This study developed an analytical cloud profile model based on the dominant patterns of LWC and ER that derived from simulations of stratocumulus. Cloud profile retrieval from passive satellites is very challenging, this study simplifies the characterization of cloud profiles and enables the potential predication of precipitating or entraining level. The analytical cloud profile model is a very interesting tool for the futuristic retrievals with these main profile patterns are all involved. Overall, this work is very well organized and elaborated, the figures are displayed in a good manner. This work could be accepted for publication after clarifying some minor issues:

1. I noticed that the authors extract the EOFs for ER and LWC simultaneously by grafting the two profiles. The EOFs that derived from this way would be different from extracting ER and LWC separately. I would suggest add discussion on this.

Response: Thank you for the question. The grafting of the two profiles is performed to ensure the EOF1-3 for ER and LWC are representative of the features for the same group of profiles. Actually, we have also done experiments by applying EOF analyses specifically for LWC or ER profiles and the reconstructed dominant structures were also exhibiting triangle shaped features for both LWC and ER profiles. The difference is that the part of variance that the first three EOFs could explain is larger than for the grafted results. However, when interpreting the simultaneous patterns of LWC and ER profiles for a certain level of cloud-top entrainment or precipitation, the individually derived EOFs for LWC and ER could not work. Since introducing the EOF analyses individually for LWC and ER would not help the analyses and the necessities of grafting the profiles are explained in the text, we decided not to bring extra EOF results to the manuscript.

2. The analytical model is based on 4 prominent patterns of LWC and ER profiles that extracted from stratocumulus, does the model works for other liquid clouds?

Response: It is a difficult to answer this question based on our results. The cloud regimes we analyzed in this study remain very typical of stratocumulus even though we tried to simulate a wide range of situations. We can only speculate here that the analytical model is sufficiently generic and will remain valid for the description of other cloud types in terms of its ability to describe a wide range of vertical variation of cloud properties. Further investigations of the LWC-ER patterns relating to even more diverse turbulent or precipitating intensities for other types of liquid clouds may be needed in future work to generalize our results to all types of liquid clouds, especially for the potential links between profile shape, precipitation and entrainment.

3. line 65, In order to reconcile the retrievals performed using different spectral channels some studies assumed that the cloud ER profiles are linear or polylinear with no more than one turning point so that retrieval can be implemented by either a lookup table method. whether the polylinear are triangle shaped as well?

Response: We found the profiles are close to triangle shaped as shown in figure 1. For individual profiles, high-resolution detailed oscillations in the optical thickness axis could be found, but the main triangle shape feature is still distinguishable.

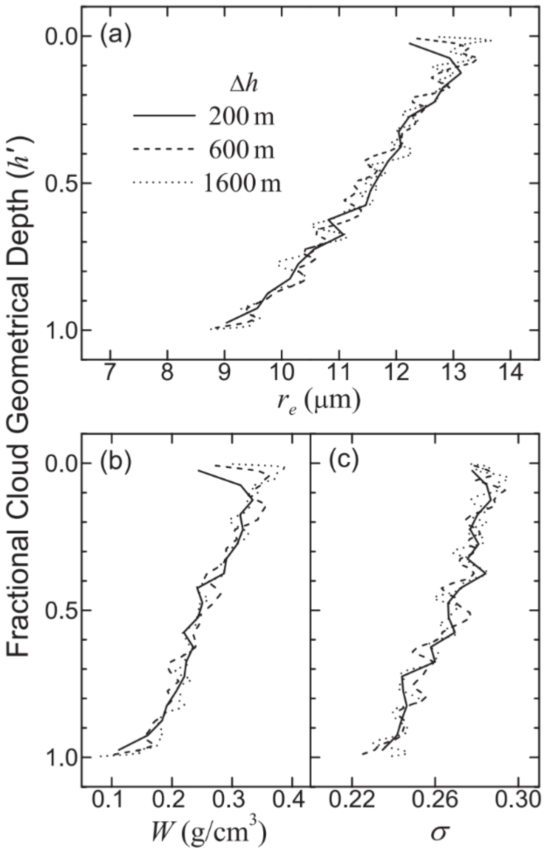

Figure 1. The figure (2) from Chang et al 2002. Vertical profiles of (a) cloud DER, (b) liquid water content, and (c) the dispersion (s) of the lognormal size distribution that were simulated for three cloud geometrical thicknesses of 200, 600, and 1600 m. These profiles were simulated based on the observed values measured at the top, middle, and bottom of a marine stratocumulus cloud during ASTEX.

