POTENTIAL APPLICATION TOPICS OF KOMPSAT-3 IMAGE IN THE FIELD OF PRECISION AGRICULTURE MODEL

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ABSTRACT...Potential application topics of KOMPSAT-3 image in the field of precision agriculture are suggested. The topics can be categorized as fundamental and applied ones that have contents of static and dynamic characteristics respectively. As fundamental topics, precision information of agriculture that is related to farmland and its crop attributes, precision information of rural infrastructure that is related to rural village and its facilities, precision information of stream environment that is related to rural water resources and its facilities, and precision information of eco-environment that is especially related to riparian ecology and environmental status are included. As applied topics, precision rural water resources that has thematic contents of continuous and event-based runoff, spatial and temporal soil moisture and evapotranspiration, precision agricultural watershed environment that has the contents of spatial and temporal soil loss, sediment and pollutants transport, and precision temporal and spatial crop growth that has the contents of temporal crop texture, spectral reflectance, leaf area index, spatial crop protein information.

KEY WORDS: KOMPSAT-3 Image, Precision Agriculture

1. INTRODUCTION

One of the KOMPSAT (KOrea Multi-Purpose SATellite) series, KOMPSAT-3 that will be launched in 2008 will have spatial resolutions of 80 cm panchromatic and 2.8 m multi-spectral images. Along with 1 m panchromatic and 4 m multi-spectral KOMPSAT-2 images, KOMPSAT-3 images are expected to use practically in the field of precision agriculture and precision farming. From the preliminary study (Kim et al., 2005) of KOMPSAT-2 image for "farm and crop management", the agriculture-related information such as crop type and cultivation boundary, irrigated area, irrigation and drainage canal types, and growing status of selected crops were successfully extracted and analyzed from IKONOS-2 image that has the same spatial and spectral characteristics with KOMPSAT-2 image.

As the KOMPSAT-3 image is more precise in spatial resolution than KOMPSAT-2 image, it would have more potential application in the field of precision agriculture and/or precision farming. "Precision farming" is the title given to a method of crop management by which areas of land/crop within a field may be managed with different levels of input depending upon the yield potential of the crop in that particular area of land. Precision farming is an integrated agricultural management system incorporating several technologies. The technological tools often include the global positioning system, geographical information system, yield monitor, variable rate technology, and remote sensing. Remote sensing image data from the soil and crops is processed and then added to the GIS database. Launching KOMPSAT-3 and KOMPSAT-2 satellites are expected to improve temporal resolution. The delivery time of remote sensing data to the customer and farmer will improve.

This paper presents potential application topics of KOMPSAT-3 image in the field of precision agriculture. As fundamental topics, precision information of agriculture, rural infrastructure, stream environment, and eco-environment are suggested. As applied topics, precision rural water resources, precision agricultural watershed environment, and precision temporal and spatial crop growth information are suggested.

2. POTENTIAL TOPICS OF KOMPSAT-3 IMAGE FOR PRECISION AGRICULTURE

The topics can be categorized as fundamental and applied ones that have contents of static and dynamic applications respectively. Static application is to produce a thematic map based on KOMPSAT-3 image and field survey data. Dynamic application is to simulate or predict the spatial and temporal variation of precision agriculture-related information by programming or using software. Precision information of agriculture, rural infrastructure, stream environment, and eco-environment are described as fundamental topics, and precision rural water resources, precision agricultural watershed environment, and precision temporal and spatial crop growth information are described as applied topics. The topics can be categorized as fundamental and applied ones that have contents of static and dynamic applications respectively.

Static application is to produce a thematic map based on KOMPSAT-3 image and field survey data. Dynamic application is to simulate or predict the spatial and temporal variation of precision agriculture-related information by programming or using software. Precision information of agriculture, rural infrastructure, stream environment, and eco-environment are described as fundamental topics, and precision rural water resources, precision agricultural watershed environment, and precision temporal and spatial crop growth information are described as applied topics.

