RCEMIP for SCAM5/6 in CESM2.1

RCEMIP Setup
& How to do the setting for SCAM5/6 in CESM2.1
(modified codes/vars; *where to*)

Surface Boundary Conditions

Prescribed SST, Sea Ice, and T$_{skin}$:

- Sea surface temperature: 295 K, 300 K, 305K.

- Sea ice: none.
  Prescribe a uniform value for SST_cpl and SST_cpl_prediddle, and zero ice_cov and ice_cov_prediddle in the SSTICE_DATA_FILENAME file, and use xmlchange to set the file in *env_run.xml*.

- Land: none.
  In *user_nl_cam*, set lat = 0. and lon = 180. in the bndtvs file; set scmlat = 0. and scmlon = 180.. Land fraction should be zero at this location.

- Set skin temperature to be the same as SST.
  In *user_nl_cam*, set Tsair to be the same value of SST in the iopfile file.

Surface Boundary Conditions

Prescribed SLP:

- Sea level pressure: 1014.8 hPa.
  In *user_nl_cam*, set Ps and PS both to 1014.8 (hPa) in the iopfile and ncdata files, respectively. The reference pressure P0, which is used in ncdata for computing the hybrid sigma-pressure levels of the model, remains to be 1000 hPa. Note that the value of SLP is a key parameter for the pressure values of layers of hybrid sigma-pressure coordinate, which is the coordinate SCAM currently uses.

Surface Boundary Conditions

Wind Speed:

- Set to 0 m/s except for the calculation of surface fluxes, in which the resolved wind speed, with the minimum of 1 m/s enforced, is used.
  In *user_nl_cam*, zero u, v, usrf, and vsrf in the iopfile file, and zero u and v in the ncdata file.

  [Source code mod., *cesm2_1_0/cime/src/share/util/shr_flux_mod.F90*]
  Set umin = 1._R8 in the subroutines *shr_flux_atmocn* and *shr_flux_atmocn_diurnal*, and put the modified file in *src.cam*.

Radiative Processes

Prescribed Trace-Gases:

- $CO_2 \rightarrow 348$ ppmv, $CH_4 \rightarrow 1650$ ppbv, $N_2O \rightarrow 306$ ppbv.
  In *user_nl_cam*, set ch4vmr = 1.650e-6, co2vmr = 348.0e-6, n2ovmr = 0.306e-6, f11vmr = 0.0, and f12vmr = 0.0. Note that the concentrations of CFC22 and CCL4 are already zero by default.

Radiative Processes

Prescribed Ozone:

- Prescribe a climatological ozone profile following Eq. (1) in Wing et al. (2018).
In *user_nl_cam*, prescribe the requested profile in the prescribed_ozone_file file; set prescribed_ozone_cycle_yr = 2000 and prescribed_ozone_name = 'O3' to avoid compile errors.

  Note that the numbers of vertical levels for the ozone profile are different in SCAM5 and SCAM6: by default, SCAM5 uses 26-level and SCAM6 uses 32-level (and, for the record, CAM5/6 use 59-level) profiles. Since the sensitivity to the number of vertical levels for the ozone profile is tiny (checked), I choose to stick to the default one of each model (i.e., L26 for SCAM5 and L32 for SCAM6).

Radiative Processes

Aerosol Effects Removal:

- Remove the aerosol direct effects by excluding aerosol from the radiative transfer calculation.
  In *user_nl_cam*, empty all the *_specifier fields: ext_frc_specifier = ""; srf_emis_specifier = ""; tracer_cnst_specifier = "".

- Remove the aerosol indirect effects by fixing the number concentrations of cloud droplet and ice crystal to 10^8 m^{-3} and 10^5 m^{-3} respectively.
  In *user_nl_cam*, set micro_mg_nccons = .true. and micro_mg_nicons = .true., which makes the model to use micro_mg_ncnst (= 100.e6_r8 by default) and micro_mg_ninst (= 0.1e6_r8 by default), respectively.

Radiative Processes (SCAM5 only)

Aerosol Effects Removal:

- Remove the aerosol direct effects by excluding aerosol from the radiative transfer calculation.
  In *user_nl_cam*, zero all the aerosol variables in the prescribed_aero_file file; set prescribed_aero_cycle_year = 2000.

- Remove the aerosol effects generally (?).
  Use *xmlchange* command to set CAM_CONFIG_OPTS="chem -none" in *env_build.xml*.

Radiative Processes

Solar Insolation Modification:

- Remove the seasonal & diurnal cycles of solar insolation.
  In *user_nl_cpl*, set orb_eccen = 0., orb_mvelp = 0., orb_obliq = 0., and orb_mode = "fixed_parameters".

  [Source code mod., *cesm2_1_0/components/cam/src/physics/rrtmg/radiation.F90*]
  Set coszrs(i) = cos(42.05_r8*pi/180._r8) in the subroutine *radiation_tend*, and put the modified file in *src.cam*. Before using pi, remember to add use shr_const_mod, only shr_const_pi and real(r8), parameter :: pi = shr_const_pi

- Prescribe a reduced solar constant of 551.58 Wm^{-2}, so that (with the fixed zenith angle) the insolation value becomes 409.6 Wm^{-2}.
  In *user_nl_cam*, prescribe a uniform value of 551.58 for tsi in the *solar_irrad_data_file* file.

Radiative Processes

Prescribed Surface Albedo:

- ## Fix the surface albedo to 0.07.
  Use *xmlchange* command to set CPL_ALBAV="TRUE" in *env_run.xml*, which sets *flux_albav = .true. in *drv_in*.

