

Spatial Resolution Assessment of BlackSky, SuperDove and WorldView-2/-3

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Introduction

NASA's Commercial Satellite Data Acquisition (CSDA) Program was established to identify, evaluate, and acquire data from commercial sources that support NASA's Earth science research and application goals. These data augment and/or complement the suite of Earth observations acquired by NASA and other U.S. government agencies and those by international partners and agencies.

Image data from commercial satellite companies, PlanetScope (PS) from Planet, WorldView (WV) from MAXAR, and BlackSky (BSG) are available for U.S. Government Federal civil agencies and National Science Foundation funded researchers. As the capabilities of commercial satellite vendors grow, NASA's Earth Sciences Division will continuously monitor the development of these companies.

Here we evaluate PS, BSG, and WV for effective footprint size. Band-to-Band registration (BBR) is evaluated with a new cross-hair method explained below.

Information about these vendors, user licenses, and data is available on the Commercial Datasets web page [1]. As additional commercial small satellite datasets are evaluated and acquired, those datasets will also be made available.

Objectives

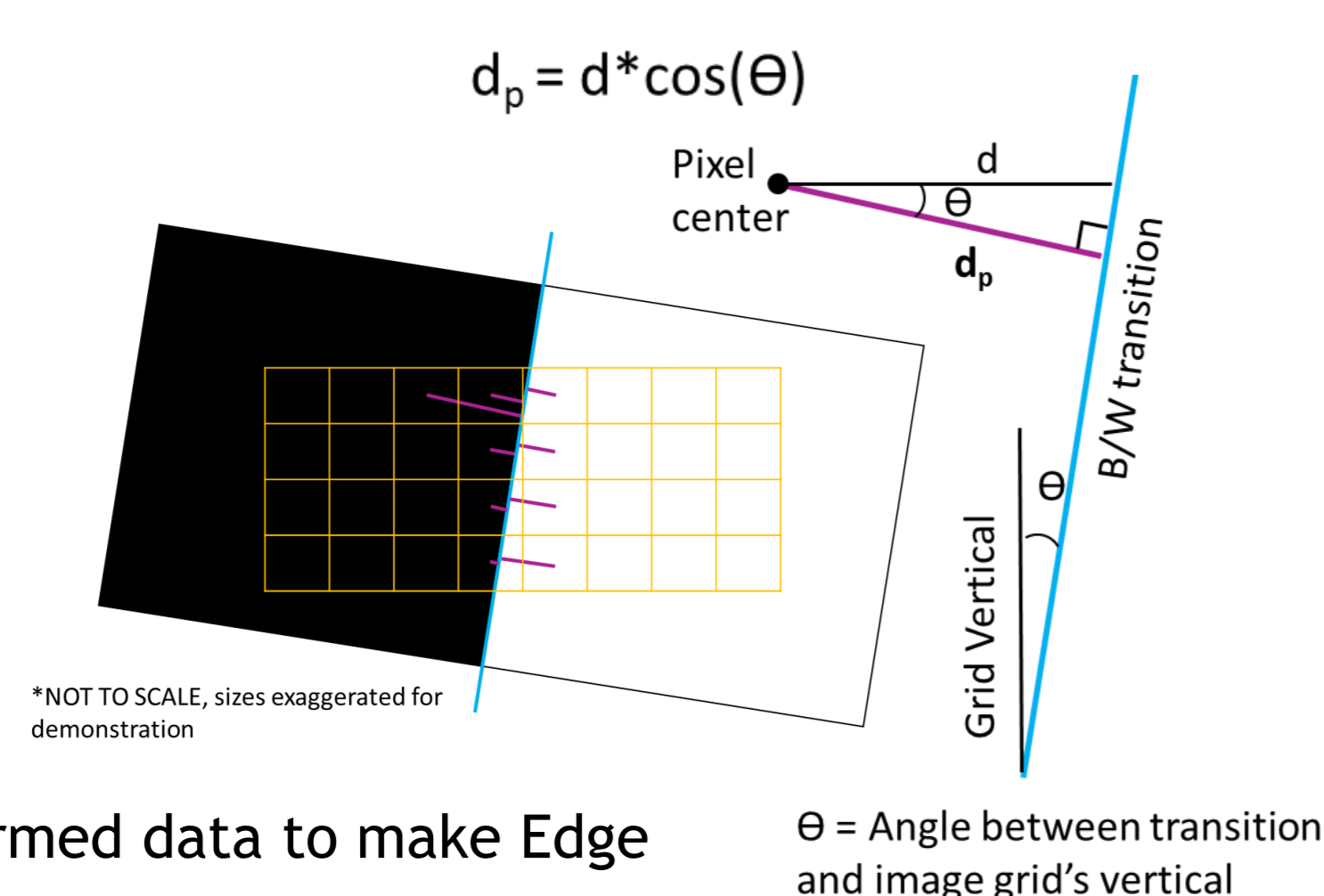
- Calculate and compare image footprint size for PS, BSG, and WV.
- Evaluate all sensor's BBR at the Cal/Val site.
- Introduce the cross-hair method for BBR evaluation.

