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A New Intelligent Method Based on Dragging Method in the Parameters Extraction of the Ocean Internal Waves

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Abstract: *For the particularity in the extraction parameters of ocean internal wave, a new intelligent system has been developed based on the author tool Multimedia ToolBook. In the intelligent system, the red dragged information point could be dragged on the positions of the corresponding reference lines for MODIS remote sensing image including ocean internal wave, Dongsha Atoll, and the crests of the ocean internal waves. And the x or y coordinate value could be read through clicking the fill-able fields. Once meeting the calculated condition in intelligent system, it will estimate the length of the longest crest, the propagation direction of the ocean internal waves, and the space of the two adjacent crests. Moreover, it will reshow the Dongsha Atoll and the crests of the ocean internal waves as clicking the button of calculation. The new method that includes three steps adopted to display the measured crests of the ocean internal waves with the angled-lines, which has saved the interface resources, and has increased the measured number of the crests for the ocean internal waves from 6 in the previous intelligent system to 8 in this paper. According to the ocean wave theory, the velocities of the ocean internal waves in different packets have been estimated based on the semidiurnal tide, where the depths of the sea have also been estimated. The extended intelligent system can also be applied to extract the parameters of ocean internal wave in remote sensing image of SAR.*

Keywords: *Intelligent system; ocean internal wave; propagation direction; angled-line; speed of wave*

1. INTRODUCTION

The ocean internal wave is a wave occurred among the water layers of density stratification inside the sea, whose generation and the mixing is a common phenomenon in the ocean. The motion of internal wave plays an important role for the transfer of the mass, the momentum and the energy, as well as the global climate change [1]. The technology of the ocean internal wave is an effective method to obtain parameters of underwater environment. The observation methods include the anchor measurement, the level dragging measurement, the vertical throwing measurement, the float measurement, the acoustic measurement, and the remote sensing measurement. Therein, the remote sensing measurement is on the basis of the remote sensing satellite or the aircraft, which is observed through the visible light images and the synthetic aperture radar (SAR) primarily, and it can monitor the motion of the internal wave occurred in shallow water. The advantage of remote sensing measurement is that it can be observed in large area, and it can extract the kinematics parameters of the isolated ocean internal waves from the remote sensing images. The research for the ocean internal wave [2-3] based on MODIS remote sensing image with large width is a brand-new topic. MODIS is one of the important detecting instruments of the TERRA spaceborne satellite, which was successfully launched by the EOS series satellites of United States National Aeronautics and Space Administration on December 18, 1999. And MODIS is an optical remote sensing instrument combining the images with the spectrums, which has 36 spectral channels distribution in the electromagnetic spectrum range of 0.4~14μm. The ground resolutions of MODIS instrument are 250m, 500m and 1 000m, respectively, the quantization level is 12bit, and the width is 2 330km, and a global observation data can be obtained every day or every two days [4]. Therefore, the researches of the ocean internal wave based on MODIS remote sensing images possess two advantages, such as the low cost for obtaining the remote sensing images, and the wide width of the remote sensing image.

2. Theoretical Basis of Ocean Internal Wave

The study of the ocean internal waves is starting from the Euler equation using the Boussinesq approximation, namely, the mass conservation is replaced with the volume conservation. The density is replaced with the constant ignoring the variation of density besides considering buoyancy baroclinic effect [5].

$$\rho(\frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t}+f_0\boldsymbol{k}\times\boldsymbol{v})=-\nabla p-\rho g\boldsymbol{k} \tag{1}$$

Where $\rho=\rho_0+\rho'$, $\rho_0=\rho_0(z)$ is static ocean density and it is only relation with the z component. $\rho'(x,y,z,t)$ is disturbed density. In the formula of $f_0=2\Omega\sin\varphi_0$, Ω is angular velocity of earth rotation, and φ_0 is the local latitude.

