GROUP ON EARTH OBSERVATIONS

GEO Cold Regions Initiative (GEOCRI)
Implementation Plan

(GEO Work Programme: Global Initiative-11)

(Draft)

GEOCRI Group

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This document is a living document and still awaiting input from GEOCRI participants in the form of specific language and text, feedback, comments, editing, improvements. The structure of the document may also be adapted slightly if deemed necessary.

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Executive Summary

The ***"Cold Regions"***, that include the Arctic, Antarctic, high-latitude oceans, Himalaya-Third Pole and Mountain cold areas, are experiencing the fastest rate of climate, ecological and environmental change. With its abundant Earth water and relevant phase changing, the cold regions severely affect the dynamic earth's systems, impact more than one hundred countries of billions of people living therein, and influence many aspects of society in all parts of the world. Recent scientific research is making it increasingly clear that "***What happens in the poles doesn't stay in the poles***".

Aiming to share the vision of the intergovernmental Group on Earth Observations (GEO) to address the global environmental change, and its resulting impacts and challenges on all aspects of society, an *Information Service for Cold Regions* was established to broaden and share Earth observations for societal benefit, and inform the decision makers, through strengthening cold regions coordination with diverse communities, and engagement and collaboration of stakeholders including decision makers.

Building on these accomplishments during the first phase of *Information Service for Cold Regions* in the first 10-year implementation of GEOSS, the **GEO Cold Regions Initiative (GEOCRI)** was proposed and accepted by GEO XII plenary in November, 2015, which is also a Year of Polar Prediction (YOPP) endorsed initiative.

By recognizing the scientific and societal requirement over the Earth cold regions, the GEOCRI **vision** is to provide coordinated Earth observations and information services across a range of stakeholders to facilitate well-informed decisions and support the sustainable development of the Cold Regions globally.

The GEOCRI **mission** is to develop a user-driven approach for Cold Regions information services to complement the mainly current science-driven effort. The Cold Regions Information Service will strengthen synergies between the environmental, climate, and cryosphere research efforts and foster the collaboration between the Arctic, Antarctic, high-latitude oceans, Himalaya-Third Pole and Mountain cold area for improved earth observations and information on a global scale.

The GEOCRI community consists of a team of Task leads, contributors and observers. Contributors can join theme-specific Task Teams to work on specific activities according to their interests. The co-lead team works together on, for example, user engagement and general coordination and reporting of the GEOCRI activities. In addition, an institution, foundation or interested group can join GEOCRI as an Observer, which means that they will be updated about the progress and activities, without not directly taking part in the activities. An Advisory Committee, consisting of high-profile scientists, leaders of relevant communities, for example, will be convened in late 2016 - early 2017 to provide advice and guidance on the GEOCRI activities. Terms of Reference will be developed in 2017 to verify the institutional management and coordination structure for GEOCRI.

Plan with time, approaches, milestones, and deliverables and task teams. The activities conducted in GEOCRI are grouped into six tasks: Data, Infrastructures, Training, Capacity Building and Knowledge Transfer, User Engagement and Communication, In situ and Remote Sensing Integration and S&T, and Monitoring and Management. Each Task consists of activities with set milestones and deliverables during the Work Program 2017-2019. The range of deliverables varies from activity reports to stakeholder and user mapping to training and capacity building events and webinars. Majority of the milestones and deliverables of the 2017-2019 implementation plan are set to the two first years of the programme period in order to add new milestones and deliverables, geared towards the transition from implementation to operational stage starting in 2019 and during the next work programme period 2020 onwards.

Most of the GEOCRI's resources are in-kind efforts, and are aimed at leveraging the resources of participating initiatives and organizations to align with GEOCRI's objectives.

1. Introduction

1.1 GEOSS and GEO Initiatives

With the background of global environmental change, and its resulting impacts on all aspects of society, the Group on Earth Observations (GEO) was launched in response to calls for action that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making, and its primary goal is to create the Global Earth Observation System of Systems (GEOSS), which is a set of coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors.

GEO will implement its strategy during the next decade (2016-2025) to ensure that decision-making is increasingly informed by Earth observations, provided through, and as a result of, the contributions of its Members and Participating Organizations.

While, GEO Initiatives allow Members and Participating Organizations to coordinate their actions and contributions towards a common objective within an agreed, yet flexible framework. They develop and implement prototype services according to GEO priorities and have identified committed resources to a certain extent. GEO Initiatives may demonstrate technical feasibilities through pilot services, or serve a user need.

1.2 GEOCRI's Nature

The GEO Cold Region Initiative (GEOCRI) was initiated at GEO XII Plenary in Nov. 2015, and which is also a YOPP-endorsed initiative.

It aims to identify, address and fill observational gaps and improve networks through coordinated observation practices and prototype information services worldwide, and coordinate the exiting efforts globally to provide Earth observations and information services over cold regions for policy makers, researchers, industry, local communities and other users, finally address the scientific and societal challenges at various aspects, including eight Societal Benefit Area (SBAs) and associated energy, transportation, tourism, and indigenous lives etc.

GEOCRI complements existing Earth observations efforts in the cold regions, such as those by EC-PHORS, GCW, SAON, WCRP, YOPP, ICIMOD initiative, PEEX, TPE, DBAR and others. It also provides a value-added role to the scientific focus by enlarging the mutual benefit through the joint synergy of research and operational observations.

1.2.1 Vision

Recognizing that Earth Cold Regions, include the Arctic, Antarctic, high-latitude oceans, Himalaya-Third Pole and Mountain cold areas, are the most ecologically and environmentally sensitive areas to global and regional climatic and environmental change, where frozen water in various forms and the induced water and energy change dominates the earth's changing systems.

Being aware of that a dominant feature of the Cold Regions is frozen water in its various forms, which is relevant to GEO eight societal benefit areas, and more than one hundred countries are directly related to or lived in the Earth cold regions. The regime - "What happens in the Poles doesn't stay in the Poles" – makes the cold region impacts spread across the whole earth planet, such as climate change, sea level rising, transportation, shipping, and energy etc.

The GEOCRI vision is to provide coordinated Earth observations and information services across a range of stakeholders to facilitate well-informed decisions and support the sustainable development of the Cold Regions globally.

1.2.2 Mission

With its strong link to user communities, GEOCRI is developing a user-driven approach for Cold Regions that will complement the current science-driven effort, and extent to the benefits of the societal benefit area through information services.

A global, sustained, comprehensive Cold Regions Information Service will strengthen synergies among the activities of the Environmental, Climate, and Cryospheric communities and foster the collaboration between the Arctic, Antarctic and Himalaya-Third Pole and Mountain cold region research and operational communities. In particular, it will support the efforts of scientists, experts and decision makers to ensure the sustainability of these environmentally stressed areas in an increasingly complex political and economic context, and to bridge a gap between research, operational communities and decision makers.

1.3 Objectives

GEOCRI aims to coordinate global, joint efforts to provide Earth observations and information services to decision-makers over the vast cold regions, including the poles, high-latitude Ocean, Himalaya-third poles and mountain cold regions. Its goal is to "*Promote Earth observations data sharing and cooperation, enabling improved information services for the inter-continent cold regions, facilitate provision of information to various stakeholder, including decision makers, private sectors"*.

1.3.1 Primary Objectives

- **Integrating, Brokering and Promoting Earth Observations**

  Build a global GEOCRI platform to access, archive and manage earth observation data, both remote sensing and *in-situ*, and the derived products across environmental, ecological human, social and economy domains for monitoring the global cold regions. This will be achieved through brokering efforts with existing systems and initiatives in support of fully-integrated and sustained observing systems for the Arctic, Antarctic, high-latitude oceans, Himalaya-Third Pole and Mountain cold regions at appropriate national, regional and global scales.

- **Advocating and Practicing Data Sharing**

Facilitate provision of sustained observations and information exchange mechanism, advocate and broad for open data policy, free access to the earth observations data, and enhance the interoperability between the existing and emerging data management systems. Link existing and emerging data management and monitoring systems with GEOSS, thus leveraging the GCI capabilities. In doing that, the GEO Data sharing and Data Management Principles will be applied by those systems.

- **Building Community Portal and Services**

  Establish the GEO Cold Regions Community Portal, a framework for the development of information and required services, and for the service practices. This is underpin the GEOSS implementation by expanding the outreach of, and maximizing synergies among, thematically wide GEO activities and thematically deep participant activities, thereby exploiting their complementary roles.

- **Strengthening Capacity building and Partnerships**

  Strengthen the mechanism for partnerships and synergies with scientific communities, policy-makers, stakeholders, and funders over the cold regions' ecological and engineering fields, to address the fragile ecosystem and environmental challenges and societal influences, and improve the public awareness and education through the capacity building.

1.3.2 Additional Practical Objectives

- Improve discoverability, accessibility and usability of cold regions Earth observation data and information by advocating broad open data policies and strengthened capacity building.
- Support existing observation networks and systems in cold regions, sharing expertise and knowledge, as well as integrating observation products into GEOSS via the GEOSS Common Infrastructure (GCI).
- Contribute to identify the gaps for observations and data/information services over cold regions.
- Facilitate full integration and interoperability of in situ and remotely sensed Earth observations in cold regions.
- Facilitate the full integration of cold region Earth observations with global Earth observations across all environmental, ecological and human domains.
- Increase the ability of all users and potential users to benefit from cold region Earth observations, including policy makers, researchers, local communities and industry, through ongoing capacity building.
- Strengthen partnerships between cold region Earth observation providers, users, funders and other stakeholders to increase efficiencies and ensure needs and requirements are effectively met.

1.4 Point of Contact and Co-leads

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PS. The partners (contributors and observers) are all listed at section 6.

2. Need for action

Cold regions are an intrinsically interconnected component of the Earth system, which induces global societal impact to ecosystem resilience, climate change, sea level rising, disaster risk, societal economy development and water resource exploitation. The environmental and human issues facing cold regions are issues for the whole planet. As such, high-quality, reliable and sustained Earth observations in cold regions are in the global interest, benefiting environment, ecosystems and societies in all regions of the Planet.

Through connections involving ocean, atmosphere, biosphere, lithosphere and cryosphere, the cold regions respond to, amplify, and drive changes elsewhere in the Earth system, so that understanding their role is essential. Predicting future conditions requires scientific knowledge of their present status as well as a process-based understanding of the mechanisms of change. The permanent presence of glacier, ice, snow, permafrost are unique features that amplify the impact of global climate change at regional level. At high latitudes, radiation regime is another element largely increasing sensitivity of the system to the climatic forcing. Peculiarities of cold regions, lead to strong and inextricable interrelationships between physical, chemical, and biological components, increasing role of feedback processes and the overall complexity of the System.

2.1 Existing Cold Region Activities and Gaps

It is important for GEOCRI to identify, insofar as possible, different organizations, networks, systems, programs and projects active in cold regions. By mapping different cold region activities, GEOCRI will be able to identify areas where Earth observations are more abundant and their use for different applications common, and areas where gaps in activity exist, or where initiatives need to be strengthened and supported.

Figure 1 attempts to visualize the distribution of the significant initiatives in cold regions identified by GEOCRI, including both Earth observation providers and users, to clearly portray where activity is strong and where significant gaps exist. The initiatives included in Figure 1 are by no means an exhaustive list; additional initiatives exist in all domains but the figure nonetheless gives a good indication as to the current state of Earth observation-related activity across cold regions. It is important to note that the figure gives indication only to the number of initiatives in each region and domain, and not the quantity of work ongoing. Additionally, as the figure includes both providers and users of Earth observations, it does not indicate the quantity of Earth observations available in each region. Rather, Figure 1 attempts to indicate how much activity, related to Earth observations and GEOCRI, is ongoing in each region, broken down by domain.

Figure 1 identifies greater activity related to GEOCRI in Polar Regions, particularly the Arctic, than in mountain areas in all domains. This imbalance is an issue that GEOCRI must work to help address. Mountainous cold regions are home to or relied upon by large populations, meaning strengthened activity and Earth observation initiatives in these regions will have a significant effect in all of the eight GEO Societal Benefit Areas (SBAs).

