Guidance for Managing Sea Level Rise Infrastructure Risk in PIC

Connon Andrews

24/01/2022

Pacific Region Infrastructure Facility

Agenda

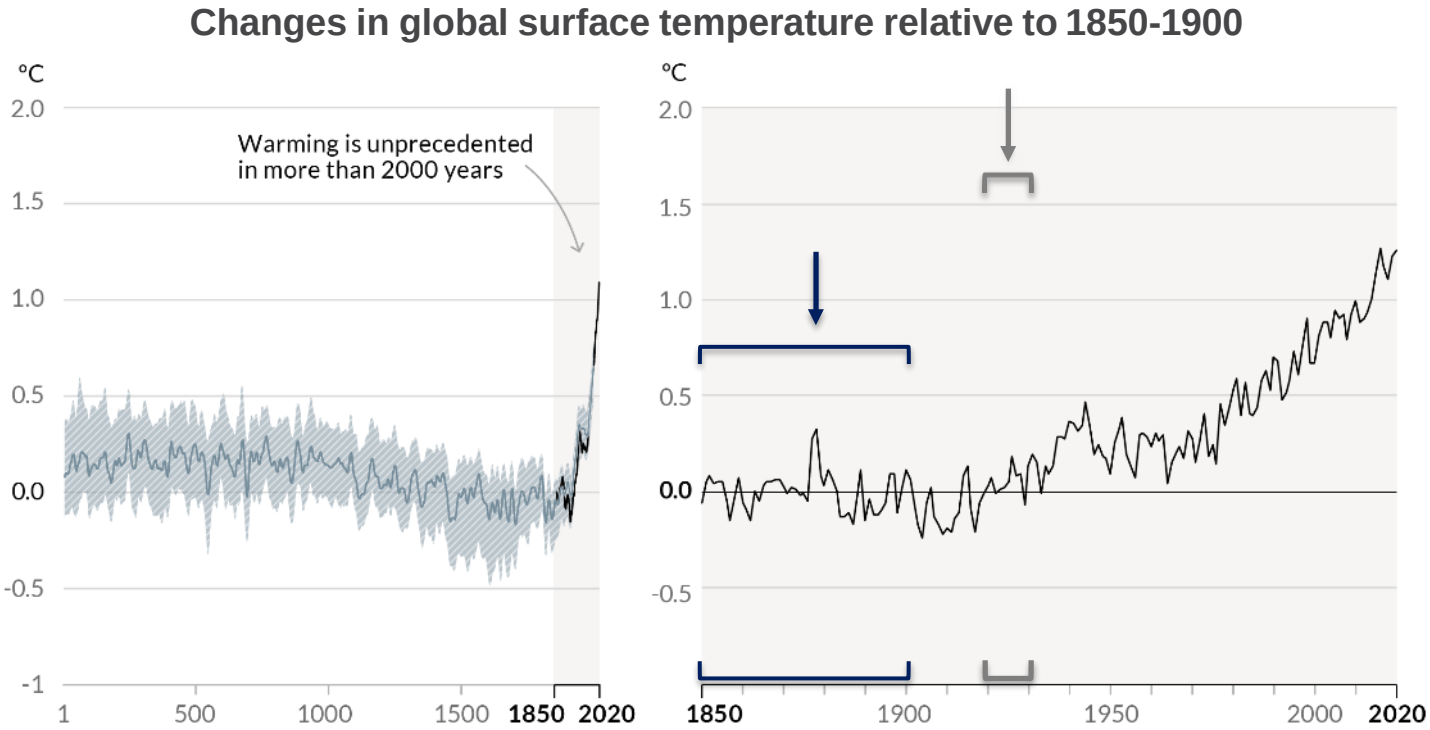
- Background to the PRIF TA
- Stocktake on climate change assessment
- Summary of the latest IPCC 6th Assessment
- Revised sea level projections for the PICs
- Adaptative planning for sea level rise
- Transitional guidance
- Summary

Stocktake – current climate

"Recent changes in the climate are widespread, rapid, and intensifying, and unprecedented in thousands of years."

Stocktake – current climate

Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years



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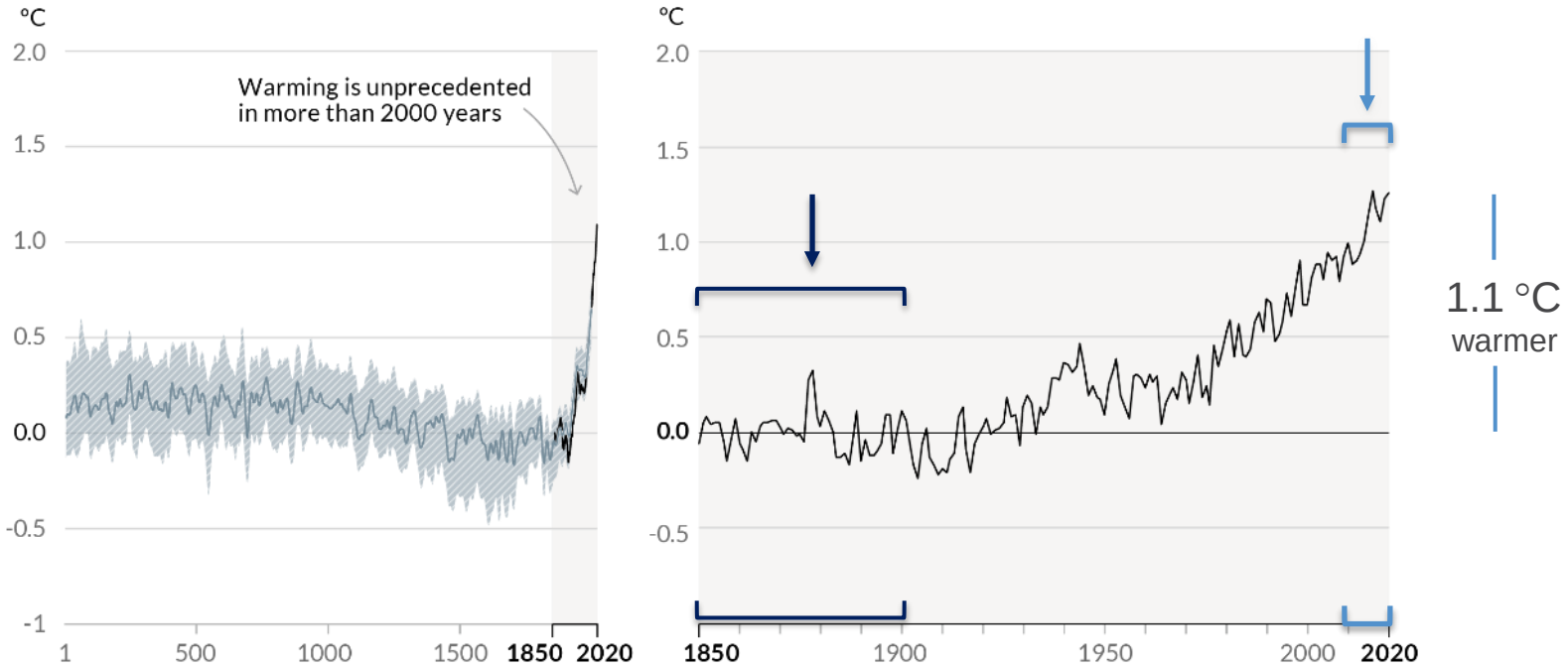
Changes in global surface temperature relative to 1850-1900



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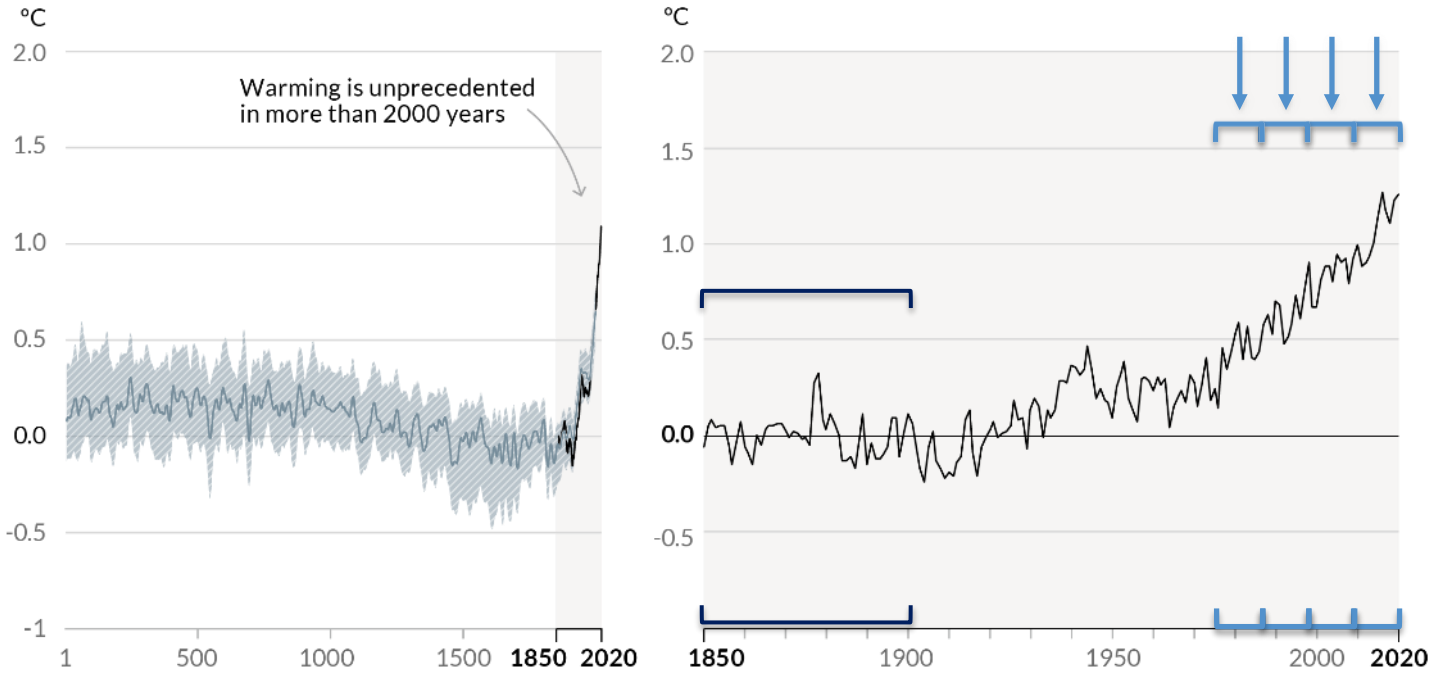

