

Bohannan▲Huston

ROBERT DZUR

A GRASS GIS Study of Open Data 1-meter NED DEM Resampling

Comparing recently published 1-meter NED to 3DEP
LiDAR-derived original product resolution DEMs.

Outline

Where are we headed ?



Open Data

7

Analysis



GRASS GIS



Findings

1

Compare LiDAR QL2 DEM Products Seamless 1 m
(NED) vs Original Product Resolution (OPR)

2

Highlight issues in recently published QL2
datasets across 7 different AOIs in 4 States

3

Use GRASS GIS to prepare 1 m data from OPR;
validate, explore, and analyze DEM differences

4

Recommend: 1. Validate 2. Understanding
Impact on Vertical Accuracy

3DEP Elevation Data

US Geological Survey - The National Map <https://nationalmap.gov/3DEP/>

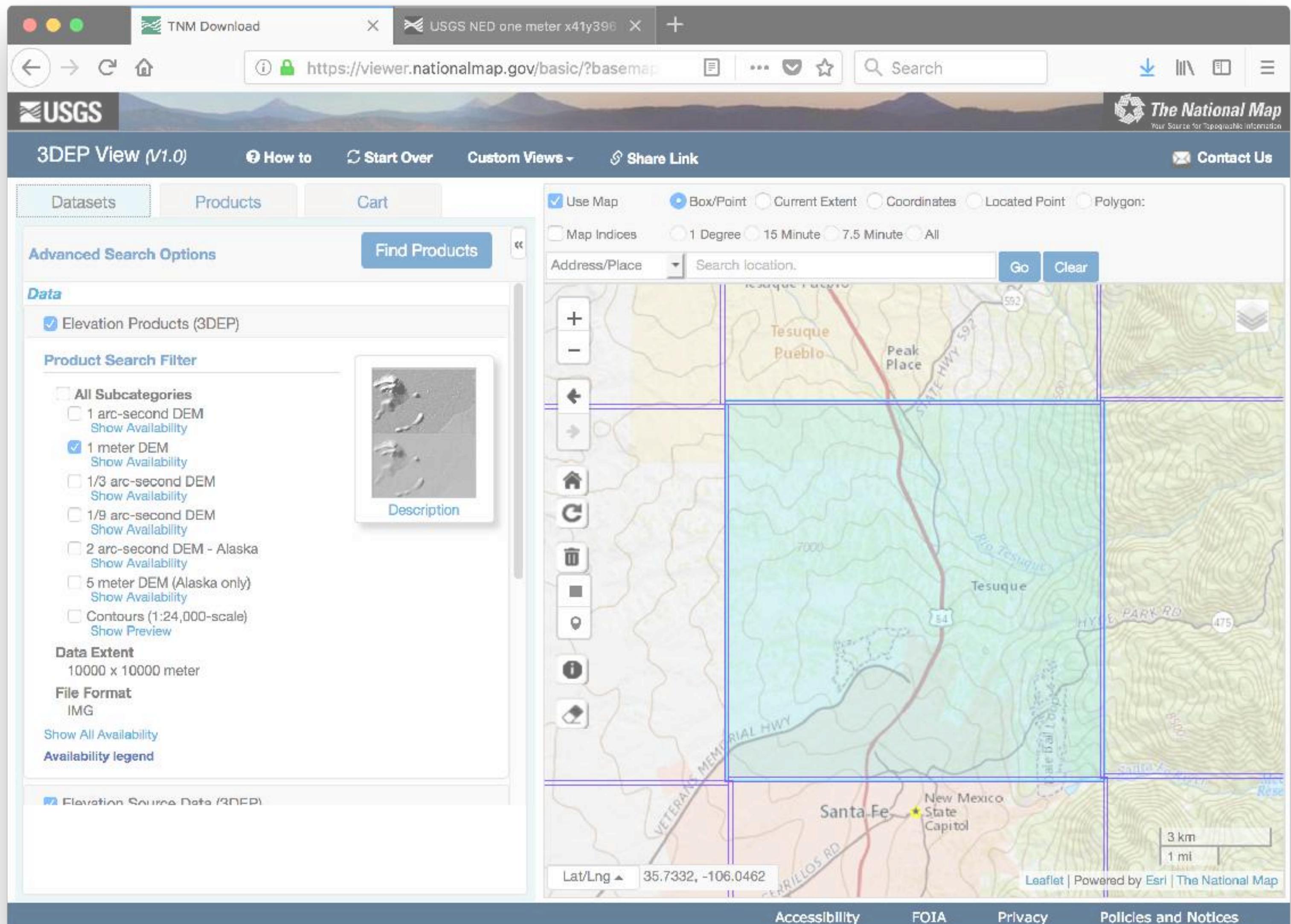
National Elevation Dataset (NED) - 1m

National Elevation Dataset (NED) changed to "the standard national DEM available through The National Map." - 1

aka - Seamless - 2

Original Product Resolution (OPR)

Digital Elevation Model (DEM) as provided to the USGS

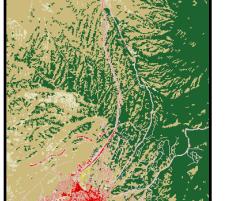
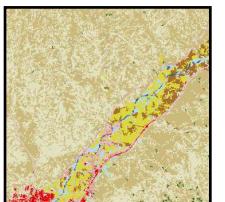
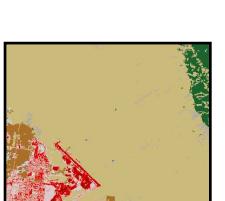
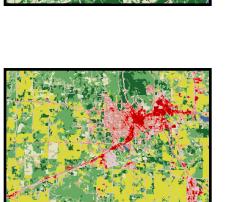


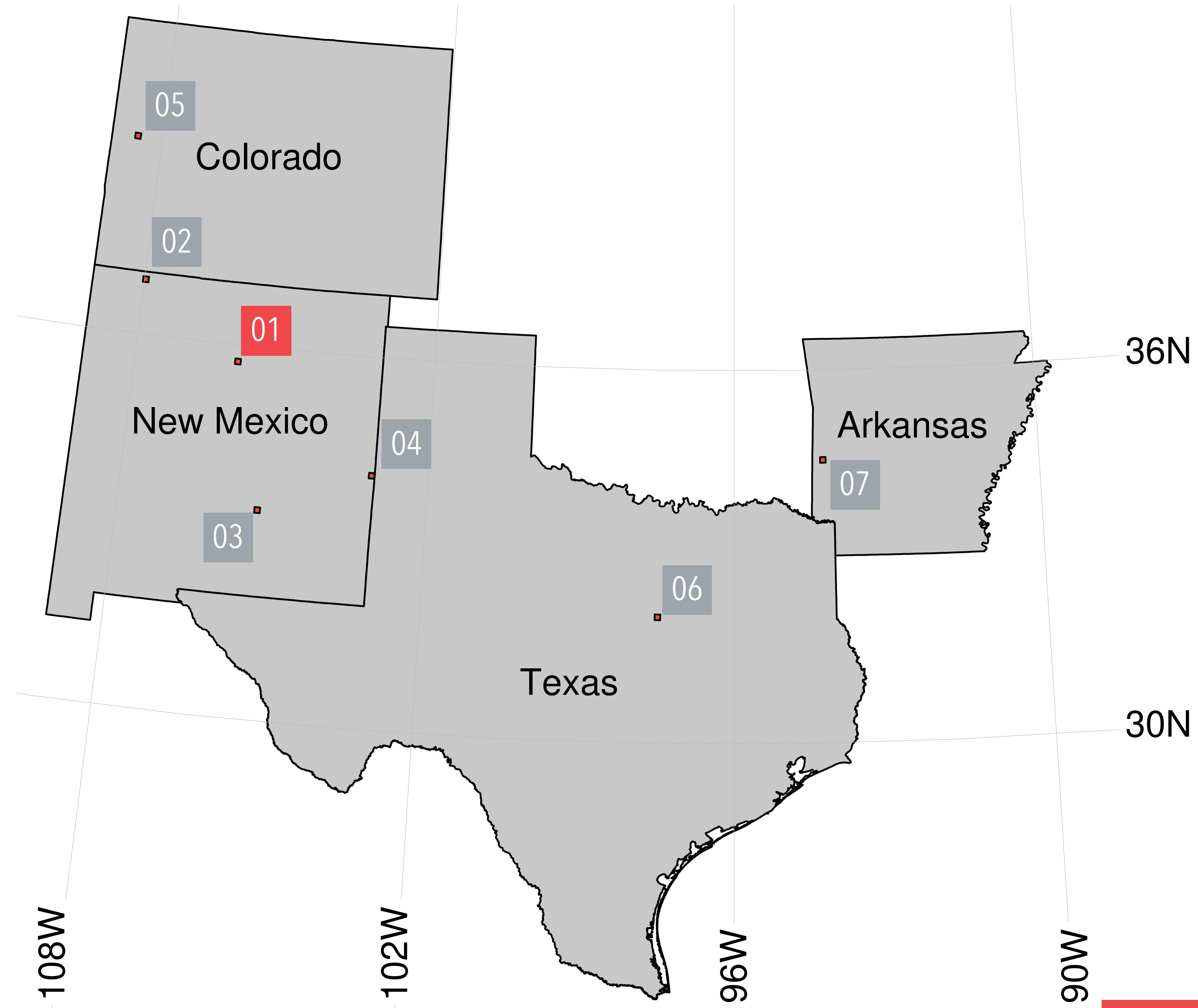
1 - Heidemann, Hans Karl, 2018, Lidar base specification (ver. 1.3, February 2018): U.S. Geological Survey Techniques and Methods, book 11, chap. B4, 101 p., <https://doi.org/10.3133/tm11b4>.

2 - Archuleta, C.M., Constance, E.W., Arundel, S.T., Lowe, A.J., Mantey, K.S., and Phillips, L.A., 2017, The National Map seamless digital elevation model specifications: U.S. Geological Survey Techniques and Methods, book 11, chap. B9, 39 p., <https://doi.org/10.3133/tm11B9>.

7

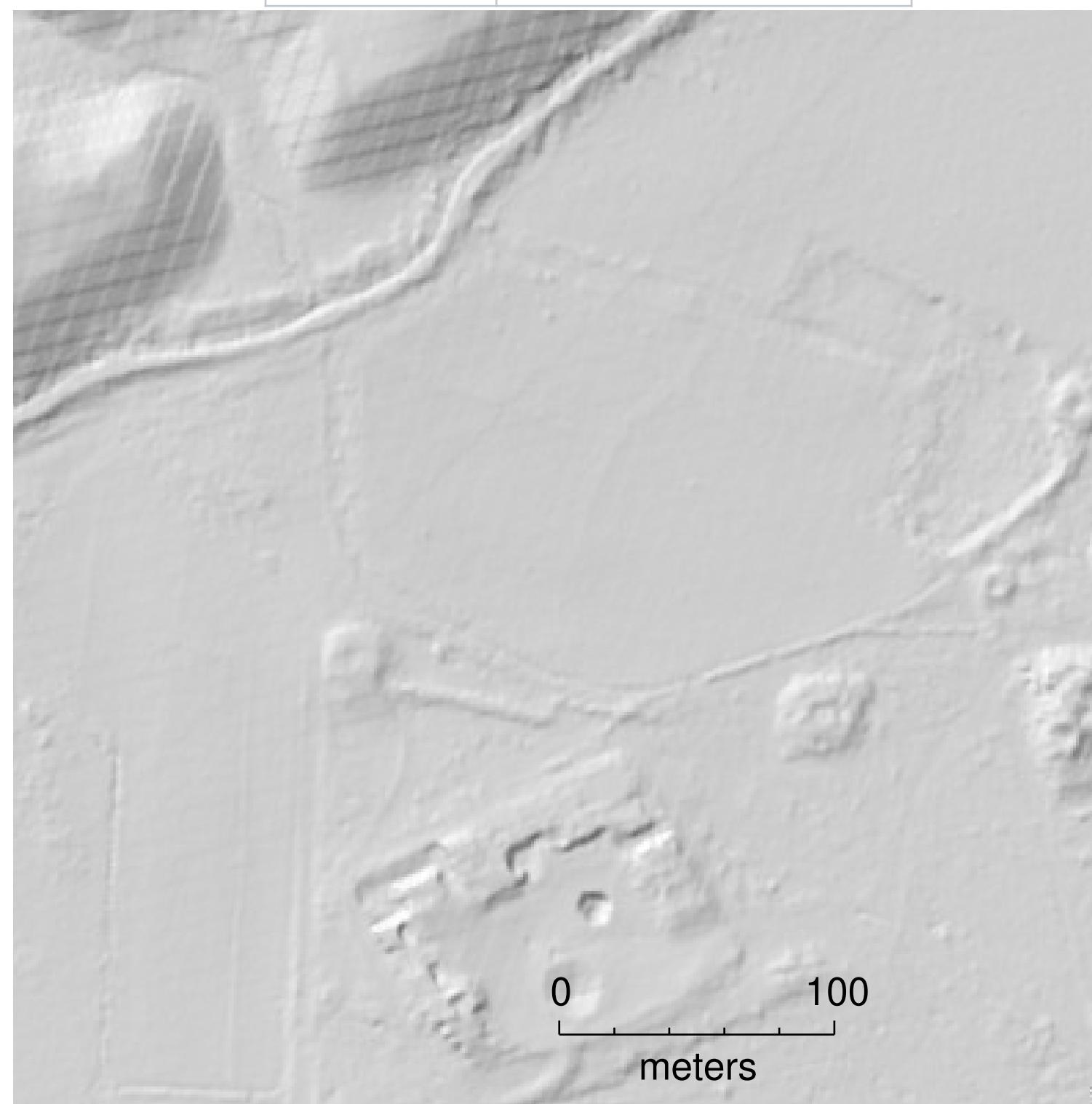
Study Sites

	01	NM_SantaFeCo - Santa Fe, NM center longitude: 105:56:23.870973W center latitude: 35:44:07.170028N
	02	NM_Animas - Aztec, NM center longitude: 107:58:22.964147W center latitude: 36:52:25.659807N
	03	NM_RioHondo - Hondo, NM center longitude: 105:16:07.767698W center latitude: 33:23:38.422506N
	04	NM_Roosevelt_Curry - Portales, NM center longitude: 103:06:10.334774W center latitude: 34:06:04.275926N
	05	CO_MesaCo - Grand Junction, CO center longitude: 108:30:44.700782W center latitude: 39:08:15.576717N
	06	TX_MiddleBrazos - Hillsboro, TX center longitude: 97:27:51.971045W center latitude: 32:01:54.778607N
	07	AR_NRCS_A2 - Mena, AR center longitude: 94:15:12.759558W center latitude: 34:33:37.16949N

