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Discussions

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

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Interactive comment on "Experimental evidence of condensation-driven airflow" by P. Bunyard et al. Anonymous Referee #1 Received and published: 5 November 2015

Evaluation is impossible unless more information is supplied about the employed dynamic models! The paper compares two competing kinds of dynamic modeling to explain the laboratory experiments that have been done, namely the usual "convection model" and the new "biotic pump model". Hence, dynamic modeling forms the core subject of the paper. However, whereas the thermodynamic equations have been worked out well, dynamic equations are almost completely missing!

Reply: As the title of the article states, the purpose of the research was not to model the usual 'convection model' versus the new 'biotic pump model', it was simply 1) to determine whether condensation of water vapour would lead to measurable and repeatable airflows and 2) simultaneously, if there were such airflow, to distinguish between the strength of the different forces (as kinetic energy) delivered a) from the partial pressure change as water vapour underwent condensation, and b) from air density changes of the same parcel of air at any moment in time during the course of each experiment (lasting approx.. 50 minutes with 30 minutes of localized chilling via copper refrigeration coils). Why bother to carry out such experiments? The simple answer is to test the dynamics of condensation under relatively controlled conditions so as to help answer the controversy relating to the biotic pump theory in which critics of the theory have maintained that condensation and consequent cloud formation would not of themselves, through partial pressure change, lead to horizontal air flows. The results from more than 100 experiments speak for themselves, with the conclusion that the physics of partial pressure change explains the airflow. The air density changes are orders of magnitude less important. In conclusion, dynamic modeling of climate processes involving convection was outside the scope of the paper. However, we do provide references to such discussions. Certainly, Makarieva and Gorshkov give admirable accounts of the biotic pump theory and, add to that the critique of their views by Meesters plus their response, and you have excellent points or entry to the extensive literature on dynamic atmospheric modeling with regard to the biotic pump.

Equation 9 relates units only, and can be omitted.

Reply: Correct, Equation 9 relates units. It is there to remind the reader that partial pressure change in Pascals multiplied by volume gives us Watt.seconds of kinetic energy and changes in air density multiplied by area per second per second will also give us Watt.seconds of kinetic energy. From thermodynamic equations applied to the experimental data we are therefore able to calculate relatively precisely the kinetic energies of the two distinct though related phenomena of partial pressure change and of air density change for precisely the same parcel of air, using exactly the same data of pressure, temperature and relative humidity. The airflow measured applies to the same data.

Equation 10 is said to be used to convert the developed power to airflow velocity, but this is to my knowledge merely a theoretical maximum corresponding to the case that 100% of the energy becomes kinetic energy (primarily it expresses the flow of kinetic energy through an area perpendicular to the flow). Moreover, it is not described how the developed power is obtained for each of the models.

Reply: We make it clear in the text that Equation 10 gives the ideal airflow were all the energy of the partial pressure change released in just one direction. Also, we were not dealing with models of the processes occurring during the experimentation, but with actual empirical data. That was the point of experimenting: to clear up which forces actually prevailed as a consequence of a particular rate of condensation. Again Equation 9 was used to determine the Watt.seconds of each of the two processes, air density change and partial pressure change. In effect, the partial pressure change from condensation will be a multi-direction implosive force, thus potentially obliterating the tendency of any airflow taking off in a particular direction. However, that is not what we find: the airflow resulting from the localized cooling is always in the same direction; moreover, we see from light gauzes hanging freely in different parts of the structure that the force derived from the localized condensation is sufficient to drive the 20 cubic metres of enclosed air in one direction, (180° in relation to the anemometer, Fig 1.) with a circulation time of approximately two minutes. The airflow force is approximately one-fifth that of the ideal airflow. We conclude that a physical bias, gravitational for instance, will set the airflow going in the same direction in each experiment. Since each parcel of air is just one part in 430 parts of total volume of air, it gives some idea of the power of a highly localized change in partial pressure. Massive cloud formation over the Amazon Basin, derived largely from an evapotranspiration (ET) total absorbing the energy equivalent from the sun of 15 atomic bombs per second, should therefore be sufficient from the abrupt pressure change brought about by cloud condensation to draw in the Trade Winds, as suggested by Makarieva et al.

Because of these omissions, it appears impossible to evaluate the discussion paper unless more information is supplied.

Reply: We hope that the above explanation as well as the information given below in answer to the questions posed will enable the reviewer to complete his/her evaluation.

Questions whose answers are urgently needed to understand the methodology and results are: (1) How exactly is the conversion from change of partial vapor pressure to velocity calculated?

