

# SEASONAL CHANGE OF NDVI CALCULATED BY JERS DATA WITH HIGHER SPATIAL RESOLUTION

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## ABSTRACT

Seasonal change of the NDVI derived from at-sensor radiance of JERS data in the urban area of Tokyo where lots of leafy parks still remain was firstly manifested by our investigation. The NDVI maps by OPS on JERS have not been exploited so much compared with those by AVHRR on NOAA or by TM on LANDSAT. The NDVI map calculated from multi-spectral data of OPS on JERS enabled us to grasp the distribution of the vegetation productivity and to be available as a simplified land classification map. It was shown that the discrepancy of NDVI values between JERS and LANDSAT in spite of the almost the same acquisition date. It might be said that since values of NDVI by OPS/JERS are larger by below 10% than those by TM/LANDSAT, it indicates that they lie in almost the same range of NDVI values. From our present study, abrupt change of NDVI in vegetation area seems to reflect an abnormal meteorological phenomenon.

## 1 INTRODUCTION

From an ecological point of view, the ongoing change of vegetation productivity in big cities is one of the major concerns. NDVI(normal difference vegetation index) has been extensively used to assess the vegetation productivity and vegetative ground cover. The NDVI maps using OPS on JERS have not been exploited so much compared with those by AVHRR on NOAA or by TM on LANDSAT. Some advantages will be offered in environmental monitoring by analyzing the characteristics of NDVI by OPS with higher spatial resolution than AVHRR. It is considered that the vegetation productivity shows its season from May to October. It is, however, difficult to obtain satellite data whose scene has below 5 percent coverage of clouds and fits the research purpose in Tokyo area in summer season when one and half pre-summer rainy season is included. However, we could fortunately get some satellite data that was acquired from 1992 to 1997 and appropriate for the present vegetation research.

## 2 DESCRIPTION OF SATELLITE DATA

We have used three bands for vegetation analysis among seven or eight bands of optical sensors on JERS and LANDSAT. The location of wavebands on JERS and LANDSAT is summarized in Table 1.

Table 1. Waveband location of sensors on JERS-1 and LANDSAT 5.

The waveband location of two satellite sensors necessary for the calculation of NDVI is almost coincident. The dates of satellite data used here that are **provided by NASDA, RESTEC in Japan** as follows:

Acquisition date and coverage are 1992.09.09, 1994.08.14, 1997.07.05 and Path=64, Row=241 for JERS and 1997.07.19 and Path=107, Row=35 for LANDSAT. The acquired data for

Mission	Instrument	Number of wavebands	Wavelength [micro meter]	Spatial resolution
JERS-1	OPS	8	V-green: 0.52 - 0.60	18x24m
			V-red : 0.63 - 0.69	
			NIR : 0.76 - 0.86	
Landsat5	TM	7	V-green: 0.52 - 0.60	30m
			V-red : 0.63 - 0.69	
			NIR : 0.76 - 0.90	

J-ERS contains one for both high and normal gain modes. After some corrections including geometric rectification of satellite data to the scanned map, the standard NDVI were calculated and its characteristics were examined. More than five GCPs(ground correction points) in 1/50,000 scale map were used for the rectification of the satellite data. Observed and clipped area for the analysis lies in the range of that from N35deg. 39min. 4sec to 42min. 2sec. in latitude and from E139deg. 4min. 23sec. to 46min. 44sec. in longitude.

The conventional definition of NDVI by using values of radiance at the height of sensor from the surface of the earth is given by

$$NDVI = \frac{L_{NIR} - L_{V-red}}{L_{NIR} + L_{V-red}} \quad (1),$$

where  $L_{NIR}$  and  $L_{V-red}$  are at-sensor radiance in Near Infrared and Visible red band, respectively.

