

Matthew Williamson, Nels J. Frazier, Trey
Flowers, Fred L. Ogden, Robert J. Bartel,
Donald Johnson, David Mattern, Shengting Cui,
Christopher Tubbs

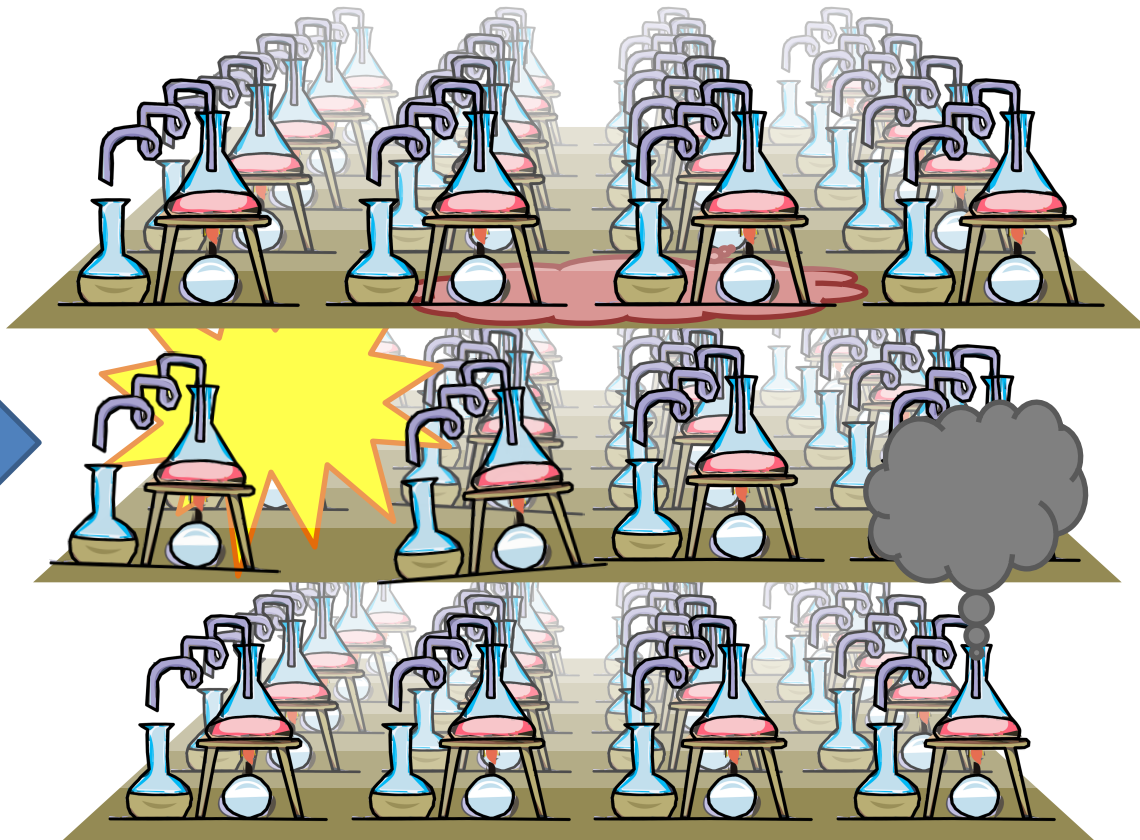
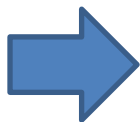
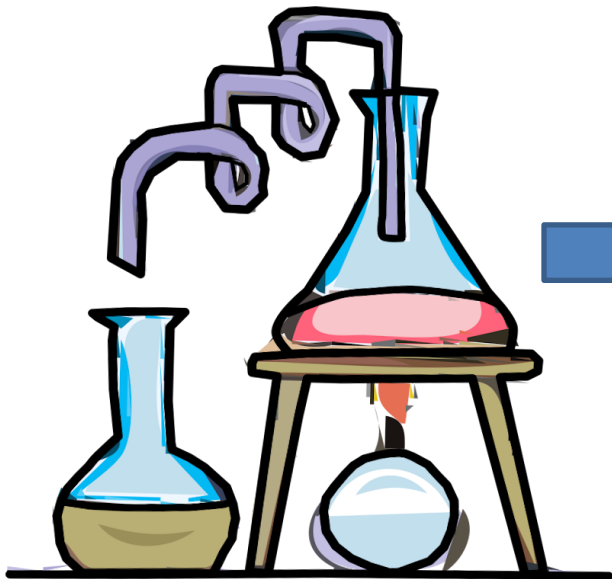
OWP | OFFICE OF
WATER
PREDICTION

