IOC

SOOP Ship-of-Opportunity Programme

WMO

JOINT IOC/WMO SHIP-OF-OPPORTUNITY PROGRAMME (SOOP)

Overview

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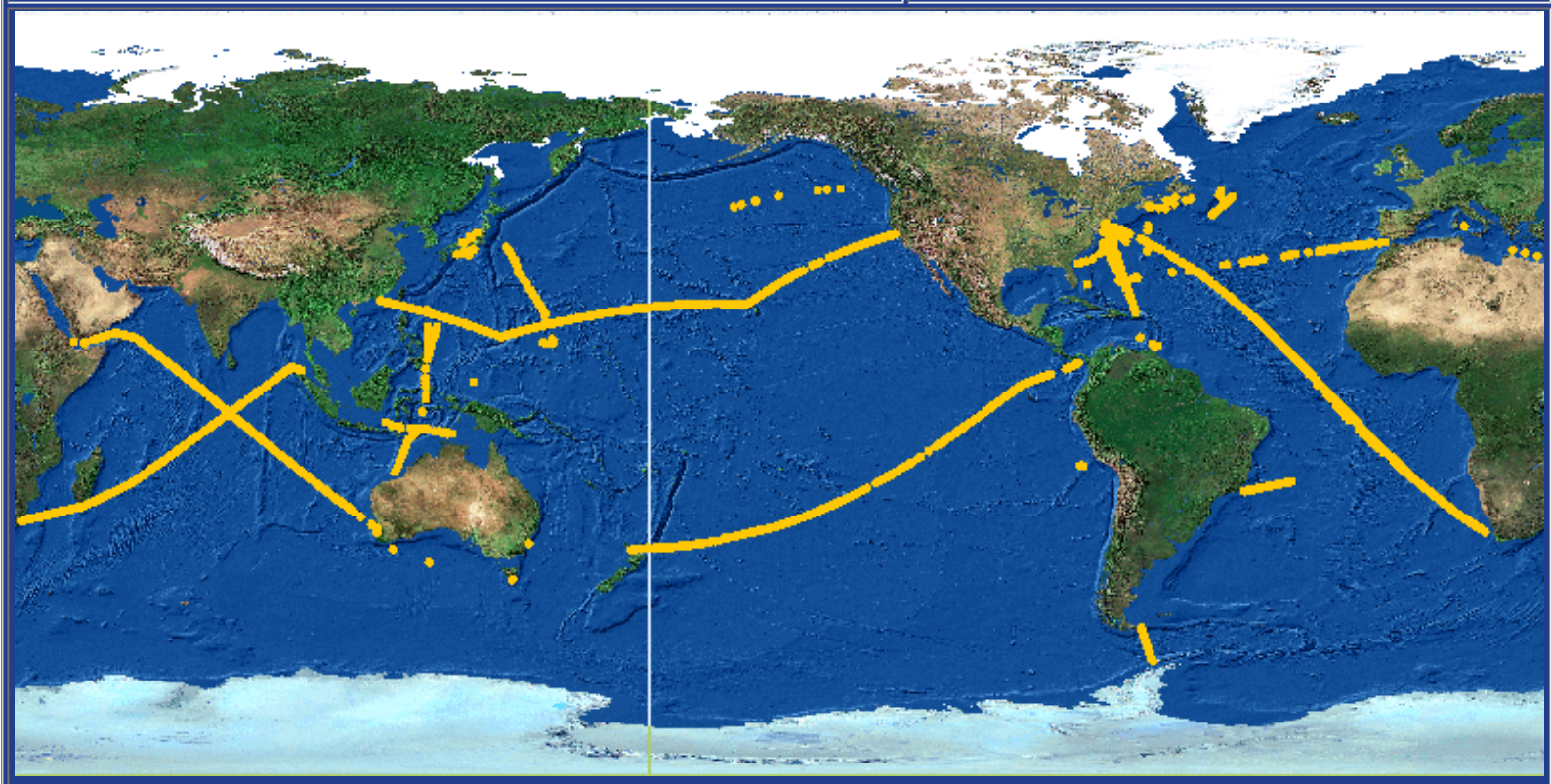


Monthly Map of XBT drops (Previous Month).
View data in the SOOP Interactive Map

1. INTRODUCTION

The primary goal of the Ship-of-Opportunity Programme (SOOP) is to fulfill upper ocean data requirements which have been established by GOOS and GCOS, and which can be met at present by measurements from ships of opportunity (SOO). SOOPIP is establishing itself as an operational programme and is therefore participating in the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) and particularly in its Ship Observations Team (SOT). Data management is taken care of through the Global Temperature Salinity Profile Programme (GTSPP).

