Professional Master (PM) and Master of Science (MSc) courses

Earth Resources and Environmental Geosciences

September 2004

Nowadays, earth scientists are continuously challenged by the need to explore, develop and manage the sustainable use of geological resources, as well as by the need to use land responsibly for agriculture, transportation networks, industry and housing. At the same time, they are becoming increasingly involved in the monitoring and mitigation of natural hazards and environmental problems.

To deal with these issues, earth scientists require not only a broad foundation in geoscience and a thorough understanding of their specialisation but also the ability to handle large amounts of geo-information. The problems now being faced are typically multidisciplinary and call for the collection, processing, interpretation and integration of many different types of geoscience data. New opportunities for managing and publishing earth science databases arise with the advent of new information and communication technology (ICT). For many national agencies this impacts on traditional methods of, for example, geological map publication. For private enterprise this opens tremendous potential to utilise hitherto inaccessible or labour-intensive data volumes. For universities this brings academic research with applications of societal relevance within reach.

What will be achieved?

The courses ensure a thorough appreciation of modern geoscience concepts and the acquisition of expertise in the management of geo-information. Emphasis is on the use of remote sensing methods for acquiring up-to-date earth observation data, including optical, (thermal) infrared, hyperspectral, microwave and geophysical data sets, and on the application of geographical information systems (GIS) for effectively managing and analysing these multiple georeferenced data sets, including field data.

Course content and structure

Starting in 2004 the Earth Resources and Environmental Geosciences programme will offer participants greater flexibility, with options to suit their individual needs. There are two main streams, and in both streams participants have the opportunity to select modules from different specialisations:

(1) **Natural Hazards,** which concentrates on earth surface (exogenous) processes and involves highland hazards, lowland hazards and land degradation. This includes: landslides, seismic hazards, volcanic hazards, flooding, coastal hazards, soil erosion and desertification, as well as inventory and risk assessment.

(2) **Geological Resources,** which is concerned with earth subsurface (endogenous) processes and involves geological inventory, dealing mainly with resources and related environmental impacts, and includes the use of geological concepts and geochemical and geophysical tools.

The courses are composed of a series of three-week modules. There are four types of modules: core modules, programme modules, elective modules and specialisation modules.

Core modules

The core modules deal with the theory, tools and techniques of GIS and remote sensing that are common to all ITC programmes. Knowledge of the principal concepts of spatial data acquisition through remote sensing and spatial data handling with GIS is supplemented by developing the practical skills required to apply these tools. During these core modules, application-relevant practical exercises will be offered in both streams. Throughout all other modules GIS and remote sensing tools are applied regularly. This provides the opportunity to develop a full understanding of their relevance to earth resources and environmental geosciences, and the ability to extract maximum utility from their use.

Programme modules

The programme modules (also subdivided into the two streams) deal with advanced remote sensing, including image interpretation techniques for geological or geomorphological applications, and advanced GIS, including data analysis and predictive modelling, for mineral exploration respectively terrain analysis.

Elective modules

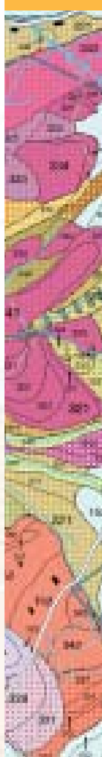
All ITC course participants may choose from a variety of elective modules offered simultaneously by all ITC's scientific departments. For the PM course, two such electives are scheduled; for the MSc course three. Examples of modules on offer include Environmental Impact Assessment, Decision Support Systems, Hyperspectral Remote Sensing, Risk Assessment, Geostatistics, Visual Basic Programming, as well as discipline-related topics.

