# EXTRACTION OF DAMAGED AREAS OF FALLEN TREES BY TYPHOONS USING LANDSAT TM DATA

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**ABSTRACT** :

Two typhoons attacked successively at intervals of about two weeks the north part of Kyushu located in the south west of Japan in Sep. 1991. Forestry have been very active in this area from old and many trees especially in artificial plantations (main tree species are cedar and cypress) were fallen by the typhoons. Two Landsat TM data taken before and after the typhoons were collected and registered in order to extract the damaged areas. Several damaged points for each group of heavy and slight damage were selected on the registered image referring the aerial photographs taken immediately after the typhoons ,and the change characteristics of TM bands 1～5,7and Vegetation Index (VI) for the heavy,slight and no damage cases were examined. It showed the characteristics that bands 1～5,7 increase whereas VI decreases due to the damage. Band 5 and 7 of middle infrared region showed more increase than other bands. A registered images of band 5,7 and VI of two temporal data before and after the damage was generated, and the damaged areas were extracted by a maximum likelihood classification method using the registered image. The damaged areas extracted by Landsat TM data were evaluated using the aerial photographs and data on the damage surveyed by a Local Development Office. It was found that Landsat TM data were effective to extract damaged areas of fallen trees by the typhoons for a broad region.

## 1. INTRODUCTION

Two typhoons attacked successively the north part of Kyushu on Sep. 14 and 27 ,1991 and they caused severe damages for agriculture and forestry. The forestry have been very active from old in this region and there are many artificial plantations where coniferous trees such as cedar or cypress were mainly planted,and those coniferous trees suffered severe damages from the typhoons. Fig.1 shows a view of the damage of fallen trees by the typhoons. Takao already extracted the damaged areas by the typhoons for the same area using MOS-1 MESSR data acquired before and after the typhoons,and reported that MESSR band 2 is effective to extract the damaged areas [1] . This study used Landsat TM data and it was found that middle infrared bands

Fig. 1. A view of the damage of fallen trees by the typhoons.

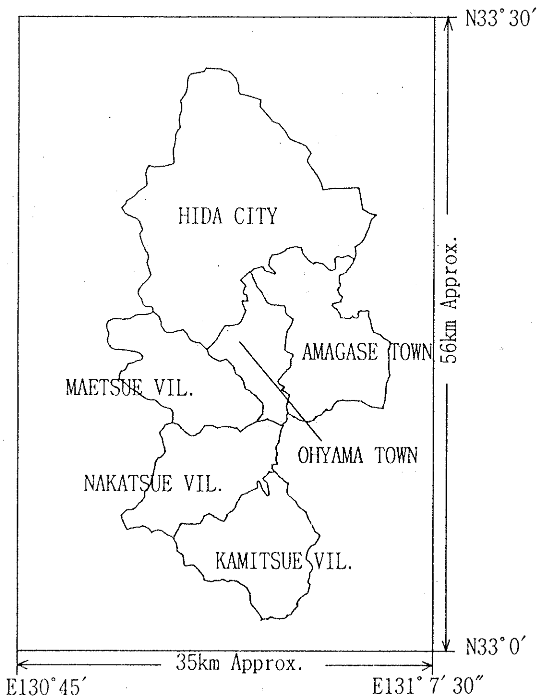


Fig. 2. Outlines of the test site

Table 1 Data used in this study

| Data | Path -Row | Date of Acquisition | Remarks |
|---|---|---|---|
| Landsat TM | 112-37 | 1990.9.21 | Before damage |
| Landsat TM | 112-37 | 1992.5.21 | After damage |
| Aerial photograph | | 1991.10.7 | Inmedately after damage Scale: About 1to30000 |

were effective to extract the damaged areas. A method to extract the damaged areas using Landsat TM data acquired before and after the damage, and the results which evaluated the extracted output using aerial photographs and data on the damage surveyed by a Local Development Office are described in this paper.

