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Open Access Earth System Science Data Discussions

Long-term sea surface temperature time series from Malin Head, Ireland

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Abstract. A 67-year, ongoing Sea Surface Temperature time series from Malin Head, in the north of Ireland, has been developed from data collected by Met Éireann and the Marine Institute. Over the course of the time-series, multiple measurement methodologies, sampling frequencies, and sub-site positions have been used for different periods. Resulting from this, two separate datasets have been created and publicised for usage, the quality controlled full-resolution measurement dataset (doi.org/10.20393/85D35444-2FB3-4791-A977-AE29BB3B3CFC; Marine Institute, 2025b), and a standardised daily average dataset (doi.org/10.20393/314DE8E2-79F0-4D36-B2BE-EE2A7E5590E2; Marine Institute, 2025a), the latter of which has undergone various processing steps, including removal of a diurnal signal. The standardised dataset creates and will continue a valuable, longstanding continuous time series which allows for more simplified long-term trend analysis compared with observation collections, which differ in measurement types and frequencies. The Malin Head sea surface temperature data, alongside a co-located tide gauge dataset are instrumental in understanding coastal ocean climate change in the region. Both datasets included are made available through the Marine Institute's Data Catalogue, have been assigned DOIs, and are made available from the Marine Institute's ERDDAP service.

1 Introduction

Observations and in-situ measurements underpin our scientific understanding of the Earth and how its environment functions, and are the basis on which modelling has been developed. While individual or short-term measurements can be useful in some applications, long-term measurements are the most informative in understanding the Earth's systems and how they evolve and change over time (Acquaotta and Fratianni, 2014). On a global scale, there are a relatively small number of long-term datasets measuring oceanographic conditions when compared to those measuring physical conditions in the terrestrial or atmospheric sphere (Luterbacher et al., 2024). This can be associated with a mass funding loss in the late 1980s, which cut off many monitoring projects with decades of data at the time (Duarte et al., 1992), as well as the fact that oceanographic monitoring can be more labour intensive and weather dependent. Due to the relative rarity of these time series, the importance of their continuation, publication and wider accessibility cannot be overstated (Luterbacher et al., 2024).

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In terms of Sea Surface Temperature (SST), this variable gives insight not only into oceanic conditions but contains a more coupled relationship, which provides some understanding of atmospheric conditions as well. It can help to elucidate changes in the ecological structuring of a region (e.g. Sailley et al., 2025), to help separate trends of natural variability from anthropogenic change (e.g. Poul et al., 2025), and is utilised to help model future climate scenarios (e.g. Vytla et al., 2025).

1.1 Malin Head

Figure 1: Map showing the locations of Malin Head (pink) and Portmore Pier (yellow) (Background map extracted from © 2025 Google: © Landsat/Copernicus, © IBCAO, © Data SIO, NOAA, U.S. Navy, NGA, GEBCO, © Airbus)

Malin Head, in County Donegal, is the most northerly point in the Republic of Ireland. This time series is located 2.4km from Malin Head on Portmore Pier, a working pier located in a small bay, which is open to the Malin Sea to the northeast (Fig. 1). Malin Head is an important site in Ireland because it is the primary ordnance datum (OD) used for mapping and surveying across the island of Ireland. An OD is a vertical location used as the basis for deriving altitude for mapping services. OD Malin has been the Irish national datum since 1970 taken as the mean sea level from the tide gauge between 1960 and 1968 (Geological Survey Ireland, 2021).

Malin Head has been the location of a weather monitoring station since 1885. In 1955, the weather station moved to a location adjacent to Portmore Pier (55°22’20” N, 7°20’20” W). Sea surface temperature began to be collected as part of the weather station output from the pier in 1958.

While Malin Head is a coastal location and thus more highly influenced by atmospheric and anthropological variances than an open ocean site may be, the SSTs recorded there are important for understanding the coastal oceanography of the region. Surface waters surrounding Malin Head are impacted by coastal currents traversing clockwise around Ireland from the southeast of the island, around the west coast, and across the northern coast before proceeding further north towards Scotland (Raine and McMahon, 1998; Fernand et al., 2006). Furthermore, the larger Northeast Atlantic region, with the presence of larger scale currents, such as the North Atlantic Current, and the dual influence from the subpolar and subtropical gyres is key to understanding connectivity between open ocean and shelf/coastal seas in the area (Caesar et al., 2021; Daly et al., 2024). Additionally, the longevity of the time series allows for the separation of the small-scale variability, evident in a coastal region, from the underlying trends which permeate these regions of influence.

The full-resolution measured data collected at Malin Head are made accessible to the public and the data have also been curated into a standardised time series. Section 2 discusses the methodologies for collection of the measured data and the creation of the standardised time series from the measured data, Sect. 3 discusses the quality check procedures undertaken for the datasets and the error for each segment of the time series, Sect. 4 overviews usages for the datasets including warming trend analysis, and Sect. 5 maps where and how to access both standardised and measured datasets.

