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SIDEBAR | Steps Toward an Integrated Arctic Ocean Observational System

By Jean Claude Gascard

Over the past 20 years, drastic changes have occurred at the basin scale in all Arctic sea ice characteristics: extent and concentration, thickness and distribution, drift and deformation, and age and category. The Arctic sea ice annual cycle is trending toward that of Antarctica, where most sea ice melts in summer and forms in winter (see Perovich, 2011, in this issue). To be able to predict future changes in the Arctic and their consequences, we need to understand and attribute the causes of rapid evolution of sea ice, ocean, and atmosphere that are currently underway. During the fourth International Polar Year (IPY), the European project DAMOCLES (Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies) demonstrated that a sea ice-centric approach was very efficient for tracking climate changes. But, to understand Arctic sea ice variability, it is essential to simultaneously observe the atmosphere and the ocean.

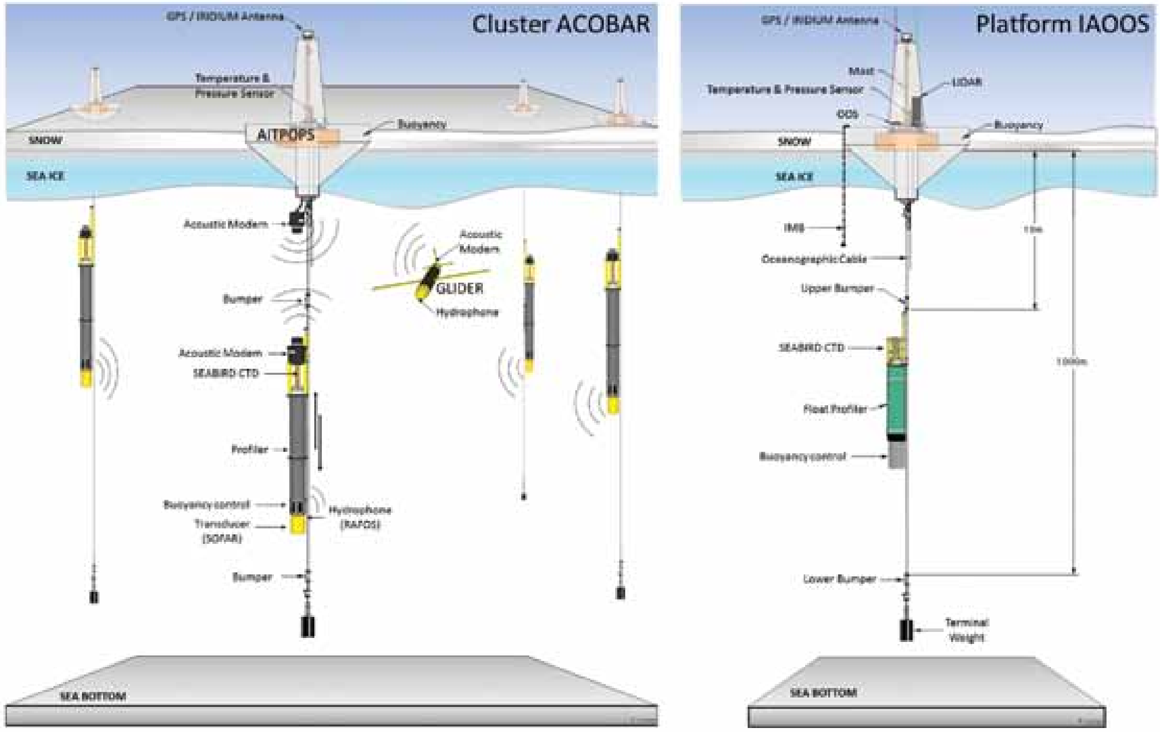
Additional observations and modeling are required to clarify identified feedbacks. We envision a future integrated Arctic Ocean Observing System (iAOOS) to include a fully coupled ice-atmosphere-ocean observing system that would collect and transmit in real time key parameters revealing: (1) coherent features (weather patterns, ocean eddies, and polar lows), (2) internal structures (e.g., atmospheric inversion layer and clouds, ocean halocline and thermocline, sea ice thickness distribution), and (3) fluxes at the interfaces between the three domains (atmosphere, sea ice, ocean). The full iAOOS should combine in situ measurements, remote sensing, data assimilation, and numerical modeling. Vertical profiles of properties throughout the troposphere (10–15 km), within sea ice (a few meters), and through at least the upper ocean (1 km) will likely be necessary. Precise measurements of sea ice thickness and snow depth, surface air temperature and pressure, temperature profiles across the snow, and ice and sea surface temperature will also likely be needed. The temporal and spatial resolution should take into account relevant processes governing heat and momentum transfer within and among the three domains. Ideally, iAOOS would cover local, regional, and pan-Arctic spatial scales and temporal scales from hours to decades.