2.1 Fundamental Topics

By referencing the USGS land use/land cover classification system, the agricultural land use that meets USGS Level IV (0.25 - 1.0 m spatial resolution) can be produced using KOMPSAT-3 image. Based on the KOMPSAT-3 agricultural land use map, precision information of agriculture is to develop farmland and its attributes such as crop type, cultivation area and period, farm owner, fertilizer management, crop yield and income.

Precision information of rural infrastructure is to develop thematic maps related to rural village and its facilities. Through the field survey and using panchromatic image of KOMPSAT-3, rural residence and the number of households, agricultural facilities and type, farm road and its condition are the contents to be developed. In addition, development of three-dimensional landscape and airscape of the village are the topics to support rural village planning and green tourism.

Precision information of stream environment is to develop rural small stream network, its related water source facilities (reservoir, diversion, pumping station) and irrigation & drainage canal and their attributes. Most of information can be obtained from KRC (Korea Rural Community and Agriculture Corporation) but the small stream network and its attributes should be obtained through the field survey with panchromatic image of KOMPSAT-3.

Precision information of eco-environment is to develop riparian ecology and its environmental status of rural area. Using the temporal KOMPSAT-3 colour composite images, the distribution of grassland, vegetation buffer strip, wetland and their type within the riparian area can be developed. This should be produced collaborating with the "Korea Natural Environment Investigation" project of MOE (Ministry of Environment) operated since 1998. RCS (River Corridor Survey) which identify important features, specify working recommendations, and outline potential rehabilitation measures of habitats is a thematic map of highly recommendable topic. The term "river corridor" is used to highlight the fact that a river, and the land adjacent to it, are not merely separate wildlife resources in their own right but together form a corridor of habitats through which species can develop and disperse. Furthermore, RCS can be applied to develop an advanced thematic map called as SCA (Stream Corridor Assessment) that is a new survey for a watershed management tool to identify environmental problems and help prioritize restoration opportunities on a watershed basis.

2.2 Applied Topics

As mentioned above, dynamic application is to create temporal and spatial information by modeling and software engineering using GIS data, KOMPSAT-3 derived land use data and field monitoring data. The necessary GIS data for dynamic application are DEM (Digital Elevation Model), soil map, stream network, geology map, meteorological station, water and water quality gauging station, groundwater production well and point source pollution distribution map.

Precision rural water resources topic is to develop thematic contents of continuous and event-based runoff, spatial & temporal evapotranspiration, soil moisture and groundwater recharge. Distributed hydrologic modeling such as TOPMODEL (Beven et al., 1979, 1984), KIMSTORM (Kim et al., 1998) is preferred to apply rather than lumped hydrologic modeling because the former uses the spatial information at its maximum.

Precision agricultural watershed environment topic is to develop thematic contents of spatial and temporal soil loss, sediment and pollutants transport. Likewise precision rural water resources, distributed modeling such as MUSLE (Modified Universal Soil Loss Equation, Williams, 1975; Onstad and Foster, 1975), ANSWERS (Beasley et al., 1980), AGNPS (Agricultural Nonpoint Source, Young et al., 1987), KIMEROM (Kim, 2001) are recommended.

Precision temporal and spatial crop growth topic is to develop thematic contents of temporal crop texture, spectral reflectance, leaf area index, spatial crop protein information. This topic is closely related to precision farming. The temporal and spatial analysis of KOMPSAT-3 colour composite image will meet the goal of precision farming that gather and analyze information about the variability of soil and crop conditions in order to maximize the efficiency of crop inputs within small areas of the farm field. KOMPSAT-3 images provide farmers with the ability to monitor the health and condition of crops. It can detect healthy, stressed and damaged by blight and harmful insects. Stressed and damaged plants reflect various wavelengths of light that are different from healthy plants. Healthy plants reflect more infrared energy from the spongy mesophyll plant leaf tissue than stressed and damaged plants. By being able to detect areas of plant stress before it becomes visible, farmers will have additional time to analyze the problem area and apply a treatment.

