Tests of E3SM_v2_alpha with U-MICH radiation treatments

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The purpose of this file is to document the tests done to check the correctness of the implementation of new longwave radiation treatments (longwave scattering of ice cloud and surface emissivity) into E3SM_v2_alpha.

Four switches have been introduced to the model namelist (can be set in user_nl_cam): flag_mc6, flag_scat, flag_rtr2, and flag_emis. The following are the various configurations according to the setups of the flags (flag values in [ ] are in the same order as mentioned above):

1. [F, F, F, F] : to use the E3SM_v2_alpha default model radiation.
2. [T, T, T, T] : to use both the new treatments (ice LW scattering + surface emissivity).
3. [T, T, T, F] : to use the new ice LW scattering treatment, but not the surface emissivity.
4. [F, F, F, T] : to use the surface emissivity, but not the new ice LW scattering.
5. [T, F, T, F] : to use only the absorption optical depth from the new ice LW scattering treatment (discarding scattering optics), and no surface emissivity treatment.

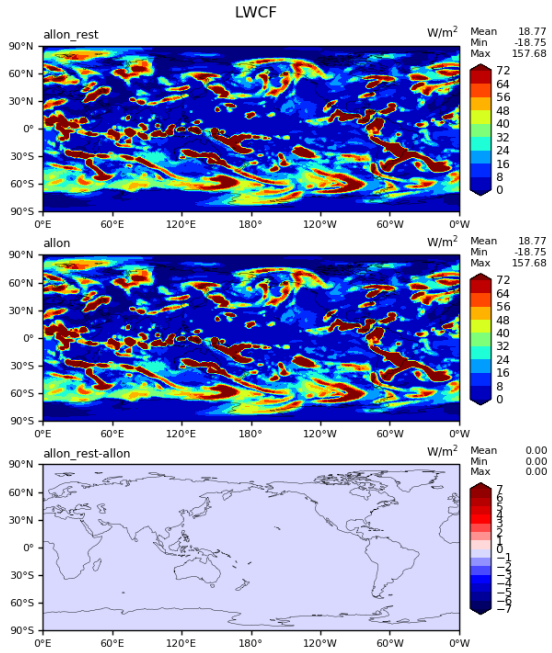
The queries that have been tested are as follows.

1. Is the implementation BFB?
2. Are the emissivity data correctly read into the model?
3. Can flag_mc6 and flag_scat correctly control ice optics calculation?
4. What's the effect of the new 2/4 stream radiative transfer?

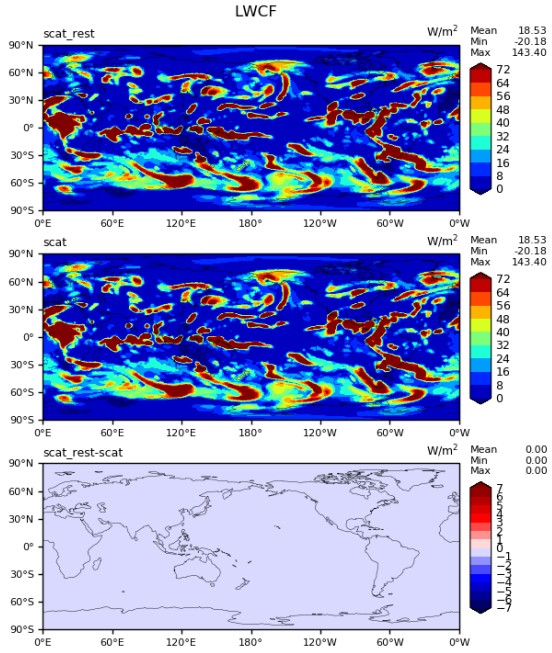
Each query has been tested with both RRTMG and RRTMGP, and for various flag setups if necessary. For the BFB tests, the model is run for 3 hours and restarted from the end of the first hour (time 03600), and results for the second hour (at time 07200) are compared. For other tests, the model is run for 3 hours and results for the second hour are used, except for query 4 which uses results at the first step (time 00000). Detailed results are shown below.

