Interpolating Lidar Point Clouds

Various interpolation methods of lidar point-cloud data using computative efficient approaches

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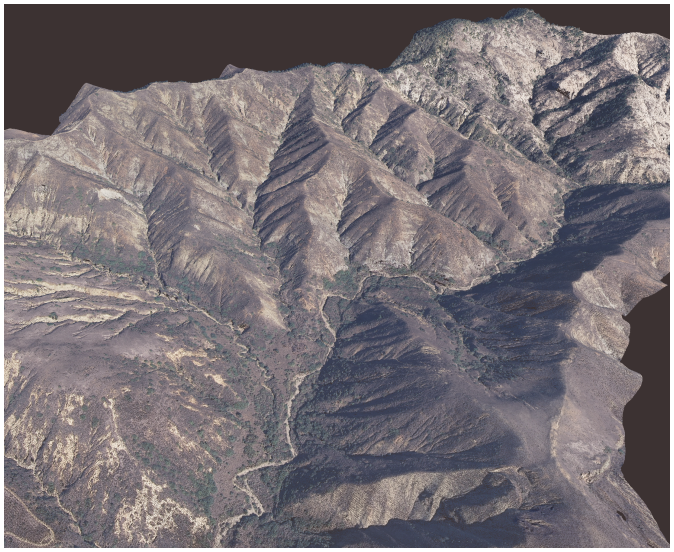

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1 Preparing Point Cloud Data

1.1 Ground classification

The original (pre-classified) files from the USGS data / opentopography website were reclassified using LASTools lasground. Note that this is a commercial software that requires a license. Tests indicate that ground-classification with pdal and the Progressive Morphological Filter (PMF) provides similar results. In short, the steps were:

```
cd /raid/lidar_research/lidar_data/usgs_channel_islands/processed/SANTA_CRUZ
mkdir cl2_july2018
cd cl2_july2018

mkdir tiles
wine /opt/LAStools/bin/lastile.exe -set_classification 0 -flag_as_withheld -tile_size  \
    500 -buffer 10 -cores 8 -i ../unclass_og/ARRA*.laz -olaz -odir tiles
```

```
# quick overview by thinning file (keep lowest points)
wine /opt/LAStools/bin/lasthin.exe -sparse -step 30 -lowest -i tiles/*.laz -olaz  \
    -merged -olaz -o SCI_ARRA_noise_30m_lowest.laz
wine /opt/LAStools/bin/blast2dem.exe -hillshade -utm 11N -nad83 -meter  \
    -elevation_meter -merged -step 30 -i SCI_ARRA_5m_lowest.laz -o  \
    dtm_interp/SCI_USGS_UTM11_NAD83_lowest5m_30m_HS.tif
wine /opt/LAStools/bin/blast2dem.exe -utm 11N -nad83 -meter -elevation_meter -merged  \
    -step 30 -i SCI_ARRA_5m_lowest.laz -o  \
    dtm_interp/SCI_USGS_UTM11_NAD83_lowest5m_30m.tif
gdalinfo -hist -stats dtm_interp/SCI_USGS_UTM11_NAD83_lowest5m_30m.tif
gdalinfo -hist -stats dtm_interp/SCI_USGS_UTM11_NAD83_lowest5m_30m_HS.tif


mkdir tilesn
wine /opt/LAStools/bin/lasnoise.exe -cores 12 -i tiles/22*.laz -step_xy 2 -step_z 1  \
    -isolated 5 -olaz -odir tilesn -odix n
wine /opt/LAStools/bin/lasnoise.exe -cores 12 -i tiles/23*.laz -step_xy 2 -step_z 1  \
    -isolated 5 -olaz -odir tilesn -odix n
wine /opt/LAStools/bin/lasnoise.exe -cores 12 -i tiles/24*.laz -step_xy 2 -step_z 1  \
    -isolated 5 -olaz -odir tilesn -odix n
wine /opt/LAStools/bin/lasnoise.exe -cores 12 -i tiles/25*.laz -step_xy 2 -step_z 1  \
    -isolated 5 -olaz -odir tilesn -odix n
wine /opt/LAStools/bin/lasnoise.exe -cores 12 -i tiles/26*.laz -step_xy 2 -step_z 1  \
    -isolated 5 -olaz -odir tilesn -odix n


#MEDIUM classification with high offset, medium standard dev, and medium spike:  \
    CHANNELS do not come out good, but little vegetation
###LIKELY BEST CANDIDATE For channel extraction. There is some vegetation, but  \
    channels are clear
mkdir ground_overlap
wine /opt/LAStools/bin/lasground.exe -cores 12 -i tilesn/22*n.laz -by_flightline  \
    -wilderness -extra_fine -offset 0.25 -stddev 20 -spike 0.5 -bulge 0.5 -olaz -odir  \
    ground_overlap -odix g 2>&1 | tee lasground_output_22n.out
wine /opt/LAStools/bin/lasground.exe -cores 12 -i tilesn/23*n.laz -by_flightline  \
    -wilderness -extra_fine -offset 0.25 -stddev 20 -spike 0.5 -bulge 0.5 -olaz -odir  \
    ground_overlap -odix g 2>&1 | tee lasground_output_22n.out
wine /opt/LAStools/bin/lasground.exe -cores 12 -i tilesn/24*n.laz -by_flightline  \
    -wilderness -extra_fine -offset 0.25 -stddev 20 -spike 0.5 -bulge 0.5 -olaz -odir  \
    ground_overlap -odix g 2>&1 | tee lasground_output_22n.out
wine /opt/LAStools/bin/lasground.exe -cores 12 -i tilesn/25*n.laz -by_flightline  \
    -wilderness -extra_fine -offset 0.25 -stddev 20 -spike 0.5 -bulge 0.5 -olaz -odir  \
    ground_overlap -odix g 2>&1 | tee lasground_output_22n.out
```

```
wine /opt/LAStools/bin/lasground.exe -cores 12 -i tilesn/26*n.laz -by_flightline  \
    -wilderness -extra_fine -offset 0.25 -stddev 20 -spike 0.5 -bulge 0.5 -olaz -odir  \
    ground_overlap -odix g 2>&1 | tee lasground_output_22n.out

#instead of processing chunks of tiles, one could also use the -lof - list of files  \
    options.
```

For this example, we only process a subset of the data from the Pozo catchment. We clip the Pozo catchment with a shapefile `SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp` and generate an output LAZ file `SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.laz`.

```
cd  \
    /raid-everest/lidar_research/lidar_data/usgs_channel_islands/processed/SANTA_CRUZ/cl2_july2018/
ls -1 ground_overlap/*ng.laz > SCI_ground_overlap_filelist.lst
wine /opt/LAStools/bin/lasclip.exe -lof SCI_ground_overlap_filelist.lst -olaz  \
    -drop_withheld -o SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.laz -keep_class  \
    2 -merged -poly SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp
```

1.2 Export to ASCII

```
conda activate PC_py3
```

Convert ground-classified LAS/LAZ to ASCII for GMT processing and compress with `bzip2`, but using parallel bzip2 (pbzip2):

```
wine /opt/LAStools/bin/las2las.exe -i  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.laz -o  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz -oparse xyz
#head -100 SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz  \
    >SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_100rows.xyz
pbzip2 -7 SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz
```

1.3 Prepare DEM

In order to provide best results and produce overlapping grids, you would want to clip the DEM with a shapefile - this way you ensure that all grids will have the same dimensions. You can clip every output grid with the same shapefile stored in CLIP_SHAPEFILE.

We extract the subset from the interpolated DTM using blast2dem.

```
gdalwarp  \
    /raid-everest/lidar_research/lidar_data/usgs_channel_islands/processed/SANTA_CRUZ/cl2_july2018/dtm_i
    dtm_interp/Pozo_USGS_UTM11_NAD83_g_1m.tif -cutline  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp -cl  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83 -crop_to_cutline -tap -multi -tr 1 1  \
    -t_srs epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
```

Set `$DATA_BASEDIR` variable:

```
export DATA_BASEDIR=/home/bodo/Dropbox/California/SCI/Pozo/pc_interpolation
```

If the DEM exists already, you can clip it with the shapefile to generate a clipped version that is aligned to integer UTM coordinates (`-tap`):

```
DEM_GRID_IN=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1m.tif
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
export CLIP_SHAPEFILE=SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp
gdalwarp -cutline $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -crop_to_cutline -tap -multi -tr 1 1 -t_srs epsg:26911 $DEM_GRID_IN $DEM_GRID -co  \
    COMPRESS=DEFLATE -co ZLEVEL=7
```

