Water and Food Security Satellite System

This resolution has been formulated, discussed and approved by the participants of the International Conference on Earth Observation for Vegetation Monitoring and Water Management held in Naples, Italy on 10-11 November 2005[1].

Justification

The operational utilisation of services based on information products generated from satellite remote sensing data has gained momentum in areas having high economic interest. This is the case in particular with precision farming. Space-based systems provide intensive agriculture with the capability to monitor crop status, predict crop yield, detect disease and insect infestations, and support the management of farming tasks, including addition of fertilisers.

The management of irrigation, however, is often not addressed by these precision farming systems because of the lack of information to detect crop water status. Furthermore, such support is nearly nonexistent in developing countries. The support of irrigation requires observation of the thermal infrared (TIR) spectral region to determine surface temperature in addition to surface albedo. It is the combined variations and changes in surface temperature and surface albedo that provide the indication of plant water stress and need to support water management. Unfortunately, the addition of TIR imaging adds a step of complexity to otherwise relatively simple space systems that are characteristically based only on observations in the visible, near- and shortwave infrared regions of the solar spectrum. Consequently, there are few systems providing TIR observations at high spatial resolution. The management and monitoring of irrigation is, however, so important to food production in all countries, that TIR is considered to be an essential component of a Food Security satellite system and the cost for TIR is fully justified by this need and application.

There are some automated ground based systems that have been developed to provide advice on irrigation. These systems however are necessarily local and rely on limited spatial sampling and therefore the level of confidence is low when advice is extended to large fields and entire farms. A space-based system is capable of covering the entire globe and can observe all areas of Earth requiring better water management. Advice on water management and food production can be based on actual, detailed observation of each monitored zone at relatively high spatial resolution.

A dedicated Earth Observation (EO) System for Water and Food Security is proposed to provide 'water management' support products for two distinct, but very complementary, application areas:

a) Sustainable management of land- and water resources: this applies at two primary and critical levels: planning at the national level and project implementation at the local level.

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[1] A total of 90 participants represented 15 countries on four continents. The Conference program and abstracts are available at: http://www.agraria.unina.it/CONGRESS/EOnapoli2005/ and show examples of recently developed and implemented operational EO-based water management services.

b) Irrigation management as part of effective and efficient food production and precision farming: this is based on evapotranspiration (ET) maps and other indicators of crop response to water availability derived from multi-spectral and TIR observations at high spatial resolution (around 20 to 100 m).

Irrigated agriculture has high public visibility, is a high-value market segment, and is a highly relevant component of water, agricultural, and rural development policy. Irrigated agriculture requires appropriate information to support the implementation of specific environmental and rural development policies. *Saving water in irrigated agriculture* (where 75% of water is used worldwide) can be *achieved through the use of EO-derived information in operational irrigation scheduling at farm and field scales.* Accurate irrigation water management helps to reduce groundwater pollution by agro-chemicals.

Neither individuals nor organizations can manage what they cannot measure. Countries cannot know how much irrigation water is lost and how much is effectively used to produce food. unless they can detect ET from crop vegetation systems from space. *We stress that a quantum leap in our current knowledge of consumptive water use can only be achieved using multi-spectral and TIR observations.*

End-beneficiaries of water management information based on multi-spectral and TIR measurements are the *farmers*, who experience benefits in the form of "more crop per drop" (enhanced water productivity) and "more jobs per drop" (boost of rural development). *Space-assisted Irrigation Advisory Services* at the community level can provide EO-derived irrigation scheduling information to farmers for reducing crop water stress and for maximizing food production; can provide ET information to water management and regulation authorities for quantifying depletion of water resources and for assessing spatial distribution of water use and equity of scarcity; can interact with *water management decision makers at river basin* levels, and can serve as a *potential policy instrument at national and continental scales*.