2 Data Curation

At Malin Head, there have been almost continuous measurements of SST since the beginning of 1958 (see Table 1 for an outline of the gaps within the time series). However, due to differing collection methods, sampling frequencies, and slightly different collection positions at the location, these measurements have been separated into three different segments.

Table 1: Gaps in SST data within the full-resolution dataset. A time difference is considered a gap if at least a full day of data is missing. Presence of bad data does not constitute a gap.

Date of Gap	Length of Data Gap
1960/05/31 – 1960/07/15	45 days
1994/03/31 – 1994/05/01	30 days
2004/03/31 – 2004/05/01	30 days

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2006/09/30 – 2006/11/01	31 days
2007/06/30 – 2008/11/16	505 days
2011/08/16 – 2011/08/18	2 days
2021/11/16 – 2021/11/16	1.5 days
2021/11/25 – 2021/11/27	2 days
2021/12/05 – 2021/12/12	5.2 days
2021/12/24 – 2021/12/25	1.2 days
2022/01/03 – 2022/01/04	1.3 days
2022/01/06 – 2022/01/12	5.3 days
2022/01/28 – 2022/02/02	4.5 days
2022/02/03 – 2022/02/10	6.9 days
2022/02/15 – 2022/02/17	1.1 days
2022/02/19 – 2022/03/01	11 days
2022/03/03 – 2022/03/05	2.1 days
2022/03/08 – 2022/03/15	7.5 days

2.1 Segment 1 – Well Measurements

Met Éireann began twice-daily measurements of sea surface temperature on the 1st of January 1958 at Malin Head (Nolan et al., 2021). The first few months of data have been identified as bad and thus not included in the published datasets, so the datasets begin on the 28th of April 1958. These measurements were taken 2 m below the surface of a well on Portmore Pier. The well was connected by pipe to 30 m offshore of the pier (Cannaby and Hüsrevoğlu, 2009; Dunne et al., 2009). These twice-daily measurements continued until the 31st of March 1991.

2.2 Segment 2 – Bucket Measurements

On the 1st of April 1991, there was a transition from the twice-daily well measurements to once-daily measurements. These measurements were collected by either collecting a bucket of water from beside the pier and measuring the temperature from the bucket or by directly lowering an electronic temperature sensor into the water from Portmore Pier and reading the temperature value from it (Dunne et al., 2009). These measurements continued until the 30th of June 2007.

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2.3 Segment 3 – Continuous Measurements

After a 17-month gap (see Table 1), the Marine Institute took over the time series and established long-term deployments of in-situ temperature loggers beginning on the 16th of November 2008 and these deployments have been continuous since then (Nolan et al., 2021). Seabird 39 (or 39plus) instruments are fixed to the pier 3 to 4 m below OD Malin. Measurements have been collected every 30 minutes continuously throughout this segment of the time series, excluding minor gaps between sensor deployments and due to occasional sensor issues (Table 1). From 2008 – 2012, there was a combination of pier locations chosen for sensor deployment (middle: 55.371480° N, 7.334372° W; and end: 55.371308° N, 7.334328° W). From 2012 – 2021, deployments included both mid- and end- pier deployments but the end-pier deployments are exclusively included in the standardised time series due to the location being less sheltered and diurnally impacted. Since 2022, two sensors have been deployed together at the end of the pier, to ensure a backup in case of sensor issues, and mid-pier deployments have ceased. Where there have been two sensors deployed for the same time period, after review of the data, a primary sensor has been chosen for inclusion within the publicised datasets.

