Formation factors of the 2015 Kanto-Tohoku heavy rainfall and its correspondences and NWP results of the JMA

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In the 2015 Kanto-Tohoku heavy rainfall, 48-hourly accumulated rainfall amounts until 21 JST (= 9 hours + UTC) on 10 Sep. exceeded 500 mm in the northern part of Tochigi Prefecture, and that exceeding 300 mm was also observed in the southern part, which caused the collapse of an embankment of Kinu River in Joso City, Ibaraki Prefecture around 13 JST on 10 Sep. The Japan Meteorological Agency (JMA) alerted emergency warning at 0020JST on 10 Sep. for whole the region of Tochigi Prefecture and at 0745JST for Ibaraki Prefecture. For Kinu River, the information of overflowing occurrence was alerted for Kinu River at 0630JST on 10 Sep. In Tohoku area, 24-hourly accumulated rainfall amounts until 09 JST on 11 Sep. exceeded 300 mm around Ohsaki City, Miyagi Prefecture, which caused the collapse of an embankment of Shibui River around 07 JST on 11 Sep. JMA also alerted emergency warning at 0320JST on 11 Sep. for whole the region of Miyagi Prefecture.
In the heavy rainfall in Kanto area, many band-shaped precipitation systems (BPSs) with the width of 20~30 km and the length of about 100 km successively formed to organize a huge rainfall area with the width of 100~200 km that extended over 500 km in a south-north direction. The formation and maintenance factors of the huge extending rainfall area could be that atmospheric conditions favorable for BPS formation (Kato 2015; 2016) maintained over Kanto area. These conditions were produced by the continuous inflow of low-level humid air to Kanto area that was initiated from the surrounding of Typhoon 1517 and was directed northwestward to the low pressure in the Sea of Japan changed from Severe Tropical Storm 1518. It also influenced the conditions that Kanto area was located between a deep pressure trough over western Japan and a sharp pressure ridge around Hokkaido. The heavy rainfall in Miyagi Prefecture was also caused by several BPSs.
The maximum 24-hourly accumulated rainfall amount (R24max) of 605 mm was analyzed in northern Kanto until 12 JST on 10 Sep. Here, numerical weather predictions (NWP) are evaluated based on this value. The JMA global model (horizontal resolution: 20 km) with initial conditions at 09 JST on 9 Sep. predicted R24max of 165 mm in northern Kanto, but not any extending rainfall area. On the other hand, the JMA mesoscale model (horizontal resolution: 5km) with initial conditions at 12 JST on 9 Sep. predicted a south-north extending rainfall area in Tochigi Prefecture and R24max of 447 mm close to analyzed rainfall amounts. The location of the extending rainfall area predicted by the mesoscale model moved in northern Kanto for different initial conditions, and the predicted Rmax24 ranged between 300 and 500 mm. The mesoscale model, however, predicted the extended rainfall area between eastern Gunma Prefecture and Tochigi Prefecture before 24 hours (initial: 21 JST on 8 Sep.), and could indicate high potential to BPS formation in northern Kanto before further 12 hours (initial: 12 JST 8 Sep.) that was estimated from atmospheric conditions favorable for BPS formation (Kato 2016).

