

Wave height possibility distribution characteristics of significant wave height in China Sea based on multi-satellite grid data

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Abstract. This paper discusses the group of wave height possibility distribution characteristics of significant wave height in China Sea based on multi-satellite grid data, the grid SWH data merges six satellites (TOPEX/Poseidon, Jason-1/2, ENVISAT, Cryosat-2, HY-2A) corrected satellite altimeter data into the global SWH grid data in 2000~2015 using Inverse Distance Weighting Method. Comparing the difference of wave height possibility distribution of two schemes that scheme two includes all of 6 satellite data and scheme one includes all of other 5 satellite data except HY-2A in two wave height interval, the first interval is $[0, 25)$ m, the second interval is $[4, 25)$ m, finding that two schemes have close wave height probability distribution and the probability change trend, there are difference only in interval $[0.4, 1.8)$ m and the possibility in this interval occupies over 70%; then mainly discussing scheme two, finding that the interval of greatest wave height possibility is $[0.6, 3)$ m, and the wave height possibility that the SWH is greater than 4m is less than 0.18%.

Keywords: Significant wave height; China Sea; Satellite grid data; Possibility distribution

1. Introduction

Significant wave height (SWH), defined as the crest-to-trough height of the 1/3 highest waves in the sea wave field of view, is an important parameter of ocean research and marine environment forecast. SWH measurements are used for a variety of purposes, these studies improve the understanding of the physical processes responsible for wind-wave evolution to the validation and calibration of models for waves and other ocean processes as well as wave climate investigations, which have implications for shipping and offshore engineering projects[1].

Wave data over periods of many years are necessary for estimating the wave climate all over the



world, traditionally, data coverage over the ocean has been poor, and wave observations have come from ships and moored buoys clustered around coastlines. During the 1970s, global monitoring of SWH became a reality and resulted in the first global atlas of SWH data derived from satellite observation [6]. Since then, the SWH data from several different satellites have become available, including SEASAT (1978), GEOSAT (1985-1990), TOPEX/POSEIDON (1992-2006), ERS-1 (1991-2000), ERS-2 (1995-2011), ENVISAT (2002-2012), Jason-1 (2002-2013)[7], Jason-2 (2008-present), Cryosat-2 (2010-present), HY-2 (2011-present), Saral/Altika (2013-present), Jason-3(2016.01.17), SENTINEL-3A (2016.02.16) [2].

In this paper, first, introducing the satellite altimeter data and multi-satellite grid data, next, representing wave height possibility statistics analysis method, then, comparing the difference of wave height possibility distribution of two schemes and mainly analyzing the wave height possibility of scheme two, finally, the last part states some conclusions.

2. Data

Merging SWH data comes from 6 satellite altimeter data that are distributed by the various space agencies, the detailed information of satellite altimeter is given in Table1[1]. SWH data from these satellite altimeters is corrected through regression equations, merging corrected SWH data into global grid SWH data using Inverse Distance Weighting(IDW) method[3,4], the grid data starts Jan. 1, 2000, ends to Sep. 1, 2015, the spatial resolution is $0.25^{\circ} \times 0.25^{\circ}$ [5], temporal resolution is one day. Selecting the grid data in China Sea that is $100^{\circ}\sim 130^{\circ}$ E, $0^{\circ}\sim 40^{\circ}$ N.

Table 1. Basic Information for satellite radar altimeter[2]

Satellite	T/P	Jason-1	ENVISAT	Jason-2	Cryosat-2	HY-2A
Operational	1992.8.10-20	2001.12.7-201	2002.03.01-2	2008.06.20-	2010.04.0	2011.08.1
Period	05.10.18	3.07.03	012.04.08		8-	6-
Data Period	1992.09.25-2	2002.01.15-20	2002.05.17-2	2008.07.04-20	2010.07.1	2011.10.0
	005.0924	12.12.11	012.04.08	15.09.01	6-2014.09	1-2015.08
					.12	.16
Orbital	1336	1336	799.8/782.4	1336	717	971/973
Altitude/km						
Inclination / °	66	66	98.5	66	92.03	99.34
Spacing at	315	315	80	315	7.5	207.6/18.
equator /km						3
Repeat /days	9.9156	9.9156	35/30	9.9156	369	14/168
Institute	NASA,CNES	NASA,CNES	ESA	NASA,CNES	ESA	NSOAS

