Using scenario predictions of climate, chemical and physical stressors for probabilistic effects assessment of nearshore coral reefs

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INTRODUCTION

- The Great Barrier Reef (GBR) is facing increasing risk from multiple stressors, with climate change being a primary [1,2].
- This work is part of a Great Barrier Reef case study from the SETAC Pellston workshop on integrating climate change into environmental risk assessment (ERA) [3].
- Adverse Outcome Pathways (AOP) and Bayesian networks (BN) have been explored to improve the incorporation of future climate change scenarios into probabilistic ERA frameworks.
- This study focuses on the climate and environmental modelling efforts undertaken to establish prior probabilities and causal relationships for parameterizing the BN model.

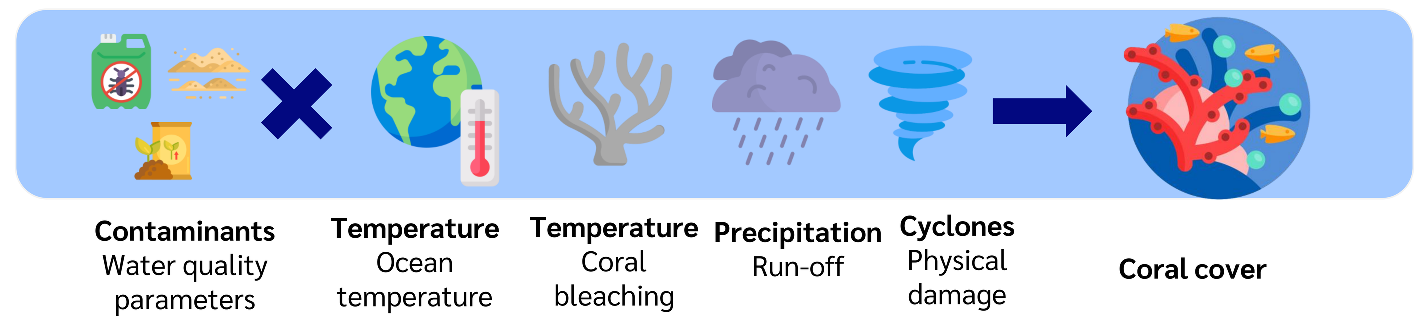

Figure 1. Example of climate and catchment stressors included in this case study. The figure is adapted from Integrating Expertise on Climate Modeling and environmental risk assessment: A SETAC Pellston Workshop in the Oslo fjord. Poster at SETAC Europe 2023.

METHOD

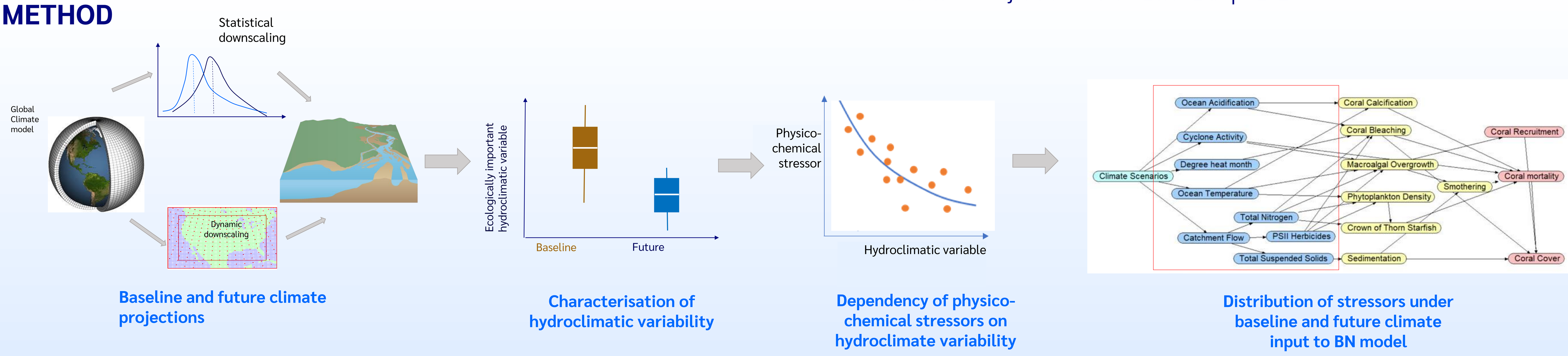

Figure 2. From Global Climate models to Bayesian network inputs, is adapted from [4].