The formula to convert from raw DN(digital numbers) to radiance at sensor level are given by

$$L_{JERS} = DN * A / A' + B, \quad L_{Landsat} = cal\_gain * DN + cal\_offset \quad (2),$$

where conversion coefficients are given in Table 2-1 for J-ERS and in Table 2-2 for Landsat, respectively.

Table 2-1 Conversion coefficients for JERS

		Band 1	Band 2	Band 3
Normal	A	1	1	1
Gain	A'	0.6975	0.936	0.9597
	B	0	0	0
High	A	1	1	1
Gain	A'	2.216	3.016	3.04
	B	0	0	0

unit: [W/(m<sup>2</sup>m<sup>2</sup>str<sup>2</sup> μ m)]

Table 2-2 Conversion coefficients for Landsat

Band	cal_gain	cal_offset
1	0.642	-2.568
2	1.274	-5.098
3	0.979	-3.914
4	0.925	-4.629

We were unfortunately obliged to skip atmospheric corrections due to difficulty to estimate sufficiently good approximation for transparency of atmosphere and path radiance in summer seasons in Japan.

We selected six ground spots in the present area of Tokyo as typical reference places for analyzing seasonal change of NDVI values. The next Table 3 shows the location, comment for the spots, and calculated value of NDVI from five satellite scenes.

Table 3. NDVI at various sampled spots in Tokyo from summer to autumn season

Location	comment	J970705	J940814	J920909	J971001	L970719
(1)N35° 41'06",E139° 45'10"	Forest(Imperial Palace)	0.75	0.72	0.48	0.66	0.62
(2)N35° 41'14",E139° 44'11"	Urban 1(Ichigaya)	0.39	0.55	0.34	0.46	0.25
(3)N35° 39'30",E139° 46'33"	Water(Sumida River)	0.01	-0.03	-0.10	-0.13	-0.15
(4)N35° 40'59",E139° 45'54"	Urban 2(Ootemachi)	0.18	0.16	0.11	0.11	0.13
(5)N35° 39'31",E139° 46'02"	Grass(Hamanorikyu Park)	0.56	0.64	0.30	0.52	0.46
(6)N35° 40'56",E139° 41'43"	Urban 3(Shinjuku)	0.11	0.16	0.03	0.16	0.16

The date of acquisition as "July 5, 1997 by JERS" is abbreviated to "J970705" in Table 3.

The satellite data is fairly precisely rectified and geo-referenced to

the corresponding map in scale of 1/50,000. The root means square of errors is approximately below 0.1 pixel for five satellite scenes.

Figure 1 shows various selected six spots for the analysis of seasonal change of NDVI in aerial photo of Tokyo whose scale is about 1/30,000.

### 3 SEASONAL CHANGE OF NDVI VALUES BY OPTICAL SENSOR ON JERS

We present the seasonal change of NDVI derived from radiance of sensors at typical six spots in Tokyo indicated in Figure 1. By ground survey of six spots in Table 3, "Forest", "Grassy park", "Water" and "Urban" area are identified and their characteristics of radiance for three bands of sensors are manifested. The difference in digital



Fig.1 Selected six spots for checking seasonal NDVI change in Tokyo

numbers caused by 'high gain mode' on JERS is adjusted and corrected by adopting conversion coefficients in Table 2-1 as referred in section 2.

Based on radiometric-corrected values of radiance acquired from JERS, the calculated NDVI are summarized in Fig. 2, where the valuable seasonal changes of NDVI in typical ground spots are shown.