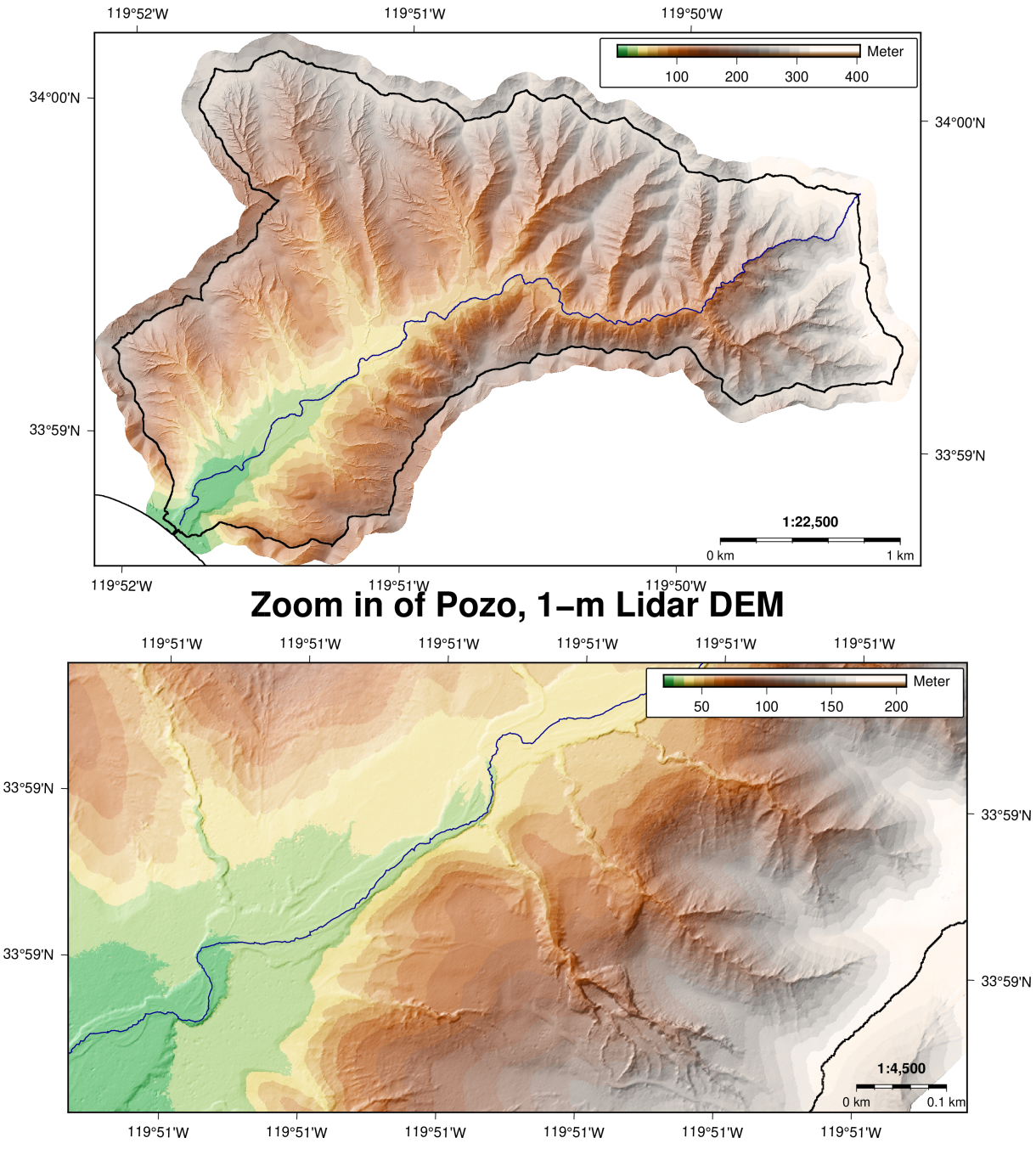

Figure 1: Map view of the Pozo catchment and the zoom-in area.

The DEM of the Pozo catchment and the area of interest is shown in Figure 1.

2 Interpolation of grids with GMT and GDAL

2.1 Interpolate with GMT 6

```
conda config --prepend channels conda-forge/label/dev
conda create -y -c conda-forge/label/cf201901 -n gmt6 gmt=6* python=3* scipy pandas  \
    numpy matplotlib scikit-image gdal spyder
```

And start the environment:

```
source activate gmt6
```

Set $DATA_BASEDIR variable:

```
export DATA_BASEDIR=/home/bodo/Dropbox/California/SCI/Pozo/pc_interpolation
```

Make sure, the DEM exist as NetCDF file:

```
gmt grdconvert $DEM_GRID=gd/1/0/-9999  \
    $DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.nc
```

2.1.1 blockmean

See http://gmt.soest.hawaii.edu/doc/5.3.2/blockmean.html

```
mkdir $DATA_BASEDIR/blockmean
```

```
BLOCKMEAN_GRID=$DATA_BASEDIR/blockmean/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1m
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt blockmean  \
    -R$DEM_GRID -C -G${BLOCKMEAN_GRID}%s.nc -Az,s
```

Convert the NetCDF files to a compress geotiff:

```
cd $DATA_BASEDIR/blockmean
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1mz.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1mz.tif -a_srs  \
    epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1ms.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1ms.tif -a_srs  \
    epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
```

```
cd ..
```

A map of the blockmean data is generated with gmt:

```
### GMT V 5 file!
gmt gmtset MAP_FRAME_PEN    1
gmt gmtset MAP_FRAME_WIDTH    0.1
gmt gmtset MAP_FRAME_TYPE     plain
gmt gmtset FONT_TITLE    Helvetica-Bold
gmt gmtset FONT_LABEL    Helvetica-Bold 14p
gmt gmtset PS_PAGE_ORIENTATION    landscape
gmt gmtset PS_MEDIA    A4
gmt gmtset FORMAT_GEO_MAP    D
gmt gmtset MAP_DEGREE_SYMBOL degree
gmt gmtset PROJ_LENGTH_UNIT cm
gmt gmtset MAP_FRAME_AXES WESNZ

POZO_DEM=dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.nc
POZO_DEM_HS=${POZO_DEM::-3}_HS.nc
gmt grd2cpt $POZO_DEM -E25 -Cdem2 > dem2_color.cpt
#additional color tables are: -Cdem1, -Cdem3, -Cdem4
if [ ! -e $POZO_DEM_HS ]
then
    echo "generate hillshade $DEM_GRID_HS"
    #more fancy hillshading:
    gmt grdgradient $POZO_DEM -Em315/45+a -Ne0.8 -G$POZO_DEM_HS
fi

POZO_BOUNDARY=/raid2/bodo/Dropbox/California/SCI/SCI_Pozo_catchment_UTM11N_NAD83.gmt

### Plotting DEM differences
OVERVIEW_SCALE=1:4500
OVERVIEW_REGION=236000/237000/3764000/3764500
OVERVIEW_XSTEPS=0.04
OVERVIEW_YSTEPS=0.04
CPT="seis_zoom.cpt"
gmt makecpt -D -D -Cseis -T-1/1/0.1 > $CPT
#gmt makecpt -Q -D -Cseis -T-1/1/0.1 > $CPT


POSTSCRIPT3=figures/Pozo_catchment_zoom_D_blockmean.ps
TITLE="1m: dtm_interp minus blockmean"
DEM_POZO_DIFF_BLOCKMEAN=blockmean/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1mz_diff
```

```
gmt grdmath $POZO_DEM  \
    blockmean/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1mz.tif  \
    SUB = $DEM_POZO_DIFF_BLOCKMEAN
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_BLOCKMEAN -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT3
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT3
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT3
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT3
gmt psbasemap -R -J -O -K -B+t"$TITLE"  --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT3
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT3
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim  $POSTSCRIPT3  \
    ${POSTSCRIPT3::-3}.png
```

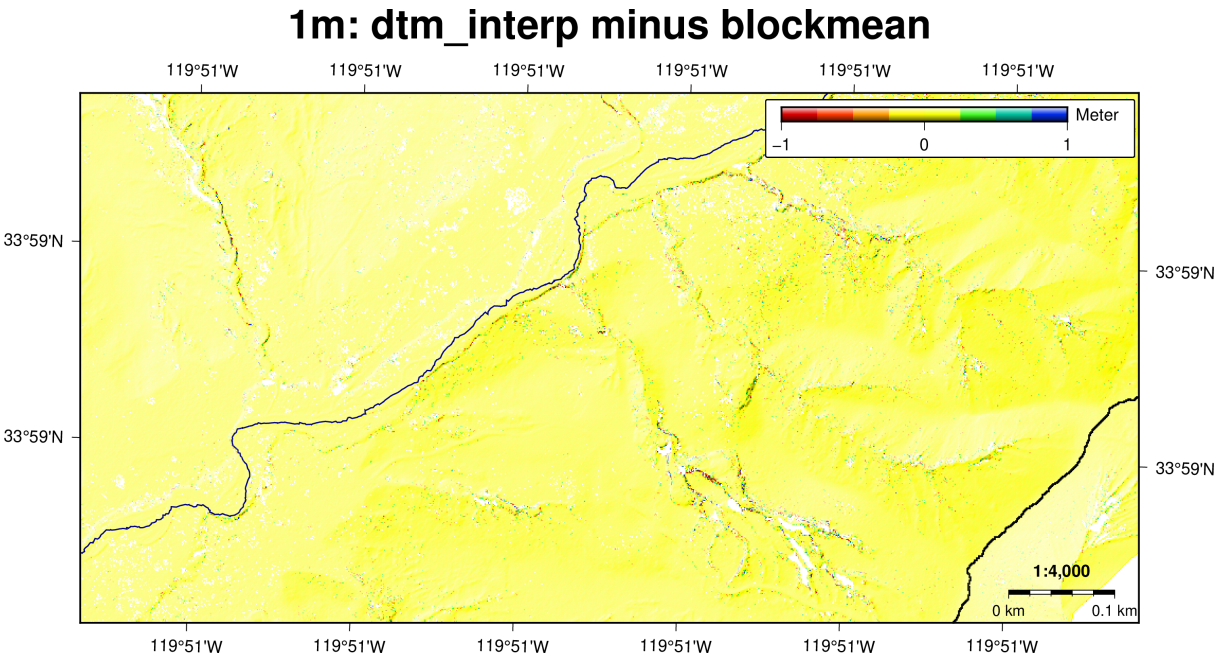

Figure 2: Map view of the LAStools-triangulated minus gmt:blockmean interpolation of the zoomed-in part of the Pozo catchment