Technological innovation will be important. For example, in addition to the well-known Arctic haze, aerosol layers are frequently observed in the mid-troposphere from early spring to summer. Even though their optical depth is moderate, they contribute significantly to the radiative budget of the Arctic Ocean. These layers are not detectable by space-borne instruments, so ground-based observations with lidars and optical depth sensors will likely be necessary, though their deployment may be complex.

New steps toward an iAOOS are gaining momentum. Several agencies have agreed to fund autonomous, Lagrangian platforms operating in the Arctic Ocean for the next decade (2011–2019) to address vertical heat exchange governed by the circulation of surface waters, the halocline, Pacific waters, and the underlying Atlantic water. Deployed on sea ice as well as in open water, these platforms will drift with sea ice motions and currents mainly imposed by the Arctic Transpolar Drift and the Beaufort Gyre. Most of the platforms deployed each year in the Beaufort and Chukchi Seas in September (open water) will drift toward the Eurasian Basin and will require replacement each following year by new platforms deployed at the same initial positions, similar to ongoing US-funded projects that are part of the current Arctic Observing Network (AON). Based on our experience during IPY and DAMOCLES (see also Toole et al., 2011, in this issue), the expected lifetime for each platform is, on average, two years. Each platform will be composed of three elements for oceanographic, sea ice, and atmospheric vertical soundings of physical parameters.

Another example is the European ACCESS project (Arctic Climate Change, Economy and Society, Seventh Framework Programme, 2011–2015) that, in partnership with SAMS (Scottish Association for Marine Sciences), is supporting equipping these drifters with tightly spaced thermistors (2 cm spacing) to provide ice mass balance information. Each sensor will be periodically heated in order to identify, by monitoring thermal response, the medium (air, snow, ice, water) in which the sensor is embedded; in addition, snow and sea ice thickness can be measured with 2 cm accuracy.

Through the ACOBAR (Acoustic technology for observing the interior of the Arctic Ocean) project coordinated by NERSC (Nansen Environmental and Remote Sensing Center) in Bergen, Norway, and funded by the European Union under the Seventh Framework Programme, a conductivity-temperature-depth (CTD) profiling instrument similar to an Argo float, but moving along a cable from the surface to 1 km depth or less, will provide oceanic physical observations from drifters deployed in the Arctic Ocean. This iAOOS component will be developed in close coordination with current Ice-Tethered Platforms deployed by US scientists and related partners (see Toole et al., 2011, in this issue). As



technology advances, clusters of drifting platforms equipped with long-range acoustic transducers may be employed to operate Seagliders cruising under sea ice and transmitting data in near-real time to platforms that are linked to satellites.

These examples are drifting platforms. Yet, to be successful, an integrated Arctic Ocean Observing System will take advantage of a mix of advanced technology based on both Lagrangian and Eulerian concepts. The Lagrangian contribution to this effort being integrated into the existing International Arctic Buoy Project will constitute an extension of the Argo program, and complements other ongoing national programs such as AON and the Canadian ArcticNet, which already coordinate or support long-term field observation efforts complementary to those described here. Essential Eulerian components of iAOOS include oceanographic moorings, used to monitor gateways and the boundary currents along continental slope and shelves and perhaps elsewhere in the Arctic. The gateway moorings have been established for some years already (see Beszczynska-Möller et al., 2011, in this issue) and in part extend the previous Arctic Subarctic Ocean Fluxes project (ASOF). Multiyear moorings have also been established in at the North Pole (NPEO), in the Beaufort Gyre (BGEP), and along the basin margins (NABOS, CABOS, ArcticNET). A future atmospheric Eulerian physical component of iAOOS would also include the existing atmospheric land-based stations: Barrow Alaska, Summit Greenland, Eureka Canada, Ny Ålesund Svalbard, and Tiksi Russia.

To integrate the components described above requires ongoing international discussions, collaboration, and coordination by various groups, including IASC (International Arctic Science Committee) and its Working Groups, SEARCH (Study of Environmental Arctic Change) and its observing component AON, ArcticNet, SAON (Sustained Arctic Observing Network), and PAG (Pacific Arctic Group). An essential component of any Arctic observing program is access to the field, primarily by means of scarce national icebreakers; their availability and their cost is a grand challenge for international scientific collaboration. Both in scientific objectives and international connections and approach, these next steps toward iAOOS build upon a successful IPY legacy.

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