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The Cryosphere Discussions

Interactive comment on "Numerical modeling of permafrost dynamics in Alaska using a high spatial resolution dataset" *by* E. E. Jafarov et al.

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Dear reviewer, Thank you for your review of the manuscript. We understand that good reviewing is a time consuming process, so we appreciate the effort you put into completing this review. We found your comments particularly helpful and modify our manuscript according to them.

1. It is unclear how the 18 geothermal zones (pg 97, Fig 1) were obtained. Do these 18 geothermal zones represent the same initial conditions (soil texture, ice content, initial moisture content, temperature profiles, etc.)? Elaboration of this paragraph and determination of the initial conditions is needed. While not necessary, a table describing the initial conditions and source of information would be valuable.

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Interactive Discussion

Discussion Paper

We completely agree with this comment. The text was revised accordingly. The revised text is located at the Methods section of the manuscript and also shown below:

We analyzed the ground temperature profiles (boreholes ground temperature distribution is available online at Geophysical Institute Permafrost Laboratory and CADIS websites [www.permafrostwatch.org, www.aoncadis.org]) in more than 25 relatively deep boreholes from 29 m to 89 m in depth (Osterkamp & Romanovsky 1999, Osterkamp 2003) along the Trans-Alaskan transect. This analysis revealed a ground temperature zonality in Alaska with generally lower permafrost temperatures in the north and higher ground temperatures in the south. Based on this zonality we extrapolated available initial ground temperature profiles to the wider areas and classified them into 18 ground temperature zones. The 18 ground temperature zones represent the 18 classes of temperature distribution with depth, which were used as initial conditions for simulation. The thermo-physical properties (volumetric soil ice/water content, unfrozen water curve parameters, soil heat capacity and thermal conductivity, thickness of soil layers, etc.) for 18 ground temperature zones may be different and depend on many factors including surficial geology. The number of soil type classes we used in these simulations was 26 and each class had its own number of soil and bedrock layers with different thermal properties (e.g. peat, silt, bedrock, gravel etc). The multilayered soil columns assigned for each of soil class according to the Modified Surficial Geology Map of Alaska (Karlstrom et al., 1964). The thermo-physical properties were assigned to each ground mineral layer according to surficial geological (soil type) class. The model was calibrated against the ground temperature measurements from the shallow boreholes, which were specific for each soil class and geographical location (the method used and its limitations were described in more detail by Nicolsky et al. 2007). Organic layer in the model was introduced as a separate layer(s) which could be added at the top of mineral soil column. For upper organic soil layers we used the data obtained from the numerous field observations and Ecosystem Map of Alaska from the National Atlas of the United States of America (http://www.nationalatlas.gov). To further optimize the number and the thermal properties of the organic layers we developed an algorithm

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described in the Optimization of ground thermal parameters section.

2. Similarly, in the 'Model sensitivity analysis' section, the algorithm description of organic layer mask (pg 102, 2nd and 3rd paragraphs) is hard to difficult for me to follow. Further clarification and expansion of this section is needed.

Thank You for the comment. We renamed the Sensitivity Analysis section into "Optimization of ground thermal parameters" section and made corresponding changes in the structure of that section in order to make it more clear.

3. Finally, the final manuscript should be edited by a native English speaker for grammar and punctuation. There too many errors (predominately minor) to list out individually.

We agree with this comment. This time we gave the revised manuscript to a larger number of internal reviewers. All the sections were reviewed by native English speakers, necessary corrections were made.

P90, L14. Remove "preliminary" done

P92, L16/19, enthalpy (not Enthalpy) done

P93, L17, substitute "employ" for 'use so called' done

P94, L2, 'has a higher computational cost. The transient model simulations result in a more . . ..' Thank You. Changes are made

P94, L6, reference for the Stefan problem? We included the following reference: Alexiades, Vasilios (1993), Mathematical Modeling of Melting and Freezing Processes, Hemisphere Publishing Corporation, ISBN1560321253

P94, L6+, First 2 sentences are awkward. We rephrased first sentence and removed the second one The GIPL2-MPI numerical model solves the Stefan problem (Vasilios and Solomon, 1993), which is the problem of thawing or freezing via conduction of heat.

