4. AON: A Conceptual Framework for Participation, Activities, and Outcomes

The success of the AON implementation depends, in part, on individuals (e.g., a university professor, a government scientist, a northern resident) and institutions (e.g., a university, a government agency, a northern non-governmental organization) understanding the goal of AON, and recognizing the role they have to play and the contributions they can make to achieving the goal. This section describes a conceptual framework (Figure 12) that has been developed to help individuals and institutions see where they can fit into and be part of AON by defining, in broad terms, its core components and the activities that contribute to its goal.

The conceptual framework identifies Arctic and Global Value-added Services and Societal Benefits as the over-arching goal or outcome of AON. That goal is defined by five activities, of which two are outcomes of the other three. That is, decision- and policy-making rely on scientific research and education, technology and data product development, and forecasting and prediction. Decision- and policy-making can also inform the other three activities; hence the horizontal arrows in both directions (Figure 12). Any of the five activities that define the goal of AON can also inform AON itself; hence the vertical arrows in both directions (Figure 12).

In the context of the three pillars of SEARCH, decision- and policy-making are synonymous with responding to change, while scientific research and education, technology and data product development, and forecasting and prediction represent knowledge and understanding. Understanding and responding require basic information, and AON is the source of that information. Thus AON is a fundamental pillar of SEARCH.
As Figure 12 shows, AON has four core components: operational observing; research observing; community-based observing/local and traditional knowledge;

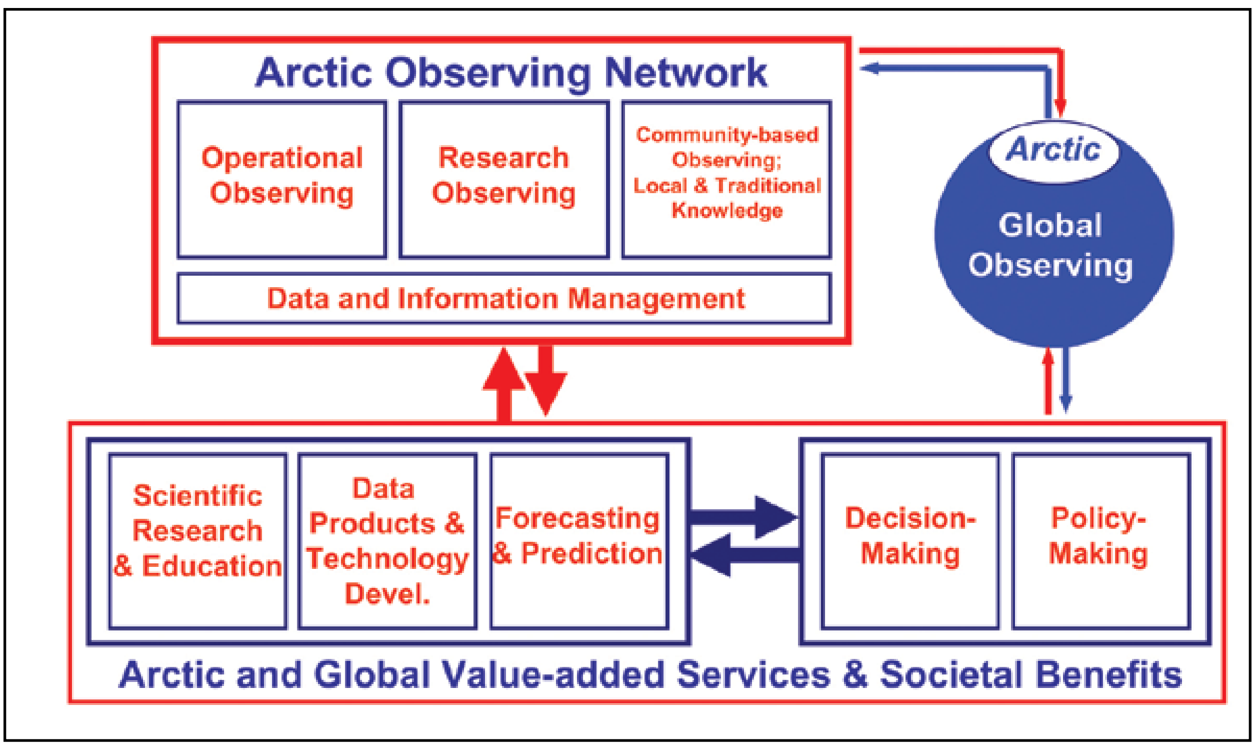

Figure 12. Conceptual framework for AON. Arrows represent flows and exchanges of data and information that are necessary to realize value-added services and societal benefits for the Arctic and the World.

and data and information management. It must be understood that these are not isolated from each other; there are overlaps and connections, but for the sake of simplicity these are omitted from the diagram.

Operational observing programs are exemplified by NOAA/National Weather Service (NWS) stations that make long-term, routine, standardized meteorological observations that are coordinated with other nations through the World Meteorological Organization (WMO). Research observing is supported by several Federal agencies, and is typically short-term in nature. However, research observing projects and data can be baseline data sets when properly archived and made available at some future date for comparison with new observations. For example, the National Aeronautics and Space Administration (NASA) designs, builds, launches and operates satellites and instruments, often in partnership with industry and academia in the US and other nations, primarily for the purpose of scientific research, and to gather long term climate data. The current NASA constellation of fourteen orbiting satellites is shown in Figure 13.

