# A DIGITAL COMPOSITE OF DMSP NIGHTTIME IMAGE AND NOAA/AVHRR DATA WITH ITS GEOGRAPHICAL CONSIDERATION

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ABSTRACT:

A digital producing method of global composite image of the DMSP nighttime data and the corresponding NOAA GVI and geographical information data was studied. The procedure consists of the map projection, satellite image geographical correction, the mosaicking operation and the compiling system. Analyzing thus produced image with the other geographical information, the night light distribution was recognized to be related with the land cover condition.

KEY WORDS: DMSP. Global Monitoring. GVI. NOAA. Registration. Remote Sensing.

## 1. INTRODUCTION

Natural changes as carbon dioxide discharge to the atmosphere due to the energy consumption with human activity or forest cutting are indicated as a factor of natural environmental change of global scale.

Night image of the earth surface observed from satellite includes one which shows various light patterns by artificial factors or one which shows natural phenomena. we know today that these major night light patterns are derived from the light distribution due to the human activities in urban area, forest, farmland, ocean, or oil fields. The authors have studied the local characteristics about the relationships between the artificial light distribution and human activities. As a result of our past study, we recognize the necessity of the global assessment of the light distribution accompanied with human activities. In order to perform the detail investigation on the state of light distribution, its types, its changes, it is important that other satellite images and geographical information are combined and the state is analyzed from the geographical points of view.

As one of the data sets of the land area of the globe operationally observed and kept, NOAA/AVHRR data and its derived product, global vegetation index GVIP are counted.

In this study, first, several DMSP night time images distributed as the film were digitized and geometrically corrected, and produced as a mosaicked night image of full sphere. Next, an analysis was performed combining this, GVI data, and the geographical information, and the global scale light distribution was investigated. In addition, the study from the geographical point of view was done about the relationship between light distribution and the human activity in global scale.

## 2. Used Data

The utilized nighttime image was observed by DMSP(Defense Meteorological Satellite Program) of an polar orbital satellite being launched in the series from the half 1960's. This mounting sensor system(OLS:Operational Linescan System) provides, the images of visible mode (0.4 - 1.1 μ m) and infrared mode (10.4 -12.4 μ m) regions 4 times in a day. The visible band detects nighttime image which observe for 3000km width with 2.7km spatial resolution. The observational image is stored in WDC/NSIDC(World Data Center/National Snow and Ice Data Center) put in Colorado university and it is distributed as a film. In this study, 41 nighttime images including a lot of lights were used as shown Fig.1. The nighttime images which shows the distribution of lights clearly was selected from the images observed in the latter half in 1980's. However, some images observed in the latter half in 1970's about the region which a good scene could not be selected by influence of clouds, was used. And also, the GVI data and geographical information (WDB-II:World Data Bank II) data were analyzed together with the nighttime image for detailed investigation of the distribution, kind, and change of lights on the earth.

