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Advancing Arctic observing within the Global Earth Observation System of Systems (GEOSS) through Community-Based Monitoring

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Abstract

The intent of this paper is to advance the discussion on the complementarity of, and the existing connections between, the Sustaining Arctic Observing Networks (SAON) process and the Group on Earth Observations' (GEO) effort to develop the Global Earth Observation System of Systems (GEOSS). Better coordination may be achieved through an explicit focus on pan-Arctic observing networks, with particular attention to community based monitoring (CBM), which is gaining attention in deliberations associated with the U.S. Chairmanship of the Arctic Council (2015-2017). Community-based monitoring (CBM) has many definitions, but is here recognized as a process of systematic or *ad hoc* observing of environmental phenomena in a social context that is co-led and implemented by Arctic residents, typically in partnership with external collaborators and/or with the support of visiting researchers, government agencies, and non-governmental organizations. The increasing coherence of CBM in the Arctic, along with growing recognition of the utility of community-based observing network systems (CBONS), provides an opportunity to strategically work toward a template and best practices for CBM to be applied to other GEO regions worldwide. We recommend the formation of a CBM Community of Practice (CoP) within GEO, preceded by an organized effort to gather expressions of shared interests from across the GEO community. Such an effort will result in improved interoperability and the application of local and ground-based data, as well as, advance understanding of how and where traditional and local knowledge can best interface with scientific monitoring to improve our understanding of social-ecological systems.

Introduction

The Group on Earth Observations (GEO) has concluded its first ten years (2005-2015) of implementing the Global Earth Observation System of Systems (GEOSS)[1], which is an observation-to-information value chain derived from multiple interoperable Earth observation systems, highly dependent on the foundational elements of *user engagement* and *capacity building*. GEOSS has relied on the voluntary contributions from Member States and Participating Organizations, which have been inventoried and coordinated through the GEO Work Plan. The *Information Services for Cold Regions* Component Task[2], which was intended to support and facilitate the archival, management, and accessibility of *in-situ* and remote observations of the Arctic, Antarctic, and high mountain regions, was included within all previous Work Plans and represents the clearest intention of GEO to integrate Arctic observing. However, Arctic observations are also connected to GEO in other ways; for example, the Circumpolar Biodiversity Monitoring Program (CBMP) contributes via the GEO Biological Observing Network (GEOBON). GEO's membership is open to all member states of the United Nations and to the European Commission. As of January 2016, GEO has 102 members, which include all eight Arctic states and the majority on high-mountain states.

In 2014, GEO renewed its commitment to GEOSS for another decade and accordingly developed the *GEO Strategic Plan 2016-2025*[3], which was released in September 2015 for deliberation at the GEO XII Plenary in Mexico City held in November 2015. *Information Services for Cold Regions* remains present in GEO's 2016 Work Programme[4], and is highlighted as one of 21 *GEO Initiatives*.. In the Work Programme, the Sustaining Arctic Observing Networks (SAON) process is listed as a key contribution to GEO Cold Regions. Importantly, SAON became a Participating Organization within GEO in 2014 to serve as an "Arctic extension" for GEO/GEOSS. This, together with a GEO Cold Regions Side Event at the GEO-X Plenary in January 2014, represents significant progress, especially following a long period of relative inactivity in GEO's efforts to engage the *Cold Regions*[5]. In addition to SAON, GEO Cold Regions has made connections with the World Meteorological Organization's Global Cryosphere Watch (GCW) portal, the Svalbard Integrated Arctic Earth Observing System (SIOS), the Year of Polar Prediction (YOPP), and other cryospheric focused initiatives[6].

SAON, however, is unique in its ability to document and coordinate Arctic observing activities including community based monitoring (CBM) and community-based observing network systems (CBONS). SAON was conceived during the International Polar Year (IPY) 2007-08 and formally established in 2012. Its purpose is to support and strengthen the development of multinational engagement for sustained and coordinated pan-Arctic

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[1] Ad hoc GEO (February 16, 2005) *GEOSS 10-Year Implementation Plan*. Third Earth Observation Summit, Brussels.
[2] GEO's past Work Plans were divided into Tasks, which were sub-divided into Components. *Information Services for Cold Regions* was a component within GEO's Task for Integrated Water Information.
[3] GEO Implementation Plan Working Group. GEO Strategic Plan 2016-2025: Implementing GEOSS. Document MS4, GEO X-II, November 11-12, 2015.
[4] Beginning in 2016, GEO has shift from a Work Plan toward a Work Programme.
[5] Fifth GEOSS Evaluation Team (June 2104) *GEOSS Evaluation of Water, Weather and Climate Societal Benefit*.
[6] GEO 2016 Work Programme (version 4), 22 December 2015.

