# DEPHY – Common format for SCM simulations
# Version 1

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

- A file “REF”, which defines the case as close to its reference definition (literature, intercomparison project) as possible;
- A file “SCM” similar to the file “REF”, but with a vertical axis common to all variables (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 “REF” file.

## 1. **Formatting common to both files:**

All netCDF files should have NETCDF3 format.

All netCDF variables are of type *double*. Variables standard names and units follow [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

## 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_temp` is associated with the initial temperature profile `ta(t0,lev_ta)` and contains the vertical level (altitude above the ground or pressure).

**Initial profiles:**

Expected v*ariables:*

- 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 v*ariables:*

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

*Axes :*

- `time_$X$`: time axis defining the date of the forcing `$X$` (from `startDate` to `endDate`): `long_name=”forcing_time_for_$X$”`, same `units` attribute as `t0`
- `lev_$X$`: see above, subsection Initial profiles
- `coordinates: “time_$X$ zh_$X$ lat lon”` or `“time_$X$ pa_$X$ lat lon”`

3. **<u>File “SCM”</u>**

The objective is to have a netCDF file in which all variables (initial profiles and forcing variable profiles) share the same axes. The use of a high-resolution vertical axis should allow 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 used to setup SCM simulation (or possibly LES), on a unique high-resolution vertical grid (generally 10 m, possibly to be adapted when arriving at higher resolution for specific cases). Extrapolation may be performed, possibly by incorporating data from reanalysis or of other origin.

The temporal grid is also common to all forcing. It can correspond to the highest frequent forcing.

**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 with either 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 attribute of the “REF” file (Appendix 2) and allowing to force the SCM in T or θ, $q_v$, $q_t$, $r_v$, or $r_t$.
- 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 “REF” 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** | ***standard_name*** | **units** | **comment** |
|---|---|---|---|
| lat | *latitude* | degrees_north | mandatory |
| lon | *longitude* | degrees_east | mandatory ; values between -180 and 180 are preferred |
| orog | *surface_altitude* | m | mandatory |
| zh | *height* | m | |
| zh_$X$ | *height_for_X* | m | |
| pa | *air_pressure* | Pa | |
| pa_$X$ | *air_pressure_for_X* | Pa | |
| zh_forc | *height_forcing* | m | |
| pa_forc | *air_pressure_forcing* | Pa | |
| ta | *air_temperature* | K | Field for initialization |
| theta | *air_potential_temperature* | K | Field for initialization |
| thetal | *air_liquid_potential_temperature* | K | Field for initialization. Definition ? |
| rv | *humidity_mixing_ratio* | 1 | Field for initialization |
| rl | *cloud_liquid_water_mixing_ratio* | 1 | Field for initialization |
| ri | *cloud_ice_water_mixing_ratio* | 1 | Field for initialization |
| rt | *water_mixing_ratio* | -1 | Field for initialization |
| qv | *specific_humidity* | 1 | Field for initialization |

| | | | |
|---|---|---|---|
| ql | *mass_fraction_of_cloud_liquid_water_in_air* | 1 | Field for initialization |
| qi | *mass_fraction_of_cloud_ice_water_in_air* | 1 | Field for initialization |
| qt | *mass_fraction_of_water_in_air* | 1 | Field for initialization |
| hur | *relative_humidity* | % | Field for initialization |
| tke | *specific_turbulent_kinetic_energy* | m2 s-2 | Field for initialization |
| ua | *eastward_wind* | m s-1 | Field for initialization |
| va | *northward_wind* | m s-1 | Field for initialization |
| wa | *upward_air_velocity* | m s-1 | |
| wap | *lagrangian_tendency_of_air_pressure* | Pa s-1 | |
| ug | *geostrophic_eastward_wind* | m s-1 | |
| vg | *geostrophic_northward_wind* | m s-1 | |
| tnua_adv | *tendency_of_eastward_wind_due_to_advection* | m s-2 | |
| tnva_adv | *tendency_of_northward_wind_due_to_advection* | m s-2 | |
| tnta_adv | *tendency_of_air_temperature_due_to_advection* | K s-1 | |
| tntheta_adv | *tendency_of_air_potential_temperature_due_to_advection* | K s-1 | |
| tnthetal_adv | *tendency_of_air_liquid_potential_temperature_due_to_advection* | K s-1 | |
| tnqv_adv | *tendency_of_specific_humidity_due_to_advection* | s-1 | |
| tnqt_adv | *tendency_of_mass_fraction_of_water_in_air_due_to_advection* | s-1 | |
| tnrv_adv | *tendency_of_humidity_mixing_ratio_due_to_advection* | s-1 | |
| tnrt_adv | *tendency_of_water_mixing_ratio_due_to_advection* | s-1 | |

