G52B-0047 1330h POSTER

Towards a Realistic Uncertainty Budget for GPS Heights

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Precise GPS-determined heights play a key role in many geodetic and geophysical applications, in particular as input for studies on loading or rebound effects. For a meaningful interpretation of the heights and height changes their effective uncertainty has to be considered. It consists of stochasticity (reflecting the purely random component) and imprecision due to unknown systematic deviations between observations and model. Its assessment is indispensable for the distinction between signal and noise. In case of local GPS networks the entire uncertainty budget can sufficiently be described by normally distributed measurement errors since many disturbing effects are cancelled out by measurements methods or analysis strategies. In case of regional (or global) networks imprecision becomes the dominant component. In the common approach, both components are modeled by stochastic means. However, there are two main shortcomings yielding too optimistic uncertainty measures of the results. First, this strategy pretends a reduction of systematics. Second, since GPS permanent networks provide a sufficiently large number of observations, the total uncertainty of the results will decrease below any limit. As both effects massively contradict any practical experience, stochasticity and imprecision should be treated in a more adequate way. For this purpose, this contribution focusses on the description of imprecision by means of deterministic intervals without any stochastic properties. In a first part, the imprecision of GPS phase observations is quantified by intervals using a forward modelling approach based on a set of basic parameters. The different processi ng and correction steps which are applied to the original GPS observations in GPS data analysis (such as, e.g., due to tropospheric or ionospheric refraction, or antenna phase cen ter variation) are studied in detail. As a result, typical imprecision intervals are composed which show the impact of standard correction models as well as of different baseline lengths and satellite constellations. In a second part, these intervals are transferred to the estimated point coordinates. It will be shown that the imprecision is maximum for the vertical coordinate component (height). This is similar to the random errors which are adequately represented by the variance-covariance matrix. The extended uncertainty is finally derived by superposing stochasticity and imprecision. Numerical examples are computed for a network of GPS permanent stations in Europe (EUREF) in order to illustrate the theoretical results.

G52C MCC: Level 1 Friday 1330h

Seasonal Signals in Space Geodetic Solutions Posters

***Presiding:* G Blewitt,** Nevada Bureau of Mines and Geology and Seismological Laboratory**; D Dong,** Jet Propulsion Laboratory, California Institute of Technology

G52C-0048 1330h POSTER

The effect of the second order GPS ionospheric correction on receiver positions

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The Global Positioning System (GPS) transmits two frequencies, allowing users to correct for the first-order ionospheric signal group delay (or phase advance) of 1-50 m. The second-order ionospheric term, caused by the Faraday rotation effect induced by the Earth magnetic field, is about 1000 times smaller and usually ignored. In this study, we implement the 2nd-order correction suggested by Bassiri and Hajj [1993] and investigate its effect on GPS-inferred station positions. The correction causes a latitude dependent 0.1-0.5 cm southward shift to the position which is roughly proportional to the integrated electron density above the receiver, and has strong diurnal, seasonal and decadal signatures. By analyzing a three-year time series of equatorial station positions obtained without the 2nd-order correction, a strong semi-annual north-south oscillation is observed, the origin of which has not been hitherto explained. We verify that this apparent oscillation can be largely removed once the 2nd-order correction is applied.

G52C-0049 1330h POSTER

Groundwater-Driven Vertical Movement in Tsukuba Detected by GPS

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Seasonal variations observed in the vertical coordinate timeseries of an IGS site TSKB (in Tsukuba, Japan) are investigated. First, we compared the GPS timeseries with the vertical displacements measured by a subsidence meter installed in a 190m-well near the site. It is found that the coherence between the two timeseries is as high as 0.7 and admittance is close to 1. Since the subsidence meter measures displacements occurred in the depth shallower than 190m, it suggests that the seasonal variations in the GPS timeseries are also caused in the corresponding depth. Here we focused on the ground-water as a possible cause of the displacements. A simple model is employed where strains caused by pore pressure changes in water tables are responsible for the vertical coordinate changes. Assuming the static pressure caused by the water column in wells are in equilibrium with the pore pressure in the corresponding water table, we simulate the vertical displacements using the water-level changes observed in the nearby wells, and estimate the volume compressibility of the rocks in the water tables by a least-square method. It is found that water tables between 40m and 190m are responsible for the displacements, and the model successfully explains 65% of the variances of the GPS timeseries. The volume compressibility of the rocks in the water tables is estimated to be $3\times10^{-9} N/m^2$, which is a reasonable value. Our hypothesis that the water tables deeper than 40m are responsible is consistent with the fact that TSKB station and the Tsukuba VLBI station, which has a basis on the top of the water table just below 40m, move coherently.

