· Trend ·

doi: 10.13679/j.advps.2014.2.00121

Advances in Polar Science

June 2014 Vol. 25 No. 2: 121-125

The SOOS Asian Workshop on Southern Ocean research and observations

LIU Jiping[1]*, Sebastiaan Swart[2,3], Parli V. Bhaskar[4], Louise Newman[5], Michael Meredith[6], Oscar Schofield[7] & HE Jianfeng[8]

[1] Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, NY, 12222, USA;

[2] Southern Ocean Carbon & Climate Observatory, CSIR, PO Box 320, Stellenbosch, 7955, South Africa;

[3] Department of Oceanography, Marine Research Institute, University of Cape Town, Rondebosch, 7701, South Africa;

[4] National Centre for Antarctic & Ocean Research, Headland Sada, Vasco-da-Gama, Goa, India;

[5] Southern Ocean Observing System International Project Office, Institute for Marine and Antarctic Studies, University of Tasmania, Australia;

[6] British Antarctic Survey, Cambridge, Cambridgeshire, CB3 0ET, United Kingdom;

[7] Coastal Ocean Observation Laboratory, Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, 08901, USA;

[8] Polar Research Institute of China, Shanghai, China

Received 23 November 2013; accepted 13 February 2014

Keywords **Southern Ocean Observing System, Physical Oceanography, Biological Sciences, Carbon Chemistry**

Citation: Liu J P, Swart S, Bhaskar P V, et al. The SOOS Asian Workshop on Southern Ocean research and observations. Adv Polar Sci, 2014, 25:121-125, doi: 10.10.13679/j.advps.2014.2.00121

1 Background and purpose of workshop

The Southern Ocean plays a fundamental role in the function of the Earth System, influencing climate, sea level, biogeochemical cycles, and biological productivity on a variety of scales[1]. Observations from the Southern Ocean suggest that dramatic changes are taking place, which are of global concern, yet because of its remote location, seasonal sea ice, and harsh environment, the Southern Ocean remains one of the least sampled zones in the world.

The Southern Ocean Observing System (SOOS) was developed as an international initiative both to address these issues and to provide an overarching structure to coordinate and expand the efforts of all nations that collect and disseminate observations from the Southern Ocean. Since its launch in 2011, SOOS has focused much of its attention on identifying the scientific platforms currently capable of delivering (or that need development to deliver) the measurements required to address six key challenges identified in the SOOS Initial Science and Implementation Strategy[2]. To meet these challenges, sustained data collection by the international research community is required.

The long-term vision of SOOS is to achieve the sustained, multi-disciplinary observations required to address key scientific and societal issues in the Southern Ocean (i.e., climate change, sea level rise, and the impacts of global

* Corresponding author (email: jliu26@albany.edu)

change on marine ecosystems). To meet this vision, SOOS must be a fully integrated and coordinated international system with infrastructure, resources and investment from all nations involved in the Southern Ocean research and observations. This was the motivation behind the organization of the SOOS Asian workshop. The objective of the SOOS Asian Workshop was to highlight the activities of Asian countries currently engaged in Southern Ocean research and observations relevant to the SOOS science strategy, and to stimulate discussion and foster further involvement from Asian countries in the SOOS activities. 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), were also encouraged to attend. Over 50 scientists participated in the workshop (including the SOOS Scientific Steering Committee (SSC) members), with representations from six Asian nations (China, India, Japan, South Korea, Russia, and Iran).

2 Scientific sessions on international activities in Southern Ocean research

In the opening remark, Jiping Liu introduced the motivation and objectives of the SOOS Asian Workshop (as described above), and emphasized that the workshop aimed to facilitate and enhance involvement by Asian countries in SOOS, as SOOS strives to reach its ultimate goal: development of a sustained, multi-disciplinary and internationally coordinated Southern Ocean observing system. Sebastiaan Swart then provided an overview of the SOOS mission and objectives. Interested readers are encouraged to visit the SOOS web page (www.soos.aq/index.php/about-us/mission).

Session 1 was devoted to presentations from the SOOS SSC to provide an overview of international activities in Southern Ocean research, structured around the six scientific themes of SOOS (www.soos.aq/index.php/science/themes).

