



emsaplib

April 16, 2023

Abstract

Library of routines developped for EPIC MOS tasks.

1 Instruments/Modes

Instrument	Mode
EPIC MOS	-

2 Description

This library contains 3 modules for F90 :

- `emutils_mod` (Sect 2.1)
- `edusoft_mod` (Sect 2.2)
- `badpixutils_mod` (Sect 2.3)

They are described in the following subsections.

It also contains the test directory `emodf` for the EPIC MOS routines, and the utilities `compare_columns` and `compare_realcols` used in test harnesses.

2.1 `emutils_mod` module

This module contains F90 routines and functions developped for the MOS tasks, but which are of general interest.

2.1.1 `addFilename`

Aim: Write history line with the name of an input file, removing the directory.



The routine declaration is:

```
subroutine addFilename(in_tab, filename, comment)

! in_tab      : handle to the output table
! filename    : name of the file
! comment     : comment string to introduce file name

type(BlockT), intent(in) :: in_tab
character(len=*), intent(in) :: filename, comment
```

2.1.2 changeCase

Aim: Switch from lower to upper case or vice-versa.

The routine declaration is:

```
function changeCase(instrstring,dir) result(outstring)

! instrstring : input string
! dir         : direction (1: to lower case; 2: to uppercase; 0: switch case)

character(len=*), intent(in) :: instrstring
integer, intent(in) :: dir
character(len=len(instrstring)) :: outstring
```

2.1.3 getCcd

Aim: Get the CCD value from the keywords (returns 0 if error).

The routine declaration is:

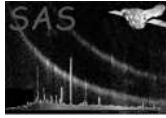
```
integer function getCcd(in_tab)

! in_tab : handle to the input block for the DAL

type(BlockT), intent(in) :: in_tab
```

2.1.4 getMode

Aim: Return logicals defining the data mode.



The routine declaration is:

```
subroutine getMode(ev_tab, imaging, timing, redImaging, compTiming)

! ev_tab:      handle to the events extension
! imaging:     set to True if IMAGING (EPIC) or SPECTROSCOPY (RGS) mode
! timing:      set to True if TIMING (EPIC) or HTR (RGS) mode
! redImaging:  set to True if REDUCED IMAGING (MOS) mode
! compTiming:  set to True if COMPRESSED TIMING (MOS) or BURST (PN) mode

type(TableT), intent(in) :: ev_tab
logical, intent(out)      :: imaging, timing, redImaging, compTiming
```

2.1.5 keywordDone

Aim: Write keyword stating that an action governed by a boolean parameter was performed.

The routine declaration is:

```
subroutine keywordDone(in_tab, taskname, paramname)

! in_tab:      handle to the table where the keyword will be written
! taskname:    name of the calling task
! paramname:   name of the boolean parameter

type(BlockT), intent(in) :: in_tab
character(len=*), intent(in) :: taskname, paramname
```

2.1.6 keywordRemove

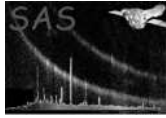
Aim: Remove a keyword written with keywordDone.

The routine declaration is:

```
subroutine keywordRemove(in_tab, paramname)

! in_tab:      handle to the table where the keyword will be set to 0
! paramname:   name of the boolean parameter

type(BlockT), intent(in) :: in_tab
character(len=*), intent(in) :: paramname
```



2.1.7 wasDone

Aim: Test using keywords whether an action governed by a boolean parameter was already performed.

The routine declaration is:

```
function wasDone(in_tab,paramname) result(done)

! in_tab:    handle to the table where to look for the keyword
! paramname: name of the boolean parameter

type(BlockT), intent(in) :: in_tab
character(len=*), intent(in) :: paramname
logical :: done
```

2.1.8 equalKeywords

Aim: Check that two files share a number of attributes.

The routine declaration is:

```
function equalKeywords(handle1,handle2,keywList,strict,onwarn) result(compat)

! handle1    : handle to the first table or set
! handle2    : handle to the second table or data set
! keywList   : array of keywords to test for compatibility
! strict     : set to true if need to check existence also (default is true)
! onwarn     : set to true if warnings are to be sent (default is true)
!           : if false then messages are sent instead

type(AttributableT), intent(in) :: handle1, handle2
character(len=*), dimension(:), intent(in) :: keywList
logical, intent(in), optional :: strict, onwarn
logical :: compat
```

2.1.9 putPrimaryKeywords

Aim: Copy general keywords from extension to primary header.

