CLIO 3.0 : Description of some routines

H. Goosse, J.-M. Campin and B. Tartinville

Contents

The pre-processing

Before compiling, some routines undergo a pre-processing procedure in order to activate (or suppress) the options which could not be implemented as a modification in the parameters. This is achieved by a simple script "prep" that relies on the standard unix command "sed" (also available on Linux system). The choice of a particular configuration of CLIO only requires to modify the file "prep.sed" that contains the “sed” preprocessing instructions (see “man sed” on the local machine for more informations). An example of a "prep.sed" file that corresponds to the standard version of CLIO3.0, is given below:

```
# fichier "prep.sed" (=> modif des 5 1er caract) (06/10/99) pour version clio3
#  20 levels, avc TKE, avc ICE, no  NetCDF, avc ISOPYC, no  CFC,
#  not CRAY, Advc.Sch.1, avc FW_flx, not CouPL. :
#---+----^----+^---2----^----3----+----4----+----5----+----6----+----7-|--+----|
# CL15 ou CL20 ou CL30 : with 15, 20 or 30 vertical levels
s/^CL20 /     /g
# Ctk0 ou Ctke : without or with TKE scheme for vertical difusion
s/^Ctke /     /g
# Cic0 ou Cice : without or with ice
s/^Cice /     /g
# Cnc0 ou Cncd : without or with Netcdf
s/^Cncd /     /g
# Cis0 ou Ciso : without or with isopycnal diffusion and Gent-McWilliams scheme
s/^Ciso /     /g
# Ccf0 ou Ccfc : without or with CFC
s/^Ccf0 /     /g
# Cra0 ou Cray : to be run on a "classical" machine or on Cray
s/^Cra0 /     /g
# Cabs ou Ca2  : Advec. Scheme : Abs() or square()
s/^Cabs /     /g
# Cfd0 ou Cfdd :without or with a natural Fresh Water Flux
s/^Cfdd /     /g
# Ccp0 ou Ccpl : Not Coupled or coupled with an atmospheric model
s/^Ccp0 /     /g
#---+----^----+^---2----^----3----+----4----+----5----+----6----+----7-|--+----|
```

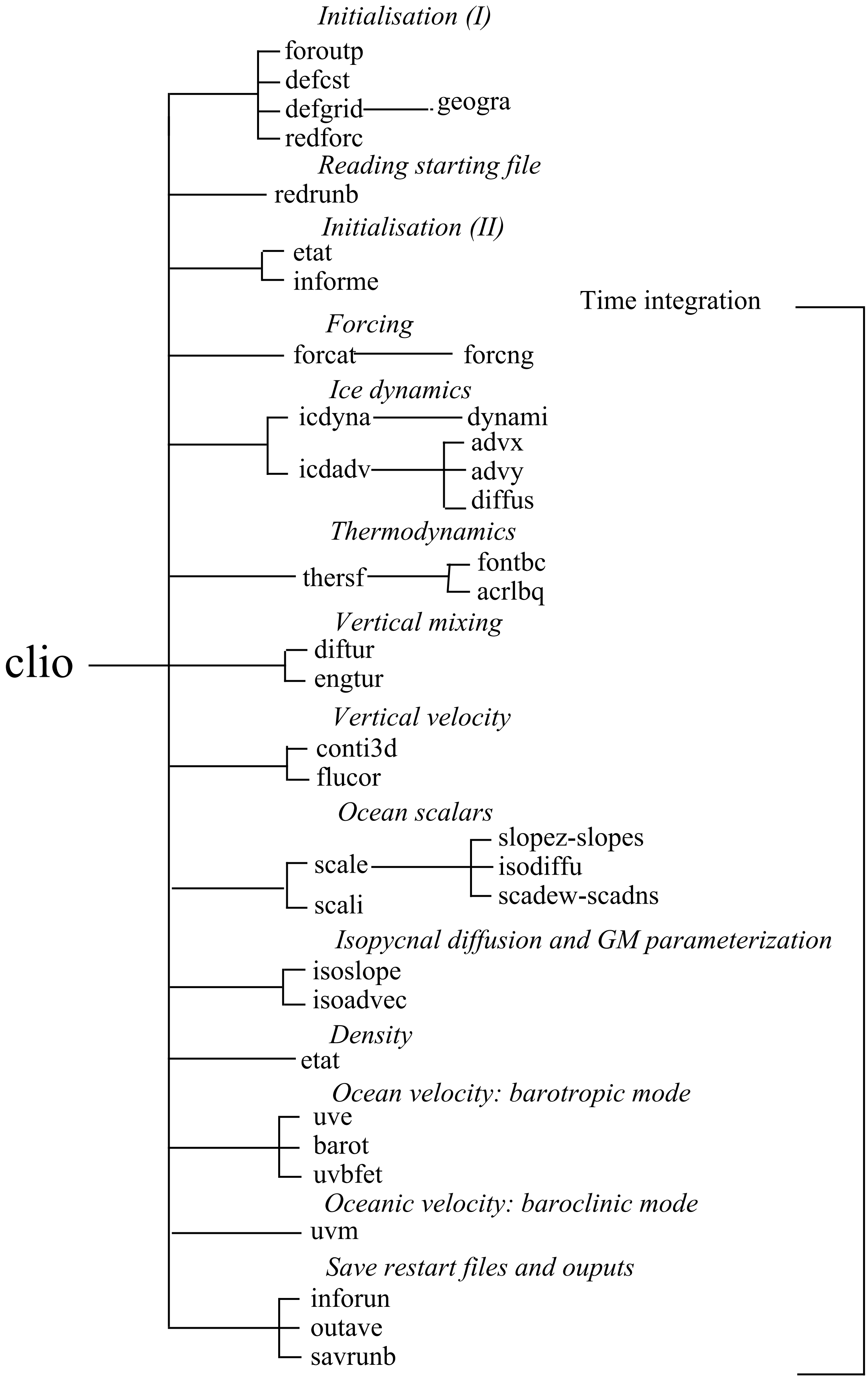
Note that line beginning with "#" are comments. Actually, "prep" processes the original source code as follows: the sed command replaces by spaces all strings of character at the beginning of a new line that matches one of the instruction of "prep.sed" file (e.g.: "Ctke "). By doing this the lines commented in the original source code, using this particular string, are now active. The subroutines that need to be processed by *prep* have the extension *.Fom* (or *.Com* for the included files). After being modified by prep, they are copied in the corresponding *.f* file (or .com respectively) and then directly used by the compiler. Therefore, if a modification of a routine is needed, it is only necessary to make the changes in the *.Fom* (*.Com*) file. To clarify the procedure, the reader can compare a particular *.Fom* (*.Com*) file with the corresponding *.f* (*.com*).

It must be stressed that some options are incompatible: the TKE scheme, the CFC or the coupling with an atmospheric model can only be used if the ice is activated.

The main programme: clio

Clio is the main routine of the code which call the sub-routines. It has been mainly developed by J.-M. Campin with modification introduced by H. Goosse (the computation of the date, the call of the daily forcing and the ice routines), P.P Mathieu (the call of isopycnal and Gent-MacWilliams schemes) and C. Poncin (Coupling with the atmosphere).

