The Case for a Framework - Optimizing Observing and Data Systems for Sea Ice Forecasting & Monitoring under the Arctic Observing Network

S. Starkweather, S. Farrell, S. Helfrich, J. Intrieri

Background

The case for a sustained, international, multi-disciplinary Arctic Observing Network (AON) has been upheld and advanced within national and international settings for more than a decade (NRC, 2006; IARPC, 2007; AOS, 2016). Recently, the U.S. has indicated its readiness to act by formally establishing a U.S. Arctic Observing Network (U.S. AON), which is also intended to support the strategy of the international Sustaining Arctic Observing Networks (SAON). The U.S. AON Office, under the guidance of a Federal U.S. AON Board, coordinates funders, subject matter experts, research networks, international partners, and stakeholders through advancing two distinct, but interrelated, approaches: an AON Framework and U.S. AON Tasks.

Structured Approaches to Observing Network Development

A value-based observing framework is an organizational tool that brings systematic coherence to a complex of observing objectives. The goal is to elucidate and build upon common denominators across these objectives, in order to maximize the user base and societal benefits of the observing system. Framework development should be undertaken by an authoritative body whose mandate fits the scope of the effort. SAON, whose mandate is suitable to the scope of an international AON, has recently made progress on a key input to an AON framework through the International Arctic Observing Assessment Framework (IAOAF, IDA, 2017), which identified Arctic-specific societal benefits and 120 "Key Objectives" that support those benefits.

Tasks provide an implementation structure through which an AON framework can be advanced at national or international levels. Tasks must also be supported by authoritative (and ideally, funded) bodies to legitimize and sustain their efforts. For example, U.S. AON Tasks are led by one or more U.S. agency in alignment with their mission; each has the potential to internationalize. SAON has already endorsed many international Tasks that represent large, thematic observing efforts. Tasks rely upon a strong base of grassroots support from voluntary subject matter experts.

Frameworks and Tasks progress in relation to one another. Tasks provide organizational starting points for Framework development and manageable units for Framework implementation. Frameworks enhance the collective benefits of the Tasks and generate coherence and linkages across the constituent parts. In network parlance, Tasks are the Nodes and the Framework demonstrates how the Nodes are Linked or related, thereby enhancing their value.

U.S. AON Task: Mobilizing Observations in Support of Sea Ice Forecasting

The recently initiated U.S. AON - Sea Ice Forecasting (U.S. AON - SIF) Task has drawn together subject matter experts in sea ice, satellite, airborne and in situ observing, data assimilation, coupled model development, operational model development, and data product and data service providers. The first purpose of U.S. AON - SIF is to drive greater integration across sea ice observing activities of relevance to

ice forecasting services, with the aim of generating new and more accessible observational products. The extended purpose of U.S. AON - SIF is to take a holistic and strategic view (i.e. framework) towards the required sea ice observing systems of the future AON. In the near term U.S. AON - SIF is focused on mobilizing algorithm development for a multi-sensor, sea ice thickness (SIT) product in support of operational forecasts. It is anticipated that this effort will demonstrate the utility of a sea ice thickness product for improved forecasting and thereby provide the impetus for an operationalized daily product.

Facilitating the U.S. AON - SIF with the Framework for Ocean Observing

This AOS Conference Statement demonstrates how an existing observing framework, the Framework for Ocean Observing (FOO, UNESCO, 2012), provides a coherent structure that can be adopted, with modification, for the successful implementation and internationalization of Tasks such as the U.S. AON - SIF. Through the FOO, the Global Ocean Observing System (GOOS) mobilizes broad, sustained, international participation in ocean observing to serve a large research and operational user base. We here illustrate how a Framework for Arctic Observing would consolidate and extend the benefits of U.S. AON - SIF through the elements of the FOO, defined below.

1. Requirements Element: *Subject Matter Experts identify the system requirements based on their level of scientific and societal impact as well as on how feasible they are to observe.*

A number of U.S. federal agencies, including the National Ice Center (NIC), National Oceanic and Atmospheric Administration (NOAA) and the U.S. Navy, have defined mission requirements for accurate monitoring and timely charting of sea ice conditions. The U.S. AON - SIF team is working to assemble the federal mission observational requirements for sea ice into a consolidated national view.

