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ANALYSIS OF METEOROLOGICAL CONDITIONS FOR THE BASE OF MARINE SPORTS IN THE 26TH SUMMER UNIVERSIADE IN SHENZHEN IN 2011

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Abstract: Based on the real-time wind direction and speed data from an automatic meteorological monitoring network in Shenzhen, the wind characteristics of Jue Diao Sha maritime area are analyzed. As indicated in the results, the wind speed of this area is higher than that over the land, the average wind speed is above 3 m/s and the probability for the maximum wind speed to drop below 20 m/s is above 90%. Moreover, the probability for the hourly swing angle of wind direction to become less than 50º is above 80%, suggesting that the wind conditions in the Jue Diao Sha area could meet the requirements of the sporting events. According to the numerical simulation, this area is the best selected site among three candidates. Furthermore, the characteristics of daily land and sea breezes are such that it is suggested the game will be best carried out from 1000 to 1700 Beijing Standard Time.

Key words: meteorological condition; numerical simulation; statistics analysis; selection of marine sporting sites; Summer Universiade

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1 INTRODUCTION

The 26th Summer Universiade will be held in Shenzhen August 2011. A marine sports base is the key construction project to be carried out by the munucipality. The Planning Bureau of Shenzhen has decided on three schemes to choose the site, which is Ju Diao Sha, Sha Yu Cong and Guan Hu, presented in the order of priority. Shenzhen Meteorological Bureau has studied in detail the meteorological conditions in the sea area of Ju Diao Sha to see if it is suitable for the sailing sports so as to provide scientific basis for the selection of a marine base.

Sea winds, sea waves and sea currents are important factors affecting the sailing sports, among which winds are the most important[1, 2]. In accordance with the requirements of the Shenzhen Sports Bureau, marine sports must be performed with winds ranging from 3–20 m/s and wind speed swing angle being less than 50° . Based on an analysis of weather situations of August over a period of more than 50 years in Shenzhen that have great impacts on sporting competitions, this study uses data from a network of automatic weather stations (AWSs) and marine sites to investigate in detail the wind conditions of August in the sea area of Ju Diao Sha by means of mathematical statistics and numerical simulation. The results are then compared with the other two site selection schemes to obtain a comprehensive report on the final choice of the marine base.

2 MATERIALS AND METHODS

2.1 *Description of data*

(1) Surface meteorological observations in Shenzhen from 1952 to 2006; (2) Data of tropical cyclones from 1952 to 2006 extracted from *General Graphics and Tables About Typhoons Affecting Shenzhen Over the Past Years* edited by Shenzhen Meteorological Bureau; (3) hourly data of wind speed and direction at Lingxia station from 1997 to 2006, a site that is closest to the waters of Jue Diao Sha (about 3 km) in the AWS network of Shenzhen. To reflect the true conditions of winds of the future marine base, patrol ships were employed to perform real-time marinetime meteorological observation, lasting from 0800 Beijing Standard Time (BST) to 1730 BST, at

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fixed points about 3 km off the coast of Ju Diao Sha from August 19 to September 8, 2008. Observation was not conducted on August 22 to 23 due to the effect of an approaching typhoon.

2.2 *Techniques of data processing and methods of assessment*

Wind speed is in declining distribution from the shoreline to inland[3, 4]. The methods of ratio and spatial correlation are normally used to study the law of attenuation. In our study, the real-time marinetime observations of 2008 were used, together with the methods above, to correct the wind speed and direction of the sea area of interest[5, 6]. *K*, a mean ratio of the mean wind speed of the representative station over land to that of the sea surface, is sought for the simultaneous period. Here in our case, *K*=1.4, is actually a coefficient indicating the enhancement of wind speed at sea surface relative to that of the representative land station. In the meteorological assessment for selecting the marine site of the Summer Universiade, mathematical statistics and numerical simulation are two methods used in combination.