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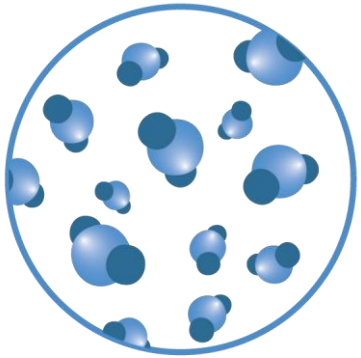
CO_2
concentration



Highest

in at least

2 million years

Sea level
rise

Fastest rates

in at least

3000 years

Arctic sea ice
area

Lowest level

in at least

1000 years

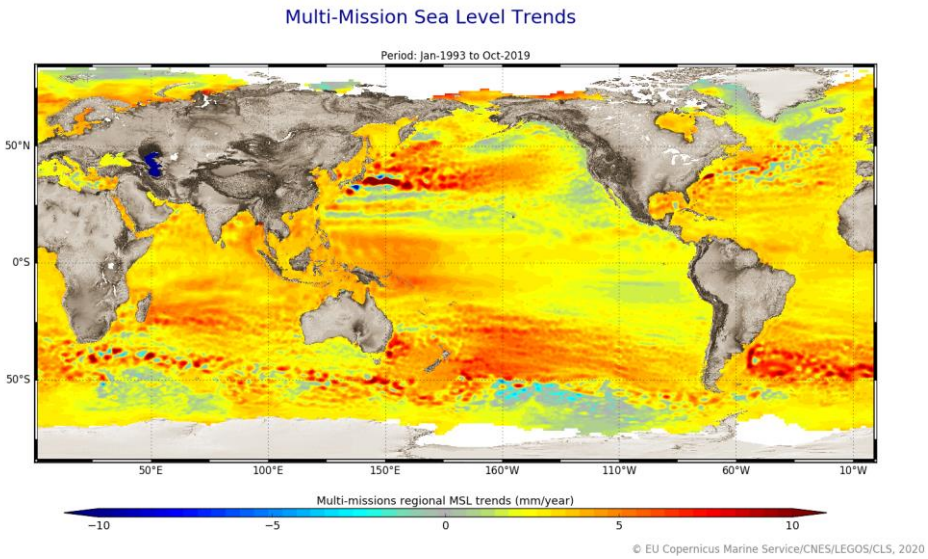
Glaciers
retreat

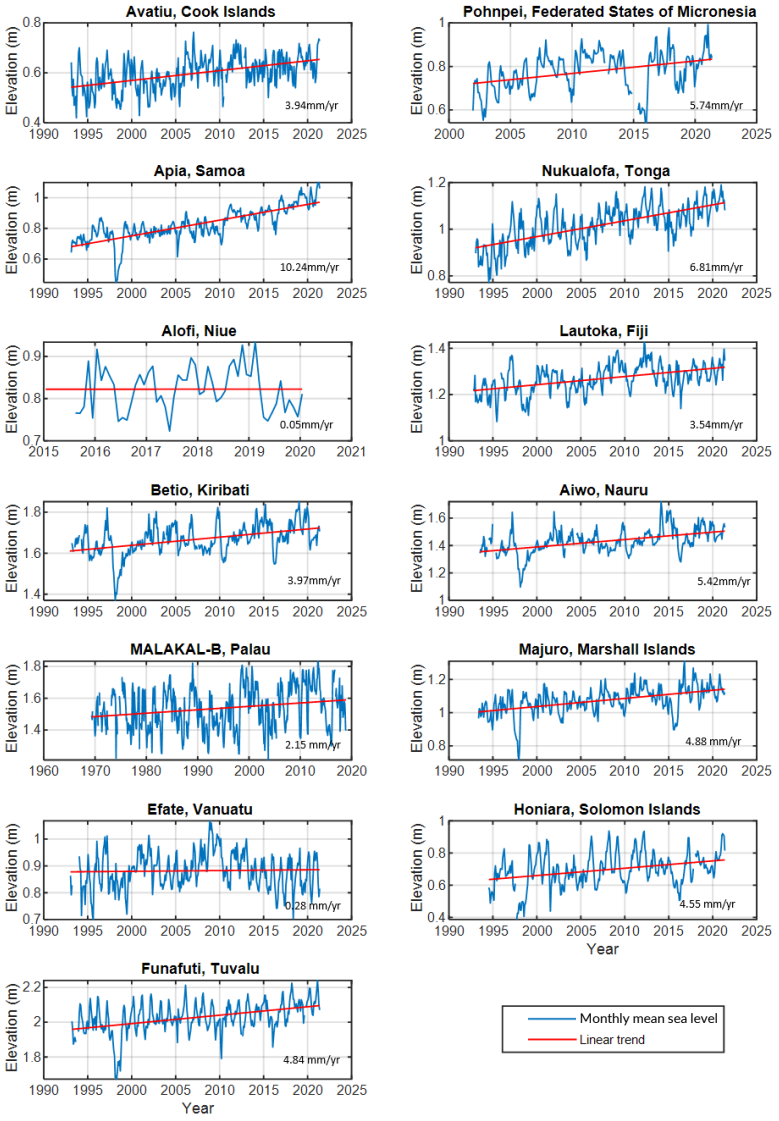
Unprecedented

in at least

2000 years

PIC Sea level rise trends





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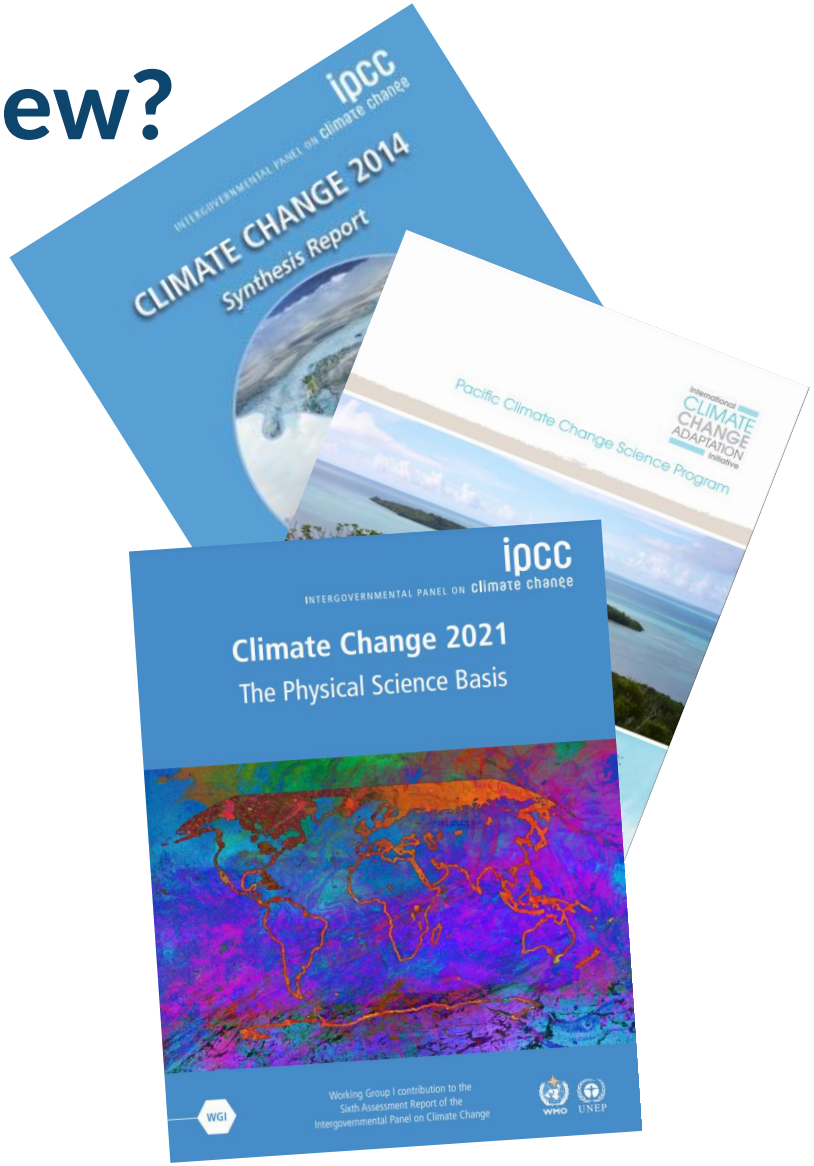
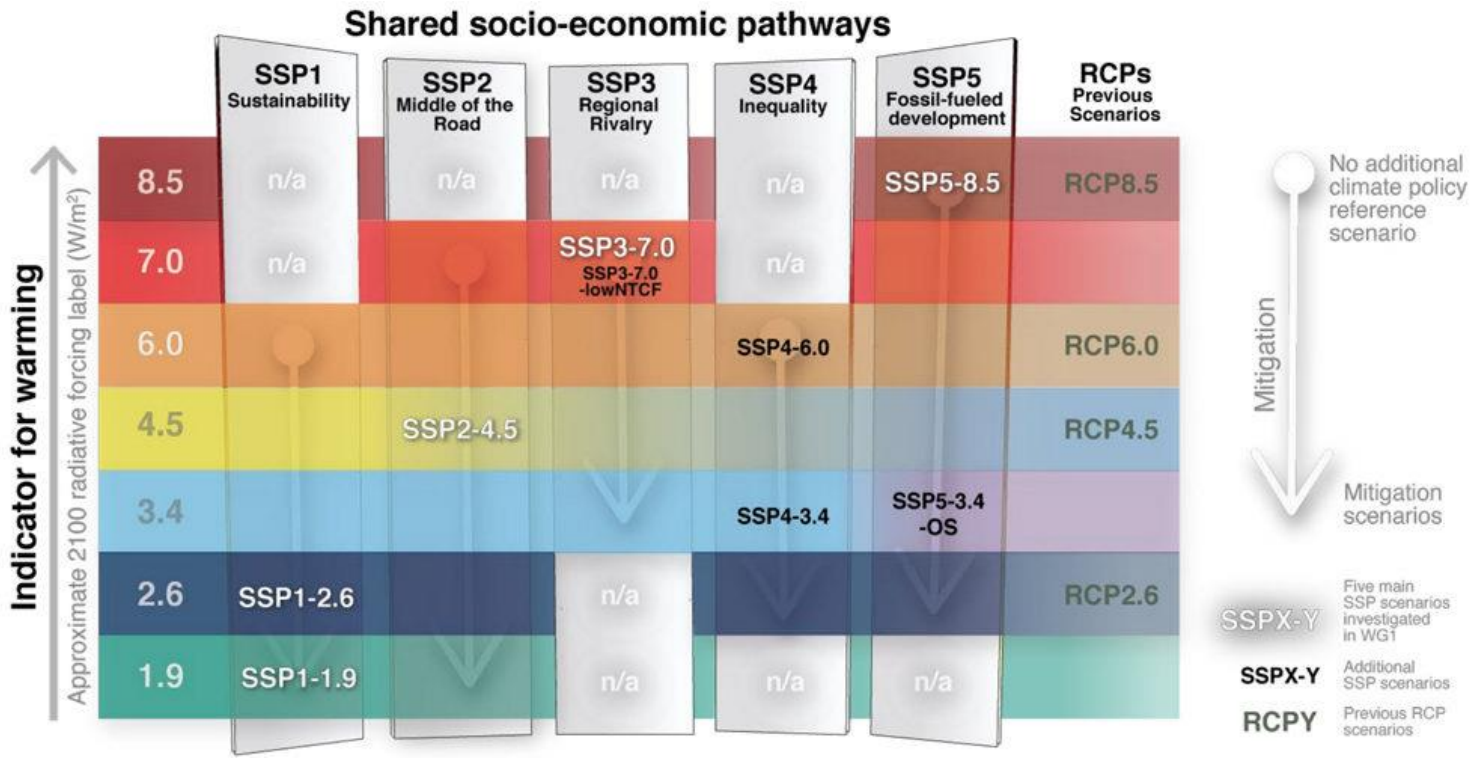
Stocktake – what is new?

