



2009-2012 report

→ THE TIGER INITIATIVE

Looking for water in Africa



TIGER
AFRICA

GEN113B

TIGER INITIATIVE



Honourable Buyelwa Sonjica MP,
Former Minister of Water Affairs and Forestry
of the Republic of South Africa

“we should always remember that in developing nations, water limitations present some of the most important contributing factors to poverty and human misery. Food security, wellbeing, and ultimately economic and political stability depend upon the availability of reliable supplies of clean water. Initiatives such as TIGER, which will deliver enhanced and timely information for water resource management, are therefore of critical importance to developing nations.”

Recognizing the utility of satellite data for Integrated Water Resources Management (IWRM) and responding to the urgent need for action in Africa stressed by the Johannesburg World Summit on Sustainable Development (WSSD), the European Space Agency (ESA) launched the **TIGER initiative** in 2002, within the context of the Committee of Earth Observation Satellites (CEOS).

The overall objective of the initiative is to **assist African countries to overcome problems faced in the collection, analysis and use of water related geo-information by exploiting the advantages of Earth Observation (EO) technology.**

The TIGER initiative follows four major action lines to realize its objective:

- ◆ Facilitating Access to EO data
- ◆ Capacity Building & Training
- ◆ Knowledge and Information Network
- ◆ Development of EO Information Services

Over its 10 years of existence the TIGER initiative has established and supported capacity building activities and development projects **involving some 42 African countries**, with a total budget of **more than 11 Mio euro** and **reaching more than 150 African water authorities and research institutes** (see more details on p. 6-7).

The TIGER Partnership

The TIGER initiative is a demand driven process, where the main focus is on the needs and requirements, in terms of water related information, of water authorities and other stakeholders involved in IWRM in Africa (i.e., Ministries of water and river basin authorities, African technical centres and universities).

TIGER is an international endeavour that has been endorsed by the African Ministerial Council on Water (AMCOW), contributes to the strategy of the Group on Earth Observations (GEO) and involves the contributions of UNESCO (the UN Educational, Scientific and Cultural Organization) as well as the Canadian Space Agency (CSA).

A Steering Committee was created in 2005 to provide strategic direction and advice concerning the evolution and implementation of the TIGER initiative. The TIGER Steering Committee (TSC) includes representatives from AMCOW, African Union Commission, African Water Facility, Department of Water Affairs and Forestry of the Republic of

South Africa, CSA, ESA, Ramsar Secretariat, UNESCO-IHP and the UN Economic Commission for Africa.

Progress of TIGER

In 2002-2004 the founding members of the TIGER initiative, include ESA, UNESCO (IHP), CSA and CSIR (South Africa), started a consultation process in collaboration with African water authorities, technical centres and other stakeholders in both the water and the EO sectors in Africa. Four workshops helped to collect and define the institutional, technical, economic and social needs of the water sector in Africa, which helped to develop the TIGER strategy.

The first implementation period 2005-2007 benefited by the endorsement of the African Ministerial Council on Water (AMCOW) and attracted further new key partners such as the African Development Bank and the Economic Commission for Africa (UN-ECA). The first TIGER period involved some 150 African institutions (water authorities, universities, technical centers) through projects and training activities.

As a response to a clear recommendation of the First African Water Week in 2008, a second period of the TIGER initiative was launched aiming at supporting African countries to enhance their scientific and technical capacities to better understand, monitor and manage water resources. Recent efforts are focused on preparing African institutions to fully exploit the increasing operational observation capacity offered by satellites such the upcoming Sentinel missions.

“International initiatives like TIGER which provide useful tools to the countries to strengthen their capacities for ensuring water security should be encouraged and supported”

Recommendation at the First African Water week organized in Tunis on 25-29 March 2008

TIGER IMPLEMENTATION

A long-term strategy has been put in place pursuing three main categories of results:

Support improved governance and decision-making

Contribute to development and implementation of sustainable information services and systems to improve IWRM (at regional, national and local scales) by using space-based technology to overcome the water information gap in African countries.

Contribute to enhance institutional, human and technical capacity

Support the consolidation of a critical mass of technical centres, water authorities and universities in Africa with the skills and capabilities to derive, disseminate and use space-based water relevant information for IWRM.

Foster sustainability

Development of a strategy for strengthening and sustaining EO-supported IWRM information and decision-support systems in the long term.

TIGER builds upon existing capacities, initiatives and programmes in order to exploit synergies maximising results and avoiding duplications. The development and implementation of the TIGER initiative is carried out primarily by a number of contributors such as ESA, CSA, UNESCO-IHP and the African Water Facility. In addition, many other institutions support and collaborate in TIGER (e.g., AMCOW, AUC, ITC, Ramsar Secretariat, DWA of South Africa, UN-ECA, CRTS, AGRHYMET, OSS, RCMRD). Resources are mobilised on a best effort basis, and programmatic activities are coordinated towards the achievement of the TIGER objectives.

Action lines

The TIGER initiative is being implemented through four main Action Lines supported by a crosscutting coordination activity.

Facilitating access to EO data and EO-derived information

Poor access to EO data and EO-derived products is a critical issue for African organisations. In this context, the action line is dedicated to develop long-term mechanisms to overcome these problems. One element of this action line is the installation of the ESA Data Dissemination System (DDS) at African institutions to receive EO data broadcasted over communication satellites.

Capacity Building & Training

This action line involves training and capacity building actions dedicated to support African partners (water authorities, technical centres, universities) to advance towards independent capacity to exploit EO technology for improving knowledge on water resources and climate change. The action supports the consolidation of a critical mass of technical centres in Africa with the skills and capabilities to derive and disseminate space-based water relevant information for scientific research and management at regional, national and local scales.

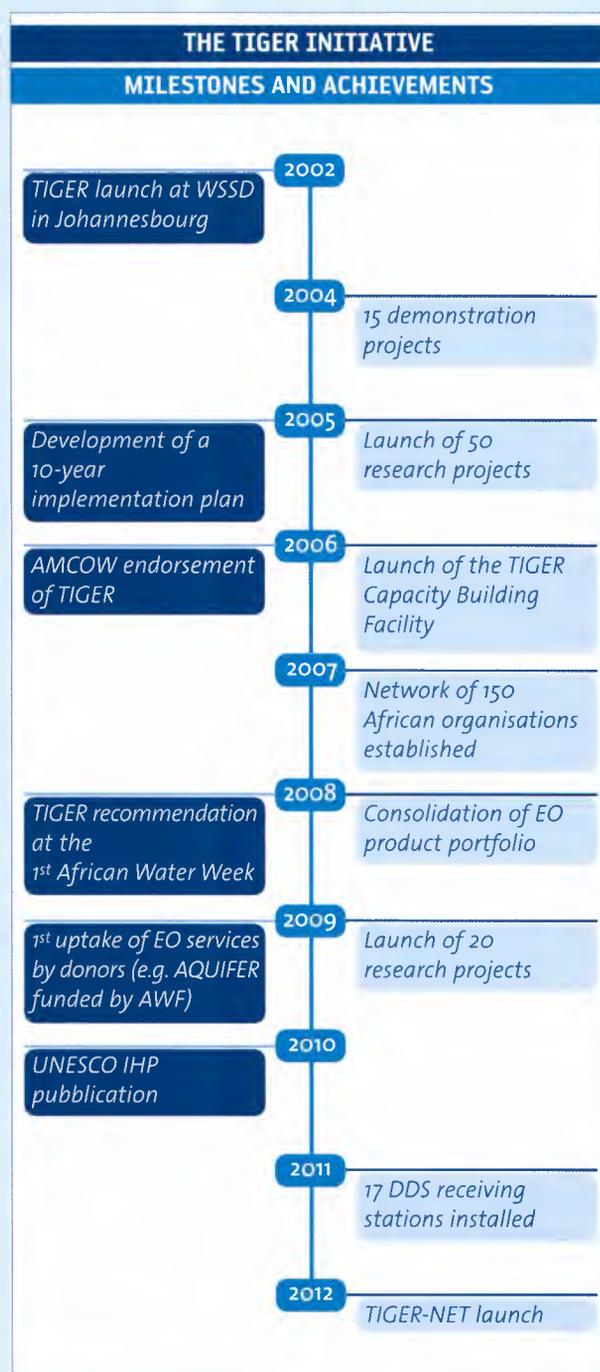
Information and Knowledge Network

So far, more than 150 organisations were involved in TIGER. In order to extract the maximum benefit from the TIGER

activities, efficient networking mechanisms are set up in order to stimulate knowledge, information and data sharing, identify and promote best practice and facilitate coordination among the different partners.

Development of EO-based information services for IWRM

This action line represents the core of the TIGER initiative. Through this action, and on the basis of the specific information needs and requirements of the users community (i.e. African water authorities) EO-based information and services are developed, demonstrated, validated and transferred to relevant African institutions for operations. The implementation of this Action Line involves a complex and long-term process, supporting the transitions of information services and systems from a research stage towards operations.



ACHIEVEMENTS: 10 YEARS OF TIGER

Over the first 10 years of Tiger, several achievements were reached:

Facilitating access to EO data and EO-derived information

The initiative is supporting African partners with free access to spaceborne data and products. Some 4000 MERIS/AATSR, 7000 (A)SAR and 600 high resolution optical products (SPOT, KOMPSAT-2, AVNIR, PRISM...) gathered in the framework of ESA and ESA Third Party Missions have been distributed by ESA.

RadarSat and Landsat data have been distributed by partner organizations. To facilitate data reception, some 17 DDS (Data Dissemination System) stations have been or are in the process of being installed at the premises of organisations involved in TIGER: data are effectively and rapidly disseminated to the users through this channel.

Capacity Building & Training

Training and capacity building actions have been enforced to support African partners to advance towards an independent capacity to make operational use of EO technology for improving IWRM. To date, some 19 training sessions have been organised focused on both the needs of the dif-

ferent research projects and the requirements of the water authorities and end users involved in TIGER projects.

Almost 200 individuals from 26 different African countries have been involved in actions performed by the TIGER Capacity Building Facility (TCBF), lead by the International Institute for Geo-Information Science and Earth Observation, ITC (www.itc.nl).

This facility involves advanced training, hands-on learning and mentoring and has been entirely funded by ESA to a level of more than 1m Euros. To reinforce the capacity building actions, training and education tools have been produced and distributed by ESA to all the TIGER research teams. In particular, a TIGER Training Kit was compiled and made freely available on the TIGER website (www.tiger.esa.int/training.asp)

to provide African partners with a common baseline in terms of knowledge and understanding of the use of EO technology in support to water-related issues.



THE TIGER DEVELOPMENT MODEL

The use of EO techniques in Africa is still far from being considered operational and the transition from research and demonstration projects to a full operational level is still a challenge for the future. In this context, TIGER has put in place a development model aimed at bridging that technological gap following a three-stage approach:

1. Research Stage:

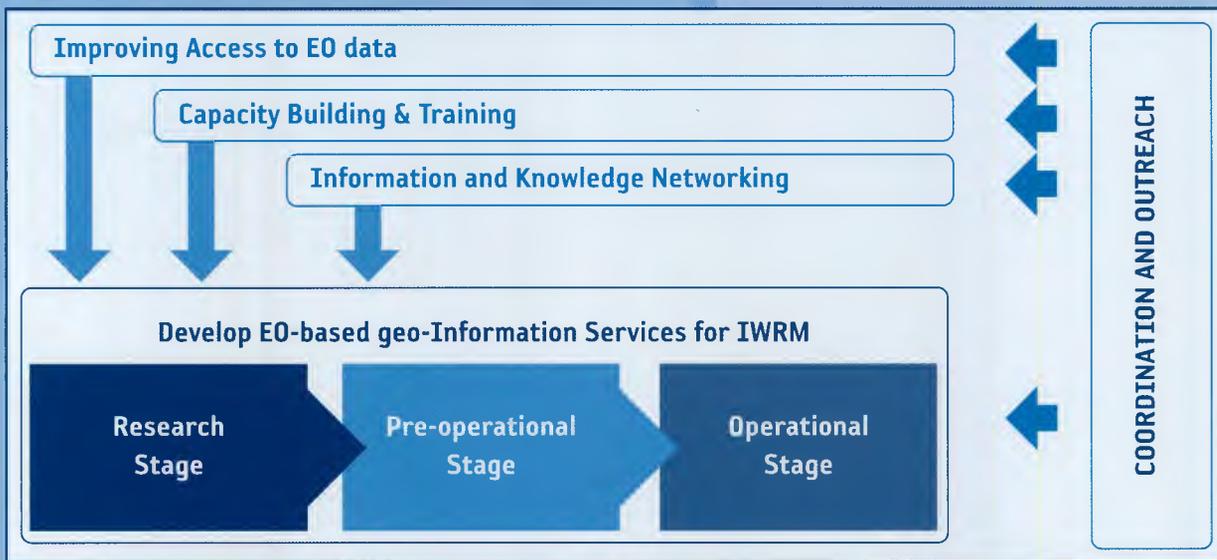
Aimed at supporting universities and technical centres in Africa to develop the knowledge and capacity for deriving geo-spatial information on water resources relevant for water authorities. The research teams are supported with dedicated training and capacity building actions as well as with facilitated access to EO data and tools. The objective of this component is twofold: 1) on the one hand, to improve knowledge on local and regional water resources in Africa; 2) on the other hand, to enhance human, technical and institutional capacity to derive, disseminate and use water-relevant information by exploiting the advantages of EO technology.

2. Pre-operational stage:

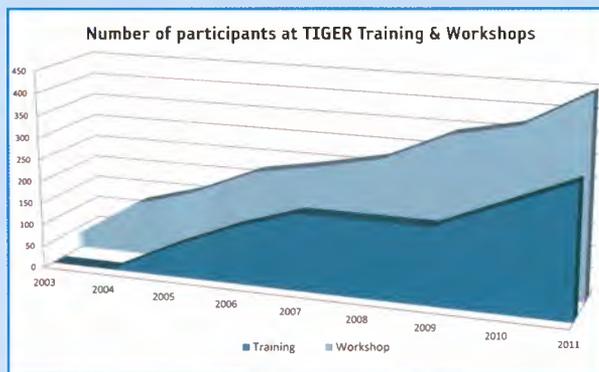
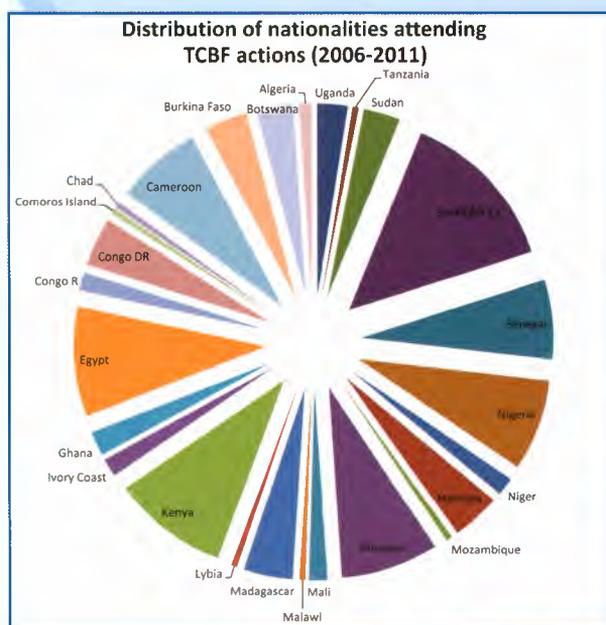
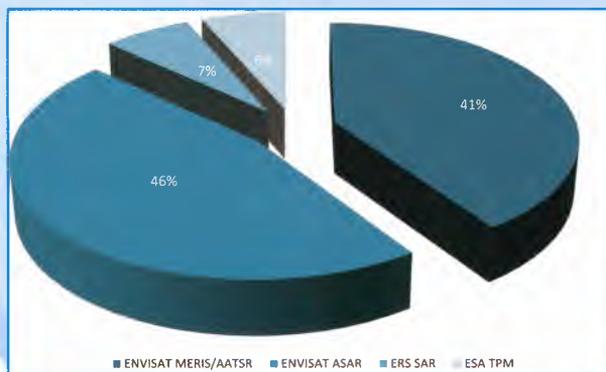
Aimed at developing and demonstrating tailored EO-based information services and systems to support African water authorities in collecting water-relevant information on a regular basis. Project teams including the African users and involving EO experts, are adapting EO techniques and methods to the real institutional and technical conditions of water authorities in African countries. This will facilitate the transfer of skills to the user or to local service providers for operations after the project lifetime. These projects represent a test bed to develop suitable implementation strategies and best practices in preparation for a full operational stage.

3. Towards Operations:

On the basis of successful development and demonstration results, trans-boundary or national projects lead by African water authorities will be implemented, aimed at supporting the transition from a pre-operational stage to a sustainable operational phase. This process is carried out in collaboration with development partners and donors, who support such a transition financially.



