Our world is facing the effects of global change and the ongoing growth of its population. Globalization continues to transform our world into an increasingly interdependent system, linking developed and developing countries more than ever before. Developments are increasingly dominated by the interference of global and local transitions. There is consequently an urgent need for spatially and temporally explicit contributions and solutions for adapting to our changing world. This is why research at ITC focuses on ‘Space for Global Development’. Current global challenges all relate to sustainable development. Local development problems are often attributed to causes such as climate and global change, while in reality they are caused by a multitude of local and regional interactions within the complex coupled human-environmental system. Working under the slogan ‘Space for global development’, ITC aims to serve society by providing and developing relevant spatial information technologies. Research mainly focuses on the methodological developments that address the sustainable use of land, water, natural resources and energy, while simultaneously increasing rural/agricultural and industrial production for our growing and wealthier population. Population growth in a globalizing world has led to increased vulnerability in rural and urban areas, where disasters and other crises have become more frequent. Vulnerability often increases when complex interactions between human and environmental systems are neglected. Too often disasters and local problems are attributed to causes such as climate change, while in reality they are caused by specific local and regional interactions within the complex coupled human-environmental system (GLP, 2005). Multi-disciplinary approaches are common at ITC, where the challenge of sustainable development is addressed from different perspectives. Research is characterized by the geo-information data loop and the thematic data loop. The geo-information data loop is focused on data acquisition, spatial statistics, inventory to data processing, spatial data quality and modelling towards data dissemination and visualization. The thematic data loop focuses on the knowledge domains in which human needs and demands are linked to processes, and system knowledge in thematic integrated mathematical models. The domains in earth sciences at ITC include Agriculture, Environment, Hydrology, Geology and Ecology.

An essential component of research at ITC is that it is driven by real demands from stakeholders and other representatives from developing/developed society. The programme outcomes are applicable or usable for the economic sector and policy development, ranging from the raising of awareness to implementation and evaluation. These links to the economic sector and governance join the human dimensions of global development, and will be facilitated by collaborating departments at ITC.

Prof. Dr. Ir. Alfred Stein
TWENTE GRADUATE SCHOOL

TWENTE GRADUATE SCHOOL COORDINATES HIGH-QUALITY EDUCATIONAL PROGRAMMES BASED ON TOPICS CLOSELY RELATED TO THE WORK OF THE UNIVERSITY’S RESEARCH INSTITUTES, TAUGHT AND SUPERVISED BY EXPERT RESEARCHERS. WE OFFER STRUCTURED PHD PROGRAMMES FOR OUTSTANDING GRADUATE STUDENTS WHO ARE KEEN TO PURSUE A CAREER IN SCIENTIFIC RESEARCH.

Besides the PhD research project leading to a dissertation, a broad variety of discipline related, academic skills and career development courses enable students to specialize in the research area they are interested in while broadening their perspective on the societal context of technology and research.

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

One of humankind’s greatest challenges is to achieve an appropriate balance between developing natural resources and maintaining an optimal natural environment. To meet this challenge, we need detailed and reliable geo-information and geo-information management tools.

At the Faculty of Geo-Information Science and Earth Observation (ITC), knowledge of geo-information management is readily available and is continually being developed and extended. By means of education, research and project services, we contribute to capacity building in developing countries and emerging economies. In doing so, considerable attention is paid to the development and application of satellite-based earth observations and geographical information systems (GIS) for solving problems. Such problems can range from determining the risks of landslides, mapping forest fires, planning urban infrastructure and implementing land administration systems to monitoring food production, forecasting droughts and floods, designing a good wildlife management system and detecting environmental pollution.

The key words characterizing our activities are remote sensing observation, geo-information management, worldwide and innovative. We concentrate on earth observation, the generation of spatial information and the development of data integration methods. Furthermore, we provide tools that can support the processes of planning and decision-making for sustainable development and the alleviation of poverty in developing countries and emerging economies.

