CHAMBARA

A CONCEPT FOR ATMOSPHERE-SURFACE OBSERVATIONS FROM THE INTERNATIONAL SPACE STATION

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ABSTRACT

In parallel to vegetation mapping exemplified by VEGETATION and spectral thematic instruments as MERIS, other important natural and man-made phenomena characterize the equatorial and low latitude regions region covered especially well by the International Space Station orbit. The agreement between the space agencies evolves now to a lifetime of the ISS up to 2025. Two themes can be proposed: hydrography and biomass burning.

Hydrography has an extreme human importance as human life and agriculture depend on water, transport as well; also the hydroelectric energy which could be harnessed from the hydrological network is tremendous and would allow a sustainable development of the entire region. Biomass burning is also a major issue, both due to its direct agricultural management aspects and also to its influence on global pollution.

1. OBJECTIVES: BIOMASS BURNING AND HYDROGRAPHY.

The CHAMBARA proposed concept differs from other satellite observation programmes in a sense that the images are taken either according either to pre-planned scientific campaigns controlled from an operation centre either according to real time unexpected events or emergencies. For example, biomass burning imaging campaigns are organised at the end of the dry season, while deltas and lake are monitored at specific points of the dry seasons and, if the cloud cover allows it, at periods of the wet season. In exceptional cases, as natural disasters or rapidly varying scenes, the operation centre will reschedule the programme and even ask for exceptional crew assistance.

This project aims at this point to the European and African scientific communities specialized on Sub-Saharan Africa which is currently studied by several Belgian scientific institutions but its techniques could also be extended to the Amazon basin, tropical Asia and Oceania.

The equipment proposed will be an advanced true colour rapid camera, external mounting is wished in order to free the optical windows but nadir pointing should be the nominal position.

An example of the concept is given by the serendipitous image ISS004E11 Central African observation (ISS photograph, May 16, 2002, centered near 8.6 degrees south latitude, 27.4 degrees east longitude, NASA document). This image is a unique representation of the start of a slash and burn process on several agricultural plots, it exemplifies the requirement for a rapid camera able to follow the evolution of plumes and other variable earth surface phenomena. (Fig.1).

Fig. 1: an example of Central African observation from the ISS: ISS photograph, May 16, 2002, centered near 8.6 degrees south latitude, 27.4 degrees east longitude. (180 mm still camera). This image shows a simultaneous start of several fires in the dry season in Katanga for trash and burn agriculture. (Image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Centre.).

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The hydrography of Africa has always puzzled explorers from the regular floods of the Nile to the discovery of the quasi constant debit of the Congo River in the 16th century. It has now become a major issue in the entire continent. In North Africa, strategic choices for development have to be made between the building of dams and desalinisation plants. In the Sahel and tropical regions, the monitoring of seasonal rivers is a necessity for the urban planning of megacities where there were sixty years ago only small colonial administrative implantations. An example is given by the city of Ouagadougou situated between dry branches of the Volta River (Fig.2).

Fig. 2: 2002 SPOT image of the city of Ouagadougou, http://gallery.spotimage.com/product_info.php?products_id=1087, document CNES Spot-image. This image was used for a study of the water supply of the city (Kombassere, 2007).

More to the South, hydroelectricity constitutes a still largely untapped source of energy and the monitoring of the stability of the rivers can be made from the ISS together with a systematic prospection of favourable sites. Figure 3 and 4 show situations where the stability of the river courses is still far from being assessed. In both cases, huge debits could be used for the production of electricity.

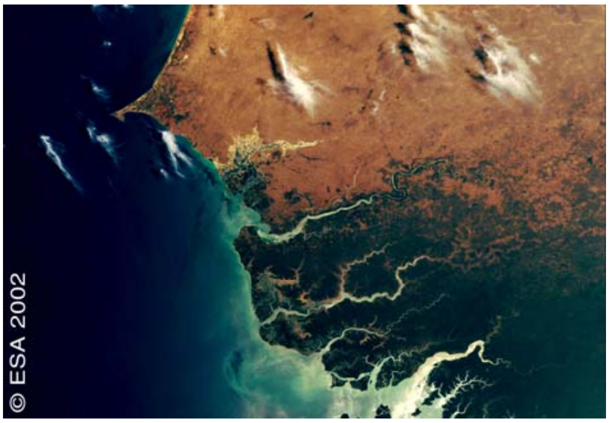

Fig. 3: 2002 ENVISAT MERIS image of the Senegal delta, this image shows at the same time sand dunes, the city of Dakar, the nutrients released by the delta to the sea, the baobab savannas and the very complex hydrography of the Casamance region. (ESA document). All of these phenomena vary with time, a higher spatial resolution from the ISS would allow a fine tuned study of all these phenomena.

