THE WATER INSTITUTE
OF THE GULF

Numerical Modeling of the Louisiana, Mississippi, and Alabama Coastal System (LMACS)

MODEL INVENTORY AND RECOMMENDATIONS

March 6, 2020

P. Soupy Dalyander, Michael Miner, Alyssa Dausman, Charley Cameron,
Noel Dudeck, and Ioannis Georgiou

Introduction

Considerable investment has been made in the development of numerical models, data access portals, and decision-support frameworks in the northern Gulf of Mexico. Despite this investment, existing tools are rarely leveraged in restoration project planning. Instead, planners often support the costly development of customized tools for their specific needs or, where resources are limited, rely on best professional judgement to inform project selection or prioritization. Through the support of NOAA's National Marine Fisheries Service (NMFS) Restoration Center, the Water Institute of the Gulf ("the Institute") developed and piloted strategies to increase awareness of, and collaboration across, ongoing numerical modeling efforts to enable more effective application of models to inform coastal resources management and restoration decisions. The Institute's effort focused on models that resolve the hydrodynamics and water quality of Louisiana, Mississippi, and Alabama coastal systems (LMACS), including the basins of Mississippi Sound and Pontchartrain-Breton Sound (Figure 1), and on tools to predict habitat suitability or distribution of associated species (Gulf sturgeon, oysters, etc.). To complement this effort, the Institute built a list of existing numerical models for the LMACS region that can be leveraged in coastal resource management (provided in a separate file, "LMACS_Hydro_WQ_Model_Inventory.xlsx").

Objectives

The overarching goal of the LMACS project was to enable more effective, cost-efficient, and informed decision-making in the management of the LMACS region. There are two specific objectives associated with this goal:

1. To further the establishment of a community of practice that consists of scientists, engineers, decision-makers, and stakeholders with an interest in hydrodynamics, water quality, and habitat suitability within the LMACS.
2. Inventory existing predictive models that can be leveraged to evaluate hydrodynamic and water quality changes in the LMACS region, along with changes in habitat suitability for associated species.

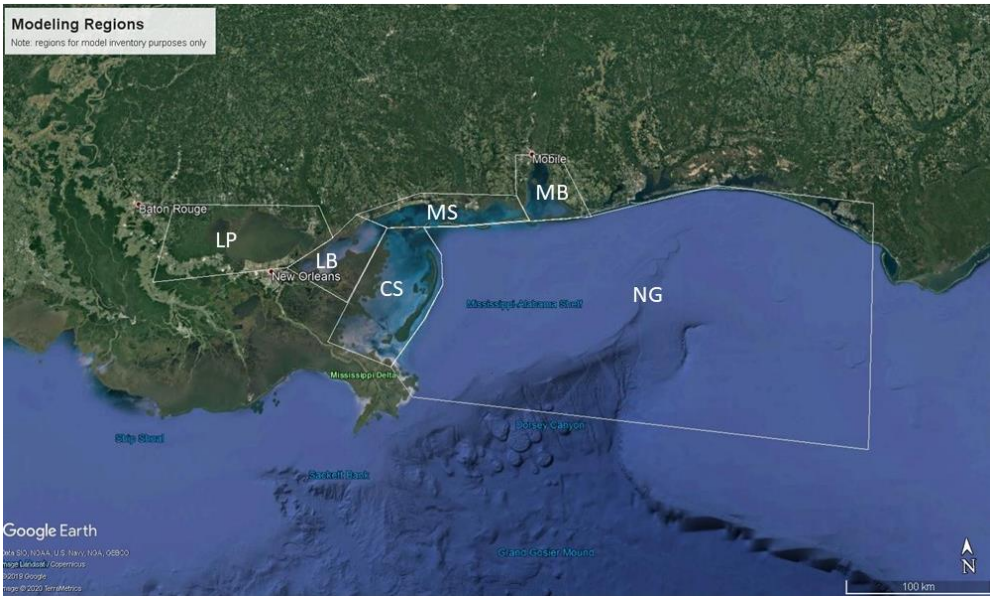

Figure 1. Louisiana, Mississippi, and Alabama Coastal System (LMACS). White polygons delineate the subregions used in the model inventory: LP, Lake Pontchartrain; LB, Lake Borgne; CS, Chandeleur Sound; MS, Mississippi Sound; MB, Mobile Bay; and NG, Northern Gulf. The subregions together comprise the overall region of interest for this project.

