



XLIV ANTARCTIC TREATY  
CONSULTATIVE MEETING



BERLIN  
2022

SCAR SCIENCE LECTURE 2022

# Antarctic Climate Change and the Environment

A synopsis and recommendations for  
action

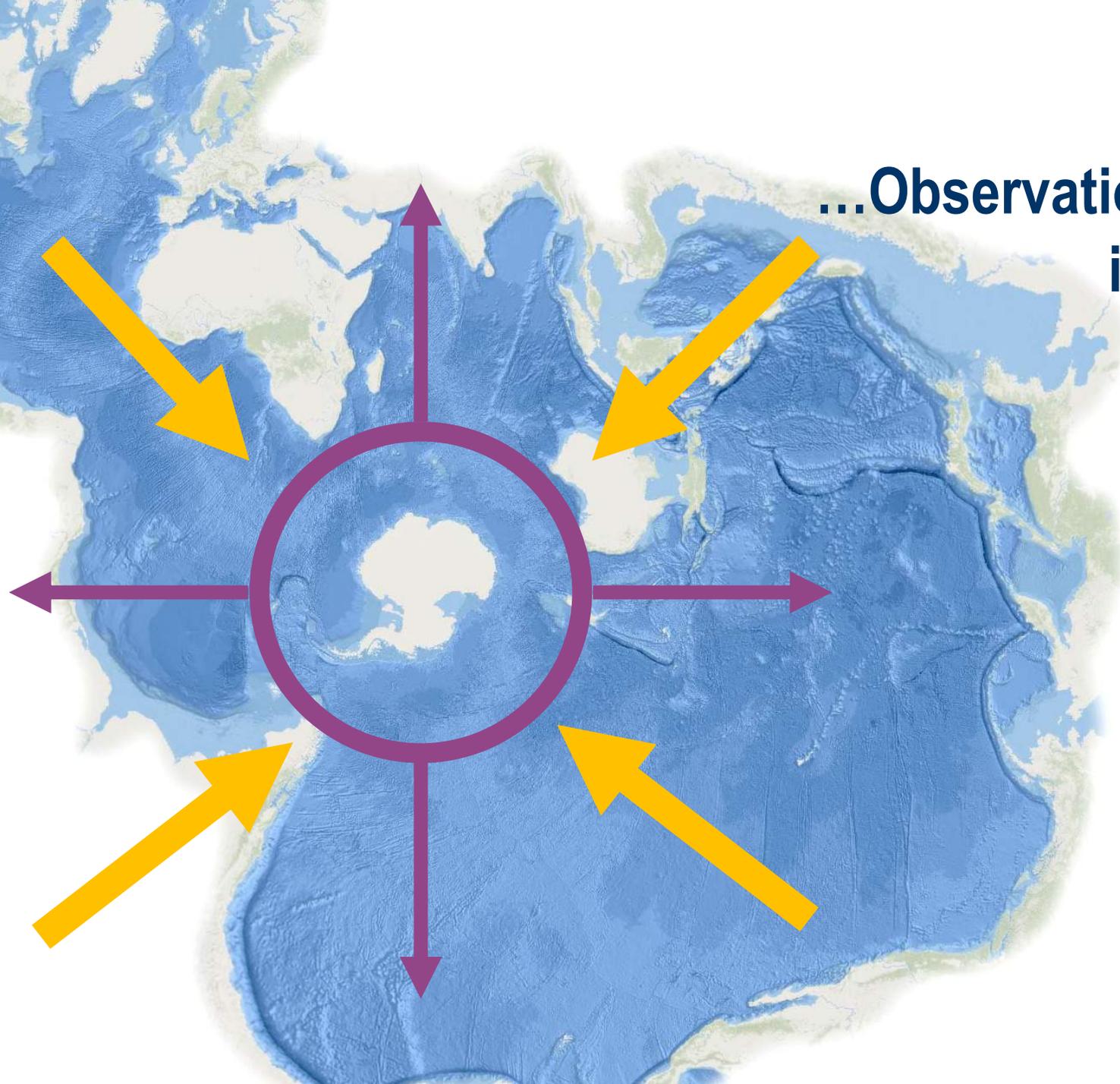
Hans-O. Pörtner,  
XLIV Antarctic Treaty Consultative Meeting

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)

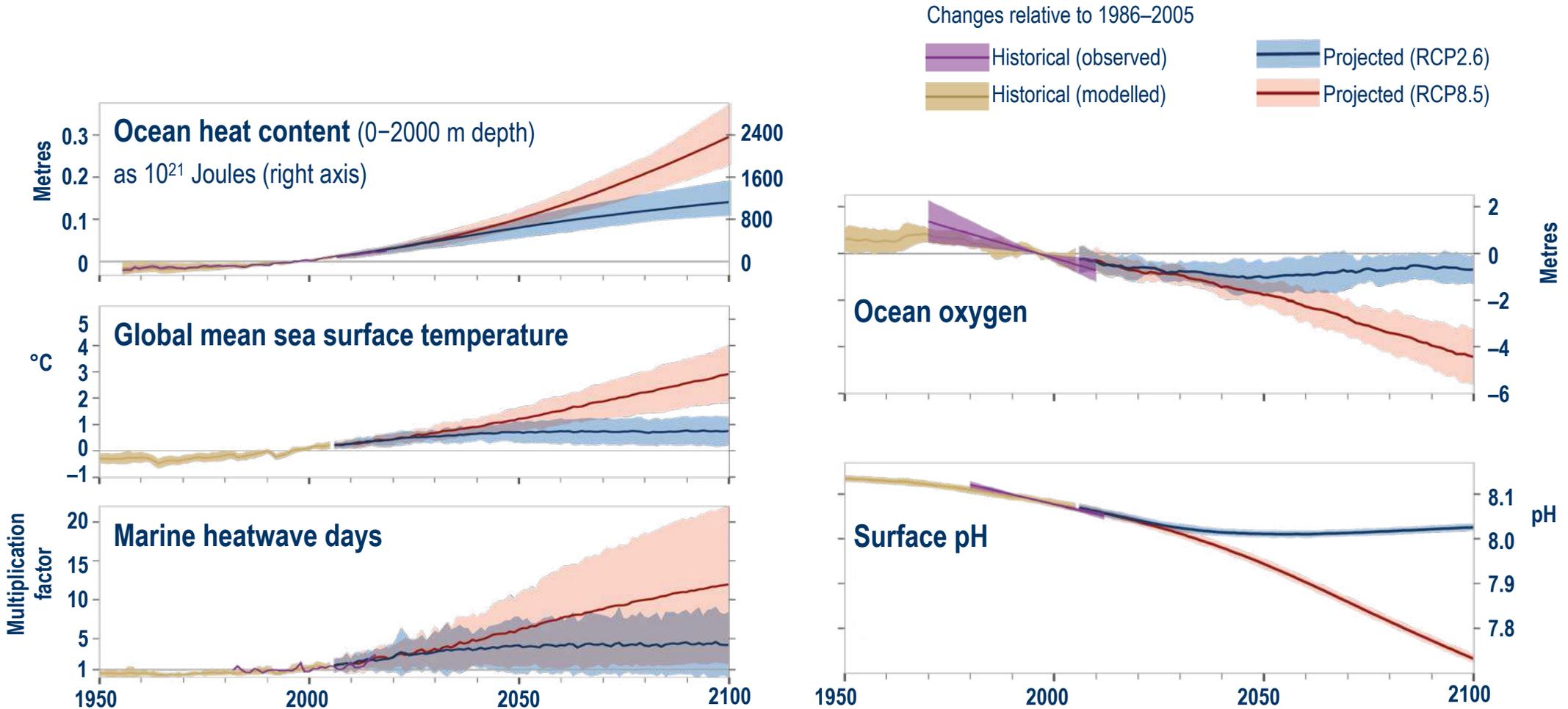
A large, rectangular iceberg floats in the ocean. The sky is overcast with grey clouds. The water is a deep blue, and the iceberg's surface shows vertical ridges and shadows, suggesting its massive scale. A semi-transparent blue rectangle is overlaid on the left side of the image, containing white text.

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.

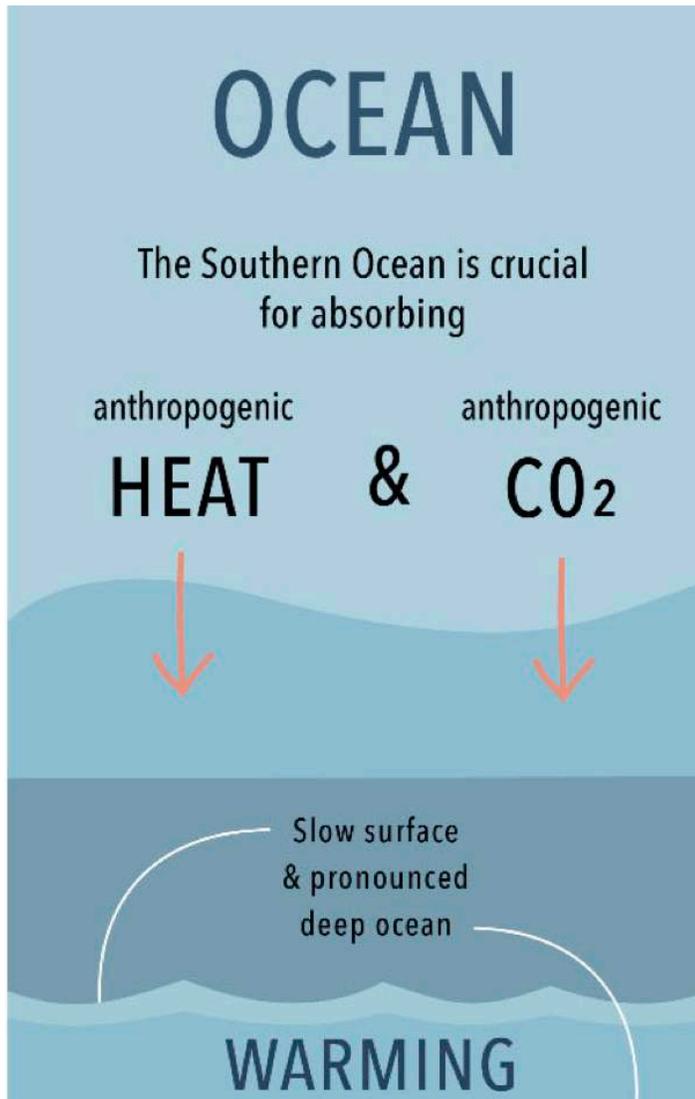
A humpback whale is captured mid-breach, its large, dark, curved tail fluke rising out of the water. The background features a range of rugged, snow-covered mountains under a clear sky. The water in the foreground is dark blue with gentle ripples.

