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Constraining the retrieval of vegetation properties from remote sensing data

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Radiative transfer models of vegetation canopies describe the interaction between incoming radiation and the land surface, and therefore provide a direct physical link between Earth observation data and the state of vegetation. Radiative transfer models may be inverted against optical Earth observation data such as broadband albedo to retrieve canopy biophysical properties, but the limited information content of the observations, computational complexity and high number of parameters of these models has historically made this approach impractical. Assimilation approaches, where extra information is used to further constrain the inverse problem are a pragmatic way of improving this situation.

However, the assimilation of remote sensing data through the use of physically-based radiative transfer models is attractive because it allows quantification of errors and the use of multiple data sources. In this study we assimilate broadband visible and near infra-red albedo products which contain information on the absorptance of the surface, driven primarily by vegetation. We assimilate the MODIS albedo product using the biophysically-based radiative transfer model PROSAIL to retrieve a time-series of leaf area index and a set of leaf traits such as leaf chlorophyll and leaf water content that influence optical reflectance. To address the impracticality of inverting the radiative transfer model, we use statistical emulators in its place, a method which significantly speeds up the inversion process and provides a highly flexible approach to assimilation. We further constrain the optimisation by coupling the emulator of the radiative transfer model to a phenology model, to smooth temporal leaf dynamics. We also present the impact of including ground-based measurements of key leaf properties as prior information on inversions, and suggest that the use of existing large scale leaf trait databases to inform inversion could improve the accuracy of data assimilation.