

# Airborne Post Processing Summary

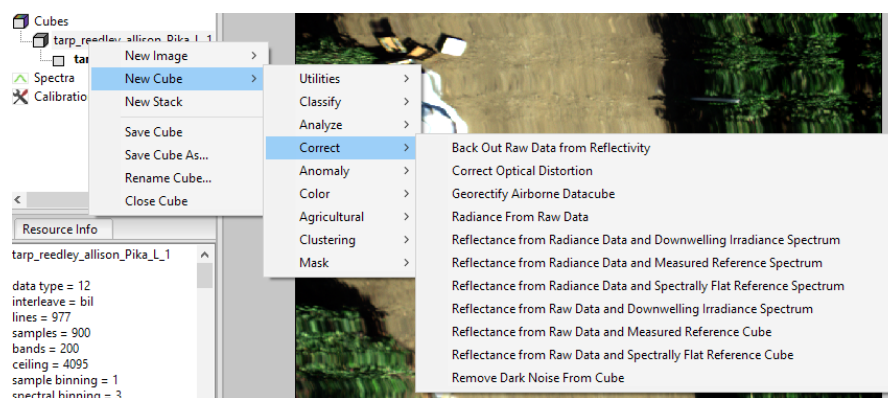
## Transfer Data

To transfer the data from the flight computer to a PC, simply unplug the USB cable from the SSD and remove the SSD from its mount on the flight computer, then plug the drive into a Windows computer to transfer.

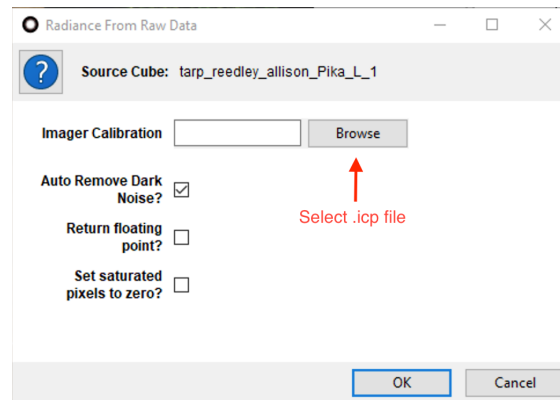
## Convert to Radiance or Reflectance

### Radiance

1. With Spectronon, open the airborne datacube to convert.
2. Right click on the datacube to convert in the Resource Tree in the left-hand side of the main Spectronon window. Select New Cube -> Correct -> Radiance from Raw Data.



3. In the resulting window, select the name of the radiometric calibration pack ('.icp' extension), then press OK. The resulting cube will be in units of microflicks (1 microwatt per steradian per square centimeter of surface per micrometer of span in wavelength,  $\mu\text{W}\cdot\text{sr}^{-1}\cdot\text{cm}^{-2}\cdot\mu\text{m}^{-1}$ ).
4. Optionally, saturated pixels can be set to zero as the saturation state of pixels is lost after radiance conversion.



## Reflectance via Downwelling Irradiance

1. Open the airborne datacube to convert.
2. Optionally, open the downwelling irradiance spectrum to be used. The plugin can also automatically use the downwelling spectrum in the airborne datacube folder for Resonon calibrated downwelling sensors.
3. Right click on the datacube to convert in the Resource Tree in the right-hand side of the main Spectronon window. Select New Cube -> Correct -> Reflectance from Raw Data with Downwelling Irradiance Spectrum (of Reflectance from Radiance Data with Downwelling Irradiance Spectrum, depending).
4. If the downwelling sensor was radiometrically calibrated by Resonon, select Resonon Calibrated and the appropriate DCP calibration file in the Downwelling Calibration field.
5. If a third-party sensor is to be used, select the units the sensor outputs in the drop-down menu and the downwelling spectrum from the sensor.
6. By default, the plugin will correct for dark current using the ICP and DCP calibration files (for Resonon calibrated systems). If it is preferred to use a previously measured dark current during the correction, unselect the Auto Remove Dark Noise and choose the measured dark current cube or spectrum.
7. Press OK. The resulting cube will be in Reflectivity on a scale of 0 to 1, 0-10,000, or Bit Depth depending on preferences.