3 SUMMARY OF POSSIBLE HIGH-IMPACT WEATHER DURING THE SUMMER UNIVERSIADE

Located on the coast facing the South China Sea, Shenzhen is of subtropical marinetime climate. The Summer Universiade will be held in a season marked with frequent occurrence of typhoons, heavy rain, thunderstorms and heat waves in Shenzhen[7]; its schedules of marine sports will be affected by typhoons, heavy rain and thunderstorms to some extent. According to the statistics based on data from 1953 to 2006, there are 1.2 tropical cyclones on average affecting Shenzhen in August, four at most (in 1973). The probability for the city to be affected by tropical cyclones is about 72% in the month but it is relatively small, about 10%, on a day-to-day basis. In August, heavy rain occurs on 1.9 days on average and 6 days at most (in 1995), with a monthly probability of 85%. The month also is a peak time for thunderstorms in Shenzhen[8-10], which occur on 14.5 days on average and 25 days at most (in 1955); thunderstorms occur at a frequency as high as 47%. When there are typhoons, heavy rain and thunderstorms, sports events will be at risk and should not be conducted. Especially, as thunderstorms are with the highest probability of occurrence among the local high-impact weather types, precautionary measures should be taken in advance by taking into account all possible effects of thunderstorms on the sporting events.

4 CONDITIONS OF WIND ENVIRONMENT FOR THE WATERS OF JU DIAO SHA

4.1 *Analysis of wind speed*

Following a wind-speed correction coefficient, the mean and maximum wind speeds are corrected for a representative station (Lingxia) to obtain approximate sea-surface wind speeds. It should be noted that there may be some differences between the coefficient of wind-speed correction and the real situation due to relatively short duration of marine observation. It is necessary to conduct longer-time measurement at sea to get a picture of the wind environment that is closer to the reality.

4.1.1 MEAN WIND SPEED

Figure 1 gives the curves of the variations of hourly averaged sea surface wind speed at the station of Lingxia and those with corrections in August 1997–2006. The mean wind speed in the Ju Diao Sha waters is characterized by significant diurnal variations: it decreases gradually during the night, increases in the morning and attains its maximum after midday, which is related to the land-sea effect[11]. The land station has a mean wind speed of ≥ 3 m/s from 1000–1900 BST, with the period 1300–1500 BST witnessing the maximum wind that maintains more than 3.5 m/s. The marine sporting events are, therefore, suitable to be held after 1000 BST as shown in the case of the land-representing station. For all time of measurement, the corrected sea-surface wind speed meet the requirement of relevant sporting competition.

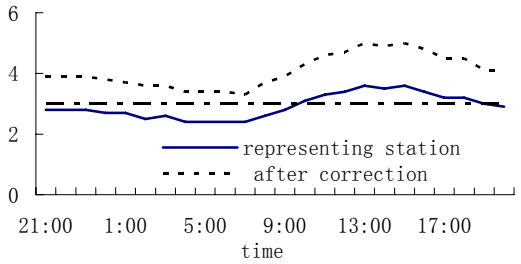

Fig. 1. Variations of hourly averaged sea surface wind speed at the station of Lingxia (solid line) and those with corrections (dashed line) over the period 1997–2006

4.1.2 MAXIMUM WIND SPEED

As shown in the analysis of the daily maximum wind speed from the representative station over the period 1997–2006 and those with corrections, the land-representing station has only one case of extreme winds (20 m/s) that occurred on August 3–4, 2006, or with a probability of only 0.32%. It was caused by Typhoon Prapiroon (coded 0606). Extreme winds are all below 20 m/s in other years of the study period. With the correction, there are 31 occurrences of

extreme winds exceeding 20 m/s, or with a probability of about 10%, which all result from tropical cyclones. For the period 0900–2000 BST during which sporting events will be taking place, the 20 m/s extreme winds occurred for 23 times, or at a probability of 7.4%. It is then concluded that the 20 m/s extreme winds do not occur during the races unless there is activity of tropical cyclones. According to the statistics, tropical cyclones usually affect the area of Shenzhen persistently for one to two days. It is then concluded that the waters of Ju Diao Sha can meet the requirement of marine sporting events as far as the wind speed is concerned.