  [Source code mod., *cesm2_1_0/cime/src/drivers/mct/main/seq_flux_mct.F90*]
  Set **albdif = 0.07_R8 in the subroutines *seq_flux_ocnalb_mct* and *seq_flux_atmocn_mct*, and put the modified file in *src.drv*.

* When running the aquaplanet (in which -ocn aquaplanet) simulations, flux_albav (which is false in default) will be set to true automatically.

** The albedo parameter that corresponds to diffusive radiation; the default value is 0.06. We're not sure if this parameter would affect the "general" surface albedo calculation, but (after personal communication with Brian Medeiros @NCAR) just to set its value to be the same as albdir (the albedo parameter that corresponds to direct radiation), whose default value is 0.07.

Initialization Procedure

Removal of Earth's Rotation:

- Either zero the Coriolis parameter, or Earth's angular velocity.
  [Source code mod., *cesm2_1_0/components/cam/src/utils/physconst.F90*]
  Set omega = 0.0_R8 in the subroutine *physconst_readnl*, and put the modified file in *src.cam*.

Initialization Procedure

Initial Conditions:

- Use Eqs. (2), (4), and (5) in Wing et al. (2018) for generating the initial vertical profiles of T, qv, and p, respectively.
  In *user_nl_cam*, set T and qv to their corresponding analytic soundings in the iopfile and ncdata files. Two offline NCL scripts (init_RCEMIP.ncl and iop_4D_RCEMIP.ncl) are used to generate these analytic soundings on pressure levels as initial conditions.

- Alternative idealized moist adiabat can be used to test the sensitivity of simulation to initial conditions.
  A moist adiabat appropriate to the given SST, patched to a 200-K isothermal stratosphere (for T). The corresponding saturated moisture profile is computed based on the T profile, and a constant relative humidity (70%) is specified to generate qv profile. In addition, a uniform zonal wind (5 m/s) is applied to the column.

Initialization Procedure

Thermal Noise:

- Prescribe a small amount of thermal noise in the five lowest layers (0.1 K in the lowest layer and decreases linearly to 0.02 K in the fifth layer) to break the symmetry and allow convection to start within the first few hours of each simulation.
This part is meant for the CRM simulations, no modification is needed for CAM/SCAM simulations for now, but maybe some sensitivity tests would help to evaluate the model's performances.

Geophysical Constants

Prescribed Geophysical Constants:

- Use Table 1 in Wing et al. (2018) for recommended values.
  In *user_nl_cam*, set cpwv = 1.846e3, gravit = 9.79764, rearth = 6.37100e6, *mwdry = 28.96623324623746, *mwh2o = 18.01618112892741, and sday = 86164.10063718943.

* The changes to mwdry and mwh2o will change the values of SHR_CONST_RDAIR and SHR_CONST_RWV, respectively, in *cesm2_1_0/cime/src/share/util/shr_const_mod.F90*.

RCEMIP Setup: SCAM vs. CAM
(modified codes/vars; *where to*)

Different Parameters (mainly due to EUL vs. FV/SE)

SCAM5 vs. CAM5:

- Value of cldfrc_sh1 in *user_nl_cam*: 0.07D0 vs. 0.04D0
- Value of zmconv_ke in *user_nl_cam*: 3.0E-6 vs. 5.0E-6

SCAM6 vs. CAM6

- Value of cldfrc_premit in *user_nl_cam*: 75000.0D0 vs. 25000.0D0
- Value of cldfrc_sh1 in *user_nl_cam*: 0.07D0 vs. 0.04D0
- Value of dust_emis_fact in *user_nl_cam*: 0.35D0 vs. 0.55D0
- Value of zmconv_ke in *user_nl_cam*: 3.0E-6 vs. 5.0E-6

SCAM's Extra Effort

Setups that are automatically included in CAM (aquaplanet) but not in SCAM:

- Set use_topo_file = .false. in *user_nl_cam*.

- Set prescribed_strataero_feedback = .false. in *user_nl_cam*.

- Set ch4vmr = 1.650e-6, co2vmr = 348.0e-6, n2ovmr = 0.306e-6 in *user_nl_cam*.

- Set ext_frc_specifier = ""; srf_emis_specifier = ""; tracer_cnst_specifier = "" in *user_nl_cam*.

- Set micro_mg_nccons = .true. and micro_mg_nicons = .true. in *user_nl_cam*.

- Set cpwv = 1.846.e3, gravit = 9.79764, mwdry = 28.96623324623746, mwh2o = 18.01618112892741, rearth = 6.37100e6, and sday = 86164.10063718943 in *user_nl_cam*.

- Set orb_eccen = 0., orb_mvelp = 0., orb_obliq = 0., and orb_mode = "fixed_parameters" in *user_nl_cpl*.

- Use *xmlchange* command to set CPL_ALBAV="TRUE" in *env_run.xml*, which sets et flux_albav = .true. in *drv_in*.

SCAM's Extra Effort

Setups that are somehow needed in SCAM for a successful build/run:

- Set use_gw_front = .false. in *user_nl_cam*.

- Set histfreq = "x", "x", "x", "x", "x" in *user_nl_cice*.

- Set histfreq_n = 0, 0, 0, 0, 0 in *user_nl_cice*.

I forgot the relevant error messages (which pop out without these lines), but had a impression that these need to be in the namelists so that SCAM can successfully run.