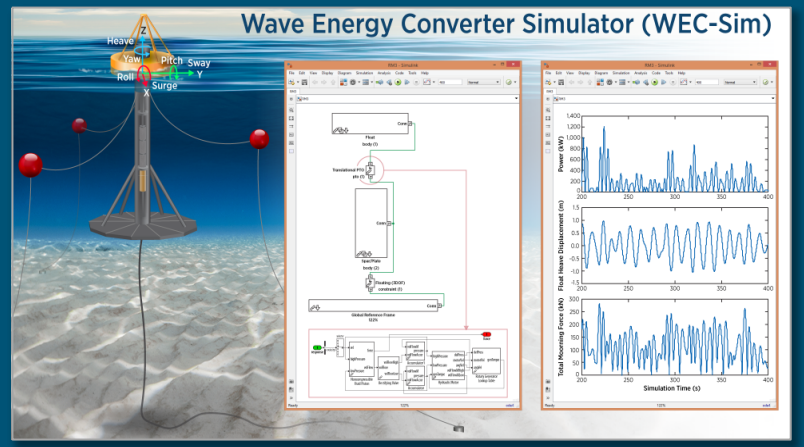
SAND2022-12102C

Sandia National Laboratories

Development and application of WEC-Sim v5.0 open-source software

NREL



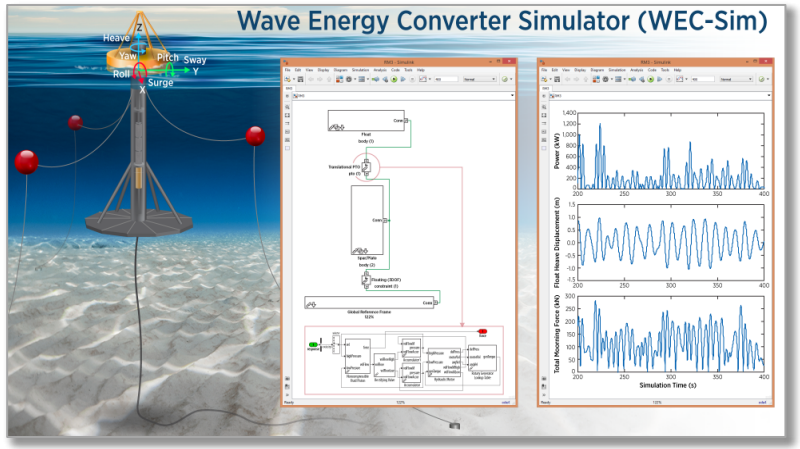
PRESENTED BY

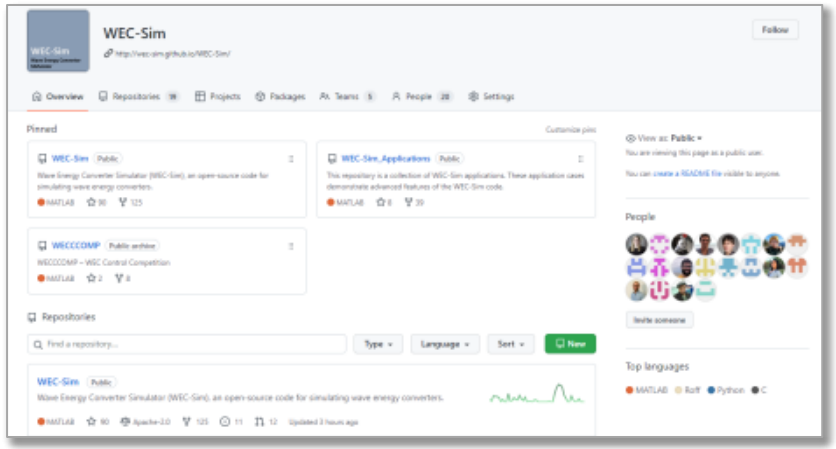
Kelley Ruehl, Sandia National Laboratories

WEC-Sim

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Table of Contents





Background

What is WEC-Sim?

WEC-Sim (Wave Energy Converter Simulator)

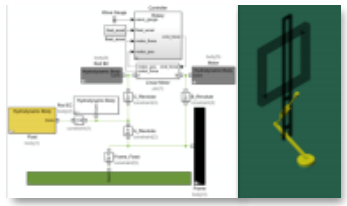
- Simulates wave energy converter dynamics
- Time-domain equation of motion solver based on Cummins' formulation
- Open source code developed in MATLAB/SIMULINK
  - Available at https://github.com/WEC-Sim/WEC-Sim
- Joint NREL/Sandia project
- Funded by the US Department of Energy
- First Release: v1.0 in June 2014
- Current Release: v5.0 in May 2022

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Project Timeline



WECCCOMP control competition numerical (Phase 1)

WECCCOMP special session (OMAE 2019)

WEC-Sim Course at Universidad de Costa Rica (PAMEC 2020)

GitHub WEC-Sim v4.0

GitHub WEC-Sim v4.1

GitHub WEC-Sim v4.2

Review open source BEM

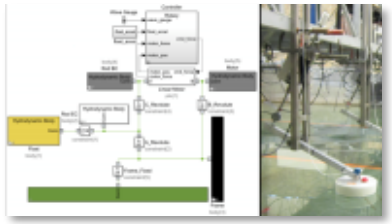
TEAMER Testing & Expertise for Marine Energy
RFTS1 awards for WEC-Sim Support

GitHub WEC-Sim v4.3

R&D 100 AWARDS
WEC-Sim wins R&D 100 Award

FY 2019

GitHub WEC-Sim v3.1



WECCCOMP control competition experimental (Phase 2)

FY 2020

WECCCOMP winner announced

AALBORG UNIVERSITY DENMARK

Maynooth University National University of Ireland Maynooth

IEA OES phase III OWC V&V complete (KRISO tank test data)

FY 2021

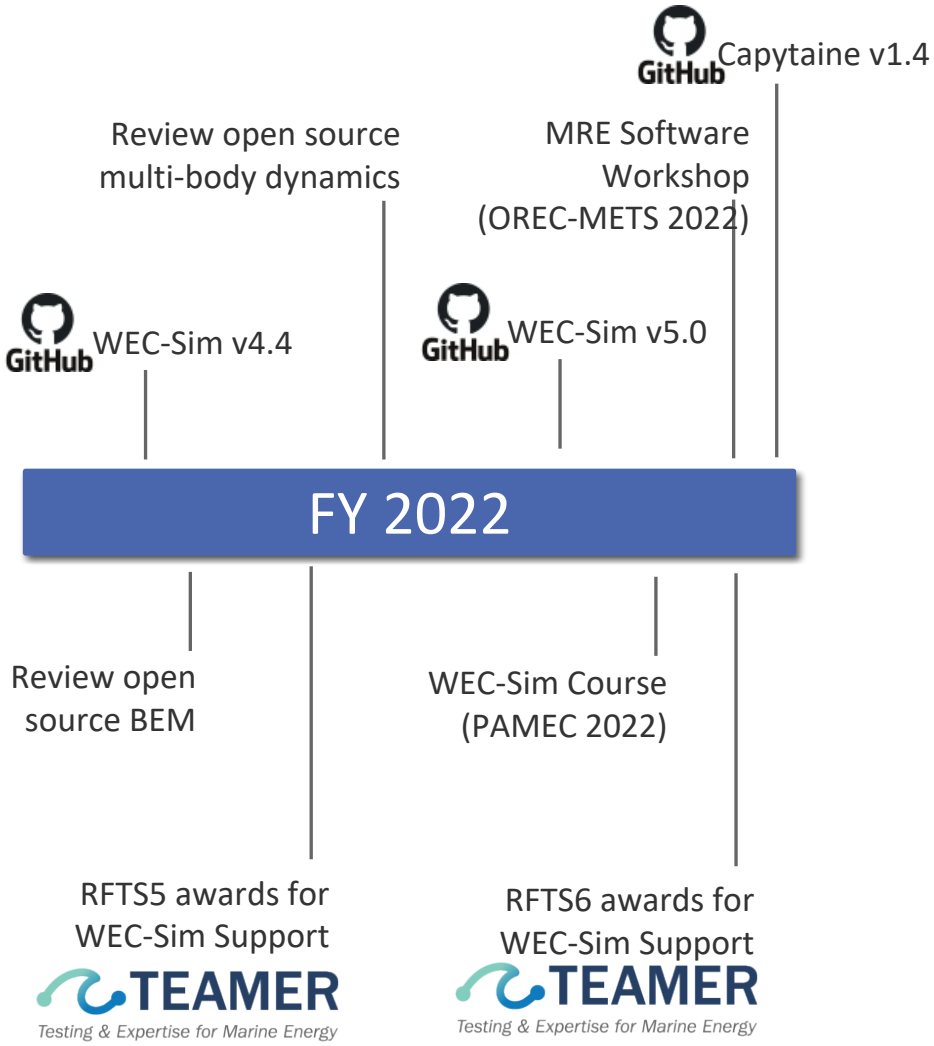
Oregon State University
WEC-Sim lectures at OSU for CEE 411/511

