domain and often use GCM outputs to provide this information

How often are regional climate model projections updated?

- Updated GCM projections are released every 5 to 7 years and then new regional climate projections are released in the subsequent 2 years.
- CMIP5 (Coupled Model Intercomparison Projects 5) are associated with the IPCC Fifth Assessment Report that was released in 2013
- The current generation of high resolution projections for Australia use the outputs for the CMIP5 climate models at ~150 km resolution as inputs to drive the RCMs to produce projections at 12-50 km resolution with further downscaling using statistical quantile scaling methods to obtain projections at a 5 km spatial resolution.

How are the climate models different and what is model uncertainty?

Each regional climate model is different in its atmosphere and land components and the underlying physics used to simulate climate dynamics operates at a finer scale than the individual model grid scale (e.g., a thunderstorm or single cloud). Further, if a different GCM is used to drive the RCM there can be differences in the resulting projections. Thus, there is a range in magnitude (and sign) in how the climate evolves at each simulated point on Earth in each model – this leads to a spread in climate model projections and model 'uncertainty'. The uncertainty is often largest in metrics that are hard to measure and model, particularly those associated with mean and extreme rain. Therefore, a multi-model average is used to capture the overarching trends and has been shown to outperform individual models across multiple metrics[1]. We also compare the multi-model regional model findings with literature and other data sources.

[1]This has been demonstrated in both CMIP3 and CMIP5 models (e.g., Reichler and Kim 2008; Gleckler et al. 2008; Knutti 2010; Loikith and Broccoli 2015)

CSA | Methodology – Climate Data Processing

Data & Assumptions

To assess extreme heat, flood and bushfire hazard the Electricity Sector Climate Information (ESCI) Climate Data is used. These datasets are available on a 5 km by 5 km spatial resolution and are currently **the best available climate datasets at this spatial scale** and were specifically created for use in the electricity sector.

Climate models provide a sophisticated representation of the Earth's climate system and build upon the fundamental laws of physics of the atmosphere, ocean, ice, and land. The calculations made by these tools are performed on three-dimensional grids that typically do not resolve all processes (e.g. cloud formation) with differences in how these are treated mathematically varying between climate models that can lead to different estimates across multiple climate hazards and their characteristics. Therefore, it is best practice to use projections from multiple climate models. Within this report, ESCI data has been used from the following climate models: ACCESS1.0 CCAM, ACCESS1.0 NARCLIMJ, ACCESS1.0 NARCLIMK, ACCESS1.3 NARCLIMJ, CANESM2 CCAM, CANESM2 NARCLIMK, MIROC5 CCAM. This selection climate models is a subset of the 40 CMIP5 models that informed the IPCC AR5 report, with the selection based on the ability to simulate characteristics of the Australian climate, with details available in the Climate Change in Australia technical report. It is possible that projections from other data sources may differ from those presented here.

Note that global climate models have a resolution of ~200 km and downscaling (here, using quantile mapping) to 5 km resolution may have introduced biases in the final model outputs. Moreover, near-term climate (next 10-20 years) is dominated by natural variability leading to uncertainty in projections.

Statistical Methods & Data Transformations

Weather and climate are not the same thing, where weather refers to short-term atmospheric conditions associated with an event (e.g. storm) while climate refers to the long-term characteristics in a region that considers the average condition and variability over a period of at least 30 years to account for the influence of large-scale climate variability. The ESCI climate data is only available as 20-year averages to capture for the role of interannual climate variability. Furthermore, all climate models do better at representing the climate in some areas than others so it is important to capture the spread across many climate models when assessing projected climate changes. To limit the bias of individual climate models, the multi-model mean estimate across the seven ESCI models is used.

Due to the large quantity of assets within Endeavour's portfolio, the assessment of projected changes for each of the climate hazards will often yield the same value for multiple assets that fall within the same 5 km by 5 km grid cell of the data. Therefore, projected climate changes are assessed by consolidating the asset types and corresponding coordinates according to the postcode to which the asset is located. The central latitude and longitude coordinates are used to extract the climate data for the nearest grid cell including data from adjacent grid cells to estimate a postcode level estimate that is calculated consistently across all relevant locations.

CSA | Methodology – Likelihood Ratings

The methodology for determining the likelihood of each physical climate hazard and the corresponding likelihood scale following the Endeavour's ERM categories is provided below. The categories are based on the distribution of both historical and future values across Endeavour's portfolio.

1. The current and future values for each physical hazard (e.g., extreme heat) is extracted for postcode within the Endeavour network area across available scenarios and horizons.
2. For each physical climate hazard, the range of values is assessed and categorised into likelihood ratings (illustrated below).
3. The likelihood ratings for each climate hazard are provided in the data file and used with the likelihood values in the financial model.

Climate Hazard *(Associated metric description)*	ERM likelihood category (assuming impact/intensity remains constant)				
	Rare	Unlikely	Possible	Likely	Almost Certain
Bushfire (Very high fire days) *Defined as the future percentage of days per year with a very high fire danger rating*	0% of the year	Up to 2.5% of the year (0 to 9 days)	2.5 to 5% of the year (9 to 18 days)	5 to 7.5% of the year (18 to 27 days)	>7.5% of the year (Over 27 days)
Extreme heat (Days over 35°C) *Defined as the future percentage of days per year where the maximum daily temperature is above 35°C*	0% of the year	Up to 2.5% of the year (0 to 7 days)	2.5 to 5% of the year (7 to 18 days)	5 to 10% of the year (18 to 37 days)	Over 10% of the year (Over 37 days)
Flood (1-in-20yr extreme rain) *Defined as the future percentage of the maximum 1-in-20yr wettest day rainfall amount*	<20% of the maximum (<53 mm/day)	20 to 50% of the maximum (53 to 132 mm/day)	50 to 60% of the maximum (132 to 159 mm/day)	60 to 70% of the maximum (159 to 185 mm/day)	Over 70% of the maximum (Over 185 mm/day)
Storm Surge (Return period 1-in-100yr ESL) *Defined as the future annual exceedance probability for a 1-in-100yr extreme sea level event*	Not near coast	0 to 0.99% AEP (Over 100 year return period)	1 to 7% AEP (100 to 70 year return period)	7 to 10% AEP (70 to 10 year return period)	>10% AEP (Less than 10 year return period)

CSA |Extreme Wind Validation

To assess projected changes in extreme wind, the NSW and Australian Regional Climate Modelling (NARCliM) data version 1.5 is used. Evaluation of these climate models that includes validating against observations is presented in Evans et al. 2020 and Nishant et al. 2021. However these studies focus of temperature and precipitation characteristics and not on wind speed. Therefore, we present a high level assessment on how well these climate models can characterise the spatial variation in extreme wind conditions across the Endeavour Network area.

