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Comment on gmd-2022-58

Laura Rontu (Referee)

Referee comment on "HORAYZON v1.2: an efficient and flexible ray-tracing algorithm to compute horizon and sky view factor" by Christian R. Steger et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-58-RC1>, 2022

Reviewer comments to

HORAYZON v1.1: An efficient and flexible ray-tracing algorithm to compute horizon and sky view factor
by Christian R. Steger, Benjamin Steger, and Christoph Schär

The authors propose a new method for calculation of topographic horizon and sky view factor based on ray tracing library and using a high-resolution digital elevation model. For calculation of the orographic radiation effects it is necessary to consider the geometry of non-local terrain. The main parameter to consider is the local horizon, from which the sky view factor can be derived. It is important that the horizon is calculated with the highest possible resolution of the surface elevation data. Such calculations, especially if done using less optimal conventional algorithms, require large computational resources in terms of memory usage and processing time.

The authors propose, test and document a new and more efficient method that is based on a high-performance ray tracing library. It is demonstrated that the calculations could perform up to two orders of magnitude faster than conventional ones. In addition to the application the ray tracing method that stores terrain information in an efficient way, optimizations are related to limitation of the calculation domain to only what is strictly necessary at each point (terrain simplification in the boundary zone, masking of ocean points). The suggested method is surely valuable for the applications, like the numerical weather and climate prediction.

The manuscript is of applied, technical character which is fine in this case when new software is described. It is well written, contains detailed documentation and discussion of the suggested method, gives sufficient background and demonstrates the authors' good understanding of the previous methods and applications. The paper can be used as basic documentation of the method. The underlying data and the HORAYZON source code are of public domain and available via github, even together with user support, that makes the application especially valuable.

The manuscript seems ready for publication with minor corrections. I do not have sufficient expertise to verify the derivation of the equations and technical details of the ray tracing method but rely on the authors that these have been done and presented correctly. I would however like to use the opportunity to raise for discussion some general questions, suggestions, concerning application of HORAYZON in numerical weather prediction models (General comments). This is not to suggest modifications to the manuscript but perhaps to take into account for further developments and application. Some minor comments concerning the manuscript text follow (Minor comments).

General comments

I would like to shortly describe our experience on preparing basic terrain data for orographic radiation parametrizations within the NWP models of HIRLAM and ACCORD NWP consortia. Here, methods described first by Senkova et al. (2007) have been applied. In the latest experiments, we took SRTM of 3" resolution over a limited domain (e.g. over Caucasian mountains, Rontu et al., 2016, see also <https://www.ecmwf.int/sites/default/files/elibrary/2018/18234-radiation-and-orography-weather-models.pdf>).

In each SRTM (lat,lon) point we calculated local horizon angles (LHA) for (8) directional sectors. First we estimated the horizon for 360 sectors, resulting in one value per each one-degree sector, then averaged these for 8 sectors. This was done using a simple home-made fortran programme, searching maximum elevation within an assumed radius around each point (for SRTM 3", we only took a radius of 5 km). In addition to the original (1) SRTM surface elevation field we now got 8 extra LHA fields in the the same grid. Separately, we calculated at each SRTM point the maximum slope angle and its azimuth angle using 8 neighbours. This added two more SRTM-grid fields. We used the standard tools (by gdal) for slope calculations. All these calculations in SRTM grid were first done by using external programs

within a workstation, later more approximately within the physiography generation phase of the NWP model, before aggregation of the data to the model grid for derivation of slope, shadow and sky view factors.

The resulting 8 + 2 extra fine-resolution fields (could be e.g. 16 + 2 as well, with LHA sectors of 22.5 degrees instead of 45) are all we need for the second step, (statistical) aggregation to the NWP model grid. We also tried to calculate the sky view factor at each SRTM point, possibly using the slope angle of the point in the sector LHA was facing. In hindcast, it seems that SVF could rather be estimated in the aggregation phase for the model grid, building on the precalculated sectorial LHA and slope angles in the source grid.