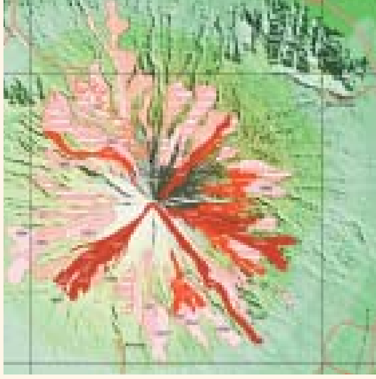
Specialisation modules

The specialisation modules offered in the two streams are as follows:

(1) Natural Hazards

- Coastal Zone Studies
- Land Degradation and Conservation
- Natural Hazard Studies





(2) Geological Resources
- Applied Geophysics
- Geological Resource Management and Environmental Geology
- Mineral Resource Exploration

Two further specialisations are also on offer:
- Geological Engineering (partly conducted in Delft and joining the first six modules of the Geological Resources stream)
- Geo-information Management (interdisciplinary specialisation and open to participants of both streams)

Aspects of the former interdisciplinary specialisation Environmental System Analysis and Management have been incorporated into Geological Resource Management and Environmental Geology, including the possibility to opt for specialisation modules of the Water Resources and Environmental Management programme.

Five modules are dedicated to specialisation-specific topics (besides the two specialisation-oriented modules for the PM individual final assignment and the nine MSc research modules). In addition, the disciplinary topics covered within the two streams form a continuous thread with the practicals and assignments of the core and programme modules at the beginning of the courses. Fieldwork and excursions constitute part of all courses, in order to apply the theoretical concepts in practice in a field project, covering 3 modules.

The main thrust of each specialisation offered is summarised below:

(1) Natural Hazards

Coastal Zone Studies

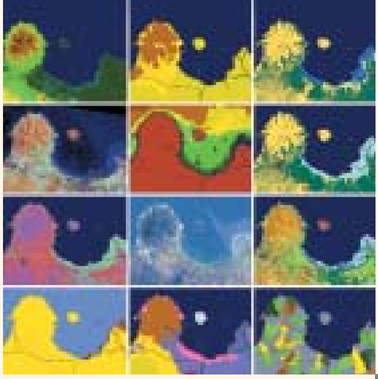
Almost 80% of the world's population lives within 100 km of the coast. Coastal zones bring together a large number of functions that have made the areas attractive for people to settle. They are the focus of intense housing, agricultural, fishery, industrial and tourist development. Nevertheless, the increasing demand for resources creates a threat to often unique and economically valuable ecosystems. The degradation of tropical coastal and marine environments includes such problems as pollution, eutrophication, shoreline erosion, flooding, saltwater intrusion, land subsidence and the degradation of coral reefs and mangrove forests. Sustainable and wise management of the coastal zone requires coordination of these different interests. Such an integrated approach to coastal zone management can only be realised with the help of up-to-date geographical information to support planning and decision making.

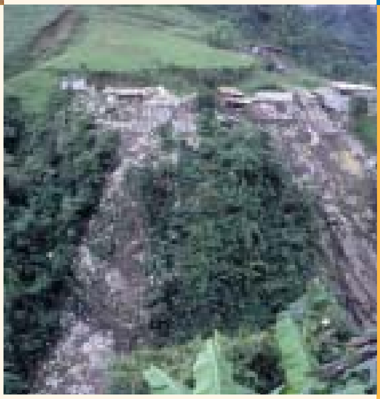
In this specialisation, participants learn how to utilise satellite and airborne capabilities in remote sensing-based methodologies for data collection, analysis and extraction of relevant parameters for an integrated assessment of the coastal environment. These are input into spatio-temporal modelling of dynamic coastal change, in a GIS environment, using other types of data sets from field observations, simulation models and online databases. The challenge is to discover how man-induced disturbances are superimposed on naturally occurring phenomena, at different time and space scales. Topics for in-depth training include the impact of global change on coastal areas and societies, such as accelerated sea-level rise and El Niño and La Niña effects, and the resulting coastal hazards that dramatically increase the number of people threatened by severe storms and annual flooding.

Land Degradation and Conservation

Land degradation is widely considered to be a major threat to global food security and environmental quality. Every year, millions of hectares of land are exposed to physical, chemical and biological degradation, of which the estimated human-induced soil degradation affects nearly a quarter of the inhabited land area, thus reducing the capability of the land to provide goods and services. The 1991 United Nations Environmental Programme estimates that crop productivity becomes uneconomic on about 20 million hectares a year solely because of soil erosion. Since land degradation is largely human-induced, it bears a strong socio-cultural component. Remedial action, including land conservation and rehabilitation, may be technically feasible but often involves high costs. Land degradation and conservation studies are usually complex, requiring the collection and integration of many different types of data, for example on climate, lithology, vegetation and soils, in order to make a sound environmental assessment. Remote sensing and GIS have proven to be indispensable tools in this process.

