G22D MC: 121 Tuesday 1330h

Explaining Geodetic Observations of Nonlinearly Time-Varying Surface Deformation I *(joint with NG, H, S, T, V)*

Presiding: **G W Bawden,** U.S. Geological Survey**; E Harding Hearn,** Massachusetts Institute of Technology

G22D-01 1330h INVITED

Time-Depended Inversion for Post-Seismic Slip Following the 1999 Chi-Chi Taiwan Earthquake Using GPS Observations

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A remarkable set of GPS measurements was collected following the Mw=7.5 1999 ChiChi, Taiwan earthquake by the Institute of Earth Sciences, Academia Sinica (IESAS) and the Central Geological Survey, Ministry of economic Affairs (CGS), and processed by IESAS. Cumulative displacements in the first 3 months following the earthquake range up to 7 cm, and include the effects of three Mw 6.2 to 6.4 aftershocks. Typical temporal evolution of the time series shows exponential decay with decay constants ranging from 160 to 230 days.

We inverted for afterslip distribution using the fault geometry inferred from the co-seismic GPS observations (Johnson et al. 2001, GRL), and find that most of the transient signal can be explained by afterslip, located south and down dip of the main co-seismic slip concentration. This suggests that afterslip was driven by the increase in stress due to coseismic slip.

We invert for afterslip as a function of space and time during the first 15 months following the earthquake. The observed GPS signal is modelled as the sum of deformation due slip on the fault, measurement error, and benchmark random walk. Errors in the reference frame are reduced by modeling baselines instead of point positions. The slip is modelled as an integrated random walk. The background tectonic deformation field was estimated separately using GPS data collected during the year before the earthquake. Results suggest spatial as well as temporal evolution of slip with time in the first few months after the earthquake; spatial evolution decays after about a year.

URL: http://pangea.stanford.edu/∼nbechor/chichi.html

G22D-02 1345h INVITED

Geodetic evidence for nonlinear mantle rheology beneath the Mojave Desert, California

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Horizontal deformation rates following the M7.3 1992 Landers and M7.1 1999 Hector Mine earthquakes in the Mojave Desert, California, measured by the SCIGN network were elevated above the background (pre-1992) rate by an average factor of 4 during the first year following each earthquake. Comparable vertical uplift rates, ranging from +-20 mm/yr over a 10000 km^2 area centered on the ruptures, were measured by InSAR over the same time period. Deformation rates measured during the first month following each earthquake were much larger (+- 50 mm/yr), and those measured between 1 and 3 years after the Landers earthquake were much smaller (+-7 mm/yr). The sense of postseismic uplift and its long wavelength character point towards viscoelastic relaxation of the mantle as the main contributor to the observed postseismic deformation. However, no simple viscoelastic model with a linear constitutive law fits the measurements from all of the postseismic epochs. Specifically, the falloff in postseismic velocity with time is sharper than can be predicted with such a model.

We propose that the effective mantle viscosity increases with time after the stressing event. Analysis of post-Landers and post-Hector Mine interferograms suggests an initial mantle viscosity value of 4 X 10^{17} Pa s for the first 8 postseismic months, evolving to about 2 X 10^{19} Pa s between 1 and 3 years after a M7 stressing event. This is consistent with the stress-dependent rheology of the mantle based on laboratory experiments. If this interpretation is correct, continued monitoring of deformation using SCIGN will provide important constraints on decadal scale mantle relaxation and further evolution of stress-dependent rheology.

