洪水灾害模拟及评估

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摘　要：针对洪水灾害评估的特点，将 GIS 技术与 RS 技术相结合，根据数字高程模型 DEM 提供的三维数据和遥感影像数据，运用 GIS 的空间分析功能来预测、模拟显示红水河流域洪水淹没场景，并结合该流域水文站降雨量数据和各乡镇人口密度数据以及其他辅助数据进行洪水灾害评估。

关键词：洪水灾害；GIS；RS；分类；模拟
中图分类号：P208　　**文献标志码**：B　　**文章编号**：1672-4623（2011）04-0122-03

发挥 GIS 技术在数据管理和空间分析方面和遥感技术在土地信息获取的优势，以数字高程模型 DEM 和 RS 影像为基础，运用 GIS 的空间分析功能，研究试验区洪水河流域的洪水淹没情况。利用研究区域的数字高程模型（DEM）和遥感影像数据对其进行三维场景仿真，再通过给定洪水水位高程值，认为在水位以下则是淹没区域，反之则不属于淹没范围，并对淹没过程进行模拟，通过人工方法确定连通区域来计算洪水淹没面积，并结合研究区域土地利用类型数据、泰森多边形生成的各水文站降雨量情况等数据进行加权叠置生成洪水灾害风险图，为防洪抗灾做决策。研究区域为红水河流域中的整个龙滩流域及其 6 个子流域。采用的基本数据为空间数据和水文数据以及其他辅助数据。其中，空间数据包括 DEM 底图、ETM 遥感影像底图、省市县行政边界等。水文数据是各子流域水文站获取的降雨量数据，辅助数据是流域流经区域人口密度数据以及部分建筑物纹理数据。研究的主要内容有：ETM 遥感影像进行分类，生成土地利用类型图；探讨洪水灾害淹没真实三维场景模拟；利用 Arcmap 软件确定洪水淹没面积；初步制作灾害风险图。

1　遥感影像分类

以惠水县为例，对遥感影像进行分类。研究区以惠水县的行政边界为准，选择不规则分幅裁剪。将惠水县行政边界矢量化转换成 ROI 区域，再进行裁减。惠水县主要地类的 ETM 遥感影像判读标志有：林地：影像上呈深绿色，有较强的立体感，呈明暗交错；农用地：包括旱地和道路，影像上呈淡紫红色，其中零散的点缀着淡绿色；水系：呈墨色或黑色，呈条状；湖泊和水塘：呈墨色或黑色，呈面状；居民建筑用地：呈暗紫色，在整幅影像上呈零星排列[1]。利用目视解译和 Google Earth 对应地物进行观察可大致区分出地物的类型，每种地物都点选 30 个以上的样本，对采集的样本数据进行统计，得到地物光谱反射图。

1）阴阳坡归一化。归一化处理是将每一个像元的光谱值统一到整体平均亮度水平，以减少地形变化造成的影响[2-3]。计算公式为：

$$p'_i = \frac{(\frac{1}{m}\sum_{j=1}^{m} p_j + \frac{1}{m'}\sum_{j=1}^{m'} p'_j)/2}{\frac{1}{n}\sum_{i=1}^{n} p_i} \cdot p_i$$

式中，p'_i 为归一化后 i 像元值；p_i 为原始影像 i 像元值；m 为阴坡像元数量；m' 为阳坡像元数量；n 为图像波段数；p_j 为阴坡 j 像元值；p'_j 为阳坡 J 像元值。

实现思路：首先求出阴坡和阳坡的均值，再求出 TM 影像 6 个波段的均值，取两者的中值作为阴阳坡归一化的标准。利用 IDL 依据该算法编写功能函数，并进行调用，再将阴阳坡处理后的各波段进行合成。

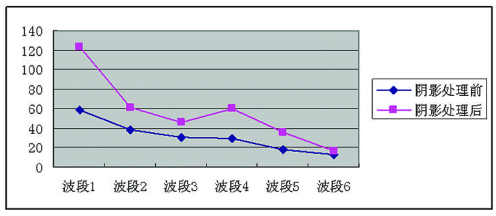

图 1　归一化前后阴影区样本平均波谱图

从图 1 可以看出，阴阳坡归一化处理后，阴坡的像元值将相应地放大，可以有效地恢复阴影区域地物类型的光谱，从而很好地帮助去除地物影响。

2）水体和阴影区分。经过阴阳坡归一化处理后还存在部分阴影，需要根据水体的多波段谱间关系特征，采取“波谱趋势判定法”，提取出水体信息。运用感兴趣区对图进行裁剪，去除较明显的阴影区域，得到最终提取水体信息的效果图。利用波段运算获取混合水体和阴影后，利用掩模方法将水体信息去除，再将得

