



WP 15
Agenda Item: 2.3
Person Responsible: T Wilson

EXCOM 2015

Tromsø, Norway 27-28 August 2015

Solid Earth Response and influence on Cryospheric Evolution



Executive Summary

Title: Solid Earth Response and influence on Cryospheric Evolution

Authors: Terry Wilson

Introduction/ Background: (Summary of SRP)

The Solid Earth Response and influence on Cryospheric Evolution (SERCE) SRP targets new understanding of solid earth – cryosphere interactions at a crucial time in earth history when global change is driving changes in mass balance of the polar ice sheets. SERCE promotes integration of new earth science data sets into modeling of ice mass balance, ice dynamics, and solid earth responses to mass change.

Important Issues or Factors: (what do the SSGs and SCAR ExCom need to be aware of)

SERCE sponsored several major events in 2014-2015 period, including a) thematic session at EGU, b) workshop in Alaska, c) workshop at Goa ISAES, d) thematic session at Goa ISAES, and e) GIA training school to take place in September.

Recommendations/Actions and Justification:

- Approval of budget requests to implement programme plans

Expected Benefits/Outcomes:

- The SCAR-SERCE strategy of partnering with other organizations effectively leverages the scope and impact of science and outreach activities
- SCAR-SERCE has an increasing mission to promote infrastructure, capacity, data sharing and collaboration in light of highlighted thematic questions of the SCAR Horizon Scan and studies (e.g. USA-National Academies) emphasizing terrestrial observation systems in Antarctica.

Partners: SERCE has engaged international partners to leverage each activity. Partners include:

- International Lithosphere Programme, proposed new Task Force: Dynamics and Interaction of Mantle, Lithosphere and Ice Masses (DynaM-Ice), Markku Poutanen & Irina Rogozhina
- International Association of Geodesy, Subcommittee 3.4 Cryospheric Deformation
- U.S. National Science Foundation (training schools)
- ISMASS, PAIS, AntClim21
- APECS

Budget Implications: Carry over of Funding of \$19,780 from 2014, and \$20,000 allocated for 2015, will be fully expended in 2015 for the Alaska GIA Modeling Workshop, the ISAES-Goa Autonomous Instruments Workshop, and the GIA Training School. Although \$20,000 per year has been allocated, \$25,000 for 2016 and 2017 are requested to support SERCE activities.

Solid Earth Response and influence on Cryospheric Evolution

1. Rationale for the Programme

The Solid Earth Response and influence on Cryospheric Evolution (SERCE) scientific research programme aims to *advance understanding of the interactions between the solid earth and the cryosphere to better constrain ice mass balance, ice dynamics and sea level change in a warming world*. This objective will be accomplished through integrated analysis and incorporation of geological, geodetic and geophysical measurements into models of glacial isostatic adjustment (GIA) and ice sheet dynamics. The programme is designed to synthesize and integrate the extensive new geological and geophysical data sets obtained during and subsequent to the International Polar Year with modeling studies, in a timeframe to contribute to IPCC AR6. SERCE will provide the international collaborative framework and scientific leadership to investigate systems-scale solid earth – ice sheet interactions across Antarctica and relate these results to global earth system and geodynamic processes. A series of expert workshops and thematic symposia are designed to improve data-modeling integration and will propel the science of solid earth – cryosphere interactions beyond the current state of knowledge. The SERCE programme will conduct major efforts in capacity building, training and public outreach using complementary strategies to achieve technical capacity via information exchange, analytical capacity via training schools, engagement of new polar researchers via thematic science sessions, and public outreach via the world-wide web.

2. Important Issues or Factors

i) Five Scientific Highlights

Development of a new generation of ‘earth models’, one fundamental element of glacial isostatic adjustment (GIA) models, is essential to capture the solid earth response to ice mass change in Antarctica. Progress in model development is reported in:

van der Wal, W., Whitehouse, P. L., & Schrama, E. J. (2015). Effect of GIA models with 3D composite mantle viscosity on GRACE mass balance estimates for Antarctica. Earth and Planetary Science Letters, 414, 134-143.

The first exploration of how uplift and subsidence of the earth’s surface due to glacial isostatic adjustment will modify the configuration of the bedrock surface underlying the ice sheets, and thus impact ice dynamics, is reported in:

Adhikari, S., Ivins, E. R., Larour, E., Seroussi, H., Morlighem, M., & Nowicki, S. (2014). Future Antarctic bed topography and its implications for ice sheet dynamics. Solid Earth, 5(1).

Models for glacial isostatic adjustment (‘post-glacial rebound’) in Antarctica, and globally, are continually being revised. New models are incorporating GPS vertical uplift constraints from the POLENET results:

Argus, D. F., Peltier, W. R., Drummond, R., & Moore, A. W. (2014). The Antarctica component of postglacial rebound model ICE-6G_C (VM5a) based on GPS positioning, exposure age dating of ice thicknesses, and relative sea level histories. Geophysical Journal International, 198(1), 537-563.

