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Supporting Information for

Extreme marine warming across tropical Australia during austral summer 2015-16

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Introduction

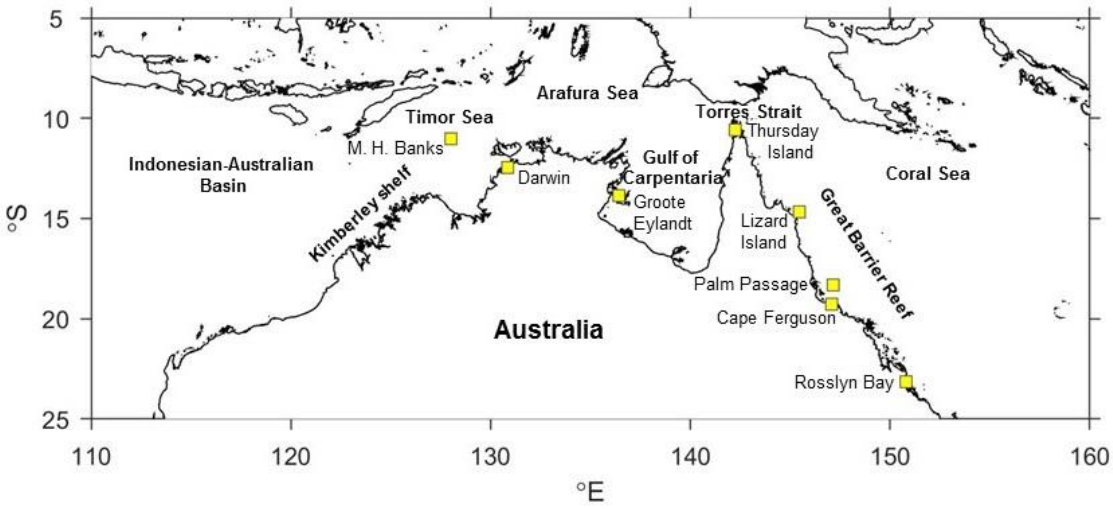
This file contains supplementary text, figures, and tables for the paper. A regional map is shown in Figure S1. The supplementary figures, Figure S2-S5, and tables (Table S1, S2) provide information on the time series homogenization procedures used for the *in situ* temperature data. For both Lizard Island (LIZ) and Thursday Island (THU), there were four separate time series covering various subsets of the time period from late 1995 to early 2017 (Tables S1 and S2; Figures S2 and S3). For both LIZ and THU, these four time series were combined to create a single homogenized time series. The homogenization technique was as follows, using LIZ as an example. First, LIZFL1 was set as the reference series and regressed onto LIZSL1. Regression coefficients were estimated by Ordinary Least Squares and then used to predict data where LIZFL1 was missing but LIZSL1 provided valid data. This combined series was then regressed onto LIZSF2, a new combined series was produced, and the process repeated for the final station, LIZRP2. The regression coefficients (>= 0.933) at each step in the procedure are provided in Table A1. In this way, missing data in LIZFL1 was filled in from a combination of the other three series. The same technique was used to generate a homogenized Thursday Island time series using THUFL1 as the reference series (regression coefficients >= 0.996; Table S2).

At the Indonesian Throughflow (ITF) Margaret Harries Banks (MHB) mooring site, temperature data was hourly averaged and low-pass filtered for a number of separate time series at depths between 20.5 m and 37.8 m. These depths were clustered in two groups: 20.5-23.5 m (Figure S4a) and 32.0-37.8 m (Figure S5a). The depths were clustered rather than interpolated onto a single vertical level to examine the temperature fluctuations over those range in depths and the vertical changes in the near-surface marine heatwave (MHW) characteristics for 2015-16. For each cluster, we generated a homogenized daily average time series by averaging across all depths with data available on each day (Figure S4b and S5b).

At the Palm Passage mooring site, temperature data were hourly averaged and low-pass filtered for a number of separate time series. Rather than clustering the depths, the Palm Passage data were interpolated onto two vertical levels at 15 m and 60 m, following the procedures in *Benthuysen et al.* [2016]. These depths were chosen to examine near-surface and near-bottom MHW characteristics, given that the site is a location for intrusive upwelling.

