Response to Referee #1's interactive comment on "Integrating Multi-Media Models to Assess Nitrogen Losses from the Mississippi River Basin to the Gulf of Mexico" by Yongping Yuan et al.

GENERAL COMMENTS:

In this manuscript, the IMS framework was developed to incorporate multiple models such as the SWAT, WRF, EPIC, and etc. In general, the manuscript is well-written. On the other hand, I would like to see more details/rationales about the framework:

Response from AUTHORS: Dear Referee, thank you for the time you devoted to reviewing this manuscript and for your valuable comments. We carefully considered your comments and have taken them into consideration during revisions. In the first two paragraphs of the introduction, we talked about the need for an Integrated Modeling System (IMS) linking air, land surface, and stream processes to fill the research gap for integrated, multi-media modeling for N studies in large river basins (page 3 line 22 to page 4 line 2). The next step would be to select air, climate, land surface, and stream processes models for this integrated system; thus, we started to talk about the existing system FEST-C and we were debating to put more details regarding this system in introduction or methods; then we decided to put more details of this system in method section…; following your suggestions, we elaborated more on why we used those models. More details can be found below.

Comment 1. The first issue is the selection of different models. It seems that the combination of SWAT, EPIC, WRF, and others are more or less a subjective decision. Can you elaborate why these models are chosen in the first place? Otherwise, maybe we can also do the same thing by using HSPF or perhaps other models.

Response from AUTHORS: It is not subjective, and we added more detail in the introduction to elaborate why these models are chosen.

Starting page 4 Line 4 "The Community Multiscale Air Quality (CMAQ) Modeling System has been developed by the USEPA for conducting air quality simulations (https://www.epa.gov/cmaq); while the Weather Research and Forecast (WRF) is a community next-generation mesoscale numerical weather prediction system designed for atmospheric research and forecasting applications by the US National Center for Atmospheric Research (https://www.mmm.ucar.edu/weather-research-and-forecasting-model). The combined meteorology and air quality modeling system WRF/CMAQ is an important decision support tool that is used to help understand the chemical and physical processes for research and policy-making to mitigate harmful effects of air pollution on human health and the environment around the world (Cohan et al., 2007; Wang et al., 2010; Compton et al., 2011). This system (WRF/CMAQ) has long been used by the federal and state governments and institutions in US and around the world for air quality research and regulatory decisions.

During air quality simulations, it is often a challenge to accurately estimate NH_3 emissions from agricultural land because N fertilization varies spatially and temporally by production types (e.g. corn vs. soybean) and locations (e.g. different soil and weather). Therefore, the USEPA developed the Fertilizer Emission Scenario Tool for CMAQ (FEST-C) system (Cooter et al., 2012; Ran et al., 2011), an advanced user interface, to integrate the Environmental Policy Integrated Climate (EPIC) model (Williams, 1995; Williams, 1990; Williams and Arnold, 1996), a field-scale agricultural biogeochemical model, with WRF model (Skamarock et al., 2008) and CMAQ; and WRF/CMAQ simulates mesoscale meteorology and air quality (Fig. 1). . .”

Comment 2. In the current format, we can find EPIC, WRF, and CMAQ in Section 2.2. I suggest allocating them into subsections such as 2.2.1, 2.2.2, and 2.2.3, instead.

Response from AUTHORS: Changes were made following your advices.

Comment 3. As mentioned in 2.7 that the given work was not validate through calibration process. It can be problematic since it may be difficult to evaluate the corresponding performance of the given framework. I’m not saying the authors have to conduct additional work on calibration. However, I believe more justifications are required to alleviate the associated concerns.

Response from AUTHORS: There are some misunderstand: although the given work was not calibrated, we performed model evaluation (or validation) through comparing simulation results with the USGS monitoring data as we descript in section 2.7 and section 3.2 and 3.3. Furthermore, the given work builds on SWAT through HAWQS and FEST-C; and streamflow calibration was performed on SWAT for the HAWQS previously by EPA-OW as descript in section 2.7 Model Evaluation, which are the justifications. We totally revised the section 2.7 and section 3.2 and 3.3 to increase clarity.

Comment 4. I suggest separating the Conclusions and Future Work to independent sections, since the developed framework will be very useful to most readers and they may want you to elaborate more ideas and potential opportunities in the near future.

Response from AUTHORS: Changes were made following your advices.

Comment 5. The quality of Figure 3, 4, 7, and 8 should be further enhanced in the next round. The current format is very much the version of default settings from Excel.

Response from AUTHORS: Figures 3, 4, 7, and 8 were enhanced following your advices and they clearly show what we want to present.

Response to Referee #2's interactive comment on "Integrating Multi-Media Models to Assess Nitrogen Losses from the Mississippi River Basin to the Gulf of Mexico" by Yongping Yuan et al.

GENERAL COMMENTS:

It's an interesting paper. You tested a new integrated modeling tool (IMS) and compared IMS with other modeling approaches. A new method could significantly improve the strength of the modeling approach on examining environmental problems. However, several revisions are needed to clarify your work in the paper.

Response from AUTHORS: Dear Referee, first of all, we would like to thank you for the time you devoted to reviewing this manuscript. Secondly, we would like to thank you for your compliments and your helpful comments on the paper. We have carefully considered your comments and took them into account during revisions.

Comment 1: Please clearly explain your research design. After reading the introduction, I expected that since you proposed IMS by integrating SWAT into FEST-C and will only show results from IMS. Your method section suddenly stated that SWAT-HAWQS and SWAT-HAWQS WRF were tested together. At least, you should briefly introduce SWAT-HAWQS and SWAT-HAWQS WRF and simulations from those two methods will be compared with IMS.

