WORLD CLIMATE RESEARCH PROGRAMME

42nd Session of the WCRP Joint Scientific Committee (JSC42)

CliC - Climate and Cryosphere Core Project

Melting Ice & Global Consequences Grand Challenge

Tim Naish (presenting), Fiamma Straneo, James Renwick, Beatriz Balino, Helene Asbjørnsen

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Climate and Cryosphere - *Report to JSC42*

Understanding the changing cryosphere and its climate connections

Who we are	• Organisational Structure • WRCP Ecosystem • Cryosphere Ecosystem
Vision & Mission	• A changing strategic direction • Old • New
What we do	• Melting Ice Grand Challenge and Modeling Intercomparison Projects (MIPs) • Core Activities and Projects
JSC 42 Report	• Highlights • Primary Science Issues • Future Challenges & Opportunities • New Strategic Plan

Current Mission & Who we are

CliC promotes activities aimed at improving our understanding of the cryosphere components of the climate system (sea ice, land-ice, snow cover, permafrost) and their interaction with the Earth System, including the biosphere and humans.

Co-Chairs – Fiamma Straneo (Scripps, UCSD, USA), James Renwick (VUW, NZ)

Scientific Steering Group SSG:
Hanne H. Christiansen (UNIS, NO); Camille Lique (IFREMER, FR); Amy Lovecraft (UAF; USA); Helene Seroussi (JPL-NASA, USA); Lars H. Smedsrud (UiB, NO); Shin Sugiyama (Hokkaido U.; JP); Martin Vancoppenolle (IPSL, FR); Tingjun Zhang (Lanzhou U., CN)

WCRP Grand Challenge Melting Ice: Tim Naish (VUW, NZ)

WCRP Joint Science Committee Liaisons: Jens H. Christensen, Igor Shkolnik

International Project Office: Beatriz Balino & Helene Asbjørnsen (Bjerknes Center, NO)
(Gwen Hamon, Executive Officer of CliC IPO from 2014 to 2020)

