DEVELOPMENT OF INTEGRATED SRA-BASED DATA VISUALIZATION PLATFORM FOR THE PREDICTION AND RESPONSE OF FLOODS AND DROUGHTS

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ABSTRACT: The recent acceleration of climate change increases natural disasters such as floods, droughts and the frequency of torrential rains. Thus, it is expected that disaster response and water resources management will become increasingly difficult. Therefore, in this study, the integrated SRA-based data visualization platform for the prediction and response of floods and droughts thereto was established to continuously and intuitively visualize the observation information and flood disaster information acquired by land observation sensors and SRA(Satellite, Radar, AWS), etc. by using spatial information construction technology and computer graphics technology so as to deliver the information to users. The platform consists of a high-precision hydrological radar-based precipitation monitoring and scenario-based multidimensional urban flood prediction simulation system, a satellite-based drought monitoring system that can detect drought changes and a monitoring system for estimation of the current water balance in ungauged watersheds. It supports decision-making in the event of a disaster and is equipped with functions that can quickly deliver a vast amount of information. This integrated platform for providing real-time floods and droughts information and for the comprehensive utilization of observation data is deemed to be able to function as a universal system designed for the prediction of flood disasters and the provision of water-related information.

1. INTRODUCTION

There is an increasing risk of water-related disasters such as droughts and floods (Yang, 2012) due to global climate change. Recently, in Asia, heavy rains accompanied by inundation and strong winds have caused tragic damage. In Korea as well, flood damage caused by flooding in a short period due to torrential rains in the summer, and irregular and widespread drought damage over a long period is on the rise. Thus, it is necessary to prepare comprehensive measures to reduce possible large-scale human and property damage.

In the case of meteorological observation radars, large S-band radars focused on a large area and high altitude are dominant (Jang et al., 2013). However, electromagnetic wave-based, high-precision X-band level hydrological radars have been developed and utilized (Hwang et al., 2015) (Yu et al., 2018). These radars can contribute to disaster prevention by precisely observing the recent surge in localized heavy rains and typhoons at low altitudes close to the ground. There has been an increased need for a system that can comprehensively analyze large-scale weather data and monitor water disasters in real-time.

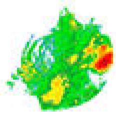
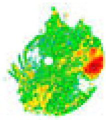
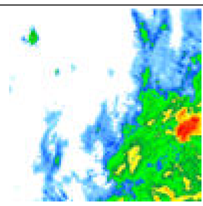
This study developed the Unity 3D-based advanced visualization platform (VIP, Visual Information Platform) that can actively respond to water disasters and utilize them for decision-making by integrating large-capacity hydrometeorological data gathered from territorial observation sensors and SRA (satellite, radar, automatic weather station), etc. The system consists of a high-precision hydrological radar observation information integrated system, a high-precision radar-linked urban flood visualization system, a satellite-based drought monitoring system, and a water balance monitoring system for unmeasured areas.

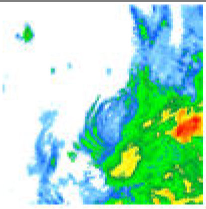
2. MAIN FFUNCTION OF THE SYSTEM

2.1 High-precision, hydrological radar observation information integrated system

By processing the received radar data into visualization information, the system provides rainfall monitoring and real-time rainfall prediction data and enables inquiry according to date and time from a total of five radar types. It can calculate individual rainfall and composite rainfall data every minute through two high-precision, low-altitude hydrological radars (Xnet) installed at the Korea University and Yonsei University in Seoul. It can calculate the SBand composite rainfall and X-SBand convergence rainfall in units of 5 minutes in connection with the existing large S-band (SBand) radar and high-precision hydrological radar. Table 1 shows the result for the sample data at 09:10 on August 11, 2020.

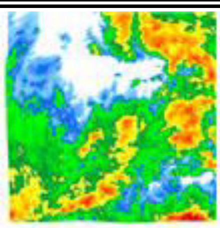
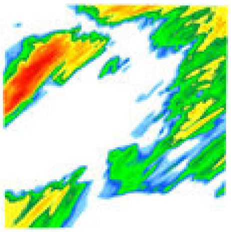
Table 1. Examples of information calculation based on the high-precision, hydrological radar

Radar type	Result of inquiry	Time resolution
Xnet Composite Images		1m
Xnet Individual Images (Korea Univ)		
Xnet Individual Images (Yonsei Univ)		
SBand Composite Images		5m

X-SBand Convergence Images		

The system generates the optimal convergence rainfall to provide a radar-based live forecast for up to 3 hours in 10-minute increments. It applies high-precision hydrological, radar-based real-time hydrological information and the storm-scale ultra-short-term cloud resolution prediction model (the Weather Research and Forecasting (WRF) model) (Jeong et al., 2008) to provide high-resolution rainfall prediction information for up to 6 hours in 1-hour increments. Table 2 shows the live forecast inquired between 09:00 and 09:10 for the same date as the observation data sample.

