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doi: 10.13679/j.advps.2014.2.00001

Advances in Polar Science
June 2014 Vol. 25 No. 2: 1-10

# The SOOS Asian Workshop: Exploring possibilities for collaboration

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**Received 14 November 2013; accepted 9 May 2014**

**Abstract** The first Southern Ocean Observing System (SOOS) Asian Workshop was successfully held in Shanghai, China in May 2013, attracting over 40 participants from six Asian nations and widening exposure to the objectives and plans of SOOS. The workshop was organized to clarify Asian research activities currently taking place in the Southern Ocean and to discuss, amongst other items, the potential for collaborative efforts with and between Asian countries in SOOS-related activities. The workshop was an important mechanism to initiate discussion, understanding and collaborative avenues in the Asian domain of SOOS beyond current established efforts. Here we present some of the major outcomes of the workshop covering the principle themes of SOOS and attempt to provide a way forward to achieve a more integrated research community, enhance data collection and quality, and guide scientific strategy in the Southern Ocean.

**Keywords** **Southern Ocean Observing System, collaboration, Working Group**

**Citation:** Swart S, Liu J P, Bhaskar P, et al. The SOOS Asian Workshop: Exploring possibilities for collaboration. Adv Polar Sci, 2014, 25:138-145, doi: 10.10.13679/j.advps.2014.2.00000

## 1 Introduction and rationale

The Southern Ocean Observing System (SOOS) is being developed as an international initiative to address the lack of observations in the remote and harsh environments of the Southern Ocean, as well as to provide an overarching structure to coordinate and expand the efforts of all nations that collect and disseminate observations from the Southern Ocean[1]. The long-term vision of SOOS is to achieve sustained, multi-disciplinary observations in the Southern

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Ocean to address key scientific and societal issues, including climate change, sea-level rise and the impacts of global change on marine ecosystems. To meet this vision, SOOS needs to develop into a fully integrated and coordinated international platform with infrastructure, resources and investment from all nations involved in Southern Ocean research and observations. A key step towards achieving the mission is to bring the scientific activities and research programs of various countries and institutes into a common framework to facilitate a unified approach towards addressing the six science themes of SOOS[2]. Given the breadth of research carried out in the Southern Ocean, it is difficult to fully comprehend the totality of current activities, which hinders identification of observation gaps and potential for collaborative efforts.

For these reasons, clarification of the extensive research activities conducted by Asian nations in the Southern Ocean, which are seen as a crucial and valuable element of SOOS, was the overall motivation behind the first SOOS Asian Workshop. Specific elements that the workshop provided a forum to address include:

(1) Identifying current Asian research activities, projects and observations in the Southern Ocean.

(2) Understanding Asian research aspirations and how these may contribute to SOOS.

(3) Fostering further involvement of Asian nations into current SOOS activities and plans.

(4) Understanding the barriers (e.g., shortage of funding or resources, lack of access to the field to make observations) that may hamper efforts by Asian countries to conduct quality research and observations and assess the means by which SOOS could provide assistance to or provide guidance in limiting these obstacles to research.

(5) Identify overlap in national strategic science plans in order to enhance collaborative efforts

(6) Providing a forum of communication with and between Asian individuals, nations and programs that allows for collaboration and cooperation going forward.

## 2 Workshop outline and summary

The two-day workshop was separated into two main parts. The first comprised of an open day introducing SOOS and international Southern Ocean research activities focused around the six scientific themes of SOOS[1-2] (see www.soos.aq). This provided many Asian participants with the opportunity to hear about SOOS, how Asian researchers and programs can get involved in SOOS, and how SOOS may be beneficial to their efforts and vice versa. This was followed by an overview of research and capabilities from Asian nations and programs that provided an excellent overview of the depth and variety of research currently taking place by Asian nations in the Southern Ocean. This information was an important foundation upon which to build SOOS-Asian engagement and interaction.

