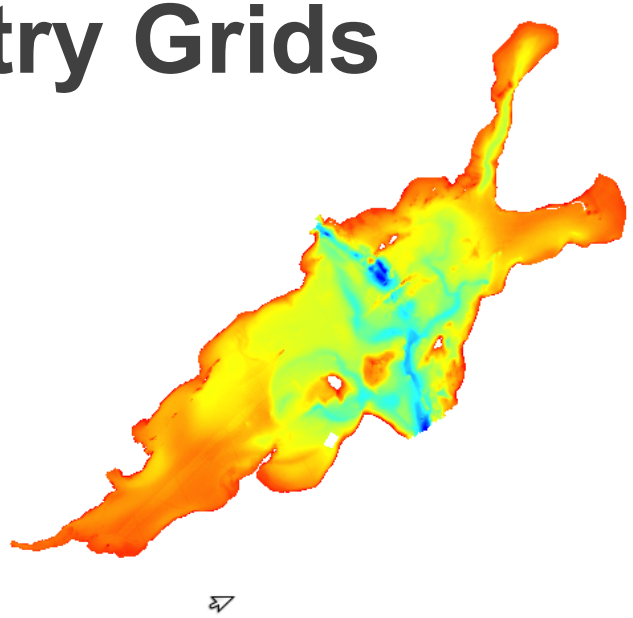
Classification of Bathymetry Grids Using Open Source Tools



Google Ocean

Kurt Schwehr, Jamie Adams, Jenifer Austin Foulkes

http://earth.google.com/ocean

http://maps.google.com/ocean

http://schwehr.org/blog

The Open Navigation Surfa

www.opennavsurf.org

Open Navigation Surface

LINKS

BACKGROUND

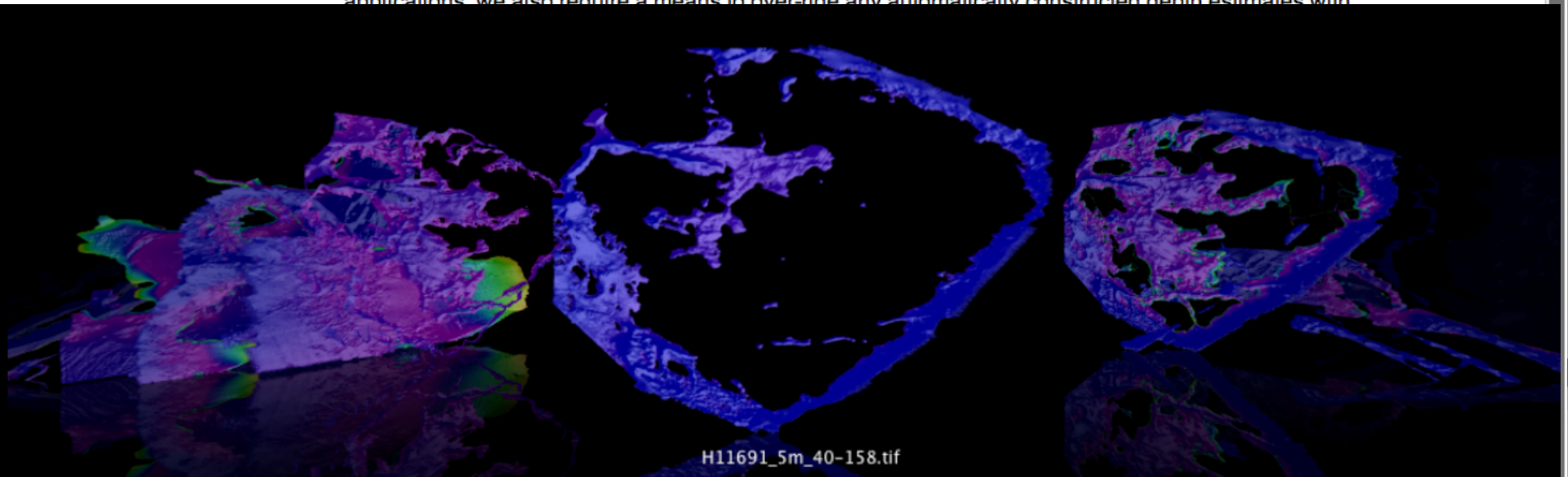
WHITEPAPERS

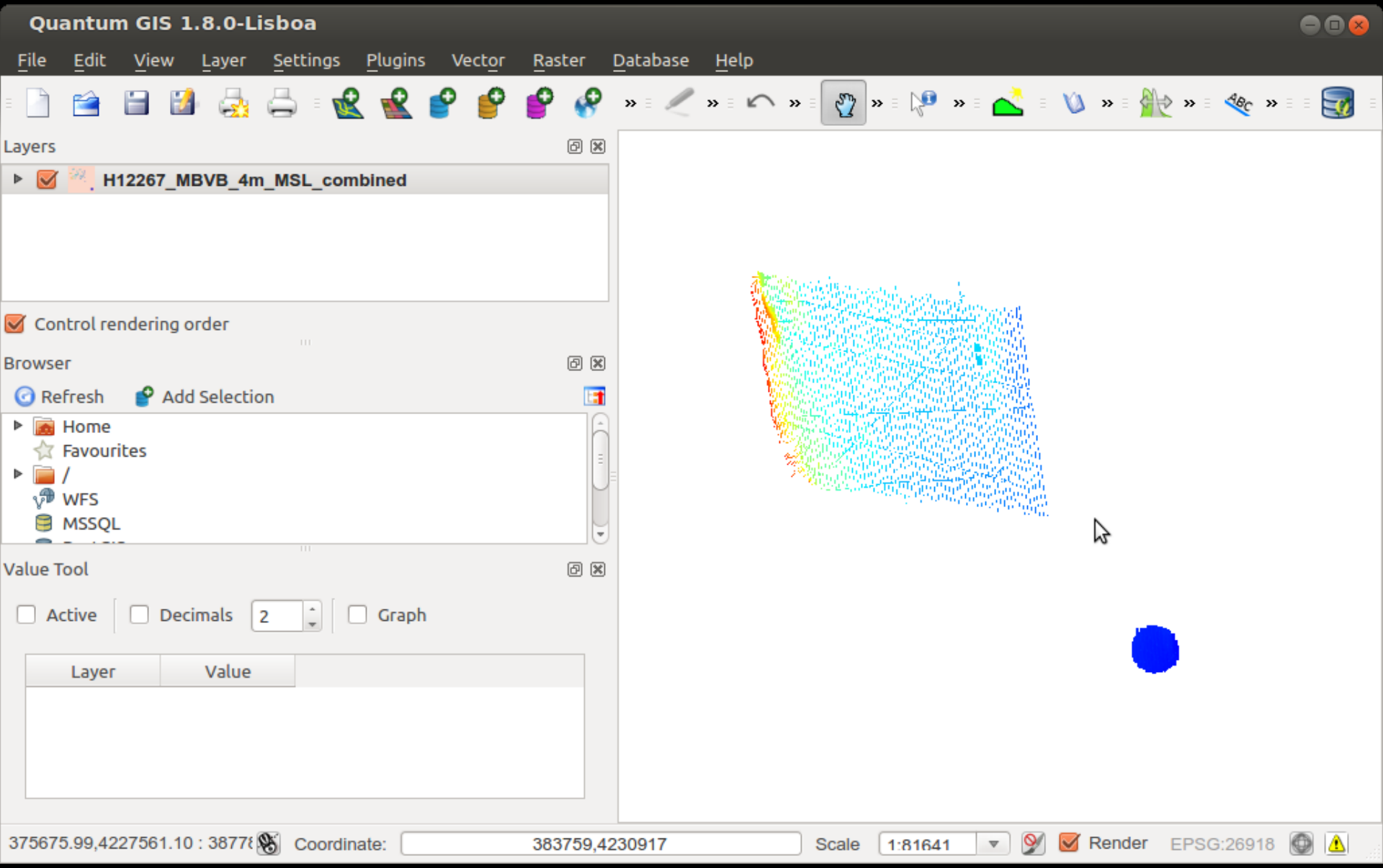
PRESENTATIONS

MEETINGS

The Navigation Surface (DOWNLOAD [2.56M]) paradigm is a design for a databased alternative to traditional methods of representing bathymetric data. It aims to preserve the highest level of detail in every bathymetric dataset and provide methods for their combination and manipulation to generate multiple products for both hydrographic and non-hydrographic purposes. The advantages of the method over traditional schemes are such that a number of commercial vendors have adopted the technology. However, this means that there is a strong requirement for a method to communicate results in a vendor neutral technology. The Open Navigation Surface (ONS) project was designed to fill this gap by implementing a freely available source-code library to read and write all of the information required for a Navigation Surface.

The Navigation Surface concept requires that in addition to estimation of depth, we must also estimate the uncertainty associated with the depth. In order to make the system suitable to support Safety of Navigation applications, we also require a means to over-ride any automatically constructed depth estimates with