The routine declaration is:

```
subroutine putPrimaryKeywords(fr_tab)

! fr_tab    : Handle to the input block
```



```
type(BlockT), intent(in)    :: fr_tab

! Names of the keywords to be copied into the primary header from the extension

integer, parameter :: num_keyw_prim = 6
character(len=8), dimension(num_keyw_prim), parameter :: &
    name_keyw_prim = (/"TELESCOP","INSTRUME", "OBS_ID  ", "EXP_ID  ", &
        "DATE-OBS","DATE-END"/)
```

2.1.10 sizeListParam

Aim: Read the size of a parameter list.

The routine declaration is:

```
function sizeListParam( paramlist ) result( numlist )

! paramlist : name of the string list parameter
! numlist   : number of strings in list

character(len=*), intent(in)          :: paramlist
integer                               :: numlist
```

2.1.11 readListParam

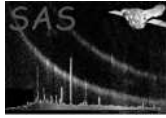
Aim: Read a parameter list (strings only).

The routine declaration is:

```
subroutine readListParam(paramlist,list,numlist)

! paramlist : name of the string list parameter
! list      : list of strings
! numlist   : number of strings in list

character(len=*), intent(in)          :: paramlist
character(len=*), dimension(:), intent(inout) :: list
integer, intent(in)                   :: numlist
```



2.2 edusoft_mod module

This module contains F90 declarations and routines used to interface the simulation of the Event Detection Unit (EDU) of the EPIC MOS camera. This simulation (EDUSOFT) is written in C and is here interfaced with F90.

2.2.1 declarations

Here are declarations of parameters and data structures used together with the EDUSOFT routines

- **es_nmax**: Maximum number of events that can be found in a frame by EDUSOFT.

Type and value :

```
integer, parameter :: es_nmax = 50000
```

- **edu_npat**: Number of EDU patterns.

Type and value :

```
integer, parameter :: edu_npat = 32
```

- **edu_nsid**: Side dimension of the square EDU patterns.

Type and value :

```
integer, parameter :: edu_nsid = 5
```

- **edu_pattern**: Data structure describing each EDU pattern.

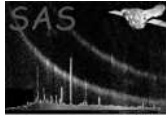
Type :

```
type edu_pattern
  integer          id_patt
  integer          id_mask
  integer(kind=int8) mat(edu_nsid,edu_nsid)
  integer(kind=int8) number
  integer(kind=int8) id_kind
end type edu_pattern
```

- **edu_evt**: Data structure describing an EDU event in output of EDUSOFT.

Type :

```
type edu_evt
  integer(kind=int16) x
  integer(kind=int16) y
  integer(kind=int16) pattern
  integer(kind=int16) e1
  integer(kind=int16) e2
  integer(kind=int16) e3
  integer(kind=int16) e4
  integer(kind=int16) peripix
end type edu_evt
```



- `edu_out`: Data structure containing the EDUSOFT output event list.

Type :

```
type edu_out
  integer          nevent
  type(edu_evt)    evt(es_nmax)
  integer          npix
  integer          fifoovf
end type edu_out
```

- `sas_evt`: Data structure describing an EDU event as used by the SAS. Type :

```
type sas_evt
  integer(kind=int8)  pattern
  integer(kind=int8)  peripix
  integer(kind=int16) rawx
  integer(kind=int16) rawy
  integer(kind=int32) frame
  integer(kind=int32) flag
  integer(kind=int16) e1
  integer(kind=int16) e2
  integer(kind=int16) e3
  integer(kind=int16) e4
end type sas_evt
```

2.2.2 getpixelInE2

Aim: Get the number of pixels making E2 for all patterns, return mask itself if required. CAL must be initialised beforehand.

