Proposals for SCAR INSTANT sub-committees

February 11th, 2021

Proposals will be discussed during the kick-off.
Additional sub-committees can be proposed during and after the kick-off.

Theme 1: Atmosphere - Ice interactions

No actual proposals

Theme 2: Ocean – Ice interactions

1- Southern Ocean-Antarctic interactions - **Proposers:** Mike Weber & Frank Lamy

Theme 3: Earth – Ice interactions

1- Antarctic geological Boundary Conditions (ABC) - **Proposers:** Stewart Jamieson (proposer) & Pippa Whitehouse (co-proposer)

2- Antarctic Geothermal Heat Flow - **Proposers:** Tobias Stål (University of Tasmania), Mareen Lösing (Kiel University), Alex Burton-Johnson (British Antarctic Survey)

3- Probing the solid Earth and its interactions - **Proposer:** Mirko Scheinert (TU Dresden, Germany)

Theme 4: Science stakeholders interactions

No actual proposals

Across-Theme:

1- Earth-Ice-Sea Level (EIS) **- Proposers:** Matt King and Pippa Whitehouse – actual leaders to be discussed, but should include diversity in career stage, gender, and geography

2- Inter ice-sheet models simulation design **- Promoted by:** Catherine Ritz

3- Exploiting satellite observations for understanding ice sheet dynamics - **Promoted by:** Martin Horwath (TU Dresden). Matthias Willen (ECS, TU Dresden)

4- Global and regional climate models (no actual written proposal) - **Promoted by**: Ayako Abe-Ouchi, Florence Colleoni (leadership to be decided)

5- Paleoclimate Proxies: interpretations (no actual written proposal) - **Promoted by**: Tim Naish

Theme 2: proposals of sub-committee

Proposal 1/1:
Southern Ocean-Antarctic interactions
Proposers: Mike Weber & Frank Lamy

PROPOSAL 1:

Southern Ocean-Antarctic interactions

Mike Weber
Frank Lamy

Purpose of the sub-committee:

We would like to propose a subgroup with a focus on the Southern Ocean with the Antarctic Circumpolar Current (ACC) and its interaction with the Antarctic Ice Sheet (AIS). What can we learn from new and emerging records of past AIS, ACC and Southern Hemisphere Westerly Winds dynamics? How does this relate to past and future development of global mean sea level and the global thermohaline circulation? How do we integrate these findings with records from the continent? How can we make use of these findings in numerical modeling of AIS mass loss and global mean sea-level rise and the impact of ACC changes on global climate and oceanography?

High-latitude Southern Ocean marine records cover an important gap between far-field records and projections of the tropics and the Northern Hemisphere, and the near-field records from the Antarctic continent. The advantage of such marine records is the high temporal resolution, the continuity of the records, the long stratigraphic extent and the spatial integration of information relevant to ice-atmosphere-ocean interactions, and intensity and source of AIS mass loss and associated sea-level rise.

The ACC, arguably the most important ocean current on the planet. The ACC is the world's strongest current by far, carrying more than 150 times the volume of the world's rivers combined. As it encircles the Antarctic continent, it connects all three major global ocean basins (the Atlantic, the Pacific, and the Indian Oceans) and therefore integrates and responds to global climate variability.

Recent results from ocean drilling and their implications to ice-ocean-atmosphere dynamics around Antarctica have pushed the envelope and provided benchmarks for future work. A few relevant high-impact papers are listed below and further groundbreaking work is in the making.

How this sub-committee supports INSTANT objectives:

"The Southern Ocean-Antarctic interactions" sub-committee mainly relates to Themes 2 (ocean-ice interaction) and 1 (atmosphere-ice interactions) of the INSTANT program. This is just an initial step towards organizing and structuring such a group. It will be of course open to anybody who wishes to contribute. Leader would be Mike Weber, co-leader Frank Lamy. Both were co-chiefs on recent Southern Ocean IODP expeditions.

