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Investigation of atmospheric profiles of CO_2 & H_2O using a novel coupled model - WRF-SPA

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Vertical profiles of CO_2 contain an important source of information about the distribution of sources and sinks of carbon in an ecosystem. Here, we have developed a forward running model based on combining WRF with SPA to generate vertical CO_2 profiles for comparison with observations. We use these modelled profiles to infer the strength and distribution of sources and sinks of carbon and water.

The specific aim of this research is to combine a high resolution (4 km) forward running meteorological model (WRF) with a modified version of a mechanistic biosphere model (SPA). The combined model is used to investigate the sources and sinks of CO_2 and to explore which land surfaces contribute to vertical profiles of CO_2 observed over Aberfeldy, Scotland. The profiles were collected as part of the Aerocarb, and later, CarboEurope projects.

SPA provides surface fluxes calculated from coupled energy, hydrological and carbon cycles. This closely coupled representation of the biosphere provides realistic surface exchanges to drive mixing within the planetary boundary layer. In addition to the analysis of aircraft profiles, land based eddy covariance measurements of CO_2, H_2O and energy fluxes between the atmosphere and several different vegetation types (forest, grassland & crop land) are used for validation of surface fluxes and surface meteorology generated by WRF-SPA. Preliminary comparisons with observations has shown that WRF-SPA is capable of producing realistic annual fluxes of net carbon exchange compared to observations of a evergreen forest (obs = 3.6 tC ha^{-1} yr^{-1} ; modelled = 3.5 tC ha^{-1} yr^{-1}) and barley field (obs = 2.6 tC ha^{-1} yr^{-1} ; modelled = 2.8 tC.ha^{-1} yr^{-1}) during 2005 in Scotland.

Forward running models have a potentially significant advantage over inverse models when investigating terrestrial carbon balance. For example, inverse models are able to model carbon sink distribution as areas which do not contribute CO_2 to a given profile, while in a forward running model the sink strength is also determined by default.