

Working group proposal submitted to SCOR

IQuOD

International Quality Controlled Ocean Database:

Subsurface temperature profiles

June, 2015

1. Summary

Historical ocean temperature profile observations provide a critical element for a host of ocean and climate research activities. These include providing initial conditions for seasonal-to-decadal prediction systems, evaluating past variations in sea level and Earth's energy imbalance, ocean state estimation for studying variability and change, and climate model evaluation and development. The International Quality controlled Ocean Database (IQuOD) initiative represents a community effort to create the most globally complete temperature profile dataset, with comprehensive metadata and uncertainty information to promote progress in all of the above research avenues. In particular, IQuOD will facilitate improvements in expendable bathythermograph (and other) bias corrections and improved ocean state estimate products for forecast initialization and climate change studies through more complete metadata and uncertainty information. Internationally agreed "best practice" approaches to data quality control will be developed, documented and shared with the wider research community through open-source code bases. The freely available IQuOD database will be based on, and served alongside, the World Ocean Database – the most complete and widely used ocean profile database in the world. An IQuOD SCOR working group will be fundamental to progress 5 key elements of the wider IQuOD initiative: (1) development and application of algorithms to populate missing profile metadata; (2) development and documentation of "best practice" automated quality control procedures; (3) development and application of uncertainty estimates for each observation in a profile; (4) assembly and distribution of the IQuOD database; and (5) knowledge transfer and capacity building through international collaboration.

2. Scientific Background and Rationale

2.1 Importance of subsurface ocean temperature observations

Subsurface temperature is an essential ocean variable required to monitor variability and change in the physical ocean, Earth's energy flows, global and regional sea level, and also the overall state of health and wealth of the marine environment (FOO, 2012).

Variations in ocean temperature give rise to changes in mixed-layer depth, stratification, mixing rates, sea ice extent, and atmosphere and ocean circulation. All of these changes in the physical environment can affect marine biology, directly and indirectly through changes in marine biogeochemistry, such as nutrient and oxygen recycling, uptake of (anthropogenic) carbon emissions, ocean acidification, etc (Pörtner et al., 2014).

Changes in ocean heat content are directly derived from subsurface temperature. Since 1970s, heat uptake by the global ocean accounts for more than 90% of the excess heat accumulated in the Earth system associated with anthropogenic climate change (Rhein et al., 2013). While this ocean heat

uptake mitigates surface warming, it increases the ocean's volume through thermal expansion, accounting for about 1/3 of the observed global mean sea level rise (Church et al., 2013).

Subsurface ocean temperature observations also underpin a number of modeling activities (e.g., www.godae.org/What-is-GODAE.html). In particular, high quality long-term ocean temperature records with well characterized uncertainty estimates are needed to evaluate and constrain global climate and Earth system models in order to better quantify the physical drivers of past and current change, and also to predict future changes in both the marine and terrestrial environment (Flato et al., 2013).

Improved understanding of global climate change represents one of society's most pressing challenges and also the most demanding application of subsurface ocean temperature data. This is because it requires the highest quality, most consistent and complete database, to place modern changes in the context of past changes (e.g., mean trends and extremes), to separate the influence of natural drivers from human activities (Bindoff et al., 2013), and to improve the effectiveness of risk management assessments (identification of vulnerabilities, adaptation and mitigation responses).

2.2 The challenge

There is an increasing demand for a climate-quality global ocean temperature profile database (including complete metadata and well characterized uncertainty estimates) to underpin a host of climate change research activities carried out by both observational and modeling communities. Historical subsurface temperature observations, however, have been largely collected for purposes other than understanding global change, by a mix of evolving technologies (e.g., instruments with various accuracies and biases), and in many instances only available with reduced vertical resolution and/or incomplete metadata. Despite dedicated efforts by independent groups, the global historical database still contains a relatively large fraction of biased, duplicate and poorly quality controlled temperature observations that can confound global ocean and climate change research.

2.3 The IQuOD initiative

The overarching goal of the IQuOD initiative is to produce and to freely distribute the highest quality, most complete and consistent historical subsurface ocean temperature global database, along with (intelligent) metadata and assigned uncertainties.

