Application and Development of Integration Technique to Generate Land-cover and Soil Moisture Map Using High Resolution Optical and SAR images

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ABSTRACT:

Research and development of remote sensing technique is necessary so that more accurate and extensive information may be obtained. To achieve this goal, the synthesized technique which integrates the high resolution optic and SAR image, and topographical information was examined to investigate the quantitative/qualitative characteristics of the Earth's surface environment. For this purpose, high-precision DEMs of Jeju-Island was generated and data fusion algorithm was developed in order to integrate the multi-spectral optic and polarimetric SAR image. Three dimensional land-cover and two dimensional soil moisture maps were generated conclusively so as to investigate the Earth's surface environments and extract the geophysical parameters.

KEY WORDS: KOMPSAT-2, Optic image, SAR image, DEM, Data fusion, Land-cover map, Soil moisture map

1. INTRODUCTION

KOMPSAT-2 (KOrea Multi-Purpose Satellite) will provide high-resolution images of the Korean peninsula for the production of maps and digital elevation models. Therefore, KOMPSAT-2 is expected to have a practical use more than KOMPSAT-1 and make an offer for the development of spatial data infrastructure. As the global Earth observation systems develop rapidly, the development of remote sensing technique is required so as to investigate the Earth's surface environment and acquire more accurate and extensive information. Acquiring know-how and accumulating knowledge must be settled without delay.

In addition, the necessity of the use of multi-source data is come to the front as the spatial information increases. Remote sensing with single sensor is under many restrictions to meet the spatial and temporal resolution. Multi-spectral high resolution optical sensors like as KOMPSAT 2 have advantages which they offer high resolution and are easy to interpret, but also have disadvantages which are affected by weather condition. On the other hand, SAR(Synthetic Aperture Radar) sensors which employ microwave active remote sensing system are all weather imaging system but they cannot satisfy spatial resolution as much as the high resolution optical sensors. In this research, SAR and multi-spectral high resolution optic data was processed in order to investigate and analyze the Earth's surface environment in and around Korea peninsula. The main objectives of this research is to detect the changes of Earth's surface environments and extract the geophysical parameters by using the development of integration technique of high resolution multi-spectral optic and all-weather SAR images(Figure 1). IKONOS and KOMPSAT-1 EOC optic images and NASA/JPL AIRSAR and JERS-1 SAR images were used for the study. NASA/JPL AIRSAR images were acquired during PACRIM-II Experiments. The study sites are located in Jeju-Island off the southern coast of the Korean peninsula (Figure 2).

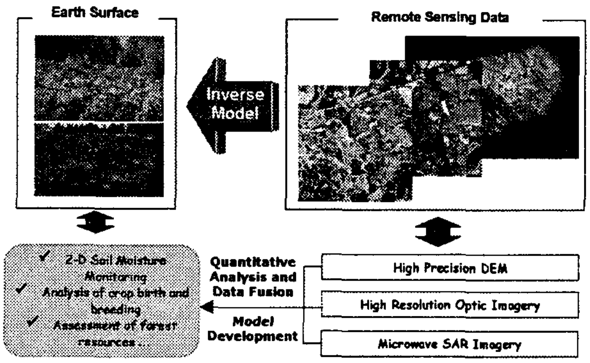

Figure 1 Development of data integration technique and spatial reasoning for quantitative Earth environment observation,

2. HIGH PRECISION DEM GENERATION AND DEVELOPMENT OF OPTIC AND POLSAR DATA FUSION TECHNIQUE

High-precision DEMs of Jeju Island was produced by using AIRSAR TOPSAR mosaic, KOMPSAT-1 stereo pair, and JERS-1 SAR interferometry techniques (Figure 3). High-precision DEM (Digital Elevation Model) plays a critical role in making the ortho-rectification image of KOMPSAT-2 which will be launched hereafter. By using 3-types of different data sets, we derived the DEMs with 95% total accuracy, ±2.8m horizontal accuracy, and ±9.5m vertical accuracy. Each DEM was integrated its priority of accuracy and complement the defects of SAR interferometry and stereoscopic strategy generate high-precision DEM. Since the relative vertical accuracy of the DEMs which were produced in this project was within a meter, they can be used to make ortho-image of KOMPSAT-2 MSC (PAN: 1 m, MS: 4 m). Also Generated high-precision DEM can be used to improve and update the 1:25000 scale topographic maps due to its efficiency and ability to give vertical accuracy of 1m.

