SECOND JCOMM MARINE INSTRUMENTATION WORKSHOP FOR THE

ASIA PACIFIC REGION

Tianjin, China

3-6 December 2012

FINAL REPORT

JCOMM Meeting Report No. 95

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WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

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NOTES

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WMO Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

WMO Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

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C O N T E N T S

EXECUTIVE SUMMARY

The second JCOMM Marine Instrumentation Workshop for the Asia Pacific Region was held in Tianjin, China, from 3 to 6 December 2012 at the kind invitation of the State Oceanic Administration (SOA) and the National Centre of Ocean Standards and Metrology (NCOSM) of China. About 50 participants from 8 Members/Member States attended the workshop.

The workshop recalled the importance of ocean observations to achieve socio-economical benefits at the global, regional, national, and local (e.g. Tianjin city) levels by addressing the requirements of WMO and IOC Applications, including the Global Framework for Climate Services (GFCS), and working in the multi-disciplinary frameworks of the IOC-WMO-UNEP-ICSU Global Ocean Observing System (GOOS) and the WMO Integrated Global Observing System (WIGOS).

The participants acknowledged the importance of standards and quality management on marine meteorology and oceanographic measurements, and received training on the theory, standards, methods, procedure, practice and data processing of the calibration of marine instruments (CTD in particular), aiming at improving participants' capacity of applying CTD instruments, therefore improving the data quality of ocean observation on a regional basis. Also, the Workshop served as a platform for discussions on methods, procedures and techniques of the intercomparison of CTD instruments as well as other ocean observation instruments. This work will contribute to the global intercomparison activities in the future.

The workshop issued series of recommendations detailed in *Annex III*, and concurred with the workplan proposed by the RMIC for Asia Pacific (RMIC/AP) for 2013.

The workshop thanked China, SOA, and the NCOSM for providing such excellent facilities to the countries of the Asia Pacific Region and to their strong commitment to operate the RMIC from now on.

WORKSHOP REPORT

1. Introduction

1.1 The WMO-IOC Regional Marine Instrument Center for the Asia-Pacific Region (RMIC/AP) was established by the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO through WMO Congress Resolution 9 (Cg-XVI) and IOC Resolution XXVI-9. The RMIC/AP holds activities in support of the Observation Programme Area (OPA), under the auspices of the Joint WMO-IOC Technical Commission for the Oceanography and Marine Meteorology (JCOMM).

1.2 In accordance with its Terms of Reference (JCOMM-III Recommendation 1), the goals of the RMIC/AP are: (i) to assist WMO Members/IOC Member States within its region in calibrating their national meteorological standards and related oceanographic monitoring instruments according to the RMIC capabilities; (ii) to organize training workshops; and (iii) to organize marine instrument inter-laboratory comparisons. It should be noted that recently, the RMIC/AP has begun to offer calibration services (seawater conductivity/salinity, seawater temperature, seawater depth, tide, wave) to WMO Members/IOC Member States.

1.3 Following the successful outcome of the First Workshop on Marine Instrumentation for the Asia-Pacific Region, held in Tianjin, China, in July 2011 (see JCOMM Meeting Report No. 87[1]), which focused on focused on metrological instrumentation technology, the Second JCOMM Marine Instrument Workshop for the Asia-Pacific Region was held at the RMIC in Tianjin, China, from 3 to 5 December 2012, at the kind invitation of the National Center of Ocean Standards and Metrology (NCOSM), China State Oceanic Administration (SOA). About 50 participants from 8 Members/Member States attended the workshop.

1.4 The objectives of the second Workshop are: (i) to enhance the Members/Member States capability with regard to their CTD operations; (ii) to facilitate the calibration and maintenance of marine instruments (CTD in particular); and (iii) to improve the data quality control of marine observations.

1.5 This Workshop was therefore especially designed for training on the theory, standards, methods, procedure, practice and data processing of the calibration of marine instruments (CTD in particular), aiming at improving participants' capacity of applying CTD instruments, therefore improving the data quality of ocean observation on a regional basis. Also, the Workshop served as a platform for discussions on methods, procedures and techniques of the intercomparison of CTD instruments as well as other ocean observation instruments. This work will contribute to the global intercomparison activities in the future.

1.6 Participants to the Workshop included scientists, experts, researchers, engineers and government managers involved in the fields of oceanography and marine meteorology from Member countries of WMO and IOC of the Asia-Pacific region, as well as members of RIMCs. The list of participants is provided in *Annex II*.

2. Main Activities of RMIC for the Asia-Pacific Region since the first workshop (i.e. July 2011-December 2012)

2.1 The RMIC/AP recalled the main activities of the centre since the first workshop in July 2011.

2.2 On 20 May 2012, the Unveiling Ceremony of RMIC for the Asia-Pacific Region was successfully held in Tianjin, with participation from the Executive Secretary of IOC, Dr. Wendy

1 ftp://ftp.wmo.int/Documents/PublicWeb/amp/mmop/documents/JCOMM-MR/JCOMM-MR-87-Rev2-RMIC2.pdf

Watson-Wright. At the fourth JCOMM Session, Yeosu, Republic of Korea, 23-31 May 2012, the official Certificate of the WMO-IOC Regional Marine Instrument Center for the Asia-Pacific Region was delivered to the representative of China.

2.3 The JCOMM-4 Session also selected an expert from the RMIC for the Asia-Pacific Region, Dr Jingli SUN (China), for leading JCOMM Observations Coordination Group (OCG) international inter-comparison activities. The RMIC/AP is also planning to lead JCOMM inter-comparison for specific variables.

2.4 The workshop noted with appreciation that the RMIC has now completed the translations into English of Specifications for the Calibration of CTD measuring instruments (*Annex IV*), as well as the China Observation/Instrumentation Standards List in 2012. These are made available to Members/Member States in the region. Preparations are underway for the RMIC to provide seawater temperature/conductivity/pressure/tides/waves instruments calibration services to Members/Member States as of 2013.

