Representation of dissolved organic carbon in the JULES land surface model (vn4.4_JULES-DOCM) by Mahdi Nakhavali et al.

The authors represent a model which calculates the DOC concentration to inland waters. They extended the JULES model for DOC, including soil carbon processes and leaching. This manuscript is a step towards a carbon model for aquatic systems and their export to the oceans.
In general, I think that the manuscript is well structured, but the description of the model needs some improvement. I recommend publishing the manuscript in GMD after revision.

Before I start with my comments, I must point out that I am giving feedback from a modelling point of view. My work on the global aquatic C cycle has just started, but I have a lot of expertise on global modelling.
From that point of view, I was very happy that both the abstract and the introduction start with sentences about global transport to the oceans. The importance of lateral transport is emphasized, but the model description itself does not contain a word on lateral transport. The model is actually a 1-D model and the outcome could be used to transport in the river network.

The second remark is the mentioning of the C cycle in the abstract "A model that represents the whole continuum from atmosphere to land and into the ocean would provide better understanding of the Earth's C cycle and hence more reliable historical or future projection" and introduction "Hence we need to move towards a boundless C cycle model which accounts for lateral fluxes". Why did you choose, after emphasizing C (as in total C) transport, to represent DOC only instead of modelling other species like POC, SOC and DIC as well?

Comments/Questions
Abstract line 29-30: I think that part of the leaching to the riverine system is explained by this model. The flux from groundwater or other sources going to the riverine network are not explained by this model. You could shortly elaborate on the relevance or importance of groundwater and give a short explanation on why you ignore it for now. The model comparison is done in the soil and not in the river network.
Introduction: Should be more clear on the objective/aim of the model study. Same for abstract.
Page 3, line 12: Why 3 meters deep?
Page 3, line 24: 9 PFTs at global scale. What about crops? They are mentioned in Figure S1. Names and the number of PFT do not match with Figure S1.
Page 4, eq 2: I think dz should be without subscript (2x). I don't see why it is important to calculate x? Remove eq 2?
Page 4, eq 3: I think z=1 and z=4 should be replaced by i=1 and i=4. This 1 and 4 is not explained yet (I think they are the four soil layers that will be used).
Page 4, line 30-31: These lines do not say anything. Which measurements? When and where taken? Why this remark here? The DOC is not mentioned here. Why are there continuous lines for measurements? For the modelled results? Eq. 3 only gives four outcomes…..
Page 5, line 3: In figure 1 I see four carbon pools added (two for lock and two for free).
Page 5, eq 4: k is indicator for labile or recalcitrant. But none of the other parameters is dependent on k, so why is k included?
Page 5, line 15: add i subscript in F_S(S) and F_T(T_soil)
Page 5, line 17: RothC formulations. Reference needed.
Page 5, eq 5: What is the unit of silt and clay?

Page 5, eq 6,7,8,9: What is S_CARB,DPM? Why twice substracting R_DPM? What is F_DOC,DPM? Please make the parameter names consistent. This system is solved for each soil layer, so why "i" is not in the equations? These formulas are not clear.

Page 5, eq 8,9: I don't understand why part of respiration (R_s) is flowing to BIO and HUM? Can you take another parameter name for beta_R? Confusing. What is F_BIO,IN?
Page 6, line 3: R_s neglects R_DOC but it is called total respiration?
Page 6, line 12: add i subscript in S_DOC and k subscript in K_DOC
Page 6, line 13: add i subscript in F_T(T_soil). Is this the same parameter as mentioned on the previous page?
Page 6, eq 11 and 12: Should there not be a sum over k (labile and recalcitrant) in these formulas?
Page 6, line 24-26: "The assumption … (k)." I don't know what you trying to say here….
Page 6, eq 14: I don't understand. The size of the labile DOC pool is the old value minus a flux plus total size of the adsorbed pool??
Page 7, eq 15: I don't understand. This means that size of adsorbed pool is equal to F_AD_i???
Page 7, line 4: add i subscript teta_v.
Page 7, line 7: add k,i subscript C_DOC.
Page 7, line 8: do you mean distance between midpoints of the soil layers?
Page 7, eq 16: add i subscript in the formula (C_DOC and z). Do I miss which direction the diffusion goes. Does it always go from layer 2 to 1 or layer 2 to layer 3? Then there should be a subscript i,j or something….
Page 7, eq 17 and 18: add subscript k and i to the formulas and in the text.
Page 7, eq 17 an 18: It is confusing to have another teta with another unit in these formulas.
Page 7, eq 19: I should expect that F_P is negative? Add all the k and i subscripts to this equation.
Page 7, line 29: What do you mean by main DOC model parameters? In what sense?
Page 8, line 32: explain Al/Ap, A/E and Cg
Page 9, line 29: analytical spin-up? What does that mean? Why the assumption that it must be a steady state?
Page 10, line 1: HWSD global data. Reference needed.
Page 10, line 6: "test the sensitivity of DOC related model parameters" On what? DOC leaching?
Page 10, line 6-7: Why are these parameters chosen? These parameters can say something about the inner-sensitivity of the model. But how about the inputs like for example assumptions on PFT or precipitation, temperature, and so on? What about choosing different number of soil layers?
Page 10, line 6: How can you change beta_z? It is calculated in eq. 3. But that is a normalization?? Should you not change z_0? And what are you changing? Beta_z for each layer?
Page 10, line 8: Remark. The method of changing one parameter at the time. This is a popular method. However, it renders no information on the effects of interactions of the parameters and that it covers only a limited part of the entire parameter space.
Page 10, line 8: Why 50%? 10 or 5% was also enough to say something about the sensitivity around the default values.
Page 20: Figure 1 is confusing. All 8 boxes are defined for all the four soil layers, but the diffusion and soil depth give the impression that for example DOC_lock_labile only are defined in the deeper soils. Suggestion: split up the figure with the 8 pools (left hand side) and the righthand side the diffusion. Leaching and soil depth and 4 boxes (which are of the lefthand side type).

Table 2 should be updated with the right subscripts and so on. "i" has not the unit m….

Table S1: Z_0 should be with lower case characters.

Table S4: What are the numbers in the matrix? Leaching? Unit?

General

Page 15, line 7: “Hence, it is important to introduce a depth-dependence decay rate for these parameters.”. Now the sensitivity is used to draw this conclusion. But why not show the contribution of the DOC leaching of each soil layer? That should give a clear picture. I miss a kind of analysis of the importance of the different processes. Because the model that is proposed here has a lot of parameters. Is it possible to reduce the number of assumptions/soil layers/flows between the different pools? A broader sensitivity analysis could help.

What is the used spatial distribution? And the temporal resolution of the input?