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Advanced SRTM DEM Void-Filling In A Production Environment

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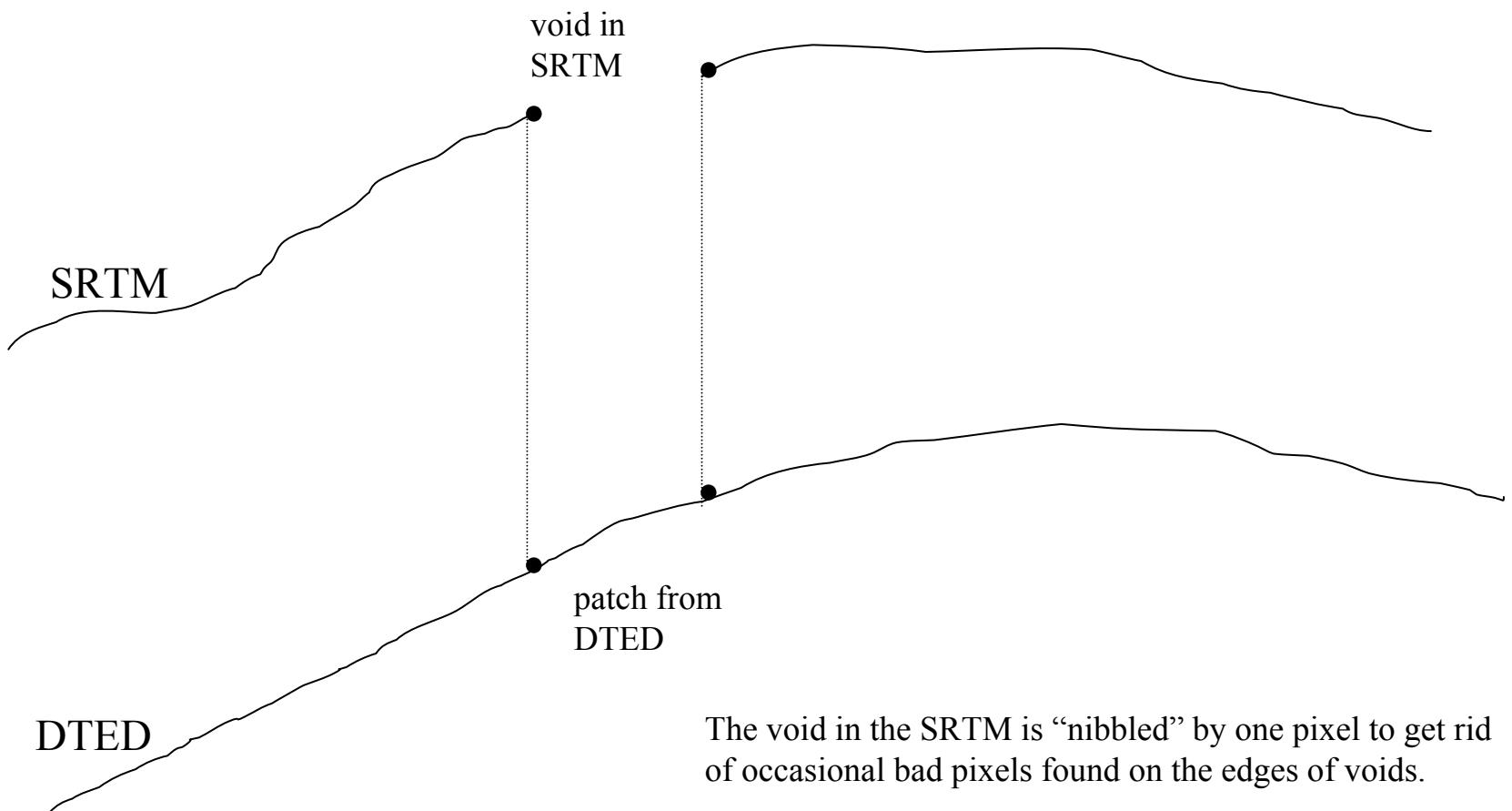
Outline

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- Block adjust of the DTED fill
- Residual edge smoothing of the DTED fill
- Example of unfilled and filled SRTM
- Other aspects of filling algorithm
- Use of filled SRTM in the JPL AFIDS system
- Example of orthorectified satellite images using SRTM elevation data in AFIDS



