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


STT057-01 Room:105 Time:May 24 10:45-11:00

# Estimate of a non-planar fault model based on crustal deformation data due to the Iwate-Miyagi Nairiku earthquake(Mw6.9)

Takahiro Abe[1*], Masato Furuya[1], Youichiro Takada[2]

[1]Natural History Sci., Hokkaido Univ., [2]DPRI, Kyoto Univ.

## Iwate-Miyagi Nairiku Earthquake

On 14 June, 2008, Iwate-Miyagi Nairiku earthquake occurred in the south of Iwate. The epicenter was located in the strain concentration zone along the Ou Backbone Mountains (Miura et al., 2004), in which the reverse faulting earthquake by EW compression was not surprising. However, there are no previously known active faults near the epicenter and thus crustal deformation observation has been mainly performed around Dedana fault to the northeast. There are 17 casualties in five prefectures of Iwate, Miyagi, Akita, Yamagata and Fukushima, and more than 2600 houses were damaged (Cabinet Office, AM11:00 on 23 June, 2010). It seems much more human suffering than the buildings collapsed and landslides because its epicenter is located in mountain area despite inland earthquake.

## Previous Research and Purpose of study

Several studies on this earthquake have already been published. For example, Takada et al. (2009) estimated fault models using SAR data, in which five rectangular fault segments with uniform slip was assumed. Iinuma et al. (2009) inferred two west-dipping faults based on GPS data. Around its epicenter, however, there are few GPS observation points, and it is difficult to explain the detailed signals revealed by SAR data. Moreover, while all previous studies assumed rectangular-planar models, the observed crustal deformation data show complex spatial distributions. In order to explain the observed data, it is necessary to assume non-planar fault surfaces.

## Observed Result

As a result of data analysis by InSAR and pixel offset technique, both data of ascending (South-North orbit) and descending (North-South orbit) detected more than 1 meter displacements along LOS (Line Of Sight). InSAR data indicates that this fault motion is consistent with reverse fault caused by EW compression. Also, in the result of pixel offset technique, there are characteristic displacements around the eastern edge of Mt. Kurikoma. This is a signal that can't be explained by a west-dipping fault. Thus, we inferred the fault plane normal to the ground surface, and assumed the non-planar east-dipping fault.

## Estimate of non-planar fault model

Based on data by InSAR and pixel offset technique, we inferred a number of non-planar fault models, and performed inversion analysis. In modeling, we used triangular dislocation model assumed in a uniform elastic half space, and Gmsh (Geuzaine and Remacle, 2009) for its shape decision. Then, we calculated Green's function by triangular dislocation using Meade (2007) script. For the estimate of slip distribution, we applied a smoothness constraint as well as a"non-negativity"constraint (Maerten et al., 2005) on the slip direction.

We are going to show the fault model that can better-explain the observed data and analysis result, using GPS data as well.

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


STT057-02 Room:105 Time:May 24 11:00-11:15

# Long-term afterslip after the 2008 Iwate-Miyagi Nairiku earthquake deduced from InSAR data

Yusaku Ohta[1*], Taku Ozawa[2], Mako Ohzono[1], Satoshi Miura[1]

[1]RCPEVE, Tohoku University, [2]NIED, Japan

We detected the anomalous long-term crustal deformation after the 2008 Iwate-Miyagi Nairiku earthquake (heare after IMEQ) deduced from ALOS/PALSAR interferograms. This anomalous crustal deformation possibly caused by afterslip near the mainshock fault.

The 2008 Iwate-Miyagi Nairiku (inland) earthquake occurred beneath the border between the Iwate and Miyagi prefectures at northeastern Japan in 13 June 2008. Based on the long-term GPS time series (~1.5 years), Ohzono et al. (in revision) detected clear postseismic signal, which indicates wider-area crustal shortening between the focal area and the subsidence signal in the focal area. They conclude that this postseimsic signal is caused by viscoelastic relaxation process in the lower crust and/or upper mantle, and constructed a simple spherical 2-layerd (elastic and Maxwell viscoelatic layer) model. The viscoelastic model, however, could not explain the large GPS displacement near the focal area. In this study, we discuss the long-term crustal deformation after the IMEQ deduced from ALOS/PALSAR InSAR data.

