

# How New Zealand's Ocean is changing – New Zealand's Earth System Model

Erik Behrens

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Climate, Freshwater & Ocean Science

THE DEEP SOUTH

Te Kōmata o  
Te Tonga

National  
**SCIENCE**  
Challenges



**NIWA**

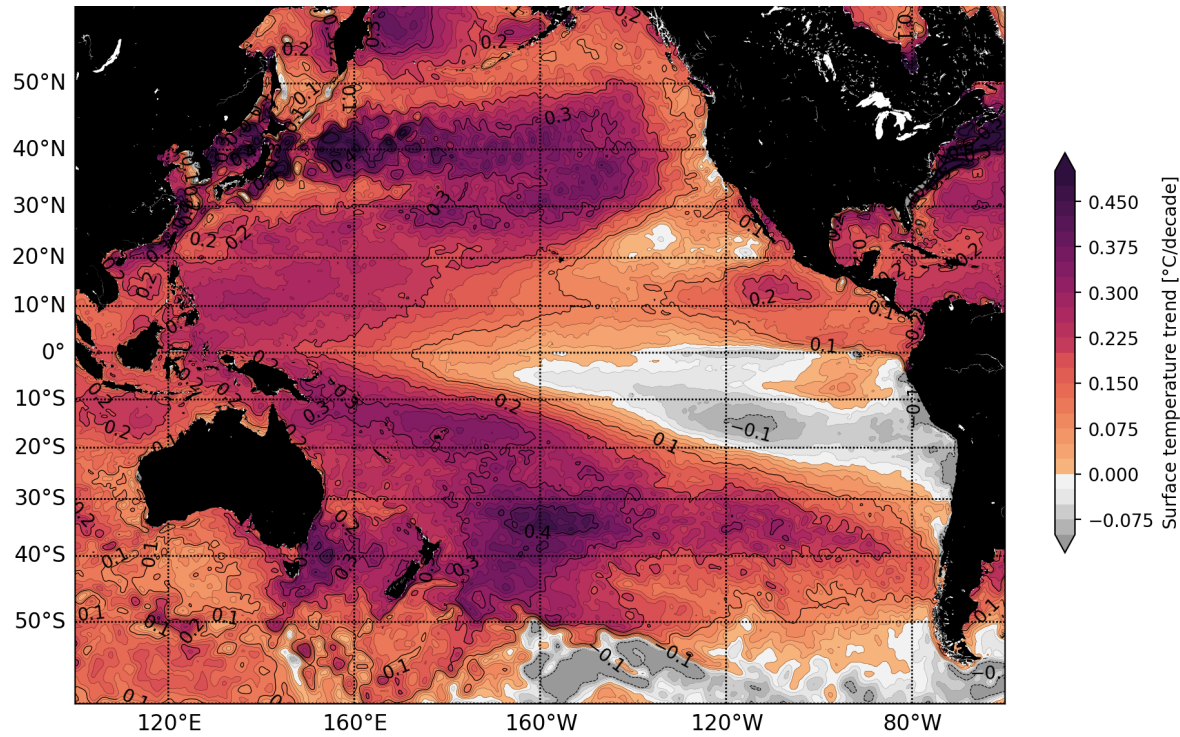
Taihoro Nukurangi

# Outline

- Observed oceanic changes
- New Zealand Earth System Model
- How is the ocean changing over the next decade(s)?
  - Temperature anomalies
  - Temperature extremes (MHWs)
- How do habitats and species distribution will change
- Take home messages

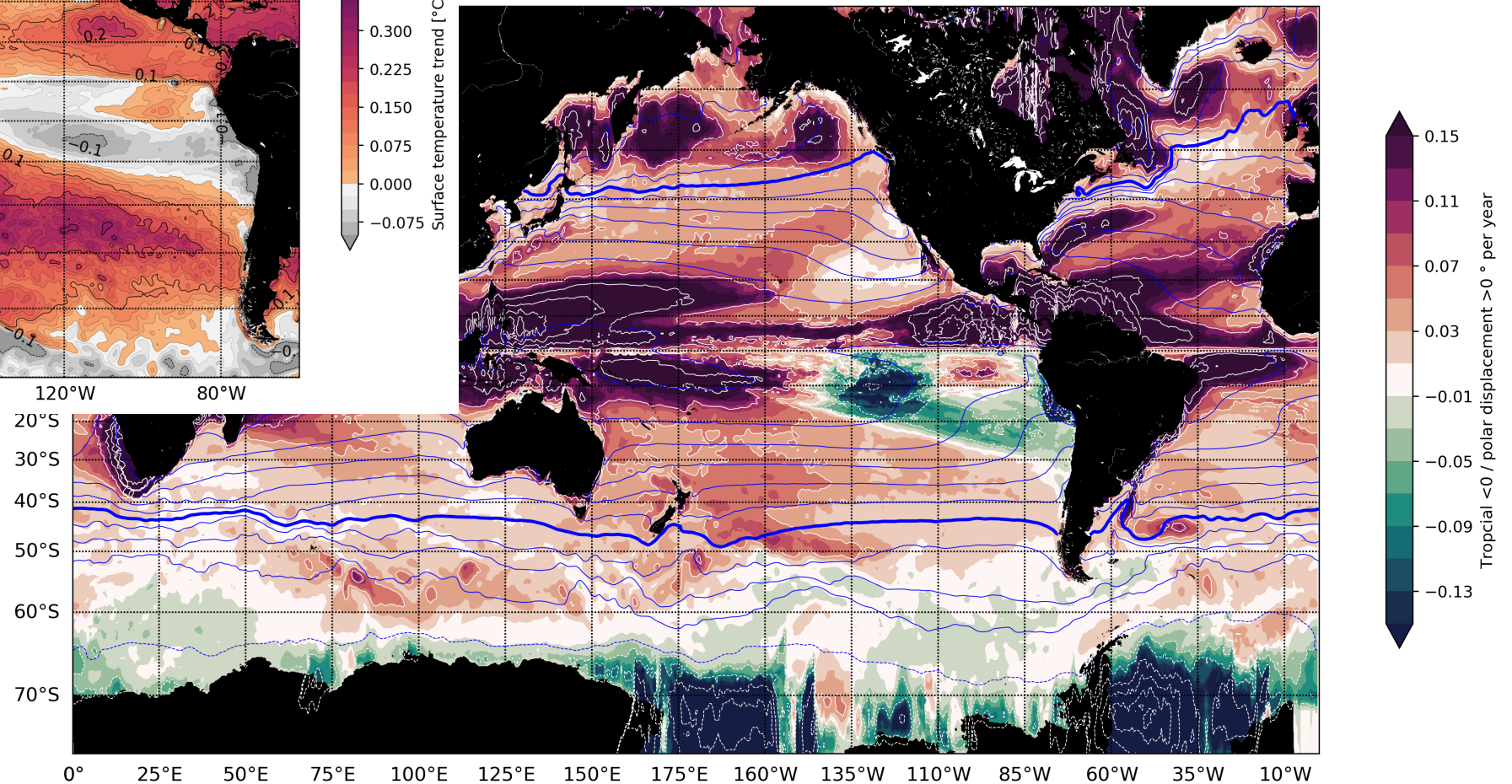
# The observed warming and expansion of the (sub)tropics