TEAMER Testing & Expertise for Marine Energy
RFTS2 awards for WEC-Sim Support

MATLAB Energy Speaker Series

GitHub WEC-Sim v4.4

FY22 Accomplishments



FY22 Accomplishments

Support the WEC modeling community through WEC-Sim development, maintenance, support and training.

- **Develop and maintain** the WEC-Sim software on GitHub, and **resolve bugs** with the software
- Provide **WEC-Sim support** via responding to and resolving issues posted by users, and updating the publicly available examples and online documentation
- **Outreach** via hosting in-person and online training courses (e.g. PAMEC 2022), presenting and **publishing WEC-Sim articles**, and **training the next generation** of WEC numerical modelers

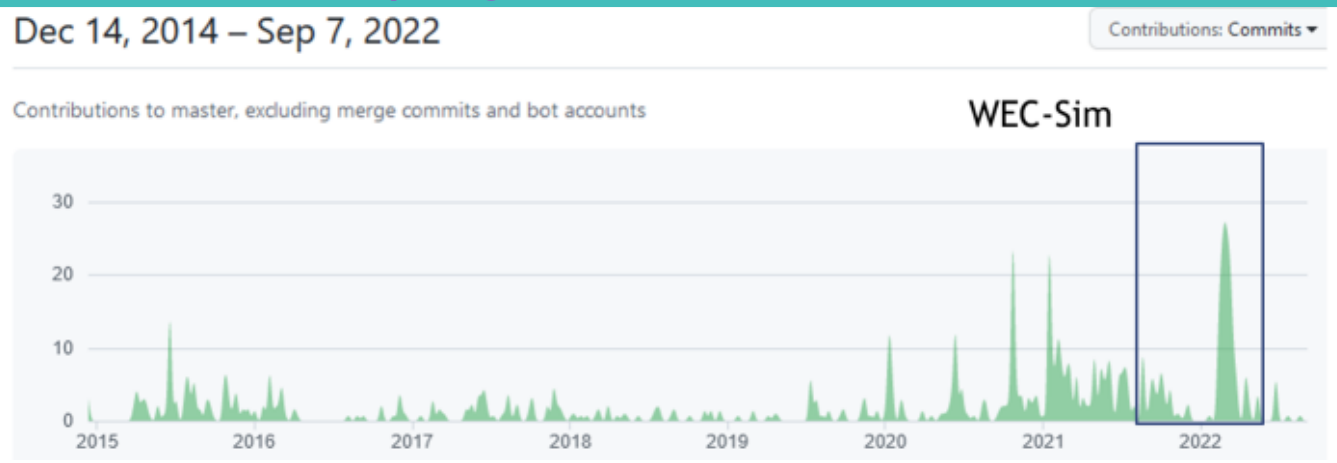
Assess the current MRE Software landscape, and identify future development needs.

- Solicit public feedback via MRE Software Workshop (e.g. OREC-METS 2022) and online webinar
- Draft report on current MRE Software landscape, identifying gaps and potential needs for public feedback

