Know the Earth…Show the Way

Evaluation of SRTM DTED® -2 Using "Standard" DTED® -2

Barry Heady/ headyb@nga.mil

Co-authors: Bill Curtis, Jeff Haase, George Kroenung, Jim Little, Kevin Tracy

Global Foundation Office

June 2005

Approved for Public Release 05-232

Presentation Content

- SRTM Data Examples
- Comparison purpose
- SRTM DTED ® 2 to “Standard” DTED ® 2 Statistical Comparison Results
- SRTM DTED ® 2 to “Standard DTED ® 2 examples
  - Voids (SRTM data)
  - Random Vertical Noise (SRTM data)
  - Phase Unwrap errors (SRTM data)
  - Anomalies in “Standard” DTED ® 2
- Conclusions

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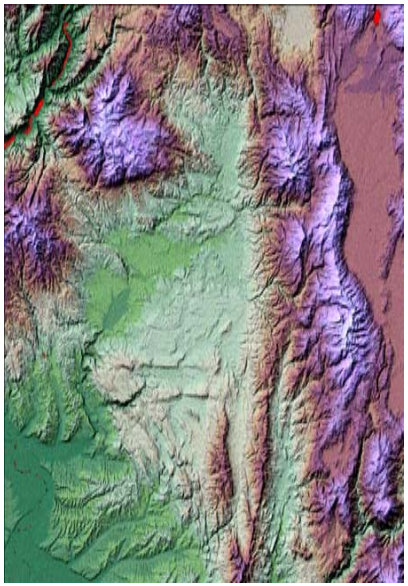
Unfinished SRTM DTED ® 2



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Orthorectified Image Mosaic, 30m, NITF 2.1

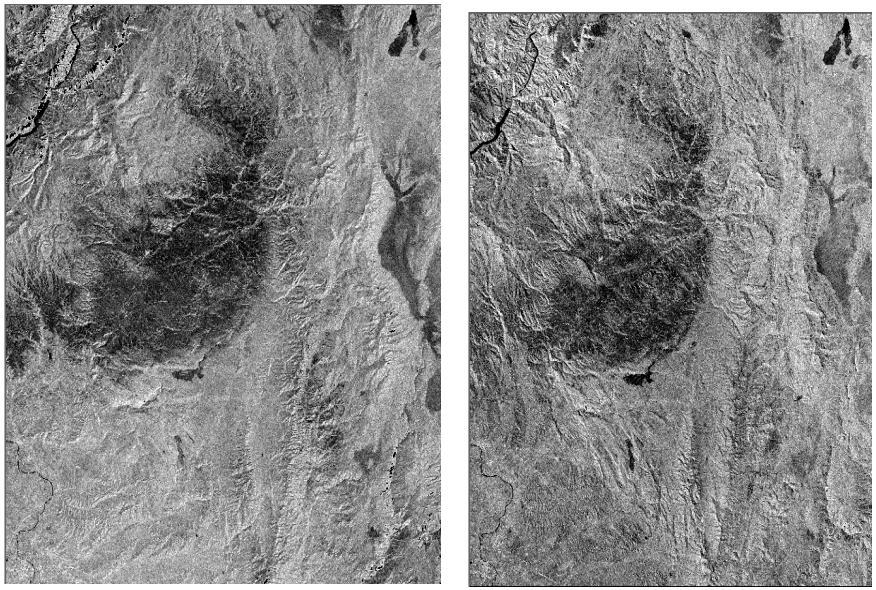

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Chart Information

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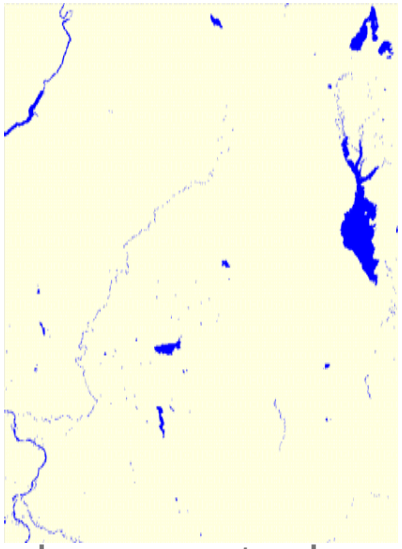

Landcover water layer

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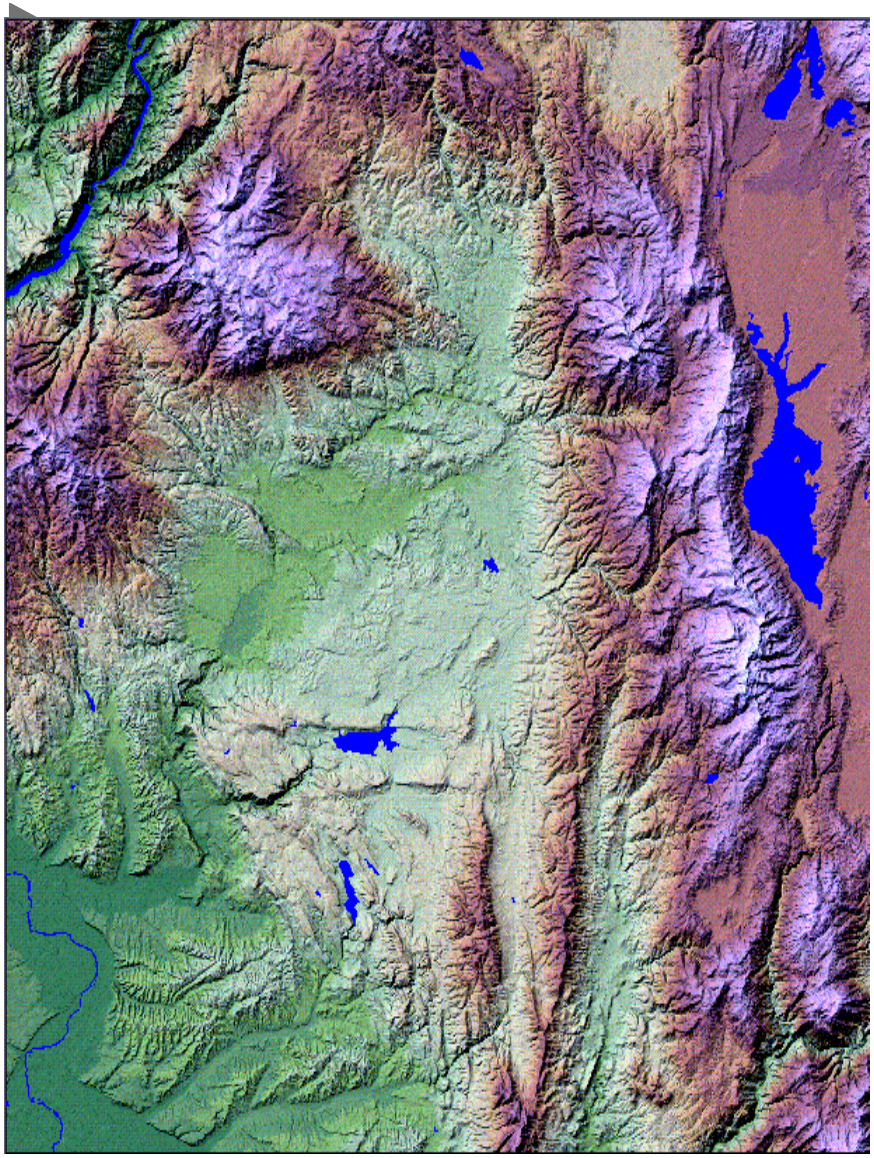
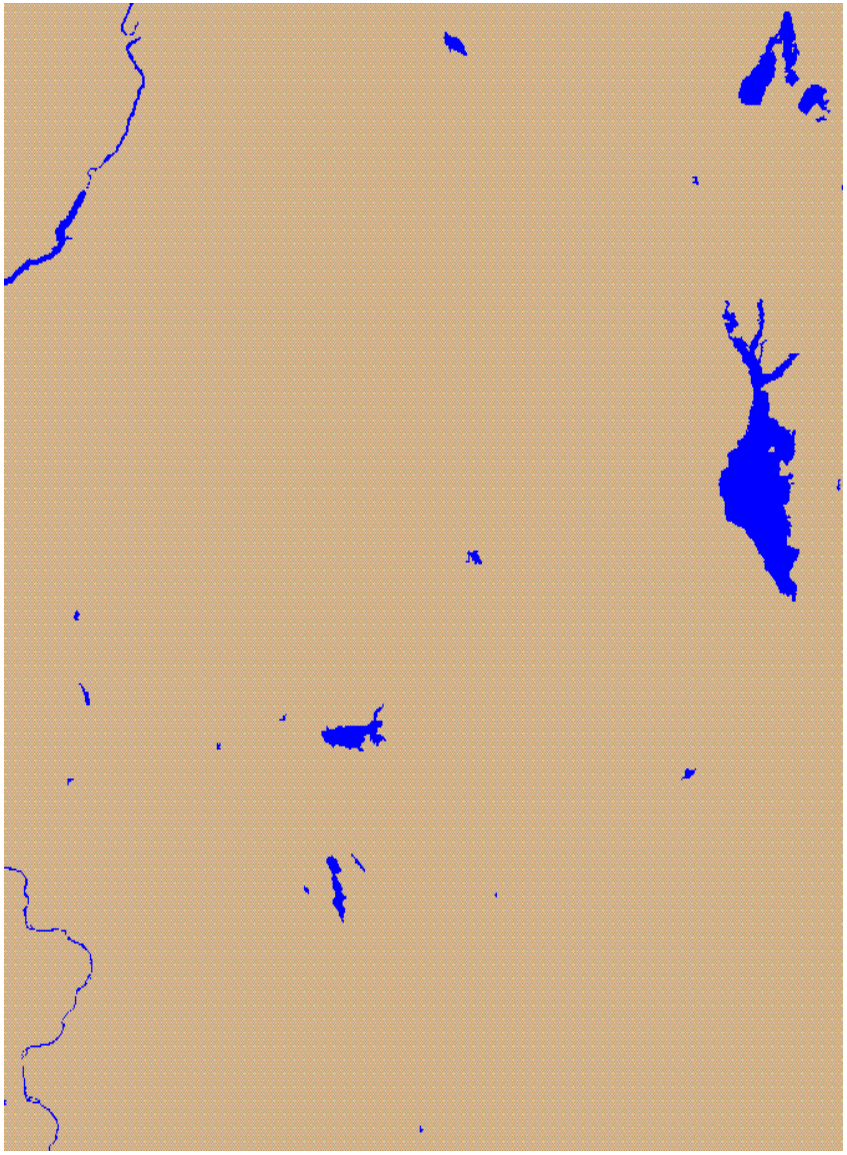


Finished Digital Terrain Elevation Data



SRTM Water Body Data (NITF 2.1)

