

Aqua

Studying the Earth's Water Cycle

Two months after the launch of the European Envisat, another major Earth remote sensing observatory in the form of NASA's Aqua satellite was launched from Vandenberg Air Force Base in California on Saturday, 4th May, 2002 - just after the conclusion of the FIG/ASPRS Congress. In fact, this launch forms part of NASA's plan to orbit a whole series of satellites under the title Earth Observing System (EOS). This plan has been implemented from 1997 onwards. It has included the launch of Landsat-7 and a number of smaller satellites, one or two of which have been provided by other countries - e.g. the Russian Meteor and Japanese ADEOS-II satellites. Besides which, several of NASA's own satellites have also had experiments or imagers mounted on them that have been supplied by other countries, e.g. by Japan, Canada and Brazil. In summary, led by NASA, the EOS programme has been a truly international cooperative effort of considerable scientific importance and one which will continue for quite some time to come.

By Prof. Gordon Petrie

Terra & Aqua

The two largest of the NASA satellites were originally named EOS AM-1 - designed to cross the Equator in a descending orbit at 10.30am daily - and EOS PM-1 - designed to cross the Equator at 1.30pm daily in an ascending orbit. The two satellites were then renamed Terra (AM-1) and Aqua (PM-1) before being launched. Terra had been launched in December 1999; the new Aqua satellite was launched on Saturday, 4th May, 2002. The two satellites were constructed by different companies - Lockheed-Martin and TRW - to rather different designs. Also the Terra satellite was launched using an Atlas IAS rocket, while

the Aqua satellite used a Boeing Delta-2 launcher. However the two main imagers - MODIS and CERES - that have been mounted on both the Terra and Aqua satellites are the same.

• Aqua

Although the Aqua satellite is intended to investigate the planet's water cycle, much of this is being done using non-imaging devices such as atmospheric sounders. However, for most practical purposes, the key imaging instrument for geoinformatics use is MODIS with CERES occupying a secondary role.

• MODIS

The MODIS instruments on the Terra and Aqua satellites are intended to provide comprehensive global images of the Earth's land, oceans and atmosphere in the visible and infra-red parts of the spectrum. These will allow the MODIS imagers to be able to view the entire surface of the Earth every two days. Thus MODIS is supplementing and extending the data sets acquired by the well-known AVHRR instruments mounted on the NOAA weather satellites. The two high-



Figure 2: An artist's impression of the Aqua satellite operating in space with its solar panel extended. (Source: NASA).

Figure 1: The night launch of the Aqua satellite on a Boeing Delta-2 rocket from Vandenberg Air Force Base in California. (Source: NASA).



Figure 3: The MODIS ground receiving station at the University of Dundee with the bridge across the Firth of Tay in the background. (Source: NERC Satellite Station, University of Dundee.)

est resolution bands (1 and 2) of the MODIS imagers operate in the red and NIR bands to produce images with a ground pixel size of 250m over the swath dimension of 2,330km. Five more bands - two in the visi-

ble and three in the SWIR region - provide images having a ground pixel of 500m over the same swath width. Finally the remaining 29 bands produce images with very specific spectral bands across the spectrum from the visible to the thermal infra-red - albeit with a quite coarse ground pixel size of 1 x 1km. The Terra satellite with its MODIS imager has already been having a fairly dramatic impact on the provision of global low-resolution imagery. Innumerable projects are already under way - whether monitoring dust over north-west Africa; wildfires over Siberia; the flooding of the Nile; or icebergs breaking off the Ross Ice Shelf in the Antarctic. Already numerous ground stations have been set up to receive MODIS images in Europe and Asia, besides those in the



Figure 4: Most of the British Isles, Northern France and the Benelux countries are visible in the cloud-free image acquired by the MODIS imager mounted on the Terra satellite. (Source: NERC Satellite Station, University of Dundee).

U.S.A. When Aqua becomes operational in a few weeks' time, the number of MODIS images available world-wide will double.

• CERES

The CERES imager is altogether a different and much coarser imaging instrument. It has a $\pm 78^\circ$ (156°) cross-scan coverage giving a limb-to-limb coverage of the Earth with a 20km ground pixel size at nadir. It covers two spectral regions - $\lambda = 0.3$ to $5.0\mu\text{m}$ (the VIS/NIR/SWIR region) for solar generated radiation and $\lambda = 8.0$ to $12\mu\text{m}$ for Earth emitted radiation. Besides which, it also gives total coverage over the optical range $\lambda = 0.3$ to $>200\mu\text{m}$. The CERES imager is designed to better understand the balance between (a) the incoming solar radiation (i.e. sunlight) and (b) the outgoing reflected sunlight from the Earth's surface, atmosphere and clouds and the heat emitted from the Earth. Scientists will use the CERES observations to study the energy being exchanged between the Sun, the Earth's atmosphere and space.

• AMSR-E

A new microwave scanning radiometer has also been mounted on Aqua that has been built in Japan and provided by the Japanese NASDA space agency. It takes the place of the ASTER stereo-imager which is still being operated on the Terra satellite. The AMSR-E is a passive microwave radiometer that will measure rainfall rates over land and oceans and will provide sea surface temperatures and ocean surface roughness (that can be converted to near-surface wind speeds).

• Sounders

For the rest, there is a comprehensive suite of sounders (AIRS, AMSU and HSU) that will measure profiles of temperature, pressure, humidity, cloud properties and greenhouse gases throughout the Earth's atmosphere. However there is little doubt that most practitioners in the geoinformatics field will find the MODIS and CERES images to be of most interest and application to their activities - especially on a global or regional scale.

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