For austral autumn/winter 2016, the monthly air-sea heat flux anomalies derived from BRAN-2016 are shown in Figure S6, the monthly wind stress and climatological means are shown in Figure S7, and the wind stress anomalies from December 2015-July 2016 are shown in Figure S8. The outgoing longwave radiation (OLR) time series (Figure S9) has been provided by the Bureau of Meteorology, and regional time series are available at: http://www.bom.gov.au/climate/mjo/#tabs=Regional-cloudiness.

Over a broad area encompassing waters across tropical Australia, sea surface temperature (SST) anomalies were calculated from NOAA OISST V2. The 2016 MHW was the most intense and longest on record and lasted for 217 days. To determine how the warming trend from 1982-2016 impacted the MHW characteristics, the trend was removed and the MHW characteristics were recalculated. The maximum intensity reduced from 1.7°C to 1.4°C, and the 2016 event was now composed of three shorter events with a total duration of 148 days.



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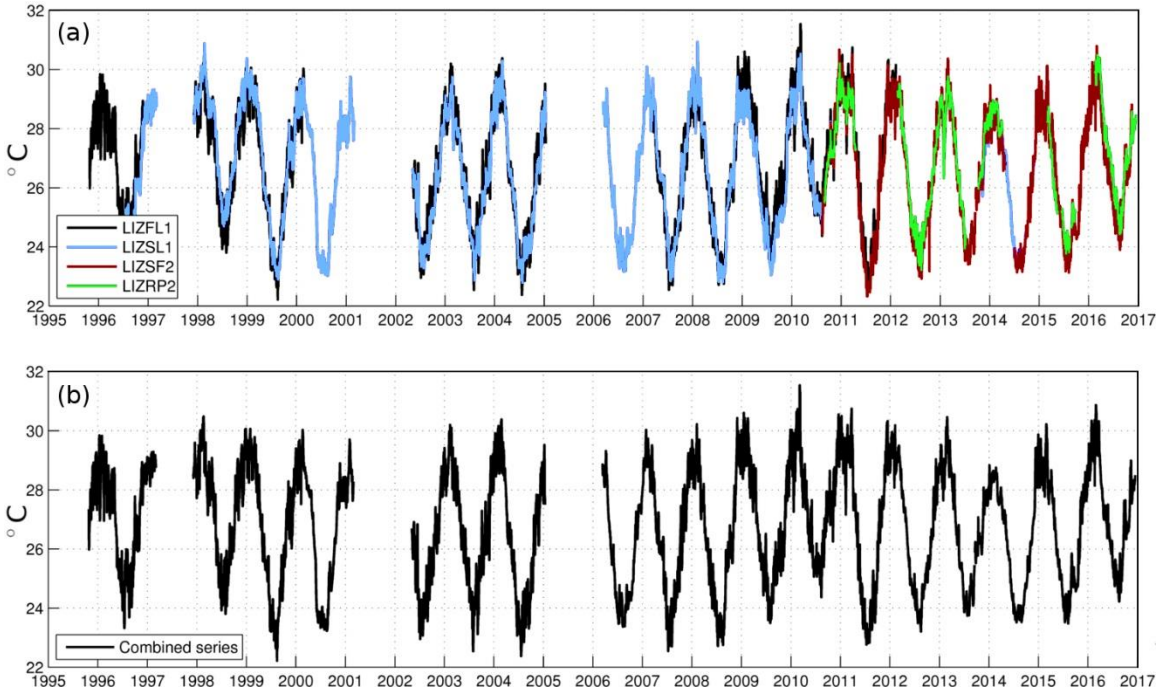