The gmt:blockmean interpolated map (see Figure 2)

2.1.2 blockmedian

http://gmt.soest.hawaii.edu/doc/5.3.2/blockmedian.html

```
cd $DATA_BASEDIR/
mkdir $DATA_BASEDIR/blockmedian
```

```
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
BLOCKMEDIAN_GRID=$DATA_BASEDIR/blockmedian/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmedi
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt blockmedian  \
    -R$DEM_GRID -C -G${BLOCKMEDIAN_GRID}%s.nc -Az,s
```

Convert the NetCDF files to a compress geotiff:

```
cd $DATA_BASEDIR/blockmedian
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmedian_1mz.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmedian_1mz.tif -a_srs  \
    epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmedian_1ms.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmedian_1ms.tif -a_srs  \
    epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
cd ..
```

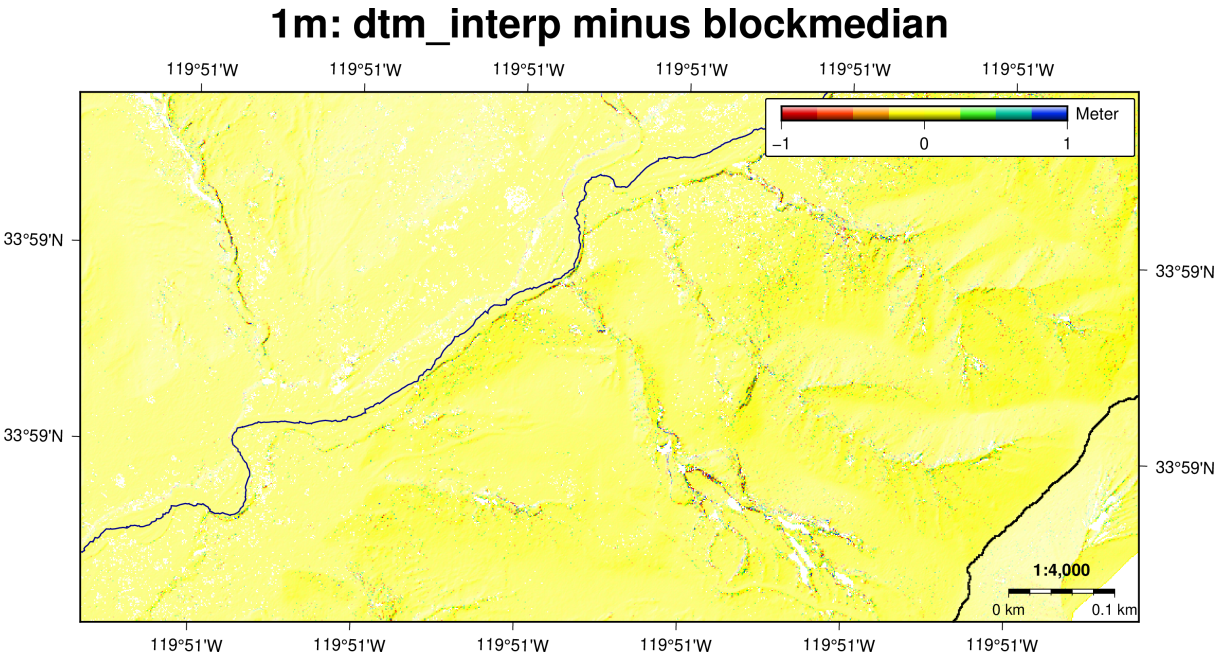

Figure 3: Map view of the LAStools-triangulated minus gmt:blockmedian interpolation of the zoomed-in part of the Pozo catchment

The gmt:blockmedian interpolated map (see Figure 4).

2.1.3 Green's function

Not working yet, takes a long time for large points

http://gmt.soest.hawaii.edu/doc/latest/greenspline.html

```
cd $DATA_BASEDIR/
mkdir $DATA_BASEDIR/greenspline
```

```
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
GREENSPLINE_GRID=$DATA_BASEDIR/greenspline/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_greenspli
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt greenspline  \
    -R$DEM_GRID -C -D1 -Sc -G${GREENSPLINE_GRID}%s.nc
GREENSPLINE_GRID=$DATA_BASEDIR/greenspline/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_greenspli
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt greenspline  \
    -R$DEM_GRID -C -D1 -St0.3 -G${GREENSPLINE_GRID}%s.nc
```

2.1.4 Triangulation

Delauny Triangulation

http://gmt.soest.hawaii.edu/doc/latest/triangulate.html

```
cd $DATA_BASEDIR/
mkdir $DATA_BASEDIR/triangulation
```

```
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
TRIANGULATION_GRID=$DATA_BASEDIR/triangulation/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_trian
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt triangulate  \
    -R$DEM_GRID -G${TRIANGULATION_GRID}
```

Convert the NetCDF files to a compressed geotiff:

```
cd $DATA_BASEDIR/triangulation
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_triangulation_1m.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_triangulation_1m.tif -a_srs  \
    epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
cd ..
```

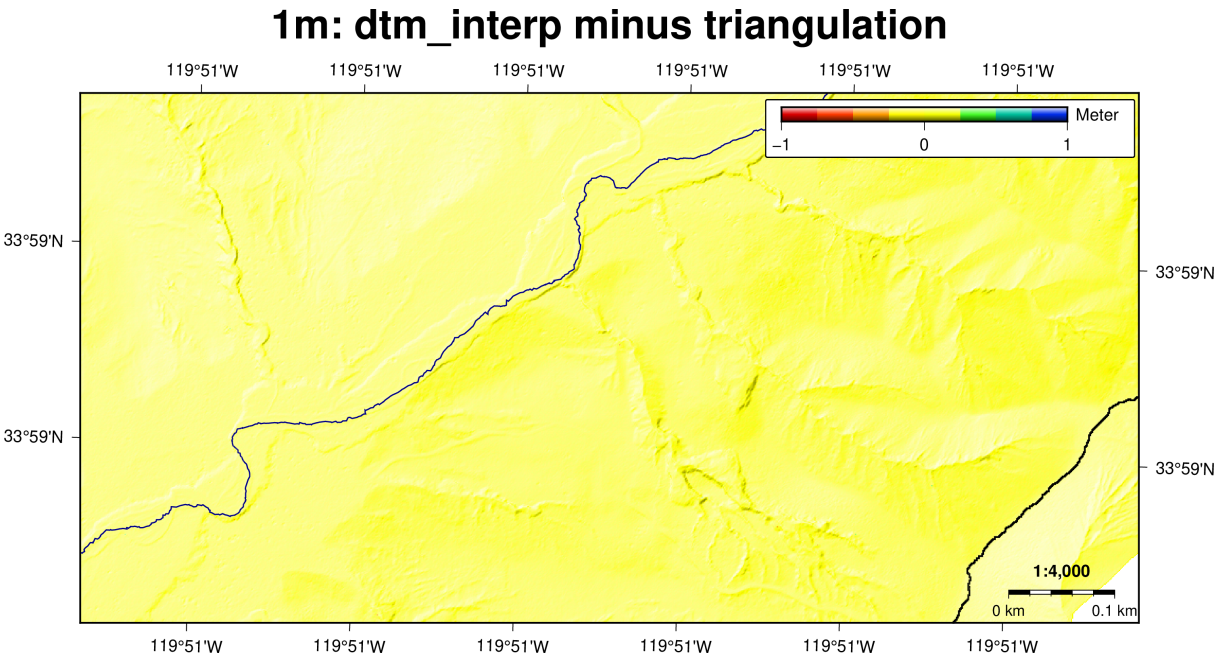

Figure 4: Map view of the LAStools-triangulated minus gmt:blockmedian interpolation of the zoomed-in part of the Pozo catchment

The DEM difference gmt:triangulation interpolated map (see Figure 4).

2.1.5 Surface

http://gmt.soest.hawaii.edu/doc/latest/surface.html

```
cd $DATA_BASEDIR/
mkdir $DATA_BASEDIR/surface
```

```
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
SURFACE_GRID=$DATA_BASEDIR/surface/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension02
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt surface  \
    -R$DEM_GRID -G${SURFACE_GRID} -M0c -T0.25 -C0.1
```

Convert the NetCDF files to a compress geotiff:

```
cd $DATA_BASEDIR/surface
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension025_c01_1m.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension025_c01_1m.tif  \
    -a_srs epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
cd ..
```

Using Tension=0.35:

```
cd $DATA_BASEDIR
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
SURFACE_GRID=$DATA_BASEDIR/surface/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension03
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt surface  \
    -R$DEM_GRID -G${SURFACE_GRID} -M0c -T0.35 -C0.1
```

Convert the NetCDF files to a compress geotiff:

```
cd $DATA_BASEDIR/surface
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension035_c01_1m.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension035_c01_1m.tif  \
    -a_srs epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
cd ..
```

