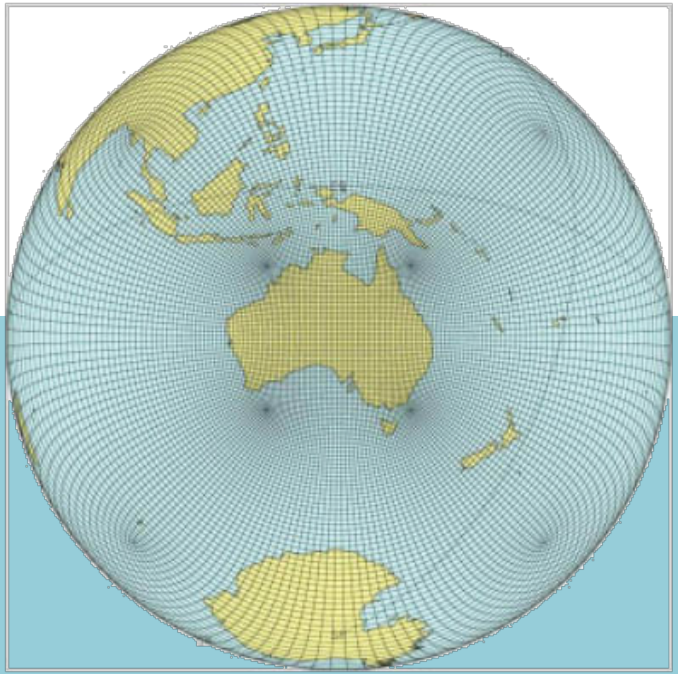

REGIONAL CLIMATE INFORMATION NEEDS FOR ECOLOGICAL STUDIES AND ASSESSMENT

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UNIVERSITY of TASMANIA

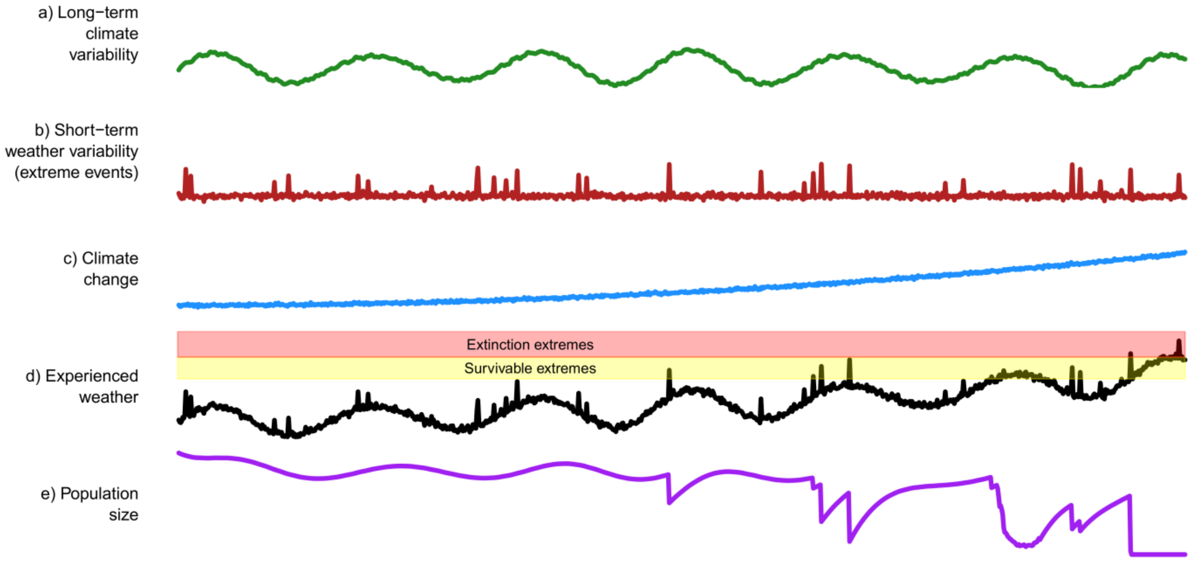
USC

INFORMATION NEEDS for ECOLOGICAL STUDIES

- Aim to characterise regional patterns of change, detect responses to recent trends and project future impacts

- Key risks differ across regions and realms, but ecological approaches and information needs are similar:

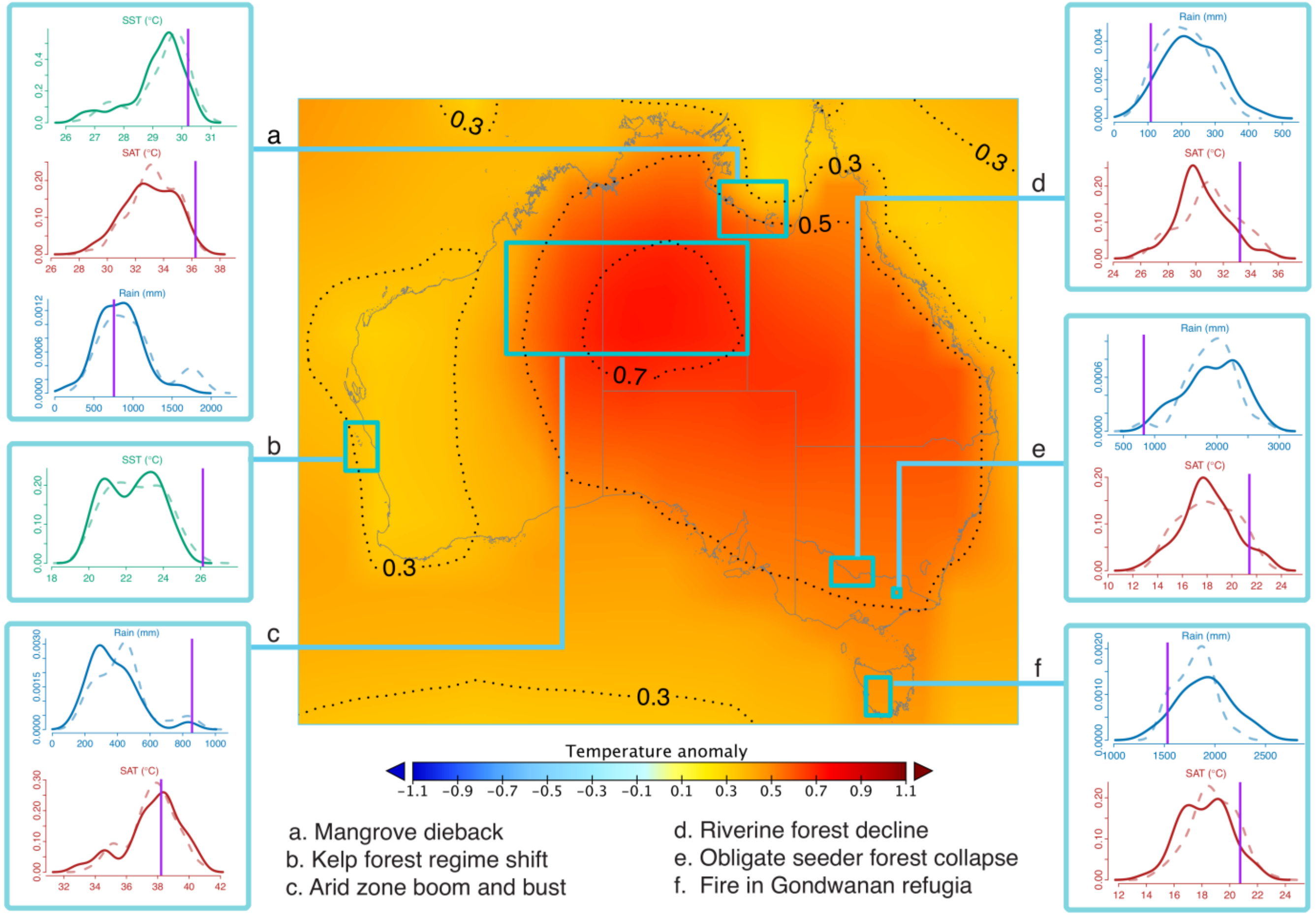
1. Summary statistics/maps
2. Data products
3. Guidance on appropriate usage

