ASSEMBLE
ASSOCIATION OF EUROPEAN MARINE BIOLOGICAL LABORATORIES EXPANDED

Acronym: ASSEMBLE Plus

Title: Association of European Marine Biological Laboratories Expanded

Grant Agreement: 730984

Deliverable D11.2

Developing an underwater observation network

March 2023

Lead parties for Deliverable: TSL
Due date of deliverable: M48
Actual submission date: M52

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

GENERAL DATA

Acronym:	**ASSEMBLE Plus**
Contract N°:	**730984**
Start Date:	**1st October 2017**
Duration:	**60 months**

Deliverable number	D11.2
Deliverable title	Developing an underwater observation network
Submission due date	M60
Actual submission date	M64
WP number & title	WP11 Scientific Diving (JRA5)
WP Lead Beneficiary	TSL
Participants (names & institutions)	Karl Roberts,TSL Piotr Balazy, IO-PAN Piotr Kuklinski, IO-PAN Thanos Dailianos, HMCR Karl Attard, TZS Martin Sayer, TSL

Dissemination Type

Report	☒
Websites, patent filling, etc.	☐
Ethics	☐
Open Research Data Pilot (ORDP)	☐
Demonstrator	☐
Other	☐

Dissemination Level

Public	☒
Confidential, only for members of the consortium (including the Commission Services)	☐

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Document properties

Author(s)	Karl Roberts, Piotr Balazy, Piotr Kuklinski, Thanos Dailianos, Karl Attard
Editor(s)	Martin Sayer
Version	V1.0

Abstract

Aquatic physicochemical data are important for understanding how ecosystems function and the long-term consequences of anthropogenic drivers, for example the steady rise in greenhouse gas emissions, and temperature rise. There is large-scale monitoring of sea surface conditions using both remote sensing and in-situ platforms but there is a lack of depth-resolved profiles for inshore regions. This is a significant data gap as inshore water conditions are important for commercial activities (e.g. aquaculture and fisheries), as well as driving many of the biological traits that determine productivity and distribution of species.

Subtidal seawater temperature recording stations were deployed during the WP and data were delivered by four of the partners (TSL, IO-PAN, HMCR and TZS). The diver-deployed dataloggers returned data that show marked differences in results depending on the depths of deployment. Comparisons with accepted remote sensing based surface seawater temperature datasets (e.g. The Operational Sea Surface Temperature and Ice Analysis (OSTIA) system) demonstrate that established methods of broad-scale seawater temperature produce erroneous results when compared with data collated from quite moderate water depths. In some cases the errors are small and can be compensated for. However, the differences were considerably larger where the diver-placed loggers were at, or below, water column thermoclines. The main implication from this study is that submerged loggers should be employed in all cases where the target depth is relevant.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

1. Introduction

Subsurface temperature is defined as essential ocean variable (EOV) (“Global Ocean Observing System - Essential Ocean Variables” n.d.), but there is a shortage of depth-resolved temperature data (Wright et al. 2016), especially in subtidal areas where research vessels and Argo floats do not commonly reach (Hyder et al. 2015).

Water temperatures, along with the rate and severity of occurrence of extreme events such as heat waves, are expected to increase with global warming (Oliver et al. 2019). However, there is regional variability (Kennedy 2013); for example, sea surface temperature (SST) around the UK has been increasing at up to 6 times the global average (Dye et al. 2013), while, in contrast to the global temperature rise, parts of the North Atlantic have experienced cooling (Wright et al. 2016).

There is, therefore, an essential need to gather as much depth-resolved in-situ temperature data as possible, to allow monitoring and identifying seasonal patterns at local level, to supplement satellite data and to validate ocean models (Brewin et al. 2017a and b).

SST is a variable that can be retrieved routinely, and operationally, with high spatial coverage and good temporal resolution using Earth Observation (EO), through measurements of radiation in the infrared (Llewellyn-Jones et al. 1984) and microwave (Wentz et al. 2000) portion of the electromagnetic spectrum from radiometers mounted on satellite platforms. To evaluate the use of EO SST products for various operational applications, it is imperative to know the accuracy and precision of the data. This typically requires direct comparison of EO data with co-located and concomitant in situ data. In the open-ocean, knowledge of the accuracy and precision is generally high. However, the reliability of EO SST data at the coastline is not well known, impeded by a lack of in situ data resulting in few validation studies (Smit et al. 2013).

Where marine research institutes employ scientific diving teams there are resources available to cost-effectively deploy and maintain monitoring stations to cost-effectively measure and monitor sub-surface seawater temperature. The monitoring devices can be relatively basic in design and usually consist of a weighted base placed in an area of seabed that makes them easy to locate and recover (Figure 1). The recording instruments are relatively low-cost, robust, small and make use of advances in data memory to record significant volumes of data over long deployment times.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Figure 1: Diver attaching Aquatic-2 dataloggers to a weighted chain

This part of JRA5/WP11 has made use of the geospatial pan-European transect of four of its members to demonstrate the potential value of developing and maintaining a co-ordinated sub-surface seawater temperature monitoring network. In addition to collating associated datasets, comparisons with co-located SST data will provide an assessment of the scale of variation in shallow coastal waters, determine if variations are influenced by the major differences in deployment conditions that the large-scale transect provided, and relate these to future programmes that may depend on reliable sub-surface seawater temperature measurement.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

2. Objectives

The objectives of this part of JRA5 were to:

a. establish a nascent network of sub-surface seawater monitoring stations based on the scientific diving capacity existing withing the jra5 partnership;

b. collate data at location-relevant depths from self-contained temperature loggers recording over at least one complete annual cycle;

c. compare the sub-surface datasets with satellite-based sea surface temperature data derived from the identical locations over the same timescales using an established data provider;

d. provide an evidence base for decision making on how best to obtain relevant seawater data in coastal waters in the future.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

3. Methods

3.1 Recording Stations

Data were obtained from recording stations established at four locations: Svalbard (IO-PAN), Finland (TZS), Greece (HMCR) and Scotland (TSL) (Figure 2).

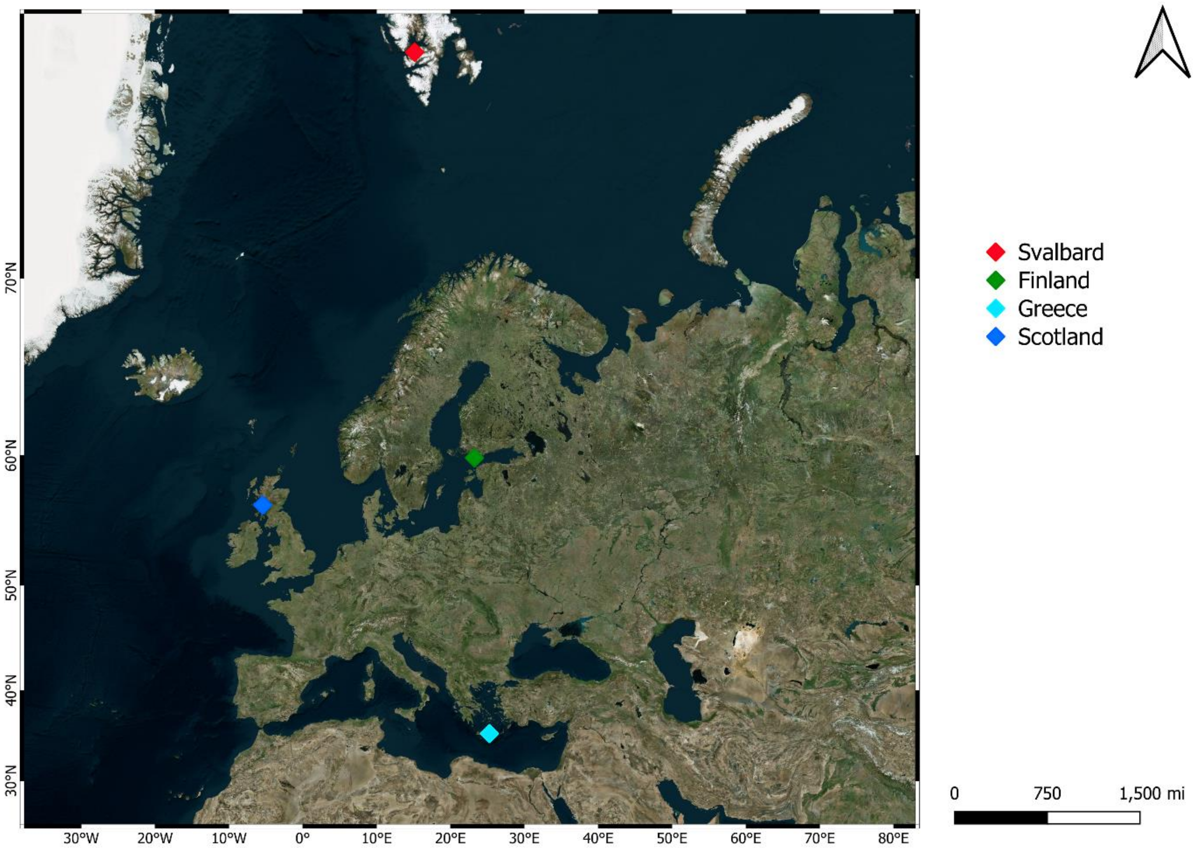

Figure 2: JRA5 partner locations delivering sub-surface seawater temperature datasets

