Advance understanding of the interactions between the solid earth and the cryosphere, to better constrain ice mass balance and sea level change in a warming world........
Polar earth systems approach

Geodynamic Interactions:

- solid earth
  - plate tectonics
  - bedrock motions
  - heat flux
- cryosphere
  - ice mass change
  - ice dynamics
- sea level
- climate
Polar research: Six priorities for Antarctic science

Mahlon C. Kennicutt, Steven L. Chown, John J. Cassano, Daniela Liggett, Rob Massom, Lloyd S. Peck, Steve R. Rintoul, John W. V. Storey, David G. Vaughan, Terry J. Wilson & William J. Sutherland

Post-Glacial Sea Level Rise

- Santa Catarina
- Rio de Janeiro
- Senegal
- Malacca Straits
- Australia
- Jamaica
- Tahiti
- Huon Peninsula
- Barbados
- Sunda/Vietnam Shelf
- Meltwater Pulse 1A
- Last Glacial Maximum

Sea Level Change (m)

Thousands of Years Ago

New volcano will probably not break through the ice cap, but melt it from beneath instead.

1. Volcano may be one of many, caused by a plume of superheated molten rock rising from beneath.

2. Heat released by such volcanoes could destabilize parts of the ice cap.
Solid earth deformation due to glacial isostatic adjustment

Why do we care?

⇒ Contributions of polar ice sheets to global sea level change
Glacial isostatic adjustment = solid earth motion driven by changes in ice mass

→ Record of ice mass change

GPS motions
GIA uplift due to thinning of the inland ice promotes the GL migration towards the continental shelf.

Pinning point, raised by GIA uplift due to thinning of the inland ice, provides basal resistance and buttressing to the ice sheet.

Adhikari et al. 2014
GIA uplift has stabilizing effects on the future ice sheet dynamics.

Average model predictions for bed uplift due to GIA under the proxy RCP 8.5 scenario.

Adhikari et al. 2014, Future Antarctic bed topography and its implications for ice sheet dynamics. Solid Earth Discuss., 6, 191–228
Deep earth structure?
Improved knowledge from seismology

Crustal Thickness

Lithospheric Thickness

Sun et al. in prep.
Chaput et al. [2014]
Stable craton?
young rift?
Mantle plume?

Heterogeneous crust & mantle:
- Modulates isostatic response
- Ice sheet boundary conditions

- Subglacial volcanism
- Heat flux to ice sheet
- Substrate below ice sheet

Transantarctic Mountains
Stable craton?
young rift?
Mantle plume?
Seismic detection of an active subglacial magmatic complex in Marie Byrd Land, Antarctica

Amanda C. Lough1*, Douglas A. Wiens1, C. Grace Barcheck1,2, Sridhar Anandakrishnan3, Richard C. Aster4,5, Donald D. Blankenship6, Audrey D. Huerta7, Andrew Nyblade3, Duncan A. Young6 and Terry J. Wilson8

Subglacial volcanism: melting & lubrication base of ice sheet
HEAT FLUX- large variability and uncertainty

seismic

magnetic

Shapiro & Ritzwoller, 2004

Fox-Maule et al. 2005
Heat Flow estimated from seismic velocity data

An et al., 2015
Overview of 2014-16 Activities

Symposia:
• SCAR Open Science Conference, Auckland, New Zealand; Kuala Lumpur, Malaysia
• EGU, Vienna, April, 2015
• 26th IUGG General Assembly, June, 2015
• XII SCAR International Antarctic Symposium on Antarctic Earth Science, Goa, India, 13-17th July 2015
• AGU, San Francisco, 2016

Expert Workshop:
GIA Modeling 2015, Symposium and Workshop, Alaska, USA

Capacity-building:
• Autonomous GPS & Seismic Station Workshop, Goa, India, 13-17th July 2015
• 2015 Glacial Isostatic Adjustment (GIA) Modeling Training School, Ohio, USA, 2015

Future Science
Horizon Scan (2014), Antarctic Roadmap Challenges (2015)
Next Generation: training new cohort of GIA modelers, cryo-geodesists/seismologists

10 instructors

On site:
41 students
16 countries

Virtual:
31 participants
17 countries

Lectures available on line……..