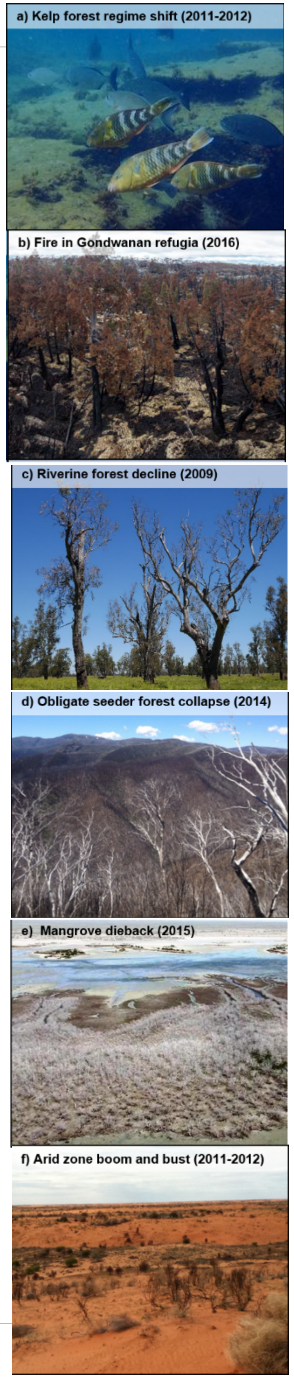


The 'Press-Pulse' framework

1. SUMMARY DATA - HISTORICAL DATA

- Recent regional trends in temperature and precipitation
- Necessary to understand if recent climate variability exceeds natural variability – emergence of climate change signal and impact



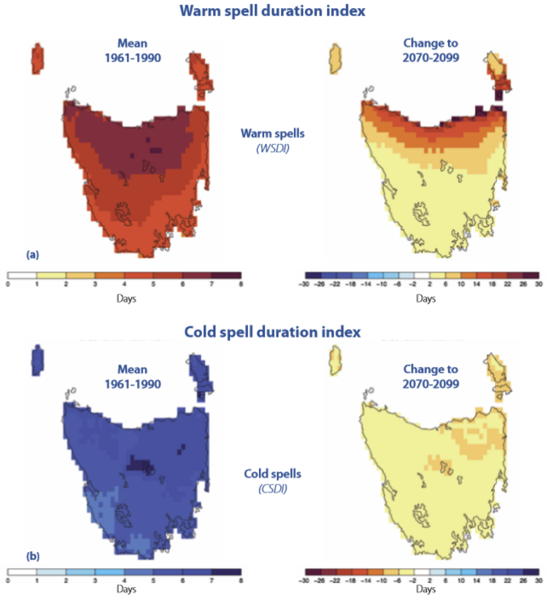


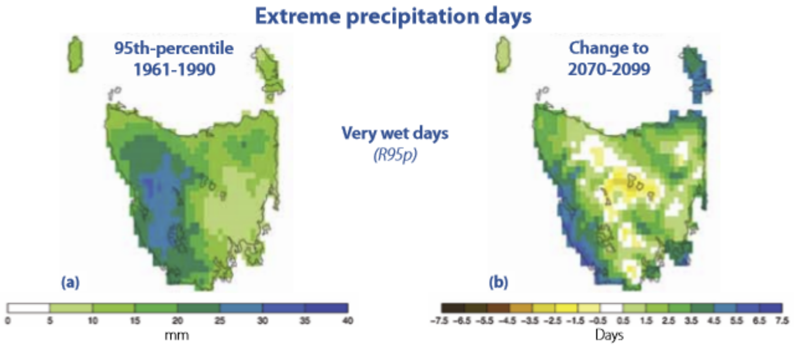
Harris et al. (In Press) Nature Climate Change

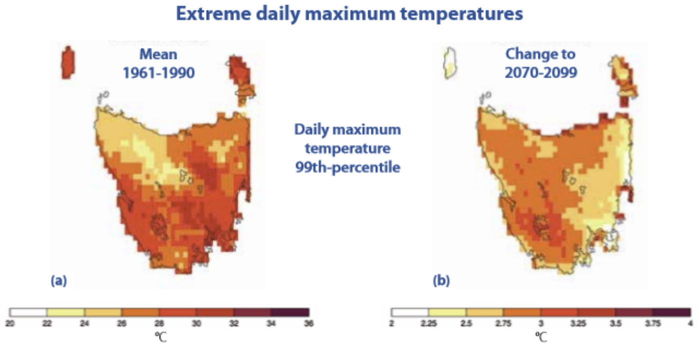
1. SUMMARY DATA - PROJECTIONS

INFORMATION about EXTREMES

- Indices describing heat waves, heavy rain, drought, coastal flooding
- Absolute values reflecting physiological limits
- Percentiles relative to the historical mean