Also highlighted by Figure 1 is the relative inactivity in some domains across all regions. Water, geology, social science and policy initiatives in cold regions are relatively few. GEOCRI must work to help increase activity in these domains, and fill gaps that may exist in related Earth observation data and information. Other domains, notably climate/weather, cryosphere, biodiversity/ecosystems and oceans (at the poles) appear to be highly active across cold regions. GEOCRI will continue to support efforts in these more active domains to ensure effective coordination and to ensure that cold region Earth observations are coordinated to effectively address the SBAs and have a real positive impact on environment, ecosystems and people in cold regions and beyond.

Figure 1 highlights key areas where GEOCRI is needed to support development of Earth observing and utilization of Earth observations in cold regions. Particular areas of focus must be increasing activity and supporting initiatives in mountain regions, as well as the strengthening of initiatives within the domains of water, geology, social science and policy.

Except the Earth observation gaps described in Figure 1, the gaps obviously exit in the follow points, and the requirement is still there,

1) An aspect not included in Figure 1 refers to cross-regional initiatives (e.g. pan-arctic activities/networks). GEOCRI is needed to support development of initiatives promoting latitudinal and mainly longitudinal transects, since they can from one side help to better separate local influence from large scale effects/processes and from another side improve capability of the ground-based component of the observing system to perform satellite Cal/Val activities.

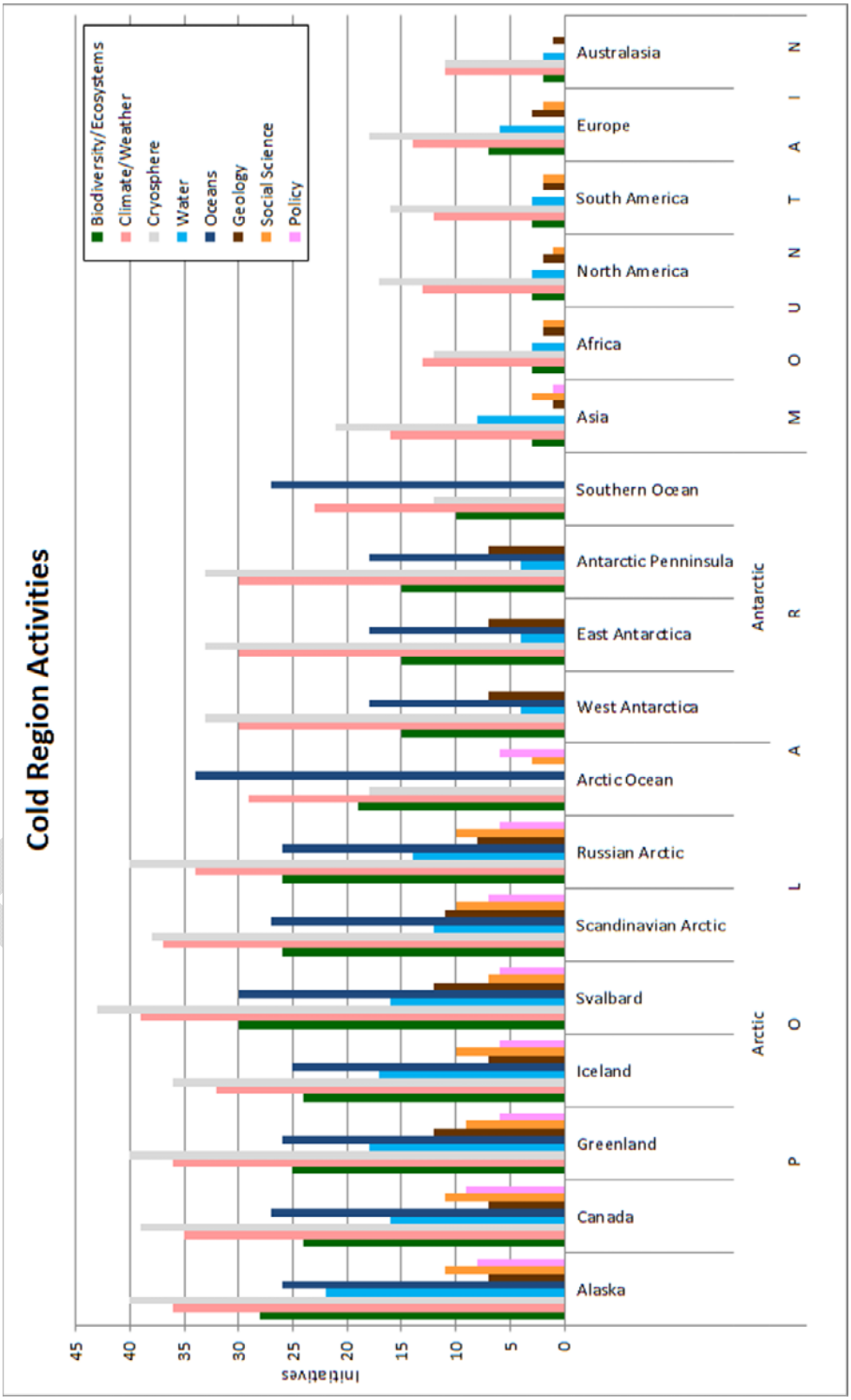

Figure 1 Statics of the Activates related to Earth Observations over Earth Cold Regions

2) Regarding the explicit characteristic of cold regions, there is no factors or indicators that can clearly be the representative variables as sensitive variables - the Essential Variables (EV) relevant for cold regions, especially those from the satellite observations. There is one need to move towards a comprehensive set of EV's in the cold regions that will be a useful framework for designing future sustainability EO systems.

2.2 Cold Region Earth Observation Needs and Requirements

This section describes environmental and socio-political challenges facing cold regions, many of which are unique to cold regions, and outlines how specific Earth observations are needed to help address them. It identifies information or data needs associated with each issue, as well as networks, systems, infrastructure, etc. required to address issues. By addressing the Earth observation needs and requirements in cold regions to support efforts to tackle the identified issues, GEOCRI will contribute to all eight of SBAs outlined by GEO as well as the 2030 Agenda for Sustainable development and other initiatives.

Despite best efforts, the list of Earth observation needs and requirements for cold regions defined here are by no means exhaustive. The needs and requirements which GEOCRI aims to address will continuously grow and evolve as issues emerge and develop.

Cold region Earth observation needs and requirements are organized distinctly topic area; however many issues are cross-cutting and relevant across multiple or all domains. While these issues are categorized in a particular domain, addressing the issue will be beneficial to several need and requirement areas. For example, climate and weather is a cross-cutting issue, addressing which will be beneficial to issues in all or multiple domains to varying degrees, including biodiversity/ecosystem, agriculture, water, hazards, and others.

2.2.1 Climate & Weather

Global climate change is amplified in cold regions. The Poles are the most rapidly warming regions of the planet and unprecedented change is occurring in mountainous areas. Better understanding of climate and climate change in cold regions is essential for effective adaptation and mitigation, as well as identifying new opportunities and challenges presented by climate change. Earth observations can contribute to climate knowledge, through monitoring of climate systems and change.

Weather in cold regions is highly changeable and difficult to predict. Better understanding of weather and higher resolution, accurate forecasting (both spatially and temporally) is needed to provide accurate weather information to people living and working in the cold regions. This will improve safety as well as economic productivity, allowing people to plan and prepare their activities more appropriately for the weather.

Specific Earth observation needs and requirements for weather and climate in cold regions include:

- Improved meteorological and related environmental observations throughout cold regions, including an improved network of weather stations and increased high-resolution

remote sensing from satellites, unmanned aerial vehicles (UAVs) and aircraft. This is particularly needed in remote/inaccessible regions where data are sparse, regions where weather forecasting is currently poor (e.g. with steep orography), and where model error is frequent. Improved observations will help improve weather and climate forecasting at all temporal and spatial scales.

- Improved observation of ABL (Atmospheric Boundary Layer) dynamic structure, turbulent exchanges (energy, mass, heat ...), coupling processes at the interfaces (air-land-snow, sea-air-ice), also to validate/ameliorate parametric schemes in regional models and fully understand effects of orography in mountain regions.

- Improved monitoring of the impacts of ongoing climate change on environments, ecosystems and society in all cold regions.

(Sources: EC-PHORS [1], IPCC [2], WCRP [3], WMO [4], CAS-NASA HMA [5], ESA – NRSCC DRAGON [29])

2.2.2 Biodiversity & Ecosystems

Due to intense climate and environmental change, ecosystems are under threat in cold regions. Species are forced to adapt to change, and in many cases struggle. Further direct pressure is placed on biodiversity and ecosystems human activities, such as extractive industries, tourism, forestry, agriculture and hunting. A decline in biodiversity and diminishing ecosystem health in cold regions is a socio-political, as well as environmental, issue, with ramifications in areas of the planet beyond cold regions. Resilient ecosystems in all regions are needed to support the planet and human activities in a number of areas, including food production, water, health and tourism.

Specific Earth observation needs and requirements for biodiversity and ecosystems in cold regions include:

- Detailed, accurate and ongoing ecosystem and biodiversity monitoring and assessment throughout cold regions via both in situ and remote sensing observations to assess and monitor ecological health and change.
- Full understanding of coupling processes with atmosphere and influence of atmospheric conditions (radiation, cloudiness, precipitation ...)

(Source: CAFF [6], GEOBON [7], ICIMOD [8])

2.2.3 International Relations & Cooperation

Due to the complex opportunities and challenges presented in polar and mountain areas, many countries, organizations and groups have interests in cold regions. Without common understanding and cooperation between all stakeholders disagreements can potentially arise and escalate. Earth observations and Earth observation initiatives contribute to the process of settling

disagreements and bringing stakeholders together to address common issues of importance peacefully.

Specific Earth observation needs and requirements for international relations and cooperation in cold regions include:

- Systematic international cooperation and sharing of Earth observation data, information and expertise regarding cold regions, and the promotion of broad open data policies as a default.
- Improved communications and infrastructure in cold regions to help better utilization of and access to Earth observations for all users.
- Improved international observation networks and systems at regional and global scales, particularly to support tackling trans-boundary issues such as water, pollution, biodiversity etc.
- Comprehensive and definitive independent land and sea floor surveys to help settle territorial disputes in cold regions (e.g. Arctic Ocean).
- Development of Earth observation campaigns in cold regions as opportunities for peaceful international scientific cooperation and collaboration that pave the way for improved relations between nations in all areas.

(Sources: Arctic Institute [9], GEO [10], ICIMOD [8], CAS-NASA HMA [5], ESA-NRSCC DRAGON [29])

2.2.4 Sustainable Development, Indigenous Communities & Traditional Practices

As with all regions, sustainable development is essential in polar and mountain areas. Many cold regions encompass developing nations or communities with relatively high levels of poverty and limited access to services. Development opportunities are often scarce and there are many unique challenges facing development in cold regions, such as protecting the fragile environments. Sustainable development in cold regions, supported by Earth observations, needs a bespoke approach in order to address these specific and unique challenges.

Indigenous communities compose a large percentage of cold region inhabitants. These communities have their own specific needs and traditional practices, to which Earth observation efforts and initiatives must be sensitive. Supported by Earth observations, Indigenous populations can effectively conserve their cultures and way of life, while enjoying the benefits of the modern world, for example, having access to modern health care while maintaining traditional communities, practices and ways of living.

It is important to note that Indigenous and local communities can make real positive contributions to Earth observations, in addition to benefitting from Earth observations themselves. Traditional knowledge from Indigenous and local communities contributes valuable information to benefit cold region Earth observation efforts through active participation in research and community-based monitoring schemes. By engaging with or leading Earth observation efforts, local and Indigenous communities' needs and requirements can be more

effectively and appropriately met than if communities only engage with products of Earth observations.