In this specialisation, emphasis is on the use of remote sensing for mapping relevant input data, in particular geopedologically oriented attributes in the landscape. These data are used for assessing and monitoring land degradation on a regional and semi-detailed scale. Several types of qualitative and quantitative data analysis of multidisciplinary data sets are used for modelling land degradation processes, using GIS. Participants receive in-depth training in the use and interpretation of different types of remote sensing data, the application of image processing techniques in monitoring land degradation, and the extraction of relevant parameters.





Natural Hazard Studies

The impact of natural disasters on the global environment has become increasingly severe over the last decades. The reported number of disasters has risen dramatically, as well as the number of people affected and the cost to the global economy. About 95% of the deaths occur in developing countries, while economic losses attributable to natural hazards in developing countries may represent as much as 10% of their gross national product. Disaster management consists of disaster prevention and disaster preparedness before disasters occur, and disaster relief, rehabilitation and reconstruction after they have occurred. Although natural disasters in the last decades have shown a drastic increase in magnitude and frequency, technical capabilities to mitigate them have also dramatically increased.

In this specialisation emphasis is on the use of remote sensing for mapping relevant input data. These data are used for assessing and monitoring natural hazards on a regional and semi-detailed scale. Several types of GIS analysis of multidisciplinary data sets are used for modelling a wide range of natural hazards. An important part of the course is dedicated to enhancing skills in interpreting multi-temporal and multiscale satellite images and aerial photographs for purposes of detecting and mapping those features relevant to the occurrence of natural hazards. Participants then receive more in-depth training in the use of different types of remote sensing data, the application of image processing techniques in monitoring natural hazards, and the extraction of relevant parameters. They also work with various GIS methods (heuristic, statistical and deterministic) for hazard assessment.

(2) Geological Resources

Applied Geophysics

In the context of geological reconnaissance, mineral exploration, groundwater development and environmental monitoring, geophysical surveys often provide subsurface information that is unobtainable by any other means at such low cost per unit area. The effective use of information acquired in geophysical surveys is therefore an important part of any country's geoscientific capability. Several geophysical techniques (including airborne applications) are highly appropriate for many practical situations and they form the focus of ITC's capacity in applied geophysics, with emphasis on geological reconnaissance, mineral exploration and groundwater development. Geophysicists need to acquire, process, manage and interpret their data in cooperation with specialists from other geoscience disciplines. By teaching geophysical techniques within the context of modern digital geo-information management practice, ITC offers a unique combination of disciplines designed to stimulate the application of appropriate geophysical surveys and existing databases in solving a broad range of development-oriented geoscience problems typically experienced in national survey organisations.

Geological Resource Management and Environmental Geology

This specialisation focuses on the establishment of geological databases that incorporate multiple geoscience data sets for inventorying, mapping, assessing and monitoring geological processes and resources on a regional and semi-detailed scale. This includes various remotely sensed data sets, as well as field and other ground-based observations involving spectroscopy, thermography, geophysics and geochemistry. Several types of data analysis of multidisciplinary georeferenced data sets are used for modelling a wide range of geological, structural and environmental problems, using GIS. Our goal is to maintain a balance between a traditional geological background and the development of geoscience information system management. Therefore, we aim to develop a sound understanding of the geological processes relevant to the exploration for non-renewable resources and to the sustainable development and management of these resources, as well as to the protection of the environment. In fact this specialisation provides an up-to-date curriculum in the application of remote sensing and GIS in geology, resource management and environmental geology (with particular reference to mine waste pollution).

The undesired outcomes of many human activities, such as mine waste pollution and land degradation, as well as other natural and man-induced hazards, interfere with the earth and have repercussions on the environment. The detrimental effects are not limited to the geological environment but extend into the biological and hydrological realms. Moreover, natural hazards and global environmental change are increasingly extending their damaging effects. Fundamental understanding of the consequences of these changes is paramount. Recent advances in the fields of environmental science, environmental monitoring and earth observation have had a huge impact on available methods and techniques. New sensors, satellites and other measuring devices have led to better insight into the system Earth.