The AON scope for SIF requirements includes key objectives under the IAOAF societal benefit areas: Weather and Climate, Infrastructure and Operations, Food Security, and Disaster Preparedness. This scope guides which subject matter experts need to be included in requirements setting. For example, the key objective - *Ensure domain awareness for disaster response* - under Disaster Preparedness suggests that operational responders must be included. Following the FOO requirement template, applying the IAOAF and involving international partners would generate a valuable input to AON for sea ice.

2. Essential Observing Variables Element: *A discrete set of technology-neutral observing targets that have been demonstrated to be highly impactful across the framework objectives with a mature 'readiness level'.*

Sea Ice is already an 'essential ocean variable' under the FOO (see link), with observing requirements that are heavily focused on the societal benefit of global climate projections. Applying the IAOAF societal benefits lens to this variable under the FOO would enhance AON for SIF. For example, SIT has been identified as high impact for Arctic SIF through ad hoc model experiments, but it's operational readiness in the Arctic is very low. A community level focus on this issue is needed to advance the operational readiness of SIT observations (see Element 4).

3. Observations Element: *Under observations, the framework clarifies specific bodies that undertake specific observations and their data accessibility.*

While U.S. AON - SIF provides a valuable national interface to improve readiness, sea ice monitoring and forecasting ultimately requires international collaboration and coordination. Many organizations work around this issue, but there has been limited success in providing a holistic, consistent, and sustainable approach towards polar ice monitoring. WMO's Snow Watch under Global Cryosphere Watch (GCW) has set out to improve international cooperation and can serve as a model for creation of an "Ice Watch". The main goals of Snow Watch are improvement of in situ snow reporting and measurements, evaluation of snow product accuracy and maturity, exchange of snow data and information, and identification of critical snow-related issues. It would be valuable to provide similar international cooperation between ice charting services, ice remote sensing data providers, in situ observers, ice modelers and data assimilators, and long-term ice monitoring agencies.

4. Improving Readiness Element: *Partnerships and tasks improve the readiness levels of requirements, observations elements and data systems.*

A focal point for this element is improving observational approaches for those sub-variables identified as high impact and low readiness under the essential variable process. For example, the U.S. AON SIF Task Team is focused on algorithm development for a multi-sensor, sea ice thickness product in support of operational forecasts. The team will utilize satellite sea ice freeboard and thickness observations from the European Space Agency (ESA) CryoSat-2 and the NASA ICESat-2 (due for launch in Sept. 2018) missions to develop high-resolution, along-track products, as well as weekly-, monthly- and seasonally-averaged grids, for data assimilation (DA) and forecasting experiments. The outcome of this effort will improve the readiness of this sub-variable under an AON for sea ice.

5. System Evaluation Element: *The observing system should be under constant evaluation to discern changes in readiness and identify risks to its sustainability.*

Several partners of the US AON - SIF Team (Naval Research Lab, NOAA's RASM-ESRL-SIFT, NOAA's Arctic Test Bed) already contribute towards system evaluation and welcome the opportunity to align approaches and share lessons. Additionally, the team includes efforts to independently verify the impact of specific parameters on forecasts through Observing System Simulation Experiments (OSSE's). It was through such an OSSE that high impact of SIT on forecast bias was identified. Needless to say, international alignment greatly accelerates the pace of evaluation efforts.

Conclusion

The purpose of this statement was to explore how relevant AON Tasks might benefit from applying an approach like FOO, with regionally specific considerations. The FOO approach provides a valuable, systematic means to organize U.S. AON - SIF, and ultimately provides a gateway to well coordinated international partnership. A valuable outcome of the AOS would be the systematic mobilization of

such an approach towards a Framework for Arctic Observing. We encourage SAON and its members to advance its efforts towards a framework in order provide the vital linkages between the nodes of the Arctic Observing Network.

References

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