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Comment

## ***Interactive comment on “Seasonal cycle of solar energy fluxes through Arctic sea ice” by S. Arndt and M. Nicolaus***

### **Anonymous Referee #1**

Received and published: 1 July 2014

This manuscript describes a significant data synthesis effort for estimating the total amount of sunlight propagated through the Arctic ice cover between 1979 and 2011. No new observations are presented. Sensitivity studies address the effects of uncertainties in key parameters in the observational records. The study was done with care and attention to detail, so the results are useful and of interest to the community.

The study has limitations, of course, and some of these limitations are discussed, but others are not really addressed. I wish there had been some discussion of the fact that ice thickness was not included as an independent variable, of course thickness was not explicitly considered because reliable records (with adequate spatial and temporal resolution) do not exist. This seems to be a significant gap in this work. The manuscript is publishable, except I would like to see some acknowledgement and discussion of the

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role of an ice thickness distribution for the Arctic and some estimate of the uncertainty created by not having this distribution. I have chosen "reconsideration after major revisions" for this reason.

My only other general comment is that there are numerous occasions where the English is awkward, to the point of leading to considerable confusion, in this manuscript. I did not attempt to flag each instance. It would be helpful to have someone read it strictly for the purpose of improving the written English.

Minor comments: Abstract line 2: "ice is thinner". So why not consider ice thickness? Clearly there is no comprehensive record, but there is very little discussion on the role of ice thickness on the total heat calculations.

Abstract line 5: "But until now, it is not possible to quantify..." It is not clear here what has changed. Why "until now"? It would probably be better to just say "In this study, we quantify..."

Line 8: Please qualify the "annual maximum ... flux of ...occurs in June, then also matching the under ice ... flux" This sentence is very confusing. Is that a daily maximum? Do the authors mean "annual maximum" or "maximum annual"? What is matching the under ice flux? Very confusing.

Line 12 -13: increase in light transmission? Thru all ice types? This needs to be more specific.

Line 18 – 20: Is this claim substantiated or speculative? I see nothing in this study that conclusively leads to this statement!

p.2926, line 1: "multi-year radiation transfer" – what does this mean?

2926, 10-11: "Finally, it was possible to derive trends for the years from 1979 to 2011 for radiation transfer through Arctic sea ice." How is this statement credible if meltpond records only go back to 2000? Is it because the changing date of melt onset is significant enough to make the trend significant? This should be explained more clearly.

Eqn 2:  $\tau_b$  should be function of (time,  $x$ ,  $y$ )? 2929,12-13: “After EMO, melting FYI and melting MYI are introduced for sea ice not surviving summer melt.” What is meant by “not surviving”? I don’t understand this statement.

2929, 16-17: “FYI surviving the summer melt turns into new MYI after week 36 of the year, and furthermore into MYI at the end of the year.” This is not clear.

2930, 1: Surface Heat Budget. . .

2930, 22-25: “However, at MO, the surface albedo of FYI is only about half that of MYI (Perovich and Polashenski, 2012). Since Nicolaus et al. (2010a) calculated a transmittance of 0.02 for MYI for the day of MO, the transmittance of FYI is assumed as 0.04 following the albedo evolution.” I don’t follow either of these sentences. Please rewrite for clarity.

2930, 27-29: “After EMO, it is considered that the annual sea ice retreat in summer strongly impacts the light transmittance. Thus, melting FYI and melting MYI is separated in the parameterization of  $\tau_i$ .” Not at all clear. Please rewrite.

2931, 1-4: Since melting has an approximately inverse effect on transmittance compared to albedo, we use a transmittance of 0.4 for the last existing sea ice ( $< 10$  cm) and fit an exponential increase between EMO and the last day of melting for the according pixel.” Confusing and needs to be rewritten.

2931, 6-8: “After MO, snow is assumed to melt completely within 14 days (Nicolaus et al., 2006) and pond cover fraction increases rapidly until the maximum pond cover is reached at the end of this phase.” Is this from Rosel data? Or an assumption?

2931, 12: continues until ice extent minimum? Really? No, I think freeze up starts at high latitude prior to extent minimum.

2932: 20 – 21: What scaling factor?

2933. 12: “for ice covered areas only” Does this mean the calculations are normalized

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to ice area (i.e., per  $\text{km}^2$ )? Or is it just total accumulated heat for only all ice covered area?

2933, 23-24: “From May to June, the most pronounced increase was found for QT (x,y) (to  $9.3 \times 10^5 \text{ Jm}^{-2}$ ) and the transmittance (0.054)..” I don’t think this is intended to mean what it says.

2933, 25-26: June was the month of the highest QT ( $20.9 \times 10^{19} \text{ J}$ ) associated with the highest solar surface irradiance over the entire Arctic Ocean ( $851 \times 10^{19} \text{ J}$ ). Not sure I believe this. The ponds in June aren’t really that transparent yet, so I think  $\tau_p$  isn’t the same all summer.

2934, 4-6: In July, QT (x,y) reached its maximum 5 of  $9.8 \times 10^5 \text{ Jm}^{-2}$  resulting from a maximum mean transmittance of 0.089. The maximum QT (x,y) reached still about  $28 \times 10^5 \text{ Jm}^{-2}$  with a QT of  $18.4 \times 10^{19} \text{ J}$ . Please rewrite for clarity.

2934, 6-8: “The different impact of MYI and FYI, becomes most obvious in July. Also continuation of sea ice melt along the ice edge becomes more important for the under-ice heat fluxes.” Neither of these sentences make sense to me. Please rewrite.

Curves in fig. 6 are too faint.

2938, 15 -16: albedo increase? Or decrease?

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Interactive comment on The Cryosphere Discuss., 8, 2923, 2014.

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