OBSERVING FLUORESCENCE FROM SPACE: ESA'S MISSION CONCEPTS

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Abstract

Terrestrial ecosystems absorb an amount of ~ 120 Gt of carbon annually through the physiological process of photosynthesis. Since the estimated annual turnover between the atmosphere and terrestrial ecosystems is considerably greater than the amount of fossil fuel emissions (~ 6 Gt), small alterations in the terrestrial carbon balance are likely to have a significant impact on atmospheric CO_2 concentrations.

Consequently, vegetation monitoring continues to be a key issue in global Earth Observation. Despite the fact that several missions are already dedicated directly (e.g. the SPOT/VEGETATION) or indirectly (e.g. ENVISAT/MERIS) to global terrestrial vegetation monitoring, the derived information is mostly related to the amount of vegetation (e.g. leaf area index, fractional vegetation cover, biomass) or to the *potential* photosynthetic activity (e.g., based on the fraction of absorbed photosynthetically active radiation, chlorophyll content). However, not all the absorbed light finally results in carbon assimilation through photosynthesis. Plants are living organisms, and according to the climatic and environmental conditions they regulate the internal physiological processes. In optimum conditions, about 80% of the absorbed light is used for photosynthesis, but this is rather variable, and can range from 0% up about to 80% according to the availability of water, nutrients, excess light or other conditions.

A crucial remaining topic to be covered in global vegetation monitoring is the measurement of the *actual* photosynthesis. For this particular purpose, chlorophyll fluorescence measurements represent a unique capability to be exploited, as no other measurement protocol applicable to satellite measurements allows the retrieval of such a direct indicator of actual canopy photosynthesis.

The FLuorescence EXplorer (FLEX) mission concept [1] was studied within ESA's Living Planet Programme Earth Explorer 7 framework in 2008/2009 as an independent stand-alone mission providing a full set of observations required for

photosynthesis retrieval. In this mission concept, the FLEX satellite carries a set of four passive optical sensors. The main instrument, the Fluorescence Imager Spectrometer, provides Top of the Atmosphere spectral radiance measurements in two 20-nm wide spectral bands centred at 760 nm and 687 nm respectively. It features sub-nanometre spectral resolution and a spatial sampling distance of 300 m. Three companion instruments provide additional measurements of surface reflectance in the Visible and Near-Infrared and in the Short Wave Infrared, as well as surface temperature and atmospheric observations. These observations support the interpretation of the fluorescence signal and enable atmospheric modelling for fluorescence retrieval to be applied in the data processing [2].

Following the Earth Explorer 7 assessment process, ESA's Programme Board stressed the importance of fluorescence measurements and recommended to develop a mission concept, in which the Fluorescence Imager Spectrometer would be operated from a small satellite platform flying in tandem with the Sentinel-3 mission [3]. Sentinel-3 is a dedicated land and ocean mission carrying – among other instruments – an Ocean and Land Colour Instrument (OLCI, based on ENVISAT MERIS) with up to 21 bands and the Sea and Land Surface Temperature Radiometer (SLSTR, based on AATSR) with 9 channels and dual-view capability. Both instruments shall provide the auxiliary data needed for the derivation of fluorescence and subsequently photosynthesis. Challenges of this tandem concept that have been studied in detail comprise (1) the radiometric cross-calibration, (2) the combined cloud screening and atmospheric correction, and (3) the derivation of geophysical parameters [4].

This presentation will outline the two different mission concepts and summarize the fluorescence retrieval methods and scientific results from the supporting studies.

[1] Drusch, M. and the FLEX Mission Advisory Group, 2008: FLEX Report for Assessment. ESA SP-1313/4, ESA-ESTEC, Nordwijk, The Netherlands, 116 pages

[2] Guanter, L., Alonso, L., Gomez-Chova, L., Amoros, J., Vila, J. and J. Moreno, 2007: Estimation of solar induced vegetation fluorescence from space measurements. Geophysical Research Letters, 34, doi:10.1029/2007GL029289

[3] Drinkwater, M.R. and H. Rebhahn, 2007: Sentinel-3: Mission Requirement Document. EOP-SMO/1151/MD-md 2.0, ESA-ESTEC, Noordwijk, The Netherlands.

[4] Moreno, J. and L. Guanter, 2009: Scientific assessment and mission requirements update of a Fluorescence Imaging Spectrometer flying in tandem with Sentinel-3. Final Report, ESA-ESTEC Contract 21264/07/NL/FF – CCN1, 75 pages