

THE INTERNATIONAL OCEAN CARBON COORDINATION PROJECT (IOCCP)

A joint project of SCOR and IOC and an affiliate program of the Global Carbon Project.

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Surface Ocean CO₂ Variability and Vulnerabilities Workshop Report

April 11-14 2007 at IOC/UNESCO, Paris. Report contributed by Nicolas Metzl and Bronte Tilbrook, Co-Chairs.

Short History and Objectives

In October 2005, the first joint meeting of the SOLAS-IMBER Carbon group (SIC) and the International Carbon Coordination Project (IOCCP) was held during the 7th International CO₂ conference in Broomfield, Colorado. A major outcome of the Broomfield gathering was an agreement for the SIC-SOS sub-group (Surface Ocean Systems) to work with IOCCP to plan an international workshop on the scientific basis for VOS network design and data synthesis efforts related to CO₂ sources and sinks in the ocean. At the time of planning it was clear the research community needed to consider a broad range of issues concerning ocean CO₂ variabilities and vulnerability that covered observation system design, detection of trends, developments in instrumentation, regional and global synthesis, modelling and data-management. The initial agenda changed from 2.5 days to 4 days in order to accommodate the many speakers and participants needed to best review the state of our knowledge on surface CO₂. This was only possible with the support of multiple sponsors (IOCCP, SOLAS, IMBER, GCP and SCOR) and about 100 participants attended this highly successful workshop. The workshop agenda and aims, and maps and tables of CO₂-VOS & time series sites, are available on the meeting webpage: www.ioc.unesco.org/ioccp/pCO2_2007.htm. Presentations are currently available on-line. The meeting report including working group reports will be available soon.

The main goals of the meeting were:

- (i) to review our knowledge of the air-sea CO₂ flux variability and uncertainties from seasonal to decadal scales, and to promote global CO₂ data synthesis activities, (ii) to address new questions regarding the vulnerability of the oceanic carbon cycle, (iii) to obtain prior to the meeting, at national and regional levels, information on recent and future CO₂ VOS lines, time-series stations, and ocean carbon processes studies, and (iv) to develop future observing system and data management strategies for ocean carbon sources and sinks.

To achieve these goals, the workshop was organised as:

(i) invited talks and posters on selected topics relative ranging from regional synthesis, sensor developments, extrapolation and interpolation methods for surface CO₂, ocean and coupled carbon/climate models, atmospheric constraints, air-sea gas exchange parametrisations, surface pCO₂ and flux climatologies, and changes in primary production and ecosystems.

(ii) national reports were prepared and merged in order to obtain basin scale views on the current observations networks (North Atlantic and Arctic, Indian and Southern Oceans, North Pacific, Equatorial and South Pacific, coastal zones and marginal seas).

(iii) working group discussions on three main topics: vulnerability, observations and data synthesis strategies.

The meeting resulted in several important outcomes. Chiefly the strong endorsement by the community that improving our knowledge on both air-sea CO₂ fluxes variability and vulnerabilities issues requires sustained observations, sustained data-management, and a sustained international coordination of the work. Other major outcomes resulting from the meeting were:

(i) a coordinated international effort to produce a publicly available Global Ocean pCO₂ data synthesis (quality controlled products for all regions, including the open ocean and coastal zones). This will start with a careful inspection of several existing global CO₂ data sets (coordination C.Sabine, NOAA in collaboration with CARBOOCEAN, CDIAC, LDEO). Other data synthesis for surface ocean carbon parameters (DIC, TA, pH) are being considered. The Global ocean pCO₂ data product will be revised on an annual basis as new observations are regularly included in the data-base.

(ii) the production of a Surface CO₂ Atlas, composed of gridded average pCO₂ and related parameters for each year on a monthly 1°x1° squares, with perhaps greater resolution in the Coastal zone. Such product will serve a large community of scientists to address many questions related to the detection of oceanic pCO₂ trends, better understanding of temporal and spatial variability in sources and sinks, the initialization and validation of ocean and coupled carbon/climate models, use in assimilation mode, testing and validating extrapolation/interpolation methods, constraints for atmospheric inverse models.

