



HORIZON 2020 - Coordination and Support Action

Grant Agreement No: 101003766



**EU-PolarNet 2 - Co-ordinating and Co-designing the
European Polar Research Area**

Deliverable No. 6.7

**White paper with recommendations to
accelerate the development of a sustained and
fully integrated Polar observing system**

Submission of Deliverable

Document information	
Work Package	WP6 European Polar Coordination Office
Deliverable No	D6.7
Deliverable title	White paper with recommendations to accelerate the development of a sustained and fully integrated Polar observing system
Version	Final
Dissemination level	<input checked="" type="checkbox"/> PU - Public <input type="checkbox"/> PP - Restricted to programme partners <input type="checkbox"/> RE - Restricted to a group specified by the consortium <input type="checkbox"/> CO - Confidential, only for members of the consortium
Lead Beneficiary	BELSPO (partner 15)
Contributors	<input type="checkbox"/> 1 – AWI, <input type="checkbox"/> 2 – MICINN, <input checked="" type="checkbox"/> 3 – UOULU, <input type="checkbox"/> 4 – ISP-CNR, <input type="checkbox"/> 5 – RCN, <input type="checkbox"/> 6 – EPB, <input checked="" type="checkbox"/> 7 - NWO, <input type="checkbox"/> 8 – DAFSHE, <input type="checkbox"/> 9 - CNRS, <input type="checkbox"/> 10 – UoS-CPS, <input type="checkbox"/> 11 – BAI, <input type="checkbox"/> 12 – UNIVIE, <input type="checkbox"/> 13 –IG-TUT, <input type="checkbox"/> 14 – WOC Europe, <input checked="" type="checkbox"/> 15 – BELSPO, <input checked="" type="checkbox"/> 16 – AMAP, <input type="checkbox"/> 17 – IGOT UL, <input type="checkbox"/> 18 - SPRS, <input type="checkbox"/> 19 – UKRI-BAS, <input type="checkbox"/> 20 – ITU, <input type="checkbox"/> 21 – USB, <input type="checkbox"/> 22 – RANNIS, <input type="checkbox"/> 23 – FAMRI, <input type="checkbox"/> 24 – ICR, <input type="checkbox"/> 25 – SPI
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Due date	29.02.2024
Delivery date	25.03.2024

Document history	
Creation Date	
Revision	V2
Revision Date	22 March 2024
Author	AWI
Status	<input type="checkbox"/> Draft <input checked="" type="checkbox"/> WP lead approved <input checked="" type="checkbox"/> Coordinator approved <input checked="" type="checkbox"/> Executive Board approved
Status date	22 March 2024



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003766

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PUBLISHABLE SUMMARY

Global climate change is rapidly intensifying, but nowhere are these changes more pronounced than in the polar regions. Yet polar observations remain sparse, with fragmented observing networks lacking large-scale coordination. Increased cooperation in observing the polar regions would create a coordinated system for sustainable and inclusive, standardised data and transnational polar observation, supporting research actions of high societal relevance and well-informed decision-making processes.

This EU-PolarNet 2 White Paper provides more than 80 actionable policy-level recommendations within seven pillars, to strengthen international collaboration in polar observation and facilitate transfer of knowledge between the Arctic and the Antarctic. The recommendations seek to consolidate existing initiatives, integrate infrastructures and funding mechanisms to enhance collective comprehension of polar environmental changes. Collaboration between EU (European Union) Member States and non-EU Arctic and Antarctic countries is recommended to address climate change threats and to encourage unity among nations in polar observation.

The recommendations will benefit people, research, environmental policies and businesses beyond the polar regions. Implementation of the recommendations should start immediately, adjusting step by step the levels of collaboration within each pillar.

1 Motivation and Background

Human societies are highly dependent on Earth's climate, with even minor changes having major implications for our livelihoods. The two polar regions are the regions that currently experience the fastest changes related to the climate crisis (Casado et al., 2023; Rantanen et al., 2022; Willis et al., 2023): Pollution levels are rising, accompanied by a dramatic decline in biodiversity. Instances of heavy rainfalls, floods, high winds, and storms are becoming increasingly frequent, while the reliability of snow and ice conditions has diminished. In summer 2023, Antarctic sea ice has declined at a rate never observed since the beginning of satellite records in the 1970s (Copernicus.eu/sea-ice-cover-2023).

Changes occurring in the polar regions significantly influence global climate patterns through a range of natural feedback mechanisms that remain to be fully understood. Our understanding of the whole breadth of climate-related changes is incomplete, as is our understanding of the "tipping points", beyond which the observed changes in the earth system may become irreversible (Armstrong *et al.*, 2022). There is a crucial need to enhance and integrate observation methods to advance scientific knowledge of polar evolution (Arctic Science Ministerial, 2021).

At the same time, there are needs to enhance inclusivity in polar science and develop collaborative models that address societal needs. Significant changes are already affecting polar environments, endangering the cultures, ways of life and livelihood of local and Indigenous Peoples. Strengthening collaboration for observing polar regions (Textbox 1) necessitates the inclusion of local communities and Indigenous Peoples in decisions making processes. It will support a much-needed alignment between funding, observations, data collection, research and human society: "A green shift is needed but it must be just and fair and it cannot be based on colonialist practices" (Saami Council conference declaration, 2022).

Textbox 1: Integrated Polar observing system - Brief definition - See section 4

- Enhanced collaboration for polar observation is called for by the rights holders, and by the international-scientific, -stakeholders, -civil societies, and -funders communities.
- Objectives will be to collaborate on a range of scientific aspects (e.g., data, research, funding strategies, infrastructures) for both polar regions, fostering collaboration among international communities engaged in polar regions. Eventually, the aim will be to link, align and integrate observing and data system requirements where feasible and make them serve societal needs, to best inform decision-making processes.
- The actionable recommendations provided in this white paper aim to develop collaboration for observing polar regions. It will require political and funding commitments to implement the recommendations. Collaborations should be developed where there are natural common interests between the poles, while remaining aspects may continue to be managed and developed within their respective regions.

The primary objective of this white paper is to provide recommendations aimed at strengthening collaboration for observing polar regions by bringing existing polar initiatives and their best assets together, to build on their respective strengths, expertise, experience, knowledge, and networks. Strengthening collaboration for observing polar regions will provide sustainable support for long-term data collection and monitoring. It will facilitate the integration of expertise, infrastructures, and fundings available for each polar region, while aligning with societal needs. It will enhance polar knowledge- and scientific bases to support a better understanding of polar environmental changes and optimally advise decision-making processes. Investing in such a collaboration holds significant potential for economic returns for the EU, potentially exceeding at least 50% of annual investments. This return on investment could be realised through ecosystem preservation, safeguarding human

health and lives, and reducing pollution and economic losses (Dobricic *et al.*, 2018). Moreover, strengthening collaboration presents a unique opportunity for the EU to lead multidisciplinary scientific efforts in the polar regions at the international level. By rallying nations around the flags of polar research and the International Polar Year 2032/2033, the EU can enhance international collaboration and diplomacy to address global threats posed by climate change and promote a more inclusive society.

This white paper presents an overview of current initiatives and gaps of polar observation and provides actionable policy-level recommendations to accelerate and advance collaboration for observing polar regions. The recommendations, primarily intended for decision-makers, were gathered from a diverse range of experts and stakeholders (Section 4 and Annexes 1 & 2). The recommendations particularly focus on addressing user needs, including those of local and indigenous communities, on improving data systems, advancing infrastructures and technology, enhancing funding cooperation, refining governance, fostering international collaboration in research, and emphasising societal relevance.

For each identified topic, or “pillar”, risks and benefits are outlined (Section 4), alongside a discussion on areas and levels of integration. Actionable recommendations for each pillar are formulated in Section 5, with additional recommendations tailored specifically for EU decision makers in section 6.



Polar spotlight. K. Roef

2 Societal Challenges

2.1 Climate emergency



Breaking ice. R. Badhe

The World Meteorological Organisation (WMO) reported that 2023 was officially the hottest year ever recorded ([WOM.int/climate-change-record-2023](https://www.wmo.int/climate-change-record-2023)). There might be no summer sea ice in the Arctic by 2030 (Kim et al., 2023), which would be unprecedented in ~6000 years; at that time agriculture had just been invented and was spreading around the world. United Nations Secretary-General declared that the planet is “on the brink” ([UNwebtv.org](https://www.unwebtv.org)), and scientists and citizens worldwide raise alarm and urge nations and international institutions to take actions and honour the engagements taken under the Conference of the Parties (COP)21 Paris agreements (signed by all 27 EU countries).

The Arctic has warmed almost four times faster than the rest of the world (Rantanen et al., 2022), while warming and melting in Antarctica are underestimated due to the lack of instrumental data (Casado et al., 2023). Climate changes pose significant risks of intensification and could trigger changes across the entire planet, with profound impacts on lives and livelihoods (Textbox 2). The most alarming effects of polar changes on climate and society include: reduction in sea ice, global sea level rise, increasing freshwater flow changing marine waters and oceanic circulations, degradation of permafrost and terrestrial habitats, increasing frequency and intensified wildfires, and increasing air pollution. Coastal communities, ecosystems and environments, vital infrastructures and major capital assets across the globe are under threat from the ongoing climate changes.

Textbox 2: Our changing home

Arctic Indigenous Peoples are seeing their lives and traditions altered by climate change.

Testimony from Chief Bill Erasmus - Reykjavik Ministerial statement: “We are especially concerned about the climate crisis that affects us globally. It is obvious with the forest fires, flooding, melting permafrost and ice, and the low number of caribou to rely on for sustenance.” Read more personal stories from direct witnesses of climate change here: [Arctic-council/our-changing-home](https://arctic-council.org/our-changing-home)

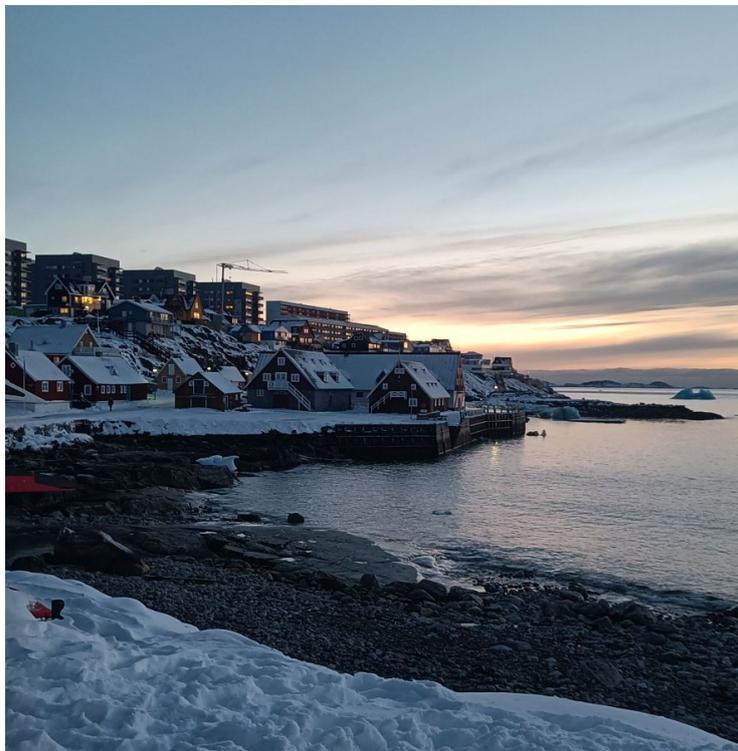
2.2 Preserving polar life

2.2.1 Polar communities

In Antarctica, there are no permanent residents or states, and the polar community is primarily focused on scientific activities, tourism, and fishing industry.