Keywords: heavy rainfall, band-shaped precipitation system, numerical prediction

Estimation of Catchment Averaged Extreme Rainfall in Kinu River

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The Kinu river, which is a tributary of the Tone river, runs from Tochigi prefecture to Ibaragi prefecture. The Kinu river basin was devastated by the 2015 Kanto-Tohoku torrential rainfall. Heavy rain continued along narrow area between the typhoon 17 and the extratropical cyclone reduced from typhoon 18 and the cumulative rainfall reached 500mm at upstream of the basin. This heavy rain caused a breach at the left bank in Joso city and then devastating inundation. Rescue activities with helicopters were broadcasted many times.
This paper shows extreme analysis on several durations of catchment averaged rainfall at Ishii reference point of the Kinu river. While Annual Maximum Series(AMS) analysis has been usually employed so far, the author also uses Peaks Over Threshold(POT) analysis. POT with a threshold large enough can be analyzed with generalized Pareto distribution(GP) which includes Exponential distribution(Exp) as its special case of shape parameter is equal to zero. Generalized Extreme Value distribution(GEV) and Gumbel distribution which is a special case of GEV with shape parameter is zero for AMS correspond to GP and Exp for POT. When AMS and POT are compared, the Poisson process is assumed for the occurrence of POT.
Rainfall data of 15 rain gages of both Ministry of Land, Infrastructure, Transport and Tourism and Japan Meteorological Agency in and around the Kinu river basin are used to calculate the catchment averaged hourly rainfall. The data from 1979 to 2015 were collected and processed with Thiessen poligons. Analyzed rainfall durations are 6, 12, 18, 24, 48, 72 hours and 1, 2, 3 days. In order to check stationarity in AMS of all durations, Mann-Kendall test was employed and the result showed all time series are stationary with significant level of 5% but slightly in increasing trend.
Several methods for selecting threshold have been proposed. One of them is to use Sample Mean Excess Function(SMEF) which is based on the characteristics that the mean of threshold excess of Exponential distribution is constant for varying threshold. Thus the thresholds of POT of every duration were set to 48, 64, 75, 80, 85, 98, 67, 80, 94mm respectively with drawing SMEF. The sample size of POT with these thresholds became 69, 77, 78, 82, 96, 88, 86, 95, 88 and more than twice of AMS except for 6h. The parameters of the four distributions were estimated with L-moment method. The estimated Exp and Gumbel have almost same return levels in the extrapolating range while three parameter distributions such as GEV and GP shows different extreme estimations.
When these four distributions are compared with each other, several points should be noted that 1)POT uses just threshold excess and does not care about smaller data than threshold which may appear in AMS, 2)three parameter distribution such as GEV and GP uses skewness but two parameter distribution Gumbel and Exp does not, that is, the former will bend(with upper bound or with thick tail) on Gumbel probability paper but the latter will be in straight line.
The patterns of estimated distributions are classified as 1)for short durations such as 6h and 12h, Gumbel, Exp and GP have almost same extrapolations but just GEV has upper bound, 2)for 18h and 1 day, Gumble, Exp and GEV are almost same but just GP has thick tail, 3)for other durations, Gumbel and Exp are almost same but GEV and GP have thick tails.
The event of 2015 is the historical record from 1979 in the time series of AMS for each duration except for 6h and 12h,. However, corresponding plots are located around estimated distributions on the Gumbel probability paper and not unprecedented, namely “outlier”. Their return periods are estimated to be 50 to 100 years. Comparing to the result for 1979 to 2014, some of fitted GEV changed from having upper bound to having thick tail. The 100 year return levels of Gumbel for each

durations are about 30mm larger than that of 1979 to 2015.

Keywords: Kinu river, 2015 Kanto-Tohoku Torrential Rain, POT Analysis

The levee-breaching and scoured region characteristics of the Kinugawa River and some rivers in Ibaraki Prefecture at Kanto& Tohoku heavy rain in September 2015

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To clarify the levee breaching process at large flood event is very important for flood protection and mitigation countermeasures. Especially, scoured characteristics at levee toe by overflowing water from embankment is closely related to the enlargement of the breaching length and total flood volume to the hinterland. At the breaching point of the Kinugawa River in Kanto& Tohoku heavy rain in September 2015, very complex scoured region was generated. The scouring process is supposed to be related to the ratio of overflowing water depth and levee height, and breaching length in streamwise direction. The objective of this study is to elucidate the breaching phenomena not only for the Kinugawa River but other rivers in Ibaraki Pref., Miyato River, Nishinizure River, and Hachikenbori River, and relates the breaching length and the depth of the scoured region with the hydraulic parameters.

For the objective, post flood survey and flume experiment were conducted after the September flood. The characteristics of the breaching is that the overflowing water depth is small compared with the levee height, and half of the levee is scoured before breaching. The condition was set in a flume with 1/100 scale with two wooden levee. The levee shape were selected as the full shape and the half-scoured levee shape. Clear water scour condition was set at the downstream of the levee, and the scoured characteristics were measured.

The number of scoured region for the two-type levee condition were around 6, and is similar to the actual situation at the breaching point of the Kinugawa River. The scoured depth for half scoured levee shape was 1.5-1.8 times larger for full-size embankment case. The breaching widths for Miyato, Nishinizure, and Hachikenbori River, were relatively small, but was similar to the initial breaching width of the Kinugawa River. Initial breaching width is assumed to be closely related to the embankment height, but final breaching width is related to the flood duration, thus it is related to the river width.

Keywords: levee breach, scoured region, back water effect

Topographic changes of Kinugawa Lowland caused by the flood in September, 2015, Joso City, Ibaraki Prefecture

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The banks of the Kinu River were damaged by the 2015 heavy rain, with seven overtopping points and one bank breachment point. In this study, we researched the relationship of topographic changes and flood deposits around the bank breachment point in Misaka town, Joso city, Ibaraki prefecture. Also, we researched the sediment at an overtopping point in Wakamiyado, 4 km upstream of the Misaka town to make a comparison.

The Kinu River is one of the major rivers in the Kanto Plain and is a tributary of Tone River now, but originally was an independent river flowing to the Pacific Ocean. Research areas are located in the lower part of the present the Kinu River. In this region the Kinu River flows in the western edge of an alluvial lowland, which is 4 - 5 km wide in east and west, limited by Pleistocene terraces and is elongated in north and south direction. Misaka town is located on natural levees of the Kinu River, and river bank dunes are developed at Wakamiyado.