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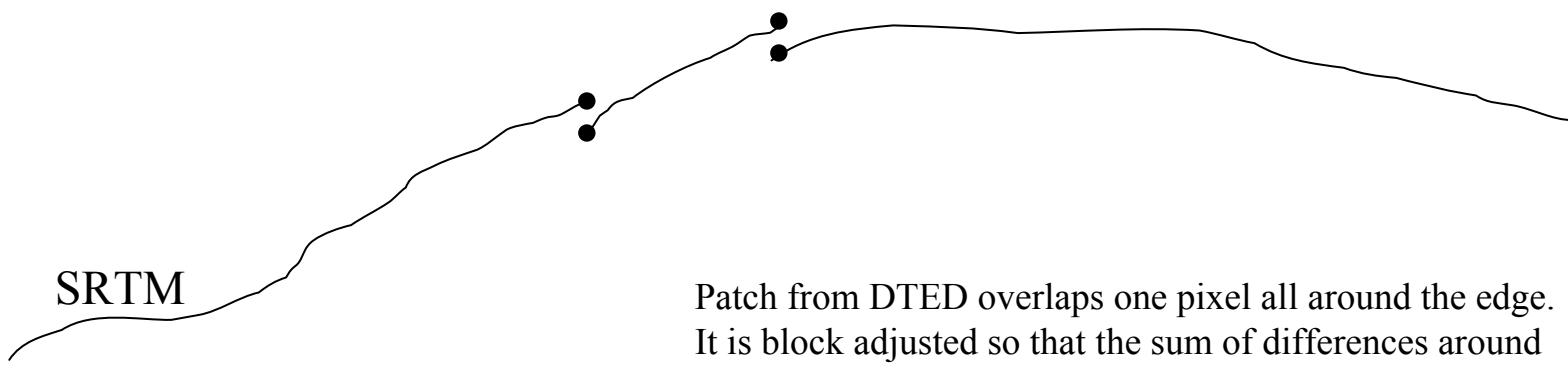
Filling the void in SRTM from DTED





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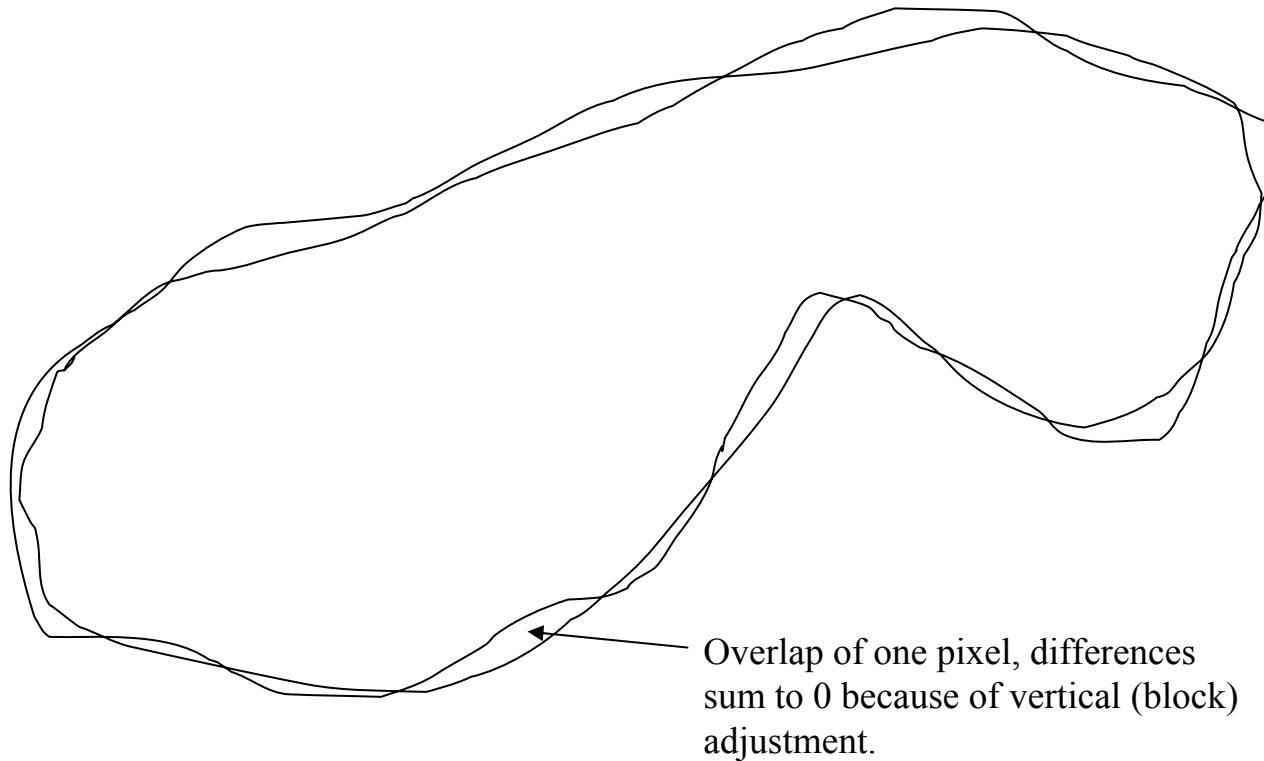
Block adjust of the DTED fill





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Block adjust of the DTED fill (3-D view)