The routine declaration is:

```
subroutine getpixelInE2(pixelInE2, patabove, npatterns)

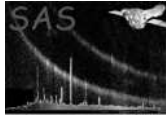
! pixelInE2: number of pixels in E2 for each pattern
! patabove : mask of E2 for each pattern
! npatterns: number of patterns

  integer(kind=int16), dimension(0:edu_npat-1), intent(out) :: pixelInE2
  integer(kind=int16), dimension(-1:1,-1:1,0:edu_npat-1), &
    intent(out), optional :: patabove
  integer,              intent(out), optional :: npatterns
```

2.2.3 inMask

Aim: Returns sum of offsets through mask.

The routine declaration is:



```
integer function inMask(offX, offY, patabove)

! offX, offY: local column and row offsets
! patabove : 1 means count, 0 means ignore (like output of getpixelInE2)

integer,          dimension(-1:1),      intent(in) :: offX, offY
integer(kind=int16), dimension(-1:1,-1:1), intent(in) :: patabove
```

2.2.4 projectEventsCounts

Aim: Project the pixels above threshold of an array of events onto an image.

The routine declaration is:

```
subroutine projectEventsCounts(evt, patabove, image)

! evt      : Array of event structure
! patabove : Geometry of event outside central pixel (from getpixelInE2)
! image    : Image upon which to project

type(sas_evt), dimension(:), intent(in) :: evt
integer(kind=int16), dimension(-1:1,-1:1,0:edu_npat-1), &
    intent(in)      :: patabove
integer(kind=int32), dimension(-2:,-2:), intent(inout) :: image
```

2.2.5 projectEventsEnergy

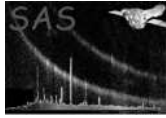
Aim: Project the energy of an array of events onto an image.

The routine declaration is:

```
subroutine projectEventsEnergy(evt, patabove, image)

! evt      : Array of event structure
! patabove : Geometry of event outside central pixel (from getpixelInE2)
! image    : Image upon which to project

type(sas_evt), dimension(:), intent(in) :: evt
integer(kind=int16), dimension(-1:1,-1:1,0:edu_npat-1), &
    intent(in)      :: patabove
integer(kind=int32), dimension(-2:,-2:), intent(inout) :: image
```



2.2.6 pat_init

Aim: Initialization of the pattern library for EDUSOFT.

The F90 calling sequence is:

```
! patterns : input argument. Pattern library read from the CAL by a call like
!           call CAL_getEventPatterns(patterns, eduThreshold)
integer(kind=int8), dimension(:, :, :), pointer :: patterns

! edupat: output argument. Pattern library as used by edusoft routine.
type(edu_pattern) :: edupat(edu_npat)

call pat_init(patterns, edupat)
```

2.2.7 edusoft

This is the EDUSOFT call.

The F90 calling sequence is:

```
! Input arguments :

integer :: edumode                                ! 0 diagnostic mode
                                                ! 1 timing mode
                                                ! 2 reduced imaging (threshold) mode
                                                ! 3 imaging mode

type(edu_pattern) :: edupat(edu_npat) ! initialized by pat_init().
integer(kind=int32) :: dx                ! x size of the input image.
integer(kind=int32) :: dy                ! y size of the input image.
integer(kind=int16), dimension(dx,dy) :: im ! input image.
integer(kind=int16) :: threshold         ! EDU threshold.

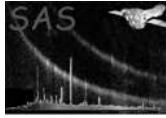
! x EDU offset (must contain at least x0+dx data).
integer(kind=int16), dimension(0:x0+dx-1) :: offX

! y EDU offset (must contain at least y0+dy data).
integer(kind=int16), dimension(0:y0+dy-1) :: offY

! x coordinate of the closest pixel to the output CCD node.
integer(kind=int32) :: x0

! y coordinate of the closest pixel to the output CCD node.
integer(kind=int32) :: y0

! es_nmax : Maximum number of events that can be found in a frame by EDUSOFT.
```



```
!           (See declaration subsection).

! Output argument :

! Data structure containing the EDUSOFT output event list.
type(edu_out)  :: eduout

call edusoft(edumode,edupat,dx,dy,im,threshold, &
             offX(0:x0+dx-1),offY(0:y0+dy-1),x0,y0,es_nmax,eduout)
```

2.3 badpixutils_mod module

This module contains F90 routines and functions developed for dealing with bad pixels, including generalist Poisson and correlation routines.