It became clear from the presentations that numerous Asian research activities were not well known to the broader international community and that the prospect for multiple avenues of collaboration and integration exist between SOOS and the different research groups. Particularly enlightening was the fact that there were abundant observations currently made on Asian research ships (Figure 1; Table 1), ships of opportunity and at Asian Antarctic research bases (Table 2) that could, with minimal effort, be linked to standard environmental observations to bolster the observation platform already being established by SOOS. For a more detailed overview of the workshop presentations, please see the workshop report[3] or visit the following website to view the presentations made available by Association of Polar Early Career Scientists (APECS): https://vimeo.com/channels/587781/.

The second part of the workshop was focused around working groups and discussions and is detailed below.

## 3 Summary of the Workshop Scientific Sessions

The workshop scientific sessions were separated into four key research domains: physical oceanography, carbon chemistry, biological sciences and data management.

### 3.1 Physical Oceanography Working Group

The Physical Oceanography Working Group (POWG) discussed observations and research carried out by Asian countries either independently or in collaboration with the international scientific community.

Through evaluation of the routine observations taken by Asian countries, the POWG found that the majority of Asian counties have an overlap in regional focus (e.g., Prydz Bay; Figure 1). China, Korea, Japan and Russia have obtained hydrographic profiles, measured currents, circulation, and sea ice (including concentration and thickness) in Prydz Bay and the adjacent seas. In addition, China, Korea and Japan have deployed more than 20 moorings in the area, and plan to deploy more through a number of international collaborations. Therefore, POWG recommended the formation of a Prydz Bay Action Group to communicate and cross-fertilize ideas and activities between programs and nations. This would also benefit other Southern Ocean researchers, and enhance collaboration across the SOOS community.

A number of specific field activities were also discussed. Korea (KOPRI) is leading a major international research project in the Amundsen Sea based on fieldwork from their icebreaker, RV *Araon*. The project is SOOS endorsed and currently involves researchers from UK, US, Sweden, Norway and France. It was identified that there was significant potential for Asian countries to enhance their observations of ice shelves and tides. For example, of the nations present at the meeting, only China has been involved in ice shelf drilling and deployment of instruments below ice shelves (Amery Shelf). Further, tide gauge measurements are valuable to