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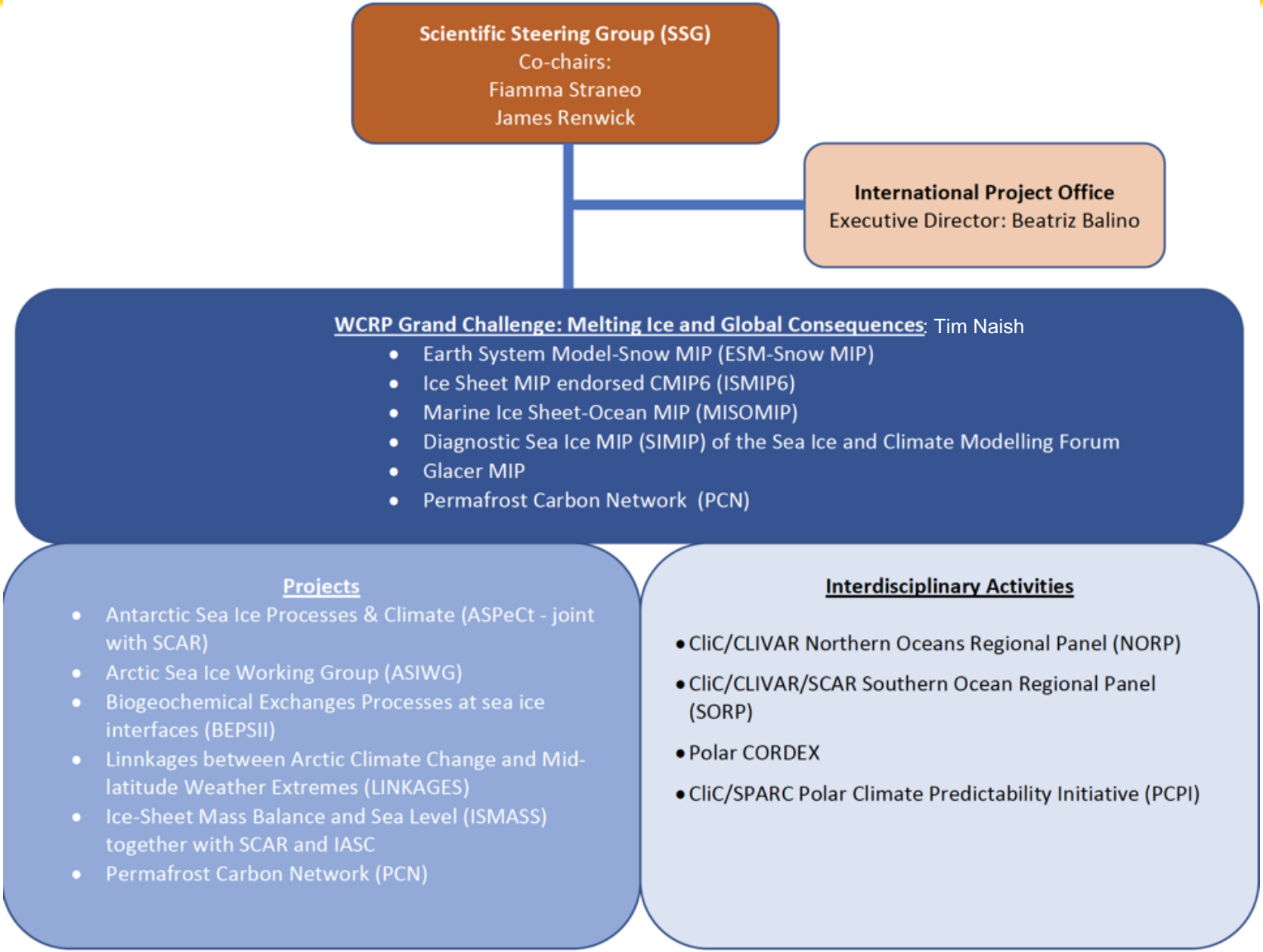
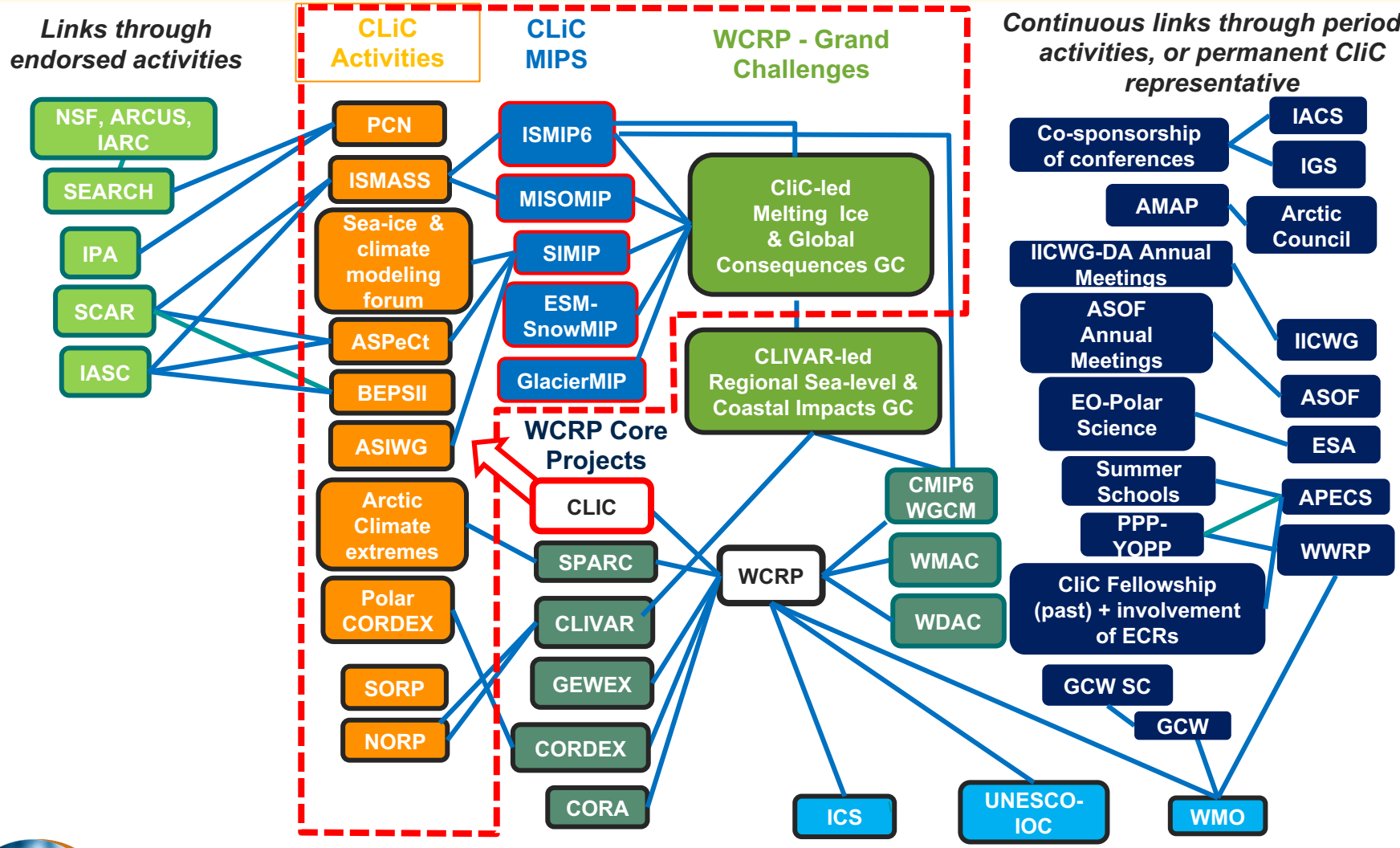
Organisational Structure



WCRP and the broader cryosphere research ecosystem



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What we do

Melting Ice - Grand Challenge and Modeling Intercomparison Projects (MIPs)

- **Earth System Model-Snow (ESM-SnowMIP/LS3MIP) –** Gerhard Krinner (CNRS, FR) Evaluation of current snow schemes (including those in ESM) against observations tied to CMIP6
- **Glacier Model Intercomparison Project (GlacierMIP)** – Ben Marzeion (U. Bremen, DE). Global-scale glacier mass change models
- **Marine Ice Sheet-Ocean MIP (MISOMIP2)** – N. Jourdain (U. Grenoble, FR) Ice sheet/ocean interactions aimed at reducing sea level rise from land-ice loss uncertaintities.
- **Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6)** – S. Nowicki (U. Buffalo, NY) Ice sheet scale simulations for Antarctica and Greenland forced by CMIP6 offline
- **Sea Ice Modeling Intercomparison Project (SIMIP)** – A. Jahn (NCAR, USA) Sea-ice in climate model simulations