4.2 *Analysis of wind direction*

4.2.1 FREQUENCY OF WIND DIRECTION

The method of conditional probability is used to make corrections to the wind direction of the Ju Diao Sha waters. Fig. 2 gives the frequency of the corrected wind direction. In August, the local wind mainly comes from two directions, S-SE and SWW-SW, at respective frequency of 48% and 29%. For this area, SEE is the dominant direction at a probability of 34%.

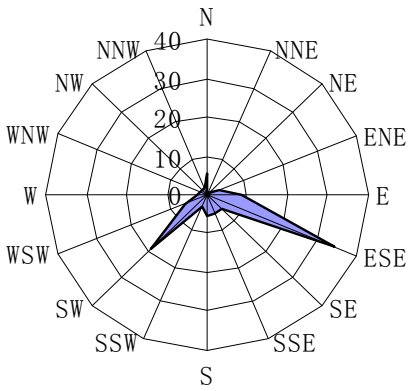

Fig. 2. Frequency of wind direction corrected for the waters of Ju Diao Sha in August

4.2.2 SWING OF WIND DIRECTION IN THE JU DIAO SHA WATERS

Being a factor most sensitive to terrain, topographic features and the nature of the underlying surface, wind is usually less stable in terms of direction over land than at sea. As found in a contrastive analysis of wind direction records for the same time of measurement for 2008, wind direction differs between land and sea but it has comparable probability as far as hourly less-than-50° swing angle is concerned. It is therefore decided that the swing of wind direction measured at the land station of Ju Diao Sha will take the place of that of the sea in study.

4.2.2.1 Day-to-day variations of hourly swing of wind direction

Figure 3 gives the curves of diurnal variations of the probability of hourly wind direction swing and hourly frequency of greater-than-50° wind direction swing from 0900 BST to 1800 BST at the station of Lingxia in August 1997–2006. Over the ten-year period, the mean swing is all less than 50° on the hourly basis and concentrates between 25–35° . Furthermore, the probability is less than 20% for the wind direction to swing at an angle of 50° , i.e., there is more than 80% of chance that the wind swing angle meets the requirements of marine sporting events. According to the statistics, the duration in which wind swings by an angle of more than 50° is usually less than 2 hours. Hence, races are recommended to postpone for one to two hours when encountering large swings of wind direction.

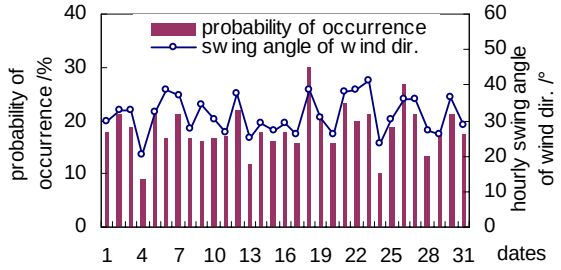

Fig. 3. Diurnal variations of the probability of hourly wind direction swing and hourly frequency of greater-than-50° wind direction swing from 0900 BST to 1800 BST at the station of Lingxia in August 1997–2006

4.2.2.2 Hourly swing of wind direction

It is known from the day-to-day variations of hourly wind direction swing from 0900 BST to 1800 BST in August 1997–2006 (figure omitted) that the hourly swing is all mild for all time of measurement over the 10 years and concentrates in a range of 15–45° . It is the largest of all time of measurement at 0900 and 1800 BST, being larger than 50° in 6 out of 31 days of the month; for the time between 1000 and 1700 BST the swing is larger than 50° in only one to two days, with the smallest angle of swing appearing at 1000 and 1200 BST. It is appropriate that the marine sporting events are performed between 1000 and 1700 BST when the swing of wind direction is taken into account.