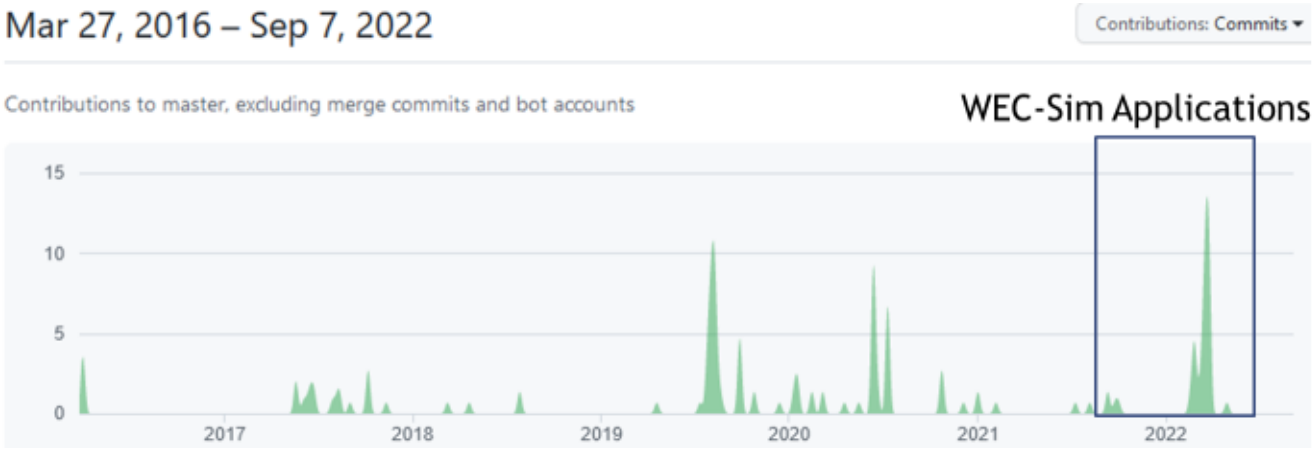
WEC-Sim v5.0

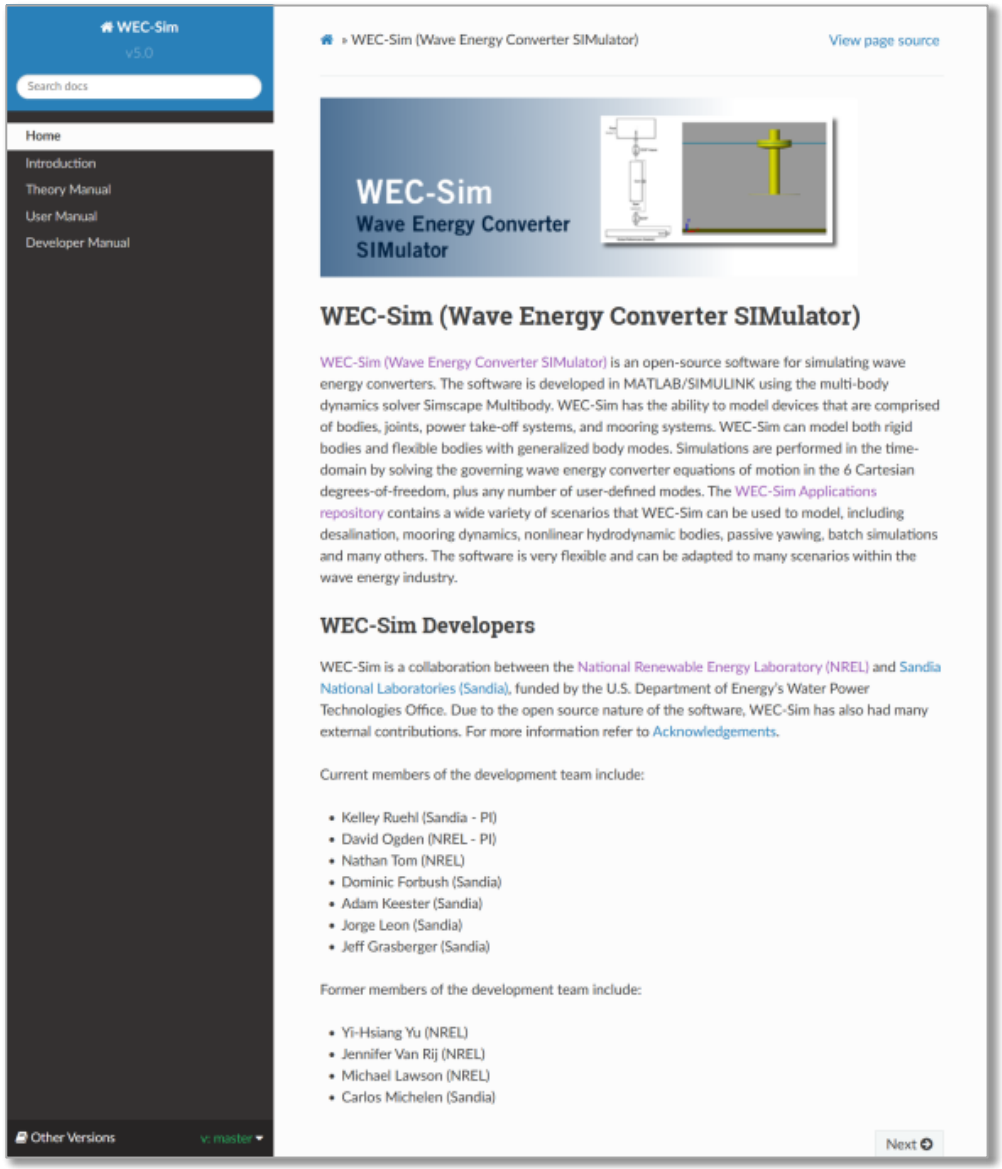
WEC-Sim v5.0

WEC-Sim on GitHub:
https://github.com/WEC-Sim/WEC-Sim



WEC-Sim Applications on GitHub:
https://github.com/WEC-Sim/WEC-Sim_Applications





Introduction to v5.0

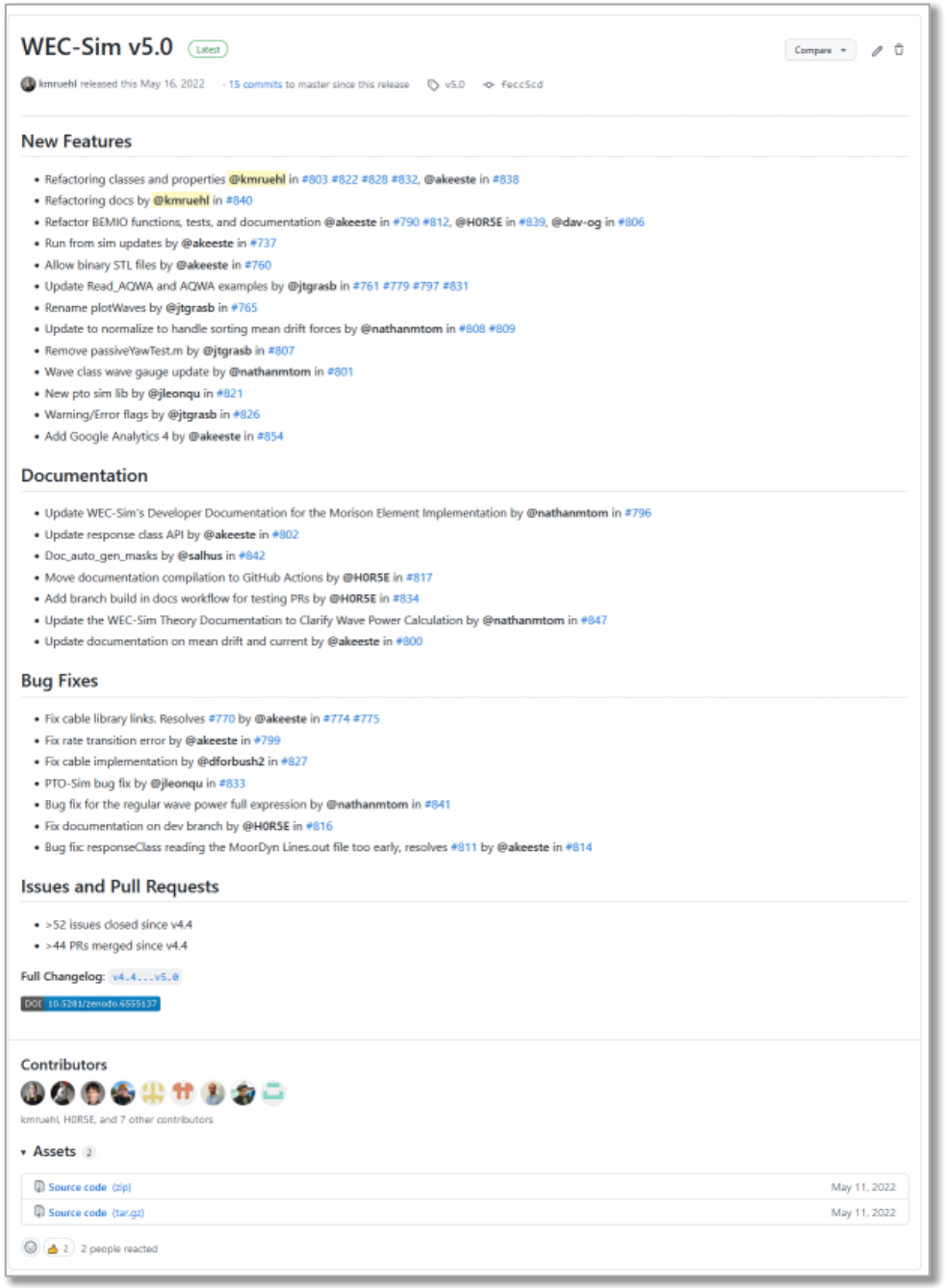
v5.0, released May 16, 2022, represents a significant code overhaul and feature addition.

