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Toward Improved Observing of the Rapidly Changing Arctic Ocean

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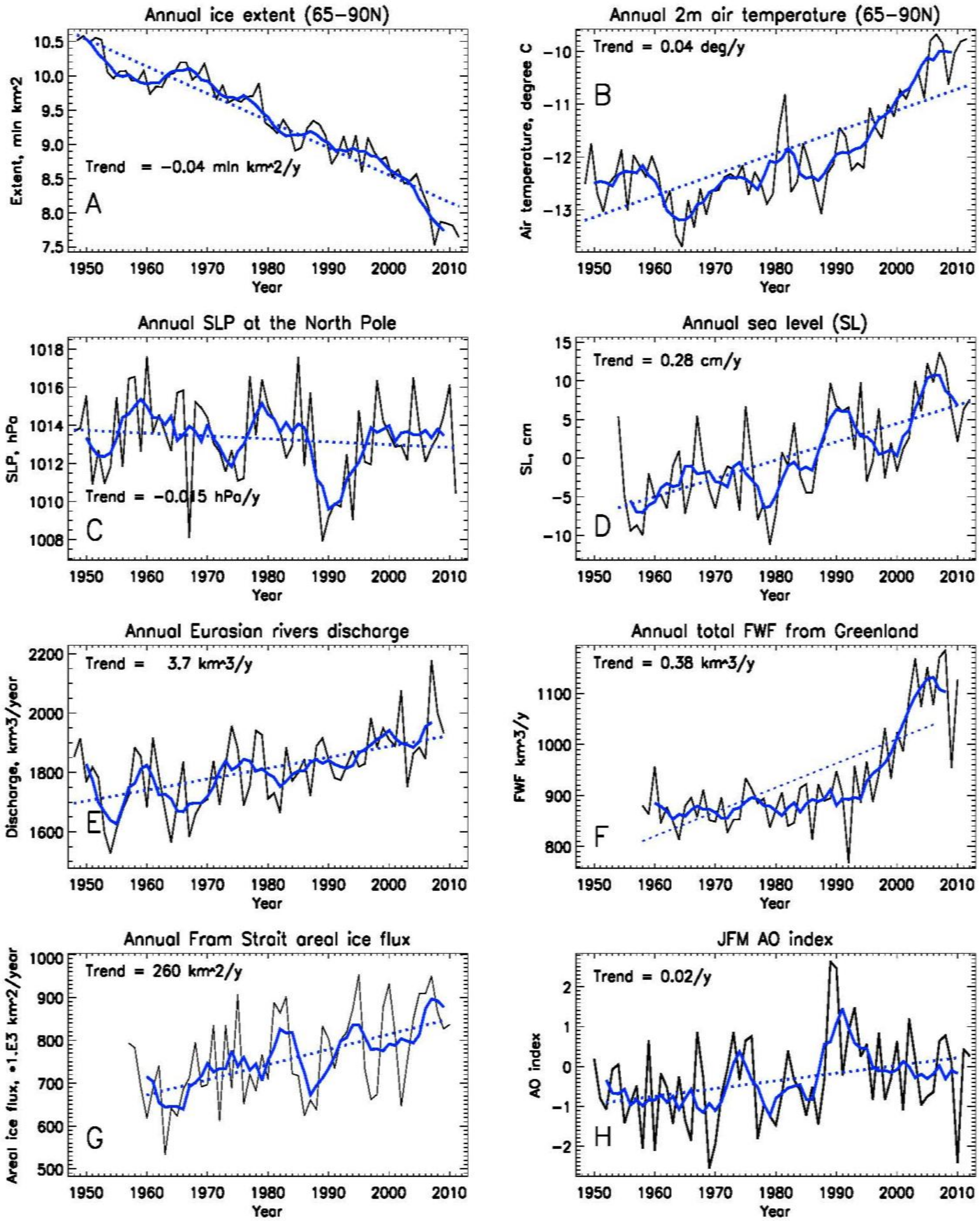
In order to observe and understand the Arctic Ocean and its response to climate change, the traditional approach of acquiring observations when and where the Arctic is accessible has to be enhanced with multi-faceted measurement systems operating autonomously to provide year-round information in real time. The major goal of such a network of autonomous sensors is to measure and monitor physical, chemical and biological parameters in the atmosphere, sea ice and ocean on at least daily intervals. Our vision for a basin-scale system follows recommendations put forward in several community reports and white papers [see references] that highlight a mix of shelf, continental slope and deep ocean observatories, drifting buoys, floats and mobile vehicles. These observational assets should be configured to monitor changes in ocean and sea ice volume and heat and fresh water content over the continental slope regions and deep Arctic, and observe the heat and fresh water fluxes through ocean straits and openings connecting to the south. Nevertheless, data collected by traditional ship-based and airborne expeditions designed for specific process studies will continue to be essential, and should complement the automated observing systems. Combined, these systems will provide year-round observations of key oceanographic, cryospheric and atmospheric processes both through the complementary nature of the platform types and through platform interactions. It will be necessary to maximize capabilities both in the marginal/seasonal ice zones and in the year-round pack ice with innovative, reliable and cost-effective approaches for under-, in-, and-over-ice measurements. *An efficient network of autonomous Arctic observing systems measuring environmental parameters in the ocean, ice, and atmosphere year round and transferring measurements in real time to data centers via satellites is urgently needed.*

Rapid changes in key environmental parameters (see Figure) evince the importance of a sustained (i.e. longer than a decade) environmental Arctic *monitoring* system targeted to address specific scientific questions, and employing automated instrumentation approaches. Such an autonomous observing system is less costly and enables long term measurements to be made at multiple locations. Such long-term, continuous measurements are essential due to the interannual variability present in a multitude of important environmental parameters.

The development of basin-scale, under-ice geopositioning and communications should be a priority for an Arctic Ocean observing network. An example of *in situ* ocean, atmosphere and sea ice observing systems is the Ice Based Observatory (IBO) [Proshutinsky *et al.*, 2004; Toole *et al*., 2006] which includes meteorological, biogeochemical, oceanographic, and sea ice sensors. Over the past decade, numerous IBOs have been deployed Arctic-wide, measuring important environmental parameters with high spatial and temporal resolution year round. Future developments could include, for example, integration of IBOs, moored instrumentation and mobile platforms, such as AUVs. Future autonomous observing systems should have enhanced abilities to survive ice ridging and operate reliably in the seasonal ice zone and open water.

Data returned from autonomous and integrated systems are necessary for operational arctic weather predictions, numerical model initialization and validation, and improved understanding of Arctic Ocean processes and long-term change. Although expeditionary field programs will continue to provide valuable information about Arctic change, true understanding will require sustained, integrated observing systems.



Time series of annual (black) and 5-year running mean (blue) Arctic parameters: A – sea ice extent, B – 2m air temperature, C – North Pole sea level pressure, D – sea level, E – Eurasian river discharge, F – total fresh water flux from Greenland (ice sheet melt, iceberg calving and Greenland river runoff), G – Fram Strait areal ice flux, H – winter (Jan.-Mar. average) Arctic Oscillation index (AO). The dotted line in each panel depicts the linear trend. Note the sizeable interannual variability in these fields - signals that can alias limited-duration field observations.

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