ESTIMATION OF NIGHT LIGHT FROM THE DMSP/OLS

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ABSTRACT:

Night light on land includes the temporal light which occurs by forests and fields fire, city fire and a volcanic explosion. However, the most part of the night light based on human activity, and this light can say a symbol of energy consumption. To observe night light can be said the barometer of this human activity quantitatively, and it can also be one way to measure spatial distribution of energy consumption handily. For these possibilities there is a satellite, DMSP (Defense Meteorological Satellite Program) observing night light. The OLS (Operational Linescan System) sensor onboard DMSP mission observes the night light periodically and globally. However, , there are few issues to be resolved in the observation data, such as the moon surface reflection of sunlight, secondary reflection from surface of the sea in influence of sunlight and an age of the moon by a change in solar altitude by night observations of OLS. The sensor gain of OLS is adjusted to minimize the influence. Therefore, analyzing quantitatively using the observed intensity of light, a method to revise the gain adjustment has to derive. But the information concerned with this gain adjustment isn't exhibited. So the object of the research is to take gain tuning parameter by these sunlight and surface of the moon light and to develop a correction way to the data observed by the fixed gain.

1. INTRODUCTION

The light coming from the bio-mass fire and volcanic eruptions generate temporarily but one part of the lights at night. However, the bigger part of the night light is coming from the artificial origin or sources. Therefore, this part of night light can also be said to be a symbol of energy consumption. In other words, it's a barometer of human activities which can be observed quantitatively, providing one method for measuring spatial distribution of energy consumption on the earth surface. Now, the U.S. polar orbit circumference type meteorological satellite DMSP (Defense Meteorological Satellite Program) is operative and observing light at night. The sensor called OLS (Operational Linescan System) is carried in DMSP, and observation is performed periodically and globally. However, these nights light observations by OLS is influenced by the changes in solar altitudes and the impact of the secondary reflection from sea surface. In order to minimize this influence, adjustment of the sensor gain of OLS is performed. Therefore, when conducting quantities analysis using the observed intensity of light, you have to rectify a part for gain adjustment. However, the information in connection with this gain adjustment is not well published. In this research, the amount of gain adjustments by this sunlight and moon's surface catoptrics light was removed, and focused on developing a correction method to the data observed by the fixed gain.

2. DATA SOURCES

The 1999 data observed in the visible band (night mode) of DMSP/OLS was used in the study. The geometric correction of the data has done by U.S. NGDC, and spatial resolution has set to 1km. Moreover, the region made applicable to analysis falls from 124 degrees to 146 degrees east longitudes and 24 north degrees to 46 north degrees latitude as presents by the Fig. 1. DMSP and specifications of OLS which is the loading sensor are shown in Fig. 2.

Fig1. Analysed Area

DMSP(Defense Meteorological Satellite Program) specification

Orbit	Sun synchronous near polar orbit
Altitude	830km
Revisit	101min
Sensor	OLS(Operational Linescan System) SSM/I(Microwave Imager) SSM/T(Atmospheric Temperature Profiler) SSMT/2(Atmospheric Water Vapor Profiler) SSJ/4(Precipitating Electron and Ion Spectrometer) SSIES(Ion Scintillation Monitor)

OLS Sensor specification

Band	Spectral range	Spatial resolution		Swath	Radiometric
		fine	smooth	width	resolution
Visible(Day)	0.40−1.10 μm	0.55km	2.7km	3000km	6bit
Visible(Night)	0.47−0.95 μm	0.55km	2.7km	3000km	6bit
Thermal-IR	10.0−13.4 μm	0.55km	2.7km	3000km	8bit

Note : 1 km spatial resolution data, which is resampled from the fine mode resolution, is distributed by NGDC in U.S.A.

