United Nations/Austria/European Space Agency Symposium on
Space Applications for Sustainable Development to Support the Plan of Implementation of the World Summit on Sustainable Development

"Water for the World: Space Solutions for Water Management"
(Graz, Austria, 13-16 September 2004)

REPORT BY THE CHAIRPERSON

"Providing Critical Information in a Timely Manner to Decision Makers"
Chairperson: Professor J. Ortner (Austria)
Presented by: S. Hughes (South Africa)

Introduction

Information is the life-blood of Integrated Water Resource Management (IWRM). Without information planners and decision makers are incapacitated and unable to correctly manage the resources they are custodians of. The provision of appropriate Earth observation (EO) derived data, information, tools and solutions to water resource management institutions could lead to their empowerment and ultimately contribute to the Millennium Development Goals of sustainable development and poverty alleviation.

Satellite Communication in support of water resource management

Dr. Koudelka (Austria) presented a series of options for data transfer using different space based technologies. Options presented were appropriate for different applications (depending on their features, applications & needs). They offered some very practical tried and tested methods for data transfer. There are a range of costs involved with these technologies which will ultimately determine their applicability in a development context.

Communication satellites provide interconnection of remote areas with management centres by means of voice (telephony) and video (video conference) communications, and data transmission (Intranet/Internet, database access). These services are provided by a variety of space based solutions:

1. Satellite voice connection can be provided by Thuraya, Globalstar and Inmarsat. Inmarsat can also provide data transmission services at 256 kbit/s. Thuraya covers most of Europe, Asia and Africa. Globastar covers all of Americas, Europe, Middle East, Australia, some African and most of Asian countries. Inmarsat covers all of the continents, with the exception of some areas in the extreme North and Antarctica.

2. Low Earth orbit constellations such as "ORBCOM" offer the option for reducing costs associated with data transfer using the "store and forward principle". The data is uploaded over sender's country, the data is stored until it reaches the destination country, where it transmits the data to a receiving station. This is not a real time data transfer, but much more cost effective.

3. Another solution for data transmission is the use of VSATs. They provide high data transmission rates at several Mbits/s applying proven technology operating through "mesh and star" networks. VSATs can be serviced by ARABSAT and EUTELSAT using both stationary and mobile receiving equipment and stations. However, the cost of setting up this system can be high.

4. A cheaper solution for data transmission is SIT terminals. The dish of the antenna can be as small as 75 cm in diameter. The station can cost approximately $1.500. Such terminals are

suitable for high-speed data transmission (including remote sensing data), Intranet/Internet access and data collection. At the same time, direct terminal-to-terminal communications are limited due to the necessity of performing a “double-hop” between orbiting satellites in space to make the connection. This technology can be used on-board aircraft for a “switching in the sky” mode. This network can currently be serviced by HISPASAT AMAZONAS satellite (South American coverage). Another system that can be used is DVB technology, which could be used to transfer processed images such as ENVISAT data.

There are some limitations in the technologies, mainly related to temporal scale. No reference was made to durability in conditions outside of Europe.

Remote sensing of critical hydrological parameters: soil moisture, topography & vegetation
Dr. K. Scipal (Austria) presented Spatial information on water resources and catchment hydrology crucial for the efficient management and use of water resources. This is particularly relevant for food production, particularly in dry environments. He focused on three key parameters of water resource management and how EO and space-based sensors can contribute to the development of sustainable data and information sources for these parameters:

1. Topography – The role of topographic data in water resource management is key for understanding drainage, run-off and groundwater. LIDAR and Inferrometry from Synthetic Aperture Radar (SAR) and the Shuttle Radar Topography Mission (SRTM) were presented. Filtered LIDAR provides a very detailed data set for sub-metre accuracy elevation data. However, huge data volumes and specialised techniques are required to process the data to achieve meaningful results.

2. Vegetation – A good understanding of vegetation is vital to be able to effectively model hydrological conditions. In addition to traditional optical EO techniques, raw LIDAR data can be filtered to extract vegetation canopy and texture. SAR can also be used to derive vegetation parameters.

3. Soil Moisture – A significant amount of progress has been made in recent years on reliable measurement of soil moisture from space. Functional methods are based on SAR methodologies including ERS 1 & 2, Radarsat and ASAR. These results were achieved with sensors not designed for this application. Dedicated future soil moisture missions include SMOS, HYDROS (experimental), METEOP and AMSR (operational).

These applications must be integrated with in-situ measurements and modelling to extract meaningful results. Not all remote sensing techniques for measuring these three parameters are equally successful and not all are affordable by developing countries. Very few projects make jump from projects and pilots to operational implementation.

GMES – *Global Monitoring for the Environment and Security*
Dr. S. Briggs (ESA)
Initiated in 1998, this *service oriented* programme is designed for EO to support European Policy & Implementation. It is based on the integration of EO with ground measurements & socio-economic data. The fundamental concept is: accurate, consistent and wide-reaching monitoring assessment and forecasting can be achieved through models and data assimilation. A wide variety of service and application concepts and examples were presented:

- Urban Mapping Services - Land cover change and encroachment into protected areas;
- Forest Monitoring - Forest area and use change mapping;
- SAGE - water pollution risk and soil sealing maps for water management and soil protection;
- Risk-EOS - EO based risk information services for forest fire and flood management;
- TerraFirma - Monitoring of urban subsidence for European cities;
- GMFS - Global Monitoring for Food Security - crop monitoring services;
- CoastWatch - geo-information services in support of integrated coastal zone management;

- ROSES - Real time Ocean Surveillance for Environment and Security covering oil pollution and water quality;
- ICEMON - operational ice monitoring for marine operations and climate change;
- Northern View - ice and arctic monitoring services;
- RESPOND - access to maps, satellite imagery and geographic information for humanitarian community;
- PROMOTE - Protocol Monitoring for the GSE on Atmosphere.