It is known that the sea water can not be compressed, so the density does not change with time $\frac{\mathrm{d}\rho}{\mathrm{d}t}=0$. The density changes in the directions of x and y are ignored [6].

$$\frac{\partial\rho}{\partial t}+w\frac{\partial\rho_0}{\partial z}=0 \tag{2}$$

The linearization Euler equation is obtained after ignoring the influent of the earth rotation

$$\rho_0\frac{\partial u}{\partial t}=-\frac{\partial p}{\partial x} \tag{3}$$

$$\rho_0\frac{\partial v}{\partial t}=-\frac{\partial p}{\partial y} \tag{4}$$

$$\rho_0\frac{\partial w}{\partial t}=-\frac{\partial p}{\partial z}-g\rho \tag{5}$$

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \tag{6}$$

The ρ is removed by the formula (5) and the formula (2).

$$\frac{\partial}{\partial t}\frac{\partial p}{\partial z}+\rho_0\frac{\partial^2 w}{\partial t^2}=wg\frac{\mathrm{d}\rho_0}{\mathrm{d}z} \tag{7}$$

The u and v are removed by the formula (3), the formula (4), and the formula (6).

$$\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial y^2}=\rho_0\frac{\partial}{\partial t}\frac{\partial w}{\partial z} \tag{8}$$

The formula (10) could be obtained by the formula (7) and the formula (8) with Brunt- Väisälä $N(z)$. $N(z)$ is satisfied to the formula (9).

$$-N^2=\frac{g}{\rho_0}\frac{\mathrm{d}\rho_0}{\mathrm{d}z} \tag{9}$$

$$-\frac{N^2}{g}\frac{\partial^2}{\partial t^2}\frac{\partial w}{\partial z}+\frac{\partial^2}{\partial t^2}\frac{\partial^2 w}{\partial z^2}+[\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}]\frac{\partial^2 w}{\partial t^2}+N^2[\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}]w=0 \tag{10}$$

The travelling solution of the formula (10) is supposed as $w=W(z)\mathrm{e}^{\mathrm{i}(\omega t-k_1x-k_2y)}$. Where k_1 and k_2 are the wave numbers with 2π times in x and y respectively. The solutions are as the formula (11) and the formula (12).

$$w=(A\mathrm{e}^{-\frac{N^2}{2g}z+\mathrm{i}\sqrt{\frac{(N^2-\omega^2)(k_1^2+k_2^2)}{\omega^2}}z}+B\mathrm{e}^{-\frac{N^2}{2g}z-\mathrm{i}\sqrt{\frac{(N^2-\omega^2)(k_1^2+k_2^2)}{\omega^2}}z})\mathrm{e}^{\mathrm{i}(\omega t-k_1x-k_2y)}\text{, when } N^2>\omega^2 \tag{11}$$

$$w=(A\mathrm{e}^{-\frac{N^2}{2g}z+\sqrt{\frac{(\omega^2-N^2)(k_1^2+k_2^2)}{\omega^2}}z}+B\mathrm{e}^{-\frac{N^2}{2g}z-\sqrt{\frac{(\omega^2-N^2)(k_1^2+k_2^2)}{\omega^2}}z})\mathrm{e}^{\mathrm{i}(\omega t-k_1x-k_2y)}\text{, when } N^2<\omega^2 \tag{12}$$

The constants of A and B are determined by the boundary conditions.

3. DEVELOPMENT OF THE NEW INTELLIGENT SYSTEM

The MODIS remote sensing image at 13: 25 (Beijing time) on July 3, 2011 is shown in Figure 1. The geometric corrected image is shown in Figure 2, and the method of geometric corrected refers to the reference [7] in detail. The enlarged image including the fringes of ocean internal waves is shown in Figure 3. The Dongsha Atoll [8] is particularly clear, including at least 3 groups of complete information of the ocean internal wave packets, which lie in the directions of the north, the northwest, and the southwest direction for the Dongsha Atoll, respectively. As seen from the shape of the three internal wave packets, they spread from east to west of Dongsha Atoll in Luzon Strait.

The research in extraction parameters of ocean internal waves based on MODIS remote sensing image is from 2007. The intelligent systems for extraction parameters of ocean internal waves have developed by Jiang et al. based on Multimedia ToolBook [2, 3, 7]. The research includes several stages. The first stage [2] is that the measurement data are filled by hand, which includes the data of the coordinates of the reference lines, Dongsha Atoll, and the crests of the ocean internal waves. The longest length of the crest in the ocean internal wave packet, the propagation direction of the ocean internal wave, and the space between the adjacent crests in the ocean internal wave packet will be shown after clicking the button of “Calculation” when the calculation condition is met.

The second stage [3] is that the red information point is used. The red information point may be dragged. The red information point maybe lay in the reference lines, Dongsha Atoll, and the crests of the ocean internal waves. The *x* (or *y*) coordinate could be obtained in the fill-able field when the fill-able field is clicked.

