POTENTIAL CONTRIBUTION OF GMES / SENTINELS TO EARTH SYSTEM SCIENCE: LAND SURFACE

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ABSTRACT

The Global Monitoring for Environment and Security programme (GMES), the European contribution to the international Global Earth Observation System of Systems (GEOSS), will provide accurate, up-to-date and globally-available information on an operational basis, which will open new possibilities for improved Land Models within the context of Earth System Science, beyond operational services.

Monitoring land surface processes requires consistent temporal series of data at adequate spatial and temporal resolutions. Until now, Earth Observation data consisted on somehow isolated different data sources, most of then not defined for specific applications but for a general use oriented to mapping purposes. Problems with data availability, data inconsistency and lack of adequate temporal sampling have limited the potential usefulness of such observations.

In parallel to that, given the lack of adequate data, the models developed to describe land surface processes have to rely on available inputs, and as a consequence such models have been parameterised as a function of quite local measurements, fixed parameters for given land types and avoiding the parameterisation of processes for which no inputs were available. As a result, models have been rather simplistic, accounting only for main effects but neglecting feedbacks and simplifying the description of land/atmosphere interactions and anthropogenic effects.

Two are the main tendencies now in modelling and monitoring land surface processes using Earth Observation data: On the one hand, a general tendency in the current status of representation of Land Surface schemes into Earth System models is driven by the parameterisation of "cycles" instead of individual processes. The global water cycle, global carbon cycle, and other bio/geo-chemical cycles are linked together within the Earth System model by accounting for vertical and horizontal transport of mass, energy and momentum. Particular emphasis is made to account for couplings among the individual cycles, particularly between the carbon and water cycles. On the other hand, contrary to the approach of retrieving the information directly from the measured data by means of simple correlations or empirical approaches, a common tendency is the derivation from the data of a number of parameters that are later used as inputs to models of land surfaces processes to derive the final outputs in a more consistent way, in most cases through model-inversion techniques. Moreover, instead of retrieving biophysical parameters from the measured data separately, the tendency is to use the measured data –time series in most cases- together with models, in a data assimilation scenario where inputs from multiple sources are integrated in a transparent way. Such approach is more and more necessary as land models tend to be more complex, and particularly due to the fact that land surface variability is not just driven by physical and chemical processes, but intricate biological processes also altered by anthropogenic influences. Human influences in the land system (land use changes, urban development, etc.) and the impacts of natural disasters are becoming also part of land models, but critical data in high spatial and temporal resolutions are needed to properly model such processes.

In such context, the availability of the GMES / Sentinel series of satellites represents a quite unique opportunity for consolidation of current tendencies and development of new science based on the new

type of data that soon will become available. The usefulness of the different Sentinel missions for Land science has been recognised. Although the Sentinel satellite series were primarily designed to provide observations for operational services and routine applications, there is a growing interest in the scientific community towards the usage of Sentinel data for more advanced and innovative science. Moreover, the availability of consistent time series covering a period of over 20 years opens possibilities never explored before, such as systematic data assimilation approaches exploiting the time-series concept, or the incorporation in the modelling approaches of processes covering time scales from weeks to decades.

Sentinel-1 will provide continuity for applications already developed by using ERS-1, ERS-2 and ENVISAT ASAR data, although now with improved capabilities and more regular and systematic data availability. The all-weather capability of radar data provides time series of land surface properties even in areas with persistent cloud coverage. Sentinel-3 will provide continuity to current ENVISAT MERIS/AATSR capabilities, but with enhanced performances by means of the new OLCI and SLST instruments, which will also have a significant impact on land applications at regional to global scales. The results already derived from MERIS will be more systematically exploited by using OLCI in synergy with SLST. Particularly innovative is the case of Sentinel-2, which is specifically designed for land applications. Built on a constellation of two satellites operating simultaneously to provide 5 days geometric revisit time, the Sentinel-2 system will providing global and systematic acquisitions with high spatial resolution and with a high revisit time tailored towards the needs of land monitoring. Apart from providing continuity to Landsat and SPOT time series, the Sentinel-2 Multi-Spectral Instrument (MSI) incorporates new narrow bands around the red-edge for improved retrievals. The limitations imposed by the need of a proper cloud screening and atmospheric corrections have represented a serious constraint in the past for optical data. The fact that both Sentinel-2 and 3 have dedicated bands to allow such needed corrections for optical data represents an important step towards a proper exploitation, guarantying consistent time series showing actual variability in land surface conditions without the artefacts introduced by the atmosphere. For the first time data will be delivered including atmospheric corrections, cloud/shadows screening, adjacency effect and slope corrections, thus making possible higher-level applications. Expected operational products (such as Land Cover maps, Leaf Area Index, Fractional Vegetation Cover, Fraction of Absorbed Photosynthetically Active Radiation, and Leaf Chlorophyll and Water Contents), will be enhanced with new scientific applications. Higher level products will also be provided, by means of mosaicking, averaging, synthesising or compositing of spatially and/or temporally resampled data.

A key element in the exploitation of the Sentinel series will be the adequate use of data synergy. The synergistic use of the data is recognised as a convenient way of extracting the maximum potential of the combined time series, but in practice the synergy among the different type of data will require new developments due to the different spatial / temporal / spectral sampling of the different Sentinels. Such synergistic exploitation of data coming from the different Sentinels systems will open new potential for the development of new tools, leading to new methodological developments and new science results.

The Land community has suffered in the past a large dispersion of objectives due to the intrinsic complicate processes to be addressed involving different approaches and the diversity of scientific topics and applications. The GMES / Sentinel programme can serve as an incentive to put together activities in a coordinated way, making possible a Land Data Assimilation scheme that can guarantee a proper scientific exploitation of the data, studying and monitoring key relevant land surface processes by taking advantage of the unique manifold of active/passive instrumentation covering all spectral ranges, and the unique combination of global coverage and high spatial / temporal resolutions, and the long-term operational commitment never available before. Steps towards such operational Land Data Assimilation scheme must be initiated soon to get prepared for the amount of data to become available in the near future for land science.