学 位 論 文 内 容 の 要 旨
DISSERTATION ABSTRACT

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The use of geostationary satellite based rainfall estimation and rainfall-runoff modelling for regional flash flood assessment
(静止衛星による観測データを用いた降雨推定手法と降雨流出モデルによる山地流域における突発的出水評価)

The availability of rainfall triggered hazard data such as flash flood is crucial in the flood disaster management and mitigation. However, providing those data is hampered due to the shortage of data. This situation is mainly because of the absence of hydrology and/or meteorological measurement instruments. Remote sensing techniques that make frequent observations with continuous spatial coverage provide useful information for monitoring and the early warning the hydrometeorological phenomena such as rainfall and floods. This study aims to develop and evaluate geostationary satellite based rainfall estimation by considering cloud types and atmospheric environmental condition and to apply it for regional flash flood assessment. The rainfall estimation method uses assumption that for the convective cloud situation, the relationship between cloud top temperature and rain rate shows that the low cloud top temperature is associated with heavier rainfall. Moreover, the estimated rainfall is integrated with rainfall−runoff model for a regional flash flood assessment.

First, a simple rainfall estimation method using geostationary satellite i.e. Multi−functional Transport Satellite (MTSAT) blended with Tropical Rainfall Measuring Mission (TRMM) 2A12 is performed for Java Island, Indonesia and its surrounding area. The blending process is conducted by developing statistical relationship between cloud top temperature from MTSAT 10.8 micrometers channel T_{IR1} which is collocated with rainfall rate (RR) acquired by TRMM 2A12. Comparison to TRMM Multi Precipitation Analysis (TMPA) data product is conducted. Temporal validation result shows that TMPA demonstrated better statistical performance than T_{IR1} and RR statistical relationship model. However for the spatial correlation, T_{IR1} and RR statistical relationship model shows reasonably better performance than TMPA.

Second, in order to fulfill the rainfall estimation assumption, the statistical relationship is developed by considering only cumulonimbus (Cb) cloud type. A new two-dimensional threshold diagram (2D−THR) has been developed based on maximum likelihood cloud classification results, which can readily be applied for MTSAT split window datasets. The study area is Japan and its surrounding area. By integrating the cloud type classification especially by separating Cb cloud type from other cloud types can improve the T_{IR1} and RR statistical relationship, which is indicated by increasing correlation coefficient and the gradient of regression line. Therefore, underestimating rainfall intensity can be avoided by applying rainfall rate and cloud top temperature relationship that uses Cb cloud type only

rather than using all cloud types. A good agreement between estimated and measured storm rainfall also has been demonstrated when use this approach.

The geostationary satellite based rainfall estimation then applied for characterizing the storm severity. The Hosking−Wallis Regional Frequency Analysis (HW−RFA) method is used to define the frequency distribution of long−term hourly maximum rainfall over Hokkaido Island. HW−RFA indicates that Generalized Normal/Log Normal three parameters (GNO/LN3) is suitable to describe the frequency distribution of long-term hourly maximum rainfall over Hokkaido Island. A return period map during heavy rainfall event is generated by using MTSAT based rainfall estimation, based on the GNO/LN3 distribution. The maximum return periods during that heavy rainfall event show 5−year return period and it is considered underestimation when compared with the current situation of flood event in Ishikari river basin. However this information meets the requirement for providing the severity information for flood mitigation.

Third, total Precipitable Water Vapor (PWV) as a product of Global Possitioning System observation and atmospheric vertical instability were considered to represent the atmospheric environmental conditions during the development of T_{IR1} and RR statistical models. The results demonstrated that the models that considered the combination of total PWV and atmospheric vertical instability were relatively more sensitive to heavy rainfall than were the models that considered no atmospheric environmental conditions. Intercomparison results with the TRMM 3B42 rainfall estimation product confirmed that MTSAT-based rainfall estimations made by considering atmospheric environmental conditions were more accurate for estimating rainfall generated by Cb cloud.

Lastly, a regional flash flood assessment is conducted based on two rainfall-runoff models: (i) empirical regression model approach and (ii) physical based approach using land surface model. The regression model approach uses a multiple regression model to draw a relationship between the flash flood severity and hydro-morpho-meteorologic conditions. A geostationary based rainfall estimation that statistically downscaled with observed rainfall is integrated to generate the actual flash flood severity index. Despite the poor statistical relationship shown by the hydro−morpho−meteorological parameters with flash flood severity, the actual flash flood severity index map demonstrates its potential to show a dynamic flash flood index for early warning purpose. The physical based approach for flash flood assessment implements the minimal advance treatments of surface interaction and runoff (MATSIRO). A comparison of estimated peak discharge by using observed and satellite based rainfall data forcing is performed and evaluated. The result shows that the river flow simulation is overestimated during normal flood but underestimated for the flash flood. Since the intensive use of remote sensing data, this research provides an integrated approach for flash flood assessment which is suitable to be applied in the area which the availability of hydro−meteorological data is limited.