



SCAR SCIENCE LECTURE 2022

Antarctic Climate Change and the Environment

A synopsis and recommendations for
action

Hans-O. Pörtner,
XLIV Antarctic Treaty Consultative Meeting

BERLIN, MAY 24 2022


[NASA earth observatory]

...Observations of increasing human impacts on the Antarctic

- Ocean warming
- Ice melt
- Ocean acidification
- Ocean oxygen loss
- Fishing, Pollution, Tourism
- Invasive species
- Human activities

...Will we be able to keep the (global) benefits of a stable Antarctic?

- Stable sea level
- Engine of global ocean circulation
- Biodiversity distribution and pump
- Reducing climate change through heat and carbon uptake (cooling of the planet)

A large, blue-tinted iceberg floats in the ocean. The iceberg has a jagged, layered top and a steep, vertical face. The water is dark blue with gentle ripples. The sky is overcast with soft, grey clouds. A semi-transparent blue rectangle is overlaid on the left side of the image, containing white text.

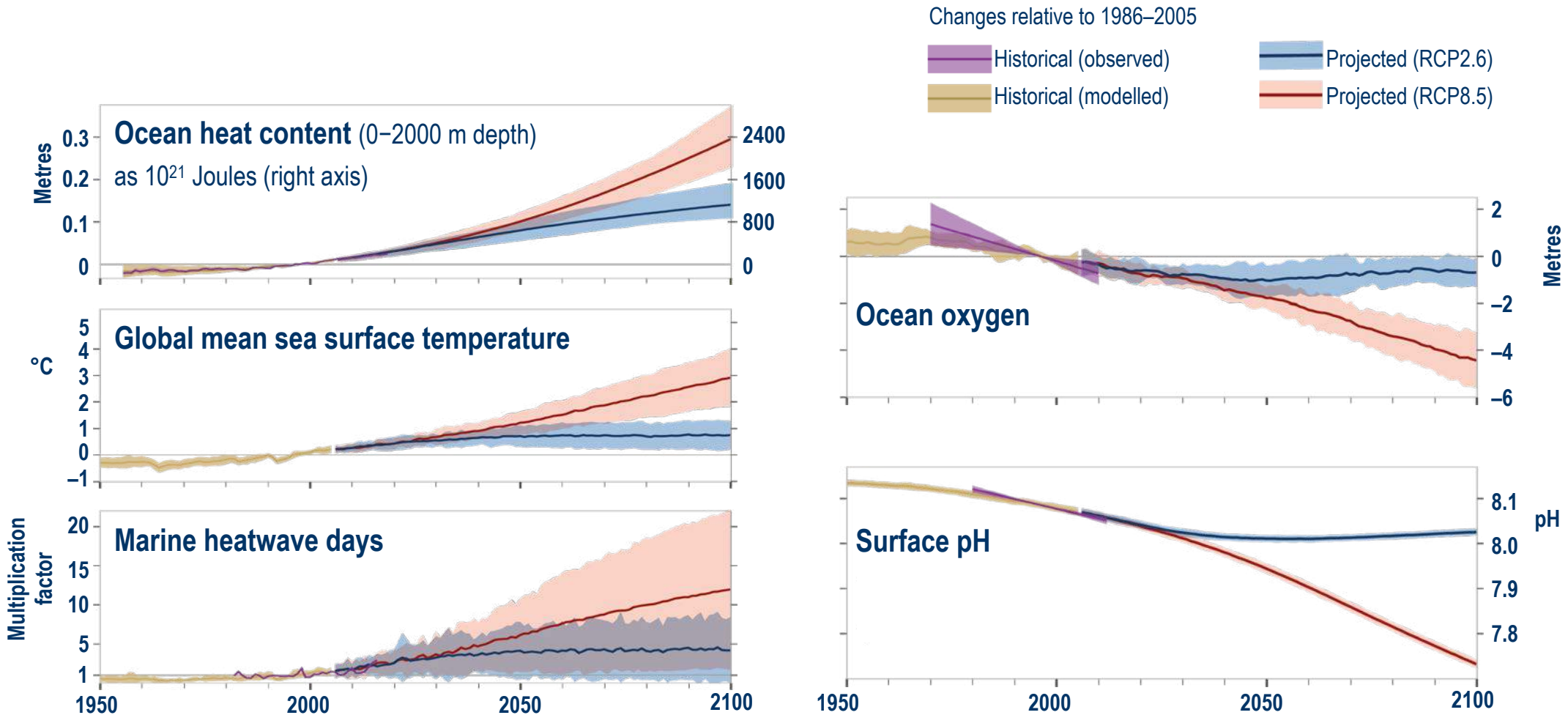
The Antarctic may seem far away, but it provides crucial services to all life around the world... and can provide challenging feedbacks... Our actions today determine its future as well as ours.

A humpback whale is captured mid-breach, its large, dark, curved tail fluke rising out of the water. The background features a range of rugged, snow-covered mountains under a clear sky. The water in the foreground is dark with gentle ripples.

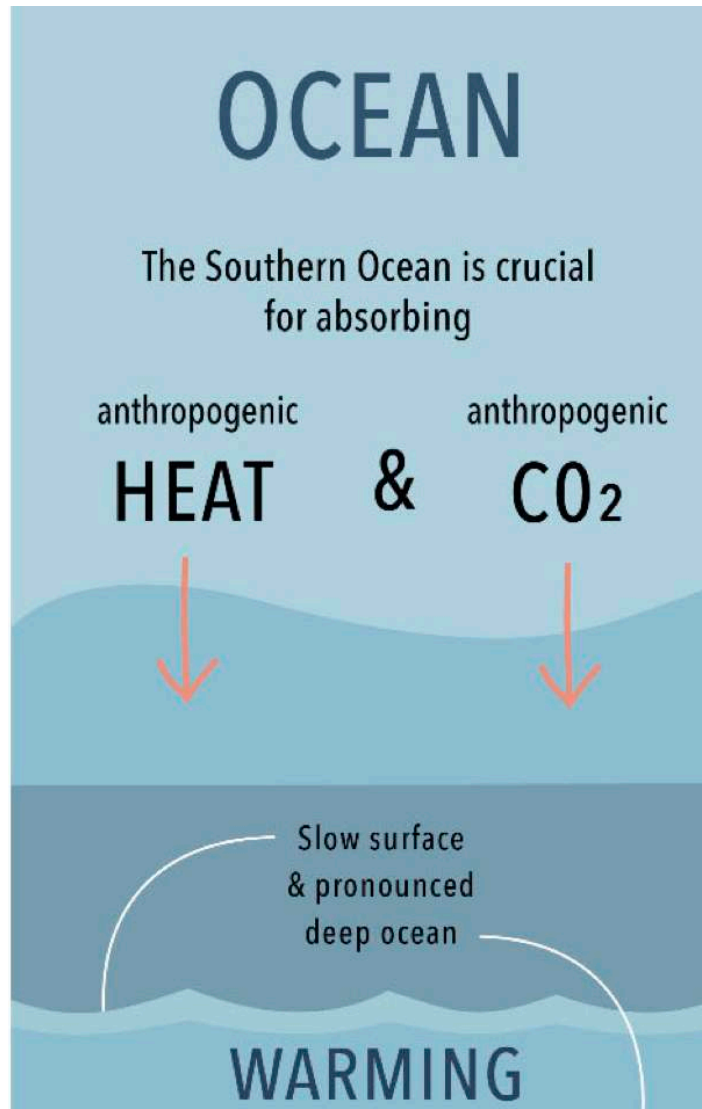
...in the global context

From the latest IPCC reports &
SCAR ACCE decadal synopsis

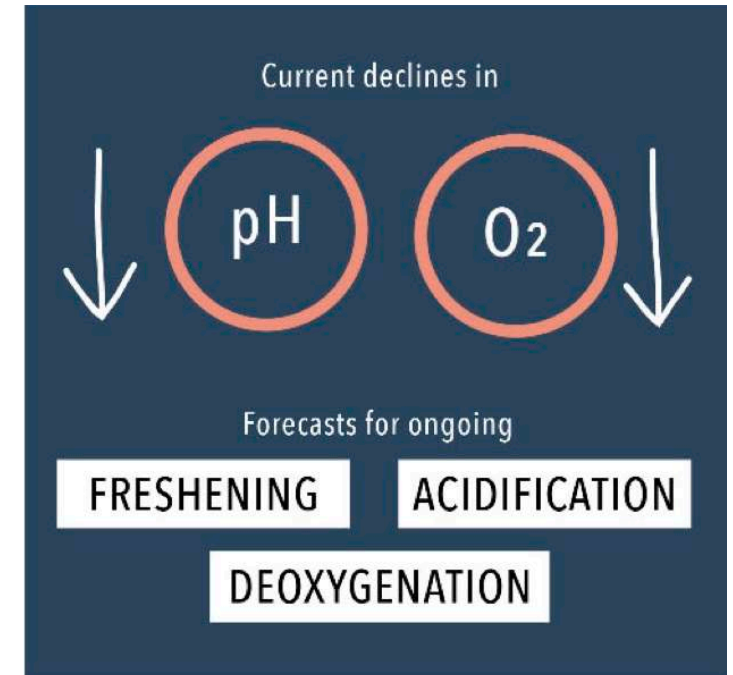
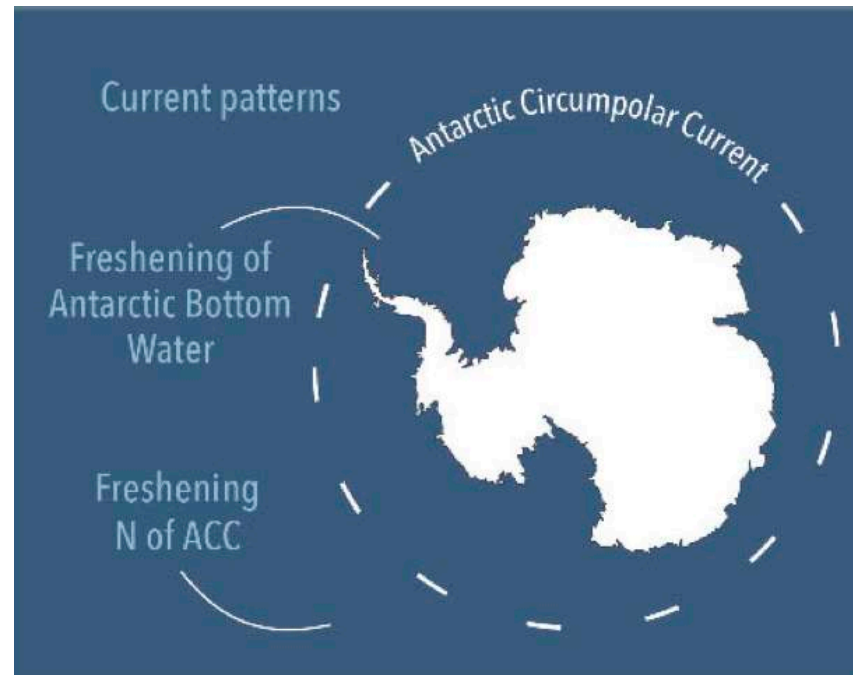
The ocean is projected to transition to unprecedented conditions