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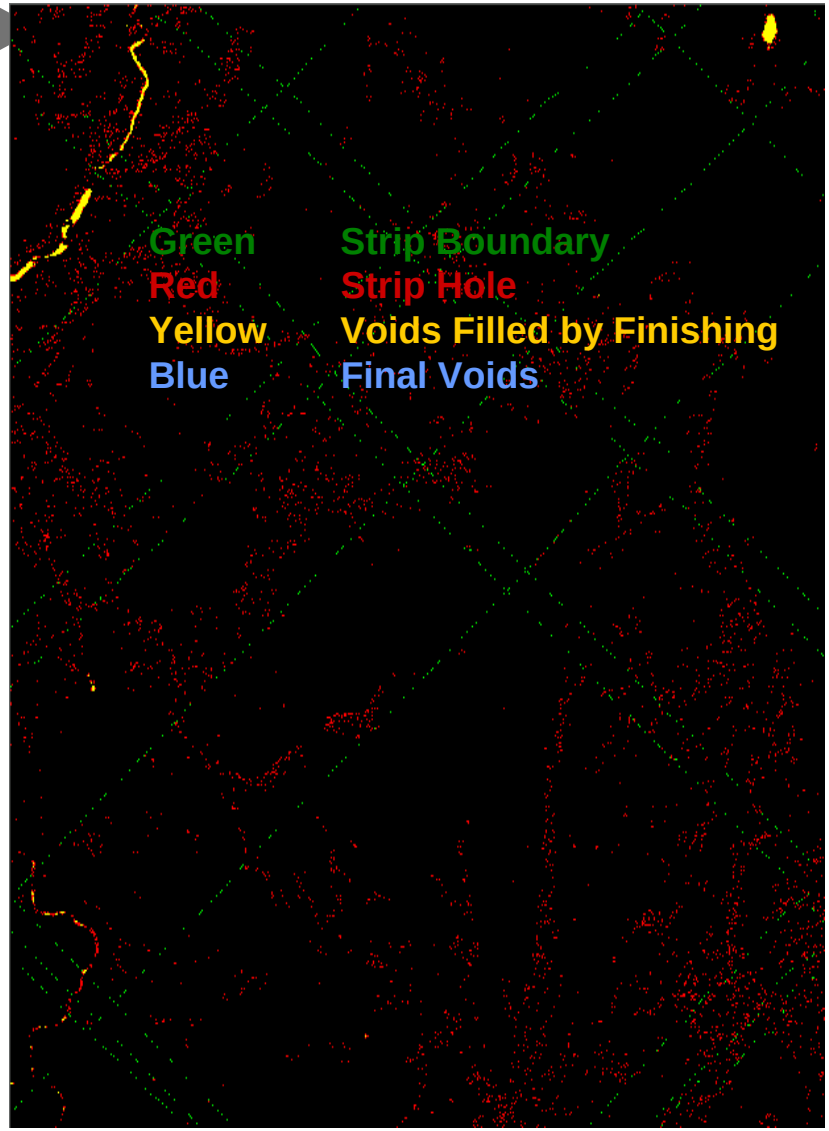
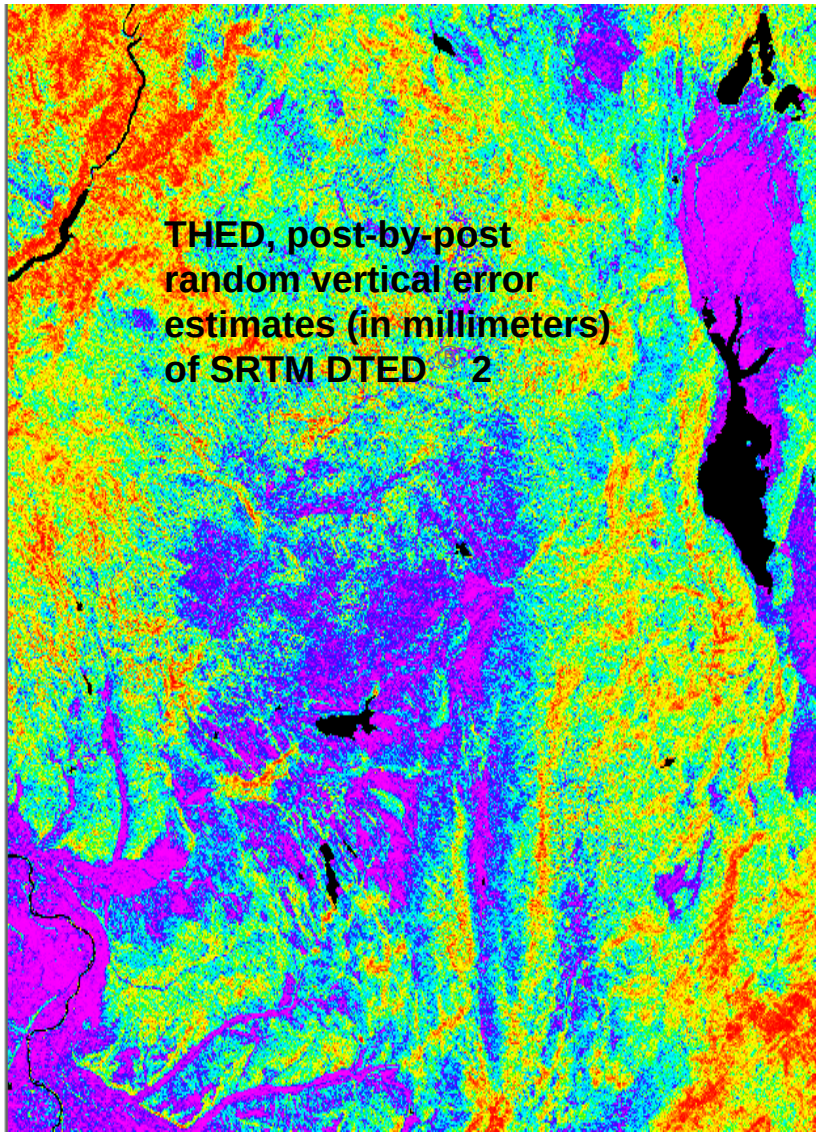


Seam Hole Composite Map (NITF 2.1)



Terrain Height Error Data (NITF 2.1)

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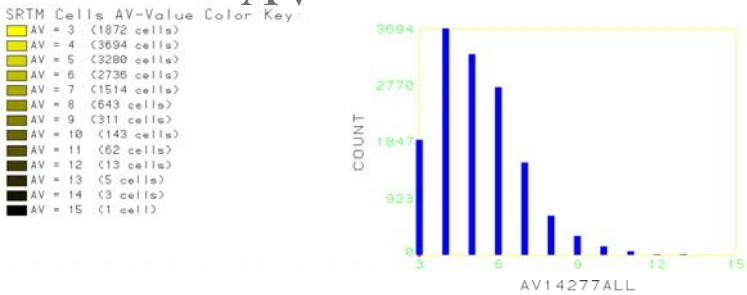
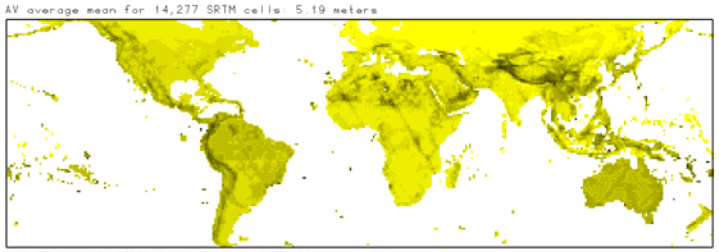
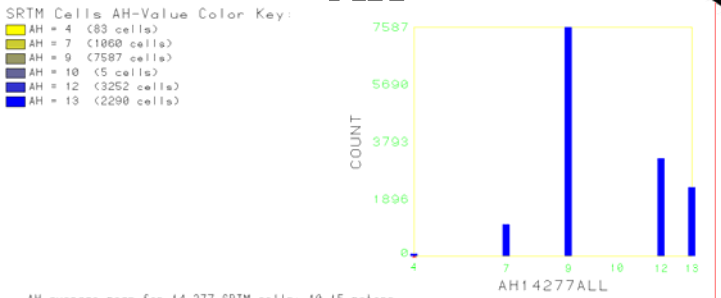
Finished SRTM Accuracy

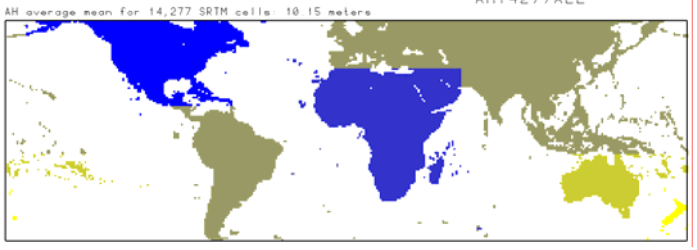
AV

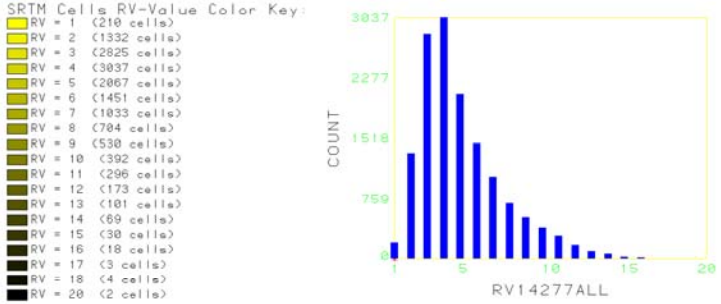


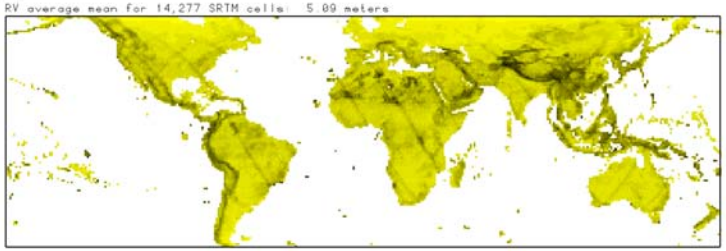


AH









RV

AV = typically <8m 90%
AH = typically <12m 90%
RV = typically <7m 90%

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NGA SRTM Evaluation Purpose

- ***Compare SRTM DTED® 2 to existing DTED® 2 for two purposes:***
  - ***Provide an independent statistical check on JPL output***
    - Initially performed upon ingest at contractor sites
    - NGA performed additional comprehensive analysis on smaller samples
  - ***Assess the data characteristics of SRTM DTED ® 2 compared to traditional DTED® 2 to familiarize NGA with the new source/product and to assess any potential impacts to NGA DTED® 2 customers***
    - Random vertical noise
    - Reflective surface
    - Water processing
    - Voids

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Data used in comparisons

- *SRTM DTED® 2*
  - C-band IFSAR source
  - Accuracy typically ~5-7 m AV, ~5-7 m RV, ~10m AH
  - C-band reflective surface
  - 14,277 cells
- *"Standard"DTED® 2*
  - NTM optical source
  - Accuracy typically ~5m AV, <5m RV, ~10m AH
  - Ground surface*
  - ~1500 cells mostly partial
- *NGA Ground Control Points*
  - Typically photogrammetrically derived during NTM triangulation process
  - Accuracy typically ~5-10m AV, <5m RV, ~10m AH
  - ~200 points/one degree cell/~9,000 cells

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COMPARISON OF SRTM DTED ® 2 WITH PHOTOGRAMMETRIC GROUND CONTROL

CELL STATISTICS FOR (GCP – SRTM) ELEVATION DIFFERENCES (METERS)
AGGREGATED FOR EACH CONTINENT

	AFRICA	AUSTRALIA	EURASIA-E	EURASIA-W	N. AMERICA	S. AMERICA
No. of Cells w/ GCPs*	2,396	168	1,943	1,957	1,857	644
Mean of Mean Differences	-1.9	-1.8	-0.4	0.6	-0.2	-2.0
Median of Mean Differences	-1.9	-1.4	-0.4	0.6	0.0	-2.1
Mean of 90% Elev. Difference Errors	5.5	6.5	8.2	6.0	6.0	7.0
Mean of RMS Elev. Differences	4.4	4.7	5.7	4.4	4.3	5.5

* Includes only cells with 6 or more GCPs.

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COMPARISON OF SRTM DTED ® 2 WITH REFERENCE DTED ® 2

CELL STATISTICS FOR (REFERENCE DTED ® – SRTM DTED ®) ELEVATION DIFFERENCES (METERS) AGGREGATED FOR EACH CONTINENT

	AFRICA	AUSTRALIA	EURASIA-E	EURASIA-W	N. AMERICA	S. AMERICA
No. of Cells w/ Reference DTED	234	355	102	184	146	10
Mean of Mean Differences	-1.4	2.2	1.9	-0.6	1.6	-8.0
Median of Mean Differences	-1.1	2.0	1.9	-0.3	1.8	-7.8
Mean of 90% Elev. Difference Errors	6.7	7.0	10.1	7.0	8.4	8.6
Mean of RMS Elev. Differences	4.9	5.1	7.1	4.8	6.1	10.1

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Data Examples

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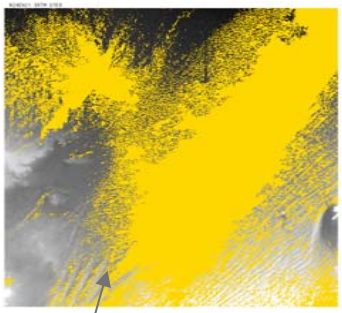
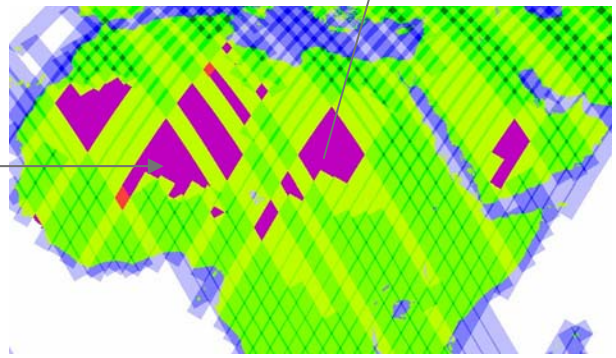
DataVoids

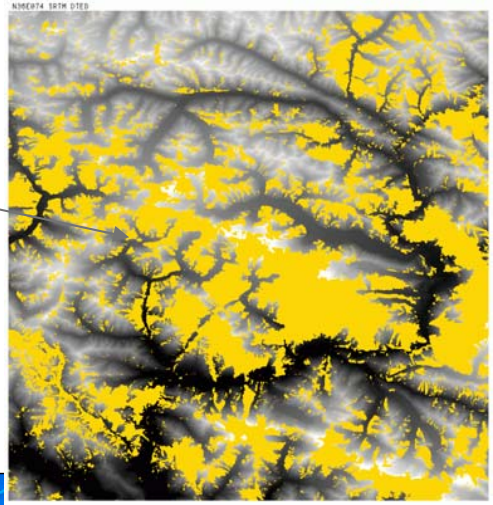
- Voids
  - Description:
    - Phase unwrapping problems atypically produce large void areas in low relief areas
    - Non-green shaded land areas have low SNR and prone to unwrapping problems
      - Desert
      - Water/Swamp



Desert
(Dry sand = low SNR)
voids = yellow



- Shadowing and layover in high relief areas may also produce significant voids
- Data immediately surrounding the voids may be noisy