2.5 The workshop also noted that the RMIC has organized in June 2012 two national inter-comparisons separately focused on salinity meter and hygrothermograph. The RMIC/AP participated in the proficiency testing programme on the determination of sulphate, conductivity, pH and colour in waters that was conducted in February 2012 by Proficiency Testing Australia (PTA). The main aim of the program was to assess laboratories' abilities to competently perform the prescribed analyses. The RMIC/AP obtained satisfactory result in this programme (see Proficiency Testing Australia (PTA) report No. 758).

3. Training delivered to participants

3.1 The Workshop was conducted through class sessions, hands-on exercises and discussions.

3.2 The programme for the workshop is provided in *Annex I*.

3.3 The participants acknowledged the importance of standards and quality management on marine meteorology and oceanographic measurements, and thereby received comprehensive information for realizing the integration of ocean observations in the GOOS and WIGOS frameworks, and achieving the WMO and IOC Applications requirements. Training was provided on the following aspects:

- Introduction to the RMIC for the Asia-Pacific region;
- Need for high quality marine meteorological and oceanographic data, in particular for the Global Framework for Climate Services, and related development of the JCOMM Marine Climate Data System (MCDS);
- Global Ocean Observing System (GOOS) and IOC Standards for Seawater Calculation;
- Laboratory measurement uncertainty;
- CTD and its application in marine sciences;
- Accurate and reliable temperature measurement;
- XBT fall rate and temperature biases – correcting the historical record and planning for the future;
- CTD calibration methods and its application. Details of the RMIC/AP Metrological Verification Regulations for CTD Measuring Instruments are provided in *Annex IV*.

3.4 The workshop allowed information sharing and networking among the countries within and outside the region.In addition, a visit of the RMIC for the Asia-Pacific region was organized on

5 December. This included a visit of the laboratories, and hands on calibration of pressure, temperature, and salinity.

3.5 Training materials and presentations of the workshop are available on the JCOMM website[2].

4. Workshop recommendations and RMIC/AP workplan for 2013

4.1 The workshop reviewed and agreed on series of recommendations which are detailed in *Annex III*. The workshop concurred with the RMIC/AP workplan for 2013 as proposed by NOSCM. The workplan is also provided in *Annex III*.

4.2 The workshop thanked China, SOA, and the NCOSM for operating the RMIC/AP, for providing such excellent facilities, and for China's strong commitment to operate the RMIC from now on, and thereby to assist countries in the region in developing their capacities.

2: www.jcomm.info/rmic2-ra2

ANNEX I

PROGRAMME OF THE SECOND JCOMM MARINE INSTRUMENTATION WORKSHOP FOR THE ASIA-PACIFIC REGION
(Tianjin, China, 3-6 December 2012)

3th December 2012 (09:00 h – 17:00 h):

Morning (09:00 h – 11:40 h)

Time	*speakers*	*Title*	*Moderator*
09:00 (5 min)	Prof. MAO Bin Senior Advisor of RMIC for Asia-Pacific Region	Opening of the workshop	Prof. MAO Bin
09:05 (15 min)	Prof. WU Aina Director-General of RIMC for Asia-Pacific	Welcome remarks	
09:20 (10 min)	Mr. Charpentier Etienne WMO Scientific Officer	Opening remarks	
9:30 (10 min)	Mr. Gross Thomas UNESCO/IOC Programme Specialist	Opening remarks	
09:40 - Tea break and group photo(30 min)			
10:10 (20 min)	Prof. MAO Bin	Introduction to RMIC for Asia-Pacific Region	Prof. MAO Bin
10:30 (35 min)	Etienne Charpentier, WMO Scientific Officer	Marine Climate Data System (MCDS)	
11:05 (35 min)	Mr. Gross Thomas IOC/UNESCO Programme Specialist	Global Ocean Observing Systems(GOOS) and IOC Standards for Seawater Calculations	

Afternoon (14:00 h – 17:00 h)

Time	*speakers*	*Title*	*Moderator*
14:00 (70 min)	Ms. GAO Wei National Institute of Metrology (NIM)	Laboratory measurement uncertainty	Mr. Etienne
15:10 - Tea break (20 min)			
15:30 (60 min)	Ms. GAO Wei NIM	Continued	
16:30 (30 min)	Ms. GAO Wei NIM	Q&A	

4th December 2012 (8:30 h – 17:50 h):

Morning (08:30 h – 12:00 h)

Time	***Lead/speaker***	***Title***	***Moderator***
08:30 (80 min)	Dr.YU Huaming Ocean University of China	Quality Control and Pre-processing of the CTD Data	Mr.GROSS
09:50 (10min)		Q&A	
10:00 - Tea break (30 min)			
10:30 (80 min)	Prof. YAN Xiaoke NIM	Accurate and Reliable Temperature Measurement	
11:50 (10 min)		Q&A	

Afternoon (14:00 h – 17:50 h)

Time	***speakers***	***Title***	***Moderator***
14:00 (80 min)	Ms. Rebecca Lee COWLEY Centre for Australian Weather and Climate Research	XBT fall rate and temperature biases – correcting the historical record and planning for the future	Prof. MAO Bin
15:20 (10 min)		Q&A	
15:30 – Tea break (30 min)			
16:00 (100min)	Ms. SUO Lili Engineer RIMC for Asia-Pacific	CTD Calibration method and its application	
17:40 (10 min)		Q&A	

5th December 2012 (8:30 h – 18:00 h):

Morning (08:00 h – 12:00 h)

Time	
08:00 (60 min)	Meet at the hotel lobby and transport to RMIC for Asia-Pacific Region
09:00 (45min)	Visit the Laboratories at the Center
09:45 (120min)	Hands on calibration of pressure /temperature/salinity
11:45 (60 min)	Return to Hotel

Afternoon (14:30 h – 17:00 h)

Time	
14:30 (150min)	Meet at the hotel lobby & city tour

6th Dec. 2012 (7:50 h – 18:00 h):

Time	
7:50	Meet at the hotel lobby
09:00 (480min)	Attend the 2nd APEC Blue Economy Forum
17:40 (60 min)	Return to Hotel

ANNEX II

LIST OF PARTICIPANTS

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ANNEX III

RECOMMENDATIONS FROM THE WORKSHOP AND RMIC WORKPLAN FOR 2013

1) Recommendations from the workshop

The workshop agreed on the following recommendations:

1. The Recommendations from the first JCOMM Marine Instrumentation Workshop for the Asia-Pacific region (Tianjin, China, 11-13 July 2011) are still valid (see Annex V of JCOMM MR No. 87, Rev. 2);
2. A cooperation and technical coordination mechanism should be established in the region to allow the RMIC/AP to better address its Terms of Reference and maintain a close liaison and coordination in the region regarding the related activities. In particular, an international list of national focal points for ocean and marine meteorological instrumentation should be established within JCOMM (including a sub-list for the Asia Pacific). External institutions not directly involved in JCOMM should also be involved in this coordination mechanism (e.g. fisheries);
3. The RMIC/AP is invited to collect information on ocean observation programmes existing in the Asia Pacific region, and to make this information available to all through the RMIC/AP website;
4. Observing programme operators should use the recommended terminology and practices regarding the uncertainty of measurements as documented in the Guide to the Expression of Uncertainty Measurement (GUM 1995[3]) and in the WMO Guide to Meteorological Instruments and Methods of Observation (WMO No. 8).
5. Link with the marine meteorological and ocean instrument manufacturers should be enhanced, in particular to encourage them to use the recommended terminology and practices regarding the uncertainty of measurements (i.e. GUM guide);
6. Users of CTD instruments in the Asia-Pacific region are encouraged to use similar metrological verification regulations for CTD measuring instruments as used by the RMIC/AP as reproduced in *Annex IV*;
7. The Secretariat is invited to encourage Members and Members States of the Asia Pacific region to send marine meteorological and oceanographic measuring instruments (seawater temperature, conductivity, pressure, tides and waves) to the RMIC/AP for calibration and test purposes (calibration service to be provided free of charge in 2013);
8. Members and Member States of the Asia Pacific region are encouraged to participate in the planned inter-comparison of salinity measurements that will be organized in 2013 by the RMIC/AP;
9. A cooperation should be established between all RMICs so that they provide consistent support to their respective regions of interest, and can complement each other if needed;
10. The RMIC/AP is invited to develop training material (e.g. powerpoint presentations, videos), and make them available through the RMIC website; Members/Member States in the Asia Pacific region are also invited to contribute to the translation of such materials in their local own languages, and make the translated materials available to the RMIC for publication via the RMIC website.

3 JCGM 100:2008 (GUM 1995 with minor corrections) *Evaluation of measurement data - Guide to the expression of uncertainty in measurement* - http://www.bipm.org/en/publications/guides/

2) Work Plan of RMIC for the Asia-Pacific Region for 2013

No.	***Activity***	***Lead***	***Time frame***
1	To draft Terms of Reference of the Liaison/Coordination group for ocean instrumentation in the Asia Pacific region and submit to the Secretariat	RMIC/AP	By Feb. 2013
2	To consider establishing such groups in other regions	JCOMM OCG	May 2013
3	To issue WMO/IOC letters to Members/Member states in the Asia Pacific region (and beyond if such groups have to be established in other regions), requesting them to nominate national focal point for participating in the Liaison/Coordination group	Secretariat	May 2013
4	Members/Member States to nominate focal points for participating in the Liaison/Coordination group	Members/Member States	Jul. 2013
5	To provide to Members/Member States calibration services for seawater temperature, conductivity, pressure, tides and waves instruments	RMIC/AP	Ongoing
6	To encourage Members and Members States of the Asia Pacific region to send marine meteorological and oceanographic measuring instruments to the RMIC/AP for calibration and test purposes (calibration service to be provided free of charge in 2013)	WMO/IOC Secretariats	Ongoing
7	To organize the first meeting of the regional Liaison/Coordination group and the third Marine Instrumentation Workshop of the RMIC for the Asia-Pacific Region. The meeting will discuss how to carry out researches and practice on the marine standards, metrology and quality assurance in their own country, and gradually set up relevant management information database in the respective countries.	RMIC/AP	Jul. 2013
8	To organize Global Salinity Inter-comparison (with support/coordination by WMO/IOC Secretariat). RMIC/AP will particularly receive the information of the Inter-comparison and provide the summary of the activities to the workshop of 2013	RMIC/AP	Aug./Sep. 2013
9	To participate in the planned inter-comparison of salinity measurements that will be organized in Aug./Sep. 2013 by the RMIC/AP	Members/Member States	Aug./Sep. 2013
10	To collect information on ocean observation programmes existing in the Asia Pacific region, and to make this information available to all through the RMIC website	RMIC/AP	Ongoing
11	To approach the manufacturers and encourage them to use the recommended terminology and practices regarding the uncertainty of measurements (i.e. GUM guide)	WMO/IOC Secretariats	May 2013
12	To develop training material (e.g. powerpoint presentations, videos), and make them available through the RMIC website	RMIC/AP	End 2013
13	To contribute to the translation of such materials in their local own languages, and make the translated materials available to the RMIC for publication via the RMIC website	Members/Member States in the Asia Pacific region	Ongoing
14	To translate additional national marine standards and specifications of China calibration practices, and share them with Members/Member States in the Asia Pacific region	RMIC/AP	2013

ANNEX IV

RMIC FOR ASIA PACIFIC METROLOGICAL VERIFICATION REGULATIONS FOR CTD MEASURING INSTRUMENTS

The Metrological Verification Regulations
The People's Republic of China

JJG 763-2002

CTD Measuring Instruments

General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China

The Verification Regulation for CTD Measuring Instruments

JJG 763-2002
Is Substituted for
JJG 763-1992

The Verification Regulation for CTD Instruments

The Verification Regulation for CTD Instruments was approved by the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China on September 13, 2002 and came into force on March 13, 2003.

The Competent Organization:
The National Technical Committee on Environmental Chemistry Metrology

The Principal Institute for Drafting the Regulation:
The National Center of Ocean Standards and Metrology

The Co- Institute for Drafting the Regulation:
The National Institute of Ocean Technology of State Oceanic Administration

The interpretation of the regulation is entrusted to the National Technical Committee on Environmental Chemistry Metrology

The Principal drafters:

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The Co-drafters:

Yu Houlong (The National Institute of Ocean Technology of State Oceanic Administration)
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Contents

The Verification Regulation for CTD Instruments

1. Scope

The CTD Instruments Verification Regulations (the Regulations) is applicable for initial verification, subsequent verifications and in-use inspections of CTD instruments.