Next Generation Water Resources Modeling

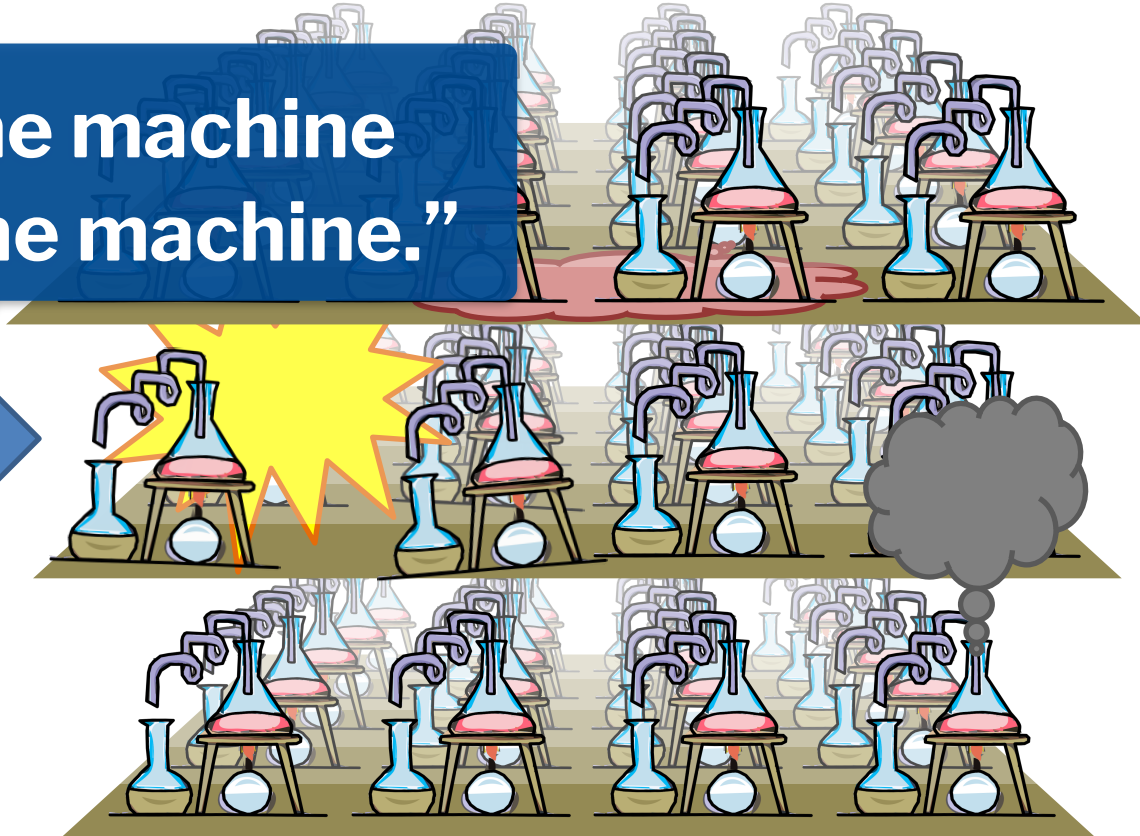
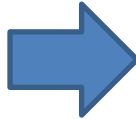
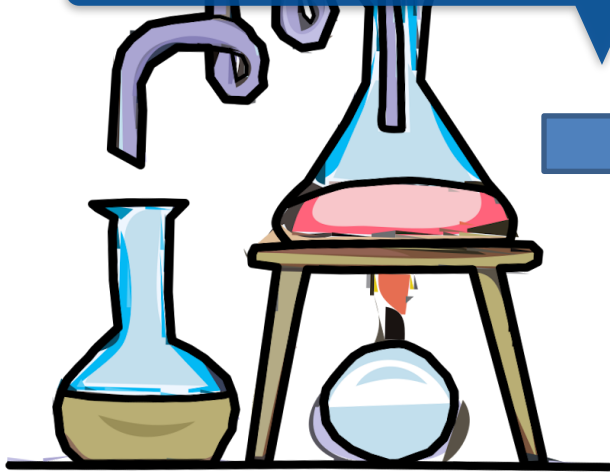


