A scientific and technical workshop on traceability of drifter SST measurements

A meeting hosted at Scripps on 13-14 October 2016 under the auspices of the ESA FRM4STS initiative

Report by David Meldrum

1. Introduction

Following the efforts of the DBCP and GHRSST in establishing a dialogue between the satellite and *in situ* communities to encourage the roll-out of better buoy SST (so-called HRSST) measurements in support of satellite SST performance monitoring and validation, both ESA and EUMETSAT have recently taken positive steps in this direction: ESA by commissioning a wide-ranging desk study of drifter SST (FRM4STS option 1), EUMETSAT by inviting tenders for the procurement and deployment of drifters with enhanced SST capabilities. The aim of both initiatives is to better understand and improve the uncertainty budget associated with drifter SST, and to demonstrate the value (or otherwise) of drifter HRSST as specified in the 'GHRSST Standard' (see Table 1). Of particular note is the need to establish a route to SI traceability for drifter SST measurements and to provide sufficient knowledge to quantify the stability of SST measurements reported by the global drifter array. It is important to understand in this context that early efforts by the DBCP and GHRSST in deploying and evaluating a significant number of HRSST drifters did not demonstrate a positive outcome, possibly because of the limited overlap between the HRSST drifter deployments and the availability of the high-quality AATSR satellite sensor on ENVISAT. However, with the launch of the SLSTR instrument on Sentinel-3, it is now appropriate and timely to revisit this evaluation activity.

The ESA FRM4STS contract, being delivered by David Meldrum, includes the holding of an international workshop of both satellite and *in situ* practitioners to foster a dialogue that might lead to positive outcomes in terms of better understanding each other's needs and priorities, and in quantifying the uncertainty budget associated with drifter SST. A target outcome from the workshop is to develop best practice and a workplan for future activities, as discussed further below. The workshop was hosted by Luca Centurioni at Scripps on the 13th and 14th October 2016, and attracted 20 participants, including four out of the five current manufacturers of the SVP drifter. The only manufacturer unable to participate in person has nonetheless offered full co-operation with the aims of the project. The agenda is attached as Annex A.

2. Narrative

The workshop explored a number of issues:

- The methodology and needs of the satellite community in extracting SST from the space and *in situ* data and metadata at its disposal;
- A detailed discussion of the complexity of the SST variable and the multi-dimensional uncertainty budget and its implications for the buoy community (see Figure 1 and Table 2);
- Evolution of the 'standard' drifter design, end to end calibration, characterisation and traceability: current and historical practice in the drifter community;
- Experiences of both the satellite and drifter communities with HRSST drifter deployments and evaluation, including recalibration;
- The way forward towards better traceability, a better understanding of the value (or otherwise) of the HRSST drifter, and a better satellite SST product.

Overall, the agenda and discussion proceeded in an open and honest manner, and all agreed that the activity was worthwhile and should be repeated in a year's time, when inter-comparison data from the Sentinel-3 SLSTR and from the projected EUMETSAT drifter study should be available. The meeting was also pleased to note that the pressing need for harmonization of the various drifter metadata datasets into a single searchable resource that was being actively addressed by David Meldrum, and that a comprehensive metadata dataset would be published early in 2017.

3. Main outcomes

The DBCP and GHRSST are asked to note that consensus was reached by the meeting in a number of areas:

- Acceptance in principle of the GHRSST Standard (Table 1) for global drifter SST implementation and reporting, subject to the eventual validation of its usefulness;

- Acknowledgement that the space component and the drifter array are elements of a composite network and that both are required for different but complementary purposes;
- Acceptance in principle of the requirement for SI traceability of drifter SST;
- Endorsement of the efforts to harmonize and publish available drifter metadata in a global dataset;
- Agreement that mechanisms must be found to maintain the harmonized metadata dataset in the future;
- Agreement that the routine reporting of diagnostic data (e.g. drifter internal temperature) and access to collateral information (e.g. wave spectral estimates) are important components of best practice for developing drifter capability in general and SI traceability in particular;
- Agreement that a working group be established to take forward the above and to further develop standards and best practices, possibly through reactivation of the DBCP's PP-GHRSST that had been disbanded in 2014 (see Annex C for its legacy ToRs);
- Agreement on the desirability of an online tool and access to data and metrics that would facilitate intercomparison of satellite and drifter SST: the development of such a tool to be an area for ongoing collaboration;
- Agreement to reconvene in a year's time, possibly just ahead of the next DBCP session.

