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An analysis of Factors Influencing Disaster Mobility using Location Data from Smartphones: Case study of Western Japan Flooding

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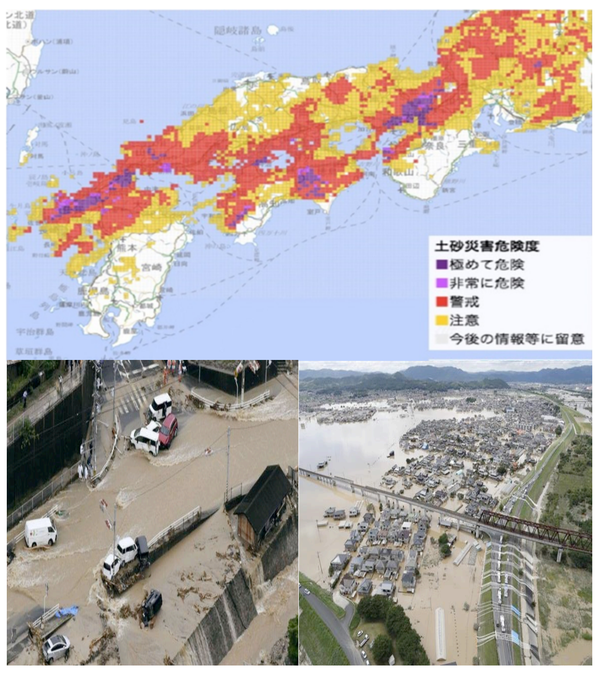
Background

Heavy rain occurred from June 28 to July 8, mainly in a wide range of areas including Hokkaido and Chubu regions (in western Japan). The death toll from torrential rains rose to at least 176 on July 11, and dozens of people were still missing after massive flooding and landslides. The heavy rain set the record for total number of special heavy rain warnings. The record is a sign of their efforts to make people evacuate. However, Western Japan has been badly damaged by heavy rain. This means that special alarms couldn't make people go to safe location. In other words, challenge facing officials is to inform them of alarm system and to improve it more effectively. To make effective system, we think that they need to understand which factor causes them to do evacuation and how much influence it has when disaster occur.

Study Area and Data

Western Japan heavy rain occurred severe damage in mainly Chugoku region. This region is one of Japan's regions located in the western part of Honshu. The 3-day rainfall from July 5 to 7 is about 292.2mm. This record is the largest after 1982. Among some prefectures in Chugoku region, Hiroshima and Okayama have the largest damages including the loss of life. So, we set this two prefectures as the spatial extents



GPS data of smartphones

Each GPS record contains a daily user ID, longitude, latitude, and timestamp. GPS data assembled every day when the user's position was changed.

Period of Collecting	Average daily number of IDs in target area	Average daily total GPS logs in target area
2018/06/01 ~2018/07/31	3,817 (0.26% sample rate)	102,821 (avg, 27 logs/user/day)

