RESEARCH ON MODELING BASED ON GIS COM ABOUT METEOROLOGIC FORECAST AND ALARM OF GEOLOGICAL HAZARDS

W. D. Zhao [a], J. Q. Wang [a], Y. X. Li [a]

[a] School of Resources & Environmental Engineering, Hefei University of Technology, 193 Tunxi Road, Hefei, P.R .China, troet68@163.com

KEY WORDS: Geographic Information System, Geological Hazard, Modeling, Forecast and Alarm, ComGIS, Digital Terrain Model

ABSTRACT:

According to the field investigation data, a meteorological forecast and alarm model of geologic disasters in Hefei Area has been established. This model was based on GIS raster data model in order to be integrated with GIS Digital Terrain Model (DTM) Component Object Model (COM). Some important factors that put premium on geological hazards, such as intraday and five-day forecasting and liminal precipitation, subareas of geologic disasters, have been considered in the model. The model has been integrated with forecast and alarm information system based on GIS seamlessly by the way of using ComGIS. The meteorological forecast and alarm information system of geologic disaster can be used to publish the forecasting and alarming information of geologic disaster according to the intraday and five-day forecasting precipitation from day to day in rainy seasons every year in Hefei Area. The successful establishment of the meteorological forecast and alarm information system of geologic disasters in Hefei Area demonstrated that this integrating method is feasible and it has the value of practicality and popularization in a certain degree.

1. INTRODUCTION

1.1 Instructions of Research

China is one of the countries that the geologic hazards are most serious. More than 1000 people were killed and almost ten billions of Yuan's property were lost yearly because of geologic hazard in recent years (Wang, 2005). It is necessary to establish a forecast and alarm information system of geologic disasters to decrease the loss caused by geologic hazards. Because that the happenings of geologic hazards are correlative to geographic space information, precipitation and geologic conditions and so on, it is suitable to use GIS in the forecast and alarm information system. All the relative factors have been discussed in details and some most important factors have been considered in the forecast and alarm models of geologic hazards. How can we integrate the forecast and alarm models of geologic hazards with GIS seamlessly to establish a GIS-based forecast and alarm information system of geologic hazards? First and foremost the pretreatment of spatial data and its' attributes are necessary.

1.2 Instructions of Research Area

Our research area is Hefei Area which includes Hefei city, Feidong county, Feixi county and Changfeng county. The area of Hefei Area is about 7266 km^2 (Wang, 2005). Landslips, unstable slopes, breakdowns, ground fissures, breakdowns of riversides and lakeshores are the main investigating objects. But only Landslips, unstable slopes and breakdowns were considered in the meteorologic forecast and alarm model of geologic disasters because that the mechanism of ground fissures, breakdowns of riversides and lakeshores are very different from the other types of geologic disasters mentioned above. Another important reason is that the rainfall affects landslips, unstable slopes and breakdowns intensively.

2. PRETREATMENT OF SPATIAL DATA AND ITS' ATTRIBUTES

2.1 Pretreatment of Spatial Data

The base map of research area was translated into MAPGIS data format from AutoCAD data format, and some new layers were established to meet the needs of modelling. There are 23 geographic layers and 4 geological disaster layers, such as geological disaster point layer, precipitation point layer and so on，in our research project.

2.2 Pretreatment of Attributes

Some important attributes have been created to meet the needs of forecast and alarm model of geological hazards, which include the observational and liminal precipitation of every precipitation observation station and subareas of geologic hazards in our research area. In which, the liminal precipitation and subareas of geologic hazard can not be obtained directly before some analysis and calculations have been done.

3. MODELING AND FORECAST AND ALARM OF GEOLOGICAL HAZARD

3.1 Meteorological Forecast and Alarm Modelling of Geological Hazards

With the rapid development of computer technology, many forecast and alarm models of geological hazards have been established in recent years. According to the field investigation data, precipitation has put premium on 65% of geological hazards of Hefei Area(Wang, 2005). Actually, the happening of geologic disasters is correlative to geographic space information, precipitation and geologic conditions and so on. A mud-rock flow alarm system was established by United States Geological Survey and National Weather Service according to precipitation, capacity of penetration and moisture of rock and soil, and meteorological change in 1985(Liu, 2004). A countrywide statistic meteorological forecast and alarm model has been built up to forecast and alarm geological hazard of China in rainy seasons, and the forecast and alarm system has been run for 2 years (Liu, 2004).