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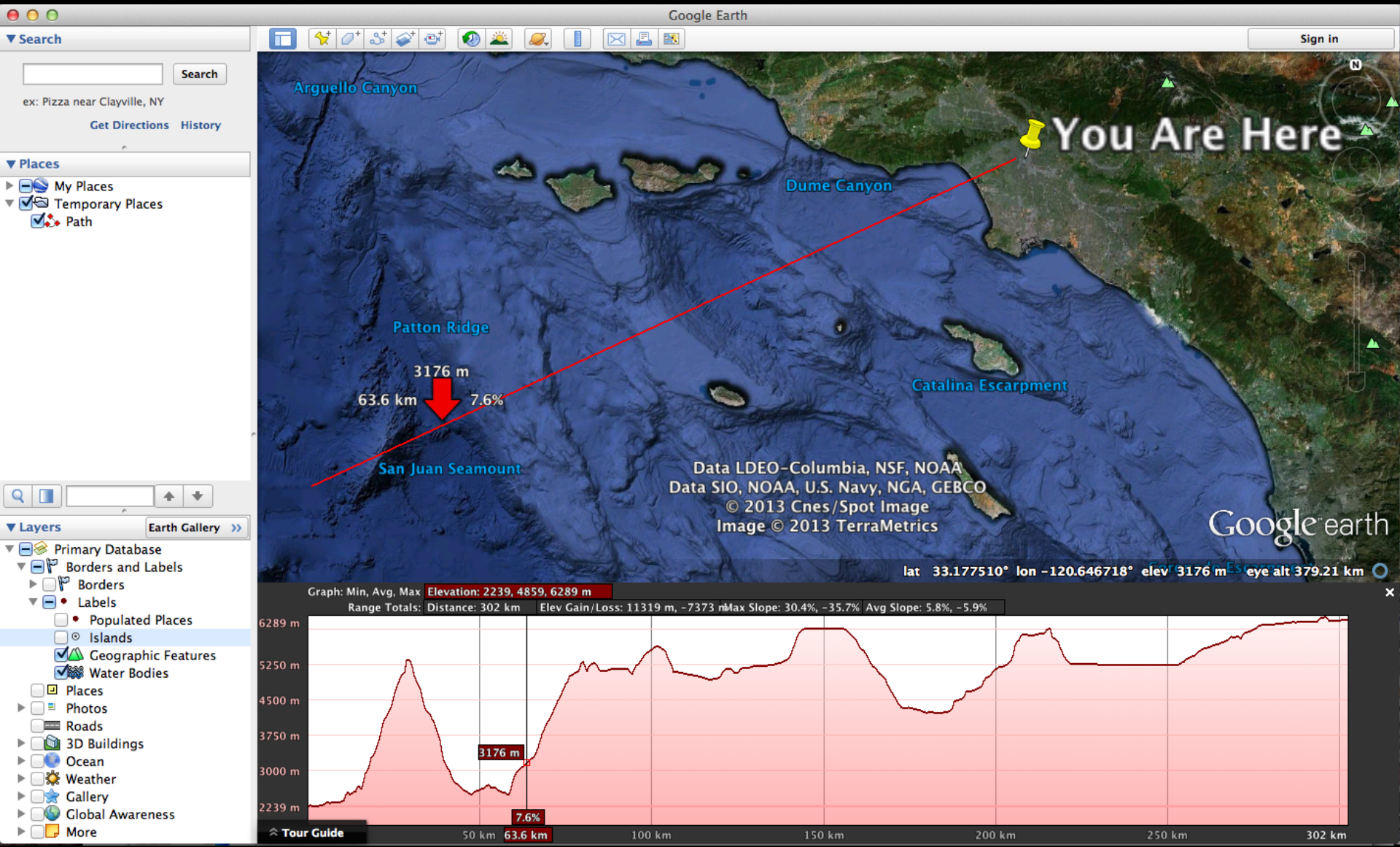
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Populated Places
Islands
Geographic Features
Water Bodies
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
More
Sign in
Arguello Canyon
You Are Here
Dume Canyon
Patton Ridge
3176 m
63.6 km
7.6%
Catalina Escarpment
San Juan Seamount
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Cnes/Spot Image
Image © 2013 TerraMetrics
Google earth
lat 33.177510° lon -120.646718° elev 3176 m eye alt 379.21 km
Graph: Min, Avg, Max Elevation: 2239, 4859, 6289 m
Range Totals: Distance: 302 km Elev Gain/Loss: 11319 m, -7373 m Max Slope: 30.4%, -35.7% Avg Slope: 5.8%, -5.9%
6289 m
5250 m
4500 m
3750 m
3000 m
2239 m
3176 m
7.6%
Tour Guide
50 km
63.6 km
100 km
150 km
200 km
250 km
302 km

NOAA Coast Survey The Nation's Nautical Chartmaker

NOAA Ship Thomas Jefferson mapping Long Island Sound seafloor: contributing to multi-level collaboration

Leave a comment

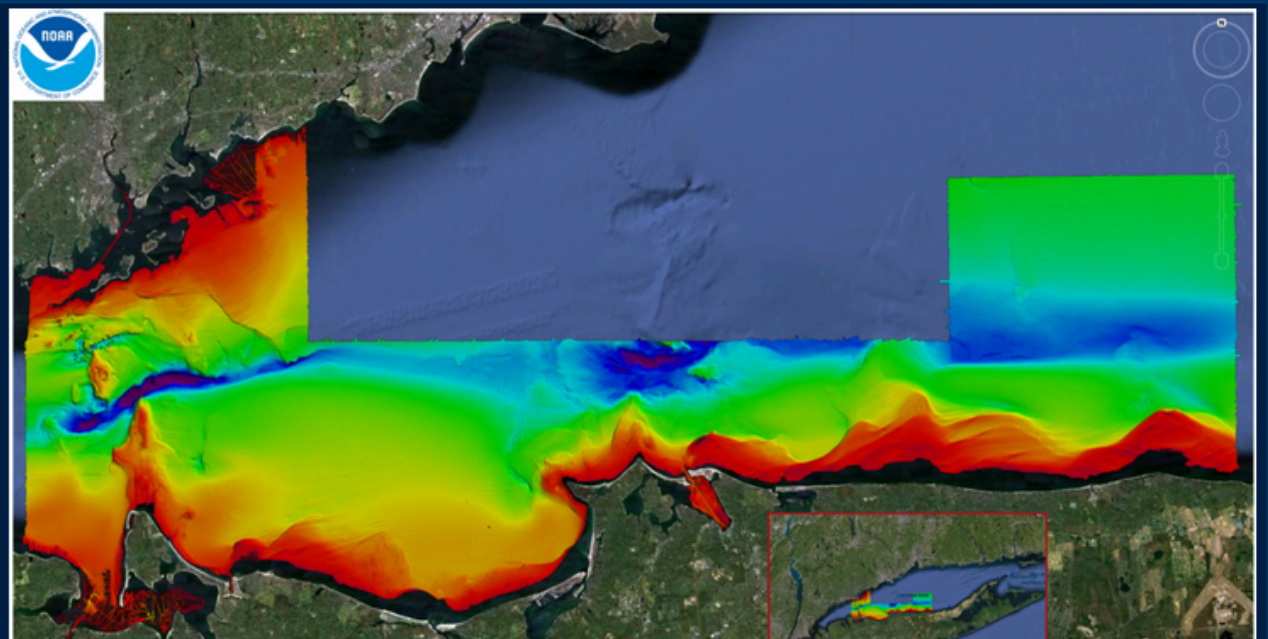
How many geospatial products can be developed by one seafloor mapping project? As a phased-in project for Long Island Sound shows, a strong collaboration among diverse groups of researchers and technology developers can integrate temporal and geospatial data sources to produce dozens of products. In addition to updating NOAA's nautical charts, ongoing collaborations in Long Island Sound will create products that depict physical, geological, ecological, geomorphological, and biological conditions and processes – all to balance the development of new ocean uses while protecting and restoring essential habitats.

In 2011, the Long Island Sound Program (representing a partnership between the State of Connecticut, State of New York, Connecticut and New York Sea Grant, and the U.S. Environmental Protection Agency) requested assistance from NOAA. They asked for help in providing management and technical expertise; acquiring data; and developing products. They required key temporal and spatial information about seafloor conditions in the Sound. They needed bathymetry and backscatter, and biological and physical observational and sampling data, to produce all the products needed by governments, industry, academia, and the public.

Coast Survey already had plans for NOAA Ship *Thomas Jefferson* to survey in Long Island Sound, to acquire new bathymetry for chart updates. With some adjustments to survey areas and project parameters, a mutually beneficial partnership was formed for long-term seafloor mapping of Long Island Sound habitats over the next several years, as an integrated ocean and coastal mapping project.

This summer, *Thomas Jefferson* conducted hydrographic surveys in the mid-Sound area of Stratford Shoal and vicinity, extending from New York on the north shore of Long Island to the Connecticut shoreline.

"Ocean floors are amazingly dynamic, and we have to chart those changes to provide precise and accurate navigational data for today's maritime economy," explained Cmdr. Lawrence Krepp, commanding officer of the *Thomas Jefferson* and the ship's chief scientist. "Our data is used to update NOAA's nautical charts, but the hydrographic information can also be used to support a number of non-navigation uses, ranging from benefits to fisheries management to support of regional ocean planning efforts like this."



Keeping mariners safe and commerce flowing

The men and women of Coast Survey continue a long tradition of navigational, cartographic, and hydrographic excellence. Because of their expertise, mariners have trusted Coast Survey's nautical products and services for over two centuries.

Search

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NOAA ENC posting Oct 11: US4MA13M go.usa.gov/KOT 3 hours ago

NOAA ENC posting for Oct 10: US2GC15M US2HA05M US3EC08M US4GA17M US4NY24M US4TX58M US5IN11M US5MD14M go.usa.gov/KOT 1 day ago

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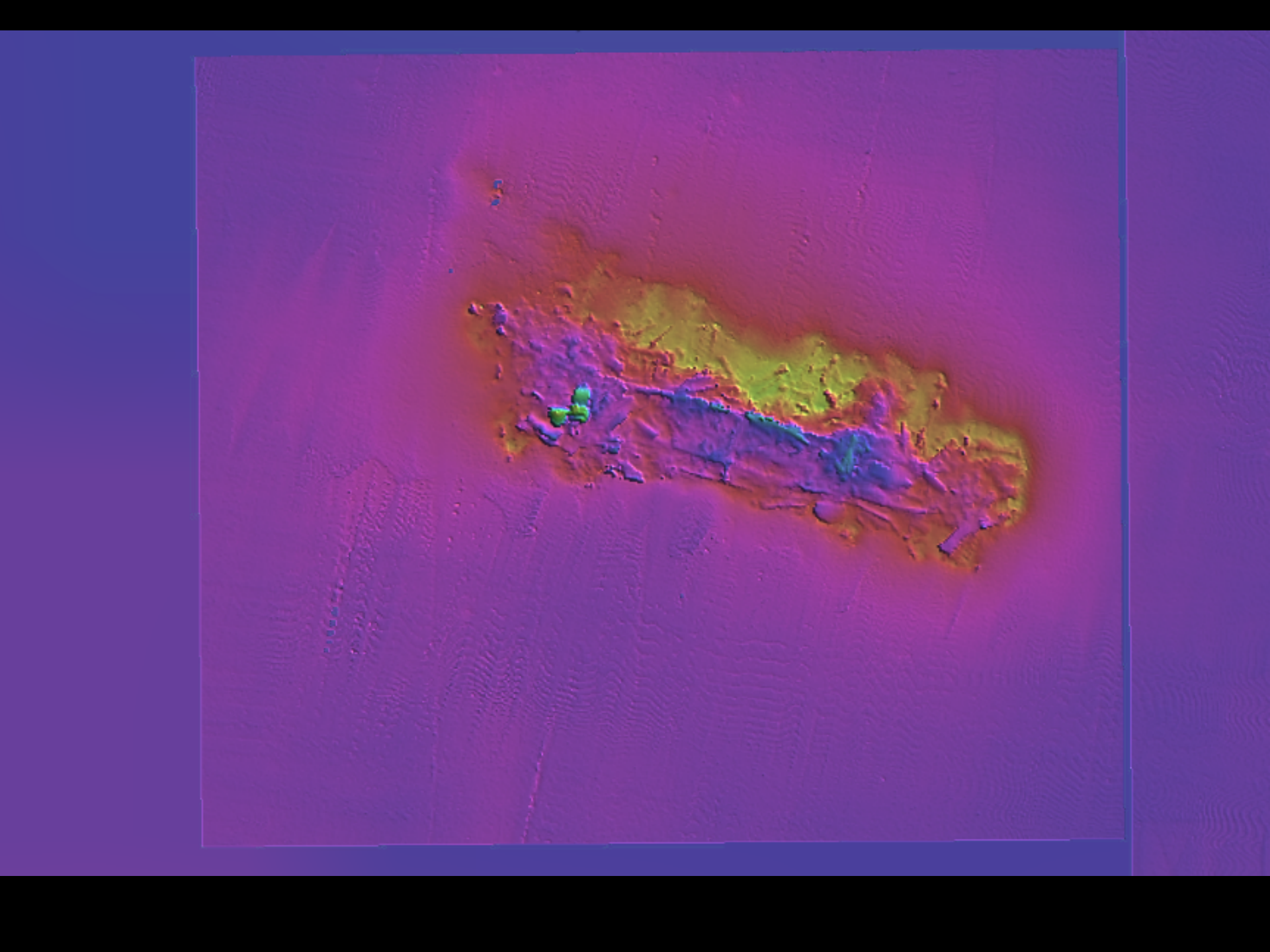
NOAA Ship Tracker