Methods

Footprint Size

Step 1. Define a line as the transition from black to white (blue line in diagram to the right)

Step 2. Calculate perpendicular distance from pixel center to blue line (purple lines in diagram, d_p),



Step 3. Fit a polynomial to the transformed data to make Edge Spread Function (ESF).

Step 4. Calculate derivative of ESF to find Line Spread Function (LSF). Resolution metric, full width at half maximum (FWHM), is calculated here.

Step 5. Fourier transform the LSF to find Modulation Transfer Function (MTF). Calculate resolution metrics MTF at Nyquist and Ground Resolved Distance (GRD, where $MTF(1/(2GRD)) = 0.5$) here. These results are not shown on this poster.

Cross-Hair BBR

Step 1. From Step 4 above, switch the band examined and record the offset of the peak in the LSF. This is the band offset in the tilted coordinate system.

Step 2. Transform the offsets into the column/row coordinate system with the pair of equations below:

$$x_T = x_{off} \cos \theta + y_{off} \sin \theta$$

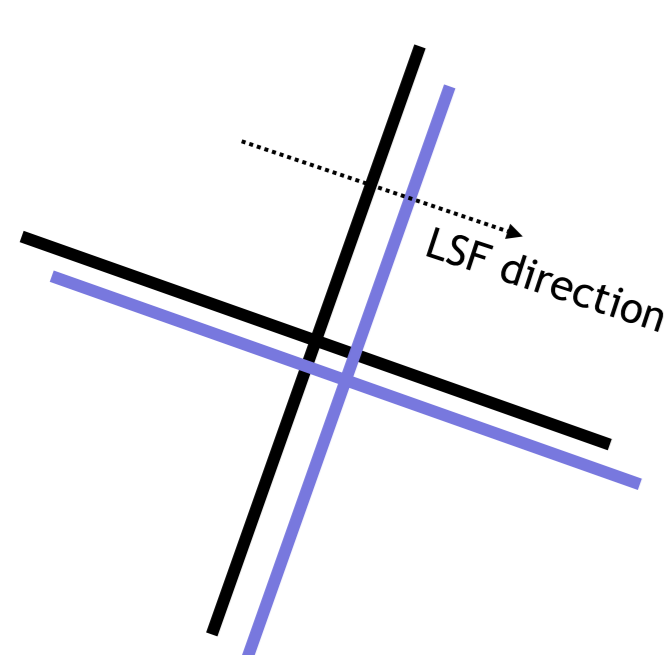
$$y_T = y_{off} \cos \theta - x_{off} \sin \theta$$

x_T = the true x direction offset in the image grid reference frame
 y_T = the true y direction offset in the image grid reference frame

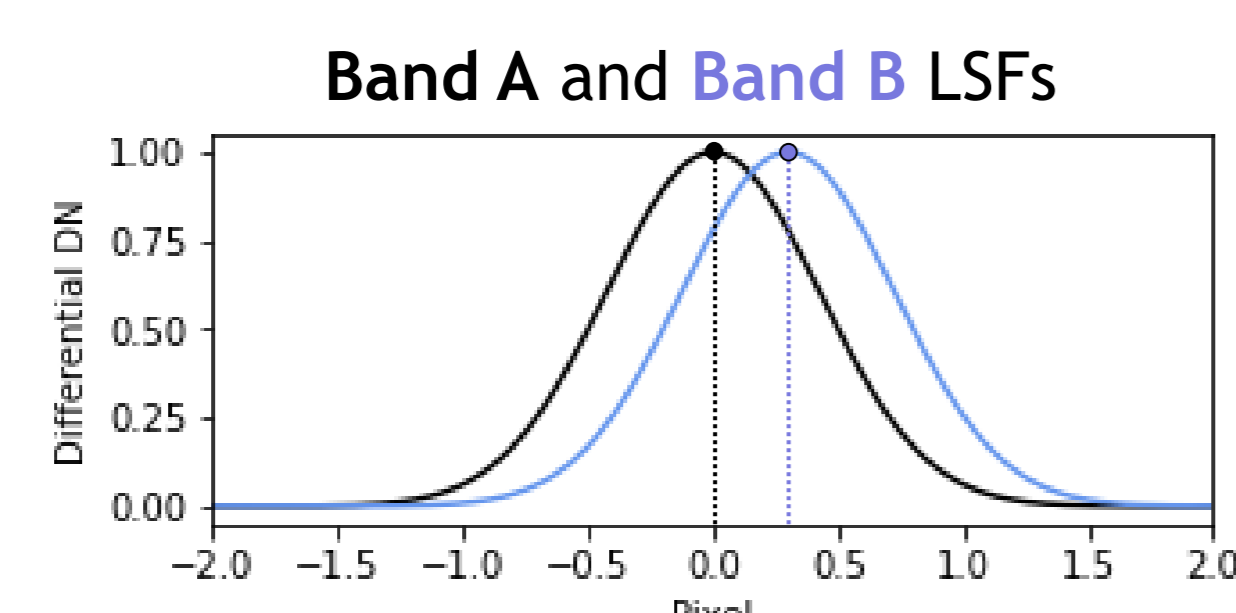
θ = angle between the B/W transition line and the image's grid