The downwelling sensor can be operated on the ground for short flights around a local area. This option saves weight while adding minimal complexity. To do this, collect data with the downwelling sensor using Ocean Optics' OceanView software. The cosine corrector should point up with a clear, hemispherical view of the sky. Save the spectra as a text file and use the Open Spectrum (select Text (.txt) format in drop down menu) option in Spectronon to import the data. This spectrum can now be used in the above procedure.

## Creating and using Correlation Coefficients

If you have both downwelling data and reflectance standard data, a correlation coefficient spectrum can be created to better control for the additional calibration uncertainty that the downwelling sensor

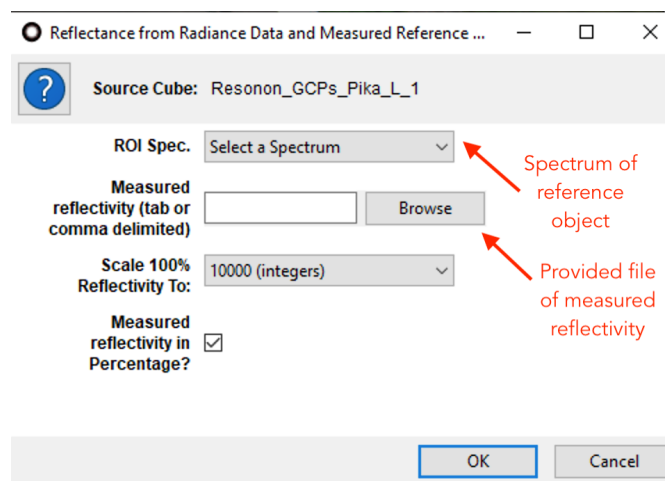
introduces. In this manner, you can take advantage of the capability of the downwelling sensor to continuously monitor irradiance, and the accuracy advantages of using a ground reference standard.

1. Open a datacube containing the reference standard.
2. Convert this cube to reflectance using the Reflectance from Raw Data and Downwelling Irradiance Spectrum (or Reflectance from Radiance Data and Downwelling Irradiance Spectrum).
3. Use the selection tools to create a ROI of the tarp. Right-click and select Create Correlation Coefficients.
4. Select the file containing the measured reflectance of your standard.
5. Use this spectrum in the either of the Reflectance from Downwelling Irradiance plugins to better control for calibration uncertainty in the conversion process.

## Reflectance via Reflectance Reference

If there is an object in the scene of measured reflectivity, it can be used to convert the data to reflectivity via the following steps.

1. Convert data to units of radiance using the Radiance from Raw plugin.
2. Select ROI of object of known reflectivity and create a Mean Spectrum.
3. Select New Cube -> Correct -> Reflectivity from Radiance Data with Measured Reference Spectrum.
4. Press the Measured Reflectivity button and select the file containing the reflectivity measurements. This file should be a tab or space delimited, with wavelength units in nanometers.



5. Select the desired scaling factor (0-10000, 0-1, or bit depth)
6. Press OK

If the reflectivity of the reference is spectrally flat over the wavelength range of interest, you do not need to use a Measured Reflectivity file. Instead, you can use the Correct from Reflectivity from Radiance Data and Spectrally Flat Reference Spectrum plugin and specify the flat reflectance value of the reference (0-1).

## Create Data Product (Analyze, Classify, Etc)

After processing the data to units of radiance or reflectivity, the next step is typically to create one or more output products (process *data* to *information* relevant to your experimental goal) Please see the document titled *Processing Data with Spectronon* for information on processing techniques. The data product(s) can then be georectified in order to rectify the images and assign a geographical location to each pixel. Raw, radiance, or reflectivity data can also be georectified and the results processed to output products, but this approach is less common and has the disadvantages of larger file sizes and slower processing times.

