

The author thanks the referee for the evaluation and especially for the recommendations to improve the manuscript. In the replies that follow, the referee comments are repeated (bold font) followed by the responses from the author (normal font).

Replies to Anonymous Referee #3

General comments: Vertical velocity has a tiny magnitude near surface and is difficult to measure because its magnitude is usually smaller than errors. However, vertical velocity plays a substantial role in mass and energy exchanges between land and atmosphere. For simplicity, they usually assume it is zero at surface. The author argues that it is non-zero by a “thought experiment”. The author is a theoretical thinker. This paper shines light on this knowledge gap. I recommend it to be published with minor revision.

The author thanks the referee for this endorsement.

Specific comments:

(1) 2.1.2 The 0th Law of Thermodynamics – I do believe that this is a case from second law of thermodynamics (Postulate of Clausius, see Thermodynamics by Enrico Fermi, 1936). I don’t think that “The 0th Law of Thermodynamics” is independent from second law of thermodynamics. So I suggest using the second law of thermodynamics instead of the 0th Law so that your statements no matter heat transfer and mass diffusion are govern by the same second law of thermodynamics. Fourier’s law and Fick’s law are empirical relationships between fluxes and gradients. Gradients are drivers for fluxes and consequences of fluxes reduce gradients, following a single irreversible direction (entropy increasing) – equilibrium (entropy maximum) –second law of thermodynamics.

The 1936 textbook cited, although authored by a great physicist, is nonetheless out of date regarding this issue. Modern physics texts (e.g., Giancoli, 1984) recognize that the 1st and 2nd Laws, although definitively stated first, logically depend on the prior assertion of the 0th Law; this explains its odd name. Formalization of the 0th Law occurred in the mid-1930s, but was not broadly accepted until well after the publication of Fermi’s textbook.

(2) Vertical velocity at surface is always positive (upward) predicted by the equation (4). Based on your thought experiment, this looks true everywhere (leaves, ground, water surface) including large scale (e.g. synoptic scale). To my knowledge, it is sure that vertical velocity is negative in high pressure system areas and positive in low pressure system areas. Therefore, it is difficult for me to understand the positive vertical velocity predicted by your theory in high pressure system areas or divergent air-flow near surface at any scale. Please clarify the conflict in your revision.

Synoptic-scale velocities are of order 3 cm s^{-1} (e.g., Carlson and Stull, 1986, Subsidence in the nocturnal boundary layer, *J. Clim. Appl. Met.*, **25**, 1088-1099). Whether the boundary condition at the surface is the traditionally conceived $\mathbf{w}|_0 = 0 \text{ cm s}^{-1}$, or $0.000031 \text{ cm s}^{-1}$ as derived from eq. (4), synoptic-scale subsidence implies a convergence in the vertical winds between the surface and the height at which it occurs. It seems that there is no conflict that requires clarification.

(3) Page 6 second paragraph, It is fine to me with “vertical advection” because it is clearly defined by vertical component It does not need to assume horizontal homogeneity.

The author agrees, and proposes to delete the last two sentences of this paragraph.