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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Technical note: rectifying systematic underestimation of the specific energy required to evaporate water into the atmosphere" *by* Andrew S. Kowalski

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First, I fully agree with the comments that the L used in standard practice is an "enthalpy", which means that it already includes the work done by expansion against the air pressure when the water evaporates. So the point made by the Note is incorrect.

At the same time, I must say that the Note does not come as a great surprise to me ! I was wondering about the matter years ago, and fortunately I found the correct answer in books on thermodynamics. But since then I have paid attention to the matter, and I have seen that some texts define latent heat without hesitation in term like "energy needed to overcome intermolecular forces which hold the substance together as a liq-

uid" etcetera; just like the definition that is the starting point of the Note. And once a reader is prejudiced by this, he/she is not readily corrected even by the some of the most respectable textbooks of hydrology and meteorology, whose definitions ("energy needed to evaporate water"), are quite ambiguous in this respect. One time I also encountered an internet discussion on the subject, and it went wrong. Added to this, the well-known problems with not-closing energy balances make it tempting to doubt everything in the end, including latent heat values. Hopefully, the note and the surrounding discussion may be of some use after all.

For completeness, something should be added about the magnitude of the work-term, which is a thing of interest for its own sake. In the Note, the Stefan flow velocity w is expressed as $w = E/\rho$ with E the evaporation and ρ the mass density of the *air*. But it would seem that consistency requires instead the use of the mass density of *water vapor*, put in equilibrium with the air pressure according to the gas law:

$$\rho = \frac{p}{R_w T}$$

in which R_w is the gas constant for water. If this is substituted, the calculation in the Note would end up with

$$\lambda - L = R_w T$$

and not $R_d T_v$ as stated in the Note.

This value is the classical result obtained in the thermodynamics textbooks experiments where water evaporates into an empty cylinder (no air inside), topped by a piston. It turns out that its use is allowed irrespective whether the vapor is mixed with air molecules or not, see the end of G. Petty's second comment (SC3). In accordance with this, it is of old the practice of hydrology and meteorology to use latent heat values which are identical to the ones obtained by laboratory physics.

It would be most helpful if someone could give a reference to literature where the whole matter (including the open air case) is explained in a clear way. I could not find one, possibly one will have to search in the literature of an older era, which is a bit less accessible nowadays.

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