G22D-03 1400h

Postseismic Deformations Following the 2000 Western Tottori Earthquake Detected by Dense GPS Observations

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The Japanese University Consortium for GPS Research (JUNCO) carried out observations of postseismic deformation immediately following the Western Tottori earthquake of October 6, 2000, with a dense GPS network surrounding the source region. This earthquake is a typical inland earthquake in Japan with a left-lateral strike-slip faulting on a NNW-SSE trending vertical fault plane. 16 dual frequency receivers (Ashtech Z12 and Z-Surveyor) and 11 single frequency receivers (Furuno MG-11, 21) were deployed in an area approximately 20km in the EW direction by 30km in the NS direction. Phase data were sampled every 30 seconds and the elevation mask was 15 degree. Most observations were done continuously until the end of October 2000, and some sites occupied with dual frequency receiver were reoccupied in March 2001. Daily solutions of each station were determined using Bernese 4.2, with reference to IGS sites and nearby GEONET sites. We present the results of the dual frequency observations and an interpretation in terms of afterslip on the source fault.

We observed decaying motions at many sites, despite large fluctuations mainly due to meteorological disturbances. Some sites in the northwestern part of the network show step-like movements around Oct. 18. This movement might be related to a conjugate distribution of aftershocks recognized in this area. If we fit exponentially decaying functions to the data from the sites occupied in March 2001, we obtain time constants of 20 to 40 days. Unfortunately fitting with the logarithmic decaying function proposed by Marone et al. (1991) was so far unsuccessful, probably because of the lack of data between October 2000 and March 2001.

The spatial pattern of displacements shows left lateral motion across the source fault, which is concordant with the mechanism of the mainshock. Stations on the NE side of the fault moved northwestward, and stations on the SW side moved southeastward. The largest displacement amounts to 2cm for half a year. Displacements are larger at the stations closer to the aftershock region. We tried to estimate fault parameters by a Monte-Carlo method referring to the aftershock distribution. An optimal solution is oriented nearly along the aftershock distribution with a near vertical dip. This model suggests that afterslip may have occurred on the shallow part (0.2 - 4.2km) of the mainshock fault, with amounts of about 4cm during half a year.

G22D-04 1415h

First-order Leveling and Campaign GPS Reveal Anomalous, Interseismic, Contractile, Transient Strain Across Teton Normal Fault, 1988-2001, Grand Teton National Park, Wyoming

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As part of a comprehensive neotectonic study of interseismic behavior of active faults, we have done six first order leveling surveys of 50 permanent bench marks in a 22 km-long base line across the Teton fault to characterize its interseismic behavior between 1988 and 2001. This 55 km-long normal fault extends along the eastern base of the Teton Range, exhibits up to 30 m of post-glacial offset, and has one the highest rates of Holocene slip of any fault in the Basin-Range. It is seismically dormant at the M2+ level, however, and presently lies in the center of a 50 km-long seismic gap. Results of five of the six levelings are remarkably similar and suggest that the alluvium-filled valley of northern Jackson Hole (hanging wall) subsided 6-8 mm relative to bedrock of the Teton Range (footwall) relative to the 1989 survey. In 1997, however, a 2 km-wide zone adjacent to the fault rose 12 mm relative to the 1993 survey, and then dropped 16 mm by the 2001 leveling. This zone coincides with an area of low topography characterized by lakes ponded along the fault and south-flowing streams parallel to the range front, rather than eastward away from the range. This subsidence zone records hanging wall subsidence related to long term faulting. The 1997 uplift of the valley floor and subsidence zone may reflect an unexpected, reverse loading and local crustal shortening between 1993 and 2001. Campaign GPS surveys (1987 to 2000) support this hypothesis, indicating that the principal horizontal strain axis is locally E-W perpendicular to the fault, and suggesting crustal shortening occurred in the period 1995-2000. Regionally during 1987-1995, subsidence and contraction characterized deformation of the Yellowstone caldera only 30 km to the north, when GPS recorded uplift and extension across the Teton fault. During 1995-2000, subsidence slowed or ceased for much of the caldera, whereas the overall GPS vectors across Jackson Hole were directed west with almost 2 mm/yr of E-W motion (N. America fixed). This strain field would load the east-dipping Teton normal fault in contraction, implying that the regional stress field was compressional against the fault at the time of the 2000 GPS survey. The return of the 2001 leveling signal to pre-1997 values suggests that the strain reversed, and that the 1997 leveling anomaly was a contractile strain transient that passed across the fault probably between 1995 when the strain pattern at Yellowstone caldera changed and the 2000 GPS survey, but before the 2001 leveling. Preliminary elastic dislocation models indicate 10-20 mm reverse slip at a depth of 1-2 km. Alternatively the observed leveling changes may reflect a complex combination of other processes including local poroelastic effects, or nearfield drag of the hangingwall as it subsides overall in farfield extension.