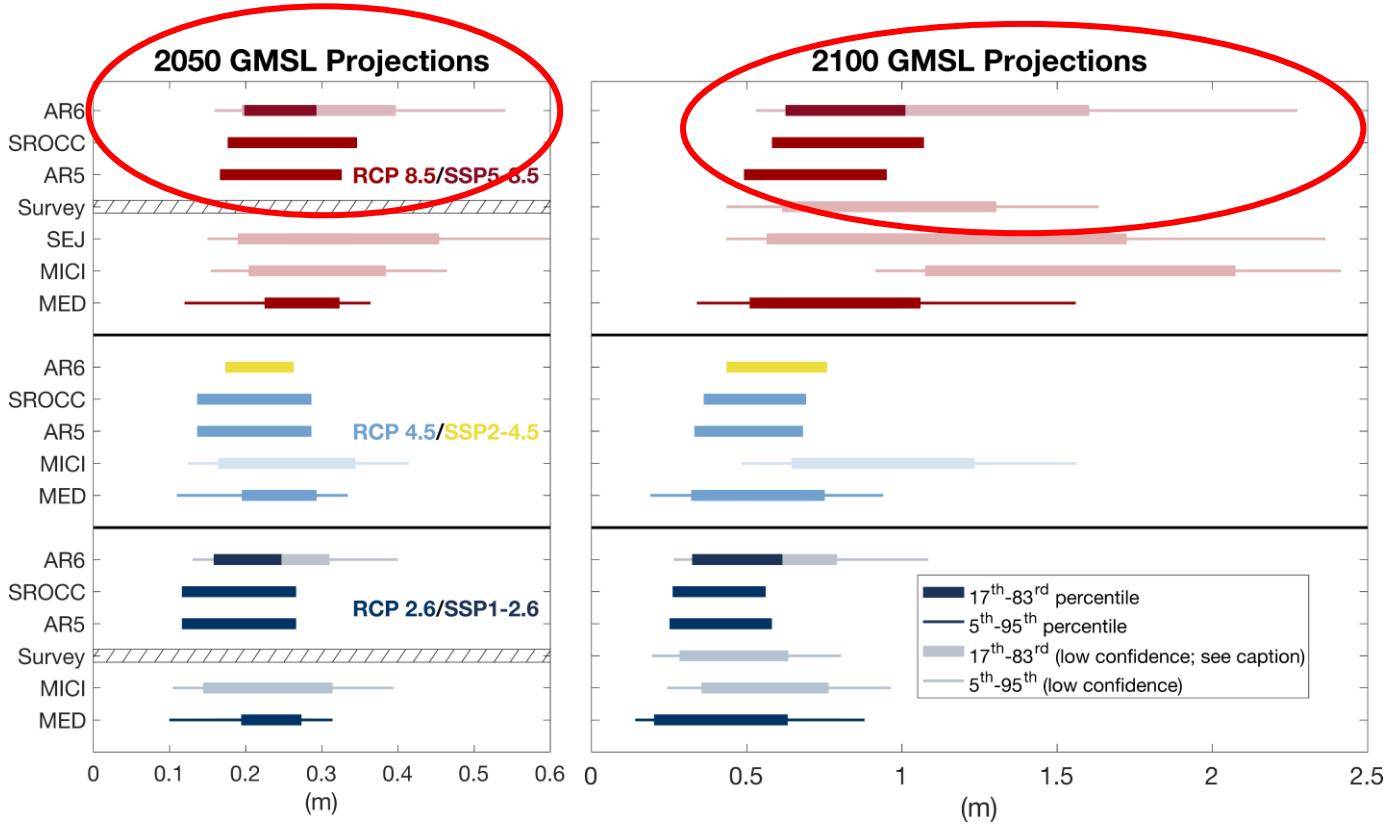
- Partial release of AR6
- New set of projection scenarios
- New baselines (1995-2014)
- More emphasis on uncertainty
- Refined estimates via CMIP model ensemble
- Greater emphasis on regional information



New set of Projections



Since AR5



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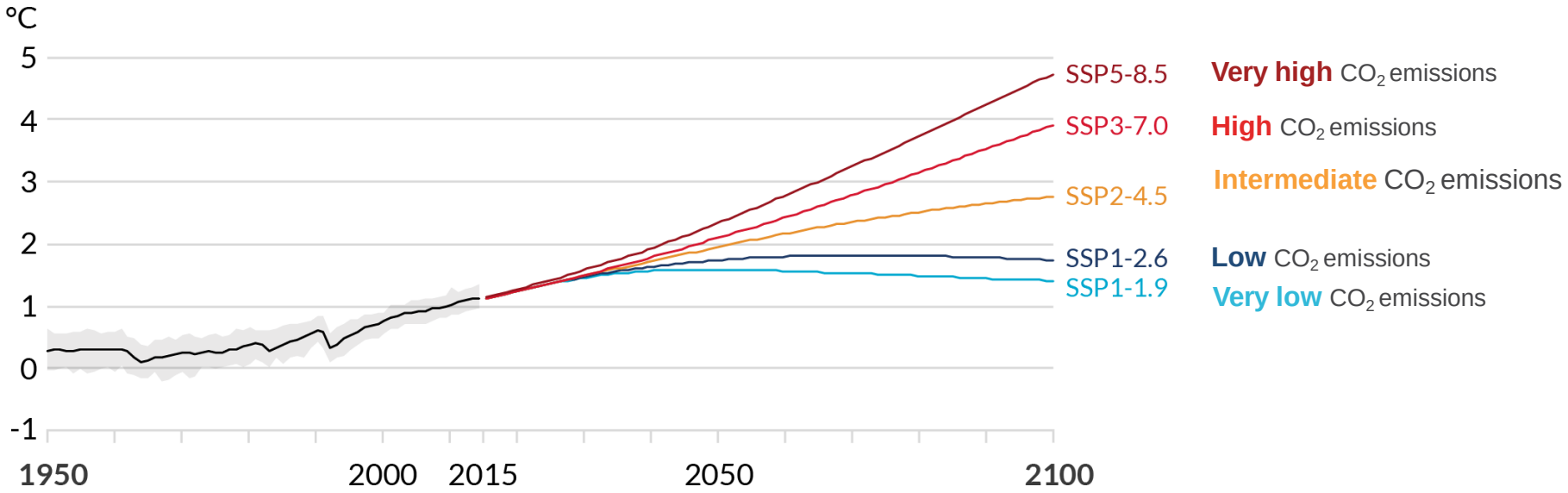
New set of Projections

