I. Model code structure

I-1. Model structure and job step

Job is divided into 4 steps currently.

Job Step 1

Preparation of orography file (Section K-1).

Job Step 2

Preparation of initial and boundary files (Section K-2).

Job Step 3

Running the model (Section K-3).

Job Step 4

Plotting the results (Section K-4).

I-2. Members and subroutine list of Job Step 3

I-2-1 Member list

In job step 3, following members exist. Here asterisk in each member name is the wild card, which stands for the source code version.

main*.f : main program

subadj*.f : convective adjustment

subadv*.f : computation of advection terms

subchk*.f : subroutines for check

subcvp*.f : computation of velocity

subdif*.f : subroutines for diffusion

subhel*.f : pressure equation solver

subhevi*.f : subroutines for E-HE-VI scheme

subhyd*.f : hydrostatic version

subini*.f : initial model setting

subios*.f : I/O subroutines

sublbc*.f : boundary condition

subpgf*.f : pressure gradient and forcing terms

subptg*.f : prediction ground temperature

subrad*.f : atmospheric radiation using relative humidity for cloud amount

subrade*.f : atmospheric radiation using cloud water and cloud ice

subsnw*.f : cloud microphysics

subtrb*.f : turbulent closure model

deigs.f : eigen function by Jacobi method

gamma.f : gamma function

comm.f : subroutines for data copy for HE-VI scheme

wrtfct.f : write forecast values for GrADS

I-2-2 Subroutine list

Following subroutines and functions are included in the above members.

a. subadj.f*

ADJUST : moist convective adjustment

CLBASE : calculation condensation level

RRMDFY : evaporation during the rain dropping to the surface

b. subadv.f*

CADVE1M : advection term for scholar variables

CADVC4W : compute advection term for W

CADV4UV : compute advection terms for U and V

CADVUP : upstream advection

CADVE3M : compute advection term for cloud water

CADVQN : compute advection term of number concentration

DVDNS : divide by density (currently not used)

UVMEAN : compute u/m and v/m at scholar point

CWMEAN : compute w/m at scholar point

DEFORM : compute deformation term

CLEARH : zero setting

LTRLB2 : adjust boundary values for cyclic condition (P point)

LTRLBU : adjust boundary values for cyclic condition (U point)

LTRLBV : adjust boundary values for cyclic condition (V point)

LTRLUV : adjust boundary values for cyclic condition (deformation terms)

ADJ2D1 : adjust boundary values for cyclic condition

MODADV : modify advection term in E-HI-VI scheme

c. subchk.f*

CHKEN3 : advection term for scholar variables

CHKMX : check maximum and minimum

CHKDIV : check maximum divergence in each level

CHKVAP : check total amount of *Qv, Qc, Qr* (currently not used)

CHKVAL : output values

CHKBDV : check boundary values (currently not used)

CHKFLX : check vertical flux

CHKFXM : check momentum flux (currently not used)

CHKAVR : check average value

CHKMNS : simple check of minus values

CHKMN0 : check of minus values

CHKMN2 : set u, v, w^* for modifed advection scheme

CHKMN20 : modify advection term by modified advection scheme

CHKMN21 : compute maximum and minimum of advection term

CHKMN22 : compute maximum of advection term (for MSWSYS(30)=3)

)CHKMN2-CHKMN22 are used for dry model or advection terms of U, V, W

CHKMN23 : prepare minimum values for modified advection scheme

CHKMN3 : modify advection terms of physical variables by modified advection scheme

CHKMN30 : compute advection flux of physical variables for modified advection scheme

CHKMN31 : compute maximum and minimum of advection term

CHKMN32 : compute maximum of advection term (for MSWSYS(30)=3)

