

# A Study on the Changes in NDVI of Panjin Reed Wetland and an Analysis on Its Correlation with Meteorological Factors

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**Abstract.** As the main body of the Liaohe River Delta, the Panjin Wetland plays a vital role in maintaining the ecological balance throughout the region. The analysis of the correlation between NDVI and meteorological factors was carried out on reed wetland by using the normalized differential vegetation index (NDVI) data of Panjin Reed Wetland from 2006 to 2015 and such meteorological data as ten-day average temperature, ten-day precipitation, ten-day sunshine duration, ten-day relative humidity and ten-day evaporation capacity. The results showed that the NDVI of Panjin Reed Wetland had no obvious year-to-year changes from 2006 to 2015 and showed a slight upward trend with small fluctuations. However, the NDVI of Panjin Reed Wetland had significant intra-annual changes and was depicted as a single-peaked curve in the crop growing season. The curve reached the peak value in early- and mid-July, which was highly consistent with the phenophase. The ten-day NDVI of reed wetland is most and positively correlated to the ten-day average temperature, with the correlation coefficient reaching a value of 0.7874.

## 1. Introduction

Wetlands are considered as a type of the Earth's most important ecosystems, and are consequently regarded as "the Earth's kidneys". Wetland plays an irreplaceable role in regulating runoff and maintaining ecological balance, among many other aspects [1]. Located at the southern extremity of Liaohe Plain, which is at southwestern part of the Liaoning Province, the Liaohe River Delta is one of the eight world's famous river deltas [2]. The Panjin Wetland is located in the core area of Liaohe River Delta and covers an area of about 314,900 hm<sup>2</sup>. The area of reed wetland accounts for 21.08% of the total wetland area [3]. The Panjin Reed Wetland is the second largest reed producer in Asia [4]. NDVI can well reflect the vegetation coverage of the underlying surface and is widely applied in vegetation growth monitoring, land classification, drought monitoring, and other studies [5-8]. In recent years, domestic and foreign scholars have carried out many studies on the correlation between NDVI and meteorological factors. The results showed that the varying correlations between NDVI and meteorological factors in different climatic regions of different land surface types [9-13]. Therefore, this paper analyzed the dynamic changes in the last decade on the basis of the NDVI data and meteorological data such as temperature and precipitation of Panjin Reed Wetland so as to provide the fundamental data and scientific basis for the wetland's regional ecological environment protection.



## 2.Data and Methods

### 2.1. Overview of the studied wetland

Panjin Wetland is located at the southernmost extremity of the Liaohe Alluvial Plain, at the 40°41'~41°27' North and 121°31'~122°28' East. Some of its wetland types mainly include the reed swamps, mud flats, and paddy fields, all of which are rich in both floral and faunal resources, in addition to its unique wetland landscape [14]. Figure 1 depicts the location of the reed wetland.