The basic structure of the standard version of CLIO3.0 (standard file prep.sed) is described in the sketch displayed on the next page. At the beginning, it initialises some constants and the characteristics of the grid. It then reads the restart file. It computes some variables such as the density or the vertical velocity which are not saved in the restart file. One file for the outputs is also initialised. Then, starts the daily do-loop which begins by reading the forcing. Then the ice dynamics and ice advection are computed. Afterwards, the surface thermodynamic computations are performed (including ice thermodynamics). In the next step, vertical diffusion is calculated. Then, the evolution of ocean scalars (temperature, salinity, and any tracer) is computed. The new density can be obtained and then the new oceanic velocity (barotropic mode and then baroclinic mode). Finally variables are saved on output or restart files.


clio
Initialisation (I)
foroutp
defcst
defgrid
geogra
redforc
Reading starting file
redrunb
Initialisation (II)
etat
informe
Time integration
Forcing
forcat
forcng
Ice dynamics
icdyna
dynami
icdadv
advx
advy
diffus
Thermodynamics
thersf
fontbc
acrlbq
Vertical mixing
diftur
engtur
Vertical velocity
conti3d
flucor
Ocean scalars
scale
slopez-slopes
isodiffu
scadew-scadns
scali
Isopycnal diffusion and GM parameterization
isoslope
isoadvec
Density
etat
Ocean velocity: barotropic mode
uve
barot
uvbfet
Oceanic velocity: baroclinic mode
uvm
Save restart files and ouputs
inforun
outave
savrunb

acrlbq :

Goal of the routine:

Computation of the evolution of the ice thickness and concentration as a function of the heat balance in the leads. It is only used in case of lateral accretion.

Author(s):

Th. Fichefet, M.A. Morales Maqueda, H. Goosse

Reference(s):

Fichefet and Gaspar, 1988; Fichefet and Morales Maqueda, 1997

Called by :

thersf

Call :

None

Arguments:

kiut, kideb	the computation is applied over (kiut-kideb+1) points begining at number kideb until point kiut

Major inputs:

Ice and snow thicknesses, ice concentration, sensible and latent heat content in the ice, heat flux over the leads

Major outputs:

New ice and snow thicknesses, ice concentration, sensible and latent heat content in the ice

Structure:

Determination if there is lateral accretion of ice in the lead
Adjustment of snow thickness as well as of the heat content of the ice and snow layer
Computation of the variation of ice volume

Remarks:

Recent modifications:

adv :

Goal of the routine:

Advection of the ice with the method proposed by Hibler(1979).

Author(s):

M.A. Morales Maqueda

Reference(s):

Hibler (1979)

Called by :

icdadv

Call :

none

Arguments:

dt time step
ut velocity in the x direction
vt velocity in the y direction
s0 field before advection
s1 field modified by adv (transit variable used latter to compute the new filed after advection)

Major inputs:

Arguments dt, ut, vt, s0, s1

Major outputs:

New s1

Structure:

Computing the fluxes
Computing the divergence of the fluxes
Impact of the divergence on the fluxes

Remarks:

This method of advection is rarely used because it is not accurate and not stable.

Recent modifications:

advx :

Goal of the routine:
Advection of ice variables in the x direction.

Authors(s):
M.A. Morales Maqueda

Reference(s):
Prather (1986)

Called by :
icdadv

Call :
raccord

Arguments:

dt	time step
ut	velocity in x direction
crh	test if passage of advx before advy (1) or not (0)
sm	"area" of the grid modified by the advection
s0	field to advect (zero order moment)
sx	first order moment (x)
sxx	second order moment (x2)
sy	first order moment (y)
syy	second order moment (y2)
sxy	second order moment (xy)

Major inputs:
Arguments dt, ut, crh, sm, s0, sx, sxx, sy, syy, sxy

Major outputs:
Arguments sm, s0, sx, sxx, sy, syy, sxy

Structure:
Limitation of moments and initialisation
Determination of the volume of the grid
Computing the fluxes between grids, the new value of the field and the new moments

Remarks:
advy do the same job in the y direction

Recent modifications:

advy :

Goal of the routine:
Advection of ice variables in the y direction.

Authors(s):
M.A. Morales Maqueda

Reference(s):
Prather (1986)

Called by :
icdadv

Call :
raccord

Arguments:

dt	time step
vt	velocity in y direction
crh	test if passage of advy before advx (1) or not (0)
sm	"area" of the grid modified by the advection
s0	field to advect (zero order moment)
sx	first order moment (x)
sxx	second order moment (x2)
sy	first order moment (y)
syy	second order moment (y2)
sxy	second order moment (xy)

Major inputs:
Arguments dt, ut, crh, sm, s0, sx, sxx, sy, syy, sxy

Major outputs:
Arguments sm, s0, sx, sxx, sy, syy, sxy

Structure:
Limitation of moments and initialisation
Determination of the volume of the grid
Computing the fluxes between grids, the new value of the field and the new moments

Remarks:
advx do the same job in the x direction

Recent modifications:
Some initialisations have been added so that the routine can be compiled with the option -K.

cfc_flx :

Goal of the routine:

Computing the flux of CFC 11 & 12 at the ocean surface.

Authors(s):

H. Goosse, M.England, J.M Campin

Reference(s):

England et al. (1994)

Called by :

clio

Call :

None

Arguments:

nn99 parameter used for the output in the file "mouchard" of some diagnostics used to verify if the run performs correctly.

Major inputs:

Atnospheric and oceanic CFC concentrations, sea surface temperature and salinity

Major outputs:

CFC fluxes

Structure:

Computation of the solubility
Computation of the exchange coefficient
Computation the CFC flux

Remarks:

Recent modifications:

Before, this routine was included in icdyna

conti3d :

Goal of the routine:
    Computation of the vertical velocity.

Author(s):
    J.M. Campin

Reference(s):
    None

Called by :
    clio

Call :
    None

Arguments:
    None

Major inputs:
    Horizontal velocity

Major outputs:
    Vertical velocity

Structure:
    Initialise the vertical velocity at surface at zero (fd0) or at the value of imposed by the forcing (fdd).
    Computes the vertical velocity from the surface to the bottom using the continuity equation

Remarks:

Recent modifications:
    Non zero vertical velocity at surface in case of real freshwater flux (natural boundary conditions).

defcst:

Goal of the routine:

Definition of all the constants and parameters (physical and numerical) needed in CLIO as well as the parameters corresponding to a particular run.

Authors(s): :

J.-M. Campin, H. Goosse, P.-P. Matthieu

Reference(s):

None

Called by :

clio

Call :

None

Arguments:

nn99 parameter used for the output in the file "mouchard" of some diagnostics used to verify if the run performs correctly.

Major inputs:

Reads the files run.param, thermo.param, dynami.param

Major outputs:

Physical and numerical constants of the model and parameters of the run which are transmitted to the other routines by commons (mainly const.com, bloc.com, ice.com, dynami.com)

Structure:

Opening and reading of the file run.param
Definition of physical and numerical constants for the ocean
Definition of physical, numerical constants and parameters for the ice thermodynamics (in particular opening and reading of thermo.param)
Definition of physical, numerical constants and parameters for the ice dynamics (in particular opening and reading of dynami.param)

Remarks:

Recent modifications:

Modification of the reading of the input files
Suprresion of useless parameters

defgrid :

Goal of the routine:
    Definition of the characteristics of the numerical grid.

