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Assessing the response of the Australian carbon balance to climate variability by assimilating satellite observations in a distributed ecosystem model

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Terrestrial ecosystems offset about 25% of anthropogenic emissions of fossil fuel responsible for the current global warming. This long-term carbon sink exhibits a large inter-annual variability that recent studies have associated to the response of semi-arid ecosystems to variations in climate conditions and especially the occurrence of extreme events. For example, wet conditions during the 2010-2011 La Niña episode led to the strongest annual terrestrial carbon sink ever observed. Satellite observations of plant productivity and modelling experiments indicate that this anomalous sink was mostly located in the southern hemisphere where Australia experienced record-breaking rainfall. However, the durability of this extra-sink has yet to be assessed as dry conditions returned in northern Australia at the end of 2011, causing large-scale fires.

In this paper we investigate the influence of climate variability on Australian ecosystems and we particularly focus on the resilience of the La Niña driven 2010-2011 sink to subsequent dry years. Therefore, we use the CARbon Data MOdel fraMework (CARDAMOM) data-assimilation system to retrieve the 21st century Australian terrestrial carbon cycle simulated by an ecosystem model in agreement with climate data and Earth Observations relevant to the biosphere: burned area, leaf area index and biomass. Accordingly with previous studies results indicate a strong influence of the El Niño/Southern Oscillation on the inter-annual variability of the Australian carbon balance at the continent-scale. More precisely, in 2010-2011 the La Niña-driven wet conditions led the continent to become a strong sink of atmospheric carbon. Then, dry conditions accompanied by intense fires returned at the end of 2011 and our analyses indicate that the totality of the northern Australian sink (north of 30°S) was re-emitted by late 2011 as fires immediately burnt the extra-fuel produced during the record wet seasons.

These results raise concerns on the capacity of Australian vegetation to offset anthropogenic emissions in the future as climate variability is projected to increase under global warming. They also highlight the need to consider both instantaneous and delayed impacts of climate extremes on the terrestrial carbon cycle.