

CICE Consortium tutorial - Coupled CICE activity

Learning Goals:

In this activity you will use standalone CICE and the Community Earth System Model (CESM) to understand some of the scientific impacts of coupling CICE.

Background:

We want to explore the impacts of changing CICE parameters and their impacts on the sea ice. Any of these tests are expected to fail the bit-for-bit test. However, we do not know if changing the parameters also impacts the climate. You will test these changes in both coupled and uncoupled experiments to determine whether changing the sea ice parameters has a big impact on the resulting sea ice.

We will focus on two namelist parameters:

- 1) The Cf parameter corresponds to the frictional dissipation that occurs during ridging. The default Cf value is 17, and we will test possible values in the range from 1 to 100.
- 2) The R_snw parameter is a tuning parameter for the Delta Eddington dry snow albedo. The default value is 1.5, and we will test reasonable values ranging from -1.5 to 1.5.

For this activity each student should choose a different value to test in standalone CICE experiments so that we can cover a full range of parameter space. We recommend you use the naming conventions detailed below for consistency among all the runs. We want to make sure all the values below are chosen by at least one person because we will analyze corresponding coupled Community Earth System Model (CESM) experiments this afternoon.

Parameter value	Experiment name	Student Running	QC vs. baseline (Pass or Fail)	QC vs. others (Can expand as needed)
Cf = 1	cice_cf1			
Cf = 2	cice_cf2			
Cf = 5	cice_cf5			
Cf = 17	cice_cf17		(default)	
Cf = 50	cice_cf50			
Cf = 100	cice_cf100			

Parameter value	Experiment name	Student Running	QC vs. baseline (Pass or Fail)	QC vs. others (Can expand as needed)
R_snw = 1.5	cice_rsnw15		(default)	
R_snw = 1.0	cice_rsnw10			
R_snw = 0.5	cice_rsnw05			
R_snw = 0.0	cice_rsnw0			
R_snw = -0.5	cice_rsnwm05			
R_snw = -1.0	cice_rsnwm10			
R_snw = -1.5	cice_rsnwm15			

Part 2 - Evaluating coupled and standalone namelist changes (~2hrs):

This morning you started a standalone CICE experiment running with a namelist change. Now you want to assess if the changes you made to the parameter have a large impact on the experiments.

As you did yesterday afternoon, log into **Casper** and load the necessary python modules to run the python script that compares experiments.

Standalone QC test

1. Move to your cice_master directory and copy the cice.t-test.py script there
 - > cd ~/cice-tutorial/cice_master/
 - > cp configuration/scripts/tests/QC/cice.t-test.py .
2. Compare your parameter test against the baseline.

Run the script and point at your directory with the parameter test and the baseline. Note that the run against which you should compare is called either cice_cf17 or cice_rsnw15 (choose the appropriate run against which to compare).

e.g.

```
> ./cice.t-test.py
/glade/p/cgd/ppc/cice_tutorial_2020/parameters/standalone/cheyenne_intel_smoke_gx1_36x1_
medium_qc.cice_cf17/history
/glade/scratch/<username>/CICE_RUNS/cheyenne_intel_smoke_gx1_36x1_medium_qc.cice_c
f1/history
```

There should be four output files: three *.png figures and one qc_log.txt. We will be running additional QC tests, so you may want to make a directory to keep all the output from each test so you can refer back to the results.

3. Look at the results

The QC test output you created have only daily instantaneous ice thickness, but for each experiment, we have created monthly mean files with additional output for the 5 years you tested over. The monthly data are here:

```
/glade/p/cgd/ppc/cice_tutorial_2020/parameters/standalone/cheyenne_intel_smoke_gx1_36x1_
medium_qc.cice_<parameter>/history_monthly/
```

You may want to look at these using `ncview` or the `ncdiff` operator to see what other mean state differences exist between experiments.

Additionally, you can use the `timeseries.py` script (see instructions from yesterday) to create five year timeseries from the `cice.runlog.*` files. These `cice.runlog.*` are here:

```
/glade/p/cgd/ppc/cice_tutorial_2020/parameters/standalone/cheyenne_intel_smoke_gx1_36x1_
medium_qc.cice_<parameter>/
```

4. Run the tests again

Run the QC script comparing against other students' experiments. (e.g. run `cice_cf1` vs. `cice_cf2` or `cice_rsnw10` vs. `cice_rsnw05`). Be sure to point to their directory with the history files. You may also want to run the `timeseries.py` script or look at the files with `ncview` to better understand the differences you see.

5. Questions to consider:

- Which QC tests passed? Is that expected? What does this mean?
- Look at the figures created by the scripts? What differences do you see and where, spatially, do you see the biggest differences in the experiments?
- Do you think you will see similar results in a coupled experiment that uses CICE?

Coupled QC test

1. It requires significant time and resources to run a fully coupled CESM simulation for 5 years with instantaneous sea ice thickness. Thus, we "pre-baked" (Thanks, Dave!) some CESM experiments that mirror the parameter sensitivity experiments you performed. The parallel CESM sensitivity experiments with `cf` and `R_snw` can be found here:

```
/glade/p/cgd/ppc/cice_tutorial_2020/parameters/cesm/cesm_*
```

Note that the baseline against which you should compare is also in this directory and is called either `cesm_cf17` or `cesm_rsnw15`. Depending on the parameter you chose for your CICE standalone experiment, choose the appropriate CESM experiments.

