Monitoring and analysis of global surface environmental changes by satellite data

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Abstract

The Project 1 of the CEReS research project aims to understand the present situation and changes of global surface environment. This project is an integrated project of several sub-projects. This paper describes a framework of the Project 1 and its achievements which include Re-calibration of NOAA/AVHRR over Land, Production of global MODIS data of 2003, Global land cover, Global percent tree cover and Behavior of a surface temperature/vegetation index (TVX) matrix derived from 10-day composite AVHRR images over monsoon Asia.

Keywords **:** land cover, percent tree cover, AVHRR, MODIS

1. Introduction (Framework of Project 1)

For the final goal of understanding global change, the Project 1 consists of the following three parts. The first part is to produce global/local datasets of land cover, percent tree cover, snow/ice distribution from satellite data to know the present surface environment. The second part is to extract global surface changes by detecting vegetation changes from global 20-30 year satellite data and by analyzing it with climate data. The third part is to analyze detail environmental changes considering natural and human factors in local scale of the test sites of East Asia.

Fig. 1 shows overall concept of the Project 1. In order to obtain global surface information, preprocessing of global satellite data is prerequisite. In this project two preprocessing has been completed. One is post-launch calibration of Pathfinder AVHRR Land (PAL) data. The other one is cloud removal of MODIS 16-day composite data.

In the step of "Mapping current environment", land cover and percent tree cover has been completed.

In the step of "Change/trend analysis," global/continental vegetation changes have been found[1)-5)].

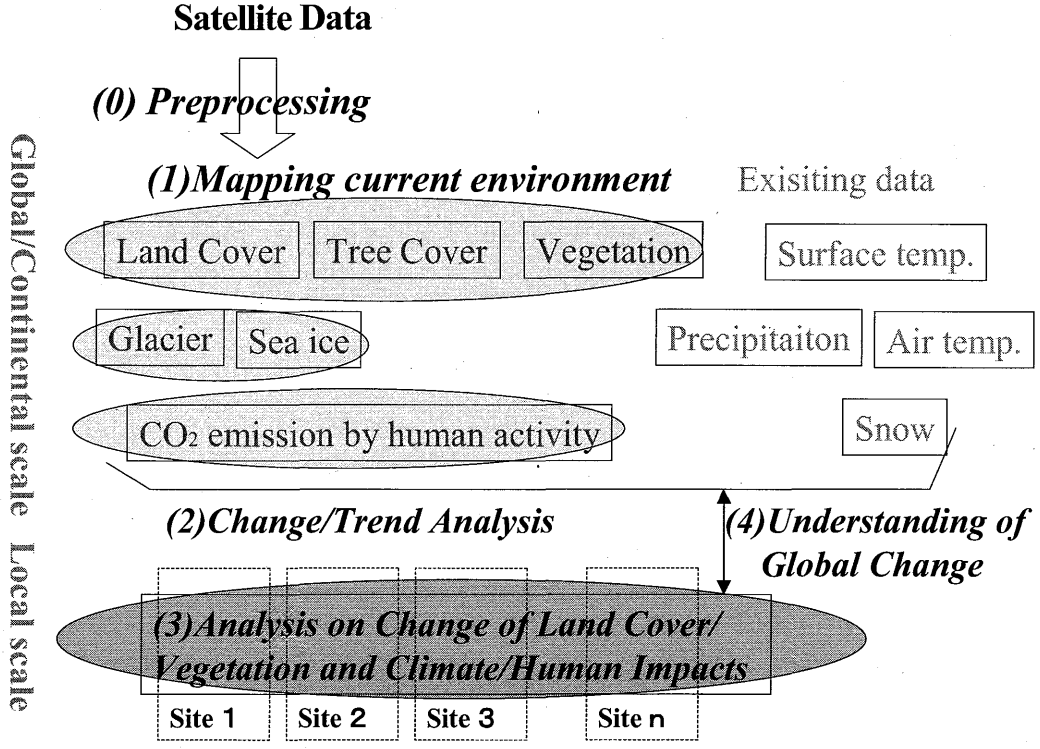

Fig. 1 Framework of Project 1

The environmental analysis of local scale focused on "analysis on change of land cover/vegetation and climate/human impacts" is closely related with the Project 4 of CEReS research projects, these are reported in the Achievement of Project 4.