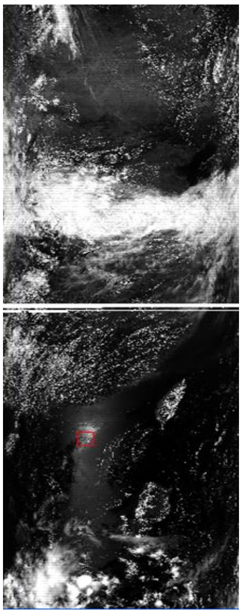

Fig1. *Original remote sensing image.*

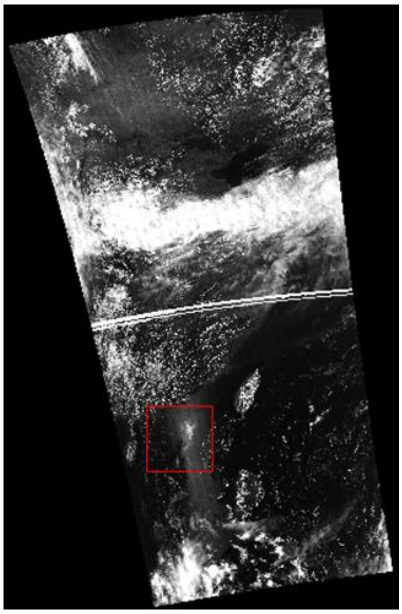

Fig2. *Geometric corrected remote sensing image.*

The third stage [7] is for the geometric corrected remote sensing image by ENIV. The 54 straight lines are probably used for showing the 6 crests of the ocean internal wave. There are 10 characteristic points for each crest of the ocean internal wave. Each characteristic point is scripted with *x* and *y* coordinates, so there are 120 fill-able fields.

The fourth stage based on the geometric corrected remote sensing image is the same as the third stage. The results are similar to the front three stages, those mean the extraction parameters of ocean internal waves including the longest length of the crest in ocean internal wave packets, the propagation direction of ocean internal waves, and the space between crests in the ocean internal wave packet. The same points also include the fill-able fields of two reference lines, Dongsha Atoll, and ocean internal waves, in which the characteristic points coordinates include the *x* and *y* coordinates. There are at least three characteristic points in each reference line, at least three characteristic points in Dongsha Atoll, and at least two crests of the ocean internal wave, in which there are at least two characteristic points.

The differences involve three aspects. Firstly, the remote sensing image including ocean internal waves used in the fourth stage is larger than that in the third stage. Secondly, the straight lines are replaced in the third stage by the angle-lines in the fourth stage, and the maximum of the crest of the ocean internal waves is 8. Thirdly, the velocities of the ocean internal waves and the depths of the sea for the positions of the ocean internal wave are estimated in the fourth stage. There are 160 fill-able fields for 8 crests of the ocean internal waves.

In the fourth stage, the maximum of the crest of the ocean internal waves is 8. The number is large, implying the difficulty is heavy. The problem is that the object resource in each interface of Multimedia ToolBook is limited. In the third stages, there are 54 lines for showing the 6 crests of ocean internal waves. The object resource has been limited in each interface of Multimedia ToolBook. The new method that the straight lines are replaced with angled-lines must be projected in the fourth stage for providing 8 crests of ocean internal waves. At the same time, the new problem occurs again. In front stages, the exact numbers of the characteristic points in each ocean internal waves are obtained, and the corresponding straight lines are chosen to show the crest of the ocean internal waves. But a new problem appears that both the numbers of the chosen crest of the ocean internal waves for the measure and the number of characteristic points for the chosen crest can not be determined using the common program.

In order to solve this problem, a novel method is put forward, which includes three steps. The first one is to judge whether the fill-able fields of the first characteristic point in each crest of ocean internal waves are filled. If the two fill-able fields of the first characteristic point are filled, indicating the crest of the ocean internal waves is chosen, so the corresponding array will be endowed with the value of *x* or *y* coordinate, such as, *x*[1][1], *y*[1][1], *x*[2][1], *y*[2][1], *x*[3][1], *y*[3][1].

