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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

DATA BUOY COOPERATION PANEL

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PROGRESS REPORT ON PILOT PROJECT FOR HIGH RESOLUTION SST

(Submitted by Pierre Blouch, France and David Meldrum, UK)

Summary and purpose of the document

This document provides information on the development and current status of the Pilot Project for High Resolution SST (PP-HRSST).

ACTION PROPOSED

The Panel will review the information contained in this report and comment and make decisions or recommendations as appropriate. See part A for the details of recommended actions.

Appendices:
A. Workplan and ToRs for the PP-HRSST
B. Progress report on the PP-HRSST
C. Outline of the 'Smart' HRSST sensor being developed by Metocean
D. GHRSST specifications for drifter HRSST

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

8.5.1 Mr David Meldrum (UK) reported on the Pilot Project for High Resolution SST (PP-HRSST). The PP-HRSST had been established at the previous DBCP session as the outcome of a dialogue between the Group on High Resolution Sea Surface Temperature (GHRSST) and the DBCP, resulting in a proposal for a joint PP[1]. GHRSST is concerned to improve the quality of SST retrievals from satellites, and relies heavily on drifter SST as a validation mechanism, by comparing selected drifter SST values with co-located satellite estimates, so-called 'matchups'. Despite the best efforts of GHRSST, progress is severely hampered both by the resolution (0.1C) and by the accuracy (~0.2C) of the SST reported by drifters. As a result of the dialogue, a basic set of standards was agreed for HRSST drifters, in the hope that they would eventually lead to a universal standard applicable to all new drifters. The aim of PP-HRSST is to evaluate and develop this standard through the deployment of pilot drifters conforming to the standard, in the expectation that such drifters will in due course demonstrably improve the quality of satellite SST retrievals.

8.5.2 Noting with approval the progress that had already been made by E-SURFMAR, Météo France, the UK Met Office and Metocean in implementing HRSST in production drifters, the Panel was nonetheless concerned that little positive and practical response had been forthcoming from GHRSST, despite active DBCP participation in its science meetings. It therefore urged the emerging PP-HRSST Steering Group (SG) to pursue GHRSST in this regard as a matter of urgency (***action; Chair; PP-HRSST***).

8.5.3 The PP-HRSST SG was also asked to develop a workplan for the next three years and to report back to the next Panel session on its progress (***action; Chair; PP-HRSST***).

8.5.4 The Terms of Reference, draft workplan and initial membership of the PP-HRSST SG are attached as Annex Appendix A.

-B- BACKGROUND INFORMATION

1. The PP-HRSST was established at the previous DBCP session as the outcome of a dialogue between the Group on High Resolution Sea Surface Temperature (GHRSST) and the DBCP, resulting in a proposal for a joint PP. GHRSST is concerned to improve the quality of SST retrievals from satellites, and relies heavily on drifter SST as a validation mechanism, by comparing selected drifter SST values with co-located satellite estimates, so-called 'matchups'. Despite the best efforts of GHRSST, progress is severely hampered both by the resolution (0.1C) and by the accuracy (~0.2C) of the SST reported by drifters. As a result of the dialogue, a basic set of standards was agreed for HRSST drifters (see Appendix D), in the hope that they would eventually lead to a universal standard applicable to all new drifters. The aim of PP-HRSST is to evaluate and develop this standard through the deployment of pilot drifters conforming to the standard, in the expectation that such drifters will in due course demonstrably improve the quality of satellite SST retrievals.

2. At the outset it was clear that while better resolution (0.01C) could relatively easily be achieved through changes in the drifter reporting format, and by migrating from GTS character codes (resolution 0.1C) to BUFR, there nonetheless remained a major problem in calibrating drifter SST sensors to the required accuracy. Although sensors with the required stability did exist, they were but components in an extended integrated system (the buoy), whose calibration in conventional environmental chambers on a production-line basis would be tedious at the least, and also expensive.