2.3.1 readBadpix

Aim: Read bad pixels table into an array.

The routine declaration is:

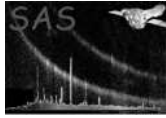
```
subroutine readBadpix(bad_tab, incremental, &
                    xbad, ybad, yext, tbad, fbad, nbad)

! bad_tab : Handle to the bad pixels table
! incremental : Should normally be set to True. If False, no bad pixel
!               is read (nbad is set to 0) and the bad pixels columns
!               (RAWX,RAWY,TYPE,YEXTENT,BADFLAG) are added to the bad_tab table
! xbad      : array of RAWX coordinates
! ybad      : array of RAWY coordinates
! yext      : array of RAWY extensions (YEXTENT)
! tbad      : array of bad pixel types (TYPE)
! fbad      : array of bad pixel status (BADFLAG: uplinked, CCF or new)
! nbad      : number of bad pixels
! Those arrays must be dimensioned (large enough) in the calling program.

type(TableT),          intent(in)  :: bad_tab
logical,               intent(in)  :: incremental
integer(kind=int16), dimension(:), intent(out) :: xbad, ybad, yext, &
                                                    tbad, fbad
integer,               intent(out) :: nbad
```

2.3.2 writeBadpix

Aim: Write bad pixels array into a table.



The routine declaration is:

```
subroutine writeBadpix(bad_tab, xbad, ybad, yext, tbad, fbad, nbad)

! bad_tab : Handle to the output bad pixels table
!          The columns should exist already
! xbad    : array of RAWX coordinates
! ybad    : array of RAWY coordinates
! yext    : array of RAWY extensions (YEXTENT)
! tbad    : array of bad pixel types (TYPE)
! fbad    : array of bad pixel status (BADFLAG: uplinked, CCF or new)
! nbad    : number of bad pixels

type(TableT),                                intent(in) :: bad_tab
integer(kind=int16), dimension(:), intent(in) :: xbad, ybad, yext, &
                                                    tbad, fbad
integer,                                           intent(in) :: nbad
```

2.3.3 mergeBad

Aim: Compute Y extent of bad pixels, remove redundancies. Column segments are built only for identical type and status. In case of redundancy, the lower status is kept (uplinked $\wedge$ CCF $\wedge$ new) and for the types the precedence is set as follows: HOT(1) $\wedge$ FLICKERING(2) $\wedge$ PIN_HOLE(4) $\wedge$ DEAD(3) $\wedge$ UNSPECIFIED(5) $\wedge$ INTACT(0)

The routine declaration is:

```
subroutine mergeBad(xbad, ybad, yext, tbad, fbad, nbad)

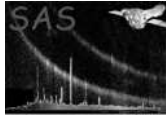
! xbad    : array of RAWX coordinates
! ybad    : array of RAWY coordinates
! yext    : array of RAWY extensions
! tbad    : array of bad pixel types
! fbad    : array of bad pixel status (uplinked, CCF or new)
! nbad    : number of bad pixels

integer(kind=int16), dimension(:), intent(inout) :: xbad, ybad, yext, &
                                                    tbad, fbad
integer,                                           intent(inout) :: nbad
```

2.3.4 readBadOffsets

Aim: Read bad offset values in SAS coordinates 1-600. Beware: contains under/overscans $\wedge$ 1 and $\wedge$ 600.