Antarctica, Halley VI British Research Station back covered with Aurora. M. Krzysztofowicz



Arctic, Nuuk, Capital City of Greenland. K. Latola

Conversely, the Arctic has been inhabited for probably 10.000 years, and is today the home to almost four million people across eight states: Canada, Denmark (with Greenland having self-rule under Denmark), Finland, Iceland, Norway, the United States, Russia, and Sweden. Arctic inhabitants constitute a broad variety of Polar rights holders and stakeholders, including local and Indigenous

communities, and other stakeholder groups such as industry and tourism. Local people and Indigenous Peoples in the polar regions have developed deep knowledge and expertise to adapt and live in extreme and changing environments, rooted in their profound connection to the lands and waters of the North (Textbox 3). Indigenous and local activities in the polar regions typically include travelling on ice, reindeer herding, hunting and fishing, harvesting, and crafting. Indigenous ways of life include practising and developing Indigenous language and culture and work as a circular governance system that prioritises sustainably care of the environment rather than dominating it.

Textbox 3: Indigenous knowledge ([Knowledge \(arcticcentre.org\)](https://www.knowledge.arcticcentre.org/))

Indigenous knowledge encompasses the knowledge and practices of Indigenous and local communities, passed down through generations via oral traditions, rituals, songs, and laws. It is dynamic and often the sole repository of historical environmental data in remote Arctic regions. This invaluable resource not only informs traditional ways of life but can also serve as a rich source of data for scientific programs. This white paper recommends taking Indigenous knowledge into account and include Indigenous Peoples in future European polar scientific initiatives.

Textbox 4: Dialogue with Indigenous communities and stakeholders

Definitions: Stakeholders and Rights Holders

Stakeholders encompass those potentially affected by, interested in, or influential over the polar research agenda, including public and private sectors, governmental and non-governmental organisations (NGOs), and broader society, including local non-Indigenous peoples. An inclusive polar observing system necessitates co-design with local stakeholders and Indigenous communities, recognised as rights holders. Topic identification and observation planning should occur through open dialogue and common planification, addressing the needs of both rights holders and stakeholders.

Recommendations for successful dialogue with stakeholders and rights holders

- 1 & 2.** Trust building & on-going dialogue: Take the required time to work together with local rights holders to establish mutual trust and cooperation.
- 3.** Time and funding: Equitably compensate stakeholders and rights holders for their contributions.
- 4.** Stakeholder Representation and Diversity: Adapt engagement strategies to accommodate the diverse nature of stakeholders.
- 5.** Active Participation: Involve stakeholders and rights holders directly in the project, asking their preferred level of engagement.
- 6.** Societally Relevant Research Questions: Engage with stakeholders and rights holders to identify research questions that address societal needs.
- 7.** Knowledge sharing: Avoid scientific terms and use various communication methods: Written text, films, drawings, workshops, and community events.
- 8.** Engagement via intermediaries: Work with intermediaries who represent stakeholders and rights holders or function as liaisons to the project.

This textbox is based on Latola *et al.* (2020). EU-PolarNet 2 is developing a “Stakeholder Involvement Tool”, which will provide best practices and guidelines for dialogue with rights holders and stakeholder. Once developed, this tool will be available via the Catalyst Platform and the European Polar Coordination Office’s website (Autumn 2024).

In recent decades, increasing political, economic, and social interests in the polar regions have intensified pressure on these areas, with states expressing interest in exploiting resources and developing polar business such as mining, oil and gas extraction, establishing shipping routes, and industrial fishing. While one may consider climate driven changes as a source of new economic opportunities, there is no room for repeating mistakes from the past. The industrialisation of polar

regions, particularly with fossil fuel industries, may prioritise short-term profit over long-term sustainability. In this context, strengthening collaboration for observing polar regions can serve as a powerful tool to establish dialogues with local communities to ensure sustainable polar development (Textbox 4).

2.2.2 Biodiversity

Polar bears, penguins, arctic wolves and foxes, and whales, are iconic representatives of polar biodiversity. Antarctica hosts over 48.000 recorded species (Wauchope *et al.*, 2019), while more than 21.000 species are known in the Arctic ([Arctic-council/biodiversity](#)). The polar regions are home for cold-adapted marine, freshwater and terrestrial mammals, birds, fish, invertebrates, plants, fungi, and microbe species.

Rapidly changing environments pose a significant threat to polar biodiversity, with organisms facing challenges of adaptation, migration, or extinction (Wilmotte *et al.*, 2019). While polar species are adapted to cold environments, now that polar regions warm up, they simply cannot migrate to colder places on Earth. Moreover, invasive species from warmer areas becoming too hot to live in are now migrating to polar habitats. As a result, polar biodiversity is already drastically declining (CAFF, 2021), with further migrations and losses expected due to ongoing global climate change.



Group of penguins on rocks. R. Bahde

3 Existing initiatives

3.1 State of the art of current polar initiatives

The EU-PolarNet consortium Deliverable (D) 2.3 (2016) lists 670 polar monitoring/observational programmes, while EU-PolarNet 2 consortium D6.1 (2022) offers a comprehensive list of existing polar observing assets. Annex 3 provides the latest ongoing polar initiatives, while Annex 4 contains a provisional mapping of Arctic and Antarctic initiatives. Some of these have developed relationships, for example between the Arctic Council and its various working groups (see *Intergovernmental*

Organisations in Annex 3). Despite six integrated observing systems being listed (4 in the Arctic and 2 in the Antarctic), most initiatives do not directly aim towards integration of observations and convergence of efforts.

Various legislations and initiatives encourage EU Member States to develop monitoring and observing programs, including those for polar regions. Annex 3 contains a non-exhaustive list of these legislations, while Elshout *et al.* (2023) provide a synthesis of legal frameworks concerning polar environmental regulations.



Polar scientific cruise, crew on the deck. M. Meredith

3.2 Gaps in polar observations strategies

Polar observations are currently sparse, with observing networks fragmented and lacking large-scale coordination. Consultations of existing polar observing initiatives have revealed fundamental gaps in observation strategies at the national, EU, and international levels (see Textbox 5).

Textbox 5: Roadmaps for strengthening polar observing

Scientific polar observation is a critical societal necessity. A well-resourced, comprehensive effort is required to assess strengths and gaps in existing initiatives, sensors, networks, infrastructures, and surveys. Initiatives like the work by Sustaining Arctic Observing Networks (SAON) on Arctic inventory and gap analysis ([SAON/CONInventoryWork](#)) and efforts such as the Southern Ocean Action Plan (SOAP, [Sodecade.org](#)) to enhance links between science, industry, and policy, are encouraged to inform scientific and policy strategies effectively. Establishing a knowledge map linking polar observations to societal benefits can serve as a fundamental tool to guide new observations, address data management needs, and develop products and services.

Major gaps in polar observations and modelling are outlined in the EU-PolarNet consortium D2.5 (2018), emphasising the underrepresentation of the Antarctic (25% of all programs) and the limited integration of observing programs (only 2% involve both polar regions). Key gaps include:

Prospect for improvement of climate system understanding: Uncertainties remain regarding the effects of polar climate changes and “tipping points” on global climate and ecosystems. Improved integration of the interactions between natural physical processes (e.g., between rainfall, salinity, and thickness of sea-ice) in earth system models is crucial.

Prospect to improve long-term funding: Most funding is research-based and/or short-term, although there is a strong need for securing long-term, sustainable, funding sources for enhanced basic observations, monitoring, and technological advancement, shifting towards operationalisation of observing networks and systems.

Prospect for data harmonisation, standardisation, and best practices: Variable data collection and management hinder collaboration and interoperability among institutions.

Prospect for international collaboration: Scientific activities are often fragmented and individually initiated. There is opportunity for the EU to participate more as a whole in international polar collaboration, with opportunities for large-scale collaboration programs.

Prospect for prioritisation in observation & research: Definition of key variables (Textbox 6; Starkweather *et al.*, 2021) and improved coordination between observation, research, policy, and funding are necessary for meeting societal needs and supporting trans-disciplinary integration.

Prospect to include Indigenous Peoples and local communities: Equitable participation and leadership of Indigenous Peoples are lacking (Saami Council conference declarations, 2022), hindering acknowledgment of their rights and knowledge in their own homeland. Better collaboration with countries of the Southern Hemisphere is also vital for Antarctic projects.

Prospect for integrating observations from both polar regions: There are opportunities to link the initiatives that are currently either dedicated to the Arctic or to the Antarctic, and to enhance collaboration and share expertise between the polar regions.

Prospect for economic benefits: Strengthening collaboration for polar observation yields significant economic benefits, outweighing associated costs (Dobricic *et al.*, 2018).

Textbox 6: Key variables - SAON's Shared Arctic Variables & SOOS' Science and Implementation Plan

“Key variables” are the essential parameters (variables) to prioritise, observe and monitor to better understand a given facet of the Earth system. Essential variables are identified by global organisations (like the WMO) in their respective scientific areas. Initiatives such as the Roadmap for Arctic Observing and Data Systems (ROADS) mechanism of SAON (Starkweather *et al.*, 2021) in the Arctic and the Science Implementation Plan of the Southern Ocean Observing System (SOOS) (Newman *et al.*, 2022) in the Antarctic aim to establish these key variables based on their societal relevance for informing both scientific and global decision-making processes. Examples of such essential variables include 'Cryosphere,' 'Circulation,' and 'Biodiversity.'

4 Pillars towards strengthening collaboration for observing polar regions

Strengthening collaboration in observing polar regions to understand processes and enhance predictability of climate change effects will benefit global society, environmental policy, ecosystem management, and businesses beyond polar regions. It will favour development and coordination of observation strategies, foster integration of data, and support informed decision-making. The methodology for this white paper is detailed in Annex 1, with information gathered from meetings, workshops, and interviews involving polar experts in science, data, funding, international relations,

policy, and dialogue with Indigenous Peoples and local communities. Collected information were adapted into actionable-recommendations for European, non-European, national, and international decision-makers, funding agencies, academia, NGOs, and others involved in polar observation development. The input of Indigenous Peoples was ensured through integration of relevant documents (References and Annex 5), involvement in meetings (see Annex 2), and dialogues (EU-PolarNet 2 WP2).

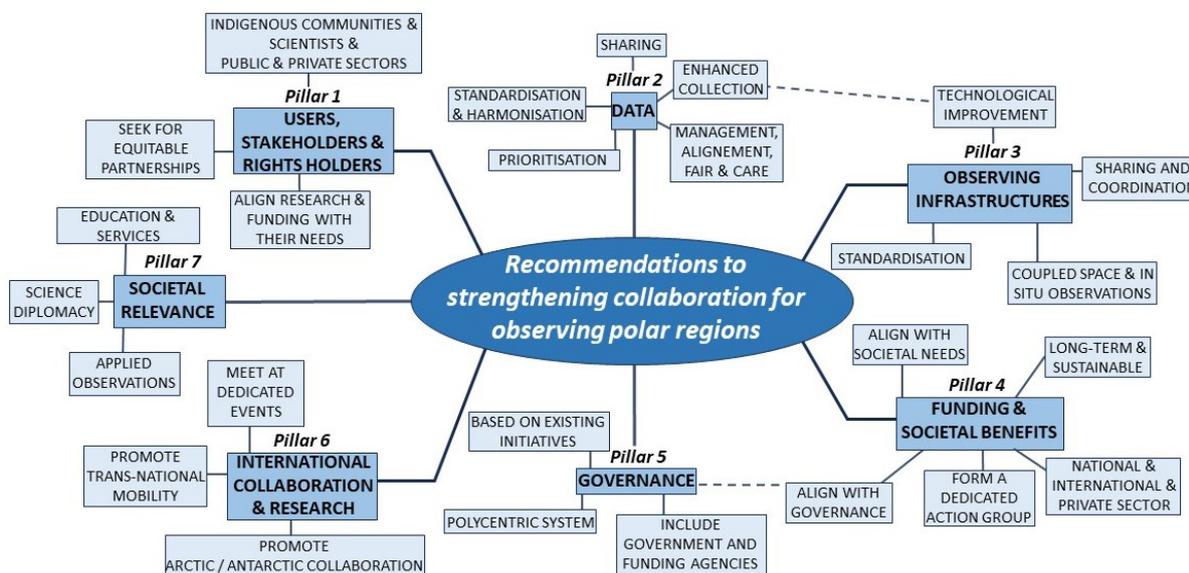


Figure 1: Mind map presenting the main pillars and main recommendations for each pillar.

