

DEPHY – Common format for SCM simulations

Version 1.0

R. Roehrig, E. Vignon, F. Couvreur, F. Hourdin, C. Rio, M.-P Lefebvre

For each case, 2 netCDF files will be made available:

- A file “DEF”, which defines the case as close to its reference definition (literature, intercomparison project) as possible;
- A file “SCM” similar to the file “DEF”, but with a vertical axis common to all variables (possibly with high vertical resolution, e.g., 10 m in the lower troposphere, in order to ensure a quasi convergence of profiles applied to any SCM), and a time axis common to all forcing variables. The file will also contain anything required to initialize and force a model which uses T or θ , q_v , q_t , r_v , or r_t as state variables. Therefore interpolation/extrapolation and variable conversion will be handled by shared tools when creating the “SCM” file from the “DEF” file.

1. Formatting common to both files:

All netCDF files should have NETCDF3 format to enhance compatibility.

All netCDF variables are of type *double*. Variables standard names and units follow the [CF conventions Version 1.8](#) where applicable and are defined in Appendix 1. Variable ids generally follow CMIP6 vocabulary, but consistency and readability are privileged when necessary.

Each file contains a series of global attributes which define the forcing type of the case. This series of attributes is defined in Appendix 2.

Each variable should have, at least, the following attributes, consistently with Appendix 1:

- `standard_name`: name of the variable as provided by the CF standards where applicable
- `units`: units of the variable
- `coordinates`: of the form "time zh* lon lat" or "time pa* lon lat"

Time axes should have the following attributes:

- `standard_name`: name of the axis
- `units`: unit of the axis, of the form “seconds since YYYY-MM-DD HH:MM:SS” where YYYY-MM-DD HH:MM:SS is the initial date of the simulation
- `calendar`: calendar to be used to interpret the date in the time axis (generally gregorian)

Vertical axes should have the following attributes:

- `standard_name`: name of the axis
- `units`: usually “m”, “Pa”, but may simply be the level number.
- They may simply be level number or provide relevant altitude or pressure to ease rapid visualization. But, most of the time, information given by the coordinates attribute should be preferred to fully interpret the data.

2. File “DEF”

This file is named `$CASE$_$SUBCASE$_DEF_driver.nc`. It contains the initial conditions and forcings of the case `$CASE$_$SUBCASE$_`, in a way as close to its original definition as possible (e.g., as in the reference paper or the intercomparison documentation). `$SUBCASE$_` is by default REF if the case has no subcase. Each field is defined with its own spatial and temporal grid, except the initial conditions which share the same time axis `t0`. For instance, the vertical axis `lev_ta` is associated with the initial temperature profile `ta(t0,lev_ta)` and contains its vertical levels (level number, altitude above the ground or pressure).

Initial profiles:

Expected variables:

- only the variables defined in the reference paper/document of the case.

Axes:

- `t0`: time axis of length 1, which contains the initial date of the case, consistently with the global attribute `start_date`. See section 1 for its attributes. The attribute `standard_name` should be equal to “initial_time”.
- `lev_X`: vertical axis of the variable `X` which contains either the altitude above the ground (`standard_name=“height_for_X”, units=“m”`), the pressure (`standard_name=“air_pressure_for_X”, units=“Pa”`), or the level number (`standard_name=“level_number_for_X”, units=“-”`). Altitude is preferred, except if the case was defined directly on pressure levels.
- coordinates: “`t0 zh_X lat lon`” or “`t0 pa_X lat lon`”

Forcing variables:

Expected variables:

- variables defined in the reference paper/document of the case

Axes :

- `time_X`: time axis defining the date of the forcing `X` (from `start_date` to `end_date`): `long_name=“forcing_time_for_X”, same units attribute as t0`
- `lev_X`: same as in paragraph Initial profiles
- coordinates: “`time_X zh_X lat lon`” or “`time_X pa_X lat lon`”

3. File “SCM”

The objective is to have a netCDF file in which all variables (initial profiles and forcing variable profiles) share the same axes. A high-resolution vertical axis may be used in order to deal with the interpolation problem ahead from the simulation, in a consistent way for each model. Besides, a consistent computation of the various state variables that can be used in a wide variety of SCM (and LES) should allow a more rigorous inter-comparison of simulations coming from different models.