**...in the global context**  
From the latest IPCC reports &  
SCAR ACCE decadal synopsis

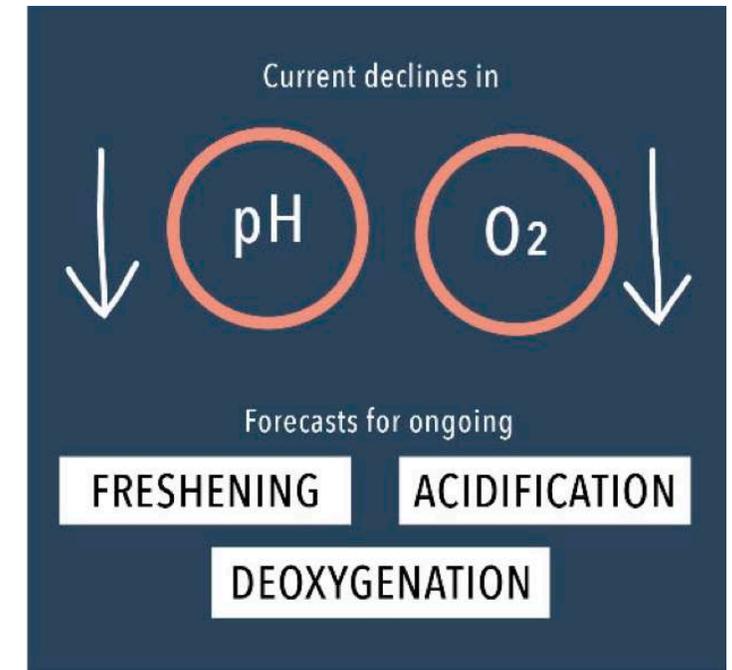
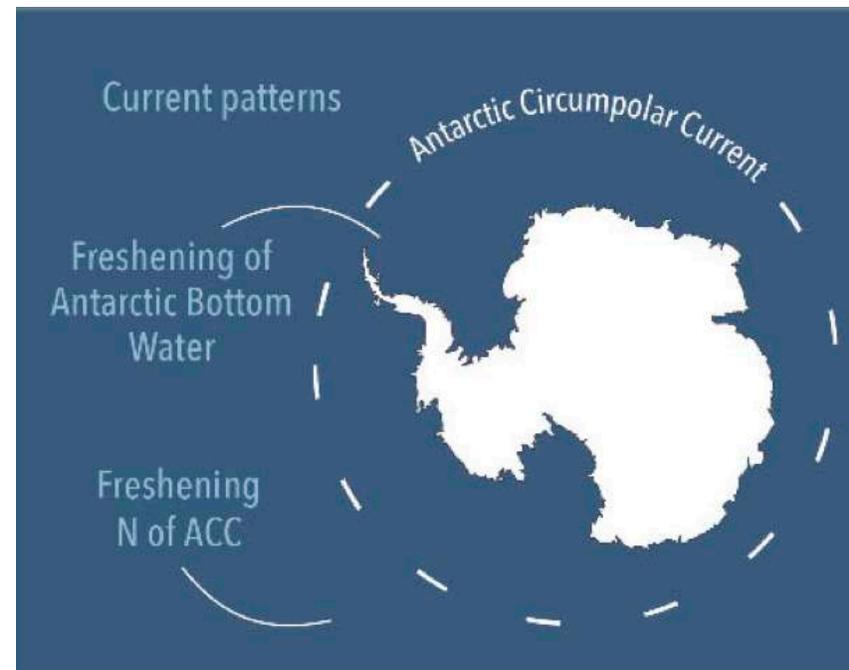
# The ocean is projected to transition to unprecedented conditions



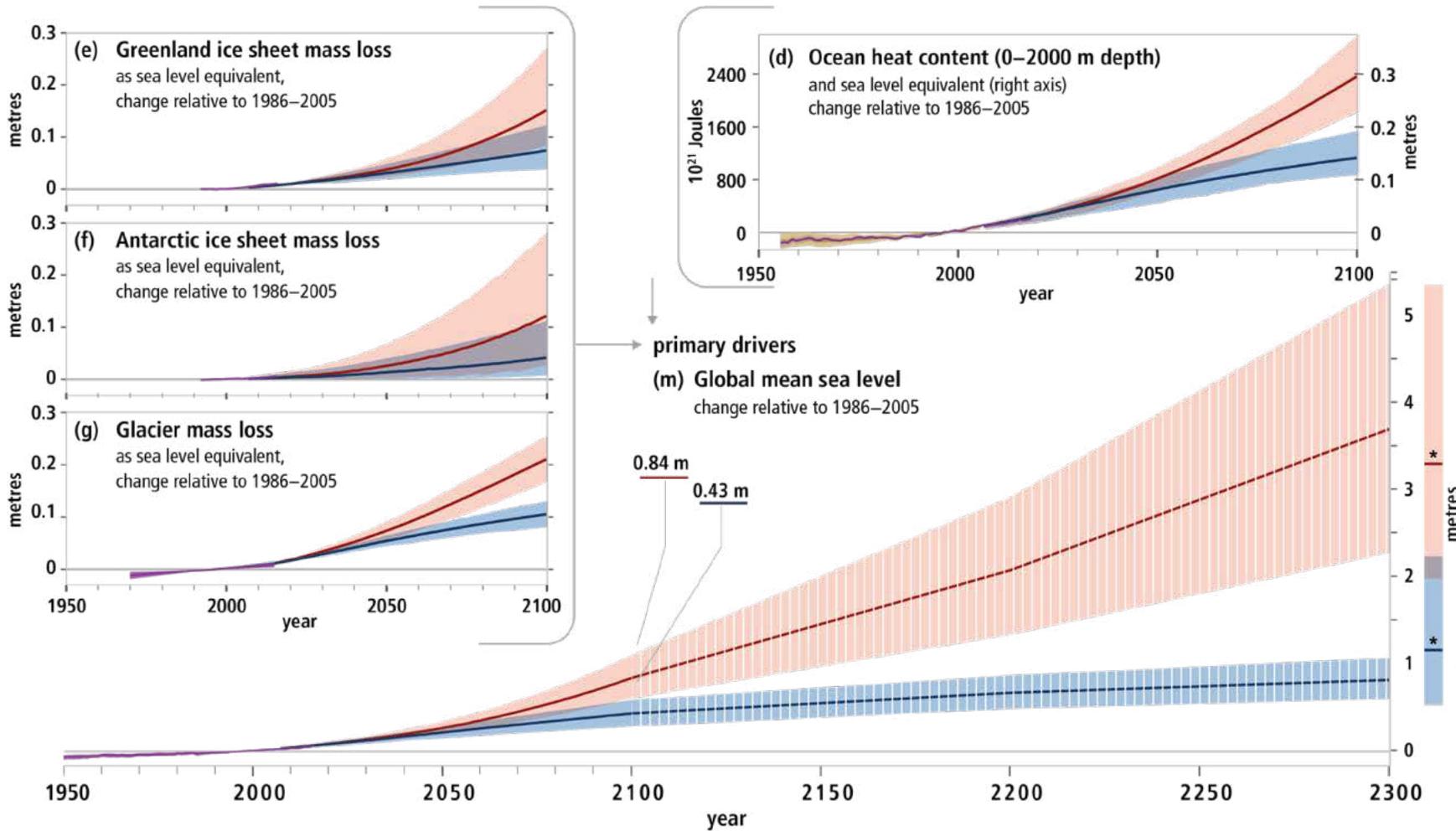
## Antarctic contribution...



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

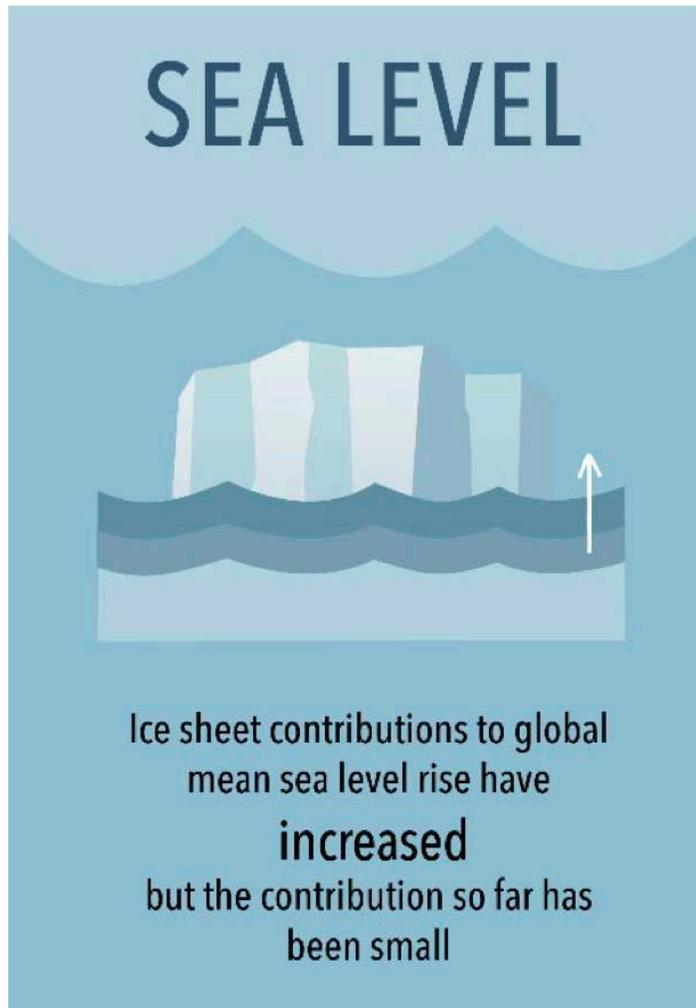
- Thermal expansion
- Glacier melt
- Ice sheet melt