ITC has six research themes:
1. 4D Earth
2. Acquisition and quality of geo-spatial information (ACQUAL)
3. Forest agriculture and environment in the spatial sciences (FORAGES)
4. People, land and urban systems (PLUS)
5. Spatio-temporal analytics, maps and processing (STAMP)
6. Water Cycle and Climate (WCC)

MANPOWER

ABOUT 140 PhD RESEARCHERS AND 30 SCIENTIFIC STAFF

INTERNATIONAL EMPLOYEES

> 75%

TURNOVER

€10 MILLION FOR RESEARCH

EXAMPLES OF COLLABORATIONS

4D-EARTH consists of two main research themes: Geothermal Energy and Earth Resources (chaired by Van der Meer), and Natural Hazards and Disaster Risk Management (chaired by Jetten). Integrative themes are i) climate research: the impact of the rapidly growing world population manifests itself in an increasing demand on scarce earth resources and energy, leading to climate change and an increase in the frequency and impact of natural disasters, and ii) ‘geodynamics’: research into the earth’s crust and mantle provides insights into the geothermal pathways on the one hand and the dynamics of earthquakes and related damage on the other. Over the years we have reached a high level of expertise in understanding geothermal systems and related alteration geochemistry and in combining spatial predictive modelling of hydro-meteorological hazards and the variability of societal vulnerability in space and time. At the heart of this research are earth observation methods, from object-oriented (OOA) to multi- and hyperspectral analysis, used to gain a better understanding of the spatial and temporal links and dynamics between driving forces and their impacts. The two themes also integrate in terms of methodology: an example is the use of hyperspectral information to determine soil properties, providing valuable information for spatial modelling of land degradation. In line with the mission of the ITC, we specifically aim to make our research useful for society: 4D-EARTH has a strong track record in research and capacity development projects in Europe, East Africa and Central and Southeast Asia, working with research institutes, industry and institutes that work in the field of disaster risk reduction.

PROGRAMME LEADER:
PROF. DR. IR. FREEK VAN DER MEER
PROF. DR. VICTOR JETTEN

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RELATED UT MASTER’S PROGRAMMES:
- NATURAL HAZARDS AND DISASTER RISK MANAGEMENT
- GEOLOGICAL REMOTE SENSING

Use earth sciences to contribute to a sustainable use of energy and earth resources and reduce the impact of natural hazards on society.
The use of global resources for food and biomass is exerting critical pressure on the environment, as well as stretching the ability of humankind to feed itself. Monitoring vegetation through Earth Observation (EO) and geo-information allows us to understand and manage this pressure. A scientific understanding of the health, vigour and diversity of vegetation through Earth Observation allows managers to plan food security, preserve biodiversity and generate energy biomass. The NRS group at ITC University of Twente focuses on developing scientific and engineering solutions in combination with cutting-edge, remotely sensed data from satellite, aircraft and ground sensor systems for understanding and monitoring vegetation in order to gain insights into and manage renewable natural resources. NRS has a vibrant MSc community studying for the Natural Resource Management or the Erasmus Mundus GEM (Geo-information for Environmental Management) MSc, taught in cooperation with the Universities of Southampton, Lund, Iceland and Poland. All MSc and PhD programme alumni are either working in high-level positions in research, business and government, or have started their own successful companies. In addition to cooperation within ITC and the University of Twente, NRS researchers and students are active within international networks and carry out research activities in Africa, China, Europe and Australia. NRS is well known for its high productivity and the quality of its research output, especially at PhD level. With an emphasis on a global approach to food security and biodiversity and on developing state-of-the-art Earth Observation and GIS approaches, NRS provides relevant and timely information for effective natural resource management.
PEOPLE, LAND AND URBAN SYSTEMS (PLUS)

Twente Graduate School’s ‘People, Land and Urban Systems’ group sits at the nexus of Geo-Information, Land Management and Urban Development. We use a socio-technical approach to deliver on the global development agenda. The context of PLUS is the Anthropocene: an urban age where the global challenges of rapid and massive scale urbanization and migration coincides with climate change and major conflict situations, relating to land, food security, water, infrastructure, and other resources. In the setting of changing environmental conditions PLUS is primarily concerned with the future of urban regions and their citizens. We address local challenges associated with global forces. In line with the broader research agenda of ITC, a spatial-temporal and pro-poor focus is adopted. Consequently, the PLUS research objectives are to develop, apply, and evaluate 1) Integrated concepts of land administration, urban development and social equity; and 2) Spatial methods and tools for sustainable development and resiliency in urbanizing regions.


