付録 C　変数一覧

ATM 本体（第 2 章）で使用する主要な変数とパラメータ、定数および型定義をまとめる。ESP 作成（第 3 章）と GPV 前処理（第 4 章）で共用するものも含む。ソースコードではそれぞれ、変数モジュール（`variable.f90`）、パラメータモジュール（`parm.f90`）、定数モジュール（`const.f90`）、Numerical Recipes (`nrtype.f90`, Press *et al.*, 1996) および構造型（`mytype.f90`）の型定義モジュールにまとめ、`public` 属性と `variable.f90` には `save` 属性もつけてグローバル変数として共有する。各モジュール・サブルーチンからは、必要なものだけを `use` 宣言文で `only` をつけて使用する。変数名は、可読性を高めるために、単独でも意味が通じるように長い名前も許容している。

C.1　主要変数一覧

主な変数を Table C.1 にまとめる。付録 D のネームリストにあるスイッチ、パラメータ、作業変数は除く。

Table C.1　Main variables (`variable.f90`)

Variable name	Description	Remarks
Basic variable		
n_tracer	Number of tracer	
n_stage	Number of emission stages	
Breakdown variable		
n_tracer_esp	Number of tracer (ESP)	
n_tracer_anl	Number of tracer (ANL)	
n_stage_esp	Number of emission stages (ESP)	
n_stage_anl	Number of emission stages (ANL)	
Setting of MPI		
n_tracer_mpi	Total number of tracer (each MPI)	
n_tracer_mpi_start	Number of tracer (start of each MPI)	
n_tracer_mpi_end	Number of tracer (end of each MPI)	
mpi_myrank	Rank (each MPI)	
mpi_rank_num	Sum of rank	
io_mpi_log	Unit number of MPI log	
log_mpi	file name of MPI log	
Source variable		
emission_start_time(5)	Start time of release 1st [UTC]	
starttime_seq_min	Start time [sequential min]	
elapse_starttime	Initial elapse time [sec]	
emission_duration	Total duration of emission [sec]	
emission_mass	Total mass of emission [kg]	
Source variable at each stage		
n_tracer_stage(n_stage)	Number of tracer at each stage	
source_name_stage(n_stage)	Name of source	e.g. "Fujisan"
source_lat_stage(n_stage)	Latitude of source [deg]	
source_lon_stage(n_stage)	Longitude of source [deg]	
source_btm_asl_stage(n_stage)	Bottom altitude of source [m asl]	
source_top_asl_stage(n_stage)	Top altitude of source [m asl]	
emission_start_time_stage(n_stage, 5)	Emission start time at each stage [UTC]	
emission_duration_stage(n_stage)	Emission duration at each stage [sec]	
emission_mass_stage(n_stage)	Emission mass at each stage [kg]	
cutoff_min_stage(n_stage)	Cutoff grain size (Min) [m]	
cutoff_max_stage(n_stage)	Cutoff grain size (Max) [m]	
median_diameter_stage(n_stage)	Median diameter of size distribution [m]	
sig_stage(n_stage)	Standard deviation of size distribution	
emission_point_id_stage(n_stage)	Emission point ID	8-Byte Integer

Table C.1　(Continued)