Fig.2 DMSP specification

3. METHOD

DMSP goes the direction of a pole of the earth around in 101 minutes, and whenever it completes one earth round, a shift of 25.25 degrees in the direction of latitude, is observed due to the global rotation. Therefore, DMSP passes to the same point in about 23.5 days (returning cycle). It means that about 23 degrees of earths had rotated on the circumference (revolution) orbit of the earth [thing / on the 23.5th / to shift] cantering on the sun, and a solar altitude changes. By neither the gain of a sensor, nor change of the solar altitude according that the offset is constant to global rotation and revolution in this way, the exaggerated scale (saturation) of the dynamic range of a sensor cannot be carried out, or it becomes a under scale and sufficient observational data can be obtained. Then, the sun with periodicity; assuming that adjustment of offset was considered as the gain which can see by carrying out cancellation out of the advanced influence, and considering it as a picture, the intensity of light of arbitrary specific subjects performed the compensation which is not based on change of time (season) but serves as the fixed intensity of light (luminosity).

The cloud-less data set of 36 scenes was created for visible data with the time maximum synthetic method (10-dayMVC) in the DMSP/OLS night for one year in 1999, and NRF(Noise Reduction Filter : one formula) *1 was processed to the data set. The frequency component which the arbitrary time series pixels in a picture have, its amplitude, and a phase are obtained by performing NRF processing (two formulas). It reconstructs as a 10-dayNRF data set by carrying out inverse transform of this NRF processing result and carrying out imaging. Supposing the source of luminescence of a terrestrial subject is always constant here, it should not come together at Time t, but C_0(Fig.3) should become fixed. However, it is *2,3 which does not become constant [C_0] by change of a solar altitude with periodicity. Furthermore, the gain adjustment depending on a solar altitude does not perform gain adjustment which the intensity of light of the arbitrary subjects which have emitted the fixed intensity of light can always observe uniformly, but is considered to be adjustment in the range which can do it. It is possible that the solar altitude contained in the amplitude intensity of the sin ingredient of C_0 and two formula from this and the amount of gain adjustments depending on it have influenced change of C_0. Then, the influence and its amount of gain adjustments of a solar altitude will be removed about reconstructed 10-dayNRF by having subtracted a sin ingredient and its amplitude intensity from ft of every time t. However, ft obtained in this way always is not obtained as a fixed DN value in the intensity of light of arbitrary specific subjects.

It is possible that the calibration based on a specific reference is not performed as the cause. Fig. 4 -- the East China Sea -- the charity under operation -- it being what was plotted on the picture observed by OLS, and the operation position which carried out tracking of the fishing fire (the total intensity-of-light 250kw) of a benevolence ships (medium size cuttlefish fishing boat) during January [about], and was notified by vessel fax DN value of the position, i.e., charity, -- a ship releases -- shining (Fig. 5) -- it is Fig. 6 which read and was expressed with graph *4. It turns out that the source of luminescence of the total intensity of light of 250kw is not observed as a fixed DN value which clearly displays in graph. Therefore, the gap of the amount of gain adjustments and a reference value and the phase difference of the change cycle of a solar altitude may remain in fcomp which subtracted the amplitude intensity of the sin ingredient in Time t from ft. Gain adjustment is considered to be has lower influence of the phase difference if gain adjustment depending on the large solar altitude of the influence is performed. Here, it was possible that gain adjustment gap is obtained as primary frequency by reprocessing NRF data set of obtained fcomp, and the performed processing was.

$$f_t = c_0 + c_1 t + \sum_{l=1}^{N} \left\{ c_{2l+1} \sin\left(\frac{2\pi k_t}{M} t\right) + c_{2l} \cos\left(\frac{2\pi k_t}{M} t\right) \right\} \quad \cdot\cdot (1)$$

Where M = Cycle (1 Year =36 for 10-day MVC)
t = Time period (1Year = 36, 2Years = 72, 3Year=108, 4Years=144)
k_t = Frequency (1,2,3,4,6,12 month(s))
N = Number of pixels
$c_0, c_1, c_{2l}, c_{2l+1}$ = Coefficient of each function

$$f_t = c_0 + c_1 t + \sum_{l=1}^{N} \left\{ a_l \sin\left(\frac{2\pi k_t}{M} t + \theta_l\right) \right\} \quad \cdot\cdot (2)$$

