CLIMATE SCALE

Climate risks assessments for wind and solar assets: challenges and way forward

Ana López

ana.lopez@climatescale.com

Conferencia Eólica Chile

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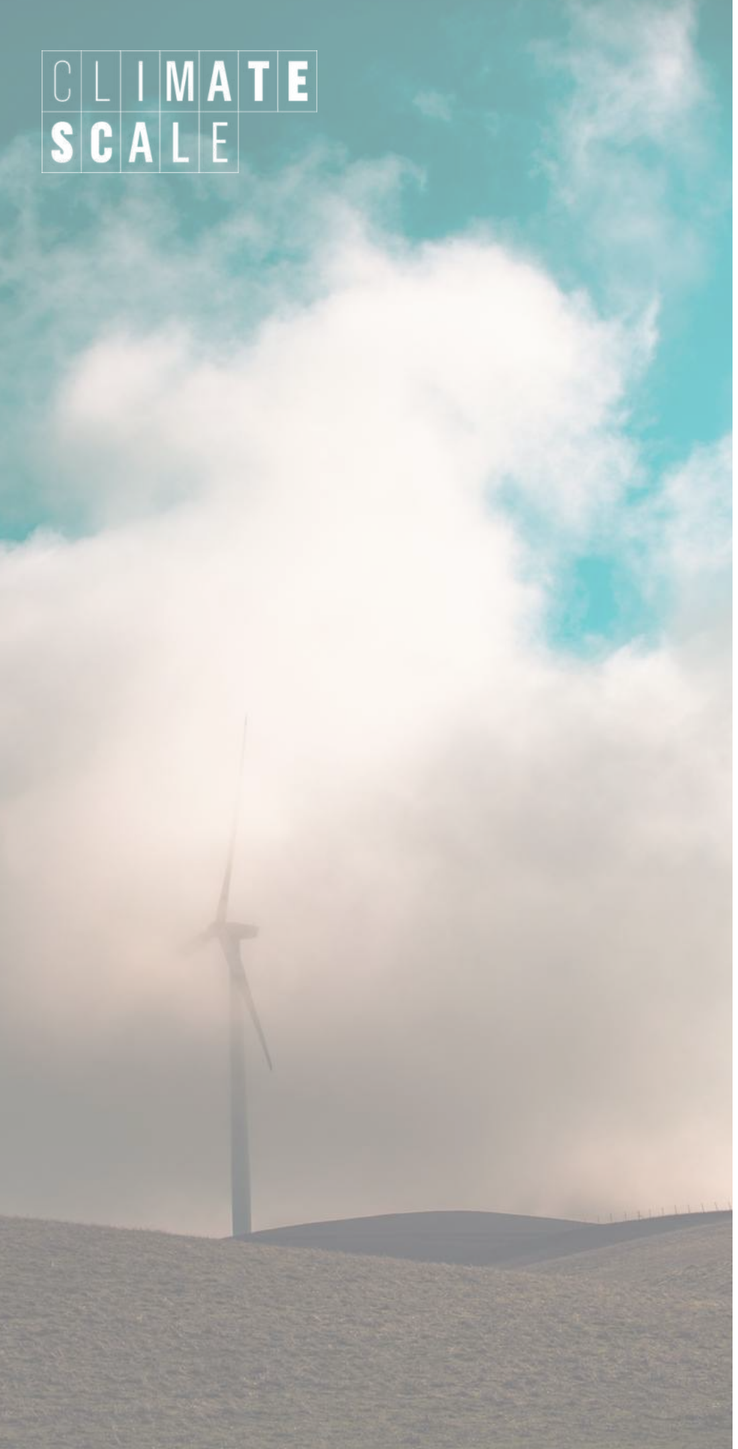


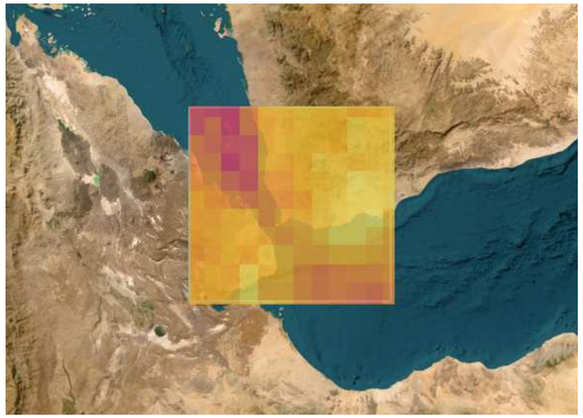
Outline

- About Climate Scale
- Mapping Climate Risks
- Examples
  - A Simple Use Case
  - Mapping Climate Risks for Chile - Wind Speed Changes
- Climate change risks assessment
  - Approach
  - Translating Climate Risk into Financial Impacts

About Climate Scale

Asset Managers & Wind Analysts

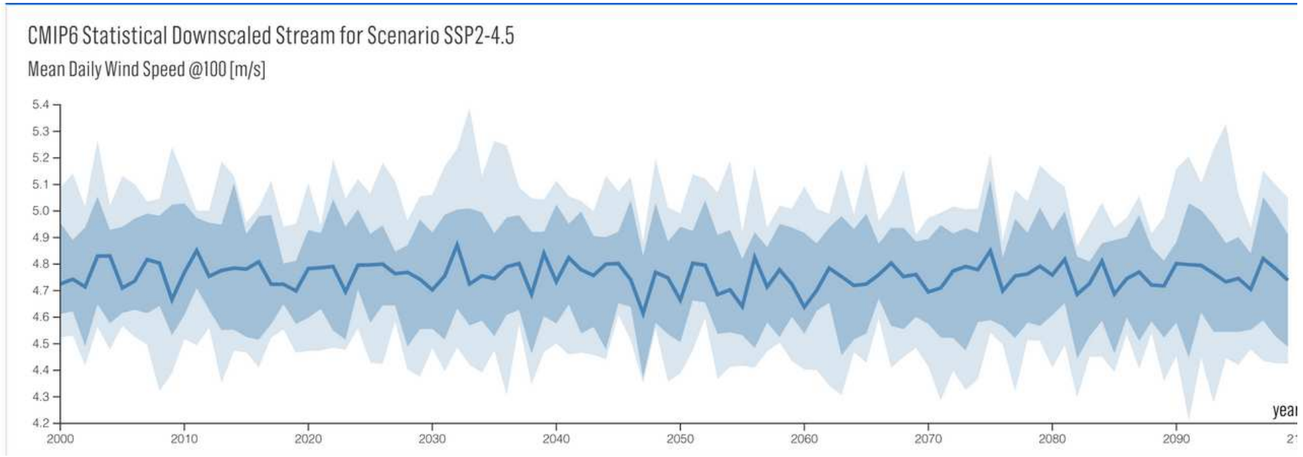
Deploy specialised risk analysis for Renewable Energy Technologies and build in climate resilience for climate proofing assets.



Sustainability Teams

Fulfil your Reporting financial implications of climate change for investors and meet sustainability requirements

#EUTaxonomy #TCFD #ESRS #IFRS #CSRD ...



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Why Climate Risks

nature

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nature > world view > article

WORLD VIEW | 19 March 2024

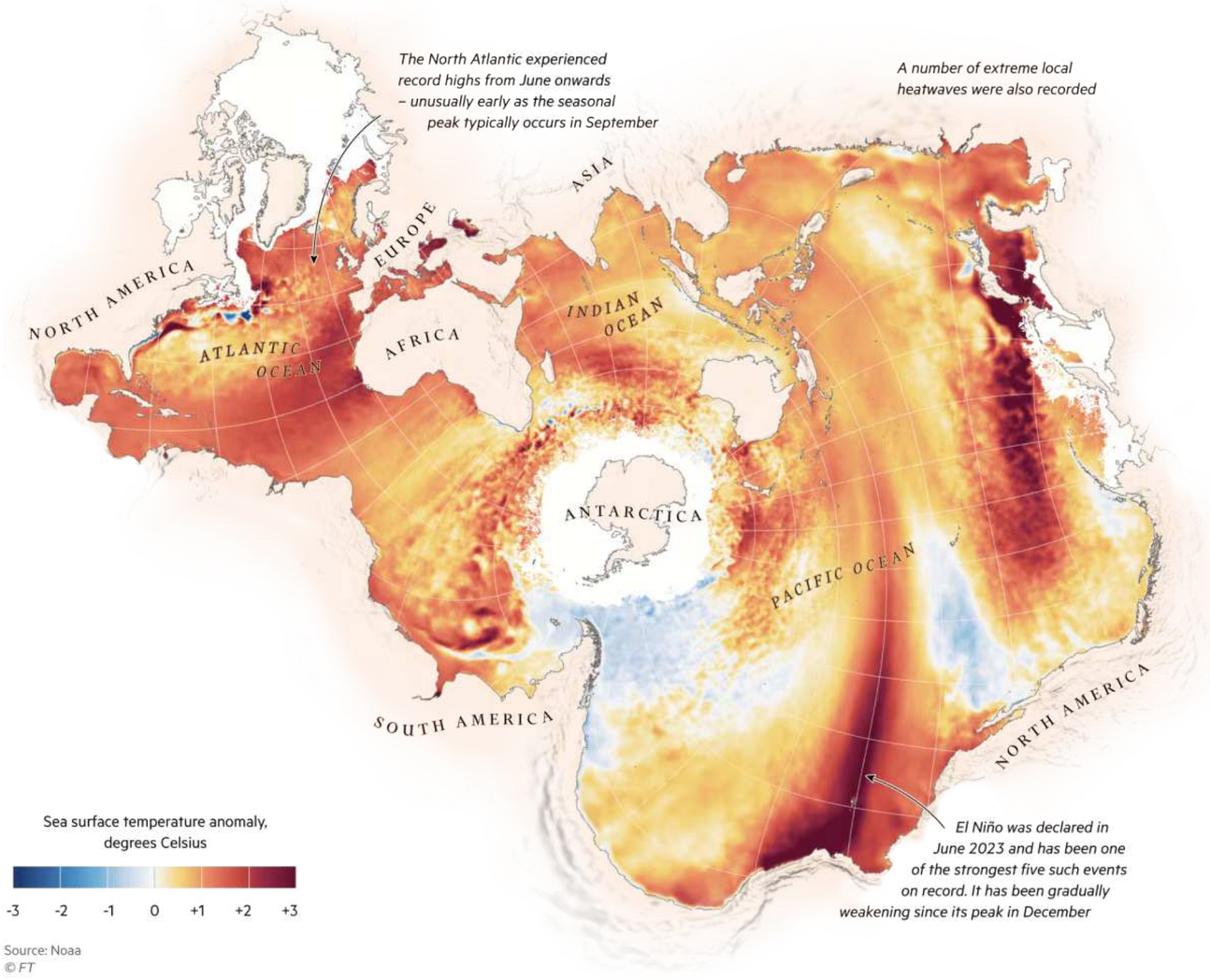
Climate models can't explain 2023's huge heat anomaly — we could be in uncharted territory

Taking into account all known factors, the planet warmed 0.2 °C more last year than climate scientists expected. More and better data are urgently needed.