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What we do

CliC Core Activities and Projects

- **SOLAS/CliC/IASC/SCAR Biogeochemical Exchanges at Sea Ice Interfaces – BEPSII** – J. Stefels (NL) Biogeochemical processes at the sea-ice interface – polar ecosystems services

- **Arctic Sea Ice Working Group (ASIWG)** – M. Webster (UAF, USA) Coordination of sea-ice observations and modeling

- **Polar Coordinated Regional Downscaling Exp. (Arctic and Antarctic) Polar-CORDEX**– R. Mottram (DMI, DK) Generation of regional scale projections over the Arctic and Antarctic

- **Northern Oceans Regional Panel (NORP) Joint with CLIVAR** – A. Solomon (NOAA, USA)

- **Southern Ocean Regional Panel (SORP) Joint with CLIVAR/SCAR** – I. Smith (U Otago, NZ)

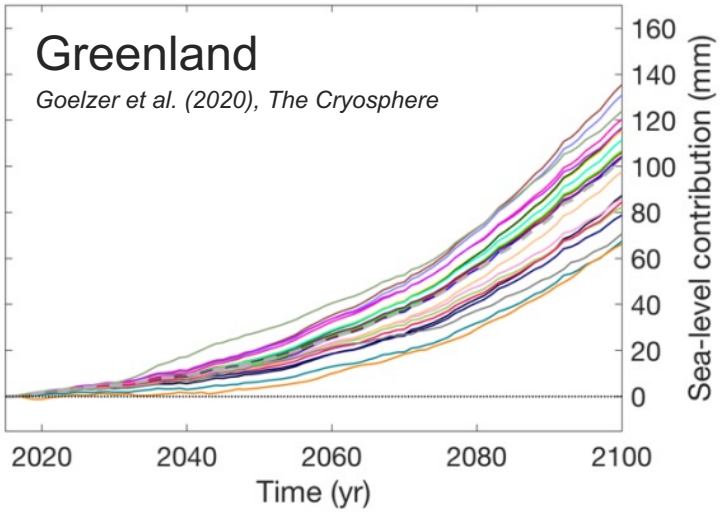
What we do

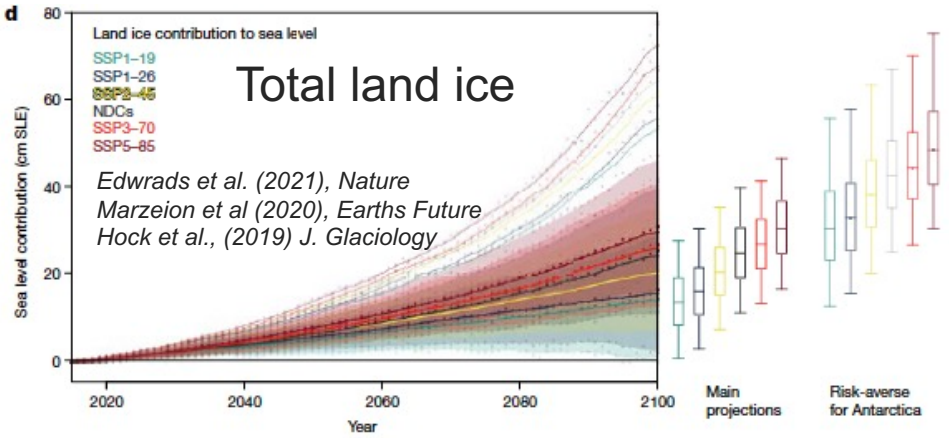
CliC Core Activities and Projects

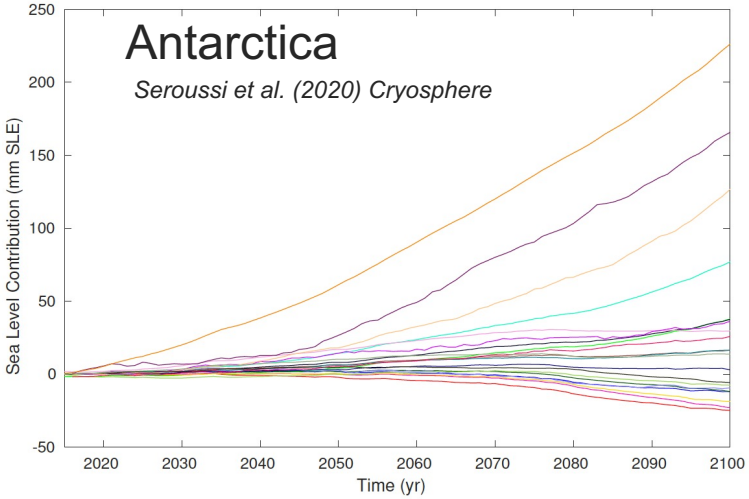
- **Polar Climate Predictability Initiative – PCPI** – M. Raphael (UCLA, USA)
- **Antarctic Sea Ice Processes & Climate (ASPeCt) Joint with SCAR** – M. Raphael (UCLA, USA)
- **Ice Sheet Mass Balance and Sea Level (ISMASS) – Joint with SCAR/IASC** – H. Goelzer (NO)
- **Permafrost Carbon Network** – T. Schuur (NAU, USA)
- **Instabilities & Thresholds in Antarctica (INSTANT) – Joint with SCAR –** T. Naish (VUW, NZ) & F. Colleoni (OGS, Italy)

Research Highlights – ISMIP6 & GlacierMIP

- 20 publications in 2020 *Nature*, *GRL*, and *The Cryosphere in 2021*.







