

Active Source Seismic Investigation of Firn Aquifer Structure in Southeastern Greenland

Abstract: In 2011, it was discovered that there is perennial storage of water in the firn of the southeastern Greenland ice sheet, a region of both high snow accumulation and high melt. This aquifer is created through percolation of surface meltwater downward through the firn, saturating the pore space above the ice-firn transition. The aquifer may play a significant role in sea level rise through storage or draining freshwater into the ocean. Our team carried out a series of active source seismic experiments that used refracted P-wave arrivals, inverted with a transdimensional Bayesian approach, to identify the seismic velocities associated with the base of the aquifer. When our seismic approach is combined with a radar sounding of the water table situated at the top of the firn aquifer, we are able to quantify the volume of water present. In our study region, the base of the aquifer lies on average 27.7 ± 2.9 meters beneath the surface, with an average thickness of 11.5 ± 5.5 meters. We found the aquifer had an average water content of $26.7 \pm 6.3\%$, with considerable variation in volume fraction of water along the studied regional flow line. Between 2015 and 2016, we observed a 1-2 km uphill expansion of the aquifer system, with a site dry in 2015 with over 4000 kg m^{-2} water in 2016. We estimate the volume of water stored in the aquifer across the entire region upstream of Helheim glacier to be 7.9 ± 3.3 gigatons. Elucidating the volume of water stored within these recently discovered aquifers is vital for determining the hydrological structure and stability of the southeastern Greenland ice sheet.

Bio: Dr. Schmerr has over a decade and a half of experience in seismology and geophysical research on planetary objects. He received his PhD in geophysics from Arizona State University in 2008 where he worked with Dr. Ed Garnero on deep Earth research topics. He was a postdoc at the Department of Terrestrial Magnetism at the Carnegie Institution of Washington from 2008-2010 where he worked on terrestrial mantle seismology with Drs. Paul Silver and David James. He went on from DTM to another postdoctoral position at NASA Goddard from 2010-2013, where he became involved in a number of planetary research problems, including studying the interiors of the Moon, Mars, and the icy worlds of the outer Solar System. He has since become an assistant professor at the University of Maryland in the Department of Geology where he leads a group of 3 PhD students and multiple undergraduates in Earth and planetary research. He has conducted seismic experiments in the United States, Greenland, and Canada, has grown his interests in terrestrial and cryosphere seismic science. Dr. Schmerr is a science collaborator on the upcoming InSight mission to place a seismometer on Mars. He resides in Seabrook, MD with his wife, Dr. Amy McAdam.

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Education and Training

- 2010-2013 NASA Postdoctoral Program Fellow, NASA Goddard Space Flight Center, Greenbelt, MD.
- 2008-2010 Postdoctoral Fellow, Carnegie Institution of Washington, Washington, DC.
- 2001-2008 Ph.D, Geological Sciences, Arizona State University, Tempe, AZ.
- 1997-2001 B.S., Geology, summa cum laude Beloit College, Beloit, WI.

Employment History

- 2014-present Assistant Professor, Department of Geology, University of Maryland, College Park, MD.
- 2013-2014 Assistant Research Scientist, Department of Geology, University of Maryland, College Park, MD.

Honors and Awards

- 2014 Doornbos Memorial Prize, Study of Earth's Deep Interior (<http://hope.simons-rock.edu/~bergman/sedi/doornbos.html>)
- 2010-2013 NASA Postdoctoral Position Fellowship
<http://nasa.orau.org/postdoc/>
- 2008-2010 Carnegie Institution of Washington of Postdoctoral Fellowship
<https://dtm.carnegiescience.edu/postdoctoral/fellowships>
- 2008 Outstanding Student Paper Award, American Geophysical Union
<https://membership.agu.org/ospa-winners/>
- 2006-2007 Achievement Rewards for College Scientists Fellowship
<https://www.arcsfoundation.org>
- 2003-2007 National Science Foundation Graduate Research Fellowship
<https://www.nsfgrfp.org>
- 2001 Outstanding Teacher Assistantship Award, Beloit College
- 2000 Outstanding Teacher Assistantship Award, Beloit College
- 2000 James Ferwerda Science Scholarship, Beloit College
<http://www.beloit.edu/prospective/afford/merit/>
- 1997-2001 Presidential Scholarship, Beloit College
<http://www.beloit.edu/prospective/afford/merit/>

Select Peer-Reviewed Publications

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- Whittaker, S., Thorne, M. S., **Schmerr, N. C.** and Miyagi, L. (2015), Seismic array constraints on the D" discontinuity beneath Central America. *J Geophys Res-Sol Earth* <http://dx.doi.org/10.1002/2015JB012392>.
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- Antonangeli, D., G. Morard, **N. C. Schmerr**, T. Komabayashi, M. Krisch, G. Fiquet, and Y. Fei (2015), Toward a mineral physics reference model for the Moon's core, *Proceedings of the National Academy of Sciences of the United States of America*, **112**(13), 3916–3919 <http://dx.doi.org/10.1073/pnas.1417490112>.
- Lessing, S., C. Thomas, M. Saki, **N. Schmerr**, and E. Vanacore (2015), On the difficulties of detecting PP precursors, *Geophysical Journal International*, **201**(3), 1666–1681 <http://dx.doi.org/10.1093/gji/ggv105>.
- Reeves, Z., V. Lekic, **N. Schmerr**, M. Kohler, and D. Weeraratne (2015), Lithospheric structure across the California Continental Borderland from receiver functions, *Geochemistry Geophysics Geosystems*, **16**(1), 246–266 <http://dx.doi.org/10.1002/2014gc005617>.
- Zhao, C., E. J. Garnero, A. K. McNamara, **N. Schmerr**, and R. W. Carlson (2015), Seismic evidence for a chemically distinct thermochemical reservoir in Earth's deep mantle beneath Hawaii, *Earth and Planetary Science Letters*, **426**, 143–153 <http://dx.doi.org/10.1016/j.epsl.2015.06.012>.
- Beghein, C., K. Yuan, **N. Schmerr**, and Z. Xing (2014), Changes in Seismic Anisotropy Shed Light on the Nature of the Gutenberg Discontinuity, *Science*, **343**(6176), 1237–1240 <http://dx.doi.org/10.1126/science.1246724>.
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- Schmerr, N.**, **B. M. Kelly**, and M. S. Thorne (2013), Broadband array observations of the 300 km seismic discontinuity, *Geophysical Research Letters*, **40**(5), 841–846 <http://dx.doi.org/10.1002/grl.50257>.