The Weatherproof Detection System of Sea Fog by Remote Sensing and its Applications

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Abstract: Detection of sea fog by remote sensing with spectroscopic analysis method and structural analysis method is introduced in this paper. On this base, designing principles and frame of weatherproof detection system of sea fog by remote sensing are systemically explained. Using GMS5 and NOAA visible and infrared channel data, progresses of sea fog on yellow sea on April 17,18, 2001 is monitored which accord with the observing.

Keywords: spectroscopic analysis method, structure analysis method, remote sensing, sea fog

Introduction

Sea fog, because of its low visibility, could bring some catastrophic influences on sea transport, fishing, port entry and departure of vessels, agriculture and traffic of littoral and even the military activities on the sea. Normal detection and forecast of sea fog are limited by the distribution of the platforms, while wide band and synchronous remote sensing data from satellite have incomparable advantages which are used to inspect the sea fog. Gurka[1,2](1974;1978) studied recognition and the dissipation of cloud and mist of daytime. Bader et al[3](1995) utilize the visible light and infrared images from quiescent satellite to distinguish the fog and stratus through their differences of gray shadows which can be expressed in the images. Eyre et al[4] (1984) indicated that single-channel couldn't distinguish the fog from the surface at night. Ellrod[5] use multiple spectral infrared images of GOES to analysis the different detective functions of fog at night. In this article, we use data of visible light and infrared channel from both GMS5 and NOAA, manager the spectroscopic analysis method and structural analysis method to separate cloud and fog automatically. Furthermore, we carry the inspective experiment of the fog on the Yellow Sea progress and get a reliable result.

The Detection of Sea Fog in the Daytime and Night

The fogdrop is smaller than waterdrop which affects distinctly the characters of optics and the atmospheric

visibility, results in the difference of the radialization between fog and cloud.

(1) In the Daytime

According to the remote sensing theory, the albedo of fog and stratus is more than one of water and land, but is less than mediocris and high cloud. On the visible light images, these differences by the different brightness and veins characters are observed. The radiation characters of the clouddrop and fogdrop vary with the wave length in infrared wave band. Because of the different height of cloud and fog, the brightness temperature reflected by infrared wave varies distinctly. Using the characteristic difference in visible wave band and the infrared wave band, the sea fog in the daytime can be detected. These differences of the remote sensing images are generally represented as follows: fog field seems more smoothness and have thinner veins, the field of stratus and cirrus seems fleckiness and have thicker veins. Under the same condition of thickness, the sea fog field is brighter than the field of stratus and cirrus. Sea fog fields have obvious brim, but the high cloud fields appear shadow. At the infrared channel, the brightness temperature in the fog field is higher than the brightness temperature of in the cloud field. The activity (evolvement) of fog field is slower than that of cloud field.

(2)At Night

There isn't visible wave band at night, but the brightness temperature of the infrared wave band in 3.9 mm and 10.7 mm is different in clear sky, cirrus area and fog area. The sea fog at night can be detected by these differences. According to the brightness temperature of middle infrared channel and far infrared channel of cirrus field and fog field from GOES on 22:00, March 24th, 1999, we find that the brightness temperature of far infrared channel is wholly consistent with its background, that is to say if we only have the data of the far infrared channel, sea fog could't be detected at night. Though the image of middle infrared channel shows the fog field, it is not obviously different from the background field. But the gray scale of the compound picture using middle infrared channel and far infrared channel could fairly show the position of the fog field, also it could well distinguish the cirrus field, clear sky field and fog field.

The Weatherproof Detection System of Sea Fog

The analysis shows that the characters of the sea fog focus on the spectrum, veins and movement both in the daytime and at night. The weatherproof detection system of sea fog can use these information to detect sea fog.

Firstly, the system uses the spectral differences of sea fog to realize the automatic detection and separation. The mainly representations are: use threshold method of albedo to realize the automatic separating of visible light information and the underlying surface background. Brightness temperature of infrared can realize the automatic separating of fog, low clouds, mediocris clouds and high clouds. Use the infrared bispectral method can detect the fog at night. The system can detect and separate the cloud and fog using the difference of the spectrum.

Secondly the system separates the stratus and fog by the veins character of the fog. In the images of remote sensing, the surface veins' thickness of gray scale of cloud and fog is different, that is correspond with the different fractal dimensions. The veins of cloud are coarse and mussy, the corresponding fractal dimension is greater, the veins of fog are thinner, the corresponding fractal dimension is smaller, so the system could use the fractal dimensions to identify the stratus and fog automatically. Besides this, because the fog is more regular than the cloud in space, the structure analysis method can be used automatically to detect the fog in system again.

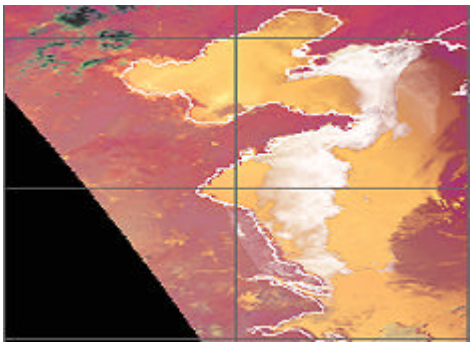
The Example of the Applying

Using GMS5 and NOAA visible and infrared channel data, progresses of sea fog on yellow sea on April 17th, 18th,2001 is monitored which accord with the observing.

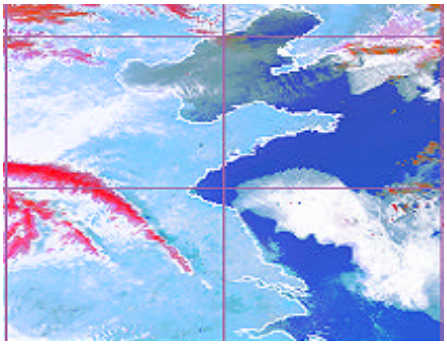
From the hour-to-hour GMS5 data of daytime sea fog

progress on April 17th, we could fairly see that sea fog covers the downtown of Qingdao from 14:30 to 17:30,which correspond with visibility data of a certain Aerial Arms Island Base of Qingdao

Fig.1is the result of fog detection which is using NOAA data, the white parts in fig.1a represent sea fog in the noon of 17th ,2001. When compared with the result of GMS5 data, it obviously have higher spatial resolution, show the fine structure of sea fog distribution more clearly. This fine structure can not only confirm the distributions of sea fog accurately but also provide the remote sensing information for retrieving the visibility of sea fog. Fig,1b is the detective result of fog at night, April,18th, 2001 which is make use of the bispectrum method（3.7 μm channel and 10.7 μm channel）. These images show a large area of sea fog, though the real-time data is short of, the result is consistent with the synoptic chart analysis result.



a) daytime



b) night

fig.1 the detective images using NOAA

Conclusions

There are still many technique problems in detection system of sea fog by remote sensing, including the shortage of sea fog information, the similar physical characteristics of fog and low-level cloud and etc. Under the actual satellite data conditions, how to make full use of the differences of the spectral characters and the structural characters, distill the corresponding information and study the discrimination technique is the effective approach of automatic separating of fog and cloud. From the result of the detection of sea fog progress, the compositive method of spectral analysis and structural analysis that we used in this article and the corresponding technique are effective.

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