After the flood occurred, surveying of the crevasse topography was conducted using a total station and GNSS with VRS corrections to draw cross sections. 5 m mesh DEM (served by GSI) was used to draw ones of original topography, too. In laboratory, grain size distributions were measured with SHIMADZU, SALD-3000S, a laser diffraction particle size analyzer. Particle size analysis was carried out in both location, but surveying was conducted only in Misaka town.

In bank breachment area, pool rags with more than 2 m depth were formed in the center path of the flood. Over 150 m along the downstream path of the flood erosive process was prior, and the elevation was lowered by 30 -40 cm, although flood sediment was deposited by 5 -30 cm in thickness. The deposit was generally divided into two parts. The lower part consisted of upward coarsening muddy fine to very fine sand, and the upper part well sorted medium sand.

The figure shows the relationship between topographic changes and grain sizes of flood deposits in side path. Erosive interval was limited close to the collapsed bank, and topographic changes was small downstream of its path. The surface sediment in this interval was muddy sand, while subsurface sediment was finer, probably containing some field soil. A lobe-shaped depositional landform which had a sharp edge with 30 -40 cm height was formed halfway in the path. The thickness of the lobe sand was over 60 cm, and it had parallel or cross lamination. A muddy sand bed existed between the lobe sand and the original field soil.

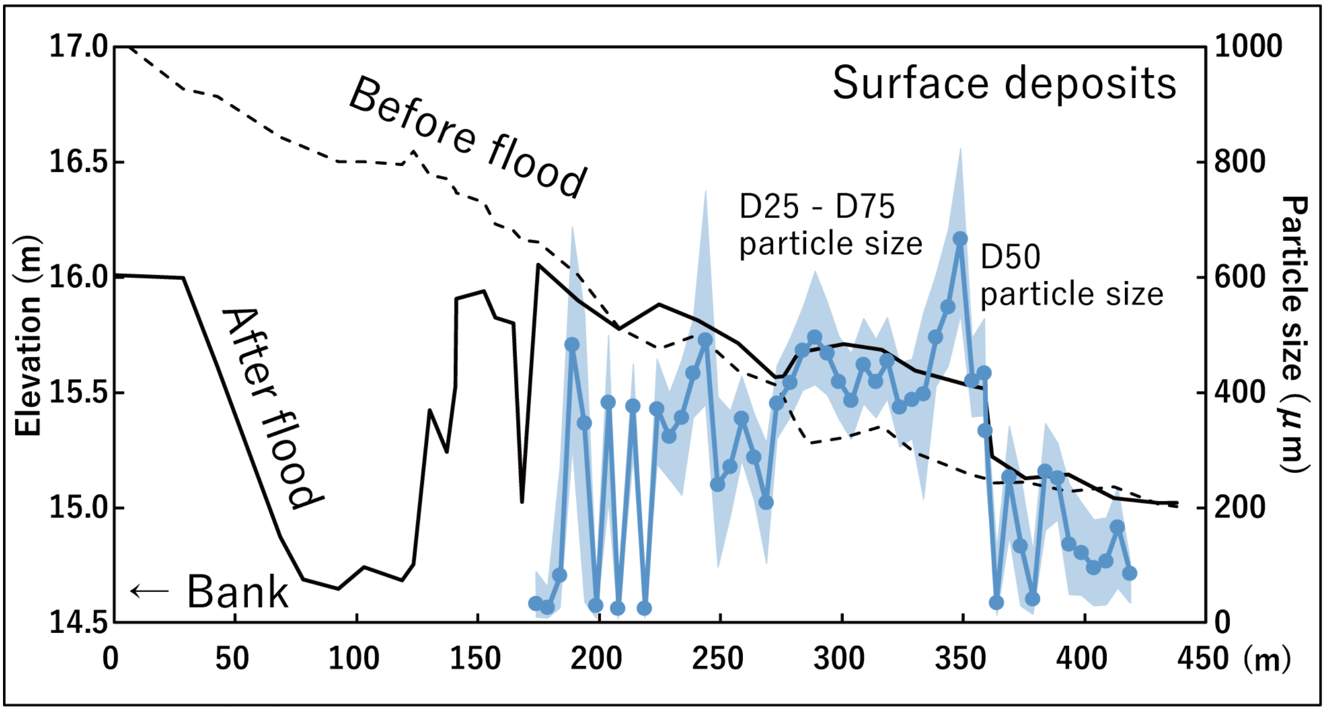
General succession of flood deposits, lower muddy fine sand and upper well sorted medium sand, may reflect transportation order of flood deposits, namely, bank body or original ground of pool rags, or suspension materials in flood water may be the sources of the early fine particles, and that of later medium sand may be river bed sand.

