ICARP IV - RPT2: Observing, Reconstructing, and Predicting Future Climate Dynamics and Ecosystem Responses

Tuesday, 25 March · 16:00 – 18:00

ICARP IV
INTERNATIONAL CONFERENCE ON ARCTIC RESEARCH PLANNING

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ICARP IV SUMMIT : Research Priority Team 2

ASSW Code of Conduct

- Strive for transparent and open communication.
- This is an opportunity to be curious - put aside assumptions.
- Share the air - we all have something to learn and something to share.
- Be considerate, respectful, and collaborative in speaking and listening.
- Take a holistic approach

Read the full Code of Conduct
https://assw.info/meeting-info/assw-code-of-conduct

ICARP IV - RPT2: Observing, Reconstructing, and Predicting Future Climate Dynamics and Ecosystem Responses

Introduction & Overview of RPT 2

RPT2
Definition & Scope

Observing, reconstructing, and predicting future climate dynamics and ecosystem responses

Scope: pan-Arctic

Focus: Observations that will inform our understanding of ecosystem responses (both stability and change), and that will contribute to larger scale modeling efforts

RPT 2 is concerned with similar drivers to RPT 1, but from the bottom-up perspective of ecosystem response, rather than the contribution of the Arctic to the rest of the earth system.

RPT2 Constraints

Observing, reconstructing, and predicting future climate dynamics and ecosystem responses

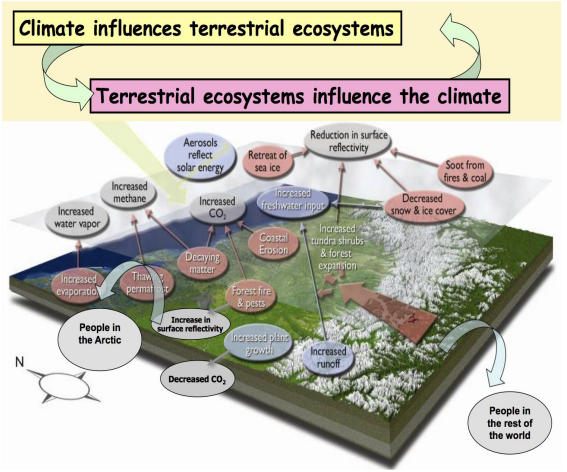
ICARP Steering Committee says:

No more than ~5 RPT-specific needs and priorities per RPT

No more than 5 cross-cutting needs and priorities per RPT

- Therefore, these must be broad. Implementation can be more specific.
- Much more detail for each need, priority, and implementation suggestions is in the draft document, which will be shared for input

Syndonia Bret-Harte

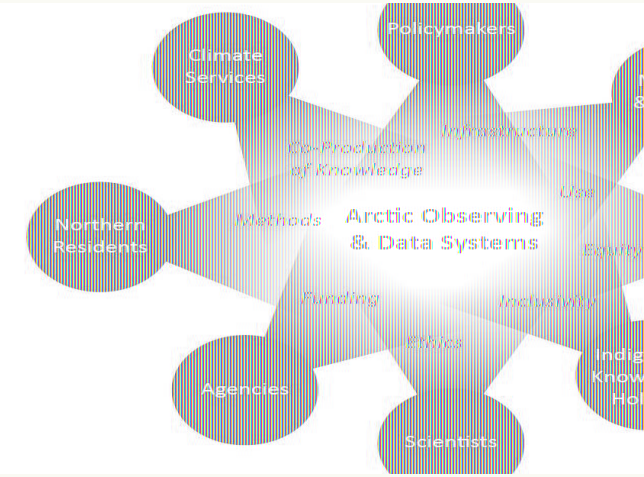


Role: RPT 2 Co-Chair

Affiliation: Professor, University of Alaska Fairbanks; Science co-Director, Toolik Field Station