Theme 3: proposals of sub-committee

Proposal 1/3
Antarctic geological Boundary Conditions (ABC)
Proposers: Stewart Jamieson (proposer) & Pippa Whitehouse (co-proposer)

Proposal 2/3
Antarctic Geothermal Heat Flow
Proposers: Tobias Stål (University of Tasmania), Mareen Lösing (Kiel University), Alex Burton-Johnson (British Antarctic Survey)

Proposal 3/3
Probing the solid Earth and its interactions
Proposer: Mirko Scheinert (TU Dresden, Germany)

PROPOSAL 1:

Antarctic geological Boundary Conditions (ABC)

Stewart Jamieson (proposer) & Pippa Whitehouse (co-proposer)

Purpose of the sub-committees:

The aim is to continue developing knowledge of geological boundary conditions on and offshore in order to support studies of past, present and future Antarctic stability. As we saw under PAIS and via various SCAR action groups, the integration of geological information relating to the landscape beneath the ice sheet past and present has enabled significant advances to be made relating to our understanding of Antarctic ice sheet response to changing climates. However, by making stronger links between the geology, geomorphology and glaciology we might gain better understanding of controls on past and present ice behaviour and how the subglacial environment may modulate ice sheet response to climate.

Objectives might include:

- Continuing to improve maps of present-day topography and bathymetry
- Developing/improving reconstructions of past topography and bathymetry by quantifying erosion/deposition patterns and vertical movements in the landscape
- Enhancing understanding of the distribution of water at the base of the ice sheet via modelling and geophysical data analysis
- Quantifying Antarctic geothermal heat flow
- Mapping subglacial geology (e.g. linking potential fields and drilling etc.)

The overall goal of such a group would be to continue developing better quantifications (e.g. maps with uncertainties) of the above geological boundary conditions that could be used as inputs to numerical models of ice sheet behaviour. Where such work is operating as a SCAR-Action group, this sub-committee might act to integrate that work with INSTANT's goals.

Note that such a sub-committee might be too large, in which case it could be sub-divided depending on discussion. However, a point to make is that encouraging cross-disciplinary discussion may bring new understanding of geological boundary conditions. Until now, the objectives above have to some extent been addressed independently, with either their own sub-committees or action groups within SCAR, PAIS, or SERCE. However, given INSTANT's broader remit as compared to PAIS or SERCE, focused work on integrating these fields might allow us to improve understanding. For example, by linking our understanding of geology, sediment distribution, topography and water distribution, we might better understand controls on the pattern of basal slip. If we understand the geology and the way the ice interacts with it over time, we might produce better reconstructions of past Antarctic topography and heat flux which might allow us to better model ice sheet behaviour during past warm periods. Feedbacks between geology and ice behaviour can therefore be better understood and integrated into modelling frameworks. This sub-committee might address some of these aspects.

How this sub-committee supports INSTANT objectives:

INSTANT will implement research in each of its themes using observations, reconstructions, increased understanding of processes and numerical modelling.

The proposed theme (or multiple themes should this be favoured) would have a goal of developing better quantifications (e.g. maps with uncertainties attached) of modern and past geological boundary conditions that could be used as inputs into numerical models testing the past, present and future response of the ice sheet. In particular, this sub-committee might help address a range of priority research questions as highlighted below (italics indicate possible input from this sub-committee):

<u>Theme 2: Ocean-Ice interactions:</u>

- What is the role of bathymetry in heat exchange between the ice and the ocean – needs improved bathymetry maps (past and present) and sub-ice shelf cavity maps.
- What is the role of ocean dynamics at the margins of ice shelf cavities? Relies on better bathymetric and cavity maps.
- How do marine sediment records inform us about past variability? – Needs better understanding of bathymetry and offshore stratigraphy (e.g. linked to palaeo topography)

<u>Theme 3 – Earth-Ice interactions:</u>

- What are the subglacial properties and processes relevant for past and future ice dynamics? – needs knowledge of ice bed and processes operating at that interface as well as heterogeneity of heat and water.
- What is the role of geological controls and erosion and sedimentation on ice sheet dynamics? Needs understanding of coupled evolution (e.g. feedbacks) of the ice sheet and its bed, on and offshore.
- How do glaciological, geological and geophysical records inform us about ice sheet and landscape? Needs knowledge of subglacial geology, investigations of provenance (e.g. erosion and deposition), and basin evolution.

By bringing together geological aspects of basal boundary conditions, we might be better placed to address Theme 4 of Stakeholder engagement by developing an integrated suite of basal boundary conditions that can be used in numerical models to explore uncertainty in ice sheet response to warming climate using past warm periods to guide understanding the future.