The routine declaration is:



```
subroutine readBadOffsets(ev_set, offX, offY, ccdnr)

! ev_set      : Handle to the data set where the OFFSETS extension is
! offX, offY  : additional offset values
! ccdnr       : CCD number as CCDNR column (if merged table)

      type(DataSetT),                intent(in)  :: ev_set
      integer, dimension(-10:EMOS_MAX_X+20), intent(out) :: offX
      integer, dimension(-10:EMOS_MAX_Y+20), intent(out) :: offY
      integer, optional,              intent(in)  :: ccdnr
```

2.3.5 cumulativeBinomial

Aim: Compute cumulative binomial distribution. $\text{cumulativeBinomial}(\text{Non}, \text{Noff}, p) = \text{Sum}(\text{Non to Non+Noff})$
PB(Non,Noff,p) PB(Non,Noff,p) is the probability to get Non source counts and Noff background counts,
if p is the a priori probability that a count is attributed to the source (on assumption of no source)

The routine declaration is:

```
real(double) function cumulativeBinomial(Non, Noff, p)

! Input:
! Non   : number of observed source counts
! Noff  : number of observed background counts
! p     : a priori probability that a count is attributed to the source

      real(double), intent(in) :: p
      integer,      intent(in) :: Non, Noff
```

2.3.6 cumulativePoisson

Aim: Compute cumulative Poisson distribution over some range. $\text{cumulativePoisson}(k) = \text{Sum}(0 \text{ to } k)$
P(k)

The routine declaration is:

```
subroutine cumulativePoisson(mu, kmin, kmax, cvf)

! mu      : average value
! kmin    : minimum number of counts
! kmax    : maximum number of counts
! cvf(1:kmax-kmin+1) : cumulative Poisson distribution from kmin to kmax

      real(double), intent(in) :: mu
      integer,      intent(in) :: kmin, kmax
```



```
real(double), dimension(:), intent(out) :: cvf
```

2.3.7 compCumulPoisson

Aim: Compute complementary cumulative Poisson distribution over some range. compCumulPoisson(k) = Sum(k to infinity) P(k)

The routine declaration is:

```
subroutine compCumulPoisson(mu, kmin, kmax, cvf)

! Input:
! mu      : average value
! kmin    : minimum number of counts
! kmax    : maximum number of counts
! Output:
! cvf(1:kmax-kmin+1) : complementary cumulative Poisson distribution
!                      from kmin to kmax

real(double), intent(in) :: mu
integer,       intent(in) :: kmin, kmax
real(double), dimension(:), intent(out) :: cvf
```

2.3.8 quantilePoisson

Aim: Return quantiles for the Poisson distribution. Probability to get quantile or less is always $\geq 1 - \epsilon$. Probability to get 1+quantile or more is always $\geq \epsilon$. Return lower quantile if $\epsilon \geq 0.5$ such that probability to get quantile or more is always $\geq 1 - \epsilon$. Probability to get quantile-1 or less is always $\geq \epsilon$.

The routine declaration is:

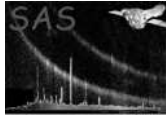
```
integer function quantilePoisson(mu, epsilon)

! mu      : average value
! epsilon : probability level

real, intent(in) :: mu, epsilon
```

2.3.9 corrCoeff

Aim: Compute correlation coefficient and main axes from a list of (X,Y) coordinates assuming identical and independent errors on X and Y.



The routine declaration is:

```

real function corrCoeff(x, y, theta, sigma1, sigma2)

! x, y    : list of X and Y values
! Returns if present:
! theta   : rotation angle (radians, between -pi/4 and pi/4) to main axes
! sigma1  : dispersion along theta (not necessarily major axis)
! sigma2  : dispersion perpendicular to theta

real, intent(in) , dimension(:) :: x, y
real, intent(out), optional      :: theta, sigma1, sigma2

```

2.3.10 localMedian

Aim: Compute median of an array (either integer or real).

The routine declaration is:

```

function localMedian(toto,nval)

! toto: 1-D input array of integer or real values
! nval: number of values in toto to consider (optional)

integer or real, dimension(:), intent(in)  :: toto
integer, optional,      intent(in)  :: nval

```

2.4 energy combination

CAL_mosPhaBuild call:

Computes a single energy PHA (in ADU) for each event from a weighted sum of the E_i , and the residual background $Bkg(x, y)$ computed in CCDBKG, assumed not to vary with time (*i.e.* the time series output from CCDBKG is not used).

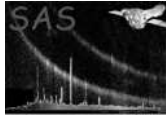
The coefficients $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ are defined by the CAL from a CCF file. They have 1 value for each of the 32 patterns.