Expertise: Long term observations, terrestrial vegetation and ecosystem ecology

Margaret Rudolf

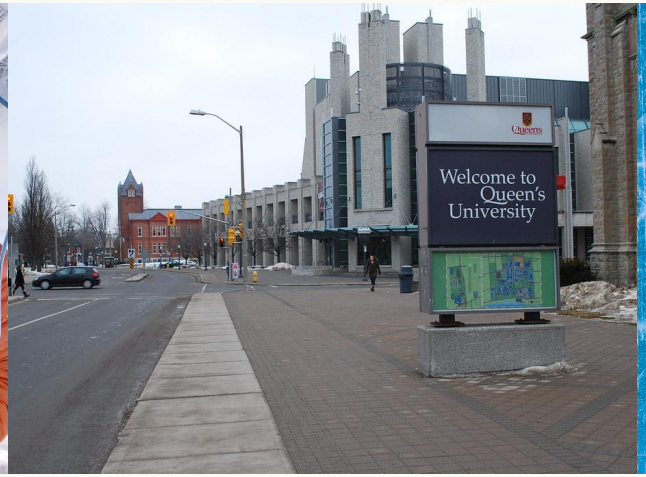


Role: RPT 2 Co-Chair

Affiliation: Post-doc with RNA CoObs & Advisory Panel member on SAON's Arctic ROADS Process

Expertise: Co-production of knowledge, convergence, evaluation, Indigenous engagement, Arctic research and observing

Wai Yin Cheung (Wilson)



Role: RPT 2 Co-Chair

Affiliation: ICElab, Queen's University

Expertise: Glaciology, Remote Sensing, Photogrammetry, Machine Learning, Cross Cultural Studies

Queen's University

Ice Climate & Environment Lab

Robbie Mallett

Role: RPT2 Co-Chair

Affiliation: Earth Observation Group, Physics & Technology Dept, UiT The Arctic University of Norway

Expertise: Satellite Monitoring of Sea ice; Snow science

UiT The Arctic University of Norway

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Acknowledgment of RPT2 Members

We gratefully acknowledge the contributions of the ICARP IV Research Priority Team 2 (RPT2) members:

Hélène Angot, Maurizio Azzaro, Manuel Bensi, João Canário, Tom Christensen, Lauren Divine, Eugenie Euskirchen, Kaitlyn Fleming, Lisa Winberg von Friesen, Laura Ghigliotti, Ramona Heim, Laurie Juranek, Tsubasa Kodaira, Astrid Lampert, Jan Rene Larsen, Maarten Loonen, Rob Middag, Arnab Mukherjee, Susan M. Natali, Shigeto Nishino, Anna H. Ólafsdóttir, Sergi Pla-Rabes, Bjørg Risebrobakken, Brendan M. Rogers, Alcide di Sarra, Kazutoshi Sato, Warsha Singh, Nozomu Takeuchi, Vito Vitale, Deniz Vural, Patrik Winiger, Gabriel Wolken, Xiaofan Yang, and Kathleen Orndahl.

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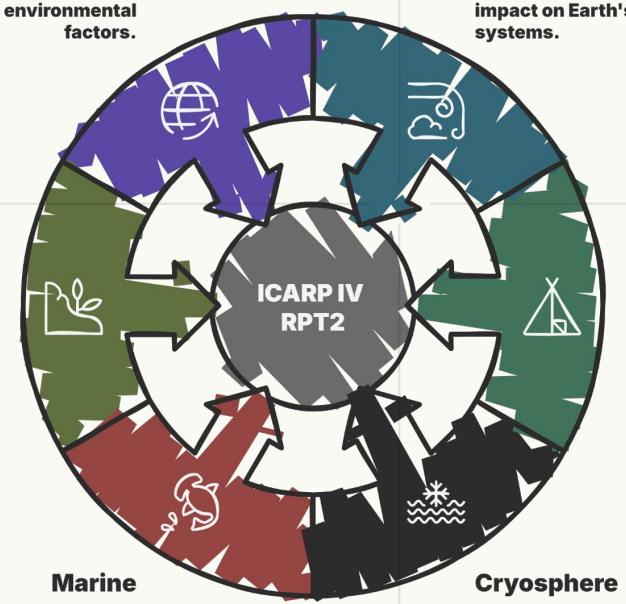
About RPT2

Interaction

Highlights the interconnections between different environmental factors.

Atmospheric

Examines atmospheric circulation and its impact on Earth's systems.



Terrestrial

Investigates land-based ecosystems and their ecological dynamics.

Indigenous

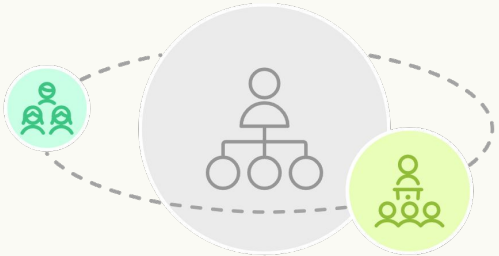
Focuses on integrating indigenous knowledge and perspectives into research.