Variable name	Description	Remarks
Tracer variable		
tracer_tag(n_tracer)	Tags of tracer	Table C.5
tracer_lat(n_tracer)	Latitude of tracer [deg]	
tracer_lon(n_tracer)	Longitude of tracer [deg]	
tracer_alt(n_tracer)	Altitude of tracer [m asl]	
tracer_size(n_tracer)	Diameter of tracer [m]	
tracer_dens(n_tracer)	Density of tracer [kg/m^3]	
tracer_mass(n_tracer)	Mass of tracer [kg]	
tracer_release_time(n_tracer)	Release time of tracer [sec]	
tracer_current_time(n_tracer)	Current/stop time of tracer [sec]	
n_flag_tracer(n_tracer)	Action flag of tracer	Table C.5
Atmospheric GPV parameter		
basetime_gpv(5)	Base time [UTC]	
basetime_seq_min	Base time [sequential min]	
fcst_time_gpv	Forecast time of input GPV [sec]	
interval_gpv	Time interval of input GPV [sec]	
Atmospheric GPV parameter (Space)		
plane_name_gpv(ne_gpv)	Plane namelist for NWP-GPV	Allocate after
element_gpv(ne_gpv)	Element namelist for NWP-GPV	NUSDAS_INQ_CNTL
nz_gpv	Vertical plane number	
nx_gpv	Grid number of EW direction	
ny_gpv	Grid number of NS direction	
ne_gpv	Element number	
GPV cut area parameter		
cut_startpoint_ix	Startpoint of EW direction (cut)	
cut_startpoint_jy	Startpoint of NS direction (cut)	
cut_endpoint_ix	Endpoint of EW direction (cut)	
cut_endpoint_jy	Endpoint of NS direction (cut)	
Original atmospheric GPV parameter (NuSDaS type1–3)		
type1_air	NuSDaS Type1 (atmosphere)	
type2_air	NuSDaS Type2 (atmosphere)	
type3_air	NuSDaS Type3 (atmosphere)	
member_air	NuSDaS member (atmosphere)	
air_basepoint_ix	Basepoint of EW direction	
air_basepoint_jy	Basepoint of NS direction	
air_basepoint_lat	Basepoint latitude [deg]	
air_basepoint_lon	Basepoint longitude [deg]	
air_distance_x	Grid distance of EW direction [deg or m]	
air_distance_y	Grid distance of NS direction [deg or m]	
air_standard_lat1	Standard latitude1 [deg]	
air_standard_lat2	Standard latitude2 [deg]	
air_standard_lon1	Standard longitude [deg]	
nx_air	Grid number of EW direction (air)	
ny_air	Grid number of NS direction (air)	
Original surface GPV parameter (NuSDaS type1–3)		
type1_surf	NuSDaS Type1 (surface land)	
type2_surf	NuSDaS Type2 (surface land)	
type3_surf	NuSDaS Type3 (surface land)	
member_surf	NuSDaS member (surface land)	
surf_basepoint_ix	Basepoint of EW direction	
surf_basepoint_jy	Basepoint of NS direction	
surf_basepoint_lat	Basepoint latitude [deg]	
surf_basepoint_lon	Basepoint longitude [deg]	
surf_distance_x	Grid distance of EW direction [deg or m]	
surf_distance_y	Grid distance of NS direction [deg or m]	
surf_standard_lat1	Standard latitude1 [deg]	
surf_standard_lat2	Standard latitude2 [deg]	
surf_standard_lon1	Standard longitude [deg]	
nx_surf	Grid number of EW direction (surface)	
ny_surf	Grid number of NS direction (surface)	
Input atmospheric GPV parameter for ATM (NuSDaS type1–3)		
type1_gpv	NuSDaS Type1 (input ATM)	
type2_gpv	NuSDaS Type2 (input ATM)	
type3_gpv	NuSDaS Type3 (input ATM)	
member_gpv	NuSDaS member (input ATM)	

Table C.1　(Continued)

