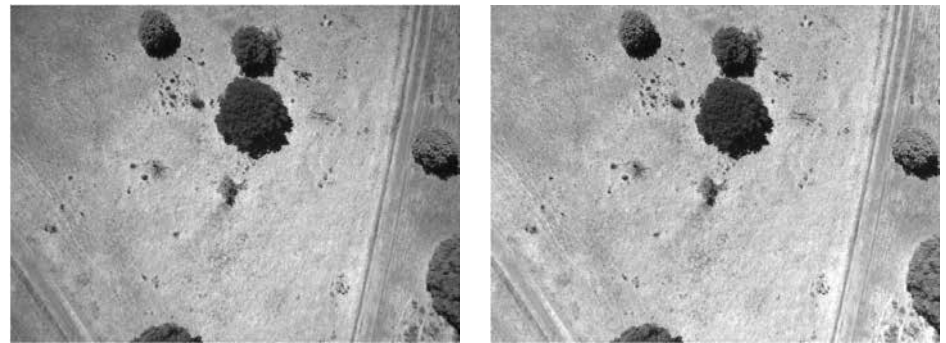# Lens Correction

All camera lenses introduce geometric and illumination artifacts into the acquired images. Artifacts such as geometric (barrel) distortion, vignetting, and transverse chromatic aberration may be especially severe in aerial images acquired by small Unmanned Aerial Vehicles (UAVs), many of which use light-weight, low-cost cameras designed for the consumer market. Removing geometric, tonal, and color artifacts is a prerequisite for creating seamless and geometrically correct mosaics of UAV images.

The Image Lens Correction process in TNTmips is designed to remove common geometric and illumination artifacts in aerial camera images. The process can balance exposure for sets of images acquired with varying camera settings, remove vignetting and transverse chromatic aberration, and correct geometric lens distortion. The process automatically reads required image attributes such as focal length, aperture, ISO speed, and shutter speed from the EXIF tags for the input images and uses an open-source lens calibration library called Lensfun to provide additional correction parameters. Corrected images can be output as RVC raster objects, JPEG files, or TIFF files.
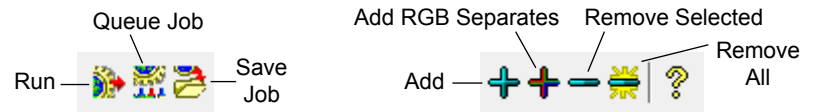


Left: UAV camera color image with severe barrel distortion from a very wide angle lens.
Right: same image after correction in TNTmips for Geometric Distortion.



Left: UAV camera grayscale image with modest vignetting (darkening near the edges).
Right: same image after Flat Field correction in TNTmips.



**Definitions:**

**Barrel Distortion**: a radially-symmetrical lens distortion in which image magnification decreases with distance away from the center. Objects near the edges of the image appear closer to the center than their true position. Straight-line features curve inward as they approach the edges of the image.

**Vignetting**: reduction of brightness toward the image edges due to light obstruction and differences in light paths in the optic system, which depends on lens focal length, aperture, and distance to the subject.

**Transverse Chromatic Aberration**: color fringing along boundaries separating bright and dark areas near the edges of the image. These fringes appear because the geometric distortion introduced by the lens varies with wavelength, so different colors do not focus to the same point on the focal plane.
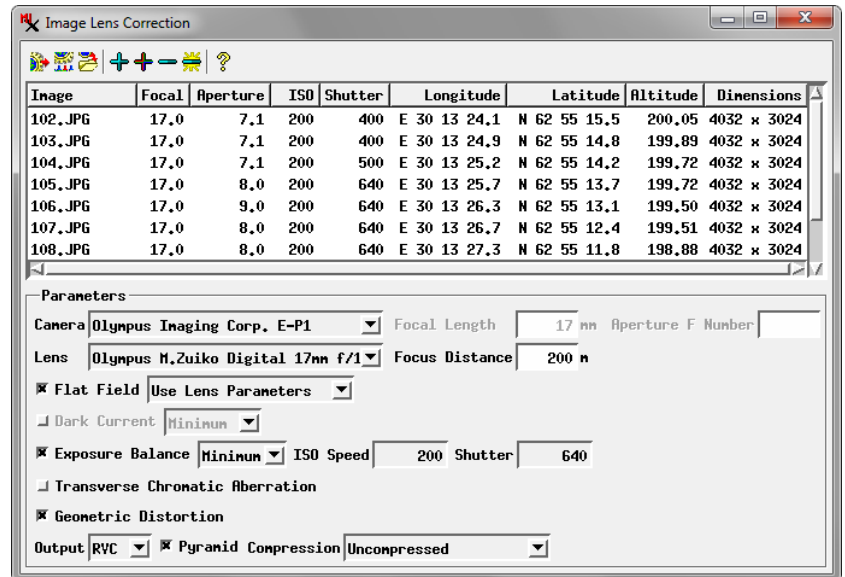
## Image List

Use the Add icon button in the Image Lens Correction window toolbar to add a set of either color-composite or grayscale images. Alternatively, you can add 3-raster color-separate images individually using the Add RGB Separates icon button. You can add camera images saved in common formats such as JPEG and TIFF, or images that have been previously imported to TNTgis Project Files. The selected images are added to the Image list, which has columns for the image name and for the image properties automatically read from each image's EXIF tags, including camera/lens

parameters, image dimensions, and, if the images are geotagged, longitude, latitude, and altitude.

