Exploiting the DMC Satellite Constellation for Applications in Agriculture, Forest Monitoring and Disaster Response

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ABSTRACT:

This paper presents examples of how a number of organisations are exploiting the powerful data source provided by the international Disaster Monitoring Constellation (DMC) for applications such as precision farming, tropical forest monitoring, land cover mapping, illicit crop detection, agricultural statistics and disaster response. The DMC consists of a growing constellation of advanced small Earth Observation satellites, each carrying a wide swath (up to 650km) multispectral optical sensor. Joint campaigns by the international partners are coordinated centrally by DMC International Imaging (DMCii). The optical imaging sensors on all the satellites in the constellation are rigorously calibrated to enable data from each individual satellite to be used interchangeably within any given campaign and to enable quantitative biophysical information to be extracted from the data. The constellation provides a daily global imaging capability at 22m-32m resolution in three Vis/NIR spectral bands. The capability to cover large areas on a regular basis enables a different approach to be taken regarding a number of applications that are either difficult or impossible with other data sources and examples will be presented.

1. THE DMC CONCEPT

The DMC Members each own and operate an SSTL-built DMC satellite via their ground station for national requirements. However they all agree to work together in a coordinated constellation for disaster response free of charge, and share information and resources for mutual benefit.

DMC International Imaging Ltd (DMCii) was established in 2003 to provide coordinated commercial imaging services and disaster response. DMCii has established a strong brand for coordinated constellation imaging with major customers in all continents, generating revenue for the DMC Consortium Members.

2. DAILY REPEAT IMAGING

To achieve daily revisit the constellation was designed with a 650m wide swath imaging system with a 32metre resolution similar to Landsat and using the same core spectral bands for close compatibility. By placing four satellites into the same orbit, and equally phased, the swaths overlap and daily revisit imaging becomes feasible. The DMC has proved the benefits of this both in disaster response and in bringing new capabilities to the commercial market.

The new generation of satellites (UK-DMC2, Deimos-1 and NigeriaSat-X) carry improved 22 metre Vis/NIR sensors delivering double the pixel density of the first 32metre generation whilst maintaining the 650 km wide swath. Improved power and storage technology enables the satellites to acquire and download much larger volumes of imagery every day.

The highly agile NigeriaSat-2 also provides 2.5metre panchromatic, 5metre 4-band multispectral and 32metre 4-band multispectral data.

3. CROSS-CALIBRATION

In order to maintain highly calibrated data. DMCii uses a technique based primarily on accurate cross-calibration against a stable reference sensor. In previous years this has been the Landsat 7 ETM+. The uncertainty of the cross-

calibration relative to Landsat 7 using the Libya 4 calibration site is less than 1% giving an overall absolute calibration better than 5%.

4. COMMERCIAL APPLICATIONS

The advent of daily repeat imaging capability stimulated the market for new applications. DMCii provides high quality rapid repeat imaging with 650km swath width, which gives advantages in reducing the number of scenes that a customer has to process. Cross calibration of the constellation is regularly carried out. DMC satellites are radiometrically calibrated to within 1% of Landsat, and use the same core spectral bands. This provides synergy with the long term archive of cross calibrated Landsat data.

Precision Agriculture

First amongst the new applications has been precision agriculture which has demanding requirements for wide area imaging at key stages in the growing season. DMCii has developed close working relationships with its customers to respond effectively to their needs. Over the last ten years the main areas of growth for precision agriculture have been in Europe, North America and Asia, where the image resolution enables the service provider to derive useful information within each field. The imagery comes geo-rectified, as is standard, for integration into users' Geographical Information Systems (GIS) software. But because the DMC satellites are operated together as a constellation, they offer much more timely data than a single satellite, delivering rapid revisit opportunities every 1-2 days.

In precision agriculture, satellite data is used to gather precise knowledge of a farmer's land, pinpointing variations in crop growth and condition. The farmer is shown just where fertiliser or crop protection chemicals need to be applied, and in what quantities. GPS-based instructions can be relayed directly to tractors and other automated farm equipment. The aim is to maximise crop yield and quality while minimising production costs and environmental impact.

Figure 1 Precision agriculture application

There are many crops to which precision agriculture is being applied. For example in Japan, DMC 22m data is used to monitor and manage rice yield and quality, whereas in the Netherlands repeat imaging every three days enables potato crop yield to be calculated to within 5%.

Forest monitoring

Forest monitoring is an important application of DMC 22m imagery, with the largest project being the regular imaging of the entire Amazon Basin for the Brazilian Instituto Nacional deo Pesquisas Espaciais (INPE).