Temperature monitoring was achieved by divers deploying autonomous dataloggers (Figure 3) in pairs on weighted structures in underwater locations that were easy to relocate. Some deployments previous to this project had become compromised where there were surface buoys attached to the loggers through damage from other water users.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

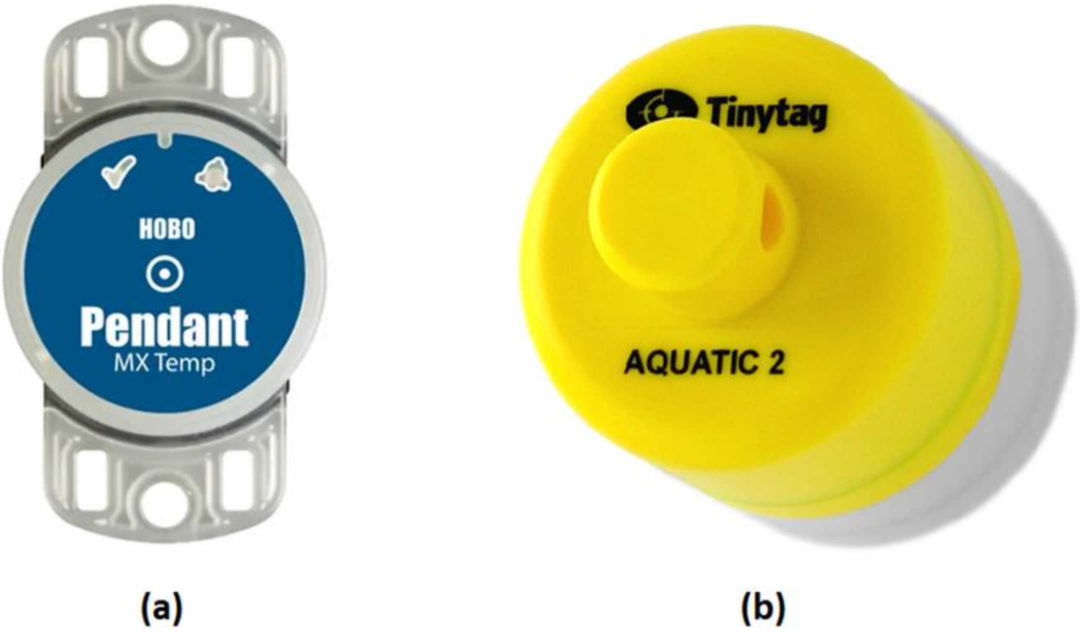

Figure 3: Autonomous underwater temperature loggers: (a) HOBO Pendant MX2201, (b) Tinytag Aquatic-2

The geolocation details of the actual monitoring station locations and the depth of logger deployments were:

Partner	**Location**	**GPS co-ordinates**	**Deployment depth**
IO-PAN	Svlbard, Norway	78.188333°N 15.144750°E	6 and 12 metres
TZS	Tvärminne Zoological Station, Finland.	59.841608°N 23.250197°E.	3-4 metres
HMCR	Crete, Greece	35.346621°N 25.278761°E	7 metres
TSL	Dunstaffnage Bay, Oban, Scotland	56.453917°N 5.412278°W	10 and 30 metres

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

3.2 Data Collation

3.2.1 Logging-based seawater temperature (LSST)

Although there was an attempt to standardise the dates, durations and frequencies of recording, differences in access (travel or seasonal), availability of divers/loggers, existing/ongoing recording profiling, and logger type resulted in a variety of data collection profiles:

Partner	**Location**	**Collection dates**	**Recording frequency**
IO-PAN	Svlbard, Norway	10/07/2018 – 27/07/2020	30 minutes
TZS	Tvärminne Zoological Station, Finland.	18/05/2019 – 24/11/2019 27/04/2020 – 01/09/2020 18/09/2020 – 08/12/2020 21/05/2021 – 02/11/2021 25/05/2022 – 31/08/2022	60 minutes
HMCR	Crete, Greece	01/11/2018 – 18/08/2021	60 minutes
TSL	Dunstaffnage Bay, Oban, Scotland	01/01/2018 – 31/12/2020	10 or 12 minutes

3.2.2 Satellite-based surface seawater temperature (SSST)

For each of the four logging stations used for data analyses, daily satellite-derived SST data were obtained from the global ocean OSTIA sea surface temperature and sea ice product (E.U. Copernicus Marine Service Information, 2020). The data source provides foundation sea surface temperature at 0.05° x 0.05° horizontal grid resolution and uses in-situ and satellite data from both infrared and microwave radiometers. The OSTIA cell centre that was closest to the stations' geolocations was chosen and distances between the two locations ranged between 2 and 3 km (Figure 4).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

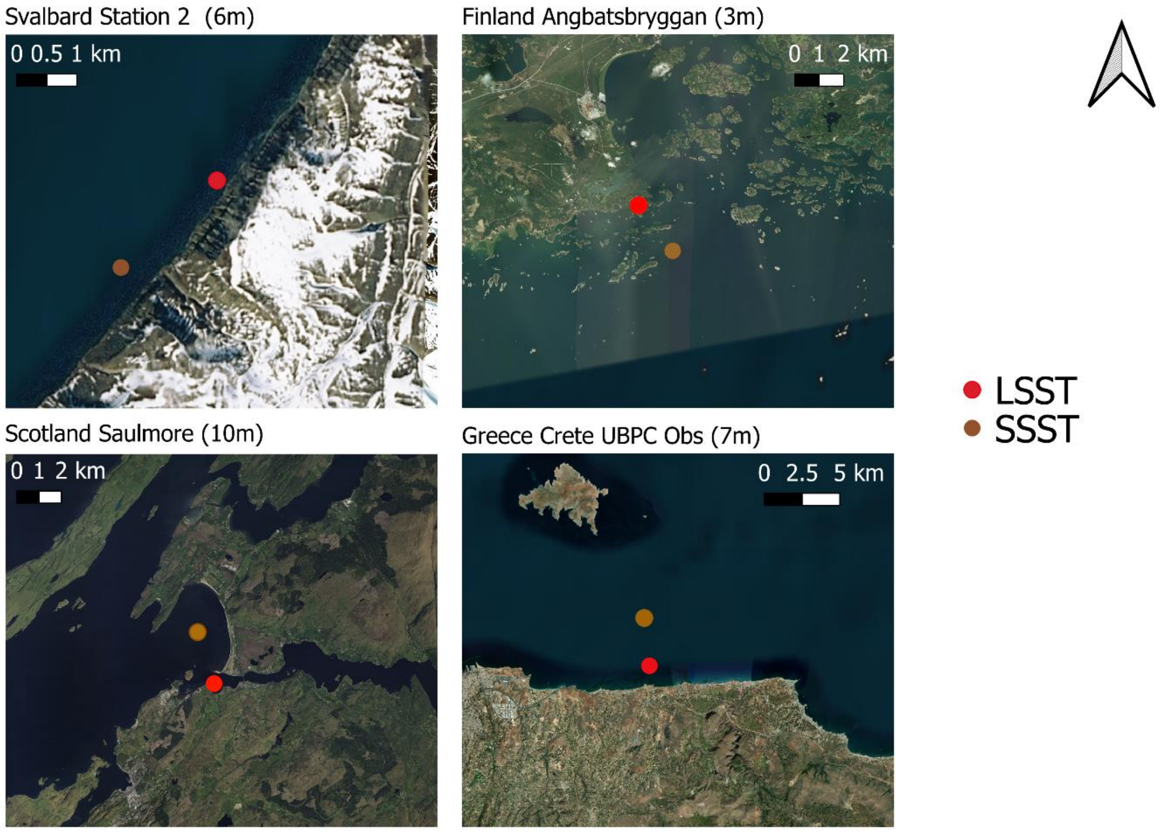

Figure 4: Relative geolocations of the four logging stations (LSST) compared to the centres of the satellite SST cells (SSST)

3.3 Data Analysis

3.3.1 LSST v SSST

SSST NetCDF data was converted to csv format using an opensource python package called 'netcdf2csv' in python v3.10. This data was then transformed from Kelvin (K) to the Celsius (°C) scale using a subtraction of 273.15. Only data from the shallowest temperature loggers were used for comparisons. This data was filtered to a daily frequency with the temperature reading from GMT 12:00:00 used per day with the exception of Scotland which used a daily mean. Suitable adjustments were made from data collected in varying UTC zones. Resulting LSST and SSST data were then compiled and compared for each geographical region.

