Projecting the future hydrodynamic environment of the Great Barrier Reef:

a dynamic climate to ocean downscaling

Jodie Schlaefer[a*], Clothilde Langlais[a], Mark Baird[a], Mathieu Mongin[a]

[a] Commonwealth Scientific and Industrial Research Organisation (CSIRO)

* Corresponding author. *E-mail address*: jodie.schlaefer@csiro.au

© Trafalgar and The Real Word

We are developing a future climate to ocean dynamic downscaling of the Great Barrier Reef (GBR) using the eReefs framework (Fig. 1, Fig. 2) to model the impacts of climate change at ecologically and managerially relevant temporal and spatial scales.

Motivation

The GBR is facing an uncertain future due to climate change[1,2]. eReefs is a digital twin of the GBR, and is a key tool in the management of the GBR. It encompasses a suite of models, where dynamically downscaled hydrodynamic models of increasing resolution (Fig. 1) inform sediment and biogeochemical modules at ecologically relevant spatial scales[3]. However, eReefs is run in hindcast or near-real time, and so does not provide projections of how climate change impacts will intensify in the decades ahead. Such forward-looking information would be of great utility for managers. Therefore, the aim of this project is to develop an eReefs projection.

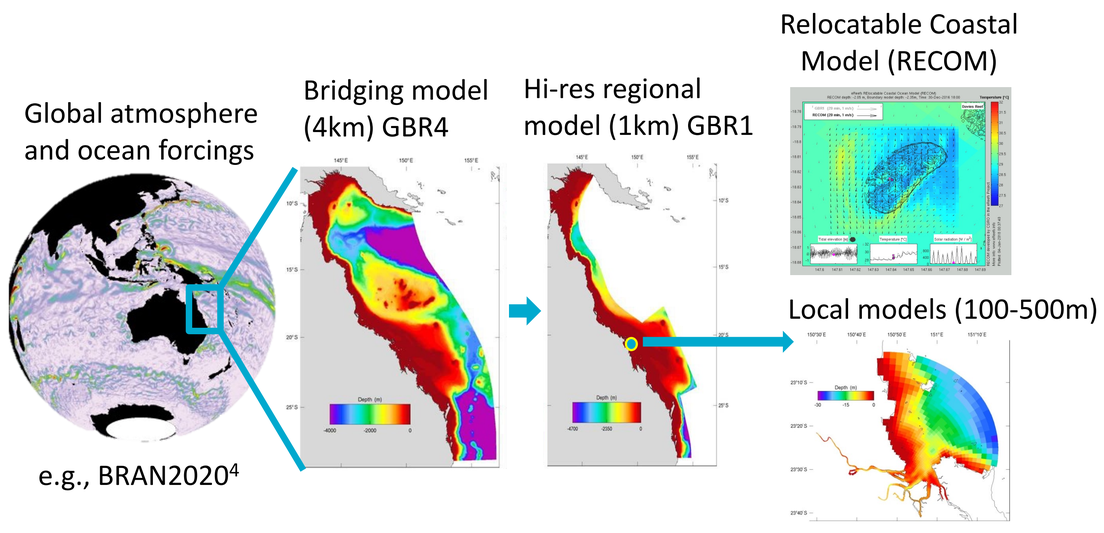

Fig. 1: eReefs dynamic downscaling framework. The nominal resolutions of the models are indicated.

