Work package 1:

Net ecosystem CO_2 exchange

Aim

Aim of WP 1 is to provide estimates of the annual net ecosystem carbon exchange of differently managed European mountain ecosystems and their seasonal and inter-annual variability.

Deliverables

* Annual sums, seasonal and inter-annual variability of NEE
* Effects of land use/management on NEE
* Effects of climatic conditions on NEE
* Comparison of NEE of non-forest and adjacent forest ecosystems (from other projects)
* Cross-calibration of micrometeorological and chamber methods

No.	Work description
1	Continuous (2+ years) measurements of net ecosystem exchange (NEE) will be made employing the Eddy-Covariance technique at least at one plot in each study site which satisfies the requirements of the Eddy-Covariance (EC) method (terrain, slope, fetch).
2	Discontinuous measurements of net ecosystem exchange (NEE) will be made employing the EC method at sites, which do not permit continuous long-term measurements or by means of alternative techniques such as the Bowen-Ratio-Energy-Balance (BREB) method or chamber techniques at sites where the assumptions underlying the EC method are violated.
3	The validity of nighttime EC flux measurements will be assessed using chamber methods.
4	Flux measurements will be accompanied by continuous measurements of the environmental driving forces (global radiation, net radiation, air temperature, humidity and wind profiles, canopy temperature, soil temperature and water content profiles, precipitation).
5	Data gaps will be filled following the guide-lines for gap filling developed in existing flux networks and by means of a process-oriented model of ecosystem mass and energy exchange (cf. WP 4).

Detailed assessment of the contribution of each partner team to the work description above, separately for each of the 23 study sites:

	UIBK					UBT		UNITUS		CEA		CEH		ULUND		UHEL		CEAM		LAC		SIRG	
	A1	A2	A3	A4	A5	G1	G2	I1	I2	I3	I4	UK1	UK2	S1	S2	F1	F2	E1	E2	CH1	CH2	CH1	CH2
1	v	v	-	-	-	v	-	v	-	v	-	v	-	v	-	v	-	v	-	v	-	-	-
2	-	-	v	v	v	-	v	-	v	-	v	-	v	-	v	-	v	-	v	-	v	-	-
3	v	v	-	-	-	v	-	v	-	-	-	v	-	v	-	v	-	v	-	v	-	-	-
4	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	-	-
5	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	-	-

1. NEE measurements by means of eddy covariance (EC)

The protocols for eddy covariance generally adhere to the standard set by the EUROFLUX project, as pinned down in Aubinet et al. (2000). In addition, some teams will employ open-path infrared gas analysers instead of the closed-path model Li-6262. In these cases, some corrections to raw fluxes do not apply (eg. tube attenuation), while others need to be made (density effects). Profiling systems to estimate storage of scalar material below the height of the EC sensors are considered voluntary, given that storage is likely to play a minor role with short vegetation and low sensor heights. Each team is though encouraged to corroborate this hypothesis. The following parameters represent the main output parameters (half-hourly averages):

Output	**Units**
Net ecosystem CO_2 exchange (NEE)	µmol m^{-2} s^{-1}
Sensible heat exchange (H)	W m^{-2}
Latent heat exchange (LE)	W m^{-2}

2. NEE measurements by chamber techniques

Chamber measurements should be compared against eddy covariance measurements.

In as far as complimentary chamber flux measurements are carried out the following draft protocol is suggested

Experiments	Protocol	Optional
Parameters	CO_2 (Li-Cor) †††#	$CH_4 + N_2O$ etc.
	Soil concentration profiles††	
		CH_4 prod./cons. rates in situ††
	Soil moisture (TDR) *	Water table (automatic logged)
	Thaw depth†††	
	Total C, N, P† 0-10, 10-20, 20-30 cm	
	Bulk density†	
	pH†	
	Vegetation composition†	Detailed quantitative veg. analyses
	Photographs of all plots†	
	Root distribution†	
	Standing crop - phytomass††	
	NDVI††	
	Soil temp (min three depths, 5 cm int.) *	
	PAR*	

* Continous measurements
† Once or twice during experiments
†† Three times per season or more frequent
††† Weekly July-August (biweekly or less outside peak season)
\# Automated measurements are optional