4. Line 91, the acronym 'LWP' is first introduced here, liquid water content?

Response: Yes, thank you for pointing out. The full name is used instead.

5. Line 105, what do you mean by "with different levels of complexity"

Response: The sentence has been revised as: "LES models with different levels of complexity can capture microphysical processes in response to the effects of turbulent mixing by focusing on different length scales and time scales."

Line 108, probably add more references for airborne measurements of cloud profiles.

Response: Thank you for the suggestion, the description has been detailed with more references and moved close to ground-based profiling measurements. The modified version is as followed:

"Airborne equipped particle probe, imager and spectrometer are able to capture the profile of size distribution and droplet number concentration for cloud and precipitation droplets (Lawson et al., 2001; Dadashazar et al., 2022) . Even though uncertainties such as capturing the extremely small or large droplets, unrealistic assumptions, types of probes and impact from their installations exist in the measurements, these kinds of datasets provide valuable reference for understanding the cloud profiles in nature and evaluating these simulations or satellite retrievals (Grosvenor et al., 2018; Alexandrov et al., 2020; Zhao et al., 2018)."

Line 109, the ground-based cloud profiling measurements is another choice for validating cloud profile retrievals.

Response: we do agree that ground-based measurements are an important reference for satellite retrievals, the discussion related to ground-based profiling of LWC and ER has been expanded as follows:

" Cloud profiles characterized by active radars operated on ground-based sites or onboard spaceborne satellites often served as the truth to validate cloud retrievals from passive sensors (Roebeling et al., 2008). Ground-based radars such as the scanning ARM cloud radars operating at X band (9.4 GHz), Ka band (35 GHz), and W band (94 GHz) are capable to characterize vertical profiles of cloud reflectivities (Kollias et al., 2014; Lhermitte, 1988). Combined with liquid water path measured by microwave radiometer and cloud base identified by Ceilometer, the profiles of LWC, ER and cloud droplet number concentration (CDNC) can be estimated (Frisch et al., 1995; Dong and Mace, 2003; Mace and Sassen, 2000; Rémillard et al., 2013). It is also reported that ground-based radar could distinguish drizzle from cloud particles (Chen et al., 2008) and derive the LWC and ER profiles of each feature (Wu et al., 2020)."

Line 150 temperature – potential temperature

Response: Revised as suggested.

References:

Alexandrov, M. D., Miller, D. J., Rajapakshe, C., Fridlind, A., van Diedenhoven, B., Cairns, B., Ackerman, A. S., and Zhang, Z.: Vertical profiles of droplet size distributions derived from cloud-side observations by the research scanning polarimeter: Tests on simulated data, Journal Atmospheric Research, 239, 104924, 2020.

Chen, R., Wood, R., Li, Z., Ferraro, R., and Chang, F.-L.: Studying the vertical variation of cloud droplet effective radius using ship and space-borne remote sensing data, Journal of Geophysical Research, 113, 10.1029/2007jd009596, 2008.

Dadashazar, H., Corral, A. F., Crosbie, E., Dmitrovic, S., Kirschler, S., McCauley, K., Moore, R., Robinson, C., Schlosser, J. S., Shook, M., Thornhill, K. L., Voigt, C., Winstead, E., Ziemba, L., and Sorooshian, A.: Organic enrichment in droplet residual particles relative to out of cloud over the northwestern Atlantic: analysis of airborne ACTIVATE data, Atmos. Chem. Phys., 22, 13897-13913, 10.5194/acp-22-13897-2022, 2022.

