

Introduction of using RRTMGP with MC6 ice scattering optics

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- How to run RRTMGP

1. Build the libraries
 - a. `$ cd build`
 - b. set environment variables (FC, FCFLAGS) in Makefile.conf.
 - c. `$ make`
2. Build and run example executables
 - a. `$ cd ../examples/all-sky-XJ`
 - b. Set environment variables (RRTMGP_ROOT, RRTMGP_BUILD, NCHOME, and NFHOME) in Makefile.libs
 - c. `$ make` (this will generate an executable 'rrtmgp_allsky')
 - d. `$ python run-rfmip-examples.py` (this will run the executable and generate outputfile 'rrtmgp_allsky.nc')
 - e. `$ python compare-to-reference.py` (this compares the output with the reference file in ./ref/. Since cloud field is modified as shown below, this comparison is NOT valid anymore.)

- Output variables

1. **Flux profiles** ($n_{lev} \times n_{col}$): lw_flux_dn, lw_flux_up, sw_flux_dn, sw_flux_up
2. **Optics profiles** ($n_{bnd} \times n_{lay} \times n_{col}$): lw_tau, lw_ssa, lw_g, sw_tau, sw_ssa, sw_g
3. **Vertically accumulated optics** ($n_{bnd} \times n_{col}$): lw_tau_tot, lw_ssa_tot, lw_g_tot, sw_tau_tot, sw_ssa_tot, sw_g_tot
4. **Cloud profiles** ($n_{lay} \times n_{col}$): lwp, iwp, rel, rei

- MC6 longwave ice scattering related codes

1. **`$ROOT/examples/all-sky-XJ/mo_ice_optics_mc6.F90`:**
Switch on/off MC6 ice optics: `flag_mc6 = .true./.false.`
Switch on/off MC6 ice scattering: `flag_scat = .true./.false.`
Compute MC6 ice optics according to cloud input: subroutine `compute_all_from_mc6()`
2. **`$ROOT/examples/all-sky-XJ/mo_mc6_table.F90`:**
The table of MC6 ice optics: subroutine `mc6_table_init()`
3. **`$ROOT/extensions/cloud_optics/mo_cloud_optics.F90`:**

Call compute_all_from_mc6()

4. **\$ROOT/examples/all-sky-XJ/mo_garand_atmos_io.F90:**

Write out cloud optics and microphysical properties: subroutine write_lw_optics, write_sw_optics, write_clouds

- Cloud layer setup in rrtmgp_allsky.F90

Clouds are represented by **lwp**, **iwp**, **rel**, and **rei** in rrtmgp_allsky.F90.

Current setups (May 26, 2020):

1. Ice clouds only (i.e., **lwp** and **rel** = 0.0)
2. Ice cloud layer locate at layers where pressure is between 100-500 hPa and temperature is < 263 K.
3. Ice water path (i.e., **iwp**) equals 10.0 g/m² in each single layer.
4. Ice effective radius (i.e., **rei**) ranges linearly from 11.3 To 180 μm , from the first to the last column.

The outputs with the above cloud setups are saved in files [\\$ROOT/examples/all-sky-XJ/ref/rrtmgp-allsky-std-ice-ref-XJ.nc](#), [rrtmgp-allsky-mc6-ice-ref-XJ.nc](#), and [rrtmgp-allsky-mc6-noscat-ice-ref-XJ.nc](#) for RRTMGP standard, MC6 scattering, and MC6 absorption (without scattering) ice optics, respectively.