Specific Earth observation needs and requirements for sustainable development, Indigenous communities and traditional practices in cold regions include:

- Full harnessing of traditional and Indigenous knowledge of environments, ecosystems and resources throughout the cold regions for the benefit of all.
- Engagement with local and Indigenous communities in Earth observation efforts at all levels and stages throughout the cold regions, with increased capacity to quantify, document and manage Earth observations.
- Development and improvement of community-based monitoring initiatives in cold regions to improve engagement, more effectively tailor Earth observation efforts to local needs, and improve efficiencies.
- Monitoring of species to help inform policies and enforce sustainable limits on traditional hunting, trapping, whaling and fishing, etc. in cold regions to ensure environmental and ecological protection while maintaining important cultural practices.
- Identification of unique regional characteristics in cold regions for high value economic exploitation (e.g. endemic species, beautiful scenery, natural resources etc.) to support communities and their sustainable development.

(Sources: Arctic Health [11], HRCF [12], ICIMOD [8], SDWG [13], AMAP [14], CAFF [6])

2.2.5 Public Health

Cold region populations often have lower levels of health compared to wider populations, and have less access to health services than in other regions. Earth observations related to health include monitoring environmental health indicators such as pollution, water quality and food contaminants, and can inform improved access to health services for remote and isolated communities.

Specific Earth observation needs and requirements for health in cold regions include:

- Monitoring of toxic substances, pollutants and contaminants in cold regions to which humans may be harmfully exposed, including in food sources, water sources, atmosphere and the environment generally.
- Land surveys to determine current best access to health services for remote and isolated communities, and inform efforts to improve accessibility.
- Monitoring of vector species in cold regions which carry parasites/diseases with potential harmful health effects, particularly vector species which carry new, previously absent parasites and diseases to cold regions.

(Sources: Arctic Health [11], ICIMOD [8], SDWG [13])

2.2.6 Agriculture, Fisheries, Hunting & Food

Due to the harshness of the environment and climate, opportunities for agriculture in cold regions are often limited. Earth observations can help identify opportunities to improve production to better meet the food needs of cold region populations, increase economic output, and help meet the growing demands for food globally.

Hunting and fishing, for food production and other goods, are key activities in cold regions. Earth observations can help inform policies and actions to ensure sustainable yields from hunting and fishing, while minimizing environmental and ecological damage.

Specific Earth observation needs and requirements for agriculture, fisheries, hunting and food in cold regions include:

- Assessment of the impact of ongoing climate and environmental change on agriculture in cold regions to inform adaptation where necessary.
- Identification of regions viable for new agricultural opportunities in light of ongoing climate and environmental change.
- Detailed soil surveys in cold region agricultural areas to inform sustainable yields and environmental protection.
- Crop surveys to identify opportunities for agricultural diversification and sustainable intensification of production in cold regions, and the development of "climate smart" agricultural policies and practices.
- Identification of endemic species, local climate, and soil conditions, etc. that provide new or locally specific agricultural opportunities, particularly for high-value produce.
- Monitoring of the impacts of agriculture on environments and ecosystems (irrigation, pesticides, over-grazing etc.) to inform sustainable regulatory policies where necessary.
- Accurate and ongoing monitoring of hunted species populations to inform and help enforce regulated sustainable hunting limits and policies.
- Accurate and ongoing monitoring herded species populations, herd health, size and density, and the condition of pastures to support effective, efficient and sustainable management.
- Accurate and ongoing monitoring of fish stocks in all cold regions waters to inform and help enforce regulated sustainable catch limits and policies.

(Sources: CAFF [6], ICIMOD [8], GEOGLAM [15], SDWG [13], AMAP [14])

2.2.7 Water

As with many areas of the globe, water is a key issue for cold regions. Regions such as the Hindu Kush – Karakorum – Himalayas (HKKH) provide water to over a billion people living downstream of rivers fed by meltwater from glaciers and snowpack. Other cold regions are themselves water stressed, with scarce water supplies for local communities. Earth observations

can help monitor water supplies within and from cold regions, for both quantity and quality, supporting effective sustainable water resources management that considers environmental, ecological and human needs.

Specific Earth observation needs and requirements for water in cold regions include:

- Improved network of hydrological stations, particularly in remote/inaccessible regions where data are sparse, and where hydrological model accuracy is currently poor.
- Improved glacier mass balance and snow cover monitoring in regions reliant on melt water resources, especially in stressed areas and areas which supply water to large populations outside of the cold regions (e.g. the HKKH and the Andes).
- Detailed and ongoing monitoring of water table and reservoir levels in cold regions, particularly in water-stressed areas.

(Sources: ACAP [16], AMAP [14], CAFF [6], ICIMOD [8], SDWG [13], CAS-NASA HMA [5] , ESA – NRSCC DRAGON [29])

2.2.8 Pollution & Environmental Protection

The fragility and sensitivity of cold region environments and ecosystems means that they are particularly susceptible to the impacts of pollution and other environmental damage. EOs can help monitor pollution and environmental damage in cold regions, assess their environmental impacts and inform necessary responses.

Specific Earth observation needs and requirements for pollution and environmental protection in cold regions include:

- Accurate and precise real time monitoring and early warning systems of oil spills in cold region waters via remote sensing, to inform more effective clean up response. Monitoring updates should ideally be in the order of minutes to hours. Oil spill events must be followed by environmental impact assessments and recovery monitoring.
- Identification and monitoring of the sources, pathways, transport and deposition of pollutants, contaminants and toxic substances within, to, from and between cold regions, via the atmosphere, water, land, ecosystems and human activity.
- Identification and assessment of contaminated environments and monitoring of clean up and recovery.
- Monitoring of pollutant impacts on cold region ecosystems and environments, with particular attention to highly susceptible species (e.g. top predators due to bio-magnification) and selected indicator species.
- Monitoring of UV fluxes and dosimetric measurements to evaluate impact in changing habits caused by societal as well as climate changes.

- Ongoing environmental and ecosystem assessments to identify the need for environmental protection policies and protected areas in cold regions. Monitor the effectiveness of existing environmental protection efforts.
- Monitoring of black carbon sources, transport and deposition within, to, from and between cold regions, and assessments of its environmental impacts (increased glacier ablation etc.).
- Enhance the GMOS link and contributions from CNR-IIA.

(Sources: ACAP [16], AMAP [14], PAME [17])

2.2.9 Hazards

Cold region related hazards include large-scale disasters that threaten entire communities or populations, e.g., avalanches, landslides, flooding, severe weather and tectonic hazards, and small-scale hazards to individuals. Earth observations can help identify hazards, determine risks, inform efforts to reduce risk, and inform effective response to events.

Specific Earth observation needs and requirements for hazards in cold regions include:

- A fully integrated snow and avalanche monitoring and warning system covering all populated regions where avalanches are a risk (particularly, but not limited to, mountainous areas).
- The expansion and integration of glacial lake monitoring systems across all glaciated regions to predict and mitigate glacier lake outburst floods (GLOFs), including monitoring of lake and river levels and moraine/ice dam structural integrity.
- A fully integrated slope stability monitoring close to populations and infrastructure, especially in mountainous regions. Integrate slope stability monitoring with GLOF prediction.
- Improved volcanic/seismic monitoring in tectonically active glaciated regions to forecast and mitigate geothermal melt outburst floods (Jökulhlaups). Integrate tectonic monitoring with avalanche, GLOF and slope stability monitoring.
- Accurate, precise, real time tracking of wildfires throughout cold regions, using satellite observation to inform most effective and early response. Updates in the order of minutes.
- Improved land/vegetation surveys to improve fire management (e.g. identification of natural firebreaks).
- Improved weather forecasting, hydrological monitoring and land surveys, to improve flood prediction, monitoring, management, defenses, warning systems and response efforts throughout the cold regions.
- Detailed surveys of the natural and built landscape to facilitate better identification of populations and infrastructure at risk due to different hazards, and to inform effective protection, emergency response and evacuation efforts.

- Improved monitoring and tracking of potentially dangerous animals (e.g. polar bears) close to human populations in cold regions to inform safe response for all parties.

(Sources: C-DAC Glacier Lake Monitoring System [18], EPPR [19], ICIMOD [8], S:GLA:MO [20], CAS-NASA HMA [5])

2.2.10 Built Environment, Infrastructure & Transport

The harsh and difficult conditions in cold regions present unique challenges for the built environment, infrastructure and transport. Difficulties are escalated due to ongoing environmental change. Earth observations can help inform how and where to build in cold environments, as well as maintenance needs.

Specific Earth observation needs and requirements for the built environment, infrastructure and transport in cold regions include:

- Monitoring of permafrost active layer in areas where infrastructure has been built on tundra, and of the structural integrity and stability of buildings, roads, etc. in permafrost areas. Use of satellite radar interferometry (DInSAR) to generate long term time series and separate long term contribution due to permafrost melting from seasonal variation of the active layer.
- Detailed surveys throughout cold regions to identify areas suitable for development.
- Comprehensive, accurate real-time monitoring of roads, rail and other transport networks, in all cold regions, including for ice, flooding, landslides and other potential hazards to users and infrastructure.

(Sources: GTN-P [21], ICIMOD [8], IPA [22], PAGE21 [23], SDWG [13])

2.2.11 Energy

The remoteness of many cold region communities often demands that energy is produced locally. This often means reliance on high-emission, polluting fuels for energy, such as diesel, which can be imported by air or sea. Earth observations can help improve energy infrastructure, increasing energy access, and develop renewable energy capabilities in cold regions, reducing emissions, costs and reliance on energy from other regions.

Specific Earth observation needs and requirements for energy in cold regions include:

- Extensive surveys throughout cold regions to assess the viability of developing different renewable energy sources (including wind, solar, geothermal and hydro) particularly for local clean energy production in isolated communities, reducing pollution and reliance on imported fuel.
- Development of nowcasting techniques for solar, wind, renewable energy sources suitable to be included in smart grid technology for offline energy systems.

- Land surveys to inform development of energy grids to deliver power to remote communities.

(Sources: ICIMOD [8], SDWG [13])

2.2.12 Mining & Fossil Fuels

Cold regions, particularly the Arctic, are home to abundant, potentially exploitable mineral and fossil fuel resources. The growing global demand for resources suggests that widespread resource extraction in cold regions may be inevitable. Earth observations can not only inform what resources exist in cold regions, and the viability of their extraction, but also responsible practices to minimize environmental and ecological impacts.

Specific Earth observation needs and requirements for mining and fossil fuels in cold regions include:

- Extensive and detailed geological surveys to identify viably exploitable minerals in cold regions, on land and at sea.
- Extensive and detailed fossil fuel surveys to identify viably exploitable resources in cold regions, on land and at sea.
- Monitoring and assessment of the environmental impacts of mining and fossil fuel exploration/extraction and related activities in cold regions to inform necessary mitigation.
- Assessments of likely environmental impacts of potential future mining and fossil fuel exploration/extraction and related activities in cold regions.

(Sources: ACAP [15], AMAP [14], EPPR [18], GEUS [24])

2.2.13 Forestry

Forestry is a key economic activity in cold regions. Earth observations can monitor forests and forestry to inform sustainable practices and necessary environmental protection.

Specific Earth observation needs and requirements for forestry in cold regions include:

- Extensive and detailed surveys to identify viably exploitable timber resources in cold regions.
- Forest extent, density and health monitoring throughout cold regions, particularly in areas of intensive logging.
- Monitoring and assessment of the environmental impacts of forestry and related activities in cold regions to inform necessary mitigation.
- Assessments of likely environmental impacts of potential future forestry and related activities in cold regions.

- Identification of opportunities for sustainable plantations with minimal impact on environment and ecology, and monitoring of the impacts of existing plantations, particularly where non-native species have been introduced.

(Sources: AMAP [14], GFOI [25], ICIMOD [8])

2.2.14 Shipping

Shipping, already a key activity in cold regions, is predicted to grow as environmental and climate changes open up new sea passages that offer shorter trade routes (i.e., diminishing sea ice in the Arctic Ocean). Nonetheless, shipping in polar waters remains dangerous, and many hazards to life and environment exist. Earth observations can help minimize risks for shipping, by identifying hazards and informing mitigation efforts.