Modern, Open Source Development Strategies for Building
an Extensible Research to Operations Framework

Science at Scale



**“Building the machine
that builds the machine.”**



Our Solution

- Open Source Project
- Iterative, Agile development
- Modularity emphasis
- Open, standard interfaces (HY_Features, BMI)
- Modern software development best practices

Tools

- Git
 - Version Control
- GitHub
 - Shared Version Control / Open Source Development
 - Issue Tracking / Feature Requests
 - Developer Workflow (Pull Requests / Merge Strategy)
- GoogleTest
 - Test writing and mocking framework
- GitHub Workflows
 - Test Automation / Continuous Integration
- Standard interfaces and libraries
 - BMI
 - HY_Features
 - Boost
 - UDUNITS-2

Modularity and Reuse

- BMI (Basic Model Interface)
 - Uniform, generalized interface for model implementation
 - Allows the framework to be completely ignorant of the models it is running
 - Model modules written in any of 4 languages and can reside in their own libraries
 - <https://csdms.colorado.edu/wiki/BMI>
- HY_Features
 - OGC Standard
 - Describes graph-based hydrofabric structure and its features
 - Will provide an interface for hydrofabric and routing modules
 - http://opengeospatial.github.io/HY_Features/
- Others
 - Boost
 - UDUNITS-2



Why borrow when you can steal?

C++ BMI Module Integration #343

[Edit](#)[Code](#)

[Open](#) mattw-nws wants to merge 9 commits into NOAA-OWP:master from mattw-nws:integrate-freezethaw

Conversation 2 Commits 9 Checks 15 Files changed 20

+3,031 -16

Changes from 1 commit **WHY** Clear filters Conversations Jump to

[Review changes](#)

✓ Adds `dLError` handling to `dynamic_library_load`

[Prev](#) [Next](#)

mattw-nws committed 5 days ago

commit 05c7a2b34a5a49e718d2b7febbf365558413cd12

WHO

WHEN

WHERE

WHAT

```
@@ -94,8 +94,19 @@ namespace models {
    94      throw std::runtime_error(this->init_exception_msg);
    95    }
    96
    97 +    // Call first to ensure any previous error is cleared before trying to load the symbol
    98 +    dLError();
    99
   100    // Load up the necessary library dynamically
   101    dyn_lib_handle = dlopen(bmi_lib_file.c_str(), RTLD_NOW | RTLD_LOCAL);
   102
   103    // Now call again to see if there was an error (if there was, this will not be null)
   104    char *err_message = dLError();
   105    if (dyn_lib_handle == nullptr && err_message != nullptr) {
   106      this->init_exception_msg = "Cannot load shared lib " + bmi_lib_file + " for model " + this->model_name;
   107      if (err_message != nullptr) {
```

Version Control / Source Code Control (Git)

C++ BMI Module Integration #343

Issue/Feature Tracking

Edit

<> Code

Open

mattw-nws wants to merge 9 commits into NOAA-OWP:master from mattw-nws:integrate-freezethaw

Merge Workflow

Conversation 2

Commits 9

Checks 15

Files changed 20

+3,031 -16

Changes commit File filter Clear filters Conversations Jump to

Review Workflow

Review changes

✓ Add error handling to dynamic_library

Test Automation Workflow

< Prev Next >

Internal/External Collaboration

commit 05c7a2b34a5a49e718d2b7febbf365558413cd12

```
include/realizations/catchment/AbstractCLibBmiAdapter.hpp

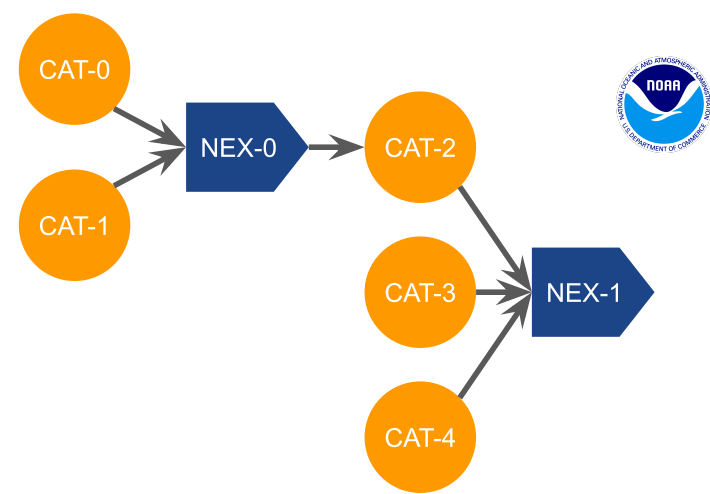
@@ -94,8 +94,19 @@ namespace models {
    94    94         throw std::runtime_error(this->init_exception_msg);
    95    95     }
    96    96
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    103    +         if (dyn_lib_handle == nullptr && err_message != nullptr) {
    104    +             this->init_exception_msg = "Cannot load shared lib " + bmi_lib_file + " for model " + this->model_name;
    105    +             if (err_message != nullptr) {
```