~1.5°C

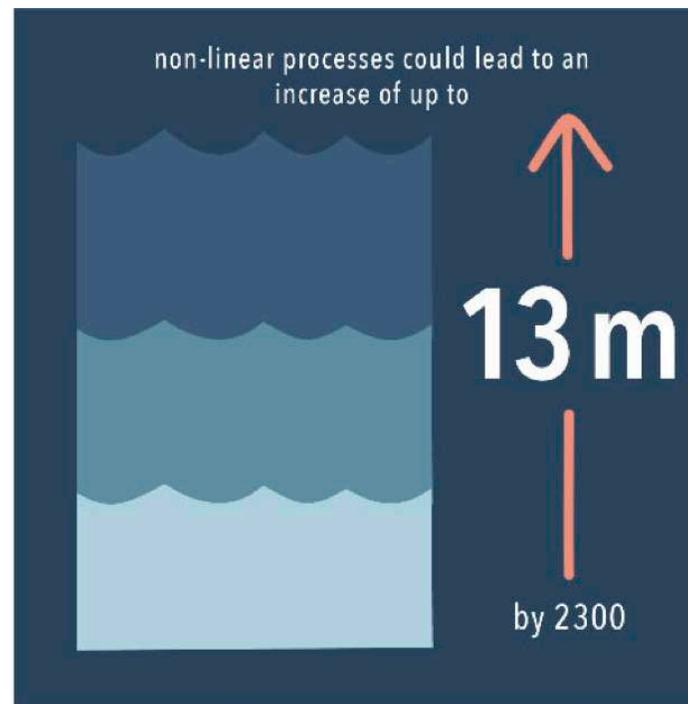
Historical changes (observed and modelled) and projections under RCP2.6 and RCP8.5 for key indicators

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

## Antarctic contribution



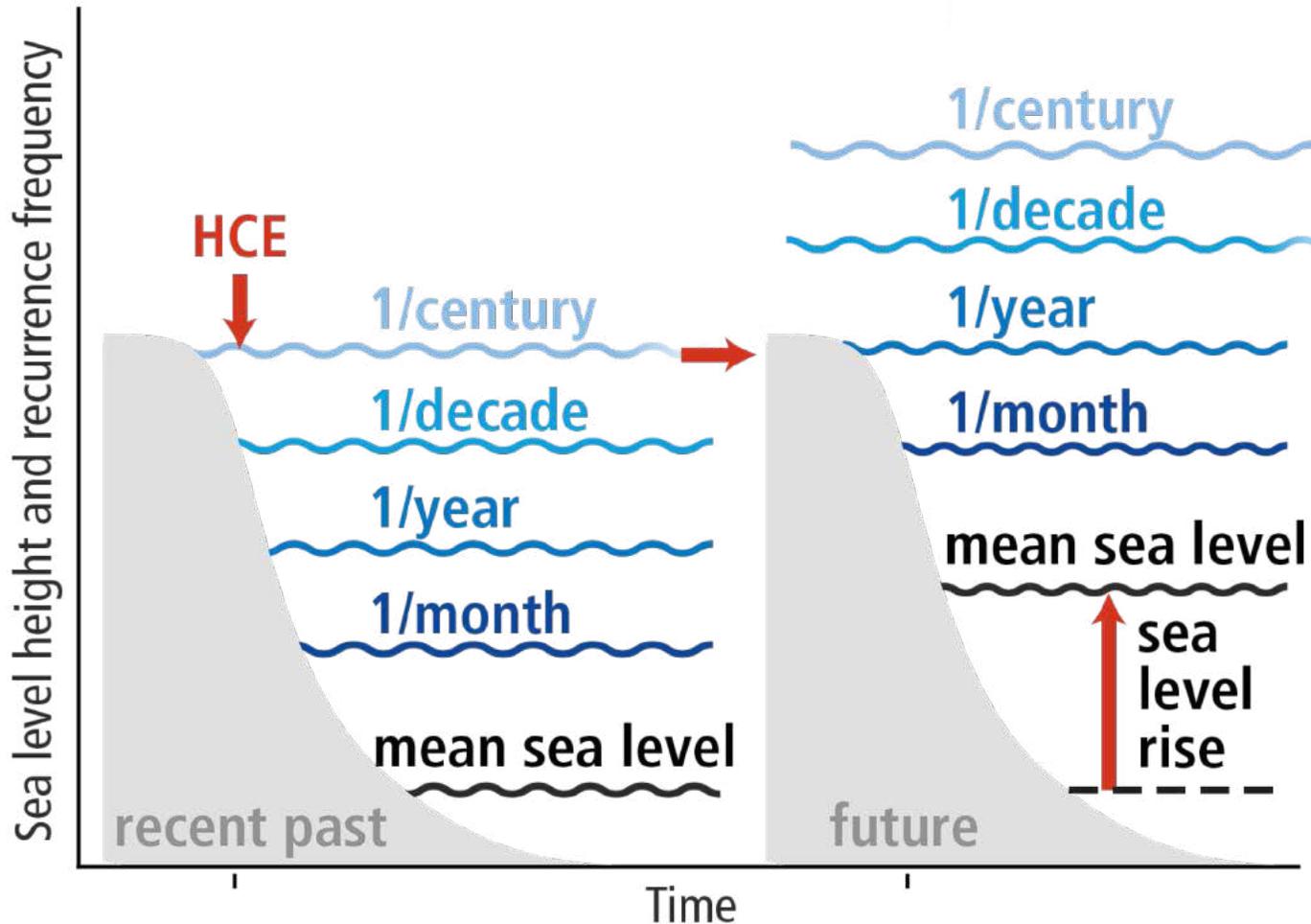
High uncertainty in the Antarctic contribution to global sea level rise.