E_1 is entered as real in order to allow randomisation before calling CAL_mosPhaBuild.

Two different formulae are used depending on whether α_4 is positive or negative.

If $\alpha_4 \leq 0$ (and normally ≥ -1), then the idea is to use a weighted average of E_4 and Bkg to estimate the local background. This is adapted to compact events.

$$\begin{aligned}
 Wght &= \alpha_1 + \alpha_2 N_{above} + \alpha_3 (8 - N_{above}) \\
 Pha &= \alpha_1 E_1 + \alpha_2 E_2 + \alpha_3 E_3 - Wght \left((1 + \alpha_4) Bkg - \frac{\alpha_4 E_4}{16 - Peripix} \right)
 \end{aligned} \tag{1}$$



If $\alpha_4 \geq 0$, then the idea is to use E_4 as part of the signal, and estimate the local background entirely from Bkg . This is adapted to events spread out over many pixels.

$$\begin{aligned} Wght &= \alpha_1 + \alpha_2 N_{above} + \alpha_3(8 - N_{above}) + \alpha_4(16 - Peripix) \\ Pha &= \alpha_1 E_1 + \alpha_2 E_2 + \alpha_3 E_3 + \alpha_4 E_4 - Wght Bkg \end{aligned} \quad (2)$$

In both cases N_{above} is the number of secondary pixels above threshold (for example 1 for bipixels). E_4 is used only where $PERIPIX < 7$. E_3 and E_4 are not used if next to a bad line or column.

Depending on the calibration results (not yet known) the α_i may depend on the pattern and possibly also on energy. The idea is then to loop on **emenergy** for different selections on the events.

The C++ possible call are :

```
CalReal32Vector &EnergyCombinator::combine(const CalReal32Vector &energye1,
                                             const CalInt16Vector &energye2,
                                             const CalInt8Vector &pattern,
                                             CalReal32Vector &pha,      // out

                                             const CalReal32Vector &locbkg,
                                             const CalInt16Vector &energye3,
                                             const CalInt16Vector &energye4,
                                             const CalInt8Vector &peripix,
                                             const CalInt32Vector &flag
                                             )
```

Input: energye1 : array of real32 with event energy E1 energye2 : array of int16 with event energy E2
energye3 : array of int16 with event energy E3 (optional) energye4 : array of int16 with event energy E4
(optional) pattern : array of int8 with event pattern number peripix : array of int8 with event peripix
number (optional) flag : array of int32 with event flag (optional) locbkg : array of real32 with event local
background (optional) Out: pha : array of computed event PHA

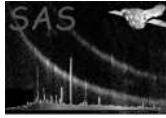
energye3, energye4, peripix and flag : are present or not in the same time, while locbkg is optional
independently. Which leads to 4 possible calls.

```
CalReal32Vector &EnergyCombinator::combine(const CalReal32Vector &energye1,
                                             const CalInt16Vector &energye2,
                                             const CalInt8Vector &pattern,
                                             CalReal32Vector &pha      // out
                                             )
```

```
CalReal32Vector &EnergyCombinator::combine(const CalReal32Vector &energye1,
                                             const CalInt16Vector &energye2,
                                             const CalInt8Vector &pattern,
                                             CalReal32Vector &pha,      // out

                                             const CalReal32Vector &locbkg
                                             )
```

```
CalReal32Vector &EnergyCombinator::combine(const CalReal32Vector &energye1,
                                             const CalInt16Vector &energye2,
                                             const CalInt8Vector &pattern,
                                             CalReal32Vector &pha,      // out
```



```
        const CalInt16Vector &energye3,
        const CalInt16Vector &energye4,
        const CalInt8Vector &peripix,
        const CalInt32Vector &flag
    )
    CalReal32Vector &EnergyCombinator::combine(const CalReal32Vector &energye1,
        const CalInt16Vector &energye2,
        const CalInt8Vector &pattern,
        CalReal32Vector &pha,    // out

        const CalReal32Vector &locbkg,
        const CalInt16Vector &energye3,
        const CalInt16Vector &energye4,
        const CalInt8Vector &peripix,
        const CalInt32Vector &flag
    )
```