3. Fortunately Metocean of Canada, a major supplier of drifters to European agencies, has

1 : http://www.jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=6044

worked with ESURFMAR to tackle this problem, and has implemented a 2-step solution, HRSST-1 and HRSST-2. HRSST-1 is an interim solution which merely increases the resolution, but not the accuracy of the reported SST. HRSST-2, shortly to be rolled out in a number of UK Met Office drifters, supported by PP-HRSST, takes an entirely new approach, and features a 'smart' demountable, premium grade, high stability SST sensor capable of pre- and post-calibration. Significantly, the sensor module contains its own calibration coefficients and abandons error-prone analogue communication to the buoy controller in favour of digital transmission. See Appendix C for more details. It is hoped that this approach will in due course become an industry standard, not just for SST, but for other variables and for other platforms as well.

4. Demonstration of the value of HRSST-2 drifters will require a co-ordinated plan of action with GHRSST, and the identification of a suitable pilot deployment area. Recent discussions with GHRSST (Edinburgh, June 2011) have reinforced and applauded this approach, but have yet to draw clear recommendations as to a deployment area (and collateral funding) from this group. Informal discussions identified the seas around the Canaries as a potential high impact area, offering a high number of matchups, while still being of interest to operational met services such as ESURFMAR. GHRSST are being actively pursued for guidance on this issue, as well as commitments to collateral funding.

5. It is also clear that HRSST-2 drifters will have to be clearly flagged and recognised through associated metadata, otherwise their potential impact risks being missed.

6. Despite the uncertainties and lack of direct guidance, Météo France and the UK Met Office, acting as part of ESURFMAR, and aided proactively by Metocean, have moved swiftly to implement HRSST in the operational fleet (see Appendix B). The impacts of this initiative on satellite SST products will be reported in due course.

7. A meeting of interested parties in PP-GHRSST will take place before the main session of DBCP-XXVII

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Appendices: 3

APPENDIX A

DRAFT TERMS OF REFERENCE AND WORKPLAN OF THE PP-HRSST

Following a dialogue between the DBCP and the Group for High Resolution Sea Surface Temperature (GHRSST), the 26th session of the DBCP recognised that drifter SST was critical for the validation of satellite-derived SST, and that the resolution and accuracy of currently reported drifter SST was inadequate. The Panel accordingly decided to establish a Pilot Project for HRSST, overseen by a Steering Group (SG), and with a defined workplan and a three-year duration. A draft of the Terms of Reference of the SG, its possible membership, and a workplan are listed below.

Terms of Reference of the SG

1. The SG will work closely with the GHRSST to:

    a. agree and review instrumentation standards
    b. identify optimal target ocean areas that will be likely to deliver a high number of matchups and demonstrate the impact of drifter HRSST within the project lifespan
    c. secure sufficient funding to allow the project to proceed expeditiously
    d. work with buoy agencies and manufacturers to allow a sufficient number of upgraded HRSST drifters to be procured and deployed in the chosen target area(s)
    e. ensure that HRSST data flow onto the GTS and are clearly identified as HRSST in associated meta-data and/or bulletin headers
    f. assist in the analysis of the impact of the data on satellite SST retrievals
    g. report to the Panel at its annual sessions and in the published literature

2. The SG chair and vice chair will be appointed by the Panel, and will recruit other members of the team, drawn from buoy operators, manufacturers, the scientific community, GHRSST, end-users and other interested parties.

3. The SG chair will convene annual meetings of the SG, will communicate regularly with SG members by e-mail, and will report annually to the Panel.

Workplan

Year 1: Planning

1. Form SG and agree on working procedures
2. Recruit additional members as required, including key players from within the GHRSST
3. Review progress to date with Metocean HRSST-1 and HRSST-2 drifters
4. Ensure that proposed technology solutions adequately address GHRSST requirements
5. Identify the cost of an HRSST upgrade and identify buoy operators and manufacturers willing to participate in the PP
6. Work proactively with GHRSST and buoy operators to define and cost a practicable PP plan
7. Present this plan to the annual GHRSST science meeting (June 2012) and secure GHRSST financial support
8. Draw up a detailed costed implementation plan for approval at DBCP-XXVIII