2. Overview

CTD instruments are primarily used for on-board surveys of the profiles of designated points on environmental elements such as conductivity, temperature, and depth, etc., thereby providing oceanic environmental data to support marine engineering, development and researches.

CTD instruments are classified into two types according to the ways of data recording: the self-contained type and the data-transmitting type. [1] A self-contained one has a data recorder and an individual power supply in its underwater part, the measured data are saved in the recorder and read out in the lab after the survey; A data-transmitting one has neither a data recorder nor an individual power supply in its underwater part. Its power is provided by surface power on deck with armored cables.[2] The measuring data are simultaneously transmitted to a deck unit for displaying and recording.

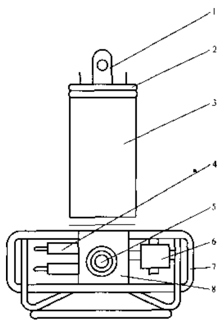

Fig.1 The Schematic diagram of the underwater component
1- hoist ring; 2- upper cover; 3-casing; 4-temperature sensor; 5-depth sensor; 6-salinity sensor; 7-protective frame; 8-tetrahedron

[1] The data-transmitting type also is called the direct-reading type now -- translator's note.
[2] The underwater part equipped with individual power supply currently is a trend – translator's note.

As the distinguished underwater components of the two types of CTDs are all enclosed inside the casing, the self-contained type and data-transmitting type share the same outline structure. The outline structure of the underwater components is shown in Fig. 1.

3. The requirements for a CTD performance verification

The verification of a CTD's performance should be conducted in accordance with the requirements shown in Table 1.

Table-1 The requirements for the performance of CTDs in various grades

Accuracy Grade		Superior	1st	2nd	3rd
Temperature /°C	Range	-2-35	-2~35	-2 ~35	-2-35
	Repeatability	≤0.0007	≤0.006	≤0.016	≤0.033
	Error of Indication	±0.002	±0.02	±0.05	±0.10
Conductivity /(mS/cm)	Range	0-65	0-65	0-65	0~65
	Repeatability	≤0.001	≤0.006	≤0.016	≤0.033
	Error of Indication	±0.003	±0.02	±0.05	±0.10
Pressure /MPa	Range	0.04-60	0-30	0-30	0-30
	Repeatability	≤0.003	≤0.01	≤0.05	≤0.2

	Error of Indication*	±0.015%F.S	±0.1%F.S	±0.5%F.S	±2.0%F.S
*：For pressure verification, the error of indication in the process of depressurization at the identical temperature and pressure points shall not exceed the corresponding values shown in this table.					

4. General technical requirements

4.1 Appearance inspection

4.1.1 The surface paint or coating of CTD instruments should be uniform in color, smooth and firm. No appearance damage that may affect the normal performance test is acceptable.

4.1.2 A CTD instrument should have the following nameplates and marks: the name and model of the instrument, the name of manufacturer, the date of production, the ex-factory number and the CMC mark. The instrument should come with complete spare parts and documents, as well as with the conformity certificate issued by the manufacturer.

4.1.3 The fasteners and connectors of a CTD instrument should be firmly held and fixed, without any loose sign.

5. The control of the verification equipment

The verification equipment includes those using for initial verification, subsequent verifications and in-use inspections.

5.1 The conditions of verification

5.1.1 The verification equipment

5.1.1.1 Key technical indicators of the equipment for verifying superior CTD instruments are shown in Table 2.

Table-2 Key technical indicators of the equipment for verifying superior CTD instruments

Standard Equipment	Measurement Ranges	Technical Indicators
Precision AC bridge for measuring temperature	(-5~35)℃	The limit of permissible error: ±0.0001℃
Benchmark platinum resistance thermometer	(-5~35)℃	The limit of permissible error: ±0.0003℃
Thermostatic seawater bath filled with verified natural seawater.	Seawater medium: (-2~40)℃ Glycol water medium: can reach down to -5℃	The volatility of controlled temperature: ≤0.000 3 ℃ The uniformity of temperature field: ≤0.000 3 ℃
Laboratory salinometer	(2~42)	The limit of permissible error: ±0.001
IAPSO International standard seawater	35	Uncertainty: 0.001 (*k*=3)
Standard dual-piston pressure gauge	(0.04 ~ 60) MPa	The limit of permissible error: ±0.005%
Note: When the pressure value ranges between 10% and		

Standard Equipment	Measurement Ranges	Technical Indicators
100% of the upper measuring limit, the indication error is ±0.005% of the actual value measured, while the pressure value is below 10% of the upper measuring limit, the indication error is ±0.005% of 10% of the measuring upper limit. This note also applies to Table-3.		

5.1.1.2 Key technical indicators of the equipment for verifying the 1st, 2nd and 3rd -grade CTD instruments are shown in Table 3.

Table-3 Key technical indicators of the verification equipment for verifying the 1st, 2nd and 3rd -grade CTD instruments

Standard Equipment	Measurement Ranges	Technical Indicators
Precision AC bridge for measuring temperature	(-5~35)℃	The limit of permissible error: ±0.001℃
First-class platinum resistance thermometer	(-5~35)℃	The limit of permissible error: ±0.002℃
Thermostatic seawater bath filled with verified pure natural seawater)*	Seawater medium: (-2~40)℃ Glycol water medium: -5℃	The volatility of controlled temperature: ≤0.002 ℃ The uniformity of temperature field: ≤0.001℃
Laboratory salinometer	(2 ~ 42)	The limit of permissible error: ±0.005
The standard seawater of China	35	Uncertainty: 0.003 (*k*=3)
Standard dual-piston pressure gauge	(1 ~ 60) MPa	The limit of permissible error: ±0.02%
* : 1. To measure the temperature coefficient of the seawater sample with a laboratory salinometer, the seawater sample must satisfy the requirements of natural seawater. Filter the seawater in the bath with the filtering devices for preparing the standard seawater and make it as clean as standard seawater. This procedure also applies to that in table 2. 2. When the temperature of thermostat bath is stable, read the indicated temperature value for 15 min with a uniform interval of no more than 1 min. The temperature volatility of the thermostat bath is ±1/2 of the difference of the maximum and the minimum values of the measured temperature values. The temperature uniformity of the temperature field refers to the temperature difference of any two points within the working area.		