ACHIEVEMENTS: 10 YEARS OF TIGER



- exploitation of EO data to derive information about catchments characteristics and changes (lineaments and geology, landcover and landuse..);
- estimation of water balance over large basins, exploiting EO data
- extraction of water bodies from multi-temporal datasets for the creation of inventories and assessment of flooding patterns;
- estimation and assessment of water quality of main inland water bodies
- derivation of soil moisture information on a dynamic basis from satellite data.

Results obtained by the projects have been published in the scientific literature (e.g. IEEE Transactions on Geoscience and Remote Sensing, Hydrology and Earth System Sciences, Journal of Environmental Management...) and a special UNESCO publication (Technical documents on hydrology) dedicated to TIGER results was released in 2010. This is available at: <http://unesdoc.unesco.org/images/0018/001880/188045m.pdf>

Information and Knowledge Network

TIGER has involved more than 150 African institutions (water authorities, universities, technical centres) through projects and training activities. Dedicated TIGER workshops (in 2003, 2004, 2005, 2006, 2009 and 2011) and TIGER side events have been organised during international symposia (such as AfricaGIS 2007, AARSE 2008, 4th and 5th Water Forum 2006/2009, IGARSS 2009, 6th World Water Forum 2012), to raise awareness of the Initiative and disseminate results. The TIGER newsletter is regularly distributed to a list of more than 1000 entries and is also made available on the TIGER Website.

Development of EO-based information services for IWRM:

The Research Component of TIGER has included 70 research projects submitted by African and north-south scientific teams since 2004. Projects are distributed all around the African continent and, jointly with the areas of interest identified by the TIGER Development and Demonstration projects, interest 42 different African countries.

Research activities deal with different thematic:

- use of multi-source EO data to facilitate analysis and management of large aquifers (national and transboundary);

The Development and Demonstration projects involve African stakeholders and African service providers/technical centers, as well as European and Canadian value adding companies. EO techniques and methods are adapted to the real institutional, human and technical local conditions of different areas in Africa, so that they can be easily transferred to operations after the project lifetime.

The results provided by such projects constitute a solid service portfolio including among others:

- **Catchments characterization and base mapping,**
- **Water quality monitoring,**
- **Soil moisture and water levels information services,**
- **Water infrastructure monitoring,**
- **Support to ground water management and exploration.**

The GEO-AQUIFER project is an example of the successful transition to operations of a Development and Demonstration project. This follow on of the Aquifer project has in fact been co-funded by OSS (Observatoire du Sahara et du Sahel) and the African Water Facility (AWF), demonstrating the sustainability of the TIGER process.



TIGER aims at, among others, contributing to the enhancement of institutional, human and technical capacity for the use of EO technology in IWRM in Africa. The main instrument for this is the TIGER Capacity Building Facility (TCBF), launched already in the first phase of TIGER and became a key activity in the second phase. The TCBF aims to support the African research capacities to act as equal partners and to develop solutions on their own.

TCBF Phase I

In the first phase of TIGER training courses and workshops were organized in relation to several projects activities. TCBF was launched in the second half of 2006 as a coordinated action to assist 15 selected TIGER projects. It supported 94 individuals involving more than 20 institutions all around the African continent with training at various levels and methods. The International Institute for Geo-Information Science and Earth Observation, ITC (since 2010: Faculty of Geo-Information Science and Earth Observation of the University of Twente) implemented the facility with capacity building actions at different levels:

- Basic EO education, provided via distance learning.
- Advanced short courses, focused on selected earth observation techniques.
- Applied short courses, tailored to the research interest and technical background of the participants.
- Research supervision, provided by EO specialists at ITC.

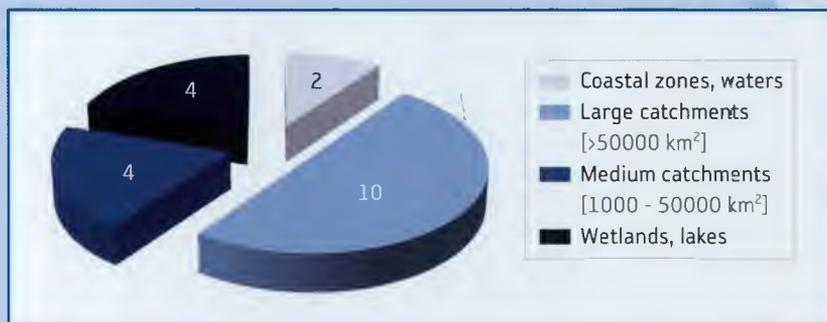
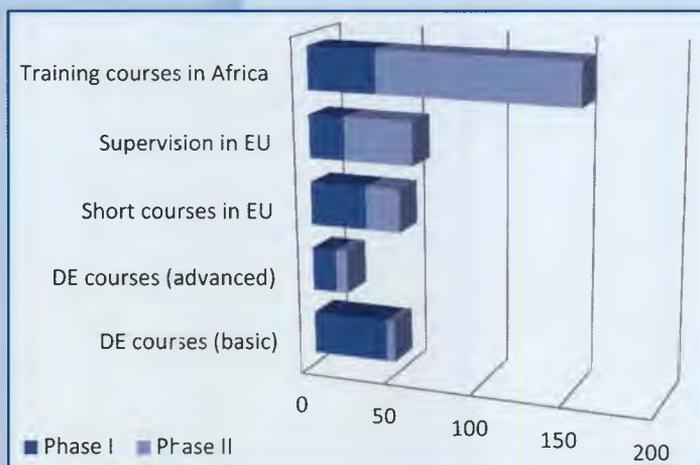
These coordinated capacity building actions provided a forum for researchers and stakeholders from all around Africa to meet and exchange ideas, which developed into a continental network, the TIGER community.

TCBF Phase II

TCBF II is implemented by a consortium of four partners (ITC, TU Delft, VITO and ISEGI-UNL), with the aim of supporting 20 research projects and reinforcing 3 Regional Offices. The TCBF II focuses on the research component of TIGER fostering the scientific skills and the technical capacity of African scientists for monitoring water resources in Africa by providing a tailored capacity building programme including individual supervision and training.

The objective of the TCBF II is to support African efforts developing sustainable water observation systems based on EO technology to learn more about the water cycle and to establish sound scientific bases for developing effective adaptation or mitigation measures against the impacts of climate change.

Participating African institutions range from universities to regional water authorities, located in 19 countries. Several projects are carried out by multinational teams addressing trans-boundary issues.



↑ Number of participants in the different capacity building action types of TCBF (up) DE: Distance Education

← Distribution of research test areas among the TIGER projects in Phase II. (left)

CAPACITY BUILDING & TRAINING 2009-12



“The transfer of these scientific developments into operations would be very valuable in supporting our newly-founded office in monitoring the condition of Lake Guiers”

Birane Ndiaye Dièye, Director General of the Lake Guiers Office, TIGER workshop 2011 in South Africa

Research projects

The 20 research projects of the TCBF II supported by free access to EO data and individual research supervision as well as training cover a wide range of topics (see more details in the TIGER Research Projects section). Both quantity and quality aspects of water resources are the main research focus. Although the projects are technically oriented, each of them puts the research into societal context, addressing, e.g., poverty alleviation or ecosystems services. All research activities are related to the development and implementation of EO techniques for the solution of a water-related problem demonstrated over selected test areas. Geographic scales vary from medium catchments to large trans-boundary basins. Consequently, the EO data types used for the research vary in spatial, spectral and temporal character.

Capacity Building Actions

A new capacity building element in TCBF II is the central role of project supervision. Scientific supervisors supported the projects (mentoring 40 African scientists) from the very beginning by fine-tuning the original research ideas and developing the capacity building plan. More than 150 participants were trained on the six training courses of

TCBF. The first course provided training on basic EO techniques, whilst the others were at advanced level, covering: optical remote sensing (water quality and classification techniques), active and passive microwave techniques (water body mapping, soil moisture and altimetry) and advanced EO methods in water management (surface energy balance, evapotranspiration and drought monitoring). Not only researchers attended these courses, but users (water professionals) also joined to learn about how to use EO technology in their fields.

Regional Offices

Three Regional Offices are participating in TCBF II: the Regional Centre for Mapping of Resources for Development (RCMRD) in Kenya, the AGRHYMET Regional Centre (ARC) in Niger and the Water Research Commission (WRC) in South Africa. TCBF aims at strengthening the local capacity of the Regional Offices to train their own stakeholders in the use of EO for water monitoring and assessment. For this purpose the Regional Offices took part in training courses both as participants and as organizers. They also actively contributed to the development of the DDS exploitation tool improving the access and usability of EO data (discussed in the next section).

TIGER WORKSHOP 2011

An important milestone in the TIGER Initiative was the TIGER Workshop 2011, held on 12-13 December 2011, in South Africa with the participation of more than 100 stakeholders and researchers from 23 African and 4 European countries. The main objective was to review the results of the TIGER research projects and to share their

scientific outcomes with the African water resource community. Representatives of UN-ECA, World Bank, UNESCO-IHP and high-level regional stakeholders joined the meeting to highlight issues and information requirements for water resource assessment and IWRM.



The ESA Data Dissemination System

ESA has developed a satellite-based Earth Observation Data Dissemination System (DDS) to facilitate dissemination of ESA and ESA Third Party Mission products. Since March 2005, any part of the African continent can be reached by this service, which is based on an uplink station located at the premises of ESA-ESRIN, Frascati, Italy. Using satellite telecommunication technology the DDS provides a fully operational and reliable service for the dissemination of EO data. The DDS system transmits the EO data through a C-band satellite connection to 17 DDS receiving stations in Africa installed at the premises of local water authorities or technical centers. The current DDS portfolio is composed of



MERIS, AATSR and ASAR GM data, but is being extended to selected data sets of ESA's Third Party Missions.

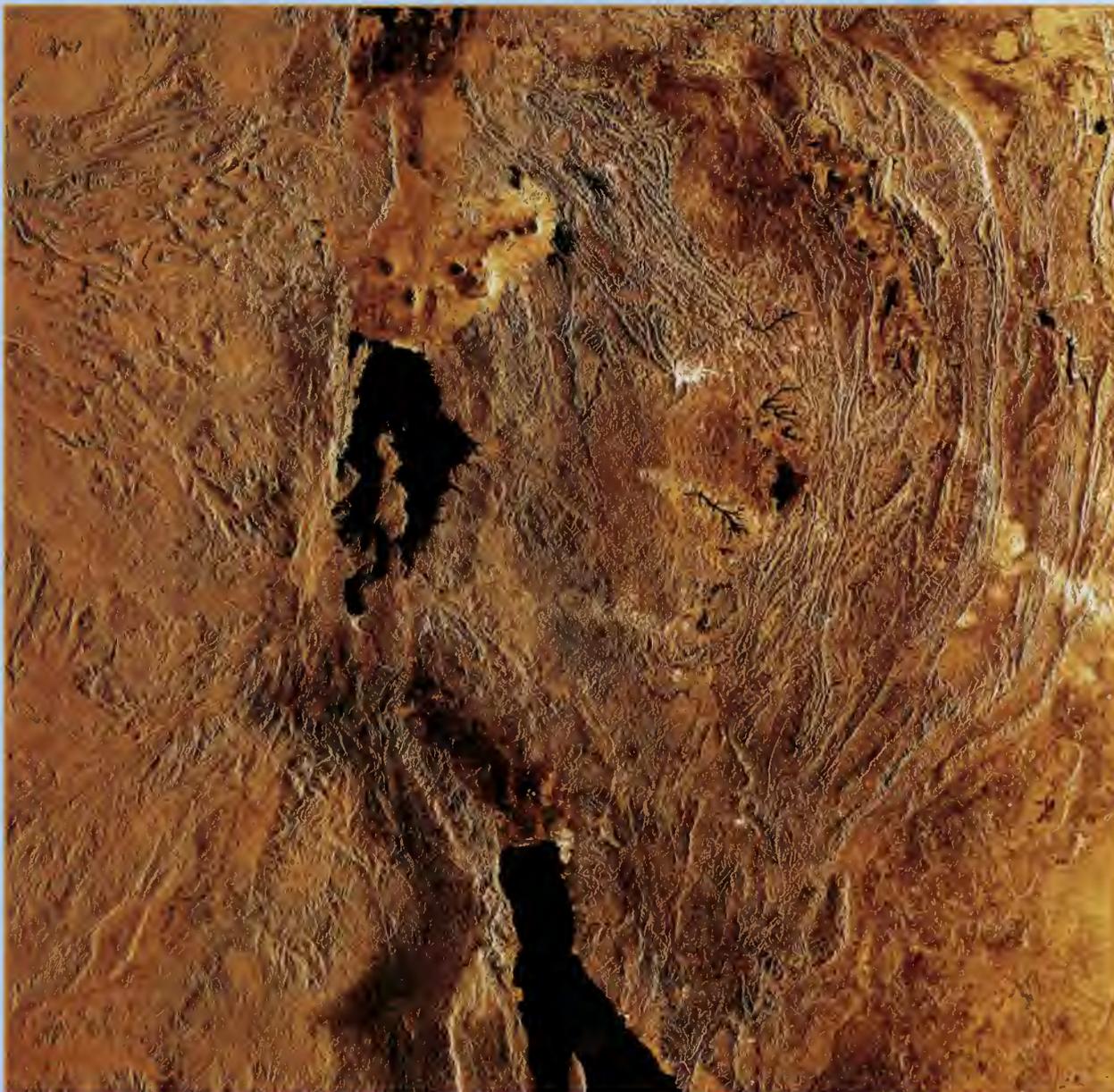
Especially in large areas of Africa with slow and unreliable Internet access, the DDS has improved African users' access to data considerably and is in fact the only access to near-real-time EO data for most TIGER users. To date, almost 15 TB of data have been transmitted to African users through the 2.8 Mbps dedicated satellite channel. For an improved usability and for supporting the exploitation of the EO data disseminated through the DDS system the TIGER Capacity Building Facility focused on providing dedicated tools to the African DDS stations. In collaboration with the three TIGER Regional Offices: AGRHYMET (Niger), RCMRD (Kenya) and the Department of Water Affairs (DWA) of South Africa a DDS exploitation tool was developed in 2011.

For an improved usability and for supporting the exploitation of the EO data disseminated through the DDS system the TIGER Capacity Building Facility focused on providing dedicated tools to the African DDS stations. In collaboration with the three TIGER Regional Offices: AGRHYMET (Niger), RCMRD (Kenya) and the Department of Water Affairs (DWA) of South Africa a DDS exploitation tool was developed in 2011.

For an improved usability and for supporting the exploitation of the EO data disseminated through the DDS system the TIGER Capacity Building Facility focused on providing dedicated tools to the African DDS stations. In collaboration with the three TIGER Regional Offices: AGRHYMET (Niger), RCMRD (Kenya) and the Department of Water Affairs (DWA) of South Africa a DDS exploitation tool was developed in 2011.

← DDS station in Nairobi

[Lake Albert - Lake Tanganyika ENVISAT, ASAR \[24-Sep-2007\]](#) ↓



EO DATA ACCESS AND DISSEMINATION

The DDS Exploitation tool

The main objective was to facilitate the access and creation of a number of EO-derived products related to water management. To this end, the DDS exploitation tool has been implemented enhancing the capacity of the Regional Offices to receive, process and disseminate water related products derived from EO data on a routine basis and in an automated way. Dedicated training sessions and support to the Regional Offices have been further provided to increase their own training capacity to involve their regional stakeholders in using EO for water resources. The tool is not only intended for the Regional Offices, but will be available for all DDS users.

The tool was developed following the needs expressed by the Regional Offices. Personnel from the Regional Offices and from several TIGER projects were trained to work with the DDS exploitation tool, and to customize the processing chains of the tool according to their specific regional needs. The Regional Offices are now operating their customized processing chains with support of the TCBF.

The following features are included in the DDS Exploitation tool:

- Automatic selection and extraction of EO data received by the DDS (customizable region of interest and products)
- L2 EO product generation based on several BEAM modules: fAPAR processor, Case2 regional waters processor, Eutrophic lakes processor, MERIS cloud probability processor
- Generation of spatial and temporal composites, including quick looks
- Fully open configuration by means of easy-to-create configuration files
- Support for automation via a command-line interface
- Designed for Linux and Windows operating systems.

The functionality of the tool will be further broadened in the future, to meet developing user requirements.

↳ Lake Malawi ENVISAT, MERIS [12-Oct-2010]



TIGER RESEARCH PROJECTS

In March 2009 during the Fifth World Water Forum in Istanbul (Turkey) TIGER invited African scientists, technical centres and water authorities to participate in the scientific component of the second implementation phase “Assessment of water resources in Africa under Global Climate Variability: Turning Science into Operations”. A large number of proposals were received and, based on the evaluation performed by a joint international team, 20 proposals were selected.