We use SAR data from the JAXA ALOS satellite acquired between July 2008 and December 2010 to construct interferograms across the focal area that include 14 scenes. A single frame (2830) from descending (north to south) orbit path 57 was used. Several obtained interferograms shows the LOS (Line of Sight) anomaly. For example, between July 2008 and June 2009 interferograms clearly shows the increase LOS in the footwall side of the mainshock fault. In contrast, LOS shortening appears in hanging wall side, which mainly concentrated in northerly of Mt. Kurikoma. In contrast, there is no similar anomaly between July 2008 and October 2008 interferogram. It suggests that the anomalies may generate during October 2008 to June 2009. These LOS anomalies are possible to explain by simple reverse fault model at deeper portion of the mainshock as first order of approximation.

Acknowledgements
PALSAR level 1.0 data are provided by JAXA through PIXEL (PALSAR Interferometry Consortium to Study our Evolving Land surface) under a cooperative research contract with ERI, Univ. Tokyo. PALSAR data belongs to the Ministry of Economy, Trade and Industry of Japan and JAXA.

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


STT057-03 Room:105 Time:May 24 11:15-11:30

# Image of earthquake in South Island, New Zealand detected by ALOS/PALSAR

Manabu Hashimoto[1*]

[1]DPRI,Kyoto University

We detected coseismic deformation from the Canterbury Earthquake (M7.0), South Island, New Zealand, that occurred on September 3, 2010, with ALOS/PALSAR. This earthquake occurred on a previously unknown fault in the Canterbury plane. Beautiful surface ruptures with many jogs and steps were found in this plane by researchers in New Zealand. We utilized both ascending and descending images to produce interferograms and pixel offsets. Resulted interferograms show very complicated rupture of the earth's surface, which implies geometrically complex fault planes. The maximum LOS displacements were measured to be more than 130 cm. We will invert these interferograms to reveal fault motion associated with this inland earthquake.

Keywords: ALOS/PALSAR, InSAR, New Zealand, Canterbury Earthquake, Coseismic deformation

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


STT057-04 Room:105 Time:May 24 11:30-11:45

# Crustal deformation due to the 2010 southeastern Iran earthquake, obtained from InSAR analysis using ALOS/PALSAR data

Tomokazu Kobayashi[1*], Mikio Tobita[1], Akira Suzuki[1], Yuko Noguchi[1]

[1]GSI of Japan

Preface:

Active deformation in Iran is a result of the convergence between the Arabian and Eurasian plates. In eastern Iran, where nearly north-south shortening is dominant with rates about 2-3 cm/yr, two major north-south strike-slip fault systems develop with mainly right-lateral shear component. In these fault zone, several M6-7 class earthquakes have occurred historically. On 26 December 2003, a M=6.6 earthquake occurred at the Bam fault that is a southern portion of the western fault zone, which struck the town of Bam with devastating damages. A large inland earthquake with M=6.5 (USGS) occurred in southeastern Iran on 20 December 2010. The epicenter is about 100 km distant from that of the Bam earthquake. To map the surface displacement associated with this earthquake, we conduct interferometric SAR (InSAR) analysis using ALOS/PALSAR data. We will report the crustal deformation obtained from the InSAR analysis.

InSAR analysis:

We analyze SAR data acquired from the Path559 (ascending orbit) which are strip-map imagery with off-nadir angle of 34.3 degrees. We process the SAR data from a level-1.0 product using a software package GSISAR. The Path559 data acquired on 30 September 2010 and 31 December 2010 are used for master and slave images, respectively. We use hole-filled SRTM3 DEM (Jarvis et al., 2008) to remove the topographic phase.

SAR interferograms obtained show clear coseismic deformation due to this earthquake with high coherence. We can identify two major fringes in the interferogram; in the western part about 25 cm lengthening of slant range at maximum is observed, while in the eastern part about 11 cm shortening of slant range at maximum is observed. A displacement boundary across which the ground movement is in the opposite direction runs on an orientation of N40-50E, suggesting the fault involved with this seismic event has a strike of NE-SW direction.

In this presentation, we will report further detailed features of the crustal deformation with adding new observation data and a preliminary fault model constructed on the basis of the InSAR data.

Acknowledgment: PALSAR data are provided from Earthquake Working Group under a cooperative research contract with JAXA. The ownership of PALSAR data belongs to METI (Ministry of Economy, Trade and Industry) and JAXA.

Keywords: 2010 Iran Earthquake, InSAR, ALOS/PALSAR, Crustal deformation

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


STT057-05 Room:105 Time:May 24 11:45-12:00

# Ground deformation in and around Sakurajima volcano revealed by ALOS/PALSAR data

Keigo Yamamoto[1*]

[1]DPRI, Kyoto university

Sakurajima volcano is an andesitic stratovolcano located in southern Kyushu, Japan. The current eruptive activity at the summit crater began in 1955. While the activity has been gradually decayed after the 1990s, the eruptive activity at the Showa crater on the eastern slope of the volcano started in June 2006 and this activity has increased in recent years. Repeated precise leveling surveys have been conducted in and around Sakurajima volcano since 1957 (Yoshikawa, 1961; Eto et al., 1997). The results indicated that the ground subsidence around the northern and the central parts of Sakurajima continued due to the pressure decrease at the magma reservoirs associated with the intense eruptive activity since 1973. It was found that the ground around the northern part of Sakurajima was turned to the uplift when the eruptive activity was gradually decayed after the 1990s (Eto et al., 1997). The recent precise leveling surveys were conducted in October - December 2007 (Yamamoto et al, 2008), in November 2009 and in April 2010 (Yamamoto et al., 2010) and in November 2010. The obtained survey data indicated that the ground uplifts around the northern part of Sakurajima continued during the period from 1996 to 2010.

The recent InSAR technique allows us to detect nearly continuous deformation image which covers the whole target area. We analyzed the ALOS/PALSAR image pairs, in order to detect the ground deformation associated with the volcanic activity of Sakurajima volcano. In this paper, the results of the InSAR analysis by using the ALOS/PALSAR data are shown to discuss the recent ground deformation of this volcano.

A few centimeters of LOS distance decrease are detected at the northern part of Sakurajima in the resultant interferograms during the period from 2007 to 2010. The quasi-upward components calculated by the 2.5-D deformation analysis (Fujiwara et al., 2000) are consistent with the ground uplifts measured by the leveling surveys conducted in Oct.-Dec., 2007, Nov., 2009 and Apr., 2010. From the analysis according to Mogi's model by using the InSAR results, the inflation source is located beneath the northern flank of the volcano. The resultant interferograms also show a few centimeters of LOS distance increase at the eastern and the southern parts of Sakurajima, which may be related to the ground subsidence around the areas of relatively new lava flows.

Acknowledgements: We thank JAXA SIGMA-SAR software to generate our interferograms (M. Shimada, 1999). PALSAR level 1.0 data are shared among PIXEL (PALSAR Interferometry Consortium to Study our Evolving Land surface), and provided from JAXA under a cooperative research contract with ERI, Univ, Tokyo. The ownership of PALSAR data belongs to METI (Ministry of Economy, Trade and Industry) and JAXA. This study was supported by the Earthquake Research Institute cooperative research program.

Keywords: Sakurajima volcano, ground deformation, InSAR

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


STT057-06 Room:105 Time:May 24 12:00-12:15

# Crustal Movement Observation in Active Volcanic Region (Kamchatka, Central America, and Indonesia) using ALOS/PALSAR

Yosuke Miyagi[1*]

[1]JAXA, EORC

Japanese earth observation satellite ALOS (Advanced Land Observing Satellite) was launched on January 24, 2006, and has been operated by Japan Aerospace Exploration Agency (JAXA). ALOS operation has been going well and a lot of data from all over the world was accumulated using three sensors (PRISM, AVNIR-2, and PALSAR). Because PALSAR (Phased Array type L-band Synthetic Aperture Radar) is active microwave sensor, it can observe earth surface (targets) at anytime of the day or night, and under almost all weather conditions. And PALSAR data can be applied to Differential Interferometric SAR (DInSAR) technique to detect crustal movement. DInSAR technique enables us to obtain spatially detailed crustal movement with high accuracy, and to understand volcanic activities.

In the Kamchatka Peninsula at the far east of Russia, there are many active volcanoes, for example Kliuchevskoi, Shiveluch, and potentially active volcanoes. We tried to detect crustal movement in whole area of the Kamchatka volcanic region using PALSAR/DInSAR technique. Actually, we are suffer from snow cover in winter season and long baseline between two acquisition time due to the high latitude of the target area, which usually destroy the coherence and bring difficulties into DInSAR processing. However, accumulation of PALSAR data for 5 years enables us to make DInSAR observation over Kamchatka peninsula, and we could detect crustal movement associated with volcanic activity in Gorely volcano. Also in Indonesia and Central America volcanic regions, there are so many active volcanoes, e.g. Merapi volcano or Arenal volcano, and we tried to detect crustal movement from extensive PALSAR/DInSAR observations.

