REMOVAL OF NOISES IN CHRIS/PROBA IMAGES: APPLICATION TO THE SPARC CAMPAIGN DATA

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ABSTRACT

CHRIS/PROBA images are affected by two main noises, and for simplicity we will call them horizontal and vertical noises.

Horizontal noise consists in the random loss of partial data from some lines of the images. In the same image, the lost lines appear always in different bands and positions. When that noise appears, there is not a complete loss of the whole line, maintaining a correct value for the even pixels. Using that property of the noise, it is easy to detect the lines with horizontal noise because they always have a correct value followed by an incorrect value along all the line. Once we have detected the lost lines, even pixels for such lines are corrected using the average of the nearest pixels with a correct value.

On the one hand, vertical noise or vertical striping is due to errors in the alignment of the sensors in the construction of the instrument (we can consider these errors as a constant). On the other hand, thermal fluctuations during the orbit causes small variations in the alignment of the optical elements, making that this vertical noise does not stay constant during all the time [Settle, 2001]. In the literature we can find a couple of methods to obtain the factors to correct this type of noise, and they are always based in the application of a filter in some point of the methodology, so that they have an important dependence with the image content. We have developed a new methodology to obtain the correction factors without the use of any filter, and we have demonstrated that these factors are constant during an orbit, using the same factors obtained in the nadir image to correct all the images of the same orbit.

That procedure for the removal of noises in CHRIS/PROBA images has been developed and used for the correction of all the images acquired during the SPARC campaign, but is general enough to be applicable to any other CHRIS data due to the no dependence on the image content. It has been tested in other core sites as Libian desert.

1. INTRODUCTION

Before doing geometric and atmospheric corrections in the CHRIS/PROBA images, it is convenient to apply some algorithms to reduce the noises of the images.

A CHRIS/PROBA image is affected basicaly by horizontal and vertical noises. This paper describes the new methodology developed by DIELMO 3D and the University of Valencia to detect and correct this two different noises in the images acquired during the SPARC campaign, but this methodology can be applicable to other study sites because there is not a dependence with the image content.

2. HORIZONTAL NOISE

Horizontal noise consists in the random loss of partial data from some lines of the images. In the same image, the lost lines appear always in different bands and positions. When that noise appears, there is not a complete loss of the whole line, maintaining a correct value for the even pixels, as we can see in Fig. 1.

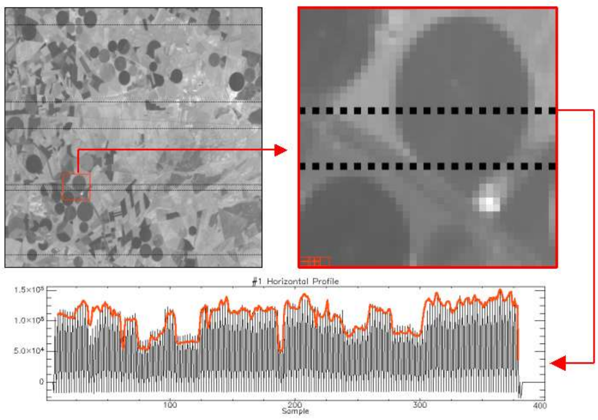

Fig. 1. Horizontal noise in a CHRIS/PROBA image.

Using that property of the noise, it is easy to detect the lines with horizontal noise because they always have a correct value followed by an incorrect value along all the line. To do that, we compare the horizontal profile of each file of the image with the next one. If two adjacent lines do not have this error, their profiles are very similar, but if one of the lines has this error, we obtain the result shown in Fig. 1, where even pixels are similar

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and there is a strong variation in the odd pixels.

Once we have detected the lost lines, we produce a text file with the locations of the erros (band and line), and even pixels for such lines are corrected using the average of the nearest pixels with a correct value (as shown in Fig. 2).

