Review of manuscript “A global assessment of nitrogen concentrations using spatiotemporal random forests” by Razi Sheikholeslami and Jim W. Hall

Sheikholeslami and Hall, 2022 utilize machine learning approach to build a random forest model of nitrogen concentration in major river basins. They apply the model to global river basins to identify nitrogen concentration hot-spots and decadal increase in nitrogen concentration. The manuscript applies random forest approach for estimating riverine nitrogen concentration, but their findings are not filling a gap in the literature. Their finding that highest nitrogen concentrations are observed in United States, Europe, China, and India is not new given that these regions are agriculture dominated and utilize large amount of fertilizer and manure. The manuscript lacks a novel motivation, several important predictor variables are not considered, and the final analysis does not provide any new information.

Introduction:

1. The authors include “three critical observations” from the literature review of ML applications for studying water quality. What is the reason for including these observations?
2. The two main objectives of the study related to identifying global nitrogen pollution hotspots and key drivers of nitrogen variability at a global scale are weak since various studies have examined these and it is not a novelty.
3. The Introduction currently has three section and is quite long. Condensing this section will improve the readability of the manuscript.

Data and Methodology:

4. Lines 218-222: The authors mention reshaping all predictors to 0.5-degree resolution, but they have not described how precipitation, runoff, and other predictors from the entire upstream catchment/watershed is accounted for in predicting river nitrogen concentration. It appears that they only considered the contribution of the various predictors from the 0.5-degree grid. It is highly likely that only a fraction of this grid falls in the upstream catchment and for several

observations large fraction of the upstream catchment is not included in this grid. Thus, the estimation of contribution from various predictor variables is likely flawed.

5. Adding latitude and longitude as predictor variables does not fully capture the spatial relationship between observations and predictors.
6. Additional land use predictors should be considered in the study for example, forest fraction, urban fraction.
7. In addition to considering monthly precipitation, extreme precipitation variables and variables capturing dry spells should also be considered as they impact nitrogen concentration. For example, a long dry spell will result in high nitrogen concentrations however, if the dry spell is followed by a large precipitation event concentrations will drop. The monthly mean precipitation will ignore this temporal variability and thus not accurately predict nitrogen concentration.
8. Table 2 should be replaced with a table containing the final 17 predictor variables. In its current format the table 2 does not list the four time and space predictors and lists the livestock predictors in a single row that makes it appear as a single predictor not five different predictors.

Results:

9. In the Results section, the authors have not compared their findings with any of studies listed in Table 1. The authors should discuss the similarity and differences between their findings and that of others using similar model building approach.
10. In addition to the annual concentrations (Figure 6), authors should also analyze and discuss monthly or seasonal maximum concentration.
11. The authors had developed spatial plots of nitrogen concentration for every month between 1992-2000, then why did the limit the analysis of change in nitrogen concentration to a decadal scale difference only. For large river basins, they can perform trend analysis. This will me more useful information for policy makers than decadal scale difference.

12. Line 387 – 389: What factors contributed to the decline in nitrogen concentrations? Just merrily stating decline is not enough and the drivers behind this observation should be discussed especially given that few regions with highest nitrogen concentration (India and South Korea) also have the largest decline.
13. The fact that month of year (MOY) is significantly more important than precipitation, runoff, and temperature seems concerning. If precipitation, runoff, and/or temperature, were selected as predictor variables it would have a direct physical meaning. For example, increase/decrease in precipitation can decrease/increase the nitrogen concentration.
14. What is the physical meaning behind cumulative month (CM) variable being identified as the second most influential predictor?
15. Figure 9 - Why is the relative importance of 3-15 predictors almost same?
16. Did the most influential predictors vary over space and/or time?