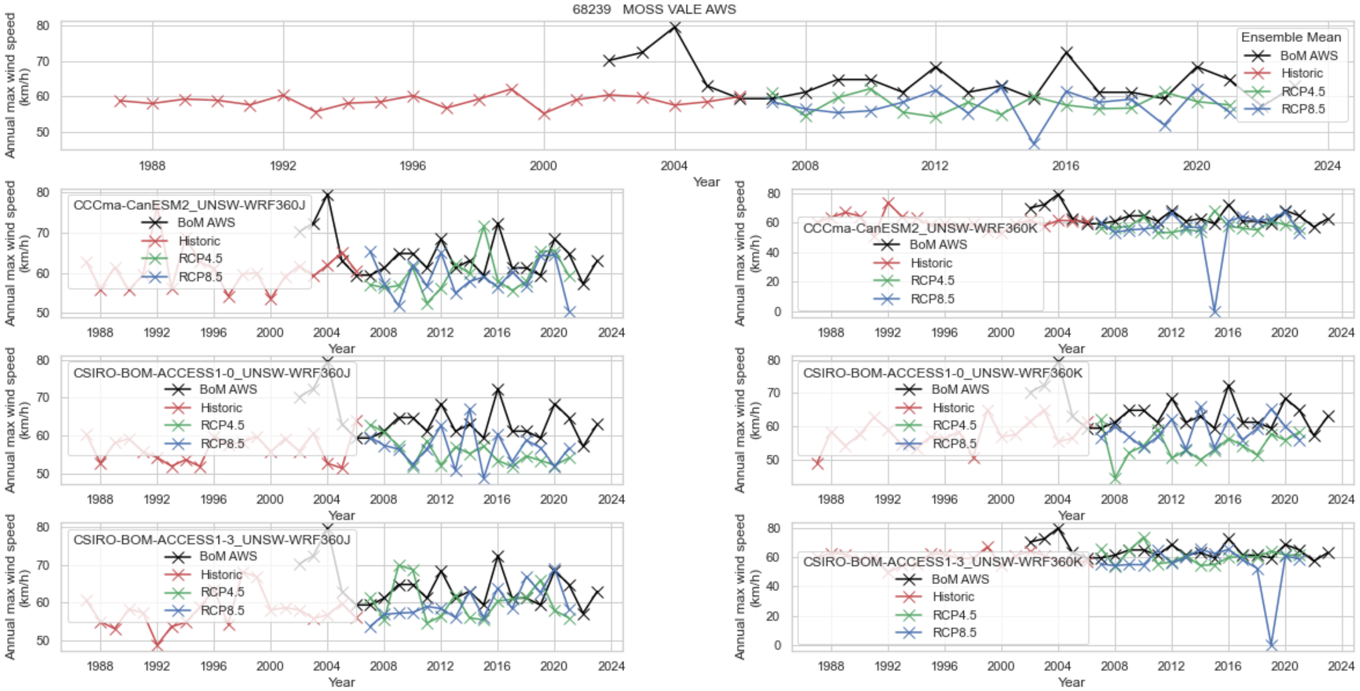
Key Insights from the Validation

- There are systemic biases across the entire Endeavour network area with the NARCliM.5 data having a poor ability to represent the magnitude and temporal variability of the observed extreme wind speeds.
- Time series analysis shows that the climate models do not resolve the influence of small scale processes that are measured at weather stations.
- Outliers exists in both observations and climate models, which can arise from limitations in the data.
- Skill varies between the weather stations which is expected, with coastal stations underestimated and inland stations overestimated.

Caveats and Limitations for Wind Validation

Discrepancies between the climate model estimates and what is observed at individual weather stations are expected. This is due to the difference in what each is measuring, where the estimates from the climate models represent the wind speed conditions averaged across a 50 km by 50 km square area while the weather station observations provide a more precise estimate at a point location.

Weather station observations of wind speed are sensitive to changes in site conditions, including vegetation, built structures, and instrumentation that are not detected at the coarse resolution of the climate models used here. Therefore, the projections presented here provide an indication of changes in extreme wind and it is possible that larger projected changes are possible. To minimise the impacts of systematic biases in the climate model representation of extreme wind conditions, future estimates are presented as the future change (future value minus historical value).