Steve Ackley presented on international Southern Ocean sea ice research activities. He outlined the sea ice Essential Climate Variables (ECVs) that are measurable by satellite observations on a circumpolar basis (ice extent and concentration, ice thickness, ice types, ice drift, and snow depth), the effectiveness of current methodologies, and the role of SOOS in enhancing sea-ice observations. The importance of other international efforts, such as ICEBell, ICEBridge and SIPEXII were also mentioned. Andrew Constable then presented benchmarking Southern Ocean ecosystems as a basis for measuring change: the role of SOOS, ICED and other international programs. His presentation summarized why benchmarking is needed, particularly for assisting assessments of ecosystem change by the Intergovernmental Panel on Climate Change (IPCC) and for managing the conservation of biodiversity by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and other forums governing the region. He also outlined a work program leading to benchmarking the overall status of Southern Ocean ecosystems by 2020, and detailed how international collaboration between nations in the Southern Ocean through the Council Of Managers of National Antarctic Programs (COMNAP), SCAR, and the CCAMLR Ecosystem Monitoring Program (CEMP) can help deliver this initiative.

Following this, Tosca Ballerini introduced the topic of food web modeling to the workshop participants. She showed that extensive biological datasets collected under international programs can be used to develop qualitative and quantitative food web models, which are useful tools for integrating observations from different sources and for testing conceptual models of ecosystem structure and functioning. These models provide a framework for comparing the responses of regional ecosystems to common environmental drivers and a basis for linking food web models to larger integrated ecosystem models that include the physics and biogeochemistry of the Southern Ocean. Daniel Costa discussed animal oceanographers within the framework of SOOS. He highlighted electronic tags have considerably increased our ability to study the movements and behavior of marine mammals at sea. Recent developments from tracking studies carried out on marine mammals have confirmed that mammals can be employed as autonomous ocean profilers to provide environmental observation data in diverse and remote ocean regions. Significant advantages of tag-collected oceanographic data are that they are collected at a scale and resolution that matches the animals' behavior. These data therefore provide not only insight into the animals behavior, but also information as to how they respond to environmental variability on daily, seasonal, and inter-annual time scales. Alberto Naveira Garabato discussed the Southern Ocean circulation. He highlighted a number of key issues, such as the need for involvement of the data assimilation community, and the need to continue present observations but enhance technological developments for observations of the deep ocean (below 2 000 m) and the sea ice zone, which are two 'blind spots' in current observations.

Research into mapping and understanding abyssal life in the Southern Ocean was presented by Angelika Brant. She emphasized that for the past 10 years an enormous effort has been made to investigate marine life, but our knowledge of the biodiversity decreases with depth. She introduced a new initiative, the multi-authored "Biogeographic Atlas of the Southern Ocean", under the aegis of SCAR. It provides an up-to-date synthesis of Antarctic biogeographic knowledge, and documents the scarcity of bathyal and abyssal biological sampling. Bronte Tilbrook presented the status of international research on Southern Ocean carbon. He highlighted that ocean acidification in the Southern Ocean is driven by carbon uptake and has the potential to cause widespread disruption of marine ecosystems. The lack of observational data from the region was also highlighted, although new instrumentation and ships are providing opportunities to enhance the observing network. Tilbrook then introduced plans and opportunities to

develop an observing system for carbon and acidification, and the international efforts already in place to produce quality controlled data products for use by the research community.

The final SOOS-related presentation was made by Kim Finney who introduced the SOOS data management strategy. Sharing of, and open access to, the diverse observational data obtained by national Antarctic science programs, research institutes and programs conducting science in the Southern Ocean is key to the success of SOOS. Finney demonstrated that data from these sources are generally managed and published in a highly heterogeneous fashion, with only some of the data being managed by established, sustainable Data Centres or repositories. A unified window through which Southern Ocean data can be discovered and accessed is required. The solution involves leveraging existing infrastructure and resources of SOOS-affiliates to create a blended system, cemented together by standards, norms of behavior and explicitly stated protocols. Following on from the SOOS introduction and specific scientific domain presentations, Session 2 continued with Asian national data management strategies, with presentations made by respective representatives from China, South Korea, Japan, Russia and India. Each introduced their current data management systems and policy.