In our case study, the most important factors that put premium on geological hazards of Hefei Area are intraday and five-day forecasting and liminal precipitation, subareas of geologic disasters.

Intraday forecasting precipitation means the forecasting precipitation of the forecasting day from intraday 20:00 pm to 20:00 pm in next day. Five-day forecasting precipitation means the summation of intraday forecasting precipitation and four days practical precipitation before the forecasting day. It is necessary to consider the five-day forecasting precipitation because that the precipitation affects the geologic disasters lingeringly. Some geologic disasters occur when the rain has stopped for a long time. The liminal precipitation means the minimum precipitation that will cause the happening of geological hazards.

A model based on GIS raster data model has been established to forecast and alarm the geologic disasters in Hefei Area. The researching area has been divided into grid cells which edges are all 5 Km long. There are 460 grid cells in all in the researching area. Each grid cell has its own intraday and five-day forecasting and liminal precipitation and belongs to its own subareas of geologic disasters. In this model, the distribution of subareas of geologic disasters affects the forecasting and alarming results of geologic disasters greatly. A lot of factors, such as stratum, lithology, tectonic and topography and so on, have been considered while the subareas of geologic disasters were divided by our geologists. According to the field investigation and the important factors above, Hefei Area has been divided into 10 subareas of geologic disasters totally (Fig. 1). There are four types of geological subareas showed in figure 1. The High Zone means that the possibility of geological hazards happening is high and the Low Zone means that is low. The possibility of geological hazards happening of Middle Zone is between the High Zone and Middle Zone. The Lower Zone means that the possibility of geological hazards happening is very low.

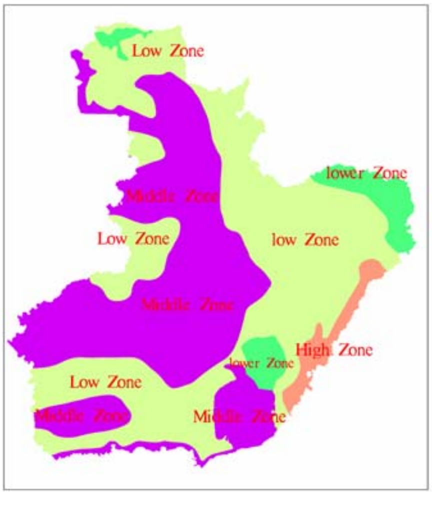

Figure 1. Distribution of subareas of geologic disasters in Hefei Area Anhui Province

In order to get the liminal precipitation of every grid cell, some important data obtained from field investigation must be analyzed in details. All of the data about happened geological hazards, such as the location and geological subareas to which the geologic hazards belong, scale, precipitation and so on should be investigated in details. According to these data, the liminal precipitation of every cell can be obtained by using statistical analysis. Because that the grid cells in the same geological subareas have similar geological conditions and that the grid model should be simplified in order to improve its efficiency, the grid cells belonging to same geological subareas have same liminal precipitation. In the light of forecast and liminal precipitation of intraday and five-day, the classified value of easiness of geologic disasters happening of every grid cell can be calculated out.

According to the forecast and alarm model of geologic disasters, the classified value of easiness of geologic disasters happening can be represented as the following:

$$C(i,j) = \frac{F(i,j)}{P(i,j)} \tag{1}$$

Where C(i,j) = the classified value of easiness of geologic disasters happening of the grid cell which row number is i and column number is j
F(i,j) = intraday or five-day forecasting precipitation of the grid cell which row number is i and column number is j
P(i,j) = intraday or five-day liminal precipitation of the grid cell which row number is i and column number is j
i =the serial number of grid rows
j = the serial number of grid columns