3.3.2 RMSE (Root Mean Square Error)

Error (E) was calculated using the difference between LSST and SSST for GMT 12:00:00. RMSE for aforementioned date was then calculated by the square root of the sum of E squared divided by the number of entries (see formula).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

.

$$RMSE = \sqrt{\frac{\sum E^2}{N}}$$

3.3.3 Water depth

In one case (Scotland), where logging data existed for two depths at the same location (10 and 30 metres), and previous data recording and analyses had indicated a seasonal thermocline, sub-tidal data were compared with OSTIA SSST data derived from the same geolocation and over the same date range.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

4. Results

4.1. LSST v SSST

LSST data were recorded by four JRA partners at the following locations, collection dates and recording frequencies.

Partner	**Location**	**Collection dates**	**Recording frequency**
IO-PAN	Svlbard, Norway	10/07/2018 – 27/07/2020	30 minutes
TZS	Tvärminne Zoological Station, Finland.	18/05/2019 – 24/11/2019 27/04/2020 – 01/09/2020 18/09/2020 – 08/12/2020 21/05/2021 – 02/11/2021 25/05/2022 – 31/08/2022	60 minutes
HMCR	Crete, Greece	01/11/2018 – 18/08/2021	60 minutes
TSL	Dunstaffnage Bay, Oban, Scotland	01/01/2018 – 31/12/2020	10 or 12 minutes

Not all partners were able to deploy recording stations at different depths and so only data from the shallowest of the stations that were deployed were used for the primary comparisons with the matching SSST datasets (Figure 5).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

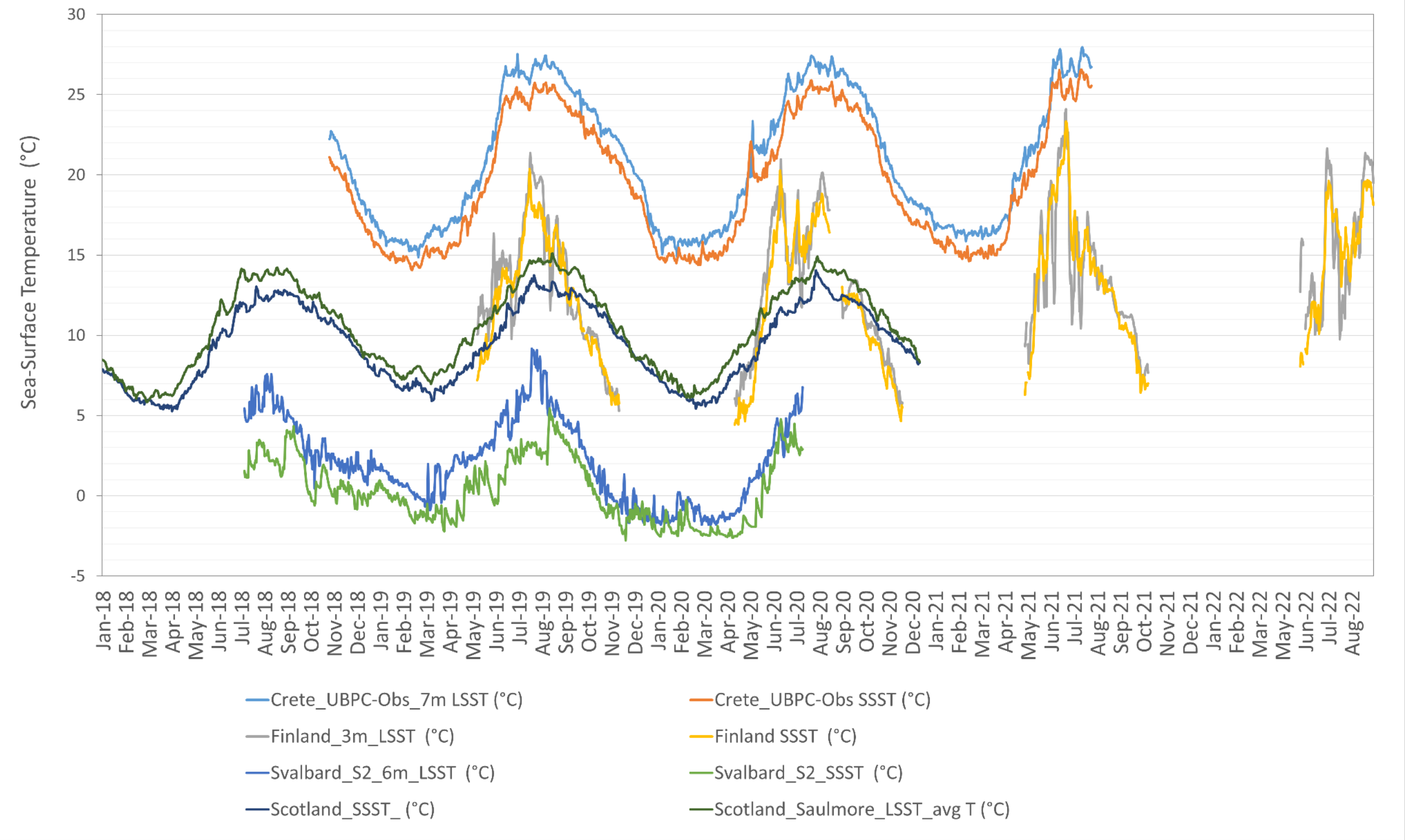

Figure 5: LSST v SSST records from all four study locations collected between 2018 and 2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

4.2. RMSE (Root Mean Square Error)

From the shallow station LSST data recorded at each of the four stations, RMSE relationships were derived for matched pair SSST data (Figures 6 to 9).

The station recording the lowest water temperatures at Svalbard had the RMSE relationship with the lowest R^2 value of 0.7728 (Figure 6). For some of the recording periods, the temperature loggers were below sea-ice.

The RMSE relationship for the Finland data had a R^2 value of 0.8165 (Figure 7). Here the loggers were in shallow water (3 metres) and recorded the largest range of seawater temperatures (ca 20°C) with the most frequent large-scale fluctuations.

The logging data from Crete and Scotland had RMSE relationships with their SSST data with R^2 values of 0.9914 and 0.9702, respectively (Figures 8 and 9). Both locations were subject to moderate temperature ranges (Crete ca 13°C; Scotland ca 10°C) and displayed limited fluctuation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

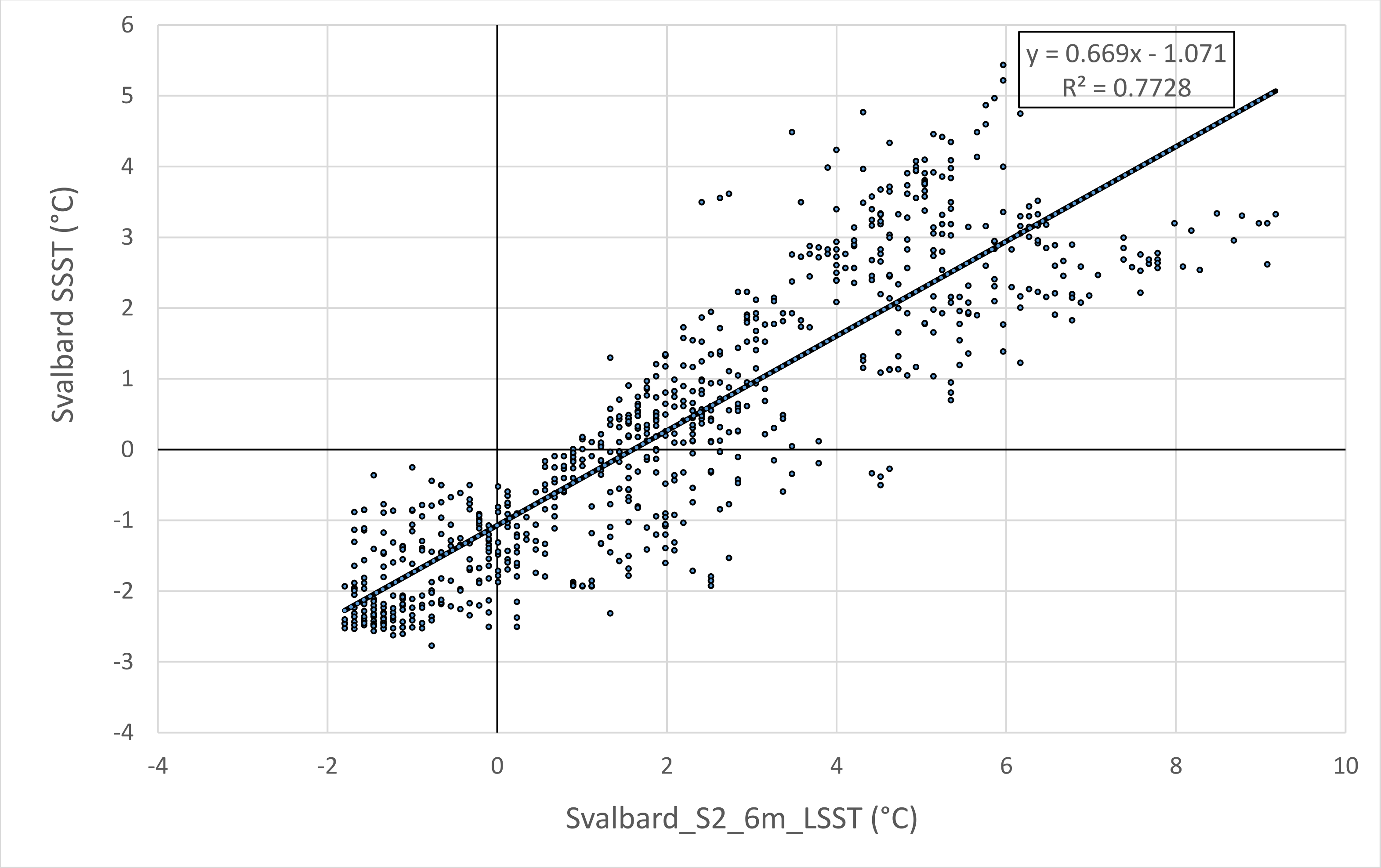

Figure 6: Root Mean Square Error relationship between paired LSST and SSST recordings at Svalbard

