Carbon storage potential of a managed mountain grassland

Inverse modelling and uncertainty analysis

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Background

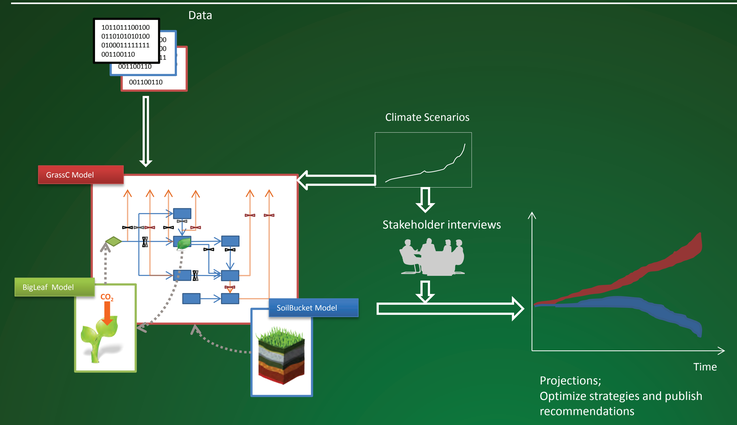
Biogeochemical models are often difficult to calibrate due to their complex structure and/or their large number of parameters. To provide reliable results as well as defensible estimations of uncertainty any model-data fusion approach has to account for and quantify all errors consisting of input, model structural and parameter errors. Here we present a modelling study of the carbon cycling of a managed temperate mountain grassland in the Austrian Alps.

In this study we

i) provide a comprehensive model inversion scheme using multiple data sets for parameter constrainment

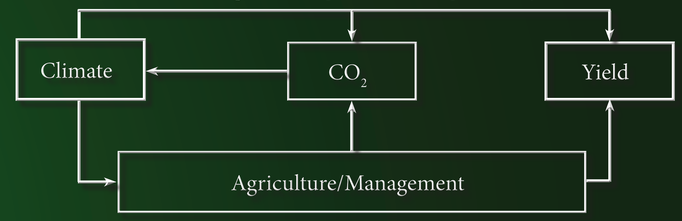
ii) focus on the correct residual handling in the parameter estimation scheme in order to provide a robust parameter- and predictive uncertainty estimation

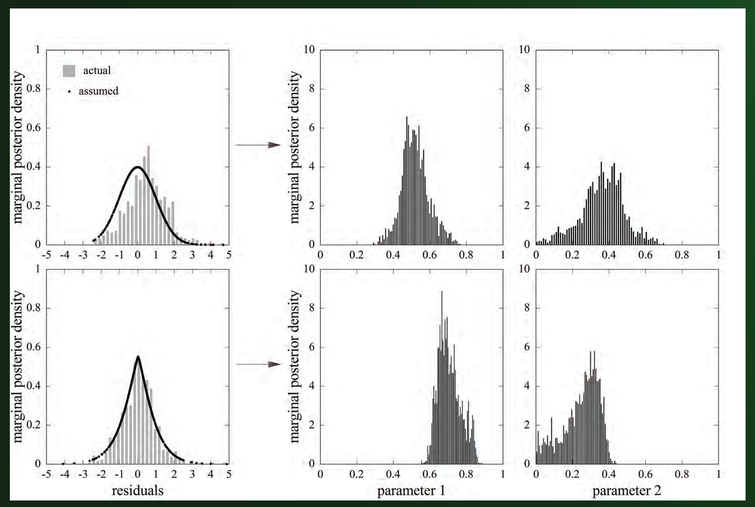
iii) project future carbon storage potentials and yields using the models in combination with local climate scenarios and management strategies.



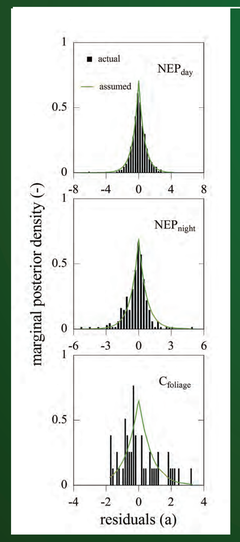
Project outline - Multiple data sets from the LTER grassland site in Neustift (A) and 10 more short term sites are used to calibrate a model group. This group consists of a big leaf photosynthesis model (BigLeaf), a soil water content model (SoilBucket) and a carbon balance model for managed grasslands (GrassC). Once calibrated these models are used to explore the carbon storage potential of managed grassland ecosystems under different future management- and climate-scenarios. Given these model results optimal management strategies can be provided to maximize the carbon storage potential without compromising yield.