With an internationally coordinated effort organized by oceanographers, with data and ocean instrumentation expertise, and in close consultation with end users (e.g., climate modelers), the IQuOD initiative will assess and maximize the potential of an irreplaceable collection of ocean temperature observations (tens of millions of profiles collected at a cost of tens of billions of dollars, since 1772) to fulfil the demand for a climate-quality global database that can be used with greater confidence in a vast range of climate change related research and services of societal benefit. Current

IQuOD membership includes groups from Argentina, Australia, Brazil, Canada, France, Germany, India, Japan, Mexico, Norway, Russia, Senegal, Spain, South Africa, UK, and USA.

2.4 Rationale and timeliness for an IQuOD-SCOR working group

Only by focusing expertise and resources into a single best practice international community effort, we will be able to deliver a much needed historical “climate quality” subsurface temperature database to the global ocean and climate research communities. No single group has the combined expertise and resources to develop, implement and apply the best standard quality control procedures, in an effective and timely manner.

An internationally coordinated SCOR working group, potentially co-sponsored by IAPSO, and with formal support from the IOC Committee on International Oceanographic Data and Information Exchange (IODE), will provide the best mechanism to progress 5 critical steps towards the overarching goal of the IQuOD initiative during the next 3 years. These are: (1) development and application of algorithms to populate missing profile metadata; (2) development and documentation of “best practice” automated quality control procedures; (3) development and application of uncertainty estimates for each observation in a profile; (4) assembly and distribution of the IQuOD database; and (5) knowledge transfer and capacity building through close international collaboration.

Strong international participation is essential to draw on the widest possible pool of expertise and for IQuOD to be adopted as the definitive database for ocean and climate research activities. The IQuOD community has shown itself to be a well-organized international group – having already held two international workshops (in Hobart, Australia June 2013 and Silver Spring, USA in June 2014). However, insufficient funding has prevented key members from attending these workshops. Funding from SCOR would allow the IQuOD initiative to gain 'critical mass' to ensure good progress over the next 3 years. This progress would be used to leverage further funding for task team activities as well as to expand the membership of the IQuOD community.

There are two main elements to the timeliness of the IQuOD-SCOR working group. The first is that there is an urgent need to capture and retain the knowledge of the older instrumentation types from researchers who are nearing retirement age. The second is that the Argo array of profiling floats has now provided about a decade of quasi-global observations and improved understanding of the ocean mean state and variability with which to refine our quality control procedures and better discriminate between good and bad data points in the historical record.

3. Terms of Reference

1. To develop, implement and document algorithms for assignment of “intelligent” metadata – i.e. an informed guess as to likely values for missing information – for temperature profiles where crucial metadata is missing.
2. To evaluate and document the most effective combination of automated quality control (AutoQC) procedures for temperature profile observations. International collaboration will be required for the design and coordination of benchmarking experiments using high quality reference datasets.
3. To establish and implement a set of optimal automated quality control procedures, by reaching international community consensus and using the knowledge gained in the benchmarking tests from ToR-2 (above); to produce and publish a reference guide for best practices in automated quality control of ocean temperature profiles; and to develop and freely distribute an open-source quality control software toolkit to promote wide and rapid adoption of best practices by the oceanographic community.
4. To examine and document the feasibility of machine learning and other novel computational methods for enhanced quality control, to potentially minimize labor costs associated with human expert quality control procedures.
5. To develop, implement and document internationally agreed best practice methods for assignment of uncertainty estimates to each temperature observation.
6. To freely disseminate (interim) versions of the IQuOD global temperature profile database (and added value-products) as it evolves over the next 3 years, in user-friendly file formats.
7. To share knowledge and transfer skills in instrumentation, regional oceanography, quality control procedures and data stewardship with international scientists in both developed and developing nations.

4. Work Plan

The IQuOD working group will progress the Terms of Reference in Section 3 by convening annual meetings over the next 3 years (upon funding by SCOR), together with regular email exchange, online meetings, information exchange through web-based access (www.iquod.org) and code development via the Mozilla Science Lab (gitHub) validation suite forum (www.mozillascience.org/projects/autoqc).

SCOR-funded meetings will be scheduled to coincide with relevant group meetings (e.g., SOT/SOPIP, GTSP, XBT Science Team, GO-SHIP, Argo, IAPSO/IUGG, GODAE) to encourage interactions with both data experts and user groups, and maximize visibility and community participation in IQuOD activities. We will seek joint sponsorship and/or endorsement for IQuOD from IAPSO, WCRP/CLIVAR and US CLIVAR (Section 9).

