Geophysical Research Abstracts
Vol. 14, EGU2012-11748, 2012
EGU General Assembly 2012

Simultaneous Assimilation of FAPAR and Atmospheric CO_2 into a Terrestrial Vegetation Model

T. Kaminski (1), W. Knorr (2,3), M. Scholze (2), N. Gobron (4), B. Pinty (4), R. Giering (1), and P.P. Mathieu (5)

(1) FastOpt, Hamburg, Germany (thomas.kaminski@fastopt.com), (2) School of Earth Sciences, University of Bristol, U.K., (3) Department of Meteorology and Climatology, Aristotle University of Thessaloniki, Greece, (4) European Commission, DG Joint Research Centre, Institute for Environment and Sustainability, Global Environment Monitoring Unit, Ispra, Italy, (5) European Space Agency, Earth Observation Science & Application, Frascati, Italy

Tackling the possible severe impacts of climate change on the carbon cycle and land water resources requires further development of simulation models and monitoring capabilities. Carbon cycle impacts can lead to further climate change through releases of CO_2, and impacts on water resources are critical for human survival. A rapidly increasing monitoring capability is Earth Observation (EO) by satellites. Usually, EO by its very nature focuses on diagnosing the current state of the planet. However, it is possible to use EO products in data assimilation systems to improve not only the diagnostics of the current state, but also the accuracy of future predictions. This study investigates the simultaneous assimilation of ground-based atmospheric CO_2 concentration data and Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) derived from measurements made by the MERIS sensor on-board ENVISAT and to what extent these data can be used to improve models of terrestrial ecosystems, carbon cycling and hydrology. Further development of the Carbon Cycle Data Assimilation System (CCDAS, see http://CCDAS.org) for the purpose of simultaneous assimilation of FAPAR and atmospheric carbon dioxide measurements showed that the design of the ecosystem model is critical for successful implementation of highly efficient variational data assimilation schemes. This is important, because each newly added data stream will typically require a separate observational operator. In the case of this study, it was the leaf development (phenology) sub-model that needed to be developed. As a variational data assimilation scheme, CCDAS relies on first and second derivatives of the underlying model for estimating process parameters with uncertainty ranges. In a subsequent step these parameter uncertainties are mapped forward onto uncertainty ranges for predicted carbon and water fluxes. We present assimilation experiments of MERIS FAPAR at the global scale together with in situ observations of atmospheric CO_2 in a coarse-resolution setup of CCDAS. We also present a set of mission benefit analyses, which explore design options for future space mission through quantitative network design (QND) techniques. The benefit is quantified by the reduction in uncertainty on simulated carbon and water fluxes. We analyse the effects of FAPAR and carbon dioxide observations individually as well as the effects of mission length and sensor resolution. The reduction of uncertainties from assimilating FAPAR is modest for carbon fluxes, but considerable for hydrological quantities, in particular evapotranspiration. Sensor resolution is less critical for successful data assimilation, and with even relatively short time series of only a few years, significant uncertainty reduction can be achieved. Regionally, the highest constraint for both carbon fluxes and hydrological quantities is found for Australia and Africa (in that order). This can be explained by the fact that most of the vegetation on these continents grows in tropical or sub-tropical semi-arid environments, where observation conditions are especially favourable, as already noted. Here, vegetation is water limited, which underlines the usefulness of FAPAR assimilation for hydrological studies. The study demonstrates how QND techniques can be applied to assess the complementarity of multiple data streams and the value of multi-data synergies.