Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2019-157-SC2, 2019


Geoscientific Model Development Discussions

# *Interactive comment on* "GlobSim (v1.0): Deriving meteorological time series for point locations from multiple global reanalyses" *by* Bin Cao et al.

**Bin Cao**

bincao@cunet.carleton.ca

Received and published: 28 August 2019



**Anonymous Referee #1**
Received and published: 3 August 2019

**Response to Anonymous Referee #1**

The authors would like to thank the reviewer for the constructive feedback, and the thorough assessment of the manuscript. Below we provide a point-to-point response to each comment, reviewer comments are given in black, responses are given in blue. Additionally, we have included details of how we intend to address these changes in a revised submission.

## General Comments

This paper proposed by Cao et al. presents a new tool, GlobSim, to derive meteorological variables from multiple reanalyses (ERA-Interim, ERA5, JRA-55, MERRA-2) for ensemble simulation. The motivation and novelty of the paper–as stated by the authors–lie in the technical challenges which limit the ease of reanalysis data can be applied to models at site scale. As far as I know, a tool like GlobSim does not exist so far. The authors show the suitability of GlobSim via applying it in a large number (156 sites) of soil temperature simulation in permafrost-affected regions. I am very impressed by the strength of GlobSim, combined with GEOtop, in capturing fine-scale temperature variability due to local scales, such as snow and vegetation cover, soil moisture, and a peat layer. In general, the paper and tool are well written and described, this is an interesting study. Although it lacks additional scaling methods and is limited to site scale, GlobSim would be a useful tool in modeling a number of land surface processes. I have two concerns.

**(1) Long-term simulation**

The authors showed the changes of permafrost temperature at different depths

(0.1, 10, and 20 m) since 1980. However, only the upmost 12 m soil profile is shown in Figure 7. How did the author conduct a simulation at the depth of 20 m. Please clarify. I can understand this is provided as a demonstration of the utility of GlobSim for supporting long-term simulation. However, permafrost temperature change at a long-term scale is normally complex. This is because it is driven by both climate conditions (air temperature, precipitation as already considered by the authors) and related factors, such as such as soil moisture and vegetation. Unfortunately, the authors have not mentioned these at all. Given the description in Table 3, I assume the simulations present here is heavily simplified by ignoring such important processes. Please clarify. I suggest the authors, at least, discuss the potential influences on the temperature influences.
Response: The long-term simulation is conducted based on 60 soil layers with a total depth of 50 m. We will add detailed introduction (see below) of long-term simulation in section 4.5. Additionally, we will add *"In the long-term simulation, the layer of bedrock is extended to 50 m."* in the caption of Figure 7 to clarify. Regard to the potential influences of soil moisture and vegetation, we will discuss the uncertainties.

*"Reanalysis produces multi-decadal meteorological variables (Table 1), and this makes simulating long-term changes of land-surface processes possible. To demonstrate the utility of GlobSim for supporting long-term simulation, we conducted an additional deep ground temperature simulation from 1980 to 2017 for a single terrain type. The soil profile increased to 60 layers with a total depth of 50 m via expending the bedrock layer. The model was spun up by repeating the reanalysis of 01/1980–12/1984 100 times (500 years). To improve simulation efficiency, we simplified GEOtop simulation by assuming the vegetation and soil moisture is constant over time. This is warranted as we aim to simply demonstrate the potential for long-term application."*



**(2) Spatial interpolation**

A number of meteorological variables from three fields are derived and processed (interpolation and scaling) in GlobSim. As authors mentioned, the pressure level is also interpolated or derived via 3D interpolation. However, some of the variables, such as air temperature, wind speed and direction, are available for both the surface analysis and pressure level analysis. In this context, what's the field (surface analysis or pressure level analysis) used here in permafrost simulation? More general, what is the selection strategy for such variables? This is important because different treating ways, 2D interpolation for surface analysis and 3D interpolation for pressure level analysis, would lead to different values for the same variable. This has been demonstrated by authors' another paper (Cao et al, 2017).
Response: Yes, both 2D (for single level) and 3D (for multiple levels or pressure level) are available in GlobSim. Given the relatively flat topography of the study area, here, we used only the single-level surface analysis or 2D interpolation. However, for mountains, 3D interpolation is preferred in order to capture the strong spatial variability of lapse rate caused by topography. This combined with suitable scaling methods (e.g., Fiddes J. and Gruber, S., 2014; Sen, A. and Tarbonton, G., 2016; Cao et al., 2017) will make GlobSim also suitable in mountains in the future. In the section 4.5 model setting and parameters, we will revise to
*"Given the gentle topography and small test area, the time-series were derived from single level analysis for the geographic centre of measurement sites, only (Figure 4)"*. to clarify.
Additionally, in section 3.3.2 Spatial interpolation, we will add the suggestion of selection strategy
*"Although, the 3D interpolation combined surface and atmospheric information is not used here due to the relatively flat study area, this would be useful for further development of GlobSim by coupling additional scaling methods."*