ENVIRONMENTAL PROJECTIONS

Climate modelling

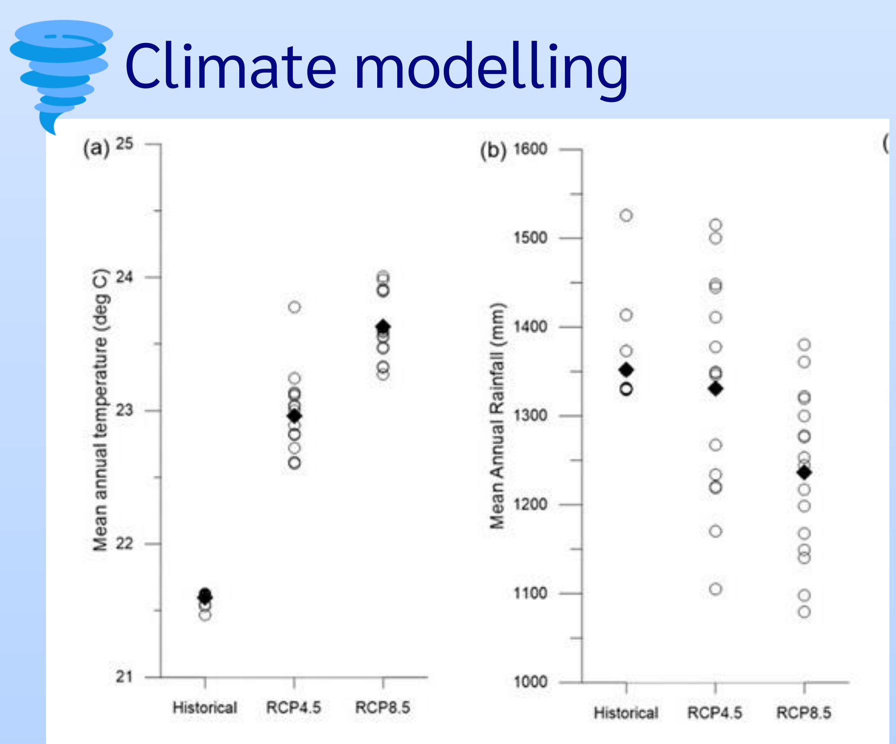

Figure 3. Projections of average annual (a) air temperature and (b) rainfall in Blacks Creek catchment derived from a 16-member ensemble based on four climate models and four downscaling methods (GCM: ACCESS1-0, CNRM-CM5, GFDL-ESM2M and MIROC5 Downscaling: ISIMIP2b, MRNBC, QME, CCAM). Historical projections are provided for the period 1976 to 2005, and those for future scenarios extend from 2006 to 2100 (RCP4.5 and RCP8.5 scenarios are each for a 30 year period).

Sea temperature modelling

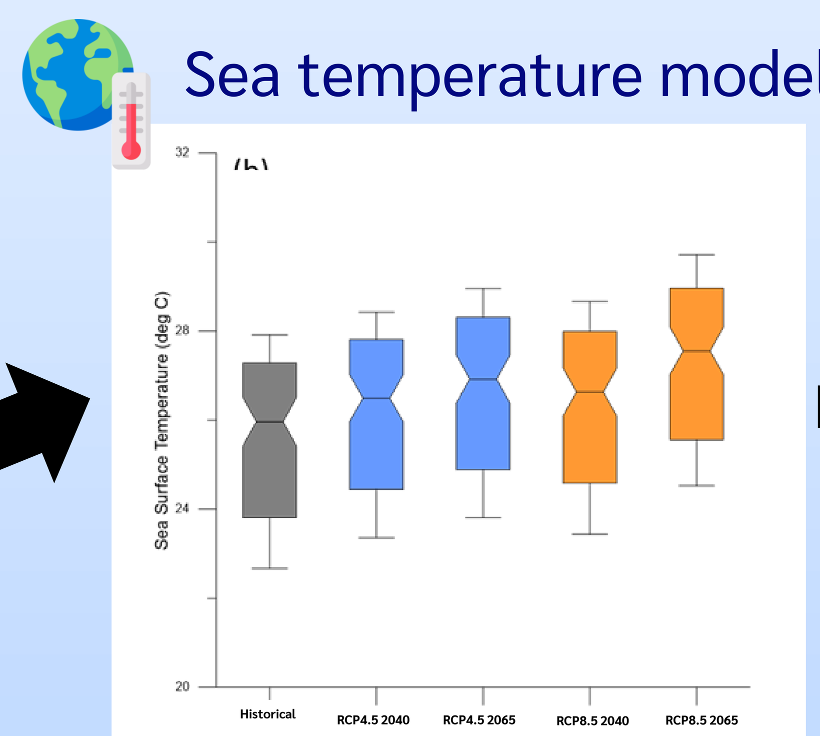

Figure 4. Projected probability distributions of sea surface temperatures for adopted historical and future climate scenarios. A functional relationship was developed between monthly air temperature and sea surface temperature from records.