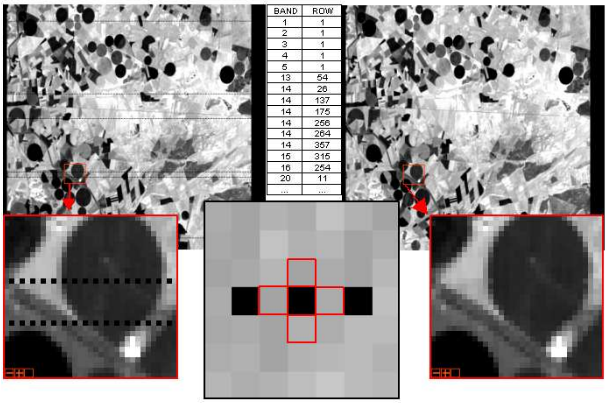

Fig. 2. Correction of the horizontal noise in a CHRIS/PROBA image.

3. VERTICAL NOISE

Vertical noise or vertical striping consists in strong variations in the average value of each column of the image.

Fig. 3 shows an example of this noise:

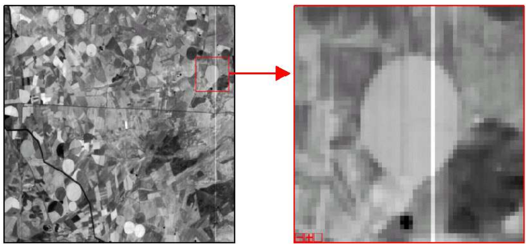

Fig. 3. Example of the vertical noise in a CHRIS/PROBA image.

In the literature we can find a couple of methods to obtain the factors to correct this type of noise. For example, [Settle, 2004] proposes:

- A) For each band, calculate an average radiance for each column of data.
- B) Calculate the logarithm of A (the use logarithms is because this striping is a multiplicative effect).
- C) Apply a low pass filter to B (in order to eliminate the high frecuency variations).
- D) Subtract C from B to obtain only the high frecuency variations, considered as the noise.
- E) Calculate the anti-logarithm of D. The resulting numbers should all be close to one.

At the end of this algorithm, we obtain the correction factors, that are applied to each column of the image to correct the vertical noise.

We have implemented an algorithm based in that procedure, and the results are shown in Fig. 4 and 5.

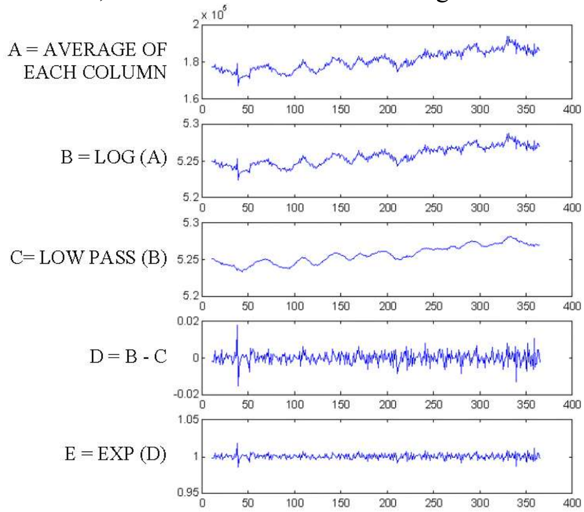

Fig. 4. Procedure for the estimation of the correction factors using the methodology developed by Settle.

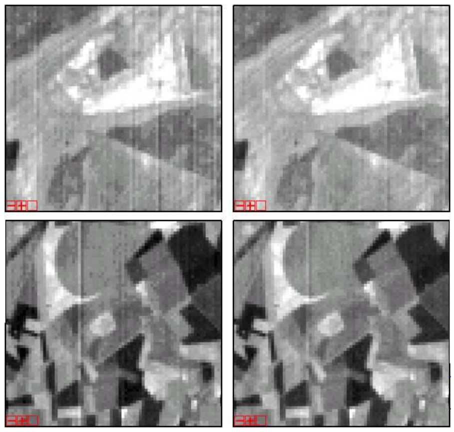

Fig. 5. Results obtained using Settle's methodology.

Fig. 5 shows two original images (in the left) and the correction obtained with the factors of Fig. 4. We can see that part of the vertical noise has been removed, but not completely.

This type of algorithms are always based in the application of a filter in some point of the methodology, so that they have an important dependence with the image content, and they do not always work well if the image has large amounts of bright and dark targets (for example, some coastal images).

4. DIELMO – U.V. METHODOLOGY TO CORRECT THE VERTICAL NOISE.

We have developed a new methodology to estimate directly the correction factors without the use of any filter.

