Tellus (1993), 45B, 299–300
Printed in Belgium – all rights reserved

TELLUS
ISSN 0280–6495

The gas transfer velocity – wind speed relationship at Siblyback Lake. A reply to comments by Kwan and Taylor

By ROBERT C. UPSTILL-GODDARD[1]*, ANDREW J. WATSON[1] and PETER S. LISS[2]

(Manuscript received 11 February 1993)

In their reassessment of our windspeed results from Siblyback Lake (Upstill-Goddard et al., 1990), Kwan and Taylor (1993) critically re-evaluate our graphical extrapolation of the 10-m wind (U_{10}) made from simultaneous measurements at 1.5 m and 3 m. A detailed re-appraisal of our time-averaged wind data tends to support Kwan and Taylor's principal criticism that the values for the surface roughness length, z_0, implicit in our results are in general too high for a free water surface, and in view of these observations, we agree in principle that some revision of our original estimates for U_{10} (Upstill-Goddard et al., 1990) is required. Alternative methods for the estimation of U_{10} all have their own particular advantages and disadvantages, and it seems appropriate here to restate the principal reason behind our selection of the graphical derivation of U_{10}, namely that it avoids the uncertainties which accompany assumptions about the values of relevant meteorological variables required in other approaches, such as that of Kwan and Taylor (1993). Our view is that, despite the problem outlined above, and which we address in more detail here, the graphical approach should be preferred wherever possible.

In order to intercalibrate the two anemometers subsequently used in the Siblyback Lake study (Upstill-Goddard et al., 1990), they were installed on the roof of the Plymouth Laboratory, about 15 m above ground level, and their outputs compared over several days. Windspeeds during these trials generally were higher than 3 m s^{-1}, and agreement between the two instruments was satisfactory. However, detailed re-inspection of the raw 4-min wind averages from Siblyback Lake reveals periods during which a significant number of the 1.5 m records averaged zero. This may have been due to the anemometer stalling at low speeds, or possibly a problem with the data logger. In any case, slight underestimation of the windspeed at 1.5 m may have resulted, leading to some overestimation of U_{10}.

We have compared the respective "fits" of the two alternative sets of Siblyback Lake U_{10} estimates (Upstill-Goddard et al., 1990; Kwan and Taylor, 1993) with corresponding U_{10} values derived from our own transfer velocity (k) results (Upstill-Goddard et al., 1990) and the appropriate equations describing the Liss and Merlivat (1986) curve. This treatment reveals that the re-calculated data of Kwan and Taylor (1993) do not in general lie closer to the Liss and Merlivat (1986) curve than our original estimates, but it is clear that those which do (13 from a total of 34 points) tend to lie towards the high end of the observed wind spectrum, i.e., with $U_{10} > 5.8$ m s^{-1} on the Liss and Merlivat curve (see Fig. 1., Kwan and Taylor, 1993). However, for the 8 other data points which lie above this threshold, our original estimates of U_{10} (Upstill-Goddard et al., 1990) in fact group more closely to the curve. Although the differences between the two sets of results are generally small relative to the existing field data base (see for example Upstill-Goddard et al., 1990: Watson et al., 1991), they are nevertheless potentially of considerable importance, because it is in this higher wind region that clarification of the relationship between k and U_{10} requires the greatest effort, and

* Corresponding author.
[1] *Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth PL1 3DH, UK*
[2] *School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK*

this is particularly relevant to the oceanic situation. At all windspeeds below 5.8 m s^{-1}, all of our original estimates of U_{10} (Upstill-Goddard et al., 1990) lie somewhat closer to the Liss and Merlivat curve than those of Kwan and Taylor (1993). Their assertion that our k values for the low wind regime are high relative to the Liss and Merlivat curve implies some overestimate of k at low windspeed. However, reworking of these data to U_1, the corresponding windspeed at 1 m, (Kwan and Taylor, 1993) yields results which are consistent with those from a similar lake study (Crusius and Wanninkhof, personal communication). Siblyback Lake is generally very well mixed, even at relatively low windspeeds (Upstill-Goddard et al., 1990), and we have no reason to believe k estimates made under such conditions to be significantly in error. In view of these observations, it seems inescapable that neither the original nor reworked version of the Siblyback wind data is fully consistent with the Liss and Merlivat curve. Therefore, our original conclusion that the functionality of k with windspeed for small lakes is apparently complex (Upstill-Goddard et al., 1990) still remains, and further detailed experimental work clearly is necessary.

REFERENCES

Kwan, J. and Taylor, P. A. 1993. A reassessment of the gas transfer velocity – wind speed relationship from the Siblyback Lake data. *Tellus 45B*, 296–298.

Liss, P. S. and Merlivat, L. 1986. Air-sea gas exchange rates: introduction and synthesis. In: *The role of air-sea exchange in geochemical cycling*, (ed. Buat-Menard, P.). Reidel, Dordrecht, 113–127.

Upstill-Goddard, R. C., Watson, A. J., Liss, P. S. and Liddicoat, M. I. 1990. Gas transfer velocities in lakes measured with SF_6. *Tellus 42B*, 364–377.

Watson, A. J., Upstill-Goddard, R. C. and Liss, P. S. 1991. Air-sea gas exchange in rough and stormy seas measured by a dual tracer technique. *Nature 349*, 145–147.