*)CHKMN3-CHKMN32 are used for advection terms of physical variables

CHKBGT : check budget for cloud microphysics

CHKSUM : check sum

CHKMN1 : check minus values (for TKE)

d. subcvp.f*

SVELCH : time integration of velocity

ORUCHH : compute Orlanski's radiation condition phase velocity for U

ORVCHH : compute Orlanski's radiation condition phase velocity for V

EXTRX1 : extrapolation scholar values at x-boundary

EXTRY1 : extrapolation scholar values at y-boundary

EXTRX2 : extrapolation Qv at x-boundary

EXTRY2 : extrapolation Qv at y-boundary

EXTWX2 : extrapolation W at x-boundary

EXTWY2 : extrapolation W at y-boundary

EXTPX2 : extrapolation θ at x-boundary

EXTPY2 : extrapolation θ at y-boundary

EXTVX2 : extrapolation V at x-boundary

EXTUY2 : extrapolation U at y-boundary

EXTNUH : extrapolation U at x-boundary

EXTNVH : extrapolation V at y-boundary

CPSEA : compute sea level pressure

ADJPRS : adjust press at top boundary (currently not used)

e. subdif.f*

DAMPCN : computation of numerical diffusion

SETDCF : set diffusion coefficients

TSMOTH : Asselin's time filter

TSMTUV : Asselin's time filter for U and V

OSAVEH : save old value for time filter

COPYH : copy data set

RLDAMP3 : Rayleigh damping

f. subhel.f*

CPRESS : compute pressure

CPAI3 : solve pressure equation

VHELMH : Helmholtz equation solver

TRIDGH : Gaussian elimination method

TREGXH : Fourier transformation for x-direction

TREGYH : Fourier transformation for y-direction

GENCIN : set tri-diagonal matrix for pressure solver

UVPBD : lateral boundary treatment for U and V

INIVG1 : set eigen vector function by Jacobi method

INIVG2 : set eigen vector function for uniform grid

GMATD1 : set eigen vector matrix

g. subhevi.f*

TRIMAT : set matrix coefficient

SNDUV : update horizontal velocity with forward scheme

SNDWP : update vertical velocity and pressure with backward scheme

BUNDRY : apply boundary conditions

ASELIN : apply time filter

h. subhyd.f*

CHYDPRE : compute pressure for hydrostatic version

CHYPAI2 : compute surface pressure by solving pressure equation

CHYPAIA : compute pressure vertically

CPFHYI : set invariant forcing term

CPFHYV : set variant forcing term

HYVSTCO : compute co-efficient of pressure for surface pressure

HYVSTC1 : compute vertical sum of advection term and DU(V)DTBC

ZEROEIGV : set number of eigen value which is zero CHYDPRE :

i. subini.f*

INIT3 : read orographic file and set initial constants

INIUVD : initial set U and V from the parameter card

SETREF : set reference atmosphere

HRMEAN : compute horizontal mean

CSTATP : compute hydrostatic pressure

INIEX1 : interpolate initial reference field

RANDOM : make random perturbation (currently not used)

SETPTD : set barotropic geostrophically balanced field

CPTGRD : set ground temperature

DIVFLOW : set divergent flow (currently not used)