Future emissions cause future additional warming



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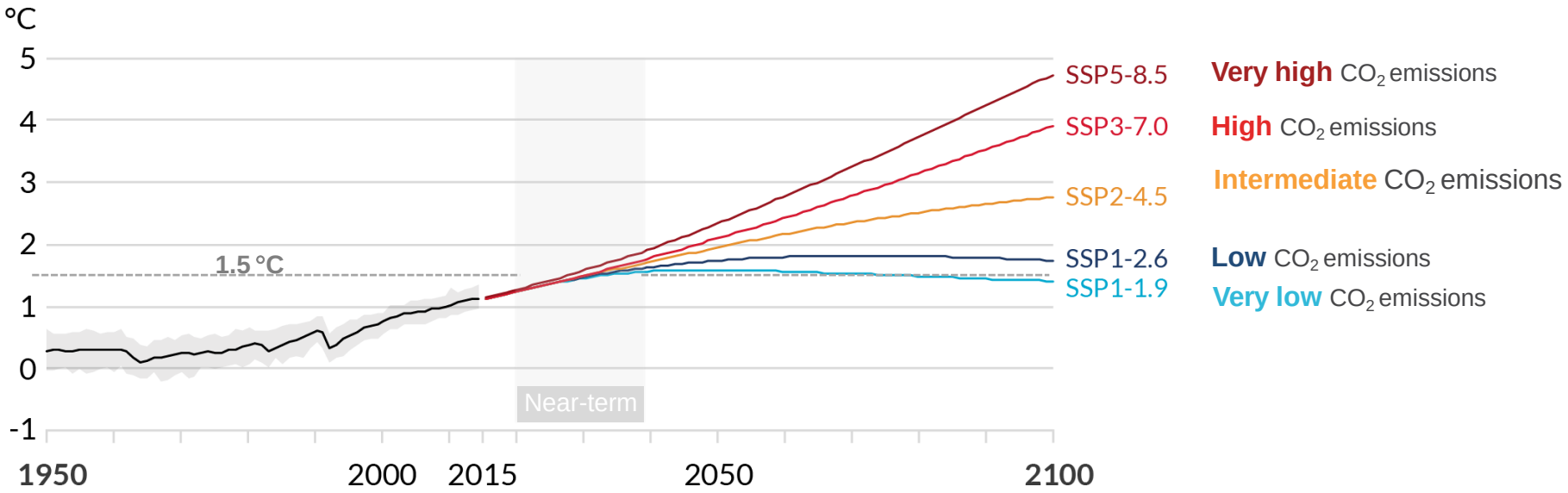

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New set of Projections

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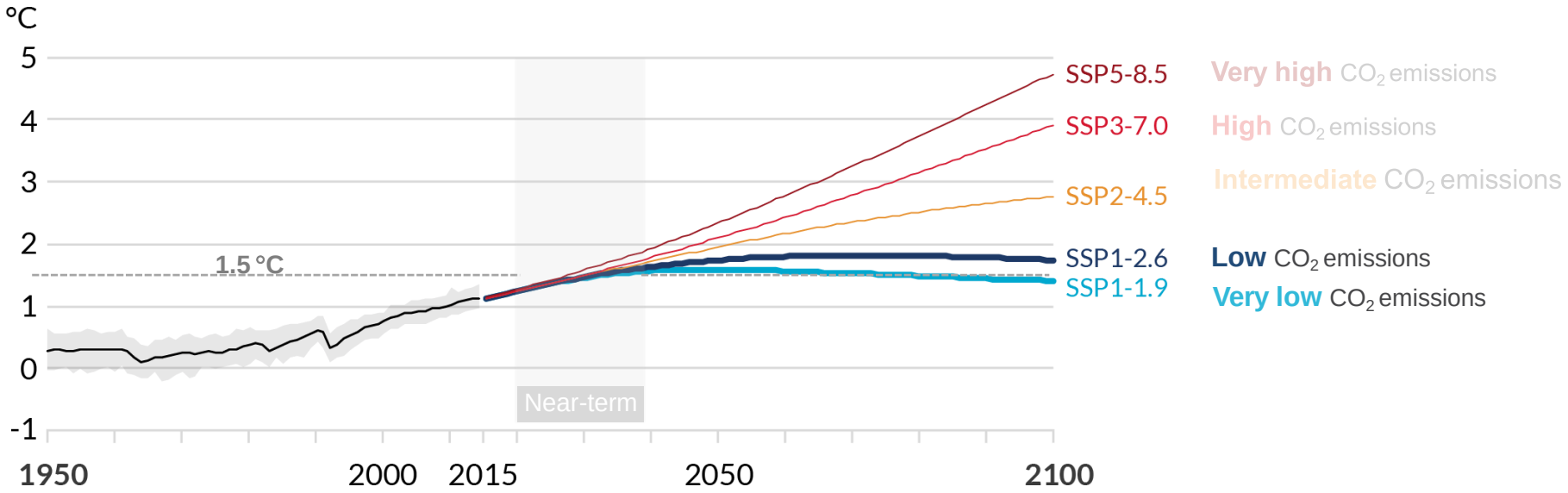

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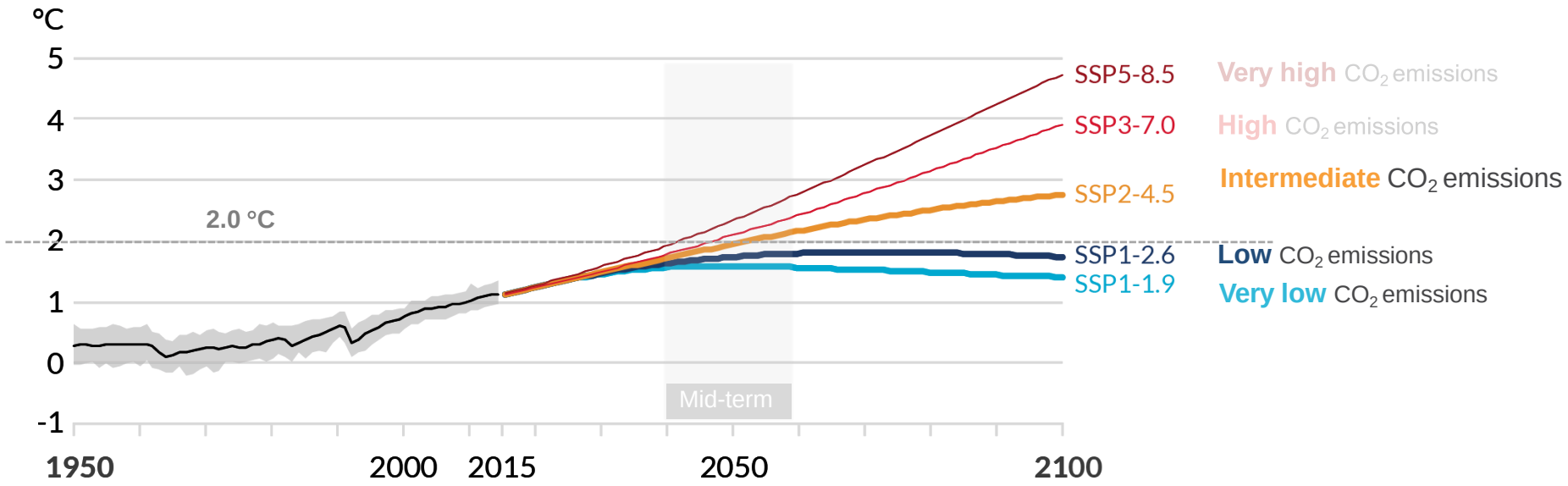

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"Unless there are immediate, rapid, and large-scale reductions in greenhouse gas emissions, limiting warming to 1.5°C will be beyond reach."

“There’s no going back from some changes in the climate system…”

