Geophysical Research Abstracts
Vol. 18, EGU2016-12188-1, 2016
EGU General Assembly 2016

Using the CARDAMOM framework to retrieve global terrestrial ecosystem functioning properties

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Terrestrial ecosystems act as a sink for anthropogenic emissions of fossil-fuel and thereby partially offset the ongoing global warming. However, recent model benchmarking and intercomparison studies have highlighted the non-trivial uncertainties that exist in our understanding of key ecosystem properties like plant carbon allocation and residence times. It leads to worrisome differences in terrestrial carbon stocks simulated by Earth system models, and their evolution in a warming future.

In this presentation we attempt to provide global insights on these properties by merging an ecosystem model with remotely-sensed global observations of leaf area and biomass through a data-assimilation system: the CARbon Data MOdel fraMework (CARDAMOM). CARDAMOM relies on a Markov Chain Monte Carlo algorithm to retrieve confidence intervals of model parameters that regulate ecosystem properties independently of any prior land-cover information. The MCMC method thereby enables an explicit representation of the uncertainty in land-atmosphere fluxes and the evolution of terrestrial carbon stocks through time.

Global experiments are performed for the first decade of the 21st century using a $1^\circ \times 1^\circ$ spatial resolution. Relationships emerge globally between key ecosystem properties. For example, our analyses indicate that leaf lifespan and leaf mass per area are highly correlated. Furthermore, there exists a latitudinal gradient in allocation patterns: high latitude ecosystems allocate more carbon to photosynthetic carbon (leaves) while plants invest more carbon in their structural parts (wood and root) in the wet tropics.

Overall, the spatial distribution of these ecosystem properties does not correspond to usual land-cover maps and are also partially correlated with disturbance regimes. For example, fire-prone ecosystems present statistically significant higher values of carbon use efficiency than less disturbed ecosystems experiencing similar climatic conditions. These results raise concerns on the suitability of the plant functional type paradigm for terrestrial carbon cycling.