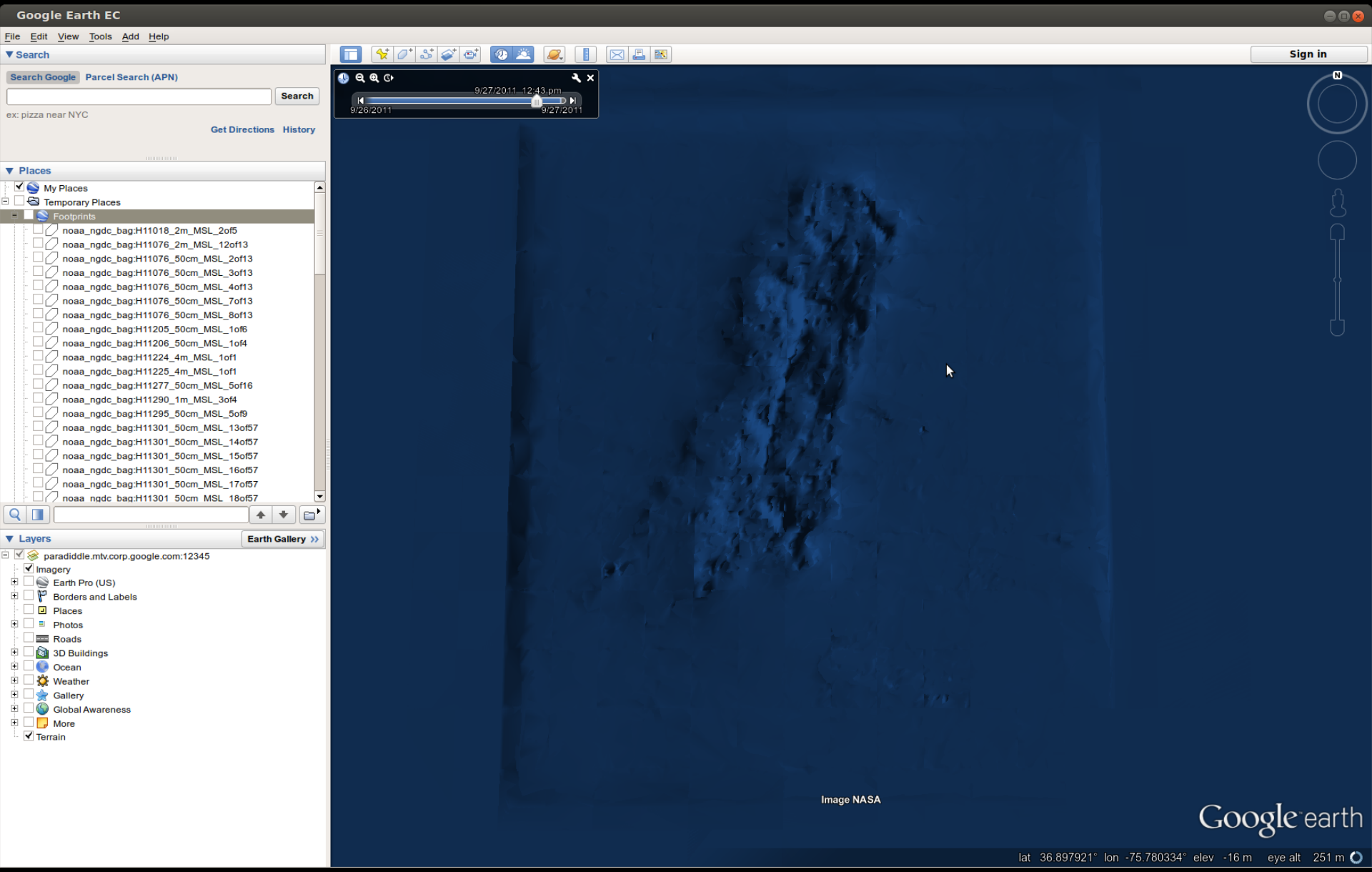
Coast Survey in the news

- Surveying the Florida Reef
- Coast Survey's Alaskan cartography influenced by Native mapmakers
- New edition of seminal Coast Pilot
- An Odd Geodetic Survey Crew

NOAA blogroll

- Marine Debris Blog
- NOAA Hurricane Research Division Blog
- NOAA's Response and Restoration Blog
- NOAA Ocean Science Blog