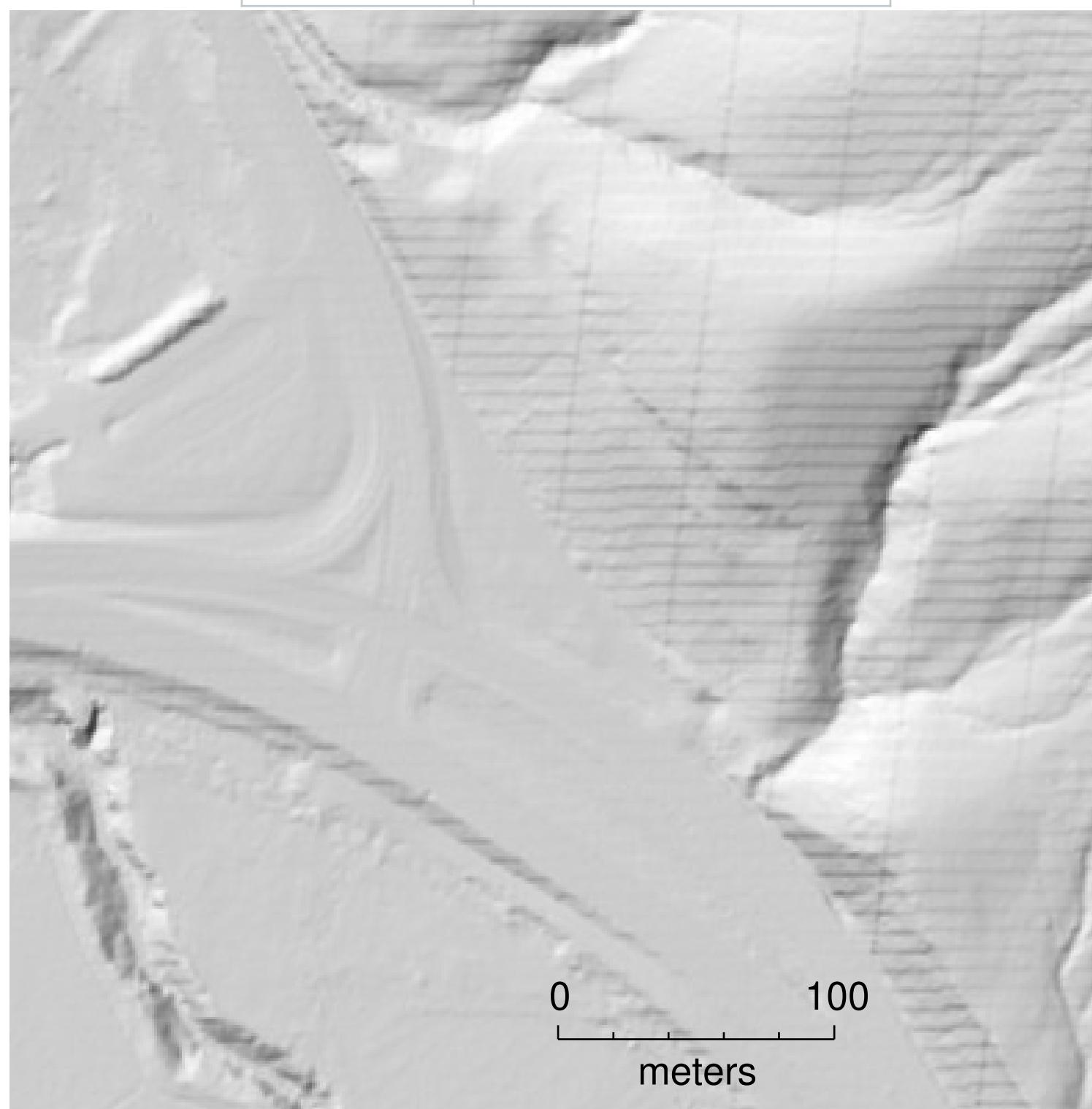


Tour

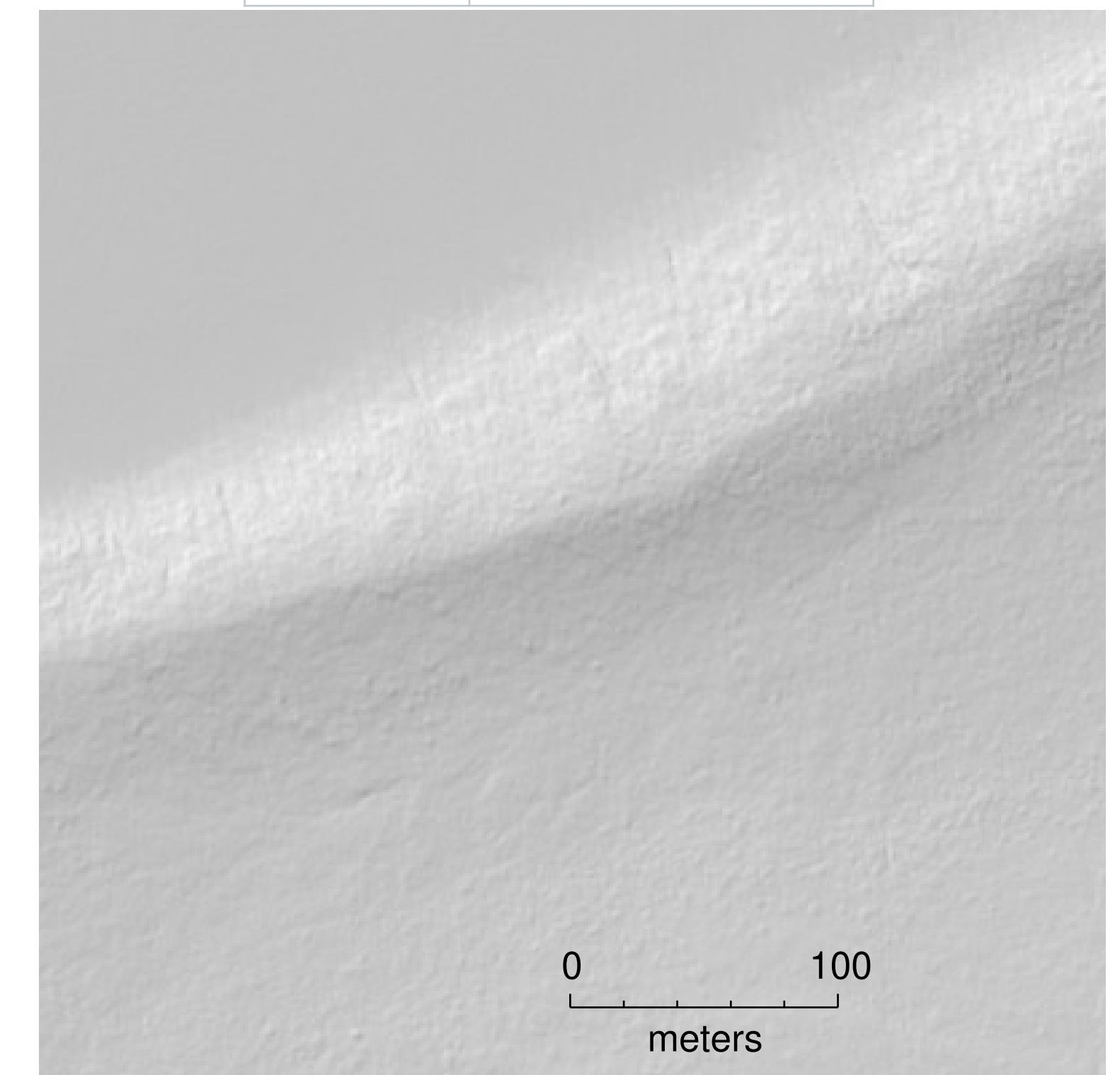
NM_Animas



NM_RioHondo



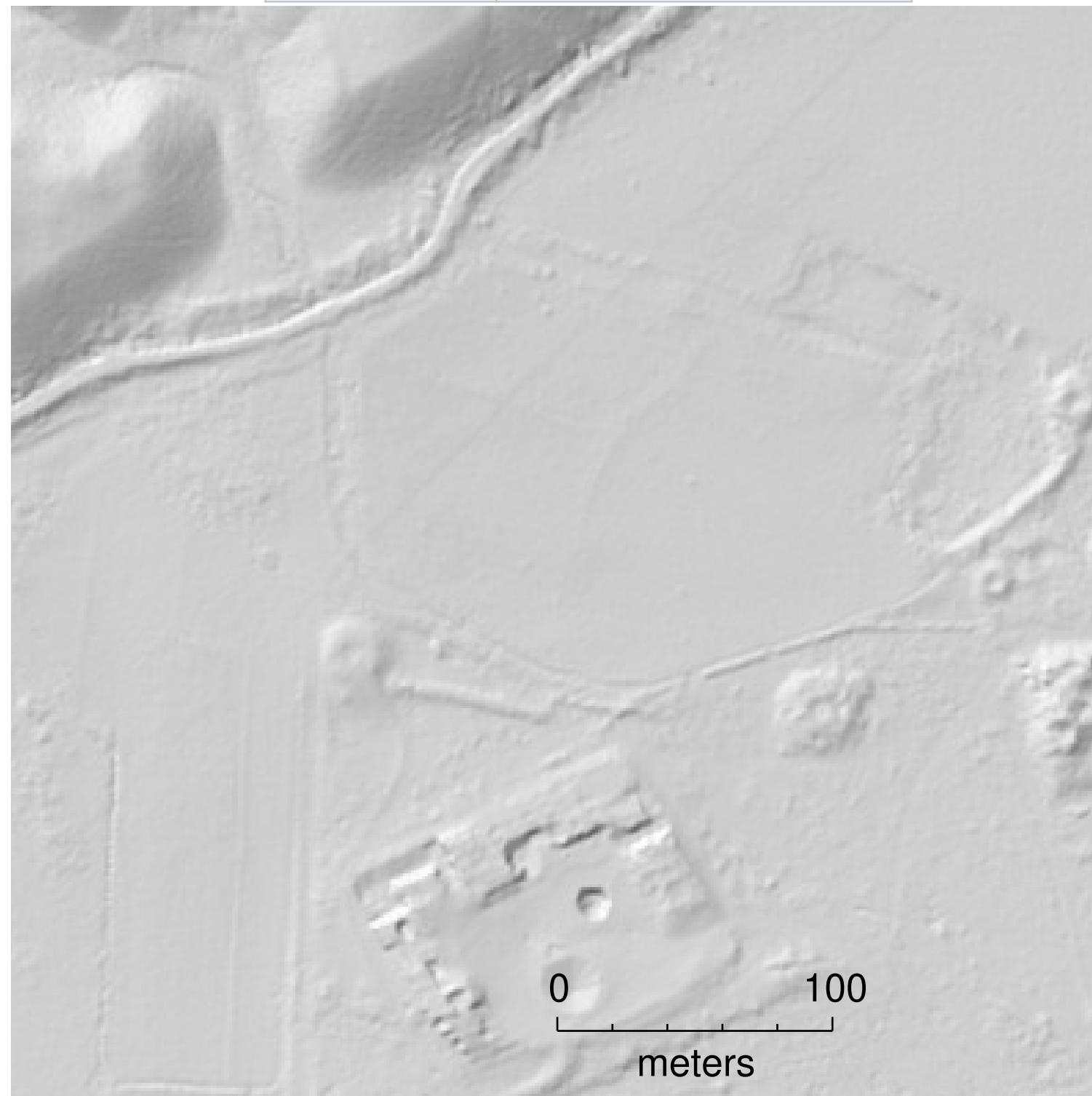
NM_Roosevelt_Curry



Tour

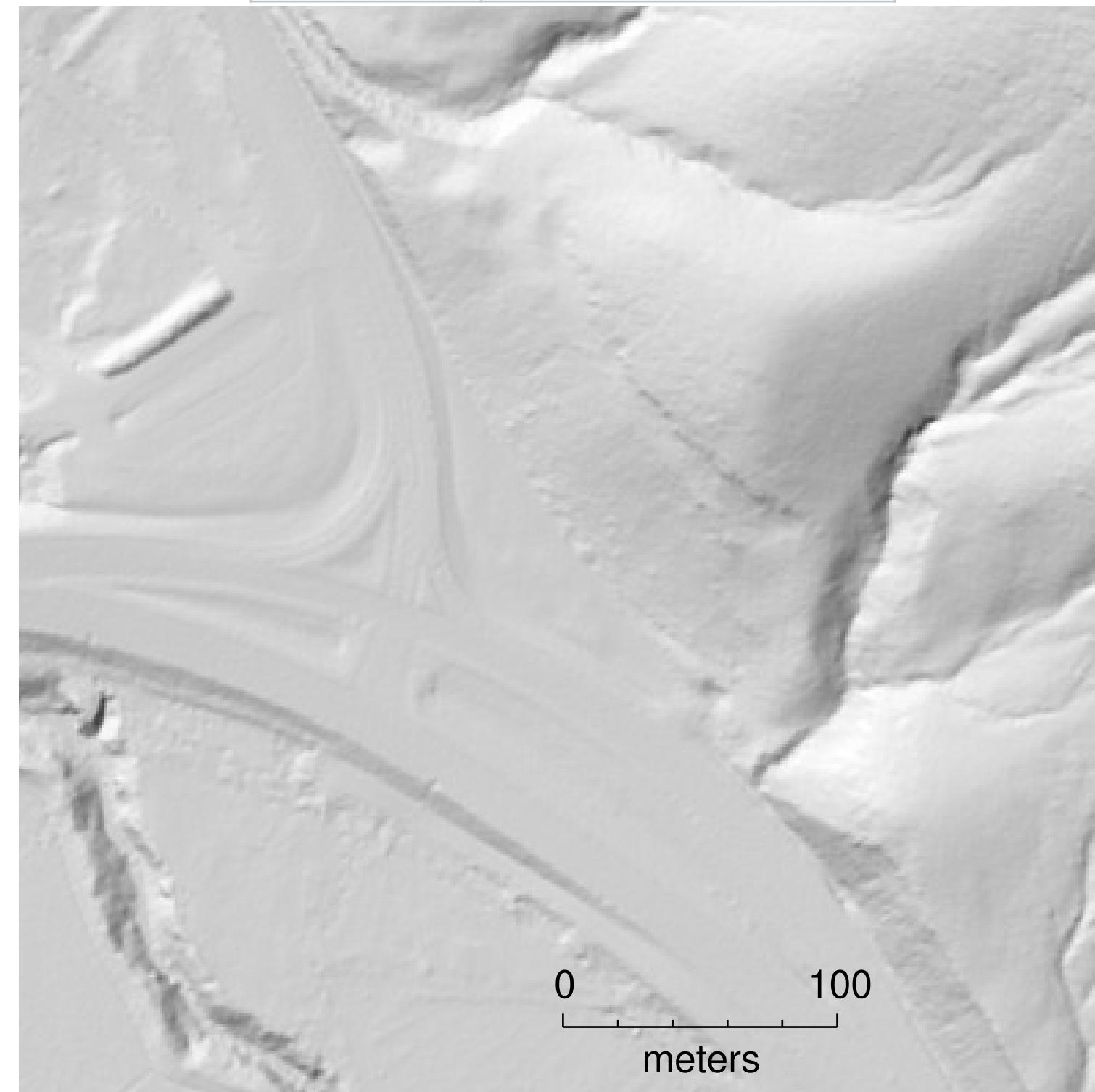
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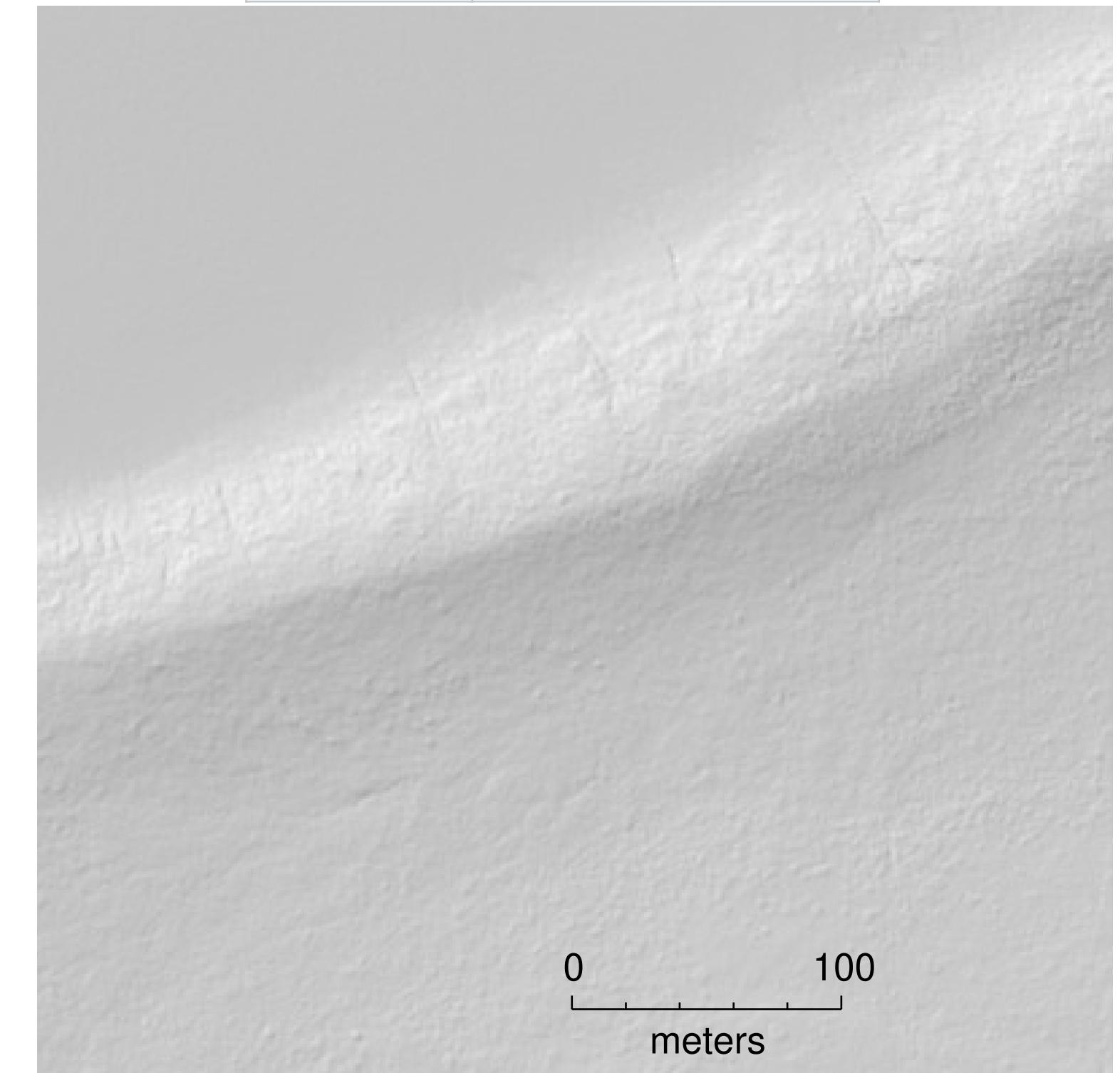
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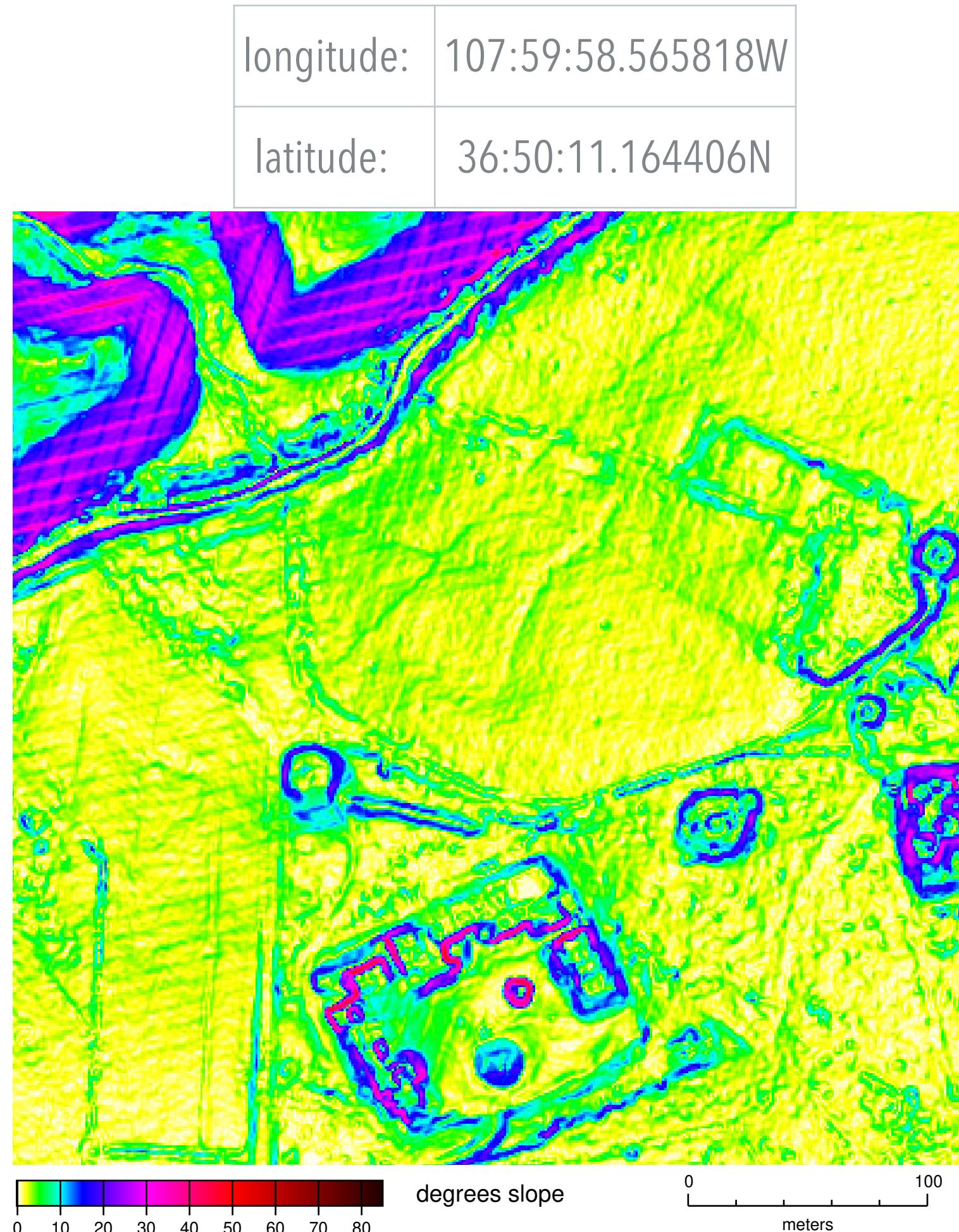
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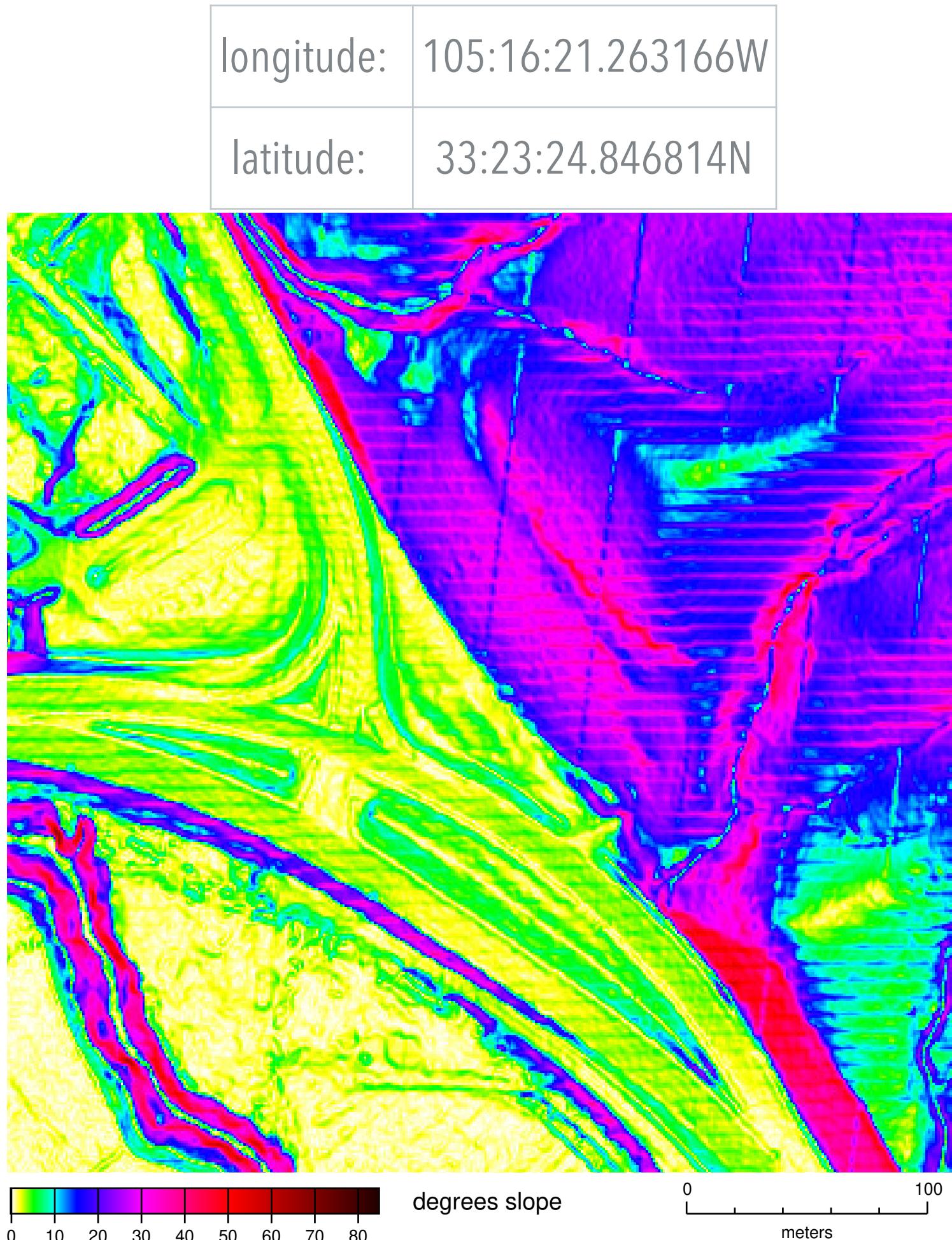


