GEOL 695-Environmental Geodesy
Assignment #3 - Lectures 6-8

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Problem 1: Describe the main characteristics of point-geodetic observations versus imaging techniques in terms of spatial and temporal resolution and coverage.

Generally speaking, point-geodetic observations have low spatial but high temporal resolution and coverage, while imaging techniques have better spatial resolution and coverage but lower temporal resolution.

Problem 2: What is the "station motion model" and how does it enter into the analysis of point-geodetic techniques?

The station motion model accounts for position variations having periods shorter than the analysis interval. (Actually, by the Nyquist theorem, variations shorter than half the analysis interval must be accounted for.) These variations must be accounted for when producing a time series so that aliasing is avoided.

Problem 3: Which space-geodetic techniques provide the origin of the reference frame with respect to the center of mass and which provide the scale? Why?

(Artificial) satellite (SLR) and lunar (LLR) laser ranging provide the reference frame origin; the scale is determined by laser ranging in combination with very-long-baseline interferometry (VLBI). Satellites, both artificial and natural, obey the laws of gravitation. To first approximation in the two-body problem, a satellite and its parent body revolve around their common barycenter, which is the average of their two centers of mass. For a satellite which is small in comparison to the other body, this will be very close to the CM of that body (e.g. the earth). Scale from VLBI is based on differenes in the times-of-arrival of wavefronts at each end of a baseline and from knowledge of the speed of light.

Problem 4: Explain the principle of GNSS reflectometry.

Reflectometry uses the delay between direct and ocean-reflected signals to extract altimetric height.

Problem 5: Why are laser retroreflectors on satellites like Global Navigation Satellites, altimeter satellites, and other satellites that use geometrical principles important?

Laser retroreflectors provide the means to obtain precise range measurements to satellites which are independent of, for example, the L-band ranging inherent in GPS or other GNS systems and thus can contribute to improved orbit determination. Precise positioning, expecially point positioning, requires precise orbits.

Problem 6: Explain briefly the principle of InSAR and identify the major limitations for accuracy and and applicability. How could these challenges be addressed?

Synthetic aperture radar (SAR) is a technique that synthesizes a larger antenna by exploiting the motion a smaller one to get a larger effective aperture. Interferometric SAR (InSAR) is a processing technique in which interferograms are produced from spatially (to measure topography) or temporally-separated SAR images (to measure range changes along the line of sight). Limitations to InSAR include satellite orbit uncertainties and atmospheric (primarily wet tropospheric) variations. Orbit uncertainties could be reduced, for example, if retroreflectors were provided for laser ranging. Uncertainties induced by tropospheric effects can be mitigated by utilizing GNSS in a complementary mode.

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Problem 7: What are the main characteristic of in situ, airborne and spaceborne gravity measurements in terms of temporal and spatial resolution, as well as accuracy as function of spatial and temporal scale?

In-situ gravity measurements can provide high temporal but only low spatial coverage. In principal, short spatial wavelengths may be resolved with in-situ measurements, but practical considerations limit thoroughness of spatial coverage. Furthermore, because in-situ measurements must be performed in conjunction with differential leveling, error propagation in the latter technique induces large errors in the longer spatial wavelengths of the determined gravity field. Because ground-based measurements suffer less attenuation than airborne or spaceborne measurements, they can provide higher accuracy in determining anomalous gravity than either of these other techniques. Airborne gravity measurements can provide excellent spatial resolution, with somewhat lower temporal resolution than in-situ measurement. Although they suffer less gravity signal attenuation than measurements on satellites, airborne gravity measurements require knowledge of motion-induced accelerations (due to the equivalence principle). Spaceborne gravity measurements can provide very good temporal resolution and coverage, with spatial coverage somewhere in between airborne and in-situ techniques. However, due to gravity attenuation (as characterized by the inverse square law), some low-pass spatial filtering results, making it harder to resolve smaller spatial wavelengths.

Problem 8: Explain the principle of GRACE and its main limitations in terms of accuracy.

The Gravity Recovery and Climate Experiment (GRACE) uses measurements of the changes in distance and speed between two satellites (using GPS and microwave ranging) to measure spatial and temporal variations in the gravity field. The satellites orbit with a frequency of 1/16 days, and, in practice, gravity maps are produced by GRACE on a monthly basis. Factors which limit accuracy include sensor accuracy limitation, "disturbances[1]", insufficient spatial and temporal sampling, and limitiations in models and representation.

1 The most prominent feature of Slide 22, Lecture 8 appears to be a Schuler period which is common to all inertial measurements in the vicinity of the earth. This is a predictable effect and can be modeled. The variation around the Schuler period is probably mostly sensor noise.