Modeling Workgroup Quarterly Review Minutes

October 4, 2022

Event webpage: Link

This meeting was recorded for internal use only to assure the accuracy of meeting notes.

ACTION ITEMS

- **Alex Gunnerson will schedule a follow-up meeting for continued discussion on CalCAST at an upcoming Modeling Ad Hoc weekly meeting - DONE**
- **Alex Gunnerson will schedule a follow up to Gopal Bhatt's presentation about the Dynamic Model - DONE**
- **Schedule an Ad Hoc on shoreline erosion with Carl Cerco and Larry Sanford - DONE**
- **Joseph Zhang will send Richard Tian maps that the VIMS MBM team has for the Choptank to include in his grid**
- **At a future Ad Hoc, Alex Gunnerson will set up standard operating procedures for MTMs. This includes decision rules to ensure we don't have artifacts because of some fundamental differences in decisions made - DONE**
- **Joseph Zhang will ask Karinna Nunez to send Richard Tian the VIMS shoreline layer**
- **Nicole Cai will share the NOAA bathymetry data charts with Richard Tian for the Corsica - DONE**

Meeting Minutes

10:00 Announcements and Amendments to the Agenda – Mark Bennett, USGS and Dave Montali, Tetra Tech

Summary

Lew Linker reminded participants that the Chesapeake Bay Program (CBP) has sent in proposals for the Coastal and Estuarine Research Federation (CERF) in Portland, Oregon for the 2023 conference.

10:05 Phase 7 Watershed Model Overview – Gary Shenk, USGS-CBPO

Gary provided an overall summary of progress.

Summary

Gary emphasized this is the same presentation he has been giving all year and that we are on schedule for Phase 7 Development, which can be tracked on the Phase 7 Development page here. Gary gave a very brief overview of Phase 7 Chesapeake Assessment Scenario Tool (CAST), CalCAST, and the Dynamic Model (DM) development. Gary also gave an example of how sediment will be included in the Phase 7 data.

10:20 Discussion of the Phase 7 Model Overview

Summary

Bill Keeling asked what the data are being calibrated to, specifically if the river gauge is serving as a calibration target. Gary replied that Watershed Model (WSM) data in Phase 7 are being calibrated to all the data acquired from Phase 6 at the moment. The Bayesian framework of CalCAST will also assist with calibration since prior knowledge will be incorporated as a suggested starting point, but the flexibility to change values is retained. Bill followed up, asking if we are calibrating to previous model outputs. Gary replied that the Revised Universal Soil Loss Equation (RUSLE) is a source of knowledge for interconnectivity related to delivery factors there is some calibrating to Phase 5 model outputs. Bill replied he is comfortable with calibration to observed data, but not previous model outputs. Bill said Hydrologic Simulation Program-FORTRAN (HSPF) is one thing since it is peer reviewed but does not think the other approach is a good idea. Gary replied that data in both the river and outside of the river are being calibrated with observed data.

Lew Linker commented that there is more data being brought in and being reconciled in Phase 7 compared to Phase 6, emphasizing observations of flow and sediment loads are considered. Gary replied ideally, we would not need to do that since in reconciling moves outputs off their most likely value and it does not explain where the change is happening. Gary thinks what will happen over the next few years is that a calibration will fail in certain areas and then they will be corrected. An example from Phase 6 was soil phosphorus in the Eastern Shore, where they were able to look at the root causes and fix the conception of the model. Lew replied that makes sense since phosphorus is in need of more effort, but the sediment calibration was rather good in Phase 6. Lew said calibration stations add more information than just what comes off the land and is especially useful for large rivers with large transport factors, which have lots of mobilized sediments. Lew emphasized calibration stations in the river bring much unique information. Gary replied CalCAST is calibrating to those stations, in addition to the nontidal network. The less we have to mess around to get a good calibration, the better. Lew said ultimately it is important to get a good calibration for estuarine model inputs. Gary said there are two purposes of the WSM: 1) load the estuarine model and 2) determine the source of anthropogenic change in load due to management actions. We may need to balance these two priorities in 2024. Lew replied that these reconciling decisions can be made later in Phase 7 development.

Robert Sabo commented the calibration will be optimizing the model to match predicted and observed values. However, the one unique element is that the range of individual model parameters will be constrained using prior knowledge (e.g., literature reported values, Bayesian insights). For a rudimentary example, the retention factor for a conventionally tilled corn field will be "a priori" constrained to 50-75% rather having a theoretical range of 0-100% or just being assigned a single value. Isabella agreed with this explanation.

Dave commented his understanding is that we are using CalCAST to calibrate the WSM in the most correct places they should be made, such as RUSLE or land to water factors, as recommended by Scientific and Technical Advisory Committee (STAC). Gary said yes, we are responding to STAC’s suggestion to calibrate at a higher resolution. Additionally, we are trying to estimate uncertainty, which depends on the Water Quality Goal Implementation Team (WQGIT). Dave said while some parameters are controllable by the Modeling Workgroup, other

inputs are determined by the WQGIT and that is partially the role of the Agricultural Modeling Team (AMT). Dave expressed how with the efforts on both of these fronts, there will be a better model in the end that will still calibrate to the river observations, but just in a different way. Gary agreed, saying in every phase ancillary information is used to set up the model, like the relative infiltration rates and the Spatially Referenced Regression On Watershed (SPARROW) attributes, and the new addition in Phase 7 is doing all of that within a statistical framework.

10:30 Update on CalCAST Development: Nitrogen Component – Isabella Bertani, UMCES

Isabella provided an update on the progress made in the development of CalCAST, specifically focusing on adding the capability to predict nitrogen load. CalCAST is a relatively parsimonious Bayesian modeling tool that is being developed to test predictors and spatially calibrate parameters that will ultimately inform prediction of flow and loads at monitoring stations throughout the watershed.