Survey Q5: I would recommend this course to colleagues
Weighted Average – 4.83 / 5
<table>
<thead>
<tr>
<th>YEAR</th>
<th>WORKSHOP/SYMPOSIA</th>
<th>THEME SESSION</th>
<th>TRAINING</th>
<th>OUTREACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Earth–Cryo Interactions SCAR OSC ✓</td>
<td>Earth–Cryo Interactions</td>
<td>• GIA Training School ✓</td>
<td>Training Videos on web</td>
</tr>
<tr>
<td></td>
<td>Ice load changes and Earth deformation ✓</td>
<td>EGU ✓</td>
<td>• Autonomous Systems-ISAES ✓</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>The Antarctic ice sheet from past 2 future (w/ AntClim^{21}, ISMASS &amp; PAIS at SCAR OSC) ✓</td>
<td>Earth–Cryo. Interactions SCAR OSC ✓</td>
<td>Complete Web site ✓</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Separation of elastic and viscoelastic GIA signals (w/ IAG, Reykjavik, Iceland)</td>
<td>EGU thematic session</td>
<td>Cryoseismology Training School</td>
<td>Training Videos on web</td>
</tr>
<tr>
<td></td>
<td>Antarctic Heat Flow</td>
<td>Earth–Cryo. Interactions SCAR OSC ✓</td>
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</tbody>
</table>
Next Generation: training new cohort of GIA modelers, cryo-geodesists/seismologists

Glacial Seismology Training School
June 11-17, 2017
Fort Collins, Colorado, USA


Mechanics of ice shelf calving / breakup

Mechanics of basal sliding
SERCE SRP External Reviews & Recommendations:

4 External Reviews

Science quality: “Excellent”

Science importance/relevance/timeliness – advanced scientific understanding?: YES

Data archival and access:
• While SERCE is not designed to collect data, data coordination encouraged
  **working group established to develop knowledge resource

Communication activities:
• Good, BUT, need to improve website**

Education: Training Schools – Excellent!
…“filled an important gap”… [by] “teaching how to use software”
• Better advertise availability of recorded lectures
SERCE SRP External Reviews & Recommendations:

**Building capacity across all SCAR Member countries:**
Excellent; via support early-career participation in workshops/symposia and via Training Schools

**Value for Money:**
- excellent, via partnering / leveraging with other programs.
  **following up suggestions for additional partners (e.g. WCRP)**

**Terms of Reference:** Meeting TOR “to a large extent”

**Issue for all SRPs - Publications:**
- Request submission of article citations for listing on SERCE website
- Acknowledgment in papers
  - “This work is a scientific contribution to the SCAR-SERCE research programme”
Budget

2014-16 Expenditures

2014: Budget of $20,000 – carried over to 2015 for GIA School.

2015: Budget of $20,000 + $19,780.
• $6,515 for support of GIA Modeling workshop, Fairbanks, Alaska, USA
• $1,765 for support of ‘Autonomous Remote Instrumentation’ workshop, ISAES-Goa, India.
• $31,000 for support of GIA Training School, Gibraltar Island, USA, September, 2015

2016-17 Requests

2016: Budget of $21,500 – Request carry forward to 2017 for Training School

2017: Budget of $21,000 + $21,500 carry forward.
• Cryoseismology Training School - $20,000
• Joint workshop with IAG in Reykjavik - $20,000
• Other: $2,500
New Chief Officers: Matt King (AUS) & Pippa Whitehouse (UK)

Draft List of New/Ongoing SC Members:

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jacqui Halpin? (AUS)</td>
<td>Heat Flow</td>
</tr>
<tr>
<td>Dustin Schroeder? (US)</td>
<td>Heat Flow</td>
</tr>
<tr>
<td>*Samantha Hansen</td>
<td>Seismology</td>
</tr>
<tr>
<td>*Masaki Kanao (Japan)</td>
<td>Seismology</td>
</tr>
<tr>
<td>Meijin An? (China)</td>
<td>Seismology</td>
</tr>
<tr>
<td>Yongcheol Park? (Korea)</td>
<td>Seismology</td>
</tr>
<tr>
<td>Songtao Ai? (China)</td>
<td>GPS</td>
</tr>
<tr>
<td>*Terry Wilson</td>
<td>GPS, tectonics</td>
</tr>
<tr>
<td>*Mirko Scheinert (Germany)</td>
<td>GPS/Gravity; GIANT liaison</td>
</tr>
<tr>
<td>Anthony Memin? (France)</td>
<td>Gravity</td>
</tr>
<tr>
<td>Natalya Gomez (Canada)</td>
<td>GIA modeling; WCRP liaison</td>
</tr>
<tr>
<td>Tom James (Canada)</td>
<td>GIA modeling</td>
</tr>
<tr>
<td>*Mike Bentley (UK)</td>
<td>Ice history; PAIS liaison</td>
</tr>
</tbody>
</table>

Rotating off:

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chris Carson (AUS)</td>
<td>Heat Flow</td>
</tr>
<tr>
<td>Stefania Danesi (Italy)</td>
<td>cryoseismology</td>
</tr>
<tr>
<td>Francisco Navarro (Spain)</td>
<td>ISMASS liaison</td>
</tr>
<tr>
<td>Markku Poutanen (Finland)</td>
<td>GPS; DynaQlim liaison</td>
</tr>
<tr>
<td>Yves Rogister (France)</td>
<td>Gravity</td>
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</table>
SOLID EARTH RESPONSE AND INFLUENCE ON CRYOSPHERIC EVOLUTION

SCAR

THE INTERNATIONAL COUNCIL FOR SCIENCE

SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH