Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)


HTT08-01 Room:101B Time:May 26 09:00-09:15

# Accuracy evaluation of UAV-measured DSM by RTK-GPS on Midori fault scarp of Neodani active fault, Gifu Prefecture, Japan

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Accuracy of UAV (Unmanned Aerial Vehicle) -measured DSM (Digital Surface Model, Uchiyama et al., 2014) was evaluated using RTK (Real-Time Kinematic) GPS survey on Midori fault scarp of Neodani active fault, Gifu Prefecture, Japan. The accuracy was evaluated on the surveyed six control points at the accuracy not more than 8 mm in plane. As a result, 3 cm, -8 - -9 cm, -5 - -7cm in difference were found at three points on the top of the scarp. And ca.40 cm, -3 - -4 cm, -0.6 - -2 cm were at three points on the bottom of the scarp. Apart from 40 cm-difference at the one point, approximately less than 10 cm was revealed as measurement accuracy for the DSM.

Acknowledgement
Survey result of RTK-GPS using virtual reference station was given by Tamano consultants Co.,Ltd.

Reference
Uchiyama et al., 2014, Mapping active faults by using small unmanned aerial vehicle and structure from motion software: A case study on Midori fault scarp formed by the 1891 Nobi earthquake, Active fault study, 40, 35-41.

Keywords: fault, UAV, GPS, RTK, DSM, VRC

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# Comparison of accuracy using various cameras and Structure from Motion

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Recently, the significance of Unmanned Aerial Vehicle (UAV) and Structure from Motion (SfM) has been increasing in geoscience field to understand geomorphological phenomena. These two new technologies can be used inexpensively, easily, rapidly and automatically in comparison to a traditional photogrammetry method, so that geomorphological changes that are caused by various agencies can be estimated at close interval. For these reasons, geomorphological information (e.g. DEM and Orthophotograph) can be made flexibly to suit researcher preferences. Most mountain national parks in Japan have been suffered from serious trail erosion for long time. Especially, some mountain trails in Daisetsuzan National Park in Hokkaido, northern Japan, have been eroded in a few meters in depth. This serious soil erosion bothers national park managers, mountain hikers and also alpine vegetation. It is important for park managers to accurately and easily understand that eroded soil volume and geomorphological changes. For the purpose of the management, this study demonstrated two new technologies and evaluated quality of DEMs and orthophotographs. This study aims: (1) to demonstrate two new technologies under various conditions, and (2) to understand differences of accuracy in some cameras and some software to make three-dimensional data.

This study used two methods to take photographs: (1) UAV (DJI Phantom2 +Vision) at 5 m, 10 m and 20 m flying height; and 2) a monopod at distance of 1.5 m and 3 m from the ground surface at 24 viewpoints. In order to compare difference of accuracy of cameras, Ricoh GR, Ricoh CapioR7 and DJI camera were used with UAV; and Ricoh GR, Canon power shot SX150IS, NikonD90, Panasonic LUMIX DMC TZ-60, Ricoh CapioR7, SONY Cyber-shot DSC-TX5, Ricoh GR, and Panasonic LUMIX DMC-GX1 camera were used with monopod. Sixty pictures were taken by the cameras on UAV, and 24 pictures were taken by the cameras on the monopod. Moreover the following software was used for making DEMs and orthophotographs: Visual SfM (free), Photo Scan Pro (commercial) and 123Dcatch (free). In place of the actual micro-topography, artificial sheet and blocks were placed on a flat ground for targets when taking photographs to evaluate absolute positional accuracy.

The analysis of the photographs taken with UAV by Photo Scan Pro shows that the average absolute positional error score was almost the same in Ricoh GR (0.001 cm) and Ricoh CapioR7 (0.042 cm) at the 5-m flying height. But, at the 10-m flying height the average absolute positional error score was as large as 1.371 cm in Ricoh CapioR7. On the other hand, the score for Ricoh GR was 0.039 cm. At the 20-m flying height, the score for Ricoh GR was 0.066 cm. In this flying height, Ricoh CapioR7 was not suitable due to bad resolution. DJI camera was not suitable in all cases. When using a monopod, the average absolute positional error score was less than 1 mm in all cameras from distance of 1.5 m (Ricoh GR: 0.89 mm, Canon Power Shot SX150IS: 0.71 mm, Nikon D90: 0.68 mm, Panasonic LUMIX DMC TZ-60: 0.68 mm, SONY Cyber-Shot DSC-TX5: 0.65 mm, Ricoh CapioR7: Not suitable). The results show that UAV-SfM is a useful method for national park managers and even mountain hikers to obtain high-resolution models by using inexpensive cameras to record trail conditions.