The main activities for the work plan are:

(1) Development and application of algorithms for inclusion of intelligent metadata

We will develop and apply algorithms to attach “intelligent metadata” to historical temperature profiles with missing metadata. These algorithms will be developed as informed guesses, based on the available metadata. For instance, XBT manufacturer can often be inferred by the nationality of the vessel or research cruise, and likely probe type can be inferred from profile termination depth. Our initial focus will be on improving XBT metadata, but will later be expanding to include additional instrument types. XBT data comprise the largest fraction of the historical temperature observations and about 50% of these observations in the World Ocean Database have missing metadata (e.g., probe type, manufacturer, logging system, etc; Abraham et al., 2013). Inclusion of intelligent metadata will facilitate refinements to instrumental bias corrections and will promote a more homogeneous long-term ocean record critical for climate change research, data assimilation and modeling efforts.

(2) Development, implementation and dissemination of best practice automated quality control procedures

We will share expertise by performing a series of quantitative “benchmarking” automated quality control (AutoQC) tests among several data center groups and will establish an agreed best practice approach. Benchmarking results will be published in an open access peer-reviewed journal and will form the basis of the SCOR-funded IQuOD AutoQC toolkit, including open access reference guides and software tools made freely available to the wider oceanographic community. Data flagged as questionable by the best practice AutoQC tests will be carried forward to an IQuOD Task Team on “Enhanced Quality Control Procedures” (these activities are outside the scope of the SCOR working group).

(3) Development of uncertainty estimates

We will develop and document estimates of the random error for each individual observation, based on the current literature and manufacturer specifications. In liaison with end user communities, we will consider the wider treatment of uncertainties – such as that associated with XBT bias corrections in light of incomplete metadata – and how to best combine several sources of uncertainty.

(4) Global database assembly and distribution

The starting point for the IQuOD database will be NOAA's National Centers for Environmental Information (NCEI) World Ocean Database, which is the most complete global repository of ocean temperature profiles. We will ensure that the data format can accommodate all of the additional information that the IQuOD working group will provide. NCEI will also serve the IQuOD database (interim) versions (and any related gridded products), as it becomes available along the course of the next 3 years. IQuOD data products will also be served alongside Coupled Model Intercomparison (CMIP) data for climate model evaluation in collaboration with colleagues from the Program for Climate Model Diagnostics and Intercomparison (PCMDI, see attached letter of support).

Timeline

Year 1: will focus on the development and delivery of 'first cut' algorithms for intelligent metadata and random error assignments. We will also work towards coding up of all partner AutoQC procedures in a standard, open-source programming language (python). Version 1 of the IQuOD database will include intelligent metadata and initial uncertainty estimates. The first SCOR working group meeting will focus on achieving an agreed roadmap to progression of these tasks.

Year 2: will focus on the benchmarking of the various AutoQC procedures using a number of high quality regional reference data sets. These reference datasets have been quality controlled by skilled operators familiar with the regional oceanography, e.g., the QuOTA dataset (<http://www.marine.csiro.au/~cow074/quota/quota.htm>). The benchmarking analysis will identify the most effective combination of AutoQC checks and the work will be submitted to an open access scientific journal. The AutoQCed database, in combination with any advances in random error and intelligent metadata assignment, will constitute version 2 of the IQuOD database. The second SCOR working group meeting will serve to discuss the outcomes of Year 1, to share the results of the benchmarking tests and to provide an international forum for a consensus on best practices for AutoQC procedures for temperature observations.

Year 3: will focus in the preparation and submission of scientific papers related to the AutoQC benchmarking exercise; on the publication of version 3 of the IQuOD database with updates and improvements from the previous two years, including related documentation (reference guides and software tools). We will also be report on the feasibility of using machine learning (or other novel computational) methods for the expert quality control step, through publication of a discussion article. The third SCOR working group meeting will be organized as a large international workshop for knowledge transfer and capacity building, to encourage rapid and wide adoption of best standards for quality control of historical temperature profile data, inclusion of intelligent metadata and uncertainty. We will also seek additional funding sources to ensure maximum international participation, particularly from developing countries not yet involved in IQuOD.