Variable name	Description	Remarks
Input atmospheric GPV for ATM (Constant)		
lat_gpv(nx_gpv, ny_gpv)	Latitude of grid [deg]	
lon_gpv(nx_gpv, ny_gpv)	Longitude of grid [deg]	
zs_gpv(nx_gpv, ny_gpv)	Modeled terrain elevation [m asl]	
sl_gpv(nx_gpv, ny_gpv)	Land coverage rate	
Input atmospheric GPV for ATM (Before)		
alt_gpv1(nx_gpv, ny_gpv, nz_gpv)	Altitude of grid [m asl]	
u_gpv1(nx_gpv, ny_gpv, nz_gpv)	Horizontal wind (EW) [m/s]	
v_gpv1(nx_gpv, ny_gpv, nz_gpv)	Horizontal wind (NS) [m/s]	
w_gpv1(nx_gpv, ny_gpv, nz_gpv)	Vertical wind [m/s]	
vdens_gpv1(nx_gpv, ny_gpv, nz_gpv)	Air density [kg/m^3]	
temp_gpv1(nx_gpv, ny_gpv, nz_gpv)	Air temperature [K]	
pres_gpv1(nx_gpv, ny_gpv, nz_gpv)	Air pressure [hPa]	
vdf_gpv1(nx_gpv, ny_gpv, nz_gpv)	Vertical diffusion coefficient [m^2/s]	
resist_air_gpv1(nx_gpv, ny_gpv)	Aerodynamic resistance [s/m]	
cwc_gpv1(nx_gpv, ny_gpv, nz_gpv)	Cloud water content [kg/m^3]	
cloud_top_gpv1(nx_gpv, ny_gpv)	Cloud top [m asl]	
cloud_base_gpv1(nx_gpv, ny_gpv)	Cloud base [m asl]	
rain_gpv1(nx_gpv, ny_gpv)	Precipitation intensity (rain) [mm/h]	
snow_gpv1(nx_gpv, ny_gpv)	Precipitation intensity (snow) [mm/h]	
grpl_gpv1(nx_gpv, ny_gpv)	Precipitation intensity (graupel) [mm/h]	
Input atmospheric GPV for ATM (After)		
alt_gpv2(nx_gpv, ny_gpv, nz_gpv)	Altitude of grid [m asl]	
u_gpv2(nx_gpv, ny_gpv, nz_gpv)	Horizontal wind (EW) [m/s]	
v_gpv2(nx_gpv, ny_gpv, nz_gpv)	Horizontal wind (NS) [m/s]	
w_gpv2(nx_gpv, ny_gpv, nz_gpv)	Vertical wind [m/s]	
dens_gpv2(nx_gpv, ny_gpv, nz_gpv)	Air density [kg/m^3]	
temp_gpv2(nx_gpv, ny_gpv, nz_gpv)	Air temperature [K]	
pres_gpv2(nx_gpv, ny_gpv, nz_gpv)	Air pressure [hPa]	
vdf_gpv2(nx_gpv, ny_gpv, nz_gpv)	Vertical diffusion coefficient [m^2/s]	
resist_air_gpv2(nx_gpv, ny_gpv)	Aerodynamic resistance [s/m]	
cwc_gpv2(nx_gpv, ny_gpv, nz_gpv)	Cloud water content [kg/m^3]	
cloud_top_gpv2(nx_gpv, ny_gpv)	Cloud top [m asl]	
cloud_base_gpv2(nx_gpv, ny_gpv)	Cloud base [m asl]	
rain_gpv2(nx_gpv, ny_gpv)	Precipitation intensity (rain) [mm/h]	
snow_gpv2(nx_gpv, ny_gpv)	Precipitation intensity (snow) [mm/h]	
grpl_gpv2(nx_gpv, ny_gpv)	Precipitation intensity (graupel) [mm/h]	
Input GPV grid index & interpolation time at tracer		
tracer_gpv_ii(n_tracer_mpi)	Grid index (EW) at tracer point	
tracer_gpv_jj(n_tracer_mpi)	Grid index (NS) at tracer point	
tracer_gpv_k1(2, 2, n_tracer_mpi)	Grid index (before Z) neighbor tracer point	
tracer_gpv_k2(2, 2, n_tracer_mpi)	Grid index (after Z) neighbor tracer point	
tracer_gpv_time(n_tracer_mpi)	Interpolation time from nearest GPV	
Interpolate atmospheric GPV to tracer point		
u_at_tracer(n_tracer_mpi)	Horizontal wind (EW) [m/s]	
v_at_tracer(n_tracer_mpi)	Horizontal wind (NS) [m/s]	
w_at_tracer(n_tracer_mpi)	Vertical wind [m/s]	
dens_at_tracer(n_tracer_mpi)	Air density at tracer level [kg/m^3]	
temp_at_tracer(n_tracer_mpi)	Air temperature at tracer level [K]	
pres_at_tracer(n_tracer_mpi)	Air Pressure at tracer level [hPa]	
vdf_at_tracer(n_tracer_mpi)	Vertical diffusion coef. at tracer level [m^2/s]	
resist_air_at_tracer(n_tracer_mpi)	Aerodynamic resistance at tracer point [s/m]	
cwc_at_tracer(n_tracer_mpi)	Cloud water content at tracer level [kg/m^3]	
cloud_top_at_tracer(n_tracer_mpi)	Cloud top at tracer point [m asl]	
cloud_base_at_tracer(n_tracer_mpi)	Cloud base at tracer point [m asl]	
rain_under_tracer(n_tracer_mpi)	Rain under tracer point [mm]	
snow_under_tracer(n_tracer_mpi)	Snow under tracer point [mm]	
grpl_under_tracer(n_tracer_mpi)	Graupel under tracer point [mm]	
Diagnostic variable at tracer point		
yuragi_u(n_tracer_mpi)	Fluctuation of horizontal wind (EW) [m/s]	
yuragi_v(n_tracer_mpi)	Fluctuation of horizontal wind (NS) [m/s]	
Input data variable		
roughness_length(m_parm_vegetation_type2)	Roughness length [m]	m_parm_vegetation_type2 = 25
displacement_height(m_parm_vegetation_type2)	Zero-plane displacement [m]	
vegetation_mask(nx_surf_tl319, ny_surf_tl319)	Vegetation distribution	nx_surf_tl319 = 640
sst_climate(nx_surf_tl319, ny_surf_tl319)	Sea surface temperature [K]	ny_surf_tl319 = 320