Keywords: Structure from Motion, UAV

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HTT08-03 Room:101B Time:May 26 09:30-09:45

# Tsunami-induced bedrock erosion and sediment deposition on uplifted coastal bench: Cape Todogasaki, eastern Japan

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An uplifted coastal bench at an elevation of ca. 20 m a.s.l. is located around Cape Todogasaki of the ria-type rocky coast in Sanriku, northeastern Japan. Tsunami waves induced by the 2011 Tohoku Earthquake were high enough to spread over the 20-m high terrace. To clarify the effects of tsunamis on the terrace surface micromorphology, we performed field measurements of structure-from-motion multi-view stereo (SfM-MVS) photogrammetry using an unmanned aerial system (UAS), composed of a digital camera mounted on a small unmanned aerial vehicle (sUAV), and terrestrial laser scanning (TLS). Global navigation satellite system (GNSS) rover was used to obtain geographical coordinates (centimeter accuracies) of ground control points for the georeferencing of the UAS and TLS data. Using digital elevation models (DEMs) with a 20-cm resolution generated from the point clouds of UAS and TLS, micromorphology of the terrace surface was analyzed. Despite limited basin area draining into the terrace, erosional features in the bedrock were identified. These features appear to be formed by the tsunami flow. Furthermore, sedimentological characteristics of small thin clasts and large (>2 m) boulders located on the terrace were examined in the field, revealing that the sediments are likely disloaded from in-situ bedrock at the terrace edge. Evidences of landward flow were also found from the sediment structure. We conclude that the uplifted terrace surface underwent erosion by not only the 2011 tsunami but also repeated significant tsunamis in the past, some of which could have been much larger than that in 2011.

Keywords: tsunami, UAS, TLS, erosion, sediments

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HTT08-04 Room:101B Time:May 26 09:45-10:00

# High-resolution multibeam bathymetric survey for coastal seafloor geomorphology and related sciences

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The geomorphology of shallow coastal regions has been modulated by repeated subaerial and submarine processes during glacio-eustatic sea-level change. However, in contrast to the vast knowledge that has been accumulated regarding terrestrial landforms, few previous studies have dealt with shallow seafloor landforms, which represent former terrestrial landscapes modified by present marine processes, from a geomorphological perspective.

A broadband multibeam echosounder (Sonic 2022, R2 Sonic, LLC) and its accessory system were introduced to H. Kan's laboratory in 2010 using JSPS Grant-in-Aid for Scientific Research A. We have carried out our bathymetric survey in Kume, Ishigaki, Kikai Islands and the southeastern and northwestern coasts of Okinawa Island in the Ryukyus, southwestern Japan since 2010.

The Sonic 2022 has a variable ultrasonic frequency of 200 to 400 kHz, 256 ultrasonic beams and selectable swath coverage of 10 to 160 degrees. The typical ultrasonic beam widths parallel and orthogonal to the direction of travel are within one degree of each other when an ultrasonic frequency of 400 kHz is selected. We used a VS111 GPS compass system with A20 and A30 antennas (Hemisphere Inc.) combined with a dynamic motion sensor (DMS-10, Teledyne TSS Ltd.), a sea surface sound velocity sensor (miniSVS, Valeport Ltd.), a sound velocity profiler (MicroSVP, AML Oceanographic Ltd.). Overlap of at least ˜20% (typically ˜50%) was implemented throughout the bathymetric survey to ensure 100% coverage of the surveyed area. The minimum and maximum depth was 1m and 400m, respectively. The HYPACK2010 software was used for both hydrographic survey and data processing. IVS3D Fledermaus was used for three-dimensional visualization.

We conducted geomorphological studies of the coastal seafloor in the coral reef areas of the Ryukyu Islands based on our high-resolution bathymetric map with a grid size of 1 m combined with SCUBA diving observations. For example, the submerged tropical karst features were discovered in Nagura Bay, Ishigaki Island (Kan *et al.* 2015). This is the first description of submerged humid tropical karst using multibeam bathymetry. Along with the geomorphological studies, we have also started biological and archeological studies in our bathymetric areas to promote interdisciplinary researches which link natural and human sciences.

Keywords: multibeam ecosounder, coastal seafloor geomorphology, biology, archaeology, coral reefs, Ryukyu Islands

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HTT08-P01 Room:Convention Hall Time:May 26 18:15-19:30