RELAX1 : Poisson equation solver by successive over relaxation

CADJP1 : adjust initial field by the variable calculus

SETOMW : set initial field of W^*

VRGDIS : compute variable grid distances

ORGIN3 : set metric tensors and their mean values

CPTRFT : compute reference atmosphere

INTRF3 : interpolate reference atmosphere to 3-D model planes

INTRF2 : interpolate reference atmosphere to 3-D model planes for half level

SETZRP : set height of full levels

SETZRW : set height of half levels

SETVDZ2 : set depth of half levels

READZS : read orography file

SETVRG : set variable grid levels

j. subios.f*

RDPAR1 : read parameter card

STRMTS : store grid point values

STRMTS2 : store grid point values with compression

COMPRE : compress GPVs into 2 byte integer

RESTFL : store restart file

SFTRCD : shift record number in case of restart

LOADPS : load sea-level pressure from the boundary file

LOADUV : load grid point values from the boundary file

LOADOM : load adjusted wind at the lateral boundary

STOROM : store adjusted wind at the lateral boundary

LOADBD : load boundary condition

STORBD : store boundary values and their tendencies

STMTC1 : store basic variables

LOADTG : load ground temperature from the ground temperature file

TIMSTP : time control

k. sublbc.f*

SETEXT : set time tendency of prognostic variables

SETEX2 : set time tendency of prognostic variables at lateral boundary

SETEXU : set time tendency of U at lateral boundary

SETEXV : set time tendency of V at lateral boundary

CDMFDT2 : compute time tendency of mass flux through lateral boundary

SETEXW : set time tendency of W at lateral boundary

SETEXP : set time tendency of θ at lateral boundary

CEXTBD : set value of prognostic variables at lateral boundary

JYSET2 : set start and end of JY

PRSTR1 : print out variables

CONDQV : compute condensation

PTCOND : compute condensation level

WDGROW : wind grow procedure

CDMFDT : compute time tendency of mass flux in case of wind grow

ADJFLX : adjust U and V according to mass flux at lateral boundary

CHKMFX : compute mass flux at lateral boundary

SETEXT2 : set time tendency of prognostic variables using SETEX3

SETEX3 : set time tendency of external wind and potential temperature

LOADEX : load external reference value and time tendency at boundary

ADJEXT : adjust external reference wind according to precipitation rates

l. subpgf.f*

CPFORI : compute invariant part of forcing term for pressure equation

CPFRV1 : compute variant part of forcing term for pressure equation

CFPBDV : compute boundary condition for pressure equation

WCVOMWM : convert W to W^*

OMWCVWM : convert W^* to W

UCVDNUM : convert u and v to U and V

WCVDNWM : convert w to W

ADJUVW : adjust wind in case of mountain grow initial start up

CPFX1 : compute pressure gradient force for x-direction

CPFY1 : compute pressure gradient force for y-direction

CPFZ : compute pressure gradient force for z-direction

CDIVTM : compute total divergence

CDIVS : compute separable part of divergence

CPTM : compute mass-virtual potential temperature

CDENS : compute density from state equation

CBUOYD : compute buoyancy term

m. subptg.f*

TGFCST : compute ground temperature

RADIAT : compute short and long wave radiations

GNCLD : compute cloud amount by diagnosis of relative humidity

GNCLOUD : sub program of GNCLD

RADIATD : compute solar and long wave radiation for dry model

GNCLDD : compute shade area for dry model

TGCONC : initial setting of the wetness, albedo, .. *etc.* for no-nesting model

TGSET : set initial ground temperature for no-nesting model

SETDAY : set UTC from the boundary file

n. subrad.f*

RADIAT3 : main program for atmospheric radiation

ZENITH : compute zenith angle

SPMNEW : compute short and long wave radiations

SCALEL : compute scale of *Qv,* carbon, ozone for long wave radiation

SCALES : compute scale of *Qv,* carbon, ozone for short wave radiation

QTINT : interpolate *T, Qv* vertically

LGWAVE : compute energy flux of long wave radiation

LGTRNS : set transmission function (*TAU*)

FTTRNS : set *TAU* for vertical surrounding grids

GTTRNS : set total *TAU* from bottom and top

TAUTBL : compute *TAU*

SOLAR : compute atmospheric absorption for short wave radiation

SOLSC : compute absorption of scattered part of solar radiation

SOLAB : compute absorption of absorbed part of solar radiation

MTOG : program for saving cpu time

GCLNEW : compute cloud amount by diagnosis of relative humidity

GCLNEW2 : compute cloud rate between vertical grids

TGFCST2 : compute ground temperature

o. subrade.f*

RADIAT3E : main program for atmospheric radiation using cloud water

ZENITHE : compute zenith angle

SPMNEWE : compute short and long wave radiations

SCALELE : compute scale of *Qv,* carbon, ozone for long wave radiation

SCALESE : compute scale of *Qv,* carbon, ozone for short wave radiation

QTINTE : interpolate *T, Qv* vertically

LGWAVEE : compute energy flux of long wave radiation

CTRNSE : compute transmission function (*TAU*) in cloud grids

LGTRNSE : compute total *TAU* of *Qv,* carbon, ozone for each level

FTTRNSE : compute total *TAU* of *Qv,* carbon, ozone for vertical surrounding

GTTRNSE : compute total *TAU* of *Qv,* carbon, ozone for bottom and top

TAUTBLE : compute *TAU* of each band by broad band models

SOLARE : compute atmospheric absorption for short wave radiation

SOLSCE : compute absorption of scattered part of solar radiation

SOLABE : compute absorption of absorbed part of solar radiation

MTOGE : program for saving cpu time

TGFCSTE : compute ground temperature

*p. subsnw * .f*

CPTQVN : compute potential temperature

CLDPHN : main program of cloud microphysics

CLDBG2 : cloud budget

CDTV : molecular dynamic viscosity of air

KOENIG : depositional growth of ice crystal

CLCWR1 : calculation of warm rain process

CLCWR2 : computation of cloud water in warm rain

CLRSHN : conversion from snow to graupel

CLVSHN : depositional growth of snow and graupel

CPICE : product of ice crystal

OUT03N : output list

OUT04N : output list

OUT05 : output list

CVRSH1 : melting of snow and graupel

CTRVF2 : compute terminal fall velocity

CTRVD2 : compute precipitation (Box Lagrangian scheme)