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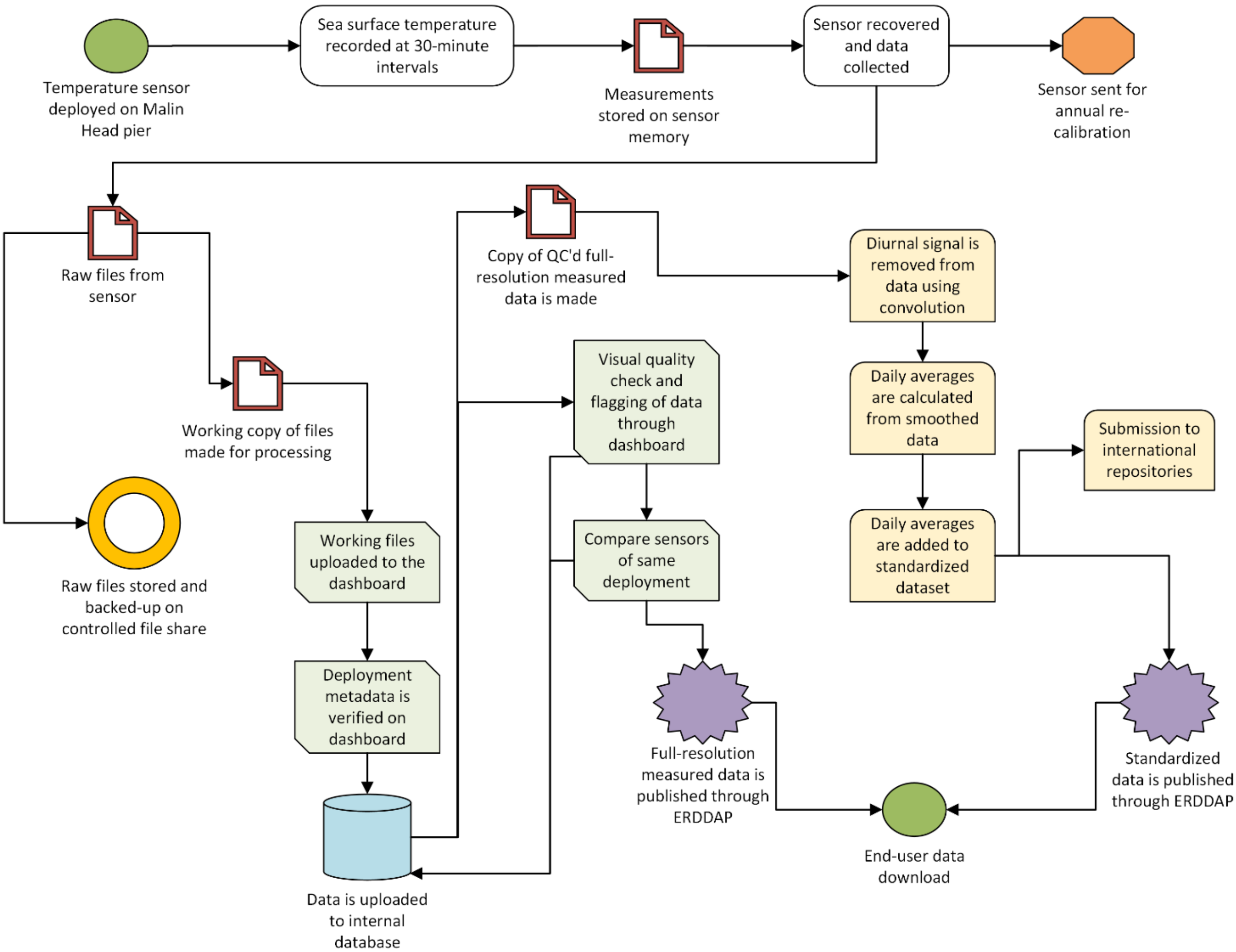

Figure 2: Process flow diagram for Malin Head data from sensor deployment to the download of data by the end-user. Green boxes denote steps that occur on the in-house dashboard developed for fixed CTD processing and quality control. Yellow boxes denote steps that only occur in the creation and publishing of the standardised dataset from the measured data.

2.4 Standardised Time Series

The collected data from the various sensors can be considered an observed time series within each of the segments themselves, but for consideration as a continuous time series, a standardised daily averaged data product has been separately developed from the raw data. In developing this dataset, the three segments needed to be processed differently to achieve as consistent of a time series as possible.

In order to remove the diurnal signal from Segments 1 and 2 (twice daily and once daily measurements, respectively) for generating daily averages, a normalised diurnal signal was calculated from the 30-minute data in Segment 3, which could be

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applied to the data in Segments 1 and 2 to normalise the variable measurement times to noon average. In the development of the normalised signal, all 30-minute data was averaged per day, centred at noon, up to when the curve was developed in 2017. All of the daily averaged data for a month (over the entire set 2008 – 2017) was combined to create a daily average per month (DPM). From the raw data, hourly averages were also developed per month (HPM). The DPM was subtracted from the HPM which resulted in a normalised monthly diurnal signal which gave the hourly adjustments for each month that could be applied to data to remove the diurnal signal and standardise it to a daily average value. The normalised signal was verified by using the same methodology for developing the diurnal signal to attempt to find left-over signal in a dataset from which the diurnal signal had been removed using the normalised signal. Doing this confirmed that the diurnal signal had been properly removed from the dataset.

While there were twice-daily measurements throughout Segment 1, it was not possible to just use one of the measurements, due to an inconsistency in data collection times, as the ‘morning’ measurement was sometimes collected after noon. This inconsistency in timing also meant that the diurnal signal needed to be removed from the data before utilisation. The diurnal signal for the Segment 1, open-water, was found to be considerably smaller than the diurnal signal in the pier-water Segment 3 data, but they were found to broadly follow a similar pattern. It was decided that the normalised diurnal curve would be dampened to half the amplitude before using it to remove diurnal signal from the just-offshore data in Segment 1. Once the two data points were normalised to adjust for the diurnal signal, they were averaged together to create the daily averages for the standardised time series for this segment.