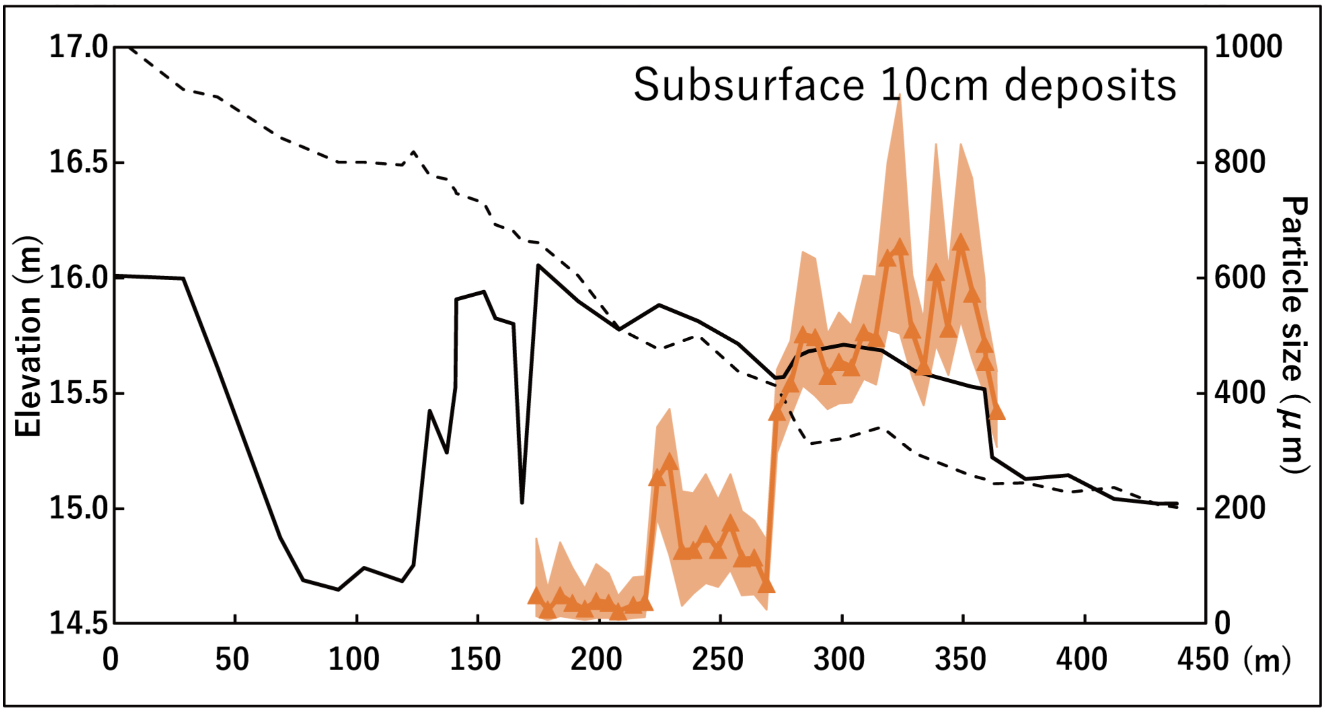
At the overtopping point of Wakamiyado, we gathered surface and subsurface (20 cm) flood deposits and measured their particle size with SALD-3000S. In both depths the median particle size was ca. 500 -800 μm, and they were well sorted. The median size of sand at a sand bar in the river channel there was ca. 700 μm, so this sand may be transported outside the channel. However, it is possible that sand of river bank dunes was redeposited by the flood.

There was a difference in the amount of fine particles between the two regions. It probably is due to occurrence of bank collapse or forming of pool rags, although investigation of Wakamiyado may be

insufficient.
It is rare to be able to research original topography formed by the flood. Moreover, this study can help consideration on developing processes of floodplain because formation of crevasse splays and crevasse channels may trigger channel avulsion and formation of natural levee. In other words, this flood event might be an elementary process of floodplain development.

Keywords: the 2015 heavy rain, Crevasse splay, Inundation by river water





Relationship between flood and landform in Shimotsuma City

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The disaster research group of Kinu River Flood in 2015 was established in Ibaraki University, and the authors participate as a member of a Geosphere Environment group of this research group. An interim report was up on university web site. In this presentation, the authors introduce the relationship between flood disaster damages and landform classification in Shimotsuma City, Ibaraki Prefecture.

Keywords: Kinu-River flood, Shimotuma City, landform

Importance of the evacuation plan in a flood -The case for the elderly people facility devastated by the Kanto and Tohoku heavy rain in 2015-