By Gavin Schmidt

Exceptional ocean heat across the globe

Sea surface temperatures for March 2023-February 2024, compared with long-term average



Source: Noaa

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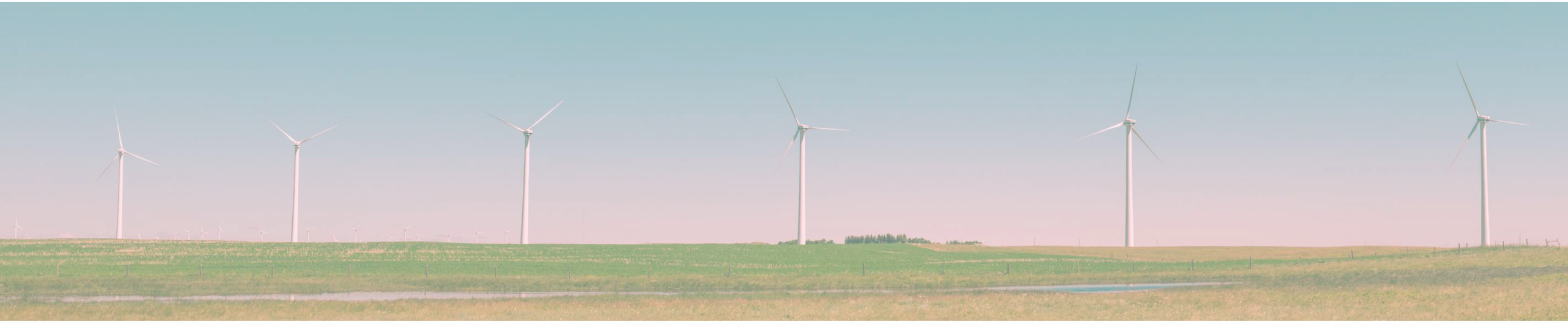
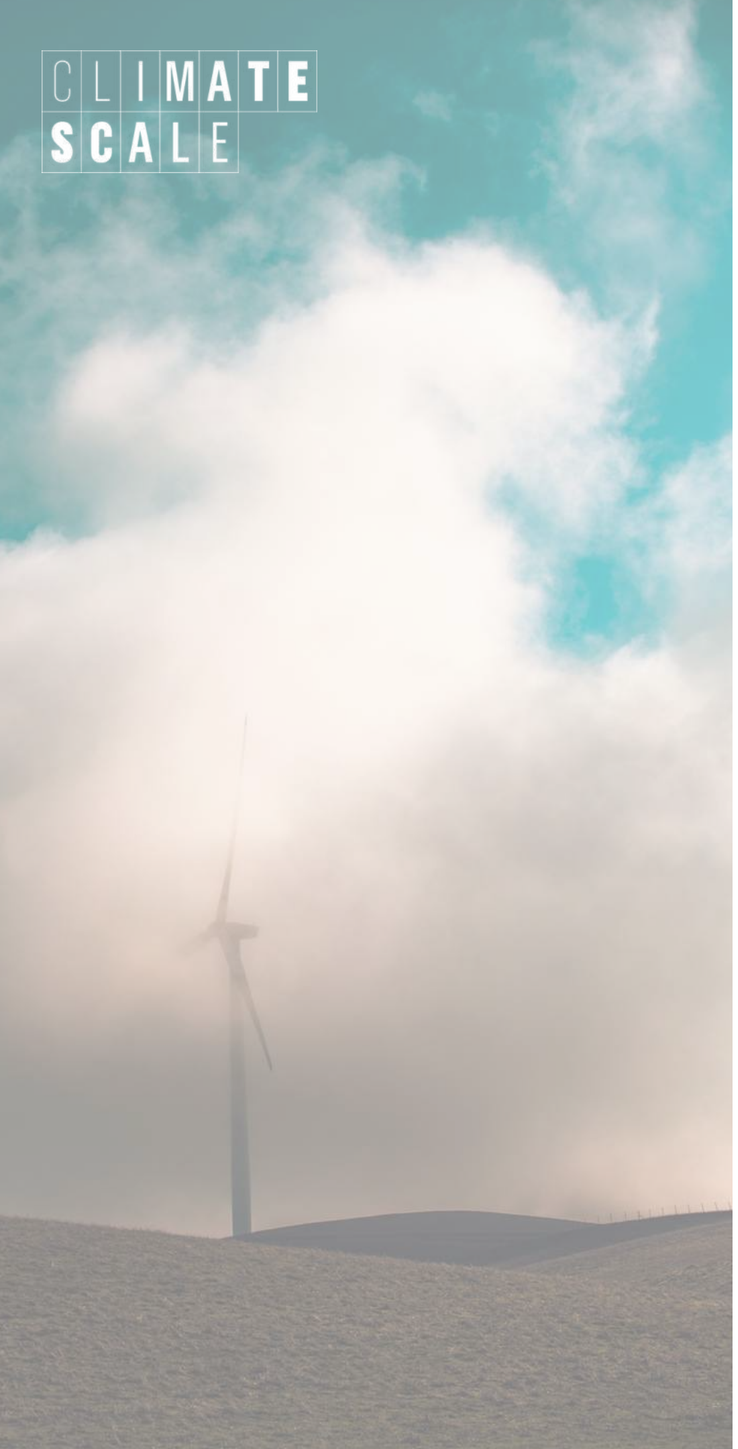
Why climate risks analysis for wind and solar assets?

- To be prepared, by managing the potential climate risks affecting assets and operations.
- To meet reporting regulations and respond to investors' requests about the financial implications of climate change.

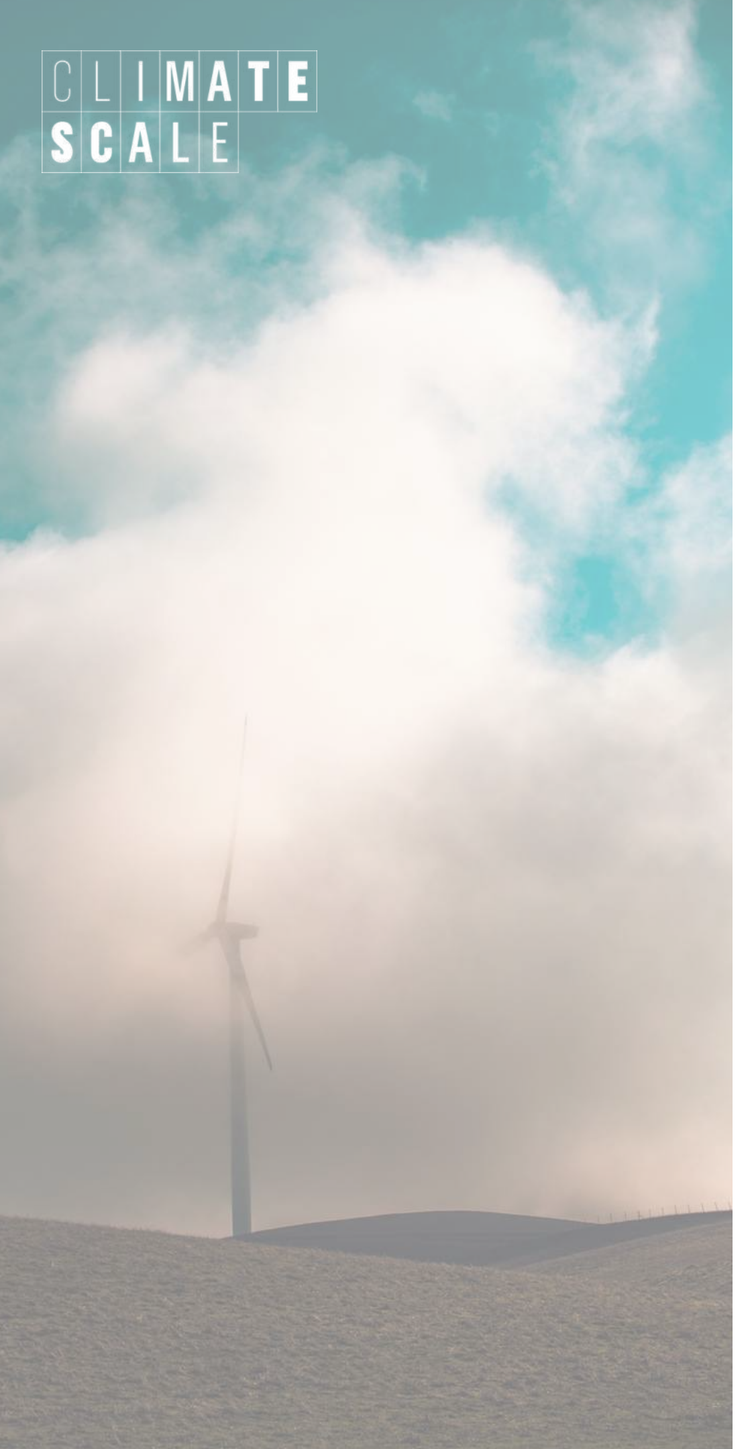




Mapping Climate Risks

Climate Physical Risks for any asset

Any Infrastructure



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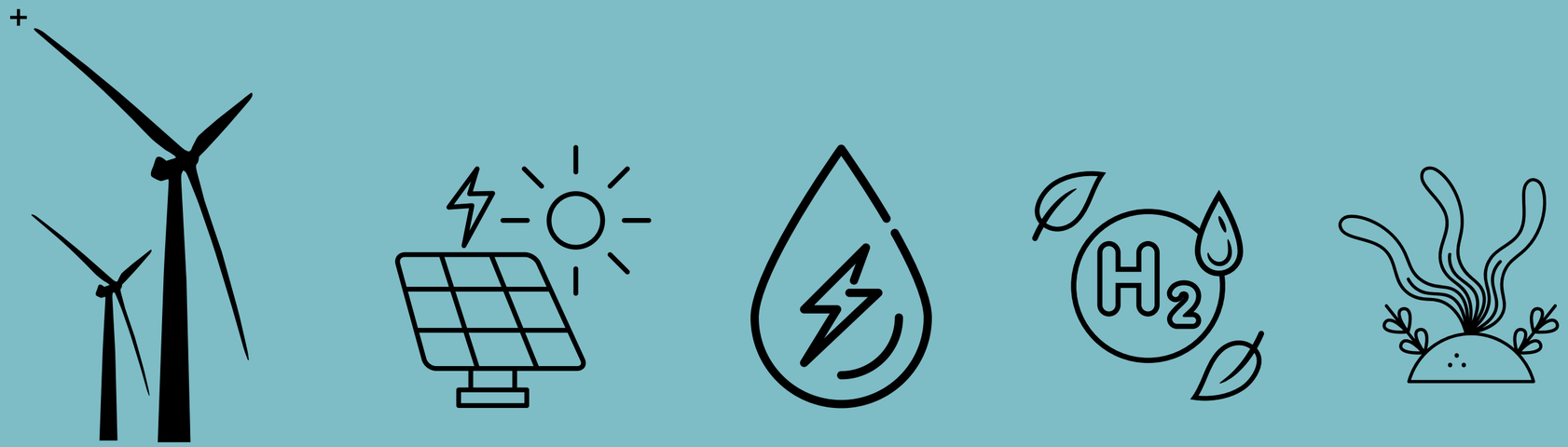
Technology Specific



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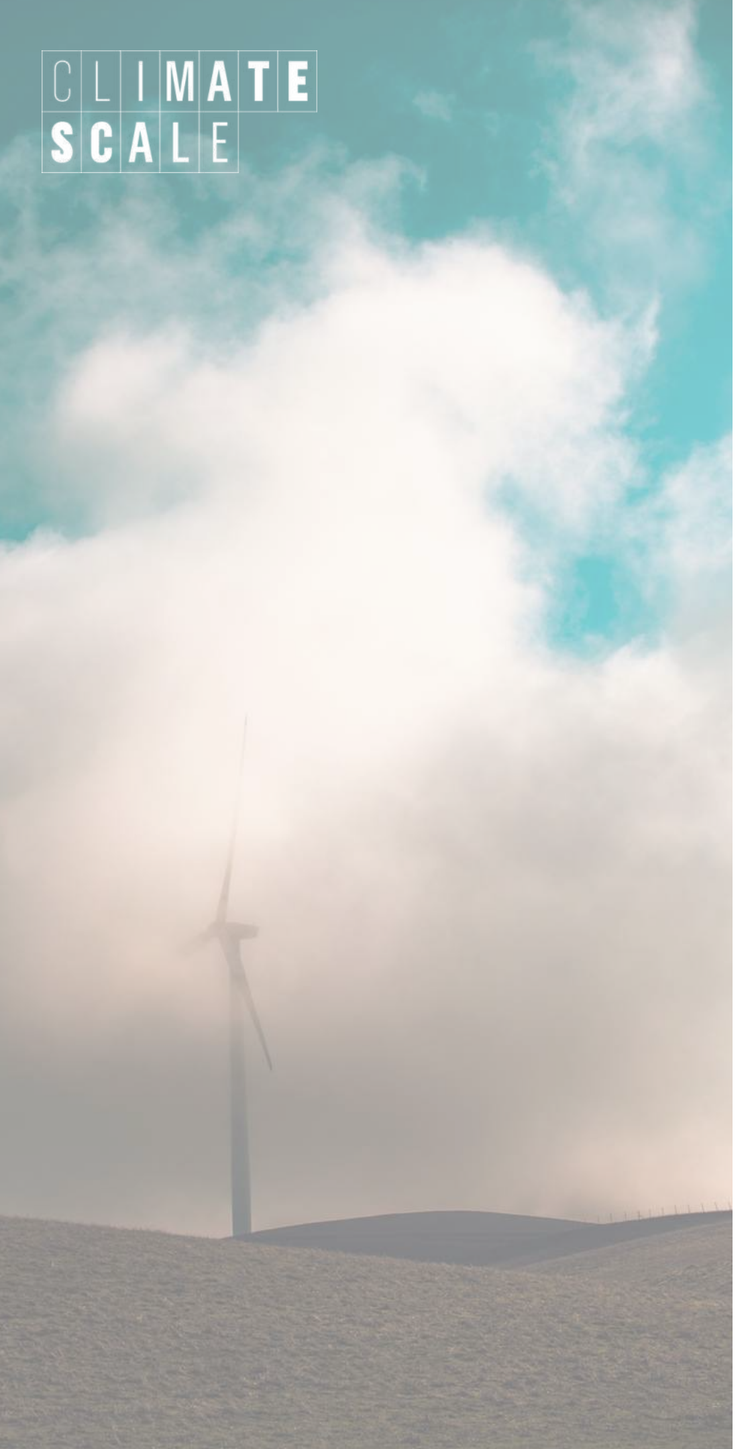