CTRVFM : compute precipitation (Euler scheme)

CQS3 : time integration of *Qc, Qr, Qs, Qg* and *Qi*

CQS2 : time integration of *Qv*

ADJNUM : adjust number concentration

CPT5 : compute time tendency of potential temperature

CPTQV1 : time integration of potential temperature

ADJQVH : adjust *Qv* after condensation and sublimation

ADJQCW : adjust *Qc* after condensation and sublimation

CGMMA : compute functions for terminal fall velocity etc.

FSUERM : error message

CQVSAT : compute saturation mixing ratio

CQVSAT1 : compute saturation mixing ratio for reference atmosphere

q. subtrb.f*

CETUR5 : compute turbulent kinetic energy

CNVED3 : diagnose diffusion coefficients

CDIFET : compute diffusion term of turbulent energy

STRSED : compute stress terms

SETEMX : set maximum eddy diffusion coefficients

CRSTUV : compute Reynolds stress

KONDOH : compute bulk transfer coefficients over sea surface

GRDFXH : compute bulk transfer coefficients over ground surface

r. comm.f

SCATTER : copy from longtime step data to short time step data

GATHER : copy from short time step data to long time step data

I-3. Flow chart of Job Step 3

The flow of Job Step 3 (model run) is as follows :

I-3-1 Initial declaration and setting

a. Setting parameter

b. Declaration of arrays, common variables.

c. Setting of model constants

RDPAR1 — read parameter card

VRGDIS — set variable grid distance

SETZRP, SETZRW — set levels's heights

d. INIVG1 or INIVG2 — set eigen functions

e. Setting of constants for diffusion processes

SETEMX — set maximum eddy diffusion coefficients

SETDCF — set diffusion coefficients

f. Setting of orography file

INIT3 — read orography file and set initial constants

ORGIN3 — set metric tensors and their mean values

I-3-2 Model initiation

Two model initiation procedures are available ; stand alone initiation and nesting initiation, described in Chapter E. The control parameter is mode switch MSWSYS(12).

if (MSWSYS(12)=<2) then

a. Stand alone initiation

(═══Stand alone initiation start═══)

INIUVD — set of wind field (U and V) from the parameter card

SETREF — set reference atmosphere

CPTRFT — compute reference atmosphere

INTRF3 — interpolate reference atmosphere to 3-D model planes (for Qv)

CSTATP — compute hydrostatic pressure

CPTM — compute mass-virtual potential temperature

CDENSE — compute density from the state equation

GENCIN — set tri-diagonal matrix for pressure solver

UCVDNUM — convert u and v to U and V, multiplying reference density

CLEARH — set $W^*=0$

OMWCVWM — compute W from U and V (assuming $W^*=0$)

SETEXT — set external values for u, v, w, θ, Qv, and P

SETEXT2 — set zero for time tendency of external values of u, v and θ

LOADEX — load time tendency of external values of u, v and θ

(═══ Stand alone initiation end═══)

else if (MSWSYS(12)>=3) then

b. Nesting initiation

(═══ Nesting initiation start═══)

LOADUV — load grid point values from the boundary file

HRMEAN — compute horizontal mean state

CPTRFT — compute the reference atmosphere

CSTATP — compute hydrostatic pressure

CPTM — compute mass-virtual potential temperature

CDENSE — compute density from the state equation

GENCIN — set tri-diagonal matrix for pressure solver

LOADPS — load sea level pressure from the boundary file to set the total mass tendency

