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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the transitions in marine boundary layer cloudiness" *by* I. Sandu et al.

Anonymous Referee #2

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Review of "On the transitions in marine boundary layer cloudiness", by Sandu, Stevens and Pincus

Overview: This is an interesting paper detailing a composite analysis of satellite cloud and other data along Lagrangian trajectories from the subtropical eastern oceans to the trade winds. The satellite data permit composites based on a large number of individual cases which is a novel approach to studying the stratocumulus to cumulus transition and builds on the approach proposed by one of the authors in an earlier study. There are some notable findings that I think will be of interest to ACP readers, namely:

1) The initial transition from overcast to broken Sc appears to be more closely related to decreases in static stability than in divergence. Since both divergence and stability

can in principle control the MBL depth, and since MBL depth is a key player in driving decoupling and cloud breakup (e.g. Bretherton and Wyant 1997, Wood and Bretherton 2004), one might expect that divergence decreases could play an important role in driving cloud breakup. As I discuss below, I am a little concerned that some of this behavior might be partially an artifact of the way in which trajectories were chosen.

2) Transitions from overcast to broken clouds are similar in all four oceanic basins. This is an interesting, and first-of-its-kind result. Again, one could argue that this might not be the case based on significant differences in the meteorological forcings in the different basins, so this result is interesting.

I make some specific comments and recommend that the manuscript is accepted subject to some revisions.

Major Issues:

1) I am concerned that selecting only the subset of trajectories whose initial locations are the most cloudy may bias the conclusion regarding the relative importance of stability vs divergence in driving the cloudiness transition. A qualitative argument is as follows:

(a) Instantaneous correlations between cloud cover and any chosen exogenous meteorological variable (e.g. stability, temperature advection, divergence, etc.) are low. This is likely because there exists much "noise" in the system that can create or destroy clouds fairly readily. This noise originates from mesoscale and short timescale variability like gravity waves, mesoscale flow variability, warm SST patches, and so on.

(b) If one could document the cloud evolution along individual Lagrangian trajectories (assuming perfect sampling), then this noise would manifest itself as noise in each C(t) series where C is the cloud cover. Each trajectory would therefore have a decorrelation time that is relatively short, perhaps 1 day.

(c) By selecting only trajectories where C(t=0) is large, one is thus artificially raising the mean value of C(t) (call this <C(t)>) at short times, and therefore the decrease in <C> over a time period shorter than the decorrelation timescale. Thus, the initial decrease in <C> may be larger than it would be if did not select trajectories based on C(t=0).

(d) Since stability decreases most strongly initially, while divergence decreases are delayed until later, this may skew the decrease in <C> to correspond more closely with stability than with divergence.

These ideas can be tested numerically using artificially created random variables. Of course, we do not know a priori the level of noise, but the spread in C(t) values could help constrain this. A beta distribution (B[0,1]) with values of the distribution parameters consistent with observations could be used to create an initial set of cloud cover values. We can then make <C(t)> decreases with time in an arbitrary way. The effect of selecting only the largest values of C(t=0) could be estimated in this way.

2) The divergence decreases most strongly between days 3 and 5. According to Fig. 2, there are significant decreases in cloud cover through this period, although they are not as strong as those earlier. So, it seems to be difficult to rule out the importance of divergence entirely. Indeed, Fig. 7 seems to show stronger decreases in C in the climatological data along the mean streamlines corresponding to where the divergence starts to decrease signficiantly.

3) The argument (lines 5-10 on P23599) that longwave cooling changes along the trajectory are likely of secondary importance does not seem to be based on any quantitative assessment. Some simple radiative transfer calculations using the observed water vapor profiles would be quite enlightening here.

4) Fast and slow transitions: why not repeat the analysis with just the central initial trajectory location of the nine in each basin?

5) I don't see what the aerosol data really add to this study since both the NEA and SEA are characterized by optically thick aerosols sitting above the cloud deck and not really

interacting with it, while the NEP and SEP aerosol levels are too low to be detected with passive sensors. Since nothing conclusive can be drawn from the results, the authors should consider removing this part of the analysis.

Minor issues:

1) Why are the most pertinent findings not highlighted in the abstract?

2) Abstract: What does it mean to say that a transition is a “persistent feature”?

3) Are the trajectories 2D or 3D? I assume 2D but I could find where this was stated. If 2D what level is used?

4) Section 2.2.1: At what height is the large scale divergence estimated? In an earlier paper (Stevens et al. 2007, MWR) this was found to be quite height dependent.

5) Section 2.2.2. State that the times given here are local times.

6) Section 2.3. How are the initial directions chosen? How close to southwestward (NH) do they have to be to qualify? Why can't they go southward? This would be over warmer water too? What fraction is excluded based on their direction?

7) Fig. 1 composite structure: are means or median values of the cloud cover shown?

8) Many of the SEA trajectories end up on the African coast helps explains why Gabon has the highest incidence of Sc of any country in the world - despite being on the equator.

9) Line 12, P23600: “later” rather than “latter”.

10) Line 9, P23602: “built” rather than “build”

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