

THE DEVELOPMENT AND THE APPLICATION OF NORMAL WATER EXTENT DATABASE FOR FLOOD MONITORING USING REMOTE SENSING

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ABSTRACT:

Flood occurs every year in the world, but the flood information is often greatly different from various sources. Most of them are not accurate and not reliable. They are usually exaggerated comparing with the fact. With the development of remote sensing technology, scientists have found some ways to monitor floods in a large scale. And sometimes, these methods can play an important role in checking the real situation for rescuing and its controlling. However, in these researches, no any standard for flood assessment has been established. This will lead to various results because of some reasons, such as different remote sensing sources, experience of interpretation and et al. The promising approach is to establish the standard of assessment for each flooding area. To solve this problem, "normal water extent" concept was put forward in our research. In one hand, they mean the minimal values for the assessment of flood losses. In the other hand, they are some special areas according to the situation around the areas of river, lake, reservoir and dyke, land use and etc., which are easy to suffer from flooding during the flooding season. The objective of our research is to study the methodology for identification of normal water extent and for setting up its database, which can be used as a standard for monitoring and assessing floods for the same area. This will be very helpful to unify the standard of assessment for various organizations and departments, and it can also help the decision-maker to check the real situation of flood for a large scale. In our study, a database for normal water extent of seven-large-river basins in China was set up, and it was quoted for monitoring the floods in China since 1999. The assessment results were utilized in several government ministries of China, such as State Planning Committee, Civil Administration Ministries and et al. This paper will introduce how to set up a normal water extent database and its application in flood's monitoring and its assessment

1. INTRODUCTION

Floods are one of the most serious natural disasters, and often cause great losses. The decision-maker needs to know their real situations and check the losses by floods eagerly in order to control and mitigate them. However, due to some reasons, not all the information is reliable and accurate. They usually are greatly different from many sources. How to provide the true information to make decision of flood controlling and mitigating is becoming the important task for remote sensing scientists. Despite scientists have made a great progress in monitoring floods, especially for a large area in a short time using remote sensing technology. But because of no any assessment standard before, the results from different groups are still various. How to check them? It is very difficult for the decision-maker to believe which. Therefore, by our research, "normal water extent" concept was put forward. In one hand, they mean the minimal values for the assessment of flood losses. If the water extent is larger than this value, it will cause some losses. In the other hand, they are some special areas according to the situation around the regions of river, lake, reservoir and dyke, land use and etc., which are easy to suffer from flooding during the flooding season. The objective of our study is to establish the methodology for identification of normal water extent and for setting up the database, which can be used as a standard for monitoring and assessing floods. In this paper, how to set up a normal water extent database and use it to monitor and assess flood will be introduced in detail, some applications will be given.

2. METHODOLOGY

For establishment of normal water extent database (NWED), the data sources include Landsat 5 TM data which resolution is 30 meters, NOAA/AVHRR images which resolution is 1.1 kilometers, thematic maps, including topographic maps, some important linear objects such as highway, railway and bridges, administrative boundaries, some related attribution data, such as toponym data, statistic data for land use and et al. If possible, some Airborne SAR data can be used as the original data for the reference of normal water extent.

The methodology for establishment of normal water extent is to use TM and NOAA/AVHRR images to identify normal water extent by automatic extraction or human-computer interactive interpretation, and then to integrate the normal water extent for each flooding area into a database, which can be called "normal water extent database" with some related spatial data, remote sensing images and attribution data.

The main procedures of establishment normal water extent database include data preprocessing, data merging, information extraction for normal water extent, producing vector format data for normal water extent and integrating the data into NWED. In general, the normal water extent database is composed of three kinds of data, images, graphic data and attribution data. The working flow chart shows in figure 1. The details are explained as follows.

2.1 Pre-processing of Remote Sensing Image

The preprocessing procedures for images include image composition, projection transform, and geometric rectification, and image mosaic. For Landsat 5 TM data, the pseudo-color image can be produced by composition of band 4, 3, and 2 according to red, green and blue bands. For NOAA/AVHRR data, the composite images need two steps. The first step is to separate the 1B data, the next step is to produce the pseudo-color image by composition of CH1, CH2, and CH4 according to red, green and blue bands.

All the composite images can be transformed to the local standard. For example, equal-area conic projection transformation was applied in China. After projection, geometric rectification can be implemented. The final step is to mosaic the images according to the flooding area. When do the image mosaic, the algorithm of minimal difference of gray can be used.