Ocean and ice sheets

Ocean temperature

Increasing

Greenland & Antarctic Ice Sheets

Melting

Sea level

Rising

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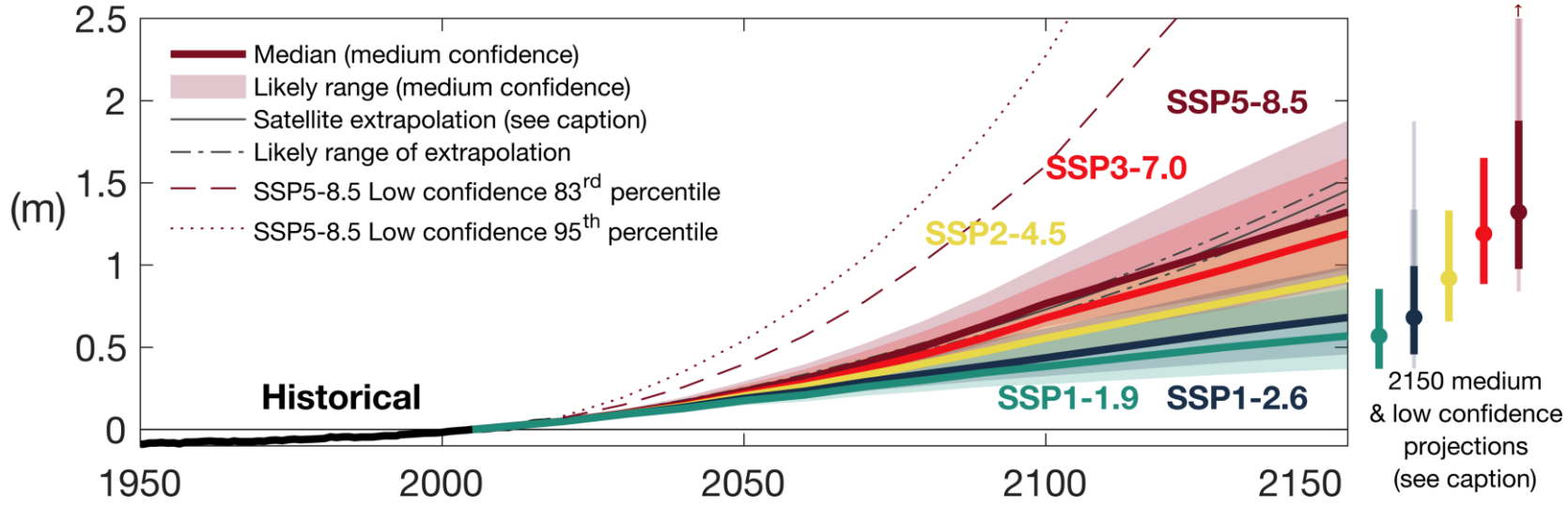
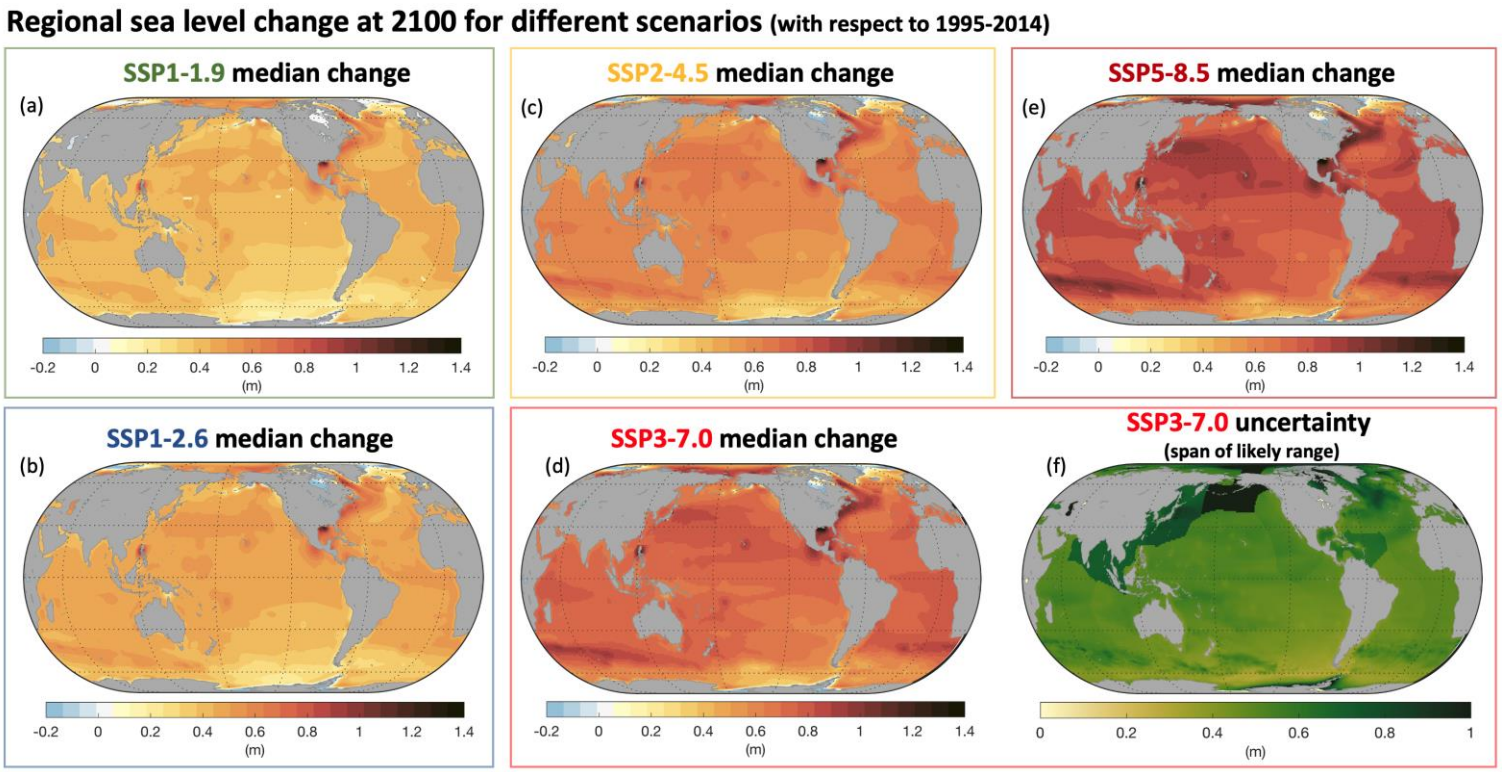
Photo Credits from left: NOAA; Konrad Steffen; Allan Grinberg

Global Sea Level Rise

Projected global mean sea level rise under different SSP scenarios



Regional Sea Level Rise



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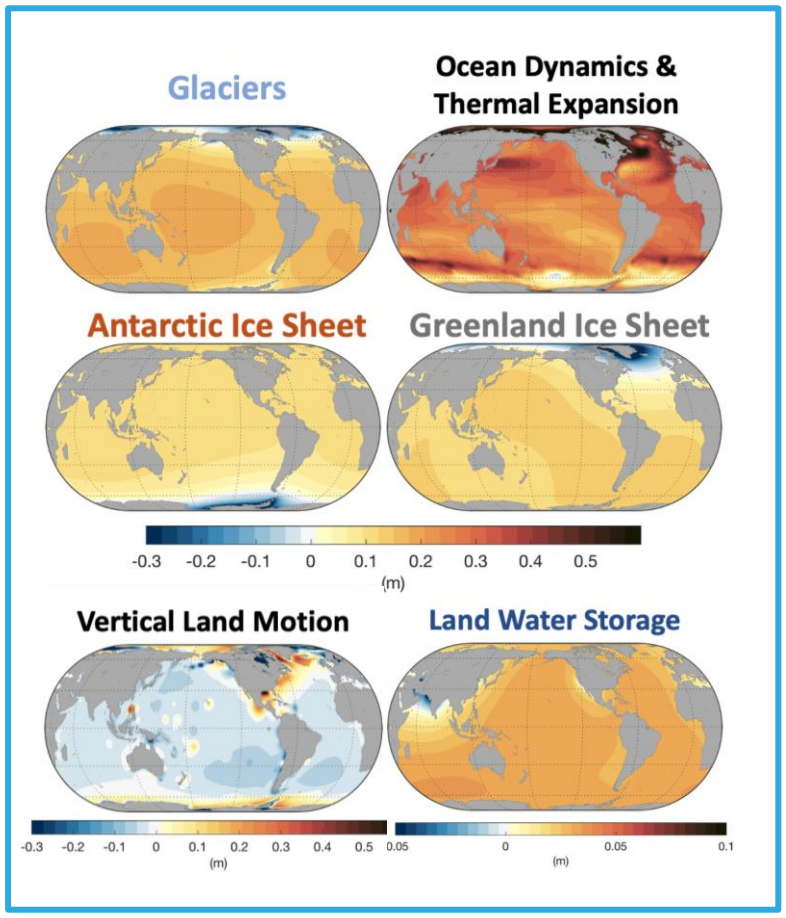
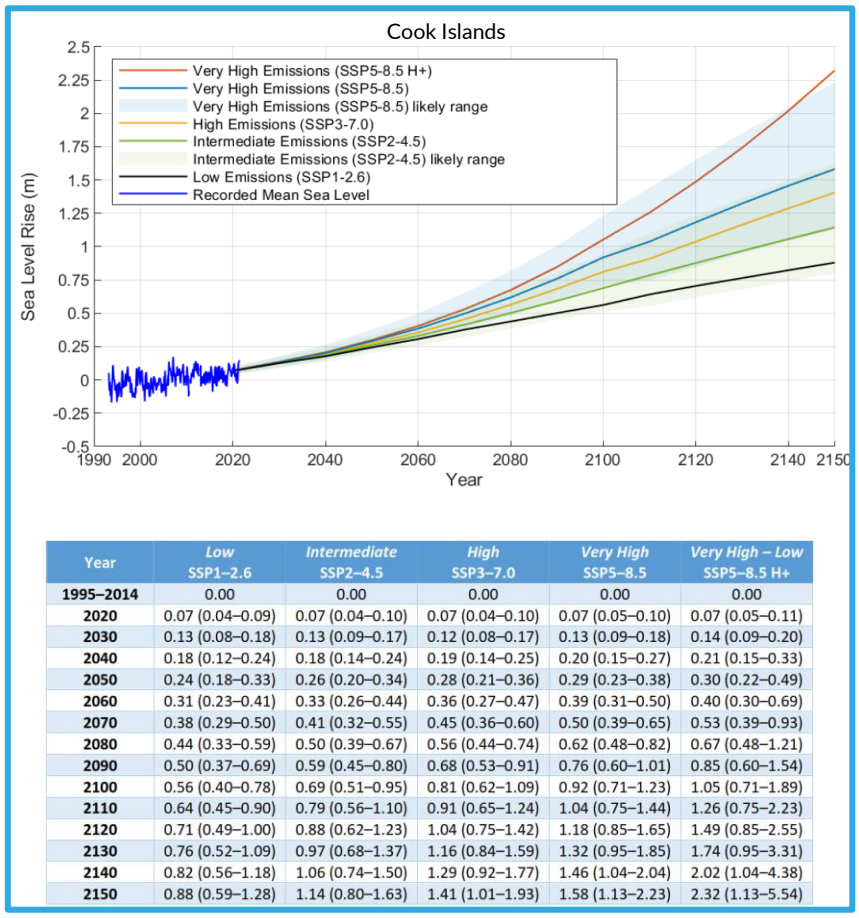
PIC Sea Level Projections