RRTMG

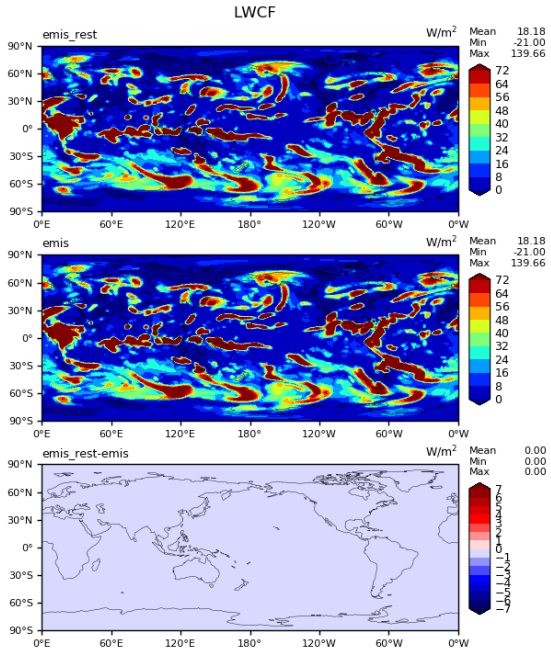
1. Is the implementation BFB? (**Answer: YES**)
   This is tested for various flag setups as follows.
   a. All new treatments turned-on ([T, T, T, T])



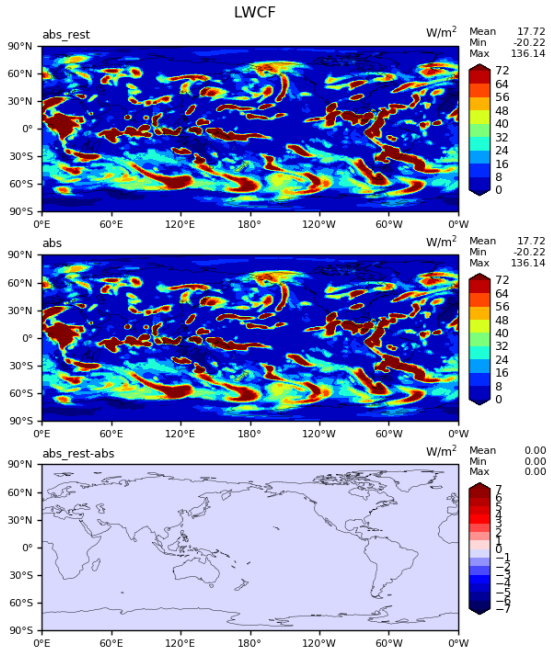
   b. Ice scattering only ([T, T, T, F])



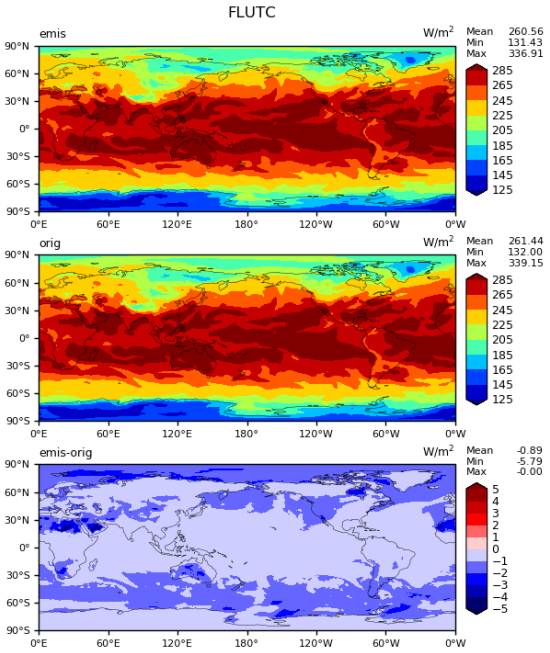
c. Emissivity only ([F, F, F, T])