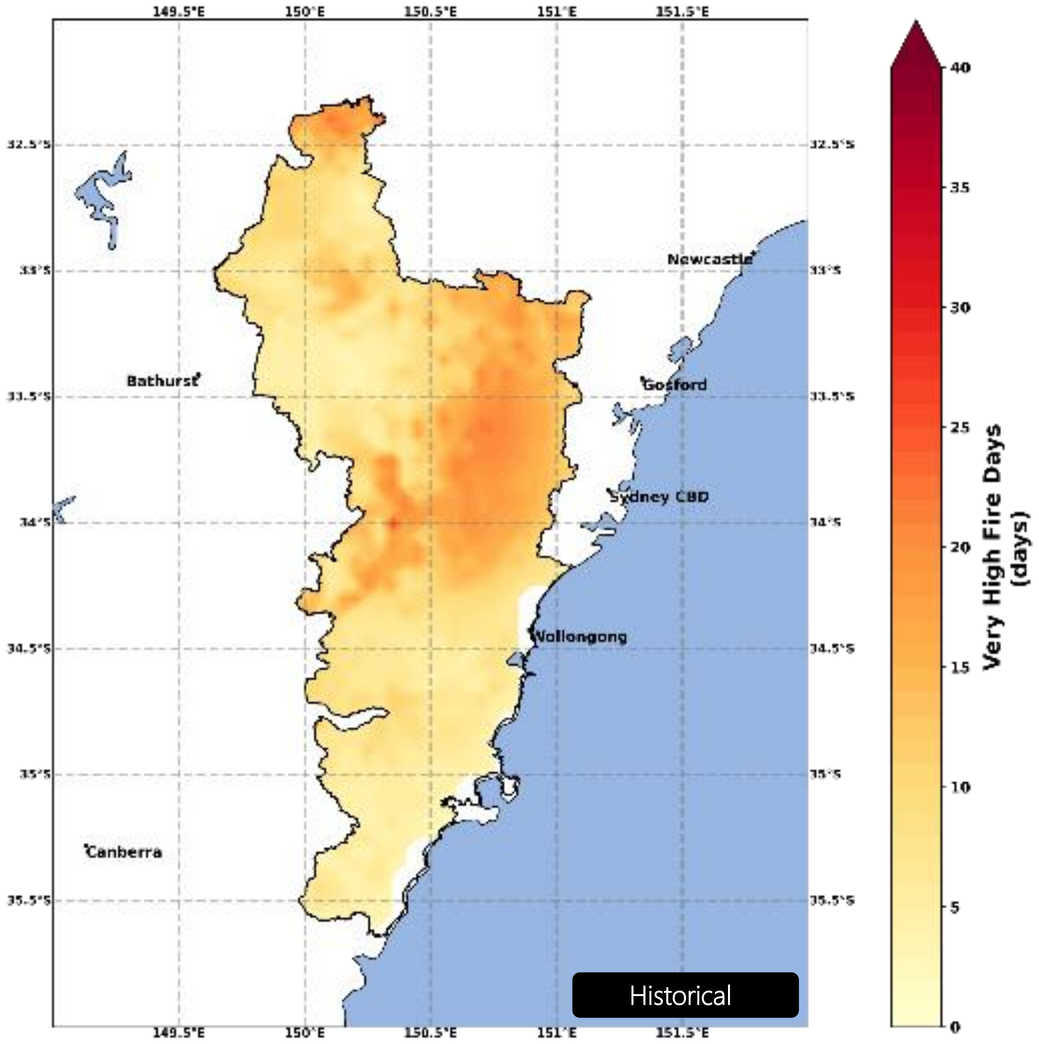
Above: Example graphic illustrating a time series comparison between automatic weather station observations and climate model estimates of annual maximum daily wind speed (km/hr) at the Moss Vale BoM AWS (station number: 068239). The top time series illustrates the ensemble mean, while the rest illustrate the time series of individual climate models. For the climate model estimates the historic period (1986 to 2005) is presented in red, RCP4.5 in green and RCP8.5 in blue, the weather station observations are presented in black.

CSA |Extreme Wind Validation

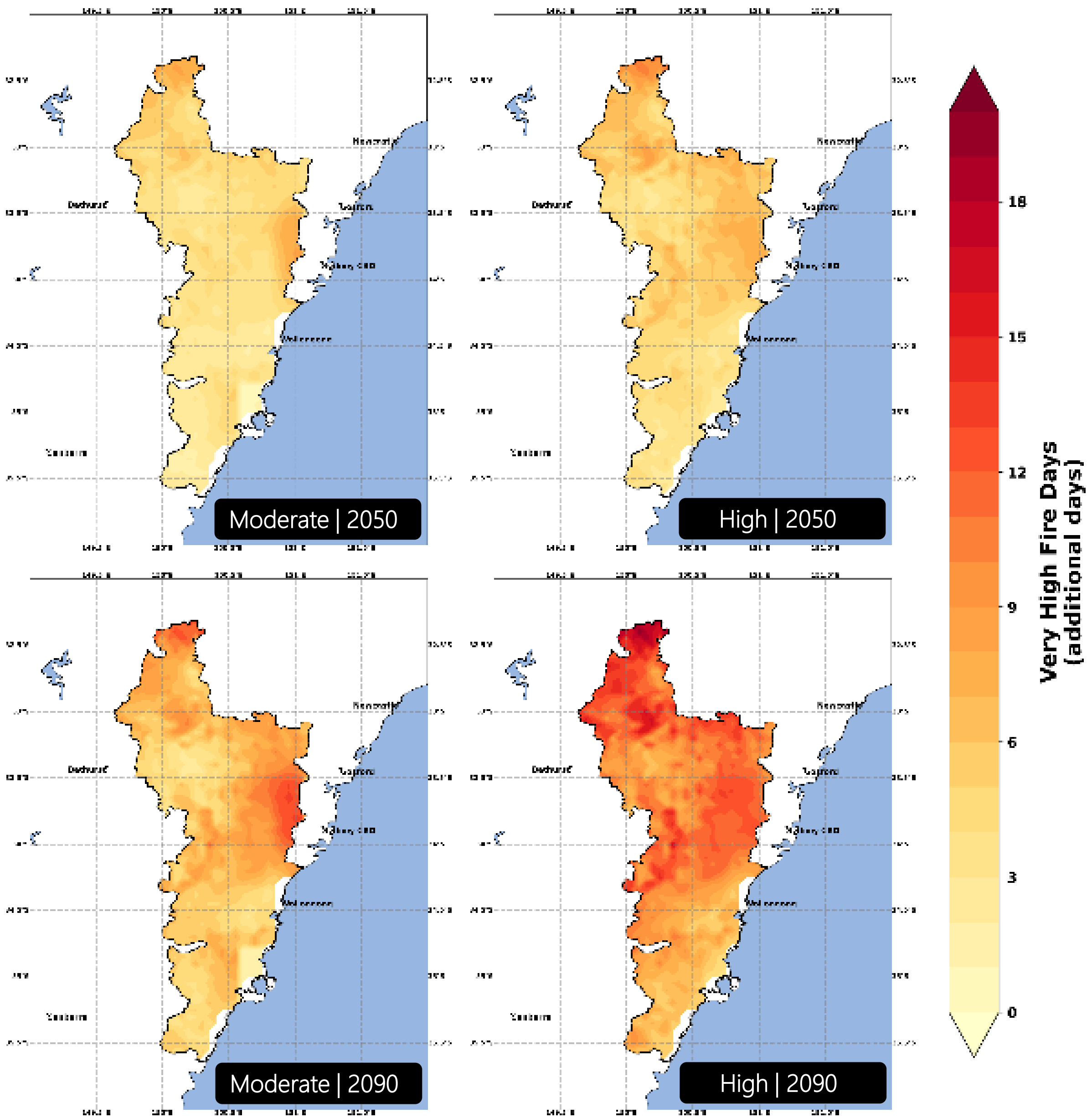
To assess climate model skill in characterising extreme wind, half-hourly wind gust observations measured at automatic weather stations [maintained by the Bureau of Meteorology]are compared to climate model data extracted from the grid cells closest to each weather station. Observations are aggregated to a daily maximum value with comparisons over the 2000 to 2020 period to enable the maximum overlap between datasets. Validation assessments examined the ability of each model to characterise observational estimates for each weather station. Key features are noted in the table below for an excerpt of the weather stations assessed.