4.3 *Numerical simulation of typical meteorological fields*

Weather differs depending on what synoptic systems are in control and which part of the systems are exerting influence, which is especially true with the change in the wind field. To understand the variation of wind direction/speed over the waters of Ju Diao Sha under the condition of different synoptic regimes, weather patterns affecting Shenzhen in August 2008 are categorized into a number of fields of typical situations. They include patterns resulting from the dominance of the subtropical high, the effect of the edge of this high, the tropical cyclone and

Intertropical Convergence Zone (ITCZ), of which the subtropical high is the synoptic system that has the most influence on Shenzhen. As the tropical cyclone and ITCZ would normally bring severe rainfall and/or strong winds to Shenzhen, sporting events are unlikely to take place as schedule. In this study, numerical simulation was conducted, with the purpose of providing scientific basis for assessment, of a process of the subtropical high strengthening and extending westward on August 28–30, 2006 to obtain an illustrative and true picture of the wind field of the Ju Diao Sha waters under the effect of the subtropical high. During the time, Shenzhen was first affected by the edge of the subtropical high and then gradually by the high itself. Comparisons and analysis indicated that the Fifth-Generation National Center for Atmospheric Research (NCAR, USA) / Penn State Mesoscale Model (MM5) model was successful in forecasting the process of the subtropical high strengthening and extending westward, which agreed with the real situation.

4.3.1 SIMULATION OF WIND ENVIRONMENT FIELD WITH THE IMPACT OF SUBTROPICAL HIGH EDGE

On August 28, 2006, Shenzhen was at the southern edge of the subtropical high and NE-SE winds at 2–3 m/s were recorded at the Zhu Zi Lin station inside one of national basic measurement stations. Fig. 4 gives the simulated wind field for 1000 and 1400 BST of the same day. The figure shows that E-SE winds prevails at 1000 and 1400 BST in urban Shenzhen at speeds of 2–4 m/s, i.e., the simulated results agreed with observations of the wind field. With the effect of the subtropical high edge, the wind field differs sharply among the three candidates for the marine sports base. The wind speed decreases from south to north over the waters of Sha Yu Cong-Guan Hu, from 6 m/s to 2 m/s at 1000 BST and from 8 m/s to 3 m/s at 1400 BST; it is stable inside the area of Ju Diao Sha, increasing from 6 m/s at 1000 BST to 8 m/s at 1400 BST; the wind direction swings substantially over the waters of Sha Yu Cong-Guan Hu, changing gradually from the easterly to the southeasterly while maintaining consistent southeasterly over the waters of Ju Diao Sha at both 1000 and 1400 BST.

To learn more clearly about the temporal changes of wind direction/speed in the individual candidate waters, curves depicting changes in wind speed/direction over time are plotted (See Fig. 5) for the waters of Sha Yu Cong-Guan Hu (denoted by W) and Ju Diao Sha (denoted by E). It shows that wind speed changes moderately at 3–4 m/s at Sha Yu Cong-Guan Hu during 0900–1800 BST; the wind swings mildly prior to 1200 BST but drastically at 1200–1300 BST changing from southeasterly to southerly, with an angle of almost 90°, before gradually shifting back to southeasterly. Although the wind speed is consistent at Ju Diao Sha with that of Sha Yu Cong-Guan Hu during 0900–1800 BST and the wind swings between SE and SW, no large-scale shifts occur on the hourly basis with the swing between 35–45° . The simulation shows that with the influence of the subtropical high edge, the wind speed is larger in the waters of Ju Diao Sha than that of Sha Yu Cong-Guan Hu and the swing of wind direction is relatively small on the hourly basis, meeting the requirements of marine sporting events, while the swing of wind direction is so large in the waters of Sha Yu Cong-Guan Hu that it is not favorable for them.