Mountainous
(Shadowing & Layover)
voids = yellow

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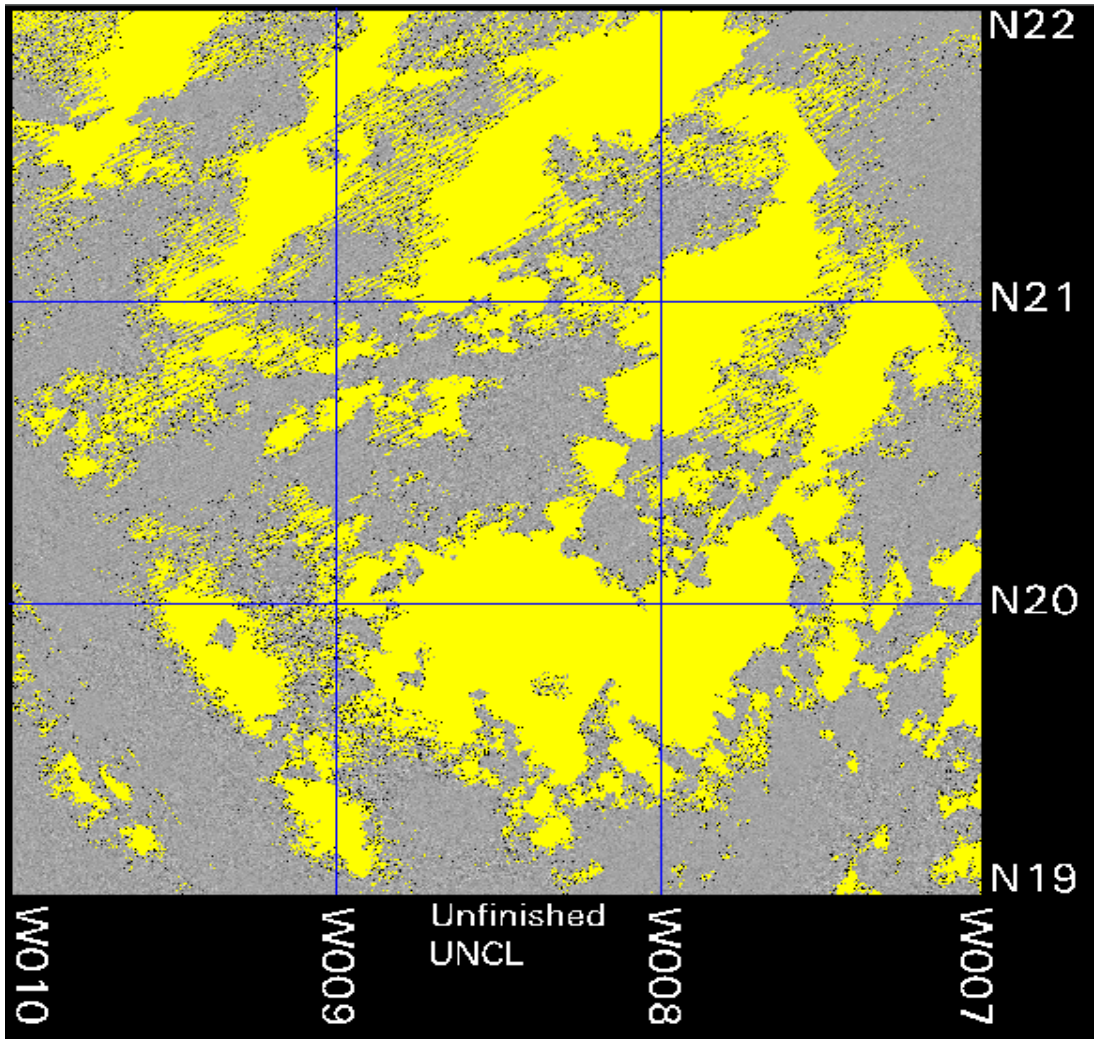
DataVoids

Atypical data voids in Northern Africa

Yellow = void



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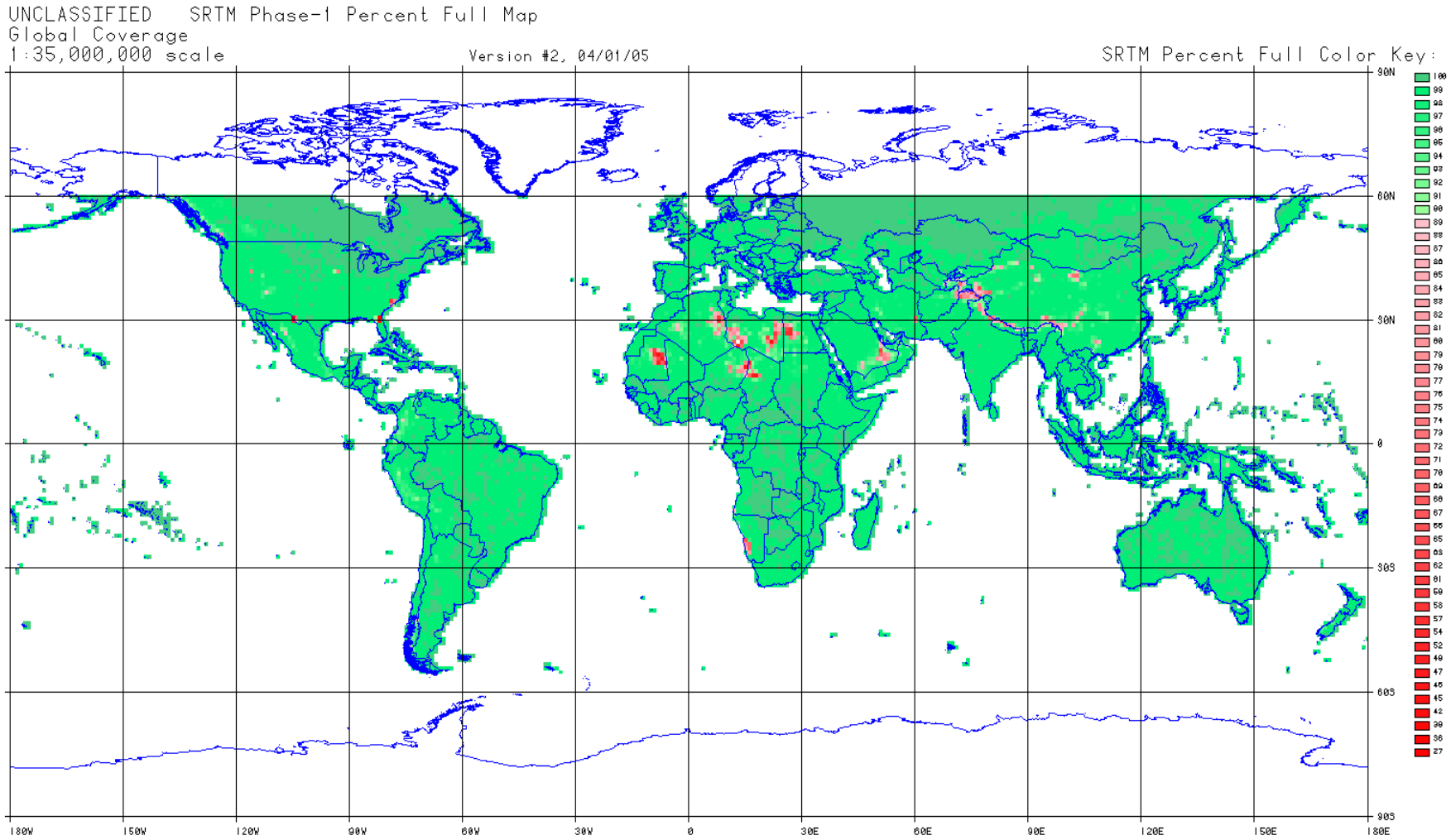
SRTM DTED ® 2 Finished Percent Full



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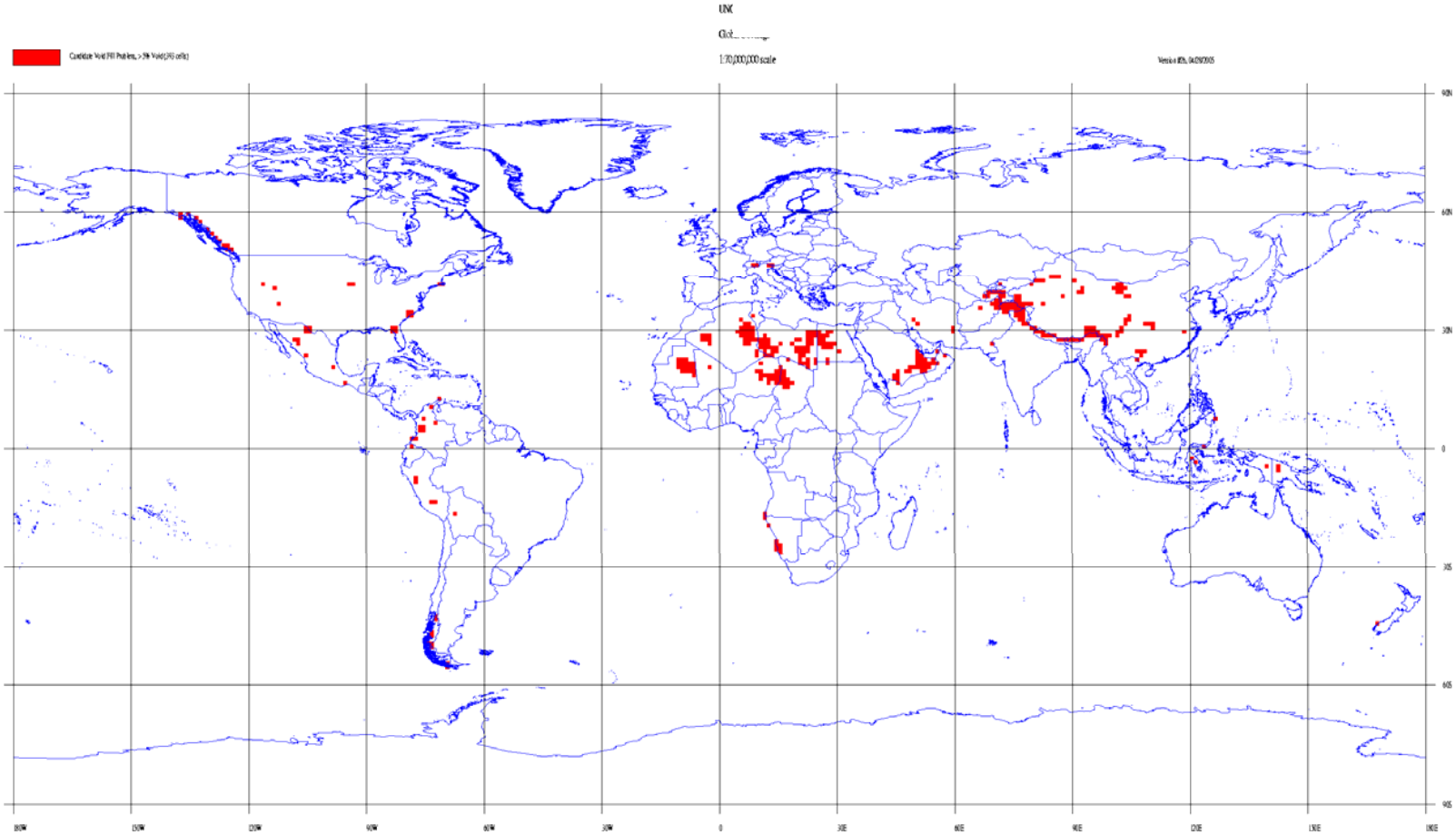
SRTM Cells > 5% void (~400 out of 14,277)



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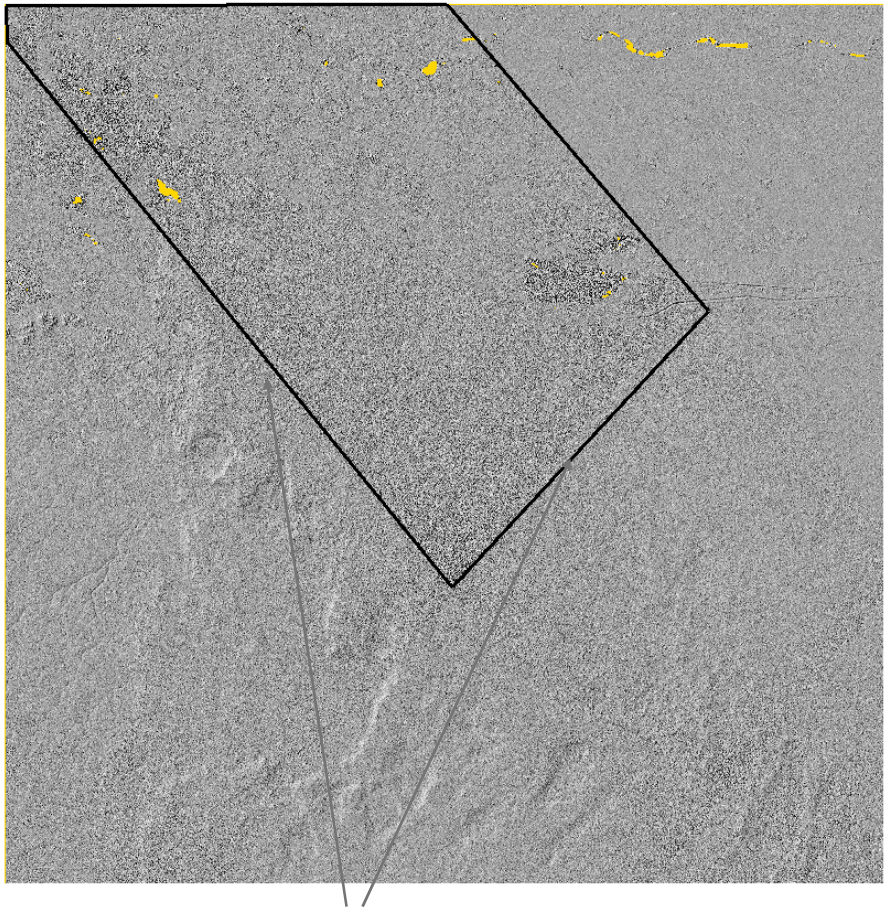
Random Vertical Noise

