F-2.2 Monitoring and Mapping of Wetlands with Remote Sensing (Final Report)

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Abstract Satellite remote sensing was applied to monitoring and mapping of wetland environment. Satellite imageries from Landsat TM, JERS-1 SAR and other satellite sensors over typical wetlands from different areas of the world were retrieved, and satellite mosaic maps, vegetation maps and other environmental thematic maps were produced for several test sites with ground truth data. The selected test sites include Kushiro Mire in Japan, Matang Mangrove Forest in Malaysia, Pracho Khiri Kahn wetland in Thailand and several wetland areas in Australia. Sensor fusion techniques with different types of sensors and scaling techniques with different spatial resolution sensors were investigated as new data processing tools to monitor wetland environment and to produce thematic maps in local/regional/global scales .

1. Introduction

Wetland is one the most valuable ecosystems on the earth. It abounds biological diversity and are treasure houses of living things. Also today the importance of wetland is pointed out as a major emission source of methane which is one of the green house gases. As changes in wetlands are rapid and serious due to various human activities, it is urgent to monitor wetlands and their surrounding environment from physical, biological or social viewpoints. Ground survey of wetland is, however, difficult and time-consuming(1), and because of its difficulty there have been very few information on wetland in both of the local and the global scale.

The objective of the study is to develop remote sensing methodologies for monitoring wetland environment with satellite imageries. This study consists of two phases including the local and global approaches. The first phase takes the local or regional approach, and in this phase the detail land cover maps including vegetation maps in and around wetlands are produced by using high spatial resolution satellite data such as LANDSAT TM, SPOT HRV or JERS SAR imageries. This approach is individually applied to the several typical wetlands selected from the world. Sensor and data fusion techniques are devised to integrate data from various different types of sensors including optical sensors and microwave sensors, and to delineate complicated surface conditions of wetland in a mixture of vegetation, soil and water.

The second phase is global, and in this phase wetland type maps are produced in global or continental scale by using rather low spatial resolution but wide coverage data such as NOAA AVHRR imageries. The current objective area covers the Asian-Pacific region. Scaling techniques are devised to model the relation between high spatial resolution data and low spatial resolution data, and to extrapolate the local knowledge derived in the first phase to global scale.

This report summarizes the results of the regional case studies in the first phase. Landcover mapping in Kushiro Mire in Japan, Matang mangrove forest in Malaysia and Warrego wetland in Australia are demonstrated with special emphasis on the sensor fusion techniques. The second phase (global approach) is going to start from 1995 as a new program.

2. Outline of the project

This project consists of two phases including local (/regional) and global (/continental). As the first step of the study, several wetlands from different areas over the world are selected and their local landcover information is extracted from satellite data with high spatial resolution. Next, the local information obtained in specific test sites is extrapolated to global scale by combining the low spatial resolution (wide coverage) data to the high spatial resolution data used in the local approach and by formulating the scaling model (bridging model) between them.

The outline of the project is summarized in Fig. 1.

Output of the project

☆ Local approach

Wetland landcover maps for specific test sites (30～100m spatial resolution)

☆ Global approach (currently for Asia- Pacific region):

Wetland type map (1km～4km spatial resolution)

Methods

☆ Local approach

① Select typical wetlands from different latitude regions over the world as test sites, and collect satellite images (high spatial resolution data from LANDSAT TM, SPOT HRV, MOS MESSR, ERS SAR, JERS SAR etc.) and ground truth data.

② Produce environmental thematic maps including vegetation maps or landcover condition maps with 30m ～100m spatial resolution.

☆ Global approach

① Overlay NOAA AVHRR image (spatial resolution: 1km) to the high spatial resolution image at the test sites and formulate the scaling model which relates the low spatial resolution data (NOAA AVHRR) with the high resolution one.

② Identify and classify wetland with NOAA AVHRR images based on the model. Mosaic the classified wetland map to produce global or continental scale map.