Station Number	Weather Station Name	Systematic Bias *Describes whether the climate models over- or underestimate the magnitude of extreme wind speed*	Temporal Variability *Describes the representation of year-to-year variability by the climate models compared to the observations*	Additional Comments
068239	Moss Vale	Underestimates	Reasonable	RCP8.5 represents the historical temporal variability better
063308	Marrangaroo	Underestimates	Poor	2 of 6 climate models do a reasonable job of representing the temporal variability.
068263	Holsworth Defence	Overestimates	Poor	2 of 6 climate models do a reasonable job of representing the temporal variability.
068241	Albion Park (Shellharbour Airport)	Underestimates	Reasonable	3 of 6 climate models do a reasonable job of representing the temporal variability.
069138	Ulladulla	Underestimates magnitude of extreme wind speed from 1986 to 2005, overestimates from 2006 to 2020.	Poor	All climate models represents parts of the temporal variability well and other parts poorly. The result is that the ensemble mean provides a poor representation.
068253	Port Kembla	Underestimates	Reasonable	RCP8.5 represents the temporal variability better
068242	Kiama (Bombo Headland)	Underestimates	Poor	1 of 6 climate models do a reasonable job of representing the temporal variability.
068192	Camden Airport	Generally overestimate extreme wind speed, but doesn’t match the magnitude of the highest observed events.	Poor	RCP4.5 represents the temporal variability better
067119	Horsley Park Equestrian Centre	Generally overestimates, but matches the highest observed events	Poor	2 of 6 climate models do a reasonable job of representing the temporal variability.
067113	Penrith Lakes	Reasonable	Reasonable	RCP4.5 represents the temporal variability better
067108	Badgerys Creek	Underestimates	Reasonable	RCP8.5 represents the temporal variability better
063292	Mount Boyce	Underestimates	Reasonable	Both RCP4.5 & RCP8.5 represents the temporal variability reasonably
062100	Nullo Mountain	Generally overestimates extreme wind speed	Reasonable	Both RCP4.5 & RCP8.5 represent the temporal variability reasonably

CSA | Bushfire

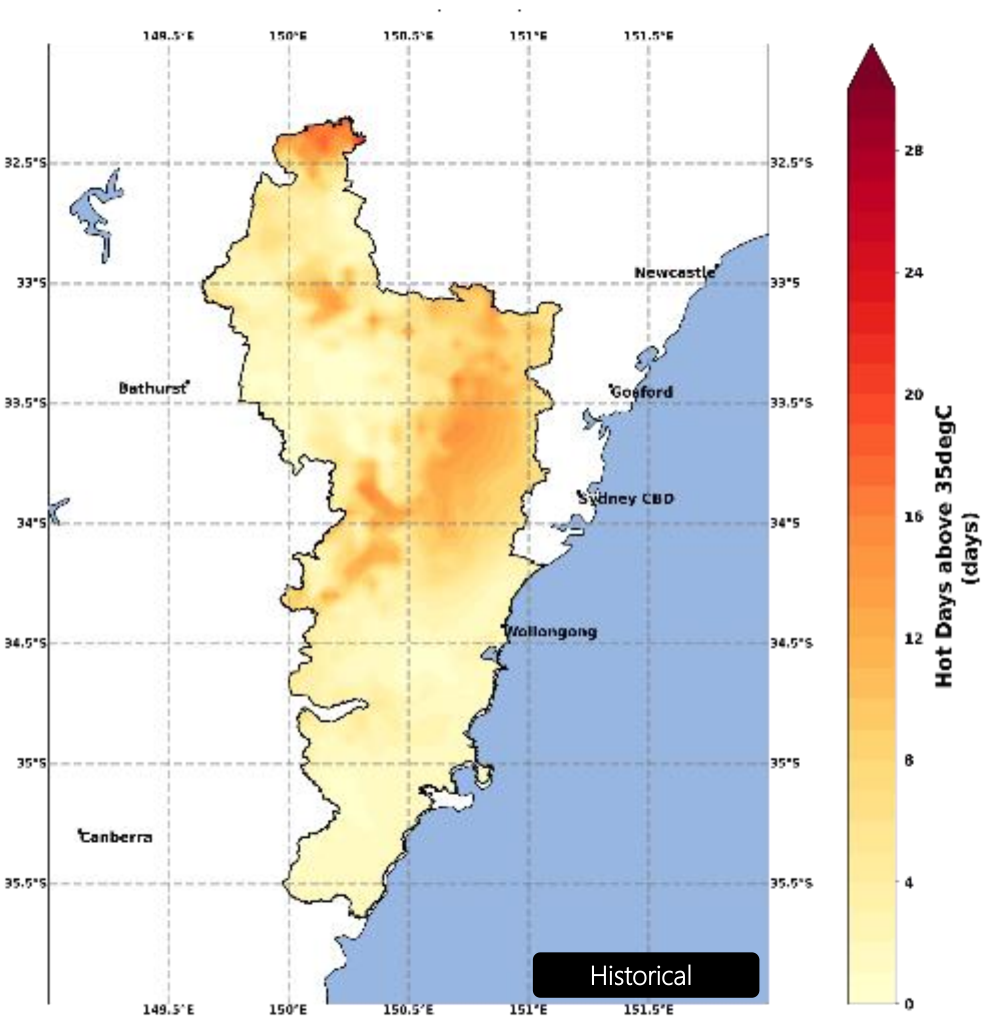


Above: Number of days with very high bushfire weather conditions for the historical period (1986-2005).