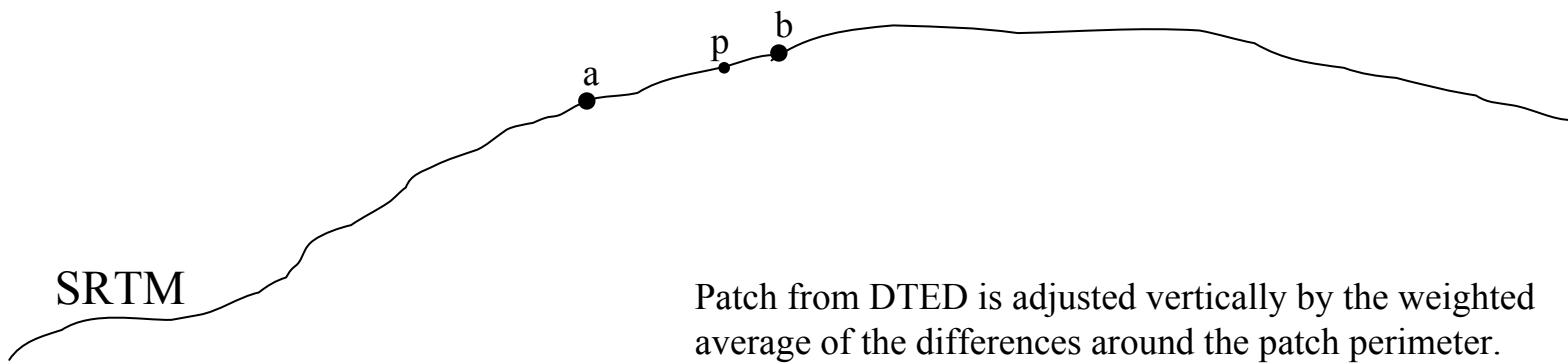


Overlap of one pixel, differences
sum to 0 because of vertical (block)
adjustment.



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Residual edge smoothing of the DTED fill

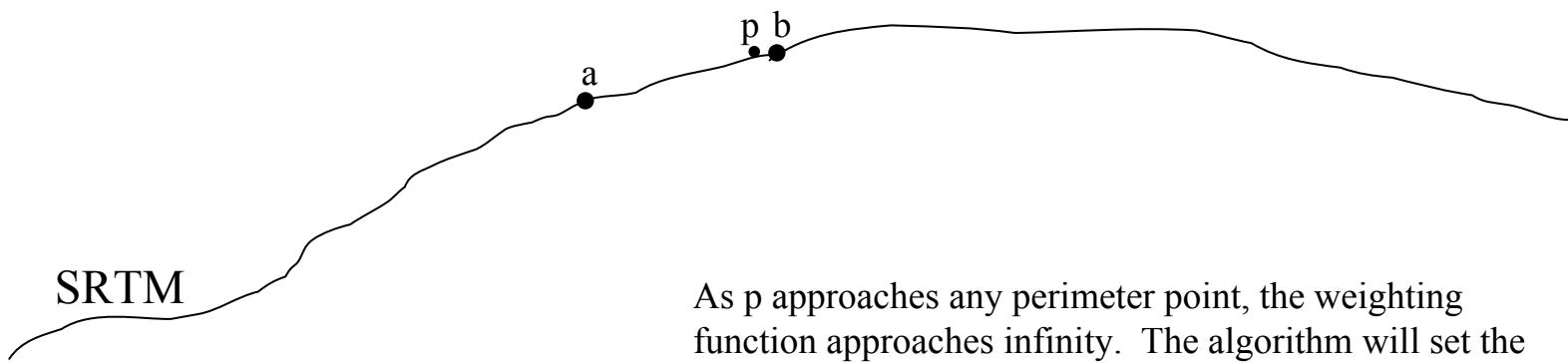


Patch from DTED is adjusted vertically by the weighted average of the differences around the patch perimeter. The weight function is related to the distance from the point being adjusted to the perimeter point. In this simplified 2-D diagram, the point p was adjusted down by the negative gap at a and up by the positive gap at b. The weighting function is $\text{distance}(\text{power } -k)$.



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Residual edge smoothing of the DTED fill

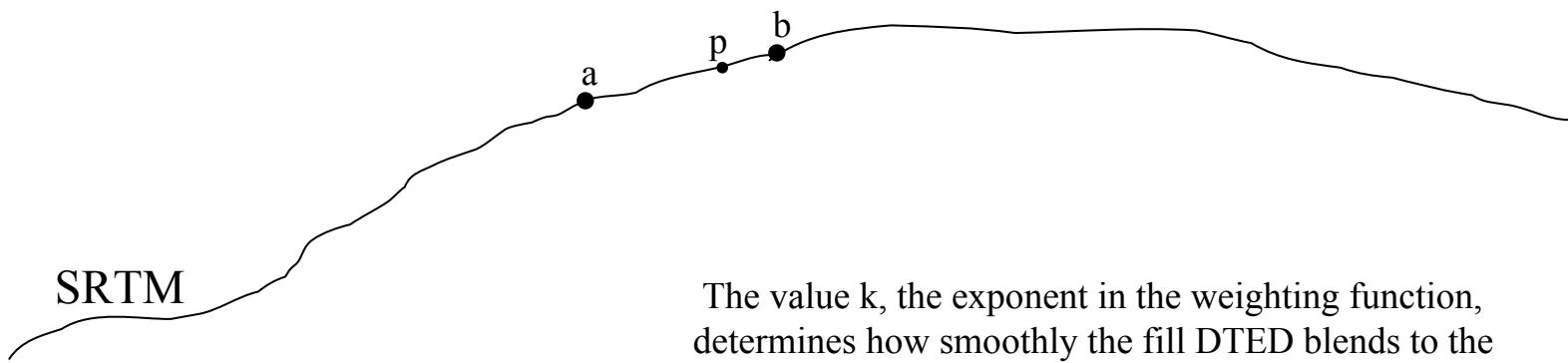


As p approaches any perimeter point, the weighting function approaches infinity. The algorithm will set the fill value to the perimeter point in that case. This results in a gap-free fill of the void in the SRTM. In the middle of the void, the adjustment will be the sum of somewhat equally weighted terms (and the unweighted terms sum to zero) hence the correction will be very small in the middle of the void.