Goals and achievements of such projects, that received facilitated data access and scientific support through the activities organised by the TIGER Capacity Building Facility, are illustrated in the following pages.



TIGER RESEARCH PROJECTS

EO data to support the optimal management of water in the Doukkala Irrigation System (Western Morocco) PI: Professor Kamal Labbassi	Morocco	14
Integration of geospatial data to develop a water resources management system for the Sebou Basin: contribution to climate change adaptation PI: Dr. Ahmed Er-Raji	Morocco	15
Impact of Climate Change on Water Quality in Coastal lakes in Egypt PI: Dr. Hanan Ali Farag	Egypt	16
Enhancing sedimentation modelling data sets in the Nile Basin, Egypt PI: Prof. Dr. Karima Attia	Nile Basin	17
Hydrological and environmental aspects of wetlands in the Nile Basin (analytical tools for wetlands management) PI: Dr. Amel Azab	Nile Basin	18
Potential vulnerability of the Saloum and Casamance estuary systems: implication of climate change PI: Professor Serigne Faye	Senegal	19
Guiers Lake Integrated Water Resources Management PI: Dr. Souleye Wade	Senegal	20
Application of satellite imagery to assess and monitor the effect of climate variability on the water resources in the Bani transboundary basin, Mali PI: Dr. Adama Mariko	Mali	21
Integrated Water Resources Management and Forestry in Eastern Burkina Faso PI: Ludovic Tapsoba	Burkina Faso	22
Sustainable Water Use and Allocation in the Volta Basin PI: Dr. Charles Biney	Volta Basin	23
Lake Chad Water And Environmental Observatory Systems PI: Garba H. Sambo	Lake Chad	24
Earth observation for regional water balance estimation & surface energy balance assessment in the Volta Basin, West Africa PI: Dr. Kwabena Kankam-Yeboah	Ghana	25
Vulnerability of water resources to climate change and adaptation of population in the Kouilou-Niari watershed PI: Eng. Jérôme Ntoulani	Republic of Congo	26
Water Resources Management in the Democratic Republic of Congo PI: Dr. Dieudonné Nsadsisa Faka	Dem. Republic of Congo	27
Groundwater resource assessment, development and monitoring - Kenya PI: Dr. John Nyoroge Kimani	Kenya	28
Development of an operational system for monitoring and predicting the aquatic plants proliferation in the Lake Victoria - Kenya PI: Dr. Mito Collins Omulo	Lake Victoria	29
Programme to Develop Capacity in IWRM in Zambia PI: Prof. Imasiku A. Nyambe	Zambia	30
New flooding patterns on the borders of Namibia PI: Pauline Mufeti	Namibia	31
Biomass evaluation of tropical dry and wet forests. Climate change impacts PI: Professor Solofo Rakotondraompiana	Madagascar	32
Satellite monitoring of inland and near coastal water quality in southern Africa PI: Mark Matthews	South Africa	33

IRRIGATION WATER MANAGEMENT OF DOUKKALA MOROCCO



PI

Professor Kamal Labbassi, Chouaib Doukkali University, Faculty of Sciences (UCD), Morocco.

Team

- Chouaib Doukkali University (UCD), Morocco.
- Office National de Mise en Valeur Agricole de Doukkala (ORMAVAD), Morocco.
- Institut Agronomique et Vétérinaire (IAV), Morocco.
- Faculty of Aerospace Engineering, Delft University of Technology (TUD-LR), the Netherlands

Project

EO data to support the optimal management of water in the Doukkala Irrigation System (Western Morocco)

Project Progress

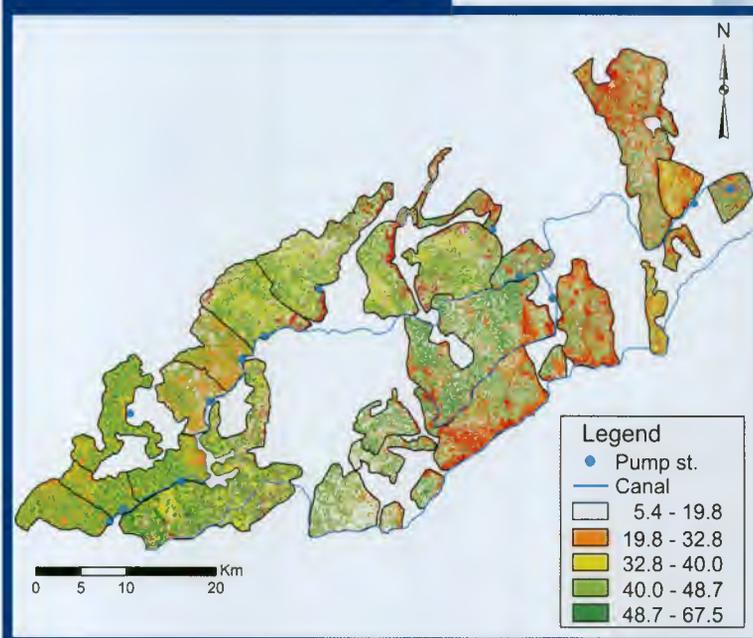
The investigation involves two components:

- Ground water exploration, in the Sahel area, production of a high-resolution DEM from ALOS data.
- In the irrigated area, SPOT data is used to produce maps of Crop Water requirement (CWR) using the FAO-56 model. Two parameters are required to produce maps of CWR: the crop coefficient (Kc) and crop evapotranspiration (Etc). The use of multirate SPOT images on a monthly scale (November 2000, March 2001 and July 2001) and on an annual basis (November 2000, November 2005 and November 2008) allows us to track the evolution of the various parameters. In a first step, this approach is applied to a pilot agricultural area of 182 km² (district of Sidi Bennour). Subsequently the approach is generalized to the entire irrigated perimeter of Doukkala choosing a drought year (2004-2005), normal year (2005-2006) and wet year (2008-2009).

Results and further steps

The comparison between the CWR and water allocation given by ORMVAD to farmers shows that the water allocations are much higher than the CWR on a monthly basis while the irrigation efficiency does not exceed 50%. This is due to the loss of water via evaporation from the soil related to the use of the gravitational technique of irrigation in a semi-arid climate. This large amount of lost water could be saved by the judicious choice of irrigation technique (drip for example). On the scale of the entire irrigated area of Doukkala the establishment of CWR for each center of agricultural development (CDA) served by a given pumping station and its comparison with the water allocations, constitute a good performance indicator.

Map of crop water requirement (in mm) for the month of May 2006, in the Doukkala irrigation system (generated from Spot 4 HRV1, 20m spatial resolution).



In the future, we will continue our investigations in the following ways:

- Use another model (analytical approach) and another classification. We have already started to apply the analytical approach with the aim to map the crop coefficient Kc from the parameters of vegetation cover (LAI, albedo, and crop height) and meteorological parameters.
- Up-scaling; in the agricultural parcel high-resolution data (Komsat) is used and this has to be extended to the entire basin of Oum Er-Rabia by the use of low-resolution data (MERIS).

INTEGRATED WATER RESOURCES MANAGEMENT OF SEBOU BASIN MOROCCO

Project

Integration of geospatial data to develop a water resources management system for the Sebou Basin: contribution to climate change adaptation

Project Progress

The overall objective is the development of a prototype tool for environmental monitoring and water resources management to better characterize key hydrological variables in the Sebou Basin to support decision makers for a sustainable climate change adaptation. This is achieved through the fusion of environmental parameters derived from medium and high resolution satellite images with in situ measurements and numerical models.

The project is based on three components:

- Monitoring the impact of climate variability on water resources. The component is directly built on the skills developed during our TIGER Phase 1 project in the Souss-Massa Basin. In the second phase, we use new satellite-based techniques to better characterize and understand the different impacts of climatic variations on the territorial dynamics and their relationship to water availability and water use.
- Water balance Characterization for improved water productivity. An example is the use of the Surface Energy Balance System (SEBS) to estimate evapotranspiration (ET) at the basin level with special focus on the irrigated areas, providing information on the actual water consumption. This enables us to calculate the water budget with higher accuracy and considering its spatial aspects with more detail.
- Capacity building (operability).

The project team participates in various actions of training and coaching through the Tiger Capacity Building Facility

Results and further steps

The following scientific topics are covered:

- Hydrology: Energy balance, evapotranspiration, water balance
- Fusion of optical and radar imagery for flood rapid mapping and monitoring
- Estimation of water use by crops in irrigated sectors
- Water productivity (biomass) including rain-fed areas
- Monitoring and assessing climate change impacts on land use/land cover dynamics

The prototype system includes, among others, the following achievements: Land use/land cover layers, change detection routines, flood zones and vulnerability routines and layers, routines for assessing crop water use (SEBS) and demand.

An important aspect is sustainability. In terms of EO methods the TIGER Capacity Building Facility enabled the project team to transfer the gained knowledge to the beneficiaries in the basin. At the end, the local team should be able to make an operational and sustainable use of the project results. This will be ensured through integrating data from earth observation in the water management process to support the ongoing climate change adaptation measures.



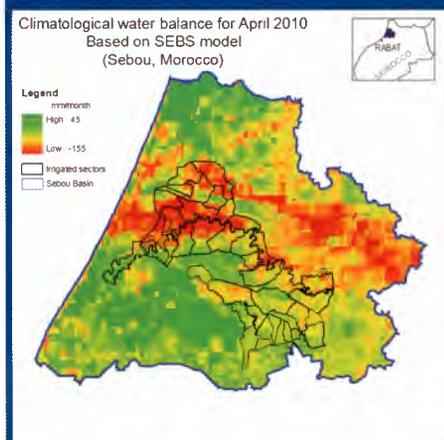
PI

Dr. Ahmed Er-Raji, Centre Royal de Télédétection Spatiale (CRTS), Morocco

TEAM

- Centre Royal de Télédétection Spatiale (CRTS), Morocco
- Agence du Bassin Hydraulique du Sebou (ABHS), Morocco
- Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands

Map calculate as the difference between precipitation and actual evapotranspiration (based on SEBS)



WATER QUALITY MONITORING OF COASTAL LAKES EGYPT



PI

Dr. Hanan Ali Farag, Environment and Climate Research Institute (ECRI), Egypt

Team

- Environment and Climate Research Institute (ECRI), Egypt
- Higher Institute of Statistics and Information Management - New University of Lisbon (ISEGI-UNL), Portugal

Project

Impact of Climate Change on Water Quality in Coastal lakes in Egypt

Project Progress

The main objective of the project is to transfer knowledge and use new technology to monitor water quality of lakes and identify appropriate management strategies that maximize the benefits and minimize the risks associated with the impact of climate change on the water quality of coastal lakes in Egypt.

During the course of the project, we have conducted a fieldwork in July 2010 for water quality sampling on Lake Burullus. Thirty locations were recorded in the lake and its surrounding area. From each sampling point we have measured the pH, DO, depth, temperature, TDS, TSS and turbidity.

Results and further steps

With the collected in situ data and remote sensing data we have developed a statistical model using multivariate regression. We also have applied the MERIS Case-2 Water Processor to extract the TSM.

Additionally, we have applied a classification process to extract relevant land cover classes, such as water, vegetation (two different types), agriculture and fish ponds.

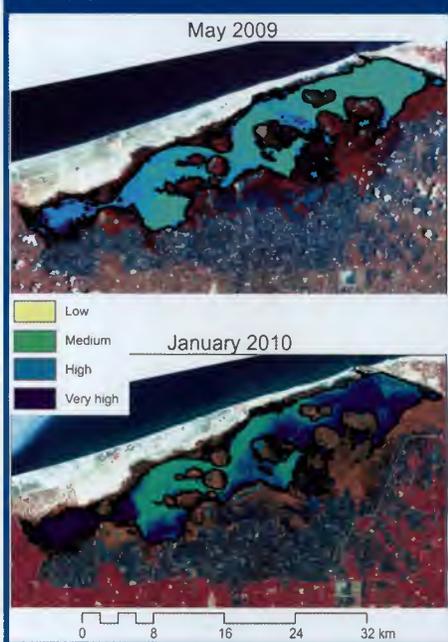
We have also assessed the trophic status of the Burullus lake in two seasons, winter and spring.

We have also constructed a geodatabase for different geographic entities (drainage discharged in the lake, monitoring sites at the drains outfall, Water Quality samples from the lake, etc).

The project has produced two papers to be published: one in the International Journal of Environment Science and Engineering (IJESE), with the title "Assessment of Eutrophic Status of Lake Burullus using Remote Sensing" and the other in the Nile Water Science and Engineering Journal, with the title "Using Earth Observation (EO) Technique for Monitoring Water Quality in Lake Burullus".

Future work will include the application of other classification techniques with more coarse resolution images, the extraction of meteorological parameters from MERIS and AATSR data and validation of the resulting maps.

Chlorophyll-a distribution in Lake Burullus



MODELLING SEDIMENT TRANSPORT PROCESSES NILE BASIN

Project

Enhancing sedimentation modelling data sets in the Nile Basin, Egypt

Project Progress

The project research activities have focused on Lake Nasser. In August 2010, two field missions were carried out to collect in situ data. The data collected in these missions was complemented with that collected from a previous mission conducted in 2007. This data set was used to establish a statistical model to predict the total suspended solids (TSS), relating its measurements with spectral information extracted from remote sensing sensors. Three models were developed to estimate TSS in different seasons using the MERIS level 1B data. The MERIS Case-2 Regional Processor (C2RP) was used to validate the results. The results from this study suggest that the most suitable reflectance combination is achieved with Meris bands 7 and 8.

The project's staff participated in the four TIGER workshops held in Egypt (four persons attended it), Kenya (one person attended it), Netherlands (one person attended it) and South Africa (one person attended it). Additionally one person attended the training at the Instituto Superior de Estatística e Gestão de Informação (ISEGI) in Portugal.

Results and further steps

During the project activities, one paper was produced, and presented in the 26th Arab Engineering Conference "Water resources in the Arab countries: opportunities and challenges", with the title "Remote sensing as a tool to detect suspended sediment of Lake Nasser". This conference was held in January 2012, Jeddah, Kingdom of Saudi Arabia (KSA). The KSA covered the first author's cost to attend this conference.

We are preparing a research paper for the African Association of Remote Sensing of Environment Conference to be held in October 2012, in Morocco. We have also registered a Ph.D student in the Ain Shams University to work in the project. His research will be focus on change detection to predict water quality parameters in Lake Nasser, using remote sensing techniques.



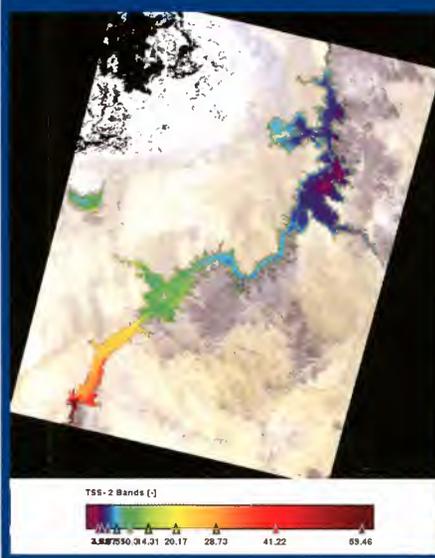
PI

Prof. Dr. Karima Attia, Nile Research Institute,
National Water Research Centre, Egypt

Team

- Nile Research Institute, National Water Research Centre (NRI), Egypt
- Higher Institute of Statistics and Information Management - New University of Lisbon (ISEGI-UNL), Portugal

TSS map of Lake Nasser, 2007



ECO-HYDROLOGICAL MODELLING NILE BASIN



PI

Dr. Amel Azab, Nile Basin Capacity Building Network Secretariat / Hydraulic Research Institute, Egypt

Team

- Nile Basin Capacity Building Network Secretariat (NBCBN), Egypt
- Makerere University (MU), Uganda
- Kinshasa University (UNIKIN), D.R. Congo
- Institute of Scientific and Technological Research (IRST), Rwanda
- University of Dar es Salaam (UDSM), Tanzania
- UNESCO Institute for Water Education, (UNESCO-IHE), the Netherlands
- Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands

Project

Hydrological and environmental aspects of wetlands in the Nile Basin (analytical tools for wetlands management)

Project Progress

The major objective of the project is to better understand the different wetland systems in the Nile Basin, and to develop tools for management and conservation of wetlands by applying EO data, analysis and modelling.

We are in the process of developing a geo-database of wetlands in the Nile Basin on regional, national and pilot wetlands levels. This includes the mapping of different types of wetlands (delineation of water bodies, vegetation mapping, fisheries), identification of major changes affecting the selected pilot wetlands, applying remote sensing techniques for developing evapotranspiration time series (application on Edko case study), developing an applicable monitoring system for wetlands based on the use of EO data, ground truth and remote sensing analysis techniques including water quality, fisheries, and vegetation (application on Edko/Burullus case studies), publishing research results via an online mapping system to be accessible by a broader community of professionals.