This white paper identifies seven pillars to accelerate strengthening collaboration for observing polar regions (Figure 1): User needs, stakeholders and rights holders (Pillar 1), Strengthen collaboration to manage polar data (Pillar 2), Polar observing infrastructures (Pillar 3), Funding and societal benefit (Pillar 4), Organisational structure & Governance (Pillar 5), International collaboration & Research (Pillar 6), and Societal relevance (Pillar 7).

4.1 Main pillars of recommendations

4.1.1 Pillar 1) User needs, stakeholders, and rights holders

Themes	Risks	Benefits & Possibilities
Inclusivity, engagement, funding and needs alignment, communities, collaboration, monitoring.	<ul style="list-style-type: none"> - Challenge in converging international regulations and practices. - Long-term issues may arise if local communities are not involved from the beginning in the process. - Stake and rightsholders fatigue and frustration caused by duplicated efforts and inefficiency. 	<ul style="list-style-type: none"> - Reduction of duplicated efforts & records. - More meaningful engagement. - Increased diversity & innovation; Easier sharing of expertise, infrastructures, information, and funding. - Collaboration for observation and sampling (better knowledge, traditional knowledge, expenses reduction). - Services aligned with societal needs.

Table 1: Pillar 1 - User needs, stakeholders, and rights holders. Themes, risks, and benefits.

4.1.2 Pillar 2) Strengthen collaboration to manage polar data

Themes	Risks	Benefits & Possibilities
Data-ownership, data-collection, data-management, data-sharing, standardisation, and harmonisation.	<ul style="list-style-type: none"> - Difficulties hiring IT skilled personnel (higher salaries in the private sector). - Nationally owned observing systems may block collaboration (e.g., priority for hiring national scientists & restricted national data). - Data sharing is blocked by lack of standardisation and harmonisation & by multiple data centres using different systems. 	<ul style="list-style-type: none"> - Streamline of existing organisations for simplified coordination. - Technology advances to enhance data collection. - Implication of more data collectors, e.g., local communities, industry, tourism. - Improved and larger amount of collected data on larger areas. - Diplomatic beneficials (agreements between nations to share data). - Re-use of data and aggregated dataset to look at long-term trends, larger spatial areas.

Table 2: Pillar 2 - Strengthen collaboration to manage polar data. Themes, risks, and benefits

4.1.3 Pillar 3) Polar observing infrastructures

Themes	Risks	Benefits & Possibilities
Technological advancement, physical infrastructures (technical equipment), observing sites, and ownership and sharing of infrastructures between nations and with the private sector.	<ul style="list-style-type: none"> - Nationally owned infrastructures may block sharing them and scientific staff mobility (e.g., non-national scientists may not be hired to do operations with national vessels and equipment). 	<ul style="list-style-type: none"> - Collective sharing of infrastructures at the international level (as for during COVID19 pandemic) is a beneficial strategy for increasing cost-efficiency of projects and expeditions, favouring international collaboration and sharing of expertise, sharing of data, staff, and international standing, e.g., the French-Italian Concordia station, the Dutch Dirck Gerritzs Lab in the British Rothera Station. - Better streamlined data collection process, and collection of a larger amount of data.

Table 3: Pillar 3 - Polar observing infrastructures. Themes, risks, and benefits.

4.1.4 Pillar 4) Funding and societal benefits

Themes	Risks	Benefits & Possibilities
Long-term and sustainable funding, prioritisation of funding, societal benefits, communication strategy, international collaboration and agreements, alignment with funding agencies.	<ul style="list-style-type: none"> - Difficulties to raise interest for funding for remote polar regions. - National funding depends on national priorities that may differ between countries and from international priorities. - International funding may generate a loss of visibility at national level and may require setting up a legal structure (e.g., with fee collection). 	<ul style="list-style-type: none"> - Reduction of costs and increasing cost-efficient solutions via improved funding management. - Political agreement between different national funding agencies to ease overcoming national assets and interests. - Access to larger (international) funding pools. - Financial stability favouring reliable and stable data sources.

Table 4: Pillar 4 - Funding and societal benefits. Themes, risks, and benefits.

4.1.5 Pillar 5) Organisational structure and governance

Themes	Risks	Benefits & Possibilities
Integration with existing structures, type and composition of governance committee, and definition of policy.	- The national ownership of data and infrastructure may constitute a governance issue.	- A governing structure covering an Arctic/Antarctic collaboration would benefit from the advantages and experience acquired at both polar regions. E.g.: Arctic: experience with funding agencies and close relationship with the EU; Antarctic: easier access to observation sites and more collaboration with tourism.

Table 5: Pillar 5 - Organisational structure and governance. Themes, risks, and benefits.

4.1.6 Pillar 6) International collaboration & research

Themes	Risks	Benefits & Possibilities
Arctic & Antarctic stakeholders, Indigenous communities, international partners, equity, inclusivity, and integration, trans-national scientists mobility, integration of existing structures and cooperation.	- Existing international agreements (for funding, data, mobility) are often misaligned and struggle to get prioritised at national level. - Geopolitical tensions that may impact international collaboration.	- Enhanced cost-efficiency and avoided duplication of efforts and records. - Aligned and standardised circumpolar observations conducted across nations and programs to answer key questions/challenges and feed model projections. - Enhanced diversity & skill transfers & cross-cultural exchanges. - Research capacity development

Table 6: Pillar 6 - International collaboration & research. Themes, risks, and benefits.

4.1.7 Pillar 7) Societal relevance

Themes	Risks	Benefits & Possibilities
International relations and diplomacy, collaborations, inclusivity and equality, alignment between science and societal needs, and education.	- Sufficient maturity may take time to reach before societal applied services could be provided.	- Powerful EU tool for developing international science diplomacy around polar observation. - Better alignment between funding, observation, and societal needs, and better bridges between public and private sectors, and between research and policy. - Raised education and awareness on polar regions and inhabitants, climate change and challenges. - Identification of potential economic opportunities for local communities through collaborative projects, e.g., eco-tourism, skill-development, or sustainable resource management.

Table 7: Pillar 7 - Societal relevance. Themes, risks, and benefits.

4.2 Areas and level of integration between Arctic and Antarctic observations

The Antarctic and Arctic, while distinct in stakeholders, in legal and socio-cultural status, and often in research communities, share concerns over rapid climate changes and geopolitical challenges (Dodds and Raspotnik, 2023). Both regions, characterised by extreme environments and remote locations, are currently under separated observing strategies. Yet, their similarities offer opportunities for mutual learning and collaboration, especially in feeding global climate model projections and understanding climate change impacts, like sea-level rise. Collaboration in observing and data systems, along with logistical and funding aspects, can optimise their societal relevance and integration with decision-makers and governments. Recent studies (e.g., Dodds and Raspotnik, 2023) highlight the necessity of enhancing collaboration in observing polar regions. This would address shared concerns, bridge knowledge gaps between the polar regions, and improve alignment and integration of key polar

variables (Textbox 6). In this way, strengthening collaboration can be viewed as a *defragmentation* of polar initiatives, optimising their fundamental and logistical efficacy across both polar regions.



A small rigid inflatable boat makes its way through brash ice in the polar regions. O. Vassilev

It is the first time that united collaboration within and between the two polar regions is recommended at this scale. By doing so, this white paper seeks to address current gaps, prevent duplicates in observing initiatives, and promote harmonisation and standardisation. Its ambition is to integrate areas where collaboration can yield benefits, as outlined in Section 4, while acknowledging that certain aspects of existing polar observing systems, particularly those related to human dimensions, should remain specific to each polar region. The actionable recommendations provided in the next sections aim to foster collaborations within and between seven key pillars, leveraging natural shared interests between the Arctic and Antarctic. Predicting the exact level of collaboration within each pillar, particularly in terms of funding and governance, is challenging at this stage. Commitment from all parties is essential, and the recommendations should be activated promptly, progressing incrementally while adjusting collaboration levels. Collaboration and comparison are inherent for globally significant scientific data, including food security and variables crucial for Earth's environments and climate such as sea ice, atmosphere composition, wildfires, and in situ and remote measurements supporting global modelling efforts.

5 The way forward and key action areas: Actionable recommendations

In this chapter, the recommendations are organised to first present those enabling integration between the two polar regions. Antarctic-specific and Arctic-specific recommendations are provided in the following subsections. In complement of the general mind map of the main pillars and recommendations presented in Figure 1, detailed mind maps per pillar are also presented in Annex 5.

5.1 Recommendations relevant for both polar regions

5.1.1 Pillar 1) User needs, stakeholders, and rights holders – Figure 2, Annex 5

- Include stakeholders and rights holders from the outset, using existing fora: Scientific Committee on Antarctic Research (SCAR), SOOS for the Antarctic, and the Arctic Council Working Groups, the International Arctic Science Committee (IASC) and SAON for the Arctic, the Arctic Council including its six Permanent Participants, the organisations representing the Arctic Indigenous Peoples. Note that this inclusion needs funding from the start.
- Collaborative efforts should complement current initiatives with particular emphasis on:
 - Ensuring equitable partnerships with Indigenous peoples and local communities, with a focus on long-term dialogue strategy formulation.
 - Developing partnership with the business sector, for example tourism and shipping companies, to collaborate on data collection and monitoring.
 - Developing partnerships with local and sub-national policy-making bodies (e.g. municipalities, the Arctic Mayors Forum).
 - Developing partnership with public global scientific institutions, like the WMO and their Global Cryosphere Watch, to organise large scale and continuous monitoring.
- Use the EU-PolarNet2 tool for dialoguing with stake- and rights holders (available Autumn 2024) in planning polar proposals, observation, and research.

5.1.2 Pillar 2) Strengthen collaboration to manage polar data – Figure 3, Annex 5

Data management:

- Strengthen collaboration among existing data management bodies to enhance the FAIRness of polar data (Wilkinson *et al.*, 2016), and define data prioritisation: The Arctic Data Committee (ADC), Standing Committee on Antarctic Data Management (SCADM) and SOOS. Encourage collaboration at all levels for sharing metadata and data related to polar observation.
- Define discovery metadata, data standards, and persistent identifiers to facilitate machine-readable and shareable data across centres, promoting FAIRness.
- Ensure funding for observing activities systematically includes a component for data management.
- Develop training programs for data standardisation and data security for personnel and communities involved in data collection and management operations.