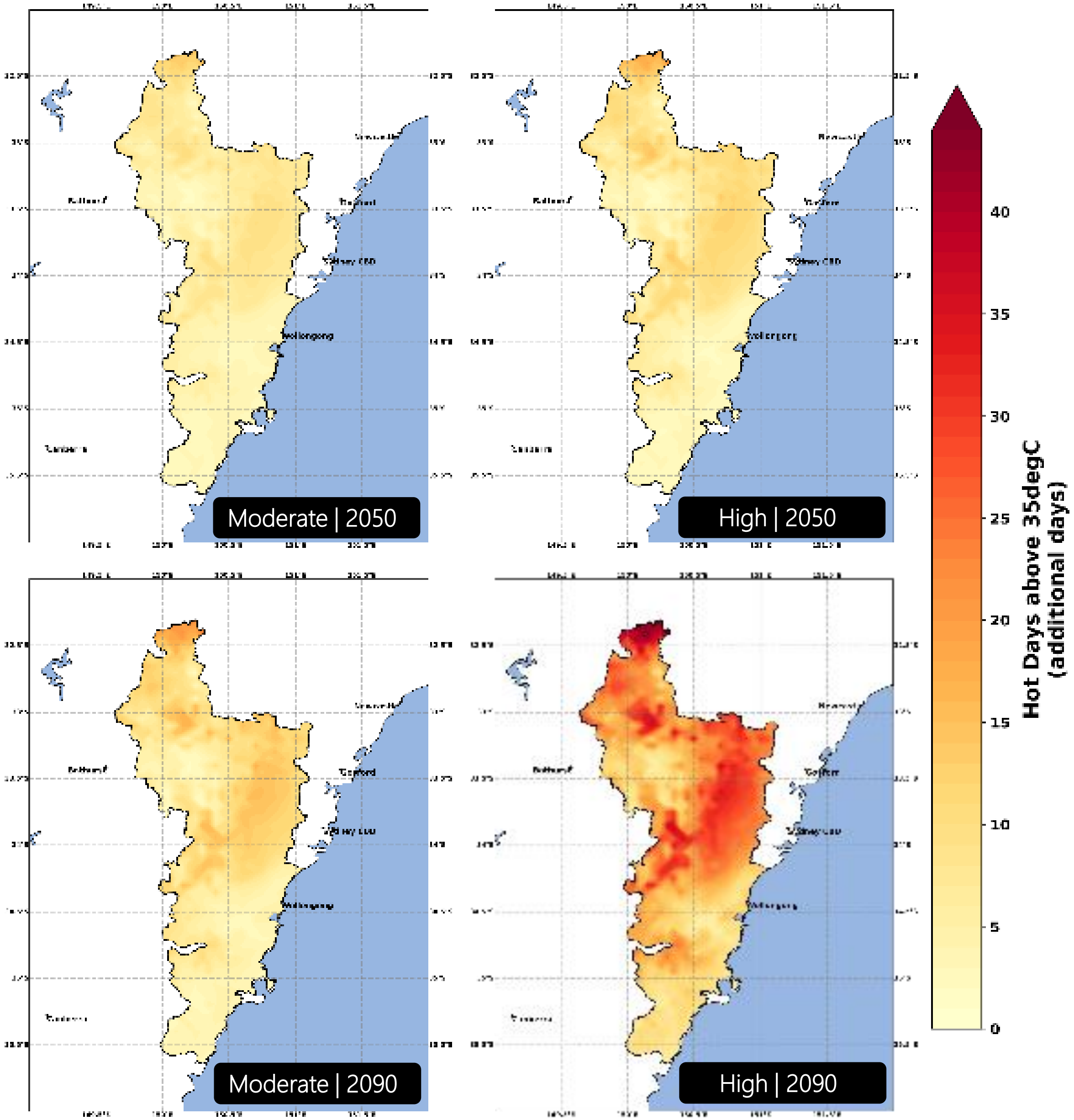


Above: Additional days with very high bushfire weather conditions by 2050 (top) and 2090 (bottom) under moderate (left) and high (right) emissions scenarios compared to (1986-2005).