Session 3 was devoted to an overview of Southern Ocean research capabilities and perspectives from varying Asian nations. It commenced with China's Southern Ocean activities. Jianfeng He presented Southern Ocean research and observation activities conducted by the Polar Research Institute of China since the mid 1980s. A total of twenty-nine Chinese National Antarctic Research Expeditions (CHINARE) have been completed focusing on oceanography, meteorology, biology and glaciology. Fangli Qiao then discussed recent and future research activities of the First Institute of Oceanography in the Southern and Indian Oceans, including a national key project of comprehensive evaluation of the role of Southern Ocean in global and regional climate change, observations in the Indian Ocean through international cooperation on southeast Asian Monsoon onset and evolution, and ocean forecasting system for the Indian Ocean under UNESCO/IOC. Liqi Chen presented investigations of air-sea fluxes of carbon, nitrogen, sulfur, and iron in the Southern Ocean during CHINARE through Sino-US collaborations. His team focus has been on the distribution of pCO_2, air-sea CO_2 fluxes and their controlling mechanisms. Their observations show a weakening of CO_2 sequestration in the Southern Ocean during the decadal CO_2 investigations from 1999 to 2008, an undersaturation of N_2O south of the Subantarctic Front due to a combination of sea surface temperature variation and intrusion of N_2O-depleted ice melt water during summer, no significant correlation between MSA/nss-SO_4^{2-} and air temperature at southern high-latitudes, which indicates latitudinal temperature variations are not a main factor responsible for the MSA/nss-SO_4^{2-} variation there, and the estimated deposition flux of total dissolved Fe varying from 0.01 to 0.56 $mg \cdot m^{-2} \cdot a^{-1}$ over the Southern Ocean.

On behalf of India, Parli Bhaskar presented India's Southern Ocean studies program and highlighted ongoing and future activities. India's sojourn in the Southern Ocean started in 2004. The Indian Southern Ocean Studies Program became an umbrella program under which various long-term projects and short-term research studies from several premier research institutions and universities were accommodated. One of the key requirements of this program was to develop a core long-term research project addressing globally important issues and linking their impacts to more local issues (e.g., Indian Monsoon System). Based on the results from initial expeditions, a study area has been identified between 47.5°E and 58.5°E and between 35°S and 67°S encompassing all the major fronts of the Antarctic Circumpolar Current, as well as Antarctic coastal waters. Since its inception, a total of seven Indian Southern Ocean Expeditions have been completed focusing largely on oceanography (e.g., hydrodynamics and heat transport, biological food-web dynamics, biogeochemistry of carbon, marine mammalian studies), atmospheric (e.g., black carbon distribution, rain water isotopic studies) and paleoclimatic links to the Indian Monsoon system. He further highlighted India's proposed long-term sediment trap and current meter mooring program under Southern Ocean Carbon Processes (SOCarP), and findings from the ongoing project "Hydrodynamics and Biogeochemistry of Indian Sector of Southern Ocean".

Tae Siek Rhee represented Korea and presented observations of trace gases relevant to global climate change in the Southern Ocean. Korea has measured trace gases, including CO_2, CH_4, N_2O, CO, and H_2 in the surface waters and atmospherically from the Korean ice-breaking research vessel *Araon*, since 2010. It was found that in the open ocean, CO_2 in the surface waters was mostly undersaturated, CH_4 was slightly undersaturated, and N_2O and CO were supersaturated with respect to the marine boundary layer. These features were not observed in the sea-ice region; CO_2 in the seawater was slightly supersaturated in 2011, but not in 2012, and CH_4 in the seawater was undersaturated, while dissolved N_2O and CO were supersaturated for both years. In the polynya of the Amundsen Sea, CO_2 and CH_4 were depleted in the seawater while N_2O and CO in the seawater was supersaturated with respect to the atmosphere. Based on these 3-year observations during austral summer season, the high latitude of the Southern Ocean contributes as a sink for atmospheric CO_2, whilst as a source for N_2O and CO. For CH_4, the open ocean was slightly undersaturated overall, which differs from the role of the ocean in the global scale. Ho Kyung Ha introduced the Korean Amundsen project: a Potent Tributary to SOOS in the western Antarctic. He further discussed rapid flushing of warm deep water on the Amundsen Shelf. He showed that the warm deep water makes a clockwise circulation path across a trough on the Amundsen Shelf, based on the velocity, temperature and salinity from 4 moorings and ship-borne transects. Warm, salty water enters the shelf, flows southward parallel to the eastern flank of trough and into the ice shelf cavity where it is cooled and freshened by subsurface melting

