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Hydrology and Earth System Sciences
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# *Interactive comment on* "Experimental evidence of condensation-driven airflow" *by* P. Bunyard et al.

**P. Bunyard et al.**

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We would respectfully urge the three reviewers to take into account the latest experimental data in considering their advice on our submitted manuscript. We are well aware that we will need to make corrections and adjustments to the manuscript and are willing to do so.

We realize our oversight in that previous to the December experiments we had omitted the gravity constant from our calculations. That has been remedied. Nevertheless, our previous results of the airflows associated with refrigeration, as indicated in the original manuscript, show strong correlations between the trajectories of airflow and the rate of condensation. We believe that those associations were correctly analysed.

Recent experiments, carried out at the beginning of December, 2015, and the results analysed with the changes to the equations variously recommended by the reviewers, in our view indicate that air density differences between the two columns cannot be responsible for the observed airflow. Another factor must prevail and the obvious candidate is the rate of change in condensation. Accordingly, we now submit the results from two experiments, as shown in figures 1 and 2 below.

In analysing the force associated with changes in air density of the right hand column of our experimental equipment, we carry out a number of calculations (Mass x Gravity): 1) the kg change per second of the volume of air associated with the cooling coils; 2) the kg change per second of the remaining air in that section (subtracting the surface area of the cooling coils from the cross-sectional area of the right column); 3) the kg change per second of the volume of air beneath the cooling coils and 4) the kg change per second of the remaining air in the mid to lower part of the right-hand column. We do the same for the left-hand column and then subtract the result from the total obtained from the right-hand column.

The results of the calculations of net air density force are seen in the graphs displayed below. That of December 1st, 2015, indicates that the net air density force is positive only before and after the period of refrigeration. That result is confirmed by the directionality observed in the overall airflow (anemometer) in those periods. During refrigeration the airflow is observed to be clockwise and therefore counter to that indicated by the air density force. That finding suggests that another factor must be responsible for the clockwise flow. Inevitably we return to the consideration that a small percentage of the total energy associated with condensation and partial pressure change would suffice to bring about clockwise airflow. We suggest that the initial downward flow of the chilled air could act as a ‘trigger’ to distort the kinetic energy associated with condensation.

In conclusion, we believe that we have a sufficient body of evidence that condensation, as studied in the experiments, is the prevailing factor in causing the air circulation. We are well aware that in an ideal situation, which in the real world may never exist, the implosion of air from all around the point of condensation would nullify the associated



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kinetic energy. However, in the world of the experiments, by means of refrigeration we have artificially created a distinct difference in the conditions above the coils and below, thereby providing a distortion in the distribution of kinetic energy from the sudden volume change associated with water vapour condensation.

In the case of a spherical implosion in static air (a very strange situation!) then the forces probably do cancel, resulting in no net movement. However, as the process of condensation and hence pressure reduction is continuous, air must be drawn in towards the zone of condensation, continuously, and the rising air already has momentum.

In the experiment and in cloud formation, condensation is a continuous process (likely, many hours for cloud formation) with a continuous supply of rising humid air whose movement is initially driven by density differences. This rising air clearly has momentum. In the case of cloud formation in the humid tropics, the rising air is often is discrete units, forming individual clouds and then later, perhaps thunderheads. In this situation condensation occurs in a more cylindrical rather than spherical zone.

We therefore suggest that air density differences above and below the cooling coils may act as a trigger to the lopsidedness of the energy flow generated by condensation. Whether or not similar distortions play a role in the atmosphere at large is at present a moot point.

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

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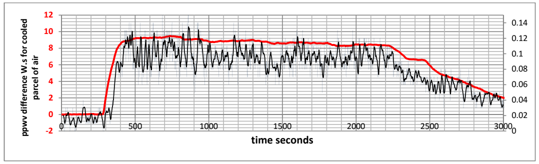


Figure 1. Experiment of Dec 1st, 2015. The right hand column is heated with a 150 W halogen lamp. The graph shows the airflow (blue) and the total kinetic energy of the partial pressure change (red). The correlation is significant. The airflow is seen to be clockwise (see Fig.3 below) during the period of refrigeration, which is switched on at 300 seconds and switched off at 2100 seconds. The net air density (see Fig.2 below), determined by subtracting the total mass-force of air in the left hand column from the total mass-force Ws) of the right hand column, is seen to become negative (hence indicating a counter-clockwise flow) at 400 seconds until 2700 seconds, when the right column air density dominates. That period of 'negative' net air density is not reflected in the observed airflow, suggesting another factor other than air density must be at play. A small percentage of the total kinetic energy from water vapour condensation would be sufficient to overcome the counter-clockwise flow of net air density.