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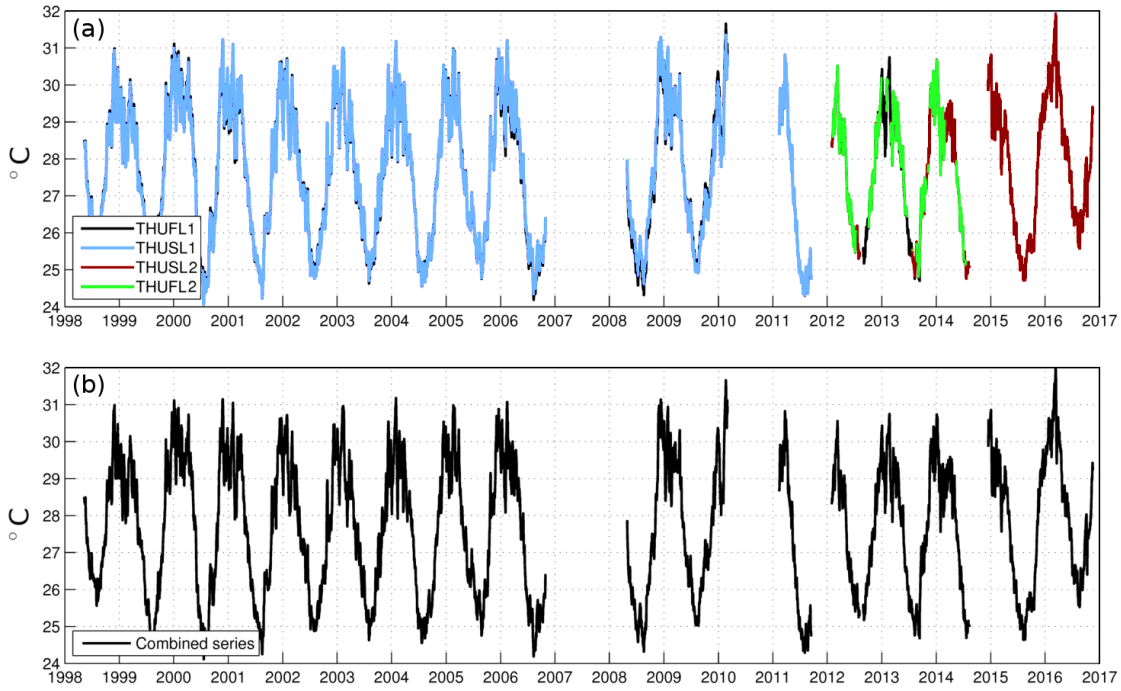

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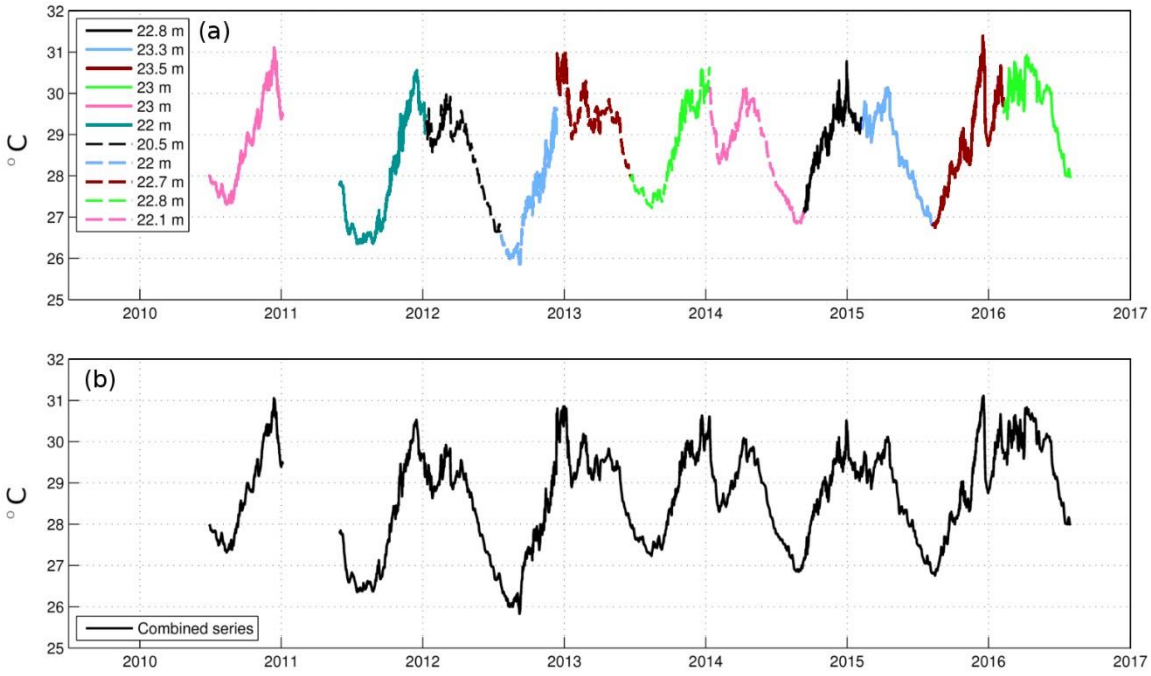