PROPOSAL 2:

Antarctic Geothermal Heat Flow

Tobias Stål (University of Tasmania)
Mareen Lösing (Kiel University)
Alex Burton-Johnson (British Antarctic Survey)

Purpose of the sub-committee:

The Antarctic ice sheet is the world's largest potential driver of sea level change, and accurate dynamic modelling relies on constraining conditions at the ice-bedrock interface. Measuring basal conditions is inherently challenging and geothermal heat flow (GHF) is one of the least constrained variables affecting ice sheet dynamics. Despite this uncertainty, GHF affects: 1) the basal ice temperature and mechanical properties; 2) basal melting and sliding (affecting the subglacial hydrological systems and subglacial lakes); and 3) the development of unconsolidated water-saturated sediments; all of which promote ice flow. Beyond ice dynamics, constraining GHF allows us to model past basal melt rates to explore for old ice core climate records, constrain glacial isostatic adjustment (GIA) models, inform on Antarctica's geological and tectonic development, and study the conditions for subglacial habitats.

In recognition of the ambiguity and importance of Antarctic GHF, studies in geology, geophysics, and glaciology have sought to constrain it. This posed the challenge of communicating and coordinating research across different fields and institutes. We propose the evolution of the SERCE GHF sub-group as an INSTANT Sub-Committee. This group will take an interdisciplinary approach to constrain Antarctic GHF, providing a platform to support international interdisciplinary communication and data access, highlighting and communicating developments, challenges, and questions via publications and meetings, both in person and online.

The SCAR-SERCE sub-group on GHF proposed specific interdisciplinary research directions for INSTANT in their 2020 White Paper (Burton-Johnson, A. et al. (2020). Antarctic Geothermal Heat Flow: Future research directions. SCAR-SERCE White Paper. https://tinyurl.com/y237qwjb).

Glaciological objectives
- Use evidence for basal melting to improve and expand inverse glaciological GHF estimates.
- Improve the thermal models used for inverse glaciological modelling, developing continental models incorporating the variation and effects of temperature between glacial and interglacial periods.
- Consider topographic effects on GHF.
- Support the development of radar sounding systems and analyses optimised for constraining englacial and basal temperatures.
- Collate radar reflectivity data to identift basal melting, englacial layers, and englacial temperature-dependent radar attenuation.

- Validate the feasibility for GHF estimation from shallow glacial boreholes, using new and existing borehole data to expand local GHF estimates.
- Support collection of long-wavelength microwave emissivity data via satellite, airborne, and ground-based sensors.

Geophysical objectives
- Derive new geophysically-derived GHF estimates combining seismic, magnetic, gravity and thermal isostasy models to constrain the three-dimensional structure and composition of the mantle and lithosphere.
- Support better resolved 3D models of the Antarctic mantle using integrated geophysical and remote sensing techniques, and geological information from outcrop and mantle xenoliths.
- Integrate into the geophysical approaches a more accurate model of the structure and distribution of heat producing elements within the crust, considering heterogeneities in the underlying mantle.

Geological objectives
- Estimate local GHF from the thermal gradient in subglacial bedrock boreholes (e.g. via Rapid Access Ice Drilling).
- Expand the crustal geochemistry database from rock outcrops and glacial deposits.
- Validate GHF models against geology, using xenoliths, crustal sections, and exposed outcrops.

Cross-disciplinary objectives
- Apply statistical techniques to existing data to estimate GHF and uncertainty metrics.
- Ensure GHF estimates and uncertainties are accurately and transparently communicated, hosting estimates and models on an accessible platform.
- Support studies of subglacial habitats and integration of GHF and ecological observations.

How this sub-committee would support INSTANT objectives:

INSTANT aims to constrain Antarctica's uncertain past and future contribution to sea-level change via an interdisciplinary Earth systems approach, improving our understanding of the interactions and feedbacks between the ocean, atmosphere, solid earth and the Antarctic ice sheet (AIS), and effectively communicating this with stakeholders. Like its SERCE predecessor, the proposed INSTANT sub-committee on Antarctic geothermal heat flow (GHF) will support these objectives by integrating glaciologists, geologists, and geophysicists from across SCAR to address one of the least constrained basal parameters of the AIS. The remit of the GHF sub-committee would most closely align with INSTANT Theme 3: Earth-Ice Interactions.
The prosed GHF Sub-Committee will support the Scientific Research Programme by following INSTANT's data-model approach (https://tinyurl.com/yybuxqfh):

1. Recent observations and paleo-reconstructions of the ice-atmosphere-ocean-Earth system, identifying forcings, feedbacks, and rates of change.
GHF estimation and implementation requires integrating independent data and estimates from geology, geophysics, and glaciology. We will coordinate and communicate research in

all of these fields and provide a platform to discuss their implications and discrepancies between fields over all geographic and temporal scales.

