Scaling between NOAA AVHRR Data and LANDSAT TM Data for Monitoring and Mapping of Wetland

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Abstract

A scaling technique was investigated to extrapolate the local information on landcover type mixtures derived from high spatial resolution data (TM) to more extensive area through low spatial resolution but wide coverage data (AVHRR). Over a combined set of TM and AVHRR, first, landcover types of the area was classified into three categories including vegetation, water and others (non-vegetation) with TM data, and next AVHRR image density was statistically regressed with category mixture conditions derived from TM pixels in each AVHRR pixel. Based on the regression model (scaling model) local information on the category mixture was estimated only from AVHRR data over more extensive area. The method is applied to the wetland type categorization and mapping with AVHRR where landcover is required to be characterized by the complex mixtures of vegetation, water and soil..

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 now 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, and because of its difficulty there have been very few information on wetland in both of the local and the global scale. Remote sensing may provide an effective tool for monitoring a wide range of wetland parameters.

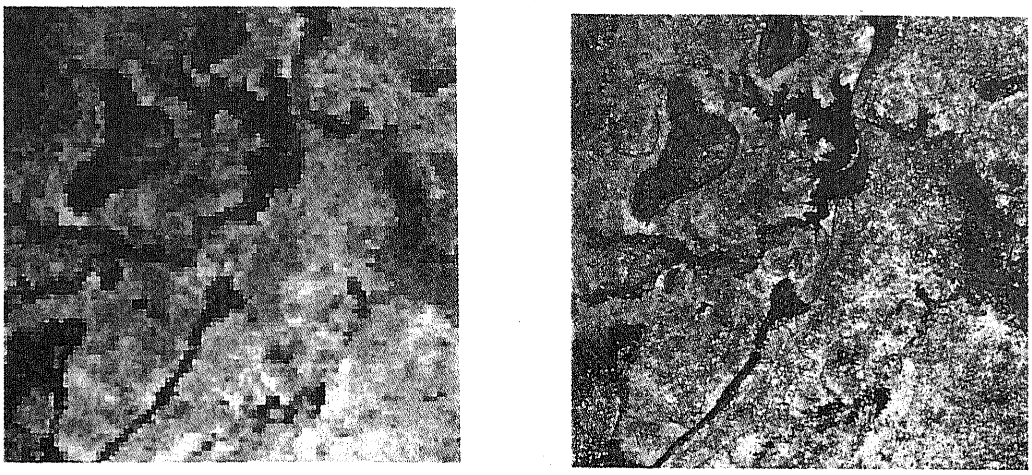
There are two approaches to apply remote sensing to wetland monitoring (Yasuoka et al. 1994). The first approach is local, and in this approach various kinds of thematic maps including a vegetation map or a landcover map are produced with high spatial resolution data over individual wetlands. The other approach is continental/global, and in this approach wetland type maps are produced on a continental or a global scale by classifying wetlands into several categories such as bog, fen or marsh in terms of mixture conditions between vegetation, water and soil. This approach would require to use wide coverage (but low spatial resolution) data.

There have been several studies to produce landcover maps of individual wetlands by using high spatial resolution data from LANDSAT MSS, TM , SPOT HRV or JERS-1 SAR (e.g., Federal Geographic Data Committee 1992; Yamagata et al. 1992). High spatial resolution data is effective to monitor wetland environment on a local or a regional scale, however, it can not cover an extensive area because their coverage is not so wide. Extending the area would require to use wide coverage data from NOAA AVHRR. Normalized Difference Vegetation Index (NDVI) from AVHRR, for example, has been successfully utilized to monitor vegetation conditions on a global scale (e.g., Tucker et al. 1995; Defries et al. 1995). However, on the other hand, AVHRR data can not detect fine spatial structures in mixtures of vegetation, water and soil in wetland because its resolution is too coarse (1.1km).

In this study a scaling technique between TM and AVHRR is investigated to unmix each AVHRR pixel and to estimate the landcover mixture conditions in vegetation, water and soil from AVHRR data. Scaling model relates high spatial resolution data to low spatial resolution data, and to extrapolate the local knowledge derived from high spatial resolution data to global scale (Hlavka et al. 1995; Iverson et al. 1989). In this paper, first, vegetation index and other parameters are compared between TM and AVHRR, and next the relation between the AVHRR image density and the landcover mixture condition based on TM classification is investigated.

2. Comparison of Vegetation Index between TM and AVHRR

LANDSAT TM data of February 9, 1990 and NOAA AVHRR data of February 1, 1990 over Kohn Kaen area in Thailand were geometrically corrected and overlayed so that one pixel of AVHRR covers a set of TM pixels in a rectangular block of 36 x 36 (Fig. 1). Spatial resolution of one pixel of AVHRR is around 1.1 kilometers and that of TM is around 30 meters. Then the relations between each pixel of AVHRR and corresponding block of 36 x 36 pixels of TM were statistically investigated in several parameters including image densities (CCT counts), vegetation index values, landcover categories.