Funded by NSF, NEHRP, UREP, UW/NPS Research Station, Teton Science School

URL: http://www.geol.ucsb.edu/∼geodesy

G22D-05 1430h

Seasonal Loads, Crustal Deformation, and Seismicity in Japan

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Heki (2001) found that snow loads over the Japan Sea side of the backbone range is responsible for the seasonal crustal deformation in northeastern Japan found by the Global Positioning System (Murakami and Miyazaki, 2001). It is known that earthquakes in and around Japan have a clear seasonality (Mogi, 1969). Ohtake & Nakahara (1999) confirmed statistical significance of the seasonality of interplate earthquakes at the Nankai-Suruga Trough (M>7.9); they concentrate in autumn/winter. Okada (1982) compiled inland historic earthquakes (M>7.0) and found that shallow earthquakes in the snow covered region preferentially occur in spring and summer. The latter may simply reflect the Coulomb failure function (CFF) increase in spring due to the unclamping of the fault by the removal of the snow load whose maximum reaches 10 kPa in February/March. Heki (2001), however, failed to verify the causal relation between snow loads and the seasonalily of the offshore interplate earthquake since a 10 kPa snow load could increase the CFF at plate interface by only 0.1 kPa. Stress for a typical interplate earthquake with 1 MPa stress drop and 100 yr recurrence interval, would be built up by 10 kPa/yr (Ohtake and Nakahara, 1999). A simple calculation shows that annual stress perturbation of a 1 kPa amplitude to this secular increase could cause a seasonality such that earthquakes occur > 4 times more frequently in the maximum month than in the minimum month, and that the maximum comes three months earlier than the CFF

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peak. Sea surface along the Pacific coast of Japan becomes highest in August-September, whose amplitude is > 10 cm even after thermal steric correction (Sato et al., 2001). This would cause a CFF increase of about 1 kPa in February-March (due mainly to the decrease in normal stress), which might be responsible for the observed maximum seismicity approximately three months earlier (Ohtake & Nakahara, 1999).

G22D-06 1445h INVITED

Constraining Spatially Varying Elastic Storage Properties in Deforming Aquifer Systems Using Interferometric Synthetic Aperture Radar

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The pumpage of groundwater for agricultural and urban use has often led to large declines in groundwater levels, especially in arid environments. These declines can cause highly compressible unconsolidated sediments in the aquifer system to deform under the increasing effective stress, resulting in measurable subsidence of the land surface. Subsidence measured at the surface can be used to estimate storage properties in the aquifer system. Traditionally, surface subsidence measurements have been spatially and temporally sparse, limiting stress-strain analyses of the aquifer system to a few point locations. Interferometric synthetic aperture radar (InSAR) can yield high-resolution maps of surface displacement that permit a far more detailed characterization of the spatial variability of aquifer-system storage properties.

We present spatially extensive InSAR-derived maps of seasonal subsidence and rebound over the Las Vegas Valley aquifer system. While the value of these maps for monitoring land subsidence has been pointed out previously, little work has been done to exploit these data to estimate the typically poorly known aquifer-system storage properties. We relate the observed surface subsidence and rebound to seasonally fluctuating groundwater levels and demonstrate how the displacement maps can be used in conjunction with measurements of water-levels in wells to derive spatially varying estimates of aquifer-system elastic storage coefficients.

This technique is applicable where the aquifer heads measured in wells adequately represent the heads in the deforming portions of the aquifer system, and where the surface conditions allow interferometric measurements. InSAR measurements can greatly enhance our ability to simulate the geomechanical processes in developed or developing aquifer systems, and ultimately, can help planners and scientists mitigate the adverse effects of groundwater exploration.

