Real-time monitoring of soil information in agricultural fields in Asia using Fieldserver

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Abstract

Spatial and temporal soil monitoring is required for assessing impacts of land use and management on soil quality over large areas. In order to validate soil moisture data obtained by satellite remote-sensing, we are testing real-time monitoring of soil information at a rain-fed field Khon Kaen in Thailand using Field Server with soil sensors. In this study, we outline this new monitoring system and demonstrate the results obtained, then discuss the possibilities of the system for digital soil mapping.

Keywords: Soil Information, Monitoring, Fieldserver, ICT, Agricultural field

1. Introduction

Spatial and temporal soil monitoring is required for assessing impacts of land use and management on soil quality over large area. Although remote-sensing techniques by orbiting satellite is often used for such soil monitoring, it gives us information on only the surface but not the inside of soil. On the other hand, soil scientists survey soil profiles and measure soil physical properties, i.e. soil water moisture, temperature, electrical conductivity(EC), with some sensors connected to a data logger in a pit selected from large area. However, they need to set a lot of data loggers to get more reliable soil information in a large area because the selected point is not guaranteed to be representative. In order to validate satellite remote-sensing data, we are testing real-time monitoring of soil information including vegetation and soil moisture in a rain-fed field Khon Kaen in Northeast Thailand by using Fieldserver with soil moisture sensors. (Mizoguchi, et.al. 2007a, Mizoguchi, et.al. 2007b, Mizoguchi, 2007)

In this study, we outline this new monitoring system and demonstrate the results obtained, then discuss the possibilities of the system for digital soil mapping.

2. Experimental Methods

2.1 Fieldserver

Fieldserver (FS) is an automatic monitoring system, which consists of CPU (Web server), AD converter, DA converter, Ethernet controller, high intensity LED lighting and sensors such as air temperature, relative humidity, solar radiation (PPFD), soil moisture, soil temperature, electrical conductivity, leaf wetness, infra-red sensor, CMOS/CCD camera. (NARO, 2007) The Fieldservers are interconnected by Wireless LAN (Wi-Fi, IEEE802.11b). Digital cameras and Web cameras can be connected, and high-resolution pictures of fields are transferred through Wi-Fi broadband networks, and stored on Web servers. The cameras can be remotely controlled by a web browser.

2.2 Soil information monitoring system

Figure 1 shows diagram of real-time soil information monitoring system. The system we used composed of a Fieldserver, a solor panel, a router, an agent box (in-site data logger).

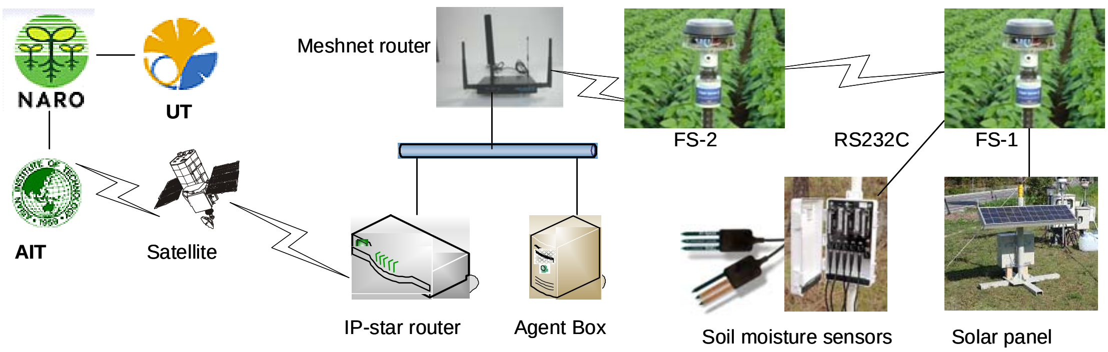

Fig.1 Diagram of real-time soil information monitoring system

2.3 Experimental site

We installed three Fieldservers in a rain-fed field in Khon Kaen, Northeast Thailand (16^{o}27.657 N, 102 ^{o}32.443 E) in December 25, 2006. (Fig. 2) Each Fieldserver is about 300 m apart, but signals are less interfered because the Fieldserver is stood higher the rice canopy. We got meteorological data (air temperature, humidity, radiation, wind velocity, precipitation) and soil information (soil moisture content, ground temperature, electrical conductivity) with image data of the site.

