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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Night-time enhanced atmospheric ion concentrations in the marine boundary layer" *by* N. Kalivitis et al.

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The authors would like to thank the reviewers for their constructive comments and helpful suggestions. All of the reviewer's comments have been taken into account and we respond point by point to all of them below.

Introduction: pp 11811, l6 - The ion spectrometer is mentioned. What is it meant here: AIS or BSMA ?

The ion spectrometer used was an AIS.

pp 11811, l8 - Typo: The lowest limit of the DMPS is 3 nm (not 83 nm) in Hirsikko et al., 2007.

The lowest detection limit of the DMPS in Hirsikko et al., 2007 is indeed 3 nm.

pp 11811, last line: add "ion" between "day time" and "concentrations".

The word "ion" is now added in the manuscript.

pp 11813, l14: What are the station routine measurements ?

At the Finokalia research station a number of different measurements is taking place on a regular basis. Of these measurements, we have used data to explore the variability of ions in the atmosphere. As explained afterwards in the text SMPS, ozone, aethalometer and meteorological data were used.

pp 11814, l17-20: Authors made the assumption that higher ion concentrations at night are due to a weaker dilution of the MBL through thermal mixing. What does it mean in terms of ions sources? Is it assumed that ion sources are the same during the day and the night?

After the suggestions of the reviewers we performed coagulation (CoagS) and condensation (CS) sink calculations. After these calculations, the assumption about dilution is now removed and instead explanation of the observations was made based on sinks. Diurnal cycle of both CS and CoagS can explain the daily patterns observed for ion concentrations. Finokalia is a natural rural site with no local sources in the vicinity. In addition no change in air masses direction during day and night time occurs (no sea-land breeze occurrence). Based on that information we assume that ion sources are the same during night and day. Even if the sources remain the same, the sources of the condensable species that can lead to cluster ion growth to particle diameters can vary significantly between day and night.

pp 11814, l21: The annual variability is investigated through meteorological parameters analysis such as the temperature or the wind direction and speed. In my opinion the same analysis should be done to investigate factors controlling the observed ion concentration daily pattern.

In order to investigate the dependence of ion concentration on meteorological parameters we calculated daily ion concentration average values as well as daily averages for wind velocity, wind direction, temperature, relative humidity, ozone and BC concentration. During the whole measuring period we calculated median values for ion concentrations for every 5 minutes (which is the time resolution of the AIS) and mean values for the atmospheric factors with the same time resolution. Thus we were able to visualize their diurnal cycles and also perform linear regression to these measurements.

pp 11815, l1: The radon is suspected to be the main source of atmospheric ions at the measurement site. This comment is speculative without more analysis, I'm not sure it is relevant to mention the radon to explain the observations.

All three reviewers have expressed their objections about using assumptions about radon to explain the observations. Since no measurements are available that could be used to explain these data, all relevant parts referring radon have been removed.

pp 11815, l6: No clear dependence was found between RH and ion concentration. What is it meant here ? I think a more statistical analysis should be done for each factor (T, RH, WD, WS, BC and ozone). This would provide a more accurate analysis. Again, I think an average daily variation pattern sould be presented and analyzed.

In order to examine the dependence we performed linear regression followed by an F-test to our data and also correlation coefficient calculations. For the F-test the null hypothesis was that there is a good linear fit to our data pairs. The significance level α was set to 0.05. The F-test returned p-values very close to 0 for all cases thus forcing us to reject the null hypothesis. The R-square values were also very close to 0

pp 11815, l23: Here ozone is assumed to be a tracer of polluted air mass. I think an analysis of air mass back-trajectories for polluted and non-polluted events in terms of BC and ozone could improve the analysis.

In order to categorize the events as polluted and non polluted we calculated the mean values of BC concentration throughout the two days between which the event occurred. We classified as polluted those events that occurred in the days when mean BC concentration was above 400 ngr/m3 and found 14 polluted and 19 non-polluted events, while 6 events were not classified as there are no available BC measurements for these days. During 64% of the polluted events the origin is generally from the wide W/SWsector. However this is the sector that is dominant for all the events.

pp 11815, l28: "On the other hand values for ozone levels lower than 30 ppbv can be attributed to advection and dry deposition mechanisms reducing air ions concentrations as well." I'm not sure to understand what authors mean. Please clarify.

As our site is a coastal one no significant dry deposition of ozone occurs. After further analysis of ozone data we concluded that a very weak correlation existed to ion concentrations. Higher ozone concentrations resulted to lower ion concentrations. Therefore, this sentence was replaced by the above conclusion.

In the section "Enhanced ion concentrations during the night at Finokalia": SMPS data were not presented. In my opinion, condensational and coagulation sinks should be analyzed. Such new informations could help to understand the observed phenomenon.

As suggested by the reviewer we performed calculations of CS and also CoagS for particles of 2 nm, 2.5 nm, 3 nm, 3.5 nm and 4 nm. We calculated means for these sinks with a time resolution of 5 minutes, which is the SMPS time Diurnal circles of CS and CoagS have been calculated.

pp 11816, l26: According to the figure 6, the cluster concentration is enhanced at night. Authors connect this cluster production to the nucleation process. In my opinion, the cluster lifetime is too short to be connected to a nucleation event that will occur few hours later. On the figure 6, the night-time ion concentration enhancement seem to be strongly decreased prior to the nucleation event. Mean values of cluster ion concentration during the night and just before the nucleation is triggered could help to

investigate the role of such night-time enhancement on the nucleation occurence.

We have investigated the variation of mean ion concentrations between event and non-event days. However no significant changes were observed.

pp 11818, l9: Again, I think a statistical analysis of an average event vs. Nonevent day would improve the clarity of the paper.

We have performed a comparison between event and nonevent days for the various parameters but no significant differences were observed. The comparison results will be referred to in the manuscript

pp 11819, l10: A map with sector description would be useful to understand the air mass origin analysis.

We have designed a map to demonstrate the different sectors of air mass origin and it will be added in the manuscript.

pp 11819, l16: In my opinion there is a conflict between two results here: "The results showed intrusion of air masses from higher altitudes for the majority of the events and thus influence of cleaner air masses" and "the contact of air masses with the soil was the major source of atmospheric ions for Finokalia". Moreover, Hysplit backtrajectories were computed to reach the sampling site at 1000 m a.s.l. How could you explain that air masses from higher altitudes could be enriched in radon ? Again, no radon measurements are presented here, so I do not think it is relevant to speculate that much on the potential role of radon on the night time enhancement events.

We have computed air mass back trajectories at an altitude of 1000m because it has been shown in the past that this altitude is the most representative for Finokalia site to represent boundary layer (Mihalopoulos et al, 1997). Due to the presence of high mountains in the region, calculation of trajectories at lower altitudes would be affected and would not be representative of the regional conditions. All mentioned before all discussion on radon was now removed from the manuscript. âĂć Conclusion: Do the

authors have some assumptions to explain their observations ? I think the presented results should be more discussed. After performing CS and CoagS calculations, the ion observations can be explained more adequately.

References: The reference Gagné et al., 2011 is now available in its final form.

The reference has now been added in its final form.

References

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 11809, 2011.