Marine

Explores oceanic ecosystems and their interactions with global processes.

Cryosphere

Studies ice, snow, and glacial processes within the Earth's climate system.



Team Size

39 team members

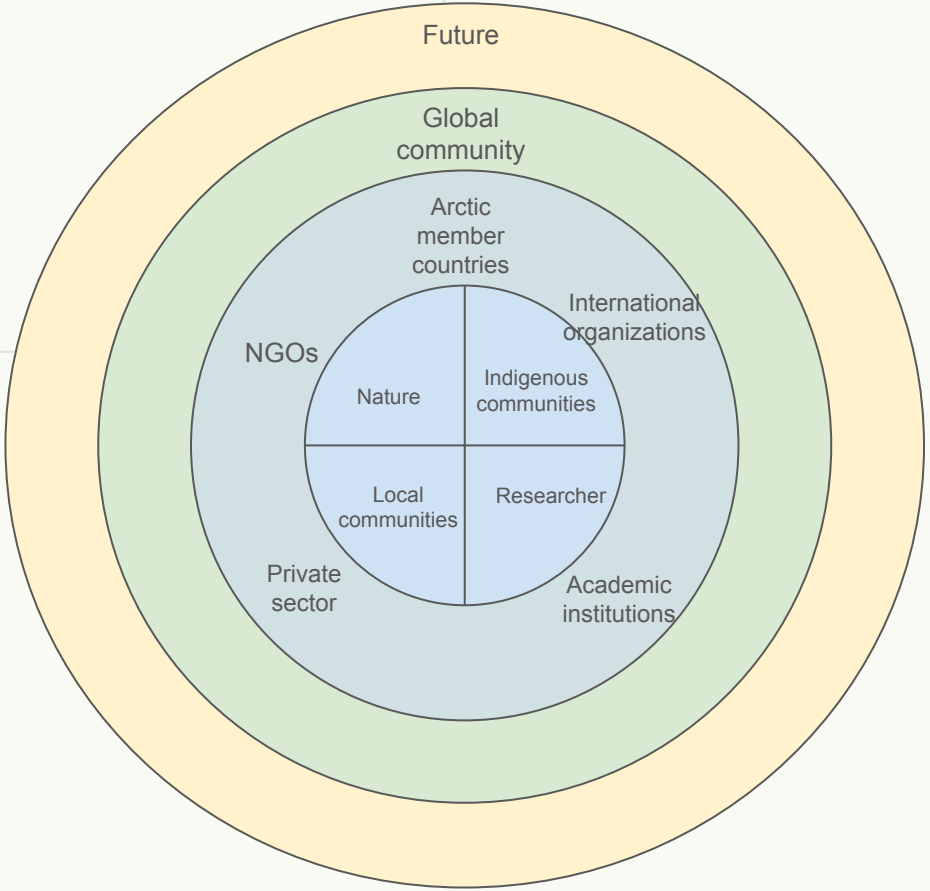
Co-Chairs

Margaret, Syndonia, Robbie, Wilson

Timeline


Project Timeline from Input to Final Report
1st working group meeting in Edinburgh, UK
March 2024
Reach/seek input from stakeholders
June - July 2024
Co-Chairs RPT meeting in Iceland
October 2024
Refine the research priority
January - February 2025
Draft the final report
April - May 2025
April - May 2024
Develop engagement strategies
Input Phase
August - September 2024
Analyze and review stakeholder input
Review Phase
November - December 2024
Draft the RP report in subgroup
Draft Phase
March 2025
Preliminary output & Consultation in USA
Preliminary Phase
October 2025
Final report
Refine & Final Phase

Rightsholders, Stakeholders & Literature Review



Notes:

- Global and local businesses - local and state control of businesses complexity
- Countries mostly in the Arctic are represented in the local communities
- Indigenous and local communities is inclusive of their local governance
- Policy makers are under Arctic member countries and local communities
- Climate services under research/government
- Other RPTs might be good to note somewhere (should the RPTs be denoted somewhere within the schematic or outside of the schematic but connected?)
- Iterative feedback that will help us determine the priorities

Details

- Create separate word document with more detail and categorize more detailed representatives into these broader categories
- Record why certain groups are left out