Data policy:

- Ensure data policies adhere to both FAIR (Findability, Accessibility, Interoperability, and Reusability) and CARE (Collective Benefit, Authority to Control, Responsibility, and Ethics) criteria.
- Align polar data policies with principles outlined in Tronstad *et al.* (2021), particularly updating the *Statement of Principles and Practices for Arctic Data Management* by IASC ([IASC data statement.pdf](#)).
- Emphasise federated search via single-entry points, with portals like the Polar Federated Search site (Verhey *et al.*, 2022) and the SAON Data Portal ([Data.ArcticObserving](#)), for data-organisation, -storage, and -accessibility.

Data sharing:

- Encourage data centres to register in relevant catalogues such as the 'Polar Data Ecosystem Mapping' (Pulsifer *et al.*, 2020) to enhance data discoverability.
- Centralise information on polar observing assets in catalogues like the Registry of Polar Observing Networks (RoPON), that also covers the European Polar Board's polar infrastructure catalogue, "Polarindex," to prevent duplication of effort and improve cost efficiency.

5.1.3 Pillar 3) Polar observing infrastructures – Figure 4, Annex 5

Remote Earth Observation:

- Enhance integration of observations across scales (e.g. “Calibration / Validation” efforts, [Nasa.gov/cal-val](https://nasa.gov/cal-val)) and complementarity between in-situ and remote observations.
- Pursue efforts for collaboration with the European Space Agency (ESA, e.g. [ESA and EC to unite on climate action from space](#)).
- Adopt unmanned monitoring technology and advance polar Earth observation from space ([Ec.europa.eu/earth-observation-arctic](https://ec.europa.eu/earth-observation-arctic)).
- Expand satellite coupled observations, addressing in situ data gaps accessibility, especially in the Russian Arctic territories.

Technological advancement of observing infrastructures:

- Enhance material, measurement quality and sustainability, particularly through aerial views.
- Improve real-time measurements, e.g., by enhancing communication capabilities with instrumentation, such as strengthening power and energy-saving features.
- Facilitate access and exchanges between international polar observatories through mapping and fostered connections and collaboration.
- Ensure proper registration of infrastructure information in relevant catalogues, such as RoPON and Polardex.
- Aim for the development of "zero emissions" infrastructures, e.g., the Princess Elisabeth Station ([Belspo.be/PES](https://belspo.be/PES)). Collaborate with infrastructure managers and vendors to enhance standardisation.

Observation sites:

- Develop international agreements for sharing national infrastructures.
- Invest in updating, sustaining, and maintaining existing infrastructures, including polar stations like Concordia, and research vessels.
- Establish additional observing and multi-parameter sites to meet the recommendations of the [SOOSymposium 2023 Statement](#).

5.1.4 Pillar 4) Funding and societal benefits – Figure 5, Annex 5

Need for funding of organisational structures and organisations:

- Implement dedicated funding calls tailored to meet the needs of stakeholders and rights holders for socially relevant observation and research.
- Establish funding mechanisms that enable Indigenous Peoples and local communities to contribute to proposal formulation and writing from the outset, promoting equitable partnerships.
- Ease international collaboration, mobility, visa application processes, and data sharing requirements within funding calls.

Communication strategy:

- Use the impacts of climate change and initiatives such as the 2021-2030 UN Decade of Ocean Science for Sustainable Development (UNDOS) ([Unesco.org/ocean-decade](https://unesco.org/ocean-decade)), the Decade Collaborative Centre for the Southern Ocean Region ([Oceandecade.org](https://oceandecade.org)), and the International Polar Years ([IPY2032-33](https://ip2032-33.org)) to raise interest on polar observation and attract fundings.
- Ensure all communications emphasise tangible societal benefits and achievable outcomes of observations and findings.
- Establish prioritised key variables (Textbox 6) to guide funding allocation, emphasising societal relevance through value-tree analysis (IDA, 2017). Use this approach to underscore the societal benefits of collaboration in observing polar regions and get support from funding agencies and society.

Funding strategy:

- Prioritise sustainable national funding from countries with long-term interest in polar research, while seeking short-term support from EU funding to enhance polar collaboration.
- Establish a funding action group to identify funding sources, engage the private sector, set joint business-research priorities, and facilitate dialogue between researchers and funding agencies.
- Advocate for a portion of profits from private companies extracting natural resources in polar regions to be allocated to public polar observation, through voluntary sponsorship or mandated legal requirements.
- Develop a political transnational agreement among national funding agencies to ensure a stable and sustainable funding structure, particularly for underrepresented cross-national initiatives. Allow nations to contribute to the collaborative observing system based on their economic situation, national interests, and priorities.

5.1.5 Pillar 5) Organisational structure and governance – Figure 6, Annex 5

- Establish a polycentric organisational structure based on existing polar initiatives and identify a representing organisation for communication with different audiences including funding agencies.
- Ensure the structure includes governmental and funding agencies from various countries, each with a relevant national mandate.
- Investigate Europe-wide opportunities or models for sustained research infrastructure coordination and funding, e.g. RIs, ERICs, ESFRI Landmarks.

*5.1.6 Pillar 6) International collaboration & research – Figure 7, Annex 5*Meetings and communication:

- Convene at dedicated polar community events like the Arctic Observing Summit (AOS) and SOOS Symposium to discuss observations from both polar regions. Enhance funding opportunities to support Indigenous Peoples and Early Career Researchers (ECRs) in attending these events.
- Establish discussion groups to connect existing organisations: a Data committee (Pillar 2), a Funding Action group (Pillar 4), a Private sector action group (Pillar 4), and a Governing committee (Pillar 5).

Connexions and integration:

- Identify and foster collaboration between groups and initiatives with similar mandates in the Arctic and Antarctic (See our Mapping of Arctic and Antarctic initiatives in Annex 4), such as the Arctic Monitoring and Assessment Programme (AMAP) and the Antarctic Monitoring and Assessment Programme (ANMAP) and working groups under IASC and SCAR.
- Facilitate coordination of observation between polar regions and adjacent regions (e.g., Arctic with North-Atlantic).
- Promote and enable trans-national mobility for scientists, leveraging the Agreement on Enhancing International Arctic Scientific Cooperation (2017) to implement concrete measures for transnational access. Refer to the work of the EU-project INTERACT (<https://eu-interact.org/>) for insights into transnational access challenges.

5.1.7 Pillar 7) Societal relevance – Figure 8, Annex 5

- Strengthen connections between public and private sectors, research, education, and decision makers.
- Develop relevant societal services based on observations, such as the services developed by ArcticPASSION (ArcticPassion/Services).

Science diplomacy:

- Engage in science diplomacy through participation in high-level fora involving polar and non-polar states, such as the Arctic Circle Assembly ([Assemblies \(arcticcircle.org\)](https://Assemblies.arcticcircle.org/)).

- Participate in the planning process for the International Polar Years 2032-33 (IPY2032-33).
- Foster a more inclusive and respectful society by enhancing collaboration between north- and south-hemisphere polar science, addressing colonial practices (e.g., Herrmann *et al.*, 2023), and ensuring equal participation and decision-making powers for all stakeholders.

Education and awareness:

- Expand and promote easily accessible platforms providing real-time polar observations information to all citizens, such as The National Snow and Data Centre ([Sea Ice Viewer](#)) and Polar Change Explorer ([Polar \(change\) Explorer](#)).
- Develop communication programs with multiple objectives, including observation and data collection, citizen science participation, and highlighting social benefits of climate change monitoring supported by public funding.

5.2 Antarctic-specific recommendations – Figure 9, Annex 5

Funding

- Collaborate with experts, researchers, educators, and actors of existing initiatives (Section 3) to develop specific funding calls and attract funding for Antarctic observation.
- Strengthen collaboration with southern hemisphere countries, including the “Gateway states”: Argentina, Australia, Chile, New Zealand, and South Africa, to enhance existing, and develop further, scientific programs in the Antarctic. Invite these countries to participate in strengthening collaboration for observing polar regions.

Communication and Policy

- Enhance communication efforts to promote scientific activities in the Antarctic and emphasise its relevance for Europe. Use successful international collaboration stories and produce communication materials focusing on wildlife, and climate change (e.g., Naughten *et al.*, 2023).
- Facilitate the establishment of marine protection areas and link the Antarctic with the wider earth system.
- Engage in discussions with signatories and consultative parties of the Antarctic Treaty to reaffirm their commitment to maintain the Antarctic as an area for peace, for science, and under global agreement of environmental protection.

5.3 Arctic-specific recommendations – Figure 10, Annex 5

- Encourage scientists to respect and learn about the local history, current situations, and ethical implications for local and Indigenous Peoples. Consult documents from Indigenous Peoples public institutions like the Inuit Circumpolar Council (Inuit Circumpolar Council, 2021) or the Sami Council ([Saami-councils-participation-in-research-projects](#); Herrmann *et al.*, 2023).

Governance and funding

- Provide input to key Arctic governance bodies such as the Arctic Council and its working groups (e.g., AMAP and the Conservation of Arctic Flora and Fauna (CAFF)), IASC, the International Conference on Arctic Research Planning, SAON, and the Arctic Mayors’ Forum.
- Engage with Research and Funding Agencies (Annex 3) and Arctic States to establish continuous funding for observation.
- Promote Indigenous leadership within funding agencies and institutions involved in polar research policy and grant development. Encourage joint assessment and evaluation of research needs by Indigenous and non-Indigenous experts (Herrmann *et al.*, 2023).
- Funding mechanisms should require applicants to encourage capacity building with Indigenous Peoples for independent leadership of research projects (Wheeler *et al.*, 2020).

- Adhere to the *Agreement on Enhancing International Arctic Scientific Cooperation* (Arctic Council, 2017) to facilitate access to observation sites.
- Use the ROADS process for defining key variables and planning observations, applying the guiding principles on Indigenous Peoples' equitable partnership, shared benefit, complementarity with existing networks, and grassroots participation.

Collaboration on data-oriented questions

- Integrate sharing and FAIRness of metadata and data into science cooperation agreements (Arctic Council, 2017), following the ten principles outlined in Tronstad *et al.* (2021).
- Support initiatives like the pan-Arctic alliance for ocean observing (e.g., GOOS Regional Alliance (GRA)) to address fragmentation in Arctic Ocean and sea ice observing networks.
- Ensure data collected in the Arctic is used and shared in accordance with the rights holders of the lands, following recommended decolonial research practices (e.g., Hermann *et al.*, 2023).

6 Strengthening the EU contribution to polar observations: Specific recommendations to the European Commission & decision makers

A collaborative and inclusive Polar observing system has the potential to position the EU as an international scientific beacon in the polar regions. Within this white paper, certain recommendations are directly aimed at the European Commission and EU decision makers (Figure 11, Annex 5). These EU-specific recommendations come in association with the recommendations presented in Section 5, and revolve around three key themes: **1)** Enhancing the societal relevance of polar science, **2)** Strengthening international collaboration in polar science, and **3)** Advancing science diplomacy.

6.1 Recommendations to enhance the societal relevance of polar science

- See measures in Section 5.1.7, Pillar 7) Societal relevance.

Funding

- Engage all relevant rights holders, stakeholders, and funding agencies in a discussion group to align polar observations and research with their needs and funding requirements.
- Establish dedicated funding calls for polar projects, integrating themes relevant to both polar regions (e.g., 2022 Belgian Science Policy Office's (BELSPO) polar call; [Belspo/call_polar](#)). Create a specific call focusing on addressing and monitoring climate change issues.

Policy

- Expand dialogue initiatives such as the EU Arctic Forum and Indigenous Peoples' Dialogue to shape EU policies for Indigenous Peoples ([Eu-arctic-forum-and-indigenous-peoples-dialogue-2024](#)).
- Improve transparency regarding public investments in polar regions and scientific operations.

