# Removing Systematics for the End of Mission Light Curves

Guterman. P[1,2], Mazeh. T[3], Faigler. S[3]

[1]*Division Technique INSU, BP 330, 83507 La Seyne cedex, France,* [2] *LAM (Laboratoire d'Astrophysique de Marseille) UMR 7326, F-13388 Marseille, France,*
[3]*School of Physics and Astronomy, Tel Aviv University, Tel Aviv 69978, Israel*

*Introduction* : The CoRoT space mission (Baglin et al. 2006), which has been active for almost 6 years, produced continuous photometry of thousands of stars. Each of the two CCD of the satellite transferred simultaneously fluxes of 6,000 stars. The pipeline corrected the data from known instrumental effects such as EMI, background, jitter correction, but some systematics are left, as seen in Figure 1. Previous work to correct for these effects included Mazeh et al. (2009) and Ofir (2010), which used SysRem (Tamuz, Mazeh & Zucker 2005) or an additive version of it. The present algorithm is a substantial simplification of the previous algorithms.

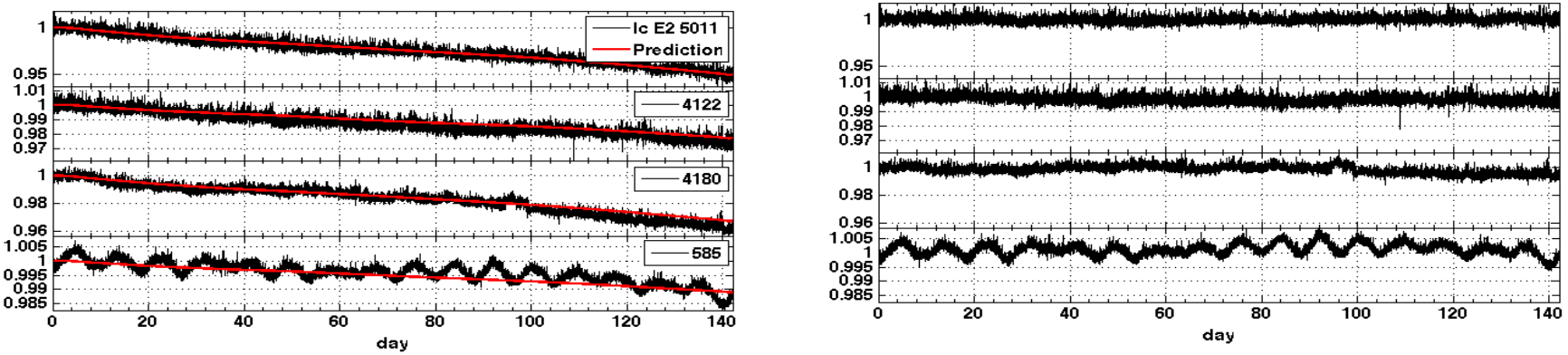


Figure 1: Before-after systematics diagram. Left, in black a few light curves of run *LRc01* sampled at 512s on a common time base. In red line the predicted systematics. Right pane, the same curves with pattern subtracted.

*Method*: For each exposure and each star, we determined the "residual" of the flux, relative to the average flux of this star. We then determine for each exposure 3 coefficients of a basic model to characterize the trends of the whole 6,000 residuals. Iteration on all exposures gives the full temporal behavior of these 3 systematic effects.

We noticed that for each of the CoRoT exposures, the 6,000 residuals present a trend that depends on 3 CoRoT parameters: ***x***, ***y,*** the stellar position on the CCD, and the area of the photometric mask of each individual star. See Figure 2.

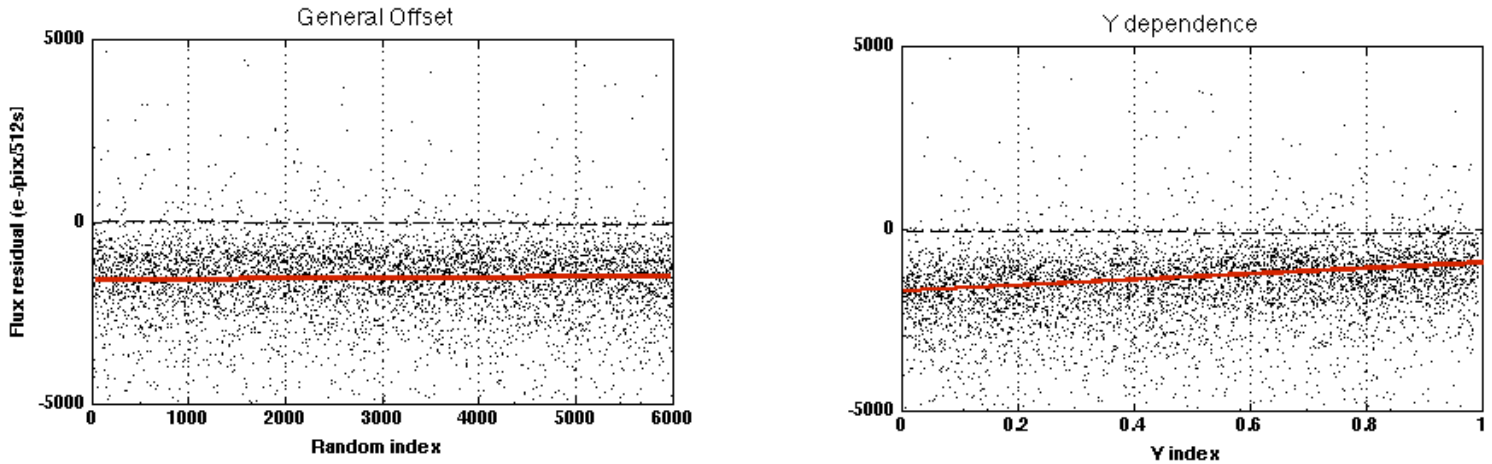


Figure 2: *Residuals* correlation with the star's position. Left, black dots are the 6,000 *residuals* sorted at random. Red line, the average offset. Right panel: same stars ordered by increasing *y* position. The *y* dependence is linear.