Mineral Resource Exploration

Sustainable development of a country's mineral resources is generally seen as a key factor in economic growth. First, however, mineral resources need to be discovered. The more promising discoveries require detailed investigation if their economic potential is to be realised. The search for mineral resources relies on conceptual models and modern technolo-

gies. Selection of suitable search areas is based on a thorough knowledge of the concepts of ore genesis and the geological terrains likely to host particular types of mineral deposits. Exploration data on a prospective area are acquired from satellite and airborne sensors, geochemical and heavy mineral surveys, geological mapping, and geophysical surveys. Using computer-based geographical information database and modelling systems, these data, captured in or converted to digital format, are brought together for integration and analysis in order to identify likely mineral resource targets. In addition, it is also important to understand the workings of local and global markets for mineral commodities, and the social and environmental consequences of mineral development.

In this specialisation the emphasis is on recognition of the key features of metalliferous and industrial mineral deposits in the context of their discovery, economic viability and environmental impact. Participants learn to extract exploration criteria from aerial photographs, satellite images and geophysical survey data and to carry out geochemical mineral prospecting surveys. At the end of the course, participants should be able to competently use GIS modelling, statistical analysis and forward processing to handle exploration geodata and present the interpretation results for decision making.

Separate specialisation *Geological Engineering*

Participants that opt for the Geological Engineering specialisation, after having followed the first six (core and programme) modules of the Geological Resources stream at ITC in Enschede, will continue with their specialisation at ITC in Delft, in cooperation with the Technical University Delft.

The ever-increasing world population, and especially the rapid growth of urbanised areas in developing countries, demands the sustainable use of “ground” for competing land activities (e.g. construction of housing and industry, road and rail infrastructure, waste disposal, extraction of construction materials). For a proper appraisal of the geological engineering situation at and below terrain surface, a three-dimensional geological model is necessary, with an accurate description of the spatial variation in geotechnical conditions. This model can be used to study the consequences of a number of engineering alternatives.

This specialisation offers training and research possibilities, in the field of geo-information technology, to use remote sensing and GIS techniques and methods of spatial and temporal (four-dimensional) modelling for geological engineering and geotechnical applications. Participants are trained in all aspects of the application and development of modern information technology in relation to geological engineering, so that they will be able to take part in or lead site investigations, applying and managing modern information technology tools for obtaining and integrating geological and geotechnical data, and will be able to characterise and ascertain the properties and parameters of the subsurface, such that optimum and cost-effective use in geological engineering is ensured. Data analysis is an essential part of this, and whether data are derived from aerial photographs, satellite images, geophysical surveys or other sources, dealing with the accuracy and uncertainty of geotechnical data, and modelling the variability of the geotechnical properties of the subsurface are of key importance for the modern-day engineering geologist. For this, tools such as two-, three- and four-dimensional GIS will be used.

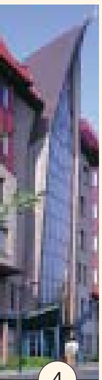
Inter-specialisation Geo-information Management

Participants may elect to follow the Geo-information Management interdisciplinary specialisation spanning modules 9 to 12.

Participants should have an interest in working with geo-data and geo-information technology to improve the quality and performance of organisational processes. These processes can range from data capture, via planning and analysis, to monitoring and decision support information provision.

Participants will study:

- the geo-information flow within an organisation,
- implementation of GIS capacity within an organisation (including third party support)
- information system development and appropriate ways of introducing geo-ICT into the organisation (including aspects of technical, financial and human resource development).



For more information:
http://www.itc.nl
ITC - Education Affairs
P.O. Box 6, 7500 AA Enschede
The Netherlands
Phone: +31 (0)53 487 44 44
Fax: +31 (0)53 487 42 38
E-mail: education@itc.nl

ITC

INTERNATIONAL INSTITUTE FOR GEO-INFORMATION SCIENCE AND EARTH OBSERVATION