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出的阴影与后面分类结果进行合并 [3]。

3) 形态学知识。在提取水体时，要用到形态学知识。形态学指数方程为：

$$t=\sqrt{s}/p$$

式中，p 为图斑周长；s 为图斑的面积；t 为形状指数。

将提取到的水体和阴影转换成 shp 文件导入 ArcGIS 软件中，根据公式计算出对应的形态指数，将大于某个阈值的阴影删除，再叠加到 envi 软件中，利用膨胀运算进行水系断线连接，再用数学形态学中闭运算进行平滑，最后提取水系 [4]。

4) 分类过程。先按照多波段结合的方法将林地和阴影从研究区域中分离出来，将提取出来的林地和阴影掩模后，再利用水体特殊的光谱知识，通过利用高程信息和形态学知识将水体有效区分开，再将分类出来的水体进行掩摸，对其他地物进行分类；最后利用决策树方法将提取到的各种地物合成再一起，得到如下的惠水县土地利用类型图（见图 2）。

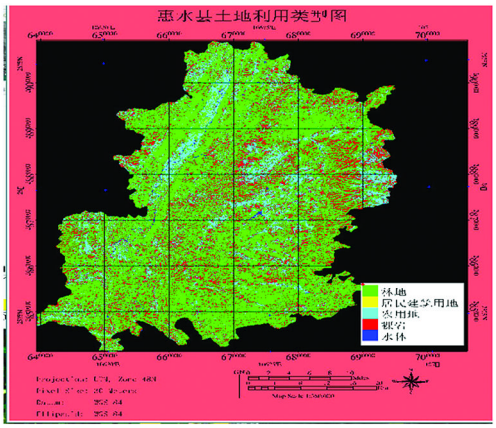

图 2　惠水县土地利用类型图

2　洪水灾害三维场景模拟

采用 quickbird 遥感影像数据及对应的 DEM 数据。三维场景的制作是将数字地形模型（DEM）和遥感图像数据进行叠加，再将利用 Google sketchup 建好的建筑物模型和树木模型，通过 ESRI sketchup 插件导入场景中，生成具有三维可视的地貌景观图。在此基础上可以进行红水河流域水资源的研究、洪涝灾害快速监测与评估等 [5-6]，技术路线如图 3 所示。

洪水淹没模型是以三维地形和不同水位来综合演示洪水淹没行为的时空变化及水体形态。运用 ArcGIS 中的 3D 扩展模块，在研究区域数字高程模型的基础上，利用 ArcScene 实现该区域洪水淹没演进过程，直观地显示不同时刻、水位该区域洪水淹没情况，为防洪救灾作出重要的决策。

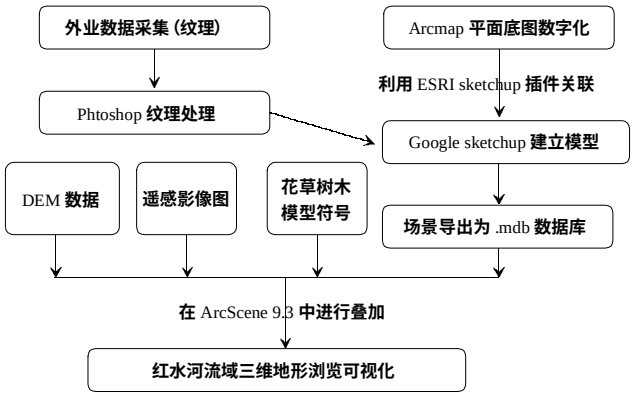

图 3　建立三维场景流程图

3　洪水淹没面积计算及风险图制作

3.1　洪水淹没面积计算

操作主要是利用 Arcmap 软件完成，通过已知红水河流域各水文站水文数据确定洪水位，由已知 DEM 数据和给定洪水水位来确定淹没区域并计算淹没面积[7-10]。具体操作流程在 Arctoolbox 中新建 model builder 模型，只需给定水文数据，即可直观地观察到其淹没区域及面积（如图 4、图 5 所示）。