- Random Noise
  - Description: clusters of local errors that are typically ~ ± 5m but can exceed ±10 m
  - Cause:
    - Correlation threshold selection
    - Topography/scene content impacts data signal-to-noise ratio
      - Low relief (most noticeable)
      - High relief
    - Data acquisition geometry
    - single pass vs. multi pass coverage
      - some localized areas of single pass may occur when other pass(es) fail due to low SNR or other problems



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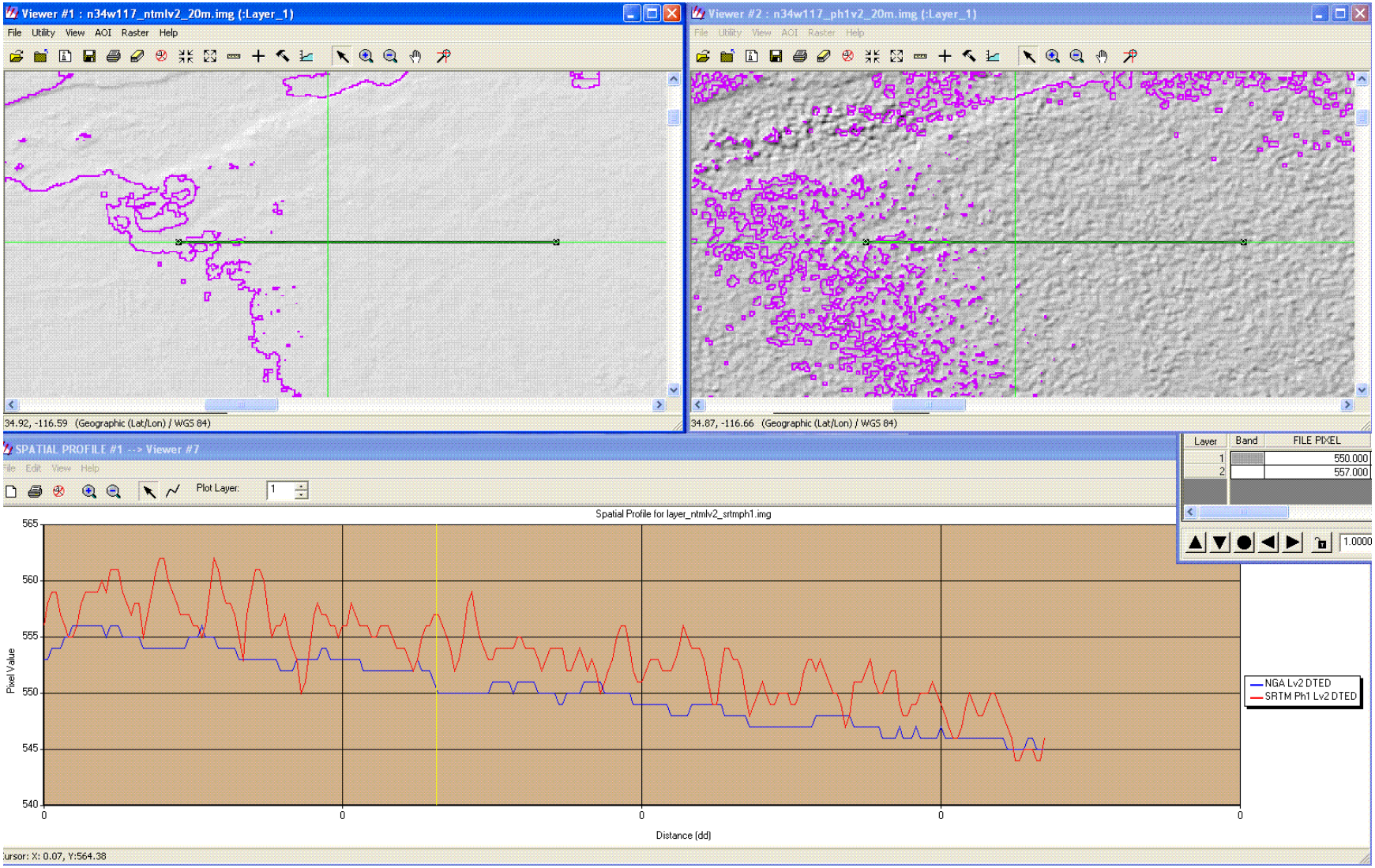
SRTM Random Vertical Noise (typical about 3-6 meters)



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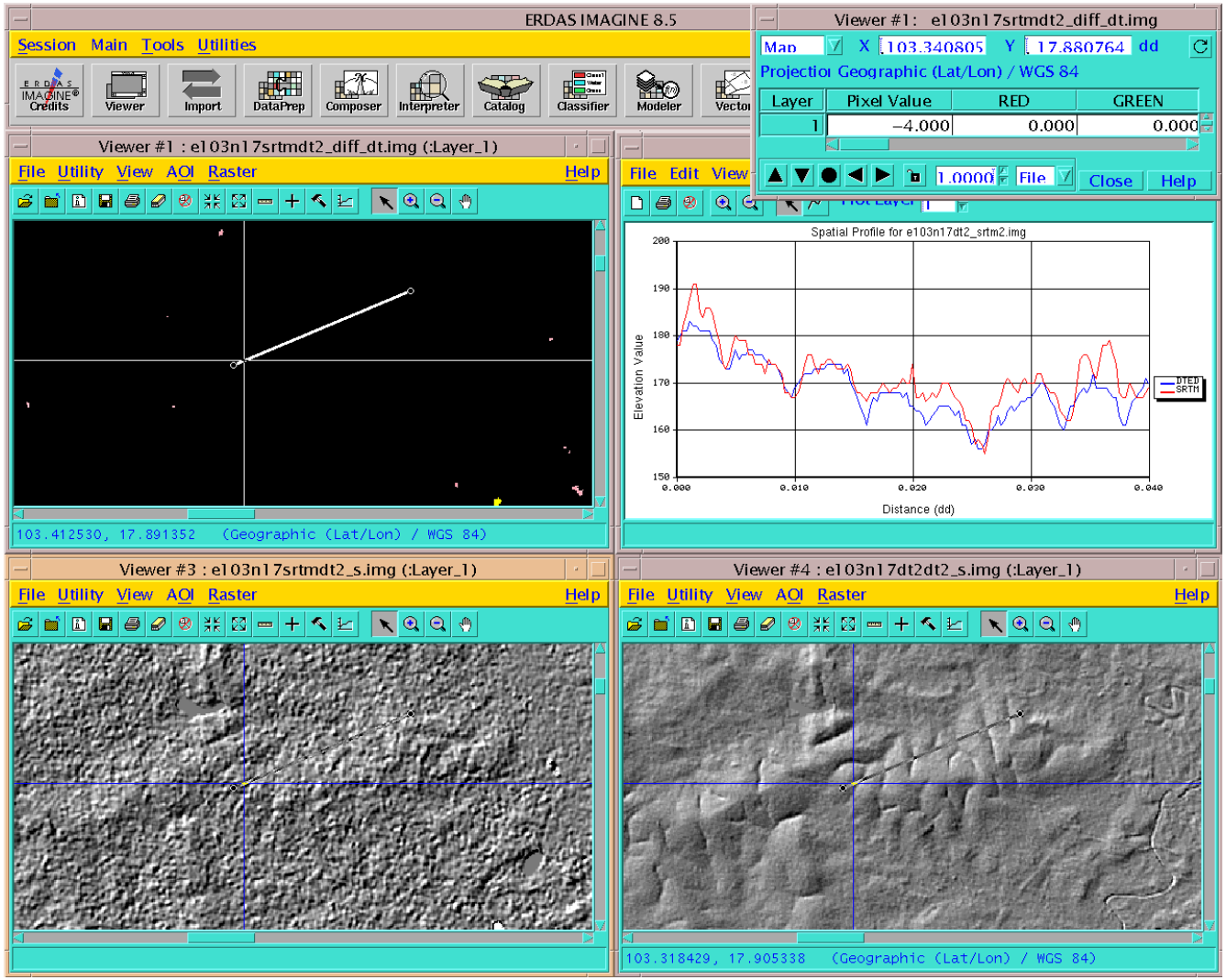
Random Vertical Noise /reflective surface/vegetation



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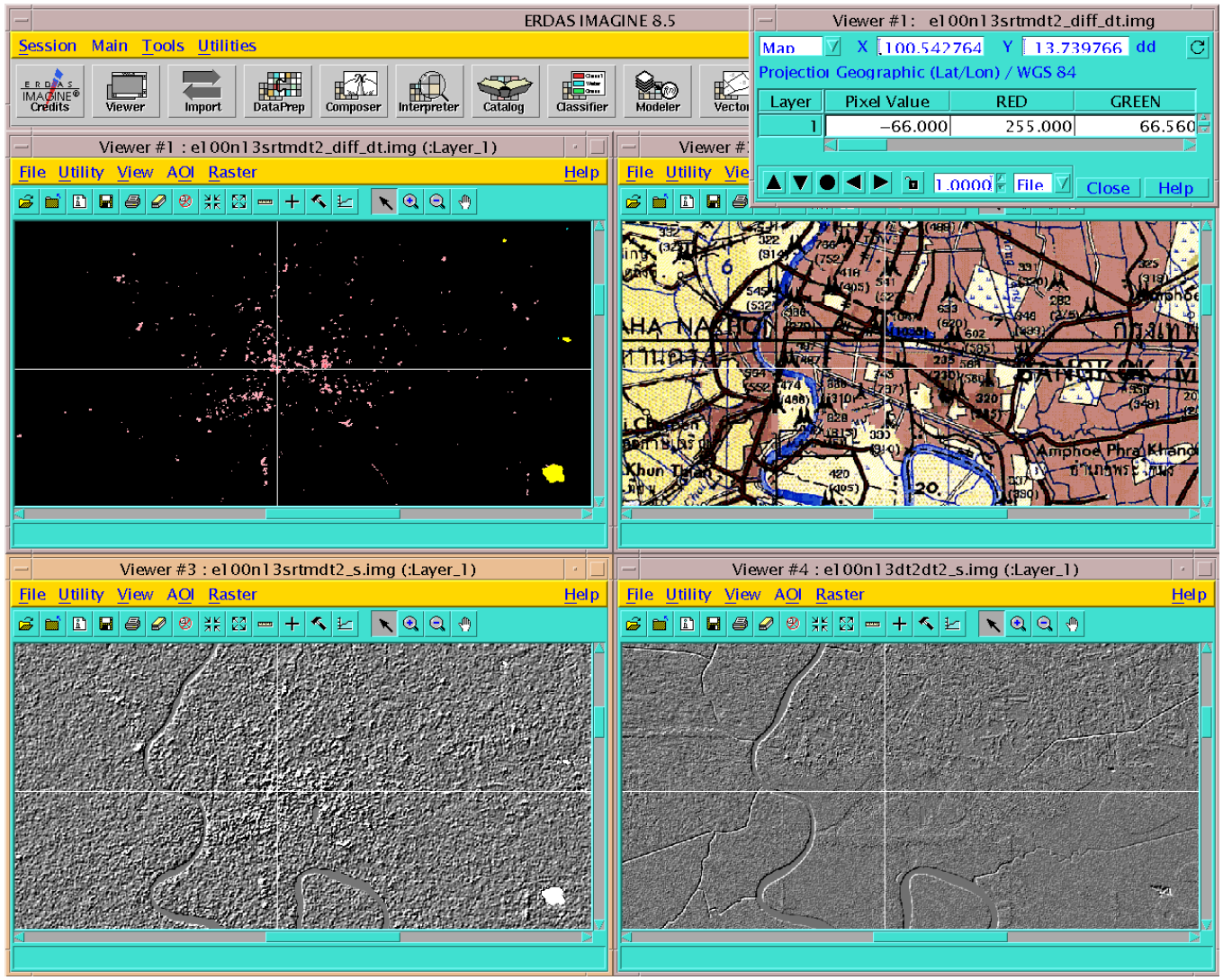
Random Vertical Noise – Urban Environment/reflective surface