Methodologies

Chambers

Bases of aluminium or steel with a water channel for sealing. Depth in soil between 5 and 20 cm depending on stability and seal.
Plexiglas chambers (squared between 20 and 60 cm sides, 10 - 30 liters).
Plexiglas should be of a quality and thickness which reduces PAR with <10%.
Chambers equipped with a hole (to avoid pressurising the system when installing the chamber), which can be closed with a rubber stopper or cork when the measurement is

starting. IRGA system (Li-Cor, PP Systems or the like) for continuous measurement of CO2 over a 4-minute chamber installation period logged at < 1 minute intervals. IRGA equipped with desiccant (magnesium perchlorate) in the flowline to the sample cell. Flow-through measurements may also be applied but under the condition occasional comparisons are made with closed chamber measurements

A probe for logging temp., PAR and RH situated inside the chamber.

A small internal fan should be installed and operated in connection with all chamber measurements. Cooling is optional but preferred where applicable.

3. Supporting meteorological (above- and below-ground) measurements

Parameter	Instrument	Units
Level I		
Net radiation (R_n)	Net radiometer	W m^{-2}
Global radiation (R_g)	Pyranometer	W m^{-2}
Diffuse radiation (R_d)	Pyranometer & shadow band	W m^{-2}
Soil heat flux (G)	Heat flux plates/temperature profile [1]	W m^{-2}
Air temperature (T_a) [2]	Resistance/thermocouple	°C
Soil temperature (T_s) [3]	Resistance/thermocouple	°C
Precipitation (PPT)	Rain gauge	mm
Relative humidity (RH) [2]	Resistance/capacitance/psychrometer	%
Soil water content (SWC) [4]	TDR/theta probe	m^3 m^{-3}
Wind speed (U) [2]	Cup anemometer	m s^{-1}
Wind direction (U_{dir}) [5]	Wind vane	°
Static air pressure (P_a)	Barometer	kPa
Level II		
Incident PPFD (PPFD)	Photodiode	µmol m^{-2} s^{-1}
Reflected radiation (R_{ref})	Pyranometer	W m^{-2}
Canopy temperature (T_c)	Infrared sensor/resistance/thermocouple	°C
Soil water potential (SWP) [4]	Tensiometer	kPa
Snow depth (SNOWD) [6]	manual/?	m
Profiling system (CO_2, H_2O, T_a)	IRGA & temperature sensor	µmol mol^{-1}, mmol mol^{-1}, °C

Except for snow depth, half-hourly averages (synchronised with EC measurements) of these parameters are calculated. See Tappeiner et al. (1999) and Aubinet et al. (2000) for further details.

[1] … heat flux calculated using combination of temperature integral and temperature gradient method; necessary measurements: profile of soil temperature and water content, organic and mineral volume fractions (per soil horizon)
[2] … at reference height; above-canopy profile on voluntary basis
[3] … at 0.0, 0.05, 0.1, 0.2, and 0.5 m soil depth
[4] … at 0.05, 0.1, 0.2, 0.35 and 0.5 m soil depth
[5] … at reference height
[6] … at weekly intervals

4. Gap filling

Gap filling of eddy covariance data sets will be done using the routines proposed by Falge et al. (2001a,b). Given the dynamic nature of grassland growth, care is to be taken, that, whatever method is employed, these dynamics are adequately captured, which should be discussed at a workshop during the later stage of the project. Gaps in continuous chamber measurements will be filled employing the same approach. In case chambers are operated periodically, gap filling algorithms will be parameterised separately for each campaign and applied in a non-overlapping manner between subsequent campaigns or on a longer time frame (based on pooled data) if changes in NEE turn out to be negligible between campaigns.

5. References

Aubinet M. *et al.* (2000) Estimates of the annual net carbon and water exchange of forest: the EUROFLUX methodology. *Advances in Ecological Research* **30**, 113-175.

Falge E. *et al*. (2001*a*) Gap filling strategies for defensible annual sums of net ecosystem exchange. *Agricultural and Forest Meteorology* **107**, 43-69.

Falge E. *et al*. (2001*b*) Gap filling strategies for long term energy flux data sets, a short communication. *Agricultural and Forest Meteorology* **107**, 71-77.

Tappeiner U. *et al.* (1999) Microclimate, energy budget and CO_2 gas exchange of ecosystems. In: *Land-use changes in European mountain ecosystems. ECOMONT – concepts and results* (Cernusca A., Tappeiner U., Bayfield N. Eds.), Blackwell Wiss. Verlag, Berlin, 135-145.