OSCAR v3.1

Manual

Basic simulation

Essentially, to make a basic simulation one must:

1. import the `OSCAR` object from `core_fct.mod_process`;
2. define the `For` (forcing data) and `Par` (parameters) arguments;
3. call `OSCAR` with these arguments (and possibly other optional arguments, like `Ini` (initial state)).

The `run_model` function found in `core_fct.fct_wrap` is a wrapper that does all that and more, using internal data for forcings and parameters. However, this function may not be adequate for advanced usage of OSCAR, in which case it should be used as inspiration for defining one's own run scripts. To further help with this, the `run_scripts` folder contains a few basic examples.

Core structure

Here is a quick overview of the files contained in the `core_fct` folder and their content.

File	Content
`cls_main`	definition of the `Model` and `Process` classes upon which OSCAR v3 is based
`fct_calib`	functions to calibrate some of the model's parameters
`fct_genD`	functions to generate consistent timeseries of drivers
`fct_genMC`	functions to generate the Monte Carlo setup
`fct_loadD`	functions to load the primary drivers
`fct_loadP`	functions to load the primary parameters, some of them being loaded from files and others manually written there
`fct_process_alt`	functions to replace some processes with alternative formulations
`fct_misc`	a bunch of useful functions, notably including the solving schemes, a generic loading function called `load_data`, and a function to regionally aggregate datasets called `aggreg_region`
`fct_wrap`	wrapper function to run the model in a not-so-flexible standard mode
`mod_process`	equations for the physical processes constituting OSCAR; also contains `OSCAR` and submodels

Dimensions, drivers, variables and parameters

Dimensions

Here is a table summarizing the various dimensions over which OSCAR's input, internal and output data may be defined. Additional dimensions can be added freely to the `Ini`, `For` and/or `Par` arguments, in which case they will be conserved throughout the run, which allows easily parallelizing experiments (e.g. scenarios). This can be heavy on the memory, however.

Dims	Description
year	time axis
config	Monte Carlo elements
spc_halo	species of halogenated compounds
box_osurf	pools for the surface ocean carbon cycling
reg_land	land carbon-cycle regions
bio_land	land carbon-cycle biomes
bio_from	origine biomes of the land-use perturbations
bio_to	destination biomes of the land-use perturbations
box_hwp	pools of harvested wood products
reg_pf	regions specific to the permafrost module
box_thaw	pools of thawed permafrost
spc_bb	species from biomass burning
reg_slcf	regions specific to SLCF regional saturation effects
reg_bcsnow	regions specific to BC deposition on snow

Drivers

Drivers are the forcing data that need to be prescribed to the model for it to be able to run. They must be prescribed using the `For` argument when calling a `Model` object. The model automatically connects the various processes it is made of, and deduces what input data are required, so that it will display an error message if some drivers are missing in `For`. Assuming `OSCAR` has been imported, a list of the model's drivers can be displayed with `OSCAR.var_in`. More information on the drivers is available in `core_fct.fct_loadD`.

In code	In papers	Units	Dims
Eff	E_{FF}	PgC yr^{-1}	year, reg_land
E_CH4	E_{CH_4}	TgC yr^{-1}	year, reg_land
E_N2O	$E_{\mathrm{N}_2\mathrm{O}}$	TgN yr^{-1}	year, reg_land
E_Xhalo	E_{X}	Gg yr^{-1}	year, reg_land, spc_halo
E_NOX	E_{NO_x}	TgN yr^{-1}	year, reg_land

In code	In papers	Units	Dims
E_CO	E_{CO}	TgC yr^{-1}	year, reg_land
E_VOC	E_{VOC}	Tg yr^{-1}	year, reg_land
E_SO2	E_{SO_2}	TgS yr^{-1}	year, reg_land
E_NH3	E_{NH_3}	TgN yr^{-1}	year, reg_land
E_OC	E_{OC}	TgC yr^{-1}	year, reg_land
E_BC	E_{BC}	TgC yr^{-1}	year, reg_land
d_Acover	δA	Mha yr^{-1}	year, reg_land, bio_from, bio_to
d_Hwood	δH	PgC yr^{-1}	year, reg_land, bio_land
d_Ashift	δS	Mha yr^{-1}	year, reg_land, bio_from, bio_to
RF_contr	RF_{con}	W m^{-2}	year
RF_volc	RF_{volc}	W m^{-2}	year
RF_solar	RF_{solar}	W m^{-2}	year

Variables

Each of the model's variable is defined through a Process object; and a Model object is essentially a collection of connected processes. Prognostic variables (i.e. state variables) are those defined through a time-differential equation, while diagnostic variables are defined at any time *t* as a function of prognostic variables and/or other diagnostic variables at that same time *t*. When solving, at every single timestep, the model first solves all prognostic variables, and only then calculates the diagnostic variables. Assuming OSCAR has been imported, a list of the model's variables can be displayed with OSCAR.proc_all, or somewhat equivalently with OSCAR.var_mid | OSCAR.var_out. Prognostic and diagnostic variables can be displayed with OSCAR.var_prog and OSCAR.var_diag, respectively. More information on each variable/process is available in core_fct.fct_process.