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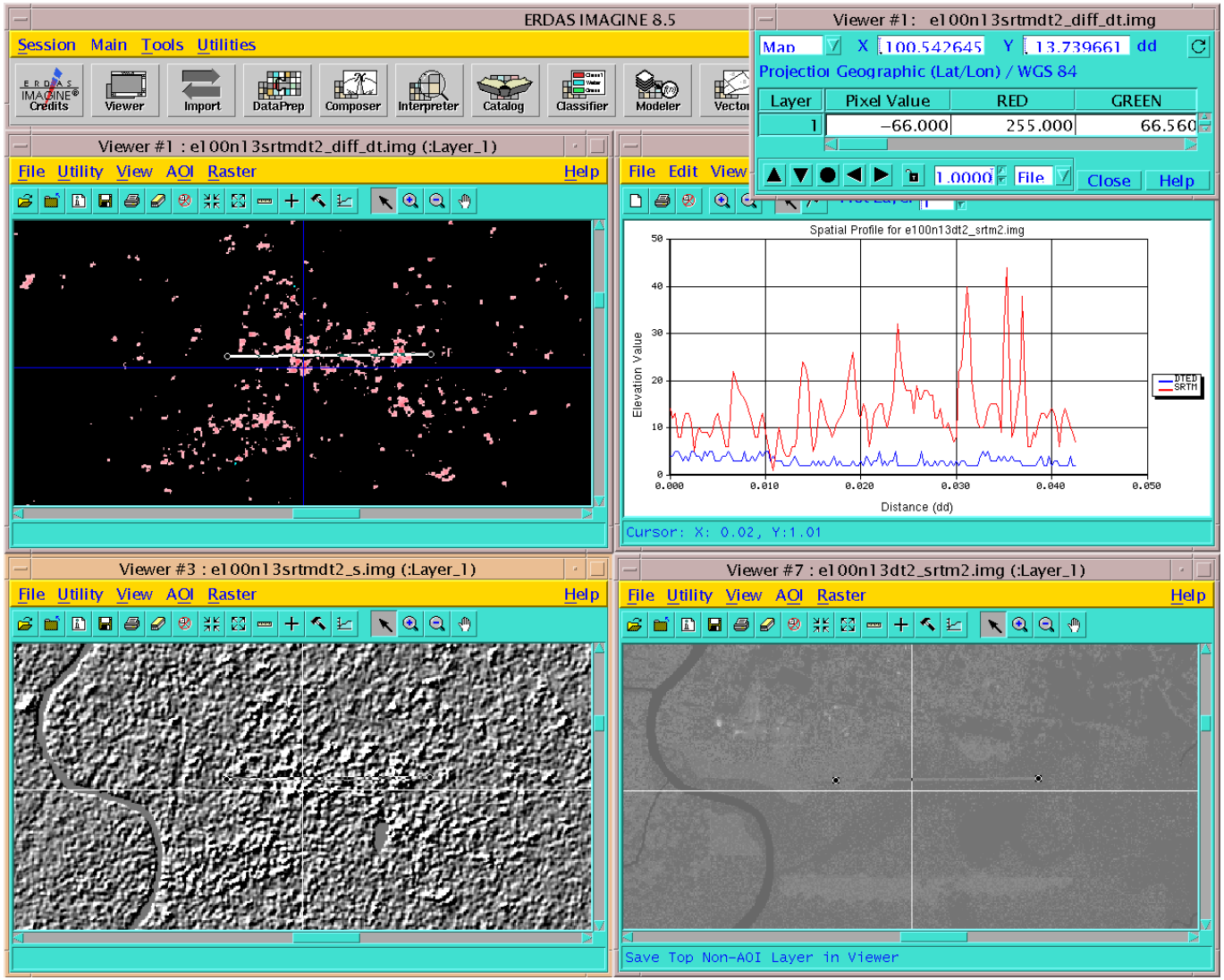
Random Vertical Noise/reflective surface



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Phase Unwrapping Errors

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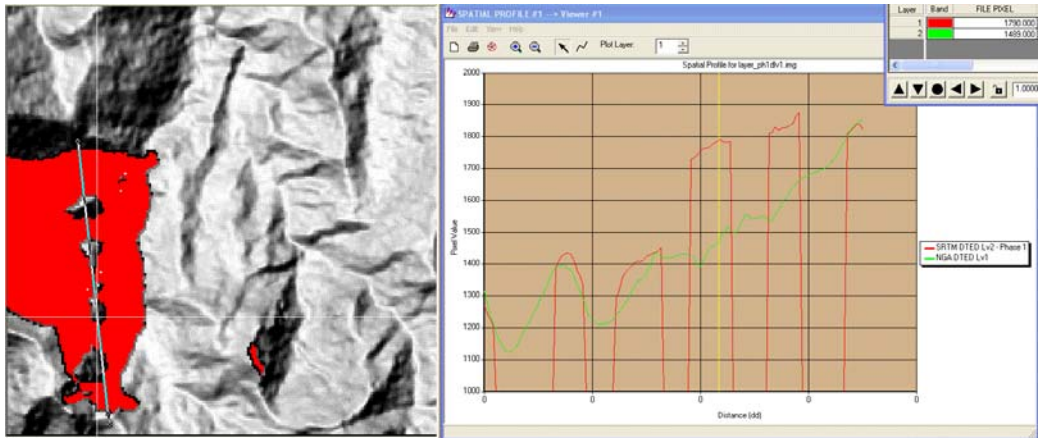
Phase Unwrapping Errors (PUE)

- Phase Unwrapping Error
  - Description: clusters of elevations that are vertically (and possibly horizontally) indexed out of sequence by some factor of the phase cycle - typically occurs when data is completely or almost completely surrounded by void
    - Not necessarily obvious
  - Cause:
    - Phase unwrapping algorithm incorrectly unwraps elevation(s)



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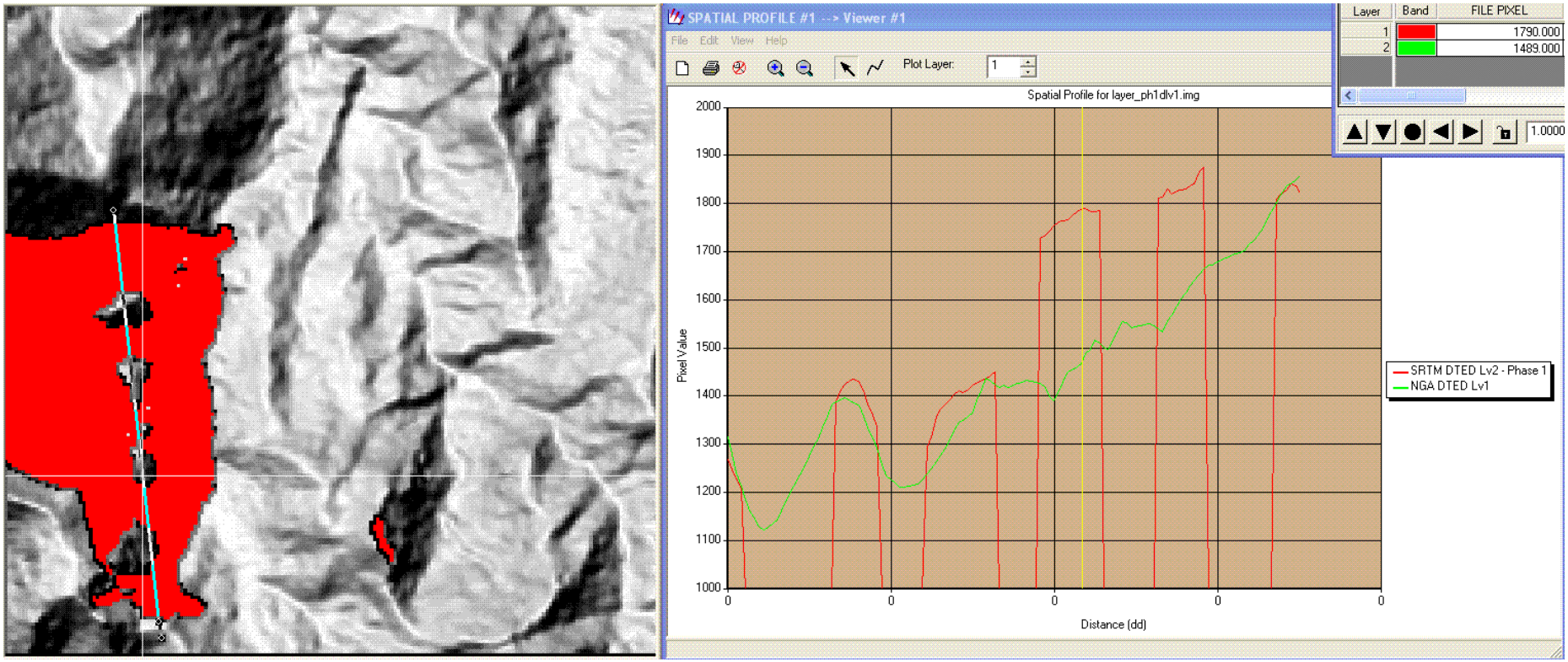
Phase Unwrapping Error



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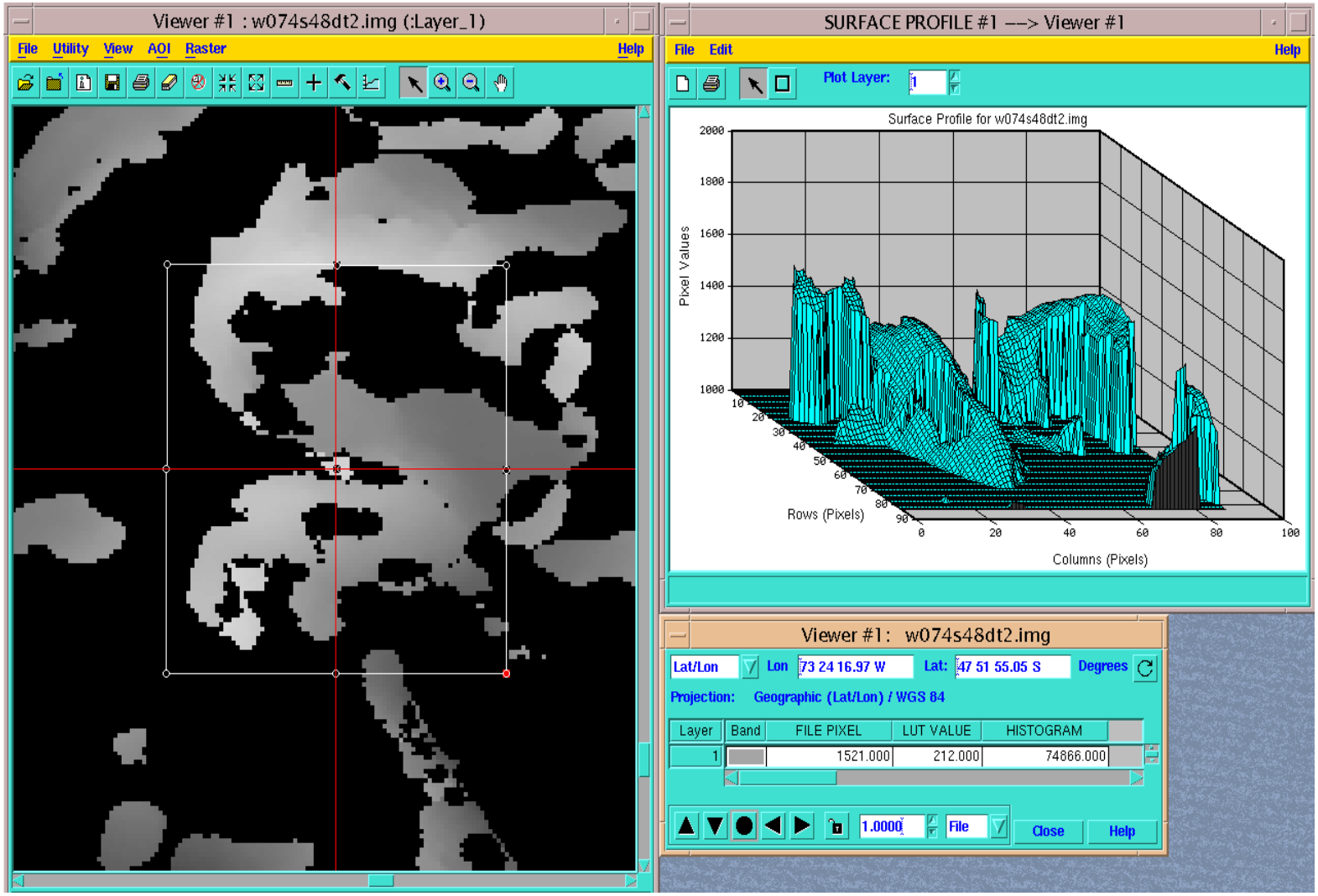
Phase Unwrapping Error