The file is named `$CASE$_$SUBCASE$_SCM_driver.nc` and contains the initial profiles and the forcing to be used to setup SCM simulation (or possibly LES), on a unique vertical grid (possibly at high-resolution, especially in the low levels). Extrapolation may be performed, possibly by incorporating data from reanalysis or of other origin.

The temporal grid is also common to all forcings. Generally, it corresponds to the highest frequent forcing.

In any case, the choices made to go from the DEF to the SCM files must be documented in a README file.

Initial profiles:

Expected variables:

- ta, theta, qv, qt, rv, rt, ua, va, pa, zh of dimension (t0, lev);
- ps (t0, lat, lon);
- ql, qi, rl, ri, tke set to 0 if not defined in the case

Axes:

- t0: see section 2
- lev: vertical axis containing either the altitude above the ground (standard_name="height", units="m"), the pressure (standard_name="air_pressure", units="Pa"), or the level number (standard_name="level_number", units="-"). Altitude is preferred, except if the case was defined directly on pressure levels.
- coordinates: "t0 zh lat lon" or "t0 pa lat lon"

Forcing :

Expected variables:

- Forcing fields consistent with the global attributes of the "DEF" file (Appendix 2) and allowing to force the SCM in T or θ , qv, qt, rv, or rt.
- Altitude of the forcing : pa_forc and zh_forc of dimension (time, lev)
- Forcing fields at the surface, consistently with the global attribute of the "DEF" file (cf. Appendix 2).
- ps_forc of dimension (time)

Axes:

- time : axis with the forcing dates, from start_date to end_date, following section 1: standard_name="forcing_time". Must be unlimited.
- lev : see previous subsection
- coordinates: "time zh lat lon" or "time pa lat lon"

Appendix 1: Standards for variables

id	<i>standard_name</i>	units	comment
lat	<i>latitude</i>	degrees_north	mandatory
lon	<i>longitude</i>	degrees_east	mandatory ; values between -180 and 180 are preferred
orog	<i>surface_altitude</i>	m	mandatory
zh	<i>height</i>	m	above the ground
zh_\$X\$	<i>height_for_X</i>	m	above the ground
pa	<i>air_pressure</i>	Pa	
pa_\$X\$	<i>air_pressure_for_X</i>	Pa	
zh_forc	<i>height_forcing</i>	m	above the ground
pa_forc	<i>air_pressure_forcing</i>	Pa	
ta	<i>air_temperature</i>	K	Field for initialization
theta	<i>air_potential_temperature</i>	K	Field for initialization
theta1	<i>air_liquid_potential_temperature</i>	K	Field for initialization. Definition ?
rv	<i>humidity_mixing_ratio</i>	1	Field for initialization
r1	<i>cloud_liquid_water_mixing_ratio</i>	1	Field for initialization
ri	<i>cloud_ice_water_mixing_ratio</i>	1	Field for initialization
rt	<i>water_mixing_ratio</i>	1	Field for initialization
qv	<i>specific_humidity</i>	1	Field for initialization
ql	<i>mass_fraction_of_cloud_liquid_water_in_air</i>	1	Field for initialization
qi	<i>mass_fraction_of_cloud_ice_water_in_air</i>	1	Field for initialization

