02-01

Crustal Deformaion around TOKYO Area Observed by the Keystone Network in the Summer of 2000

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ABSTRACT

Since June in 1997, real-time VLBI (very long baseline interferometry) observations have been conducted in the Keystone network after a series of observations by tape recording. By the cooperation with NTT, the received data from the radio sources at each Keystone station are sent to the central station at Koganei with 256 Mbps data rate via a high speed network for an on-line data processing. At the Keystone stations, SLR (Satellite Laser Ranging) and GPS (Global Positioning System) facilities are also operated within c.a. 100 m.

Furthermore, two GPS receivers from the nationwide GPS network operated by the Geographical Survey Institute (GSI) are collocated at Koganei and Kashima. At the end of June in 2000, volcanic and seismic events started at Izu islands about 150 km south of Tokyo. Following the event, extraordinary crustal deformation was observed not only around the Izu islands by GPS, but also at the Keystone network. We changed the frequency of observations from every two days to every day. Until the end of August, both the volcanic and seismic activities were high. Between Kashima and Tateyama, the baseline length changed over 2 cm/month, which is maximum among the Keystone stations in the above time period. This is the first observation that VLBI system monitored the full process of crustal deformation together with GPS and SLR.

The data observed by real-time VLBI system was provided immediately to the Meteorological Agency in Japan. Moreover, it was put on the Keystone Web site. These results contributed to understand the status of on-going volcanic and eismic activities.

It is explained that the crustal deformation was caused by the dyke intrusion event at Izu islands. The data was used to estimate the volcanic model. Though a thick column of volcanic smoke is still emitted at Miyakejima, seismic activities almost stopped. After-effect is under investigation.

Seismic Wave Observations with GPS and Other Real-Time Applications

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ABSTRACT

We describe the direct measurement of ground displacement caused by the Hector Mine earthquake in southern California (Mw 7.1, October 16, 1999). We use a new method of instantaneous positioning, which estimates site coordinates from only a single epoch of Global Positioning System (GPS) data, to measure dynamic as well as static displacements at 24 stations of the Southern California Integrated GPS Network (SCIGN), with epicentral distances from 50 to 200 km. For sites outside the Los Angeles basin, the observed displacements are well predicted by an elastic half-space model with a point shear dislocation; within the sedimentary basin, we observe large displacements with amplitudes up to several cm that last as long as 3-4 minutes. Since we resolve the GPS phase ambiguities and determine site coordinates independently at each epoch, the GPS solution rate is the same as the receiver sampling rate. For the SCIGN data, this is 0.033Hz (once per 30 seconds), though sample rates up to 2 Hz are possible with the SCIGN receivers. Since the GPS phase data are largely uncorrelated at 1 s, a higher sampling rate would offer improved temporal resolution of ground displacement, so that, in combination with inertial seismic data, instantaneous GPS positioning would in many cases significantly increase the observable frequency band for strong ground motions. We present other examples of real-time applications.

On Crustal Movement in Mt.Everest Area[*]

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ABSTRACT

Mt. Everest lies in the collision zone between the fringe of Eurasia plate and Indian plate. The crustal movement there is still very active so far. In the past three decades China carried out five geodetic campaigns in Mt. Everest and its north vicinity area, independently or cooperatively with other countries, including triangulation, leveling, GPS positioning, atmospheric, astronomical and gravity measurement. On the basis of observed results achieved the campaigns the crustal movement in the area are studied and explored. A non-stationary phenomenon both in time and space of the crustal vertical

movement in the area is found. It seems to be some relevance between the phenomenon of non-stationary in time and seismic episode in China. The phenomenon of non-stationary in space is possibly relevant with the no-homogeneity of crustal medium and non-uniform absorption of terrestrial stress. The horizontal crustal

movement in the area moves in the direction of NEE at the speed of 6-7cm per year, and the trends of strike slip movement is manifested evidently in the collision fringe of Indian plate and Tibetan block.

02-04

Global Plate Motion Model from ITRF2000 and Contemporary Crustal Deformation in China

