Meteorological controls of gas exchange at a small English lake

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ABSTRACT: The relationships between gas transfer velocity, k_{600}, wind speed, wind direction, rainfall, and relative humidity were examined using measurements of SF_6 evasion from Coatenhill Reservoir, a small (0.017 km²), shallow (1.9 ± 0.1 m), man-made lake in northeast England characterized by predominantly low to intermediate wind speeds ~1-10 m s^{-1}. A graphical method was used to estimate the wind speed at a standard height of 10 m, U_{10}, from wind speed measurements at 2 m and 3.8 m. Derived values of U_{10} normalized to remove thermal stability effects (U_{10}-n) were significantly correlated with k_{600} ($R^2 = 0.71$, $p < 0.001$). A detailed analysis of surface roughness lengths estimated with this procedure showed the k_{600} versus U_{10}-n relationship to be sensitive to wind speed modification by the meteorological mast and sensors. With normalization to remove these effects, the correlation between k_{600} and U_{10}-n substantially improved ($R^2 = 0.86$, $p < 0.001$). In contrast to previous laboratory findings, relative humidity was not significantly correlated with k_{600} and rainfall rate (R_n) was only weakly correlated with k_{600}, possibly as a consequence of the effects of these variables being largely masked by the time scales of data averaging and SF_6 sampling. Similarly, k600 was not correlated with wind direction (i.e., fetch). An empirical gas exchange model accounted for 88% of the total variance in k_{600} ($p = 0.01$) at Coatenhill, with U_{10}-n and R_n accounting for 86% and 2%, respectively. Future field investigations of the meteorological controls of k_{600} will require careful experimental design to allow for more detailed sampling than hitherto has been possible.

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