GrassClim

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Interactive Effects of changes in climate and management on yield and CO_2 source/sink strength of grassland ecosystems in the Alps

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Introduction

Climate change is affecting agriculture and changes in agriculture are very likely affecting the CO_2 source/sink of the managed land, feeding back to climate. The most important form of agricultural management in the European Alps is grassland farming, characterized by grazing and mowing (Pic.1). Higher temperatures are likely to decrease the duration of snow cover, thus prolonging the vegetation period and allowing for more intensive management with higher annual yields, whereas decreased summer rains may lower annual yields. Hence droughts and more intensive management could counteract the increased CO_2 uptake resulting from longer vegetation periods of the grasslands.

These interactive effects of climate change and adaption in management on the yield and CO_2 uptake/release of Alpine grasslands are analyzed within the Sparkling Science project GrassClim. The three main objectives are:

1) Development of future scenarios of grassland management and regional climate.
2) Simulation of grassland yield and CO_2 sources/sink strength with respect to the developed scenarios and development of sustainable forms of management for future climatic conditions.
3) Demonstrating the relevance of ecological science for decision-making processes of young farmers.

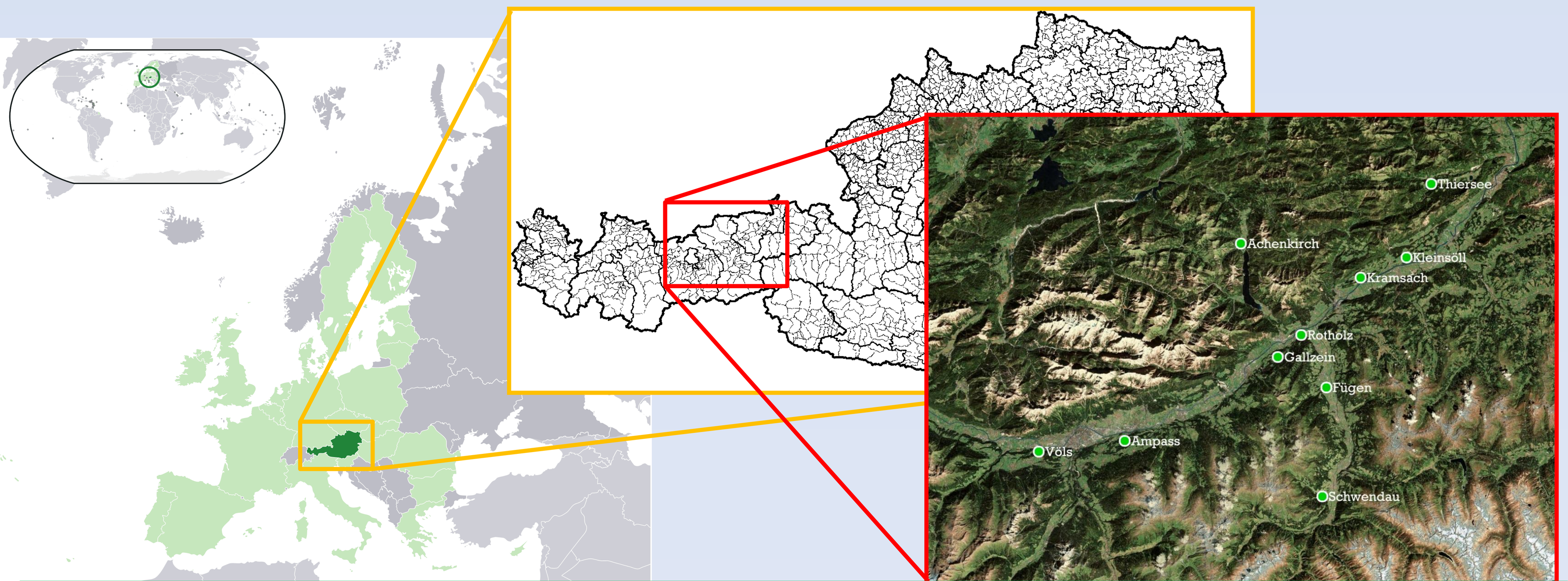

Fig.1: The ten study sites are situated in the Eastern half of North Tyrol (Austria).

Pic.1: The mowing of the grassland at a site in Neustift in the Stubai valley (Austria) – the typical form of management on all study sites.

Pic. 2: Young farmers study the function of the micrometeorological station at one of the ten study sites. Measured variables are photosynthetically active radiation (PAR), precipitation, air and soil temperature, humidity, and soil water content.

Pic.3: Eddy covariance flux tower in Neustift in the Stubai valley. The measured CO_2 net ecosystem exchange is used for calibrating the GrassC model.