Observed SST trend 1981-2023



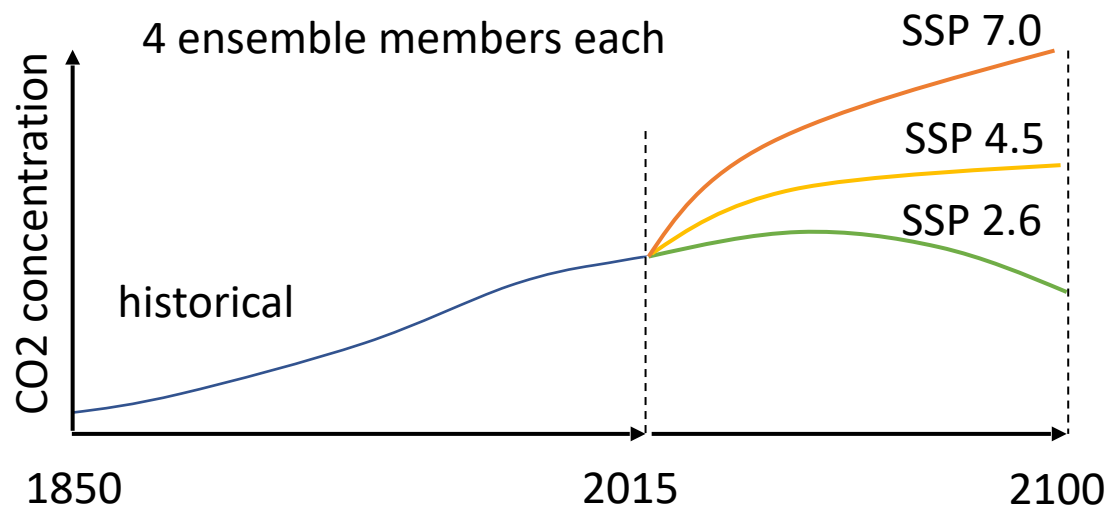
- New Zealand's Ocean warms about  $\sim 0.3\text{C}$  per decade
- Isotherms shift about 5km per year southward

Observed meridional shift of isotherms

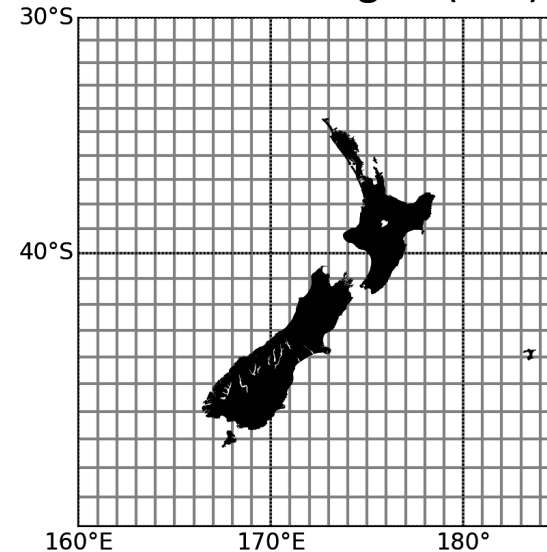


# New Zealand's Earth System Model in a nutshell

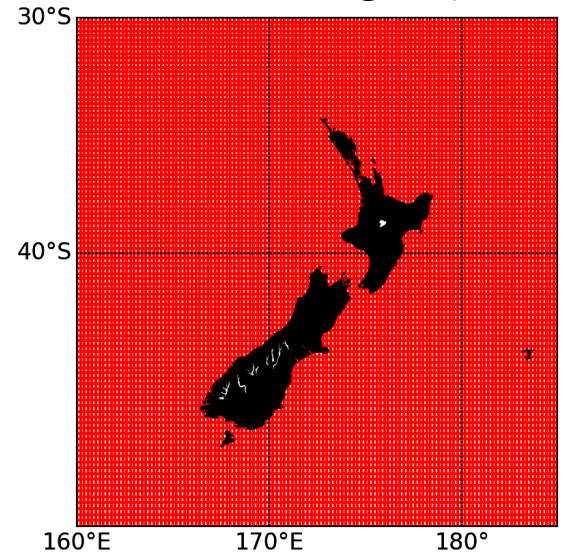
- New Zealand Earth System Model (NZESM) is CMIP6 class earth system model based on UKESM
- NZESM simulates past and possible future changes in relation to CO<sub>2</sub> emissions (CMIP6, IPCC)
- NZESM has a refined ocean grid to capture local conditions better ('dynamic downscaling')



UKESM model grid (1x1)