2. We have made minor modifications to the `cice.t-test.py` script that tests for the `cesm` output. The changes are only to point to the correct output and name it appropriately. Copy the `cesm` script to your `cice_master` directory:

```
>cd ~/cice-tutorial/cice_master/
>cp /glade/p/cgd/ppc/cice_tutorial_2020/parameters/cesm.t-test.py .
```

3. Run the CESM QC script for the relevant cases. e.g.

```
>./cesm.t-test.py
/glade/p/cgd/ppc/cice_tutorial_2020/parameters/cesm/cesm_cf17/ice/hist
/glade/p/cgd/ppc/cice_tutorial_2020/parameters/cesm/cesm_cf1/ice/hist
```

As with the standalone QC tests you performed for the standalone experiments, there should be four output files: three *.png figures and one qc_log.txt. You may want to make a directory to keep all the output from each test so you can refer back to the results.

4. Look at the results

The QC tests with CESM use daily, instantaneous ice thickness. However, the CESM output files also have a number of other fields. You may want to look at the output files using nview and ncdiff to see how the differences compare with the standalone differences. It may also be useful to use nra or other similar operators to take averages over particular time periods of interest to you (e.g. particular months, particular years, etc.).

Additionally, we have modified the timeseries.py script to work with the CESM log files.

```
>cd ~/cice-tutorial/cice_master/  
>cp /glade/p/cgd/ppc/cice_tutorial_2020/parameters/cesm-timeseries.py .
```

You can use the cesm-timeseries.py script just like the CICE timeseries.py script. E.g.

```
>./cesm-timeseries.py /glade/p/cgd/ppc/cice_tutorial_2020/parameters/cesm/cesm_cf1/ -  
-bdir /glade/p/cgd/ppc/cice_tutorial_2020/parameters/cesm/cesm_cf17/
```

5. Run additional tests

Run the QC script comparing against other students' experiments or any other experiments you think will be instructive. (e.g. run cice_cf1 vs. cice_cf2 or cice_rsnw10 vs. cice_rsnw05). Be sure to point to their directory with the history files. You may also want to run the cesm-timeseries.py script or look at the files with nview to better understand the differences you see.

6. Questions to consider:

- Did the QC test pass? Is that expected?
- What does this mean?
- Look at the figures created by the scripts? What changes do you see and where, spatially, do you see the biggest differences in the experiments? How do these compare to the standalone differences?

Discussion

Did changing your namelist parameter made a climate difference in the standalone experiment? What about the coupled experiment? Add your results to the table at the top of the page.

a. The Cf parameter:

The Cf parameter refers to the fraction of energy lost during ridging. Values of Cf = 2 (Rothrock, 1975; <https://doi.org/10.1029/JC080i033p04514>) and Cf=17 (Flato and Hibler, 1995; <https://doi.org/10.1029/95JC02091>) have been tested in published literature, but tests with the other values have not been published. The parameter is not well constrained and has a large range of possible values, and it is difficult to verify observationally or even confirm that it is a constant.

Find where C_f is used in `icepack/columnphysics/icepack_mechred.F90` and `icepack/columnphysics/icepack_parameters.F90`. Note that if a value is not set the default value of 17 will be used.

What fraction of kinetic energy involved in ridging is lost to friction for values of $C_f = 1, 2, 5, 17, 50, 100$? See Roberts et al. (2019; <https://doi.org/10.1029/2018MS001395>) and Lipscomb et al. (2007; <https://doi.org/10.1029/2005JC003355>) for useful formulas. What does this mean about the linearity of varying C_f in these experiments?

b. The R_{snw} parameter

The R_{snw} parameter is an albedo tuning parameter in the delta-Eddington radiation scheme that adjusts the non-melting snow grain radius. Find the equation where it is used in `/icepack/columnphysics/icepack_shortwave.F90` (see line 3483).

Adjusting R_{snw} is actually adjusting number of standard deviations ($rsnw_sig$) from observations. What are the other components of the equation, and what are their values?

What is the non-melting snow grain radius without any adjustment (i.e. $R_{\text{snw}} = 0$)? What happens to the value of the non-melting snow grain radius if we use a negative value of R_{snw} ? How about a positive value of R_{snw} ?

Note that a smaller non-melting snow grain radius leads to a higher albedo. Given this relationship, what happens to the albedo if we use a negative value of R_{snw} ? How about a positive value of R_{snw} ?

What are the limits on $rsnw_nm$ (see immediately below the equation). Is there a threshold above or below which further adjusting R_{snw} will not be effective?

For more information see: <https://xenforo.cgd.ucar.edu/cesm/threads/faq-albedo-radiation-tuning-in-cesm-cice.2649/>

c. Applications when developing sea ice models

Urrego-Blanco et al. 2016 (<https://doi.org/10.1002/2015JC011558>) tested a number of different CICE parameters in standalone CICE experiments and ranked their impact on the sea ice volume for the Northern and Southern Hemispheres. Their results indicate that R_{snw} has a large impact on the sea ice volume while C_f is the least important parameter tested. Do your results agree with theirs?

What sorts of lessons do you think you should take away from your experiments today about development using standalone CICE or Icepack might change once you start using your developments in a coupled model? This FAQ entry may also be useful to read: [https://github.com/CICE-Consortium/About-Us/wiki/FAQ-\(Frequently-Asked-Questions\)#stand-alone-configuration-and-forcing](https://github.com/CICE-Consortium/About-Us/wiki/FAQ-(Frequently-Asked-Questions)#stand-alone-configuration-and-forcing)

It is also important to note that sea ice has large internal variability (e.g. <https://doi.org/10.1175/2011JCLI4146.1>; <https://doi.org/10.1029/2011GL048008>). What does this mean about testing any model developments or modifications to see if they have a climate impact?

- d. What other questions do you have about the results? e.g. impact of the grid? Forcing dataset? Initial conditions?