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Using model-data fusion to analyze the interannual variability of NEE of an alpine grassland

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To understand the processes and magnitude of carbon dynamics of the biosphere, modeling approaches are an important tool to analyze carbon budgets from regional to global scale.
Here, a simple process-based ecosystem carbon model was used to investigate differences in CO_2 fluxes of a high mountain grassland near Furka Pass in the Swiss central Alps at an elevation of about 2400 m a.s.l. during two growing seasons differing in snow melt date.
Data on net ecosystem CO_2 exchange (NEE) as well as meteorological conditions was available from 20.06.2013 – 08.10.2014 covering two snow free periods. The NEE data indicates that the carbon uptake during the growing season in 2013 was considerably lower than in 2014.
To investigate whether the lower carbon uptake in 2013 was mainly due to the short growing season, an effect of biotic response to spring environmental conditions, or the direct effect of the weather conditions during the growing season, a modeling approach was applied. For this purpose, an ecosystem mass balance C model with 13 unknown parameters was constructed based on the DALEC model to represent the major C fluxes among six carbon pools (foliage, roots, necromass, litter, soil organic carbon and a labile pool to support leaf onset in spring) of the grassland ecosystem. Daily gross primary production was estimated by use of a sun/shade big-leaf model of canopy photosynthesis. By calibrating the model with NEE data from individual years, two sets of parameters were retrieved which were then used to run the model under environmental conditions of the same as well as the other year.
The parameter estimation was done using DREAM, an algorithm for statistical inference of parameters using Bayesian statistics. In order to account for non-normality, heteroscedasticity and correlation of model residuals, a common problem in ecological modeling, a generalized likelihood function was applied.
The results indicate that the late growing season start in 2013 led to a slower structural development of the grassland in the beginning. Nevertheless, maximum daily NEE values in 2013 were comparable to those in 2014. Moreover, the analysis showed that there was no direct effect of weather conditions during the snow free period. This indicates that the overall lower carbon uptake in 2013 was due to a slow start and the short growing season.