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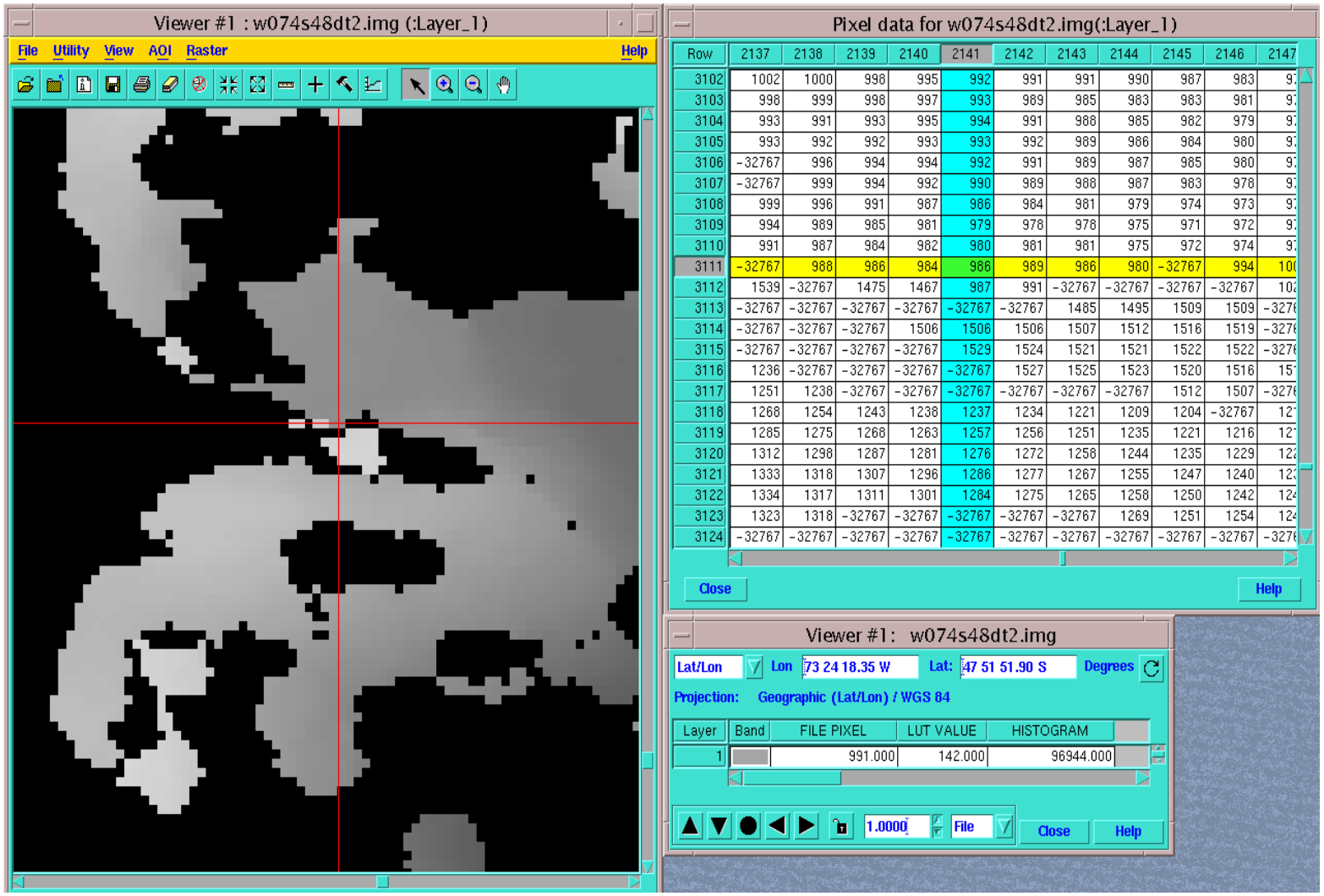
Phase Unwrapping Error



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Additional Data Examples

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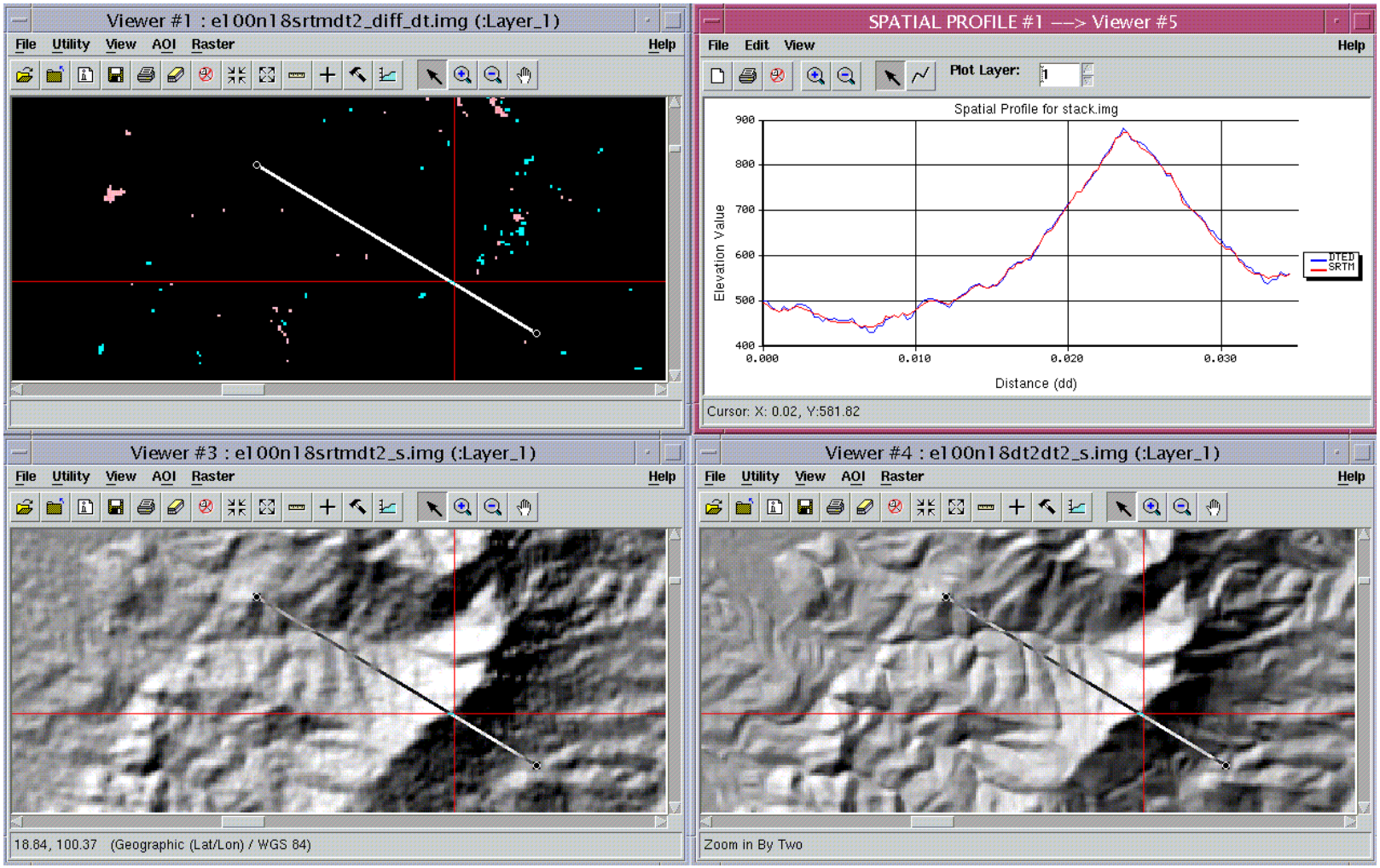
Typical area of good agreement across ridge



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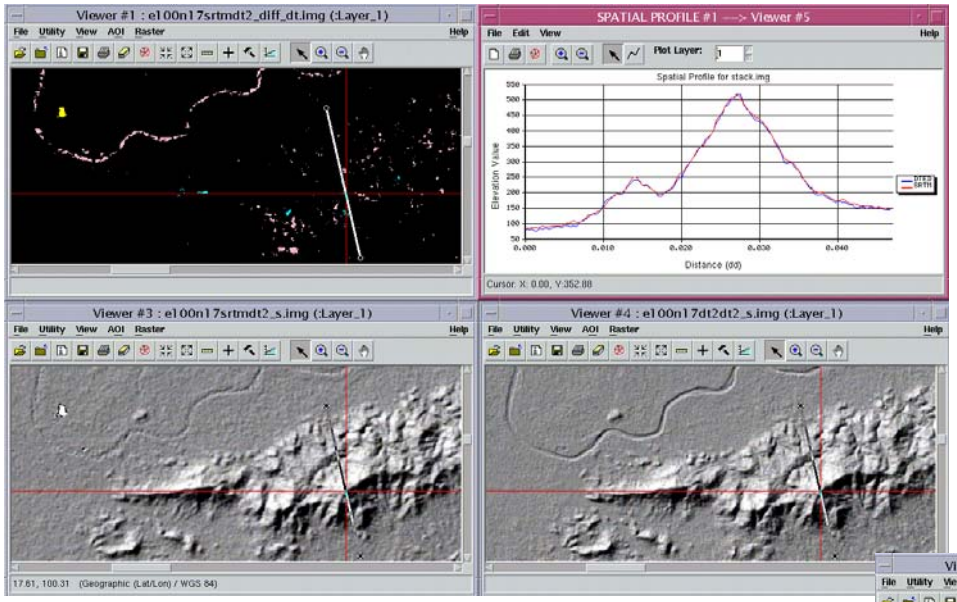
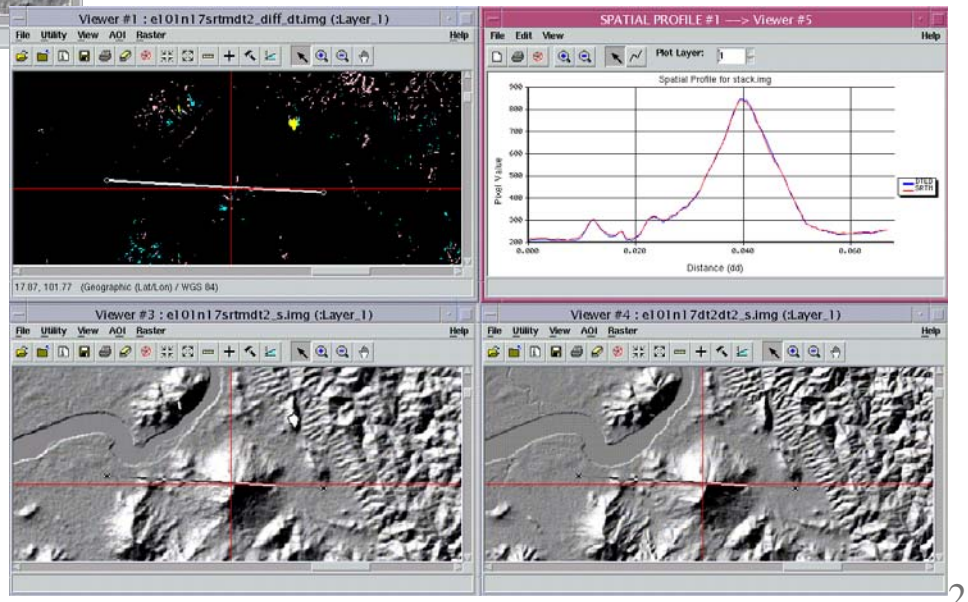
Typical areas of good agreement across ridge (2)





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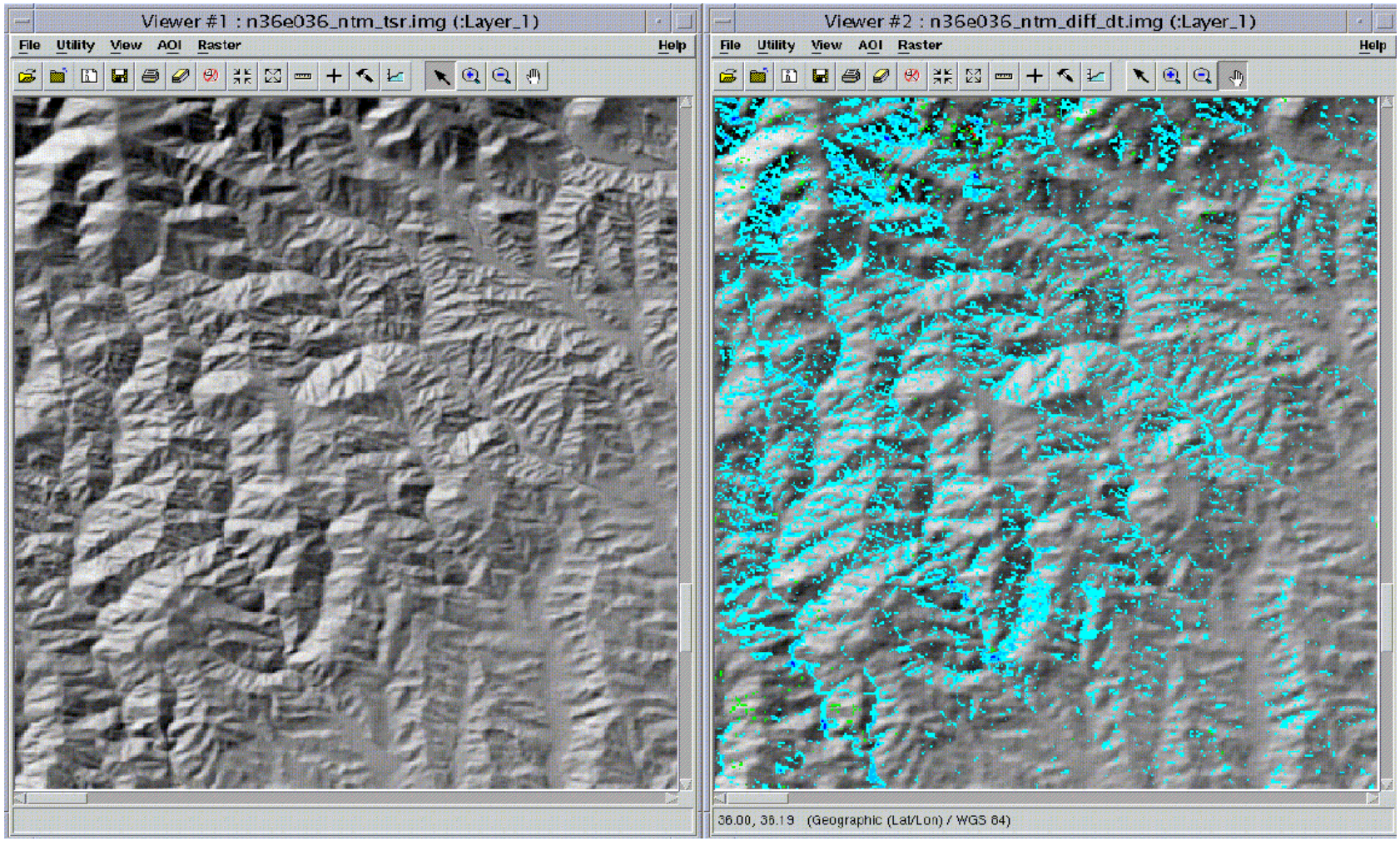