In code	In papers	Units	Dims	Prog?
D_pCO2	$\mathcal{F}_{pCO_2}$	ppm	-	
D_mld	Δh_{mld}	m	-	
D_dic	Δdic	µmol kg^{-1}	-	
D_Fin	ΔF_{in}	PgC yr^{-1}	box_osurf	
D_Fout	ΔF_{out}	PgC yr^{-1}	box_osurf	

In code	In papers	Units	Dims	Prog?
D_Fcirc	ΔF_{circ}	PgC yr^{-1}	box_osurf	
D_Focean	$\Delta F_{\downarrow\mathrm{ocean}}$	PgC yr^{-1}	-	
D_Cosurf	ΔC_{surf}	PgC	-	**yes**
f_fert	$\mathcal{F}_{\mathrm{fert}}$	1	reg_land, bio_land	
D_npp	$\Delta\mathrm{npp}$	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
f_igni	$\mathcal{F}_{\mathrm{igni}}$	1	reg_land, bio_land	
D_efire	Δe_{fire}	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_eharv	Δe_{harv}	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_egraz	Δe_{graz}	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_fmort1	$\Delta f_{\mathrm{mort1}}$	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_fmort2	$\Delta f_{\mathrm{mort2}}$	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
f_resp	$\mathcal{F}_{\mathrm{resp}}$	1	reg_land, bio_land	
D_rh1	$\Delta\mathrm{rh}_1$	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_fmet	Δf_{met}	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_rh2	$\Delta\mathrm{rh}_2$	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_nbp	-	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	
D_cveg	Δc_{veg}	PgC Mha^{-1}	reg_land, bio_land	**yes**
D_csoil1	$\Delta c_{\mathrm{soil1}}$	PgC Mha^{-1}	reg_land, bio_land	**yes**
D_csoil2	$\Delta c_{\mathrm{soil2}}$	PgC Mha^{-1}	reg_land, bio_land	**yes**

In code	In papers	Units	Dims	Prog?
D_Fveg_bk	$\delta C_{\mathrm{veg,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fsoil1_bk	$\delta C_{\mathrm{soil1,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fsoil2_bk	$\delta C_{\mathrm{soil2,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fslash	-	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fslash1	$\Delta F_{\mathrm{slash1}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fslash2	$\Delta F_{\mathrm{slash2}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fhwp	ΔF_{hwp}	PgC yr^{-1}	reg_land, bio_from, bio_to, box_hwp	
D_NPP_bk	$\Delta \mathrm{NPP}_{\mathrm{bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Efire_bk	$\Delta E_{\mathrm{fire,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Eharv_bk	$\Delta E_{\mathrm{harv,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Egraz_bk	$\Delta E_{\mathrm{graz,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fmort1_bk	$\Delta F_{\mathrm{mort1,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fmort2_bk	$\Delta F_{\mathrm{mort2,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Rh1_bk	$\Delta \mathrm{Rh}_{1,\mathrm{bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Fmet_bk	$\Delta F_{\mathrm{met,bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Rh2_bk	$\Delta \mathrm{Rh}_{2,\mathrm{bk}}$	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Ehwp	ΔE_{hwp}	PgC yr^{-1}	reg_land, bio_from, bio_to, box_hwp	
D_NBP_bk	-	PgC yr^{-1}	reg_land, bio_from, bio_to	
D_Eluc	ΔE_{LUC}	PgC yr^{-1}	-	
D_Fland	$\Delta F_{\downarrow\mathrm{land}}$	PgC yr^{-1}	-	
D_Aland	ΔA	Mha	reg_land, bio_land	**yes**
D_Cveg_bk	$\Delta C_{\mathrm{veg,bk}}$	PgC	reg_land, bio_from, bio_to	**yes**
D_Csoil1_bk	$\Delta C_{\mathrm{soil1,bk}}$	PgC	reg_land, bio_from, bio_to	**yes**
D_Csoil2_bk	$\Delta C_{\mathrm{soil2,bk}}$	PgC	reg_land, bio_from, bio_to	**yes**
D_Chwp	ΔC_{hwp}	PgC	reg_land, bio_from, bio_to, box_hwp	**yes**
f_resp_pf	-	1	reg_pf	