Authors(s):
    J.-M. Campin, H. Goosse

Reference(s):
    Deleersnijder, van Ypersele and Campin 1993, Campin 1997

Called by :
    clio

Call :
    geogra

Arguments:
    nflag if nflag = 2 then output of diagnostics in the file "mouchard"

Major inputs:
    Reads bath.om, typeaux.dat

Major outputs:
    Constants linked with the grid (grid spacing, location of Bering, ...)
    All the metric coefficient for ocean and sea-ice
    Define the bathymetry, the masks, the depth of the vertical levels
    Clouds optical depth and coefficients solar absorption in the ocean

Structure:
    Initialisation of some global variables
    Definition of some constants linked with the grid
    Definition of the metric coefficients for the ocean
    Definition of the metric coefficients for sea ice
    Definition of the bathymetry (reading bath.om)
    Definition of the masks
    Control writing on the file "mouchard"
    Definition of the mask for advection and diffusion of sea -ice
    Definition of cloud optical depth and of the coefficients solar absorption in the ocean
    Error messages

Remarks:

Recent modifications:

diffus :

Goal of the routine:

Horizontal diffusion of ice variables with an implicit method.

Authors(s):

M.A. Morales Maqueda

Reference(s):

None

Called by :

icdadv

Call :

None

Arguments:

dt	time step
difhx	diffusion coefficient (modified) in the x direction (computed in defgrid and icdyna)
difhy	diffusion coefficient (modified) in the y direction (computed in defgrid and icdyna)
fld0	field before diffusion
fld1	field after diffusion

Major inputs:

Arguments dt, difhx, difhy, fld0

Major outputs:

Argument fld1

Structure:

Computing the flux
Computing the divergence of the flux
Computing the impact of the divergence on the field
Test if the loop has to be continued

Remarks:

Recent modifications:

Some initialisations have been added so that the routine can be compiled with the option -K.

diftur :

Goal of the routine:
Computation of the mixing length (vlturb), of the diffusivity and of the viscosity.

Authors(s):
H.Goosse

Reference(s):
Goosse et al. (1998)

Called by :
clio

Call :
None

Arguments:
None

Major inputs:
Brunt Vaisala frequency, horizontal velocity, turbulent kinetic energy

Major outputs:
The mixing length (vlturb), the diffusivity and viscosity

Structure:
Initialisation
Computation of the mixing length
Computation of the Prandl frequency
Computation of the stability functions
Computation of the diffusion coefficients (associated with the surface layer) including the background value

Remarks:

Recent modifications:
Some optimization of the routine
Suppression of the c Computation of the diffusion coefficients in the highly sheared region below the ML because it is useless at large-scale.

dynami :

Goal of the routine:
    Computing the ice velocity.

Authors(s):
    M.A. Morales Maqueda, H. Goosse

Reference(s):
    Fichefet and Morales Maqueda 1997

Called by :
    icdyna

Call :
    None

Arguments:
    ih +1 Northern Hemisphere
    -1 Southern Hemisphere

Major inputs:
    Ice thickness and concentration, wind stress, ocean surface velocity

Major outputs:
    Ice velocity

Structure:
    Initialisation
    Computation of the ice mass, ice strength, weighted wind stress
    Computation of ice strength gradient
    Computation of the velocity at Bering Strait
    Computation of the ice velocity by the relaxation method

Remarks:

Recent modifications:

engtur :

Goal of the routine:
Computation of the evolution of the turbulent kinetic energy.

Authors(s):
H. Goosse

Reference(s):
Goosse et al. 1998

Called by :
clio

Call :
None

Arguments:
None

Major inputs:
Turbulent kinetic energy, Brunt Vaisala frequency, mixing length, Prandl frequency, diffusivity and viscosity

Major outputs:
Turbulent kinetic energy

Structure:
Initialisation
Identifying the points where the water column is unstable
Increase in the vertical diffusion of TKE
Building the matrix for the resolution of the equations
Resolution of the system of equations
Convective adjustment by an increase of the vertical diffusion

Remarks:

Recent modifications:
New options in the convective adjustment scheme

flucor :

Goal of the routine:

Computation of the corrective fluxes which are applied at the ocean bottom.

Authors(s):

J.-M. Campin & B. Tartinville

Reference(s):

None

Called by :

clio

Call :

None

Arguments:

None

Major inputs:

Mass fluxes at the ocean surface.

Major outputs:

Corrective heat and mass fluxes at the ocean bottom

Structure:

Compute the bottom mass flux and the corresponding corrective fluxes of heat salt and scalar quantities.

Remarks:

Recent modifications:

Take into account the freshwater flux at the ocean surface

fontbc :

Goal of the routine:

Computation of the evolution of ice and snow thicknesses and of ice concentration as a response to air-ice and atmosphere-ice fluxes. fontbc only treats the case of lateral ablation, in case of lateral accretion see acrlbq.

Authors(s):

Th. Fichefet, M.A. Morales Maqueda, H. Goosse

Reference(s):

Fichefet and Morales Maqueda 1997

Called by :

thersf

Call :

none

Arguments:

kiut, kideb	the computation is applied over (kiut-kideb+1) points beginning at number kideb until point kiut

Major inputs:

Ice and snow thicknesses, ice concentration, thermal heat content of the snow-ice system, heat flux at the ice base and the surface +air temperature and humidity (in uncoupled mode)

Major outputs:

Updated ice and snow thicknesses, ice concentration and thermal heat content

Structure:

Testing if the ice and snow temperature are in an acceptable range
Calculation of some intermediate values
Calculation of the surface temperature
Calculation of the available heat for surface ablation
Calculation of the changes in internal temperature due to vertical diffusion processes
Taking into account surface ablation and bottom accretion-ablation
Snow ice formation
Lateral ablation

Remarks:

Recent modifications:

Optimization of the code
Distinction between salt and freshwater fluxes allowed.
Snow-ice scheme of Fichefet and Morale Maqueda, 1999

forcat :

Goal of the routine:

Computation the heat flux at the ocean surface (except longwave) and the solar heat at the ice surface from atmospheric data.

Authors(s):

H. Goosse and M.A. Morales Maqueda

Reference(s):

Goosse 1997

Called by :

clio

Call :

forcng
shine

Arguments:

iyear	corresponding year reached by the simulation
xjour	day of the year

Major inputs:

atmospheric data (call forcng)

Major outputs:

Heat flux at the ocean surface and the solar heat at the ice surface

Structure:

Call focrng and store the wind stress in a different variable
Computation of snow precipitation and incorporation of the runoff in the precipitation
Computation of solar flux at the ocean at ice surface
Calculation of the turbulent heat fluxes and evaporation over water

Remarks:

Recent modifications:

Optimization of the code
Taking into account the ellipsity of the earth orbit in the computation of the solar flux.

forcng :

Goal of the routine:
    Reading the data files and interpolating it on the right day.

Authors(s):
    H. Goosse and M.A. Morales Maqueda

Reference(s):
    None

Called by :
    forcat

Call :
    None

Arguments:

ja	corresponding year reached by the simulation
xjour	day of the year

Major inputs:
    Read the files of atmospheric forcing : ground pressure, precipitation, cloudiness, wind stress, wind velocity, air temperature, humidity, river runoff, ustar
    Atmospheric CFC concentration
    Longwave radiation for the ocean and sea ice

Major outputs:
    Forcing data interpolated for the right day

Structure:
    Open files
    Reading the data
    Interpolating the data
    Computing the longwave radiation
    Computing the wind velocity from ground pressure (if necessary)
    Computing the wind stress if data are not wind stresses

Remarks:

Recent modifications:
    Optimization of the code
    ratbqo also includes the upward longwave flux (be careful in coupled mode).

foroutp :

Goal of the routine:
Initialization and definition of the model variable attributes used for multi-variables post-treatment and output.