Peltier, W. R., Argus, D. F., & Drummond, R. (2015). Space geodesy constraints on ice age terminal deglaciation: The global ICE-6G_C (VM5a) model. *Journal of Geophysical Research: Solid Earth*, 120(1), 450-487.

Mismatch between vertical uplift of the earth's surface measured by GPS and the rates of uplift predicted by GIA models are being identified, and new ice history models are being developed to reconcile the discrepancies:

Bradley, S. L., Hindmarsh, R. C., Whitehouse, P. L., Bentley, M. J., & King, M. A. (2015). Low post-glacial rebound rates in the Weddell Sea due to Late Holocene ice-sheet readvance. *Earth and Planetary Science Letters*, 413, 79-89.

ii) Progress against prior work plan, including metrics of performance.

SCAR-SERCE has met the activity schedule outlined in 2014-15, with the exception of completing the SERCE website (see summary table below).

YEAR	WORKSHOP/ SYMPOSIA	THEME SESSION	TRAINING	OUTREACH
2014		Earth – Cryo. Interactions EGU ✓ SCAR OSC ✓	GIA Training School <i>Postponed to 2015</i>	Complete Web site X
2015	• Joint Workshop w/ IAG: Modeling Elastic deformation due to ice mass change (Alaska, USA, May, 2015) ✓	Earth – Cryo. Interactions ISAES ✓ EGU ✓	• GIA Training School ✓ (Sept, 2015) • Autonomous Systems-ISAES ✓	Training Videos on web (Sept, 2015)
2016		SCAR OSC -Earth – Cryo. Interactions -Mini-Symposium: AntClim21, ISMASS, PAIS, SERCE <i>The Antarctic ice sheet from past 2 future</i>	Cryoseismology Training School	Training Videos on web
2017	Joint Workshop w/ IAG	Earth – Cryo. Interactions AGU		

✓ denotes completed. X denotes delayed.

3. Outputs/Deliverables

SYMPOSIA, WORKSHOPS, TRAINING SCHOOL – Education and Outreach

1. SCAR Open Science Conference, Auckland, New Zealand, August, 2014: SERCE Thematic Science Session Convenor: Terry Wilson

2. EGU General Assembly 2015 (EGU2015), 12 Apr 2015 - 17 Apr 2015, Vienna, Austria.

GD6.2/CR2.5: ***Geodynamic evolution of the polar regions and interaction with the cryosphere***

Thematic Session

Conveners: Douglas Wiens, Terry J. Wilson, Karsten Gohl, Pippa Whitehouse

3. GIA Modeling 2015, Symposium and Workshop

May 26-29, University of Alaska-Fairbanks. International Association of Geodesy subcommission 3.4 Cryospheric Deformation & SCAR/SERCE

The elastic deformation of the crust is focused very near places where mass changes are occurring. Scientists studying glacial melt therefore need an effective model of short-term glacier-related deformation so that it can later be separated from long-term trends of the crust's response to the last ice age. A workshop supported by SCAR-SERCE was focused on computation of the high-resolution elastic response of Earth to surface load changes. The session explored the theory and practical application of two software tools - REAR and SPOTL – as well as a summary of sources for obtaining observed or modeled ice loading changes and their treatments.

4. 26th IUGG General Assembly, June 22 – July 02, 2015

Symposium JG1 "Dynamics of the Cryosphere from Geometric and Gravimetric Observations"

Conveners: Mirko Scheinert (TU Dresden) (IAG), Pippa Whitehouse (University of Durham) (IACS), Matt King (University of Tasmania) (IAG), Erik Ivins (NASA/JPL) (IAG)

**5. XII SCAR International Antarctic Symposium on Antarctic Earth Science
Goa, India, 13-17th July 2015**

A. Invited Plenary lecture for conference: *New Insights on Interactions between the Solid Earth and the Cryosphere* (SRP Chief Officer, T. Wilson).

B. A SERCE-related thematic session on the topics of ***Cryosphere – Solid Earth Interactions & Antarctic Geothermal Heat Flux, Subglacial Geology and Ice Dynamics*** was held at the Goa ISAES

Session Conveners:

Terry Wilson, Ohio State University, USA; Samantha Hansen, Univ. of Alabama, USA; Wouter van der Wal, Univ. Delft, Netherlands; Chris Carson, Geoscience Australia; Sridhar Anandakrishnan, Penn State Univ., USA

C. A workshop convened by SCAR-SERCE and partners in the NSF-USA POLENET project, Geolce project, GeoPebbles Project, and the UNAVCO (GPS) and IRIS/PASSCAL (Seismic) facilities was convened: ***Autonomous GPS & Seismic Station Workshop***

**6. POLENET/SERCE: 2015 Glacial Isostatic Adjustment (GIA) Modeling Training School
Ohio State University, Stone Lab, Gibraltar Island, Lake Erie, 13-19 September 2015**

A training school focused on exploring glacial isostatic adjustment (GIA) modeling will be held from 13-19 September 2015 on Gibraltar Island, Lake Erie, USA. The program includes lectures and practical exercises aimed at investigating the interactions between solid-earth deformation, ice mass change, and associated sea-level and geoid variations. Students will complete homework exercises utilizing freely available modeling software and will have the opportunity to spend one-on-one time with leading researchers in the GIA community while working through examples in class. The list of instructors includes Mike Bentley, Mike Bevis, Ian Dalziel, Erik Ivins, Meredith Nettles, Giorgio Spada, Holger Steffen, Wouter van der Wal, Pippa Whitehouse, Doug Wiens, and Terry Wilson.