G52C-0050 1330h POSTER

Laser, GPS and absolute gravimetry vertical positioning time series comparison at the OCA observatory, France

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Time-dependent displacements of stations usually have magnitude close to the accuracy of each individual technique, and it still remains difficult to separate the true geophysical motion from possible artifacts inherent to each space geodetic technique. The Observatoire de la Côte d'Azur (OCA), located at Grasse, France benefits from the collocation of several geodetic instruments and techniques (3 laser ranging stations, and a permanent GPS) what allows us to do a direct comparison of the time series. Moreover, absolute gravimetry measurement campaigns have also been regularly performed since 1997, first by the "Ecole et Observatoire des Sciences de la Terre (EOST) of Strasbourg, France, and more recently by the Royal Observatory of Belgium. This study presents a comparison between the positioning time series of the vertical component derived from the SLR and GPS analysis with the gravimetric results from 1997 to 2003. The laser station coordinates are based on a LAGEOS -1 and -2 combined solution using reference 10-day arc orbits, the ITRF2000 reference frame, and the IERS96 conventions. Different GPS weekly global solutions provided from several IGS are combined and compared to the SLR results. The absolute gravimetry measurements are converted into vertical displacements with a classical gradient. The laser time series indicate a strong annual signal at the level of about 3-4 cm peak to peak amplitude on the vertical component. Absolute gravimetry data agrees with the SLR results. GPS positioning solutions also indicate a significant annual term, but with a magnitude of only 50% of the one shown by the SLR solution and by the gravimetry measurements. Similar annual terms are also observed on other SLR sites we processed, but usually with! lower and various amplitudes. These annual signals are also compared to vertical positioning variations corresponding to an atmospheric loading model. We present the level of agreement between the different techniques and we discuss possible explanations for the discrepancy noted between the signals. At last, we expose explanations for the large annual term at Grasse: These annual variations could be partly due to an hydrological loading effect on the karstic massif on which the observatory is located.

G52C-0051 1330h POSTER

Common-mode Signals Observed from the Korean GPS Network

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As of September 2003, there are more than 70 permanent Global Positioning System (GPS) stations in South Korea. We have been observing the three-dimensional velocity of each site for geodynamical studies in the northeast Asia. From the time series of the estimated site positions, most of which are longer than three years now, we found very interesting common-mode signals. Especially, in the vertical direction, the amplitude of the seasonal (annual) signal reaches up to a few centimeters. Other than the seasonal signal, we also could observe very intriguing dips and peaks occurring randomly. In this discussion, we will first introduce the current Korean GPS Network and will show two different ways to get the common-mode signals from a set of time series. By trying out many different data processing schemes, we will infer the best candidates for the real cause for those common-mode signals.

G52C-0052 1330h POSTER

Analysis of Site Position Time Series Derived From Space Geodetic Solutions

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This presentation deals with the analysis of station coordinate time series obtained from VLBI, SLR, GPS and DORIS solutions. We also present time series for the origin and scale derived from these solutions and discuss their contribution to the realization of the terrestrial reference frame. For these investigations we used SLR and VLBI solutions computed at DGFI with the software systems DOGS (SLR) and OCCAM (VLBI). The GPS and DORIS time series were obtained from weekly station coordinates solutions provided by the IGS, and from the joint DORIS analysis center (IGN-JPL). We analysed the time series with respect to various aspects, such as non-linear motions, periodic signals and systematic differences (biases). A major focus is on a comparison of the results at co-location sites in order to identify technique- and/or solution related problems. This may also help to separate and quantify possible effects, and to understand the origin of still existing discrepancies. Technique-related systematic effects (biases) should be reduced to the highest possible extent, before using the space geodetic solutions for a geophysical interpretation of seasonal signals in site position time series.

G52C-0053 1330h POSTER

Effect of Seasonal Mass Loading Signals on VLBI Crustal Displacement Measurements

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Observed VLBI site position variations contain significant contributions at annual and semiannual frequencies (2-8 mm for the vertical). We have determined the extent to which these observed site variations can be explained by mass loading signals. Specifically, we examined the effects of hydrologic (soil moisture and snow) loading [Milly and Shmakin, 2002], nontidal ocean loading [ECCO model], and atmospheric pressure loading [using NCEP reanalysis data]. We find that application of mass loading models reduces annual vertical amplitudes for 70% of the 36 most frequently observed sites by up to 2-3 mm. Baseline length repeatabilities are reduced for about 2/3 of the baselines between these sites. In addition, we have examined corrections for errors specific to the VLBI technique, troposphere delay mismodeling and antenna thermal deformation, which also have seasonal signatures. We have also compared GPS site annual amplitudes derived from site vertical position time series [Dong et al., 2002] with corresponding VLBI amplitudes for colocated sites.

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