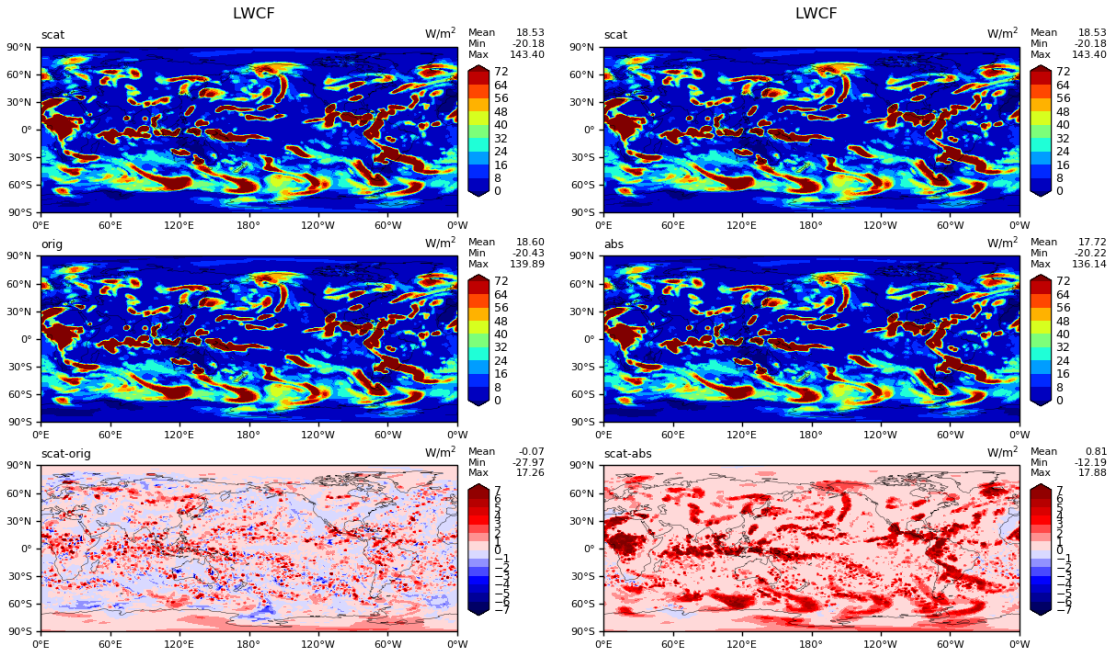
d. Absorption only ([T, F, T, F])



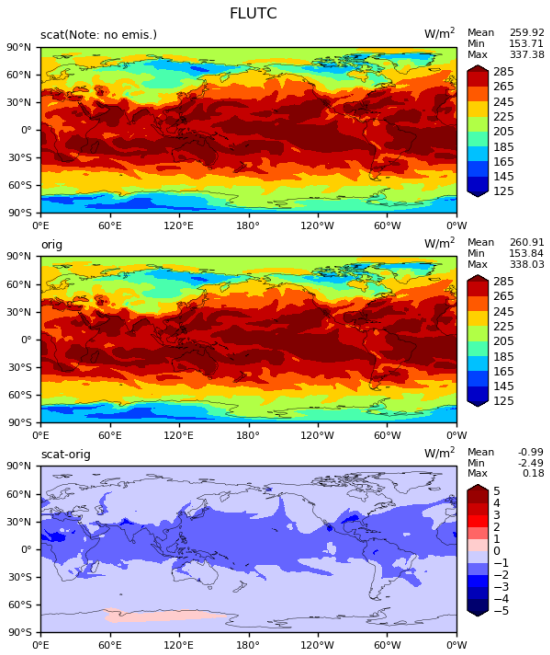
2. Are the emissivity data correctly read into the model? (**Answer: YES**)
   This is implied from the clear-sky OLR difference between emissivity only ([F, F, F, T]) and the default ([F, F, F, F]) runs.