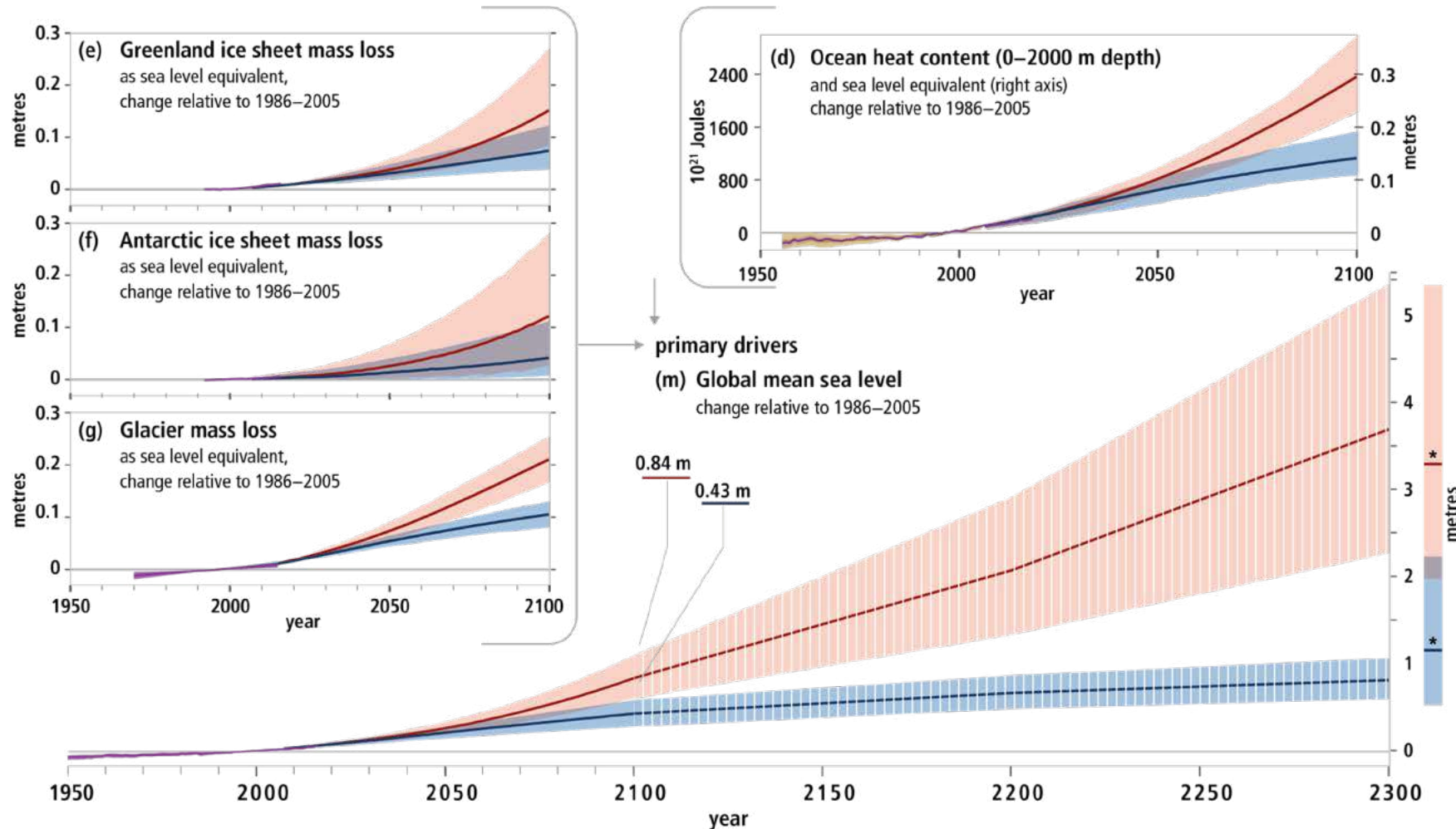
Antarctic contribution...



Ongoing changes reflect the crucial role of the Southern Ocean in the global climate system ...
at the expense of climate impacts on marine ecosystems



Processes contributing to global sea level rise (metres)



... according to present knowledge... we have **choices between below 1 metre or several metres by 2300** due to

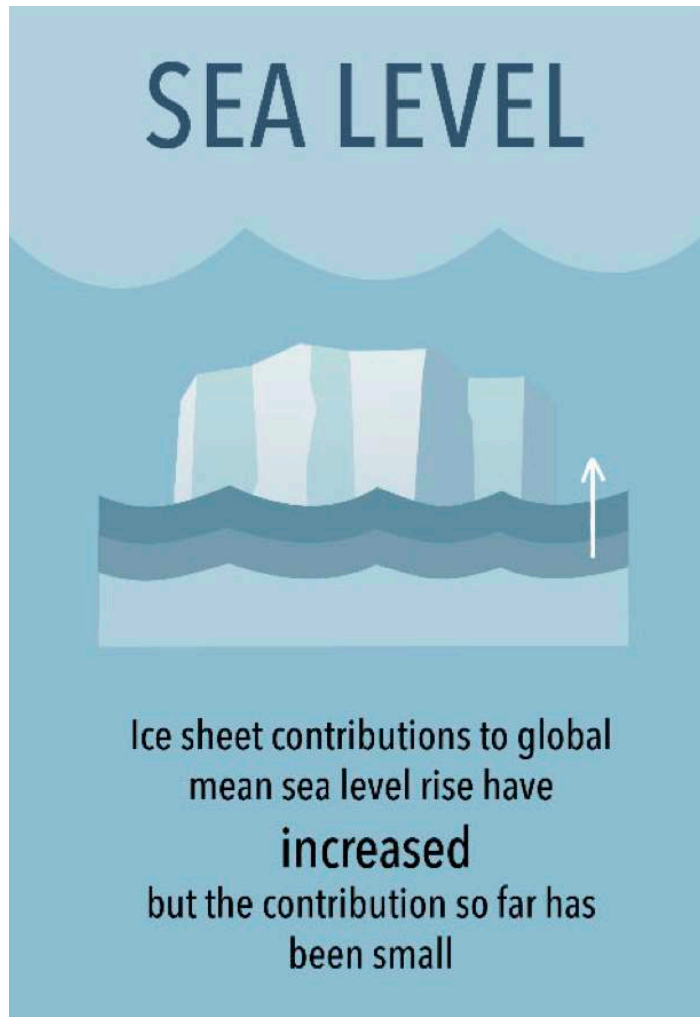
- Thermal expansion
- Glacier melt
- Ice sheet melt

~1.5°C

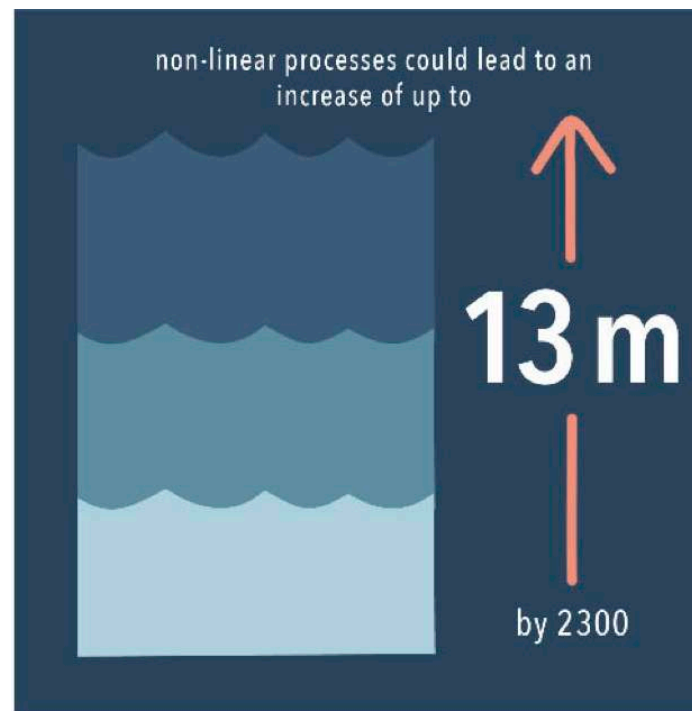
Historical changes (observed and modelled) and projections under RCP2.6 and RCP8.5 for key indicators

Historical (observed)
 Historical (modelled)
 Projected (RCP2.6)
 Projected (RCP8.5)

Antarctic contribution



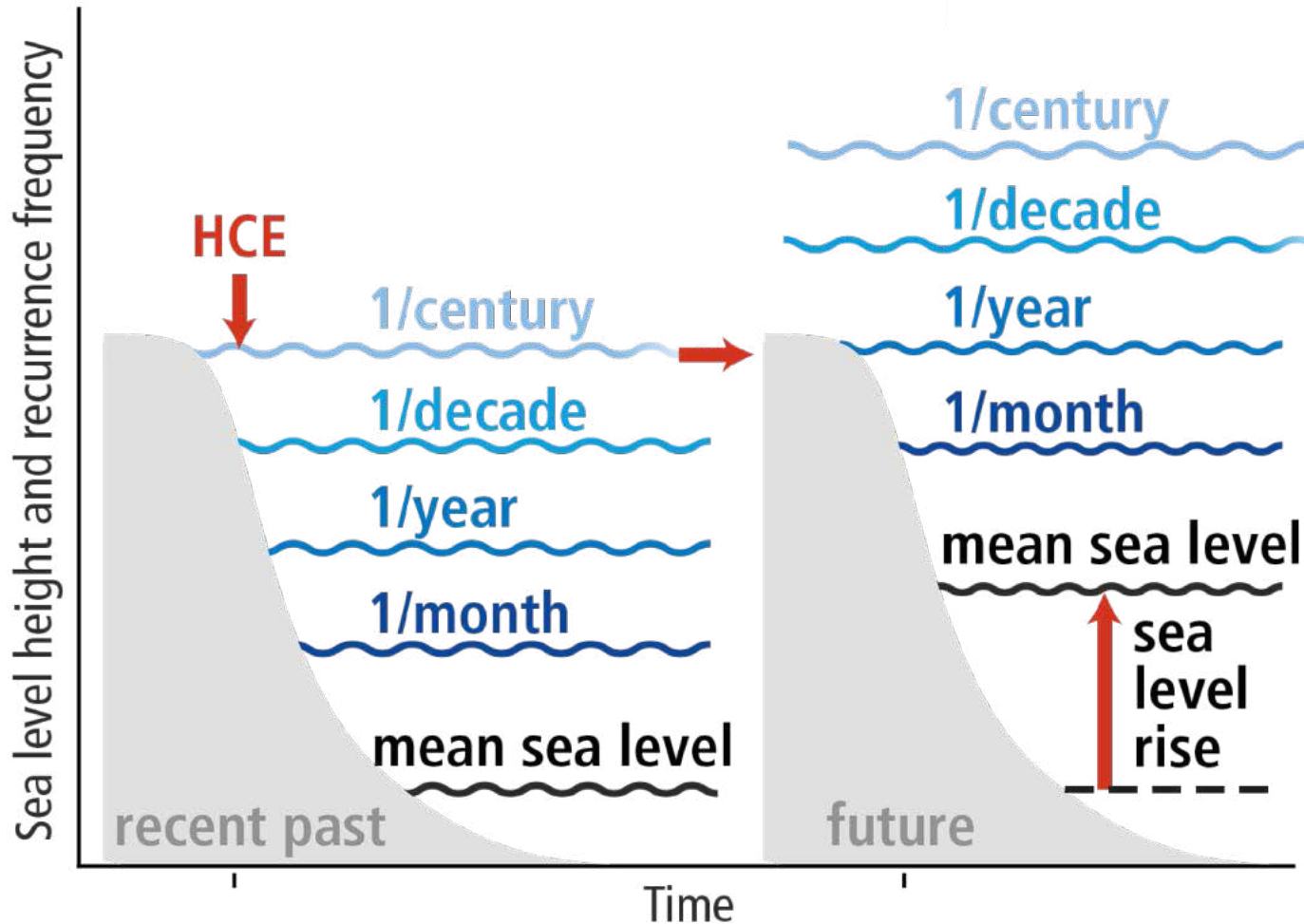
High uncertainty in the Antarctic contribution to global sea level rise.



e.g. due to ice cliff instability

The most significant global influence of Antarctic changes will be on mean sea level rise and its influence on society and nature in all coastal regions.