Keywords: ALOS, PALSAR, DInSAR, crustal movement, volcano

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


STT057-07 Room:105 Time:May 24 12:15-12:30

# Application of 3-D migration in problem of subsurface sensing on an uneven ground surface

Andrey Klokov[1*], Motoyuki Sato[1]

[1]CNEAS, Tohoku Univ.

At the present time due to technological progress and cost reduction are widely distributed GPR (Ground Penetration Radar) systems. These systems allow carrying out subsurface studies and successful results have been obtained for industrial applications such as searching for lost communication lines, control of pipes state of water and gas supply systems, landmine detection, groundwater investigations, exploration of mineral resources, and also for archaeological and historical applications, i.e. study of archaeological layers of the Earth, searching for different types of artifacts and etc. Methods of seismic data processing come to the help us. The main method of seismic data processing is migration.

As a result of diffraction of each point reflector located in a homogeneous medium is displayed in the form of a hyperbola. In this case the true position of the point scatterer corresponds to the apex of hyperbola. Process of migration moves reflections to their true positions and collapses diffractions, thus increasing spatial resolution and yielding image. In seismic data processing the most commonly used methods of migration are the method of diffraction summation in time-domain and Stolt method in f-k ?domain. We have compared these methods using simulation of reflection of point scatterers. Using both methods we can find the true position of a scatterer. The main limitation of Stolt migration consists in the fact that a velocity of wave propagation in a medium is constant and another limitation is the interpolation a dataset on a regular grid. Diffraction summation method is more universal method, but Stolt migration using the Fourier transform is faster more than 1000 times.

The experiments were carried out in different sites of Japan. For positioning of the antenna was used rotary laser positioning system. This system gives more accuracy spatial coordinates, than GPS. The datasets are processed using the following steps: time zero correction, gain application, background removal and 3D migration. Migration was processed using by diffraction summation algorithm and under the assumption of a flat surface. But, really, survey area is not flat, and we need take into account topographical properties of surface and make correction on height in the migration process. We developed algorithm based on diffraction summation method which takes into consideration irregularity of surface. Simulation tests of this algorithm were successful in 2D and 3D migration cases. Now we are trying to apply algorithm for real datasets.

The experiment result demonstrates the possibility of performing a full 3-D migration. We found some targets with small slope in depth direction due to topographical properties of surface. Further work will focus on implementing and testing these methods for reconstructing images takes into account topographical properties of surface.

Keywords: Remote sensing, Ground Penetration Radar, Migration

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


STT057-08 Room:105 Time:May 24 12:30-12:45

# Recent Progress of PASCO's SAR Application Studies

Tadashi Sasagawa[1], Takashi Nonaka[1*], Susumu Takagishi[1]

[1]PASCO CORPORATION

Great disasters (1995 South Hyogo Prefecture Earthquake, Mid Niigata Prefecture Earthquake in 2004, 2008 Iwate-Miyagi Nairiku earthquake, and 2004 Indian Ocean Earthquake, etc.) have increased worldwide in the recent years and caused huge damages. In the basic plan for earthquake disaster prevention, the Central Disaster Prevention Council emphasizes the necessity of the research and development activities for minimizing the risk and scale of the damages at different stages of the countermeasures, e.g., beforehand, disaster emergency response, and disaster recovery.

Based on these backgrounds, PASCO CORPORATION started organizing TerraSAR-X Workshops about various application studies since 2005. Application studies were selected especially from a viewpoint of National Land Environment and Disaster Prevention. This was the basis since most of the committee members are specialists of disaster prevention field. We also discuss the technical development plans of handling SAR data such as Differential Interferometry, Polarmetric aspects etc., during the workshops. TerraSAR-X is one of the sophisticated modest high-resolution SAR satellite launched in 2006, and second series as TanDEM-X with the same specification of TerraSAR-X, was also launched in 2010. More than thirty thousand imageries of the data were acquired for the past five years, and are available as reference in case of disaster occurrence.

We have adopted 16 research subjects so far, in the past couple of years we were focusing on the earthquakes, volcanoes, windstorm and flood monitoring but recently we have also started dealing with environmental monitoring and notification of snow and ice events. In our presentation, we summarize the outcomes of five subjects in the second series of Workshops held in 2010. In addition to these workshops, we also introduce the progress of our internal project of Himalayan Glacier Lake monitoring using TerraSAR-X data, and the future plans.

Reference:http://www.pasco.co.jp/products/survey/satellite/terrasarx/sar-conf/

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


STT057-09 Room:105 Time:May 24 14:15-14:30

# Possibility of detection of active landslide block by In-SAR image

Takaki Okatani[1*], Hiroshi, P. Sato[1], Akira Suzuki[1], Mikio Tobita[1], Tatsuo Sekiguchi[1], Takayuki Nakano[1], Mamoru Koarai[1]

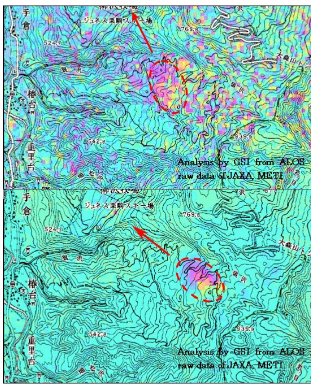
[1]GSI of Japan

In-SAR image is well-known as detecting crustal movement in wide area when hazardous events like earthquakes and volcanic activities occur. In addition to detecting such wide movement, small and regional movements were observed at Noto Hanto Earthquake in 2007 using In-SAR image. Most of those small movements were occurred at known landslides, and these facts were thought to express that landslides were triggered by the earthquake (Une et. al., 2008). Those results show that detection and monitoring of landslides might be done with In-SAR image. On the basis of the results, we delved into possibility of the detection and monitoring at Higashinasuse village in Akita prefecture using ALOS/PALSAR data in this study.

There are many famous landslides in this area, e.g. Yachi Landslide. Among those landslides, Ohkamizawa landslide on the right bank of Naruse river is an active one at rates of more than 10cm/year, and this landslide movement could be observed at In-SAR image.

Ohkamizawa landslide is delimited into several blocks by making out micro- topography. In-SAR image shows that locations of vivid fringes seen at 2006-2007 (Upper image) and at 2008-2009 (Lower image) are different. In fact, the fringe in 2006-2007 corresponds with a lower block, and 2008-2009 corresponds with a upper block.

These results show that it might be mentioned not only existence of landslide but also detection and monitoring of individual block movement, using In-SAR image.




Keywords: SAR, ALOS/PALSAR, Landslide

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


STT057-10 Room:105 Time:May 24 14:30-14:45

# Estimation of the peatland subsidence and Green-house-gas emissions at the Central Kalimantan using the PALSARInSAR

Masanobu Shimada[1]*, Inoue Takashi[2], hatano ryusuke[2], awaya yoshio[3], kiyono yoshiyuki[4]

[1]Japan Aerospace Exploration Agency, [2]Hokkaido University, [3]Gifu University, [4]Forestry and forest product research ins

Emission of the $CO_2$ from the Indonesian forest is mainly composed of the deforestation, forest degradation, and the peat land subsidence. Peat land subsidence of Indonesian islands represented by the Central Kalimantan is induced by the global warming and the resultant chemical processes at the peat land emit the $CO_2$ to the air. The measurement of a relationship between the subsidence speed and the $CO_2$ emission amount and the two dimensional subsidence speed measurement using the PALSAR interferometry were applied to estimate the gross amount of the $CO_2$ emission at the test site of the Central Kalimantan. In the presentation, we will show the estimated value of the $CO_2$ emissions. PALSAR and interferometry was introduced in [1].

Availability of the InSAR technique for the peat land was evaluated, first, by checking the quality of the interferometric coherence, then the value on the subsidence by InSAR was compared with the position of the peat land surface that was obtained as an length along the iron pipe which is piled to the solid ground of around 3 meter below the surface. We have used the in total seven PALSAR image pairs for measurement of the subsidence al of which are referred to the July 9 2007. We obtained the ground control point at three areas, Vegetation area (KV), Fire scared and regrowth forest (RF), and Forest region (FT). RMS errors of these areas are, 0.79 cm for KV, 2.24 cm for RF, and 3.51 cm for FT.