Collaboration and Developer Workflow (GitHub)


```

132 Nels Frazier, 7 months ago | 1 author (Nels Frazier)
133 class Network_Test2 : public Network_Test, public ::testing::Test{
134 public:
135     Network_Test2(){}
136     void SetUp(){
137         this->add_catchment("cat-0", "nex-0");
138         this->add_catchment("cat-1", "nex-0");
139         this->add_nexus("nex-0", "cat-2");
140         this->add_catchment("cat-2", "nex-1");
141         this->add_catchment("cat-3", "nex-1");
142         this->add_catchment("cat-4", "nex-1");
143         this->add_nexus("nex-1");
144         n = Network(this->get_fabric());
145     }
146 };
147

```

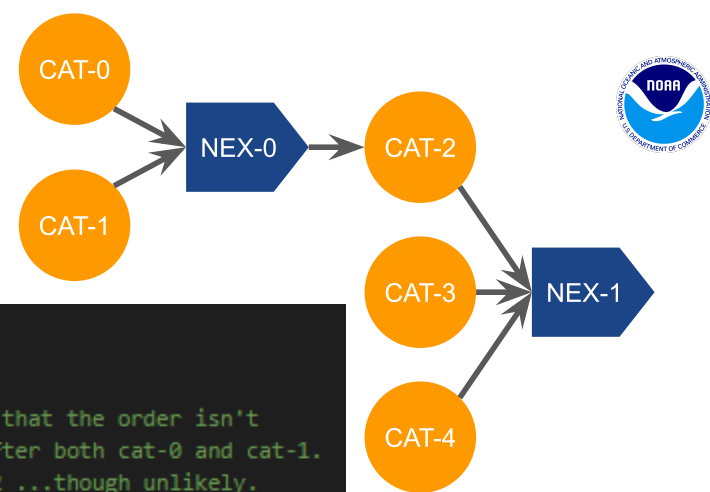


Automated Unit Testing (GoogleTest)

```

132 Nels Frazier, 7 months ago | 1 author (Nels Frazier)
133 class Network_Test2 : public Network_Test, public ::testing::Test{
134 public:
135     Network_Test2(){}
136     void SetUp(){
137         this->add_catchment("cat-0", "nex-0");
138         this->add_catchment("cat-1", "nex-0");
139         this->add_nexus("nex-0", "cat-2");
140         this->add_catchment("cat-2", "nex-1");

```



```

291 TEST_F(Network_Test2, test_catchments_filter)
292
293

```

```

294 //This order IS IMPORTANT, it should be the topological order of catchments. Note that the order isn't
295 //guaranteed on the leafs, the only guarantees for this test is that cat-2 comes after both cat-0 and cat-1.
296 //Technically, this is a valid topological order: cat-0, cat-3, cat-1, cat-4, cat-2 ...though unlikely.
297 auto catchments = n.filter("cat");
298 //auto catchments_it = catchments.begin();
299 for(const auto& id : n) std::cout<<"topo_id: "<<n.get_id(id)<<std::endl;
300 for(const auto& id : catchments) std::cout<<"id: "<<id<<std::endl;
301 auto cat0_it = std::find(catchments.begin(), catchments.end(), "cat-0");
302 auto cat1_it = std::find(catchments.begin(), catchments.end(), "cat-1");
303 auto cat2_it = std::find(catchments.begin(), catchments.end(), "cat-2");
304 std::cout << "cat-0 to cat-2 distance: " << std::distance(cat0_it, cat2_it) << std::endl;
305 std::cout << "cat-1 to cat-2 distance: " << std::distance(cat1_it, cat2_it) << std::endl;
306 ASSERT_TRUE( std::distance(cat0_it, cat2_it) > 0);
307 ASSERT_TRUE( std::distance(cat1_it, cat2_it) > 0);
308 ASSERT_TRUE( cat2_it != catchments.end() );
309

