Darks, Biases, and Flats, oh my!

Excerpted from Dr. Jim Simonetti's description: http://www.phys.vt.edu/~jhs/SIP/processing.html)

Raw CCD images of the sky must be corrected for a number of "errors" produced by the image taking process. Skynet conducts three procedures to correct raw CCD images for these errors.

Any pixel value in a raw image taken at the telescope is related to the number of electrons collected in that pixel during the exposure. In the ideal case, the number of electrons is exactly proportional to number of photons from that portion of sky imaged onto that pixel. But in practice:

- The number of electrons is equal to the number freed by photons from the sky hitting that pixel AND by **thermal agitation** in the pixel (**the "dark current"**).
- Furthermore, the pixel value is typically **biased** upward from zero by some amount, even before the exposure starts.
- Finally, the number of electrons produced by sky photons is dependent upon the **sensitivity of that particular pixel** to photons hitting it (due in part to variations in structure across the chip, and in part to variations in the telescope itself).

The standard procedures used to correct raw images for dark current, bias, and sensitivity variations are described briefly below:

- **Dark current correction.** Dark current fills each pixel with electrons at a steady rate dependent upon the temperature of the CCD chip. The final number of electrons contributed by the dark current depends upon the temperature of the chip and the length of the exposure.

  The standard way to correct for this added error in the pixel values of a sky image is to subtract an image that contains only the dark current values. The image to subtract is made by taking an exposure of the same length of time as the sky exposure, and with the chip at the same temperature, but **with the shutter closed**: a so-called **"dark image"**.

- **Bias correction.** CCD cameras typically add a bias value to each image they record. If you know that the same specific bias value has been added to each pixel, you can correct for this by subtracting a constant from your sky image.

  Some CCD cameras add a different bias value to each pixel. Correcting for this sort of bias can be done by subtracting a separate dark image (which also has the bias in it) from the sky image.

- **Flat field correction.** To correct for the variation in sensitivity across the chip, the astronomer collects one or more "flat field images" while at the telescope. A flat field image is taken while, for example, pointing the telescope at the sky at dusk (or dawn), or while pointing the telescope at a uniformly illuminated screen. The idea is that any variation in a flat field image records the pixel-to-pixel variation in the sensitivity of the imaging system. Once the raw image of the sky is corrected for any dark current (and bias), a flat field correction can be done.