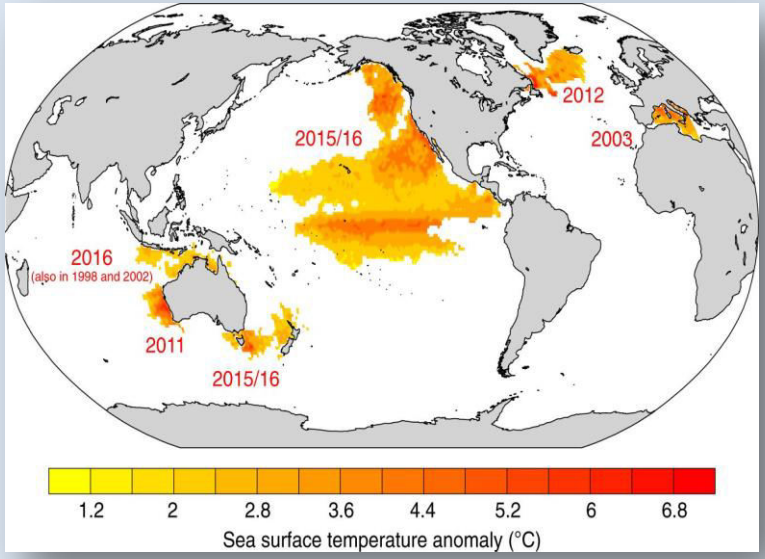
# Detecting marine heatwaves (MHWs)

```
plot1 <- ggplot(aviso, aes(x = lon, y = lat)) +
    geom_raster(aes(fill = velocity)) +
    scale_fill_gradientn(colours = rev(rainbow(7, end = 4/6)),
                         space = "Lab", limits = c(0, 1.45),
                         guide = guide_colorbar(title = expression(Velocity~(m~s^{-1})),
                                                position = "bottom",
                                                direction = "horizontal",
                                                barheight = unit(2, units = "mm"),
                                                barwidth = unit(50, units = "mm"),
                                                draw.ulim = F,
                                                title.position = 'top',
                                                title.hjust = 0.5,
                                                label.hjust = 0.5)) +
  geom_segment(data = vec,
               aes(xend = lon + u * current_uv_scalar,
                   yend = lat + v * current_uv_scalar, alpha = velocity),
               colour = "black",
               arrow = arrow(angle = 20, length = unit(0.1, "cm"), type = "open"),
               linejoin = "mitre", size = 0.35, show.legend = FALSE) +
  scale_alpha_continuous(range = c(0, 1.0)) + theme_map() +
  plot.parameters
```


Presenter: Amieroh Abrahams
Supervisor: Prof. AJ Smit and Dr. Robert Schlegel
University of the Western Cape
Department of Biodiversity and Conservation Biology

# Introduction

- Anthropogenically mediated warming
- Climate change, a general long-term rise in mean surface temperatures
- During 2015/16 one quarter of the ocean experienced a MHW



# Introduction

A marine heatwave (MHW) is defined as a discrete prolonged anomalously warm water event

*MHWs have set metrics used to describe their properties, these are:*

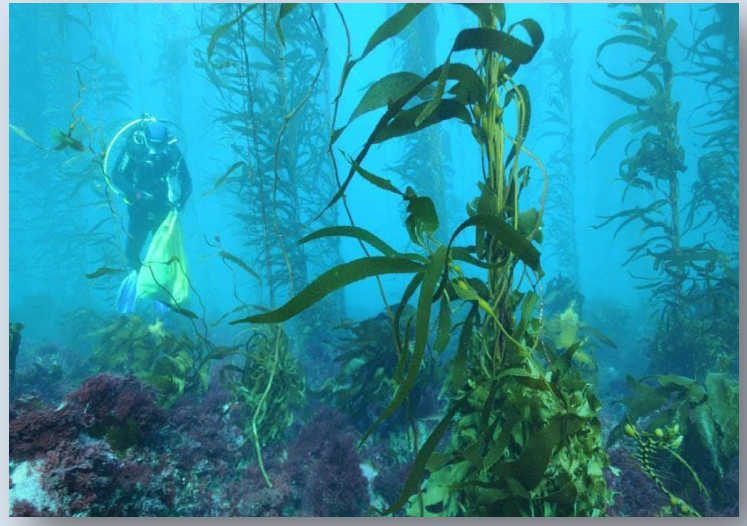
- Duration

- Mean intensity

- Maximum intensity

- Cumulative intensity

# Consequences of marine heatwaves



# Consequences of marine heatwaves

PHYS.ORG Nanotechnology Physics Earth Astronomy & Space Technology Chemistry Biology Other Scien

search

Home » Earth » Environment » July 25, 2018

## NE Australian marine heatwave shakes up coral reef animal populations

July 25, 2018, University of Tasmania

MATTHEW SALMONS/STUF

Swimmers at Christchurch's Spencer Beach in February, during the country's hottest summer on record.