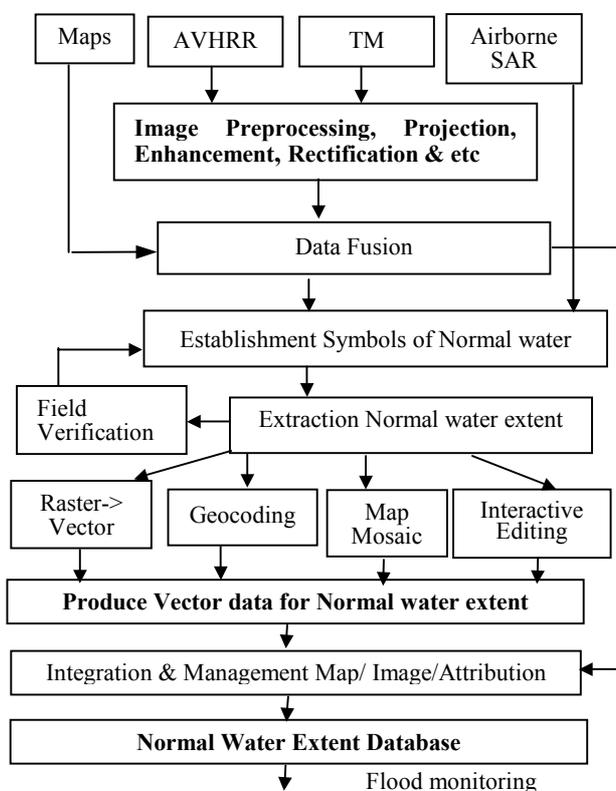


Figure 1. the Flowchart of Establishment NWED

2.2 Multi-Sources Data Merging

For normal water extent database, the data sets are acquired from different sources, including remote sensing images, thematic map and statistic data. Firstly, it is necessary for all the data to be registered by means of accurate geometric correction, and then to merge the data. The method is to use remote sensing, GIS and database technology. Its content includes the fusion between remote sensing data, remote sensing data and statistic data, thematic maps and images, maps and statistic data. After merging, all data sets have the same geo-reference system, which can enhance flood information and make the normal water extent easier to extract.

2.3 Extracting Normal Water Extent Information

As defined above, normal water extent is the minimal value for flood assessment. However, it can't simply be regarded as the water area in remote sensing image. In fact, they are different from water area. So, some important rules for identification normal water extent need to be emphasized here. The first one is that they are some special areas, which can be identified according to the situations around the areas of river, lake, reservoir and dyke, land use and etc. These are easy to suffer from flooding during the flooding season. The second one is that they can be identified by water extent in the image during non-flooding season and the flooding water extent in previous year. The third one is based on the above two rules. When cultivated lands and residential areas which width are more than 25 meters and inside or outside the dyke of river, and the region more than 50 kilometers and nearby large lakes, they can be regarded as normal water extent. When the area of normal water extent is more than 3 x 3 pixels, it can be delineated as polygon normal water extent. If the width is less than 3 pixels for the narrow regions, it can be regarded as linear normal water extent. When the rules are established, some typical sample images for study area can be selected for identification normal water extent from images. By field verification, these sample images can be used to instruct the identification of normal water extent. For its interpretation, a new layer needs to be created based on raster format, and identify normal water extent one by one.

2.4 Producing Vector Format Data for Normal Water Extent

After normal water extents being extracted, they can be imported and transferred to vector format files. Then they can be edited interactively in GIS software, and be given the related attribution data for each object in the maps, and then mosaic each interpretation result of normal water extent and its related data according to the region of river basin or administrative boundaries.

2.5 Data Integration and Management

For NWED, the data sets have a large volume, and the format and structure are very different. It is necessary to integrate and manage them in GIS software. According to image, topographic data and attribution data, and their structure and format, the NWED can be integrated into 3 kinds of database, i.e. image database, topographic database and attribution database. With the unified geo-coding, the final integrated database for normal water extent can be used to monitor flood.

3. APPLICATIONS

In our study, a database for normal water extent of seven-large-river basins in China was set up according to the above method. It was utilized for monitoring the floods occurring in China since 1999. The assessment results were applied in several government ministries of China, such as State Planning Committee, Civil Administration Ministries and et al. The applications of NWED include flood monitoring and its assessment. For monitoring, submerged area, locations of flood and the losses of crop output can be derived from NWED.