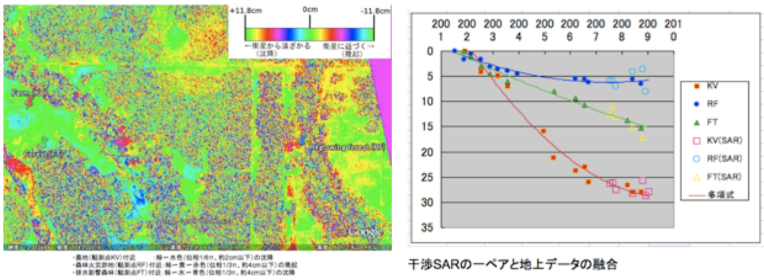



Fig.1 Test site in the Central Kalimantan (left) and the relationship between the subsidences's (InSAR and ground truth data comparison)

Keywords: SAR, ALOS, Subsidence, Peatland, SAR interferometry

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


STT057-11 Room:105 Time:May 24 14:45-15:00

# Crustal deformation of Miyakejima by InSAR time-series analysis

Taku Ozawa[1*], Hideki Ueda[1]

[1]NIED, Japan

To investigate volcanic deformation in detail, we developed new InSAR time-series analysis using interferograms for multiple orbit paths. For one-side looking SAR, incidence directions for ascending/descending orbits and different offnadir modes are almost included in a plane, and therefore slant-range changes for their interferograms can be expressed by two components in the common plane. This analysis estimates time-series of those components by the inversion analysis. Since this analysis has noise reduction effect by the least-square analysis, higher accuracy is obtained if many interferograms for different orbits/modes are available. Furthermore this analysis has another advantage that it can connect interferograms for different SAR sensors seamlessly. In a case study in Miyake-jima volcano, we obtained deformation time-series from PALSAR interferograms for six orbit paths, corresponding to GPS observation. Although improvement of accuracy from SBAS approach was negligible, it demonstrated an advantage that can connect interferograms for different orbit paths. Accuracy must have been improved if SAR observations have been carried out more frequently in all orbit paths. Obtained deformation shows the uplift in the west coast and the subsidence with contraction around the caldera. Although speed of uplift was almost constant, the subsidence around the caldera had decelerated from 2009. Its deformation source was estimated to horizontal source located to roughly sea level under the caldera, suggesting that subsidence was induced by the interaction between volcanic thermal activity and the aquifer. If higher accuracy is obtained from such InSAR time-series analysis, more detailed deformation change may be detected.

Keywords: InSAR, time-series analysis, Miyake-jima, Crustal deformation, Volcano

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


STT057-12 Room:105 Time:May 24 15:00-15:15

# Elevation Correlating Residuals in D-InSAR Phases for the Central Part of Kyushu, Japan

Makoto Omura[1*], Shigeki KOBAYASHI[2], Katsuaki Koike[3], Nobuhiro Tomiyama[4]

[1]Kochi Women's Univ., [2]Tokai Univ., [3]Kumamoto Univ., [4]RESTEC

There are some reports on the D-InSAR crustal movement monitoring around Kuju volcanic area where the eruption occurred at Mt. Hossho on October 1995 (e.g. Tomiyama et al., 2004). D-InSAR processing of the L-band SAR data is very effective to monitor crustal movements on the vegetated and steep terrains. However, sometimes residual D-InSAR phases correlated with elevation of the terrain, and it is inferred as atmospheric disturbance. In some case, a simple linear relationship between the residual D-InSAR phase and the elevation is applied to reduce the disturbance, if the meteorological data are insufficient for the detailed calculation. We carried out detailed study on the characteristics of the linear relationship in the different regions and orientations for the central Kyushu, Japan. The data were acquired by JERS-1 SAR (78-245) between 1992 and 1998. According to preliminary analyses, there are some cases in which magnitude of the proportionality factors showed differences of more than 20% in the different orientation at the same region and those of more than 15% in the same orientation at the adjacent different regions, Aso volcano and Kuju volcanic area, which are apart about 30km. METI/JAXA retains ownership of JERS-1 SAR data. We are grateful to Dr. M. Shimada for his providing the SIGMA-SAR software (Shimada, 1999), and part of this study was carried out under the support by the Earthquake Research Institute, The University of Tokyo, Cooperative Research Program (2009-B-02).

[References]

Shimada M. (1999), Adv. Space Res. 23, 8, 1477-1486.
Tomiyama N, K. Koike, M. Omura (2004), Adv. Space Res. 33, 3, 279-283.