## 3. PRODUCTION OF GLOBAL NIGHTTIME IMAGE

### 3.1 Outline of Production Procedure

After geometrical correction using ground control point (GCP), a global nighttime image was created through the mosaicking operation from the several scenes of the DMSP nighttime image which converted a black and white film into digital image .
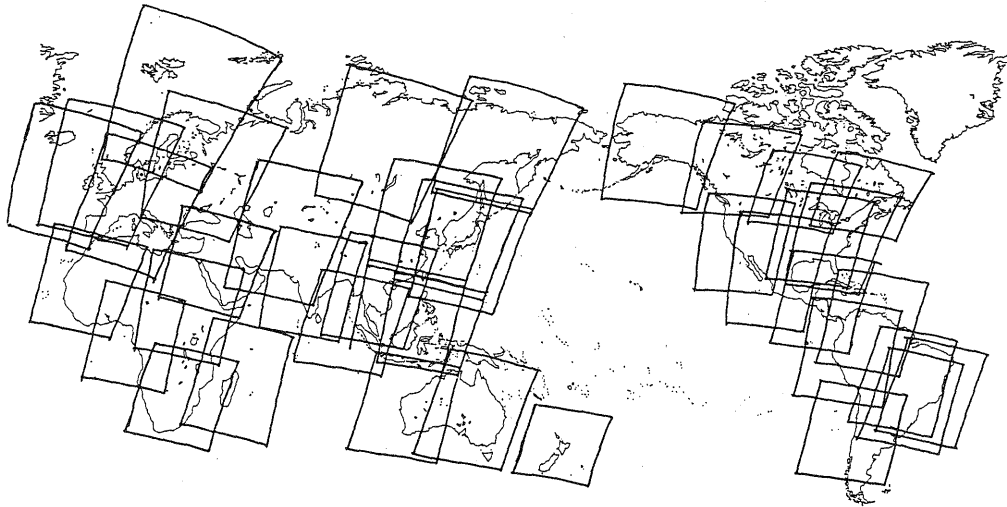
The production of the mosaicked global

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Figure 1  Area of Utilized DMSP Nighttime Image

nighttime image from several DMSP night-
time images is necessary taking care to
the following items:
a) Map projection for global scale
b) Detailed geometrical correction
c) Mosaicking among several images
d) Exclusion of cloudy image
   And, the principal stages of production
procedure are as follows:
1) Analog to digital conversion
2) Image projection
3) Mosaicking
A production procedure is shown in Fig.2
and each processing item is described
below.

## 3.2 Analog to Digital Conversion

The A/D conversion was performed by a
drum scanner   using  a  black and white
image of the 8x10 size almost printed from
the negative film.  It was the same condi-
tion, and a conversion executed all scenes
at 50 μm pitch was made about 4000 pixels
by 4900 lines by the scanning method of a
reflection   type.  But   it   was   actually
converted into the number of picture
elements of one eight because this conver-
sion size for the processing of creation
of global mosaic images by this conversion
size for 3000km DMSP observation widths is
too  big.

## 3.3  Image Projection (Geometrical
       Correction

A method of plate carree projection was
used as a  map projection for the global
nighttime  image.   While this is one of
the  map  projection  applied  to  the  GVI
data, and the distortion of the area near
the poles is large. Because the conversion
expression of latitude, longitude   and
the X, Y coordinates was simple, it was
adopted.  The size of all global images
was made longitude direction 5000 pixels
(180 degrees west to 180 degrees east) and
made its latitude direction 2600 lines (90
degrees north to 90 degrees south).    In
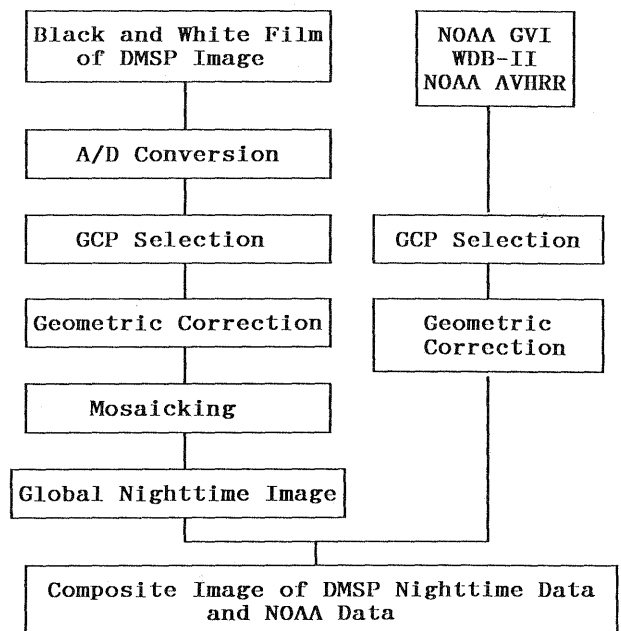this case, the size of a pixel   near the



