Comment on acp-2022-637
Anonymous Referee #1

Referee comment on "Long-range transported continental aerosol in the Eastern North Atlantic: three multiday event regimes influence cloud condensation nuclei" by Francesca Gallo et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-637-RC1, 2022

General Comments:

This paper presents novel research with a developed algorithm that utilizes several aerosol properties using thresholds from previous studies to identify and classify multi day aerosol plume transports in the Eastern North Atlantic (ENA). The authors perform statistical analysis to determine if differences in aerosol properties during regional aerosol baseline conditions and plume transport events are statistically significant. They go a step further by using HYSPLIT to determine their origin and CALIPSO to determine their type. Finally, the authors present 3 case studies corresponding to each of the 3 classification schemes. Overall, this is a good quality study with clear motivation, methodology, and discussion of results that is strongly supported by past literature. It could provide a useful constraint for climate models. It is certainly of interest for publication, although without a stronger comparison to literature to make the significance of the findings more clear, it may fit better as a Measurement Report.

The main weakness with the paper is that it seems to be attempting source attribution without chemical measurements, relying solely on back trajectories. Certainly this has been done before, but the authors would need to carefully review the success of those attempts in order to provide appropriate context for this work. However, I do wonder why this is done here, given that AOS includes ACSM measurements. Is there some problem with those that prevents their inclusion? If ACSM only available for part of the time, could that be used to strengthen the conclusions of this work by showing similarities for part of time?
The work discusses the algorithm for classification and how it is applied, but never actually provides the algorithm. There is a discussion of “multiday transport” criteria, but I am more interested in the differences of the 3 categories identified in abstract. Or is this just a subjective classification of 9 events based on Table 2? Table 3 provides the average characteristics of each, but if the separation is based on backtrajectories then what are the specific criteria for those or are they clustered or something? Sorry if I missed it, but I assume it is not based on CALIPSO as Table 2 might indicate. Also, the CALIPSO mixtures show more complexity than the three categories in Table 3 and the abstract. Or does that result refer to just 3 case studies rather than 3 categories of the 9 events (abstract: “group the events into 3 categories”)?

Given the diversity of the origins of these events, why is it appropriate to summarize the results of all of them together? (p.2 line 5) It would seem that averaging such events dampens the differences between them rather than showing how they contribute to variability.

Also the authors cite Wang et al. 2021, but I think a more quantitative and specific comparison to that work is needed to clearly show how this work improves/extends their results.

**Specific Comments:**

Table 3 Which events are summarized in each category? Need to specify here or in Table 2. I think Table 3 would also benefit from some punctuation. It looks more like a ppt slide than an archival table.

Many places – significant increases of WHAT with respect to WHAT? (The latter is often missing.)
Why was $N_{\text{tot}}$ higher for marine and dust? Seems like marine should be same or lower than baseline and dust would have low N (high M), so please explain.

How was baseline defined?

Section 2.2

Averaging aerosol properties for 6 hour periods results in a coarse time resolution. A recent study by Dedrick et al. 2022 using ARM instrument aerosol properties to define marine and non-marine periods in the Southeast Atlantic shows moderate variability with 2 hour averaging periods. Please state the reason for 6-hr averaging.

How high is the variability of your aerosol properties using 6 hour averaging periods?

There is a lot of comparison/citation to Mace Head, but is that really the most appropriate comparison for ENA? Please consider a more broad consideration of the literature for some discussions, and/or please justify why Mace Head is same.
What is a phytoplankton-derived aerosol? Do you mean sulfate from DMS?

Does it result in a different amount of multi day aerosol plume transport events?

Why do certain aerosol properties use mean or median to define thresholds?

Section 3.1.1

Entrainment is mentioned several times in this paper. Have you looked into separating aerosol property data using proxies for entrainment rate such as delta-T at top of MBL?

Section 3.1.1 and Section 3.1.2

The paper discusses the removal of large particles by precipitation several times. What happens when you separate the aerosol properties that follow precipitation events?

The paper also discusses the effect of wind speed on large Ac mode several times. How well do wind speed and parameters of the large Ac mode such as mean diameter and number concentration correlation at the ENA?
Section 3.2.4

The paper introduces HSD to define statistically significant changes on baseline aerosol number concentrations, aerosol size modes, and CCN potential activation fraction. However, scattered throughout the paper in sections before that significance is also used interchangeably to describe differences in seasonal statistics and baseline conditions. I recommend a different word or plainly writing out the quantitative differences to avoid confusion.

In this paper, the authors use activated CCN fraction and N_tot to speculate whether aerosol composition or increased aerosol concentration affect CCN at the ENA. Have collocated cloud properties (by either ARM ground or NASA satellite retrievals) such as cloud effective radius been analyzed for these case studies? It would be convincing to see if there is a statistically significant difference in cloud properties versus baseline conditions due to rapid cloud adjustments.

Technical Corrections:

There are a significant number of typos. Some are noted below. Please reread and check for these.

p.6 line 8 “era”

p.5 line 21 Saliba et al. was not at Mace Head
p.1 line 34 "mixture of dust and marine aerosols from North Af" – is the marine from N.A. too or is that just the dust?

p.2 line 1 cloud concentration nuclei concentrations

Overall, please stay consistent with usage At mode and Ac mode versus fully writing out Accumulation Mode and Aitken mode.

Section 2.1 “is given” should be “are given”

Section 3.1.1 Please define what months belong to which seasons earlier in the paper as you discuss summer mean values before doing so.

Section 3.1.1 “The influence of local aerosol sources on Ac mode aerosols measurements at ENA is minimal” can be written more concisely as “There is minimal influence of local aerosol sources on Ac mode aerosol measurements at ENA”
Section 3.2 Line 40 Can remove “specific” in front of case studies to reduce redundancy

Section 3.2.3 Line 13 Missing space before “Here we”

Section 3.2.3 Line 14 Missing space after “September 09th”. “September 09th” should also be “September 9th”. “During the period in analysis,” can be written more concisely as “During this period”.

Section 3.2.3 Line 23 Can remove “under” to be more concise.

Section 3.2.3 Line 32 This sentence is worded confusingly.

Section 3.2.3 Line 37 Add comparison values in parenthesis to your percentage increases.
Section 3.2.3 Line 37 Can more concisely word this as “aged wildfire aerosols dominate the accumulation mode and act better as CCN”

Section 4 Line 23-24 add “a” before “mixture” and remove “,” after “March 2017”

Section 4 Line 25 add ”a“ before mixture

Section 4 Line 26 “form” should be “from”

Section 4 Line 27 “the aerosol plumes composition” can be written as “aerosol plume composition”

Section 4 Line 29 “causeed” should be “caused”

Section 4 Line 30 “ Mixture of marine and polluted continental aerosol plumes showed high CCN concentrations attributable to both high Ntot, and predominance of large particles (Dp > 100 nm) of sufficient size to readily serve as CCN.” can be written in active voice and more concisely as “High CCN concentrations are attributed to both high Ntot and dominance of particles large enough to act as CCN (Dp > 100 nm) from mixed marine and polluted continental aerosol plumes.”
Section 4 Line 35 Move ", in 2017," to the end of the sentence.