2. Process understanding at all time scales.
GHF and its effects vary over geological and glaciological time scales. This variation requires understanding of the geological processes producing GHF, and the glaciological processes (including shallow thermal variation) that both influence and obscure basal temperatures. The proposed group will investigate and communicate these processes and their implications across disciplines.

3. Modelling at all time scales (reconstructions and projections).
Past and future AIS models are influenced by GHF and its effects and we will provide and communicate the constraints required to incorporate GHF into ice dynamic modelling at various temporal and geographical scales. This includes continental models incorporating low-frequency variation, and regional models incorporating high-frequency variation, utilising and communicating the strengths, limitations, and implications of the interdisciplinary methods by which GHF is estimated.

4. Engagement with representative stakeholders throughout the SRP.
We will communicate with stakeholders within and outside the GHF community. GHF research itself requires interdisciplinary communication and coordination, and the sub-committee will provide a platform to communicate findings, challenges, and future questions, enabling successful and efficient research. We will also provide a platform to coordinate effective communication with the ice sheet and GIA modellers utilising GHF estimates, including encouraging attendance of our meetings and distribution of our group's findings and recommendations.

PROPOSAL 3:

Probing the solid Earth and its interactions
Mirko Scheinert (TU Dresden, Germany)

Purpose of sub-committee:

To fulfil its overall goal questioning Antarctica's uncertain contribution to sea-level, INSTANT puts a major focus to increasing the amount and coverage of observations. With regard to the solid Earth and its interaction with ice, ocean and atmosphere there is a variety of geodetic and geophysical techniques having the capability to provide in-situ (ground-based or near-surface) observations of a number of processes and/or parameters. However, technique-specific capabilities might not have been exploited to their optimum, either caused by the severe environmental Antarctic conditions and difficult logistics, or by not considering synergies between different techniques. Amongst these techniques are:

• geodetic GNSS to infer bedrock displacement;
• seismology to infer rheological properties of the Earth interior;
• tide gauges to provide long-term time series to infer relative sea-level changes;
• airborne gravimetry and magnetometry to infer observables of the Earth potential fields, further utilized
– to adjust a proper reference for mean sea level (regional gravity field solution);
– to infer subglacial and ocean bottom topography (inversion of gravity observables);
– to aid the inference of rheological properties and Antarctic orogeny;
• airborne radar echo sounding (RES) to infer properties of the interior ice body and to determine subglacial topography;
• ground-based gravimetry (absolute and time series recordings) to provide additional observables to study Earth deformation (and providing reference for airborne gravimetry).

This sub-committee aims to considerably improve the cooperation between scientists from different disciplines being active in realising in-situ geodetic and geophysical measurements in Antarctica as well as between "observers" and "modellers".
To highlight questions which should be tackled:

• Which observations are needed by modellers to improve the observational basis and to deliver (more and better) constraints for the modelling?
• Where are new / repeated / time series observations needed?
• How can observations be combined to reveal interrelations within processes or between different processes that (otherwise) remain hidden?
• How can findings resulting from an improved modelling feed back to better process geodetic and geophysical data? (For example, when dealing with the so-called "elastic correction" of GNSS-inferred vertical displacement rates.)
• How can national Antarctic and funding agencies be convinced so that continuous data recordings can be continued and new (permanently recording) equipment be installed? (Monitoring and infrastructure aspects)
• How can scientists of other/neighbouring disciplines be trained to carry out specific observations / to set-up special equipment in order to optimize efforts and costs of field work in Antarctica?

