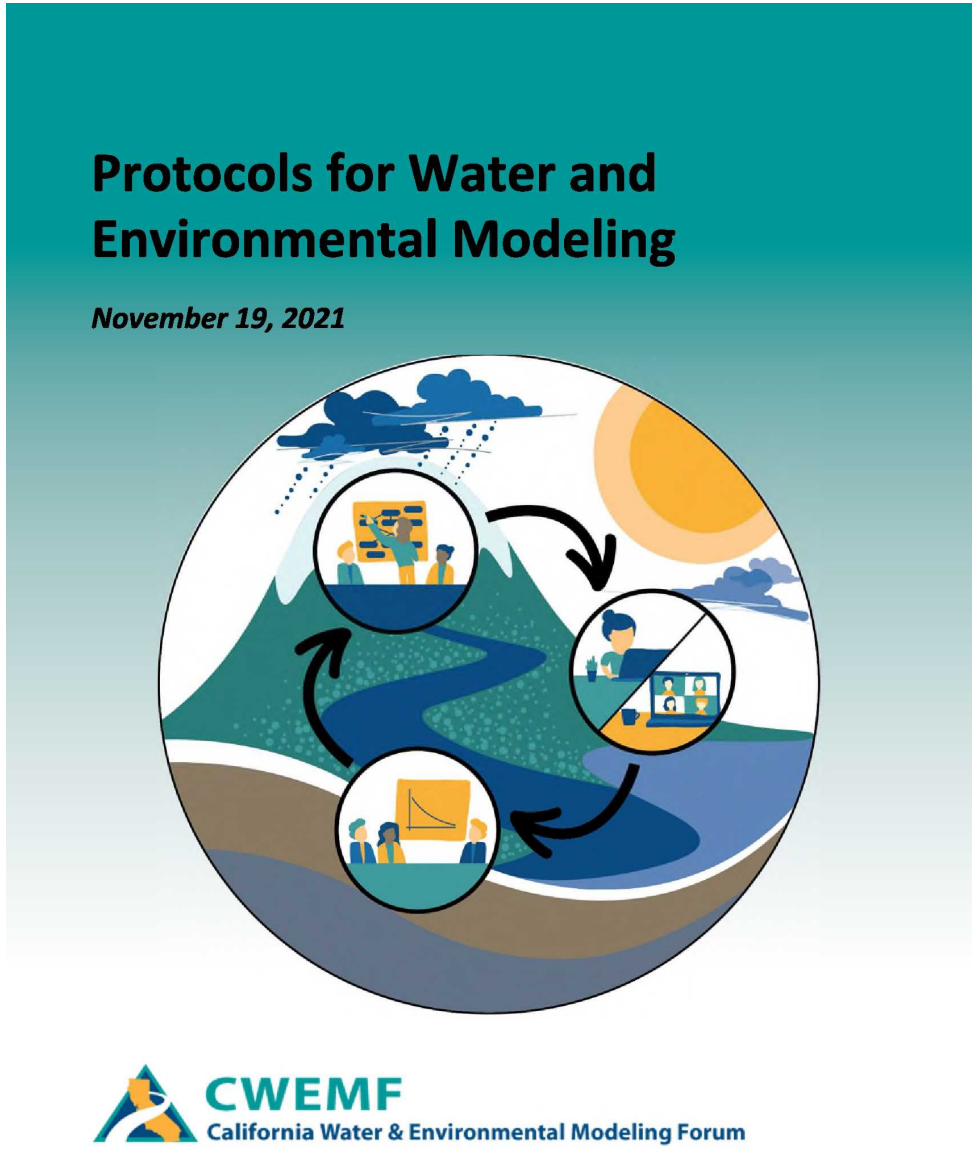


Protocols for Water and Environmental Modeling

Rich Satkowski,
SWRCB-Retired
and
John DeGeorge,
RMA

April 6, 2022

Ad Hoc Modeling Protocols Committee

* Objective: Revise CWEMF's 2000 MP document, "Protocols for Water and Environmental Modeling," which provides guidance to water stakeholders, decision-makers, and technical staff as models are developed and used to solve CA's water and environmental problems

- Improving the development of models
- Providing better documentation of models and modeling studies
- Providing easier professional/public access to models and modeling studies
- Making models and modeling studies more easily understood and amenable to examination
- Increasing confidence in models and modeling studies

Ad Hoc Modeling Protocols Committee

- Ali Taghavi, Woodard Curran
- Ben Geske, DSC
- Chuching Wang, MWD
- George Nichol, USACE, SWRCB (retired)
- Jamie Anderson, DWR
- John DeGeorge, RMA
- Josue Medellin-Azuara, UC Merced
- Mike Deas, Watercourse Inc.
- Nicky Sandhu, DWR
- Rich Satkowski, SWRCB (retired), Committee Lead
- Tad Slawecki, Limnotech
- Tariq Kadir, DWR
- Will Anderson, CCWD

Supported by the consultant team at Tetra Tech: Sujoy Roy, Paul Hutton, Katherine Heidel, John Rath, and Arushi Sinha.

Modeling Protocols Report Process

- Obtained CWEMF Steering Committee approval to form the MP Committee (Mar 2019)
- Conducted 25 MP meetings (May 2019-Sep 2021)
- Obtained SC approval for funding of $95,890 (May, Sep and Nov 2019)
- Contracted with UC Davis to conduct a literature review and modeling study interviews (Jul 2019)
- Developed a MP report outline (Jul 2019)