and mixing processes. The product water is more buoyant than the source water, but still the densest water in the water column, and thus remains on the bottom. After interacting with the ice shelves as it flows northward again, following the western flank of trough guided by the Coriolis force.

Alexander Klepikov presented Russian studies of physical oceanography in the Southern Ocean. He showed that several sections were made from the AARI's RV *Akademik Fedorov* in the Prydz Bay, the Pine Island Bay, the Amundsen Sea, and the West Coast of the Antarctic Peninsula under the IPY's Synoptic Antarctic Shelf-Slope Interaction project. Under BONUS/GoodHope IPY project, RV *Akademik Ioffe* made 53 CTD stations in November 2007 and RV *Akademik Sergei Vavilov* made 66 stations in October 2008 in the Drake Passage. During the pre- and post-IPY periods the shelf-slope processes were investigated in Prydz Bay. A 70° E section was repeated seven times during 2004-2013. Descending plumes in the region to the west of Prydz Channel (72° E) results in bottom water formation. Prydz Bay Bottom Water (PBBW) with the temperature −0.3°C−1.6°C and salinity 34.54−34.62 psu was found between 62° and 72°E at a depth of 1300−2000 m (colder and fresher than Antarctic Bottom Water observed in this region). Sinking of dense water plumes along continental slope was not found to the east of 72°E. In 1998, 2011 and 2012 water structure near the Amery Ice Shelf edge was investigated. The bottom layer 100−700 m thick contains Ice Shelf Water formed by cooling of Antarctic Shelf Water due to basal melting. In February 2013 during the testing cruise of the new AARI's ice class RV *Akademik Treshnikov* the transect of 36 CTD stations was made in Margaret Bay starting from the front of George VI Ice Shelf. For the February—March 2014 Russia plans to continue CTD sections in Prydz Bay and also to make sections in the Pacific sector of the Southern Ocean. Alexandra Stupnikova presented Russia's biological activities in her presentation "Drake Passage as a Universal Link and a Unique Antarctic Region". The research had identified genetic differentiation of several zooplankton species within the complex hydrophysical zonality of the Drake Passage. Researchers had sequenced barcoding region of mitochondrial COI gene for several species of zooplanktonic organisms sampled from two meridional transects (one in the Drake Passage and the other near the Greenwich Meridian) in the Atlantic sector of the Southern Ocean. No genetic differentiation has been found for the majority of zooplankter, however mitochondrial haplotypes of Metridia lucens and Eukrohnia hamata cluster in two genetically distant groups, that was supported by ITS1-5,8S-ITS2 region sequences.

Mitsuo Fukuchi, from Japan, presented marine biology research activities in Japan: past, present and future. The Japanese Antarctic Research Expedition (JARE) established a routine oceanographic observation program in 1965/66 and annual observations have been carried out in the Southern Ocean since then (e.g., CTD, XBT, XCTD, and plankton investigation). Surface chlorophyll and vertical profiles of chlorophyll-*a* have been observed. Regular NORPAC net vertical hauls have been carried out for zooplankton. Recently, CPR tows have been introduced and the SCAR SO-CPR Survey is now a highly successful international program led by Australia and Japan. The CPR sampling is an endorsed major marine biological program of SOOS. These data are subjected to analysis of the long-term variability of plankton communities in the Indian sector of the Southern Ocean. Part of the analysis is a joint collaboration with Australian colleagues who have been collecting data in the Indian sector. Based on these analyses they are now focusing on the next generation approach of monitoring, which is the "Southern Ocean Sentinel".