Tour

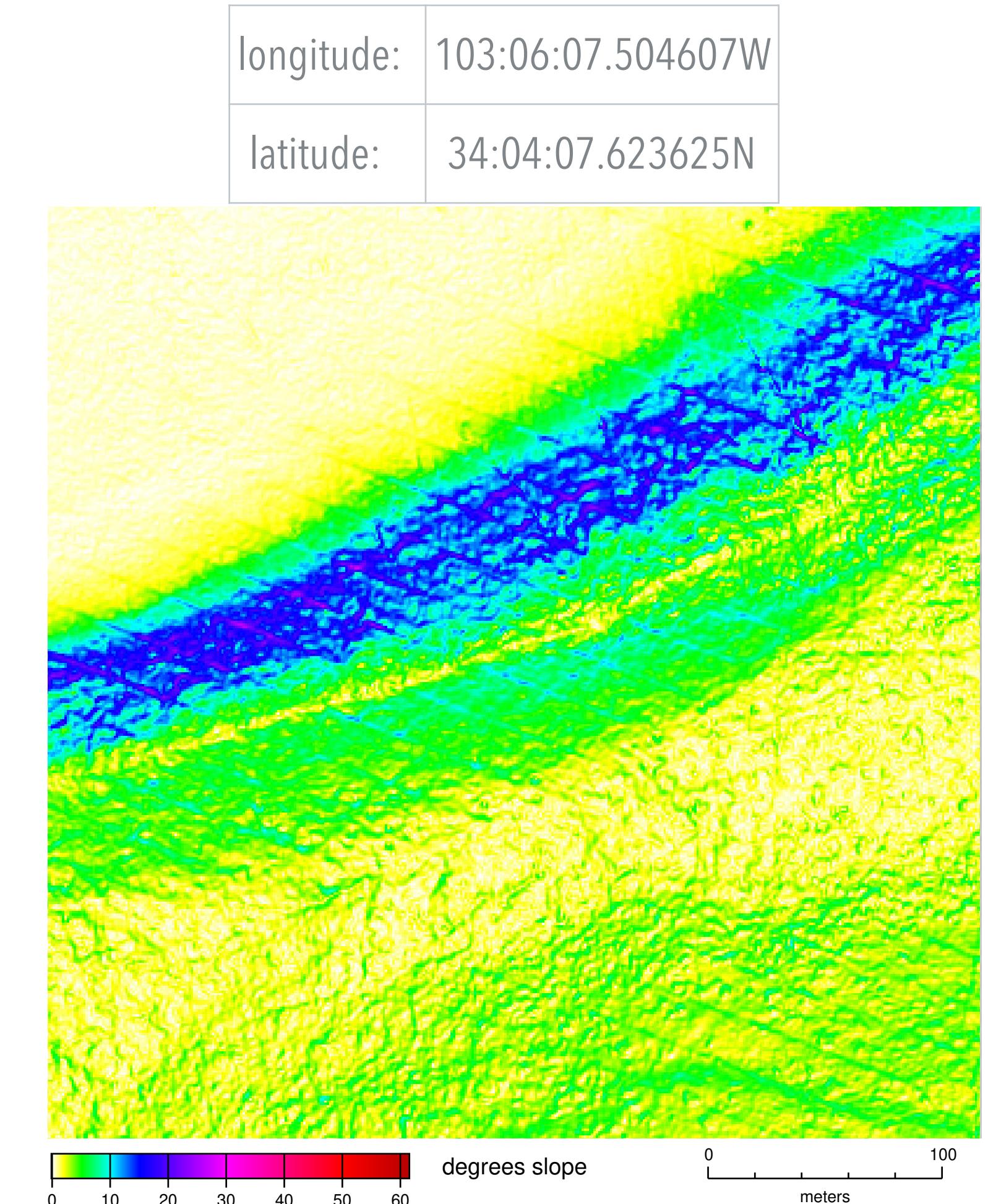
NM_Animas



NM_RioHondo

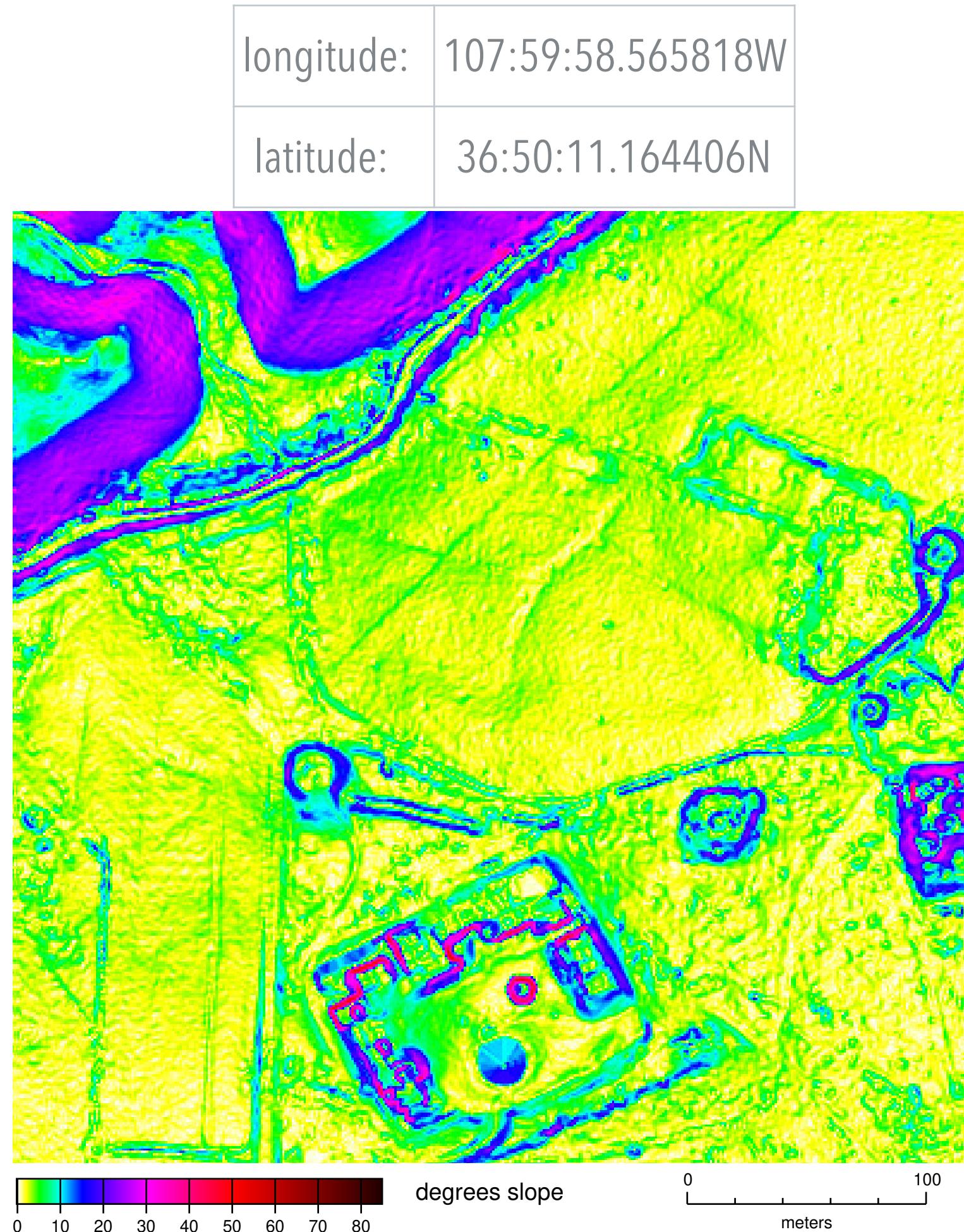


NM_Roosevelt_Curry

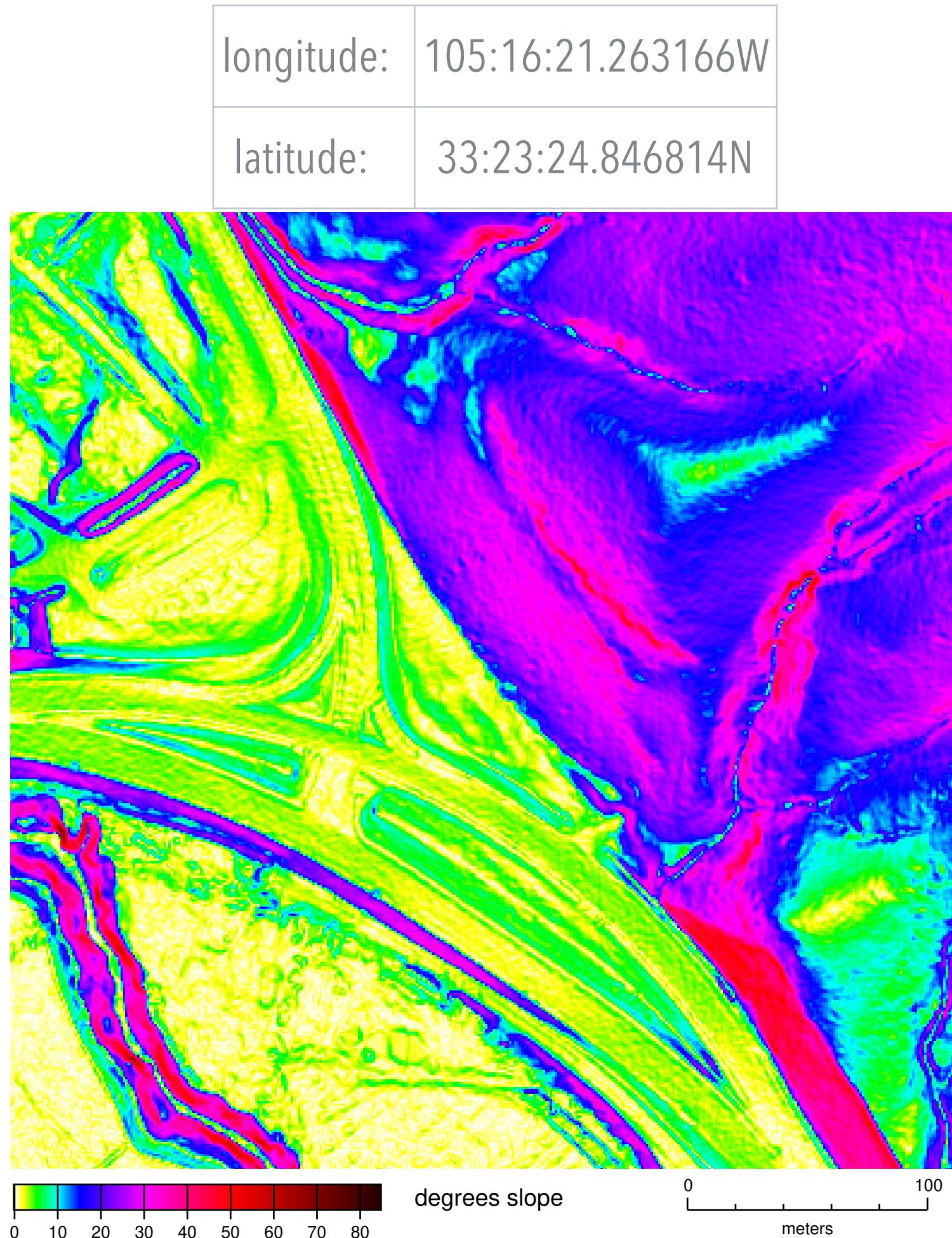


Tour

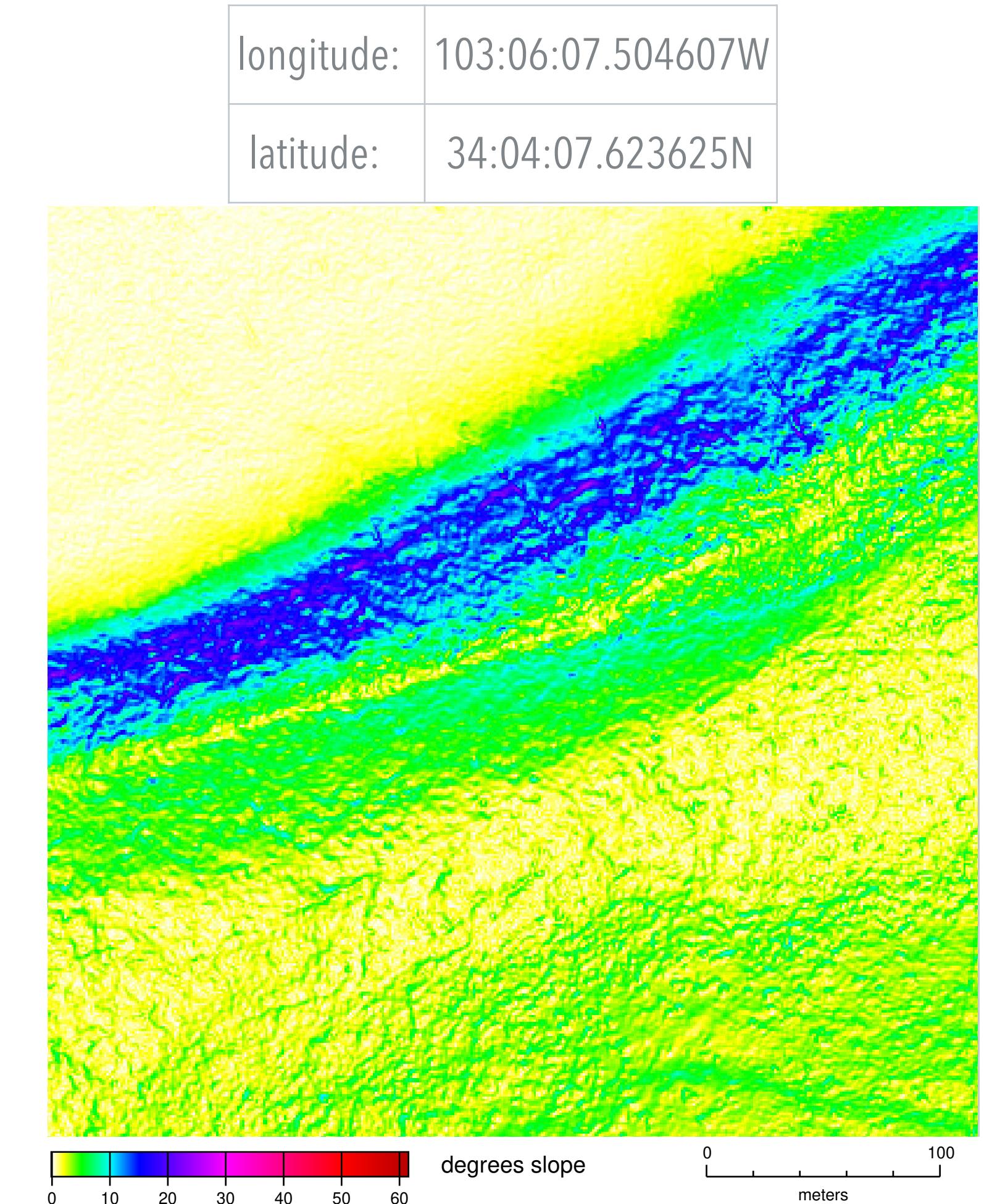
NM_Animas



NM_RioHondo



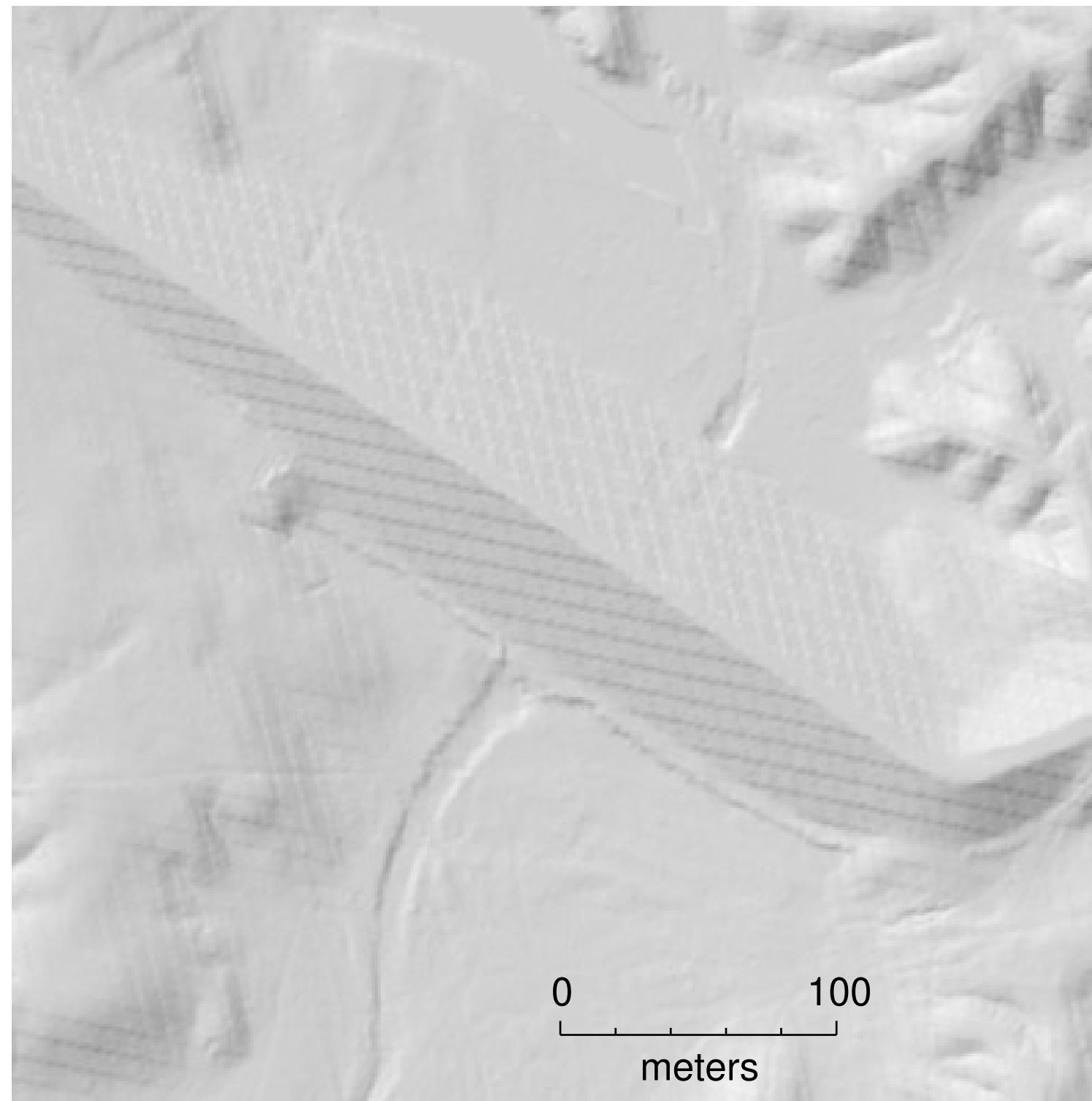
NM_Roosevelt_Curry



Tour

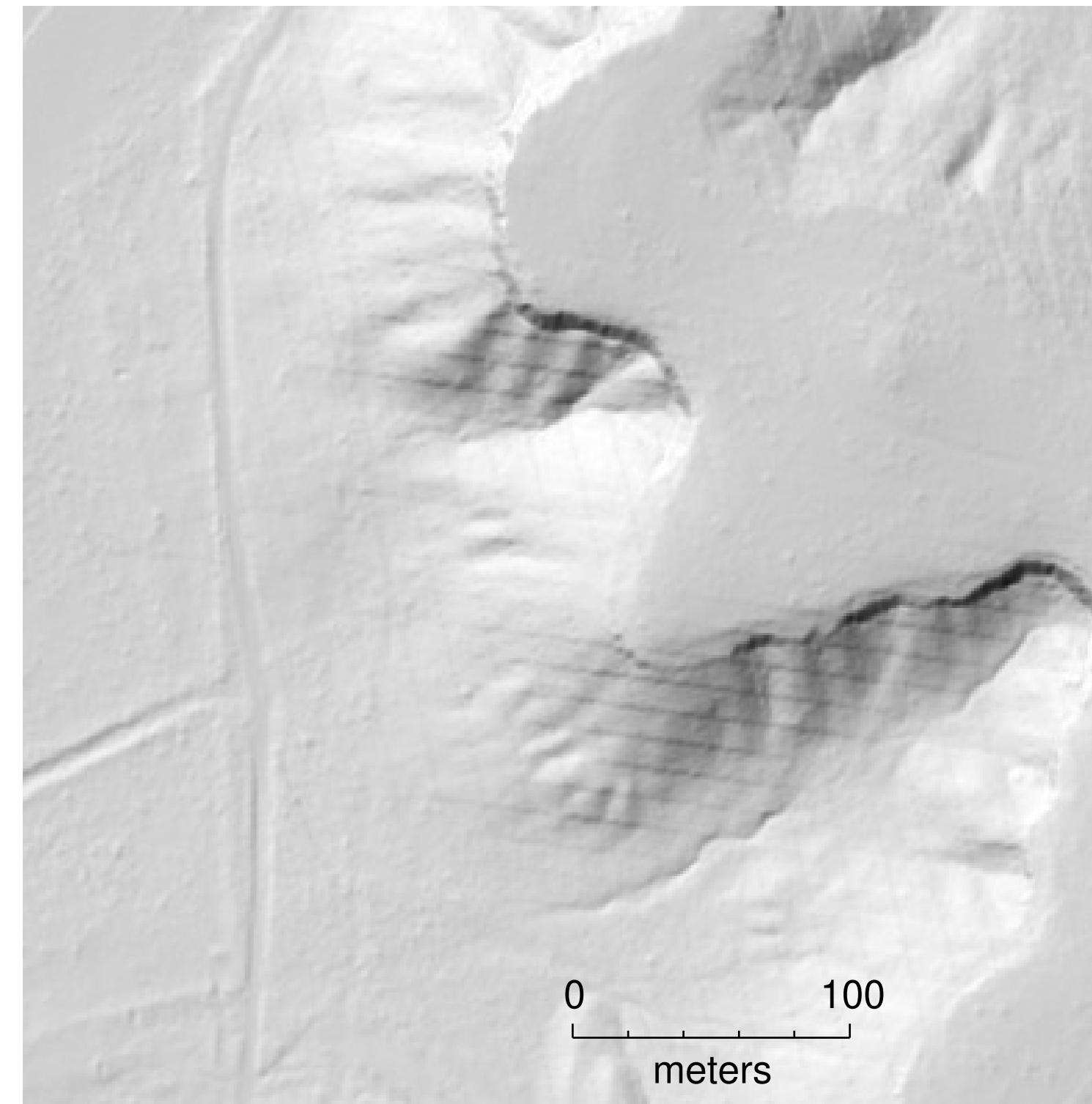
CO_MesaCo

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latitude:	39:07:43.264779N