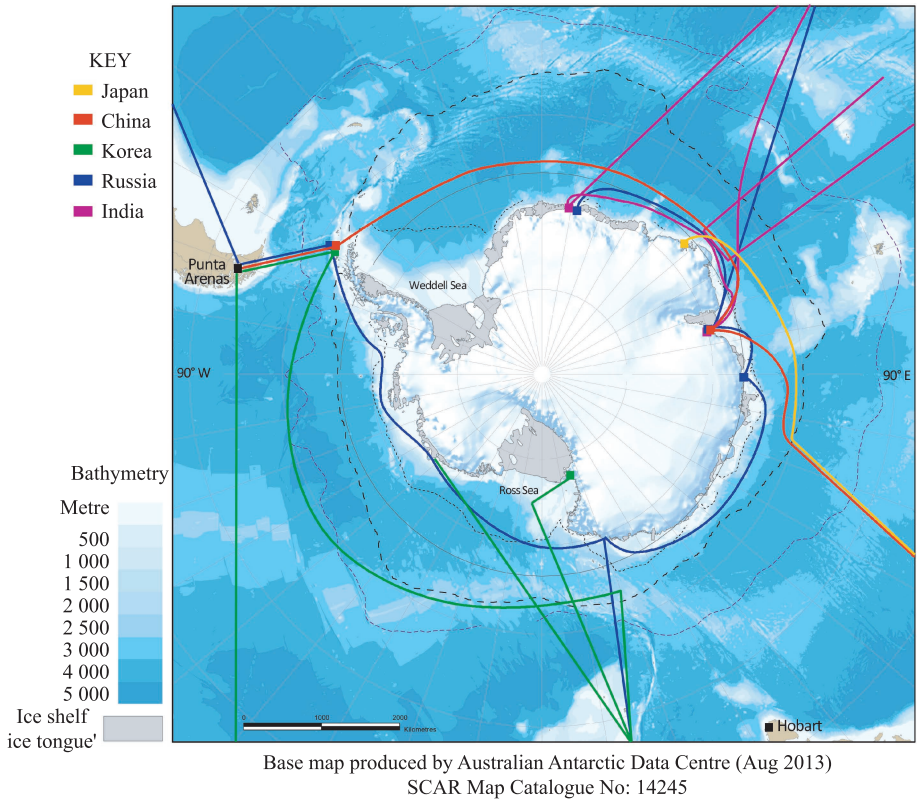


**Figure 1** Map of the Southern Ocean and approximate location of regular shipping transects maintained by Asian nations. The Russian transect (blue) is approximated from the planned 2013/2014 and 2014/2015 route (as of Aug 2013) and is covered by two vessels (RV *Akademik Fedorov* and RV *Akademik Treshnikov*); the Korean transect (green) is approximated from the shipping routes during 2011/2012 and 2012/2013 (RV *Araon*); the Chinese transect (red) is based on the voyages of the RV *XUELONG*; the Japanese route (yellow) is the standard annual route (RV *Shirase*); the Indian route (pink) is the standard annual route and includes the coastal re-supply voyage (RV *Ivan Papanin*) between Cape Town, South Africa and the Antarctic coast on which limited marine science is done, and the specific marine science U-shaped transect (RV *Sagar Nidhi*), which starts from Port Louis, Mauritius.

the broader research community but not all coastal stations were equipped to make these measurements. Increased capabilities in this sphere would be of great interest to the Permanent Service for Mean Sea Level (PSMSL) and the Global Sea Level Observing System (GLOSS) communities and efforts should be made to connect with these international programmes where possible.

The POWG acknowledged that international collaboration has been and will remain a crucial aspect in carrying out quality observations and research in the Southern Ocean. Although remarkable progress has been made in data collection and scientific research by Asian countries over the past few decades, contributions from Asian countries are generally under-represented in multi-national efforts and publications. To remedy this situation, Asian scientists would like to engage in international research hotspots, adopt international standards for observational instruments and methods (to improve data quality), and promote the integration of national expeditions to the Southern Ocean into international programs like SOOS (e.g., through the development of regional Action Groups).

### 3.2 Carbon Chemistry Working Group

The Carbon Chemistry Working Group (CCWG) session highlighted that many carbon-related observations were already being made from research ships and Antarctic stations operated by the Asian nations. The importance of making this data available to the wider Southern Ocean research community was acknowledged by all and communicated to the SOOS Data Management Sub-Committee for consideration and future planning. The SOOS community would benefit from more detail on the observations taking place, their locations, and contact persons. The collection of this information is being coordinated through the CCWG. This information could also be of immense value to established international programs, such as the International Ocean Carbon Coordination Project (IOCCP), which coordinates global $CO_2$ observations and the Surface Ocean $CO_2$ Atlas (SOCAT), which assembles quality controlled global surface ocean $CO_2$-related data for archiving and distribution of gridded products. SOCAT is an international effort that delivers comprehensive baseline data for synthesis efforts including the development of regional