## 2. TEST SITE AND DATA USED

Forests in Ohita Prefecture, a region of north Kyushu suffered big damages from the typhoons and an area under the control of Hida Local Development Office,a branch of Ohita Prefectural Office selected as a test site. Fig. 2 shows the outlines of the test site. The area of the test site is about 35km east and west by 56km south and north ,and it includes 6 munincipalities. Table 1 shows data used in this study.Landsat TM data covering the test site before and after the damage were searched and two Landsat TM data shown in Table 1 were available for the study.Data observed at a same season were not available. Aerial photographs were acquired by request of Ohita Prefectural Office immediately after the damage ,and taken at an altitude of 4400m ,therefore those scale are about 1 to 30000. The aerial photographs covering a part of the test site were obtained about 10 days after the damage and used for the study.

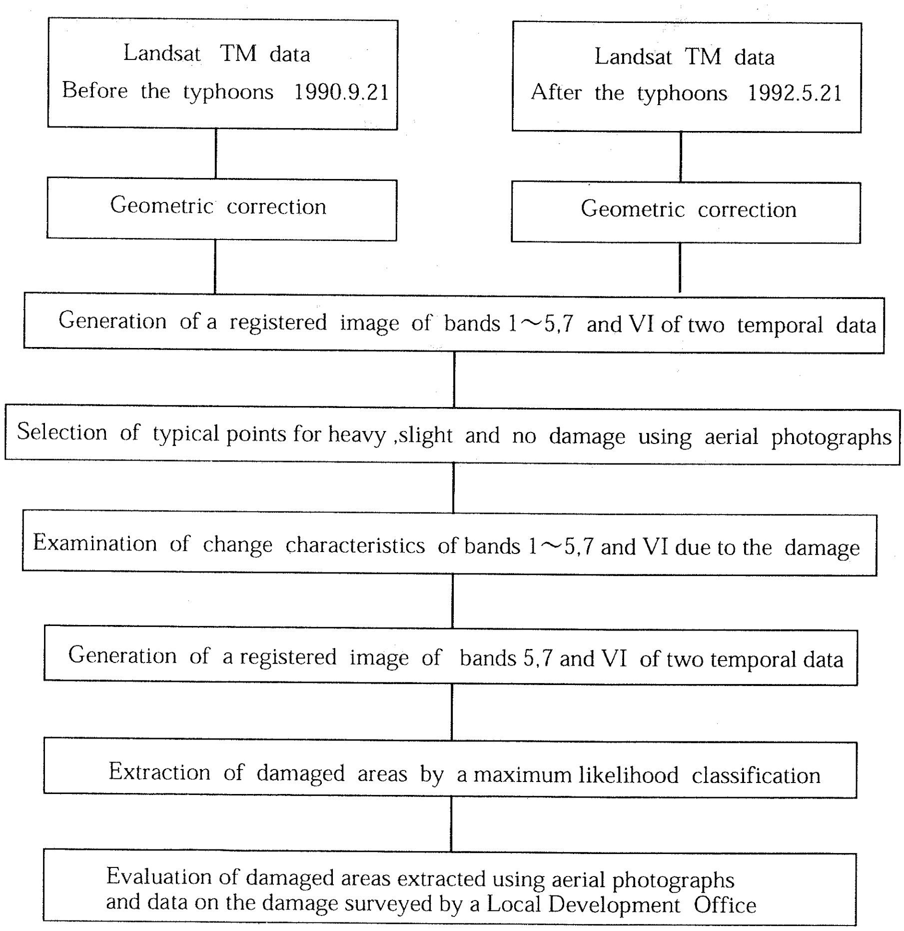


Fig. 3 Procedures of the study

Table 2 Values of bands 1～5,7 and VI before (BD) and after (AD) the damage for heavy,slight and no damage

| | Before Damage (1990.9.21) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Band1(BD) | Band2(BD) | Band3(BD) | Band4(BD) | Band5(BD) | Band7(BD) | VI(BD) |
| Heavy damage | 54.5 | 20.6 | 15.3 | 51.6 | 29.7 | 8 | 153.3 |
| Slight damage | 53.5 | 20.4 | 15.2 | 54.1 | 31.5 | 8.7 | 155.2 |
| No damage | 53.1 | 20.6 | 15.4 | 54 | 28.6 | 7.8 | 154.6 |
| | After Damage (1992.5.21) | | | | | | |
| | Band1(AD) | Band2(AD) | Band3(AD) | Band4(AD) | Band5(AD) | Band7(AD) | VI(AD) |
| Heavy damage | 93.1 | 39.5 | 43.5 | 67.8 | 94.9 | 43.4 | 121.3 |
| Slight damage | 84.8 | 34.9 | 34.1 | 61.1 | 59.2 | 23.2 | 127.9 |
| No damage | 83.4 | 34.4 | 31.4 | 64.7 | 44.9 | 14.5 | 133.9 |

