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The Contribution of GGOS to Understanding Dynamic Earth Processes

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Geodesy is the science of the Earth's shape, size, gravity and rotation, including their evolution in time. Geodetic observations play a major role in the solid Earth sciences because they are fundamental for the understanding and modeling of Earth system processes. Changes in the Earth's shape, its gravitational field, and its rotation are caused by external forces acting on the Earth system and internal processes involving mass transfer and exchange of angular and linear momentum. Thus, variations in these geodetic quantities of the Earth reflect and constrain mechanical and thermo-dynamic processes in the Earth system. Mitigating the impact on human life and property of natural hazards such as earthquakes, volcanic eruptions, debris flows, landslides, land subsidence, sea level change, tsunamis, floods, storm surges, hurricanes and extreme weather is an important scientific task to which geodetic observations make fundamental contributions. Geodetic observations can be used to monitor the pre-eruptive deformation of volcanoes and the pre-seismic deformation of earthquake fault zones, aiding in the issuance of volcanic eruption and earthquake warnings. They can also be used to rapidly estimate earthquake fault motion, aiding in the modeling of tsunami genesis and the issuance of tsunami warnings. Geodetic observations are also used in other areas of the Earth sciences, not just the solid Earth sciences. For example, geodesy contributes to atmospheric science by supporting both observation and prediction of the weather by geo-referencing meteorological observing data and by globally tracking change in stratospheric mass and lower tropospheric water vapor fields. Geodetic measurements of refraction profiles derived from satellite occultation data are routinely assimilated into numerical weather prediction models. Geodesy contributes to hydrologic studies by providing a unique global reference system for measurements of: sub-seasonal, seasonal and secular movements of continental and basin-scale water masses; loading and unloading of the land surface due to seasonal changes of groundwater; measurement of water level of major lakes and rivers by satellite altimetry; and improved digital terrain models as basis for flux modeling of surface water and flood modeling. Geodesy is crucial for cryospheric studies because of its ability to measure the motions of ice masses and changes in their volumes. Ice sheets, glaciers, and sea ice are intricately linked to the Earth's climate system. They store a record of past climate; they strongly affect surface energy budget, global water cycle, and sea-level change; and they are sensitive indicators of climate change. Geodesy is at the heart of all present-day ocean studies. Geodetic observations uniquely produce accurate, quantitative, and integrated observations of gravity, ocean circulation, sea surface height, ocean bottom pressure, and mass exchanges among the ocean, cryosphere, and land. Geodetic observations have made fundamental contributions to monitoring and understanding physical ocean processes. In particular, geodesy is the basic technique used to determine an accurate geoid model, allowing for the determination of absolute surface geostrophic currents, which are necessary to quantify heat transport of the ocean. Geodesy also provides the absolute reference for tide gauge measurements, allowing those measurements to be merged with satellite altimetric measurements to provide a coherent worldwide monitoring system for sea level change. In this presentation, selected examples of the contribution of geodetic observations to understanding the dynamic Earth system will be presented.