Input Phase

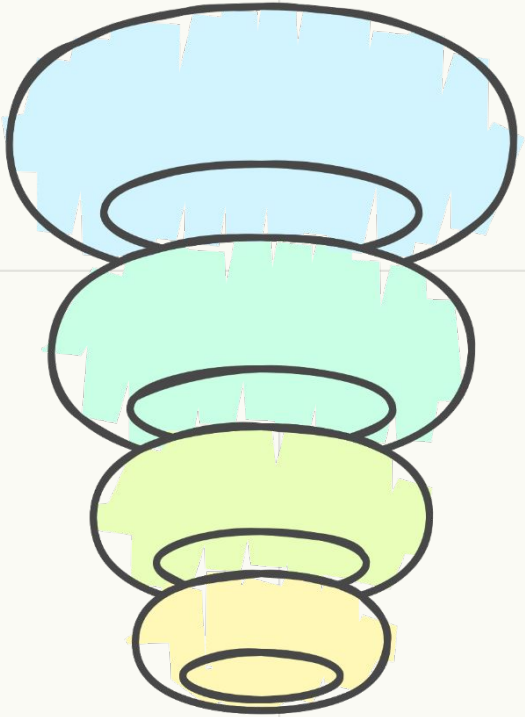
ICARP Survey

Literature review

- Peer-reviewed journal articles
- ICARP III Reports
- Policy Papers & Indigenous Knowledge Sources
- Conference Proceedings
- Government and NGO Reports

RPT 2 members' contributions

Review Phase - AI Integration



Data Preprocessing

Cleaning and standardizing data for consistency

Thematic Analysis

Identifying and categorizing key research themes

Knowledge Gap Identification

Highlighting underexplored areas in research

AI-Driven Summarization

Synthesizing and summarizing findings effectively

Preliminary Phase

- **One need** and **one broad priority** for each of the terrestrial, marine, cryosphere, atmosphere, interactions, and indigenous subgroups
- **Cross-cutting needs** and **cross-cutting priorities** that span across all subgroups and other RPTs (hopefully)

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Recommendations to Feedback Today

Preliminary Recommendations

- 🎯 RPT 2 Needs & Priorities
- 🔗 Cross-Cutting Needs & Priorities
- ✅ Recommendations for Implementation (Specific to RPT2 + Cross-Cutting Priorities)

Structured Discussion

Engaging in focused and guided dialogue

Open Discussion & Feedback

Gathering audience reflections and comments

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ICARP IV - RPT2
Preliminary recommendations

Needs and Priorities specific to the RPT 2 topic area

RPT 2 Research Priority Needs

1. Knowledge Gaps in the Arctic Ocean along the Land-Shelf-Basin Continuum

Description:
Data gaps in the Central Arctic Ocean and knowledge gaps along the Arctic land-shelf-basin continuum and Arctic-Subarctic ocean linkages regarding ongoing climate change

Why It Matters:
Critical gaps in sustained observations in the Central Arctic hinder our ability to assess polar amplification impacts on ecosystems, global carbon cycles, and Indigenous communities.

2. Ecosystem Stability & Responses to Disturbance Under Global Change

Description:
Investigating the cumulative impacts of disturbances (such as permafrost thaw, wildfires, and rain-on-snow events) and climate driven change, including species-specific responses and factors that govern ecosystem resilience.

Why It Matters:
Cumulative disturbances may trigger feedback loops or tipping points, impacting food security, carbon cycling, and Arctic socio-ecological systems.

RPT 2 Research Priority Needs

3. Atmospheric interconnection and changes

Description: Understand the impact of changes in transport of moisture, contaminants, aerosols, and trace gases on ecosystems and populations.

Why It Matters: The Atmosphere largely determines the input of mass, momentum and heat to all other spheres, connecting all of them. The impact of a changing Atmosphere should be assessed considering its influence on life of ecosystems and humans.

RPT 2 Research Priority Needs

4. Advancing Cryosphere Research for a Resilient Arctic and Panet

Description: Improving our understanding of cryosphere-climate interactions is critical for enhancing climate projections, and mitigation and adaptation strategies.

Why It Matters: Rapid cryosphere changes impacts sea level, climate, hazards, ecosystems and ecosystem services, and Arctic communities. There is a critical need to focus on investigating nonlinear feedbacks in the cryosphere, the broader environmental and health impacts of cryosphere change (e.g. carbon, contaminants and pathogens) and improving cryosphere monitoring through integrated observation networks to support better cryosphere representation in climate models.

RPT 2 Research Priority Needs

5. Interactions across Earth System Spheres and how they influence climate feedbacks remain poorly understood

Description:
Assessing how processes at the atmosphere–cryosphere–hydrosphere–biosphere interfaces interact under climate forcing (e.g. heat fluxes, land-ocean exchange) and affect climate feedbacks and ecosystem responses.

