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A model of errors in field-based temperature sensitivity of heterotrophic soil respiration as introduced by temperature measurement depth

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Simultaneous field measurements of CO_2 flux and temperature are often used to quantify the temperature sensitivity of respiration. If soil surface CO_2 efflux and temperature at a specific depth are used to establish such a relation, the sensitivity parameter (e.g. Q10) depends on temperature measurement depth. This effect, while of little significance for pure gap-filling purposes, is unwanted whenever comparisons between sites or parameterization of process-based models follow. Empirical data from recent literature suggest that large changes in apparent Q10 can result from the choice of temperature measurement depth at some sites. We present a simple model to quantify the extend of such errors, and its dependence on measurement conditions. The model first generates the soil temperature field in depth and time using an analytical approach, depth-variant soil thermal properties, and temperature amplitudes of few harmonics such as the daily and annual cycle. Respiration at each point in depth and time, and CO_2 diffusion to the surface are then modelled numerically using further depth-arrays of soil properties. The model is validated against one-year field data of heterotrophic CO_2 efflux at a bare soil surface and temperature in multiple depths. Numerical experiments with the model help explaining the variance of depth errors between studies, and defining measurement conditions where errors will be comparatively small. The model can also be used as a tool for inverse determination of the "true" temperature sensitivity of a site, provided multiple temperature measurement depths are available.