Trace Gas Flux Measurements by the Eddy Correlation Technique: A Time Domain Stability Criterion for Stationarity Tests.

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Abstract

Integrated ecosystem-atmosphere processes studies provide a better understanding how the interacting physical, chemical and biological processes transport and transform energy and matter through the land-atmosphere interface from the cell level to a global scale. To predict the impact of future changes to air quality, climate and ecosystems, there is a need to understand the details of carbon and nitrogen cycling between the terrestrial and atmospheric systems [1]. Diode laser spectroscopy is increasingly being used in atmospheric research [2] and allows the design of chemical species sensors with the time response and sensitivity required for direct eddy correlation flux measurements [3]. For the measurement of the total transport the requirements are less stringent than for the determination of turbulent surface emission and deposition fluxes. For measurements of the turbulent transport the method is rigorous when specific criteria are met. Ideally, the meteorological conditions controlling the state of the turbulence should not vary over the course of the measurement. Since frozen turbulence is assumed, the spatial properties are translated into temporal properties. Almost all measurements are performed by averaging over time. Thus, we must assume that the atmosphere is statistically stationary and ergodic over some limited time and vertical dimension. Trends on micrometeorological time series data are mainly caused by drifts of different devices and by non-stationary micrometeorological conditions itself and, therefore, must be removed before starting the flux calculation. This can be achieved using a running mean or a band limit [4]. Determination of the high pass filter time constant is a tricky procedure. The Allan variance is a valuable tool to characterize drift and overall system stability and, therefore, it is increasingly used to characterize the performance of spectroscopic instrumentation applied in atmospheric research [5]. In this paper a concept based on this approach is described and utilized to characterize the stability of both, instrumentation and micrometeorological data in the time and frequency domain.

References

1. Schmid, H.P., H.-B. Su, C. S. Vogel, and P. S. Curtis, Ecosystem-atmosphere exchange of carbon dioxide over a mixed hardwood forest in northern lower Michigan, J. Geophys. Res., **108** (D14), 4417 (2003).
2. Werle, P., "Diode-laser sensors for in-situ gas analysis", in: P. Hering, P. Lay, S. Stry (eds) *Lasers in Environmental and Life Sciences – Modern Analytical Methods*, Springer Verlag, Heidelberg pp.223-243 (2004).
3. Werle, P. and R. Kormann, "A fast chemical sensor for eddy correlation measurements of Methane emissions from rice paddy fields“, Appl. Opt. **40**, 846-858 (2001).
4. Kormann, R., H. Mueller and P. Werle, "Eddy flux measurements of Methane over the fen Murnauer Moos, 11°11´E, 47°39´N, using a Fast Tunable Diode-Laser Spectrometer“, Atmospheric Environment **35**, 2533-2544 (2001).
5. Werle, P., R. Mücke and F. Slemr, "The limits of signal averaging in atmospheric trace gas monitoring by tunable diode-laser absorption spectroscopy", Appl. Phys. B **57**, 131-139 (1993).