(iii) regional synthesis groups have been created with the aim of better understanding the seasonal to centennial air-sea CO₂ flux variability in collaboration with modelers and physical and biological oceanographers: North Atlantic/Arctic (P.I. U. Shuster, UK), North Pacific (Y. Nojiri, Japan), Equatorial and South Pacific (D. Feely, USA), Indian (V. Sarma, India), Southern Oceans (B. Tilbrook, Australia), Coastal zones (A. Chen, Taiwan and A. Borges, Belgium).

(iv) a special issue of Deep Sea Research II will be published with a deadline for submission of August 31, 2007. About 25 manuscripts have been proposed (authors and titles identified).

(v) A detailed meeting report including the science highlights, tables and maps of the observing networks and details of the working group discussions, decisions and action items. This report will be available soon on the IOCCP website.

Workshop Committee:

N. Metzl (IPSL, France), B. Tilbrook (CSIRO, Australia), D. Bakker (UEA, UK), S. Doney (WHOI, USA), R. Feely (PMEL, USA), K. Lee (PU, Korea), C. Le Quere (UEA, UK)

Sponsor Members: R. Dargaville (IOCCP), P. Canadell (GCP), J. Hare (SOLAS), M. Hood (IOCCP), S.Roy (IMBER), E. Urban (SCOR)

IOCCP Scientific Steering Group 2nd session report

The IOCCP held its 2nd Session of the Scientific Steering Group on April 10 at UNESCO in Paris. The group also met jointly with the SOLAS-IMBER joint carbon coordination group (hereafter referred to as the SIC) to discuss areas of collaboration between the two groups. The SSG reviewed the actions since the first SSG meeting in October 2005 and outlined the major activities for the 2007-2008 period. The full report can be downloaded here (pdf, 164Kb)

A number of actions set at SSG-I have been completed (some with follow-on activities) or transitioned to the responsibility of other groups:

Ocean Sensors Workshop - The development of a sensor workshop has been expanded and includes several new co-sponsors: ORION, OceanSITES, and the OOPC. The IOCCP will continue to be active in the development of this workshop, but will no longer take a leading role in its implementation. It was also agreed that the IOCCP should develop a simple version of this catalogue on the IOCCP web-site, outlining the most-often used carbon sensors and providing a forum for information exchange.

The Guide of Best Practices - The Guide of Best Practices on Oceanic CO₂ Measurement and Data Reporting, by Andrew Dickson, is in final editing stages and should be published by the end of the year. Dennis Hansell and Cindy Lee have agreed to write two new standard-operating-procedure chapters to include organic carbon measurements. These are already well-underway and should not affect the publication schedule (big thanks, Cindy and Dennis). The IOCCP also agreed to develop training courses aimed at students and post-docs based on the manual; one in partnership with the proposed European Project on Ocean Acidification (EPOCA) and one in partnership with the Southeast Asia Regional Carbon group led by Arthur Chen.

Argo-Oxygen Program- The initial technical coordination phase for the development of a pilot project of O₂ sensors on profiling floats has been completed, and the project has now moved into the implementation of a proof-of-concept experiment that has a significant scientific competent to demonstrate the scientific value of such a system. It was agreed that this new phase would be more appropriately coordinated by the SIC.

Atmospheric CO₂ from VOS - The IOCCP investigated the feasibility and utility of installing high-precision continuous atmospheric sensors on VOS in conjunction with the underway pCO₂ network. After the initial set-up of the experiments required, the project stalled when the group decided that this was a very time-consuming undertaking and there did not seem to be a significant push from either the atmospheric or oceanic communities to continue. The SSG agreed to discuss this with the Global Carbon Project to see if they are interested in pursuing this further.

Mesocosm Guidelines - The IOCCP agreed to assist the SIC to develop guidelines and protocols for mesocosm experiments. The SSG and SIC agreed that this is a difficult issue to address, and that perhaps the focus on mesocosm alone was too narrow. There are now many techniques for measuring calcification that have never been compared, and certain techniques and approaches should be examined more rigorously before large research programs move forward in the coming years. The SSG agreed that this is an issue for the SIC to pursue through its working group if they feel that there is a sufficient need and interest in the community.