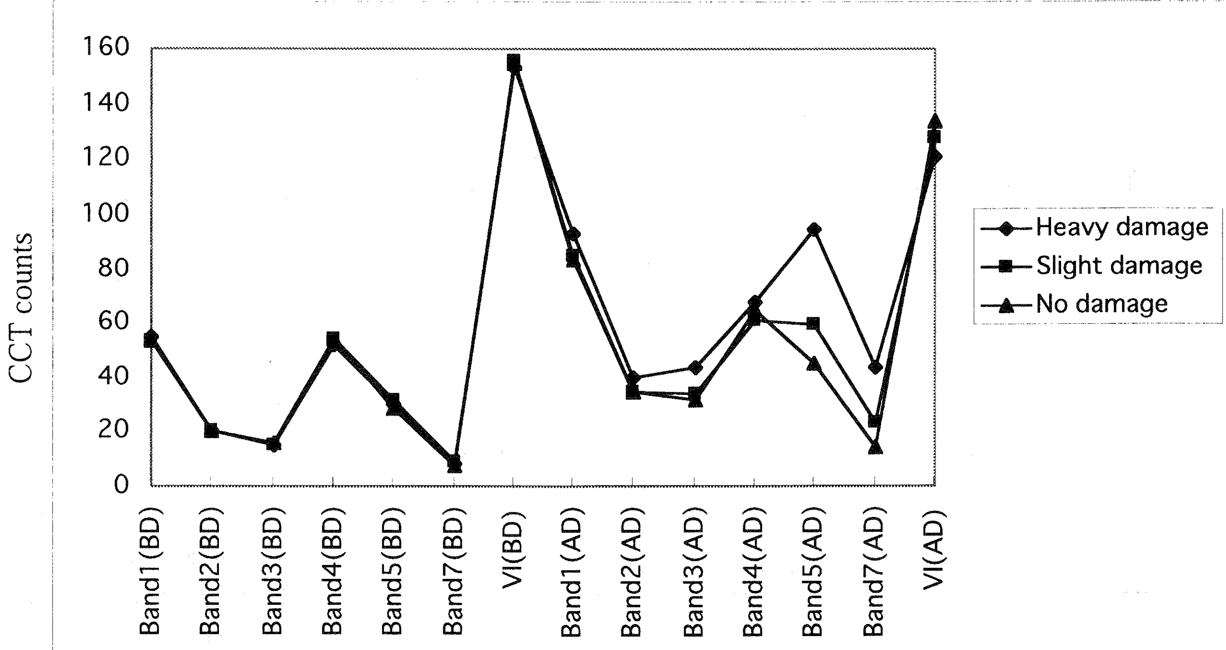


Fig. 4 Characteristics of bands 1～5,7 and VI before (BD) and after (AD) the damage for heavy,slight and no damage

## 3. METHOD OF THE STUDY

Fig. 3 shows procedures of the study. A geometric corrected image of the test site was generated through the geometric correction process using Ground Control Points from each Landsat TM data acquired before and after the damage. The accuracy of the geometric correction was less than 1 pixel and its pixel size was 25m square. Vegetation Index (VI) was generated by the following equation.

$$VI=100 \times (Band 4 - Band3) / (Band4 + Band3) + 100 \quad (1)$$

A registered image of bands 1～5,7 and VI of two temporal data were generated. Typical points for heavy ,slight and no damage were selected in the registered image referring the aerial photographs, and the change characteristics of bands 1～5,7 and VI due to the damage were examined using the typical points selected above.