G22D-07 1520h

Sudden aseismic fault slip on the South Flank of Kilauea Volcano, Hawaii

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An episode of sudden aseismic fault slip was observed on Kilauea Volcano in early November, 2000 by an array of continuously recording GPS receivers, strainmeters and tiltmeters. Inversion of the deformation signal images a thrust dipping shallowly toward the volcanic edifice at a depth of 4.5 km below sea level; total slip was about 9 cm giving an equivalent seismic moment magnitude of 5.7. We interpret this structure as being the down-dip extension of the Hilina / Holei fault system, which itself has been interpreted as a mega-landslide complex.

We estimated the source time function of this event by using the GPS phase data to solve directly for the slip as a function of time, without the intervening step of estimating station coordinates. The source duration was about 36 hours, and the source time function estimated from the GPS data agrees very well with strain and tilt observations.

A very large rainstorm (accumulations of nearly 1 m) occurred about one week prior to this event, and we raise the possibility that the rainfall acted as a trigger by increasing pore-fluid pressure on the slipping surface. Simple estimates of the hydraulic diffusivity and permeability required for such a scenario are consistent with previous measurements made at Kilauea volcano.

URL: http://kilauea.stanford.edu/cervelli/Papers/

G22D-08 1535h

Time-varying deformation recorded by continuous GPS networks on Taal Volcano, Philippines

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Continuous GPS measurements of crustal deformation at Taal Volcano, Philippines provide new constraints on ongoing volcanic and hydrothermal activity. Taal is an historically active basaltic-andesitic stratovolcano which forms an island (Volcano Island) within a large (25x30 km), geologically recent, lake-filled caldera. Taal's most recent eruptive sequence, from 1965-1977, included violent phreatomagmatic eruptions accompanied by base surges, basaltic lava flows, and lesser phreatic explosions. In 1992 and 1994, Taal experienced crises including shallow seismic swarms and significant ground deformation almost certainly related to dike intrusion. Continuous GPS measurements at Taal were initiated in June 1998, with the installation of a three-station dual-frequency, telemetered network. One year later, this network was supplemented by a newly developed 12-station telemetered, single-frequency GPS volcano-monitoring network. During this period, Taal experienced reactivation (and termination one year later) of a large hydrothermal vent within its main crater, and one small seismic swarm, both associated with short-term inflationary behavior. The first three years of GPS measurements reveal nearly continuous, but highly time-variable, volcano-wide deformation, including two major deflationary trends and two major inflationary trends, with no ensuing eruption. The duration of each trend is variable (from ∼4 to 9 months) with relative motions of up to 8 cm horizontal and 7 cm vertical between sites on Volcano Island; we see no evidence for annual cyclicity nor correlation with precipitation patterns. Inflation in both cases is rapid and characterized by a nearly constant velocity throughout the trend; deflation is less rapid and more variable. The deflationary and inflationary trends recorded since installation of the single-frequency GPS network have been modeled as Mogi point sources centered beneath the Main Crater at 4.2 km and 5.2 km depth, respectively, consistent with a depth of 5 km previously obtained for the source of deformation and with depths of seismic events during the 1994 crisis. Source modeling for a running 4-month time window reveals little, if any, migration of the source over time. Although the effect of the hydrothermal system on the deformation signal is unclear, we favor magmatic intrusion into a shallow magma body (at ∼5km depth beneath the Main Crater) as a likely mechanism for inflation. Deflation may result from migration of magmatic fluids or gases from the newly intruded magma, or from migration of hydrothermal fluids outward from the volcanic edifice to accommodate the new volume of magma at depth.

