EUROPEAN SOUTHERN OBSERVATORY
Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
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LA SILLA OBSERVATORY

NEW TECHNOLOGY TELESCOPE

Stability of the imagery flats of SOFI
Report

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1 Presentation of the document

We wanted to check that the flats of SOFI (in large field) are stable enough to prove that the astronomers don't need to take several flats during the run, or at least, just once per day.
To do that, we just retrieve in the archive the special dome flats in J during 5 months, we reduced them and check the statistics. Details of the procedure and results are presented in the following sections.

2 Data

The special dome flat is a special calibration related to SOFI. To have a complete description, have a look to the SOFI manual. The data are reduced with the special_flat.cl IRAF script, available on the SOFI web page.

3 What we did with the data

First, we corrected the flats by the bad pixel mask using the IRAF task **fixpix** and the bad pixel mask available in the SOFI web page: a good statistics cannot be done with bad values due to some defect of the detector. Then the flats are normalized. We combine the 28 flats (listed in the Table 2) to have the **average flat**, that will be the reference to monitore the behavior of the flats. Finally, we do the statistics of the ratio of each flat by the **average flat** .
Because SOFI is a mosaic of 4 detectors, each detector being different from the others, we compute the statistics quadrant by quadrant (cf. Table 1 for the pixel values of each quadrant), to see if some tendencies or problem are detectable.

Table 1: Pixel values of the 4 quadrants

Quadrant	xmin	ymin	xmax	ymax
# 1 lower left	50	50	462	462
# 2 lower right	562	50	974	562
# 3 upper left	50	562	462	974
# 4 upper right	562	562	974	974

4 Results

We use the **imstat** task in IRAF to simply obtain the statistics. The results are summarized in the Table 2, where the mean and the standard deviation of the 4 quadrants for each flat are presented. Moreover, Figure 1 plots the mean (lower left panel), the standard deviation (upper left panel), the minimum value (upper right panel) and the maximum value (lower right panel) for all the flats: the quadrant #1 is symbolized by the filled black dots, the quadrant #2 by the red triangles, the quadrant # 3 by the green squares and the quadrant #4 by the blue circles.

The main comments are :
- the mean standard deviation of each quadrant is #1: 0.0049, #2: 0.0084, #3: 0.0079, #4: 0.0180. The first 3 quadrants have a mean standard deviation lower than 0.1% of the flat value. The last quadrant looks less stable with larger variation. But the global variation of the flats is less than 2%,

what is relatively good.

- It's pretty clear on the graph that the stability is not perfect, as you can see fluctuation over the 5 months. But if you don't do high photometry measurements, you will have a 2% error due to the flat.