observing and data sharing systems that serve societal needs, particularly related to environmental, social, economic, and cultural issues. SAON was established on the initiative of the Arctic Council and the International Arctic Science Committee (IASC). SAON has worked with the Arctic research and operational communities and Arctic Indigenous Peoples organizations to evaluate the state of Arctic observing (e.g., through national inventories), assess observing needs, and support cross-community discussions (e.g., co-organizing the Arctic Observing Summit series). Starting in late 2014, this work is continuing through two committees: the Arctic Data Committee (ADC) and the Committee on Observations and Networks (CON). These committees are actively working to move SAON forward in its mission. This includes further developing the Atlas of Community Based Monitoring project (www.arcticcbm.org) led by the Inuit Circumpolar Council, which is described below, as well as continuing work by the Conservation of Arctic Flora and Fauna (CAFF; www.caff.is), which has led the way in supporting CBONS. SAON is working to understand the state and user requirements of Arctic observing, however the body will not directly undertake science planning, policy setting, observations, data archival, or funding of these efforts.

Opportunities for Operational Linkages

GEO has made significant progress in establishing an operational system of systems. The Summative GEOSS Evaluation[7] found that GEO, during its first 10 years, was largely successful in including satellite-based programs, while relatively falling behind in efforts to integrate *in-situ* or ground-based observations. The Evaluation also concluded that GEOSS is far from realizing its vision of being *user-driven*. A multi-pronged approach from across the GEO community will be needed to address these challenges moving forward. A focus on CBM could represent one element to such an approach, and would serve to engage a cross-section of the in-situ and ground-based observing communities that are not yet represented within GEO.

CBM has many definitions, but is here recognized as the process of systematic or *ad hoc* observing of environmental and/or social phenomena that is co-led and implemented by Arctic residents, typically in partnership with external collaborators and/or with the support of visiting researchers, government agencies, and non-governmental organizations. CBM, unlike other forms of observations, often incorporates "user-contexts" within the process of making observations. CBM refers to a broad range of approaches and can serve many purposes, including contributing to CBONS, which are distributed networks of community residents throughout a region who regularly observe their environment, typically in context of local livelihood activities that may include hunting, fishing, and traditional forms of travel across land or water[8]. CBONS rely on observations being systematically documented and shared beyond a single community, guided and informed by an overarching purpose and organizing framework. CBONS are primarily distinguished from instrument-based monitoring by their paramount focus on variables of greatest

[7] Sixth GEOSS Evaluation Team. Report on the Sixth and Summative Evaluation of GEOSS Implementation. Document 6, GEO X-II, November 11-12, 2015.
[8] Alessa, L., et al. (2015) Bering Sea Sub-Network II: Sharing Knowledge, Improving Understanding, Enabling Response - International community-based environmental observation alliance for a changing Arctic. Conservation of Arctic Flora and Fauna, 61 pp.

interest and impacts to communities[9]. It has been noted that the results from this form of observing are variably shared beyond the community[9], often by design through data protections reflecting cultural concerns and the potential for misuse by outside users.

Coalescing the strengths of SAON and GEO will establish a significant contribution toward developing a sustained, integrated Arctic observing system that is part of the larger global system. In this context, the increasing coherence of CBM in the Arctic, facilitated in part by relationships formed during the recent IPY between community members and researchers, both from the social and physical sciences, provides an opportunity to develop a template for CBM for elsewhere around the globe. Furthermore, the unprecedented climate and environmental changes being observed in the Arctic, together with the new suite of stakeholders and societal concerns that arise with these changes, provide areas where CBONS may significantly contribute, such as disaster preparedness, monitoring threats to food security, or understanding shifts in phenology. The rate and scale of change in the Arctic is unique to the region; however, the types of change are not.

The GEOSS vision and approach may, in turn, provide added-value to SAON and Arctic CBM projects by linking their observations and information (e.g., that which is available through the Atlas of Community Based Monitoring) to the GEOSS Portal and other global databases. Such linkages, which often serve to connect seemingly disparate communities, may provide opportunities to explore new applications for CBM, for example, through tailored approaches to inform or integrate with scientific modeling. As new international, collaborative polar initiatives get underway a closer connection between SAON and GEO, framed, in part, in the context of advancing CBM, will serve to propagate forward lessons-learned and partnerships formed during the IPY. For example, it may be worth exploring whether CBONS could contribute to the verification and user-engagement priorities of the YOPP, which aims to improve environmental prediction capabilities in the Polar Regions, including sea ice and weather predictions on various time scales.