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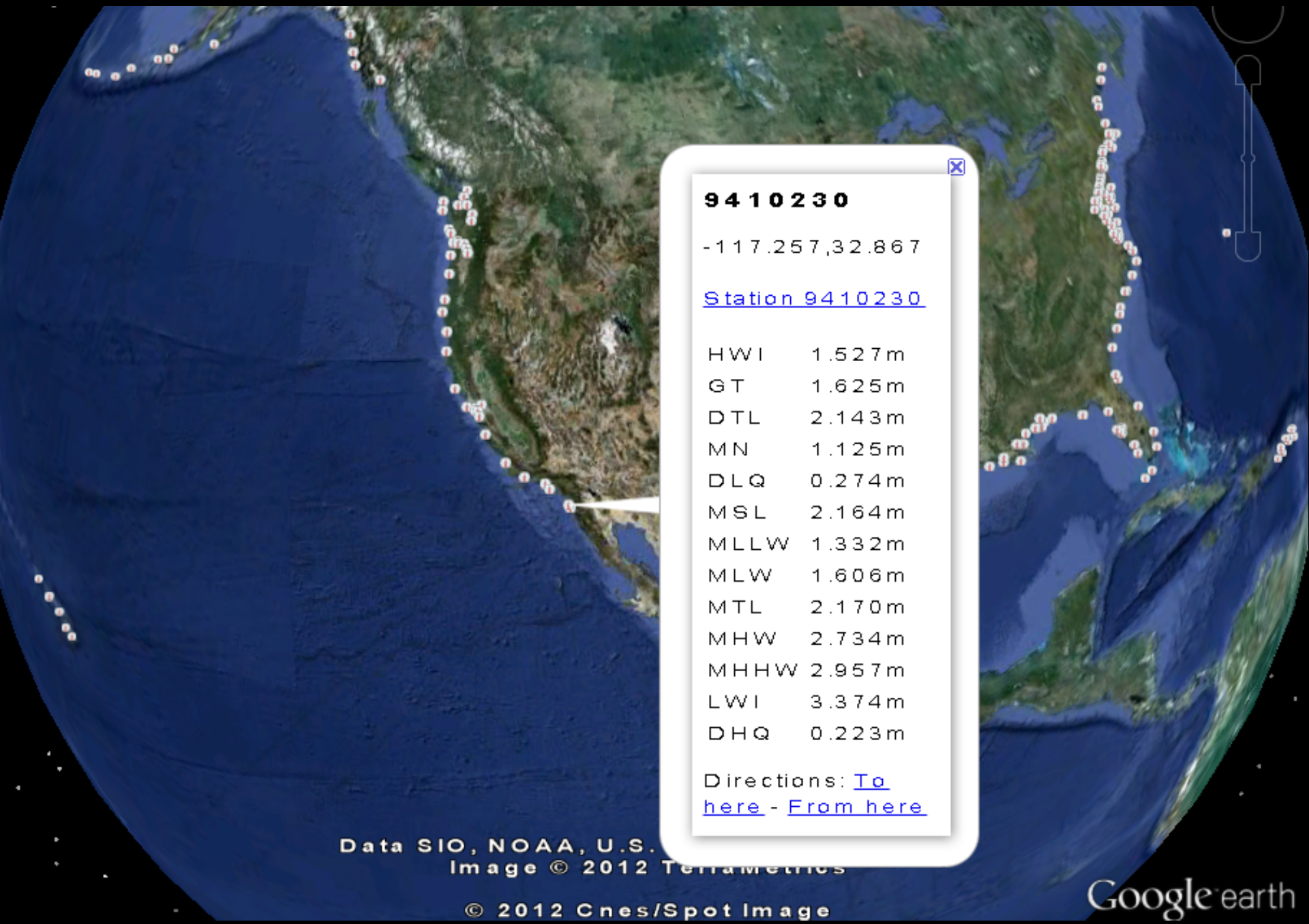
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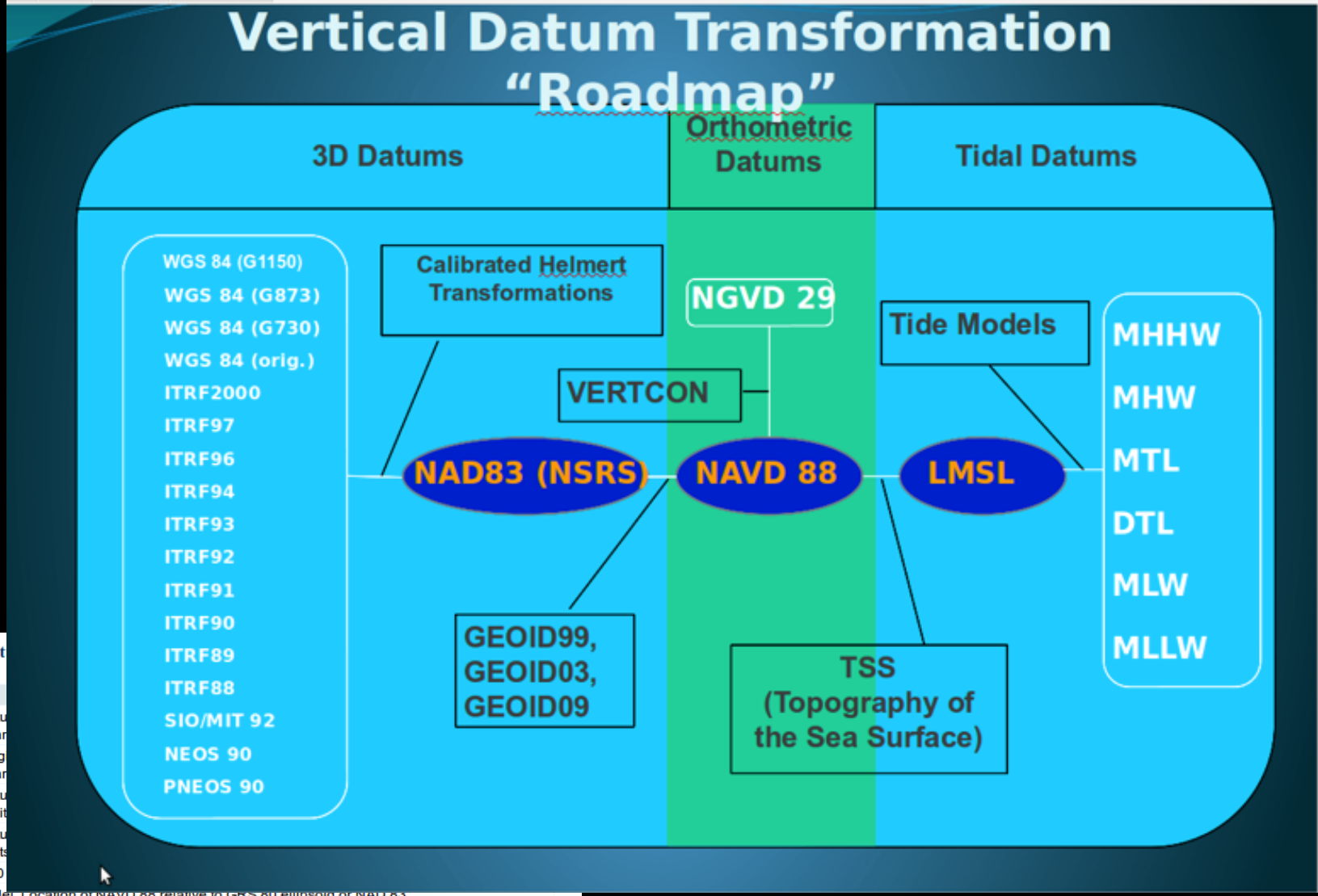
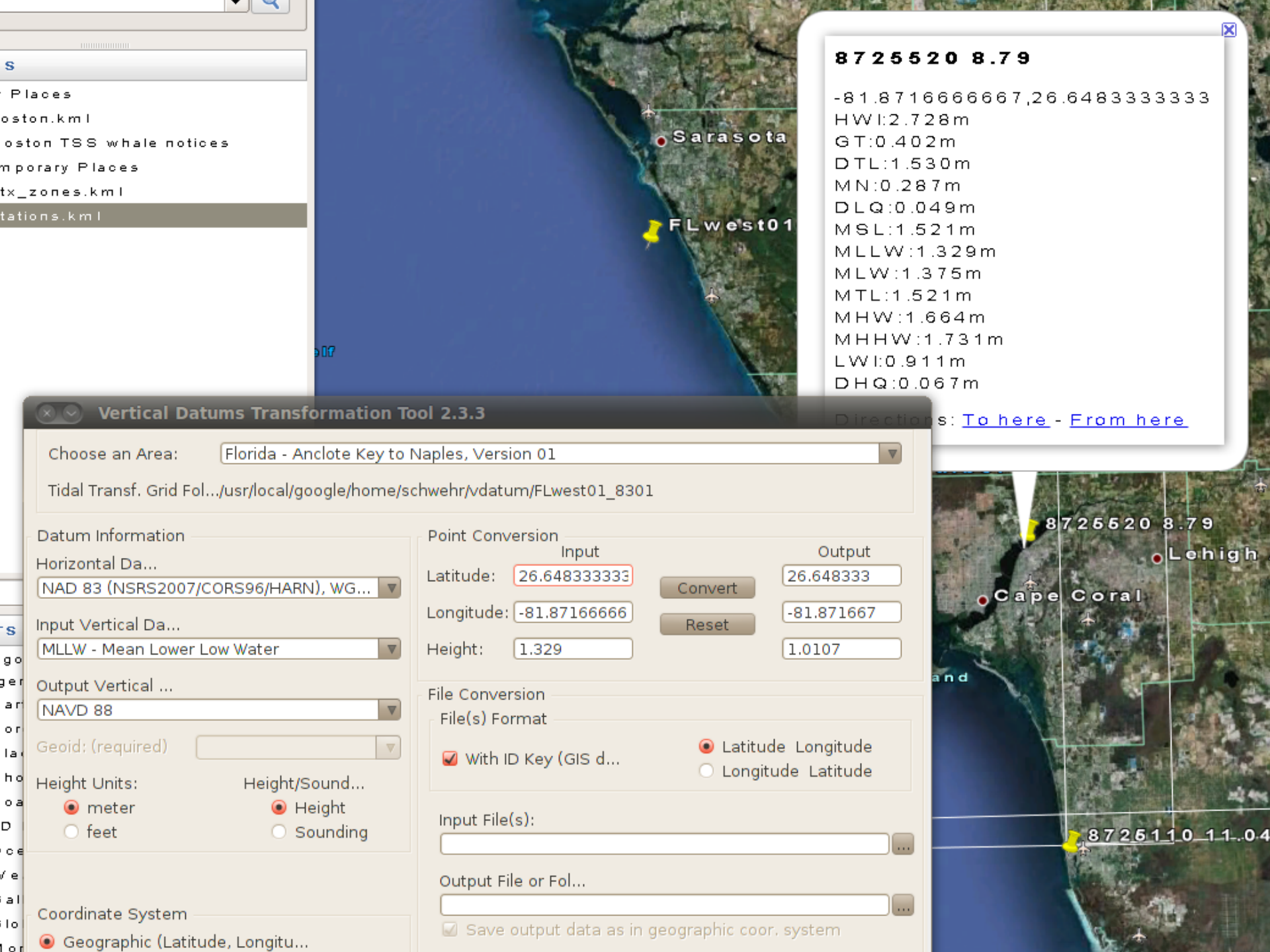
GT 1.625m
DTL 2.143m
MN 1.125m
DLQ 0.274m
MSL 2.164m
MLLW 1.332m
MLW 1.606m
MTL 2.170m
MHW 2.734m
MHHW 2.957m
LWI 3.374m
DHQ 0.223m
Directions: To here - From here
Data SIO, NOAA, U.S.
Image © 2012 TerraMetrics
© 2012 Cnes/Spot Image
Google earth

Vertical Datum Transformation "Roadmap"



Description of Dat

File name	
NCLA	NADCON latitu shift, units of ar
NCLO	NADCON long shift, units of ar
HPGNLA	NADCON latitu North shift, unit
HPGNLO	NADCON latitu West shift, units
VCN	VERTCON 2.0
Gxx	GEOIDxx model. Location of NAVD 88 relative to GRS 80 ellipsoid of NAD 83 (NSRS2007/CORS96). Values are also known as geoid heights. Values are negative throughout the conterminous U.S.
TSS	Inverse topography of sea surface. Location of NAVD 88 relative to LMSL. In the near future, this file will be named as TSSxx where xx is from the corresponded Gxx.
MHHW	Tidal model. Location of MHHW relative to LMSL. Values are always positive.
MHW	Tidal model. Location of MHW relative to LMSL. Values are always positive. MHW is closer to LMSL than MHHW.
MTL	Tidal model. Location of MTL relative to LMSL. This surface is "near" LMSL.
DTL	Tidal model. Location of DTL relative to LMSL. This surface is "near" LMSL.
MLW	Tidal model. Location of MLW relative to LMSL. Values are always negative. MLW is closer to LMSL than MLLW.
MLLW	Tidal model. Location of MLLW relative to LMSL. Values are always negative.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GT:0.402m
DTL:1.530m
MN:0.287m
DLQ:0.049m
MSL:1.521m
MLLW:1.329m
MLW:1.375m
MTL:1.521m
MHW:1.664m
MHHW:1.731m
LWI:0.911m
DHQ:0.067m
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Vertical Datums Transformation Tool 2.3.3
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MLLW - Mean Lower Low Water
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NAVD 88
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Cape Coral
8726110 11.04

CALIFORNIA

NOAA Chart: 18765 **Latitude: 32° 52.0' N**
USGS Quad: LA JOLLA **Longitude: 117° 15.5' W**

T I D A L D A T U M S

Tidal datums at LA JOLLA, PACIFIC OCEAN based on:

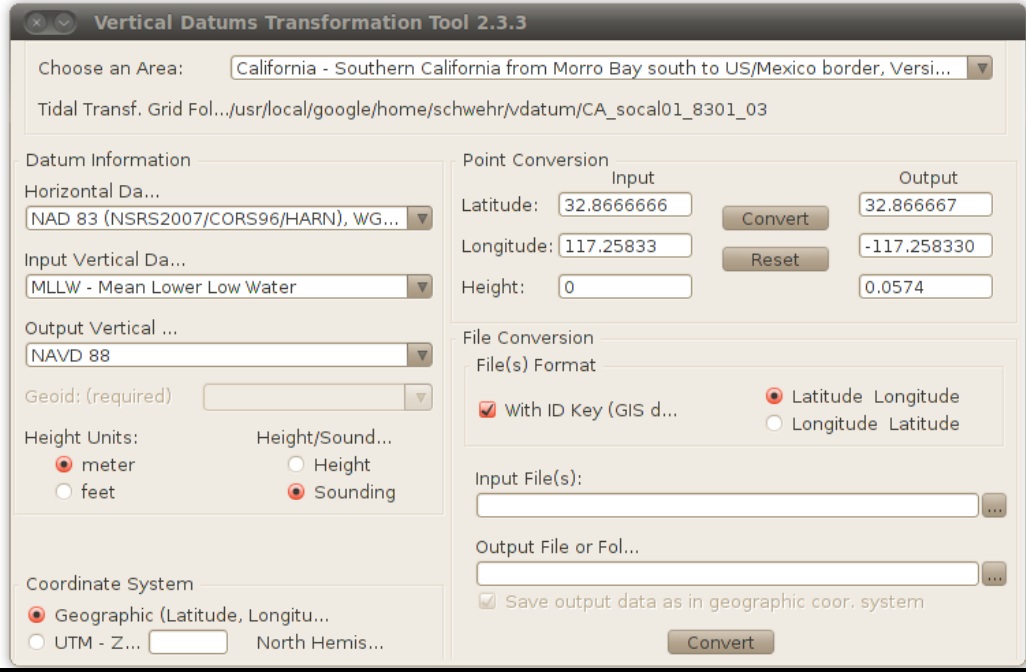
LENGTH OF SERIES: 19 YEARS
TIME PERIOD: January 1983 - December 2001
TIDAL EPOCH: 1983-2001
CONTROL TIDE STATION:

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in METERS:

HIGHEST OBSERVED WATER LEVEL (01/11/2005)		=	2.335
MEAN HIGHER HIGH WATER	MHHW	=	1.624
MEAN HIGH WATER	MHW	=	1.402
MEAN TIDE LEVEL	MTL	=	0.839
MEAN SEA LEVEL	MSL	=	0.833
MEAN LOW WATER	MLW	=	0.276
North American Vertical Datum	NAVD88	=	0.058
MEAN LOWER LOW WATER	MLLW	=	0.000
LOWEST OBSERVED WATER LEVEL (12/17/1933)		=	-0.874

North American Vertical Datum (NAVD88)

Bench Mark Elevation Information In METERS above:



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File Edit View Layer Settings Plugins Vector Raster Help

Layers

- F00574_MB_2m_MLLW_2of3
- mllw-2960-crop
- mllw-2960

Value Tool

Active (Shift+A) Graph

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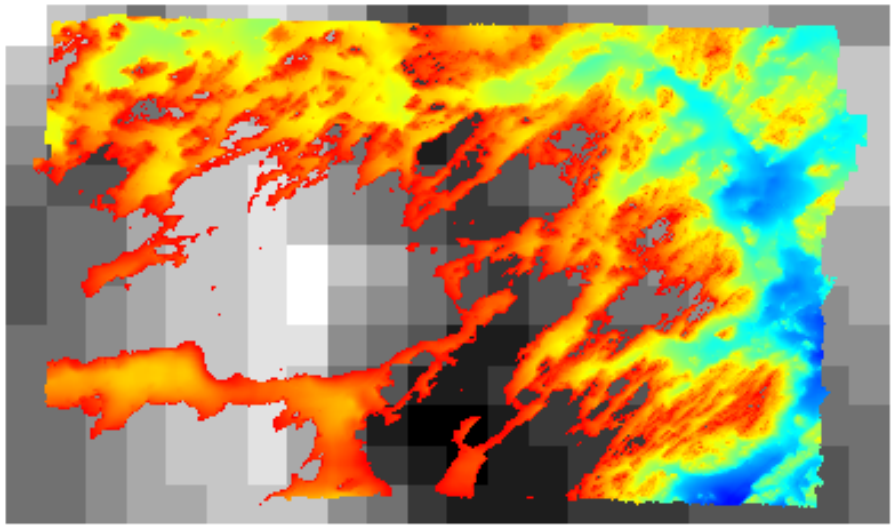
3	mllw-2960-crop	-1.4427



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Layers

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- mllw-2960-crop-resample
- mllw-2960-crop
- mllw-2960

Value Tool

Active (Shift+A) Graph

	Layer	Value
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3	mllw-2960-crop-resample	-1.44251

Profile

Profile Statistics Setup About

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-1.4429
-1.443
-1.4431

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mllw-2960-crop-resample

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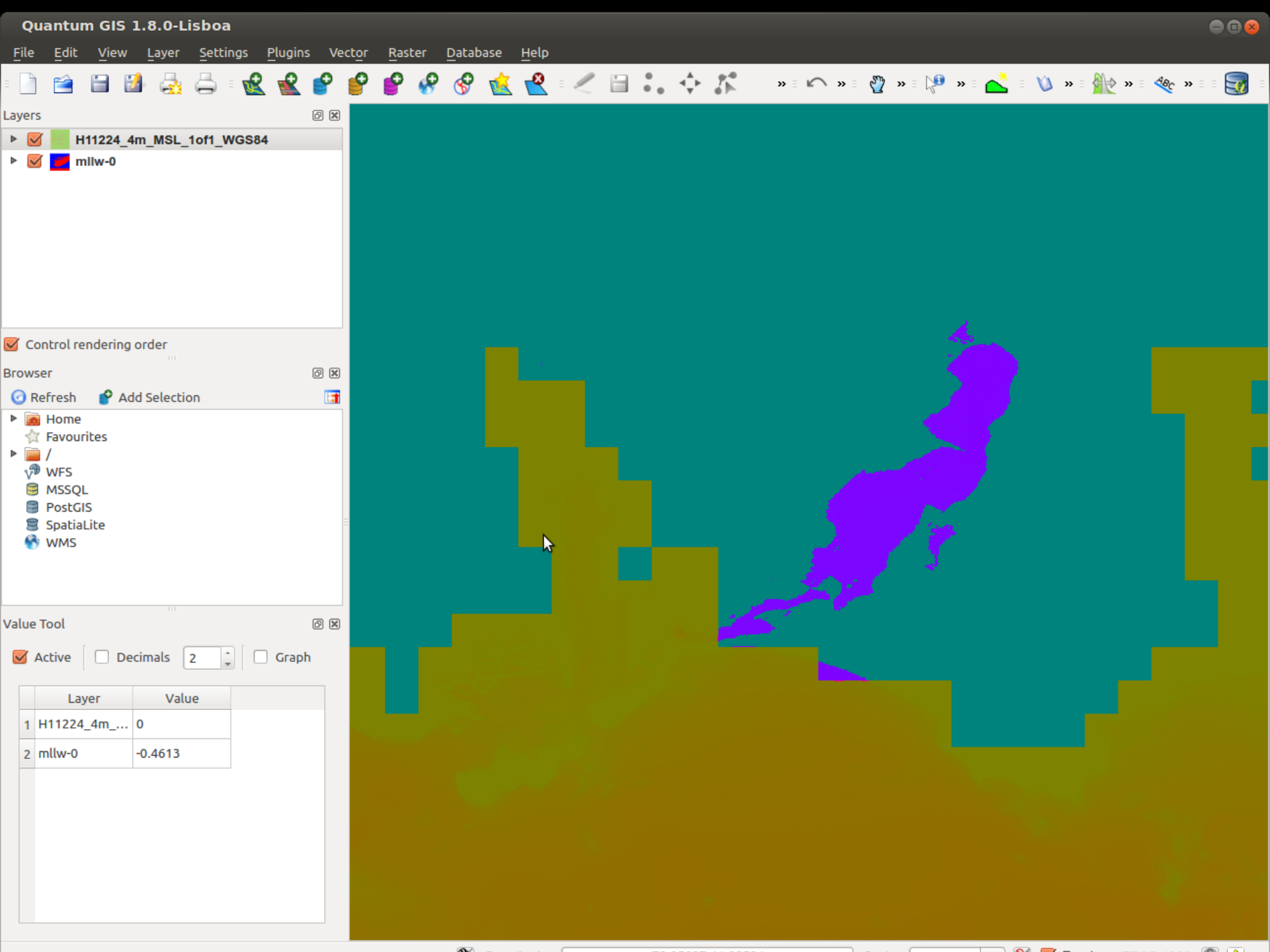
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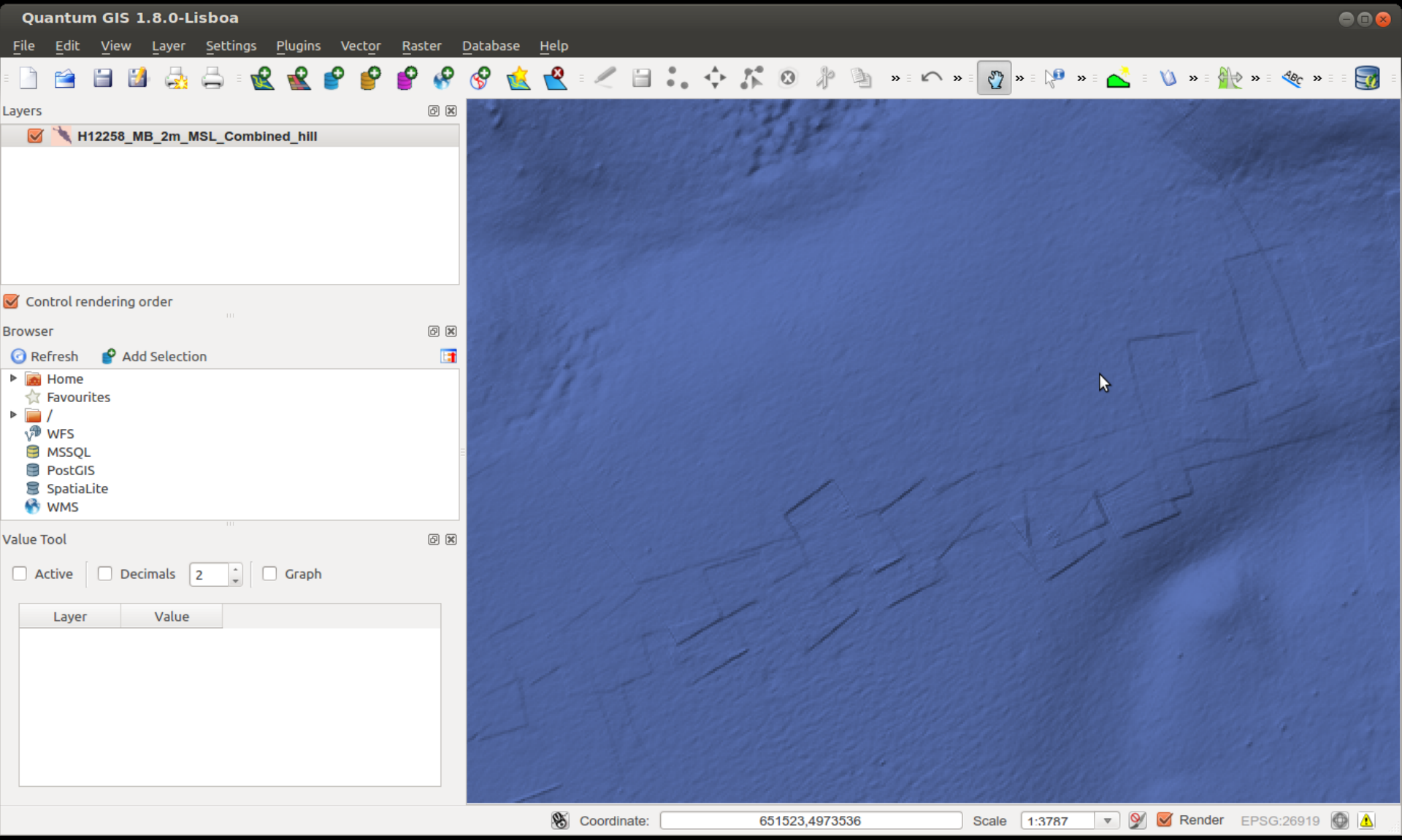
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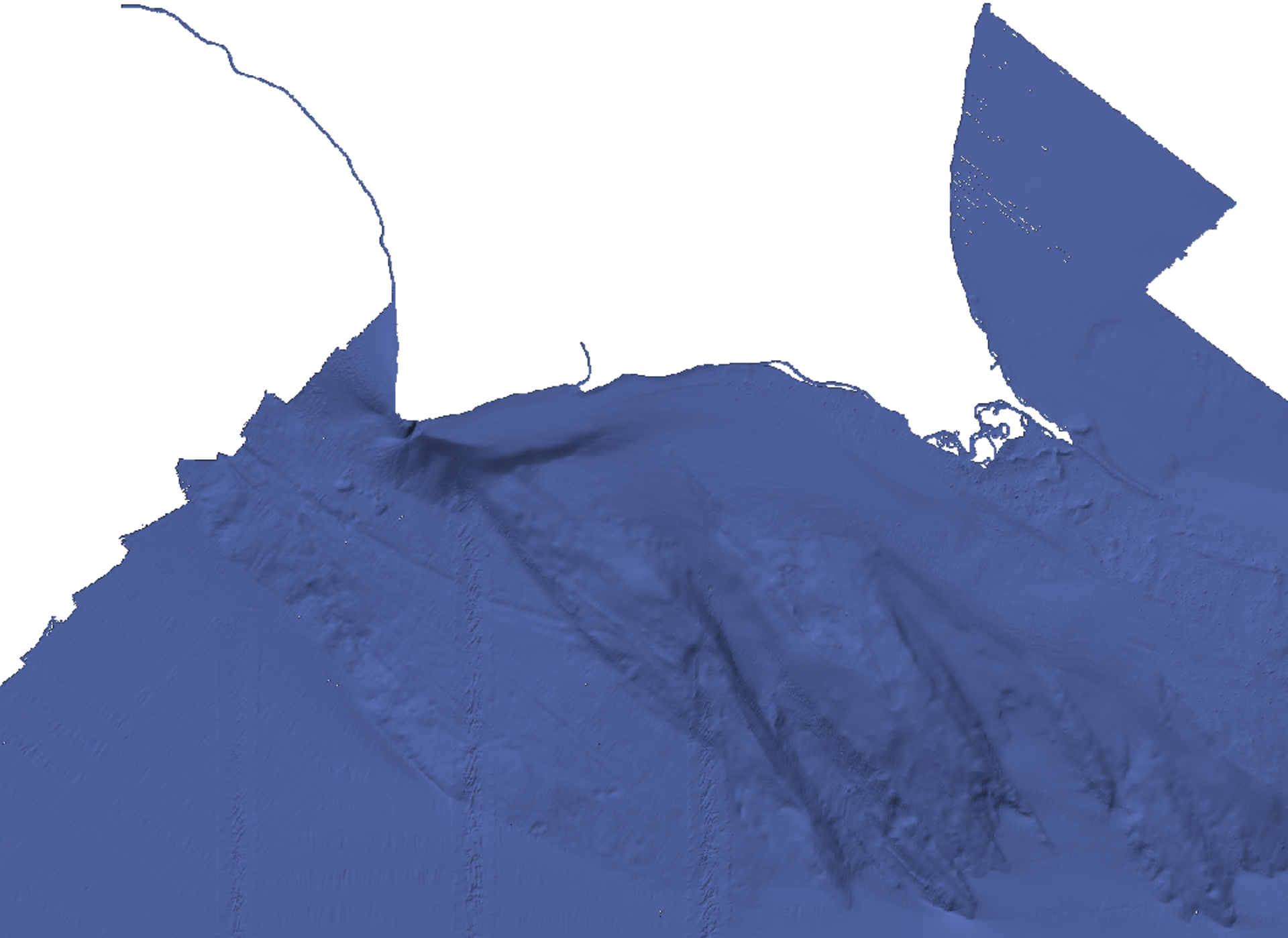