**Table 1** Compilation of the Asian stations currently in service in Antarctica

| Base | Country | Open | Established | Location |
|---|---|---|---|---|
| Asuka Station | Japan | Unmanned obs. | 1985 | Queen Maud Land |
| Bellingshausen Station | Russia | Permanent | 1968 | King George Island |
| Bharati | India | Permanent | 2012 | Larsemann Hills |
| Dome Fuji Station | Japan | Permanent | 1995 | Queen Maud Land |
| Great Wall Station | China | Permanent | 1985 | King George Island |
| Jang Bogo Station | Korea | Permanent | 2014 | Terra Nova Bay |
| Jinnah Antarctic Station | Pakistan | Summer | 1991 | Queen Maud Land |
| King Sejong Station | Korea | Permanent | 1988 | King George Island |
| Kunlun Station | China | Summer | 2009 | Dome A |
| Leningradskaya Station | Russia | Summer; Unmanned obs. | 1971 | Victoria Land |
| Maitri Station | India | Permanent | 1989 | Schirmacher Oasis |
| Mirny Station | Russia | Permanent | 1956 | Davis Sea |
| Mizuho Station | Japan | Permanent | 1970 | Enderby Land |
| Molodezhnaya Station | Russia | Summer; Unmanned obs. | 1962 | Coast of Cosmonaut Sea |
| Novolazarevskaya Station | Russia | Permanent | 1961 | Queen Maud Land |
| Russkaya Station | Russia | Summer; Unmanned obs. | 1980 | Marie Byrd Land |
| Showa Station | Japan | Permanent | 1957 | East Ongul Island |
| Taishan Station | China | Permanent | 2014 | Princess Elizabeth Land |
| Vostok Station | Russia | Permanent | 1957 | Antarctic Ice Sheet |
| Zhongshan Station | China | Permanent | 1989 | Larsemann Hills, Prydz Bay |

**Table 2** Compilation of the Asian ships accessing the Southern Ocean

| Ship | Country | Commissioned | Type |
|---|---|---|---|
| RV *XUELONG* | China | 1993 | Ice breaker |
| New PRIC vessel (still to be named) | China | 2016 or later | Ice breaker |
| *Shirase* | Japan | 2009 | Ice breaker |
| *Akademik Fedorov* | Russia | 1987 | Ice breaker |
| *Akademik Tryoshnikov* | Russia | 2011 | Ice breaker |
| RV *Araon* | Korea | 2009 | Ice breaker |
| ORV *Sagar Nidhi* | India | 2007 | Ice strengthened |

climatologies, the detection of long term trends in ocean carbon sinks, and providing data for the testing and validation of ocean biogeochemical models. Such programs also provide guidelines and standardized methods to nations and institutes collecting environmental observations in order to ensure internationally accepted quality and uniformity of the observations. Linkage to programs, like SOCAT, is a particularly useful way for new research groups to contribute to the global effort of carbon-climate observations and to access the outputs of the international community.

A major step towards developing a coordinated approach across all nations with existing or developing Southern Ocean carbon programs is to ensure all ships are equipped with high accuracy, validated instruments to measure fundamental carbon-related variables in surface waters (such as temperature, salinity, $pCO_2$, total alkalinity, and oxygen) and where possible additional auxiliary variables (nutrients, $TCO_2$, alkalinity, chlorophyll-*a*, $O_2$/Ar, bio-optics, POC and PIC). Furthermore, sustained time series measurements of carbon and related parameters are already made at a few Antarctic bases and establishing similar measurements at other bases was considered another high priority. These data are needed to determine the variability in the marine biogeochemistry and ocean acidification of Antarctic shelf and near shore waters and is a foundation for establishing ecosystem responses to environmental change. Many bases already have much of the infrastructure in place to support the time series observations. Data acquired at stations in Antarctica need to be assessed, validated and eventually submitted to international databases. Nations supporting bases and not collecting these types of observations should be encouraged to become part of an international observing network. The potential also exists to coordinate efforts across nations to facilitate time series observations at offshore sites using moorings and arrays of profiling floats equipped with biogeochemical sensors.

A key component of the ocean observing system needed to detect changes in the storage and transport of carbon, oxygen, and nutrients in the ocean interior are repeat hydrographic sections (e.g., Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIPS); http://www.go-ship.org). The subsurface carbon-related measurements need to be carried out about every 5-10 years in order to understand climate-induced environmental change. Collaboration across all nations with active Antarctic

programs and research capable ships will allow for access to new regions of the Southern Ocean for ocean interior work to be undertaken, as well as the provision of support for existing sections to be sampled at regular enough intervals. It is hoped that collaboration with Asian nations will allow for access to new regions of the Southern Ocean for ocean interior work to be undertaken, as well as the provision of support for existing sections to be sampled at regular enough intervals.