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

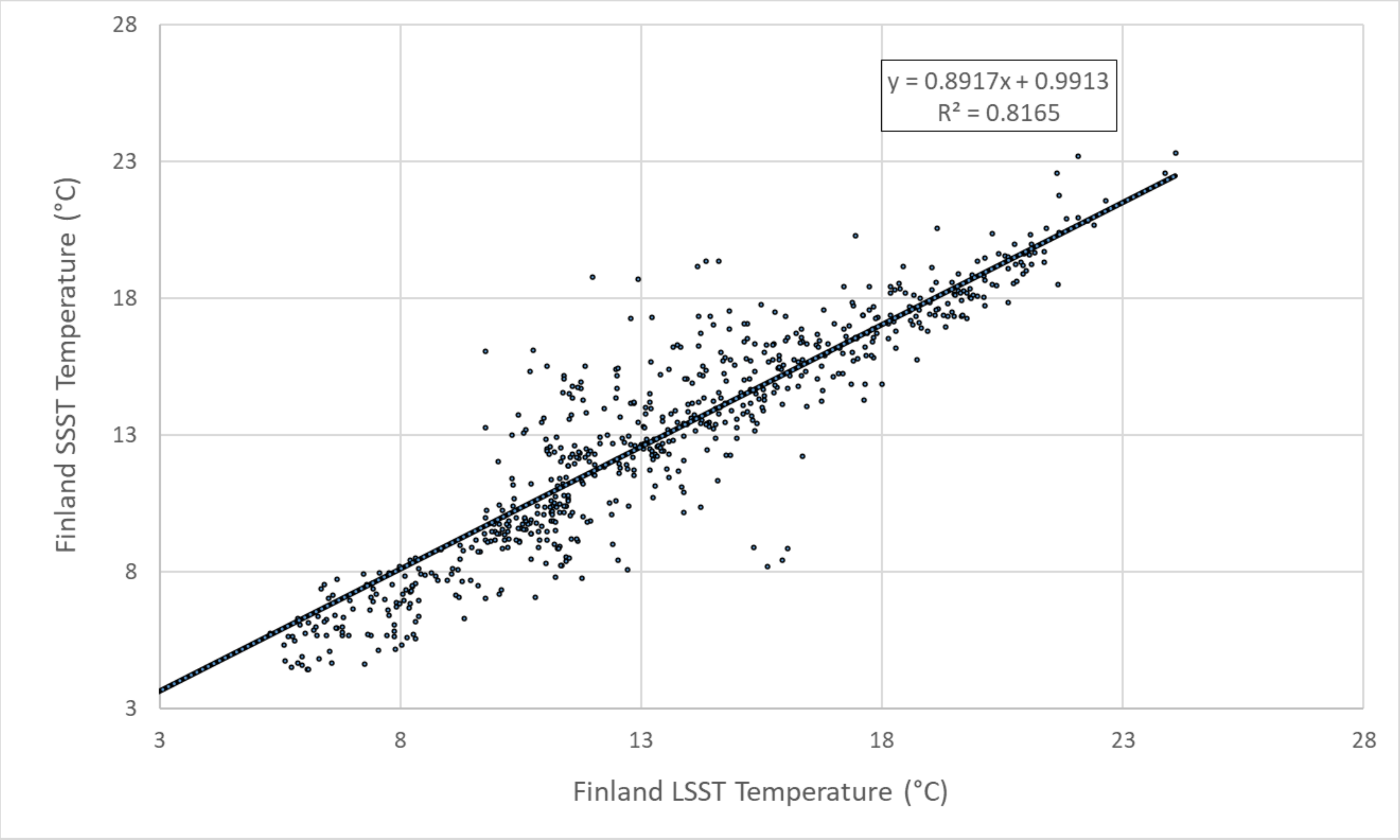

Figure 7: Root Mean Square Error relationship between paired LSST and SSST recordings in Finland

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

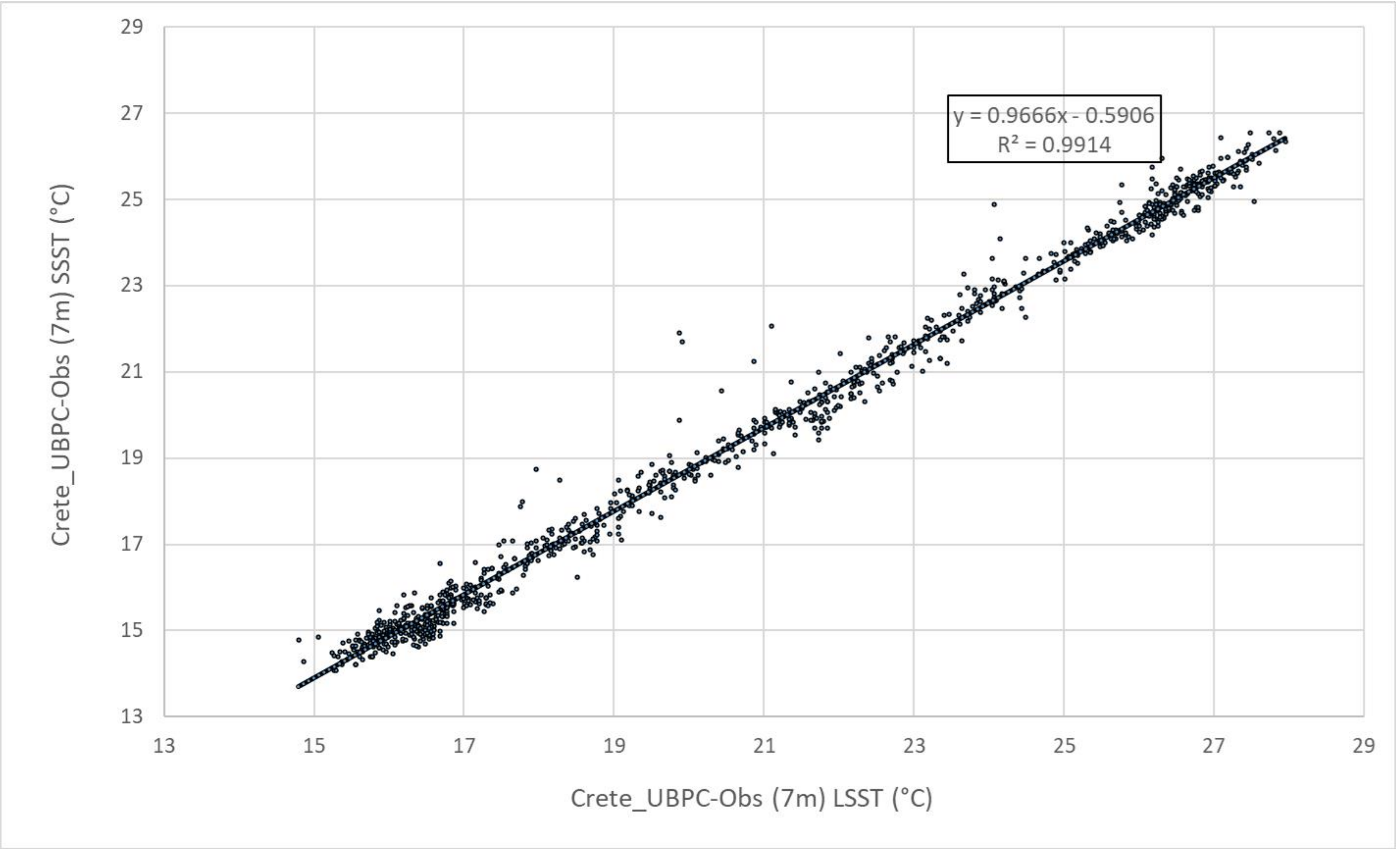

Figure 8: Root Mean Square Error relationship between paired LSST and SSST recordings in Crete