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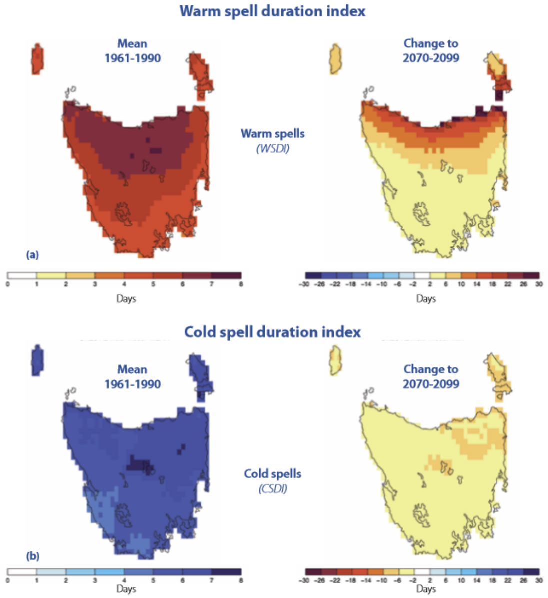
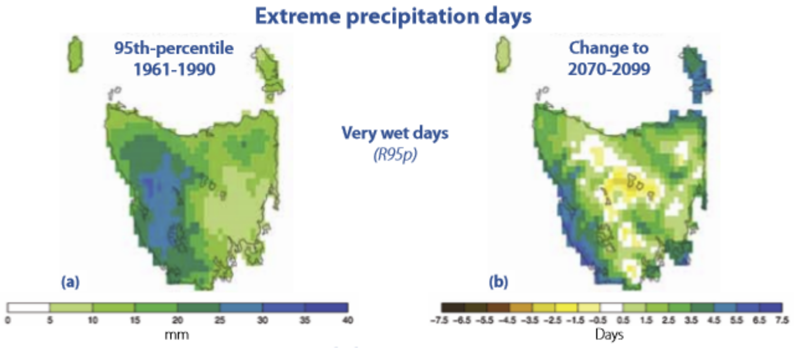
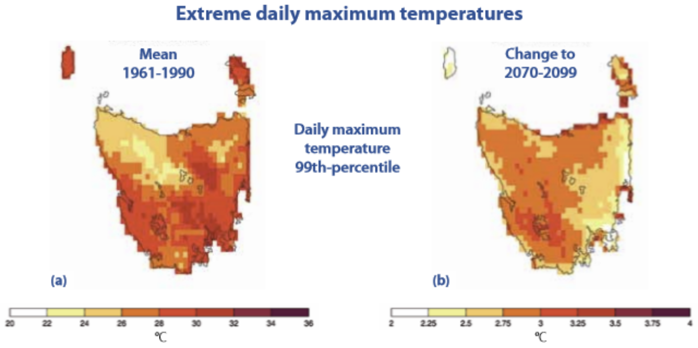


