attbin

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Abstract

The task **attbin** bins up variations in the spacecraft attitude.

1 Instruments/Modes

Instrument	Mode
EPIC MOS	ALL
EPIC PN	ALL
RGS	ALL
OM	ALL

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

3.1 Introduction

Tasks which compute sky coordinates of events (x-ray or optical photons) which are detected on one of the XMM cameras must take account of the fact that the attitude of the spacecraft (ie its direction of point and its roll angle) are not exactly constant during an exposure. It is of course possible, for each separate event, to obtain the attitude at the time of the event and compute the entire transform to sky coordinates. The attitude wander from one event to the next is however usually not very great, thus computing time can be saved at little expense in accuracy by using the same attitude value for several successive computations. The job of the present task is to generate an attitude time series, with variable bin duration, which has the property that, within any given bin, the attitude does not vary outside preset limits (section 3.2).

The format of the binned attitude file (see section 6 for a description) is accepted by SAS tasks **evproject**, **eootemap**, **epnoisemap**, **eimchip2sky** and **eexpchipmap**.

3.2 Limits on attitude wander

The limits on attitude wander are defined via the parameter `maxdelta`, which is in arcseconds. The RA limit $\Delta\alpha$ is set to

$$\Delta\alpha = \Delta A / \cos(\delta), \tag{1}$$

where Δa =`maxdelta` and δ is the average declination value (the exact meaning of 'average' in this context is discussed in section 3.3 below). The declination limit is just set to ΔA, and the position angle (apos) limit Δp is set to

$$\Delta p = \Delta A \times 60 \times 180/\pi/R_{\rm arcmin},$$

where $R_{\rm arcmin} = 15.0$ is the nominal radius of the field of view of the XMM EPIC cameras.

3.3 Average attitude

Besides being used in equation 1, the average attitude is written to the output dataset in the form of the following keywords:

- `RA_PNT`: the average right ascension of the spacecraft -X axis during the time period of interest.
- `DEC_PNT`: the average declination of the spacecraft -X axis during the time period of interest.
- `PA_PNT`: the average roll angle, ie the position angle of the spacecraft -Z axis during the time period of interest.
- `AVRG_PNT`: records the type of average. In the present case this can take values 'MEAN' or 'MEDIAN'.

The way in which the average attitude is calculated depends on the `attsource` and `odfattsource` parameters as follows:

- `attsource`='odf':
  - `timesource`='eventlist': in this case the average values are not calculated at all, rather they are sought from the file pointed to by parameter `pntkwdset`. Why doesn't **attbin** calculate the average itself in this circumstance? Because the time difference between successive events in the event list can vary. 'Average attitude' only makes sense if the times of the attitude samples are regularly spaced.

    The filename supplied to `pntkwdset` should normally be the output file of **atthkgen**, which is the SSC product file with the name string ATTTSR. The sought keywords have the form 'tsa', where 't' is either 'M' for median or 'A' for mean, 's' is either 'AHF' or 'OM', and 'a' is either 'RA', 'DEC' or 'PA'. The exact values of 't' and 's' looked for depend on the parameters `withmedianpnt` and `odfattsource`. The relevant keywords are copied to the output dataset, but in the *_PNT format. The value written to `AVRG_PNT` is 'MEDIAN' if `withmedianpnt`='yes' and 'MEAN' if `withmedianpnt`='no'.

– `timesource`='user': here the time samples are evenly spaced, so it makes sense to calculate an average. The attitude is obtained from the ODF via an **oal** call for each time sample. This call returns either true, for successful, or false, for unsuccessful. The average of each attitude component (ie RA, dec and apos) is calculated as either the mean or the median (depending on the value of `withmedianpnt`) of all the successful values.

- `attsource`='atthk': in this case the time samples are obtained from the atthk file (`atthkset`), therefore are expected to be uniform; however the averages of these values have already been calculated and are present as keywords. The action of the task in this circumstance is thus identical to that described in the first item above (except that the choice between AHF and OM is governed by parameter `atthkattsource`).

3.4 Construction of the binned-attitude time series

Each bin is associated with a start time (which is equal to the end time of the previous bin, if there is one), and end time (which is equal to the start time of the following bin, if there is one) and an attitude. The binning is done as follows. For each time value, **evproject** attempts to obtain the spacecraft attitude (via an **oal** call if `attsource`='odf', or from the `atthkset` file if `attsource`='atthk'). This attempt is either successful or unsuccessful (logical returned value of the **oal** call, or null value in the `atthkset` column). **evproject** begins a new attitude bin if any of the following occur:

- if the attitude is being obtained for the first time;
- if the present attitude call was successful but the preceding call was unsuccessful;
- if the present call was unsuccessful but the preceding call was successful;
- if the call was successful, but the returned attitude varies by more than a set amount (section 3.2) from the 'baseline attitude'.

It can thus be seen that each bin duration spans attitude calls which were either all successful or all unsuccessful. The whole bin can therefore be labelled as either 'good' or 'bad'.