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

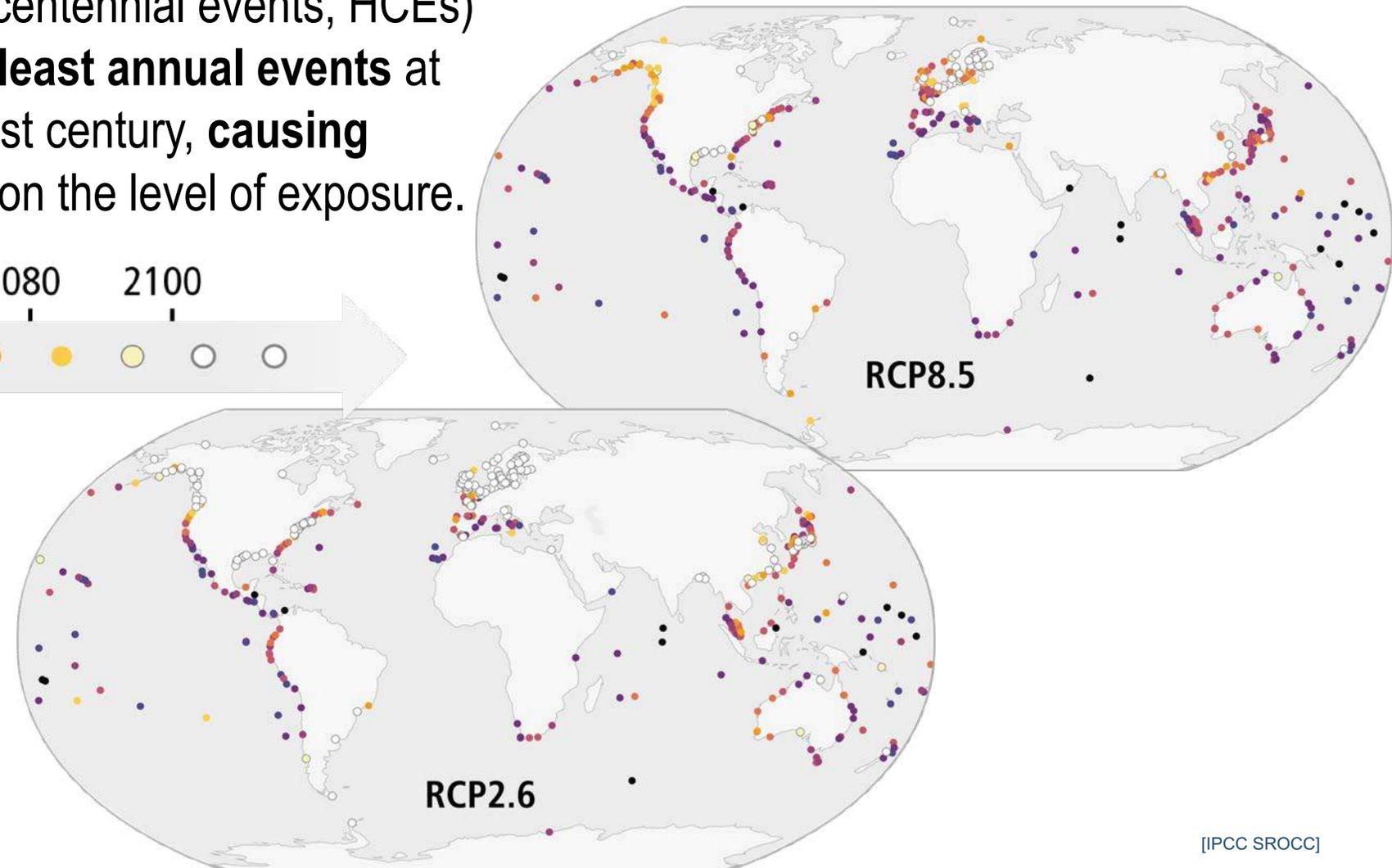
# Extreme sea levels rise progressively

**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.

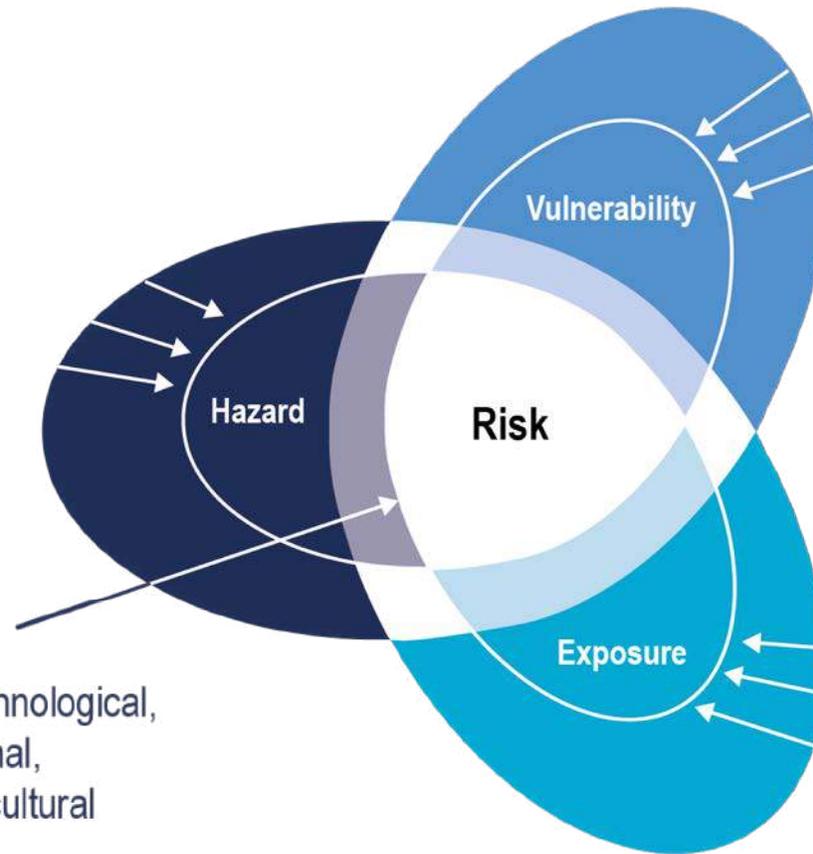


**Black dots:** Locations where HCEs already recur annually

**White dots:** Locations where HCEs recur annually after 2100



# Evaluating risks



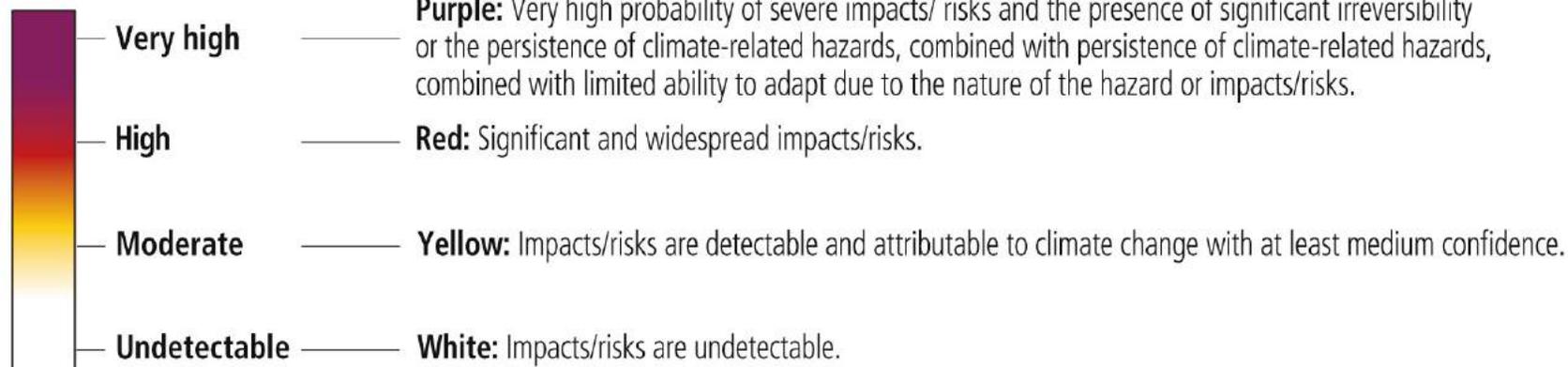
## The IPCC concept of risk

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



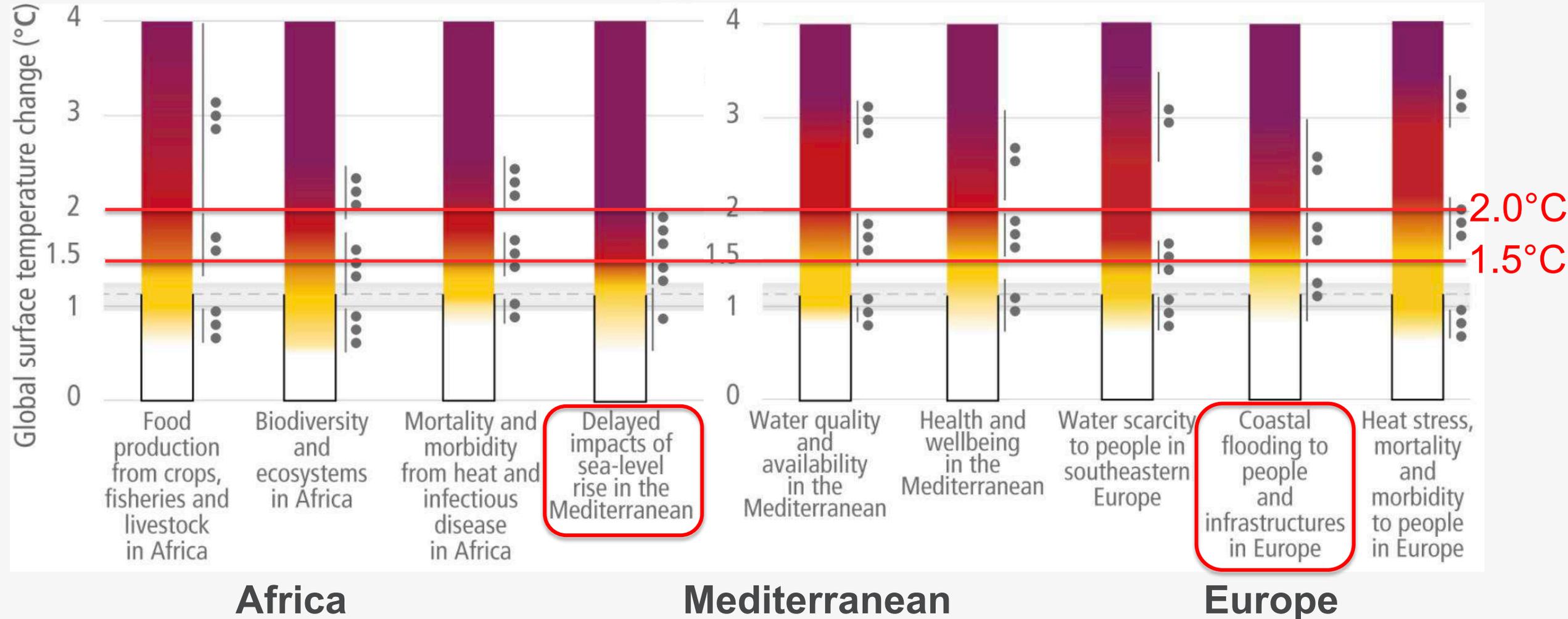
### Confidence level for transition

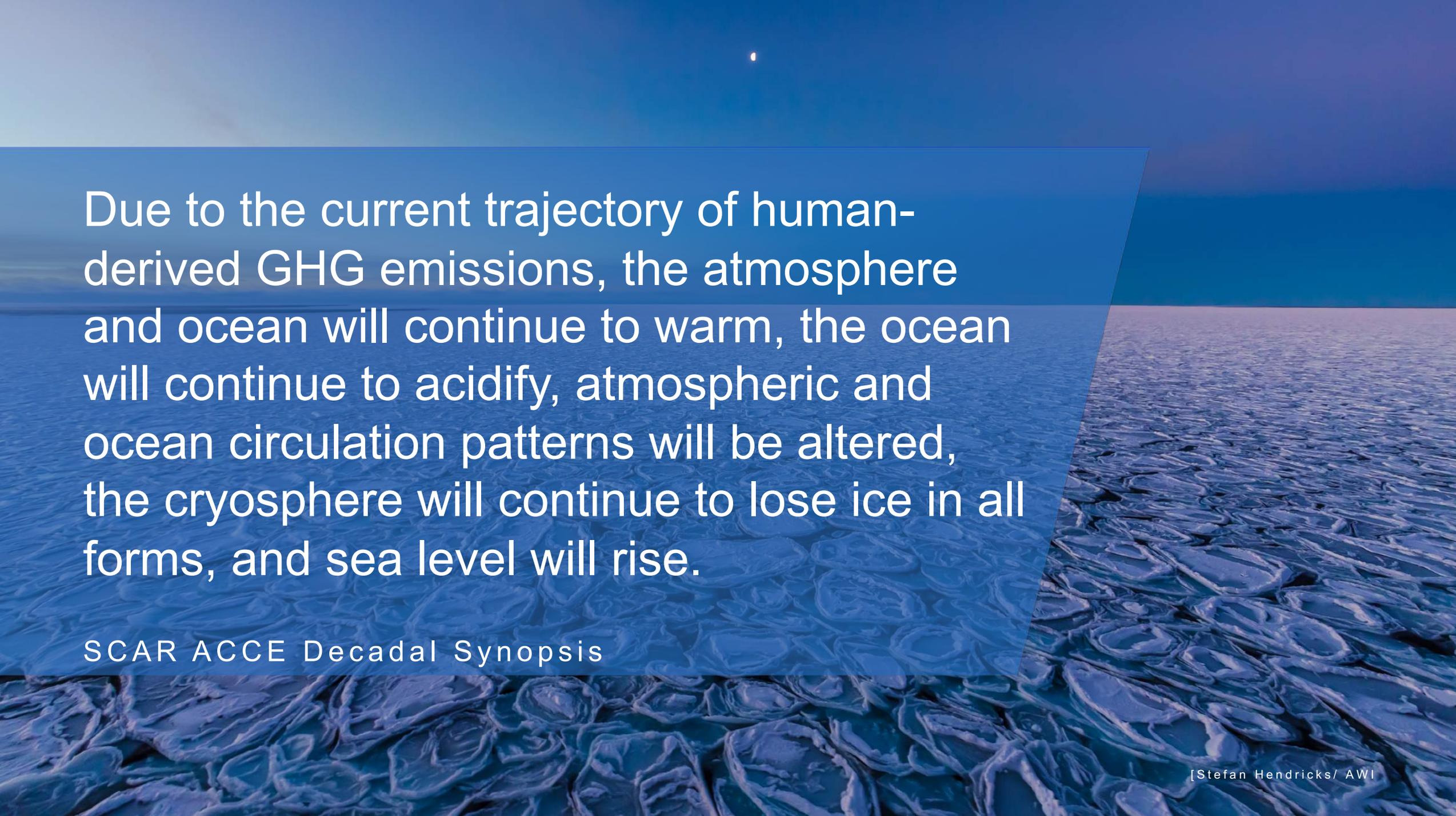
- = Very high
- = High
- = Medium
- = Low
- | = Transition range