For example, in Fig. 6 we can appreciate that the central column has an important offset regarding the two adjacent columns. The idea is to obtain the mean factor that allows to reduce the offset of the central column, to place it in the theoretical point D between Columns A and C.

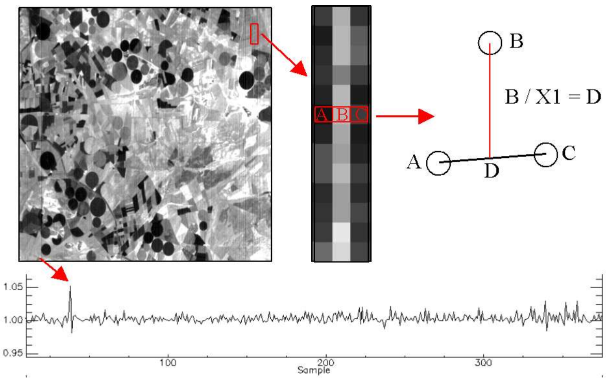

Fig. 6. Correction factors calculation using the DIELMO - U.V. methodology.

To do that, for each band and each column of the image we obtain the average of all the theoretical correction factors (X1) of each pixel of the column. X1 is defined as indicated in Fig. 6.

When we have an important offset over the nearest colums (as in column B of Fig. 6), the correction factor is well estimated usig A and C columns, but it produces an underestimation in the correction factors of the previous and next column (as we can see in the right of Fig. 7). The same case appears if we have an important offset under the nearest columns, producing an overestimation in the correction factors of the previous and next columns

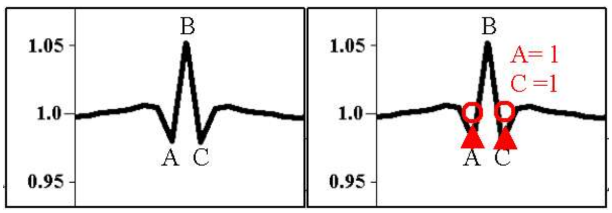

Fig. 7. Underestimation of the correction factors in colums A and C due to an important offset over the nearest colums.

To solve that problem, we detect an important peak in the final correction factors (for example B in Fig. 7) followed by two peaks in the inverse direction (A and C in Fig. 7). As these two peaks in the inverse direction are incorrect, we put them to 1, apply the correction factors to the image and then we calculate the correct factors for the points that were put to 1 and apply the correction again only for that columns.

On the one hand, vertical striping is due to errors in the alignment of the sensors in the construction of the instrument (we can consider these errors as a constant). On the other hand, thermal fluctuations during the orbit causes small variations in the alignment of the optical elements, making that this vertical noise does not stay constant during all the time.

In any case, we can considere that the correction factors are constant during one orbit or more. We have demonstrated that we can use the nadir image to estimate the correction factors in each orbit and apply these factors to the rest of the images of the orbit [Barnsley, 2004] (see Fig. 8).

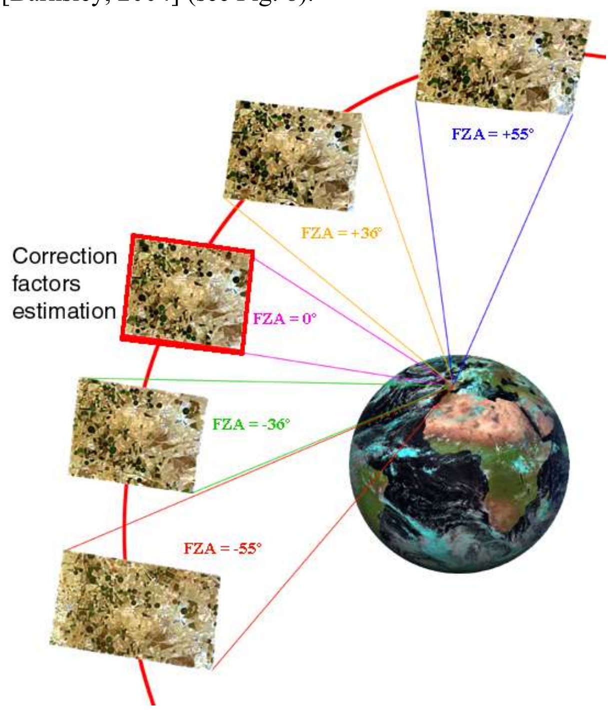

Fig. 8. Viewing angles in a CHRIS/PROBA acquisition.

