

15th IOCCG Committee Meeting
Rio de Janeiro, Brazil, 18-20 January 2010

MINUTES

1.0 Welcome and Opening Session

1.1 Welcome and Opening Remarks

The Chairman, Prof. James Yoder opened the 15th IOCCG Committee meeting and welcomed all the participants to Brazil, commenting that he was happy to be in such a beautiful location (see Appendix I for list of participants). He thanked INPE for graciously hosting the meeting.

Dr. Marco Chamon, Coordinator of Technological Management (INPE) welcomed participants and informed them that he was honoured to host the IOCCG meeting in Brazil, on behalf of the INPE Director, Dr. Gilberto Câmara. He hoped that presentations made during the meeting would improve knowledge and understanding of ocean colour and its applications, and hoped that the discussion and debates would demonstrate to decision makers the importance of information gathered by space-based sensors in coping with urgent problems in society. He thanked participants for coming to Brazil and wished them a fruitful meeting and pleasant stay.

Dr. Joao Viane Soares, Director of Earth Observation Branch (INPE) also welcomed the participants. He noted that he was very pleased to have the opportunity to host the IOCCG meeting in Rio de Janeiro, and that it was very important for INPE. The organisation would be 50 years old in two year's time, and initially the Earth observation programme focussed on continental applications. Now, coastal and marine applications were very important. He hoped the IOCCG meeting would help to increase the importance of ocean colour in South America and also promote increased coastal and marine observations.

Next, Mr. Carlos Ganem, President of the Brazilian Space Agency (AEB), addressed the meeting. He noted that AEB was the civilian authority in Brazil responsible for the country's space program, and that INPE's role was to execute the policies. Despite the fact that Brazil had 804 km of coastline, there were no activities concerning fishing within the agency, and he hoped that various new initiatives would improve research in ocean activities. Included in these was the special new project with Argentina, the SABIA-MAR mission. He hoped the group would help to create solutions for the planet through cooperation and improved correspondence, providing the best economic results and respect for our oceans. He thanked Dr Milton Kampel for helping to host the meeting and coordinating the arrangements.

Prof. Yoder thanked the members stepping down for their service (Samantha Lavender and Curtiss Davis), and welcomed new members Scarla Weeks (University of Queensland, Australia) and Zhihua Mao (Second Institute of Oceanography, China).

1.2 Introduction of new IOCCG Chairman, Dr. David Antoine

James Yoder then introduced the new IOCCG Chairman, Dr. David Antoine. He noted that David had made many important scientific contributions in the field of bio-optics and had worked extensively with ESA and CNES, so he was very happy to have him take over as Chair.

David Antoine thanked Jim Yoder for the nice introduction and thanked the Executive Committee for the opportunity to chair the group. He hoped to continue the great activity lead by James Yoder and Trevor Platt, and looked forward to working with the group. He also thanked Prof. Yoder for ably chairing the Committee over the past 3 years.

1.3 Adoption of the IOCCG-15 agenda, minutes from the 14th Committee meeting and status of actions

The agenda was adopted with no modifications, and the minutes the 14th IOCCG Committee meeting were approved as written. The Chairman summarised the status of the actions from the 14th Committee meeting, most of which had either been completed, or would be addressed later in the meeting.

Action 14/1: Brochures had been printed by INPE and mailed out to senior policy makers in Latin America, Spain and Portugal.

Action 14/2: The Ecological Provinces report will be mailed to the GCOS Secretariat once printed.

Actions 14/3: The issue of an IOCCG representative for the Ocean Observations Panel for Climate (OOPC) would be addressed again in the meeting.

Actions 14/4: The draft chapters of Calibration Report had been placed on IOCCG website for review and comment.

Actions 14/5: The GO-SHIP action had been closed.

Actions 14/6: Paul DiGiacomo noted that the action concerning the GEO Inland and Nearshore Coastal Water Quality working group was still open. The group had held two meetings, the latest was a technical workshop focussing on algorithms. They were trying to formally move this activity forward. Stewart Bernard noted that it was important for the group to use available activities, and it was a good link to the inland remote sensing community. This action would be kept open and Paul DiGiacomo would give a report at next IOCCG meeting.

Actions 14/7: Band changes to GOCI-2 would be discussed during the meeting.

Action 14/8 and 14/9: Mark Dowel would post the Ocean Colour entry into Wikipedia.

Action 14/10: Jim Yoder had submitted an article on the OCR-VC, plus an article for a newsletter on ocean colour biogeochemistry, and 2-3 other short articles. Paula Bontempi noted that this agenda item was important as there were many special issues and groups writing reports on remote sensing of ocean colour. The IOCCG should have a position on observations of ocean colour from space and an 'IOCCG perspective' about the future. This item would be addressed again later in the agenda.

ACTION 15/1: PAUL DIGIACOMO TO GIVE A BRIEF REPORT ON THE COASTAL GEO INLAND AND NEARSHORE COASTAL WATER QUALITY WORKING GROUP AT NEXT IOCCG MEETING.

1.4a New Topics for Consideration: Interagency Body to Develop Long-Term OC Time Series.

David Antoine introduced a new topic on how the IOCCG could foster the development of ocean colour 'Climate Quality Data Records' (CQDRs). These constitute a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change. Satellite-based CDRs can be grouped into two types: the 'Fundamental Climate Data Records' (FCDRs) i.e. calibrated and quality-controlled sensor data that have been improved over time and; 'Thematic Climate Data Records' (TCDRs) i.e. geophysical variables

derived from the FCDRs, such as sea surface temperature and cloud fraction. The need for CQDRs is well established and examples were given of recent studies. The promotion of long-term datasets is within the mandate of the IOCCG, and four IOCCG Reports (numbers 1, 2, 4 & 6) are directly related to the CQDR issue. In terms of sensors providing global data sets, the future is still a bit uncertain. Regarding long term data sets, there have been a number of major space agency initiatives to pave the way for production of CQDRs e.g. NASA's SIMBIOS, REASoN and MEASURES projects, and ESA's GlobColour Project and Climate Change Initiative, as well as the CEOS Ocean-Colour Radiometry-Virtual Constellation (OCR-VC). However, the situation beyond ~2015 is still unclear: several research missions are near the end of their lifetimes and new operational missions may not totally fulfill the need. There are a number of important merging efforts, but they are essentially 'Agency-specific'. It is likely that we will never have global, multi-sensor, multi-decadal, ocean colour CQDRs if we only rely on single agency-based activities and best-effort international coordination. We need a new entity, working on top of, and in conjunction with, the international coordination. This new entity would have the mandate of generating CQDRs from the data provided by space agencies willing to contribute to this effort, and would be linked to space agencies. Examples of such programs include ISCCP (International Satellite Cloud Climatology Project), established as part of the WCRP with NOAA, EUMETSAT, NASA and Meteo-France participating, and the GHRSSST Project (Group for High-Resolution Sea Surface Temperature) with about 20 contributing organizations including ESA, UK MetOffice, NASA, JAXA, NOAA and EUMETSAT.

In order to proceed, the science community could encourage space agencies to create a new body, the role of which could be accurately defined. A small IOCCG working group could be established to address this issue, or it could be added to the mandate of the OCR-VC. Paula Bontempi noted that she had also pointed out the need for a coordinated centralized group to produce global climate quality data at NASA, and NASA would certainly support this activity. Peter Regner pointed that many of these items were also being addressed within ESA. He noted that the structure already exists within the IOCCG and that it was not necessary to form another group. He suggested reorganizing IOCCG to address these issues. Mark Dowell suggested that mandate of the virtual constellations be increased to take on the implementation, at least where the constellations are relevant to CQDRs. Space agencies could be mandated to commit resources to do this.

James Yoder suggested that a working group could be formed to discuss these issues and that the implementation could become an OCR-VC activity. Mark Dowell noted that there was a start-up initiative to have a climate change task within CEOS. If this went ahead, IOCCG could be a proto-type demonstration group to implement this. Paula Bontempi pointed out that IOCCG was the body for ocean colour and should interface with other potential groups that spin off. Representatives were required to take this initiative forward, not necessarily the agencies themselves.

1.4b New Topics for Consideration: Advanced IOCCG Summer School

David Antoine also proposed an IOCCG summer school dedicated to high-level training in the fundamentals of optics and bio-optics, addressing current critical issues related to ocean-colour science. It could be organized every other year. He noted that previous IOCCG training efforts were essentially devoted to capacity building in developing countries, focussing on ocean-

colour applications. The proposed course could be 2-3 weeks long, and could be run by senior scientists with highly-respected publication records in the appropriate fields. Possible course topics could include a review of the current knowledge and issues of IOPs, assimilating ocean-colour observations into coupled BGC models, data merging and creation of CQDRs. James Yoder thought it was a good idea and that, in addition to the training course, high-level presentations could be given to non-specialists in this area e.g. journalists, or agency representatives. Scarla Weeks strongly encouraged the initiative and noted that the application of ocean colour in Australia was not very well developed. Peter Regner agreed that there was definitely a need for this type of training, and that ESA could only host ~30% of applicants for training courses. André Morel pointed out that most of the previous IOCCG training courses were designed to provide a quick introduction to ocean colour, but the proposed summer school would promote a better understanding of the problems, and would educate young scientists in carrying out new research. The course would not be application oriented. Shubha Sathyendranath supported the idea and mentioned that a center was being established at Harwell in the UK, which could also become a center for continuing education.

Paula Bontempi remarked that a similar activity was the advanced physics and bio-optics courses that were conducted every year at the Darling Marine Centre, University of Maine. James Yoder suggested that there should also be an option to take course for credit.