Data fusion of multi-source/multi-temporal data sets is the essential technique to extract high-level information by making up for the defects of each sensor. In this research, data fusion technique which integrates the multi-spectral optic and polarimetric SAR images and classifies the fused image effectively was developed. The land-cover classification was performed based on the developed data fusion algorithm. Firstly each mono-source data was independently classified considering its statistical distribution. The Bayesian maximum likelihood classification method was adapted to classify the IKONOS image. The AIRSAR image was classified using Wishart classifier. After classification of each mono-source data, the Fuzzy reasoning was processed during the decision making stage. Figure 4 depicts the fusion image of IKONOS high resolution optic and L-band polarimetric SAR data. We concluded that each value of mono-source classification accuracy can be approved after image fusion process (Table 1).

Class	Accuracy	
	optic image	fused image
Forest land	89.6 %	91.8 %
Urban, Constructions	90.7 %	91.0 %
Soil	91.5 %	92.7 %
Crop	66.5 %	89.2 %
Pasture, lawn	88.7 %	90.1 %
Grass, Bush	68.1 %	89.5 %

Table 1 Classification accuracy assessment after fusion of IKONOS and AIRSAR image.

3. THREE DIMENSIONAL THEMATIC MAP GENERATION

3.1 Generation of Land-use Map

The land use status over Jeju Island was monitored and assessed by analyzing the land-cover classification results. By using topographical information based on the generated high precision DEM and classification image through developed fusion algorithm, three dimensional land use map was obtained over Jeju Island. Three dimensional (3-D) land-cover classification image was produced by integrating the high-precision DEM and land-cover classification image (Figure 5).

3.2 Soil Moisture Map

Microwave is affected by dielectric constant (permittivity) of a target. The volumetric moisture contents are closely related with dielectric constant of scatterers (Figure 6). Soil moisture estimation algorithm over bare soil and low vegetated area was developed. Synthesized inversion model which integrates the land-cover, topographical information, and soil moisture of the Earth surface was produced. The physical properties of natural bare soil can be described in terms of its dielectric and geometric properties. In this study, the Oh model [Oh, 1992] was adapted and regulated to estimate soil moisture over bare soil and low vegetated area. The other area (high vegetated, urban area, road, etc.) except bare soil and low vegetated area were masked out in a preprocessing step. Two dimensional soil moisture map was generated over bare soil and low vegetated area in Jeju Island (Figure 7). The soil moisture parameters were measured through field analysis to validate developed inversion model. Soil moisture values of test site were measured using TDR (Time Domain Reflectometry). The model accuracy assessment was performed by analyzing the measured and estimated moisture values. The measurements results over study site are in accord with estimation results (Figure 8).

4. FUTURE PLAN

The multi-source (multi-spectral optic and polarimetric SAR) data fusion technique which was developed in this research offers powerful tool which meets the spatial and temporal resolution. Developed data fusion technique would be widely used for hazard monitoring and environmental management. Soil moisture inversion model enables quantitative analysis of the Earth surface environment.

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6. ACKNOWLEDGEMENTS

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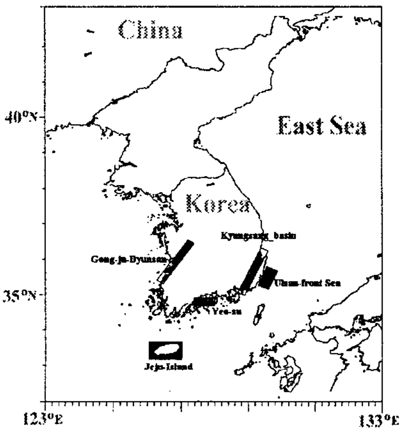

Figure 2 PACRIM-II AIRSAR Experiment in Korea and Jeju-Island selected for this research