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

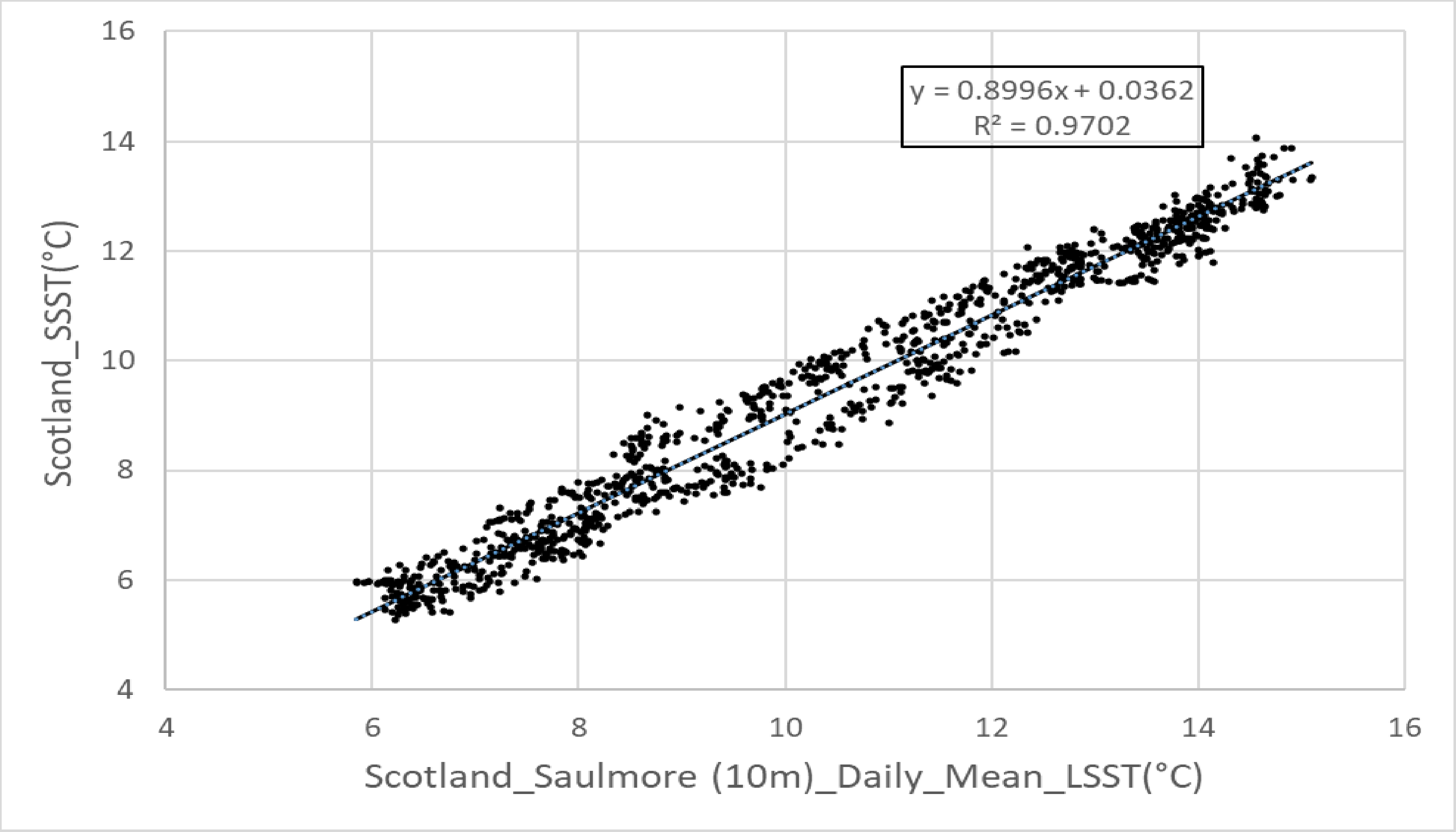

Figure 9: Root Mean Square Error relationship between paired LSST and SSST recordings in Scotland

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

4.3. Water Depth

Data records from two deployments depths (10 and 30 metres) were collected for two complete years (2018 and 2019) and are shown in Figures 10 and 13. As above, when comparing SSST records with LSST data collected from a relatively shallow deployment depth (10 m) there were differences between the two records but these were relatively consistent and minor (Figures 11 and 14). At 30 metres there was less annual variation in temperature, and this resulted in the LSST data being much lower than SSST in warming/warm months, and higher in the cooling/cool months (Figures 12 and 15) with some differences being in excess of 2.0°C.

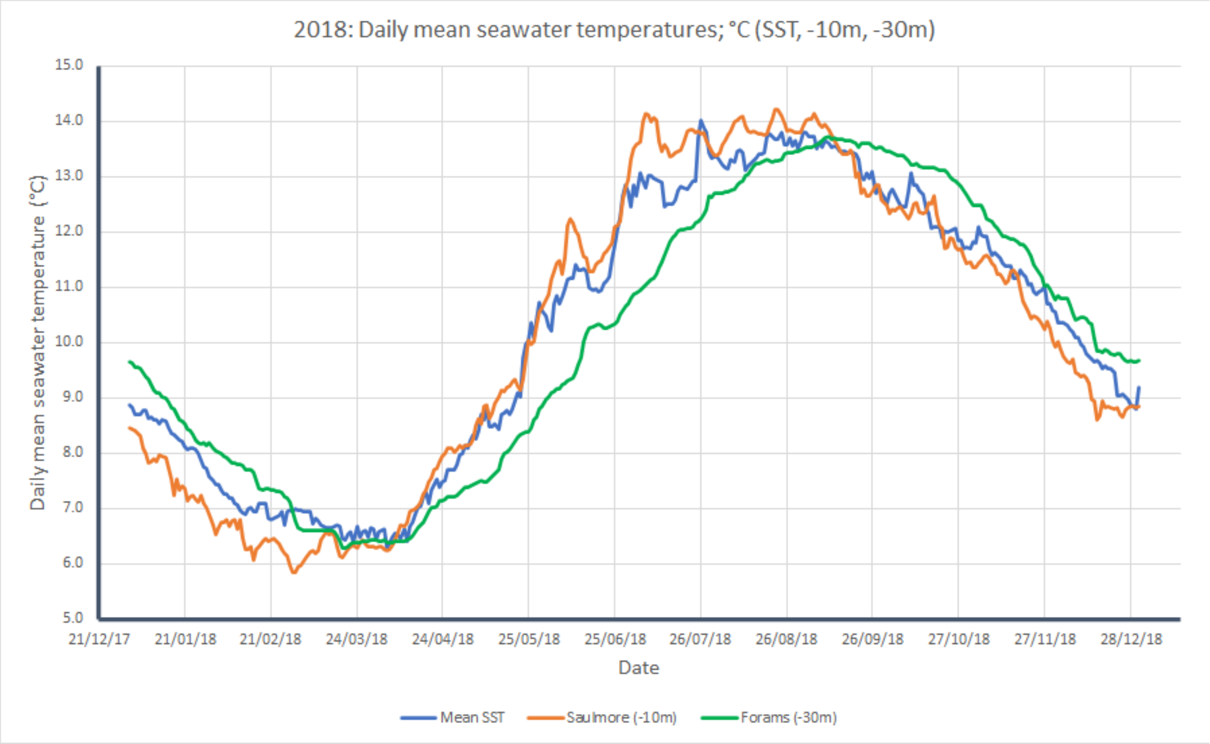

Figure 10: Annual LSST temperature records at 10 and 30 metres compared with SSST during 2018

