

## ***Interactive comment on “Analysis of local AWS and NCEP/NCAR reanalysis data at Lake El’gygytgyn, and its implications for maintaining multi-year lake-ice covers” by M. Nolan***

**Anonymous Referee #2**

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General comments:

This article uses AWS and reanalysis climate data along with models to estimate what temperatures are required for Lake E. to maintain a multi-year ice cover. The AWS and NNR data are sufficient for this purpose but the model(s) require ice thickness to work properly and this is apparently lacking. The models were calibrated with one year’s data but their performance has not been evaluated. As such the use of these models to examine the ice cover in the past is ambitious. Having said that, the rationale behind this paper is interesting and the author seems to be aware of some of the shortcomings of the research.

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Specific comments:

The paper is organized in a way that doesn’t conform to the classical format of a scientific paper. I think that reorganizing it with a defined Methods, Results, Discussion and Conclusion section would improve it substantially. At present, the paper reads as one long Discussion. This discussion meanders somewhat and lacks the rigor of a more formal scientific paper (ie, what are the objectives and rationale, what methods/approach will be used to meet these objectives, what data were produced from these methods, how can they be interpreted).

Site description: As a standalone article, it would be valuable to include some rudimentary site description on Lake E. - size, depth, shape, etc as well as a map of the lake.

AWS: AWS data were included to compare with NNR data. The purpose here is to show that the NNR data capture the climate of the lake adequately to drive the models. The correlation between these two data sets is not a very good measure of this. The fact that the air temperature from one method is not statistically independent from the air temperature from another method violates a key assumption of correlation analysis (no wonder  $r$  is very high – you are confirming that the seasonal cycle of both temperature series are similar). A better measure here would be the RMSE value to show the difference between NNR and AWS. What RMSE error level would be tolerable for your purpose? Can/should the relationship between the NNR and AWS be used to estimate Lake E local temperature (ie., is the slope 0 and the offset/intercept a constant value)? Finally, why not examine the PDD/NDD differences between the data sets in addition to or instead of the air temperature? It is hoped that an ‘apple to apple’ comparison was made between AWS (2002-2008) and NNR (2002-2008) not to NNR (1961-2009). When using NNR to show ‘modern day’ conditions, why stop at 1961 when the data set goes back even further?

Considerable text is devoted to the description of data availability for the AWS. While

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we can all appreciate the issues with gathering the data (and some of the unusual circumstances you reveal), the reason for data interruptions are not relevant to the analysis at hand. Also, letting the reader know to take care when interpreting the data and that sensors were flaky, does not instill confidence - either it is good enough or not. Focus only on the data that you need for the analysis (why describe the whole station – net radiometers etc...?) A table showing the instrument, make/model, installation height and periods of operation might accomplish this efficiently.

No information is given on how ice thickness was measured and in what years. This is critical for the calibration and validation of the ice thickness model (equation 1). As well, more information should be given regarding the remote sensing evidence (onset of ice on and off). This should include how ice on/off is determined and how often the imagery was acquired.

A more rigorous approach is warranted for the model development. Both the ice growth and melt models are calibrated against 1999-2000. This appears arbitrary to me without any knowledge of the ice thickness data. There is no independent validation of the model and an attempt to do so would lend some credence to the model hindcasts and estimation of MAAT required for multiyear ice cover. Perhaps remote sensing data of ice on/off can help? Tuning of the model is critical (by your own admission). The application of these models that are calibrated with one data point and not tested is highly suspect.

To evaluate the model performance, it might be advisable to compare the critical MAAT temperature for multiyear ice formation to the MAAT at lakes with perennial or residual ice covers. The dry valley lakes is one possible comparison, but the (non-alpine) lakes closest to Lake E with perennial and residual ice are on Axel Heigberg and Ellesmere Island as well as Greenland. The MAAT in these locations is on the order of -18C. The model here implies multiyear ice at -14C.

One of the messages of the paper seems to be that only the summer melt matters and

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that the growth of ice is not a determinant of multiyear ice cover. I don't dispute the importance of summer melt, but I am unconvinced that ice growth is not important. Part of this conclusion might arise from the models chosen to examine ice growth and melt. The growth model is proportional to the square root of NDD whereas the melt model is proportional to PDD. It is therefore an algebraic certainty that PDD is more important than NDD. These models are not formally tested in this paper. Also, given the recent change in winter temperatures and their variability, it seems that winter temperatures may play a larger role than is implied here.