Due to the difference in location of water source for the Segment 1 and Segment 3 measurements, there is not a scientific basis for attempting to match the data. This is because Segment 1 is sourced from an open-water site, which experiences much less extreme fluctuations than the water near the pier does. Therefore, in the standardised dataset, no single correction factor or offset has been applied to match these segments.

Daily SST values were measured for the duration of Segment 2, but there was inconsistency in the timing of the measurements. This inconsistency meant that the diurnal signal needed to be removed from the data before it could be included in the standardised dataset, similar to that described for Segment 1 just above. Again, the diurnal curve derived from Segment 3 was used to standardise the measurement times, thus removing diurnal signal from the Segment 2 data.

In 2010, the bucket methodology was reinstated for five months (28 June 2010 – 26 Nov 2010) in an effort to compare the measurements from the ongoing Segment 3 methodology to the Segment 2 methodology with the objective of adjusting the original bucket data to make a more continuous dataset. After the reinstated bucket data had the diurnal signal removed by using the normalised Seabird signal, as was done with the whole Segment 2 time series, the contemporaneous sensor and bucket datasets were compared through monthly mean values. The monthly mean values found using the bucket methodology trended warmer than the sensor data from the same time period. There was a variance in the trend month-to-month with the summer months showing strongest variation. Since the reinstatement of the bucket data only lasted five months, it was not

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possible to extrapolate trends for the whole year. In order to do this, all of the sensor and bucket data for the 2000s was compared using mean monthly values. Doing this allowed for a comparison of the years as a whole. To incorporate both methods of bias calculation, an average of the biases found using both the contemporaneous data and the whole 2000s data was calculated. The averaged data was adjusted slightly to account for anomalous data and for consistency. This resulted in a roughly sinusoidal shape that peaks in the summer with a change of 0.7 °C and troughed in the winter with a change of 0.5 °C. The adjustments were made to the entirety of the Segment 2 dataset to account for the variance between Segment 2 and 3.

The 30-minute frequency data from Segment 3 goes through a smoothing and averaging process to ensure the removal of the diurnal signal and to provide a consistency with the values submitted. To do this, the MATLAB conv() function was used to facilitate the smoothing of the data using a 49 data point (24.5-hour) window. This is completed for each sensor deployment independently and, due to the functionality of conv(), where there are data gaps larger than two hours within a dataset, the dataset is split and smoothed independently and then put back together. In the shape parameter of the function, 'same' is used to output data of the same length as the input. However, using this shape parameter can exacerbate edge effects, which are lower than expected values on the beginning and end of the dataset, due to the introduction of filler zeros when the window lies outside of the dataset. These edges effects are reduced in the resultant dataset by getting rid of 24 points from the beginning and end of the output from the convolution. Doing this means that one day of data is lost for each deployment, or deployment segment put through this process, but it ensures that all output data is good data. Using this 24.5 hour convolution (12 hours on either side of the central data point), allows for the removal of diurnal signal, while longer-term trends, like seasonality, are retained. Each point in the smoothed dataset is representative of the 24.5-hour window centred around it. From this smoothed data, daily averages for each day of a deployment are calculated and included into the standardised time series.

For brevity, all segments in the standardised product are reported as daily averages and not as values at any given time of day.

3 Data Quality

Data management is a keystone in data processing as it provides the framework to ensure that data is handled and stored the same way no matter who is dealing with it. At the Marine Institute, which is the Irish National Oceanographic Data Centre (NODC), data is managed through the creation and implementation of quality management framework (QMF) packs which are organised to focus on a specific project or type of sensor which collects data. The packs are comprised of a number of documents, which provide the background and structure for the collection, processing, and publishing of datasets, as well as process flow diagrams (e.g. Fig. 2), which allow for the visualisation of the steps for data processing. The data management through the QMF structure at the Marine Institute has been accredited under UNESCO's International Oceanographic Commission (IOC) IODE programme (IODE, 2025) and it holds CoreTrustSeal certification (CoreTrustSeal, 2025) as a trusted data repository for data management and preservation. The QMF packs are built to ensure adherence to the FAIR data

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principles (Findability, Accessibility, Interoperability, and Reusability) which make sure that data and metadata are handled adequately for potential future uses (Wilkinson et al., 2016). Another advantage of developing data process flows under the guidance of a quality management framework is that it lends well to disseminating and publishing not just the datasets, but the methodologies constructed to do so. A recent example is the Marine Institute's vessel CTD dataset and open source Jupyter Notebook toolbox for processing vessel CTD data, developed under the same framework as the Malin Head datasets (O'Sullivan et al., 2025).