Fig. 4: This image shows the confluence of the OUBANGI and OUAKA rivers in the Central African Republic obtained on December 17 2004 using a 180mm still camera on the ISS. Due to 10% cloud or haze attenuation this image should be enhanced or colour adjusted to the needs of the user. (Image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Centre.).

2. OBSERVATION OPPORTUNITIES FROM THE ISS.

The 51.63 degrees orbit of the ISS, inherited from the MIR and from the constraints of the Baikonur spaceport is advantageous for the coverage of the African continent as shown on figure 4.

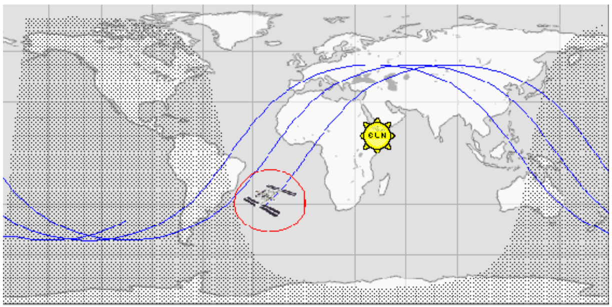

Fig. 4: a typical ISS set of orbits, the African coverage is excellent while high latitude regions an especially Antarctica are can only be observed in limb mode. (Brantschen et al, 2010).

Its altitude varies between 350 and 450 km according to operational needs. It is permanently manned since 2000 and in 2010, its optical windows have been supplemented by the cupola, a set of optical windows for both observation and operation purposes. The ISS has also a number of external locations which can accommodate instruments as the present Coarse Pointing Device installed on COLUMBUS and supporting SOLAR.

3. An example of external payload support: the ESA Coarse Pointing Device.

The Coarse Pointing Device is a multi-purpose system that has the function of keeping the supported instruments pointed to a target (e.g.: to the Sun), compensating for the orbital motion of the ISS. During each observation orbit, the Coarse Pointing Device keeps the instruments pointed to the Sun during an observation period of about 15 minutes per orbit. The Coarse Pointing Device provides a movable frame, which can rotate around two axes, thanks to a cardanic type mechanism. The motion is controlled in closed loop, using a sun sensor located on the moving frame, brushless motors and encoders mounted on each axis. The control loops for the two axes are implemented in the soft ware running on the Control Unit. The maximum range of the Coarse Pointing Device angular motion is +/- 25° around the axis compensating for the seasonal variation of the ISS orbit inclination, and +/- 40° around the axis compensating for the ISS orbital motion.

The pointing accuracy is +/- 1 degree; the pointing stability is 0.3 deg over 10 seconds.
The Coarse Pointing Device is developed in two versions, one for the SOLAR payload and one for the EXPORT payload. Each version has different instruments accommodation and mess carrying capabilities. For SOLAR the maximum mass carrying capability is 75 kg. An example of operation of this system for pointing the sun is given by Brantschen et al (2010).

A second Coarse Pointing Device exists as it was also designed for the astronomical payload SPOrt (Sky Polarisation Observatory) which was abandoned in 2005 in favour of studies of the cosmic background using free-flyers, this CPD could be used for earth observations and would be much more flexible than hand held cameras.

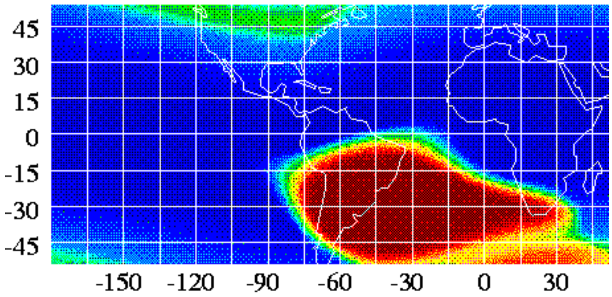

Figure 5. The South Atlantic anomaly (ROSAT image, ESA document), the South Atlantic anomaly is a supplemental reason of non availability for sensitive instruments, in this plot, the SAA clearly covers the Amazonia region. Beside the orbit, another reason of unavailability is to be found in the electromagnetic perturbations related to the South Atlantic anomaly; this affects still significantly the electro-optical detectors and is still a major cause of satellites unavailability. Fortunately for this project, most of the African continent is not concerned.

