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A model ensemble for explaining the seasonal cycle of globally averaged atmospheric carbon dioxide concentration

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The seasonal cycle of the globally averaged atmospheric carbon dioxide concentrations results from the seasonal changes in the gas exchange between the atmosphere and other carbon pools. Terrestrial pools are the most important. Boreal and temperate ecosystems provide a sink for carbon dioxide only during the warm period of the year, and, therefore, the summertime reduction in the atmospheric carbon dioxide concentration is usually explained by the seasonal changes in the magnitude of terrestrial carbon sink. Although this explanation seems almost obvious, it is surprisingly difficult to support it by calculations of the seasonal changes in the strength of the sink provided by boreal and temperate ecosystems. The traditional conceptual framework for modelling net ecosystem exchange (NEE) leads to the estimates of the NEE seasonal cycle amplitude which are too low for explaining the amplitude of the seasonal cycle of the atmospheric carbon dioxide concentration. To propose a more suitable conceptual framework we develop a model ensemble that consists of nine structurally different models and covers various approaches to modelling gross primary production and heterotrophic respiration, including the effects of light saturation, limited light use efficiency, limited water use efficiency, substrate limitation and microbiological priming. The use of model ensembles is a well recognized methodology for evaluating structural uncertainty of model-based predictions. In this study we use this methodology for exploratory modelling analysis – that is, to identify the mechanisms that cause the observed amplitude of the seasonal cycle of the atmospheric carbon dioxide concentration and its slow but steady growth.