\*\*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





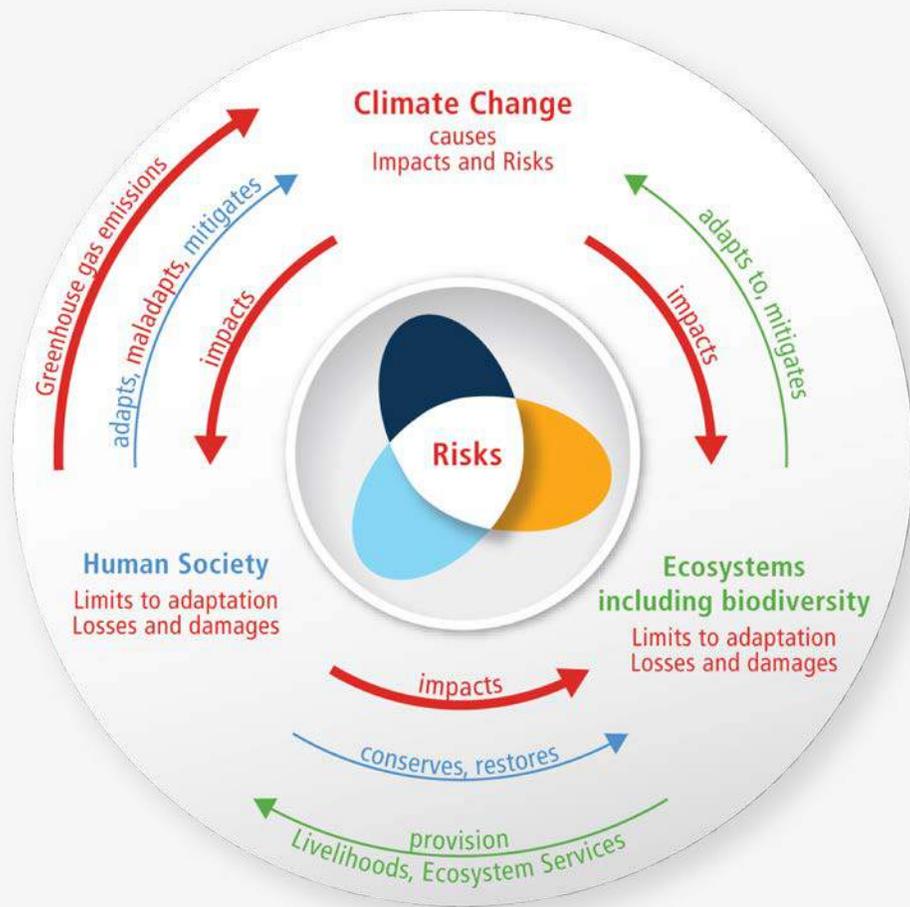
Due to the current trajectory of human-derived GHG emissions, the atmosphere and ocean will continue to warm, the ocean will continue to acidify, atmospheric and ocean circulation patterns will be altered, the cryosphere will continue to lose ice in all forms, and sea level will rise.

SCAR ACCE Decadal Synopsis

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

From current imbalance ...

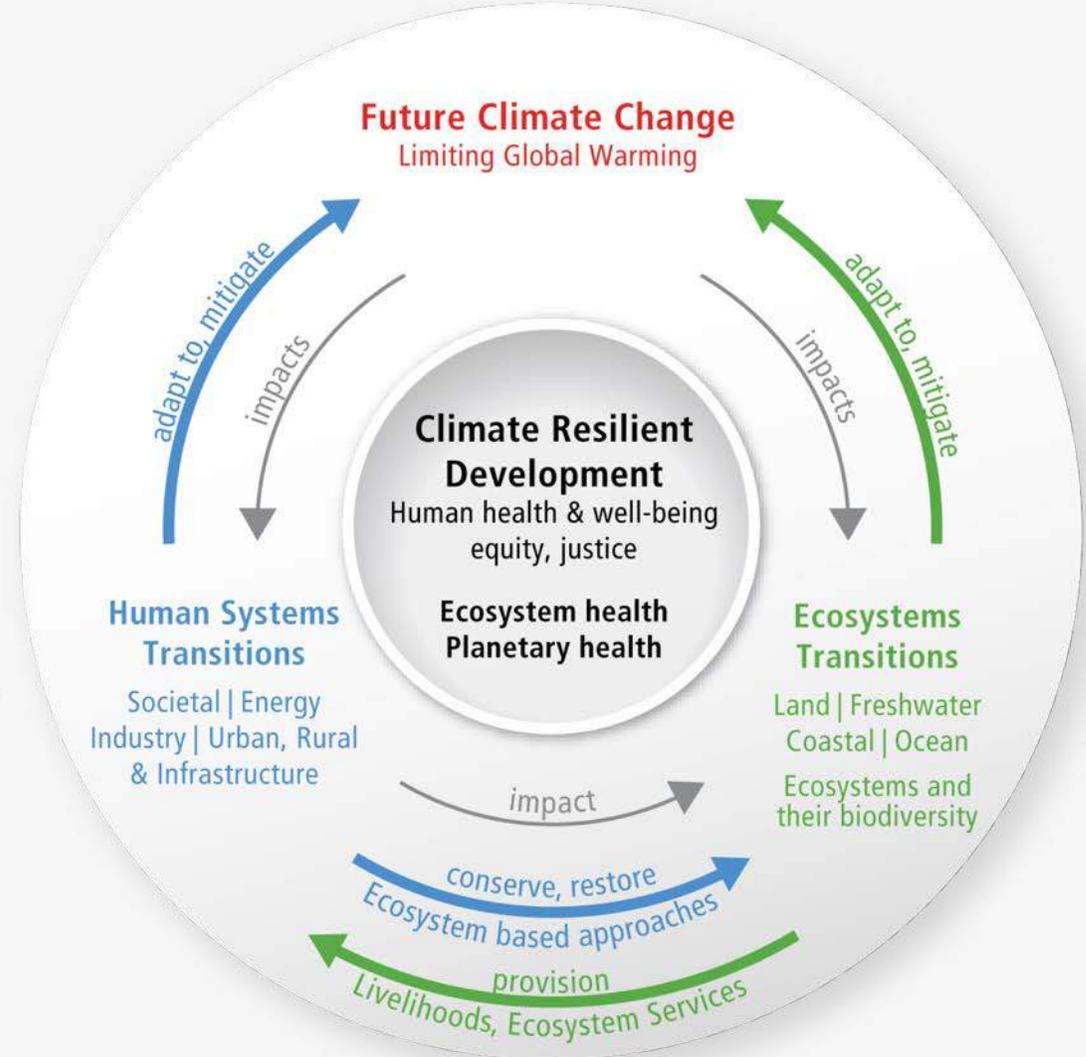
... towards a sustainable future



From urgent to  
timely action

►

Governance  
Finance  
Knowledge and capacity  
Catalysing conditions  
Technologies



The risk propeller shows that risk emerges from the overlap of:

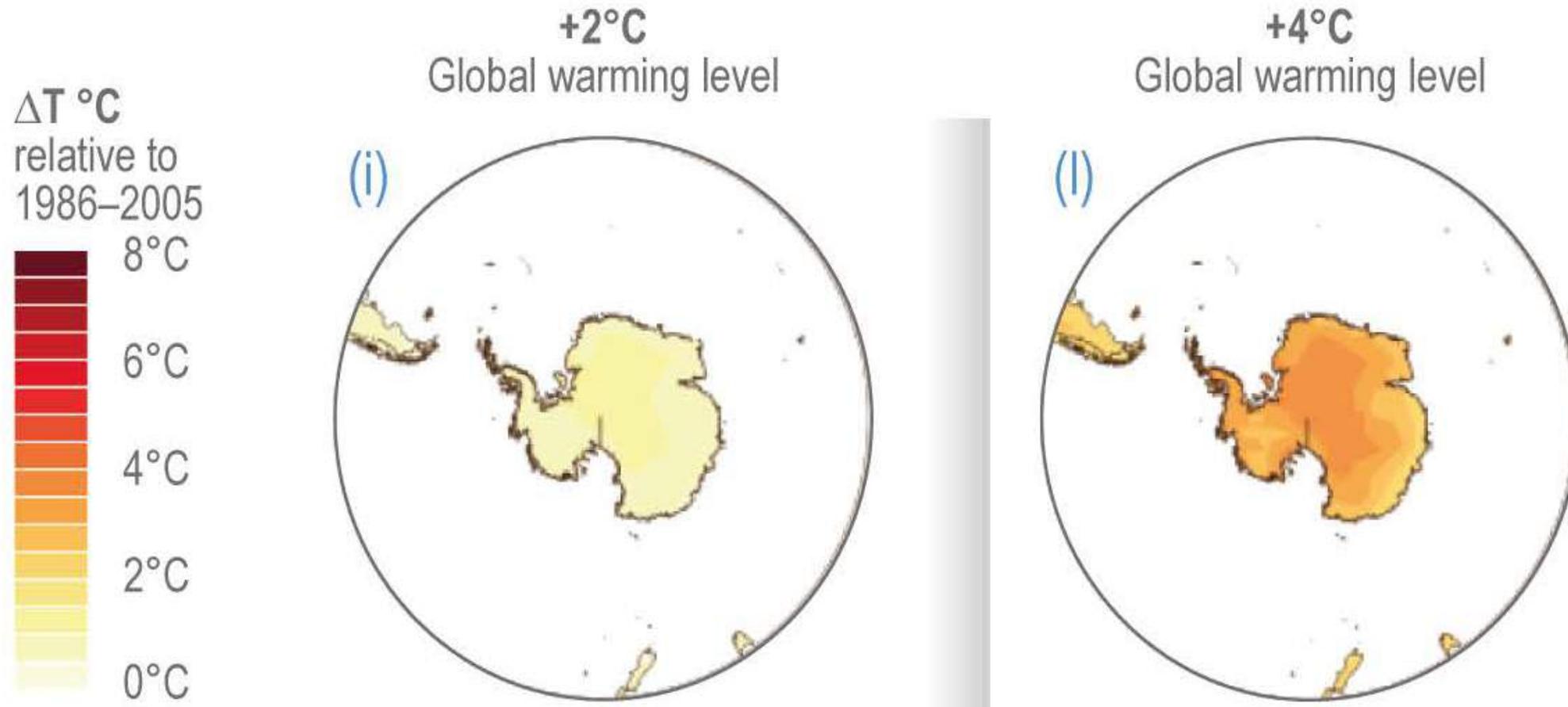


A wide-angle photograph of an Antarctic landscape. The foreground is dominated by low-lying, green, moss-like vegetation growing between dark, grey rocks. In the middle ground, there are patches of snow and ice. In the background, a large, snow-covered mountain peak rises against a clear blue sky with a few wispy clouds. A semi-transparent blue banner 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:

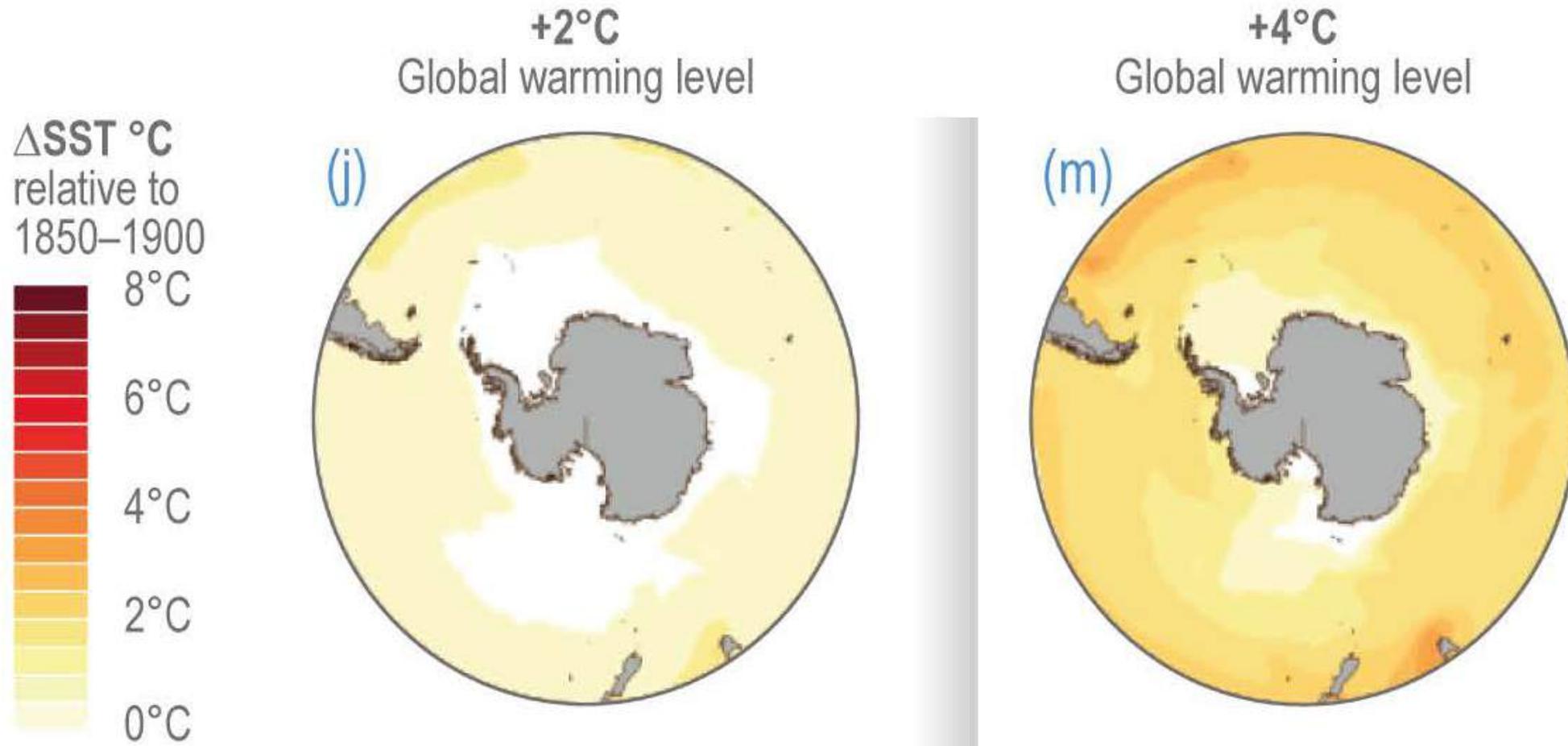
- The number and distribution of invasive species will increase



## Antarctic changes:

### Projected Sea Surface Temperatures (SSTs)

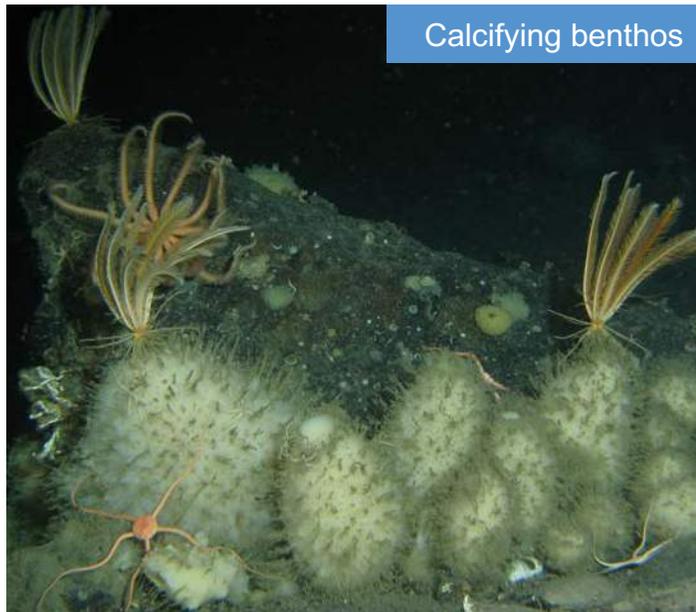
– approaching and surpassing the thermal tolerance limits of marine fauna



## Antarctic changes:

### Marine fauna is threatened by climate change

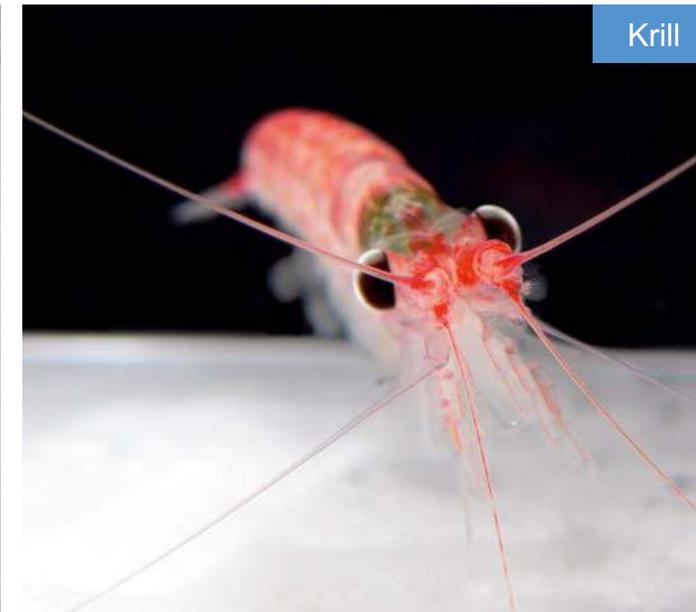
Observations, modelling and global assessments describe significant changes in Antarctic physical and living systems. Antarctic species and systems are highly vulnerable.



Invasion/expansion of crabs as crushing predators due to warming



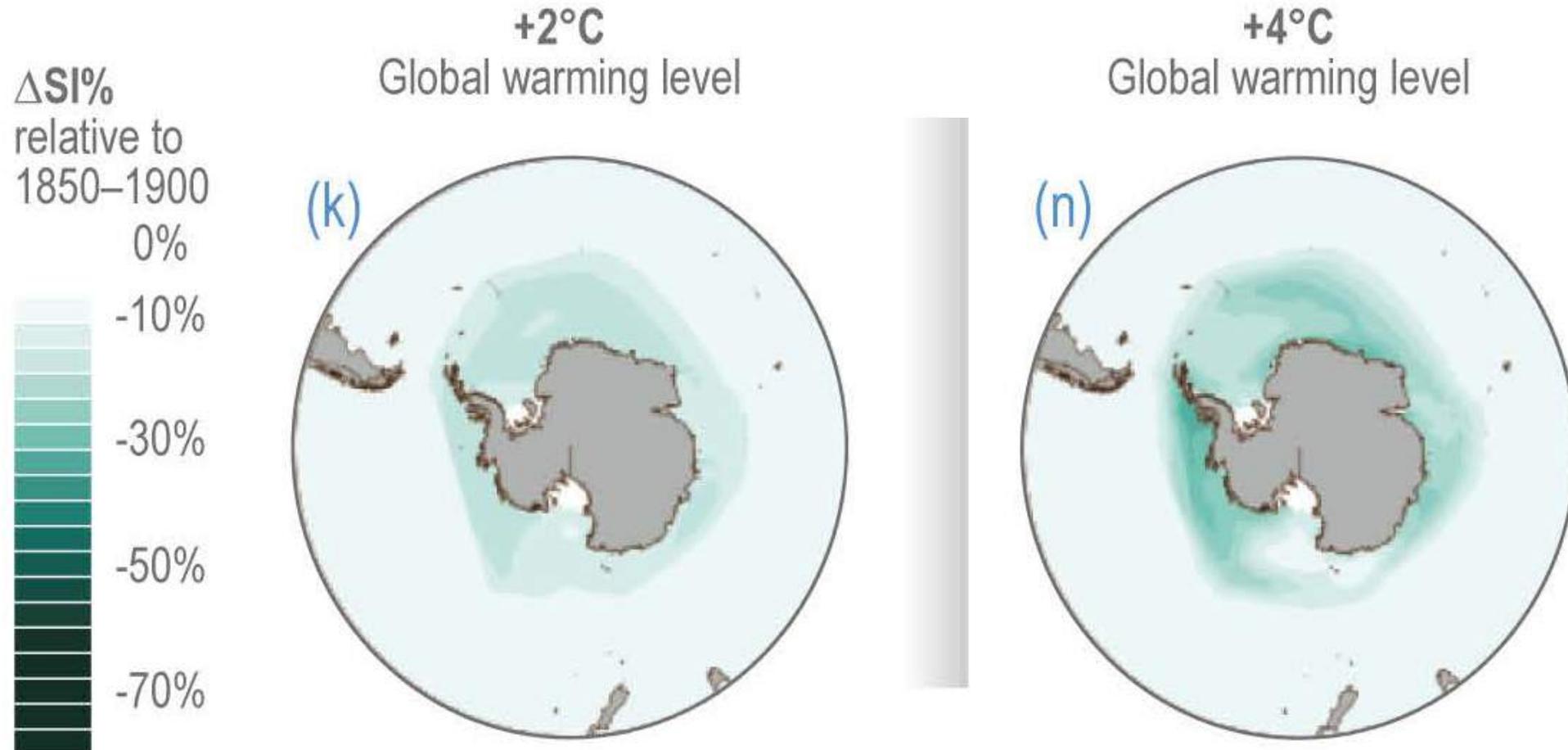
High thermal vulnerability



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.