Why It Matters:
Integrated, cross-sphere understanding is essential for predicting complex feedbacks and ecosystem responses across Arctic environments. Feedback loops (e.g. albedo changes due to increasing ocean warming) can result in tipping points (e.g. transition of the Arctic from a white to a blue system with sea ice disappearance or terrestrial Arctic greening).

RPT 2 Research Priorities

1. Co-develop Integrated Monitoring & Management Frameworks with Arctic Indigenous Peoples

Why It Matters:
Ensuring Indigenous Knowledge Systems are equally valued alongside scientific methods, leading to more holistic and effective monitoring.

ICARP IV Relevance:
High-impact, community-driven research with global implications

2. Enhance Integrated Cryosphere Monitoring & Modeling

Why It Matters:
Captures nonlinear cryospheric feedbacks (e.g. albedo, greenhouse gas release)
Critical for sea-level rise projections and cryosphere hazard susceptibility mapping and disaster preparedness
Refines predictions through inclusion of Indigenous observations

ICARP IV Relevance:
Actionable through existing tech and Arctic Council frameworks

RPT 2 Research Priorities

3. Assess current and past Arctic Ocean circulation and land-shelf-basin interactions, and their interaction with marine biogeochemical cycles and ecosystems

Why It Matters:

Ocean changes impact carbon cycles, ecosystems, and global circulation
Urgent need to sustain long-term observation networks
Key to understanding marine productivity and biodiversity shifts

ICARP IV Relevance:

Informs mitigation and conservation strategies at Arctic and global levels

4. Understand effects of arctic disturbances and factors that govern ecosystem stability under climate change

Why It Matters:

Focus on comprehensive, long-term monitoring of disturbances and identifying potential ecological tipping points
Tipping points risk irreversible change
Builds resilience by identifying adaptation pathways

ICARP IV Relevance:

Directly supports ecosystem-based adaptation and forecasting

RPT 2 Research Priorities

5. Identifying and understanding key interactive processes at the interface between Arctic systems

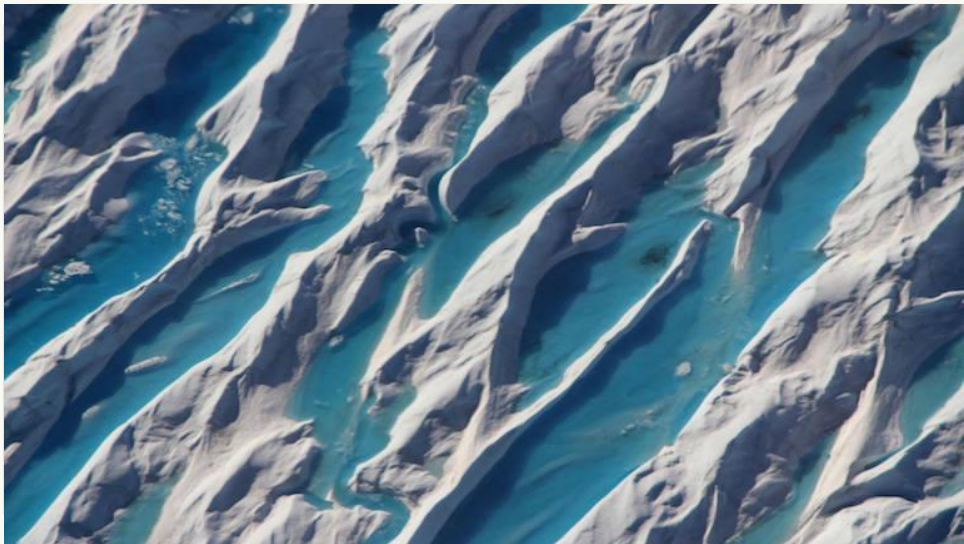
Why It Matters:
These cross-sphere processes (e.g., glacier meltwater→marine ecosystems→biological productivity) influence cascading changes across Arctic systems. Integrated modeling, observation, and paleo reconstructions are essential for forecasting

ICARP IV Relevance:
Enables system-level climate predictions and risk assessments for irreversible Arctic change

6. Coupling models and observations of atmospheric circulation patterns over different spatial and time scales, to better understand the current state of knowledge and gaps

Why It Matters:
Atmospheric changes impact extreme weather, sea ice, and biosphere interactions, requiring urgent understanding for effective preparedness and adaptation in Arctic communities

ICARP IV Relevance:
Supports development of predictions for policy and societal planning



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ICARP IV - RPT2
Cross-Cutting Needs and Priorities
(topics relevant for more than one RPT)

Cross-Cutting Needs

1. Equitable Indigenous Participation in Arctic Research

What: Ensure Indigenous Peoples are involved in observing, reconstructing, and predicting Arctic change.