How this sub-committee: would support INSTANT objectives:

All the named observation techniques deliver valuable data to constrain modelling efforts to better understand the processes that interlink solid Earth with cryosphere, hydrosphere and atmosphere. Thus, all three main themes 1 to 3 are supported. For instance, geodetic GNSS is the only (widely used, standard) technique to provide direct constraints to study glacial-isostatic adjustment (GIA). However, questions have to be answered like: Are the geodetic GNSS observations already sufficient in terms of both spatial and temporal coverage? What can we learn from continuing the recordings? These geodetic GNSS observations should be complemented by ground-based gravimetry and by tide gauge recordings. Especially (long-term) tide gauge records have the capability to provide a valuable link between regional sea-level change and the vertically displacing bedrock. However, tide gauge recordings are very sparse in Antarctica, hence, major efforts are needed that involve scientists and responsible agencies to improve that specific situation. Aircraft surveys have the capability to accommodate the entire suite of airborne geodetic and geophysical equipment to acquire observations of a number of solid-Earth as well as ice-related quantities in the same time. E.g., if laser altimeter (or scanner) and RES are flown together it will be possible to learn about the different penetration depths of the various electro-magnetic waves, and thus to validate and/or correct satellite measurements. Seismology provides measurements to learn about the rheology of the Earth interior. Here we may build upon excellent experiences bringing geodetic GNSS and seismology together in the framework of the IPY project POLENET. However, insights from seismology still have to be combined with potential field measurements in a better way to further constrain the inference of rheological parameters which is a highly ill-posed problem.
Thus, the cooperation between observers and modellers should be strengthened in order to improve the mutual understanding and to being able to utilize the modelling to better understanding the involved processes.
A strong support to all themes will be gained in bringing together scientists from all disciplines carrying out in-situ observations in Antarctica. There is ample space to improve the cooperation and to fully use synergies when realizing measurements in Antarctica. This also means to increase the level of awareness w.r.t. to observational techniques of neighbouring disciplines. Another synergetic aspect arises when developing new observation platforms (e.g. unmanned aerial vehicles) or technologies (e.g. for unattended power supply).
Also, to aid an improved understanding of policy makers (theme 4) can feed back to these observational disciplines in order to ensure the continuation as well as the initiation of new recordings and the provision of infrastructure to realize new and repeated measurement (especially airborne) campaigns.
This sub-committee will be based on fully exploiting cross-linkages between already existing SCAR groups, namely (among others) SCAR EGs GIANT, ADMAP, GRAPE, IBSCO and ISMASS, and bodies outside of SCAR (e.g. International Association of Geodesy sub-commissions 1.3f on Antarctic reference frame and 2.4f on Geoid and Gravity Field in Antarctica).

ACROSS-THEME

Proposal 1/5
Earth-Ice-Sea Level (EIS)
Proposers: Matt King and Pippa Whitehouse – actual leaders to be discussed, but should include diversity in career stage, gender, and geography

Proposal 2/5
Inter ice-sheet models simulation design
Promoted by: Catherine Ritz

Proposal 3/5
Exploiting satellite observations for understanding ice sheet dynamics
Promoted by: Martin Horwath (TU Dresden). Matthias Willen (ECS, TU Dresden)

Proposal 4/5 (no actual written proposal)
Global and regional climate models
Promoted by: Ayako Abe-Ouchi, Florence Colleoni (leadership to be decided)

Proposal 5/5 (no actual written proposal)
Paleoclimate Proxies: interpretations
Promoted by: Tim Naish

PROPOSAL 1

Earth-Ice-Sea Level (EIS)

Matt King and Pippa Whitehouse

– actual leaders to be discussed, but should include diversity in career stage, gender, and geography

Main related INSTANT Theme (or across several themes)

Earth-Ice Interactions and Ocean-Ice interactions

Short description of the objectives (max 4000 char.)

The aim of this sub-committee is to advance our understanding of the feedbacks operating between ice sheet dynamics, Earth deformation, and sea-level change in order to support the overall goal of better constraining the past, present, and future stability of the Antarctic Ice Sheet. Significant progress has been made in this area under the remit of the SERCE SRP. During SERCE-funded workshops in 2017 and 2019 participants were tasked with identifying the 'top ten research questions' that need to be addressed to further research in their area. The objectives below reflect the key points emerging from those discussions relating to Earth-ice-sea level interactions:

- Investigate the strength of feedbacks between Earth deformation, sea-level change, and ice dynamics over a range of timescales, especially in regions of low viscosity upper mantle
- Quantify spatial variations in the rheological properties of the Earth beneath Antarctica and investigate the degree to which it is important to represent such variability within numerical models
- Reconstruct recent – millennial, centennial, decadal scale – ice sheet change in regions of low upper mantle viscosity, e.g. West Antarctica, and multi-millennial ice sheet change in regions of high upper mantle viscosity, e.g. East Antarctica, to improve quantification of the present-day glacial isostatic adjustment (GIA) signal
- Encourage the collection of new data and data types, and the novel interpretation of existing data, to quantify ice sheet change, regional and global sea-level change, and infer spatially varying Earth rheology – reflecting on data quality, relevance, and the potential for non-uniqueness
- Improve treatment of uncertainties in data, models, and model output relating to Earth-ice-sea level feedbacks to reduce bias in our understanding of processes
- Explore the use of sophisticated modelling/data-model techniques, e.g. coupled modelling, ensemble modelling, adjoint methods, emulators, machine learning, to reconstruct past Earth-ice-sea level change
- Encourage the sharing of code, numerical output, geological and geodetic data
- Provide insight into the rate and spatial pattern of global sea-level change resulting from Antarctic Ice Sheet change over a range of timescales

A broad goal of the group is to facilitate collaboration across disciplines, allowing modellers to understand the nuances of field data, and observational scientists to understand the strengths and weaknesses of models. We anticipate strong links with other groups interested in the ice-bed interface, e.g. the proposed sub-committees on Antarctic geological Boundary Conditions, and Geothermal Heat Flow, and the ice-ocean interface. This group is distinct from those in that it seeks to understand the geometry of the ice-Earth/ice-ocean boundaries rather than the material properties/processes operating at those boundaries.

This group will continue to facilitate activities initiated under the SERCE SRP in the field of glacial isostatic adjustment. However, the focus is extended from SERCE in that we seek stronger links with the global sea-level and palaeoclimate communities, drawing on global-scale knowledge to understand the role of Antarctica in global climate/sea-level change.

How this can support INSTANT main theme(s) (max 4000 char).

The proposed sub-committee would facilitate the quantification of past and future ice sheet and sea-level change via enhanced understanding of the feedbacks operating between the ice sheet, sea level, and the deforming Earth.

This sub-committee might help address a range of priority research questions. The questions below are drawn from the INSTANT Science and Implementation Plan (italics indicate possible input from this sub-committee):

Theme 2: Ocean-Ice interactions:

- What is the role of bathymetry – how does it affect cavity-scale circulation and how does it influence the stability of marine-based ice sheets? – *needs input from isostatic models of bathymetric change through time due to ice and ocean load changes*
- What was the rate and pattern of ice sheet retreat during past deglaciations? – *data that constrain past ice sheet retreat can be used to tune or validate numerical models that seek to understand the dominant processes controlling ice sheet retreat rates*

Theme 3: Earth-Ice interactions:

- What are the subglacial properties and processes relevant for past and future ice dynamics? – *needs knowledge of the configuration of the ice sheet bed*
- What is the strength of feedbacks between processes associated with glacial isostatic adjustment and ice dynamics? – *addressing this is a central goal of this sub-committee and will require progress on the follow-up questions:*
    - What is the spatial pattern of Earth rheology beneath Antarctica? – *can be addressed via the interpretation of the Earth response to contemporary ice sheet change, or via the interpretation of independent data sets, e.g. seismic and magnetotelluric data*
    - What is the sensitivity of grounding line dynamics to the spatial resolution at which GIA and bathymetry are represented within models? – *an important question that is linked to questions raised above about the complexity of information and processes that need to be represented in prognostic models*
- How do glaciological, geological, and geophysical records inform us about ice sheet and landscape evolution? – *related to the approach of inferring past ice sheet change from observations of past Earth deformation and/or sea-level change.*

Theme 4: Science-Stakeholder interactions:

- What controls grounding line migration and are there thresholds? – *the role of bed deformation in controlling grounding line migration is currently poorly understood*
- What is public and stakeholders' current understanding of the amount, rate, timing, and causal mechanism of sea-level rise? – *this sub-committee would hold extensive knowledge on the factors controlling global and regional sea-level change*

PROPOSAL 2

Inter ice-sheet models simulation design

An ice sheet modeller
Another modeller (eventually ocean, Earth modeler
Promoted by Catherine Ritz

Purpose of the sub-committee:

How to compare the range of models in a meaningful way is an ongoing issue. One future approach may be to use models of similar type if trying to understand the importance of a specific process such as MICI and/or MISI, or develop experiments using sub-classes of models constrained by paleo data to evaluate specific issues. Developing a methodology on these issues deserves a sub-committee.