4. Requests to the DBCP

The DBCP is asked to:

1. Note and endorse the efforts of the workshop and its participants;
2. Advise the group as to its future workplan;
3. Consider how it might assist the work of group by, *inter alia*:
    a. Reactivating the PP-HRSST;
    b. Assigning sustained resources, possibly through JCOMMOPS, for the diligent maintenance of the drifter metadata database;
    c. Endorsing any standards and best-practice guidance that might be developed by the group;
4. Discuss whether the *modus operandi* and objectives of the group might in due course serve as a model for the timely implementation of best practice, not only for SST, but for other ECVs, particularly wave spectral data;
5. Report its deliberations with respect to all of the above to JCOMM, and seek additional resources as deemed necessary.

5. Closure of the session

All presentations made to the meeting will eventually be uploaded to the FRM4STS website (www.frm4sts.org). The Scripps team were thanked for the excellence of the local arrangements and the meeting closed at 1700 on 14 October 2016.

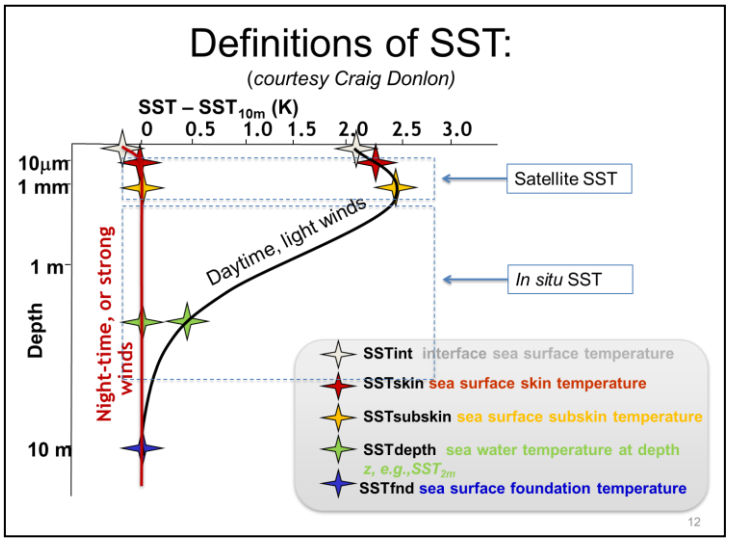

Figure 1: *A representation of the variation of SST with depth in calm and windy conditions*

- Hourly measurements
- Report design depth in calm water to ± 5 cm
- Report geographical location to ± 0.5 km or better
- SST total standard uncertainty ± 0.05K or better, resolution 0.01K
- Report time of SST measurements to ± 5 minutes

Table 1: *The GHRSST 'standard' for drifter HRSST reports*

- Sensor accuracy/characterisation
  - Calibrated or batch-qualified?
    - Before or after integration into drifter?
    - What errors are introduced in signal processing and message formatting?
  - Traceability to national standards
  - Sensor drift
    - Target obs system stability of 3 mK per year
    - What should be target for drifters?
  - Post-calibration seldom possible
- Positional and temporal accuracy
  - Errors in the above look like sensor errors to the analyst
- Depth uncertainty
  - 'SST' is a function of depth
  - How does the depth of the sensor vary?
  - Drogue on/off
  - How is the sensor output sampled/averaged?
- Metadata
  - Collection, distribution, archival
- What errors are introduced in downstream processing and archival?

Table 2: *Measurement uncertainty and traceability: issues to consider*

ANNEX A

A scientific and technical workshop on traceability of drifter SST measurements

Sea Cave Room, Eckart Building, Scripps Institution for Oceanography, La Jolla, California: 13-14 October 2016

Objective
To review scientific needs and historical practice in drifter SST measurement and **agree best practice** for the future, for adoption and ratification by the DBCP and the satellite SST community.

AGENDA (rev 12 October)