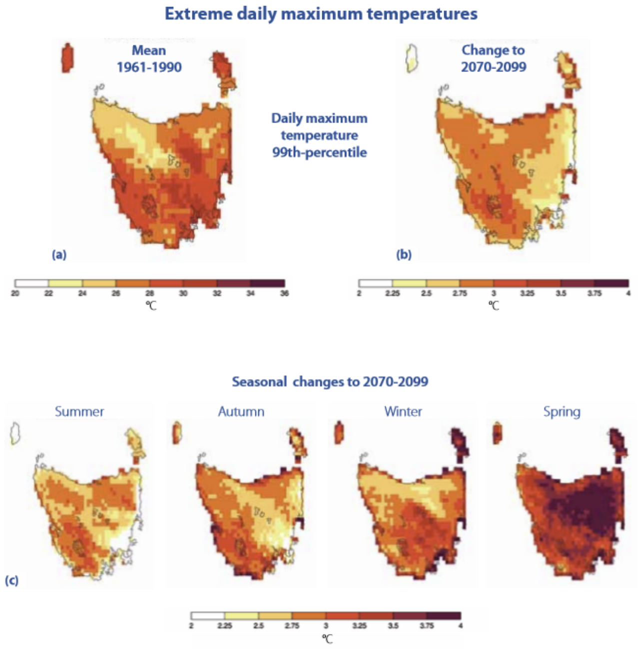


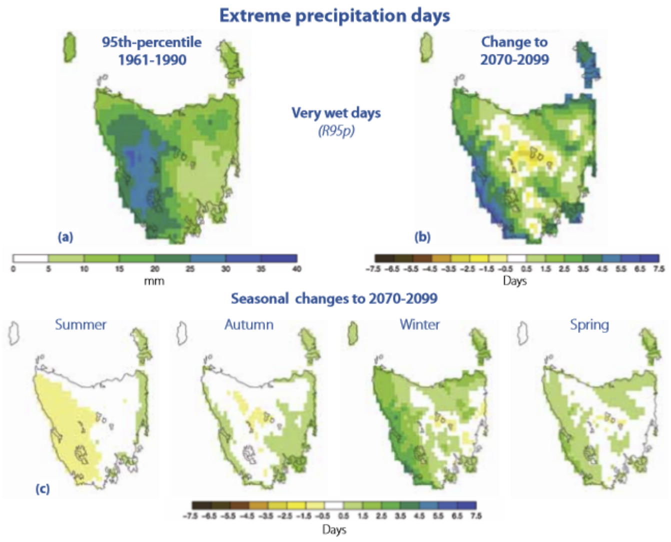


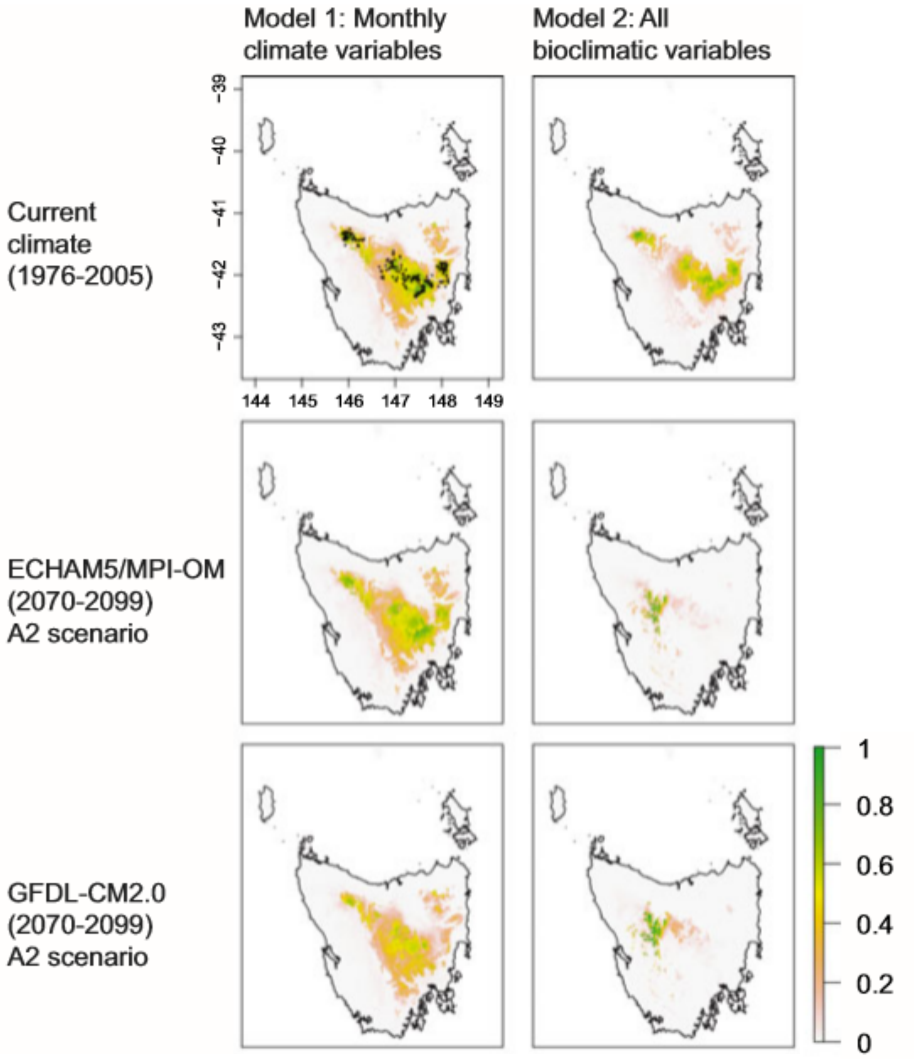
1. SUMMARY DATA - PROJECTIONS

INFORMATION about SEASONALITY

- Seasonal changes
- Monthly summaries
- Shifts in fire/growing season







Harris et al. (2013) Ecological Restoration and Management **14**, 230-234

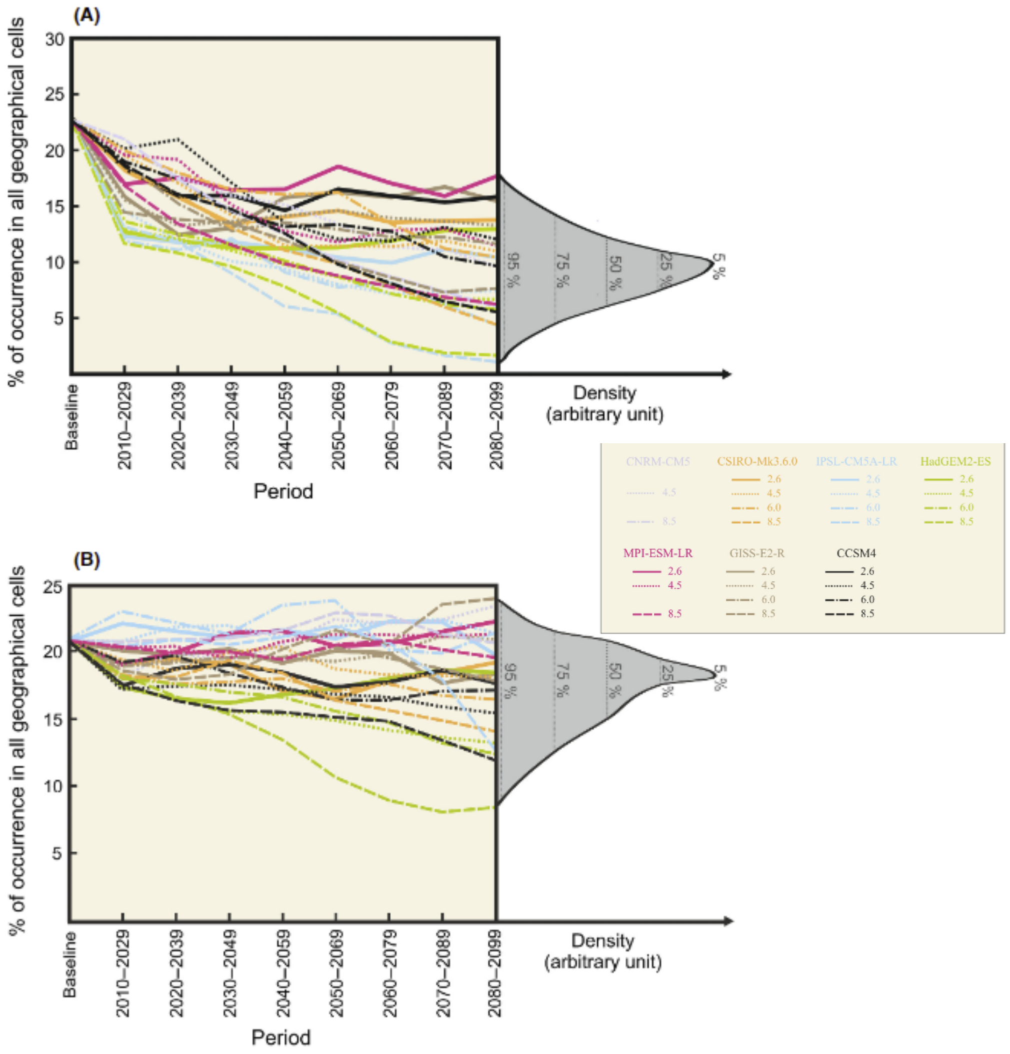
1. SUMMARY DATA - PROJECTIONS

MULTIPLE GLOBAL CLIMATE MODELS AND SCENARIOS

- Model Uncertainty – range of GCMs

- Multi model mean not appropriate:
  - Gives a 'central estimate', not compatible with a risk-assessment approach ('worst case' and 'best case' scenarios)
  - Lose information about variability and extremes

- Assessment of skill and comparison of means in relation to archive mean for each region