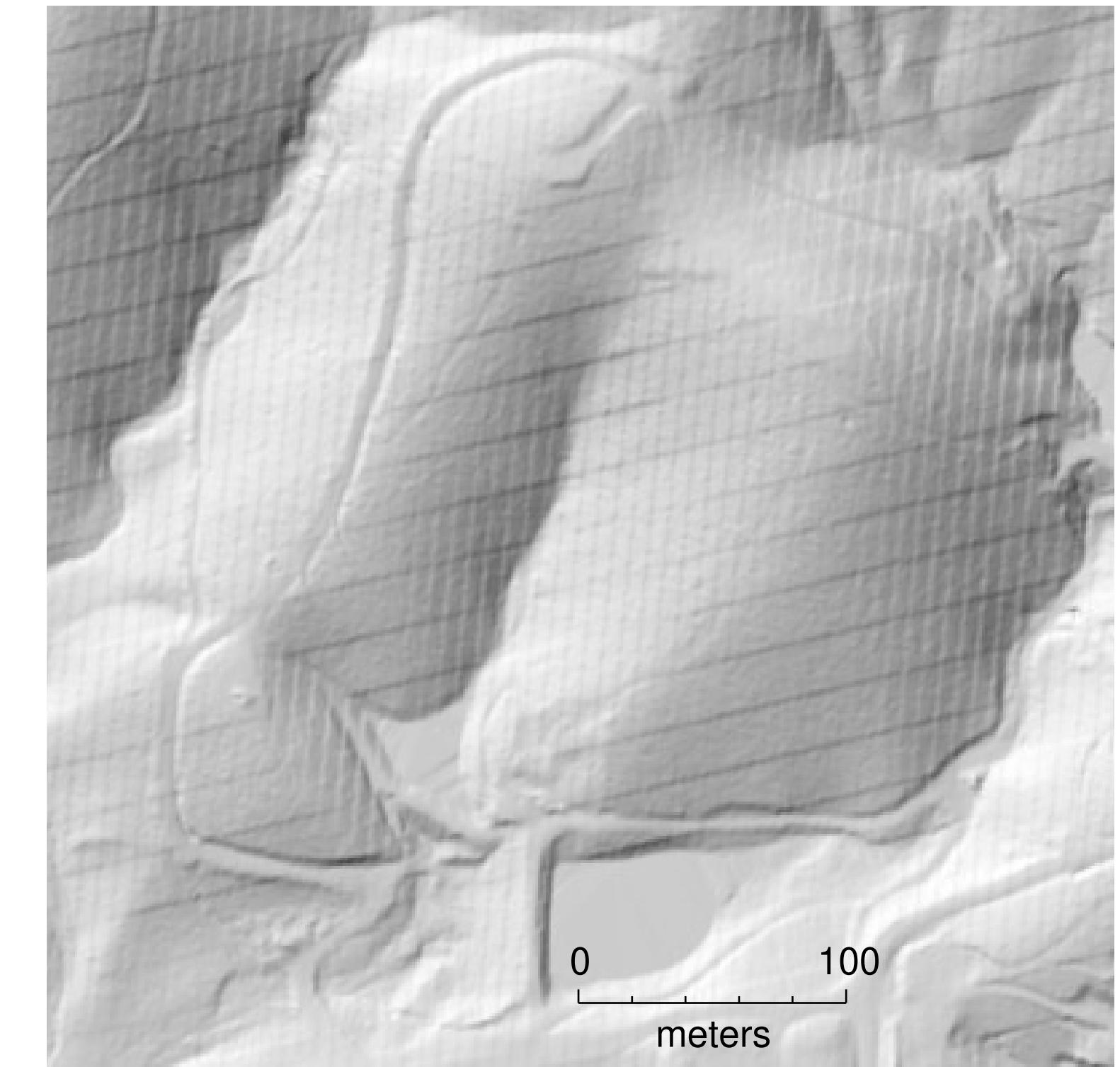
TX_MiddleBrazos

longitude:	97:28:49.035391W
latitude:	32:03:10.17391N



AR_NRCS_A2

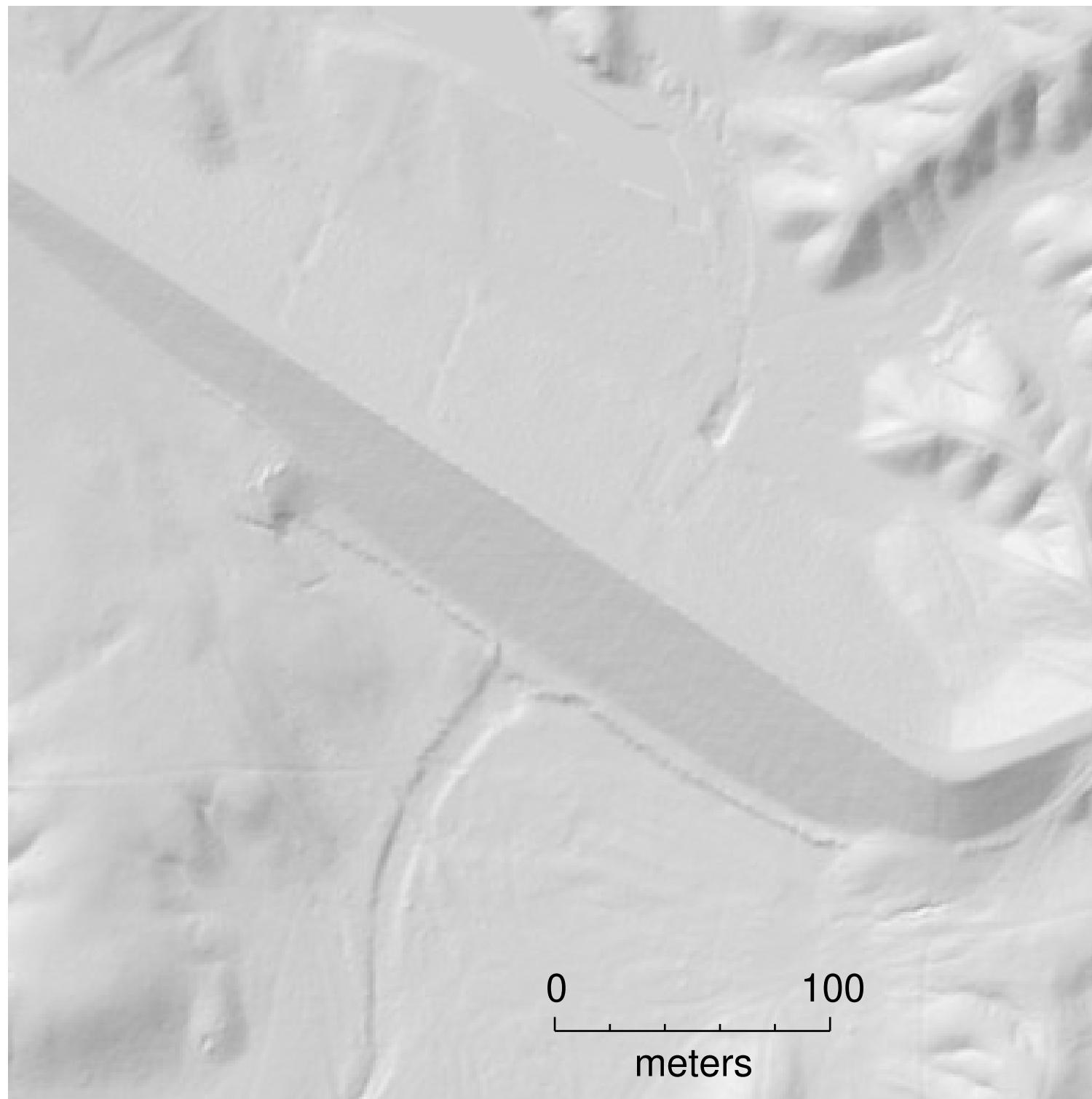
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Tour

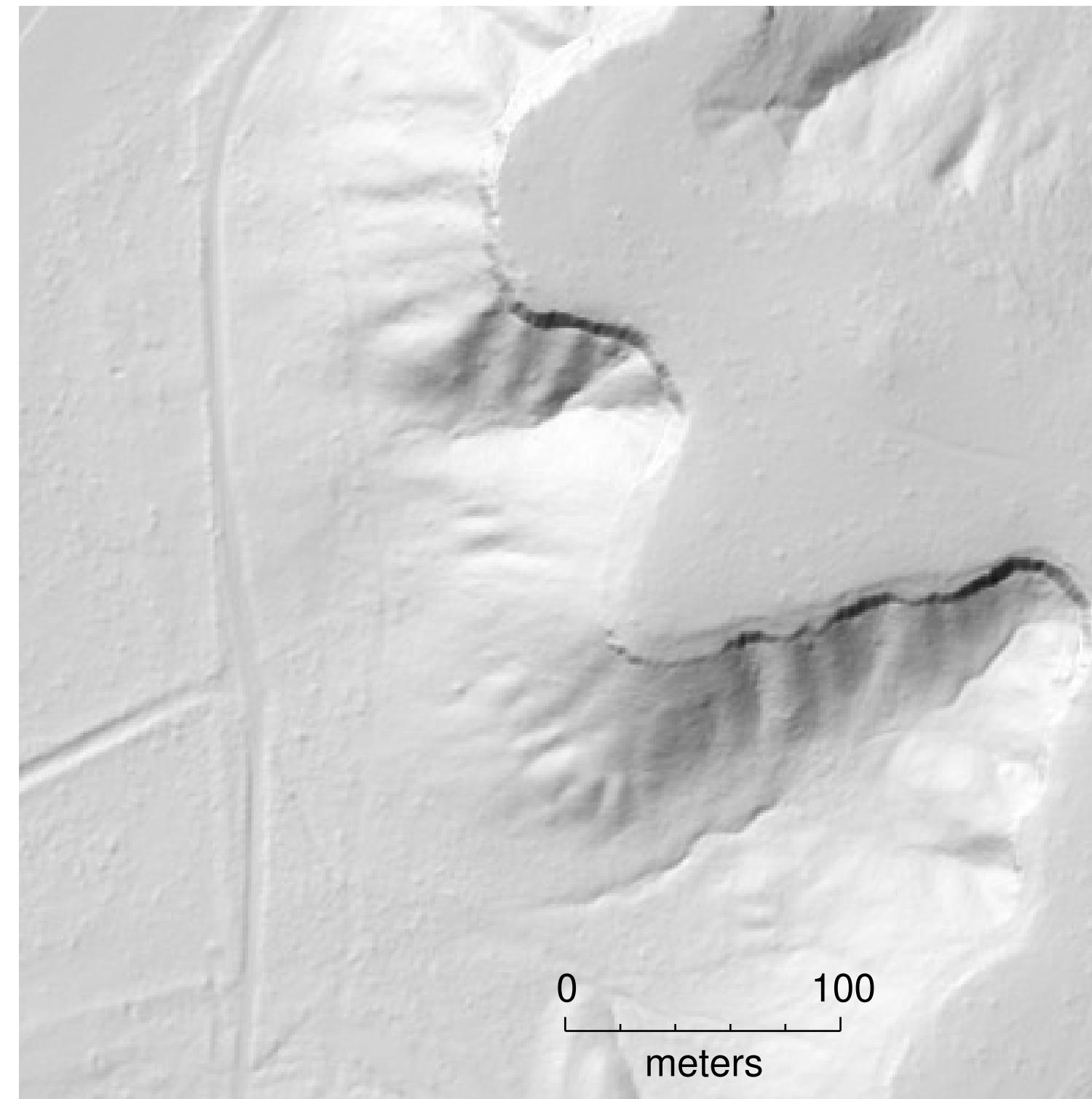
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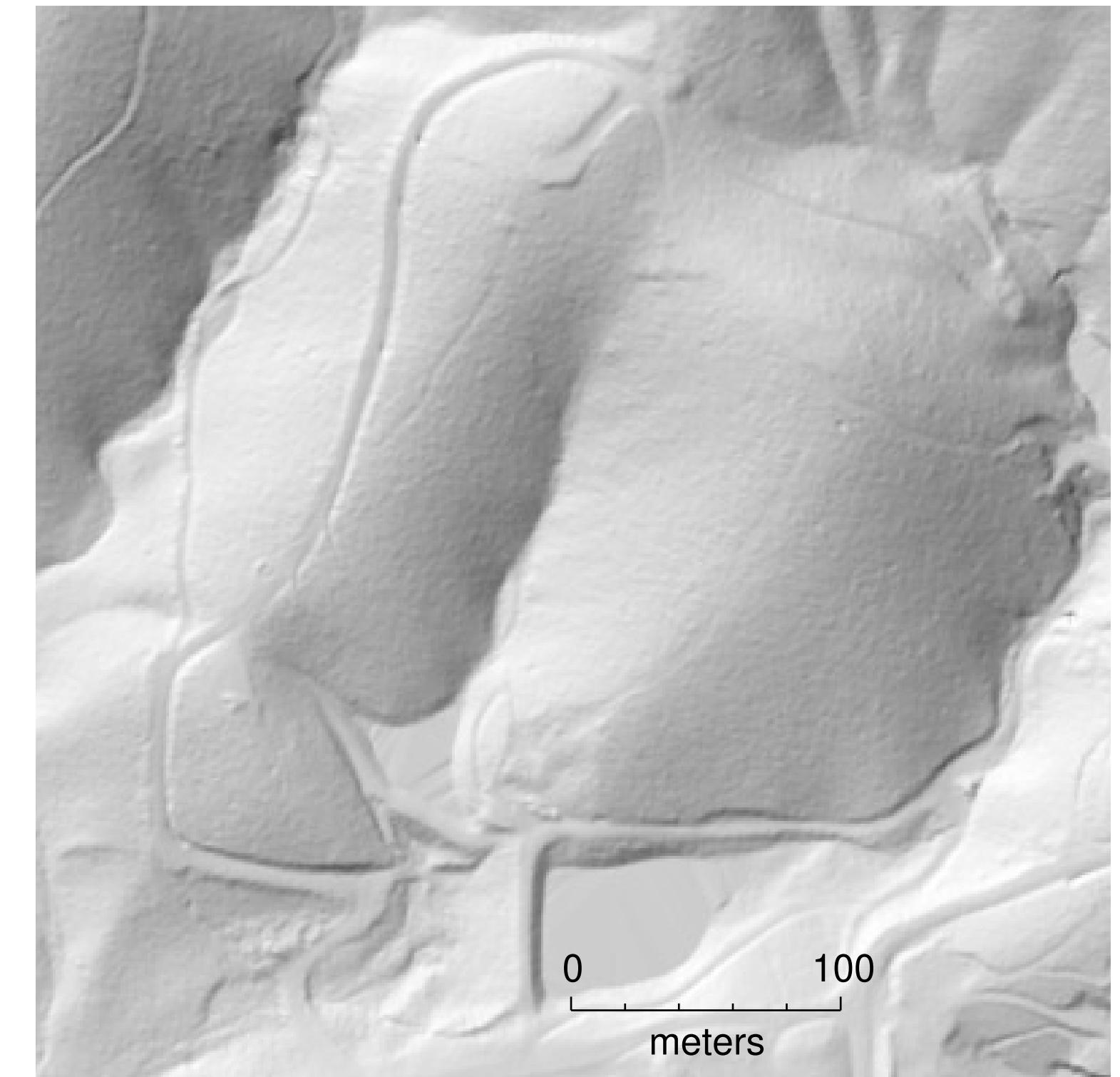
TX_MiddleBrazos