Figure 2 shows the detail procedures for monitoring flood in Poyang lake region using NWED in 1999. Table1 is the statistic data for normal area, flooding area and submerged area. Figure 3 are two applications of normal water extent database for flood monitoring in Dongting Lake region of China in 1999. 3a) is the flooding area distribution map using NOAA/AVHRR, and 3b)

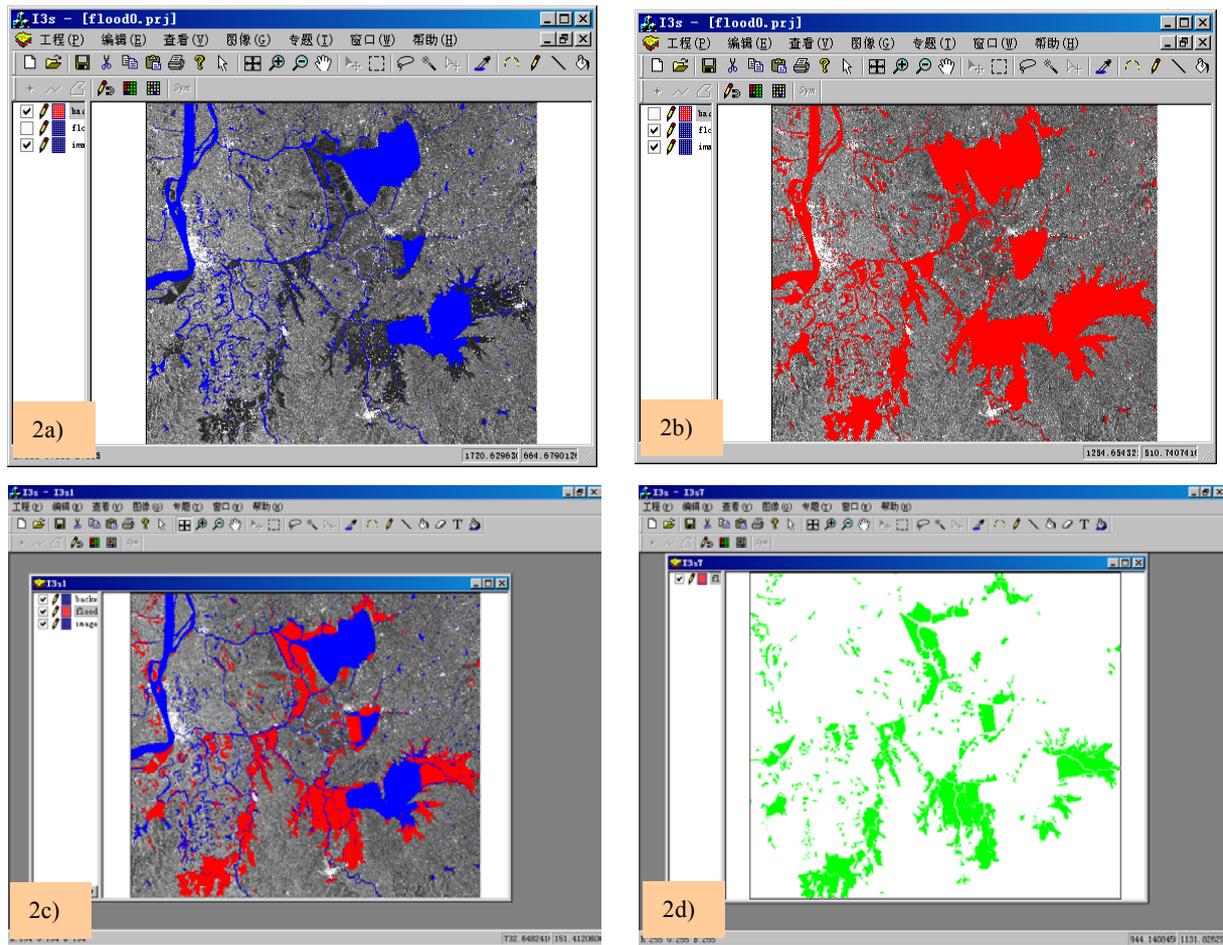


Figure 2. Monitoring Flood in Poyang Lake Region Using Normal Water Extent Database
 2a) Normal Water Extent, 2b) Flooding Area, 2c) Overlaying Image, 3d) Flood Submerged Area