Year 2: Implementation

1. Agree a deployment schedule with buoy operator(s)
2. Procure HRSST upgrades
3. Oversee calibration/recalibration protocols
4. Implement BUFR encoding for HRSST data
5. Monitor buoy deployments, data flow and data ingestion by GHRSST
6. Present at GHRSST science meeting (June 2013)

7. Make interim report to DBCP-XXIX

Year 3: Analysis

1. Continue with deployments as far as possible within budget
2. Attempt recovery of failed or failing buoys for analysis and sensor post-calibration
3. Review technology and data-flow performance and make recommendations as appropriate
4. Work with GHRSST to identify impacts and shortcomings of PP
5. Agree recommendations for future activities, if any
6. Report to GHRSST science meeting (June 2014)
7. Final report to DBCP-XXX
8. Work with GHRSST on a journal article
9. Disband

Membership

Chair (DBCP appointee)
Vice chair (DBCP appointee)

DBCP chair (*ex officio*)
DBCP TC (*ex officio*)
Buoy programme manager(s)
Buoy data analyst(s)
Buoy manufacturer(s)
GHRSST representative(s)
Oceanographic user(s)
Secretariat (*ex officio*)

APPENDIX B

PROGRESS REPORT ON PILOT PROJECT FOR HIGH RESOLUTION SST

DBCP and GHRSST established a joint Pilot Project in 2010 to upgrade elements of the GDP buoy fleet to allow the reporting of higher resolution SST and position. The objective is to operate SVP drifting buoys measuring SST with an accuracy of 0.05K (resolution 0.01K), location with an accuracy of 0.5km and observation time with an accuracy of 5 minutes.

It was agreed that only buoys fitted with a GPS could meet the location requirement. Initial practical steps have been taken by Météo France over the past 18 months. Thanks to their experience with Iridium SBD, Meteo-France thought that Iridium SVP-B drifters would be more suitable than Argos ones for the purpose.

First step was to enhance the dataformat used by standard Iridium SVP-B drifters to allow the transmission of SST with a resolution of 0.01K instead of 0.1K as previously. The description of this new format, called #000, may be downloaded from the DBCP Iridium Pilot Project webpages (http://www.jcommops.org/dbcp/iridium-pp/findings.html). It is considered as being the final format for SVP-B drifters and it is now recommended to be used on all drifters of that kind and not only HRSST ones.

In parallel, Meteo-France developed the necessary processings to convert raw Iridium data into BUFR messages sent onto the GTS in real time. Contrarily to FM18 BUOY messages, the resolution of 0.01K is kept in BUFR. Bulletin headers are presently IOBx13 LFPW with 'x' set to values A, B, C, D... according to the geographical area in which the buoy is (Table C3 of WMO Pub 386 - Attachment II-5).

Since October 2010, about 170 HRSST-1 drifters have been built by Metocean and half of them have been deployed in the Atlantic and in the Indian Ocean:

- 63 out of 127 drifters fully funded by E-SURFMAR for the North Atlantic or provided by the manufactuer buoys as replacement for previous units which failed quickly (warranty). 57 more were ordered in July 2011;
- 19 deployed in the Indian Ocean out of 30 Iridium SVP drifters owned by NOAA, upgraded with a barometer by Meteo-France;
- 7 drifters owned by the Met Office and deployed in the South Atlantic;
- 4 drifters owned by Environment Canada and deployed in the North Atlantic.

An Excel file containing the deployment information and buoy metadata is regularly updated at ftp://esurfmar.meteo.fr/pub/pb/ghrsst/ . The IMEIs of the most recent 55 built buoys, ready to be shipped from the manufacturer, are not yet known. All these buoys are fitted with a SST probe (YSI 46000) having a better accuracy than the previous one (YSI 44032) used on this kind of buoys. However, these probes are not calibrated.

So, next step will consist in building drifters, called HRSST-2, which could have their SST probe pre- and post-calibrated. The purpose of post-calibrations is to improve the quality of delayed mode data but also to statistically assess the possible trends in these measurements.

Metocean proposed to build a de-mountable digital sensor module, carrying its own programmable calibration coefficients. Other manufacturers are invited to study the feasability. It is hoping that space agency money could be found in order to make the HRSST-2 drifters as the standard one.