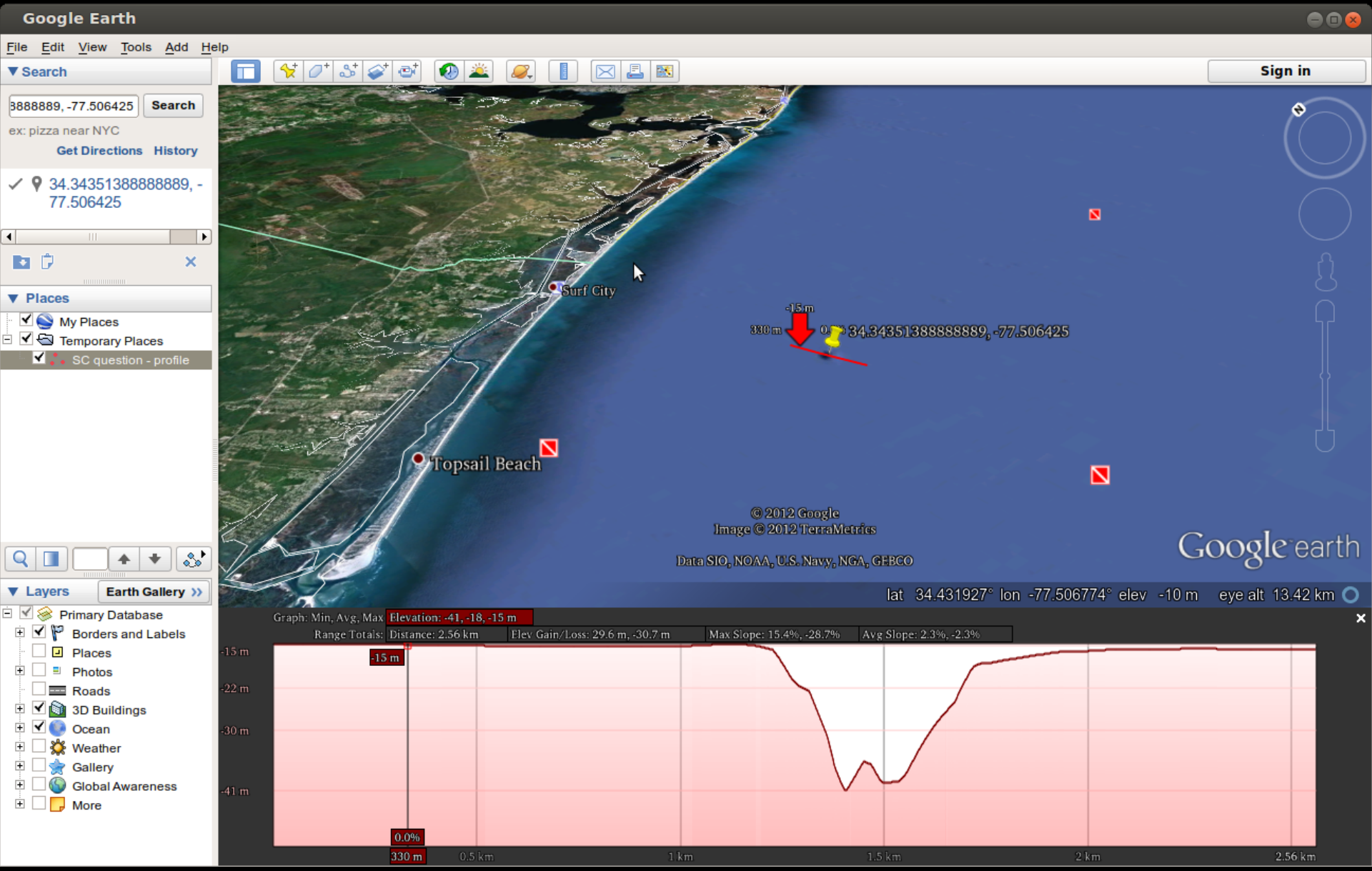
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Borders and Labels
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Photos
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3D Buildings
Ocean
Weather
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Image © 2012 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
lat 34.431927° lon -77.506774° elev -10 m eye alt 13.42 km
Graph: Min, Avg, Max Elevation: -41, -18, -15 m
Range Totals: Distance: 2.56 km Elev Gain/Loss: 29.6 m, -30.7 m Max Slope: 15.4%, -28.7% Avg Slope: 2.3%, -2.3%
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-30 m
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20121115-BagClassification - Google Chrome

IPython Dashboard | 20121115-BagClassificati

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IP[y]: Notebook 20121115-BagClassification Last saved: Nov 15 1:54 PM

File Edit View Insert Cell Kernel Help

Code

In [4]:
```
filenames = !ls -S *.tif | tail | head -1
filename = filenames[0]
filename
```

Out[4]: 'H11207_50cm_MLLW_9of12.tif'

In [5]:
```
import gdal
```

In [6]:
```
tif = gdal.Open(filename)
```

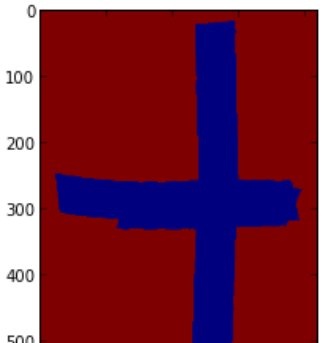
In [7]:
```
grid = tif.GetRasterBand(1).ReadAsArray()
```

