

## Commentary for *Nature Climate Change*

### Global Ocean Summit: a forum for institutional coordination of global ocean observations

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### Short summary

*A sustainable global ocean observation system requires timely implementation of a global ocean observation framework. The recent Qingdao Global Ocean Summit offers an effective mechanism for a coherent institutional response to emerging scientific and societal drivers, and for promoting the capacity building in developing economies that is essential for increasing the value and broadening the funding base of the observation system.*

Approximately 93% of the additional heat associated with global warming is stored in the ocean<sup>1</sup>, and recent discoveries show that an enhanced heat storage in the subsurface ocean over the past decades contributed to the global surface warming hiatus<sup>2-5</sup>. These highlight the importance of ocean observations in understanding, monitoring and detecting global climate change. Ocean observations, the ‘bread and butter’ of climate change science, are predominantly conducted by ocean research institutions. However, these endeavors are rarely discussed, let alone organized or coordinated across institutions. Although the Intergovernmental Panel on Climate Change provides an effective mechanism to review and assess scientific, technical and socio-economic information, there is no mechanism for identification of observations that are critically needed, or for coordination of observations that are being made or planned. The absence of such a mechanism represents an impediment to the realization of the full value of the investment in ocean research, and is detrimental to the establishment of a sustainable global ocean observation system. We

believe that the recent Global Ocean Summit, initiated by newly elected member of the Chinese Academy of Sciences, Prof. Lixin Wu of the Ocean University of China, and held on 25–26 October in Qingdao, provides such a coordinating mechanism, and we call for such a summit to continue.

At this inaugural summit, leaders from 61 universities and research institutions from both developing (22 institutions) and developed (39 institutions) nations presented new ocean observing technologies and their activities in on-going and planned ocean observations in open water, deep ocean and below sea ice. Importantly, leaders also solicited inter-institutional scientific and logistic coordination and collaboration. Such coordination is particularly challenging because of the sporadic and incoherent nature of funding cycles between nations. There was a realisation that coordination is a must in order to deliver both a great return on investment and strong science outcomes, and that as technologies and capability to observe deep and unknown parts of the ocean emerge, a globally coordinated effort will reap enormous benefits. The international Argo program<sup>6</sup> provides an example of the success of such coordination. A collaborative partnership of more than 30 nations, the program has built a seamless global array of more than 3,500 free-drifting profiling floats, measuring the upper 2,000 meters of the ocean. This program, for the first time, allows continuous monitoring of ocean temperature, salinity and velocity concurrently and on a global scale, with all data relayed and made publicly available within hours after collection. The data have been used widely, including for study of hemispheric heat distribution and changes in hydrological cycle<sup>7-9</sup>.

There are many functions such a global summit can perform. Firstly, it can be a forum to ensure implementation and coordination of the existing framework of ocean observations<sup>10</sup>. This framework (**Fig. 1**) was established as a result of the OceanObs'09 conference (<http://www.oceanobs09.net/>), which took place 21-25 September 2009 in Venice, Italy and brought together more than 600 participants from 36 countries to focus on defining a collective vision of ocean observations for societal benefits. The framework aims to establish an enhanced sustainable global ocean observing system, and to ultimately integrate new physical, biogeochemical and biological observations while sustaining present observations. Informed by scientific and societal issues, the framework builds on our existing observing units, networks and systems, such as Argo, satellites, ships of opportunity, and Expendable Bathythermographs (XBTs) and identifies Essential Climate Variables, such as ocean temperature, salinity and velocity, as our climate observing requirements. These requirements are expressed in Global Climate Observation System plans (<http://www.ioc-goos.org/>), the implementation of which has been adopted by the United Nations Framework Convention on Climate Change (<http://unfccc.int/2860.php>). Through this United Nations process, the framework attracts buy-ins from nations. Different observing units or networks measure different *Essential Ocean Variables* and contribute to different data streams and products. These products in turn help inform climate research and

climate-related societal issues – which are the drivers that originally set the requirements – in an important feedback loop that ideally keeps the observing system ‘fit for purpose’.

However, there is no timely mechanism for implementing the framework in a manner that addresses fast-emerging scientific and societal drivers requiring a coherent global response, such as understanding global warming hiatus, sea level variability, upper ocean heat content change, or deep ocean warming. The Global Ocean Summit provides such a mechanism because summit-attending institutions are key players in their national involvement.