3.2 Integration of GIS and Geological Hazard Models

There are four main types of integrating GIS with Geological Hazard Models. ①. Integration of using extensible GIS platform software. Geological Hazard models can be embedded into the GIS software by use of programming language provided by GIS software. ②. Integration of using single GIS component. It is the main way of integrating GIS with Geological Hazard at present. ③. Integration of using ComGIS. Being different from the single GIS Component, ComGIS is made up of many GIS components that have different functions, such as component of editing map, component of spatial analysis etc. ArcObjects and MAPGIS are famous ComGIS software. ④. Integration of using technology of COM purely (Bao, 2000; Chen, 2002; Marble, 2000; Qian, 2002; Weng, 2001; Zhao, 2002, 2004). We can establish any kind of integrating system seamlessly according to our needs by assembling components of GIS and Geological Hazard Models. This integration is the highest goal of integrating GIS with geological hazard models, but it is difficult to be realized in near future because of many commercial and technological factors. For example, we can not obtain any COM of geological hazard models at present.

The first type of integration is not commonly used by many people because that the functions of programming languages provided by embedded GIS are not so strong and the languages are not widely used. The developers always have to learn new programming languages. Though integration of using single GIS component is widely used at present, it is common that many important GIS analysis functions, such as DTM analysis functions, GIS network analysis functions and so on, are not included into single GIS component. For our case study, it is impossible to develop the DTM analysis functions by ourselves. The advantages of integration of using ComGIS are obvious. Firstly, the geological hazard models are based on grid data, it is very difficult for us to establish the digital terrain models (DTM) of geological hazard and realize the complex functions of DTM by ourselves. But we can use the DTM COM of ComGIS called MAPGIS to solve the problem. The DTM COM can be used to divide our research area into grid, draw the isoclines of the grade of meteorological forecast and alarm of geological hazard and so on. Secondly, the different GIS components with different functions can be easily assembled into our integrating system according to our needs. Our forecast and alarm models of geological hazard can also be easily integrated with GIS-base system. By using the way of integrating with ComGIS, meteorological forecast and alarm models of geological hazard of Hefei Area have been integrated with GIS successfully.

3.3 Meteorological Forecast and Alarm of Geological Hazard

A practical forecast and alarm information system of geologic disaster has been established by using the above integrating way, which demonstrated that the integrating way is feasible and efficient.

In order to publish the subareas map of easiness of geologic disasters happening to the public in a simple and visual way, the classified value of easiness of geologic disasters happening has been classified into 5 grades, including the forecasting grades of blue and green, and the alarming grades of yellow, orange and red. Therefore, the subareas map of easiness of geologic disasters happening can be drawn out automatically by using the DTM functions of GIS COM called MAPGIS. The subareas map can be used to publish the forecasting and alarming information. But only the alarming subareas including yellow, orange and red alarming subareas are published to the publics by Hefei TV weather forecast program at 6:50 pm in the forecasting evening or the Web sites of the Bureau of Land and Resources of Hefei City (figure. 2). Figure 2 shows that there are 3 red alarming subareas, 2 orange alarming subareas and 4 yellow alarming subareas published to the public in this alarm. The green and blue forecast subareas were not shown in figure 2. According to the type of geologic disaster alarming information, corresponding actions should be taken to avoid the loss of property and human being. For example, if the red alarming information were published, the people in the red geologic disaster alarming area should evacuate as soon as possible while the people in yellow geologic disaster alarming areas only need to pay attention to the areas where geologic disaster will occur easily and the change of precipitation.