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ABSTRACT

To monitor and study the crustal motion in China, some nationwide GPS networks and serveral regional GPS monitoring networks have been set up since 1991. Using recent 10-year GPS measurement data of about 180 sites from these networks and three-campaign GPS measurements provided by the Asia-Pacific Regional Geodetic Project(APRGP), a combined and consistent velocity field solution in ITRF2000 are obtained. In order to study the characteristics of contemporary intra-plate crustal deformation of China, we have constructed a new present-time plate motion model named ITRF2000VEL based on ITRF2000 velocity field. The model can better describe contemporary features of global plate motion than the geological model NNR-NUVEL1A. Taking the ITRF2000VEL motion of the Eurasia plate as the background motion, we calculated the residual velocities of all GPS sites. From these results, we can see the crustal deformations in the west of China are far stronger and more complicated than those in the east of China taking the N-S seismic belt of China as a boundary. The deformation velocity gradually reduce from south to north in the west of China by energy release in several W-E direction arc suture zones. The Qinghai-Tibet plateau is shortening in north-south direction and extending in west-east direction due to the strong shove of Indian plate. The shortening of about 15 mm/yr and 9~13 mm/yr is accommodated across Hymalayan block and the west Tian Shan respectively. Within southern Tibet, between the longitudes of 80^0 E to 91^0E, there is E-W extension of 20.2 ± 1.2 mm/yr. The slip rates of KJFZ in south Tibet and Altyn Tagh fault are 2~3 mm/yr and 4~6 mm/yr respectively. Our GPS results indicate there is a lesser than 7 mm/yr shortening within the Longmen Shan. These results support the supposition of crustal thickening.

Current Crustal Strain Field in Chinese Mainland and the Surrounding Areas Obtained from GPS Observation

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ABSTRACT

In the paper, a rotational strain model for crustal blocks is derived and established, and the strain field in Chinese Mainland and the surrounding areas has been obtained based on the GPS velocity field in the same territory. It has been discovered in the analysis of strain field in Chinese Mainland that the strain field in Chinese Mainland is characterized by distinct zonation of east and west areas with compressive strain behavior in the west one and the weak extensional behavior in the east one; The strain rate in the western area is 4 times as large as the small rate in the eastern area; Taiwan, NS seismic belt and the southern Xizang plateau are 3 high- strain areas with the surface strain rates of 6×10^{-8}/y, 4×10^{-8}/y and 46×10^{-8}/y, respectively; Taiwan, the Luzon region in Philippine, NS seismic belt, southern Xizang plateau and Tianshan Mountain region are 4 high strain gradient zones; Taiwan, the south foot of Tainshan Mountain and Changbai Mountain are 3 high strain accumulation areas with local strain rates of 80.2×10^{-8}/y, 24.3×10^{-8}/y and 32.1×10^{-8}/y, respectively. Discussion is made for the relation between the number and spatial distribution of GPS sites and the resolution and accuracy of strain field, the relation between the high strain accumulation area, high strain gradient zone and the seismogeny of great earthquakes when the strain field is established with the block rotational strain model. It can be seen from the analysis of the strain field in Chinese Mainland and the surrounding areas that the driving force for the strain field in Chinese Mainland is mainly the NE-trending collision of India plate to Eurasia plate and the NW-trending down-thrust of Philippine Sea plate to Eurasia plate.

Main Active Tectonic Boundaries and Motion Patterns Derived from GPS in China Mainland

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ABSTRACT

The velocity fields at 79 stations distributed on different tectonic blocks in Mainland China are analyzed in order to test the relative movement signification and determine the activity patterns on the boundary zones between the main active tectonic blocks. The velocity fields are derived from the observation data of the "Crustal Movement Observation Network of China" (CMONOC) which has been observed for two times in Aug. 1998 and Jun. 2000, respectively. The results show there are significant relative motions along the boundaries in the western part of China. As contrasted with the western part, significant relative motion is not found in the eastern part of China. Based on the analyzed results of the active boundaries, China Mainland can

be re-divided into 11 active blocks. The movement amounts and patterns between these active blocks are calculated.

02-07

Deformation Kinematics and Dynamics of Tibetan Plateau

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ABSTRACT

Field investigation was done along the Jiali fault in south-eastern Tibet. An interesting phenomena is that the large displacement can only be found at those places where the fault is related to the basins that extend roughly north-south. Outside the basins, no convincing evidence was found for late Quaternary surface ruptures and the average slip rate for the whole fault is only about 4mm/a during Quaternary. By modeling the complete horizontal strain rate field of the Tibetan plateau with the velocity boundary constraints from plate motions, GPS, and VLBI data, the calculated left-lateral strike-slip motion on the Altyn Tagh fault zone is 7-10mm/a, which is consistent with the GPS observation. The compression across the Himalayas absorbs almost half of the relative motion between India and Eurasia, the Tien Shan takes up about one fourth, and less than one fourth is absorbed across the Altyn Tagh. This means that more than 75% of the north-south shortening between India and Eurasia is absorbed by crustal thickening strains. It seems that the strike-slip faults in southern Tibet plateau behave like a transform fault and the strike-slip motion along them were a consequence of east-west extension that creates the north-south graben systems.