CSA | Extreme Heat

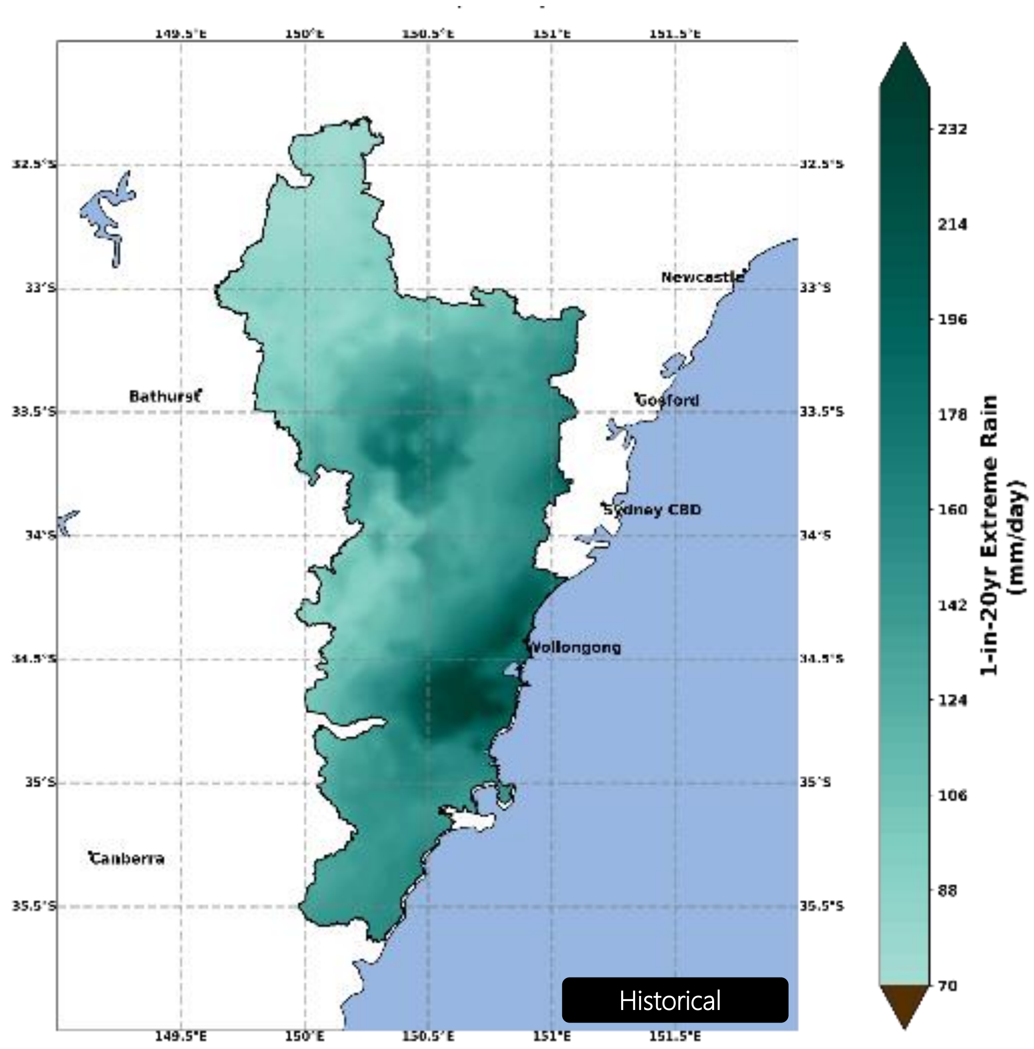


Above: Number of hot days over 35°C for the historical period (1986-2005).

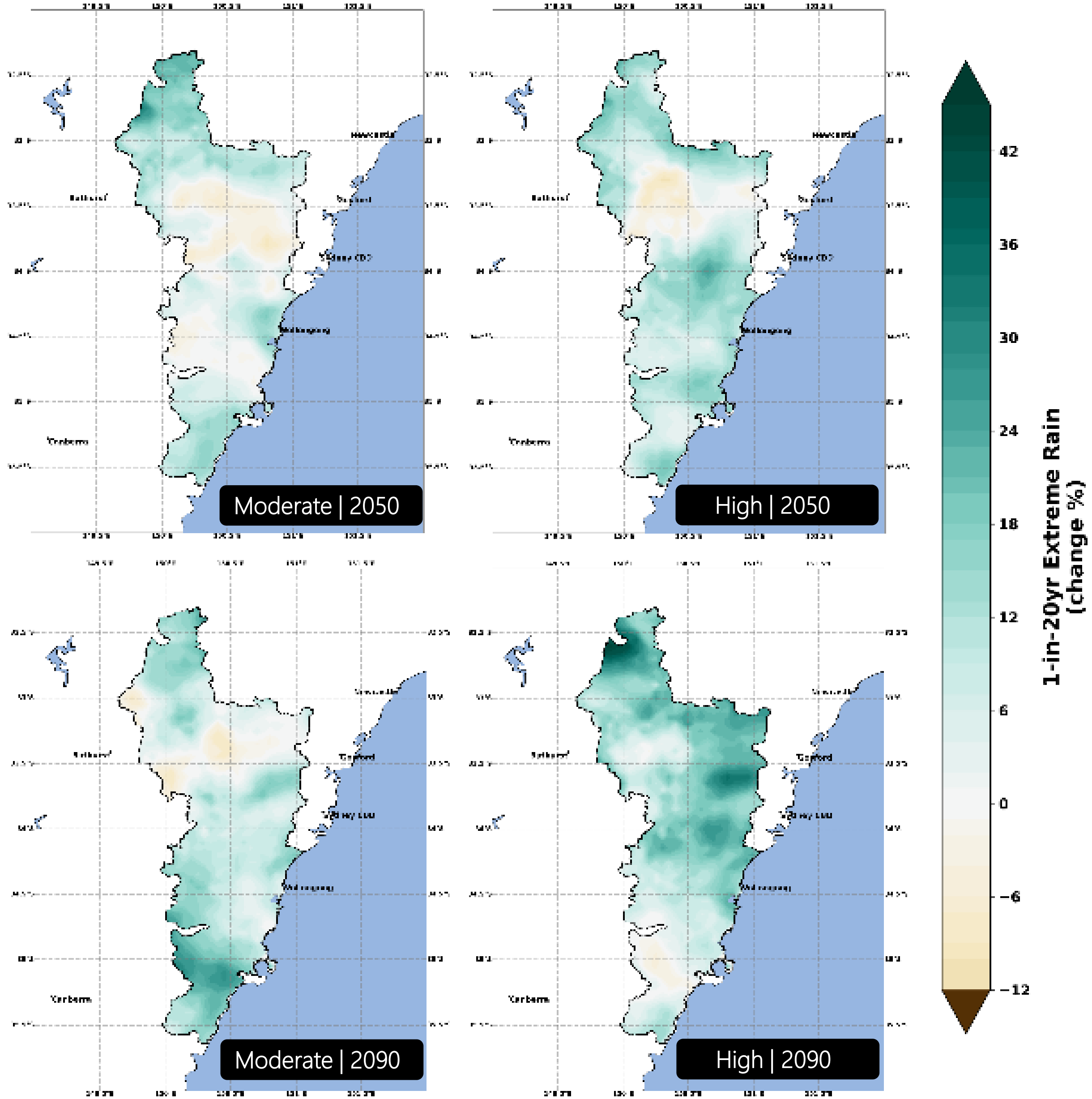


Above: Additional hot days over 35°C by 2050 (top) and 2090 (bottom) under moderate (left) and high (right) emissions scenarios compared to (1986-2005).