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P96, L1. What specific SNAP data are you using? The following changes were made in the Method section of the manuscript: The dataset is a composite of five GCMs,which according to SNAP performs the best for Alaska (Walsh et al., 2008). It includes monthly averaged temperatures and precipitation data for the years 1980-2099 using A1B carbon emission scenario. The output from the selected five models were downscaled to 2 by 2 km resolution by SNAP using the knowledge-based system PRISM .

P96, L4. Is there a reference for 'performed best for Alaska" We added the following reference to the text and to the list of references: Walsh, J. E., Chapman, W. L., Romanovsky, V., Christensen,J. H., and Stendel, M.: Global Climate Model Performance over Alaska and Greenland, J. Climate, 21, 6156–6174, doi:http://dx.doi.org/10.1175/2008JCLI2163.1, 2008.

P96, L20. "dataset:" changed

P96, L22. "1997):" changed

P97, L27, "...and becomes more coarse toward..." changed

P98, L10, specifically reference Figure 2 in this sentence done

P98, L14, specifically reference Figure 3 in this sentence done

P98, L15, specifically reference Figure 4 in this sentence done

P99, L15, substitute "greater" for "higher" done

P100, L1, reference Figure 6 done

P100, L19, change "form" to "from" done

P100, last sentence, awkward sentence, reword This sentence was reworded: During model validation the values of soil properties for several observation stations have been adjusted by assigning additional organic layers

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P101, 1st paragraph, what is the significance of the MBE? The MAE and RMSE are The sign of the MBE shows that model underestimates or overestimates the measured data The last sentence in the Model Calibration and Validation section now says: The MAE shows an overall error for all compared stations, when the RMSE emphasizes an error variation within the individual stations and the MBE shows that the model underestimates or overestimates the observed data. The MBE in Table 1 shows that our simulations were mainly underestimated.

P101, L7, change “run” to “simulation” done

P101, L9, “stay close to ___oC”... what is the ___? This section was significantly reworked and your suggestions were taken into account

P102, L17, “organic layers for corresponding grid points” The text was modified in accordance with your suggestion

P103, L27, discontinuous changed

P104, L6, MAAT is already defined and used in the paper changed

P105/106, last sentence, long and awkward sentence This last paragraph was edited and shortened

P106, L8, change “far enough” to “sufficient” changed

Figures 2,3,4, Capitalize left legend. Bottom axis should be Year (monthly is defined in the titles) done

Figures 5, 6, 7, Capitalize left and bottom axis legends. Include some sort of statistical analysis. Expand the figure description We capitalized the axis and the legends. All the statistical analysis included in the Table 1. Usually in the modeling papers the errors estimates are the most important. The rest of the statistics would not be useful in this context since the simulated ground temperatures depend on the composite GCM inputs and the ground thermo-physical properties set up.

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Figure 9, A figure showing the differences between the top and bottom panels would be very useful. Label the panels (a) and (b) as they are referenced in the description We introduced the difference map between MAGTs simulated with and without additional organic layer at 1m depth.in Fig 10

Figure 10, What area are you referring to? The whole state of Alaska? The following changes were made to the Figure 10 caption: The amount of area over entire State of Alaska occupied by colder and warmer than 0C MAGTs averaged over ten years time interval from 1980 to 2099 at different ground depths

Figure 11, A figure showing the difference in temperature between 2000 and 2099 would be useful. Label all panels (a), (b), and (c) Panels were labeled for some reason in the discussion version of the paper they did not come out. Our aim with this figures were to show the overall impact, however, we agree the difference map could be useful too.

Figure 12, Spell out your figure legend (Barrow, Happy Valley, etc), not BR, HV. Add trend lines and list the slope (the change over time). Capitalize the axis Axis capitalized, legend is changed. Thank You.

Interactive comment on The Cryosphere Discuss., 6, 89, 2012.