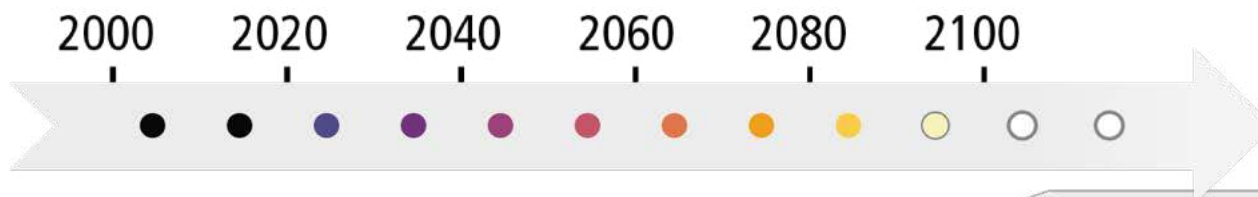
Extreme sea levels rise progressively at most locations



- Historical Centennial Events (HCE) become more common
- Many low-lying coastal cities and small islands will be exposed to risks of flooding and land loss annually by 2050

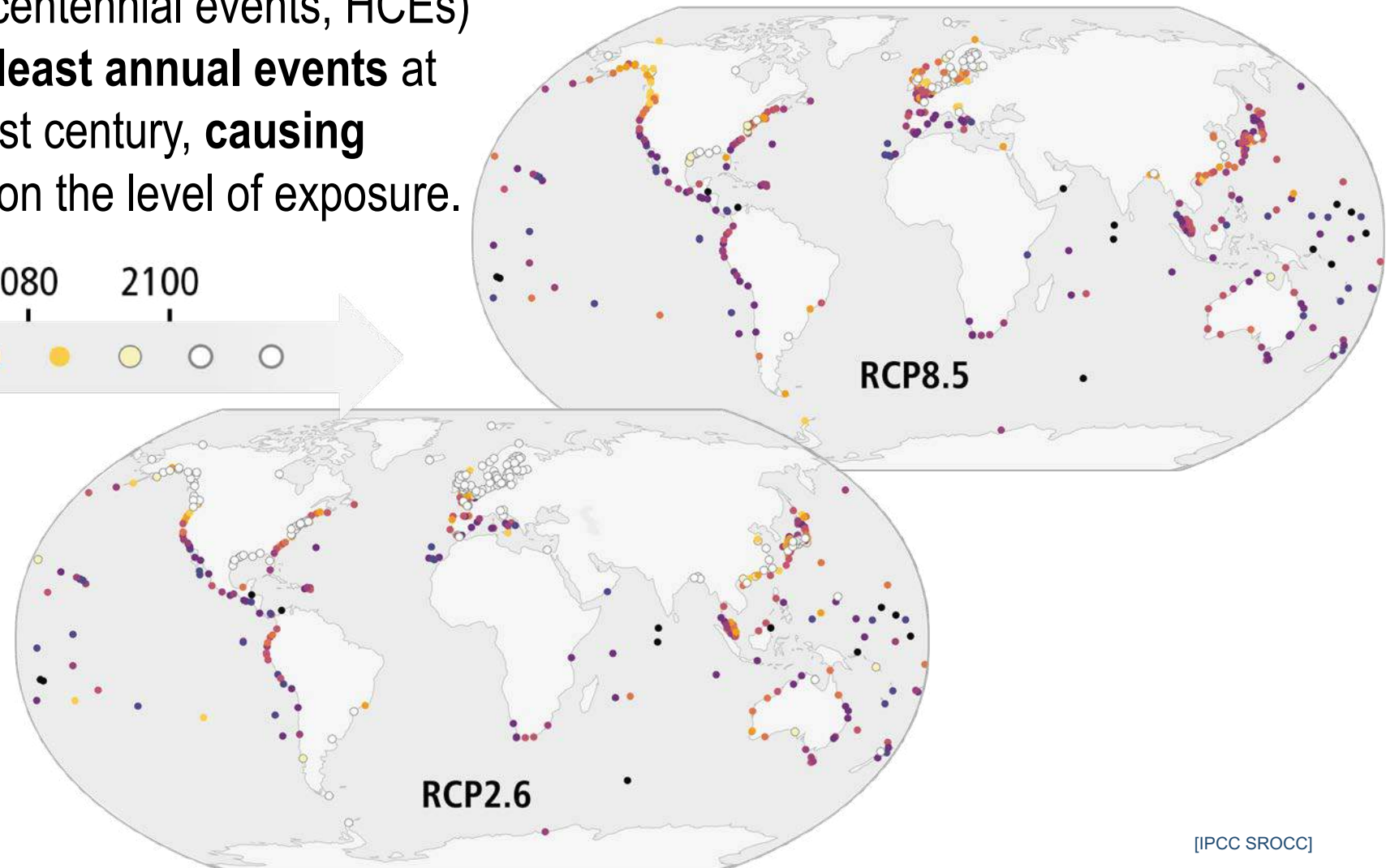
Extreme sea levels rise progressively

Local extreme sea levels that historically occurred once per century (historical centennial events, HCEs) are projected to **become at least annual events** at most locations during the 21st century, **causing severe impacts** depending on the level of exposure.

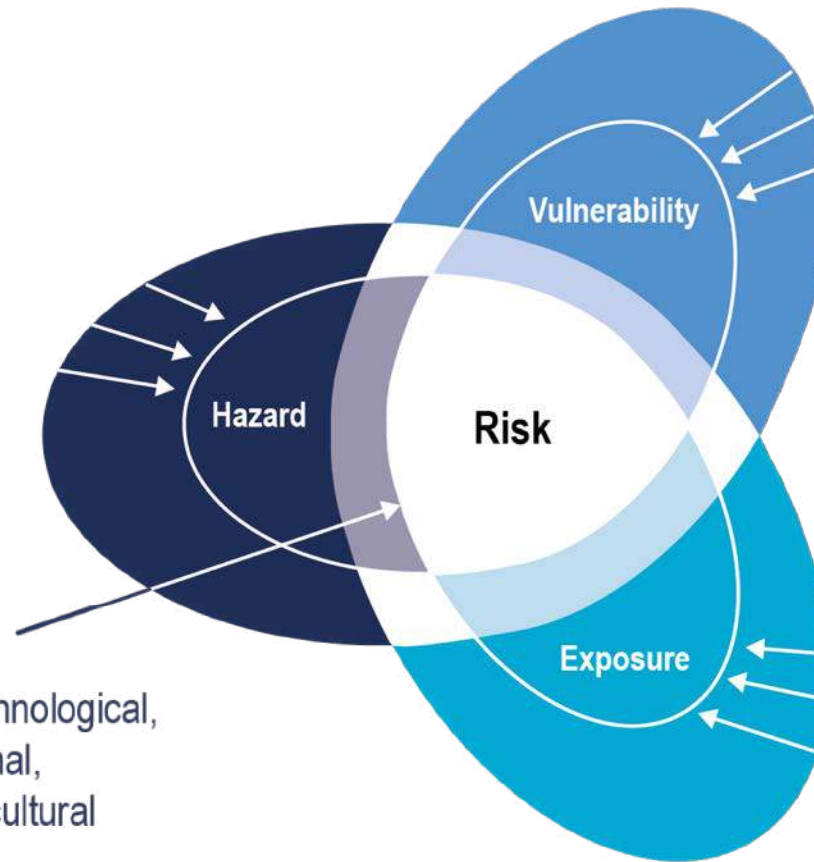


Black dots: Locations where HCEs already recur annually

White dots: Locations where HCEs recur annually after 2100



Evaluating risks



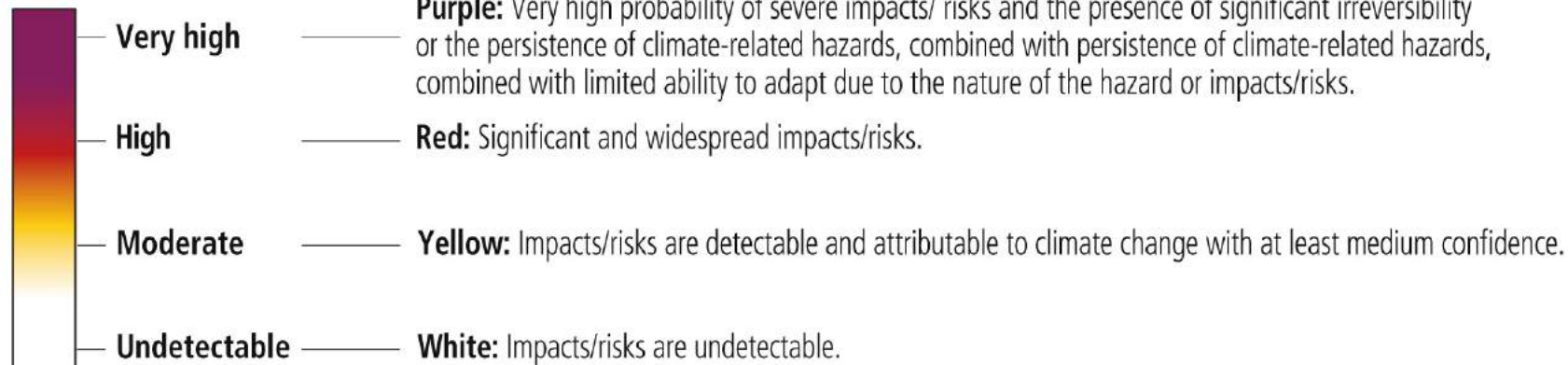
The IPCC concept of risk

Climate action entails
risk reduction by
adaptation and mitigation
.... considering limits to
adaptation

Limits to Adaptation

- E.g. physical, ecological, technological, economic, political, institutional, psychological, and/or socio-cultural