CSA | Flood

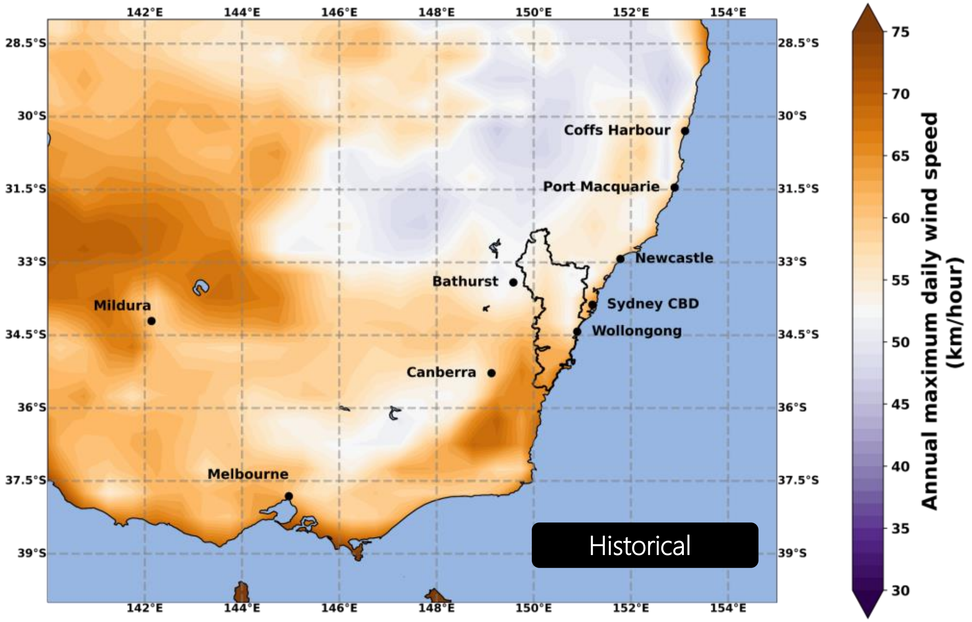


Above: The 1-in-20yr wettest day rainfall (mm/day) for the historical period (1986-2005).

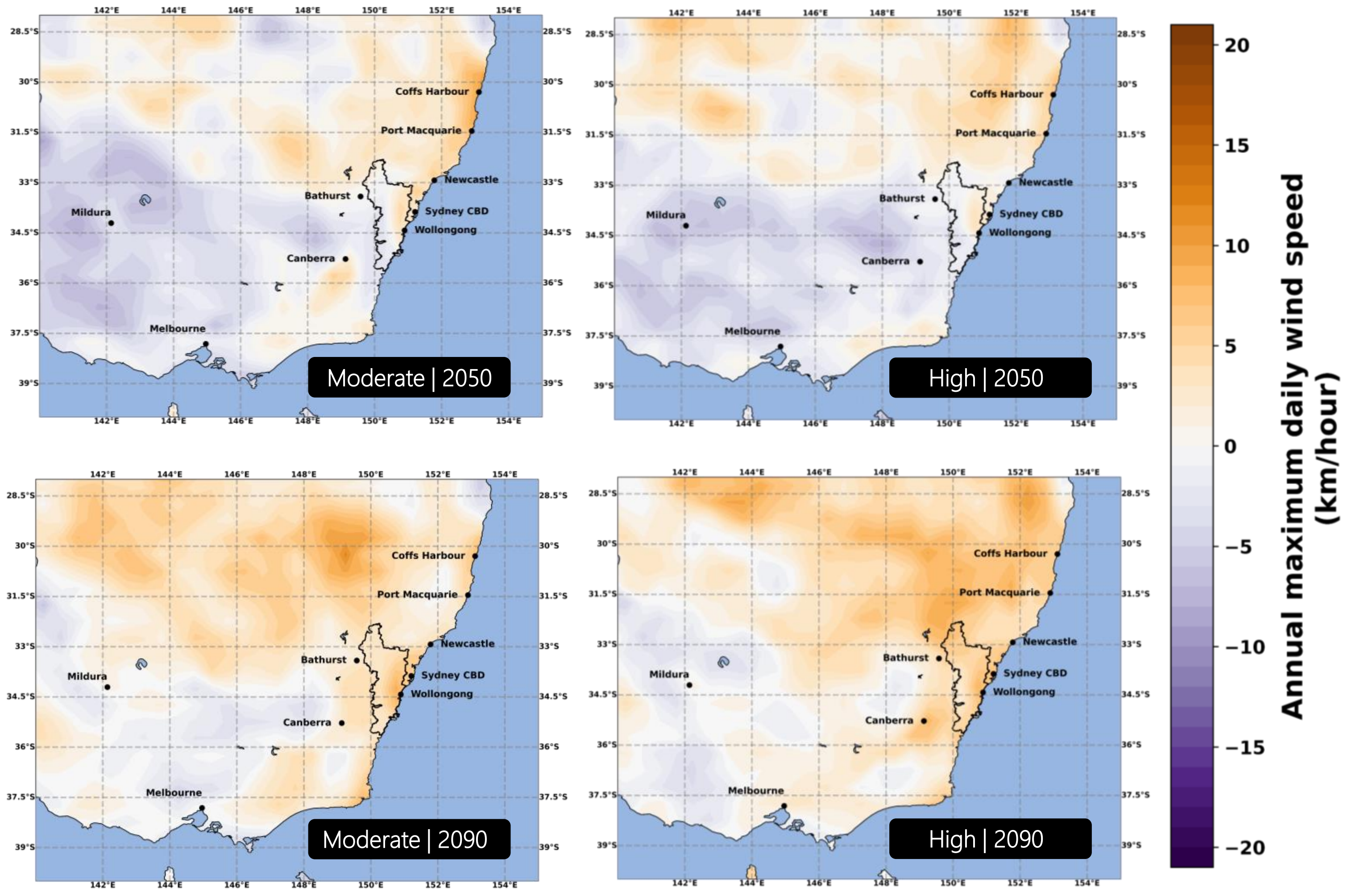


Above: Projected change in the 1-in-20yr wettest day rainfall (mm/day) by 2050 (top) and 2090 (bottom) under moderate (left) and high (right) emissions scenarios compared to (1986-2005).

CSA | Extreme Wind Intensity



Above: The annual maximum daily wind speed (km/hour) for the historical period (1986-2005).



Above: Projected change in the annual maximum daily wind speed (km/hour) by 2050 (top) and 2090 (bottom) under moderate (left) and high (right) emissions scenarios compared to (1986-2005).

