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Atmospheric Measurement Techniques Discussions

Interactive comment on "Zernike polynomials applied to apparent solar disk flattening for pressure profile retrievals" *by* E. Dekemper et al.

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Dear Referee,

We would like to thank you for your interest in this work and for the balanced review you submitted. In this review, you raised a number of comments and questions. Please, find our answers in the following paragraphs. We hope our explanations will meet your expectancies.

1 Onboard processing

A projection of the solar images onto a finite basis of discrete Zernike polynomials would reduce the amount of data to be downloaded to ground. This is achieved at the cost of a non-negligible onboard processing power as you noticed. However, as the number of pixels is frozen, the Zernike polynomials do not have to be recomputed each time, and the Zernike moments are obtained after a simple product between the pixels values and the corresponding polynomials amplitude. Higher spatial resolution would only mean a higher number of product operations (directly proportional to the number of pixels involved). We believe this onboard application for solar imagers is worth mentioning but a discussion on practical aspects could not be meaningful in this introduction paper. Though, we agree with the Referee on the need for a careful assessment of onboard processing requirements if this method had to be applied.

2 Error analysis

We agree that the error analysis based on shot noises is very light. However, other sources of noise or image degradation are pretty difficult to implement at the preliminary simulation stage. This should be kept for actual application of the method with real instrumental defects. However, a number of comments can be made concerning general instrumental issues:

- **Dead pixels:** A marginal proportion of dead pixels should not reduce the efficiency of the method as all the pixels illuminated by the solar disk image are considered. These dead pixels should simply be set to a fixed value (zero for instance) and form a frozen pattern that will be captured by the highest Zernike moments and taken into account in the inversion algorithm as a systematic feature of the pictures.

- **Distortion:** Image distortion is also a systematic pattern that can be easily emphasized by Zernike moments. This should allow to either remove the distortion effect from the refractive effect (the flattening) by a correct isolation of the concerned moments, either take it into account in the inversion algorithm.
- **Blur:** In solar occultation geometry, the blur originating from the optical modulation transfer function should result in a somewhat smoother solar limb darkening as the outline of the solar shape would be softened. Again, this feature can be captured by the Zernike moments and should be accounted for in the inversion algorithm.

In order to reflect these aspects in the manuscript, we propose to add a few sentences in the discussion section about the robustness of the method with respect to typical systematic effects such as those mentioned here above.

3 Test cases

The number of test pressure profiles and the fact that they were generated at random is considered afterwards to be not significant enough in the frame of this study. We propose to show results on a larger number of realistic profiles. We will also include a figure showing these profiles and their positioning with respect to the training dataset. Therefore, we expect a somewhat different aspect for figure 6, panel a) as the test cases will be different. However, the conclusions should remain valid.

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4 Vertical resolution

This work has been carried out in the frame of ALTIUS, a future atmospheric mission with some optical aspects quite close to ACE imagers. As many other instruments, the pressure or temperature information, if retrieved, should match the vertical resolution of other retrieved geophysical products. In this case, the target for ALTIUS is not more than 1 km vertical sampling from UT/LS to US. We did not address the vertical resolution issue because our point was to present what is feasible with this new method, based on standard dataset (CIRA-86) and atmospheric grid (US Standard 1976). Regarding the obtained results, the currently achieved vertical sampling is probably coarser than the final product, but no attempt was made to optimize the degrees of freedom of the measurements by changing the number of images along the occultation for instance. This question should be addressed in future developments where the limits of the method would be assessed.

5 Platform attitude requirements

The problem the Referee correctly spotted could be rephrased as the following: how bad would be the consequences if the pictures could not be taken at the foreseen Sun-Earth-Spacecraft angles? It is true that the inversion strategy needs identical situations between the simulations of the lookup table and the actual measurements. A mismatch in the Sun-Earth-Spacecraft angles would critically affect the quality of the retrieved profiles (this is of course also related to the vertical resolution issue). In real conditions, the easiest working solution is probably to take more snapshots than needed by the inversion algorithm and match them afterwards with the required positions. A "nearest neighbour" approach can be followed, or one can take advantage of the Zernike moments once again and interpolate a missing intermediate image by interpolating a sufficiently large number of moments allowing to reconstruct the solar

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shape precisely.

6 Retrieval error decrease at 80 km

Though the results obtained at 80 km are not really meaningful and should probably have been omitted in the manuscript, it is true that we observed most of the time a shrinking of the error at this altitude. First, it is by accident that the effect is so strong: preliminary results on different random samples showed sometimes larger errors at this altitude. Second, the training dataset does actually exhibit a small convergence of the profiles at this altitude, constraining a bit more the retrieval. Finally, in the simulation, the highest altitude of the solar disk center tangent point is also 80 km (i.e. it is the tangent altitude of the first simulated picture). Consequently, the measurements are less sensitive to higher layers and result in an increase of the error again, adding to the narrowing impression at 80 km. The final version of the manuscript will use a different test sample and the retrieval will be bounded to 60 km.

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