In addition to these fundamental elements, carbon research in polynyas and coastal ice-shelf and sea-ice regions is seen as a key knowledge gap for the international carbon research community. There is currently little overlap and discussion occurring between programs obtaining carbon observation in polynyas and within the sea-ice domains. Observations and research by Asian nations provide an additional opportunity to sample these areas in greater detail than is currently being undertaken. These regions are seen as a prime target for focused process studies that may make use of autonomous platforms (e.g., surface wave gliders and profiling gliders), in conjunction with ships, to fulfill the temporal and spatial scales required to understand the processes and variability that govern the carbon cycle in the Southern Ocean.

### 3.3 Biology Working Group

The Biology Working Group (BWG) evaluated the nature of biological and ecosystem research work carried out by different Asian countries. During the course of discussions and based on the presentations of the participants, it was evident that some basic knowledge on the current routine measurements being conducted and the regional coverage of activities need to be defined.

A primary task is to identify sampling transects covered by Asian countries (Figure 1) but potentially not known to the greater international community, as well as the timing of sampling and the parameters being investigated. The purpose of this is to identify potential for overlap in areas of focus with those outlined in the SOOS Theme 6 work plan. For example, transects in the Indian Ocean sector along 47.5E, 57.5E and between Cape Town and Princess Astrid Coast (Queen Maud Land), along with additional transects of Korea, Japan and China (Figure 1) are not represented in the current transect map outlined in Theme 6. With the addition of these new transects to those proposed in the Theme 6 workplan, supplementary data (biological and other) should now be available and assist in covering larger domains of the Southern Ocean. The knowledge of such new transects can help the Southern Ocean research community to plan and develop collaborations, while addressing multiple themes identified under SOOS.

To facilitate collaboration between different research groups at the national and international level, the BWG started to develop a table to record the different types of samples collected along oceanic transects on a routine basis. This requires a comprehensive overview of national activities, which is often difficult for nations with multiple active institutes and research groups. To facilitate the development of such a table, the BWG suggested identifying project leaders or national representatives that can acts as contact people and assist in finding other researchers in their countries involved in Southern Ocean research. Over the next year, SOOS will continue to populate this table as part of the Priority Observation Task Group (PO-TaG). The table will be made available on the SOOS website.

As was identified by the other Working Groups, internationally agreed standard methods of sample collection need to be adopted, or if protocols are lacking, there needs to be development towards identification of best-practice. In order to start the evaluation of available best-practiced methods, the BWG identified various disciplines that should be involved in such discussions, such as physics (hydrography), biology (benthos, plankton biology, mesopelagics), microbiology (bacteria, microbial loop, etc.), biological production (primary, bacterial), top predators, remote sensing, acoustic and animal tags. Many international projects and organizations have already developed standard methods for specific observations, and that these parties will be contacted to contribute this information (e.g., Scientific Committee on Antarctic Research (SCAR), Southern Ocean Continuous Plankton Recorder (SO-CPR), SCAR Expert Group on Birds And Marine Mammals (EGBAMM) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)).

Southern Ocean research requires continuous and collaborative effort to address all the topics identified under the SOOS Science Themes. Many of the Asian research programs presented during this workshop have either overlapping schedules or a similar set of parameters being investigated. The need to maximize information sharing and synergy between the countries involved was highlighted as of key importance in developing SOOS. Similarly, the need to build capacity and enhance the skill base was also identified as critical, and the need for adequate funding in developing countries was seen as a hurdle to be overcome. Apart from funding availability, additional barriers in conducting Southern Ocean research were identified as a lack of ship-time, berths, gaps in method practice and lack of collaborative studies both on a national and international level. Organizing cross-national workshops for training in calibration-validation of equipment, training for new methods and identification of best-practiced techniques, is likely to make a significant contribution to overcoming some of these problems. SOOS endorsement of national science projects that propose to conduct research according to the best practices identified above may facilitate success of funding proposals and identification of potential collaborations.