- Underpins IPCC AR6 sea-level projections
- **GrIS -** good agreement, spread due to models
- **AIS -** poor agreement due to EAIS SMB, ocean forcing, and basal melt rates & MISI matters
- **Glaciers -** will lose 18% (79mm) (RCP2.6) to 36% (159mm) (RCP8.5) of their mass by 2100,
- Emulator approach to explore uncertainties
- Large uncertainty remains, but nature of uncertainty better understood

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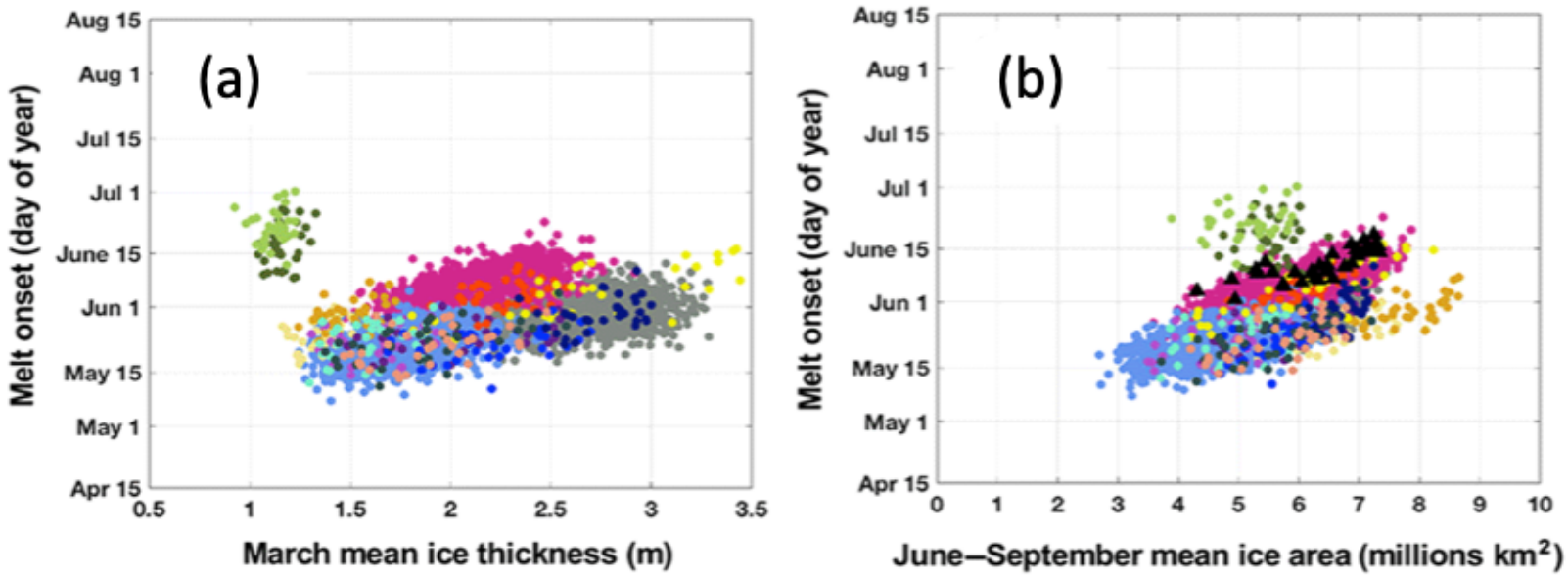
Research Highlights - SIMIP

- Overview on Antarctic Sea ice in CMIP6 models (Roach et al., 2020, GRL).
- CMIP6 sea ice output looking at biases in Arctic sea ice simulations (Smith et al.2020, The Cryosphere)
- The Community SIMIP paper on Arctic sea ice in CMIP6 models (SIMIP Community 2020, GRL)



Research Highlights - ASIGW Arctic Sea Ice Working Group

•Participation in the MOSAiC field experiment. Many of the MOSAiC protocols for sea ice observations were developed by the ASIWG (e.g. measurements of albedo, snow depth, mass balance, melt ponds, ice core stratigraphy).