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Mapping Climate Risks

Climate Physical Risks for the Energy Sector

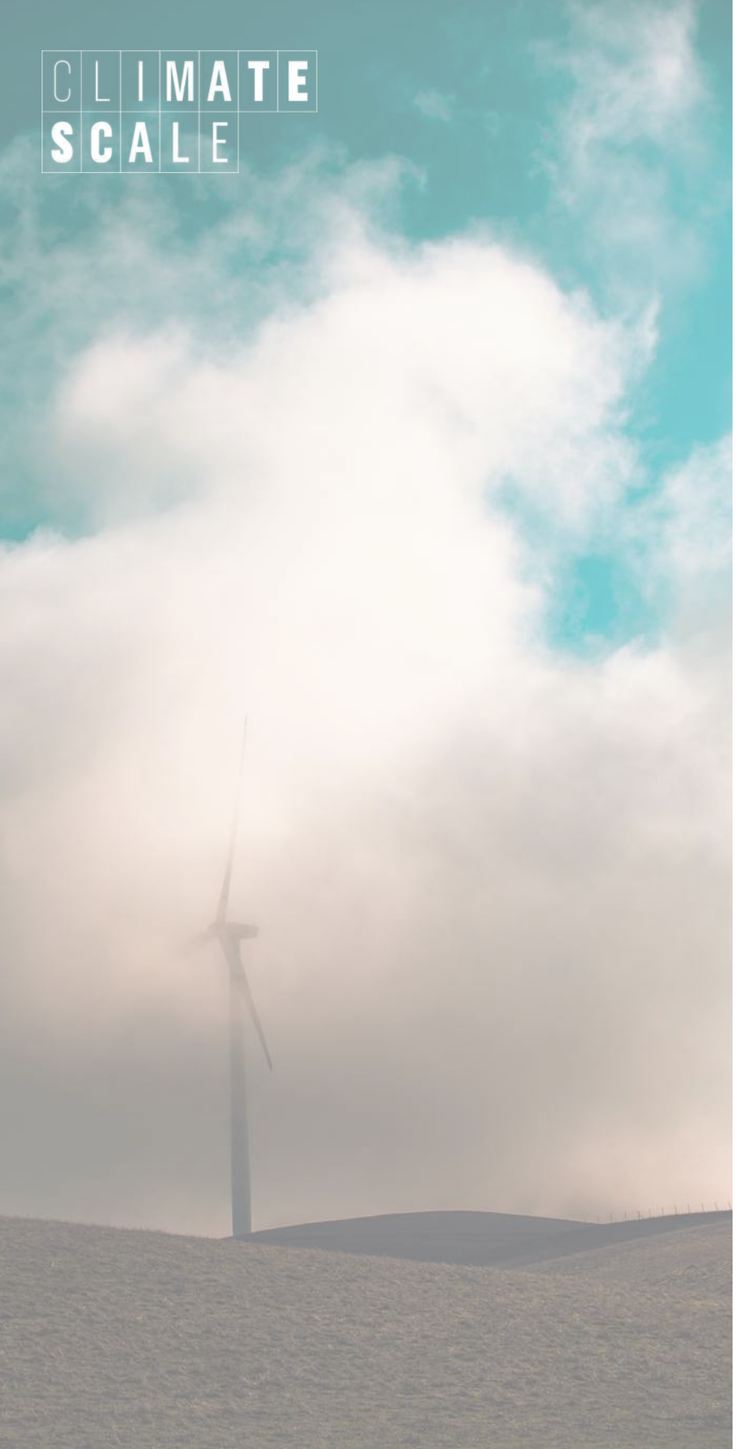
Any Infrastructure

Technology Specific

+ Focus on impacts on revenue, operation and design of a windfarm project

For Example:

- Changes in long-term average Winds speed
- Changes on extreme Wind speeds
- Extreme heat and Power Curve Derating due to peak temperatures
- Extreme precipitation
- Changes on Waves conditions (averages and extremes)



CLIMATE SCALE

Mapping Climate Risks

Climate Physical Risks for the Energy Sector

Any Infrastructure

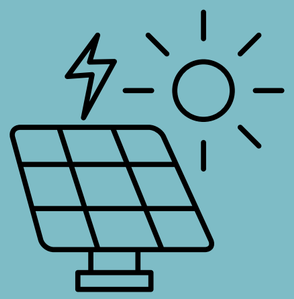
We provide localised data for more than 30 climate hazards

Technology Specific

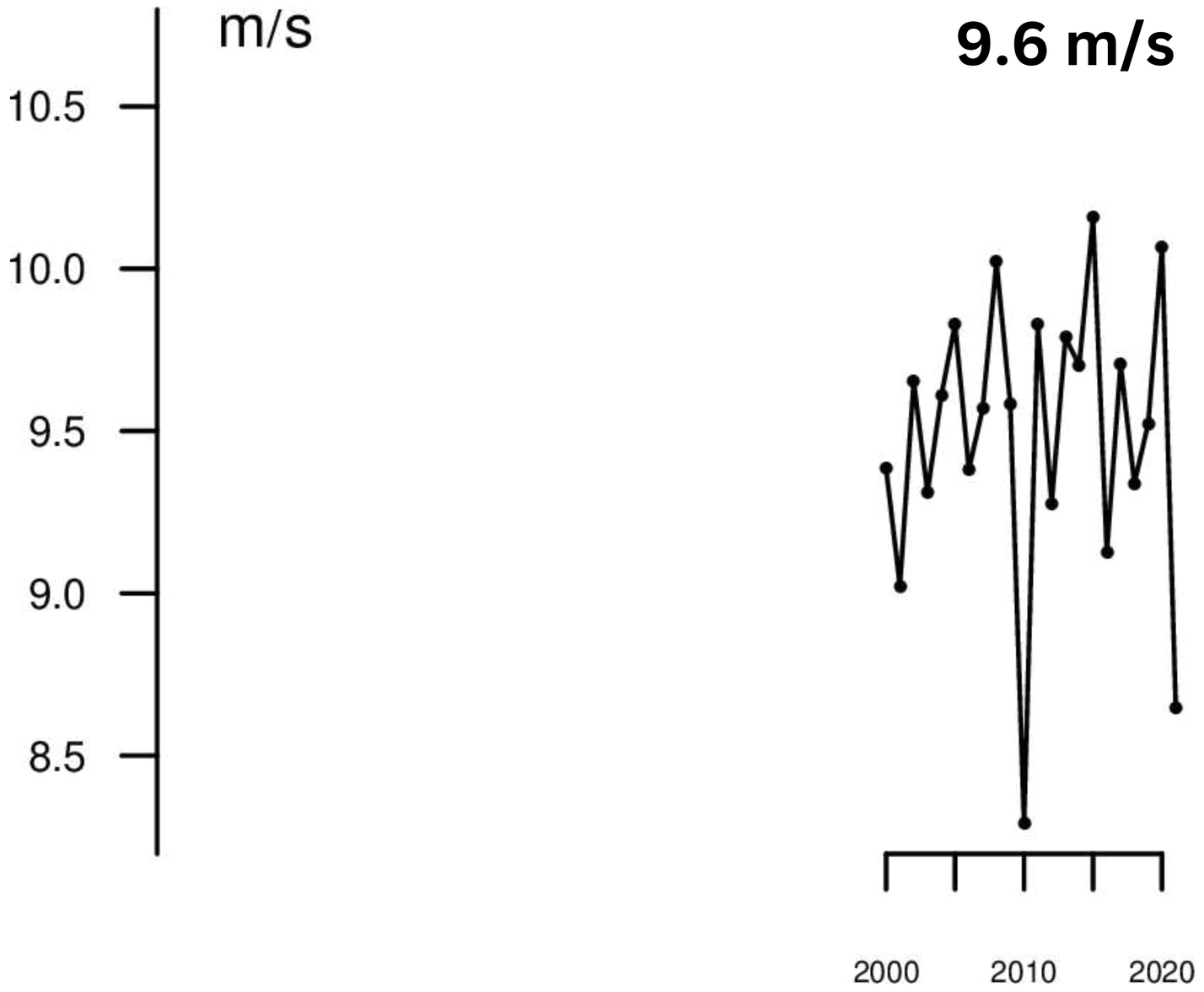
+ Focus on impacts on revenue, operation and design of a solar plant

For Example:

- Changes in long-term average in solar irradiances (GHI,DHI)
- Increases in temperature
- Decreases in wind speeds , extreme winds
- Droughts
- Hail