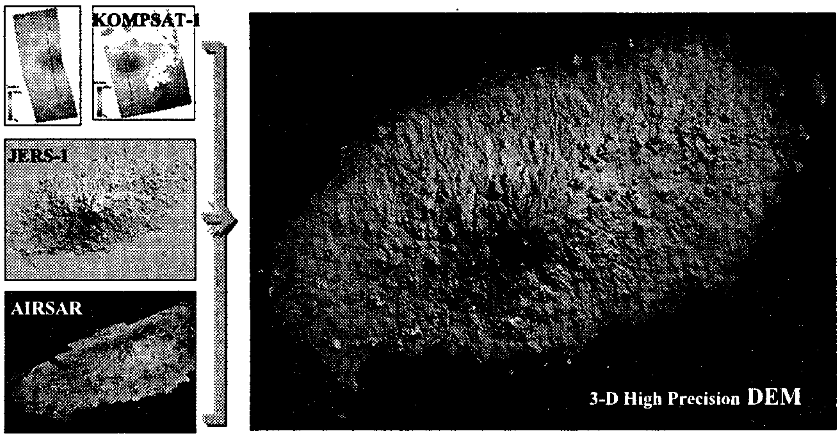

Figure 3 Generated high-precision DEM composite with JERS-1, AIRSAR, and KOMOSAT-1 DEMs over Jeju Island

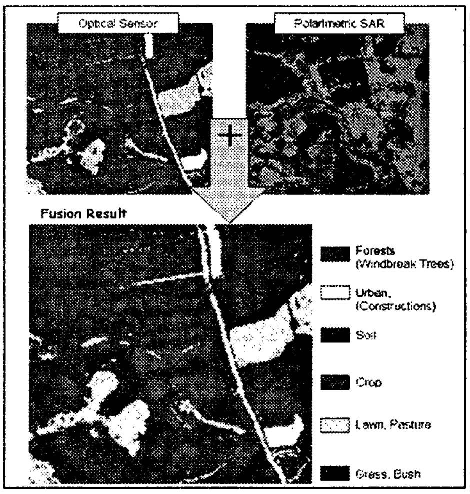

Figure 4 Data fusion result over study area using IKONOS optic and L-band polarimetric SAR imagery

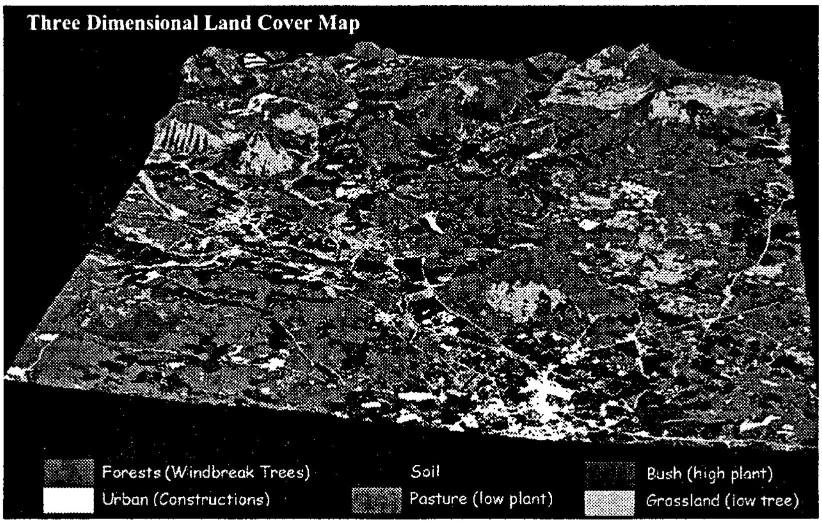

Figure 5 Three dimensional land cover map using high precision DEM and classified land use map from IKONOS and L-band POLSAR image.

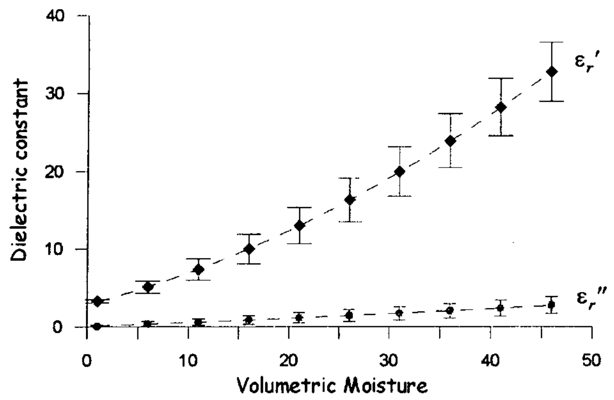

Figure 6 The relation dielectric constant and volumetric moisture.