Table 2: Results of the statistics for the flats

Name/Date	Mean1	Mean2	Mean3	Mean4	StdDev1	StdDev2	StdDev3	StdDev4
spec_100702_1	1.005	0.9993	0.9923	0.9813	0.00476	0.009182	0.007067	0.007022
spec_120702	1.004	0.9964	0.9963	0.982	0.004894	0.009082	0.007226	0.007742
spec_160702	1.002	0.9996	0.9872	0.9891	0.005156	0.005209	0.006687	0.005846
spec_160702_2	1.002	0.9999	0.987	0.989	0.005256	0.005449	0.006837	0.006031
spec_180701_1	0.9942	0.9993	0.9981	1.004	0.00418	0.005329	0.005625	0.005469
spec_190702	0.9921	1.009	0.9944	1.009	0.006223	0.008575	0.008102	0.007856
spec_150802	1.011	0.9996	1.004	0.9832	0.005338	0.007736	0.00928	0.01021
spec_170802	0.9985	1.003	1.014	1.002	0.00527	0.01078	0.008611	0.02954
spec_220802	1.03	1.006	1.038	0.9933	0.01032	0.01429	0.01728	0.0363
spec_310802	0.991	0.9909	1.011	0.9882	0.003395	0.01377	0.01548	0.04123
spec_010902	0.9907	0.9915	1.011	0.9893	0.00325	0.01387	0.01484	0.04113
spec_110902	1.008	1.009	0.991	1.007	0.006531	0.008361	0.006547	0.01981
spec_120902_1	1.019	1.008	1.005	0.986	0.004496	0.006029	0.008231	0.01035
spec_120902_2	1.026	1.014	1.031	1.013	0.01033	0.009879	0.01737	0.01428
spec_130902	0.9758	1.01	0.9902	1.038	0.008938	0.01256	0.01131	0.02381
spec_140902	0.9896	1.001	1.004	1.021	0.004873	0.00901	0.00554	0.01017
spec_160902	1.001	1.009	0.9934	1.014	0.003477	0.007038	0.004624	0.01424
spec_180902	1.013	1.01	1.002	0.9933	0.002746	0.006194	0.004645	0.01718
spec_190902	1.007	1.013	0.9969	1.001	0.00355	0.005711	0.004966	0.01668
spec_240902	0.9936	1.004	1.009	1.009	0.005019	0.008914	0.005711	0.02394
spec_191002	0.9975	1.013	1.004	1.023	0.004768	0.006982	0.007305	0.009929
spec_261002	0.9955	0.9875	0.9913	0.9952	0.003664	0.007584	0.004972	0.02147
spec_281002_2	0.9974	0.9885	0.9915	0.9932	0.003617	0.007785	0.0055	0.02164
spec_291002	0.9963	0.9878	0.9922	0.9938	0.003565	0.007478	0.005323	0.02102
spec_021102	0.9833	0.9911	0.9864	1.009	0.003319	0.007863	0.005541	0.02148
spec_031102	0.9946	0.9828	0.9966	0.9937	0.004368	0.007643	0.006472	0.0205
spec_031102b	0.9835	0.9913	0.9864	1.009	0.00331	0.007679	0.005489	0.02117
spec_041102	0.9968	0.9857	0.9964	0.9912	0.004221	0.007605	0.006739	0.01996

5 Visual inspection

As the area defined to do the statistics are smaller than each complete chip, we avoid the border effects and mainly any change in the position of the wheel (each time we lose the slit/mask wheel, we have to realign it, and it's not exactly the same position). Having a visual look to the ratio (flat field to average) could explain some strong variations. Here, the flats with difference are notified.

spec_100701_1: the spot is visible and moreover some strange pattern too
spec_120702: the spot is visible and moreover some strange pattern too
spec_160702_2: the spot is visible and moreover some strange pattern too
spec_160702: the spot is visible and moreover some strange pattern too
spec_180702: spot again, with some duplicated pattern in the right side