x_{off} = measured x offset in the slanted squares reference frame
 y_{off} = measured y offset in the slanted squares reference frame

Visual Demonstration

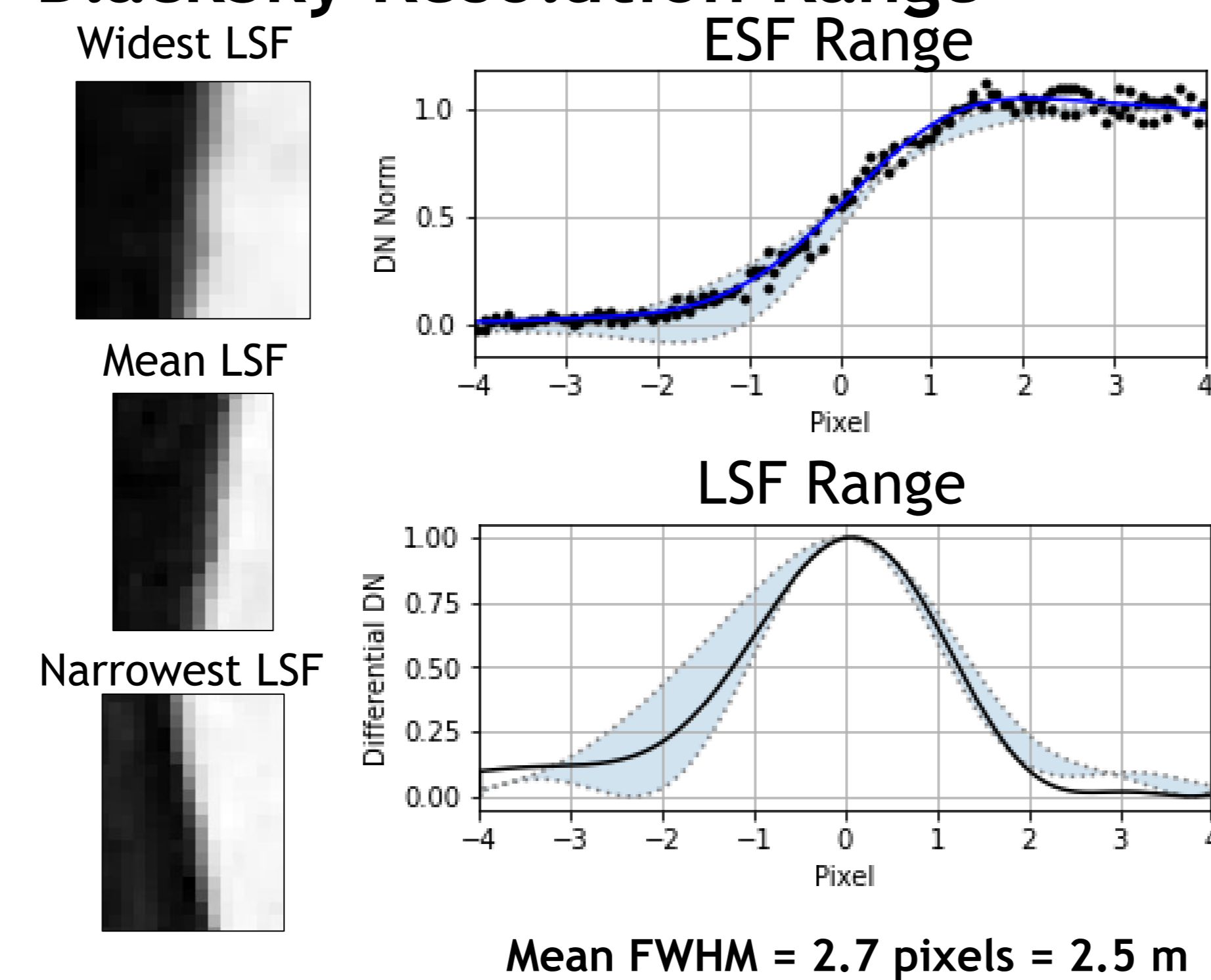


Band A's and band B's cross-hairs.



