Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P01 Room:Convention Hall Time:May 23 14:00-16:30

True polar wander of a quasi-fluid planet with a fossil shape: Effect of strain energy due to tidal deformation

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Elastic strain energy stored in lithospheres of solid planets and satellites affect evolution of these rotation axes, especially true polar wander (hereafter ”TPW”). If we suppose an ideal planet without a lithosphere which completely behave as fluid body, its figure always keeps hydrostatic state. In this case, its spin pole finally coincides with the principal axis of its moment of inertia tensor. It is because this state minimizes the rotational energy. On the other hand, in the case of more realistic planet with an elastic lithosphere, one previous research pointed out a possibility that its spin axis and principal axis are not coincident each other. This remarkable argument is concluded solely because of the fact that huge amount of strain energy is accumulated in a lithosphere due to tidal stress by long-term polar motion. Thus, a pole position is settled at the different place in order that this position minimizes total energy including not only rotational energy but also strain energy.

The content treated in the previous study shown above, however, is just a difference of paleo-pole positions before and after TPW. In other words, the previous study did not handle secular time variation of a spin pole location from an initial state to a final state.

In the present study, therefore, temporal variation of a paleo-pole position due to TPW is formulated and calculated based on the strain energy as mentioned above in the previous study. Especially, the quasi-fluid approximation is suitable to deal with large-scale and long-term variation of a paleo-pole position. Thus, an orientation of a paleo-rotation axis in each time step is estimated in here by following the conventional formulation with the quasi-fluid approximation for TPW, and simultaneously by taking total energy minimization into account. In practice, this procedure is physically same as to incorporate elastic torque due to tidal deformation of a lithosphere into the Liouville equation including the quasi-fluid approximation. In this study, like the previous one, only one symmetric surface load is regarded as a driving force of TPW for the sake of convenience. In this calculation, the variable parameters are defined as follows: a location of emplacement, duration of formation, and maximum of intensity of a load. The result with strain energy is compared with that without strain energy.

As a result, the case with the strain energy indicates different characteristics from that without the strain energy in the following points. First, the paleo-poles under the steady states are different each other even in the cases for same parameters. These results have no contradiction to the previous results concerning just the final condition. Second, also in the cases for same parameters, time scales when the paleo-poles reach the static limits are different. These results demonstrate the fact that strain energy within a lithosphere effectively weakens influence of a load on TPW. Although such influence has already been pointed out by the previous results just in the case of the steady state, the present results further revealed similar effect also on a characteristic time scale of TPW. Strictly speaking, however, it is impossible to estimate this exact time scale only by reducing an effective size of a load. This is because secular variation in strain energy induced by TPW inevitably occurs after variation of a load itself as driving force. This delay results from visco-elastic readjustment of centrifugal bulge in response to long-term polar motion.

In conclusion, the present results imply that strain energy is not necessarily negligible in terms of physical interpretation for realistic TPW of the planets and satellites in the solar system, especially characteristic time scales and time variation between the initial and final state of the spin axis.

Keywords: fossil shape, quasi-fluid approximation, polar wander, elastic lithosphere, tidal deformation, strain energy

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Research on the parallel processing of VLBI USB samplers by using virtualization OS

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K5/VSSP(Versatile Scientific Sampling Processor)32 sampler can beconnected by USB. It is used for VLBI(Very Long Baseline Interferometry) observation. In the normal operation only one sampler can operate by one PC. To improve the problem, we introduce the latest Multi-virtual OS technology. We installed four virtual OSs in one PC. And we operated one sampler by one virtual OS, respectively. We have succeeded in the realize the geodetic VLBI observation of 16ch/8Mbps and 16Mbps by using only one PC with our multi-virt system. We will report our analysis of the experiment by using the correlation processing.

Keywords: virtualization, VLBI, sampler, correlation processing

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Development of space geodetic analysis software c5++, Part-2

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New analysis software ”c5++” is being developed at NICT, Hitotsubashi Univ and JAXA for high-precision geodesy/navigation data such as SLR (Satellite Laser Ranging) and VLBI (Very Long Baseline Interferometry).

This software is oriented for combining multiple types of observations, which is getting common in geodetic analyses and other purposes. The ”c5++” software is equipped with the combination procedure such as ”VLBI+SLR” data set at the observation level.

The physical models in Earth rotation, site displacement, satellite acceleration and propagation delay are being updated so that it has full compatibility with the newly-released IERS Conventions 2010.