In code	In papers	Units	Dims	Prog?
D_pthaw_bar	$\Delta \bar{p}_{\text{thaw}}$	1	reg_pf	
d_pthaw	$\frac{\text{d}}{\text{d}t} p_{\text{thaw}}$	yr^{-1}	reg_pf	
D_pthaw	Δp_{thaw}	1	reg_pf	**yes**
D_Fthaw	ΔF_{thaw}	PgC yr^{-1}	reg_pf	
D_Ethaw	-	PgC yr^{-1}	reg_pf, box_thaw	
D_Epf	ΔE_{pf}	PgC yr^{-1}	reg_pf	
D_Epf_CO2	-	PgC yr^{-1}	reg_pf	
D_Epf_CH4	-	TgC yr^{-1}	reg_pf	
D_Cfroz	ΔC_{froz}	PgC	reg_pf	**yes**
D_Cthaw	ΔC_{thaw}	PgC	reg_pf, box_thaw	**yes**
D_CO2	ΔCO_2	ppm	-	**yes**
AF	-	1	-	
kS	-	yr^{-1}	-	
RF_CO2	$\Delta \text{RF}^{\text{CO}_2}$	W m^{-2}	-	
D_Efire	ΔE_{fire}	PgC yr^{-1}	reg_land, bio_land	
D_Ebb_nat	-	TgX yr^{-1}	reg_land, bio_land, spc_bb	
D_Ebb_ant	-	TgX yr^{-1}	reg_land, bio_land, spc_bb	
D_Ebb	ΔE_{bb}	TgX yr^{-1}	reg_land, bio_land, spc_bb	
D_CH4_lag	$\Delta \text{CH}_{4\text{lag}}$	ppb	-	**yes**
D_N2O_lag	$\Delta \text{N}_2\text{O}_{\text{lag}}$	ppb	-	**yes**
D_Xhalo_lag	ΔX_{lag}	ppt	spc_halo	**yes**
D_Ta	ΔT_A	K	-	
D_f_Qa	$\frac{\Delta Q_A}{Q_{A,0}}$	1	-	
f_kOH	$\mathcal{F}_{\text{OH}}$	1	-	
D_Foh_CH4	-	TgC yr^{-1}	-	

In code	In papers	Units	Dims		Prog?
D_Fhv_CH4	-	TgC yr^{-1}	-		
D_Fsoil_CH4	-	TgC yr^{-1}	-		
D_Focean_CH4	-	TgC yr^{-1}	-		
D_Fsink_CH4	$\Delta F_{\downarrow}^{\mathrm{CH_4}}$	TgC yr^{-1}	-		
D_Foxi_CH4	-	PgC yr^{-1}	-		
D_ewet	Δe_{wet}	TgC Mha^{-1} yr^{-1}	reg_land		
D_Awet	ΔA_{wet}	Mha	reg_land		
D_Ewet	ΔE_{wet}	TgC yr^{-1}	reg_land		
D_CH4	$\Delta\mathrm{CH_4}$	ppb	-		**yes**
tau_CH4	-	yr	-		
RF_CH4	$\Delta\mathrm{RF}^{\mathrm{CH_4}}$	W m^{-2}	-		
RF_H2Os	$\Delta\mathrm{RF}^{\mathrm{H2Os}}$	W m^{-2}	-		
D_f_ageair	-	1	-		
f_hv	$\mathcal{F}_{\mathrm{h\nu}}$	1	-		
D_Fhv_N2O	-	TgN yr^{-1}	-		
D_Fsink_N2O	$\Delta F_{\downarrow}^{\mathrm{N_2O}}$	TgN yr^{-1}	-		
D_N2O	$\Delta\mathrm{N_2O}$	ppb	-		**yes**
tau_N2O	-	yr	-		
RF_N2O	$\Delta\mathrm{RF}^{\mathrm{N2O}}$	W m^{-2}	-		
D_Foh_Xhalo	-	Gg yr^{-1}	spc_halo		
D_Fhv_CH4	-	Gg yr^{-1}	spc_halo		
D_Fother_CH4	-	Gg yr^{-1}	spc_halo		
D_Fsink_CH4	$\Delta F_{\downarrow}^{X}$	Gg yr^{-1}	spc_halo		
D_Xhalo	ΔX	ppt	spc_halo		**yes**
RF_Xhalo	$\Delta\mathrm{RF}^{X}$	W m^{-2}	spc_halo		

