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IMOS

IMOS AusTemp

Degree Heating Days / SST anomaly product

v1.2

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Australia's Integrated Marine Observing System (IMOS) is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent.

Version Control Information (if necessary)

Version	Date	Comments	Author
v1.0	March-2025	Creation of document	Li, Leo
v1.1	November-2025	Updated link to BOM Technical Report	Li, Leo
v1.2	March-2026	Updated product descriptions with effective start years.	Li, Leo

Citation

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Background

Overview

AusTemp is a specialised remote sensing application for the monitoring of SST conditions that lead to coral bleaching. The BOM legacy system was developed in consultation with Great Barrier Reef Marine Park Authority (GBRMPA) reef management and replaces the original CSIRO ReefTemp system (Maynard et al, 2008). IMOS regenerated the product and extended it to cover Australia region.

Datasets

- **Product 1: Nighttime AusTemp: Degree Heating Days DHD grids for the Australian Maritime Region**
    - This dataset contains the summer Degree Heating Days (DHD) from the 1st of December to the 30th of April since 2012, which is calculated by accumulating the daily positive Sea Surface Temperature anomalies (SSTa). The SSTa is calculated by comparing the current SST to long-term averages (1993-2003, the "CSIRO Legacy climatology" or 2002-2011, the "IMOS climatology") . The magnitude of the DHD correlates well with past coral bleaching events. In cases where 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.
    - **Filename**: satellite_AusTemp_degree-heating-day_australia.zarr
    - **Duration**: 2012 - present
    - **Variables**

Variable	Full Name	Description
dhd	Degree Heating Days	Cumulative measure of heat stress above a defined temperature threshold, used for monitoring coral bleaching risk.
dhd_count	Degree Heating Days Count	Number of days when the temperature exceeds a specific threshold, contributing to cumulative heat stress.
dhd_count_mosaic	Degree Heating Days Count Mosaic	A composite image combining multiple observations of degree heating days count over a specific period, typically 14 days.
dhd_mosaic	Degree Heating Days Mosaic	A composite image combining multiple observations of degree heating days over a specific period, typically 14 days.
dhd_mosaic_age	Degree Heating Days Mosaic Age	The age of a composite degree heating days image, typically spanning 14 days, combining multiple observations to improve completeness and cloud-free coverage.
mpsa	Mean Positive Summer Anomaly	The mean of positive temperature anomalies during the summer period, used for assessing seasonal heat stress on marine ecosystems.
mpsa_mosaic	Mean Positive Summer Anomaly Mosaic	A composite image combining multiple observations of Mean Positive Summer Anomalies over a specific period, typically 14 days.

- **Product 2: Nighttime AusTemp: Sea Surface Water Temperature anomalies SSTa grids for the Australian Maritime Region**
    - This dataset contains the summer Sea Surface Water Temperature anomalies (SSTa) from the 1st of January since 2012 by comparing the current SST to long-term averages (1993-2003, the “CSIRO Legacy climatology” or 2002-2011, the “IMOS climatology”). The magnitude and duration of anomalously warm sea temperatures correlate well with past coral bleaching events. In cases where 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.
    - **Filename**: austemp_sstanomaly_australia.zarr
    - **Duration**: 2012 - present
    - **Variables:**