3. Can flag_mc6 and flag_scat correctly control ice optics calculation? (**Answer: YES**)
   This is tested by comparing scattering ([T, T, T, F]) and default ([F, F, F, F]) runs (left), as well as scattering ([T, T, T, F]) and absorption only ([T, F, T, F]) runs (right).

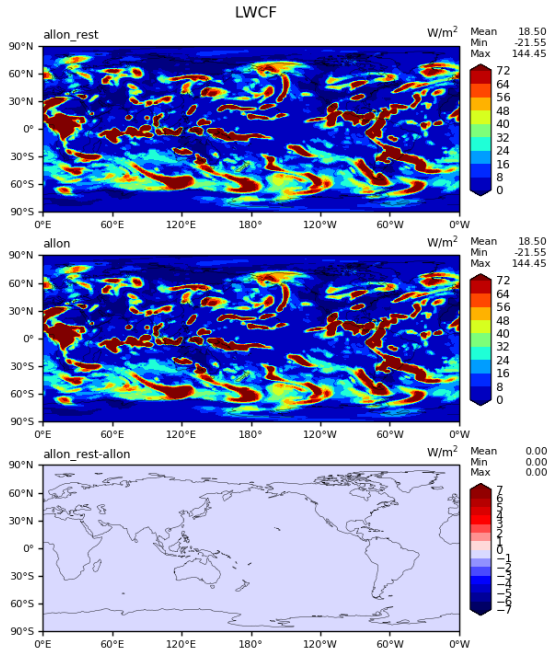


4. What's the effect of the new 2/4 stream radiative transfer?
   (**Answer: globally ~ -1 Wm^{-2}**)
   This is shown as the clear-sky OLR difference between the scattering only ([T, T, T, F]) and the default ([F, F, F, F]) runs at the first most time step (time 00000).