Authors(s):
J.-M. Campin, H. Goosse, P.-P. Mathieu

Reference(s):
None

Called by :
clio

Call :
None

Arguments:
irn,jrn : index of the 8 neighbouring points (output)

Major inputs:
None

Major outputs:
The model variable attributes, that are: the short title, the location on the grid, the position index ("krl1") in the common, the relative size (=3rd dim), the variable status ("nvrl")

Structure:
Initialization of the model variable attributes
Definition, for each variable, of the short title, of the location on the grid, of the position index in the common, of the relative size, that is the 3rd dimension in case of 3.D variable, 1 in case of a single 2.D variable and of the number of 2.D variables stored in the same array
Definiton of the index of the 8 neighbouring points in the horizontal plane

Remarks:
A specific number (defined in the included file "datadc.com") corresponds to each variable and is used for multi-variables processing and output.

Recent modifications:

gather :

Goal of the routine:

Putting the elements of an array (any dimension) into a 1-D array keeping tracks of the correspondence.

Authors(s):

?

Reference(s):

None

Called by :

thersf

Call :

None

Arguments:

n	number of point of the original array to put in the new 1-D array
a	1-D array obtained after the transformation
b	original array
index	table of correspondence between a and b

Major inputs:

Arguments n,b, index

Major outputs:

Argument a

Structure:

Putting of the right elements of b into a

Remarks:

Scater makes the opposite job

Recent modifications:

icdadv :

Goal of the routine:

Managing horizontal ice advection and horizontal ice diffusion.

Authors(s):

H. Goosse, M.A. Morales Maqueda

Reference(s):

None

Called by :

clio

Call :

advx
advy
diffus

Arguments:

xjour	day of the year (used for alternating the first direction of advection)

Major inputs:

Ice velocities, ice and snow thickness, ice concentartion, heat content

Major outputs:

New ice and snow thicknesses, ice concentartion, heat content modified as a result of advection and horizontal diffusion

Structure:

Computation of the velocities as needed for advection
Storage of the different variables in a transfer array
Advection of the different variables
Diffusion
Reconstruction of the original variables

Remarks:

Recent modifications:

Addition of the age of the ice as an advected variable
Slip or no slip boundary condition for advection

icdyna :

Goal of the routine:
    Computing the ice velocities.

Authors(s):
    H. Goosse, M.A. Morales Maqueda

Reference(s):
    None

Called by :
    clio

Call :
    dynami

Arguments:
    None

Major inputs:
    Ice and snow thickness, ice concentration, ocean surface velocity, wind stress

Major outputs:
    Ice velocity, stress at the ocean surface

Structure:
    Initialisation
    Call of the dynamic routine
    Computing the stress at the ocean surface
    Treating the case if no ice dynamic

Remarks:
    icdyna also computes the freezing point temperature of the ocean which includes a square root of the salinity. As a consequence, if the salinity becomes negative, an error appears there,even if the origin is not in this routine.

Recent modifications:
    The computation of the CFC fluxes has been transferred to cfc_flux.

informe :

Goal of the routine:

Preparation of the file evolu for the output of the temporal evolution of key variables

Author(s):

J.-M. Campin, H. Goosse

Reference(s):

None

Called by :

clio

Call :

none

Arguments:

nn99	parameter used for the outputs in the file "mouchard" of some diagnostics used to verify if the run performs correctly.

Major inputs:

The major variables of the model

Major outputs:

Some variables needed latter on in inforun such as the vlosume of the ocean at each levels .

Structure:

Initialisation of the titles and writing of the header of evolu

Computation of various oceanic volumes or surfaces needed later on in inforun

Remarks:

Recent modifications:

In CLIO2.1, informe and inforun was only one routine.

Some variables have been added

inforun :

Goal of the routine:
Output on file evolu the temporal evolution of some key variables

Author(s):
J.M. Campin, H. Goosse

Reference(s):
None

Called by :
clio

Call :
raccord

Arguments:

nn99	parameter used for the outputs in the file "mouchard" of some diagnostics used to verify if the run performs correctly.

Major inputs:
The major variables of the model

Major outputs:
Some key variables written on the file evolu

Structure:
Computation of the various variables for the output
Writing of those variables on the file

Remarks:

Recent modifications:
In CLIO2.1, informe and inforun was only one routine.
Some variables have been added
A new option has been introduced allowing to give instantaneous values or averaged over the period between two outputs.

ocesla:

Goal of the routine:
	Simulation of a slab ocean of fixed depth.

Author(s):
	H. Goosse

Reference(s):
	None

Called by :
	clio

Call :
	None

Arguments:
	None

Major inputs:
	Heat and freshwater fluxes, ocean surface temperature and salinity

Major outputs:
	Updated ocean surface temperature and salinity

Structure:
	Modification of the temperature and salinity as a function of the flux.

Remarks:
	This routine is only used for debugging.

Recent modifications:

outave :

Goal of the routine:

Creating monthly or annual averages and managing the ouputs

Author(s):

H. Goosse, M.A. Morales Maqueda

Reference(s):

None

Called by :

clio

Call :

None

Arguments:

ja	corresponding year reached by the simulation
xjour	day of the year

Major inputs:

All the variables that needs to be written on a file

Major outputs:

Output files : cresum.dat, cresua.dat, cresujl.dat, cresal.dat

Structure:

Initialization and opening of the files
Reading of ouput.param
Writing dayly local ouputs
Computing and writing monthly means
Computing and writing annual means
Computing and writing monthly means avergaed over the whole run

Remarks:

Recent modifications:

Even if the goal of the routine has not changed between CLIO2.1 and CLIO3.0, the structure of the computation and of the outputs has been completely modified. It is now possible to choose the variables which are outputted (output.param), to obtain, monthly means averaged over the whole run, or to use a time step different to one day.

raccord :

Goal of the routine:

Performing the cyclic correspondence.

Author(s):

J.-M. Campin

Reference(s):

None

Called by :

advx, advy, alphdec, etat, informe, scale, staocb, thersf, uvb0et, uvbfet, uvm, vdiffu

Call :

None

Arguments:

var	variables for which the correspondence is needed
spv	special value
krac	number of level on which the correspondence has to be performed
ltyp	type of variables (scalar point, vector point,...)

Major inputs:

Arguments var, spv, krac, ltyp

Major outputs:

Argument var

Structure:

Making the correspondence on the E/W boundaries
Making the correspondence at Bering Strait

Remarks:

Recent modifications:

redrunb :

Goal of the routine:

Reading a restart file written in binary format.