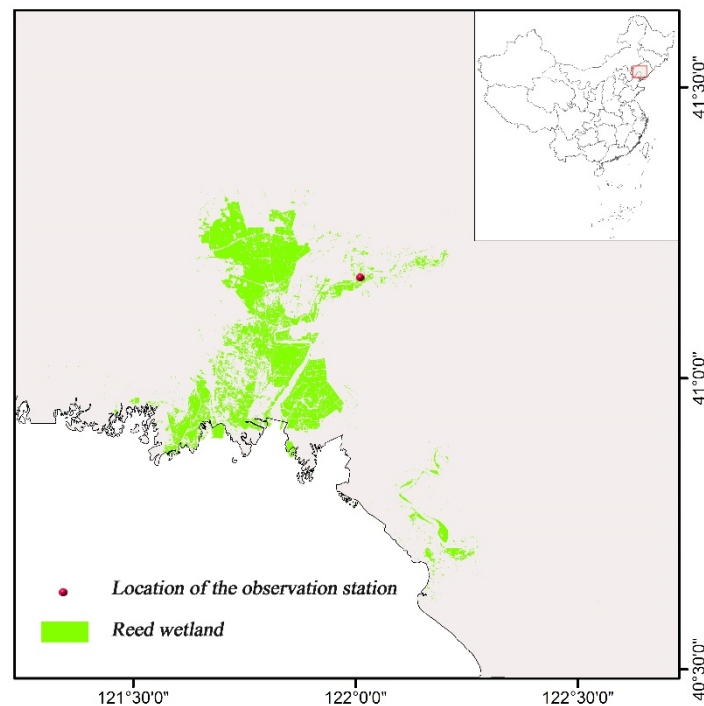


Figure 1. Location of the Panjin Reed Wetland

### 2.2. Data sources

The EOS/MODIS used in this paper is taken from China Satellite Data Service Network. According to the growth characteristics of Panjin Reed Wetland, the EOS/MODIS data with a data resolution of 250 m from late May to late September, spanning from 2006 to 2015, were selected as the data source. The data selection conforms to the principle of having clear images of the studied wetland, and having an amount of cloud cover that is 30% less than that in the studied wetland. The daily vegetation index was calculated first; and then the ten-day vegetation index was calculated by the maximum value composite procedure; finally, the monthly vegetation index was calculated by averaging. The processes of data pre-processing, vegetation index calculation and maximum value composite procedure were completed with the support of the self-developed “Application Demonstration System for Remote Sensing Monitoring and Evaluation of Northeast Wetland”, which mainly includes the functions for data projection, geometric correction and registration of remote sensing image, data resampling, vegetation index calculation, and maximum value composite procedure.

The meteorological data for the purposes of this research, including the ten-day average temperature, ten-day precipitation, ten-day sunshine duration, ten-day relative humidity and ten-day evaporation capacity, were all obtained from the CIMISS (China Integrated Meteorological Information Service System). The observation station selected is numbered 54338 and is located within the Panjin Wetland, at 122.02° East and 41.18° North, at the registered time series of 2006-2015.

### 2.3. Methods

Correlation coefficient was applied to analyze the correlation between different meteorological factors and the NDVI of Panjin Reed Wetland. The greater the correlation coefficient  $r$  is, the better the correlation between the factor and NDVI is, and it shows that the greater the impact of the factor on the growth status of the reed wetland. The calculation formula is as follows:

$$r = \frac{n \sum_{i=1}^n x_i y_i - \sum_{i=1}^n x_i \sum_{i=1}^n y_i}{\sqrt{n \sum_{i=1}^n x_i^2 - (\sum_{i=1}^n x_i)^2} \sqrt{n \sum_{i=1}^n y_i^2 - (\sum_{i=1}^n y_i)^2}}$$

Where,  $r$  is the correlation coefficient,  $x_i$  is the wetland NDVI,  $y_i$  is the meteorological factor,  $n$  is the number of variables.

## 3. Analysis of Results

### 3.1. Inter- and intra-annual change characteristics of the reed wetland's NDVI

It can be seen from Fig. 2(a) that the NDVI of Panjin Reed Wetland had no obvious year-to-year changes from 2006 to 2015, with only a slight upward trend. The correlation coefficient of its linear regression equation was 0.4573, and passed the significance test of  $p < 0.01$ .

It can be seen from Fig. 2 (b) that the NDVI of Panjin Reed Wetland had significant intra-annual changes and was depicted as a single-peaked curve in the crop growing season. The NDVI of reed wetland is low in late May and suddenly increases in early June, which is correlated to the arrival of the reeds' leaf-expansion period at the end of May. NDVI reaches the peak value around early or middle July; the peak value is between 0.71 and 0.75 and has no significant inter-annual change. Then NDVI gradually decreases by about 0.07 from late July to late August, but the change is not obvious. NDVI decreases quickly since mid-September and reaches its minimum in late September, which is consistent with the occurrence of the reeds' withering period. The NDVI at this period has no significant difference to the value in late May. Generally speaking, the changes in the NDVI of reed wetland are highly consistent with its phenophase.

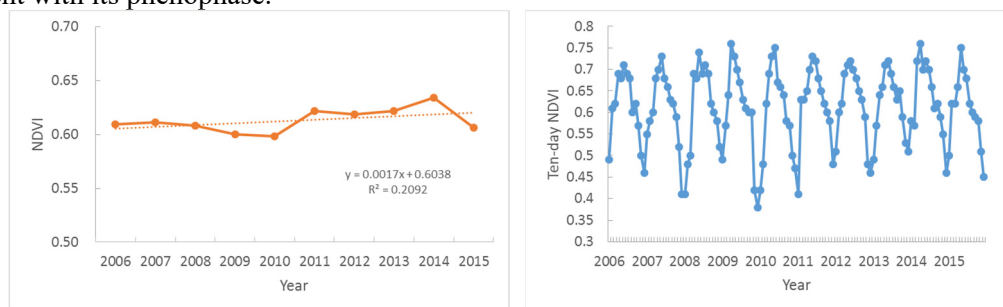


Figure 2. Inter- and intra-annual changes in the NDVI of Panjin Reed Wetland, 2006-2015

### 3.2. Correlation between NDVI of reed wetland and meteorological factors

A correlation analysis was conducted between the ten-day NDVI of Panjin Reed Wetland and 5 meteorological factors (ten-day average temperature, ten-day precipitation, ten-day sunshine duration, ten-day relative humidity and ten-day evaporation capacity) from 2006 to 2015. All of the 5 meteorological factors passed the significance test of 0.01. It can be seen from Fig. 3 that the NDVI of reed wetland is most and positively correlated to the ten-day average temperature, with a correlation coefficient of 0.7874. Next on the order is the ten-day relative humidity with a correlation coefficient of 0.4567. However, the ten-day evaporation capacity and the ten-day sunshine duration are negatively correlated to the NDVI of reed wetland; and the correlation is low. This is especially true for the correlation with the ten-day evaporation capacity, with the correlation coefficient of as low as -0.1658.