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

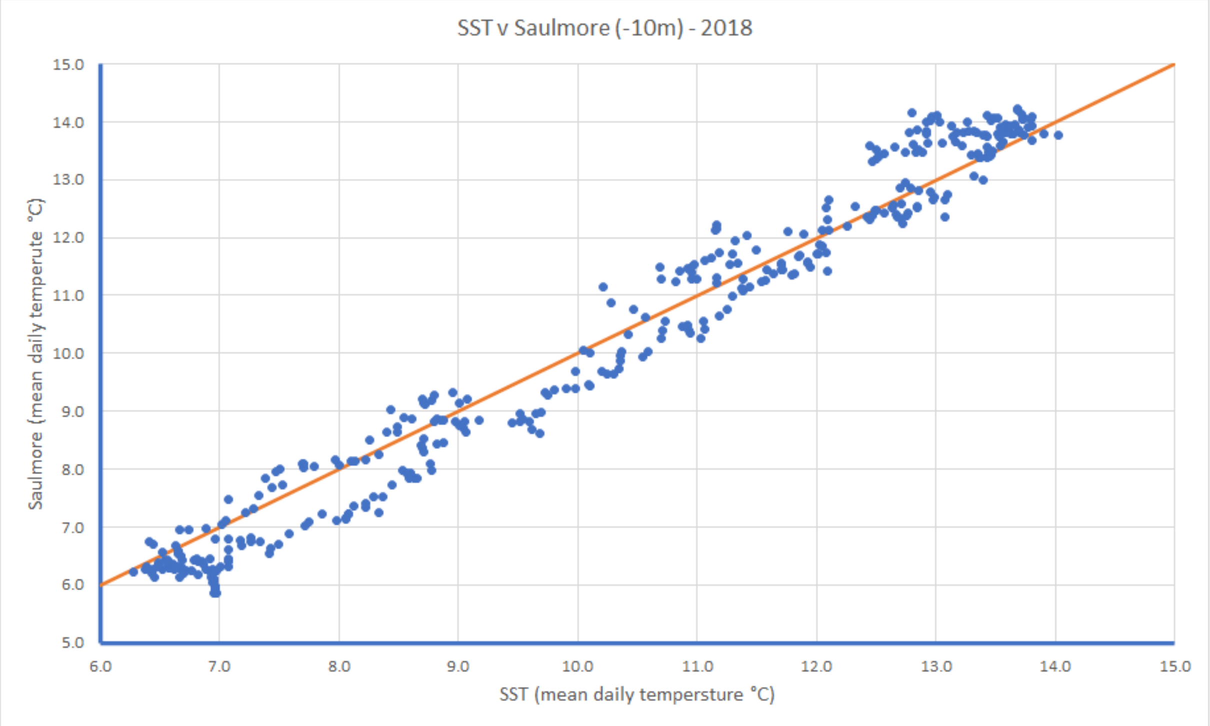

Figure 11: LSST v SSST data at 10 metres in 2018

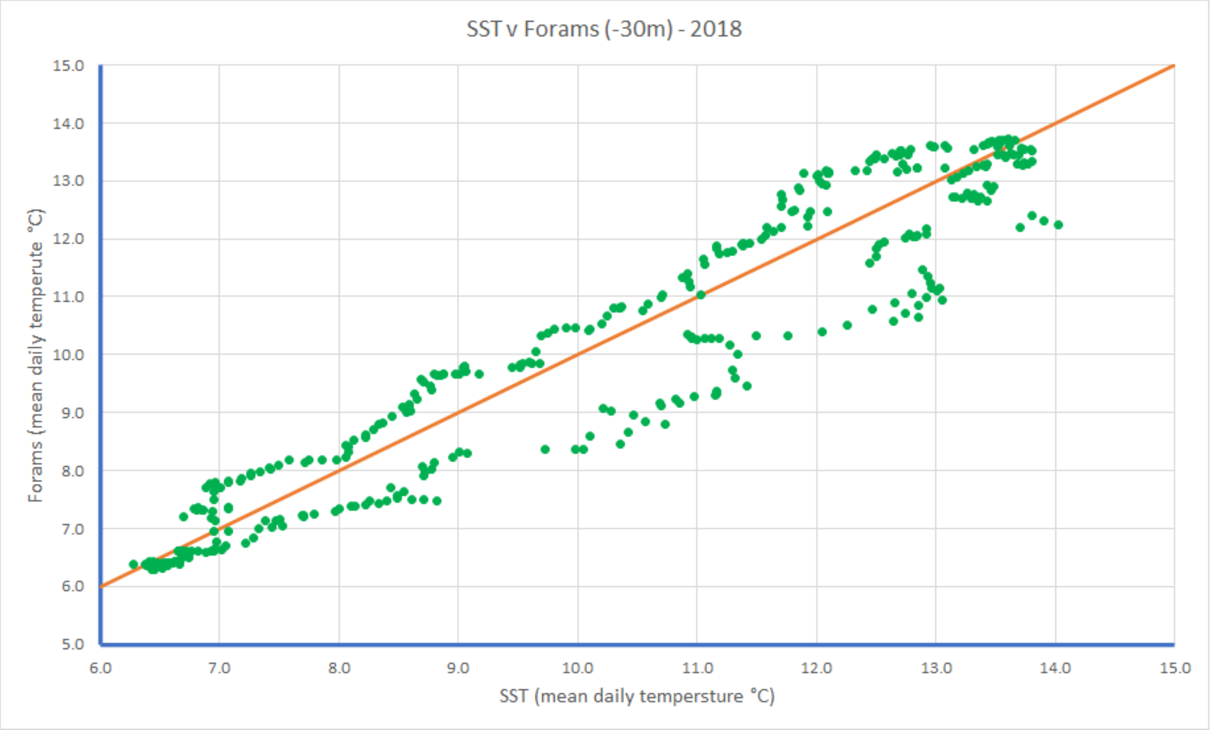

Figure 12: LSST v SSST data at 30 metres in 2018

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

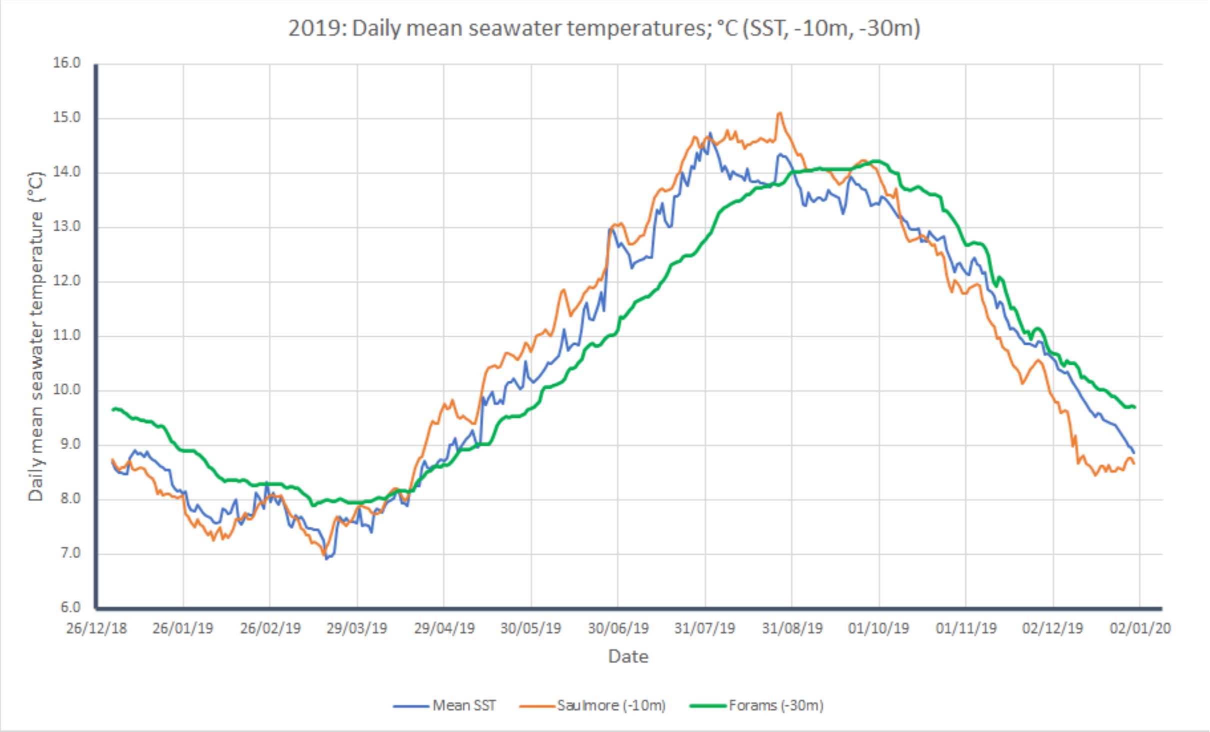

Figure 13: Annual LSST temperature records at 10 and 30 metres compared with SSST during 2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