Setting of threshold above which bleaching is assumed

Coral bleaching modelling

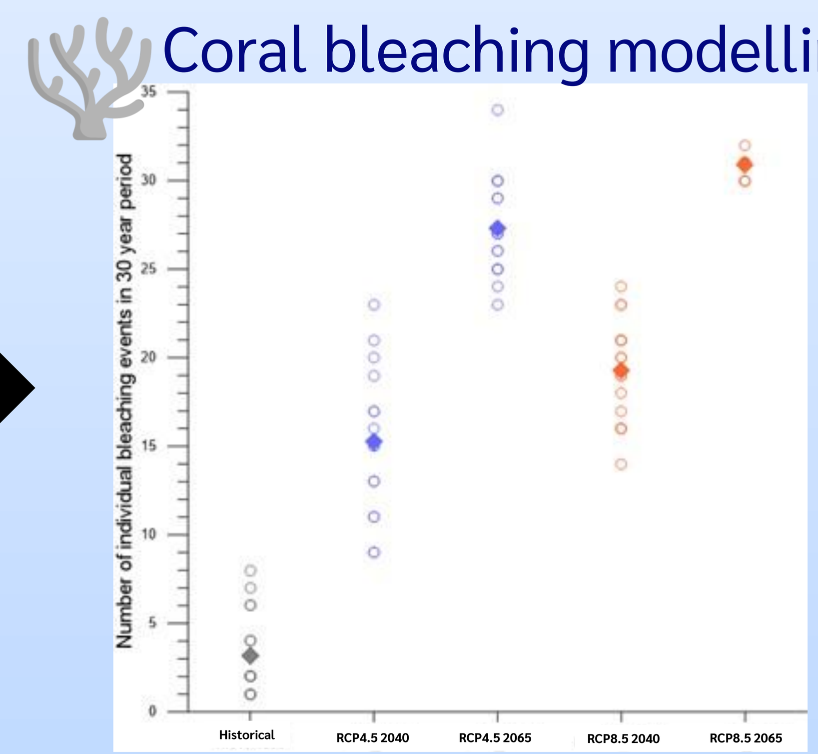

Figure 5. Projected frequency of bleaching events in a 30-year period obtained from individual climate models (open circle symbols) and the mean of the ensemble (solid diamond symbol).

Hydrological modelling

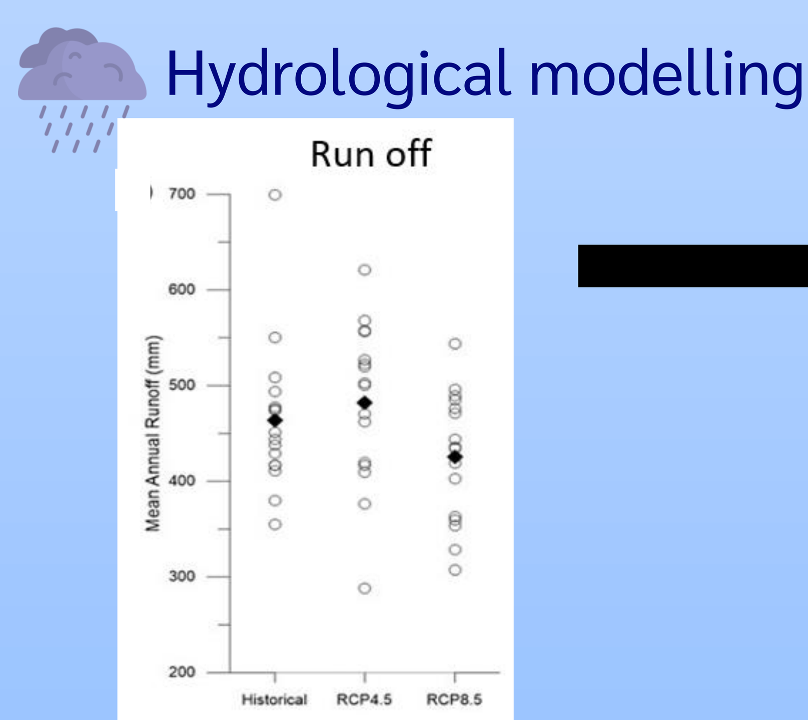

Figure 6. Projections of average annual (c) runoff (see additional info fig. 3) using Australian Water Resource Assessment Landscape modelling system (AWRA-L). The method was a semi-distributed hydrological model representing water stores at the surface, shallow, and deep soil layers