```

Automated Unit Testing (GoogleTest)

```

110 const std::string EXAMPLE_1 = "{ "
111     "\"global\": { "
112         "\"formulations\": [ "
113             "{
114                 \"name\": \"tshirt\", "
115                 \"params\": {
116                     \"maxsmc\": 0.81, "
117                     \"wltsmc\": 1.0, "
118                     \"satdk\": 0.48, "
119                     \"satpsi\": 0.1, "
120                     \"slope\": 0.58, "
121                     \"scaled_distribution_fn_shape_parameter\": 1.3, "
122                     \"multiplier\": 1.0, "
123                     \"alpha_fc\": 1.0, "
124                     \"Klf\": 0.000672, "
125                     \"Kn\": 0.1, "
126                     \"nash_n\": 8, "
127                     \"Cgw\": 1.08, "
128                     \"expon\": 6.0, "
129                     \"max_groundwater_storage_meters\": 16.0, "
130                     \"nash_storage\": [ "
131                         "1.0, "
132                         "1.0, "
133                         "1.0, "
134                         "1.0, "
135                         "1.0, "
136                         "1.0, "
137                         "1.0, "
138                         "1.0 "
139                     ], "
140                     \"soil_storage_percentage\": 1.0, "
141                     \"groundwater_storage_percentage\": 1.0, "
142                     \"timestep\": 3600, "
143                     \"giuh\": { "
144                         \"giuh_path\": \"./test/data/giuh/GIUH.json\", "
145                         \"crosswalk_path\": \"./data/crosswalk.json\" "
146                     } "

```

```

659 TEST_F(Formulation_Manager_Test, basic_run_1) {
660     std::stringstream stream;
661     stream << fix_paths(EXAMPLE_1);
662
663     std::ostream* raw_pointer = &std::cout;
664     std::shared_ptr<std::ostream> s_ptr(raw_pointer, [](void*) {});
665     utils::StreamHandler catchment_output(s_ptr);
666
667     realization::Formulation_Manager manager = realization::Formulation_Manager(stream);
668
669     this->add_feature("cat-52");
670     this->add_feature("cat-67");
671     manager.read(this->fabric, catchment_output);
672
673     ASSERT_EQ(manager.get_size(), 2);
674
675     std::map<std::string, std::map<long, double>> calculated_results;
676
677     pdm03_struct pdm_et_data;
678     pdm_et_data.scaled_distribution_fn_shape_parameter = 1.3;
679     pdm_et_data.vegetation_adjustment = 0.99;
680     pdm_et_data.model_time_step = 0.0;
681     pdm_et_data.max_height_soil_moisture_storage_tank = 400.0;
682     pdm_et_data.maximum_combined_contents = pdm_et_data.max_height_soil_moisture_storage_tank / (1
683
684     std::shared_ptr<pdm03_struct> et_params_ptr = std::make_shared<pdm03_struct>(pdm_et_data);
685
686     double dt = 3600.0;
687
688     for (std::pair<std::string, std::shared_ptr<realization::Formulation>> formulation : manager) {
689         if (calculated_results.count(formulation.first) == 0) {
690             calculated_results.emplace(formulation.first, std::map<long, double>());
691         }
692     }

```

Automated Integration Testing (GoogleTest)

```

43 - name: Build surfacebmi module
44   run: |
45     cmake -B extern/noah-mp-modular/cmake_build cmake_build -S extern/noah-mp-modular
46     cmake --build extern/noah-mp-modular/cmake_build --target surfacebmi -- -j ${ env.LINUX_NUM_PROC_CORES }}
47
48
49 - name: Build cfebmi module
50   run: |
51     cmake -B extern/cfe/cmake_build -S extern/cfe/
52     cmake --build extern/cfe/cmake_build/ --target cfebmi -- -j ${ env.LINUX_NUM_PROC_CORES }}
53
54 - name: Build iso_c_fortran_bmi module
55   run: |
56     cmake -B extern/iso_c_fortran_bmi/cmake_build -S extern/iso_c_fortran_bmi
57     cmake --build extern/iso_c_fortran_bmi/cmake_build --target iso_c_bmi -- -j ${ env.LINUX_NUM_PROC_CORES }}
58
59 - name: cmake_init_build
60   run: |
61     export BOOST_ROOT="$(pwd)/boost_1_72_0"
62     [ ! -d "$BOOST_ROOT" ] && echo "Error: no Boost root found at $BOOST_ROOT" && exit 1
63     cmake -B cmake_build -DBMI_C_LIB_ACTIVE:BOOL=ON -DBMI_FORTTRAN_ACTIVE=ON -DNGEN_ACTIVATE_PYTHON:BOOL=OFF -S .
64
65 - name: Build ngen
66   run: cmake --build cmake_build --target ngen -- -j ${ env.LINUX_NUM_PROC_CORES }}
67   timeout-minutes: 15
68
69 - name: Run surfacebmi plus cfebmi
70   run: ./cmake_build/ngen data/catchment_data.geojson "cat-27" data/nexus_data.geojson "nex-26" data/example_bmi_multi_realization_config.json