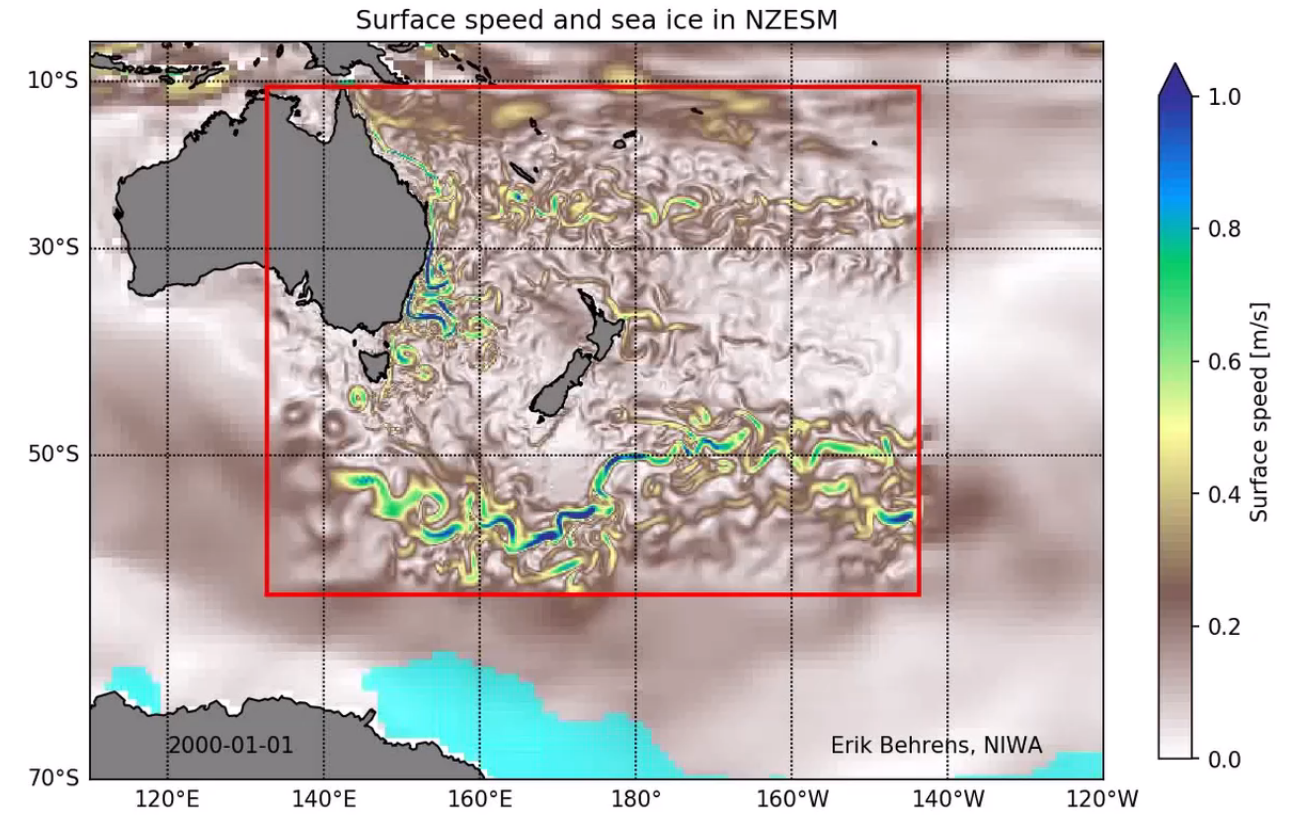
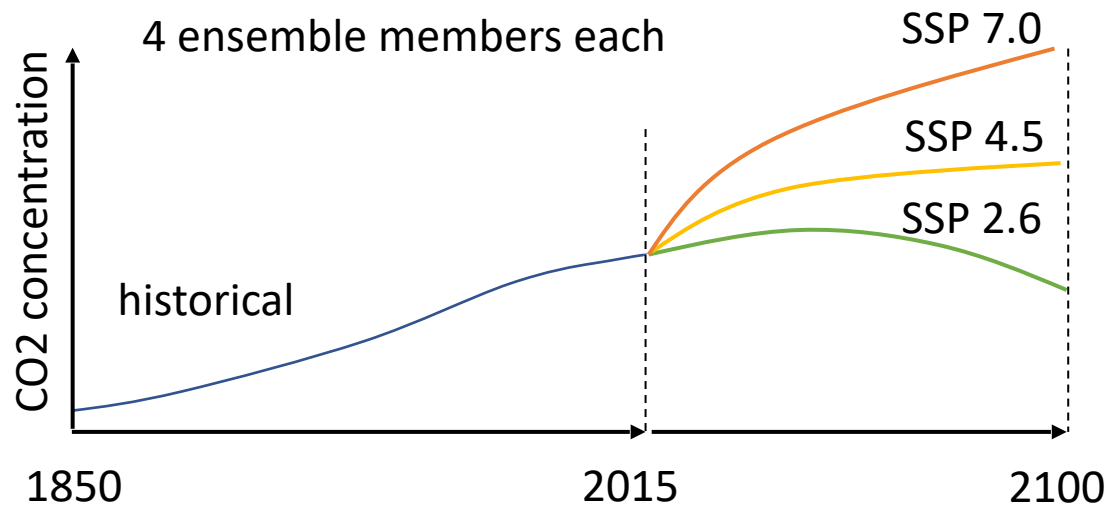
NZESM model grid (0.2x0.2)





