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From micro to macro: the role of defects in the mechanical response of Earth and Planetary materials

Christine McCarthy
United States (mccarthy@ldeo.columbia.edu)

Microstructural features can greatly influence the bulk behavior of materials. Impurities, grain (and subgrain) size, dislocations, and partial melt can all affect the way that seismic waves are damped in the mantle, for instance, or how tidal energy is dissipated within an icy moon's outer shell. With proper scaling of the viscoelastic response, it is possible to use the attenuation signature—for instance, the variation of Q with the micro/mesoscale evolution of deformation-induced strain (i.e. fabric)—as a prospecting tool to determine active deformation structure within bodies of ice or rock at macroscopic (km) scale. In order to better interpret seismic data and provide better constraints for geophysical modeling, I design and perform laboratory experiments to directly measure the plastic and anelastic behaviours of various Earth and planetary materials, including polycrystalline ice. I will discuss findings from attenuation experiments, in particular results that suggest a coupling between deformation-induced microstructure effected by tectonics and attenuation behaviour. I will also discuss recent experiments that combine anelastic and frictional response using a custom-built biaxial friction apparatus. The experiments provide dynamic, frequency-dependent material properties of ice and ice on rock deformation at frequencies consistent with tidal forcing of Antarctic and Greenland glaciers. Such data can be used directly in models of glacier and ice stream flow and will inform our understanding of the complex glacier dynamics needed to improve predictions of sea level rise. Additionally, the experimental measurements can ultimately be compared with field observations to infer characteristics of the bed interface and the material composition of the bulk glacier.