Specific Earth observation needs and requirements for shipping in cold regions include:

- Comprehensive, accurate real-time sea ice monitoring and forecasting (hourly) systems in both the Arctic and Antarctic, including ice extent, concentration, thickness, drift and freeze/break up timing.
- Comprehensive, accurate real-time iceberg monitoring and forecasting (hourly) systems in both the Arctic and Antarctic. Including ice berg frequency, dimensions, draft, motion and disintegration.
- Detailed, accurate, high-resolution and regularly updated bathymetric surveys in all cold region waters, including within fjords and close to calving glaciers, using autonomous underwater vehicles (AUVs) where hazards prevent use of more conventional vessels.
- Establishment of baseline ecosystem conditions to monitor impact of invasive species from ballast waters.
- A comprehensive polar marine traffic awareness system, tracking vessels and improving communications and information sharing between vessels (e.g. local sea ice conditions).
- Continued monitoring of the environmental and ecological impacts of shipping and related activities in cold regions to inform necessary mitigation.
- Assessments of the likely environmental impacts of potential future shipping and related activities in cold regions, particularly in newly accessible waters.

(Sources: Arctic Institute [9], EPPR [18], PAME [16])

2.2.15 Tourism

Cold regions have long been attractive destinations for various forms of tourism, be it for the scenery, wildlife, culture, or sport such as skiing and mountaineering. Earth observations can support the development of sustainable tourism that does not damage environment or ecology, while providing much needed economic support for developing communities. In cold regions where tourism is already established, such as the European Alps, Earth observations can provide

services for tourists and operators alike, such as snow monitoring and prediction for the skiing industry.

Specific Earth observation needs and requirements for tourism in cold regions include:

- Improved snow and ice forecasting and monitoring for winter and alpine sports.
- Continued monitoring of environmental and ecological impacts specifically related to tourism, e.g. erosion of footpaths and ski pistes, increased pollution, introduction of invasive species and litter.
- Observations about the invasive species from tourism vector over cold region area

(Sources: AMAP [14], CAFF [14] ICIMOD [8], SDWG [13])

2.3 Fundamental Requirement for GEOCRI

2.3.1 Development on EVs and Sensitive Indicators

Towards a comprehensive set of EV's in the cold regions will be a useful framework for designing future sustainability EO systems. At this stage, the ECV, and EBVs are two variable sets that can be leverage for the cold regions. The combination of the Essential Variables will lead to the Cold Region Indicators, which may not be measured directly, but could service to the science and societal benefit directly. The related data products (EVs and Indicators for cold regions) are less sharing and developed.

An interesting exercise could be to start to define specific GEOCRI essential variables (e.g. Sea Ice, etc.) and non-specific essential variables (valid and necessary for any region or domain). A way to start is to propose adopting many of the variables defined in the Climate domain (ECV's).

2.3.2 Coordination requirement for In-situ Observations

There are many key projects that may fill the gaps of stations measurement over earth cold regions, there is a need to integrate, coordinate different stations thematically over Earth cold regions, and manage the gap analysis, namely few of them,

1) The strategically important task of PEEX is to filling the observational gap in atmospheric in-situ data in the Northern Eurasian cold region. The PEEX program aims to deliver comprehensive, continuous ground-based observations on atmospheric composition that can be used to construct reliable early warning systems for extreme weather events and to estimate environmental contamination and pollution dispersion. Along with the operational services, the comprehensive high-quality data is required to improve performance of global climate models, regional air quality models and to validate satellite observations and to derive new satellite based proxy variables.

2) Establish long-term fixed-site observation and monitoring stations within the Third Pole region for comprehensive study and a more complete understanding of the regional environments. Establishment of Flagship Stations will be one of the long-term goals of TPE. On

specific items (e.g. tall towers) promote bilateral, multilateral initiatives for longitudinal transects (from Alaska to Russia, crossing through Canada, Greenland, Svalbard).

While the coordination for the *In-situ* Observations are important and required to better understanding of the physical process, and an inventory of *in-situ* metadata are based on the successful coordination.

2.3.3 Coordination requirement for Space Observations

Space observations, especially, the satellite-based observation are providing fasting, near-real-time (not less than one day from Polar Orbit satellite) coverage over Earth cold regions, especially the three poles. The coordination and metadata of remote sensing scenes are required, especially from the free downloadable and accessible observations, such as Copernicus, Landsat, and Chinese Gaofen series. The gap analysis is still needed to address the requirement of dataset for the faraway cold regions.

2.3.4 Knowledge gaps from the mature services

The activities and programs are in different development stage of services, star-ups and mature applications and serves, like CryoClim, are pioneers for the GEOCRI's strategy. An enhancement of the interlinkage and exchange are needed for guiding the ways of local, national, and regional projects that contribute to GEOCRI implementation.

3. Previous development and results

The GEO Cold Regions Initiative build on the successful coordination of the third component under Water SBA: Information Service for Cold Regions (WA-01-C3) from 2012-2015 with the basis legacy of GEO work program development from 2009 to 2011. In the past years, the WA-01-W3 was presented at different platform, including the WMO EC-PHORS, WMO GCW, WMO PSTG, annual GEO Work Program symposium, AOS 2014, AOS 2016, and CRP CliC, Arctic Circle, and INTERACT snow meeting, and EoE of UNEP, and on board the SAON meeting. Several communicates, and statement have been issued and released, they mainly are,

3.1 GEO Cold Regions at GEOSS Work Plan and GEO Annual Report

At the GEOSS Work Plan, the GEO Cold Regions (WA-01-C3) were developed aiming to the gather the contributors and force on the community building, main activities are mainly include,

- **Observations and Information**

- Conduct a distributed cyber(e)-infrastructure to collect, manage, publish and share polar research results and implement multi-disciplinary interoperability following a Brokering approach, supporting SCAR data policy and in accordance with European and international standards, including GEO/GEOSS, INSPIRE.
- Fully aware of all the cryosphere projects applied for at 20 of INTERACT's 44 research stations, with the INTERACT's infrastructure project which base in northern Europe, Russia,

US, Canada, Greenland, Iceland, the Faroe Islands and Scotland, and to build capacity for research and monitoring in the European Arctic and beyond, and is offering access to numerous research stations through the Transnational Access program. INTERACT is also offering metadata and some datasets and possibilities for additional observations required by GEO.

- Implement the information services for Cold Regions, for example, the CryoClim Cryospheric climate monitoring. Provide the parameter data product and tools/systems/models to the GEO DataCORE.
- Provide the polar station observation and satellite data coordination through appropriate national, regional and global systems and centres (Validation and Calibration).
- Promote the integration with integrated atmospheric and climatic observation and modeling data from a network of high-altitude mountain stations in the Alps, Himalaya Karakoram, Rwenzori and Andes in the framework of the Ev-K2-CNR SHARE program and the national Italian project Next Data.
- CAFFs provide the Arctic Biodiversity Data Service (www.abds.is)
- Coordinated Asia-European long-term Observing system of Qinghai–Tibet Plateau hydro-meteorological processes and the Asian-monsoon system with Ground satellite Image data and numerical Simulations (CEOP AEGIS)

■ **Coordination and Programs**

- Build a polar data catalogue through integrated observation and modelling data from the broad range of "International Polar Year" research activities, for example: CAFF/CBMP data - http://www.polardata.ca/.
- As a component of the Global Cryosphere Watch (GCW) Data Portal, establish a Cryosphere Constellation of Portals by linking existing and proposed portals of cryospheric information.
- Support the development of sustained and coordinated pan‐Arctic observing and data sharing systems that serve societal needs. Improve the networking among existing observing systems and sites to create pan‐Arctic observing networks (CAFF and INTERACT pan-Arctic observation networks). Promote the implementation of the Sustainable Arctic Observation Network (SAON).
- Integrate the Svalbard Integrated Arctic Earth Observing System (SIOS) and the CryoClim Cryospheric climate monitoring service into GEOSS.
- Implementation the Third Pole Environment program and Mountain ecosystem observations.
- And other individuals (with GEO volunteer mechanism) who are interested in this Cold Region efforts.

3.2 Conclusion and Recommendations for GEO Cold Regions

A high level side event for GEO Cold Regions was hosted in Geneva at the GEO X plenary 2014, the Conclusion and Recommendations was released. Attendance are from the world leading

agencies, and international organization, such as directors from ESA, ESD/NASA, National Principle(Canada and Norway), World Glacier Monitoring Service (WGMS), Arctic Council, WMO, GEO Secretary, etc. The main outcomes are to reinforce the importance and vision of GEO Cold Regions, observations to date, and recommendations. (See attachment for)

- Vision and Importance
- Observations and Information Service Progress to Date
- GEOSS Information Service for Cold Regions

3.3 Statement on GEO Cold Region Initiative (GEOCRI)

The GEO Cold Regions was emphasized to be an emerging initiative, GEO Cold Region Initiative (GEOCRI) was formally proposed to the Arctic Observation Summit 2016 in Alaska. Where the summit featured the GEO Cold Region Initiative (GEOCRI) that aims to identify, address and fill observational gaps and improve networks through coordinated observation practices and information services worldwide.

Arctic observations have been improved by the work of International Arctic Systems for Observing the Atmosphere (IASOA), Year of Polar Prediction (YOPP), scheduled to take place from mid-2017 to mid-2019; and Global Cryosphere Watch (GCW), and coordination and data sharing enhanced by GEOCRI and GEOSS.

The article paper “Advancing Arctic observing within the Global Earth Observation System of Systems (GEOSS) through Community-Based Monitoring” was published to foster and improve interoperability among GEOSS.

3.4 Other Activities

An abstract was submitted titled “An information Service for cold Regions GEO Cold Regions - a framework for observations in polar and mountainous areas” to raise the awareness of the coordination of information service for cold regions (See reference).

Co-organized with a workshop hosted by the European Environment Agency with the IASC ICARP III Activity grant, GEO were with the scientific communities to reinforce the international platform regarding the Arctic, a scientific paper has been published in Ambio - Changing Arctic snow cover: A review of recent developments and assessment of future needs for observations, modelling, and impacts.

The GEO-co-authored White Paper on Advancing Arctic observing within the Global Earth Observation System of Systems (GEOSS) through a focus on Community-Based Monitoring has been submitted to the Arctic Observation Summit 2016 (AOS2016), where the information service for cold regions (GEO Cold Regions) was fully exploited to make connections and opportunities with activities over the arctic areas.

4. Activities description

4.1 Overall planning

The activities conducted in GEOCRI are grouped into six tasks: Data, Infrastructures, Training, Capacity Building and Knowledge Transfer, User Engagement and Communication, In situ and Remote Sensing Integration, and Monitoring and Management. Each task consists of activities with set milestones and deliverables during the Work Program 2017-2019. The range of deliverables varies from activity reports to stakeholder and user mapping to training and capacity building events and webinars. Majority of the milestones and deliverables in the Implementation Plan for 2017-2019 are set on the two first years of the programme period in order to later add new milestones and deliverables, geared towards transition to implementation and operational stage starting in 2019 and during the next work programme period 2020 onwards.

Capacity building and training activities include events to educate new generation of scientists to work on Cold Region related questions, which can be done especially with a focus on supporting young scientists from developing regions of the High Mountain and Arctic areas, including indigenous youth. Capacity building and training activities will be planned and conducted in collaboration with relevant key actors in the field (e.g. University of the Arctic network and APECS, PEEX, TPE, DBAR ettc). Another focus are in training and capacity building will be in providing technical advice and facilitating institutions hosting cold regions data to register their datasets to GCI and/or GEOSS Data-Core.

4.2 Tasks

Tasks are overarching themes that consist of activities done with ***Task Teams***. There are 6 Tasks in GEOCRI:

Task 1：Observation Data

Task 2：Infrastructures

Task 3：Capacity Building and Knowledge Transfer

Task 4：User Engagement and Communication

Task 5：In-situ and Remote Sensing Integration

Task 6：Monitoring and Management

The Tasks and related activities are on a general level defined by the whole GEOCRI community, who can also suggest activities and their outcomes to be conducted under the tasks. Contributors can assign themselves to work for different tasks and related activities; these will form Task Teams. Task Teams will themselves decide on the planning and responsibilities of their activities, and the set milestones and deliverables will be reported to the co-leads and presented to contributors who will provide feedback.