Level of added impacts/risks



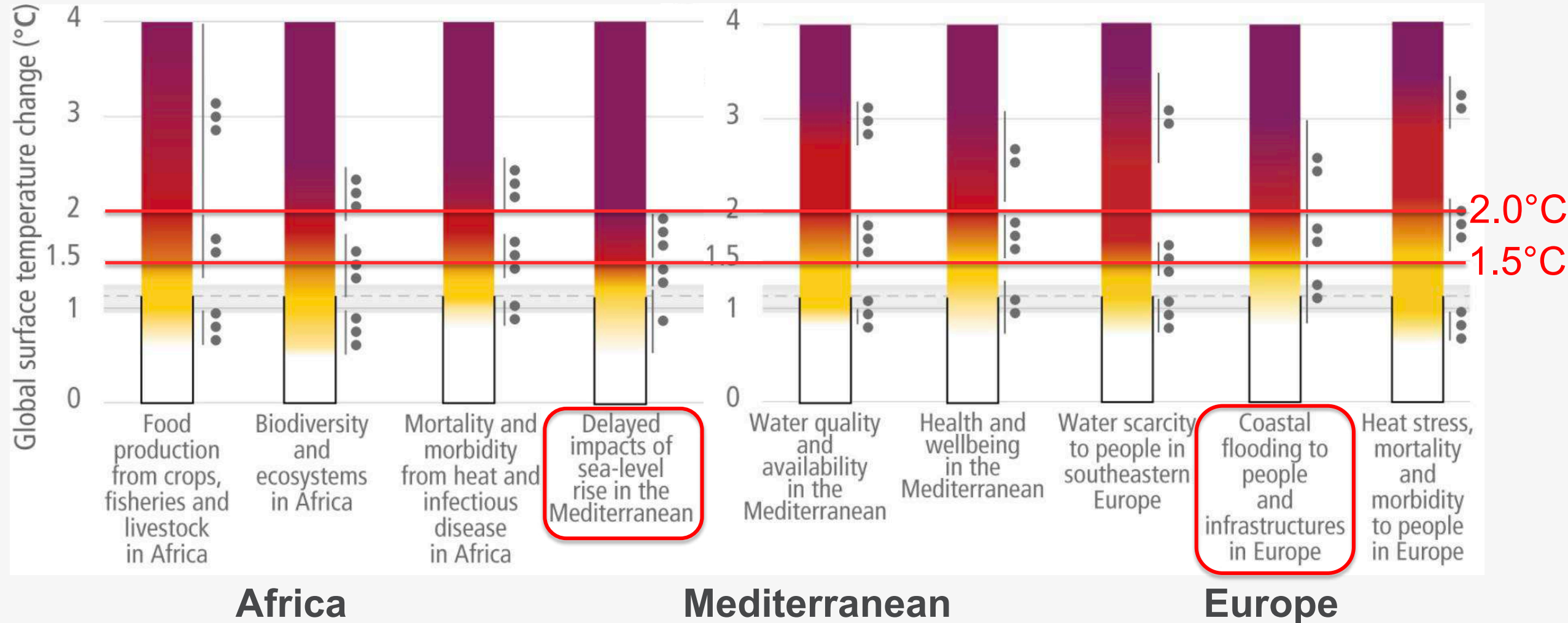
Confidence level for transition

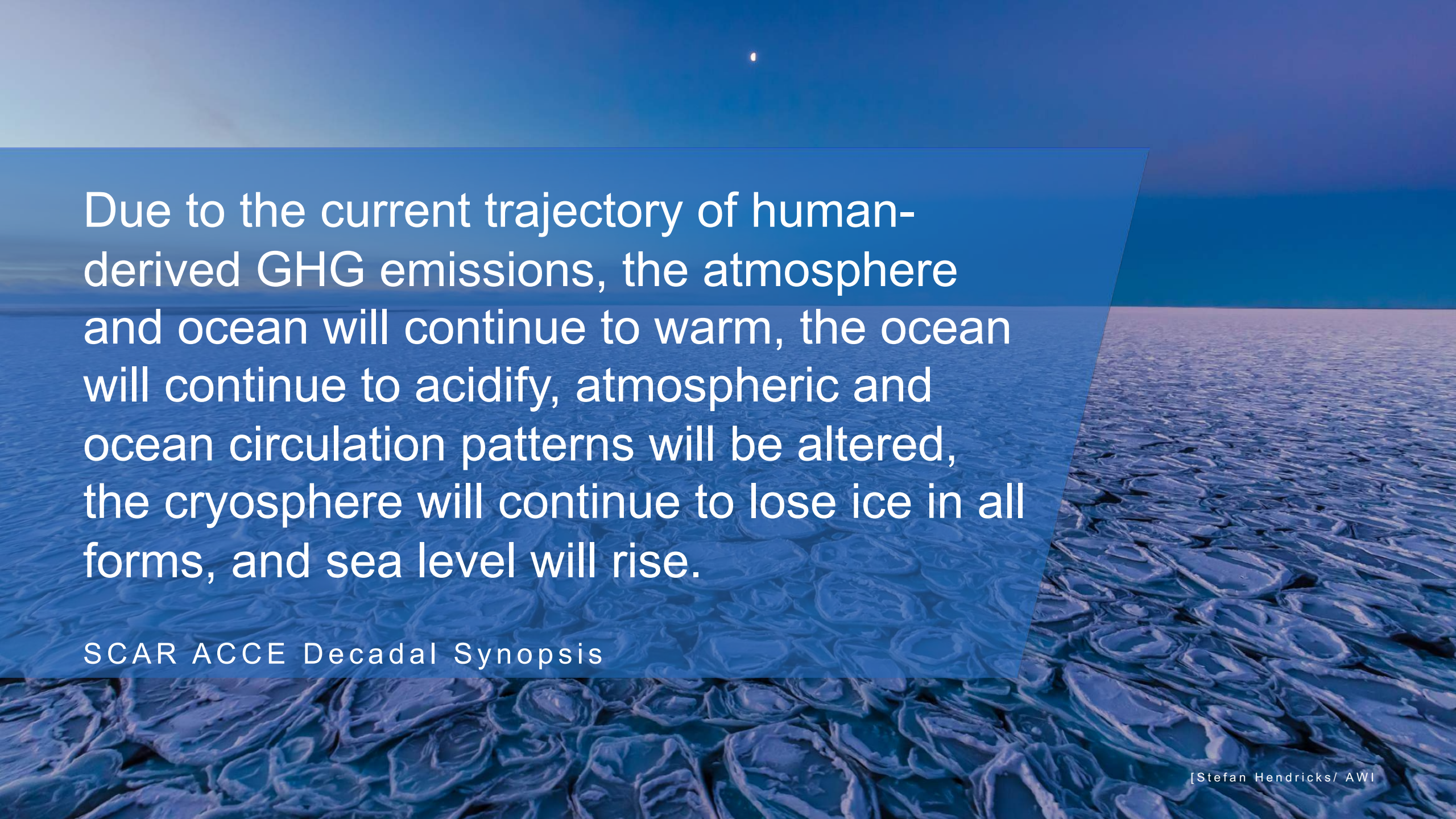
- = Very high
- = High
- = Medium
- = Low
- | = Transition range

**see figure caption for definition

Global and regional risk provide orientation for action (adaptation/mitigation)

... avoiding high risk by keeping global warming below 1.5°C





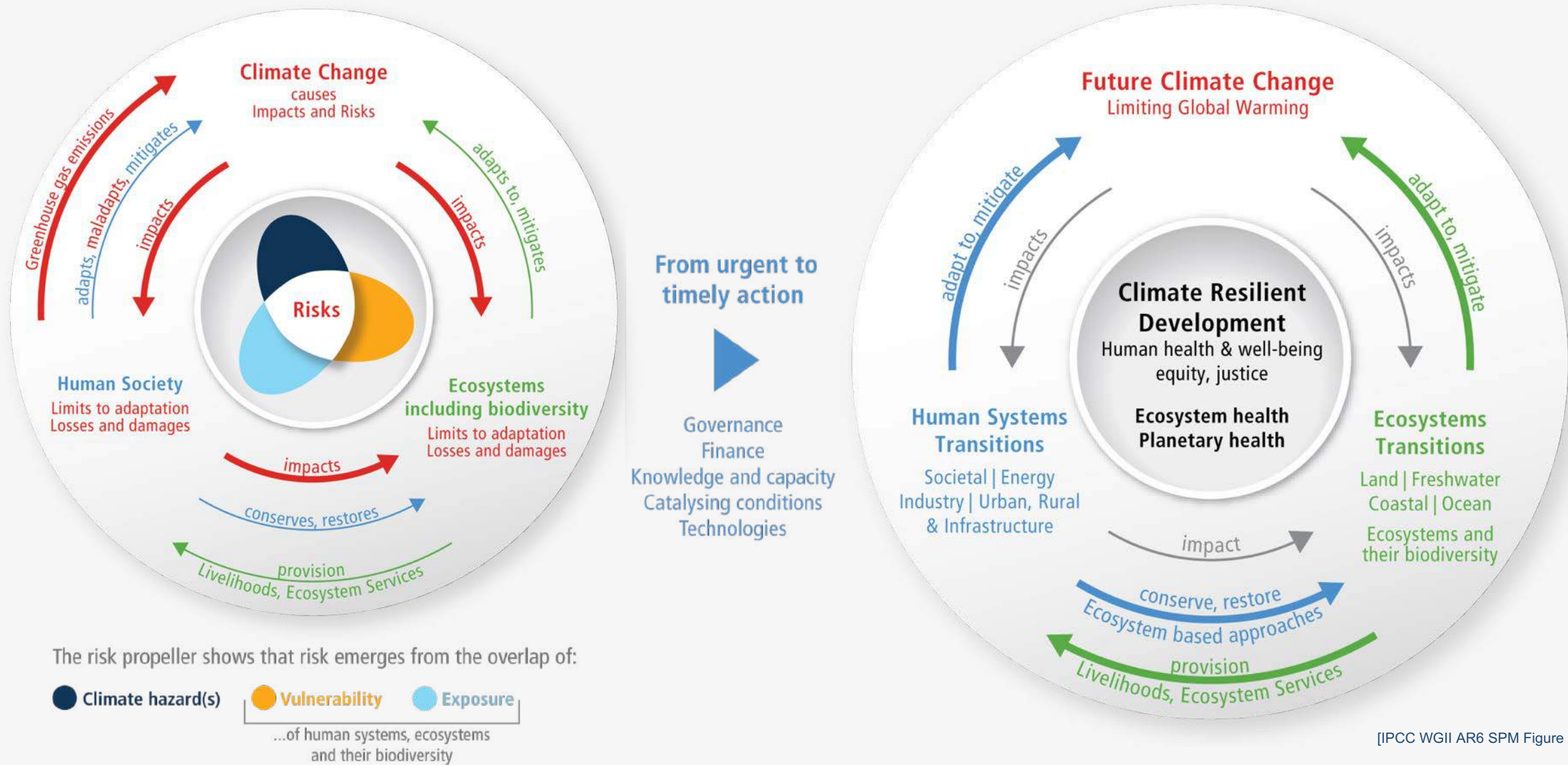
Due to the current trajectory of human-derived GHG emissions, the atmosphere and ocean will continue to warm, the ocean will continue to acidify, atmospheric and ocean circulation patterns will be altered, the cryosphere will continue to lose ice in all forms, and sea level will rise.

SCAR ACCE Decadal Synopsis

Antarctic contributions to global change support the synthetic view by IPCC 2022:

From current imbalance ...