In code	In papers	Units	Dims	Prog?
RF_halo	$\Delta\mathrm{RF}^{\mathrm{halo}}$	W m^{-2}	-	
D_O3t	$\Delta\mathrm{O}_3\mathrm{t}$	DU	-	
RF_O3t	$\Delta\mathrm{RF}^{\mathrm{O3t}}$	W m^{-2}	-	
D_EESC	$\Delta\mathrm{EESC}$	ppt	-	
D_O3s	$\Delta\mathrm{O}_3\mathrm{s}$	DU	-	
RF_O3s	$\Delta\mathrm{RF}^{\mathrm{O3s}}$	W m^{-2}	-	
D_Edms	ΔE_{DMS}	TgS yr^{-1}	-	
D_Ebvoc	ΔE_{BVOC}	Tg yr^{-1}	-	
D_Edust	-	Tg yr^{-1}	-	
D_Esalt	-	Tg yr^{-1}	-	
D_SO4	$\Delta\mathrm{SO}_4$	Tg	-	
D_POA	$\Delta\mathrm{POA}$	Tg	-	
D_BC	$\Delta\mathrm{BC}$	Tg	-	
D_NO3	$\Delta\mathrm{NO}_3$	Tg	-	
D_SOA	$\Delta\mathrm{SOA}$	Tg	-	
D_Mdust	-	Tg	-	
D_Msalt	-	Tg	-	
RF_SO4	$\Delta\mathrm{RF}^{\mathrm{SO4}}$	W m^{-2}	-	
RF_POA	$\Delta\mathrm{RF}^{\mathrm{POA}}$	W m^{-2}	-	
RF_BC	$\Delta\mathrm{RF}^{\mathrm{BC}}$	W m^{-2}	-	
RF_NO3	$\Delta\mathrm{RF}^{\mathrm{NO3}}$	W m^{-2}	-	
RF_SOA	$\Delta\mathrm{RF}^{\mathrm{SOA}}$	W m^{-2}	-	
RF_dust	-	W m^{-2}	-	
RF_salt	-	W m^{-2}	-	
D_AERsol	$\Delta\mathrm{AER}_{\mathrm{sol}}$	Tg	-	
RF_cloud1	-	W m^{-2}	-	
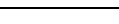
In code	In papers	Units	Dims	Prog?
RF_cloud2	-	W m^{-2}	-	
RF_cloud	ΔRF^{cloud}	W m^{-2}	-	
RF_BCsnow	ΔRF^{BCsnow}	W m^{-2}	-	
RF_lcc	ΔRF^{LCC}	W m^{-2}	-	
RF_nonCO2	-	W m^{-2}	-	
RF_wmghg	-	W m^{-2}	-	
RF_strat	-	W m^{-2}	-	
RF_scatter	-	W m^{-2}	-	
RF_absorb	-	W m^{-2}	-	
RF_AERtot	-	W m^{-2}	-	
RF_slcf	-	W m^{-2}	-	
RF_alb	-	W m^{-2}	-	
RF	ΔRF	W m^{-2}	-	
RF_warm	ΔRF_{warm}	W m^{-2}	-	
RF_atm	ΔRF_{atm}	W m^{-2}	-	
D_Tg	ΔT_G	K	-	**yes**
D_Td	ΔT_D	K	-	**yes**
d_Tg	$\frac{d}{dt} T_G$	K yr^{-1}	-	
D_Tl	ΔT_L	K	reg_land	
D_To	ΔT_S	K	-	
D_Pg	ΔP_G	mm yr^{-1}	-	**yes**
D_Pl	ΔP_L	mm yr^{-1}	reg_land	
D_OHC	ΔOHC	ZJ	-	**yes**
D_pH	-	1	-	

Parameters

Parameters are implicitly defined when creating a model's processes. When OSCAR is run, it does not check whether the needed parameters are actually provided in the `Par` argument. Primary parameters can be loaded with the `load_all_param` function defined in `core_fct.fct_loadP`. Many parameters have several possible values, and these different configurations are defined along the various `mod_` dimensions of the dataset containing the primary parameters. Sets of randomly drawn parameters for Monte Carlo runs can be generated using the `generate_config` function defined in `core_fct.fct_genMC`. More information on each parameter is available in `core_fct.fct_loadP`.

In code	In papers	Units	Dims	Mods
a_dic	α_{sol}	µmol kg^{-1} [ppm m^{-3}]$^{-1}$	-	-
mld_0	$h_{\mathrm{mld},0}$	m	-	mod_Focean_struct
A_ocean	A_{ocean}	m^2	-	mod_Focean_struct
To_0	$T_{S,0}$	K	-	mod_Focean_struct
v_fg	ν_{fg}	yr^{-1}	-	mod_Focean_struct
p_circ	π_{circ}	1	box_osurf	mod_Focean_struct
t_circ	τ_{circ}	yr	box_osurf	mod_Focean_struct
pCO2_is_Pade	-	bool	-	mod_Focean_chem
p_mld	π_{mld}	1	-	mod_Focean_trans
g_mld	γ_{mld}	K^{-1}	-	mod_Focean_trans
fert_is_Log	-	bool	-	mod_Fland_fert
t_shift	τ_{shift}	yr	-	-
npp_0	η	PgC Mha^{-1} yr^{-1}	reg_land, bio_land	mod_Fland_preind
igni_0	ι	yr^{-1}	reg_land, bio_land	mod_Efire_preind
harv_0	ϵ_{harv}	yr^{-1}	reg_land, bio_land	mod_Eharv_preind
graz_0	ϵ_{graz}	yr^{-1}	reg_land, bio_land	mod_Egraz_preind
mu1_0	μ_1	yr^{-1}	reg_land, bio_land	mod_Fland_preind

