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Interactive comment on "Stratocumulus Cloud Clearings: Statistics from Satellites, Reanalysis Models, and Airborne Measurements" *by* Hossein Dadashazar et al.

Anonymous Referee #2

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Review of "Stratocumulus cloud clearing: Statistics from satellites, reanalysis models, and airborne measurements" by Dadashazar et al.

Using several data sources and a machine learning technique, this paper examines the topic of marine boundary layer stratiform cloud clearings over the northeastern Pacific Ocean. The study uses a holistic approach by considering spatial scales ranging from the synpoptic-scale to the microscale. The authors' do a nice job of utilizing satellite retrievals, reanalysis grids, and airborne measurements to highlight the complexity of the problem which involves interactions between the western United States coastline and the marine environment – a region which has historically received much attention

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Discussion paper

in the literature.

I think that the results stemming from this work are certainly interesting and worthy of publication. Because the authors' cover so many topics, I do have several major comments and many minor comments. The major comments concern one of the techniques used for the MODIS processing in addition to interpretation of some of the results. Overall, I recommend that the paper be accepted for publication once the authors' address my comments.

Major/general comments: 1. I am slightly concerned about the methods used to estimate cloud droplet number concentration, Nd. Because the authors' compare plots of Nd between clearing and non-clearing days, certainly there are differences in cloud base temperature and pressure (as implied by several figures shown in this study) that would affect the adiabatic lapse rate of LWC. Therefore, using an average value of the adiabatic lapse rate of LWC, which is derived from measurements concentrated near the central California coastline (Braun et al., 2018), may not be representative of the much larger domain on which the present study focuses. I recommend that the authors' calculate the adiabatic lapse rate of LWC using the MODIS retrievals of cloud top temperature and pressure. I do not mean to sound nitpicky here, but estimation of Nd already carries relatively large uncertainty, so I think that it is only fair that you estimate it as accurately as possible. It will be interesting to see how sensitive the Nd estimate is to this lapse rate calculation.

2. I think that the arguments presented in Section 3.2 regarding the spatial differences in PBLH (P11, L420-425) require additional explanation. Firstly, citations are needed to support the presented hypotheses. More importantly, why do you think that CF is higher for the broad study region on clearing days? What about the synoptic scale scenarios and the role of offshore flow? Advection of warm air combined with compressional warming near the coastline will increase layer thickness and therefore thin out the MBL below. This seems like a chicken-egg problem. Is it actually cloud processes that are responsible for the shallower PBLHs or are the large-scale dynam-

ics/thermodynamics reducing clouds and therefore causing the shallower PBLHs or perhaps some combination of the two mechanisms?

3. The discussion in Section 3.2 connecting the MERRA-2 and MODIS results raises numerous questions that the authors' should address. For example, on P11, L447-448: This is an interesting yet surprising result. I am wondering how aerosol are treated in MERRA-2. Which aerosol types are included in the reanalysis? Is AOD calculated differently when clouds are present in a column? I must say that I am quite surprised that between clearing and non-clearing days, the MODIS retrievals show a clear difference in microphysical variables suggestive of aerosol influence, but MERRA-2 AOD does not show a clear deference in aerosol loading. While the authors' do provide a possible explanation for this confounding result, I am wondering if it is possible to look at precipitation rates from the MERRA-2 outputs? Or use the MODIS retrievals and the RCB-LWP-Nd relationship derived in Comstock et al. (2004) to estimate cloud base precipitation rate? I think that some general investigative work here would be nice to help shed light.

Reference: Comstock, K.K., Wood, R., Yuter, S.E. and Bretherton, C.S. (2004), Reflectivity and rain rate in and below drizzling stratocumulus. Q.J.R. Meteorol. Soc., 130: 2891-2918. doi:10.1256/qj.03.187

Minor/specific comments: 1. P2, L41: Do you mean model simulations from this study or previous studies? Please clarify.

2. P3, L54-56: This statement deserves citations; please cite some papers here.

3. P3, L85-86: Introduce abbreviations for cloud fraction and cloud liquid water path here?

4. P4, L110-112: Are there differences in retrieval and/or post-processing techniques between GOES-11 and GOES-15 that could impact interpretation/comparison of their results?

5. P4, 119-121: Please explain how you identified a clearing event using visual inspection.

6. P5, L146: From which wavelength retrieval are you using data?

7. P5, L147: Is any day that is not a clearing day lumped in with non-clearing days? Or were some days not considered in the analysis?

8. P5, L148: Why use 1 deg x 1 deg data rather than the higher resolution data that are available? I imagine that the resolution of the GOES data are much higher than 1 deg x 1 deg.

9. P5, L150-153: Why are all of these cloud microphysical properties important in the context of cloud clearings? Some justification in this section would be nice.

10. P5, L151-153, L156: Please italicize variables here and throughout the remaining text.

11. P5, L167-170: Does this need to be its own paragraph?

12. P5, Section 2.2: Similar to the previous section, it would be nice to hear some justification as to why you choose the listed parameters/vertical levels. Why are these parameters/vertical levels important to the analysis? Were other variables considered and found to be not useful?

13. Figure 2: The gray shading in panels c and d are a bit deceiving. Is the cloud base/top/depth in panel c truly that horizontally homogeneous? Panel d makes it seem as though cloud extends from the surface to 1000 m. I think that I understand what you are trying to show, but perhaps showing it a bit differently would be less confusing.

14. P6-7, L222-234: Please explain how all of these turbulence measurements will aid in understanding the physical mechanism(s) that contribute to cloud clearing processes.