Summary

Isabella began with a recap of information from the July Quarterly, such as what CalCAST is and why it exists. CalCAST's main purpose is to probabilistically test hypotheses on factors related to spatial variation in contaminant loads and quantify parameters that describe such relationships. CalCAST is similar to SPARROW. Isabella said the objective for this year is to implement the Bayesian calibration framework, get the code infrastructure up and running, and find somewhat reasonable results for hydrology, sediment, and nutrients.

Isabella introduced Nitrogen in the context of CalCAST. Isabella began with the calibration stations for total nitrogen (TN), which is based in the nontidal network at Weighted Regression Total Discharge Season (WRTDS) flow normalized loads. These are observed values.

Isabella focused on implementing Phase 6 at the National Hydrography Dataset Plus (NHDPlus) scale in CalCAST. For watershed wide average land use loading rates, Isabella explained how land use classes are grouped and the calculation for averaged loading rates. Isabella then explained the inputs for TN, their sensitivities, land to water factors, and stream delivery.

Isabella showed the estimates of the initial code structure for average loading rate of land class and land use.

Isabella compared the observed and predicted values for Total Nitrogen and Total Phosphorus. One of the lessons from this exercise was that the influence of point sources might be more influential at the finer NHDPlus scale. Isabella gave the example of a significant industrial National Pollutant Discharge Elimination System (NPDES) site in Mount Clinton, VA.

Some next steps for CalCAST involve code checking/de-bugging, building in an annual time step, and refining/improving the hydrology, sediment, and nutrients in CalCAST.

10:50 Discussion of CalCAST development

Summary

Dave asked how we should incorporate the new information from Phase 7 inputs into CalCAST. Isabella replied that the code right now is very flexible and accessible for nearly any type of data. The main issue right now may be downscaling the input to NHDPlus segment, but CalCAST can

still receive inputs at the land river segment. Isabella said we can feed Phase 7 inputs into the model as soon as they are available, which would allow for using CalCAST as a test bed for inputs like new phosphorus data for calibration. Dave concluded that arguments about using Phase 6 inputs at this point in the process are moot since the latest and greatest information will be used in CalCAST in Phase 7. Isabella agreed because Phase 6 inputs are placeholders, and we can compare calibration results with better inputs in Phase 7.

Lew asked about the parameters on slide 16 and how deep they will burrow down spatially. Isabella replied these results are basin wide and are expected to remain basin wide. From a statistical perspective, it is possible to change the spatial scale but from a management perspective we might not want to. Lew asked why we would think that these relationships are universal and why it should not be down on a whole watershed level. Isabella said if we decided to match loading rates with different parts of the watershed, we might not be able to justify on a statistical basis the differences between various parts of the watershed. Gary added that they are finding the averaged ratio between crop and natural for the entire Chesapeake watershed. For every catchment where natural and crop are sitting on the same type of geology and running into rivers in the same way and running into loading rates in the same way, then this ratio would hold. But because there will be differences in the arrangements of the geology, the inputs to cropland, and the atmospheric deposition, this ratio holds to nowhere except for the average of the entire Chesapeake Bay Watershed. Lew said his understanding is that there would be a geographically specific ratio if there was a physical reason. Gary replied if there was a physical reason, it would be in the land to water factors already.

Lew asked Isabella to reexplain slide 17. Isabella walked through the equation and table on slide 11 to provide the context for slide 17. RL is being charted on slide 17.

Robert Sabo asked if the correct way to interpret the ratio is 2 to 5% of the nitrogen deposited by atmospheric deposition is yielded by forest. Isabella explained that on slide 16, the average loading rate of cropland is 38 lbs/acre, and pasture will be 30% of that value. These ratios allow for a pound per acre watershed average that can then be modified by local inputs.

Robert Sabo asked about the use of land use terms, saying you can explain the spatial variations in loads with a few terms. Robert asked if it was worthwhile to discuss how parsimonious the model should be and what the appropriate number of terms are, and which ones are less helpful. Isabella replied they try to make it as parsimonious as possible, but there are already too many terms and not enough information for the model to estimate. Isabella said the beauty of the Bayesian approach is that we can use prior information to inform the model and the model will fall back on that prior information if it feels there is not enough data available. Robert replied this sounds like a good approach. Isabella emphasized the modeling workgroup will be able to weigh in during a transparent process on how the prior information given to CalCAST will be specified. Isabella stressed literature reviews will be conducted and the priors will be selected from a large body of work in a community driven process. Gary replied that these types of models are the opposite of academic models, so they already have the structure dictated by managers and they need to answer those specific questions. Robert added these questions can also inform future research efforts.

Samuel Canfield asked if grouping factors would be beneficial. Isabella replied she has been in favor of grouping factors because they would improve model performance, but Gary has been pushing back because this is a management model and considerations other than statistical logic must be accounted for. Samuel said grouping factors would be a natural extension of the model, especially a spatial factor, but understands there are fears of overfeeding. Participants agreed the conversation should be continued in more detail at a future Ad Hoc meeting.

11:00 Progress in Phase 7 WSM Development – Gopal Bhatt, Penn State

This quarter the NHDplus scale Phase 7 Dynamic Watershed Model (DWM) was expanded to include sediment simulation. DWM is using the nested model segmentation and hybrid process simulation structure as presented previously. Gopal provided an overview of the progress made during this quarter on the aspects of (a) incorporation of CalCAST Stormflow in an operational DWM hydrology calibration framework, (b) incorporation of CalCAST Sediment in the DWM, and (c) minor refinements to the Total Flow model calibration.

Summary

Gopal began with a reminder of the framework the dynamic model is working within and the purpose of the NHD scale for DWM, which are inputs for the estuarine models, watershed model calibration and scenario applications, and support various research and collaboration activities.