Figure 2  Production Procedure

equator is about 8 km.  The relationship
between a latitude, a longitude, a pixel
and a line is the following;

$$M P = X + 2 5 0 0 \qquad (1)$$
$$M L = - Y + 1 2 5 0 \qquad (2)$$
$$X = N L / 3 6 0 * (\lambda - \lambda_0) \quad (3)$$
$$Y = N L / 3 6 0 * \phi \qquad (4)$$

Where:  M P : pixel number on the plate carree
              projection
        M L : line number on the plate carree
              projection
        N L : pixel number of the longitude
              direction (=5000)
        $\lambda_0$ : 0 ° (central meridian)
        $\lambda$ : longitude coordinates
        $\phi$ : latitude coordinates

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In order to orientate the image into a plate carree projection coordinates, many ground control points (GCPs) were selected on each DMSP nighttime image. As the pattern of the earth surface cannot appear in the nighttime image like the daytime image coastal line (cape, bay, etc.), island, lake and pond, river, and road cannot be selected as the object of GCP. Therefore, the city that was caught as a distribution of light was selected as the GCP on the nighttime image. And also, the plate carree coordinates of each GCP point was measured on the GVI data and WDB-II CIL(coastline, islands, and lakes) and RIV (rivers) data translated into a plate carree projection by comparing with Operational Navigation Charts (ONC) map. However, the latitude and longitude were only measured on 1:1,000,000 scale ONC map about the point that it was impossible to select on GVI and WDB-II ,and it was oriented to plate carree coordinates. About 20 - 30 points of GCP were selected in each scene to equalize. The three cubic polynomials that is derived below from GCPs was used for the orientation from the DMSP image coordinates (u,v) to plate carree coordinates (x,y).

$$u = p_1 x^3 + p_2 y^3 + p_3 x^2 y + p_4 x y^2 + p_5 x^2$$
$$+ p_6 y^2 + p_7 x y + p_8 x + p_9 y + p_{10} \quad (5)$$
$$v = p_{11} x^3 + p_{12} y^3 + p_{13} x^2 y + p_{14} x y^2 + p_{15} x^2$$
$$+ p_{16} y^2 + p_{17} x y + p_{18} x + p_{19} y + p_{20} \quad (6)$$
$$\text{where} : p_1 \sim p_{20} \text{ are coefficients}$$

The GCP accuracy of each scene was about within 1.5 pixels and 1.5 lines (rms). However, as for the case of the scene in which few distributions of light were contained remarkably, the secondary expression or affine transformation was used. Each DMSP nighttime image was transformed to the plate carree projection by resampling operation using nearest-neighbor method.

## 3.4 Mosaicking Process

The global nighttime image transformed to the plate carree projection was produced from each geometrical corrected DMSP image through the mosaicking. As for mosaicking between each scene, a pixel of highest CCT value was selected in the overlap area. As the result, it is thought that the connecting image that had few influence of a cloud is created.

## 3.5 Comparison with GVI data and WDB-II data

The GVI data and WDB-II geographical information data transformed the plate carree projection were analyzed together in order to investigate the geographical distribution of lights on the global nighttime image. The pixel and line size of GVI image composing visible, near infrared, far infrared, solar zenith angle, scan angle, and vegetation index were doubled because the GVI data transformed to the plate carree projection was

included 2500 pixels and 1250 lines as shown in Fig.3. The WDB-II vector data of coastline, islands, lakes and rivers were converted to the raster image translated into the plate carree projection as same size as the global nighttime image as shown in Fig.4.

## 4. GEOGRAPHICAL DISTRIBUTION OF LIGHT ON GLOBAL NIGHTTIME IMAGE

The great part of lights on the nighttime image based on the thing by human activity of the light of cites, shifting cultivation, fishing, if natural lights such as the aurora and lightning at night are excluded. As for those distribution, regional merit can be recognized, and it can be investigated in detail by comparison with the GVI data, and geographical information data. The feature is described below.