Approach

Three primary approaches were used to meet the project objectives. The first component was a background and literature review, designed to (a) inform development of the model inventory and (b) identify individuals with capacity and/or expertise in hydrodynamics, water quality, and marine/estuarine species to be included in a network of LMACS practitioners. To accomplish this, the Institute evaluated the peer-reviewed scientific literature (journal manuscripts) as well as relevant government, non-profit, and academic reports. In addition, the Institute identified prior and ongoing model coordination efforts that could be leveraged for this project.

The second component consisted of identifying and networking model practitioners and stakeholders with interest and expertise in the region of interest. These individuals and entities (e.g., state agencies; research institutions, etc.) were identified in multiple ways, including through authorship on relevant reports; prior participation in modeling communities of practice; and surveying of identified participations (i.e., making use of each identified participant's own professional acquaintances and knowledge of the field). Prior and ongoing efforts to coordinate practitioners with relevant expertise to the area and region of focus here were also leveraged where possible.

The last component of the project was to develop and pilot strategies that can advance the use of numerical models in coastal resource management. The Institute team identified several factors that inhibit more widespread use of existing numerical models in resource management application. One reason that leveraging opportunities are not identified is that support for tool development often does not include resources for improving the visibility of the outcomes or facilitating their access by the non-technical community. Decision-makers may also find it challenging to identify appropriate existing tools

because the range of variability in models is large, making it difficult for a someone with a non-technical background to evaluate the range of available options that may vary widely in the environmental parameters predicted (hydrodynamic, habitat suitability, etc.), spatial domain and resolution, time period and type of simulation, degree of validation, and underlying formulation. Answering a management question may potentially require the use of output from multiple prior modeling efforts, making it even more difficult for a decision-maker to identify when existing tools could be combined and utilized for their purposes.

To overcome these challenges, the team developed a facilitated workshop approach to bring together decision-makers and modelers to work together in developing model-based tools to support specific management decisions related to the LMACS.

Outcomes

APPROACHES FOR INCREASING COORDINATION AND COLLABORATION

Prior and Ongoing Model Coordination Efforts in the northern Gulf of Mexico

The team identified several prior and ongoing modeling coordination efforts within the LMACS region of various scope that could be leveraged under this project. The first effort, coordinated by the U.S. Geological Survey (point of contact: Greg Steyer), focused on establishing a modeling community of practice for the Gulf region. This effort was initiated in 2018 and included the use of an online survey to query practitioners on available models for the Gulf (Texas through Florida). The scope of this previous coordination effort was broader than the current effort in terms of spatial region and the types of models included. Relevant models from the Gulf modeling community of practice have been included in the LMACS model inventory. Additionally, Gulf modeling community of practice participants with expertise in the LMACS region were invited to attend the workshops. For the Louisiana coastal areas, the Louisiana Department of Natural Resources (LDNR) supported the development of a model inventory for the Louisiana Coastal Zone[1]. In addition, the Louisiana Coastal Information Management Systems (CIMS; https://cims.coastal.louisiana.gov/masterplan/) includes a model inventory that delineates the domains of models that have been applied in this region. These inventories primarily focus on Louisiana state waters, with some models extending out into Mississippi Sound and the northern Gulf of Mexico. Models from the LDNR and CIMS inventories that are relevant to the area and focus of interest have been included in the current model inventory.

Facilitated Decision-Maker, Stakeholder, and Modeler Workshops

Prior to conducting workshops, the Institute discussed high priority management needs with stakeholders and decision-makers to identify a selection of key concerns that could be informed through predictive

[1] Dragos, P., and Wisneski, C. 2010. *An inventory of hydrodynamic, water quality, and ecosystem models applied to the Louisiana Coastal Zone. Final Report in support of LADNR Contract Number 2503-07-12.* Duxbury, Massachusetts: Batelle, 167 p.

model application. The team then identified researchers and model developers who had existing frameworks that could potentially be leveraged for the identified management needs. These decision-makers and modelers, along with facilitators from the Institute, comprised the workshop attendees.

The workshops were structured to begin with an overview of the goals of the project and attendee introductions. A facilitator then gave a short "Models 101" presentation covering the basic principles used to select or develop a predictive model framework. This presentation was designed to establish a common lexicon for workshop attendees and provide a baseline understanding of practical considerations in model development for stakeholders who might be less familiar with choices that must be made in setting up a model. For example, this presentation included an overview of types of models (deterministic vs. probabilistic); definitions of model terms; and considerations in model development. The decision-makers then presented overviews of their high-priority management concerns. Finally, the full group engaged in a facilitated discussion to identify the specific requirements of a predictive model that would be necessary to inform the identified management decisions and/or actions.

This approach was piloted in two settings. The first was an in-person workshop that brought together decision-makers and modelers with an interest in the hydrodynamics and water quality of a subset of the LMACS, specifically the Mississippi Sound. This workshop was co-hosted with the Northern Gulf Institute (NGI) and was held at the Stennis Space Center on January 22, 2020 (Appendix A). The second pilot effort was a virtual workshop that included participants with a wider range of modeling expertise and decision-makers with interest in hydrodynamics, water quality, and species management across the full LMACS region. This workshop was held on February 19, 2020 (Appendix B) and enabled the pros and cons of a virtual setting versus an in-person meeting to be evaluated.

The facilitated workshop approach was successful in connecting decision-makers and the modeling community and in defining a predictive modeling approach that can inform decision-maker action. Having management areas of interest to define the interaction (i.e., specific objectives that could frame the conversation) was found to be an effective way to foster discussion and collaboration. In addition, the use of a facilitator was found to be beneficial in bridging the gap between decision-makers who may have limited experience with the details and technical considerations of model development, and the modeling community, who may be unfamiliar with specific management questions that could be addressed through existing tools or targeted model development.

Several tradeoffs were identified between hosting an in-person workshop versus a virtual one. The in-person workshop was particularly effective at establishing connections between decision-makers and modelers, and allowed for sidebar one-on-one conversations outside of the facilitated discussion. This format was also conducive to fuller participation by all attendees, who could readily jump into the discussion. However, the in-person workshop required a greater time commitment from attendees and organizers, and incurred greater expense for facilities and travel. The virtual workshop was relatively straightforward to coordinate, cost less, and could accommodate a much larger number of attendees. The drawbacks of this approach were that it was not as straightforward for all attendees to actively participate in the discussion and it was not possible for individuals to have sidebar conversations about their specific interests during breaks.

Recommended Path Forward

Potential strategies for continuing to enhance coordination between decision-makers, stakeholders, and numerical modelers were elicited during the virtual and in-person workshops and combined with evaluation of the approaches piloted by the WI team. Model inventories were identified as useful frameworks ("first steps") to understand the tools that are available on the landscape. One key component of predictive models is observational data that can be used as boundary conditions or to assess model accuracy, therefore one recommendation for enhancing model inventories in the future is integrating them more directly with data inventories. In addition, including the types of decisions for which models had been used in the past or could be used in the future was identified as critical to the practical use of inventories in decision-maker support.

Feedback from the management and technical communities indicated that models designed to address specific needs are most effective when decision-makers, stakeholders, and modelers work together collaboratively in designing the model framework. Stakeholder input enables decision-relevant uncertainties to be clearly identified, which enables modelers to appropriately adjust the type and complexity of numerical model. Including a diversity of modelers in this discussion can potentially result in identifying additional leveraging opportunities compared to one-on-one discussions between decision-makers and modelers. For example, an existing coarser-resolution model may be available to provide boundary conditions to a higher-resolution model that has the domain and spatial resolution needed to address decision-maker needs. Based on this consensus concerning the vital role active collaboration between decision-makers and modelers plays in effective designing model frameworks, the recommended path forward is the creation of a forum for decision-makers and modelers to connect and interact in developing model frameworks for management application. This forum could include recurrent facilitated workshops, such as those piloted for hydrodynamics and water quality in Mississippi Sound and the LMACS. In-person interaction could be augmented through the creation of an online hub, a "virtual community of practice", to host a dynamic model and data inventory (and/or linkages to existing data and model hosting portals), and enable stakeholders and modelers to directly connect to discuss management needs and potential modeling solutions as they arise.