The first HRSST-2 prototypes should be deployed before the end of 2011/beginning of 2012.

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- All of the above change with temperature
- Tolerances of the test equipment

In addition, we do a single point verification, at room temperature using a calibrated thermocouple. The test limits are presently +/- 0.3 degrees C, we ultimately need to achieve +/- 0.1 degrees C.

Smart SST Probe

1.- Background

Last year, the DBCP and GHRSST established a joint Pilot Project to upgrade elements of the GDP buoy fleet to allow the reporting of higher resolution SST and position. The preparatory document may be downloaded via: https://www.ghrsst.org/documents.htm?parent=832. The objective is to operate SVP drifting buoys measuring SST with an accuracy of 0.05 deg C (resolution 0.01 deg C), location with an accuracy of 0.5 km and observation time with an accuracy of 5 minutes.

2.- Objectives

According to the above document, the following items are required:

Item	Description	MetOcean Compliance
System accuracy	Measure SST to +/- 0.05 deg C	We use a higher accuracy thermistor.
System accuracy	Calibrate buoy to meet SST	No calibration is done on this product.
System resolution	Report SST to +/-0.01 deg C	We implemented the new DBCP format
Location accuracy	+/- 500 meters	We use Iridium and GPS
Time accuracy	+/- 5 minutes	PID samples within 5 minutes of top of the hour
Data on GTS	Use BUFR	JouBeh Technologies / Iridium GTS VAR

3.- SVP System Accuracy

We need to address the cumulative SVP system tolerances and inaccuracies. We currently measure SST by comparing the value of the thermistor to a fixed-value resistor, located on the controller board and measuring the voltage across these. This is an analogue circuit developed by MetOcean back in the early '80s. This leads to the following cumulative errors:

- Tolerances of the various electronic components in the system
- Tolerances for the length of the copper wire and any connectors in the system
- All of the above change with temperature
- Tolerances of the test equipment

In addition, we do a single point verification, at room temperature using a calibrated thermocouple. The test limits are presently +/- 0.3 degrees C, we ultimately need to achieve +/- 0.1 degrees C.

4.- Proposal for the development of a "Smart SST Probe"

In order to meet the requirements of the GHRSST Pilot Project, the above cumulative errors need to be removed. To do this, we propose developing a completely digital system. This will require a small circuit board that will be mounted directly to the SST probe. This will allow us to calibrate only the probe and not the entire buoy or the controller. All the coefficients will be stored on the board after calibration and corrections will be applied to the measured value of SST. The controller will simply send a message to the probe asking for the current stored value of SST. This will be sent as a number, using a digital format, so no errors are introduced after calibration.

The following tasks need to be first accomplished:

1. New mechanical design of the Smart SST probe using a Swagelok
2. Develop a small circuit board with flash memory mounted on the fitting
3. Develop the calibration equipment and techniques required to automatically calibrate each probe.

We are currently putting together estimates for the three tasks above. The first task does not require a lot of effort, but the other two require some time to estimate them. We believe that at the conclusion of this design, we will have a probe that will exceed the required accuracy of the GHRSST Pilot Project.

In addition, this design has the advantage of not requiring any custom firmware to turn off Iridium and GPS while the buoy is ion the chamber. This introduces a risk that buoys could be deployed without GPS and Iridium being re-activated. As well, this does not require the development of a detachable drogue. The design of the drogue attachment is an area of high risk on these buoys today and any changes would require long-term, at sea testing.

Should this approach be acceptable to our clients, MetOcean will proceed to estimate the cost of the three tasks above.

APPENDIX D

GHRSST RECOMMENDATIONS FOR DRIFTER HRSST

GHRSST recommendations agreed in 2008 + 1

- (1) Make hourly reporting universal
- (2) Report design depth in calm water to ±5 cm
- (3) Report of geographical location to ±0.5 km or better
- (4) SST accuracy to ±0.05 K or better, resolve 0.01 K
- (5) Use NetCDF CF-1.3
- (6) Report of the time of SST measurement to ±5 minutes
- (7) No requirement to report on or close to integer hours

- *(8) (Extra) Report estimate of absolute accuracy*