Several project staff members participated in training courses in Africa, on short courses in Europe and also followed distance education courses. Two PhD research projects are directly linked to the project (one has been successfully completed in 2012).

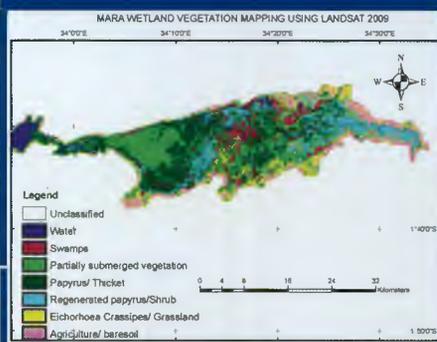
Results and Further Steps

Two major pilot areas have been selected: Lake Edko and Lake Burullus in the Nile Delta, Egypt and the Mara Wetland at the lower reach of the Mara River in Tanzania. Basic EO data were downloaded.

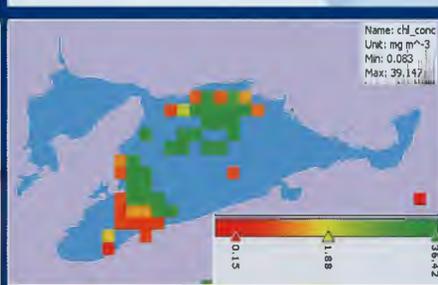
A water quality model was developed for Lake Edko using EO data for the quantification of forcing factors as well as for the calibration and validation of the model.

Further plans contain: mapping of all pilot selected wetlands; preparing and processing the MERIS datasets for the time series analysis (2003-2010); water quality (TSM and CHL-a) time series analysis for coastal wetlands; evapotranspiration time series analysis for Lake Edko; completion of the prototype of the wetland geo-database; developing guidelines for wetland monitoring based on pilot case studies using EO data and remote sensing tools.

Landsat TM-based land cover map of the Mara wetland



MERIS-FR Subset Scene of the Edko Wetland
MERIS-FR based CHL-a concentrations map of Edko Lake (right)



CHANGE MONITORING OF SALOUM AND CASAMANCE ESTUARIES SENEGAL

Project

Potential vulnerability of the Saloum and Casamance estuary systems: implication of climate change

Project Progress

The present study aims at assessing the consequences of salinization during the last three decades in these estuaries to land, biodiversity and water degradation.

Landsat and Spot images, provided by the TIGER Capacity Building Facility, were used to generate regional and local time series of land use / land cover maps. Landsat images were classified into eight classes namely: water bodies, high mangrove, low mangrove, denuded and salty soils (locally called "tan"), savannah, rain-fed agriculture, forest and urban or built-up land. In addition to this classification, SPOT images, with finer spatial resolution were used to identify three other classes: halophyte grassland, acacia populated depression and plantation. We paid particular attention to the change detection analysis concerning the mangrove system degradation as well as saline soils expansion that can reflect the level of salinization.

Results and Further Steps

The analysis results suggest that from 1984 to 2010, low and high mangroves, rain-fed agriculture and savannah have been converted to "tan" soil. Additionally, these results have shown that significant changes in land use / land cover occurred within the whole estuary system. Degradation could be identified, such as land desertification, salinization and vegetation degradation that reflect increasing soil and water salinity content.

The following steps will be taken for the completion of the project:

- diachronic land cover and change detection of Casamance estuary;
- comparative study of the two systems will be carried out in order to provide basic information to evaluate the vulnerability of the systems;
- use of ERS 1-2 radar data for monitoring the seasonal and annual trends of the coast line, the risk zone and flooding. A DEM will be also generated using ERS 1-2 data.



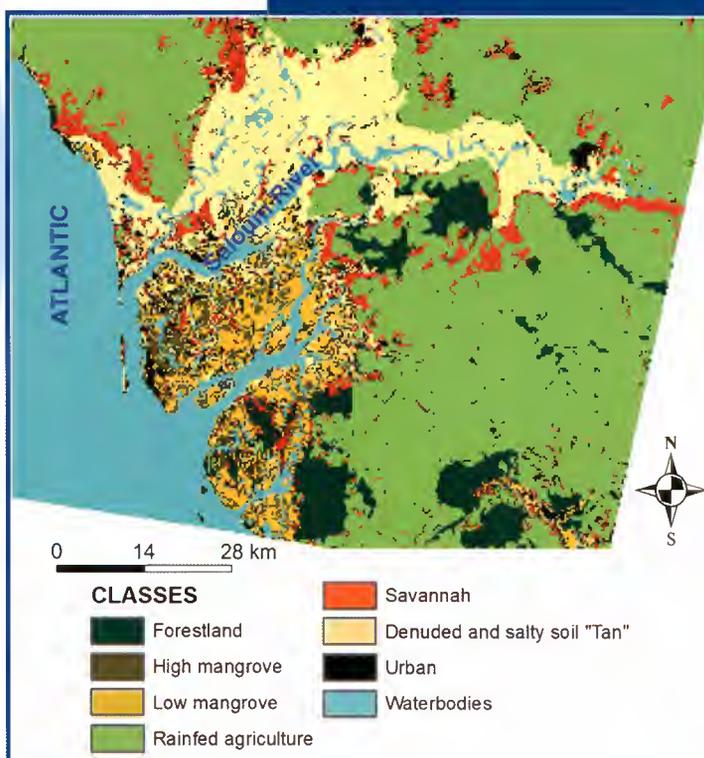
PI

Professor Serigne Faye, University Cheikh Anta Diop (UCAD) / Faculty of Sciences and Techniques, Senegal

Team

- Centre for Ecological Monitoring (CSE), Senegal
- Laboratory of Physical Atmosphere and Ocean Simoen Fongung (LPAO-SF), Senegal
- University Cheikh Anta Diop (UCAD), Senegal
- Higher Institute of Statistics and Information Management - New University of Lisbon (ISEGI-UNL), Portugal

Land use / land cover map based on Landsat imagery (2010) for the Saloum estuary (Senegal)



WATER QUALITY MONITORING OF THE GUIERS LAKE SENEGAL



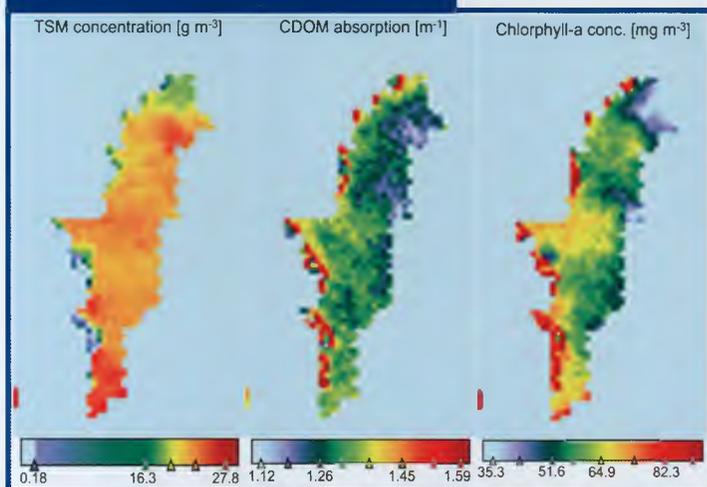
PI

Dr. Souleye Wade, Institute of Earth Sciences,
Cheikh Anta Diop University of Dakar, Senegal

Team

- Cheikh Anta Diop University (UCAD), Senegal
- Polytechnical High School (EPT), Senegal
- National Water Authority (EPT), Senegal
- Senegal River Water Authority (OMVS), Senegal
- Guiers Lake Water Authority (OLAG), Senegal
- Ecological Surveying Centre (CSE), Senegal
- Marne la Vallée University (UMLV), France
- Faculty of Geo-Information Science and Earth Observation, University of Twente (ITC), the Netherlands

First analysis results: Spatial distribution of SPM, CHL-a and CDOM concentrations in the Northern and Central sections of the Guiers Lake, based on FUB algorithm retrieval from the April, 27, 2007 MERIS image.



Project

Guiers Lake Integrated Water Resources Management

Project Progress

The Guiers lake is an important drinking water supplier of Dakar, so timely information about the spatial distribution of water quality parameters is important for managing the lake. The project was started with a positive test of an ENVISAT/MERIS Level 1b image of April, 27, 2007 processed with FUB algorithm to retrieve the spatial distribution of SPM, CHL-a and CDOM concentrations in Lake Guiers waters. Results were presented at the 2nd MERIS/(A)ATSR User Workshop, Frascati, Italy, 22-26 September 2008.

Then, about forty MERIS full resolution (FR) level 2b images covering the period of 2003-2010 (with at least 4 images per year: cold dry season, hot dry season, early rainy season, late rainy season) were acquired by the project under the TIGER Initiative. The temporal coverage of the data is representative of the seasonal variability of the hydrological conditions of the Lake (at least one image per season, dry or rainy).

Data were processed and analyzed at ITC in the framework of TCBF. Image processing is supported with fieldworks with the following tasks:

- Environmental observations
- In situ measurements
- Collection of water samples for chemical and bacteriological analysis

Multitemporal optical images from USGS and microwave ASAR data from ESA are processed for various themes:

- landuse/landcover mapping
- aquatic vegetation monitoring,
- lake extent mapping, etc..

Results and further steps

Current thematic studies of the project provide the basis of the following results and outputs: (i) comprehensive mapping of the hydrological system of the Guiers Lake. Thematic maps will serve for monitoring the quantitative and qualitative evolution of water resources as well as assessing environmental factors; (ii) assessment of climate change impacts on the lake

with digital processing and analysis of a multitemporal set of aerial photographs and satellite data, taken over a period of 50 years; (iii) design of a geospatial information system dedicated to the integrated management of the Guiers lake water resources; (iv) capacity building in the field of data collection, laboratory analysis, Earth observation data processing and analysis, GIS designing; (v) awareness raising on the potential negative impacts of anthropogenic activities on Guiers lake water resources, through discussion forums involving the main stakeholders.

MONITORING WATER RESOURCES OF BANI BASIN MALI

Project

Application of satellite imagery to assess and monitor the effect of climate variability on the water resources in the Bani transboundary basin, Mali

Project Progress

Bani River, the main tributary of the Niger in Mali, experienced a 20-30% drop of discharge in the last decades that needs a thorough monitoring and analysis. In this study, we propose an extensive use of earth observation data for the characterization, assessment and monitoring of surface waters and the identification of fracture networks, which contain most of the groundwater in the region. An advanced knowledge of water resources, essential for the development of a management tool, is expected to optimize water-related measures to achieve a sustainable development necessary for improving the population's standard of life.

Based on a literature review, the best algorithms have been chosen for the delineation and monitoring of water-covered areas and other features. Areas with high lineament/fracture density (mostly in the Birimian formations) are studied through the interpretation of multispectral satellite imagery interpretation of high resolution (e.g. SPOT-4), radar (e.g. ERS, ENVISAT, ALOS) and aerial photographs. Further activities include: land use/land cover mapping and the construction of a Digital Terrain Model (DTM). Surface water mapping leads to knowledge of the water stored in surface water bodies, like small reservoirs, in the Bani Basin. Surface energy balance based ET assessment is also carried out. With these, we refine the hydrological rainfall-runoff models and assess their impact on the flooded areas in the Inner Niger Delta in Mali.

Results and further steps

As part of the surface energy balance calculations, time series of land surface temperature maps were calculated for the period 2003 till 2010, using ENVISAT / AATSR Ch6 and Ch7 radiometric data and a dedicated BEAM module.

In order to validate the image processing results, ground surveying will be conducted in the basin of Bani. Field visits will be organized for this purpose during periods of high and low water.



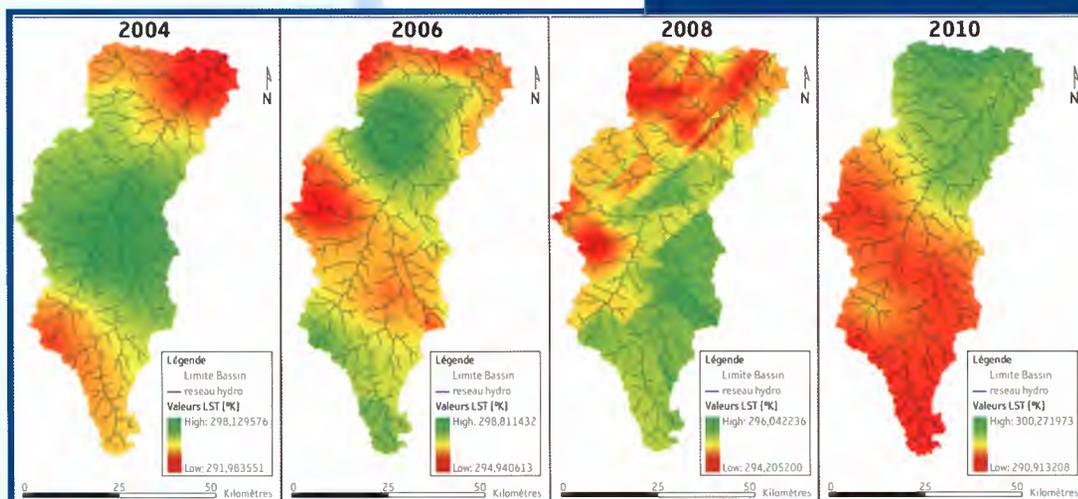
PI

Dr. Adama Mariko, Ecole Nationale d'Ingénieurs Abderhamane Baba Touré (ENI-ABT), Mali

Team

- Ecole Nationale d'Ingénieurs Abderhamane Baba Touré (ENI-ABT), Mali
- Université de Bamako, FAST (DER Sciences de la Terre), Mali
- Direction Nationale de l'Hydraulique (DNH), Mali
- Université d'Abobo-Adjamé, UFR des Sciences et Gestion de l'Environnement (UAA), Ivory Coast
- Université de Cocody, Centre Universitaire de Recherche et d'Application en Télédétection (CURAT), Ivory Coast
- Université Paris-Est Marne la Vallée (UPEMLV), France
- Institut Francilien des Sciences Appliquées (IFSA), France
- Faculty of Aerospace Engineering, Delft University of Technology (TUD-LR), the Netherlands

Mean Land Surface Temperature retrieved using AATSR radiometric data in Channels 6 and 7 with the split-window algorithm as implemented in BEAM



INTEGRATED WATER RESOURCE MANAGEMENT BURKINA FASO



PI

Ludovic Tapsoba, International Union for Conservation of Nature (IUCN), Burkina Faso

Team

- International Union for Conservation of Nature (IUCN), Burkina Faso
- Faculty of Engineering and Geosciences, Delft University of Technology (TUD-CiTG), the Netherlands

Project

Integrated Water Resources Management and Forestry in Eastern Burkina Faso

Project Progress

The global objective is a study on the dynamics of ecosystems between two periods: 1972/1974 to 1991/1992 and 1991/1992 to 2009, focusing on biodiversity, in two administrative regions of Burkina Faso, Centre East and Centre West.

Specific objectives are:

- to establish the state of vegetation cover in the form of land use in the two regions during both periods, i.e. carry out temporal and spatial analysis of land use;
 - to explain the observed changes using climate and demographic data in particular
 - to carry out a literature review of existing information on biodiversity in both regions in relation to the observed trends in land use
- The study uses Landsat imagery of 1972/74 and 1991/92, and DMCii data of 2009, in combination with demographic and meteorological data from the period 1972-2009. Also a field campaign is part of the study.

Results and further steps

Spatial analysis of the images over the same area for different periods was carried out using the module MATRIX Geomatica of PCI. The study reveals drastic land use changes occurring especially during the second interval of the study period. The figure refers to the Centre East region and shows the relative area of cultivated land increasing from just over 20% to more than 50% between 1992 and 2009. This happened at the expense of forested areas and various types of savannah with combined contributions going down from 70% to less than 40%.

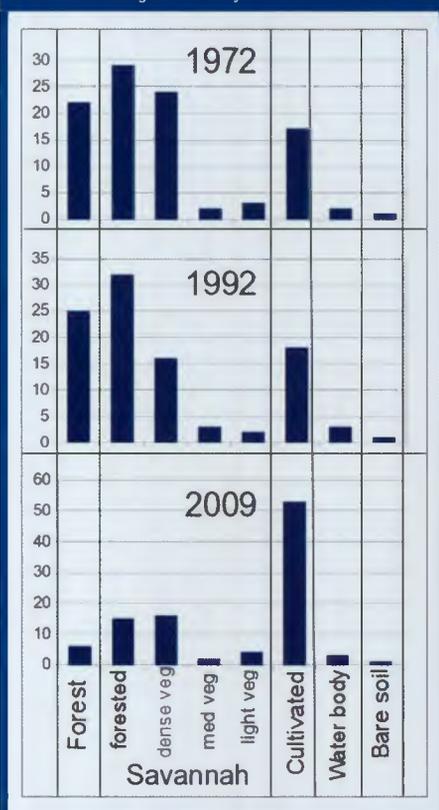
Resource persons interviewed acknowledged the reduction in the vegetations cover and biodiversity due to human activities. They were unanimous on land restoration activities for recovering degraded lands and sustainable actions to protect relatively undegraded lands.

