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Dr. Emma Hill is a Nanyang Assistant Professor at the Earth Observatory of Singapore, NTU. She is a geodesist, with research interested in climate change and natural hazards. She obtained her B.Sc. in Surveying and Mapping Science from the University of Newcastle-upon-Tyne, UK, and her Ph.D. in Geophysics from the University of Nevada, Reno, USA. Prior to moving to Singapore, she was a Postdoctoral Fellowship with the Space Geodesy Group at the Harvard-Smithsonian Center for Astrophysics, USA. Dr. Hill is a Singapore National Research Foundation Fellow.

Abstract

The Dynamic Surface of the Earth

Geodesy is a field that studies changes in the Earth's shape, and gravity field. These changes can be caused by, amongst other things, earthquakes and tectonic deformation, melting of glaciers and ice sheets, volcanic eruptions, sea-level rise, and seasonal variations in the amount of water stored in a particular region. The advent of space-geodetic techniques means that we can study these parameters with great precision, high temporal resolution, and often with global coverage. Geodesy is thus a particularly interdisciplinary subject, contributing to significant developments in many areas of earth science, and also working to connect the different processes together.

As one example of geodetic investigation, the GRACE gravity satellites take a monthly snapshot of the Earth's gravity field, and thus show how mass (primarily water) moves around the surface of the Earth, both seasonally and over the long term. The response to this movement of mass is complex: Newton's law of universal gravitation states that all mass attracts other mass. Thus, for example, as melting reduces the mass of a glacier, the gravitational attraction between the ocean water and the glacier is reduced. This causes a distinct spatial change in sea level. Additionally, the Earth's crust rebounds upward as the glacier load is reduced, also causing a spatial response in sea level. This leads to the rather counterintuitive result that in the vicinity of a large melting glacier, sea level will actually fall, but in the tropics, sea level will rise at rates faster than the global average. We thus see how sea-level rise in Singapore is connected to the melting of distant glaciers not only because the meltwater enters the global ocean, but also because the shifting mass causes subtle changes in the Earth's gravity field.
As a second example, high-precision Global Positioning System (GPS) stations can continuously monitor their exact position, and thus record how the Earth responds

to processes such as tectonic deformation and earthquakes. We maintain a network of GPS stations across Sumatra and its offshore islands; these stations have recorded their displacements from the 100 or so moderate to large earthquakes that have occurred in the region since the devastating great earthquake in 2004, and many of the 1000s of smaller earthquakes. We currently face the complex problem of separating the spatially and temporally differing signals in the GPS time series from these many tectonic displacements. Figuring out if and how these earthquakes interact with each other (through stress changes in the Earth) is also a highly relevant question that may be of interest to the complexity community.