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A ten-year study period of carbon and water vapour fluxes in a spruce forest: inter- and intra-annual variability analysed at plot and ecosystem scale

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At a long-term study site in the Tharandt forest (375 m a.s.l.; eastern Germany) dominated by old-growth Norway spruce (*Picea abies* (L.) Karst.) net ecosystem exchange of carbon dioxide and water vapour are continuously measured by eddy-covariance technique since 1996. Measurements are accompanied by standard meteorological and soil physical observations as well as by studies of above-ground tree growth and sap flow. The period since 1996 covers almost all meteorological extremes observed at the site during the last 45 years: the coldest year with annual mean air temperature (T_a) of 6.1 ˚C (1996), the warmest year with 9.6 ˚C (2000), the year with maximum annual precipitation of 1098 mm (2002, Saxonian flood), and the driest year with 501 mm (2003). Annual net ecosystem production (NEP = total net carbon uptake by the plant plus soil compartment) derived from eddy-covariance measurements ranged between 698 gC m^{-2} a^{-1} (2000) and 395 gC m^{-2} a^{-1} (2003). The ratio of sensible and latent heat fluxes (H/LE) was found to be highest in 2003 (1.4) and lowest in 1998 and 2001 (0.6). Excluding the singular cold year 1996, no correlation was found between T_a and NEP (range of T_a 8.3-9.6 ˚C) on an annual basis. But NEP was positively correlated with length of growing season determined from phenological observations except for the years with summer drought (2003, 2004). Significant reduction in tree sap flow and canopy conductance during summer drought allowed estimation of "lost days" of the growing period. Annual above-ground net primary production (NPP_{ag}) determined from radial stem growth and tree harvests in the vicinity of the tower as

well as from forest inventories (ΔC-method) within the total source area (500 m radius) represented on average 63% of NEP and was not correlated with annual T_a or precipitation. Results on an annual basis are analysed with respect to (1) differences in the seasonal performance of selected years, (2) differences in carbon and water relationships, and (3) differences related to spatial integration, e.g., plot and ecosystem level.