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The University of Manchester

Introduction to *Code_Saturne*

Working with subroutines

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- Different modules require different subroutines.
- For full description of subroutines see the user's guide.

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- usts??.f90 : Source terms for each computed variable, including scalars (e.g. ΔP).

Structure

Subroutines start with the list of arguments passed from the calling routine.

```
subroutine usclim &
!================

 ( idbia0 , idbra0 ,                                                  &
   ndim   , ncelet , ncel   , nfac   , nfabor , nfml   , nprfml , &
   nnod   , lndfac , lndfbr , ncelbr ,                                &
   nvar   , nscal  , nphas  ,                                         &
   nideve , nrdeve , nituse , nrtuse ,                                &
   ifacel , ifabor , ifmfbr , ifmcel , iprfml , maxelt , lstelt , &
   ipnfac , nodfac , ipnfbr , nodfbr ,                                &
   icodcl , itrifb , itypfb ,                                         &
   idevel , ituser , ia     ,                                         &
   xyzcen , surfac , surfbo , cdgfac , cdgfbo , xyznod , volume , &
   dt     , rtp    , rtpa   , propce , propfa , propfb ,           &
   coefa  , coefb  , rcodcl ,                                         &
   w1     , w2     , w3     , w4     , w5     , w6     , coefu  , &
   rdevel , rtuser , ra     )
!===============================================================================
! Purpose:
! -------

!    User subroutine.

!    Fill boundary conditions arrays (icodcl, rcodcl) for unknown variables.
```

Structure

Then, a table with the explanation of the arguments is presented:

```
!-------------------------------------------------------------------------------
! Arguments
!------------------.----.-----.-----------------------------------------------.
! name              !type!mode ! role                                          !
!------------------!----!-----!-----------------------------------------------!
! idbia0            ! i  ! <-- ! number of first free position in ia           !
! idbra0            ! i  ! <-- ! number of first free position in ra           !
! ndim              ! i  ! <-- ! spatial dimension                             !
! ncelet            ! i  ! <-- ! number of extended (real + ghost) cells       !
! ncel              ! i  ! <-- ! number of cells                               !
! nfac              ! i  ! <-- ! number of interior faces                      !
! nfabor            ! i  ! <-- ! number of boundary faces                      !
! nfml              ! i  ! <-- ! number of families (group classes)            !
! nprfml            ! i  ! <-- ! number of properties per family (group class) !
! nnod              ! i  ! <-- ! number of vertices                            !
! lndfac            ! i  ! <-- ! size of nodfac indexed array                  !
! lndfbr            ! i  ! <-- ! size of nodfbr indexed array                  !
! ncelbr            ! i  ! <-- ! number of cells with faces on boundary        !
! nvar              ! i  ! <-- ! total number of variables                     !
! nscal             ! i  ! <-- ! total number of scalars                       !
! nphas             ! i  ! <-- ! number of phases                              !
! ifacel(2, nfac)   ! ia ! <-- ! interior faces -> cells connectivity          !
! ifabor(nfabor)    ! ia ! <-- ! boundary faces -> cells connectivity          !
! ifmfbr(nfabor)    ! ia ! <-- ! boundary face family numbers                  !
!------------------!----!-----!-----------------------------------------------!

!     Type: i (integer), r (real), s (string), a (array), l (logical),
!           and composite types (ex: ra real array)
!     mode: <-- input, --> output, <-> modifies data, --- work array
!===============================================================================
```

Structure

Common blocks and Arguments declarations:

```
  implicit none
!===============================================================================
! Common blocks
!===============================================================================
include "paramx.h"
include "pointe.h"
include "numvar.h"
include "optcal.h"
include "cstphy.h"
include "cstnum.h"
include "entsor.h"
include "parall.h"
include "period.h"
include "ihmpre.h"
!===============================================================================
! Arguments
integer          idbia0 , idbra0
integer          ndim   , ncelet , ncel   , nfac   , nfabor
integer          nfml   , nprfml
integer          nnod   , lndfac , lndfbr , ncelbr
integer          nvar   , nscal  , nphas
integer          nideve , nrdeve , nituse , nrtuse
integer          ifacel(2,nfac) , ifabor(nfabor)
integer          ifmfbr(nfabor) , ifmcel(ncelet)
integer          iprfml(nfml,nprfml), maxelt, lstelt(maxelt)
integer          ipnfac(nfac+1), nodfac(lndfac)
integer          ipnfbr(nfabor+1), nodfbr(lndfbr)
integer          icodcl(nfabor,nvar)
integer          itrifb(nfabor,nphas), itypfb(nfabor,nphas)
integer          idevel(nideve), ituser(nituse), ia(*)
```

Structure

Local variables and initialisation:

```
! Local variables

integer           idebia, idebra
integer           ifac, iel, ii, ivar, iphas
integer           ilelt, nlelt
double precision  uref2, d2s3
double precision  rhomoy, dh, ustar2
double precision  xintur
double precision  xkent, xeent

!===============================================================================


!===============================================================================
! 1.  Initialization
!===============================================================================

idebia = idbia0
idebra = idbra0

d2s3 = 2.d0/3.d0
```

Continue with the rest .....

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Important points to take into account:

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- If an input file is needed, place it in **DATA** and link it by editing the `runcase` file.
- To check potential compilation errors before running, use the command `code_saturne compile` inside the **SRC** directory.

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- `NPROFA, NPROFB`: Number of properties defined at the internal and at the boundary faces.

