Anticipated expenses

I will need a desktop ($\sim\$1,000$) for code development and small scale simulations. For high performance computing needs, I will apply for a cluster allocation through the Extreme Science and Engineering Discovery Environment (XSEDE), which has no cost. The only software that I will need, Python and Pylith (Aagaard et al., 2013), are free and open source. Additional expenses will include travel for conferences ($\sim\$3,000$) and publication fees ($\sim\$2,000$). In total, I do not expect my research expenses to significantly exceed $6,000.

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Trever T. Hines
Resumé

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Research Opportunity

RO 16-15: Novel crustal deformation models for characterizing earthquake hazard and its uncertainties in the western U.S.

I became aware of the Mendenhall research fellowship through my colleagues who have spoken highly of the program. I become aware of this particular project after communicating with potential advisor Sarah Minson.

Education

PhD candidate, *University of Michigan, Ann Arbor* 2012-present
- Geophysics (certificate in Computational Discovery and Engineering)
- GPA: 3.92 / 4.00
- Advisor: Eric A. Hetland
- Thesis: postseismic and interseismic signature of viscoelasticity in the lower crust and upper mantle

BS, *University of Illinois, Urbana-Champaign* 2008 - 2012
- Geology (minor in Natural Resource Conservation)
- GPA: 3.67 / 4.00

Research Positions

Ecological modeling intern, *Smithsonian Environmental Research Center* Summer 2012
- Created statistical models to describe spatial variability in blue crab populations throughout Chesapeake Bay

Crop science research assistant, *University of Illinois* 2010 - 2011

Teaching Experience

Michigan Math and Science Scholars instructor, *University of Michigan* Summer 2015

- Co-taught a summer course for High School students on the mathematics of natural hazard

Graduate student instructor, *University of Michigan* Fall 2014 and 2015

- Led labs for EARTH 468, Data Analysis and Model Estimation

Publications

Hines, T. T., and E. A. Hetland (submitted to J. Geophys. Res.), Rheologic constraints on the upper mantle from five years of postseismic deformation following the El Mayor-Cucapah earthquake

Hines, T. T., and E. A. Hetland (2016), Rapid and simultaneous estimation of fault slip and heterogeneous lithospheric viscosity from post-seismic deformation. Geophys. J. Int. 204, doi: 10.1093/gji/ggv477

Hines, T. T., and E. A. Hetland (2013), Bias in estimates of lithosphere viscosity from interseismic deformation. Geophys. Res. Lett., 40, doi:10.1002/grl.50839.

Abstracts

Hines, T. T. and E. A. Hetland (2015 invited speaker), Kalman filter based estimation of lithospheric viscosity and fault slip from postseismic deformation: application to the 2010 El Mayor-Cucapah earthquake. American Geophysical Union 2015 Fall Meeting, San Francisco, CA.

Hines, T. T. and E. A. Hetland (2015), Inversion of postseismic deformation for lithospheric viscosity and fault slip. Society for Industrial and Applied Mathematics: Geosciences 2015 meeting, Stanford CA.

Hines, T. T. and E. A. Hetland (2014), Direct inversion of postseismic deformation for lithospheric viscosity structure and fault slip. American Geophysical Union 2014 Fall Meeting, San Francisco, CA.

Hines, T. T. and E. A. Hetland (2014), Determination of lithosphere rheology from interseismic deformation and implications for fault stress accumulation. Seismological Society of America 2014 Annual Meeting, Anchorage, AK.

Hines, T. T. and E. A. Hetland (2013), Bias in estimates of lithosphere viscosity from interseismic deformation. American Geophysical Union 2013 Fall Meeting, San Francisco, CA.

Hines, T. T. and E. A. Hetland (2013), Evaluating geodetic constraints on the strength of the lithosphere. Michigan Geophysical Union, Ann Arbor, MI.