ACTION 15/2: IOCCG COMMITTEE MEMBERS TO SUBMIT INFORMATION ON EXISTING TRAINING COURSES IN BIO-OPTICS TO THE CHAIRMAN (CC: VENETIA STUART) IN ORDER TO FACILITATE PREPARATIONS FOR THE PROPOSED IOCCG SUMMER TRAINING COURSE.

2.0 Status of IOCCG Scientific Working Groups

2.1 Ecological Provinces Report

Mark Dowell reported that at last years meeting he had presented a full draft of the report and had requested feedback. All the comments received had been taken into account and the final report (IOCCG Report 9) had just been printed, and copies were being mailed out. He was very satisfied with the end-product. The Chairman mentioned that it was always good to see a new report come out, and that the IOCCG report series was one of the most visible outputs from the IOCCG.

2.2 Atmospheric Correction Algorithms Report

Menghua Wang informed the Committee that the final report had been completed and was ready for printing. It would be published in 2010 and would be printed by NOAA. The report discussed four atmospheric correction algorithms and compared their performance using a common simulated data set. A number of recommendations were proposed for various water types and the authors concluded that future ocean-colour remote sensing development needed to focus on retrieving ocean-colour products in the coastal ocean regions, where waters are often Case-2 types, with strongly absorbing aerosols. It was suggested that spectral matching algorithms, spectral optimization algorithms and neural network approaches were particularly useful in dealing with coastal complex ocean waters.

2.3 Bio-optical Sensors on Argo Floats

Hervé Claustre presented the scientific context of the BIO-Argo working group. The Argo Programme was a very successful programme for scientific applications as well as for operational measurements. In 2008, 130,000 high quality CTD profiles were acquired through the Argo programme, representing 95% of CTD profiles in the world. The recent development of low-consumption, miniature, neutrally buoyant sensors (e.g. oxygen, radiometers, backscattering meters, fluorometers) provided good candidates for mounting on floats, and biogeochemists have begun to implement these sensors on Argo floats for dedicated local or regional studies. The BIO-Argo working group was involved in the preliminary steps before envisaging a BIO-Argo program. The WG had held two meetings in February and November 2008, both in Villefranche. Most of the Terms of Reference had been addressed and three types of floats had been identified for bio-optical / bio-geochemical activities: Cal-Val , BIO-Argo and Carbo Float.

The preparatory phase of the WG was underway and various groups (most of them represented in the WG) are developing and testing various configurations of floats. A pilot study was being discussed within a broader community to develop interactions with other groups (e.g. friends of oxygen on Argo). Dr. Claustre had attended a scoping workshop in Monterey (April 2009) and a paper would be published in *Oceanography* this year. In addition, the BIO-Argo group had submitted a Community White Paper to OceanObs'09 entitled "Bio-optical profiling floats as new observational tools for biogeochemical and ecosystem studies: potential synergies with ocean colour remote sensing" which is currently in press, as well as two Plenary Papers which are in revision.

Bio-optical activities on Argo floats are now accepted by the community and the BIO-Argo program is emerging. Other promising sensors for large-scale deployment include fluorescence (to estimate chlorophyll-a) and optical backscattering (to estimate particulate organic carbon, POC). The BIO-Argo group has recommended that 20% of the Argo array (600 floats) be equipped with Chl-a and POC sensors for objectives such as the extension of satellite measurements of the sea surface into the ocean interior, validation of satellite ocean colour, assimilation into future biogeochemical models, and detection of climate-related large-scale variability and trends. Dr. Claustre had been invited to participate in next Argo science team meeting (San Diego, March 2010). Currently, 19 floats are measuring bio-optics, with plans for ~100 floats with bio-optical capabilities in the near future. Most proposals for floats include measurements of b_b and Chl. In order for the Bio-Argo project to be 'accepted' by Argo, regional case studies or pilot studies are required to demonstrate that sensor accuracy and stability is sufficient for stated scientific objectives (being demonstrated) and also to demonstrate real-time and delayed mode quality control capabilities for the community (not yet demonstrated). The key to success for an integrated Bio-Argo observation system will be data management, distribution and quality control (including practical training, intercomparison exercises and calibration centres).

Paul DiGiacomo pointed out that if IOCCG had representation on OOPC (one of the three panels of GCOS), they could integrate these activities and help move the WG forward. André Morel noted that the activities of BIO-Argo might not be appropriate for a classic-type IOCCG report, as publication time was rather long. Another way should be found to communicate the

outcomes of the WG. Shubha Sathyendranath commented that a report with IOCCG backing could only help, and that it could be followed up with brochures etc. The Chairman recommended that items be identified for a short IOCCG report, and that other technical material could be included in published papers. It was also recommended that a link be created on the IOCCG website showing the current location of the BIO-Argo floats. Dr. Claustre also requested that each IOCCG member contact an Argo representative in their country to promote the importance of bio-optical sensors on Argo floats. The Argo white paper is available on the IOCCG website at: http://www.ioccg.org/groups/OceanObs09_White_Paper_Claustre.pdf

ACTION 15/3: VENETIA STUART TO IMPLEMENT A LINK ON THE IOCCG WEBSITE SHOWING CURRENT LOCATION OF THE BIO-ARGO FLOATS.

ACTION 15/4: IOCCG MEMBERS TO CONTACT THEIR ARGO REPRESENTATIVE TO PROMOTE THE BIO-ARGO FLOATS.

2.4 Ocean Colour Observations from a Geostationary Platform

David Antoine drew attention to the spatial and temporal scales presently covered by remote sensors (a spatial scale of a few hundred meters, and time scales of around a week). To understand rapidly-evolving phenomena, especially in coastal areas, it was essential to look at the correct temporal scale, and complement the data with observing systems that provide information at the scale of hours and a spatial resolution of a few hundred meters i.e. geostationary sensors. This was the motivation to establish an IOCCG working group on this topic. Several projects with a focus on geostationary observations have been submitted to agencies in the past decade, and one is planned for launch (Korea's GOCI on COMS-1). The Terms of Reference for the WG were reviewed and a preliminary draft report had been distributed. Feedback from Committee members was requested.

ACTION 15/5: IOCCG COMMITTEE MEMBERS TO PROVIDE FEEDBACK ON DRAFT REPORT OF THE GEOSTATIONARY WG.

An outline of the draft report was presented, and it was noted that there may be possible overlap with other WGs. An improved version of the report would be available by April 2010 and a second WG meeting might be required before summer 2010.

2.5 Assessing Level-1 Requirements for Ocean-Colour Remote Sensing

Paula Bontempi reported that this WG had been proposed because the science had evolved considerably since publication of the first IOCCG report in 1998. Charles McClain, Gerhard Meister and Paula Bontempi (all from NASA/GSFC) had agreed to co-chair the WG. The list of members for the WG was reviewed, and it was noted that they were all agency representatives and that additional expertise may be required. The Terms of Reference were quite comprehensive and the scope was rather broad and needed to be constrained. There was also some potential overlap with existing WGs. The following issues were addressed by the Committee:

1. Should geostationary observations be considered by this working group? The consensus was that the WG should focus on polar orbiters. It was noted that a future IOCCG WG

- may be required to address geostationary Level-1 requirements, but that most of the requirements for polar orbiters would be valid for geostationary sensors as well.
2. If Level-1 requirements were to be derived based on science objectives, where should they be obtained? The Committee recommended that the group focus on nLw (TOA) with a link to global climate quality. Most of the report should be able to address operational requirements as well. The report could also address TOA versus nLw.
 3. To what extent should the WG delve into *in situ* measurement requirements for calibration, validation, and algorithm development? The Committee recommended that the group cross-reference appropriate IOCCG reports e.g. the Atmospheric Correction report and Robert Frouin's draft calibration report. Gaps could then be identified and the group could decide if they needed to be addressed. The group could also cross-reference NASA's series of technical memoranda, which were currently being updated.
 4. Level-1 requirements can vary depending on the mission objectives and a single 'minimum set' may not be adequate or even particularly useful. The Committee recommended that the WG should have one overarching objective, and that the report should be seen as a science report, and not an agency perspective.
 5. The TOR specify that the WG define requirements for data processing, reprocessing, distribution, and archiving. How far into this topic should the working group delve? The Committee recommended that the WG briefly address data processing and the need for re-processing, but that it was not necessary to design an ideal ground processing system.

It was noted that the Level-1 WG had a much broader focus than IOCCG Report 1, and that the Level-1 WG report would be complementary to the activities of the US National Research Council which is providing feedback to US Federal Government Agencies on scientific priorities for sustained ocean-colour research and operations.

2.6 Calibration of Ocean-Colour Sensors

Robert Frouin had sent an email pointing out that some items pertaining to the calibration report overlapped with that of the Level-1 Requirements report, but that the themes of the two reports were quite different. He was open to the idea of combining his report with the Level-1 Report, but that he was still planning on working on the calibration report until the end of February 2010. The Level-1 WG would read the draft calibration report and decide if it should be incorporated or not.

2.7 Phytoplankton Functional Types

Shubha Sathyendranath noted they had not made as much progress on the report as she would have liked, but that some elements were coming together. She would do her best to proceed. The research area of PFTs was moving so fast, that a delay was not harming the report and it would be better in the long run.