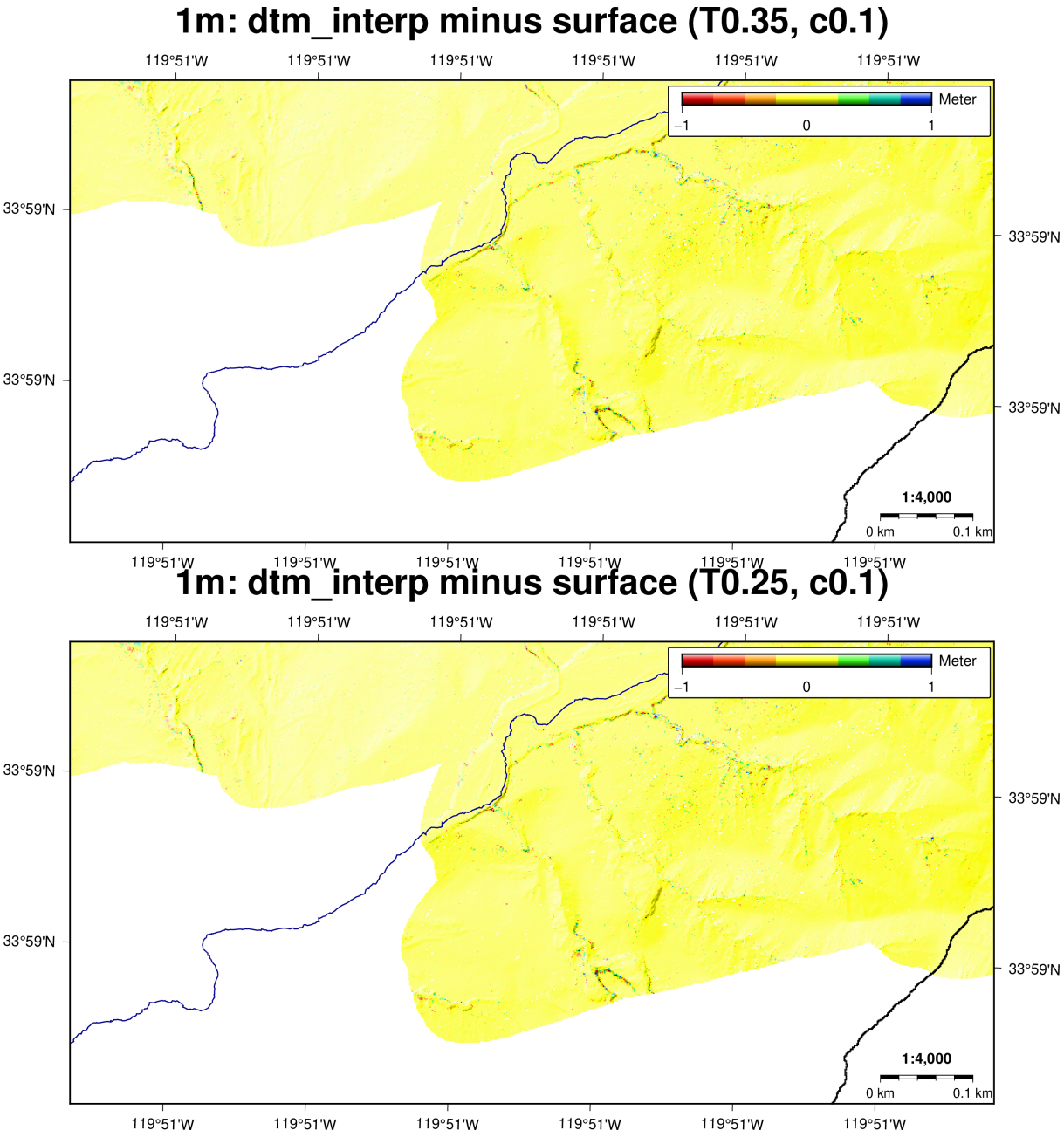

Figure 5: Map view of the LAStools-triangulated minus gmt:surface tension interpolation (t=0.25 and t=0.35) for the Pozo zoom-in area.

The DEM difference of surface tension of the Pozo catchment and the area of interest is shown in Figure 5.

2.1.6 NearestNeighbor interpolation with GMT using `gmt nearneighbor`

This is currently not working http://gmt.soest.hawaii.edu/doc/latest/nearneighbor.html The average value is computed as a weighted mean of the nearest point from each sector inside the search radius. The weighting function used is w(r) = 1 / (1 + d ^ 2), where d = 3 * r / search_radius and r is distance from the node. Distances (-S) are grid-cell size * sqrt(2)

For a grid-cell size of 1m, the radius is 0.5, so `-S0.707e`:

```
cd $DATA_BASEDIR/
mkdir $DATA_BASEDIR/nearneighbor
```

```
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
NEARNEIGHBOR_GRID=$DATA_BASEDIR/nearneighbor/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gmtnear
pbzip2 -dc SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz.bz2 | gmt nearneighbor  \
    -R$DEM_GRID -G${NEARNEIGHBOR_GRID} -S0.707e -nn -N2+m2
```

Convert the NetCDF files to a compress geotiff:

```
cd $DATA_BASEDIR/nearneighbor
gdal_translate -of GTIFF  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gmtnearneighbor_1m.nc  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gmtnearneighbor_1m.tif -a_srs  \
    epsg:26911 -co COMPRESS=DEFLATE -co ZLEVEL=7
cd ..
```

2.2 Interpolate with gdal_grid

2.2.1 NearestNeighbor interpolation using gdal_grid

The above described approach with gmt does not appear to work well. Better to use a gdal_grid approach:

First, you have to set the variables for import/export from gdal:

```
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
# get x,y bounds
export minx= gmt grdinfo -C $DEM_GRID |cut -f 2
export maxx= gmt grdinfo -C $DEM_GRID |cut -f 3
export nx= gmt grdinfo -C $DEM_GRID |cut -f 10
export boundsx="$minx $maxx"
export miny= gmt grdinfo -C $DEM_GRID |cut -f 4
```

```
export maxy= gmt grdinfo -C $DEM_GRID |cut -f 5
export ny= gmt grdinfo -C $DEM_GRID |cut -f 11
export boundsy="$miny $maxy"
export boundsyr="$maxy $miny"
```

Next, prepare the file to be read by gdal_grid:

First, add column header with x, y, z to column file containing data:

```
cp -rv SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz  \
    SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.csv
pbzip2 -7 SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz
sed -i '1s/^/x y z\n/' SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.csv
```

Next, Generate a VRT file `SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.vrt` that contains information about the file to be read:

```
<OGRVRTDataSource>
    <OGRVRTLayer name="SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2">
        <SrcDataSource>CSV:SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.csv</SrcDataSource>
        <SrcLayer>SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2</SrcLayer>
        <LayerSRS>EPSG:26911</LayerSRS>
        <GeometryType>wkbPoint</GeometryType>
        <GeometryField encoding="PointFromColumns" x="x" y="y" z="z"/>
    </OGRVRTLayer>
</OGRVRTDataSource>
```

Next, perform the actual interpolation and clip output with `gdalwarp`:

```
PC_IN=SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2
NEARNEIGHBOR_GRID=$DATA_BASEDIR/nearneighbor/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gdalnea
R_M=0.707
export CLIP_SHAPEFILE=SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp
gdal_grid -zfield "z" -a  \
    nearest:radius1=$R_M:radius2=$R_M:min_points=3:max_points=1000:nodata=-9999 -txe  \
    $boundsx -tye $boundsyr -outsize $nx $ny -of GTiff -ot Float32 -l ${PC_IN}  \
    ${PC_IN}.vrt ${NEARNEIGHBOR_GRID} -co COMPRESS=DEFLATE -co ZLEVEL=7 --config  \
    GDAL_NUM_THREADS ALL_CPUS --config GDAL_CACHEMAX 2000

gdalwarp -cutline $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -crop_to_cutline -tap -multi -tr 1 1 -t_srs epsg:26911 $NEARNEIGHBOR_GRID  \
    ${NEARNEIGHBOR_GRID::-4}_c.tif -co COMPRESS=DEFLATE -co ZLEVEL=7
```

If needed, one can convert to NetCDF GMT grid:

```
gmt grdconvert ${NEARNEIGHBOR_GRID::-4}_c.tif=gd/1/0/-9999 ${NEARNEIGHBOR_GRID}.nc
```

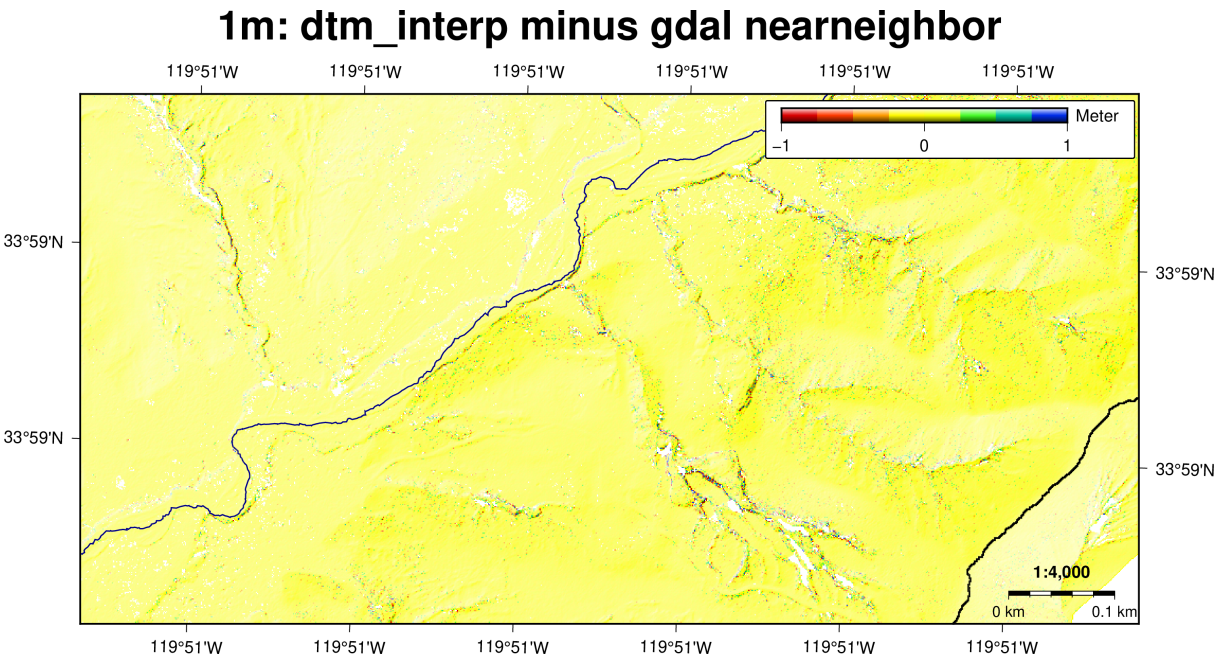

Figure 6: Map view of the LAStools-triangulated minus gdal_grid:nearneighbor interpolation for the Pozo zoom-in area.