Use Case



9.6 m/s

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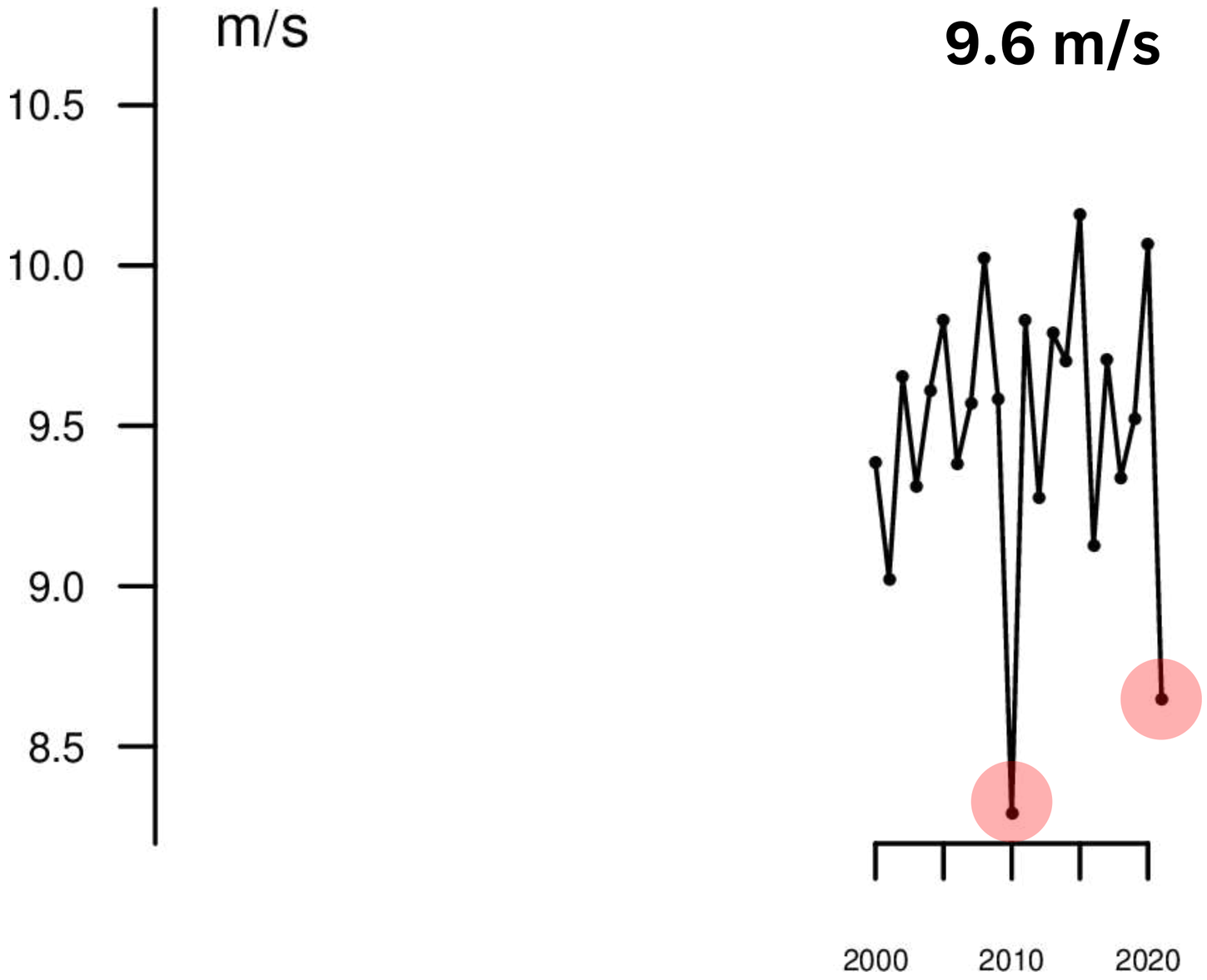
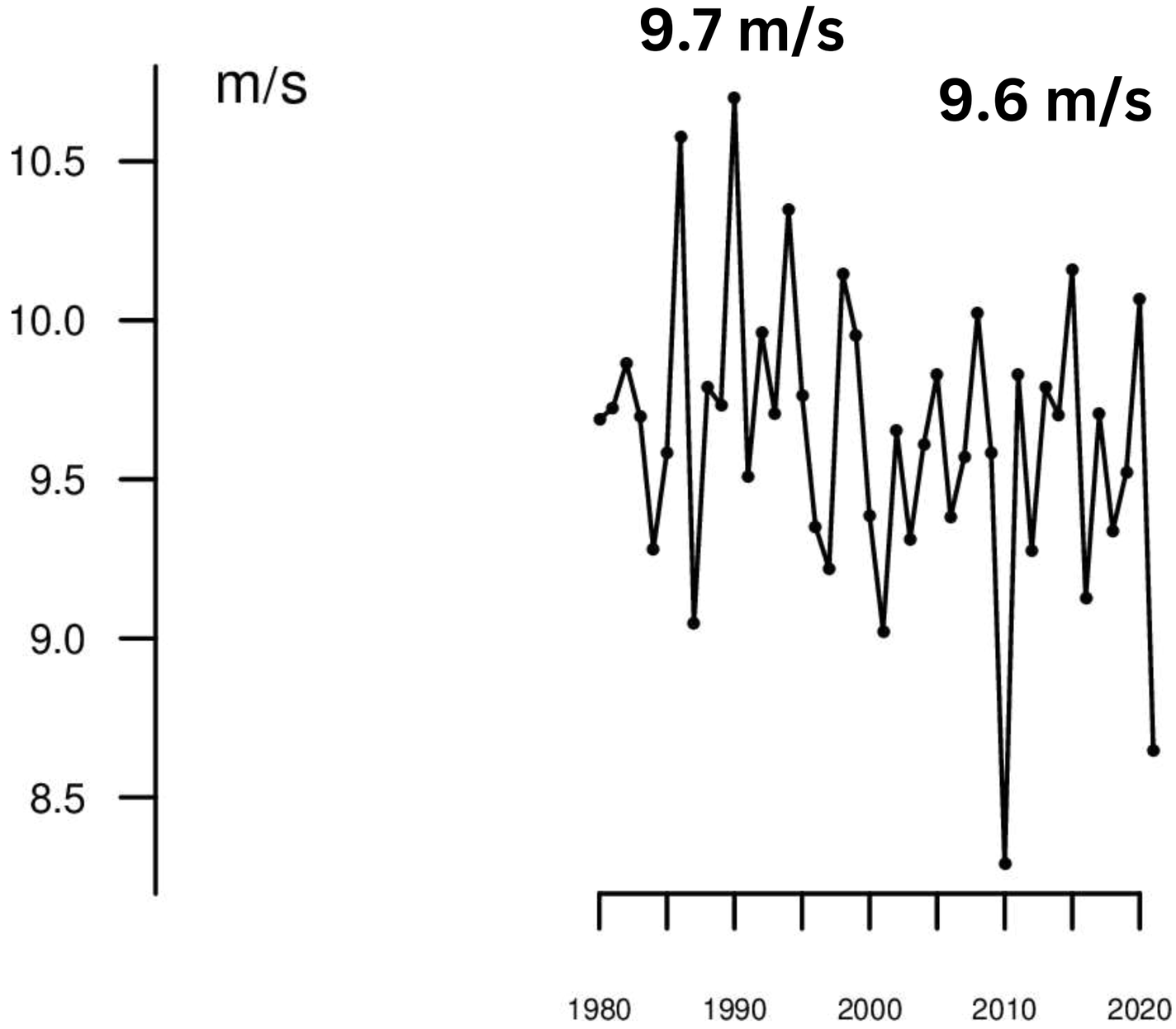
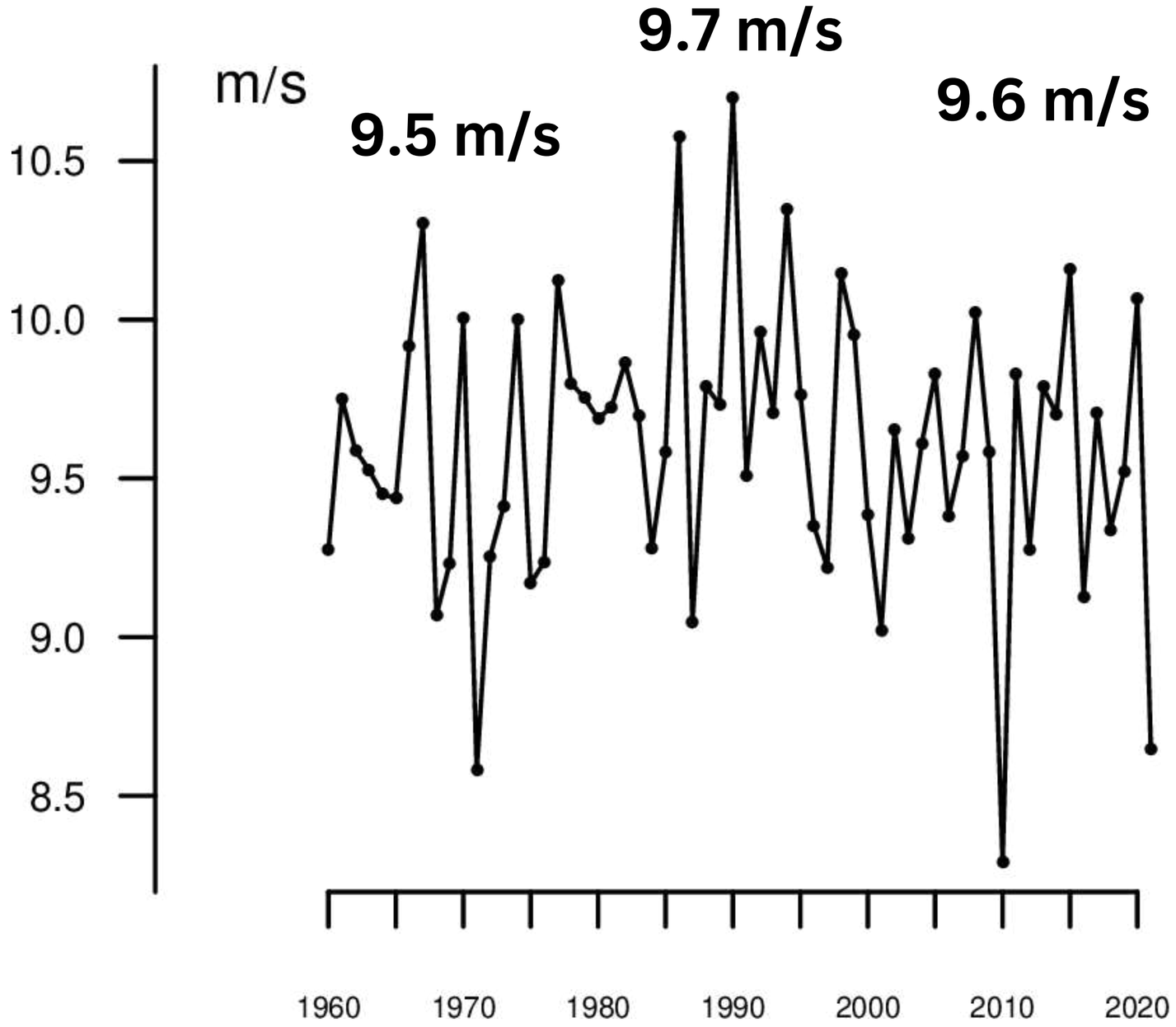
Use Case



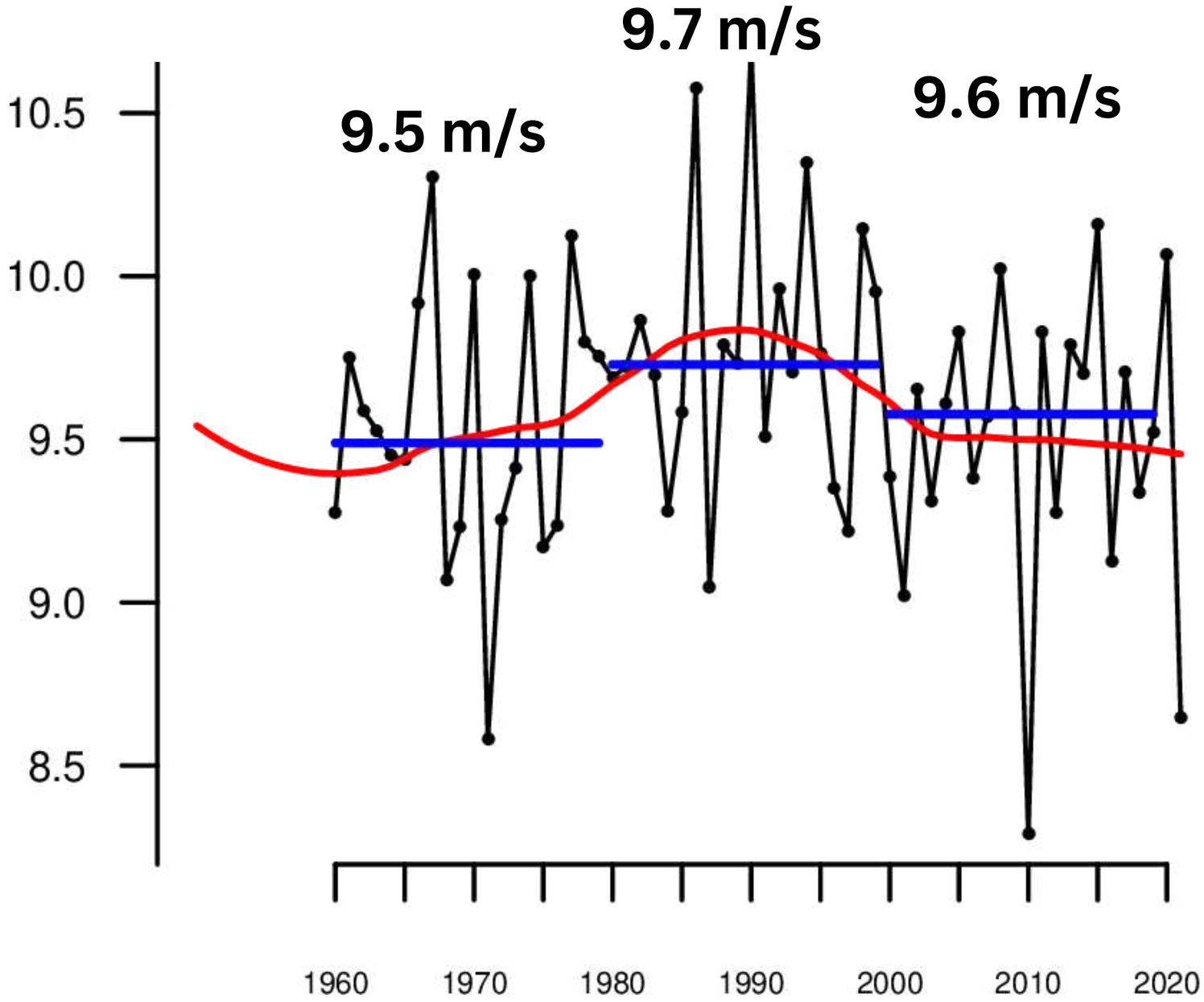
Use Case



Use Case

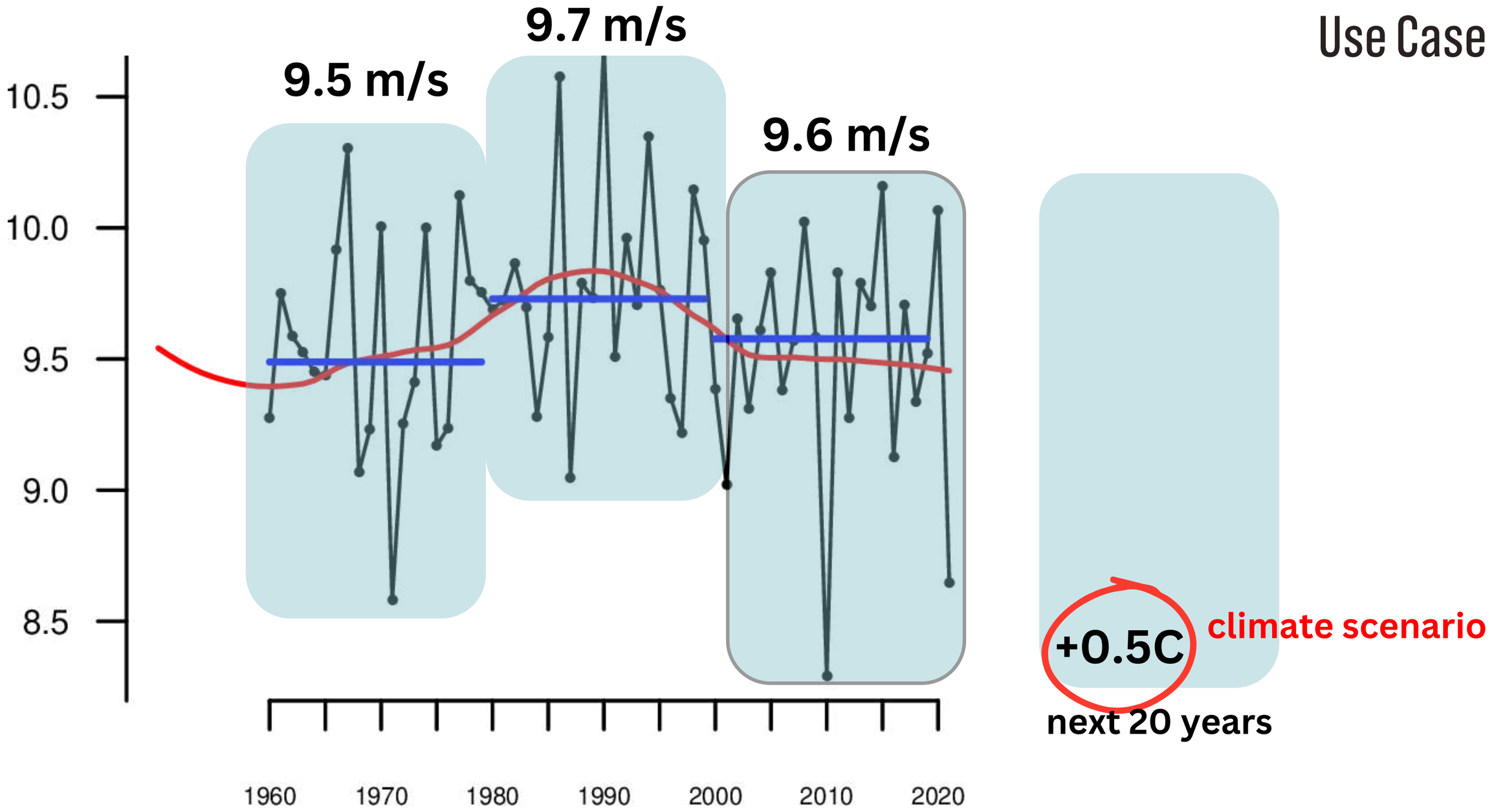

9.7 m/s
9.5 m/s
9.6 m/s
m/s
10.5
10.0
9.5
9.0
8.5
1960
1970
1980
1990
2000
2010
2020