G22D-09 1550h

Transient Tectonics of the Hayward, Calaveras, and Mission Fault Junction

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Geodetic data collected over the past decade reveal non-linear crustal deformation in Fremont, California, along the southern extent of the Hayward fault. The deformation is greatest within a crustal block bounded on the west by the Hayward fault, a segment lacking microseismicity, and on the east by the Mission fault, a structure that is illuminated by strike-slip dominated seismicity. The Mission fault is believed to accommodate the transfer of slip between the Calaveras and Hayward faults. Prior to the 1989 Loma Prieta earthquake, the southernmost 5 km of the Hayward fault exhibited a high surface slip rate of ∼9 mm/yr, which is surprisingly close to the geologic slip rate. A reduction in slip rate since Loma Prieta is consistent with regional stress changes. Neither the three dimensional structure nor the kinematics and interaction of this complex fault network are well understood. Creepmeter and InSAR data reveal time varying deformation including both horizontal and vertical motion along the southern Hayward fault. Localized subsidence and uplift associated with changes in the water table have been suspected of playing an important role in the deformation. InSAR results do not identify a strong seasonal signal in the basin suggesting that the elastic response associated with the withdrawal and recharge of the local aquifer does not fully explain the vertical deformation. InSAR, creepmeter, alignment array, and GPS data are used to decipher the complex, localized deformation signal. Using elastic models to simulate the kinematics and structure of the region, we determine how to best understand this transient deformation in light of the long term crustal deformation associated with the transfer of slip from the Calaveras to the Hayward fault. This analysis demonstrates how geodetic data collected using different instrumentation, and spanning a range of spatial and temporal scales can be used to pinpoint the complex, active tectonics of a localized region.

G22D-10 1605h

Transient fault slip in Guerrero, southern Mexico

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The Guerrero region of southern Mexico has accumulated more than 5 m of relative plate motion since the last major earthquake in 1911, and estimates of the accumulated strain moment are equivalent to an M_w 8.1–8.4 earthquake. In early 1998, a continuous GPS site in Guerrero recorded a transient displacement. Modeling indicates that anomalous aseismic fault slip propagated from east to west along-strike of the subduction megathrust over a period of several months. Campaign GPS data corroborate the model. Moment released during the event was equivalent to an M_w 6.5–6.8 earthquake. The slip event has several possible implications for seismic hazard in Guerrero. One possibility is that similar events occur every few years somewhere on the fault, in which case virtually all of the relative plate motion at Guerrero could be accommodated aseismically. This scenario is unlikely given that both campaign and continuous GPS data indicate strong frictional locking up-dip of where the event occurred, and background seismicity up to $M = 5$ commonly occurs on the plate interface in that region. However, the lack of accompanying seismicity at the locus of the slip event suggests that frictional behavior is velocity-strengthening on that portion of the fault, implying that seismogenic rupture in future large earthquakes will be limited to the area up-dip of the slip event. That region could generate an event of up to $M_w = 8.0$.

G22D-11 1620h

The Great Alaska "Earthquake" of 1998-2001

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Annual Global Positioning System (GPS) campaign surveys since 1995 in the area of the 1964 Great Alaska earthquake (Mw 9.2) show evidence for a large aseismic slip event beginning in late 1997 or early 1998 and apparently ending in 2001. Prior to 1998, velocities of sites in Anchorage and the area to the north were oriented toward the NNW, consistent with strain associated with a locked subduction interface to the south. Between fall 1997 and summer 1998, velocities of GPS sites in an area at least 150 km by 100 km in size changed by as much as 25 mm/year. North of Anchorage, the change in site velocities was large enough that sites changed direction, from NNW-directed motion to SSE-directed motion. One permanent site in the area, installed in late 1998, shows a clear time-dependent signal, moving rapidly to the south shortly after installation and then slowing down over the next two years. A preliminary evaluation of data from summer 2001 suggests that the anomalous southward motion has ended or nearly so. These observations are consistent with the sudden activation (taking less than several months) of some process that causes southward motion of the sites, and a slow decay of that process over a span of 3-4 years.