The DEM difference of gdal_grid:nearneighbor of the Pozo catchment and the area of interest is shown in Figure 6.

2.2.2 Interpolate IDW using gdal_grid

Interpolate using gdal_grid. For details see section “NearestNeighbor interpolation using gdal_grid”. Here, we assume there exists already a CSV and VRT file:

```
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
# get x,y bounds
export minx= gmt grdinfo -C $DEM_GRID |cut -f 2
export maxx= gmt grdinfo -C $DEM_GRID |cut -f 3
export nx= gmt grdinfo -C $DEM_GRID |cut -f 10
export boundsx="$minx $maxx"
export miny= gmt grdinfo -C $DEM_GRID |cut -f 4
export maxy= gmt grdinfo -C $DEM_GRID |cut -f 5
export ny= gmt grdinfo -C $DEM_GRID |cut -f 11
```

```
export boundsy="$miny $maxy"
export boundsyr="$maxy $miny"

PC_IN=SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2
IDW_GRID=$DATA_BASEDIR/idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_idwp2_1m.tif
R_M=0.707
```

NOTE that the next command is the standard way to run IDW, but not the most efficient way. Please look at option #1 and #2 below to speed up processing for a large number of points

```
gdal_grid -zfield "z" -a  \
    invdist:power=2.0:smoothin=0.0:radius1=$R_M:radius2=$R_M:min_points=3:max_points=1000:nodata=-9999
    -txe $boundsx -tye $boundsyr -outsize $nx $ny -of GTiff -ot Float32 -l ${PC_IN}  \
    ${PC_IN}.vrt ${IDW_GRID} -co COMPRESS=DEFLATE -co ZLEVEL=7 --config  \
    GDAL_NUM_THREADS ALL_CPUS --config GDAL_CACHEMAX 2000
```

Not necessary, but just in case:

```
gdalwarp -cutline $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -crop_to_cutline -tap -multi -tr 1 1 -t_srs epsg:26911 $IDW_GRID  \
    ${IDW_GRID::-4}_c.tif -co COMPRESS=DEFLATE -co ZLEVEL=7
gmt grdconvert ${IDW_GRID::-4}_c.tif=gd/1/0/-9999 ${IDW_GRID::-4}_c.nc
```

Speeding up processing, option #1: Use a maximum point number:

```
export  \
    CLIP_SHAPEFILE=/home/bodo//Dropbox/California/SCI/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp
gdal_grid -clipsrc $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -zfield "z" -a  \
    invdist:power=2.0:smoothin=0.0:radius1=$R_M:radius2=$R_M:min_points=3:max_points=1000:nodata=-9999
    -txe $boundsx -tye $boundsyr -outsize $nx $ny -of GTiff -ot Float32 -l ${PC_IN}  \
    ${PC_IN}.vrt ${IDW_GRID} -co COMPRESS=DEFLATE -co ZLEVEL=7 --config  \
    GDAL_NUM_THREADS ALL_CPUS --config GDAL_CACHEMAX 2000
```

Not necessary, but just in case:

```
gdalwarp -cutline $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -crop_to_cutline -tap -multi -tr 1 1 -t_srs epsg:26911 $IDW_GRID  \
    ${IDW_GRID::-4}_c.tif -co COMPRESS=DEFLATE -co ZLEVEL=7
gmt grdconvert ${IDW_GRID::-4}_c.tif=gd/1/0/-9999 ${IDW_GRID::-4}_c.nc
```

Speeding up processing, option #2: Use a maximum point number and the `invdistnn` algorithm:

```
IDW_GRID=$DATA_BASEDIR/idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_idwp2_invdistnn_1m.tif
export  \
    CLIP_SHAPEFILE=/home/bodo//Dropbox/California/SCI/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp
gdal_grid -zfield "z" -a  \
    invdistnn:power=2.0:smoothin=0.0:radius=$R_M:min_points=3:max_points=1000:nodata=-9999  \
    -txe $boundsx -tye $boundsyr -outsize $nx $ny -of GTiff -ot Float32 -l ${PC_IN}  \
    ${PC_IN}.vrt ${IDW_GRID} -co COMPRESS=DEFLATE -co ZLEVEL=7 --config  \
    GDAL_NUM_THREADS ALL_CPUS --config GDAL_CACHEMAX 2000
```

Not necessary, but just in case:

```
gdalwarp -cutline $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -crop_to_cutline -tap -multi -tr 1 1 -t_srs epsg:26911 $IDW_GRID  \
    ${IDW_GRID::-4}_c.tif -co COMPRESS=DEFLATE -co ZLEVEL=7
gmt grdconvert ${IDW_GRID::-4}_c.tif=gd/1/0/-9999 ${IDW_GRID::-4}_c.nc
```

Using algorithm `invdistnn` with power=3

```
IDW_GRID=$DATA_BASEDIR/idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_idwp3_invdistnn_1m.tif
export  \
    CLIP_SHAPEFILE=/home/bodo//Dropbox/California/SCI/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp
gdal_grid -zfield "z" -a  \
    invdistnn:power=3.0:smoothin=0.0:radius=$R_M:min_points=3:max_points=1000:nodata=-9999  \
    -txe $boundsx -tye $boundsyr -outsize $nx $ny -of GTiff -ot Float32 -l ${PC_IN}  \
    ${PC_IN}.vrt ${IDW_GRID} -co COMPRESS=DEFLATE -co ZLEVEL=7 --config  \
    GDAL_NUM_THREADS ALL_CPUS --config GDAL_CACHEMAX 2000
```

Not necessary, but just in case:

```
gdalwarp -cutline $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -crop_to_cutline -tap -multi -tr 1 1 -t_srs epsg:26911 $IDW_GRID  \
    ${IDW_GRID::-4}_c.tif -co COMPRESS=DEFLATE -co ZLEVEL=7
gmt grdconvert ${IDW_GRID::-4}_c.tif=gd/1/0/-9999 ${IDW_GRID::-4}_c.nc
```

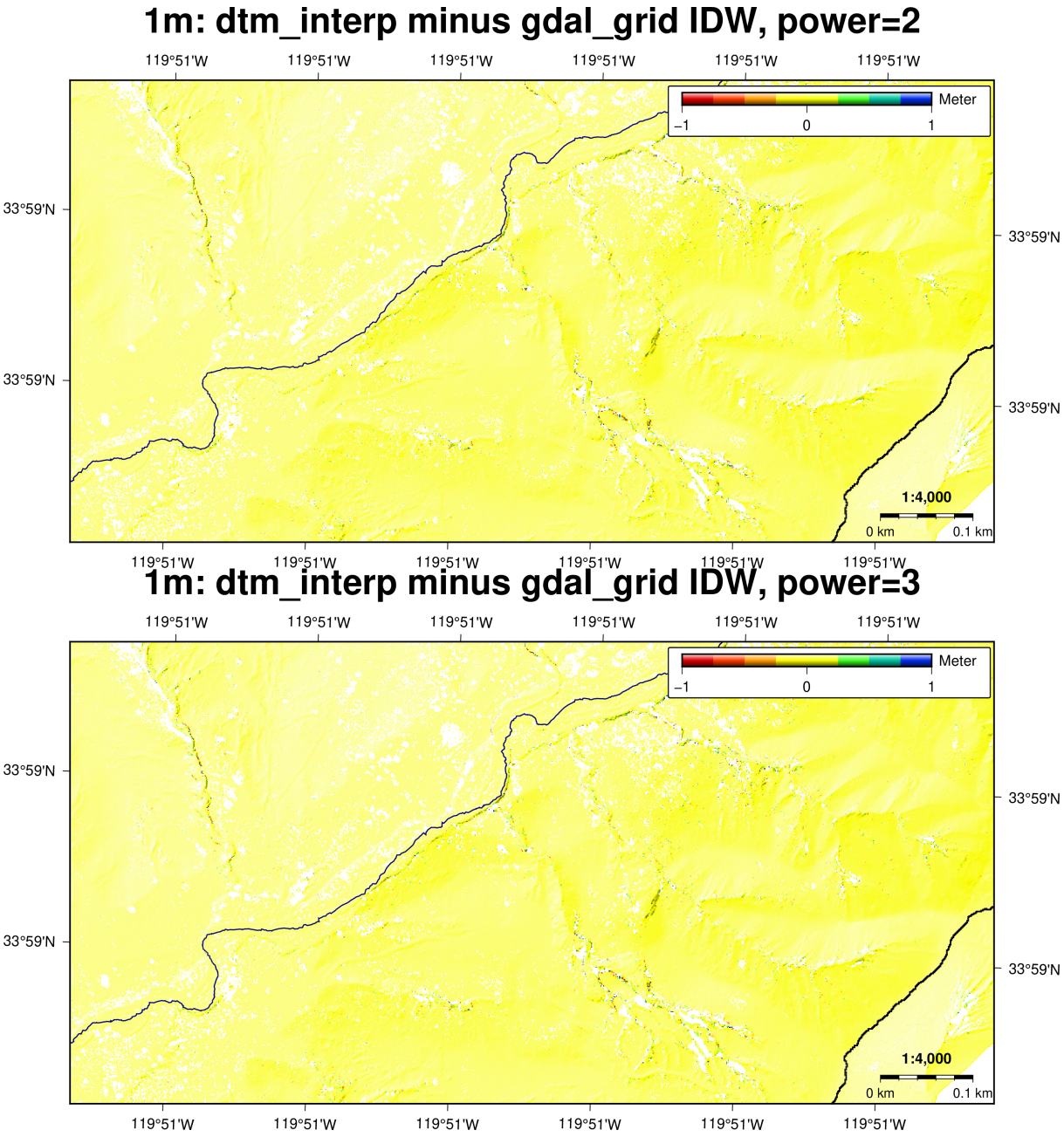

Figure 7: Map view of the LAStools-triangulated minus gdal_grid:idw (power=2 and 3) interpolation for the Pozo zoom-in area.

The DEM difference of gdal_grid:idw (power=2 and 3) of the Pozo catchment and the area of interest is shown in Figure 7.

2.2.3 IDW Interpolation via pdal with writers.gdal

This uses writers.gdal following the Points2Grid approach.

Generate a pipeline along these lines:

```
mkdir $DATA_BASEDIR/idw
```

File SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m_pipeline.json:

```
{
  "pipeline":[
    "SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.laz",
    {
      "resolution": 1,
      "gdaldriver": "GTiff",
      "gdalopts": "COMPRESS=DEFLATE, ZLEVEL=7, GDAL_NUM_THREADS=ALL CPUS",
      "data_type": "float",
      "output_type": "mean, idw, count, stdev",
      "filename":"idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m.tif"
    }
  ]
}
```

Run with:

```
pdal pipeline SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m_pipeline.json
```

You will need to clip the file to have the same size as the input file:

```
CLIP_SHAPEFILE=SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83.shp
DEM_GRID=$DATA_BASEDIR/dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.tif
# get x,y bounds
export minx= gmt grdinfo -C $DEM_GRID |cut -f 2
export maxx= gmt grdinfo -C $DEM_GRID |cut -f 3
export nx= gmt grdinfo -C $DEM_GRID |cut -f 10
export miny= gmt grdinfo -C $DEM_GRID |cut -f 4
export maxy= gmt grdinfo -C $DEM_GRID |cut -f 5
export ny= gmt grdinfo -C $DEM_GRID |cut -f 11
export boundste="$minx $miny $maxx $maxy"

#-cutline $CLIP_SHAPEFILE -cl SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83  \
    -crop_to_cutline
```

```
gdalwarp -multi -te $boundste -ts $nx $ny -t_srs epsg:26911  \
    idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m.tif  \
    idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m_c.tif -co  \
    COMPRESS=DEFLATE -co ZLEVEL=7

gdal_translate -b 2 idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m_c.tif  \
    idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m_c2.tif
```

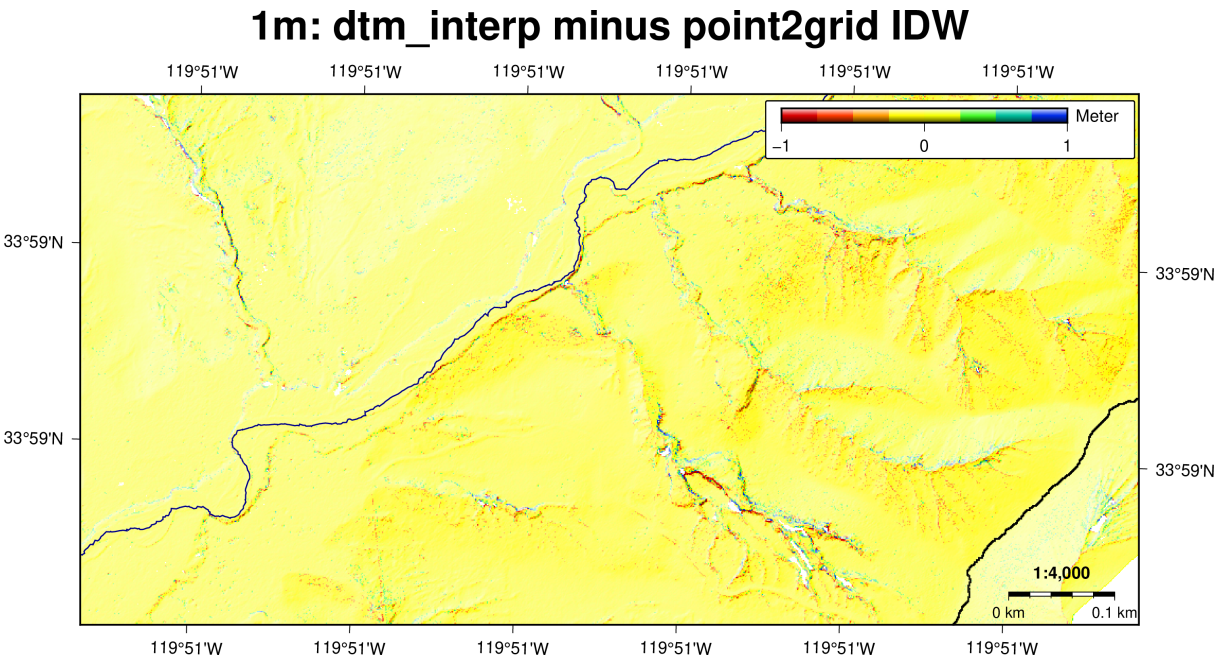

Figure 8: Map view of the LAStools-triangulated minus pdal:Points2Grid interpolation for the Pozo zoom-in area.

The DEM difference of pdal:Points2Grid of the Pozo catchment and the area of interest is shown in Figure 7.

3 Plot with GMT 5

Below, we provide a simple GMT Version 5 (GMT5) shell script to plot the DEM difference data. We zoom in to a smaller area to provide a better view of the changes of the DEMs

This script will generate the above shown maps, but also many more.

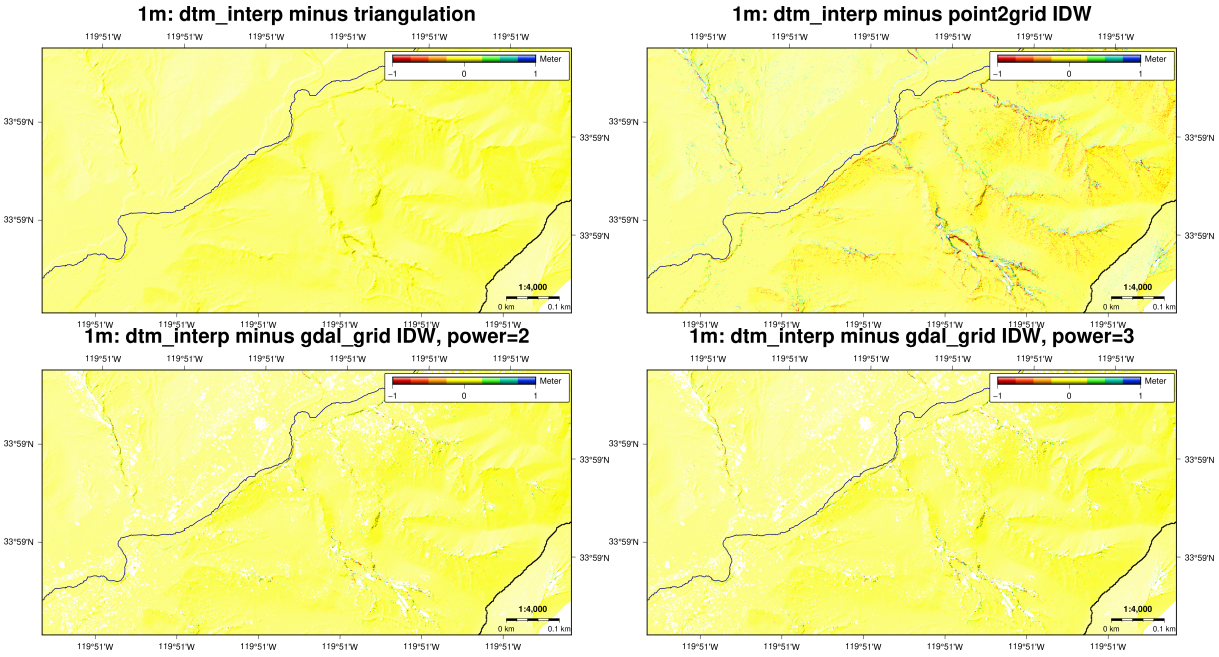

Figure 9: Map view of the LAStools-triangulated minus various interpolated DEMs for the Pozo zoom-in area.