Table 1. Potential application topics in precision rural water resources

Layer	KOMPSAT-3 Image (①)	KOMPSAT-3 + DEM (②)	② + Meteorological station (③)	③ + Soil map (④)	④ + Land use map (⑤)
Basic items	•Watershed area •Watershed perimeter	•Watershed average slope •Slope/aspect distribution	•Station location	•Attribute standardization	•Water resources estimation
Low level application	•Precision agricultural land use •Change detection and update of land use	•Stream network generation	•Thiessen network •Watershed average rainfall	•Soil type distribution •Hydrologic soil group	•Watershed runoff
High level application	•3-dimensional rural landscape •Landscape analysis	•Flow direction & accumulation •Watershed characteristics (Bifercation ratio, Stream order, Stream length, Stream frequency, Drainage density etc.)	•Spatial interpolation of meteorological factors •Water resources estimation •Spatial hydrograph	•Soil physical parameters (porosity, field capacity, wilting point etc.) •Storage capacity •Subsurface flow	•Spatial ET •Direct runoff (SCS method) •Storm runoff (lumped & distributed model) •Storm runoff using radar rainfall distribution •Continuous rainfall-runoff & soil moisture prediction
Layer	⑤ + Groundwater well + Geology map(⑥)	② + Stream GIS + Land use map (⑦)	⑤ + Groundwater well + Geology map (⑥)	⑥ + Groundwater GIS/DB	
Basic items	•Water resources estimation •Groundwater use	•Flood inundation mapping	•Water resources estimation •Groundwater use distribution	•Groundwater quality	
Low level application	•Watershed runoff •Dam inflow	•River discharge	•Free & deep groundwater level dist. •Watershed runoff •Dam inflow	•Groundwater quality distribution	
High level application	•Continuous rainfall-runoff & soil moisture prediction •Drought index & distribution •Groundwater recharge •Groundwater flow	•River flow •Flood inundation forecasting •Shock wave propagation by dam break •Water propagation by river bank collapse	•Continuous rainfall-runoff & soil moisture prediction •Soil moisture dist. •Drought dist. •Groundwater discharge •Groundwater flow	•Pollutant movement in soil •Pollutant movement in groundwater	

Table 2. Potential application topics in precision agricultural environment

Layer	① + Administration boundary (⑧)	⑧ + DEM + Point source location (⑨)	⑤	⑥
Basic items	•Pollutant load produced	•Pollutant load produced •Pollution vulnerable area	•Soil erosion vulnerable area •Sediment load •Pollutant inflows	•Soil erosion vulnerable area •Sediment load •Pollutant inflows
Low level application	•Pollutant load discharged	•Tracing pollutants	•Soil erosion (event)	•Soil erosion (continuous)
High level application	•Delivery ratio		•Pollutograph •Distributed water quality modeling	•Pollutograph •Remained pollutants in soil •Pollutant movement to groundwater •Distributed modeling (MUSLE, MODFLOW etc.)

Table 3. Potential application topics in precision crop growth

Layer	①	① + LAI (⑩)	① + Protein contents (⑪)
Basic items	•Cultivation area		
Low level application	•Crop type •Temporal characteristics of crop growth (Texture DB)	•Crop growing status (LAI mapping and analysis)	•Crop growing status (Protein mapping and analysis)
High level application	•Temporal characteristics of crop growth (Spectral reflectance)	•Yield prediction using LAI	•Production quality and yield prediction using protein contents

3. CONCLUSION

Potential application topics of KOMPSAT-3 image in the field of precision agriculture are suggested by categorizing fundamental and applied ones that have contents of static and dynamic applications respectively. As fundamental topics, precision information of agriculture, rural infrastructure, stream environment, and eco-environment are suggested. As applied topics, precision rural water resources, precision agricultural watershed environment, and precision temporal and spatial crop growth information are suggested.

The key point of KOMPSAT-3 for precision agriculture is that KOMPSAT-3 has to establish a special operational policy to acquire imageries off-nadir and oblique viewing at critical dates for specific agricultural areas. Especially during the early period of KOMPSAT-3, this approach would be a practical application for crop management to identify crop species, cultivation area, and crop condition. If the crop information from KOMPSAT-3 images and field surveys are accumulated for several years, reasonable crop mapping, crop condition and crop yield estimation would be possible.

3.1 References

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