Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2021-540

Anonymous Referee #2

Referee comment on "North Atlantic Ocean SST-gradient-driven variations in aerosol and cloud evolution along Lagrangian cold-air outbreak trajectories" by Kevin J. Sanchez et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-540-RC2, 2021

The manuscript presents a 3-days case study of a cold air outbreak. The study builds on combined observations from satellite, airborne and ship-based, as well as reanalysis data. The Lagrangian design of the observations provides insights into cloud morphology and its relations to particle concentrations and sea surface temperature. The sea surface temperature varies due to the Labrador current and controls the boundary stability, thus clouds. The study shows that although air masses origin for both trajectories had similar aerosol characteristics, the aerosol characteristics downwind were different, attributed to aerosol-clouds interactions along the trajectory. Linking these findings to the role SST in the two different trajectories is interesting. Although the study focuses on a single case study, the authors show that the observed pattern they identified occurs annually due to the location of ocean currents in the region, enhancing the relevance of the study.

The manuscript is clearly written and I would recommend publications after addressing the following issues:

Major comments:

1. In the introduction the authors nicely describe in details the theory of Sc-to-Cu transitions that was developed based on subtropical Stratocumulus cloud transitions. I am not sure the same arguments apply also for cold air outbreaks. I would like the authors to discuss and show how the decoupling and breakup processes in the stratocumulus regions are relevant to cold air outbreak as well (e.g., SST gradients, subsidence rates, humidity above the inversion layer and boundary layer deepening are fundamental ingredients of the Sc-to-Cu transitions. Are those important for cold air outbreak as well? Or that ocean fluxes due to the large air-sea temperature is the main cause of the transition? See, e.g., https://doi.org/10.1002/2017JD027031).

2. The authors emphasis the role of meteorology. As far as I understand, by meteorology the authors mean the SST (and subsequently stability) along the air mass trajectories. So why not calling it stability? Meteorology in that sense is somewhat miss leading, since meteorology is more than SST and stabilty. I would ask the authors to explain what they mean by meteorology. The explanation given in Line 161 for the different meteorological condition is not informative with respect to the role meteorology.

3. The case study presents a trajectory that passed through a cold air outbreak. But it is the different is SST between that trajtory and another one that makes it an interesting story. I think that emphaising this in the title, rather than the cold air outbreak, would be more infomative.

Specific comments:

Line 72: Not clear what the authors mean by “particle trajectory”.

Line 114: Instead of “break-up” I suggest writing “dissipation”, as the clouds are drying, as the authors write.

Line 243: Please elaborate on “cloud conditions”.

Line 271: https://doi.org/10.1002/2015JD023176 and https://doi.org/10.1073/pnas.261712099 showed case studies of continental air associated with overcast cloud regime over the north east Atlantic. Might be relevant.

Line 325: What do you mean by “differences in meteorology”?

Line 353-356: How decoupling can form along with a rapid increase in SST? Wouldn’t it enhance cumulus formation from the surface? Can you shows SST along the trajectory?

In addition, the authors relate closed-to-open cells transition to decoupling. The decoupling is part of the Stratocumulus break up to cumulus clouds, while closed to open cells transition process is more associated to drizzle formation (e.g., https://doi.org/10.5194/acp-6-2503-2006).

How is the decoupling measured?

Have you looked on the relationship between decoupling and warm advection? (e.g., https://doi.org/10.1029/2018GL078122 and DOI:10.1002/essoar.10507144.1)

Line 412: check for typos.

Line 499: Can entertainment of aerosol from the free troposphere explain aerosol properties (e.g. https://doi.org/10.1175/BAMS-D-13-00180.1)

Line 506: Do you have an estimate of the replenishing rate?

Figure 1: Can resolution be improved? Consider also enhancing the colors in the darker images to improve visibility.