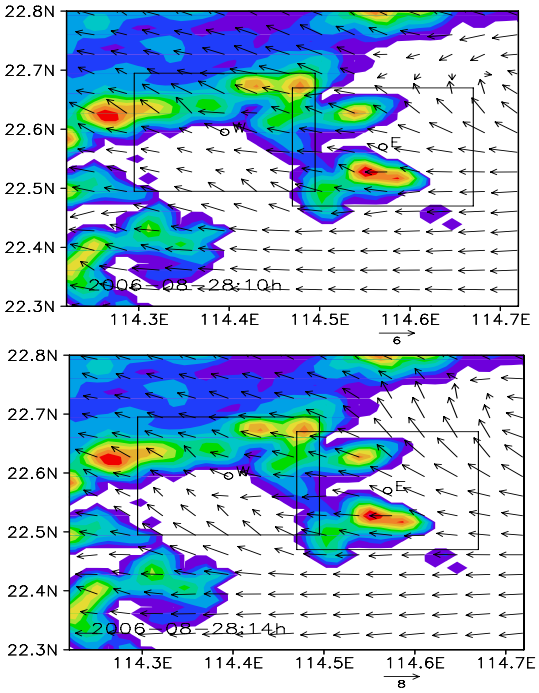

Fig. 4. Simulated surface wind field for 1000 BST (upper panel) and 1400 BST (lower panel) August 28, 2006

4.3.2 SIMULATION OF WIND ENVIRONMENT FIELD WITH THE IMPACT OF SUBTROPICAL HIGH

The subtropical high continued to strengthen and extend westward. By August 30, the powerful subtropical high dominated over the south of China so that a weak southwesterly prevailed in Shenzhen in the morning, and wind speed increased to 3 m/s at 1100 BST and 5 m/s in the afternoon. Fig. 6 gives the simulated field of the surface wind at 1000 and 1400 BST. The simulation shows that the urban area was mainly controlled by SW-S winds at 2–4 m/s, generally consistent with the observation. In the three candidate waters, wind speed was mild and wind direction was disorganized at 1000 BST; the former increased to 8 m/s while the latter remained stable at 1400 BST. Southerly is the main wind over the waters of Ju Diao Sha while southwesterly is dominant over the waters of Sha Yu Cong-Guan Hu.

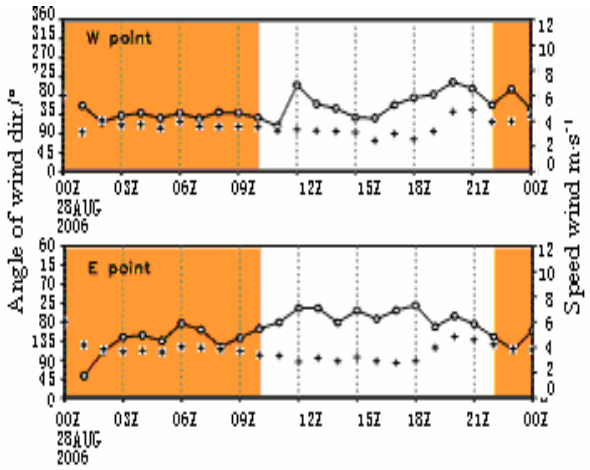

Fig. 5. Temporal variations of the wind speed (dots with asterisks) and wind direction (curve with hallow circles) for Point W and Point E on August 28th

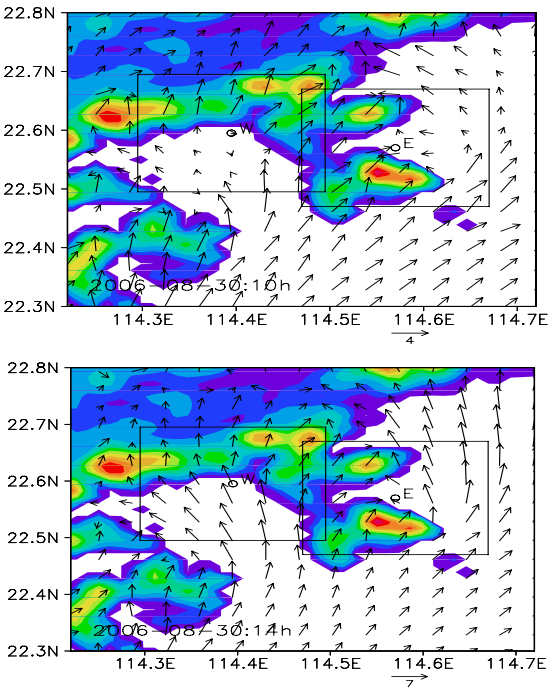

Fig. 6. Simulated surface wind field at 1000 BST (upper panel) and 1400 BST (lower panel) August 30

