Work package 4:
Modelling net ecosystem CO_2 exchange

Aim

The objective of WP 4 is to simulate the annual net ecosystem CO_2 exchange (NEE) of mountain ecosystems in order to assess the contribution of various ecosystem components, their interactions and the way these are influenced by land use and climate, and to provide an alternative method for gap filling for annual carbon balance estimates (WP 1).

Deliverables

* Development and adaptation of ecosystem SVAT modelling software
* Parameterised and validated models of NEE for all ecosystems studied
* Data sets for filling gaps in measured NEE (WP 1)
* Application of models for a detailed process analysis of NEE
* Scenarios of land-use effects on NEE

No.	Work description
1	Regression-type models (Level I): Measured net ecosystem CO_2 exchange will be separated into the soil and vegetation component using eddy covariance and soil respiration measurements. Regression-type models will then be used to study biological and physical controls on the two component processes.
2	SVAT models (Level II): A multi-layer modelling approach will be followed, dividing both the canopy space and the soil into a finite number of discrete layers. The above-ground modules calculate the fluxes of CO_2 and energy originating from the canopy phytoelements within the boundaries defined by an arbitrary reference level above the canopy and the soil surface. Radiative transfer, the absorption of momentum, and the turbulent fluxes of CO_2 and energy and the respective source/sink strengths will be explicitly resolved for each canopy layer. The below-ground modules calculate soil respiration, the transport of water and heat within the soil and the regulation of stomatal conductance by soil water availability. Input data consist of time series for the meteorological forcing variables, and structural/functional parameters describing the state of the soil-vegetation system. Necessary model input data have been gathered largely within the frame of previous projects, additional data will be acquired within the frame of WP 2 and 3, validation data will be contributed by WP 1.

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	v	v	v	v	v	v	v	v	v	v	v	-	-
2	v	v	v	v	v	-	-	-	-	v	v	-	-	-	-	-	-	-	-	-	-	-	-

Level 1: Regression-type models

In order to study and explain the biological and physical controls on net ecosystem CO_2 exchange and its component processes, the following Level I approach will be employed at all sites: Measured net ecosystem CO_2 exchange will be separated into the soil and vegetation component using eddy covariance and soil respiration measurements. Regression-type models will then be used to study biological and physical controls on the two component processes. Some of this work will be anyhow done if teams aim to use regression models to fill data gaps in NEE (see protocol WP1), but within the frame of WP 4 the aim rather is to use these relationships as tools to detect general patterns/differences in the controls across all sites. Regression-type models will be validated using a subset of the flux data not part of parameter estimation procedure.

Level II: SVAT model

In the following there is a general description of the SVAT model used by teams CEA and UIBK, including the respective input and output parameters, their units, spatial and temporal resolution, etc.:

The SVAT model employed is a 1-dimensional, multi-layer representation of the soil-vegetation-atmosphere continuum and calculates half-hourly to hourly fluxes of CO_2 and energy between the soil-vegetation system and a specified reference height above the canopy. It consists of coupled micrometeorological and physiological modules: The micrometeorological modules compute radiative transfer, the interception of precipitation, the transfer of momentum and the turbulent dispersion of CO_2, H_2O and sensible heat within and above the canopy using a random-flight scheme. Turbulence statistics required for the turbulent dispersion calculations are derived from a second-order closure model. Soil heat and water fluxes as well as soil respiration are simulated within a soil sub-module. The environmental variables computed in the micrometeorological modules represent the driving forces for the energy balance model, which partitions absorbed energy into emitted long-wave radiation, latent and sensible heat fluxes. Net photosynthesis, respiration, and stomatal conductance are calculated in a sub-module of the energy balance, whenever applicable. SVAT models will be validated using NEE measured by means of eddy covariance, chambers and alternative micrometeorological methods.

Main modules	Main output parameters
phytoelement gas exchange	net photosynthesis (µmol m^{-2} s^{-1}), stomatal conductance (mmol m^{-2} s^{-1}), internal CO_2 concentration (µmol mol^{-1})
energy balance	surface temperature (°C), sensible heat exchange (W m^{-2}), latent heat exchange (W m^{-2}), net radiation (W m^{-2}), heat storage (W m^{-2}), dew status and amount (kg m^{-2})
soil respiration	soil respiration (µmol m^{-2} s^{-1})
soil heat flux	soil heat flux (W m^{-2}), soil temperature (°C)
soil water flux	soil water content (m^3 m^{-3})and matric potential (Pa), soil evaporation (W m^{-2})
radiative transfer	NIR (W m^{-2}), PAR (µmol m^{-2} s^{-1}) and long-wave radiation (W m^{-2}) absorbed by canopy and soil surface, NIR, PAR and long-wave radiation emitted and reflected by the canopy
momentum transfer, turbulence statistics	within and above canopy profiles of mean wind speed (m s^{-1}), shear stress (m^2 s^{-2}), vertical velocity standard deviation (m s^{-1}) and Lagrangian time scale (s)
turbulent dispersion of CO_2, H_2O and heat	within and above canopy profiles of CO_2 (µmol mol^{-1}), H_2O (hPa) and air temperature (°C)
rainfall and dew interception	interception (kg m^{-2} s^{-1}), throughfall (kg m^{-2} s^{-1})

List of input parameters

See appendix to protocol of work package 4