Geoscientific Model Development Discussions

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Comment on gmd-2021-115

Haiyan Jiang et al.

Author comment on "ANEMI_Yangtze v1.0: a coupled human–natural systems model for the Yangtze Economic Belt – model description" by Haiyan Jiang et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-115-AC1, 2021

Response to Comments

Referee #1

The authors introduce and describe a new version of the ANEMI integrated assessment model that simulates the regional dynamics of the Yangtze River basin, China. This paper is the first of two; it sets out the rationale for the work and describes the model. The stated aim of the overall study is "to improve the understanding of the complex interactions among human and natural systems in the Yangtze Economic Belt to provide [a] foundation for science-based policies…". Application of ANEMI_Yangtze is to provide this greater insight.

Model downscaling is an active area in integrated assessment modeling, and so the topic may be of interest to GMD readers. In this case, the downscaling is from the global version of ANEMI to the river basin scale. The resulting "ANEMI_Yangtze" model contains a large number of sectors – climate, carbon, population, land use, food production, sea level rise, hydrologic cycle, water demand, energy-economy, water supply development, nutrient cycles, and persistent pollution – that are dynamically linked through feedbacks in system dynamics software. The model has been updated continuously from its first publication in 2010 (Davies and Simonovic) to a most recent edition in 2020 (Breach and Simonovic). Regionalization of the model for application to the Yangtze has required changes to ANEMI's global structure that have replaced dynamic linkages with exogenous inputs in several cases, and the authors have added a "fish" sector, since fisheries are important for the regional economy and diet.

The work is topical and interesting overall, but the paper suffers from several deficiencies. These include 1) insufficient presentation of the data available for model development and validation, 2) insufficient model detail for understanding, and for replicability of the work, and 3) a rather lengthy and vague presentation style. In terms of the first point, the paper is not clear on sources of information for model development and validation. Can the authors provide quantitative values in the case study description, for the equations and parameter settings, and for model validation? Can they compare model projections with values from other studies? For the second and third points, the model is described through a high-level overview only. Clearly, space does not permit a detailed description of each sector, and the authors reasonably refer the reader to previous papers for further information. However, some aspects of the work are new and should be described in

greater detail, ideally also with relevant model structures, equations and data sources. The major problem here is that the authors have developed a quantitative simulation model, but have presented their work entirely qualitatively. This high-level framing means that the study cannot meet its aims of improving "understanding of the complex interactions among human and natural systems…", since it is not clear exactly how these systems are connected and the effects of these connections are not analyzed in the paper. Additionally, in terms of study context, the work should also be presented in the context of river basin models and perhaps integrated water resources management (IWRM), as well as its current focus on IAM.

I believe GMD to be an appropriate journal for publication, and so recommend major revisions rather than rejection; however, making the necessary changes will take significant time – perhaps longer than the journal permits for revisions.

- The authors appreciate your comments and have made significant changes based on your comments. These include: 1) addition of the ANEMI_Yangtze data system and comprehensive model validation and sensitivity analysis (see Line 1095-1109, Line 1294-1350), 2) detailed description of the new aspects of the model, including the stock and flow diagrams, the equations and their underlying theoretical basis, parameters and their associated sources (see Line 1110-1292), and 3) improvement of paper presentation.

The following are specific comments:

- Line 71: Include also models like MESSAGE, AIM, POLES, REMIND, TIMES and others? The authors should also review recent publications on integrated assessment modeling, such as Fisher-Vanden and Weyant (2020, Annu. Review Resour. Econ.), Calvin et al. (2019, GMD), Krey et al. (2019, Energy), Gambhir et al. (2019, Energies), and others
- The authors appreciate your comments and have updated related references.
- Line 78: Downscaling of IAMs is an ongoing effort. There have even been recent calls to downscale them to the city level (Dermody et al., 2018, Earth Syst. Dynam.). The GCAM model currently has several sub-national versions, including GCAM-USA, GCAM-China, GCAM-Latin America and others in development. The references here should be revised
- The authors appreciate this comment and have updated related references.
- Lines 81-106: This section contains neither numerical values nor references to literature/government reports. Please revise
- The authors appreciate this comment and have made significant changes in this section. Please see Line 115-478.
- Section 2 of the paper is also very light on details. For example, line 146 states "[The Yangtze Economic Belt] is home to many advanced manufacturing industries, modern service industries, major national infrastructure projects…". Given that the paper is intended to introduce and discuss a simulation model of the river basin, more information must be provided. A model is neither understandable nor reproducible from this level of description. Can data tables be provided here? Alternatively, a thoughtful discussion of data limitations and necessary assumptions could be provided instead. System dynamics can prove valuable in such contexts, but this point is not explored in the article.
- The authors appreciate your comments and have rewritten this section. Please see Line 115-478. The background of Sytem dynamcis is also added, please see Line 543-555.
- The purposes of sections 3 and 4 could be explained. It was not clear to me why two different sections were required, when both described the model in general terms
- The authors appreciate this comment and have merged these two sections into one section.
- Line 222: ANEMI represents "a different approach" to which other options?
- The authors have deleted this description.

- Line 227: Other IAMs also capture feedbacks and nonlinearities. What is it about ANEMI that is unique?
- The authors have deleted this sentence.
- Line 245: ANEMI_Yangtze is "downscaled" to the river basin scale. The literature review should therefore also reference basin-scale models and their capabilities. How does ANEMI-Yangtze compare?
- The authors appreicate your comment and have referenced a few basin-scale models. Please see Line 128-133. Comparison will be a bit "too much" considering that models at that scale should and are reflecting specific characteristics of the basins.
- Line 268: Please demonstrate the point that interactions matter through analysis of model results
- The authors appreciate this comment. We have added a new S_energy scenario to explore the impacts of shifting energy consumption patterns on the Belt's system performance. In this section, we have thoroughly analyzed the nonlinearity and feedbacks in determining the system behavioural of the Belt. Please see Line 1351-1457.
- Line 302: Please define terms like "water stress" with reference to relevant literature. Which equation is used?
- The authors have defined the term "water stress" in the **6 Water** subsection. Please see Line 1257-1274.
- Line 307: Increased N and P concentrations are important. However, other studies use measures like dissolved oxygen. Can the authors please discuss modeling choices like this in more detail, or refer to alternative sources?
- The ANEMI_Yangtze's representation of the N and P nutrient cycle is adapted from ANEMI (Breach and Simonovic 2018; 2020; 2021), which has its basis on Mackenzie et al. (1993).

Breach, P. A., and Simonovic, S. P.: Wastewater treatment energy recovery potential for adaptation to global change: an integrated assessment. Environmental Management, 61, 624-636, https://doi.org/10.1007/s00267-018-0997-6, 2018.

Breach, P. A., and Simonovic, S. P.: ANEMI 3: Tool for investigating impacts of global change, Water Resources Research Report no. 108, Facility for Intelligent Decision Support, Department of Civil and Environmental Engineering, London, Ontario, Canada, 133 pages. ISBN: (print) 978-0-7714-3145-6; (online) 978-0-7714-3146-3, https://www.eng.uwo.ca/research/iclr/fids/publications/products/108.pdf., 2020.

Breach, P. A., and Simonovic, S. P.: ANEMI: A tool for global change analysis, Plos One, 16, 0251489, https://doi.org/10.1371/journal.pone.0251489, 2021.

Mackenzie, F. T., Ver, L. M., Sabine, C., and Lane, M.: C, N, P, S Global Biogeochemical Cycles and Modeling of Global Change. Interactions of C, N, P and S Biogeochemical Cycles and Global Change, Springer, Verlag, pp 1-61, 1993.

- Section 4 explains some of the connections shown in its CLDs, but not the model structure, parameters, equations, and reasoning behind modeling assumptions. Describing a new model in a journal paper is difficult – so much to explain and so little space. However, a more quantitative presentation would help, and GMD is a journal that is well-suited to such a description. Since much of the model structure has been explained in earlier papers, the authors could focus these detailed descriptions on novel components. The CLDs themselves are very nicely presented.
- The authors appreciate your comments and have made revisions accordingly. In the original manuscript, Section 3 describes the background of the model and the cross-sectoral interactions and feedbacks, and Section 4 mainly describes the interactions and feedbacks within each of the nine sectors. These two sections are all about the interactions and the causal loop diagrams (qualitative in nature). Therefore, in this

revision, we have merged these two sections into one section. In addition, we have added a new section describing the novel components of the model, including the stock and flow diagrams, the equations and their underlying theoretical basis, parameters and their associated sources. Please see Line 1094-1292.