Major new activities were developed for the 2007-2008 timeframe:

Advisory Group for Repeat Hydrography – As a follow-up to the November 2005 workshop “International Repeat Hydrography and Carbon”, the IOCCP, CLIVAR-GSOP, and SIC agreed to develop an advisory group to define what the international community wants to see in a comprehensive international repeat hydrography and carbon network, including what information should be compiled and maintained as part of this network, how to develop a single information source and/or data directory for ship-based repeat hydrography, needs for updating the hydrographic program manuals, and how best to coordinate with other programs looking at ocean interior changes such as Argo, CLIVAR, and OceanSITES. All co-sponsors have now agreed to move forward with this and have agreed on an initial list of experts including representatives from physical hydrography, Argo, carbon, and biogeochemistry. Further consultations have suggested also including representatives from POGO (who are planning to develop a research cruise database) and Geotraces.

Regional synthesis groups and global standard database for surface CO₂ – At the workshop, “Surface Ocean CO₂ Vulnerability and Variability” that immediately followed the SSG meeting, IOCCP chair Chris Sabine agreed to lead a comparison of global data sets currently being used by different groups to generate seasonal flux maps to examine which data have been incorporated into the datasets and how those data are treated to generate the global compilation. This analysis should provide the information necessary for the community to decide which global data set should be considered the standard global community dataset on which we should continue to build. Based on this, IOCCP SSG member Dorothee Bakker and Benjamin Pfeil will be asked to provide guidance and assistance to develop appropriate secondary QC procedures. Once a standard global data set is chosen, the community will be asked to decide on data products that may be produced regularly. A global seasonal pCO₂ map (e.g. without extrapolation of data points, at a high resolution (1° x 1°) for successive years) was discussed. The IOCCP will investigate the interest and feasibility of hosting a workshop on methods to estimate global seasonal pCO₂ flux as well as methods to estimate surface CO₂ based on satellite data and proxy techniques. This workshop would also decide on the regular development of data products. The workshop also established surface CO₂ synthesis groups for the North Atlantic (including Arctic), the Pacific, the Southern Ocean, the Indian Ocean, and the Coastal Ocean. These groups were asked to identify key science questions in their regions that require regional and global datasets, and to identify data in their regions that are not yet part of the global data set.

Coordination between Synthesis Activities – The SSG highlighted the necessity of providing a point of information and coordination for the synthesis activities currently being implemented or developed, including the ocean interior synthesis groups established by the 2006 CarboOcean-IOCCP meeting in Iceland, the PICES Pacific synthesis groups, and the new surface CO₂ synthesis groups just established at the April meeting. The IOCCP will develop a web-based information resource on the Atlantic and Pacific synthesis activities and encourage wider participation in these activities. The IOCCP will also include information as possible on other regions that should eventually be integrated into a global synthesis, including the Indian Ocean and Arctic Ocean. The IOCCP will also ensure technical coordination among the groups during the data compilation and quality control phases.

Time Series - While all agree that time-series data are both unique and crucial, keeping these sites funded is still precarious, and the ocean carbon community has not been as well-coordinated in supporting and advocating for time series stations as for repeat hydrography or VOS programs. The IOCCP agreed to work with the OceanSITES community and relevant research programs to

investigate the interest and feasibility of developing a workshop to enhance coordination and scientific advocacy for carbon and biogeochemistry time series work.

Technical Coordination for Process Studies and Coastal Carbon - The SSG agreed to investigate the interest and feasibility of developing a small workshop to develop recommended practices for metadata / data reporting in process studies, with a special emphasis on coastal carbon issues.

Summary from the Second meeting of the SOLAS/IMBER Carbon research group

Contributed by Sylie Roy, Executive Directory, IMBER.

A SOLAS/IMBER Carbon research working group was jointly appointed by SOLAS and IMBER to provide scientific guidance to, and oversee the development, planning and implementation of the oceanic carbon research. The group is co-chaired by Dr Arne Körtzinger (IMBER) and Dr Truls Johannessen (SOLAS). In 2006, this group completed the edition of the Joint SOLAS/IMBER Carbon (S.I.C.) Research Implementation plan available electronically on both websites (www.imber.info and www.uea.ac.uk/env/solas/). Three Sub-groups were charged to set out research priorities for ocean carbon research to be conducted over the next ten years.