### 3.4 Data Management Working Group

Several Asian nations reported in plenary on their national data management activities and it was clear that nations such

as China, Korea, India and Japan were currently placing emphasis on improving the management and publication of polar and Southern Ocean data. All were in the process of establishing an appropriate policy and planning framework (nationally or institutionally) to underpin data management activities and were looking for the best ways to encourage policy compliance at the scientific coalface. Rather uniquely, Korea had developed an incentive scheme whereby scientists were paid a small sum of money to deposit their data within the approved national repository. Whilst this has resulted in an increase in data deposit rates, the sustainability of this approach in fiscally constrained contexts may be challenging. It was also evident that Asian nations have individually developed sophisticated tooling to address the tasks of data archiving and publication, and many Asian-language-based data discovery Portals were demonstrated. The current accessibility of some of these Portals to the international scientific community, however, remains constrained by language barriers. Language issues are also responsible for the apparent lack of interoperability between many systems in Asia and other parts of the world. The burden of translation is a significant overhead in sharing data with non-Asian nations.

Despite the issues mentioned above many common data management themes emerged from discussions between Asian and non-Asian colleagues during the working group breakout session. All nations were grappling with the fact that Southern Ocean data tends to be captured by many and varied sources and in the main these data tend to be:

(1) not uniformly discoverable;

(2) not necessarily accessible online;

(3) scattered within and between institutions;

(4) almost always poorly documented;

(5) in variable (often bespoke) formats;

(6) created using terms and variable names with local (not globally understood definitions); and

(7) lacking important within-dataset level metadata (e.g., units of measure).

The current state-of-play with respect to SOOS data is a result of historically variable national approaches to data management across all jurisdictions interested in Southern Ocean research. Whilst some nations have nurtured capability at the institutional level, others have left management of data to individual science projects. In these latter approaches the relatively short-term focus of 'projects' has led to long-term data custodianship legacy issues that are now difficult to address.

Recognising that some consistency is required in how scientific data are managed into the future, the concept of global repository 'accreditation' has recently gained international traction. The Data Management Working Group discussed the desirability of encouraging a higher level of uniformity in national data management capability through the alignment of SOOS (and associated National Antarctic Data Centres) with the International Council for Science (ICSU) World Data System accreditation scheme. Australia is already accredited and China indicated that it was about to seek accreditation. The applicability of using accreditation to improve capability will be explored further at a Polar Data Forum organised by Japan in October 2013.

# 4 Identifying avenues for collaboration and way forward

A key objective of the SOOS Asian workshop was to bring the Asian and SOOS communities together to identify areas of potential collaboration and enhancement of current scientific research strategy. Towards this end, the final session of the workshop was dedicated to integrating the findings of the breakout groups, and determine the best approaches for achieving the workshop goals.

A number of key requirements were identified by the scientific working groups. One overarching conclusion was the pressing need to identify the current compilation of observations being undertaken by Asian research programs (and indeed the research programs of all nations), as well as the regional access and coverage of Asian research ships and stations (Figure 1; Tables 1 and 2). Towards achieving this, SOOS will develop a focused Task Group to compile the information, in collaboration with other international coordination efforts (e.g., Council of Managers of National Antarctic Program (COMNAP), Partnership for Observation of the Global Oceans (POGO), etc.). A SOOS Task Group will also be formed to compile all available international standards for various methods, and where these standards do not exist, the Task Group will initiate activities to develop them. This information will be made publically available to all interested parties.