The main problems with land cover and biodiversity are:

- Agricultural practice and surface mining
- Increase in cultivated areas of cash crops such as cotton.
- Establishment of agribusinesses in the Central West region
- Increase in livestock numbers and reduction in pastures, resulting in overgrazing

In both regions rainfall does not seem to significantly influence the spatial and temporal variation in vegetation cover. Human influence is the principal agent in the modification of the ecosystems. However, this conclusion cannot be extended to other regions of the country situated in different climatic zones. It will be interesting to extend the study to the other regions to study the effect of climate on the spatial and temporal variation in land use and vegetation cover. The analysis will continue on water bodies in the eastern part of the country.

Accelerated land cover changes were proved by the use of remote sensing in the study area



INTEGRATED WATER RESOURCE MANAGEMENT VOLTA BASIN

Project

Sustainable Water Use and Allocation in the Volta Basin

Project Progress

This project aims at modelling the terrestrial water cycle in the Volta Basin to support progress towards Integrated Water Resources Management. In most Sub-Saharan African countries the challenge is to get the necessary data for the models because most of the catchments are ungauged. This project seeks to find a way of using EO data to monitor land use/land cover changes estimate hydrological variables to establish the water balance of the basin and allocate the resources in a sustainable and efficient manner. The most difficult aspect is the quantification of the ground water resources.

Models have been built for the basin and will be further developed and calibrated. The WEAP Volta Model which is a water allocation model has been improved together with other models of hydrological processes. This will then be used to build a decision support system to enhance collaboration and avoid conflicts among the riparian countries of the Volta Basin. All stakeholders will have access to the required data and thus will be able to monitor and quantify the available water resources and water use. Earth Observation from space accessible for all is the ideal means to achieve this goal. This will enhance trust and help avoid conflicts and strenghten sustainable use of resources, i.e. by putting Integrated Water Resources Management into practice.

Results and further steps

Modelling work focused on updating and adapting the WEAP model to the characteristics and requirements of the Volta Basin. As regards satellite data products to monitor the terrestrial water cycle, the project focused on the evaluation of the soil moisture retrievals from ESA / SMOS data over Ghana and Burkina Faso. Soil moisture retrievals were evaluated against field measurements and retrievals from other satellite data. The purpose of this comparison was to validate the algorithm used to determine soil moisture contents from SMOS satellite measurements. The work done provided some advance indications on the reliability of the SMOS satellite for West-Africa. The field work was carried out in Northern Ghana, near the Kusawgu junction and in South-East Burkina Faso near the town of Madjoari. Other comparisons were done with measurements in Burkina Faso, Soil Moisture data from other satellites and precipitation data.



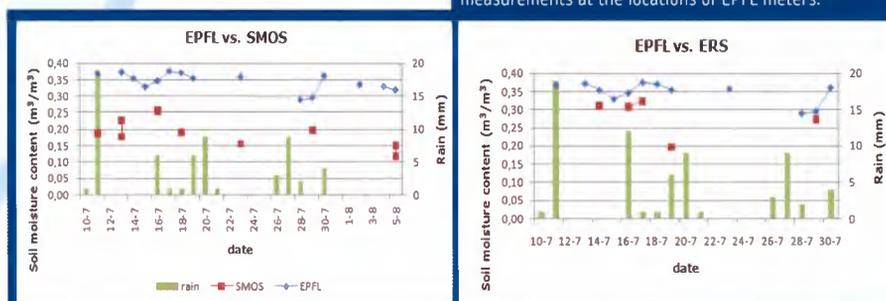
PI

Dr. Charles Biney - Volta Basin Authority (VBA), Burkina Faso

Team

- Department of Civil Engineering KNUST, Ghana
- Project for Improving Water Governance in the Volta River Basin (PAGEV IUCN), Burkina Faso
- Water Resources Directorate, Cote d'Ivoire
- Water Resources Commission, Ghana
- Faculty of Engineering and Geosciences, Delft University of Technology (TUD-CiTG), the Netherlands

ERS-ASCAT and SMOS satellite data compared to EPFL measurements at the locations of EPFL meters.



OBSERVATORY SYSTEMS

LAKE CHAD



PI

Garba H. Sambo, University of Maiduguri, Nigeria

Team

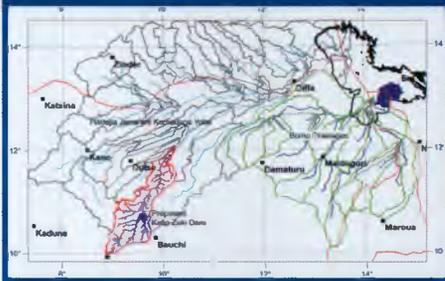
- University of Maiduguri, Nigeria
- Lake Chad Basin Commission, Chad
- Kano University of Science and Technology, Nigeria
- Lake Chad Research Institute, Nigeria
- Chad Basin Development Authority, Nigeria
- Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands



Lake Chad maximum water extent in 2006-07 (up) 2010-11 (bottom) based on MERIS FR image



Proposed Kafin Zaki Dam and its Sub-Watershed in the Nigerian sector of Lake Chad. Source: SRTM DEM 90m Delineated Sub-Basins of Lake Chad (Komadugu Yobe Catchment), processed by the Team.



Project

Lake Chad Water And Environmental Observatory Systems

Project Progress

Lake Chad is shared by Nigeria, Niger, Chad and Cameroon. The Region benefits from the ESA TIGER Initiative immensely; baseline data was produced and referenced during the GlobWetland project, producing maps of the minimum (1970 km²) and the maximum (3159 km²) water extent of the lake in the base year of 2001/02 using bands 3 and 4 of Landsat ETM+ in ILWIS. With TCBF, the project used MERIS FR images (reflectance of bands 6 and 10) to generate the Lake Chad Water Cycle Regime. At the moment, most organisations are using our results for 2006/07 as base information for comparison purposes in researches and decisions in the region. TCBF found that in the 2010/11 hydrological year the lake was smaller than both in 2001 and 2006/07.

For field validation, the Lake Chad Research Institute, the Kano University of Science and Technology, Wudil, and the University of Maiduguri released two vehicles and funded the team's DSA for TIGER fieldwork at one of the proposed contentious sites, the Kafin Zaki dam in the Basin, from early 2000. Thus the team exploits the advantage of EO data to solve the dispute by conducting an EIA and quantifying the water balance of the dam. The fieldwork started in late January 2012. The final result would be used to advise decision makers.

Training under the TCBF: Nine scientists attended tailor-made training on the extraction of water related information from DDS – GEONETCast/DevCoCast at ITC, in June-August 2011.

For sustaining and promoting the TIGER project, the recipient organizations approved their own contribution to cover more the costs for the members of the team to re-visit ITC for a follow-up research, as a direct spin-off of TCBF.

Results and further steps

The baseline database is one of the most important technical result of the project, based on data acquired in the framework of TIGER. Furthermore, the CB actions exposed the team to EO technology, stimulating the stakeholders to invest in further applications. Organisations in the Lake Chad region are ready to support TIGER-related activities:

- A fieldwork campaign has already started, and ITC has been requested for supervision and provision of processing infrastructure. This work aims at an EIA and a WB calculation of the selected sub-basin;
- More of the team members will be sent for further study and research at ITC;
- The Governor of Kano State showed interest in visiting European TIGER partners, with a delegation of the participating Universities and the Lake Chad Basin Commission.

WATER BALANCE RETRIEVAL VOLTA BASIN

Project

Earth observation for regional water balance estimation & surface energy balance assessment in the Volta Basin, West Africa

Project Progress

The project sought support from ESA to facilitate training and implementation of a fully functioning computer model in CSIR-WRI in Ghana and thus contribute to sustainable water resources management in the region. The goal is to derive regional water balance estimates operationally using spatially distributed ET and runoff estimates (from readily available ESA EO data through TIGER). Progress includes:

- Participation in all the short training courses of the TCBF.
- Hands-on training at supervisor's organisation in EO data processing/analysis and use of hydrologic modelling tools such as SEBAL in the Netherlands.
- A Research analysis and Results on "Validation of TRMM data in the Black Volta Basin of Ghana" using TRMM data compared with ground recorded rainfall data.
- Acquisition hardware and open source software for image processing.
- Downloaded some EO data (MERIS Full Resolution and Reduced Resolution, ATS-Top of the Atmosphere (TOA) images, etc..) for processing with open source software such as BEAM, NEST and ILWIS among others.

Results and further steps

To assimilate empirical data from West Africa and use software available (e.g., SEBAL, ILWIS, BEAM, NEST) and distributed hydrological modelling, and new Earth observation data (albedo, temperature, ET, vegetation cover, rainfall) to make significant improvements to regional water balance estimates. To this end, the following would be carried out:

- Extract land surface variables as inputs to models that predict evapotranspiration (ET) and runoff from savannah catchments of the Volta Basin
- Improve on existing SEBAL model by incorporating satellite-derived rainfall estimates and to validate the model for the whole Upper Volta Basin using ground-based runoff measurements.

Spatial estimates of rainfall using active microwave remote sensing were obtained using data collected by the Tropical Rainfall Measuring Mission (TRMM). These data need to be adjusted to a specific region using sparse rain gauge data and surrogate estimation of rainfall quantities based on optical remote sensing observations of vegetation change.



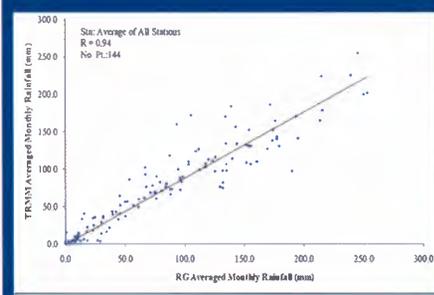
PI

Dr. Kwabena Kankam-Yeboah, CSIR Water Research Institute (CSIR-WRI), Ghana

Team

- CSIR Water Research Institute (CSIR-WRI), Ghana
- Kwame Nkrumah University Of Science & Technology (KNUST), Ghana
- University of Ghana (UG), Ghana
- Durham University (DU), Great Britain
- Ohio Valley University (OVU), USA
- Faculty of Engineering and Geosciences, Delft University of Technology (TUD-CiTG), the Netherlands

TRMM rainfall retrievals compared with rainfall observations averaged over 5 rain gauge stations, 1998-2009, in the Black Volta basin



WATER RESOURCES VULNERABILITY REPUBLIC OF THE CONGO



PI

Eng. Jérôme Ntoulani, Ministry of Energy and Water, Republic of the Congo

Team

- Ministry of Energy and Water, Republic of the Congo
- Higher Institute of Statistics and Information Management - New University of Lisbon (ISEGI-UNL), Portugal

Project

Vulnerability of water resources to climate change and adaptation of population in the Kouilou-Niari watershed

Project Progress

This project aims at performing a qualitative assessment of water resources vulnerability and agricultural practices adaptations to climate change at the Kouilou-Niari Valley and Batéké Plateau, Congo. To accomplish the goals of the project, a climate change monitoring system is proposed to track natural ecosystems sensitivity, to identify agricultural species resistance and level of adaptation, and to follow population dynamics. Nevertheless, due to the lack of remote sensing and digital image processing skills as well as the lack of hardware, such as computers and DDS, project research activities were not optimal. Therefore, the project has focused its activities on capacity building actions.

From October to December 2010, a project staff member attended a long training in the Instituto Superior de Estatística e Gestão de Informação da Universidade de Lisboa (ISEGI) focusing his studies in geo-information sciences, such as remote sensing, geographic information systems (GIS) and GIS applications. He also received project-oriented supervision at the institute where he has initiated the process of selecting and downloading the images to be used in the project in future work. Other project staff members have participated in training courses in Africa, and the TIGER project workshops.

Results and further steps

Some basic processing was carried out on the downloaded images, but the lack of infrastructure makes work difficult. In the next steps the project continues to build a technically sound team to speed up work for achieving the project goals (personal capacity building) and to build a processing centre, where a set of computers and DDS may be installed (institutional capacity building).

Land cover map based on Landsat ETM classification. (bottom)

The test area of the project: Kouilou-Niari watershed. (right)



INTEGRATED WATER RESOURCE MANAGEMENT DEMOCRATIC REPUBLIC OF THE CONGO

Project

Water Resources Management in the Democratic Republic of the Congo

Project Progress

The general objective of the project is to support the development of a comprehensive observational network for a hydro-information system, as well as technical capacity building that will promote sustainable planning, utilization, and management of the DRC water resources.

The Congo River is the cornerstone of the economy and livelihood of the Democratic Republic of Congo, facilitating water supply, navigation, hydropower, agriculture, ecosystems, tourism, etc. It is an important regional resource, extending into Angola, Democratic Republic of Congo, Gabon, Burundi, Cameroon, Central African Republic, Rwanda, Zambia, and Tanzania, offering potential for water and energy exports.

Challenges, however, are presented by poverty, disease, restricted clean water access, deforestation and climate change. In addition the country is facing a lack of adequate institutional and technical capacity, of adequate and reliable observational data, hydro-informatics tools, and of trained human resources for holistic planning, utilization, and management.

Results and further steps

Case studies in literature indicate that the people in the rural areas of DR Congo perceive effects of climate change, notably by being exposed to fresh water access limitations (83% of the respondents) and hydro-meteorological natural disaster threats during the last 10 years (90%). Key climate risks of extreme rainfall, seasonal droughts, floods, heat waves and coastal erosion are all increasing to varying extents.

Subsequent phases in the project concern building of a consensus towards a new water law. The focus is on continued development of the Congo Decision Support System, with models for rainfall-runoff, routing, hydropower facilities and economics. It also includes flood and drought forecasting systems.

Groundwater, water quality and the impacts of agriculture developments and deforestation will be addressed later. In connection to all project phases specific capacity building needs have been identified.

Work initially focused on an inventory of available hydro-meteorological data, which are increasingly scarce, it should be definitively redirected to the use of satellite earth observation technology for water resource assessment for sustainable development. The purpose of the water resources assessment is to quantify the water resources, within the Congo River Basin. Outputs from the study will be an essential input for the pre-feasibility assessment and design of future development projects in the river basin as well as environmental studies



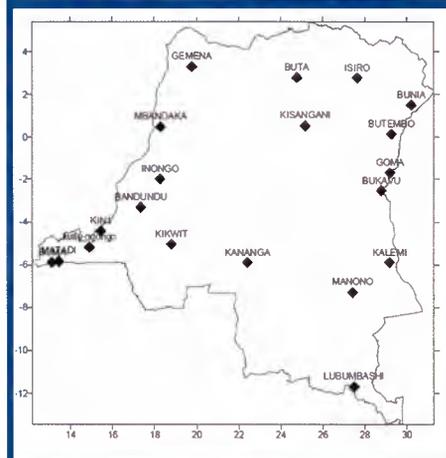
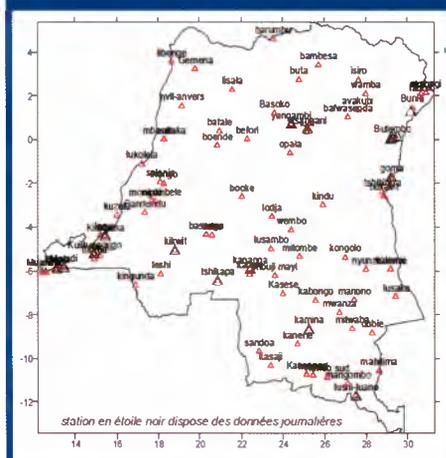
PI

Dr. Dieudonné Nsadisa Faka, Institut Supérieur de Techniques Appliquées (ISTA), DR Congo

Team

- Institut Supérieur de Techniques Appliquées (ISTA), DR Congo
- Ministry of Environment, Nature Conservation and Tourism, DR Congo
- Faculty of Engineering and Geosciences, Delft University of Technology (TUD-CITG), the Netherlands

Meteorological stations in the past (top) and present (bottom).