Keywords: D-InSAR, Aso, Kuju, Elevation, Atmospheric Disturbance

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


STT057-13 Room:105 Time:May 24 15:15-15:30

# Effect of the traveling ionospheric disturbances on space-borne SAR observation

Akinori Saito[1*], Dai Mineyama[1], Manabu Hashimoto[2]

[1]Graduate School of Science, Kyoto Univer, [2]DPRI, Kyoto University

We investigated the ionospheric effect on the Interferometric Synthetic Aperture Radar (InSAR) observation from the ALOS satellite. The plasma is a dispersive media for radio wave. It will delay the propagation of radio waves according to its density and the radio frequency. The plasma in the ionosphere below the satellite orbit affects the L-band frequency radio wave of PALSAR on the ALOS satellite. The ionospheric structures whose horizontal spatial scale is shorter than the field-of-view of PALSAR cause the error of the ranging. In InSAR observations, the error can cause the pseudo ground movement. We compared the ionospheric plasma structures that was observed by a ground-based GPS network with the InSAR observational data, and concluded that most of the large scale structures of the apparent ground movement seen in InSAR data was error caused by the medium scale traveling ionospheric disturbances whose scale size is a few kilometer. The relation between the ionospheric structures and the structures seen in InSAR data will be discussed in the presentation.

Keywords: SAR, Ionosphere, ALOS, PALSAR, InSAR

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


STT057-14 Room:105 Time:May 24 15:30-15:45

# Correction on ionospheric delay in ALOS/PALSAR interferogram using dense GPS data

Yuki Takemura[1], Takeshi Sagiya[1*]

[1]Environmental Studies, Nagoya Univ.

Interferometric Synthetic Aperture Radar (InSAR) is a space geodetic technique using radar images to map surface displacement. Recent technical development has enabled us to detect interseismic steady deformation of a few mm/year by stacking multiple images acquired by C-band SAR images. However, the technique has not been applicable to vegetated areas like Japan because of low coherency in the C-band SAR images. Instead, a similar technique for L-band SAR data is necessary. Thus we investigate applicability of stacking technique to data obtained by the Phased Array type L-band Synthetic Aperture Radar (PALSAR) on the Advanced Land Observation Satellite (ALOS). We processed 18 images of the area including the Atotsugawa Fault in central Japan. There are mainly two obstacles to perform stacking analysis of InSAR in this area. Firstly, the total number of coherent pairs is too small to resolve interseismic deformation in this area because of the large distances between satellite locations due to the orbital control and low coherency in the mountain areas due to snow. The second obstacle is a systematic long wavelength noise appearing in the interferograms. The amplitude of the long wavelength noise exceeds 10 cm and it is mandatory to make a correction on it. It is considered that this long wavelength noise is caused by ionospheric delay since the L-band SAR is 16 times more sensitive to such disturbance than the C-band SAR. Thus we try to establish methodology to correct ionospheric delay in the SAR interferogram by using continuous GPS data. We estimate spatio-temporal distribution of Total Electron Content (TEC) over the ionosphere using dual-band GPS phase measurement data and project it onto the ground along the line of sight of the SAR satellite to estimate phase delay or apparent crustal deformation. The estimated TEC distribution is verified and calibrated through a comparison with the International Reference Ionosphere (IRI) model. The obtained phase delay distribution on the ground resembles the original interferogram before the correction. Such an ionospheric correction is indispensable to obtain significant signals from L-band SAR analysis.

Keywords: InSAR, Ionospheric delay, GPS

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


STT057-15 Room:105 Time:May 24 15:45-16:00

# An approach to reduction of ionospheric noise in SAR interferometry for detecting small and secular deformation

Yo Fukushima[1]*

[1]DPRI, Kyoto Univ.

SAR interferograms produced from ALOS/PALSAR images, when compared with other C-band sensors, have a great advantage of obtaining signals on vegetated areas. It is becoming evident from case studies, however, that many interferograms are affected by large ionospheric noise that may critically mask small deformation signals. Such ionospheric noise is not a large issue for detection of localized signals on volcanoes or landslides, but it is essential to remove such noise for detection of broader signals due to, for example, plate subduction. This presentation proposes an idea of reduction of such ionospheric noise.