... towards a sustainable future

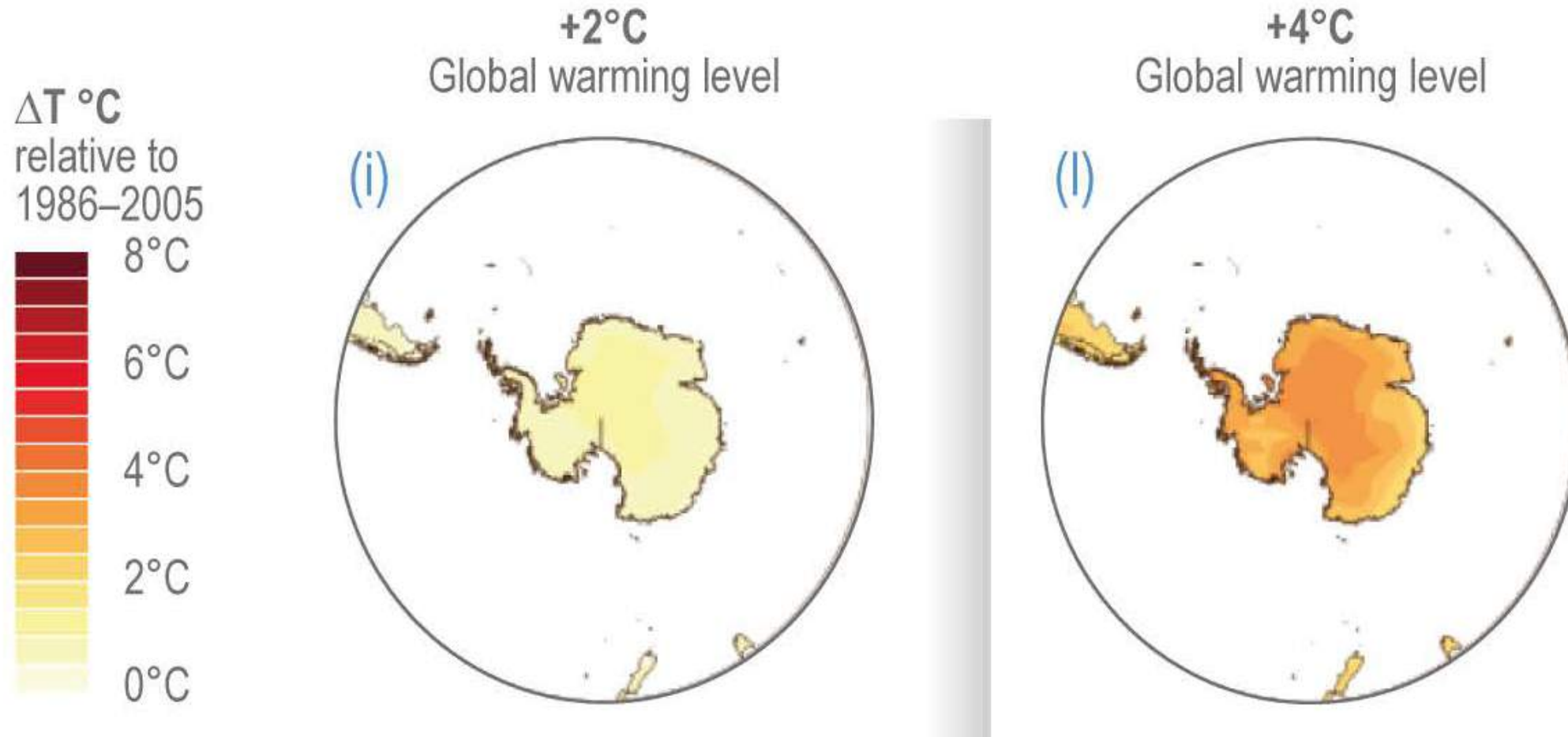


A photograph of an Antarctic landscape. The foreground is covered in dense, low-lying green vegetation, possibly moss or algae, interspersed with dark, rounded rocks. In the background, there are snow-capped mountains under a clear blue sky with a few wispy clouds. A semi-transparent blue rectangle is overlaid on the left side of the image, containing the title text.

Impacts in the Antarctic

Antarctic changes:

Projected Temperature changes over land



Life on Land is changing

- The Antarctic Peninsula and parts of West Antarctica are seeing increases in the abundance and distribution of a variety of Antarctic plants
- Growth rates have increased
- Species replacement has occurred in East Antarctica and the Dry Valleys
- Future changes in ranges and populations are uncertain with little long-term data

Forecast:

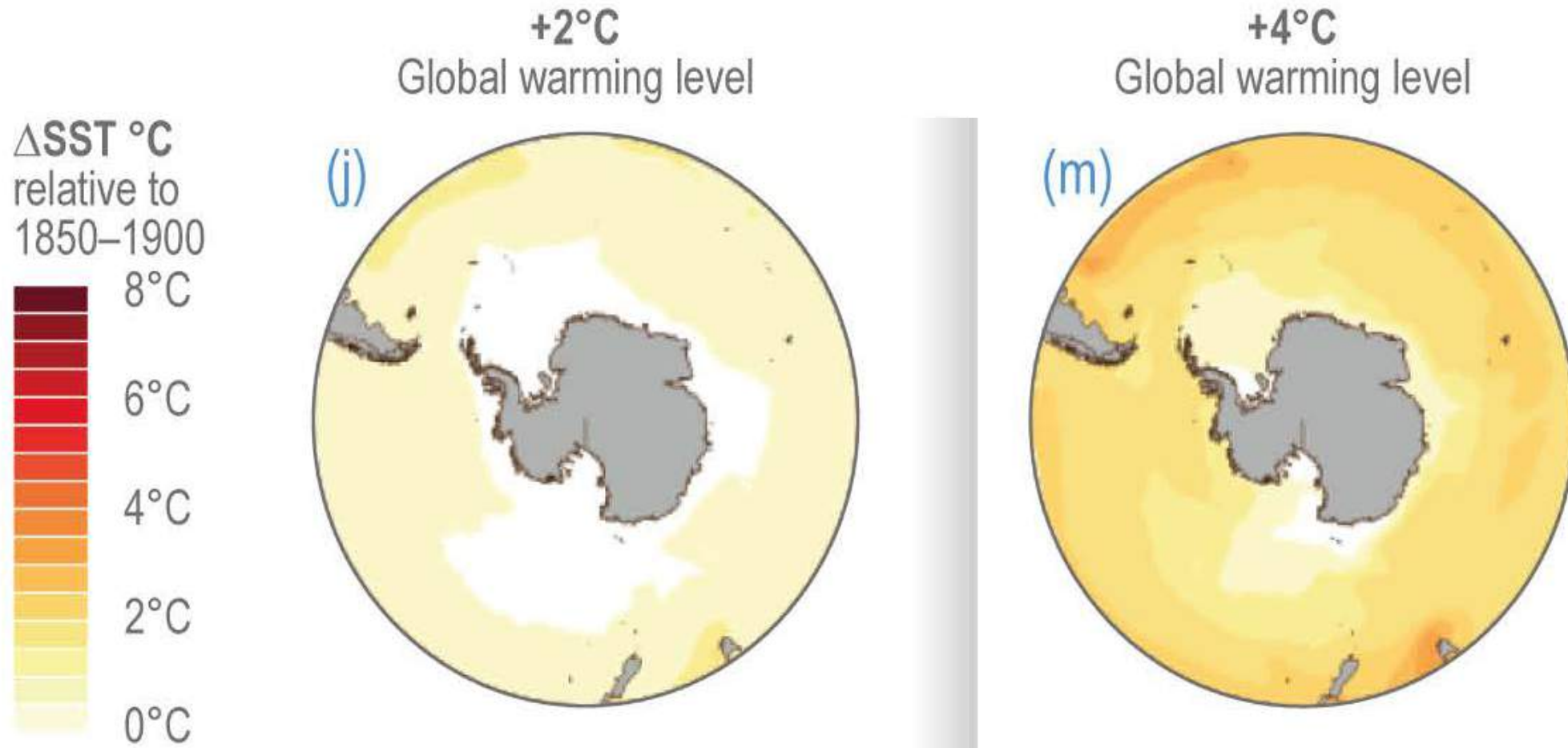
- The number and distribution of invasive species will increase



Antarctic changes:

Projected Sea Surface Temperatures (SSTs)

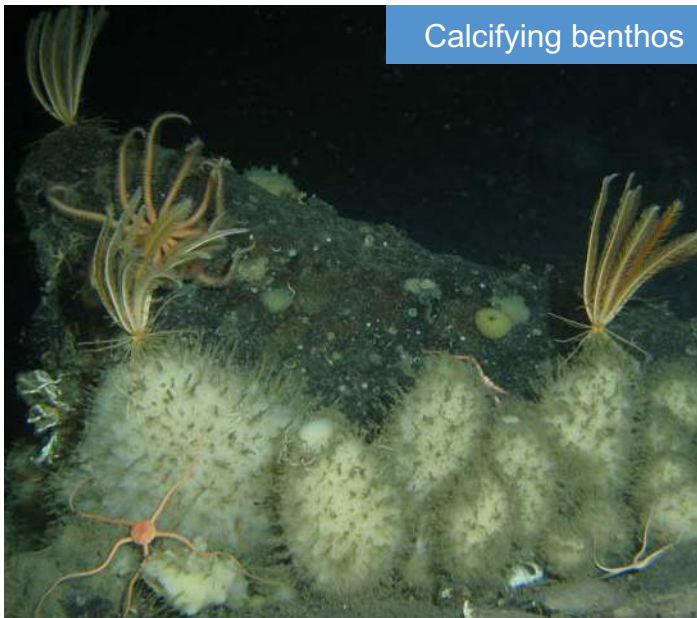
– approaching and surpassing the thermal tolerance limits of marine fauna



Antarctic changes:

Marine fauna is threatened by climate change

Observations, modelling and global assessments describe significant changes in Antarctic physical and living systems. Antarctic species and systems are highly vulnerable.