5. Deliverables

1. (Years 1-3 and ToR 1-7) Versions 1 to 3 of the IQuOD database will be served from the NCEI website annually. Version 1 will contain all available metadata and intelligent metadata for XBTs, with initial uncertainty estimates. Version 2 will contain Automated QC flags and any other improvements to version 1. Version 3 will further contain updates and improvements from version 2.
2. (Years 1-2 and ToR 1, 5) Algorithms developed for assigning intelligent metadata and uncertainties will be published in an open-access peer-reviewed journal as part of the IQuOD v1 documentation. The source code will be made publicly available.
3. (Years 2-3 and ToR 2, 3) The IQuOD Automated QC algorithms will be documented and the source code made available on an open source software repository. The benchmarking results will be published in an open-access peer-reviewed journal as part of the IQuOD v2 documentation.
4. (Year 3 and ToR 4) The IQuOD community will publish a discussion article on the potential for novel methods (e.g. machine learning) to improve automated quality control systems.

6. Capacity Building

One of the key aims of IQuOD is to provide a long-lasting database for oceanography and climate change studies. It will be maintained at the National Centers for Environmental Information (formerly the National Oceanography Data Center, USA) alongside the World Ocean Database. IQuOD will facilitate new ocean and climate research based on the highest possible data quality with the most complete uncertainty and metadata information. All data, documentation and processing algorithms will be placed in the public domain to ensure maximum utility of working group activities for the wider research community.

The global IQuOD database will draw on and preserve knowledge and skills from a large community of data experts. These skills and knowledge pertain to a number of areas, including: instrumentation; quality control methods; data homogenization techniques; and regional oceanography. Knowledge transfer will be initially facilitated through international workshops but we expect to achieve longevity through fostering a new community of ocean scientists from both developed and developing nations. Guidance on “best practices” and open-access documentation will ensure that the progress made by this community is recorded and long lasting.

The SCOR working group will actively help build capacity by funding participants from developing nations to attend workshops and working with the community to leverage further funding from other sources.

7. Working Group Composition

7.1 Full members

	Name	Gender	Place of work	Expertise
1	TVS Udaya Bhaskar	M	Indian National Centre for Ocean Information Services (INCOIS), India	Automated and manual quality control; data processing; development of gridded products; web hosting; and ocean climate science.
2	Tim Boyer	M	National Centers for Environmental Information (former NODC), NOAA, USA	Data aggregation, quality control; database management; interoperability (file format); gridded data products; web hosting, and ocean climate change science.
3	Marcela Charo	F	Departamento Oceanografía, Servicio de Hidrografía Naval, Ministerio de Defensa, Argentina	Quality control; database management (Southwestern Atlantic Ocean); calibration and sensor expertise; software development, and ocean climate science.
4	Christine Coatanoan	F	Coriolis Data Center, IFREMER, France	Quality control procedures, data validation, management and objective analysis.
5	Catia Domingues (co-chair)	F	University of Tasmania, Australia	User: Global ocean content and implications for sea level. Steering team member of the WCRP Grand Challenge on sea level change and coastal impacts. Steering team member of the CLIVAR Research Foci CONCEPT-HEAT. Member of the CLIVAR Global Synthesis and Observations Panel.
6	Viktor Gouretski	M	University of Hamburg, Center for Earth System Research and Sustainability, Germany	Ocean instrumentation, quality control of hydrographic data, data processing and analysis, instrumental bias assessment and correction, uncertainty estimation, ocean climate change science (Southern Ocean and global).
7	Shoichi Kizu	M	Tohoku University, Japan	Theoretical knowledge on quality control, ocean instrumentation and bias corrections.
8	Alison Macdonald	F	Woods Hole Oceanographic Institute, USA	Quality control of temperature and salinity in density space, production of hydrographic data sets, database management, ocean instrumentation and calibration, uncertainty estimation, property transports and decadal scale property differences.
9	Matt	M	Met Office,	User: Climate modeling, ocean reanalysis.

	Palmer (co-chair)		UK	WCRP CLIVAR Global Synthesis and Observations Panel co-chair. Steering member for CLIVAR Research Foci CONCEPT-HEAT.
10	Ann (Gronell) Thresher	F	CSIRO, Australia	Auto and manual quality control procedures, ocean instrumentation and sensors, data management and software development. Extensive scientific, GTSP, WOCE and Argo quality control experience.