3.0 Proposals for New IOCCG Working Groups

3.1 Procedure for Proposing a New IOCCG Working Group

David Antoine recommended that there should be a more formal procedure for proposing new IOCCG working groups. He proposed adapting the SCOR guidelines for new working groups,

and placing the guidelines on the IOCCG website, which would also encourage submissions from outside the IOCCG Committee. The guidelines should include the background and rationale for the proposed WG, why the activity is better done through an IOCCG working group than through some other mechanism, and how the project will benefit from an international approach. The proposal should also include the Terms of Reference, suggested WG members and potential WG Chair.

ACTION 15/6: ADAPT SCOR GUIDELINES FOR NEW WORKING GROUPS AND MAKE AVAILABLE ON THE IOCCG WEBSITE.

3.2 Using OC Remote Sensing for Studying and Monitoring the Arctic Ocean

Hervé Claustre presented a proposal by Marcel Babin, Kevin Arrigo and Simon Bélanger to form a new IOCCG WG to address the use of OC remote sensing in the Arctic Ocean. He reviewed some of the consequences of climate change in the Arctic such as sea ice retreating, permafrost thawing, increase in river runoff and increase in UV, which may all have possible impacts on light-driven carbon fluxes (primary production and CDOM photo-oxidation). Ocean-colour remote sensing was essential to access the whole Arctic Ocean on a regular and sustained basis, to determine the impact of climate change. Potential difficulties of using ocean-colour remote sensing over the Arctic Ocean include high CDOM absorption and high package effect leading to problems with current algorithms. A dedicated algorithm for Arctic waters would perform best. In addition, a pronounced deep chlorophyll maximum is associated with primary production in the Arctic, unlike other waters. Cloud cover was also an issue (only cloud free 10-20% of the time) and prevailing sun elevations were low.

The proposed Terms of Reference included a review of the current literature on the issues described above, a reassessment of current Arctic Ocean algorithms through intercomparisons, and recommendations to space agencies and the scientific community on future research avenues and algorithm development. Shubha Sathyendranath suggested that the group broaden its perspective to include the Antarctic. Low sun angle was a problem in many areas. Other Committee members agreed that the WG should not have such a regional focus and should encompass all high latitude areas. Paula Bontempi recommended that they include a modeller in the WG.

Chairman to write to Marcel Babin asking him to revise his working group proposal to encompass all high-latitude/low-sun angle waters (i.e. to include the Antarctic) and re-submit for approval by the IOCCG Executive Committee

ACTION 15/7: CHAIRMAN TO WRITE TO MARCEL BABIN ASKING HIM TO REVISE HIS WORKING GROUP PROPOSAL TO ENCOMPASS ALL HIGH-LATITUDE/LOW-SUN ANGLE WATERS (I.E. TO INCLUDE THE ANTARCTIC) AND RE-SUBMIT FOR APPROVAL BY THE IOCCG EXECUTIVE COMMITTEE.

3.3 Uncertainties in Ocean-Colour Remote Sensing

Roland Doerffer presented a proposal for an IOCCG WG on errors and uncertainties. He pointed out that complex coastal waters contain a variety of constituents with different optical properties, large concentration ranges and difficulties with atmospheric correction, leading to large retrieval uncertainties. Coastal waters are extremely complex systems with many

ambiguities and error sources. Up to now, flags have been used to warn or exclude pixels from processing, but they require thresholds and do not quantify the uncertainties. Thus we need procedures to detect conditions which are out of scope of an algorithm, to determine the remaining uncertainties on a pixel-by-pixel basis, and to present the errors and uncertainties in a proper form, which is the goal of the new WG. A draft set of Terms of Reference was presented along with a list of potential members of the WG. It was proposed that the work be carried out in conjunction with ESA's CoastColour Project.

Peter Regner commented that these errors on uncertainties were a very important topic, and that the discussion was driven by end users. This information was also important for the modelling community and for data assimilation. He recommended that this WG should definitely be considered. He noted that product quality information in ESA standard products is currently provided in terms of quality flags. More complex per pixel error statistics decomposed into instrument errors and uncertainties propagated through the retrieval scheme are at present not provided. Mark Dowell queried whether Roland Doerffer's activity should perhaps be integrated into the CoastColour Project itself, but Peter Regner pointed out that CoastColor was not tasked to talk to modellers, and that the proposed IOCCG WG had a broader scope than just CoastColour. Paula Bontempi was also concerned that this WG could be too focussed on CoastColour. She recommended that the WG should also address errors in the open ocean, and that optically-deep waters might be the best place to start. Shubha Sathyendranath pointed out that it would be good to build on the momentum of CoastColour, and that some of the work could be undertaken within CoastColour, but the report could be broadened if there was interest from other agencies.

ACTION 15/8: IOCCG COMMITTEE MEMBERS TO SUBMIT SUGGESTIONS TO ROLAND DOERFFER (CC: VENETIA STUART) FOR MEMBERS FOR HIS "UNCERTAINTY WORKING GROUP".

3.4 Potential Joint GEOHAB/IOCCG WG on HABs

Stewart Bernard presented a proposal for a combined GEOHAB/IOCCG working group. He noted that harmful algal blooms (HABs) are a global problem with high impact, and that ocean-colour radiometry is a powerful, cost-effective and potentially relatively easily-used means of observing many of these blooms. Currently no synopsis or guide was available for ocean-colour HAB applications across different ecosystems. An outline of a potential WG report was presented based on an ecological driver approach. The different techniques available for detecting HABs would be summarised, and the characteristics of different types of ecosystems where HABs might occur would be reviewed, using HAB and ecosystem case studies. This would include inland freshwater case studies. The WG would be composed of HAB scientists as well as ocean-colour scientists. Some funding had already been secured from GEOHAB and JRC for a first meeting, provisionally scheduled for August 2010 in South Africa or Europe. This meeting would focus on finalising the Terms of Reference and reviewing the structure and preliminary analyses of case study material. The final output would be aimed at a journal special issue, in addition to a GEOHAB or IOCCG monograph on the topic. Links would be created with CoastColour and the GEO Coastal and Inland WQ Algorithm Group in order to avoid overlap. Use of case studies from within ESA's CoastColour 'Champion User Sites' had the potential to make an active contribution to CoastColour and help drive GEO Coastal and Inland WQ Algorithm Group.

Shubha Sathyendranath suggested that this WG could be promoted at the level of GEO, as another application to water quality. Prakash Chauhan recommended that the WG use Arabian Sea as a case study, as there was good ocean-colour data from the Indian OCM sensor, and *Trichodesmium* blooms were common in the area. ISRO could also contribute to this WG. Stewart Bernard agreed to use as many case studies as possible, and pointed out that it was also necessary to have *in situ* data to go along with bloom data. Paula Bontempi informed Stewart that in the US there is a program called EcoHAB which funds many bio-optical studies. It may be possible to use some of the data from that group. Scarla Weeks noted that Arnold Dekker had a student working on an algorithm for *Trichodesmium* blooms on Great Barrier Reef.

4.0 Agency Contributions to the OCR-VC Implementation Plan

4.1 SIO: Status of Chinese Ocean Colour Sensors

Zhihua Mao summarised the status of Chinese ocean-colour sensors. He noted that China launched the HY-1B satellite in April 2007, carrying two ocean-colour sensors: COCTS with 10 bands, and CZI with 4 bands. There is no on-board calibration system so COCTS was cross calibrated with SeaWiFS. The HY-1C/1D ocean colour satellite was planned for launch in 2012, and HY-1E/1F in 2016. China also had another series of satellites to investigate environment and disaster monitoring, called the HJ series. HJ-1A/1B was launched on 6 September 2008, and other HJ satellite constellations are scheduled for launch in 2010 and 2014. HJ-1A carries a hyperspectral imager with 15 bands from 0.45 to 0.95 μm , a spatial resolution of 100 m and a swath of 15 km. Potential applications of hyperspectral data include remote sensing of pigment composition and identification of algal type. Radiance calibration and atmospheric correction procedures needed to be addressed before the Hyperspectral data could be used. The instrument was optimized for inland waters.

4.2 Argentine-Brazilian SABIA-MAR Mission

Marco Antonio Chamon (INPE) reported on the new cooperative satellite between Brazil and Argentina. The SABIA-MAR mission was conceived to provide information and products for studies of ocean ecosystems, carbon cycling, marine habitat mapping, coastal hazards, and coastal land cover/land use. Basic requirements were to have two cameras (sensors): one for global coverage, and one for use in the coastal zone. It was intended to have almost daily coverage of global open oceans (swath 2200 km, resolution 1.1 km) while there would be detailed imaging for coastal waters (swath 200 km, resolution 200 m). A number of spectral bands were envisaged from 0.38 μm to 11.8 μm (still under investigation). The main instruments would be the global and regional cameras (built by Brazil), and the secondary payload would consist of a SST sensor and a land imaging camera (built by Argentina) if there was enough room. The platform would be the same as for Aquarius.

The initial phase of the project (0+A) would be completed in about 9 months time. Some points had not been addressed in the first analysis, including calibration and development of products. Data policy would be addressed in the next phase. In principle, there would be a completely open access data policy, similar to the policy for land imagers, but depending on tri-lateral agreements. The anticipated launch was optimistically 5 years from now, around 2015.