Refactoring and SCM changes

- An intuitive and consistent naming convention applied throughout (not reverse compatible)
- Related functions grouped together, redundant functions removed.
- Embedded Simulink functions saved as separate scripts
- Updated and expanded documentation

New features

- Continuous integration
- Modeling cables
- Capytaine BEM
- Run from Simulink
- Wave visualization



WEC-Sim v5.0 Latest

Compare

kmruehl released this May 16, 2022 · 15 commits to master since this release v5.0 fecc5cd

New Features

- Refactoring classes and properties @kmruehl in #803 #822 #828 #832, @akeeste in #838
- Refactoring docs by @kmruehl in #840
- Refactor BEMIO functions, tests, and documentation @akeeste in #790 #812, @H0R5E in #839, @dav-og in #806
- Run from sim updates by @akeeste in #737
- Allow binary STL files by @akeeste in #760
- Update Read_AQWA and AQWA examples by @jtgrasb in #761 #779 #797 #831
- Rename plotWaves by @jtgrasb in #765
- Update to normalize to handle sorting mean drift forces by @nathanmtom in #808 #809
- Remove passiveYawTest.m by @jtgrasb in #807
- Wave class wave gauge update by @nathanmtom in #801
- New pto sim lib by @jleonqu in #821
- Warning/Error flags by @jtgrasb in #826
- Add Google Analytics 4 by @akeeste in #854

Documentation

- Update WEC-Sim's Developer Documentation for the Morison Element Implementation by @nathanmtom in #796
- Update response class API by @akeeste in #802
- Doc_auto_gen_masks by @salhus in #842
- Move documentation compilation to GitHub Actions by @H0R5E in #817
- Add branch build in docs workflow for testing PRs by @H0R5E in #834
- Update the WEC-Sim Theory Documentation to Clarify Wave Power Calculation by @nathanmtom in #847
- Update documentation on mean drift and current by @akeeste in #800

Bug Fixes

- Fix cable library links. Resolves #770 by @akeeste in #774 #775
- Fix rate transition error by @akeeste in #799
- Fix cable implementation by @dforbush2 in #827
- PTO-Sim bug fix by @jleonqu in #833
- Bug fix for the regular wave power full expression by @nathanmtom in #841
- Fix documentation on dev branch by @H0R5E in #816
- Bug fix responseClass reading the MoorDyn Lines.out file too early, resolves #811 by @akeeste in #814

Issues and Pull Requests

- >52 issues closed since v4.4
- >44 PRs merged since v4.4

Full Changelog: v4.4...v5.0

DOI 10.5281/zenodo.6555137

Contributors

kmruehl, H0R5E, and 7 other contributors

▾ Assets 2

Source code (zip) May 11, 2022

Source code (tar.gz) May 11, 2022

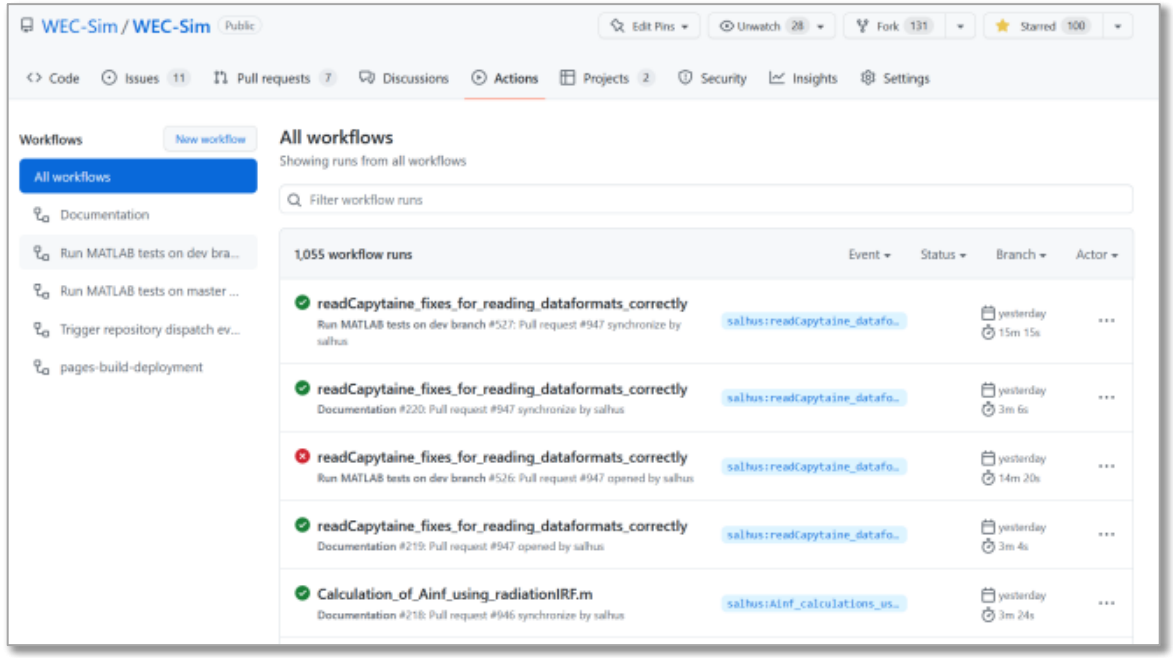
2 people reacted

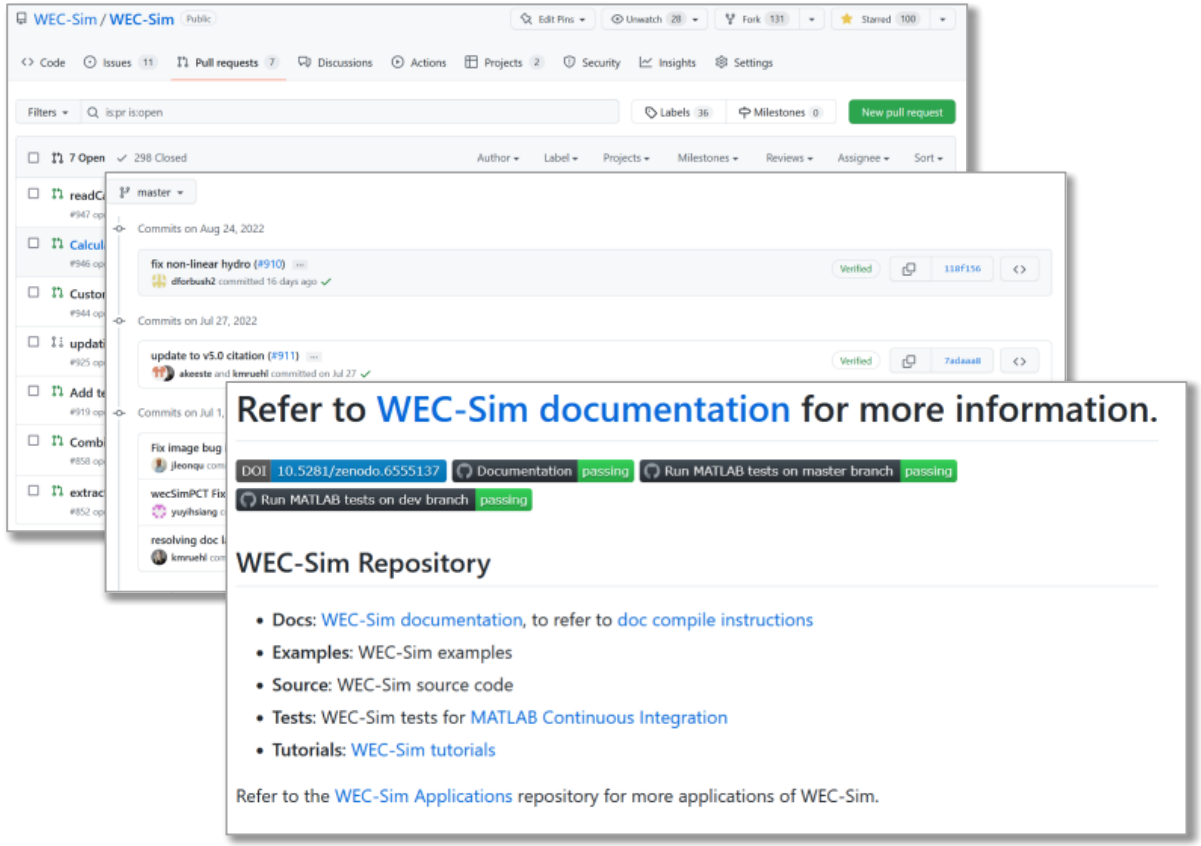
New Features - Continuous Integration

New features – Continuous integration

WEC-Sim tests developed for WEC-Sim source repository and WEC-Sim Applications

- Tests can be run locally when developing new features, to ensure stability of source code
- Tests automatically executed on both master and dev branches, on both repositories
- Tests automatically executed for documentation build
- Tests automatically for each commit and pull request
- Build reports automatically generated





