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Use of data assimilation to infer the effects of sink strength on plant carbon balance processes

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Predicting the carbon balance of terrestrial plants, and its vulnerability to environmental change, is a fundamental problem common to agriculture, ecology and ecosystem science. Plant productivity is fuelled by the carbon taken up during photosynthesis, but other limitations to growth may restrict the ability of plants to utilise this carbon in production, a phenomenon known as sink limitation. Understanding how sink limitation affects the carbon balance of plants is one of the key challenges to developing better predictions of productivity. Here, we applied data assimilation (DA) to an experiment in which sink limitation was induced by restriction of the rooting volume of *Eucalyptus tereticornis* seedlings, in order to infer how carbon balance processes were affected. The ultimate goal of our study was to examine how carbon balance models should be modified to represent sink limitation of growth, whilst maintaining mass balance.

Our results demonstrate that several process representations need to be modified, including a clear need to incorporate a temporary storage pool of carbon as non-structural carbohydrate (NSC), with a dynamic utilization rate for growth. We were able to infer that, in addition to a reduction in photosynthetic rates, sink limitation reduced the NSC utilization rate, increased growth respiration, modified the carbon allocation pattern and accelerated senescence. The attribution analysis indicated that all of these process responses contributed significantly to the overall reduction in biomass observed under low rooting volume. Our DA-model analysis of this root volume restriction experiment provided significant new insights in the response of key carbon balance processes to sink limitation. Applying this approach more broadly would potentially allow us to identify general patterns in these responses that could then be formulated for inclusion into models. Overall, this approach provides important insights into the relationship between carbon uptake and plant growth, and could significantly advance our models of vegetation responses to global change.

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