Reaching for the Horizon: Advancing Ice Sheet Dynamics Science

Mahlon C. Kennicutt II[1]

[1] Texas A&M University, mckennicutt@gmail.com

Abstract

Technological advances necessary to progress ice-sheet dynamics science include: 1) improved process-driven numerical ice sheet models; 2) enhanced subglacial (including sediment recovery) and englacial sampling and sensing methods; 3) combined, multiple geophysical measurement and sampling of ice; 4) expanded satellite-based synoptic measurements; and 5) more capable AUVs, in-ice observatories and submersible sensors (Kennicutt et al. 2014, 2015 and COMNAP 2016).

Improved predictions of ice sheet change and response to forcings are essential (Church *et al.* 2013). Integration of in-field observations will be critical to developing the next-generation of ice-sheet models capable of describing and predicting realistic ice flow. A better understanding of the influence of bed topography, ice fabric, basal heat flow, underlying sediments, temperature, and other basic parameters is important for improving models. Comprehensive and more-accurate ice-sheet mass balance assessments and predictions must know the flow of ice in vertical profile in all places, from the interior to the grounding zone. The requisite observations require englacial placement of sensors and observatories.

Access to geographical targets that are vulnerable to change are essential. Marine ice sheets and associated grounding zones are regarded as most vulnerable to rapid and irreversible change. Areas of high interest include: 1) the Amundsen Sea Embayment (Joughin *et al.* 2014); 2) marine margins (Aitken *et al.* 2016); 3) the deep interior/Antarctic Plateau (Vance et al. 2016); 4) coastal islands and ice rises (Siegert *et al.* 2016); 5) basins that influence the enhanced flow of ice and contain sedimentary records; 6) ice shelf cavities and systems that buttress grounded ice (Greenbaum *et al.* 2015); and 7) ice-stream shear margins which dictate the size and location of ice streams and where records of ice-sheet change are likely to be recovered (Dustin *et al.* 2016).

The stability and configuration of ice shelves that fringe marine ice sheets are important controls on the potential contribution of grounded ice to sea level change. Understanding ice shelves and the adjacent grounding lines requires access to a complex and dynamic region of sea ice, icebergs and crevasses. Thus access will require technological innovation and significant logistical efforts. In a similar manner, lateral shear margins of glaciers (which separate rapidly from slow-flowing ice) are poorly understood features of the ice sheet that need study. These areas are difficult to access but technologies similar to those proposed for grounding zones and ice shelves are applicable.

International collaborations, sharing of knowledge and data, coordination of logistics, advancement of enabling technologies, optimizing the utilization of infrastructure and partnerships are cost efficient and indispensable. It will be important to engage skills, capabilities, and capacities across national programs particularly in regard to fast-developing and technology-intensive research, through researcher exchange programs and capacity building to advance ice sheet dynamics science.

Keywords: models, observations, international cooperation

References

Aitken, A.R.A., Roberts, J.L., Van Ommen, T., Young, D.A., Golledge, N.R., Greenbaum, J.S., Blankenship, D.D. and Siegert, M.J. 2016. Repeated large-scale retreat and advance of Totten Glacier indicated by inland bed erosion. Nature, 533, 385-389.

COMNAP, Antarctic Roadmap Challenges. 2016. 140 pp.

Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer and A.S. Unnikrishnan. Sea Level Change. 2013. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Dustin M. Schroeder, C. Grima, and D. D. Blankenship.2016. Evidence for variable grounding-zone and shear-margin basal conditions across Thwaites Glacier, West Antarctica. Geophysics, 81, WA35-WA43. doi: 10.1190/geo2015-0122.1.

Greenbaum, J.S., Blankenship, D.D., Young, D.A., Richter T.G., Roberts, J.L., Aitken, A.R.A., Legresy, B., Schroeder, D.M., Warner, R.C., van Ommen, T.D. and Siegert, M.J. 2015. Ocean access to a cavity beneath Totten Glacier in East Antarctica. Nature Geoscience 8, 294–298.

Joughin, I. Smith, B.E. and Medley, B. 2014. Marine ice sheet collapse potentially under way for the Thwaites Glacier basin, West Antarctica. Science, 344, 735-738.

Kennicutt, M. C., Chown, S. L., Cassano, J. J, Liggett, D., Massom, R., Peck, L.S., Rintoul, S.R. Storey, J. W. V., Vaughan, D. G., Wilson D.J. and Sutherland, W. J. 2014. Polar research: Six priorities for Antarctic science. Nature 512, 23–25.

Kennicutt, M. C., S. L. Chown, S.L., Cassano, J.J., Liggett, D., Peck, L.S., Massom, R., Rintoul, S. R., Storey, J., Vaughan, D.G., Wilson, T.J. et al. 2015. A roadmap for Antarctic and Southern Ocean science for the next two decades and beyond. Antarctic Science 27, 3–18.

Siegert, M.J., Clarke, R.J., Mowlem, M., Ross, N., Hill, C.S.,Tait A., Hodgson, D., Parnell, J., Tranter, M., Pearce, D., Michael J. Bentley, M. J., Cockell, C., Tsaloglou M-N, Smith, A., Woodward, J., Mario P. Brito M. P., and Waugh, E. 2012. Clean access, measurement, and sampling of Ellsworth Subglacial Lake: A method for exploring deep Antarctic subglacial lake environments. Reviews of Geophysical, 50, Version of Record online: 7 Jan 2012 DOI: 10.1029/2011RG000361. http://onlinelibrary.wiley.com/doi/10.1029/2011RG000361/full (last accessed 5/31/2016).

Vance, T.R., Roberts. J.L., Moy, A.D., Curran, M, Tozer, A., Gallant, A., Abram, T., van Ommen, T.A., Young, D.A., Grima, C., Blankenship, D.D., Siegert, M.J. 2016. Optimal site selection for a high resolution ice core record in East Antarctica. Climate of the Past, 12, 595-610.