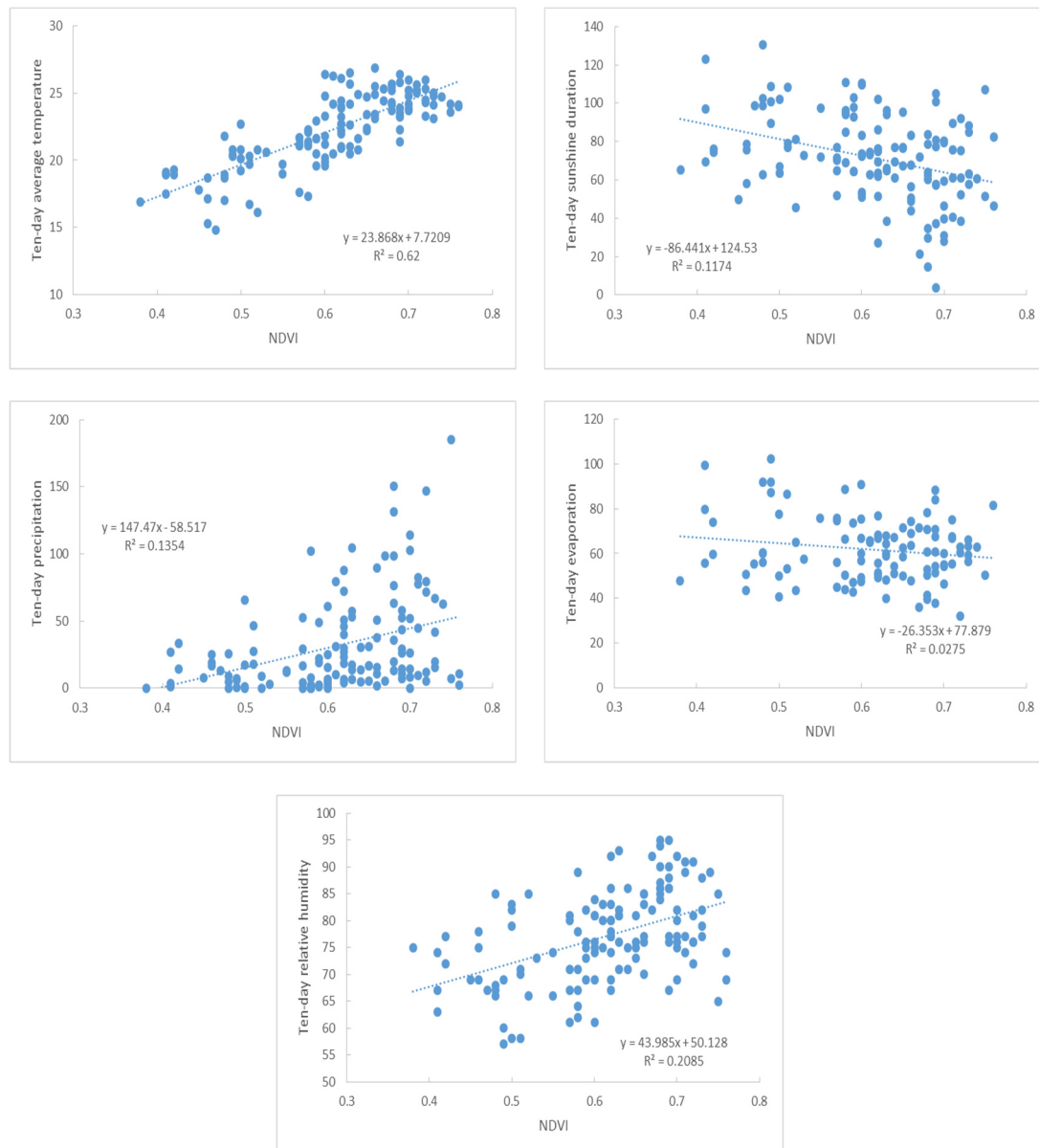


Figure 3. The correlation between wetland and meteorological factors

### 3.3. Change characteristics of the reed wetland's LAI

In crop growing seasons, owing to the rise in average temperature, the increase in the leaf area index (LAI) is represented as a wavelike pattern. The maximum value of LAI corresponds to the peak value of the average temperature. The low value of LAI is not noticeably correlated to the temperature changes. The changes in the LAI of reed wetland are basically consistent with the precipitation pattern. Especially from mid-July, if the precipitation is low, the LAI is also low; if the precipitation is high, the LAI is high as well.