GROUNDWATER RESOURCE ASSESSMENT KENYA



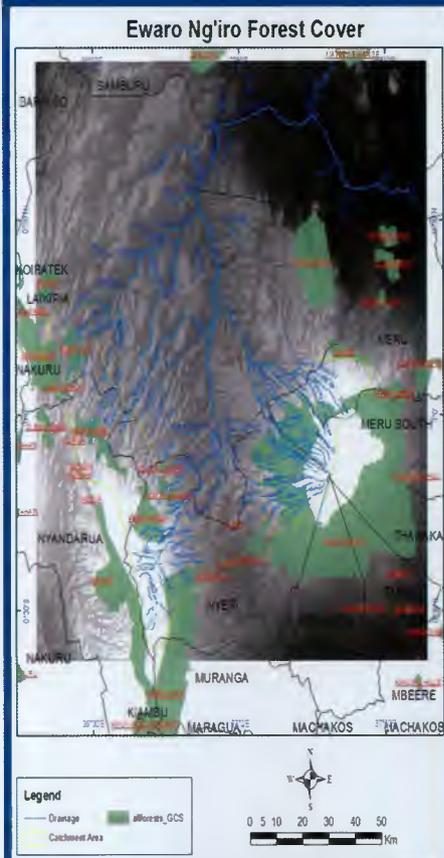
PI

Dr. John Nyoroge Kimani, National Space Secretariat (NSS), Kenya

Team

- National Space Secretariat (NSS), Kenya
- Water Resources Management Authority, Ewaso Ng'iro North Catchment Area (WRMA-ENNCA), Kenya
- Centre for Training and Integrated Research in ASAL Development (CETRAD), Kenya
- Regional Centre for Mapping of Resources for Development (RCMRD), Kenya
- University of Nairobi (UN), Kenya
- Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands

Thematic layers merged with DEM for the southern part of the catchment (Mount Kenya region)



Project

Groundwater resource assessment, development and monitoring, Kenya

Project Progress

The aim of this project is to identify the sustainable water sources and to develop capacity in using EO methods to achieve this objective.

The Ewaso Ng'iro North Catchment Area (ENNCA) was selected as the test area for the project. After a review of the research objectives, a work plan was made and the capacity gaps were identified.

The regional water cycle has been affected by human activities, which cause some severe eco-environmental issues, such as decline of ground water level, reduction of natural streams (lag-gas) and vanishing of wetlands. Severe vegetation degradation and desertification takes place due to human activities and water scarcity, increasing conflicts between people and between people and wildlife.

Results and further steps

Work is underway to use the available data sets and techniques to improve on the estimation of the Regional Water Balance in the ENNCA using SEBS. Data requirements were identified and the basic data (ENVISAT MERIS AND SAR) download has started.

As part of a project-oriented supervision, the technical leader of the project participated in the Hydro-Land course at ITC. Furthermore, project personnel joined the TCBF Training Courses to learn up-to-date RS techniques.

Further capacity building actions are planned, especially a dedicated training on the use of SAR data for surface water body mapping.

Sub-catchments of the ENNCA



WATER QUALITY MONITORING LAKE VICTORIA

Project

Development of an operational system for monitoring and predicting the aquatic plants proliferation in Lake Victoria, Kenya

Project Progress

This project aims to demonstrate the use of time series of multi-spectral satellite images to improve management of water bodies through the monitoring of the area covered by aquatic plants and optical remote sensing indicators of water quality. The approach has been demonstrated by a case-study on Lake Victoria. This lake is one of the largest freshwater bodies of the world where, during the last few years environmental challenges and human impact have perturbed the ecological balance affecting the biodiversity.

The approach includes:

- retrieval of the water compounds concentration by using an inversion technique of a physically based model of the radiative transfer equation for the water;
- estimate of the abundance of weed species using multispectral satellite images in combination with in-situ measurements of the spectral characteristics of the weeds;
- change detection analysis of time series of image data to evaluate the correlation of the area occupied by aquatic plants with observed water quality indicators.

The products, if provided with an appropriate time frequency, are useful to identify the preconditions for the occurrence of hazard events like abnormal macrophyte proliferation and to develop an up-to-date decision support system.

Results and further steps

MERIS FR data is suitable for monitoring aquatic plants in Lake Victoria because its spatial and spectral resolution is sufficient to obtain cover maps, useful in identifying vegetation infested areas. Spectral unmixing as a supervised classification technique is very suitable for application with relatively low spatial resolution multi-spectral data. Together with the image derived endmembers, the algorithm performed very well, producing a mean classification accuracy of 98.82% based on RMSE.

The results showed, for the Winam Gulf section, a generally increasing abundance which peaked at 146 km² in the year 2007 before decreasing again. It is evident from the cover maps that the Winam Gulf, which is highly eutrophicated, is prone to aquatic weed infestation.

There was very low relationship between vegetation abundance and TSM, Chl-a and rainfall. A linear relationship, however, exists between TSM and Chl-a, with correlation coefficient, $R_2 > 0.59$.



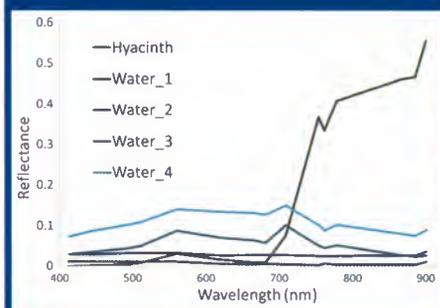
PI

Dr. Mito Collins Omulo - University of Nairobi, Department of Physics, Kenya

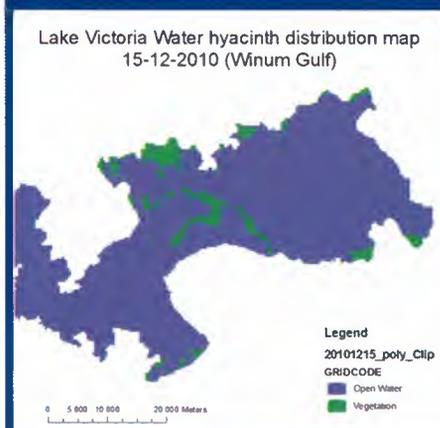
Team

- University of Nairobi, Department of Physics, Kenya
- National Environment Management Authority (NEMA), Kenya
- National Research Council - Institute for Environmental Analysis (CNR-IMAA), Italy
- National Research Council - Institute for Atmospheric Pollution (CNR-IAA), Italy
- University of Rome - Centro di Ricerca Progetto San Marco (CRPSM), Italy
- Faculty of Aerospace Engineering, Delft University of Technology (TUD), The Netherlands

Spectral end-members extracted from MERIS-FR data



Distribution of water hyacinth in the Winam Gulf of Lake Victoria on 15. December 2010



CAPACITY BUILDING ON INTEGRATED WATER RESOURCE MANAGEMENT, ZAMBIA



PI

Prof. Imasiku A. Nyambe, Integrated Water Resources Management Centre, School of Mines, University of Zambia (UNZA), Zambia

Team

- Integrated Water Resources Management Centre, School of Mines, University of Zambia (UNZA), Zambia
- Ministry of Water Affairs and Water Development (MEWD), Zambia
- Environmental Council of Zambia (ECZ), Zambia
- Geological Survey of Greenland and Denmark (GEUS), Denmark
- Danish Technical University (DTU), Denmark
- Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands

Project

Programme to Develop Capacity in IWRM in Zambia

Project Progress

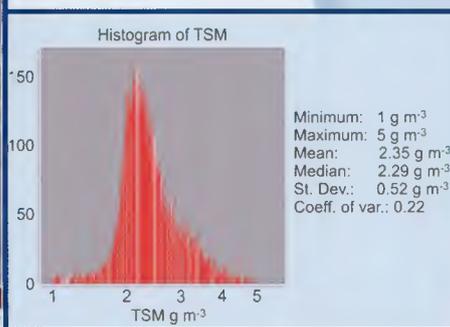
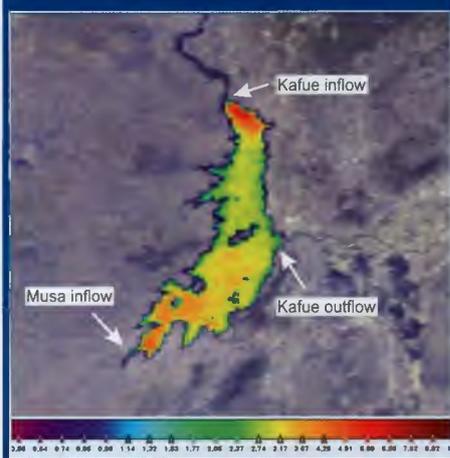
Since inception, the project has participated in two capacity building courses in Egypt and Kenya facilitated through TCBF and has been in consultation with ITC and GKSS on technical issues towards implementation. To date, the project has focused on large scale hydrological modelling with a bias towards derivation of bio-optical properties of large water bodies, e.g., in the case of the Itzhi-tezhi Dam in the Kafue River Basin of the Zambezi River. This dam contains a highly complex and dynamic pattern of various water masses originated from the mining region of the Copperbelt Province. The 65 m high dam at Itzhi-tezhi was completed in 1976 with a storage capacity of 5700 x 106 m³ of water at the full retention level of 1029.5 m a.s.l. covering a 370 km² area of the Kafue River and its tributary the Musa River (Obrdlink et al., 1989).

Results and further steps

A MERIS Full Resolution scene dated August 4, 2007, was processed with the software BEAM (version 1.4.1) for the analysis. The software is configured with a 'Case 2 Regional Algorithm (C2R)' plug in. The algorithm runs an inversion technique based on neural networks (NN) on a MERIS image to simultaneously retrieve case II water constituents from water colour data. The product (TSM map) of the C2R algorithm shows high concentration levels (≥ 2.17 g m⁻³) in the areas near to the Musa and Kafue inflow while the other area range from 1.32 – 2.17 g m⁻³. Unfortunately, there was no possibility to validate these results with field spectrometer readings.

The TIGER Capacity Building Facility contributes to the project through tailor-made project support. In the short term we plan to receive support with equipment (such as spectrometer) to help with further data collection in the field campaigns, further interactions with experienced research organisation/partners such as GKSS for improvement of the algorithm and to provide a forum to share experiences and challenges with the product. With the contribution from TIGER, the next steps are to develop a bio-optical model, strengthen existing partnership and knowledge transfer to other stakeholders in the project towards strengthening Integrated Water Resources Management (IWRM) in Zambia.

Spatial distribution of TSM (Total Suspended Matter) in the Itzhi-tezhi Dam waters based on a MERIS FR level 1b, August 4, 2007 image.



FLOOD MONITORING AND MANAGEMENT NAMIBIA

Project

New flooding patterns on the borders of Namibia

Project Progress

Exceptional floods occurred in Namibia in the last four years, causing emergency disaster conditions for 1/3 of Namibia's population, losses of lives, disruption of agriculture and economic activities as well as damage to infrastructure.

The objective of our project is to develop a flood management system for the Cuvelai catchments focusing on flood modelling and flood mapping using earth observation data and techniques.

The work consists of the following steps:

- Radar Flood Mapping
- Build a simple flood forecasting model that relates rainfall in Angola to the floods in the Cuvelai area
- Satellite based rainfall-runoff model for flood simulation
- Modelling of hydrological processes (LISFLOOD model)

Results and further steps

The LISFLOOD model was set up for the Cuvelai catchment. The model was chosen because of its proven ability to forecast floods over larger spatial domains and since the model allows for assessing effects of land cover changes, effects by climate change, etc.

An MSc thesis was written (Mabande, P.K.-2011, Application of a satellite based rainfall - runoff model for large scale flood simulation: a case study of Cuvelai basin in Namibia. Enschede, ITC, 2011.)

Further steps are:

- Acquisition and processing of satellite data to parameterize the distributed runoff/flood model and then evaluate and validate the capacity of the model to predict and forecast runoff/flood events.
- Obtain and process the ALOS PRISM 2.5 m resolution imagery from ESA and create a high resolution DEM.
- Downscaling LISFLOOD model to finer resolution DEM generated from 2.5 m ALOS PRISM data and short duration rainfall satellite imagery data.
- Acquisition of ground observation data for model validation and calibration.



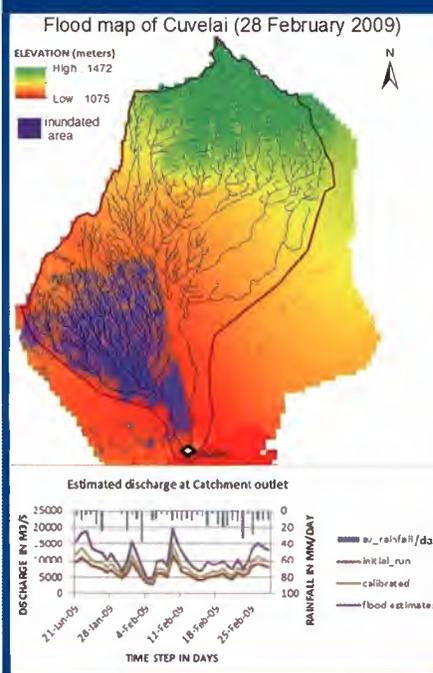
PI

Pauline Mufeti, Namibia Hydrological Services (NHS), Namibia

Team

- Namibia Hydrological Services (NHS), Namibia
- Resource Management, Ministry of Agriculture, Water and Forestry, Namibia
- Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands

Preliminary modelling result



IMPACT OF CLIMATE CHANGE ON BIOMASS MADAGASCAR



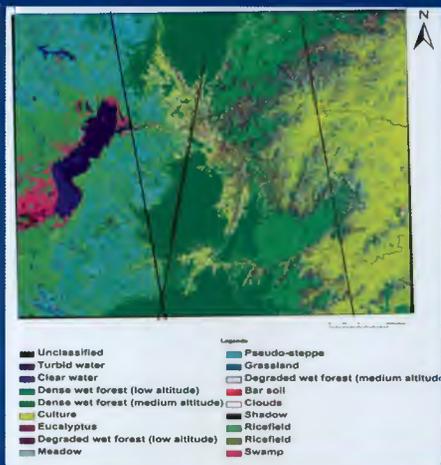
PI

Professor Solofo Rakotondraompiana, University of Antananarivo - Institute & Observatory of Geophysics Antananarivo (I.O.G.A), Madagascar.

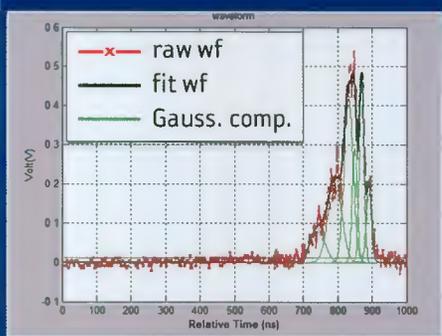
Team

- Observatory of Geophysics Antananarivo (I.O.G.A), University of Antananarivo, Madagascar.
- Faculty of Aerospace Engineering, Delft University of Technology (TUD-LR), The Netherlands.

ICESAT / GLAS data locations (diagonal lines formed by many data points) with a land cover map of Zahamena area as background. Each point matches waveforms and Gaussian distributions.



Example of curves showing waveforms (raw waveform in red and fitting waveform in black) and the corresponding Gaussian distributions (in green) for one point of the ICESAT / GLAS data.



Project

Biomass evaluation of tropical dry and wet forests. Climate change impacts

Project Progress

Both tropical wet and dry forests of Madagascar are affected by climate change. This project aims at developing methods for assessing these changes using remote sensing methods.

There are two study areas of the project: Zahamena in the north-eastern part of Madagascar, covered with tropical wet forests, and Anosy, in the southern part of the island, covered with tropical dry forests.

We estimate the forest biomass using a wide range of remote sensing data (Optical, RADAR and LiDAR data). The change in biomass is then related to forest degradation / deforestation and climate change.

The following RS data types were used: Landsat ETM+, SPOT 5, LiDAR data (ICESAT / GLAS), ALOS AVNIR-2, PRISM and PALSAR.

Three parameters can characterize the forest biomass such as surface, density and height.

- The forest was mapped by supervised classification of optical images. For selecting the optimal one, we compare a series of different algorithms (Maximum Likelihood, SVM, k-NN, ICM, object-oriented...)
- The forest density is determined by backscatter coefficients from the ALOS PALSAR data. In addition, this data is used to improve the forest land cover mapping.
- The GLAS data (LiDAR) are used to estimate forest heights. The raw data were transformed and processed to obtain the waveforms and the fitting Gaussian distributions.

Based on multitemporal mapping of the above parameters, changes in the biomass are quantified.

Contribution of the TIGER Capacity Building Facility to our project:

- Project staff members participated in the TCBF training courses.
- A research stay in LiDAR data processing took place at TU Delft. It helps us to estimate forest height.
- Project-oriented supervision helped in the use of RADAR data and processing software on biomass estimation. Furthermore, an identification of best products (SPOT 5 and ALOS PALSAR images) over our study areas was also realized with EOLI-SA.

Results and Further Steps

Land cover classifications were made with images of different spatial and spectral resolutions. Improvements were achieved with object-oriented methods. First estimates of biomass were made by correlating LAI and field measurements for different land cover types. Several MSc theses document the intermediate results, and further MSc and PhD research work is in progress on:

- Determination of forest density by the backscatter coefficient from ALOS PALSAR data and improvement of the forest land cover mapping.
- Determination of forest height using the waveforms.
- Determination of an appropriate change detection method to map forest land cover and biomass values changes.