In code	In papers	Units	Dims	Mods
mu2_0	μ_2	yr^{-1}	reg_land, bio_land	mod_Fland_preind
muM_0	μ_{met}	yr^{-1}	reg_land, bio_land	mod_Fland_preind
rho1_0	ρ_1	yr^{-1}	reg_land, bio_land	mod_Fland_preind
rho2_0	ρ_2	yr^{-1}	reg_land, bio_land	mod_Fland_preind
p_agb	π_{agb}	1	reg_land, bio_land	mod_Eluc_agb
b_npp	β_{npp}	1	reg_land, bio_land	mod_Fland_trans
b2_npp	$\tilde{\beta}_{\mathrm{npp}}$	1	reg_land, bio_land	mod_Fland_trans
CO2_cp	$\mathrm{CO}_{2\mathrm{cp}}$	ppm	reg_land, bio_land	mod_Fland_trans
g_nppT	$\gamma_{\mathrm{npp},T}$	K^{-1}	reg_land, bio_land	mod_Fland_trans, mod_Fland_fert
g_nppP	$\gamma_{\mathrm{npp},P}$	[mm yr^{-1}]$^{-1}$	reg_land, bio_land	mod_Fland_trans, mod_Fland_fert
g_rhoT	$\gamma_{\mathrm{resp},T}$	K^{-1}	reg_land, bio_land	mod_Fland_trans, mod_Fland_resp
g_rhoT1	$\gamma_{\mathrm{resp},T_1}$	K^{-1}	reg_land, bio_land	mod_Fland_trans, mod_Fland_resp
g_rhoT2	$\gamma_{\mathrm{resp},T_2}$	K^{-2}	reg_land, bio_land	mod_Fland_trans, mod_Fland_resp
g_rhoP	$\gamma_{\mathrm{resp},P}$	[mm yr^{-1}]$^{-1}$	reg_land, bio_land	mod_Fland_trans
g_igniC	$\gamma_{\mathrm{igni},C}$	ppm^{-1}	reg_land, bio_land	mod_Efire_trans
g_igniT	$\gamma_{\mathrm{igni},T}$	K^{-1}	reg_land, bio_land	mod_Efire_trans
g_igniP	$\gamma_{\mathrm{igni},P}$	[mm yr^{-1}]$^{-1}$	reg_land, bio_land	mod_Efire_trans
t_hwp	τ_{hwp}	yr	box_hwp	mod_Ehwp_tau

In code	In papers	Units	Dims	Mods
w_t_hwp	-	1	-	mod_Ehwp_speed
p_hwp_bb	-	1	box_hwp	-
p_hwp	π_{hwp}	1	reg_land, bio_land, box_hwp	mod_Ehwp_bb
a_bb	α_{bb}	TgX PgC^{-1}	reg_land, bio_land, spc_bb	-
Cfroz_0	⚠ Unbalanced Eqn	PgC	reg_pf	mod_Epf_main
w_clim_pf	⚠ Unbalanced Eqn	1	reg_pf	mod_Epf_main
g_respT_pf	⚠ Unbalanced Eqn	K^{-1}	reg_pf	mod_Epf_main
g_respT2_pf	⚠ Unbalanced Eqn	K^{-2}	reg_pf	mod_Epf_main
k_resp_pf	⚠ Unbalanced Eqn	1	reg_pf	mod_Epf_main
pthaw_min	⚠ Unbalanced Eqn	1	reg_pf	mod_Epf_main
g_pthaw	⚠ Unbalanced Eqn	K^{-1}	reg_pf	mod_Epf_main
k_pthaw	⚠ Unbalanced Eqn	1	reg_pf	mod_Epf_main
v_thaw	⚠ Unbalanced Eqn	yr^{-1}	reg_pf	mod_Epf_main
v_froz	⚠ Unbalanced Eqn	yr^{-1}	reg_pf	mod_Epf_main
p_pf_thaw	⚠ Unbalanced Eqn	1	reg_pf, box_thaw	mod_Epf_main
t_pf_thaw	⚠ Unbalanced Eqn	yr	reg_pf, box_thaw	mod_Epf_main
p_pf_inst	-	1	-	-
p_pf_CH4	-	1	-	mod_Epf_CH4
ewet_0	$e_{\text{wet},0}$	TgC yr^{-1}	reg_land	mod_Ewet_preind
Awet_0	$A_{\text{wet},0}$	Mha	reg_land	mod_Ewet_preind
p_wet	π_{wet}	1	reg_land, bio_land	mod_Ewet_preind
g_wetC	$\gamma_{\text{wet},C}$	ppm^{-1}	reg_land	mod_Awet_trans
g_wetT	$\gamma_{\text{wet},T}$	K^{-1}	reg_land	mod_Awet_trans

