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Original Research Paper

Assessment of the Forest Damage by Typhoon Saomai using Remote Sensing and GIS

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ABSTRACT

Saomai (August 10, 2006) was one of the most significant typhoons to hit the coast in southeast China. Quantitative assessment of forest disturbances is important for improving management strategies. This study used remote sensing techniques to investigate vegetation changes after Saomai in Changnan county. Two landsat ETM+ satellite images were acquired before and after landfall. The results showed that averaged NDVI values decreased by 17.8% after Saomai. Elevation and relative aspect present strong influence on the typhoon damage. These results provide insight into the sensitivity of coastal vegetation from the interactions of both tropical cyclones and long-term environmental conditions.

INTRODUCTION

China is affected by an average of seven landfalling tropical cyclones every year. These typhoons have caused significant damage in China over the years. Typhoons can extensively influence the composition, structure and natural succession of forests (Foster 1992, Conner 1989, Gresham 1991, Wang 2009), and it is one of the major natural disturbances in forest ecosystems in the southeast China. Saomai (August 10, 2006) was one of the most significant typhoons to hit the coast in southeast China. Quantitative assessment of forest disturbances is important for improving management strategies. Traditional field survey can, however, be very time consuming and confined to local areas. Satellite remote sensing techniques have been gradually adopted for monitoring forest status at regional and global scales since early 2000 (Rodgers 2009, Ramsey 1997, Ayala-Silva 2004, Lee 2008). Ayala-Silva and Twumasi (Ayala-Silva 2004) investigated the vegetation change caused by Typhoon Georges in Puerto Rico using the standardized change of NDVI derived from AVHRR images (Lillesand 2004, Lee 2008). Mukai (2000) analysed the relationship of forest type, topographic aspects, elevation and forest damage caused by Typhoon Herb in central Taiwan using NDVI derived from SPOT images.

According to the preliminary survey results, Typhoon Saomai had an adverse effect on the coastal vegetation, yet the extent and magnitude of the vegetation damage within the region has not been fully investigated. The goal of this study is to investigate vegetation disturbance by using NDVI as an indicator of post-typhoon forest damage.

MATERIALS AND METHODS

Study Area

Typhoon Saomai became the sixth tropical cyclone to hit China in 2006 when it made landfall at 09:25 UTC (August 10, 2006) in Cangnan County near the city of Wenzhou in Zhejiang Province (Fig. 1). The study area (Cangnan county, 27°302 N'120°232 E) lying the south of Zhejiang Province covers a land area of 1261.08 km^2, and a sea area of 3,720,000 km^2 with a coastline of 168.88 km. The study area is located in the subtropical maritime monsoon climate region with an annual mean temperature and precipitation of 17.9°C and 1670.1 mm respectively. The present study area is dominated by mixed deciduous/broadleaf forest, along with shrubs, herbaceous vegetation, bare land and built-up areas.

Data and Methods

Satellite image data acquisition and preprocessing: Landsat ETM+ images were used in this study to monitor changes before and after Typhoon Saomai. Pre and post-Saomai Landsat ETM+ remote sensing images (October 18, 2005 and October 5, 2006) were used for typhoon disturbance detection. Images were rectified to the October 2005 base image. Total root mean square for each image rectification process was less than 1/2 pixel (±15 m). The images were radiometrically corrected using standard remote sensing techniques (Kovacs et al. 2001). Normalized Difference Vegetation Index (NDVI) values were calculated for each of the two images respectively.