## 4.1 Light Distribution of City

The crowded regions of the population of the world are the eastern North America, Europe, India, and east Asia. The lights of the large city of the star type are scattered, and lights of the small city become a range of points are linked between large cities. The region in which the large city distribution much indicated that the vegetation index is relatively high by comparing between global nighttime image and GVI image. According to the authors past research, it was ascertained that a size of the light of the city showed the relation that was close to the economic activity of the region including the city and the electric power consumption quantity of the city itself. The light size to the population in the advanced nations such as USA, Europe, Japan showed larger than the ones in the developing nations such as India, China and south east Asia regarding the comparison among regions. This is thought to be showing the proportion relation between the situation (national income) and of the economic activity. For example, as for the metropolis more than the population of five million, the light size on the nighttime image of New York and London in the advanced nation were two or three times as large as the ones of Mexico City and Calcutta in developing nation. And, in the comparison among each cities, the tendency of the size of the light for the electric power consumption quantity was shown the metropolis of the West and the United States of America was larger than the ones of East Europe and Asia.

As for this, possibility of a over consumption energy and a difference of the structure of the city were guessed.

## 4.2 Light Distribution of Shifting Cultivation

The global nighttime image shows several areas including a lot of small lights in inland mountain region far from the coastline. They are Sahelian zone of central Africa, Madagascar island, the eastern part of India peninsula, Indo-
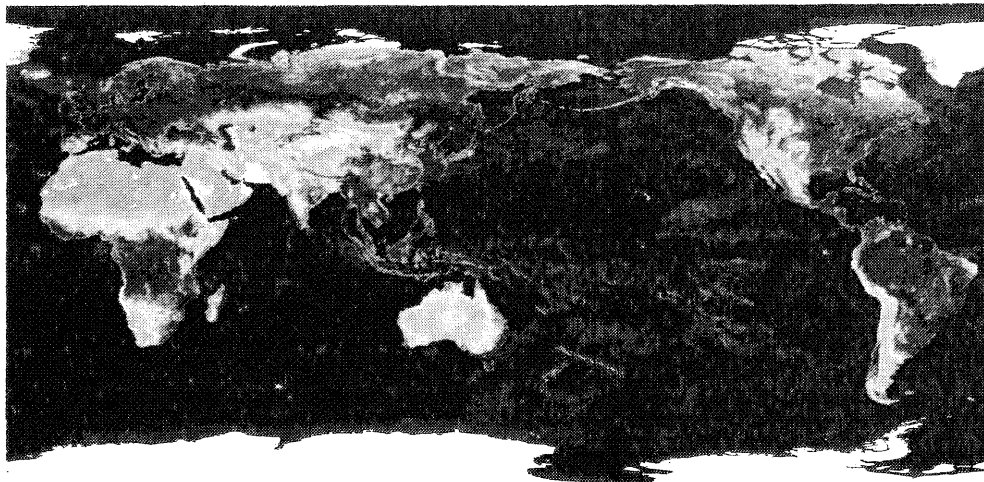
Figure 3   NOAA GVI Data



Figure 4   Utilized WDB-II Data on Plate Carree Projection

China peninsula and Brazilian Plateau. These area show relatively thick population density and small distribution of city. The great part of this light is thought to detect by the shifting cultivation. The consideration of the feature of the distributive pattern of light by the shifting cultivation was performed below in representative 3 regions.

### 4.2.1   Light Distribution of Shifting Cultivation in Indo-China Peninsula
The distribution of clear small lights distribution in the large region stretches central portion to north-west part of Indo-China peninsula. The distribution of a lot of lights are the northeast area of Khorat plateau, the mountain zone of the North of Thailand, Shan plateau and Arakan mountain range of Myanmar by the comparison with the GVI data and the WDB-II geographical information of this. These region almost coincide with the region that has few population density relatively and the residence area of the racial minority that performs self supporting

agriculture by traditional shifting cultivation in except the neighborhood of Chiang May of Thailand and Mandalay of Myanmar. Therefore, it is thought that the distributive region of the fine lights on the nighttime image is the firing based on the shifting cultivation. The area of the greatest number of light distribution is the slope zone in mountain region lying north of Thailand and east of Myanmar. The distribution is limited to the area of Thailand and Myanmar across the internal boundary, and there are few lights distribution in the area of Laos.