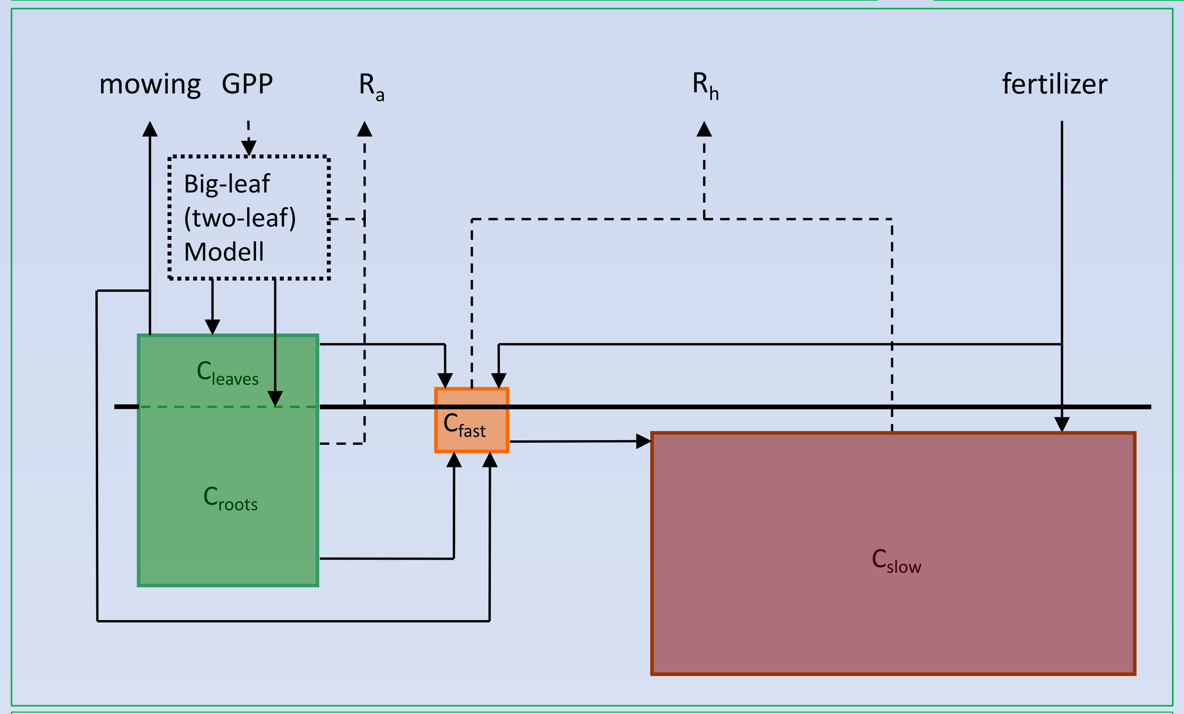

Fig.2: Diagram of the GrassC model. Dashed arrows symbolize gaseous fluxes, solid arrows symbolize solid and fluid fluxes, colored rectangles symbolize carbon pools. (modified according to Williams et al., 2005).

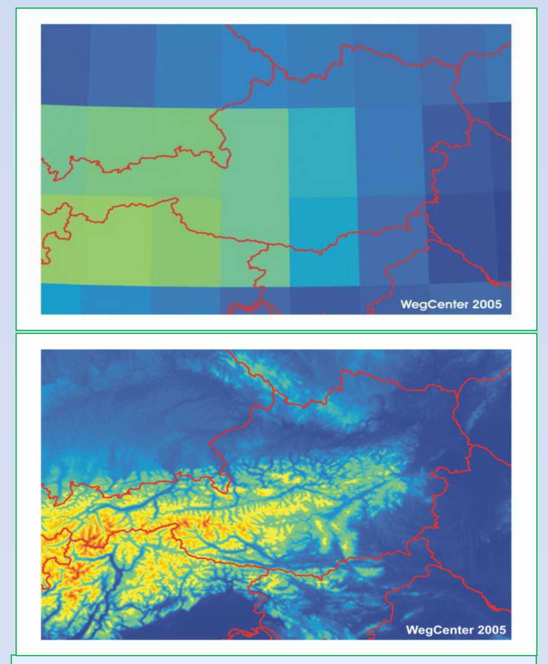

Fig.3: The local climate scenarios (lower picture) are generated by downscaling regional climate models (upper picture).

Methods

The ten study sites are situated in the eastern half of North Tyrol (Austria) (Fig. 1). On each site a micrometeorological station measures the incident photosynthetically active radiation (PAR), air temperature and humidity, soil temperature and water content, as well as the precipitation (Pic.2). In addition, the above ground biomass is measured regularly, which is also used to validate remote sensing data of theses sites.

The future local climate scenarios are generated through statistical downscaling (Fig.3) and the future management scenarios through questionnaires completed by young farmers. The various scenarios are used in the model GrassC, a process-oriented carbon cycle model for managed grassland ecosystems (Williams et al., 2005) (Fig.2), in which a big-leaf (two-leaf) model according to DePury and Farquhar (1997) is included. The model is calibrated in the Bayesian framework DREAM (DiffeRential Evolution Adaptive algorithM), which is a Markov-chain Monte Carlo algorithm (Vrugt et al., 2008). The calibration data are above-ground biomass and CO_2 net ecosystem exchange fluxes measured with eddy covariance flux towers on seven sites in the North Tyrolean Alps since 2001 (Pic. 3).