We can explain this change in velocities by a model of increased creep on a large section of the plate interface downdip of the 1964 rupture zone. In this model, slip on the interface increased from roughly the rate of plate motion to roughly double that, decaying back to roughly the rate of plate motion after 3+ years. This event is different from the recent creep event observed in Cascadia, as it extends well downdip of the seismogenic zone and appears to have affected a very large area simultaeously rather than propagating along strike. The westward extent of the zone of anomalous creep is uncertain due to a lack of data prior to 1997, but this zone is inferred to be at least 100 km by 100 km, lying at a depth of 35 km or more. The change in velocities was accompanied by a significant change in the rate of microseismicity in two volumes within the subducting Pacific plate, which lie on the edges of the inferred creeping zone. We infer that these changes, in one case a reduction in the rate of seismicity and the other an increase, had the same root cause as the creep event.

G22D-12 1635h INVITED

Episodic Silent Slip: A New Aspect of Cascadia Megathrust Behaviour

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The gradual densification of continuous GPS sites in southwestern British Columbia and northwestern Washington over the past 4 years, accompanied by improvements in GPS data analyses for regional networks, have led to the discovery of aseismic slip occurring on the deeper portions of the Cascadia subduction interface. The most convincing evidence comes from a transient crustal deformation signal observed in the late summer of 1999 (Dragert et al., Science, Vol. 292). This signal, observed at 7 contiguous sites spread over an area of about 300 by 100 km along the northern Cascadia margin, consisted of systematic changes in site positions ranging from 2 to 4 mm over a period of 5 to 15 days in a direction opposite to the longer term secular deformation motion caused by the locked state of the Cascadia subduction fault. A second similar but more spatially limited slip event has been found to have occurred in December 2000, and it is strongly suspected that the hereto unexplained transient motion observed in October 1994 at the Victoria GPS site (ALBH) was also caused by aseismic slip. The total surface displacements observed for these transients can be modelled by silent slip of up to 2 cm occurring on the subduction interface below the seismogenic zone, bounded roughly by the 30 and 40 km depth contours of the subducting slab. The downdip boundary of the aseismic rupture is relatively sharp, possibly controlled by the depth of contact with the moho of the overlying crustal margin. The updip boundary requires a more gradual transition from full rupture to zero displacement, suggesting that it is thermally controlled. The absence of seismic triggers and anomalous seismicity and the apparent modulation of secular deformation velocities suggest that this deep-slip behaviour is episodic and likely triggered by rheological instabilities. Episodic slip behaviour implies time-variant coupling across the deeper subduction interface which not only generates non-linear transient motions but may also play a key role in the stress loading of the seismogenic zone, perhaps generating a trigger mechanism for a great subduction earthquake.

G31A MC: Hall D Wednesday 0830h

Explaining Geodetic Observations of Nonlinearly Time-Varying Surface Deformation II *(joint with NG, H, S, T, V)*

Presiding: **G W Bawden,** U.S. Geological Survey**; E Harding Hearn,** Massachusetts Institute of Technology

G31A-0120 0830h POSTER

Anatomy of apparent seasonal variations from GPS derived site position time series

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Apparent seasonal site position variations are derived from 4.5 years of global continuous GPS time series and explored through the peering approach, i.e. depicting the contributions of the comparatively well-known seasonal sources to garner insight into the relatively poorly-known contributors. Contributions from pole tide, ocean tide loading, atmospheric loading, non-tidal oceanic mass and ground water loading are evaluated. Our results show that about 40% of the power of the observed annual vertical variations in site positions can be explained by the joint contribution of these seasonal surface mass redistributions. After removing surface mass redistribution inferred seasonal effects from the observations, the potential contributions from unmodeled wet troposphere effects, bedrock thermal expansion, errors in phase center variation models and errors in orbital modeling are also investigated. A scaled sensitivity matrix analysis approach is proposed to assess the contributions from highly correlated parameters. The effects of employing different analysis strategies are investigated by comparing the solutions from different analysis centers. Comparison results indicate that current solutions of several GPS analysis centers are able to catch the seasonal signals but that the differences between these solutions are the main obstruction in further studying the residual seasonal effects. Potential implications for modeling seasonal variations in global site positions are explored, in particular as a way to improve the stability of the terrestrial reference frame on seasonal time scales.