4. EXAMPLES OF IMAGING FROM THE ISS

The ISS has been used for imaging up to now in several programmes, one of the most productive having been the *NASA* Johnson Space Centre imaging analysis project using commercial high end hand held digital cameras. An other one has been the Earth-Kam programme based on a modified commercial camera installed on the optical window of the American module and operated as a student project by the University of California San Diego (https://earthkam.ucsd.edu/) . A similar project aimed at the monitoring of natural disaster is used in the Russian module: the URAGAN camera, it is based on SONY commercial equipment (http://www.nasa.gov/mission_pages/station/science/experiments/Uragan.html) and the few released images are closed to the in quality to the Earth-Kam images.
The viewing location inside the ISS has recently been much enhanced by the 2010 addition of the ESA cupola; all the cupola windows have optical quality (Fig. 4). This project proposes to design a new external camera

for operation from a ground centre in order to relieve the crew as much as possible.

Fig. 4: One of the first images obtained through the ISS cupola, an ancient hydrographic network in the Sahara appears on the image.. (NASA document).

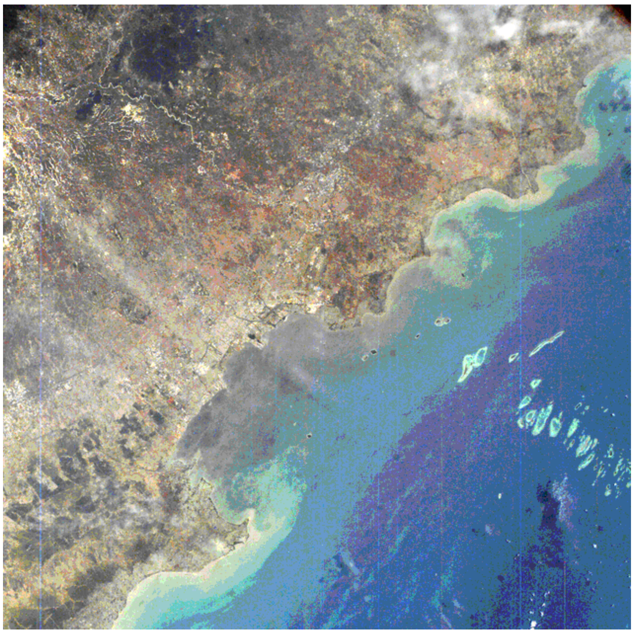

Fig. 5: NASA-UCSD Earth-Kam image of SUMATRA (439393 Time Taken (GMT) 2009/293/04:55:02). This image was requested by a Japanese school and can be related to observation of coastal changes after the 2004 Tsunami. (https://earthkam.ucsd.edu/)

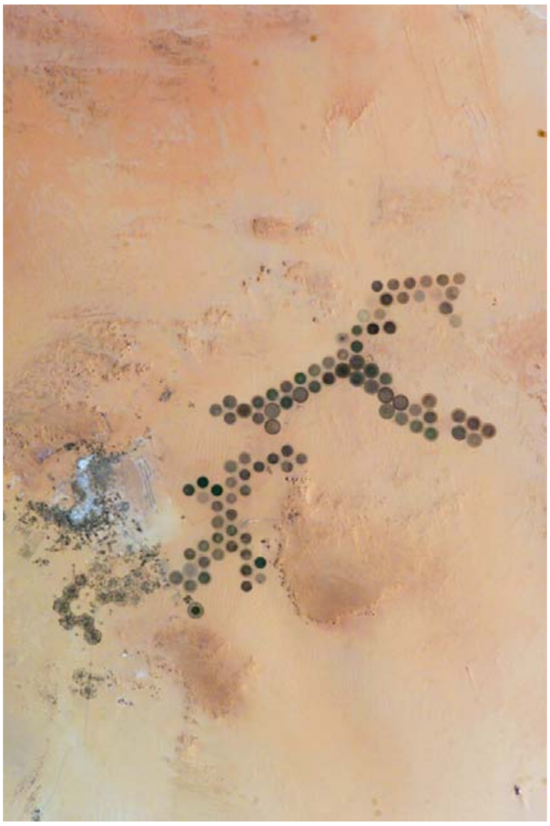

Fig. 5: *Al Khufrah Oasis in southeastern Libya (near the Egyptian border)is an example of irrigation from fossil water. Astronaut photograph ISS010-E-5266 was acquired October 28, 2004 with a Kodak 760C digital camera with a 180 mm lens. (Image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Center.)*

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5. ACKNOWLEDGMENTS

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