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latitude:	32:03:10.17391N



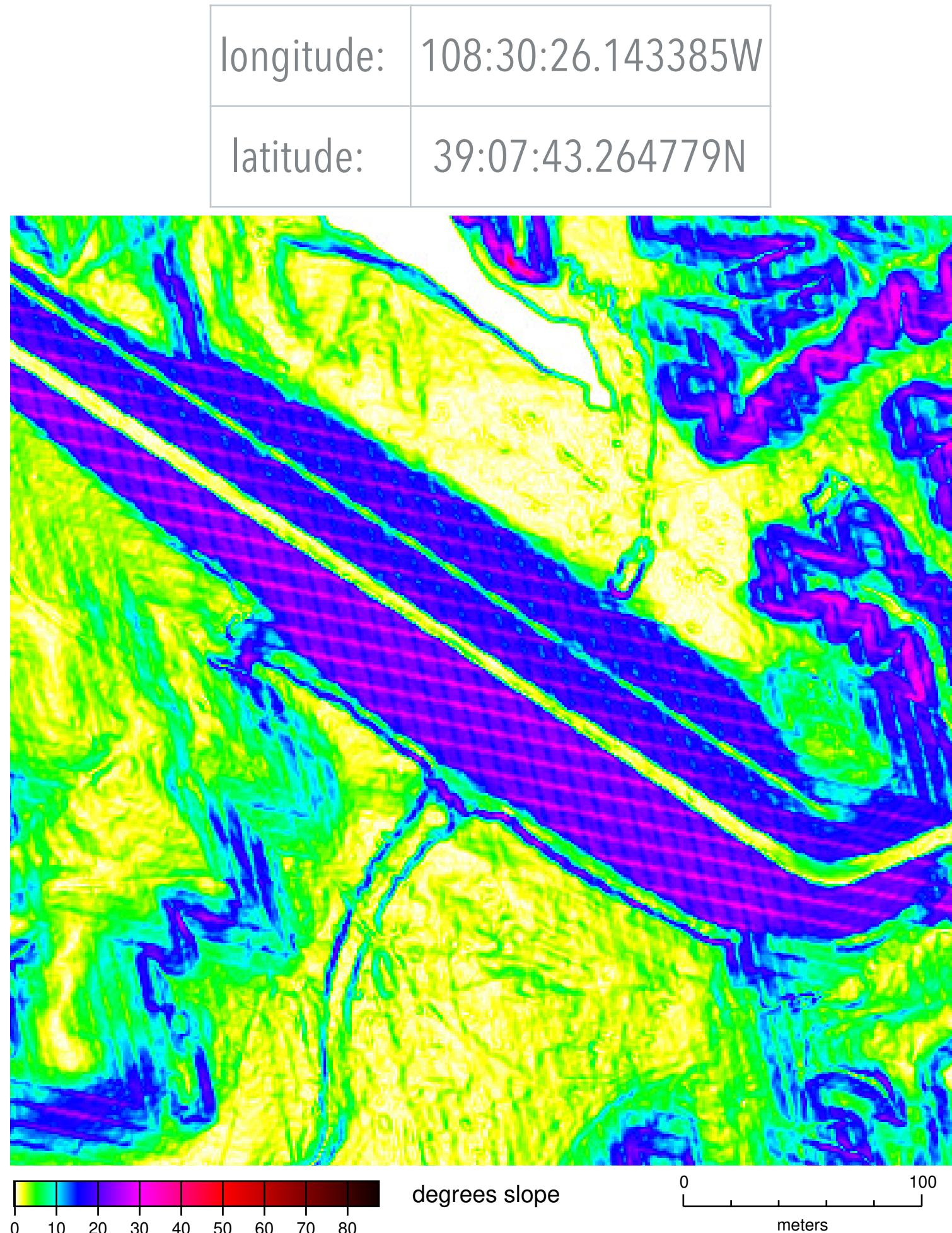
AR_NRCS_A2

longitude:	94:14:55.491845W
latitude:	34:32:15.014232N

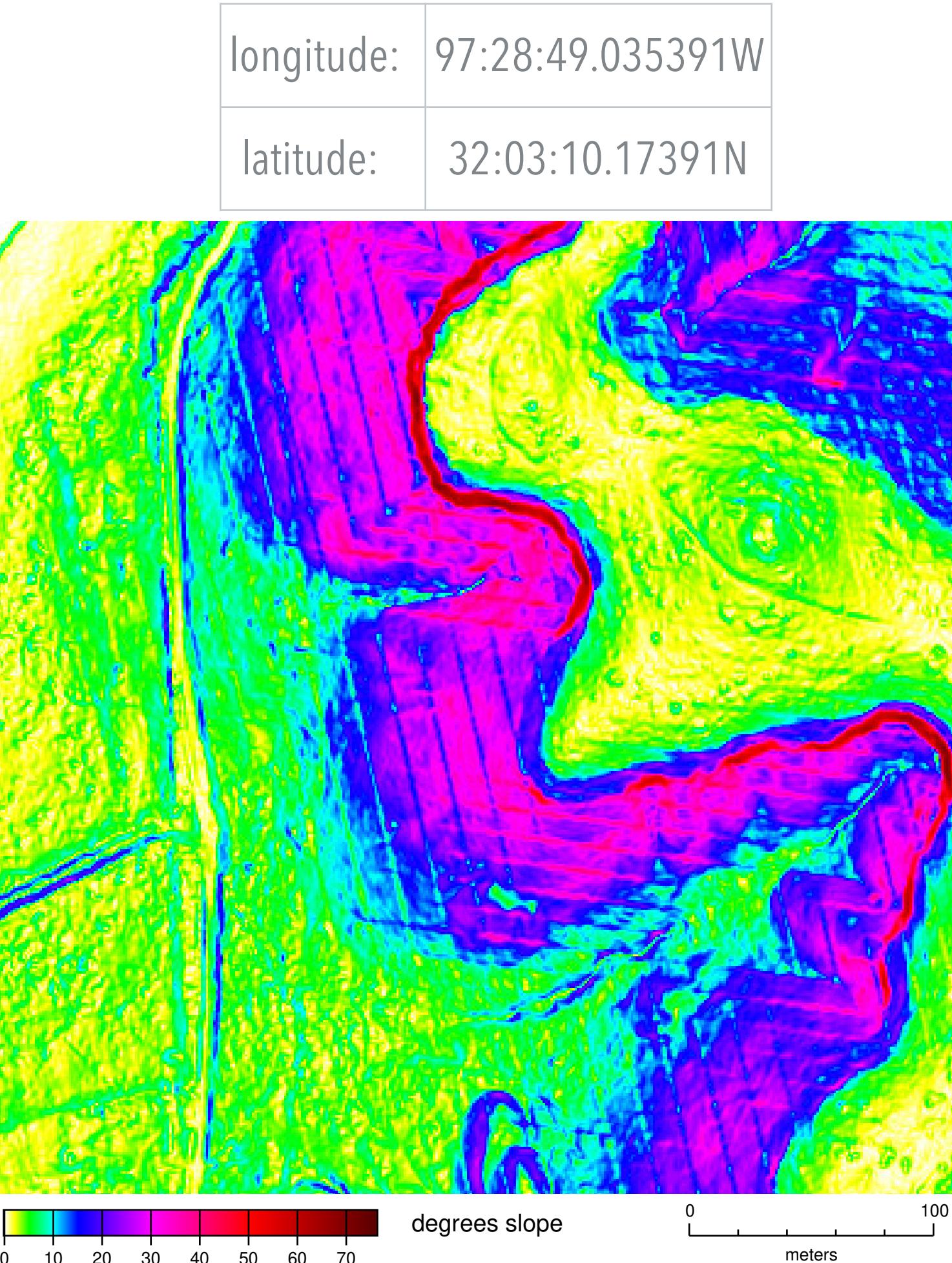


Tour

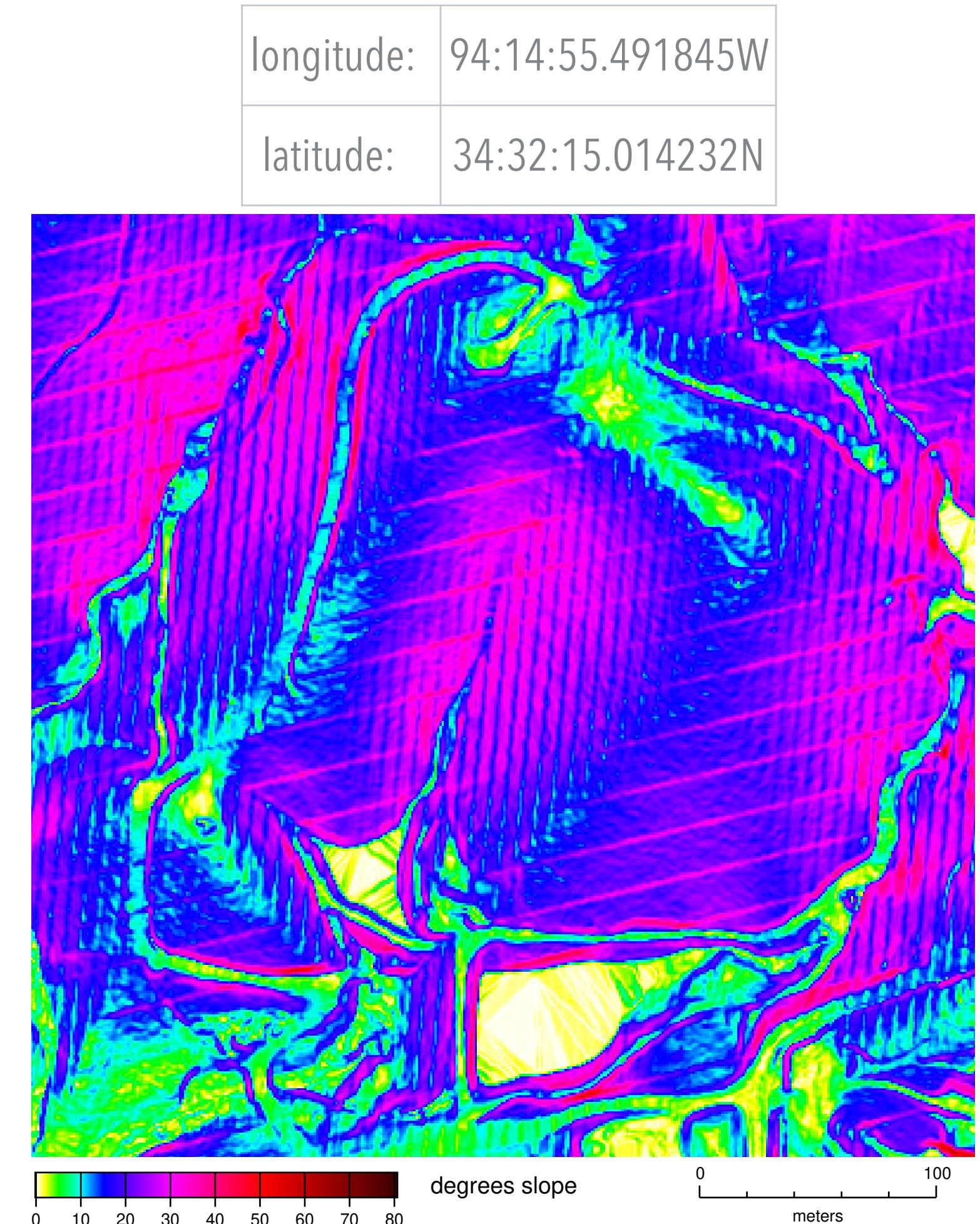
CO_MesaCo



TX_MiddleBrazos



