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In situ SST measurements for the validation of satellite SST

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Summary: This document describes how the Sea Surface Temperature is measured by drifting buoys and ships (organization, type of buoys, data transmissions, quality controls…) and how its quality could be improved.

Action required: For information

Distribution: Unrestricted

Reference	Date	Author(s)	Content
SURFMAR-2010_01_v05	27 January 2010	Pierre Blouch	Draft 0.5
SURFMAR-2010_01_v07	9 February 2010	Pierre Blouch	Draft 0.7
SURFMAR-2010_01_v10	16 February 2010	Pierre Blouch	Final 1.0

1. Background

JCOMM is the WMO-IOC Joint Commission for Oceanography and Meteorology. Its first aim is "*to develop the observing networks under the guidance of the Global Ocean Observing System (GOOS), the Global Climate Observing System (GCOS), the World Weather Watch (WWW) and other operational programmes, and cooperation with these bodies in seeking commitments for all components of an operational programme in the global oceans*". For more information see "About JCOMM" on the official Website: http://www.jcomm.info/.

Among various activities, JCOMM comprises an Observation Programme Area (OPA) which includes three programmes: the Data Buoy Cooperation Panel (**DBCP**), the Ship Observation Team (**SOT**) and the Global Sea Level Observing System (GLOSS). Although they are not part of OPA, JCOMM maintain a strong relationship with three other international observation programmes. These are the Argo Profiling Float Program, the Ocean reference stations (OceanSITES) and the International Ocean Carbon Coordination Project (IOCCP).

JCOMMOPS is the JCOMM in situ Observing Platform Support Centre. It should become the Observing Programme Support Centre (**OPSC**) of JCOMM soon. Presently, it is based in Toulouse (hosted by CLS) and serves four programmes: DBCP, SOT, Argo and OceanSITES..

GIE EUMETNET is a network grouping 26 European National Meteorological Services (NMS). All these NMS are members of the WMO. GIE EUMETNET provides a framework to organise co-operative programmes between the Members in the various fields of basic meteorological activities such as observing systems, data processing, basic forecasting products, research and development, training. With ECMWF and EUMETSAT, it forms the European Meteorological Infrastructure.

The EUMETNET Composite Observing System (EUCOS) is one of the EUMETNET programme. It comprises the Aircraft Meteorological Data Relay (E-AMDAR), the Automated Shipboard Aerological Programme (E-ASAP), the Surface Marine observation programme (**E-SURFMAR**) and the Wind Profiler programme (E-WINPROF).

E-SURFMAR has two components: data buoys and Voluntary Observing Ships (VOS). Each component itself includes two parts: drifting and moored buoys for the first, manned and automated VOS for the second. For data buoys, E-SURFMAR acts as regional action group of the DBCP. Among other regional action groups, one can mention the International Arctic Buoy Programme (IABP).

2. Drifting buoys

Drifting buoys provide SST measurements globally with a reasonable precision: they are **the main source of *in situ* SST observations for satellite SST validation**. Satellite SST measurements are made by sensing the ocean radiations in a few wavelengths (e.g. infrared) which can be empirically related to SST. These measurements may however be disturbed by the water vapour and the aerosols present in the atmosphere. Algorithms are used to correct these disturbances. *In situ* measurements serve to validate them.

Drifting buoys are coordinated by the DBCP. Although different types of drifting buoys exists, the most common one for operational purposes is the **SVP drifter** and its derivatives. These drifters were used at first within the Surface Velocity Programme (SVP) of TOGA, then WOCE. The programme is now called Global Drifter Programme and participants in this programme are constituting one action group of the DBCP. The goal of this programme, defined by the Ocean Observation Panel for Climate (OOPC), was to have **1250 drifters** of that kind operating permanently at sea. This target was reached in 2005.