Use Case



next 20 years

Use Case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9.0
8.5
1960
1970
1980
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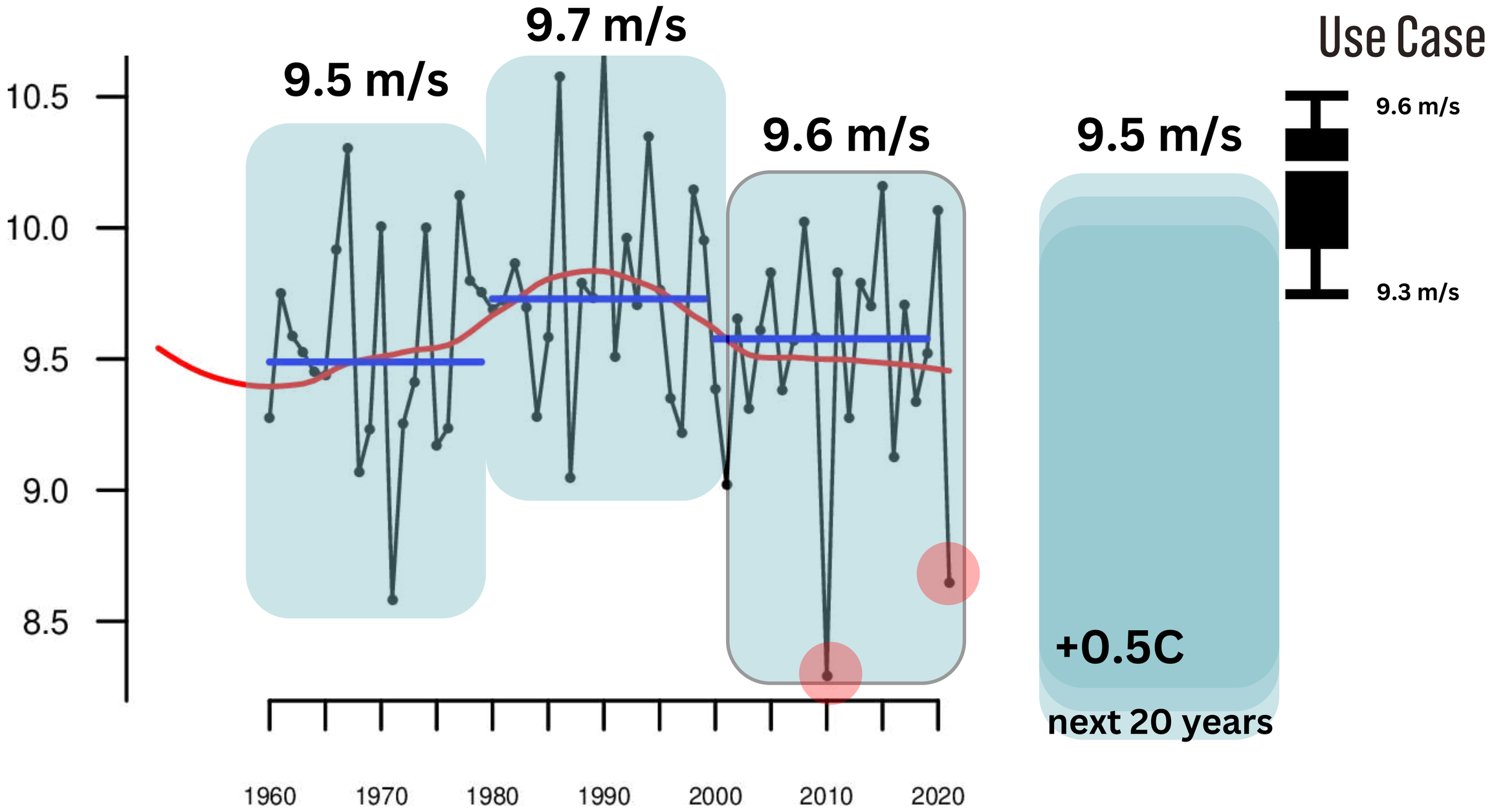
2020
+0.5C
climate scenario
next 20 years


9.7 m/s
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Use Case
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9.3 m/s
10.5
10.0
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next 20 years
1960
1970
1980
1990
2000
2010
2020

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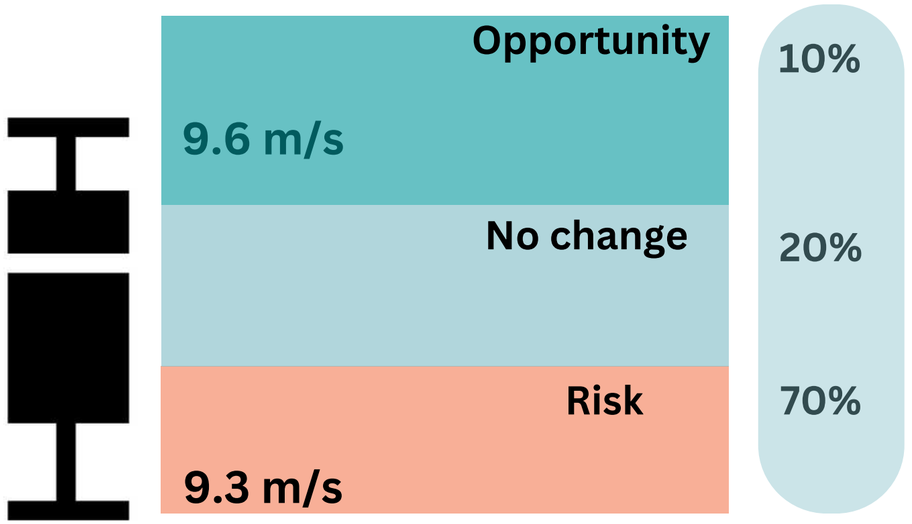
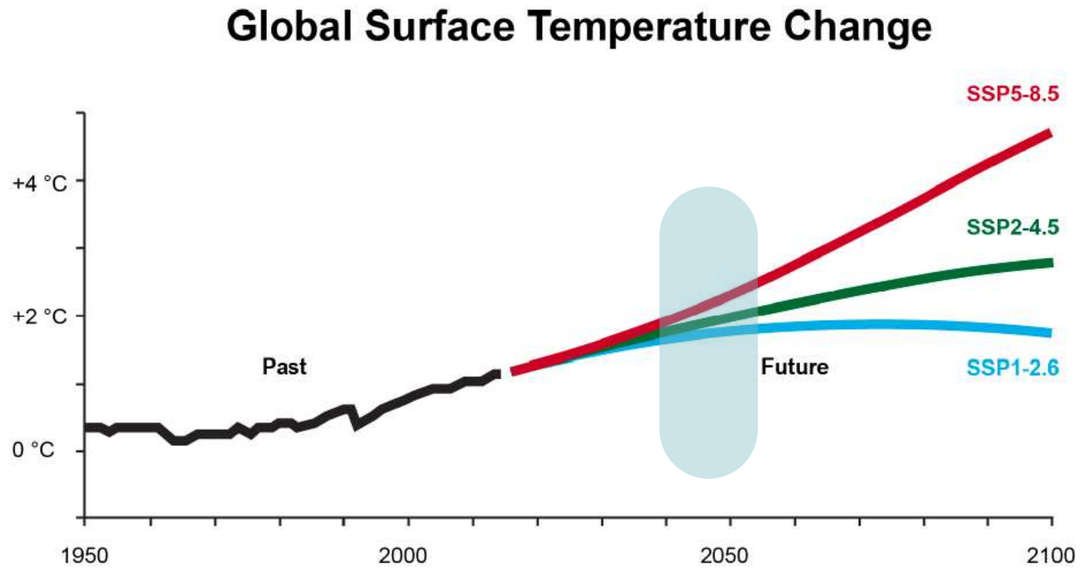
Use Case

9.5 m/s





Mapping Climate Risks for Chile

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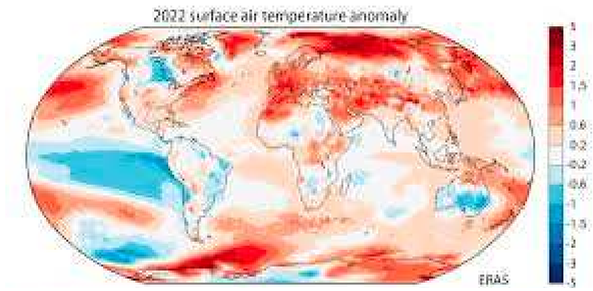
ERA5

Climate Change Service

climate.copernicus.eu

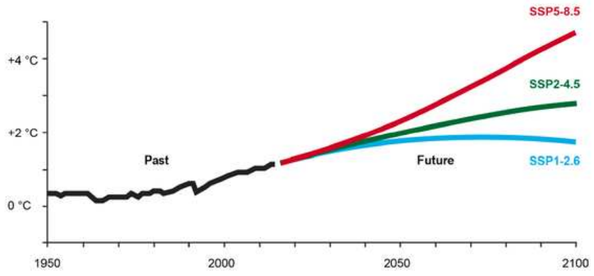
Ocean
Land
Soil



WCRP CMIP6

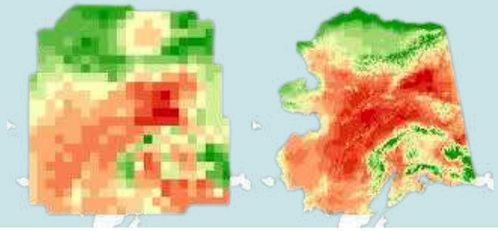
World Climate Research Programme

- More than 100TB of Data
- 30-40 Climate Models
- 4 Climate Scenarios
- 1900-2100
- 10 Essential Climate Variables