Workshop Attendance

CIG Crustal Deformation Modeling Workshop, *Stanford University* Summer 2014

- One week course on using Pylith, a finite element program for modeling lithosphere dynamics

InSAR: An introduction to ISCE and GIAnT, *UNAVCO* Summer 2014

- Three day course on processing Interferometric Synthetic Aperture Radar (InSAR) data

Field Work

Wasatch-Uinta Summer Field Camp, *University of Illinois* Summer 2012

- Six week field mapping course in the Wasatch and Uinta mountains in Utah

The Geology of County Clare, Western Eire, *University of Illinois* Spring 2012

- Two week course studying the sedimentology, paleoecology and evolution of a sedimentary basin with an emphasis on hydrocarbon exploration

Honors / Involvement

Best Graduate Student Instructor Award, University of Michigan 2015
Seismological Society of America, member 2013-present
American Geophysical Union, member 2013-present
Society for Industrial and Applied Mathematics, member 2012-present
Outstanding Senior Award, University of Illinois 2012

References

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Abstracts of Manuscripts

Bias in Estimates of lithosphere viscosity from interseismic deformation:

The estimation of uniform viscosities representing the lower crust and uppermost mantle from postseismic or interseismic deformation (i.e., apparent viscosities) is inherently biased with respect to a depth dependence of the viscosities within each layer. Estimates are biased toward a more viscous lower crust or a less viscous lithospheric mantle, depending on the relative geometric mean viscosities of the two layers. When there is a low-viscosity shear zone beneath the fault, apparent viscosities are close to that of the shear zone immediately after the earthquake, although the apparent viscosities increase significantly during the later interseismic period. Inferences made from interseismic deformation that the lower crust is more viscous than the upper mantle may be entirely consistent with depth-dependent viscosity profiles that have a significant increase in viscosity from the lowermost crust to the uppermost mantle.

Rapid and Simultaneous estimation of fault slip and heterogeneous lithospheric viscosity from post-seismic deformation:

Post-seismic deformation is commonly attributed to viscoelastic relaxation and/or afterslip, although discerning between the two driving mechanisms can be difficult. A major complication in modeling post-seismic deformation is that forward models can be computationally expensive, making it difficult to adequately search model space to find the optimal fault slip distribution and lithospheric viscosity structure that can explain observable post-seismic deformation. We propose an inverse method which uses coseismic and early post-seismic deformation to rapidly and simultaneously estimate a fault slip history and an arbitrarily discretized viscosity structure of the lithosphere. Our method is based on an approximation which is applicable to the early post-seismic period and expresses surface deformation resulting from viscoelastic relaxation as a linearized function with respect to lithospheric fluidity. We demonstrate this approximation using two-dimensional earthquake models. We validate the approximation and our inverse method using two three-dimensional synthetic tests. The success of our synthetic tests suggests that our method is capable of distinguishing the mechanisms driving early post-seismic deformation and recovering an effective viscosity structure of the lithosphere.

Rheologic constraints on the upper mantle from five years of postseismic deformation following the El Mayor-Cucapah earthquake:

Five years of postseismic deformation following the Mw7.2 El Mayor-Cucapah earthquake reveals transient deformation that decays back to its pre-earthquake trend after about three years at epicentral distances greater than $\sim$200 km. At closer distances, the rapid transience decays to a sustained rate which exceeds its pre-earthquake trend. We attempt to determine the mechanisms driving this deformation, where we consider afterslip at seismogenic depths and viscoelastic relaxation in the lower crust and upper mantle as candidate mechanisms. We find that early, rapid, near-field deformation can be explained with afterslip on the fault that ruptured coseismically, while the later, sustained, near-field deformation can be explained with either continued afterslip in an effectively elastic lower crust, or lower crustal viscoelastic relaxation with a steady-state viscosity of $\sim 10^{19}$ Pa s. The trend in far-field deformation is best explained with a transient viscosity of $\sim 10^{18}$ Pa s in the upper mantle. We argue that a transient rheology in the mantle is preferable over a Maxwell rheology because it better predicts the decay in postseismic deformation, and also because it does not conflict with the generally higher, steady-state viscosities inferred from studies of geophysical processes occurring over longer time-scales.