- Line 389: The number provided here illustrates a key problem with the model description. What is the source of the number 0.95? It is uncited. It is also the only number in the entire subsection.
- The authors appreciate your comments and have referenced the source.
- Figure 8: What is "water demand"? Is it "water withdrawal" or "water use"? Or is it an economic term, with the possibility that water demand > water supply? Please define terms
- Water demand here is an economic term defined as "as the volume of water requested by users to satisfy their needs - in a simplified way it is often considered equal to water withdrawal, although conceptually the two terms do not have the same meaning". In addition, there is a possibility that water demand > water supply.
- Line 487: How does water pollution affect life expectancy in the model?
- The effect of water pollution acts as a multiplier ($Pollution_{multi}$) on life expectancy and takes the following form: $Pollution_{multi}=aPI^2+bPI+c$, where PI is pollution index, a, b, and c are calibrated parameters.
- Line 491: Does "weathering" also include releases of N and P to surface waters through fertilizer use, domestic wastewater, and so on?
- The "weathering" here refers to the natural process. The releases of N and P to surface waters through fertilizer use, domestic wastewater are anthropogenic processes.
- Line 515: Please rephrase "to verify the feasibility…". The model is validated, rather than verified, and "feasibility" is not the correct word
- The authors appreciate your comment and have rephrased this sentence.
- Section 5: What are the data sources used to validate the model? Please tabulate or discuss
- We have added a new subsection 4.1 The ANEMI_Yangtze data system. In this subsection we discuss both historical data that are used to initialize and validate the model and future parameters that govern changes in the future. Please see Line 1095-1109.
- Line 523: Can the authors provide examples of the types of policies ANEMI omits?
- The authors have provided an example at the Line 1307-1311.

"For example, overcapacity in coal production gradually appeared after the mid-1990s, and this situation worsened after the outbreak of the 1997 Asian financial crisis. To alleviate the overcapacity crisis, the government issued series of documents to reduce production, and this is responsible for the production drop around 2000 seen in Figure 16(d)."

- Figure 13: Please describe the reference scenario used here
- We do describe the reference scenario in the original manuscript. Please see Line 1352-1362.

"Under the S_base scenario, all the policies remain at their 2015 values during the simulation. Specifically, the one-child policy remains unchanged for the Population Sector. The intensity of water withdrawals/consumptions in industry and agriculture for the Water Sector, the energy shares among different energy sources for the Energy Sector, and the fishing mortality for the Fish Sector shall all remain their 2015 values, respectively. The N/P removal efficiency in the Nutrient Sector is 0. The exogenous inputs of precipitation and temperature take their historical average annual values."

- Line 578: "We focus on analyzing the nonlinearity, delays and feedbacks…". The paper did not really analyze the results. Rather, it presented simulation results, compared them against historical values, and identified causes briefly on pages 26-27. The

analysis should be expanded.

- The authors appreciate this comment. In this revision, we have added a new S_energy scenario to explore the impacts of shifting energy consumption patterns on the Belt's system performance. In this new section, we have thoroughly analyzed the nonlinearity and feedbacks. Please see Line 1351-1457.
- Lines 580-598: The results presented in the paper do not really support these conclusions. Indeed, these points are not explicitly presented in the results section. For example, please show results that illustrate the effects of an increasing population on demands for resources and the resulting pollution effects (line 582), or that a growing economy drives energy production and consumption (line 585).
- The authors value your comments and have rewritten the conclusion and discussion sections. Please see Line 1458-1573. Also, we have added S_energy scenario in the model application section. In this scenario, the impacts of shifting energy consumption patterns on the Belt's system dynamics was analyzed thoroughly. Please see Line 1351-1457.
- Line 595: Why was this connection not modeled?
- The reseason why we didn't include this connection in our model is because the data necessary to describe this relationship are currently not available. So, we envisage including this in our future work when more data are available.