Sony ZV-E10 Black-Point Jitter Analysis for AurorEye

April 14, 2026 - Initial version

ZV-E10 and the AurorEye project

The AurorEye project is currently using the Sony ZV-E10 consumer APS-C mirrorless camera for fielded experimental units. This is a USB-controllable, compact, cost-effective, high resolution RGGB Bayer-sensor camera with a fully electronic shutter, and supports use of a suitable Meike 6.5mm f/2 ~190 degree fisheye lens.

Currently, out-of-camera JPGs are captured by AurorEye units in the field, and uploaded by citizen scientists for processing into time- and location-tagged aurora activity timelapses, accessible on a YouTube channel and an offline image archive.

One goal of the project is to migrate to a custom RAW-based image workflow to reduce or remove ‘black box’ image processing decisions by the Sony consumer cameras, which has required some analysis of the raw image data.

Visual Dark-Area Color Jitter

In reviewing timelapses of thousands of frames of AurorEye captures, **occasional sequences would show a visible full-frame flicker in apparent color temperature in very dark and/or uniform skies (Figure 1).** This was evident in all tested camera settings in multiple cameras (i.e. color-processing, shutter behaviour, noise reduction, compression, exposure, ISO, power source, firmware version etc.) Importantly, **this was apparent in the ARW (i.e. Sony RAW) Bayer color filter array data from a test camera, indicating it was upstream of in-camera JPEG processing.**

Image 1 Normal Exposure Image 2 Image 1 Increased Exposure Image 2

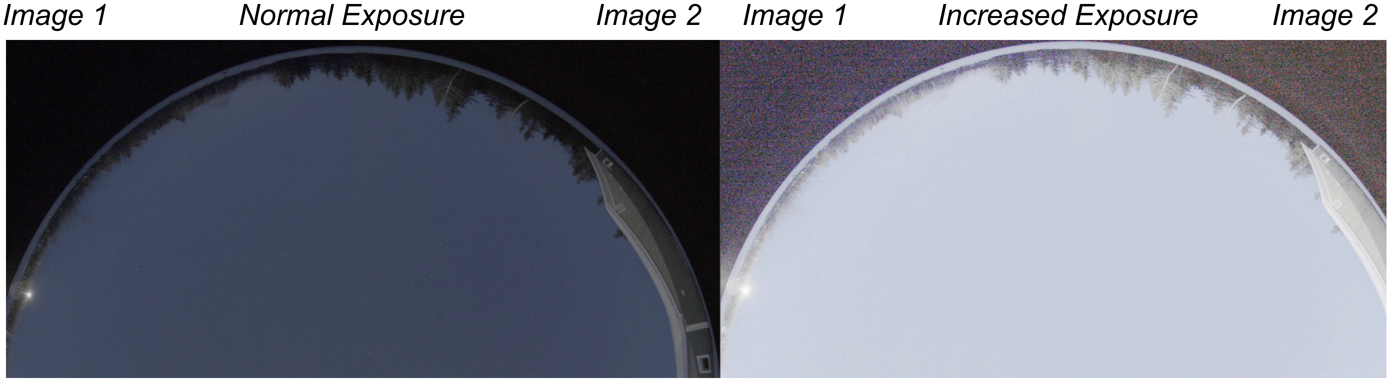

Figure 1. Split view comparison of two sequential frames comparing black point color shift.
Left: Output JPG from camera with consecutive frames in the left and right quadrants.
Right: Boosted to show black point color balance variation in noise.

Note on Sony RAW Image Data format

The ZVE-10, when using electronic shutter and the Sony ARW raw data file format, truncates ADC quantization from 14-bit to 12-bit. Investigation showed the files' Exif data still reports black levels and white levels as 14-bit scaled values for consistency across imaging modes, and a result is that DN count data is quantized to steps of 4 (i.e. 2 bits that are zero'd due to the truncation from 14- to 12-bit). The Exif data also defines a fixed black point of 512DN for all channels.

Hypothesis for mechanism

The hypothesis tested is that there is a 1-2 count jitter in the actual black points for each channel, independent of one another and independent of prior and subsequent frames. This is not [fully] corrected in either the sensor hardware or the camera firmware before storing DN counts to the ARW raw files.

This jitter is 'stepped up' when bit shifting from the 12-bit data to the 14-bit format of the RAW image container. Consumer RAW converters appear to use a hardcoded 512DN blackpoint value in the Exif data for all channels, however the actual per-channel blackpoint may vary +/-4DN or more. (There is no indication that a per channel black point is stored in any Exif tags when examining ARW files with *Exiftool*.)

If, by a roll of the dice, the R and B channels jitter in opposite directions, a noticeable color temperature-like shift in a single frame results, because neither the internal JPEG engine nor external RAW converters use per-channel black point data. This mechanism is consistent with observations that the jitter seems somewhat quantized, seemingly random in time, full-frame, and mainly visible in dark areas of sky.

Analysis

Sampling dark areas of the image frame outside the image circle of the circular fisheye lens can approximate a statistical black point measurement. This allows 10,000 or more sample DN counts per channel, per frame. (We do not have access to the Optical Black pixels that may or may not be a part of the sensor.)

Plotting these as histograms for eight consecutive frames on a test camera, a skewed Gaussian distribution centered roughly around 512DN is apparent for each color channel, with 4DN count quantization (Figure 2).

This data shows median black point per channel does frequently differ from expected 512DN by 4-8DN, and seems at least partially independent (or at least pseudo-random) compared to the other channels in the same image and in other frames captured immediately before or after.

Image Correction Results

Using the per-channel median value of the sampled dark areas as a black point instead of a fixed 512DN does visually improve image jitter when developed through rawpy. However, these medians have the same 4DN quantization as the data, limiting the adjustment fineness.