We can do that because our estimation of the correction factors does not use any filter, and there is not a dependence with the image content. This is an important point in the correction of the vertical striping, because the correction is consistent for all the images of the same orbit, applying exactly the same correction factors.

Fig. 9 shows a zoom of the same part of the images for the 5 viewing angles. Of course in each image the content is different (because changes the angle of overestimation), but the vertical noise is constant because they correspond with the same columns of the image.

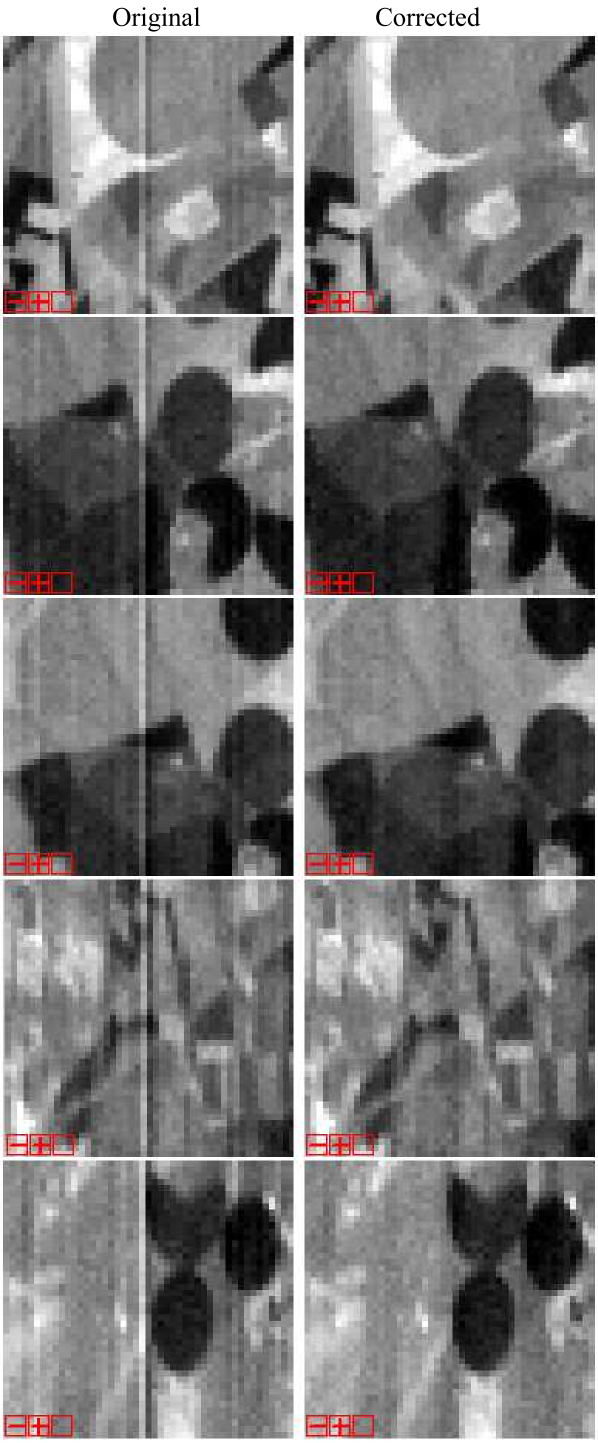

Fig. 9. Correction of the 5 angles of a CHRIS/PROBA image using the factors obtained from the nadir image.

We have observed that this methodology works well in the study area of Barrax, using CHRIS/PROBA images of the SPARC campaign. We also have tested it in other sites as the Libian desert (results are shown in Fig. 10).