The F90 possible call will be :

```
subroutine CAL_mosPhaBuild(energye1, energye2, pattern, pha )

subroutine CAL_mosPhaBuild(energye1, energye2, pattern, pha, &
                           locbkg )

subroutine CAL_mosPhaBuild(energye1, energye2, pattern, pha, &
                           energye3, energye4, peripix, flag)

subroutine CAL_mosPhaBuild(energye1, energye2, pattern, pha, &
                           locbkg, energye3, energye4, peripix, flag)
```

2.5 emodf directory

This directory contains a very simple ODF with a single scientific exposure with CCDs 2 and 7 in Imaging mode, CCD 6 in Reduced Imaging mode, and CCD 1 in Timing mode.

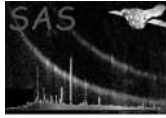
2.6 compare_columns utility

This sh script allows to compare columns from two files. It ends in error whenever two values don't match.

The calling sequence is:

```
compare_columns reffile[ext] newfile[ext] "column list" "comment"

# reffile[ext]: name of the first file with extension number
# newfile[ext]: name of the second file with extension number
# "column list": names of the columns to be compared (separated by a blank)
```



```
# "comment":      comment used to make the output message specific
```

2.7 compare_realcols utility

This SAS routine allows to compare real columns from two files, with absolute and relative tolerance. It ends in error whenever two values don't match.

The calling sequence is:

```
compare_realcols table=newfile(:table) reffile(:table)
                  colnames="column list" (abstol=tol1 reltol=tol2 operation=op)

# newfile(:table): name of the first file with table (first by default)
# reffile(:table): name of the second file with table (first by default)
# "column list"   : names of the columns to be compared (separated by a blank)
# tol1            : absolute tolerance on difference (1E-4 is default)
# tol2            : relative tolerance on difference (1E-4 is default)
# op              : OR (default) to apply the less stringent of both tests
                  AND          to apply the most stringent of both tests
```

3 Errors

This section documents warnings and errors generated by this task (if any). Note that warnings and errors can also be generated in the SAS infrastructure libraries, in which case they would not be documented here. Refer to the index of all errors and warnings available in the HTML version of the SAS documentation.

getMode01 (*error*)
unexpected DATATYPE in input table

getMode02 (*error*)
No DATATYPE in input table

readBadpix01 (*error*)
Array size smaller than the number of bad pixels

getCcd10 (*warning*)
No CCDID in input table
corrective action: return 0

getCcd11 (*warning*)
No INSTRUME in input table
corrective action: return 0

getCcd12 (*warning*)
INSTRUME=EMOS and no CCDNODE in input table
corrective action: return 0

getCcd13 (*warning*)
INSTRUME=EPN and CCDID not 0,1,2 in input table
corrective action: return 0

**getCcd14** (*warning*)

INSTRUME=EMOS and CCDID not in 1-7 in input table

corrective action: return 0**getCcd15** (*warning*)

INSTRUME=EPN and no QUADRANT in input table

corrective action: return 0**getCcd16** (*warning*)

Unrecognized INSTRUME in input table

corrective action: return 0**getCcd17** (*warning*)

INSTRUME=EPN and QUADRANT not in 0-3 in input table

corrective action: return 0**getCcd18** (*warning*)

INSTRUME=EMOS and CCDNODE not 0,1 in input table

corrective action: return 0**equalKeywords11** (*warning*)

One of the keywords is not present in the first input table

corrective action: return False**equalKeywords12** (*warning*)

One of the keywords is not present in the second input table

corrective action: return False**equalKeywords13** (*warning*)

One of the keywords is not identical in both tables

corrective action: return False**equalKeywords14** (*warning*)

One of the keywords has unknown type in the first input table

corrective action: ignore keyword**equalKeywords15** (*warning*)

One of the keywords does not have the same type in both tables

corrective action: return False**putPrimaryKeywords10** (*warning*)

One of the keywords is not present in the input table

corrective action: continue**sizeListParam10** (*warning*)

parameterCount returned a negative value

corrective action: return 0**readListParam10** (*warning*)

string parameter too long

corrective action: truncate

4 Future developments

References