Innovative Cosmic Ray Rejection in ISOCAM Data

S. Ott, L. Metcalfe, A. Pollock

ISO Data Centre, Astrophysics Division, Space Science Dept. of ESA, Villafranca, P.O. Box 50727, 28080 Madrid, Spain

R. Tuffs

Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Abstract.
Cosmic ray rejection (deglitching) is one of the challenging data analysis problems for ISOCAM, the infrared camera on board ESA's Infrared Space Observatory (ISO).

Artifacts, caused by undetected glitches, limit the calibration accuracy and sensitivity, and directly influence the quality of the final data products.

We present five new deglitching algorithms suited for different types of ISOCAM data and discuss their applicability.

We also show examples demonstrating the improvements gained by these deglitching techniques.

1. Introduction

Glitches (remnants of cosmic ray impacts) have been found to be a powerful (and often dominant) limiting factor for all aspects of the data analysis of ISOCAM (Cesarsky et al, 1996), the infrared camera on board ESA's Infrared Space Observatory (ISO) (Kessler et al., 1996)[1].

Standard deglitching techniques[2] like multi-resolution (Starck et al., 1998) or sigma clipping work "blindly" on a data vector only and therefore ignore valuable information about

- ISOCAM's current configuration
- our knowledge of glitch distribution in time
- the current flux level per pixel

Therefore the standard deglitchers have often to rely on badly chosen thresholds, which consequently result in

- too high noise level due to un-suppressed glitches
- masked out sources or gradients during stabilisation
- no deglitching for observations with few read-outs

[1] ISO is an ESA project with instruments funded by ESA member states (especially the PI countries: France, Germany, the Netherlands and the United Kingdom) and with the participation of ISAS and NASA.

[2] See Siebenmorgen et al., 1999 for the effects of cosmic ray impacts and a description of conventional deglitchers

2. MMMS (Multi-Method, Multi-Step)

field of application: dark current calibration with highly redundant data. The signal (trends) are buried in the noise, and the value of the final result is known, as a perfectly dark-corrected dark must be zero

algorithm: repeated application of multi-resoltution deglitching and conventional sigma clipping

result: reduction of the noise level by a factor of five and of the standard error by a factor of four. The number of rejected pixels is a strong indicator of deviations due to hidden features and trends

caveats: true features are partially clipped out. To avoid this, iterations are necessary

3. Sky-cube Deglitching

field of application: all datasets with stabilised and highly redundant data (especially faint source data)

algorithm: after conventional deglitching, each detector pixel, for each raster position, is projected into the sky to generate a "sky cube". Afterwards sigma-clipping is performed for each sky-cube-pixel

result: excellent rejection of remaining faders and dippers (Siebenmorgen et al., 1999) not caught by earlier deglitching

caveats: none known yet

annotation: as sky-cube deglitching relies on the comparison between detector- and sky-pixel, the actual ISO pointing and the distortion corrections for ISOCAM have to be accurately known. Correction for ISOCAM's long and short term drift will result in further improvements

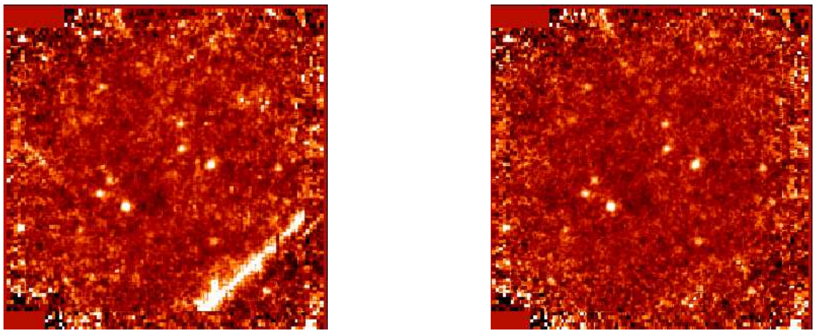


Figure 1. CAM survey data after multiresolution deglitching (left) and after sky-cube deglitching (right)