UNDERSTANDING THE INTERACTIONS IN SPACE AND TIME BETWEEN PEOPLE, LAND AND URBAN SYSTEMS IS THE KEY TO A SUSTAINABLE FUTURE

PROGRAMME LEADERS:
PROF. DR. JAAP ZEVENBERGEN
PROF. DR. YOLA GEORGIADOU
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RELATED UT MASTER’S PROGRAMMES:
URBAN PLANNING AND MANAGEMENT, LAND ADMINISTRATION
The research programme of the Department of Earth Observation Science focuses on the acquisition and quality analysis of geo-spatial information. Developments in sensor and web technology have led to the unprecedented availability of geo-spatial data from a wide range of sensors. Big geo-spatial data are thus becoming available almost instantly, whereas the automatic conversion of the data into useful information remains a challenge. Users of geo-information require high-speed image analysis in order to quasi-continuously monitor global and local geo-spatial processes.

Our research is conducted in three overlapping fields, focusing on 3D geometric modelling, process modelling and semantics. The range of analyzed sensor data varies from time series of multispectral satellite imagery over large-scale aerial photographs and laser scans to very high-resolution imagery and point clouds recorded from terrestrial platforms (cars/trains) and low-flying UAVs.

The aim of our research is to develop new methods for the acquisition and quality analysis of geo-spatial information. This involves spatial statistics and uncertain reasoning, as well as 3D modelling. In this way, the collected information can offer improved support for decision-making in applications such as disaster management, air quality, soils, agronomy, the environment, urban planning, land registers, water management and health studies. Participating in both national and international projects, we closely cooperate with stakeholders in order to pursue this aim and transfer developed methods to practice.

Our PhD students are enrolled in the research school for Socio-Economic and Natural Sciences of the Environment (SENSE). They can also take courses from other research schools, such as the Advanced School for Computing and Imaging (ASCI).
SPATIO-TEMPORAL ANALYTICS, MAPS AND PROCESSING (STAMP)

Organizations, as well as the general public, are in constant need of information about their changing environment in space and time. There is a huge demand for up-to-date or (near) real-time information about virtually anything, anywhere, and anytime. Moreover, this information needs to be delivered in meaningful, appealing, compelling ways that are clear and useful for decision-making purposes.

In part, this demand is driven by the internet/sensor/mobile revolution that is equipping professionals and laypersons alike with tools to acquire spatial data 24/7. We are seeing the emergence of a data landscape with all levels of detail, accuracy, structure, semantics and associated understanding and trust. Highly heterogeneous and ‘big’ data sources are becoming the norm, which means that the classical linear acquire-prepare-store-analyze-visualize workflow for information production will need to be replaced by cyclic and iterative and sometimes even ad-hoc approaches that include learning, adaptation, optimization and systems thinking.

Our mission is to provide optimal support for the provision of modern and fit-for-purpose information/geo-information products and services that address the needs of many different user contexts.