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104 **Figure S4.** Margaret Harries Banks time series for depths between 20.5 m and 23.5 m. The top
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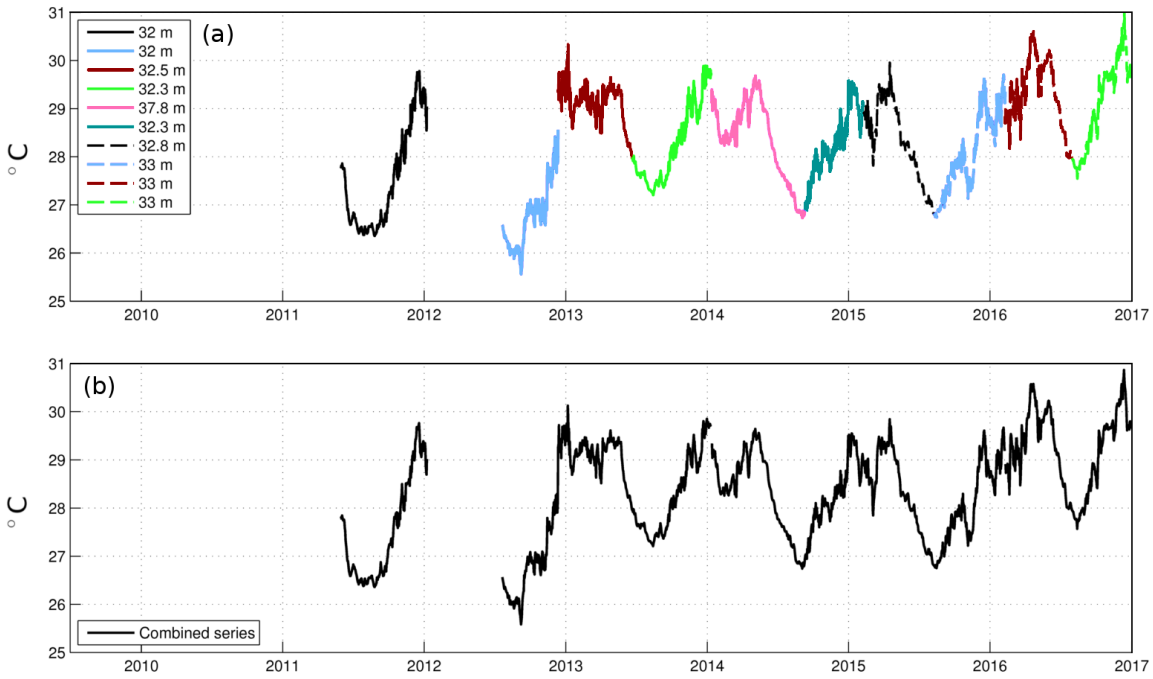