New Features – Cable Modeling

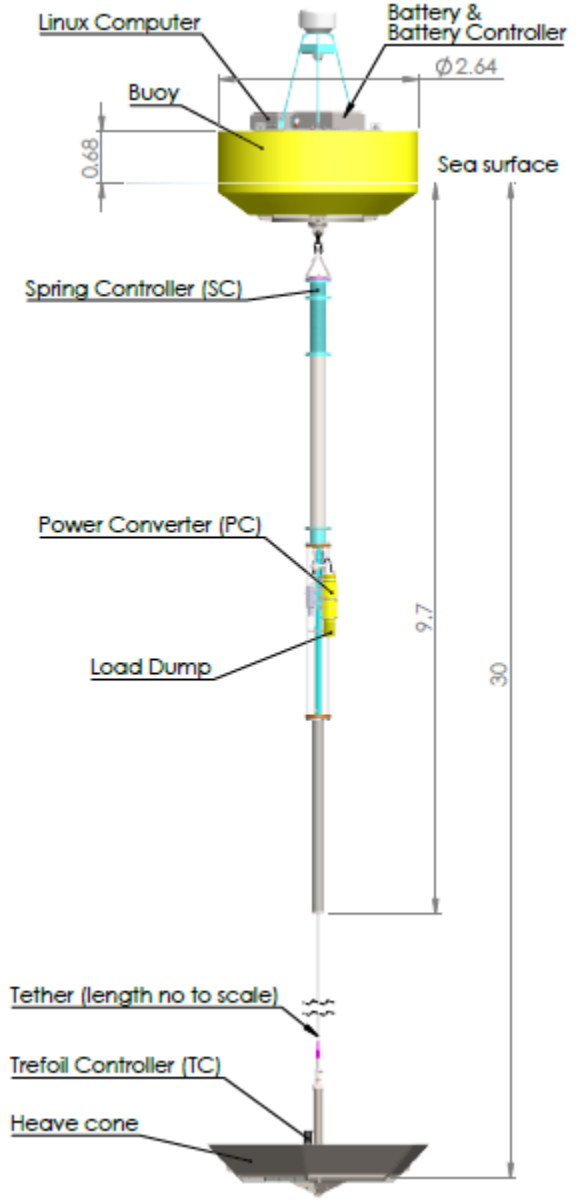
New features – Modeling cables

A number of industry WECs rely on cables/winches/tethers as a means of coupling two or more bodies: a frequent subject of user -posted issues.

These elements are non-linear as they only transmit tensile forces between the connection points .

At right: Schematic of the MBARI-WEC*.

At far right: Mechanics Explorer visualization of the MBARI-WEC. The end-points of the cable connection shown as oversize grey spheres.



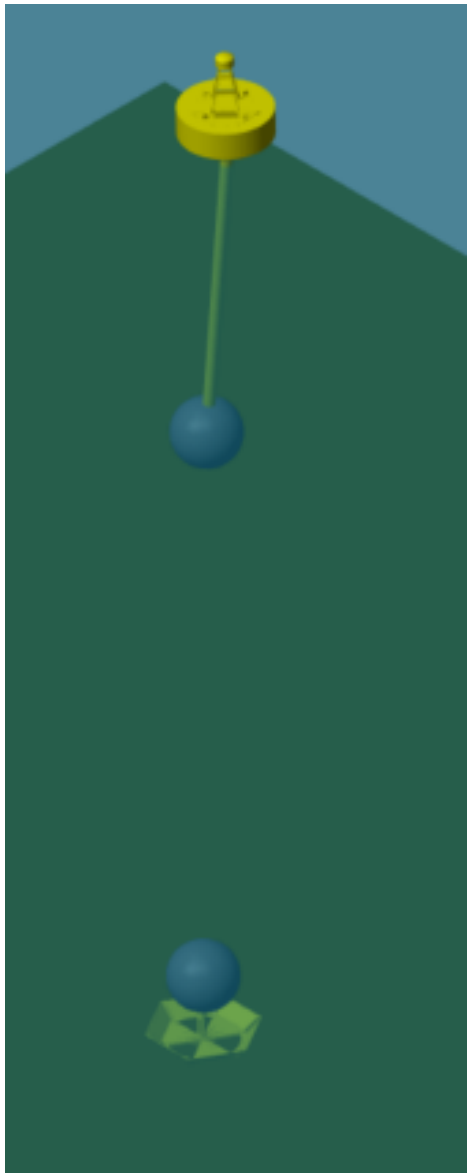


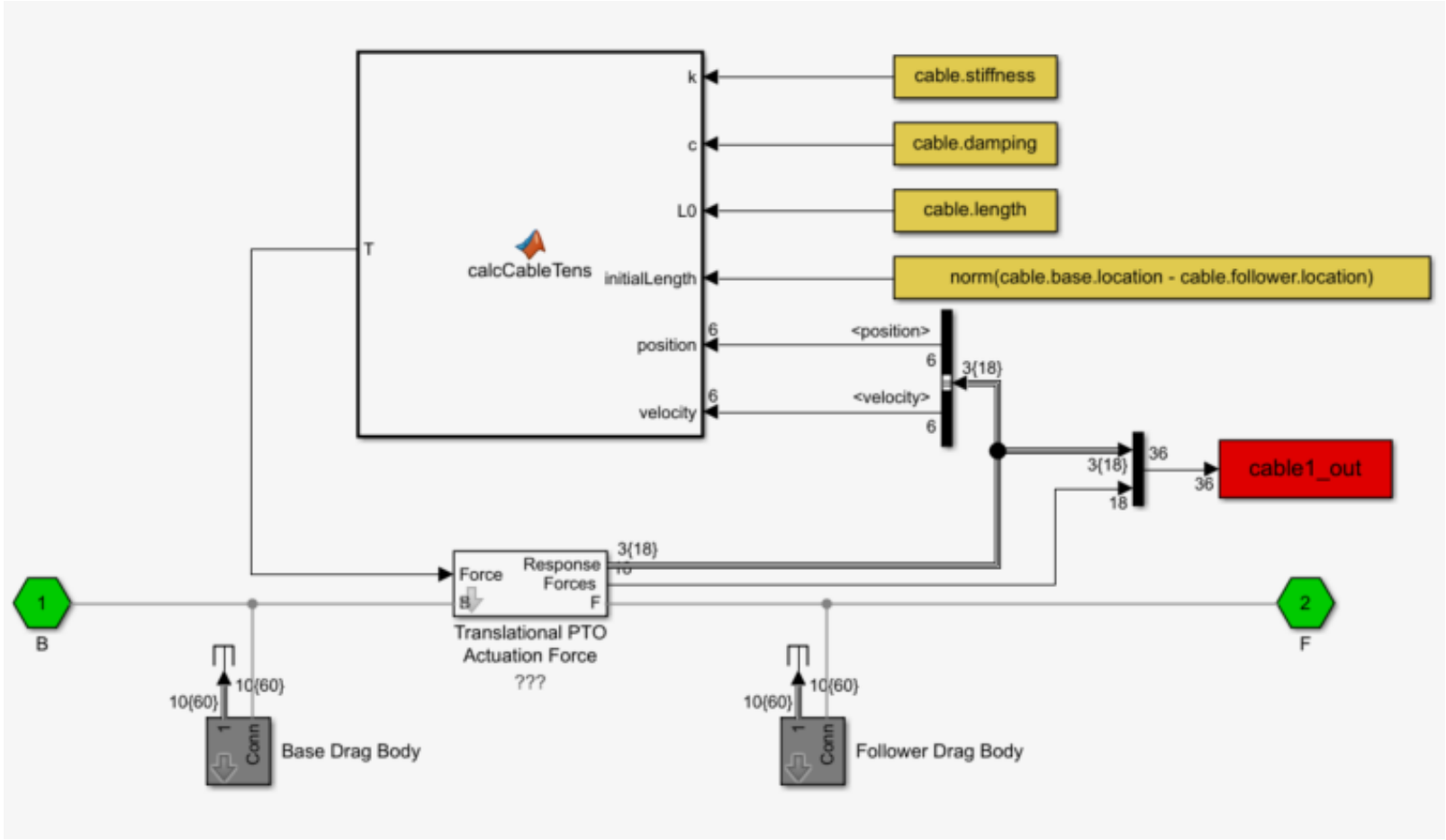
Image from Hamilton, A., Cazenave, F., Forbush, D. *et al.* The MBARI-WEC: a power source for ocean sensing. *J. Ocean Eng. Mar. Energy* **7**, 189–200 (2021). https://doi.org/10.1007/s40722-021-00197-9

New features – Modeling cables

Implemented as a logic check: cable stiffness + damping force exerted if extended beyond equilibrium length, no force exerted if not.

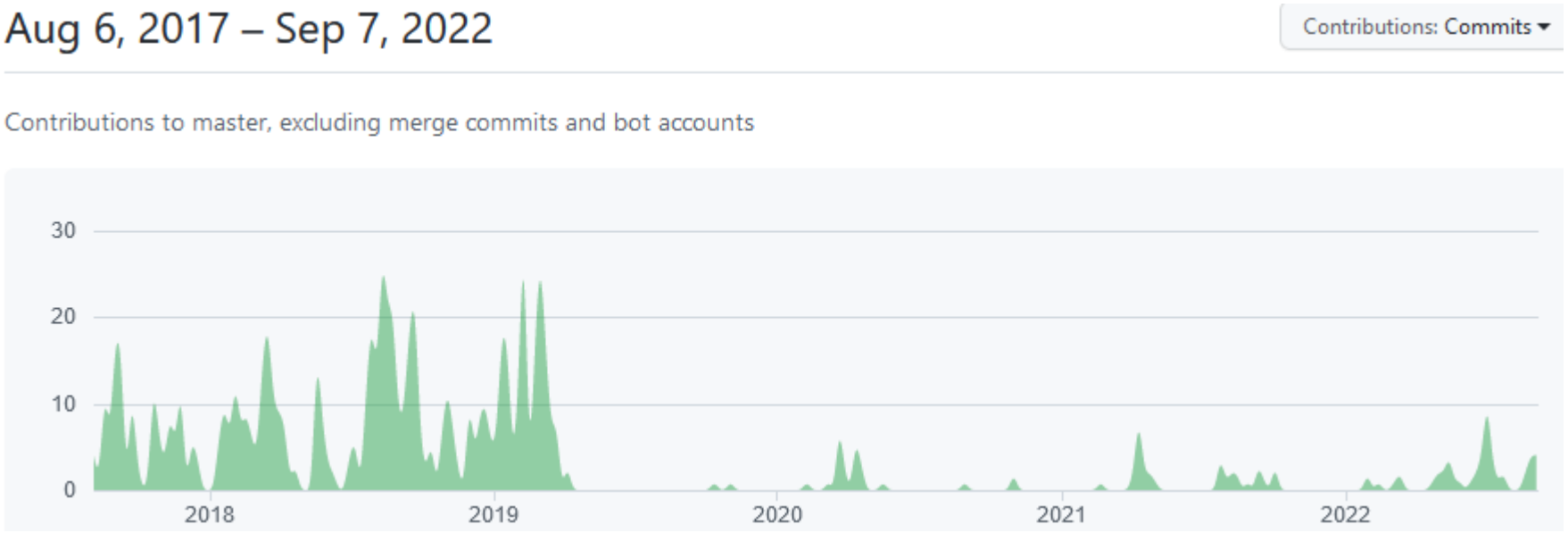
This does NOT resolve the motions of the cable, but transmits appropriate forces between the coupled bodies.

Alternative modeling suggestions available for stiff systems.



New Features – Capytaine BEM

New features – Capytaine



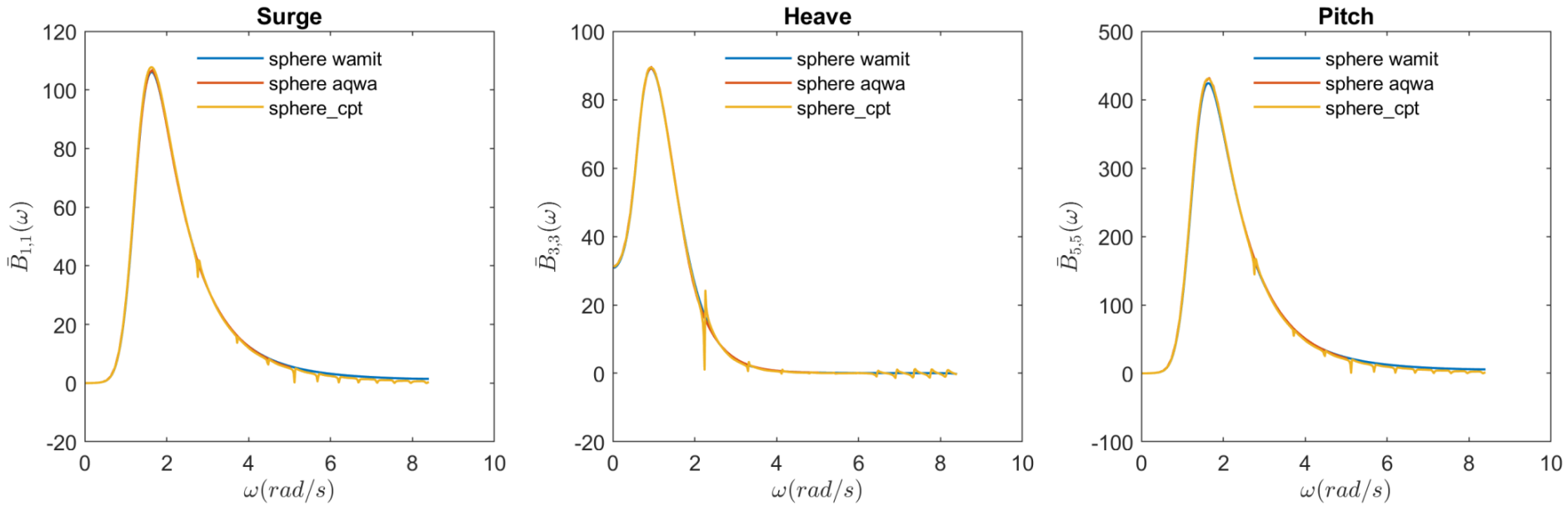
WEC-Sim relies on boundary element method solutions to define hydrodynamic coefficients. Supported codes are NEMOH, WAMIT, AQWA, and now Capytaine

Open-source Python code: https://github.com/capytaine/capytaine

Capytaine support is current and ongoing.

Capytaine developer: Matthieu Ancellin

New features – Capytaine



WEC-Sim relies on boundary element method solutions to define hydrodynamic coefficients. Supported codes are NEMOH, WAMIT, AQWA, and now Capytaine

Open-source Python code: https://github.com/capytaine/capytaine

Capytaine support is current and ongoing.

Capytaine developer: Matthieu Ancellin

New Features – Run from Simulink

New features – Run from Simulink

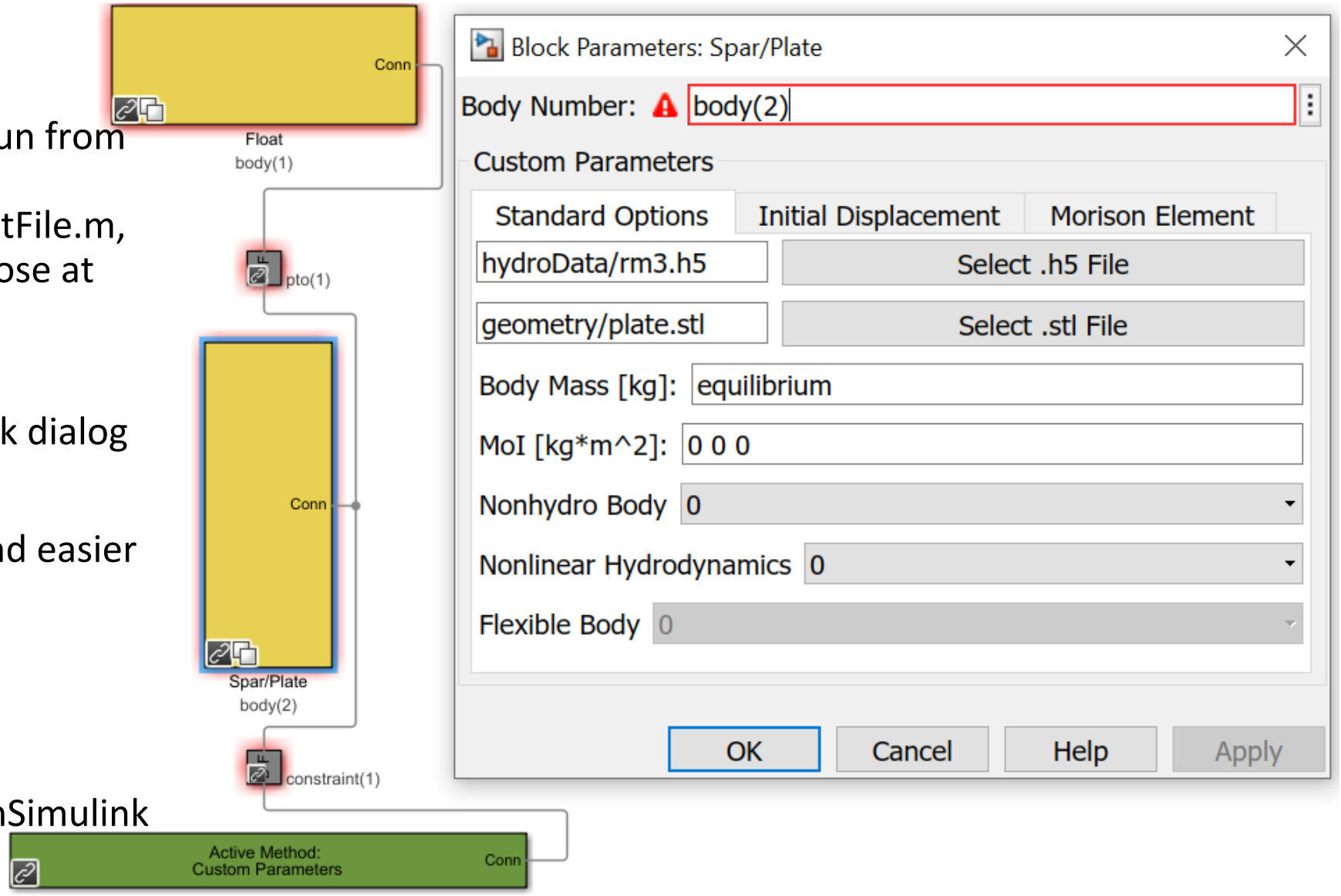
Previously, a simulation was run from the command line, reading information from wecSimInputFile.m, and Simulink models would close at run time.

Now, user option to specify parameters directly in Simulink dialog and run from GUI.

A more common workflow, and easier for debugging.

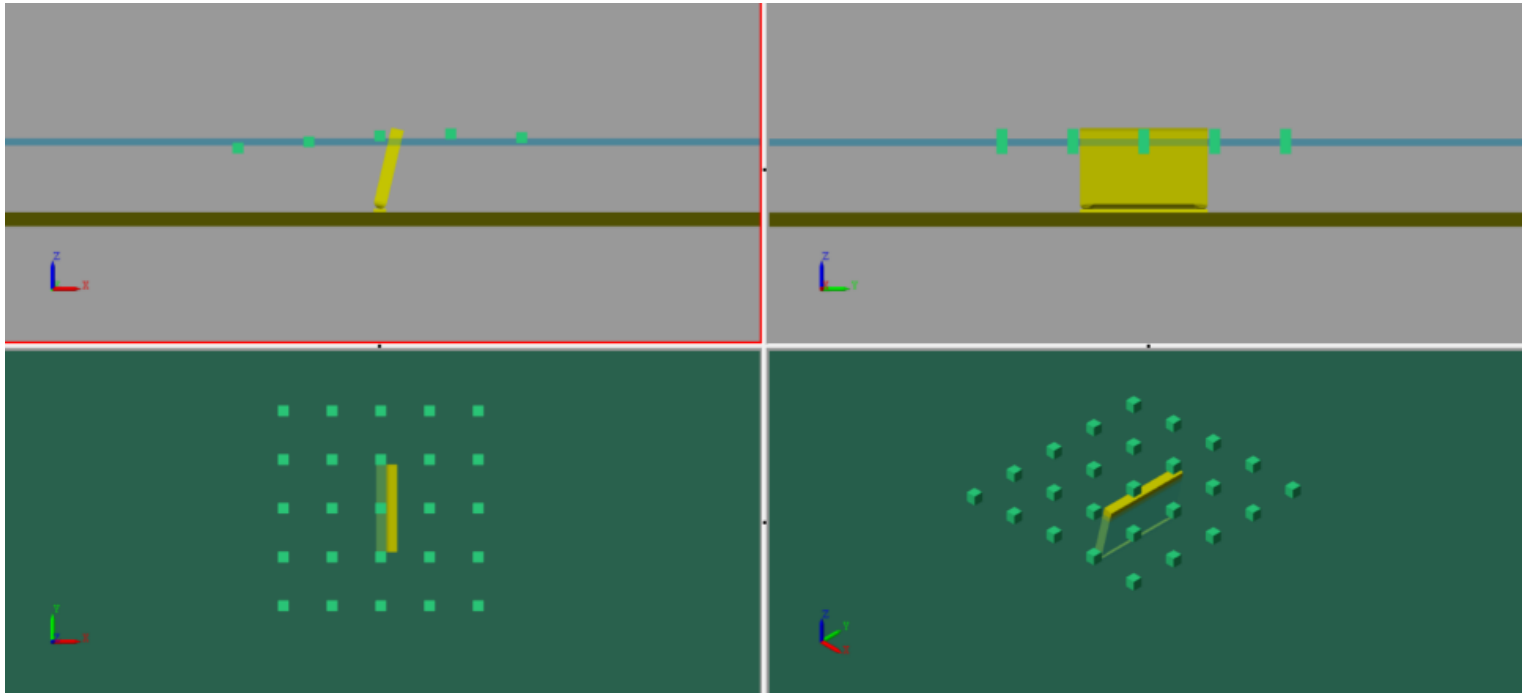
Example given:

WEC-Sim/examples/RM3FromSimulink



New Features – Wave Visualization

New features – Wave Visualization



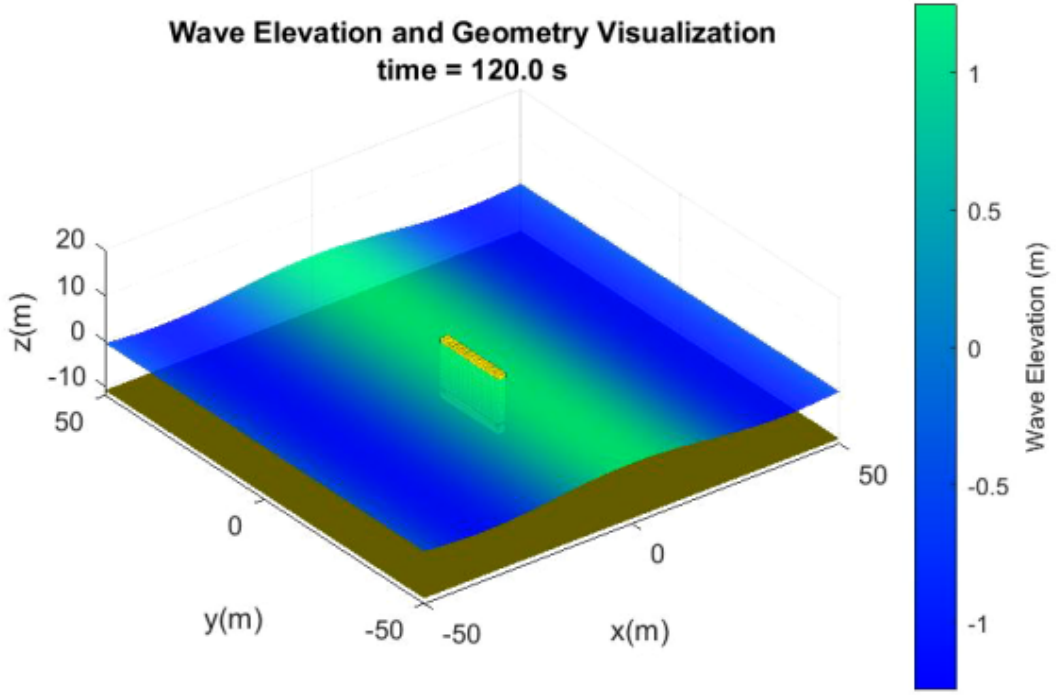
User-defined wave markers offer a simple way to aid free surface visualization in the native Mechanics Explorer. A useful debugging tool!

Videos files (*.avi of *.gif) can be created using responseClass.saveViz() function.

Example shown: WEC-Sim_Applications/Wave_Markers

ParaView (VTK) visualization is still supported as a visualization alternative.

New features – Wave Visualization



User-defined wave markers offer a simple way to aid free surface visualization in the native Mechanics Explorer. A useful debugging tool!

Videos files (*.avi of *.gif) can be created using responseClass.saveViz() function.

Example shown: WEC-Sim_Applications/Wave_Markers

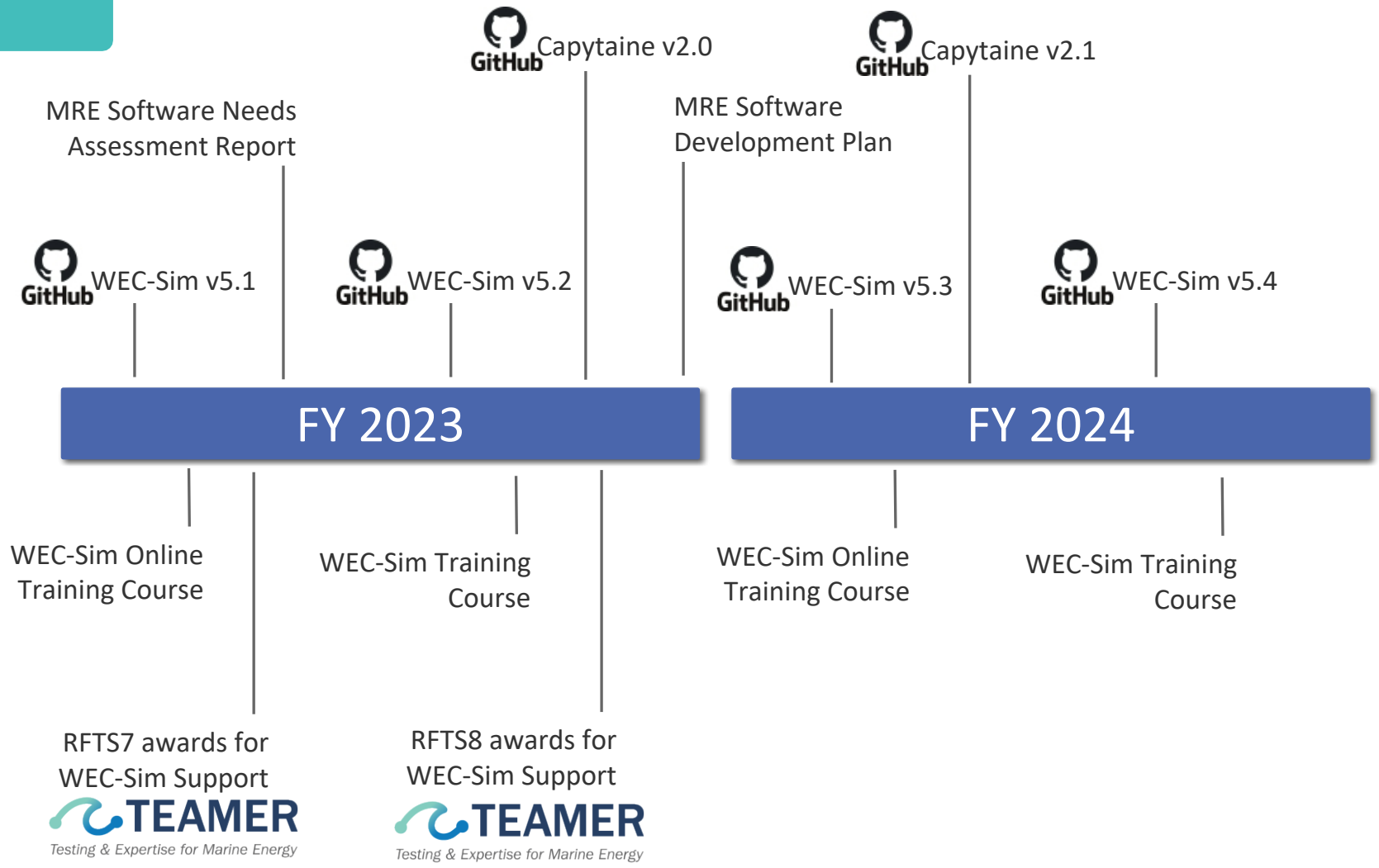
ParaView (VTK) visualization is still supported as a visualization alternative.

Future Development

Future Work

Advance the state of open source software within the wave energy sector

- Improve WEC-Sim **interoperability with open-source meshing, BEM and optimization** software to facilitate device performance improvements and cost reduction
- **Improve parallelization** to leverage HPC systems for scientific discovery
- **Support the development of the open-source BEM software Capytaine** – improving accuracy, speed and functionality.
- **Outreach and training,** including short courses, webinars, and additional WEC-Sim applications (e.g. offshore wind, flexible bodies)



Conclusion

- User feedback guides development! Contributions are always welcomed.
- Report a bug, seek support, request a feature: https://github.com/WEC-Sim/WEC-Sim/issues
- Contribute to the WEC-Sim or WEC-Sim Applications code directly: https://github.com/WEC-Sim/WEC-Sim/pulls
- Direct industry/research support available through the TEAMER program: https://teamer-us.org/

For more information please visit the WEC-Sim website:

http://wec-sim.github.io/WEC-Sim

Kelley Ruehl (Sandia)
Kelley.Ruehl@sandia.gov

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308.

Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Water Power Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.