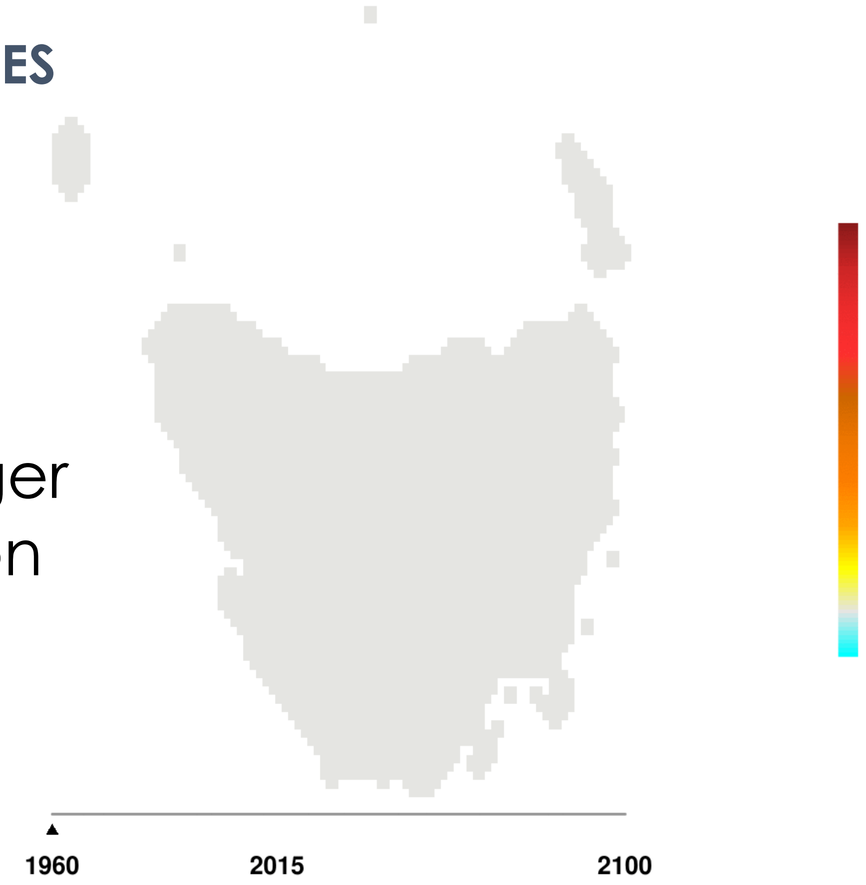


Goberville et al. (2015) Ecology and Evolution 5(5): 1100 – 1116

1. SUMMARY DATA - PROJECTIONS

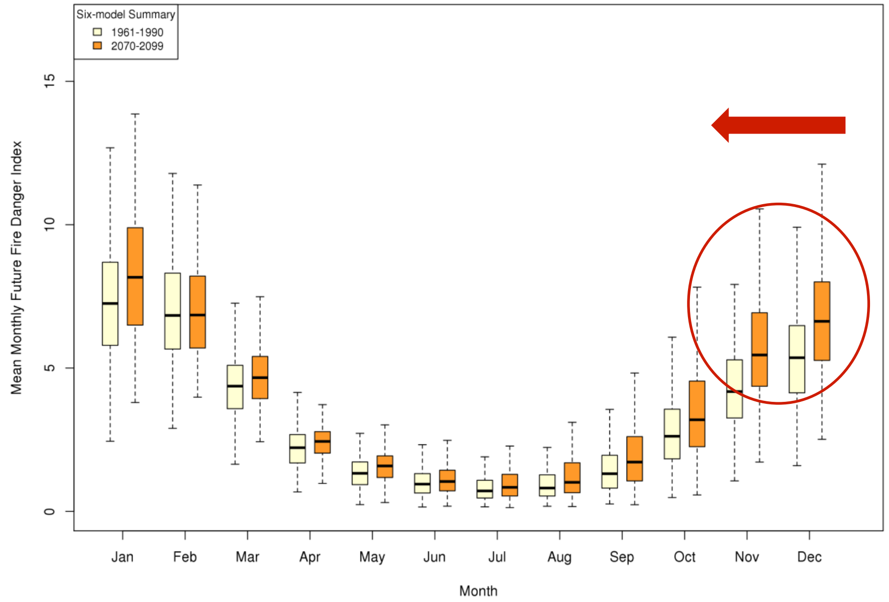
RANGE of VARIABLES

- Wind, humidity, evaporation
- Future Fire Danger (FFDI), Population Growth Models



Cumulative Forest Fire Danger Index

Fire danger in SE Australia



1. SUMMARY DATA - PROJECTIONS

RANGE of VARIABLES

- In some cases, variables important to marine & terrestrial impacts overlap

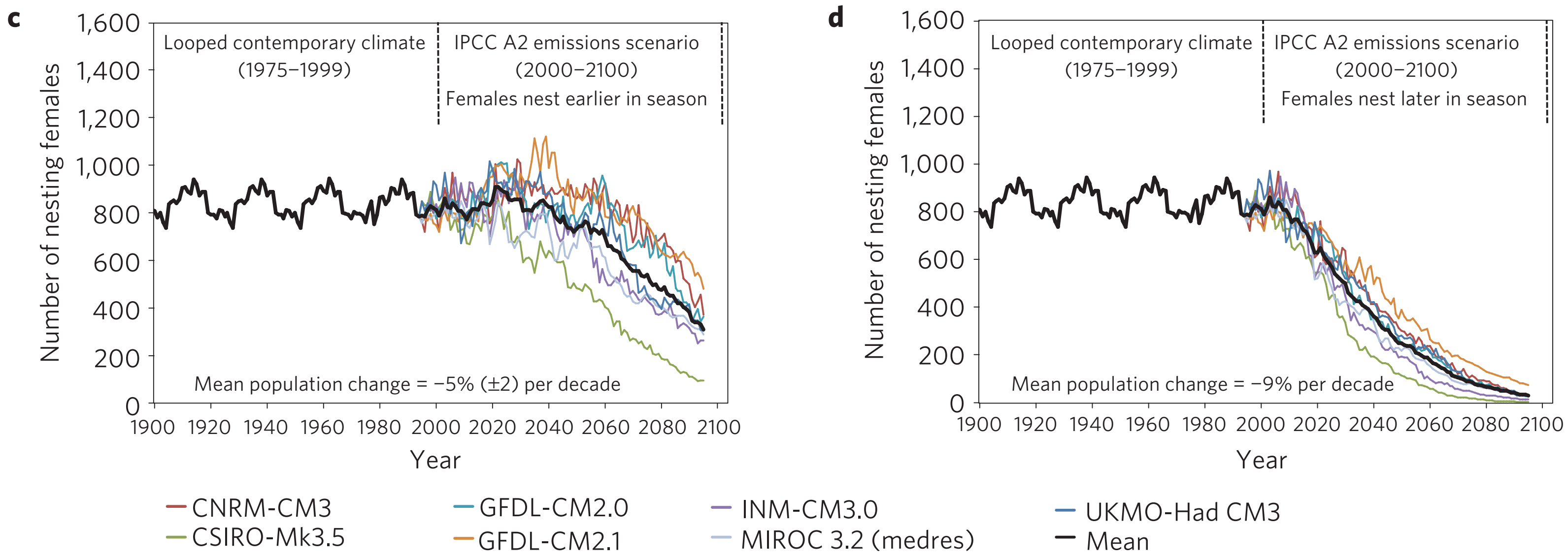


Figure 4 | Nesting phenology of leatherbacks in relation to the local climate at Playa Grande, Costa Rica. a,**b**, Observed mean annual proportion (±standard deviation) of nesting females during each month of the nesting season (October–February) compared with observed mean monthly precipitation at Playa Grande from 1975 to 1999 (from local airport; Supplementary Methods) (**a**) and observed mean monthly air temperature at Playa Grande from 1975 to 1999 (from local airport; Supplementary Methods) (**b**). **c**,**d**, CLIMPOP projections of annual numbers of nesting female leatherbacks at Playa Grande, Costa Rica, during SRES A2 (among seven climate models) when considering that the turtles exclusively nest in the earlier portion of the nesting season (**c**) and the later portion of the nesting season after the year 1999 (**d**).

Saba et al. (2012) Projected response of an endangered marine turtle population to climate change. *Nature Climate Change* **2:** 814-820

1. SUMMARY DATA - PROJECTIONS

RANGE of VARIABLES

- But in marine systems, temperature is generally the variable of most interest, often as a direct proxy for impact