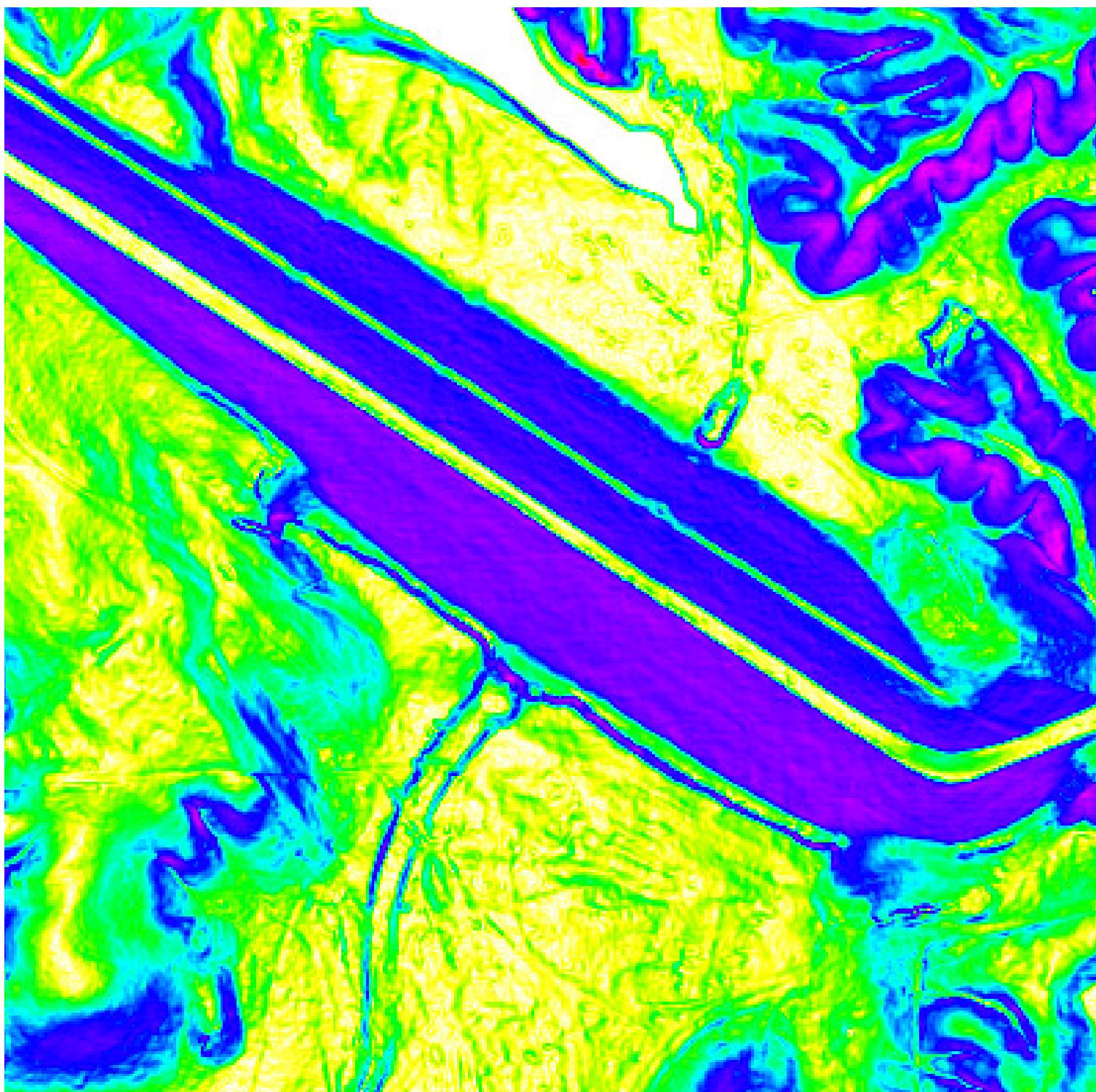
AR_NRCS_A2



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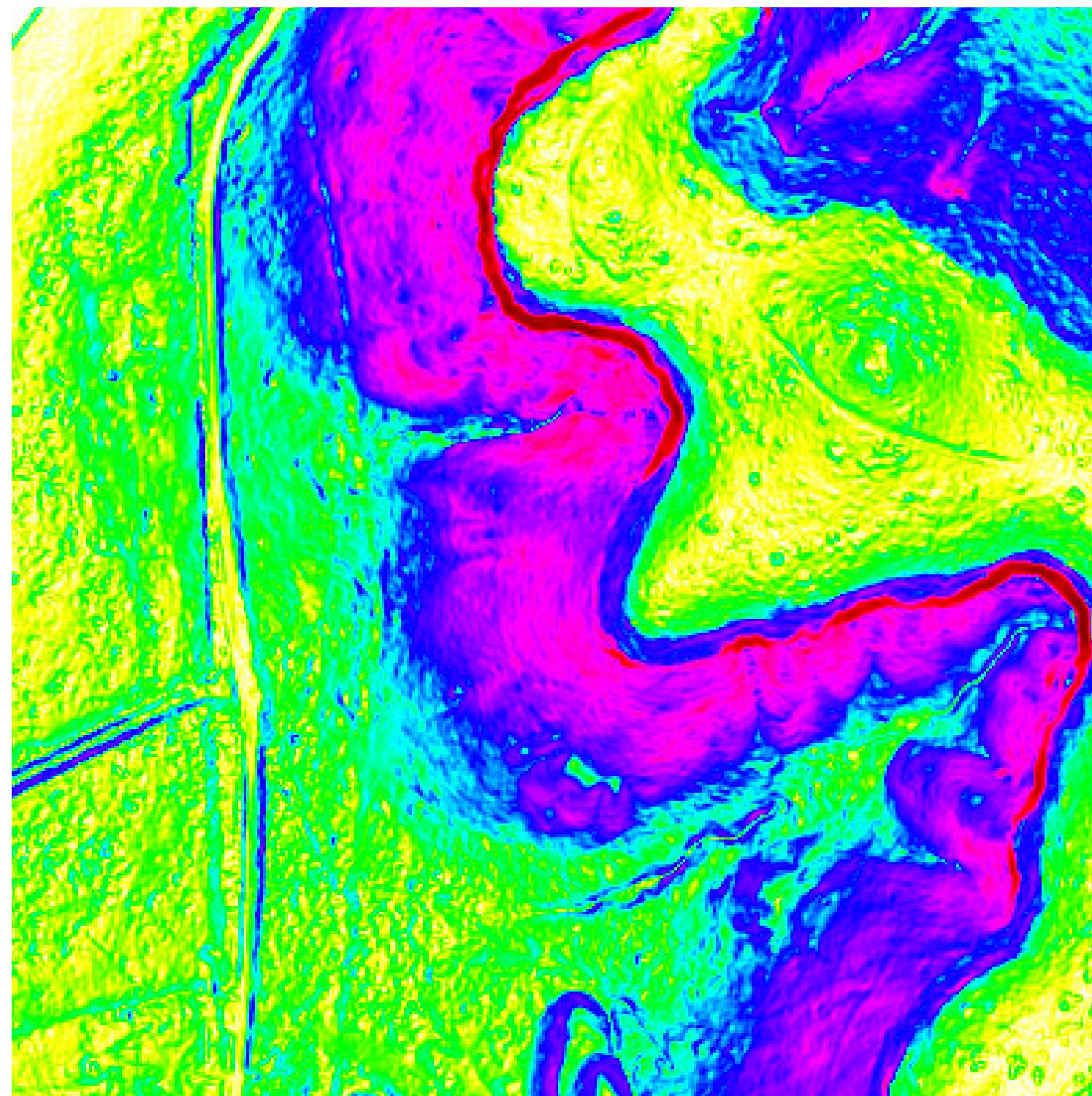
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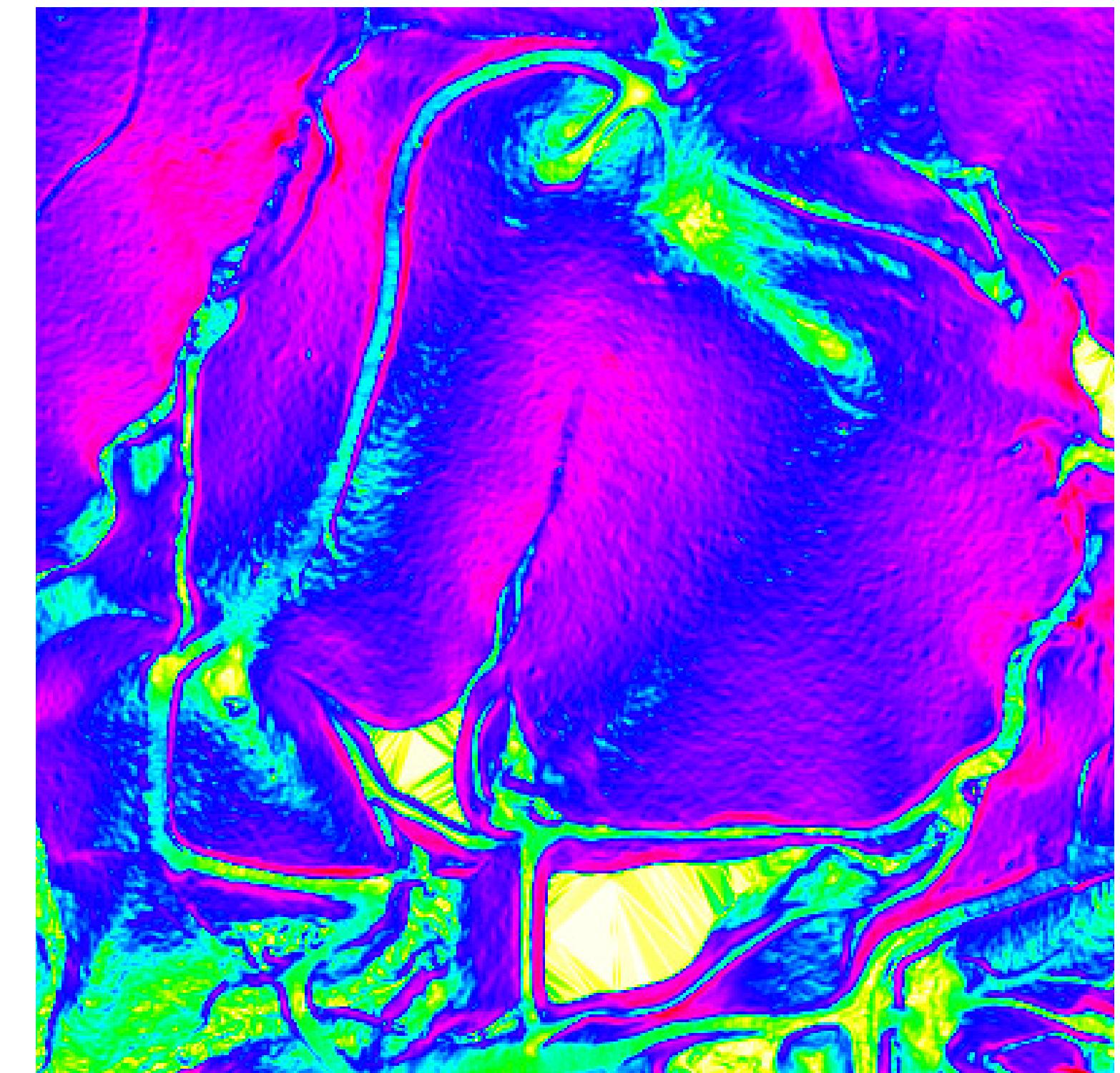
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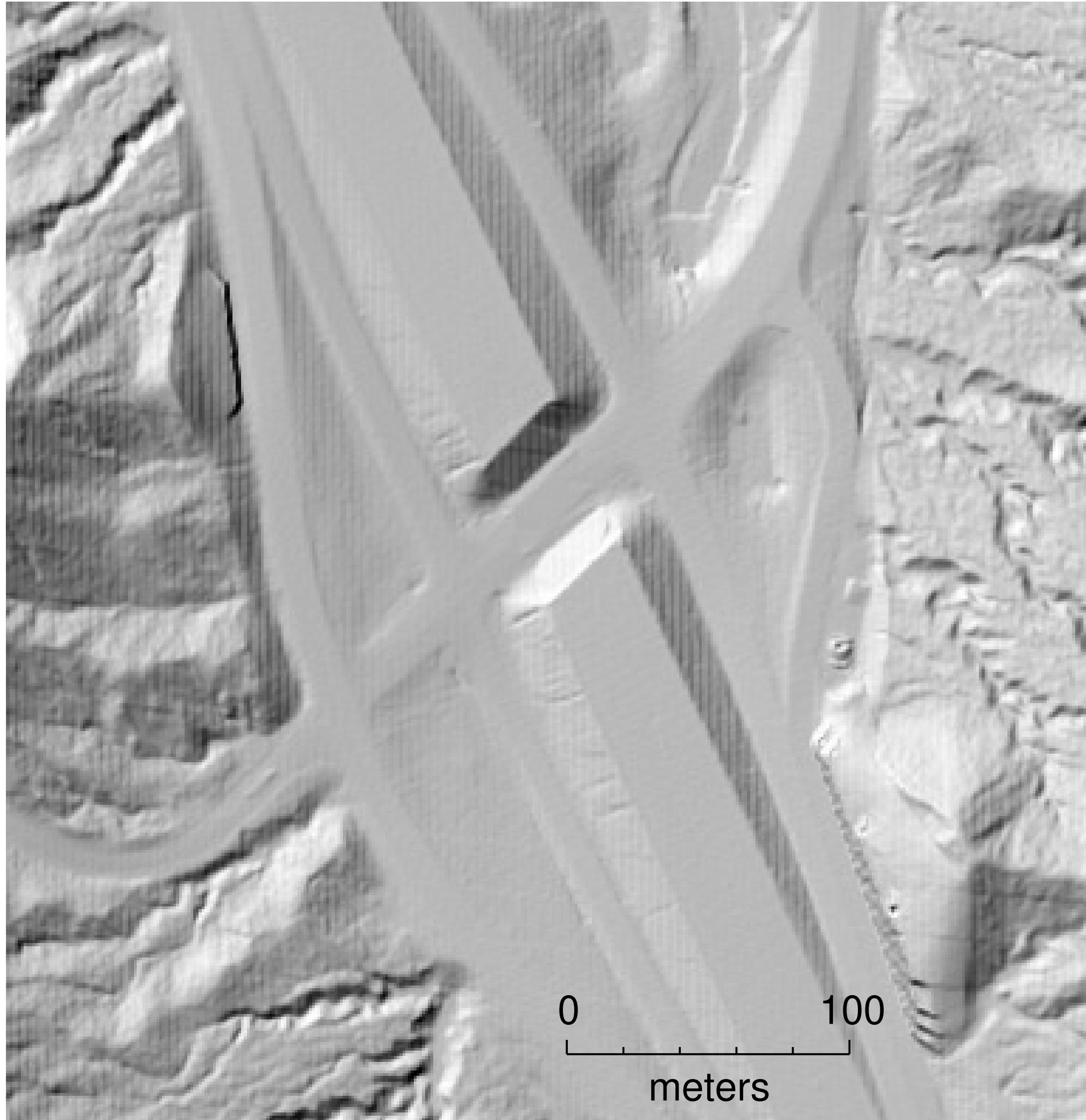
AR_NRCS_A2