5.1.2 Environmental conditions

5.1.2.1 Room temperature: for verifying the metering performances of the superior CTD instruments for temperature and conductivity: (20±2) ℃, for pressure: (20±1) ℃； for verifying the metering performances of other level CTD instruments: (20±2)℃.

5.1.2.2 Requirement for relative humidity: ≤70%

5.1.3 Source voltage: (220±22) V

5.2 The verification items

5.2.1 Table 4 The verification items.

Table 4 The list of verification items

No.	Verification items	Initial verification	Subsequent verifications	In-use inspection
1	Appearance inspection	+	+	+
2	Temperature error of indication	+	+	+
3	Temperature repeatability	+	-	-
4	Conductivity error of indication	+	+	+
5	Conductivity repeatability	+	-	-
6	Pressure error of indication	+	+	+
7	Pressure repeatability	+	-	-
Note: 1. The "+" sign indicates that inspection/verification is necessary for this item; while, the "-" sign indicates that inspection/verification is optional for this item; 2. Whenever installation or maintenance imposes significant impact on the metering performance of a CTD instrument, the subsequent verifications shall be conducted with the verification items of the initial verification.				

5.3 The methods of verification

5.3.1 Appearance inspection

In accordance with the requirements specified in paragraphs 4.1.1, 4.1.2 and 4.1.3 of the Regulations, the appearance of the CTD instruments should be inspected by vision and touch.

5.3.2 The verification of temperature error of indication and temperature Repeatability

5.3.2.1 Immerse the CTD instrument completely into the thermostat seawater bath, then carefully insert the standard platinum resistance thermometer and seawater sampling tube as close as possible to the inspected sensor, then put on the insulation cover of the thermostat seawater bath, and control the temperature in accordance with the *Operating Instruction of Thermostatic Seawater Bath*.

5.3.2.2 The specified temperature verification points are -5, 0, 5, 10, 15, 20, 25, 30 and 35□. When conduct temperature at the point of -5□, the medium in the thermostat bath shall be changed to 10% glycol water to meet the low temperature requirement.

5.3.2.3 When the temperature of the bath stabilizes at a verification point (i.e., the temperature volatility meets the requirement specified in table 2 or table 3), concurrently read out at least 10 sets of temperature data within 3 min with the standard bridge for measuring temperature and the verified CTD instrument as the data measured at this temperature point.

5.3.2.4 Calculate the temperature error of indication formula (1):

$$\Delta T_j = t_{jp} - T_{jp} \quad (1)$$

Where: t_{jp} -- Arithmetic mean of temperature readings at temperature verification point j measured by the verified CTD instrument, ^{0}C

T_{jp} -- Arithmetic mean of temperature readings at temperature verification point j measured by the standard bridge for measuring temperature, ^{0}C;

ΔT_j --- temperature error of indication at the temperature verification point j, ^{0}C, measured by the verified CTD instrument;

Take the ΔT_j with the largest absolute value (ΔT_j) as the temperature error of indication of the verified CTD instrument.

5.3.2.5 Calculate the instrument temperature repeatability by formula (2):

$$\sigma_{jt} = \left[\sum_{i=1}^{n} (t_{ji} - t_{jp})^2 / (n-1) \right]^{1/2} \quad (2)$$

Where: tji--- The ith temperature reading measured at the verification point j by the verified CTD instrument, 0C;
T_{jp} -- Arithmetic mean of temperature readings at verification point *j* by the verified CTD instrument, ^{0}C
n—number of temperature readings at the verification point measured by the verified CTD instrument, *n*=10;
σ_{jt} ---temperature repeatability measured at the verification point *j* by the verified CTD instrument, ℃;

Take the largest σ_{jt} as the temperature repeatability of the verified CTD instrument.

5.3.3 The verification of conductivity indication error and conductivity repeatability

5.3.3.1 Conductivity error of indication and conductivity repeatability should be verified according to the cooling sequence. The salinity value of the seawater in the thermostatic seawater bath is generally 35. Before immersing a pump-free CTD instrument into the thermostatic seawater bath, its conductance cell should be washed for 3 to 5 times with seawater.

5.3.3.2 Before reading the value at each verification point, use a brush to scrub the guide holes of the inductive conductance cell for 3 times, and move the instrument with the pump-free long electrode conductance cell up and down 3 times in the bath. Then, read at least 10 sets of conductivity values within 3 minutes, and use the numbered sampling bottles to take 2 bottles of seawater as sample from the sampling pipe. The sampling bottles should be washed 3 times beforehand, and then filled up to the bottleneck. The sampling bottles should then be corked and registered on the log sheet.

5.3.3.3 In accordance with the Operation Regulations for the Laboratory Salinometer, measure each bottle of seawater sample 3 times, and calculate the arithmetic mean as the measured salinity value of the sample. Lastly, calculate the standard conductivity value according to Appendix A at the corresponding temperature.

5.3.3.4 Calculate the conductivity error of indication of the verified CTD instrument according to formula (3):

$$\Delta C_j = C_{jp} - C_{jo} \quad (3)$$

Where: C_{jp} -- Arithmetic mean of temperature readings at verification point *j* of the verified CTD instrument, mS/cm;
Cj_o -- Arithmetic mean of standard conductivity indication values at verification point *j*, mS/cm;
ΔCj --- Conductivity error of indication measured at the verification point j of the verified CTD instrument, mS/cm;
Take the largest absolute value (ΔC_j) as the conductivity error of indication of the verified CTD instrument.