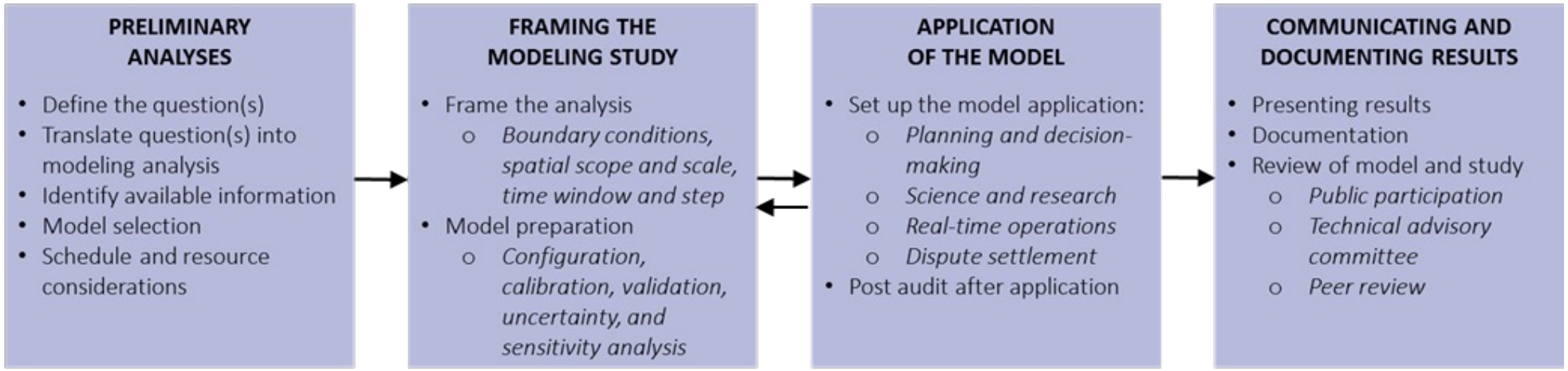
Modeling Protocols Report Process

- Contracted with Tetra Tech to provide technical assistance (Nov 2019)
- Conducted five topic-specific meetings with 70 participants to obtain their input (Feb-Mar 2020)
  - Hydraulics, Hydrodynamics and Water Quality
  - Groundwater and Integrated SW/GW
  - Surface Watershed Hydrology and Reservoir Operations
  - Biological Ecosystem Models
  - Hydro-Economics Modeling and Economic Analysis
- Completed 1st and 2nd drafts of MP report (Aug 2020 and Mar 2021)

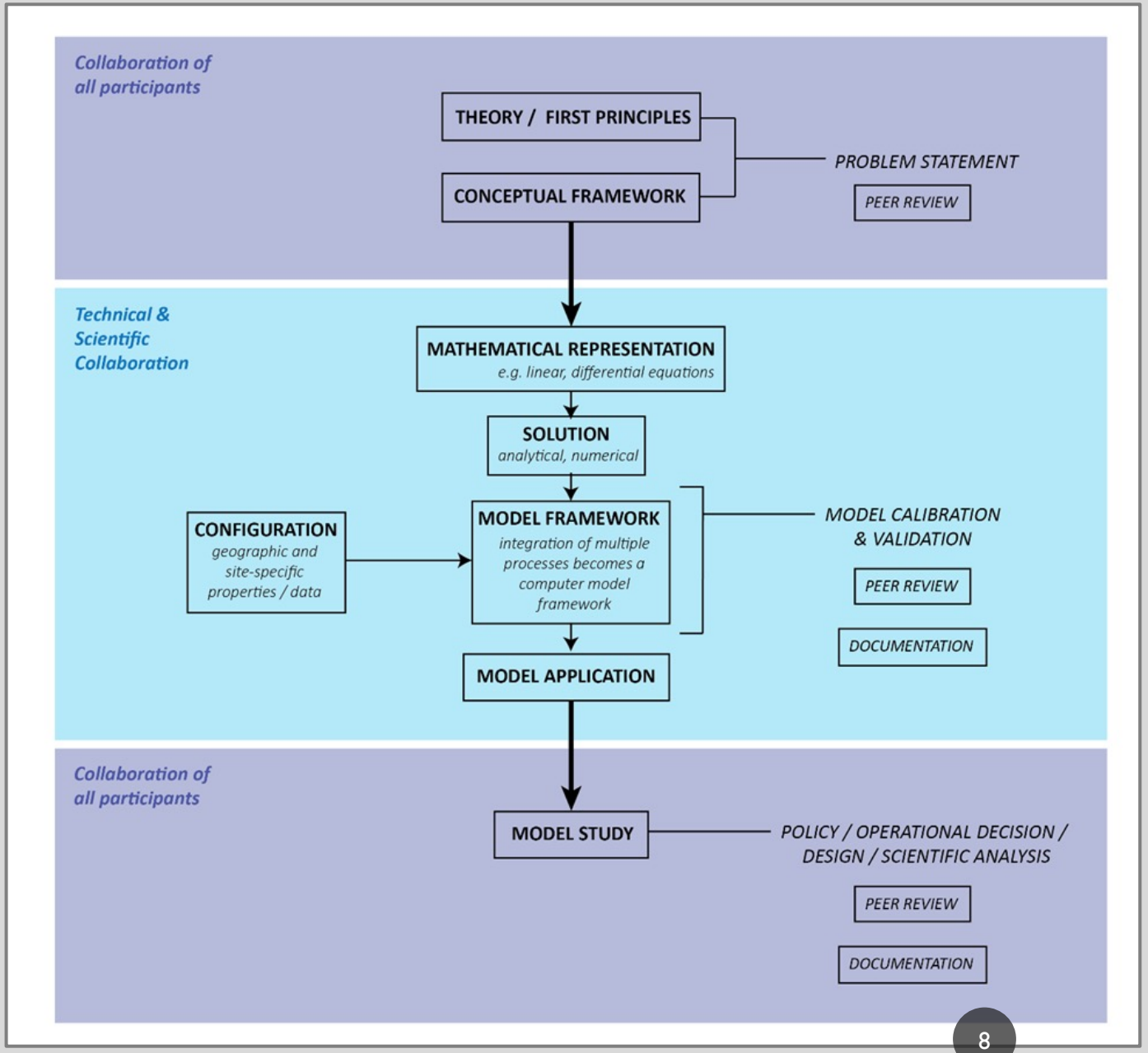
Modeling Protocols Report Process

- Conducted half-day public workshop on draft report with 35 participants (Jun 2021)
- Received written comments on draft report (Jun 2021)
- Finalized report (Nov 2021)
- Obtained Steering Committee's "acceptance" of the final report (Nov 2021)
- Posted report on the CWEMF website (Nov 2021)
- Presented final report at the CWEMF Annual Meeting (Apr 2022)

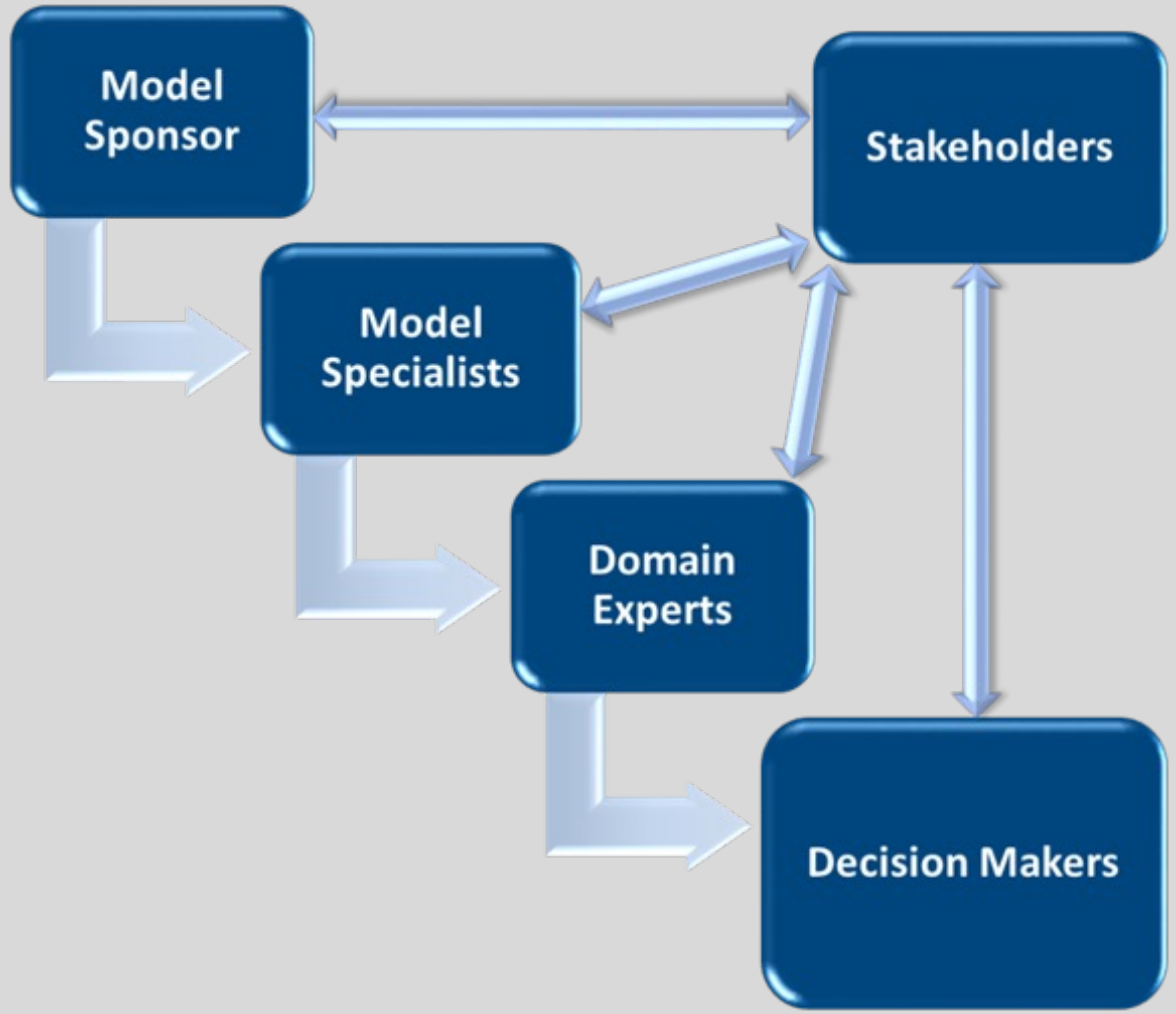
PHASES IN TYPICAL MODELING STUDY



COMMON TERMS USED IN DOCUMENT

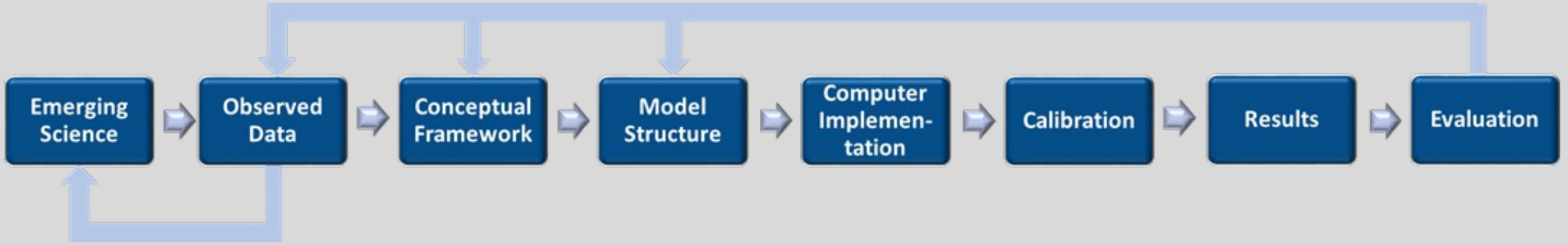


KEY ROLES IN MODELING STUDIES



MODELING WITH ESTABLISHED FRAMEWORKS

MODELING WHERE SCIENCE IS EVOLVING



CHAPTER 3: PRELIMINARY ANALYSES

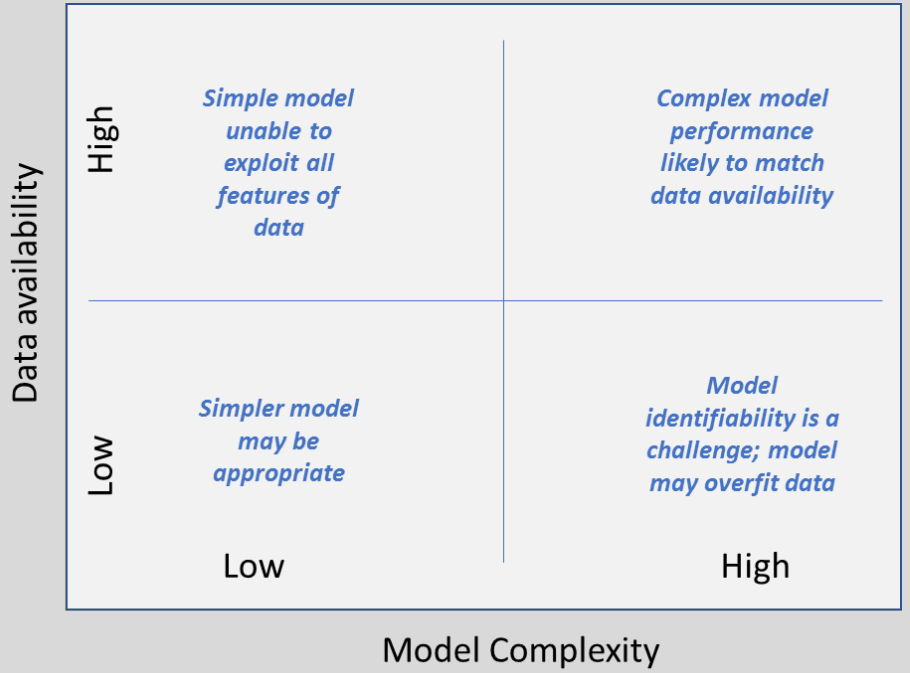
Define the Question(s)

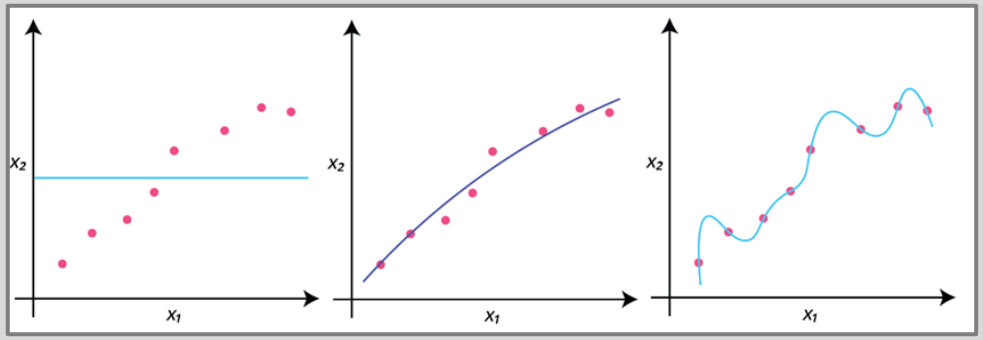
Translate Question(s) into Modeling Analysis

Identify Available Information

Model Selection

Schedule and Resource Considerations





A schematic representation of model fitting (blue line) for observed data (red points).

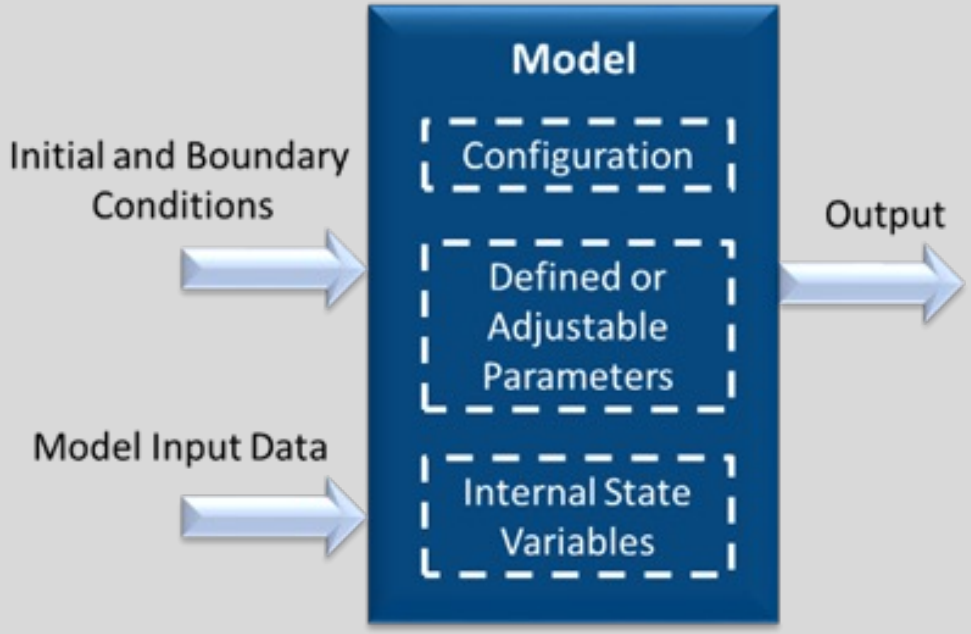
CHAPTER 4: FRAMING THE MODELING STUDY

Frame the Analysis

- Boundary and Initial Conditions
- Geographic Scope/Spatial Scale
- Time Window

Model Preparation and Analysis

- Model Configuration
- Data Quality Assurance
- Model Calibration/Testing
- Sensitivity and Uncertainty



Major elements in model systems

CHAPTER 4: FRAMING THE MODELING STUDY

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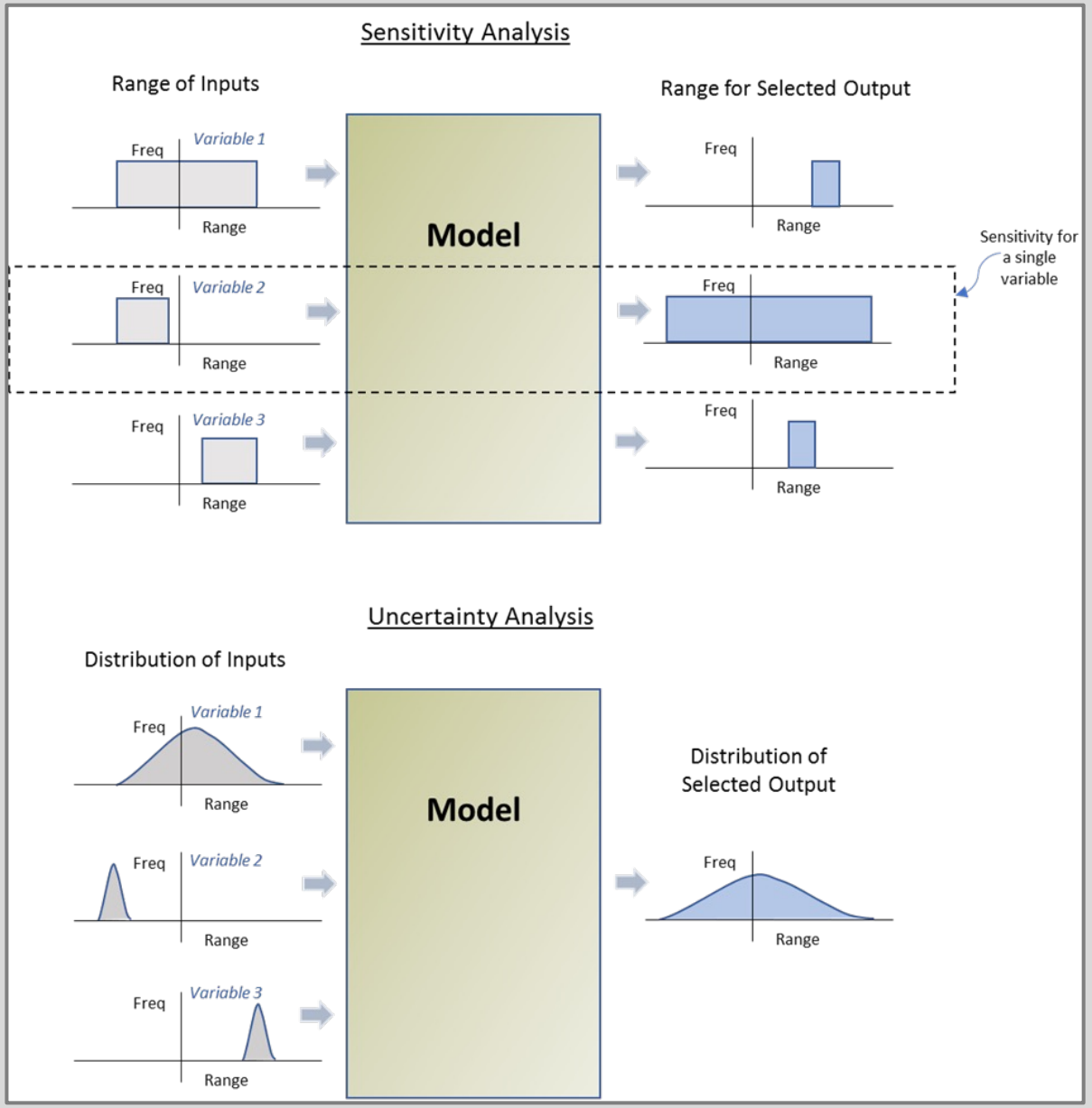

Simplified representation of sensitivity and uncertainty analyses

CHAPTER 5: APPLICATION OF THE MODEL

Consideration of Generalization During Application

Modeling in Support of Planning and Decision-Making

Modeling in Support of Science and Research

Modeling in Support of Real-Time Operations

Modeling in Support of Dispute Settlement

Post Audit after Application

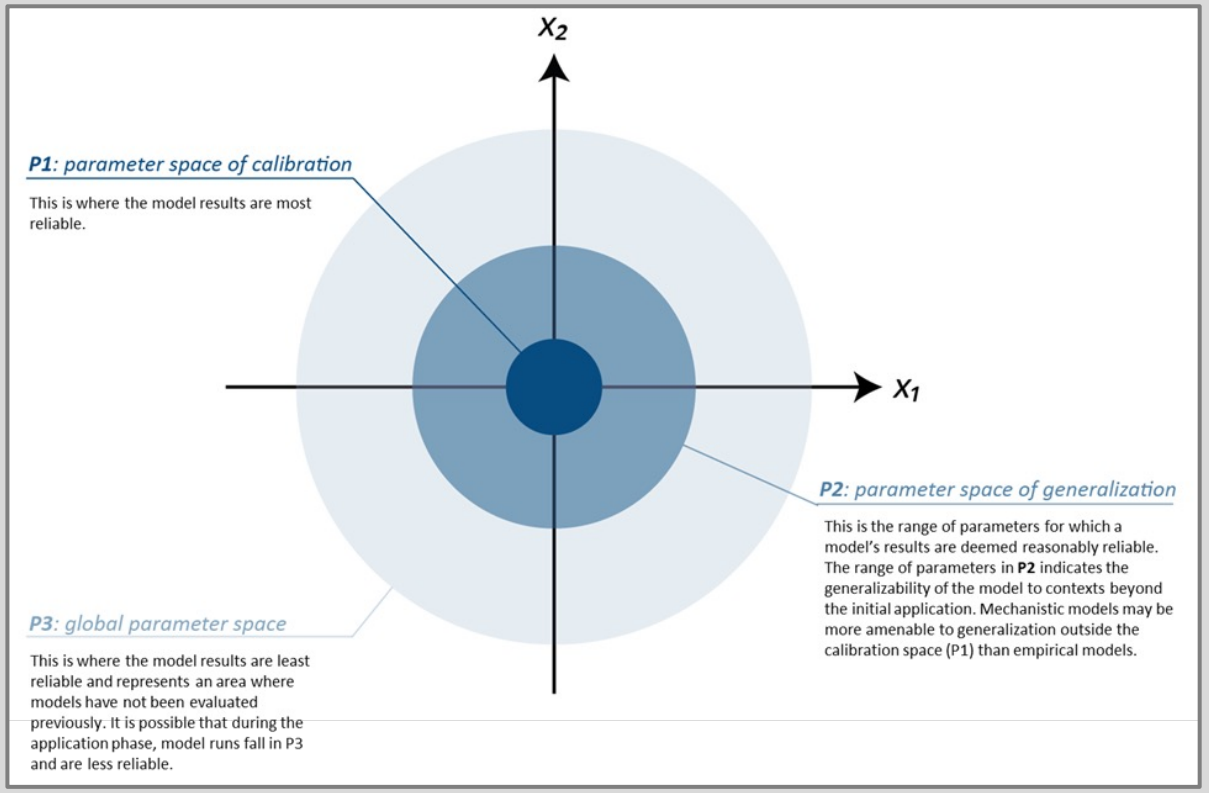

Illustration of concept of parameter generalization and the global parameter space

CHAPTER 6: COMMUNICATING AND DOCUMENTING RESULTS

Presenting Results

Documentation

Review of Model and Study

- Public participation
- Technical advisory committees
- Shared-vision modeling
- Peer-review of model
- Reproducibility of results

CHAPTER 7: ENCOURAGING COLLABORATION IN THE MODELING COMMUNITY

User Groups

Virtual Community of Practice

- Delta Modeling
- Integrated Water Flow Model
- Water Evaluation and Planning
- Ground Water Exchange
- MODFLOW User Group

CHAPTER 8: EMERGING TECHNOLOGIES SUPPORTING MODEL DEVELOPMENT

Innovations in Data Capture

Data Analysis Framework

Machine Learning Methodologies and Frameworks

Data Visualization and Communication Techniques

Workflow Organization Tools

New Methods in Software Engineering and Architecture

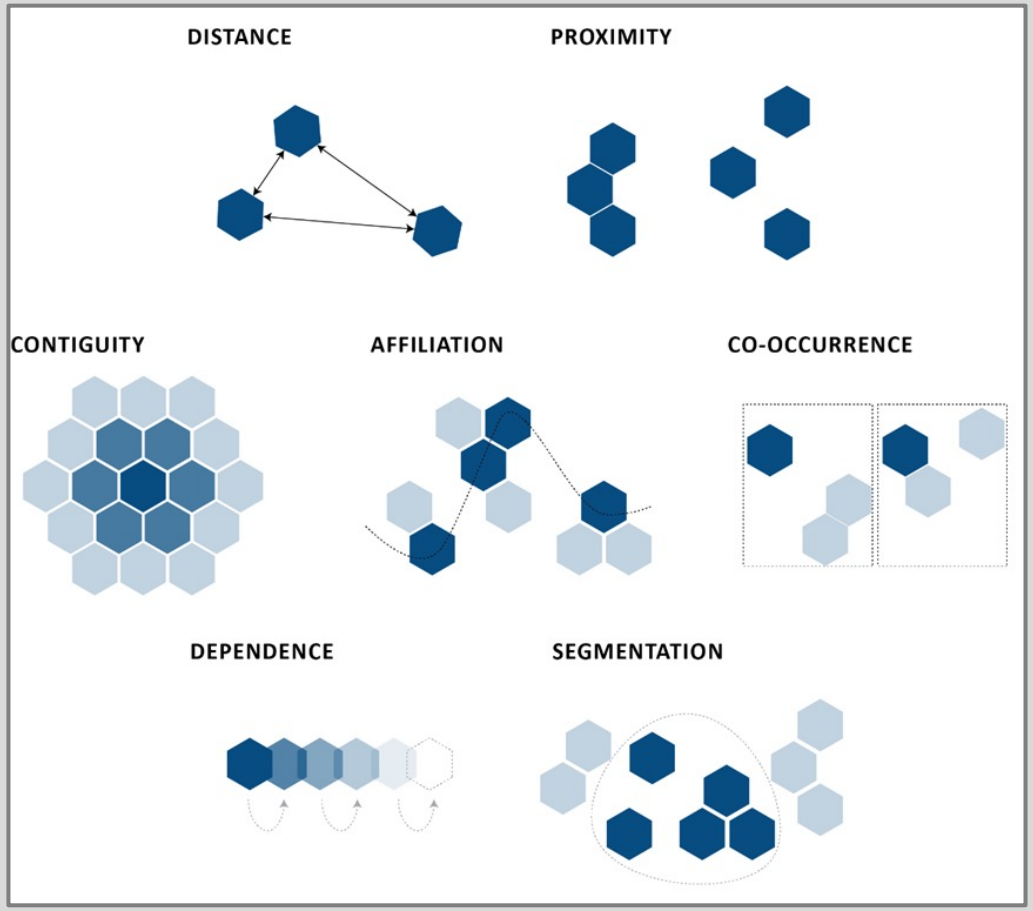

Illustration of relationships such as distance, proximity, contiguity, affiliation, co-occurrence, dependence, and segmentation that could be used for evaluating spatial data

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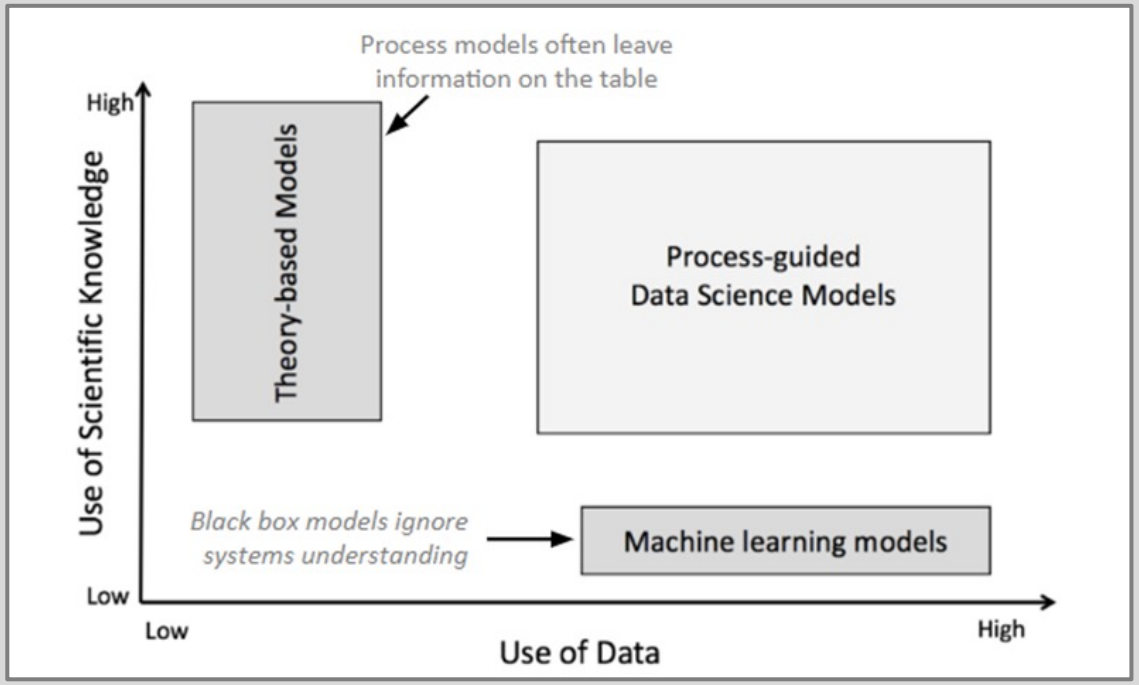

Big data analysis can help benefit both black box and process-based modeling approaches

CHAPTER 8: EMERGING TECHNOLOGIES SUPPORTING MODEL DEVELOPMENT

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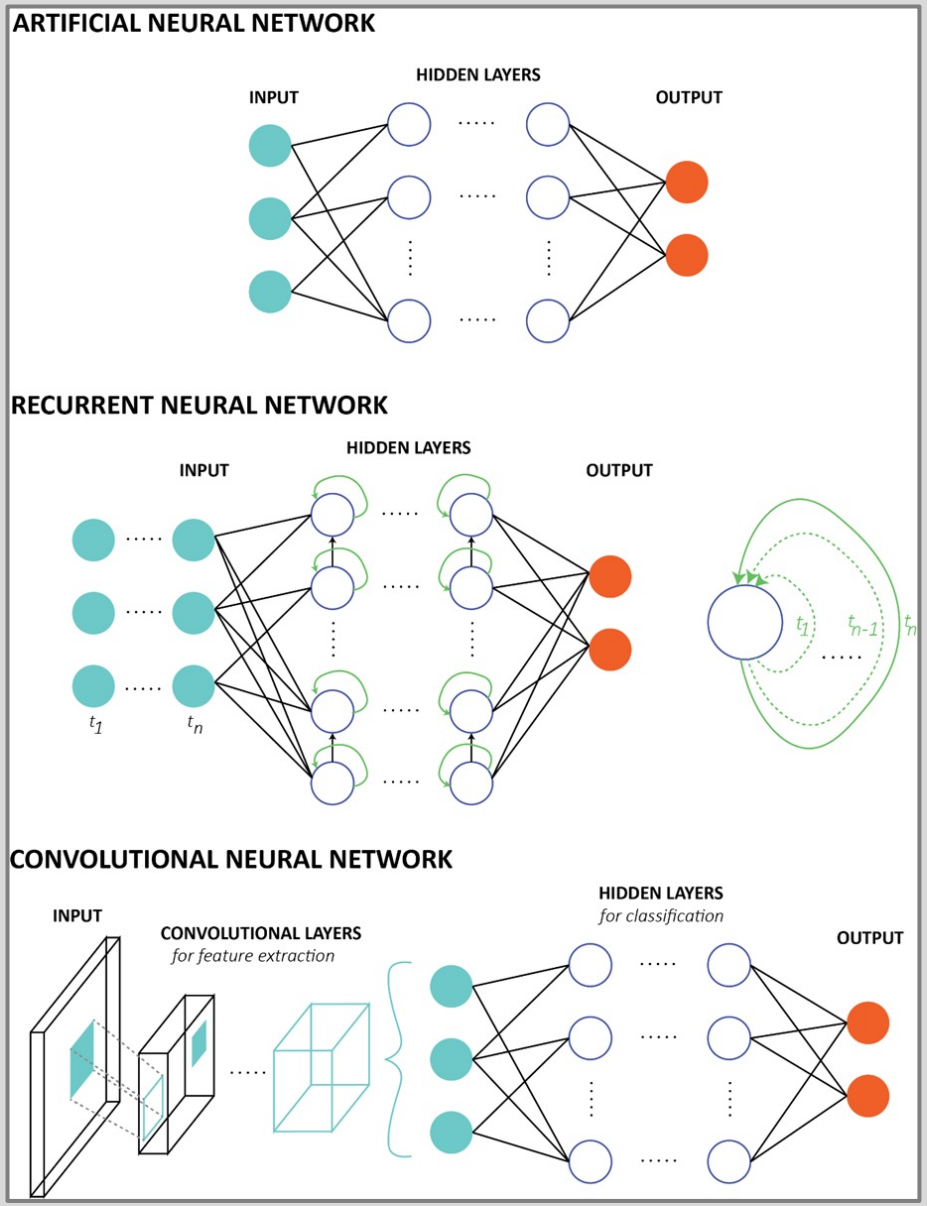

Graphical illustration of a feedforward artificial neural network, a recurrent neural network (RNN), and a convolutional neural network (CNN)

CHAPTER 8: EMERGING TECHNOLOGIES SUPPORTING MODEL DEVELOPMENT

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New Methods in Software Engineering and Architecture

DevOps

- Version Control
- Continuous Integration
- Artifact Management
- Automated Testing
- Continuous Delivery
- System Monitoring