This opportunity comes at an appropriate time in the evolution of GEOSS. The GEO Strategic Plan 2016-2025 has shifted GEO's societal benefit areas (SBAs) toward more information-user domains. These proposed new SBAs include Biodiversity and Ecosystem Sustainability, Disaster Resilience, Energy and Mineral Resources Management, Food Security and Sustainable Agriculture, Infrastructure and Transportation Management, Public Health Surveillance, Water Resources Management, and Sustainable Urban Development. Within all of these areas, Arctic CBM could play a role in defining user needs at local to regional scales and demonstrating the societal value of utilizing local observations and/or traditional knowledge together with satellite-based or instrument-based observations at larger scales. Specifically, the potential observational contributions from CBM should be assessed as GEO establishes key or essential variables for the cold regions[6]. CBM approaches and CBONS should also be considered for their ability to engage local communities in ways that are broader than local and traditional knowledge contributions. New technologies (e.g., inexpensive and easily deployable unmanned aerial and underwater vehicles) and social media platforms provide emerging opportunities for local residents to partner with science. These opportunities, in turn, may highlight key prospects for capacity building to support

[9] Johnson, N., et al. (2015) The Contributions of Community-Based Monitoring and Traditional Knowledge to Arctic Observing Networks: Reflections on the State of the Field. Arctic, Vol. 68, Suppl 1.

lasting and mutually beneficial relationships that underpin most sustained joint-observation campaigns.

Mapping the Arctic's Community-Based Observing Networks

There is an urgent need to assess and evaluate Arctic CBM. Significant progress has been made toward this goal through the development of the Atlas of Community Based Monitoring & Traditional Knowledge in a Changing Arctic. The Atlas was designed to showcase the many CBM and traditional knowledge initiatives across the circumpolar region. A full report analyzing the different types of CBM included in the Atlas, how they are being implemented, and their respective strengths is complete and currently under review (see Johnson et al. AOS statement). It currently contains close to one hundred examples of environmental focused CBM projects. Funding has been applied for to allow Polar Knowledge Canada to add terrestrial biodiversity CBM projects to the atlas; however more will be required to grow and maintain the resource. This globally-oriented project is also working to link to other regional or local initiatives that are focused on CBM, bridging the range of approaches from, for example, the Community Based Observing Network for Adaptation and Security (CONAS) to the Inuvialuit Settlement Region Community-based Monitoring Program (ISR-CBMP) to the Local Environmental Observer (LEO) health program. SOAN's continued work on the Atlas is listed as a contribution to the Information Services for Cold Regions Initiative within the GEO 2016 Work Programme, yet it remains to be seen how such a contribution may integrate with the GEOSS Common Infrastructure[10].

Recommendations for Integrating Arctic CBM into GEO

1. We recommend the formation of a CBM Community of Practice (CoP)[11] within GEO, with an initial priority focus on the Arctic. This would most appropriately follow an organized effort by the GEO Community (e.g., coordinated by the GEO Secretariat) to gather expressions of shared interests from GEO Member States and Participating Organizations. A CoP could leverage and integrate the critical mass that now exists in Arctic CBM with observing systems that are within the scope of GEOSS. Here, SAON efforts to understand and document the state of Arctic observations, particularly CBONS, would be a valuable contribution for the CoP to understand how CBM can develop and support shared interests. Established best practices and applications could then be transferable to regions outside the Arctic, especially where GEO's local community engagement and capacity building efforts have shown significant progress, such as the regions served by the SERVIR Program and its growing number of regional hubs[12]. Such an effort could address shared resources and efforts to create an infrastructure that unites data generators and users. This

[10] https://www.earthobservations.org/gci_gci.shtml

[11] GEO defines a CoP as "a user-led community of stakeholders, from providers to the final beneficiaries of Earth observation data and information, with a common interest in specific aspects of societal benefits to be realized by GEOSS implementation" (https://www.earthobservations.org/cops.php).

[12] SERVIR (The Regional Visualization and Monitoring System), a joint initiative of the National Aeronautics and Space Administration (NASA) and United States Agency for International Development (USAID), works with regional organizations around the globe to assist developing countries in using Earth observing information in managing climate risks and land use.

will result in improved interoperability and the application of local and ground-based data. A CBM CoP may also advance understanding of how and where traditional and local knowledge can best interface with scientific monitoring to improve our understanding of social-ecological systems.

2. Toward this end, we propose a discussion on this topic at the 2016 Arctic Observing Summit in Fairbanks, Alaska, focusing on: (a) characterizing and understanding shared interests in CBM in the Arctic; (b) exploring opportunities for new CBM applications and new linkages to international, collaborative polar initiatives, such as the Year of Polar Prediction (YOPP); and (c) the continued need to develop and document best practices, both for improved local benefits to Arctic communities and to support the transferability of approaches to regions outside the Arctic[13].

[13] This was the topic of the Workshop on Best Practices for Community Based Observing Networks and Systems (CBONS), held October 2015 in Seattle, WA, for which a workshop report should be available in early 2016.