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In this study, we suggest that the welfare facility should have own evacuation plan to avoid future disasters. For the 2011 Kii Peninsula-heavy rain, the 2013 Kyoto-Shiga heavy rain, the 2013 Yamaguchi-Shimane heavy rain and the 11th / 12th typhoons in 2014, we have conducted the field survey to check their damages in an elderly people facility and interviewed them. We report the survey result about the one elderly people facility that declined to name as the ‘C elderly people facility’ that devastated by the Kanto and Tohoku heavy rain in 2015. We interviewed victims in the elderly people facility with focus on their behaviors and support by other organizations in evacuation. By comparing this case and the past case, we show that the evacuation plan is important from the point of necessity of the local co-operations.
We interviewed people in ‘C elderly people facility’ and their associated organization and we observed the site in November 26, 2015 and January 14-16, 2016. Some groups; the disaster countermeasures office managed ‘C elderly people facility’, disaster countermeasures office in other office, the welfare department in Ibaraki prefecture and Japan Self-Defense Forces, involved to help ‘C elderly people facility’. The disaster countermeasures office properly fulfilled their roles by working as follows; collecting information, the safety confirmation, procurement, calling for help and requesting acceptable facility of users. The other corporation concludes ‘Fureai partnership’- agreement with ‘C elderly people facility’. They prepared the supply goods and a car for ‘C elderly people facility’. The welfare department of Ibaraki Prefecture arranged a helicopter of Japan Self-Defense Forces. In this case,most important point is "multistory cooperation". Concretely, important point is three co-operations of three organizations as follows; their own co-operation, other co-operations and the co-operation by Prefecture. Quick refuge was achieved by "3, multistory cooperation". On the other hands, the one facility; ‘S elderly people facility’ at Naka-Cho, Tokushima Prefecture, devastated by the 11th and 12th typhoons in 2014 did not have some co-operations with other organizations. Therefore, they were confused about making arrangements for transportation of users. "Cooperation with vicinage's other corporations" is a key point in disaster.

Keywords: Elderly people facility, Evacuation plan, Cooperation

Fundamental study on accumulation of pore air pressure in geomaterials due to excessive supply of water

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The purpose of this study is to observe and explain the behavior of pore air pressure in geomaterials due to excessive supply of water. The pore air pressure has a significant effect under the conditions that there is oversupplied water from heavy rain or the rise of the river water level. In order to reveal the system of infiltration considering the pore air pressure, we did simple experiments of one-dimensional vertical infiltration. As a result, we deduced that flooding happens on the surface of a specimen when pore air pressure reached the value caused by capillary action. Moreover, besides water pressure head and capillary pressure, weights of saturated portion contribute increasing pore air pressure. In addition, we recognized the remarkable difference between Toyoura-sand and Kanto-roam. Then the state of dry or low gaseous phase ratio are likely to generate higher maximum pore air pressure.

Keywords: geomaterial, excessive supply of water, pore air pressure

Issues on Hazard Information during 2015 Kanto-Tohoku Heavy Rain Disaster from the View Point of a Health and Medical Responder

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The author will talk about the outline of his activities on health and medical assistance in Joso and Tsukuba city during Kanto-Tohoku heavy rain disaster in 2015, and also provide information on the workers' response of Joso health center to the emergency warnings such as the evacuation alert with the intention of enhancing discussions for better countermeasures. National Institute of Public Health (NIPH), in which the author works, is a national agency under the Ministry of Health, Labour and Welfare for conducting research that yields evidence-base of public health policies as well as providing training courses for health center workers. The institute is now discussing the curriculum of health emergency management to improve countermeasures on public health during large-scale disasters. The author also takes part in "Enhancement of Societal Resiliency against Natural Disasters", one of the topics of "Cross-ministerial Strategic Innovation Promotion (SIP) Program" of Council for Science, Technology and Innovation and conduct research on the information sharing among multiple agencies during disasters. The author visited Joso city and Tsukuba health center during Kanto-Tohoku heavy rain disaster in 2015 to reveal issues to be tackled in SIP program. The author will focus on the initial response of health center workers revealed by the interview to the director of the health center in his presentation.