Table below lists the Tasks and related activities, as well as the milestones and deliverables to be completed by the GEOCRI Task Teams, led by nominated Task Coordinators during the Work Programme 2017-2019. Some activities can be fulfilled quickly, whereas others require sustained efforts to fully implement. Some activities are relatively easy to realize, and others are more difficult, requiring significant resources or high-level mandates to be obtained. Majority of the milestones and deliverables are set on the two first years of the programme period, in order to later add new milestones and deliverables, geared towards transition to implementation and operational stage in 2019 and the next work programme period 2020 onwards.

The importance, difficulty and progress of each activity are roughly indicated by the following criteria (low scores indicate priority activities or 'low hanging fruit' that should be implemented first).

Importance:

1 - An important activity, which if GEOCRI does not do, nobody will. GEOCRI will take the leading role
2 - GEOCRI can offer support to other initiatives working towards this activity
3 - GEOCRI supports this activity, but is not needed to actively participate directly

Difficulty:

1 - Relatively easy, can be implemented quickly without additional resources or mandate
2 - Will take time (maybe even years) and work to implement, but is possible without additional mandate. No political or funding barriers to action
3 - Difficult to implement, requires political mandate or funding/other resources to be secured.

Progress:

1 - Activity has already begun and is ongoing with progress
2 - Activity has not started or has started but is not currently active. No significant barrier is preventing progress
3 - Activity has not started, or has stopped. A significant barrier is currently blocking progress for the time being.

Tasks	**Importance**	**Difficulty**	**Progress**	**Contributors**	**Milestones and Deliverables & Time schedule**

Task 1. Data Task Team: Jeff Key, Yubao Qiu, Julie Friddell, Peter Pulsifer, Tom Barry, Hiroyki Enomoto, NIPR, Massimo Menenti, Weicai Wang, Carolina Gabarró , and Emili Garcia Ladona…					
Activity 1.1 Identify and document needs and requirements for cold region Earth observation data and information for all users, both within and outside of cold regions. Make regular updates as needs and requirements change and emerge. Coordinate user requirements with WMO and its Rolling Review of Requirements (RRR) mechanism.	1	2	1	CCIN/ PDC RADI/CAS GCW SAON	**Milestone:** Analysis of existing and ongoing consultations on user needs **(**XII 2017). **Deliverable (:** Summary of the identified needs and requirements and action plan to implement the findings. XII2018)
1.3 Incorporate cold region databases, such as the Arctic Data archive System (ADS), the SAON data inventory and ICIMOD's Regional Database System, The Arctic Biodiversity Data Service, and the Italian Arctic Data Centre (IADC) into the GCI.	1	2	1	CCIN/ PDC RADI/CAS CAFF JAMSTEC NIPR TPE CNR	**Milestone :** Institutions hosting Cold region databases identified and contacted (XII 2017). **Deliberable :** List of Cold Region database holders + promotional material (XII 2017)
1.5 Engage with Arctic Portal to explore potential for registering datasets hosted on their websites with GCI.	1	2	2	CCIN/ PDC	**Milestone:** Arctic Portal contacted for discussions (VI2017)
1.6 Support GCW in the development and expansion of CryoNet, identifying best practices for observations, sharing open data principles and capacity development activities. Allow for discovery of CryoNet through GCW Data Portal.	2	2	1	CCIN/ PDC GCW?	**Milestone:** Discussions initiated with GCW and possibilities for supported activities and related actions identified (VI2017).
1.7 Support ICIMOD in developing a HimalyanGEOSS, sharing GEO's broad open data principles and capacity building expertise, and register Himalayan observations into the GCI. Connect other initiatives, such as TPE, WMO/GCW, PEEX, and WCRP/CliC to maximize the effectiveness and scope of the Himalaya GEOSS.	1	2	1	GCW RADI/CAS TUD	**Milestone** : ICIMOD contacted for discusisons (III2017) **Deliverable :** Jointly produced action plan for possible collaboration and related activities (IX2017)
1.7 Start to define specific GEOCRI essential variables (e.g. Sea Ice…) and non-specific essential variables (valid and necessary for any region or domain). A way to start is to propose adopting many of the variables defined in the Climate domain (ECV's). Work with ECVs, EBVs, use sea ice as the example.	1	2	1	CSIC RADI INTERACT	**Milestone** : document articulate the variable for cold regions.(III2017) **Deliverable** :variable table

1.8 Support the Digital Belt and Road (DBAR) initiative to broker the related activities with the big data platform along the Belt and Road region.	1	2	1	RADI,CAS	**Milestone** : create the interface with DBAR.(III2017) **Deliverable** : developmetn report
Task 2 Infrastructures Task Team: Hannele Savela, Jeff Key, Vito Vitale, Angelo Viola, Stefano Nativi …					
Activity 2.1 Create dialogue between infrastructure networks for collaboration and more efficient use of infrastructures	1	2	2	INTERACT GCW	**Milestone 1:** Cold regions related infrastructure networks and projects invited to GEOCRI (III2017) **Milestone 2**: Meeting arranged to facilitate collaboration (III2018) **Deliverable**: Minutes of the meeting (IV2018)
2.2 Advocate and support incorporation of different research infrastructure catalogues on cold regions (e.g. INTERACT, Eu-PolarNet, UArctic).	1	2	2	INTERACT GCW	**Milestone 1:** Cold regions related infrastructure catalogue hosts contacted (III2017) **Milestone 2:** Training/webinar for technical support (III2018) **Deliverable:** Summary of the development (XII2019)
2.3 Interoperability of GEOCRI with the GCI (resources registration and brokering, Community portal development, etc.)	1	2		CNR (S.N.)	
2.4 Promote a dialogue to realize connection along longitudinal/latitudinal transect on specific items (e.g. tall towers for ABL, flux measurements)	2	2	2	CNR	
2.5 Consolidating operational users' needs and information gaps to support development of future Arctic infrastructure (e.g. ESA Polaris and EU PolarNet).	2	2	2	ESA EOP? EU-PolarNet INTERACT Others?	**Milestone:** Analysis of existing and ongoing consultations on user needs and information gaps (III 2018) **Deliverable :**Summary of the identified needs and gaps and action plan of the support process. (III2019)

Task 3. Training and Capacity Building Task Team: Hannele Savela, Julie Friddell, Weicai Wang, Massimo Menenti, other Co-leads…					
Activity 3.1 Increase awareness of possibilities related to GEOCRI, GCI and GEOSS Data-CORE.	1	1	2	Co-leads team?	**Milestones:** Ongoing process 2017-2019. **Deliverables:** Promotional material, e-mail campaigns etc. in 2017-2019.
3.2 Arrange practical training on incorporating data to GCI and GEOSS Data-CORE	2	2	2	Co-leads team?	**Milestone:** Webinar training on how to tag data to GEOSS Data-CORE and/or register it to GCI (XII2017, XII2018, XII2019).
3.3 Arrange training to build capacity and educate new generation of researches on cold regions (e.g. via UArctic network and APECS)	3	2	2	INTERACT CSIC TPE	
Task 4. User Engagement and Communication Task Team: Hannele Savela, Yubao Qiu, Co-leads?					
Activity 4.1 Maintain regular communications with all GEOCRI participants, GEO secretariat and other members of GEO community with updates on activities. Help to forge synergies and collaborations between GEOCRI	1	1	2	INTERACT DBAR Co-leads team	**Milestone:** GEOCRI meetings (on-line or physical (XII2017-2019) **Deliverable:** Minutes of the meetings (XII2017-2019).
4.2 Engage with current non-GEO member cold region countries to explore potential for membership – notably Bhutan, Bolivia, Kyrgyzstan, Mongolia and others. Engage existing members and participating organizations to participate in GEOCRI activities more actively.	1	3	2	Co-leads?	**Milestone:** Country representatives and potential new contributors contacted to initiate discussions (VI2017).
4.3 Look to engage new organizations working in cold regions with GEOCRI and GEO.	1	2	2	INTERACT Co-leads team?	**Milestone:** Campaign to invite new contributors to GEOCRI conducted (VI2017). **Deliverable:** Promotional material (XII2019)

4.4 Liaise with other GEO activities to find potential synergies and map potential overlaps with them.	1	2	2	INTERACT Co-leads team?	**Mileston1e:** Related GEO activities contacted for discussions (XII 2017). **Milestone2:** Potential synergies and overlaps identified (VI2019). **Milestone3:** Map of potential synergies and overlaps with an action plan of possible collaboration (XII2019).
4.6 Promote and advocate the use of coordinated, comprehensive and sustained cold region Earth observations to inform decisions and actions by policy makers, industry, local communities, researchers and others.	2	1	1	INTERACT GCW Co-leads team?	**Milestone**: Participation with presentation(s) to joint forums with different stakeholders (ongoing 2017-2019) **Deliverables:** Presentations, abstracts, statements, white papers.
4.7 Advocate defining of cold regions earth observations essential variables (EVs) to more effectively meet the cold region Earth observation needs and requirements of users.	2	3	2	SAON INTERACT RADI	**Milestone1:** Key actors for defining the cold region key variables identified (XII2017) **Milestone2:** Key actors contacted for discussions (III2018) **Deliverable:** Work plan for defining the cold regions earth obsrvations essential variables (XII2018)
4.8 Develop GEOCRI logo and visual branding. Push for GEOCRI, GEO and GEOSS lto feature in cold region Earth observation relevant reports and documents where appropriate.	1	1	2	RADI/CAS	**Milestone:** GEOCRI logo and visual branding developed (XII2017) **Deliverable 1:** Logo (XII2017) **Deliverable 2:** Visual image instructions (XII2017)

4.9 Coordination to incorporate input from the ocean monitoring communities, inluding Several larger ongoing efforts were suggested to be engaged in the plan.	1	2	1		**Milestone:** Connect with EuroGOOS, CMEMS, Copernicus Climate services, JPI Climate services, ESA CCI ,EumetSat Satellite Application Facilities
Task 5 Integrating in situ and Remote Sensing Observations Task Team: Hannele Savela, Yubao Qiu, Jeff Key, Emilio Garcia Ladona, Massimo Menenti, Vito Vitale, Eugenio Sansosti, Weicai Wang, SAON…					
Activity 5.1 Establish a forum for meeting and dialogue to encourage links and collaboration of cold regions in situ and remote sensing communities	1	2	1	INTERACT CSIC GCW RADI/CAS TUD CNR TPE	**Milestone1:** Relevant community members identified and contacted. (IX2017) **Milestone2:** Joint meeting or webinar arranged (III2019) **Deliverable3**:Meeting minutes (IV2019) **Deliverable4:** Joint publication? (XII2019)
5.2 Develop a set of Cold Region Sensitive Indicators and ECRVs, based on the excise of ECVs and EBVs, to provide the most needed observations parameter over Earth cold regions.	1	2	1	CSIC RADI/CAS CNR **…**	**Milestone1:** Relevant community members identified and contacted. (IX2017) **Deliverable1:**list of the variable or indicator for Earth cold regions **Deliverable2:** Joint Publications (XII2019)
Task 6. Monitoring Task Team: Jeff Key, Hannele Savela, SAON, JAMSTEC, Hiroyki Enomoto , Tom Barry, Julie Friddel, Vito Vitale, Weicai Wang, Yubao Qiu…					
Activity 6.1 Develop and maintain an inventory of existing cold region Earth observations initiatives including organizations, programs, projects, networks and systems, particularly those which are active or have impact internationally and regionally.	1	1	1	SAON INTERACT, GCW RADI/CAS	**Milestone :** Existing cold region Earth observations initiatives identified (XII2019). **Deliberable :** List of existing cold region EO initiatives (XII 2017)