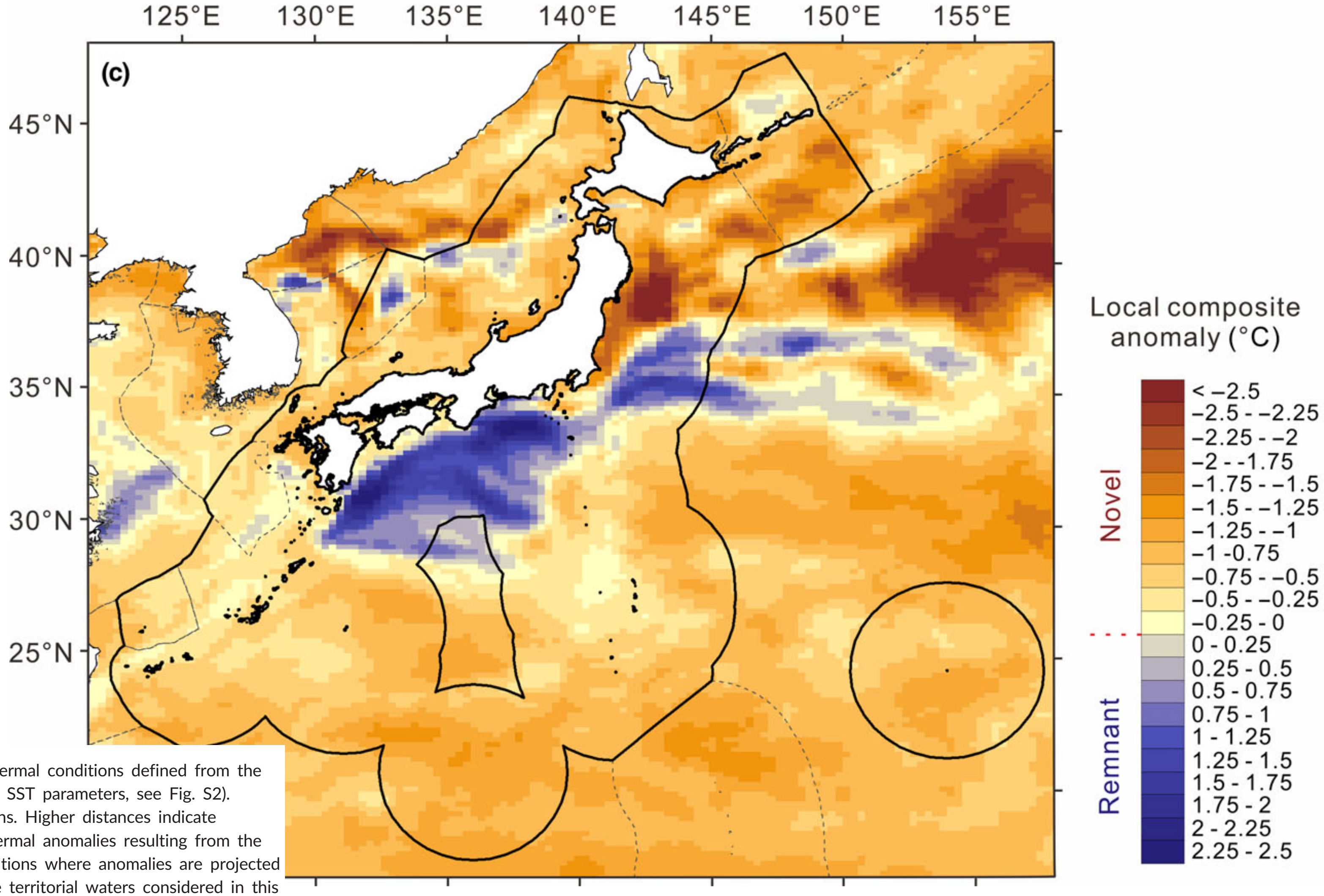


FIGURE 3 Projected local climate stability. (a) Climate analogue threshold for composite local thermal conditions defined from the baseline (1986–2005) standard deviation of all temperature parameters (see Methods; for individual SST parameters, see Fig. S2). (b) Euclidean distances between baseline and future (2026–2035) composite mean thermal conditions. Higher distances indicate increasing dissimilarity between future local climates and current conditions. (c) Local composite thermal anomalies resulting from the difference between (a) and (b). Blueish/brownish colours indicate remnant/novel local climatic conditions where anomalies are projected to stay within/surpass background climate variability at each locality. The black contour defines the territorial waters considered in this study

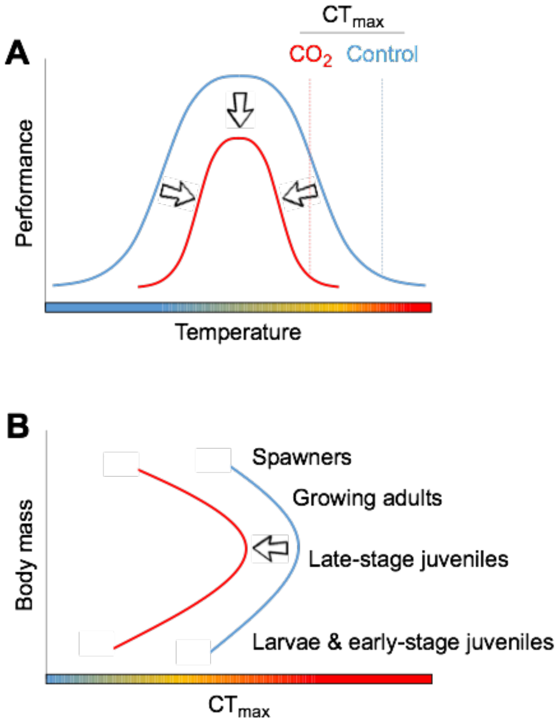
García Molinos et al. (2017) Improving the interpretability of climate landscape metrics: An ecological risk analysis of Japan's Marine Protected Areas. *Global Change Biology* **23:** 4440–445

1. SUMMARY DATA - PROJECTIONS

RANGE of VARIABLES

- Other variables of interest include pH, nutrient concentrations, etc.

Fig. 1. Theoretical models of the effects of temperature and elevated P_{CO_2} on ectotherms. (A) Theoretical changes in the performance (i.e. fitness) of ectothermic animals as a function of temperature, where animals under present-day levels of P_{CO_2} (blue curve; e.g. 400 µatm) have higher performance and a broader thermal performance curve than animals under future projected levels of P_{CO_2} (red curve; e.g. 1000 µatm). Putative mechanisms to explain this hypothetical response include cellular acid–base disequilibria and/or a reduction in the scope for oxygen transport (i.e. aerobic metabolic scope) of the animal. Such a response to P_{CO_2} would lower the critical thermal maximum (CT_{max}) of animals in an elevated P_{CO_2} environment (leftward shift in dashed vertical line). (B) Thermal limits (e.g. CT_{max}) have been proposed to increase throughout ontogeny and reach peak values in late-stage juveniles, subsequently declining as animals approach reproductive maturation and spawning. Increased environmental P_{CO_2} is predicted to decrease the thermal limits of all life stages (shift from blue to red curve) (adapted from: Pörtner, 2008; Pörtner and Farrell, 2008).