You can left-click on any image list entry to select it; the selected entry is highlighted in black. Press the Remove Selected icon button to remove a selected image from the input list; press Remove All to clear the list.

## Camera and Lens Parameters

When you choose the input images, the camera make and model are read from the image EXIF metadata. If this information matches a camera in the Lensfun database, the Camera and Lens combobox fields in the Parameters box are automatically filled in. If the camera has a removable lens mount, you can press the arrow icon button on the Lens combobox control to open a menu of the available lenses for the camera. If you are not sure of the lens used, the focal length and aperture values shown in the image list may indicate which of the available lens selections matches the images.

If no match is found in the Lensfun database for the camera make and model, a Select Camera and Lens window automatically opens and shows the list of supported cameras. If you find an equivalent camera in the list, select it to populate the list of lenses in the window; select the lens and press the OK button. If no entry in the supported list matches the camera, press the Cancel button; the images are not added to the list and you cannot perform the lens correction.

If your camera or lens is not in the Lensfun database, you can submit test images to the Lensfun Calibration Service for calibration and addition to the database. For more information see the Lensfun Lens Calibration website:
**http://lensfun.sourceforge.net/calibration**

If Focal Length and Aperture values were not found in the EXIF tags for the input images, the corresponding fields to the right of the Camera menu are editable, allowing you to enter these required values, assuming that the same settings apply to all of the photos.

The value in the Focus Distance field is used in the Flat Field (vignetting) correction. If the exact focus distance is not known, enter a value equal to or greater than the average altitude of the camera platform, or accept the default value of 1000 meters.

## Lens Corrections

The suite of potential lens corrections that can be applied are Flat Field (vignetting), Dark Current, Exposure Balance, Transverse Chromatic Aberration, and Geometric Distortion. Corrections are applied in that order; turn on the toggle button for each correction you wish to apply. If the parameters necessary for a correction are not available in the Lensfun database (or in the image EXIF tags for the Dark Current correction), then that correction cannot be applied and its controls are dimmed and inactive.

### Flat Field (Vignetting)

Two methods are potentially available from the Flat Field menu for correcting vignetting.

**Use Lens Parameters**: This method uses a mathematical model of the variation in light intensity due to vignetting, with coefficients in the Lensfun database that were derived from tests at various camera settings. This method is only available if there are correction parameters in the database for the lens and exposure settings.

**Multiply by Reference**: This method requires the use of a reference raster derived from a *flat field* image, an image of a target with uniform color and brightness, so that all brightness variations are solely due to vignetting. The flat field image should be acquired with the same camera and lens settings as the images to be corrected. From the flat field image, compute a scaling factor for each image cell to boost the brightness of the darker edge cells to match the brightness in the center of the image. The resulting scaling factors should be stored in a reference raster for use in the Multiply by Reference method. When you choose the Multiply by Reference method, you are prompted to select the reference raster to use for the correction.

### Dark Current

The Dark Current correction controls are active if multiple dark current values are found in the image EXIF metadata. *Dark current* is the signal recorded by the camera sensor elements when not exposed to light. If not automatically corrected by the camera firmware, the dark current value should be subtracted from the brightness values recorded during a camera exposure. Some cameras report multiple dark current values; the Dark Current menu allows you to choose to correct brightness using the Minimum value or using a Bilinear method. The latter method assumes that four reported dark current readings represent the four corners of the image, and applies a bilinear interpolation from the reported values to compute a dark current value for each image cell.

### Exposure Balance

The Exposure Balance controls allow you to adjust for the differing relative brightness of images that were acquired with different ISO and Shutter settings. The process computes an exposure value for each image by dividing the ISO value by the shutter speed. The Exposure Balance menu lets you adjust the images to the Average, Minimum, or Maximum exposure value; the shutter value corresponding to your selection is shown automatically in the Shutter field. If you choose the Manual option from the Exposure Balance menu, the ISO and Shutter fields are editable so you can enter specific values for the adjustment. This correction is unnecessary if all images were acquired with the same exposure settings.

### Transverse Chromatic Aberration and Geometric Distortion

These methods correct for color artifacts and barrel distortion, respectively; they have no user-defined parameters. These methods are selectable if correction parameters are available in the Lensfun database for the selected camera and lens.

### Output Settings

Use the Output menu to choose the format for the corrected images. Choose RVC to save the images as raster objects in a TNTgis Project File; EXIF image information is automatically saved in a metadata subobject for each image. Alternatively, you can choose to output either JPEG files or TIFF files. EXIF tags are automatically saved to output JPEG files.

### Running the Process

When you have set the processing parameters, press the Run icon button to run the process immediately. Standard Queue Job and Save Job icon buttons are also provided to allow you to execute the process using the TNTmips Job Process system (see the Technical Guide entitled *System: TNTmips Job Processing System*).