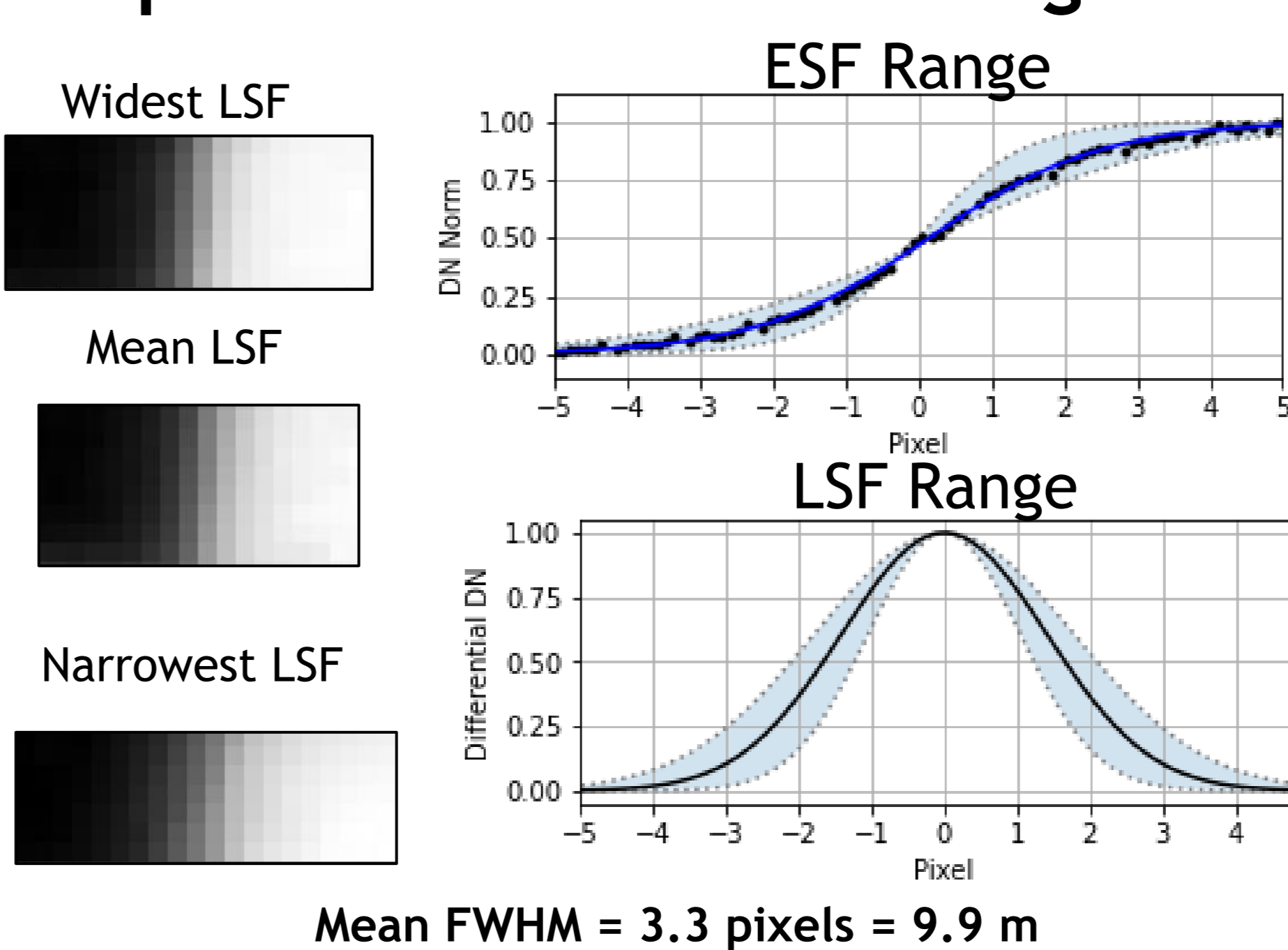
Dotted lines show the offset between B and A in the slanted squares reference frame.