It was found that band 5,7 and VI were effective to identify the damage. A registered image of band 5,7and VI of two temporal data was generated and the damaged areas were

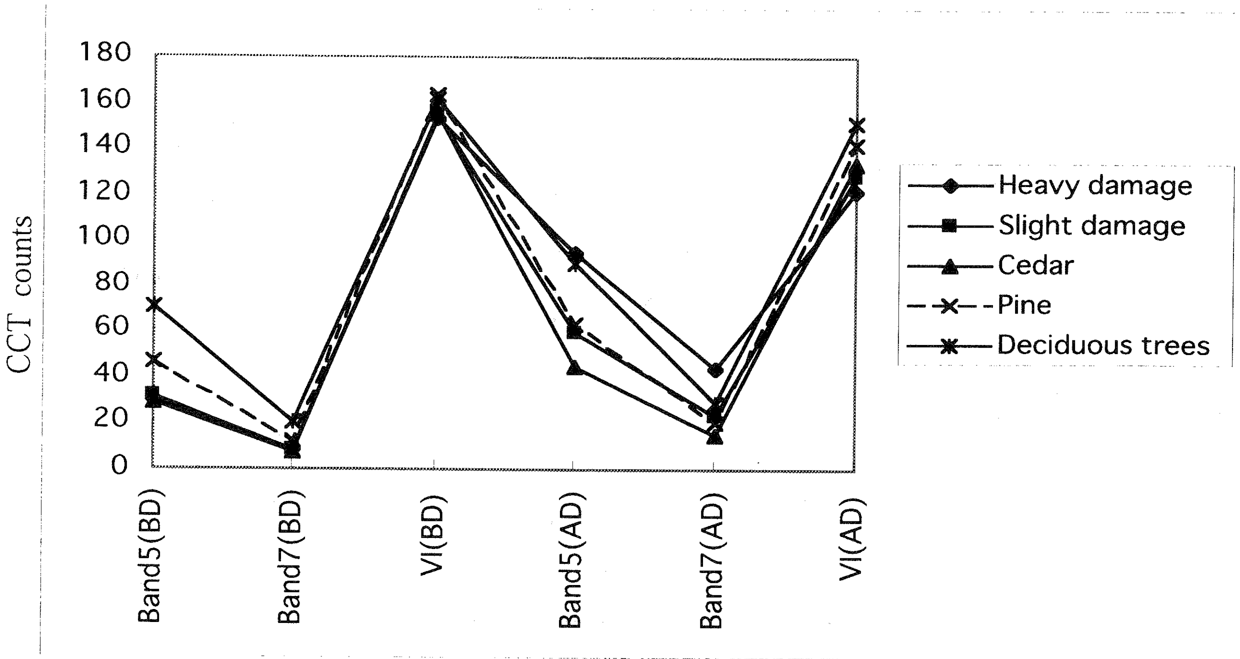


Fig. The characteristics of bands 5,7 and VI before (BD and after (AD) the damage for the categories of the heavy and slight damage,cedar,pine and deciduous trees.

extracted by a maximum likelihood classification method using the registered image of band 5,7 and VI. The damaged areas extracted by Landsat TM data were evaluated using the aerial photographs and data on the damage surveyed by the Local Development Office.

## 4.EXAMINATION OF CHANGE CHARACTERISTICS OF BANDS 1~5,7 AND VI DUE TO THE DAMAGE

Typical points representing each group of heavy,slight and no damage were selected reffering the aerial photographs in the registered image of bands 1~5,7 and VI of two temporal data. The extent of the damage was classified into two stages of heavy and slight and the state of each damage is as follows :

Heavy damage : Trees are entirely fallen in the selected points.

Slight damage : Trees are partly fallen in the selected points.

As most of the damage occurred in coniferous trees where cedar or cypress were mainly planted, no damaged areas in plantations of cedar were selected as the typical points of no damage. About 10 points were selected for each group of heavy,slight and no damage. Table 2 shows the values of bands 1~5,7 and VI before (BD) and after (AD) the damage for heavy, slight and no damage,which were obtained by the average data of the selected points for each group and Fig. 4 shows their graph. It can be seen from Fig. 4 that there is no change among each damage group for bands 1~5,7 and VI before the damage but bands 1~5,7 increase and VI decreases after the damage. It seems that the change among each damage group are larger in bands 5, 7 and VI than bands 1~4. It is conspicuous that band 5 and 7 of middle infrared increase much due to the damage. It is considered that the fallen trees show a high reflectance for middle infrared because they are dried at the time of satellite observation after the damage. A registered image of band 5,7 and VI of two temporal data was generated and used for the extraction of the damaged areas.