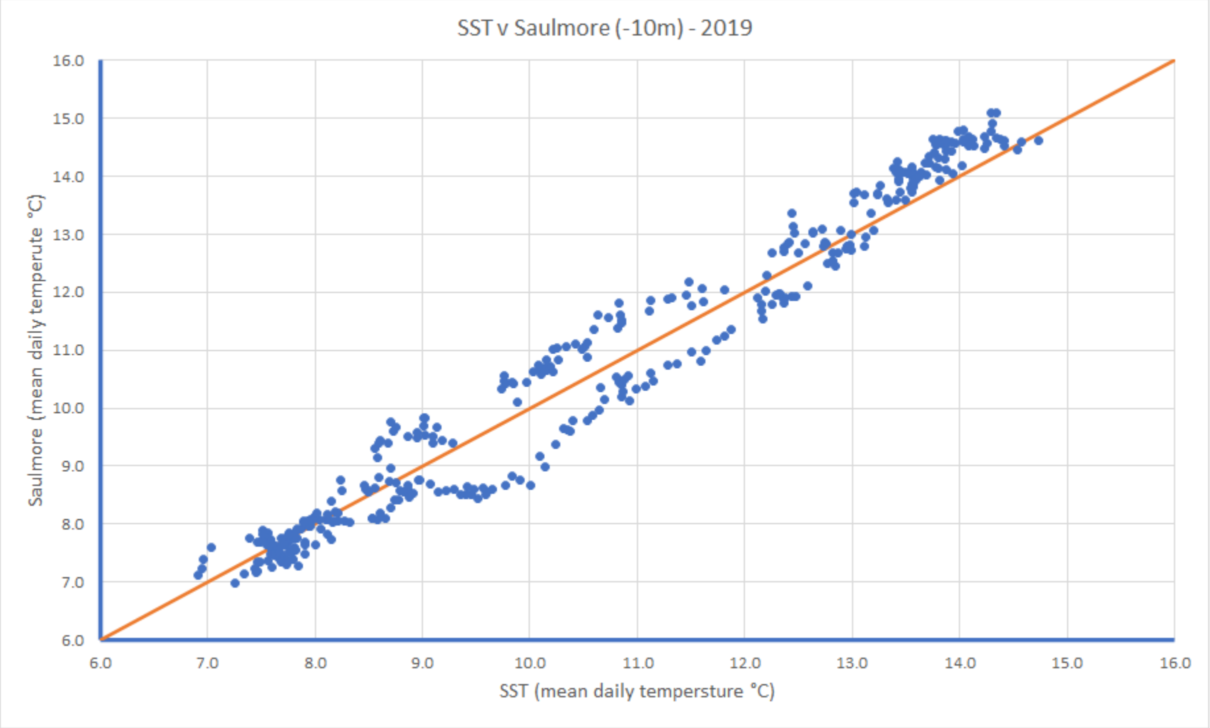

Figure 14: LSST v SSST data at 10 metres in 2019

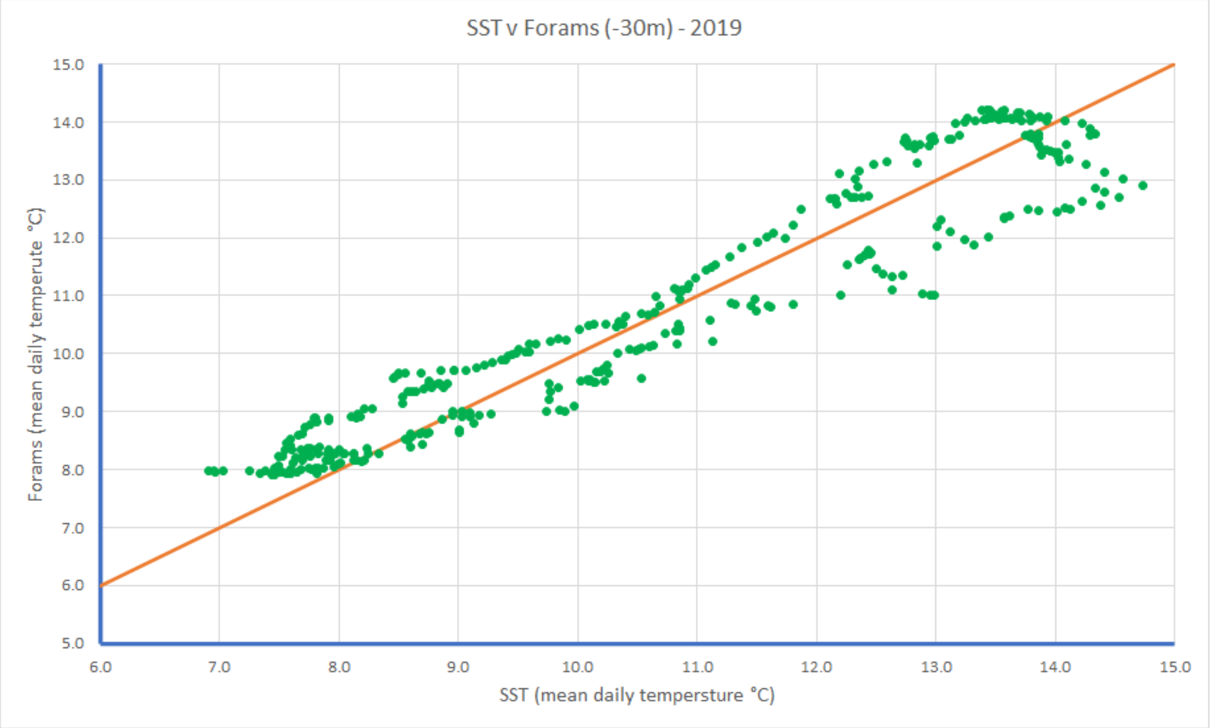

Figure 15: LSST v SSST data at 30 metres in 2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

5. Conclusion

This element of JRA5/WP11 has provided a demonstration of how reliable depth-resolved seawater temperature data can be collected in shallow coastal waters over a range of operational conditions in a highly cost-effective way based on using scientific divers to deploy and maintain autonomous recording stations. Although in general the satellite-based records mostly under-estimated the temperatures recorded in situ by the sub-surface loggers, the errors were relatively constant in the shallow deployments and could provide a basis from improving the calibration of broad-scale remote monitoring. A similar conclusion was reached by Androulakis et al (2020) who concluded that near-shore autonomous coastal underwater temperature arrays could, in the future, provide valuable in situ data for the validation of satellite coastal SST measurements.

The cost-effectiveness of the diver-based methodologies is developed on the use of low-cost temperature data loggers. These are usually deployed in pairs to ensure continuity of data in case of any isolated failures, but the frequently used loggers cost in the range of €100-150 each. The manufacturers' recommendations state a duration of logging, as determined by battery function, to be limited to one year. In most cases, the duration is not restricted by data memory as long as the recording rates are set appropriately according to the volume of free memory. Replacing sets of loggers on an annual basis, therefore, only requires a single diving operation if swapping over functioning loggers. Between two or three replacement divers per year are usually undertaken to minimise the impacts of accidental data loss, and reduce any effects of biofouling of logger functionality.

Data collection in this project was limited to periods of 2-3 years. Outside of time-limited programmes such as ASSEMBLE+ diver-based temperature logging can deliver datasets of significant durations. Figure XX shows a record collected by one partner (TSL) where divers have maintained a time-series for 28 years, consisting of 2.4 million data points. Relatively basic analyses indicate that seawater temperatures in that location are 1°C warmer in 2022 compared to 1996 (Figure XX). In addition to identifying and observing long-term changes, datasets of this size and complexity (two independent measurements each recorded at 12 minute intervals) are also suitable for other applications such as, for example, harmful algal bloom modelling in areas of complex coastline and topography (Aleynik et al. 2016).

It is acknowledged that where there is consistent mixing, shallow water logger deployments deliver relatively limited additional complexity to SSST records or where there are errors, these can be corrected for. The main scientific benefit to these diver-based monitoring stations is when they are deployed, even at relatively moderate depths, below a full-time or seasonal thermocline. In these cases, the relationship between the sub-surface loggers and the SSST data are less constant, and whereas re-calibrating SSST records could be an option, it would still require input from the in situ loggers. It would, therefore, be a recommendation that where monitoring subsurface seawater

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

temperature is of relevance in areas with low surface mixing, using diving to deploy and maintain appropriate logging facilities should be considered.

These forms of diver-based seawater monitoring solutions provide a limited geospatial resource if the data records are restricted only to marine institutes supporting occupational scientific diving programmes. Recent studies have identified the potential benefit of engaging with Citizen Science initiatives to generate more broad-scale depth-resolved seawater temperature datasets (Marlowe et al. 2021, 2022).

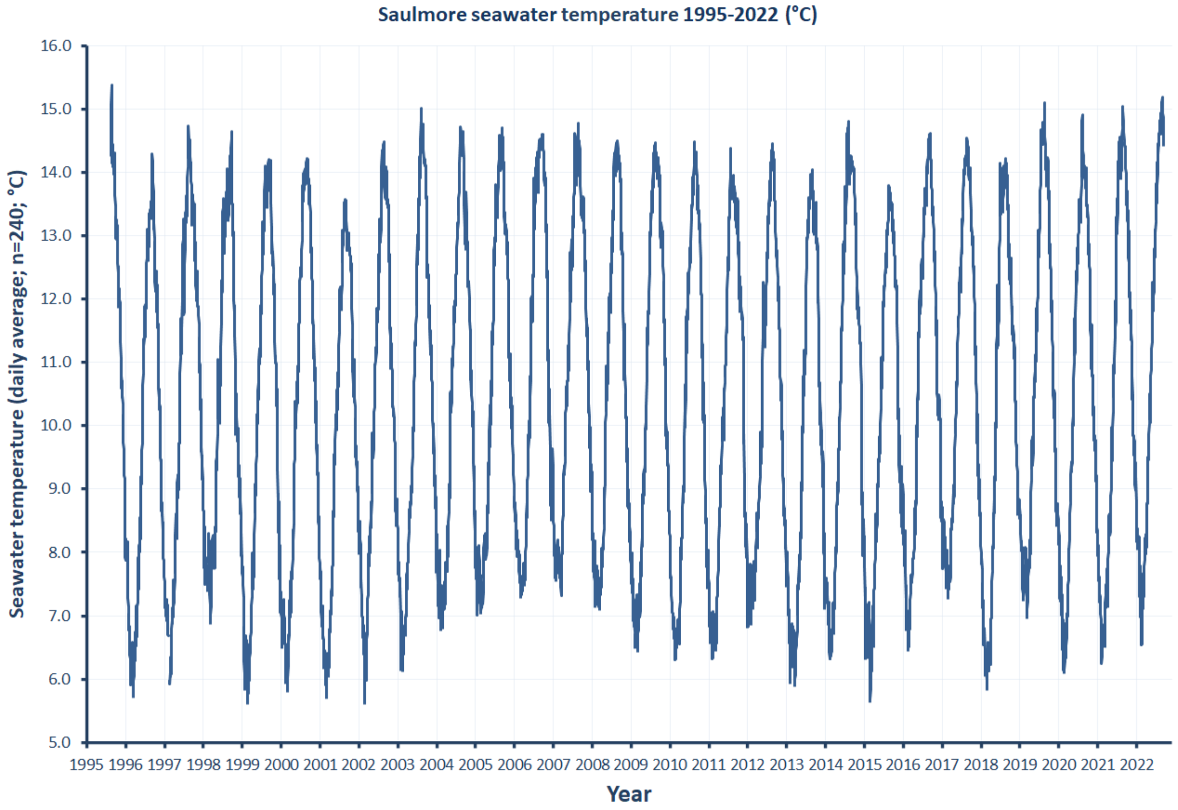

Figure 16: 28-years of seawater temperature data collected by diver-deployed autonomous loggers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