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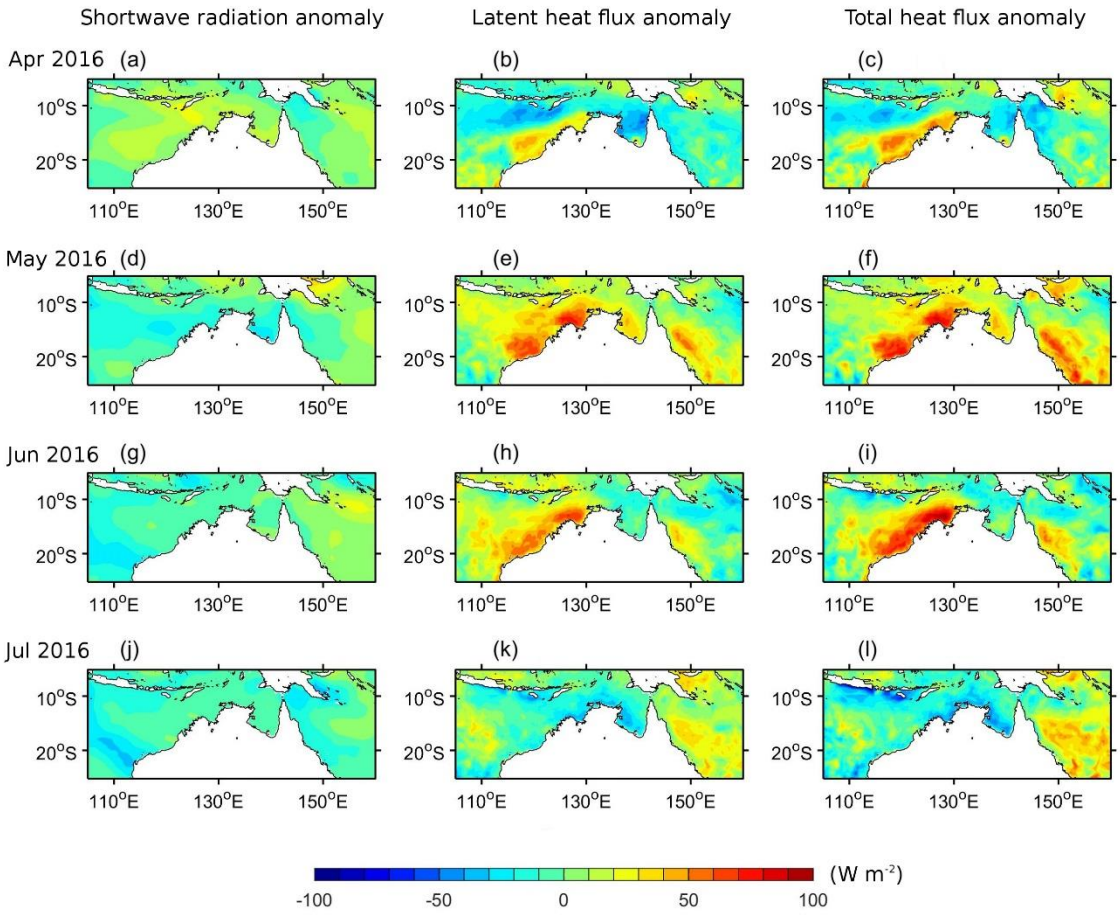