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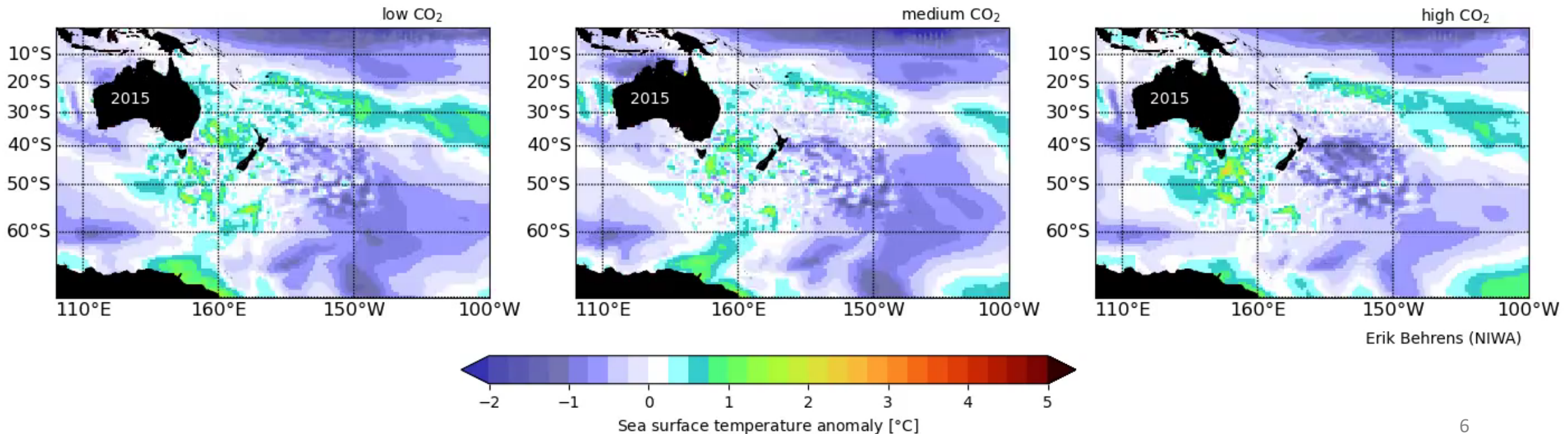
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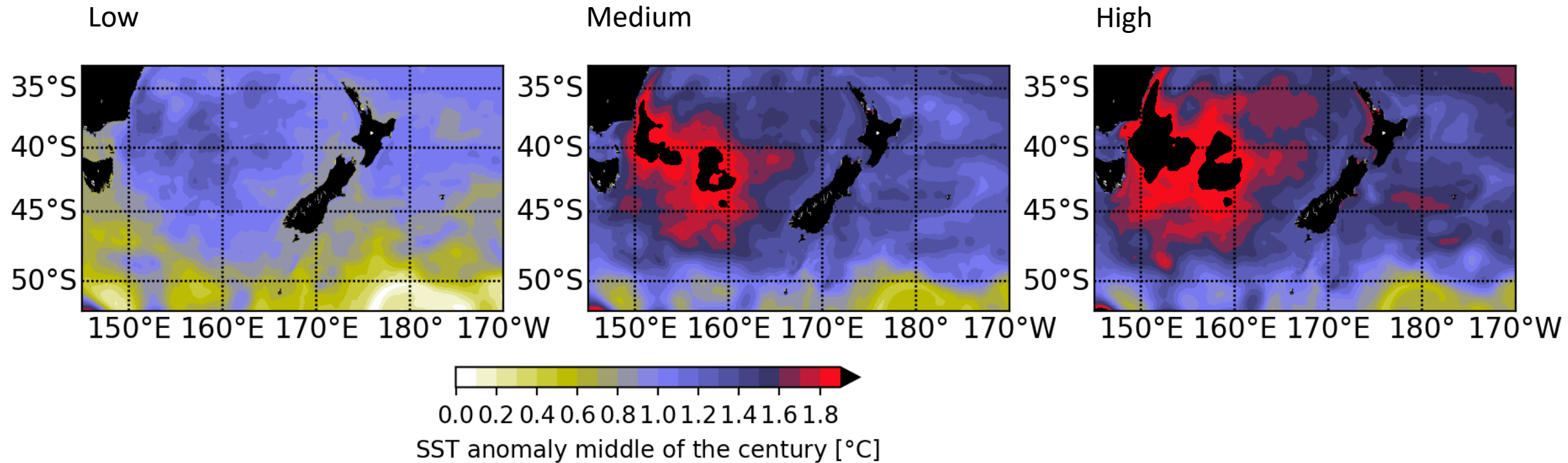
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Sea surface temperature anomalies SSP2.6, SSP4.5 and SSP7.0



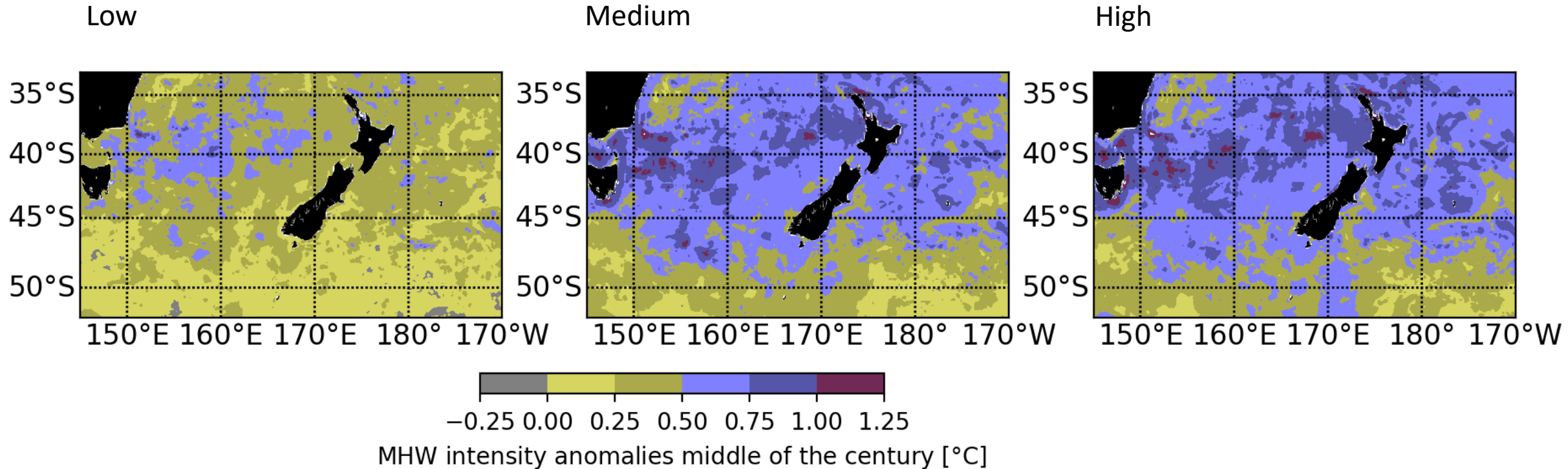
# Sea surface temperature anomalies middle of the century

- NZ surface ocean will have warmed by at least 0.8 to 1.5 degrees on average by 2050
- Australia east coast will be more impacted



# Median MHW intensities anomalies middle of the century

- A normal MHW will be at least 0.25-0.75 degrees more intense than present day conditions
- MHW impacts between Australia and Aotearoa-NZ will be similar