The organization for the training school has been implemented by Wilson and colleagues at Ohio State University. A widely publicized call for applications yielded nearly 150 submissions. Through a selection process, 45 students from nearly 30 countries were selected and invited.

Financial support for the training school is provided by the National Science Foundation (NSF) through the Antarctica Network (ANET) component of the Polar Earth Observing Network (POLENET) project and by the Scientific Community on Antarctic Research (SCAR) through the Solid Earth Responses and influences on Cryospheric Evolution (SERCE) program.

4. Budgetary Implications

Expenditures

2014: Original budget of \$20,000.

1. Cleared \$220 overspend from 2013.

Remaining Funds: \$19,780 ***Carried Forward to 2015 for GIA Training School***

2015: Budget Allocation of \$20,000, plus \$19,780 carried forward.

- \$6,415 for support of GIA Modeling workshop, Fairbanks, Alaska, USA
- \$2,385* for support of 'Autonomous Remote Instrumentation' workshop, ISAES-Goa, India. [*exact number to be finalized]
- \$30,980** for support of GIA Training School, Gibraltar Island, USA, September, 2015 [**to be finalized, expenditure in September, 2015]

All 2015 funds to be expended.

Budget Request

2016: New funds requested: \$25,000

1. Cryoseismology Training School, Colorado, USA, August 2016. \$20,000 funding to support students/early career scientist participation.
2. Mini-Symposium: collaboration with PAIS and AntClim21 SRPs and ISMASS EG: *The Antarctic ice sheet from past 2 future*. \$5,000 funding requested to support early-career participation in this symposium, and SERCE business meeting at SCAR biennial meeting.

2016 – Budget Explanation:

A 'training school' designed to build capacity in applying geodesy and seismology to study the cryosphere is planned. The 5-day short course will be jointly organized and funded by the NSF-sponsored POLENET-ANET project and other partners will be sought for funding. We expect that 20 U.S. (funded by NSF) and 20 additional students (funded by SCAR and, perhaps, additional partners) from a large number of nations will attend the course.

2017: New funds requested: \$20,000

1. Joint workshop with Intl Association of Geodesy Subcommittee 3.4 – Cryospheric Deformation, on elastic rebound modelling due to modern ice mass change and establishing a common reference frame for comparison of GIA Models and GPS-derived crustal velocity fields. \$12,000 requested to support student/early-career participation workshop, support for this activity will also be sought from partner science programmes, using the successful strategy for the 2013 Greenland and 2014 Alaska symposia.
2. Funding of \$8,000 is sought to support student/early-career participation in an AGU special session on Solid Earth – Cryosphere interactions.

5. Future Plans

1. SCAR Open Science Conference, Malaysia, 2016
 - a. *SERCE Thematic Session*
 - b. SERCE-PAIS-AntClim21-ISMALSS mini-symposium
 - c. Steering Committee & Business meeting
2. *Cryo-Seismology Training School*, Colorado, USA, September 2016

A 'training school' (short courses) for graduate students and early-career researchers is planned, with the overarching goal of developing a new cadre of polar scientists trained in emerging/critical research areas that are currently underpopulated, specifically integrated geodetic and 'cryoseismology' techniques to study ice dynamics. This 5-day short course will a) provide intensive training, including lectures and hands-on exercises b) provide students access to scientific leaders in multiple disciplines, and c) through the opportunity to network with other students, form the basis for future multidisciplinary, international collaboration. The Cryoseismology Training School will be co-funded by the U.S. NSF as part of the outreach program of the POLENET-ANET project. We expect that 20 U.S. (funded by NSF) and 20 additional students (funded by SCAR and, perhaps, additional partners) from a large number of nations will attend the course, and we will provide broader access via 'live' participation of off-site students using videocom and by recording and posting the school content on the POLENET and SERCE web sites. A venue for the course is being explored at the Pingree Park Mountain Campus of Colorado State University, USA (<http://www.pingree.colostate.edu/conferences>).
3. Convene 'expert workshop' in partnership with Intl Association of Geodesy Subcommittee 3.4 – Cryospheric Deformation.
4. Convene thematic science session at AGU Fall Meeting.
5. *Find time and resources to post information and links on SERCE website!*
6. *Plan rotation of steering committee*

Appendices

e.g. SRP Steering Committee