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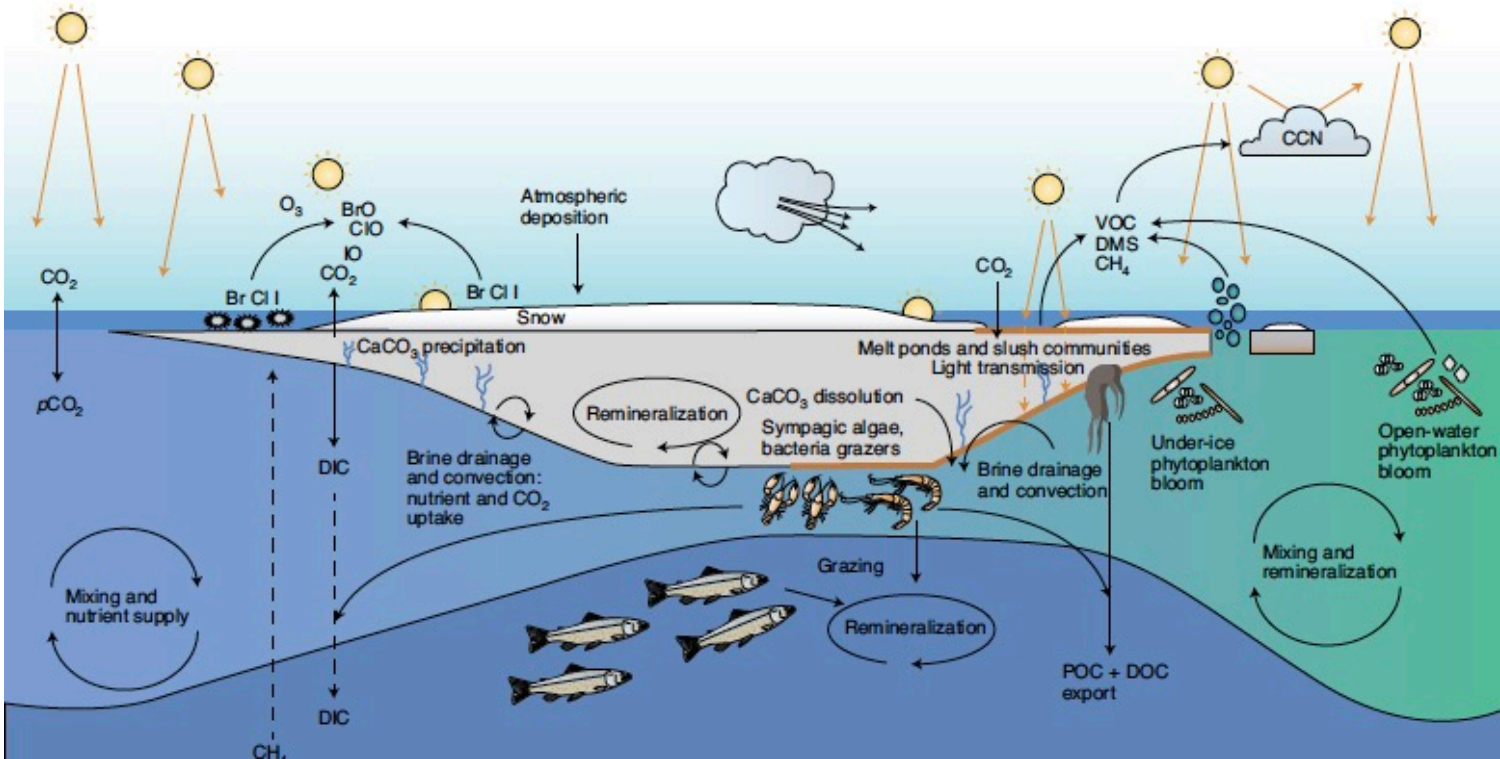
Research Highlights - BEPSII

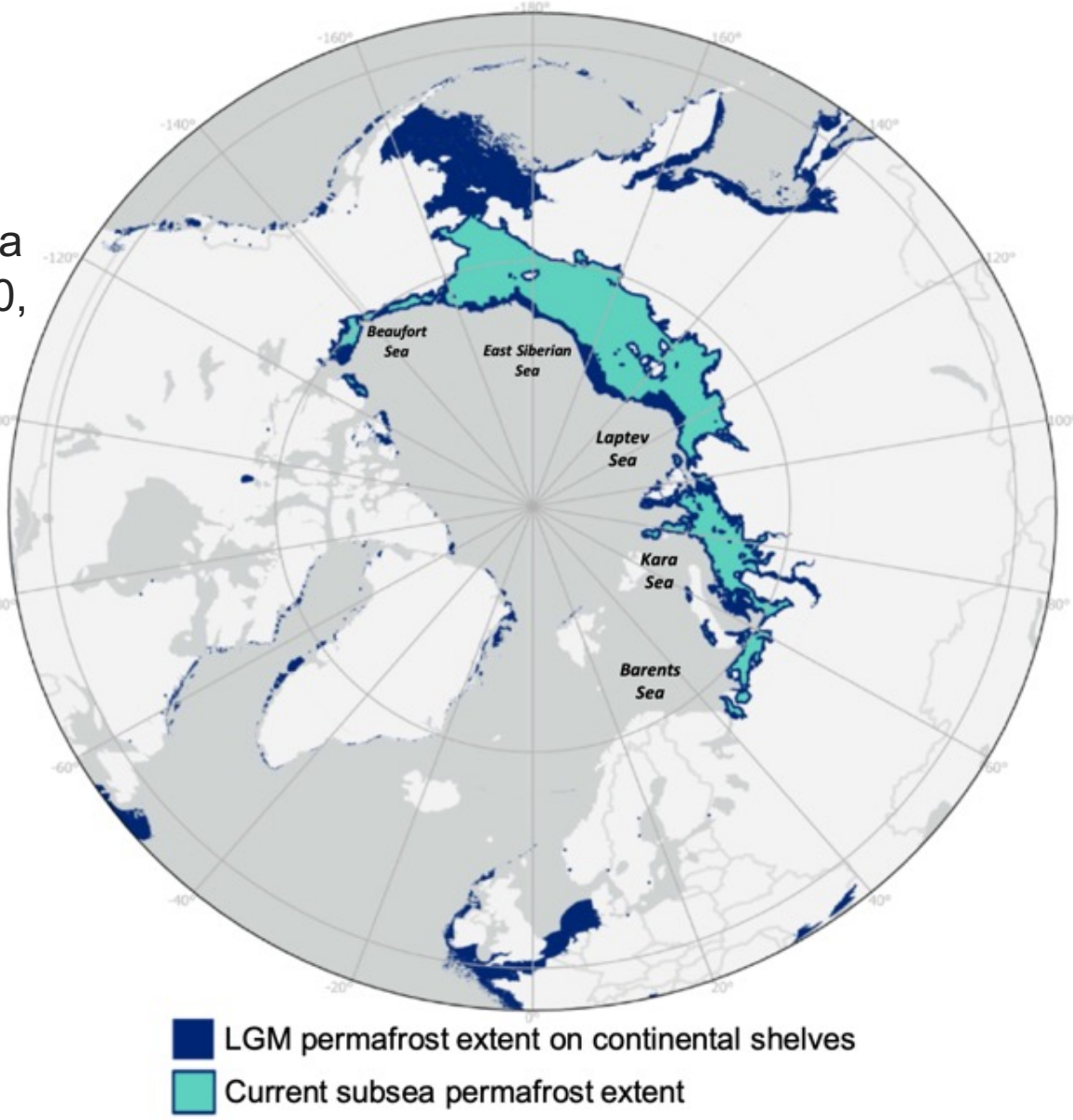
Biogeochemical Exchange Processes at Sea Ice Interfaces