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Residual edge smoothing of the DTED fill

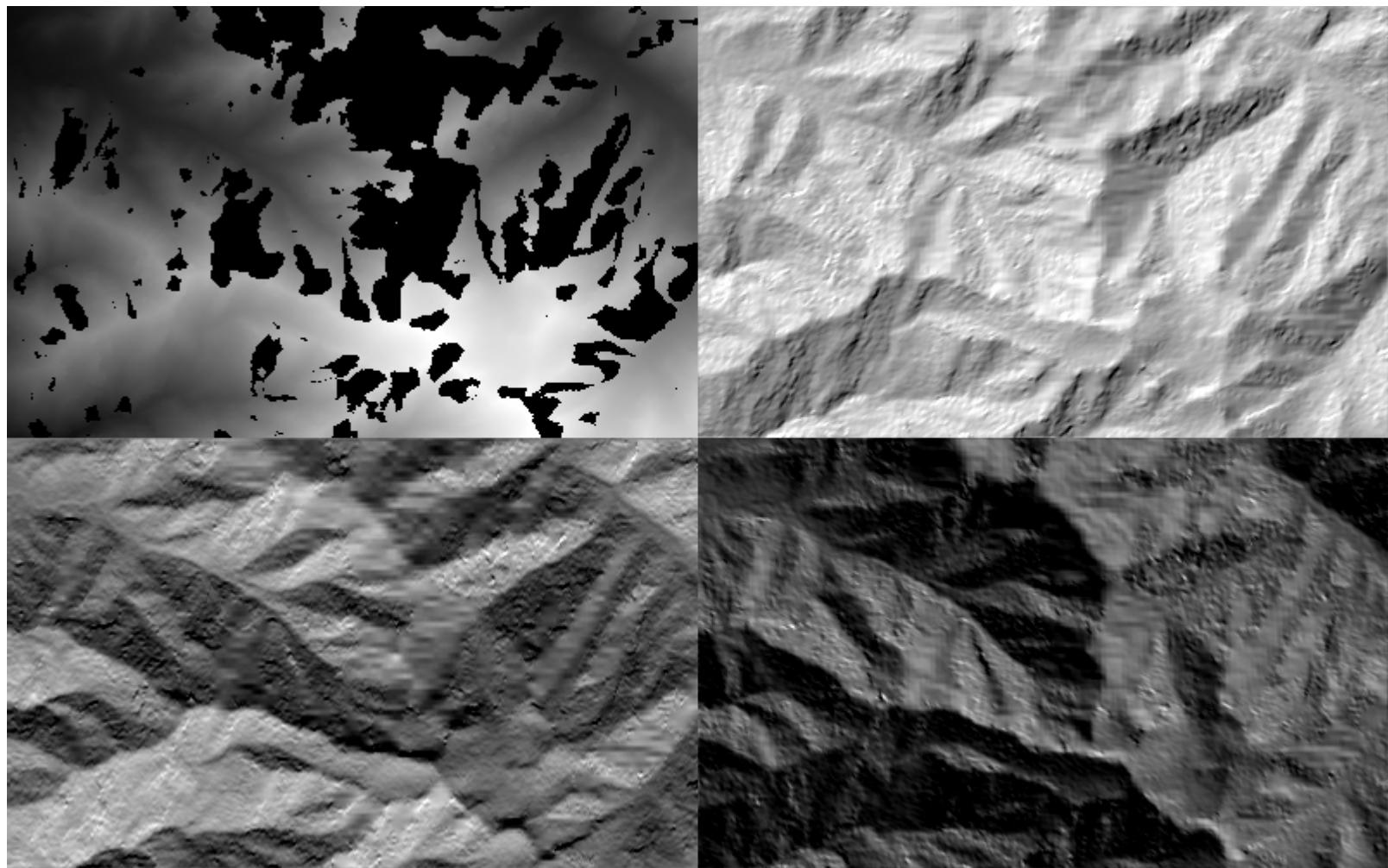


The value k , the exponent in the weighting function, determines how smoothly the fill DTED blends to the SRTM edge vs. how far out into the fill area the blend takes place. We selected a value of $k = 2$.