3.1 Dashboard and Visual QC

A containerised online dashboard has been recently developed at the Marine Institute, on a Python platform, through which data files downloaded directly from instrument-specific software can be uploaded and archived to an SQL database, quality checked using automated routines (e.g. range checks and spike identification) and visual screening, and published publicly to the Marine Institute's ERDDAP data service. The advantage of using dashboards is in standardisation and streamlining of the data process flow from acquisition to publication of a wide array of environmental parameters and instrument make/models. This dashboard standardises data processing for all fixed CTD-DO datasets hosted by the Marine Institute. For the Malin Head data, which is temperature-only, the dashboard facilitates the visualisation and screening of the collected data. Visual screening of the SST data focuses on finding spot outliers and anomalous data, which are not the result of natural variation, but likely from sensor malfunction or error. When there are multiple sensors deployed together in the same location on the pier at Malin Head over the same period, they are also compared to each other to help differentiate natural variation from sensor issues. This comparison is also important in distinguishing which sensor will be utilised for the complete time series.
The Marine Institute's dashboard, database, and publishing server utilise the SeaDataNet's standards for data quality control (SeaDataNet, 2010) for the data flagging system (Table 2).

Table 2: Overview of the SeaDataNet quality control flags that are utilised in the Malin Head time series

Flag Value	Flag Meaning
0	Data has not been quality controlled. Raw data.
1	Good quality data as verified through quality control procedures.
4	Bad quality data as verified through quality control procedures.
9	Missing data value

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3.2 Error Evaluations

When presenting a dataset such as the Malin Head SST product, error (combined system error, accuracy, sensitivity, drift etc.) is an important metric to consider with it. However, with the nature of the time series discussed, the ability to calculate error for the measurements is hampered by the lack of specification on instrumentation used for the first two segments of the time series. Without accurate information on what exact instrumentation was used for SST measurements for these periods of time it would be impossible to quantify a specific error value. For the first two segments, SST is reported to a tenth of a degree, so the error margin is at least ± 0.1 °C. Both segments are modified for inclusion in the standardised dataset and thus the error of the reported temperatures will change accordingly.

For Segment 3, the SBE 39 and 39plus instruments report temperature with a resolution of 0.0001 °C. Seabird reports the accuracy of the SBE 39 instruments to a margin of ± 0.002 °C and a drift of no more than 0.0002 °C monthly (Seabird, 2024). In order to minimize the effects of the drift in the instrumentation over time, sensors are sent to the Seabird factory for calibration annually between deployments. The maximum error on data points in the full-resolution dataset for Segment 3 would be ± 0.0044 °C, which accounts for the instrument margin and up to a year of drift (deployment length for sensors) for each data point.

With the process taken to prepare Segment 3 data for inclusion in the standardised time series, the error introduced is minimized because the data points that could have been affected by edge errors during the convolution process are removed from the dataset. Errors on data points do change through the process of convolution and in creation of the daily averages and thus must be accounted for. Each data point which is output from the convolution has an error value associated with the combined errors which are used in the window for convolution (Eqn. 1). This post-convolution error can be estimated at ± 0.0006 °C for each point. After convolution, the resultant data points are averaged over the span of a day and the propagation of error associated with this is summarized in Eqn. 2. The resultant daily averages for Segment 3, which are included within the standardised data product, would have an error of ± 0.00009 °C, which is significantly lower than the instrument error for the full-resolution dataset.

$$\sigma_c = \frac{\sqrt{49 \cdot \sigma_i}}{49} \quad (1)$$

$$\sigma_t = \frac{\sqrt{48 \cdot \sigma_c}}{48} \quad (2)$$

Where σ_i is the maximum instrument error for a data point, σ_c is the error resultant from convolution, and σ_t is the total error on standardised Segment 3 data points after making the daily averages.

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Convolution using a 49-point window is also used in the creation of the normalised diurnal signal which is used to remove the diurnal signal from the data points in Segment 1 and 2 in order to prepare them for inclusion in the standardised time series. Adding or subtracting the normalised diurnal signal value from the original data points (with an error of ± 0.1 °C) would result in normalized values with an error of essentially ± 0.1 °C as the incoming error from the convolution is so much lower than the instrument error. Since the two daily values in Segment 1 are furthermore averaged, the final average errors for Segment 1 data would be ± 0.0707 °C in the standardised time series, which is lower than the instrument error for this segment due to the use of the higher resolution Segment 3 data. The Segment 2 bucket data is also adjusted to be more similar to Segment 3 data after the diurnal signal has been removed (for full detail see Sect. 2.4). After the processing used for this adjustment, the average error for Segment 2 data is approximately ± 0.1004 °C when it is included in the standardised data set (this does not account for changes in error from manual adjustments to account for anomalous data, but these were intended to decrease error within the dataset).