longitude:	94:14:55.491845W
latitude:	34:32:15.014232N



Visual Analysis

Santa Fe County, New Mexico



longitude:	105:56:02.348054W
latitude:	35:44:36.062112N



01

```
gdaldem hillshade -compute_edges  
USGS_NED_one_meter_x41y396_NM_SantaFeCo_2014_IMG_2017/  
USGS_NED_one_meter_x41y396_NM_SantaFeCo_2014_IMG_2017.img  
USGS_NED_one_meter_x41y396_NM_SantaFeCo_2014_IMG_2017_sr.tif
```

02

```
gdalbuildvrt -input_file_list NM_SantaFeCo_OPR.txt  
NM_SantaFeCo_OPR.vrt
```

03

```
gdaldem hillshade -compute_edges NM_SantaFeCo_OPR.vrt  
NM_SantaFeCo_OPR_sr.tif
```



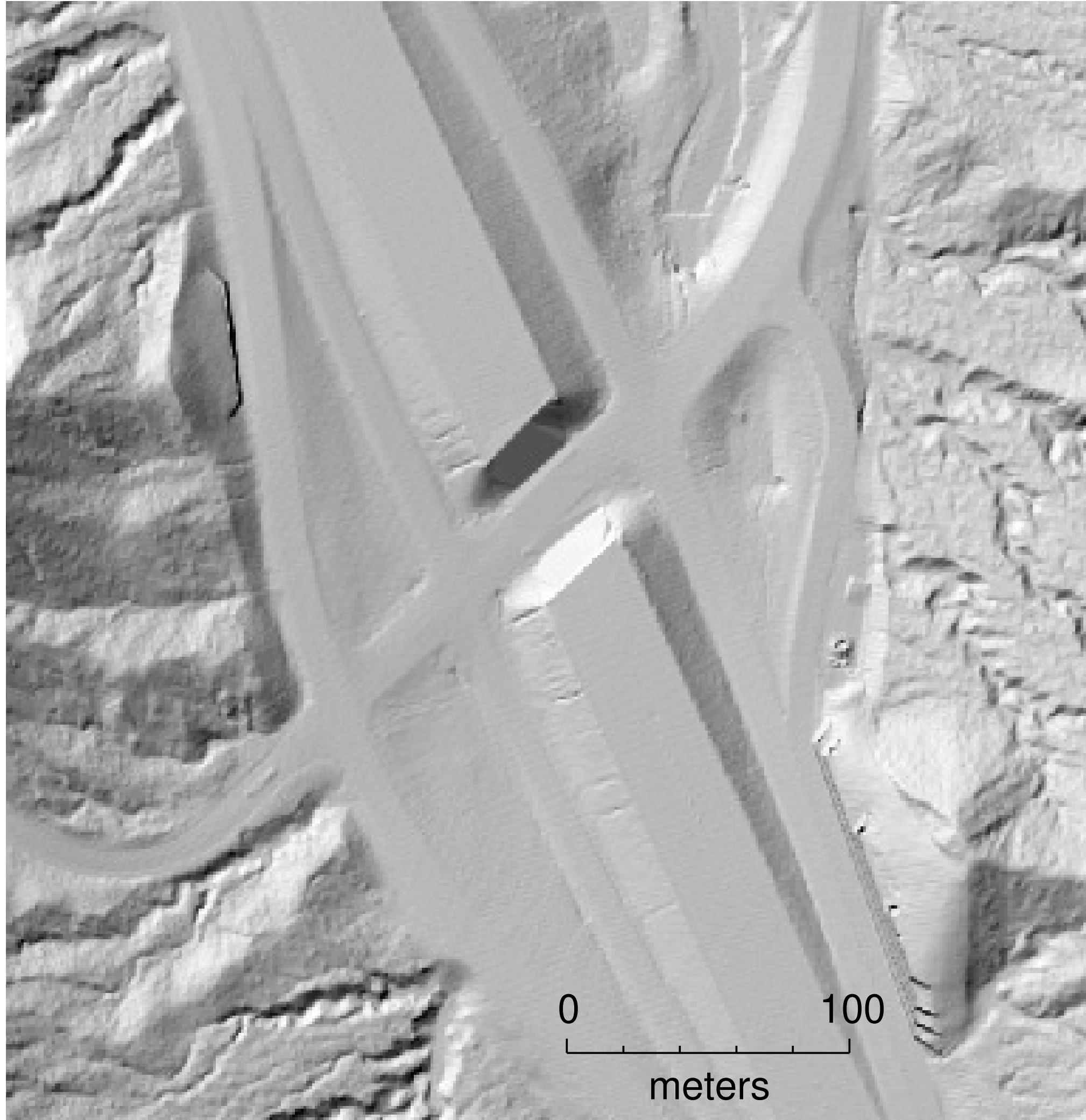
```
gdal_translate -of KMLSUPEROVERLAY NM_SantaFeCo_OPR_sr.tif  
NM_SantaFeCo_OPR_sr.kmz
```

<http://www.gdal.org/> - GDAL/OGR

<https://www.osgeo.org> - Open Source Geospatial Foundation (OSGEO)

Visual Analysis

Santa Fe County, New Mexico



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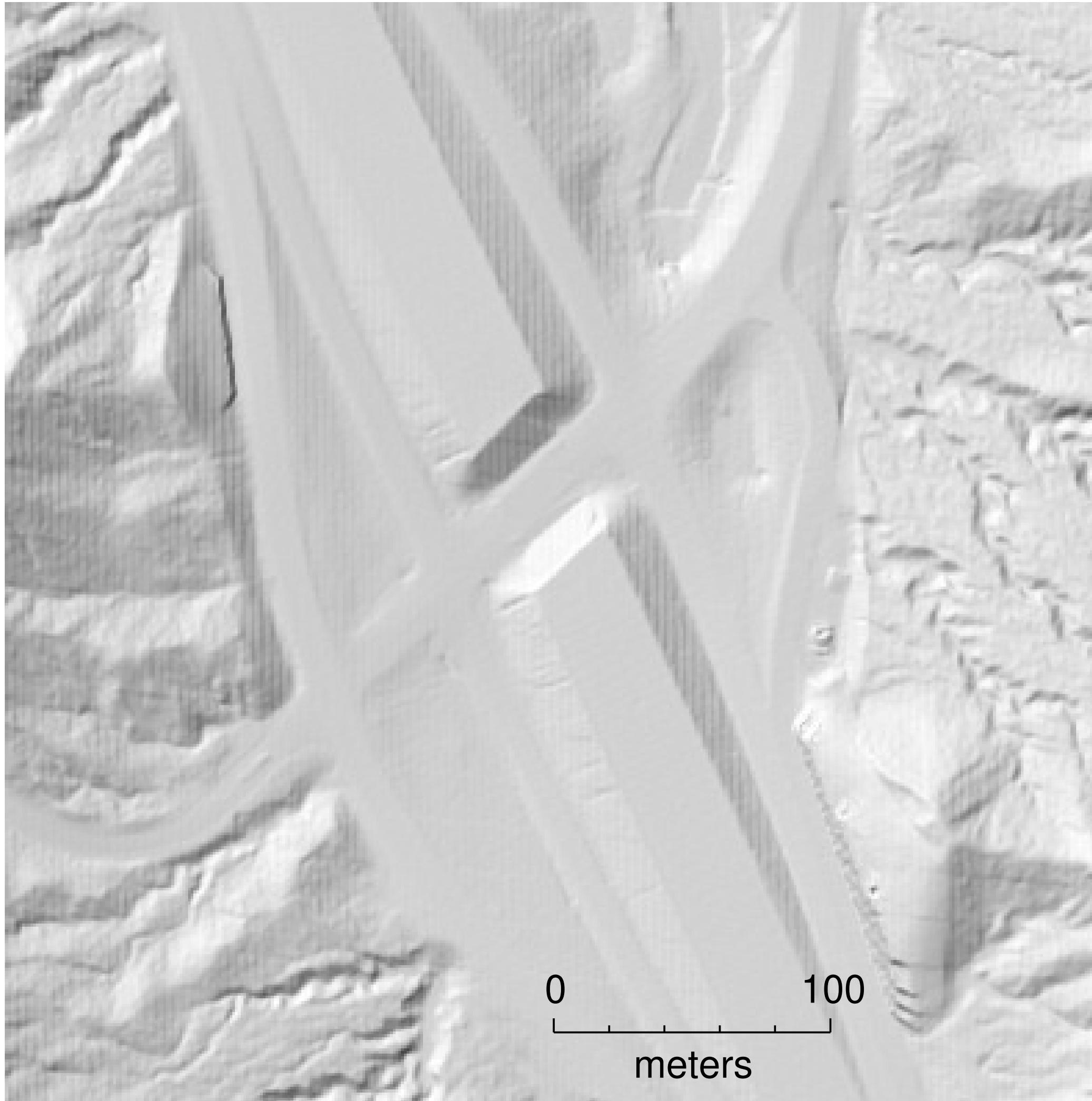
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NM_SantaFeCo_OPR_sr.kmz
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<http://www.gdal.org/> - GDAL/OGR

<https://www.osgeo.org> - Open Source Geospatial Foundation (OSGEO)

Workflow

Santa Fe County, New Mexico



Create GRASS GIS Database

01

NED - EPSG:26913 UTM/NAD83

Import NED

02

```
r.in.gdal -o --overwrite  
input=USGS_NED_one_meter_x41y396_NM_SantaFeCo_2014_IMG_2017/  
USGS_NED_one_meter_x41y396_NM_SantaFeCo_2014_IMG_2017.img  
output=NM_SantaFeCo_NED
```

Import OPR

03

```
r.import input=NM_SantaFeCo_OPR.vrt output=NM_SantaFeCo_OPR_ft  
resample=bilinear_f
```

Set Region

04

```
g.region -p rast=NM_SantaFeCo_OPR_ft
```

Scale Vertical

05

```
r.mapcalc "NM_SantaFeCo_OPR_60cm = NM_SantaFeCo_OPR_ft *  
(12/39.37)" --overwrite
```

Region 1m

06

```
g.region -p res=1.0
```

Resample 1m

07

```
r.resamp.stats -w --overwrite input=NM_SantaFeCo_OPR_60cm  
output=NM_SantaFeCo_OPR
```

Visualize

08

```
r.relief input=NM_SantaFeCo_OPR output=NM_SantaFeCo_OPR_sr alt=45  
az=315
```

09

Next Step - Deeper Dive Analysis



USGS Digital Elevation Model (DEM) Resampling FAQ: <https://www.usgs.gov/faqs/which-resampling-methods-are-best-preserving-dem-accuracy-and-terrain-characteristics>

GRASS GIS

Workflow

Santa Fe County, New Mexico



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NED - EPSG:26913 UTM/NAD83

Import NED

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USGS_NED_one_meter_x41y396_NM_SantaFeCo_2014_IMG_2017.img  
output=NM_SantaFeCo_NED
```

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GRASS GIS

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Analysis

Santa Fe County, New Mexico



Create Slope Maps

01

```
r.slope.aspect elevation=NM_SantaFeCo_OPR  
slope=NM_SantaFeCo_OPR_slope
```

Difference Map

02

```
r.mapcalc "NM_SantaFeCo_diff = NM_SantaFeCo_NED -  
NM_SantaFeCo_OPR"
```

MASK

03

```
r.mapcalc "MASK = if(NM_SantaFeCo_OPR_slope>=10.0,1,null())"
```

Statistics

04