qt	<i>mass_fraction_of_water_in_air</i>	1	Field for initialization
hur	<i>relative_humidity</i>	%	Field for initialization
tke	<i>specific_turbulent_kinetic_energy</i>	m ² s ⁻²	Field for initialization
ua	<i>eastward_wind</i>	m s ⁻¹	Field for initialization
va	<i>northward_wind</i>	m s ⁻¹	Field for initialization
wa	<i>upward_air_velocity</i>	m s ⁻¹	
wap	<i>lagrangian_tendency_of_air_pressure</i>	Pa s ⁻¹	
ug	<i>geostrophic_eastward_wind</i>	m s ⁻¹	
vg	<i>geostrophic_northward_wind</i>	m s ⁻¹	
tnua_adv	<i>tendency_of_eastward_wind_due_to_advection</i>	m s ⁻²	
tnva_adv	<i>tendency_of_northward_wind_due_to_advection</i>	m s ⁻²	
tnta_adv	<i>tendency_of_air_temperature_due_to_advection</i>	K s ⁻¹	
tntheta_adv	<i>tendency_of_air_potential_temperature_due_to_advection</i>	K s ⁻¹	
tntheta1_adv	<i>tendency_of_air_liquid_potential_temperature_due_to_advection</i>	K s ⁻¹	
tnqv_adv	<i>tendency_of_specific_humidity_due_to_advection</i>	s ⁻¹	
tnqt_adv	<i>tendency_of_mass_fraction_of_water_in_air_due_to_advection</i>	s ⁻¹	
tnrv_adv	<i>tendency_of_humidity_mixing_ratio_due_to_advection</i>	s ⁻¹	
tnrt_adv	<i>tendency_of_water_mixing_ratio_due_to_advection</i>	s ⁻¹	
tnta_rad	<i>tendency_of_air_temperature_due_to_radiative_heating</i>	K s ⁻¹	

tntheta_rad	<i>tendency_of_air_potential_temperature_due_to_radiative_heating</i>	K s-1	
tntheta1_rad	<i>tendency_of_air_liquid_potential_temperature_due_to_radiative_heating</i>	K s-1	
ta_nud	<i>nudging_air_temperature</i>	K	
theta_nud	<i>nudging_air_potential_temperature</i>	K	
theta1_nud	<i>nudging_air_liquid_potential_temperature</i>	K	
qv_nud	<i>nudging_specific_humidity</i>	1	
qt_nud	<i>nudging_mass_fraction_of_water_in_air</i>	1	
rv_nud	<i>nudging_humidity_mixing_ratio</i>	1	
rt_nud	<i>nudging_water_mixing_ratio</i>	1	
ua_nud	<i>nudging_eastward_wind</i>	m s-1	
va_nud	<i>nudging_northward_wind</i>	m s-1	
nudging_constant_\$X\$	<i>nudging_constant_for_\$X\$</i>	s-1	
hfss	<i>surface_upward_sensible_heat_flux</i>	W m-2	
hfls	<i>surface_upward_latent_heat_flux</i>	W m-2	
wpthetap_s	<i>surface_upward_potential_temperature_flux</i>	K m s-1	
wpqvp_s	<i>surface_upward_specific_humidity_flux</i>	m s-1	
wpqtp_s	<i>surface_upward_water_mass_fraction_flux</i>	m s-1	
wprvp_s	<i>surface_upward_humidity_mixing_ratio_flux</i>	m s-1	
wprtp_s	<i>surface_upward_water_mixing_Ratio_flux</i>	m s-1	
ts	<i>surface_temperature</i>	K	Field for initialization
ts_forc	<i>forcing_surface_temperature</i>	K	
tskin	<i>surface_skin_temperatue</i>	K	
ps	<i>surface_air_pressure</i>	Pa	Field for initialization

ps_forc	<i>forcing_surface_air_pressure</i>	Pa	
ustar	<i>surface_friction_velocity</i>	m s-1	
z0	<i>surface_roughness_length_for_momentum_in_a ir</i>	m	
z0h	<i>surface_roughness_length_for_heat_in_air</i>	m	
z0q	<i>surface_roughness_length_for_humidity_in_air</i>	m	
beta	<i>soil_water_stress_factor</i>	-	
mrsos	<i>mass_content_of_water_in_soil_layer</i>	kg m-2	The mass of water in all phases in the upper 10cm of the soil layer. Field for initialization
mrsos_forc	<i>forcing_mass_content_of_water_in_soil_layer</i>	kg m-2	The mass of water in all phases in the upper 10cm of the soil layer.
o3	<i>mole_fraction_of_ozone_in_air</i>	1	
sza	<i>solar_zenith_angle</i>	degree	
i0	<i>solar_irradiance</i>	W m-2	
alb	<i>surface_albedo</i>	1	
emis	<i>surface_longwave_emissivity</i>	1	