Emperor Penguin  
*Aptenodytes forsteri*

## Projected Population Decline

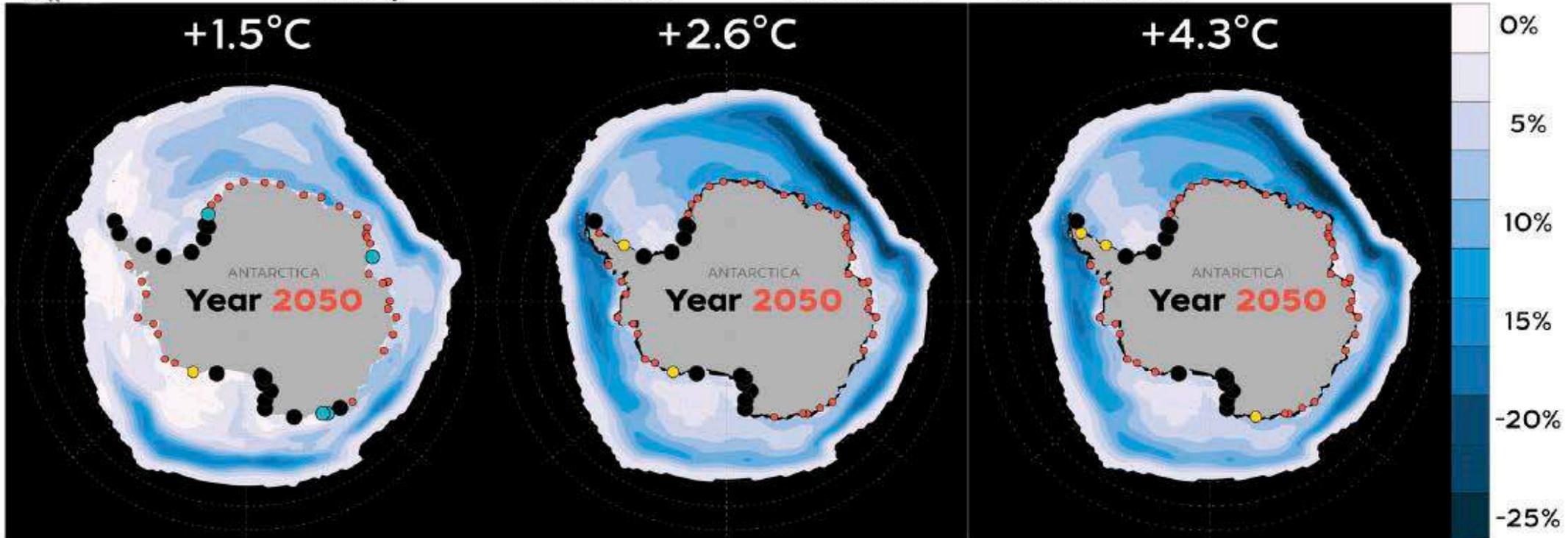
 >30% is unlikely

 >30% Vulnerable

 >50% Endangered

 >90% Quasi-Extinct

Sea Ice Loss



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

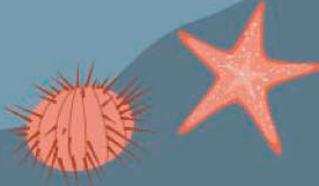
Acidification has had mixed and negative impacts  
Ongoing impacts will be negative



Fish will be negatively impacted



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

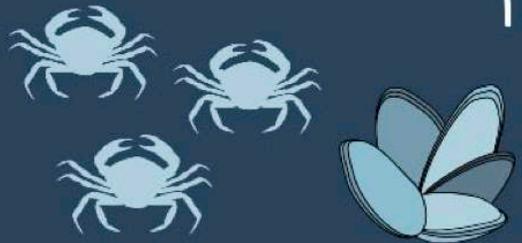


# EMPEROR PENGUIN EXTINCTION RISK

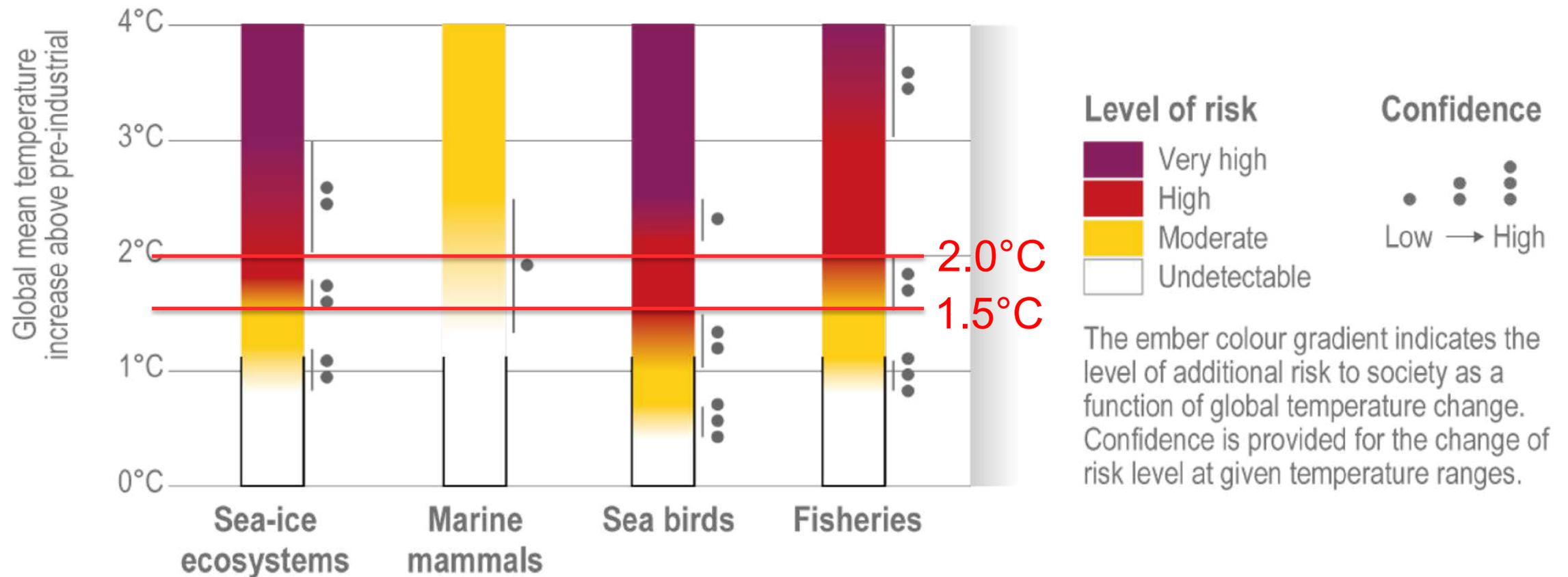
under business-as-usual climate scenarios

# INVASIONS

Few currently but forecast to INCREASE



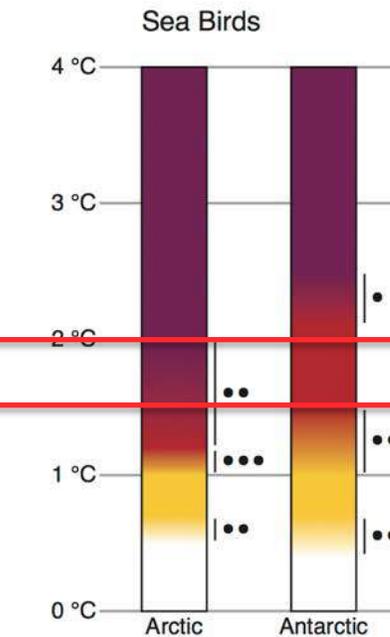
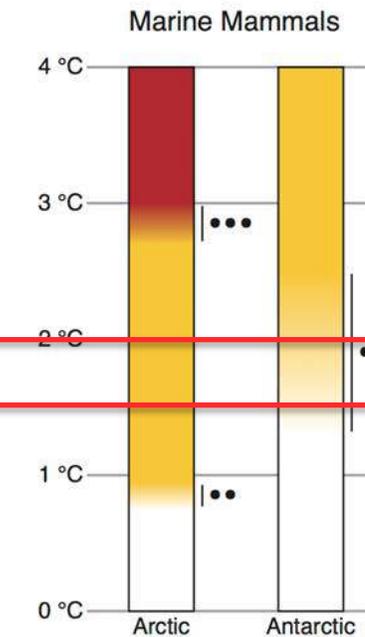
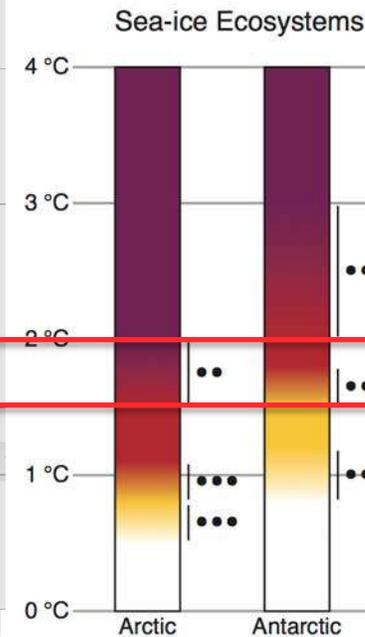
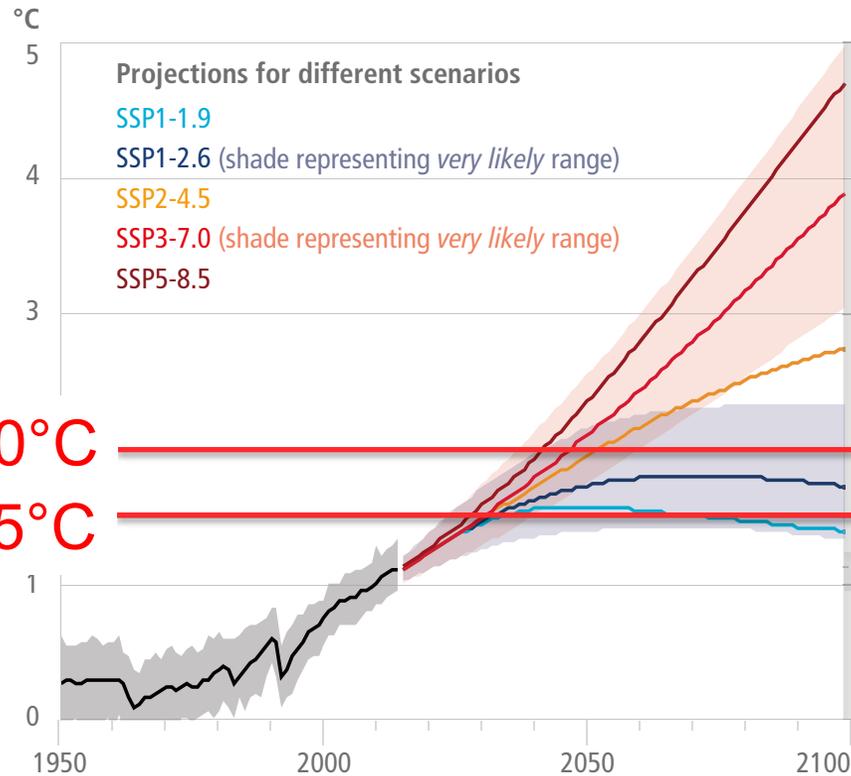
# Risks for Antarctic Sea Ice Ecosystems and Fisheries in relation to global warming levels



# 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**

- Very high
- High
- Moderate
- Undetectable

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



2.0°C  
1.5°C

A photograph of two researchers in red protective suits on a vast, flat ice field. The scene is set at sunset, with the sun low on the horizon, casting a warm orange and yellow glow. One researcher on the right is actively using a hand-operated drill to bore a hole into the ice. The other researcher on the left stands observing. A blue semi-transparent banner is overlaid on the left side of the image, containing the text 'Research Recommendations'.