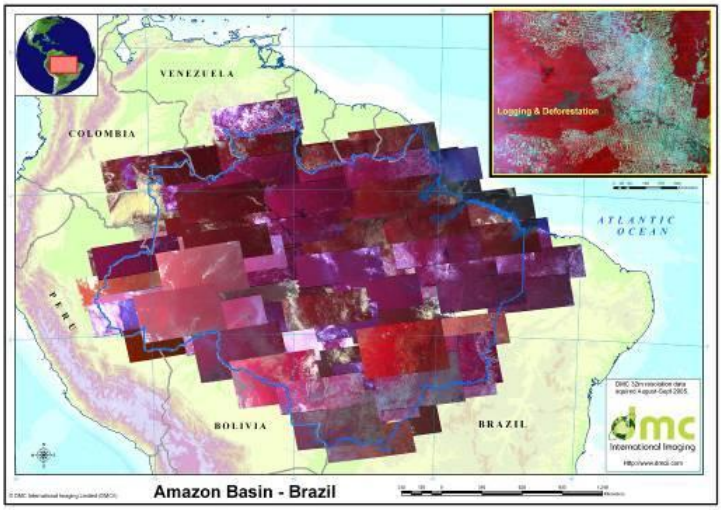

Figure 2 DMC coverage - Amazon Basin

The wide area imaging dramatically reduces the amount of image processing required and achieves a view of the area within a very short time window. DMCii's new direct download service provides near real-time imagery every day from the UK-DMC2 satellite directly to the ground station in Cuiaba, Brazil. The Brazilian Space Agency's groundbreaking DETER programme uses regular satellite images to detect forest clearance as it happens – rather than surveying the damage afterwards – guiding Brazil's enforcement officers to provide effective forest clearing control. However in recent years, the authorities have discovered that illegal loggers are clearing smaller areas to evade detection by the 250metre-pixel MODIS data that is currently in use. With approximately 130 times as many pixels per hectare as the MODIS images currently in use, the data will detect these smaller clearings and provide more detailed maps. The UK-DMC2 satellite will image the entire Amazon basin every two weeks, so that the authorities are alerted as soon as possible after logging is detected. In a unique agreement, the data covering Brazil will be made freely available on open licence through the INPE website so the general public can follow progress against deforestation.

Agriculture and Food Security

The effective monitoring of crops requires regular imaging of the fields throughout the growth season, as this provides excellent information from the relative phenological profiles of each crop. For example, imaging of the entire continental USA is carried out by the DMC satellites every 15 days between May and October, and results in an improvement in crop statistics for the US Department of Agriculture[*] .

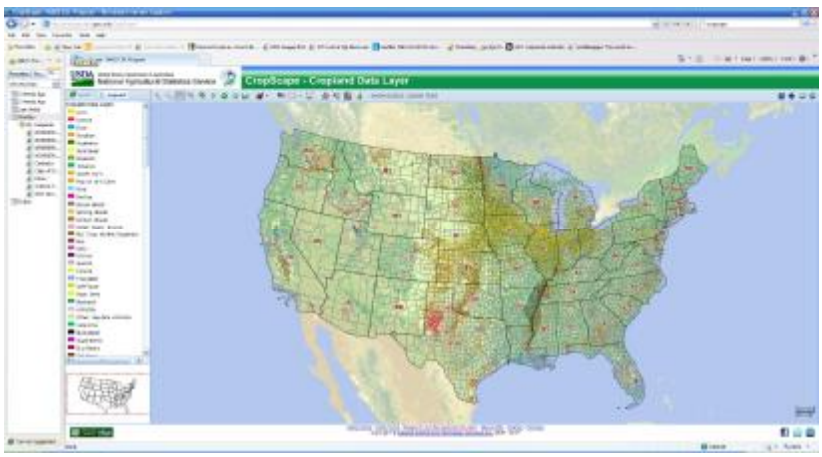

Figure 3 USDA Cropland Layer, derived from DMC imagery

[*] "Improving Agricultural Landcover Classification in the Cropland Data Layer Using the Disaster Monitoring Constellation" Audra Zakzeski, JACIE 2012 Workshop, Fair Oaks, VA, April 17-19, 2012

In addition to commercial contracts DMCii operates a background imaging campaign collecting the first annual coverage of Africa at 22m for each of 2010, 2011 and 2012 providing an invaluable snapshot of more than 40 countries, including Cameroon, Congo, and Ethiopia for assessing phenomena such as deforestation, urbanisation and desertification. Satellite imagery is an invaluable tool for monitoring region-wide changes in land use and the environment.

DMCii also obtains regular coverage of Asia which is available through its on-line catalogue.

5. A LOOK AT THE FUTURE

Low cost access to space enables cost effective constellations to be launched, creating a new paradigm in Earth Observation. DMC Consortium Members benefit from an operational system with proven performance as well as established routes to markets and applications.

The next step is a constellation of 1metre DMC satellites delivering the high temporal resolution of the first DMC generation. This is closely followed by a new low cost SAR satellite, NovaSAR which opens up the potential for new space nations to own and operate leading-edge systems at an affordable price point.

The DMC is a sustainable system which provides real benefits for its Members and generates a synergy between the satellites. It has enabled large coordinated imaging campaigns which would never otherwise have been feasible, and has opened up new applications in agriculture and forestry governance which had only previously been dreamed of.

Looking ahead it is clear that international cooperation in space can deliver effective coordinated services to meet the needs of governments and commerce alike. As long as working together delivers mutual benefits, and as access to space becomes more affordable, so we should expect Earth Observation to become ever more useful.