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# An Estimation of Chaohu Lake Wave Parameters from Wave Predictive Methods

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**Abstract:** The shoreline of Chaohu Lake (Anhui Province) is undergoing these last decades serious erosion with rates up to 10 m year$^{-1}$. To assess this problem in the standing point of dynamic geomorphology waves data are necessary because they are the primary force of shoreline erosion. Such wave data are not available for Chaohu Lake. This study uses the wave predictive method to deduce Chaohu Lake wave parameters: wave height, wave period, wavelength from wind speed and fetch. The results show a great variability of waves parameters under normal winds and extremes winds (Storm events).

**Key words:** Chaohu lake, shoreline erosion, wave predictive method

## INTRODUCTION

Chaohu Lake, the fifth biggest freshwater lake of China, located in the central part of Anhui province, 15 km of Heifei city (Anhui province capital), between 30°25'28'' and 31°43'28'' North and between 117°16'54'' and 117°51'46'' East, is undergoing a severe shoreline erosion problem. During the last 50 years, 88.9 km of the 184.66 km of Chaohu lakeshore has been eroding at rates that reaches -10 m year$^{-1}$ (Gao *et al*., 2005).

For now, the real causes of this erosion problem have not been addressed with satisfaction in regard to its complexity and the amount of variables that have to be understood and integrated.

For Gao *et al*. (2005), "faults are the most important factors that affect the Chaohu lake shore's collapse during its evolvement". That seems to be in contradiction with the theoretical research on coastal geomorphology and coastal research. Since the pioneering research of Johnson (1919), coastal geomorphologists and engineers have emphasized the importance of waves in the erosion of shorelines and their recession. Sunamura (1992), states that shoreline erosion depends on the rapport wave energy (Fw) and the shoreline materials strength (Fr). He states that it is only when Fw is superior to Fr that shoreline erosion can take place.

So, It is clear that waves are the primary force of shoreline erosion. Wave data are thus prerequisite for the study of any shoreline problem from the standpoint of dynamic geomorphology (Sunamura, 1992).

Such data are not available for Chaohu Lake, but some methods can be used to deduce wave parameters from wind and fetch. These methods are called Waves Predictive Methods.

The aim of this research is to deduce the different wave parameters: wave height, wave period and wavelength from wind parameters and fetch.

These parameters can help to understand the different behavior of wave variables and their effects on the shoreline erosion of Chaohu Lake.

## MATERIALS AND METHODS

This research uses the wave predictive methods. A wave predictive method is a method of estimating wave height and period if the wind speed and fetch are known (Smith and Sinclair, 1972). This method was first developed by the Beach Erosion Board (US Army, 1962) and was a modification of that originated by Bretschneider (1972).

Sunamura (1992) showed the usability of such methods in the lack of a wave monitoring system:" Although, full understanding of wave generating mechanisms has not been achieved, studies of wave generation in the 1950's enable us to forecast (or hind cast) wave height and period from wind parameters i.e., wind speed, duration length of fetch.

The equations relating significant wave height, period, wind speed and the fetch are given:

$$Hs = \frac{0.0026[gf / W^2]^{0.47}}{g} \quad (1)$$

where, Hs is the wave height in meters, g is the acceleration due to gravity (9.8 m s$^{-1}$), W is the wind speed, F is the Fetch, 0.0026 and 0.47 are constants.

The wave period can be obtained by the equation:

$$gTs/W = 0.46\left(\frac{gF}{W^2}\right)^{0.28} \quad (2)$$

where, Ts is the wave period in seconds.

Knowing the wave height and wave period, the wavelength and the celerity can be deduced.

$$\lambda = 1.56Ts \quad (3)$$

$\lambda$ is the wavelength and the 1.56 is a constant.

As the wind speeds and directions of Chaohu Lake area are known. The fetches were measured from Landsat orthorectified images (ETM+, 2000) using MapInfo and they were drawn in regard the different wind directions as they cross the erosional shores.

Two types of wind speeds were used: the wind speeds during normal conditions and their speed during extreme events (storm events). These two types of wind data can give an overview of the variability of waves and wind parameters.