The marine heatwave that contributed to the recent scorching summer was rare. The previous event was more than 80 years earlier, during the 1934–35 summer.

# Detecting MHWs

- Duration (length) of a time series
- For the detection of MHWs it is recommended that one has at least 30 years of data in order to accurately detect events
- Satellite SST production


# R Packages

**heatwaveR: Detect Heatwaves and Cold-Spells**

The different methods of defining and detecting extreme events, known as heatwaves or cold-spells in both air and water temperature data are encompassed within this package. These detection algorithms may be used on non-temperature data as well however, this is not catered for explicitly here as no use of this technique in the literature currently exists.

| | |
|---|---|
| Version: | 0.3.3 |
| Depends: | R (≥ 3.0.2), data.table, ggplot2 |
| Imports: | tibble, lubridate, dplyr, stats, utils, zoo, grid, RcppRoll |
| LinkingTo: | Rcpp (≥ 0.12.16), RcppArmadillo |
| Suggests: | tidyverse, ggpubr, testthat, knitr, rmarkdown |
| Published: | 2018-08-02 |
| Author: | Robert W. Schlegel [aut, cre, ctb], Albertus J. Smit [aut, ctb] |
| Maintainer: | Robert W. Schlegel <robwschlegel at gmail.com> |
| BugReports: | https://github.com/robwschlegel/heatwaveR/issues |
| License: | MIT + file LICENSE |
| URL: | https://robwschlegel.github.io/heatwaveR/index.html, https://github.com/robwschlegel/heatwaveR |
| NeedsCompilation: | yes |
| Materials: | README NEWS |
| CRAN checks: | heatwaveR results |

**Downloads:**

| | |
|---|---|
| Reference manual: | heatwaveR.pdf |
| Vignettes: | OISST retrieval and processing<br>Vignette Title<br>Vignette Title<br>Vignette Title<br>Vignette Title<br>Extreme event detection in gridded data |
| Package source: | heatwaveR_0.3.3.tar.gz |
| Windows binaries: | r-devel: heatwaveR_0.3.3.zip, r-release: heatwaveR_0.3.3.zip, r-oldrel: heatwaveR_0.3.3.zip |
| OS X binaries: | r-release: heatwaveR_0.3.3.tgz, r-oldrel: heatwaveR_0.3.3.tgz |
| Old sources: | heatwaveR archive |

**RmarineHeatWaves: Detect Marine Heat Waves and Marine Cold Spells**

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.

| | |
|---|---|
| Version: | 0.17.0 |
| Depends: | R (≥ 3.00) |
| Imports: | tibble, ggplot2, lubridate, dplyr, stats, utils, zoo, tidyr, plyr, raster, grid, lazyeval, rlang |
| Suggests: | knitr, rmarkdown |
| Published: | 2018-06-04 |
| Author: | Albertus J. Smit [aut, cre] (R implementation.), Eric C. J. Oliver [aut] (The brain behind the Python implementation.), Robert W. Schlegel [ctb] (Graphical and data summaries.) |
| Maintainer: | Albertus J. Smit <albertus.smit at gmail.com> |
| License: | MIT + file LICENSE |
| URL: | https://github.com/ajsmit/RmarineHeatWaves |
| NeedsCompilation: | no |
| Citation: | RmarineHeatWaves citation info |
| Materials: | README NEWS |
| CRAN checks: | RmarineHeatWaves results |

**Downloads:**

| | |
|---|---|
| Reference manual: | RmarineHeatWaves.pdf |
| Vignettes: | Extreme event detection in gridded data |
| Package source: | RmarineHeatWaves_0.17.0.tar.gz |
| Windows binaries: | r-devel: RmarineHeatWaves_0.17.0.zip, r-release: RmarineHeatWaves_0.17.0.zip, r-oldrel: RmarineHeatWaves_0.17.0.zip |
| OS X binaries: | r-release: RmarineHeatWaves_0.17.0.tgz, r-oldrel: RmarineHeatWaves_0.17.0.tgz |
| Old sources: | RmarineHeatWaves archive |

```r
library(tidyverse)
library(heatwaveR)
```

