利用 SCIAMACHY 资料分析中国 CH_4 柱浓度分布

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摘　要：对基于 SCIAMACHY 传感器，WFM-DOAS 反演的 CH_4 柱浓度数据进行分析，分析了全国 CH_4 柱浓度的时空变化，并对我国八大自然区的 CH_4 柱浓度的时间变化规律作了研究。从研究结果分析得到，CH_4 柱浓度的空间分布，青藏区整体较低，在我国东部地区，CH_4 柱浓度随纬度的增加而降低；整体来看，CH_4 柱浓度夏季高，冬季低，有明显的季节性变化规律。

关键词：CH_4 柱浓度；SCIAMACHY；自然区
中图分类号：P237.3　　**文献标志码**：B　　**文章编号**：1672-4623（2011）04-0115-03

SCIAMACHY（Scanning Imaging Absorption spectrometer for Atmospheric Cartography），即扫描成像吸收光谱大气制图仪，搭载在欧空局 ESA 于 2002 年 3 月 1 日发射的大型环境监测卫星 ENVISAT 上，是其十大载荷之一[1]。SCIAMACHY 的空间分辨率为 60 km × 30 km，6 天可以获得覆盖全球的观测[2]。CH_4 是仅次于 CO2 的最重要的温室气体之一，是大气中含量最丰富的有机痕量气体[3]。分析数据来源于德国不来梅大学用 WFM-DOAS 方法反演的全球 CH4 柱浓度的月平均数据（分辨率为 0.5 ° × 0.5 °），时间跨度为 3 年，即从 2003 年 1 月至 2005 年 12 月。WFM-DOAS（Weighting Function Modified Differential Optical Absorption Spectroscopy）是一种改进的 DOAS 算法，它主要通过 SCIAMACHY 传感器测量的近红外最低辐射谱来反演痕量气体的柱浓度。对原始数据插值处理，并且用 ArcGIS 对其做地理空间分析，分析我国 CH_4 柱浓度的时空分布状况。

1　插值方法选取

对全球 CH_4 柱浓度原始数据用中国地图裁剪，得到中国地区 CH_4 柱浓度数据。由于各种条件的限制，原始数据存在着大量的无数据点，因此，需要对原始数据进行插值。利用 ArcGIS 中的地统计分析工具对原始数据进行插值。拟采用普通克里金插值（Ordinary Kriging）和反距离加权（Inverse Distance Weighting）2 种方法进行插值，为了对 2 种插值方法作对比分析，选用 2005 年 9 月的数据作为验证数据，用 Creat Subsets 工具选取 15%的点作为检验点，不参与插值，利用其余的 85%的点进行插值验证，见图 1。

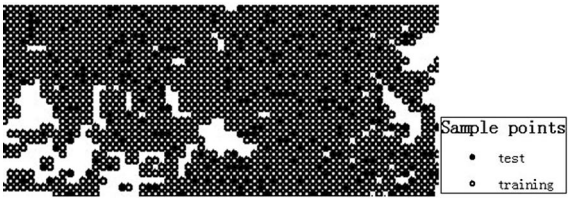

图 1　训练点和测试点的空间分布示意图

对图 1 中训练点、测试点以及所有点的统计分析结果如表 1 所示。分析知，训练点、测试点以及所有点的最小值、最大值、平均值都大致相等，而偏度和峰度也大致相等，训练点和测试点具有类似的频率分布，由此可以判断，训练点的选取是随机的。

表 1　大气 CH4 柱浓度描述性统计

	最小值	最大值	平均	标准差	偏度	峰度
Train	1562.9	1938.3	1735.2	42.52	0.076118	3.5028
Test	1563.5	1938.3	1736.4	42.405	0.21029	4.1458
Total	1562.9	1938.3	1735.3	42.499	0.09599	3.6001

以平均预测误差 MPE（Mean Prediction Error）和均方根预测误差 RMSE（Root Mean Prediction Error）作为衡量插值方法的指标，评价预测结果精度。

$$MPE = \frac{1}{m}\sum_{i=1}^{m}[Z^*(s_i) - Z(s_i)]$$
$$RMSE = \sqrt{\frac{1}{m}\sum_{i=1}^{m}[Z^*(s_i) - Z(s_i)]^2} \quad (1)$$