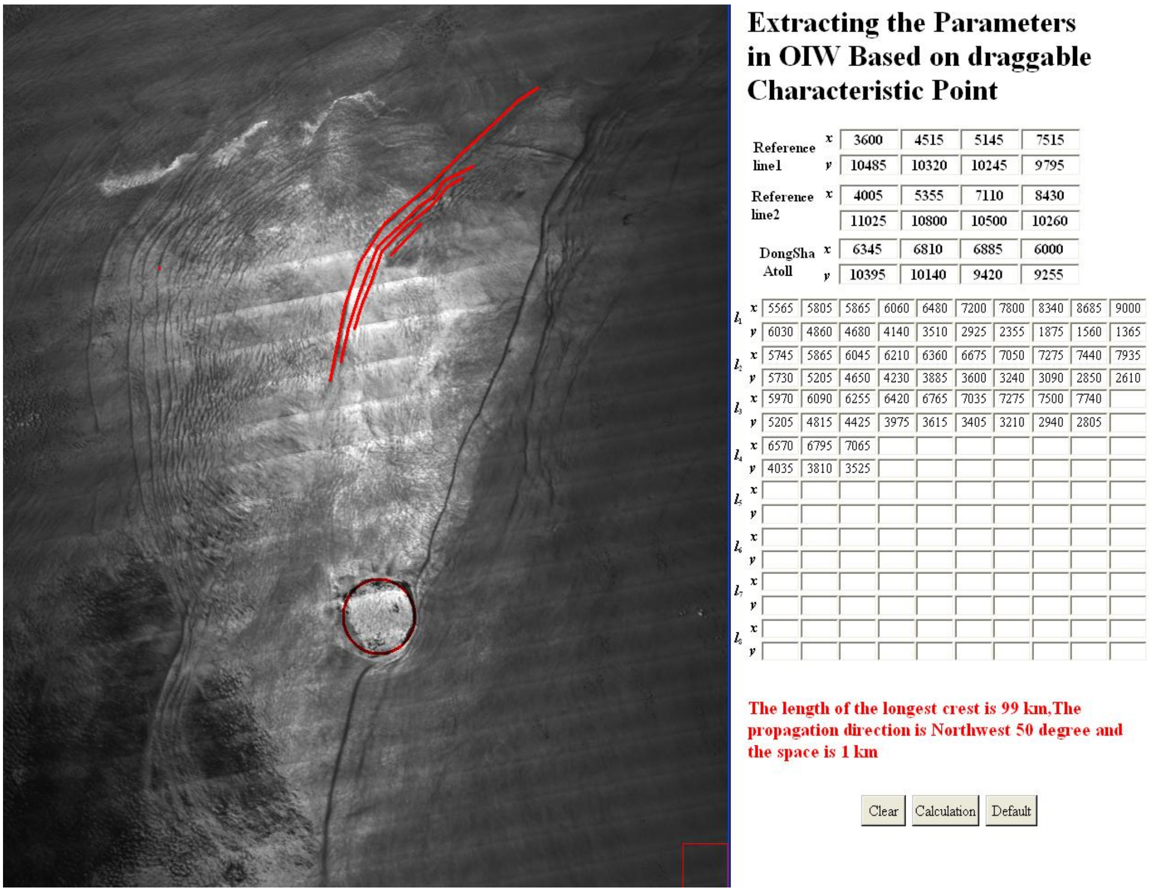

Fig3. *The interface diagram of the intelligent system and the result of calculation.*

While if the two fill-able field are not filled, implying this crest of the ocean internal waves is not chosen, so the corresponding array will be endowed with -1000, such as *x*[4][1]=-1000, *y*[4][1]=-1000. Because the angled-line displaying the crest of the ocean internal wave has a width of 90, the value of -1000 is shown for hiding the angled-line off the screen.

The second step is that the arrays from the second to the tenth for each crest of ocean internal waves are replaced with the first arrays, that is, *x*[1][2]=*x*[1][3]=…=*x*[1][1], *y*[1][2]=*y*[1][3]=… =*y*[1][1], …, *x*[8][2]=*x*[8][3]=…=*x*[8][1], *y*[8][2]=*y*[8][3]=…=*y*[8][1]. The third step is to judge the fill-able fields from the second to the tenth coordinates of the characteristic points for each crest of ocean internal waves. If a fill-able field is filled, the corresponding array for the *x* or *y* coordinate will be endowed with the value of *x* or *y* coordinate, and the followed arrays of the crest of ocean internal wave will be endowed with the corresponding *x* or *y* coordinate. For example, when the fill-able fields of *x*[2][3] and *y*[2][3] are filled, the corresponding arrays will be endowed with *x*[2][3] or *y*[2][3], namely, *x*[2][4]=*x*[2][5]=…=*x*[2][10], *y*[2][4]=*y*[2][5]=… =*y*[2][10].

