APPENDIX E
REPORT BY THE TASK TEAM ON CODING
(submitted by Craig Donlon, chair, Task Team)

Dr Craig Donlon (United Kingdom) made a presentation at the SOT-III Scientific and Technical Workshop, entitled "Validation of SST data products within the Global Ocean Data Assimilation Experiment (GODAE) High Resolution Sea Surface Temperature Pilot Project (GHRSST-PP)", which provided background information on the GHRSST-PP, which is primarily concerned with developing the best SST data sets from satellite systems for assimilation into ocean and atmospheric forecast systems and for use in climate monitoring. In situ observations are required as input to empirical retrieval algorithms that account for the impact of atmospheric absorption and emission that bias infrared satellite SST retrievals, for bias correction of different satellite data sets when used in combined level-4 (L4) analyses, for independent validation of individual satellite data sets and, as input to the climate data record. In all of these cases the in situ observations are generally taken to represent the 'true' SST despite the fact that strong vertical gradients may exist in the upper ocean that require that SST measurements must always be reported with an accompanying measure of the depth beneath the water surface for that given observation. (Annex to this Appendix). Consequently, the GHRSST-PP notes that ideally, wind speed and solar radiation should be reported together with SST for use in diurnal variability parameterizations.

The meeting noted that given the rapid development of a new class of real-time reporting of in situ technology for VOS style deployment, here was a need for a new set of reporting codes that would enable this new class of observations to be used in operational agencies. The meeting agreed that the SOT, with the agreement of JCOMM, should propose BUFR descriptors for this purpose. The meeting therefore decided to establish a Task Team on SST Coding chaired by Dr Donlon with the following terms of reference

1. Develop a draft new code table for BUFR, which accommodates new types of SST measurements.
2. Submit the draft proposal to a relevant body of the CBS.
3. Investigate possible future inclusion of bio-chemical data in BUFR through various interactions with other ship-based observation communities.
4. Reports to SOT-IV.

Members:

Craig Donlon (TT chairperson, United Kingdom)
Graeme Ball (Australia)
Etienne Charpentier (JCOMMOPS)
Bob Keeley (Canada)
Loïc Petit de la Villéon (France)

The Task team conducted all of its work via email communication during the intersessional period. Initially the GHRST-PP definitions were reviewed and a common understating of the issues established. Bob Keely provided a new BUFR Master Table 10 for consideration by the group, which contained an extensive structure for oceanographic variables and common atmospheric variables. A new set of codes for SST that included reporting the depth of SST measurement were developed and submitted to the CBS by the secretariat. The new BUFR codes also included the GHRSST-PP standard SST definition names SSTskin, SSTsub-skin, SSTz (depth) and SST foundation. The TT urges all operators to report the depth of SST observation and for adequate alphanumeric codes to be developed, especially for use in electronic logbooks.

Noting the important role of in situ SST observations in the context of satellite observations, the TT urges the SOT to consider that accuracies of better than 0.1K ±0.05K should be the target for SSTz observations. Furthermore, as satellite validation work is often conducted using in situ data matched to within ±0.5 hours, it recommends that sampling of SST should be conducted on a ½ hourly basis or hourly basis. Noting that the smallest satellite SST pixel is 0.5km and assuming a ship speed of 15kt, when using automated sampling systems, the mean SST value obtained over a one-minute sample provides an adequate sampling strategy.

The Team urges the utmost care and attention to calibration of in situ SST sensors and the proper reporting of the location of sensor relative to ships datum (via WMO Pub. 47) and notes the excellent work conducted by Port Meteorological Officers in this respect. However the team remains concerned at the falling number of PMOs available to service ships in some countries. Ultimately, poor calibration and installation metadata records will lead to reduced quality of SST observations, reduced quality of satellite validation results and incorrect bias correction of satellite data when blending complementary satellite observations.

Unfortunately, while the TT completed the major task of upgrading the BUFR definitions of SST, only moderate progress was made under item 3. Master Table 10 requires further review and harmonization with Master Table 1 – especially for the definition and inclusion of ‘standard’ MetOcean variables, which probably should appear in both tables. The work is urgent as ocean forecast systems require bio-geo-chemical observations (particularly of Chlorophyll-a, nutrients, Oxygen) and partial pressure CO2 observations for both atmosphere and ocean are routinely reported from ships for use in carbon cycle monitoring.

The TT recommended revise its terms of reference to focus on the development of BUFR Master Table 10 for use across all of the SOT, ready for operational use as soon as possible, bearing in mind the requirements of operational ocean forecast systems, environmental and climate monitoring requirements and ecosystem modeling. Accordingly the TT further recommends that the TT on Codes liaise closely with the DMPA TT on Codes (See SOT-IV preparatory document I-6.2.2, “Coding Issues”) and merge the TT by PM03 on Codes. The aim of this combined and revised TT is to develop MT10 for operational use and to submit this for approval to CBS.

