Global Surface Mass Loads Estimated From GPS Data

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The solid Earth is surrounded by oceans and by a fluid, mobile atmosphere. A continually changing distribution of ice, snow, and ground water lies upon its land surface. The changing distribution of mass associated with the migration of these surficial fluids changes Earth’s gravitational field, changes Earth’s rotation by changing its inertia tensor, and changes Earth’s shape by changing the load on the solid Earth. Changes in Earth’s rotation have been measured for more than a century and the Gravity Recovery and Climate Experiment (GRACE) is currently measuring changes in the Earth’s gravitational field at monthly intervals. Recent studies indicate that large-scale changes of the Earth’s shape, and hence of the mass load causing Earth’s shape to change, can be measured using the global network of GPS receivers.

Data from the approximately 400 station International GNSS Service (IGS) network of globally distributed GPS stations has been used to characterize global changes in Earth’s shape. In this approach, the point displacements at each GPS station are used to fit the coefficients of a vector spherical harmonic expansion. These spherical harmonic coefficients are then related to the density of the surface mass load that is causing Earth’s shape to change. In Figure 1, changes in the degree-2, order-1 sine coefficient of the surface density field that has been inferred from GPS measurements during 1997–2000 are compared to those determined from Earth rotation measurements from which the effects of tides, winds, and currents have been removed. As can be seen, there is excellent agreement between these independent estimates of the spherical harmonic coefficient of the surface mass density. This finding demonstrates that the global GPS network can provide an independent method of investigating global surface mass load variations.

Publications

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Figure 1. Changes in the degree-2, order-1 sine coefficient of the surface density inferred from both GPS measurements of changes in the shape of the Earth’s surface (red curves) and from Earth rotation measurements (black curves). All displayed curves have had a mean and trend removed from them. In addition, the curves displayed in the right-hand-side panel have also had periodic terms at the annual, semiannual, and terannual (3 cpy) frequencies removed from them.