4. BISC (Best Iterative Sigma Clipping)

field of application: all datasets with relatively well stabilised data

algorithm: iterative method; the data-cube is normalised by estimations of flux level per state[3]

result: stringent deglitching, including a very good rejection of faders and dippers. The low residual noise permits additional treatments for faint sources

caveats: pixels with a high gradient (e.g. due to cross-talk in the neighbourhood of strong extended sources) or strong point sources with high noise can be masked out and have to be recovered by a NOSC post-processing step (see section 5 below)

annotation: Overruling of the on-target-flag (normally set to bad during slews of the satellite) enables the recovery of a significant amount of otherwise ignored data for raster observation of a flat sky

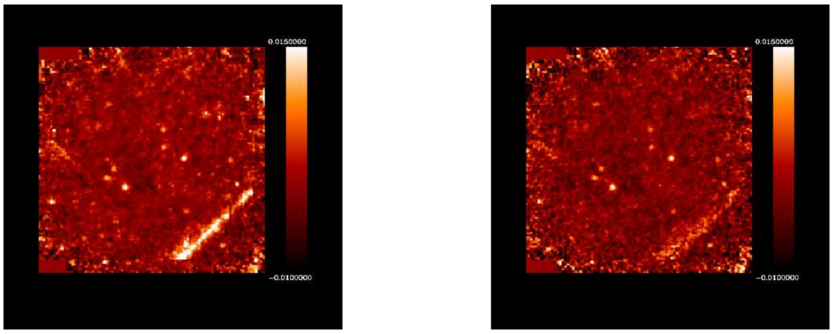


Figure 2. CAM survey data after multiresolution deglitching (left) and after BISC deglitching (right)

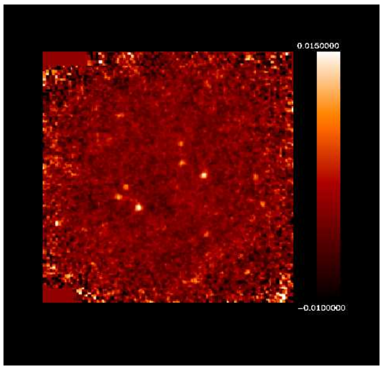


Figure 3. BISC deglitched CAM survey data with additional faint source processing

[3] state: the finest division time division of ISOCAM activities. All CAM and satellite (pointing) parameters are fixed during a state

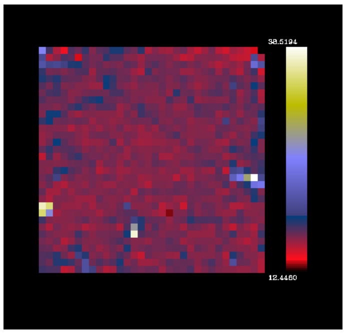
5. NOSC (Normalised Sigma Clipping)

field of application: all datasets with stabilised data and very few (down to four!) read-outs

algorithm: per step, 25% of the read-outs (alternately with the highest and then with the lowest signal within a state) are ignored. On the remaining sample, sigma clipping is performed using modified values for mean and variance

result: spectacular results for CAM parallel, on its own and as BISC postprocessor

caveats: imperfect glitch rejection in case of higher than expected number of strong glitches during a state



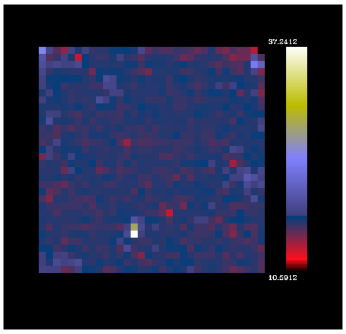


Figure 4. CAM paralled exposure with six readouts after multiresolution deglitching (left) and after NOSC deglitching (right)

6. Clipper

field of application: in principle, all datasets

algorithm: Currently, there are two algorithms under evaluation:
- polynomial or spline fitting of the data vector and clipping of the outlying points
- spline interpolation and rejection of points where the second derivative has a significantly high value

result: promising examples on data with high gradients

caveats: still under development

References

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Starck, J-L., Murtagh, F. & Bijaoui, A., Image Processing and Data Analysis: The Multiscape Approach, Cambridge Univeristy Press, Cambridge (GB), 1998