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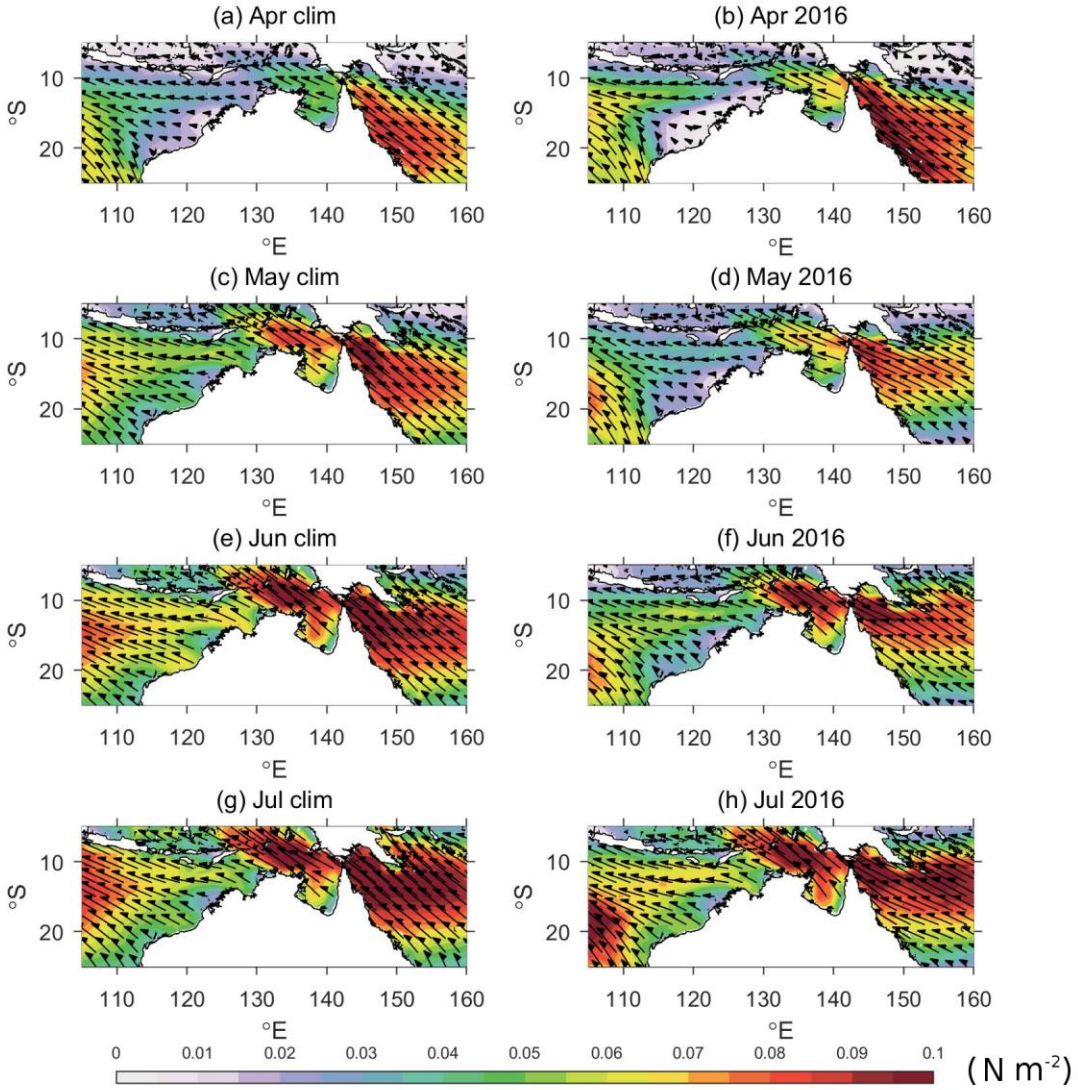