- Collective study from the BEPSII community in *Nature Climate Change* (Lannuzel et al. 2020)
- Disruptive changes to the Arctic sea-ice biogeochemical system and associated ecosystem are expected in the future.
- There is an urgent need for the establishment of long-term observing platforms in climate-sensitive sea-ice regions to collect benchmark data, record seasonal and decadal trends, and to anticipate thresholds and tipping points.



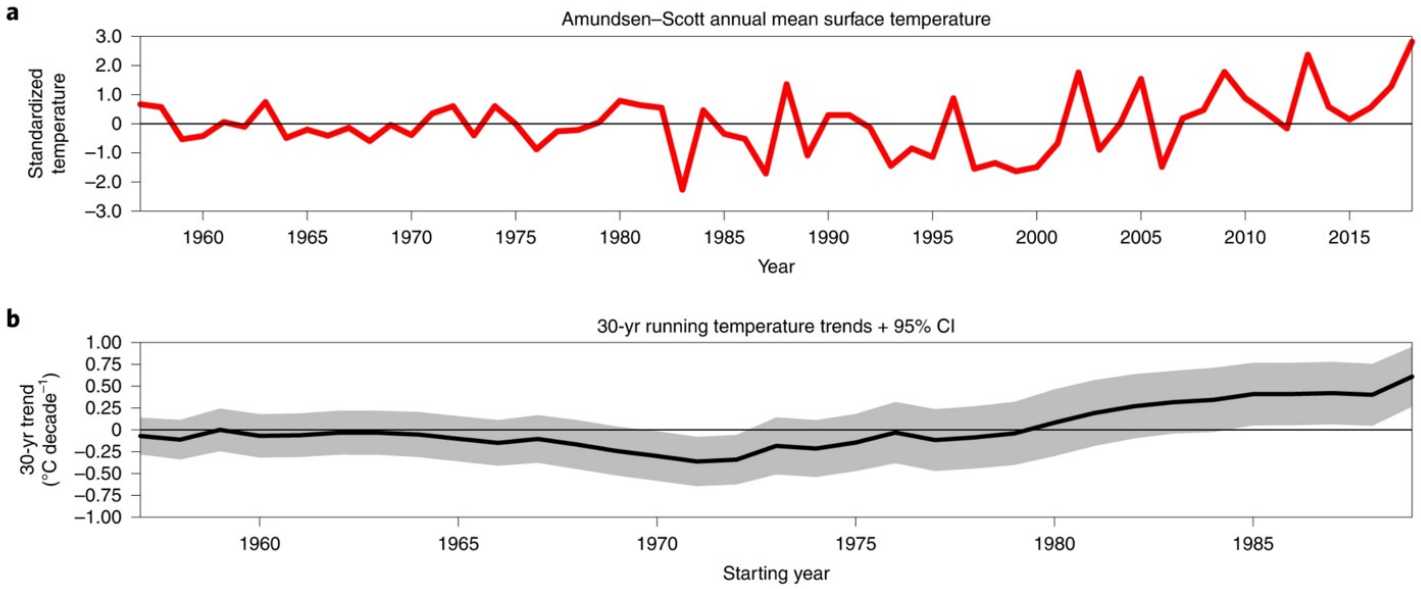
Research Highlights – PCN – Polar Carbon Network

- An expert assessment provides the first circumarctic estimate of the quantity and climate sensitivity of organic carbon in Arctic Ocean subsea permafrost (Sayedi et al. 2020, ERL).
- Slow but substantial greenhouse gas release from submarine permafrost should be expected in the future.
- RCP8.5, the subsea permafrost domain could release 43 Gt by 2100, with approximately 30% fewer emissions under RCP2.6.