Authors(s):

J.-M. Campin, H. Goosse, P.-P. Mathieu

Reference(s):

None

Called by :

clio

Call :

redtab

Arguments:

nnt define the form of the file to read :

nnt/2=0 corresponds to a binary file produced by the actual version of CLIO.

nnt/2= 1,2,3,4 read a file produced by an old version (before May 1996)

nn99 if nn99=2 then write some feedback informations on file "mouchard"

ccfile name of the file to read

Major inputs:

Read the file “ccfile” (="rest.om" in most cases)

Major outputs:

Fill in commons with the main variables that define the state of the ocean sea-ice model at one time step

Structure:

Opening the file `ccfile'

Reading old form of file results according to nnt and return

- or -

Reading the header of the file (iteration No, simulated time, experiment title, the number of variable arrays stored in the file)

For each variable, reading the variable number, the relative size of the array (3rd dim) and the short variable name (3 characters)

Reading the variable itself (call redtab).

Dealing with incomplete file, undefine variables (Warning)

Reading error case, early end of file occurrence (stop).

Preventing velocity misfit when the bathymetry has been changed.

Remarks:

A specific number corresponds to each variable and is defined in the included file "datadc.com".

Recent modifications:

scater :

Goal of the routine:

Transfering the elements of a 1-D array into another array (any dimension) as a function of a particular correspondence table.

Authors(s):

Th. Fichefet

Reference(s):

None

Called by :

thersf

Call :

None

Arguments:

n	number of point of the 1-D array
a	array obtained after the transformation
index	table of correspondence between a and b
b	original array

Major inputs:

Arguments n,b, index

Major outputs:

Argument a

Structure:

Puting the right elements of b into a

Remarks:

gather makes the opposite job

Recent modifications:

savrunb :

Goal of the routine:

Writing all model results (of 1 time step) in a binary file, for both restart or post-processing analyses.

Authors(s):

J.-M. Campin, H. Goosse, P.-P. Mathieu

Reference(s):

None

Called by :

clio

Call :

savtab

Arguments:

nnt integer flag : nnt=2 (or >2) reset cumulative array to zero.
nnt/2=1 corresponds to a binary file produced by the actual version
nn99 if nn99=2 then write some feedback informations on file "mouchard"
ccfile name of the file to write

Major inputs:

The main variables (stored in commons) that define the state of the ocean sea-ice model at one time step.

Major outputs:

The binary file `ccfile' (="res[].om" in most cases)

Structure:

Opening the file `ccfile'
Writing the header of the file (iteration No, simulated time, experiment title, the number of variable arrays stored in the file)
For each variable, writing the associated variable number, the relative size of the array (3rd dim) and the short variable name (3 characters);
Writing the variable itself (call savtab)
Reset of the cumulative array (if nnt=2)
Dealing with I/O error or missing variables

Remarks:

A specific number corresponds to each variable and is defined in the included file "datadc.com".
The last file written has the number 0 (generally res0.om).

Recent modifications:

shine :

Goal of the routine:

Computation of the albedo of the snow-ice system as well as the one of the ocean

Authors(s):

M.A. Morales Maqueda, H. Goosse

Reference(s):

Shine & Hendersson-Sellers [1985]

Called by :

forcat

Call :

None

Arguments:

ih	hemisphere (1=North, 0=south)
zmue	cosine of the solar angle
tfsn	freezing point temperature of snow
tfsg	freezing point temperature of ice
ts	snow or ice surface temperature
hgbq	ice-thickness
hnbq	snow thickness
zalbp	ice-snow albedo for clear sky
zalcnp	ocean albedo for clear sky
zalb	ice-snow albedo for overcast sky
zalcn	ocean albedo for overcast sky

Major inputs:

Arguments ih, zmue, tfsn, ts, hgbq, hnbq

Major outputs:

Arguments zalbp, zalcnp, zalb, zalcn

Structure:

Computation of the albedo of snow or ice (choose the right one by a large number of tests)

Computation of the albedo of the ocean

Remarks:

Recent modifications:

staocb:

Goal of the routine:
	Starting a run from a binary file which contains only oceanic variables and then prescribing the ice cover

Authors(s):
	H. Goosse, J.-M.Campin, M.A. Morales Maqueda

Reference(s):
	None

Called by :
	clio

Call :
	raccord

Arguments:

nnt	help to determine which type of file has to be read
ccfile	file which contains the oceanic variables

Major inputs:
	arguments nnt, ccfilr

Major outputs:
	Initial conditions for the ocean and the ice

Structure:
	Reading the ocenic variables
	Reading parameters for sea ice initial conditions
	Determination of the sea ice initial conditions

Remarks:
	This routine does not work any more with the new type of restart files

Recent modifications:

staocc:

Goal of the routine:
Starting a run from a NCDF file which contains only oceanic variables and then prescribing the ice cover.

Authors(s):
H. Goosse, J.-M.Campin, M.A. Morales Maqueda

Reference(s):
None

Called by :
clio

Call :
raccord

Arguments:

nnt	help to determine which type of file has to be read
ccfile	file which contains the oceanic variables

Major inputs:
Arguments nnt, ccfilr

Major outputs:
Initial conditions for the ocean and the ice

Structure:
Reading the ocenic variables
Reading parameters for sea ice initial conditions
Definition of the sea ice initial conditions

Remarks:
This routine does not work any more with the new type of restart files

Recent modifications:

start :

Goal of the routine:
Starting a run form an (horizontally) homogenous ocean at rest.

Author(s):
J.M. Campin, H. Goosse

Reference(s):
None

Called by :
clio

Call :
None

Arguments:
None

Major inputs:
Initial value of temperature and salinity as a function of depth (1-D field)

Major outputs:
3-D field of temperature, salinity, velocity as well as ice variables

Structure:
Initialisation of the scalars (mainly temperature and salinity)
Initialisation of the velocity at zero
Initialisation of all the ice variables (no ice)

Remarks:

Recent modifications:

thersf :

Goal of the routine:

Managing the ice thermodynamicc and computes the mass and heat fluxes to the ocean.

Authors(s):

H. Goosse, M.A. Morales Maqueda

Reference(s):

None

Called by :

clio

Call :

gather
scater
fontbc
acrlbq
raccord

Arguments:

ntrmax number of iterations of the ice thermodynamics corresponding to one iteration of the scalars at ocean surface.

Major inputs:

Ice and snow thicknesses, ice concentration, atmospheric forcing, ocean surface temperature

Major outputs:

New ice and snow thicknesses, ice concentration, heat and mass fluxes at the ocean surface

Structure:

Initialisation
Some preliminary computation (oceanic heat flux at the ice base, snow Accumulation, heat budget of the lead)
Selection of the icy points and put them in an array (see gather)
Call of the ice thermodynamic routine and back to the geographic grid
Selection of the points with lateral accretion
Call of acrlbq and back to the geographic grid
Computation the flux at the ice ocean interface

Remarks:

Recent modifications:

Optimisation
Correction for time step different than zero
Computation of the age of the ice

Modification of the absorption of solar energy below leads
Upward longwave radiation over the ocean included in ratbqo (be careful for coupling)
Separation of salt and freshwater fluxes

vdiffu :

Goal of the routine:

Computation of the vertical diffusivity and viscosity using the method of Pacanowski and Philander (1981).