SAR interferograms contain LOS displacement signals and noise due to ionospheric disturbance, tropospheric phase delay and error in the orbit data. If we ignore such noise, we can obtain the LOS displacement time-series by an InSAR time-series analysis. On the other hand, if we can assume that there is no deformation in a specific period, and if we add a further constraint such that, for example, noise is small enough on a certain acquisition date, then we can estimate the noise component in all the SAR data. If we do such noise estimation on multiple different periods and remove the noise components from all the SAR data, we can then compute "noise-free" interferograms that bridge different time periods, and can hence estimate LOS displacements precisely.

I will present results of a synthetic test and of application to ALOS/PALSAR data acquired in Kinki district that are supposed to have recorded the deformation due to the subduction of the Philippine Sea Plate.

Keywords: InSAR, Ionosphere, Crustal deformation, ALOS, PALSAR

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


STT057-16 Room:105 Time:May 24 16:00-16:15

# Concentrated heavy rain detected by InSAR Part2 : Ionospheric model estimated from azimuth offset data

Youhei Kinoshita[1*], Masanobu Shimada[2], Masato Furuya[1]

[1]Natural History Sci. Hokkaido Univ., [2]JAXA/EORC

The ionospheric effects have a significant impact on the space geodetic technique based on lower frequency microwave like GPS or L-band InSAR. Due to the dispersive nature of the medium, dual-frequency observations can remove the effects almost completely. However it is impossible for a single-frequency SAR observation to separate the ionospheric signals from other signals like crustal deformation, tropospheric delay and so on. Therefore it is necessary to develop a method that can somehow correct for the ionospheric effects in the L-band InSAR data.

In the previous report (Kinoshita et al., Geodetic Society of Japan 2010 meeting), we could detect localized signals in InSAR data and we validated this point, having shown other InSAR images as well as azimuth component of pixel-offset data. Then we concluded that the signal was due to neither ground deformation nor DEM errors. However, although we considered that the signal was probably not due to ionospheric effect, the influence of ionospheric effect remained to be isolated. Therefore, in order to disprove the possible influence of ionosphere on the derived InSAR data, some other approach to correct for the ionospheric signals is necessary.

Gray et al. (2000) first reported that ionospheric anomalies became obvious as streaking in azimuth component derived from offset tracking. Offset tracking is a method to detect ground displacement using two SAR amplitude images. Then Meyer et al. (2006) showed that azimuth streaking was proportional to the gradient of differential total electron density (TEC) along the ray path. Wegmuller et al. (2006) also described the same approach. Based on the relation by Meyer et al. (2006), Raucoules and Michele (2010) applied the Meyer's approach to the case of InSAR data including the 2008 Wenchuan earthquake signal and showed the effectiveness of the approach.

Based on that relation, we also tried to correct ionospheric effect in InSAR data. This correction method consists of the following steps; 1) calculating azimuth offset field from offset tracking technique that uses two SAR amplitude images; 2) numerically integrating azimuth offset field along the azimuth direction to generate differential TEC model in InSAR; 3) Multiplying this model by some factor and subtracting multiplied model and one offset parameter from observed InSAR data. The factor and offset parameter is estimated by least square method to minimize the residual. To validate the efficiency of this, we applied the correction described above to two InSAR data, which location is Tokachidake and Niigata respectively. The strong ionospheric effect appears in both two InSAR data and azimuth streaking is clearly seen in both two azimuth offset data. After correction, we achieved the good result in both two sites. Therefore we also applied this correction to the InSAR data including the localized signal. We will show that results and discuss about the efficiency of this correction.

Now we newly tried to model the ionospheric effect using azimuth offset data with the method proposed by Meyer et al. (2006). As a result, we concluded again that the ionospheric effect hardly correlated with the signal. Besides above, we compare the tropospheric delay in InSAR data with that in GEONET data, the Japanese GPS network. The principle of atmospheric propagation delay in GPS is inherently same as that of InSAR, so it is worth to compare of tropospheric delay between GPS and InSAR. At the lecture, we will discuss what we can learn from the InSAR image and GPS zenith wet delay data.

References

[1] Meyer, F., R. Bamler, N. Jakowski, and T. Fritz (2006): Methods for small scale ionospheric TEC mapping from broadband L-band SAR data, in Proc. IGARSS, Denver, CO, Jul. 31-Aug. 4., 3735-3738.

Keywords: InSAR, ionosphere, azimuth offset