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A True Eddy Accumulation - Eddy Covariance hybrid for measurements of turbulent trace gas fluxes

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Eddy covariance (EC) is state-of-the-art in directly and continuously measuring turbulent fluxes of carbon dioxide and water vapor. However, low signal-to-noise ratios, high flow rates and missing or complex gas analyzers limit it's application to few scalars.

True eddy accumulation, based on conditional sampling ideas by Desjardins in 1972, requires no fast response analyzers and is therefore potentially applicable to a wider range of scalars. Recently we showed possibly the first successful implementation of True Eddy Accumulation (TEA) measuring net ecosystem exchange of carbon dioxide of a grassland. However, most accumulation systems share the complexity of having to store discrete air samples in physical containers representing entire flux averaging intervals.

The current study investigates merging principles of eddy accumulation and eddy covariance, which we here refer to as “true eddy accumulation in transient mode” (TEA-TM). This direct flux method TEA-TM combines true eddy accumulation with continuous sampling. The TEA-TM setup is simpler than discrete accumulation methods while avoiding the need for fast response gas analyzers and high flow rates required for EC.

We implemented the proposed TEA-TM method and measured fluxes of carbon dioxide (CO_2), methane (CH_4) and water vapor (H_2O) above a mixed beech forest at the Hainich Fluxnet and ICOS site, Germany, using a G2301 laser spectrometer (Picarro Inc., USA). We further simulated a TEA-TM sampling system using measured high frequency CO_2 time series from an open-path gas analyzer. We operated TEA-TM side-by-side with open-, enclosed- and closed-path EC flux systems for CO_2, H_2O and CH_4 (LI-7500, LI-7200, LI-6262, LI-7700, Licor, USA, and FGGA LGR, USA).

First results show that TEA-TM CO_2 fluxes were similar to EC fluxes. Remaining differences were similar to those between the three eddy covariance setups (open-, enclosed- and closed-path gas analyzers). Measured TEA-TM CO_2 fluxes from our physical sampling system closely reproduced dynamics of simulated TEA-TM fluxes.

In conclusion this study introduces a new approach to trace gas flux measurements using transient-mode true eddy accumulation. First TEA-TM CO_2 fluxes compared favorably with side-by-side EC fluxes, in agreement with our previous experiments comparing discrete TEA to EC. True eddy accumulation has thus potential for measuring turbulent fluxes of a range of atmospheric tracers using slow response analyzers.