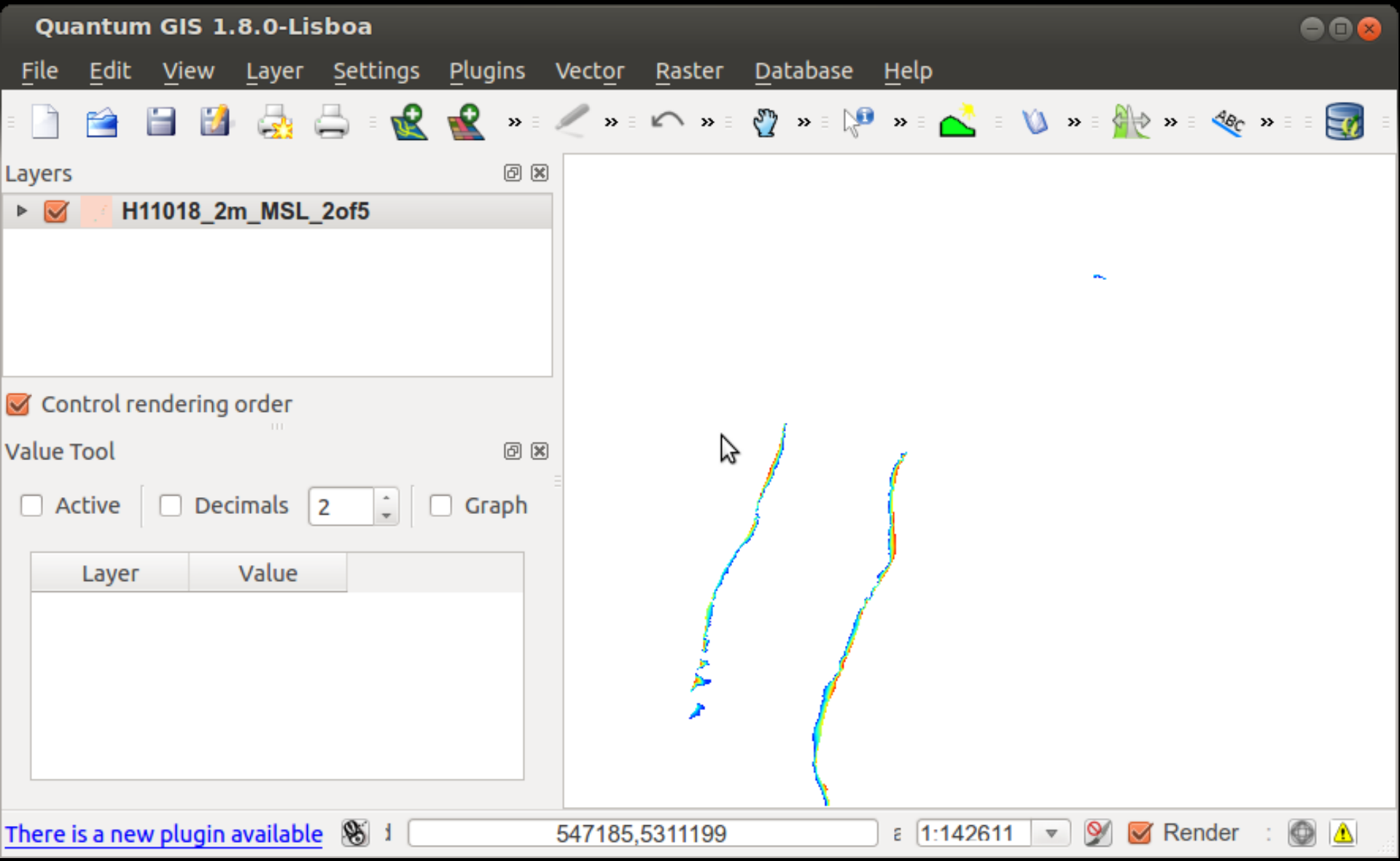
In [8]:
```
whos
```

```
Variable    Type       Data/Info
--------------------------------
filename    str        H11207_50cm_MLLW_9of12.tif
filenames   SList      ['H11207_50cm_MLLW_9of12.tif']
gdal        module     <module 'gdal' from '/usr<...>nux-x86_64.egg/gdal.pyc'>
tif         Dataset    <osgeo.gdal.Dataset; prox<...>Shadow *' at 0x452d6c0> >
```

In [9]:
```
imshow(grid)
```

Out[9]: <matplotlib.image.AxesImage at 0x46553d0>

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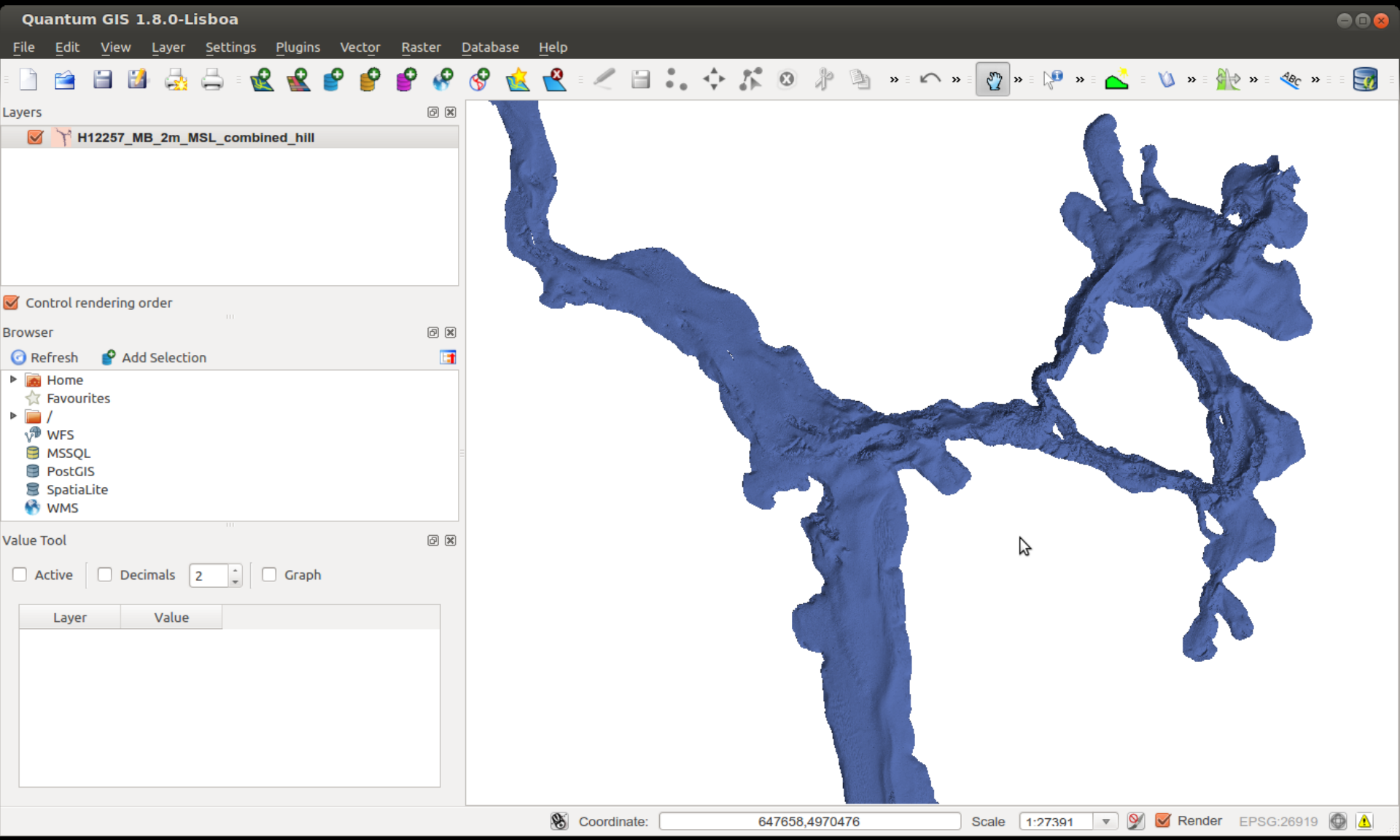
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PostGIS
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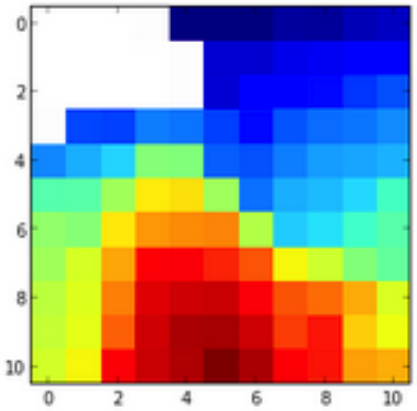
Coordinate:
647658,4970476
Scale
1:27391
Render
EPSG:26919

In [13]:
```
f1 = FillWithAveNeighbors(data_nd, labels, 2)
```

In [15]:
```
np.set_printoptions(linewidth=180)
```

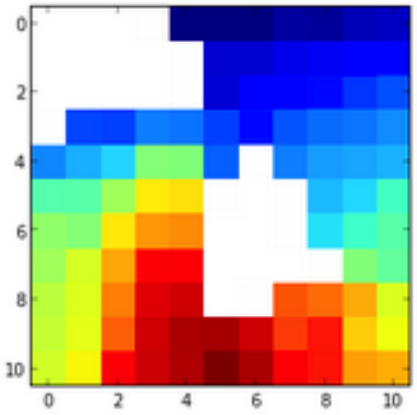
In [18]:
```
imshow(f1, interpolation='none')
```

Out[18]:
```
(<matplotlib.image.AxesImage at 0x3ec6350>,
 <matplotlib.image.AxesImage at 0x3ec6610>)
```



In [19]:
```
imshow(data_nd, interpolation='none')
```

Out[19]:
```
<matplotlib.image.AxesImage at 0x41b9f10>
```



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File Edit View Layer Settings Plugins Vector Raster Database Help

Layers

H12335_MB_2m_MSL_Combined

Control rendering order

Browser

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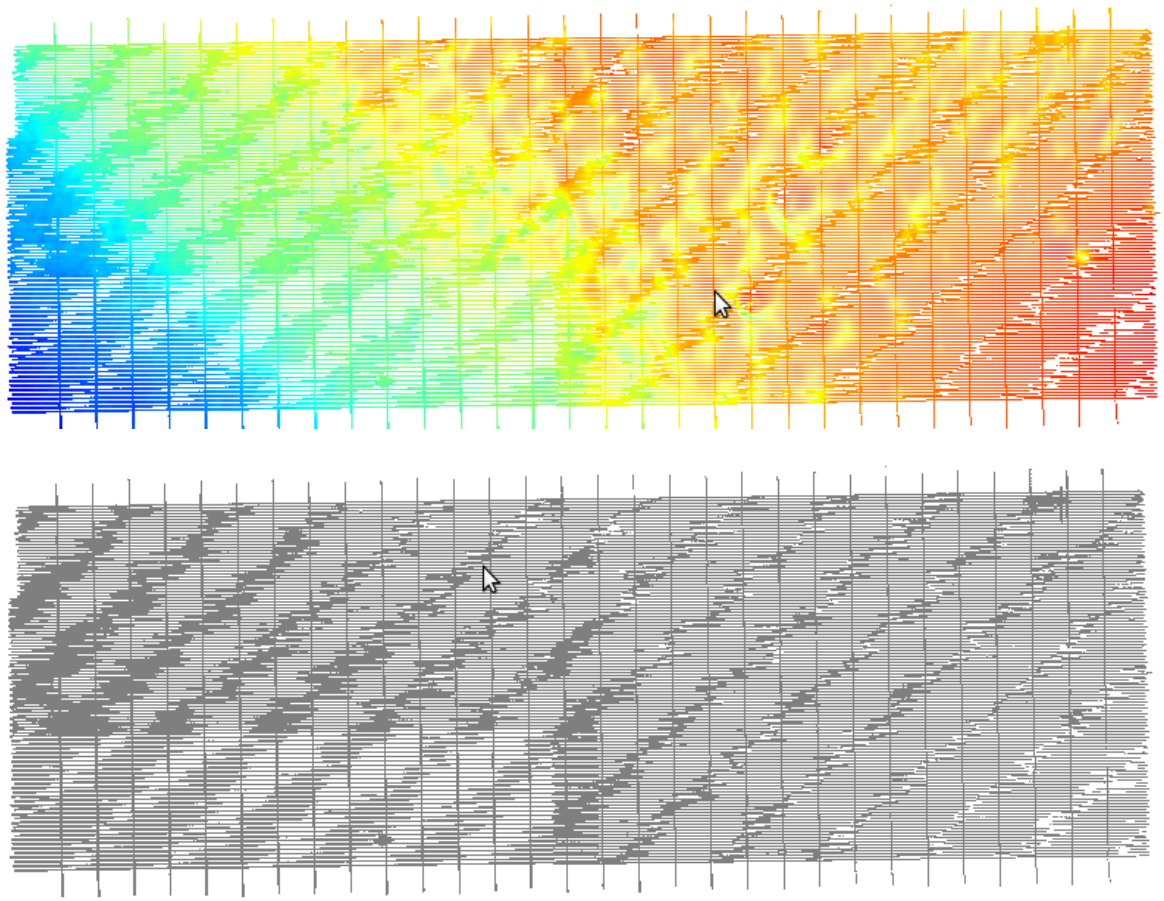
/
WFS
MSSQL
PostGIS
SpatiaLite
WMS