(a) NOAA AVHRR: Feb.1, 1990 (b) Landsat-5/TM: Feb.9, 1990

Fig.1 Image overlay between NOAA AVHRR and LANDSAT TM over Kohn Kaen in Thailand (AVHRR: 1990/2/1, TM: 1990/2/9).

(1) AVHRR NDVI and TM NDVI

Normalized Difference Vegetation Index (NDVI) for AVHRR and TM are defined by

$$NDVI_{AVHRR} = (AV_2 - AV_1) / (AV_2 + AV_1) \qquad (1)$$
$$NDVI_{TM} = (TM_4 - TM_3) / (TM_4 + TM_3)$$

where AV_1, AV_2, TM_3 and TM_4 are the CCT counts for NOAA AVHRR band 1 and 2, and LANDSAT TM band 3 and 4 respectively. The relation between NDVI value for each AVHRR pixel and an average NDVI value for a corresponding TM block of 36 x 36 pixels is examined (Fig.2). Regression analysis between $NDVI_{AVHRR}$ and $NDVI_{TM}$ shows high correlation between the vegetation index of LANDSAT TM and NOAA AVHRR (r=0.88);

$$NDVI_{AVHRR} = 0.52\ NDVI_{TM} + 0.14. \qquad (2)$$

(2) AVHRR NDVI and TM Tasseled Cap Greenness Index

Greenness Index (GI) was calculated from TM data by

$$GI = -0.27TM_1 - 0.22TM_2 - 0.55\ TM_3 + 0.72\ TM_4 + 0.07\ TM_5 - 0.16\ TM_7 - 0.73. \qquad (3)$$

The relation between AVHRR NDVI and TM GI is shown in Fig.3.

$$NDVI_{AVHRR} = 0.28 + 0.0070\ GI \qquad (4)$$

It indicated lower correlation than the case for AVHRR NDVI and TM NDVI and this may be the effect of water area in TM data which shows relatively lower GI values than NDVI.

3. Estimation of category mixing ratio from NOAA AVHRR data

Scaling model between LANDSAT TM and NOAA AVHRR was investigated to estimate the mixing ratio of landcover categories in each pixel of AVHRR data. Based on the derived model, the local information around Kohn Kaen derived from TM data was extrapolated to the whole South-East Asia region through AVHRR data.

(1) AVHRR NDVI and TM landcover category (vegetation, non-vegetation, water)

Each pixel of LANDSAT TM was, first, classified into three categories including vegetation, non-vegetation and water area by using unsupervised classification, and in each block of 36 x 36 pixels, ratio in area of each category , V, N, W for vegetation, non-vegetation and water respectively, was calculated (V+N+W=1). Then AVHRR NDVI was correlated with V, N, W using multiple regression analysis. The regression model

$$NDVI_{AVHRR} = 0.24\ V + 0.10\ N - 0.04\ W \qquad (5)$$

was obtained in high correlation (Fig.4). Three parameters V, N, W are mixing ratio of vegetation, non-vegetation and water in one AVHRR pixel, therefore, Eq.(5) shows that AVHRR NDVI can be

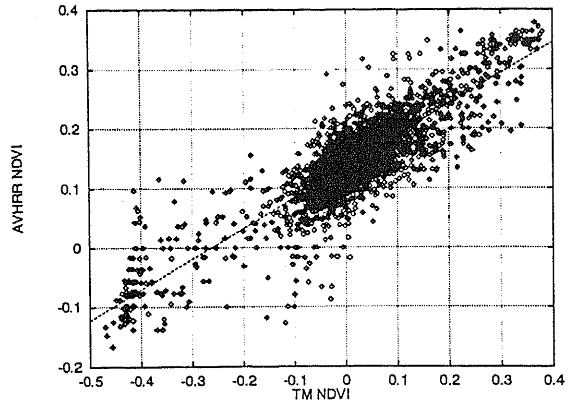


Fig. 2 Relation between AVHRR NDVI and TM NDVI

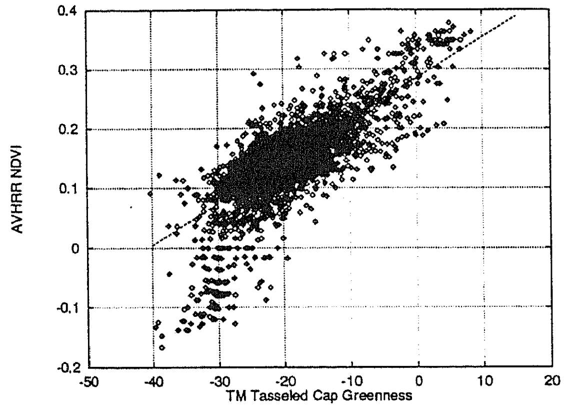


Fig. 3 Relation between AVHRR NDVI and TM Greenness Index

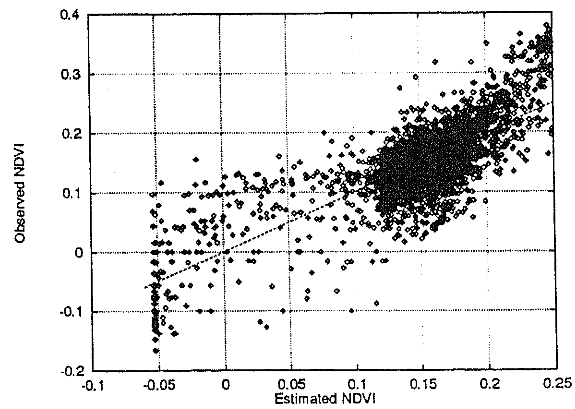


Fig. 4 Relation between AVHRR NDVI and landcover category mixing ratio from TM classification.

estimated from the category mixing ratio based on the landcover classification using TM data.