## Georectify

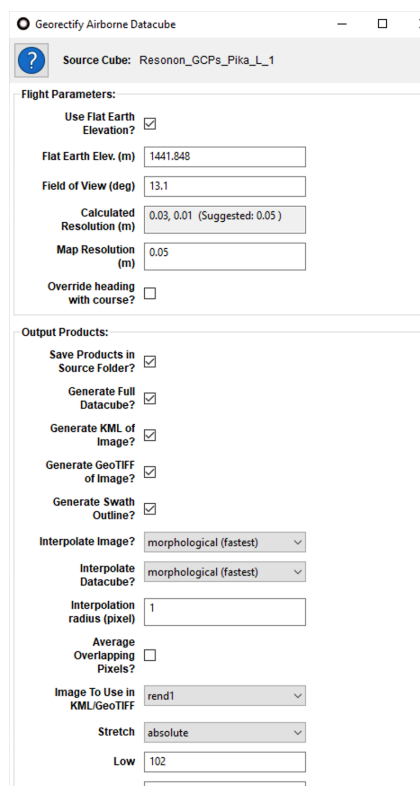
1. Launch Spectronon.
2. Open the datacube to geo-correct. If units of radiance or reflectivity are desired, these operations should be performed first as the conversion to radiance is not possible after georectification.
3. Right-click on the datacube and select New Cube->Correct->Georectify Airborne Datacube.
4. The georectification plugin needs to know the ground altitude of the image area. This can be done using the assumption of a flat area at a known altitude or by using a Digital Elevation Map (DEM). If using a DEM file instead of a Flat Earth Altitude, uncheck the Use Flat Earth checkbox and select the DEM file to use. DEM formats supported by GDAL ([www.gdal.org](http://www.gdal.org)) are supported by this plugin. If using Flat Earth Altitude, enter the value in meters of the ground altitude. In general, the resolution and accuracy of freely available DEMs such as SRTM is not sufficient for low altitude flights and a flat earth altitude should be used instead. **NOTE:** The SBG Ellipse GPS/IMU uses the EGM96 geoid for reporting MSL altitudes. Use this reference datum for both Flat Earth altitudes and DEMs for best results.
5. Enter the FOV of the instrument/objective lens combination. Charts of these values are shown at the bottom of this document.
6. Enter the desired resolution (in meters) of the end products. The Calculated Resolution numbers (cross track, along track) provide a minimum value, but typically a larger number is used to account for aircraft instabilities and avoid large amounts of interpolation.
7. Optionally, the magnetometer heading can be overridden with course (direction of path of aircraft). This can result in better georectification if the heading data are unreliable and the imaging system is aligned to the course.
8. By default, all output products except for the datacube will be saved in the source folder. If this is not the desired behavior, unselect the Save Products in Source Folder and select another folder. **NOTE:** When using the Batch Processor with this plugin, output products will still be saved according to this preference. Datacubes generated by this plugin will be saved by the preference selected in the Batch Processor.
9. Select the desired output data products. The swath outline simply shows the outline of the imager FOV. This can be useful to show the coverage and direction of flight. Please note that only the Full Datacube will show up in the Spectronon file tree, all other products are generated and saved without any visible indication.



10. Select the desired interpolation option for both the images and datacube, if applicable. The 'inpaint' interpolation method is the fastest. Interpolating full datacubes can be slow.
11. If you have multiple renders of a datacube open, you can choose which render you would like to use for KML/GeoTIFF. You can also choose to apply a stretch or not. Renders are not shown by name, rather by 'rend0', 'rend1', etc, in the order they were created in. You must match up the order of the render desired by looking in the Spectronon file tree.

**NOTE:** If mosaicing renders or datacubes made with the Georectification plugin, it is important to only use the Linear Absolute Stretch with the same Low/High cutoff values across all renders/datacubes or the brightness and colors of each will not be consistent within the mosaic.

12. If there is a known time offset between the imager and GPS/IMU, enter the value (in seconds) in the Sync Offset field. This value is typically left at 0.
13. Enter any known angular offsets (in degrees) between the imager and GPS/IMU in the appropriate fields. Read the section below on Biases to determine sign convention.
14. If you would like to only georectify a portion of a datacube, check the Crop Cube to Start/End Lines and enter starting and ending line numbers. Care must be utilized if using this feature in the Batch Processor as cubes may have different numbers of lines.
15. Press OK.



