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Sea Surface Temperature monitoring in Italian Seas: Analysis of long-term trends and short-term dynamics

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ABSTRACT

The aim of this paper is to give an overview of the various measurement collections that contribute to the observation of Sea Surface Temperature in Italian Seas. Long term time series are collected since the 19th century but are affected by a large systematic errors. Despite the lack of accuracy, their contribution to the analysis of trends is fundamental into the climate change context. On the other hand, recent systematic observations are more accurate and continuous in space and time. Short term time series better define the status of the temperature during the last years in term of variability and dynamics.

1. Introduction

Sea Surface Temperature (SST) is one of the most important physical parameter in marine climatological studies. It is a relevant predictor of a number of meteorological variables, such as parameters of general circulation and windstorm formation, it is fundamental in climate modelling, for studying earth heat balance, and to detect atmospheric and oceanic circulation patterns and anomalies, moreover it is critical in the evaluation of the biological component.

Quality of long time series is variable, several different methods of measuring have been used over the years through different instruments including ships, buoys, coastal platforms, or oceanographic tools. Datasets are often limited in space and time, especially at the beginning of the twentieth century and during the world wars. In the last decades, quality of in situ and remote sensed data has improved significantly in parallel with the increase of marine observations and a large number of studies have been implemented in order to investigate the long term SST changes and the effects of spatial variability over the marine system.

SST datasets have been independently developed by research groups with different upgrading time-frame. Some studies use only in situ observations, as in the case of the Extended Reconstructed SST (ERSST, [1,2]) and the Hadley Centre SST, version 3 (HadSST3, [3,4]). In others cases both in situ and satellite observations are used, as for the National Centers for Environmental Prediction (NCEP) Weekly Optimum Interpolation SST (WOISST, [5]) and the National Centers for Environmental Information (NCEI) Daily Optimum Interpolation SST (DOISST, [6]).

In situ observations are available from 1600 but methods of measurement and locations have changed substantively through time. It is fundamental to reconstruct the measurements history with respect to adopted observing protocol and possible systematic bias sources. These issues have driven several studies to highlight the importance of uncertainty in SST measurements and to adjust and homogenise these time series, such as in [7].

The global-scale features and long-term trends study using different SST products show a general agreement (e.g., [8,9]); the differences among the available products mostly result on how the in situ SST data biases are corrected [2,7], in particular main result from quality control and gap-filling procedures, especially in early record periods. In the present work the use of the “Rete mareografica nazionale” (Italian tide gauge monitoring network – RMN) SST data could represent a challenge in order to add knowledge and information useful to quantify the uncertainty which led to potential innovations and improvements on SST monitoring.

2. Data sets

Four dataset have been analysed in this study as represented in Fig. 1.

1. Long term time series are extracted from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS; [10]). It represents the most complete and heterogeneous collection of surface marine data, based on records from a great number of sources such as ships, buoys and other platform types as summarised in Fig. 2. The first systematic observations were collected using buckets made

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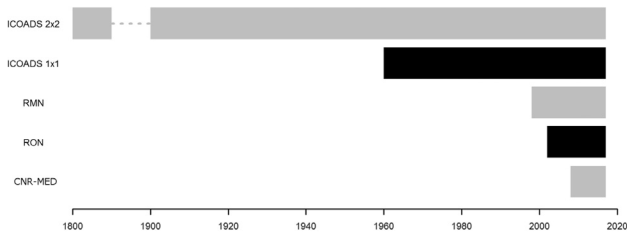

Fig. 1. SST Dataset from 1800. ICOADS dataset has been splitted in two subset according to the different spatial resolution.

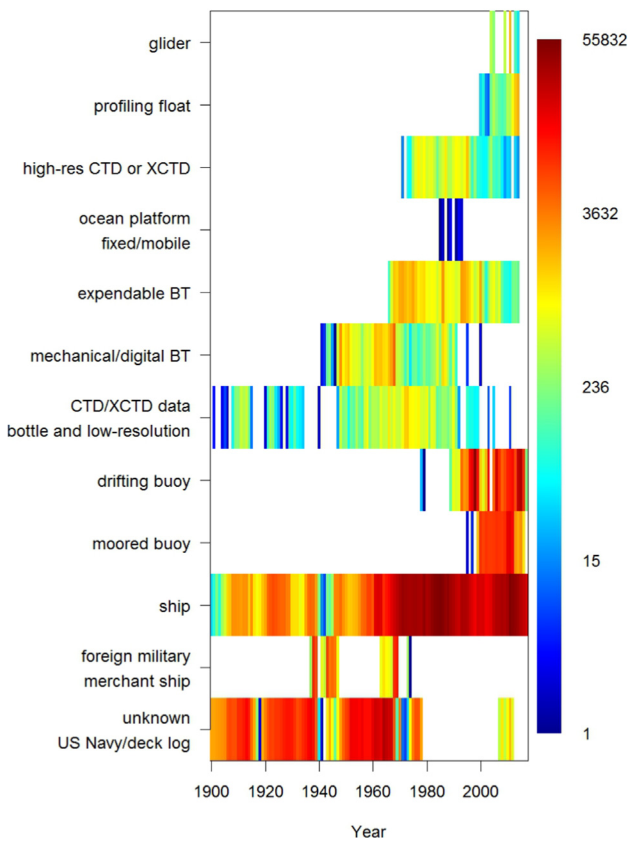

Fig. 2. Instruments for SST in situ measurements from 1800 in ICOADS.