Training, education, and communication

- Sustain efforts to raise public awareness, especially in non-polar Member States, regarding climate changes, polar environment evolution, and effects on global climate.
- Include local and Indigenous Peoples as equal partners in communicating the observed changes in polar regions.
- Prioritise polar science in discussions during the presidency of the European Council. For example, Hungary can draw upon its long history of Hungarian Arctic explorers (Németh, 2023), during its presidency in the second half of 2024.

6.2 Recommendations to strengthen international collaboration in polar science

Funding

- Use international climate change assessments and events like the UN 2021-2030 Decade of Ocean Science for Sustainable Development ([Unesco.org/ocean-decade](https://unesco.org/ocean-decade)), and the International Polar Years 2032-2033 ([WMO.int/ip2032-33](https://wmo.int/ip2032-33)) to invest in large-scale polar infrastructures and scientific projects in collaboration with EU Member States, supporting their commitments under the 2015 Paris agreement.
- Expand large-scale international polar scientific programs, such as those led by the ESA or the European Consortium for Ocean Research Drilling (ECORD), to enhance polar observations efforts.

Policy

- Establish agreement among national funding agencies and with EU institutions and Member States institutions for transnational scientific mobility and to create a unified polar investment program. Long-term funding for collaborative polar observations could be provided through this program, with initial development funded by the EU.
- Develop common policy frameworks among European Member States to streamline procedures for international funding, data sharing, access to national infrastructures, facilitate transnational scientist mobility, and establish shared goals and objectives. Consider leveraging tools like Interreg for this purpose ([InterregEurope.eu](https://interreg.eu)).
- Formulate a unified EU polar science policy to harmonise actions and organise joint operations among national polar institutions of EU Member States and align positions on polar observations and evidence-based decision-making.

Knowledge exchange

- Strengthen EU relations with Indigenous Peoples by improving their access to and involvement in polar funding calls and to the governance of polar initiatives.
- Collaborate with experienced countries in tourism management to protect polar environments, including measures like ship size restrictions, limitation of number of tourists and prioritisation of eco-tourism.
- Take a leadership role in the harmonisation and standardisation of polar data to facilitate sharing and global collaboration.

6.3 Recommendations to advance science diplomacy

- Utilise the EU Science Diplomacy Working Groups ([Science Diplomacy Working Groups](#)) to establish a sustainable EU presence at both poles in collaboration with Member States. This can involve hosting EU scientific programs and teams at Member State's stations, as well as establishing EU-run facilities such as stations or permanent monitoring facilities managed by the EU, for example by the European Polar Coordination Office.
- Leverage the EU's advanced scientific capabilities, including innovative satellite technology for Earth observation.
- Develop an EU polar policy supported by the potential appointment of an EU Polar Special Envoy to manage EU Polar affairs.
- Enhance collaboration with UK and non-EU Arctic countries, like Norway, USA, and Canada, as well as with southern hemisphere states ("Gateway states"), referring to the recommendations by Dodds and Raspotnik (2023).
- Expand marine protected areas in both polar regions; maintain and enhance discussions with China regarding environmental protection initiatives.



Snowy path ahead. J. Jania

7 Conclusion

Enhanced European and international collaboration in polar observations is essential to deepen our understanding of the ecological and environmental changes occurring both in the polar regions and on a global scale, and to develop adaptive strategies to address the significant changes that pose threats to our society.

This white paper presents over 80 actionable recommendations across 7 pillars aimed at enhancing cooperation in observing the polar regions. It offers specific guidance for Antarctic and Arctic observations, as well as tailored recommendations for the European Commission to strengthen collaboration in polar observations within and beyond the EU. The overarching objective is to establish a coordinated system for international and inclusive polar observations, facilitating research actions of significant societal relevance and supporting informed decision-making processes

The implementation of the recommendations should commence promptly, prioritising key areas of development. These include recognising the needs of users, stakeholders, and rights holders, standardising data and data systems, facilitating the international sharing of research infrastructures, and establishing joint funding mechanisms for polar observation. Certain recommendations, such as those supporting improved inclusivity and the enhanced utilisation of existing resources like portals, repositories, infrastructures, and registries, are ready for immediate activation and could be implemented in the short term. Meanwhile, other recommendations, such as those advising the development of international agreements, may necessitate more time for preparation and activation, thus should be initiated as soon as feasible.

The recommendations tailored specifically for EU decision-makers emphasise the significance of collaboration between EU Member States and other Arctic and Antarctic countries. The EU could work at uniting nations in advancing polar research and supporting initiatives such as the International Polar Years. By doing so, it can emerge as a significant contributor to the collective response against the global threats posed by climate change, while also fostering a more inclusive scientific community.

Given their experience, expertise, focus on relevant issues, and robust networking capabilities, the existing initiatives referenced in Chapter 3 and in Annexes 3 & 4 are identified as crucial partners for enacting the recommendations outlined in this white paper. Through sustained commitment and cooperation, decision-makers and the EU can facilitate the implementation of these recommendations, advancing gradually while adapting the level of collaboration within each pillar. This collective effort will contribute to a more comprehensive understanding of polar environmental changes and their broader impacts on the planet.

8 References

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9 Acronyms

AC	Arctic Council	https://arctic-council.org/
ADC	IASC/SAON Arctic Data Committee	https://arcticdc.org
ASFF	Arctic Science Funders Forum	iasc/Arctic-science-funders-forum
AMAP	Arctic Monitoring and Assessment Programme	www.amap.no
AMAP/CEG	AMAP Climate Expert Groups	https://climate.amap.no/
AMAP/LMEG	AMAP Litter and Microplastics Expert Group	https://litterandmicroplastics.amap.no/
AMAP/POPs	AMAP Persistent Organic Pollutions Expert Group	https://pops.amap.no/
AOS	Arctic Observing Summit	https://arcticobservingsummit.org
ANTOS	Antarctic Near-Shore and Terrestrial Observation System	scar.org/antos
ANMAP	The Antarctic Monitoring and Assessment Programme	scar.org/anmap-scar
APECS	Association of Polar Early Career Researchers	https://apecs.is/

ArcticGEOSS	ARCTIC GEOSS Global Earth Observations for the Arctic	https://arcticgeoss.org/
ArcticPASSION	Pan-Arctic Observing System of Systems: Implementing Observations for Societal Needs	https://arcticpassion.eu/
Arctic ROADS	Roadmap for Arctic Observing and Data Systems	https://roadsadvisorypanel.org
Arctic ROOS	Arctic Regional Ocean Observing System	Arctic.EuroGOOS.eu
ASM	Arctic Science Ministerial	https://asm3.org
ATS	Antarctic Treaty System	www.ats.aq
BBNJ	Biological diversity of areas Beyond National Jurisdiction	Europe OceansAndFisheries
BELSPO	Belgian Science Policy	www.belspo.be
GBIF	Global Biodiversity Information Facility	https://www.gbif.org/
CAFF	Conservation of Arctic Flora and Fauna	CAFF.is
CARE	Collective Benefit, Authority to Control, Responsibility, and Ethics	
CBD	Convention on Biological Diversity	www.cbd.int
CliC	Climate and Cryosphere - World Climate Research Program	https://www.wcrp-climate.org/clic
COMNAP	Council of Managers of National Antarctic Programs	https://www.comnap.aq/
CON	SAON Committee on Observations and Networks	https://arcticobserving.org/committees/con
COP	Conference of the Parties	unfccc.int/conference-of-the-parties-cop
ECORD	European Consortium for Ocean Research Drilling	www.ecord.org
EPB	European Polar Board	www.europeanpolarboard.org

ERIC	European Research Infrastructure Consortium	Research-and-innovation.ec.europa.eu/eric
ESA	European Space Agency	www.esa.int
ESFRI	European Strategy Forum on Research Infrastructures	www.esfri.eu
EU	European Union	European-union.europa.eu
EuroGOOS	European Global Ocean Observing System	EuroGOOS.eu
FAIR	Findable Accessible Interoperable Reusable	
FARO	Forum of Arctic Research Operators	Faro-arctic.org
GCW	Global Cryosphere Watch	https://globalcryospherewatch.org/
GOOS Global	Global Ocean Observing System	https://goosocean.org/
GOOS Regional Alliance	Global Ocean Observing System Regional Alliance	GoosOcean.org/regional-alliances
IASC	International Arctic Science Committee	iasc.info
IASC/MWG	IASC Marine Working Group	iasc.info/working-groups/marine
ICARP IV	<u>Fourth International Conference on Arctic Research Planning</u>	(iasc.info)
INTAROS	INTEgrated ARctic Observation System	Cordis.europa.eu/project/id/727890
INTERACT	International Network for Terrestrial Research and Monitoring in the Arctic	https://eu-interact.org/
ICES	International Council for the Exploration of the Sea	www.ices.dk
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services	www.ipbes.net

IPS	Indigenous People Secretariat	Arcticpeoples.com
IT	Information Technology	
NGOs	Non-governmental organisations	
MPDE	Mapping of the Polar Data Ecosystem	https://mpde.gcrc.carleton.ca/index.html
OA-ICC	Ocean Acidification International Coordination Centre	iaea.org/oa-icc
OSPAR	Oslo - Paris Convention	www.ospar.org
PAME	Protection of the Arctic Marine Environment	https://pame.is/
Pan-AOSS	Pan-Arctic Observing System of Systems	Cordis.europa.eu/project/id/101003472
PEI	Polar Educators International	https://polareducator.org/
P2G	Polar to Global Interoperability and Data Sharing Workshops	https://p2g-data.org
POAwg	Polar Observing Assets Working Group	https://www.polarobservingassets.org/
Polardex		https://polardex.org/
RIs	Research Infrastructures	European Research Infrastructures
ROADS	Roadmap for Arctic Observing and Data Systems	Cordis.europa.eu/project/id/101003472
RoPON	The Registry of Polar Observing Networks	https://polarobservingregistry.org
SAON	Sustaining Arctic Observing Networks	https://arcticobserving.org
SCADM	Standing Committee on Antarctic Data Management	SCAR.org/scadm
SCAR	Scientific Committee on Antarctic Research	https://scar.org/
SIOS	Svalbard Integrated Arctic Earth Observing System	https://sios-svalbard.org/
SOAP	Southern Ocean Action Plan	Sodecade.org/action-plan/

SOLAS	International Convention for the Safety of Life at Sea	www.imo.org/SOLAS
SOOS	Southern Ocean Observing System	www.soos.aq
SOOS-DMSC	SOOS-Data Management Sub-Committee	soos.aq/data/data-committee
UN	United Nations	www.un.org
UNDOS	UN Decade of Ocean Science for Sustainable Development	oceandecade.org
UNESCO	United Nations Educational, Scientific and Cultural Organisation	www.unesco.org
WMO	World Meteorological Organisation	https://wmo.int/

10 Annexes

10.1 Annex 1 - White paper methodology: Process of writing, feedback, and consultation

This EU-PolarNet2 White Paper, aimed at strengthening collaboration in observing polar regions, underwent an inclusive process, engaging various Polar stakeholders, including the scientific community, governmental and funding agencies, local communities, and Indigenous Peoples.