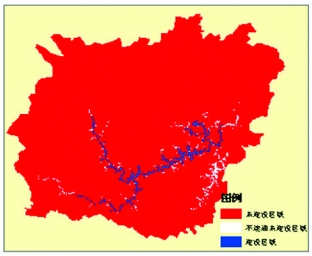

图 4　水位为 450 m 时流域淹没情况

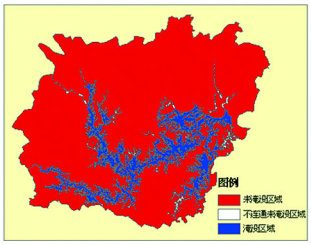

图 5　水位为 650 m 时流域淹没情况

3.2　洪水风险图制作

洪水风险图是以图的形式直观反映洪水威胁区域发生某一频率洪水后，可能淹没的范围、水深以及不同量级洪水可能造成的灾害及经济损失的工具 [11-13]。在 GIS 的支持下，利用计算得到的淹没范围、淹没水深，与专题图层进行叠加和分析，即可生成专题淹没图件。如关联背景数据库中的社会经济信息，并结合数学模型，可统计由洪水淹没造成的灾害损失。洪水风险图制作制作基本流程见图 6，对各影响图层确定评价系数以及子类型进行打分，得到洪水风险图（如图 7 所示）。

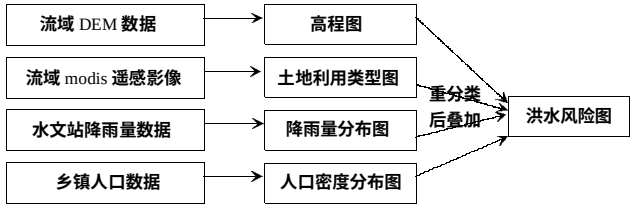

图 6　洪水风险图制作流程

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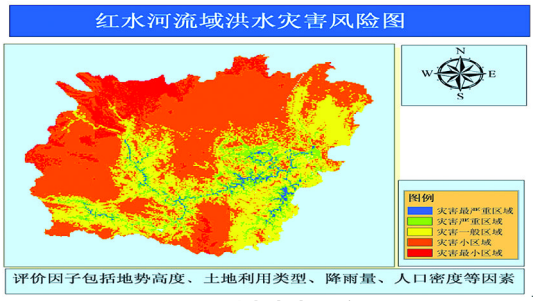

图 7 洪水灾害风险图

4 结 语

1）利用 DEM 数据、遥感影像数据和建筑物属性可以真实地模拟洪水淹没真实场景，对于确定洪水淹没区地形起着重要的作用。

2）依据洪水水位确定洪水淹没范围后，结合土地利用类型及经济数据，对可能受淹地区的林地、居民用地以及人口数据等进行评估，并进一步预测洪水灾害损失。

3）充分利用该地区水文数据，预测近几年洪水水位以及降水量情况，结合该区域经济数据，制作洪水灾害风险图，估计洪水发生时影响范围，可以为防灾救灾作决策支持。

参考文献

[1] 孟春林, 喻庆国.卫星TM影像阴影消除方法的探讨[J].地球信息科学, 2001(04):66-70
[2] 李栋梁.基于 TM 影像的水系信息提取及变化制图研究[D].南京 :河海大学, 2006
[3] 翟宜峰, 殷峻暹.基于 GIS ／ RS 的洪水灾害评估模型[J].人民黄河, 2003, 25(4) :6-7
[4] 向素玉, 陈军.基于 GIS 城市洪水淹没模拟分析[J].中国地质大学学报, l995, 20(5) :575-580
[5] 刘仁义, 刘南.基于 GIS 的复杂地形洪水淹没区计算方法[J].地理学报, 2001, 56(1):1-6
[6] 丁志雄, 李纪人.基于 GIS 格网模型的洪水淹没分析方法[J].水利学报, 2004(6):56-67
[7] 刘小生, 黄玉生. 基于 Arcinfo 的洪水淹没面积的计算方法[J].测绘通报, 2003(6):46-49
[8] 郭利华, 龙毅.基于 DEM 的洪水淹没分析[J].测绘通报, 2002(11):25-27, 30
[9] 张彦召.基于三维可视化技术的流域仿真模拟研究[D].大连：大连理工大学, 2006
[10] 冯丽丽, 李天文, 陈正江, 等.基于 ArcGIS 的渭河下游洪水淹没面积的计算[J].干旱区地理, 2007, 30(6) :921-925
[11] 袁红梅, 邓彩琼.应用 GIS 技术制作洪水风险图[J].江西水利科技, 2004, 30(4):198-200
[12] 封殿波, 赵杰.基于 ArcGIS 的太平湖可视化研究[J].遥感与航空摄影, 2008(4) :49-51
[13] 李红英.基于 GIS 的洪灾损失评估研究--以黑河为例[D].西安 :西安理工大学, 2007