Table 2. Examples of application of the high-precision, hydrological radar-based live forecast and the rainfall prediction model

Radar type	Result of inquiry	Time resolution	Time duration
Real-time prediction model		10m	1~3h
WRF prediction model		1h	1~6h

2.2 High-precision radar-linked urban flood visualization system

A user-centered urban flood prediction visualization system was constructed using real-time rainfall prediction information and urban flood prediction data calculated using a high-precision hydrological radar [Figure 1]. The flood risk area can be simulated by selecting real-time flood data or predicted rainfall-based data calculated by the data processing algorithm. In the case of hazardous drainage basins, only the depth of submersion greater than the value selected by the user among 0.5m, 1.0m, and 1.5m can be displayed through the dangerous drainage basin board and simulation. In addition, there is a function that helps users make decisions by mapping in real-time the flood trace data of the area where flood damage has occurred in the past to the base map.

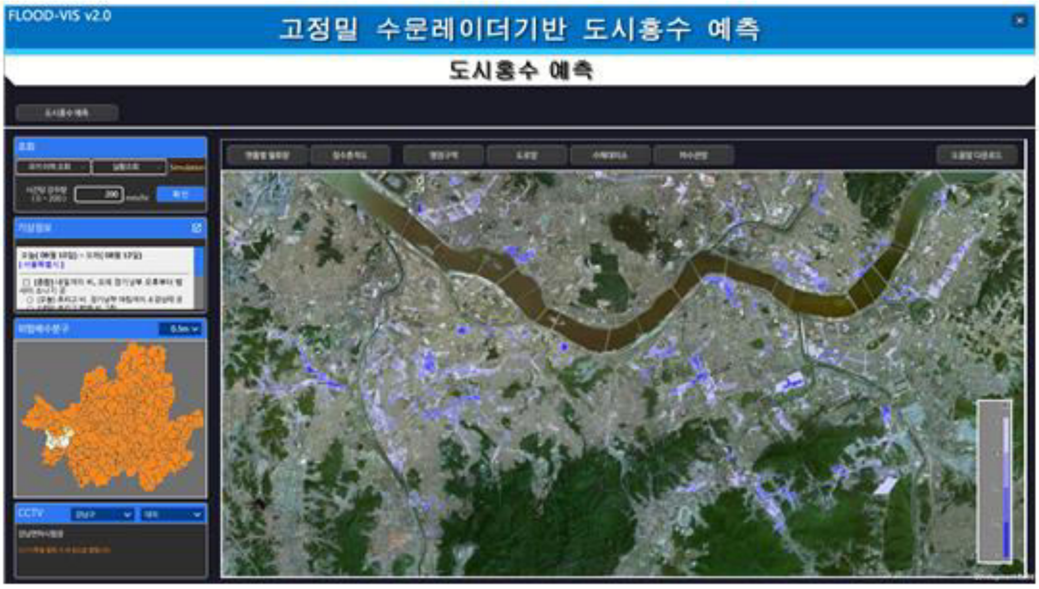


Figure 1. High-precision, hydrological radar-based urban flood prediction system

2.3. Satellite-based drought monitoring system

A system was developed to quantify and efficiently monitor various drought-related factors by combining them through satellite remote sensing. This system consists of drought monitoring, drought comparison, and drought change detection functions. For drought monitoring, it provides data for each drought index according to the monthly meteorological, hydrological, and agricultural drought classifications for the Korean Peninsula by administrative boundary and basin since January 2001. For drought monitoring, a window explaining the drought index and calculation method is located in the upper left corner. Drought conditions are mapped and visualized in 5 steps in the main map area based on the legend for each drought index inquired: severe (red), alert (orange), caution (yellow), concern (light yellow), and normal (white). At the bottom of the screen, the results of the drought analysis for each administrative district can be seen in the bar graph [Figure 2].

Figure 2. Drought monitoring function

The drought comparison function is designed to conveniently compare the monthly data according to the drought index and the change according to the administrative district by providing the two data sets searched by the user on the left and right sides of the screen [Figure 3].

