Journal of Global
Positioning
2022 Systems
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Ocean Wind Vector Retrieval Based on Spaceborne Global Navigation Satellite System Reflectometry

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Defense Date: **May 26, 2022**

Abstract

Global Navigation Satellite System Reflectometry (GNSS-R) uses GNSS signals as the microwave remote sensing signal source to detect physical parameters of the global surface. GNSS-R is an organic fusion of navigation and remote sensing, an innovative application of GNSS signals. GNSS-R has the advantages of all-weather, multiple signal sources, high spatial and temporal resolution, which is beneficial to be carried on microsatellite platforms.

The ocean wind vector is an important part of ocean dynamic parameters. Accurate ocean wind vector detection plays a vital role in the early warning and forecasting of marine dynamic disasters. The research of ocean wind vector retrieval using spaceborne GNSS-R is helpful for the realization of global high temporal and spatial resolution ocean wind detection, which has important practical significance and urgent national needs. Although a lot of research and progress has been made in ocean wind vector retrieval using spaceborne GNSS-R, there are still many problems before commercial application, such as wind speed accuracy and wind direction retrieval, which hinder its popularization and application. Aiming at these problems, the main research contents and achievements of this thesis are as follows:

(1) In order to make spaceborne GNSS-R cyclone wind research get rid of the dependence on the prior information of whether the cyclone event occurs, a single-pass cyclone event detection algorithm using spaceborne GNSS-R full delay-Doppler map (DDM) is presented. The study focuses on investigating the influence of cyclone on the spaceborne GNSS-R full DDM. An observable is defined to describe full DDM asymmetry, and demonstrated to be sensitive to cyclone event using the simulator. The proposed method is based on a time sliding window to detect the full DDM asymmetry anomalies. The results show that cyclone event can be detected by the algorithm. These results provide information to guide the high wind speed retrieval in real-time using spaceborne GNSS-R.

(2) Spaceborne GNSS-R ocean wind speed retrieval has the problems of high data quality control standards and low accuracy of high wind speed. Based on the cyclone event detection algorithm, an

ocean wind speed retrieval algorithm based on ocean state is presented. The ocean state types are divided into conventional ocean state and cyclone ocean state. Before wind speed retrieval, the cyclone monitoring algorithm is used to identify the ocean state type. Then, the ocean wind speed is retrieved using the empirical geophysical model function of different ocean state types. The retrieval accuracy of high wind speed is improved while the retrieval accuracy of medium and low wind speed is ensured. The wind speed retrieval algorithm is suitable for spaceborne real-time retrieval.

(3) There are few studies on the ocean wind direction retrieval using spaceborne GNSS-R, because the specular reflection signal is not sensitive to the sea surface wind direction. The wind direction retrieval algorithms using spaceborne GNSS-R in non-specular geometry are presented. The sensitivity of the scattered GNSS signal in the non-specular geometry to wind direction is analyzed. The sub-satellite non-specular observation mode is constructed. The observable that is sensitive to wind direction in this mode is defined. A wind direction retrieval algorithm based on wind speed and a wind vector retrieval algorithm based on maximum likelihood estimation are constructed. It solves the problem that the specular reflection signal is difficult to retrieve the wind direction and can achieve real-time wind direction retrieval using spaceborne GNSS-R.

(4) In order to meet the needs of real-time processing and fast retrieval of ocean wind vector using spaceborne GNSS-R, the spaceborne GNSS-R fast retrieval software for ocean wind vector is designed and implemented. The data processing system including cyclone event detection, ocean wind speed retrieval and ocean wind direction retrieval is constructed. It can provide a reliable and stable application software for the research and application of ocean wind vector real-time retrieval using spaceborne GNSS-R.

Keywords: GNSS-R, Cyclone event, Ocean wind speed, Ocean wind direction, Remote sensing