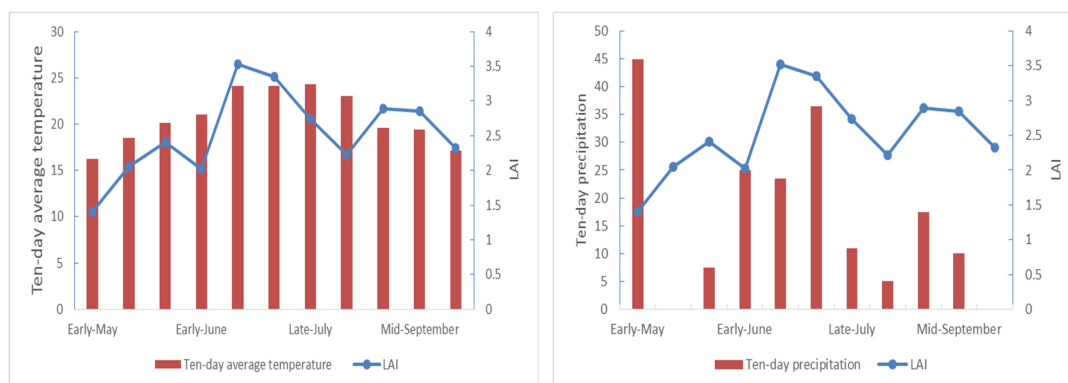


Figure 4. Correlation between the LAI of reed wetland and average temperature and precipitation

### 3.4. Analysis on the changes in monthly evaporation capacity of Panjin Reed Wetland and its surrounding meteorological stations

The eddy-covariance observed evaporation capacity data within the reed wetland from May to December 2013 was compared with the evaporation capacity data observed at the adjacent observation stations. The evaporation capacity of the reed wetland is less than those of its adjacent meteorological stations; and the difference is significant in May.

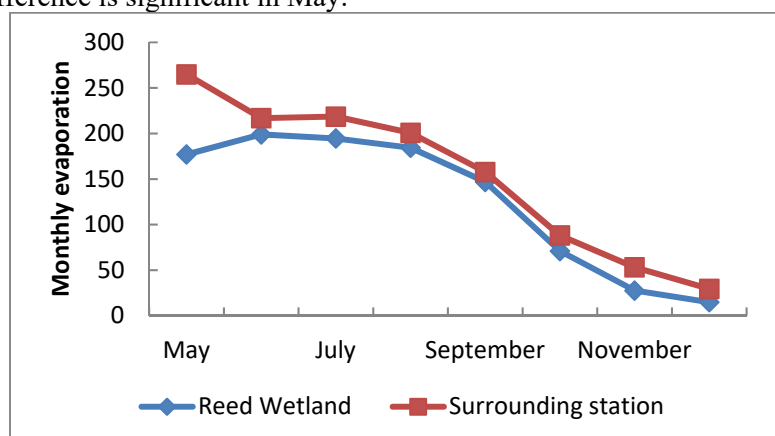


Figure 5. Correlation between the monthly evaporation capacity of reed wetland and that of the meteorological observation stations

## 4. Conclusions and Discussion

This paper analyzed the correlation between the NDVI of Panjin reed wetland and meteorological factors according to the EOS/MODIS data from 2006 to 2015 and drew the following conclusions:

(1) The NDVI of Panjin reed wetland had no obvious year-to-year changes from 2006 to 2015 and showed a slight upward trend with small fluctuations. However, the NDVI of Panjin Reed Wetland had significant intra-annual changes and was represented as a single-peaked curve in the crop growing season. The curve reached its peak value in early- and mid- July, which was highly consistent with the phenophase.

(2) The ten-day NDVI of reed wetland is positively correlated to the ten-day average temperature, ten-day precipitation and ten-day relative humidity, and is most correlated to the ten-day average temperature, with a correlation coefficient of 0.7874. The NDVI of reed wetland is negatively correlated to the ten-day evaporation capacity and ten-day sunshine duration, presenting a relatively low correlation.

(3) The LAI of reed wetland in the growing season is consistent with the changes in precipitation; the monthly evaporation capacity of reed wetland is less than that of its adjacent meteorological stations. In particular, the evaporation capacity in May is noticeably small.

### Acknowledgments

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