BlackSky Resolution Range



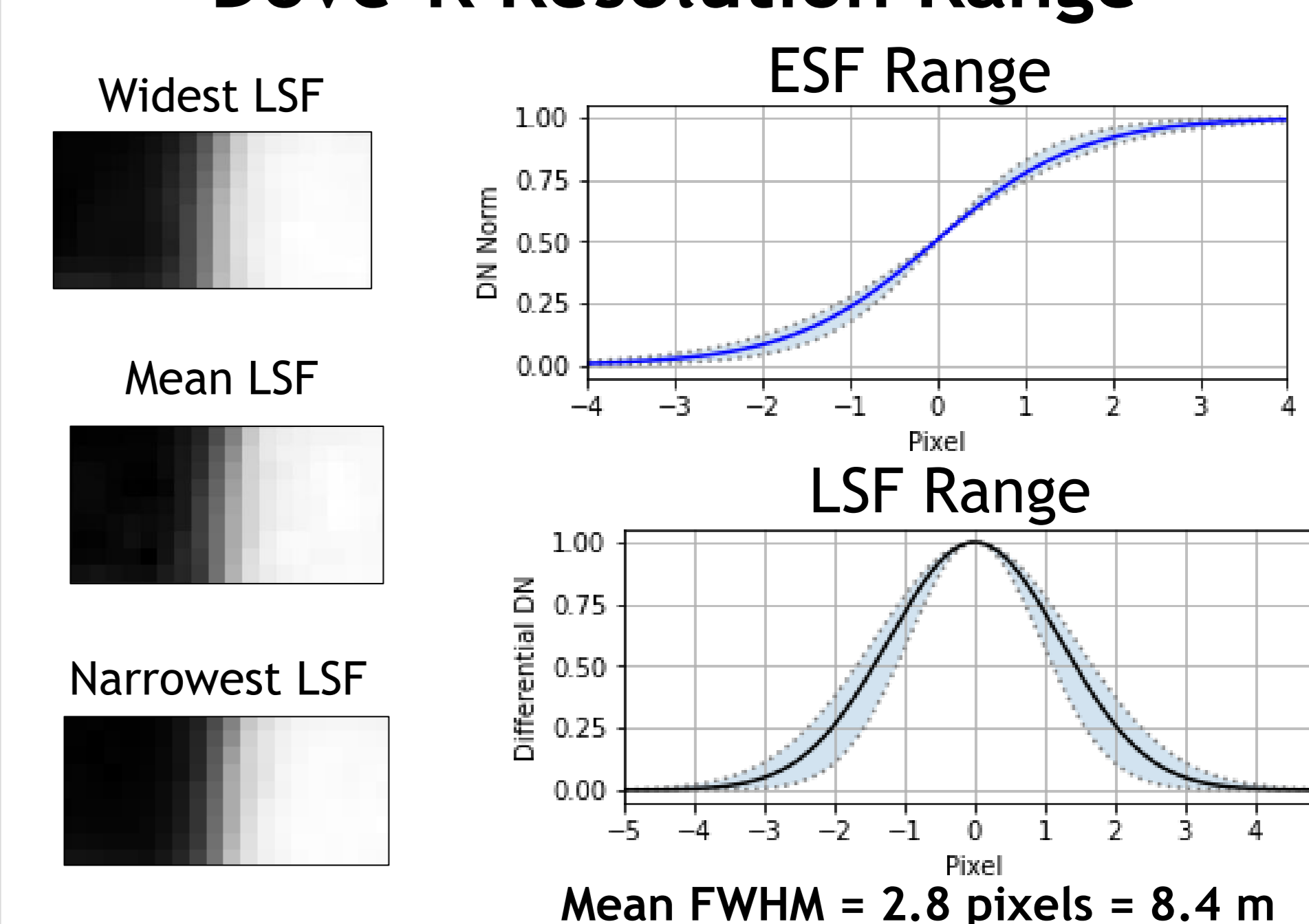
Twelve BSG sensors were examined at Cal/Val sites.