How does the sub-committee supports INSTANT objectives:

Projection of the future ice sheet evolution obviously relies on numerical models. However, the current projections display a considerable range of uncertainty to the point that Antarctica was tagged ""source of deep uncertainty"" for future sea level rise (SROCC).
The models themselves are not the only source of uncertainty but it is one that needs to be explored and it would fully support INSTANT objective to reduce uncertainty on sea level rise as well as providing a framework to understand data.

Among the questions that could be tackled by this sub-committee:

- Design intercomparison experiments
- What type of simulations to assess the importance of the various processes?
- What is the best way to use data to reduce the uncertainty on the processes?
- Are all the models equivalent? Up to now, the best models to simulate the past are not the state of the art for simulating next centuries. Does it matter? how to get around this difficulty?
- There are already on-going models intercomparisons (ISMIP6 and later ISMIP7, MISOMIP). How to work with these initiatives to be complementary without too much overlap?

PROPOSAL 3

Exploiting satellite observations for understanding ice sheet dynamics
Promoted by Martin Horwath (TU Dresden).
Matthias Willen (ECS, TU Dresden)

Leader and co-leader names are provisionary placeholders (at least one of them to be exchanged, and someone from the modeling community should be included)

Purpose of the sub-committee:

The sub-commission coordinates and promotes activities to ensure the maximum benefit from satellite geodesy and satellite remote sensing for the understanding and projection of ice sheet dynamics.

The satellite techniques include, but are not restricted to:
- satellite altimetry (surface elevation changes)
- satellite gravimetry (mass changes)
- satellite radar and optical imagery (surface flow velocity and other applications)

These are key techniques to discover and observe present-day ice sheet changes.

Yet, the EO data are available for only 2-4 decades. They reflect a superposition of natural variability and long-term changes of the ice sheet, where the long-term changes are sometimes hard to detect in the presence of natural variability. INSTANT as a whole aim at understanding ice sheet changes up to the millennial time scale.

There are manifold ways how numerical modeling can benefit from EO and vice-versa. These ways are not fully explored and exploited yet. Exploiting the synergistic use of EO data and numerical modeling is a key requirement for INSTANT. At the same time, INSTANT, with its interdisciplinary, holistic approach is an excellent framework for pushing forward the required developments.

Key questions are the following:

<u>(a) How can numerical modeling of ice sheet dynamics and ice sheet mass balance benefit from the EO data?</u>

Related aspects include the following: We have already inter-compared GRACE and altimetry data with SMB modeling results, which led to a mutual validation of both EO and modeling results (e.g. within IMBIE). How can we exploit synergies beyond inter-comparison? Can observed present-day changes be used to identify deficiencies in models? Can observed present-day changes be used as boundary conditions for ice sheet models, or for the initiation of ice sheet models? Can EO data be ultimately assimilated into ice sheet models? What are the requirements to the observations and to their uncertainty characterization?

<u>(b) Conversely, how can numerical models help to analyse and interpret the satellite data?</u>

Related aspects include the following: Model outputs aid the signal detection in EO data. For example, results from SMB and firn modeling are currently involved for the volume-to-mass conversion in altimetry-based mass balance estimates. The uncertainty of such models (and of the assumption of a long-term stable firn layer sometimes made) is among crucial uncertainties of present-day mass balance estimates. As another example, GIA models are crucial for satellite gravimetry estimates of mass balance. However, GIA model uncertainties are the major contributor to the overall mass balance uncertainty. The uncertainty characterizations for both modeling and EO results need to be further advanced for more rigorous model-observation combinations and is highly promising to improve the quantification of geophysical signals over ice sheets.

How the sub-committee supports INSTANT objectives:

The activities support Theme 1, 2, and 3, and thereby, Theme 4. Satellite altimetry and satellite gravimetry observe effects of SMB changes and SMB variations (Theme 1), ice flow dynamics (Theme 2) and bedrock displacement (Theme 3). Flow velocity observations are key to monitor effects of ocean-ice interactions (Theme 2).

Earth observation is therefore an essential link between those themes. The sub-committee promotes cross-fertilization between themes with respect to a coherent and synergistic exploitation of EO data.

The sub-committee will exploit cross-linkages to other SCAR groups, like the new Earth Observation Action Group (focussing on EO data acquisition), ISMASS, and bodies outside SCAR, like the International Association of Geodesy Joint Working Group "Geodesy for the Cryosphere".