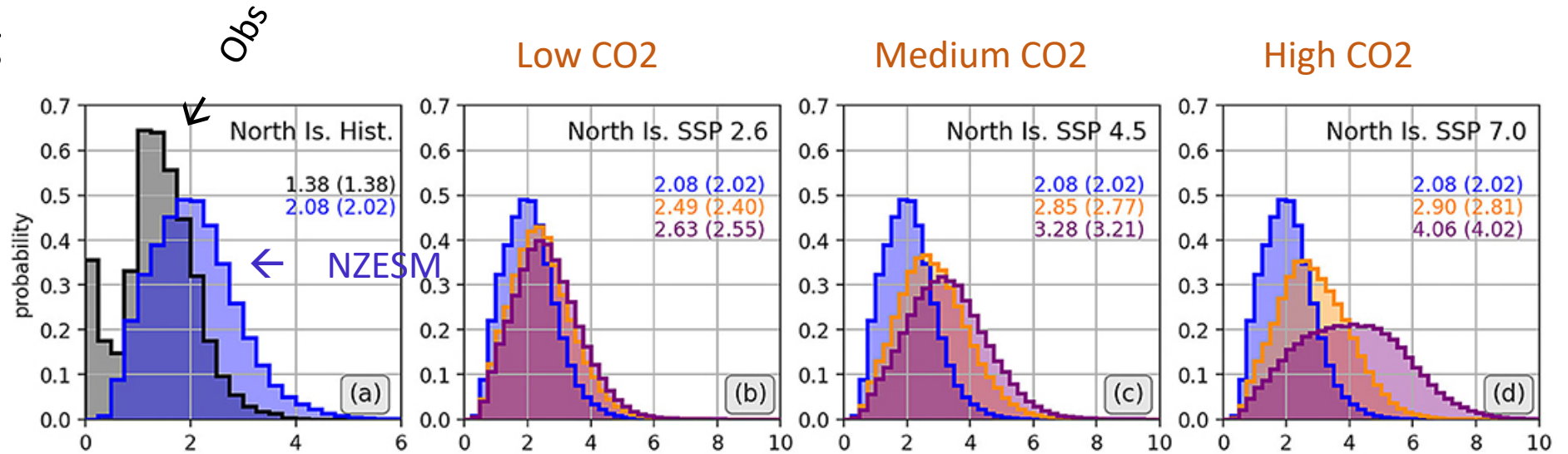




# MHWs intensity in coastal waters

- NZESM misses low intensity MHWs and has too many strong MHWs.
- North Island +0.5-1C increase
- South Island +0.3-0.6C increase
- Increased likelihood for intense MHWs

OBS 1995-2014, NZESM 1995-2014, 2040-2059, 2080-2099

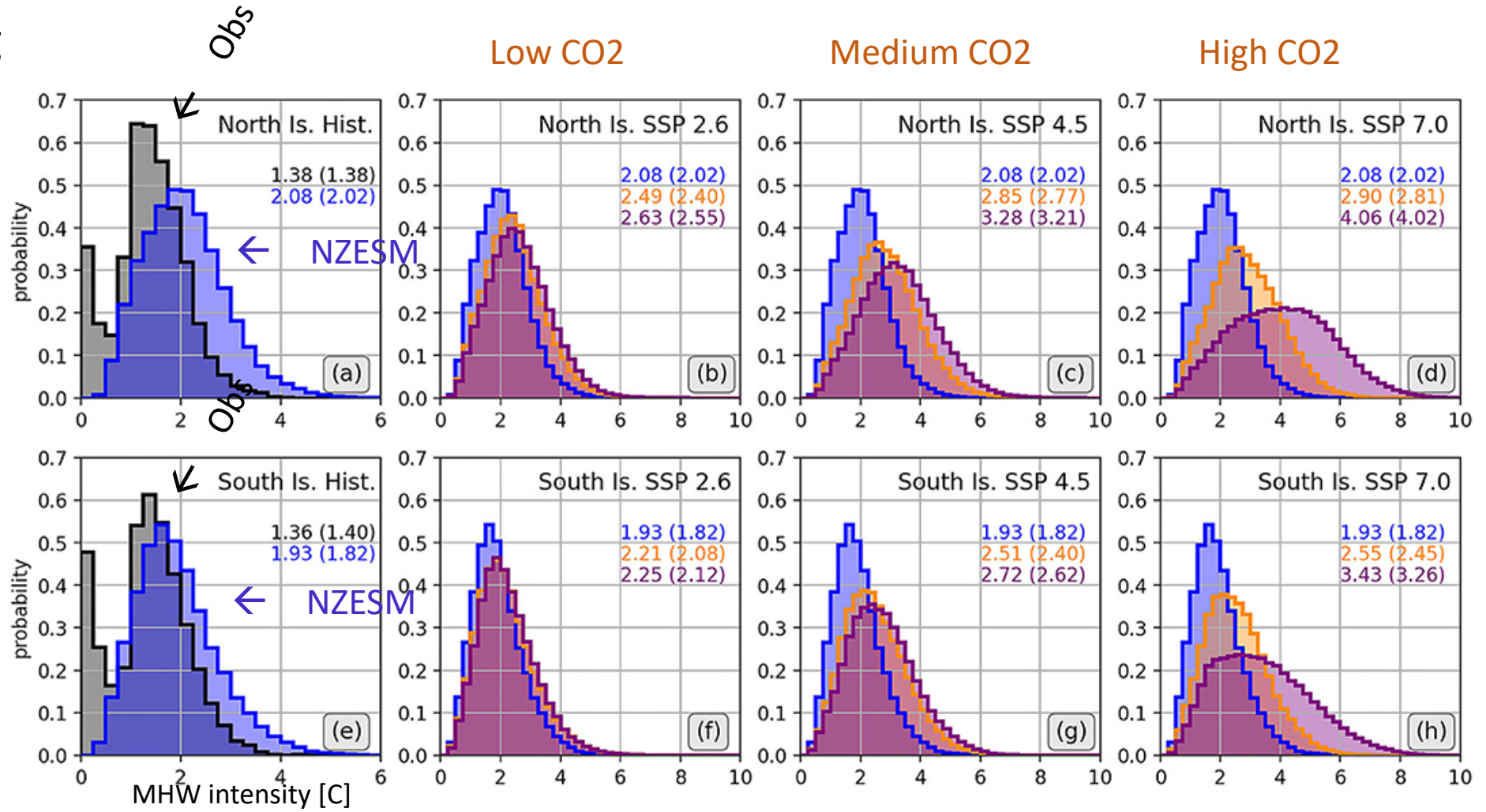


MHW intensity [C]