Contaminant water quality modelling

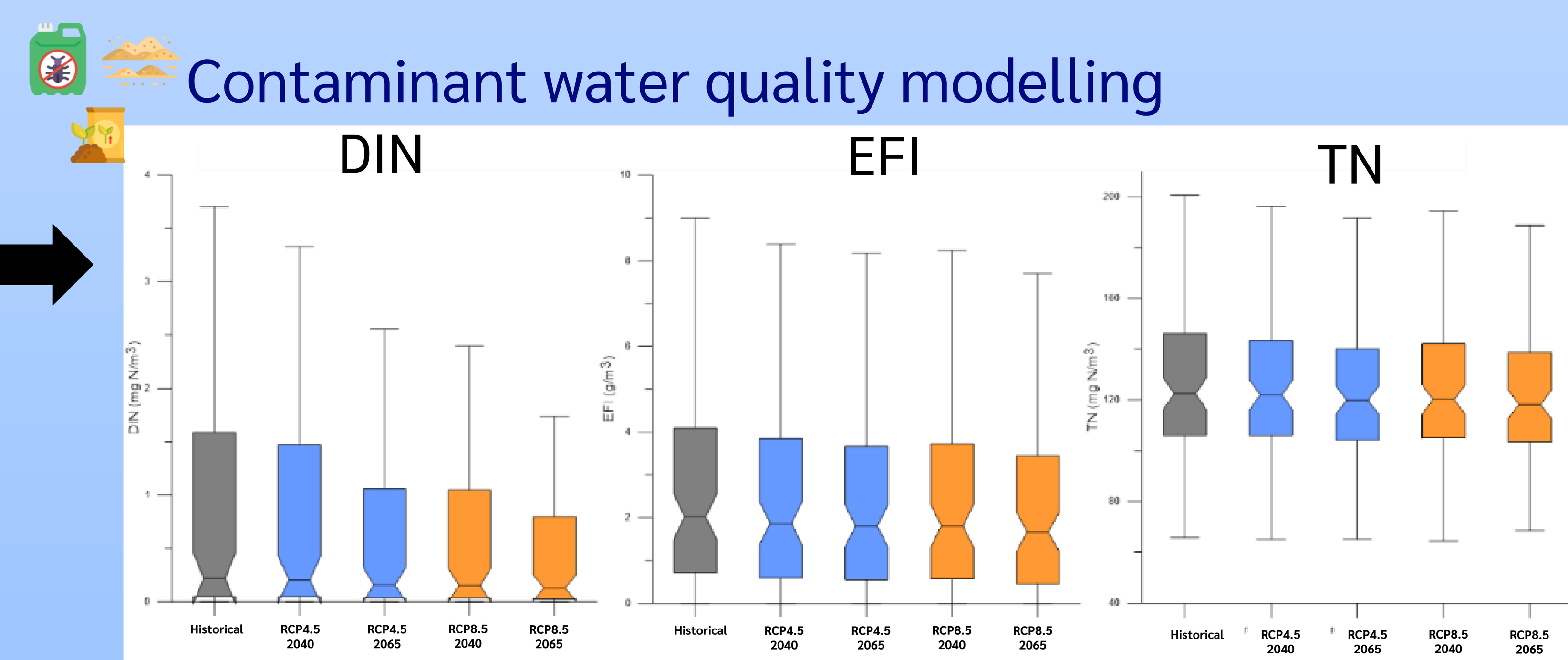

Figure 7. Projected distributions of Dissolved Inorganic Nitrogen (DIN), ecology fine inorganics (EFI) and total nitrogen (TN) for adopted historical and future climate scenarios using eReefs model with the GBR4 BGC q3b method.

INTEGRATION OF MODELLING RESULTS INTO A BAYESIAN NETWORK

Our study integrated information from several sources into a BN: global climate models (Fig. 3), regional downscaling (Fig. 4), literature on coral ecology (Fig. 5), hydrological modeling (Fig. 6), and catchment modeling (Fig. 7). The temporal variability in environmental model projections within different scenarios (e.g. sea temperature, Fig. 4) was quantified as conditional probability distributions in the BN. Stressor-response relationship of corals (e.g., coral bleaching, Fig. 5) was expressed as equations in the BN.

The resulting BN aims to quantify probabilistic risk to coral communities by multiple assessment endpoints: coral recruitment, coral mortality and coral cover. It is a promising approach for conceptualizing and integrating climate information into ERA [5].

References

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Acknowledgement

The workshop was supported by: BHP, Chevron, Corteva Agrisciences, CSIRO, International Copper Association, NiPERA, NIVA's Computational Toxicology Program, Research Council of Norway, Rio Tinto, SETAC, Shell, Teck Resources, US EPA.

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