		<	-31
	-21	to	-30
	-11	to	-20
	-10	to	10
	11	to	20
	21	to	30
	31	>	
	Void		

NGA **N36 E036** **SRTM** (DIFF FILE OVERLAID)

In this area we see what is often typical of SRTM (the valleys are slightly higher - blue.

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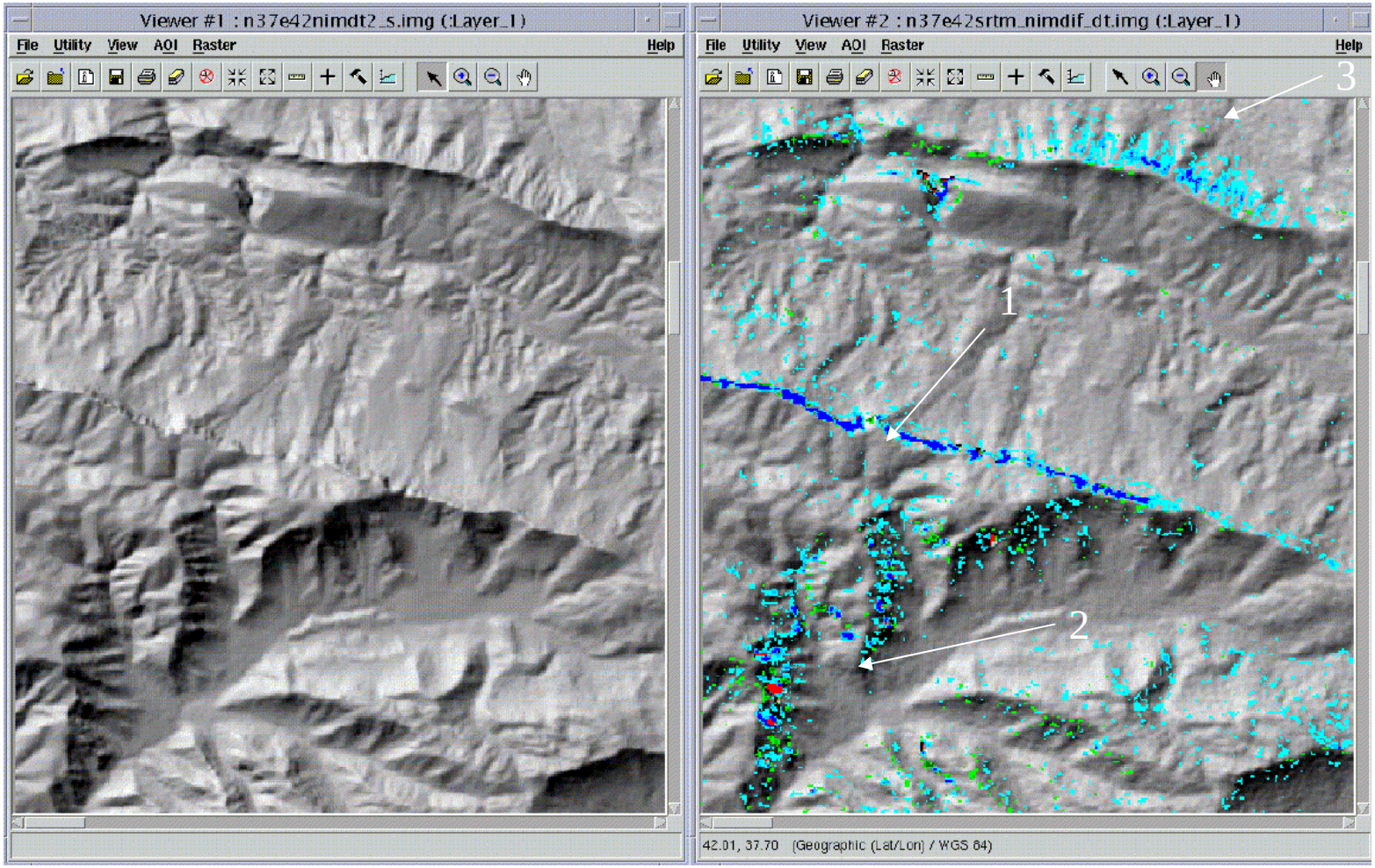

		<	-31
	-21	to	-30
	-11	to	-20
	-10	to	10
	11	to	20
	21	to	30
	31	>	
	Void		

NGA **N37 E042** **SRTM** **(DIFF FILE OVERLAID)**

North/northeast looking escarpment (1) faces are higher as indicated by blue color – note the higher deltas as indicated by the darker blue. North (2) and north/northeast looking slope faces (3) are higher as indicated by blue. (Scattered to no vegetation present)

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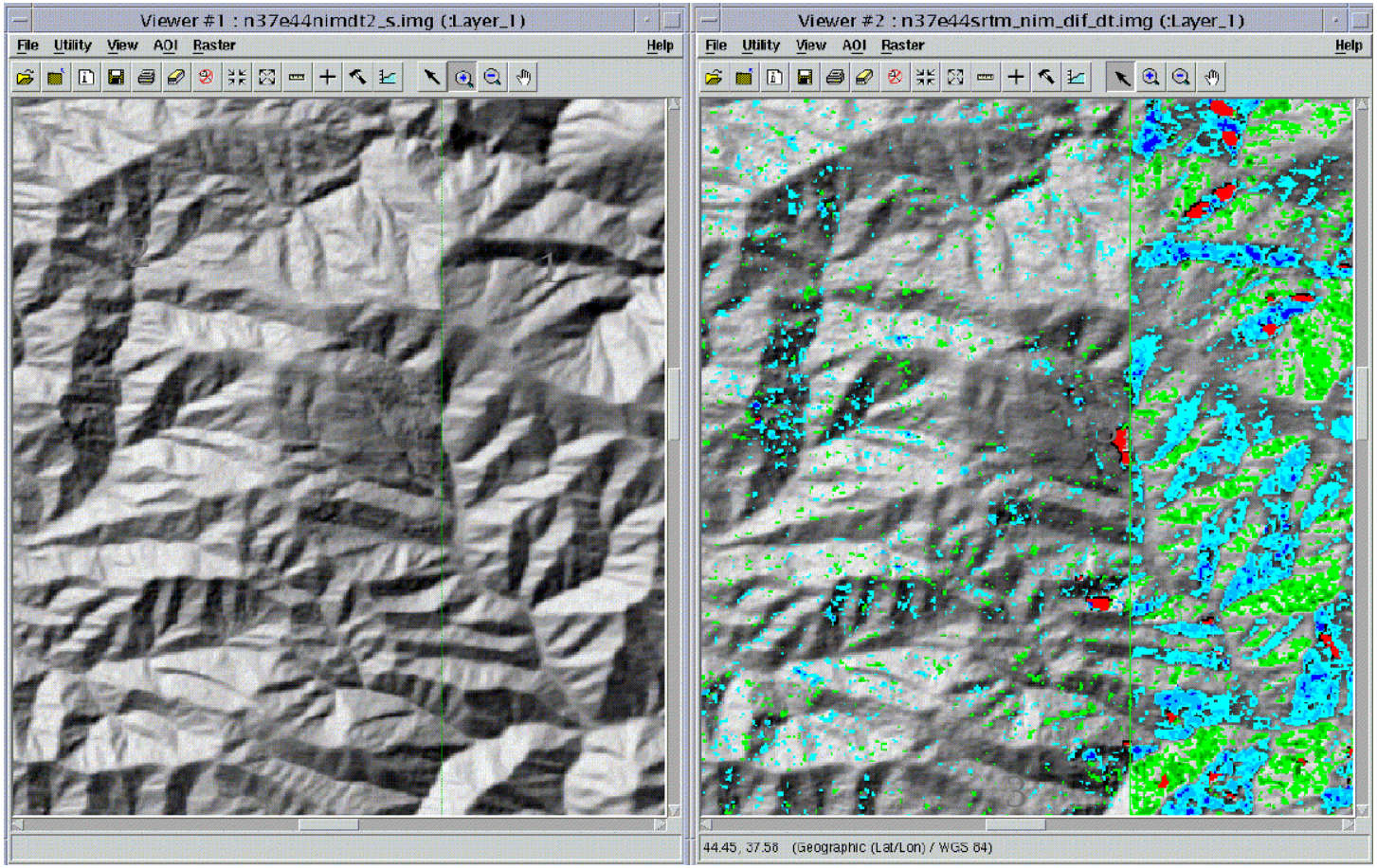
"Standard" DTED ® 2 Artifact - data was smoothed



1

		<	-31
	-21	to	-30
	-11	to	-20
	-10	to	10
	11	to	20
	21	to	30
	31	>	
	Void		

NIMA **N37 E044** **SRTM** (DIFF FILE OVERLAID)

This is a example of mixing older extraction/finished NGA NTM data (1) to more current solutions (2). The older NIMA appears to have been "smoothed" and has introduced greater delta differences.