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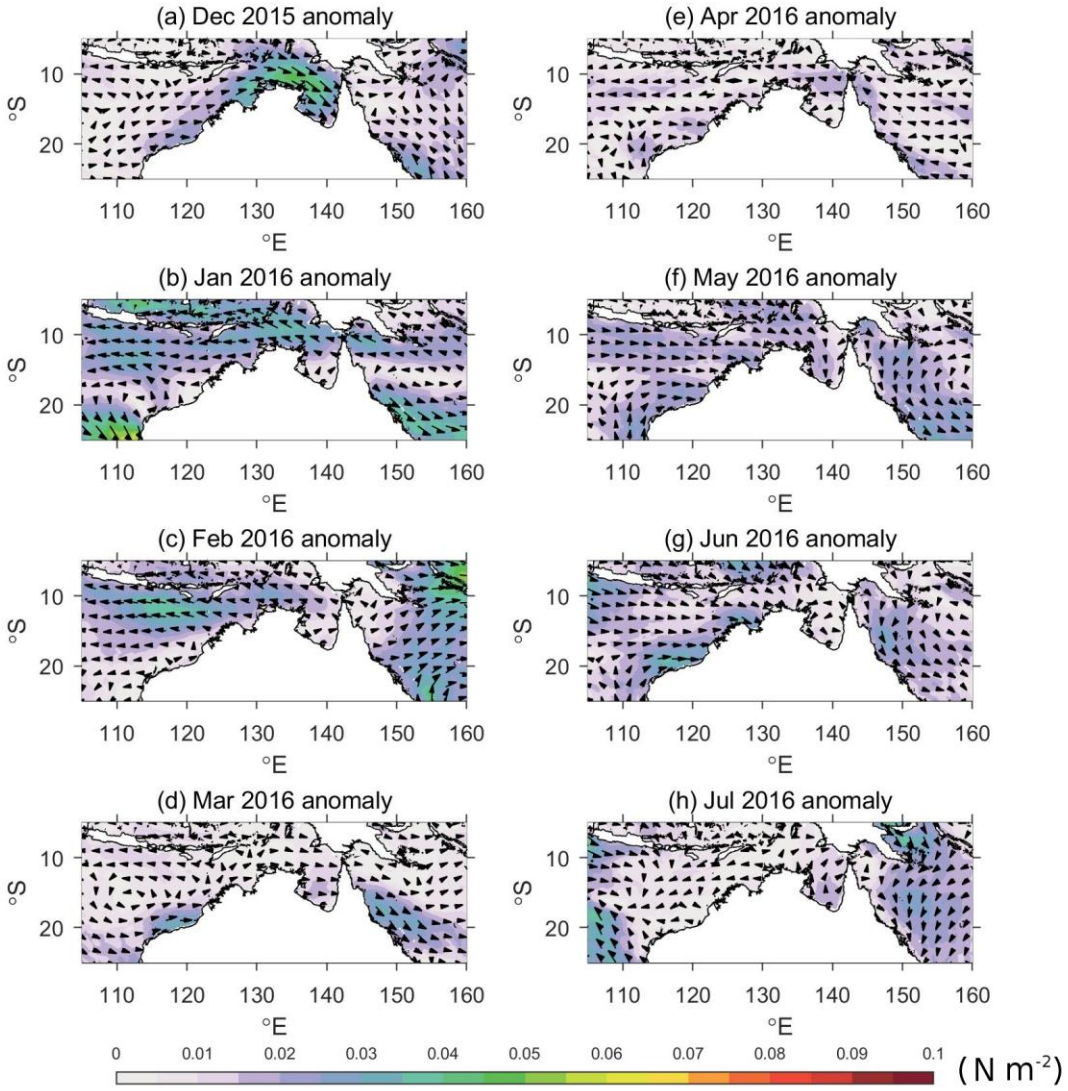

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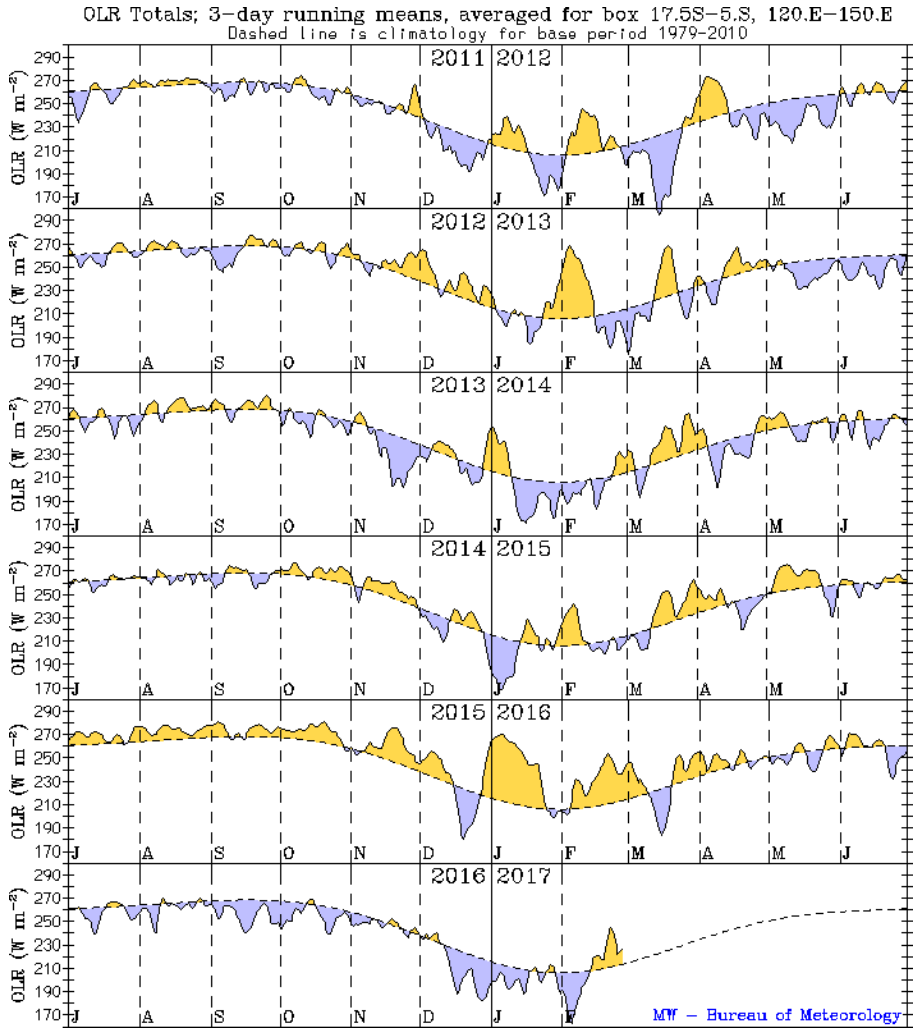