5.3.3.5 Calculate the conductivity repeatability of the instrument by formula (4):

$$\sigma_{jc} = \left[\sum_{i=1}^{n} (C_{ji} - C_{jp})^2 / (n-1) \right]^{1/2} \quad (4)$$

Where: C_{ji} --- The *ith* conductivity reading of the verified CTD instrument at the verification point *j*, mS/cm;
C_{jp} -- Arithmetic mean of conductivity readings of the verified CTD instrument at verification point *j*, mS/cm;
n—number of conductivity readings of the verified CTD instrument at the verification point, *n*=10;
σ_{jc} --- Conductivity repeatability of the verified CTD instrument at the verification point j, mS/cm;
Take the largest σ_{jc} as the conductivity repeatability of the verified CTD instrument.

5.3.4 The verification of pressure error of indication and pressure repeatability

5.3.4.1 Pressure verification points shall be taken at equal intervals within the pressure range of the verified CTD instrument, and the pressure shall be verified in the order from highest pressure point to the lowest pressure point.

5.3.4.2 Place the CTD instrument on the work bench of the standard piston pressure gauge, and then use a special quick connecting pipe to connect the gauge to the CTD's pressure sensor interface (drain the air inside the pipe beforehand), place weight gently in order at each verification point and simultaneously apply pressure gradually, within 3 min after the pressure is stabilized, read at least 10 sets of pressure values. Conduct air buoyancy correction according to Appendix B: Formula for Calculating Mass of Weight, Piston and Its Connecting Part when perform verification for a high-grade CTD instrument.

5.3.4.3 Temperature compensation performance shall be tested where the pressure measurement of the CTD instrument has a temperature compensation performance. Connect the pressure sensor of the instrument to the piston pressure gauge with a special copper tube before put the instrument into the thermostat seawater bath, adjust the height of the piston pressure gauge to the same level with the pressure sensor of the CTD instrument, so as to avoid any position difference. Temperature compensation points should be at 30□ and 0□, implement a pressure rising and descending process at each point according to the operating steps specified in paragraph 5.3.4.2 of the Regulation.

5.3.4.4 Calculate the pressure error of indication by formula (5):

$$\Delta p_j = p_{jp} - p_{jo} \qquad (5)$$

Where: P_{jp} -- Arithmetic mean of pressure readings of the verified CTD instrument at verification point *j*, MPa;
P_{jo} ---Standard pressure reading of the standard piston pressure gauge at the pressure verification point *j,* MPa;
ΔP_j – pressure error of indication of the verified CTD instrument at the verification point j , MPa;

Take ΔP_j with the largest absolute value as the pressure error of indication of the verified CTD instrument.

5.3.4.5 Calculate the pressure repeatability of the verified CTD by formula (6):

$$\sigma_{jp} = \left[\sum_{i=1}^{n} (p_{ji} - p_{jp})^2 / (n-1) \right]^{1/2} \qquad (6)$$

Where: P_{ji} – the *ith* pressure reading of the verified CTD instrument at the pressure verification point j, MPa;
P_{jp} -- Arithmetic mean of pressure readings of the verified CTD instrument at verification point *j*, MPa;
n—number of pressure readings of the verified CTD instrument at the verification point , *n*=10;
σ_{jp} – pressure repeatability of the verified CTD measuring instrument at the verification point j , MPa;

Take the largest σ_{jp} as the pressure repeatability of the verified CTD instrument.

5.4 Issuing verification certificate or rejection notice

A CTD instrument having passed the verification shall be issued with a verification certificate while that having failed the verification shall be issued with a rejection notice indicating non-conforming items.

5.5 The period of verification

The verification period of a CTD instrument generally should not be longer than 1 year. However, subsequent verification shall be carried out before and after a CTD instrument is shipped to and from the sea so as to ensure the quality of the marine environmental data measured by it.

Appendix A

The conversion formula between salinity and conductivity

A.1

$$S = a_0 + a_1 R_t^{1/2} + a_2 R_t + a_3 R_t^{3/2} + a_4 R_t^2 + a_5 R_t^{5/2} + \frac{t-15}{1+K\ (t-15)}\ (b_0 + b_1 R_t^{1/2} + b_2 R_t + b_3 R_t^{3/2} + b_4 R_t^2 + b_5 R_t^{5/2})$$

Coefficients: K=0.016 2, a_0 =0.003 0, a_1 = -0.169 2, a_2 =25.385 1, a_3 = 14.094 1, a_4 = -7 .0261 , a_5 = 2 .7081 , b_0 = 0 .0005,b_1 = -0.0056, b_2 = -0 .0066 , b_3= -0.0375 ,b_4 = 0.0636 ,b_5 = -0.0144;

R_t – The conductivity ratio of seawater at temperature *t;*

S-- The practical salinity of the seawater (PSS-78) .

A.2

$$R = R_t R_p r_t$$

where: R-- Conductivity ratio measured by CTD measuring instrument;

R_t – The conductivity ratio of seawater at temperature *t;*

R_p – The function of seawater depth (pressure),

$$R_p = 1+a$$

where:

$a = (A_1 p + A_2 p^2 + A_3 P^3) / (1 + \beta_1 t + \beta_2 t^2 + \beta_3 R + \beta_4 tR)$

$A_1 = 2.070 \times 10^{-5}$, $A_2 = -6.370 \times 10^{-10}$, $A_3 = 3.989 \times 10^{-15}$,

$\beta_1 = 3.426 \times 10^{-2}$, $\beta_2 = 4.464 \times 10^{-4}$, $\beta_3 = 4.215 \times 10^{-1}$,

$\beta_4 = -3.107 \times 10^{-3}$;

r_t – The function of the standard seawater temperature,

$$r_t = C_0 + C_1 t + C_2 t^2 + C_3 t^3 + C_4 t^4$$

where:

C_0 =0.676 609 7, $C_1 = 2.005\ 64 \times 10^{-2}$, $C_2 = 1.104\ 259 \times 10^{-4}$,

$C_3 = -6.969\ 8 \times 10^{-7}$, $C_4 = 1.003\ 1 \times 10^{-9}$.