The objective of the programme is to develop methods and techniques that process (collect, organize, model, analyze and visualize) spatio-temporal data in order to create valuable and accessible geo-information products and services that improve our understanding of complex and dynamic systems and help in decision-making on a variety of spatial and temporal scales.
The question whether life is possible on Mars is always linked to the question about whether there is, or has ever been, water on that planet. Our planet Earth is fortunate enough to have plenty of water, but the situation on Mars directly illustrates the importance of water, and that the sustainable use of water resources is crucial for the survival and well-functioning of the whole terrestrial biosphere. Because of the dynamic character of the global water cycle, information about the geographical distribution of water in all of its states (vapour, liquid and solid) must be collected in order to produce inventories of available water resources for various purposes and to make predictions about the availability of water in the future through the use of simulation models. Water is also of fundamental importance for climate change, since the climate has an enormous impact on water resources and, in turn, water abundance is one of the main aspects of climate. Earth observation techniques using a variety of optical, thermal and radar sensors operated from satellites, aircraft and, more recently, also drones, as well as measurements in the field, are indispensable tools for the collection of information about water. In the Water Resources Department, we investigate how these techniques can best be employed for monitoring the streams of water in river basins and for identifying water scarcity problems at an early stage, before damage (in the form of drought stress in the vegetation or an increased risk of flooding) can develop past the point of no return. The department has representatives at several international sites (e.g. the Tibetan Plateau, Kenya, Spain, the Netherlands) working on developing methods for optimizing the use of earth observation data for the accurate monitoring of the amounts and quality of water, and for integrating these data with process models of the water flow, by looking at precipitation, evapotranspiration, runoff and groundwater storage. This can provide information to water managers that will enable them to take well-justified decisions about the use and control of water resources in a sustainable manner.

PHD COURSES
An individualized training plan will be developed for all PhD candidates at ITC. Besides the courses offered by TGS, courses to be attended are available at the Research School for Socio Economic and Natural Sciences of the Environment (SENSE) and the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PEGRC).
There were two things that first attracted me to the University of Twente - Faculty ITC: a solid international reputation and its mission to share knowledge around the world. So when I saw an open PhD position in Spring 2014, I applied immediately. Now I’m actually here, both of my expectations have been fulfilled. I have the opportunity to work with some of the best researchers in the field. The international aspect has also been an eye-opener. I liked to think I had seen some of the world, and here I meet people from so many countries that I realize I really have little idea about what is out there. It is a great place to get to know different cultures and ideas.

The topic of my PhD research is the use of Unmanned Aerial Vehicles (UAVs), commonly known as drones, for informal settlement mapping. UAVs have recently become the rage among hobbyists who see it as a fun toy to take selfies, but they can also be an important tool for spatial data collection. Managing informal settlements is a great challenge, especially because it’s really difficult to understand what’s going on in the slum if you only have access to outdated maps or low-resolution satellite imagery. The motivation of my research is to analyze how a low-cost UAV system could be used to provide city planners with the information they need to plan effective upgrading interventions.

The project is a collaboration between the Earth Observation Science (EOS) department, which focuses on developing methods to automatically extract information from raw data, and the Urban and Regional Planning and Geo-Information Management (PGM) department, which has a lot of expertise on slum upgrading projects. So on the one hand my research has a strong social component, to identify what type of spatial information is needed for slum upgrading projects, and how such spatial information could be used to improve communication between stakeholders and empower the local communities. On the other hand, there is the scientific aspect. Many photogrammetric methods have been developed to process point clouds in order to, for example, automatically identify buildings or provide accurate digital surface models for water management. However, most of these methods have been designed using study areas in developed countries. I recently had the opportunity to perform field work in Kigali, Rwanda, where I gained a first-hand impression of the issues of slum upgrading projects and flew a UAV over three slums to collect images. Now I have a lot of data, and my task is to adapt the current information extraction methods so they perform well in slums areas.