7.2 Associate members

	Name	Gender	Place of work	Expertise
1	Lijing Cheng	M	International Center for Climate and Environment Sciences, Institute of Atmospheric Physics Chinese Academy of Sciences, Beijing, China	XBT bias assessment, development of bias correction, and ocean climate science.
2	Mauro Cirano	M	Oceanographic Modeling and Observation Network (REMO), Tropical Oceanography Group (GOAT), Federal Univ. of Rio de Janeiro, Brazil	Data assimilation, numerical modeling, observational and modeling network.
3	Rebecca Cowley	F	CSIRO Marine and Atmospheric Research, Australia	Hydrographic data calibration and processing, quality control, data management, instrumental bias correction, and ocean climate science. Chair of XBT SOOPIP (Ship of Opportunity Implementation Program) under WMO-IOC JCOMMOPS (Joint Technical Commission for Oceanography and Marine Meteorology in situ Observations Programme Support Centre).
4	Sergey Gladyshev	M	P.P. Shirshov Institute of Oceanology, Moscow, Russia	Quality control, data management, ocean instrumentation and ocean climate science.
5	Simon Good	M	UK Met Office Hadley Centre, UK	Data aggregation, quality control; database management; interoperability (file format); gridded data products; software development, web hosting, and ocean climate change science.

6	Francis Bringas Gutierrez	M	Atlantic Oceanographic and Meteorological Laboratory, (AOML, NOAA), USA	Data acquisition, quality control, and management.
7	Katherine Hutchinson	F	University of Cape Town - Department of Oceanography (UCT), South Africa	Instrumental bias assessment and Southern Ocean science.
8	Gabriel Jorda	M	University of the Balearic Islands, Mediterranean Institute for Advanced Studies (IMEDEA CSIC-UIB), Spain	Hydrographic data analysis, atlas production (Mediterranean), ocean modeling and ocean climate science.
9	Sergio Larios	M	Centro Nacional de Datos Oceanograficos, Universidad Autonoma de Baja California, Instituto de Investigaciones Oceanologicas (CENDO - IIO – UABC), Mexico	Data acquisition and processing, quality control, database management, web hosting, outreach (teaching data visualization tools).
10	Toru Suzuki	M	Marine Information Research Center, Japan	Data archaeology, quality control and data management.

8. Working Group Contributions

TVS Udaya Bhaskar is Scientist-in-Charge for ocean observational data and is involved in data search, rescue and archaeology of historical in situ data of the Indian Ocean. He has considerable experience in quality control of in situ data and is involved in developing new quality control methods.

Tim Boyer oversees the World Ocean Database (WOD) project for the National Center for Environmental Information (NCEI, former National Oceanographic Data Center (NODC)) at the National Oceanographic and Atmospheric Administration (NOAA) in the United States. He has been involved in collaborative international work for the World Data Center – Oceanography (WDC-O) and in using ocean temperature profile data to study ocean heat content change.

Marcela Charo is a data scientist with wide experience in planning and acquisition of oceanographic data, on-board sensor calibration, quality control of various instruments (XBT, CTD, Thermosalinograph) and sensors (temperature, conductivity, oxygen, fluorescence). She also has extensive experience in post-processing and data management after cruise acquisition to ensure high quality measurements now and in the future.

Christine Coatanoan is an expert on quality control applied to oceanographic datasets (floats, buoys, research vessels, ships of opportunity, drifters, gliders, sea mammals), which are collected at the

Coriolis data center in France. She is also involved in the Argo program, and has experience in data validation using objective analysis.

Catia Domingues (co-chair) is an expert on the application of observational data sets to the understanding of variability and change in ocean heat content and implications for sea level. Her role in the project is scientific oversight and end user engagement to promote the greatest utility of IQuOD products for downstream applications (e.g., climate science and services).

Viktor Gouretski is responsible for quality assessment and analysis of global hydrographic data as a member of the Integrated Climate Data Center (ICDC) at the University of Hamburg, Germany. He has considerable experience in the quality assessment of hydrographic data obtained during the World Ocean Circulation Experiment (WOCE) and during pre-WOCE period, particularly from the Southern Ocean. His role in the IQuOD project is the development and assessment of automated quality control procedures and the development of bias correction schemes for the bathythermograph data and uncertainty estimation.

