Correcting for Long Term Trends in the IRIS Flat Fields
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Abstract
Increasing dose accumulation (“burn-in”) is an expected effect of the exposure of a detector to light of short ultraviolet wavelengths, while exposure to longer UV or visible wavelengths can reverse sensitivity losses. For IRIS, prolonged exposure has resulted in decreased sensitivity and a noticeable burn-in pattern in the lines of C II in the FUV spectrograph and in the FUV slit-jaw, while the NUV spectrograph and slit-jaw channels show increased sensitivity with time. In this poster we examine the long term changes the flat field patterns for the IRIS slit-jaw imager and spectrographs based on monthly calibration sequences. We discuss how the spatially dependent sensitivity changes due to burn-in can be taken into account to improve the calibration of intensity.

1. Spectrograph Flat Fields
Observations for the spectrograph flat fields are taken once a month on regions of quiescent plage near disk center. An average frame is constructed and transformed geometrically to make the spatial and spectral dimensions orthogonal. The spatial and spectral patterns are determined and removed from the original average image. The resulting flat fields do not include changes in sensitivity or the burn-in pattern, which would be removed along with the rest of the spectral pattern.

In order to track the burn-in we turn to the daily synoptic observations of the quiet Sun (“A1”). These are a large 64-step coarse raster taken at or near disk center. The FUV spectra are dark subtracted and the median is taken across the raster dimension. We apply the pre-flight lamp flat field, geometrically correct the resulting frame, divide by the median flat field for the SJI 2796 channel which is representative of the behavior in both channels. Most of the changes are due to thermal flexure of the instrument and the residuals of solar structure in the flat fields. The movies can be found online.

2. Slit-jaw Imager Flat Fields
Slit-jaw flat fields are constructed for each filter channel using the technique of Chae (2004). To obtain flat field observations, the telescope is dithered in a triangular pattern. The telescope is tilted out of focus for the FUV and Mg II 2796 flats to reduce the contrast and provide sufficient counts over the entire detector area. The dither pattern is repeated three times on different areas of quiescent plage. The Chae flat field technique separates the stationary flat field pattern from the moving solar structure, which is done for each pointing, and the three sets of flat fields are combined to produce the final flat field. The region around the slit is removed and replaced with the pattern from the pre-flight lamp flat. Residuals of solar structure are present in the flat field images due to changes in the solar surface during the flat field observation. Combining multiple flat fields could smooth these changes and decrease the noise in the flat field, but changes the spatial sensitivity must be taken into account.

The figure below shows the effect of burn-in in the FUV slit-jaw flat fields. A 2D Gaussian was fit to the central depression in each flat field, this was repeated three times on different areas of quiet plage. The Chae flat field technique separates the stationary flat field pattern from the moving solar structure, which is done for each pointing, and the three sets of flat fields are combined to produce the final flat field. The region around the slit is removed and replaced with the pattern from the pre-flight lamp flat. Residuals of solar structure are present in the flat field images due to changes in the solar surface during the flat field observation. Combining multiple flat fields could smooth these changes and decrease the noise in the flat field, but changes the spatial sensitivity must be taken into account.

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3. FUV Background
The stray light “background” in the FUV spectrograph was discovered after first light. It is a smoothly varying pattern and demonstrates photon statistics consistent with visible or infrared photons. The background characteristics depend on the SJI filter in place, and is probably due to the back reflection of visible and IR light from the filter. The shape of the background pattern changes only slightly with pointing and filter, but it shows an overall intensity variation similar to a smoothed limb-darkening function with a center that is shifted from the IRIS pointing.

The background is characterized on a monthly basis outside of eclipse season by taking deep x 30 observations at 65 pointings arranged in 8 radial spokes about the solar disk. The background image used in calibration is a median of all off-limb pointings. A modified limb-darkening function, smoothed with a Gaussian and with an additional pedestal level added, is fit to the average intensity level of the background as a function of pointing.

The fitted parameters for the modified limb-darkening function are shown on the right as a function of time. Although the intensity of the background changes with time, it does not seem to be affected by dosage accumulation.

4. Conclusions
The flat fields for the NUV spectrograph and slit-jaw imaging channels have changed little with time. It should be possible to construct very high quality flat fields using the calibrations obtained throughout the mission.

The FUV spectrograph and slit-jaw imaging channels are continuously losing sensitivity. Overall sensitivity can be recovered during bake-outs but the burn-in pattern remains and must be accounted for when constructing mission-long flat fields.