

March 2026

IMOS

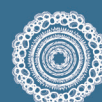
IMOS AusTemp

Marine Heatwave Data Product

v1.0

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Version Control Information (if necessary)

Version	Date	Comments	Author
v1.0	March-2026	Creation of document	Li, Leo

Citation

Li, L. (2026). IMOS AustTemp, Marine Heatwave Data Product. Version 1.0. Integrated Marine Observing System.

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1 Background

This dataset contains the marine heatwave (MHW) and marine cold spell (MCS) categories from the 1st of January 2012. The SST Atlas of Australian Regional Seas (SSTAARS) daily climatology (Wijffels et al., 2018) is used as the baseline for developing heat-stress monitoring metrics. SSTAARS daily 90th-, 50th-, and 10th-percentile thresholds are applied to classify MHW and MCS according to established Hobday definitions. The dataset also contains the Sea Surface Temperature anomalies (SSTa), calculated by comparing the current SST to a monthly SSTAARS climatology, and the Degree Heating-Days (DHD) metrics, calculated by accumulating the daily positive Sea Surface Temperature anomalies (SSTa). When SST cannot be calculated due to cloud cover, the grid cell is left blank (white in web plots, transparent in Google Earth) to indicate missing data.

This product follows on from the Bureau of Meteorology's (Bureau) decommissioned ReefTemp Next Generation, a high resolution mapping product that provided information on coral bleaching risk for the Great Barrier Reef region for 2012-2024. In the first stage of operational deployment of AusTemp, the current operational satellite-derived, night-time-only MultiSensor Level 3 Super-collated (MS L3S, Govekar et al 2022) sea surface temperature (SST) product is being used to define heat stress and MHW/MCS monitoring metrics. A new GeoPolar MultiSensor L3S adds geostationary Himawari-8/9 data to the polar-orbiting satellites. It provides significantly improved spatial coverage, due to Himawari's 10 minute sampling period filling in SST gaps caused by fast moving cloud, with an additional 20% data on average over the MS L3S product (Govekar et al 2024).

The improved spatial and temporal resolution of AusTemp allows for high-detail mapping of MHWs across Australian waters, supporting accurate assessments of local ecological impacts, including coral bleaching and mortality in marine species. These tools are valuable for conservation, reef management, aquaculture, and fisheries, helping stakeholders manage the growing risks associated with marine heatwaves in a warming ocean.

2 Data sources

2.1 SST source (L3S IMOS)

Primary input is the IMOS L3S nightly SST product (MultiSensor, night-time):

- [AODN THREDDS Catalog](#)

If the primary file is missing, the pipeline falls back to:

- [CSIRO THREDDS Mirror](#)
- [BOM THREDDS Mirror](#)

2.2 Climatology (SSTAARS daily mean)

Daily SSTAARS climatology is used to compute SST anomalies:

- [SSTAARS Daily Climatology Catalog](#)
- Daily climatology file template: SSTAARS_daily_fit_{day_of_year}.nc

2.3 Percentiles for heatwave categories

Daily percentiles (sst_10, sst_50, sst_90) are read from a Zarr store:

s3://data-uplift-public/AUSTemp/ SSTAARS_daily_percentiles.zarr/

2.4 Spatial and temporal coverage

- Region bounds: lon 96.0 to 174.0, lat -48.0 to -8.0 (EPSG:4326)
- Resolution: 0.02 degree
- Temporal resolution: daily (night-time SST)

2.5 Output products and variables

The daily NetCDF file name is:

{YYYYMMDD}_IMOS_AusTemp-marine-heatwave_AUS_fv02.nc

Files are uploaded to the AODN THREDDS server on the AusTemp Marine Heatwave folder:

- [AusTemp Marine Heatwave Data Catalog](#)

2.6 Variable summary

Variable	Description	Units	Notes
sst	Sea surface sub-skin temperature (bias-corrected)	degrees Celsius	SST corrected by SSES bias and +0.17 C offset
ssta	SST anomaly relative to SSTAARS daily climatology	degrees Celsius	Daily anomaly
l2p_flags	L2P quality flags from source	none	Used for QC and masking
sst_mosaic	14-day SST mosaic	degrees Celsius	Gap-filled from last 14 days

Variable	Description	Units	Notes
ssta_mosaic	14-day SST anomaly mosaic	degrees Celsius	Anomaly of mosaic SST
mosaic_age	Mosaic age	days	Days since valid observation used per pixel
MHW_category	Marine heatwave category	category 0-4	Hobday et al. 2018
MCS_category	Marine cold spell category	category 0-4	Hobday et al. 2018
MHW_category_mosaic	MHW category from mosaic SST	category 0-4	14-day mosaic
MCS_category_mosaic	MCS category from mosaic SST	category 0-4	14-day mosaic
dhd	Degree Heating Days	degree C days	Summer only (Dec-Apr)
dhdc	Degree Heating Days counts	days	Days contributing to DHD
dhd_mosaic	DHD from mosaic SST	degree C days	Summer only
dhdc_mosaic	DHD counts from mosaic SST	days	Summer only

Quality control is applied using:

- `quality_level > 2` in the L3S source
- `l2p_flags != 2` (poor quality flag)

3 Calculation methods

3.1 SST preprocessing

1. Read L3S nightly SST for the target date.
2. Convert SST to Celsius, apply bias correction and offset:
 - $sst_corrected = sst + 0.17 - sses_bias$
3. Mask poor-quality pixels ($quality_level \leq 2$ or $l2p_flags == 2$).

3.2 SST anomaly (SSTA)

Daily anomaly is computed from SSTAARS climatology:

$SSTA = SST_corrected - SST_climatology(doy)$

Leap years adjust the day-of-year index to align with the 365-day climatology.

3.3 14-day mosaics

For each pixel, the mosaic selects the most recent valid value within the previous 14 days. The `mosaic_age` stores the age (in days) of the selected value. This reduces cloud gaps while retaining the most recent observation.

3.4 Marine heatwave (MHW) and cold spell (MCS) categories

Daily percentile thresholds are loaded for the same day-of-year:

`sst_10`, `sst_50`, `sst_90`

Marine heatwave category (Hobday et al. 2018):

$cat_mhw = \text{floor}(1 + (sst - sst_{90}) / (sst_{90} - sst_{50}))$

Category is set to 0 when $SST \leq sst_{90}$ and clipped to a max of 4.

Marine cold spell categories are computed similarly using the negative SST and the `sst_10` and `sst_50` thresholds.

3.5 Degree Heating Days (DHD)

DHD accumulates positive anomalies (threshold default is 0.0 C):

$dhd_t = \max(SSTA, 0) + dhd_{\{t-1\}}$

DHD is computed only during summer months (December to April). On Dec 1, DHD arrays are reset.

`dhd_c` counts the number of days contributing to DHD (incremented for positive anomalies).

4 Data Pipeline overview

We use Prefect Workflows to orchestrate the data pipeline. Using Prefect for the AusTemp heatwave dataset flow gives reliable orchestration of the yearly + daily update pipeline with clear step separation and parallel execution of yearly runs, then daily incremental updates.

4.1 heatwave_daily_flow

Processes a single day:

1. Load SST and compute SSTA.
2. Create 14-day mosaics.
3. Compute MHW/MCS categories.
4. Compute DHD (summer months only).
5. Write NetCDF and upload to S3.

4.2 heatwave_flow (historical range)

Runs `marine_heatwave_daily_flow` across a date range for historical backfill.

4.3 heatwave_daily_update

Compares the latest SST file date (THREDDS) with the latest heatwave NetCDF on S3 and processes missing days.

4.4 Configuration (flows/config.yaml)

Key parameters:

- `bbox`: [96.0, 174.0, -48.0, -8.0]
- `summer_months`: December to April
- `dhd_threshold`: 0.0
- `l3s_filename`: {date}152000-ABOM-L3S_GHRSST-SSTskin-MultiSensor-1d_night.nc
- `output_file`: {date}_IMOS_AusTemp-marine-heatwave_AUS_fv02.nc
- `clim_netcdf`: SSTAARS_daily_fit_{day_of_year}.nc
- `clim_percentiles_zarr`: s3://data-uplift-public/AUSTemp/SSTAARS_daily_percentiles.zarr/
- `s3_bucket_block_name` and `nc_s3_folder` for output storage

4.5 Python libraries

Key libraries used in the heatwave flows:

- `numpy`, `pandas`
- `xarray`
- `netCDF4`
- `s3fs`

- prefect, prefect-aws

5 References

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