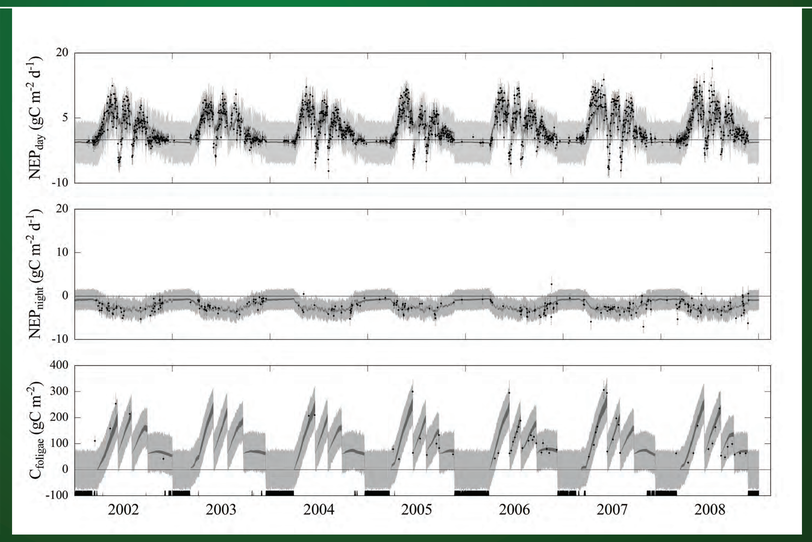
Mutual dependences of CO_2, climate, agriculture and generated yield.





Correct residual handling - Illustrative example of biased parameter estimations due to incorrect assumptions about the actual error probability model. Wrong assumptions about the actual residuals lead to worse estimates of parameter- and total prediction-uncertainty (upper panels). The generalized likelihood function, introduced by Schoups et al. (2010) allows for the handling of dependent, heteroscedastic, and non-normally distributed model residuals and improves uncertainty estimates (lower panels).

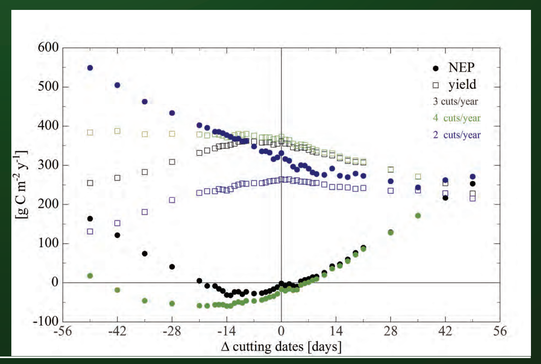




Modelling results - Assumed and actual residual distributions for the NEP_{day}, NEP_{night} and $C_{foliage}$ data sets derived from parallel estimation of carbon model, GPP model and the three error model parameters (left figure).

Modelling results are depicted in the right figure. Measured NEP_{day}, NEP_{night} and $C_{foliage}$ data are shown as solid black circles including error bars for ± 1 stdv. Model uncertainties resulting from parameter uncertainties are depicted as dark grey shaded areas. Predictive uncertainties, comprising measurement, model input and model structural errors, are depicted as bright grey areas.

Snow covered periods are shown as black horizontal bars in lowermost panel. Sudden drops in $C_{foliage}$ data are caused by cutting events taking place three times a year or the establishment of a long lasting snow cover, respectively.



Modelling results - Effects of changes in cutting dates and/or frequencies on the net ecosystem production (NEP) and generated yield.

Outlook

Further research will focus on the application of the established model group and inversion scheme at different grassland sites. Subsequently recommendations for future management strategies will be established. These will be derived from model runs given likely future climate scenarios and management options worked out in stakeholder interviews.

We are aiming for future management strategies of grassland ecosystems that provide a win-win-situation concerning the carbon storage potential and the farmers yield.

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Schoups, G. & Vrugt, J. A. A formal likelihood function for parameter and predictive inference of hydrologic models with correlated, heteroscedastic, and non-Gaussian errors. Water Resour Res 46, 10531-10531 (2010).