UCVDNUM — convert u and v to U and V, by multiplying reference density

WCVDNWM — convert w to W, by multiplying reference density

ADJFLX — adjust U and V according to mass flux at lateral boundary

CHKMFX — compute mass flux at lateral boundary

SETOMW — set initial field of W^*

CDIVTM, CHGKDIV — check divergence

if (MSWSYS(20)=0) then

═══ anelastic, variational calculus start═══

RELAX — mass-consistent variational calculus

CADJP1 — adust U. V and W

═══ variational calculus end═══

OMWCVWM — convert W to W^*

else if (MSWSYS(20)>0) then

OMWCVWM — convert W to W^*

end if

STOROM

do KTREAD=KTSTO+KTDTO,KTENO,KTDT

LOADUV — load grid point values from the boundary file

UCVDNUM — convert u and v to U and V, multiplying reference density

WCVDNWM — convert w to W, by multiplying reference density

CSTATP — compute hydrostatic pressure

CPTM — compute mass-virtual potential temperature

CDENSE — compute density from the state equation

GENCIN — set tri-diagonal matrix for pressure solver

UCVDNUM — convert u and v to U and V, by multiplying reference density

WCVDNWM — convert w to W, by multiplying reference density

ADJFLX — adjust U and V according to mass flux at lateral boundary

CHKMFX — compute mass flux at lateral boundary

SETOMW — set initial field of W^*

OMWCVWM — convert W to W^*

SETEXT — set external values for u, v, w, θ, Qv, and P

SETEX2 — set time tendency of prognostic variables at lateral boundary

SETEXT2 — set zero for time tendency of external values of u, v and θ

CDMFDT2 — compute time tendency of mass flux through lateral boundary

STORBD — store boundary values and their tendencies

enddo

(═══ Nesting initiation end═══)

c. Initiation of ground temperature

if (MSWSYS(12) =<2) then

TGCONC : initial setting of the wetness, albedo, etc., for stand alone run

TGSET : set initial ground temperature for stand alone run

else if (MSWSYS(12)>=3) then

LOADTG : load ground temperature from the ground temperature file

endif

d. Reset of initial value of model at start (restart) time

if (ITST=1) then

STMTC1 — store basic variables

LOADUV : load grid point values from the boundary file

LOADOM : load adjusted wind at the lateral boundary

CHKMFX — compute mass flux at lateral boundary

SETDAY — set universal time

CSTATP — compute hydrostatic pressure

CPTM — compute mass-virtual potential temperature

CDENSE — compute density from the state equation

CDIVT, CHKDIV — check divergence

else if (ITST>=2) then

RESTFL — read the restart file

CDIVT, CHKDIV — check divergence

SFTRCD — shift record number of the output file

end if

I-3-3 Time integration

do IT=ITST, ITEN

a. Setting of time step, model time

b. Diagnosis of density and set tri-diagonal matrix

CDENSE — compute density from the state equation

GENCIN — set tri-diagonal matrix for pressure solver

c. Computation

CEXTBD, SETEXW, ADJEXT — compute external value at boundary

CADVC4W, CADV4UV — compute advection terms

CRSTUV — compute stress terms

if (MSWSYS(13)>=8) then

RADIATE3E, TGFCST2E — cloud radiation process

else if (MSWSYS(13)>=6) then

RADIAT3, TGFCST2 — radiation relative humidity

else if (MSWSYS(13)>=2) then

TGFCST — no atmospheric radiation

end if

CETUR5 — Compute the turbulent kinetic energy

CPTQVN — Compute potential temperature with cloud microphysics

CNVED3 — Diagnose diffusion coefficients

CBUOYD — Diagnose buoyancy term

UVPBD — Treatment of lateral boundary condition

if (MSWSYS(20)<2) then

if (MSWSYS(20)=-1) then

＊＊＊HYDROSTTATIC VERSION＊＊＊

CHYDPRE — compute pressure for hydrostatic version

else if MSWSYS(20)>=0) then

＊＊＊ANELASTIC, ELASTIC-HI-VI VERSION＊＊＊

if (MSWSYS(20)=1) then

MODADV — Modify advection term

end if

CPRESS — compute pressure for non-hydrostatic version

end if

SVELCH — compute velocity

else if (MSWSYS(20)=2) then

＊＊＊ELASTIC-HE-VI VERSION＊＊＊

TRIMAT — set matrix coefficient

do m=1, nsound

SNDUV — update horizontal velocity with forward scheme

SNDWP — update vertical velocity and pressure with backward scheme

end do

BUNDRY — apply boundary conditions

ASELIN — apply time filter

end if

CPTM — Diagnose mass-virtual potential temperature

d. Output

STRMTS, STRMTS2 — Output grid point values

RESTFL — Output restart file

end do