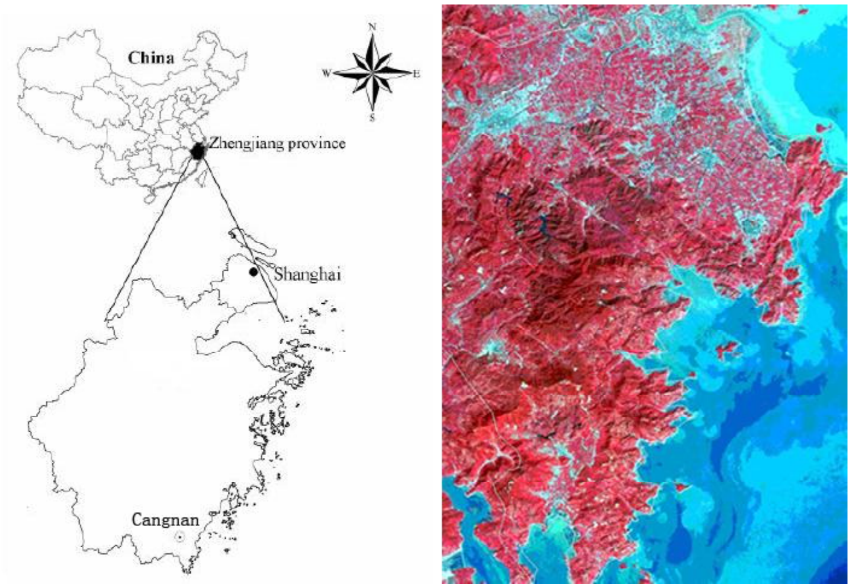

Fig. 1: Location of the study area (left) and Landsat ETM+ image (right) of the study area.

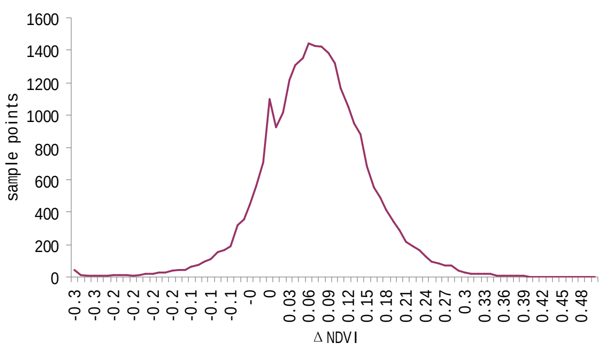

Fig. 2: The histogram of ΔNDVI before and after landfall.

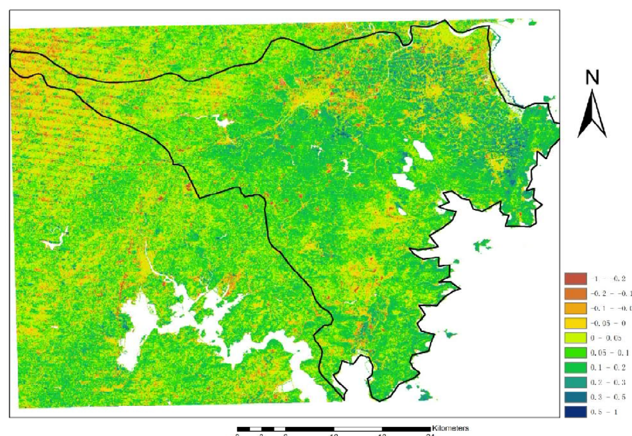

Fig. 3: Subtraction of the October 5, 2006 NDVI image from the October 18, 2005 NDVI image for the study area.

Environmental data: Land cover types, elevation, and relative aspect during the typhoon period were analysed to help evaluate the changes in NDVI. Land cover types were derived from the data product of EUROPE300. The composition of land use in the study area included urban land, farm land, wetland, shrubs and broadleaf forest. The relative aspect was defined as the angle between the aspect and wind direction with a range of 0-180 degree.

Methodology: To quantify changes in NDVI values among the two images, a geographic information system (GIS) was used to generate 26131 spatial random points across to the study region. To assess temporal changes in the vegetation, NDVI image of October 18, 2005 was subtracted from that of October 5, 2006 by using map algebra, which is a cell-by-cell process performed on each coregistered pixel from both input images.

RESULTS AND DISCUSSION

Overall NDVI comparisons: Vegetation changed greatly during this particular temporal comparison. The average NDVI value and maximum NDVI value of pre-Saomai image were 0.64 and 0.88, whereas these two indices of post-Saomai image were 0.57 and 0.79 respectively. The change of NDVI value had a wild range from -0.96 to 1.24 (Fig. 2). The average subtracted NDVI value between the October 18, 2005 and October 5, 2006 images was 0.14 and the average percent decrease was -17.68%.