Where $a_l = \sqrt{c^2{}_{2l} + c^2{}_{2l+1}}$ $\cdot\cdot$ amplitude at k_l

$$\theta_l = \tan^{-1} \frac{c_{2l}}{c_{2l+1}} \quad \cdot\cdot \text{amplitude at } k_l$$

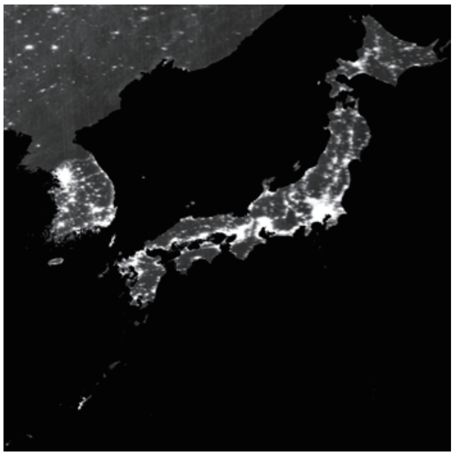

Fig.3 NRF C_0 data

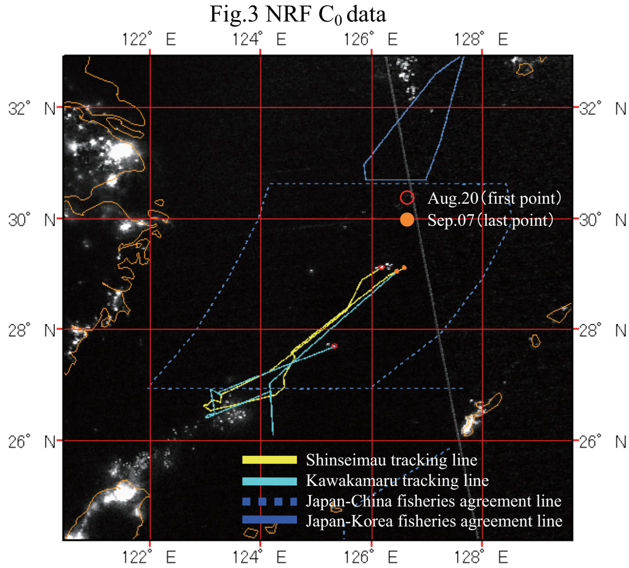

Fig.4 Tracking of benevolence ships

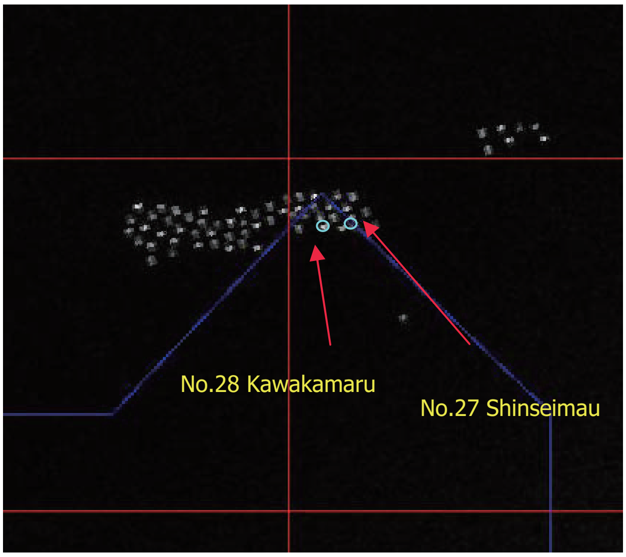

Fig.5 Lights of benevolence ships (250kw)