02-08

The Establishment and the Precision Analysis on the Chinese High Precision Vertical Continent-ocean Movement Monitoring Network

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ABSTRACT

A high precision GPS monitoring network, which consists of five tide gauge stations, was established along the coastal line to separate the sea level changes information obtained by the tide gauge stations from the vertical continental movement at the tide gauge stations. We used GAMIT and Globk software and the improved Niell model in the data processing and considered the atmospheric delay, which is from azimuth asymmetry and has influence on the height measuring. At last, we achieved the mm level precision on height measuring.

The Origin Shift of 1985 National Height Datum

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ABSTRACT

The 1985 National Height Datum was defined by the mean sea level of Yellow Sea at the tide gauge of Qingdao. We found the origin of the local vertical datum to have a vertical shift with respect to the proposed World Height System defined by the geoidal geopotential value. In this paper we deal with how to resolve the shift by using the Earth gravity field model (e.g. EGM96 and DQM99) and GPS/leveling data, and present our findings. Based upon a data set of 201 GPS/Leveling points distributed throughout the country, the geopotential value of 62636853.669 m^2s^{-2} was produced for the mean sea level at the tide gauge of Qingdao. It indicates that the origin of the 1985 National Height Datum has a vertical shift of 23.8 cm with respect to the geiodal surface having the geopotential value of W_0=62 636 856.0±0.5 m^2s^{-2}.

Slip Rates Along Faults and Accumulated Seismic Moments From GPS and Neotectonic Studies in Central Asia

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ABSTRACT

Recent GPS results, taken from a regional network covering the Tien Shan and adjacent areas, along with seismicity data were used to compare geodetic and seismic strain rates and to estimate the apparent sizes of the accumulated seismic moments for the last 100 years. In order to do this we a) divided the study area into block units using 79 straight fault segments, b) approximated block motions, c) estimated differential motions along faults assuming that these faults are seismically fully coupled, d) divided the area into seismotectonic regions, and e) approximated geodetic strain rates in these regions. Results were compared to strain

rates estimated by 1) accumulating the last 112 yrs of historical seismicity and 2) integrating over truncated Gutenberg-Richter distributions. Approximate coincidence of seismic and geodetic strain rates was achieved and rates are assumed to reflect loading. A ' moment budget' i.e. a listing of computed changes in moments was derived for the last 100 years, which takes into account the static (elastic) redistribution of strains/stresses due to geodetically derived loading and seismic release. Results suggest high values of accumulated strains along the Alai range north of the area where the Tien Shan underthrusts the Pamirs, within the Middle Tien Shan, East of Bishkek, and south of Almaty.

02-12

Updated velocity estimate from reprocessing of permantent GPS sites in and around Southeast Asia from 1995 to 2001

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ABSTRACT

Based on re-analysis of a selected group of permanent GPS sites in and around Southeast Asia, their updated velocities are derived. The re-analysis used uniformed processing strategy and incorporated the latest global reference frame. Comparison is made to previous results.

02-13

Microplate Motion and Interplate Deformation in SE-Asia

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ABSTRACT

This contribution deals with new results derived from repeated measurements of a regional GPS network in SE-Asia and additional seismotectonic models that include information about fault geometries and the seismic history of the considered areas. Using 3-D forward dislocation modeling, the influence of seismic elastic loading and release on the measured site motions were approximated and results were compared to the apparent long-term straining of the area. Along with the newly derived motion of Sundaland and some prime implications of its motion for the tectonics of Asia, results from derived block and fault models are presented, apparent highly localized strains discussed, and distributions of accumulated geodetic vs. seismic moments considered.

02-14

VLBI Experiments of the APSG Program and the Results

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ABSTRACT

During the campaigns of the Asia-Pacific Space Geodynamics (APSG) program since 1997, seven VLBI experiments were successfully organized and coordinated by the Astrometry and Geodesy VLBI Group of Shanghai Astronomical Observatory, Chinese Academy of Sciences, cooperated with the geodetic VLBI group, GSFC, NASA, USA. Seven stations participated in these experiments, Seshan and Urumqi located in Eurasian plate, Gilcreek, Kashima and Tsukuba in North American plate, Hobart in Australian plate, Kokee in Pacific plate. The general descriptions are presented basing the statistical analysis of observations, correlations and single solutions. The analysis of these experiments combined with most astrometric/geodetic VLBI sessions since August 1979 shows that all the seven experiments are well consistent with others in history.

The motions of VLBI stations as well as the baseline length variations within the Asia-Pacific region are estimated. Baseline Lengths are from 1,900 km to 11,000 km and the mean relative uncertainty of the baseline lengths measurements is at the level of one ppb. The implications of the VLBI measurements to the study of modern crustal movement and the importance of further accumulation of geodetic VLBI observations within the Asia-Pacific region are also illustrated.