Domingo Antonio Gagliardini (CONAE) briefed the committee about the applications of the regional camera on the SABIA-MAR mission. To take advantage of the information provided by other missions, the optical sensors of SABIA-MAR would employ spectral bands compatible with those established for SeaWiFS and MODIS. For regional coastal applications, the resolution should be better than 200 m, with pointing capabilities to increase the virtual revisit. Dr. Gagliardini described the main oceanographic features of the highly-productive area off the Argentinean shelf that they planned to study with the regional camera. Satellite data have greatly enhanced the knowledge of these coastal environments in recent years, although the relatively low resolution of SeaWiFS and MODIS limits their ability to observe dynamic phenomena close to the coastline, or details of processes/features in the open sea. Some examples of data from the Argentinean SAC-C MMRS scanner were also presented. The MMRS scanner, launched in November 2000, has a swath of 360 km and a resolution of 180 m. It is still in orbit but the data are noisy and are not being used routinely. Ideally, the SABIA-MAR mission would have two cameras working at the same time so that images from both cameras could be combined. The regional camera could provide information about small-scale dynamical processes and the global sensor could track the evolution of the phenomena under study

4.3 Reception of FR MERIS data in Brazil

Milton Kampel reported on the reception of MERIS full-resolution data in Brazil. INPE had a number of bi-lateral agreements with China, Germany, UK and Argentina and was involved with building satellites and operating the ground systems. INPE also contributes to CEOS and GEO tasks, and strongly supports the CEOS constellations. INPE recently started routinely acquiring full resolution data from Envisat through a ground receiving station in central Brazil at Cuiab. Data were received over most of South America which was ideal for land applications. The discovery of oil and gas reserves off the continental shelf of Brazil provided an opportunity for funding, and another X-band receiving station was established at the coastal town of Cachoeira Paulista, 300 km from Rio de Janeiro. This receiving station has a data centre and processing capabilities and will increase coverage over the sea. Full-resolution MERIS data can now be acquired along with data from MODIS. Standard MERIS Level-2 products can now be produced and they were already finding problems with the atmospheric correction which is being addressed. Brazil has a new ministry for fisheries and aquaculture, and they are attempting to integrate ocean-colour information for fisheries applications.

4.4 Current status of the OCR-VC Implementation Plan

Mark Dowell provided an overview of the Ocean Colour Radiometry-Virtual Constellation (OCR-VC). The OCR-VC Implementation Plan (IP) was recently endorsed at the CEOS Plenary in Thailand (November 2009) and will be updated as new tasks and deliverables are added. The primary mission of OCR-VC is to provide long time series of calibrated ocean colour radiance (OCR) at key wavelength bands from measurements obtained from multiple satellites. OCR-VC activities will include calibration, validation, merging of satellite and *in situ* data, product generation, as well as development and demonstration of new and improved applications. NASA's SIMBIOS, ESA's GlobColour, POGO-GEO-GOOS's ChloroGIN and CSA/GEO SAFARI projects are examples and prototypes of programs that the OCR-VC will require to meet its objectives. There are two phases of implementation: Phase 1 from 2008 through to the launch of Sentinel-3 (early 2013), and Phase 2 post-launch Sentinel 3, including

VIIRS on NPOESS, GCOM-C and overlap with sensors still operating from Phase 1 (e.g. OCM-2)

The virtual constellations should be seen as the CEOS contribution to GEO as well as a contribution to GCOS (addressing the ‘Climate’ societal benefit area). The ocean-colour community is well represented in many of the GEO societal benefit areas e.g. agriculture, ecosystems, climate and water, but there is need for better networking to avoid duplication of efforts and to ensure that OCR data is readily available. Within the IP, the baseline minimum requirements are based on SeaWiFS. There are five main OCR-VC objectives: i) Providing high quality data sets, ii) Data Harmonization, supporting ECVs , iii) Facilitating timely and easy access to data, iv) Ensuring OCR continuity, and v) Capacity building and Outreach. These were all being addressed by the various agencies represented on the OCR-VC, as well as by current IOCCG working groups. The OCR-VC encourages interagency collaboration at the higher level objectives. Mark Dowell reminded participants that the OCR-VC leadership was intended to be on a rotation basis and that proposals for new co-chairs should be put forward at the next IOCCG meeting, for 2012 onwards. He also suggested bi-monthly telecons with the OCR-VC group, and perhaps a second annual meeting of space agency representatives.

Many of the OCR-VC tasks are activities which the individual space agencies are pursuing alone or through bi-lateral agreements, but they are contribution to the overall objectives. However, it was also necessary to identify top priorities for concerted tasks which should be promoted across space agencies, for example, an international SIMBIOS-like activity and ECV implementation (GAP analysis would be the first step). IOCCG was also asked to comment on the GCOS implementation plan. The main issue to address include the title of the ECV (currently “ocean colour” which is ambiguous). The IOCCG should promote “water-leaving radiance” instead since we can provide requirements in a much more accurate and specific way. Paul DiGiacomo noted that the challenge was to identify cross-agency tasks to work towards a bigger goal - not just a reporting exercise of various GEO tasks. The agencies should help to mobilize resources and get something done. It was noted that the SIT meetings were generally where agencies committed to projects and resources.

4.5 Lessons learned from SIMBIOS

Paula Bontempi reviewed some of the lessons learned from NASA’s SIMBIOS Programme (Sensor Intercomparison & Merger for Biological & Interdisciplinary Ocean Studies) in light of the fact that a similar type of activity could be carried out to support the OCR-VC. There were four main tasks in the SIMBIOS Programme, which ended in December 2003:

- Ensure development of internally consistent research products and time series from multiple satellite ocean-colour data sources
- Develop methodologies for cross-calibration of satellite ocean-colour sensors
- Develop methodologies for merging data from multiple ocean-colour missions
- Promote cooperation between ocean-colour projects

The SIMBIOS science team targeted US and international investigations, and the project was carried out in partnership with the MODIS oceans team. The SIMBIOS Project Office was co-located with SeaWiFS and was responsible for technical and program management and also interfaced with other international space agencies and other organizations and programs. The goal of SIMBIOS was to develop long-term, high quality data for climate research in the meso

to large scale. SIMBIOS project activities coordinated and spun up the SeaBASS database, support services (e.g. NRT imagery), an instrument pool, calibration round robins and data product validation (match-ups), satellite characterisation, cal/val activities, satellite data processing, and cross-calibration and merging activities. These activities can be updated with current activities being carried out by the various agencies represented in IOCCG. SIMBIOS funded the collection of global *in situ* bio-optical and atmospheric data. Research areas were targeted by the project and all investigators followed standardized protocols and participated in round-robins (one of the most important areas). Lessons learned were that high quality data are needed for both vicarious calibration and product validation and that these data must follow sampling, analysis, quality control and protocol methods approved by the community.

Follow on activities to promote SIMBIOS-type activities by agencies represented in the OCR-VC, could include parallel ‘Research Announcements’, agencies could target common scientific problems of interest, supporting what is most relevant, promote centralized databases like SeaBASS with quality control data submission requirements, protocol development, exchange of personnel and connectivity to round-robins.

David Antoine noted that these types of activities were needed in the future, and that the IOCCG should recognize the leading role NASA has played in the past decade. If we really want to go ahead in next 10 years it was necessary to rearrange the ways things are done, and inter-agency cooperation was essential. He strongly encouraged all agencies to discuss with NASA the way forward to develop such a programme. Paula Bontempi suggested that agency representatives could add an extra day after the “Ocean from Space” conference to discuss these issues. Curt Davis suggested that it could perhaps be portrayed as the ocean-colour contribution to the CEOS WGCV. Mark Dowell suggested that the IOCCG should restructure the programme so that it is seen as something new. On an *ad hoc* basis there were already some activities contributing to this type of activity e.g. aeronet, various calibration sites, and that certain agencies were already supporting some aspects. These issues would be further discussed at the end of the meeting.

4.6a ESA's Climate Change Initiative

Peter Regner briefed the Committee on ESA’s Climate Change Initiative (CCI). Ocean colour is one of the ‘Essential Climate Variables’ (ECVs) within ESA’s CCI. The objectives of the CCI are to systematically generate and distribute long-term series of ECVs (defined by GCOS), based on EO data to meet needs of UNFCCC and IPCC, and to ensure that existing space assets and data archives as well as forthcoming satellite missions can be used in an optimum way in climate modelling and research. The CCI was approved by ESA State Ministers in November 2008 (6 yr programme) and the continuation of Sentinel missions to 2025 and beyond was also approved. The data from these missions will significantly contribute to the generation of ‘Fundamental Climate Data Records’ (FCDRs) and ECVs needed by the international climate research community. FCDRs are long-term data records, involving a series of instruments, with potentially changing measurement approaches, but with overlaps and calibrations sufficient to allow the generation of homogeneous products providing a measure of the intended variable that is accurate and stable enough for climate monitoring. From these we can derive ECV products, which are often generated by blending satellite observations and *in-situ* data, and using physical model frameworks. No single data set from any single EO mission or space

agency is sufficient to constitute all data required for a complete ECV. Merging of data from different sensors and sources is critical.

GCOS has identified 45 ECVs to meet GCOS requirements and ESA has selected 11 of these to be addressed within the CCI programme. Later in the CCI programme, ESA will provide significant data sets for another 10 ECVs. GCOS provides very stringent target requirements for the ocean-colour ECV. A number of these requirements still need work e.g. algorithm improvements and validation. The end user will be the modelling and climate research community, and they need to use and test the ocean-colour ECV products in ocean carbon cycle and biochemical models. There would be a phased programme implementation: phase 1 would include scientific user consultation and ECV prototyping, phase 2 would include implementation and ECV production and dissemination, and phase 3 would include feedback from the international climate research community. International collaboration was seen as a critical component of the CCI to achieve global consistency in ECV product generation. IOCCG was considered as a key partner for fostering international collaboration and establishing community consensus within the ocean colour ECV project.