Key techniques for data processing

☆ Sensor fusion and data integration

As wetland environment is characterized by a complicated mixture of vegetation, soil and water, in order to delineate the relation between them, remotely sensed data from different types of sensors including optical, thermal and microwave sensors must be integrated. In particular, microwave sensor data is used together with optical sensor data because of its potential characteristics for monitoring soil moisture and surface water conditions that are important parameters in wetland monitoring.

☆ Scaling

High spatial resolution data such as LANDSAT TM or SPOT HRV can not cover the whole continent or globe because their coverage is not so wide. In order to cover the wide area low spatial resolution but wide coverage sensor data such as NOAA AVHRR is required. Scaling model relates high spatial resolution data to low spatial resolution data, and to extrapolate the local knowledge derived from high spatial resolution data in the first phase to global scale.

The broad definition of wetland includes not only swamps, marshes, floodplains, bogs, fens or lakes but also rice fields, estuaries or lagoons, however in this project, only the natural wetlands are object for the study and rice fields are omitted from our scope.

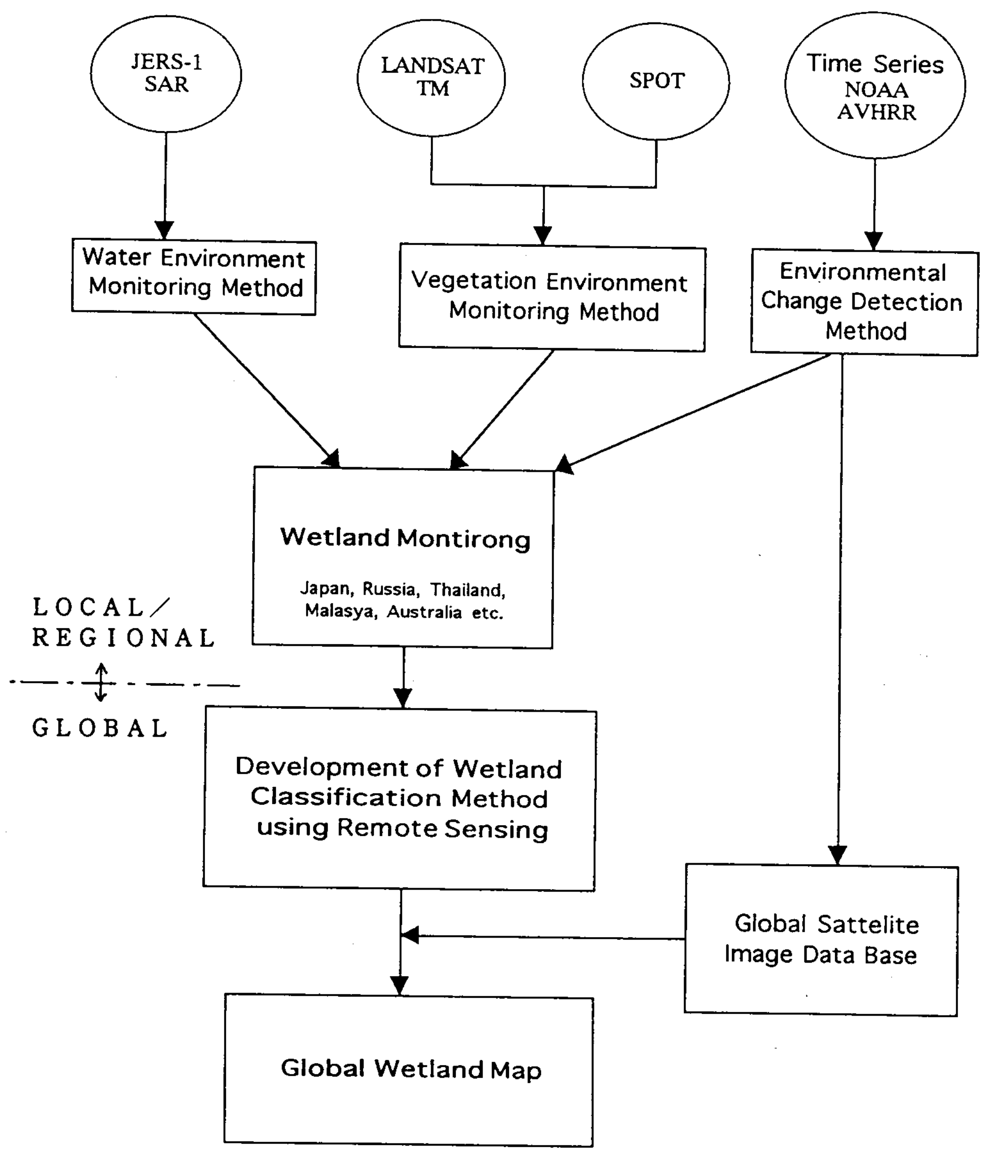


Fig. 1 Flow of the global wetland monitoring study.

3. Local case studies for specific test sites - preliminary studies

(1) Kushiro Mire - Vegetation classification with optical and microwave sensor data

LANDSAT TM, ERS SAR and JERS SAR data were applied to vegetation classification of Kushiro Mire in Hokkaido (43° 10'N, 144° 30'E). It is one of the biggest wetland in Japan and its extent is around 29,000 ha. The dominant species in vegetation are Sphagnum, Sedge, Reed and Alder. Kushiro Mire has been facing serious environmental problems due to regional developments.