Appendix B

The formula for calculating the masses of weights, pistons and connecting parts[1]

B.1

$$m = pA(1 + \rho_a/\rho_m)/g$$

where: *m*—The mass of weight, piston and its connecting part, kg;
p— The measured pressure, Pa;
A -– The effective area of the piston pressure gauge, m^2;
ρ_a --- Air density, calculated from the temperature, pressure and humidity, kg/m^3;
ρ_m— The material density of the weight, piston and its connecting part, kg/m^3
$\rho_{steel} = 7.8 \times 10^3\ kg/m^3$, $\rho_{aluminum} = 2.7 \times 10^3\ kg/m^3$
g -- The acceleration of gravity of the site where the piston pressure gauge is used, m/s^2

B.2

$$\rho_a = \frac{1.293\ 05}{1 + 0.003\ 67t} \times \frac{p - 0.377\ 9h}{1\ 013.25}$$

where: ρ_a—The air density of the verification chamber; kg/m^3
p—The air pressure of the verification chamber, hPa
h— The absolute humidity of the verification chamber, hPa
t— The air temperature of the verification chamber, ^oC

The calculation of *p and h refers to the Meteorological Table* compiled by the Central Meteorological Bureau of China (now the State Meteorological Administration of China) After the values of *p*, *h*, *t* are obtained, the air density ρ_a is then calculated by directly referring to the *Air Density Calculation Table* compiled by China Institute of Metrology.

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[1] The formula for piston pressure gauges has been revised in recent years.

Appendix C

CTD verification recoding sheet for temperature error of indication

<table>
<tr><td colspan="2">The model and name of standard bridge for measuring temperature</td><td colspan="3"></td></tr>
<tr><td colspan="2">The grade and model of standard platinum resistance thermometer</td><td colspan="3"></td></tr>
<tr><td colspan="2">The model, name, manufacturer and serial number of the CTD instrument for verification</td><td colspan="3"></td></tr>
<tr><td colspan="2">Client</td><td colspan="3"></td></tr>
<tr><td colspan="2">The appearance inspection result of the instrument</td><td colspan="3"></td></tr>
<tr><td colspan="2">The accuracy grade of the instrument</td><td colspan="3"></td></tr>
<tr><td>Verification points /℃</td><td>Standard temperature indications /℃</td><td>The mean of standard temperature indications /℃</td><td>The mean of instrument temperature indication /℃</td><td>Temperature error of indication /℃</td></tr>
<tr><td>35</td><td></td><td></td><td></td><td></td></tr>
<tr><td>30</td><td></td><td></td><td></td><td></td></tr>
<tr><td>25</td><td></td><td></td><td></td><td></td></tr>
<tr><td>20</td><td></td><td></td><td></td><td></td></tr>
<tr><td>15</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0</td><td></td><td></td><td></td><td></td></tr>
<tr><td>-5</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Verification Results</td><td colspan="4"></td></tr>
</table>

Room temperature: Air pressure: Humidity:
Tested by: Verified by: Date:

Appendix D

CTD verification recoding sheet for temperature repeatability

The model and name of standard bridge for measuring temperature	
The grade and model of standard platinum resistance thermometer	
The model, name, manufacturer and serial number of the CTD instrument for verification	
Client	
The appearance inspection result of the instrument	
The Accuracy Grade of the instrument	

Verification points /℃	Instrument temperature indication /℃	Repeatability of instrument temperature (℃)
35		
30		
25		
20		
15		
10		
5		
0		
-5		
Verification Results		

Room temperature: Air pressure: Humidity:
Tested by: Verified by: Date:

Appendix E

CTD verification recoding sheet for conductivity error of indication

The model and name of standard laboratory salinometer			
The name and batch number of standard seawater			
The model, name, manufacturer and serial number of the CTD instrument for verification			
Client			
The appearance inspection result of the instrument			
The accuracy grade of the instrument			
Standard temperature value /℃	The mean of standard conductivity /(mS/cm)	The mean of instrument conductivity indication (mS/cm)	Instrument conductivity error of indication / (mS/cm)
Verification Results			

Room temperature: Air pressure: Humidity:
Tested by: Verified by: Date:

Appendix F

CTD verification recoding sheet for conductivity repeatability

The model and name of standard laboratory salinometer	
The name and batch number of standard seawater	
The model, name, manufacturer and serial number of the CTD instrument for verification	
Client	
The appearance inspection result of the instrument	
The accuracy grade of the instrument	

Standard temperature value /℃	Instrument conductivity indication (mS/cm)	Instrument conductivity repeatability (mS/cm)
Verification Results		

Room temperature: Air pressure: Humidity:
Tested by: Verified by: Date:

Appendix G

CTD verification recoding sheet for pressure error of indication

The model and name of standard piston pressure gauge	
The model, name, manufacturer and serial number of the CTD instrument for verification	
Client	
The appearance inspection result of the instrument	
The accuracy grade of the instrument	

Standard pressure value / × 10^4Pa	The pressure indication of the verified CTD instrument			
	The mean of boosting pressure indication / × 10^4Pa	Boosting pressure error of indication / × 10^4Pa	The mean of depressurization indication / × 10^4Pa	Depressurization error of indication / × 10^4Pa
Verification Results				

Room temperature: Air pressure: Humidity:

Tested by: Verified by: Date:

Appendix H

CTD verification recoding sheet for pressure repeatability

The model and name of standard piston pressure gauge	
The model, name, manufacturer and serial number of the CTD instrument for verification	
Client	
The appearance inspection result of the instrument	
The accuracy grade of the instrument	

Standard pressure value / × 10^4Pa	Pressure indication of the verified CTD instrument			
	Boosting pressure indication / × 10^4Pa	Boosting pressure repeatability / × 10^4Pa	depressurization indication / × 10^4Pa	Depressurization repeatability / × 10^4Pa
Verification Results				

Room temperature: Air pressure: Humidity:
Tested by: Verified by: Date:

Appendix I

The page format of CTD verification certificate

The Verification Result

Items	Technical Requirements	Results	Conclusions
Appearance inspection			
Temperature error of indication			
Instrument temperature repeatability			
Conductivity error of indication			
Instrument conductivity repeatability			
Pressure error of Indication			
Instrument pressure repeatability			
Note: Please bring in this certificate for next verification.			