Appendix 2: Global attributes

case = "\$CASE\$/\$SUBCASE\$"

title = "Forcing and initial conditions for \$CASE\$/\$SUBCASE\$ case"

reference = Reference, website... where the case description is available.

author = Name of the person who created this driver file; possibly name of the persons who modified the original version.

version = "Created on \$DATE\$".

format_version = Version number of the format used for the present file.

modifications = Describe modifications done with respect to initial file.

script = script that generated the present file.

comment = Anything useful.

start_date = "YYYY-MM-DD HH:MM:SS" Date is considered UTC

end_date = "YYYY-MM-DD HH:MM:SS" Date is considered UTC

forcing_scale = scale (in m, as a float) of the proposed forcing if provided. Otherwise -1 (thus at the discretion of the modeler)

adv_\$\$ = 0 unactivated / 1 activated (tn\$\$_adv should be a variable in the file)

radiation = "on"/"off"/"tend"

- "on": radiation scheme should be activated (default).
- "no": radiation is deactivated. It is thus either neglected or already included in the temperature advection.
- "tend": radiation is deactivated and a radiative tendency is prescribed. tnta_rad, tntheta_rad, and/or tntheta1_rad is/are provided.

forc_wap = 0/1

- 0: no vertical pressure velocity is given.
- 1: vertical pressure velocity is prescribed and should be used to compute vertical advection (omega should be a variable in the file).

forc_wa = 0/1

- 0: no vertical velocity is given.
- 1: vertical velocity is prescribed and should be used to compute vertical advection (w should be a variable in the file).

forc_geo = 0/1

- 0: No geostrophic forcing of the wind.
- 1: geostrophic forcing of the wind is activated, using latitude in 1at to compute the coriolis parameter (ug and vg should be variables given in the file).

nudging_\$\$ = -1/0/positive integer

- -1: a vertical profile of the inverse nudging timescale is given in the file (variable nudging_constant_\$X\$).
- 0: no nudging
- positive integer: nudging is activated for variable \$X\$ and the positive integer defines the nudging time in seconds. \$X\$ is in {ta, theta, thetal, qv, qt, rv, rt, ua, va}. \$X\$_nudging is a variable of the file.

zh_nudging_\$X\$ = height (in m) above which variable \$X\$ should be nudged. Only if nudging_\$X\$ > 0.

pa_nudging_\$X\$ = pressure (in Pa) above which variable \$X\$ should be nudged. Only if nudging_\$X\$ > 0.

surface_type = "ocean"/"land"/"landice"...

surface_forcing_temp = "none"/"kinematic"/"surface_flux"/"ts"

- none: surface is interactive for heat. z0h may be provided, as well as radiative surface properties. Otherwise, use model relevant values for surface properties.
- kinematic: kinematic surface temperature flux (e.g., wpthetap) is provided.
- surface_flux: surface sensible heat flux is provided (hfss).
- ts: prescribed forcing surface temperature (ts_forc is a variable of the file). z0h may be provided (generally not over ocean).

surface_forcing_moisture = "none"/"kinematic"/"surface_flux"/"beta"/"mrsos"

- none: the soil moisture content and the surface evaporation are not constrained (thus interactive surface). z0q may be provided. Otherwise, use model relevant values for surface properties
- kinematic: kinematic surface evaporation (e.g., wpqtp) is provided.
- surface_flux: surface latent heat flux is provided (hf1s).
- mrsos: the mass of water in all phases in the upper 10 cm of the soil layer is provided (mrsos_forc). z0q may be provided.
- beta: surface evaporation controlled with a soil water stress factor beta that ranges between 1 for unstressed vegetation (thus evaporation set to potential evaporation as over a water surface) and 0 when wilting point is reached. Fully-dry cases should have no surface evaporation, i.e. beta=0.

surface_forcing_wind = "none"/"z0"/"ustar"

- none: the surface wind stress is computed according to the surface model.
- z0: roughness length to be used to compute the surface friction velocity based on Monin-Obukhov theory. z0 is a time-varying variable present in the file.
- ustar: ustar is a time-varying variable present in the file.