The following ToR are suggested:

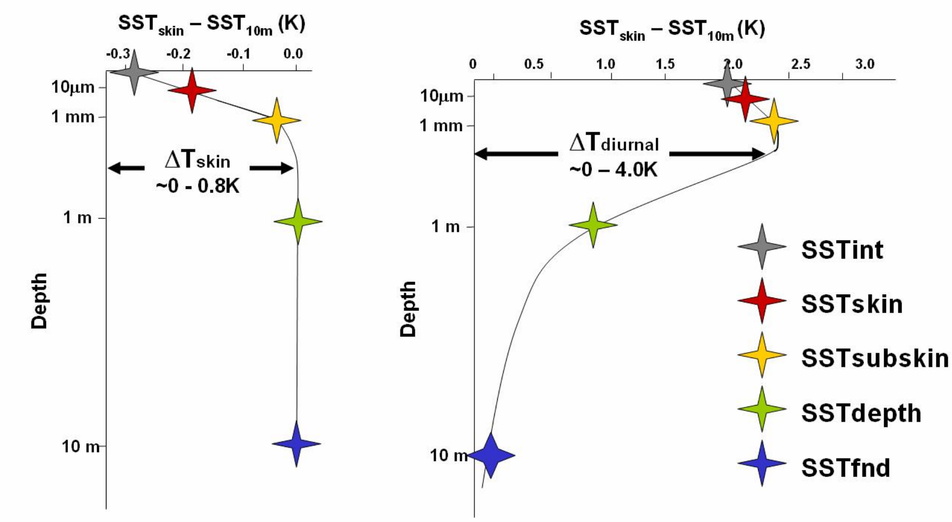
Tasks:

1. In collaboration with ocean forecasting system operators (GODAE) including ecosystem modelers, and other appropriate user communities, establish a core set of bio-geo-chemical variable definitions for MT10
2. Review and revise the draft MT-10 BUFR code table.
3. Submit the draft proposal to a relevant body of the CBS.
4. Report to SOT-V.

Membership to be defined by SOT-IV.

ANNEX TO APPENDIX E

SST is a difficult parameter to define exactly because the upper ocean (~10 m) has a complex and variable vertical temperature structure that is related to ocean turbulence and the air-sea fluxes of heat, moisture and momentum. A theoretical framework is required to understand the information content and relationships between measurements of SST made by different satellite and in situ instruments, especially if these are to be merged together. The definitions of SST developed by the GHRSST-PP SST Science Team achieve the closest possible coincidence between what is ***defined*** and what ***can be measured operationally***, bearing in mind current scientific knowledge and understanding of how the near surface thermal structure of the ocean behaves in nature.



(a) Night time situation, light wind

(b) Day time situation, strong solar radiation and light winds

The hypothetical vertical profiles of temperature in low wind speed conditions during the night and day shown in the figure encapsulate the effects of the dominant heat transport processes and time scales of variability associated with distinct vertical and volume regimes (horizontal and temporal variability is implicitly assumed). At the exact air-sea interface a hypothetical temperature called the interface temperature (SSTint) is defined although this is of no practical use because it cannot be measured using current technology. The skin temperature (SSTskin) is defined as the temperature measured by an infrared radiometer typically operating at wavelengths 3.7-12 µm (chosen for consistency with the majority of infrared satellite measurements) that represents the temperature within the conductive diffusion-dominated sub-layer at a depth of ~10-20 µm. SSTskin measurements are subject to a large potential diurnal cycle including cool skin layer effects (especially at night under clear skies and low wind speed conditions) and warm layer effects in the daytime. The subskin temperature (SSTsubskin) represents the temperature at the base of the conductive laminar sub-layer of the ocean surface. For practical purposes, SSTsubskin can be well approximated to the measurement of surface temperature by a microwave radiometer operating in the 6-11 GHz frequency range, but the relationship is neither direct nor invariant to changing physical conditions or to the specific geometry of the microwave measurements. All measurements of water temperature beneath the SSTsubskin are referred to as depth temperatures (SSTdepth) measured using a wide variety of platforms and sensors such as drifting buoys, vertical profiling floats, or deep thermistor chains at depths ranging from 10^{-2} - 10^{3}m. These temperature observations are distinct from those obtained using remote sensing techniques (SSTskin and SSTsubskin) and must be qualified by a measurement depth in meters (e.g., or SST(z) e.g. SST5m). The foundation SST, SSTfnd, is defined as the temperature of the water column free of diurnal temperature variability (daytime warming or nocturnal cooling) and is considered equivalent to the SSTsubskin in the absence of any diurnal signal. It is named to indicate that it is the foundation temperature from which the growth of the diurnal thermocline develops each day (noting that on some occasions with a deep mixed layer there is no clear SSTfnd profile in the surface layer). Only in situ contact thermometry is able to measure SSTfnd and analysis procedures must be used to estimate the

SSTfnd from radiometric satellite measurements of SSTskin and SSTsubskin. SSTfnd provides a connection with the historical concept of a "bulk" SST considered representative of the oceanic mixed layer temperature and represented by any SSTdepth measurement within the upper ocean over a depth range of 1-20+m. SSTfnd provides a more precise, well-defined quantity than previous loosely defined "bulk" SST and consequently, a better representation of the mixed layer temperature. In general, SSTfnd will be similar to a night time minimum or pre-dawn value at depths of ~1-5 m, but some differences could exist. Note that SSTfnd does not imply a constant depth mixed layer, but rather a surface layer of variable depth depending on the balance between stratification and turbulent energy and is expected to change slowly over the course of a day.