```
r.univar -g -e map=NM_SantaFeCo_diff > NM_SantaFeCo_diff_stats.txt
```

05

Next Step - Results

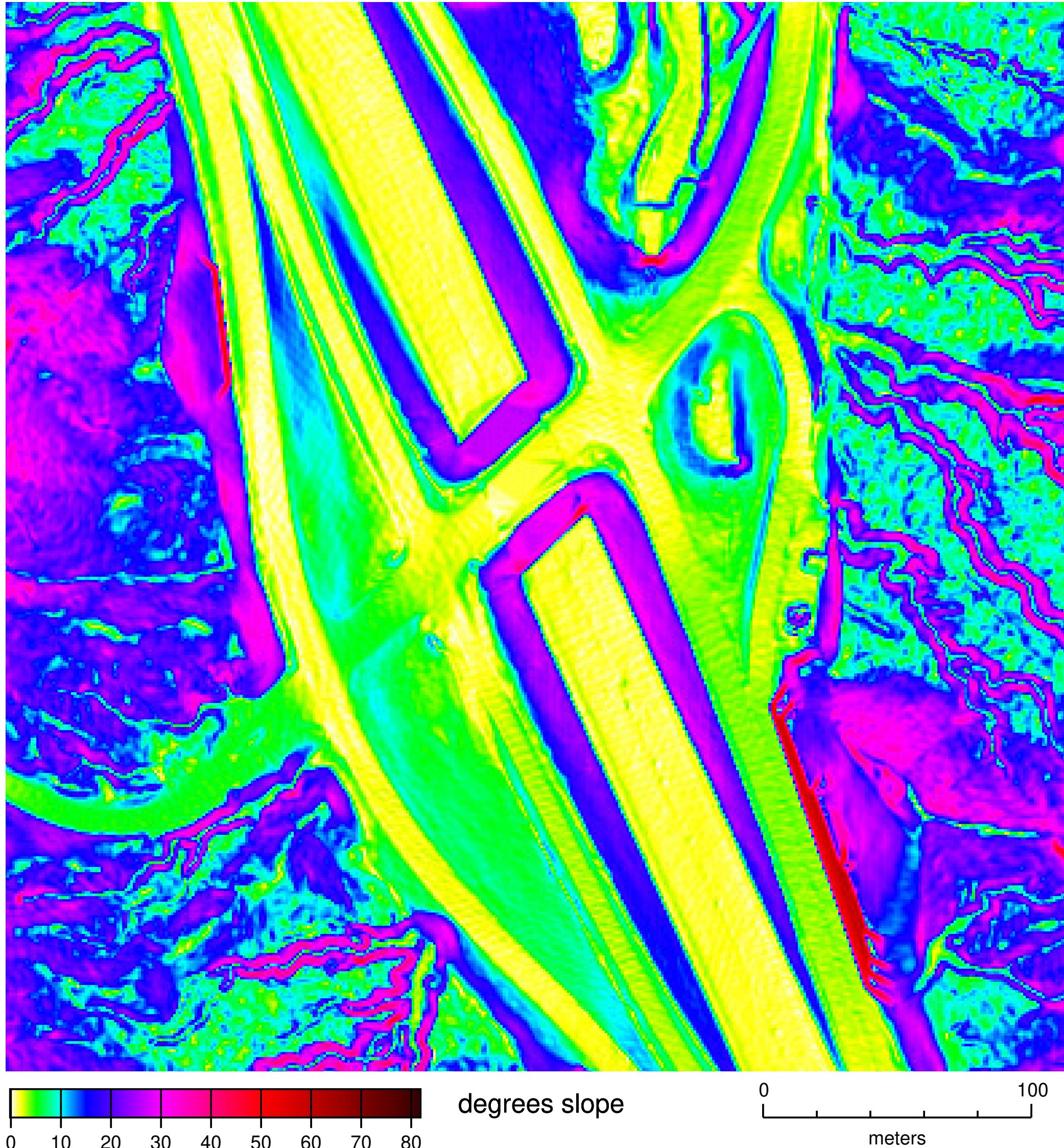
Shapiro, M., Westervelt, J. 1992. RMAPCALC An Algebra for GIS and Image Processing https://grass.osgeo.org/uploads/grass/history_docs/mapcalc-algebra.pdf US Army Construction Engineering Research Laboratory

<http://colorbrewer2.org/#type=diverging&scheme=PuOr&n=5>



Analysis

Santa Fe County, New Mexico



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Next Step - Results

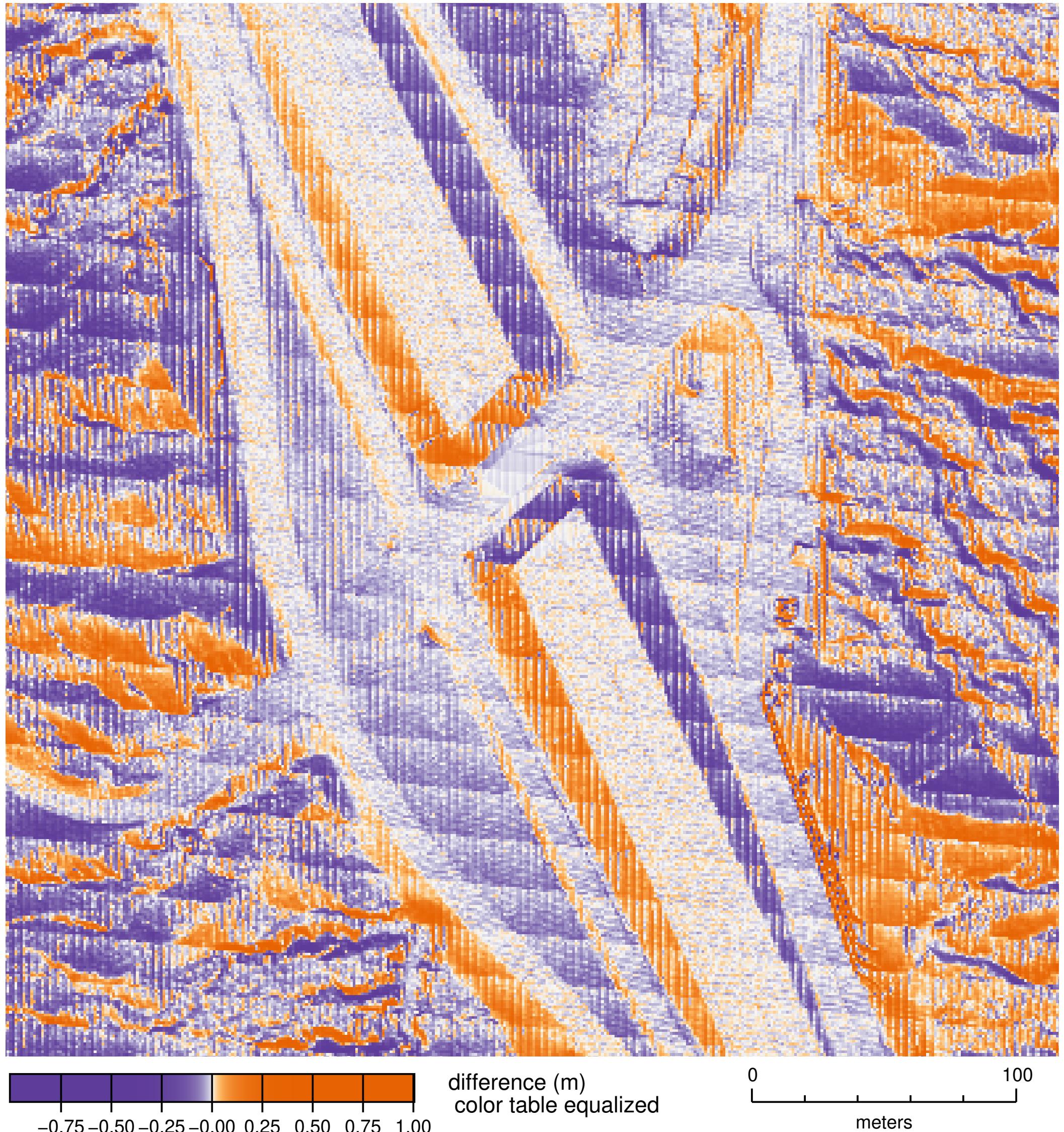
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Santa Fe County, New Mexico



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Analysis

Santa Fe County, New Mexico



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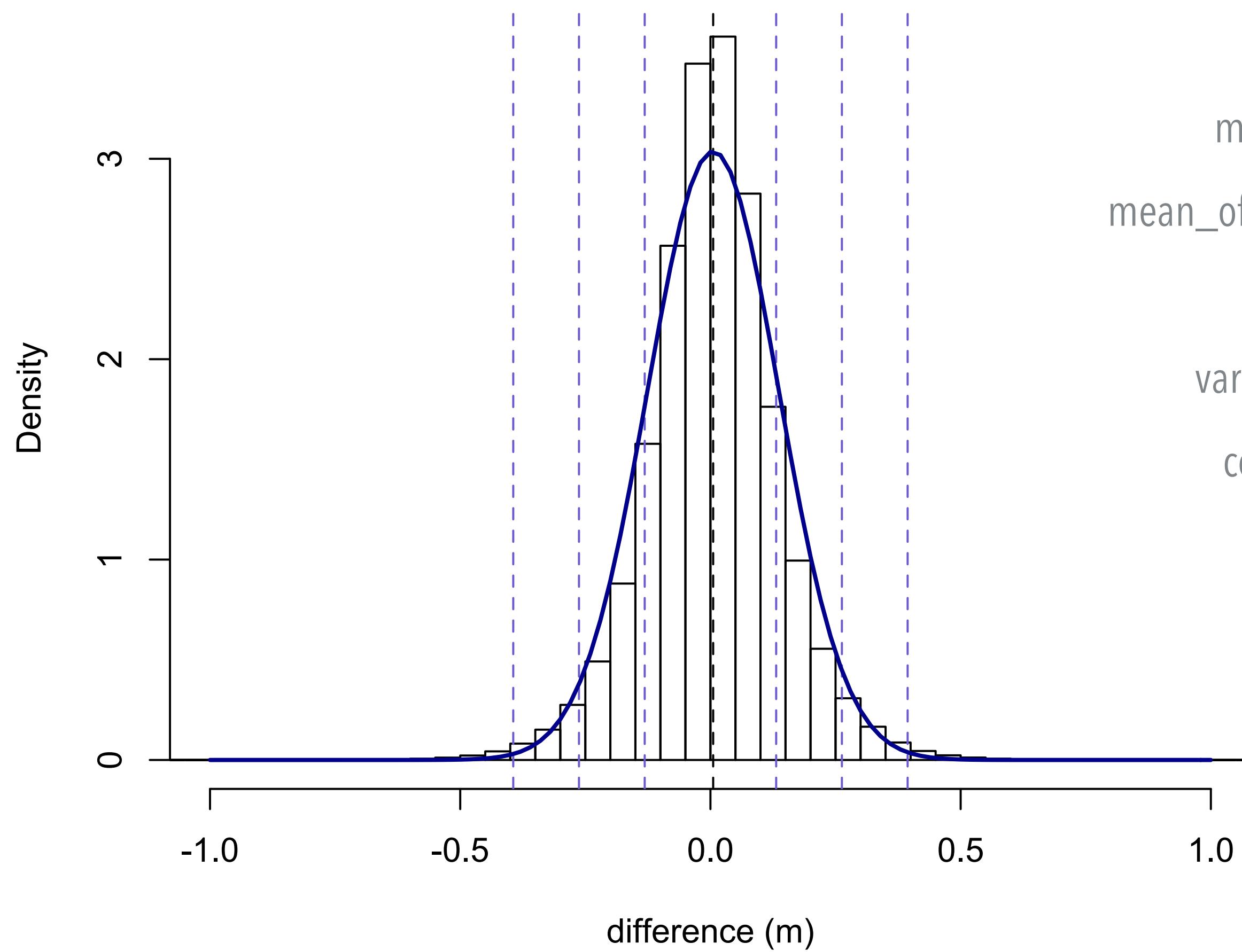
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Results

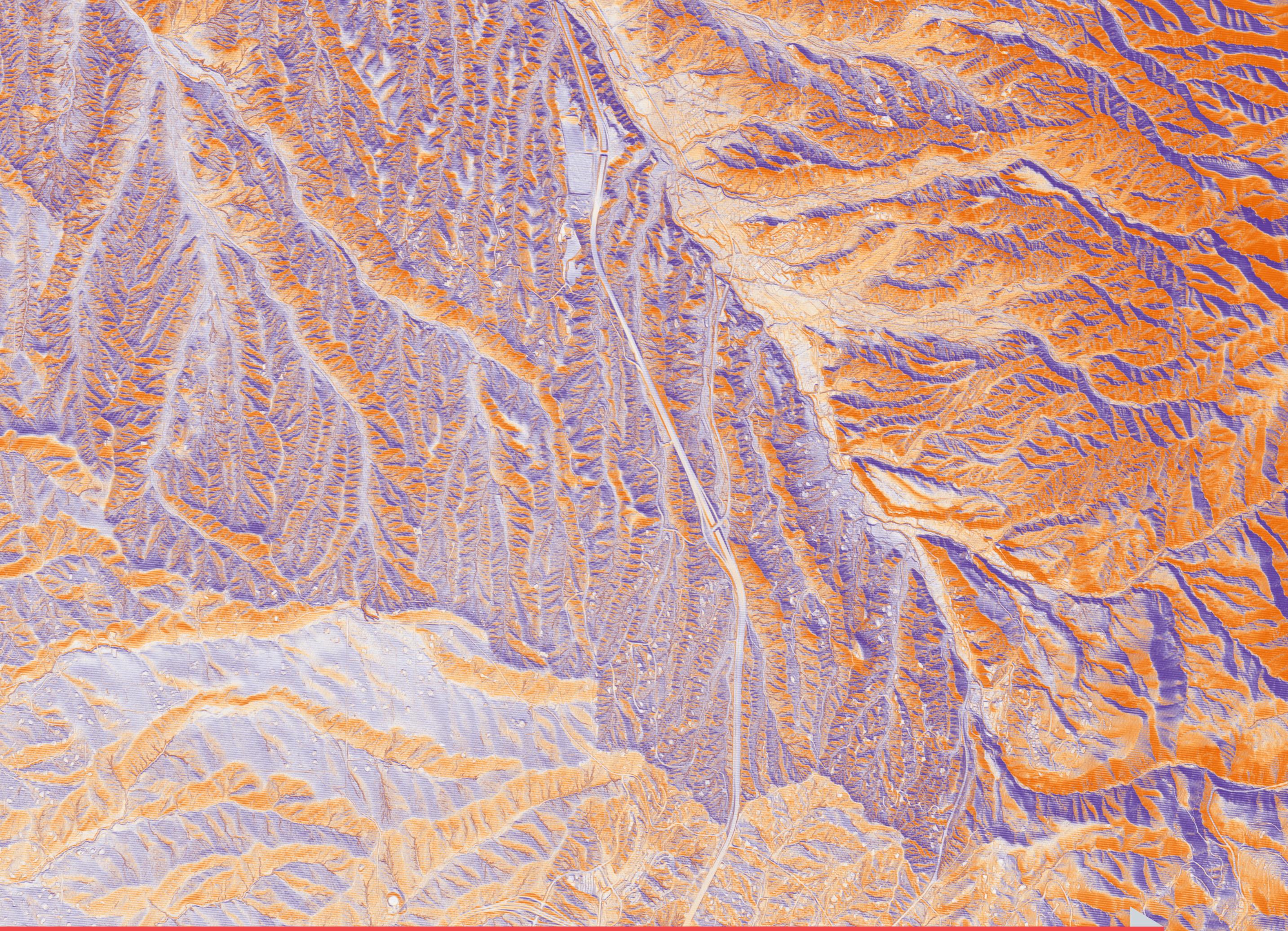
Santa Fe County, New Mexico

NM_SantaFeCo NED-OPR > 10 degrees



Study Site	Standard Deviation
NM_SantaFeCo	13 cm
NM_Animas	12 cm
NM_RioHondo	12 cm
NM_Roosevelt_Curry	7 cm
CO_MesaCo	12 cm
TX_MiddleBrazos	10 cm
AR_NRCS_A2	9 cm

n=51522334
null_cells=48717810
cells=100240144
min=-5.83628849343017
max=5.09395796215631
range=10.9302464555865
mean=0.00545624518535124
mean_of_abs=0.0977106494635113
stddev=0.131348286797204
variance=0.0172523724445605
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median=0.00593424
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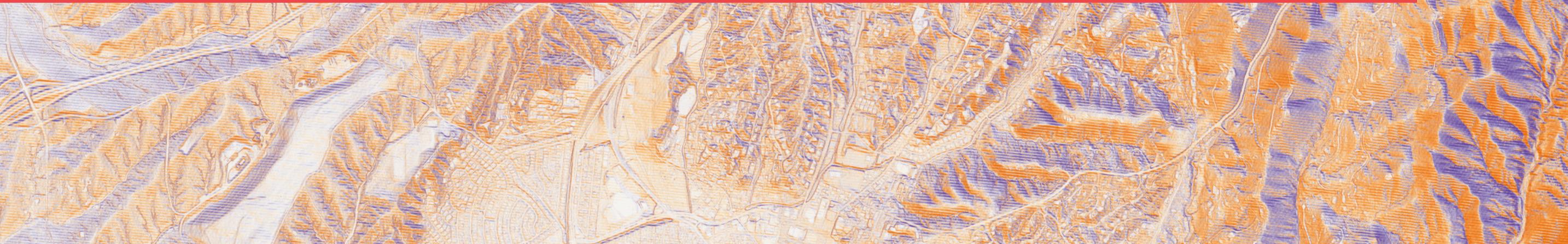
Recommend: 1. Validate Datasets 2. Use OPR Data

Insight

Seamless 1m National Elevation Dataset (NED) may contain artifacts that could degrade vertical accuracy when compared to Original Product Resolution (OPR)

For areas exceeding 10 degrees slope, study site (2017) DEM difference maps reveal 10 cm standard deviation, on average.

- **Vertical accuracy** of QL2 data may not meet expectations
- Surface may not adhere to 1-foot **contour interval**
- Derivative DEM products demonstrate **artifacts**
- Distribution exhibits **terrain dependency**
- **GRASS GIS** platform for conversion, validation, analysis



Acknowledgements



Key Project References

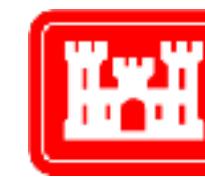
- GRASS Development Team, 2017. Geographic Resources Analysis Support System (GRASS) Software, Version 7.2. Open Source Geospatial Foundation. Electronic document: <http://grass.osgeo.org>
- Michael Barton, PhD. - GRASS Macintosh Binaries <http://grassmac.wikidot.com/>
- Geospatial Data Abstraction Library (GDAL/OGR) <http://www.gdal.org>
- US Geological Survey - 3D Elevation Program / The National Map - <https://nationalmap.gov/3DEP/>
- Santa Fe County GIS - https://www.santafecountymn.gov/growth_management/gis
- USACE ABQ District

Robert Dzur

Bohannan Huston, Inc.

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John Peterson



Erle Wright



Kimberly Mantey