4.6b Status of Envisat/MERIS and GMES Sentinel-3

Peter Regner also reported on the status of MERIS on the Envisat mission. The satellite and instruments were in good health and the demand for MERIS data was very high. The main limiting factor for the mission was on board fuel. To enable mission extension until 2013 the orbit would have to be lowered by 17.4 km. This was progressing according to schedule and would be accomplished by October 2010, and would have no major impact on MERIS. The third re-processing of MERIS data was underway. Level 1 was completed, and Level 2 reprocessing would start in March/April 2010 and would be completed before end of year. Full resolution MERIS data would only be reprocessed upon request. At Level 1, implementation of a revised instrument degradation model significantly improved the long-term temporal radiometric stability. Improvements at Level 2 would include bias removal for water leaving reflectance trends through vicarious adjustment to sea-truth data, a revised cloud screening algorithm, improved atmospheric correction algorithms, and a new case 2 neural network for inversion of marine reflectances into [Chl], TSM, a_{YS} . In addition, a company had been contracted to develop a MERIS L2 optical data processor (ODESA) to generate the same products as the ground segment (called MEGS in its prototype version). This would be available in March 2010. Combining ODESA and BEAM (another freely available complementary tool for the exploitation of optical data) would provide similar capabilities as SeaDAS.

The ESA Living Planet Symposium would take place from 28 June–2 July 2010 in Bergen (Norway) aiming to discuss latest results from ESA missions currently in operation, including Envisat, ERS, Earth Explorers, as well as from Third Party missions. The 5th ESA Earth observation summer on Earth system monitoring and modelling would take place in Frascati from 2-13 August 2010.

ESA's Sentinel-3 mission is one of a series of satellites developed within the framework of GMES and will provide an operational service for the collection of EO data for global sea and land applications over 15 to 20 years. Full performance will be achieved with two satellites in orbit launched within 15-20 months of each other (7 year design life). The 'Ocean and Land

Color Instrument' (OLCI) will provide data at least at the quality of MERIS. The instrument will have 21 spectral bands with a spatial resolution 300 m. The Sentinel data policy is free and open access to all Sentinel data and to all users. A number of Level-2 products will be provided for marine and inland waters, plus a per pixel error characterisation for each product.

4.7 ESA's CoastColour Project

Roland Doerffer reported on the ESA Data User Element Project 'CoastColour' which started in January 2010 and would end in December 2012. The project consists of a core science team as well as consultants and 'Champion Users' Users' and is aimed at the exploitation of the unique capabilities of MERIS (including 300m data) and the development of new Case 2 water algorithms and products meeting specific user needs. There are 12 globally distributed test sites which will focus on MERIS full-resolution data. There will be two alternative approaches for coastal water processing: neural network inversion of RTM (Roland Doerffer) and the quasi-analytic algorithm (QAA) from ZhongPing Lee. Each product will be delivered with an associated per-pixel error estimate. A glint processor will remove sun glint and an auto-associative neural network with a bottle neck layer will be used to detect out of scope TOA radiance spectra.

A number of special algorithms had been requested including solar stimulated fluorescence of phytoplankton, PAR, primary production, cell size distribution and, phytoplankton functional types. Many of these will be difficult to achieve. MERIS FR data from 2002 till now will be processed with the two baseline algorithms, and ~20,000 scenes will be processed with the requested algorithms. Processing will be done by Brockman Consultants, and algorithms will be provided by Doerffer, Santer and Lee. Champion users could also submit local algorithms to assess the results for different applications, and algorithm round-robins will be arranged. Match-up data will be collected from various champion user sites. Curt Davis suggested that some of this data could perhaps be used for the SIMBIOS-type activity. It was hoped that the IOCCG community would participate in the coastal water algorithm round-robin and participate in the user workshop.

Dr. Doerffer also briefly mentioned the German EnMAP hyperspectral satellite mission. It will carry a hyperspectral imager with 228 spectral bands from 420-2450 nm, with 30 m resolution, to be launched in 2013. GKSS was a member of the core science team responsible for coastal and inland waters. The mission would not provide global coverage.

4.8 NASA Report

Paula Bontempi updated the Committee on recent NASA activities. The SeaWiFS reprocessing was completed in November 2009, MODIS reprocessing would be completed by February/March 2010 after which NASA would move on to reprocessing Terra and the legacy missions (OCTS, CZCS). New products had been generated including particulate organic carbon (POC), particulate inorganic carbon (PIC), coloured dissolved organic matter (CDOM) index, photosynthetically available radiation (PAR), and fluorescence quantum yield. SeaWiFS has been collecting data since September 1997, and the sensor is operating normally with no apparent degradation in performance. Radiometric stability has been maintained with the lunar calibration. The OrbView-2 spacecraft has experienced failures or anomalies on multiple primary systems/components, and is operating on the backup units: Although there have been

gaps in data collection during the past two years, there are no indications of imminent mission-ending failure. GeoEye has not maintained the spacecraft orbit, and the equator crossing time has drifted from local noon to about 2 pm, with impacts on attitude systems, solar diffusion calibration, thermal environment and solar path geometry. The orbit drift can be reversed by raising the orbit altitude and a proposed orbit raising scenario was provided by NASA. GeoEye has stated that the orbit raising was planned with a target completion by April 2010.

For MODIS-Aqua the 551 band center had been changed to 547 nm to reduce band-pass correction. Improvements to SeaWiFS and MODIS-A included improved temporal stability in water-leaving reflectance trends, improved agreement with *in situ* chlorophyll, especially in coastal environments, substantially improved agreement with Aeronet and SeaBASS AOT match-ups, reduced high-latitude seasonal differences in MODISA vs. SeaWiFS nLw, and reduced discrepancy in MODIS-A vs. SeaWiFS oligotrophic chlorophyll. There were well documented issues with the radiometric stability of MODIS-Terra. Results will be implemented once MODIS-Aqua reprocessing is completed and some provisional products will be available through NASA's ocean color web browse and ordering system. Global IOP products will be generated and distributed in a parallel evaluation data stream, with source code available via SeaDAS, as of December 2009.

A letter of intent has been signed between ISRO, NOAA and NASA on 18 November 2009 regarding collaborations on India's OCM-2 sensor. ISRO will provide online access to global OCM-2 data (4-km) at Level-1B for research use, to all international users, at no cost. NASA will provide processing capability within SeaDAS (Level-1B through Level-3) for use by ISRO and the international community. NASA and NOAA will participate in a joint Science Team meeting (10-12 March 2010, Ahmedabad). Regarding ESA/NASA collaborations, Bryan Franz and Gerhard Meister are now participating members of the MERIS Quality Working Group. SeaDAS has been enhanced to support display and analysis of standard MERIS Level-2 products, and MERIS processing capability has been incorporated into NASA software and released in SeaDAS. NASA also has collaborations with KORDI to improve harmonization and ensure data quality of the planned geostationary ocean-colour radiometry measurements, including development of a module for GOCI processing in SeaDAS.

NASA has a number of future missions planned. The Aerosol, Cloud, Ocean Ecosystem (ACE) mission is still in development. A number of instruments are being considered for the ACE payload, including an ocean colour multi-channel spectrometer for ocean ecosystems. The Geostationary Coastal and Air Pollution Events (GEO-CAPE) mission will include three instruments on one spacecraft in geostationary orbit. The data will be used to address key water quality, ocean chemistry, ecological science questions in the coastal ocean and its response to climate or environmental variability. The HypsIRI mission will focus on terrestrial applications (sun glint problems over the sea). The PRISM instrument will provide high spatial/spectral data to identify constituents and quantify properties of complex coastal ocean waters using spectroscopic measurements with UV to SWIR channels (including episodic hazards and pollutants). The instrument should be ready for testing in two years time. NASA is also supporting a wide range of research projects including impacts of climate change in the Arctic. In 2010 a call could be made to support SIMBIOS-type research.

On another note, Paula Bontempi raised the issue of IOCCG producing a short over-arching paper about what we have achieved with ocean-colour remote sensing. The December 2010 special issue of 'Oceanography' magazine will be devoted to "Future of Oceanography from Space" but the main focus was on physical oceanography. Should the IOCCG request withdrawal of the biological oceanography topics, so the issue could focus entirely on physical oceanography, or should the IOCCG suggest an alternative list of topics and authors? After much discussion, the Committee agreed that it would be best to submit a 'contributed article' focussing on coastal ecosystems, and perhaps recommend another special issue in the future focussing on biological oceanography from space.

ACTION 15/9: JAMES YODER TO SUGGEST A COASTAL ECOSYSTEM OR ECOLOGY PAPER AS A 'CONTRIBUTED PAPER' TO THE OCEANOGRAPHY SPECIAL ISSUES ON "FUTURE OF OCEANOGRAPHY FROM SPACE".

4.9 NOAA contributions to OCR-VC

Paul DiGiacomo presented an update on NOAA's contributions to the OCR-VC. Various tasks related to VIIRS on NPP and NPOESS-C1 had been addressed. NPP was scheduled for launch in 2011 (probably September) and NPOESS-C1 in 2014. NOAA is supporting a calibration-validation plan for NPP-VIIRS that will include research and operational efforts from NOAA, NAVY, NASA as well as academic investigators and collaborators. It will ensure consistency of NPP products with heritage satellite products. A processing system called ViPER (Visible Processing and Environmental Records) is being developed to support end-to-end ocean-colour data processing capabilities. It will also support development and implementation of community consensus algorithms and ocean-colour climate quality data records. The initial capability would be ready in June 2011. NOAA, in conjunction with NASA, NSF and ONR, have sponsored an NRC Committee on Assessing Requirements for Sustained Ocean Colour Research and Operations, to help ensure that user OCR needs continue to be met.