### Specific comments

- P7, L8: Should it be term “scaling”?
  Response: Will be corrected in the revised manuscript.

- P9, L31: change ...types in in the area to ...types in the area...
  Response: The repeat of *"in"* will be deleted in the revised manuscript.

- P10, Figure 3: Relative humidity of MERRA-2 is missing. Also consider adding label for each subplot as you’ve done for the other figures since you have eight figures here.
  Response: The relative humidity of MERRA-2 will be added as well as the label.

- P11, Figure 4: what is the background, DEM or hillshade, please clarify. What does the blue part in the upper right subplot? Seems the legend of Mine is not used, suggest delete it.
  Response: The background is an elevation tinted hillshade. Elevation is represented by different hues and the topography is accentuated using darker pixel values. In this region, the elevation does not change significantly so the topographic variation from the hillshade is most prominent. The blue shaded region represents the Northwest Territories - a territory of Canada. The mine icon is visible at the leftmost edge of the map below the latitude marking and corresponds to the Ekati diamond mine main camp, a major landmark in the region. The caption has been changed to clarify:

  *"Figure 4 Study area and approximate location of measurement sites. Many point locations overlap at the scale of the map, so the positions of their markers have been dispersed to better illustrate the number and type of sites. The centroid of all measurement sites (red star) was used as the location for which GlobSim*



  *reanalysis data were derived. The top right inset map shows the location of the study area (red square) within the Northwest Territories (blue region) of Canada. The elevation tinted hillshade basemap is provided by the Natural Resources Canada Federal Geospatial Platform Elevation Data Web Mapping Service and is derived from the Canadian Digital Elevation Model (CDEM). Waterbody outlines were obtained from the ArcGIS online data library."*

- P13, Table 2: Seems the minus symbol (-) for the units of thermal capacity (should be 106 J m-3 K-1) and thermal conductivity (should be W m-1 K-1) is missing

- P2, L25-29: P14, Table 3: Similar with Table 3, the minus symbol in many units are missing, please double-check.
  Response: These are the responses of two above comments. The P13 and P14 of previous manuscript were not in correct format, and many of the symbols in Table 2 and 3 are missing "-". They will be fixed in the revised manuscript.

- P14, Table 3: simulation depth is not sufficient for the long-term simulation, which exceeds 20 m, please clarify.
  Response: A detailed introduction of long-term simulation will be added in the revised manuscript. Please see our responses to your major comment 1. In Table 3, the column will be revised to "12/50", and a caption will be added: *"The simulation depth of 12 and 30 m was used for GST and long-term simulation, respectively."*

- P16, L10–12: The last sentence of this paragraph is very unclear. Please clarify.
  Response: The sentence will be changed to *"The ensemble mean, which had a daily RMSE of 1.87℃, outperformed all individual reanalyses during the measured period and reduced RMSE by 0.07–1.78℃ (Figure 8)*"

- P3, L6: Should it be at a site scale or at the site level?
  Response: In the revised manuscript, it will be changed to *"at a site scale"*

Finally, I look forward to further development of GlobSim.

## References

Cao, B., Gruber, S., & Zhang, T.: REDCAPP (v1.0): parameterizing valley inversions in air temperature data downscaled from reanalyses. Geoscientific Model Development, 10(8): 2905–2923. https://doi.org/10.5194/gmd-10-2905-2017, 2017.

Fiddes, J., and Gruber, S.: TopoSCALE v.1.0: Downscaling gridded climate data in complex terrain. Geoscientific Model Development, 2014, 7(1): 387–405. https://doi.org/10.5194/gmd-7-387-2014, 2014.

Sen, A., and Tarboton, G.: A tool for downscaling weather data from large-grid reanalysis products to finer spatial scales for distributed hydrological applications. Environmental Modelling & Software, 84(10): 350–69. https://doi.org/10.1016/j.envsoft.2016.06.014, 2016.