After this long introduction comes the question/suggestion: would it be possible to apply HORAYZON to the (almost global) NASADEM (or even to the more local higher-resolution DEMs), in order to provide the users of the DEMs with pre-calculated sectorial LHA and slope angles? I mean, applying high-performance computing facilities with graphical processors and utilizing an available data base of some suitable programme (like the COPERNICUS services, ECMWF computers) would allow for doing the common basic work effectively and once for all, letting the NWP consortia or other users to focus instead to the task of (statistical) data aggregation for the specific parameters in their specific grids? There, plenty of different applications and approaches, variable and changing grids, surely wait for development of their specific solutions. The amount of resulting global pre-calculated horizon data would be large but not much more than one order of magnitude larger than that of the source DEM data. Most users would only need to transfer data for specific domains anyway, and as this is the question about orography fields, there are no worries of their time evolution (as opposite to the output fields of NWP or climate models).

Would you see principal or practical problems in such an approach, e.g. in view of the SVF discussions within your sections 3.3, 4.1? In several places you refer to Pillot et al. (2016), mentioning at l.306 that their algorithm was designed for point locations which makes its run time substantially larger. Yours, according to Figure 5. calculates the horizon for a predefined small area (blue shaded domain)? What would happen if you applied HORAYZON to calculate horizon in the (transformed) DEM source grid points and returned the resulting LHA fields back there? What about the additional inaccuracy due to coordinate transforms? If you feel it appropriate, perhaps you could discuss these questions in the concluding discussions. From the practical point of view, their matlab code is most probably not applicable in parallelised high performance computing environment while yours might be?

Minor comments

I.10 (abstract)

Could you please add in the abstract one sentence, one number perhaps, that would characterize the efficiency of the proposed method compared to something conventional, already existing? On the line 320 you write "In summary, the performance analysis revealed that the ray-casting method is much faster for all considered terrain sizes (by about two orders of magnitude)"

I.30 (introduction)

There are applications, like road weather models, that downscale the radiation fluxes from NWP models and apply terrain corrections in point scale for calculation of the road surface energy balance, for discussion see e.g. Karsisto, 2019 (<https://helda.helsinki.fi/handle/10138/305417>).

Section 3.1.

Would it be possible to discuss the impact, loss of accuracy due to the coordinate transformations? Are transformations kind of reversible, i.e. would it be possible to return the calculated variables back to the original source grid?

I.160

Indeed, the suggested masking approach might be useful for other applications, too, e.g. in the surface data assimilation of NWP models where practical coastline problems are met.

I.167

"High tessellation level" sounds a bit specific terminology for a reviewer not familiar with computer graphics world.

Figure 6.

Would it be possible to indicate the horizontal (vertical) scales of the valley shown?

Eq. (10) and (11)

To make sure I understood it correctly: here you allow that the point you calculate SVF for is inclined, like in Manners et al. wanted to assume (but made a mistake as you suggest)? In this case, your Eq. (11) should have been applied also instead of Eq. (1) in Rontu et al., 2016.

l.395

typo? "DEM data with high spatial resolution has to be processes*ed*, which can be done..."

Section 5.1

I did not understand from the text how you did the (reference) spatial aggregation of SVF to coarser grids? After l.420 in the next section you do discuss simplifications, sampling density etc.

Section 5.2

Sub-grid SVF calculation is expensive, true, but somewhere you might mention that such calculations are not done on daily basis but only when new experiment (or operational NWP) domains are defined. Perhaps not here but in introduction or discussions. (We also applied sub-grid SVF, horizon and slopes in Senkova et al. and Rontu et al., although using relatively coarse source DEMs.)

l.450

The approach by Helbig and Löwe could be characterized as a terrain parametrization, whose results are later applied at another level of parametrization within the radiative transfer calculations in a NWP/climate model or in their postprocessing. In my opinion, it represents a significant simplification.

I.484

"minor performance dependency on horizon search distance" is encouraging.

Appendices

I have not gone through the appendices.