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The common SVP drifter measures SST, plus the current velocity at 15 metres depth thanks to its drogue and its moving. In 2006, a DBCP users workshop recommended that all 1250 GDP drifters should be **equipped with barometers**. Presently, half of the GDP drifters only are equipped. It must be noticed that a few drifters of that kind also measure wind – through a submarine acoustic method –, salinity, or sea temperature at different levels in depth till 80 metres.

SVP and SVP-B drifters are made of a 34 cm to 41 cm diameter sphere. This sphere contains the electronics, the transmitter, the GPS (if any), the antenna(s) and the batteries. A 6-metre cylinder (60 cm in diameter), made of tissue, constitutes a drogue which is attached to the buoy hull through a wire. Once deployed, the drogue is centred at 15 metres depth.

SVP-B drifters are recognisable through the small white cylinder which top them. It is actually an air pressure intake (barometer port), which may be submerged. A Gore-Tex filter allows the air to reach the barometer but not the water. Only the lowest pressure values sampled during a few minutes are kept to deliver atmospheric pressure. Other values may be overpressure due to the submergence under the waves.

The **main contributor** of the GDP is NOAA. Operations are managed by AOML in Miami. EUMETNET (through E-SURFMAR), the South African Weather Service, the Australian Bureau of Meteorology, New Zealand Met Service, the Meteorological Service of Canada and two Indian oceanographic institutes are the main other contributors to the GDP.

At present, **five manufacturers** are building SVP and SVP-B drifters: three US (Clearwater, Pacific Gyre and Technocean), one Canadian (Metocean) and one Ukrainian (Marlin-Yug). A few years ago, the DBCP issued a SVP-B drifter construction manual. This document, regularly updated, may be downloaded at: http://www.jcommops.org/doc/DBCP/svpb_design_manual.pdf . The last version is dated August 2009.

Lifetimes of drifting buoys depend on different factors: battery capacities, ability of manufacturers to reduce power consumption, ocean basin in which the buoys are deployed and resistance of the drogue attachment. Normally, the drogue avoid the buoys to run ashore if it is present: it then follows the surface current and are not necessarily pushed by the wind. The risk to find them ashore is higher if the the drogue went off.

2.1 Data Communication

Most of the drifting buoys are using the **Argos system** to report their measurements. However, some, such as these purchased by E-SURFMAR, are now reporting through **Iridium** Short Burst Data (SBD).

Drifting buoys report their **raw data** ashore. Different formats exists for these raw data but one can find two Argos standards widely used: DBCP-O3 for SVP drifters and DBCP-M2 for SVP-B drifters. For Iridium drifters, the standard for SVP-B drifters has been version #000 since the beginning of 2010.

After digitalisation of the SST measurements, **resolutions** for SST are 0.05 ℃ on SVP drifters, 0.08 ℃ on Argos SVP-Bs and old Iridium SVP-Bs… It will be 0.01 ℃ on future Iridium SVP-Bs (dataformat #000).

Physical data are then retrieved from these raw data and sent onto the Global Telecommunication System of the **WMO** (GTS) in proper **formats**: FM18-BUOY (alphanumeric) and, in parallel, FM94-BUFR (binary). Normally, for marine observations, the migration from alphanumeric codes to BUFR should be completed in 2012.

It must be noticed that the **resolution** for SST sent onto the GTS with FM18-BUOY format is only 0.1 ℃. BUFR format will allow to report SST values with a resolution of 0.01 ℃.

Drifting buoys are identified through a **WMO number** which has presently 5 digits. The first two digits are related to the area in which the buoy was deployed. The third digit must be higher or equal to 5 for drifting buoys. Lower numbers are reserved for moored buoys. In a near future – i.e. when BUFR format is fully implemented –, data buoys will have 7-digit WMO numbers.

2.2 Drifting buoy locations

Argos buoys are generally located through the **Argos** system itself. Locations provided by the system are fitted with a **location quality index**. This index is transmitted onto the GTS with the related position. Class "3" means the accuracy is better than 150 m, class "2" means the accuracy is comprised between 150 m and 350 m, class "1" means the accuracy is comprised between 350 m and 1000 m and class "0" means it is worse than 1000 metres.