In code	In papers	Units	Dims	Mods
g_wetP	$\gamma_{\mathrm{wet},P}$	[mm yr^{-1}]$^{-1}$	reg_land	mod_Awet_trans
a_CO2	$\alpha_{\mathrm{atm}}^{\mathrm{CO_2}}$	PgC ppm^{-1}	-	-
a_CH4	$\alpha_{\mathrm{atm}}^{\mathrm{CH_4}}$	TgC ppb^{-1}	-	-
a_N2O	$\alpha_{\mathrm{atm}}^{\mathrm{N_2O}}$	TgC ppb^{-1}	-	-
a_Xhalo	$\alpha_{\mathrm{atm}}^{X}$	Gg ppt^{-1}	spc_halo	-
a_SO4	-	Tg TgS^{-1}	-	-
a_POM	$\alpha_{\mathrm{OM}}^{\mathrm{OC}}$	Tg TgC^{-1}	-	mod_POA_conv
a_NO3	-	Tg TgN^{-1}	-	-
CO2_0	$\mathrm{CO_2}_0$	ppm	-	-
CH4_0	$\mathrm{CH_4}_0$	ppb	-	-
N2O_0	$\mathrm{N_2O}_0$	ppb	-	-
Xhalo_0	X_0	ppt	spc_halo	-
p_CH4geo	-	1	-	-
g_ageair	γ_{age}	K^{-1}	-	mod_Fhv_ageair
w_t_OH	-	1	-	-
w_t_hv	-	1	-	-
t_OH_CH4	$\tau_{\mathrm{OH}}^{\mathrm{CH_4}}$	yr	-	mod_Foh_tau
t_hv_CH4	$\tau_{\mathrm{h}\nu}^{\mathrm{CH_4}}$	yr	-	-
t_soil_CH4	$\tau_{\mathrm{soil}}^{\mathrm{CH_4}}$	yr	-	-
t_ocean_CH4	$\tau_{\mathrm{ocean}}^{\mathrm{CH_4}}$	yr	-	-
x_OH_Ta	$\chi_{\mathrm{T_A}}^{\mathrm{OH}}$	1	-	mod_Foh_trans
x_OH_Qa	$\chi_{\mathrm{Q_A}}^{\mathrm{OH}}$	1	-	mod_Foh_trans
x_OH_O3s	$\chi_{\mathrm{O3s}}^{\mathrm{OH}}$	1	-	mod_Foh_trans
x_OH_CH4	$\chi_{\mathrm{CH4}}^{\mathrm{OH}}$	1	-	mod_Foh_trans
x_OH_NOX	$\tilde{\chi}_{\mathrm{NO_x}}^{\mathrm{OH}}$	1	-	mod_Foh_trans

In code	In papers	Units	Dims	Mods
x_OH_CO	$\tilde{\chi}_{CO}^{OH}$	1	-	mod_Foh_trans
x_OH_VOC	$\tilde{\chi}_{VOC}^{OH}$	1	-	mod_Foh_trans
x2_OH_NOX	$\chi_{NO_x}^{OH}$	[TgN yr^{-1}]$^{-1}$	-	mod_Foh_trans
x2_OH_CO	χ_{CO}^{OH}	[TgC yr^{-1}]$^{-1}$	-	mod_Foh_trans
x2_OH_VOC	χ_{VOC}^{OH}	[Tg yr^{-1}]$^{-1}$	-	mod_Foh_trans
w_clim_Ta	κ_{T_A}	1	-	-
k_Qa	κ_{Q_A}	1	-	-
Ta_0	$T_{A,0}$	K	-	-
k_svp	κ_{svp}	1	-	-
T_svp	T_{svp}	K	-	-
O3s_0	O_3s_0	DU	-	-
Enat_NOX	$E_{nat}^{NO_x}$	TgN yr^{-1}	-	-
Enat_CO	E_{nat}^{CO}	TgC yr^{-1}	-	-
Enat_VOC	E_{nat}^{VOC}	Tg yr^{-1}	-	-
kOH_is_Log	-	bool	-	mod_Foh_fct
t_hv_N2O	$\tau_{h\nu}^{N_2O}$	yr	-	mod_Fhv_tau
x_hv_N2O	$\chi_{N2O}^{h\nu}$	1	-	mod_Fhv_trans
x_hv_EESC	$\chi_{EESC}^{h\nu}$	1	-	mod_Fhv_trans
x_hv_age	$\chi_{age}^{h\nu}$	1	-	mod_Fhv_trans
t_OH_Xhalo	⚠ Unbalanced Eqn	yr	spc_halo	-
t_hv_Xhalo	⚠ Unbalanced Eqn	yr	spc_halo	-
t_other_Xhalo	⚠ Unbalanced Eqn	yr	spc_halo	-
p_reg_slcf	π_{reg}	1	reg_land, reg_slcf	-
w_reg_NOX	ω_{NO_x}	1	reg_slcf	mod_O3t_regsat
w_reg_CO	ω_{CO}	1	reg_slcf	mod_O3t_regsat