The attitude of each new 'successful' bin is set to the baseline attitude. The baseline attitude is initially set to the attitude returned by the first succesful attitude call. If the attitude returned by any subsequent successful call diverges from the baseline by more than set limits (item 4 in the list above), the baseline attitude is altered. However usually only one of the components of the baseline attitude is altered at a time. This comes about as follows. There are separate limits on each of the three attitude components (RA, dec and position angle). If any component of the momentary attitude diverges from the same component of the baseline attitude by more than the respective limit, that component of the baseline attitude is set to the momentary value; components which have not wandered out of bounds are left unaltered. Note also that a change of bin due to change of success of attitude call does not in itself alter the baseline. If a new bin starts because the calls have returned to the successful state, the attitude assigned to the new bin is the baseline value, which is also the attitude of the last 'successful' bin.

This binning scheme is perhaps a little complicated, but has been chosen so as to adhere as closely as possible to the original **attcalc** scheme. However note that the component limits are calculated in a different way to **attcalc** (see section 3.2).

4 Parameters

This section documents the parameters recognized by this task (if any).

Parameter	Mand	Type	Default	Constraints
attsource	no	string	odf	odf—atthk

Source of the attitude data. If this equals 'odf', the environment variable SAS_ODF must be set to point to the appropriate ODF.

odfattsource	no	string	ahf	ahf—om

Whether to use the Attitude History File or the OM pointing history file from the ODF. This parameter is read if `attsource`='odf'.

timesource	no	string	user	user—eventlist

If this = 'user', the task reads parameters `tstart`, `tstop` and `tstep`, and constructs the sequence of attitude sample times from these numbers; if it = 'eventlist', the event times from the event list supplied to parameter `eventset` are used.

tstart	yes	string	0000-00-00T00:00:00	

Date-time string of the first time sample. This is read if `timesource`='user'.

tstop	yes	string	0000-00-00T00:00:00	

Date-time string of the last allowed time sample. This is read if `timesource`='user'.

tstep	yes	real	1.0	0 >`tstep`

Separation between successive time samples. This is read if `timesource`='user'.

eventset	yes	dataset		

Name of the event-list dataset which supplies time samples from the event times. This is read if `timesource`='eventlist'.

pntkwdset	yes	dataset		

Name of the dataset from which to read the spacecraft average pointing keywords (usually expected to be the output file of **atthkgen**). This parameter is read if `attsource`='odf' and `timesource`='eventlist'.

atthkset	yes	dataset		

The dataset (normally this would be expected to be the output files from task **atthkgen**) which contains samples of the spacecraft attitude. This is read if `attsource`='atthk'.

atthkattsource	no	string	ahf	ahf—om

Whether to use the Attitude History File data or the OM pointing history data from the `atthkset` file. This parameter is read if `attsource`='atthk'.

binnedattset	no	dataset	binned_att.ds	

The dataset which is to contain the binned attitude data.

maxdelta	no	real	0.02	0 <`maxdelta`

A new attitude bin is started if the attitude jumps by more than this amount (in arcsec).

withmedianpnt	no	boolean	yes	

Whether to use/calculate median or mean pointing for the *_PNT keywords (and, if `attsource`='atthk', whether to access the mean or median atthk data).

5 Input Files

1. (if `attsource`='odf' and `timesource`='eventlist'), a dataset containing a binary table extension `EVENTS`, which contains a 4-byte-real-valued column `TIME`.
2. (if `attsource`='odf' and `timesource`='eventlist'), a file (usually expected to be the output file of **atthkgen**) which contains in the primary HDU keywords as follows:
   - if `odfattsource`='ahf':
     - if `withmedianpnt`='yes': MOMRA MOMDEC MOMPA
     - if `withmedianpnt`='no': AOMRA AOMDEC AOMPA
   - if `odfattsource`='om':
     - if `withmedianpnt`='yes': MAHFRA MAHFDEC MAHFPA
     - if `withmedianpnt`='no': AAHFRA AAHFDEC AAHFPA
3. (if `attsource`='atthk'), a file (usually expected to be the output file of **atthkgen**) which contains in the primary HDU keywords as described in the previous item, plus an extension `ATTHK`, which contains the following columns:
   - `TIME`
   - (if `atthkattsource`='ahf') `AHFRA`, `AHFDEC` and `AHFPA`
   - (if `atthkattsource`='om') `OMRA`, `OMDEC` and `OMPA`

   All these columns should be 4-byte real.

6 Output Files

1. A dataset which contains the binary table extension ATT_BINS. Keywords as follows are written to the header of this extension:

   - TIMEZERO - start time of the first bin.
   - STARTINF - whether to consider the start time of the first bin to be undefined (ie, equal to $-\infty$). Here this is set to FALSE.
   - END_INF - whether to consider the end time of the last bin to be undefined (ie, equal to $+\infty$). Here this is set to FALSE.
   - RA_PNT, DEC_PNT, PA_PNT, AVRG_PNT: described in section 3.3
   - RA_DELTA, DEC_DELTA, PA_DELTA: the attitude-wander limits discussed in section 3.2. These are in decimal degrees.

   ATT_BINS contains the 4-byte-real columns TSTOP, RA, DEC and PA, the 2-byte-real column FRACEXP and the boolean column IS_GOOD. TSTOP is the end time of the bin and also the start time of the next bin (if there is one). FRACEXP is set to equal 1.0 for all bins in the present task. IS_GOOD refers to whether the attitude calls in that bin were successful or unsuccessful.

   It should be noted that this binned-attitude 'time series' does NOT conform to OGIP recommendations. However in my view this is a deficiency in OGIP, which should be expanded to allow the edges of time bins to be recorded, not just the bin centre times.

7 Algorithm

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8 Comments

9 Future developments

References