2. Re-calibration of NOAA/AVHRR over Land[6)]

Long-term datasets derived by satellite observations are important for terrestrial studies. The longest records are daily daytime observations by the Advanced Very High Resolution Radiometers (AVHRRs) carried on NOAA spacecrafts. However, NOAA/AVHRR data are affected by spacecraft orbital delay (SOD). To address these effects, the Pathfinder AVHRR over Land (PAL) data have been derived from NOAA/AVHRR data using a time-dependent calibration method. This study examined the effect of time-dependent calibration on PAL and proposes a recalibration approach using optical channels. To evaluate the calibration effect, daily PAL (Daily-PAL) data were used, with bright clouds sampled as a white reference. The time series from clouds samples showed increasing trends in the visible channels of NOAA-14 and in the near-infrared channels of NOAA-9, -11, and -14. To recalibrate these data, the proposed time-dependent recalibration formula was used. To assess the effect of the recalibration process on the estimated normalized difference vegetation index (NDVI), annual mean global maps were created for the periods of NOAA-11 and NOAA-14. For NOAA-11, the global mean differences of the original and recalibrated NDVI in 1989 and 1992 were -0.003762 and -0.016555, respectively. On the other hand, no significant effect of recalibration was confirmed in the NDVI for NOAA-14. For the NOAA-14 period, improving the quality of related parameters is important for improving the dataset.

3. Production of global MODIS data of 2003

Global MODIS data observed in 2003 were preprocessed for wide use of global environmental stidies. The source MODIS data are of the MODIS/TERRA Nadir BRDF-Adjusted Reflectance 16-DAY L3 Global 1 KM SIN Grid Product (MOD43B4 NBAR). These are 16-day composite, 7-band, 1-km, 10-degree tile data. The source MODIS data were reprojected into a latitude/longitude coordinate system, and mosaicked to produce data of five continents (Eurasia, North America, South America, Africa, and Oceania) and three island regions, as presented in Fig. 2. Mosaicking and reprojection were done using MODIS Reprojection Tool (MRT) software. Geometric accuracy after mosaicking is 141–277 m in RMSE for the east–west direction or north–south direction in each continent when compared with Landsat images from GLCF from the University of Maryland as a correct location.

Cloud-contaminated pixels were replaced through linear interpolation of two cloud-free pixels before and after the cloud pixel in cases where the cloud-contaminated period is equal or less than six 16-day periods. The cloud-contaminated pixel was replaced by the average of 2002 and 2004 MODIS data at the same location and the same time of the year if it is more than six 16-day periods. The processed MODIS data is available from from the CEReS website (http://www.cr.chiba-u.jp/databaseGGI.htm [GG-5]).

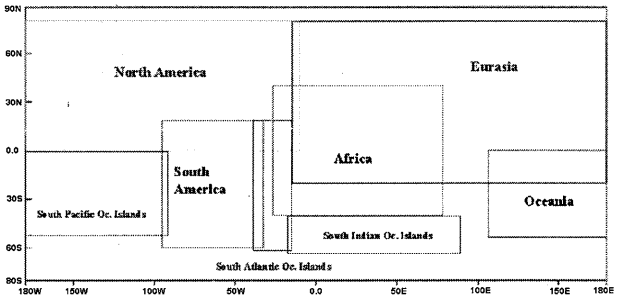

Fig.2 Regions of continental MODIS data

4. Global land cover

A 1-km global land cover dataset—Global Land Cover by National Mapping Organizations (GLCNMO)—was produced, as shown in Fig.3, both as the Project 1 of CEReS research project and as a part of Global Mapping project organized by the International Steering Committee for Global Mapping (ISCGM). It has 20 land cover classes defined using the Land Cover Classification System (LCCS). Of them, 14 classes were derived using supervised classification. The remaining six were classified independently: Urban, Tree Open, Mangrove, Wetland, Snow/Ice, and Water. Primary source data of this land cover mapping were eight periods of 16-day composite 7-band 1-km MODIS data of 2003. Training data for supervised classification were collected using Landsat images, MODIS NDVI seasonal change patterns, and comments from National Mapping Organizations with reference to Google Earth, Virtual Earth, and existing regional maps. The overall accuracy with the weight of the mapped area coverage is 81.2%, assessed using global 600 points collected through stratified random sampling. The data are available from the Global Mapping project website (http://www.iscgm.org/) or from the CEReS website (http://www.cr.chiba-u.jp/database

GGI.htm [GG-6]). The MODIS data used, land cover training data, and a list of existing regional maps are also available from the CEReS website. This mapping attempt demonstrates that training/validation data accumulation from different mapping projects must be promoted to support future global land cover mapping.