15. P6, L224: Why use a 2-km wide high pass filter? I imagine this is influenced by the

aircraft speed? By the way, what is the typical aircraft speed?

16. P7, L236: Is Fig. 2c supposed to show where the inversion sits?

17. P7, L236-238: Why use temperature rather than potential temperature?

18. P7, L238-240: This sentence is a bit confusing; please reword.

19. P7, L247-248: Please reference the GBRT method for unfamiliar readers.

20. P8, L284: How is this r2 threshold determined? Are the results sensitive to this choice?

21. P8, L298-299: What about the other MERRA-2 variables listed in Table 1 that are not listed here?

22. P9, L322-323: Please reference a figure here.

23. Figure 5: Because this plot is relatively straightforward, and only two sentences are written about it, I think that it makes more sense to add it to Figure 4, which also shows related variables as a function of time.

24. P9, L354-356: What about near Point Conception? Are similar mechanisms responsible for the reduction of CF here?

25. P9, L356-361: Is it possible to plot low-level (maybe 100 m) wind arrows over the CF contours in Fig. 6 to support/refute this hypothesis?

26. P9, L361-363: You mention southerly wind, but what about northerly wind along the coastline, which is much more common. Are expansion fan dynamics still present?

27. Figure 7: In the difference plot in panel a, are there truly no regions where the SLP is lower in clearing cases?

28. P10, L369: How might using nearly 2 times more non-clearing days influence your results?

29. P10, L383: When you reference Fig. 8a, should this instead be a reference to Fig. 8b?

30. P10, L395-396: A few more citations would be nice for a statement that is “well-documented”.

31. P11, L411-413: Can you speculate as to why you observe this?

32. P11, L414-415: Why does PBLH exhibit this trend? Is this is a well-known feature of the MBL offshore the western U.S.?

33. P11, L467: Lower LWP values because the clouds are thinner, LWCs are lower, or both?

34. Section 3.3: Generally speaking, how do sample sizes influence the interpretation of these results? Many of the steep slopes shown in Fig. 12 occur at the low or high ends of the parameter spaces which is likely where the fewest number of samples lie. Are the results robust in these areas?

35. P13, L514-516: Are the local changes in slope of the PD-T850 relationship important? For example, from 275 to 280 K, the slope is relatively small, but from 281 to 282 K, the slope is relatively large.

36. P13, L524-534: Please reference the various panels in this section to help the reader.

37. P13, L540-543: Please provide a citation for this phenomenon. An example of previous work in this region may be found in Rahn et al. (2016, Observations of Large Wind Shear above the Marine Boundary Layer near Point Buchon, California, JAS).

38. P14, L557-558: A negative U850 promoting cloud clearing makes sense due to the offshore flow component, but can you hypothesize as to why strong positive U850 values also promote cloud clearing?

39. P14, L566: Might these vertical motions also induce dynamical circulations and

thereby influence shear/turbulence/entrainment processes near cloud top?

40. P15, L592: Specific or relative humidity?

41. P15, L614-627: I like this portion of the analysis, and the topic of horizontal wind shear is one that probably does not receive enough attention. I think that perhaps a line plot showing how the horizontal shear changes with distance for each of the vertical levels may be very useful.

42. P16, L648-650: I do not understand this sentence; please reword.

43. P16, L660: How is the cloud base rain rate determined?

44. P16-17, L677-681: Are you able to hypothesize why, in all three flights, surface PCASP concentrations are higher on the cloudy side even though the surface wind speeds are higher on the clear side? Is it possible that drizzle drops evaporate after the wet scavenging processes and therefore concentrate aerosol near the surface, whereas aerosol are well-mixed in the MBL on the clear side? If available, vertical profiles may help here.

45. P17, L683: Do you mean stronger gradients in horizontal wind speed?

46. P17, L683-685: What about the role of positive (cyclonic) vorticity that is generated by this horizontal shear? Could this influence cloud properties near the cloudy-clear interface?

47. P18, L749-765: I think that in order for the authors' to argue whether buoyancy or shear production of turbulence is more important, they should calculate the terms according to the TKE equation (e.g., see Eq. 5.1a in Stull, An Introduction to Boundary Layer Meteorology, 1988).

48. P18, L754-755: Adding vertical profiles of TKE would be very useful.

49. P18, L759: What do you mean by "stabilizing effect"?

50. P19, L803-805: Can new remote sensing platforms, such as GOES-16/17, help with the diurnal analysis of cloud properties?

Grammatical/wording recommendations: 1. P6, L198: Please change "Of the relevance to this study" to "Of relevance to this study".

2. P7, L254: Please change "or each of the 306 events." to "for each of the 306 days.".

3. P8, L313: Please change "between 2009 and 2018" to "from 2009 through 2018".

4. P10, L366: Please change "Large-scale characteristics of a dynamic and thermodynamic nature were contrasted" to "Large-scale dynamic and thermodynamic characteristics were contrasted".

5. P10, L401: Please change "likely contribute" to "likely contributes".

6. P11, L410: Please change "geographical coincident" to "geographically coincident".

7. P12, L494: Consider changing "GBRT model to model clearing" to "GBRT model to reproduce clearing".

8. P12, L500: Please remove "partial dependence" as this acronym has already been defined.

9. P16, L656: Please change "lesser effect" to "reduced effect".

10. P19, L780-781: Consider changing "clearings visible from space" to "clearings as suggested by satellite retrievals".

11. P19, L782: Please change "centroid of clearings is centered" to "centroid of clearings is located"

12. P19, L808: Please change "sea spray fluxes, which subsequently can impact clouds" to "sea spray fluxes and can subsequently impact clouds".

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2020.