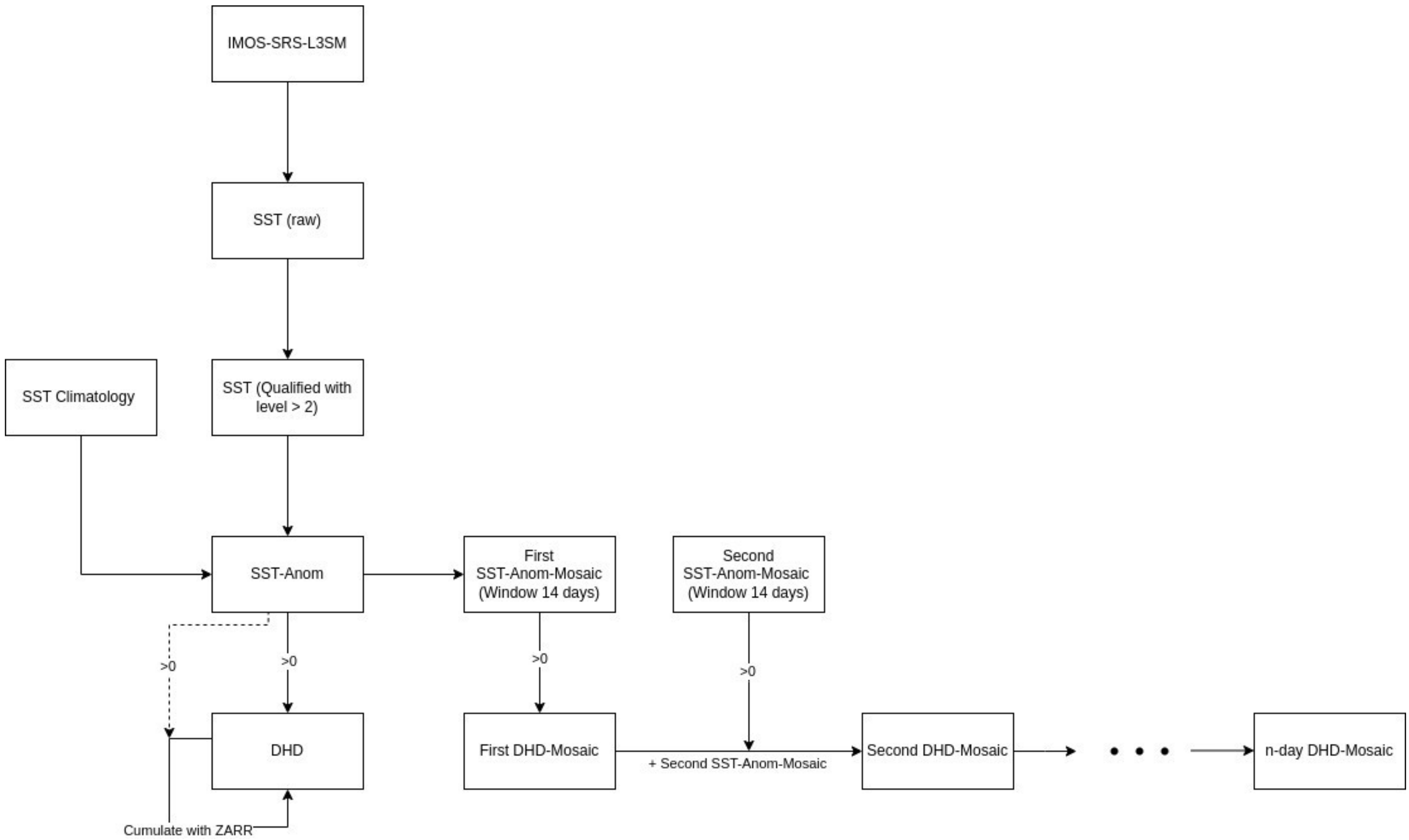
Variable	Full Name	Description
`sst`	Sea Surface Skin Temperature	The skin temperature of the ocean at a depth of approximately 10 microns.
`sst_anom`	Sea Surface Skin Temperature Anomaly	The anomaly skin temperature of the ocean at a depth of approximately 10 microns.
`sst_anom_mosaic`	Sea Surface Skin Temperature Anomaly Mosaic	A composite image that combines multiple satellite observations of sea surface temperature anomalies over a specific period, typically 14 days.
`sst_mosaic`	Sea Surface Temperature Mosaic	The composite image created by combining multiple satellite observations of ocean surface temperatures over a specific period, typically 14 days.
`sst_mosaic_age`	Sea Surface Temperature Mosaic Age	The age of a composite sea surface temperature image, typically spanning 14 days, which combines multiple satellite observations to create a more complete and cloud-free representation of ocean temperatures across a large area.