Reply: The thermodynamic equations as presented enable us to use the experimental data to calculate the partial pressure change per second in the calculated volume of air passing in direct contact with the cooling coils. The volume of such air we determine as 0.048 cubic metres. Simultaneous to the measurements of the partial pressure characteristics of the parcel of in contact with the coil we measure the partial pressure of water vapour in the upper tunnel just 0.5 metres away from the coils. That measurement gives us the characteristics of the air which will be drawn down in a matter of seconds across the cooling coils. We infer therefore that the vapour condensing, with the consequent partial pressure change (hPa/s), can be determined by subtracting the partial pressure of the cooled from the partial pressure of the pre-cooled. That determination gives us the rate of partial pressure change. By taking the volume into account, we can now convert such change in kinetic energy Watt.seconds. The realization of those calculations during the course of an experiment gives us the graphical trajectory which correlates so significantly with the airflow and its directionality as measured with a 2D-ultrasonic anemometer. Furthermore, the sum of the partial pressure changes over the course of an experiment enable us to determine the quantity of water vapour (in grams) which has condensed. On switching off the condenser the rain which precipitates is measured and compared with that calculated. We find excellent correspondence. That in itself indicates that our calculation of the volume of each parcel of air (0.048 cubic metres) is reasonably correct.

(2) How exactly is the conversion from change of density to velocity calculated?

Reply: The process is comparable in every respect to that answered above in question 1. The difference is that the air density change (kg/mˆ3) will lead gravitationally to the air from the cooling coils sinking against air of a marginal different density below the coils (localization 3 in Figure 1.) Therefore, the difference in air density of the cooled air from that below the coils is determined and, in terms of kilogram change multiplied by the area (0.96 square metres) per second per second, the kinetic energy can be calculated. As with all the data the calculation of air density is carried out using the thermodynamic equations as presented. The results of such calculations over the course of an experiment gives a graphical profile, which can be compared with that obtained for the partial pressure change of precisely the same cooled parcel of air. From that we find orders of magnitude difference between the two phenomena.

There are a few other questions which show up if one tries to understand the presented results:

(3) It should be made clear how the rate of change of the vapor pressure is defined. The most often used (Eulerian) definition takes the change in time at a fixed point in space, but this is probably not intended. A Lagrangian definition would be: the difference between the values of two points of observations, multiplied with v/L where v is the velocity and L a length scale, but which length scale?

Reply: As shown above, the rate of change of the vapour pressure is defined in terms of hPa/s, the latter being calculated as described by subtracting the parcel of cooled air with a same real time parcel of air just above the cooling coils. The velocity of air flow is obtained from the anemometer readings and the length is 5 cm or 0.05 metres. At a velocity of 0.15 m/s, three such parcels will move over the cooling coils in one second. However, the air flow above the coils is assumed to be the same as that in close proximity to the coils. Therefore the definition would be Lagrangian.

(4) Finally, how has Figure 3 been obtained?

Reply: That is a good question as it brings to bear the use of the thermodynamic equations. First of all it must be said that the curve obtained in Figure 3 of the ratio between the kinetic energies of air density change to partial pressure change (Y-axis) against the rate of change of specific humidity kg water vapour per Kg dry air per second (X-axis) is determined by using the data of a particular experiment (22nd July, 2015) and from that day’s empirical results artificially varying the relative humidity from 100 per cent all the way to 0 per cent. All the other variables are as presented in the original data for that same experiment. The same processes as indicated in the answers to Questions 1&2 to determine the trajectory of the partial pressure change and air density change are employed. Then the ratio between the respective kinetic energies at 1000 seconds into the experiment is determined from the graphs such as we see in Figures 15 to 18. Figure 3 is the result of those calculations. When we look at the ratios of partial pressure change and air density change in kinetic energy for other experiments in which starting conditions are considerably different, we find that those ratios conform to those displayed in Figure 3. The point of the exercise is to show that as the rate of change in the specific humidity declines so does the ratio. Hence, the rate of change in air density as determined through temperature changes and to an extent through changes to water vapour content (more water vapour less air density) remains more or less the same during the course of an experiment, taking into account the temperature changes at the point of cooling. On the other hand, a reduction in the relative humidity with the consequence that condensation is reduced (hPa/s reduction) leads to a significant decline in the ratio, as seen in Figure 3. Figure 3. therefore provides the basis for understanding why a high rate of condensation will result in significant air flows with little contribution from air density change. And, with little to no condensation (desert conditions) airflow will be reduced close to zero (from that particular convective process). Finally, it should be said that our experiments provide a ‘backing’ for the physics which underpin the biotic pump theory.

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