Shoichi Kizu is an Associate Professor at Tohoku University. He has carried out numerous studies on oceanographic instruments through data analysis and field and laboratory experiments, and participates in a Japanese research project on the management, service and application of observational data.

Alison Macdonald has expertise in quality controlling and analysing multiple parameters from large hydrographic data sets including repeat hydrographic sections. She is currently an active participant in the GO-SHIP program and was previously involved in large global observational programs (WOCE/CLIVAR). She is particularly interested in contributing to the discussions and formulation of the uncertainty estimates for the IQuOD database.

Matt Palmer (co-chair) is Lead Scientist for Sea Level Research at the Met Office Hadley Centre with expertise in ocean observations and climate model applications. He has considerable experience in delivering science through teamwork, having been involved in coordinating coupled model assessment and leading the delivery of scientific projects for UK government, the European Union, and commercial research projects.

Ann (Gronell) Thresher has been working in upper ocean temperature (UOT) data since the inception of WOCE, developing the principles of scientific quality control and applying this to both the data collected by Australian institutions and further developing this and applying it to the QuOTA database of Indian Ocean UOT data, a similar effort to that proposed for IQuOD. This includes development and implementation of a semi-automated quality control system which has helped illustrate the need for the IQuOD project.

9. Relationship with Other Programs and SCOR Working Groups

International Oceanographic Data and Information Exchange (IODE)

Recommendation IODE-XXIII.3: ESTABLISHMENT OF THE IODE PROJECT INTERNATIONAL QUALITY CONTROLLED OCEAN DATABASE (IODE-IQUOD)

The IOC Committee on International Oceanographic Data and Information Exchange,

Recognizing that the goal of the International Quality-controlled Ocean Database (IQuOD) is to construct the most complete, consistent and high quality ocean temperature (later including other Essential Climate Variables) historical database, with intelligent metadata and assigned uncertainties, to freely distribute for use in ocean, climate and Earth system research and applications of societal benefit,

Recognizing further that the IQuOD effort is organized by the oceanographic community and includes experts in data quality and management, data instrumentation, oceanographers, climate modelers and the broader climate-related community,

Noting the interlinked relationship with the Global Oceanographic Data Archaeology and Rescue (GODAR) and the World Ocean Database (WOD) Projects through Recommendation IODE-XXII.10 (2013) and the Global Temperature and Salinity Profile Programme (GTSP) established through Recommendation IODE-XV.4 (1996),

Noting further the potential contribution of the IQuOD to the JCOMM-IODE Marine Climate Data System (MCDS),

Convinced that joint work between the IODE and the IQuOD will be mutually beneficial,

Recommends the establishment of IQuOD as an IODE project; the establishment of the IODE Steering Group for the International Quality controlled Ocean Database (SG-IQuOD); and that the membership of the Steering Group shall initially include the Chair of GTSP, representatives of WOD and GODAR projects and of the Task Team on the MCDS.

Encourages all IOC Member States, Programmes, relevant organizations and projects, to collaborate with the IQuOD,

Invites the IQuOD Project Leaders to report on progress of the project to the Sessions of the IODE Committee.

In addition to being IQuOD members, Toru Suzuki, Charles Sun and Tim Boyer are also involved with IOC/IODE-related projects, such as GTSP, GODAR, MCDS and WOD.

Global Ocean Data Assimilation Experiment (GODAE)



GODAE OceanView

15 April 2015

Letter of support for "IQuOD: International Quality-controlled Ocean Database"

To Whom It May Concern:

In our function as co-chairs of the international programme [GODAE OceanView](#) which provides coordination and leadership in consolidating and improving global and regional ocean analysis and forecasting systems, we hereby state our support for the IQuOD (International Quality Controlled Ocean Database) initiative. IQuOD represents the first globally coordinated effort with the goal to develop the most complete, consistent and high quality ocean profile database to support a range of ocean, climate and Earth system research and services of societal benefit.

The particular aspects of the project that we would like to highlight as of direct benefit to the GODAE OceanView community are:

- Provision of a highest quality reference data set, which can be used for bench-marking ocean data assimilation systems and producing global and regional ocean analyses
- Comprehensive uncertainty estimates on a per observation basis, which will enable refinements to data assimilation schemes and could also be adopted in operational systems
- Development of improved and internationally agreed "best practice" automated QC algorithms that can be adopted by the operational data centers of the GODAE community

We intend to follow the project's progress and, as a community, be directly involved in using IQuOD data products, promoting dialogue on data quality and articulating our requirements and priorities as an end user. There are existing linkages between IQuOD and GODAE OceanView through the Ocean Reanalysis Intercomparison Project (ORA-IP) and through the activities of the CLIVAR Global Observations and Synthesis Panel, which we hope to exploit fully as IQuOD gathers momentum.