SuperDove Resolution Range



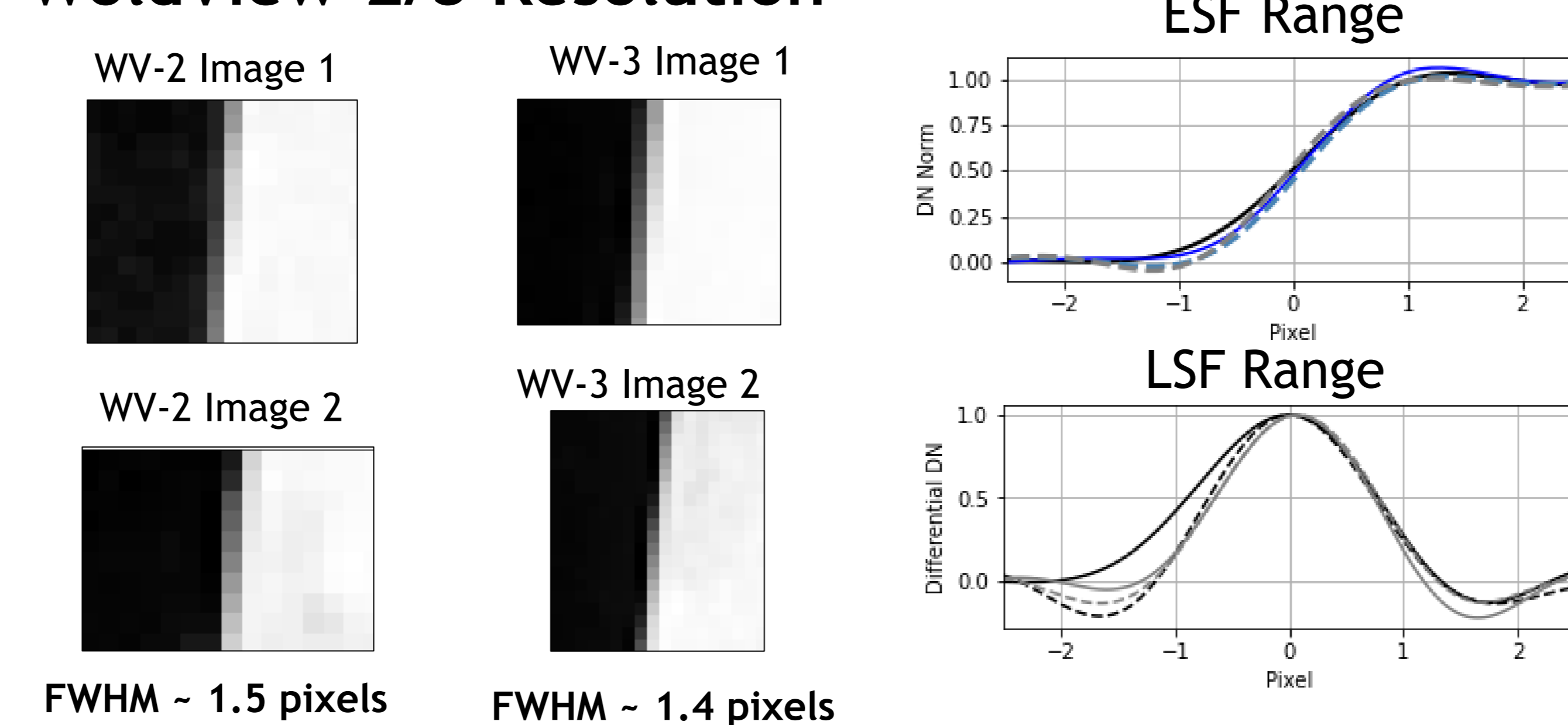
Five SD sensors were examined at two different times, soon after launch and 1yr later (10 images total).