第一作者简介：靖凤伟，硕士，研究方向为 GIS 应用。

（上接第 121 页）扩建工程中，通过福州市城市排水管网地理信息系统设计出不同埋深的管网铺设方案，并结合地面标高可轻易计算出各个方案的土方量，再结合经济、价格等方面指标可得出工程造价，经过比较可选出既经济又合理的铺设方案。在管道定线设计中，可沿管道做缓冲区分析，并将分析结果与背景图叠加可直观分析出管线与建筑物最小净距，反推定线方案是否合理。

3.2 积水区问题分析与解决

当管网区域内出现积水区时，福州市管理部门综合运用系统提供的检索、计算与纵横断面分析等基本功能，并结合专业知识，快速分析出产生的原因并制定出相应的对策，提高办事效率。例如，通过系统快速找出引起积水的各种因素，管径是否太小，管道铺设坡度是否太缓，雨水出入口布局情况与数量情况是否能满足排水要求，管道排水的流向是否不合理等。

4 结 语

在城市排水管网 GIS 中，综合运用 ArcGIS 技术、地下管线探测技术、测绘技术、数据库技术和计算机技术，建立了城市排水管网数据库和城市排水管网地理信息系统，提高了城市排水管网管理、公共基础设施突发事件监测、执法监督和指挥的能力，提高了管网管理效率和水平，产生了可观的社会效益与经济效益。

参考文献

[1] GB/T 21740-2008 基础地理信息城市数据库建设规范[S].
[2] GB/T 18578-2008 城市地理信息系统设计规范[S].
[3] CJJ61-2003 城市地下管线探测技术规程[S].
[4] 李德仁.地理信息系统导论[M].北京 :电子工业出版社, 2006
[5] 杜良法, 孙刚, 王青. 城市地下管线普查中高新技术的应用[J].地理空间信息, 2010(4) :143-145
[6] 边馥苓.地理信息系统原理与方法[M].北京 :测绘出版社, 1996
[7] 张硕.用组件式 GIS 快速开发地理信息应用系统[J].城市勘测, 2009(6) :19-23

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were studied. From the analysis, Qinghai-Tibet region had the lowest , but the eastern China CH4 column density. In eastern China CH4 column density decreased with increasing of latitude. Overall, there was significant seasonal variation , that was CH4 column density high in summer and low in summer.
Key words CH4 volume mixing ratio,SCIAMACHY,natural region (Page:115)

Loosely Coupled of Data and System Interface Design Base on Net Reflection Technology by WU Fei
Abstract Process in the development of the management information system,the business logic started around the data. In general, first of all analysis of data entities and the general design of system interface process in the analysis and design of software projects. These processes dependents on the stability of the data entities, when the entity data changes, such as modify the data structure, system design and interface design changes at same time,so this is bound to improve software development costs, while the system's operation and maintenance more difficult. This paper presented a use. Net technology system and the data reflecting the loosely coupled approach. The method could meet real-time based on changes in physical structure of data system interface requirements, improved the efficiency of system development.
Key words Net reflection technology,XML comments,loosely coupled (Page:118)

Design of the Drainpipe Networks GIS based on ArcGIS by TAO Deming
Abstract The development of city brings along the construction of city basic facilities, and high construction speed and big scale of the drainpipe networks system. The traditional labour management method already can not satisfy the need of actual work, so the constitute of modern capacity drainpipe networks management information system is sorely needed.In the case of the drainpipe networks management and application of Fuzhou, design and application of the Drainpipe Networks GIS were elaborated in this paper.
Key words ArcGIS, GIS,the Drainpipe Networks (Page:120)