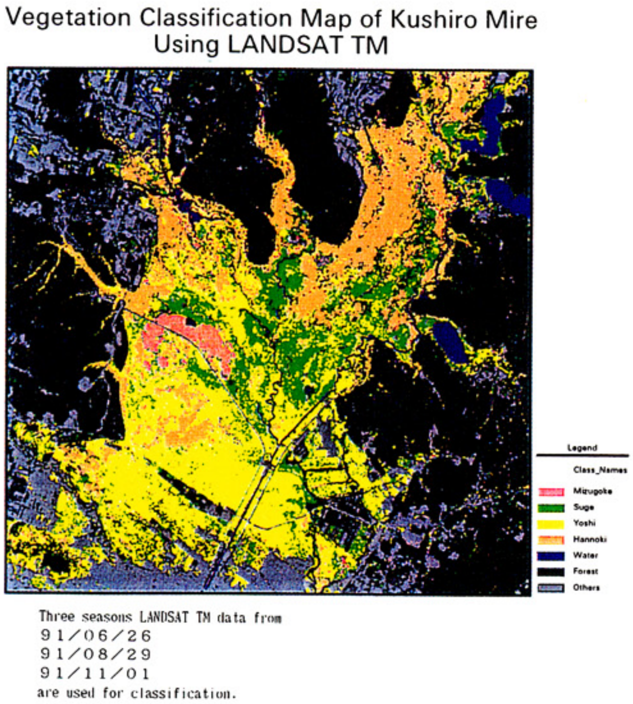
First, vegetation in the Mire were classified into seven categories including Sphagnum, Sedge, Reed, Alder, open water, forest and others by using three TM imageries from spring, summer and autumn in 1991 which represent the seasonal variations of vegetation conditions. Three dates images were registered each other and combined into eighteen bands images. Here, for each date image, six bands (Band 1-5 and 7) from visible and near-infrared were used for classification. The maximum likelihood classification (MLC) scheme was applied to the combined eighteen bands images with more than ninety training areas.

Next, ERS SAR and JERS SAR images were also applied to vegetation classification and to the measurement of other land surface conditions including soil moisture or water content. Texture analysis method was first used to delineate landcover types from SAR data (2), and also the multi-season SAR data analysis was investigated for vegetation classification as was done for LANDSAT TM images. Vegetation classification using three seasons SAR imageries from spring, summer and autumn shows that SAR data, in particular L-band SAR (JERS SAR) may reflect not only vegetation conditions but also surface water conditions under vegetations. Also the combination of TM data and SAR data was tried for vegetation classification. The results of the landcover classification of Kushiro Mire by using LANDSAT TM, and JERS and ERS SAR are shown in Fig.2. Figure 2(a) shows the land cover map produced by LANDSAT TM and (b) shows the map produced by the combination of JERS SAR and ERS SAR.