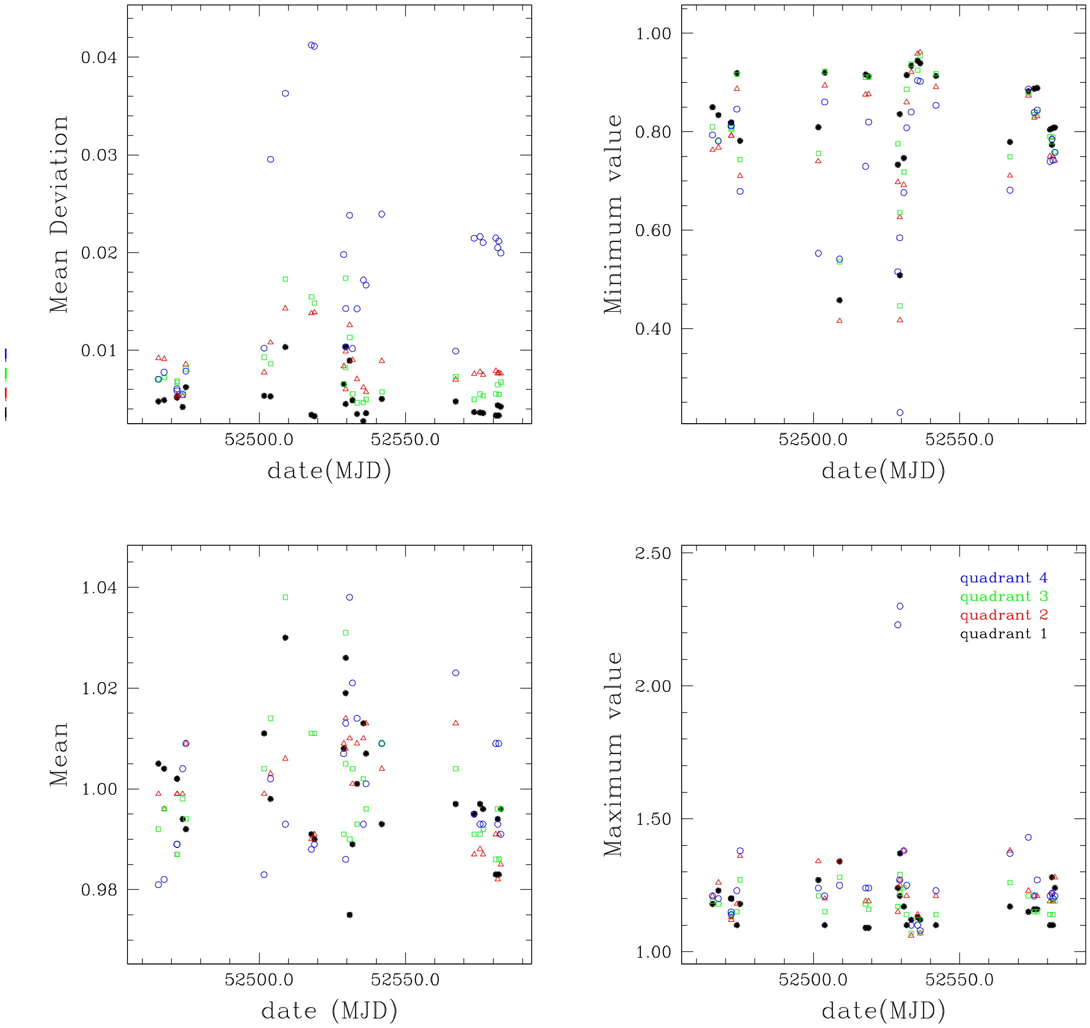

Figure 1: Statistics results: mean, standard deviation, minimum and maximum values versus the date (in Julian date: you should add 2400000 to have the complete Julian date). The different symbols and colors correspond to: quadrant 1-black dot; quadrant 2-red triangle; quadrant 3-green square; quadrant 4-blue circle.

spec_190702: pretty awful, the spot is quite strong
spec_150802: a gradient more pronounced, the spot again present.
spec_170802: 4 stranges small lights, as if some stars are presented...
spec_220802: awful ! the spot is strong and there's some other spots, smaller but as visible as the big one.
spec_310802: spot visible
spec_010902: the spot is visible in the quadrant #3
spec_110902: the spot is visible and moreover some strange pattern too
spec_120902_1: the spot is visible and moreover some strange pattern too
spec_120902_2: the contrast of the complete flat is really different from the other ones. the spot is really obvious
spec_130902: the spot is visible and moreover some strange pattern too
spec_140902: looks pretty uniform, the spot is not too visible

spec_160902: a little more uniform
spec_180902: more uniform
spec_190902: uniform
spec_240902: uniform
spec_191002: spot and duplications visible
spec_261002: spot and duplications visible
spec_281002: spot and duplications visible
spec_291002: spot and duplications visible
spec_021102: spot and duplications visible
spec_031102b: spot and duplications visible
spec_031102: spot and duplications visible
spec_031102: spot and duplications visible

One thing to underline, definitively, as the spot is most of the time visible, that means that its intensity changes with time and probably its shape too, compared to the average flat.