| | | | |
|---|---|---|---|
| tnta_rad | *tendency_of_air_temperature_due_to_radiative_heating* | K s-1 | |
| tntheta_rad | *tendency_of_air_potential_temperature_due_to_radiative_heating* | K s-1 | |
| tnthetal_rad | *tendency_of_air_liquid_potential_temperature_due_to_radiative_heating* | K s-1 | |
| ta_nud | *nudging_air_temperature* | K | |
| theta_nud | *nudging_air_potential_temperature* | K | |
| thetal_nud | *nudging_air_liquid_potential_temperature* | K | |
| qv_nud | *nudging_specific_humidity* | 1 | |
| qt_nud | *nudging_mass_fraction_of_water_in_air* | 1 | |
| rv_nud | *nudging_humidity_mixing_ratio* | 1 | |
| rt_nud | *nudging_water_mixing_ratio* | 1 | |
| ua_nud | *nudging_eastward_wind* | m s-1 | |
| va_nud | *nudging_northward_wind* | m s-1 | |
| nudging_constant_$X$ | *nudging_constant_for_$X$* | s-1 | same dimension as $X$_nud |
| hfss | *surface_upward_sensible_heat_flux* | W m-2 | |
| hfls | *surface_upward_latent_heat_flux* | W m-2 | |
| wpthetap_s | *surface_upward_potential_temperature_flux* | K m s-1 | |
| wpqvp_s | *surface_upward_specific humidity_flux* | m s-1 | |
| wpqtp_s | *surface_upward_water_mass_fraction_flux* | m s-1 | |
| wprvp_s | *surface_upward_humidity_mixing_ratio_flux* | m s-1 | |
| wprtp_s | *surface_upward_water_mixing_Ratio_flux* | m s-1 | |

| | | | |
|---|---|---|---|
| ts | *surface_temperature* | K | Field for initialization |
| ts_forc | *forcing_surface_temperature* | K | |
| tskin | *surface_skin_temperatue* | K | |
| ps | *surface_air_pressure* | Pa | Field for initialization |
| ps_forc | *forcing_surface_air_pressure* | Pa | |
| ustar | *surface_friction_velocity* | m s-1 | |
| z0 | *surface_roughness_length_for_momentum_in_air* | m | |
| z0h | *surface_roughness_length_for_heat_in_air* | m | |
| z0q | *surface_roughness_length_for_humidity_in_air* | m | |
| beta | *soil_water_stress_factor* | - | |
| mrsos | *mass_content_of_water_in_soil_layer* | kg m-2 | The mass of water in all phases in the upper 10cm of the soil layer. Field for initialization |
| mrsos_forc | *forcing_mass_content_of_water_in_soil_layer* | kg m-2 | The mass of water in all phases in the upper 10cm of the soil layer. |
| o3 | *mole_fraction_of_ozone_in_air* | 1 | |
| sza | *solar_zenith_angle* | degree | |
| i0 | *solar_irradiance* | W m-2 | |
| alb | *surface_albedo* | 1 | |
| emis | *surface_longwave_emissivity* | 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 these 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_$X$** = 0 unactivated / 1 activated (tn$X$_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 tnthetal_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 lat to compute the coriolis parameter (ug and vg should be variables given in the file).

**nudging_$X$** = -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 (hfls).
- 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.