4 Data Application

4.1 Warming Trends

The complete SST time series from Malin Head is currently 67 years old. This longevity allows for analysis of the warming trend evident in the data beneath the seasonal components. There are many ways to evaluate warming trends in data. The easiest method is creating annual means for the data from which the warming trends can be analysed without removing seasonality. Using the standardised dataset, an annual mean was created by averaging all the daily data for each year, provided that each year had at least 11 months of data, and each month had at least 20 days of data. These criteria ensure that there is enough data to be truly representative of the year as a whole. With these criteria, only the years 1958, 1960, 2007, 2008, and 2022 are removed from the trend analysis due to lack of adequate data. Using this method for analysing a warming trend, the annual warming for the standardised data over the period 1959 to 2024 is 0.015 °C (R^2 = 0.349) with a total warming for the period of 0.997 °C (Fig. 3b). When the same analysis is done for the measured dataset, which includes data for 2022 as it fits the requirements in this dataset, the annual warming trend is 0.019 °C (R^2 = 0.412) with a total warming between 1959 and 2025 of 1.27 °C (Fig. 3a).

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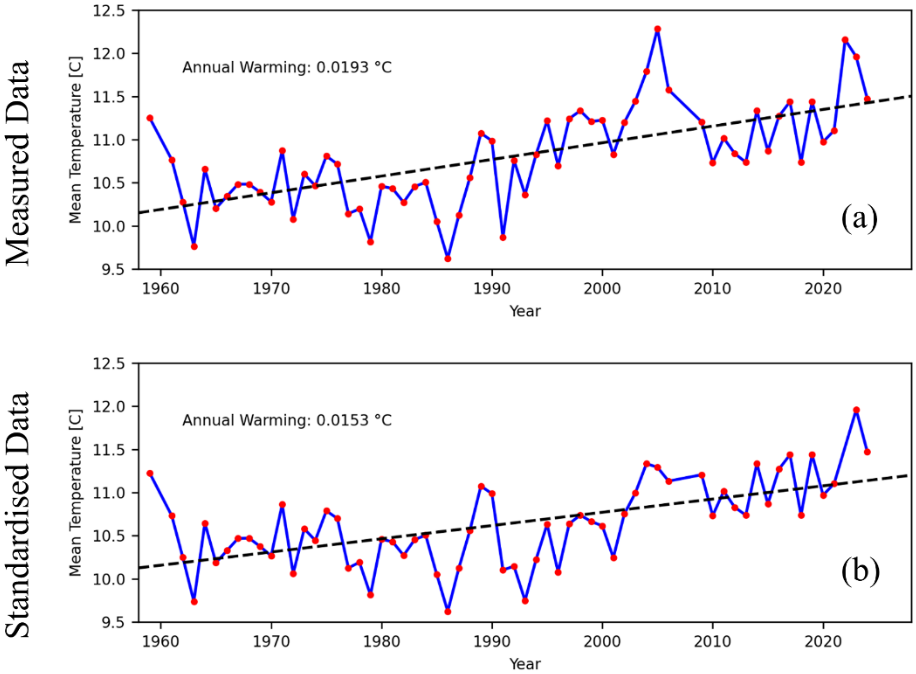

Figure 3: Warming trend analysis at Malin Head, based on annual temperatures from both the full-resolution measured data (a) and the standardised data (b).

Another way to analyse warming trends is through a separation of the seasonal components of temperature data from the underlying trend. In the open-source Python module statsmodels there is a built-in function *seasonal_decompose()* which separates the trend, seasonality, and residuals from given data with a defined period (Seabold et al., 2010). It estimates the trend using a convolution for rolling averages, removes the trend from the data, then the average for the given period is returned as the seasonal component. Using this function, the trend can be evaluated based off daily averaged data from the standardised dataset. For consistency with the annual mean trend, only data that fit the criteria for that method were used for this analysis. The resultant trend for the standardised data for the period 1958 – 2024 was evaluated as 0.016 °C (R^2 = 0.359) annually, and 1.08°C of warming for the whole period (Fig. 4b). When the measured dataset is used, the resultant warming trend comes to 0.02 °C (R^2 = 0.473) annually over the period, and 1.35 °C of warming for the whole period (Fig. 4a).