Dr. Briggs also presented information on potential future ESA Space Segment programmes currently consisting of the Sentinel constellation:

- Sentinel 1 – a new SAR sensor;
- Sentinel 2 – a 'Landsat-like' *super-spectral* sensor;
- Sentinel 3 – Ocean monitoring;
- Sentinel 4 – Atmospheric chemistry; etc.

Further information can be found at http://earth.esa.int/gmes and http://www.gmes.info

Determining Soil Moisture and Land Cover to Assist in Flood Prediction and Early Warning

Dr. Cao Chunxiang (China)

Flood and water logging are one of the main disasters in China. Chinese government pays great attention to flood disaster management, including prediction and early warning. Soil moisture and land cover play an important role in flood prediction and early warning. Space technology, especially remote sensing technology, has its special advantage in computing soil moisture and land cover. Dozens of satellites constantly collect data about our planetary system 24 hours a day, 365 days a year. Space technology can provide real time remotely sensed data to monitor soil moisture and land cover in large-scale area. Today, Microwave Remote Sensing is effectively used in monitoring soil moisture. The work of different scale of land cover all over the country is also performed. This can provide basic parameter and relevant database in flood prediction and early warning.

China uses IRSA and CAS remote sensing technology systems in flood control. This technology allows scientists and managers to:

- receive and pre-process telemetric data;
- identify inundated landforms and provide data retrieval function;
- provide a detailed estimation of flood-inflicted damaged landforms;
- speedily compile pictures, photos, data, graphic material, forms and literary reportage;
- provide communication network for dispersing the monitored and assessed results.

Identification of soil moisture is important because it can influence weather through its impact on evaporation and other surface energy fluxes. Atmospheric general circulation model (AGCM) suggest that in continental mid-latitudes, during summer, oceanic impacts on precipitation are small relative to soil moisture impacts. At the same time, precipitation should not be sensitive to soil moisture in wet climate. In dry climates, evaporation rates are sensitive to soil moisture but are also generally small. In the transition zones between wet and dry climates, where evaporation is suitably high but still sensitive to soil moisture, soil moisture has great impact on precipitation.

Land cover type has an impact on flooding. Vegetation composition of land cover types is an important factor in floods. Vegetation influences the storage of water on ground surface. Remote sensing technology can provide a good way to monitor soil moisture and land cover types at a large scale and in near-real time. In particular, microwave remote sensing and thermal infrared remote sensing technologies have been used to monitor soil moisture and land cover.

Operational EO for Water Resource Management: Southern African

S. Hughes (South Africa)

EO data and methodologies are being piloted with the view to operational application in the validation of the South African National Water Act (1998) based policy surrounding the registration and licensing of water rights.

Landsat and SPOT EO data is digitally classified and validated in the field to generate a land-use map for a catchment. This map forms the basis for consultation with farmers determining their water use and irrigation infrastructure. This information is then used with the areas of irrigation to model volumetric water use using a SAPWAT model. Once this licensing data is validated it can then form the basis of a basic water use assessment as little reliable data exists for this at present.

Once perfected, the methodology can be applied operationally. It can help to understand how to move from the predominant mentality of the application of EO on a *project* basis to a more *operational*, serviced based framework.

The ESA TIGER Initiative was also introduced and ideas of how it can be introduced in the Southern African region to address both generic and specific regional needs for Integrated Water Resource Management information. It has the potential for partnerships to develop EO-based information services and a network that can assist in meeting common goals and priorities.

Discussion Points

- There was some discussion around the soil moisture determination methods, accuracy and spatial resolution. The determination of a 1m column of soil moisture is through remote sensing of a 5mm layer and the use of an infiltration model to extrapolate.
- The question of deep groundwater detection was raised. There was some uncertainty about this, but it was suggested that this was probably going to be achieved through the planned GRACE mission.
- The success of soil moisture measurement from space was questioned as the trade-off between spatial and temporal resolution makes it difficult to apply operationally.
- The extent to which hydrological modelling is used by the departments of water is unclear. It was felt that it is generally not widely used, but is a priority for future work if the application of EO technologies for water resource management is to be successful.
- The question of what kind of data could be used for water resources management was discussed. It was noted that meteorological data could not provide all the solutions. In the United States, the thinking was that meteorological and remote sensing data did not add more clarity to the hydrological model, since all it provided was information on snow and rain run-offs. At the same time, in developing countries that do not have good infrastructure for monitoring, space based data could be used for developing and applying a hydrological model.

Overall Conclusions and Recommendations

- It is clear that EO can assist in the provision of critical, timeous data for decision makers in water resource management.
- EO is not *the* answer to water resource management information requirements, but a part of it.
- Generally speaking, EO is not used on an operational basis yet. It is still bound into pilot projects and small, area-specific projects.
- This move to operational information provision requires comprehensive approach addressing government and community defined needs in a service oriented programme. The ESA Global Monitoring for the Environment and Security (GMES) is an excellent example of this.
- Government buy-in at Regional and National level will provide a sound foundation for future development of EO services.

- Awareness building in governments, NGOs and civil society is required to increase the impact of EO in the field of water resource management.
- The contribution of communication satellite platforms must no be underestimated. These capabilities can play an important role in bridging the gaps in Internet access and continuity and data transfer.