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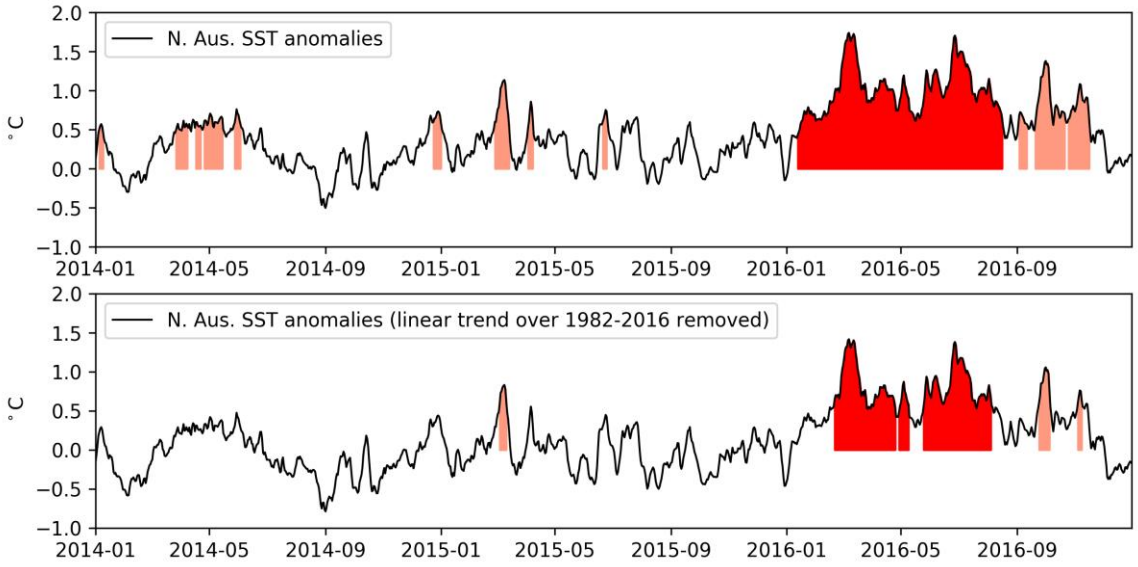

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125 (a) and SST anomalies with a linear trend (see Figure 1a) removed (b). The marine heatwave
126 periods are shaded in pink. In (a), the most intense and longest marine heatwave on record is
127 shaded in red and, in (b), is broken up into three shorter events.

Site	Latitude (°S)	Longitude (°E)	Depth (m)	Model correlation
LIZFL1	145.4460	14.6793	2.1	-
LIZSL1	145.4425	14.6882	6.7	0.937
LIZSF2	145.4571	14.6941	0.6	0.978
LIZRP2	145.4664	14.6915	10.1	0.933

128 Table S1. Lizard Island temperature logger site information.
129

Site	Latitude (°S)	Longitude (°E)	Depth (m)	Model correlation
THUFL1	142.2274	10.5835	2.0	-
THUSL1	142.2274	10.5835	4.5	0.996
THUSL2	142.2205	10.5952	6.8	0.998
THUFL2	142.2205	10.5952	3.0	0.999

130 Table S2. Thursday Island temperature logger site information.