- **Source of Files**:
  - IMOS Thredds L3SM-1d-night: https://thredds.aodn.org.au/thredds/catalog/IMOS/SRS/SST/ghrsst/L3SM-1d/ngt/2025/catalog.html
  - Climatology (1993-2003, the "CSIRO Legacy climatology" or 2002-2011, the "IMOS climatology"), accessed from `s3://data-uplift-public/AUSTemp/IMoS_climatology/imos_climatology_aus_region.nc` , monthly Climatology can also be accessed inside the parent folder `s3://data-uplift-public/AUSTemp/IMoS_climatology/` .
- **Type of Output Data**:
  - Zarr
  - NetCDF

Methodology

Generating the DHD-Mosaic dataset with ZARR

The methodology for generating the **DHD-Mosaic dataset with a 14-day window** follows these steps, as shown in the flowchart:



Step 1: Data Acquisition

- **IMOS-SRS-L3SM** (Integrated Marine Observing System - Sea Surface Temperature) provides **raw SST (Sea Surface Temperature) data**.

Step 2: SST Quality Control

- The raw SST data is **filtered** based on a quality level threshold (**Qualified with level > 2**) and also subtracted the **sses_bias**.

- This ensures only high-quality SST measurements are used.

Step 3: SST Anomaly Calculation

- **SST Climatology** is used as a reference dataset.
- The **SST Anomaly (SST-Anom)** is computed as:

$$SST\_Anom = SST_{qualified} - SST_{climatology}$$

- Only positive anomalies (>0) are considered for further processing. Negative SST anomalies will be replaced by zeros when calculating DHD.

Step 4: Degree Heating Days (DHD) Computation

- **DHD is calculated** from SST anomalies where:

$$DHD_{x,y} = \sum_{t_0=\text{1st Dec}}^{t_1=\text{today}} SSTA_{x,y} \quad \text{where } SSTA > 0^{\circ}C$$

- The cumulative DHD dataset is stored in **Zarr format**.

Step 5: SST-Anom-Mosaic Generation (14-day Window)

- A **first 14-day SST-Anom-Mosaic** is generated by fulfil Nan value pixels with anomalies over a last 14-day period that it is iterative. Starting with the previous day, and then day before that etc. until all (or most) gaps are filled.
- Only positive values (>0) are retained.

Step 6: DHD-Mosaic Generation (14-day Window)