Variability of NDVI change among land cover types: Changes in averaged NDVI after landfall varied among different locations and land cover types. From the subtraction

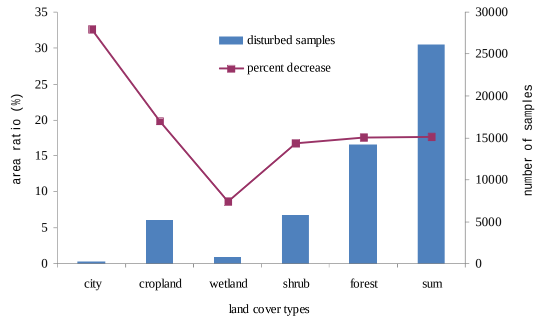

Fig. 4: The damaged area and percent decrease of change of NDVI value with different land cover types.

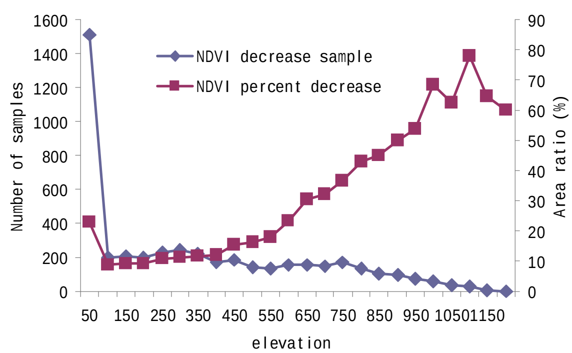

Fig. 5: The damaged area and percent decrease of change of NDVI value with different elevation.

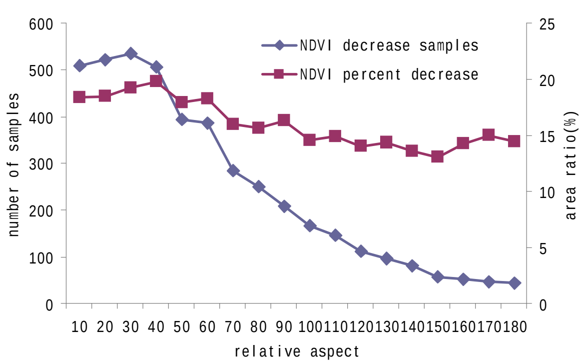

Fig. 6: The damaged area and percent decrease of change of NDVI value with different relative aspect.

of the October 18, 2005 and October 5, 2006 NDVI images (Fig. 3), it was obvious that the areas with the most pronounced decreases in NDVI were north and northeastern regions. Within the individual land cover types, urban and farmland had the largest percent decrease in averaged NDVI from October 2005 and October 2006 (32.6% and 19.8%). This was followed by coniferous and broadleaf forest (17.5%). The wetland experienced the least amount of decline in average NDVI during this period (Fig. 4).

Influence of environmental variables on the disturbance of vegetation by typhoon: Those areas below 150 m experienced the highest decrease of NDVI value, areas below 50 m and 50-100 m experienced an average decrease in averaged NDVI value from October 2005 to October 2006 of -56.0% and -29.5%, respectively (Fig. 5). The damaged area decreased with the increasing elevation, whereas percent decreases in NDVI increased with elevation. Positive correlation was showed between elevation and percent decrease in NDVI was done with a relationship coefficient of 0.925.

The damaged area and the percent decrease in NDVI both decreased with the increasing relative aspect (Fig. 6). But this reduction was not a linear decrease, the largest NDVI reduction occurred in the relative aspect between 30 and 40 degree with a proportion of 19.78%. Negative correlation was shown between relative aspect and percent decrease in NDVI was done with a relationship coefficient of -0.879.

It can be concluded that vegetation indices measured from Landsat satellite imagery showed a near 20% reduction in value from October 18, 2005 to October 5, 2006. Compared to these other studies, it appears that the NDVI decrease following Typhoon Saomai in study area was moderate in value (Loope 1994, Lodge 1991). Environmental factors such as elevation and relative aspect had close relationships with typhoon damage. Due to lack of field survey data for Saomai, these led to the uncertainty for evaluation of damage by typhoon disturbance. A more comprehensive on ground investigation of the different taxa and their respective tolerances to environmental change, especially to changes in typhoon track, would help understanding how spatial patterns enable determination of relationships between typhoons and coastal vegetation dynamics.

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