WATER QUALITY MONITORING SOUTH AFRICA

Project

Satellite monitoring of inland and near coastal water quality in southern Africa

Project Progress

Societal growth and demand on water resources have resulted in increased eutrophication and pollution, often resulting in harmful algal blooms. Toxins produced by cyanobacterial algal blooms are found in many of South Africa's freshwater systems, and are a threat to public and ecosystem health. There is an increasing need for routine observations of water quality, allowing improvement of knowledge and risk management and quantitative assessment of the extent of eutrophication. There is currently insufficient knowledge and information on the status and trends of water quality and eutrophication and substantial gaps in available data archives. Remote sensing can play a crucial role in determining water quality status across many water bodies in a cost-effective and routine manner; with an ability to make a considerable contribution to both operational monitoring systems, and ecosystem research.

Results and further steps

Near real-time trophic status monitoring products for a selection of South African reservoirs are now available using data from the Medium Resolution Imaging Spectrometer (MERIS) via the ESA Data Dissemination System, and systematic data processing chains developed at the MRSU (see <http://www.afro-sea.org.za/php/damSearch.php>). The initial selection of reservoirs includes Loskop, Hartbeespoort, Vaal, Boskop, Theewaterskloof, Midmar, Vanderkloof, and Bronkhorstspruit dams. The products provide information on the trophic status (the concentration of chlorophyll-a) of the reservoirs and the occurrence of cyanobacteria-dominant algal blooms through utilizing novel algorithms derived from data collected in situ at various inland and near-coastal South African study areas (Matthews et al 2012, submitted). The project partnership's with TIGER has made a significant contribution towards the realisation of a South African satellite-based eutrophication monitoring system. It is hoped that these products, available free of charge, will provide a wealth of information for commercial and recreational users on the status, trends and extent of eutrophication and cyanobacterial blooms in South African inland water reservoirs.

Through research directed towards the development of local in situ monitoring systems and earth observation products, continued progress is being made towards a South African national operational near real-time satellite eutrophication and cyanobacterial bloom monitoring system by the CSIR and the MRSU. Full utilization of the downstream benefits of these products is yet to be made. They have the capacity to make a significant contribution towards decision making tools for national and local governments and water institutions. Continued partnership with the European Space Agency and projects such as TIGER will enable the full realisation of these project objectives.



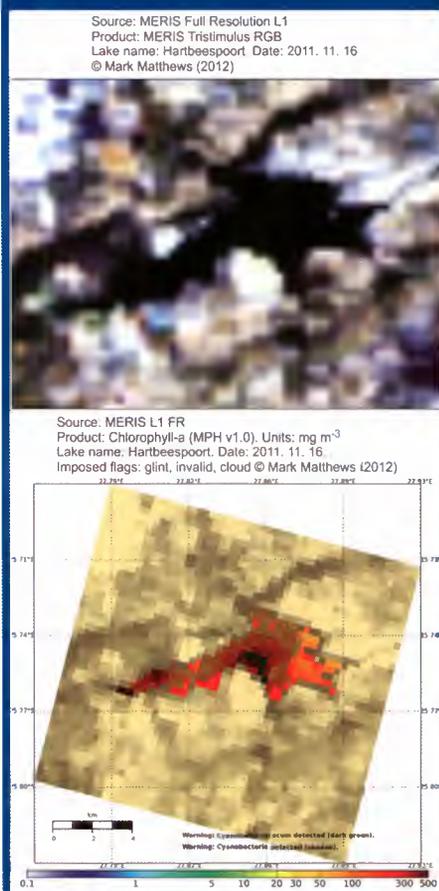
PI

Mark Matthews, Marine Remote Sensing Unit, University of Cape Town (UCT-MRSU), South Africa

Team

- Council for Scientific and Industrial Research: Natural Resources and the Environment (CSIR-NRE), South Africa
- Council for Scientific and Industrial Research: Centre for High Performance Computing (CSIR-CHPC), South Africa
- University of Cape Town, Marine Remote Sensing Unit (UCT-MRSU), South Africa
- Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands

Comparison between corrected MERIS FR reflectance at two locations, measured in situ using the Tethered Spectral Radiometer Buoy (TSRB)



PRE-OPERATIONAL PROJECTS

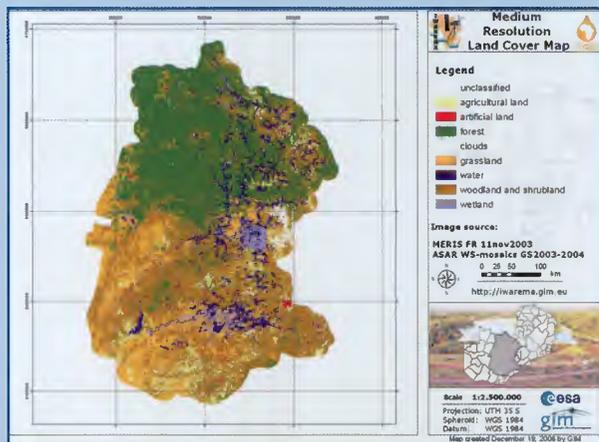
During the first phase of TIGER, several pre-operational projects were run, aiming to prototype and demonstrate products and services for African stakeholders with an institutional role in water management. Projects were run in collaboration with water authorities and a number of technical consortia involving European and Canadian value adding companies. EO techniques and methods are adapted to the real institutional, human and technical local conditions of different areas in Africa, so that they can be easily transferred to the user or to local service providers (e.g., technical centres) for operations after the project lifetime.

Interaction with stakeholders led to the creation of a portfolio of services and products customised for the final users focussing on different aspects of IWRM and water cycle:

- ◆ Catchments characterization and base mapping,
- ◆ Water quality monitoring,
- ◆ Soil moisture and water levels information services,
- ◆ Support to ground water management and exploration,
- ◆ Water infrastructure monitoring.

The overall economic investment spent in this effort by ESA and CSA has been more than 10 Millions of Euro.

Landcover map of the Kafue River Basin produced by the IWAREMA project



Catchments characterisation and base-mapping

Basin authorities have, generally, the legal responsibility to ensure the public character of the water resources and to mitigate uncertainties, vulnerabilities and risks inherent in the exploitation of water hydro resources. The interrelations between different territorial activities have the result that any considerable land-use change can impact the management and the availability of the water. This in turn may affect the production of goods and services and the prosperity of the population. Accurate solutions are needed by decision-makers to tackle increasing water demand to satisfy the regular consumption of the population and, for instance, irrigation or industrial production needs. EO data may support activities such as improved location and definition of areas subject to water use for irrigation, better detection of illicit abstraction, derivation of up-to-date information on surface water bodies and wetlands (which may act as recharge areas of aquifers) or monitoring of soil deterioration and evolution of the agricultural sector. Amongst others,

management of water supplies for irrigation is one of the most critical problems due to the amount of information needed: eg crop types, irrigation status and inventories of irrigated cropland.

Up to date information about land cover, land use, vegetation status and seasonal changes help understanding and modelling hydrological processes such as infiltration, runoff and evapotranspiration. Time series analysis may allow mapping effects of climate change as well as overexploitation (e.g. desertification, disappearance of vegetation or wetlands).

Products derived from EO have the potential to be used for IWRM as well as in transboundary consultations as a tool to promote transparency and for treaty monitoring. Within the framework of the various pre-operational projects, maps at different times of large areas of territory otherwise inaccessible are produced at various scales (from 1:250,000,000 to 1:50,000). Reported accuracies vary depending on source data, but up to 96% thematic accuracy has been reported according to validation results. Depending on the user requirements, end products vary between maps, GIS layers or information bulletins.

Water quality monitoring

Water authorities routinely need water quality information in order to tackle actions related to prevention (identification of pollution sources, eutrophication...), mitigation and monitoring of the effectiveness of corrective actions. Water quality management is crucial to satisfy a variety of different, and often competing, domestic, agricultural and industrial uses of different riparian countries. EO-based water quality products represent an up-scaling in space and time of the conventional field measurements and may capture the spatio-temporal variability of critical lake water quality parameters more accurately than the current monitoring programs. Information about water quality parameters such as turbidity, chlorophyll-a concentration, suspended sediment concentration, water plants (hyacinth) and temperature was derived from EO over different African lakes. Availability of in situ acquisitions simultaneous to EO acquisitions to calibrate and validate the retrieval algorithm is essential.

Soil moisture and water levels information services

Despite holding only a small percentage of the total global water budget, soil moisture plays an important role in the global water cycle. Soil moisture is used in the estimation of drought, to determine flooding “hot-spots” as an input for crop yield monitoring, for flux and hydrological modelling and climate change assessment. Availability of reliable and



Monthly mean of soil moisture (January 2010 and January 2011) generated by the SHARE project

PRE-OPERATIONAL PROJECTS

frequent soil moisture data on a dynamic basis is essential for hydrometeorological applications and is an issue for weather and agricultural services.

More than 2500 experimental soil moisture maps have been derived by the SHARE project (<http://www.ipf.tuwien.ac.at/radar/share/>) from ENVISAT Global Mode data and are available to interested users via the internet. The core product is a 1 km resolution soil moisture map based on a change detection approach showing soil moisture changes of the topmost soil layer with an update frequency of two weeks.

Information about changes in water volumes (discharge rate) is needed for flooding hazard, water and food resource management, assessment of the impact of land use and studies of the hydrological cycle. For instance lake volumes may respond to changes in precipitation integrated over their catchments basins and so can act as important, though indirect indicators of climate change on both regional and global scales. However for certain major rivers and wetlands, hydrological information can often be difficult to obtain due to the inaccessibility of the region, the sparse distribution of in-situ gauge stations, or the slow dissemination of data. This is specially true for Africa, where an additional 90% decline in the amount of infrastructure at water stations has been reported.

The ESA River and Lake Project (<http://earth.esa.int/riverandlake>) provides the scientific community with easy-to-use, effective and accurate river and lake height measurements, worldwide, by exploiting satellite altimeter data. In Africa these data are being used to constrain regional scale hydrological models of main river basins (e.g. Zambesi): water levels simulated by the hydrological model may be compared with water level heights retrieved from EO data.

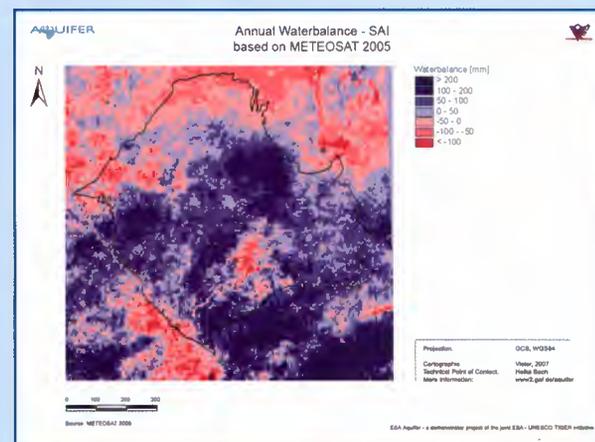
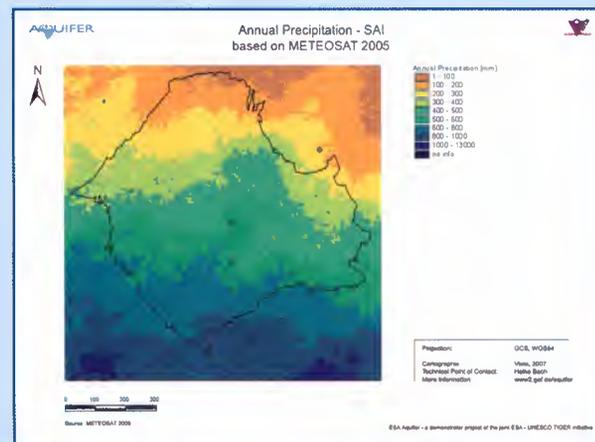
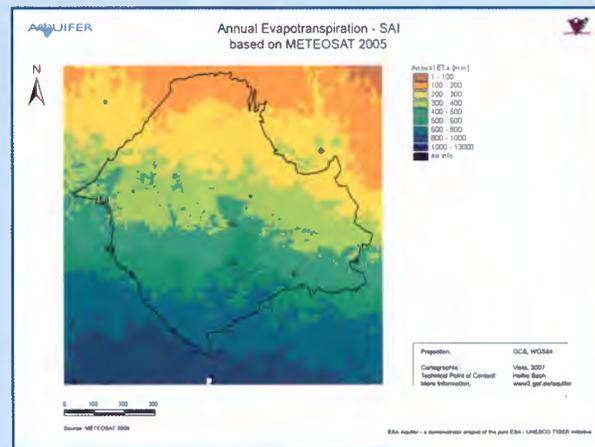
Support to ground water management and exploration

Information about groundwater is needed to strengthen the capability of National authorities and international institutions in trans-boundary aquifer management. The critical management challenges to be faced are the vulnerability to groundwater drawdown, salt water intrusions, water quality deterioration, changes in water levels and land degradation, identification of areas suitable to groundwater extraction, effective infiltration and overall water balance... Satellite observations are limited to the retrieval of surface information, therefore can not be used directly to assess groundwater. However EO-derived information, jointly with in situ observations can be used to identify/estimate parameters (open water extension and dynamics, geological settings and fault lines as potential aquifer recharge areas, crop water consumption, location of wells, precipitation distribution, evapotranspiration...) which may support the management of aquifers.

Water infrastructure monitoring

Dams and water infrastructures may be used for hydropower generation, allow all-year-round irrigated agriculture, cattle breeding and reduce the risk of domestic and drinking water shortage. In order to manage the water effectively for competing uses and to steer reservoir development, the actual distribution, storage and conditions of these reservoirs need to be known and regularly monitored. The efficient management and use of the water stored in reservoirs has a socio-economic impact on the livelihoods of the

Precipitation retrieved from meteorological satellites, evapotranspiration mapped by using satellite data as input to energy balance modelling and the water balance resulting from the comparison of the two parameters. Data processed by the Aquifer project over the SAI (Système d'Aquifères d'Iullemeden) aquifer



inhabitants using the infrastructure. One of the key elements in managing scarce resources is to determine the availability and demand for the resource so as to allocate it efficiently and effectively in space and time. For instance, EO data can be used for planning of the demand for the irrigation or as a contributor in the analysis of elements influencing the hydrological balance (e.g. morphology, vegetation, land-use, land cover changes).

PRE-OPERATIONAL PROJECTS

TIGER-NET

The concept of Integrated Water Resource Management (IWRM) is seen as an opportunity to mitigate the wide spread water scarcity in Africa. One blocking key component of IWRM in Africa is the limited knowledge of the available extent and quality of water resources at basin level. Earth Observation (EO) technology can help to fill this gap by assessing and monitoring water resources at the regional scale. Within the TIGER initiative a whole portfolio of EO products relevant to IWRM, such as water reservoir inventory or catchment characterization - has been developed and demonstrated in dedicated projects. Furthermore the wide spatial coverage of satellite images has proven to be of specific relevance for trans-boundary basins where consistent information between countries is needed for sustainable water resource management.



In response to the information needs for IWRM in Africa, a new component, the TIGER-NET project, has been introduced to the ESA TIGER initiative. TIGER-NET is launched officially at the 6th World Water Forum in March 2012 and will run for 3 years with a total budget of 1.5 M euro. The TIGER-NET project has two main

objectives in order to support the assessment and monitoring of water resources from watershed to cross-border basin level delivering indispensable information for IWRM:

- 1 Development of pre-operational Water Observation and Information Systems for monitoring, assessing and inventorying water resources in a cost-effective manner by EO data;
- 2 Capacity building and training of African water authorities and technical centers to fully exploit the increasing observation capacity offered by the next generation of satellites, including the Sentinel missions.

