JAPANESE EARLY-WARNING SYSTEM FOR DEBIRS FLOWS AND SLOPE FAILURES

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INTRODUCTION

In Japan, about 1000 sediment-related disasters happen annually and about 20 people are killed by these disaseters. Therefore evacuation is important for residents to protect themselves before a sediment-related disaster occurs. MLIT (Ministry of Land, Infrastrucuture, Transport and Tourism) has developed an early-waring system since 1984. In 2005, a new nationwide early-waring system was established by SABO (Erosion and Sediment control) department of MLIT and JMA (Japan Meteological Agency), NILIM (National Institute for Land and Infarastructure Management). A nationwide initiative for disseminaton of early-warning information (sediment-related disaster warning infomation) was implemented at the end of March 2008.

METHODOLOGY

The main methodolgy of the system is to set a criterion of disaster occurrence line (Critical line, CL) for occurrence of debris flows and slope failures based on two rainfall indices (60-min cumulative rainfall as short time rainfall index, soil-water index as long time rainfall index) in each 5-km grid mesh covering all of Japan. Because many of records of debris flows and slope failures are lacking in precision on time and location, the system applies RBFN (Radical Basis Function Network) to set the criterion based primarily on rainfall data recorded as not triggering disasters. Since the end of March 2007, under torrential rainfall conditions, early warning information has been disseminated as part of weather news using TV, radio and the Internet.

Basic comcept of early-waring system for debris flows and slope failures is to set a discriminating boundary between occurrence and non-occurrence rainfall. However, because adequate records of disasters for statistical analysis do not exist in many regions, a new early-waring system use non-occurrence rainfall with RBFN to specify the area of low probability and to draw arbitrary shaped CL objectively.

RBFN make response surface of the grid by using non-occurrence rainfall data. Fig.1(a) is three-dimensional view of the output response surface.

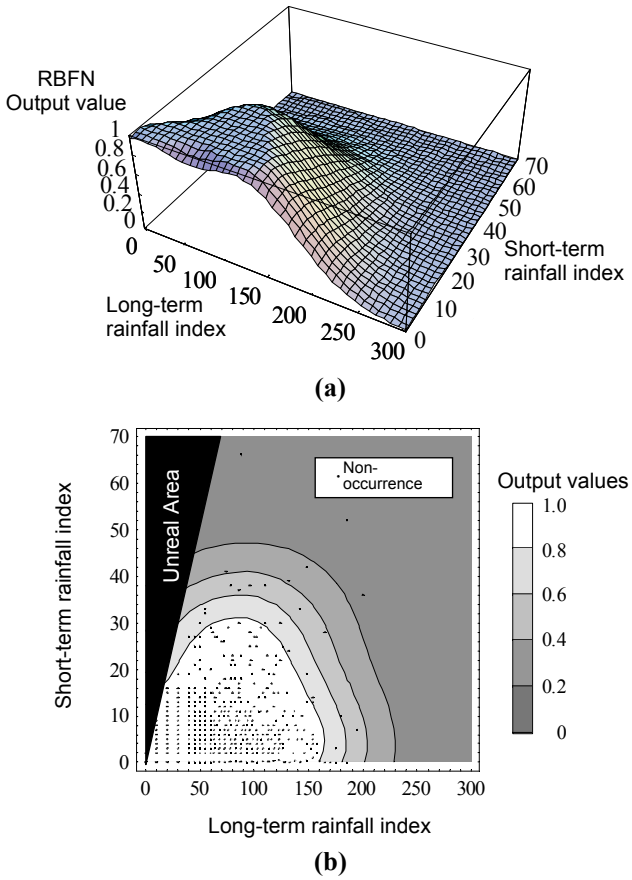

Fig.1 Response saface made by RBFN

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The maximum RBFN value is 1.0 because all of the 0 mm rainfalls with 0 mm of soil water are "non-occurrence" rainfalls. Fig.1(b) is contoured two-dimensional plot (contour lines at 0.1 intervals a potential candidates for CL) of response surface on 60-min cumulative rainfall and soilwater index as x and y axes, respectively. CL is selected from various potential candidates for CL on response surface by checking that particular large occurrence rainfall events are below the CL.

USE OF EARLY-WARNING INFORMATION

This early-warning system is aimed at facilitating the evacuation of residents in advance of the occurrence of disasters, and at assisting the decision-makers such as mayors to judge the timing when to disseminate evacuation instructions or orders.

The main players who send out early-warning information to the residential population are JMA and local government. When torrential rain is expected or falling, the timing of the issuing of early-warning information is determined by the expected values of the 60-min cumulative rainfall and soil-water index calculated using the forecast rainfall for 1-3 h into the future. The progress of the actual values of the two indices is logged graphically as a snake line so that the likelihood of exceeding the CL in the near future can be anticipated to provide enough lead time to evacuate residents before the actual rainfall causes the CL to be exceeded. This allows JMA to initiate the early-warning of debris flows and slope failures. The weather news on a TV, radio, and the Internet then deliver the early-warning information.

On 21st July, 2009, 65 debris flows and 105 slope failures occurred in Yamaguchi Prefecture, and MLIT reported that 14 people died as a result of these mass movements. The time series of 60-min rainfalls and soil-water index, the times of occurrence of debris flows and slope failures, and the period of early-warning information issue are shown in Fig.2 (left). The progress of the snake line and the timing of the disasters (red box) in this grid block are shown in Fig. 2 (right). Fig. 2 indicates that CL adequately captured the timing of these disasters occurrences.

The merit of this method is the ability to apply it to areas with no prior record of disasters. Updating is easily accomplished because the system learns from the input data. The latter characteristic means that the criteria can be revised easily while the system is operating.

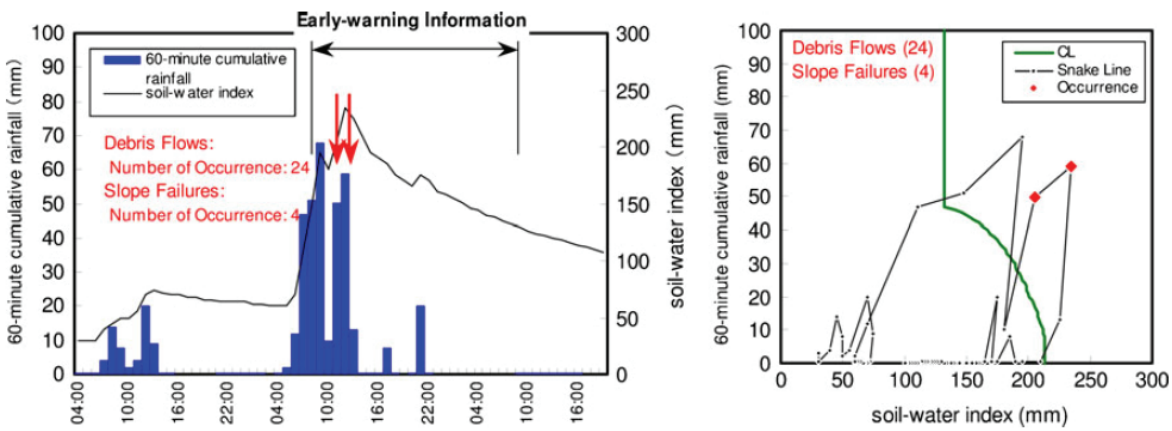

Fig.2 Relationship between early-warning information and disasters in Yamaguchi Prefecture, on 21st July, 2009

Keywords: early-warning system, debris flow, slope failure, rainfall index, radical basis function network