The sensitivity of the net ecosystem CO_2 exchange of a temperate mountain grassland to weather

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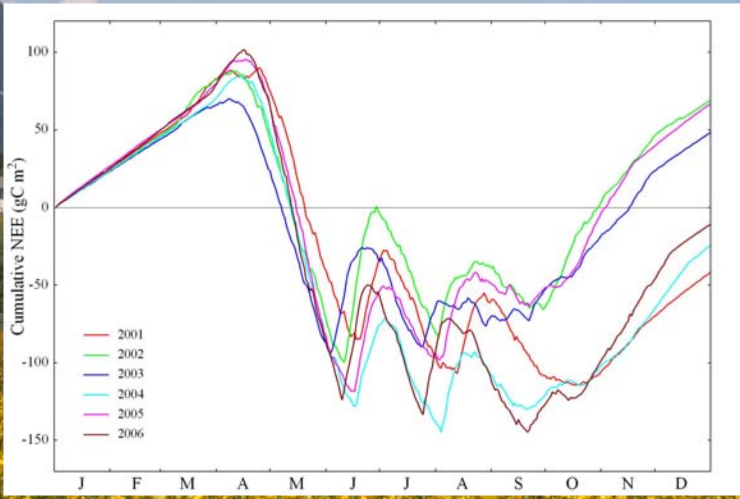
Background Of the 7 Pg carbon (C) released on average each year to the atmosphere through fossil fuel burning, the terrestrial biosphere absorbs about one third, thereby slowing the build-up of atmospheric carbon dioxide (CO_2) and the associated effects of climate change. Quantifying the net exchange 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 (R_{eco}), were highly correlated at the annual time scale – large annual carbon gains (GPP) were associated with large carbon losses (R_{eco}) 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. 3). GPP was the process dominating the seasonal variability of NEE, 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 R_{eco}, but because of the covariance of these two metrics, effects on NEE were usually not significant (Table 1). No restrictions of NEE owing to low soil water availability, even during the hot and dry summer 2003, could be determined.

Figure 1 Location of study site in Tyrol, Austria.



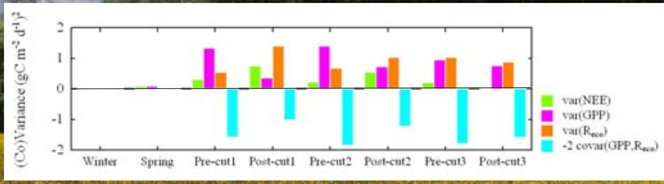


Figure 3 Components of variance of seasonal net ecosystem CO_2 exchange.

Figure 2 Cumulative net ecosystem CO_2 exchange (NEE) during the six study years.

Table 1 Correlation coefficients of linear regression analysis.

	NEE				GPP				R_{eco}			
	PAR	T_{air}	VPD	REW	PAR	T_{air}	VPD	REW	PAR	T_{air}	VPD	REW
Winter	0.29	-0.64	-0.75	0.24	-	-	-	-	0.29	-0.64	-0.75	0.24
Spring	0.57	0.54	-0.35	0.21	-0.64	**-0.80**	0.10	-0.58	-0.09	-0.41	-0.45	-0.62
Pre-cut1	0.54	0.04	0.26	0.13	-0.63	0.27	0.01	0.00	-0.61	0.45	0.21	0.10
Post-cut1	0.67	**0.76**	**0.78**	-0.07	0.16	0.53	0.19	-0.08	0.57	**0.83**	0.67	-0.09
Pre-cut2	-0.57	-0.64	-0.22	0.24	0.58	0.70	0.33	-0.31	0.51	0.64	0.35	-0.31
Post-cut2	-0.16	0.36	0.25	-0.44	0.40	0.69	0.66	-0.61	0.21	**0.83**	0.73	**-0.83**
Pre-cut3	0.03	0.04	0.47	-0.34	**0.92**	**0.97**	0.62	**-0.78**	**0.90**	**0.95**	**0.81**	**-0.91**
Post-cut3	0.44	0.56	0.17	0.09	0.72	**0.78**	0.53	-0.58	**0.76**	**0.84**	0.53	-0.52
Annual	-0.18	0.32	0.17	-0.18	-0.05	0.69	0.07	-0.15	-0.15	**0.81**	0.18	-0.23

Conclusions Our results show that the investigated meadow, under present climate and management, exhibits a relatively stable near-neutral NEE. The observed sensitivity to temperature hints to a potential susceptibility to anticipated climate change.