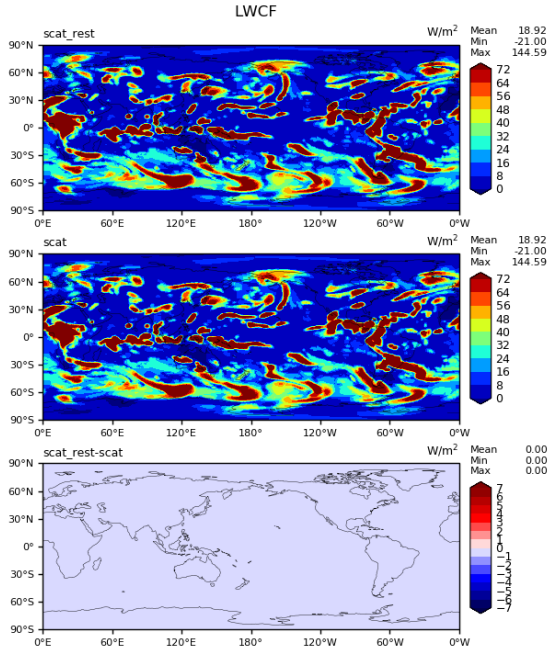


RRTMGP

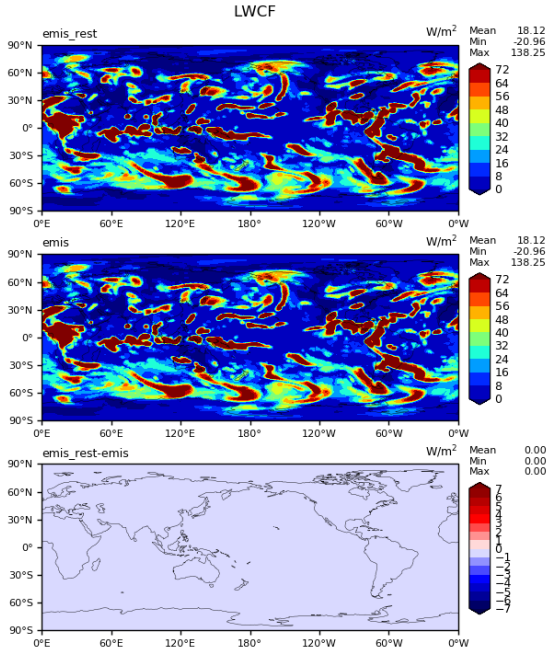
1. Is the implementation BFB? (**Answer: YES**)
   This is tested for various flag setups as follows.
   a. All new treatments turned-on ([T, T, T, T])



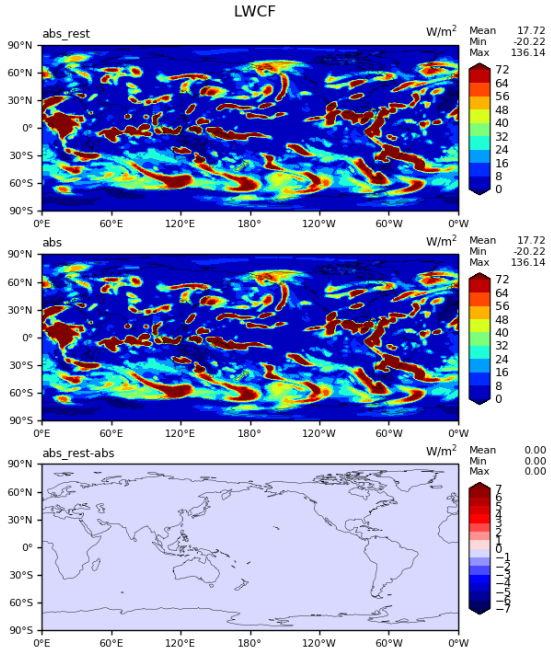
   b. Ice scattering only ([T, T, T, F])



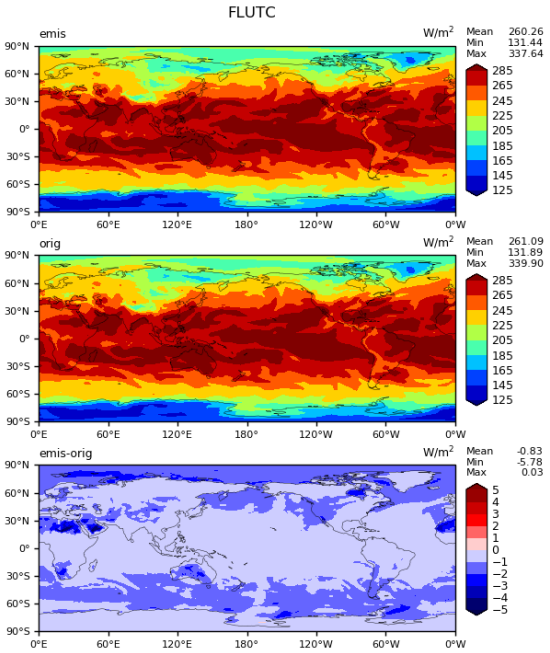
c. Emissivity only ([F, F, F, T])



d. Absorption only ([T, F, T, F])



2. Are the emissivity data correctly read into the model? (**Answer: YES**)
   This is implied from the clear-sky OLR difference between emissivity only ([F, F, F, T]) and the default ([F, F, F, F]) runs.



3. Can flag_mc6 and flag_scat correctly control ice optics calculation? (**Answer: YES**)
   This is tested by comparing scattering ([T, T, T, F]) and default ([F, F, F, F]) runs (left), as well as scattering ([T, T, T, F]) and absorption only ([T, F, T, F]) runs (right).