Georectify Airborne Datacube

Source Cube: Resonon\_GCPs\_Pika\_L\_1

**Flight Parameters:**

Use Flat Earth Elevation? ☒

Flat Earth Elev. (m) 1441.848

Field of View (deg) 13.1

Calculated Resolution (m) 0.03, 0.01 (Suggested: 0.05)

Map Resolution (m) 0.05

Override heading with course? ☐

**Output Products:**

Save Products in Source Folder? ☒

Generate Full Datacube? ☒

Generate KML of Image? ☒

Generate GeoTIFF of Image? ☒

Generate Swath Outline? ☒

Interpolate Image? morphological (fastest)

Interpolate Datacube? morphological (fastest)

Interpolation radius (pixel) 1

Average Overlapping Pixels? ☐

Image To Use in KML/GeoTIFF rend1

Stretch absolute

Low 102

High 2024

The table below lists the FOV of Resonon imagers with different objective lenses. This information is necessary for the georectification software. It is not exact and may need to be adjusted for your particular imager.

## *Pika L*

Focal Length (mm)	FOV (deg)
70	4.3
50	6.0
23	13.1
17	17.6
12	24.8
8	36.5
6	47.5

## *Pika XC2*

Focal Length (mm)	FOV (deg)
70	7.7
50	10.7
23	23.1
17	30.8
12	43.7
8	60.8
6	76

## *Pika NIR 320*

Focal Length (mm)	FOV (deg)
75	7.3
50	11.0
25	21.7

## *Pika NIR 640*

Focal Length (mm)	FOV (deg)
75	7.3
50	11.0
25	21.7

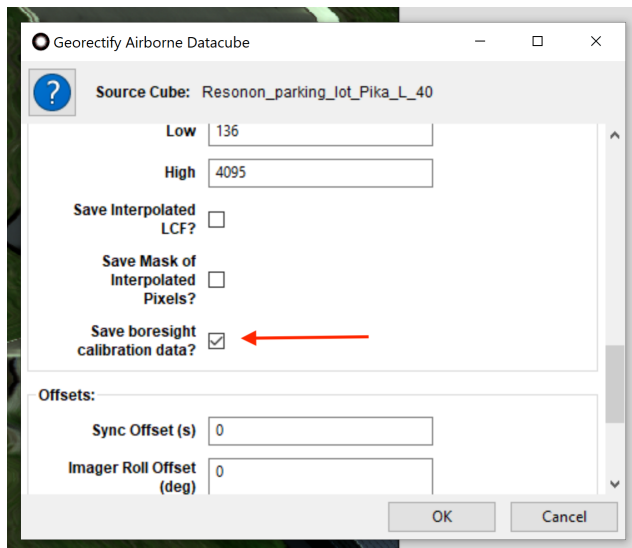
## Biases

If there are angular offsets between the GPS/IMU and the spectral imager, they can be entered and corrected for. These angles are measured from the GPS/IMU to the imager, following the following sign convention: Right wing up is positive roll, nose up is positive pitch, and clockwise looking down is positive yaw. The effect on the georectified image is the following: Positive roll bias shifts image to left (direction of flight is forward). Positive pitch bias shifts image back (again relative to flight direction). Positive yaw bias rotates lines counterclockwise.