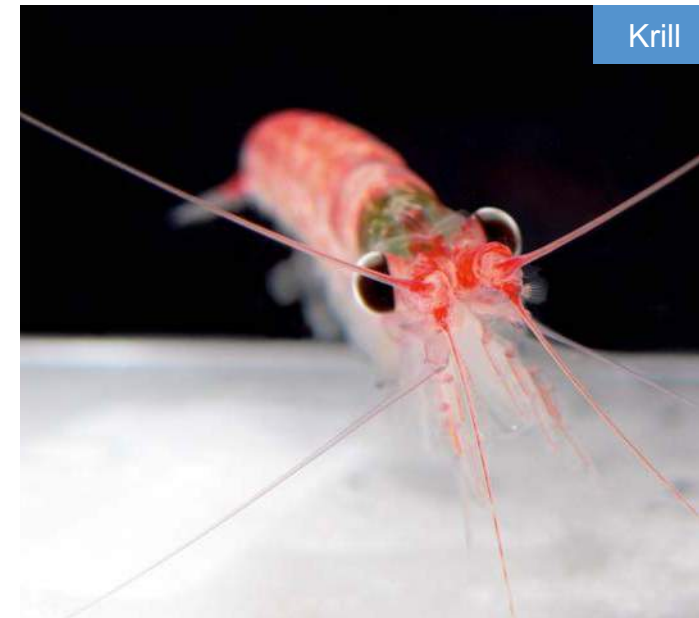
Calcifying benthos

Invasion/expansion of crabs as crushing predators due to warming



Weddell-Sea icefish breeding colony

High thermal vulnerability

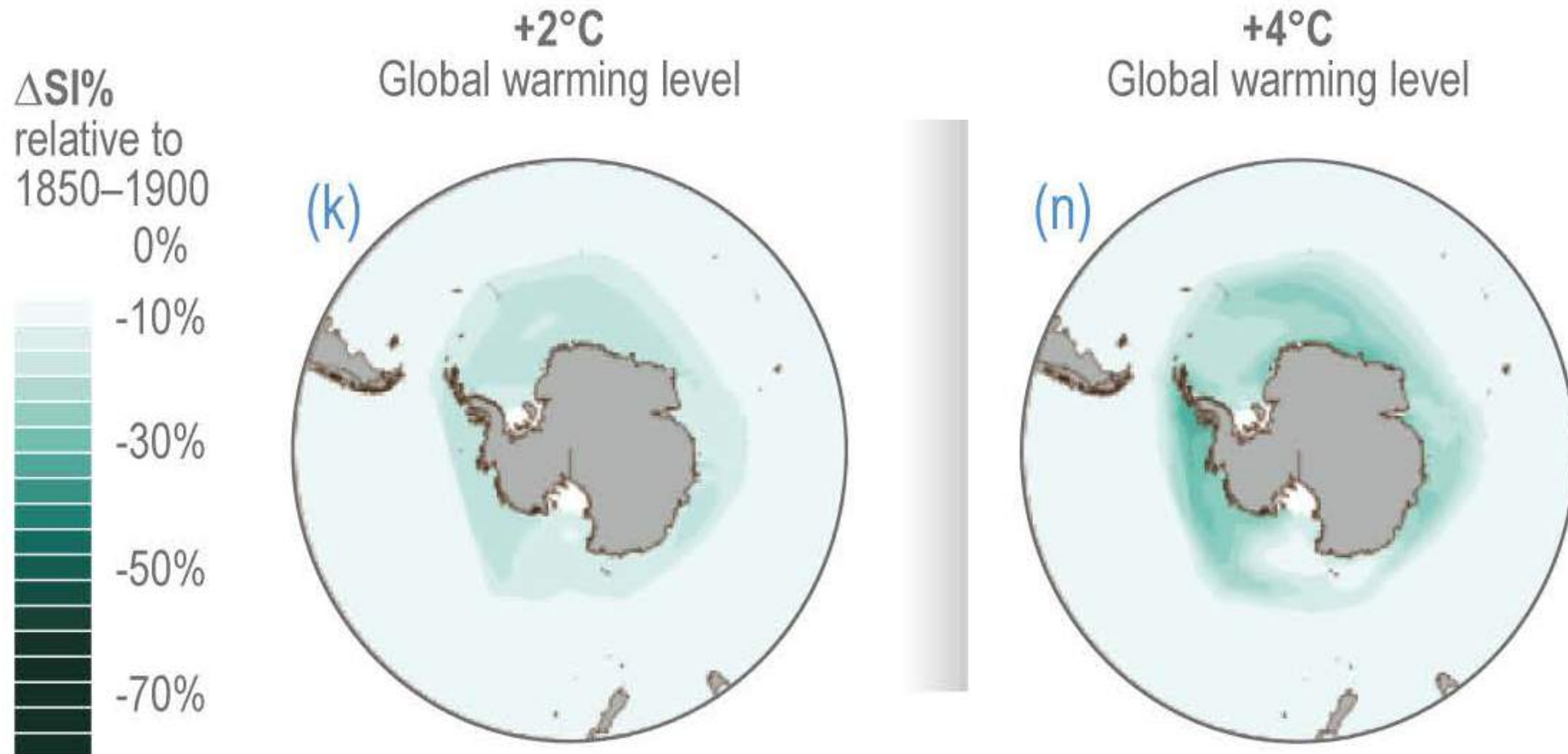


Krill

Retreating, variable sea ice

Antarctic changes:

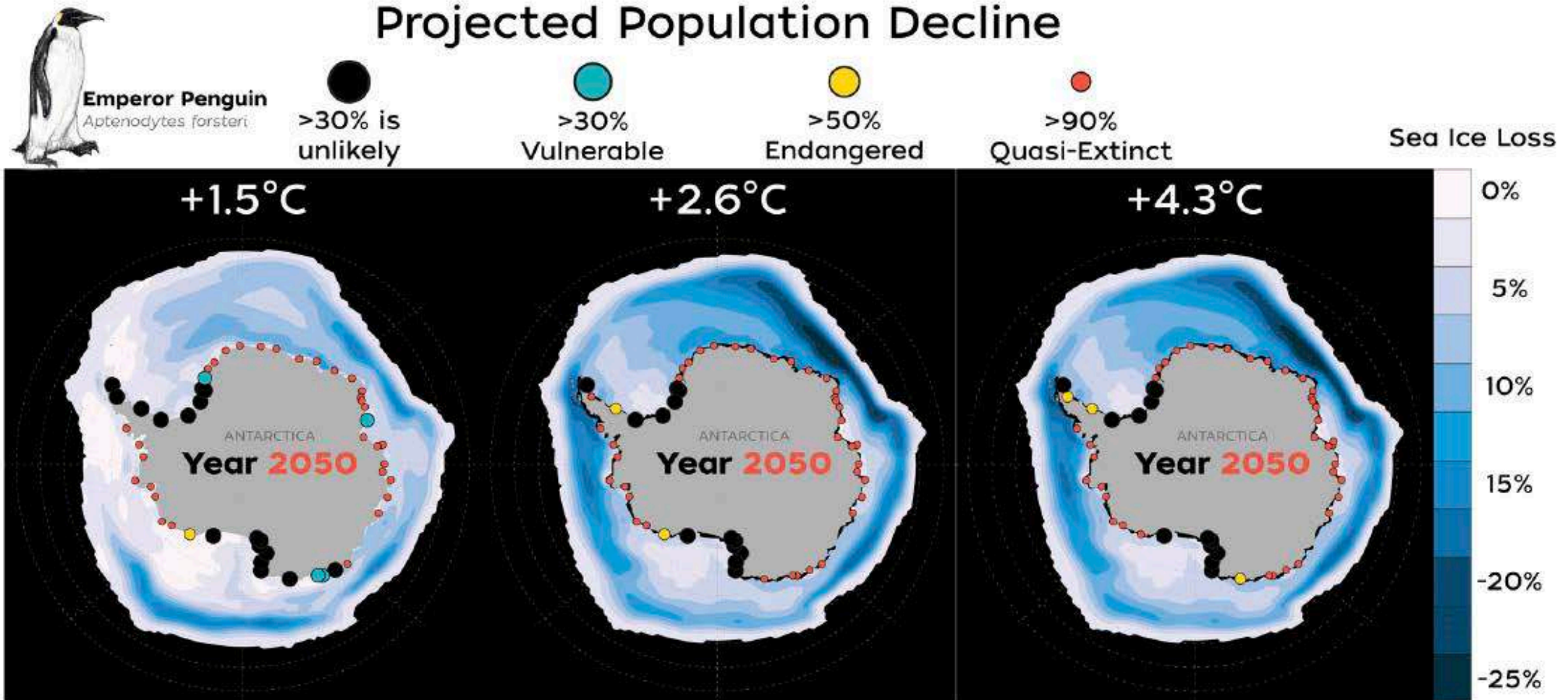
Projected Sea Ice extent, variability, stability



Antarctic changes: Ice and krill dependent species are threatened

- Affecting birds and marine mammals in the Southern Ocean, as well as their patterns of activity.





98% of emperor penguin colonies could be extinct by 2100 depending on sea ice instability and melt

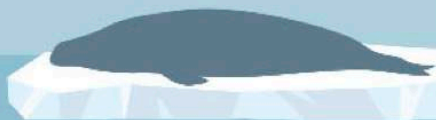
Compound risks for...

MARINE LIFE



Seabirds and mammals have experienced population declines and increases, range shifts, and changing life histories

Population changes for birds and seal populations will continue

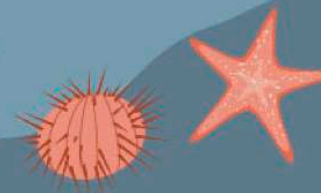


Southward movement of krill has occurred and is forecast to continue

Acidification has had mixed and negative impacts
Ongoing impacts will be negative



Fish will be negatively impacted



Changes to benthic systems are largely unknown
Changes in distributions are forecast

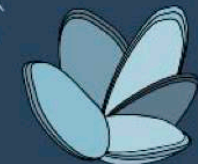
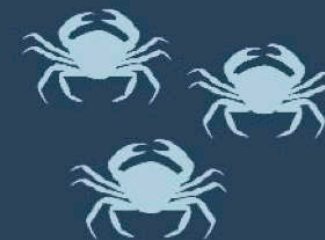


EMPEROR PENGUIN EXTINCTION RISK

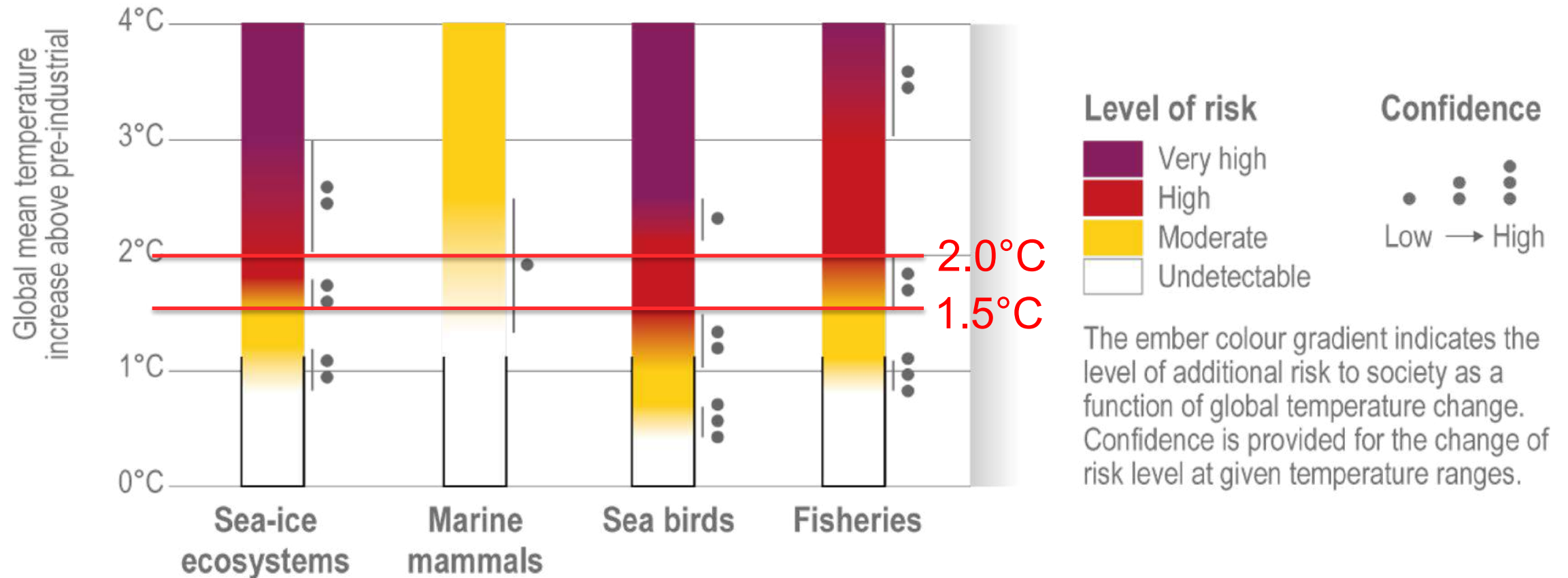
under business-as-usual
climate scenarios