Why It Matters: Supports Indigenous rights, data sovereignty, ethical engagement, and co-production of knowledge.

Cross-Cutting Needs

2. Improve modeling capabilities for hindcasting and future projections of Arctic ecosystem responses

What: Strengthen process-based models to overcome known limitations, capture nonlinear feedbacks, and identify tipping points.

Why It Matters: Crucial for accurate projections of Arctic ecosystem responses and feedbacks to climate change.

Cross-Cutting Needs

3. Continuity of observations and adequate funding
What: Provide adequate funding to continue existing long-term observation and add new observation networks

Why It Matters: Long-term observations are essential for observing change and stability of ecosystems, even as the climate is changing rapidly in the polar regions, and are needed for robust models. Continuity of funding for existing observations is essential, even as it is also important to add new observation networks.

Cross-Cutting Needs

4. Integration of diverse knowledge systems and research techniques for understanding the Arctic.

What: Systematic inclusion of Indigenous knowledge in monitoring and modeling cryosphere, terrestrial, and freshwater studies.

Why It Matters: Provides holistic understanding of ecosystem dynamics, resilience, and sustainability. Enhances accuracy, policy relevance, and socio-ecological insight; feasible via existing networks.

Cross-Cutting Priorities

1. Strengthening Indigenous-led governance and decision-making in Arctic research.

What: Indigenous decision-making within all level of research within funding systems to individual projects.

Why It Matters: Support Indigenous authority, ethical engagement, and community-driven science.

Cross-Cutting Priorities

2. Foster partnerships between scientists and Indigenous communities

What: Co-designing research and supporting adaptive strategies for Indigenous peoples.
Why It Matters: Strengthens cryosphere and ecosystem resilience; is feasible through Arctic Council mechanisms.

Cross-Cutting Priorities

3. Fund long-term data collection programs and emphasize cross-boundary data sharing

What: Continue existing and establish new permanent monitoring sites and standardized data protocols.
Why It Matters: Fills geographic and disciplinary gaps; supports climate impact tracking and ecosystem assessments.

Cross-Cutting Priorities

4. Improving modeling capabilities for Arctic terrestrial and marine ecosystems, the atmosphere and the cryosphere

What:
Invest in coordinated, modular model development and data integration; Incorporate key abiotic and biotic ecosystem processes into earth system models; Improve capabilities for both future projections and hindcasting

Why It Matters:
Speeds up improvements in predictive capability; facilitates understanding of interactions across the earth system; enables better planning across RPTs.

ICARP IV - RPT2
Preliminary recommendations

Recommendations to Implement the identified Priorities for Arctic Research

Recommendations to Implement Priorities for Arctic Research

4.1 – Implementation of RPT2 Priority 1

Co-developing Integrated Monitoring & Management Frameworks with Arctic Indigenous Peoples

🌐 **Scale:** Local, regional, pan-Arctic, and global (via communities of practice)

💰 **Funding Needs & Sources:**

- **Sustained national funding** for long-term research and monitoring
- **Seed/infrastructure funding** from global, nonprofit, and philanthropic sources
- **Examples:** NSF, EU Horizon, ArcticNet, Nordic Council

📅 **Timeframe:** Immediate and ongoing (2025–2035 and beyond)

📊 **Data Requirements:**

- Ethical data practices
- Indigenous data sovereignty
- Integration of IK with scientific observations

Recommendations to Implement Priorities for Arctic Research

4.1 – Implementation of RPT2 Priority 2

Understanding Nonlinear Feedbacks in Cryosphere–Climate Interactions

🌐 **Scale:** Pan-Arctic → Global implications

💰 **Funding Needs & Sources:**

- **Public agencies:** EU Horizon Europe, NSF, NASA, Research Council of Norway
- **Polar networks:** WCRP, AMAP, ARICE
- **Private sector & local governments** for satellite data, modeling, and co-produced research

📆 **Timeframe:**

- **Immediate (Next 5 years):** Enhance current model accuracy
- **Long-Term (Next 10 years):** Integrate findings into IPCC & global assessments