In code	In papers	Units	Dims	Mods
w_reg_VOC	ω_{VOC}	1	reg_slcf	mod_O3t_regsat
x_O3t_CH4	$\chi_{\mathrm{CH_4}}^{\mathrm{O_3t}}$	DU	-	mod_O3t_emis
x_O3t_NOX	$\chi_{\mathrm{NO_x}}^{\mathrm{O_3t}}$	DU [TgN yr^{-1}]$^{-1}$	-	mod_O3t_emis
x_O3t_CO	$\chi_{\mathrm{CO}}^{\mathrm{O_3t}}$	DU [TgC yr^{-1}]$^{-1}$	-	mod_O3t_emis
x_O3t_VOC	$\chi_{\mathrm{VOC}}^{\mathrm{O_3t}}$	DU [Tg yr^{-1}]$^{-1}$	-	mod_O3t_emis
G_O3t	$\Gamma_{\mathrm{O_3t}}$	DU K^{-1}	-	mod_O3t_clim
t_lag	τ_{lag}	yr	-	-
p_fracrel	π_{rel}^{X}	1	spc_halo	mod_O3s_fracrel
k_Br_Cl	$\alpha_{\mathrm{Cl}}^{\mathrm{Br}}$	1	-	-
n_Cl	⚠ Unbalanced Eqn	1	spc_halo	-
n_Br	⚠ Unbalanced Eqn	1	spc_halo	-
EESC_x	$\mathrm{EESC}_{\times}$	ppt	-	-
k_EESC_N2O	$\dfrac{\chi_{\mathrm{N2O}}^{\mathrm{O_3s}}}{\chi_{\mathrm{EESC}}^{\mathrm{O_3s}}}$	ppt ppb^{-1}	-	mod_O3s_nitrous, mod_O3s_fracrel
x_O3s_EESC	$\chi_{\mathrm{EESC}}^{\mathrm{O_3s}}$	DU ppt^{-1}	-	mod_O3s_trans
G_O3s	$\Gamma_{\mathrm{O_3s}}$	DU K^{-1}	-	mod_O3s_trans
w_reg_SO2	$\omega_{\mathrm{SO_2}}$	1	reg_slcf	mod_SO4_regsat
w_reg_OC	ω_{OC}	1	reg_slcf	mod_POA_regsat
w_reg_BC	ω_{BC}	1	reg_slcf	mod_BC_regsat
t_SO2	$\tau_{\mathrm{SO_2}}$	yr	-	mod_SO4_load
t_DMS	τ_{DMS}	yr	-	mod_SO4_load
G_SO4	$\Gamma_{\mathrm{SO_4}}$	Tg K^{-1}	-	mod_SO4_load
t_OMff	$\tau_{\mathrm{OM,ff}}$	yr	-	mod_POA_load
t_OMbb	$\tau_{\mathrm{OM,bb}}$	yr	-	mod_POA_load
G_POA	Γ_{POA}	Tg K^{-1}	-	mod_POA_load
t_BCff	$\tau_{\mathrm{BC,ff}}$	yr	-	mod_BC_load

In code	In papers	Units	Dims	Mods
t_BCbb	$\tau_{BC,bb}$	yr	-	mod_BC_load
G_BC	Γ_{BC}	Tg K^{-1}	-	mod_BC_load
t_NOX	τ_{NO_x}	yr	-	mod_NO3_load
t_NH3	τ_{NH_3}	yr	-	mod_NO3_load
G_NO3	Γ_{NO_3}	Tg K^{-1}	-	mod_NO3_load
t_VOC	τ_{VOC}	yr	-	mod_SOA_load
t_BVOC	τ_{BVOC}	yr	-	mod_SOA_load
G_SOA	Γ_{SOA}	Tg K^{-1}	-	mod_SOA_load
t_dust	-	yr	-	mod_Mdust_load
G_dust	-	Tg K^{-1}	-	mod_Mdust_load
t_salt	-	yr	-	mod_Msalt_load
G_salt	-	Tg K^{-1}	-	mod_Msalt_load
p_sol_SO4	$\pi_{sol}^{SO_4}$	1	-	mod_RFcloud_solub
p_sol_POA	π_{sol}^{POA}	1	-	mod_RFcloud_solub
p_sol_BC	π_{sol}^{BC}	1	-	mod_RFcloud_solub
p_sol_NO3	$\pi_{sol}^{NO_3}$	1	-	mod_RFcloud_solub
p_sol_SOA	π_{sol}^{SOA}	1	-	mod_RFcloud_solub
p_sol_dust	-	1	-	mod_RFcloud_solub
p_sol_salt	-	1	-	mod_RFcloud_solub
rf_CO2	$\alpha_{rf}^{CO_2}$	W m^{-2}	-	-
rf_CH4	$\alpha_{rf}^{CH_4}$	W m^{-2} ppb$^{-0.5}$	-	-
rf_N2O	$\alpha_{rf}^{N_2O}$	W m^{-2} ppb$^{-0.5}$	-	-
k_rf_H2Os	$\dfrac{\alpha_{rf}^{H_2Os}}{\alpha_{rf}^{CH_4}}$	1	-	-
rf_Xhalo	α_{rf}^{X}	W m^{-2} ppt^{-1}	spc_halo	-
rf_O3t	$\alpha_{rf}^{O_3t}$	W m^{-2} DU^{-1}	-	mod_O3t_radeff