Simulation and Assessment of Flood Disastersby JING Fengwei
Abstract Aim at characteristics of flood hazard assessment , combined with the GIS and RS technology, according to three-dimensional data provided by DEM and data from remote sensing image, using spatial analysis of GIS to predict, simulationed and showed flood scene of Hongshui River, then integrated rainfall data, population density data of townships and other ancillary data to evaluate disaster induced by flood.
Key words flood disasters,GIS,RS,classify,simulation (Page:122)

Study on the Spatial and Temporal Variation of Land Use Changes in Yantai Coastland by MA Jinwei
Abstract Followed by large-scale development and utilization actives of coastline resources, land use /land cover changes in coastal zone show remarkable dynamics and significant difference with distance from coastline. Taking Yantai coastal area as an example, the spatio-temporal variation resulting from different coastal location were analyzed in this paper by Remote Sensing and Geographic Information System methods. The results showed that the process of land use change was more active in coastal zone of Yantai during last 20 years, with rapid expansion of urban land and other construction land. Coastal location had a profound impact on land use change rate and transformation between different land use types. And, main factors of the spatial and temporal variation included the natural geographical conditions and coastline development closely related with the coastal location, utilization activities, population growth, economic growth, policy and management of coastal zone.
Key words Yantai, coastal location, spatio-temporal variation, impact factors (Page:125)

Study of Digital Campus Modeling Based on SuperMap Deskpro by YANG Dequan
Abstract In recent years, many colleges have begun to establish their own "digital campus", facilitate management and improve human and material resources use efficiency. As the foundation and an important part of a "digital campus", 3D landscape modeling made management to more intuitive and effective. In this article, a 3D landscape model of the center campus of Xianning University was set up through the steps of the data pre-processing, the 3D model constructing and the texture projecting by using the China-made software SuperMap Deskpro.
Key Words digital campus,3D landscape modeling,Xianning university, SuperMap Deskpro (Page:131)

Shanxi Province with Land Use / Cover Change Monitoring Based on MODIS Data by FAN Yanwei
Abstract This article was based on MODIS data for land use / land cover dynamic monitoring of the classification study. The main content was about making use of maximum likelihood supervised classification using MODIS images in Shanxi Province and other auxiliary data such as ETM+ to capture various land-use types of study area, and then compared with statistical data for land use / land cover dynamic monitoring and analysis.
Key words MODIS, land use/land cover, supervised classification, ETM+ (Page:136)

Land Surface Temperature Retrieval Based on Landsat ETM+ Data in Wuhan City by YAN An
Abstract In this article,the land surface temperature(LST) of Wuhan in summer 2002 was accurately retrieved by mono-window algorithm method, based mainly on Landsat ETM+ data, supplemented by meteorological data. The fractional vegetation cover was calculated by NDVI(normalized difference vegetation index), and estimation for Land Surface Emissivity was measured. The results indicated that urban heat island from Wuhan Wuchang, Hankou and Hanyang constitute the three major urban heat island, there were small heat islands even more serious inside Large ones. Moreover, distribution of heat islands of Wuhan is closely related to their underlying surface environment.
Key words land surface temperature retrieval,Landsat ETM+, heat island effect,mono-window algorithm method (Page:140)

Application of Handheld GPS to Land-use Database Updating by REN Dongfeng
Abstract At present, the second national land survey is a great mission for the homeland department. Field survey in the recovering the land is a very important step. The traditional survey methods took too much time and energy, and were difficult to measure the area or length and record results implementation program rapidly and accurately. This paper discussed the advantages and development prospects of the handheld GPS in field data acquisition and land updating. We put forward a simple and new method planting the result of handheld GPS absolute orientation in a topographic map, and it greatly enhanced the practicality in the land used database updates.
Key words handheld GPS, coordinate transformation,differential technique,GIS (Page:143)

Discussion on Characteristic of Technique about the Thematic Atlas of PRC's Provincial Administrative Bounds by ZHANG Hanmei
Abstract The thematic atlas of PRC's provincial administrative bounds is a major, systemic, normalized thematic atlas about provincial administrative bounds. It has authority, veracity and practicability. In this paper, we mentioned about the significance of editing the thematic atlas and the content of it. We also expounded the key link and technique characteristic of thematic atlas editing technical scheme.
Key words thematic atlas ,technical scheme, technique characteristic (Page:147)

Study on the Application of Tile Map Technology in Desktop GIS by HUANG Menglong
Abstract This paper introduced tile map technology and its relevant stan-

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