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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Marine and terrestrial influences on ice nucleating particles during continuous springtime measurements in an Arctic oilfield location" *by* Jessie M. Creamean et al.

Anonymous Referee #2

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General Comments:

"Marine and Terrestrial influences on ice nucleating particles during continuous springtime measurements in an Arctic oilfield location" by Creamean et al. describes results from a 3-month field campaign in Oliktok Point, Alaska in 2017. The field campaign included detailed measurements of in situ aerosol size distribution and number and offline measurements of aerosol composition and ice nucleating particles (INPs). Utilizing size-resolved aerosol impactors, the authors determined the ice nucleation ability of a range of particles sizes. Further, back trajectory modeling and sea ice and snow cover data were used to investigate the influence of various sources on the measured

INP concentrations. The authors provide some evidence that changes in sea ice and snow cover may influence INP number concentrations at the measurements site, but lack an explanation of the mechanism that triggers emissions of INPs due to changes in sea ice and snow cover or suggestions on how to explore this in future work. While it is stated that the data demonstrate how "efficient, natural INPs are likely important in such a relatively polluted Arctic location", the supporting evidence for this is not clearly presented and it is not obvious how this study differs from other coastal studies that were found to be influenced by non-marine aerosol sources. Additional analysis and/or details would be beneficial for supporting the conclusions of the paper. Nevertheless, these data are a certainly a substantial contribution to the field given the extreme lack of INP observations in the Arctic and a recent surge of interest in advancing scientific understanding of aerosol cloud interactions in polar regions.

Specific Comments:

Abstract:

P1 – L20 – "radiative properties" were not included in the analysis and discussion in the paper.

P1 - L21: What is meant by "efficient" INPs? Do you mean the most efficient based on the nucleation temperature (i.e., coarse mode aerosol froze at a warmer temperature than submicron aerosol samples)? Or do you mean most efficient described by ice nucleation site density (INPs normalized by surface area) or ice nucleation efficiency (INPs normalized by total number of particles)? Or simply that the highest number concentrations of INPs were observed in the coarse mode ?

P1 - L26: Please specify that these data are representative of springtime INP number concentrations at this location (rather than year-round values for the Arctic region). Also, the INP analysis was only performed on 16 days of the 3-month period. This should also be clear.

Introduction:

P2 - L9: “Immersion freezing is the most relevant. . . “ - Please provide a reference for this.

P3 – L11 – Can you elaborate on the terrestrial sources that impacted these other coastal studies? How will this study and approach uniquely address this difficult task of elucidating local terrestrial sources (natural and pollution) from pristine marine sources?

P3 - L27 – What is mean by “natural”?

P3 – L28 – I think the introduction is very well written. The overview of the different types of INPs is good, but I think some background information on the aerosol composition and sources of the Arctic Region is also needed. In particular, what are the potential sources of aerosol (i.e., pollution, transported dust, marine organic aerosol, etc.) and what seasonal and conditions are those aerosol sources present? The authors primarily focus on biological particles, but this is not the only aerosol type in the Arctic.

Methods:

P4 - L13 – Were these collections made at ambient relative humidity? If so, please discuss how this may affect the cut size diameter of each stage.

P5 – L21 – How was the focus period selected? What is mean by “interesting aerosol events”?

P6 - L10 – How were blanks collected? Were multiple blanks collected throughout the study (i.e., at the beginning, during and end?). Only one shown in Figure 3.

Throughout – the section numbers are inconsistent with the rest of the Methods section.

Results and discussion:

P8-L10 – can you say anything about the size distributions of particles during these different atmospheric conditions? E.g., the CPCf/CPCu ratio, UHSAS size distribution, etc?

P8 – L11 – “general relatively high” – relative to what?

P8 – L20 – “resulted in relatively ‘cleaner’ conditions” – What is implied by the quotations? Should this simply state that the changes in transport and increased precipitation resulted in lower particle concentrations?

P8 – L23 – The predominate wind direction during April and May looks more easterly (mostly red). Perhaps a wind rose plot would be helpful for this discussion?

P8 – L25 – If the goal of this study is the examine the role of pollution versus natural aerosol on the INP populations at this site (I think this is correct, though it is not entirely clear), a section is needed that describes the potential influence of natural vs. pollution particles and how you differentiated the difference particle classes. This of course also requires the aerosol composition during the campaign to be summarized earlier. I suggest that the Results and Discussion section be reorganized to first talk about the aerosol composition and influences of natural and anthropogenic aerosol, followed by a discussion on the INP populations measured at the site with a specific section describing the results that support the statement that was in the abstract: “. . . demonstrate strong influences from natural sources despite the relatively high pollution levels in this Arctic environment”.

Fig 2 – Adding some indicator for days of this campaign that were analyzed with the DFCP will help the reader follow along.

Fig 3 – Are these blank-corrected spectra? If so, it might be better to show the blank in a supplemental figure. If not, the blank spectra should be shown on all four panels.

P9 – L30 – The delta T parameter is presented oddly. What is the physical meaning of this parameter? The delta T here is limited by the temperature in which the DFCP

saturates (i.e., all droplets freeze), not the “range of freezing temperatures”. Is the goal to define a parameter that describe the presence of the “hump” of INPs that are active at warmer temperatures? While the delta T parameter will be lower for spectra that have a “hump” of INPs at warmer temperatures and higher for spectra those do not, the delta T parameter could also be lower for an INP spectra with a steep slope compared to a spectra with lower slope. If the authors want to describe the presence of significant differences in the number of INPs active at warmer temperatures, a better variable to use may be the temperature in which 50% of the wells were frozen. Or, perhaps the authors can clarify the meaning of this parameter.

Fig 4. Are there uncertainty bars for the INP number concentrations?

P10 – L7 – Please provide trajectory heights in Fig 6, as you refer to the trajectory height in the text and this is one of the main pieces of evidence provided for a connection between the sea ice leads and the observed aerosol.

P10 – L9 – Are these observations of leads and polynyas from satellite, an aircraft, or published? Since the importance of the observed leads are a critical point to your conclusions, these should be provided in some capacity?

P10 – L12 – Can you provide more information about the gravitational settling? I think particles in the largest stage could survive such a transit, but this could be calculated.

P10 – L19 – on May 29, it looks like there is a portion of the back trajectory (72-73 N and 137-133 W) with lower sea ice percentage compared to any portion of the May 22 source region. How are these two regions distinct? What is considered a significant amount of time to spend over an open lead?

P9-L20 – What is the hypothesized mechanism/source of INPs from open Arctic leads? Is organic marine aerosol the suspect? Are there previous studies to suggest that unique aerosol types may be emitted from Arctic leads? How does wind speed play a role? Were Chl a concentrations available for this region?

Summary:

P12 – L9 – “These higher concentrations are attributed to air masses originating from over sea ice leads and tundra surfaces” – Can the authors elaborate on what these particles are exactly? Or provide a hypothesis of what these may be? The single particle and bulk composition measurements suggests significant influence from mineral dusts, but what would be the mechanism for these particles entering the atmosphere via sea ice leads? Particularly for those that were measured in air masses originating from these open Arctic leads?

Can the authors elaborate on future needs for understanding more about these significant increases in INPs? How can the scientific understanding of Arctic INP population variability advance? More measurements? Different measurements?

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