Dong, X. and Mace, G. G.: Profiles of Low-Level Stratus Cloud Microphysics Deduced from Ground-Based Measurements, Journal of Atmospheric and Oceanic Technology, 20, 42-53, 10.1175/1520-0426(2003)020<0042:Pollsc>2.0.Co;2, 2003.

Frisch, A. S., Fairall, C. W., and Snider, J. B.: Measurement of Stratus Cloud and Drizzle Parameters in ASTEX with a Kα-Band Doppler Radar and a Microwave Radiometer Journal of Atmospheric Sciences, 52, 2788-2799, 10.1175/1520-0469(1995)052<2788:Moscad>2.0.Co;2, 1995.

Grosvenor, D. P., Sourdeval, O., Zuidema, P., Ackerman, A., Alexandrov, M. D., Bennartz, R., Boers, R., Cairns, B., Chiu, J. C., Christensen, M., Deneke, H., Diamond, M., Feingold, G., Fridlind, A., Hünerbein, A., Knist, C., Kollias, P., Marshak, A., McCoy, D., Merk, D., Painemal, D., Rausch, J., Rosenfeld, D., Russchenberg, H., Seifert, P., Sinclair, K., Stier, P., van Diedenhoven, B., Wendisch, M., Werner, F., Wood, R., Zhang, Z., and Quaas, J.: Remote Sensing of Droplet Number Concentration in Warm Clouds: A Review of the Current State of Knowledge and Perspectives, 56, 409-453, https://doi.org/10.1029/2017RG000593, 2018.

Kollias, P., Bharadwaj, N., Widener, K., Jo, I., and Johnson, K.: Scanning ARM Cloud Radars. Part I: Operational Sampling Strategies, Journal of Atmospheric and Oceanic Technology, 31, 569-582, 10.1175/jtech-d-13-00044.1, 2014.

Lawson, R. P., Baker, B. A., Schmitt, C. G., and Jensen, T. L.: An overview of microphysical properties of Arctic clouds observed in May and July 1998 during FIRE ACE, 106, 14989-15014, https://doi.org/10.1029/2000JD900789, 2001.

Lhermitte, R. M.: Cloud and precipitation remote sensing at 94 GHz, IEEE Transactions on Geoscience and Remote Sensing, 26, 207-216, 10.1109/36.3024, 1988.

Mace, G. G. and Sassen, K.: A constrained algorithm for retrieval of stratocumulus cloud properties using solar radiation, microwave radiometer, and millimeter cloud radar data, 105, 29099-29108, https://doi.org/10.1029/2000JD900403, 2000.

Rémillard, J., Kollias, P., and Szyrmer, W.: Radar-radiometer retrievals of cloud number concentration and dispersion parameter in nondrizzling marine stratocumulus, Atmos. Meas. Tech., 6, 1817-1828, 10.5194/amt-6-1817-2013, 2013.

Roebeling, R. A., Placidi, S., Donovan, D. P., Russchenberg, H. W. J., and Feijt, A. J.: Validation of liquid cloud property retrievals from SEVIRI using ground-based observations, 35, https://doi.org/10.1029/2007GL032115, 2008.

Wu, P., Dong, X., Xi, B., Tian, J., and Ward, D. M.: Profiles of MBL Cloud and Drizzle Microphysical Properties Retrieved From Ground-Based Observations and Validated by Aircraft In Situ Measurements Over the Azores, Journal of Geophysical Research: Atmospheres, 125, e2019JD032205, https://doi.org/10.1029/2019JD032205, 2020.

Zhao, C., Qiu, Y., Dong, X., Wang, Z., Peng, Y., Li, B., Wu, Z., and Wang, Y.: Negative Aerosol-Cloud re Relationship From Aircraft Observations Over Hebei, China, 5, 19-29, https://doi.org/10.1002/2017EA000346, 2018.