Regarding the OCR-VC objective of providing high quality data sets, MOBY deployment will be sustained through at least 2011, and the goal is to have MOBY-C optics deployment on the existing MOBY infrastructure by the end of 2011. NOAA is also supporting the 'MOBY Distributed Calibration Exercise' (MDCE) which will have a limited number of berths available for IOCCG agencies and scientists to go on the cruises in 2011; additional information will be sent out on this opportunity. Regarding the OCR-VC objective of facilitating timely and easy access to data, NOAA is developing an OceanWatch portal for VIIRS and other oceanographic satellite data sets, to provide access to global satellite data for operations and climate applications. In addition, NOAA CoastWatch is working to implement operational processing and distribution of MERIS FR data for U.S. coastal waters, courtesy of data provided by CSA and ESA. NOAA and NASA also plan on acquiring full resolution OCM-2 direct broadcast data for US/adjacent coastal waters as per the recent agreement with ISRO.

The GEO Inland and Coastal Water Quality Remote Sensing Algorithm workshop was held in May 2009 (Washington, DC) and a workshop report will be completed shortly. The GEOSS 'Coastal Zone Community of Practice' (CZCP) is bringing together data providers and users in the context of GEOSS to ensure that user coastal observational needs are coordinated and addressed. Ocean-colour radiometry data is a crucial observing need in support of many coastal user issues and applications (e.g., water quality, HABs, fisheries). In reply to a question about

the calibration et al. of the VIIRS instrument on NPP, it was noted per a recent community science team memo that there is presently no formal provision for mission-level data reprocessing and there were also concerns about suitable lunar et al. manoeuvres for calibration taking place, having state of the art algorithms and sustained support for vicarious calibration and validation activities, and addressing instrument performance issues associated with Integrated Filter Assembly (IFA) manufacturing anomalies. Regarding the latter, Paula Bontempi noted that the NASA team were concerned that pre-launch characterization had not been as thorough as it should have been.

4.10 CSA SAFARI Project/ NCEO New Sponsor

Shubha Sathyendranath reported on the CSA-sponsored SAFARI project because Yves Crevier was unable to attend the meeting. This was an international program related to remote sensing in support of fisheries. CSA have been a strong supporter for international coordination of this activity. SAFARI is a GEO task with the secretariat in Canada, funded by CSA. A related task is another GEO task, ChloroGIN. A proposal had been submitted to CSA to support ChloroGIN as well. The objectives of SAFARI are to create an international forum for coordination and exchange of views on the use of remotely-sensed data in fisheries oceanography. One of outputs was an IOCCG monograph on this topic, published 2009.

An upcoming event is an international symposium in Kochi, India (15-17 February 2010) which has attracted over 200 registrations. Selected paper will appear in a special issue of the ICES Journal. A 3-day training course will precede the conference and a ChloroGIN workshop will follow. The SAFARI initiative led to an invitation from OECD (Organisation for Economic Cooperation and Development) in Paris in November 2009, for a meeting on food security. A presentation on remote sensing applications for fisheries was given, and IOCCG Report 8 was very well received. The Indian work on PFZ advisories was particularly useful in reporting to OECD. Based on fuel savings alone, it was possible to justify the investment in an OC satellite.

ChloroGIN (Chlorophyll Globally Integrated Network) includes remote sensing and *in situ* observations, building on existing activities. A community white paper on ChloroGIN was submitted at OceanObs'09. A ChloroGIN website focuses on the marine component of a EC funded project called DevCoCast (GEONETCast for and by Developing Countries). Data are disseminated from sources in North and South America, Africa and Europe to user communities in South America, Africa and China in near-real time. There are a number of regional nodes in Canada, Africa, Indian Ocean, South America and Europe and potential to develop new nodes (e.g. Far East and Asia).

Dr. Sathyendranath also report on the National Centre for Earth Observation (NCEO), a new participant in IOCCG. NCEO is a relatively new initiative of NERC in UK. It is a virtual national institute with a project office at the University of Reading, and ~100 investigators around UK. It is built around seven science themes: the carbon cycle theme contains the ocean-colour component. The centre is directed by Alan O'Neil and the Carbon Theme leader is Nick Hardman-Mountford from Plymouth Marine Laboratory. At present NCEO is in the second year of a 5 year plan, and they agreed to sponsor IOCCG as part of their international coordination activities. Shubha Sathyendranath would represent NCEO on the IOCCG Executive Committee.

4.11 KORDI: Geostationary GOCI Mission

Yu-Hwan Ahn gave a brief review of the COMS-1 satellite carrying the Geostationary Ocean Color Imager (GOCI), which will be launched in March 2010. The instrument will target the area around Korean waters (2500 x 2500 km) and has similar bands to SeaWiFS, with an operational life of 7.7 years (design life 10 years). The sensor will meet the radiometric requirement of 0.01%. GOCI has been successfully integrated into the COMS-1 satellite and the final test will take place in Astrium in February 2010, after which the satellite will be launched from the Kourou Space Center in French Guiana on 29 March 2010 (with possible delays into April). Data will be distributed 6 months after launch.

Evaluation of a possible GOCI follow-on, called GOCI-2, is currently underway (2010-2016). It will fly on the Multiple-Purpose (MP) GeoSatellite. There will be two satellites (A and B) with satellite B carrying the ocean-colour payload and atmospheric chemistry. The mission failed to get funding because the economical and societal benefits analysis was not accepted. The mission will be re-evaluated in July 2010 and endorsement from the IOCCG was requested. The key requirements for the GOCI-2 mission are establishment of an ocean observation system to monitor long-term climate change with full disk observation, and environment monitoring for management of coastal waters with high resolution (GSD 250 m) local area observation. Temporal resolution would be every hour (or twice per day for global observations) with night time observations for local coverage. Local coverage (1200 x 1500 km) can be moved any place within the full disc coverage. GOCI-2 will have 13 spectral bands but recommendations were requested from IOCCG members. Stewart Bernard suggested a band at 709 nm for high biomass waters. GOCI data distribution will be free for public interest and research (Level 1B ~ Level 2, near real time distribution within 2 hours). Redistribution is not authorized except by special contact. Direct receiving stations were possible with mutual agreement between two countries.

The Chairman encouraged IOCCG members to make recommendations regarding GOCI-2 band placement before July 2010. In addition, Committee members were requested to send published material of societal benefits for geostationary observations to Dr. Ahn (IOCCG Reports 7 and 8 could also be referenced). Paul DiGiacomo agreed to send the IGOS coastal report and the Chairman would try to advance as fast as possible with the IOCCG geostationary WG report.

ACTION 15/10: CHAIRMAN TO WRITE A LETTER TO KORDI ENDORSING THE GOCI-2 INSTRUMENT.

ACTION 15/11: IOCCG MEMBERS TO MAKE SUGGESTIONS FOR GOCI-2 BAND PLACEMENT BEFORE JULY 2010.

ACTION 15/12: PAUL DIGIACOMO TO SEND IGOS REPORTS TO DR. AHN BEFORE JULY 2010.

4.12 CNES: Parasol Mission and Geostationary Interests

Eric Thouvenot presented an update on the Parasol mission which is contributing to all the objectives of the OCR-VC. Parasol is a micro-satellite to monitor aerosols and clouds and was

launched 18 December 2004, flying in formation within the A-train. On 2 December 2009 Parasol was moved to a lower orbit (3.9 km beneath the A-train orbit) to minimize the risk of collision with other A-train satellites, which could occur as a result of insufficient remaining fuel supplies. The scientific data are still interesting and funding for the mission is secured until 2010. French scientists are currently writing a proposal to extend the Parasol mission (on its new lower orbit) beyond 2010. In addition CNES is considering a follow-up mission to POLDER called 3MI (Multispectral, Multidirectional and Multipolarization Instrument). The 3MI mission will be dedicated to atmospheric aerosol global monitoring and is one of the planned missions of the next European polar meteorological programme of Eumetsat (planned launch 2018-2020). It was recommended that IOCCG should endorse this mission because it might also provide interesting data for ocean colour science.

ACTION 15/13: CHAIRMAN TO WRITE A LETTER TO CNES ENDORSING THE PROPOSED 3MI MISSION CONCEPT.

In addition CNES has been pursuing, together with industry, a continuous R&D effort in ocean colour activities related to hyperspectral and geostationary sensors, and a proposal for an Ocean Color Advanced Permanent Imager (OCAPI) in geostationary orbit was submitted to CNES in April 2009. It was recommended that a feasibility study for this mission be conducted. There is a limitation of the geostationary orbit for European activities and trade-offs with a geosynchronous orbit would have to be considered. The resolution of OCAPI will be 250 m, it will have 15 bands in the 400-900 nm range and launch should be possible in the 2017/2019 timeframe. OCAPI will therefore contribute to the OCR-VC. There was also a lot of synergy with respect to GOCI-2 and discussions were underway regarding possible cooperation.

CNES was also contributing to high quality data sets through vicarious calibration activities. Funding for the Boussole buoy was secured until 2018/19. CNES is contributing funding to the development of SIMBADA radiometers, BIO-Argo floats etc. In addition, R&D studies include development of algorithms for atmospheric correction in the presence of sun glint and bio-optical algorithms for coastal waters. CNES is also contributing to Mercator data assimilation and forecasting supporting the development of downstream services.