Keywords: Kinu river, Joso health center, Information sharing

Resourcing a disaster response map for the 2015 heavy rain in Joso city

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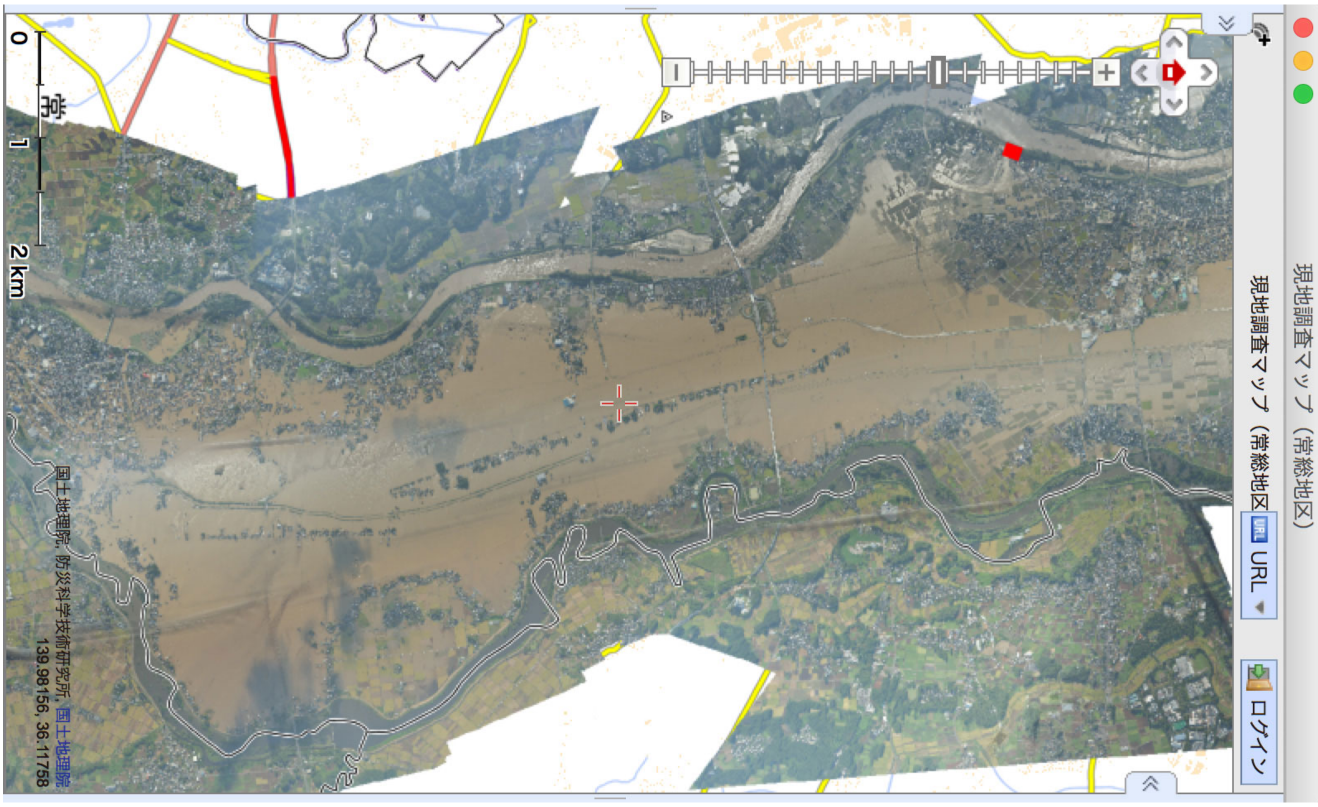
1. Motivation
From September 9th to 11th 2015, an exceptionally heavy rain storm caused the occurrence of the overflow of the Kinugawa River and landslides in a wide range of areas in the Kanto and Tohoku districts. One bank of Kinugawa River collapsed causing wide-spread flood damage in and around Joso city in the Ibaraki Prefecture of Japan. Homes were destroyed and washed away leaving many residents' property completely underwater. Gaining a quick understanding of the disaster's magnitude was critical for effective search and rescue (SAR) response, and decision-making so as to carry out local government offices' rehabilitation measures to rescue the residents of the submerged town.
2. Approach
In this case, the disaster area was as vast as 100 square kilometers as documented by aerial photography using a Nikon D810 from a manned helicopter, rather than from any unmanned aerial vehicles. The flight level was 1,200 m in altitude and course and speed were set to create a 75% overlap in the photography.
3. Results
About 600 oblique photographs were taken from flight level 1,200 m between 15:30-16:30 hours on September 11, 2015 to create a digital orthoimage of about 100 square kilometers of the flood region. In addition to the aerial photographs, ground survey data and the orthoimage were made available to the public within 12 hours on the crisis response website of the NIED. These resources have been provided under the auspices of the Creative Commons license "CC-BY 4.0 international." Subsequently, the map that overlaid the housing map of Zenrin, Inc. was created for September 15, 2015, and the disaster countermeasures office was provided with it. In addition, a missing person's distribution was estimated from the map and a professional team of private SAR and a NPO Japan rescue dog association provided search assistance on the same day.
4. Considerations
First, although a lot of information has been released by each organization, there are some problems regarding copyright, data size, and reliability. Effective use of such information in a post disaster situation is difficult. In this case, the information was provided as open data, allowing users access to the information without the difficulty of making an application for permission. The data was used by the disaster countermeasures office, the volunteer center, and the university investigating the disaster. Second, the high definition photographic map of a disaster site makes it much easier to grasp the full impact of a disaster situation. However, when the user is not familiar with how to interpret the information provided by such maps, it is difficult to utilize these map resources effectively. Consequently, it is necessary to support local public entities by also providing directions for how to understand the map information. Finally, although photography was performed from a manned helicopter, 14 or more rescue/reporting helicopters surveyed the area for only 30 minutes. Though there may be an expectation that unmanned aerial vehicles may be deployed for information gathering following a disaster, it is difficult to operate such aerial vehicles safely in airspace where manned aerial vehicles are operational simultaneously. Excellent communication and cooperation are necessary during such operations to protect the safety and integrity of both.