Figure 7 shows the temporal variation of wind speed/direction in both of the waters. For Sha Yu Cong-Guan Hu, wind speed increased gradually from 5 m/s to 8 m/s at 0900–1800 BST, the angle of wind swing was moderate at 0900–1500 BST but quite large at 1500–1700 BST. For Ju Diao Sha, changes in wind speed were basically consistent with those of the other waters though the swing of wind direction confined to a range within 35° . As indicated in the model simulation, with the control of the subtropical high, the wind speed of the three candidate waters was significantly larger than the urban areas and increased to more than 5 m/s beginning from 0900 BST, meeting the requirements of the sporting events. In all of the three candidate waters, the angle of wind direction swing meets the requirement that the wind swing should be smaller than 50° though the wind direction is more stable in that of Ju Diao Sha.

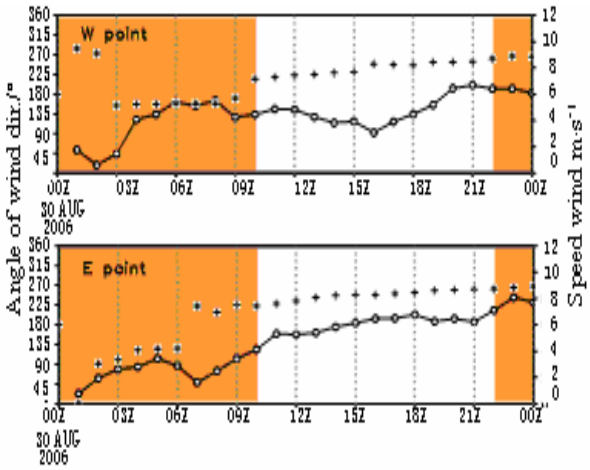

Fig. 7. Same as Fig. 5 but for August 30th

5 CONCLUSIONS AND SUGGESTIONS

(1) Among the high-impact weather for marine sporting events in August, lightning has the highest frequency of occurrence (at 47%), and the typhoon and heavy rain are 1.2 and 1.9 in terms of mean number of affecting cases and mean number of affecting days, respectively. Although the typhoon and heavy rain have limited duration of influence and lightning does not last a long time, the sporting events will be at risk and should be cancelled or postponed once they occur. They should be arranged according to weather forecasts valid for various time scales (of the season, month, 10-day period, week and day).

(2) For the waters of Ju Diao Sha, the wind speed is about 1.4 times larger than that of land, the mean wind speed is larger than 3 m/s, the probability is less than 10% for extreme wind speed to become larger than 20 m/s, and the probability is larger than 80% for the hourly angle of wind swing to meet the requirement of the competition. It is therefore concluded that the wind condition of the Ju Diao Sha waters meets the requirement of marine sporting events, which are appropriate to be held there at 1000–1700 BST, as shown in the variation of wind direction/speed on the hourly basis.

(3) The numerical simulation of typical meteorological fields shows that the waters of Ju Diao Sha is characterized by larger wind speed, more stable wind direction and smaller swing of wind direction than that of Sha Yu Cong-Guan Hu.

(4) As indicated by the numerical simulation of typical meteorological fields and on-the-spot observation in the Ju Diao Sha waters, the effect of land- and sea-breeze is obvious and should be taken into account in making schedules for specific sporting

events.

Due to limited amount of time spent on the marine observation, the corrected wind speed/direction may be with errors, marine observation will be carried out by Shenzhen Meteorological Bureau in every August prior to 2011 in the hope that the data accumulated over the past few years could be corrected further to capture the true picture of the wind environment of the sporting waters.

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