Iridium drifters may be located by the **Iridium** system too but the location accuracy is worse than with Argos. Experience showed that 75% of the Iridium positions have a better accuracy than 7 km. In general, they are fitted with "0" as location quality index.

All new built Iridium drifters should be fitted with a **GPS** now. In that case, the location quality index is equal to "3". However, old Iridium drifters – without GPS – are still in operation or ready to be deployed.

Whatever the location system is, the **time of the position** may be different from this of other parameters. The Argos positions are computed thanks to the Doppler shift which affects the transmissions during a satellite pass. A minimum of messages must be received during this pass to get a position. Many passes do not procure a position. The position time is completely disconnected from the sampling time of the other parameters. A delay (positive or negative) may elapse between the position time and the time of the other parameters. This delay may reach 2 or 3 hours in absolute value.

25% of the Iridium positions are worse than 7 km. In that case, the previous validated position is kept and reported with the other data. Its corresponding time is sent accordingly. In order to save energy, GPS fixes may be got every 3 hours only. This results in a **delay** between the position and the observation times. WMO formats allow to report both times onto the GTS.

2.3 SST measurements

As recommended in the construction manual, the **SST probe** (e.g. thermistor), should be located on the spherical hull of the drifter at a depth which is approximately 40-45% of the diameter. For old drifters having a diameter of 41 cm, the depth of the probe was about 16 cm below the floating line (equator of the sphere). For drifters having a diameter of 34 cm, the probe is located about 14 cm below the surface.

Recently, one could see buoys having their probe located in a ring situated at the drogue attachment, i.e. 17 cm below the surface.

This **depth of measurement** (14 to 17 cm) is purely theoretical. This may happen only in calm seas. It is difficult to know what happens with these drifters in rough seas. We know they dive under the wave crests when their drogue is attached. Do they roll in the wave hollows, having so their SST probe in the air ? Nobody knows.

In general, SVP-B drifters collect their data at the top of each hour. Others are performing their measurements once per hour but not necessarily at the top of an hour. SVP drifters measure SST every 15 minutes. For all of the buoys, the transmitted value is an **average** of 6 to 15 measurements carried out over 12-15 minutes.

For SVP-B drifters, the **observation time**, reported onto the GTS, is the end of this period. For SVP drifters, an uncertainty exists. The observation time may be up to 15 minutes later.

Examples of **SST probes**: BetaTherm #36K53A106i at Technocean, YSI 44032 on old Metocean drifters, YSI 46041 (more accurate than the previous one) on furure Iridium SVP-Bs built by Metocean.

SST sensors are **calibrated in factory**. Operators rely on the manufacturers to provide buoys with accurate calibrations. The only way to re-calibrate the buoys before deployments would consist in putting them – with their drogue – in a climatic chamber. The drogue can't be easily dismounted for that purpose. Then the problem of data transmission exists. Existing buoys are not done to report otherwise than through satellite. So they require to be exposed outdoors.

2.4 Drogue presence/absence

For many years, a **submergence count** has been used to know if the drogue is still attached to the buoy or not. The buoy is fitted with two electrodes on the upper part of its hull. When the buoy is submerged the electrical current passes through them. The drogue is supposed attached when the buoy is often submerged. The drogue avoid it to climb on the wave crests. A percentage of occurrences is reported within the buoy data.

At the request of DBCP, this technique was recently replaced by a measurement of the **strain** which exists at the drogue attachment. This is done with a **gauge**.

2.5 Quality controls

GTS data are controlled in near real-time.

A portal of **tools** used by E-SURFMAR participants and other operators to control the quality of surface marine data exists at http://www.meteo.shom.fr/qctools/. Results of comparisons between observations and outputs from different models are displayed through monthly statistics and graphs.