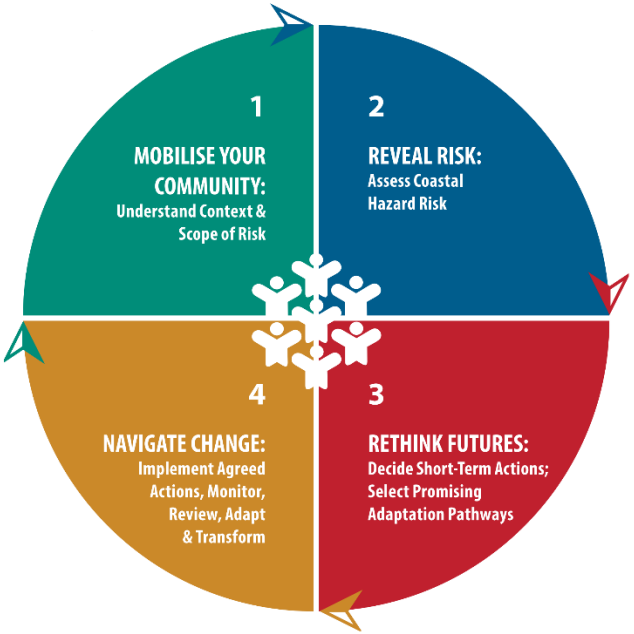


Year	*Low* SSP1–2.6	*Intermediate* SSP2–4.5	*High* SSP3–7.0	*Very High* SSP5–8.5	*Very High – Low* SSP5–8.5 H+
1995–2014	0.00	0.00	0.00	0.00	0.00
2020	0.07 (0.04–0.09)	0.07 (0.04–0.10)	0.07 (0.04–0.10)	0.07 (0.05–0.10)	0.07 (0.05–0.11)
2030	0.13 (0.08–0.18)	0.13 (0.09–0.17)	0.12 (0.08–0.17)	0.13 (0.09–0.18)	0.14 (0.09–0.20)
2040	0.18 (0.12–0.24)	0.18 (0.14–0.24)	0.19 (0.14–0.25)	0.20 (0.15–0.27)	0.21 (0.15–0.33)
2050	0.24 (0.18–0.33)	0.26 (0.20–0.34)	0.28 (0.21–0.36)	0.29 (0.23–0.38)	0.30 (0.22–0.49)
2060	0.31 (0.23–0.41)	0.33 (0.26–0.44)	0.36 (0.27–0.47)	0.39 (0.31–0.50)	0.40 (0.30–0.69)
2070	0.38 (0.29–0.50)	0.41 (0.32–0.55)	0.45 (0.36–0.60)	0.50 (0.39–0.65)	0.53 (0.39–0.93)
2080	0.44 (0.33–0.59)	0.50 (0.39–0.67)	0.56 (0.44–0.74)	0.62 (0.48–0.82)	0.67 (0.48–1.21)
2090	0.50 (0.37–0.69)	0.59 (0.45–0.80)	0.68 (0.53–0.91)	0.76 (0.60–1.01)	0.85 (0.60–1.54)
2100	0.56 (0.40–0.78)	0.69 (0.51–0.95)	0.81 (0.62–1.09)	0.92 (0.71–1.23)	1.05 (0.71–1.89)
2110	0.64 (0.45–0.90)	0.79 (0.56–1.10)	0.91 (0.65–1.24)	1.04 (0.75–1.44)	1.26 (0.75–2.23)
2120	0.71 (0.49–1.00)	0.88 (0.62–1.23)	1.04 (0.75–1.42)	1.18 (0.85–1.65)	1.49 (0.85–2.55)
2130	0.76 (0.52–1.09)	0.97 (0.68–1.37)	1.16 (0.84–1.59)	1.32 (0.95–1.85)	1.74 (0.95–3.31)
2140	0.82 (0.56–1.18)	1.06 (0.74–1.50)	1.29 (0.92–1.77)	1.46 (1.04–2.04)	2.02 (1.04–4.38)
2150	0.88 (0.59–1.28)	1.14 (0.80–1.63)	1.41 (1.01–1.93)	1.58 (1.13–2.23)	2.32 (1.13–5.54)

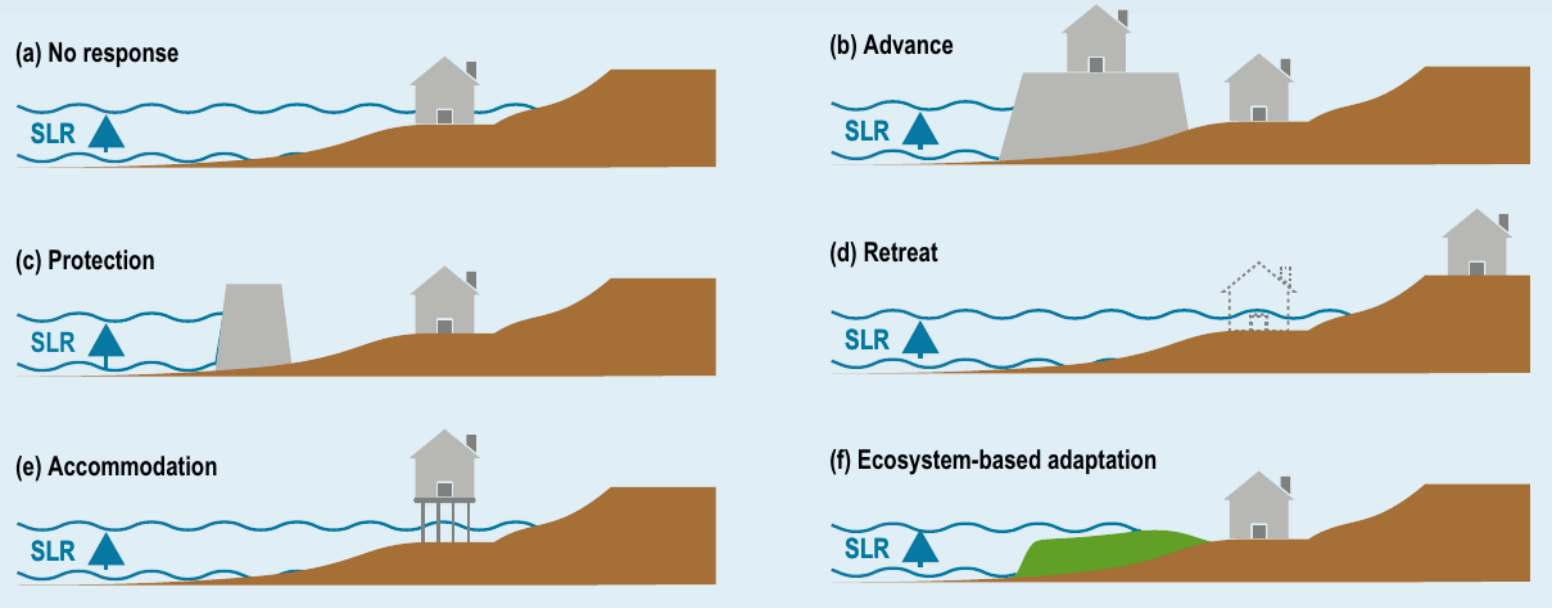
Managing Risk

Adaptative Planning Framework

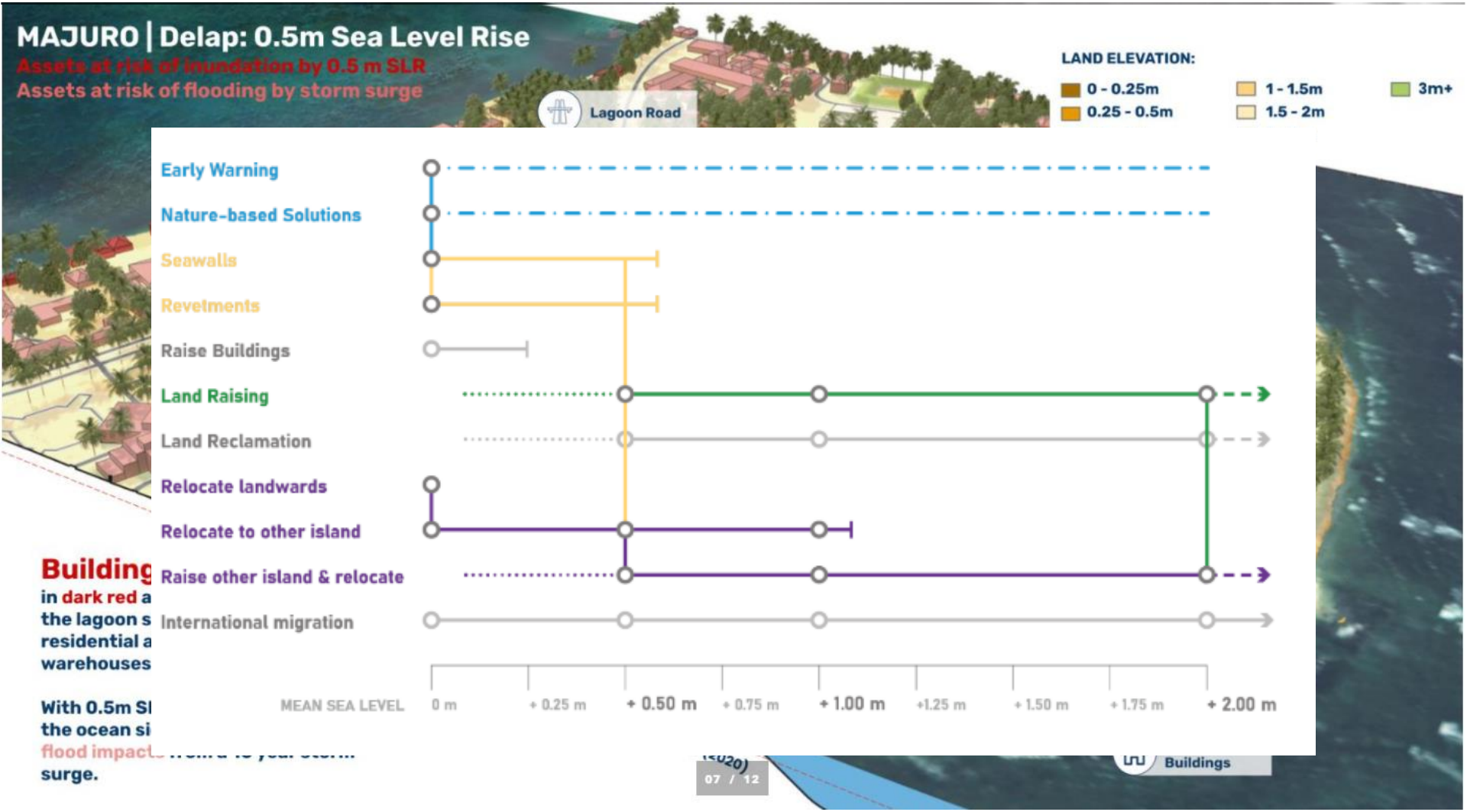
- Incorporates uncertainty and risk with the community at the centre of decision making
- Defines ways forward (pathways) despite uncertainty
- Remaining responsive to change (dynamic)



