Finnigan (2006) purports to present a formal definition of the storage change term for FLUXNET research assessing surface-atmosphere exchange via eddy fluxes, but errs in the definition of the scalar being exchanged. Although referred to somewhat ambiguously as “scalar concentration”, the scalar presented for analysis is in fact the gas density, as is clear both from previous work (Finnigan et al., 2003) and also in the context of the mass balance expression presented and integrated over a control volume. This scalar variable is inappropriate for expressing boundary-layer conservation principles in the context of the FLUXNET goal of estimating CO₂ sources or sinks at the surface (Baldocchi et al., 2001) because it has surface source terms not directly related to CO₂ exchange, as we shall now see.

The CO₂ density is defined as the ratio of conserved CO₂ mass to volume, a non-conservative variable for which thermal expansion represents a source in accordance with Charles’s Law. The definition of the source term for CO₂ density, in conjunction with the convenient and traditional inclusion of molecular transport, must therefore include sensible heat exchange with the surface by molecular conduction. Similar micrometeorological examination of gas composition reveals that isothermal, isobaric humidification by molecular diffusion near an evaporating surface also represents a sink term for the density of any dry air gas constituent such as CO₂ (Kowalski and Serrano-Ortiz, 2007). In short, the “density effects” whose influences often exceed that of CO₂ exchange in determining fluctuations in CO₂ density (Webb et al., 1980) operate also at the molecular level, where they are absorbed into the definition of the source term for CO₂ density and make this non-conservative scalar inappropriate for the expression of conservation principles within a control volume.

In the context of estimating CO₂ surface exchange, for simplicity it is preferable to express boundary-layer budgets in terms of conservation of the mixing ratio (Kowalski and Serrano-Ortiz, 2007).
REFERENCES