INVASIONS

Few currently
but forecast to INCREASE



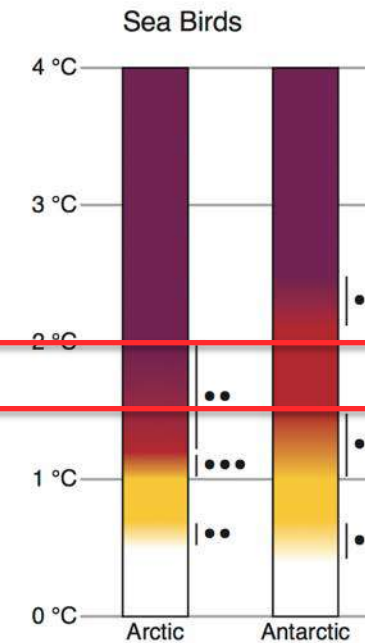
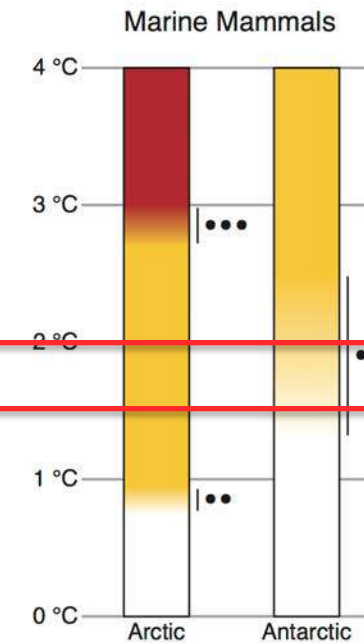
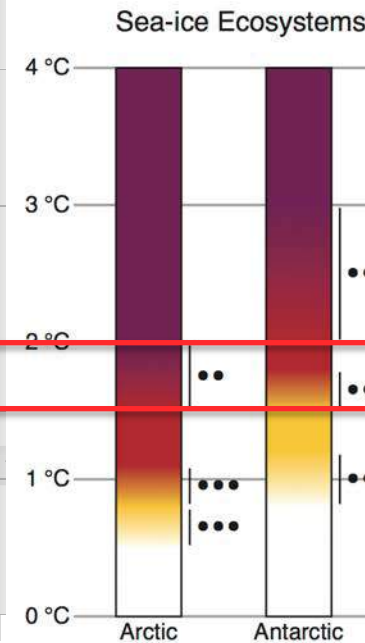
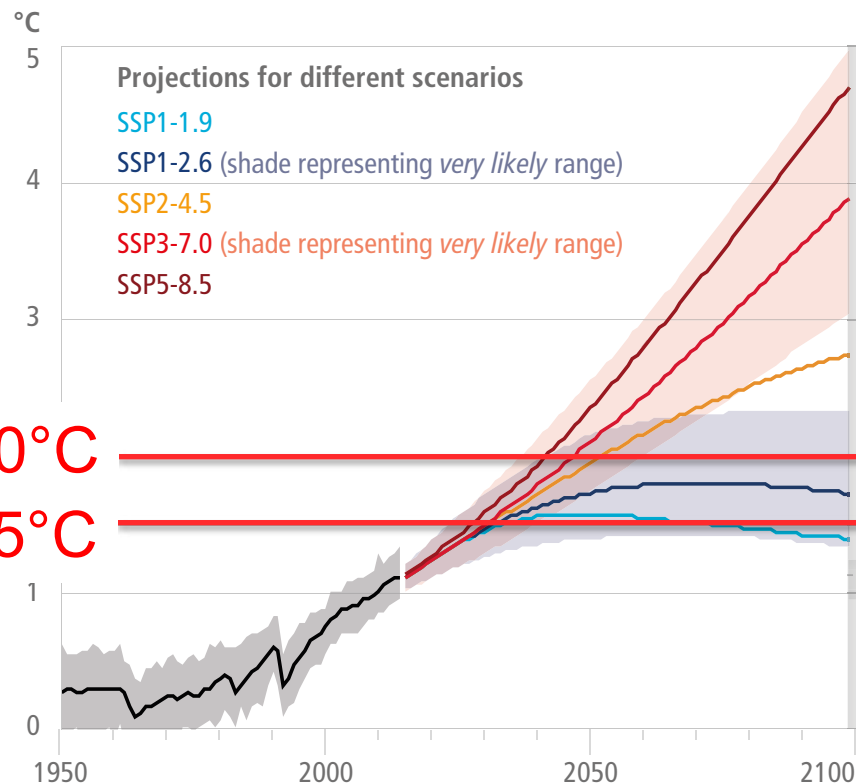
Risks for Antarctic Sea Ice Ecosystems and Fisheries in relation to global warming levels



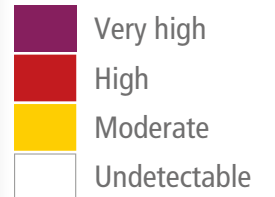
Comparing the Arctic and Antarctic:

Critical risk levels to sea ice ecosystems, marine mammals and sea birds have been or are about to be surpassed in both systems

(a) Global surface temperature change
Increase relative to the period 1850–1900



Risk/impact



Transition range

Confidence level

assigned to
transition
range

Low → Very high

Historical average
temperature increase
in 2011–2020 was
1.09°C (dashed line)
range 0.95–1.20°C

The image shows two researchers in red protective suits on a vast, flat expanse of ice under a sunset sky. The researcher on the left stands observing, while the one on the right is actively using a long-handled drill to bore into the ice. A small pool of water is visible near the first researcher. A blue semi-transparent banner is overlaid on the left side of the image, containing the title text.

Research Recommendations

Research needs while taking urgent climate action

The Antarctic: A role model for conservation?

Protection of the Southern Ocean:

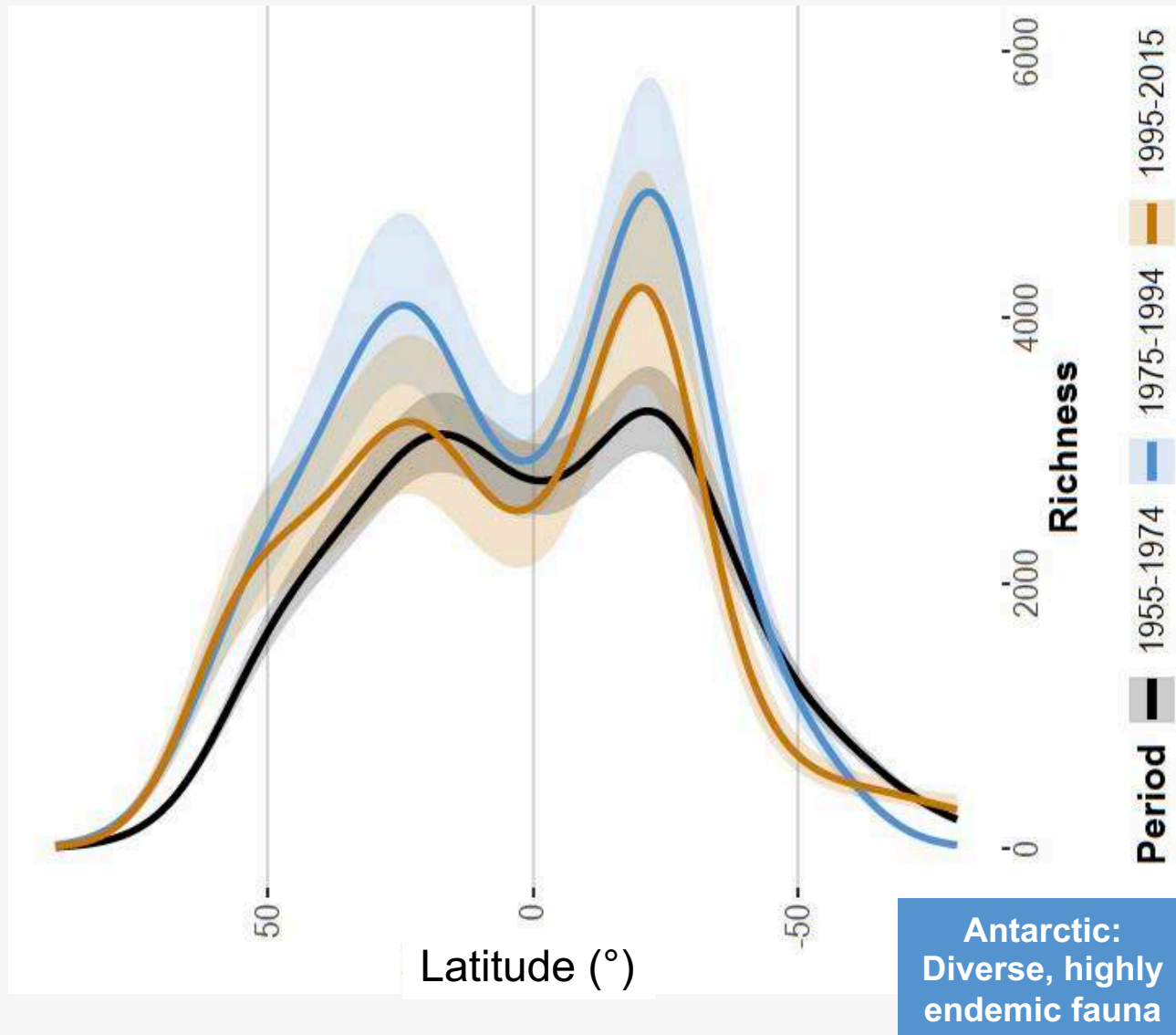
Spatial requirements (matching the 30 to 50% overall)?

- Regionalization?
- Spatial heterogeneity?
- Migration patterns and corridors?
- Comparative understanding of the spatial needs for biodiversity (e.g. biodiversity pump) across latitudes?
- Cryptic species?

Ecological consequences of:

- Life history specializations and vulnerabilities
- Physiological specializations and vulnerabilities
- Seasonality





Research needs

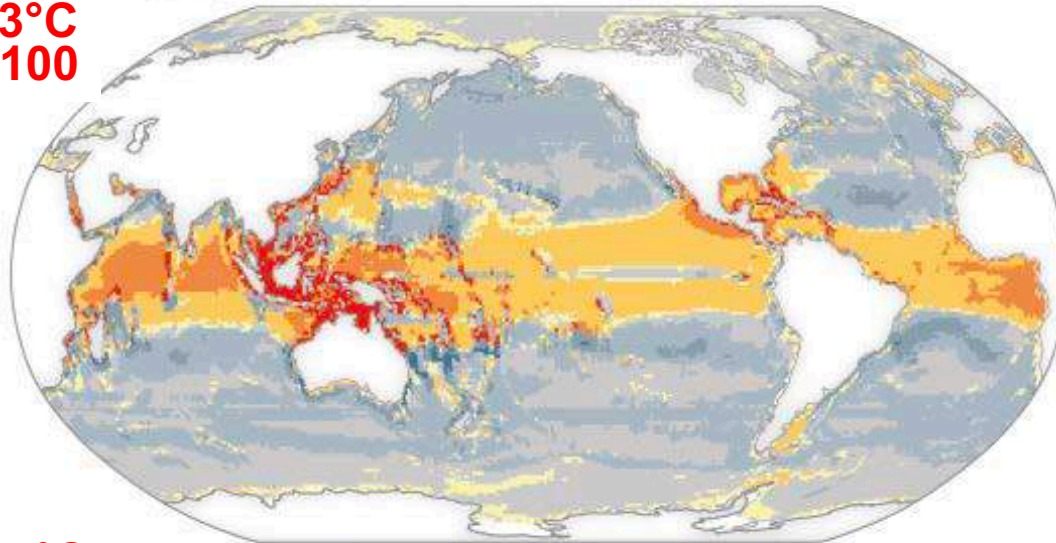
Explaining marine biodiversity across latitudes ... and in the Antarctic