Gopal began by explaining the NHD Model for Stormflow, which includes the average annual stormflow model and the hydrology calibration method, such as HSPF land-use parameters. Gopal presented a list of incremental hydrology calibration runs and compared the results on slides 9-12. Gopal said these results show how things have changed and give us insight moving forward. Generally, the model results deteriorated somewhat as runs progressed, but improvement is expected going forward. Gopal flagged some potential issues with stormflow, such as the inability to fully verify DWM stormflow against CalCAST at the gage stations. The goal is to work on verification in the 4th quarter through simplified runs.

Gopal then focused on the NHD scale sediment model, starting with the structure of the modules. Gopal then looked at the results for daily suspended sediments (slide 15), annual loads for suspended sediment (slide 16), and annual river flow (slide 17). Gopal used the 1985 Election Day Flood as an example to look at flow results for that period and compared between the NHD model and Phase 6, with a few explanations for the likely results. Gopal showed the current calibration for sediment.

Gopal then provided an update on model run time when all the hydrology and sediment runs are included.

11:30 Discussion of Phase 7 WSM Development Progress

Summary

Lew noted that the investigative story of the 1985 Floods illustrates that if we get the hydrology and land uses right, the sediment loads will also be right.

Lew commented on slide 5 that in Phase 6 the land uses were being calibrating for base flow. The flip side is that when calibrating for stormflow with land use, information is generated that may be of interest, such as seeing more stormflow from forests than crops. Lew asked is asked if he has the following message right: we are using more information from CalCAST, such as calibrating infiltration, to better characterize inputs. Gopal said this is right and they used to calibrate the performance of baseflow at the monitoring station and land use, but now they are just are reversing where things are being calibrated (does not need to calibrate to the station

because that already is being done in CalCAST, so land uses can be calibrated at the final spatial scale), the structure is not changing. Lew recommended spending more time in a future meeting exploring the trends on slide 5.

Lew commented that the changes between Pennsylvania and New York along the state border look like data artifacts (slide 5). Lew asked if these artifacts make a difference, and if so, how to reconcile them and should we still use the principle of "use all information." Gopal said he believes those artifacts are from the data inputs, which he speculated has to do with county scale rainfall. Gopal said these artifacts merit further investigation into these inputs and how they contribute to the outputs. Clint Gill made the same comment about data artifacts on the border of Delaware and Maryland. Gopal replied to Clint, pointing out that as we discussed we will certainly look into this future and update the Modeling Workgroup on what we find. Clint replied that the differences between Maryland and Delaware were far less significant than New York and Pennsylvania. Gary said this discussion highlights some of the differences between Phase 6 and Phase 7 of the WSM approaches. Gary explained the two maps on the right are the spatial distribution of stormflow per land use category. In Phase 6, the calibration was demarcated along watershed lines, meaning everything upstream of a gauging station would be modified in a certain way. For example, if more stormflow was needed at a gauge station, every land use upstream would require infiltration rates to go down. Gary said the artifact here is due to the way geology has been characterized but explained that if the map was made for Phase 2-6, there would be artifacts along delineated watershed that happen to have gauging stations. Gary emphasized what the WSM team is attempting to do here, is to smooth the data artifacts along geologic lines using the connection between CalCAST and the DWM.

Samuel Canfield commented it's also interesting to see Tree Canopy Over Turf Grass is receiving much more stormflow than Turf Grass. Gopal cautioned against evaluating the numbers, saying the numbers will change as new data is added and data is refined. Gopal said the main takeaway point is that the presence of differences between land use. Gopal said comments like Samuel's will be interesting farther down the line. This conversation was relegated to the parking lot for discussion at a future modeling team meeting given time constraints.

Karl Berger asked why would wetland forest have more stormflow than forest? Gopal speculated it might be due to the location of the land uses but emphasized these are preliminary results and are data driven. This conversation was relegated to the parking lot for discussion at a future modeling team meeting given time constraints.

Guido asked if there will be a difference between how Phase 6 and Phase 7 treat reservoirs, specifically if finer resolution will facilitate water quality simulation. Gopal replied either directly or indirectly, as was done in Phase 6, there will be a simulation for reservoirs. There is a plan to include storm ponds as well given their impact on water quality. Gopal said on the DWM and CalCAST sides, there is an opportunity to capture reservoir rules in the hydrology simulation where data is available.

Gary Shenk commented the points being brought up are exactly what the WSM team are hoping to get into in the years 2023-2025. The structures that Gopal and Isabella have created this year allow us to ask those questions and explore answers.

11:40 Development of Efficient Multi-Objective Optimization Procedures – Gregorio Toscano, Kalyan Deb, Pouyan Nejadhashemi, Rafiei Vahid, and Hoda Razavi, MSU

Progress in the development of efficient multi-objective (MO) optimization procedures including developing generative MO optimization using the current hybrid optimization procedure developed and to develop simultaneous MO customized optimization using population-based evolutionary algorithms.

Summary

Gregorio provided a reminder of the benefits of multi-objective optimization for Best Management Practice (BMP) allocation for two objectives: cost and load. He then showed some convergence plots, and maps for cost, nutrient reduction, and BMP implementation. One lesson learned from previous studies is that optimization can benefit when optimizing more counties.

Gregorio overviewed the newly developed web interface and how it can be used. Gregorio emphasized the problems that have been resolved to ensure the optimization works well. Gregorio explained the computational infrastructure needed and how it was used to assemble the API needed to interact with CoreCAST. Gregorio explained how the API interface is designed and used.

Gregorio concluded with some take home messages and next steps.

12:10 Optimization Discussion

Summary

On slide 6, Lew asked if it is possible to evaluate the cost for phosphorus and sediment in addition to nitrogen. Gregorio replied yes this is possible because the application programming interface (API) is parametric.

Lew asked what can be learned from the types of BMPs behind the inflection points in the cost-load curve on slide 6. Kalyan commented this is an excellent point which demonstrates innovation through optimization, and that the pareto front may appear completely different in a different county or state. When each county looks at their cost-load curve and compares it with their cost budget, they can determine which BMPs can give them their quickest reductions in the pollutant being optimized. Kalyan added that since only finite solutions have been provided initially, a local optimization can be run which would match a solution for that organization's cost budget.

Lew asked if this optimization framework can be used for Watershed Implementation Plans (WIPs). Gregorio replied yes, this is an option.

Lew suggested putting together a webinar to explain the results and how to use the interactive API, perhaps at a quarterly mid-2023. Kalyan agreed with the timeline and said that since the optimization framework calls CoreCAST, it will always be using the most recent version of CAST. Kalyan said one of the more challenging components to visualize is optimizing in 4-dimensional space.

Dave reiterated the value of creating a parameter versus cost optimization that encompasses nitrogen, phosphorus, and sediment since that can be easily translated for managers.

Olivia Devereux asked about the timeframe for incorporating manure BMPs into the algorithm. Gregorio said with the new team members starting, they plan on taking these types of BMPs on soon and have a goal of implementing them by the next quarterly review. Lew and Dave said

they need to have all BMPs of interest in the model before engaging with the CBP partnership and producing a webinar.

Olivia Devereux asked if it is possible to set a base scenario with the BMPs already in place (a progress scenario) instead of a no action, no BMP, scenario. Lew said it was a good idea to use different base scenarios and expressed interest in comparing progress scenarios with a base case. Gregorio replied they do not have the progress scenario currently defined, but it could easily be developed. Olivia clarified she is not asking about those parameters, but instead those that are currently implemented on the ground, which are defined in a scenario in the source database for a typical year. Olivia said the value from this scenario would be that it focuses on optimizing for BMPs while accounting for what has already been implemented. Kalyan said he believes they are currently using CAST 19 progress and perhaps they could evaluate the current costs to get to the current level of implementation and then optimize from there. Gregorio said that should be possible. Olivia commented the relationship in the current version of CAST in the nutrients applied and loads reports is visible.

Robert Sabo asked if Gregorio could include an option related to fertilizer data in the optimization framework, perhaps as a latent factor given that farmers in the Chesapeake Bay watershed have increased nutrient efficiency. Gregorio replied they will investigate accounting for fertilizer data via a custom approach and that it might make sense to consider it in terms of multi-objective optimization. Kalyan added with some collaboration, this should be feasible, and fertilizer can be considered on top of the progress scenario. Gary said he thinks fertilizer is already accounted for in optimization through BMPs related to fertilizer sales. Robert asked a follow up question about relative fertilizer use declines in the Bay watershed from 1990s to 2010 and if that is captured by nutrients in the CAST model or if it is simply a fact that farmers were buying less fertilizer. Gary replied the past is captured by fertilizer sales and there is a ratio of application to nutrient management rates that is based on total mass available and the total expected application rate. That application rate is extended into the future unless more nutrient management is implemented. Gary emphasized it is all relative to the base scenario. Robert replied that if this is better communicated, it can be powerful. Lew replied that reducing nutrient input seems accounted for, but what about nutrient uptake by crops. Gary replied that is a task being investigated by the AMT.

Lew said we have a history of increasing crop yields and asked if we would ever want to scenario uptake by future plants. Gary replied that as uptake increases, CAST accounts for this with increasing yields. Gary added this will also be looked at by the AMT and said that these are definitely things we have on the schedule to look at. Robert added that the release of the new Agricultural census data will help inform this conversation as well.

12:20 Formation of the Agricultural Modeling Team – Tom Butler, EPA-CBPO

Tom described the status of the Ag Modeling Team and its role in determining the agricultural data inputs for the Phase 7 Watershed Model. Tom provided background for how this group will function in collaboration with the Modeling Workgroup.

Summary

Tom began with an explanation of the AMT, explaining that it is not modifying the model, only looking at technical inputs. Membership in the AMT will have 12 voting members. All interested parties are invited to attend and participate in the discussion. Tom showed where the AMT fits within the hierarchy of the CBP.

Tom laid out the approach for how the AMT will support the Agricultural Workgroup with agricultural input decisions for the Phase 7 Watershed model. Tom gave an update on partnership requested topics, including how this connects to the Modeling Workgroup and where they are in the timeline.

12:30 Discussion of Agricultural Modeling Work Group

Summary

Robert Sabo said we need to track the amount of nutrient surpluses on agricultural land across the watershed through time, and was wondering if that would be a topic of the discussion for the AMT. Tom said this could fall within one of the topics the group is focusing on, and if it was determined that the topic does not fall in the pre-approved topics, it would need to be vetted by the team and then added to the queue. Robert expressed interest in exploring metrics of how farmers are improving nutrient efficiency. Robert said he will help support this group and that he can attend the meetings. Tom said he will make sure to include him.

Lew said to keep the end in the mind, we need to look at 2035 for climate change and beyond due to the challenges posed by changes in phenology and longer growing seasons. Lew expressed the need to keep in mind forcing factors induced by climate change. Tom agreed this is a good point and said the AMT will be covering climate change.

Robert shared some conclusions from element modeling done in the Mississippi River Basin, which showed that even with a near 100% reduction on surplus nutrients it would take decades to reach the goals for the Gulf of Mexico hypoxia task force goals. While the element modeling found a more reasonable timeframe response for the Chesapeake Bay (5-15 years), Robert said he wonders if organic legacy of nitrogen effects in the soil should be classified as another consideration for agricultural nutrient management. Some other questions might include has the soil been saturated with nitrogen or is it simply a hydrologic effect. Robert said he knows there is already a legacy phosphorus assessment, so maybe one already exists for nitrogen or could be developed. Tom agreed this is a good point.