Table 4. Frequency of NDVI values in 20 ranges with 0.1 step for changing seasons

NDVI	J970705	J940814	J920909	J971001	L970719
-1.0:-0.9	0	0	0	0	0
:-0.8	0	0	0	0	0
:-0.7	0	0	0	0	0
:-0.6	0	6	0	0	0
:-0.5	0	16	0	0	0
:-0.4	99	214	529	99	94
:-0.3	921	748	7,416	921	1,496
:-0.2	3,523	10,291	114,579	3,523	4,088
:-0.1	89,370	78,430	62,607	89,370	100,205
:-0.0	72,731	62,471	23,035	72,731	68,658
:+0.1	25,190	32,183	12,572	25,190	23,136
:+0.2	11,848	13,323	8,181	11,848	11,682
:+0.3	9,554	8,683	930	9,554	8,851
:+0.4	9,685	7,388	41	9,685	10,176
:+0.5	5,679	6,449	0	5,679	1,430
:+0.6	287	6,924	0	287	74
:+0.7	3	2,709	0	3	0
:+0.8	0	55	0	0	0
:+0.9	0	0	0	0	0
+0.9:+1.0	0	0	0	0	0
TotalPixels	229,890	229,890	229,890	229,890	229,890

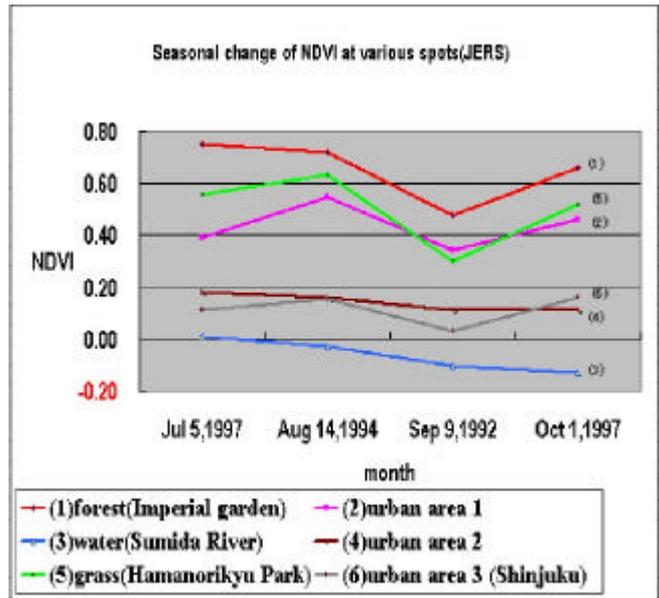


Fig.2 Seasonal change of NDVI at various spots in Tokyo urban area.

The seasonal change of values of NDVI at specified spots can be seen in Fig.2, however, the seasonal change of histogram for observed area is not clear in Fig. 2. To grasp how the distribution of NDVI values will change during vegetation seasons; the calculation of frequency of NDVI was done for five satellite scenes. The characteristics of NDVI change in seasons are shown in Fig. 3 in three-dimensional manner based on Table 4.

As seen in Fig.3, the higher range of NDVI shifts towards the lower ranges as the season changes from summer to autumn. Conspicuous characteristics of abrupt decrease of NDVI in September in 1992 are shown in Fig.2 and Fig.3. The range in October locates higher than that in September. The values of NDVI in vegetation areas in September of 1992 are rather lower in spite of still vegetation active month. What caused this influence? Is it reasonable that the change of NDVI reflects some meteorological phenomena? We'll discuss it later in section 5 of the present paper.

#### 4 NDVI MAP AS A SIMPLIFIED UNSUPERVISED LAND-COVER CLASSIFICATION

Though the NDVI map is ordinarily used for the investigation of vegetation vigor and coverage on the ground, it can also be useful as a method of simplified unsupervised classification when NDVI values are associated with a discrete land-cover classification. Here we show two examples of density colored NDVI map in Fig. 4. Both scenes were very fortunately acquired on almost the same date in 1979 and very good samples for checking the scale dependence of NDVI on the digital numbers from sensors with different spatial resolution. The distribution of NDVI values derived from TM (LANDSAT 5) remains in the lower NDVI range compared with those from OPS (JERS) as seen in Fig. 3. The density colored NDVI maps in Fig.4 show some discrepancy of the NDVI values between JERS and LANDSAT. Figure 5 shows the portion of NDVI frequency for four ranges of NDVI values. NDVI values in OPS are larger than in TM by about 9% for various places in Tokyo as in Fig.7.