The development process comprised the following key steps:

- A workshop, "Recommendations towards an integrated Polar observing system" ([EUPN2workshop](#)), convened on June 7, 2022, involved 65 participants, including polar experts in science, data, funding, international relations, stakeholders engagement and policy, coordinators of European polar observing systems, and representatives for local stakeholders and Indigenous Peoples. Breakout sessions were held to discuss technological integration, research integration, funding and governance integration, and stakeholder engagement and services integration, yielding valuable recommendations in these topics.
- An online wrap-up session on September 6, 2022, summarised the workshop's findings and draft recommendations, inviting registered workshop participants.
- EU-PolarNet2 deliverable D6.4, "Minutes of a workshop with coordinators of European Polar observing systems" (<https://doi.org/10.5281/zenodo.7276187>), published on October 31, 2022, served as a cornerstone, consolidating workshop recommendations.
- A brainstorming session at the Institute of Natural Sciences in Brussels (<https://www.naturalsciences.be/en>), Belgium, on April 20, 2023, initiated the writing process.
- Bi-monthly online meetings from May 26, 2023, onwards facilitated progress in drafting the paper, coordinating tasks, and organising expert interviews and event participation.
- Interviews conducted between summer and autumn 2023 (Annex 2) collected additional recommendations, covering various and enlarged aspects of polar science, such as international geopolitics, areas and levels of integration, and strategic communication.

All gathered recommendations were adapted into actionable-recommendations suitable for decision makers, encompassing both European (including those from the EU) and non-European stakeholders.

- Presentations at conferences and meetings (Annex 2), starting from summer 2023, disseminated the paper's objectives and initial recommendations.

- Internal review by the EU-PolarNet2 writing team and coordinators took place between November and December 2023.
- External review by a range of polar experts (Annex 2) was conducted during winter 2024.
- Reviews by EU-PolarNet2's Executive Board (Annex 2) occurred in February 2024.
- Finally, the White Paper was delivered to the European Commission in March 2024.

10.2 Annex 2 - List of events and interviews where recommendations and feedback were collected, and reviewers of the white paper

Interviews and reviewers:

We thank the participants of the EU-PolarNet2 workshop, "Recommendations towards an integrated Polar observing system" (June 7, 2022), who provided the initial recommendations. We are thankful for the support and insights of the interviewees, of the external and internal reviewers, listed below, whose contributions did help to improve the text and the recommendations of this White Paper. We finally thank the interlocutors met during the writing process of the White Paper, for informal discussions that also helped to develop and improve the recommendations of the paper.

Interviewees and external reviewers

- Thomas Diehl - European Commission, Joint Research Centre – Interviewee and external reviewer.
- Alyce Hancock – SOOS / Institute for Marine and Antarctic Studies, University of Tasmania - External reviewer.
- Michael Karcher - ArcticPASSION / Alfred Wegener Institute – Interviewee and external reviewer.
- Deneb Karentz - SCAR / Biology Department at University of San Francisco - External reviewer.
- Lina Madaj - APECS / Vrije Universiteit Amsterdam - External reviewer.
- Chandrika Nath - SCAR / Scott Polar Research Institute, University of Cambridge - External reviewer.
- Joseph Nolan - EuroGOOS – Interviewee and external reviewer.
- Volker Rachold - Head of German Arctic Office / Alfred Wegener Institute - Interviewee and external reviewer.
- Chantelle Verhey - World Data System, International Technology Office - External reviewer.
- Deniz Vural - APECS / Alfred Wegener Institute & University of Potsdam - External reviewer.
- Jeremy Wilkinson - British Antarctic Survey – Interviewee.

EU-PolarNet2 Executive Board, Advisory Board, internal reviewers

- Carlo Barbante – EU-PolarNet2, WP3 / Institute of Polar Sciences, National Research Council of Italy – Internal reviewer.
- Nicole Biebow - EU-PolarNet2 Project Coordinator / Alfred Wegener Institute - Internal reviewer.
- Jon Børre Ørbæk – EU-PolarNet2, WP4 / Norwegian Polar Institute – Interviewee and internal reviewer.
- Kirsi Latola - EU-PolarNet2, WP2 / University of Oulu – Design of Textbox 4 and Internal reviewer.
- Elle Merete Omma - EU-PolarNet2, Advisory Board / Head of EU Unit of the Saami Council – Internal reviewer.
- Antonio Quesada - EU-PolarNet2, WP 1 / Spanish Ministry of Science and Innovation - Internal reviewer.
- Annette Scheepstra - EU-PolarNet2, Stakeholder Guardian / Dutch Research Council - Design of Textbox 4 and internal reviewer.
- Anneli Strobel - EU-PolarNet2 Project Manager / Alfred Wegener Institute - Internal reviewer.

Events:

- *EU-PolarNet 2 workshop ‘Recommendations towards an integrated Polar observing system’ ([EUPN2workshop](#)) – June 7, 2022.
 - *Workshop online wrap-up session – September 6, 2022
 - *SOOS symposium, Hobart - August 17, 2023 - Poster communication: Lymer G., Badhe R., Elshout P., Larsen J.R., Savela H., Scory S., Spadetto V., Van de Putte A., 2023. *Recommendations to accelerate the development of a sustained and fully Integrated Polar Observing System: an EU-PolarNet 2 White Paper.*
 - *EU Polarnet2 General Assembly, Rokua, Finland - October 03-04, 2023 – Oral communication: Lymer G., Badhe R., Elshout P., Larsen J.R., Savela H., Scory S., Spadetto V., *White Paper with recommendations to accelerate the development of a sustained and fully integrated Polar observing system,*
 - *Arctic Circle Assembly, Reykjavik, Iceland - October 19, 2023 – Informal meetings.
 - *Arctic Futures Symposium, Brussels, Belgium - November 28-29, 2023 – Informal meetings.
- * Highlights the events where Indigenous People representatives were present

10.3 Annex 3 - Existing polar initiatives

- **Polar observation, data collection and research organisations** and other scientific communities aiming for developing key polar science to contribute to our understanding of polar systems, while promoting international cooperation among polar countries and communities, including: ArcticGEOSS, the ArcticPASSION project ([Arcticpassion.eu](#)), the International Arctic Science Committee, (IASC, [iasc.info](#)), the Sustaining Arctic Observing Networks (SAON [www.arcticobserving.org](#)), the European Polar Board (EPB, [Europeanpolarboard.org](#)), EuroGOOS’ Arctic Regional Ocean Observing System (Arctic ROOS), the Arctic Window of the European Space Agency (ESA, [ESA.int/Arctic](#)). Certain groups fall under the umbrella of the Scientific Committee on Antarctic Research (SCAR, [Scar.org](#)), such as the Southern Ocean Observing System (SOOS, [Soos.aq](#)), or ANMAP ([scar.org/anmap-scar](#)). Organisation of the SCAR can be consulted here: [Nov23 Organogram \(scar.org\)](#).

We also highlight the new UNESCO program, **Antarctica InSync** ([AntarcticaInSync](#)), facilitating synchronised scientific observations in Antarctica and the Southern Ocean for a comprehensive circumpolar assessment. It aims to address the interconnections between ice, ocean, climate, environment, and life, including human pressures, with a focus on solutions like marine protection. The program aims to reinforce scientific cooperation in polar regions, foster data and knowledge exchange, and create pathways for closer collaboration between science, industry, and decision-making.

- Integrated observing systems:

At least four integrated observing networks exist in the Arctic:

The closed (end date February 2022) EU-H2020 funded project **INTAROS** ([europa.eu/INTAROS](#)), that aimed to develop an integrated Arctic observation system by improving and unifying existing systems in the different regions of the Arctic. INTAROS is particularly aimed at developing satellite earth observation to fill gaps related to sparseness of in situ data. INTAROS also developed a platform ([Catalog-intaros.no](#)) to search for and access data from distributed databases.

Based on a similar integration approach, ArcticPASSION (<https://arcticpassion.eu/>) aims at the co-creation and implementation of a more coherent, integrated Arctic observing system. It works to overcome known flaws in the present observing system by refining its operability, improving, and extending pan-Arctic scientific and community-based monitoring and the inclusion with consented Indigenous and local knowledge. Streamlining the access and interoperability of Arctic Data systems and services and ensuring the economic viability and sustainability of the observing system. It also develops services that support needs of people living and acting in the Arctic.

Sustaining Arctic Observing Networks (SAON) is a joint initiative of the Arctic Council and the International Arctic Science Committee with the vision of a connected, collaborative, and comprehensive long-term pan-Arctic Observing System that serves societal needs. SAON facilitates, coordinates, and advocates for coordinated international pan-Arctic observations and mobilizes the support needed to sustain them ([The SAON Strategy 2018-2028](#)). As part of its strategic plan, SAON identified the need for a Roadmap for Arctic Observing and Data Systems (Arctic ROADS) to set a course towards systematically defining the needed observing and data systems and to specify how the various partners and players are going to collectively work towards achieving that system (Starkweather *et al.*, 2021).

The **Svalbard Integrated Arctic Earth Observing System (SIOS)**, an international observing system for long-term measurements in and around the Norwegian archipelago of Svalbard, addressing Earth System Science questions ([SIOS-svalbard.org](#)).

At least two integrated initiatives exist in the Antarctic:

SCAR's ANTOS (Antarctic Near-Shore and Terrestrial Observation System - [SCAR ANTOS](#)) is a biologically-focussed initiative to coordinate a cross-continent and cross-national programme-scale assessment of environmental variability and change. It was established in response to the need identified in multiple sectors for long-term commitment to acquire basic information to underpin identification of trends and changes in iconic Antarctic ecosystems.

SOOS is an integrated observing system in the way that it is fed by Internationally coordinated observing systems ([SOOS ObservingInitiatives](#)) that ensure sustained collection and delivery of observational data. SOOS works with these programs to achieve common objectives and to provide support and advocacy of their important work.

Initiatives integrating together observations and communities from both polar regions are rare, although such initiatives would facilitate data-, knowledge-, funding- and expertise-sharing. One initiative active in 2013-2014 was the Hybrid Arctic/Antarctic Float Observing System (HAFOS, [Edmerp.HAFOS](#)) which aimed at combining observations from the Antarctic and Arctic to establish an observing system for the polar oceans.

- **Intergovernmental organisations** whose policies and recommendations rely on the observation and research conducted in the polar regions, including:

The Antarctic Treaty System (ATS, [ATS.aq](#)) and Arctic Council (AC, [Arctic-council.org](#)), and its projects and working groups, such as the Arctic Monitoring & Assessment Program (AMAP, [AMAP.no](#)), the Conservation of Arctic Flora and Fauna (CAFF, [CAFF.is](#)), and the Protection of the Arctic Marine Environment (PAME, [PAME - Marine Protected Areas](#)). Within SAON, the Roadmap for Arctic Observing and Data Systems (ROADS, [Arctic-council.org/ROADS](#)) is a planning mechanism to develop and link observing and data system requirements and implementation strategies in the Arctic region. Some initiatives exist to place the obtained data in a more global context, such as the Convention on Biological Diversity (CBD, [CBD.int](#)) or the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, [IPBES.net](#)), but no organisations fully-dedicated to both poles currently exist.

- **Data committees** exist for the Arctic (the SAON/IASC Arctic data Committee, ADC ([arcticdc.org](#))), and the Antarctic (SCADM, [SCAR.org/scadm](#), or the SOOS-Data Management Sub-Committee, SOOS-DMSC, [SOOS.aq/data-committee](#)), and have collaborated for some years through the 'Polar to Global Interoperability and Data Sharing Workshops' (P2G, <https://p2g-data.org>) to define standards for interoperability, vocabularies, and data policies for polar data. Additional initiatives include the SAON/CON 'Polar Observing Assets Working Group' (POAwg, [Polarobservingassets.org](#)) that has been established for the organisation of polar observing assets metadata, and the structures identified in the EU-PolarNet2's D6.1.