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Example of unfilled and filled SRTM

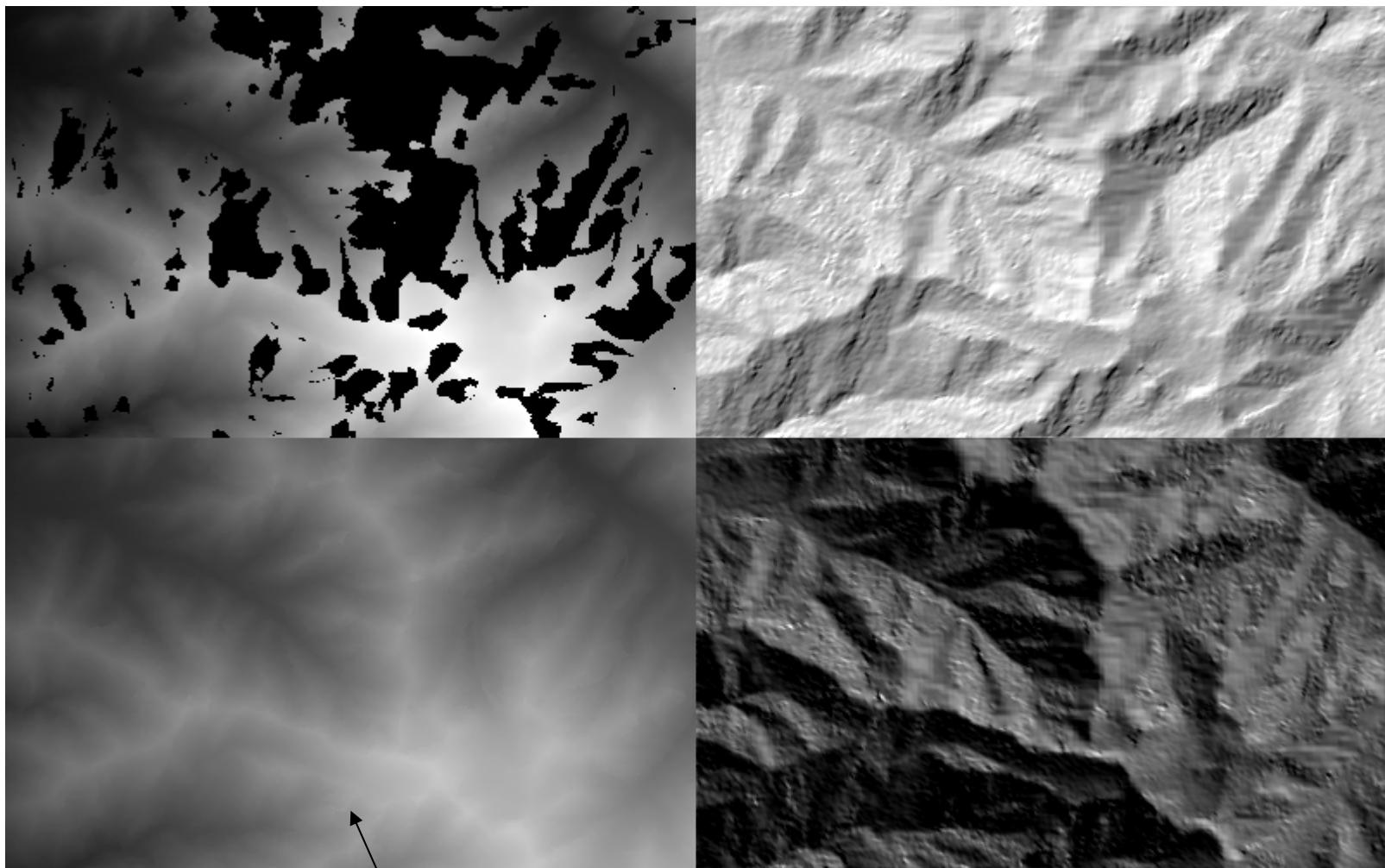


Artificial shade projected from three directions



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Example of unfilled and filled SRTM