G31A-0121 0830h POSTER

Seasonal Variation of Baseline Length Changes Observed in GEONET GPS Sites

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Murakami and Miyazaki [1999] reported that seasonal variation could be seen in the daily solutions of GEONET (the GPS Earth Observation NETwork) GPS site coordinates. Hayashi et al. [2000] and Heki [2001] also reported seasonal variation in the baseline length changes. Especially, Heki [2001] investigated the seasonal variation of the baseline length change in Tohoku area, one of the most heavy snowfall areas in Japan, and concluded that the variation was due to snow loading and melting. These studies show that the existence of the seasonal variation is almost undoubted. However the previous studies employed relatively short period of GPS data (less than 3 years) or restricted the area of analysis, they have not revealed the characteristics or the cause of the variation completely. Therefore, for the more detailed analysis, we employed all GEONET data and investigated the characteristics of the seasonal variation statistically.

First, we calculated all combinations of the baseline length changes from daily solutions of the GEONET GPS site coordinates, and then, using least squares method, we estimated secular trends, annual amplitudes and phases of the baseline length changes for every combination of the GEONET GPS sites. Finally, the estimated parameters (trends, amplitudes and phases) were employed to examine their regional or directional dependencies. The results are summarized as follows:

(· The seasonal variation can be observed in almost all the baselines.

(· Most of the large amplitudes of the seasonal variations are observed in N40W $\sim$ N70W directions.

(· The secular compressions are also observed in N40W $\sim$ N70W directions.

(· Most of the baselines expand in summer, and contract in winter.

The first result confirmed that the existence of the seasonal variations all over the Japan, and the last one was consistent with the Heki's interpretation: The snow loading causes the contraction and snow melting causes the expansion. However, his interpretation was not enough to explain the seasonal variations in no snowfall areas of the southwestern part of Japan. Further investigation of the seasonal variations, we selected the baselines with large amplitude of more than 4mm and plotted their distributions. A notable result is that the baselines that extend in summer are distributed almost all over Japan, however the baselines that extend in winter are distributed mainly in the southwestern part of Japan, especially across the mountains of the Japanese Alps. This result may help to consider the mechanism of the seasonal variation in the no snowfall areas, although we have not solved the problem yet.

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G31A-0122 0830h POSTER

Migrating Crustal Deformation from GEONET Observations

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The Geographical Survey Institute of Japan (GSI) recently completed the installation of a continuous GPS observation network in Japan, which has enabled us to investigate real-time crustal movements. In this study, we attempt to detect migrating crustal deformations in Japan, using the horizontal components, which were observed at 900 GPS observation stations during the period from April, 1994 to February, 2001. These data include the effects of plate coupling, earthquakes, annual changes and noise at each station. In order to remove these effects, we modeled the time series as a linear combination of a constant term, linear term, trigonometric function whose period is 1 year, and offsets for episodic events (earthquakes). For the episodic events, we try to remove the effects of all earthquakes shallower than 30 km with magnitudes 5.0 or greater (221 events). To remove the noise, we use a Kalman filter which estimates the local trend at each station.

Our goal is to detect migrating crustal deformation across the Japanese Islands. We closely examine the crustal deformations which have these effects removed. We try to detect the migrating crustal deformation by a semblance analysis, which can detected the velocity, direction and epoch. Moreover, we use time series of the crustal deformation formed by stacking the GPS data from several stations.

We have detected some characteristic migrating crustal deformation, that have amplitudes which are much smaller than 1cm with rather fast velocities. The migrations we observe are much smaller in amplitude and have faster velocities than those reported by H. Ishii et al.(1980) . Our observations may contain other factors, such as annual changes which are difficult to separate from tectonic movements.

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Space-Time Imaging of Aseismic Slip Transients on Subduction Zone Thrust Interfaces

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