### 4.2.2   Light Distribution of Central Africa
The innumerable lights of shifting cultivation distribute in the east to west near north latitude 10N from north latitude 7N of sahelian zone and the savanna zone of south of the Sahara desert in central Africa. This place corresponds to a region of which the annual precipitation is 400 - 1,500 mm, and the firing is done to the grassland and a shrub zone for

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the shifting cultivation and stock farming, in the end of the dry season. And also, it was thought that lights shown in the southeast of the tropical rain forest area of the Congo basin were the firing based on the shifting cultivation.

### 4.2.3 Light Distribution of Brazil Plateau

There are a lot of small lights like as starlight composing the Galaxy in inland being about 600 km distant from the east coast of Brazil including many large lights of metropolis. The belt of these lights exist in the savanna zone on the side of the east of the line that links between the capital Asuncion of Paraguay and Tocantins river being is traced back to the south from Belem at river mouth of Amazonas. The width of the belt of lights is about 600km east west, and this west end is the region that changes into the tropical rain forest area from the savanna zone. The used images were obtained in the end of the dry season (June to September) of the middle of September, and it corresponds in and the time of forest firing for the shifting cultivation and stock farm development in this season. Therefore, the belt of lights is thought to depend on the flame of the shifting cultivation and the forest firing. In addition, because this region cannot have most population density, it is recognized that some large lights distributed in this west side are the flame of forest firing.

## 4.3 Light Distribution of fishing fire

It was searched the crowded distribution of the small lights based on the fishing fire of cuttlefish in the Sea of Japan along the south-west of Japan archipelago. The distributive area of the cuttlefish is wide from Sakhalin to Taiwan, it moved to south by looking for the area of 15 degrees in centigrade of water temperature since early autumn. It was ascertained the distributive area of the lights of fishing fire coincided with the sea surface temperature distribution of 15 degree in centigrade in which cuttlefishes distributed.

## 4.4 Light Distribution of oil field zone

There is light of the flame of the gas of oil field zone as the distributive pattern of intense and circularly large light on the nighttime image. Those regions are the coast of Persian gulf, north Africa, the coast of gulf of Guinea, west Siberia. One of this light is equal to the size of the light of the large city, and it can be said consume the large quantity of energy are consuming.

## 5. SUMMARY

In this study, the global nighttime image that was oriented to the plate carree projection, was produced through resampling process after GCP selection using A/D converted DMSP nighttime image distributed as the film. Then, a study

with the geographical distribution of the light that follows human activity with the corresponding comparison of the NOAA/GVI data and the WDBII data was done. It is the following, when the view of the result of this study and future is requested.
1) The DMSP nighttime image selected GCP as each scene about 20 - 30 points after the A/D conversion and the projective conversion was done to the plate carree coordinates in three cubic polynomials.
2) The selection precision was about 1.0 pixel and 1.0 line.
3) The global nighttime image could be created by doing mosaicking operation of DMSP images after geometry correction on plate carree coordinates.
4) The global nighttime image was possible of compare with both of the GVI data and the geographical information of WDBII, and it was proved that the geographic distributive position and the range of light distribution and kind could be investigated in detail at the nighttime image.
5) It was shown that it was searched the both light of the fishing fire and the gas of oil field zone has the regional feature.
6) The distributive pattern of the light that is shown to the nighttime image is the description of a form that natural energy is consumed.
7) It is thought that the influence that the human activity exerts to the natural environment can be investigated from the new viewpoint in the future, if the detailed analysis of which the light distribution on the nighttime image is continuously done by comparing with NOAA GVI data.

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