Twente Graduate School supports PhD students in developing the skills they need to conduct their research. At the beginning, you make a plan to obtain 30 education credits made up of both in-depth skills related to your research and broadening skills, which help you learn things like how to present at scientific conferences and publish academic articles. As I’m still in my first year, I have only participated in the introductory TGS course that gives PhD students an overview of what to expect during their four years in Enschede. Outside of work, the University of Twente also offers a large number of sports and culture activities. The ITC student organization (SAB) and UT PhD student organization (P-NUT) also organize many social activities.
ADMISSION REQUIREMENTS AND ENROLMENT

THERE ARE TWO WAYS TO ENROL INTO A TGS PROGRAMME. YOU CAN START A PHD PROGRAMME IF YOU HAVE ALREADY COMPLETED A MASTER’S PROGRAMME AT THE UNIVERSITY OF TWENTE OR ELSEWHERE, OR YOU CAN START A MASTER OF SCIENCE DEGREE PROGRAMME AT THE UNIVERSITY OF TWENTE AND PREQUALIFY YOURSELF FOR A TGS PROGRAMME.

ARE YOU CURRENTLY A MASTER’S STUDENT?

- **MSc**
  - You have already obtained your Master's degree
- **PhD**
  - PhD research
  - Deepening, broadening, academic skills and career development courses, 30 credits

**OWN FUNDING**
You may enter a Twente Graduate School programme as PhD candidate with your own funding or with an international scholarship. In that case, research projects are initiated on the basis of proposals submitted by graduate students as part of their application procedure. A professor in a relevant field has to commit himself to the candidate and the proposed line of research. Before a proposed research plan is taken into consideration, it must be clear that the candidate plans to submit an application for a secured funding scholarship. All details on the procedure to apply for a PhD position at ITC are shown on the ITC research website. Please note that the University of Twente is not in a position to offer fellowships or similar funding for PhD candidates, other than the vacancies mentioned above. For information about the documents required for the application see: www.utwente.nl/tgs.

ARE YOU CURRENTLY A BACHELOR’S STUDENT?

- **BSc**
  - You have already obtained your Bachelor’s degree
- **MSc**
  - MSc programme with discipline related courses, 120 credits
  - Opportunity to start an integrated MSc/PhD programme in the second year
- **PhD**
  - PhD research
  - Deepening, broadening, academic skills and career development courses, 30 credits

**OWN FUNDING**
You may enter a Twente Graduate School programme as PhD candidate with your own funding or with an international scholarship. In that case, research projects are initiated on the basis of proposals submitted by graduate students as part of their application procedure. A professor in a relevant field has to commit himself to the candidate and the proposed line of research. Before a proposed research plan is taken into consideration, it must be clear that the candidate plans to submit an application for a secured funding scholarship. All details on the procedure to apply for a PhD position at ITC are shown on the ITC research website. Please note that the University of Twente is not in a position to offer fellowships or similar funding for PhD candidates, other than the vacancies mentioned above. For information about the documents required for the application see: www.utwente.nl/tgs.

**TGS AWARD AND BRIDGING FUND**
The TGS Award is open for six selected candidates in the last phase of their UT Master’s. They should have demonstrable research skills and above-average results. Up to six months of funding to bridge the period between graduation and full PhD funding is available for all candidates. The winner additionally receives a check of EUR 2,500 to be spend on doctoral training. Qualifying students can be nominated by a UT supervisor.

**ADDITIONAL INFORMATION**
If you would like more information about Twente Graduate School, please go to the TGS website www.utwente.nl/tgs.

After successfully attaining a Master’s degree, you may enter a Twente Graduate School programme in the PhD phase. PhD candidates may either apply for a PhD position available within one of the research groups or obtain their own funding.

**VACANCIES**
Many PhD candidates in the Netherlands are working directly for the university. Research projects are defined by the Head of the research group, who recruits the graduate students to carry out the research. If a PhD position is offered in a research field of your choice, you are invited to apply for the vacancy. Vacancies for PhD positions at the University of Twente, including those connected to Twente Graduate School, are published on the vacancies website www.utwente.nl/vacancies.

**RESEARCH HONOURS**
This excellence programme will be tailored to your needs and offers the deepening of theoretical and practical knowledge. You will acquire more knowledge by means of extracurricular courses, training courses and meetings. The programme is an addition to your Master’s programme.

* Some of our Master’s programmes are one-year programmes (77 credits).