02-15

Research of Kamchatka and Komandor Islands Earth Crust Deformation by Permanent and Mobile GPS Stations

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ABSTRACT

Since 1996, a network of 9 permanent GPS receivers records in continuous mode the deformations on Kamchatka peninsula. The report contains the description of Kamchatka GPS network and the system of observations for the earth crust deformations in the region. The velocity and direction of the relative displacement of observation points is estimated from the entire data set for 1996-2000. The deformation related to the large Kronotskoe earthquake, (Mw=7.8, Dec. 5, 1997) was identified at distances up to a few hundred kilometers. Preliminary estimates of relative plate velocities for North America, Okhotsk, and Beringia plates are given based on data of stations distant from the most active plate boundaries.

The deformations of the earth crust in Karymsky volcanic center, connected with the shallow earthquake M=7 and two simultaneous eruptions (Karymsky volcano and the new eruptive center in Karymskoe lake) in 1-2 of January 1996 are described.

02-16

A Study on the Crustal Deformation around the Cheju Island by Using Global Positioning System

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ABSTRACT

The geochemical, tectonic and geophysical studies have been reported in the continental inside area of East Asia. The upwelling of mantle in the back-arc of Kyushu has been inferred by several geological and geophysical studies [Nakada et al., 1997; Yanagi and Meada, 1998; Seno, 1999].

Hossein(2000) told us that a major zone of strong low velocity revealed west off the Kyushu Island of 40km to 100km in depth.

For confirming the crustal movement of the marginal sea between the Korean Peninsula and the Kyushu Island by mantle diapir, data for the period February 1999 to September 2000 were analy-zed, with data from

GSI and NGI sites, to estimate daily coordinates. To fix the estimated coordinates to the terrestrial reference frame (ITRF97), the reference site is the Cheju site in Korea. We find that site velocities are (Vew,Vns)=(3.530,-3.198)cm/yr at Cheju, (Vew,Vns)=(1.109,-1.694)cm/yr at Tsushima, (Vew,Vns)=(1.024,-1.234)cm/yr at Maebaru and (Vew,Vns)=(1.858, -1.519)cm/yr at Tamanoura. With this realization of a Eurasian frame, the velocity of the GPS station in the Korean Peninsula implies that the southeastward motion of Eurasia is faster than that predicted from the NUVEL1A-NNR geophysical plate model. On the other hand, its velocity in the Kyushu Island is about the same.

02-17

Adaptively Robust Filtering for Kinematic Geodetic Positioning

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ABSTRACT

The Kalman filter has been applied extensively in the area of kinematic geodetic positioning. The reliability of the linear filtering results, however, will degrade when the kinematic model noise is not accurately modeled in filtering or the measurement noises at any measurement epoch are not normally distributed. A new adaptively robust filtering is proposed based on the robust M (Maximum likelihood type) estimation. It consists in weighting the influence of the updated parameters in accordance with the magnitude of discrepancy between the updated parameters and the robust estimates obtained from the kinematic measurements and in weighting individual measurement at each discrete epoch. The new procedure is different from functional model error compensation, it changes the covariance matrix or equivalently changes the weight matrix of the predicted parameters to cover the model errors. A general estimator for adaptively robust filter is developed, which includes the estimators of classical Kalman filter, adaptive Kalman filter, robust filter, sequential least squares (LS) adjustment and robust sequential adjustment. The procedure can not only resist the influence of outlying kinematic model errors, but also control the effects of measurement outliers. In addition to the robustizing properties, feasibility in implementation of the new filter is achieved through the equivalent weights of the measurements and the predicted state parameters. A numerical example is given to demonstrate the ideas involved.

02-18

Data Processing of Deformation Monitoring Networks from the Viewpoint of Deformation Reference Frame

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ABSTRACT:

Sides are invariables of deformation monitoring networks. Differences of sides at two times called as side-deformations in this paper are also invariables of deformaion monitoring networks. They are scalar quantity and independent on coordinate reference frame. In this paper, deformation reference frame is classified and its establishment is present from the viewpoint of kinematics. Then side-deformations are considered as observations when adjustment of deformation monitoring networks from the viewpoint of deformation reference frame. A basic adjustment model of deformation monitoring networks is proposed. Since the adjustment is independent on coordinate reference frame, it clears up errors of coordinate reference frame and

errors of velocity field by unifying the coordinate reference frame. Two ideas are present about data processing with several deformation monitoring networks. One is that several deformation monitoring networks in different coordinate reference frames are united into one deformation reference frame by constructing a temporary deformation reference frame. The other is that several deformation monitoring networks are combined into one deformation reference frame with side-deformations as observations. In the end, a result and analysis on the result are present about relative movement of Chinese land and its neighboring plates with ITRF97 velocity field and repeated observations of Chinese GPS network of order A.