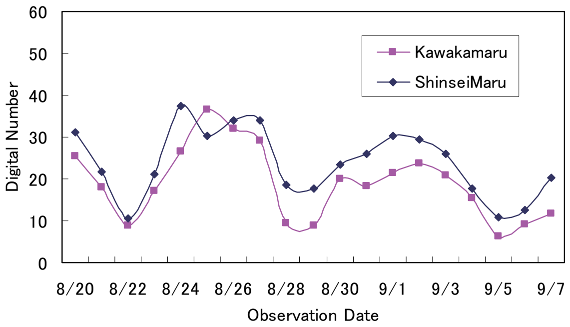

Fig.6 Changing DN value of benevolence ships

4. RESULTS AND DISCUSSSIONS

Fig.7 shows the NRF data set for one year in 1999. Fig. 8 shows the amplitude (sin ingredient) picture of primary frequency ingredients by season units from the results of performed NRF processing, using about a 10-dayMVC data set. Moreover, Fig. 9 shows the condition when reduced the amplitude of primary frequency ingredients corresponding to ft for every season unit about the result of the NRF processing expressed with one formula. Here, supposing the influence and its amount of gain adjustments of a solar altitude are removed by reducing this amplitude intensity, the intensity of light (DN value) of arbitrary specific points will show a fixed value. Then DN value of the season unit in arbitrary selected two or more points change of year the time a series have plotted (Fig. 10, Fig.11 and Fig.12). Dashed line graph shows change of DN value before compensation, and a solid line shows change of DN value after compensation. When DN value compensation before compared with the after compensation conditions, it turns out that the influence of a solar altitude or its gain adjustment is decreasing clearly. However, in order to fulfil the conditions of "always having fixed DN value", results are agreed very much.

