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

Anonymous Referee #2

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The authors sought to determine the sign and magnitude of Aerosol Radiative Forcing (ARF) at the surface over the Arctic ice pack. They attempted to do so by employing a well-documented Canadian aerosol model called NARCM and comparing results with observations made at SHEBA in 1998. While the study is relevant to ACP, timely and a difficult problem, the methodology needs to be carefully re-examined, perhaps modified to get a better answer or at least to quantify possible errors in the estimate. In addition, the article needs a thorough edit for grammar and factuality as well as more careful explanation of the methodology and results.

Dubious statements and outdated references detract from the credibility of the study.

For example, in the abstract, the statement that “Arctic warming caused by greenhouse gases (as suggested by GCMs) has not been verified” is not true. A number of studies over the past few years have shown significant rises in the mean temperature of the Arctic and many papers discuss a number of changes in the cryosphere (thinning/disappearing sea ice, thawing permfrost, melting glaciers, droughts and fires) that are consistent with a warming climate.

More care needs to be taken in explaining the numbers and figures. For example, in the abstract the authors state that “By intercomparison with ARM data we find the SCRF to is -22 W m-2 for shortwave and 36 Wm-2 for longwave. This is a very vague and inaccurate statement. Firstly, the data they were using was collected at the SHEBA camp, not the Barrow ARM site. Second, the data were not ARM data at all, but rather data from the NOAA/ETL Atmospheric Surface Flux Group (ASFG) tower - a reference needs to be given for these data (e.g., Persson et al., 2002). Third, the authors are really just stating what they found in their model, results independent of the SHEBA data. Also, these numbers are annual averages calculated for a moving ice floe in the western arctic and are not likely to be representative of the entire Arctic- especially considering how important the surface albedo is in the calculation.

The final statement in the abstract is also confusing. Do the authors mean that the numbers they give for CRF (-22 and 36 W m-2) are calculated without including the impact of aerosols in the calculations? Does -6 Wm-2 for the ARF include both direct and indirect effects of aerosols on surface radiation?

These types of inconsistencies, factual errors and confusing statements pervade the text. Also, the concluding figure is very important and yet is described in one sentence. The results are also a bit puzzling (see comment below). Based on these issues, I feel that this paper is in need of major revisions before it is published.

Other Comments:

Section 1

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1) The statement that the “Basic theory of atmospheric radiation had been doubted.” - is an absurd overstatement.

2) Why do clouds in the Arctic exert a stronger influence on the SEB than they do at lower latitudes?

3) References for GCM simulations of global warming and Kahl’s 1994 results are outdated.

4) The work of Intrieri et al. (2004), Shupe and Intrieri (2004) on Arctic CRF need to be referenced.

Section 2.1

1) Please explain what you mean by direct and indirect effects. What do you mean by CRF with aerosols and CRF without aerosols. Presumeably, aerosols are needed to nucleate the cloud particles in both cases. Is it simply that the radiative properties of the aerosols themselves are turned off?

Section 2.2

2) How do you compute the CF without aerosols with the model?

3) Some plots depicting the horizontal distribution of aerosol types and concentrations would be very useful, especially since the results hinge on their properties over the SHEBA site. Perhaps monthly mean lat/lon plots for spring and fall.

4) As far as I can tell the Lohmann and Roeckner (1996) scheme is a one-moment scheme with 2 prognostic cloud variables (cloud ice and cloud liquid drops). Aerosols are a specified function of model-derived sulphate concentrations and, for ice nuclei, temperature as well. How did you add other aerosols species with varying droplet and ice nucleating characteristics?

5) More detail needs to be given on how were the other aerosol types accounted for including their assumed physical and radiative properties - since this was never published

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before. Also, how is water uptake treated in the model both physically and radiatively - this is an important component of the ARF. The Ghan et al (2001) reference is not in the reference list.

6) Not sure why the authors set the near-ir surface albedo equal to twice the visible albedo. Hopefully this was just a typo and they meant the near-ir albedo was set to half the visible which is more commonly done in simple albedo parameterizations. In any event, this is clearly a shortcoming of the model and the CRF calculations. It may be better to redo the runs using surface albedo specified from observations (see next comment).

7) Since the authors are only looking at a single gridpoint following the SHEBA ship, why not recalculated the CRF and ARF using the modeled atmospheric profiles and the observed surface albedos. This would give a better estimate of the CRF and ARF locally at SHEBA. At the same time, since they are using a regional model. I think the ARF and CRF should be made for the entire domain, this would be a more representative number, particularly if error could be estimated based on uncertainty of the surface albedo parameterization.

Section 3

1) I assume the authors mean experiments were conducted with/ and without the direct effect of aerosols included.

2) Figure one needs to be explained more carefully in text and caption.

3) Figs 3 and 4: Are these annual means, net values, just solar?

4) Fig 10: How was cloud fraction measured by the ASFG? Are these numbers from the cloud radar/lidar dataset?

5) These CRFs should be compared with Intrieri et al.'s (2004) estimates. How did you calculate CRF from the ASFG data?

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6) Might me worth while discussing why the aerosol forcing only manifests itself during two 40 day periods in mid-winter and late spring prior to onset of melt. This seems rather strange.

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