Working in floating point instead of integer, a skewed Gaussian can be fit to the data and a fractional black point for each channel can be modelled and used in RAW development.

(continued on next page)

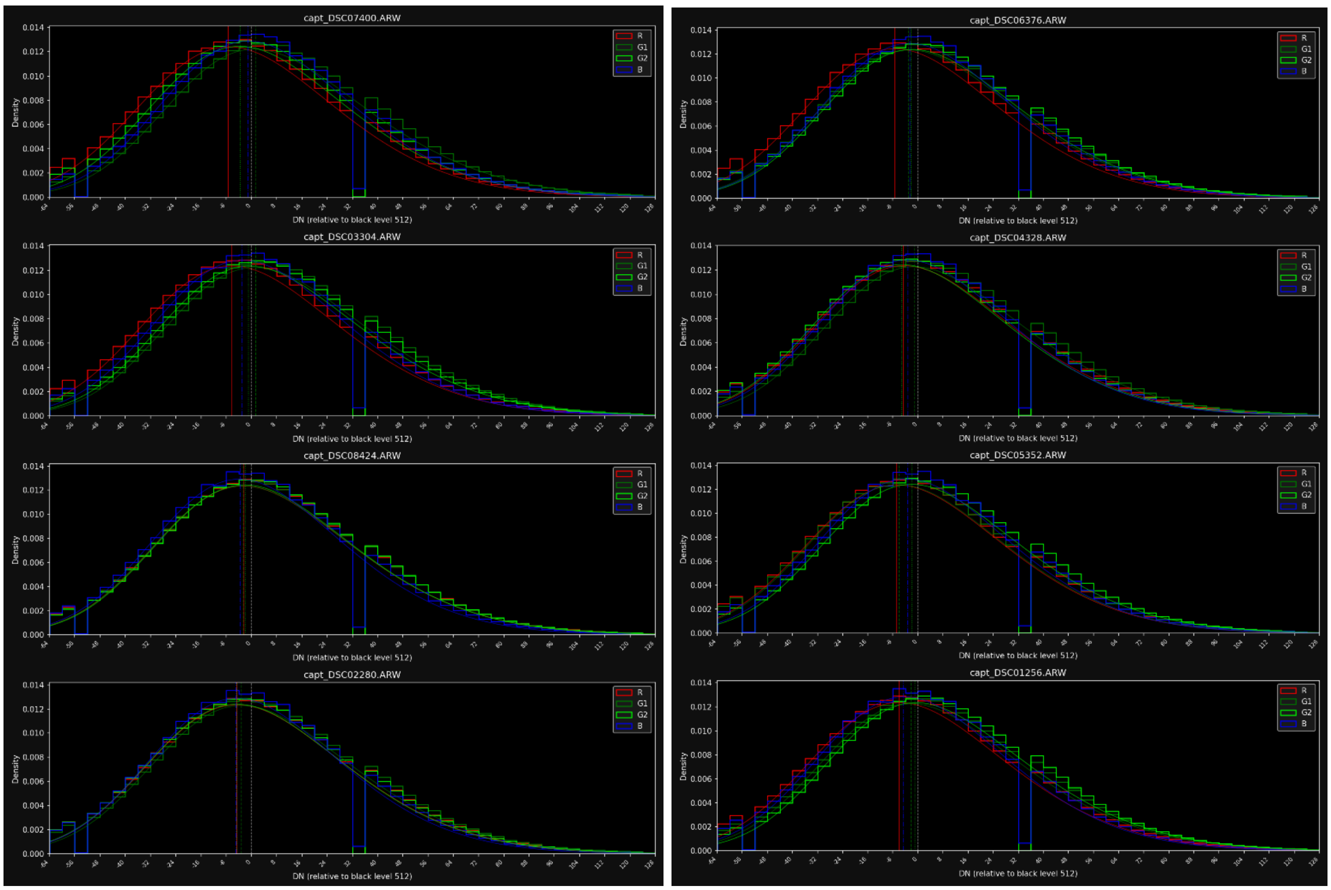

Figure 2. Black-region samples from eight sequential images of a Sony ZV-E10 at ISO 6400, 2-second exposure. R, G1, G2, and B channels histogram of DN counts are shown with corresponding skewed Gaussian fit curves. Vertical lines at the max points of each fitted curve indicate the per-channel black point tested in the raw development workflow instead of a fixed 512DN value. (The count gaps at ~512-56 and +32 are in all sampled raw data, and appear to be a camera artifact, not a histogram binning artifact)

In limited early testing using a Python pipeline and clear, dark-sky images, **this approach seems to noticeably reduce (median black point correction method) or nearly eliminate (Gaussian-fit black point method)** any perceptual color jitter as a significant source of temporal variation. This is a noticeable visual improvement, even in compressed timelapse mp4 video, over both the Sony ZV-E10 internal JPEG engine and a commercial RAW processor (Affinity Photo), both of which appear to use the same fixed black point for all color channels.

Next steps

A near-term goal is to integrate this as part of an AurorEye feature enhancement. This could be deployed as a software update to fielded AurorEye units. Suitable areas outside the image circle would be losslessly preserved in each frame to allow this color-cast removal approach to be used in post processing.

This method may introduce full-frame brightness flicker or other artifacts as a side effect of correction. This was not observed in the limited testing completed, but we do not know exactly what the Sony hardware and firmware are doing to transform sensor readouts to ARW file data.

Thanks

Thank you to Ian Griffin (Tūhura Otago Museum) and Blair MacDonald (RASC Halifax Centre) for discussing this topic and for sharing their ideas, expertise, and experience.

End