Atmospheric
Chemistry
and Physics

Open Access

Discussions

Interactive comment on "Top-down and Bottom-up aerosol-cloud-closure: towards understanding sources of uncertainty in deriving cloud radiative flux" by Kevin J. Sanchez et al.

Anonymous Referee #1

Received and published: 12 May 2017

The authors provide an analysis of cloud droplet closure using data collected at Mace Head, Ireland during summer 2015. The dataset includes surface based aerosol and remote sensing data from the Mace Head station. In addition, in situ vertical profile data was collected from a new UAV platform, which was deployed with a rotating payload comprising of meteorological probes, an aerosol optical sizing spectrometer and a cloud extinction monitor. Finally, the authors also make use of satellite cloud remote sensing products.

The authors conduct an aerosol-cloud microphysical closure analysis from the surface based data input into a parcel model (bottom-up) and from the satellite and in situ cloud extinction (top-down) to assess the uncertainty in deriving shortwave cloud radia-

tive effects associated with microphysics. The authors find that when they account for reductions in cloud drop number concentration associated with entrainment, the difference between modelled and observed shortwave fluxes are reduced. The authors also find that decoupled clouds result in larger differences between modelled and observed shortwave fluxes, compared to well mixed cases.

Overall the paper is interesting and suitable for publication in ACP. I have a number of minor points listed below, which I urge the authors to consider before the paper is finalized.

General point: It might be useful to clarify in the abstract (and in sections before you define RF) that you are discussing shortwave radiative flux

L80 "surface latent heat flux, (i.e. evaporative cooling at the surface)" – this is misleading: surface latent heat flux does not induce cooling. It is independent of the heat budget at the surface. The mechanism, described in BW97, results in decoupling because under high LHF, there is a larger jump in buoyancy flux at cloud base, the cloud layer drives the turbulent motions and a zone of negative buoyancy flux develops in the sub-cloud layer. When this zone becomes too large it becomes dynamically favorable for the cloud layer to decouple from the sub-cloud layer.

L81 BW97 claim that drizzle is not necessary for their "deepening-warming decoupling" mechanism, however they do show that it can have a substantial impact on the promotion of negative sub-cloud buoyancy fluxes and induce decoupling.

L87 also related, moving air over a higher SST does not induce cooling. Suggest reviewing Stevens, 2002, Bretherton and Wyant, 1997 and Schubert et al., 1979 (not exhaustive list) for information about the mechanism of decoupling driven by increased surface latent heat fluxes and negative sub-cloud buoyancy fluxes.

L123 (sp) Nafion.

L145-147 how is the scaling done? In Figure 7 and Figure 11, RH values are shown to

be <100% in the cloud layer.

L155 typo - Aerosols

L204-206 Mixing state: can you clarify what you mean by "externally mixed types of particles". You then state that aerosols are internally mixed: is it fair to say that aerosols are internally mixed when this paper is discussing evidence of a significant fraction of air entrained into the boundary layer from above? Would aerosols from the free troposphere not have different chemical characteristics from the boundary layer? The phrase "lack of aerosol sources" is also ambiguous.

L215-226 Does the model include the effects of coalescence scavenging, which may be quite significant for a marine cloud over the 2-hour period given here.

L222 should there be a negative sign in your equation for the adiabatic cooling term (i.e. $-gdz/c_p$)?

L340-342 I think you could be a bit clearer about how you come to this conclusion from the data shown in Table 2.

L374-390 in both well-mixed and decoupled boundary layers, there are diabatic processes affecting the cloud layer namely, long-wave cooling of the cloud top, short wave absorption, drying due to drop sedimentation. To what extent do these processes interfere with the assumption of a cloud parcel being a mixture of cloud base air and entrained air?

Fig 10: suggest putting the flight details in the caption (like Fig 11) for clarity

L388-400 I think this section could be reworded to improve its clarity. I also have a few concerns: 1) It's not clear what you are referring to with the linear proportional relationship (L392). As you clarified, the $q_v = q_t$ is only true outside the cloud, but if this mixing diagram is only used to illustrate processes in the cloud, what new information do you get for cloudy air with the addition of the second dimension (q_v) over the 1D theta-E mixing calculation done with Eq.4? 2) The dashed line is linear by design, on

C3

a q_t axis. Since $q_t = q_v$ at the two end points these would indeed be the end points of the dashed line but on this q_v axis the line would be curved 3) It is not clear what the adiabatic line is supposed to represent. Why does theta-E change during an adiabatic process?

L417 what is the sensitivity of cloud extinction if mixing is homogeneous v.s. inhomogeneous compared to, say, the magnitude of the entrainment? Are there any other clues from your data set that could help confirm that the inhomogeneous process is a suitable assumption?

L470 What was happening on the other cases? Was the cloud layer more vigorously mixed, such that entrainment warming and drying was homogenized through the layer more rapidly?

L474 "presence (of) marine biogenic..."

L474 local anthropogenic...what?

L475 "observations and simulat(ed)"?