(2) Matang Mangrove Forest - Growth age classification

MOS-1 MESSR (spatial resolution: 50m) was used for growth age classification of mangrove in Matang mangrove forest in Malaysia (4 ° 50 ' N, 100 ° 45' E) . Only one scene was used for the classification as there was no good quality cloud free image. As ground truth data, a mangrove distribution map from "A Working Plan for the Second 30 years Rotation of the Matang Mangrove Forest Reserve, Perak" published by Perak State Authority (3) was used. The map was digitized and overlayed with MESSR data, and used as a test data for the classification. Figure 3 shows the classified results. Classification includes 10 categories; Period 1 charcoal, Period 1 Firewood, Period 2 Firewood, Period 3 Firewood, Dryland, Forest, New Forest, water and others.

Next, MOS-1 MESSR data was overlayed to NOAA AVHRR data with spatial resolution of 1km to formulate the scaling model between them. The relation between an image density of a pixel of AVHRR and the image densities of a set of 400 pixels in MESSR corresponding to a pixel of AVHRR, and also the relation between the classified categories in MOS-1 MESSR and the corresponding image densities of pixels of AVHRR were examined to formulate statistical scaling model between AVHRR data and MESSR data. There were high relations between them, and the possibility of scaling between them was indicated. Figure 4 shows the overlay image between the NOAA AVHRR image and the mangrove growth age map classified from MOS-1 MESSR image.



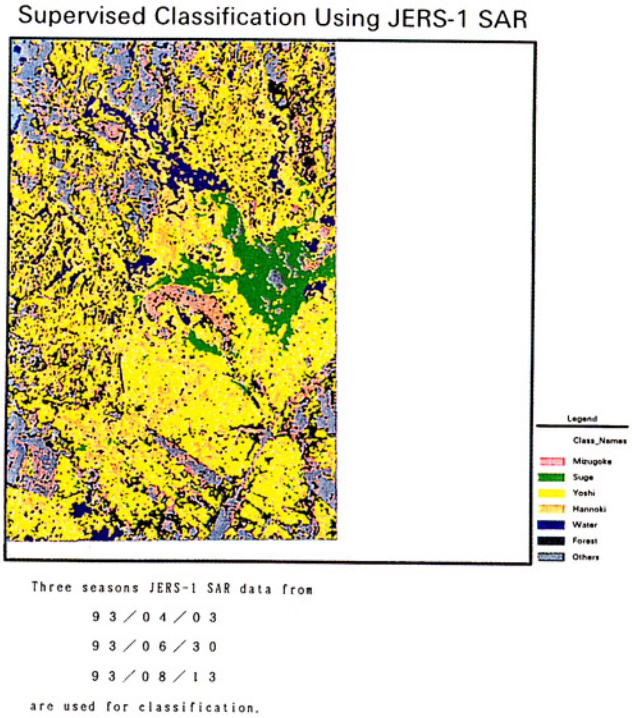


Fig. 2 Vegetation map of Kushiro Mire. (a) Classified from three seasons LANDSAT TM data, (b) Classified from three seasons JERS-1 SAR data.

Fig.3 Growth age map at Matang Mangrove forest classified from MOS-1 MESSR.

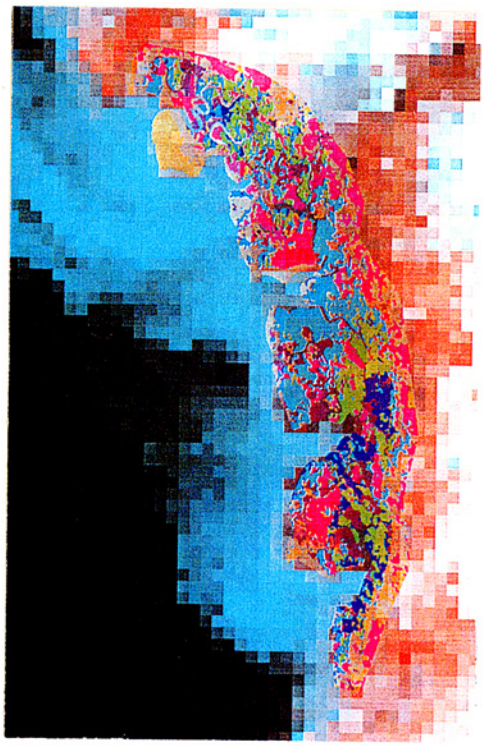


Fig.4 Overlay between NOAA AVHRR and classified map.