Keywords: the 2015 heavy rain, disaster response map, Joso city, SfM-MVS (Structure from Motion and Multi-view Stereo)



Distribution of floodwater depth and damages of road structures in Joso City, Ibaraki Prefecture, caused by the Kanto-Tohoku torrential rain in September 2015

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The torrential rain on September 2015 in Kanto-Tohoku regions caused the collapse and overflow of embankment along the Kinu River, and floodwaters inundated the widespread area of Joso City, Ibaraki Prefecture. Flood inundation depth in Joso City was estimated based on the height of flood marks on buildings and houses. Field reconnaissance in inundation area was conducted to measure the height of flood marks by using leveling rod. The height of flood marks were obtained at 100 sites in the inundated area. The height of flood marks in the inundated area were less than 3 m, and most of these obtained values were similar or below the values that were presented on the flood hazard map of Joso City. In the inundated area, severe damages of road embankments and structures were observed in the back marsh area (paddy fields) between the natural levees along the Kinu River and Kokai River.

Keywords: Kanto-Tohoku torrential rain in September 2015, Kinu River, floodwater depth, hazard map, damage of road structure, Joso City

Inundation of the eastern part of Joso city, Ibarki prefecture caused by heavy rainfall disaster in Kanto and Tohoku area

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Heavy rainfall of September 2015 in Kanto and Tohoku area caused severe flood in the eastern part of Joso city, Ibaraki prefecture. Kinu River water started to flow over banks at around 6 am at Wakamiyado district and collapse of Kinu River bank at around 12:50 PM at Kamimisaka district on 10th September resulted in extensive inundation of Ishige area located on natural levees. Then, flood moved southward along the Hakkenbori River and inundation of Mitsukaido area started at the night of 10th September to widely inundate the area nearby at 1 pm on 11th September. The maximum inundation depth confirmed by authors from the flood marks remained on the building walls are less than 1.0 m on natural levees, but it reaches 1.5 m at the maximum in core portion of the flood flow identified by flood deposits. In the floodplain, deeper inundation occurred than natural levees, and more than 2.5 m inundation was found at Okishinden and Jyukkamachi Okishinden district. Deeper inundation was observed in the southern part of the floodplain because higher natural levee surfaces at Mitsukaido area probably prevented to drain water smoothly. Although inundation of Ishige area was comparatively short and ended by the morning of 11th September, inundation of Mitsukaido area prolonged and continued until at least the morning of 13th September in the area north of Shinhakenbori River, and until 16th along the Hekenbori River. Restoration of destroyed river bank and roads was prioritized, but cleanings of flood sediments and debris take long time and still households and offices need a certain time to be fully recovered. Also, some important facilities such as hospital and school experienced inundation of more than 1.5 m. Therefore, we need to record the flood impacts and evaluate them appropriately for the formulation of flood disaster risk reduction strategies in the area.

Keywords: flood, Joso city, Kinu River, inundation depth

The relative height map which visualized the slight topography of the flooding plains by aviation laser data

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In late years the damage caused by the flood of the small and medium size scale decreases as river improvement measures of the river advance. However, the development of the flooding plains along the river advances with this, and companies performing population and economic activities to settle down in without assuming a flood risk increase.The government works on making, publication of the hazard map and the maintenance of the caution refuge system continuously now. However, it is the event of the dike over there, and, for inhabitants, a company targeted for many staffs of local government and refuge, the flood is said to be it when hard to be readily arrested as a realistic risk since it is invisible. Particularly, the slight topography of the flooding plains that greatly influence distribution of the inundation depth at the time of a flood is very incomprehensible for a citizen, and understanding is difficult when I do not have a skill to be able to comprehend the special drawings such as figures of river improvement topography classification.In late years the maintenance of the highly precise numerical value topography model by the aviation laser measurement advanced and almost completed the maintenance of the numerical value topography model of the big river riverside. In addition, I came to be able to photograph a high-resolution aerial photo relatively easily. I visualize the slight topography such as the flooding plains, at the back damp ground which I match these techniques and use it, and influences the understanding of the flood risk along the river and the three-dimensional management of river facilities for a citizen and the administrative person in charge, and a technique to be actualized with a risk attracts attention.In the case of Kanto, Tohoku heavy rain, large-scale flood damage visualized the slight topography of flooding plains about Joso-City that occurred in September, 2015 and it was plain and, in this study, produced "a relative height map" to accuse experimentally.The topography which a human being usually sees is an irregularity in comparison with the neighborhood namely relative height, and the relative height is one of the elements which it is big, and influences the big things and small things of the inundation risk for at the time of floods again."The relative height map" sets a datum level to represent level ground of the river rear and makes the thing which I analyze the relative height with it and expressed with an appropriate color by letting irregularity information of the ground do an overlay. At this chance it was important that I let you display it at appropriate gradation and it was plain and was able to express the slight topography of flooding plains as a result of adjustment to emphasize a little slight topography of flooding plains. In addition, I was able to regard the slight topography of flooding plains as dike high School integrally by making "a relative height map" with the ground about the bank of a river separately, and fitting it.I compare it with overflow water, a rip point and the distribution of the depth of the inundation that "a relative height map" and Ministry of Land, Infrastructure and Transport and the research organization others which I made announce and am going to repeat improvement in future so that it is with "the relative height map" which can read a flood risk more precisely.