The first outcome from this software is a rapid UT1 analysis from VLBI data. The poster contains the actual results from this project.

Keywords: space geodesy, satellite laser ranging, very long baseline interferometry

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Construction of GEONET quasi-real-time analysis system

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GSI has processed the GPS kinematic analysis with GEONET 1 Hz sampling data when a large earthquake occurs. The purpose of this analysis is to obtain the detailed behavior of land deformation caused by the earthquake with high time resolution. This method also has an advantage in terms of the time until we can get results. Because of processing data with epoch-by-epoch, compared to the GEONET routine analyses which need at least 6 hours data set, it enables us to start the analysis flexibly. Meanwhile, we need to be careful when we use it that the accuracy and reliability is relatively worse than the GEONET routine analyses.

A current problem is that we spend long hours until starting process because of some steps like deciding the area, choosing GEONET stations and setting appropriate parameters. We have carried out those steps manually and could not fully utilize the advantages. So we establish a new strategy to kick off the analysis automatically by using the information from the JMA Earthquake Early Warnings system. This new method has been applied since March 2011 and made us possible to get results within 1 hour in the fastest case.

Keywords: GEONET, GPS

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Monitering of atmospheric precipitable water using GPS and microwave radiometer

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Temporal variations of precipitable water (PW) from fixed continuous GPS observations are compared with those from microwave radiometer (MR) observations and radiosonde measurements. All data were collected at the same site (Kochi University) for about one month in June 2010. GPS data were processed with the precise point positioning method of GIPSY-OASIS II ver.6.0 using precise satellite orbits and clocks, Vienna mapping function, and Onsala ocean loading correction coefficients. Zenith wet delay was estimated every five minutes after resolving phase ambiguities and then converted to GPS-PW by multiplying a constant coefficient. No significant difference was recognized ($<$ 1 %) even when time-variant coefficients expected from hourly surface temperature measurements were used. The MR measured zenith brightness temperatures of the atmosphere at 23 GHz and 36 GHz frequencies every ten seconds. We have newly calculated conversion coefficients from the brightness temperature to PW based on the GPS-PW estimates. Correlation coefficient between GPS-PW and MR-PW is as high as 0.974 after abnormal MR measurements at the rain fall are excluded. Since the MR is highly mobile and capable of real-time measurements, it is applicable to the direct monitoring of water vapor disturbance in an urban area where infrastructure has been highly developed and GPS is no longer an effective observation tool.

Next we investigate effects of satellite orbit information and mapping function on the GPS atmospheric delay estimation. We processed one-year GPS data at Kochi (GEONET 0083) using the final precise orbits and Vienna mapping function and also using the ultra-rapid orbits and Global mapping function. Two time series of zenith wet delay from different combination of sattelite orbits and mapping function are consistent with one another within 2.36 mm in rms. Atmospheric delay and resultant PW estimated from quasi-real-time GPS data processing are highly reliable and applicable to the wide variety of atmospheric studies.

Keywords: GPS, precipitable water, radiosonde, radiometer, mapping function

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Numerical simulation of positioning errors using high-resolution numerical weather prediction model

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We observed characteristic positioning errors at GPS stations around Sakura-jima in Kagoshima Prefecture, Japan. The directions of these errors are usually same and observed in summer. In this research, we try to clarify that the source of these errors is troposhperic delay or not by comparing observed positioning errors with those simulated using high-resolution numerical weather prediction model. For this purpose, we used the numerical weather model with 1km horizontal resolution and 1-hour temporal resolution computed by Cloud Resolving Storm Simulator (CReSS) developed by Nagoya University while assimilating JMA meso-scale analysis data and SST data. We produced simulated GPS observation datasets using Satellite Positioning System Simulator (SPSS) developed by GSI with the numerical weather model data. Then, we analyzed simulated GPS data by the PPP method using GIPSY ver.5.0 to estimate positioning errors due to troposheric delay.

We found that the simulated positioning errors are correlated with the observed ones, which suggests that the errors of GPS observation around Sakura-jima are caused by tropospheric noise. In presentation, we will report on these results and the relation between positioning errors and weather condition.

