Hydrol. Earth Syst. Sci. Discuss., 12, C5331–C5337, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C5331/2015/

Hydrology and Earth System Sciences Discussions
Open Access

Interactive comment on "Experimental evidence of condensation-driven airflow" *by* P. Bunyard et al.

P. Bunyard et al.

pbecologist@gn.apc.org

Received and published: 2 December 2015

Reply:

To begin with, many thanks to the reviewer who has clearly taken the time to go over the original manuscript and has made some interesting suggestions with regard to calculating the potential contribution to airflow from air density differences between the columns. The reviewer also pointed to an error in the original manuscript in which the gravitational constant had been left out of air density calculations'. That important error has been dealt with and, in testing the correct application of the constant (9.81 m.s-2) in recent experiments, we find, as expected, a considerable increase in the evaluation of the energy flows related to air density differences. We must make clear that such considerations apply to the left and right columns, including the parcel of air in close proximity to the cooling coils. The correct calculation of the net kinetic energy from

air density changes in the two columns makes it clear, as discussed below and shown in the attached graphs, that air density changes alone cannot be responsible for the clockwise airflow.

Another reviewer pointed to an error in the original manuscript concerning the equation dealing with absolute humidity. We pointed out that, while the equation was wrong, we had used the correct formulation in the calculations of absolute humidity, whether for the quantity of water vapour in moist air or for dry air. That reviewer has since responded with different notations for water vapour and for the two distinct ways for measuring humidity in a kilogram of air. Taking those notations into consideration, we are keen to point out that our use throughout of the correct equations accords with those described in the literature (Robin McIlveen, 2010, Fundamentals of Weather and Climate, Oxford).

The original reviewer's remarks led us to carry out a series of experiments during which we added heating to the lower right-hand column with a 150 Watt halogen lamp. The experiments were all carried out under dull conditions with overcast skies, and, as suggested by the reviewer, we were able to determine the respective kinetic energies of the right and left columns, taking height and gravity into account. At the commencement of each experiment (three shown) the airflow was found to be in the counter clockwise direction. However, consistent with all previous experiments, once the refrigeration was switched on, the directionality changed to a clockwise circulation, which approximated well the changing rate of condensation during the course of an experiment. (see graphs).

Those recent experiments must throw in doubt the conclusion that the cold air from the cooling tubes is responsible for the clockwise airflow. That brings us again back to the conclusion that condensation and sharp localized volume change may play a significant role in generating sufficient airflow to overcome the counter-clockwise flow from net air density differences between the two columns.

First and foremost, we have a clear, highly significant relationship between airflow and its directionality when plotted against the rate of condensation (Ws). That is a regular feature of the many experiments which have been carried out.

Not surprisingly, the latent heat release per second is found to match closely the energy for the volume change as water vapour condenses to liquid and ice. That must be true too for the atmosphere at large, when clouds form. The point has been made that the implosion resulting from condensation will lead to zero energy being available for airflow because air, filling the partial vacuum, will flow from all directions. That, however, is an ideal concept which has little bearing in the real world, where marginal differences in the physical environment would generate a potential for condensation to lead to a conspicuous flow in one direction. Indeed, physical differences exist in the vicinity of the cooling tubes, including that the air is more dense than air even a few centimetres away. That, in itself, would generate a bias such that some of the energy released on condensation would effectively cause air flow.

One is reminded of the experiment with a plastic bottle when the implosion from the condensing water vapour causes collapse in the horizontal plane and not in the vertical plane.

As the reviewer has pointed out, the total energy involved in condensation far exceeds that required to explain the airflow in the experiments. In effect, just 0.1 per cent of the energy involved in condensation would be sufficient to explain the airflow. We would suggest that one factor which might give directionality to the airflow could be the chilled air sinking as it passes over the cooling coils. In the recent experiments with artificial heating, that air then mixes with warmer air and its downward flow is checked. What if the distortion caused by the sinking of the chilled air could create a bias in the air moving to the point of condensation? That would provide enough energy and force to account for the observed airflow, even against the observed counterflow caused by air being more dense in the left-hand column compared to the right.

The evidence from a multiplicity of experiments indicates that condensation is the one consistent factor in accounting for the clockwise directionality of airflow. Given the results from the latest experiments, we hope that the reviewers will reconsider their position with regard to publication.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 10921, 2015.

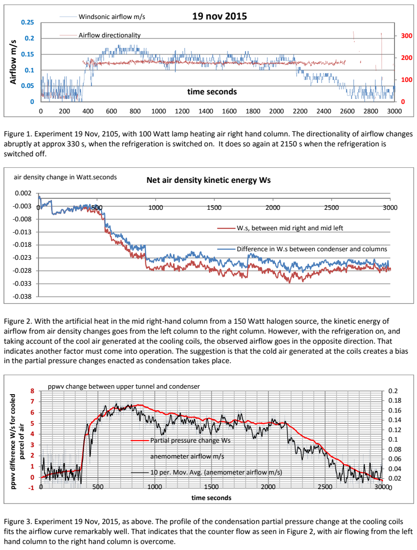

Fig. 1. experiments with added heating to rt hand column

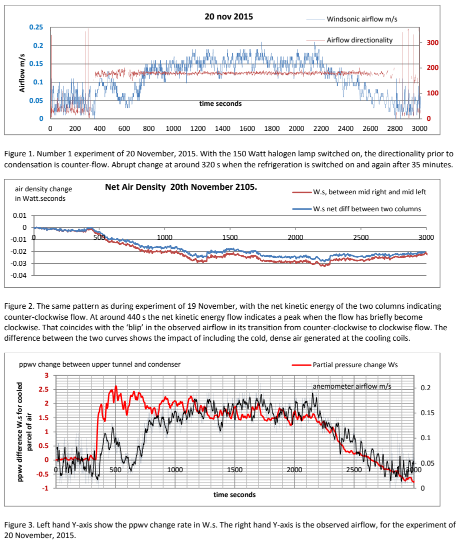

Fig. 2. experiment 2

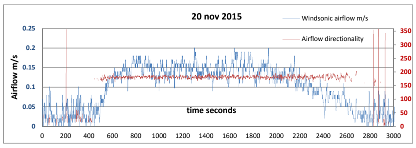

Figure 1. Second experiment of 20 November, 2005, showing a similar pattern to the other two experiments.

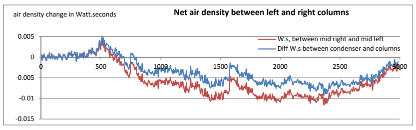

Figure 2. Similar pattern as in other experiments with right hand column heating. The counter-clockwise flow is apparent, taking into account the cool air from the condenser (blue). The peak at around 500 s corresponds with a rise in the airflow.

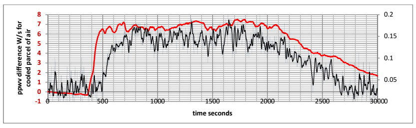

Figure 3. Second experiment of 20 November, 2015. Again we observe a good ‘fit’ between the observed airflow and the partial pressure change from condensation.

Fig. 3. experiment 3