Lacking: Mechanism-based understanding of biodiversity distribution

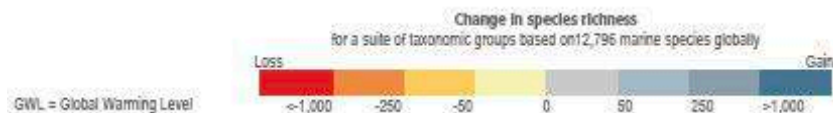
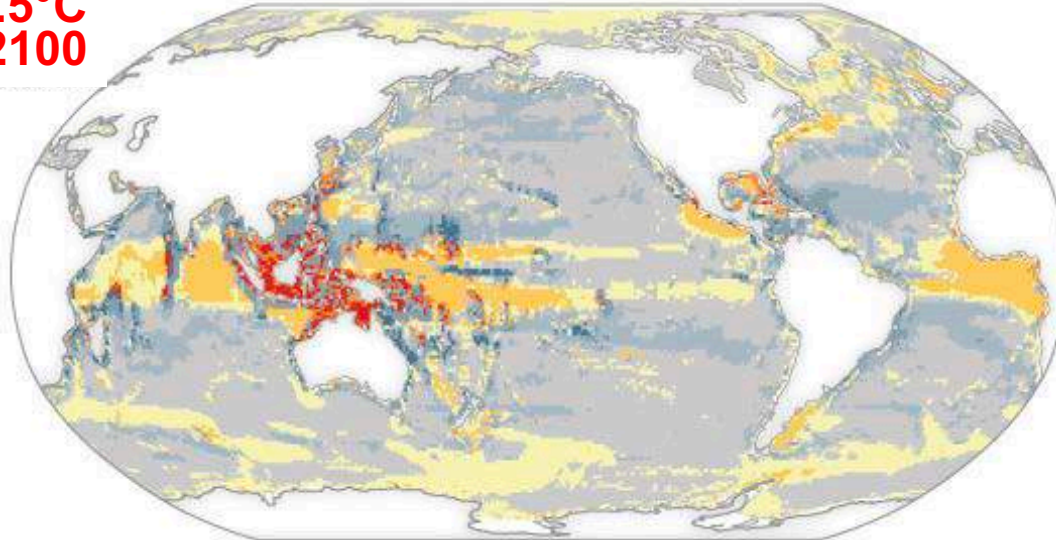
The Antarctic in a global context

Projected changes in global marine species richness in 2100 compared to 2006

+ 4.3°C
in 2100

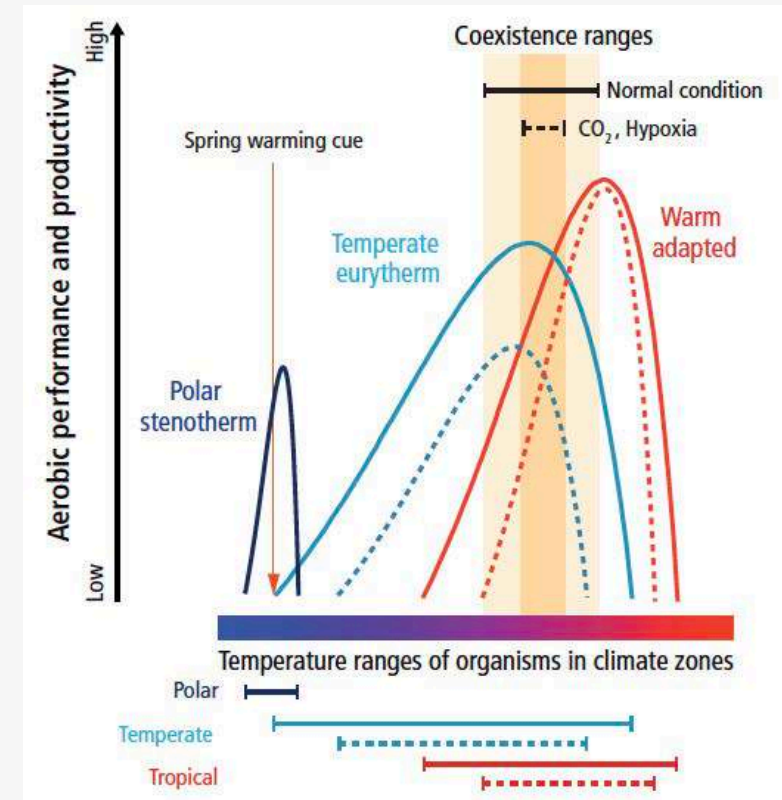


+ 2.5°C
in 2100



Explaining the ecological consequences

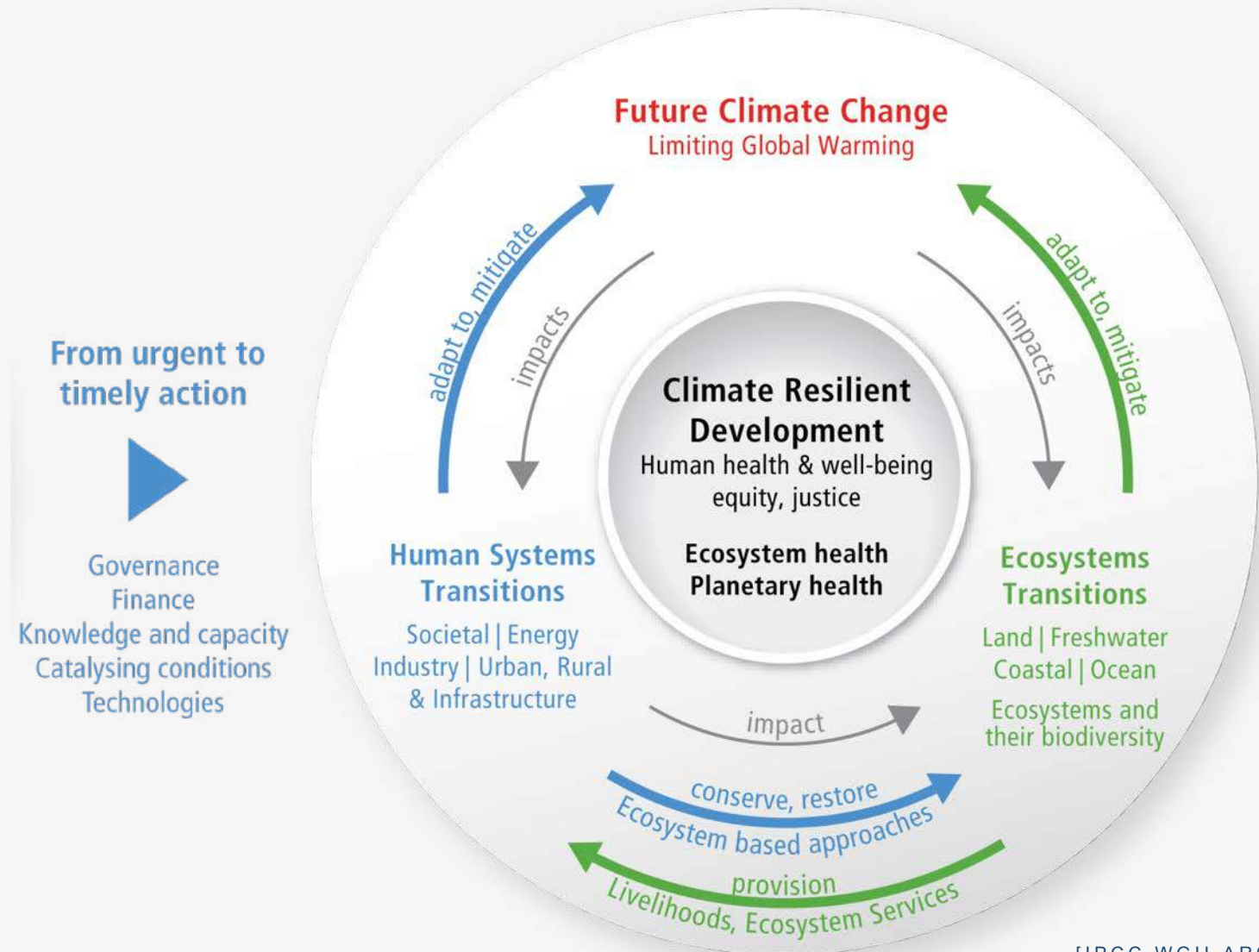
- of physiological specialization, trade-offs and constraints?
- of climate-induced biodiversity shifts?
- of extirpations and extinctions

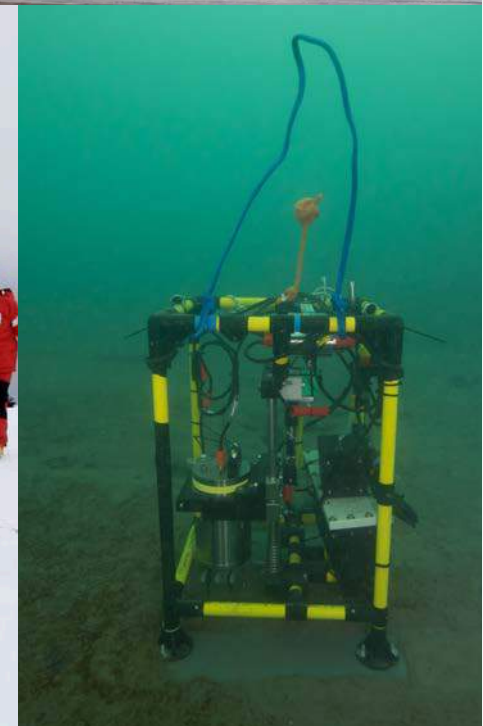


... enabling a sustainable future

Topics for Antarctic action and research, e.g.:

- Setting up a network for Antarctic conservation
- Stabilizing the role of the Southern Ocean in climate change mitigation
- Considering the adaptation limits of Antarctic organisms
- Maintaining a future for Antarctic biodiversity





Research needs while taking urgent climate action


- Long-term observatories:
 - atmospheric, cryospheric, oceanography and biology
- Experimental studies
- Modelling approaches

...through:

- coordinated, international and transdisciplinary research efforts by all Antarctic Training Programs;
- Development of an appropriately-resourced scientific workforce for the future

A wide-angle photograph of a coastal landscape. In the background, a massive glacier with white and blue ice extends to the horizon under a clear blue sky. The glacier's edge meets a body of water. In the foreground, a dark, pebbly beach is partially submerged by shallow, rippling water that flows from the glacier's melt. On the right side of the beach, a small, red and yellow striped lighthouse stands prominently. A semi-transparent blue trapezoidal shape is overlaid on the left side of the image, containing the text 'Policy Recommendations' in white.

Policy Recommendations



Rapidly changing Antarctic and Southern Ocean environments require similarly rapid environmental governance responses, including potential changes to agreements that have previously taken many years to reach.

SCAR ACCE Decadal Synopsis


Policy recommendations

Governance for managing climate impacts in Antarctic environments is considered **poorly developed**, despite its importance for decision-making.

Communicate the urgency of drastic emission reductions, to ensure that Antarctic and Southern Ocean environments including cryosphere are preserved.

Meet the growing management difficulties, logistic challenges and research requirements, elicited by changes to the Southern Ocean and its ecosystems.

Continue support for research delivering evidence-informed options, for the reduction of uncertainties and for climate change mitigation & adaptation actions.



Climate change is a threat to human well-being and planetary health.

Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all.

IPCC AR 6 WGII

A satellite image of a glacier, showing a complex network of blue and white patterns. A semi-transparent blue rectangle is overlaid on the left side of the image, containing the text.

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Thank you!

BERLIN, MARCH 24 2022

[NASA earth observatory]