INVENTORY OF EXISTING MODELS

A total of 47 hydrodynamic and water quality models, developed by academic, private, non-profit, and public institutions, were identified for the LMACS system (provided in LMACS_Hydro_WQ_Model_Invetory.xlsx). These models varied in their spatial resolution and domain, modeled environmental parameters, time period of simulation, and level of assessment or validation. This variation was expected and is due in large part to the wide range of purposes for which the models were created. For example, model frameworks that were originally developed to understand the impacts of extreme events tend to be scenario-based, predicting the impact of one or more storms on the landscape and hydrodynamics of the region. In contrast, models that are focused on understanding changes in water quality tend to be run deterministically and over longer time periods, consistent with a need to evaluate inter- and intra-annual variability. Included models span from one-dimensional to three-dimensional, with both structured and unstructured model grid configurations.

Summary

The Water Institute of the Gulf was tasked by NOAA's Restoration Center to develop strategies for increasing coordination across decision-makers, stakeholders, and numerical modelers, as well as to develop a model inventory of hydrodynamic and water quality models for the Louisiana, Mississippi, and Alabama coastal system (LMACS). This effort consisted of a literature review; identification of practitioners and researchers with interest in this area; and the development of a workshop-based approach to facilitate the use of predictive models for specific management applications. This approach was piloted with two case studies: an in-person workshop that considered hydrodynamics and water quality management applications and potentially relevant numerical models for Mississippi Sound; and a virtual workshop that more broadly considered the full LMACS region. The team found targeted, needs-based workshops to be an effective approach to focusing decision-makers and the modeling community on specific issues, as well as being an efficient way to consider opportunities for leveraging of existing models. Tradeoffs were identified between the in-person and the virtual workshop approach, where bringing together individuals in an in-person setting fostered communication and increased the effectiveness of team-based discussion in framing management needs and identifying the characteristics of a modeling framework that could inform those needs. Conversely, the virtual workshop enabled much broader participation as attendees did not have to travel, and the costs of the workshop ―both for the attendees and for the hosts―were reduced. As part of this effort, the Institute also developed an inventory of hydrodynamic and water quality models for this region, which is included in a separate file (LMACS_Hydro_WQ_Model_Invetory.xlsx).

Appendix A: Mississippi Sound Modeling Workshop (January 18, 2020)

The in-person workshop was co-hosted with the Northern Gulf Institute (NGI) and held on January 18, 2020. A list of attendees is provided in Table A-1 and the agenda is provided at the end of this appendix.

After introductions and an overview of the objectives of the project, the workshop began with a "Model 101" presentation created to establish a common lexicon between the decision-makers in attendance, who may have been less familiar with the diversity of types of models, their benefits and limitations, and their requirements; and the modelers, who themselves may use fairly different terminology across disciplines. The presentation included a description of the types of model classification (e.g., conceptual vs. numerical, deterministic vs. stochastic, process-based vs. empirical, hydrodynamic vs. water quality), model mechanics and requirements, types of uncertainty and how it can be reduced, and spatial and temporal considerations in using models for decision-making. After this introduction, the Mississippi Department of Marine Resources (DMR) and the Mississippi Department of Environmental Quality (DEQ) discussed their priority needs in simulating and predicting the water quality in Mississippi Sound. Modelers in the room were then given an opportunity to present short, high-level overviews of their existing models, i.e., those tools already on the landscape that could be leveraged in addressing coastal resource management issues.

The full group then engaged in a facilitated discussion to (1) distill the decision-maker needs as described by the Mississippi DMR and DEQ into a focused set of issues that could be addressed through the use of numerical models and (2) to map those issues into specific model requirements (i.e., to translate the key management question into specific, model-relevant terms that could be used to select or design an appropriate tool). The primary areas of interest from a decision-maker perspective were factors influencing the water quality of Mississippi Sound and the associated habitat suitability for species, particularly oysters. For both areas of interest, the controlling factor of most pressing interest was freshwater influx into the region (e.g., through the planned mid-Breton diversion and the Bonnet Carre spillway), with a longer-term interest in understanding the influence of the landscape configuration of the region (e.g., barrier islands). The decision-maker needs included those relevant to management concerns, such as how to mitigate potential negative impacts of freshwater influx changes on species; regulatory concerns, such as best practice in balancing flood control with limiting impacts to Mississippi Sound; and, in the longer-term, evaluating potential restoration projects that could locally or regionally benefit water quality. One identified point of relevance to model framing was the need to understand stakeholder and public perception, namely that considering and evaluating more extreme end-members of environmental conditions and freshwater management scenario (i.e., "worst case scenario") is of particular importance in allaying stakeholder concerns.