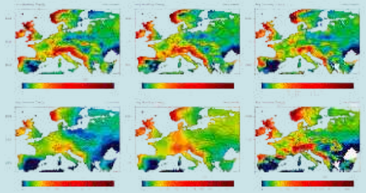


Advanced ML-Statistical Downscaling Model

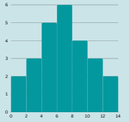
Bias Correction



Climate Quality



Data Post-Processing



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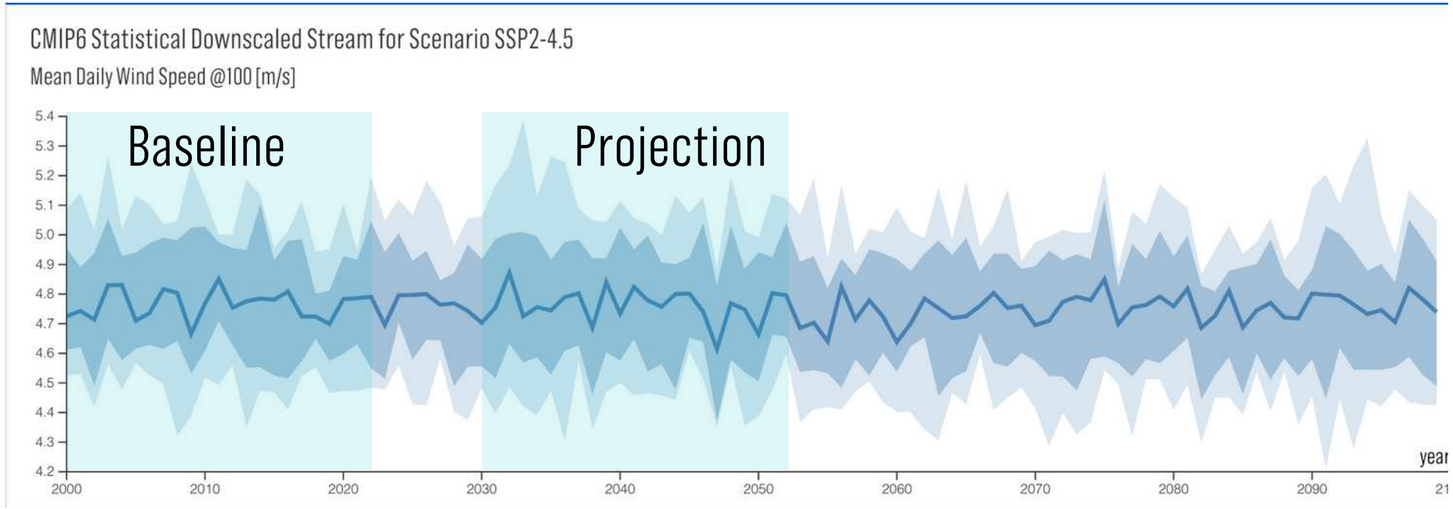
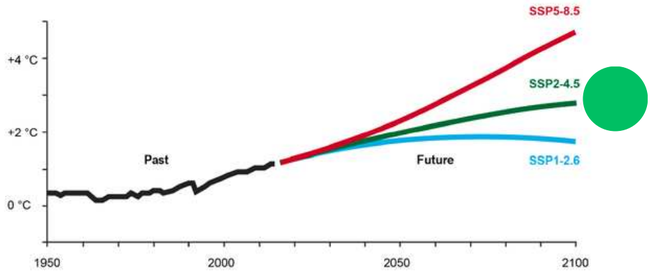
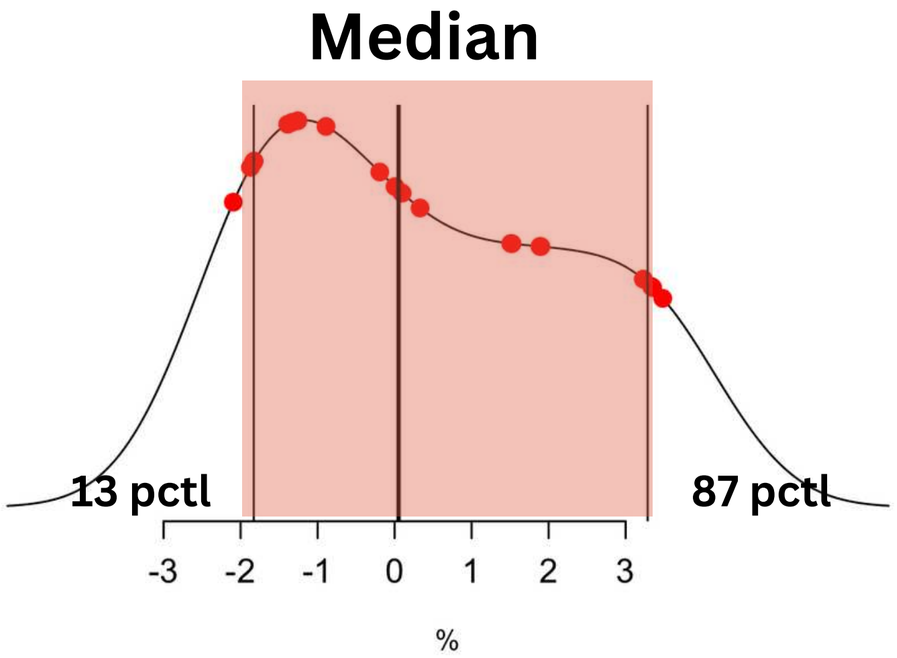
Mapping Climate Risks for Chile



Ensemble of Time Series of Wind Speed / Each Series represents a Climate Model Simulation /
One Emission Scenario



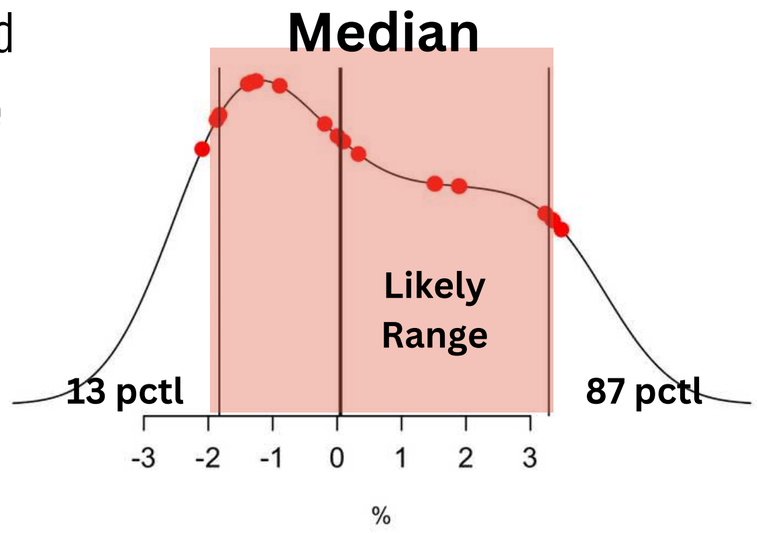


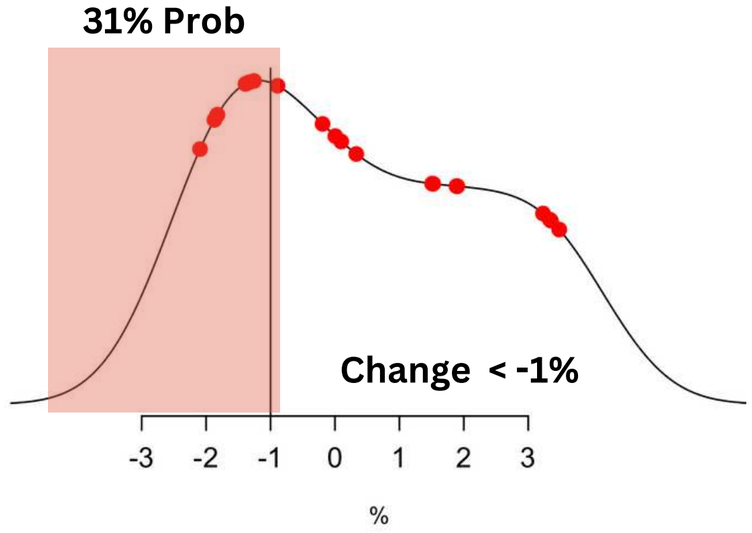
Distributions of Wind Speed Changes in % for a real Site
Each ● is a climate model

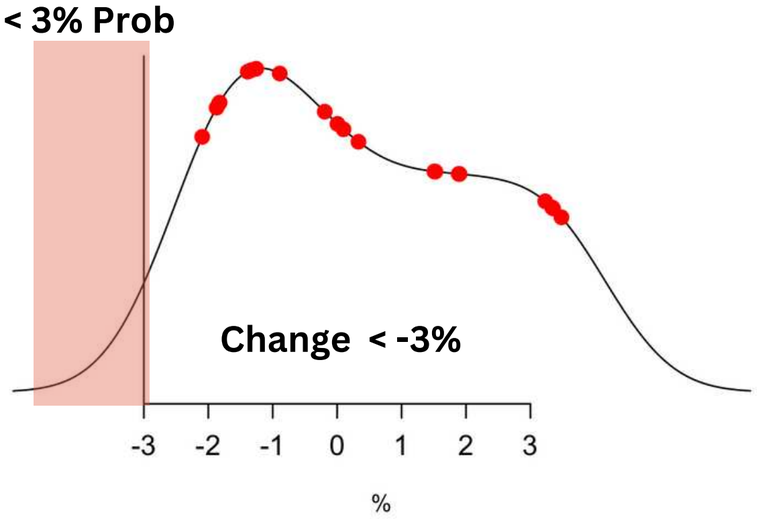
Mapping Climate Risks for Chile

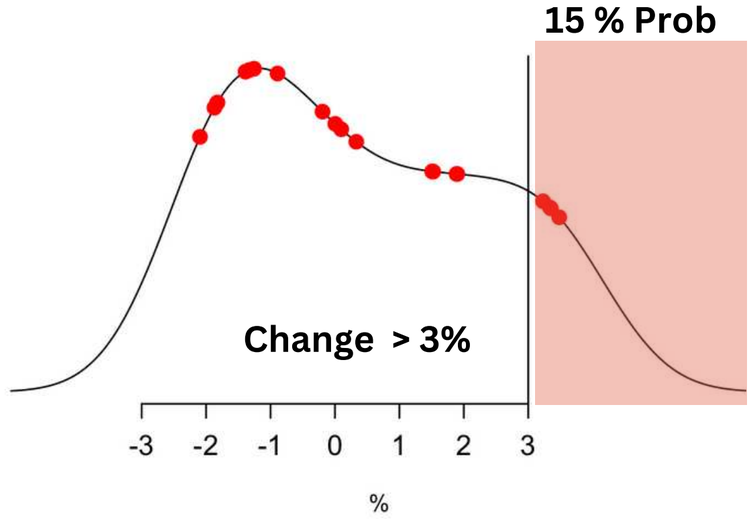
Distributions of Wind Speed Changes in % for a real Site

Each ● is a climate model



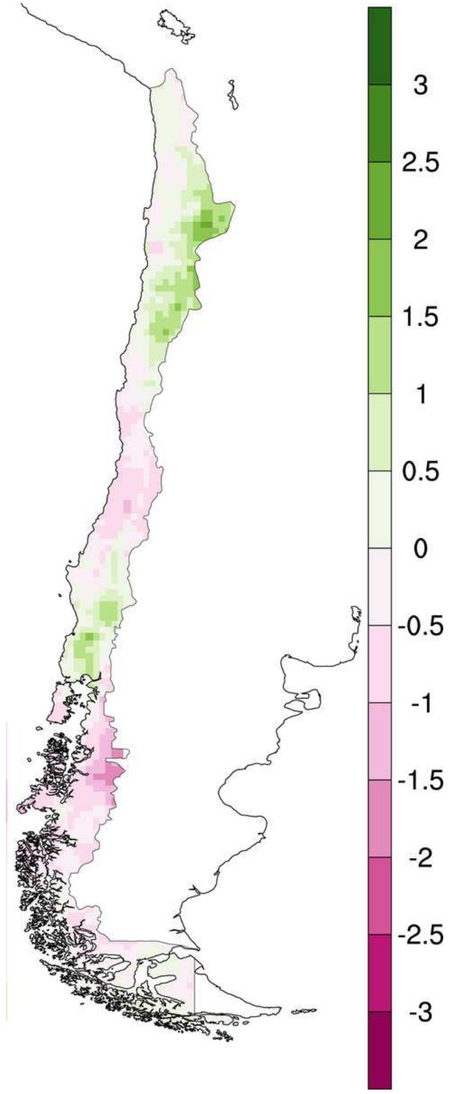




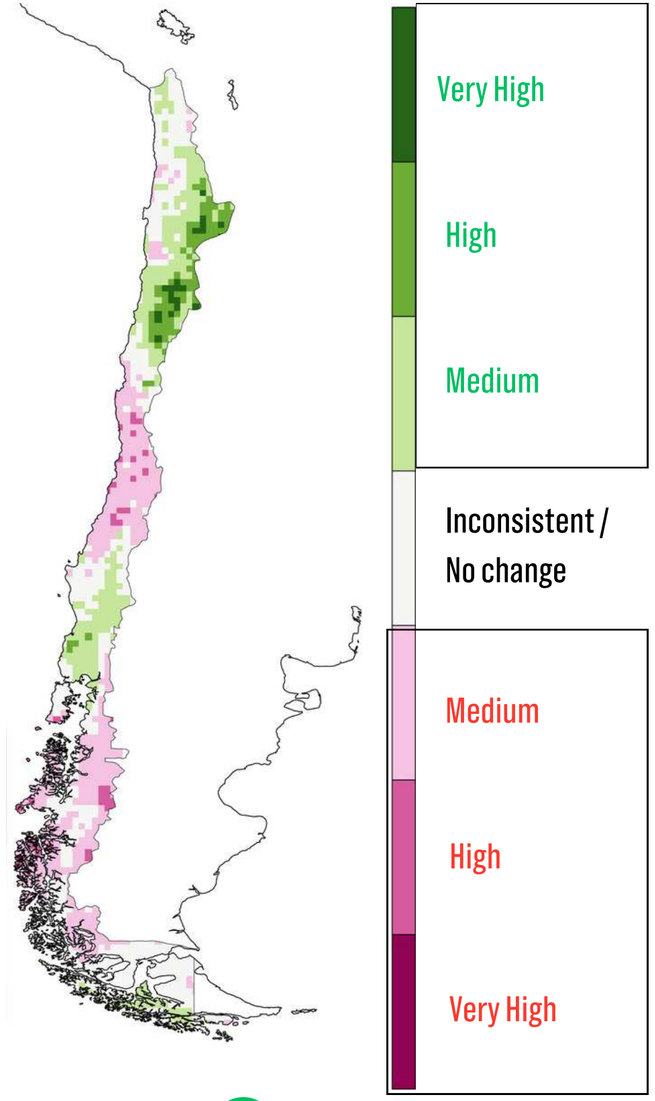


Mapping Climate Risks for Chile

Median Change (%)