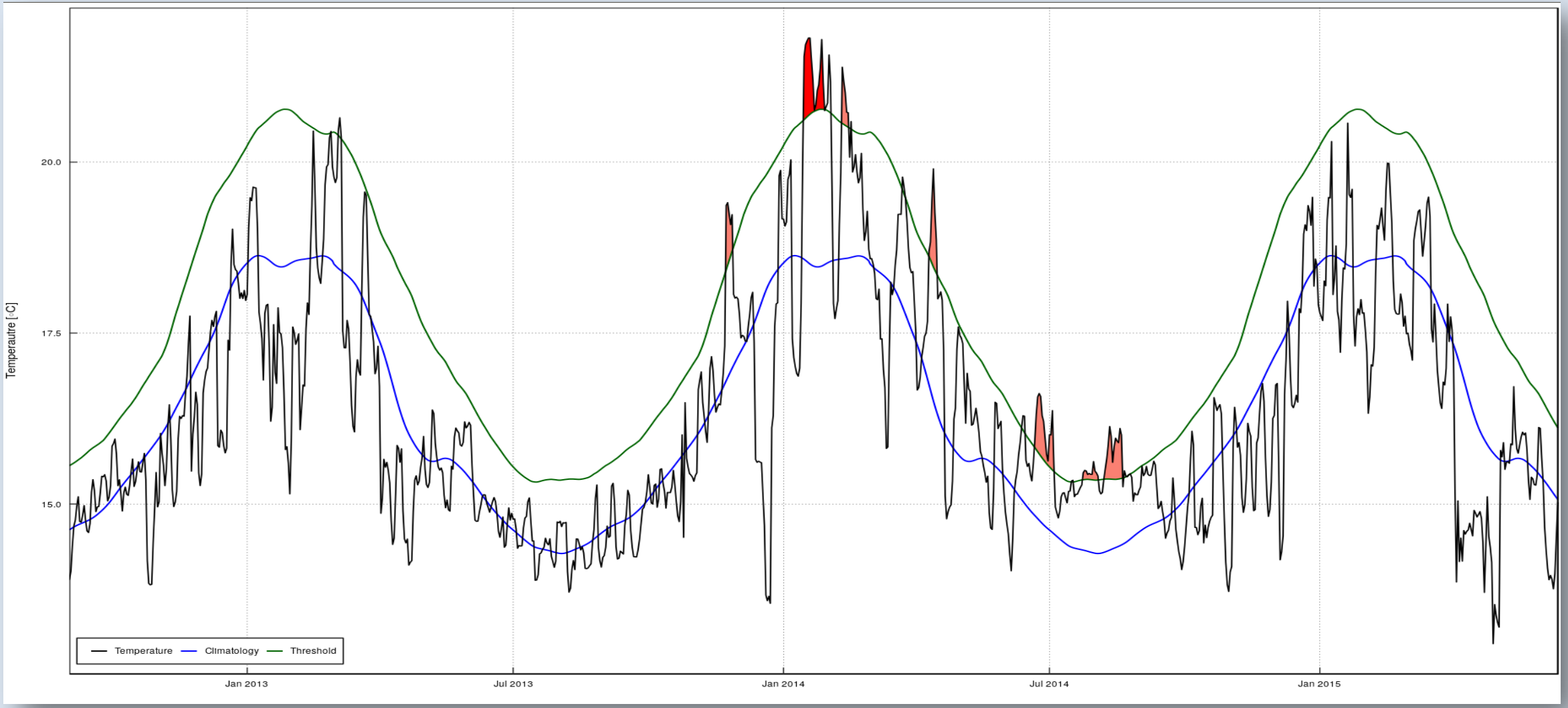
```r
ts <- ts2clm(MUR_SST_LB, climatologyPeriod = c("2002-06-01", "2015-12-30"), pctile = 90)

res <- detect_event(ts)

MHW_MUR_LB <- event_line(res, spread = 500, metric = "intensity_cumulative",
                         start_date = "2011-12-31", end_date = "2014-10-30")
```

| t | temp |
|---|---|
| 2002-06-01 | 15.310 |
| 2002-06-02 | 15.218 |
| 2002-06-03 | 15.737 |
| 2002-06-04 | 15.908 |
| 2002-06-05 | 15.906 |
| 2002-06-06 | 15.588 |
| 2002-06-07 | 15.789 |
| 2002-06-08 | 16.140 |
| 2002-06-09 | 16.211 |
| 2002-06-10 | 15.991 |
| 2002-06-11 | 16.124 |
| 2002-06-12 | 15.825 |
| 2002-06-13 | 16.128 |

