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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Quantifying hydrologic connectivity of wetlands to surface water systems" *by* Ali A. Ameli and Irena F. Creed

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COMMENT: Authors characterized surface water and subsurface connectivity of wetlands using a physically based surface-subsurface model. Groundwater level measurements, water chemistry and stable water isotopes are used to illustrate the model performance at recharge and discharge locations. While this is an interesting study, the study can benefit by providing more quantitative measures of model performance compared to observations, justification of the modelling approach compared to the existing coupled surface water-subsurface models and sensitivity analysis.

1) Authors should provide a more quantitative measure of model performance. For example in Figure 3, authors qualitatively compare simulated recharge/discharge areas with interpolated groundwater observations. Similarly, water quality data are used to

indicate differences between recharge and discharge zones using the Wilcoxon rank sum test. In Figure 5, the model predicts the second peak much earlier than the observations. The paper can greatly benefit by providing further details about the model's performance as well as discussions about discrepancy observed between simulated and observed outputs.

RESPONSE: We thank the reviewer for this concern.

For Figure 3: We quantitatively assessed the efficiency of the subsurface model; please see the following sentence on page 7, lines 10-13: "The correlation coefficient between simulated groundwater fluxes at the land surface and the distance of potentiometric surface above and below land surface is 75% ($p < 0.001$)"

We agree with the reviewer that Figure 5 needs further explanations about earlier prediction of the second peak. This inaccuracy is mainly attributed to the lack of data availability for evapotranspiration time history before 2000 including the calibration period used in our paper (April 1 - August 1 1983). We instead used the calculated evapotranspiration time history of 2015 for the same period (April 1 to August 1 2015) because the average monthly humidity, average monthly maximum air temperature and average monthly minimum air temperature were similar between April 1 to August 1 1983 and April 1 to August 1 2015. This simplification can considerably impact the hydrograph shape during summer period that led to an earlier prediction of the second peak. We think this inaccuracy (earlier prediction of the second peak) has minimal impact on the simulated connectivity map at the end of simulation period (e.g., Figure 6b), mainly because, at the measurement station, the cumulative simulated flow (2.4 107 m3) is only 7% less than the cumulative observed flow (2.6 107 m3) at the end of simulation period. Indeed, in our particle tracking scheme it does not make a big difference if particle be in its highest velocity on e.g., June 20 or June 24. We will add a paragraph to the revised version to explain these important points as the reviewer suggested.

2) Authors have used a grid-free subsurface flow model to simulate groundwater flow

and then used the 2D transient surface water flow of HydroGeosphere. It is not clear why authors did not use HydroGeosphere in the first place as it provides an integrated system to simulate surface water-groundwater interactions. I understand that the grid-free approach is computationally more efficient but authors should justify their approach. Indeed it would be really interesting to see how HydroGeosphere simulations compare with the modelling approach that authors developed. How much loss in accuracy is obtained by assuming steady state groundwater condition in the grid free approach compared to transient simulations?

RESPONSE: We appreciate this concern.

First, it should be noted that solving integrated subsurface-surface flow and transport problem in this 4,000 ha watershed with more than 100,000 wetlands is unrealistic using HydroGeoSphere. We refer the reviewer to a comprehensive review paper by [Golden et al., 2014] that clearly explained the difficulties of the integrated subsurface-surface flow models such as HydroGeoSphere in simulating the hydrologic connectivity. More recently, for a related study, we attempted to apply the integrated subsurface-surface flow model HydroGeoSphere to a considerably smaller watershed (800 ha watershed); even for this smaller and less computationally expensive scenario, the model was failed.

Second, this paper was not intended to compare the efficiency of different models in simulating the hydrologic connections. Instead we wanted to quantify the hydrologic connection of geographically isolated wetlands for the first time and also compare the surface and subsurface hydrologic connections. We used a robust line of observation (groundwater table variation for 30 years) to justify why steady-state model is valid for groundwater-surface water interaction flow simulation in this work. More importantly, our groundwater-surface water interaction model was able to appropriately repeat the observed groundwater discharge-recharge zones (Figure 3) with a R2 of 75%. So the model we used is an appropriate tool to explore the question we intended to answer in this paper. In the following comments we will also further justify why the restrictions

of the semi-coupled method does not effect the conclusions made in this paper. In the revised version, we will add a few sentences to further justify why the semi-coupled method we used is a valid tool to explore the research question raised in this paper.

3) How does the "semi-coupling" approach of surface-subsurface processes in the model impact capturing wetland connectivity and travel time distributions? Moreover, would it be more suitable to use the term one-way coupling instead of semi-coupling as the feedback from the subsurface is not included in this approach?

RESPONSE: We thank the reviewer for this great suggestion. We will add text in the revised manuscript to clarify how our semi-coupled method affects wetland connectivity and travel time distributions. Further, we agree with the reviewer that the approach we considered can be referred to as one-way coupled, and we will revise text accordingly in the revised manuscript. In general, as the reviewer suggested, this semi-coupled method does not consider the feedback from the subsurface domain to surface flow routing. However, we believe that this does not affect our results or conclusions, as we calibrated the surface flow model with observed data. Like any other model development, these simplifications can be compensated by the calibration parameters, which here include rill storage height and manning coefficients in the surface flow model.

4) It will be interesting to investigate how changes in climatic condition impact wetland connectivity and travel time distributions.

RESPONSE: We appreciate this concern. In the revised manuscript, we will show the surface connectivity map and travel time distributions for the events occurred from April to August 2009 (the driest summer since 2000). Thus, the revised manuscript will show and compare the surface connectivity and travel time distributions of the wettest and driest summer since 2000. We think a more comprehensive assessment of climate is beyond the scope of this paper, which was to showcase a method to characterize and compare the surface and subsurface connectivity of GIWs.

5) It will be useful if authors provide further details about the model input and time step.

RESPONSE: We thank the reviewer for this suggestion. We will clearly report the time steps used for the flow and transport models, and further explain the model inputs in the revised version.

6) Authors need to provide further details about the calibration approach and identify the performance of the model for calibration and evaluation periods.

RESPONSE: We thank the reviewer for bringing this to our attention. We agree that the calibration and evaluation phases were not clearly explained. We will clearly explain them in separate parts in the revised version.

Reference Cited: Golden, H. E., C. R. Lane, D. M. Amatya, K. W. Bandilla, H. R. Kiperwas, C. D. Knightes, and H. Ssegane (2014), Hydrologic connectivity between geographically isolated wetlands and surface water systems: a review of select modeling methods, Environmental Modelling & Software, 53, 190-206.

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