02-19

Suggested GPS Data Handling-and-Processing in Large Countries Such as Saudi Arabia

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ABSTRACT

Handling and Processing of the Global Positioning System (GPS) is a delicate task especially in areas where baselines may reach thousands of kilometers in length. GPS is a technique where high altitude orbiting satellites are utilized to give time, position and speed of a user on or near the surface of Earth day and night and under almost all weather conditions. This versatile system has gone a number of developments where it is now possible for a user to obtain horizontal position accuracy to within two millimeters over long distances.

This paper discusses the optimal handling and processing of GPS data used for high precision applications such as military or geodynamics applications.

02-20

Seasonal and Interannual Signals in Permanent GPS Station Solutions

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ABSTRACT

Time series of daily GPS solutions of eight permanent IGS GPS stations distributed in the Pacific region are analysed to study the seasonal and interannual variations in the solutions. It is found from the analysis that seasonal and interannual variations exist in all the three components of the station coordinates. The seasonal variations show some apparent quasi-periodic oscillations of 3 - 6 mm in amplitude in the height direction and of up to 2 mm in the latitude and longitude directions. The interannual variations fluctuate with time and their amplitudes can be up to about 3, 6 and 10 mm respectively in the latitude, longitude and height directions. The possible effects of the seasonal and interannual variations on the estimated linear rates of horizontal and vertical motions of the stations are also studied.

A Statistical Selection of Plate Fixed Stations based on VLBI Global Solution

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ABSTRACT

In the compilation of the latest version of the International Terrestrial Reference Frame, i.e., ITRF2000, the primary sites are selected based on the criteria as (1) continuously observed during at least 3 years, (2) located far away from plate boundaries and deforming zones, (3) velocity accuracy (as result of ITRF combination) better than 3 mm/y and (4) velocity residuals less than 3 mm/y for at least 3 different solutions. Considering that whether the motion of a site can be modeled or not by plate rigid motion is not necessarily depended on the distance from the site to the plate boundary or deformation area, and that, since the number of sites of modern space techniques are limited, all the sites with motions being consistence with the plate rigid motion are essential to the realization of the terrestrial reference frame and the determination of contemporary plate motion, hereby we propose a statistical selection of on-plate sites.

The main points of this selection are: (1) The motion of a site on a specified plate can be express as the vector sum of the plate-related rigid motion, the local deformation and the observation noise; (2) The plate-related rigid motion can be described by a set of systematic parameters; (3) If the observations are sufficient and the sites are ideally distributed on the plate, the systematic parameters can be accordingly estimated from the observations. Then for those on-plate sites their residual motions are mainly corresponding to the noises, while for those sites within deformation areas their residual motions are dominated by the combination of noises and local deformations. In the ideal case, a large residual motion will indicate a high possibility for a site being within the deformation area; (4) Taking all the residual motions as a random data series and suppose $\acute{o}$ be the variance of the series, while $\acute{o}_1$ be that for on-plate sites and $\acute{o}_2$ for sites within deformation areas, then it can be easily shown that $\acute{o}_2 > \acute{o} > \acute{o}_1$. In other words, the on-plate sites can be statistically distinguished from those within deformation areas by $\acute{o}$. (5) Since the estimation of systematic parameters should be biased to some extend by local deformations, it therefore should not be expected to finish the selection in one run. We accordingly design the statistical selection of on-plate sites in a reprocessing way.

By applying this method to VLBI global solution, the statistically selected on-plate sites are more than and consistence in a whole with the VLBI primary sites of ITRF2000. The statistical selection plays emphasis on the consistence between the motion of sites and the rigid motion of plates, it is not confined to the distance from the site to the plate boundaries or deformation areas. It is approaching a thoroughly use of all the qualified data and therefore is suggested to deal with limited sites.

Some of the statistically selected on-plate sites, for instance, YUMA and FLAGSTAF on North America, FORT_ORD and VNDNBERG on Pacific, they are not primaries in ITRF2000. However, by including these sites the estimations of plate rigid motion are not changed significantly, instead, the precision of parameters is increased, so they are recommended to be in the list of on-plate sites.

For RICHMOND, our analysis show that it can be taken as on-plate, but it is not in the list of the most firmly on-plate sites. It is usually used as one of the velocity constraint sites in VLBI global solution. We recommend using ALGOPARK, FD-VLBA or NRAO_140 instead.