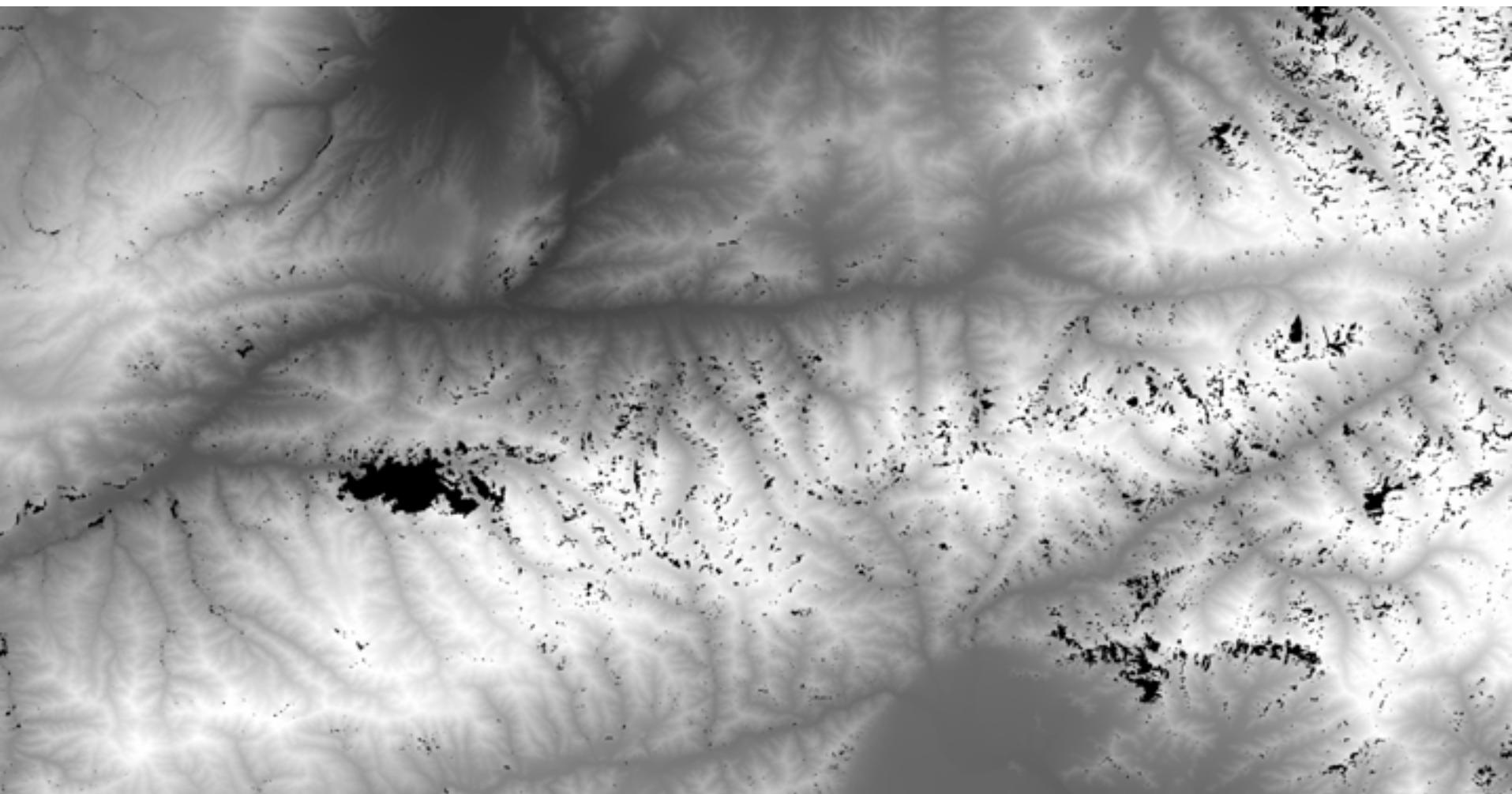


Can add height-intensity view



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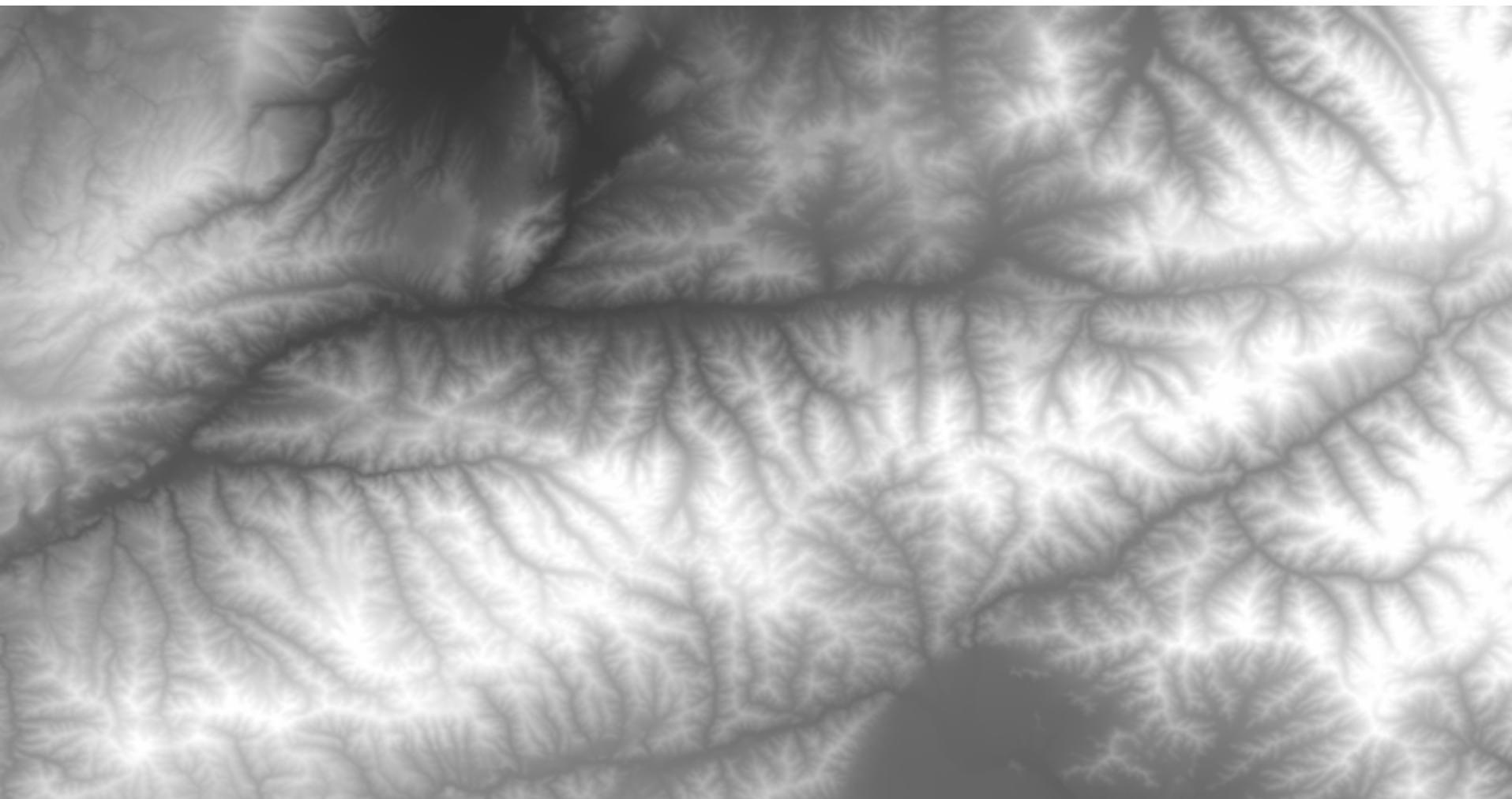
RAW 2x1 SRTM DEM WITH VOIDS





