Modeling air-water heat transfer induced by buoyant convection

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Abstract: The instantaneous 2D velocity field obtained at the air-water interface in previously performed direct numerical simulations (DNS) of interfacial heat transfer driven by buoyant convective instability is used to estimate the heat transfer velocity [2]. After reconstructing the three-dimensional velocity field immediately underneath the surface, a Lagrangian particle tracking method was used to assess the surface age. The surface heat transfer velocity, obtained using Danckwerts' surface renewal model, was found to underestimate the heat transfer velocity acquired directly from the DNS data by about 16%.

Keywords: buoyant convection, surface age.

1 Numerical method

The instantaneous heat transfer velocity across the air-water interface reads $h_L = -k \frac{T_i}{T_i - T_{bulk}} \frac{\partial T}{\partial z}\Big|_i$, where k is thermal diffusivity, T is temperature, and i indicates the interface. Previous DNS of interfacial heat transfer

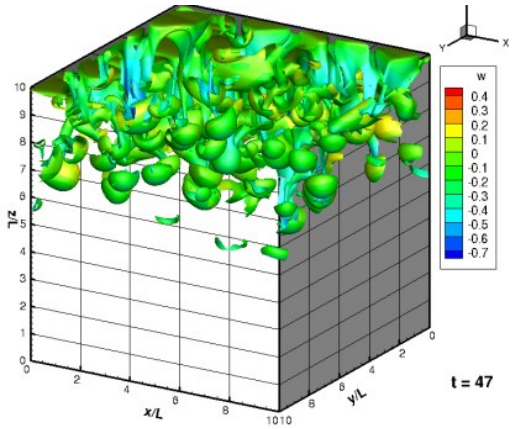

Fig. 1: *Isosurface of temp. coloured by vertical velocity*

driven by buoyant convection (see fig. 1) produced sequences of the velocity field at the surface [2]. The data comprise the horizontal velocities $u(x, y, t)$, $v(x, y, t)$ and the derivative, $\partial w/\partial z(x, y, t)$, of the vertical velocity. From this, the 3D velocity adjacent to the free-slip (flat) surface was reconstructed.

2 Results

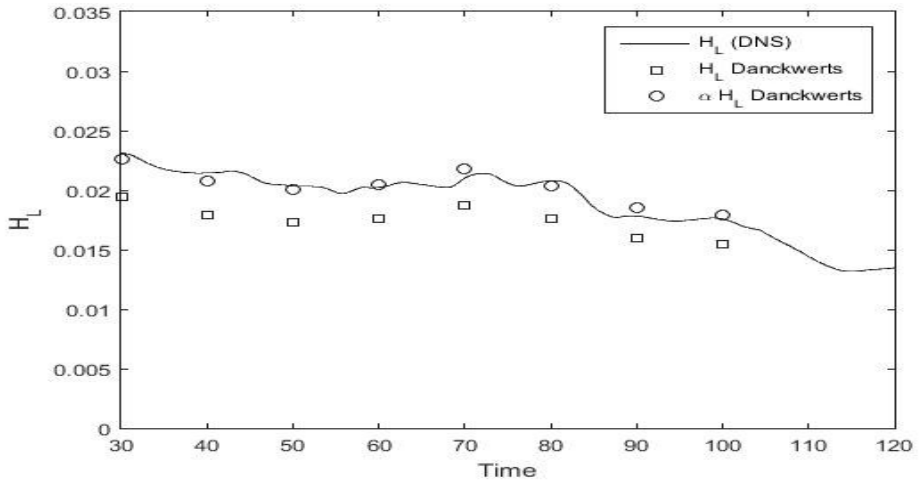

Fig. 2: *Comparison of heat transfer velocity.*

Fig. 2 shows the estimation of H_L obtained from Danckwerts' model. For this, the reconstructed velocity field was assumed to be frozen in time, while time-integration (to obtain $\overline{\tau}$) was carried out by employing the second-order Adams-Bashforth method. The real H_L was found to be somewhat underestimated. After employing a correction factor ($\alpha \approx 1.16$) the results can be seen to closely follow the trend observed in the real H_L. Note that α appears to be related to bulk temp., T_{bulk}, which increased by about 16% since the start of the calculation.

References

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