Success Story at risk: The Landsat satellite system has been the operational high resolution EO system of choice for ET determination. The Landsat system has offered high resolution TIR (60 – 120 m) since 1982 in addition to visible and near infrared (VNIR) images. Unfortunately, the two remaining Landsat satellites are either nearly worn out (Landsat 5) or are damaged (Landsat 7), and NASA has no current plans to continue TIR on any future Landsat missions. *The termination of the TIR component of the LANDSAT series will throw away 30 years of investment in and development of an unprecedented range of applications including tools for irrigation water management.* Even if Landsat 5 were to be joined by a future Landsat launched by NASA, even more EO satellites equipped with TIR are needed. A virtual constellation can, in principle, be assembled by using data collected by multi-spectral systems on-board a variety of TIR equipped satellites launched and operated, for example, by China and Brazil (the CBERS system) and India (IRS if TIR were added). However, currently the quality and availability of data from the CBERS systems is poorer than required and they are not downloadable in Africa, Europe and North America. No other systems with high resolution and consistent TIR are on the horizon. The foreseeable consequences are that the uptake and nation-wide upscaling of EO-assisted water management services will not happen at the required pace or even at all.

Needs

Farm and field sizes in many regions of the world are small, especially in developing countries and old parts of Europe, where they may be even less than 0.1 ha (30 m x 30 m). A reasonable target may be 1 ha fields. High resolution in satellite images is essential to 'see' details within individual fields. This resolution includes the TIR information. It is important to see internal variability within individual fields to identify water consumption associated with specific crop types and land holdings and to provide information relevant to farmers.

Mission requirements

The situation of pending failure of the TIR equipped Landsat system and inconsistency in coverage and quality of the few other TIR equipped high resolution satellites (CBERS and ASTER) can only be addressed by developing a dedicated EO system capable of providing low cost data at high temporal resolution and high spatial resolution. Desirable temporal resolution is once each 2 to 6 days and desired spatial resolution is 10 to 30 m in the VNIR and 20 to 100 m in the TIR (TIR can be sharpened to the resolution of VNIR using vegetation indices and other techniques). Ultra-high spatial resolution, for example, 1 m, is neither desirable nor suitable for such applications because of the likely high cost and low temporal frequency of observations. A large swath width per overpass is highly desirable to reduce processing and calibration time and expense during production of ET and crop yield images.

Summary of Mission Requirements

The proposed EO system should provide full coverage of all cultivated land areas each 2 to 6 days at a spatial resolution of 10 to 30 m for the VNIR and 20 to 100 m for the TIR spectral region. Spectral sampling should consist of seven to nine spectral bands at a spectral resolution of 10 nm in the VNIR and preferably two spectral bands at 1.0 μm in the TIR region. A fleet comprised of multiple satellites is suggested.

Programmatic

Because irrigation water management and food security are of primary interest to essentially every nation on Earth, it seems very appropriate for all nations to share in the costs for creating and operating this system. We recommend that the multi-spectral, TIR-equipped satellite mission be a contribution to the theme Natural Hazards and Food Security and it be submitted to GEOSS with support from and in concert with FAO. It would be highly desirable to implement this mission relying on the current and growing EO capabilities of newly industrialized countries such as India, China and Brasil for the design and launch of the space segment, while placing the ground segment under supervision of GEOSS to guarantee easy and global access to data, including the archived data sets after several years of operation of EO systems as IRS and CBERS. In addition this recommendation is very timely, given current progress towards the preparation of the Sentinel – Land Mission by ESA.

Strategy

There is a key, strategic need to define and follow a two-step solution to the shortage of strategic EO satellite-based information, especially in the TIR:

1. Short-term (immediate future, 6-12 months): Consolidate a virtual constellation of all high-resolution EO satellites (currently available or available in the near future), following specified and acceptable satellite 'qualification' criteria; Provide uniform access to all potential users at low cost and with operational rush-service (24-h delivery of images). The image data base for the constellation would be ideally presented as a homogenized, standardized, interoperable ground processing segment. It is noted that many of the candidate satellites for this constellation do not contain TIR. However, there are a number of irrigation water management procedures that provide useful information based on VNIR only.

2. Long-term: Plan a dedicated mission for a Water and Food Security satellite system as described above that contains TIR , and VNIR, SWIR imagers.