In terms of mapping management needs to model parameters, the spatial area of concern for the decision-maker needs discussed was the state waters of Mississippi. A model that could predict changes in water quality was identified as the most pressing priority, where the ideal model would be capable of eventually supporting a habitat suitability model for oysters. A three-dimensional model framework was identified as

beneficial given potential depth variations in water quality and parameters important to habitat suitability models. Because the priority decision-maker need was evaluating the potential impacts of freshwater management scenarios in a general sense, rather than evaluating historic conditions or long-term changes, there was not a specific time-period of highest priority identified. Instead, the preference was for a model that could evaluate the effects of high, yet still realistic, freshwater inflow scenarios.

Table A-1. List of attendees (in-person and remote) at the Mississippi Sound Modeling Workshop

Name	Institution
Steve Ashby	Northern Gulf Institute
Melissa Baustian	Water Institute of the Gulf
René Camacho-Rincón	Tetra Tech
Kemal Cambazoglu	University of Southern Mississippi
Soupy Dalyander	Water Institute of the Gulf
Alyssa Dausman	Water Institute of the Gulf
Ioannis Georgiou	Water Institute of the Gulf
Read Hendon	University of Southern Mississippi
Pat Hogan	Naval Research Laboratory
John Kwoka	Mississippi Department of Environmental Quality
Robert Kroger	Covington Civil and Environmental
Kirsten Larsen	National Oceanic and Atmospheric Administration
Erin Lincoln	Tetra Tech
Anna Linhoss	Mississippi State University
Alex McCorquodale	Water Institute of the Gulf
Paul Mickle	Mississippi Department of Marine Resources
Scott Milroy	University of Southern Mississippi
Mike Miner	Water Institute of the Gulf
George Ramseur	Mississippi Department of Marine Resources
Greg Steyer	U.S. Geological Survey
Jerry Wiggert	University of Southern Mississippi

Mississippi Sound Modeling Workshop: Agenda

Mississippi State University Science and Technology Building, Stennis Space Center, MS
1:00-5:00pm
January 22, 2020

OBJECTIVE:

The overarching goal of this effort is to enable more effective, cost-efficient, and informed decision-making in the management of Mississippi Sound by increasing awareness of prior and ongoing numerical modeling efforts, and by improving coordination across practitioners and stakeholders in this region.

AGENDA ITEMS:

Introduction and Overview

1:00-1:10	Welcome and Site Logistics	Mike Miner, Soupy Dalyander, Steve Ashby
1:10-1:20	Introductions	All
1:20-1:30	Overview and Objectives	Mike Miner
1:30-1:40	Models 101: Building a Common Lexicon	Soupy Dalyander

Stakeholder and Technical Presentations

1:40-2:00	Mississippi Department of Marine Resources Overview	George Ramseur Paul Mickle
2:00-2:20	Mississippi Department of Environmental Quality Overview	John Kwoka
2:20-2:40	Model Overviews	Group

Continued on other side

Facilitated Discussion

2:40-2:50	BREAK	

2:50-3:20	Supporting Decision-Making
	• Common list of stakeholder and decision-maker needs
	• Mapping management needs to model parameters
	  ○ Types of output needed
	  ○ Spatial domain of interest
	  ○ Spatial and temporal resolution and extent
	  ○ Processes needed
	  ○ Etc.
		Alyssa Dausman
		Soupy Dalyander

3:20-4:00	Model Synergies
	• Commonalities, synergies across model frameworks
	  ○ Connections to stakeholder needs
	  ○ Opportunities for ensemble predictions
	  ○ Potential cross-linkages
	• Gap Identification: Critical Needs and Opportunities
		Soupy Dalyander
		Alyssa Dausman

4:00-4:10	BREAK	
4:10-4:30	Continuing the Conversation: Ideas for Building a Community of Practice	Mike Miner

Wrap-Up

4:30-5:00	Next steps • Action items from discussion • Workshop report-out • Virtual Workshop, February 19, 2020	Mike Miner Soupy Dalyander Alyssa Dausman

Appendix B: LMACS Modeling Virtual Workshop (February 19, 2020)

The virtual workshop was held on February 19, 2020 and included 44 participants representing decision-makers, stakeholders, modelers, and researchers with an interest in the hydrodynamics and water quality of the LMACS region (Table B-1; agenda provided below). As with the in-person workshop, the virtual workshop began with an overview of project objectives and a truncated version of a "Model 101" presentation. The team then reviewed the in-person workshop to further introduce the group to the objectives of the project and the decision-maker/modeler engagement strategies that were developed. The workshop continued with an introduction of priority stakeholder and decision-maker needs for this region, presented by John Lopez of the Lake Pontchartrain Basin Foundation and Mel Landry of the National Oceanic and Atmospheric Administration.