The SOOP is directed primarily towards the continued operational maintenance and co-ordination of the XBT ship of opportunity network but other types of measurements are being made (e.g. TSG, XCTD, CTD, ADCP, pCO2, phytoplankton concentration). This network in itself supports many other operational needs (such as for fisheries, shipping, defense, etc.) through the provision of upper ocean data for data assimilation in models and for various other ocean analysis schemes. One of the continuing challenges is to optimally combine upper ocean thermal data collected by XBTs from the SOO with data collected from other sources such as the TAO array, Argo, and satellites (eg. AVHRR, altimeter, etc.). However, it is considered most important to have the SOOP focused on supporting climate prediction in order to ensure the continued operation of the present network.

2. REQUIREMENTS

In August 1999 an upper ocean thermal review, was conducted by OOPC, CLIVAR Upper Ocean Panel, and SOOP in order to (i) compile a consolidated account of the existing upper ocean thermal database, (ii) produce consolidated maps of information level/content based on the dominant scales of climate signals; (iii) document the existing practices for assembling, quality control and distribution of upper ocean data; (iv) document to the extent possible the "value adding" of thermal data process chains, be they automated assimilation, quick-look/semi-automated quality control or higher-level scientific quality control and assembly, (v) provide quantitative assessment of all SOOP lines including an assessment of relevance/impact against scientific objectives, (vi) provide a renovated SOOP plan taking account of, as far as is practical the existence (or potential) of other direct sampling networks (e.g., TAO, *Argo*), the indirect information available from remote sensing, particular altimetry; and the indirect information available from models, e.g. wind-forced equatorial.

The review noted that (see conclusions), till this point of time, sampling had been in three modes: low density, frequently repeated and high density. The SOOP has been extremely cost-effective for science and, latterly, for operational applications. However the review proposed a major revision of the ship-of-opportunity program. The program would gradually withdraw from areal sampling as *Argo* was implemented, and would at the same time ramp up its effort in line (transect) sampling. The line sampling would include both intermediate resolution, frequently repeated lines (see proposed FR lines) and high density (see proposed HD lines), quarterly repeat lines. This change in approach enhances complementarity with existing elements, particularly TAO and altimetry, and seeks optimum complementarity for the system envisaged for the future. The new design will address several important scientific goals, both for GOOS and CLIVAR. It will make unique contributions in terms of in situ eddy-resolving data sets and in terms of the repeated lines. It is estimated that this new design will not have significant resource implications. The review noted that this new mode of operating does open up further opportunities for observations from SOOP though this has to be balanced against the good-will being offered by the ships.

2. INSTRUMENTATION

XBT

XBT (Expandable BathyThermograph) is an expandable temperature and depth profiling system. It is typically comprised of an acquisition system onboard the ship, a launcher, and a expandable temperature probe. Falling probe is linked to the acquisition system through a thin insulated conductive wire which is used to transmit the temperature data back to the acquisition system in real time. Depth is deduced from elapsed time using a well calibrated fall rate equation (about 6.5 m/s). Processed profile data can be transmitted in real-time through satellite (e.g. Inmarsat). Profiles as deep as 1000m and comprising (T, D) data points every meter can be made although with usual probes depths range from 500 to 800 m. Accuracy is normally better than 5m for depth, and better than 0.05 C for temperature.

(photo by Captain Robert A. Pawlowski, NOAA Corps; NOAA photo library)

SOOP XBT network coverage

The Ship Of Opportunity Programme operates a global network of XBT systems onboard merchant ships which data are transmiited in real-time and made available to the oceanographic and meteorological communities for operational (assimilation in ocean models) and scientific purposes.

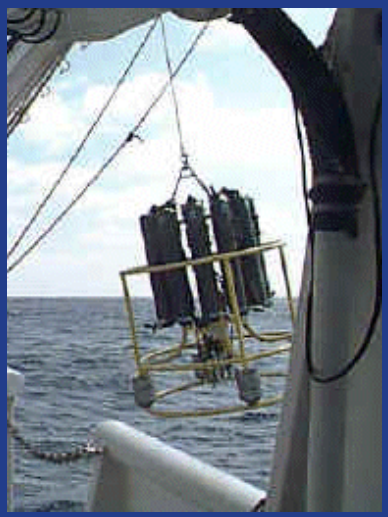
TSG

TSG (ThermoSalinoGraph) is an automated Sea Surface Temperature and Salinity measurement system making measurement onboard the ship using a water intake. A conductivity cell and a thermistor cell provide conductivity and temperature measurements. Salinity is derived from conductivity and temperature. The ship s position is given by a GPS. A computer usually located on the bridge makes the data acquisition, data processing, recording, and controls the real-time transmission of the data through satellite (e.g. GOES).