# MHWs intensity in coastal waters

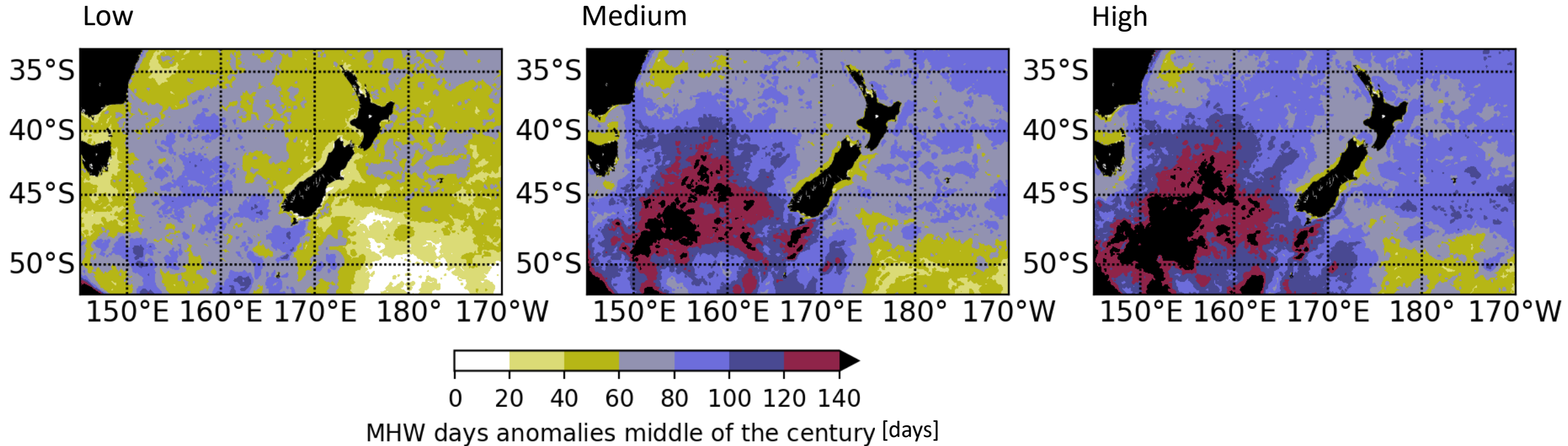
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# Median MHW days anomalies middle of the century

- Large increases in Tasman Sea as it warms and the Subtropical Front shifts south
- Currently we have about 55 days (North Island) and 30 days (South Island)





# NZESM data to predict change in species distributions

- NZESM data has been used as input in combination with information of current species distributions
  - Temperature
  - pH
  - Aragonite horizon
  - Oxygen
  - .....

## **Predicting the effects of climate change on deep-water coral distribution around New Zealand—Will there be suitable refuges for protection at the end of the 21st century?**

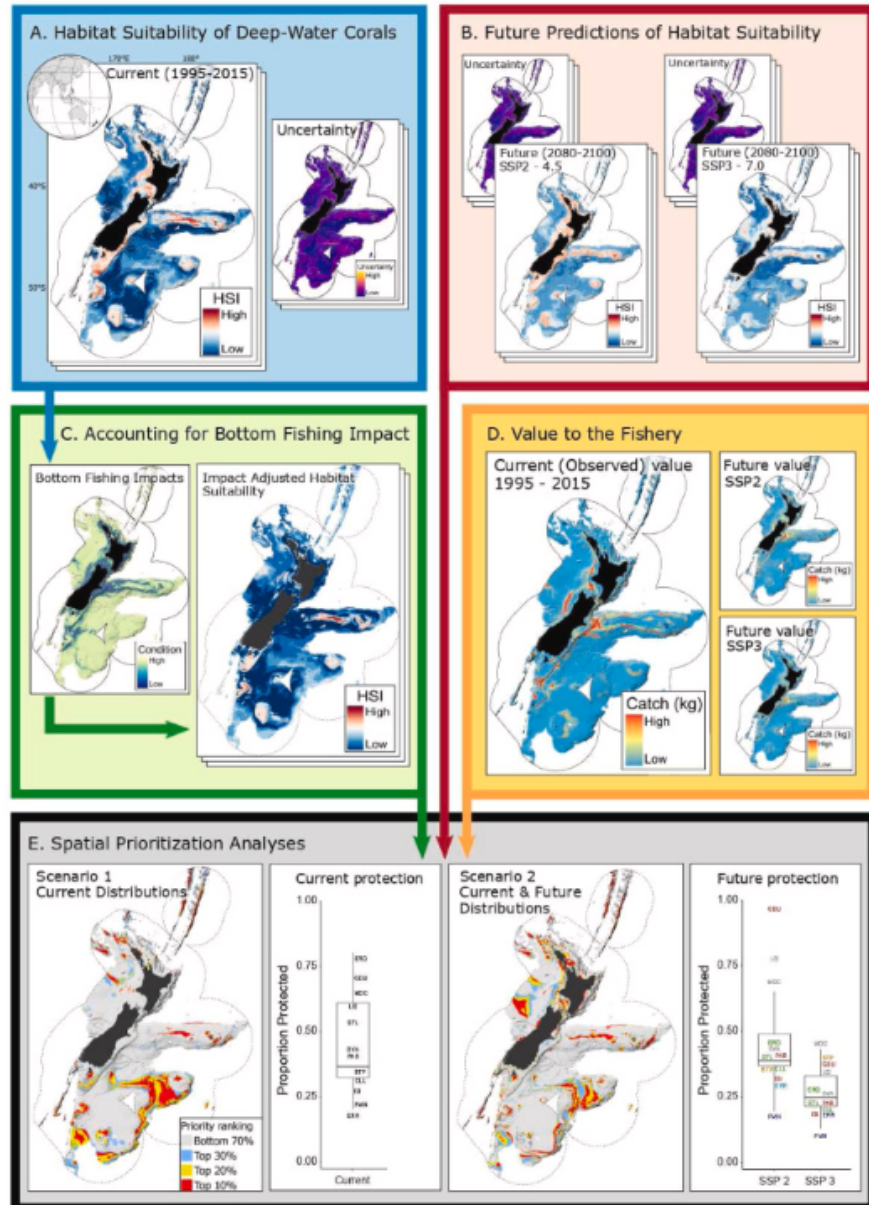
Owen F. Anderson  Fabrice Stephenson, Erik Behrens, Ashley A. Rowden