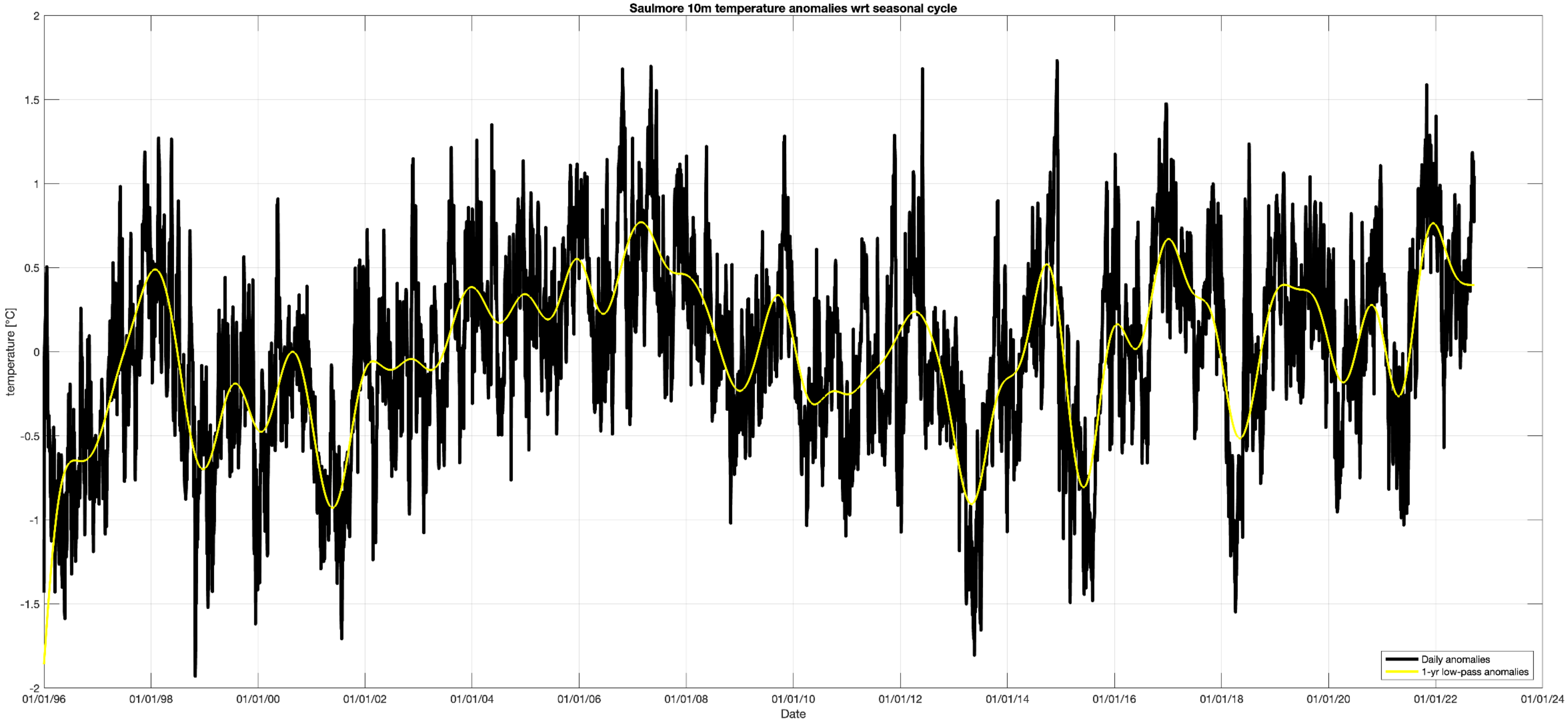

Figure 17: Daily temperature anomalies (black line) and 1-year low-pass anomalies of 10-metre dataset 1996-2022.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

6. Appendices

6.1. Appendix 1 - References

Aleynik D, Davidson K, Dale AC, Porter M. (2016). A hydrodynamic model structure suitable for harmful algal bloom modelling in areas of complex coastline and topography. *Harmful Algae* **53,** 102-17.

Androulakis DN, Banks AC, Dounas C, Margaris DP (2020). An evaluation of autonomous in situ temperature loggers in a coastal region of the eastern Mediterranean Sea for use in the validation of near-shore satellite sea surface temperature measurements. *Remote Sensing* **12,** 1140.

Brewin RJW, de Mora L, Billson O, Jackson T, Russell P, Brewin TG, Shutler JD et al. (2017a). Evaluating operational AVHRR sea surface temperature data at the coastline using surfers. *Estuarine, Coastal and Shelf Science* **196:** 276–89.

Brewin RJW, Hyder K, Andersson AJ, Billson O, Bresnahan PJ, Brewin TG, Cyronak T et al. (2017b). Expanding aquatic observations through recreation. *Frontiers in Marine Science* **4:** 351

Dye SR, Hughes SL, Tinker J, Berry DI, Holliday NP, Kent EC, Kennington K, Inall M, Tim Smyth T, Nolan G, Lyons K, Andres O, Beszczynska-Möller A. (2013). Impacts of climate change on temperature (air and sea). *Marine Climate Change Impacts Partnership: Science Review* **2013:** 1-12.

E.U. Copernicus Marine Service Information (2020) Global ocean OSTIA Sea surface temperature and Sea ice reprocessed. Available at: https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=SST_GLO_SST_L4_REP_OBSERVATIONS_010_011 Accessed March 02, 2023.

"Global Ocean Observing System - Essential Ocean Variables." (n.d.) http://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114. Accessed March 02, 2023.

Hyder K, Bryony T, Anderson LG, Delany J, Pinnegar JK (2015). Can citizen science contribute to the evidence-base that underpins marine policy? *Marine Policy* **59:** 112–20.

Kennedy JJ (2013) A review of uncertainty in in situ measurements and data sets of sea-surface temperature. https://www.metoffice.gov.uk/hadobs/hadsst3/Kennedy_2013_submitted.pdf Accessed March 02, 2023.

Llewellyn-Jones DT, Minnett PJ, Saunders RW, Zavody AM (1984). Satellite multichannel infrared measurements of sea surface temperature of the N.E. Atlantic Ocean using AVHRR/2. *Quarterly Journal of the Royal Meteorological Society* **110:** 613-31.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Marlowe C, Hyder K, Sayer MDJ, Kaiser J (2021). Divers as citizen scientists: Response time, accuracy and precision of water temperature measurement using dive computers. *Frontiers in Marine Science* **8,** 617691.

Marlowe C, Hyder K, Sayer MDJ, Kaiser J (2022). Citizen scientists' dive computers resolve seasonal and interannual temperature variations in the Red Sea. *Frontiers in Marine Science* **9,** 976771.

Oliver ECJ, Burrows MT, Donat MG, Gupta AS, Alexander LV, Perkins-Kirkpatrick SE, Benthuysen JA, et al (2019). Projected marine heatwaves in the 21st Century and the potential for ecological impact. *Frontiers in Marine Science* **6:** 734.

Smit AJ, Roberts M, Anderson RJ, Dufois F, Dudley SFJ, Bornman TG, Olbers J, Bolton JJ (2013). A coastal seawater temperature dataset for biogeographical studies: Large biases between in situ and remotely-sensed data sets around the coast of South Africa. *PLoS ONE* **8:** e81944

Wentz FJ, Gentemann C, Smith D, Chelton D (2000). Satellite measurements of sea surface temperature through clouds. *Science* **288:** 847-50.

Wright S, Hull T, Sivyer D, Pearce D, Pinnegar JK, Sayer MDJ, Mogg AOM, Gontarek S, Azzopardi E, Hyder K (2016). SCUBA divers as oceanographic samplers: the potential of dive computers to augment aquatic temperature monitoring. *Scientific Reports* **6:** 30164.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.