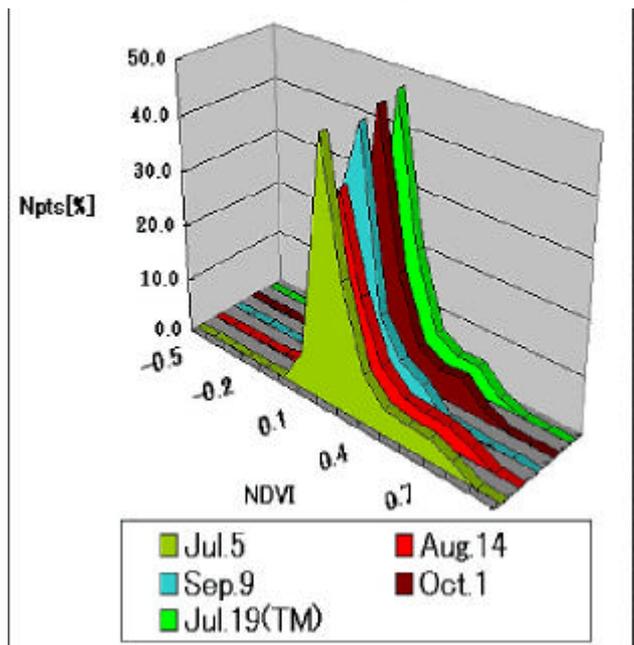


Fig. 3 Seasonal changes of the distribution of NDVI Values for four geo-rectified satellite scenes

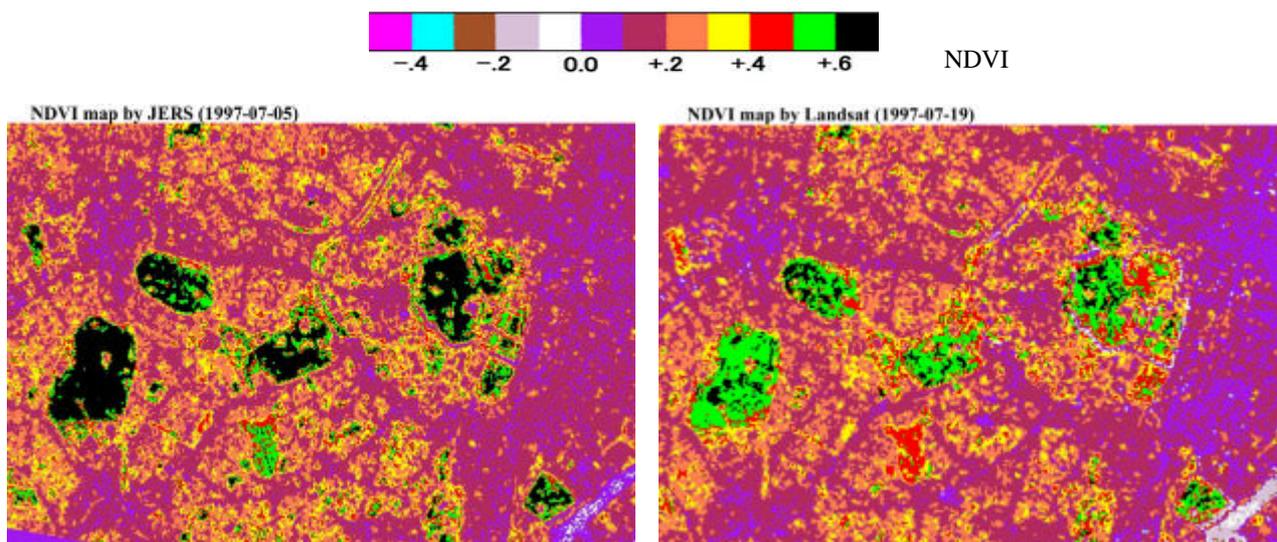


Fig. 4 Difference of density colored maps of NDVI values in urban area of Tokyo for two satellite data acquired on almost the same date in 1997. Color scale for NDVI values is shown above.