📊 **Data Needs:**

- Remote sensing (sea ice, glaciers, permafrost, snow)
- In situ (albedo, ice cores, permafrost boreholes, GHG fluxes)
- Model data (CMIP6, Arctic CORDEX)
- Indigenous/local knowledge on seasonal & ecological changes
- AI for feedback modeling & data fusion

Recommendations to Implement Priorities for Arctic Research

4.1 – Implementation of RPT2 Priority 3

Assess Arctic Ocean Circulation & Land–Shelf–Basin Interactions with Ecosystems & Biogeochemical Cycles

🌐 **Scale:** Pan-Arctic to Global (e.g. AMOC influence)

💰 **Funding Needs & Sources:**

- National funding for ship-time and expedition integration
- Shared international infrastructure platforms (e.g., icebreakers, moorings)
- AI-enhanced robotic systems for under-ice and deep-ocean data collection
- Examples: SAS II, DBO, CAOFA-aligned programs

📆 **Timeframe:**

- Immediate relevance over the next 5–10 years and beyond
- Aligns with major campaigns like Synoptic Arctic Survey II (~2030)

📊 **Data Needs:**

- Hydrographic + biological + trace metals + marine biogeochemical data
- Integrated coastal-deep ocean datasets
- AI-enhanced remote sensing & autonomous underwater vehicle outputs

Recommendations to Implement Priorities for Arctic Research

4.1 – Implementation of RPT2 Priority 4

Understanding Arctic Disturbances & Ecosystem Stability Under Climate Change

🌐 **Scale:** Local → Regional → Pan-Arctic

💰 **Funding Needs & Sources:**

- Long-term, sustained funding for monitoring and research
- Potential Sources: NSF, Arctic PASSION, WCRP, AMAP, CAFF, NEON, LTER, AON, national research councils
- Support from Indigenous organizations and local governments

📆 **Timeframe:**

- **Urgent need:** Immediate stabilization of existing observation networks
- **Sustained effort:** Over next 5–10 years and beyond

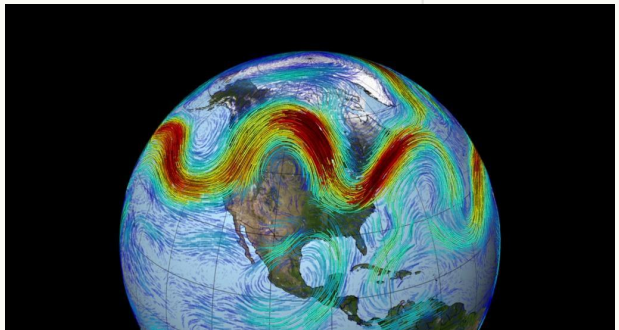
📊 **Data Needs:**

- Long-term in situ (e.g., flux towers, vegetation plots)
- Paleoecological (e.g., tree rings, lake sediments, ice cores)
- Remote sensing (e.g., satellite, UAVs, active sensors)
- Genomic and Indigenous Knowledge

Recommendations to Implement Priorities for Arctic Research

4.1 – Implementation of RPT2 Priority 5

Coupling models and observations of atmospheric circulation patterns over different spatial scales, from historical trends, current patterns to future predictions to better understand current state of knowledge and gaps.



🌐 **Scale:** Local, Regional, Pan-Arctic

💰 **Funding Needs & Sources:**

- Long-term, sustained funding for monitoring and research
- Small project grants to large consortia

📆 **Timeframe:**

- **Urgent need:** Relevant now, but as time progresses increasingly more relevant due to expected changes in the system
- **Sustained effort:** Over next 5–10 years and beyond

📊 **Data Needs:**

- Enhance ground-based networks, i.e. carry out additional projects in existing facilities
- Airborne and Ship/Vessel campaigns
- Remote sensing (e.g., satellite, UAVs, active sensors)
- Observations coupled to modeling activities

Recommendations to Implement Priorities for Arctic Research

4.2. – Cross-Cutting Priority 1

Strengthening Indigenous-led governance and decision-making in Arctic research.