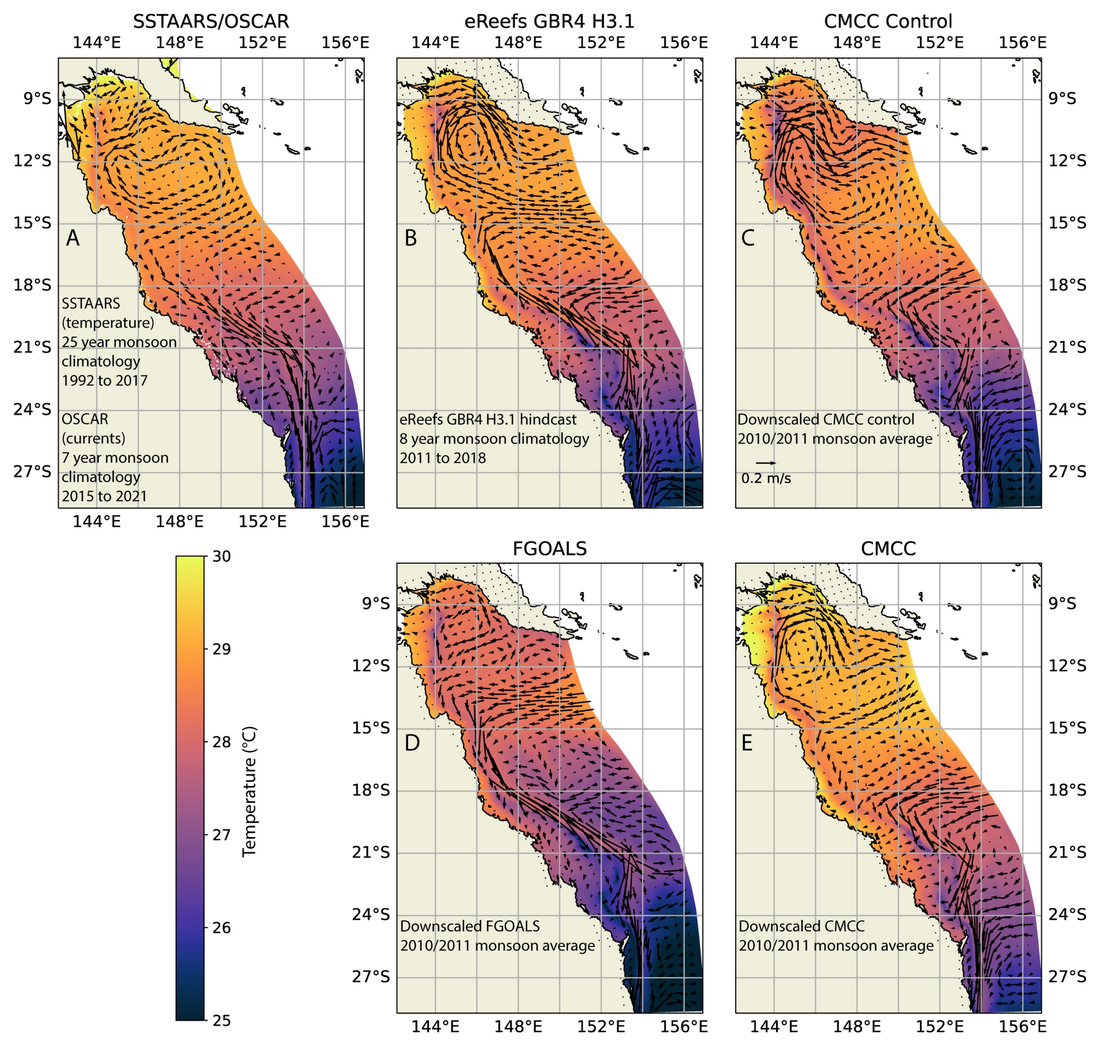

Fig. 2: Alignment of CMIP6 downscaled (C,D,E) monsoonal (Dec to Mar) sea surface temperature and surface circulation, with observed (A) and hindcast (B) monsoon climatologies. SSTAARS = Sea Surface Temperature Atlas of the Australian Regional Seas[5]. OSCAR = Earth & Space Research's Ocean Surface Current Analyses Real-time[6]. FGOALS = The Chinese Academy of Science's FGOALS-f3-H GCM[7]. CMCC = The Centro Euro-Mediterraneo sui Cambiamenti Climatici's CMCC-CM2-VHR4 GCM[8].

Methods & Results

The outputs of two CMIP6 general circulation models (GCM's) have been dynamically downscaled to the GBR, representing two possible futures under a high forcing Shared Socio-economic Pathway (SSP5 8.5). Specifically, eReefs 4 km hydrodynamic model (GBR4, Fig. 1) has been forced with the CMIP6 GCM's and river flow climatologies. To validate the downscalings, hindcast runs have been compared to climatologies derived from observations and an updated eReefs hindcast (e.g., Fig. 2). The downscalings have reproduced observed and modelled trends in temperature, salinity and currents. We will now compare historical and future simulations to assess how climate change will impact the GBR at relevant scales.

Applications

The eReefs projection could be used to answer a range of management relevant questions. Examples include:

- When is severe bleaching likely to occur annually for different reef groups? With a dynamic downscaling we can reassess this question, taking into account local hydrodynamic features, along with regional heating patterns.
- Where could the larvae of thermally tolerant coral species be advected to in the future?
- How might major flow features and plankton distributions change? And could this have flow-on effects for the delivery of pelagic subsidies to coral reefs?

REFERENCES

1. Hoegh-Guldberg, O. (1999) Climate Change, Coral Bleaching and the Future of the World's Coral Reefs. *Mar. Freshw. Res.* 50, 839–66.
2. U.N.E.P. (2020) Projections of future coral bleaching conditions using IPCC CMIP6 models: climate policy implications, management applications, and Regional Seas summaries. United Nations Environment Programme, Nairobi, Kenya
3. Steven, A.D.L., Baird, M.E., Brinkman, R., Car, N.J., Cox, S.J., Herzfeld, M., Hodge, J., et al. (2019) EReefs: An Operational Information System for Managing the Great Barrier Reef. *J. Oper. Oceanogr.* 12
4. Chamberlain, M.A., Oke, P.R., Fiedler, R.A.S., Beggs, H.M., Brassington, G.B., Divakaran, P. (2021) Next generation of Bluelink ocean reanalysis with multiscale data assimilation: BRAN2020. *Earth Syst. Sci. Data*, 13, 5663–5688.
5. Wijffels, S.E., Beggs, H., Griffin, C., Middleton, J.F., Cahill, M., King, E., et al. (2018) A fine spatial-scale sea surface temperature atlas of the Australian regional seas (SSTAARS): Seasonal variability and trends around Australasia and New Zealand revisited. *J. Mar. Syst.*, 187, 156-196.
6. Bonjean, F., Lagerloef, G.S.E. (2002) Diagnostic model and analysis of the surface currents in the tropical Pacific ocean, *J. Phys. Oceanogr.*, 32, 2938-2954.
7. Bao, Q., He, B. (2020) CAS FGOALS-f3-H model output prepared for CMIP6 HighResMIP highresSST-future. Earth System Grid Foundation.
8. Scoccimarro, E., Bellucci, A., Peano, D. (2017) CMCC CMCC-CM2-VHR4 model output prepared for CMIP6 HighResMIP. Earth System Grid Foundation.