Keywords: flooding plains, microtopography, The relative height map, visualization, digital terrain model

Crevasse-splay deposits of the 2015 Kanto-Tohoku Torrential Rain Disaster in Kami-Misaka, Joso City, Ibaraki, Japan

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Introduction
The 2015 Kanto-Tohoku Torrential Rain (JMA, 2015) caused a severe flood disaster along the middle reaches of Kinugawa River. Rapid water level rise resulted in a dike break 200 m wide in Kami-Misaka district in Joso City. The KRDB (2015) reported that overbank flow had been recognized at 11:00 and dike break began at 12:50. In order to clarify distribution and sedimentological feature of "crevasse-splay deposits (Masuda, 1998)" in this flooding, we conducted small trench excavation survey in Kami-Misaka district.
Distribution of crevasse-splay deposits
Erosional landforms, including pools and crevasse channel were dug by flood stream near the dike break site, which have >1.6 m depth and <60 m width. From that point, crevasse-splay deposits were distributed westward to southward. At least three sandy lobes elongated downward were found. Thickness of crevasse-splay deposits was less than 10 cm in the range of 150 to 250 m off the dike except for behind scattered rubbles. Thick crevasse-splay deposits were found between 250 m and 700 m, which consisted of sandy lobes. We found that thickness reached the maximum (around 80 cm) at ~400 m off the dike and decreased gradually downward from there. Only muddy flood deposits were distributed in southern area from 700 m off the dike.
Sedimentary Facies
Crevasse-splay deposits were suggested to be divided into 3 units, Facies A to C in ascending order.
Facies A: This unit was inverse graded sandy deposits from silt or silty fine sand to fine sand. This covered directly artificial soils of paddy fields with sharp boundary. Some layers of plant debris such as paddy were found. The thickness reached 25 cm in NW part of the lobe and declined southward.
Facies B: This unit consisted of fine to medium sand showing normal grading. Lenticular thin medium sand layers were sometimes found. Upper part showed parallel lamination. Concentrated layers of plant debris and small rubbles were found. The thickness became the maximum, around 20 cm, in the center of transverse section and decreased toward both edges.
Facies C: This unit consisted of well-sorted fine to medium sand with parallel lamination. Upper part showed ripple lamination. Cross lamination developed at the marginal part of the lobe. Rounded to sub-rounded granules, ~3 cm in diameter, were found. The thickness increased southward.
Discussion
Facies A to C were suggested to coincide with sedimentary processes during the flood.
It is suggested that the Facies A deposited at the overbank stage. Inverse grading shows that velocity of overbank flow and/or coarser sediments supply increased. At the beginning of flood, washed load was supplied from river, and then coarser sediments were transported by high velocity flood current (Masuda and Iseya, 1985).
Graded beds indicate that the Facies B was deposited by sediment gravity flow or at decreasing stage of clastic materials supply. It is possible that the sediment gravity flow occur when dike was broken. Distribution pattern that this facies distribute on the downstream side of the erosion landforms supports this idea. While, temporal large supply from the river just after the dike break probably resulted in few sediment supply and fine suspended materials deposition.

Parallel lamination and granules suggest that the Facies C deposited at upper flow regime. Expansion of broken dike had accelerated flood current for a few hours (Tsuneda, 2015). This suggests that the Facies C deposited after the dike break event. Ripple lamination indicates declining of flood current.

Reference

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Keywords: 2015 Kanto-Tohoku Torrential Rain Disaster, Crevasse-splay deposit, Joso City, Kinugawa River

Particle size analysis of natural levee deposit and flood sediment around the dike-broken site, Kinugawa River

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The flood on 10 Sep 2015 broke the dike in Kinugawa River, and the protected inland was covered with huge amount of flood sediment. The inland locates on natural levee, field survey revealed that natural levee deposit is finer than this flood sediment in particle size. I sampled both deposit and sediment, which were sieved and diveded at one-phi interval from -2 phi to less than 4 phi. As a result, it was found that fine sand of 4 phi notablly exists in natural levee deposit, but medium sand of 2-3 phi notablly exists in this flood sediments. This infers that contribution of scouring of natural levee is quite low for supplying this flood sediment. This study was supported by Promotion Grant of Special Study, Grant-in-aid Scientific Research (Grant number: 15H06923; Principal Researcher: Prof. Shigenobu Tanaka, Kyoto Univ).

Keywords: Flood, Natural levee, Sediment