

***Interactive comment on* “The effect of aerosol on surface cloud radiative forcing in the Arctic” by R.-M. Hu et al.**

Anonymous Referee #1

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The submission presented comparisons between a regional Arctic model (NARCM) and several observational datasets from northern Alaska and the Beaufort Sea, including SHEBA and ARM time series. While the goal of the paper was to quantify the aerosol radiative contribution to the surface energy budget through indirect effects on clouds, the results were inconclusive and unclear. Several times the authors mention the difficulty of performing the task they have set out to do, leading the reader to wonder whether and how much the study is resolving aerosol uncertainties and radiative errors in models. The text would benefit greatly from grammatical editing, more thorough explanations of figures, methodology, and results, and attention to the fluidity of thought in the document.

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Beginning with the abstract, surface cloud radiative forcing values are cited without explicitly stating their spatial or temporal averaging interval. This confusion follows through the paper and would be alleviated somewhat by including a reference map which details the ARCMIP domain, the study area, and the observational sites used for comparison, including the SHEBA ship track. This is also applicable to Figures 5-12, which compare results from a NOAA tower and the model. Whether the nearest model point was used in each of these situations or a domain average is unclear and would be influential on the interpretation of results.

Brief asides are made in the introduction to the effect of stratocumulus clouds but not to stratus, which are also observed with high frequency in the Arctic. A reference to cirrus clouds in the following sentence would be more substantial if some description of their influence on outgoing longwave radiation was discussed. A basic overview of indirect and semi-direct aerosol effects would also provide a better foundation for the rest of the article, including any previous Arctic-related studies of these phenomena.

The methodology is a point of contention, especially since the authors have used the word "surface" to characterize their forcing calculation. If they are to use this word in the title as well as throughout the text, it would be best to clarify it as "net" surface forcing, which involves surface responses to incident radiation. Since the authors acknowledge that the calculation of aerosol contribution to cloud radiative forcing is complex, it is puzzling that they should use "net" forcing and not true "surface" forcing. It would be a sensible first step to determine a) the direct effect of aerosols on the surface and b) the radiative influence of the aerosols on the clouds as the clouds directly influence the radiation incident at the surface. This would provide some measure of the energy available at the surface for melt, warming, etc, which is one of the stated goals in the abstract. By tying up the large and variable albedo response to changing radiation, the signal of the aerosol is swamped. Radiative transfer studies with the Streamer model indicate that albedo effects are an order of magnitude greater than the largest combined aerosol radiative effect and four times the largest cloud forcing effect. Indirect

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effects of aerosols will likely contribute to forcing at a level somewhere in between these two: an amount small but significant enough to change the sign of SCRF and alter the melt-freeze timing in the Arctic.

A few other matters raised questions in the methodology. The use of a look up table rather than predictive liquid cloud microphysics was curious, as was the doubling of the near-IR surface albedo compared to the visible.

Commentary on the results and conclusions follows from remarks made above. It was difficult to follow in the figures whether the comparisons between the Atmospheric Surface Flux Group tower and the NARCM output were point-to-point (using the closest model grid point) or domain average-to-point. This also holds for Figure 10, the comparison between cloudiness at SHEBA, which was derived from a single-beam measurement that was averaged over an hour to give hemispheric cloudiness, and that of the NARCM model. How can the different spatial scales between the two measures of cloudiness be resolved?

More discussion of the figures is warranted, especially some explanation of the patterns in aerosol optical depth and radiative forcing presented in Figures 2-4. A secondary axis in Figures 5-12 that clarified which calendar months were associated with the Julian day would aid in interpretation of seasonal changes in surface and radiative variables. Also, some remark about the sudden albedo-driven drop in shortwave surface cloud forcing in Figure 11 should be included in the results.

While the topic is an intriguing one and certainly full of area for exploration, this paper does not present a clear methodology or strong discussion of its findings. As is, this document requires major revisions before it can be published.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 9039, 2005.

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