式中，$Z^*(si)$，$Z(si)$ 别表示在插值数据点位置 i 上 CH_4 柱浓度的实际值和预测值；m 则表示插值数据集的样点个数。通过插值并且计算可得平均预测误差及均方根预测误差见表 2。从表 2 中可以看出，普通克里金插值法相对于反距离加权插值法有较小的平均预测误差和均方根预测误差，因此，两者相较而言，普通克里金插值法插值效果要好于 IDW 插值法。

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表 2 大气 CH_4 柱浓度插值统计分析

插值方法	MPE	RMSE
普通克里金插值	12.202 63	18.220 36
反距离加权	13.352 056	19.812 71

2 2003-2005 年中国 CH_4 柱浓度分布状况

通过对 CH_4 柱浓度数据插值，并且对插值得到的 2003 年 1 月-2005 年 12 月 CH_4 柱浓度求平均，以得到 2003-2005 年间中国 CH_4 柱浓度分布图（如图 2 所示）。

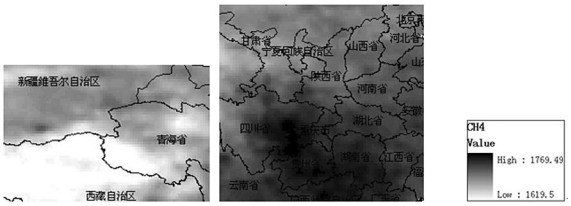


图 2 中国 2003-2005 年甲烷柱浓度平均分布示意图/ppb

图 2 表示我国西北地区、中部地区 CH_4 的平均分布图，分析可知，中国 CH_4 柱浓度空间分布：西藏地区最低，此地人为活动较少，海拔较高，CH_4 柱浓度值最低；最高值出现在四川和重庆交界的地方，而四川、重庆、贵州等省，CH_4 柱浓度较高，与此地广泛的人为活动和较大的水稻种植面积有关。

对 CH_4 柱浓度在全国范围内求平均，从而得到全国范围内 CH_4 柱浓度的平均值（见图 3）。分析可知中国 CH_4 柱浓度的变化季节性明显，一年中有 1 个最高值和 1 个最低值，呈现单峰单谷型的变化趋势。以每年的 8 月份 CH_4 柱浓度达到最高值，最低值则分别在 1 月、2 月和 12 月份的冬季。产生这种趋势的主要原因在于能源开采过程，采矿、运输、化石燃料和生物质燃烧等非生物来源占全球 CH_4 排放量的 30%，而生物来源占 70% [4]；生物源中微生物的厌氧过程与温度变化关系密切，温度越高，微生物 CH_4 排放量越高，因此CH4 柱浓度呈现夏高冬低的明显的周期性变化趋势。

为了定量地研究我国 CH_4 柱浓度的变化特征，考虑到 CH_4 柱浓度的时间变化特点，采用以下简化的正弦模型 [5] 来拟合 CH_4 柱浓度的变化:

$$y = a + bx + c\sin(2\pi x / d + e) \quad (2)$$

式中，描述了 2003 年 1 月至 2005 年 12 月 CH_4 柱浓度的线性变化趋势（其中，a 反映了 CH_4 柱浓度的总体高低水平；b 则表示我国 CH_4 柱浓度每月的变化量）；csin(2πx/d+e) 描述每年的季节性循环；x 代表 2003 年 1 月开始的月数；y 代表月平均 CH_4 柱浓度；c 代表季节性变化的振幅；d 代表变化的频率。拟合结果（见图 3）已通过 0.05 的显著性检验。