Graphical illustration of a feedforward artificial neural network, a recurrent neural network (RNN), and a convolutional neural network (CNN)

CHAPTER 10: NEXT STEPS IN THE IMPLEMENTATION OF MODELING PROTOCOLS

Using the Modeling Protocols

Targeted Outreach

Future Updates of the Protocols

Model Inventory Updates

Model Inventory - CWEMF Wiki (atlassian.net)

Checklist 1. Model Study Initial Appraisal Prior to Study Inception

Item	Description	Response
1	Is the problem or question to be addressed well defined?	Yes/No
2	Do we know how the model results will be used?	Yes/No
3	Is the model to be used specified?	Yes/No
4	Has a conceptual framework been developed?	Yes/No
...		
19		

Checklist 2. Model Study Post-Completion Appraisal

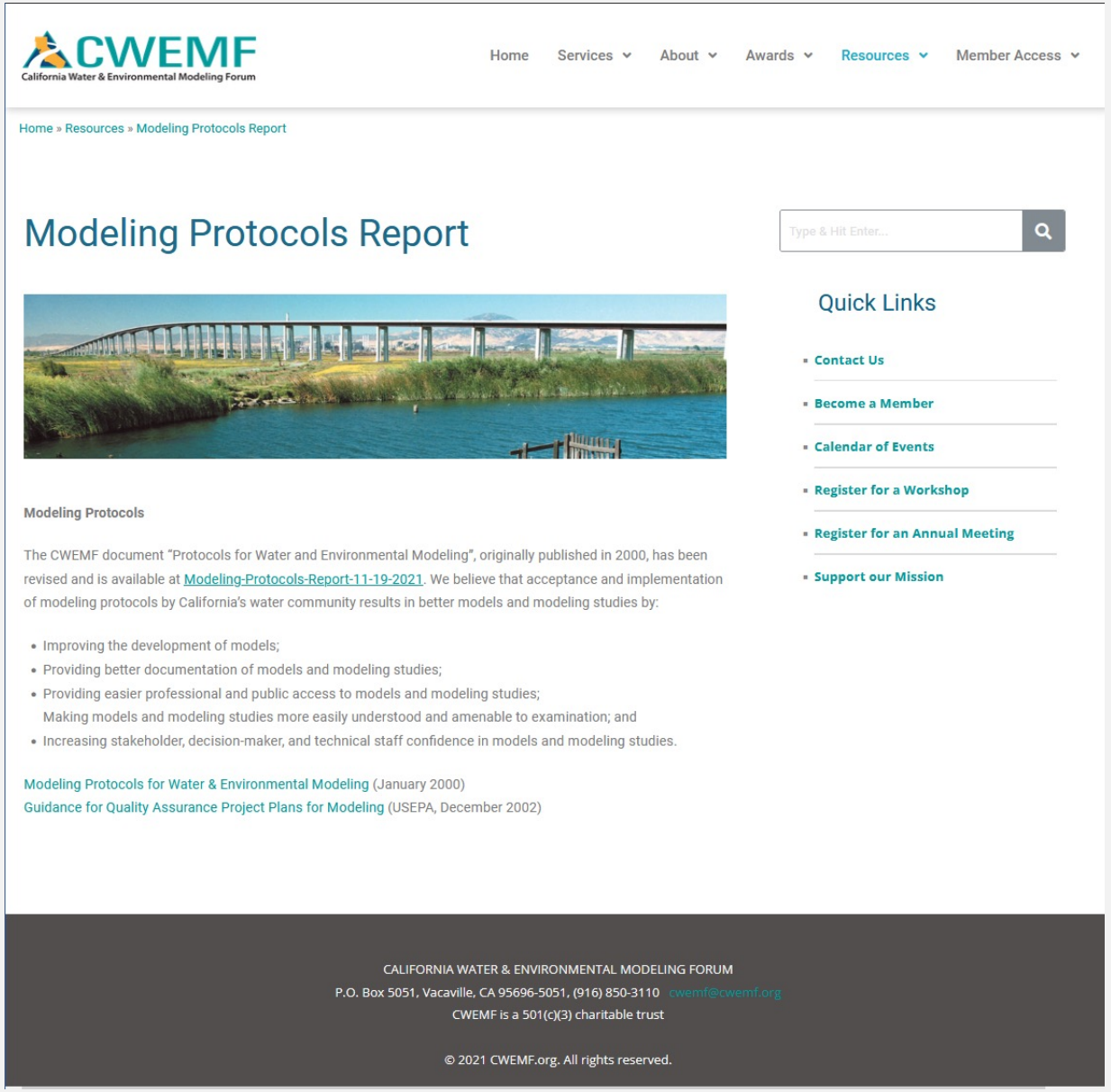
Item	Description	Response (Numeric Score or narrative)
1	Is the model a new formulation or the application of an existing code? If a new formulation, what has been done to test and verify the code?	
2	Has a conceptual framework been developed for this effort and has it been updated following completion?	
3	Are observed data used in the modeling exercise (input and output data) documented and available for review?	
4		
...		
13		

Checklist 3. Model Framework Life Cycle Evaluation

Item	Description	Narrative Response
1	Are all source codes and supporting files stored in a single location and archived in a manner that enables future access?	
2	Are the source codes documented, even if this documentation is not in the public domain?	
3	Is the model development dependent on a single individual? What is the long-term transition plan for the expertise in this model?	
4	Is the model framework applied by a community or by a single team? Is there a mechanism to share knowledge about the model application over time, such as a virtual community, trainings, etc.?	
...	...	
7	For a proprietary model framework, what is the mechanism to support the code development over the long-term?	

ACKNOWLEDGEMENTS

- More than 60 of our colleagues who provided thoughts and insights in our initial workshops (all pre-Covid). They represented different modeling domains and organization types, from academia, government and private sector
- Modeling Protocols Committee members
- Over four decades of prior guidance documents spanning the environmental field



https://cwemf.org/wp/resources-3/modeling-protocols-report/