In this way, the novel program could be compiled to realize that the crests of the ocean internal wave could be shown by different angled-lines. The program is suitable for choosing different crest number of the ocean internal waves and different characteristic points for each ocean internal wave. The ocean internal wave packet on the north of Dongsha Atoll is chosen as an example. The result of the calculation is that "The length of the longest crest is 99 km. The propagation direction is Northwest 50 degree and the space is 1km.". The crests of the ocean internal wave and Dongsha Atoll are shown in Figure 3.

4. CONCLUSION

During the process of making the intelligent system for extraction the parameters of the ocean internal wave, the angled-lines are adopted to reshow the crests of the ocean internal wave, which have saved the resource of object in the interface. So that more numbers of the crests of the ocean internal waves can be chosen for the measure than that in references [2, 3, 7]; The novel program includes three steps. The first step is that the arrays corresponding to the first characteristic points in each crest of the ocean internal waves are endowed. If the fill-able fields of the first characteristic points are not filled, the corresponding arrays will be endowed with -1000. The second step is that the arrays from the second to the tenth for each crest of ocean internal waves are replaced with the first arrays. The third step is that if a fill-able field of the characteristic points from 2 to 10 is filled, the corresponding array and the followed arrays will be endowed with the fill-able field. Therefore, the crests of the ocean internal waves and Dongsha Atoll are bigger than that in references [2, 3, 7]. At the same time the intelligent system could be used to estimate the propagation speed according to the regularity of the ocean internal wave with semidiurnal tide. Compared with the result of reference [9] there are three results. The first one is that the velocity of the ocean internal wave packet that lies in southwest of Dongsha Atoll is 1.18m/s, and the local depth of the sea is larger than 100m. The second one is that the velocity of the ocean internal wave packet that lies in north of Dongsha Atoll is 1.05m/s, and the local depth of the sea is a little larger than 100m. The third one is that the velocity of the ocean internal wave packet that lies in northwest of Dongsha Atoll is 2.57m/s, and the local depth of the sea is a little larger than 500m.

It is suitable for SAR remote sensing images for estimation parameters of ocean internal waves when the intelligent system is revised slightly. The new intelligent system has provided conditions for the prediction of ocean internal waves.

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References

[1] Yan Mei, Fan Zhi-Song, Fu Shen-Bo, et al. Preliminary discussion of the necessity and feasibility of study of internal wave prediction technology[J]. Marine forecasts. 2010, 27(2): 76-81.

[2] Jiang Xing-Fang, Bi Tian-Yu, Chen Fang-Fang, He Xian-Qiang. Making of the intelligent calculation system for physical parameters of oceanic internal waves. IEEE, SOPO. 2010.

[3] Jiang Xing-Fang, Li Yan-Ji, Bi Tian-Yu, Chen Fang-Fang. Making of the intelligent system for the parameters statistics in oceanic internal wave based on the obtaining data method from dragging target. IEEE, AICI. 2010, 3: 140-143.

[4] Liu Yu-Yi, Yang Zhong-Dong. Method and handling for remote sensing information of MODIS [M]. Beijing: Science Press. 2001.

[5] Chen Xian-Yao, Qiao Fang-Li, Wang Xiu-Hong, et al. On the study on Boussinesq approximation and hydrostatic approximation in ocean circulation model [J]. 2004, 22(1): 91-95.

[6] Ye Chun-Sheng. The dispersion relation of the ocean internal wave, the solution of Sturm-Liouville corresponding to 2D internal wave field, and the load of internal wave [D]. Thesis of Master degree of Tianjin University. 2001.

[7] Jiang Xing-Fang, Zhou Wei, Huang Yuan-Ming, et al. Development of the Intelligent System for Estimating the Parameters of Ocean Internal Wave [J]. International Journal of Computer Science and Artificial Intelligence .2012, 2(1): 23-25.

[8] Mao Zhi-Hua, Chen Jian-Yu, Lin Ming-Sen, et al, “Dongsha Atolls satellite remote sensing,” Beijing: Ocean Press, 2007 (in Chinese).

[9] Gan Xi-lin, Huang Wei-Gen, Yang Jing-Song, et al. The study of spatial and temporal distribution characteristics of internal waves in the South China sea from Multi-satellite data [J]. Remote Sensing Technology and application. 2007, 22(2): 242-246.

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