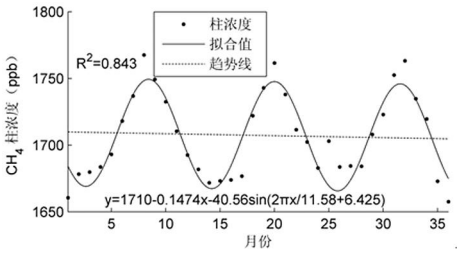


图 3 全国 CH4 柱浓度拟合结果

3 八大自然区 CH_4 柱浓度分布研究

对我国八大自然区 CH_4 柱浓度求平均，得到 2003 年-2005 年 8 个自然区 CH_4 柱浓度的年均值分布（见图 4），从 3 年平均来看，CH_4 浓度华中区＞华南区＞西南区＞华北区＞东北区＞内蒙区＞西北区＞青藏区，这与图 2 所示结果一致，这反映了在经济发达的东部地区，CH_4 柱浓度较高，而在经济不发达的青藏区、西北区、内蒙区，CH_4 柱浓度较低，西南区含量较高是因为是我国主要的水稻种植地区，而稻田 CH_4 排放是我国 CH4 的重要排放源。3 年平均值从时间上看，西南区、青藏区、以及东北区 CH_4 柱浓度有显著上升，而华南区、华中区、华北区、西北区以及内蒙区，CH_4 柱浓度有所下降。

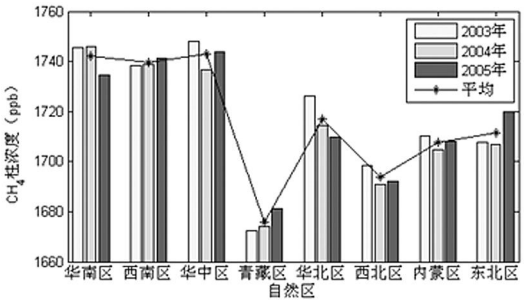
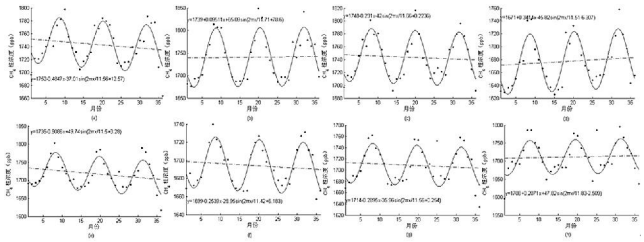


图 4 8 个自然区 CH_4 柱浓度分布的年均值

文献［6］将中国划分为 8 个自然区，为了进一步研究我国 CH_4 柱浓度的时间地域分布特征，用 Arcmap 对 36 个月的 CH_4 柱浓度在每个自然区求平均，并分析 8 个自然区 CH_4 柱浓度的时空分布的状况，采用简单正弦模型拟合八大自然区 CH_4 柱浓度的时间变化状况 [7]，结果如图 5 所示。



(a)华南区(b)西南区(c)华中区(d)青藏区
(e)华北区(f)西北区(g)内蒙区(h)东北区

图 5 八大自然区 CH_4 柱浓度正弦模型拟合结果

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对八大自然区的CH_4柱浓度正弦拟合均已通过0.05的显著性检验，从拟合精度R2来看，基本上可以反映CH_4柱浓度的分布特征，其中东北区的拟合精度不高，部分原因是由于东北地区的原始数据较少，在插值过程中产生了较大误差，而东北地区由于沼泽湿地的原因，造成春季CH_4浓度相对较高。从图中可以看出，不同自然区，CH_4柱浓度年变化的周期和振幅均不一致。从季节变动幅度上来看，西南区＞华北区＞东北区＞青藏区＞华中区＞华南区＞内蒙区＞西北区，西北区和蒙古区，动物肠道发酵是CH_4的主要排放来源，蒙古区，煤炭开采也是重要的排放源之一，因此，温度因素对CH_4柱浓度的影响不大，季节变化幅度也不大。8个自然区CH_4柱浓度拟合周期接近12个月，说明CH_4柱浓度的季节性周期变化很明显，均是冬季高夏季低，可见温度对CH_4柱浓度的影响十分显著。