- **National research and funding agencies** of Arctic countries and other countries with polar interests: The EU-PolarNet2 consortium (2022) published a list of such existing agencies per country, including

for example: the Alfred Wegener Institute, Germany (AWI.de) ; the French Polar Institute Paul Emile Victor, France (Institut-polaire.fr) ; The British Antarctic Survey, UK (BAS.ac.uk) ; etc. Some of these national funding agencies collaborate via the Arctic Funders Forum.

Textbox 7: Arctic Science Funders Forum

The Arctic Science Funders Forum (IASC/ArcticFundersForum) is a multilateral, discussion platform, originating from the Arctic Science Ministerial, for funders to initiate and investigate new and enhanced collaborative scientific activities in the Arctic.

The forum aims to: 1) Facilitate information sharing about national and international calls for Arctic research projects; 2) Develop bilateral and multilateral research funding programmes and calls; 3) Engage Indigenous Peoples and include local research priorities; 4) Provide a venue for Forum participants to meet; and 5) Serve as a means to communicate priorities, activities, and opportunities, thereby catalysing synergies and extra leverage on national funding. It also may help adapt and optimise funding calls (timing, priorities, requisites) from the parties prioritising international perspective.

It constitutes so far, the first and only systematic attempt to bring national science foundations together to form an international process to fund Arctic initiatives and observation funding issues.

- **Organisations of Arctic Indigenous Peoples:** The prominent ones are those that have status as so-called *Permanent Participants* in the Arctic Council, including Aleut International Association, Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Council, Russian Association of Indigenous Peoples of the North, and Saami Council. More information is available through the Arctic Council (Arctic-council.org/permanent-participants) and the Indigenous Peoples' Secretariat (ArcticPeoples.com).

- **Non-governmental organisations and agencies** interested in the conservation and sustainable management of polar systems, including: The Arctic Institute (Thearcticinstitute.org), ArcticNet (Arcticnet.ulaval.ca), The University of the Arctic (Uarctic.org), etc.

- **Education and outreach organisations that** will benefit from an international effort to understand polar ecosystems and how they can be protected. The portrayal of polar animals, such as polar bears, in our popular culture underscores the significance of polar biodiversity within our society, despite the seeming remoteness of these regions. Examples include: the Association of Polar Early Career Researchers (APECS, APECS.is), the EU project Edu-arctic.eu, Polar Educators International (PEI, Polareducator.org), and the UArctic network (Uarctic.org).

- **Agencies and organisations with global interests in climate, oceans, shipping and biodiversity,** as the observations from Polar Regions are relevant to feed global weather-, biological-, physical- and climate-model scenarios, including: The United Nations' World Meteorological Organisation (Public.wmo.int) and their Global Cryosphere Watch (GCW, <https://globalcryospherewatch.org>), the Forum of Arctic Research Operators (FARO, Faro-arctic.org), and the Council of Managers of National Antarctic Programs (COMNAP, Comnap.aq). The WMO constitutes a major potential partner for polar scientific initiatives and is already affiliated with SAON, the Scientific Committee on Antarctic Research/Climate and Cryosphere Sea ice Working Group (Aspect.antarctica.gov.au) and the Arctic Sea Ice Working Group (Climate-cryosphere.org/arctic-sea-ice-wg), via its co-sponsored World Climate Research Programme.

- **Non-exhaustive list of legislations regarding the development of observing programmes:**

- EU legislations: For water framework directive (EU Directive 2000/60/EC); for habitats directive (EU Directive 92/43/EEC); for birds directive, including Natura2000 sites (2009/147/EC); for

environmental impact directive ([EU Directive 2014/52/EU](#)); for products of animal origin intended for human consumption ([Regulation \(EC\) 854/2004](#)); for EU strategy on adaptation to climate change ([COM\(2021\) 82](#)), for bathing water directive ([EU Directive 2006/7/EC](#)), for marine strategy framework directive ([EU Directive 2008/56/EC](#)); for nitrates directive ([91/676/EEC](#)); for INSPIRE directive ([2007/2/EC](#)), amended by [Regulation \(EU\) 2019/1010](#); for Invasive Species Regulation ([\(EU\) 1143/2014](#)); for common fisheries policy data collection framework ([Regulation \(EU\) 2017/1004](#)), and European fisheries control regulation ([Regulation \(EU\) 2019/1241](#)).

- International initiatives: The [Antarctic Treaty](#); the international [three legally binding international agreements](#) of the Arctic Council that aim at enhancing international cooperation on issues related to maritime search and rescue, marine oil pollution, and Arctic scientific cooperation; the agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine [Biological diversity of areas Beyond National Jurisdiction](#) (BBNJ); the OSPAR convention for protection and conservation of the North-East Atlantic and its resources ([www.ospar.org](#)); the GOOS ([ioc.unesco.org/GOOS](#)); the Ocean Acidification International Coordination Centre (OA-ICC, [iaea.org/oa-icc](#)); the Regional Hydrographic Commissions ([https://iho.int/en/rhcs](#)); the International Council for the Exploration of the Sea (ICES, [www.ices.dk](#)); and the International Convention for the Safety of Life at Sea (SOLAS, [www.imo.org/SOLAS](#)).

10.4 Annex 4 - Mapping of Arctic and Antarctic initiatives

Antarctic	Arctic	Global
INStabilities and Thresholds in ANTarctica (INSTANT) Tropical Antarctic Teleconnections Action Group (TATE) Antarctic Permafrost, Soils and Periglacial Environments Expert Group (ANTPAS) Near-term Variability and Prediction of the Antarctic Climate System (AntClimnow) Biogeochemical Exchange Processes at the Sea-Ice Interfaces Action Group (BEPsII) AntArchitecture Action Group (internal architecture of ice) Antarctic Sea-ice Processes and Climate Expert Group (ASPeCt) Forum for Research into Ice Shelf Processes Expert Group (FRISP) International Partnership in Ice Core Sciences Expert Group (IPICS) Ice Sheet Mass Balance and Sea Level Expert Group (ISMAsS) Paleoclimate Records from the Antarctic Margin and Southern Ocean (PRAMSO) RINGS Action Group (ice sheet margin) CLIVAR/CliC/SCAR Southern Ocean Region Panel Expert Group (SORP) Integrating Climate and Ecosystem Dynamics (ICED)	AMAP/CEG IASC/CWG	CliC, WMO
Integrated Science to Inform Antarctic and Southern Ocean Conservation (Ant-ICON) Expert Group on Antarctic Biodiversity Informatics (EG-ABI) Expert Group on Birds and Marine Mammals (EG-BAMM) SCAR Krill Expert Group (SKEG) Expert Group on the Southern Ocean Continuous Plankton Recorder (SO-CPR)	CAFF, CBMP, NAMMCO	GEOBON, GBIF
Antarctic Geospace and ATmosphere reseArch (AGATA) Antarctic Clouds and Aerosols Action Group (ACA)	AMAP/SLCF, IASC/AWG	
Antarctic Near-shore and Terrestrial Observing System Expert Group (ANTOS)	SAON	

Geodetic Infrastructure of Antarctica Expert Group (GIANT) International Bathymetric Chart of the Southern Ocean Expert Group (IBCSO) Standing Committee on Antarctic Geographic Information (SCAGI) BEDMAP3 (topographical model of Antarctica)	ASDI	
Input Pathways of persistent organic pollutants to AntarCTica (ImPACT)	AMAP/POPs	
Joint Expert Group on Human Biology and Medicine (JEGHBM)	AMAP/HHAG IASC/SHWG	WMO
Plastic in Polar Environments (Plastic-AG)	AMAP/LMEG	UNEP/INC
Earth Observation Action Group (EOAG)	ArcticGEOSS, GEOCRI, SAON	GEO
Input Pathways of persistent organic pollutants to AntarCTica (ImPACT)	AMAP/POPs EG	
	AMAP/CEG, IASC/CWG	CliC
Standing Committee on the Humanities and Social Sciences (SC-HASS)	ICASS, SDWG	
Antarctic Tourism Action Group (Ant-TAG)	Association of Arctic Expedition Cruise Operators (AECO)	
Policy-Law-Science Nexus Action Group (PoLSciNex AG)	PAME	(UNCLOS)
Standing Committee on Antarctic Data Management (SCADM)	ADC	WDS
Southern Ocean Observing System (SOOS)	AMAP, ICES, PICES, SAON	GEO, WMO
ANMAP	AMAP	

Table 8: A provisional mapping of Arctic and Antarctic initiatives. Initiatives that have no immediate mapping to another initiative have been omitted.

10.5 Annex 5 – Mind maps of the recommendations



Figure 2: Mind map of the recommendations for Pillar 1, Users, Stakeholders and Rights Holders

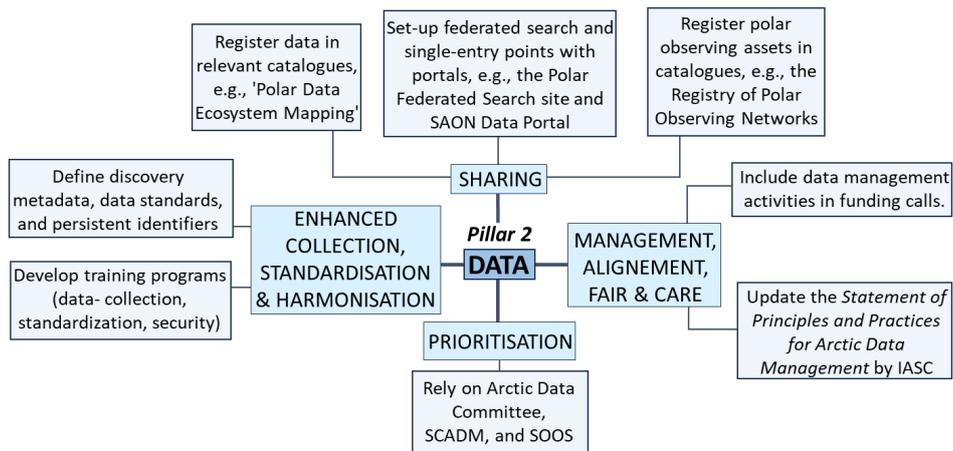


Figure 3: Mind map of the recommendations for Pillar 2, Strengthen collaboration to manage polar data

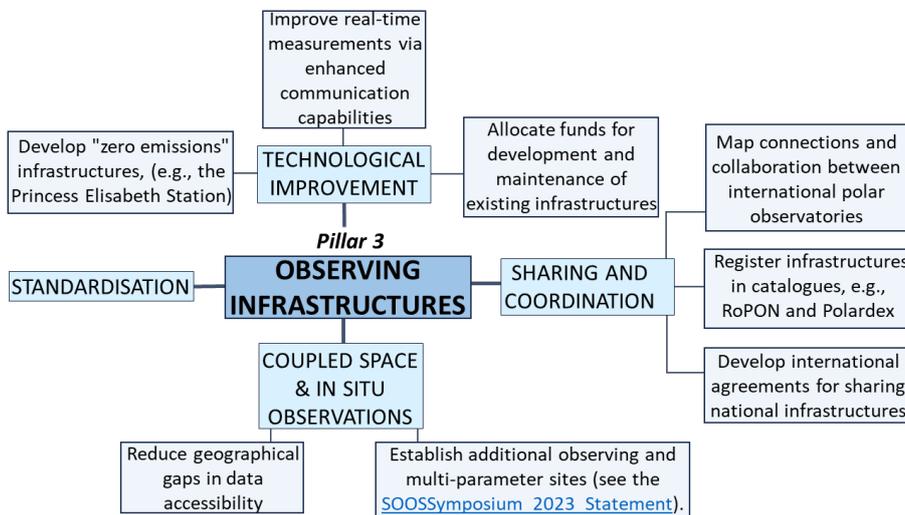


Figure 4: Mind map of the recommendations for Pillar 3, Polar observing infrastructures