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SGD021-P07 Room:Convention Hall Time:May 23 14:00-16:30

Ka-band Data Analysis of Phase Variation from WINDS Satellite Signals Interferometer System

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Japanese Super Internet Satellite WINDS sends Ka-band signals. Ka-band is influenced by rainfall and meteorological phenomenon because its wavelength is very short. We constructed the interferometer system that receives signals and thermal noise from the WINDS and measure and research the influence of rainfall and meteorological phenomenon on WINDS signals. The interferometer system receives the radio wave from the WINDS with two antennas and performs the correlation processing. Using the VLBI-type fringe stopping method to practical use, we got the amount of phase variation of the correlation. We analyzed the phase variation by comparing that to meteorological variation such as temperature and atmospheric pressure and discussed the influence of meteorological phenomenon on WINDS signals and tropospheric propagation.

Keywords: WINDS, Ka-band, interferometer, correlation processing, phase, meteorological phenomenon

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The accuracy evaluation of attitude of buoy using GPS receivers

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We observed the seafloor crustal movement using the ship, towed buoy and moored buoy. On these platforms, there is the important information to monitoring an attitude. It is a key point to determine the position of the acoustic transducer from the position of a GPS antenna after a correction for the motion of the surface platform for the improvement of accuracy on seafloor geodesy. There are two methods on the measurement of attitude. One thing is the combination of GPS and inertial navigation system (RLG and MEMS). Another is the multi antennas GPS receiver. In this presentation we carried out the accuracy evaluation of attitude using the multi antennas GPS receivers.

We use three GNSS receivers (Sigma@Javad GNSS, PolaRx2@septentrio, and GRX1200+@Leica Geosystems) for the accuracy evaluation. Basic test is the static test. We carried out the basic test for PolaRx2@ receiver on June 2006 and for Sigma receiver on October 2010. The following was obtained by this examination. The resulted accuracy is comparable to the catalog accuracy. The results of power spectrum density for the Sigma receiver was about one order smaller at the noise level than those for the PolaRx2 receiver, and there was a good correlation between the variability and DOP. However, because we did not carry out these observations at the same time, it is difficult to do a detailed comparison of receivers. Therefore, it is scheduled that using all receivers will carried out the static observation and the moving observation for the accuracy evaluation.

Keywords: GPS, attitude

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Ocean tidal observation with GPS buoy around Lutzow-Holmbukka, East Antarctica

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With the objective of measuring the ocean tide around Lutzow-Holmbukka, East Antarctica, we have been developing GPS buoys. In 2005, the first GPS buoy was installed on sea surface at Nishi-no-ura, the shore of East Ongul Island, where the ocean bottom pressure has been regularly observed as tide gauge data at Syowa Station. This GPS buoy consisted of a dual frequency GPS receiver and antenna (Lexon-GGD160T & GrAnt; Javad Inc.), the buoy with a float (Zeni-light buoy Co., Ltd.) and two Pb batteries (12V24Ah). Several continuous ocean tidal observations could be conducted for 5 - 7 days without its maintenance. Aiming to perform the continuous ocean tidal observation for a few months, we modified the GPS buoy and examined its performance in 2008. We applied a hybrid power system which was combination of the electric double layer capacitor (30VA, PowerSystems Co., Ltd.) and the Pb battery (12V24Ah) to a second generation of the GPS buoy and we attached 20W solar panel on its float. The dual frequency GPS receiver and antenna (DL-V3 and GPS-702-GG; NovAtel Inc.) ware incorporated into the GPS buoy. This GPS buoy was installed on the offing of Benten Jima which is located on about 20 km distance from Syowa Station, at the end of September, 2008. Due to malfunction of the charging to the Pb battery, the power supply of GPS was maintained by the electric charge and discharge to the capacitor. The 30VA capacity of the capacitor and 20W power generation of the solar panel were too short to perform the continuous GPS measurement. Therefore the ocean tidal observation by the GPS was intermittent. Polar day and fine weather in austral summer enabled the comparatively continuous observation. The instantaneous positions of the GPS buoy which were synchronized with the ocean tide were determined from GPS data obtained during Nov. - Dec., 2008 by adopting the kinematic precise point positioning analysis with GPS Tools. The ocean tidal analysis with BAYTAP-G was applied to the time series of the instantaneous GPS position data during Nov. - Dec., 2008.

We still continue to improve the GPS buoy. We plan to install the several GPS buoys around Lutzow-Holmbukka and to conduct the continuous ocean tidal observations in order to study the geoid and the ocean tide in this area.

Keywords: GPS bouy, Ocean tidal observation, Antarctica