In code	In papers	Units	Dims	Mods
rf_O3s	$\alpha_{rf}^{O_3s}$	W m^{-2} DU^{-1}	-	mod_O3s_radeff
rf_SO4	$\alpha_{rf}^{SO_4}$	W m^{-2} Tg^{-1}	-	mod_SO4_radeff
rf_POA	α_{rf}^{POA}	W m^{-2} Tg^{-1}	-	mod_POA_radeff
rf_BC	α_{rf}^{BC}	W m^{-2} Tg^{-1}	-	mod_BC_radeff
rf_NO3	$\alpha_{rf}^{NO_3}$	W m^{-2} Tg^{-1}	-	mod_NO3_radeff
rf_SOA	α_{rf}^{SOA}	W m^{-2} Tg^{-1}	-	mod_SOA_radeff
rf_dust	-	W m^{-2} Tg^{-1}	-	-
rf_salt	-	W m^{-2} Tg^{-1}	-	-
k_adj_BC	κ_{adj}^{BC}	1	-	mod_BC_adjust
Phi_0	Φ	W m^{-2}	-	mod_RFcloud_erf, mod_RFcloud_solub
AERsol_0	$AER_{sol,0}$	Tg	-	mod_RFcloud_solub, mod_RFcloud_erf, mod_RFcloud_preind
p_reg_bcsnow	π_{reg}	1	reg_land, reg_bcsnow	-
w_reg_bcsnow	ω_{BCsnow}	1	reg_bcsnow	mod_RFbcsnow_reg
rf_bcsnow	α_{rf}^{BCsnow}	W m^{-2} [TgC yr^{-1}]$^{-1}$	-	mod_RFbcsnow_rf
p_trans	π_{trans}	1	-	-
alpha_alb	α_{alb}	1	reg_land, bio_land	mod_RFlcc_alb, mod_RFlcc_flux, mod_RFlcc_cover
F_rsds	ϕ_{rsds}	W m^{-2}	reg_land	mod_RFlcc_flux
w_warm_volc	κ_{warm}^{volc}	1	-	-
w_warm_bcsnow	κ_{warm}^{BCsnow}	1	-	mod_RFbcsnow_warmeff
w_warm_lcc	κ_{warm}^{LCC}	1	-	mod_RFlcc_warmeff

In code	In papers	Units	Dims	Mods
p_atm_CO2	$\pi_{atm}^{CO_2}$	1	-	mod_Pg_radfact
p_atm_nonCO2	$\pi_{atm}^{noCO_2}$	1	-	mod_Pg_radfact
p_atm_O3t	$\pi_{atm}^{O_3t}$	1	-	mod_Pg_radfact
p_atm_strat	π_{atm}^{strat}	1	-	mod_Pg_radfact
p_atm_scatter	$\pi_{atm}^{scatter}$	1	-	mod_Pg_radfact
p_atm_absorb	π_{atm}^{absorb}	1	-	mod_Pg_radfact
p_atm_cloud	π_{atm}^{cloud}	1	-	mod_Pg_radfact
p_atm_alb	π_{atm}^{alb}	1	-	mod_Pg_radfact
p_atm_solar	π_{atm}^{solar}	1	-	mod_Pg_radfact
lambda_0	λ	K [W m^{-2}]$^{-1}$	-	mod_Tg_resp
Th_g	$\dfrac{\tau_{T_G}}{\lambda}$	yr W m^{-2} K^{-1}	-	mod_Tg_resp
Th_d	$\dfrac{\tau_{T_D}}{\lambda}$	yr W m^{-2} K^{-1}	-	mod_Tg_resp
th_0	$\dfrac{\theta}{\lambda}$	W m^{-2} K^{-1}	-	mod_Tg_resp
w_clim_Tl	ω_{T_L}	1	reg_land	mod_Tl_pattern, mod_Tg_resp
w_clim_To	ω_{T_S}	1	-	mod_Tl_pattern, mod_Tg_resp
a_prec	α_{P_G}	mm yr^{-1} K^{-1}	-	mod_Pg_resp
b_prec	β_{P_G}	mm yr^{-1} [W m^{-2}]$^{-1}$	-	mod_Pg_resp
w_clim_Pl	ω_{P_L}	1	reg_land	mod_Pl_pattern, mod_Pg_resp
p_ohc	π_{ohc}	1	-	-
pH_is_Log	-	bool	-	mod_pH_fct