🌐 **Scale:** Local, Regional, and Pan-Arctic

💰 **Funding Needs & Sources:**

- **Sustained funding** from national & international research agencies
- **Non-profit organizations** for capacity-sharing and operational resources
- Examples: ArcticNet, EU Horizon, NSF, private philanthropic funds

📅 **Timeframe: Immediate** and throughout the next **10 years**

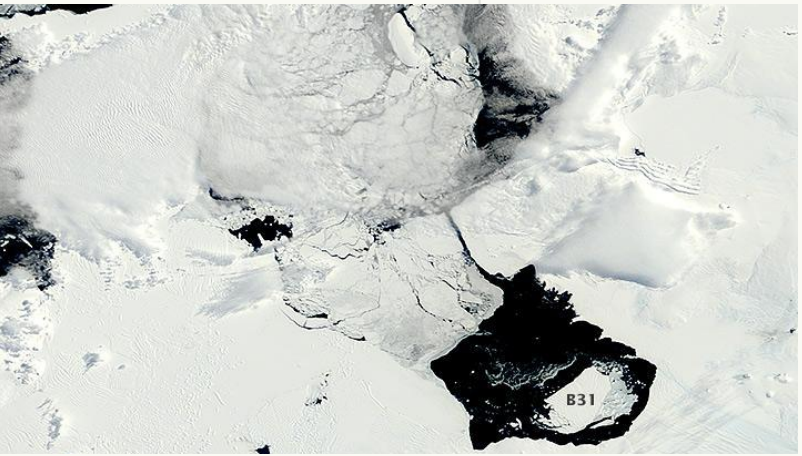
📊 **Data Needs:**

- All research must uphold **Indigenous data sovereignty**
- Full appropriate controls in place for knowledge production, storage, access, and use

Recommendations to Implement Priorities for Arctic Research

4.2. – Cross-Cutting Priority 2

Foster Partnerships Between Research Institutions and Indigenous Communities



🌐 **Scale:** Pan-Arctic

💰 **Funding Needs & Sources:**

- Estimated **$10–20 million USD**
- Potential funders: UNEP, Arctic Council, Indigenous-led research funds, philanthropic organizations

📅 **Timeframe: 2025–2030 (Next 5 years)** – Critical period for building relationships and piloting new models

📊 **Data Needs:**

- Networked community-driven observations
- Shared/ Priority datasets (climate, ecological, geospatial)
- Joint knowledge-sharing platform, framework

Recommendations to Implement Priorities for Arctic Research

4.2. – Cross-Cutting Priority 3

Fund long-term, coordinated data collection programs and emphasize cross-boundary data sharing

🌐 **Scale:** Local → Regional → Pan-Arctic

💰 **Funding Needs & Sources:**

- Long-term, sustained funding is required for existing observation networks and new observations networks to fill gaps
- Potential funding sources include national and international research funding agencies, Arctic research initiatives, and international scientific organizations.

📅 **Timeframe:** next 10 years

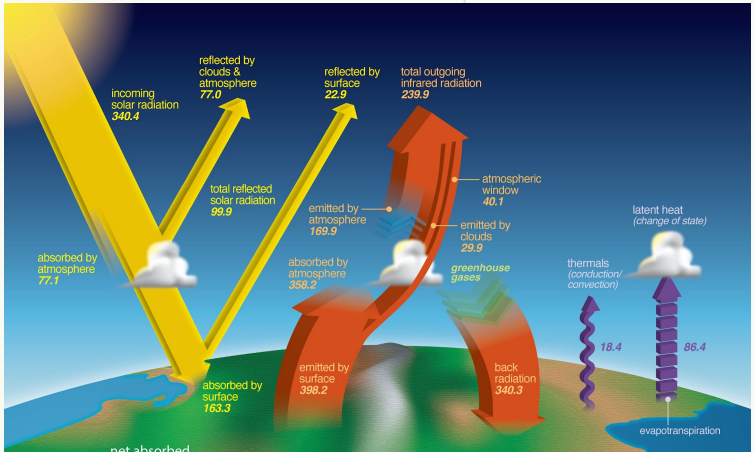
📊 **Data Needs:**

- Continue existing time series observations and collect data that fill gaps
- Data collected and archived using standardized protocols
- Data that adhere to equitable Arctic research principles

Recommendations to Implement Priorities for Arctic Research

4.2. – Cross-Cutting Priority 4

Improve modeling capabilities for Arctic's terrestrial and marine ecosystems, the atmosphere and the cryosphere



🌐 **Scale:** Pan-Arctic, Global

💰 **Funding Needs & Sources:**

- Multi-national funding is required for continuity of modeling efforts

📅 **Timeframe:** Relevant over the next 10 years

📊 **Data Needs:**

- Inventory of existing modeling groups/efforts
- Data required to constrain key model parameters

We look forward to your feedback!

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Structured and Open Discussion