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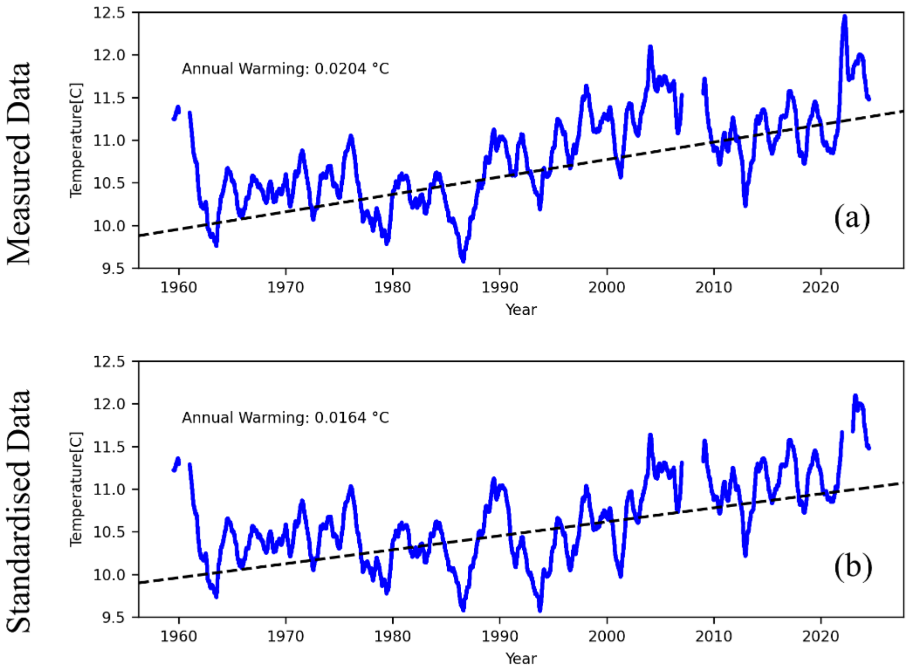

Figure 4: Warming trend analysis at Malin Head, using a seasonal decomposition function, based on daily-averaged data for both the full-resolution measured dataset (a) and the standardised dataset (b).

When looking at the patterns found in SST over time it is clear to see that warming has not been a steady or consistent rise from the beginning of the time series. While there is temperature variation from the beginning of the time series, annual average temperatures began to warm significantly in the 1990s through the early 2000s (Fig. 5). The warming undergone during this period accounts for a significant portion of the total warming at Malin Head throughout the length of the time series. When the period 1991 to 2005 is separated and the trend from annual mean values is calculated, the annual warming from the standardised data is approximately 0.085 °C (R^2 = 0.694) and the total warming for the period is estimated to 1.19 °C, which is higher than the estimation for the whole period. The same trend can be seen in the measured data with annual warming for this period at 0.107 °C (R^2 = 0.690) with a total warming from 1991 – 2005 of 1.49 °C. Cannaby and Hüsrevoğlu (2009) discussed this excess warming occurring around Ireland in the 1990s, where they analysed that the warming signal for this period could be almost evenly attributed to anthropogenic impacts and natural climate oscillations. They also discussed that the warming signal from anthropogenic sources would continue to grow over time. When annual SST anomalies are visualised based on the 1991 – 2020 average (Fig. 5), recent warming of the Malin Head site is apparent. For example, in the standardised dataset (Fig. 5b), there is a clear positive trend above the baseline since 2002 which can be contrasted with the previous cooler period. Furthermore, the two most recent years of data, 2023 and 2024, are also the two warmest years on record. The strong warm period is also clearly evident in the measured data (Fig. 5a)

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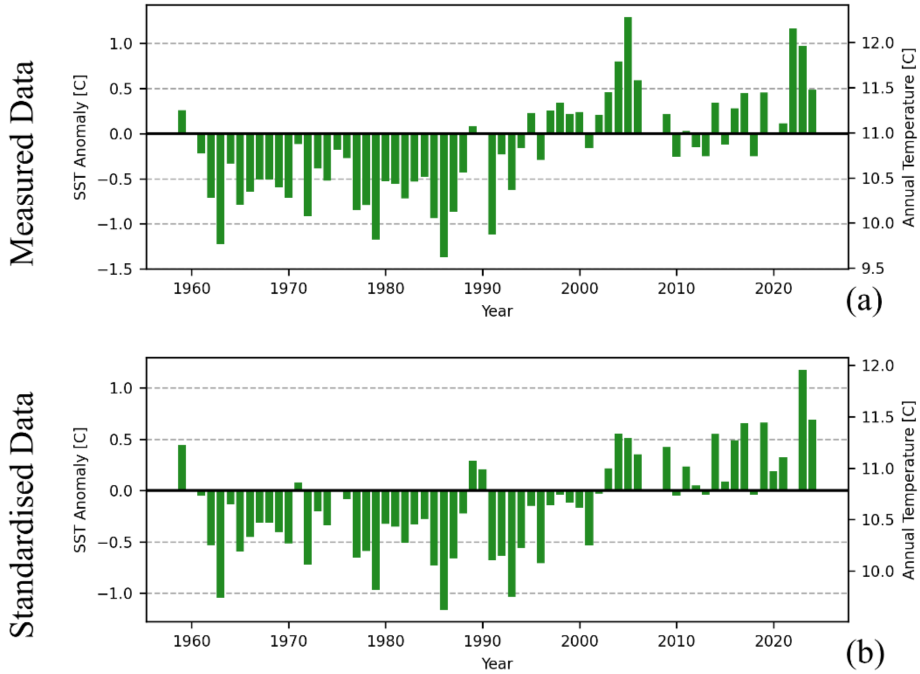

Figure 5: Annual mean temperature anomalies based on the 1991 – 2020 average, the current WMO climatological standard normal (WMO, 2017), for both the full-resolution measured data (a) and the standardised data (b).