# Research Recommendations

## Research needs while taking urgent climate action

### The Antarctic: A role model for conservation?

#### Protection of the Southern Ocean:

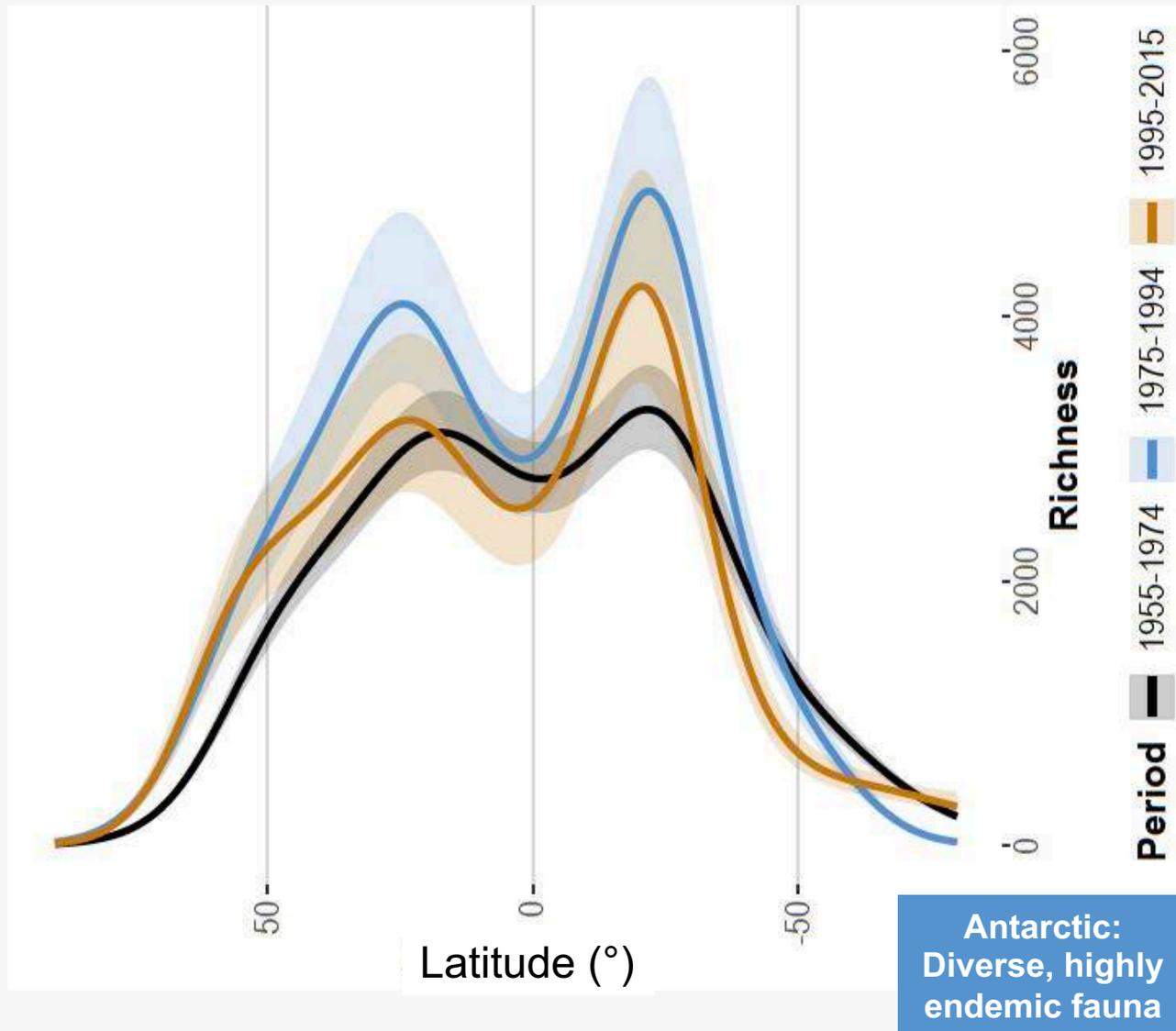
Spatial requirements (matching the 30 to 50% overall)?

- 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

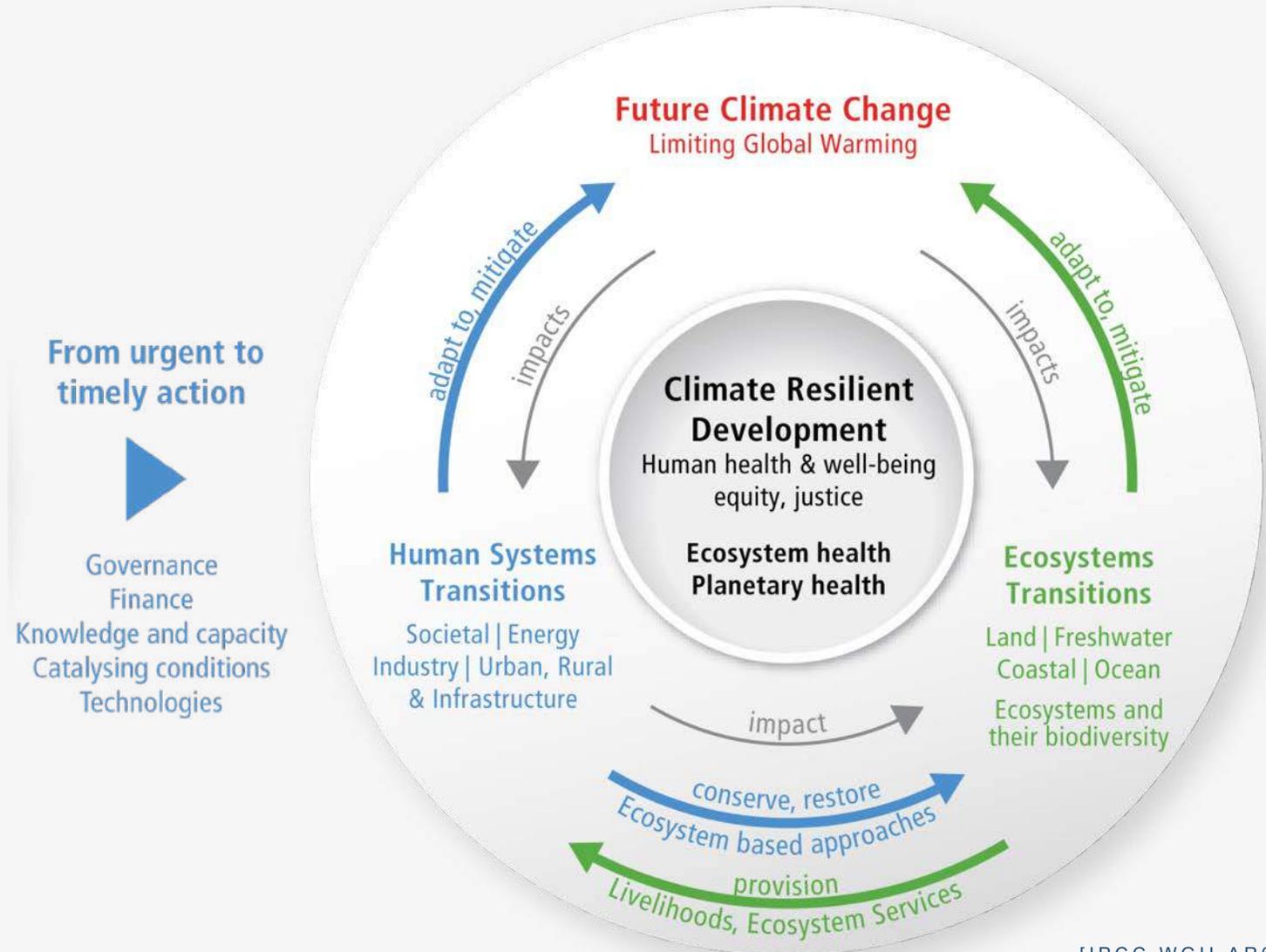
**Lacking: Mechanism-based understanding** of biodiversity distribution

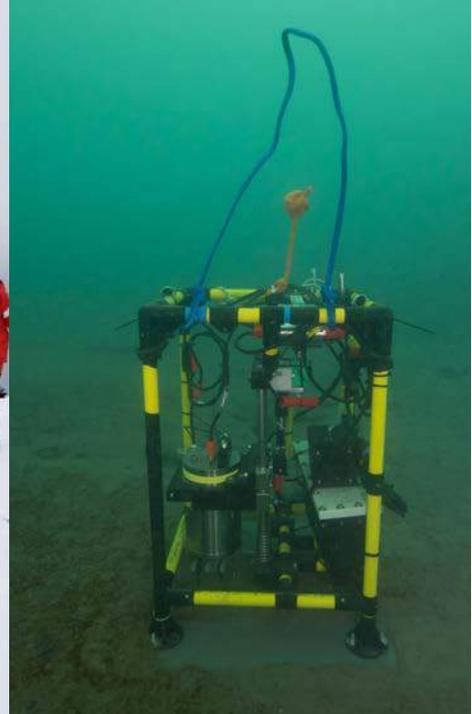
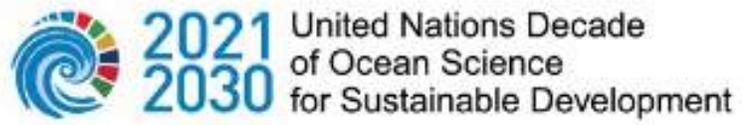


## ... enabling a sustainable future

### 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 landscape photograph showing a massive glacier in the background, its edge meeting a body of water. In the foreground, a black sand beach is crisscrossed by shallow, winding streams of water. A small, red and yellow striped lighthouse stands on the right side of the beach. The sky is clear and blue. A semi-transparent blue banner is overlaid across the middle 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

An aerial photograph of a glacier, showing its intricate patterns and textures. A semi-transparent blue overlay covers the central portion of the image, serving as a background for the text.

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Thank you!

BERLIN, MARCH 24 2022

[NASA earth observatory]