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.

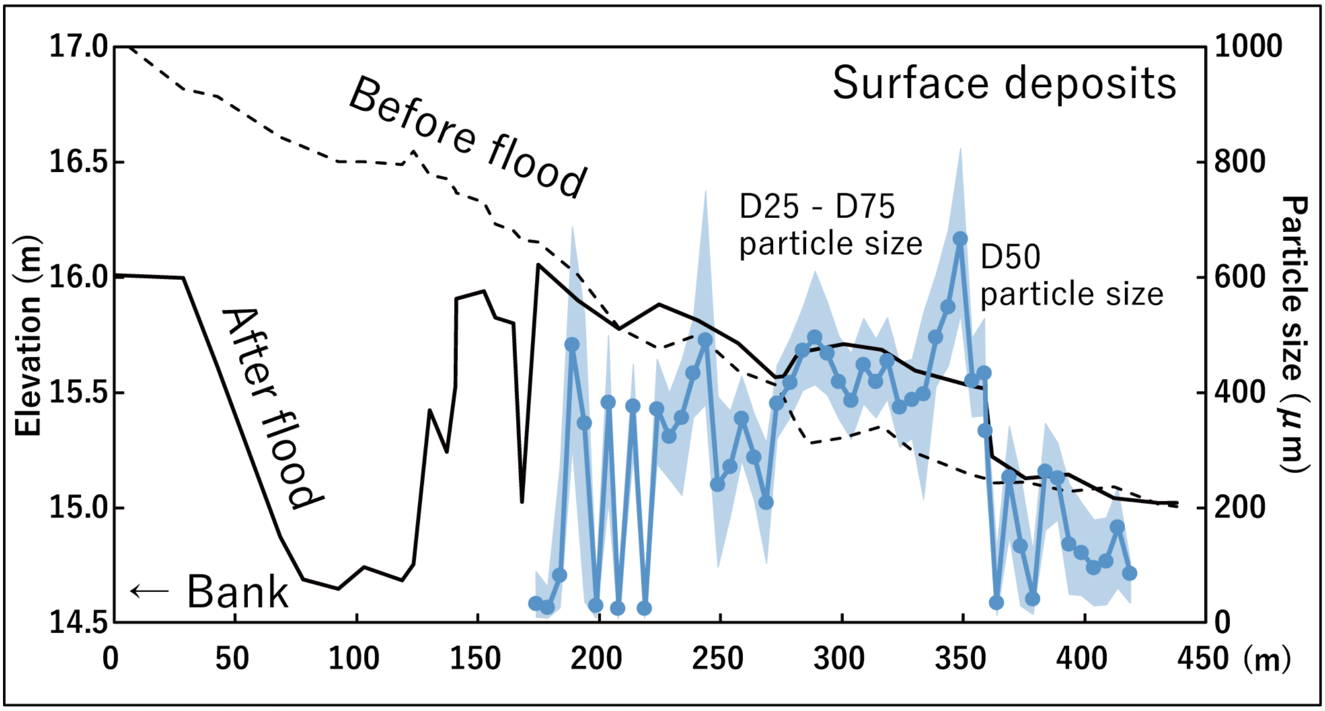
General succession of flood deposits, lower muddy fine sand and upper well sorted medium sand, may reflect transportation order of flood deposits, namely, bank body or original ground of pool rags, or suspension materials in flood water may be the sources of the early fine particles, and that of later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

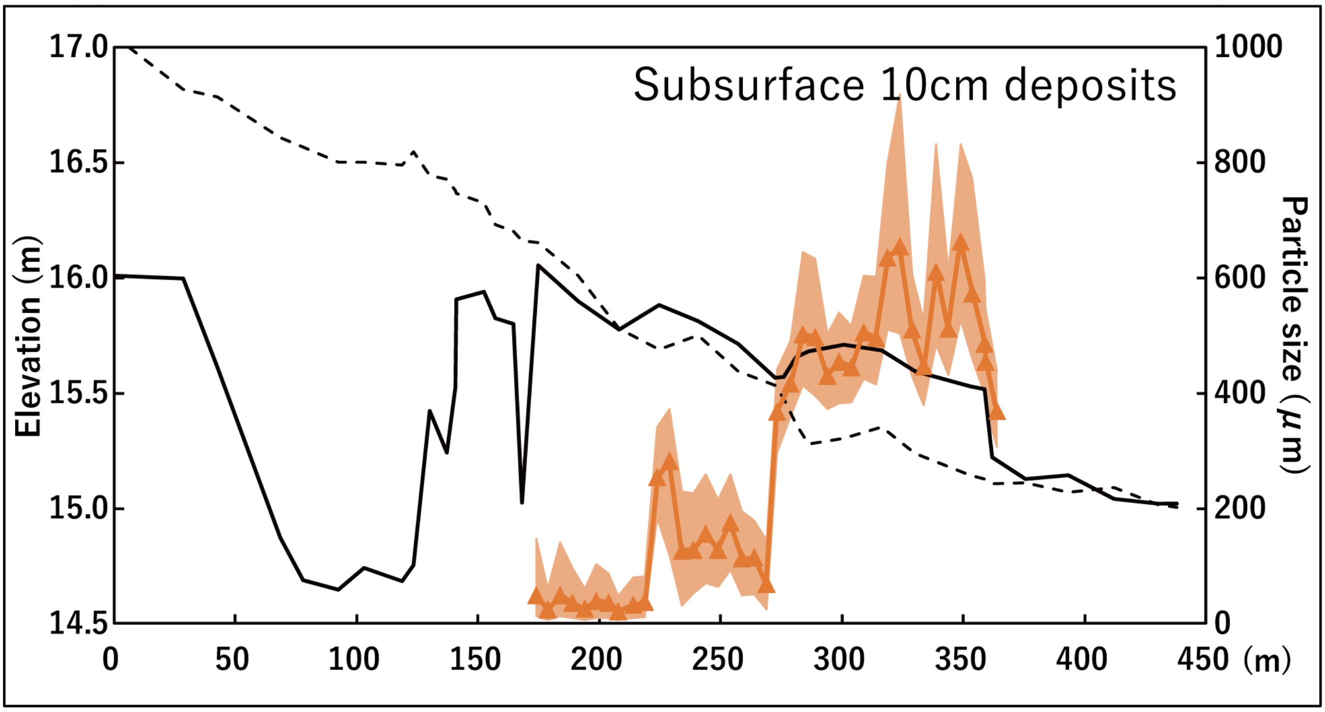
At the overtopping point of Wakamiyado, we gathered surface and subsurface (20 cm) flood deposits and measured their particle size with SALD-3000S. In both depths the median particle size was ca. 500 -800 μm, and they were well sorted. The median size of sand at a sand bar in the river channel there 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 11^{th} / 12^{th} 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 11^{th} and 12^{th} 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