Responses to Sea Level Rise



Majuro – RMI (Pacific Resilience Programme PREP II)



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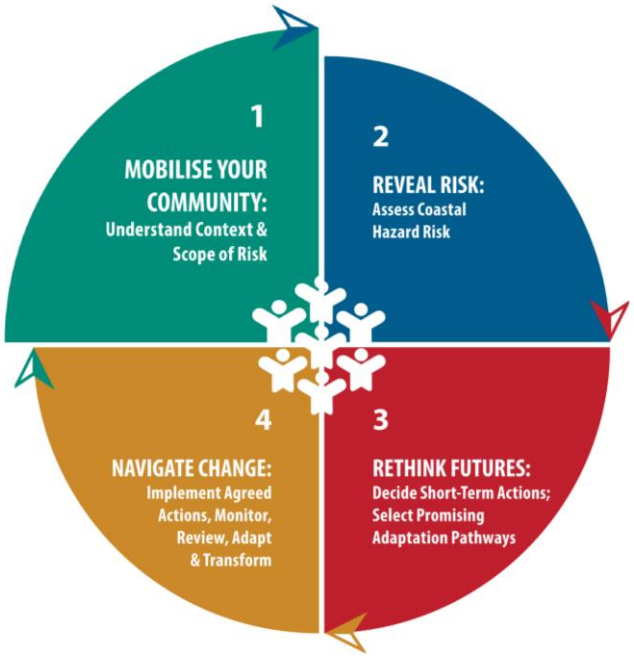
Adaptative Planning Framework – Step 1

Team	Team formation
Need	Establish the need to reduce risk
Include	Agree how to engage with community
Plan	Agree on a plan to reduce risk
Review	Review existing legislation and planning controls
Implement	Implement transitional guidance
Stocktake	Complete data stocktake



Required Inputs

Data	Derived information	Use
GIS Infrastructure Type and location	GIS spatial information of infrastructure type, extent, and location	• Mapping to define risk exposure • Quantification of vulnerability • Development of adaptation options
Sea level record	-Tidal elevations -Storm surge -Sea level maxima -Establishment of datums	• Land-sea boundary definition • Boundary conditions or calibration data for numerical models • Component of probabilistic sea level analysis
LIDAR Topography and Bathymetry	Land and seabed levels	• Input for hydrodynamic numerical models • Geographic information system hazard mapping • Definition of coastal features
Aerial photography	Maps	• Shoreline and land use change
Wave record	Wave height period and direction	• Boundary conditions or calibration data for numerical models • Extreme wave frequency-magnitude distribution • Input to empirical wave setup and runup models • Monitor wave climate variability and climate change effects on waves
Beach profile records	Beach slope, position, and volume	• Input to wave setup and run up models • Input to beach erosion models and validation of post storm effects.
Historical storm tide and elevation	Coastal hazard markers and elevation	• Verification data for coastal storm inundation and beach erosion models.
Meteorology	Wind velocity, air pressure and rainfall	• Input to hydrodynamic or empirical storm surge and wave models
Sediment composition	Sediment grain size	• Beach erosion models
Piezometer	Ground water levels	• Groundwater level and salinity response to sea level change.

Transitional Guidance

Planning

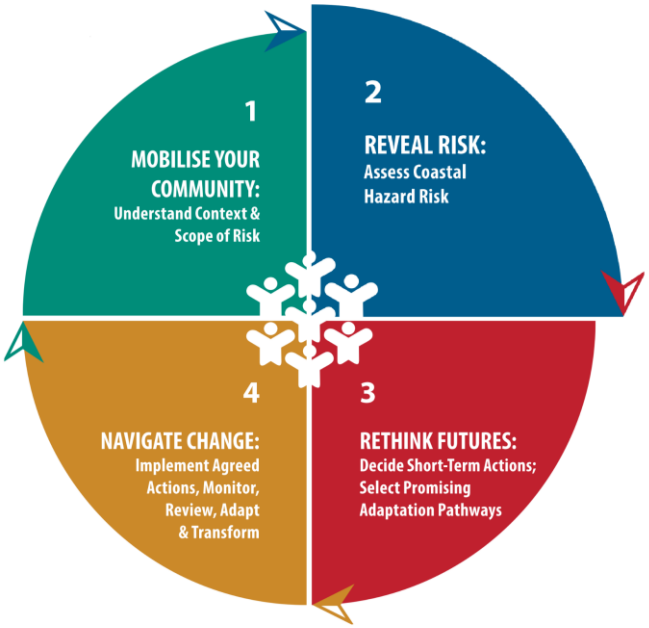
Category	Description	Minimum Transitional Response
A	Coastal subdivision, greenfield developments, and major new infrastructure.	**Avoid** risk and apply median *Very High Emissions – Low Confidence* scenario (SSP5–8.5 H+) with a 100-year planning timeframe.
B	Changes in land use and redevelopment including intensification.	**Adapt** to hazards by conducting risk assessment using the range of median *Intermediate* to *Very High Emissions* scenarios (SSP2–4.5 to SSP5–8.5).
C	Land use planning controls for existing coastal development and infrastructure planning.	**Accommodate** risk and apply 83rd percentile of the *Intermediate Emissions* scenario (SSP2–4.5) with reference to the respective planning timeframe.
D	Non habitable short-lived assets with a function that needs to be in the coastal zone and is readily adaptable.	Median *Intermediate Emissions* (SSP2–4.5) projection with reference to respective planning timeframe.

Engineering

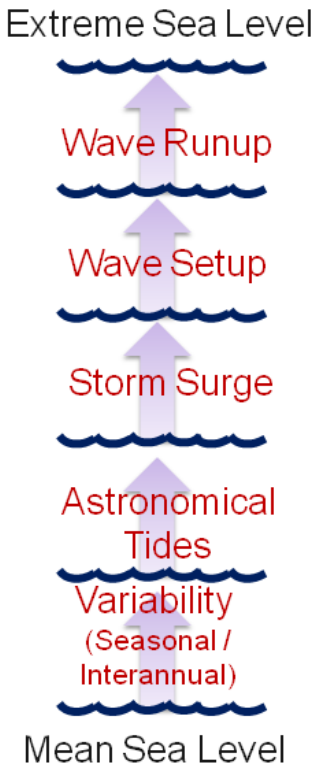
Consequence of Failure	Description	Importance Level	Minimum Transitional Response
Low	Low consequence for loss of human life, or small or moderate economic, social, or environmental consequence.	1	Minor structures (failure not likely to endanger human life. Adopt median *Intermediate Emissions* (SSP2–4.5) projection considering design life.
Ordinary	Medium consequence for loss of human life, or considerable economic, social, or environmental consequence.	2	Normal structures not falling into other levels. Adopt median *High Emissions* (SSP3–7.0) projection considering design life.
High	High consequence for loss of human life, or very great economic, social, or environmental consequence.	3	Major structures and critical infrastructure. Adopt median *Very High Emissions* (SSP5–8.5) projection considering design life.
		4	Post disaster structures. Adopt median *Very High Emissions* (SSP5–8.5 H+) projection considering a minimum design life of 100 years.