Fig.2 Setup of Fieldserver by Asian team on December 25, 2006

Fig.3 Installation of soil sensors

We inserted soil sensors (EC-TE, Decagon Device, 2007) at the depth of 4, 8, 16, 32 cm for monitoring soil information. (Fig.3) These data are automatically stored through internet into a data-server at NARO (National Agriculture and Food Research Organization) in Japan.(Fig.1)

3. Results and Discussion

Figure 4 shows real-time monitoring data sent from a Khon Kaen Fieldserver. Once data are stored in a data server at NARO, we can download the meteorological data and images data using a software (Fukatsu, 2006) which was developed at NARO as shown in Fig.5. The stability of the system is mainly dominant to internet connection in the site. We are now developing a system with a mobile phone to get data even in the field where it is hard to access internet.

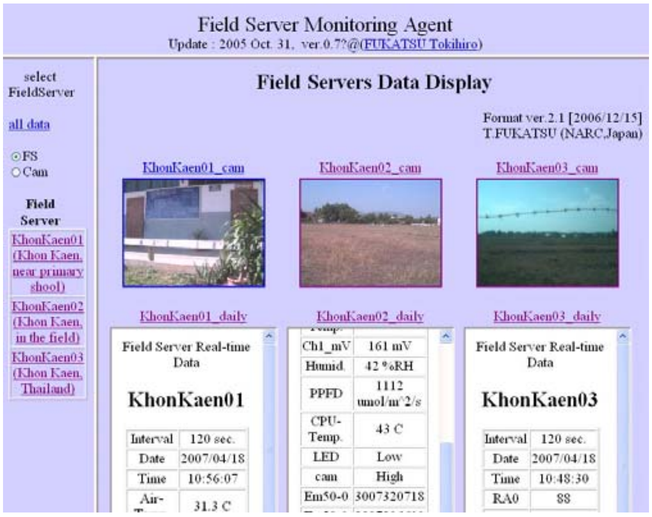

Fig.4 Real-time monitoring data sent automatically from a rain-fed field in Northeast Thailand.

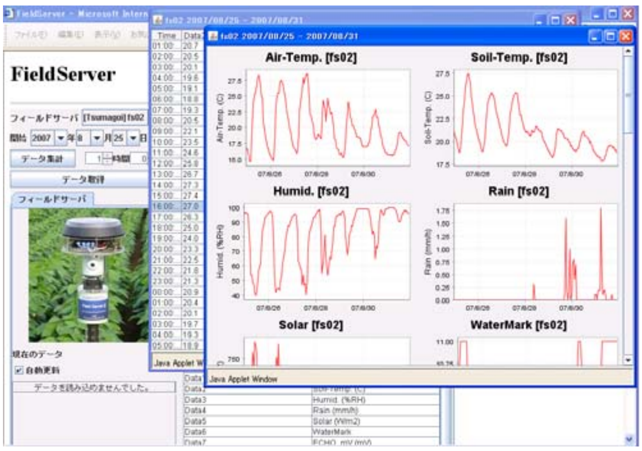

Fig.5 Meteorological data are obtained as a xml-table and graphs.