# Urban Geological Mapping in Tekirdag Region (NW of Turkey) by Integrated Geophysical methods for Disaster Mitigation

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Urban geological mapping issue is a key to assist management of land-use, new developed areas, assessment of urban geological hazards. This study has been performed in the frame of an national project, which is a complimentary project of the cooperative project between Turkey and Japan (JICA&JST), named as Earthquake and Tsunami Disaster Mitigation in the Marmara Region and Disaster Education. Integrated geophysical methods can have an important role to yield subsurface information in urban areas provided that geophysical methods are capable of dealing with challenges related to these scenarios. With this principal aim, the results from several geophysical methods (microgravity, magnetic) is evaluated to characterize lithological changes, to image fault zones and to delineate basin geometry in the urban areas. The process uses the combination of passive and active techniques as complementary data: magnetotelluric method (MT), microtremor H/V analysis and ambient noise array measurements to overcome the limitations of traditional geophysical methodology. This study is focused on Tekirdag and its surrounding region (NW of Turkey) where some uncertainties in subsurface knowledge (maps of bedrock depth and the isopach maps of thickness of quaternary sediments) need to be resolved to carry out the urban geological mapping. The subsurface structure can be estimated using integrated methods. (1) Acoustic impedance contrast between Eocene sediments and Metamorphic or Paleozoic bedrock is detected through microtremor H/V analysis that provides the soil resonance frequency. The predominant frequencies in the region range from 0.5 Hz to 8 Hz in Tekirdag city. The results of H/V technique is a fast scanner of the geometry of basement. (2) Ambient noise array measurements constrain the bedrock depth using the measurements of 1D-shear-wave velocity of soft soil. (3) Finally, the microgravity data analysis contribute mapping basin geometry and bedrock depth. The Eocene basin- Paleocene basement boundary is constrained between surface and 400m depth, approximately. The integrated geophysical measurements presented is an optimized and fast tool to refine geological mapping by adding 2D information to traditional geological data and improving the knowledge of subsoil structure in Tekirdag and its surroundings. The preliminary results will be presented.

Keywords: Geophysical Methods, Microtremor, Microgravity, Magnetic, NW Turkey

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HTT08-P02 Room:Convention Hall Time:May 26 18:15-19:30

# Ground surface deformation of small mud volcano by repeated measurements of terrestrial laser scanning (Murono, Japan)

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We perform terrestrial laser scanning to detect changes in surface morphology of a mud volcano in Murono, Niigata Prefecture, north-central Japan. The study site underwent significant deformation by the strong earthquakes in 2011, and the surface deformation has continued in the following years. The point cloud datasets at different scan times were registered by minimizing the closest point distance of the point clouds at stable ground features, and centimeter-order deformations in the central domain of the mud volcano were detected. The spatial pattern of the deformation, together with some geophysical measurement data, will be used for analysis of physical mechanics of the mud volcano.

Keywords: mud volcano, TLS, point cloud, DEM

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# High-resolution spatio-temporal topographic survey in hardly accessible sea cliff

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The present study applied Structure from Motion (SfM) photogrammetry measurement with small Unmanned Aerial Vehicle (UAV) to quantify inaccesible coastal cliff geometry. Specifically, 1) the authors have experimented multiple UAV-SfM photogrammetry on a peninsular-rock surrounded on three sides by the sea; and 2) topographic change volume and rate are calculated using the difference between 3D topographic data. A case site is located in the center part of the Taitosaki in the east of Chiba prefecture, Japan. The peninsular-rock named Suzumejima has circular shape with a diameter of 50 m and a height of 30 m. Aerial photography using the small UAV was conducted twice on 24 June and 31 October 2014. The photos were taken from various elevations and angles to cover all slopes including vertical and partially overhang cliffs. The photos were processed using the SfM photogrammetry software and the 3D point clouds and textured models were derived. Point densities are about 1,700 points/$m^2$ in the case of June and about 1,000 points/$m^2$ in October respectively. Each point of the 3D cloud has x, y, z coordinates as well as colour (RGB) enabling further qualitative analysis. Extracted profiles which are derived from 3D point cloud show the vertical cliff, wave-cut bench and sea cave including ceiling portion clearly. To detect the temporal change of the island quantitatively, firstly the 3D model was subdivided into four segments: a flat area such as the wave-cut bench and floor portion of the sea cave; b vertical cliff on the east side; c slopes on the south and west sides; d ceiling portion of the sea cave. Secondly target slope was formed on the top face by rotating the 3D model adequately for each segment. Lastly the target area was clipped appropriately and topographic change was evaluated by comparing raster data of two periods. At the beach area (segment a) on the west side of the island the difference between the geo-referenced 3D rasters is up tp 110 cm and total erosion volume is 26 $m^3$. At the floor portion of the sea cave (segment a), the maximum erosion depth is 230 cm and total volume of the topographic change is 146 $m^3$. At the segment b small erosion is recognized at the base of the cliff which depth is up to 130 cm and volume is only 12 $m^3$. At the segment c relatively small topographic changes are recognized at some parts of the slope and that total volume is only 9 $m^3$. At the segment d large collapses were occurred on the ceiling portion of the sea cave which total volume is 64 $m^3$. Average erosion rate of the cliff, i.e. segments b, c and d, is about 4.5 cm/4 months. According to the previous study using topographic maps with a scale of 1/1,000 in 1960 and 1966, erosion rate of the Taitosaki sea cliff is about 1 m/year on average. The erosional rate estimated from the present study is rather small in comparison with the previous one. However as the target period of the present study is very short, the continuous monitoring in the future will make it possible to evaluate the erosion rate of the sea cliff more accurately including seasonal and/or annual variations.

Keywords: UAV, SfM, photogrammetry, sea cliff