Adaptative Planning Framework – Step 2

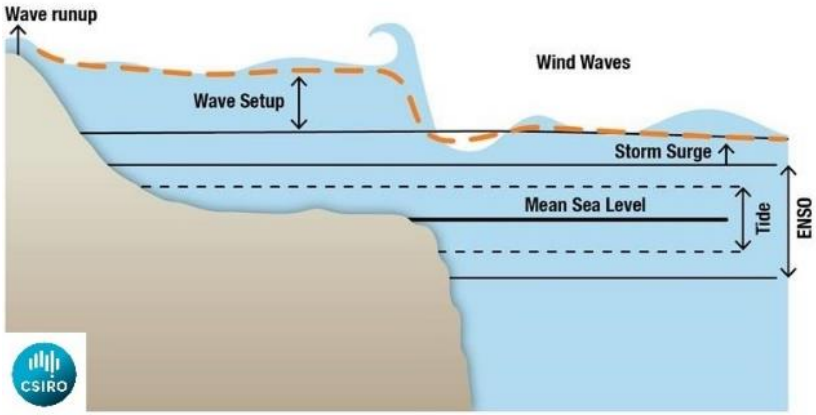
Define Risk	Describe possible hazards and occurrence
Vulnerability	Assess vulnerability to sea level rise and exacerbation of coastal hazards
Assess	Assess risk utilizing community knowledge



Sea Level Variability

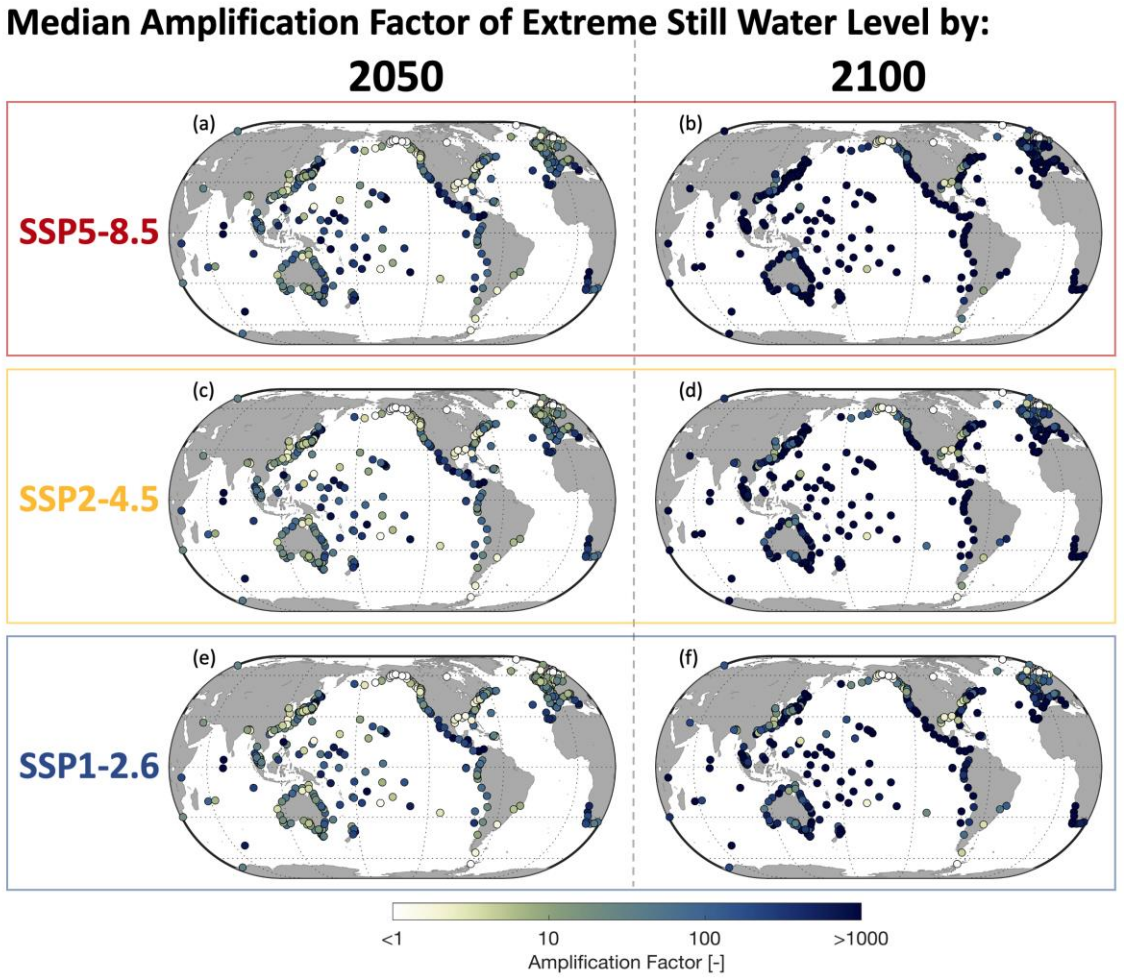


CAUSES	TIME SCALE	SPACE SCALE
swell/wind waves	seconds	wave shoaling zone 10s-100s of metres
Storms (pressure, wind stress)	hours	----------
----------	hours to days	continental shelf 10s-100s of kilometres
lunar and solar gravity	hours to decades	----------
----------	----------	ocean basin 1000s of kilometres
ocean/ atmosphere climate variability	months to years	



Change in regional extremes

- PIC King Tide exceedance (1%) to an average of 31% (14-66%) by 2050.
- 1 in 100 year sea level will be less than a 1 year event by 2050.



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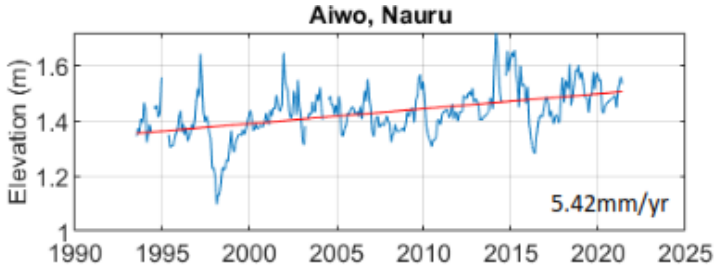
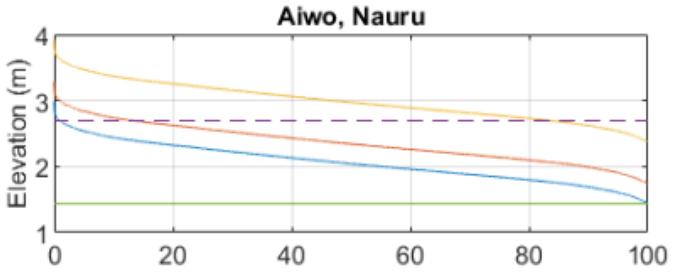
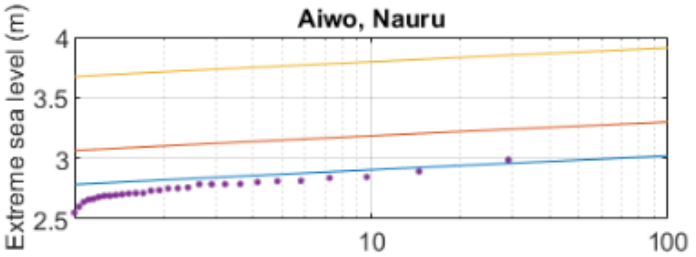
Initial Vulnerability Assessment

Site Data	Source critical input data
Datums	Define study datums
Sea Levels	Define reference sea levels
Projections	Apply sea level projections
Wave Setup	Assess wave setup for extreme conditions
Compile	Finalize inundation levels
Map	Map inundation to land elevations
Define Risk	Assess infrastructure risk







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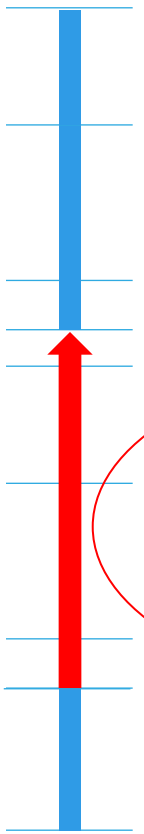
Initial Sea Level Rise Risk Assessment- Nauru



4.82m 1 in 100-year sea level

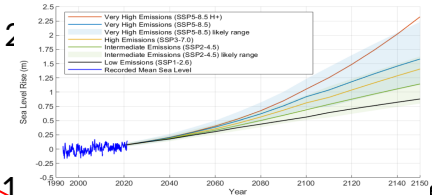
3.68m King tide

2.39-2.55m 17%/1% Mean Sea Level Anomaly

2.33m Mean Sea Level

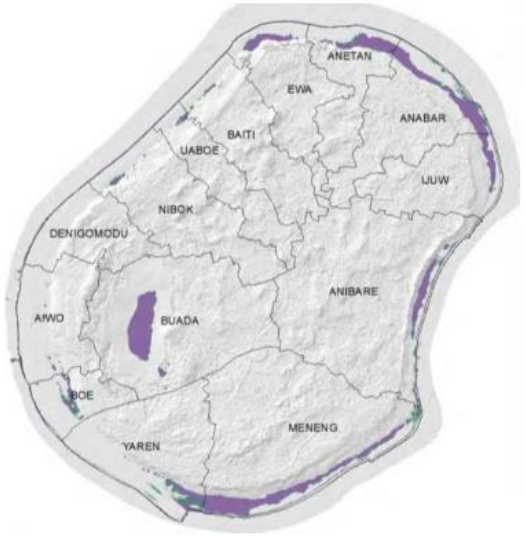
3.24m 1 in 100-year sea level

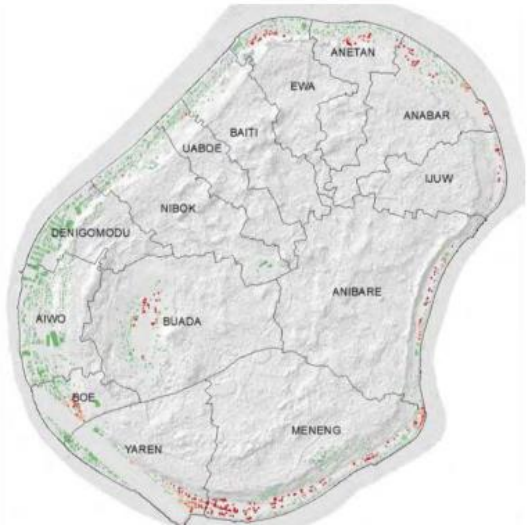
Sea Level Rise (e.g. 0.93m)



1.40m Mean Sea Level

0m NID Datum





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TA Outcome

- Updated sea level guidance based on AR6
- Provides an approach to start the adaptative management process to manage risk
- Provides base data to inform hazard delineation
- Provides interim guidance to manage risk
- Provides recommendations to progress sea level rise risk assessment

Thank You

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