Author(s):

J.M. Campin

Reference(s):

Pacanowski and Philander (1981), Campin (1997)

Called by :

clio

Call :

Arguments:

nn99 not used

Major inputs:

Brunt Vaisala frequency
horizontal velocity

Major outputs:

Diffusivity and viscosity (divided by dz)

Structure:

Initialisation of some variables
Computation of the Richardson number at velocity points
Computation of the Richardson number at scalar points
Computation of vertical viscosity
Computation of vertical diffusivity
Vertical diffusion in the deep ocean as a function of the Brunt Vaisala frequency
Convective adjustment by increasing the vertical diffusion

Remarks:

Less elaborate than engtur-diftur which make the same job but it is the only version that can be used without ice or in case of coarse vertical resolution

Recent modifications:

Different treatment of the vertical diffusion in the deep ocean as a function of the Brunt Vaisala frequency dynami.param: file of parameters used in the ice dynamics

Example :

```
c
c           *********************
c           Parameters ice dynamic
c           *********************
c
c           idyn, Switch for ice dynamics (1) or not (0)
    1
c           zepsd1,  First tolerance parameter
    1.0e-08
c           zepsd2,  Second tolerance parameter
    1.0e-20
c           nlminn,  Northern minimum index for ice drift
    38
c           nlmaxs,  Southern minimum index for ice drift
    15
c           usdt,   Inverse of the time step (=0.0 no acceleration)
    1.1574074e-5
c           alpha,  Coefficient for semi-implicit coriolis
    0.5
c           bound,  Boundary conditions (=0.0 no-slip, =1.0 free-slip)
    0.5
c           dm,     Diffusion constant for dynamics.
    0.6e+03
c           nbitdf, number of iterations for free drift
    100
c           nbiter, Number of sub-time steps for relaxation
    1
c           nbitdr, Max. number of iterations for relaxation
    250
c           om,     Relaxation constant
    0.5
c           resl,   Maximum value for the residual of relaxation
    5.0e-05
c           cw,     Drag coefficient for oceanic stress
    5.0e-03
c           angvg   Turning angle for oceanic stress
    0.0
c           pstar,  First bulk-rheology parameter
    1.5e+04
c           c,      Second bulk-rhelogy parameter
    20.0
c           zetamn, Minimun value for viscosity
    0.0e+07
c           creepl, Creep limit
    2.0e-08
c           ecc,    Eccentricity of the elliptical yield curve
```

```
     2.0
c           uvdif,  Diffusion velocity for scalars
     0.05
c           ren,    Reynolds number for the grid
     10.0
c           gridsz, Grid size for diffusion constant.
     1.5e+05
c           iameth, Method for advection (1=Modified Euler; 2=Prather)
     2
```

run.param: major parameters of the run

Example :

```
cl3std
#   ^- refexp (sio1)
1PE13.5 | 4 |p   89   41   14
#   ^- format fmtinf (8c),1X, nfrinf (I3),1X (,A1,icheck,jcheck,kcheck)
c---5----|----5----|----5----|----5----|----5----|----5----|----5----|72--5----|
fichier de parametres pour le modele : (modif 08/11/95)  kmax =< 20
c---5----|----5----|----5----|----5----|----5----|----5----|----5----|72--5----|
#      kfond(>0 =>fond plat), lstab(=>Aj.Conv), nsewfr, bering, ajcmix, xslop
-3      -0      4       0.5     0.0     1.0
#      T initiale : scal0(k,1)
18. 17.8 17.6 16.9 16.2 15.2 14. 13. 11.4 10. 8.3 6.5 4.9 3.5 2.6 2. 1.7 1.5 1.3 1.3
#      S initiale : scal0(k,2)
34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7 34.7
34.7 34.7 34.7
#      Rappel : 1/cts (yr), Coef Explic.T,S, Mur N,S : unstyr(=1/12mois),coef0
1.     6.     0.     0.     0.     0.     0.     0
#      Rappel : Coef Implic. : coef(k)
0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
#      delta t : scalaire, vitesse, barot. : dts, dtu, dtb (= 24 h, 3h, 5mn)
86400.          10800.          300.
#      dts : coef(k)
1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
#      Nb-iterat., Nb-sous-iter., Debut Moy. apres : nitrun, nsplit, nsplaj
365    46     25
#      Nb iter in mode barocline, Debut Moy. apres : nclin, nclmoy
1      7
#      Kind-of : Start, Read/Write-File : kstart, kinput, koutpu
1      0      0
#      frequence d'ecriture resultats : nsav, ninfo, ntmoy
365    10     1
#      Outputs parameter : nwjl, nwm, nwa
1      1      1
#      Switch for frequency of outputs : nwtest, nwtal
       0        1
#      Bottom drag coefficient: cdbot
       1.5E-3
#      diffusivite H. scal., qqt-mvt, eta : (ahs), ahu, ahe
50.    1.E5    150.
#      coef diffu H scal : * coef(k)
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
#      Visc. Vert. (Pac.&Phil.) :  avnub, avnu0, rifumx
1.E-4   1.E-2   1.
#      Diff.(Pac.&Phil.+simpl.) :  avkb,  avk0,  rifsmx
1.E-5   1.E-2   1.
#      coef(k)*avnub
20. 10. 5. 5. 5. 5. 5. 3. 3. 3. 1. 1. 1. 1. 1. 1. 1. 1. 1. 10.
```

```
#      coef(k)*avnu0
10. 10. 5. 3. 1. 1. 1. .5 .3 .1  0. 0. 0. 0. 0. 0. 0. 0. 0. 0.E-6
#      coef(k)*avkb
1. 1. .5 .5 .5 .5 .5 .5 .5 .6 .8  1.0 1.2 1.4 2.3 8.4 10.5 10.8 11. 2.
#      coef(k)*avk0
10.  5.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  50.
#      taux decentr.H. vitesse : alphxu,alphxv,alphyu,alphyv
0.     0.     0.     0.
#      taux decentr.H. Scalaires : alphah(2), alphgr(ns), algrmn(ns)
.0     .0     -0.1    -0.3    0.1     0.02
#      Dec.H.: alphmi(k)
.05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05
#      Dec.V.: alphaz(k)
.0 .0 .0  .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0  1.0
#      Parametres Avs(N2) : kavsmx, qavs, avsn2, ccfmn, ccfmx
0      -0.7    3.47E-9 2.E-6   3.E-4
#      taux implicit.V., flux Expl. : txiadu, txiads, txidfu, txidfs, txeflx
1.     1.     1.     1.     0.     0.
#      MoDif. FORCage & fichier-de-modifs : mdforc, filcor
0       |forc.corr
#      Type de forcage, coef.*Flux(ns) : kforc, yforc(ns)
0      0.     0.     0.
#      FRESHWATER FLUX , scal(ns) pour les precipitations (=spvr -> locale)
-100.   0.
#      valeurs de reference pour scal(ns)
290.   34.7
#      Variables liee a la turbulence q2tmin,lotur,vlmin,varfor,kajul
1.E-10  25.    1.E-3  0.0     14
#      ISOPYCNAL DIFFUSION , ai,slopemax
300.  0.01
#      coef diffu isopycnale scal : * coef8(k)
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
#      coef ponderation slopemax  : * coef9(k)
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
#      GM90 PARAMETERIZATION , aitd,slopmgm,afilt,ahh,av
200.   1    0. 0. 0.
#      coef diffu thickness scal : * coef10(k)
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
#      slopemgm, slopc,slopd,refcur,Radmn,Radmx, domdds, ddslop, ddrati
0.01 .004 .001  2. 1.5e4 1.0e5 4. .0 .02  1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
 c---5----|----5----|----5----|----5----|----5----|----5----|----5----|72--5----|
```