4　结　语

从CH_4柱浓度平均分布状况来看，我国CH_4柱浓度最低的地区分布在我国的西藏地区，东部地区CH_4柱浓度的分布自南向北递减。基于甲烷柱浓度夏高冬低的周期性变化，利用正弦模型对2003年-2005年我国甲烷柱浓度变化状况做了拟合，结果表明：我国CH_4柱浓度夏高冬低，呈现明显的季节变化。另外，对我国的八大自然区做了拟合，从拟合结果看，能反映CH_4柱浓度的周期变化情况。由于可获得数据的有限，从而导致研究的时间跨度较短，对于引起CH_4柱浓度变化的原因，还有待深入研究。

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4　应用建议

对于长期在某一区域作业的测绘单位，建议使用直接转换法。实现计算好的转换参数可靠性高，精度稳定。在网络RTK提供的空间坐标系不发生变化的情况下，可保证长时期观测成果的前后一致性。

点校正法多用于临时性的小测区，用于测量小、任务急，大规模的控制测量工作显得没有必要。点校正法的缺点在于已知点检核时偶然误差会影响到最终成果的精度，因此在选择该方法时需权衡效率、精度、可靠性等多方面因素。

事后转换法适用于大面积测量项目，在完成控制测量并计算出转换参数的情况下，通过网络RTK可一次性测定足够多的图根控制点，通过事后转换的方法求得图根控制点的当地坐标系坐标，结合使用全站仪等设备即可开展测图工作。这种方式对大量的图根控制点的测定和计算效率极高。

5　结　语

目前国内CORS系统的建设已全面展开，网络RTK的应用也越来越广泛。作为网络RTK应用过程不可缺少的一个环节，坐标转换的方式方法、精度评定、可靠性等成为我们必须面对的一个问题，只有在实践中总结出一套可靠的转换方法并明确其精度要求才能更好的应用这项技术，提高工作效率和工程质量。

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tract hazard anomaly area of earthquake.Results showed that rapid extraction of hazard anomaly area of earthquake by remote sensing technology under multi-scale could solve the problem effectively.
Key words earthquake hazard,hazard anomaly area,change detection, multi-scale segmentation,object-oriented classification (Page:88)

Design of a Web-based Distributed Spatial Data Warehouse Architecture by DONG Xingxing

Abstract It is a key to effectively integrate,storage,management,share, analysis and utilize magnanimous spatial information for the government, public sector and geospatial information services by Internet.Combining the principle of the Distributed Spatial Data Warehouse and the physical demand of the magnanimous distributed spatial data management, this paper put forward a structure of the Distributed Spatial Data Warehouse based on the Web, then it deeply studied the application of the architecture. In network environment, this structure could provide a new way to integrate and shared mass polygenetic spatial data.
Key words Web, distributed, spatial data warehouse, architecture (Page:91)

Route Analysis and ComGIS Application in Shopping Navigation System by YANG Xue

Abstract Because of the rapid development of economy, people call for higher quality of shopping environment. So it is necessary to apply scientific methods and format to improve shopping environment and shopping efficiency. This paper presented the realization of shopping navigation system through ComGIS technology and GIS Route Management. Taking the map of Zhongguancun shopping plaza as base subject, we collected and sorted map data (shops, shopping routes etc.) and designed the Network Data Structure of the plaza based on GIS Logical Network, establishing the e-map data that were suitable to route analysis. To meet the need of intelligence navigation, we applied the classic algorithm of Dijkstra to design three types of Path Analysis Algorithm of Shopping Navigation, namely, Clear-aim, High-efficiency and Killing-time. With C# and ArcEngine9.3 development environment, our shopping navigation system has the function of information inquiring and route managing, having considerable significance to the improvement of shopping environment.
Key words shopping nevigation, network analysis, Dijkstra algorithm, ComGIS technology,sofeware development (Page:94)

Land Use Changes Analysis of Mining Area Based on GIS and RS by YAN Lili

Abstract Based on remote sensing imagery data of 1997 and 2007, using the technology method of Remote Sensing (RS) and Geography Information System (GIS) , land use change data was obtained by applying the method of supervised classification. According to land use change data, dynamical transition matrix, the amplitude of land use change, dynamical degree and state index of land use were calculated to study and analyze quantitatively land use change. Results were showed out: between 1997 and 2007 year, both farm land and grass decreased largely, the rest increased; the amplitude of garden plot was the largest, and the amplitude of forest was the second; the main transition types: grass transferred to forest and farm land, farm land transferred to forest, grass and garden, LUCC was in a state of unbalance.
Key Words Remote Sensing; Geographical Information System; Land Use and Land Cover; land use change (Page:97)