The DEM differences of various interpolated DEMs of the Pozo catchment and the area of interest is shown in Figure 9.

Command file to plot all DEM differences for a small area of Pozo catchment. The GMT shell file can be downloaded from: .

```
#!/bin/bash
### GMT V 5 file!
gmt gmtset MAP_FRAME_PEN    1
gmt gmtset MAP_FRAME_WIDTH    0.1
gmt gmtset MAP_FRAME_TYPE     plain
gmt gmtset FONT_TITLE    Helvetica-Bold
gmt gmtset FONT_LABEL    Helvetica-Bold 14p
gmt gmtset PS_PAGE_ORIENTATION    landscape
gmt gmtset PS_MEDIA    A4
gmt gmtset FORMAT_GEO_MAP    D
gmt gmtset MAP_DEGREE_SYMBOL degree
gmt gmtset PROJ_LENGTH_UNIT cm
gmt gmtset MAP_FRAME_AXES WESNZ

# MAP Parameters
#
```

```
#data are in /home/bodo/Dropbox/California/SCI/Pozo

#Pozo_USGS_UTM11_NAD83_g_05m.tif
#Pozo_USGS_UTM11_NAD83_g_5m.tif
#Pozo_USGS_UTM11_NAD83_g_10m.tif
#Pozo_USGS_UTM11_NAD83_g_30m.tif
#cd /home/bodo/Dropbox/California/SCI/Pozo/dtm_interp/
#convert to compressed NetCDF format (GMT)
#gdal_translate -co COMPRESS=DEFLATE -of NetCDF Pozo_USGS_UTM11_NAD83_g_05m.tif  \
    Pozo_USGS_UTM11_NAD83_g_05m.nc
#gdal_translate -co COMPRESS=DEFLATE -of NetCDF Pozo_USGS_UTM11_NAD83_g_1m.tif  \
    Pozo_USGS_UTM11_NAD83_g_1m.nc
#gdal_translate -co COMPRESS=DEFLATE -of NetCDF Pozo_USGS_UTM11_NAD83_g_5m.tif  \
    Pozo_USGS_UTM11_NAD83_g_5m.nc
#gdal_translate -co COMPRESS=DEFLATE -of NetCDF Pozo_USGS_UTM11_NAD83_g_10m.tif  \
    Pozo_USGS_UTM11_NAD83_g_10m.nc
#gdal_translate -co COMPRESS=DEFLATE -of NetCDF Pozo_USGS_UTM11_NAD83_g_30m.tif  \
    Pozo_USGS_UTM11_NAD83_g_30m.nc

POZO_DEM=dtm_interp/Pozo_USGS_UTM11_NAD83_g_1mc.nc
POZO_DEM_HS=${POZO_DEM::-3}_HS.nc
gmt grd2cpt $POZO_DEM -E25 -Cdem2 > dem2_color.cpt
#additional color tables are: -Cdem1, -Cdem3, -Cdem4
if [ ! -e $POZO_DEM_HS ]
then
    echo "generate hillshade $DEM_GRID_HS"
    #more fancy hillshading:
    gmt grdgradient $POZO_DEM -Em315/45+a -Ne0.8 -G$POZO_DEM_HS
fi


SCI_ORTHOIMAGE_R=/raid2/bodo/Dropbox/California/SCI/SCI_Pozo_orthophoto_1m_UTM11N_NAD83_R.nc
SCI_ORTHOIMAGE_R_HISTEQ=${SCI_ORTHOIMAGE_R::-3}_histeq.nc
if [ ! -e $SCI_ORTHOIMAGE_R_HISTEQ ]
then
    echo "calculate histogram equalization for $SCI_ORTHOIMAGE_R_HISTEQ (color coding )"
    gmt grdhisteq $SCI_ORTHOIMAGE_R -G$SCI_ORTHOIMAGE_R_HISTEQ -N
fi

SCI_ORTHOIMAGE_B=/raid2/bodo/Dropbox/California/SCI/SCI_Pozo_orthophoto_1m_UTM11N_NAD83_B.nc
SCI_ORTHOIMAGE_B_HISTEQ=${SCI_ORTHOIMAGE_B::-3}_histeq.nc
if [ ! -e $SCI_ORTHOIMAGE_B_HISTEQ ]
```

```
then
    echo "calculate histogram equalization for $SCI_ORTHOIMAGE_B_HISTEQ (color coding )"
    gmt grdhisteq $SCI_ORTHOIMAGE_B -G$SCI_ORTHOIMAGE_B_HISTEQ -N
fi

SCI_ORTHOIMAGE_G=/raid2/bodo/Dropbox/California/SCI/SCI_Pozo_orthophoto_1m_UTM11N_NAD83_G.nc
SCI_ORTHOIMAGE_G_HISTEQ=${SCI_ORTHOIMAGE_G::-3}_histeq.nc
if [ ! -e $SCI_ORTHOIMAGE_G_HISTEQ ]
then
    echo "calculate histogram equalization for $SCI_ORTHOIMAGE_G_HISTEQ (color coding )"
    gmt grdhisteq $SCI_ORTHOIMAGE_G -G$SCI_ORTHOIMAGE_G_HISTEQ -N
fi

#Boundary (polygon) of SCI:  \
    /home/bodo/Dropbox/California/SCI/SCI_boundary_clip_UTM11N_NAD83.shp
#convert to GMT format
#ogr2ogr -f GMT SCI_boundary_clip_UTM11N_NAD83.gmt  \
    /home/bodo/Dropbox/California/SCI/SCI_boundary_clip_UTM11N_NAD83.shp
SCI_BOUNDARY=/raid-cachi/bodo/Dropbox/California/SCI/SCI_boundary_clip_UTM11N_NAD83.gmt

#Pozo catchment
#ogr2ogr -f GMT SCI_Pozo_catchment_UTM11N_NAD83.gmt  \
    /home/bodo/Dropbox/California/SCI/SCI_Pozo_catchment_UTM11N_NAD83.shp
POZO_BOUNDARY=/raid2/bodo/Dropbox/California/SCI/SCI_Pozo_catchment_UTM11N_NAD83.gmt

#Preparing stream network:
#extracted stream from Matlab scripts (Neely et al., 2017) stored in  \
    SCI_1m_noveg_DTM_UTM11_NAD83_shapefiles.zip
#unzip  SCI_1m_noveg_DTM_UTM11_NAD83_shapefiles.zip
#SCI_FAC=shapefiles/SCI_1m_noveg_DTM_UTM11_NAD83_all_MS_proj.shp

### Image-specific definitions
#For an example see: http://gmt.soest.hawaii.edu/doc/5.4.2/gallery/ex28.html#example-28

#width of map in cm:
OVERVIEW_WIDTH=10
OVERVIEW_SCALE=1:22500
OVERVIEW_REGION=$POZO_DEM
#OVERVIEW_REGION=236652.03/237152.03/3764517.98/3765017.98
OVERVIEW_XSTEPS=0.04
OVERVIEW_YSTEPS=0.04
echo "Creating map for Pozo"
POSTSCRIPT1=figures/Pozo_catchment_topo_overview_map.ps
```

```
TITLE="Pozo catchment, Santa Cruz Island, California, 1-m Lidar DEM"
CPT="dem2_color.cpt"
gmt grdimage -Q -R$OVERVIEW_REGION $POZO_DEM -I$POZO_DEM_HS -C$CPT -Jx$OVERVIEW_SCALE  \
    -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT1
# Overlay geographic data and coregister by using correct region and gmt projection  \
    with the same scale
#add shoreline from Lidar data
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT1
gmt psxy -Wthin,black -R$OVERVIEW_REGION -Jx$OVERVIEW_SCALE $SCI_BOUNDARY -O -K >>  \
    $POSTSCRIPT1
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT1
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx1m -By1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT1
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w1k+l1:22,500+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT1
gmt psscale -R -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I -F+gwhite+r1p+pthin,black  \
    -Bx100 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O >> $POSTSCRIPT1
#convert to pdf and PNG
#convert -rotate 90 -quality 100 -density 300 $POSTSCRIPT1 ${POSTSCRIPT1::-3}.pdf
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT1 ${POSTSCRIPT1::-3}.png

### Creating second map showing focus area in Pozo
OVERVIEW_WIDTH=10
OVERVIEW_SCALE=1:4500
OVERVIEW_REGION=236000/237000/3764000/3764500
OVERVIEW_XSTEPS=0.04
OVERVIEW_YSTEPS=0.04
echo "Creating zoom-in map for Pozo"
POSTSCRIPT2=figures/Pozo_catchment_topo_zoom_map.ps
TITLE="Zoom in of Pozo, 1-m Lidar DEM"
CPT="dem2_color_zoom.cpt"
gmt grd2cpt $POZO_DEM -R$OVERVIEW_REGION -E25 -Cdem2 > $CPT
gmt grdimage -Q -R$OVERVIEW_REGION $POZO_DEM -I$POZO_DEM_HS -C$CPT -Jx$OVERVIEW_SCALE  \
    -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT2
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT2
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT2
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT2
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,500+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT2
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx50 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
```

```
    -K >> $POSTSCRIPT2
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT2 ${POSTSCRIPT2::-3}.png

convert -quality 100 -density 300 ${POSTSCRIPT1::-3}.png ${POSTSCRIPT2::-3}.png  \
    -append figures/Pozo_catchment_topo_overview_zoom_map.png

### Plotting DEM differences
OVERVIEW_SCALE=1:4500
OVERVIEW_REGION=236000/237000/3764000/3764500
OVERVIEW_XSTEPS=0.04
OVERVIEW_YSTEPS=0.04
CPT="seis_zoom.cpt"
gmt makecpt -D -D -Cseis -T-1/1/0.25 > $CPT
#gmt makecpt -Q -D -Cseis -T-1/1/0.1 > $CPT


POSTSCRIPT3=figures/Pozo_catchment_zoom_D_blockmean.ps
TITLE="1m: dtm_interp minus blockmean"
DEM_POZO_DIFF_BLOCKMEAN=blockmean/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1mz_diff
gmt grdmath $POZO_DEM  \
    blockmean/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmean_1mz.tif  \
    SUB = $DEM_POZO_DIFF_BLOCKMEAN
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_BLOCKMEAN -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT3
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT3
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT3
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT3
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT3
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT3
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT3 ${POSTSCRIPT3::-3}.png

POSTSCRIPT4=figures/Pozo_catchment_zoom_D_blockmedian.ps
TITLE="1m: dtm_interp minus blockmedian"
DEM_POZO_DIFF_BLOCKMEDIAN=blockmedian/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmedian_1m
gmt grdmath $POZO_DEM  \
    blockmedian/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_blockmedian_1mz.tif  \
    SUB = $DEM_POZO_DIFF_BLOCKMEDIAN
```

```
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_BLOCKMEDIAN -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT4
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT4
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT4
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT4
gmt psbasemap -R -J -O -K -B+t"$TITLE"  --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT4
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT4