12:40 ADJOURN

Participants: Alex Gunnerson, Arianna Johns, Bill Keeling, Breck Sullivan, Carlington Wallace, Cassie Davis, Clifton Bell, Clint Gill, Dave Montali, Doug Austin, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano-Pulido, Guido Yactayo, Hoda Razavi, Isabella Bertani, Jeff Sweeney, Jeremy Hanson, Jeremy Testa, Jesse Bash, Jessica Rodriguez, Jiabi Du, Jian Shen, John Clune, Jonathan Leiman, Joseph Zhang, Kalyanmoy Deb, Karinna Nunez, Karl Berger, Karl Blankenship, Kaylyn Gootman, KC Filippino, Leonard Schugam, Lew Linker, Lisa Beatty, Mark Bennet, Megan Thynge, Mukhtar Ibrahim, Nicole Cai, Normand Goulet, Olivia Devereux, Pouyan Nejadhashemi, Rafiei Vahid, Raj Bojja, Rebecca Murphy, Richard Tian, Robert Burgholzer, Robert Sabo, Sam Merrill, Samuel Canfield, Scott Heidel, Sophia Grossweiler, Ted Tesler, Tim Paris, Tom Butler, Zhengua Jin, Zhengui Wang.

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9:00 Announcements and Amendments to the Agenda – Dave Montali, Tetra Tech and Mark Bennett, USGS

9:05 Update on Main Bay Model (MBM) Progress – Joseph Zhang, VIMS

Joseph presented the first results with the almost completed code for MBM, and discuss some key questions and plans for (1) the SAV simulation approach in the MBM and related revision of the MBM mesh, (2) the PIP, G1, G2, G3 approach in sediment and water column, (3) incorporation of the shoreline erosion data, and (4) the treatment of iron-oxyhydroxides as either a simulated state variable or dealt with by a "key" to a date, or temp, or DO turnover event. The data sets for oyster biomass of the different oyster groups and sediment/nutrient inputs from tidal shorelines was provided to the MBM Team.

Summary

Joseph began with Task 1, Model Implementation and Verification, that the MBM team is working on. Joseph explained MBM design, and the two steps required in that process: Hydrology step and (ICM) + (SED) step. Another part of Task 1 is the validation of new code, which requires the model set up and coupling for hydrodynamics, for waves, for sediment transport, and for ICM. Joseph then showed the preliminary, first results of validation of the new code for Total Suspended Solids (TSS), Chlorophyll-a (CHL-A), and Dissolved Oxygen (DO). Joseph highlighted that two forms of PIP will be focused on for future study based on these results.

Joseph gave an update on Task 4 as well, which is focused on communication and model documentation. Joseph displayed the interface and outputs of the MBM web app.

Joseph shared the focus of ongoing work is revision of the MBM mesh, calibration of the code, and evaluating the two outlined SAV approaches. Joseph concluded with a summary of the work and next steps.

9:40 Discussion of the Main Bay Model (MBM) Progress

Summary

Lew commented on how this was a great presentation, and he admires the collaborative approach the MBM team is taking. Lew suggested continuing to provide comparisons for managers to prove that Phase 7 MBM is as good or better than Phase 6.

Lew recommended that Carl Cerco comment on the state of simulation in the MBM at some point down the road.

Larry Sanford asked how the MBM team is specifying the wind field over the Bay. Joseph replied they are using The North American Regional Reanalysis (NARR) model data, which produces an estimation for the wave field, but are just using the observed wind field data since they got better results with that data.

Raleigh Hood asked about SAV simulation and the specification of the distribution for the climate change version. Raleigh asked if the area for simulation can change in the future. Joseph replied they do not have other observations for future projections, so they seed SAV using available parameters and let the model decide if SAV survives. Raleigh asked why the period from 1990-2000 is being used for the simulation and said any results might be more conservative since SAV has greatly expanded since then. Joseph agreed and said that is why the MBM team has been considering taking data observation from all of the years. Lew added that the team is required by the CBP to look at 1991-2000 for calibration since that is the average hydrology and requires a large calibration effort. Lew agreed with Raleigh's point and said that foreshadows future work on SAV simulation and that Joseph and the MBM team are exploring options. Carl Cerco commented that when the CBP did the WIPs, they looked at data going back to the 1930s, which was the earliest observations and largest extent of SAV in the Bay. Carl suggested looking at that data as a good place to start with the SAV simulation work in a different period. Lew suggested counting up the greatest historical extend of SAV using that data Carl pointed out and use that as criteria. Joseph agreed.

Carl said he is supporting the MBM team on the filter feeder portion of the model. Lew asked if freshwater filter feeders and clams are included. Carl said he does not know and will refer to the documentation, but that the values may have been within tuning of the range of observations. Lew suggested the team use literature derived variables.

9:50 Update on Designated Use (DU) Modification for CB6 and CB7 – Tish Robertson, DEQ and Richard Tian, UMCES-CBPO

The northernmost portions of the CB6PH and CB7PH segments are designated for both the Deep Water and Open Water uses, while the remaining portions are only designated for the Open Water use. However, the presence of a pycnocline in wider areas of the two segments than represented in published documentation on the DU boundaries (USEPA, 2003) indicates an expansion of the Deep Water designated use is warranted for the two segments. Tish and Richard provided an overview of the DU modification work and the modeling analysis that supports it.

Summary

Tish began with some recap from the previous quarterly about why this conversation is being brought up. Tish then provided an overview of the DU modification work and the modeling analysis that supports it.

10:00 Discussion of Analysis for DU Mod for CB6 & CB7

Summary

Dave said he thinks this is a reasonable and defensible approach. Dave asked about how the decision to include high resolution for Mobjack Bay in the York River MTM might affect designated uses and if other non-mainstem segments might see an investigation into designated use boundaries. Tish replied that is a great question and she has only explored a broader revision in the last few days. Tish said based on the maps Richard provided, it looks like the new areas of deep channel designated use on either side of Mobjack Bay would be connected via similar physical characteristics. While nothing about this has been put on paper yet, Tish said her management would be interested in that type of change.