(courtesy of IRD)

CTD

CTD is an electronic set of instruments to make Conductivity, Temperature, and Depth measurements. The instrument is usually mounted within a frame (e.g. within a rosette to make other types of measurements or as a stand-alone CTD). The CTD is connected to the ship by means of a conducting cable and data are sent electronically through this cable, in real-time, to the ship. A winch on the ship lowers and raises the CTD through the water. Depths as deep as 5000m can be reached. Another method is to use towed CTD while the ship is moving which permit (C, T, D) profiles of the upper 100 to 150 meters. Accuracies better than 0.005 mS/cm are usually achieved for condictivity, than 0.002 C for temperatures, and than 0.1% of full scale range for depths.



XCTD	XCTD is an Expandable Conductivity, Temperature and Depth profiling system. It is typically comprised of an acquisition system onboard the ship, a launcher, and a expandable probe which includes electronics, a temperature sensor, and a conductivity sensor. Falling probe is linked to the acquisition system through a thin insulated conductive wire which is used to transmit the temperature and condictivity data back to the acquisition system in real time. Depth is deduced from elapsed time using a well calibrated fall rate equation (about 6.5 m/s). Processed profile data can be transmitted in real-time through satellite (e.g. Inmarsat). Profiles as deep as 1000m and comprising (C, T, D) data points every meter can be made. Accuracy is normally better than 5m for depth, than 0.05 mS/cm for conductivity, and than 0.05 C for temperature.
ADCP	ADCP (Accoustic Doppler Current Profiler). A beam of sound of known frequency which is emitted by the ADCP is reflected on small particles moving with the water. Received frequency depends upon speed of the particles (Doppler effect) and therefore of the water currents. Three orthogonal beam components are needed to measure the current vector. However, more beams can be used for redundancy, and quality checking in order to improve the instrument overall performance. Adequate beam sampling permits to achieve current measurements at different depths. ADCP can for example be installed in the water on the hull of the ship and "looking" downwards" or it can be lowered at diferrent depths to measure a wider range current profile. GPS can be used on a moving ship to substract ship's speed from the measured current vector.
pCO2	pCO2: Measurements of partial pressure of CO2 (pCO2) in surface sea water are made by bringing to equilibrium on a short time scale an aliquot of water with a headspace of known CO_2 concentration. After equilibration the headspace gas is analyzed using a standardized infra-red analyzer or gas chromatograph (measuring the difference in absorbtion of infra-red radiation passing through two cells, including

(courtesy of Sippican, Inc.)

a reference cell flushed with gas of known CO_2 concentration). Partial pressure of CO_2 in the air can also be measured. Accuracies in the order of 0.2 ppm can be achieved.

3. DATA COLLECTION AND EXCHANGE

(i) Operational Observing Network

Approximately 100 dedicated SOO, operated by 7 Members, report upper ocean temperature along specified routes at sampling intervals developed under the Tropical Ocean and Global Atmosphere (TOGA) and WOCE programmes of WCRP (see Appendicies 2 and 3). These sampling requirements have been designed for climate monitoring and prediction applications, and which have been endorsed by the WCRP Ocean Observing System Development Panel (OOSDP). Each vessel is equipped with a data acquisition system provided by the operating agency. These systems vary depending upon the agency, but generally meet agreed standards. Observations (such as the deployment of expendable bathythermographs - XBTs) are made normally by ships officers on a voluntary basis, though there is increasing automation in some underway systems such as used for measuring sea surface temperature (SST) and sea surface salinity (SSS). Observations are also utilised from other "opportunistic" vessels (navy, fishing, research, etc.) not formally participating in the programme. Interface between oceanographic agencies and met services and the ships is through designated Ship Greeters from the contributing national agencies and occasionally the international network of Port Meteorological Officers. Ship Greeters and PMOs maintain, calibrate and often supply/replace instrumentation. They also provide relevant literature, stationery and computer software, train ships officers, and generally help to provide the feedback required to maintain the volunteer observer support and motivation.