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT4 ${POSTSCRIPT4::-3}.png

convert -quality 100 -density 300 ${POSTSCRIPT3::-3}.png ${POSTSCRIPT4::-3}.png  \
    +append figures/Pozo_catchment_zoom_D_blockmean_blockmedian.png

POSTSCRIPT5=figures/Pozo_catchment_zoom_D_surfacet035c01.ps
TITLE="1m: dtm_interp minus surface (T0.35, c0.1)"
DEM_POZO_DIFF_SURFACET035C01=surface/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension
gmt grdmath $POZO_DEM  \
    surface/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension035_c01_1m.tif  \
    SUB = $DEM_POZO_DIFF_SURFACET035C01
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_SURFACET035C01 -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT5
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT5
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT5
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT5
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT5
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT5
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT5 ${POSTSCRIPT5::-3}.png

POSTSCRIPT6=figures/Pozo_catchment_zoom_D_surfacet025c01.ps
TITLE="1m: dtm_interp minus surface (T0.25, c0.1)"
DEM_POZO_DIFF_SURFACET025C01=surface/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension
gmt grdmath $POZO_DEM  \
    surface/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_surface_tension025_c01_1m.tif  \
    SUB = $DEM_POZO_DIFF_SURFACET025C01
```

```
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_SURFACET025C01 -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT6
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT6
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT6
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT6
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT6
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT6
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT6 ${POSTSCRIPT6::-3}.png

convert -quality 100 -density 300 ${POSTSCRIPT5::-3}.png ${POSTSCRIPT6::-3}.png  \
    +append figures/Pozo_catchment_zoom_D_surfacet035c01_surfacet025c01.png
convert -quality 100 -density 300  \
    figures/Pozo_catchment_zoom_D_blockmean_blockmedian.png  \
    figures/Pozo_catchment_zoom_D_surfacet035c01_surfacet025c01.png -append  \
    figures/Pozo_catchment_zoom_D_blockmean_blockmedian_surfacet035c01_surfacet025c01.png

POSTSCRIPT7=figures/Pozo_catchment_zoom_D_triangulation.ps
TITLE="1m: dtm_interp minus triangulation"
DEM_POZO_DIFF_TRIANGULATION=triangulation/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_triangulat
gmt grdmath $POZO_DEM  \
    triangulation/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_triangulation_1m.tif  \
    SUB = $DEM_POZO_DIFF_TRIANGULATION
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_TRIANGULATION -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT7
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT7
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT7
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT7
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT7
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT7
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT7 ${POSTSCRIPT7::-3}.png

POSTSCRIPT8=figures/Pozo_catchment_zoom_D_idwpoint2grid.ps
TITLE="1m: dtm_interp minus point2grid IDW"
```

```
DEM_POZO_DIFF_IDW=idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m_diff.nc
gmt grdmath $POZO_DEM  \
    idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2_idw_1m_c2.tif SUB =  \
    $DEM_POZO_DIFF_IDW
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_IDW -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT8
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT8
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT8
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT8
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT8
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT8
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT8 ${POSTSCRIPT8::-3}.png

convert -quality 100 -density 300 ${POSTSCRIPT7::-3}.png ${POSTSCRIPT8::-3}.png  \
    +append figures/Pozo_catchment_zoom_D_triangulation_IDW.png

POSTSCRIPT9=figures/Pozo_catchment_zoom_D_idwP2.ps
TITLE="1m: dtm_interp minus gdal_grid IDW, power=2"
DEM_POZO_DIFF_IDWP2=idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_idwp2_invdistnn_1m_diff.nc
gmt grdmath $POZO_DEM  \
    idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_idwp2_invdistnn_1m.tif SUB  \
    = $DEM_POZO_DIFF_IDWP2
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_IDWP2 -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT9
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT9
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT9
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT9
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT9
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT9
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT9 ${POSTSCRIPT9::-3}.png

POSTSCRIPT10=figures/Pozo_catchment_zoom_D_idwP3.ps
TITLE="1m: dtm_interp minus gdal_grid IDW, power=3"
```

```
DEM_POZO_DIFF_IDWP3=idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_idwp3_invdistnn_1m_diff.nc
gmt grdmath $POZO_DEM  \
    idw/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_idwp3_invdistnn_1m.tif SUB  \
    = $DEM_POZO_DIFF_IDWP3
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_IDWP3 -I$POZO_DEM_HS -C$CPT  \
    -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT10
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT10
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT10
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT10
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT10
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT10
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT10 ${POSTSCRIPT10::-3}.png

convert -quality 100 -density 300 ${POSTSCRIPT9::-3}.png ${POSTSCRIPT10::-3}.png  \
    +append figures/Pozo_catchment_zoom_D_IDWP2_IDWP3.png

convert -quality 100 -density 300 figures/Pozo_catchment_zoom_D_triangulation_IDW.png  \
    figures/Pozo_catchment_zoom_D_IDWP2_IDWP3.png -append  \
    figures/Pozo_catchment_zoom_D_triangulation_IDW_IDWP2_IDW_P3.png

POSTSCRIPT11=figures/Pozo_catchment_zoom_D_gmtnearneighbor.ps
TITLE="1m: dtm_interp minus gmt nearneighbor"
DEM_POZO_DIFF_GMTNEARNEIGHBOR=nearneighbor/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gmtnearne
gmt grdmath $POZO_DEM  \
    nearneighbor/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gmtnearneighbor_1m.tif  \
    SUB = $DEM_POZO_DIFF_GMTNEARNEIGHBOR
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_GMTNEARNEIGHBOR -I$POZO_DEM_HS  \
    -C$CPT -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT11
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT11
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT11
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT11
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT11
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT11
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
```

```
    $POSTSCRIPT11 ${POSTSCRIPT11::-3}.png

POSTSCRIPT12=figures/Pozo_catchment_zoom_D_gdalnearneighbor.ps
TITLE="1m: dtm_interp minus gdal nearneighbor"
DEM_POZO_DIFF_GDALNEARNEIGHBOR=nearneighbor/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gdalnear
gmt grdmath $POZO_DEM  \
    nearneighbor/SCI_Pozo_100m_buffer_catchment_UTM11N_NAD83_cl2.xyz_gdalnearneighbor_1m_c.tif  \
    SUB = $DEM_POZO_DIFF_GDALNEARNEIGHBOR
gmt grdimage -Q -R$OVERVIEW_REGION $DEM_POZO_DIFF_GDALNEARNEIGHBOR -I$POZO_DEM_HS  \
    -C$CPT -Jx$OVERVIEW_SCALE -V -K --COLOR_BACKGROUND=white > $POSTSCRIPT12
gmt psxy -Wthin,darkblue -R -J < profile-xy-trace_long_profile.txt -O -K >> $POSTSCRIPT12
gmt psxy -Wthick,black -R -J $POZO_BOUNDARY -O -K >> $POSTSCRIPT12
gmt pscoast -R -Ju11S/$OVERVIEW_SCALE -V -N1 -K -O -Df -Bx0.1m -By0.1m  \
    --FONT_ANNOT_PRIMARY=10p --FORMAT_GEO_MAP=ddd:mmF >> $POSTSCRIPT12
gmt psbasemap -R -J -O -K -B+t"$TITLE" --FONT_ANNOT_PRIMARY=9p  \
    -LjRB+c19:23N+f+w0.1k+l1:4,000+u+o0.2i --FONT_LABEL=10p >> $POSTSCRIPT12
gmt psscale -R$OVERVIEW_REGION -V -J -DjTRC+o1.5c/0.3c/+w6c/0.3c+h -C$CPT -I  \
    -F+gwhite+r1p+pthin,black -Bx1.0 -By+lMeter --FONT=10p --FONT_ANNOT_PRIMARY=10p -O  \
    -K >> $POSTSCRIPT12
convert -rotate 90 -quality 100 -density 300 -flatten -fuzz 1% -trim +repage  \
    $POSTSCRIPT12 ${POSTSCRIPT12::-3}.png
```