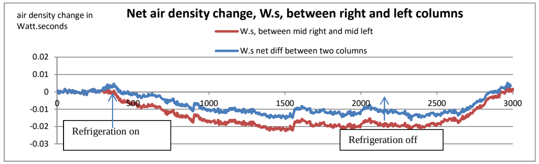


**Figure 2. The air densities of the left and right column are calculated taking into account the mass force associated with each portion of the respective column. When positive, the right hand column exhibits greater overall density (Ws) than the left; and vice versa, negative density signifies that the left column exhibits the greater density. During the period of cooling the airflow is clockwise (see following graph) even though the air density difference between the columns would appear to drive the airflow counter clockwise.**

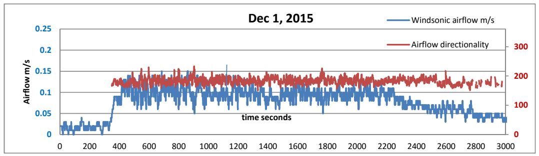


**Figure 3. The airflow (blue) is seen to be clockwise (180° red) during the period of cooling and beyond, as the airflow falls away after 35 minutes. That observation fits in with the net air density between the two columns at each period prior to and following the switching on and off of the refrigeration.**

**Fig. 1.** Experiment December 1, 2015

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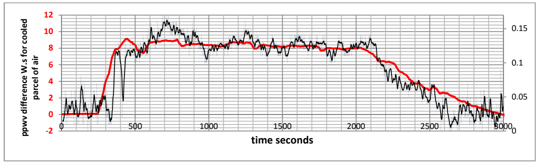


Figure 1. Experiment 3 December, 2015. The lower right column is heated with a 150 W halogen lamp. Refrigeration is switched on at 300 seconds and switched off at 2100 seconds. Again, the fit is good between the airflow (blue) and the rate of condensation (red). Prior to switching on the refrigeration and following switching off the refrigeration the airflow is counterclockwise as seen in Fig. 3. During refrigeration and condensation the airflow is clockwise (Fig.3)

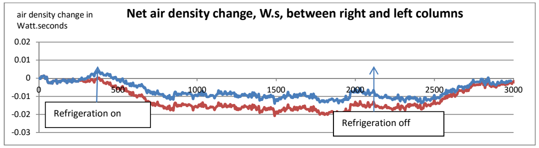


Figure 2. The net air density indicates that the flow will be counter-clockwise. That counter-clockwise flow is seen both prior to switching on the refrigeration and after switching off and it accords with that seen in the observed airflow (Fig.3). During the period of refrigeration the flow is clockwise, suggesting that a factor other than air density must be prevailing.

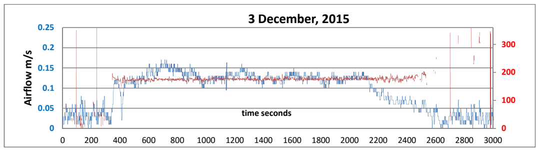


Figure 3. The airflow (blue) is counter clockwise (red) prior to switching on the refrigeration at 300s, and following the switching off at 2100s. Once the cooling is switched on the directionality of airflow changes significantly and flows clockwise (180° red). That flow is in the opposite direction to that dictated by the air density difference between the right and left columns (Fig.2). Absent any other factors, a negative net air density change should mean that any airflow would be counter clockwise, and a positive net air density change should bring a clockwise flow. The fact that the refrigeration results in a clockwise flow suggests that a factor other than air density must be prevailing.

**Fig. 2.** Experiment December 3, 2015

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