Appendix B: Physical Climate Risks

Physical Climate Risks (bushfire)

Physical Risk	Risk Description	Potential Impact
Bushfire	BF1 – **Timber poles** are damaged by bushfires due to direct contact or residual heat and ashes	• Network supply interruption • Asset damage
	BF2 - **Concrete poles** are exposed to bush fires and require replacement due to cracking	• Network supply interruption • Asset damage
	BF3 - **Steel poles** exposed to fire lose strength	• Network supply interruption • Asset damage
	BF4 - **Transmission pole/tower** is exposed to fire damage, due to direct contact or residual heat and ashes	• Network supply interruption • Asset damage
	BF5 - **Conductors (bare mains, covered mains, comms, services covered)** are exposed to fire and extreme heat resulting in damage, causing outages	• Reduction in useful life due to reduced tension and corrosion performance • Asset replacement • Network supply interruptions
	BF6 - **Pillars** are exposed to fire and extreme heat resulting in internal components being damaged, impairing the local network	• Network interruption (small scale) • Asset damage and maintenance
	BF7 – **Zone substation** assets can be affected by embers, accumulation of dust, and ash which can affect the substation performance and require maintenance	• Network interruptions (large scale) • Asset damage • Additional maintenance on substation due to ash and soot impact
	BF8 - Smoke inhalation of network crew and subcontractors undertaking repair and maintenance works	• Health impact on employees • Loss of productivity
	BF9 – **Switch** control equipment impaired due to direct contact with bushfires or residual heat and ashes	• Damage can occur to control equipment if mounting height is lower • Asset replacement if pole failure occurs
	BF10 – Increased risk of **network fire starts** which would flow into greater insurance costs	• Asset damage • Damage to public perception • Network supply interruption • Litigation and insurance costs

Physical Climate Risks (extreme heat)

Physical Risk	Risk Description	Potential Impact
Extreme Heat	EH1 - Increased failure rate of **conductors** due to increased demand	• Network supply interruption • Asset damage
	EH2- Increase in heat stress on network crew and subcontractors undertaking repair and maintenance work.	• Loss of productivity • Health impact on workers
	EH3 - Inadequate current **substation, conductor** and **switch** design specifications to cater to increased temperatures, especially during periods of extended extreme heat	• Accelerate asset degradation, reducing asset useful life
	EH4 - Increase in **overhead conductor** sag due to increased temperatures	• Network supply interruption • Overline sag below minimum electrical clearance
	EH5 – Increased failure rates on hot days **from low voltage fixtures** failing	• Network Supply interruption • Loss of productivity • Asset damage
	EH6 – Increased staff down time due to change in regulator requirements for working conditions	• Loss of productivity (delay in critical work) • Opportunity cost associated with salary of contracted staff
	EH7 – Decrease in reliability of network when extreme heat persists for at least 3 consecutive days	• Network supply interruption • Asset damage

Physical Climate Risks (flood)

Physical Risk	Risk Description	Potential Impact
Flood	FL1 –**Pillars, columns** and **zone and pad mount substation** equipment and protection is damaged due to flooding	• Network supply interruption • Asset damage
	FL2 - **Poles** are damaged due to vegetation making contact with the pole during a flood. This also impacts related **pole mounted substations**.	• Network supply interruption • Asset damage
	FL3 – **Timber, concrete, steel and composite poles** are destabilised due to expansion and contraction of soil. This also impacts related **pole mounted substations**.	• Network supply interruption • Asset damage
	FL4 - Increased moisture in the soil, termites and fungus leading to increased **timber pole** failure	• Reduced asset useful life • Asset damage
	FL5 – Extreme rain results in water damage to overhead **conductors** and/or loss of electricity supply	• Network supply interruption • Asset damage
	FL6 – **aLBS**, **Recloser** and **Regulator** switch boxes fail due to flooding	• Network supply interruption • Asset damage
	FL7 – **Reconnection costs** after flooding event for customers	• Network supply interruption
	FL8 – Communication systems impacted due to flooding resulting in lost visibility across control and monitoring systems	• Network supply interruptions • Asset damage
	FL9 – Forced staff and contractor down time due to Endeavour sites being inaccessible	• Network supply interruption • Loss of productivity

Physical Climate Risks (storm surge)

Physical Risk	Risk Description	Potential Impact
Storm Surge	SS1 - Coastal Inundation results in damage to **padmount** and **zone substation** equipment and protection.	• Network supply interruption • Asset damage
	SS2 - Coastal Inundation damages **pillars** resulting in loss of power supply to customers	• Network supply interruption • Asset damage
	SS3 - **Timber, Steel, Concrete and Transmission Poles** are destabilised due to changes in soil integrity. This also impacts related **pole mounted substations** and **switches.**	• Network supply interruption • Asset damage
	SS4 - Increased moisture in the soil, termites and fungus leading to increased **timber pole** failure	• Reduced asset useful life • Asset damage
	SS5 – Coastal inundation of **overhead conductors** resulting in water damage to asset and/or loss of electricity supply	• Network supply interruption • Asset damage
	SS6 – Coastal erosion caused by storm surge damages and exposes assets in low-lying coastal areas	• Network supply interruption • Asset damage
	SS7 – Corrosion of **steel poles** due to sea salt from encroaching oceans.	• Asset damage

Physical Climate Risks (windstorm)

Physical Risk	Risk Description	Potential Impact
Windstorm	W1 - Increased wind causing vegetation to collide with **timber, steel and concrete poles, conductors** and **zone substations** resulting in a loss of power. This would also impact any related **pole mounted substations** and **switches.**	• Network supply interruption • Asset damage
	W2 - Increased wind causing **timber poles** and **overhead lines** to be brought down. This would also impact any related **pole mounted substations** and **switches**.	• Network supply interruption • Asset damage
	W3 – Increased wind causes the **transmission tower** to overload	• Network supply interruption • Asset damage
	W4 – Increased winds causes vegetation to collide with **bare, communication mains covered and services covered conductors,** as well as phase-to-phase clashing **(bare main conductors)** and circuit-to-circuit clashing **(all conductors)**	• Network supply interruption • Asset damage

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