Supporting Information for

**Enhanced humidity pockets originating in the mid boundary layer as a mechanism of cloud formation below the lifting condensation level**

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S1.1 Analysis of parcel trajectories on a phase space of height versus difference in virtual temperature ($\Delta T_v$)

Fig. S1 presents an analysis of the parcels’ trajectories for two case studies (11 Jun 2011, panels a,b and 6 Aug 2011, panels c,d) on a phase space of height versus the difference in virtual temperature between the parcel and its environment ($\Delta T_v$). It shows that the large $\Delta T_v$ required to enable cloud formation by the temperature-perturbed parcels dictates higher cloud base height (near the higher end of each curve) than the measured ones for these dates (697 m for 6 Aug 2011 and 884 m for 11 Jun 2011).

Figure S1 – Detailed temporal analysis of the parcels’ motion for temperature (a,c) and RH (b,d) perturbations on 11 Jun 2011(a,b), and 6 Aug 2011 (c,d). The y-axis is the vertical position of the parcels and the x-axis is the difference in virtual temperature between the parcel and the environment ($\Delta T_v$). Note that the parcels under RH perturbations that originated in the middle of the boundary layer become clouds at similar heights.
Parcels that their vertical motion was initiated by RH perturbation in the middle of the boundary layer are lifted with small initial $\Delta T$, and develop small updrafts (with small variance).

### S1.3 Estimation of the effects of dilution by entrainment

How will dilution of the specific humidity (and therefore relative humidity, RH) affect the parcel’s properties? To estimate the dilution effect in our model we have added a dilution term and followed the trajectories of parcels under graduate levels of dilution. Since dilution of a given entity is proportional to the spatial gradients, the added dilution term is proportional to the RH differences between the parcel and the surrounding atmosphere on the same level. If $RH_p(z)$ is the relative humidity within the parcel (it exceeds 100% in supersaturations conditions) in height level $z$, and $RH(z)$ is the environmental relative humidity, we describe the additional dilution process in time as a sink term in the parcels relative humidity budget:

$$\frac{dRH_p(z)}{dt} = -\alpha (RH_p(z) - RH(z)).$$

The rate of the exponential decay of the elevated RH within the parcel is controlled by the dimensionless $\alpha$ factor. For each time step we subtract the above dilution term from the calculated parcel’s RH. Figure S2 shows the evolution of the dilution effect on the parcel’s properties, for a range of dilution coefficients, for two cases for which a cloud was formed. The time evolution of the parcel’s supersaturation ($S$) is shown in the upper-left panel for an initial RH perturbation of 8%. The different line colors refer to different dilution coefficients ($\alpha$) from 0.1 (blue, left most curve) to 0.9 (orange, right most curve). The dilution slows down the increase in RH (weaker updrafts) and for cases with $\alpha > 0.5$ the parcel does not reach saturation and there is no cloud formation. The differences in the cloud base height for the parcels that did reach saturation ($\alpha<0.5$) were ~10m (Fig. S2 lower-left panel). When the initial RH perturbation is increased to 13% (Fig S2, right column), all parcels reach saturation and the maximal difference in the cloud base height between no dilution ($\alpha=0$) to the maximal simulated dilution ($\alpha=0.9$) is less than 25m.
Figure S2 – The RH dilution effect on cloud base height. The upper left panel shows time evolution of parcels that were initialized using the August 6th, 2011 profile (as shown in fig. 2 in the paper), with initial height of 300m and RH perturbation of 8%. The colors refer to different dilution factors ($\alpha$). The lower left panel shows the overall effect on the saturation height for cases in which the cloud formation was not totally suppressed ($\alpha < 0.5$). The panels on the right column show the same but for initial RH perturbation of 13%.

S1.3 Similar atmospheric conditions around the globe

The specific atmospheric conditions that are required for the formation of these small convective clouds (as discussed in this work) are common during the eastern Mediterranean summer. Conditions of a hot and humid boundary layer capped by a strong inversion layer can be found in other locations as well, such as many coastal areas along the subtropical belts (Dima and Wallace, 2003). Two examples of such conditions are presented in Fig. S3, one from Palma de Mallorca and the other from Tenerife. Similar to what was seen over Israel, ceilometer data from those two locations show that the measured cloud base height is located a few hundred meters below the
LCL. This suggests that the formation mechanism presented in the paper may be quite general and applicable to other subtropical regions around the globe.

Figure S3 - Atmospheric profiles, LCL and measured cloud base height in Palma de Mallorca on 11 Aug 2011 at 12:00 UTC (left) and in Tenerife on 23 Aug 2011 at 12:00 UTC (right). The blue and red lines are the temperature and RH profiles, respectively. The horizontal cyan and magenta lines represent the ground and average LCL, respectively, and the horizontal blue line represents the measured cloud base height. Note the inversion layer that creates a layer of elevated RH below it and the discrepancy between the LCL and the measured cloud base height.

References

Dima, Ioana M., and Wallace J M. 2003 On the seasonality of the Hadley cell. Journal of the atmospheric sciences 60.12: 1522-1527.