6.2 Support SAON as the lead organization in defining an Arctic Observing System. Support their existing efforts, share expertise. Leverage GEO's international position to align other initiatives with Arctic Observing System efforts and SAON where this is not already the case, including WMO (EC-PHORS, GCW, PRCC, WWRP etc.) WCRP (CliC), PPP/YOPP, INTERACT, EU-PolarNet and the successful candidate for the H2020 topics BG-09 and BG-10 in 2016 and BG-11 in 2017.	1	2	1	SAON JAMSTEC NIPR CNR WMO	**Milestone:** Discussions initiated with SAON (III2017) **Deliverable:** Plan of support activities to SAON (XII2017)
6.3 Engage with GEOBON and CAFF/CBMP , to support the development of ArcticBON (with GEOBON) and integrate it as the biodiversity component of the Arctic Observing System.	1	2	1	CAFF INTERACT Co-leads	**Milestone:** Start discussions with relevant representatives and initiatives for possible collaboration (III2017)
6.5 Support AmeriGEOSS in developing observing systems for mountain regions in the Americas, including the Andes and Rockies, as well as North American Arctic and South American sub-Antarctic. Engage with other initiatives such as WMO/GCW, WCRP/CliC and others to collaborate and maximize the effectiveness and scope of cold region components of the AmeriGEOSS.	1	2	2	CCIN/ PDC GCW	**Milestone:** AmeriGEOSS contacted for discussions (VI2017) **Deliverables:** Minutes of the meeting(s)
6.6 Support observing system networks, including WMO/EC-PHORS in developing, expanding and sustaining the terrestrial Antarctic Observing Network (AntON), and SCAR/SCOR with the interdisciplinary Southern Ocean Observing System as well as support the development of new observing systems such as SCAR's AntOS, working with key regional actors such as SCAR, SOOS, WCRP/CliC, WMO/GCW, PPP/YOPP, COMNAP etc. and research institutions active in the Antarctic (AAD, AARI, AntarcticaNZ, AWI, BAS, BAI, CSIC, USAP, etc.).	1	3	2	WMO CNR RADI/CAS	**Milestone:** Discussions initiated with Antarctic observing system netowks key actors (XII2018) **Deliverable:** Summary of key support actions during the GEO Work Program 2017-2019 (XII2019)

6.7 Engage with existing observing networks in cold regions, such as GTN-P, GLISN, GLMS, GCW, SIOS, etc. and emerging cold region regional observation networks to contribute to GEOCRI. Promote incorporation of data from these networks to GCI.	1	2	2	INTERACT CCIN/PDC：Julie GCW TPE	**Mileston1e:** Existing networks contacted and invited (XII2017) **Milestone2:** Emerging networks contacted (XII2017-2019**)** **Deliverable:** Face-to-face or on-line meetings and their minutes.
6.8 The co-lead group to set up the management system for the GROCRI, the ToR, and inviting an advisory board for GEOCRI.	1	1	1	Co-leads	**Mileston1e:** propose a management system (XII2017) **Deliverable:** ToR and Advisory Board(2017,GEO XIII)
Reserve activities (Dormant, Activated later on)					
Support for Arctic science agenda, building on international assessments (e.g. ICARPIII), projects (e.g. H2020 EU-PolarNet) and programs (e.g. ESA Polaris) and other similar initiatives throughout Cold Regions.	2	2	2	Whole GEOCRI community	
Identify and map existing cold region Earth observation data and information collection efforts. Identify where there are gaps in cold region Earth observing efforts that must be filled to meet the needs and requirements defined in Activity 1.1	**1**	**2**	**1**	YOPP SAON	
Support the implementation of YOPP. Advocate broad open data policies for all YOPP activities and aim to incorporate Earth observations from YOPP initiatives and legacy initiatives into the GCI.	**2**	**2**	**1**	CNR	
Everage GEO's international standing and reputation to help secure a mandate from the highest government levels for fully integrated observing systems for cold regions. This mandate must not only be from cold region countries, but fully international due to the global significance and interest in cold regions.	**1**	**3**	**2**		
Work to secure funding from GEO members to develop and maintain sustained observing systems for cold regions.	**1**	**3**	**2**		

5. Impact

GEOCRI will have a positive impact on cold region Earth observation efforts. By leveraging GEO's international position and coordinating power, GEOCRI can foster collaborations between different Earth observing initiatives to identify gaps, avoid duplications and improve efficiencies. Through GEOCRI, links can be developed between observation, research, and policy actors, creating synergies which contribute effectively and efficiently to GEO's eight societal benefit areas (SBAs) as well as the UN's 2030 Agenda for Sustainable Development.

5.1 GEOCRI and existing cold region Earth observation efforts

GEOCRI adds value to existing efforts for Earth observations in cold regions in the following ways:

- GEO's convening power allows GEOCRI to provide a **stakeholder forum** to discuss cold region Earth observations, identifying needs, requirements, opportunities, and best practices etc., complimenting existing cold region Earth observation initiatives.
- GEOCRI shares GEO's **knowledge and expertise** for capacity building, enabling users to maximize their ability to benefit from Earth observations throughout cold regions.
- Through GEOSS and the GCI, GEOCRI can ensure cold region Earth observations data and information can be effectively integrated with global Earth observations and observing systems, and ensure the integration of both in situ and remotely sensed Earth observations.
- GEOCRI is able to leverage GEO's **international position** to help secure the necessary mandates for cold region observing systems and broad open data policies at the highest government levels.
- GEOCRI provides a neutral communication forum to communicate policy-relevant cold region Earth observation results in international, national and regional levels based on science and tested best practices.

5.2 GEOCRI and the Societal Benefit Areas

GEO's Societal Benefit Areas (SBAs) are the domains in which Earth observations are translated into support for decision-making. GEO will facilitate the development of solutions to societal challenges within these SBAs by mobilizing resources including observations, science, modelling and applications, to enable end-to-end systems and deliver services for users. In order to address the unique challenges and issues associated with cold regions, GEOCRI must tailor its approach to the SBAs.

It is important to highlight the interconnected nature of cold region environments with other regions of the planet. SBAs are trans-regional, with issues emanating from cold regions impacting warmer areas and vice versa. Use of Earth observations must reflect the interconnectivity of the issues which they are intended to address. This is particularly true for cold regions.

While GEOCRI is officially an initiative within the Water Resources Management SBA, its relevance is cross-cutting: issues in cold regions are entrenched in all domains represented by the SBAs.

The SBAs are listed below with a brief summary of the issues specific to cold regions and how GEOCRI can help address them.

5.2.1 Biodiversity and Ecosystem Sustainability

Cold regions are home to some of the most sensitive and threatened ecosystems on the planet. GEOCRI, in collaboration with GEOBON, GFOI and others, can coordinate Earth observation efforts to effectively monitor biodiversity and ecosystems in cold regions.

5.2.2 Disaster Resilience

Cold regions are susceptible to a wide range of potential disasters, including from hazards which threaten all regions, and hazards specific to polar and mountain regions. Cold region Earth observations can help with all aspects of disaster management (mitigation, preparedness, warning, response and recovery) and build disaster resilience for vulnerable regions and populations.

5.2.3 Energy and Mineral Resources Management

Cold regions are home to a wide variety of resources with potential for exploitation. Earth observations can help inform appropriate actions to protect populations and environment while sensibly and appropriately exploiting resources. Furthermore, Earth observations can help to inform better use of energy and mineral resources in cold regions to improve sustainability and reduce negative impacts.

5.2.4 Food Security and Sustainable Agriculture

GEOCRI advocates the value of Earth observation data and information to support Food Security and Sustainable Agriculture in cold regions, particularly in order to adapt effectively to ongoing climate change. Environmental and climatic conditions often limit opportunities for agriculture in cold regions, but with Earth observations, yields can be sustainably increased and new opportunities established to improve food security for cold region populations. GEOCRI will collaborate closely with GEOGLAM to make progress in this SBA.

5.2.5 Infrastructure and Transportation Management

Due to environmental challenges, infrastructure and transportation are key issues in cold regions. Earth observations can inform the design, maintenance and management of all infrastructure and transport facilities including roads, energy networks, buildings and utilities. Earth observations can help address issues associated with cold regions, including infrastructure and transportation issues related to extreme temperature, permafrost and slope instability, and others.

5.2.6 Public Health Surveillance

GEOCRI advocates the value of Earth observations to support Public Health Surveillance, by yielding insight into the threat of vector-borne and environmentally-linked diseases in cold regions. Earth observations can help monitor environmental pollution and health risks, substantially reducing the number of fatalities and illnesses in cold regions. This is a particularly acute issue for Indigenous communities, of which there are many in cold regions, where poor health is often a greater problem than amongst the general population.

5.2.7 Sustainable Urban Development

Due to the sensitivity and fragility of polar and mountain environments and ecosystem, sustainable urban development is essential. Earth observations, coordinated by GEOCRI, can inform urban development decisions and monitor the impacts of urban areas throughout cold regions.

5.2.8 Water Resources Management

Cold regions include some of the most water stressed areas of the planet. GEOCRI is able to coordinate Earth observations to accurately inform water resources management to ensure sustainability for populations and ecosystems. Cold regions are a source of water essential to sustaining billions of people in other regions. This adds further importance to effective water resources management in cold regions, which can only be achieved with appropriate Earth observations.

GEOCRI complements and expands "The GEOSS Water Strategy: From Observations to Decisions" (GEO, 2014) by focusing on the availability and quality of water resources in fragile yet vital areas to water and food security.

5.3 GEOCRI and the 2030 Agenda for Sustainable Development

The United Nations' 2030 Agenda for Sustainable Development provides a universal development agenda for all countries and stakeholders to use as a blueprint of action for people, the planet and prosperity. The agenda is anchored by seventeen Sustainable Development Goals (SDGs), associated targets, and a global indicator framework. Collectively, these items assist countries and the global community to measure, manage, and monitor progress on economic, social and environmental sustainability. GEOCRI, in collaboration with GEO Initiative 18 (Earth Observations in Service of the 2030 Agenda for Sustainable Development), will organize and realize the potential of Earth observations to advance the 2030 Agenda and enable societal benefits through achievement of the SDGs throughout cold regions.

The 2030 Agenda and the SDGs are highly relevant to cold regions, particularly in developing Arctic and mountainous regions. GEOCRI is uniquely positioned to coordinate both in situ and remotely sensed Earth observations to track progress within the indicator framework towards achieving the SDGs in cold regions.

Earth observations in cold regions will not only be important for monitoring SDG progress, but also for actively achieving the SDGs, with data and information informing best approaches and identifying new sustainable development opportunities.

Due to the interconnectivity and trans-regional nature of sustainable development issues, as outlined in the context of the SBAs above, Earth observations in cold regions are important for realizing the 2030 Agenda and achieving the SDGs in all regions of the planet. Cold region Earth observations are essential for sustainable development everywhere, particularly with regard to issues surrounding water, food, health, climate, energy and biodiversity.

Further, SDG targets are also of concern to people living in cold regions and thus many indicators affect related countries and communities (Reference: UE Statistical Commission, "Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators", Economic and Social Council, E/CN.3/2016/2, March 2016,39 pp). The table below highlights some of the approved SDG indicators for which cold regions Earth observations will be essential for monitoring. GEOCRI will work to coordinate Earth observation efforts in cold regions to ensure effective tracking and monitoring of progress for these indicators and others.

	Indicators requiring cold region Earth observations
2.1.2	Prevalence of population with moderate or severe food insecurity, based on the Food Insecurity Experience Scale (FIES)
2.4.1*	Percentage of agricultural area under sustainable agricultural practices
2.5.2*	Percentage of local crops and breeds and their wild relatives, classified as being at risk, not-at-risk or unknown level of risk of extinction
6.3.1	Percentage of wastewater safely treated
6.3.2	Percentage of water bodies with good ambient water quality
6.4.1*	Percentage change in water use efficiency over time
6.4.2*	Percentage of total available water resources used, taking environmental water requirements into account (level of water stress)
6.6.1	Percentage of change in water-related ecosystems extent over time
9.1.1	Share of the rural population who live within 2 km of an all season road
9.4.1	CO2 emission per unit of value added
11.3.1	Ratio of land consumption rate to population growth rate
14.3.1	Average marine acidity (pH) measured at agreed suite of representative sampling stations

14.4.1*	Proportion of fish stocks within biologically sustainable levels.
15.1.1*	Forest area as a percentage of total land area
15.2.2	Net permanent forest loss
15.3.1*	Percentage of land that is degraded over total land area
15.5.1	Red List Index
*	*Denotes indicators which have not yet been formally agreed upon*

5.4 GEOCRI and the Paris Agreement

At COP 21 in Paris, Parties to the UNFCCC reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. It is for the first time – brings all nations into a common cause to undertake take ambitious efforts to combat climate change and adapt to its effects.