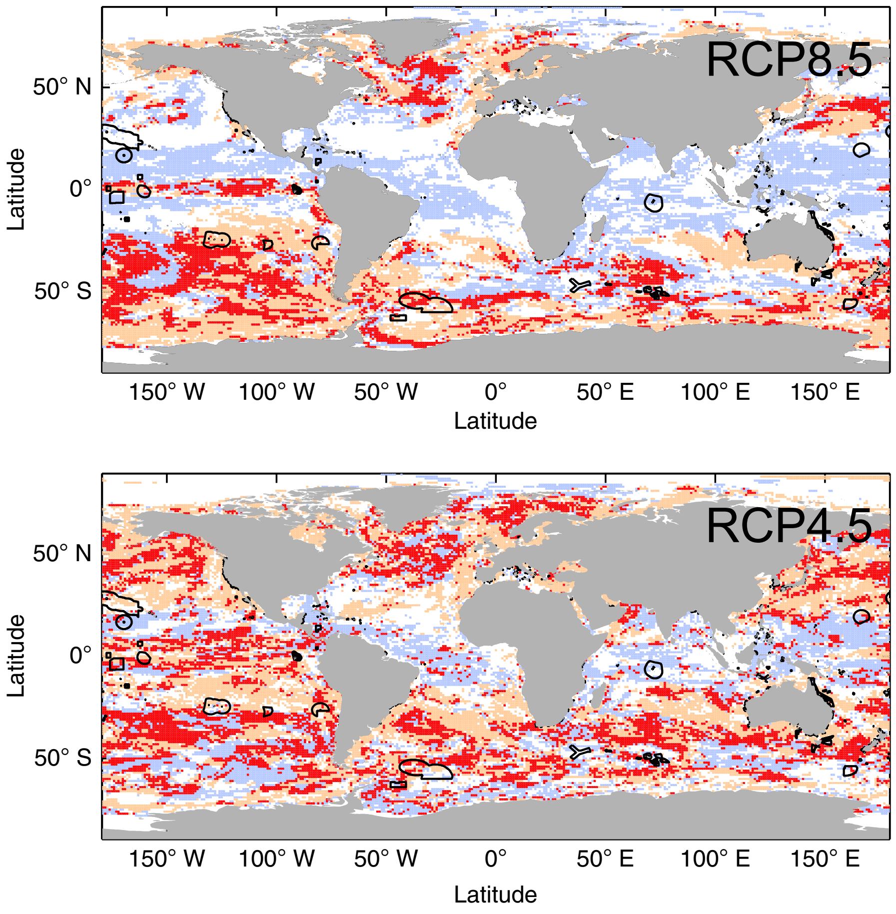


Fig. 3 | Spatial distribution of temporary refugia from climate change and current coverage of MPAs. Areas of the ocean for which SST (orange), oxygen concentration (lilac), and both variables (red) emerge after 2050 for RCP8.5 (business as usual, top panel) and 4.5 (mitigation, bottom panel). MPAs are outlined in black.

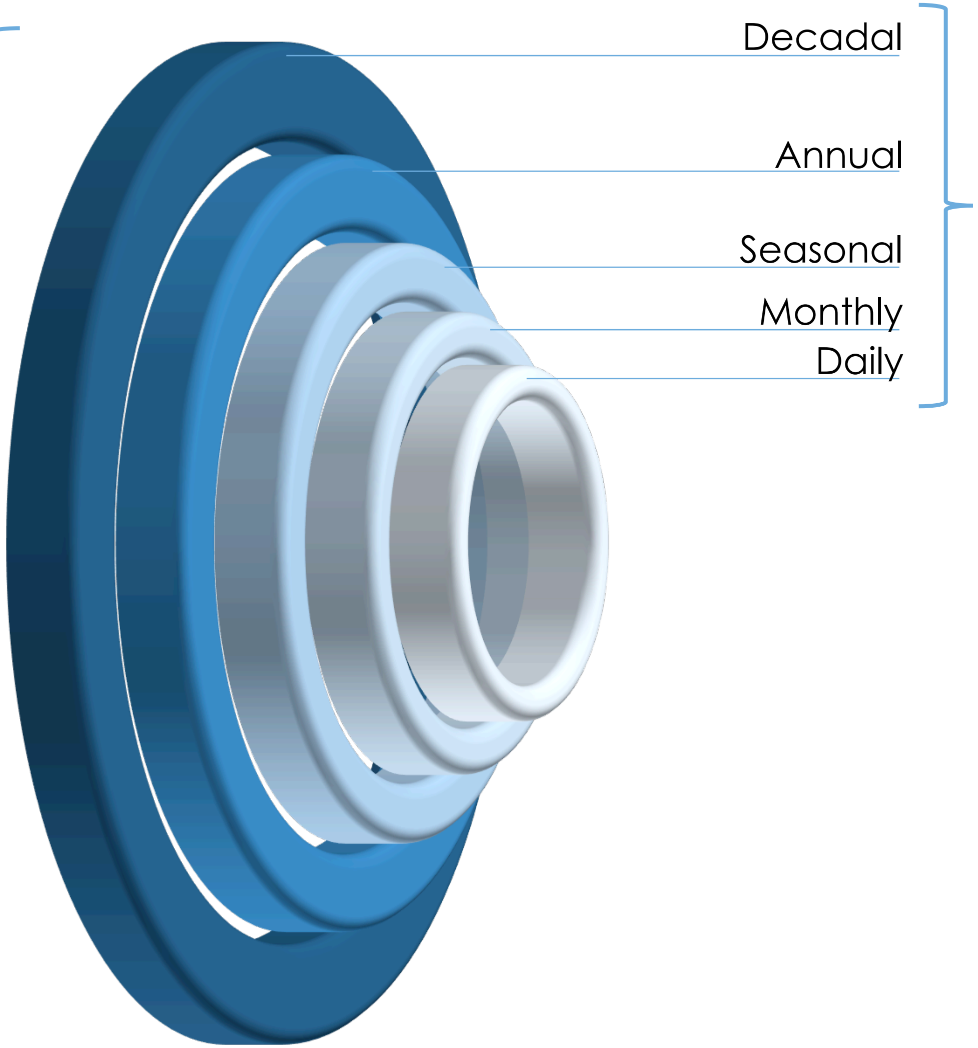
Clark et al. (2017) Maximum thermal limits of coral reef damselfishes are size dependent and resilient to near-future ocean acidification. *Journal of Experimental Biology* **220:** 3519-3526.

Bruno et al. (2018) Climate change threatens the world's marine protected areas. *Nature Climate Change* doi: 10.1038/s41558-018-0149-2

2. DATA PRODUCTS

A WISH LIST OF MARINE VARIABLES

Variables (marine)
Temperature*
pH*
Aragonite saturation state*
$[O_2]$*
[Nutrients] (NO_3, Si, etc.)*
Current velocity (u, v)*
Salinity*
Evaporation
Precipitation
Mixed-layer depth
Wind speed (u, v)
Surface air pressure
Wave height
Sea-level (rise)
Storm intensity(?)
[Chlorophyll-*a*] (?)
Ice cover