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RAW 2x1 SRTM DEM WITH VOIDS FIXED





Other aspects of filling algorithm

- Voids in SRTM are represented as connected components (by pixel adjacency) and edge overlap for each void is an unordered list.
- Ocean handling used superimposition of DTED ocean areas (contiguous zeros). OK for our use.
- This algorithm is amenable to improvements.



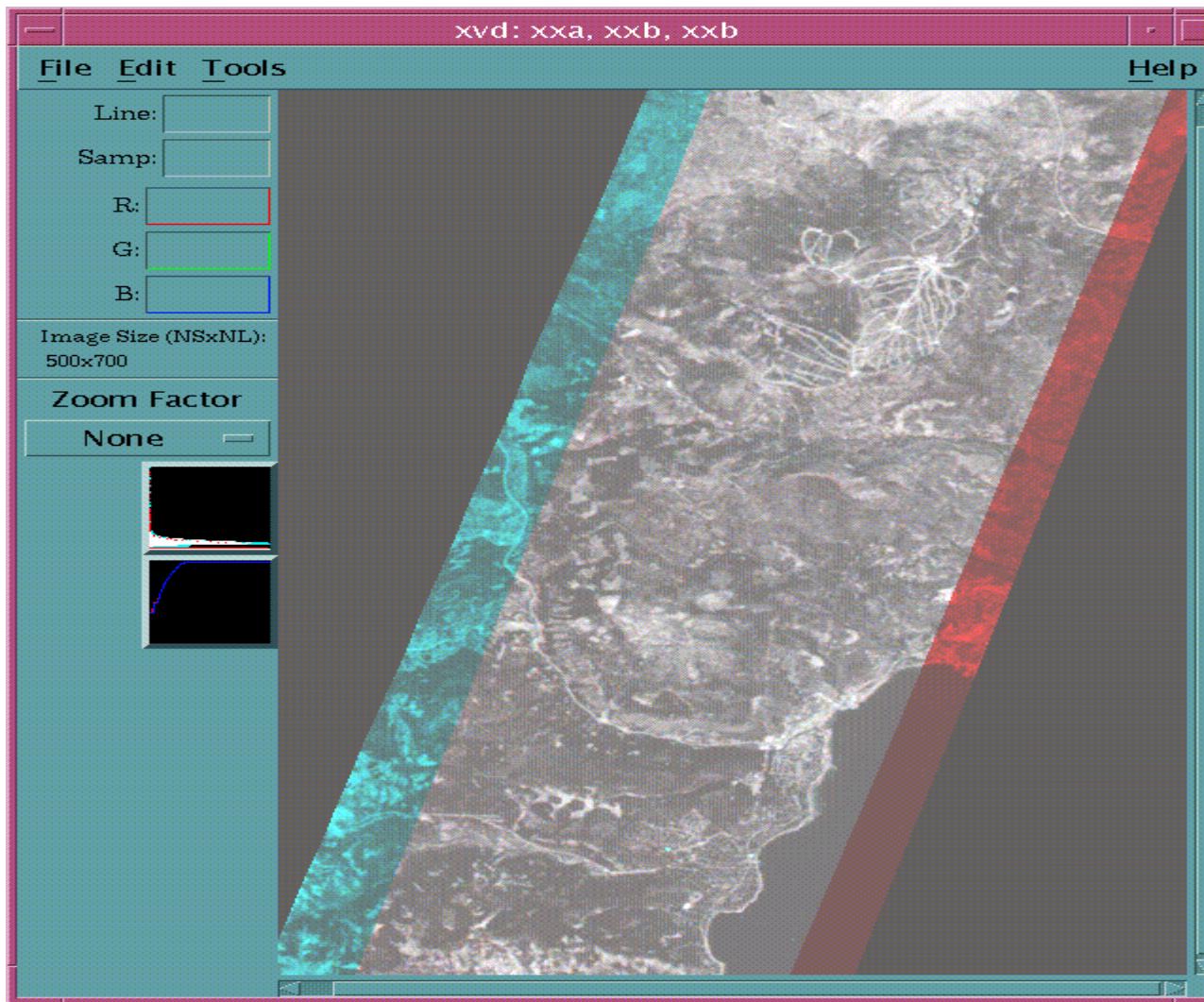
Use of filled SRTM in the JPL AFIDS system