Secondly, the Global Ocean Summit can be an effective forum for engaging different scientific questions and societal issues that require sustained ocean observations, as a way to expand the scope of the system to include observations in biodiversity, ecosystem, regional seas and regional fishery organizations, global fisheries agreements, and ecosystem management and management of the ocean environment. Many of these will be impacted by long-term changes in the ocean (e.g., ocean acidification<sup>11,12</sup>, and will need sustained physical, biogeochemical and biological observations for integrated assessment. Many institutions that attended the summit are major research entities already engaging in such multidisciplinary research and are therefore champions, within their nation, for an extension of activities into these areas. This would expand the number of *Essential Ocean Variables* to include chemical, biological and ecosystem variables, and increase the number of data products. Through this process, the observation system would broaden its funding base by generating impact on more issues. Experience with the tropical ocean and atmosphere arrays suggests a narrow funding base decreases the stability and sustainability of an observation system<sup>13</sup>.

Thirdly such a summit can play a role in capacity building and capability development in developing countries and emerging economies. The recent summit was attended by 22 institutions from developing countries and emerging economies. These institutions are a driving force for identifying scientific and societal issues, informing policy decisions and delivering data streams and products in their countries. Capacity building and capability development in these countries not only enhances the value of the ocean observation system, but also has the potential to entrain eventual buy-ins from the emerging economies.

Finally, the Global Ocean Summit can be extended to coordinate research on sustainable use of ocean resources in a changing ocean. A sustained global ocean observation system allows diagnosis of the long-term health of the global ocean. Pressure on the Earth system, including the ocean, has reached a scale where abrupt global environmental change can no longer be excluded. To ensure we live and operate safely, we must avoid critical thresholds in the system, and respect the nature of the planet's climatic, geophysical, atmospheric and ecological processes. The underpinning science to ensure that our generation meets our present needs, without jeopardising the ability of future generations to meet their needs, is not well developed. This body of science must include reconstructing past climate to

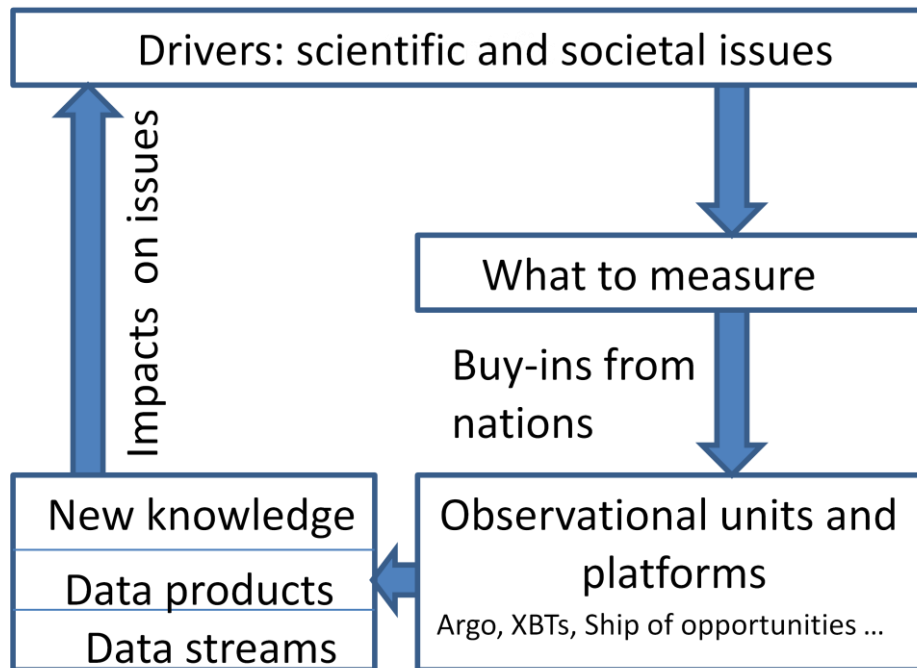
understand the thresholds, climate projection science to evaluate future pressure under plausible scenarios so as to develop strategies for sustainable use of ocean resources, and understanding marine hazards and developing risk assessment tools to inform response options. All these require ocean observations to detect changes, benchmark models, and validating strategies. Many summit-attending institutions are universities where knowledge development is also a core business, and are well positioned to be at the forefront of this new branch of science.

The inaugural Global Ocean Summit initiated a global dialogue between institutions across the world for a timely and responsive implementation of the global ocean observation framework. The summit also produced the Qingdao Consensus, calling for a faster and improved development of ocean science and observing technologies, and fast and widespread dissemination of ocean knowledge and capacity building in developing maritime nations. The continuation of such a summit is an effective mechanism for ongoing coordination of global ocean observation efforts and, in doing so, realising the vision of the inaugural summit – to build an ocean of peace, cooperation and harmony to bring prosperity for generations to come.

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**Figure 1 | A global ocean observation framework.** Scientific and societal issues determine variables to measure, attracting investment from nations through their research institutions. The outcome of the observations, i.e., data, products and new knowledge, inform both existing and new issues.