Katsuro Katsumata introduced Japanese Physical Oceanographic Observations in the Southern Ocean. Physical oceanographers' community in Japan has four research vessels that are capable of long-haul research cruises in the Southern Ocean, namely, *Hakuho*, *Umitaka*, *Shirase*, and *Mirai*. These four platforms have been effectively employed in recent research activities including mooring observation of bottom water in Cape Dranley and Vincennes Polynias and hydrographic observations in the Indian and western Pacific sectors. He also introduced Japanese Sea Ice Research Activities. Their group has been developing better thin-ice-thickness and fast-ice-detection algorithms. Combined mapping of Antarctic coastal polynyas and fast ice based on the AMSR-E algorithms shows the strong linkage between polynyas and fast ice. Huge polynyas are often formed on the lee (western) side of the fast ice regions. The Cape Darnley polynya (65°−69°E), formed west of a grounded iceberg tongue, has the second highest ice production and produces the dense shelf water which has been recently confirmed to be another significant source of Antarctic Bottom Water. In this polynya, mooring experiments with ice-profiling sonar and ADCP have been conducted to clarify high ice production process. The Mertz polynya (142°−148°E), with the third highest ice production, has experienced significant decrease in ice production after the calving of the Mertz Glacier Tongue in 2010, leading to decreased AABW production offshore. They are still improving and validating the algorithms by comparing *in-situ* observations and mooring data. During the SIPEX 2012, heli-borne observations with a portable microwave radiometer were carried out to validate the AMSR2, successor of the AMSR-E. Sea-ice condition off and in the Lützow Holm Bay (35°−40°E) has been monitored by the JARE since 2000s based on electro-magnetic inductive (EM) sounder, portable microwave radiometer, video monitoring system, and visual observation with a simplified ASPeCt protocol from the icebreaker *Shirase*. The 10-year long EM data has revealed large interannual ice-thickness variability in pack-ice zone: years of convergent wind drift result in particularly thick ice.

Session 4 was devoted to working group discussions. Participants broke into three working groups to discuss Asian's current and planned Southern Ocean research and observations and to identify potential synergies and avenues for collaboration. The three working groups were physical

oceanography, biological sciences and carbon chemistry. In addition, a data management working group met in parallel to discuss collaboration and contributions from various Asian nations that have existing data management systems. The synopsis of scientific outcomes of each working groups is discussed in a companion paper[3].

3 Concluding remarks

This workshop was very successful and all participants appreciated the presentations and the discussions. It was a great opportunity for scientists from Asian counties and SOOS members to share their knowledge, recommendations, issues, and to establish a true dialogue between communities. This workshop helped pave the way for increased international collaborations on Southern Ocean observations and research, and foster further involvements and contributions from Asian countries in the SOOS activities to implement a comprehensive and multidisciplinary observing system for the Southern Ocean.

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), Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP/CAS), the World Climate Research Programme (WCRP) “Climate and the Cryosphere” project (CliC), the Scientific Committee on Antarctic Research (SCAR), and the Scientific Committee on Oceanic Research (SCOR). SOOS acknowledges the support of its host institute, the Institute for Marine and Antarctic Studies (IMAS, University of Tasmania, Australia), and sponsors, Australian Antarctic Division, Antarctica New Zealand, and the New Zealand Antarctic Research Institute.

References

1 Mayewski P A, Meredith M P, Summerhayes C P, et al. State of the Antarctic and Southern Ocean climate system. Rev Geophys , 2009,47, RG1003, doi:10.1029/2007RG000231.

2 Rintoul S R, Sparrow M, Meredith M P, et al. The Southern Ocean Observing System: Initial Science and Implementation Strategy. Cambridge, U.K: Scientific Committee on Antarctic Research, 2012.

3 Swart S, Liu J P, Bhaskar P V, et al. The SOOS Asian Workshop: Exploring possibilities for collaboration. Advances in Polar Sciences, 2014, 26(2): 126-132. doi: 10.10.13679/j.advps.2014.2.00126.