Richard Tian suggested extending the York deep water designated use downstream to the boundary of CB6, perhaps down at the mouth of the York. Tish replied that makes sense. Richard asked when the new boundaries for CB 6 and CB 7 might be approved. Tish said optimistically, perhaps in two years, but rulemaking tends to take longer.

Lew asked about slide 5, if the x on the line represents readings less than 3 mg/L. Tish replied it means there is at least one observation during that monitoring event where the dissolved oxygen reading was less than 3 mg/L below the pycnocline. Lew concluded there was not a way to escape times where it is less than the deep-water criteria. Lew replied it bears repeating that CB 6 and CB 7 are unique in that they are the only place where a pycnocline is regularly present and an open water designation throughout. Lew said this was fine when the designated uses were first implemented in the 1980s and 1990s, but climate change has disrupted the designated use and there is precedent for change as the designated uses in those segments have been adjusted before. Lew said climate change does three things: increases stratification, decreases dissolved oxygen because of warming temperatures and lower solubility of oxygen in water, and increases respiration. Tish said she used 3 mg/L as the threshold because that is the threshold for deep water hypoxia.

Lew asked when we might expect a final report and analysis on this. Tish said her self-imposed deadline is to get a report to management by the end of the year and she is receiving support on this from the Criteria Assessment Protocol. Assuming the report is submitted by then and there are no other delays, Tish should be able to present an update at the next Modeling Quarterly.

Lew reiterated that the Modeling Workgroup does not make the final decisions on designated uses, it only reviews the technical analysis and the work completed.

10:10 Progress on Phase 7 Watershed and Tidal Water Model Boundaries – Andy Fitch, USGS-CBPO and Karinna Nunez, VIMS

Andy and Karinna described progress in the shoreline product of updated and refined model boundaries for the Phase 7 Watershed Model, MBM, and MTMs including spatially detailed estimates of the tidal wetlands.

Summary

Andy and Karinna described progress in the shoreline product of updated and refined model boundaries for the Phase 7 Watershed Model, MBM, and MTMs including spatially detailed estimates of the tidal wetlands.

10:25 Discussion of Phase 7 Watershed and Tidal Water Model Boundaries Including How Sea Level Rise Will Be Simulated in Future Climate Change Scenarios

Summary

Dave said his understanding is that within the next quarter, a draft Phase 7 shoreline layer will be completed. Dave asked if this timing works for the MBM and WSM team. Lew said he believes the timing works well.

Lew said the MBM team has graciously agreed to provide a first order water quality assessment of the coastal bays in Virginia, Maryland, and Delaware in addition to their large task of building the next generation Chesapeake Bay water quality model. Lew said this shoreline layer helps advance that work on coastal bays. Kristin Saunders replied that is a great gift and asked if there are any particular interested partners we should notify about the additional information modeled for those coastal bay areas. Kristin offered to make a connection, if it is helpful. Lew responded we should hold off a bit I think because it would be useful to makes some progress in the coastal bays and ensure we are on the right track with the calibration before we go forward with the work for potential new users. Kristin said it's a standing offer, so whenever timing is right to let her know.

Larry Sanford asked what the shoreline for the estuary model is defined as, specifically if it was mean high or high water. Andy replied originally the goal was mean high or high water for the entire Bay, but since the NOAA data had some difficulty discerning features in low lying areas, they ended up using the VIMS data which is a mixture of sources. Karinna added the VIMS data comes from a variety of sources, like photo interpretation from the latest available imagery and delineation between wet and dry. Larry was wondering if the boundary for the Phase 7 WSM is the same as the estuary model. Andy said he is not sure because it depends on the rasterization of the draft segmentation and depends on how it looks when completed. Joseph said the MBM team's aspiration is to have the same boundary, but they need to consider some other factors first. Gary said conceptually, they want the boundaries to be the same, so every acre of wetland is included in the estuarine model and all atmospheric deposition is included in one of the two models. The catch, Gary pointed out, is that the estuarine model does not want to have a cell up into every small part of tidally influence waters and that the watershed model does not have as explicit of a spatial component as the values are aggregated up to the segment scale. Gary said as long as the lands that are supposed to be in each watershed model cell are attributed to that cell, it should be alright. Lew added final comments, saying all of the land uses except for tidal wetlands will be the WSM domain and the tidal wetlands will be represented as a generalized tidal wetland, so the area is being tracked and the associated characteristics are being applied. Lew said we will need to consider atmospheric deposition to tidal wetlands as well and make sure they are not left out, although that bridge can be crossed when it arrives.

10:40 Wave Simulation – Jiabi Du, VIMS

The simulation results from a fully two-way coupled waves-sediment transport model (SCHISM-SED3D-WWM) were presented, using four sediment classes (sand, silt, and 2 classes of clays). This model is a critical component of the MBM and will provide the water quality model with the simulated TSS.

Summary

Jiabi began with an overview of the motivations for this work within the SCHISM Modeling system, as well as basic information about the wave model set up and computational efficiency. Jiabi discussed wave model performance and direction before giving an example of wave height and attenuation during Hurricane Sandy. Using this example, there was much wave energy dissipation near the mouth and the model did well at the mouth, but it underestimated wave height in the middle-upper bay. It improved greatly in the middle bay when it was corrected for wind.