## Implications for the conservation of deep-water corals in the face of multiple stressors: A case study from the New Zealand region

[Fabrice Stephenson](#)<sup>a</sup>  , [Ashley A. Rowden](#)<sup>b c</sup>, [Owen F. Anderson](#)<sup>b</sup>, [Joanne I. Ellis](#)<sup>d</sup>, [Shane W. Geange](#)<sup>e</sup>, [Tom Brough](#)<sup>f</sup>, [Erik Behrens](#)<sup>b</sup>, [Judi E. Hewitt](#)<sup>g</sup>, [Malcolm R. Clark](#)<sup>b</sup>, [Dianne M. Tracey](#)<sup>b</sup>, [Savannah L. Goode](#)<sup>b c</sup>, [Grady L. Petersen](#)<sup>f</sup>, [Carolyn J. Lundquist](#)<sup>f h</sup>





# NZESM data to predict change in species distributions



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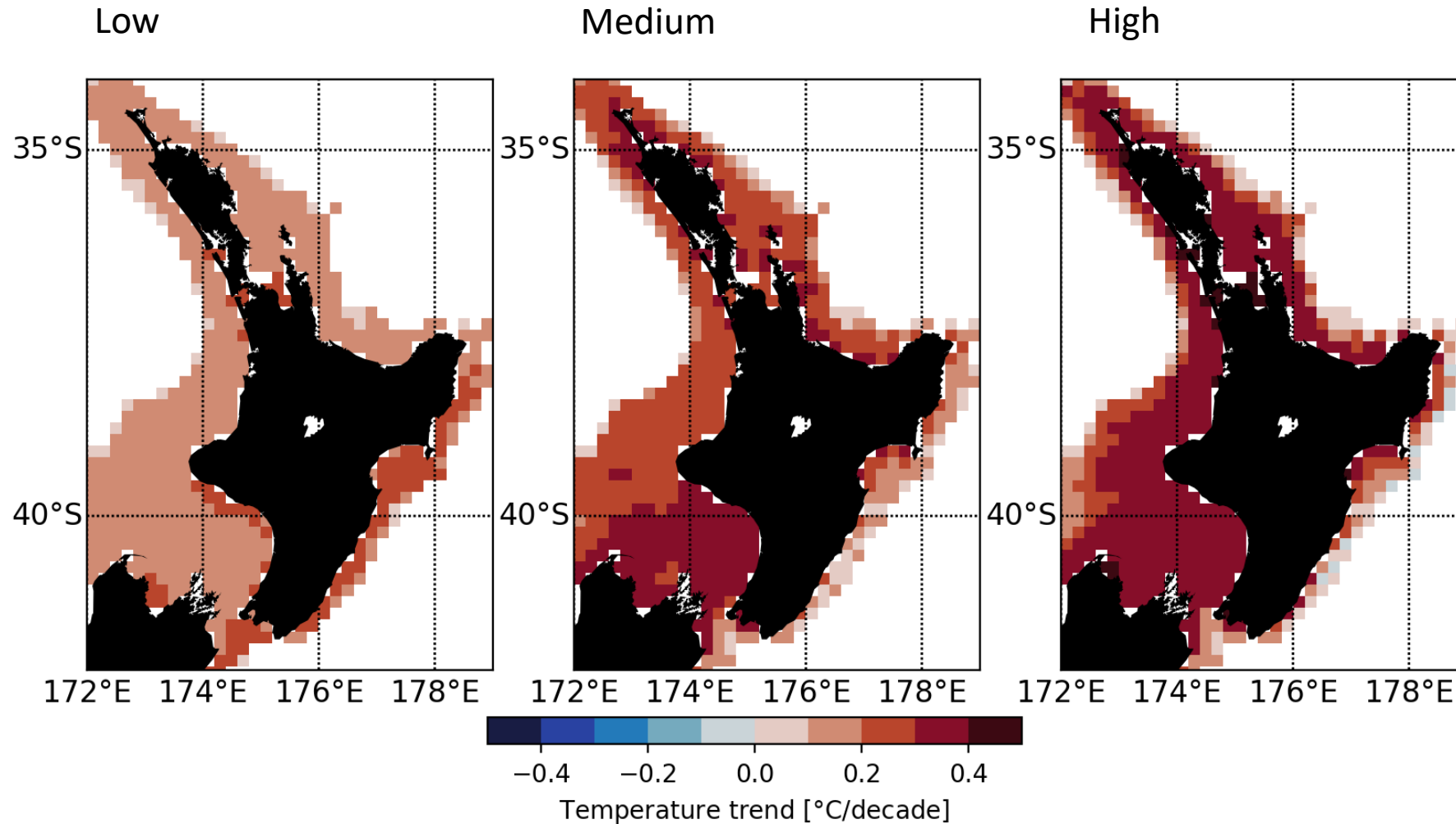
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# Take home messages

- New Zealand's Oceans warm ( $\sim 0.3\text{C}/\text{decade}$ ) about 3 times the global rate.
- Over the past decade New Zealand has seen an increasing number of MHWs. This trend will continue.
- MHW intensities are projected to increase more strongly around the North Island, while MHW days will increase more strongly around the South Island.
- Temperatures shift about 5km/year southward.
- Climate change predictions are valuable to inform spatial planning