NASA Arctic science and technology encompass Earth's atmosphere from the surface of the land and sea to the top of the stratosphere; the oceans including sea ice; land surfaces including snow and ice; the solid Earth beneath the ocean; the ecosystems in the air, oceans, and land; and all the interactions between the atmosphere, oceans, land, snow, ice, and associated ecology, including humans. NASA also studies the Sun and the interaction of its radiation with the Earth's upper atmosphere. To study the components of the global integrated Earth system and interactions between components, NASA has developed and deployed a constellation of satellites (Figure 13). NASA also deploys aircraft- and surface-based instruments for calibration, validation, and increased level of interpretation of satellite data that are required for development of sustained high-accuracy, climate-quality, stable satellite measurements.

NSF also funds research observing, as exemplified by the Long Term Ecological Research (LTER) Network sites in Alaska, and the awards made to initiate AON during the IPY (see Appendix I for a complete list of NSF AON projects). The latter observing projects are driven by science questions that need long-term observations, including human observations and indigenous knowledge, and which enable SEARCH by measuring the continuing changes that are underway in the Arctic. The DOE ARM site on the North Slope of Alaska focuses on making observations designed for research to improve and evaluate the representation of clouds in the climate models.

As noted in Section 3, the Academies' report on AON (NRC, 2006) recommends meaningful involvement for Arctic residents. Thus, the AON conceptual framework (Figure 12) deliberately places community-based observing and local & traditional knowledge in a category alongside operational and research observing. However, none of these three categories are mutually exclusive. Researchers, for example, often work in partnership with Arctic residents, who maintain equipment and continue observations in the scientist's absence. Likewise, the NOAA/NWS Cooperative Observer Program relies on individuals to make observations that are integrated into weather and climate analyses, and other public service programs, and which define the regional climate of the USA and help measure long-term change.

Each of the three observing groups has different ways of operating and sees different immediate benefits. But, the integration of all three provides greater power and mutual benefits than any one alone. Moving data, information, experience and expertise among the three observing groups has obvious value. Moreover, this value is most likely to be realized when data and information from each group are available in free, open and timely fashion. Hence, data and information management are integral to AON (Figure 12); or, to put it another way, effective data and information management, and data policy are essential to achieving the goals of AON and SEARCH. Data and information management, and data policy are discussed at greater length in sections 5g and 7c.

While the development of AON is focused on advancing the goals of SEARCH, it is not for the exclusive use and benefit of the SEARCH community. Just as AON and SEARCH must draw on operational observing activities such as NOAA

Figure 13. NASA constellation of operating satellites recording biological, chemical, physical and ecosystem measurements in the circum-Arctic with high fidelity space and time scales for studies of the changes in the circum-Arctic and for understanding the connectivity between the pan-Arctic region and the global integrated Earth system. Examples of measurements are stratosphere ozone (Ozone Monitoring Instrument/Aura), troposphere chemistry and composition (Tropospheric Emission Spectrometer/Aura), polar stratosphere clouds (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation or CALIPSO), troposphere aerosols (Multi-angle Imaging SpectroRadiometer/Terra), clouds (Cloudsat), ocean surface vector winds (QuikSCAT or Quick Scatterometer), sea ice temperature (MODIS or Moderate Resolution Imaging SpectroRadiometer/Aqua), sea surface temperature (Advanced Microwave Scanning Radiometer-E/Aqua and MODIS/Aqua), ocean color (MODIS/Aqua), total solar irradiance at the top of the atmosphere (Solar Radiation and Climate Experiment or SORCE), Greenland ice sheet mass (GRACE), Greenland ice sheet thinning (ICESat), rainfall (AMSR-E/Aqua), land imagery (Landsat-7), snow distribution on land (MODIS/Aqua), sea ice coverage (AMSR-E/Aqua), sea ice thickness (ICESat), and other variables.

NWS, for example, AON can contribute to broader, day-to-day operational and event-/incident-driven mission needs. For example, in the case of an oil spill, a particular suite of AON instruments could inform responders' decision-making, provide inputs to spill trajectory models and weather and safety information for overflights, and guide species monitoring during and after a spill. As section 5c and 7g make clear, there is a broad spectrum of AON users and stakeholders, and they must have easy, free and open access to AON for it to achieve Arctic and global value-added services and societal benefits.

Just as the combination of the three observing groups with data and information management will increase the power and mutual benefits of AON, so too will the combination of AON with global observing (Figure 12). The United States is one of many countries participating in the development of the international GEOSS, an effort to link together existing technologies in space, atmosphere, ocean and terrestrial observing and support new observing capacity as needed. GEOSS promises to provide a framework for compatible and accessible earth observations. As part of this global effort, the United States created an inter-agency Group known as GEO or USGEO. IARPC is coordinating with GEO and with other Federal entities such as the Interagency Committee on Ocean Science and Resource Management Integration (ICOS-RMI), a group co-chaired by the Office of Science and Technology Policy and the Council on Environmental Quality.

The recently issued report, *Charting the Course for Ocean Science in the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy* (National Science and Technology Council/ Joint Subcommittee on Ocean Science and Technology, 2007), identifies three critical elements of ocean science and technology: developing understanding and capability to forecast ocean processes and phenomena; providing science support for ecosystem-based management; and deploying an ocean observing system to enable the promise of forecasting and ecosystem-based management. The development of AON contributes to these comprehensive Federal and international efforts to improve forecasting and resource management through science and technology.