Technical corrections: pg-In 1444-1 Using the first person plural makes no grammatical sense 1444-24 DD – pick terms/acronyms and stick with them DD (in general) and PDD/NDD 1445-20 – change to understanding of interannual variations in ice 1445-21 – the record is 3.6M years long, the core has a length in meters. 1446-11 - NNR or reanalysis (pick one way to refer to this data set and use it throughout) 1446-20 – when you say sampled, do you mean sampled and reported? When you say logged hourly – is this an average of samples taken within the hour? 1447-6 – what levels were the thermistors at? 1447-9 – did you have glycol in the tipping bucket to melt snow? 1449-10 – I can see that undercatch would result in lower values, how can you get higher values? 1451-13 – 2-meter temperature. What product is this exactly (1000 mb or sigma .995?) 1451-13 – where is this grid point? How far away? 1451-14 – compared well with... conclusion before evidence is given. (see remark about the organization of the manuscript). 1451-18 – please cite the figures in order 1451-20 – Figure 2 – why do you compare 1960-2009 NNR average with 2000-2008 AWS? Please keep to the same time period when comparing. Especially considering the trend over time! 1452- 3 the trends – replace with the seasonal cycle... 1452-5 – if you observed diurnal swings in temperature, then report this (there is no suggestion). 1453-8 – when reporting differences, make sure it is explicit which data set has the higher or lower values 1454-24 – replace actual with estimated or modeled 1454-26 – there is no fig2b 1455-2 – change in summer or annual PDD? 1455-2 – why is there no corresponding trend? This is odd! If the time >0C is longer and PDD is not increasing

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then the temperatures must be lower (summer cooling). 1455-15-25 – important to mention snow as an insulator here, also the potential for snow ice (white ice) if the weight of the snow is enough to cause slushings (maybe not?) Any liquid precipitation represents latent heat input and this is important as well. 1455-26 – lake drying? Ok, need info.... How deep is it? What is the bathymetry? 1456-7 – and creating a need for... awkward 1456-23 – the units for degree days are exactly that – oCd not simply degrees 1457-12 – snowpack dynamics constant? This assumption is not met in the record you have, let alone over the past 3.6M years. 1457-16 – 1999-2000 why this year? Ice thickness methods? 1457-17 – the lag is an interesting idea. Is this part of the model? If not, can you modify eq. 1 to include this? 1457-19 – remote sensing method – is this robust to very thin ice that can easily be confused with open water? 1458-4-9 – why can't you calculate the NDD properly? It may be a small error in the grand scheme but it seems to be a fairly straightforward calculation. 1458-13 – could your parameter be higher than others because of the inclusion of a lag? 1458-17- growth is not as important as melt – can you supply a reference? 1459-14- what you are describing is the difference between thermal and mechanical break-up. 1459-12 – your thermistor string measures soil temperatures, how do you know the water temps? 1459-29- winter ice melt?? 1460-22-23 – you stated this backwards 1461-4 – shifted the ... +5 to -9... this is awkward and confusing. 1461-5 – seems typo 1461-7/8 – summer drives melt – this is trivial. 1461-10 - -3.5C is what we believe is the minimum MAAT... - No! This is the offset to the current MAAT... 1461-12 – picked 20 cm – this is indeed arbitrary since it is doubtful that an ice cover that thin would survive mechanical breakup. An average thickness of 80 cm to 1 m might be more reasonable. (note that much of the ice structure would be melted internally) 1461-16-18 – what about NDD? 1462-19 to 1463-23 – I find the lake drying discussion tangential to the task at hand. This could be eliminated to focus the manuscript. What is the lake depth, bathymetry? 1463-26 ...let alone continental glaciations!! 1465-7-9 – fine for terrestrial processes, but aquatic processes can continue in the water and ice cover despite below freezing air temps. 1465-10 completely eliminate summer – you mean melt-season. 1466-5 –

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have you considered sediment flows into the moat and then under the ice via interflow? Section 6 (relevance to paleo...) could be tightened up and focused.

Table 1 – NCEP – change to NNR Fig 3 – not cited -eliminate Fig 5 Why 2 NDD lines? Fig 6 – this is not critical Fig 7 – this is not discussed, nor is it relevant to the temperature/DD Fig 8 – Explain horizontal lines in caption Fig 10 – label melt potential on y-axis, Why is the melt potential for -9C offset not near or at zero? Why is the difference between current melt potential now and +5C not much greater than depicted here? Explain in the caption what you did for sensitivity MAAT+5 and MAAT-9... Fig 11 – can you put an NDD axis?

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Interactive comment on Clim. Past Discuss., 8, 1443, 2012.

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