The Quantitative Evaluation of Sea-ice Disaster in the Bohai Sea based on the GOCI and Sentinel-1 Data

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1. INTRODUCTION

Sea ice is a major marine hazard to the Bohai Sea in the winter. It is very important to evaluate the sea-ice damaging effects quantitatively, which has not been studied and analyzed systematically using long-term data so far. In this paper, the different sea-ice-hazard indexes are defined quantitatively for different hazard-bearing bodies of the marine transportation and the offshore constructions in the Bohai Sea from 2011 to 2017.

2. DATA SOURCES

(1) Sentinel-1

Sentinel-1 performs C-band synthetic aperture radar imaging and provides single- and dual-polarization images in the Bohai Sea from 2014 to 2017.

(2) GOCI (Geostationary Ocean Color Imager)

GOCI is the first geostationary sensor, which covers the whole Bohai Sea with a spatial resolution of about 500 m of 8 images for one day from 2011 to 2017 provided by the Korea Ocean Satellite Center (KOSC).

3. SEA-ICE PARAMETERS INVERSION

Sea-ice parameters should be inversely for the sea-ice-hazard evaluation, including the sea-ice concentration, thickness and velocity. According to the Sea-ice-hazard Emergency Plan, Sea-ice-hazard Bulletin from the State Oceanic Administration People’s Republic of China (SOAPRE), the sea-ice parameters can be divided to four grades:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Grade 1: Non-hazard</th>
<th>Grade 2: Low hazard</th>
<th>Grade 3: Medium hazard</th>
<th>Grade 4: Severe hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration</td>
<td>0-15%</td>
<td>15-30%</td>
<td>30-40%</td>
<td>40-100%</td>
</tr>
<tr>
<td>Thickness</td>
<td>0-0.1 m</td>
<td>0.1-0.2 m</td>
<td>0.2-0.3 m</td>
<td>&gt;0.3 m</td>
</tr>
<tr>
<td>Velocity</td>
<td>0-0.2 m/s</td>
<td>0.2-0.4 m/s</td>
<td>0.4-0.6 m/s</td>
<td>&gt;0.6 m/s</td>
</tr>
</tbody>
</table>

(1) Sea-ice thickness

The sea-ice thickness (H) is retrieved using the sea-ice optical information of GOCI in the Bohai Sea [1]. The sea-ice shortwave albedo changes with the variation of sea-ice thickness [2].

\[ \alpha_{\text{sea}} = \alpha_{\text{ref}} \times [1 - \exp(-\gamma H)] \]

The equation of \( \alpha_{\text{sea}} \) calculated by 8 visible infrared spectra of GOCI was proposed [1][3][4].

(2) Sea-ice velocity

The sea-ice velocity (V) is extracted using the GOCI images, which has employed the Maximum Cross-correlation (MCC) method for daily 1-hour sea-ice drift tracking in the Bohai Sea [5].

(3) Sea-ice concentration

- Sea-ice concentration calculated by Sentinel-1

The sea-ice and the sea water are identified using the threshold method based on the Sentinel-1 [6]. Sea-ice concentration can be extracted using the classified results of the Sentinel-1 images.

- Sea-ice concentration calculated by GOCI

The sea ice and the sea water can be recognized by the above sea-ice thickness results using GOCI data. Sea-ice concentration can be extracted using the sea ice recognition results of the GOCI images.

4. SEA-ICE-HAZARD EVALUATION

(1) For the marine transportation (I1)

For the marine transportation, its sea-ice-hazard index is equal to multiplying the sea-ice concentration (C) by the sea-ice thickness (H), which is defined by \( I_1 = C \times H \) (unit: m²/m³).

(2) For the offshore constructions (I2)

For the offshore constructions such as the oil platform, its sea-ice-hazard index is equal to multiplying I1 by the sea-ice velocity (V), which is represented by \( I_2 = I_1 \times \alpha \times T \) (unit: m²/s²).

5. DISCUSSION AND CONCLUSIONS

In the Dragon-4 programme, the sea-ice-hazard indexes I1 and I2 for the marine transportation and the offshore constructions respectively, are quantitatively illustrated the space-time distribution features of the sea-ice disaster in the Bohai Sea from 2011-2017, which can satisfy the request of the sea-ice disaster prevention and reduction and provide the reference of the monitoring and research on the sea-ice disaster.

REFERENCES