REQUIREMENTS
ENGINEERING

WOIS DEVELOPMENT
& VALIDATION

WOIS INSTALLATION
& DEMONSTRATION

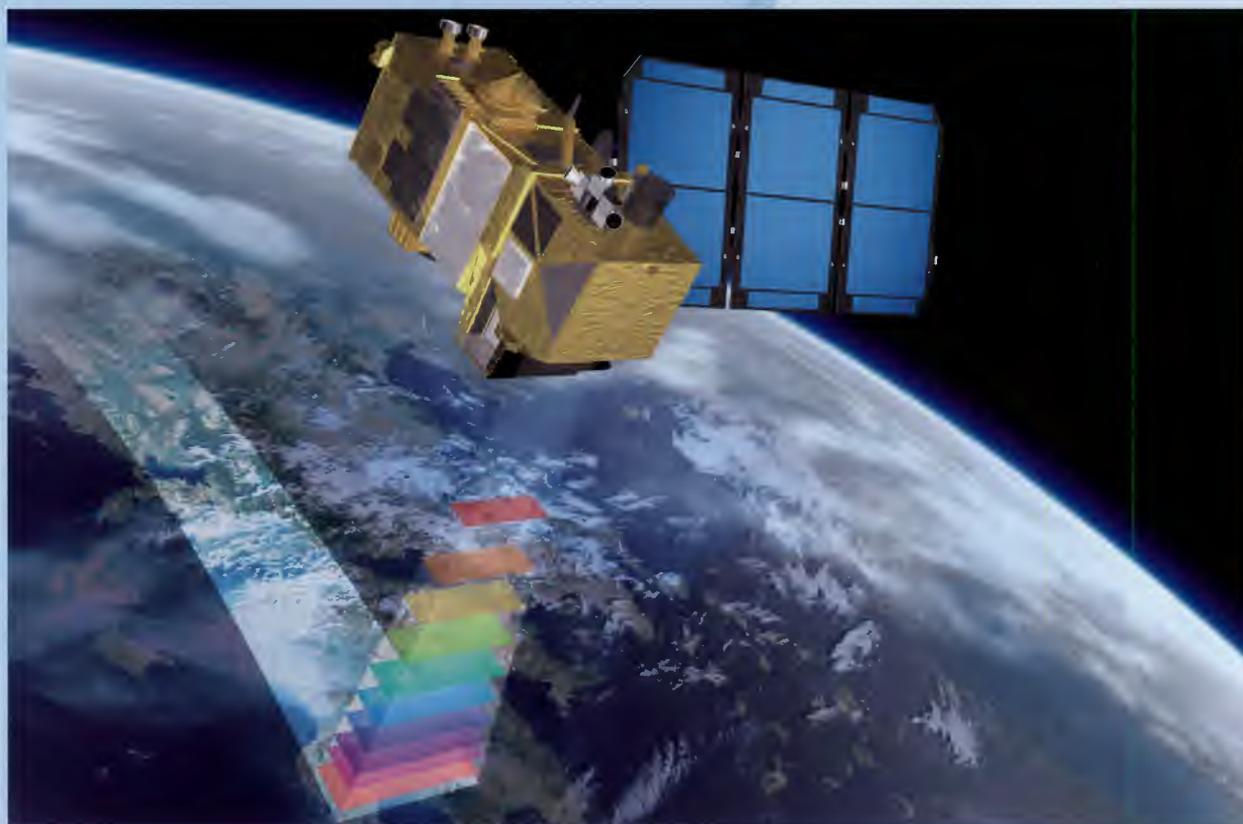
TIGER-NET is organized in three main tasks, which will demonstrate the Water Observation Information System (WOIS) to each selected water authority.

Within the TIGER-NET project EO applications, necessary EO data access and processing facilities will be developed and installed initially at the following five African water authorities to support their IWRM activities:

- Nile Basin Initiative
- Lake Chad Basin Commission
- Volta Basin Authority
- Department of Water Affairs and Forestry, South Africa
- Ministry of Agriculture, Water and Forestry, Republic of Namibia.

The resulting practices and tools, such as the freely available Water Observation Information System, will assist African institutions to build up necessary local capacity to access and exploit satellite observations for monitoring and management of water resources. The open availability of Sentinel data will make an essential difference to African water authorities supporting planning and decision making in their IWRM processes.

Sentinel-2 the operational GMES optical high resolution land mission



PARTICIPANT ORGANISATION

AFRICAN PARTNERS AND BENEFICIARIES

Agence du Bassin Hydraulique du Sebou (ABHS)	Morocco
Agence Nationale des Ressources Hydrauliques (ANRH)	Algeria
AGRHYMET	Niger
Agricultural Research Council	South Africa
Association de Recherche sur Le Climat et L'Environnement	Algeria
Biodiversity Planning Department of Environmental Affairs and Tourism (DEAT)	South Africa
Botswana College of Agriculture	Botswana
Centre de Suivi Ecologique (CSE)	Sénégal
Centre for Training and Integrated Research in ASAL Development (CETRAD)	Kenya
Centre National de Télédétection (CNT)	Tunisia
Centre National des Techniques Spatiales (CNTS)	Algeria
Centre Royal de Télédétection Spatiale (CRTS)	Morocco
Centro Nacional de Cartografia e Teledeteccão (CENACARTA)	Mozambique
Chad Basin Development Authority	Nigeria
Cheikh Anta Diop University (UCAD)	Senegal
Chouaïb Doukkali University (UCD)	Morocco
Council for Geoscience	South Africa
Council for Scientific and Industrial Research	South Africa
CSIR Water Research Institute (CSIR-WRI)	Ghana
Department of Civil Engineering, KNUST	Ghana
Department of Water Affairs (DWA)	South Africa
Desert Research Foundation of Namibia	Namibia
Direction Générale des Ressources en Eau (DGRE)	Burkina Faso
Direction Nationale de l'Hydraulique (DNH)	Mali
Directorate of Water Development	Uganda
Drainage Research Institute	Egypt
École Nationale d'Ingénieurs (ENI)	Mali
Ecological Surveying Centre (CSE)	Senegal
Egyptian Environmental Affairs Agency, Nature Conservation Sector	Egypt
Environment and Climate Research Institute (ECRI)	Egypt
Environmental Council of Zambia (ECZ)	Zambia
Federal Ministry of Water Resources (FMWR)	Nigeria
Federal University of Technology	Nigeria
Gender and Water Alliance (GWA)	Lybia
Guiers Lake Water Authority (OLAG)	Senegal
GWI/IUCN-Programme	Burkina Faso
Institut Agronomique et Vétérinaire (IAV)	Morocco
Institut Géographique du Burkina Faso (IGB)	Burkina Faso
Institut National de l'Environnement et des Recherches Agricoles (INERA)	Burkina Faso
Institut Supérieur de Techniques Appliquées (ISTA)	DR Congo
Institute & Observatory of Geophysics Antananarivo, University of Antananarivo (I.O.G.A)	Madagascar
Institute of Scientific and Technological Research (IRST)	Rwanda
Integrated Water Resources Management Centre, School of Mines, University of Zambia (UNZA)	Zambia
International Livestock Research Institute	Kenya
Intervenir pour le Développement Ecologique de l'Environnement en Casamance	Senegal
Kano University of Science and Technology	Nigeria
Kenya Medical Research Institute (KEMRI)	Kenya
Kenya Wildlife Service, Wetlands Programme	Kenya
Kinshasa University (UNIKIN)	DR Congo
Kuiseb Basin Management Committee	Namibia

PARTICIPANT ORGANISATION

Kwame Nkrumah University Of Science & Technology (KNUST)	Ghana
Laboratory of Physical Atmosphere and Ocean Simoen Fongung (LPAO-SF)	Senegal
Lake Chad Basin Commission	Cameroon, Niger, Nigeria, Chad and Central South African Republic
Lake Chad Research Institute	Nigeria
Lake Victoria Fisheries Organization (LVFO)	Uganda
Libyan Center For Remote Sensing and Space Science (LCRSSS)	Libya
Makerere University (MU)	Uganda
Mekelle University	Ethiopia
Ministère de l'Hydraulique, de l'Environnement et de la Lutte Contre la Désertification	Niger
Ministère de l'Eau, Direction Générale des Inventaires et des Ressources Hydrauliques (DGIRH)	Burkina Faso
Ministry of Agriculture and Cooperatives, Department of Agriculture	Zambia
Ministry of Agriculture and Fisheries, Directorate General of Forests	Algeria
Ministry of Agriculture, Water and Rural Development	Namibia
Ministry of Energy and Water	R Congo
Ministry of Energy and Water Development, Department of Water Affairs	Zambia
Ministry of Environment	Niger
Ministry of Environment, Nature Conservation and Tourism	DR Congo
Ministry of Health	Kenya
Ministry of Local Government and Housing, Department of Infrastructure and Support Services	Zambia
Ministry of Mining, Energy and Water	Mali
Ministry of Water Affairs and Water Development (MEWD)	Zambia
Ministry of Water Affairs and Forestry	South Africa
Ministry of Works and Housing	Ghana
Namibia Hydrological Services (NHS)	Namibia
National Environment Management Authority (NEMA)	Kenya
National Fisheries Resources Research Institute (NAFIRRI)	Uganda
National Space Secretariat (NSS)	Kenya
National Water Authority (EPT)	Senegal
Nile Basin Capacity Building Network Secretariat (NBCBN)	Egypt
Nile Basin Initiative (NBI) based in Entebbe	Uganda
Nile Research Institute, National Water Research Centre (NRI)	Egypt
Nile Transboundary Environmental Action Project (NTEAP) based in Khartoum	Sudan
Observatoire du Sahara et du Sahel (OSS)	Tunisia
Office National de Mise en Valeur Agricole de Doukkala (ORMAVAD)	Morocco
PAGEV IUCN	Burkina Faso
Polytechnical High School (EPT)	Senegal
Programme d'Action Communautaire (PAC)	Niger
Programme National de Gestion intégrée de l'Information sur le Milieu (PNGIM)	Burkina Faso
Programme Nationale de la Gestion du Terroir 2 (PNGT2)	Burkina Faso
Regional Centre for Mapping of Resources for Development (RCMRD)	Kenya
Resource Management, Ministry of Agriculture, Water and Forestry	Namibia
Senegal River Water Authority (OMVS)	Senegal
Sous-Massa Watershed Authority	Morocco
South African National Space Agency (SANSA)	South Africa
South African Weather Service	South Africa
Southern African Development Community (SADC) Regional Remote Sensing Unit	Botswana
Station Géophysique de Lamto	Ivory Coast
Survey Research Institute	Egypt
The World Conservation Union- IUCN Mozambique Office	Mozambique
The World Conservation Union- IUCN West Africa office	Mali
UNESCO Chair in Water Resources	Sudan

PARTICIPANT ORGANISATION

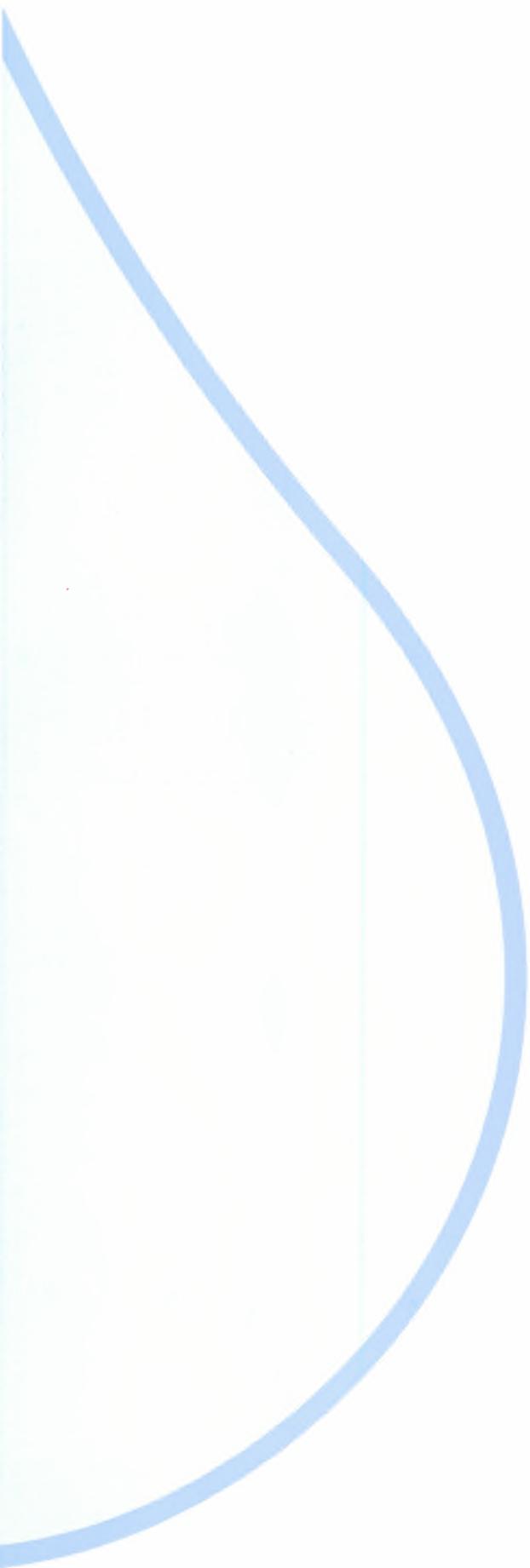
Université Chauib Doukkali	Morocco
Université Cheikh Anta Diop	Senegal
Université d'Abobo-Adjamé, UFR des Sciences et Gestion de l'Environnement (UAA)	Ivory Coast
Université d'Antananarivo, Institut et Observatoire de Géophysique d'Antananarivo	Madagascar
Université de Bamako, FAST (DER Sciences de la Terre)	Mali
Université de Cocody, Centre Universitaire de Recherche et d'Application en Télédétection (CURAT)	Ivory Coast
Université de Dschang	Cameroon
Université de Yaoundé I	Cameroon
University of Cape Town, Marine Remote Sensing Unit (UCT-MRSU)	South Africa
University of Dar es Salaam (UDSM)	Tanzania
University of Ghana (UG)	Ghana
University of Ghana Center for Geographic Information Systems (CERGIS)	Ghana
University of KwaZulu-Natal	South Africa
University of Maiduguri	Nigeria
University of Malawi	Malawi
University of Nairobi (UN)	Kenya
University of Pretoria South	South Africa
University of the Western Cape	South Africa
University of Zambia	Zambia
University of Zululand	South Africa
Water Research Commission (WRC)	South Africa
Water Resources Commission (WRC)	Ghana
Water Resources Directorate	Ivory Coast
Water Resources Management Authority, Ewaso Ng'iro North Catchment Area (WRMA-ENNCA)	Kenya
World Vision	Ghana

NON AFRICAN PARTNERS

Advanced Computer Systems SpA	Italy
C-Core	Canada
Danish Technical University (DTU)	Denmark
De Montfort University	United Kingdom
Durham University (DU)	Great Britain
Faculty of AeroSpace Engineering, Delft University of Technology (TUD-LR)	Netherlands
Faculty of Engineering and Geosciences, Delft University of Technology (TUD-CiTG)	Netherlands
Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC)	Netherlands
FAO	Italy
Finnish Environment Institute	Finland
Flemish Institute for Technological Research (VITO)	Belgium
Food and Agriculture Organization of the United Nations (FAO)	Italy
GAF AG	Germany
Gartner Lee Limited	Canada
Geographic Information Management n.v.	Belgium
Geoimage Solutions Inc.	Canada
Geological Survey of Greenland and Denmark (GEUS)	Denmark
German Aerospace Research Center	Germany
Golder Associates	Canada
Hatfield Consultants Ltd	Canada
Hegyí Geomatics International	Canada

PARTICIPANT ORGANISATION

Higher Institute of Statistics and Information Management - New University of Lisbon (ISEGI-UNL)	Portugal
Info-Electronics Systems Inc.	Canada
Institut Francilien des Sciences Appliquées (IFSA)	France
Joanneum Research	Austria
Marne la Vallée University (UMLV)	France
National Research Council - Institute for Atmospheric Pollution (CNR-IIA)	Italy
National Research Council - Institute for Environmental Analysis (CNR-IMAA)	Italy
Newfoundland and Labrador Department of Environment and Conservation	Canada
Noetix Research Inc.	Canada
Ohio Valley University (OVU)	USA
PiLDo Labs	Spain
Remote Sensing Solutions GmbH	Germany
SCOT S.A.	France
Strata360	Canada
SwedPower	Sweden
Swiss Federal Institute	Switzerland
Telespazio Spa	Italy
Texas A&M University	United States
TheWorld Conservation Union- IUCN Canada Office	Canada
UNESCO Institute for Water Education, (UNESCO-IHE)	Netherlands
Université de Liege	Belgium
Université du Québec à Montréal	Canada
Université Paris-Est Marne la Vallée (UPEMLV)	France
University Jena	Germany
University of Rome - Centro di Ricerca Progetto San Marco (CRPSM)	Italy
University of Sherbrooke	Canada
University of Tuebingen	Germany
Vexcel Canada	Canada
Vexcel Netherlands	Netherlands
VIASAT GeoTechnologies Inc.	Canada
Vienna University of Technology	Austria
VISTA GmbH	Germany
Wetlands International	Netherlands



In collaboration with:

African Ministerial Council On Water

African Water Facility

Canadian Space Agency

CEOS

Department of Water and Forestry, South Africa

Ramsar Secretariat

UN-ECA

UNESCO-IHP

info

www.tiger.esa.int

www.asc-csa.gc.ca/eng/satellites/tiger.asp



Cover image:

Conakry - Guinea | ENVISAT, ASAR [2-Aug-2003]