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Regional certified full carbon account: fusion of remotely sensed data, on-ground information and ecological modeling

A.Shvidenko [1], S.Nilsson [1], I.McCallum [1], C.Schmullius [2], S.Quegan [3], T.LeTuan [4], A. Bartsch [5], R.A. Kidd [5], W.Wagner [5], M.Santoro [2], H.Balzer[6], S. Voigt [7], A.Luckman [8]

(1) International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria. Contact: shvidenk@IIASA.ac.at (2) Friedrich-Schiller University, Jena, Germany (3) Sheffield Center for Earth Observation Science, University of Sheffield, Sheffield, UK (4) University Paul Sabatier, Toulouse, France (5) Photogrammetry and Remote Sensing, Vienna University of Technology, Vienna, Austria (6 Center for Ecology and Hydrology, Monk Wood, UK (7) German Space Agency, Wessling, Germany (8) University of Wales, Swansea, UK

The Kyoto protocol will move into force in February of 2005. This means that carbon accounting is no longer only an academic exercise but is now a subject of global economics and policy. This paper will highlight some methodological and information problems which exist, in particular, the need for meeting thresholds of uncertainty and the independent validation and verification of results. It leads to the notion of a *certified* terrestrial biota full greenhouse gas full carbon account (FCA), which has to provide predefined levels of uncertainties and to present explicit recommendations how the uncertainties could be managed. This approach requires bridging the gaps in temporal and spatial scales of current modeling of terrestrial ecosystems' biogeochemistry and incorporating inventory-based data and process knowledge into a common framework allowing for future projections.

This presentation considers a regional scheme for the FCA developed in the framework of an EU funded project, SIBERIA-II. The accounting scheme is based on a relevant combination of *in situ* measurements (production process, major fluxes, composition and concentration of the atmospheric gases, etc.), quantification of properties of individual landscapes and ecosystems in the form of a multi-layer GIS, a multi-sensor remote-sensing concept and regional ecological models. The project covers

more than 3 million km2 of Northern Eurasia. The remotely sensed information is a vitally important component of the assessment due to (1) the continental scale of the region, (2) large, remote and sparsely populated areas lacking any completeness of data in spatial, temporal and process aspects, (3) the wide distribution of natural disturbances (like wild fire and insects' outbreaks) and, consequently, abundance of significant areas of rapid changes of land cover, and (4) seasonal variability and long-term trends of important indicators.

Based on the above mentioned methodology, we elaborate on possibilities and relevant ways to realize a certified FCA for the study region. Several problems which need to be solved include the lack of information regarding some important processes; mutual inconsistencies in the capabilities and accuracy of RS sensors and the needs of biogeochemical modeling; incompatibility of definitions and classifications used by different stakeholders; specifics of uncertainties' estimation due to the fuzzy nature of the problem; etc. Generally, an integrated observing system, which is based on fusion of different information sources and modeling tools and is spatially and temporally complete and operational, seems to be an obligatory prerequisite of any decent realization of a certified FCA over large territories. We analyze the appropriateness of different remote sensing sensors (about 20) to be used in this concept; relevant sets of models designated to combine remotely sensed indicators and "hidden" ecosystem parameters; discuss the possibilities of harmonizing definitions and classification schemes taking into account both the specifics and capacity of RS data and interests of different stakeholders; and discusses the possibility to implement a multi-sensor RS concept as part of an operational monitoring system. Preliminary results show that the applied methodology is able to provide levels of details and uncertainties which presumably should satisfy the post Kyoto development during the first commitment period.