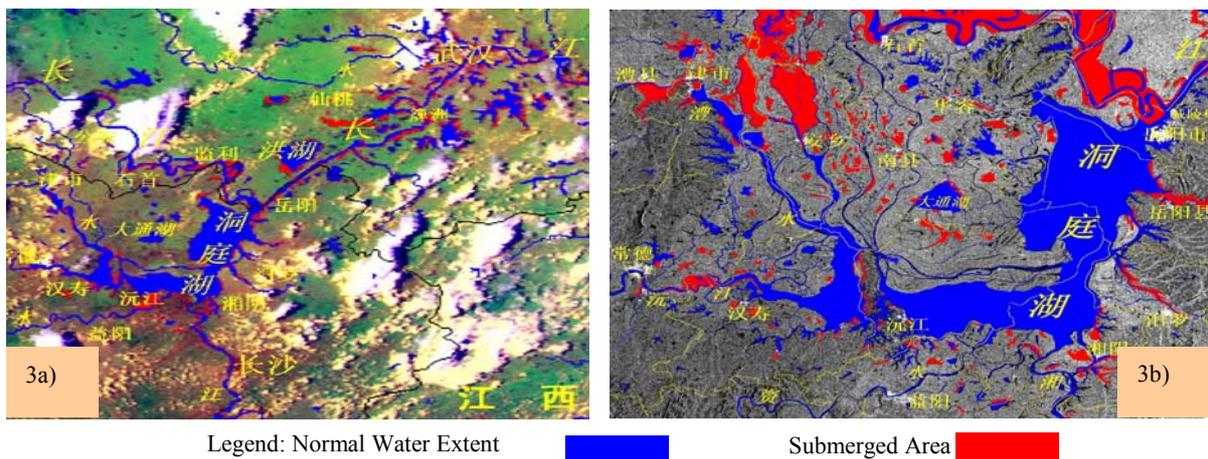


Figure 3. Flood Distribution Map of Dongting Lake Region Using Normal Water Extent Database
 3a is the result map by NOAA/AVHRR, 3b is the result map by Radarsat SAR

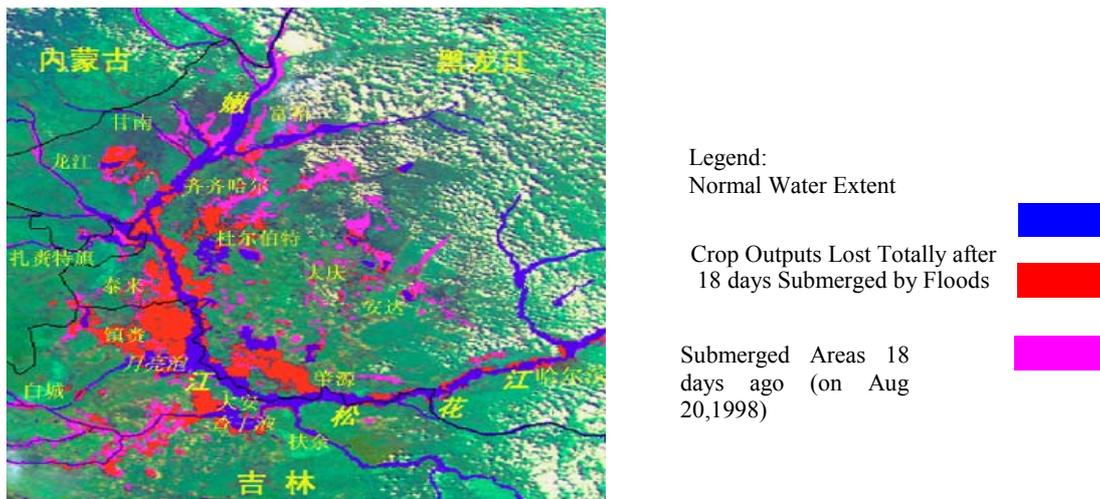


Figure 4. Loss Map of Crop Output in Neng River Region Using NWED by NOAA/AVHRR

is the flooding area distribution map using Radarsat SAR data. Figure 4 is the map for loss of crop output in Neng river region using NWED by NOAA/AVHRR. The applications appear that it can help to improve the response time of flood monitoring after the flood data input and the accuracy of assessment using NWED. It needs 2 or 3 hours for general flood information report after receiving AVHRR data, 1 day for preliminary report after getting Radarsat SAR data, 2 days for detailed report, and 4 days for detailed report after getting airborne SAR data (about 30,000 Km²). The interpretation accuracy for submerged objects is better than 95%, the area accuracy for submerged area is about 90% to 95%, and the position accuracy for flood boundaries is 1 or 2 pixels.

	Number of Pixels	Number of Areas	Total Area (Km ²)
Normal area	255964	1253	639.91
Flooding area	534868	928	1337.17
Submerged area	278904	477	697.26

Table 1. Results of Flood Monitoring

4. DISCUSSION AND CONCLUSION

Normal water extent can be identified by interpretation or automatic classification from remote sensing images. After field verification for normal water extent, it can be integrated into a database called "normal water extent database" with related maps and attribution data. Our application shows that, normal water extent database can unify the background data, quantify the submerged areas and position its distribution, qualify the land use types of submerged areas. In summary, it can help to improve the efficiency of flood assessment and accuracy of flood information, and unify the criteria of flood assessment. So normal water extent database can be used as a feasible standard of assessment for the future occurring floods.

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