4.13a JAXA: GCOM-C/SGLI Progress

Hiroshi Murakami reported on the development status of JAXA's GCOM-C mission. A preliminary design review was held last month and the critical issue was finances. If sufficient funds were available, GCOM-C1 would be launched in 2014. A science team of 35 PI's was organised in July 2009 and they were responsible for algorithm development, *in-situ* data acquisition, and research applications using other satellite data. The next focus is on operational issue. The sensor will have several operational modes: day, night, coastal, offshore etc. to reduce the amount of data for downlink. All data will be received at the Svalbard station: near-real time data will be downloaded at a station in Japan. Standard products will be distributed free of charge via the internet.

4.13b GCOM-C Research Plan

Joji Ishizaka reported on the PI's perspective of the GCOM-C project which included polar applications, coastal studies, fisheries applications and the study of red tides (HABs), as well as

algorithm development. A network is being built with JAMSTEC, National Fisheries Research Agency, local fisheries research institutes and the universities, and it is necessary to collaborate internationally specifically with regard to Case-2 water algorithm development. HABs were an important coastal application and the use of satellite data for reduction of red tide damage was being investigated. The next unofficial ocean PI-team meeting will be held during ISPRS-VIII symposium in Kyoto in August 2010 and everybody is welcome to attend. The CEARAC (Special Monitoring and Coastal Environmental Assessment Regional Activity Center) of NOWPAP (NorthWest Pacific Action Plan), which is one of regional sea programmes of UNEP, is examining the use of remote sensing for assessment of the coastal environment surrounded by Japan, Korea, China and Russia, and could perhaps contribute to ChloroGIN. The Korea-Japan Workshop on Ocean Colour (KJWOC) is held every year and supports bilateral research collaborations. The Yellow Sea Large Marine Ecosystem (YSLME) ocean-colour task team is developing a regional ocean-colour database and algorithms for the Yellow Sea and East China Sea in collaboration with Korea, China and Japan. NOWPAP held three training courses and is planning another training course in China in 2010 or 2011, and help of IOCCG and/or SIO is needed. Paula Bontempi noted that NASA was planning the 7 South East Asia Studies (7-SEAS) dealing with the impacts of aerosols and weather and the environment, and they would like to collaborate with the YSLME project.

4.14 ISRO Report

Prakash Chauhan reported on the Ocean Colour Monitor (OCM) on-board Oceansat-2. It is a global mission and was launched on 23 September 2009. The spacecraft is carrying three instruments, all of which are working fine. The OCM sensor has a swath of 1420 km and similar bands to OCM, with two changes: the 765 nm channel has been moved to 740 nm to avoid O₂ absorption and the 670 nm channel has been replaced by a 620 nm channel for better quantification of suspended sediments. Oceansat-2 has two modes of operation: Local Area Coverage (LAC) with 360 m real time transmission, and Global Area Coverage (GAC) with 1/4 km, on-board recording and playback. GAC data coverage is between $\pm 75^\circ$ latitude covering the full globe in 8 days. The OCM-2 instrument is currently providing excellent data sets. The instrument has a tilting mechanism and the tilt is changed twice per year depending on seasonality, providing minimum sun glint over Indian waters.

Users will be provided with L1B basic radiance products which can be displayed using SeaDAS. Further improvements in the radiometric normalisation of OCM-2 data is underway, to reduce stripes observed in the geophysical product. Level-2 products will consist of Chlorophyll-a concentration, Total Suspended Matter (TSM), diffuse attenuation coefficients (K_d -490 nm) and Aerosol Optical Depth (AOD) at 865 nm. Level 3 products will consist of weekly, monthly and yearly binned products (4 km). An OC-4-type algorithm has been developed for OCM-2 using bio-optical archived data collected in the Arabian Sea as well as data from NOMAD.

A permanent Cal-Val site has been set up in the Lakshdweep Sea and data from an optical buoy are being used for vicarious calibration of OCM-2 data. Extensive ship campaigns will also be organized for validation of geophysical data products, and lunar calibrations are also planned for every 6 months. The NRSA Data Center (NDC) will carry out dissemination of 4-km GAC data products on the Internet after the Cal/Val phase of the mission and a Letter of Intent with NASA/NOAA for OCEANSAT-2 data sharing was signed last year.

Future ocean-colour sensors from ISRO include a High Resolution Geostationary Imager (HR-GEO) and a 12/13 band Ocean Colour Monitor for Oceansat-3, which will have 3 fluorescence bands. Scientific feedback was requested from IOCCG members for optimal band selection for future ocean colour sensors.

ACTION 15/14: IOCCG COMMITTEE MEMBERS TO PROVIDE SCIENTIFIC FEEDBACK ON OPTIMAL BAND SELECTION FOR FUTURE ISRO OCEAN-COLOUR SENSORS.

4.15 EUMETSAT Report

Hans Bonekamp could not attend the meeting, but reported that the OCR-VC was part of the OceanObs'09 plenary paper on operational satellites, which deals with the issue of transitioning satellite missions into a sustained operational setting. Several of the other CEOS constellations were also included. He also reported that EUMETSAT had hired a new ocean scientist, Anne O'Carroll, to help out with the tasks related to OLCI on Sentinel-3. Peter Regner pointed out that the development of the Payload Data Ground Segment is carried out in cooperation between ESA and EUMETSAT who will operate the marine part of the Sentinel-3 and deliver data to end-users during operations. It was recommended that a representative from EUMETSAT be encouraged to attend the next IOCCG meeting. With regard to the OceanObs publications, it was suggested that IOCCG should think about producing a forward-looking paper or a paper on scientific achievements as requests for such documents were frequently received. Paula Bontempi noted that she was willing to make a start, and it was suggested that it could be a living document that could be updated on a regular basis.

ACTION 15/15: CHAIRMAN TO WRITE TO EUMETSAT TO ENCOURAGE REPRESENTATION AT NEXT IOCCG MEETING.

ACTION 15/16: PAULA BONTEMPI TO MAKE A START ON A FORWARD-LOOKING/ SCIENTIFIC ACHIEVEMENTS PAPER.

5.0 OCR-VC Way Forward

5.1 Prioritization of Inter-Agency Tasks within the IP of the OCR-VC

There was much discussion about forming an international SIMBIOS-type programme. It was suggested that a small workshop be held at the Oceans from Space symposium (April 2010) to bring people together at the international scale. Mark Dowell had some reservations about this type of setting and he suggested first looking at what programs already exist, and how they could fit work together. Paula Bontempi's schematic on SIMBIOS 2010 could be used to identify activities already taking place and to identify gaps (e.g. calibration strategy, collection of *in situ* data, product and algorithm validation etc.). Shubha Sathyendranath thought it would be good if the initiative could be global as well as international e.g. if projects such as ChloroGIN could be included. The structure of such a SIMBIOS-type activity was also discussed. It was agreed that a Project Office was essential to support PIs and to coordinate fieldwork, but it was agreed that a rotating Project Office would not be efficient.

In conclusion there was broad endorsement of some type of international SIMBIOS activity and general agreement that this type of activity should go forward. The approach of launching parallel calls was agreed upon, as well as better networking of existing field activities. Paul DiGiacomo suggested that a small *ad hoc* meeting at “Oceans from Space” could be used to plan for another meeting to take place later this year. It was essential to have agency representatives at these meetings.

ACTION 15/17: COMMITTEE MEMBERS TO EXAMINE THE SCHEMATIC FOR A SIMBIOS-FOLLOW ON PROGRAMME AND IDENTIFY EXISTING ACTIVITIES THAT COULD CONTRIBUTE TOWARDS AN INTERNATIONAL CROSS-CALIBRATION PROGRAMME. SUBMIT TO MARK DOWELL, PAULA BONTEMPI AND HIROSHI MURAKAMI (CC: VENETIA STUART).

The Committee also discussed whether the OCR-VC should focus on Essential Climate Variable (ECV) implementation for the next 2-3 years. The CEOS virtual constellations may be mandated to take a lead in ECV implementation, along with the possible creation of an external entity to carry out these tasks. Gap analysis would be the first step. The definition of the ECV for ocean colour was discussed and the consensus was that the focus should be on the normalized water-leaving radiance suite, from which data products and variables such as phytoplankton chlorophyll-a concentration are derived. It was agreed that the Level-1 WG could provide detailed requirements of products such as water-leaving radiance.

Two items were selected to be promoted at the next SIT meeting: an international SIMBIOS-like programme at the interagency level, and the issue of ECV implementation and production of CQDRs, with the Level-1 WG providing more precise requirements for radiometric accuracy. David Antoine’s recommendations on forming a new entity to generate CQDRs from the data provided by space Agencies (Item 1.4a) was a good and cautious way to proceed. Mark Dowell would fix a date for an *ad hoc* meeting for interested agency representatives at the “Oceans from Space” symposium.

ACTION 15/18: MARK DOWELL TO FIX A DATE FOR AN AD HOC MEETING OF AGENCY REPRESENTATIVES AT THE “OCEANS FROM SPACE” SYMPOSIUM TO DISCUSS ECV IMPLEMENTATION AND A FOLLOW-ON SIMBIOS-TYPE ACTIVITY.

Mark Dowell would also convey IOCCG’s response to the GCOS implementation plan, and would propose an updated title and description of the ECV variable.