With best wishes,

Andreas Schiller, CSIRO, Australia

Fraser Davidson, Fisheries and Oceans, Canada

Co-Chairs of the GODAE OceanView Science Team (GOVST)

For further information about GODAE OceanView please visit our website (www.godae-oceanview.org)

Program for Climate Model Diagnostics and Intercomparison (PCMDI)

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IQuOD Science Team
23rd April 2015

REF: IQuOD Project ("International Quality-controlled Ocean Database") Case for Support

To Whom It May Concern:

We are writing in support, and with the intention to collaborate with the IQuOD (International Quality Controlled Ocean Database) initiative. IQuOD represents the first globally coordinated effort with the goal to develop the most complete, consistent and high quality ocean profile database to support a range of ocean, climate and Earth system research and services of societal benefit.

IQuOD data products will be of direct benefit to a diverse range of climate modeling and research activities, including:

- Initial conditions and hindcast skill assessment for seasonal-to-decadal prediction
- Climate model evaluation and development
- Detection and attribution of historical climate change
- Development of observational constraints on future climate change

As part of this collaboration, we will work with the IQuOD team to help facilitate the integration of IQuOD data products into the World Climate Research Program's (WCRP) and Coupled Model Intercomparison Projects (CMIP) Earth System Grid Foundation (ESGF) data infrastructure. Making the IQuOD data available in this way will ensure maximum utility of IQuOD data products in climate and Earth system modeling research. We are also interested in working closely with the IQuOD team as the database evolves to include salinity observations in the future, which will be a valuable extension for assessing changes in the hydrological cycle.

We believe that a lack of critical diagnostic analyses of the ocean component of coupled climate models remains a key weakness in our understanding of future climate change – as the global oceans provide a fundamental control on the rate of climate change experienced. The IQuOD initiative is very much required.

Yours sincerely,

A handwritten signature in blue ink, appearing to read "Paul J. Durack and Peter J. Gleckler". The signature is fluid and cursive, with the names written in a single line.

Paul J. Durack and Peter J. Gleckler
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US CLIVAR

IQuOD activities will be strategically placed to support the new 15-year US CLIVAR Science Plan (<http://www.usclivar.org/sites/default/files/documents/2014/USCLIVARSciencePlanFINAL-v3.pdf>).

To achieve its mission, a list of scientific goals has been set with progress dependent on assessments of the adequacy of historical records, including the historical ocean temperature database (the focus of the IQuOD initiative). IQuOD activities will underpin the following US CLIVAR Science Plan goals:

- Understand the role of the oceans in observed climate variability on different timescales.
- Understand the processes that contribute to climate variability and change in the past, present, and future.
- Better quantify uncertainty in the observations, simulations, predictions, and projections of climate variability and change.
- Improve the development and evaluation of climate simulations and predictions.
- Collaborate with research and operational communities that develop and use climate information.

Janet Sprintall (Scripps Institution of Oceanography, USA) is the IQuOD representative and has previously been a member of the US CLIVAR Science Steering Committee (2012-2014).

CLIVAR Research Foci (RF) on planetary heat balance and ocean heat storage (CONCEPT-HEAT)

To advance understanding on the magnitude of the Earth's energy imbalance, how it is changing over time and implications for future climate change, there is a need to reduce inconsistencies between data and model products as well as to properly assess uncertainties in global and regional estimates – including the contribution from ocean heat storage, for both historical and modern periods. One activity recommended by the CONCEPT-HEAT RF is the improvement of the quality and completeness of the global database of historical ocean temperature profiles and its consistency with modern observations from the Argo era, including coordinated support for data and metadata archaeology. IQuOD will be coordinating with CONCEPT-HEAT to achieve the above goals. Catia Domingues and Matt Palmer (IQuOD co-chairs for the proposed SCOR working group) are members of the Science Steering Committee for CONCEPT-HEAT.