Table C.1　(Continued)

Variable name	Description	Remarks
ATM calculation variable		
atm_end_time(5)	End of ATM forecast time [UTC]	
fcst_time_atm	Forecast time of ATM from basetime [sec]	
dt_atm	Global time step [sec]	
dt_atm_mod	Time step (modified) [sec]	
rk_weight(n_timeloop_stage_max)	Runge-Kutta weights (b-coefficients)	
rk_node(n_timeloop_stage_max)	Runge-Kutta nodes (c-coefficients)	
interval_atm	Time interval of output ATM [sec]	
Tendency variable		
dt(n_tracer_mpi)	Time step [sec]	
dlatdt(n_tracer_mpi)	Sum of latitude increment (total step) [deg]	
dlondt(n_tracer_mpi)	Sum of longitude increment (total step) [deg]	
daltdt(n_tracer_mpi)	Sum of altitude increment (total step) [m]	
Output ATM parameter (Space)		
plane_name_atm(nz_atm)	Plane namelist for output ATM	
plane_alt_atm(nz_atm)	Plane altitude [m asl]	
plane_thickness_atm(nz_atm)	Thickness of ATM layer [m]	
nz_atm	Vertical plane number	
nx_atm	Grid number of EW direction	
ny_atm	Grid number of NS direction	
atm_basepoint_ix	Basepoint of EW direction	
atm_basepoint_jy	Basepoint of NS direction	
atm_basepoint_lat	Basepoint latitude [deg]	
atm_basepoint_lon	Basepoint longitude [deg]	
atm_distance_x	Grid distance of EW direction [deg]	
atm_distance_y	Grid distance of NS direction [deg]	
lat_atm(nx_atm, ny_atm)	Latitude of grid [deg]	
lon_atm(nx_atm, ny_atm)	Longitude of grid [deg]	
Output ATM parameter (NuSDaS type1–3)		
type1_atm	NuSDaS Type1 (output ATM)	
type2_atm	NuSDaS Type2 (output ATM)	
type3_atm	NuSDaS Type3 (output ATM)	
member_atm	NuSDaS member (output ATM)	
Output ATM grid index at tracer		
tracer_atm_ii(n_tracer_mpi)	Grid index (EW) at tracer point	
tracer_atm_jj(n_tracer_mpi)	Grid index (NS) at tracer point	
Output ATM variable (Eulerian grid)		
grid_atm_dep_total(nx_atm, ny_atm)	Total deposition (TDEP) [kg/m^2]	
grid_atm_dep_gravity(nx_atm, ny_atm)	Gravitational fallout (FOUT) [kg/m^2]	
grid_atm_dep_dry_dep(nx_atm, ny_atm)	Dry deposition (DDEP) [kg/m^2]	
grid_atm_dep_washout(nx_atm, ny_atm)	Wet scavenging (washout) (WOUT) [kg/m^2]	
grid_atm_dep_rainout(nx_atm, ny_atm)	Wet scavenging (rainout) (ROUT) [kg/m^2]	
grid_atm_max_size(nx_atm, ny_atm)	Maximum grain size (MAXD) [m]	
grid_atm_max_alt(nx_atm, ny_atm)	Tracer cloud top (CTOP) [m asl]	
grid_atm_min_alt(nx_atm, ny_atm)	Tracer cloud base (CBASE) [m asl]	
grid_atm_clm_content(nx_atm, ny_atm)	Total column content (TCLM) [kg/m^2]	
grid_atm_air_concent(nx_atm, ny_atm, nz_atm)	Atmospheric concentration (ACON) [kg/m^3]	
Time control		
n_timeloop_stage	Local timeloop stage counter	
n_timeloop_stage_max	Local timeloop stage number	
validtime_seq_min	Valid time [sequential min]	
n_total_step	Total time step (for monitor)	
n_current_step	Current time step (for monitor)	
n_flag_timing_finish	Exiting flag in timeloop	
n_flag_timing_input	Input flag in timeloop	
n_flag_timing_output	Output flag in timeloop	
elapse_time	Elapse time from basetime [sec]	
Other variable		
seed	Random seed (Xorshift)	Appendix G

C.2　主要パラメーター覧

主なパラメータを Table C.2 にまとめる。付録 D のネームリストにあるスイッチは除く。

Table C.2　Main parameters (parm.f90)

Parameter name	Description	Value	Remarks
ATM control (Tracer)			
Status flag			
m_flag_tracer_status_before_active	Not active tracer (before calculate)	-1	
m_flag_tracer_status_active	Active tracer	1	
m_flag_tracer_status_suspended	Suspended tracer	2	
m_flag_tracer_status_out	Not active tracer (after calculate)	0	
Result flag			
m_flag_tracer_result_air	In air	1	
m_flag_tracer_result_reflection	Surface reflection	2	
m_flag_tracer_result_fallout	Fallout	11	
m_flag_tracer_result_deposition_dry	Dry deposition	21	
m_flag_tracer_result_washout_rain	Washout by rain	31	
m_flag_tracer_result_washout_snow	Washout by snow	32	
m_flag_tracer_result_washout_grpl	Washout by graupel	33	
m_flag_tracer_result_rainout	Rainout	41	
m_flag_tracer_result_top_out	Over model top	0	
m_flag_tracer_result_bottom_out	Under model surface	10	
m_flag_tracer_result_domain_out	Out of domain	90	
m_flag_tracer_result_decay_out	Decayed tracer	99	
ATM control (Process)			
m_switch_process_off	Process OFF	0	
m_switch_process_on	Process ON	1	
Time control			
m_flag_is_not_timing	Elapse time check (not action)	0	
m_flag_is_timing	Elapse time check (action)	1	
Misc			
m_flag_misc_off	System OFF	0	
m_flag_misc_on	System ON	1	
Space interpolation: GPV lattice to Tracer point			
idw	Inverse distance weight	1	$\geqslant 1$
Epsila			
time_epsilon	Small number for time interpolation	epsilon5	= 1.e-5_rp
space_epsilon	Small number for space interpolation	epsilon6	= 1.e-6_rp
Null			
large_null	Large number for null value	1._rp/epsilon7	= 1.e+7_rp
I/O			
io_rank	Rank number for I/O	0	MPI output for RANK0

C.3　定数一覧

ATM で使用する定数を Table C.3 にまとめる。

Table C.3　Constants (`const.f90`)