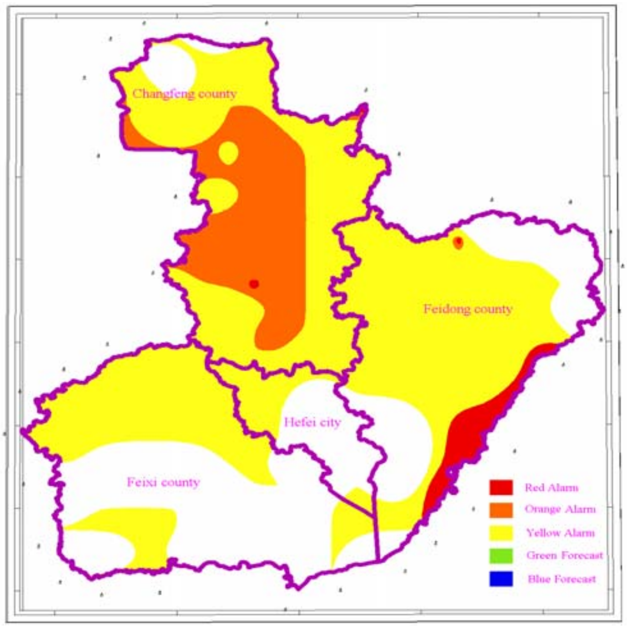

figure. 2 The forecast and alarm result of geologic disaster in Hefei Area

The meteorologic forecast and alarm information system of geologic disaster can publish the forecasting and alarming information of geologic disaster according to the intraday and five-day forecasting precipitation from day to day in rainy seasons every year in Hefei Area. The main interfaces of the meteorologic forecast and alarm information system of geologic disaster are shown as following:

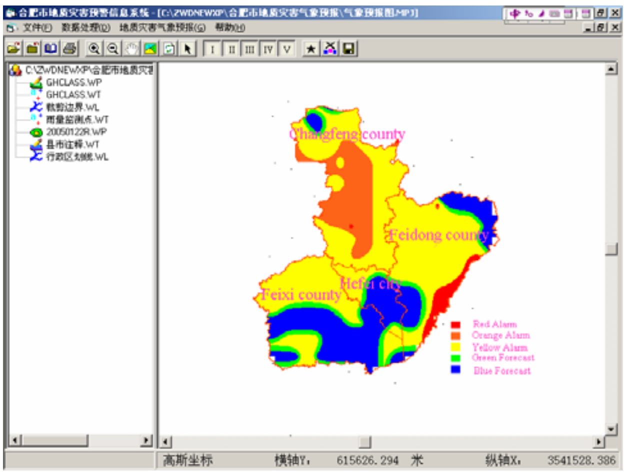

Figure. 3 The main interfaces of the meteorologic forecast and alarm information system of geologic disaster

4. CONCLUSIONS

In conclusion，the model, which based on GIS raster data, of meteorological forecast and alarm of geologic disasters in Hefei Area is reasonable and the new way of integrating GIS DTM with the meteorological forecast and alarm model of geologic disaster seamlessly is feasible. The successful establishment of the meteorological forecast and alarm information system of geologic disasters in Hefei Area demonstrated that this integrating efficiency is high and this integrating way has the value of practicality and popularization in a certain degree.

REFERENCES

References from Journals:
Bao, S.M., et. al. 2000. Seamless integration of spatial statistics and gis: the s-plus for arcview and s+grassland links. *Journal of Geographical Systems*, (2), pp. 287-306.

Chen Y.B., and Zhong E.S., etc. 2002. A seamless integration research method of gis and oa system based on ComGIS technology, *Remote Sensing for Land & Resources*, (2), pp. 56-60

Liu, C. Z., 2004. Preliminary research on the early warning of geo-hazards in china based on the rainning forecast, *Geological Bulletin of China*, 23 (4), pp. 303-309

Marble D. F. 2000. Some thoughts on integration of spatial analysis and geographic information system. *Journal of Geographical Systems***,** 2 (1), pp. 31-35**.**

Qian, C. Z., Zhao, W.D. 2002. The model of management information system based on "3s" technology about water environment, *Journal of Hefei University of Technology*, 25(4), pp. 501-503

Weng Q. H., and Haute .T., 2001. Modeling urban growth effects on surface runoff with the integration of remote sensing and GIS. *Environmental Management.* 28 (6), pp. 737-748.

Zhao, W.D. and Du W.B. 2002 The optimal management information system of water resource. *Journal of Jiaozuo Institute of Technology*, 21(4), pp.292-294.

References from Books:
Zhao w.d. 2004. The seamless integrating technology of GIS and Management Information System of water resources, *GIS and Remote Sensing in Hydrology, Water Resources and Environment.* IAHS Publication 289, IAHS Press, pp. 249-253

References from Other Literature:
Wang, J.Q, Zhao W.D, 2005. Scientific Report of the Meteorological Forecast and Alarm Information System of Hefei Area. Hefei University of Technology, Hefei City, Anhui Province, P.R.C.

Acknowledgements
I sincerely acknowledge the support of Scientific Research Development Foundation of Hefie University of Technology, Bureau of Land and Resources of Hefei City and Engineering Survey Institute of Anhui Province.