Blacklists also exists for air pressure and ship's wind observations (experimental). Links to other websites, including UK Met Office monitoring, NOAA/iQuam and EUMETSAT/SAF comparisons with satellite data are proposed.

A **feedback mechanism** exists at JCOMMOPS to relay information from data users to data providers on the quality of particular platforms. JCOMMOPS maintain databases which allow to relay feedbacks to the responsible for the data thanks to the platform identifier only. Data users are invited to use this relay (see http://wo.jcommops.org/cgi-bin/WebObjects/QCRelay).

It must be noticed that a **delayed mode** distribution exists for drifters participating in the GDP. The Global Drifter Center of NOAA/AOML in Miami, archive the raw data and perform different kind of processing on them. In particular, they produce **surface current vec**tors deduced from the drifters movements.

Meteo-France is also producing such vectors in a more real-time (every week) but without any manned checks. Meteo-France data includes surface current velocities with a time resolution of 3 hours for buoys having their drogue attached, kriged SST and SSS (if exists) as well as ECMWF wind and wind stress co-located at the buoys positions. These data are archived at **Coriolis** and will be part of the **MyOcean** products.

Every year, AOML organize the deployment of buoys from different manufacturers in some **clusters**. The purpose is to compare the quality and the performances of the buoys. Results are regularly published.

2.6 Recommendations

It appears that the **GTS** is the main source of SST data for centres which use them to calibrate satellite data. Consequently, it is important to invite/convince operators not participating in the GDP to send their data onto the GTS. This must be systematically done in areas where GDP is not present (closed seas such as Mediterranean Sea, Baltic, etc).

In order to be efficient, it is not suitable to multiply the **formats** of raw data. The use of standard must be proposed by the manufacturers as a matter of priority.

SST reported by the drifting buoys should be the **median** of samplings instead of the average.

Calibration procedures at manufacturer's should be carefully followed.

A blacklist of drifting buoys reporting **dubious SST** values, issued by the satellite SST data providers will be welcomed. It will be inserted among E-SURFMAR QC tools.

Data users must take care of the **migration** from alphanumeric codes to BUFR for GTS data. They must check if the *in situ* data they use are(will be) available at their usual providers after 2012. Bugs may occur in softwares.

Data users may also take care about the size of **WMO Id.** numbers which will pass from 5 digits to 7 digits in a near future (BUFR messages only).

It should be interesting to assess the performances (comparisons with satellite data) for **sets of drifting buoys** shared by manufacturers or operators, in addition to the usual geographical shares.

3. Ships

For a long time, ship observations have been done manually. **Human errors** in reading instruments and coding values including positions are numerous. Temperatures are often rounded to the nearest degree Celsius. Sensors are not necessarily certified by a meteorological service.

Nowadays, more and more ships are fitted with **Automated Weather Stations** (S-AWS) which avoids such errors. It is obvious that SST measurements by ships will never reach the accuracy of those of drifting buoys.

However, the **accuracy of measurements** carried out by such stations should be separated from this of "manned" observations. Today, half of the observations reported by ships are coming from S-AWS stations. Their accuracy should be better than these of manned observations. Perhaps they could be used in rough sea conditions (the upper ocean layer is well mixed), mainly at night.

In the western Mediterranean sea – were a lack of drifting buoys exist –, several ferries equipped with BaTos stations operated by Meteo-France are plying. They report their data through callsigns on the form of BATFRxx, where xx is presently a number. Some have a hull contact sensor, others measure the water temperature at the engine cooling system inlet. This metadata is available. E-SURFMAR would be interested in a **comparison study** between the temperatures reported by these ships and co-located satellite SST data.

Websites

JCOMM : http://www.jcomm.info/
DBCP : http://www.jcommops.org/dbcp/
SOT : http://sot.jcommops.org/
EUMETNET : http://www.eumetnet.eu/
EUCOS : http://www.eucos.net/
JCOMMOPS : http://wo.jcommops.org/

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