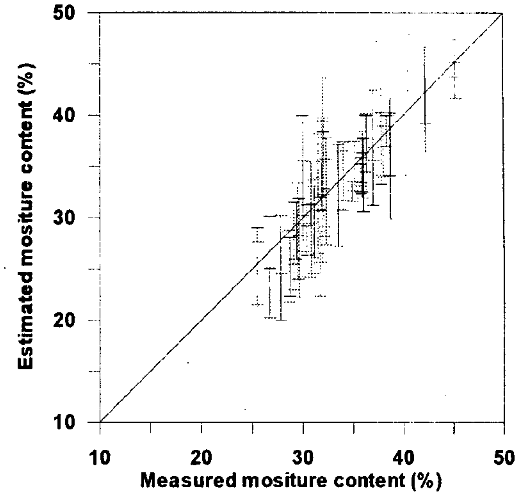

Figure 8 Verification of the accuracy in inversion model.

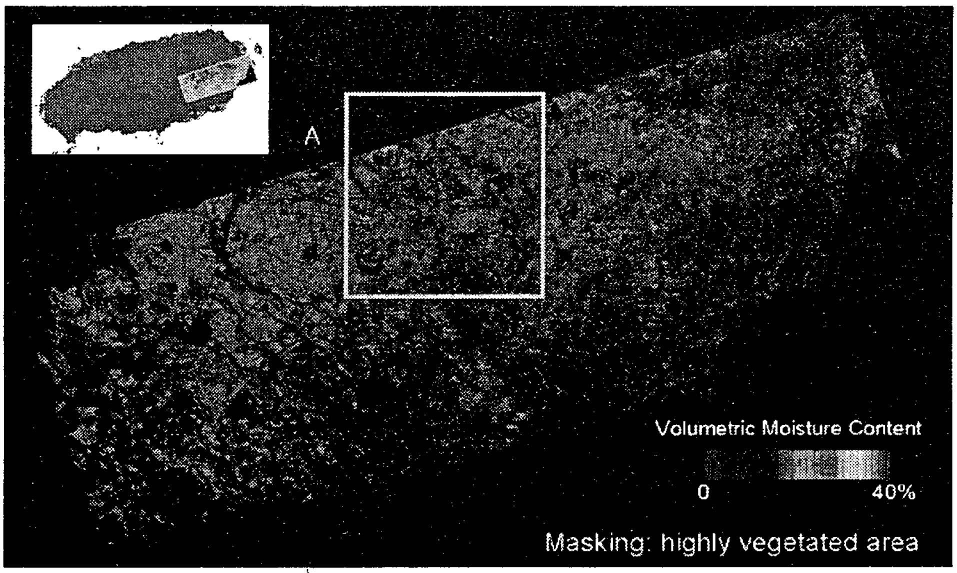

Figure 7 Soil Moisture map over bare soil and low vegetated area of Jeju Island. The highly vegetated area was masked.

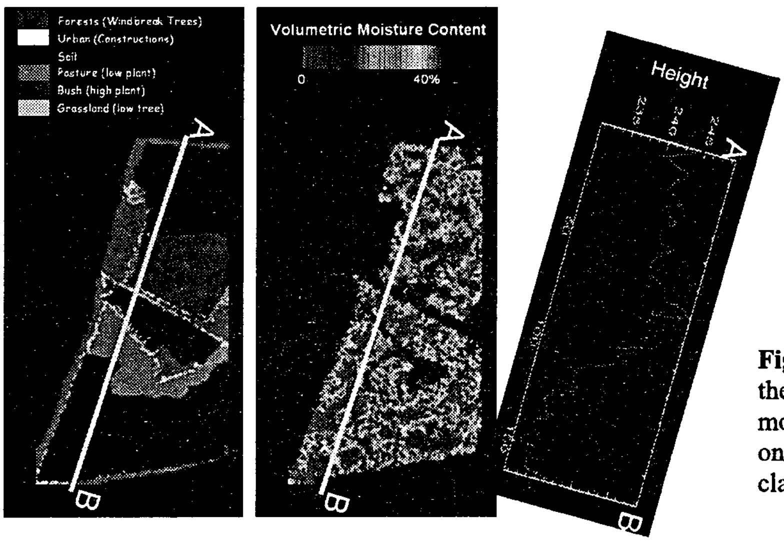

Figure 9 Analysis of the estimated soil moisture depending on the land-use classification