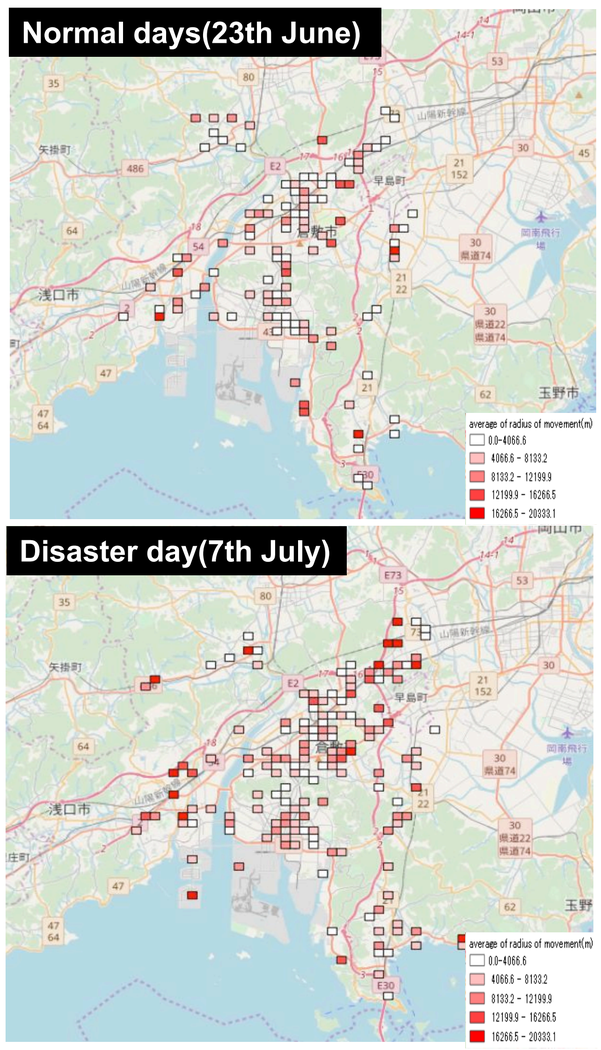
Disaster Information

GIAJ give damage's information related to western japan flooding. They utilized all images posted in Twitter. This contributes greatly to assess the damage promptly and the adequate disaster responses.

Methodology

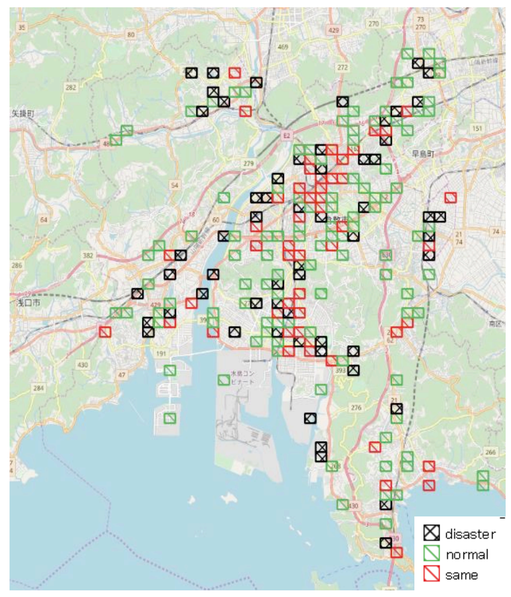
GPS data of smartphones

We assumed that the first point of each person represents his home to take into account personal movement change as much as we can. We calculated average of a radius of movement during one day per each 500m mesh using the above mentioned assumption. It is a map of Kurashiki area on 23th June and 7th July. We can capture there are many meshes which are far away from main river in comparison with normal days. Target areas suffered from serious damage related to flood and landslide. So, people living in region near sea or main river left this region. Along with this, they might be likely to be in temporary state of being unable to move. Theirs signals disappeared because they couldn't have change of movement.



Region Classification Method

As the right map was shown, there are many changes before disaster and on. In detail, there are 5 cases of movement's change when compared with normal days' movement; 1) some meshes don't have any GPS logs, 2) new mesh which have GPS signal occur. In the rest of classification, average of a radius of other meshes 3) is inside $2\delta i$, 4) is outside $2\delta i$ in a positive direction, 5) is outside $2\delta i$ in a negative direction from average on normal days. We classify the status of irregularity of individual's movement using 3-class.



Classification of Mesh's State	Classification of irregularity's state
Don't have any GPS logs	'-1'
Have average of movement less than that of normal days	
Have average of movement less than that of normal days	'0'
Occur new GPS signals	'1'
Have average of movement less than that of normal days	

Result

We use movement's change as independent variables and distance from shelter, risky place, rain's amount, average of slope, land uses etc., as dependent variables. Using Logistic Regression model, we analysis which factors have influence to people's evacuation behavior and how much. As a result, he or she is more likely to do normal behavior by 9.60% if other people around him do normal behavior. We could see that the amount of rain doesn't have great influence with evacuation behavior. Because people can't judge whether the amount of rain or water level is reached up to dangerous level or not when they see or hear observed value. The longer distance to the closest shelter, the higher average slope, probability to decrease average of radius of movement grows up by 0.63%, 0.54%.