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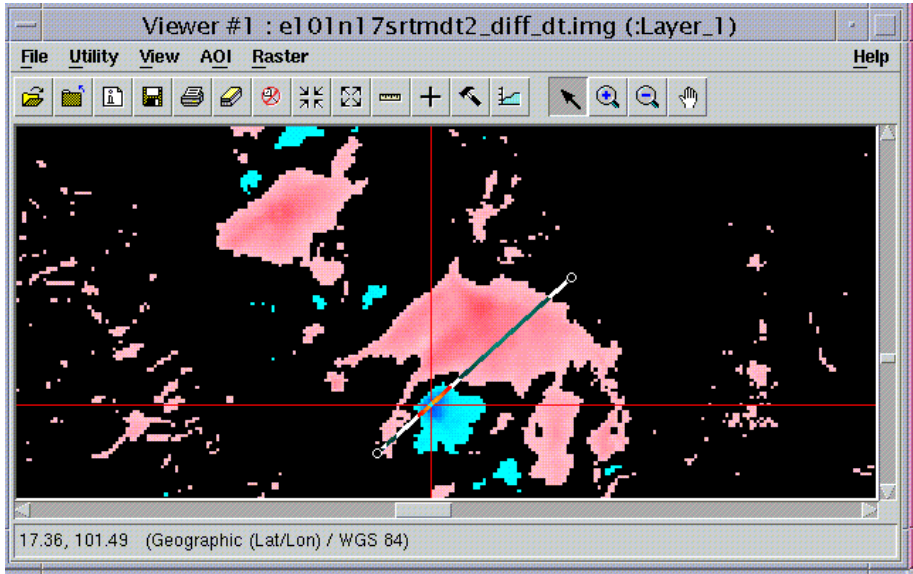
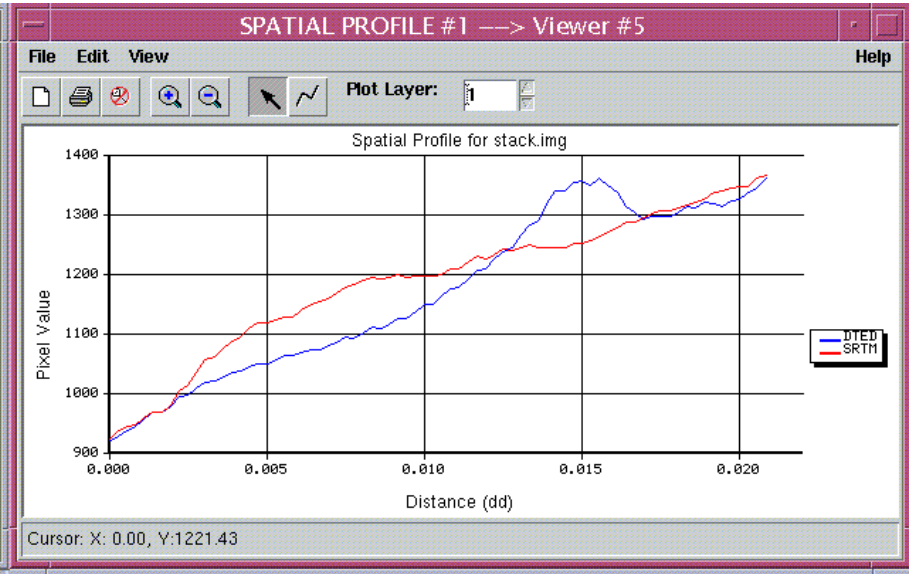
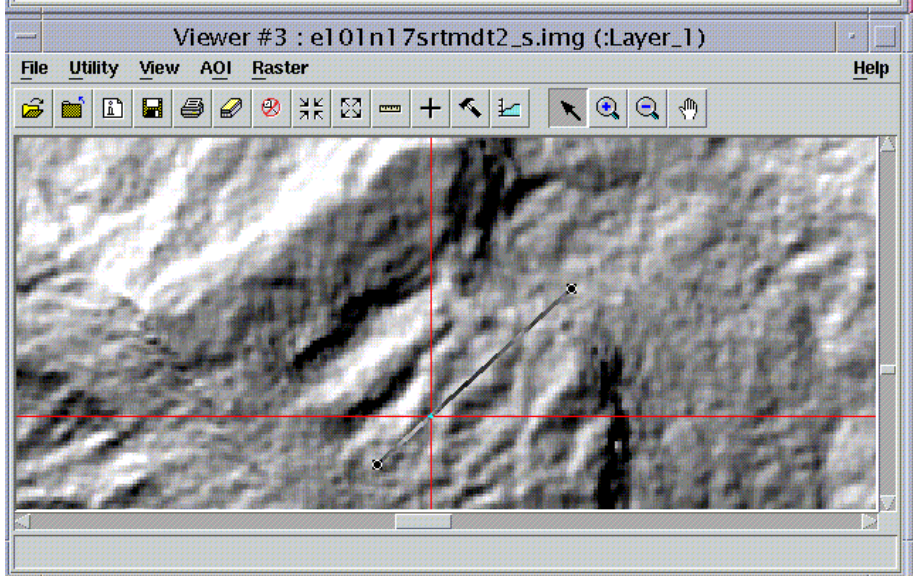
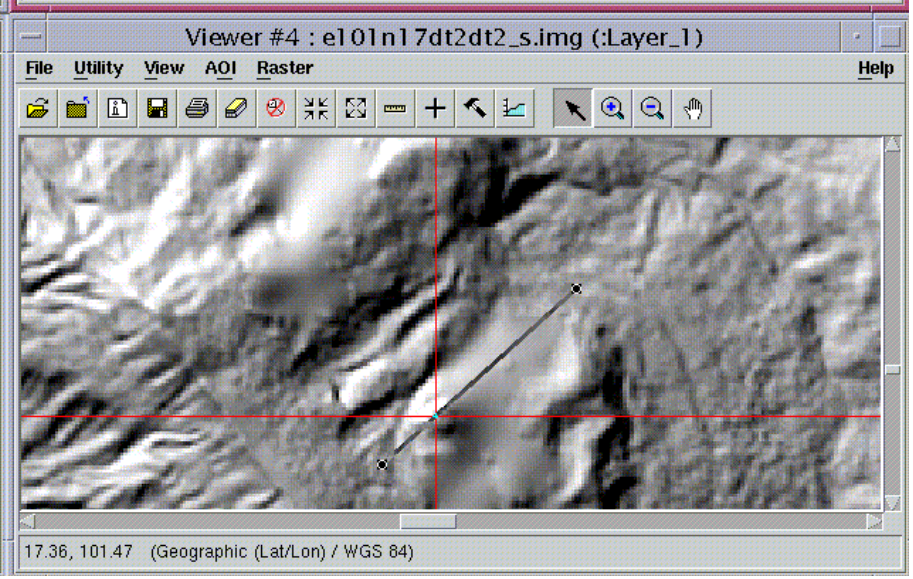
"Standard" DTED ® 2 Error









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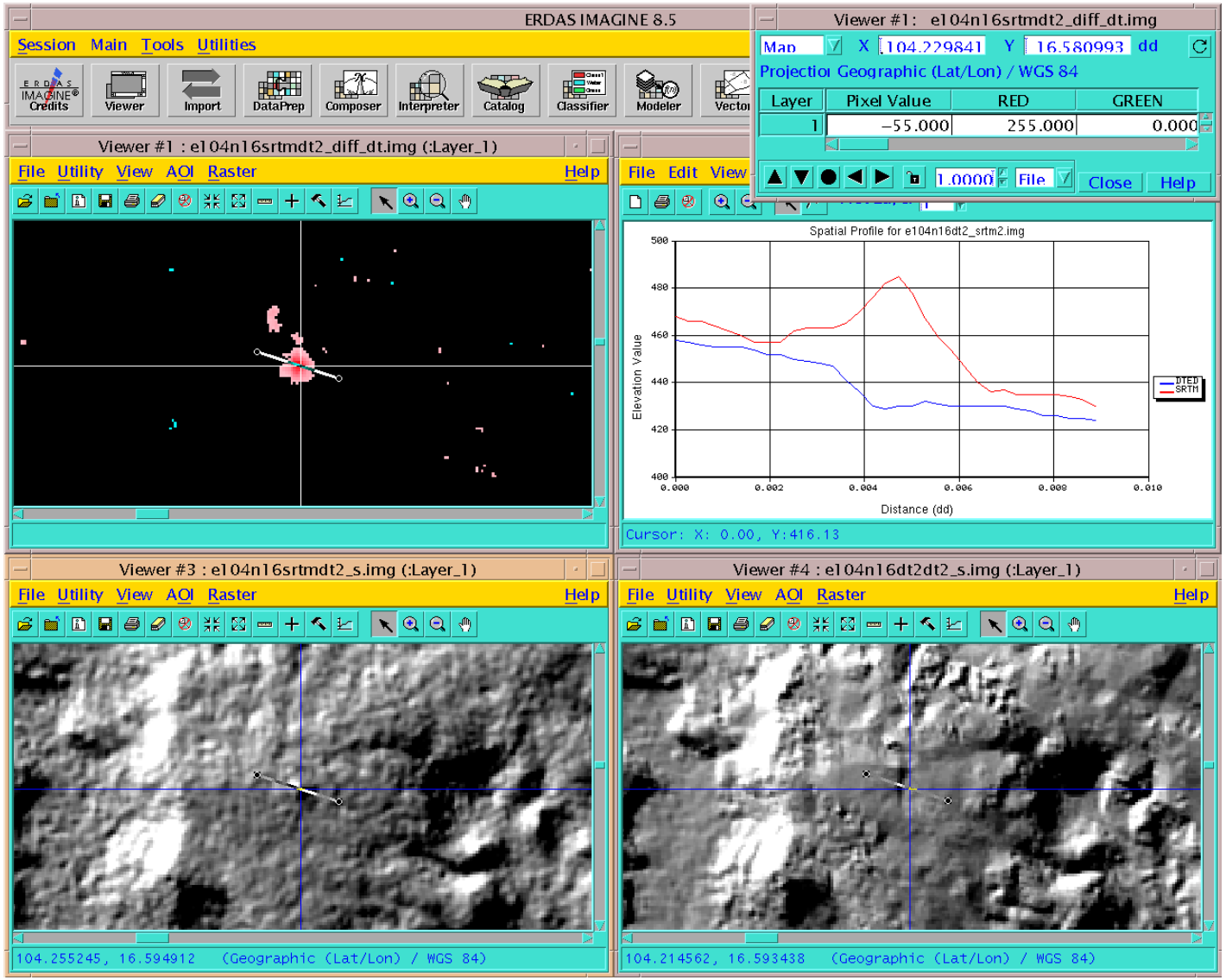
"Standard" DTED ® 2 Error



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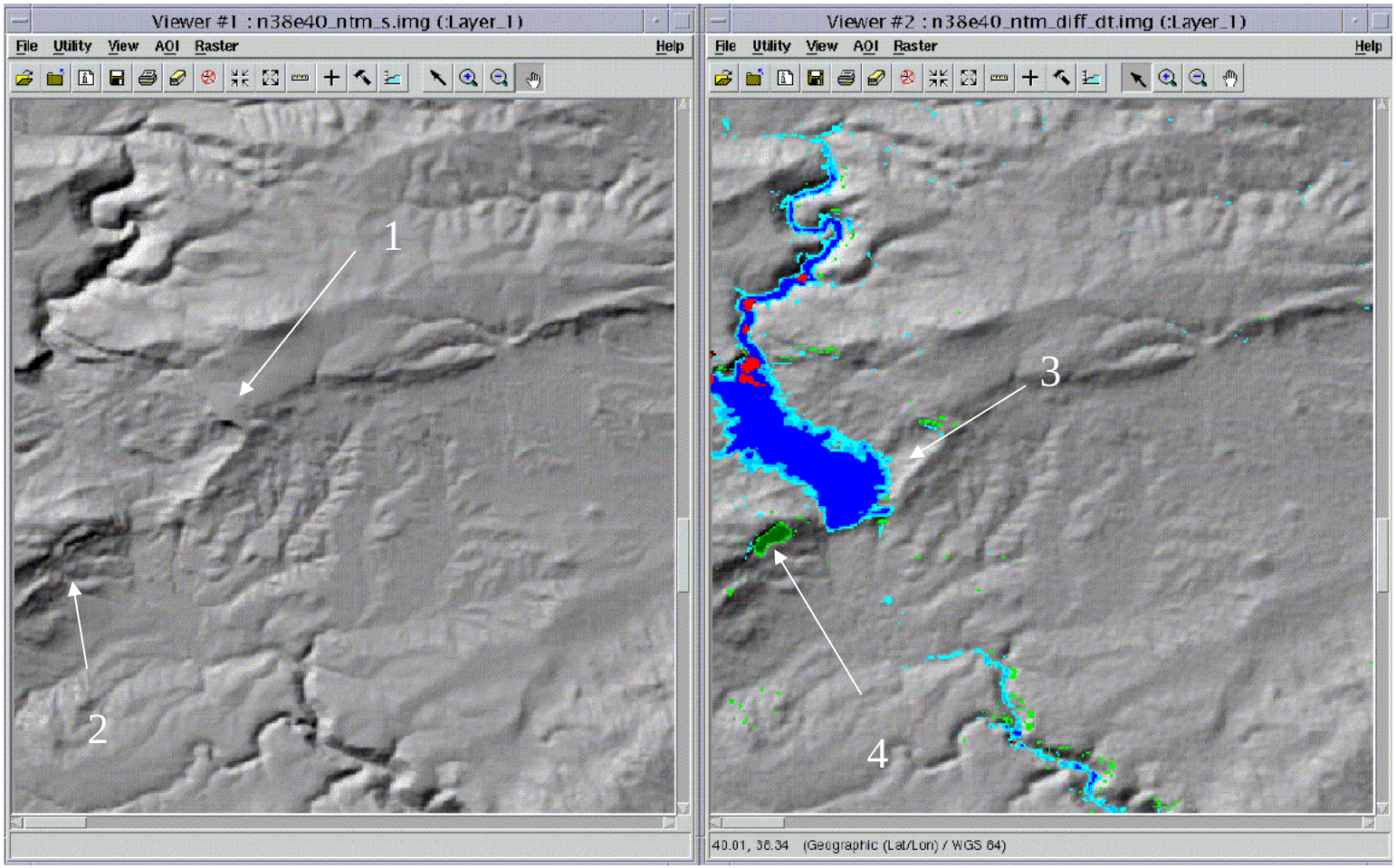

NGA **N38 E040** **SRTM** (DIFF FILE OVERLAID)

		<	-31
	-21	to	-30
	-11	to	-20
	-10	to	10
	11	to	20
	21	to	30
	31	>	
	Void		

First surface difference. The NIMA data shows the area dry (1) with the dam (2) under construction. The reservoir water (3) is indicated by the blue color. Note the excavation area (4) for use in the construction of the dam as indicated by the green color. (Scattered to no vegetation present)

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Conclusions

- Statistically SRTM DTED ® 2 is equivalent to “Standard” DTED ® 2
  - Large differences are more typically a result of “Standard” DTED 2 artifact
- SRTM DTED ® 2 is far more homogeneous than “Standard” DTED ® 2
  - “Standard” DTED ® 2 may possess slightly better resolution – but is also much more prone to edit/ correlation artifacts
  - Reflective surface difference not generally an issue– urban exception
- SRTM DTED ® 2 differs compared to “Standard” DTED ® 2 in the following ways:
  - **Voids**
    - Typically small, but scattered throughout
    - Data surrounding void may be noisy
  - **Random vertical error**
    - SRTM is typically noisier (in low relief affects contour, line of sight and may affect orthorectification)
  - **Phase Unwrap Errors**
    - These are rare and typically associated with small data “islands” that are completely surrounded by void

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