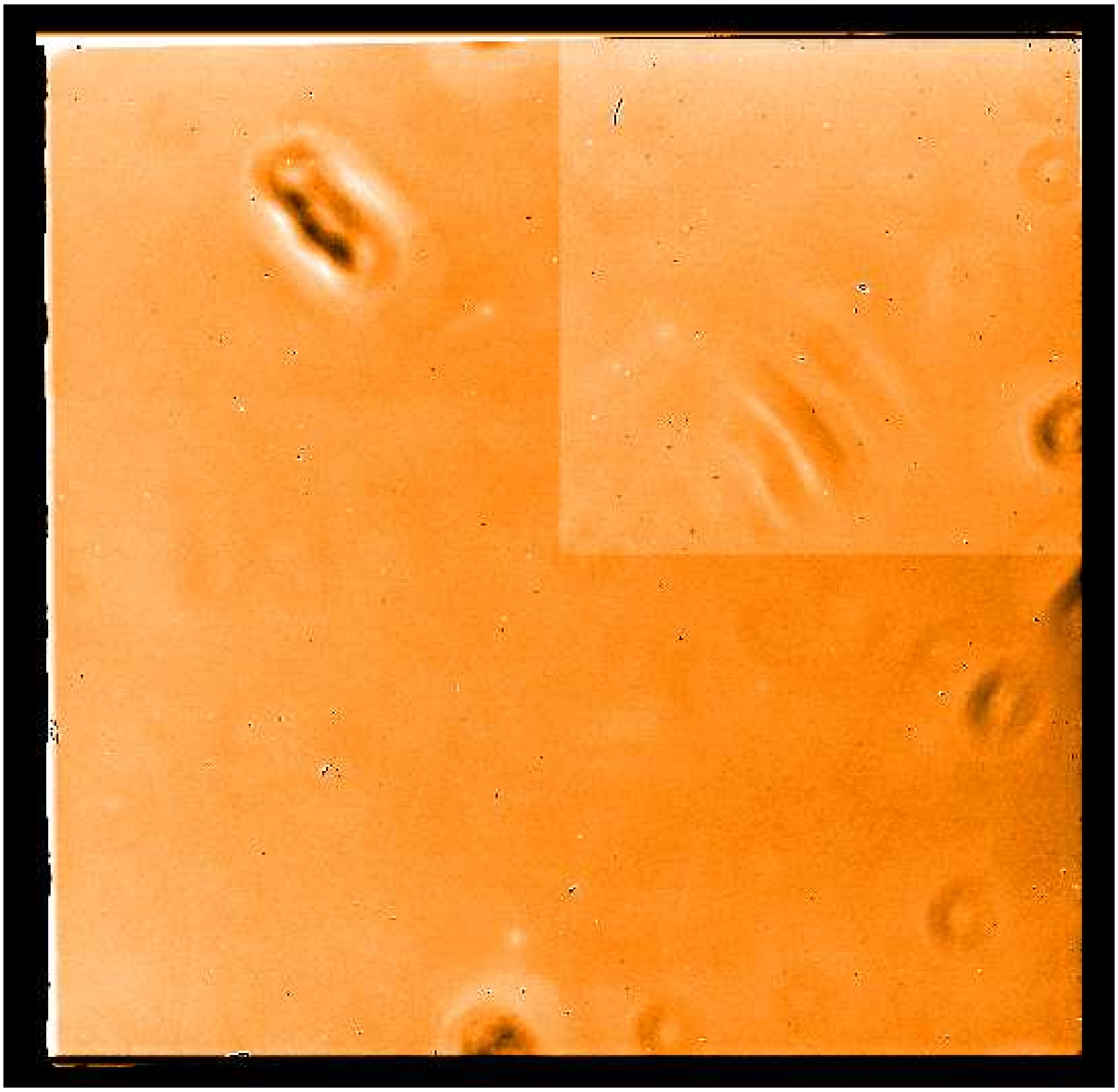

Figure 2: Example of ratio with a strong evidence of the spot.

6 Stability over the last 2 years

As all the development to check the flat stability is done, we just apply the method to the flats available in the web archive (http://www.ls.eso.org/lasilla/Telescopes/NEWNTT/sofi/images/fits/Archive). The Figure 4 plots the different parameters versus the date (mean, standard deviation, minimum value and maximum value). Again the global stability of the flat is lower than 2 % and again, the quadrant #4 is less stable than the other.
Regarding the visual inspection, we can notice that the spot was already present at the beginning of the flat check. So it's not a recent feature.