3. Methods

In order to possibility statistics analysis[8], first defining statistics parameters, assume M_h is the total number that SWH belongs to $[h, 25) m$, $[SWH_{h,i-1}, SWH_{h,i})$, $i=1,2,\dots$, I_h is SWH the interval $[h,25) m$ (the maximum measurement value of satellite altimeter SWH is $25m$), I_h is the total number of

interval $[h, 25)$ m, $SWH_{h,i-1}$ and $SWH_{h,i}$ are the left and right SWH threshold value in the group i in the interval $[h, 25)$ m, $N_{h,i}$ is the number of SWH in the group i in interval $[h, 25)$ m, $P_{h,i}$ is the frequency of SWH in the group i in interval $[h, 25)$ m, $F_{h,i}$ is the accumulative frequency of SWH in the group i in interval $[h, 25)$ m, the expressions are as follows:

$$N_{hi} = \sum_{j=1}^{M_{hi}} 1_{SWH_{hi-1} \leq SWH_{hj} < SWH_{hi}} \quad (1)$$

$$P_{hi} = \frac{N_{hi}}{M_{hi}} \quad (2)$$

$$F_{hi} = \sum_{i=1}^{I_h} P_{hi} \quad (3)$$

using above statistical models discuss probability distribution of merging grid SWH, the internal $[0, 25)$ m and $[4, 25)$ m are selected, that is $h_1=0$, $h_2=4$.

4. Results and discussions

Using IDW method merges 6 satellite altimeters according to two schemes, one scheme is foreign satellite altimeter data including T/P, Jason-1/2, ENVISAT and Cryosat-2, other scheme adds HY-2A base on scheme one.

Selecting grid SWH data that starts Oct.1, 2011 due to HY-2A data starts from Oct. 1, 2011. Here $h=0$, the interval is $[0, 25)$ m, grouping is that using interval range 0.2m divide the interval $[0, 4.8)$ m into 24 groups, the interval $[4.8, 25)$ m is the 25th group. Calculating the wave height possibility of two schemes and its possibility difference, it is showed in figure 1, it reveal two schemes have the close wave height probability distribution and the probability change trend, there are difference only in interval $[0.4, 1.8)$ m, the possibility in this interval occupies over its' total 70%, the wave height possibility of scheme two is less than the wave height possibility of scheme one in this interval, the result is opposite in interval $[1.0, 1.8)$ m, this phenomenon demonstrates that the wave height probability in interval $[0.4, 1.0)$ m is becoming lower and is becoming higher in interval $[1.0, 1.8)$ m.

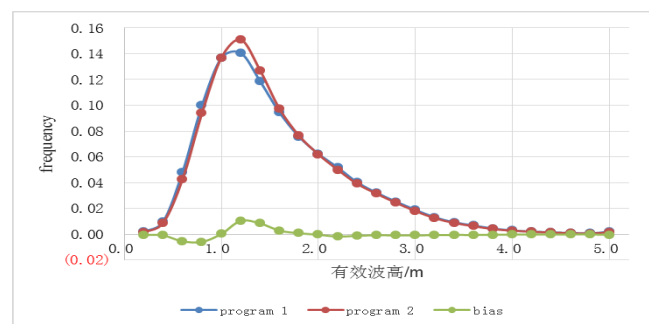


Figure 1. wave height possibility distribution of two schemes

Analyzing the SWH that the wave height is greater than 4m, here $h=4$, the group interval is $[4, 25)$ m, the grouping is that using interval range 1.0m divide the interval $[4, 25)$ m into 21 groups, calculating the wave height possibility of two schemes and its possibility difference as show in Figure 2, there are difference in the interval $[4, 7)$ m between two schemes, this interval is the interval of higher SWH, the wave height possibility of scheme two is greater than it of scheme one in interval $[4, 5)$ m, whereas, scheme two is becoming smaller in interval $[5, 7)$ m. Above all, the wave height

possibility is greater in interval $[4, 5)$ m after adding HY-2A and is becoming smaller in other interval.

