Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2018-12-RC1, 2018

Geoscientific Model Development Discussions

Interactive comment on "ATAT 1.0, an Automated Timing Accordance Tool for comparing ice-sheet model output with geochronological data" *by* Jeremy C. Ely et al.

E.J. Gowan (Referee)

evangowan@gmail.com

Received and published: 12 March 2018

Ely *et al.* present a tool that can be used to evaluate an ice sheet reconstruction or the output of an ice sheet model simulation to chronological data relating to the minimum timing of retreat or maximum timing of advance. I think such a tool is very valuable, and I can see it being useful in my own studies. As stated in the paper, there have been few attempts to directly incorporate individual dates into ice sheet reconstruction evaluation, instead using margin reconstructions such as those by Dyke (2004) and Hughes et al. (2016) for visual comparison. Ely *et al.* use a statistical approach to evaluate whether or not the area covered by the ice sheet reconstruction is consistent

with the chronological information that indicates ice free conditions. As stated in the manuscript, all dates suffer from the "minimum age problem", which is to say that there is an unknown period of time between the retreat of the ice sheet and the age of the material dated (although cosmogenic dates might be close). However, there are few other options to directly evaluate how close the reconstruction is to reality. ATAT is a valuable addition for assessing ice sheet reconstructions that should be used alongside other evaulation methods such as fit to glacial isotatic adjustment indicators.

1 ATAT software

Unfortunately, I was unable to get the software to work. I tried to follow the instructions for the format of the NetCDF file as per Table 3, but the program would not accept them, specifically with the geochronological data file. I would suggest adding scripts to build this file, or at least give some example NetCDF files so that it is possible to put things in the right format. It should be noted that the unit "Years before present" is not a valid CF compliant time unit, and will cause command line NetCDF tools like CDO to complain and not work. I would use CF compliant units to make the NetCDF files compatible with other programs.

There is no recommendation on what to do if there are multiple dates in one grid cell. When I was attempting to use the program, I just took the oldest date without regard of the error, but maybe it is better to make a combined probability using a tool like OxCal (Bronk Ramsey, 2009).

Are the errors supposed to be 1-sigma or 2-sigma? The paper does not indicate which should be used. Also, calibrated radiocarbon dates are not normally distributed, what is the recommendation for usage in this program?

Another recommendation I would have is to allow the program to read the required variables (*i.e.* DEGLACIAL/ADVANCE, filenames, THK/MASK) from a file rather than

requiring interactive input. This would greatly streamline usage in scripts where many ice sheet reconstructions are evaluated and plotted automatically.

2 Paper

In general, the paper is well written, though I think at times the authors go overboard on detail that is not directly relevant to the tool they are introducing. I think section 2 (background) should be shortened considerably. In the current form, it is almost half of the text. In particular, section 2.2 is a two and a half page review of the inadequacies of ice sheet models. I don't think Geoscience Model Development is really an appropriate venue for such a review, especially since ATAT is not really about fixing these problems. Bringing up these issues here really gives the impression that the authors don't trust ice sheet models at all, which I doubt is the intention. I think anyone doing ice sheet modeling is well aware that it may not be possible to exactly reproduce a configuration that replicates geological observations given the limitations of the models, but they may want to know how close they are!

I think rather than going into such detail on the inadequacies of ice sheet models, it would be more appropriate to detail how ice sheet reconstructions are numerically evaluated at present, such as the extensive Monte Carlo sampling technique used by Lev Tarasov (*e.g.* Tarasov et al., 2012) and evaluations based purely on glacial isostatic adjustment (*e.g* Auriac et al., 2016).

Section 3 does a nice job of explaining the usage of ATAT.

In section 4 and 5, there is a lot of emphasis that this tool be used with large ensemble of model runs. I don't know if this is a realistic outlook if you want to consider realistic climate scenarios. Computing a specific climate state (*e.g* LGM) can take weeks, and a fully coupled ice sheet-climate model is along the lines of months. While ice sheet modelling by itself takes a lot less time to run, I question how valid it is to run a large

ensemble of model runs using a linear scaling of modern day climate. During glacial periods, the ocean and atmospheric patterns were substantially perturbed, and this has follow-on impacts on the growth and retreat of ice sheets. Maybe such an exercise is useful to get a general feel for the kind of climatic conditions are necessary for glaciation, but I don't think it is diagnostic. The discrepancies between the three model runs presented in this section and the chronological data could very well be due to this issue. It could also be related to using a scaling based on the GRIP record, which may not be representative of the climatic variability in the British Iles during the Weichselian Glaciation. None of these points detract from the utility of ATAT, and I think the focus should be more on evaluating the model results. Perhaps one way to do this is to run ATAT using the DATED reconstruction and compare it with one of the model runs. This would illustrate what a good fit looks like.

3 Minor comments

- Line 57: I would include Auriac et al. (2016) here.
- Line 301: The sentence here is not complete.
- Line 441: Any reason for using the SPECMAP sea level curve rather than more up to date reconstructions?
- Figure 7: There is no frame of reference in these maps. I'd suggest putting on modern shorelines to make it easier to see what is going on with the model output.
- Figure 8: It is very hard to see the location of the geochronological data on these plots. Maybe it would be better to just plot the raw data as points, rather than plotting them as a grid. I also find it a bit confusing to put both the timing of

advance to the maximum extent and the Younger Dryas readvances on the same plot. I suggest splitting it up into two panes.

Best Regards,
Evan J. Gowan

References

Auriac, A., Whitehouse, P.L., Bentley, M.J., Patton, H., Lloyd, J.M., Hubbard, A., 2016. Glacial isostatic adjustment associated with the Barents Sea ice sheet: a modelling intercomparison. Quaternary Science Reviews 147, 122–135.

Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51, 337–360.

Dyke, A.S., 2004. An outline of North American deglaciation with emphasis on central and northern Canada, in: Ehlers, J., Gibbard, P.L., Hughes, P.D. (Eds.), Quaternary Glaciations–Extent and Chronology - Part II: North America. Elsevier. Developments in Quaternary Science, pp. 373–424.

Hughes, A.L., Gyllencreutz, R., Lohne, Ø.S., Mangerud, J., Svendsen, J.I., 2016. The last Eurasian ice sheets–a chronological database and time-slice reconstruction, DATED-1. Boreas 45, 1–45.

Tarasov, L., Dyke, A.S., Neal, R.M., Peltier, W., 2012. A data-calibrated distribution of deglacial chronologies for the North American ice complex from glaciological modeling. Earth and Planetary Science Letters 315–316, 30–40.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2018-12, 2018.