Research Highlights - PCPI – Polar Climate Predictability Initiative

- PCPI lead Kyle Clem explore the recent warming over the South Pole in *Nature Climate Change* (Clem et al. 2020)
- The warming of 0.61 ± 0.34°C per decade is more than three times the global average. The warming resulted from a strong cyclonic anomaly in the Weddell Sea caused by increasing sea surface temperatures in the western tropical Pacific.
- The results show how closely linked the interior Antarctic climate is to tropical variability.



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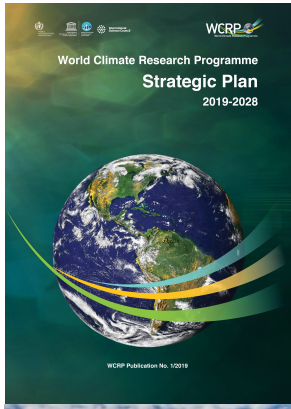
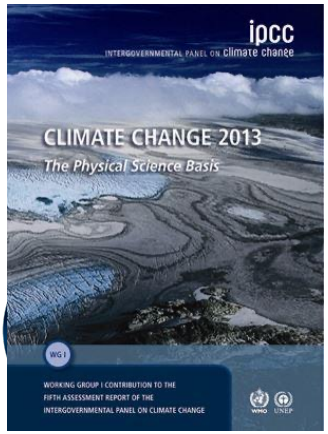
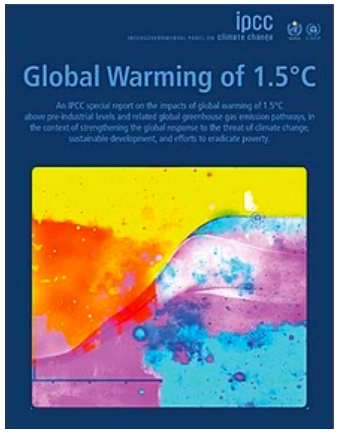
Primary science issues in the Cryosphere

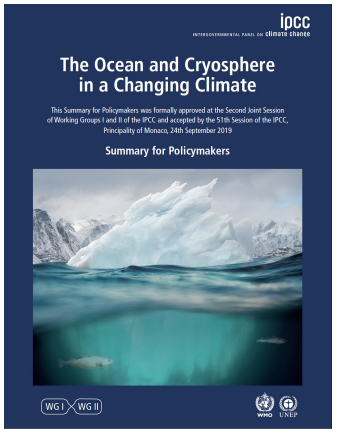
Human impacts & urgent climate services

- Arctic warming and potential for permafrost degassing
- Changes in sea-ice extent
- Polar ice sheet contribution to sea-level rise *1 B people impacted - inundation*
- Loss of Mountain glaciers and ice caps *2 B people impacted – fresh water*
- Antarctic Ice Sheet dynamics and the uncertain contribution to sea-level rise









IPCC AR6

Coming soon

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FUTURE CHALLENGES
&
OPPORTUNITIES

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Future challenges & opportunities

- To date, studies of the drivers and climate-impacts of change in the cryosphere have been largely decoupled from studies of the impact of the loss of cryosphere services for global societies.

- Climate research on the cryosphere facilitated by CliC has largely focused on the physical climate with a limited integration of other natural sciences.

- Projections are needed for adaptation, mitigation and for sustainable development require systems approaches, international collaboration, a diversity of perspectives and engagement with stakeholders.

- CliC will broaden its mission to include research that is co-designed and executed with relevant stakeholders groups, while continuing to support the research that advances understanding of processes within the cryosphere components of the climate system.

CliC Strategic and Action Plan 2022-2031 - *DRAFT*

New Vision

A system description of different cryosphere regions (polar seas, frozen and snow covered land, glaciated regions including ice sheets and mountainous regions) and of the global cryosphere as a whole, including climate, ecosystems, residents and their connections and feedbacks to global climate and society.

New Mission

CliC will facilitate collaborative, international research, and its communication, targeting the global cryosphere and regional cryosphere systems - bridging across climate, ecosystems, humans - and their change to address societal needs

GOALS

- Provide integrated assessments of global chryosphere change
- Provide a forum for launching new activities aimed at addressing the priorities described below
- Leverage cross-disciplinary and international collaboration to address cryosphere priorities
- Provide input and participate in WCRP Lighthouse Activities and link to the new Core Project "Regional Information for Society"

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A new CLiC Strategic Plan - 2022 to 2031

- CliC will promote research to determine what a *'safe cryosphere'* may look like in a *'safe landing climate'* and how the cryosphere may continue to provide the same services to society as it has done in the past
  - *access to freshwater from glaciers,*
  - *transport routes over sea ice,*
  - *solid building ground on permafrost,*
  - *dry fluffy snow for leisure activities and grazing reindeer herds,*
  - *stable sea level from stable ice sheets in Antarctica and Greenland*

- CliC's new strategic plan aligns with the vision of the WCRP's Strategic Plan (2019-2029) "*using sound, relevant, and timely climate science to ensure a more resilient present and sustainable future for humankind",* and addresses directly the fourth strategic objective of *"bridging climate science and society*".