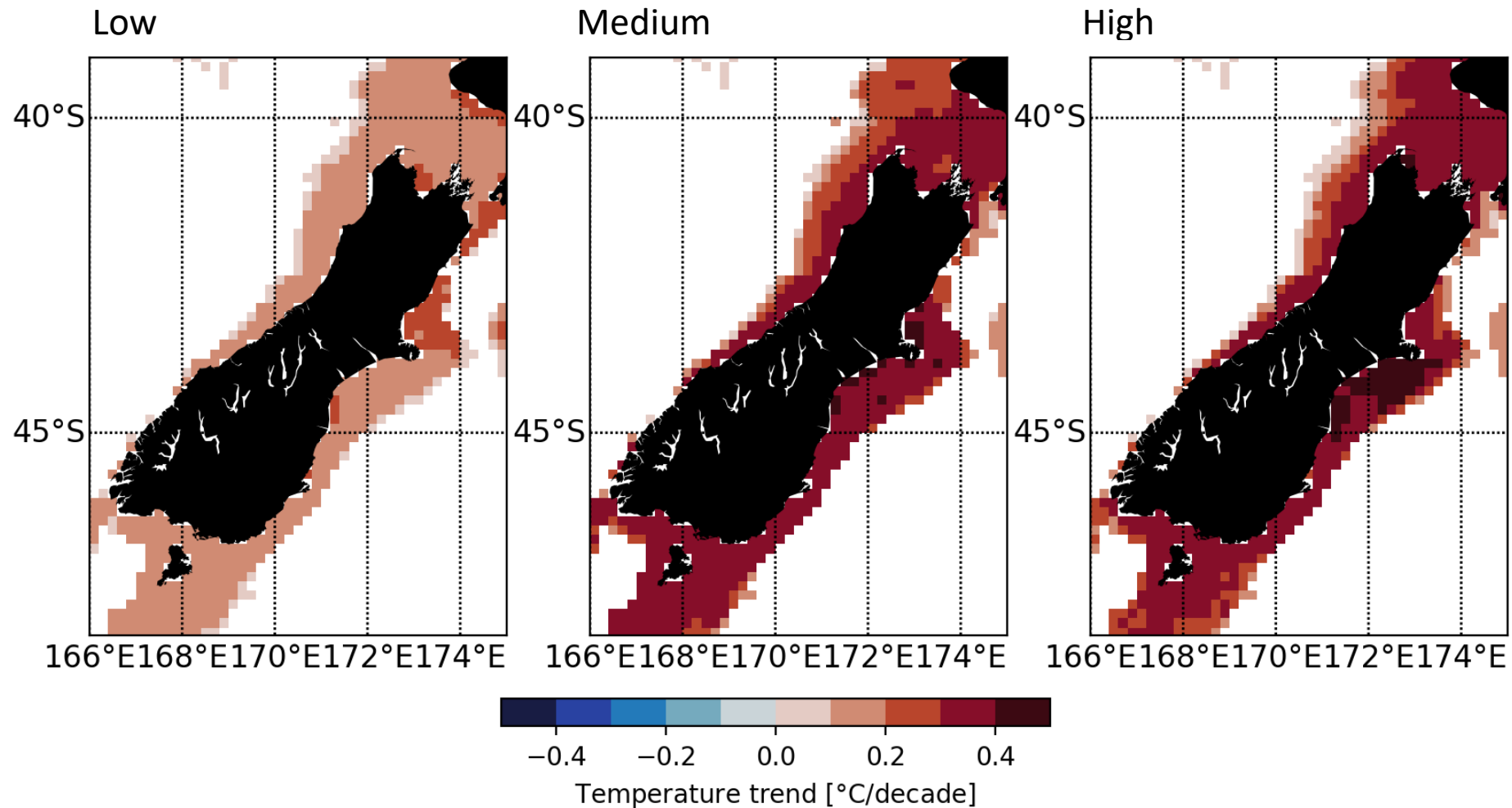
# Bottom temperature trends in coastal waters

- Enclosed bays show stronger bottom warming.
- Hotspots are North and West Coast, East Coast is not warming as much.



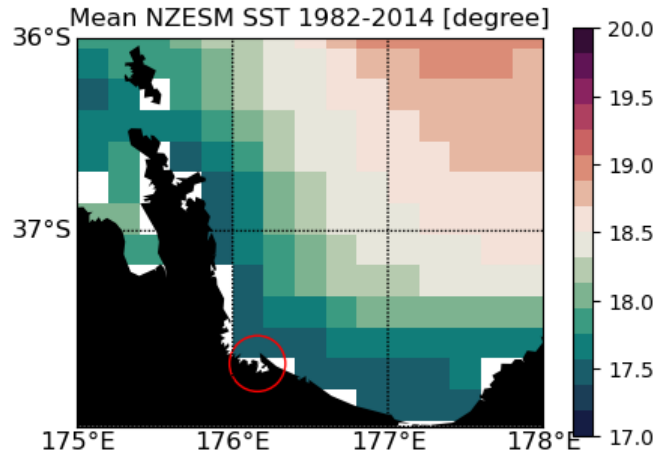
# Bottom temperature trends in coastal waters

- South Island does not show much regional differences, possibly more along North Otago Coast.

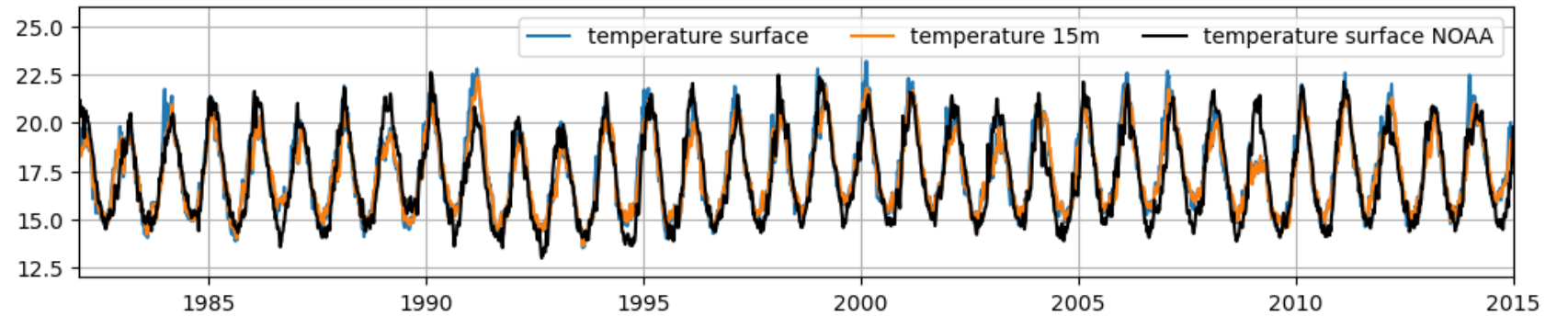




# Why dynamic downscaling?



Extracted NZESM temperatures against observations for Tauranga region



Extracted NZESM temperatures for best and worst case scenarios