Constant name	Description	Value	Remarks
Universal constants			
pi	π	3.14159265358979323846_rp	
rad_unit	[rad/°]	pi / 180._rp	
deg_unit	[°/rad]	180._rp / pi	
Constants for Earth			
earth_radius	Earth radius R_{E} [m]	6.371e+6_rp	
inv_earth_radius	Inverse Earth radius $1/R_{\mathrm{E}}$ [1/m]	1._rp / earth_radius	
earth_circumference	Earth circumference $2\pi R_{\mathrm{E}}$ [m]	2._rp * pi * earth_radius	
earth_semi_major_axis	Semi-major axis [m]	6.378137e+6_rp	GRS80
inv_earth_flattening	Inverse Earth flattening	298.257222101_rp	GRS80
grav	Gravitational constant g [m/s^2]	9.80665_rp	
Constants for Air			
gas_ideal	Ideal-gas constant R^* [J/mol/K]	8.31_rp	
gas_dry	Gas constant R_{d} [J/kg/K] for dry air	287.05_rp	
gas_vapor	Gas constant R_{v} [J/kg/K] for water vapor	461.5_rp	
dens_water	Water density under standard state [kg/m^3]	1000._rp	
inv_gas_kappa	$C_{\mathrm{p}}/R_{\mathrm{d}}$	7._rp / 2._rp	For diatomic molecule
gas_kappa	$R_{\mathrm{d}}/C_{\mathrm{p}}$	1._rp / inv_gas_kappa	= 0.286
cp_dry	Specific heat C_{p} [J/kg/K] at constant pressure	inv_gas_kappa * gas_dry	= 1004.675
gas_epsilon	ε	gas_dry / gas_vapor	= 0.622
standard_temp	Standard temperature [K]	273.15_rp	
standard_pres	Standard pressure p_0 [hPa]	1013.25_rp	
reference_pres	p_{00} [hPa]	1000._rp	For potential temperature
sound_velocity	Sound velocity for dry air [m/s]	331.45_rp	
karman	Karman constant κ	0.4_rp	
Tetens' parameters for saturation vapor pressure			
standard_vapor_pres	Standard saturation vapor pressure [hPa]	6.11_rp	
tetens_factor_water	Tetens' factor for water	7.5_rp * log(10._rp)	= 17.27
tetens_temp_water	Tetens' temperature for water [K]	237.3_rp	
tetens_factor_ice	Tetens' factor for ice	9.5_rp * log(10._rp)	= 21.875
tetens_temp_ice	Tetens' temperature for ice [K]	265.5_rp	
Sutherland's parameters for viscosity and MFP			
sutherland_temp	Sutherland constant C_{S} [K]	117._rp	
base_temp	Reference temperature T_0 [K]	293.15_rp	
base_viscos	Viscosity η_0 [Pa.s] at T_0	18.18e-6_rp	
base_freepath	Mean free path MFP_0 [m] at p_0 and T_0	6.62e-8_rp	
Cunningham's parameters for slip correction			
cc_factor_a	a-factor of Cunningham correction	1.257_rp	
cc_factor_b	b-factor of Cunningham correction	0.400_rp	
cc_factor_c	c-factor of Cunningham correction	1.100_rp	
Epsila			
epsilon2		1.e-2_rp	
epsilon3		1.e-3_rp	
epsilon4		1.e-4_rp	
epsilon5		1.e-5_rp	
epsilon6		1.e-6_rp	
epsilon7		1.e-7_rp	
epsilon8		1.e-8_rp	
epsilon9		1.e-9_rp	
epsilon10		1.e-10_rp	
epsilon11		1.e-11_rp	
epsilon12		1.e-12_rp	
epsilon13		1.e-13_rp	
epsilon14		1.e-14_rp	
epsilon15		1.e-15_rp	

C.4　型一覧

ATM で使用する型定義を Table C.4 にまとめる。実数変数の型（精度）は `rp` で指定する。また NuSDaS を読み書きする配列データの精度は `rktype` で指定する。

Table C.4　Kind types (`nrtype.f90`)

Symbolic name	Description	Value	Remarks
Numerical Recipes types (Press *et al.*, 1996)			
`sp`	Single precision	`kind(1.0e0)`	= 4
`dp`	Double precision	`kind(1.0d0)`	= 8
Select precision			
`rp`	Precision for real variables	`sp`	
		`dp`	Default
NuSDaS read/write data array types			
`r4type`	Single precision	`'R4'`	
`r8type`	Double precision	`'R8'`	
Select precision			
`rktype`	Precision for user data array type	`r4type`	
		`r8type`	Default

C.5　構造型一覧

ATM で使用する構造型を Table C.5 にまとめる。

Table C.5　Derived types (`mytype.f90`)

Component name	Component type	Description	Remarks
TYPE tag			
`tracer_id`	integer(4)	ID of tracer	1, 2, . . . , `n_tracer`
`emission_stage_id`	integer(4)	ID of emission stage	1, 2, . . . , `n_stage`
`emission_point_id`	integer(8)	ID of emission point	8-Byte Integer
TYPE flag			
`status`	integer(4)	Status flag of tracer	
`result`	integer(4)	Result flag of tracer	