Earth cold regions are the most sensitive area to the global temperature changing, whose change is quite critical for the evaluation, and assessment of actions that made to Paris Agreement agenda. GEOCEI's contribution on the enhancing Earth observations, interconnect comparative schemes among Earth Poles provide a detailed and full picture of climate change and its adaption effective. The risk analysis can be made through the activities of GEOCRI contributors, and the importance of induced effect can be traced via the jointly action from the related GEO initiatives, like GI-05: Global Carbon Observation and Analysis System.

5.5 GEOCRI and the Sendai Framework for Disaster Risk Reduction 2015-2030

The GEOCRI covers plenty of the disasters, for example, avalanche, GLOF, flood, drought, extremely low temperature disaster, etc., that are the main influence to human kind. To support the post-2015 framework for disaster risk reduction that's adopted at the Third World Conference on Disaster Risk Reduction, GEOCRI communities could work with other initiatives to provide observations data and essential knowledge for mitigation and adaption. Further actions to meet the aim of the Sendai Framework are needed.

6. Partners

The following table lists the current GEOCRI Partners, whose status is expressed in relation to levels of involvement either as a contributor or an observer. The contributor are mainly those who could representation the national, regional or international program and projects, and provide contribution to the GEOCRI implementation directly. While, the observers are those who are kept informing, and providing guidance, resource and funder agency, such as governmental bodies, national and private foundation, and etc.

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6.2 Observers

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7	*To be added*	*GEO Initiatives (partnership)*			*TBD*

GEOCRI will also liaise and work in collaboration with other GEO initiatives, including GEOBON, GFOI, GECO, GEOGLOWS, GEO-GNOME, GSNL, Global Wildfire Information System, GEO-DARMA and GEOGLAM, and regional GEOSS, like AmeriGEOSS, EuroGEOSS, etc.

7. User engagement

Cold region Earth observation user communities include scientists, policy-makers, industry, business and commerce, students, and local communities. Earth observation data and information should meet the needs and requirements of these different user communities. GEOCRI User engagement will be done by utilizing several modalities ranging from face-to-face events and capacity building to on-line surveys and –ultimately- operational services developed in contact with the users.

The ESA – NRSCC / Dragon Program is entering its 4th cycle and started 1n 2004. The Hydrology and Cryosphere Theme focuses on the HMA region and involves about 100 potential users of GEOCRI information.

In 2017-2019, the first stage of activities by the User Engagement and Communication Task Team will include the identification of current and potential user communities, and their specific features, and consultation with these user communities about their needs and expectations on the content and modality of the information services that they would like GEOCRI to offer. The second stage will be planning, development and implementation of the services based on the user community identification and consultation. Continuous dialogue and engagement with the user communities is needed at all stages of GEOCRI activities.

GEOCRI benefits all stakeholders by supporting the provision of accurate and timely Earth observation data and information. As outlined in chapter 5, GEOCRI contributes to all eight GEO SBAs.

In addressing all eight of the GEO SBAs, GEOCRI's benefits are wide reaching with impacts in all domains as well as cross-cutting issues like climate change. Furthermore, GEOCRI, through its contributors, engages with a range of stakeholders, including scientists, policymakers, local communities and businesses. Close stakeholder engagement will ensure that GEOCRI works to effectively address user needs and requirements to maximize benefit.

Examples of expected benefits to stakeholders include improved mitigation of the local inhabitants to the climate change effects, improved climate-change related decision making at national, regional, international and global level, more efficient use of research infrastructures in cold regions, and improved open data availability of cold regions related Earth observations.

By leveraging the global visibility and convening power of GEO, GEOCRI makes a positive contribution to national, regional and international decision-making processes and science strategies. GEOCRI, via its contributors, feeds reliable, science-based Earth observation data and information to policy makers, enabling better, well-informed and more effective decisions in cold regions and beyond.

8. Data policy & management

GEO has been a leader in the development of data sharing principles and this has, in turn, provided an excellent foundation for governments, institutions, researchers and others to develop sound data policy. At the same time, polar organizations have been actively developing data statements and policy to help guide the collection, use, stewardship and preservation of data. For example, in 2013 the International Arctic Science Committee released the IASC Data Statement (see http://iasc.info/data-observations/iasc-data-statement). This statement makes assertions about the value of open data, the need to provide fair attribution for data creation, and the value of professional data management. This statement references several other established data statements and policies from the WMO, and ICSU, and we have seen recent developments from ICSU and others in this area (http://www.icsu.org/news-centre/press-releases/press-releases-2015/leading-science-groups-urge-global-accord-on-open-data-in-a-big-data-world,https://www.force11.org/group/joint-declaration-data-citation-principles-final).

Many data statements and policies in existence provide data producers and users with extensive choice, however this can also make it difficult for members of the community to know which statement or principle is most relevant and appropriate for their needs. GEO and GEOCRI are in an ideal position to make a contribution through the analysis of these statements and policies with the goal of identify core elements that are common to all. This would help the community to evaluate if they need to develop new policies or if an existing policy/statement can be adopted. Additionally, this would support members of the community in establishing if their data policies contain necessary elements and will be compatible with other policies. The results of this effort can effectively be used as a policy broker with the GEO DAB and other system. A task has been added to the Tasks list in this document with the intention of working with the broader GEO community on this effort.

The use of GEOSS resources will be advocated both within the GEOCRI and to the identified key Earth observation user communities. The dialogue will be two-directional in a manner that encourages both the use of the GEOSS resources and provision of new resources to GEOSS.

The first stage is to integrate the existing cold regions datasets, products and services to the GCI via the GEO Discovery and Access Broker (GEO DAB) and GEOSS Data-CORE. The work in this field is led by the Data Task Team that will identify and approach the relevant data producers and facilitate the integration by provision of information and training. In the second stage, new datasets, products or services within GEOCRI community will be developed and integrated with the GCI and/or GEOSS Data-CORE.

GEO's advocating of broad open data policies and data sharing principles is replicated by GEOCRI as well as its contributors and community. GEOCRI shares knowledge, best practices and training to build capacity in this area.

A broad integration and comparison of exiting data principle and policy from different communities, for example, SAON, GEOSS, SOOS, etc., are encouraged to be bridged together, also with the effort from the communities of CODATA and WDS.

9. Management arrangements, monitoring and evaluation approach and reporting

9.1 Management

The management structure for GEOCRI is presented in the Figure 2.

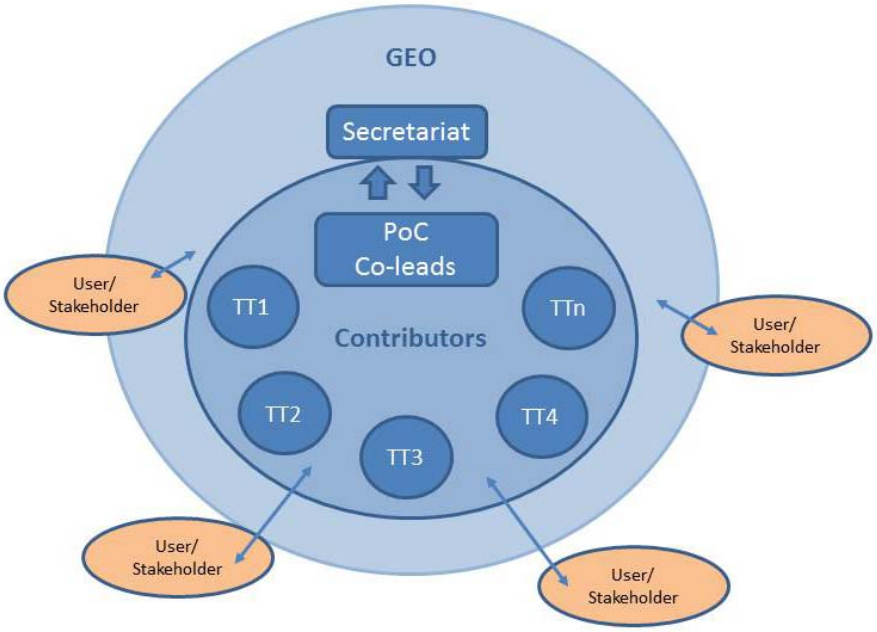

Figure 2 GEOCRI Management Structure

The GEOCRI community consists of contributors that are arranged into theme-specific Task Teams according to their interests. Each Task Team has a list of activities that they work on, and report their progress to the team of co-leads, consisting of eight GEOCRI members and the Point of Contact (Yubao Qiu). The co-lead team works together with the GEO Secretariat in producing the Implementation Plan and the Work Plan for the GEO Work Programme, and offer over all coordination of GEOCRI activities and efforts.

Task Teams convene when necessary, whereas the co-lead team convenes at least twice a year. All GEOCRI members are kept informed about the progress via summaries provided through an e-mailing list and by arranging face-to-face meeting where possible (e.g. as side events to GEO meetings and at major scientific conferences).

All GEOCRI contributors have a possibility to contribute to the work and implementation plans, and take part in those Task Teams where they find their contribution is most suitable.

In addition, an institution can join GEOCRI as an Observer, which means that they will be updated about the progress and activities, without not directly taking part in the activities.

A Scientific Advisory Committee, consisting of high-profile scientists will be convened in late 2016-early 2017. The group will convene when necessary to provide advice on the GEOCRI activities. Terms of Reference will be developed in 2017 to verify the management and coordination structure of GEOCRI.

Advisory Committee

The Advisory Committee is GEOCRI's counselling and recommendation body. It shares its vision and user's requirement with the GEO Plenary. It is made up of stakeholders, including the governors, end-users, and policy makers from the members and Participating Organizations.

9.2 Monitoring and evaluation

The GEOCRI progress will be monitored by the GEO Program Board. The progress will also be monitored internally by collection of feedback from the GEOCRI community at regular time intervals.

9.3 Reporting

Reporting on GEOCRI will be done via progress reports of the Task Teams to co-leads and short summaries of the recent developments, presented to all contributors. Also, necessary reporting of the activities and plans – e.g. the implementation and work plan – will be provided to the GEO Secretariat and **Program Board**, then to the **GEO ExCOM** and **Plenary**. Summaries of GEOCRI activities and achievements will also be provided to the observers and stakeholders to keep them updated on the progress.

10. Committed Resources and annual budget(s)

GEOCRI's resources are predominantly in kind efforts, and are aimed at leveraging the resources of participating initiatives and organizations to align with GEOCRI's objectives. Here is the list of actions and funding that could report to GEOCRI or fill the gaps described in section 2 at 2017 and later on (need further categorizing work in next two month).

- The Global Cryosphere Watch (**GCW**) will held its second Asia CryoNet meeting in February 2016 in Salekhard, Russian Federation. The goal was to further develop further CryoNet in the Region and identify best practices used for observing.
- **SAON** will continue to work with these contributions: Documenting and understanding the Arctic data management ecosystem; Identifying and promoting common metadata elements; Engaging in data citation and publication movement; Promoting interoperability through action - interoperability experiment; Inventory of arctic observational projects as a contribution to EU PolarNet; Community Based Monitorin (CBM) atlas.
- **CAFF/CBMP:** Continues to develop and maintain the Arctic Biodiversity Data Service (ABDS) as the supporting framework to facilitate long-term biodiversity data sharing and as a source of data for ecosystem-based management. This includes a focus on interoperability with partners such as GBIF, OBIS and PDC.
- **INTERACT** continues building capacity for research and in-situ observations throughout its pan-arctic station network, and bridging of the in-situ and remote sensing communities via joint activities and events. Open access to metadata and data and will be advocated in the station network, as well as efforts to connect open access metadata and data with global data portals such as the GEOSS Data-CORE. Collaboration with arctic and polar scientific organizations and input to strategic and scientific assessments continues. Outreach activities to inform policy makers, other stakeholders and the general public will be continued in various forms. (in-kind, national and international resources for 2016 to be identified later in 2015)
- **PEEX** will launch a comprehensive PEEX metadata collection and build a Modelling Demo ("PEEX View") through the implementation of PEEX, and the 3rd PEEX science meeting will be in MOSCOW.