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Main Variables

Geometrical arrays (set by the preprocessor, not be changed by the user)

- `XYZCEN(NDIM,NCELET)`: Coordinates of the cell centres.
- `CDGFAC(NDIM,NFAC)`: Coordinates of the internal
- `CDGFBO(NDIM,NFABOR)`: Coordinates of the boundary faces.
- `SURFAC(NDIM,NFAC)`: Vector normal to the internal face whose length is the area of the face.
- `SURFBO(NDIM,NFABOR)`: Vector normal to the boundary face whose length is the area of the face.
- `VOLUME(NCELET)`: Volume of each cell.
- `IFACEL(2,NFAC)`: Connectivity between faces and cells. Contains cells at each side of the face.
- `IFABOR(NFABOR)`: Connectivity between faces and cells at the boundaries (only one cell per face).

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- `IPR(IPHAS)` : Pressure for phase IPHAS.
- `IU(IPHAS)` : Velocity in the X direction.
- `IV(IPHAS)` : Velocity in the Y direction.
- `IW(IPHAS)` : Velocity in the W direction.
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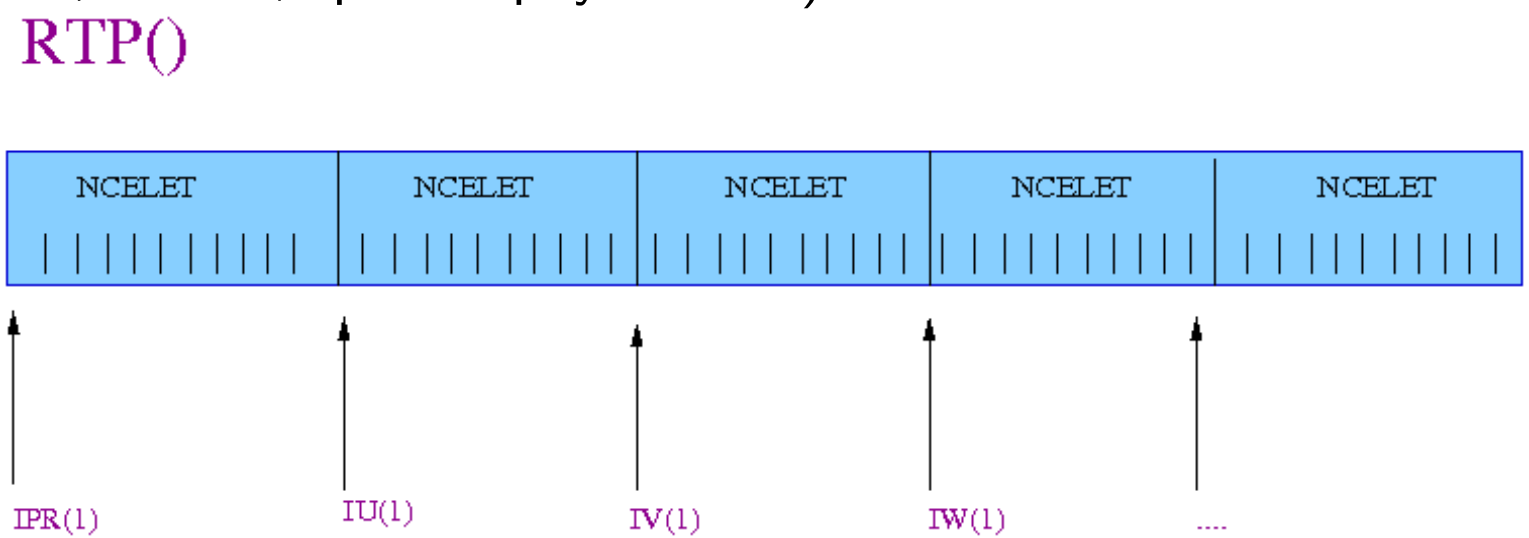

Physical properties

Physical properties are stored by default at the cell centres but some can be stored at the faces for some specific physics modules.

- `PROPCE(NCELET,NPROPCE)`: Properties at the cell centres.
- `PROPFA(NFAC,NPROPFA)`: Properties at the face centres.
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For example, to access the density ρ at a given cell index IEL use:

$\rho =$`PROPCE(IEL,IPPROC(IROM(IPHAS)))`

Memory management

All information is stored in two macro-arrays:

- `IA(LONG(IA))` : Integer array.
- `RA(LONG(RA))` : Real array.

In FORTRAN 77, memory cannot be dynamically allocated so the size of the arrays has to be determined before the calculation. They can be specified in the GUI or in usini1.f90. If they are set to zero, the code tries to estimate them based on the number of cells and variables. Each subroutine that allocates new memory checks if the size of IA and RA is large enough, if not, it stops with an error message.

Examples

Change the density ρ as a function of the temperature T.

$$\rho = T(aT + b) + c$$

```
      iphas = 1
      ivart = isca(iscalt(iphas))
      ipcrom = ipproc(irom(iphas))
!
      vara  = -4.0668d-3
      varb  = -5.0754d-2
      varc  =  1000.9d0
!
      do iel = 1, ncel
        xrtp = rtp(iel,ivart)
        propce(iel,ipcrom) = xrtp * (vara*xrtp+varb) + varc
      enddo
```

Physical properties (ρ, μ, C_p...) can be changed via the usphyv.f90 subroutine.

Examples

Initialize temperature T at the beginning of the calculation:

```
iphas = 1
ivart = isca(iscalt(iphas))
if (isuite.eq.0) then
  do iel = 1, ncel
    rtp(iel,ivart) = 25.d0
  enddo
endif
```

- ISUITE : Index for calculation restart. ($= 1$, restart.)

To initialize velocity as a cosine function:

```
iphas = 1
ivaru = iu(iphas)
xpi = 3.14159d0
A = 2.d0
if (isuite.eq.1) then
  do iel = 1, ncel
    rtp(iel,ivaru) = A*cos(2.d0*xpi*ttcabs)
  enddo
endif
```

- TTCABS : Current time (in seconds).