

## Reply to Review #2

Dear Colleague,

thank you very much for taking the time to review our paper and proposing some very constructive comments. They have contributed to improve the manuscript.

The authors propose a decomposition of atmospheric grid into so-called hydrological transfer units (HTUs) to resolve water flow on the surface more accurately. The proposed decomposition is based on a digital elevation models (HDEM) which contain flow directions. Their method introduces a truncation parameter to reduce memory requirements especially when the river flow is sufficiently resolved. The truncation parameter is dependent on the resolution of the atmospheric grid and the HDEM models in use, and is chosen to minimize a so-called topological error of the flow. Furthermore, the authors rightfully argue that the time steps a reasonable time step can be achieved in their approach, which they demonstrate in great details in a series of numerical experiments for several important grids.

This manuscript presents an interesting and a computationally useful numerical approach with a detailed study of parameters and the comparison thereof in several important studies of surface water flows. I suggest to publish this paper after a minor review.

Thank you very much for these positive general comments on the method presented in the paper.

### Remarks:

L 32 "as not to introduce any discontinuity"

How does this discontinuity arise? Does this refer to the first approach mentioned in the line 38? If yes, could you please refer the discontinuity to the "first approach"?

The sentence is indeed not very clear. It has thus been reformulated as follows : "in order to avoid the discontinuity which would have been introduced if a finer mesh would have been used for the land surface".

L 36 "which is ofter kilometric" -> "which is on a km-scale"

changed

L 69 HTU is used but not introduced

yes, in line 57 with the sentence : "The combination of both yields graphs of hydrological transfer units (HTU) ..."

L 70 What comes after "In a first step" is a list of things that you will be addressing in the paper. Could you specify where the items in this list are addressed in the paper, and also to make sure that they are really addressed.

Corrected

L 73 "simplification of the digital elevation models"

It might be a bit misleading to call them models when in fact they are just data sets, or there something more to it?

I agree that this denomination of high resolution orographic data is misleading. But it is a standard term used in many disciplines : [https://en.wikipedia.org/wiki/Digital\\_elevation\\_model](https://en.wikipedia.org/wiki/Digital_elevation_model)

L 82 "and covers the fraction" -> "and covers the area fraction"

Yes, corrected

L 87 "Because we are in a directional graph  $I+1$  is unique"

This needs reformulating. Something along the lines of "HTU\_{I+1} is unique"

Yes, corrected : "Because we are in a directional graph the vertex  $$i+1$$  is unique and at some point downstream the graph should end in the ocean or a water body for endorheic basins." should be clearer.

L 87 "at one point should be the ocean or a water body for endorheic basins" To what point are you referring to?

Sentence proposed above should clarify this point as well.

L 93 I suggest to have a consistent referring to equations in the manuscript. Sometimes it is referred to as "Eq 1", and later in text it is referred to as "equation 1". In addition,  $W_{I,stream}$  should not have italic letter for "stream", rather it should be  $W_{I,\mathit{stream}}$ . The same goes for units - they should not be in the italic letters.

Systematically the fonts for mathematical symbols are used. So either the equation environment in LaTeX is used or a simple  $\$...$$  for in-line mathematical symbols. When the equation is numbered the "Eq x" is used, else "equation" is kept.

L 104 There is no need for brackets around  $\lambda_{I,stream}$

This is to be consistent with the rest of the sentence where "(\$\lambda\_i\$)" is used.

L 106 In Eq (6) having  $dz$  in italic is a bad example,  $\mathit{dz}$  is more appropriate.

Here again the LaTeX formulation for the in-line mathematical expressions  $\$dz$$  is used.

L 127 There is no need for brackets around variables in the text.

Removed

L 145 "The hydrological data sets" -> "The hydrological data sets HDEMs"

The caption of table 2 was changed to "The hydrological digital elevation models (HDEM) used in this study to evaluate the building of routing graph and the simulated river discharge".

L 148 "30arcsec" -> "30 arcsec" and arcsec should not be in italic

Systematically we now write in LaTeX “\$30\,arcsec\$”.

L153 “As we will show...”

Could you please make a reference where is this shown?

Yes, “(section 4)” was added to the sentence.

L 163 “60arcmin” -> “60\mathrm{arcmin}” if you write in LaTeX

Error corrected : “\$60\,arcsec\$”.

L 166 Maybe rename to “Supermesh between an atmospheric grid and HDEM”

Corrected.

L 169 “the list of polygons of intersecting polygons” -> “the list of intersecting polygons”

Corrected.

L 180 “Their upstream area is computed according to the HDEM”

It has not been revealed how this is exactly performed or meant to be. Could you elaborate here a bit more?

This sentence has been updated to “Their local upstream area is computed using the the area of the overlapping HDEM pixels.”. It is important to know that at this stage only the upstream area local to the atmospheric grid cell can be evaluated.

L 182 A variable nbmax is mentioned without a meaning to it. Could you give us more information on this variable. Also, instead of writing “nbmax” one could conveniently use a shorter N\_{\mathrm{max}}.

The sentence was clarified with : for the user selected truncation \$nbmax=18\$. We prefer to keep “nbmax” to ensure consistency with the graphics.

L 184 “they contribute remains correct” In

what sense “correct”?

The catchment area is preserved.

L 185 “in a single and same” -> “in a same”

Corrected.

L 185 Please reformulate the sentence starting with “This first step”

Reformulated to : “This first step will conclude with as many HTUs as there are arrows pointing out of the grid cell, as illustrated in Figure 2”.

L 197 “HTUS” -> “HTUs”

Corrected.

L 237 “connex”

Do you mean convex? Why bringing up this property of HTU?

Connex in the sense of “connected”.

L 269 The definition of the cellular error is a bit vague. Is it possible to give a more precise definition of the cellular and the total error?

We have attempted to clarify this with the following addition : "Within each HTU we can compare the sub-segment's properties computed with the HDEM to the one used for the HTU."

L 348 We learn that  $g_X$  is the inverse of velocity. This should have been also mentioned directly after Eq 5 in L 101.

This has been added in the presentation of Eq 5.

L 362 "of the HTU : the stream" -> "of the HTU: the stream"

Corrected.

L 399 "in figure 6" -> "Fig. 6"

We now use systematically "Figure n".

L 400 "x-axis" -> "\$x\$-axis" in LaTeX

There is no need to use the mathematical fonts here in our opinion.

L 430 "But it has to kept" -> "But it has to be kept"

Corrected.

L 435 At the beginning of Sec. 5.2., could you please again mention the benefits of having  $nbmax$  as small as possible?

Excellent idea. We added : "Using small values for  $nbmax$  reduces the memory footprint and computational time of the routing scheme."

L 440 "y-axis" -> "\$y\$-axis" in LaTeX

As above.

L 547 I have not seen a study on the scaling parameter "a" but here set to  $10^5$ . Is it possible to specify values earlier in experiments?

The relaxation to the surface temperature using the "a" parameter is only a rapid solution to an explicit representation of the energy balance on the open water fraction with the atmospheric grid. It is explained in lines 128-135. This simple parameterization will be replaced by the lake model introduced in the paper of A. Bernus et al. 2022.

L 598 "hydrological Transfer Unit (HTU)" -> "hydrological transfer unit (HTU)"

Corrected.