- **SIOS** Implementation phase will become a full-fledged activity during 2016 with the establishment of the knowledge centre in Longyearbyen supported by Norway and several nations in the SIOS consortium. 2016 activities will focus on establishing an open access data portal, access and logistics program and identifying pilot projects for filling gaps in data acquisition for the Svalbard archipelago. (In kind and international resources for 2016 to be identified; Norway will contribute at least 1 000 000 EUR, Italy to CCT-IP: 100, 000 Euro).
- **IADC** (Italian Arctic Data Centre) will be implemented as the portal of the Italian research activities in the Arctic. In the frame of the Antarctic Research National Programme (PNRA) a distributed cyber-infrastructure (National Antarctic Data Center- NDAC) will also be developed. Both actions, based on the brokering approach will be integrated in a unique Polar Data Infrastructure (PDI) (Euro: 200.000).
- Establish flagship stations within the **Third Pole** region for observation and monitoring; (US Dollars : $200,000),Set up rain gauge along the altitudinal range from 2000 m to 6500 m in a river basin of the Tibetan Plateau, and to obtain the elevation-dependent precipitation data.
- Snow Observations over Tibetan Plateau (**SOTP**) will continue to explore the remote sensing snow cover products over Tibetan Plateau, with in-kind and somehow $120,000 support from NSFC.
- **ESA – MOST Dragon 4** Hydrology and Cryosphere Theme: It is expected that the current 10 projects under Dragon 3 will be clustered and continue through fewer but larger projects. As in Dragon 3, ESA is expected to provide limited support towards PhD / postdoc work under selected research projects. MOST / NRSCC supports Dragon projects through open Call for Proposals. Total resources committed to selected projects approximately estimated at 2 106 € over the period 2016~2020.
- CNR through Climate Change Integrated Project (**CCT-IP**) will continue to promote the upgrading of Ny Alesund as observation super-site in the Arctic (Euro: 100.000).
- A Chinese cubesat named **TW-1A** aiming for polar sea ice observation is scheduled to launch in October, 2015 and will provide satellite observations from December of 2015 in both Polar Regions. This satellite is proposed by Beijing Normal University and developed by Chinese Academy of Sciences.
- The observations by the intended **Chinese Water Cycle Mission (WCOM)** with a dual frequency dual polarized microwave radiometer would fill a gap in current European observations and would be highly relevant to monitoring of water resources. The mission will provide observations of SWE, precipitation and soil moisture.($1.5M).
- Cryosphere Monitoring Programme (**CMP**) will continue to explore the snow, glacier, glacial lake and GLOF over Nepal. This program is extended to Bhutan and Pakistan with support from The Norwegian Ministry of Foreign Affairs ($700,000).
- Through the Belmont Forum Initiatives Italy contributes to Cooperative Research Activities (**CRA**) of the Arctic Observing and Research for Sustainability and of the Mountains as Sentinels of Change. (Euro : 200.000).
- Japan Agency for Marine-Earth Science and Technology (JAMSTEC), National Institute of Polar Research (NIPR) and Hokkaido University will jointly conduct observations of ocean, land and atmosphere in the Arctic region and continue to promote Arctic Data Archive System (**ADS**), which will is a part of GEOSS Portal, along with the framework of the "Arctic Challenge for Sustainability Projects (ArCS)" supported by MEXT.
- The "Modelling Freeze-Thaw Processes with Active and Passive Microwave Observations" (SAMP Freeze/Thaw) project supported by the Netherlands Organisation for Scientific Research.
- Harmonizing and collecting observations in Greenland and surrounding waters by Denmark;
- The Year of Polar Prediction (**YOPP**) is a key element of the WMO-WWRP Polar Prediction Project (PPP). The YOPP mission is to enable a significant improvement in environmental prediction capabilities for the Polar Regions and beyond, by coordinating a period of intensive observing, modelling, prediction, verification, user-engagement and education activities. Of

particular relevance to GEOCRI are the additional polar observations to be taken during the YOPP Core Phase (mid-2017 to mid-2019). The data strategy of YOPP includes in particular the establishment of a YOPP data portal, building on the experience of the GCW data portal.

- Cold and Arid Regions Science Data center at Lanzhou, China (CARD), World Data System (WDS) is jointly supported by Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI), CAS, WDS, and NSFC projects to continue promote the data management, data share specifically for in Cold and Arid regions in China.
- TPE will be engaged in the acquisition of valuable field data to share with the general academic community for enhancement of scientific understanding in the region. A data portal (http://en.tpedatabase.cn/) has already been built by TPE on open-source components and will use international standards and protocols for metadata and data. All post in-situ data, modeling results etc. will be published in open, peer-reviewed literature and under existing requirements for data availability. Clearly, an integration of field monitoring and in situ measurement with modeling is essential to achieve a more complete understanding of environmental processes over the Third Pole region.
- TPE has established some long-term fixed-site observation and monitoring stations within the Third Pole region and will establish more for comprehensive study and a more complete understanding of the regional environments. Establishment of Flagship Stations will be one of the long-term goals of TPE.
- A series of intensive science and technology training workshops focused on the Third Pole Environment are planned by the TPE program for young scientists and technicians who work or study in distinguished universities or research institutes in the region. The training will include both scientific seminars given by invited experts on glaciology, hydrology, biology, atmospheric etc as well as hands on field courses.
- TPE will seek to provide data, expertise and/or advice on regional sustainability, and where applicable to social, economic, and most importantly, scientific issues. TPE scientific research will be fact-based, peer-reviewed and scientifically sound and widely available for the public and policy makers within relevant countries.
- The Barcelona Expert Center (BEC) at ICM-CSIC will contribute to provide remote sensing observations of Sea Surface Salinity at high latitudes. Arctic sea ice concentration, and sea ice thickness from the ESA SMOS mission through a data server. Additionally we will provide data from several high precision GPS buoys (SATICE) deployed in the Arctic, through a dedicated data server (http://satice.icm.csic.es/)
- Pollution & Environmental Protection: GMOS is a unique observational programme for mercury and it is the focus of one of the proposed flagship on persistent pollutants. Master sites of GMOS are in both Polar Regions, Arctic and Antarctica and provide key information on the cycle of this highly toxic pollutants in cold regions. This Flagship has a strong policy mandate from both Minamata and Stockholm conventions. The close cooperation with the Flagship on "Tracking Persistent Pollutants" would be beneficial for GEO.
- JAMSTEC will conduct hydrographic observation in the Arctic ocean for coming several years, and will provide data through the web (ADS, JAMSTEC site).

11. Transition to operational phase

GEOCRI was initiated the GEO Plenary in Nov 2015 and since then significant development has been done to organize the activities and make plans for the work programme 2017-2019. In 2016, most of the planned activities have proceeded, and GEOCRI for example published a statement in AOS2016 and was co-authoring a peer-reviewed scientific publication about snow cover changes and its consequences in the Arctic. GEOCRI is now proceeding to implementation

stage and the tasks and activities conducted in 2017-2019 will lay the basis for transitioning to operational phase with services to users during the 2020-2022 work programme.

Majority of the milestones and deliverables of the 2017-2019 implementation plan are set to the two first years of the programme period in order to add new milestones and deliverables, geared towards the transition from implementation to operational stage starting in 2019 and during the next work programme period 2020 onwards.

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ANNEXES

Technical Annex

Acronyms and Abbreviations

AAD	Australian Antarctic Division
AARI	Arctic and Antarctic Research Institute
AC	Arctic Council
ACAP	Arctic Contaminants Action Program, AC Working Group
ACAP	Arctic Contaminants Action Programme, AC Working Group
ADS	Arctic Data archive System
AH	Arctic Health
AI	The Arctic Institute
AMAP	Arctic Monitoring and Assessment Programme, AC Working Group
AntarcticaNZ	Antarctica New Zealand
AntON	Antarctic Observing Network
AP	Arctic Portal
APECS	Association of Polar Early Career Scientists
Arctic BON	Arctic Biodiversity Observation Network
AUV	Autonomous Underwater Vehicle
AWI	Alfred Wegener Institute
BAI	Bulgarian Antarctic Institute
BAS	British Antarctic Survey
CAFF	Conservation of Arctic Flora and Fauna, AC Working Group
CAREERI, CAS	Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Science
CAS-NASA HMA	Chinese Academy of Science - National Aeronautics and Space Administration High Mountain Asia Workshops
CBMP	Circumpolar Biodiversity Monitoring Program
CCIN	Canadian Cryospheric Information Network
C-DAC	Centre for Development of Advanced Computing
CliC	Climate and Cryosphere
COMNAP	Council of Managers of National Antarctic Programs
CMA	China Metrological Administrator
CNR-IIA	Institute of Atmospheric Pollution Research
CSIC	Spanish National Research Council
DRAGON	ESA – NRSCC Program / Hydrology and Cryosphere Theme
DMI	Danish Metrological Institute
EC-PHORS	WMO Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services
EPPR	Emergency Prevention, Preparedness and Response, AC Working Group

ESA	European Space Agency
FIES	Food Insecurity Experience Scale
GCI	GEOSS Common Infrastructure
GCW	Global Cryosphere Watch
GECO	GEO Global Ecosystem Initiative
GEO	Group on Earth Observations
GEO DAB	GEO Discovery and Access Broker
GEOBON	GEO Biodiversity Observation Network
GEOCRI	GEO Cold Regions Initiative
GEO-DARMA	GEO Data Access for Risk Management
GEOGLAM	GEO Global Argicultural Monitoring Initiative
GEOGLOWS	GEO Global Water Sustainability
GEO-GNOME	GEO Global Network for Observation and Information in Mountain Environments
GEOSS	Global Earth Observation System of Systems
GEOSS Data-CORE	GEOSS Data Collection of Open Resources for Everyone
GEUS	Geological Survey of Denmark and Greenland
GFOI	GEO Global Forest Observations Initiative
GINR	Greenland Institute of Natural Resources
GLISN	Greenland Ice Sheet Monitoring Network
GLMS	Glacier Lake Monitoring System
GLOF	Glacial Lake Outburst Flood
GMOS	Global Mercury Observation System
GSNL	GEO Geohazard Supersites and Natural Laboratories
GTN-P	Global Terrestrial Network for Permafrost
H2020	Horizon 2020
HKKH	Hindu Kush –Karakoram– Himalayas
HRCF	Himalayan Research and Cultural Foundation
IASC	International Arctic Science Committee
ICARP III	The Third International Conference on Arctic Research Planning
ICIMOD	International Centre for Integrated Mountain Development
INTERACT	International Network for Terrestrial Research and Monitoring in the Arctic
IPA	International Permafrost Association
IPCC	Intergovernmental Panel on Climate Change
IREA-CNR	Institute for Electromagnetic Sensing of Environment
ISAC-CNR	Institute of Atmospheric Science and Climate
ISRO-SAC	Indian Space Research Organization – Space Application Center
ISDE	International Society for Digital Earth
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
NERSC	Nansen Environmental and Remote Sensing Center
NIPR	National Institute of Polar Research
NSC	Norway Space Centre

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PAME	Protection of the Arctic Marine Environment
PDC	Polar Data Catalogue
PEEX	Pan-Eurasian Experiment Program
PPP	Polar Prediction Program
PRCC	Polar Regional Climate Centre
RADI, CAS	Institute of Remote Sensing and Digital Earth, Chinese Academic of Science
S:GLA:MO	Slope Stability and Glacial Lake Monitoring
SAON	Sustaining Arctic Observing Networks
SBA	GEO Societal Benefit Area
SCAR	Scientific Committee on Antarctic Research
SDG	Sustainable Development Goal
SDWG	Sustainable Development Working Group, AC Working Group
SIOS	Svalbard Integrated Arctic Earth Observing System
SOOS	Southern Ocean Observing System
SOTP	Snow Observations over Tibetan Plateau
TPE	Third Pole Environment
UArctic	University of the Arctic
UAV	Ünmanned Aerial Vehicle
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USAP	United Stated Antarctic Program
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
YOPP	Year of Polar Prediction