Priority needs identified included evaluating the following using numerical models:

- Impacts of the closure of the Mississippi River-Gulf Outlet Canal (MRGO) on:
    - Regional tidal prism and salinity regimes
    - Modified seasonal migration paths of estuarine-dependent aquatic species
    - Impacted regional distribution of oysters
- How freshwater inflow from, e.g., the Bonnet Carre Spillway impacts water quality and oyster distribution in the LMACS
- Effects of hydrologic, morphology, and salinity regime changes on:
    - Water quality, including seasonal hypoxia in the region
    - Distribution of threatened and endangered species
- Preliminary screening of potential restoration projects (oyster reefs, marsh, etc.), with a specific interest in impacts of restoration of the Chandeleur Islands

As a case study, the group then discussed parameters of a modeling framework that could be used to evaluate the impact of restoration of the Chandeleur Islands on the LMACS. These included the domain (the entire northern Gulf from Breton Sound through Dauphin Island, including Lake Pontchartrain) and the required spatial resolution, which was identified as needing to be high enough to evaluate potential restoration designs. The group identified several model frameworks that could potentially be leveraged; however, no single model currently exists with high enough resolution that spans from the Mississippi Delta through Dauphin Island. Therefore, a modeling framework to meet this management need would require both expanding the domain of existing frameworks and increasing the spatial resolution, and/or adding nested high-resolution model domains within a coarser resolution model.

The final portion of the call included discussion of ways to increase the awareness of existing model frameworks and facilitate the use of models by decision-makers. Model inventories were identified as a valuable first step in understanding what tools are available. However, decision-makers and stakeholders often require understanding of the decision-context for which the models were developed to understand if and how existing tools may be leveraged for their application. The most effective and efficient approach to using models for specific management applications was identified as bringing together decision-makers, stakeholders, and modelers early in the project to collaboratively design the modeling framework.

Table B-1. Institutions represented at the Louisiana, Mississippi, and Alabama Coastal System (LMACS) modeling virtual workshop

Dauphin Island Sea Lab
Lake Pontchartrain Basin Foundation
Louisiana Coastal Protection and Restoration Authority
Louisiana State University
Mississippi State University
National Oceanic and Atmospheric Administration
Northern Gulf Institute
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
U.S. Geological Survey
University of Southern Mississippi
Water Institute of the Gulf

Louisiana, Mississippi, Alabama Coastal System Modeling Workshop

11:00am-1:00pm (CST), 12:00-2:00pm (EST)
February 19, 2020

GOAL

The overarching goal of this project is to develop strategies for connecting modelers to stakeholders and decision-makers with potential needs in the Louisiana, Mississippi, and Alabama coastal system (LMACS) that could be addressed using models. The current focus is on hydrodynamics and water quality, as well as habitat suitability and/or distribution of species (Gulf sturgeon, oysters, etc.)

OBJECTIVES OF THE VIRTUAL WORKSHOP:

- Identify a set of management needs that can be addressed with the use of models
- Connect ("translate") decision-maker needs into specific model requirements
- Advance tools and strategies for increasing awareness and accessibility of existing model frameworks that can be leveraged in decision-making

AGENDA ITEMS:

11:00-11:20	Overview, Objectives, and Introductions Model 101	Soupy Dalyander
11:20-11:30	Review pilot workshop: Mississippi Sound hydrodynamics and water quality	Alyssa Dausman & Steve Ashby
11:30-12:00	Priority stakeholder needs in the LMACS – potential model applications and needs • Mel Landry • John Lopez	Soupy Dalyander (facilitator)
12:00-12:25	Synthesis of stakeholder needs and translation to model requirements	Soupy Dalyander (facilitator)
12:25-12:45	Continuing the conversation: model coordination strategies • Prior efforts: lessons learned? • Feedback on the targeted needs-matching approach – what is the group's impressions • Model inventory - feedback on potential use • Other applications and suggestions	Alyssa Dausman and Steve Ashby
12:45-1:00pm	Next Steps • Gray literature report, including report-out on Virtual Workshop • Model inventory	Soupy Dalyander