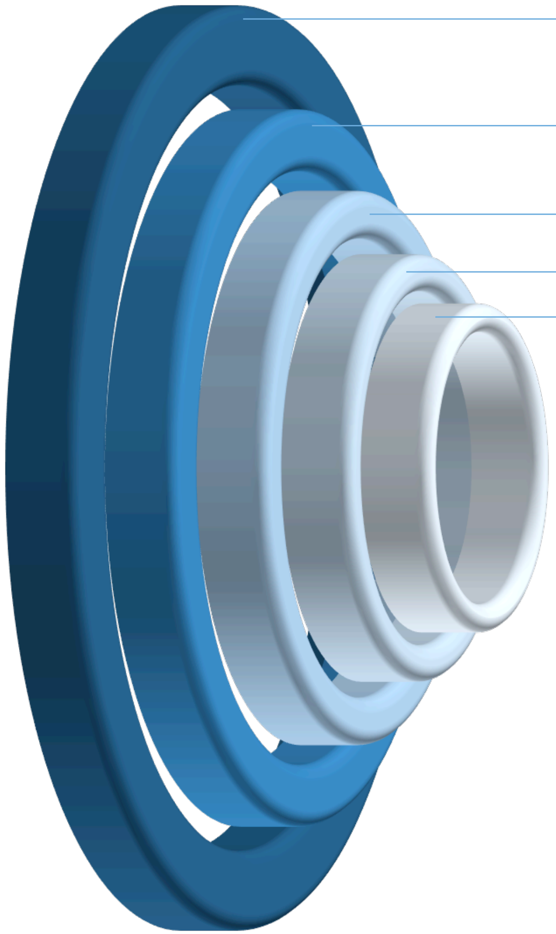


Summary Statistics
Mean
Maximum
Minimum
Range
SD
Percentiles

* Variables required at multiple depths

2. DATA PRODUCTS

RESOLUTION – THE FINER, THE BETTER



Population-level impacts/risks

- Changing abundance
- Shifting distribution
- Changes in phenology
- Changes in productivity

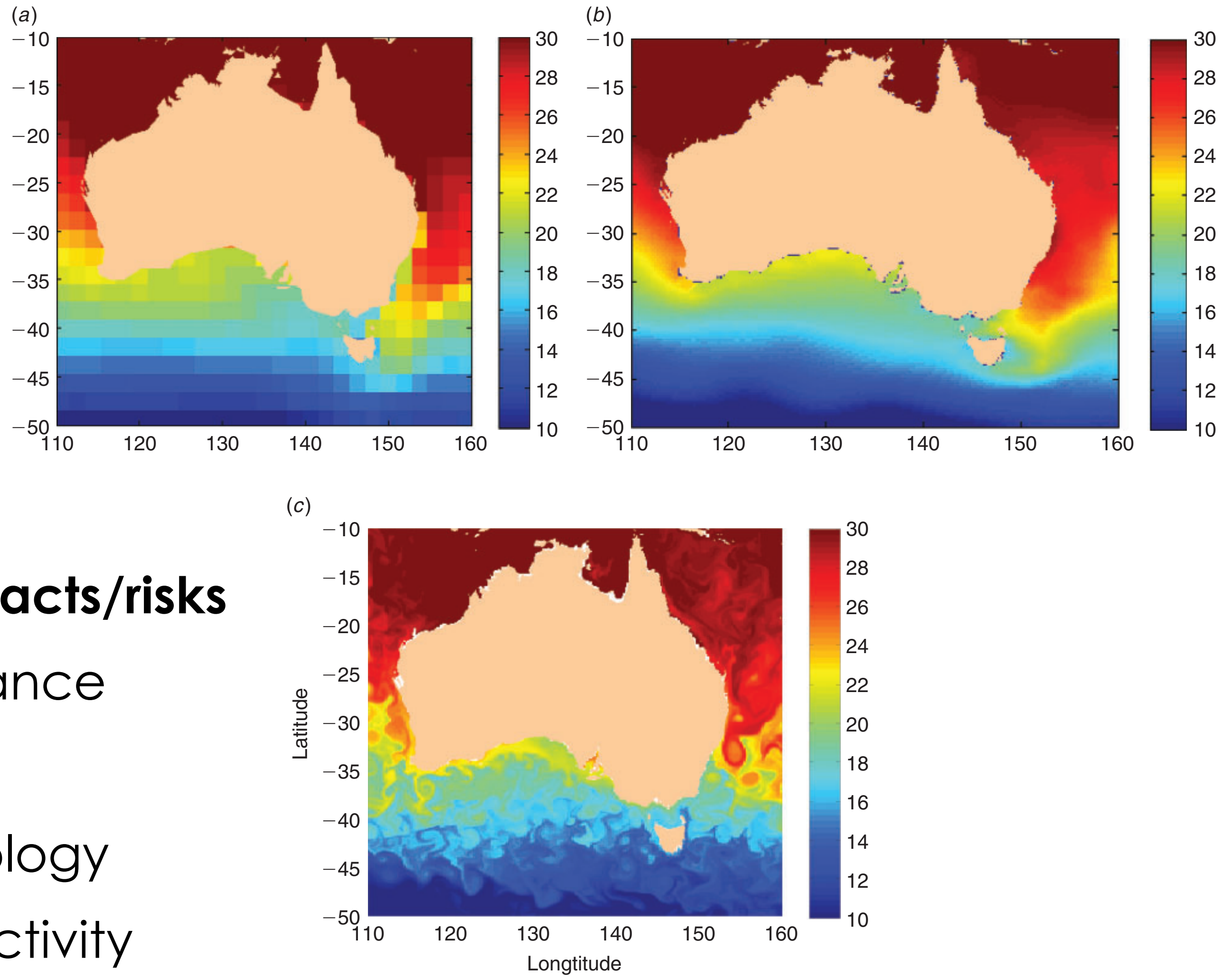


Fig. 3. Resolution in projected sea-surface temperature. (*a*) Example data from global climate model (GCM), showing projected average sea-surface temperature for April 2064 from the CSIRO Mk3.5 model. (*b*) Example of statistically downscaled data available via the OzClim approach, showing projected average sea-surface temperature for April 2064 downscaled from the CSIRO Mk3.5 model. (*c*) Example of dynamically downscaled data, showing sea-surface temperature data from the Bluelink model forced by GCMs data in April 2064. See text for explanation of models and scenarios.

Hobday and Lough (2011) Projected climate change in Australian marine and freshwater environments. *Marine and Freshwater Research* **62:** 1000-1014

2. DATA PRODUCTS

SELF-SERVICE?

- Easier methods to extract CMIP products/compute indices of risk

Package ‘RCMIP5’

August 29, 2016

Title Tools for Manipulating and Summarizing CMIP5 Data

Description Working with CMIP5 data can be tricky, forcing scientists to write custom scripts and programs. The `RCMIP5` package aims to ease this process, providing a standard, robust, and high-performance set of scripts to (i) explore what data have been downloaded, (ii) identify missing data, (iii) average (or apply other mathematical operations) across experimental ensembles, (iv) produce both temporal and spatial statistical summaries, and (v) produce easy-to-work-with graphical and data summaries.

Maintainer Kathe Todd-Brown <ktoddbrown@gmail.com>

Package ‘RmarineHeatWaves’

February 28, 2018

Title Detect Marine Heat Waves and Marine Cold Spells

Description Given a time series of daily temperatures, the package provides tools to detect extreme thermal events, including marine heat waves, and to calculate the exceedances above or below specified threshold values. It outputs the properties of all detected events and exceedances.

Maintainer Albertus J. Smit <albertus.smit@gmail.com>

3. GUIDANCE ON APPROPRIATE USAGE

TO MAXIMISE USE OF DATA BY ECOLOGISTS

- Simple lists of variables, and their meanings in the real world
- Agreed metrics of model-output uncertainty
- Maps of model skill by variable
- Identification of common pitfalls