(ii) Data Collection and Exchange

Real time. The low resolution (inflection point) realisations of the observations are transmitted to shore in real time primarily via satellite (e.g. GOES, METEOSAT, Argos, and Inmarsat systems), as either BATHY or TESAC messages, and routed directly to a small number of major oceanographic and meteorological services. Transmission costs are borne by these services. The observations are compiled into bulletins and distributed globally via the GTS under Joint WMO/ IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM).

Delayed mode. Full resolution realisations of the observations are recorded on diskette by the onboard data acquisition systems, and collected by the Ship Greeters and/or PMOs of the recruiting countries at the end of each voyage. The data are encoded in the international exchange format MEDSASCII, quality control standards applied by the operating agencies, and the data sent at 12-monthly intervals to the respective Regional National Oceanographic Data Centre (RNODC) for forwarding to the World Data Centres (WDCAs - USA, Russia). These centres undertake elementary quality control checks, compile global dat sets, and forward these at regular intervals to Science Centres (Indian Ocean Joint Australian facility for Ocean Observing Systems (JAFOOS), Atlantic - AOML/ NOAA, Pacific - SIO) for scientific quality control and analysis. The resultant value added, high quality data sets then replace the data in the global archives. The procedures for this data exchange and management, including the quality control standards, have been developed and maintained by WOCE and the GTSPP of JCOMM and the Intergovernmental Oceanographic Data Exchange (IODE). SOOPIP, with the assistance of the Operations Coordinator, undertakes six-monthly monitoring of the data coverage to ensure optimal deployment of available resources under the agreed sampling requirements and recognised priorities (in the first instance in support of seasonal-interannual climate forecasting)

The Operations Coordinator maintains information on SOOP, regularly up-dated lists of participating operators and vessels, ocean basin data coverage by line, and data flow statistics on this web site.

(iii) Standards, Codes and Software

Standards and procedures exist for on-board, real-time and high resolution (often delivered in delayed-mode) report compilation and transmission, as do codes for real-time data transmission and exchange (BATHY, TESAC, TRACKOB, BUFR). These are maintained and further developed as necessary. Procedures have been put in place to ensure compliance with these standards and codes. Software and equipment for automated report compilation, quality control and transmission exist and are in widespread use (e.g. SEAS). These will be progressively extended, and new software developed as the need arises.

(iv) Communications

Existing communication facilities for data collection and exchange include INMARSAT, Argos, coastal radio (real-time, low resolution data collection), and the GTS, Internet, etc. (both low and high resolution data exchange). Procedures are already well established within WMO for ensuring the most effective use of these facilities, as well as for enhancing cost-efficiency and accuracy of data transmission for both meteorological and oceanographic data. These procedures will continue to be applied to the SOOP data, and further refined as the need arises.

(v) Monitoring

Extensive monitoring of both low and high resolution oceanographic data transmission and exchange is undertaken by the Operations Co-ordinator, the research community (e.g. WOCE Data Information Unit), the GTSPP and WMO (main GTS centres and the Secretariat), in conjunction with ship operators. This monitoring will continue to be applied to SOOP data, with new monitoring procedures and analyses being developed and applied as necessary. Results of all monitoring are provided on a routine basis to programme operators, communication agencies and the SMC. Monitoring efforts are co-ordinated by the Operations Co-ordinator, with guidance from the SOOPIP.

4. DATA MANAGEMENT

The data management activities of the programme are integrated with the data collection activities, and handled with procedures and resources most of which are currently in place and used to support the Global Temperature and Salinity Programme (GTSPP), including regional upper ocean science centres established by WOCE. The Marine Environmental Data Service (MEDS) in Canada is the GTSPP centre responsible for collecting temperature and salinity data from the GTS in real-time on a daily basis. The data are passed through well documented quality control procedures as well as procedures to detect and remove duplicates. The GTSPP regularly monitors the volumes, timeliness and quality of data received in real-time.

The assembly and incorporation of delayed mode data into the GTSPP data stream in a timely manner is an essential activity. Experience has shown that significant amounts of real time data are not being replaced with high resolution versions, and that large quantities of additional data are only available in delayed mode. While these data are not available for operational use, they are critical for climate products and research. The responsibility for tracking and submission of delayed mode data is entrusted to SOOPIP, which works closely with IODE and the research community, e.g. WOCE IPO, to ensure that these data are submitted within one year of observation, as required by IODE.

Because the data management aspect of the SOOP makes use of existing linkages between data archives and oceanographic and meteorological research centres, the products currently available through the GTSPP continue in support of the project.

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Points of contact