| doy | t | temp | seas | thresh | var |
|---|---|---|---|---|---|
| 153 | 2002-06-01 | 15.3100 | 15.38895 | 16.53501 | 0.8768671 |
| 154 | 2002-06-02 | 15.2180 | 15.36179 | 16.49611 | 0.8702561 |
| 155 | 2002-06-03 | 15.7370 | 15.33458 | 16.45655 | 0.8633482 |
| 156 | 2002-06-04 | 15.9080 | 15.30649 | 16.41563 | 0.8570224 |
| 157 | 2002-06-05 | 15.9060 | 15.27732 | 16.37624 | 0.8511885 |
| 158 | 2002-06-06 | 15.5880 | 15.24691 | 16.33650 | 0.8457628 |
| 159 | 2002-06-07 | 15.7890 | 15.21640 | 16.29725 | 0.8408421 |
| 160 | 2002-06-08 | 16.1400 | 15.18578 | 16.25898 | 0.8361379 |
| 161 | 2002-06-09 | 16.2110 | 15.15476 | 16.22132 | 0.8319788 |
| 162 | 2002-06-10 | 15.9910 | 15.12433 | 16.18440 | 0.8285179 |
| 163 | 2002-06-11 | 16.1240 | 15.09546 | 16.14989 | 0.8256515 |
| 164 | 2002-06-12 | 15.8250 | 15.06723 | 16.11543 | 0.8226540 |
| 165 | 2002-06-13 | 16.1280 | 15.03938 | 16.08011 | 0.8192139 |
| 166 | 2002-06-14 | 16.1030 | 15.01088 | 16.04493 | 0.8155116 |
| 167 | 2002-06-15 | 15.9980 | 14.98278 | 16.00885 | 0.8115503 |
| 168 | 2002-06-16 | 16.0360 | 14.95580 | 15.97569 | 0.8075582 |

```
climatology:Classes ‘tbl_df’, ‘tbl’ and 'data.frame': 4961 obs. of 10 variable
..$ doy : int [1:4961] 153 154 155 156 157 158 159 160 161 162 ...
..$ t : Date[1:4961], format: "2002-06-01" "2002-06-02" "2002-06-03" "2002-06-
..$ temp : num [1:4961] 15.3 15.2 15.7 15.9 15.9 ...
..$ seas : num [1:4961] 15.4 15.4 15.3 15.3 15.3 ...
..$ thresh : num [1:4961] 16.5 16.5 16.5 16.4 16.4 ...
..$ var : num [1:4961] 0.877 0.87 0.863 0.857 0.851 ...
..$ threshCriterion : logi [1:4961] FALSE FALSE FALSE FALSE FALSE FALSE ...
..$ durationCriterion: logi [1:4961] FALSE FALSE FALSE FALSE FALSE FALSE ...
..$ event : logi [1:4961] FALSE FALSE FALSE FALSE FALSE FALSE ...
..$ event_no : int [1:4961] NA NA NA NA NA NA NA NA NA NA ...
..- attr(*, ".internal.selfref")=<externalptr>
event :Classes ‘tbl_df’, ‘tbl’ and 'data.frame': 28 obs. of 22 variables:
..$ event_no : int [1:28] 1 2 3 4 5 6 7 8 9 10 ...
..$ index_start : num [1:28] 82 226 248 286 324 461 474 682 720 891 ...
..$ index_peak : int [1:28] 84 229 252 286 324 467 479 687 724 908 ...
..$ index_end : num [1:28] 88 230 255 292 328 468 499 688 724 953 ...
..$ duration : int [1:28] 7 5 8 7 5 8 26 7 5 63 ...
..$ date_start : Date[1:28], format: "2002-08-21" "2003-01-12" "2003-02-03" "2
```

# Visualisations



# References

Hobday, A. J., Alexander, L. V., Perkins, S. E., Smale, D. A., Straub, S. C., Oliver, E. C., Benthuysen, J. A., Burrows, M. T., Donat, M. G., Feng, M., Holbrook, N. J., Moore, P. J., Scannell, H. A.,Sen Gupta, A., Wernberg, T., 2016. A hierarchical approach to defining marine heatwaves.Progress in Oceanography 141, 227–238.

Hoegh-Guldberg, O., Mumby, P. J., Hooten, A. J., Steneck, R. S., Greenfield, P., Gomez, E., Harvell, C. D., Sale, P. F., Edwards, A. J., Caldeira, K., Knowlton, N., Eakin, C. M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R. H., Dubi, A., Hatziolos, M. E., 2007. Coral Reefs Under Rapid Climate Change and Ocean Acidification. Science 318 (5857), 1737–1742.