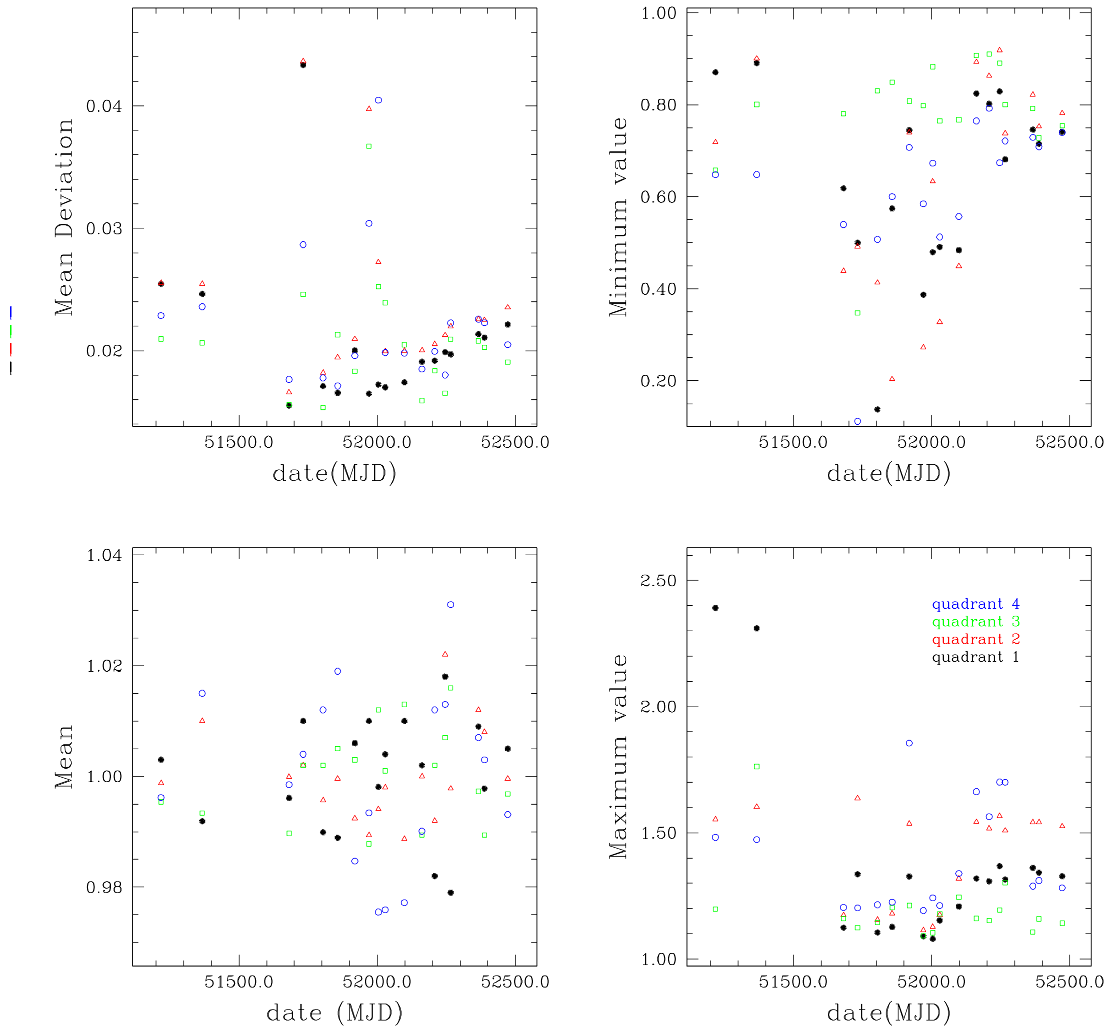

Figure 3: Statistics results: mean, standard deviation, minimum and maximum values versus the date (same comment that in Figure 1). The different symbols and colors correspond to: quadrant 1-black dot; quadrant 2-red triangle; quadrant 3-green square; quadrant 4-blue circle.

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