Preliminary Results

The vegetation period 2011 shows consistent micrometeorological data for all ten sites. For example, the data showed a clear relationship between precipitation and soil water content and between air and soil temperature.

The calibration of the model parameters with the DREAM-Algorithm was first used for only the big-leaf (two-leaf) model (DePury and Farquhar, 1997) and showed a comparably fast convergence of the four parameters to a constant probability distribution. This implies that the CO_2 flux data was sufficient for the calibration (Fig.4). Another characteristic showing that the DREAM-Algorithm works for this particular calibration, is the low correlation between the four model parameters.

Further steps will be to use the DREAM-Algorithm for the GrassC model and the combined model. The optimal model found thereof, taking account of parameter uncertainties, parameter correlation and equifinality, will be used for the ten study sites. The final step is to calculate future projections of annual yields and CO_2 source/sink strengths for combinations of the different management scenarios and local climate scenarios.

References

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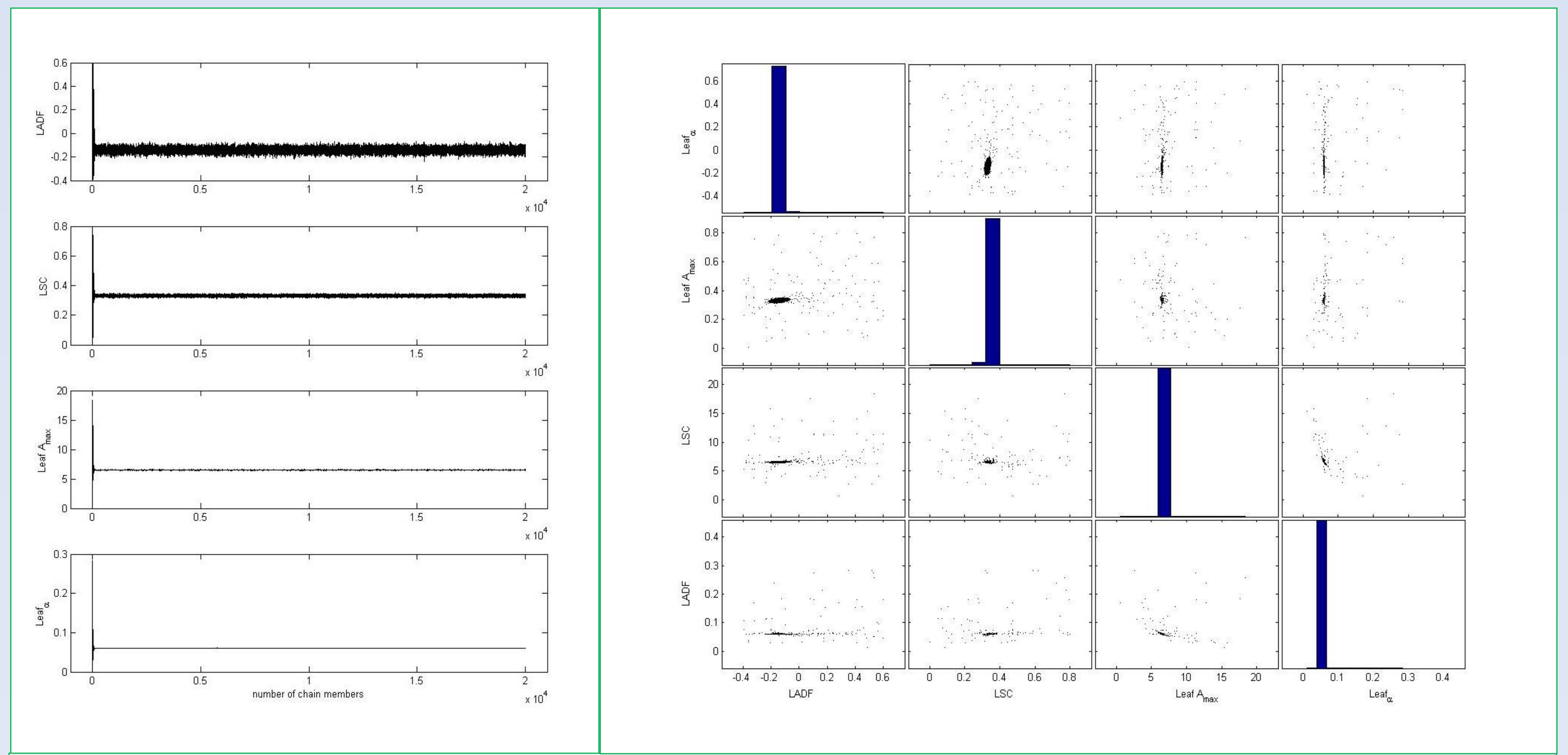

Fig.4: Left: Ten Markov-chains running the four big-leaf (two-leaf) model parameters (DePury and Farquhar, 1997) converge by using DREAM (DiffeRential Evolution Adaptive algorithM) (Vrugt et al., 2008).
Right: Probability distribution and parameter correlation of the four model parameters: leaf angle distribution factor (LADF), leaf scattering coefficient (LSF), maximum photosynthetic capacity (Leaf A_{max}), and initial quantum yield (Leafα).