doi.org/10.22498/pages.30.1.57

Unraveling the complex relationship between solid-Earth deformation and ice-sheet change

Jacqueline Austermann[1] and Alex Simms[2]

PALSEA-SERCE joint workshop, online, 13-16 September 2021

Better understanding the ice-sheet and solid-Earth processes that drive paleo sea-level change remains an important topic discussed at the 2021 joint PALSEA-SERCE virtual meeting (PALSEA: PALeo constraints on SEA level rise, pastglobalchanges.org/palsea; SERCE: Solid Earth Response and influence on Cryospheric Evolution, scar.org/science/serce/serce). The meeting (pastglobalchanges.org/calendar/26991) spanned four half-days and included 29 talks, 24 posters, and several group discussions. Over 110 participants joined the meeting and engaged in written and live conversations.

Most presentations revolved around two main themes: (1) developing and improving numerical models investigating the interactions between ice-sheet dynamics and solid-Earth deformation; and (2) providing new observations on paleo sea levels, ice-sheet retreat, and ongoing Earth deformation. From the modeling perspective, an important theme was that climate- and boundary-condition uncertainties remain large, requiring a move towards large ensemble simulations and machine-learning approaches. Within the observational science, new data were presented on important locations across the globe including Greenland, Northern Europe, Micronesia, the Bahamas, Antarctica, and the USA. These new observations and careful compilations build the foundation for improving models of solid Earth deformation (glacial isostatic adjustment, GIA) and our understanding of past ice-sheet change.

In addition to paleo observations, speakers presented geodetic observations related to modern melt loss. One issue repeatedly mentioned was the uncertain future of geodetic observations from Antarctica, which are instrumental in understanding ice-mass loss and solid Earth structure. The Polenet stations (Fig. 1), supported to date by the US National Science Foundation, are at risk of being decommissioned in the near future. These geodetic observations are instrumental to this community, and a community effort to demonstrate the value of keeping these stations running, as well as a formulation of new science goals, is needed.

As the observations increasingly improve, models of GIA used to fit them, continue to evolve as well. GIA models often assume that solid-Earth structure (most importantly viscosity) only varies with depth, which allows for fast computations and the ability to thoroughly explore trade-offs and uncertainty.

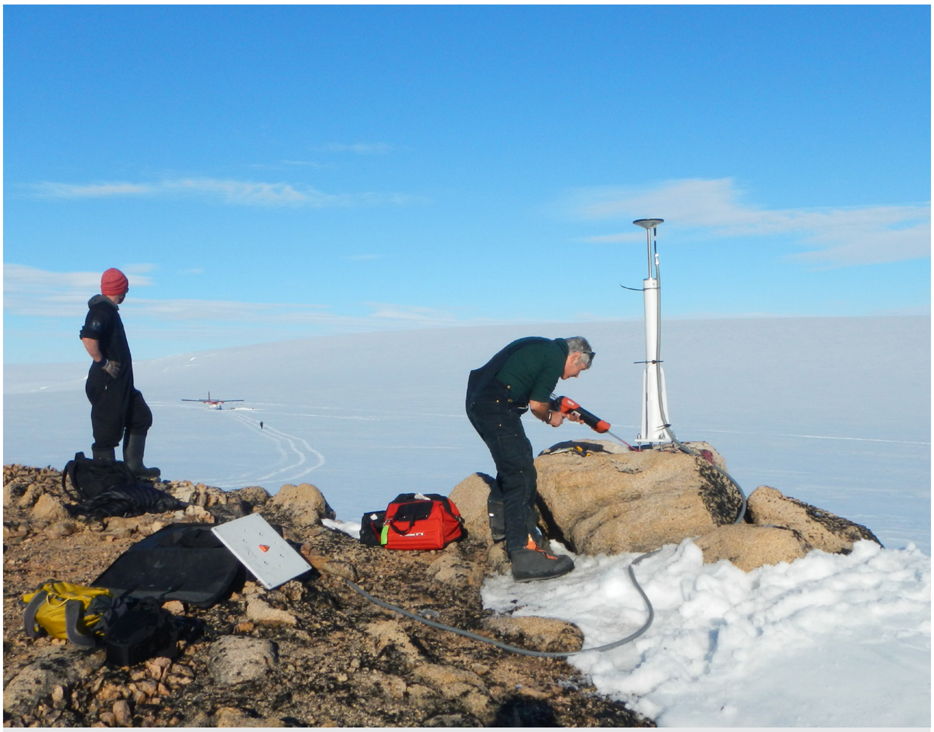

Figure 1: Erik Kendrick (right) installing the GPS monument at Gould Knoll (GLDK) on Thurston Island in the Amundsen Sea. Jeff Amantea (left) looks towards the Twin Otter and broadband seismic station that is part of the POLENET/A-NET project (polenet.org) (photo credit: Terry Wilson).

While these models continue to have merit, more complex models are increasingly employed and possibly even required by the observational record. The computational cost of these models hinders data assimilation through large ensemble runs; however, adjoint techniques might provide a path forward to efficiently constrain 3D viscosity with sea-level data. In addition to lateral variability, several speakers explored the role of transient and nonlinear rheologies and demonstrated that these complexities are not only more realistic, but may also help reconcile sea-level observations on different timescales. An upcoming challenge in the community will be to efficiently constrain all the new parameters that emerge from these models ranging from grain-size and temperature, to water content and background stress. Tighter connections to the mineral physics and geodynamic community are critical in achieving this goal.

As GIA models evolve, we need to develop standards for benchmarking and output sharing. In the past, the PALSEA community has produced community papers surrounding data compilations (Düsterhus et al. 2016) and research priorities (Capron et al. 2019). A new community effort should tackle GIA modeling standards. This could include describing and unifying modeling options, and quantifying their importance, as well as identifying a baseline set of benchmarks to be used. Additional benchmarking is needed for components related to horizontal motion and 3D viscosity structure. A community effort should develop recommendations for code and output sharing, including standardized output formats.

We thank all the participants who engaged in this workshop and the supporting organizations: PAGES, the International Union for Quaternary Research (INQUA), the Scientific Committee on Antarctic Research (SCAR), and Columbia University.

AFFILIATIONS

[1]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA

[2]Department of Earth Science, University of California, Santa Barbara, USA

CONTACT

Jacqueline Austermann: jackya@ldeo.columbia.edu

REFERENCES

Capron E et al. (2019) Quat Sci Rev 219: 308-311

Düsterhus A et al. (2016) Clim Past 12: 911-921