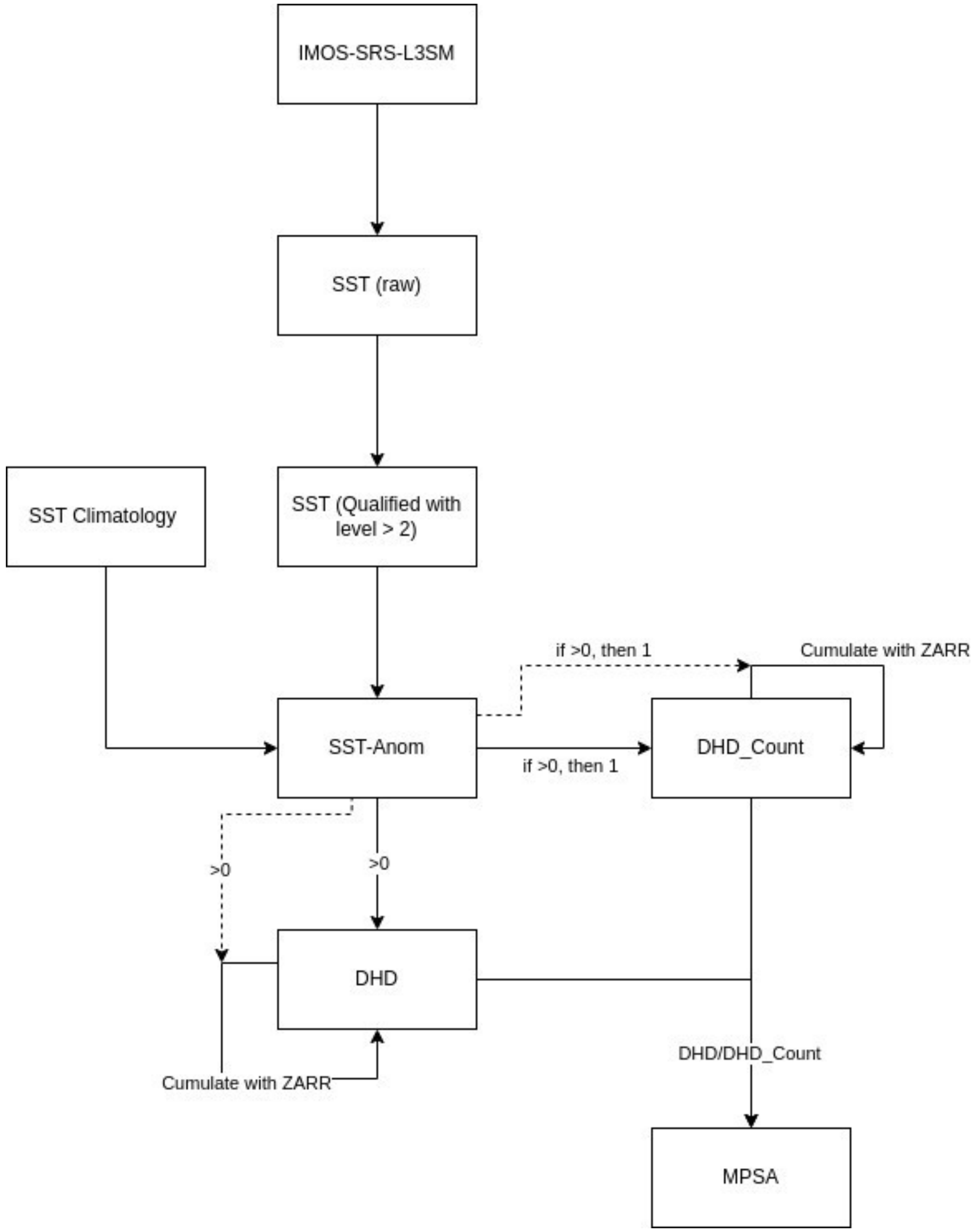
- Using the first **SST-Anom-Mosaic**, the **First DHD-Mosaic** is created.
- This process is repeated with a **Second SST-Anom-Mosaic** to compute a **Second DHD-Mosaic**.

Step 7: Continuous Aggregation

- The process continues in **14-day rolling windows** to generate **n-day DHD-Mosaics**. The selected day is at the end of the time window (uses a t-14 day window).
- Each new DHD-Mosaic is computed by accumulating previous DHD-Mosaics.

Generating the MPSA dataset with ZARR

The methodology for generating the **DHD_Count** and **MPSA (Mean Positive SST Anomaly)** datasets follows the same initial steps as the **DHD-Mosaic** process, but with additional calculations.



Step 1: Compute DHD_Count

- From the **SST-Anomaly (SST-Anom)** dataset:

$$DHD\_Count = \begin{cases} 1, & \text{if } SST\_Anom > 0 \\ 0, & \text{otherwise} \end{cases}$$

- The result is the **DHD_Count dataset**, which tracks the number of days where **positive anomalies** occur.
- This dataset is **cumulatively stored in Zarr format**.