Analysis Method of the Best Benefition of Water Supply Business Based on Business Intelligence by YU Xianyu

Abstract Water supply system is the important national life infrastructure. The combination of water supply system with network createsd Water Supply Business Intelligence System. In this paper,based on the basic theory of Business Intelligence and the factual situation of water supply,the operation flow of water supply system and factors affectting water supply were deeply analyzed,the concept of water supply priority and the method of best benefit analysis of water supply enterprise were put forawrd. In the end,a visualization analysis system of best benefit of water supply enterprise developed by the aothor based on the Business Intelligence and its application were introduced. The results of application show that the method of best benefit analysis of water supply enterprise and visualization analysis system are of certain rationality and practicality.
Key words Water Supply Business Intelligence System, data warehouse, water Supply priority,best benefit analysis (Page:101)

Design and Realization of Locust Prevention and Control Auxiliary Information System by LI Jun

Abstract This paper was based on information technology and established a framework of the locust prevention and control auxiliary information system, in order to meet the practical information requirement of the locust prevention. According to the feature of the locusts and the prevention demand,the paper discussed the application of GIS technology in locust prevention and control auxiliary information system, including system architecture, division of functional modules and key technology. Furthermore, this paper designed and implemented the locust prevention and control auxiliary information system. System was able to show the information of sample points, map the locust breeding area, displayed the level of the locust breeding area, calculated and analyzed the status of locusts occurrence, created locust occurrence's map, etc. These information provided scientific proof to the decision making about the prevention of the locust and promote the informatization of the prevention.
Key Words locusts prevention, locust breeding area, the level of occurrence, spatial analysis, GIS (Page:106)

Different Control-point Designes in Cetain Areas Based on DMC Digital Aerial Photographic Images by WANG Xiaozhun

Abstract Photograph control surveying is the base work for photogrammtry. It has mature methods of operation and perfect standards and criterions for traditional photograph control surveying. So far it hasn't a corresponding standard or criterion for DMC digital aerial photographic images, in particular it's a blankness for middle and small scale map. According the peculiarities of DMC digital aerial photographic image and required precisiones of 1:10 000 scale topographical map, it summarized the control-point designe regularity in cetain areas based on instance analysis.
Key words DMC,plan and height control points,base-line,strip-line,lateral,error of mean square (Page:109)

Dynamic Analysis of Land Use and Landscape Pattern Change in Yuechi County by LI Ting

Abstract Based on the software of ERDAS IMAGINE 9.0 and ArcGIS 9.3 and remote sensing data of 1993, 2001 and 2007, the landscape changes of Yuechi County was quantitatively analyzed by using supervised classification method and landscape ecology theory. The results showed that the area of arid land, woodland, building land and water body area was increased, and the area of arid land and building land had the biggest amplification in the recent 15 years, increased 110.41 km2 and 47.99 km2, respectively. While the area of arid land and other land use tending to decrease, and the area of arid land had the biggest amplification of 180.03 km2. From 1993 to 2007, the patch density of water body area and other land use decreased, other landscape types increased. Disturbed by human activity, landscape diversity index increased firstly, and then decreased. While the landscape fragmentation index increased.
Key words landscape pattern,patch density, dominance, landscape diversity index,landscape fragmentation index (Page:111)

Comparison of Methods of Coordinate Transformation in NET-RTK Application by ZHANG Quankai

Abstract This article introduced the three methods of coordinate transformation in CORS applications ,and analyzed their advantages and disadvantages. It gave some effective proposals for CORS applications.
Key words CORS, coordinate transformation, point correction (Page:114)

Distribution of CH4 Column in China using SCIAMACHY Data by ZHANG Guojun

Abstract Based on SCIAMACHY sensor, WFM-DOAS method retrieval CH4 volume mixing ratio, the temporal and spatial variation of CH4 volume mixing ratio of China, included the eight natural region CH4 column density

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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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