ACRONYM LIST

AIC	Argo Information Center
AP	Air Pressure
AQSIQ	General Administration of Quality Supervision, Inspection, and Quarantine (China)
Argo	Argo International Profiling Float Programme
AS	Andaman Sea
AST	Argo Steering Team
ATLAS	Autonomous Temperature Line Acquisition SystemBoB Bay of Bengal
BUFR	FM 94 BUFR GTS format: Binary Universal Form for Representation of meteorological data
BUOY	FM 18 BUOY GTS format: Report of a buoy observation
CB	Capacity-Building
CBS	Commission for Basic Systems (WMO)
Cg	Congress (WMO)
CIMO	Commission on Instruments and Methods of Observation (WMO)
CONOPS	WIGOS Concept of Operations
CTD	Conductivity, Temperature, and Depth measurement
DAR	Data Discovery, Access and Retrieval service (WMO WIS)
DB	Data Buoy
DBCP	Data Buoy Co-operation Panel (WMO-IOC)
DCPC	Data Collection and Production Centres (WMO WIS)
DMCG	Data Management Coordination Group (JCOMM)
DMPA	Data Management Programme Area (JCOMM)
DO	Dissolved Oxygen
EC	Executive Council
ET/DRC	CBS Expert Team on Data Representation and Codes (WMO)
ETDMP	Expert Team on Data Management Practices (JCOMM)
ETMC	Expert Team on Marine Climatology (JCOMM)
ETWS	Expert Team on Wind Waves and Storm Surge (JCOMM)
FG	First Guess Field
GCC	Global Collecting Centre (of MCSS)
GCOS	Global Climate Observing System (WMO, IOC, UNEP, ICSU)
GDAC	Global Data Assembly / Acquisition Centre
GDP	Global Drifter Programme
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GFCS	Global Framework for Climate Services
GHRSST	Group for High-Resolution SST
GISC	Global Information System Centres (WMO WIS)
GLOSS	Global Sea-level Observing System (JCOMM)
GOOS	Global Ocean Observing System (IOC, WMO, UNEP, ICSU)
GOS	Global Observing System (WMO)
GPS	Global Positioning System
GTS	Global Telecommunication System (WWW)
GUM	Guide to the Expression of Uncertainty Measurement
HF	High Frequency
HFSWR	HF Surface Wave Radar
HMEI	Association of Hydro-Meteorological Equipment Industry
ICOADS	International Comprehensive Ocean-Atmosphere Data Set (USA)
ICSU	International Council for Science
I-GOOS	Intergovernmental IOC-WMO-UNEP Committee for GOOS
InaGOOS	Indonesian Global Ocean Observing System
IndOOS	Indian Ocean Observing System
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IOCCP	International Ocean Carbon Coordination Project

IOCINDIO	IOC Regional Committee for the Central Indian Ocean
IODE	International Oceanographic Data and Information Exchange (IOC)
IOGOOS	Indian Ocean GOOS
ISDM	Integrated Science Data Management (formerly MEDS, Canada)
ISO	International Organization for Standardization
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
JCOMMOPS	JCOMM *in situ* Observations Programme Support Centre
MAN	JCOMM Management Committee
MCSS	Marine Climatological Summaries Scheme
MDCS	Marine Climate Data System
MOMSEI	Monsoon Onset Monitoring and its Social & Ecosystem Impacts
NC	National Centres (WMO WIS)
NCOSM	National Centre of Ocean Standards and Metrology (China)
NDBC	NOAA National Data Buoy Center (USA)
NEAR-GOOS	North East Asian Regional GOOS
NMDIS	National Marine Data and Information Service (China)
NOAA	National Oceanic and Atmospheric Administration (USA)
NOTC	Ocean Technology Center (China)
NWP	Numerical Weather Prediction
OceanSITES	OCEAN Sustained Interdisciplinary Timeseries Environment observation System
OCG	Observations Coordination Group (JCOMM)
ODAS	Ocean Data Acquisition Systems
ODASMS	ODAS Metadata Service (operated by China on behalf of JCOMM)
ODP	Ocean Data Portal (IODE)
OOPC	Ocean Observations Panel for Climate (GCOS-GOOS-WCRP)
OPA	Observations Programme Area (JCOMM)
PA	Programme Area (JCOMM)
PANGEA	Partnerships for New GEOSS Applications
PMO	Port Meteorological Officer
PP-WET	DBCP-ETWS Pilot Project on Wave measurement Evaluation and Test from moored buoys
QA	Quality Assurance
QC	Quality Control
QMF	WMO Quality Management Framework
QMS	Quality Management Systems
RAMA	Indian Ocean Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction
RMIC	IOC-WMO Regional Marine Instrument Centre
RMIC/AP	RMIC for the Asia Pacific region
RNODC	Responsible Oceanographic Data Centre (IODE)
RNODC/DB	RNODC for Drifting Buoys
RTMC	VOSClim Real-Time Monitoring Centre
SAC	Standardization Administration (China)
SAMS	Scottish Association for Marine Science
SCG	Services Coordination Group (JCOMM)
SeaDataNET	Pan-European infrastructure for Ocean & Marine Data Management
SEA-GOOS	South East Asian Regional GOOS
SFSPA	JCOMM Services and Forecasting Systems Programme Area
SLP	Sea Level Pressure
SOA	State Oceanic Administration (China)
SOC	Specialized Oceanographic Centre (JCOMM)
SOOP	Ship-Of-Opportunity Programme
SOOPIP	SOOP Implementation Panel (JCOMM)
SOT	Ship Observations Team (JCOMM)

SPA	JCOMM Services Programme Area (now SFSPA)
SST	Sea-Surface Temperature
TAO	Tropical Atmosphere Ocean Array
TC	Technical Committee
TD	Technical Document
TIP	Tropical Moored Buoys Implementation Panel
TT	Task Team
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	UN Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States fo America
VOS	Voluntary Observing Ship scheme (JCOMM)
VOSClim	VOS Climate class ship of the VOS fleet
WCRP	World Climate Research Programme
WCC-3	World Climate Conference 3
WDIP	WIGOS Test of Concept Development and Implementation Plan
WDIS	WIGOS Development and Implementation Strategy
WESTPAC	IOC Sub-Commission for the Western Pacific
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization (UN)
WTO	World Trade Organization
WWW	World Weather Watch (WMO)
XBT	Expendable BathyThermograph