The *x* dependence, not represented here, is also linear. This leads to the model for exposure *i*:

$$S_i = C_i + A_i.x + B_i.y$$

where $S_i$ is the systematic corrective plane at exposure *i* for the (*x*,*y*) position of any star. Parameters $A_i$, $B_i$ are the proportional *x* and *y* dependence, while $C_i$ is the general offset. A robust multi-linear regression deduces the effects from the full data with no selection of a proper subset. For better results, the stellar fluxes are normalized to unitary mask. The *residuals* show no correlation with the flux value itself. The procedure is insensitive to outliers that come from spurious cosmic rays and variability of the stellar pattern itself.

*Discussion*: The evolution of the three parameters across the CoRoT exposures reveals the time law of the systematics. Figure 3 shows the evolution of coefficients ***A***, ***B***, ***C*** across time for field *LRc01* that was observed for more than 140 days.

In blue, the gradual decrease to 40e-/pix/exposure on the long term may reflect the loss of efficiency of the CCD. This can represent ~3% flux loss for faint stars. In red (green), the *x* (*y*) coefficients show patterns of lower amplitude, likely caused by the star shift inside its mask due to aberration. The stars close to the line of sight of CoRoT, near (0,0) are less affected. A change of CCD temperature is visible at day 50.

The sensitivity of the method allows us to identify details as small as <1e-/pix/exp; see the red circle, presenting 1-day period modulation, and the green circle, focusing on the orbital period of the satellite. The modeling process ends up with a 1-month wide smoothing (black lines) to remove some of the numerical noise. Cleaning a light curve simply consist on subtracting the systematic, which depend of the stellar position and mask area.

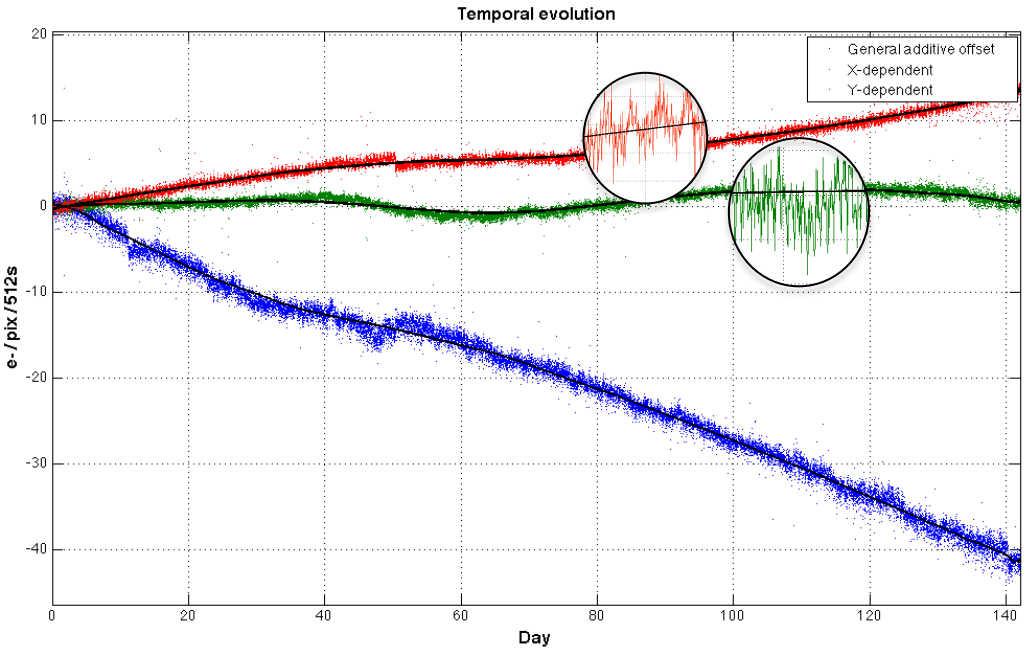


Figure 3: Temporal coefficients over the 142 days of *LRc01*. In blue the general offset *C*. In green (resp. red) the *x*-proportional (resp. *y*) added flux. Black lines are the applied coefficients after smoothing. Inside circles some magnified details.

*Conclusion* : We use a linear 3-parameters additive model to identify systematics of CoRoT, using all 6,000 stars on each of the satellite CCDs. The model depends only on the stellar position, *x*, *y*, and the mask area. These effects amounted to 2.2% long-term variation, specially in the first few runs.

Our algorithm is used in CoRoT 'legacy' release, to provide easy-to-use data to non specialists of CoRoT.

*References* :


Baglin, A., Auvergne, M., Barge, P., et al. 2006, in ESA SP, 1306, 33
Mazeh, T., Guterman, P., Aigrain, S., et al. 2009, A&A, 506, 431
Tamuz O., Mazeh T., Zucker S., 2005, MNRAS, 356, 1466
Ofir, A., et al 2010 MNRAS.404L..99O