### 5 DISCUSSION AND CONCLUSIONS

The reason why the ranges in October locate higher than those in September is speculated as follows:

-Rainfall in Tokyo in August, 1992 was the least of 9[mm]

In recorded data. Only 6% of the ordinary August rainfall

level (150mm) shown in Fig.6. This abnormal weather is suspected to damage vegetation activity in Tokyo region in 1992. It might be concluded that abrupt change of NDVI might be useful to detect the abnormality in weather.

An interesting seasonal change of NDVI values and its distribution in urban area of Tokyo was manifested for four scenes. Seasonal change of NDVI in Tokyo derived by at-sensor radiance was successfully investigated. Abrupt change of NDVI in vegetation area seems to reflect an abnormal meteorological phenomenon. It might be said that values of NDVI in OPS/JERS are larger by about 10% than in TM/LANDSAT. Future problem is the pursuit of good atmospheric correction for JERS imagery in summer season, and dependency of ground resolution of satellite on NDVI.

Seasonal change of portion of NDVI frequency

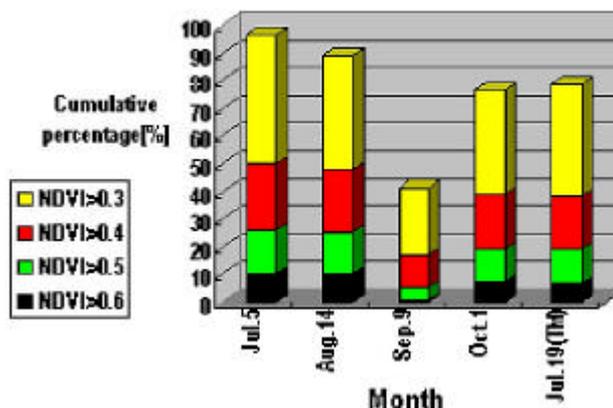


Fig. 5 Seasonal change of portion of NDVI frequency

Rainfall level in Tokyo in 1992

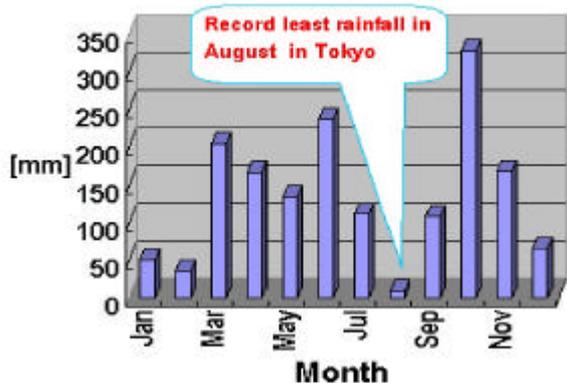


Fig. 6 Abnormal rainfall level in Tokyo in 1992

Comparison of NDVI change (TM vs. OPS)

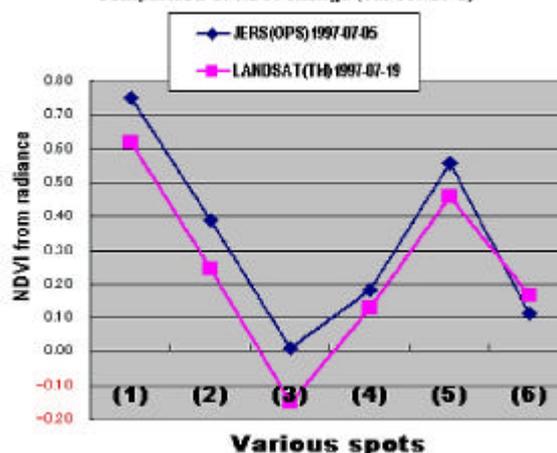


Fig. 7 Comparison of NDVI change (TM vs. OPS)