CLIVAR Global Synthesis and Ocean Panel (GSOP)

The IQuOD will be one of the future priorities for the World Climate Research Programme (WCRP) CLIVAR GSOP panel, as noted during the SSG meeting in Moscow, November 2014 (ICPO Informal Report 196/14). Matt Palmer and Catia Domingues (IQuOD co-chairs for the proposed SCOR working group) are respectively a co-chair and a panel member of the CLIVAR GSOP.

WCRP Grand Challenge on regional sea level change and coastal impacts

Thermal expansion induced by ocean heat storage is one of the two major contributions to the global mean sea level rise observed during the late 20th century. Thermal expansion is also expected to be a major component of future sea level rise. Improvement of the data quality,

consistency and completeness of the global temperature database as part of the IQuOD activities will be critical to refine the global and regional sea level budgets as well as to constrain sea level predictions (near term) and projections (long term scenarios). Catia Domingues (one of the IQuOD co-chairs for the proposed SCOR working group) has been a co-chair for the scoping team and is now co-leading one of the work packages for the WCRP Grand Challenge on sea level change.

Other WCRP and CLIVR research activities (not listed above)

Improvement of the quality and completeness of the global database of historical ocean temperature profiles and its consistency with modern observations from the Argo era, through IQuOD will also be relevant to the progress of a number of international community activities, such as the following WCRP Grand Challenges (<http://www.wcrp-climate.org/gc-regionalclimate>) and CLIVAR Research Foci (<http://www.clivar.org/science/clivar-research-foci>):

- Regional climate information (from seasonal to decadal prediction and long term projections)
- Intraseasonal, seasonal and interannual variability and predictability of monsoon systems
- Decadal variability and predictability of ocean and climate variability
- Understanding and predicting weather and climate extremes

The International Association for the Physical Sciences of the Oceans (IAPSO)

We are planning to submit a proposal to IAPSO to financially co-sponsor IQuOD jointly with SCOR. There have been already some discussions with Isabelle Ansong, Chris Meinen and Ken Ridgway, who were fully supportive of our plan and encouraged us to submit a proposal. As noted above, IQuOD has been already endorsed by IOC/IODE.

SCOR sponsored project – Southern Ocean Observing System (SOOS)

One of the objectives of the SOOS is to facilitate and enhance global southern ocean observations, including historical records. In addition to being IQuOD members, Steve Diggs (Scripps, USA) and Roger Proctor (IMOS, Australia) are also co-chair and steering member of the SOOS data management sub-committee, respectively.

SCOR Working Group 142 – Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders

Hernan Garcia is an associated member of SCOR WG 142 and an IQuOD member with interests to use the IQuOD operating template to improve the quality of global databases for historical ocean salinity and oxygen.

SCOR/IAPSO WG 127 – Thermodynamics and Equation of State of Seawater The thermodynamic equation of state for seawater, 2010 (TEOS-1)

IQuOD activities will be using the seawater tools derived by TEOS10 (e.g., conservative temperature) to more accurately estimate ocean heat content changes.

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11. Appendix – 5 key publications for full members

TVS Udaya Bhaskar

1. A Chatterjee & co-authors (incl. **TVS Udaya Bhaskar**) (2012) "A new Atlas of temperature and salinity for the Northern Indian Ocean", *Journal of Earth System Science*, Vol 121(3), pp 559 - 593.
2. **TVS Udaya Bhaskar** & co-authors (2013) "GUI based interactive system for visual quality control of Argo data", *Indian Journal of Geo-Marine Sciences*, Vol 42 (5), pp 580 - 586.
3. **TVS Udaya Bhaskar** & co-authors (2013) "A note on three way quality control of Argo temperature and salinity profiles - A semi-automated approach at INCOIS" *International Journal of Earth Sciences and Engineering*, Vol 5 (6), pp 1510 - 1514.
4. RV Shesu & co-authors (Incl. **TVS Udaya Bhaskar**) (2013) "Open Source Architecture for Web-Based Oceanographic Data Services" *Data Science Journal*, Vol 12, pp 47 - 55.
5. **TVS Udaya Bhaskar** & co-authors (2006) "Inferring mixed layer depth variability from Argo observations in the western Indian Ocean", *Journal of Marine Research*, Vol 64(3), pp 393 - 406.

Tim Boyer

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Ann (Gronell) Thresher

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