- Satellite projection models (including RCP/RPF) use void-filled SRTM to orthorectify images as part of an image registration package (Landsat, Aster, Modis, Quickbird, Hyperion, ALI, Ikonas, NTM) known as AFIDS (Automatic Fusion of Image Data System). Entire SRTM archive was void-filled.
- A Landsat mosaic of the World was performed as a rectification base for AFIDS. CIB-5 and CIB-1 are also integrated.



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Example of orthorectified and registered satellite images using SRTM elevation data in AFIDS



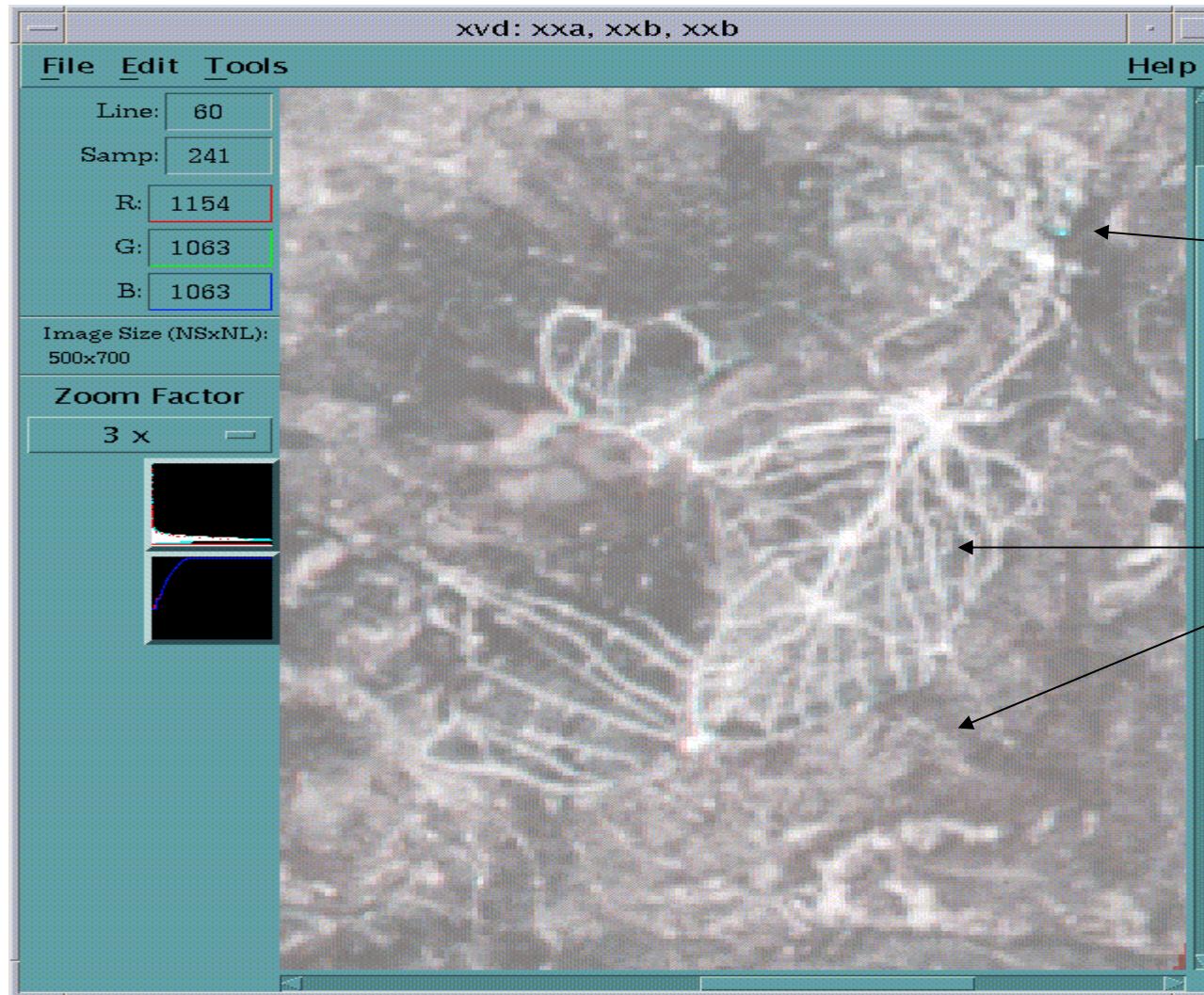
Two passes of Hyperion differ by 10 degrees in angle from nadir. Raw images should show offset of .2*height in ski area.

These are the corrected images.



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Example of orthorectified and registered satellite images using SRTM elevation data in AFIDS



Difference pixel

Grey = no difference
made possible by
accurate registration