Step 2: Compute MPSA (Mean Positive SST Anomaly)

- The **MPSA dataset** is calculated as:

$$MPSA = \frac{DHD}{DHD\_Count}$$

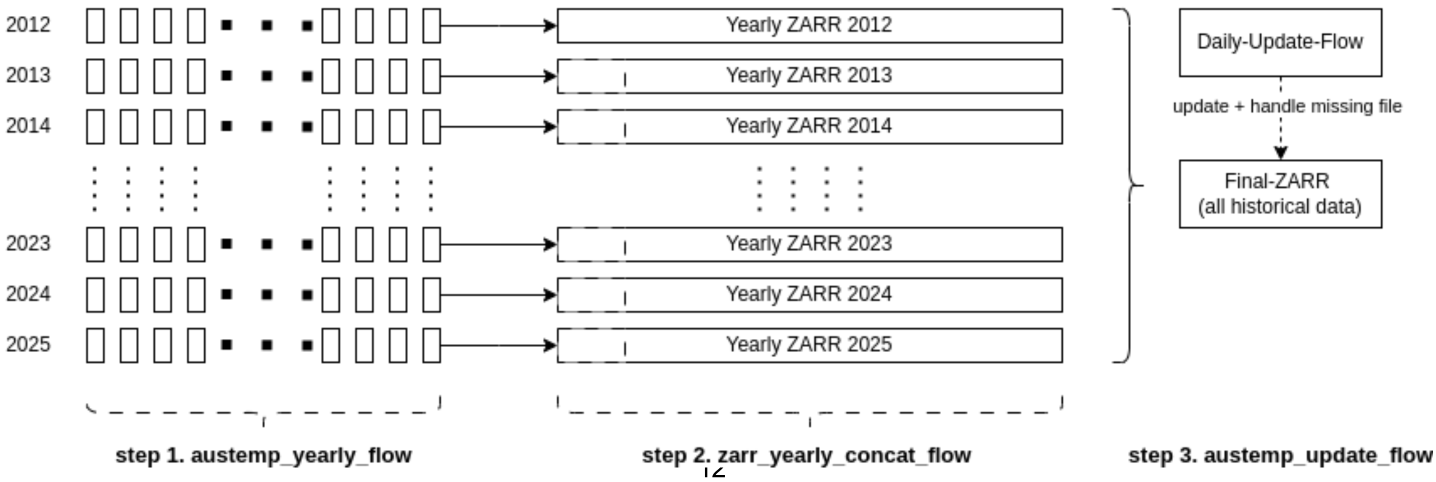
- This represents the **average intensity of heating anomalies** over the recorded period.

Note:

- The methods referring to the BoM technical report (https://nla.gov.au/nla.obj-2968723511/view?searchTerm=CTR_063#search/CTR_063).
- The equation is in LaTeX format, making it more readable in an IDE.
- The **sst_dtime** was not considered for these products. In other words, the data products are assumed to be daily at 15:20, but in reality this can change slightly day-to-day.
- The history attribute of the dataset's attributes is inherited from the source NetCDF (SRS-L3SM night datasets https://thredds.aodn.org.au/thredds/catalog/IMOS/SRS/SST/ghrsst/L3SM-1d/ngt/catalog.html).

Austemp Process Workflow

Austemp Workflow



- Step 1. run yearly flow to generate yearly ZARR and NetCDFs.
- Step 2. run the yearly flow parallel, then concat the yearly zarr into final zarr.
- Step 3. run daily update flow to update the final zarr and generate new NetCDFs daily.

Austemp ZARR Flow Advantages

- **cost-efficient** only use 4GB memory to process a day what ever end of summer with minutes
- **Faster computations** with processing with zarr. It took 7.5 hour to complete a whole year computing, while the traditional NetCDF way that 7.5 hour can only finish one month computing.
- **Cloud-native workflows** reduce I/O overhead.
- **Chunking & compression** optimize storage and access.
- **Scalability** for long-term climate data analysis.

Processing **DHD and SSTA** over long time periods (e.g., 14-day mosaics on multi-year aggregations), **Zarr is a game-changer** compared to traditional NetCDF workflows.

References

Maynard, Jeffrey A., et al. "ReefTemp: An interactive monitoring system for coral bleaching using high-resolution SST and improved stress predictors." Geophysical Research Letters 35.5 (2008).