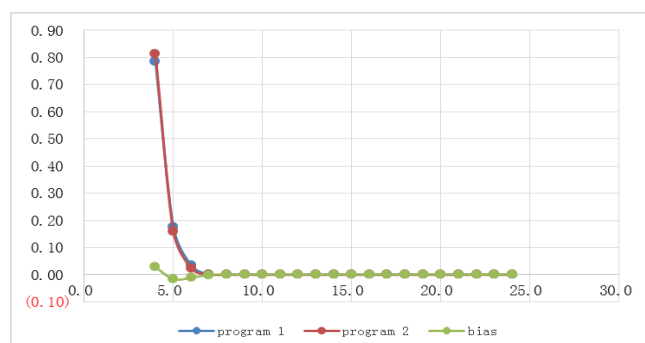


Figure 2. wave height possibility distribution of two schemes in interval $[4,25)$ m

Above the discussion between two schemes could find that the difference of SWH in the interval $[0, 2)$ m after adding HY-2A, the change trend of bias like Sine function. New HY-2A data could illustrate wave height possibility, so, it is essential to analyze the long term wave height possibility distribution of scheme two. The wave height possibility of SWH shows in Figure 3, data starts from Oct. 1, 2000 to Sep. 12, 2015 is close 16 years, the SWH mainly distributes the interval $[0.6, 3)$ m, and the sub-peak distribution interval is $[0, 0.2)$ m, the greatest wave height possibility is greater than 14%, the interval is $[1, 1.2)$ m.

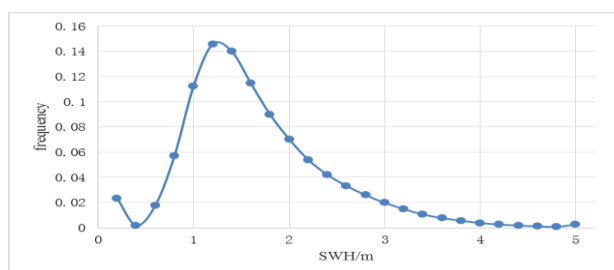


Figure 3. wave height possibility distribution in the interval $[0,5)$ m in 2000~2015

Figure 4 mainly discusses that the wave height possibility of every interval is less than 0.18% while SWH is greater than 4m, and is almost 0 while SWH is greater than 8m, so, in general, we always focus on the SWH that is lower than 8m, above is the reason.

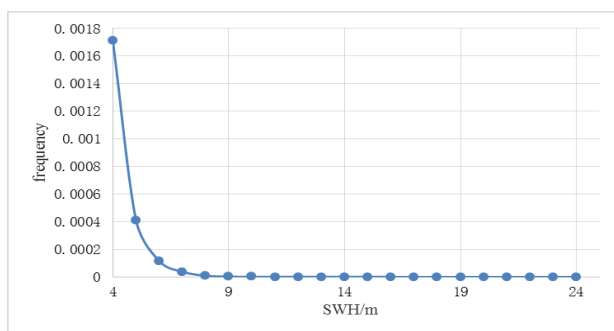


Figure 4. wave height possibility distribution in the interval $[4,25)$ m in 2000~2015

5. Conclusions

This paper discusses the wave height possibility of two SWH grid schemes in two intervals, finding that the interval of greatest wave height possibility is $[0.6, 3)$ m, and the wave height possibility that the SWH is greater than 4m is less than 0.18%. Above two schemes have the close probability distribution and the probability change trend, there are difference only in interval $[0.4, 1.8)$ m, the possibility in this interval occupies over 70%; the possibility is greater in interval $[4, 5)$ m and smaller in other interval after adding HY-2A; main distribution interval of SWH is $[0.6, 3)$ m and possibility is less than 0.18% in interval $[4, 7)$ m.

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