<u>Signification of the variables.</u> Some complementary information is given in defcst.f

refexp Name of the experiment
fmtinf Format of the outputs in evolu
nfrinf Also used in the output format for evolu
icheck,jcheck,kcheck Particular point to check some variables (integer)
kfond   Type of bottom (see defgrid.f) (integer)
(also controls writing on file "mouchard")

lstab   Type of convective adjustment (see etat.f) (integer)
nsewfr Frequency for switching between beginning by Nort-South or
West-Est advection (integer)
bering Parameter used to compute of the Bering Strait throughflow
(real between 0 and 1)
ajcmix Parameter used if lstab=-3 (reel between 0 and 1)
gibr   Parameter used to compute of the transport at Gibraltar (not used)
reel between 0 and 1
scal0(k,1) Initial value for temperature if beginning from an ocean at rest
(in celcius)
scal0(k,2) Initial value for salinity if beginning from an ocean at rest
(psu)
Parameter associated with the restoring:
unstyr   restoring intensity (affects all the other restoring param.), in yr-1
rapp0(k) restoring intensity factor (no unit) : Northern Wall, Southern
Wall (for all scalar) and at the surface (for each scalar)
ahrap   Parameter used if the model is forced as proposed by Rahmstorf
nitrap   Parameter used if the model is forced as proposed by Rahmstorf
coef(k) Explicit restoring, identical for all the scalars (years)
dts   Time step for scalars (seconds)
dtu   Time step for the baroclinic mode (seconds)
dtb   Time step for the barotropic mode (seconds)
coef(k) Coefficient which multiply dts at each level to reach the equilibrium
faster
icoupl   Model coupled (1) or not (0)
icoutp   Coupling whith which model
itau_slow fast or slow coupling (no more used)
nitrun   Number of (main) iterations of the model (integer)
(-> length of the run)
nsplit   Number of sub-iteration on the barotropic mode (integer)
nsplaj   Averaging in the barotropic mode after nsplaj iterations (integer)
nclin   Number of sub-iterations, baroclinic mode (integer)
(for each model iteration)
nclmoy   Averaging in the baroclinic mode after nclmoy iterations (not used)
kstart   Type of start of the ocean model (integer)
kinput   Type of input (integer)
koutpu   Type of output needed (integer)
nsav   Writing restart file every nsav iteration (integer)
ninfo   Writing of information in evolu every ninfo iterations (integer)
ntmoy   aveeage over ninfo (1 or 2) or instantaneous value (0)
nwjl   frequency of output of local daily values (year)
nwm   frequency of output of monthly means (year)
nwa   frequency of output of annual means (year)
nwtest   Test for the outputs
mwtal   Writing monthly mean over the whole period (1) or not(0)
cdbot   bottom drag coefficient
ahs   horizontal diffusivity for scalars (m^2/s)
ahu   horizontal viscosity (m^2/s)
ahe   horizontal diffusivity for the elevation (m^2/s)
coef(k) Coefficient which multiplies ahs in each level
avnub, avnu0, rifumx Parameters used for the computation of the viscosity

as proposed by Pacanowsski and Philander
avkb, avk0, rifsmx Parameters used for the computation of the diffusivity
as proposed by Pacanowsski and Philander
Next 4 lines of coefficients :
Coefficeint which multiplies the values of the parameters in the parameterization of Pacanowsski and Philander at each level
alphxu,alphxv,alphyu,alphyv : upwinding rate for the velocity u and v in directions x and y (advection scheme)
alphah used to compute the upwind rate of horizontal advection of scalar (no unit)
alphgr used to compute the upwind rate of horizontal advection of scalar (no unit)
algrmn typical small scalar difference between 2 grid box (scalar unit)
alphmi minimum of the upwinding rate for horizontal advection of scalar
alphaz minimum of the upwinding rate for vertical advection of scalar
kavsmx, qavs, avsn2, ccfmn, ccfmx : parameters used (if kavsmx > 0) to compute vertical diffusion as a function of N2 (Brunt Vaisala Freq.).
kforc forcing type (integer) (mainly used for time-independent forcing)
yforc forcing factor applied to time-independent surface flux
scpme(ns) value of the scalar in the precipitations (-100 correponds to the sea surface value)
scssv(ns) reference sea suerface value for the scalars
q2tmin Minimum of the turbulent kinetic energy
lotur Maximum of the mixing length
vlmin Minimum of the mixing length
varfor Multiplication of the wind energy to take into account variability of the forcing
kajul Level above which the above mentionned increase is applied
ai isopycnal diffusion (m^2/s)
slopemax Maximum of the slope used in the isopycnal diffusion
coef8 Variation of ai along the vertical
coef9 Variation of slopemax along the vertical
aitd G-M diffusion coeficient
slopmgm,afilt,ahh,av : Parameters for the G-M Parameterization
coef10 Variation of aitd along the vertical
slopemgm Maximum slope taken into account in G-M velocity computation
slopc critical slope used in F1 limiter function (refer as Sc in Large et al)
slopd typical slope scaling factor used in F1 : define the interval (around Sc) where F1 strongly varies (refer as Sd in Large et al)
refcur 1rst baroclinic wave speed (m/s) used in F2 (refer as "c" in Large et al)
Radmn Rossby Radius minimum value (m) used in F2 (see Large et al)
Radmx Rossby Radius maximum value (m) used in F2 (see Large et al)
domdds define the discretization domain of F1(slope) function : Sc-Sd*domdds, Sc+Sd*domdds]
ddslop ddslop*Sd = step for discretization of function F1(slope) (if 0 => No F1 limiter)
ddrati step for discretization of function F2(r) (r=ratio=z/R*slope, as in Large et al) (if 0 => No F2 limiter)
coef11 read but not used

NB: In place of refcur, Radmn and Radmx, the CLIO 3.0 manual refers to the explicit numerical values commonly used, that are 2 m/s, 15 km, 100 km respectively (as in Large et al).

thermo.param: file of parameters used in the ice thermodynamics

Example :

```
c           ****************************************
c           Parameters for thermodynamic computation
c           ****************************************
c
c           hmelt, Maximum melting at the bottom
    -0.15
c           acrit(1), Minimum fraction for leads in the NH
    1.0e-06
c           acrit(2), Minimum fraction for leads in the SH
    1.0e-06
c           hgcrit(1), Ice thickness for lateral accretion in the NH
    0.3
c           hgcrit(2), Ice thickness for lateral accretion in the SH
    0.3
c           hgmin, Ice thickness corr. to max. energy stored in brine pocket
    0.2
c           hndif, Computation of temp. in snow (=0.0) or not (=9999.0)
    0.0     9999.0
c           hgdif, Computation of temp. in ice (=0.0) or not (=9999.0)
    0.0    9999.0
c           hglim, Minimum ice thickness
    0.05
c           amax, Maximum lead fraction
    0.999   0.85
c           swiqst, Energy stored in brine pocket (=1) or not (=0)
    1
c           beta, Numerical caracteritic of the scheme for diffusion in ice
c               Cranck-Nicholson (=0.5), implicit (=1), explicit (=0)
    1
c           ddtb, Time step in thermodynamic calculation
    17280.00   86400.00
c           nbits, Number of time steps in Newton -Raphson procedure
    6
c           parlat, Percentage of energy used for lateral ablation
    0.0
c           hakspl, Slope of distr. for Hakkinen-Mellor's lateral melting
    0.5
c           hibspl, Slope of distribution for Hibler's lateral melting
    0.5
c           exld, Exponent for leads-closure rate
    2.0
c           hakdif, Coefficient for diffusions of ice and snow
    1.0
c           hth, Threshold thickness for comp. of eq. thermal conductivity
    0.2
c           hnzst, Thickness of the surf. layer in temp. computation
```

