A mathematical simulation of the dynamics of local Earth gravity direction referring to the Earth surface normal

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Based on the development of measurement and information technology, geodetic measurements are continually reported with high quality. ITRF2008 [1] claims a believed origin accuracy at the level of 1 cm over the time-span of 26 year of SLR observations, and further 1.2 ppb (8 mm) accuracy is achieved by integrating other three techniques together: GNSS/GPS, VLBI and DORIS. With latest technical improvements, even better accuracy could be expected in the new solution of ITRF2014 [2].
It is often expected, that geodetic measurements with high accuracy should be helpful in understanding the geo-physical principle of Earthquake. Therefore many comparative analyses have been carried out aiming at constructing a correlation between recorded giant earthquakes and the temporal variations of some geodetic measurements. The conclusions from these analyses are generally frustrating, that the observed discrepancies of measurements, e.g., Earth gravity changes, ``reflect the difference in the geodynamical settings of the studied earthquakes'' [3]. Such a frustration often leads to the widespread argument that predicting Earthquake is impossible.
The gap between the plausible achievements in geodetic measurement and the frustrating conclusions by using them for interpreting earthquakes, could be explained by the *Nyquist-Shannon* sampling theorem: to detect a single event without prior knowledge, its temporal-spatial domain should be sampled with an adequate frequency. In geo-science the situation is far from being satisfied. Normally an earthquake is a local event which accidentally happens at a particular time moment covering a close neighborhood of its epicenter. Densely sampling the dynamical behaviors on Earth is often a suffering task because of two factors: 1) the scale, and 2) the system reference. A typical velocity of plate tectonic movements which varies from 1-10 cm/year is indistinguishable from random noise in most of daily observations; The system reference of geodetic observation is often set either as man-made satellites, or as natural space objects like lunar or extragalactic reference, which are neither convenient nor flexible for local and dense geo-observations.
This paper suggests a new geo-observation in which the reference system is set as the local geometry of the Earth's surface. There are two distinct vectors existing on Earth’s surface: the surface normal, which is defined as a geometric descriptor, and the direction of the Earth's gravity force, which is defined as the gradient of the Earth's gravitational potential pointing to the Earth mass center. It is expected to get information of the mass distribution below the Earth's crust layer. A mathematical simulation is carried out with typical Earth parameters; A conceptual measurement model is described to measure the subtle angular difference between the above two vectors, where the angular difference is converted to a spatial distance according a dedicatedly designed system. Laser interferometer together with an ultra-high precision camera system provides a sub-nanometer measurement accuracy, which in principle could be measured over time span of hours, even minutes. Without systematic ambiguities like un-modelled forces in space, signal delay in ionosphere, the suggested concept physically is promising for a complementary geo-measurement besides the current mainstream techniques.

References:

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