6.0 Capacity Building

6.1 Report on JRC Training Course in Africa

Mark Dowell reported on the JRC training course in Africa that Nicolas Hoepffner had organised as part of a series within the JRC institutional responsibilities. The training course took place in Zanzibar, Tanzania from 12-23 October 2009 and was sponsored by many different organisations including the IOCCG. Eighteen participants from many different African countries were selected out of a total of 85 applications – the limitation was computer facilities. The first week consisted of background and theoretical lecture sessions, with afternoon practical sessions on processing and visualizing ocean-colour data using SeaDAS,

BEAM and Bilko. The second week consisted of lectures on various applications, with mini-projects undertaken by the students in the afternoon. There were also a few evening seminars including one on HABs by Stewart Bernard.

Paul DiGiacomo enquired whether there was any follow up with students to see how they were using their skills, and to keep them updated. Mailing lists were set up after training courses to answer questions etc. Previous students were also invited to give lectures at following courses. Stewart Bernard pointed out that this course played a vital role within a broader capacity building strategy within Africa (e.g. GOOS) and that they were trying to identify students in various areas to establish a network.

6.2 Report on Inversion Modelling Workshop

Roand Doerffer reported on the training course on “Inversion Procedures in Ocean-Colour Remote Sensing” held in Lauenburg, Germany (10-14 August 2009). There were 27 participants from 18 different countries with 5 lecturers. The objectives of the trainings course were to provide participants with an overview of inversion methods and models, to prepare bio-optical models and training data sets for inversion methods, and to teach participants how to use various inversion techniques. The training course was part of the IOCCG capacity building programme and was sponsored by the GKSS summer school programme in coastal research, the JRC and the “Friends of GKSS”. Students all brought their own notebook computers with the software download beforehand. A number of topics related to inversion modelling were addressed during the course and a number of different datasets were used including those derived from SeaBASS and NOMAD, and the test data set described in IOCCG Report 5. Many positive responses were received after the training course.

Paula Bontempi also mentioned that it was important to keep track of students who have attended a training course, to create a network of students, and suggested perhaps creating a website for alumni. James Yoder pointed out that tracking students was extremely difficult as they frequently move and change email addresses. He noted that modified software packages were available geared toward Alumni to encourage interaction and form collaborations. It was suggested that a tab be inserted on the IOCCG website for training course alumni to interact. It was also suggested that Mark Dowell and Roland Doerffer provide inputs for a standardised web syllabus for IOCCG training courses.

ACTION 15/19: VENETIA STUART TO EXAMINE THE POSSIBILITY OF INSERTING A TAB ON THE IOCCG WEBSITE FOR TRAINING COURSE ALUMNI TO INTERACT.

ACTION 15/20: ROLAND DOERFFER AND MARK DOWELL TO PROVIDE INPUTS FOR A STANDARDISED WEB SYLLABUS FOR IOCCG TRAINING COURSES.

6.3 Handbook of satellite remote sensing image interpretation

Venetia Stuart briefed the Committee on the Handbook for Satellite Remote Sensing and Image Interpretation that was being coordinated by Jesus Morales, in conjunction with the INTERREG IVB Programme and the EU PRESPO Project. The aim was to provide training material for researchers and students to obtain a better understanding of the structure and functioning of marine pelagic ecosystems. A great majority of the case studies in the handbook used ocean-

colour data and would address a range of issues including identification of potential fishing zones, description of oceanic fronts, and seasonal patterns in coastal processing. The handbook will be available on the PRESPO website until 2011 and it was agreed that it should be endorsed by IOCCG.

6.4 Proposal for an Ocean Colour Training Course in Mexico

Milton Kampel put forward a proposal to hold a two-week training course at the Universidad Autónoma de Baja California, in Mexico during the November 2010 - January 2011 time frame. He pointed out that there had not been an IOCCG training course in South America for several years. The course would focus on coastal and estuarine waters of Latin America and would include a field experiment in the Sea of Cortez and Colorado Delta. The course would be open to 10-15 participants from Latin America, and would be aimed at doctoral students and young researchers working in the area of remote sensing and biological-physical interactions. It could be seen as a continuation of a long-term, sustained effort at capacity building in the region. Dr. Kampel enquired whether the IOCCG would support this idea and perhaps fund a few instructors or trainees, on condition that he could get funding from other sources. Shubha Sathyendranath commented that she would like to see the training course supported by IOCCG and suggested that Milton apply to the POGO Visiting Professorship Programme for additional funding. Roland Doerffer pointed out that it was important to use open source software packages e.g. SILAB (similar to MATLAB). The training course would be further discussed during the Executive Committee meeting.

7.0 Other Remote Sensing Activities

7.1 HICO on the International Space Station

Curtiss Davis gave an overview of the Hyperspectral Imager for the Coastal Ocean (HICO) on the International Space Station (ISS). HICO is installed on ISS on 24 September 2009 and is the first space borne imaging spectrometer designed to sample coastal oceans at <100 m resolution, with high signal-to-noise ratio. HICO has a footprint of 92 m and records one scene per orbit (90 min). Currently ~150 locations have been identified and new sites can be added although this may mean fewer observations per site. A number of algorithms have been developed and there are several test and example products e.g. water depth for very shallow waters. Comparison of HICO with MERIS water leaving reflectance showed the instrument was performing well and had the same spectral shape. A series of standard products were being routinely processed through the automated processing system. A publication on HICO should be out soon and at website at Oregon State University would be made public next month. Scientists can request data to be collected over a particular site (51° N and S) which is scheduled 2 weeks in advance. Level-1B data or higher can be provided at no costs.

8.0 Organisation and Membership

8.1 Rotation of Committee Members

Curtiss Davis and Samantha Lavender were rotating off the Committee and the Chairman thanked them for their contributions over the past three years. Several proposals for new

Committee members had been received, and others would be accepted. At the last meeting it was recommended that a modeller and a researcher from the freshwater community be appointed to the Committee. This would be addressed at the Executive meeting, as well as the balance between Agency members and scientists.

8.2 Proposals to host IOCCG-16 Committee Meeting

Shubha Sathyendranath noted that there had been an interest to have the next IOCCG meeting at a more central location. Trevor Platt had offered for the Plymouth Marine Laboratory to host the next IOCCG meeting at Dartington Estate, 30 minutes from Plymouth. They had good food and good conference facilities, and they offered a package deal at £124 per day plus 17.5 %taxes, which included full board plus the use of conference facilities. Convenient train and bus connections are available from Heathrow airport (~3.5 hours), but it is also possible to fly to Bristol or Exeter. A tentative booking had been made from 8-10 February 2011, but this could be changed. It was pointed out that the Chinese New Year begins on 3 February 2011.

Another proposal was received from Tasuku Tanaka to hold the meeting in Bali, in June 2011. There were some concerns about distance, as well as the timing for this proposal.

8.3 Proposals for IOCCG-17 Committee meeting

Scarla Weeks mentioned that she could look into the University of Queensland hosting the IOCCG-17 meeting (2012) near Brisbane, Australia, if there was interest. The university had two research stations, one close to Brisbane (Mortons Bay) and one on Heron Island which also had a resort where participants could easily be accommodated, and it was also easily accessible. Paula Bontempi mentioned that the US had not offered to host an IOCCG meeting in a while, and that Washington or New York City could also be considered.

8.4 Closing Comments

The Chairman thanked Milton Kampel and INPE for the great organisation of the meeting, and also the evening functions. He noted that it was good to have the meeting in Brazil and he was glad to note that there was always good attendance at the IOCCG meetings, indicating that something important was being accomplished.

Appendix I: LIST OF PARTICIPANTS
15th IOCCG Meeting, Rio de Janeiro, Brazil
18-20 January 2010

IOCCG Members

Ahn, Yu-Hwan
 Antoine, David (Chair)
 Bernard, Stewart
 Bontempi, Paula
 Chauhan, Prakash
 Davis, Curtiss
 DiGiacomo, Paul
 Doerffer, Roland
 Dowell, Mark
 Kampel, Milton
 Lavender, Samantha
 Mao, Zhihua
 Murakami, Hiroshi
 Regner, Peter
 Thouvenot, Eric
 Weeks, Scarla
 Yoder, James (Past-Chair)

Affiliation

KORDI, Korea
 LOV, Villefranche, France
 CSIR, South Africa
 NASA HQ, USA
 ISRO, India
 Oregon State University, USA
 NOAA, USA
 GKSS, Germany
 JRC, Italy
 INPE, Brazil
 University of Plymouth, UK
 Second Institute of Oceanography (SIO), China
 JAXA/EORC, Japan
 ESA/ESRIN, Italy
 CNES, France
 Univ. Queensland, Australia
 Woods Hole Oceanographic Institution, USA

Invited Participants

Alvarenga, Márcia
 Chamon, Marco Antonio
 Claustre, Herve
 Gagliardini, Antonio
 Ganem, Carlos
 Helbig, James
 Ishizaka, Joji
 Morel, André
 Pan, Delu
 Sathyendranath, Shubha
 Soares, João Viane
 Stuart, Venetia
 Wang, Menghua

Affiliation

INPE, Brazil
 INPE, Brazil
 LOV, Villefranche, France
 CENPAT, Argentina
 AEB, Brazil
 Department of Fisheries and Oceans, Canada
 Nagoya University, Japan
 LOV, Villefranche, France
 Second Institute of Oceanography (SIO), China
 PML, UK
 INPE, Brazil
 IOCCG Project Office, BIO, Canada
 NOAA/NESDIS/STAR, USA

Apologies

Bonekamp, Hans
 Crevier, Yves
 Platt, Trevor
 Tanaka, Tasuku
 Torrusio, Sandra

Affiliation

EUMETSAT, EU
 CSA, Canada
 POGO, UK
 Yamaguchi University, Japan
 CONAE, Argentina