of wood, canvas, tin, leather,brass, rubber, and plastic to collect water samples [9]. After the advent of steam ships in the late nineteenth century, it was routine to measure the temperature of the sea water that was circulated through the steam condenser. Most used instruments for SST measurements were condenser or engine room inlet. Values were often reported manually on ship logbooks. Since the 1970s, a growing number of ships have been equipped with dedicated sensors either outside or inside the hull. These have been joined by a growing array of moored and drifting buoys which make automated measurements that are relayed by satellite. At present, around 90% of all SST observations come from buoys [9]. The majority of moored buoys measure SST at a nominal depth of 1 m. The largest systematic errors are found in the firsts decades since 1940s, when SST measurements were mostly made using buckets and room inlet [11]. Buckets allow to measure the temperature of the surface layers of the sea. These measure can be affected by large systematic errors due to the combined actions of latent and sensible heat transfer and the warmth of the sun. Moreover the human factor could affect the sampling and reporting accuracy. Improvements in bucket design in order to reduce the physical effects of boundary conditions and economical advantage

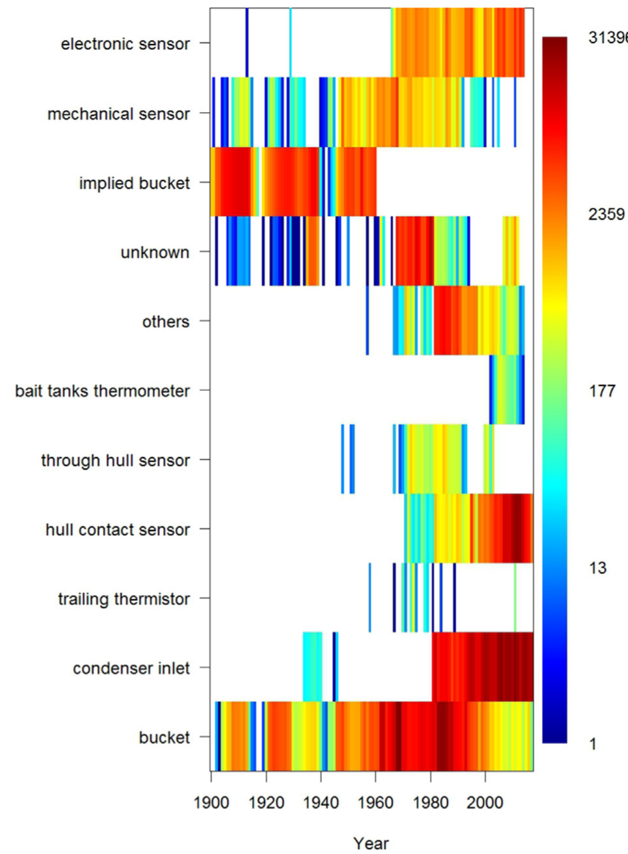

Fig. 3. Sensor for SST in situ measurements from 1800 in ICOADS.

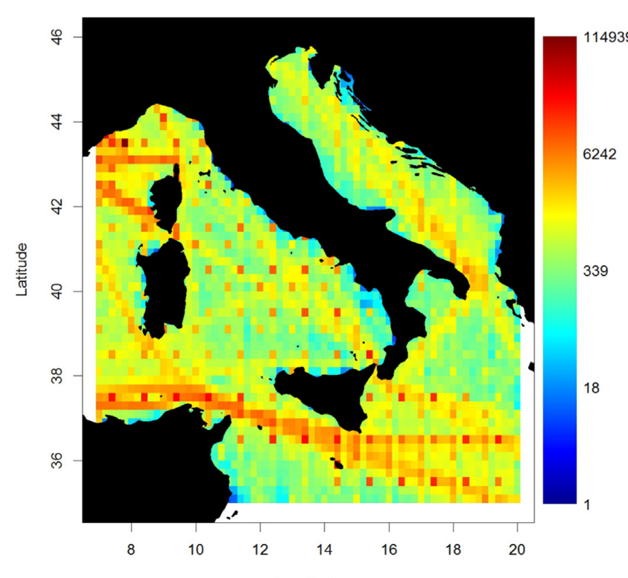

Fig. 4. Spatial frequency distribution of SST observations from 1900 in ICOADS for Italian Seas.

let this system to be already used even if larger and faster modern ships could affect the related measures. Room inlet systems measure at depth greater than 1 meter, depending on the ship, and are systematically affected by the same kind of bias due to the influence of internal engine temperature. The development of new kind of sensors (Fig. 3) such as electronic thermistors improves the quality of measures and are at the present largely used in combination with moored and drifting platforms or ship hulls.