Confidence for Positive / Negative Changes



Very High

High

Medium

Positive Change

Inconsistent / No change

Medium

High

Very High

Negative Change

Intermediate Emission Scenario

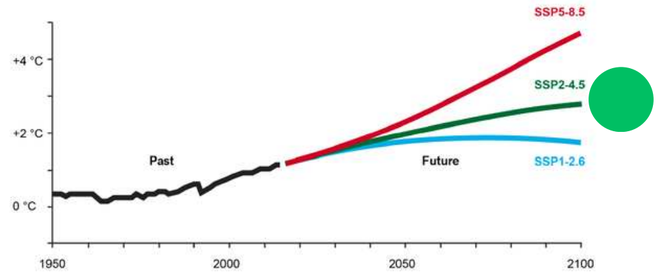
100m Long-Term Wind Speed Change

Next 20 years vs Baseline

CMIP6 Climate Scale Downscaled Data

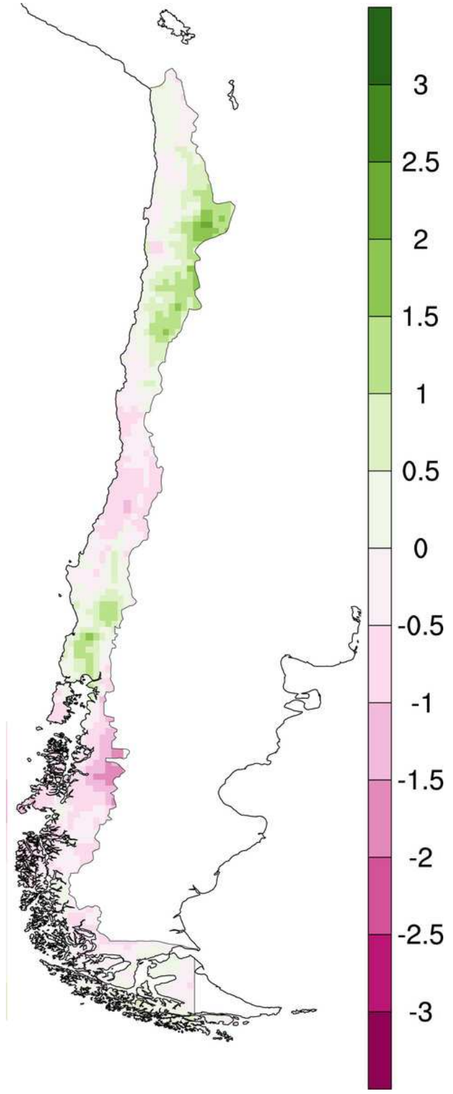
baseline: 2000-2019

horizon: 2020-2039



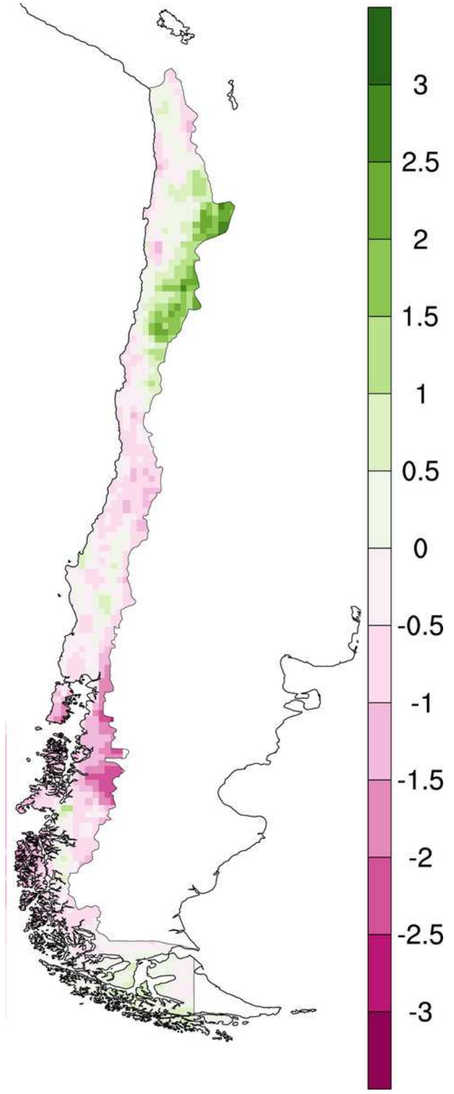
Mapping Climate Risks for Chile

Median Change (%)



Intermediate Emission Scenario

Median Change (%)



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baseline: 2000-2019

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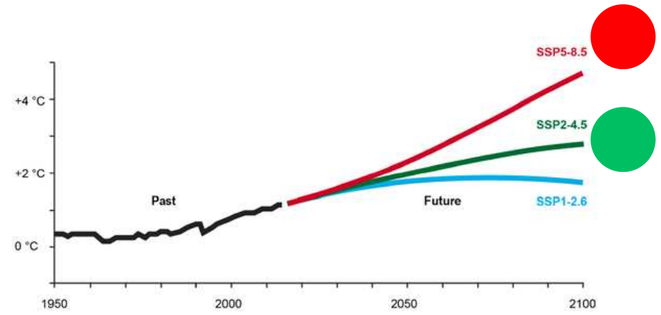
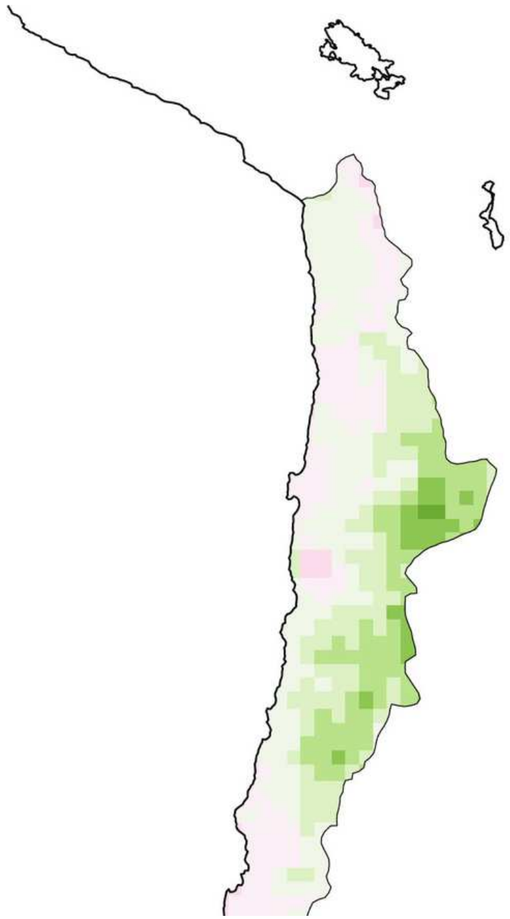
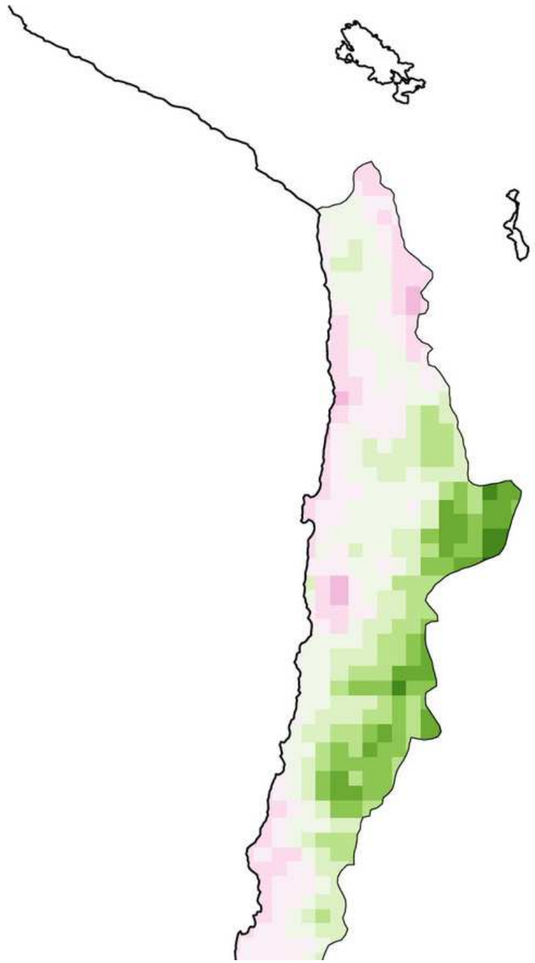


Median Change (%)



Median Change (%)



Mapping Climate Risks for Chile

100m Long-Term Wind Speed Change
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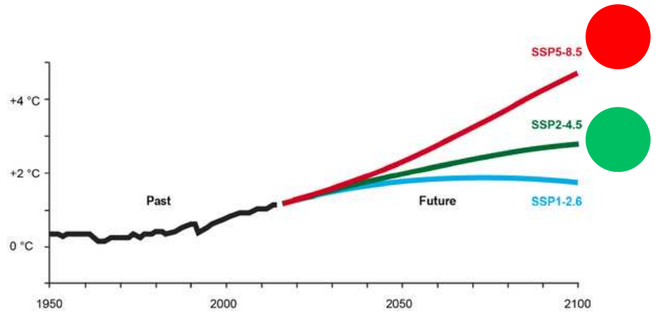

Intermediate Emission Scenario

Very High Emission Scenario

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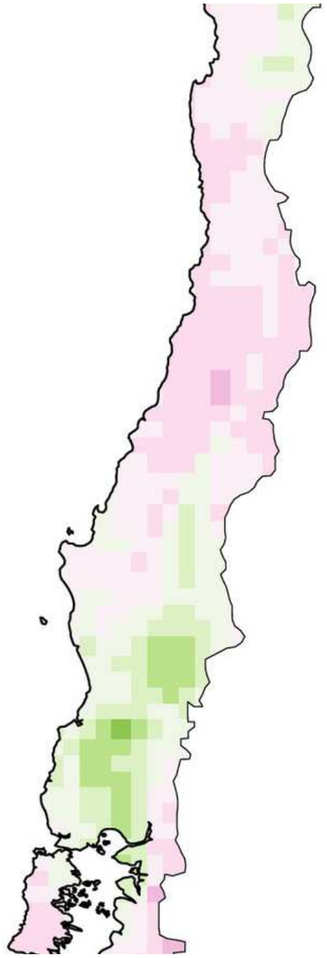

Intermediate Emission Scenario

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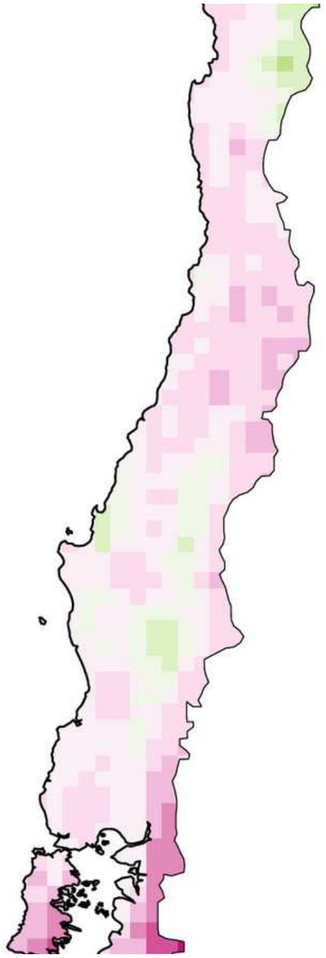

Very High Emission Scenario

Mapping Climate Risks for Chile

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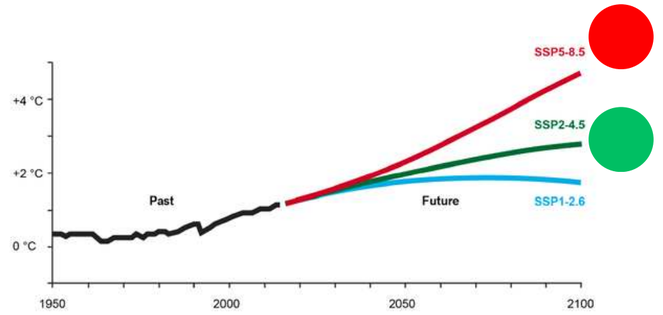