## 5. EXTRACTION OF DAMAGED AREAS

The damaged areas were extracted by a supervised maximum likelihood classification using the registered image of bands 5,7 and VI of two temporal data. Several categories such as cedar or pine etc. were selected in addition to the heavy and slight damage in the classification. Training areas for each category were selected referring the aerial photographs,geographical and vegetaion maps. Fig. 5 shows the characteristics of the bands 5,7 and VI before (BD) and after (AD) the damage for the categories of the heavy and slight damage, cedar,pine and deciduous trees. The pine and deciduous trees are larger than the heavy and slight damage before the damage,but are a little near to them after the damage.

Table 3 Discrimination table of the damage of the check points by Landsat TM data and the aerial photographs

| | | Discrimination by aerial photographs | | | No. of check points |
|---|---|---|---|---|---|
| | | Heavy damage | Slight damage | No damage | |
| Discrimination by Landsat TM data | Heavy damage | 30 (75.0) | 7 (17.5) | 3 (7.5) | 40 |
| | Slight damage | 14 (34.1) | 22 (53.7) | 5 (12.2) | 41 |

Table 4 Damged area for each municipality surveyed by Hida Local Development Office

| Municipality | Damaged area surveyed by Local Development Office (ha) | Damaged areas estimated by Landsat TM data (ha) | | |
|---|---|---|---|---|
| | | Heavy damage | Slight damage | Total |
| Hida city | 2851 | 1584 | 5379 | 6962 |
| Ohyama town | 636 | 247 | 663 | 910 |
| Amagase town | 1510 | 792 | 1593 | 2385 |
| Maetsue village | 1361 | 579 | 1449 | 2028 |
| Nakatsue village | 665 | 458 | 1186 | 1644 |
| Kamitsue village | 1825 | 478 | 1403 | 1881 |

## 6. EVALUATION OF THE DAMAGED AREAS EXTRACTED BY LANDSAT TM DATA

### 6.1 Evaluation using the aerial photographs

A part of the area covered by the aerial photographs was extracted from the output image of the damaged areas, and its magnified image was generated. 81 points extracted as the heavy and slight damages were selected as check points for the evaluation in the magnified image. 40 points were selected as the heavy damage and 41 points as the slight. The state of damages for the check points were carefully examined using the aerial photographs and Table 3 is a discrimination table of damages for the check points discriminated by Landsat TM data and the aerial photographs. Among 40 points discriminated as the heavy damage by Landsat TM data,30 points were discriminated as the heavy damage,and 7 points as the slight and 3 points as no damage by the aerial photographs. The numeral in parentheis shows percentage. Among 41 points discriminated as the slight damage by Landsat TM data,22 points were discriminated as the slight heavy,and 14 points as the heavy and 5 points as no damage by the aerial photographs. Most (75%) of the points discriminated as the heavy damage by Landsat TM data were the heavy damage, but the points discriminated as the slight damage by Landsat TM data include not a little (34.1%) the heavy damage. Putting together the heavy and slight damage,the damaged areas can be discriminated with an accuracy of about 90% by Landsat TM data. Examinating 8 points discriminated as no damage by the aerial photographs,4 points were red pines and 3 points were deciduous trees and 1 point was a cutover. Their spectral reflectance characteristics may be similar to those of the damaged areas.

