## Response to referee comments

We thank the referees for the positive comments on our manuscript. Here we describe our response to referee comments and detail how we plan to address each comment. The original review comments are in black, and our responses in blue.

## RC C3137

Specific comments:

1) Some suggestions on how this model could evolve with respect to present development in current routing model would help promote the routing model in terms of flexibility for further development. In particular, recent developments based on routing model include stream temperature, water quality modeling, inundation, ecohydrology, and reservoir operations and withdrawals. How flexible is this model with respect to this type of development so that future users understand the investment they make?

The channel routing schemes that are part of mizuRoute v1 – kinematic wave tracking (KWT) and an impulse response function (IRT) – are both 1-D approaches that do not explicitly track physical parcels of water. For example, the wave particles that are used in the KWT approach travel at the speed of the wave (celerity) rather than the mean velocity of the fluid. The 1-D approach does not allow for explicit modeling of inundation extent. Extension of mizuRoute to simulate stream temperature and water quality can be done in one of two ways: Adaptation of the existing routing methods or inclusion of an additional routing scheme that is more directly suitable for tracking water mass and their constituents. Although implementation of both approaches are outside the scope of this paper, we have added a brief discussion of the extensibility of the model to the conclusions.

2) Please add a reference to literature or justification of why a gamma distribution for deriving the hillslope unit hydrograph.

We will add a clarification and references to p.6 l.125 and will discuss potential additions to the hill-slope routing schemes in the conclusions.

The two parameter gamma distribution has been widely used in unit-hydrograph-based models for water resources engineering applications. For example, it has been used in the synthetic unit hydrograph approach (e.g., Bhunya et al. 2007; Nadarajah 2007). Kumar et al. (2007) presented methods to estimate the two parameters in the gamma distribution based on geomorphological information. The gamma distribution offers a parsimonious way to describe a wide range of hillslope-to-channel responses in a computationally efficient manner, which is important for the continental-scale domains for which mizuRoute was designed. In the future we may consider implementing multiple schemes for hill-slope routing as an option in the same way that we currently have multiple channel routing schemes. For example, a kinematic wave routing model (Koren et al. 2004) would be a possible extension.

3) "The KWT start by ordering all the segments…" How compatible is the routing model with parallel processing?

Our current implementation of mizuRoute does not use parallel processing directives such openMP or MPI, because execution time is relatively small compared to the implementation of the hydrologic model. However, both routing schemes lend themselves well for parallelization. While kinematic wave routing has to be done sequentially from upstream to downstream, the processing can be parallelized through appropriate choices of the domain decomposition. For example, subbasins that contribute to flow along a mainstream segment can be processed in parallel because the basins are independent. For example, if we route flows on a CONUS-wide river network, individual river basins (e.g. the Colorado River and Mississippi River basins) can be processed simultaneously. We will add a brief discussion of the implementation details and the opportunity for parallelization in section 3.2.1.

## RC C3807

This manuscript presents a toolbox-type of open-source package for the runoff routing methods. It is generally well written and easy to follow.

We thank the referee for taking time to read our manuscript and positive response.

But the introduction part could be significantly improved to clearly bring out the new contributions, i.e., whether and how this study has indeed advanced the science or methodology aspects of runoff routing models.

We discussed the contributions in Section 3, but will move these discussions to the introduction to clarify what is new/different in this model and framework.

The validation does not seem sufficient either due to the lack of comparison against the observations. I suggest the manuscript to be significantly improved before publication is considered.

As we specified at the beginning of Section 5, the accuracy of the simulated streamflow is dependent greatly on the performance of the hydrologic model that is used to simulate the distributed runoff fields that are input to the routing model. These hydrologic simulations can have large errors, which makes a direct comparison with observations less meaningful (since most of the error would stem from the hydrologic simulations). For this reason we focused on an inter-comparison between the two channel routing schemes. Note that the performance of the IRT approach in routing flows has been discussed in the original papers on IRF-UH (Lohmann et al. 1996)

Possible directions to improve include, but not limited to, 1) deeper analysis revealing the advantages of vector-based method, not just on the input data, but theoretical insights; 2) future climate impacts on streamflow variation (e.g., CMIP5 simulations)

We compared the vector-based method with grid-based routing (which used the IRF-UH routing scheme), and found that the difference in streamflow estimates exist due to difference in definition of drainage area between two basin definitions (1/8$^{th}$ grid defined basin versus basin defined by Geospatial Fabric, which represent more realistic basin shape and size), which is related to advantage of vector-based method. In other words, the difference seems be more due to differences in basin area than about differences in channel routing, which is of interest here. We will include this discussion in section 5 as a new subsection.

The purpose of showing CMIP5-based flows is simply as a demonstration of how the model can be applied. A more in-depth discussion of climate change impacts on future streamflow is out-of-scope for this model description paper. The purpose of illustration of mizuRoute simulation with CMIP5 data is demonstration of the model's ***capability*** of conducting large domain studies such as climate change impact on streamflow across the US.  We will rephrase the beginning of section 5 to emphasize this.

## Additional Modification of the manuscript

We plan to update the Geospatial Fabric data with an updated and corrected version.  The corrected version contains corrections to the river network connectivity. The dataset used in the manuscript contains several "broken connections" between neighboring river segments.

## References


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