Day 1		
0900-0930	*Registration and coffee*	
0930-0945	Welcome by Scripps, NOAA and the DBCP	Luca Centurioni, Sidney Thurston and Jon Turton
0945-1015	Introduction, background to the workshop, its purposes and scope	David Meldrum, DMLtd
Session 1	**How the satellite community uses *in situ* SST: its needs for the future**	
1015-1045	Contributions of drifter temperature measurements to satellite SST retrievals	Peter Minnett, U of Miami
1045-1115	Use of drifter measurements in satellite climate data records of SST	Chris Merchant, U of Reading
1115-1145	*Morning break*	
1145-1215	NOAA satellite SST products and harmonization with in situ data	Alexander Ignatov, NOAA
1215-1245	GHRSST and satellite SST uncertainty validation, early results from HRSST deployments	Gary Corlett, GHRSST PO
1245-1400	*Lunch*	
Session 2	**How the satellite community is progressing**	
1400-1430	ESA initiatives in support of Sentinel-3 and GHRSST	Craig Donlon, ESA
1430-1500	EUMETSAT initiatives: improving drifting buoy SST for Copernicus satellite validation	Anne O'Carroll, EUMETSAT
1500-1530	Discussion - satellite community priorities	Peter Minnett (facilitator)
1530-1600	*Afternoon break*	
Session 3	**Drifter SST background**	
1600-1630	Drifter SST – current and historical practice	David Meldrum
1630-1700	The Global Drifter Program: Observations of Sea Surface Temperature in the World's Oceans	Luca Centurioni, Scripps
1700-1730	Review of day's activities and objectives for Day 2	David Meldrum (facilitator)
1830-	*Ice-breaker and Hosted Dinner (partners welcome)*	
Day 2		
0900-0915	Introduction to Day 2: do we understand what we need to achieve!	David Meldrum
Session 4	**Practical progress with implementing HRSST**	
0915-0945	The Metocean HRSST sensor and its implementation	Bernie Petolas, Joubeh
0945-1015	Météo-France/E-SURFMAR practical experience with HRSST buoys	Gilbert Emzivat, Météo France
1015-1045	Météo-France/E-SURFMAR HRSST calibration and recalibration exercises	Paul Poli, Météo France
1045-1115	The evolution of the Pacific Gyre SST sensor and our view of the future	Andy Sybrandy, Pacific Gyre
1115-1145	*Morning Break*	
Session 5	**Agreeing what needs to be done**	
1145-1215	Manufacturer viewpoints	Craig Donlon and Paul Poli (facilitators)
1215-1245	Discussion, review and tabulation of requirements	David Meldrum (facilitator)
1245-1400	*Lunch*	
1400-1430	Traceability: how to meet requirements for T	Peter Minnett (facilitator)
1430-1500	Traceability: how to meet requirements for (x,y,z,t)	Bernie Petolas (facilitator)
1500-1530	Traceability: downstream processing, data and metadata dissemination and archival	Luca Centurioni (facilitator)
1530-1600	*Afternoon break*	

Session 6	**A model for best practice for adoption by DBCP**	
1600-1730	Discussion - a strawman proposal for endorsement by the DBCP	David Meldrum and Jon Turton
	Meeting close	

ANNEX B

Participant List

Participant		Affiliation	e-mail
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ANNEX C

[EXTRACTED FROM DBCP-XXVIII FINAL REPORT, 2012]

TERMS OF REFERENCE, DRAFT WORKPLAN AND INITIAL MEMBERSHIP OF THE STEERING GROUP FOR THE DBCP-GHRSST PILOT PROJECT FOR HIGH RESOLUTION SST DRIFTERS (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 **(now past)***

1. Form SG and agree on working procedures – **not achieved**
2. Recruit additional members as required, including key players from within the GHRSST – **not achieved**
3. Review progress to date with Metocean HRSST-1 and HRSST-2 drifters – **partially achieved**
4. Ensure that proposed technology solutions adequately address GHRSST requirements - **achieved**
5. Identify the cost of an HRSST upgrade and identify buoy operators and manufacturers willing to participate in the PP – **partially achieved**
6. Work proactively with GHRSST and buoy operators to define and cost a practicable PP plan – **in progress**
7. Present this plan to the annual GHRSST science meeting (June 2012) and secure GHRSST financial support – **not achieved**
8. Draw up a detailed costed implementation plan for approval at DBCP-XXVIII – **partially achieved**

Year 2: Implementation

1. Complete Year 1 work items
2. Pursue proposal to ESA for coordinated deployment campaign in support of Sentinel-3
3. Agree a deployment schedule with buoy operator(s)
4. Procure HRSST upgrades
5. Oversee calibration/recalibration protocols
6. Implement BUFR encoding for HRSST data
7. Monitor buoy deployments, data flow and data ingestion by GHRSST
8. Present at GHRSST science meeting (June 2013)
9. 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: D Meldrum appointed by Panel
Vice chair (DBCP appointee, TBA)

DBCP chair (*ex officio*)
DBCP TC (*ex officio*)
Buoy programme manager(s) - TBA
Buoy data analyst(s) - TBA
Buoy manufacturer(s) – volunteer from Metocean (Clifton Flint) + others TBA
GHRSST representative(s) - TBA
Oceanographic user(s) - TBA
Secretariat (*ex officio*)