It is also pertinent to take advantage of the momentum and interest from the Asian workshop to enhance current observational efforts. To this end, SOOS and the scientific community will develop a list of Priority Observations that can be disseminated to National Antarctic Programs and funding agencies. These Priority Observations will help to leverage resources and standardize observation efforts across all sections of the Southern Ocean. SOOS will again work with other international coordination efforts to achieve this (e.g., COMNAP, GO-SHIP, Antarctic Sea Ice Processes & Climate (ASPeCt), Antarctic Fast Ice Network (AFIN), among many others). In addition, these efforts will make a contribution to the operational oceanography community. In order to fully reach its goals and service to society, SOOS will have to work closely with the operational oceanography community by incorporating SOOS data into the latest assimilative models to deliver operational products of the Southern Ocean, like forecasts and nowcasts of the state of the sea, including living resources. At the same time, those models will be crucial to improve our understanding of numerous ocean processes that will remain unresolved despite SOOS observation efforts.

A number of near-future SOOS-endorsed workshops

(e.g., CPR training and validation of data) and meetings were proposed within the Working Groups. These will provide an active means for engagement between researchers and can provide additional catalyst to spreading information across program boundaries, addressing data quality control and submission to data portals, and spur collaboration. SOOS invites workshop participants and other interested parties to identify specific opportunities for capacity building and training workshops, and would be interested to work with these communities to achieve this.

The issue of funding for sustained Southern Ocean efforts and basic research is one that is common to many nations, not only Asian. Although little can be done to counter this directly, enhanced international collaboration is key to leveraging more resources and support. Where possible, SOOS will also ensure representation from many nations in all large-scale multi-nation funding proposals.

The data management breakout group determined that ongoing collaboration would be pursued through the activities of the SOOS Data Management Sub-Committee (DMSC). China expressed a strong desire to become a member of the DMSC so that it could forge closer links with the SOOS data management effort, and was offered membership subsequent to the workshop. Most importantly, a draft SOOS Data Policy was crafted during Working Group deliberations. This Policy sets the guiding principles for developing the SOOS data management infrastructure and establishes expectations regarding norms of behavior (with respect to data practices) for participating science partners. After ratification of the SOOS Data Policy, the main collaborative task to be pursued by the DMSC is the collation of an online inventory of SOOS relevant, but distributed, data, which will be exposed through a centralized SOOS Portal.

In conclusion, the SOOS Asia workshop was seen as a great opportunity for over 50 scientists from six Asian countries and the current SOOS Scientific Steering Committee members to share their knowledge, recommendations and concerns, and to establish a dialogue between the Asian research groups and the broader international community. It is expected that Asian counties and SOOS will continue to engage and contribute to this discussion. Asian countries that are not presently engaged in Southern Ocean research and observations, but which had expressed an interest in being active in Antarctica (e.g., Malaysia, Iran, Indonesia, Pakistan, Vietnam), are also encouraged to make contact with relevant SOOS or Asian representatives.

**Acknowledgements** The workshop was hosted and sponsored by the Polar Research Institute of China (PRIC), with additional sponsorship by the State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), the Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP/CAS), the World Climate Research Programme (WCRP) "Climate and the Cryosphere" project (CliC), SCAR) and the Scientific Committee on Oceanic Research (SCOR). We thank Alexander Klepikov, Hyoung Chul Shin, Katsuro Katsumata for providing the information on ship tracks. The conveners would like to thank the efforts by all participants, in particular the presenters, in making the first SOOS Asia Workshop a successful forum by which to highlight the extensive Asian research activities in the Southern Ocean and discuss a way forward in driving collaboration and integration with SOOS, as well as the greater international community. SOOS would like to recognize the support of the Institute for Marine and Antarctic Studies (IMAS, University of Tasmania) in hosting the SOOS International Project Office, and the sponsorship of the office by numerous international organizations (see www.soos.aq/index.php/about-us/sponsors). We thank the valuable comments provided by the SOOS SSC in preparation of this paper.

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