Dove-R Resolution Range



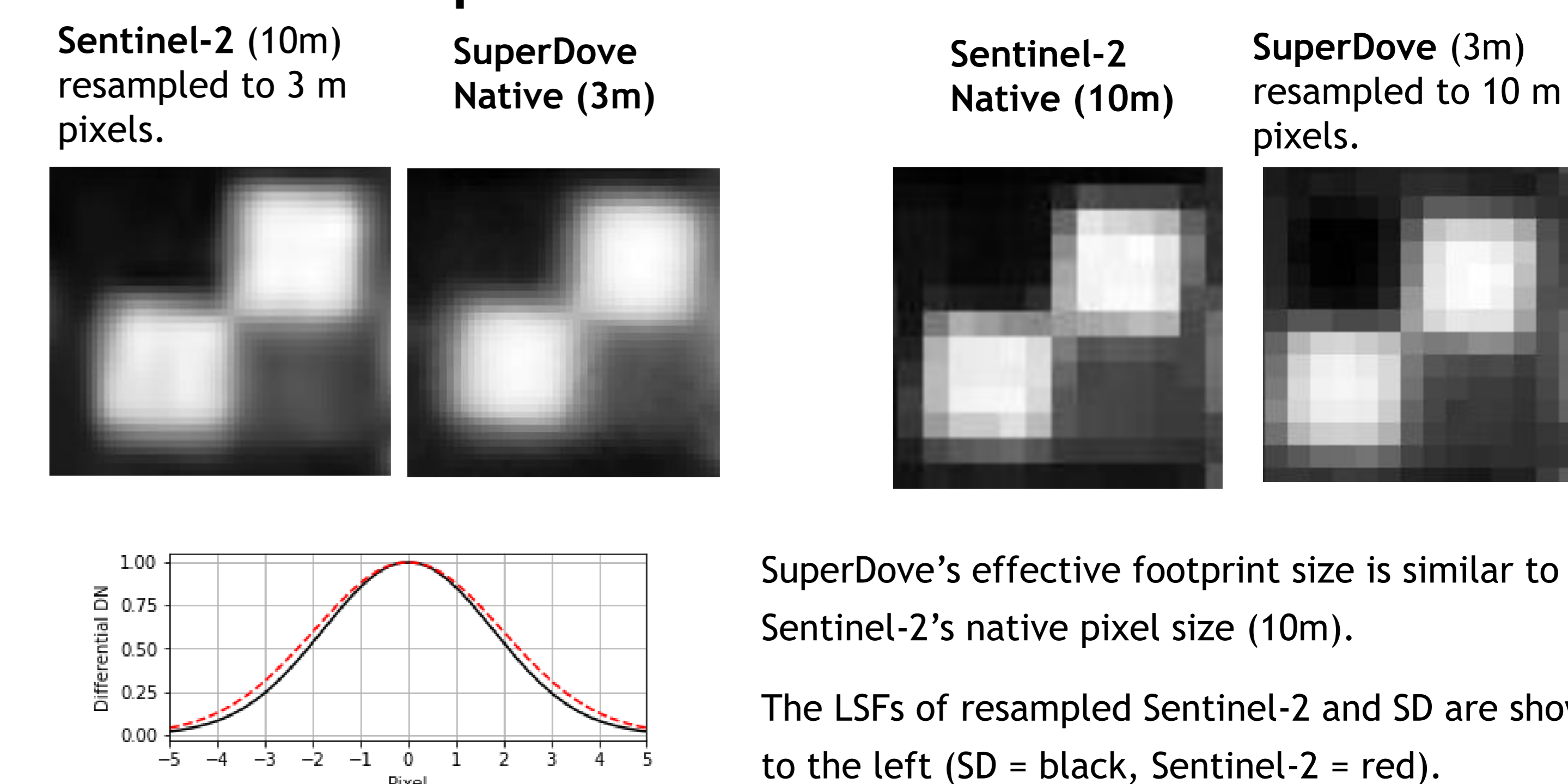
Eight DR sensors were examined at the China Cal/Val site. This evaluation is in progress.

WorldView-2/3 Resolution



Two images each for WV-2 and WV-3 were examined over the China and India Cal/Val sites. WV LSFs are sharpest among the commercial sensors examined.

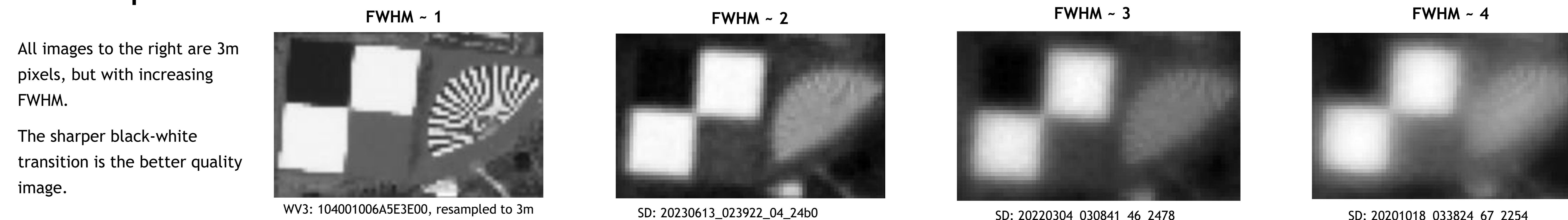
Sentinel-2 Comparison



SuperDove's effective footprint size is similar to Sentinel-2's native pixel size (10m).

The LSFs of resampled Sentinel-2 and SD are shown to the left (SD = black, Sentinel-2 = red).

Visual Impacts of FWHM



All images to the right are 3m pixels, but with increasing FWHM.

The sharper black-white transition is the better quality image.