- CLiC will also partner with SCAR's new strategic research program, INSTANT, which is focussed on improving knowledge of instabilities and thresholds in the Antarctic ice sheet to reduce uncertainties in sea-level rise projections

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5 future priorities for CLiC

1. ***Engagement of the broad and diverse community in cryosphere research***
   - researchers, indigeneous communities, residents from cryosphere regions nations and organizations currently under-represented in groups supported by CliC's activities.
2. ***Projection of Future Ice loss and Impacts***
   - improve projections of ice loss (understanding of processes and model improvement) at global, regional scales and for each cryosphere component. Implications for mitigation pathways, avoided impacts and adaptation.
   - short-term, long-term and tipping points for both the physical climate,
3. ***Cryosphere Ice Loss - Assessment and Impacts***
   - identify services provided by ice and integrate societal cost in estimates of ice loss (environmental economic, social & cultural).
4. ***System Description of the Cryosphere Regions***
   - integrated description of cryosphere systems across multiple components, disciplines and bridging across the natural and social sciences.
   - Implications for biosphere and communities directly tied to several of WCRP's LHAs
5. ***Knowledge Syntheses and Communication to Stakeholders***
   - WCRP Core project – Regional Information for Society

CLiC involvement in WCRP LHA's

Title	CliC representative / Expertise
My Climate Risk	• Hanne Christiansen, University Centre in Svalbard, Norway / Permafrost dynamics and geohazards
Digital Earths	• Camille Lique, Laboratoire d'Océanographie Physique et Spatiale (LOPS), France / Arctic Ocean dynamics • Helene Seroussi, JPL, CalTech, USA / Modelling of ice sheets and sea level rise; ISMIP6
Explaining and Predicting Earth System Change	• Patrick Heimback, University of Texas Austin, USA / Ocean and ice sheet dynamics, variability and interactions; CLIVAR/CLIC NORP
Safe Climate Landings	• Heiko Goelzer, NORCE AS & Bjerknes Centre for Climate Research, Norway/Ice sheets modelling and contribution to sea-level rise; ISMIP6 • James Renwick, University of Wellington, New Zealand
WCRP Academy	• Amy Lovecraft, University of Alaska Fairbanks & Center for Arctic Policy Studies, International Arctic Research Center/Bridging science, policy, and civic life in social-ecological systems to explore the dynamics of climate change and development uncertainties in the Arctic

Next steps

1. Complete CLiC Strategic Plan aligned with WCRP new strategic plan

2. Open call for new ideas for working groups or projects.

3. Increase diversity, participation of under-represented nations in cryosphere science: Establish a fellowship for Early Career Scientists from under-represented cryosphere regions to participate/visit partner institutions or attend conferences

4. Knowledge synthesis and increase engagement with stakeholders: Link to the new WCR Core Project "*Regional Information for Society*"

Thank you!

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CLiC involvement in WCRP LHA's

My Climate Risk* To develop a new framework for assessing and explaining regional climate risk to deliver climate information that is meaningful at the local scale.	*Hanne Christiansen* University Centre in Svalbard, Norway Permafrost dynamics and geohazards Additional Nomination submitted for a member of the Association of Early Career Scientists submitted to WCRP.
Digital Earths To develop a digital and dynamic representation of the Earth system, optimally blending models and observations, to enable an exploration of past, present, and possible futures of the Earth system.	*Camille Lique,* Laboratoire d'Océanographie Physique et Spatiale (LOPS), France /Arctic Ocean dynamics & *Helene Seroussi,* JPL, CalTech, USA/ Modelling of ice sheets and sea level rise; ISMIP6
Explaining and Predicting Earth System Change To design, and take major steps toward delivery of, an integrated capability for quantitative observation, explanation, early warning, and prediction of Earth System Change on global and regional scales, with a focus on multi- annual to decadal timescales.	*Patrick Heimback* University of Texas Austin, USA Ocean and ice sheet dynamics, variability and interactions; CLIVAR/CLIC NORP
Safe Climate Landings To explore the routes to climate-safe landing 'spaces' for human and natural systems, on multi-decadal to centennial timescales; connecting climate, Earth system, and socio- economic sciences. Explore present-to-future "pathways" for the achievement of key SDGs	*Heiko Goelzer* NORCE AS & Bjerknes Centre for Climate Research, Norway Ice sheets modelling and contribution to sea-level rise; ISMIP6 *James Renwick* University of Wellington, New Zealand.

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Current Mission

Current Mission: CliC promotes activities aimed at improving our understanding of the cryosphere components of the climate system (sea ice, land-ice, snow cover, permafrost) and their interaction with the Earth System, including the biosphere and humans.

CliC is broadening its mission to include research that is co-designed and executed with relevant stakeholder groups, while continuing to support the research that advances understanding of processes within the cryosphere components of the climate system.

New Vision: A system understanding of the global and regional cryosphere (polar seas, frozen and snow covered land, glaciated regions including ice sheets and mountainous regions), that includes the physical climate, the ecosystems, the residents and their connections, and feedbacks to global climate and society.

New Mission: CliC will facilitate collaborative, international research, and its communication, targeting the global and regional cryosphere (bridging across climate, ecosystems, human society) and their change, from regional to global scales, to address societal needs.