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Reply to Legates et al.: Negligible role of arctic cloud albedo changes in observed darkening

In a recent paper (1), we assessed the magnitude of the increase in net solar radiation in the Arctic region during recent decades as a result of the change in albedo associated with sea ice retreat. Legates et al. (2) have commented on this. We appreciate their interest in our work.

Legates et al. (2) raise two issues. First, they point out that “[t]otal solar energy input is a better metric to evaluate climate forcing” than albedo changes. We agree with this statement, and indeed our analyses and forcing estimate are based on changes in top-of-the-atmosphere total solar energy input, as was described in the *Methods* section. We also included estimates of the change in albedo, which are directly calculated from the time-space averaged incoming and reflected solar radiation at the top of the atmosphere. In other words, the procedure that Legates et al. say would be “better” is actually the one we used.

Second, Legates et al. (2) take issue with our finding that the change in albedo is “a substantial climate forcing that is not offset by

cloud albedo feedbacks” (1), which they interpret to be a claim that we are applying “at the global scale.” They respond by discussing the possible importance of tropical cloud feedbacks. Although the role of the tropics is an interesting question, the analysis in our paper focuses solely on the Arctic region, as was clearly indicated: the possibility of compensating cloud feedbacks is discussed in the penultimate paragraph of the paper, and both that paragraph and the final sentence of the abstract make clear that the paper discusses the role of cloud changes within the Arctic region only. Based on their comment, it seems possible that Legates et al. (2) have misinterpreted our use of the term “planetary albedo” to mean “global-mean albedo.” The standard definition of “planetary albedo” is the top-of-the-atmosphere albedo (as contrasted with surface albedo) at a given location (as contrasted with globally averaged values) (e.g., http://glossary.ametsoc.org/wiki/Planetary_albedo), which is the definition we specified in the third sentence of the paper and adopted; however, some have occasionally used this

term instead to refer to the global-mean albedo, as Legates et al. (2) appear to be doing.

In summary, the points raised by Legates et al. (2) do not appear to be relevant to our paper (1).

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1 Pistone K, Eisenman I, Ramanathan V (2014) Observational determination of albedo decrease caused by vanishing Arctic sea ice. *Proc Natl Acad Sci USA* 111(9):3322–3326.

2 Legates DR, Eschenbach W, Soon W (2014) Arctic albedo changes are small compared with changes in cloud cover in the tropics. *Proc Natl Acad Sci USA* 111:E2157–E2158.

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The authors declare no conflict of interest.

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