0.1
c parsub, Switch for snow sublimation or not
1.0
c alphs, Coefficient for snow density when snow ice formation
1.0 1.1236363636

Titles in evolu. Some complementary information is given in inforun.f

NoIt	Number of the iteration
T yr	Time of the output (in years)
EgAjC	Energy dissipated by convective adjustment
V_AjC	Volume of the ocean involve in convective adjustment (%)
D.Eta	Time derivative of the sea surface elevation
M.Eta	Mean sea surface elevation (m)
DrHSF	Transport through the Drake passage (Sv)
InHSF	Transport through the Indonesian Passage (Sv)
BeHSF	Transport through the Bering Strait (Sv)
FLOS	Transport through the Florida Strait (Sv)
DANS	Transport through the Danemark Strait towards the South (Sv)
DANN	Transport through the Danemark Strait towards the North (Sv)
ISCS	Transport between Iceland and Norway towards the South (Sv)
ISCN	Transport between Iceland and Norway towards the North (Sv)
FRAS	Transport through the Fram Strait towards the South (Sv)
FRAN	Transport through the Fram Strait towards the North (Sv)
PNWS	Transport through the Canadian Archipelago towards the South (Sv)
PNWN	Transport through the Canadian Archipelago towards the North (Sv)
ADGIN	NADW exported southward in the Atlantic at 20°S (Sv)
ADPro Atlantic	Maximum of the meridional overturning streamfunction in the North (Sv)
ADOut (Sv)	Maximum of the meridional overturning streamfunction in the GIN seas
AABpr	Maximum of the meridional overturning streamfunction in the Southern Ocean (Sv)
AABex	Maximum of the meridional overturning streamfunction in the bottom cell (Sv)
AABat	AABW exported northward in the Atlantic at 20°S (Sv)
Fc30A	Meridional heat flux in the ocean at 30°S (PW)
DowSo	Downsloping flow out of Antarctic shelf (Sv)
DowNo	Downsloping flow out of Arctic shelf (Sv)
T-c	Mean ocean temperature (°C)
T1-o	Difference of sea surface temeperature between model and observation (°C)
|T-o|	Mean error on the temperature
S-30	Mean ocean salinity (psu -30)
S1-o	Difference of sea surface salinity between model and observation (°C)
|S-o|	Mean error on the salinity (psu)
|w|	Mean oceanic vertical velocity (m/s)
|u|	Mean oceanic horizontal velocity (direction X) (m/s)
|v|	Mean oceanic horizontal velocity (direction Y) (m/s)
K.E	Kinetic enrgy (m^2/s^2)
T-o 1 ->T-o N	Mean error on the temeprature at every level (°C)
S-o 1- >S-o N	Mean error on the salinity at every level (psu)
AIEFN	Sea ice area in the Northern Hemisphere (10^{12} km^2)
AIEFS	Sea ice area in the Southern Hemisphere (10^{12} km^2)
A15N	Sea ice extent (15%) in the Northern Hemisphere (10^{12} km^2)
A15S	Sea ice extent (15%) in the Southern Hemisphere (10^{12} km^2)
A85N	Sea ice extent (85%) in the Northern Hemisphere (10^{12} km^2)
A85S	Sea ice extent (85%) in the Southern Hemisphere (10^{12} km^2)

ALEN	Leads area in the Northern Hemisphere (10^{12} km^2)
ALES	Leads area in the Southern Hemisphere (10^{12} km^2)
VOLN	Sea ice volume in the Northern Hemisphere (10^3 km^3)
VOLS	Sea ice volume in the Southern Hemisphere (10^3 km^3)
VONN	Snow volume over sea ice in the Northern Hemisphere (10^3 km^3)
VONS	Snow volume over sea ice in the Southern Hemisphere (10^3 km^3)
ECGN	Mean sea ice velocity in the Northern Hemisphere (m/s)
ECGS	Mean sea ice velocity in the Southern Hemisphere (m/s)
FRAG	Sea ice transport through Fram Strait (Sv)
SPNG	Sea ice transport between Spitzbergen and Norway (Sv)
BERG	Sea ice transport trough Bering Strait (Sv)

References

Campin J.M. (1997). *Modélisation tridimensionnelle de la circulation générale océanique lors du dernier maximum glaciaire.* PhD Thesis, Université Catholique de Louvain, Louvain-la-Neuve, Belgium. 342pp

Campin J.M. and H. Goosse (1998). *A parameterization of density driven downsloping flow for coarse resolution model in z-coordinate.* Tellus 51A,412-430

Deleersnijder E., J.P. van Ypersele and J.M. Campin (1993) *An orthogonal curvilinear coordinate system for a World Ocean model.* Ocean Modell. **100**, 7-10 (+figures)

Deleersnijder E. and J.M. Campin (1995). *On the computation of the barotropic mode of a free-surface world ocean model.* Ann. Geophys. **13**, 675-688

England M.H., V. Garçon and J.-F. Minster (1994). *Chlorofluorocarbon uptake in a World Ocean model 1. Sensitivity to the surface gas forcing*. J. Geophys. Res. **99**(C12), 25215-25233

Fichefet T. and P. Gaspar (1988). *A model study of upper ocean-sea ice interactions*. J. Phys. Oceanogr. **18**, 181-195

Fichefet T. and M. A. Morales Maqueda (1997). *Sensitivity of a global sea ice model to the treatment of ice thermodynamics and dynamics*. J. Geophys. Res. **102**(C6), 12609-12646

Fichefet T. and M. A. Morales Maqueda (1999). *Modelling the influence of snow accumulation and snow-ice formation on the seasonal cycle of the Antarctic sea-ice cover*. Clim. Dyn. **15**, 251-268

Gent P.R. and J.C. McWilliams (1990). Isopycnal mixing in ocean general circulation models. J. Phys. Oceanogr. 20, 150-155

Goosse H., J.-M. Campin, T. Fichefet and E. Deleersnijder (1997a). Sensitivity of a global ice-ocean model to the Bering Strait throughflow. Clim. Dyn. 13, 349-358

Goosse, H., E. Deleersnijder, T. Fichefet and M.H. England (1998). *Sensitivity of a global coupled ocean-sea ice model to the parameterization of vertical mixing.* J. Geophys. Res. 104(C6), 13,681-13,695

Hibler W.D. (1979). *A dynamic thermodynamic sea ice model.* J. Phys. Oceanogr. **9**, 815-846

Pacanowski R.C. and S.G.H. Philander (1981). *Parameterization of vertical mixing in numerical models of tropical oceans.* J. Phys. Oceanogr. **11**, 1443-1451

Prather M.C. (1986). *Numerical advection by conservation of second-order moments.* J. Geophys. Res. **91**(D6), 6671-6681

Shine K.P. and A. Henderson-Sellers (1985). The sensitivity of a thermodynamic sea ice model to changes in surface albedo paramerization. J. Geophys. Res. **90**(D1), 2243-2250