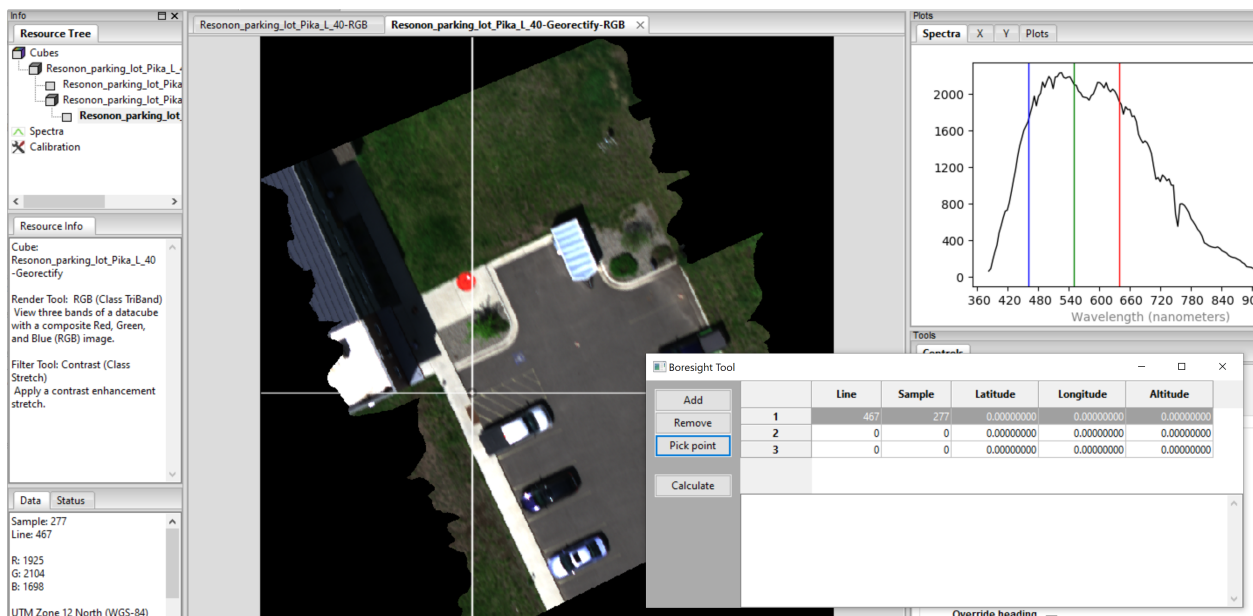
## Calculated biases with surveyed fiducials and Spectronon's Boresight Tool

Below is short summary of the use of the Boresight Tool. For more information, see the Airborne User Manual.

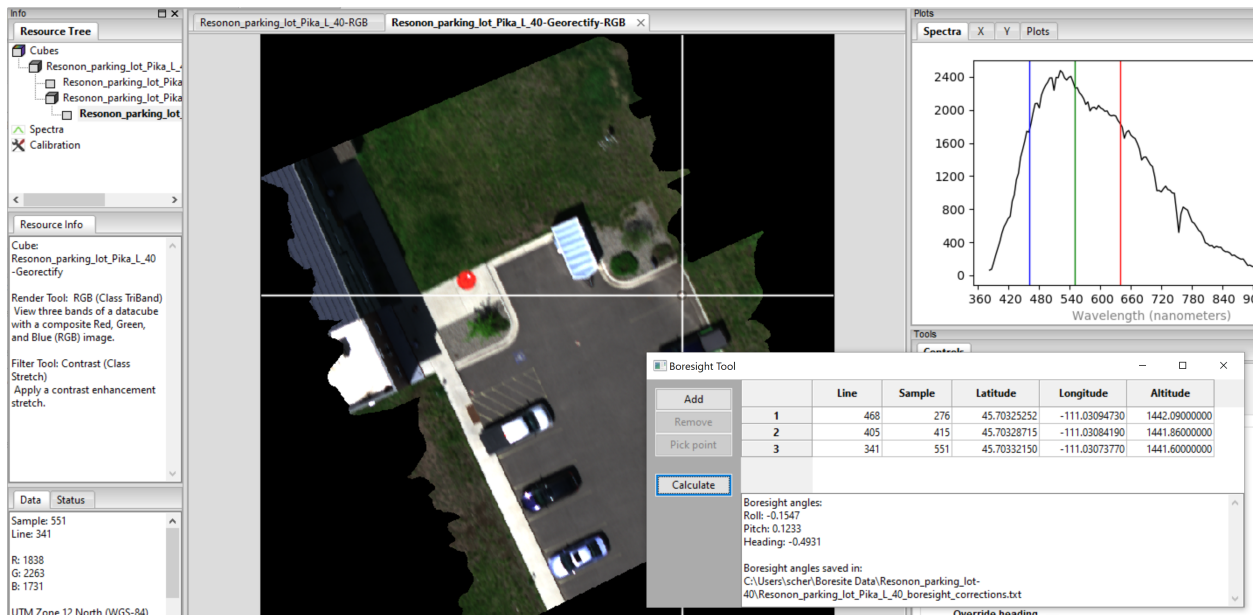
1. Georectify the dataset containing surveyed fiducials/GCPs, being sure to check the *Save boresight calibration data?* box.