(3) Warrego Wetland - Vegetation classification from satellite mosaic map

Warrego is located at south east of Australia , and is defined as arid wetland along river basin. Environmental characteristics of wetland are quite different from previous test sites. Here, JERS-1 OPS images with spatial resolution of 18m were used for landcover classification of wetland. First, nine OPS images were composited to produce satellite mosaic map covering the whole wetland area after geometric correction onto the Digital Chart of the World (DCW). Next, landcover cover conditions were categorized into eight classes including water, wetland (deep water level), wetland (mid water level), wetland (shallow water level), wetland vegetation with low height, wetland vegetation with high height, wet bare ground and dry bare ground. In the classification, first, unsupervised clustering with ISODATA method was performed to classify the area into 25 clusters, and next a specialist (human operator) examined the physical meanings of these 25 clusters and merged them into 8 classes above. Figure 5 shows the classified map of Warrego wetland with the river system on the DCW.

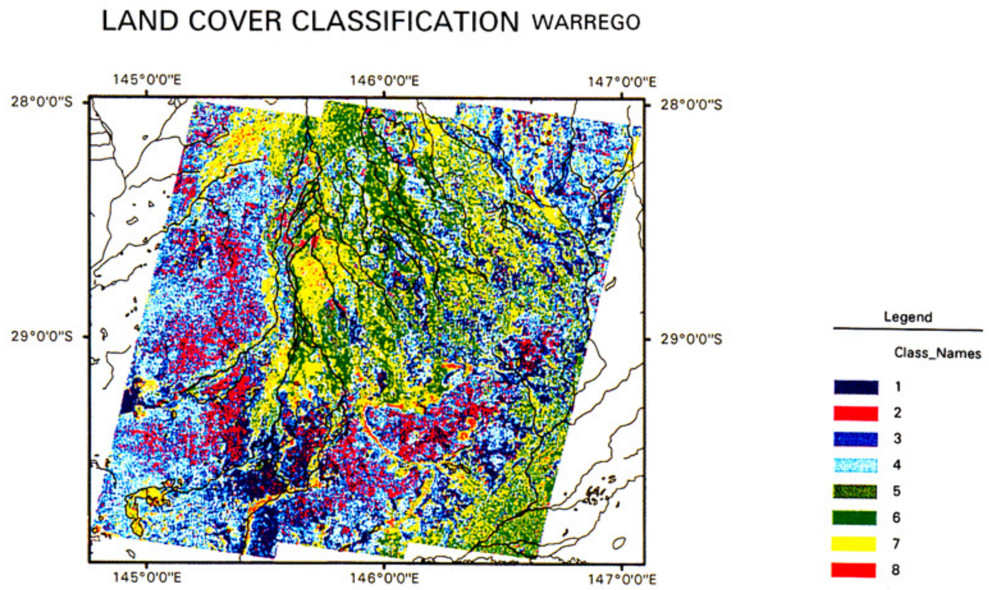


Fig. 5 Landcover classification of Warrego Wetland in Australia with JERS-1 OPS mosaic map.

4. Conclusions

The new approach for mapping and monitoring of wetlands by using remote sensing was introduced and results of preliminary studies in Japan, Malaysia and Australia were demonstrated. Remote sensing from space may provide the advantages in monitoring vegetation, soil, water and other environmental parameters in the local, regional and global scale. The results of the case studies indicate the high potentiality of applying remote sensing to wetland monitoring and mapping.

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