Response from AUTHORS: We could only show results from IMS since we proposed IMS by integrating SWAT into FEST-C; we showed SWAT-HAWQS to demonstrate if IMS has any advantages over SWAT-HAWQS, which essentially is the SWAT. Sorry for the confusion. HAWQS was descript under section **2.3 Soil and Water Assessment Tool and Hydrologic and Water Quality System** on page 10 "The Hydrologic and Water Quality System (HAWQS 1.0) (https://epahawqs.tamu.edu/) was recently developed by the USEPA Office of Water to enhance usability of SWAT in simulating effects of land management practices based on an extensive array of crops, soils, natural vegetation types, land uses, and climate change scenarios on hydrology and water quality... HAWQS is a web-based, interactive water quantity and quality modeling system that employs SWAT as its core engine (Yen et al., 2016). It provides interactive web interfaces, maps, and pre-loaded input data including NHD Plus; land use/land cover (NLCD 2006 combined with CDL 2010 and 2011 crop data layer from USDA National Agricultural Statistics Survey (NASS) to differentiate agricultural land use); soil; climate; atmospheric deposition of N; and USGS data of streamflow and pollutants. Daily weather data implemented in HAWQS is from the the National Oceanic and Atmospheric Administration - National Centers for Environmental Information (NOAA-NCEI); the atmospheric deposition implemented in HAWQS is from the National Atmospheric Deposition Program which monitors precipitation chemistry (http://nadp.sws.uiuc.edu/NADP/). In addition, SWAT default parameters used by HAWQS have been preliminarily calibrated. HAWQS serves three different spatial resolutions (8-digit, 10-digit, and 12-digit HUCs) and varying temporal scales (time steps in daily/monthly/annual) (Yen et al., 2016)". Essentially, HAWQS is a more advanced user interface for SWAT (robot version of SWAT).

Regarding to SWAT-HAWQS WRF, SWAT-HAWQS WRF is also SWAT simulation using weather data produced by WRF. As descript under "**2.4.2 Weather and Atmospheric N Deposition for the Integrated Modeling System",** the IMS simulation uses climate-forcing by WRF …it would be interesting to see how SWAT does with climate-forcing by WRF. Otherwise, readers would question the impact of using climate-forcing by WRF on model results. Please also see page 15 and 16:

2.6. Model Simulations for the MRB:

To evaluate the IMS, the following model simulations were performed:

1. HAWQS-SWAT: All SWAT inputs including climate (daily precipitation, maximum and minimum air temperature) were directly extracted from HAWQS system; the simulation was performed from 1999 to 2010 (weather in HAWQS 1.0 ends in 2010), with the first three years as a warm-up period. HAWQS-SWAT uses area-weighted NOAA-NCEI observations as climate input for each subbasin (8-digit HUC); these data are interpolated using the Theissian polygon method to create a pseudo station for each 8-digit HUC. Air deposition used in this simulation is from the National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu/).

2. HAWQS-SWAT WRF: for this simulation, climate input (daily precipitation, maximum and minimum air temperature) were replaced with WRF-produced daily precipitation, maximum and minimum air temperature, solar radiation; the rest of the inputs remain the same as the above simulation (HAWQS-SWAT). This simulation was performed because the FEST-C system were driven by process-based WRF weather simulations.

Comment 2. This comment is related to the comment above. I have a confusing on terms. FEST-C is equal to EPIC+WRF+CMAQ and to improve FEST-C, SWAT was added. Is SWAT+FEST-C equal to IMS? Is IMS equal to the integrated multi-media modeling system? SWAT-HAWQS and SWAT-HAWQS-WRF mean the integrated multi-media modeling system? It seemed to me that you used the multiple terms that have the same meaning. Please simplify it.

Response from AUTHORS: FEST-C is an advanced interface, which is equal to EPIC+WRF+CMAQ (line 4 to 22 on page 4). To develop an integrated multi-media modeling system, which is IMS as abbreviation, as stated at the end of the **Introduction** (line 5 to 11 on page 5), SWAT was integrated with FEST-C. Yes. SWAT+FEST-C equal to IMS and IMS is the abbreviation for the integrated multi-media modeling system. We have thoroughly revised the terminology throughout the paper to reduce confusion and increase clarify of the paper.

Comment 3. Section 2.2 is too lengthy. Make sub-sections for 2.2 and explain each model at each section.

Response from AUTHORS: Changes were made following your advices.

Comment 4. Please show the climate comparison results first and then streamflow. Streamflow pattern is mainly affected by climate data. If the climate results are first shown, it would be easier to understand streamflow results.

Response from AUTHORS: Changes were made following your advices.

Comment 5. You should add any fertilizer application timing information for IMS and HAWQS. Fertilizer is a major N source. Comparing timing and amount of fertilizer between IMS and HAWQS is vital for this paper. At least, you must mention any differences or similarity on fertilizer between IMS and HAWQS based on literature.

Response from AUTHORS: You made an excellent point! We all realized their impact on simulation results (as we wrote in the paper: line 18 on page 22 under section 3.3 **Dissolved N Evaluation**). However, we soon realized that providing this information is almost impossible or very difficult: 1) IMS used EPIC for agricultural land simulation and fertilization in EPIC was configured based on the plant demand using computed N stress level during simulation and they varied for each grid cell (12 km by 12 km) depending on crop type and location et al (Page 23 Line 1 to 10). For HAWQS - SWAT, fertilizer sales information from each county were configured for each subwatershed (821 HUC8 in this study) and actual timing and amount applied to each field isn't know (page 22 under section 3.3). Sales fertilizer information was generated to represent general tread in the region. For the fertilizer application amount, EPIC generated fertilizer application is 8 percent lower than NASS overall and we added this information to the paper (page 24 line 5 to 6).