(2) AVHRR CCT count and TM landcover category (vegetation, non-vegetation, water)

The relation between AVHRR image densities (CCT counts) and the category mixing ratio (V,N,W) was examined, and the multiple regression equations

$$AV_1 = 31.1\,V + 52.6\,N + 33.4\,W \qquad (6)$$
$$AV_2 = 52.6\,V + 67.5\,N + 30.0\,W$$

were derived for AVHRR image density in band 1 (AV_1) and band 2 (AV_2). This relation shows that the category mixing ratio (V, N, W) can be inversely solved from Eq.(6) and the relation V+N+W=1, and that the category mixing ratio can be estimated from NOAA AVHRR image density (AV_1 and AV_2). Figure 5 shows the category mixing ratio image of South-East Asia from NOAA AVHRR image based on Eq.(6) . This scaling model indicates that the local information (category mixing ratio) derived from LANDSAT TM data is extrapolated to more extensive area by using NOAA AVHRR data.

4. Conclusions

This study demonstrated that scaling techniques would provide a tool to extrapolate local information from high spatial resolution data to larger scale by using low spatial resolution data. As most of the global issues including deforestation or desertification originate from local events such as shifting cultivation or extensive logging, monitoring earth surface changes requires that observation of landcover should embrace the terrain from local to global. Linking local with global is one of the key aspects in tackling with global environmental issues and a method proposed in this study is expected to play a role in realizing the bridge between the local and the global in remote sensing.

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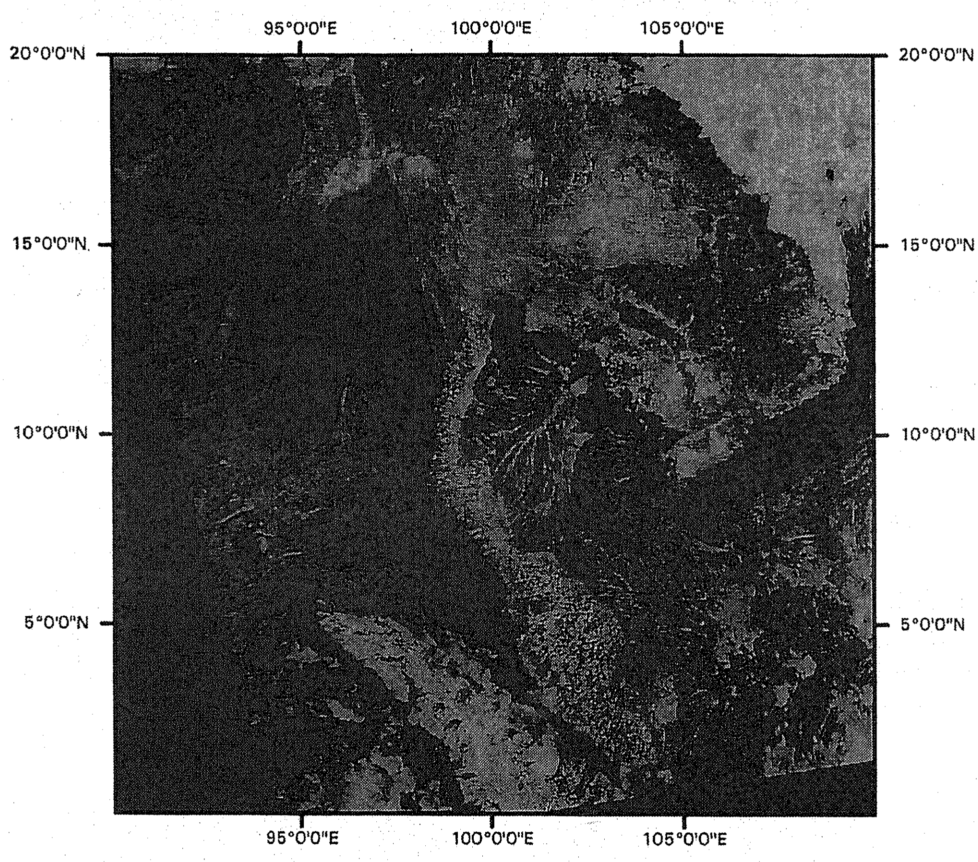

Mixel Decomposition Result
R:G:B=Non-Veget.:Veget.:Water

Fig.5 Category mixing ratio map derived from NOAA AVHRR based on the scaling model.