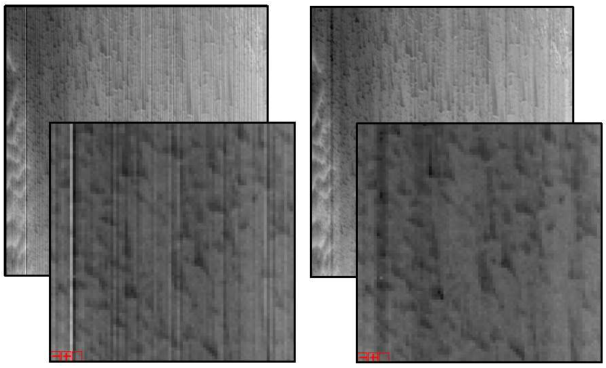

Fig. 10. Correction of CHRIS/PROBA images of the Libian desert (band 10).

Libian desert is a homogeneous area were it is more easy to study noises of the images because there is not a large dependence with the image content. The result shown in Fig. 10, inidicates that we can correct the high frecuency vertical noise, but in the left part of the zoom we appreciate that remains a low frecuency vertical noise (several darker adjacent columns). In the future, we have to solve this problem.

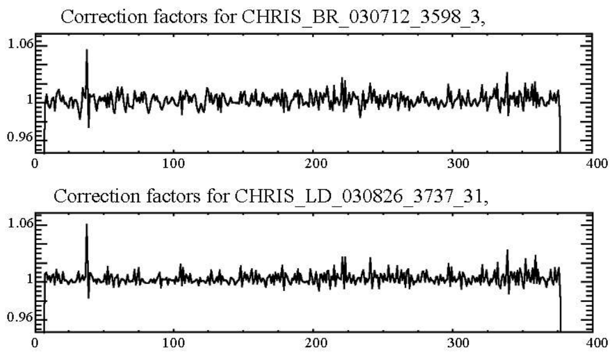

Fig. 11. Correction factors comparition for Barrax and Libiand desert study sites (band 10).

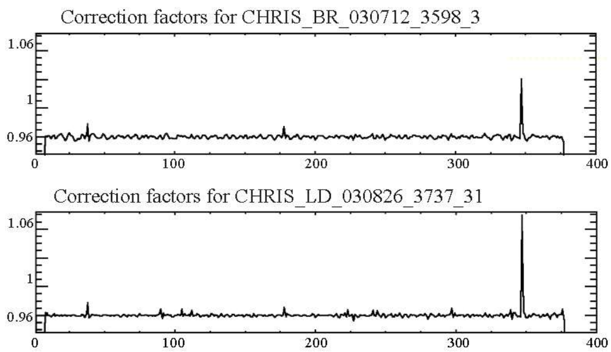

Fig. 12. Correction factors comparition for Barrax and Libiand desert study sites (band 57).

5. COMPARITION OF THE VERTICAL STRIPING CORRECTION PARAMETERS.

Fig. 11 and 12 shows a comparison of the correction parameters of two different images and two different bands.

On the one hand, we can appreciate that there are bands with more noise than others. For example, band 10 is more noisy that band 57.

On the other hand, we also can appreciate, that factors are very similar although they differ in an interval of time of 45 days.

We have said before that vertical striping is due to two main factors: errors in the alignment of the sensors in the construction of the instrument (constant) and thermal fluctuations during the orbit that causes small variations in the alignment of the optical elements (variable).

Looking to the correction parameters for different images and bands (for example Fig. 11 and 12), we can say that the main influence in the vertical striping is due to the constant part of the noise, and that the thermal fluctuations are not very significative (at least in this case).

In the future, we have to study with more detail how the correction parameters change with time, in order to find the way to define standard correction factors for all the CHRIS/PROBA images during a determined period of time.

6. CONCLUSIONS

We have corrected the two main noises in CHRIS/PROBA images: loss of horizontal lines and vertical striping.

On one hand, horizontal lines are easy to detect and correct using the horizontal profile of each file and the average of the nearest pixels to correct the bad values.

On the other hand, we have developed a new methodology to correct the vertical striping that allows to obtain the correction factors without the use of any filter, and we have demonstrated that these factors are constant during an orbit, using the same factors obtained in the nadir image to correct all the images of the same orbit (the correction is consistent for all the 5 angles images).

After the noise correction, the images are ready for geometric and atmospheric corrections.

In the future we have to improve the low frecuency vertical striping, to study with more detail the variations of the correction parameters with time (to try to define standard correction during a determined period of time), and to test with more sites with different spatial properties.

7. REFERENCES

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