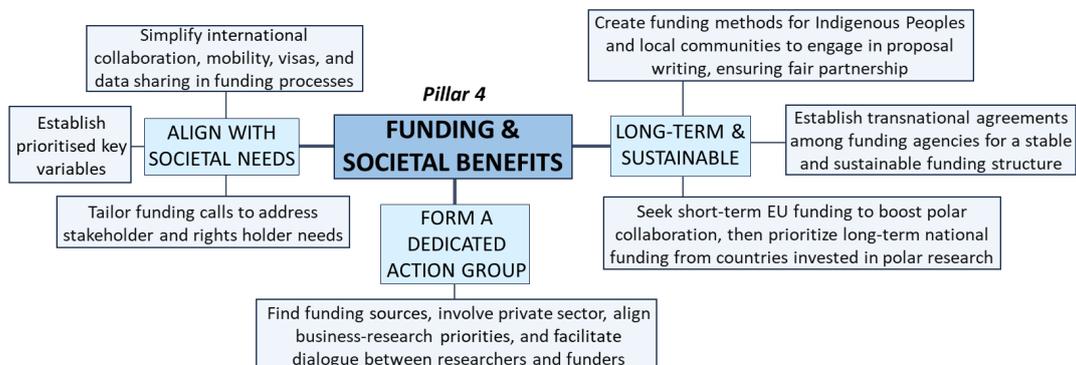


Figure 5: Mind map of the recommendations for Pillar 4, Funding and societal benefits

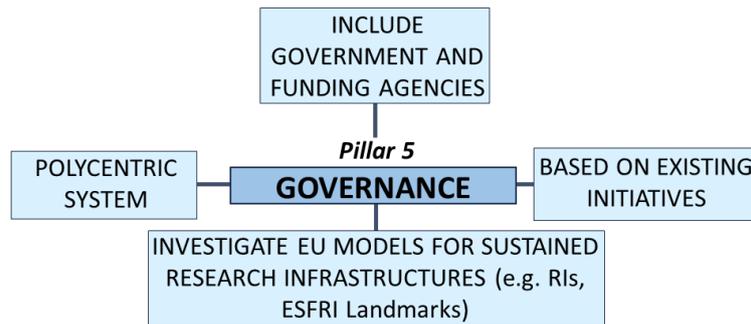


Figure 6: Mind map of the recommendations for Pillar 5, Organisational structure and governance

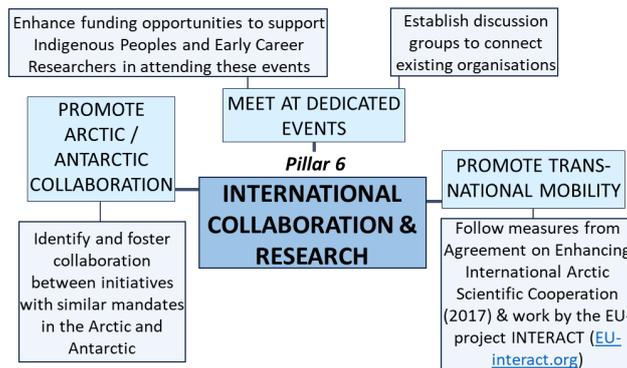


Figure 7: Mind map of the recommendations for Pillar 6, International collaboration & research

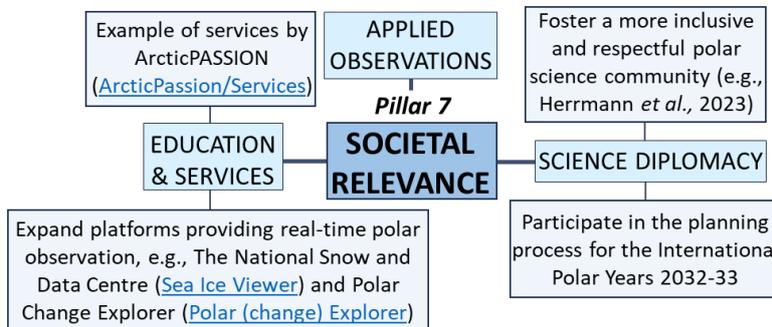


Figure 8: Mind map of the recommendations for Pillar 7, Societal relevance

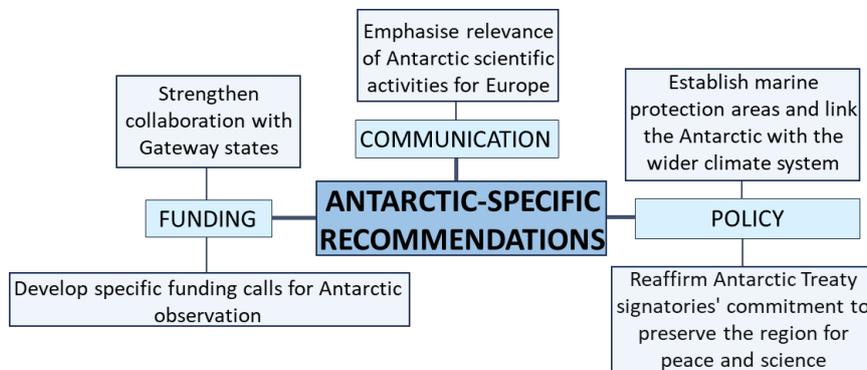


Figure 9: Mind map of the recommendations for Antarctic recommendations

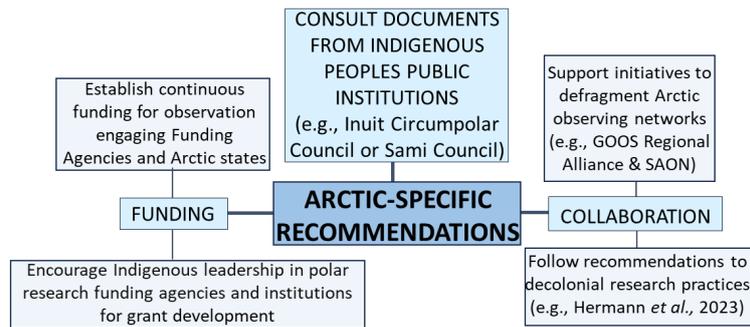


Figure 10: Mind map of the recommendations for Arctic recommendations

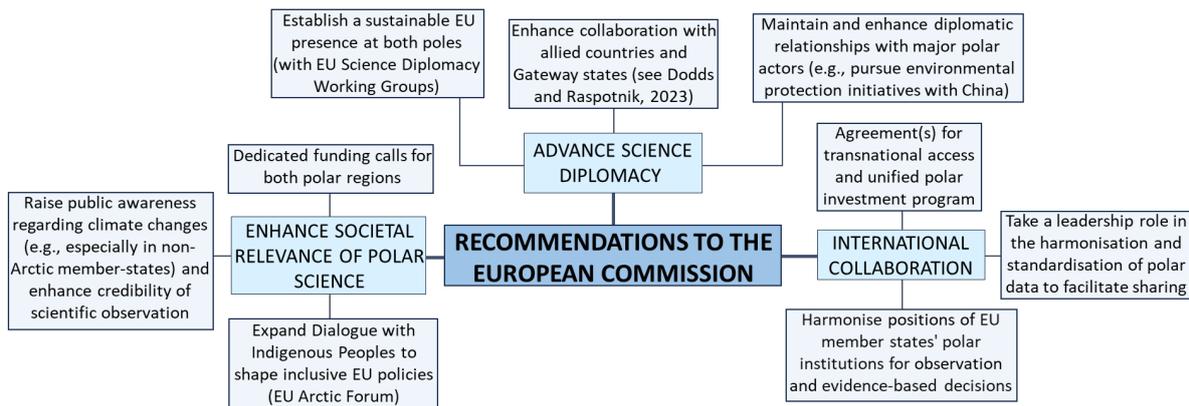


Figure 11: Mind map of the recommendations for the European Commission and EU-decision makers

10.6 Annex 6 - Further reading and resources

EU-PolarNet (2015-2020):

- Data management recommendations for polar research data systems and infrastructures in Europe (D3.5): https://eu-polarnet.eu/wp-content/uploads/2020/11/EU-PolarNet_D3.5_Data_management_recommendations.pdf
- White Paper on Polar data Accessibility (D3.8): https://eu-polarnet.eu/wp-content/uploads/2020/11/EU-PolarNet_D3_8_White_paper_on_Polar_data_accessibility.pdf
- EU-PolarNet, 2021. White papers 1: <https://eu-polarnet.eu/wp-content/uploads/2021/08/EU-PolarNet-White-Papers.pdf>

EU-PolarNet2 (2020-2024):

- Mapping all stakeholder activities from relevant polar projects including EU polar cluster projects (D2.2): <https://eu-polarnet.eu/download/d2-2-mapping-all-stakeholder-activities-from-relevant-polar-projects-including-eu-polar-cluster-projects/>
- Update of the stakeholder map developed in EU-PolarNet 1 in cooperation with the EU Polar Cluster projects (D2.3): <https://eu-polarnet.eu/download/d3-2-update-of-the-stakeholder-map-developed-in-eu-polarnet-1-in-cooperation-with-the-eu-polar-cluster-projects/>
- EU-PolarNet2 deliverable D6.4, 'Minutes of a workshop with coordinators of European Polar observing systems' (<https://doi.org/10.5281/zenodo.7276187>)

ArcticPASSION:

- Bavay, M., et al. (2023). MeteolO docker image and OGC WPS service, Arctic PASSION Deliverable Report D2.6, <https://arcticpassion.eu/deliverables/>

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25/03/2024

- Heinilä, K., et al. (2022). Lake Ice Service Readiness Report, Arctic PASSION Deliverable Report D4.1, <https://arcticpassion.eu/deliverables/>
 - Grosse, G., et al. (2023). Disturbance map for panarctic, INTERACT sites, and WP4 local communities with permafrost disturbance trends from EO data, Arctic PASSION Deliverable Report D4.2, <https://arcticpassion.eu/deliverables/>
 - Larsen, J. R. (2022). Synthesis reports on the status of the Arctic Data System, Arctic PASSION Deliverable Report D2.4, <https://arcticpassion.eu/deliverables/>
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 - Tkach Pavel, & Stepień Adam. (2022). Data-driven Subnational Decision-making in the Arctic: Towards identifying the key issues Workshop Background Paper (Policy Paper) (Version 1). Arctic PASSION Deliverable Report D7.2, Zenodo. <https://doi.org/10.5281/zenodo.7090699>
 - Vitale, V., et al. (2023). Documentation on the INFRA service and its functionalities, Arctic PASSION Deliverable Report D4.3, <https://arcticpassion.eu/deliverables/>
- Further reading on Indigenous knowledge: Arcticpeoples.com/IndigenousKnowledge
- Joint Statement of Ministers. On the Second Arctic Science Ministerial. 26 October 2018. Berlin, Federal Republic of Germany: https://www.arcticsscienceministerial.org/arctic/shareddocs/downloads/asm2_joint_statement.pdf?blob=publicationFile&v=2
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- IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019. The Global Assessment Report on Biodiversity and Ecosystem Services, Summary for Policymakers. P.14, <https://www.arctic-office.de/en/publications/arctic-indigenous-peoples/>