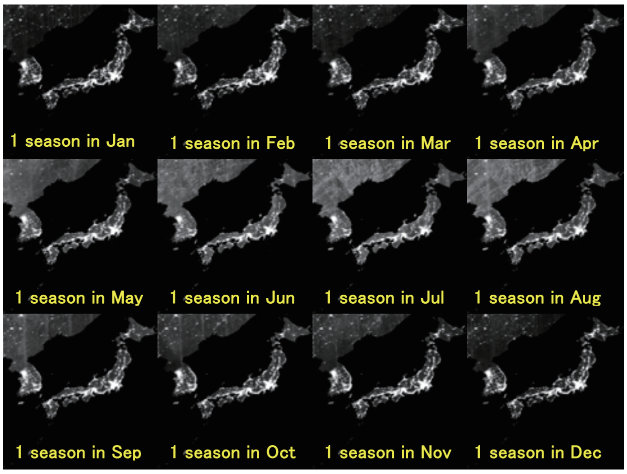

Fig.7 NRF data set for one year in 1999

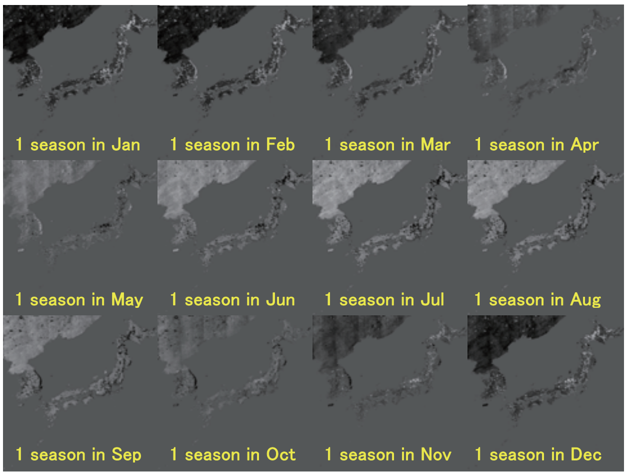

Fig.8 NRF frequency data set for one year in 1999

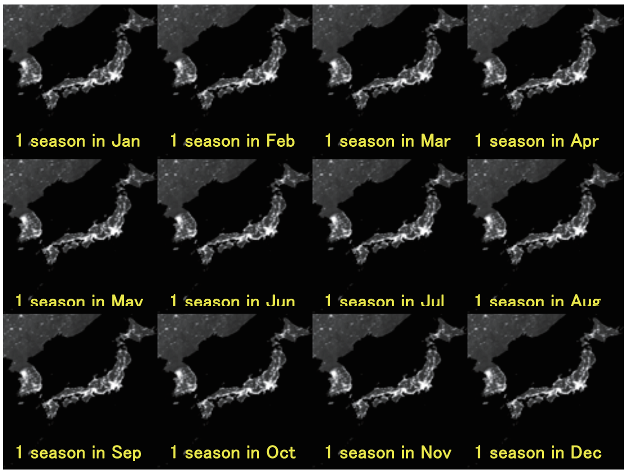

Fig.9 NRF fixed data set for one year in 1999

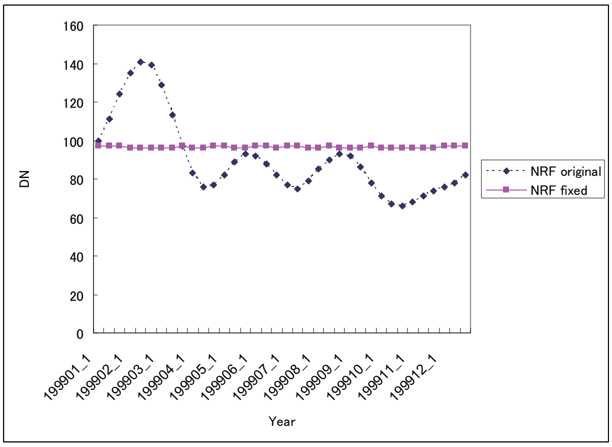

Fig.10 NRF fixed data set

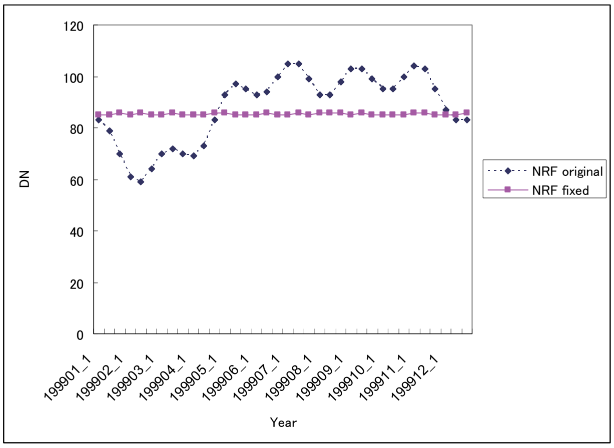

Fig.11 NRF fixed data set

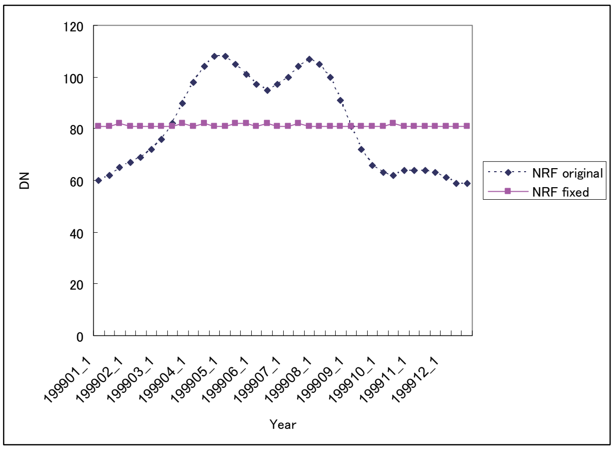

Fig.12 NRF fixed data set

5. CONCLUSTION

It was found that a fixed effect had the influence of the sunlight by change of a solar altitude by applying NRF processing in this study. It's expected to estimate the gain adjusted value which won't be published from now on.

However, when performing the monitor over a long period of time etc., there is a point which should be further taken into consideration in information extraction with high accuracy, such as carrying out the compensation which fully took into consideration the difference in the characteristic of the satellite sensor. In order to use the past data as a series of readings and its impact on compensation of this sensor characteristic can be stated as future research interests.

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