```

Automated Integration Testing (GitHub Workflows)

Jobs

- ✓ test_unit_ubuntu_latest
- ✓ test_mpi_remote_nexus_ubuntu_l...
- ✓ test_bmi_cpp_ubuntu_latest
- ✓ test_bmi_c_ubuntu_latest
- ✓ test_bmi_fortran_ubuntu_latest
- ✓ test_bmi_python_ubuntu_latest
- ✓ test_bmi_multi_ubuntu_latest
- ✓ test_unit_macos_latest
- ✗ test_bmi_cpp_macos_latest
- ✓ test_bmi_c_macos_latest
- ✓ test_bmi_fortran_macos_latest
- ✓ test_bmi_python_macos_latest
- ✓ test_bmi_multi_macos_latest

test_bmi_cpp_macos_latest

failed 5 days ago in 6m 17s

Search logs



```
110realizations_catchment.a(Bmi_Py_Adapter.cpp.o) has no symbols
170 /Applications/Xcode_12.4.app/Contents/Developer/Toolchains/XcodeDefault.xctoolchain/usr/bin/ranlib: file:
librealizations_catchment.a(Bmi_Py_Formulation.cpp.o) has no symbols
171 [ 94%] Built target realizations_catchment
172 [ 96%] Building CXX object
test/CMakeFiles/test_bmi_cpp.dir/realizations/catchments/Bmi_Cpp_Adapter_Test.cpp.o
173 [ 98%] Building CXX object
test/CMakeFiles/test_bmi_cpp.dir/realizations/catchments/Bmi_Cpp_Formulation_Test.cpp.o
174 /Users/runner/work/ngen/ngen/test/realizations/catchments/Bmi_Cpp_Adapter_Test.cpp:95:28: error: no member
named '__cxa_exception_type' in 'std::exception_ptr'
      std::clog <<(p ? p.__cxa_exception_type()->name() : "null") << std::endl;
                        ~ ^
176
177 1 error generated.
178 make[3]: *** [test/CMakeFiles/test_bmi_cpp.dir/realizations/catchments/Bmi_Cpp_Adapter_Test.cpp.o] Error 1
179 make[3]: *** Waiting for unfinished jobs....
180 make[2]: *** [test/CMakeFiles/test_bmi_cpp.dir/all] Error 2
181 make[1]: *** [test/CMakeFiles/test_bmi_cpp.dir/rule] Error 2
182 make: *** [test_bmi_cpp] Error 2
183 Error: Process completed with exit code 2.
```

✓ run_bmi_c++_tests 0s

✓ clean_build 0s

✓ clean_shared_lib_build 0s



GitHub Workflow Test Automation

- ✓ test_unit_ubuntu_latest
- ✓ test_mpi_remote_nexus_ubuntu_l...
- ✓ test_bmi_cpp_ubuntu_latest
- ✓ test_bmi_c_ubuntu_latest
- ✓ test_bmi_fortran_ubuntu_latest
- ✓ test_bmi_python_ubuntu_latest
- ✓ test_bmi_multi_ubuntu_latest
- ✓ test_unit_macos_latest
- ✗ test_bmi_cpp_macos_latest
- ✓ test_bmi_c_macos_latest
- ✓ test_bmi_fortran_macos_latest
- ✓ test_bmi_python_macos_latest
- ✓ test_bmi_multi_macos_latest

“What tests?
That’s what
the users
are for!”