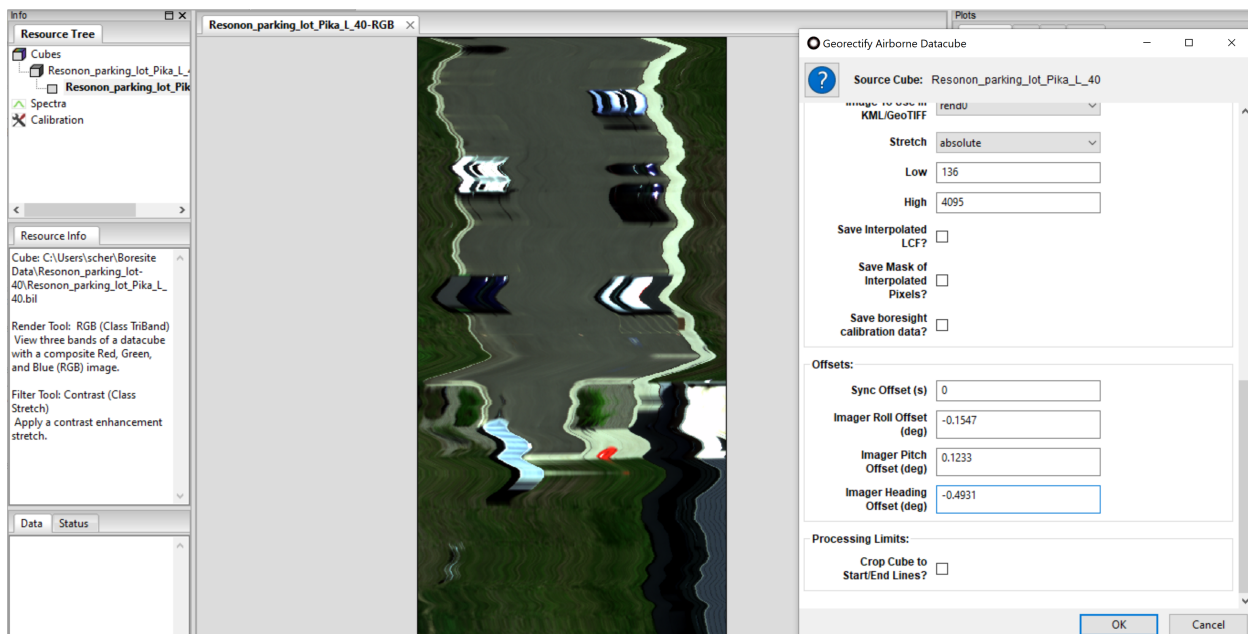
2. Once the georectified image appears, use the Spectronon menu to select Image, Airborne Boresight Tool. . .
3. In the dialog window, click Add to add a line for each GCP.
4. Click on the number (1, 2, or 3. . .) at the left of the line to select that line.
5. Click on Pick point in the vertical menu on the left side of the dialog window



6. Use the Inspection Tool of the top tool bar to select the location of the GCP in the image. This will automatically populate the Line and Sample columns with the correct values.
7. Manually enter the Latitude (in degrees), Longitude (in degrees), and Altitude (in meters) of surveyed coordinates of the GCP.
8. Repeat steps 4 through 8 for each GCP.
9. Click Calculate on the left in the dialog window.
10. The boresight correction angles will appear below the lines in the dialog window and also saved in the stated location.



11. You have now determined the correct georectification angles for your imager/IMU system. Use those angles for all future georectification procedures when precise geolocation is required, as per the instructions below.
12. To apply the boresight angles in the Georectify Airborne Datacube plugin, enter the boresight angles under Imager Roll Offset (deg), Imager Pitch Offset (deg), and Imager Heading Offset (deg).



### Estimating biases without surveyed fiducials

To determine which direction the altitude is flying from the georectified image, use the plugin to generate a Swath Outline KML and open it. The green line represents the beginning of the datacube.

To measure biases, fly the system over a fiducial landmark from multiple directions and georectify the data. Any offsets of the geocorrected images versus the fiducial are a combination of GPS error and bias. Try to eliminate the effects of GPS error by looking at the same image taken from different flight directions. Then measure the remaining offset as a distance, then convert to angle with simple geometry and knowledge of aircraft height.