How many times do people feel strong ground motions of the JMA's seismic intensity of 5- or greater by the 2016 Kumamoto Earthquakes?

*Hiroo Nemoto[1], Masatsune Hatakeyama[2], Masashige Minamishima[3], Akihiko Ito[4]

1.Division of Natural Sciences, J.F.Oberlin University, 2.Seikou Gakuin Secondary School, 3.Tokyo Metropolitan Ryogoku Secondary School, 4.Faculty of Education, Utsunomiya University

The 2016 Kumamoto Earthquakes occurred in earthquake sequences of foreshock-mainshock-aftershock type in and around Kumamoto Prefecture, Japan on April, 2016. There were 18 earthquakes which recorded JMA Seismic Intensity (SI) of 5- or greater at one or more of SI observation stations (SIOS) during 16 days after the foreshock.
Changing over the point of view, we want to examine how many times people feel strong ground motions of the SI of 5- or greater by the 2016 Kumamoto Earthquakes at each SIOS.
In this study, we used SI data of JMA's SI information, SI database by JMA, and strong ground motion data of K-NET and KiK-net. In addition to these data, we analyzed six "Rika" (similar to Natural Science) textbooks for year six of primary school, five and five Rika textbooks for the year seven and nine of lower secondary school, respectively, and four Science and Our Daily Life textbooks and five Basic Earth Science textbooks for year 11 and/or 12 of upper secondary school.
As a result, three SIOS recorded as the most number of SI of 5- or greater during this term, and the number of occurrences was seven. These stations are Miyazono Mashiki-machi (7 : twice, 6- : once, 5+ : once, 5- : three times), Tensui-machi Tamana-shi (6- : twice, 5+ : once, 5- : four times), and Kasuga Nishi-ku Kumamoto-shi (6+ : once, 6- : once, 5+ : once, 5- : four times). On the other hand, one SIOS had recorded as the most number of SI of 5- or greater during 16 days after the mainshock in the Mid Niigata Prefecture Earthquake in 2004 (the 2004 Chuetsu Earthquake), and the number of occurrences was 16. In this station, which is located in Jyounai Ojiya-shi, SI 6+, 6-, 5+, and 5- was recorded twice, twice, seven times, and five times, respectively. At the same time, K-NET station named NIG019, is located in Ojiya-shi, recorded SI 7 equivalent (e.g. Ishii, et al., 2007). When the mainshock and the largest aftershock was attacked SIOS of Jyounai Ojiya-shi, this SIOS was recorded SI 6+ for both. These data may suggest that SI 7 had hit soft ground area in the vicinity of these stations twice.
Furthermore, we searched the SI database of JMA by referring to the reference information such as the Headquarters for Earthquake Research Promotion (HERP) (1998). According to this search, there are no aftershocks greater than mainshock's JMA Magnitude (MJ), if the mainshock's MJ is 6.4 or greater for shallow inland earthquakes. This means we will need to reconsider the characteristics of shallow inland earthquakes because foreshock (MJ6.5) - mainshock (MJ7.3) - aftershock type occurred as the 2016 Kumamoto Earthquakes.
We also analyzed school textbooks. As a result, foreshock, mainshock, and aftershock are not written in all Rika, and Science and Our Daily Life textbooks. The word, foreshock, is written only in one of five Basic Earth Science textbooks.
In conclusion, at the moment, the 2016 Kumamoto Earthquakes revealed three problems through this study as below;
(1) Is this the first time in recorded history SI 7 has hit the same place twice in close succession in Japan?
(2) Will we need to reconsider the characteristics of shallow inland earthquakes, especially for earthquake of MJ6.4 or greater?
(We may also need to think about revision of the standards for earthquake resistance through the results of (1) and (2).)

(3) What kind of knowledge should school teachers teach about seismic activity including a large scale earthquake causing strong ground motion and its related basic concept such as foreshock, mainshock, aftershock?
In this presentation, we would like to discuss how to solve these problems in the fields of seismology, earthquake engineering, and earthquake and earthquake disaster prevention education using lessons from the 2016 Kumamoto Earthquakes.

Acknowledgment
We appreciate JMA for providing data of SI information and SI database. We also would like to thank NIED for providing K-NET and KiK-net strong ground motion data.

References
HERP, Aftershock Probability Evaluation Methods, 1988.
ISHI, Y., GOTO, H., and SAWADA, S., Ground motion characteristics affected by source rupture process at Kawaguchi during Niigata Chuetsu Earthquake, JSCE Journal of Earthquake Engineering, 29(0), 153-160, 2008.
Twenty five school textbooks for primary and secondary school students.

Keywords: The 2016 Kumamoto Earthquakes, Seismic Intensity Observation Station, Seismic Intensity, Rika (Natural Sciences) and Basic Chigaku (Basic Earth Science), Foreshock-Mainshock-Aftershock Type, Standards for Earthquake Resistance