11:00 Discussion of Wave Simulation and Bottom Resuspension

Summary

Lew gave a reminder that shoreline erosion loads are essentially equivalent to the riverine delivered loads, in terms of mass. Lew asked if we should make a link between high wave energy and high tidal shoreline mass wasting. Lew said this is not a decision, but instead a consideration for the MBM and MTMs. Joseph replied they are hesitant to get into that kind of detail, for the moment they are using the currently available data from the CBP. Lew said that is a fair comment and said we could explore this again in the future to explore more mass wasting. Jiabi said decisions are up to the group and said he believes the wave height and energy can be used to feed other models since it would be difficult for SCHISM to simulate erosion directly.

Carl said originally, they had shoreline erosion proportional to wave energy at the daily time scale, but the CBP wanted shoreline erosion in the WSM due to management reasons. Before the sediment transport team goes too far with how to put shoreline erosion in the MBM, Carl advised being careful as the CBP might decide to put it in the watershed model. Lew said Carl's point is excellent and management actions like bank stabilization needs to be accounted for. Carl cautioned against going too far forward with calibrating the tributaries before the WSM loads incorporated.

Carl asked if they have the watershed model loads in the sediment transport. Joseph replied he does not think they have incorporated it yet. Jiabi replied they have not incorporated that part of the WSM into the model yet, but they have included flow. Jiabi said they should be able to do so in the future, but it tends to have limited impact since sediment can settle down quickly. Jiabi's suggestion is to add the WSM load, but for the mainstem the resuspension of sediment is dominant. Lew agreed, saying settling is a huge attention for shoreline erosion. Lew said using a tracer study, they found 90% of the Susquehanna's sediment settled in CB 1 and 90% of the remaining 10% settled in the adjoining segment. Lew said this phenomenon would be even more prevalent with shoreline erosion since the depth is very shallow.

11:10 CHAMP Program Update – Marjy Friedrichs and Pierre St-Laurent, VIMS

An update on the multiyear Chesapeake Hypoxia Analysis and Modeling Project (CHAMP) that has supported the CBP climate change assessment and other areas was presented.

Summary

Marjy began with an overview of the CHAMP program, its purpose, and those involved. Marjy defined the atmospheric, land, and coastal inputs to orient the following results. Marjy followed this with a list of CHAMP results and ongoing work.

Marjy highlighted some future ongoing work related to model runs, increasing grid resolution, and going beyond hypoxia.

11:30 Discussion of CHAMP program

Summary

Lew emphasized that CHAMP has made a substantial contribution to the Chesapeake Bay Program's work related to modeling in general, but especially climate change modeling. Lew thanked Marjy and the CHAMP team for all the work they have put into explaining what is happening in the Bay and why it is happening. Marjy said the project members have enjoyed contributing to the body of work in the CBP partnership.

Marjy commented that the CHAMP team has been supporting the MBM team by providing information and hopes to continue to contribute by looking at the same problems in different ways, with different models and different teams. Lew said this is great to hear and will strengthen Phase 7 model development.

11:40 Update on Multiple Tributary Model (MTM) Selection – Alex Gunnerson, CRC

An update on the guidance for the selection of MTMs supported by an EPA Request for Assistance (RFA) that will support up to three Multiple Tributary Model (MTM) teams over five years. The CBPO can also support two in-house MTM teams. The MTM teams might begin in the first Quarter of 2023 with the following timeline: 2025 Fully Operational MTMs, 2026 CBP Review of MTMs, and 2027 CBP Application of MTMs. The WQGIT will recommend to the Management Board the five tributaries for MTM development along with the York MTM.

Summary

Alex Gunnerson began with some context as to why the MTMs are being developed, before he transitioned to explaining the process used to produce two options for MTM selection to the Management Board. Alex described the cross-partnership input used to inform the creation of the recommended tributaries for finer resolution modeling and the results of the exercises. Alex concluded with the next steps and the path being taken to come to a decision at the Management Board in November.

12:00 Discussion of Approaches to MTM Selection

Summary

Joseph asked about the timeline and expressed that it seems very aggressive given an RFA has yet to be released. Alex replied that it is a potential timeline, and it is flexible to being moved back. Alex said we do not want to rush the decision-making process, but the longer it takes for a team to start the less time they have to develop the MTMs and collaborate. Lew added there are a

lot of moving parts, and the timeline depends on how fast the RFA can be processed through the grants team. Lew acknowledged the timeline is very aggressive but said it needs to be to ensure success because the teams will only have three years to develop, one year to review, and one year to apply. Lew and Alex will work to ensure the MTM teams have what they need and can meet the aggressive timeline. Joseph said the timeline is very optimistic, but he hopes it can be met. Lew said the work of Nicole and Richard to develop boundary conditions and prototype the MTMs will be essential to ensuring the timeline can be met.

Samuel Canfield asked what the final combination of reasons was for doing the James via the in-house option. Alex explained that specific needs of Virginia DEQ for the chlorophyll-a assessment meant it would be better addressed by a team of modelers already familiar with the details of the James chlorophyll-a criteria. Lew added that in-house is a bit of a misnomer because Joseph and the MBM team have already though about how the incorporate the MTM teams into development and for the facilitation of communication and information exchange. The MBM process has been deeply collaborative and that will continue when the MTM teams are brought on. Lew added that given the immediate management applications needed for the Potomac and James, and Nicole's intimate knowledge with the York, it made sense for these tributaries to be addressed by the current team of modelers in the CBP partnership. Jeremy Hanson agreed that there will be a lot of collaboration regardless of a model being completed through an RFA or through the CBP Modeling team.

12:10 Progress on MTMs in the Potomac and Choptank Rivers – Nicole Cai, EPA ORISE and Richard Tian, UMCES-CBPO

Richard and Nicole discussed initial progress on the set up of the Choptank and Potomac MTMs.

Summary

Nicole showed the initial work for the Potomac MTM, discussing data inputs, the grid, loadings, and an evaluation of preliminary results.

Richard showed the initial work for the Choptank MTM, providing some overall information about the data inputs and current draft of the grid in detail.