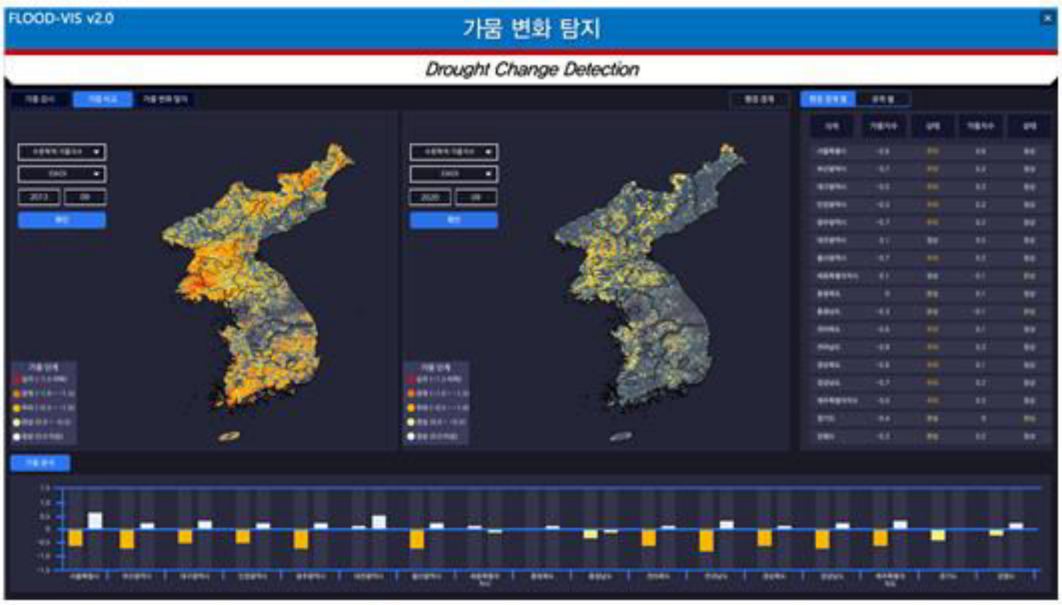


Figure 3. Drought comparison function

The drought change detection function is similar to the drought comparison function but allows only one drought index to be selected. One notable feature allows the user to move the scroll bar by dragging the mouse to check the time-series changes either vertically or horizontally by inquiring two types of data within the same drought index and calculation method [Figure 4].

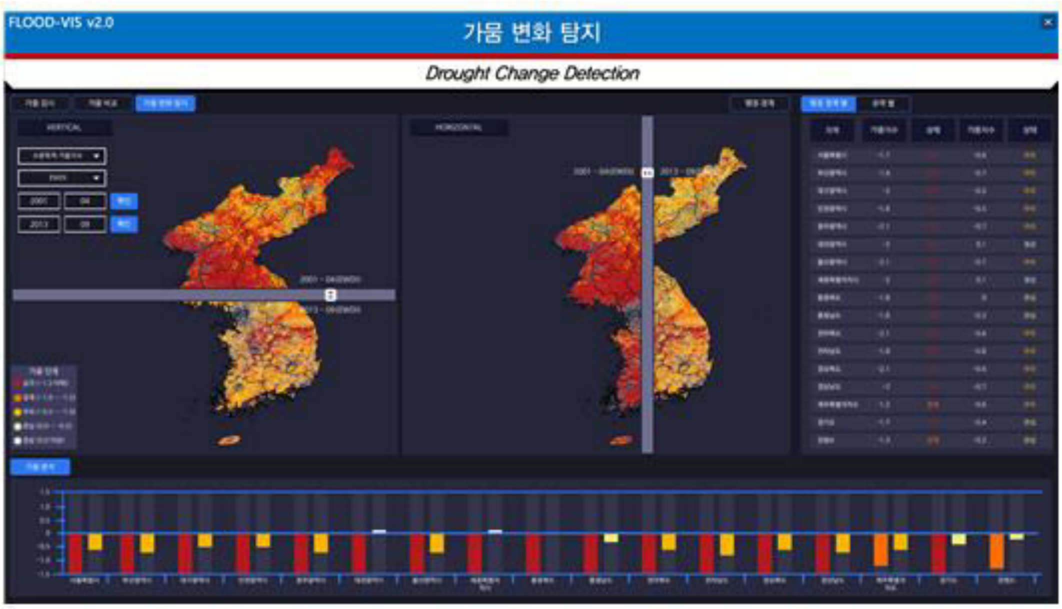


Figure 4. Drought change detection function

2.4 Monitoring system for water balance in unmeasured areas

By applying the SRA-based remote sensing technique, a monitoring system was established to manage the hydrological information and water resources of unmeasured areas in an integrated manner. The system consists of two functions: monitoring the hydrological status of the Imjin River border area and predicting the arrival at the Gunnam flood control area. The hydrological status monitoring system was constructed so that the risk level was expressed through the water level, flow rate, inflow amount, discharge amount and arrival time for Hwanggang Dam, Pilseung Bridge, and Gunnam Dam, which are major points in the Imjin River basin [Figure 5].

Figure 5. Monitoring the hydrological status of the Imjin River border area

Predicting the time for reaching the Gunnam Flood Control Area is indirectly estimated through the peak flow rate and peak water level of Hwanggang Dam and Gunnam Dam, the peak flow rate and peak water level of the Pilseung Bridge, and the arrival time and arrival duration for each point. As such, when the discharge time and discharge amount are entered and the simulation is executed, the system is designed to predict the arrival time, arrival duration, and the total arrival duration to each point in sequence, starting from the water level of the Hwanggang Dam [Figure 6].

Figure 6. Monitoring of Gunnam Flood Control Area

3. CONCLUSION

This study developed a high-precision, hydrological radar-based urban flood management system, a satellite-based drought monitoring system, and a water balance monitoring system for unmeasured areas, based on Unity 3D technology in order to achieve water disaster prediction and response. Considering the characteristics of recent meteorological disasters, the system that can predict low-altitude and local rainfall and the satellite data-based drought monitoring technology can be used jointly by all ministries. The monitoring system for unmeasured areas using satellite-radar observation information is also expected to be useful in terms of minimizing damage and preparing for integrated water resource management between the two Koreas in the future. The system is designed to facilitate an immediate response in case of an unexpected situation according to the operation of upstream North Korea.

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