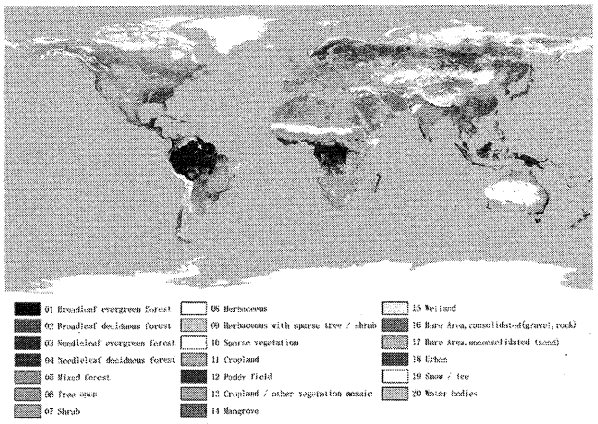

Fig.3 Global land cover - GLCNMO

5. Global percent tree cover

A 1-km global percent tree cover dataset was produced by the same project framework as the global land cover –GLCNMO, as shown in Fig. 4. It was produced from MODIS data of 2003 by the authors using decision tree method. Training data of the percent tree cover were collected globally from 221 sites with various land cover types. In fact, 68 sites are from pan-sharpened QuickBird images; 153 sites are from Google Earth images. Decision rules were obtained using MODIS predictor variables and training data using Cubist tool, a commercial regression tree program. Estimates of the percent tree cover from MODIS data were done using an NLCD mapping tool developed for a national land cover project of the United States Geological Survey (USGS). The produced data are available from the Global Mapping project website (http://www.iscgm.org/) or from the CEReS website (http://www.cr.chiba-u.jp/databaseGGI. htm [GG-9]).

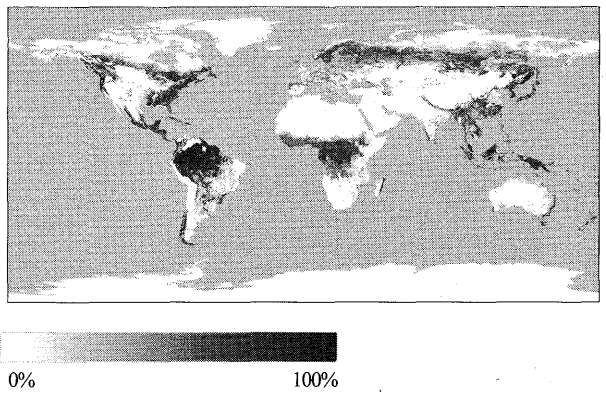

Fig.4 Global percent tree cover

5. The behavior of a surface temperature/vegetation index (TVX) matrix derived from 10-day composite AVHRR images over monsoon Asia[5)]

This study focuses on a Temperature/Vegetation Index (TVX) matrix that combines surface temperature (Ts) and a normalized difference vegetation index (NDVI). The results of our study show the behavior of the TVX matrix on continental scales. The study domain includes eastern Eurasia and monsoon Asia-regions with great variability in land-surface conditions. The data used included a 10-day composite Advanced Very High Resolution Radiometer (AVHRR) dataset compiled by the US Geological Survey (USGS). The relaxation in the determination algorithm for TVX slope (an upper envelope line in a TVX matrix box) was conducted to obtain both the negative and positive slope. The TVX slope can be derived from previous studies as the monsoon advanced and retreated over the tropics. However, over the Tibetan Plateau, a time series of the TVX slope showed an opposite sign compared to those in previous studies (represented by a positive TVX slope). Scatter plotting of the TVX matrix pixel sets was conducted for the evaluation of a variety of TVX matrix pixels. The TVX slope error sometimes occurred over arid regions because of a few green pixels corresponding to oases or irrigated areas. On the Tibetan Plateau,
'two' TVX slopes, both negative and positive, were found in the scatter plot. The reason for the two TVX slopes is the energy consumption in the soil, particularly, the phase change from frozen to liquid water (Fig.5). However, further study will be required to understand the mechanisms on the Plateau.

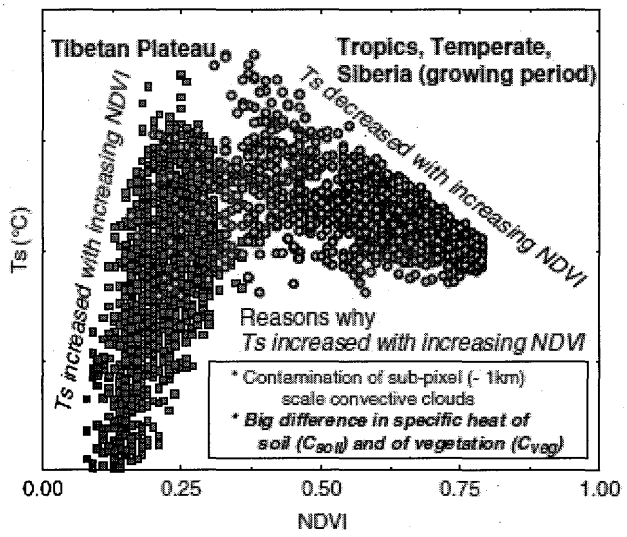

Fig. 5 Schematic diagram of 'two' TVX slopes in TVX matrixes (after Higuchi et al., 2007[5]).

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