The second meeting of the SIC group was held in Paris in April 2007. The accomplishments and future activities of the three Sub-groups were reviewed and discussed. Sub-group I focuses on Surface Ocean Systems and is chaired by Dr Nicolas Metz. Nicolas reported on the preparation of a Surface Ocean pCO₂ Vulnerability and Variability workshop that was held in Paris from April 11-14, 2007. Discussions were held around two themes, vulnerabilities and Observations, data and strategies. The working groups were asked to identify the key regions susceptible to change in fluxes, develop strategies to improve the observing system and to identify opportunities for data synthesis. The major outcomes of this workshop will be the publication of a meeting report and a Deep-Sea Research II special volume. The Sub-group plans to use the outcomes of the working group discussions to develop a plan for future activities.

Dr Nicolas Gruber, chair, reported for the Sub-group II. This group focuses on Interior Ocean and the membership and terms of reference have to be determined. Nicolas reported the preparation of a white paper promoting the addition of oxygen sensors on the Argo floats. This proposal was presented to the Argo community in April. The Argo community welcomed the initiative but it became clear that the funding for the addition of the oxygen sensors to the Argo program would have to be generated by the biogeochemical community. It was decided that the Argo-Oxygen task team takes the lead to coordinate the development of one or two pilot projects focused at a regional/basin level to evaluate the long-term stability and accuracy of the sensors.

Both IOCCP and SIC have strong interests in seeing the international synthesis activities being further developed and strengthened. It was agreed that the role of SIC Sub-group II on Ocean Interior was to lead the scientific aspects of the synthesis activities. Thus, the SIC group decided on the creation of an international synthesis group (task team II) to take the lead promotion of a global-scale synthesis of the ocean interior carbon and biogeochemical data collected since the end of the WOCE/JGOFS surveys in order to detect and analyze trends.

Finally, the Sub-group III is led by Dr Kitack Lee and will develop a membership and terms of reference to explore Ocean sensitivity to climate topics. This group will meet to synthesize our understanding of climate feedbacks to the ocean so far, identify scientific issues and develop a strategy to move forward. The Ocean acidification is a very important topic that this group should address.

Update on the Argo-Oxygen Program

Contributed by Nicolas Gruber.

The white paper prepared by Nicolas Gruber and colleagues was presented to the Argo Steering Team at their 8th meeting (AST-8) at IOC/UNESCO, March 7-9. The white paper outlines the scientific motivations for adding O₂ sensors to the Argo array, and addresses the numerous scientific and technological challenges associated with this expansion of Argo. Among the most important scientific motivations for measuring sub-seasonal to decadal variations in the ocean's oxygen content is that O₂ is a rather sensitive tracer for changes in oceanic circulation and biology, making it an ideal "bellwether" for climate change. Furthermore, subsurface O₂ changes are a reliable indicator for oceanic export production, a key quantity of the global carbon cycle. Last but not least, measuring the oceanic outgassing of oxygen helps to interpret the atmospheric O₂ budget, which can be used to understand the partitioning of the terrestrial and ocean CO₂ fluxes.

The analyses of the performance of the more than 70 floats that have been deployed with oxygen sensors to date reveals that the technology has advanced to the state where a large-scale initial deployment has become feasible and scientifically justifiable. In particular, the white paper shows that O₂ sensors can be deployed for several years with drift and accuracy remaining within the acceptable limits. Issues that remain to be addressed are sensor response time, and calibration routines. Initial estimates of the costs associated with the addition of the oxygen sensors to the Argo array suggest that it costs about 40% above the costs for the purchase and operation of a standard Argo float, or an additional about USD 7000 over 5 years.

The white paper was well received by the AST. They commended the quality of the document and welcomed Dr Gruber's proposal for a pilot project of around 100 floats to be released in a region of specific interest for O₂ observations. While the AST was positive about the project it was also cautious regarding the effects of the O₂ sensors on battery life, potential for an increase in premature instrument failure, and the legal implications of adding an additional observation to the Argo array given the current international agreements. These issues would need to be understood and resolved before O₂ measurements could be considered for integration into the operational Argo array.

IOCCP carbon observations tables and maps updated

In conjunction with the Surface Ocean CO₂ Variability and Vulnerability Workshop, IOCCP requested and received national activity reports from 20 nations. The reports are available at the IOCCP website. Using the wealth of information contained in these reports, and with the expertise of Alex Kozyr at CDIAC, updated table and maps for Underway pCO₂, Hydrography and Time Series stations are now available on the Observations Network webpage. Feedback on the maps and tables is always welcome – send your comments to Alex Kozyr (kozyra@ornl.gov) or Maria Hood (m.hood@unesco.org).