Brady Holt — no changes — CC3.0 — <https://creativecommons.org/licenses/by/3.0/>



Review required

At least 1 approving review is required by reviewers with write access. [Learn more.](#)

[Show all reviews](#)



1 pending reviewer



All checks have passed

15 successful checks


[Hide all checks](#)



 Build and Run NGEN on example data / Build_and_Run_Model (pull_request) Successful in 5m

[Details](#)



 Testing and Validation / test_surfacebmi_plus_cfe (pull_request) Successful in 2m


[Details](#)



 Testing and Validation / test_unit_ubuntu_latest (pull_request) Successful in 2m


[Details](#)



 Testing and Validation / test_mpi_remote_nexus_ubuntu_latest (pull_request) Successful in 1m

[Details](#)



 Testing and Validation / test_bmi_cpp_ubuntu_latest (pull_request) Successful in 2m

[Details](#)



Merging is blocked

Merging can be performed automatically with 1 approving review.

Squash and merge




You can also [open this in GitHub Desktop](#) or [view command line instructions](#).




Semi-Automated “Peer Review” Before Merge


255			
256			<i>// Check for and remove any stored sends requests that have completed</i>
257	▶ 2/2	192	for (auto i = stored_sends.begin(); i != stored_sends.end();)
258			{
259	▶ 2/4	60	MPI_Handle_Error(MPI_Test(&i->mpi_request, &flag, &status));
260			
261	▶ 1/2	60	if (flag)
262			{
263			<i>// remove this object from the vector</i>
264		60	i = stored_sends.erase(i);
265			}
266			else
267			{
268		X	++i;
269			}
270			}
271		132	}
272			
273		X	long HY_PointHydroNexusRemote::get
274			{
275		X	return time_step;
276			}
277			
278		X	int HY_PointHydroNexusRem
279			{
280		X	return world_rank;
281	▶ 2/4	72	}
282			



Donald Johnson 2:43 PM
 268 not be reached is interesting
 that means we never checked for a send before it arrived



Matthew Williamson - NOAA Federal 2:43 PM
 A test on get_timestep might be valuable even if the method isn't needed... to ensure that the timestep is being internally set correctly.
 Ah I was unsure what that branch indicated.

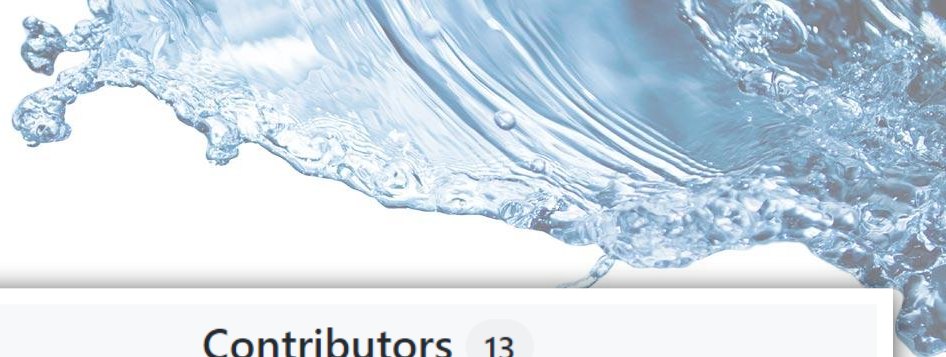


Donald Johnson 2:44 PM
 thats is why I said we should either add tests or remove the functions
 yeah 268 is where we check to see if a recieve has completed and it had not
 does that need some comments

Test Coverage Reports

QUIS CUSTODIET IPSOS CUSTODIES?


Open Source Development




 **NOAA-OWP / ngen** Public

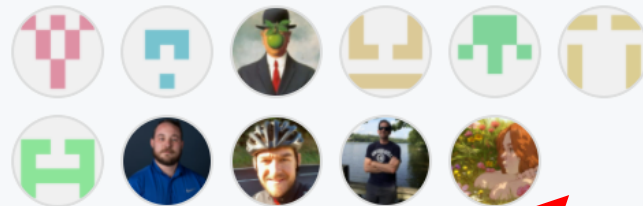
generated from [NOAA-OWP/owp-open-source-project-template](#)

 Code

 Issues 40

 Pull requests 9

Contributors 13



See you on GitHub!

**YOUR
IMAGE
HERE**



OWP | OFFICE OF
WATER
PREDICTION



Thank You!



Matt Williamson



matthew.williamson@noaa.gov



<https://water.noaa.gov>