### 6.2 Evaluation using data on the damage surveyed by the Local Development Office

Hida Local Development Office,a branch of Ohita Prefectural Office,controls over 6 municiparities shown in Fig.1 and surveyed damages of forests in the municiparities by using the aerial photographs or investigations on the ground. Damaged area for each municipality was surveyed by the Local Development Office and was used for the evaluation. Damaged area of each municipality was computed from the output image which extracted the damaged areas by Landsat TM data. Table 4 shows the damaged areas for each municipality surveyed by the Local Development Office and estimated by Landsat TM data,and Fig. 6 shows a relationship between the both data.Total data including the heavy and slight were used as the damaged areas estimated by Landsat TM data.It can be seen from Table 4 that the areas of the heavy damage estimated by Landsat TM data are smaller than those surveyed by the Local Development Office,but including the slight damage,the damaged areas by Landsat TM data become larger. As trees are partly fallen in the slight damage,it is considered that the areas of the slight damage may be estimated larger than the realities by Landsat TM data ,including no damage area. The damaged areas surveyed by the Local Development Office may count only the areas of fallen trees where fallen trees and no damage trees are mixed. The regression analysis between the both data in Fig. 6 shows a high correlation coefficient of 0.893 but not a little rms error of about 1700 ha.

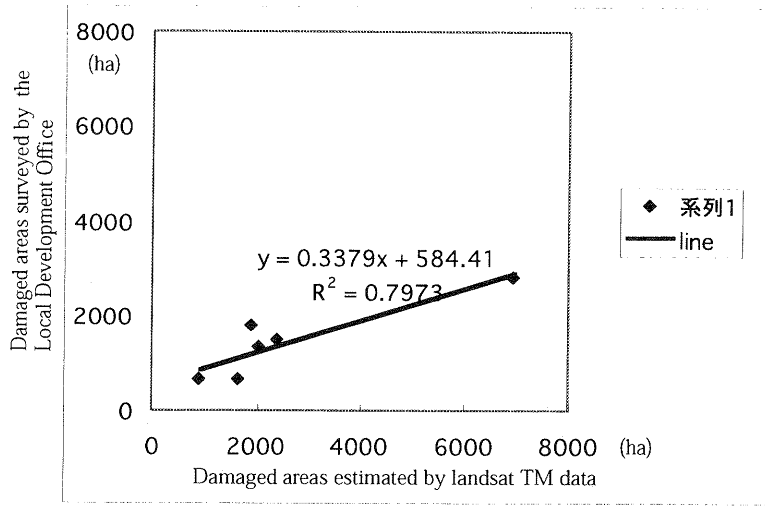


Fig. 6. Relationship between the damaged areas surveyed by the Local Development Office and estimated by Landsat TM data

It can be said that damaged areas can be extracted by Landsat TM data but the estimation of their absolute areas may be difficult.

## 7 . CONCLUSION

Damaged areas of fallen trees by typhoons using two temporal Landsat TM data acquired before and after the damage were extracted.The aerial photographs taken immediately after the damage were used to examine the change characteristics of bands 1～5,7 and VI due to the damage.The damaged areas extracted by Landsat TM data were evaluated using the aerial photographs and data on the damage surveyed by a Local Development Office. The following knowledges were obtained from this study.

(1) TM band 5 and 7 show a tendency to increase more than other bands and Vegetaion Index (VI) shows a tendency to decrease due to the damage.

(2) The damaged areas can be extracted classified into two groups of heavy and slight by a supervised maximum likelihood classification method using a registered image of band 5,7 and VI of two temporal data.

(3) . The points discriminated as the heavy damage by Landsat TM data were almost the heavy damage (75%) ,but the points discriminated as the slight damage include not a little the heavy damage (34%) . Putting together the heavy and slight damage, the damaged areas can be extracted with an accuracy of about 90%. Deciduous trees or pine trees are some times discriminated as the damaged areas.

(4) The damaged area for each municipality within the test site was computed from the the extracted image of the damaged areas by Landsat TM data, and were evaluated using the damage area for each municipality surveyed by the Local Development Office through a regression analysis. The correlation coefficient between the both data was very high (0.893) ,but the rms error was considerably large (1700ha) . The damaged areas can be extracted by Landsat TM data,but the estimation of their absolute area may be difficult.

## REFERENCE


[1] G.Takao,Detection of the Windfall Damage to Forests Caused by the Typhoons 9117 and 9119,Proceedings of the 13th Conference on Remote Sensing,pp.A-2-8-1～A-2-8-6,1992