Inter-annual variability of the net ecosystem CO_2 exchange of a temperate mountain grassland

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Background Of the 7 Pg carbon (C) released on average each year to the atmosphere through fossil fuel burning, the terrestrial biosphere absorbs about one third, thereby slowing the build-up of atmospheric carbon dioxide (CO_2) and the associated effects of climate change. Quantifying the net exchange of CO_2 (NEE) between land ecosystems and the atmosphere and projecting how their NEE will be affected by likely future climate and land use is thus a critical issue in environmental science and requires understanding of the interactions and feedbacks within the C cycle and the way these are influenced by human interference. In order to quantify the CO_2 source/sink strength of temperate mountain grasslands and to analyse the corresponding environmental and management controls we are investigating the NEE of a grassland close to the village of Neustift (Austria) since 2001 using the eddy covariance method (Fig. 1).

Results The investigated grassland was essentially carbon-neutral during the six-year study period, with both small net C gains and losses occurring (Fig. 2). Since lateral C flows in (manure) and out (hay) of the site associated with management were of approximately equal magnitude, the net ecosystem C balance of this site is around neutral as well. The two component processes of NEE, gross primary production (GPP) and ecosystem respiration (Reco), were highly correlated at the annual time scale – large annual carbon gains (GPP) were associated with large carbon losses (Reco) and *vice versa*. Subdividing the year into characteristic phenological time periods showed that GPP was more important for NEE than Reco in spring and prior to the three cuts, while the reverse was true for the post-cut periods (Fig. 2). GPP was the process dominating the seasonal variability of NEE (Fig. 3), because cutting keeps the investigated grassland in a stage of vigorous growth most of the vegetative period. Temperature explained much of the inter-annual variability in GPP and Reco, but because of the covariance of these two metrics, effects on NEE were usually not significant. No restrictions of NEE owing to low soil water availability, even during the hot and dry summer 2003, could be determined.

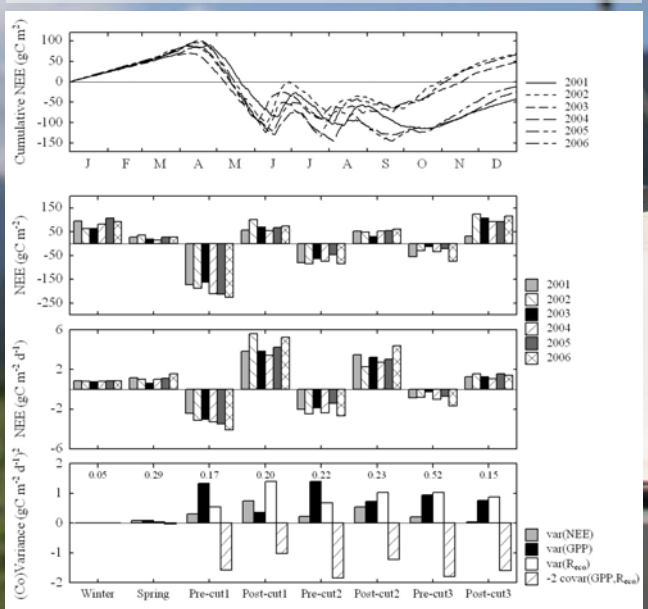

Figure 2 Cumulative net ecosystem CO_2 exchange (NEE, uppermost panel), NEE and daily average NEE (middle panels), and (co)variance of daily average NEE and its components (lowermost panel) during various periods.

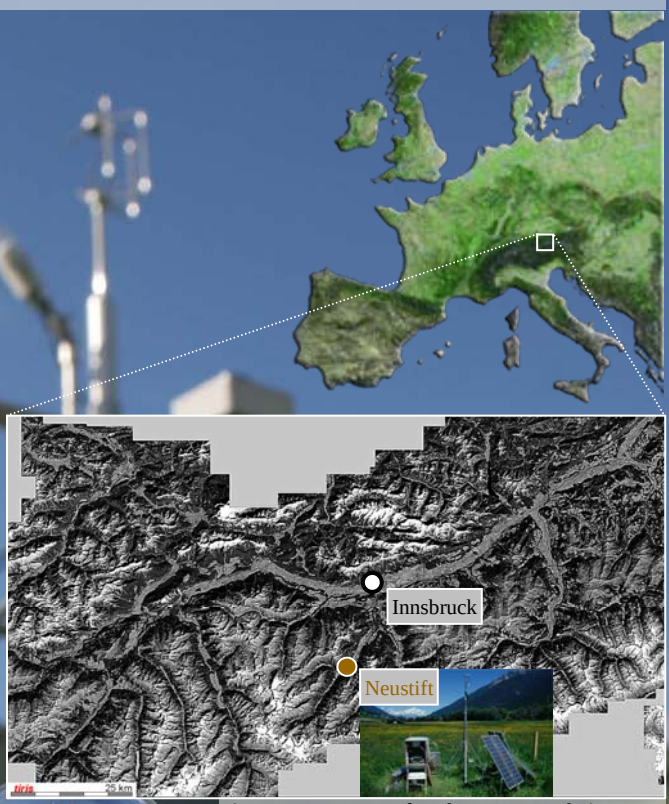

Figure 1 Location of study site in Tyrol, Austria.

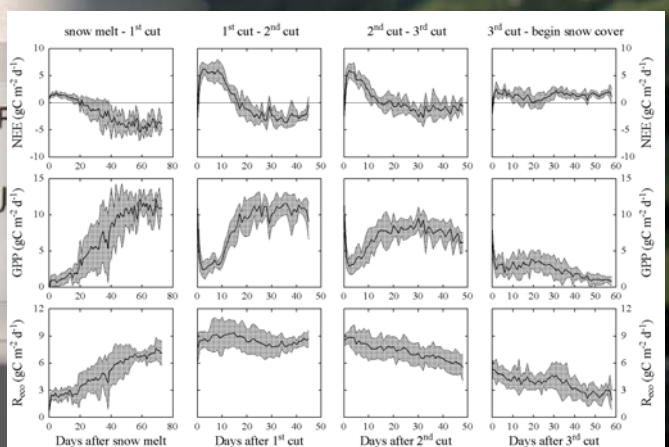

Figure 3 Seasonal variation of daily average net ecosystem CO_2 exchange (NEE, upper panels), gross primary production (GPP, middle panels) and ecosystem respiration (Reco, lower panels)

Conclusions Our results show that the investigated meadow, under present climate and management, exhibits a relatively stable near-neutral NEE – the site is neither loosing large amounts of C nor is there large potential for C storage. The observed sensitivity to temperature hints to a potential susceptibility to anticipated climate change, but it would require a model, parameterised with the present data, to faithfully extrapolate NEE to future climatic conditions.