## RESULTS

The Table 1 shows the different winds parameters over Chaohu Lake and their corresponding wave parameters under normal wind conditions. Four major winds blow over the area and they are manly from the Eastern side of the Lake. In regards to their duration and speed they are:

**The southeast wind:** It blows over the area during 4 months (April to July) and has the highest speed (3.1 m $s^{-1}$).

**The east wind:** Even if it blows only for 2 months (February to March) its speed is very close to that of the South-East wind.

**The northeast wind:** It covers the lake area for 3 months (August to October), its speed is lower than that of the former two.

**The northwest wind:** It blows during 3 months from November to January. Its speed is the same as the North East wind.

These winds induce waves that range from 16-30 cm with periods ranging from 1.6-2.5 sec.

Table 1: Waves parameters under normal winds

| Wind direction | East | South-East | North-East | North-East |
|---|---|---|---|---|
| Wind duration | Feb-March | Ap-May-June-Jul | Aug-Oct | Nov-Jan |
| Wave speed m $s^{-1}$ | 3 | 3.1 | 2.6 | 2.6 |
| Wave Height in meters | 0.16-0.30 | 0.23-0.27 | 0.14-0.21 | 0.19-0.23 |
| Wave period in seconds | 1.7-2.5 | 2.1-2.4 | 1.6-2.1 | 1.9-2.0 |
| Wavelength in meters | 2.7-3.0 | 3.0-3.7 | 2.5-3.3 | 3.0-3.4 |

Table 2: Waves under extreme wind speeds

| Wind direction | East | South-East | North-East | North-West |
|---|---|---|---|---|
| Wind speed m $s^{-1}$ | 16 | 18.6 | 16.5 | 15.7 |
| Wave height meters | 0.9-1.6 | 1.6-2.02 | 1.0-1.6 | 1.3-1.6 |
| Wave period seconds | 3.6-5.3 | 4.7-5.6 | 3.6-4.7 | 4.3-4.5 |
| Wavelength meters | 5.6-8.3 | 7.3-8.7 | 5.6-7.3 | 6.7-7.0 |

The erosional force of these waves is low because at such height and periods the potential and kinetic energy of the waves are low.

From Table 2, it appears that during storm events the wind speeds increase significantly up to 5 or 6 times the speed of normal winds. The wave heights, periods and wavelength also increase correspondingly and the highest wind speeds and waves height occur under the Southeast wind.

During such events the waves height will vary from 90 cm to 2.02 m and the wave periods reach 3.6-5.6 sec. The wavelengths also increase up to 8.7 m.

It appear clear that the erosive strength of these waves are very high and it can be deduced that they are the main agents of actual Chaohu Lake shoreline erosion.

## DISCUSSION

The wave predictive methods as described above can give an account of waves parameters of a water body such are lakes and seas.

This research showed that the same methods could be used for Chaohu Lake.

The shoreline erosion of Chaohu can be more understood in regard of these results.

The waves under normal winds are very low to erode the shoreline, but as the wind climate changes the waves respond correspondingly and can be very destructive during storm events.

So in assessing the mechanism at work on Chaohu shore a great account must be given to waves occurring during storm events. Or, storm events seem to be frequent in Chaohu Lake area and in all the South-East of China during the last decades.

Su *et al.* (2005) pointed out that the average trend of heavy rain days related to storm events show a positive

trend since 1970 and that the days of rainstorms and the magnitude of rainstorms reveal increasing events both in frequency and intensity.

Shi *et al.* (2004), have found out that the area of study has experienced 6 major flooding related to storm ssevents during the 90s.

Such rainstorms periods are those when the wind speed increases and the waves on Chaohu Lake become stronger and erode significantly the shoreline.

Even if this method helps to get an idea of the wave parameters they fail somehow to express then with a high precision because of the complexity of waves measurement. Some factors may influenced the waves such are:

- The characteristics of the wind flowing from land to the lake may change.
- These results need a calibration against some measured wave data.
- For now, the lack of a wind and wave monitoring system on the lake is an obstacle to this kind a precision. In regard of the importance of Chaohu Lake erosion problem there is an urgent need for such monitoring systems.

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