Mapping Climate Risks for Chile

				Baseline 2000-2019 Observed Climate					Short Term Horizon 2020-2039 Change			
Location Name	ADM 2	Emissions Scenario	Hazard Metric	Units	Reference	Units	IAV	Change Units	Ensemble Median	Likely Range low	Likely Range high	Confidence
Quellon	Chiloé	SSP2-4.5	Mean Daily Wind Speed @100	m/s	8.1	%	2.7	%	-0.6	-1.8	0.5	Medium
Quellon	Chiloé	SSP3-7.0	Mean Daily Wind Speed @100	m/s	8.1	%	2.7	%	-0.9	-1.6	0.0	Medium
Quellon	Chiloé	SSP5-8.5	Mean Daily Wind Speed @100	m/s	8.1	%	2.7	%	-0.8	-2.5	0.6	Medium
Tap Off Tal Tal	Antofagasta	SSP2-4.5	Mean Daily Wind Speed @100	m/s	7.4	%	6.0	%	0.8	-0.7	2.0	Medium
Tap Off Tal Tal	Antofagasta	SSP3-7.0	Mean Daily Wind Speed @100	m/s	7.4	%	6.0	%	0.3	-1.2	1.3	Low
Tap Off Tal Tal	Antofagasta	SSP5-8.5	Mean Daily Wind Speed @100	m/s	7.4	%	6.0	%	1.0	-0.4	2.5	Medium

Mapping Climate Risks for Chile

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Tap Off Tal Tal	Antofagasta	SSP3-7.0	Mean Daily Wind Speed @100	m/s	7.4	%	6.0	%	0.3	-1.2	1.3	Low
Tap Off Tal Tal	Antofagasta	SSP5-8.5	Mean Daily Wind Speed @100	m/s	7.4	%	6.0	%	1.0	-0.4	2.5	Medium

Baseline: Vortex ERA5 WRF downscaled time series

Future Projections: CMIP6 ensemble for Scenarios

- SSP2-4.5 Middle of the road development, 2.1 to 3.5˚C (*)
- SSP3-7.0 Regional rivalry, 2.8 to 4.6˚C (*)
- SPP5-8.5 Fossil fuelled development, 3.3 to 5.7˚C (*)

(*) Global Surface Air temp by 2081-2100 relative to 1850–1900

Uncertainty:

- Likely Rages: 17 and 83 quantiles
- Confidence: # of models agreeing with ensemble median sign of change

CLIMATE SCALE

Climate change risks assessments and Sustainability

Assessments of the impacts of climate change on assets and operations are being recommended or requested in a growing number of jurisdictions around the World

A Climate Change Physical Risk Assessment

Science / Technology

Identify climate drivers of impacts

Translate changes into risks

Technology / Project Specific

Estimate how climate change will affect drivers

Historical and Climate Scenarios

Risk and Opportunities // Adaptation & Mitigation

Deliverable

A Climate Change Physical Risk Assessment

- Identify climate drivers of impacts on:

  Resource - O&M - Infrastructure

			Impact Category		
			Revenue	O&M (OPEX)	Infrastructure (CAPEX)
Temperature	mean air temperature	C	✓	✓	
	extreme heat (heat waves, WBGT)	A			✓
	extreme cold (cold waves, frost, icing)	A	✓		✓
	wildfire	A			
Wind	mean wind and wind patterns	C	✓		
	severe wind storm and extreme winds	A			
	tropical cyclones	A			✓
	sand and dust storms	A			
Water	mean precipitation and precipitation patterns	C			
	extreme precipitation and pluvial floods	A			
	river flood	A			
	water stress - hydrological drought	A			
	snow and glacier melt	C			
	permafrost	C			
	heavy snowfall and ice storm	A			
	hail	A			
Coastal & Oceanic	coastal flood	A			✓
	sea level rise	C			✓
	ocean acidity	C			✓
	ocean salinity	C			✓
	wind-wave coupling changes	C			✓
Radiation	mean radiation	C			
Other	atmospheric CO2 at surface	C			

existing evidence	✓
no existing evidence	

chronic	C
accute	A

Sources: Solaun et al 2019, IEA 2019, IPCC 2022, Yalew 2020

A Climate Change Physical Risk Assessment

Translate to risk.

- What are the changes in mean wind speed that could have a significant impact in production?
- What changes in frequency or intensity of extreme conditions affect the infrastructure?
- And in all cases: what are the financial impacts?

				Climate Risk Metrics					
				Short Term Horizon 2020-2039		Mid Term Horizon 2040-2059		Long Term Horizon 2080-2099	
Location Name	ADM 2	Emissions Scenario	Risk Metric	Risk Category	Confidence	Risk Category	Confidence	Risk Category	Confidence
Quellon	Chiloé	SSP2-4.5	Average Wind@100 Reduction	Low-Medium	Medium	VLow-Low	Low	Medium-High	Medium
Quellon	Chiloé	SSP3-7.0	Average Wind@100 Reduction	Low-Medium	Medium	Low-Medium	Medium	Medium-High	Medium
Quellon	Chiloé	SSP5-8.5	Average Wind@100 Reduction	Low-Medium	Medium	Medium	Medium	High	Medium
Tap Off Tal Tal	Antofagasta	SSP2-4.5	Average Wind@100 Reduction	VLow	Medium	VLow	Medium	VLow	Medium
Tap Off Tal Tal	Antofagasta	SSP3-7.0	Average Wind@100 Reduction	VLow-Low	Medium	VLow-Low	Medium	VLow	Medium
Tap Off Tal Tal	Antofagasta	SSP5-8.5	Average Wind@100 Reduction	VLow	Medium	VLow	Medium	VLow	Medium

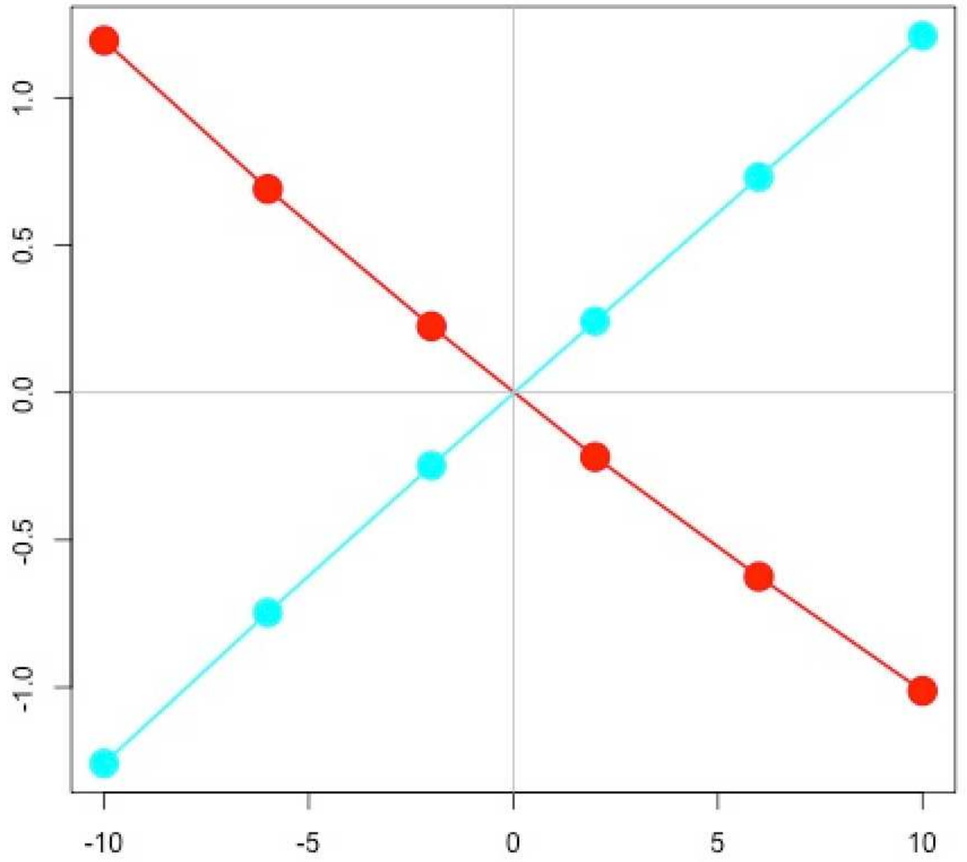
A Climate Change Physical Risk Assessment - financial implications

First Order Drivers

- Wind Resource >> Energy generation
- CAPEX, e.g increase in cost of turbine to make it more resilient to future extreme events (change in class for instance).

Note that this is not discounted, only considers upfront CAPEX expenditures.

Changes in IRR (%)



Baseline IRR = 8.21%

A Climate Change Physical Risk Assessment - financial implications

First Order Drivers

- Wind Resource >> Energy >> PPA/Spot Market
- Capex, e.g increase in cost of turbine to make it more resilient to future extreme events (change in class for instance).

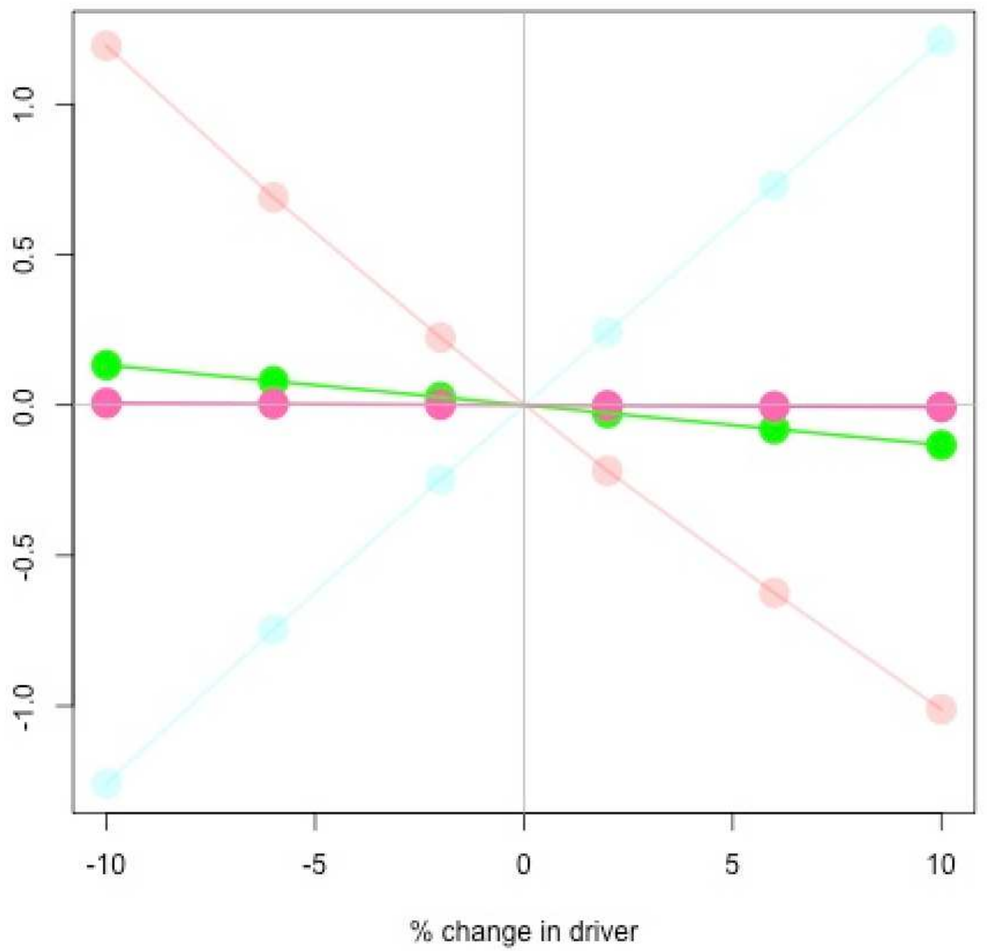
Note that this is not discounted, only considers upfront capex expenditures.

Second Order Drivers

- OPEX, e.g due to more recurrent or intense events that impede maintenance work .
- Insurance costs, e.g increases due to projected changes in extreme events.

  Note that this is based on the assumption that insurance costs is ~5% of annual OPEX.

Changes in IRR (%)



Baseline IRR= 8.21%

Conclusions

- Climate is changing - the past is not a guide to the future- specially when just looking at the recent past.

- In some cases, the climate change signal is no larger than the interanual and/or the inter decadal variability, particularly over the next few decades.

- Projected changes are uncertain due to
    - conditioning on the emissions scenario
    - variety of climate models

A CCPRA needs to explore a variety of scenarios and models to evaluate uncertainties and correctly estimate the potential risks.

- Going from physical risks to financial impacts is challenging - key driver of impacts on financial metrics is resource - more frequent and/or intense extreme events are second order.

CLIMATE SCALE

Climate risks assessments for wind and solar assets: challenges and way forward

Ana López

ana.lopez@climatescale.com

Conferencia Eólica Chile

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explore.climatescale.com