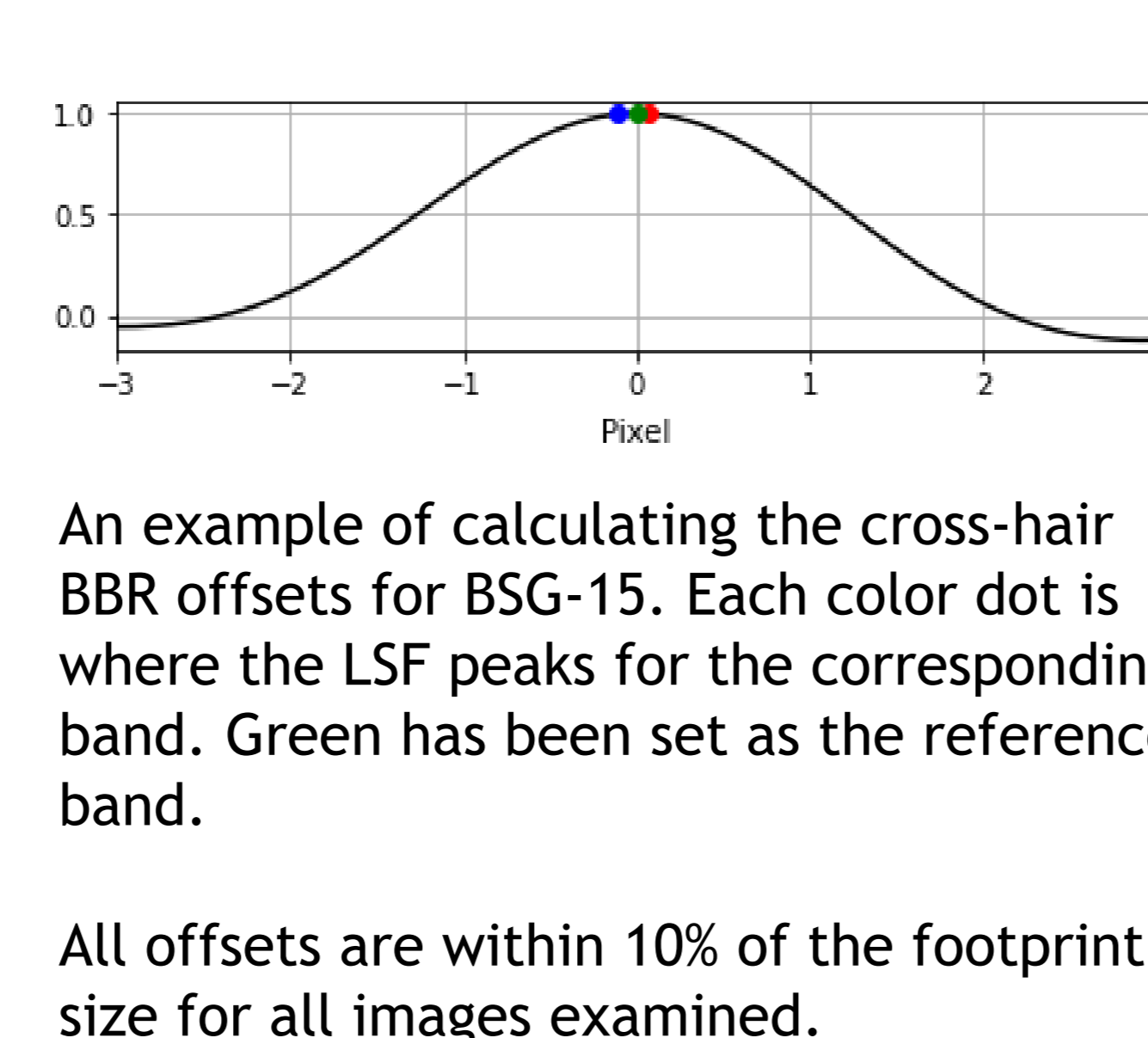
WV3: 104001006A5E3E00, resampled to 3m

SD: 20230613_023922_04_24b0

SD: 20220304_030841_46_2478

SD: 20201018_033824_67_2254

BBR



Summary

Footprint Size

- SuperDove's effective footprint size is FWHM = 3.3 pixels (9.9 m). Overall, average effective footprint size is FWHM = 3.23 pixels (9.7 m).
- SuperDove's true resolution is similar to Sentinel-2.
- Comparing to other CSDA satellites, Superdove's pixel size is the most oversampled, followed by BlackSky and Dove-R at 2+ pixels FWHM, while WV2 and WV3 are marginally oversampled.
- Aggregating SD images by 3 x 3 pixels would reduce data volume by 90% without data content lost.

Band-to-Band Registration

- Offsets are excellent for all images examined; all are well below 20% of a pixel.
- Cross-hairs method is extremely precise, but usable only at specific sites and are a spot check for BBR. If should be used in compliment to another method.