4.2 Utilisation of Data in Published Work

Along with evaluating the long-term warming trend at Malin Head, this SST dataset has been utilised in a range of published works which demonstrate numerous use-cases for the data. The following outlines some of the ways the dataset has been leveraged in published works to date:

- Understanding the impacts of climate change (Cornes et al., 2023; Dye et al., 2013).
- Modelling environments and future outcomes (Holt et al., 2012; Tinker et al., 2018).
- Evaluating the causes of warming trends in the north Atlantic (Cannaby and Hüsrevoğlu, 2009).
- Understanding the effects of increasing SST on sublittoral communities (Goodwin et al., 2012).
- Describing the regional oceanographic setting and integrating with similar datasets to catalogue the most recent ocean climate conditions over the Northwest European Shelf (Gonzalez-Pola et al., 2023).

5 Data Availability

The full-resolution measured dataset (doi.org/10.20393/85D35444-2FB3-4791-A977-AE29BB3B3CFC; Marine Institute, 2025b) is published in a few locations to ensure its accessibility to the public. The quality checked measured data at full-resolution is available for visualising or download through the Marine Institute's ERDDAP data server (https://erddap.marine.ie/erddap/tabledap/climate_malin.html). Through this portal, users have the opportunity to filter the data using QC flags (as outlined in Table 2), specific dates, specific sensors, and additional variables. While this portal includes some metadata for the dataset, full metadata, including updates, are available on the Marine Institute's Data Catalogue entry (https://data.marine.ie/geonetwork/srv/eng/catalog.search#/metadata/ie.marine.data:dataset.4454).

The standardised daily averaged data product (doi.org/10.20393/314DE8E2-79F0-4D36-B2BE-EE2A7E5590E2; Marine Institute, 2025a) is available separately on the same platforms and data servers (ERDDAP: https://erddap.marine.ie/erddap/tabledap/climate_malin_daily_average.html, Data Catalogue: https://data.marine.ie/geonetwork/srv/eng/catalog.search#/metadata/ie.marine.data:dataset.5327). This dataset is also submitted to the ICES Report on Ocean Climate (IROC) (Gonzalez-Pola et al., 2023; https://ocean.ices.dk/core/iroc) where it is publicly available. Publishing to IROC was one of the first repositories where this time series was made available to the public and has been a key provider for increasing the visibility of the data on a global scale.

Another co-located time series dataset that runs concurrent to the Malin Head SST time series is from the Tide Gauge located on Portmore Pier (2008 to present; ERDDAP: https://erddap.marine.ie/erddap/tabledap/IrishNationalTideGaugeNetwork.html, Data Catalogue: https://data.marine.ie/geonetwork/srv/eng/catalog.search#/metadata/ie.marine.data:dataset.5277). As part of the Irish National Tide Gauge Network (IN-TGN) this maturing set of sea-level data goes hand-in-hand with SST when investigating long-term change in the region.

6 Conclusion

Measurements of sea surface temperature have persisted at a pier near Malin Head, Ireland on an almost continuous basis since 1958. The resultant data has been made available to the public in both its full-resolution measured format as well as a standardised daily averaged time series. The process for the creation of the daily averaged time series required different steps for the different segments based on acquisition methods, instrumentation and frequency of measurement. Where scientifically reasonable, the early data was adjusted to be more continuous with the data collected from modern instrumentation. The daily-averaged time series has also been submitted to ICES to increase its visibility on a global scale.

These datasets have been used for multiple applications in the past and have many applications for future research and model integration or validation. Furthermore, using these datasets, a warming trend analysis was conducted for Malin Head that showed a 0.015 - 0.022 °C annual warming trend for the length of the study. The stronger warming trend from the full-resolution measured dataset when compared to the standardised dataset could be due to the lack of adjustments to Segment 2 (1991 – 2007) data and potentially the ability to include 2022 data in the analysis. The longevity of this time series is key to its relevance and so, in understanding the value of continuous time series, the Marine Institute has been developing similar long-term datasets in multiple other locations (e.g. Ballycotton: https://erddap.marine.ie/erddap/tabledap/climate_ballycotton.html) which are quickly reaching a mature level. These ongoing time-series will receive continued support to allow them to grow in longevity, while adhering to scientific and data management best practices for quality assurance and open publication of data.

Author Contribution

SD: Conceptualization, Formal Analysis, Visualisation, Writing – Original Draft, Writing – Review & Editing; **GW:** Data Collection; **GN:** Funding Acquisition, Project Administration; **RT:** Conceptualization, Software, Dataset Publication, Writing – Review & Editing, Supervision; **ED:** Conceptualization, Data Curation, Writing – Review & Editing, Supervision

Competing Interests

The authors declare that they have no conflict of interest.

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