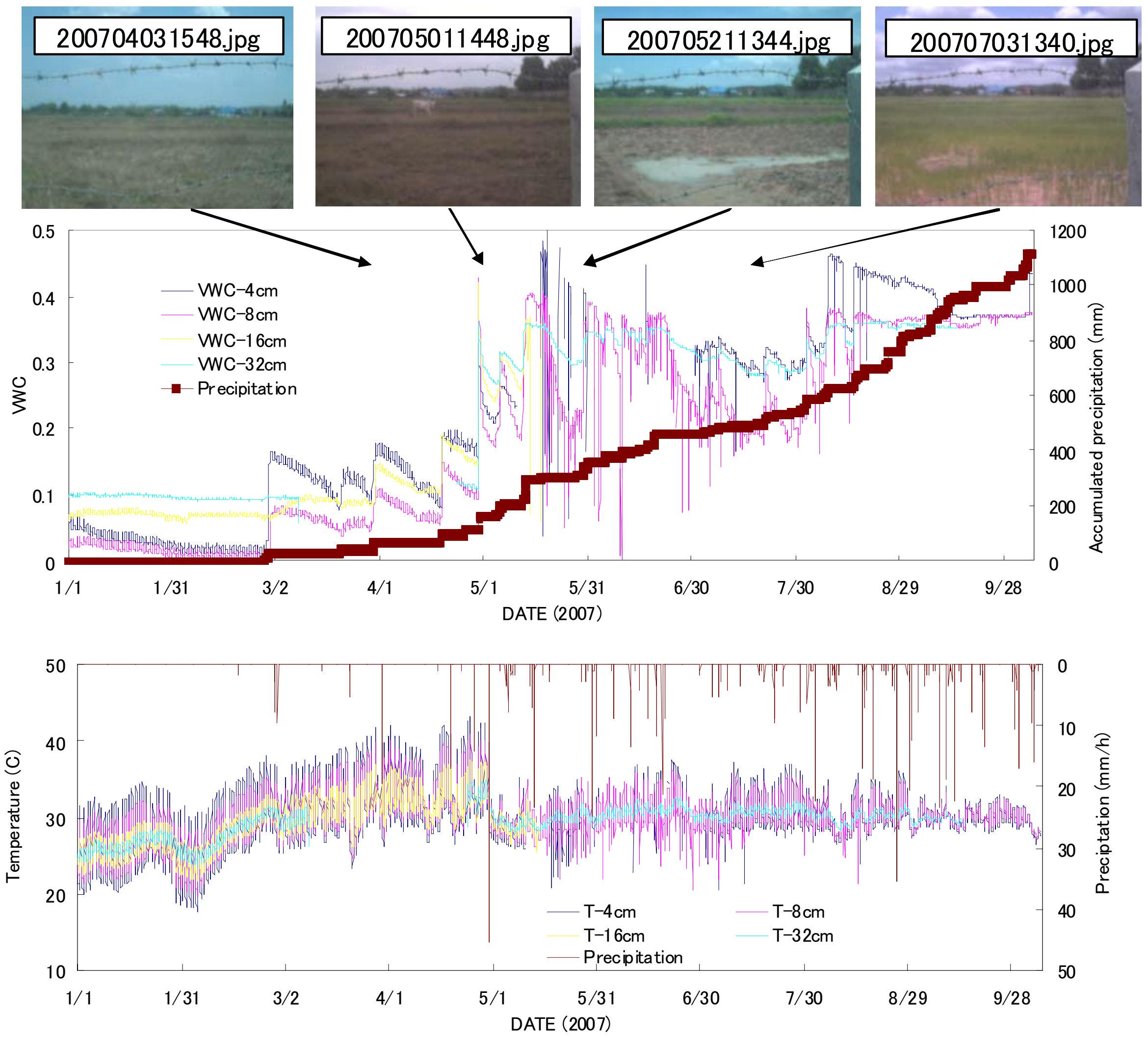

Fig.6 Change of landscape (Upper), soil moisture and accumulated precipitation (Middle), soil temperature and hourly precipitation (Lower) during 2007 dry-rainy seasons in a rain-fed field. The number in the picture denotes date and time that the image was stored.

Figure 6 shows soil moisture, soil temperature and precipitation from January to September in 2007. Soil moisture increased abruptly just after rains and decreased gradually after rain stop in March and April. On the other hand, the soil moisture kept high after a heavy rain at the end of April. The variation of soil temperature became small after May, indicating that the heat capacity of soil increased because the soil contained much water. In fact, the image on May 21 tells us the water logging in the rain-fed field. In this way, the real-time monitoring of soil information including meteorological data and image is helpful to understand events at remote agricultural fields. The present problem is the calibration for fluctuating soil moisture data after water logging. We are now studying about the calibration method (Mitsuishi, 2007) to compare these soil moisture data. Applying an appropriate model to the data can give us in-situ soil hydraulic and thermal properties.

In addition to Thailand, we are testing these real-time soil information systems at a cabbage field in Tsumagoi, Japan, a spinach field in Chiang Mai, Thailand, and a SRI (System of Rice Intensification) paddy field in Bogor, Indonesia. Thus, the more Fieldservers are installed, the more the soil data are collected. If we link the soil data to GPS, we will be able to see the real-time soil information on "Google Earth". Moreover, since Fieldserver has wireless LAN function, soil data can be automatically collected and transferred to a data center when a tractor with some sensors passes near the Fieldserver in an agricultural field. Anyway, we believe that our new monitoring system has a great potential for digital soil mapping.

4. Conclusions

The Fieldserver is a quite promising tool for field science and technology only if we can find or develop suitable soil sensors because it detects both real-time images and meteorological data including soil information. However, there are a lot of unexplored territories in Asia where it is difficult to get electric power and internet infrastructure. We need further studies to get stable soil data from all over the world including such unexplored territories.

Acknowledgment

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