12:30 Discussion of the Potomac and Choptank River Progress

Summary

Lew asked if there was a shipping channel resolved into the deep channel and if it mattered. Nicole said they added a channel because they found it in the nautical charts. Lew asked if the navigation channel was added across the Rappahannock shoal but then it added to much salt. Nicole said they realized there was a channel from Mobjack Bay to the Rappahannock and it was captured by the nautical chart, so they decided to add it because they are adding resolution. Nicole also said the channel is coarser than it should be and that is bringing in more salt than needed. Lew said it looks like the channel across Rappahannock shoal is represented.

Joseph asked why Richard is not using the same approach Nicole for the grid. Joseph explained the typical approach is to first define the channel using quads since that is where most of the

water transport is occurring. Two triangles can also be combined into one quad, which is much more efficient. Joseph said maybe that is worth looking into. Richard said he found triangles to be similar. Joseph said that quads are still more efficient, and they better align with channel flow. Joseph said Jiabi has already refined the Choptank so he will send it to Richard, and he can edit as he sees fit. Richard said he ran the Patuxent with quadrilateral cells, and it ended up being slow. Joseph said you need to look at the number of elements which ultimately matters most, so maybe more quads would be necessary.

Joseph asked why Richard is using nearest neighbor to begin with, since typically they use linear interpolation with a higher resolution grid. Richard said he used nearest neighbor because it was the default method and then realized some areas to be interpolated were above the sea level, so if you use the linear interpolation, it creates issues where they are on dry land. Joseph said that if the channel is first designated in SMS using quads lined properly, the issue brought up here with linear interpolation can be resolved. Richard said he did this in ArcGIS so he was not able to use the techniques in SMS, but he will keep these comments in mind as this is just a first draft.

Lew said it would be wise to set up standard operating procedures for the development of MTMs, especially related to grids and boundary conditions. This will prevent the generation of artifacts

Raleigh Hood commented he lives on the Choptank and noted virtually all the houses in exposed areas have hardened shorelines.

Jian Shen commented about grid and his concern about the open boundary and said the way the boundary has been set up; it would require two-way coupling. But because two-way coupling is not feasible right now for the MBM, the boundary set up would need to change. Jian said there is a tradeoff with boundary conditions and loading resolution. Richard replied that will be taken into account and said he was doing this to avoid losing interaction between the mainstem Bay and tributaries. Richard also said because they wise to include the Little Choptank, that requires a larger open boundary.

Carl said there was a data layer about the condition of the shoreline completed back in the day. Carl does not know where the dataset is but said someone at VIMS probably knows. Joseph said VIMS has a layer that includes this, and he will ask Karinna to send it to Richard. Richard said he did the contour of the data above 1m for sea level, but it was disturbed by the houses which complicated matters.

Richard asked if Jian has an idea about typical water depths for tidal wetlands. Jian said the calibration will not be affected by these small changes in area but will be affected by climate change with 1-meter increments in terms of inundation. Jian said that is the largest scale they need to cover. Jian suggested expanding the boundary and including the wet and dry in the domain but reducing resolution. Lew said all of these points will be included in the standard operating procedures. Nicole talked added that she did two experiments with Coastal National Elevation Database (CoNED) data in the York River. Nicole ended up controlling the channel but left the wetland definitions up to data inputs.

Nicole cautioned against purely relying on CoNED data and said it would influence salinity and tidal energy. Nicole suggested referring to the NOAA bathymetry dataset for a reasonable range of channel bathymetry. Nicole shared these charts with Richard so he could use them for the Choptank. Richard asked where Nicole stops for the quads in channels. Nicole said in answering

where to stops, she used the location where Curvilinear-grid Hydrodynamics 3D model (CH3D) stopped. Joseph said where you stop the quads is really a judgement call depending on the system. Richard said he did not find significant differences with quads and Joseph explained it is very system dependent.

Norm said we will need to expand the role of local stakeholders that are involved in the development of these models. Norm emphasized the need to go beyond just the Modeling Workgroup and CBP, saying we need to bring a variety of experts (like academics and riverkeepers) so there is a combination of those with local knowledge who can weigh in and provide local context. We will also need to brief them on the happenings of the CBP, so they know the context. Lew heartily agreed and said this will be part of the MTM teams' task, to develop, review, and apply the models with outreach on all components. Richard asked if other workgroups could play a role in helping with this. Norm said perhaps other workgroups can play a role, but to reach the targeted experts we will probably have to go beyond regular members of the CBP partnership. Dave expressed concerns about having time and funding to do all this outreach because it will require significant effort. Dave said maybe if the outreach can be consolidated into more straightforward questions it will be more feasible, but unsure of how to do it in the RFA. Lew said a lot of the responsibility will fall to the project officer, but they will work to thread that needle.

12:40 ADJOURN

Participants: Alex Gunnerson, Amanda Small, Andy Fitch, Angie Wei, Arianna Johns, Bill Keeling, Breck Sullivan, Carl Cerco, Carl Friedrichs, Cassie Davis, Clifton Bell, Dave Montali, Gary Shenk, George Onyullo, Gopal Bhatt, Gregorio Toscano Pulido, Isabella Bertani, Jeremy Hanson, Jeremy Testa, Jesse Bash, Jessica Rodriguez, Jiabi Du, Jian Shen, Joseph Zhang, Karinna Nunez, Karl Berger, KC Filippino, Kristin Saunders, Kyle Hinson, Larry Sanford, Leonard Schugam, Lew Linker, Lisa Beatty, Marjy Friedrichs, Mark Bennet, Mukhtar Ibrahim, Nicole Cai, Normand Goulet, Pierre St. Laurent, Raleigh Hood, Rebecca Murphy, Richard Tian, Sam Merrill, Samuel Canfield, Scott Heidel, Sophia Grossweiler, Tish Robertson, Tom Butler, Zhengui Wang.