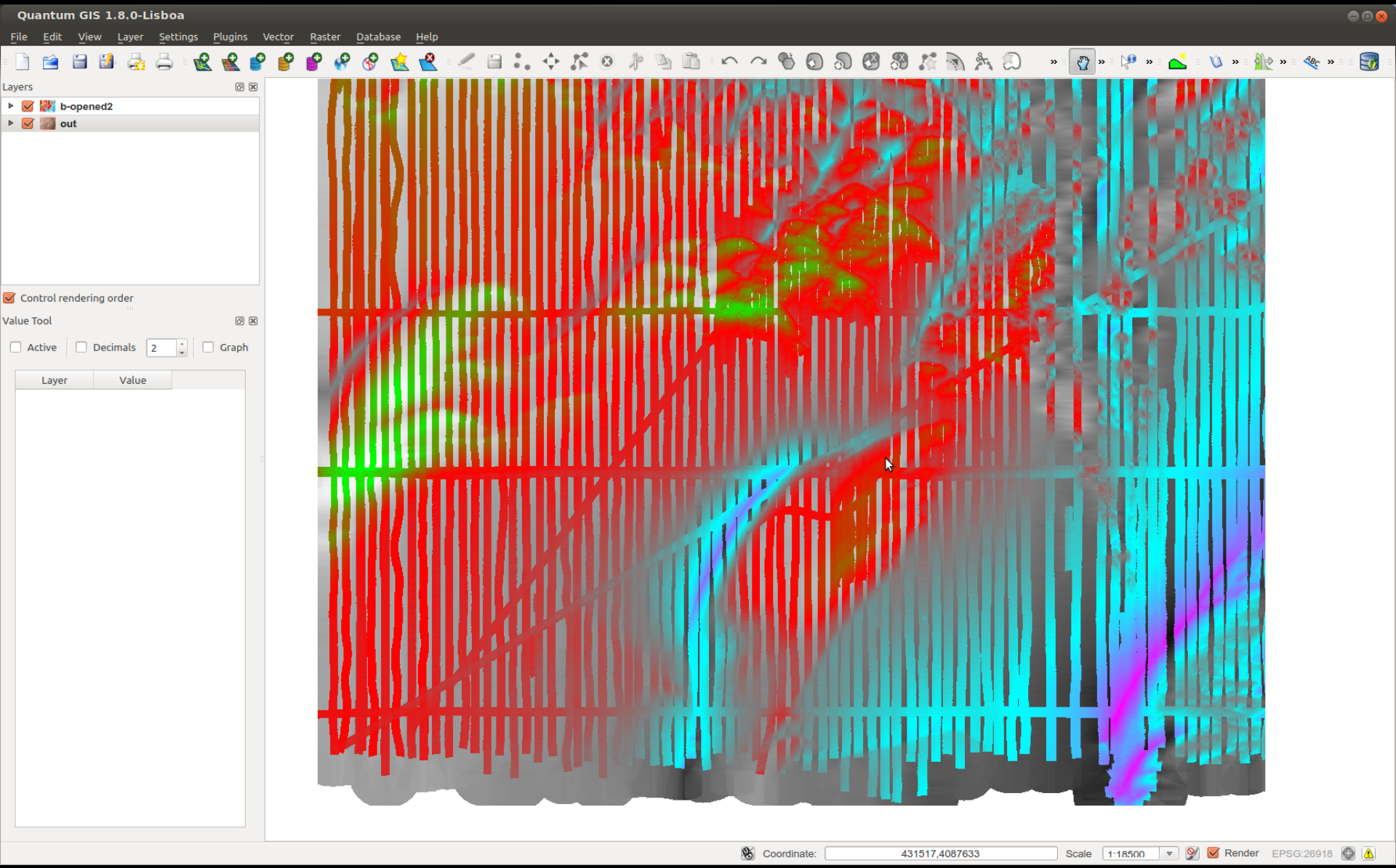
Value Tool

Active Decimals 2 Graph

Layer	Value



662624.45,3187768.91 : 679615.55,3205147.09 Coordinate: 672935,3195506 Scale 1:77000 Render EPSG:26915


Quantum GIS 1.8.0-Lisboa
File Edit View Layer Settings Plugins Vector Raster Database Help
Layers
b-opened2
out
Control rendering order
Value Tool
Active Decimals 2 Graph
Layer Value
Coordinate: 431517,4087633 Scale 1:18500 Render EPSG:26918

Quantum GIS 1.8.0-Lisboa

File Edit View Layer Settings Plugins Vector Raster Database Help

Layers

H12337_MB_4m_MSL_Combined-NJVA_mab

Control rendering order

Browser

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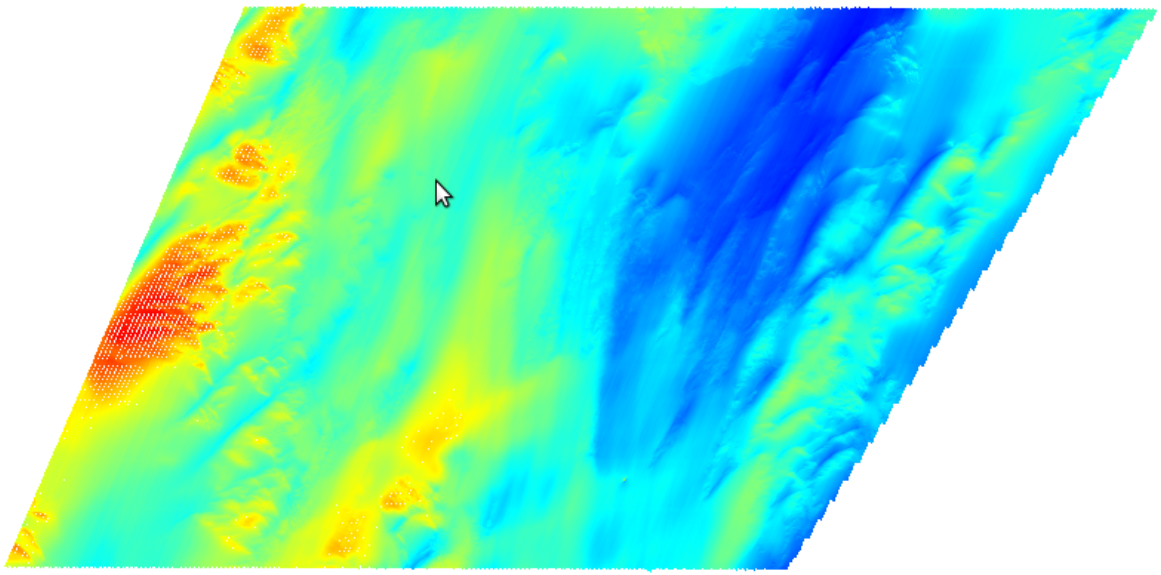
Home
Favourites
/
WFS
MSSQL
PostGIS
SpatiaLite
WMS

Value Tool

Active Decimals 2 Graph

Layer	Value



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File Edit View Layer Settings Plugins Vector Raster Database Help

Layers

out

H12336_MB_4m_MSL_Combined

-25.7427

-21.0082

-16.2736

Control rendering order

Browser

Refresh Add Selection

Home

Favourites

/

WFS

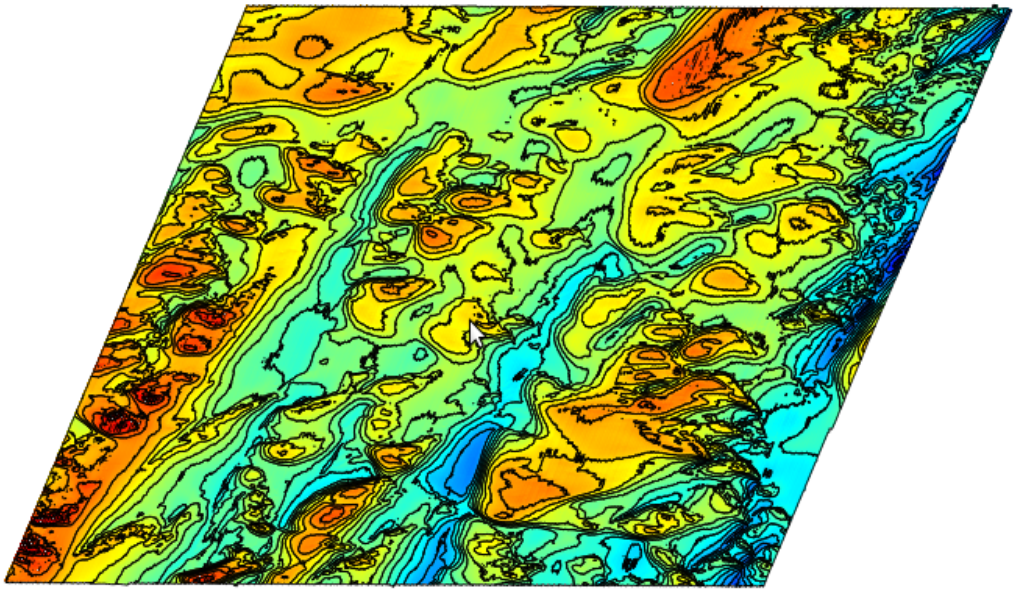
MSSQL

PostGIS

Value Tool

Active Decimals 2 Graph

Layer Value



There is a plugin update available Coordinate: 464169,4163652 Scale 1:90037 Render EPSG:26918

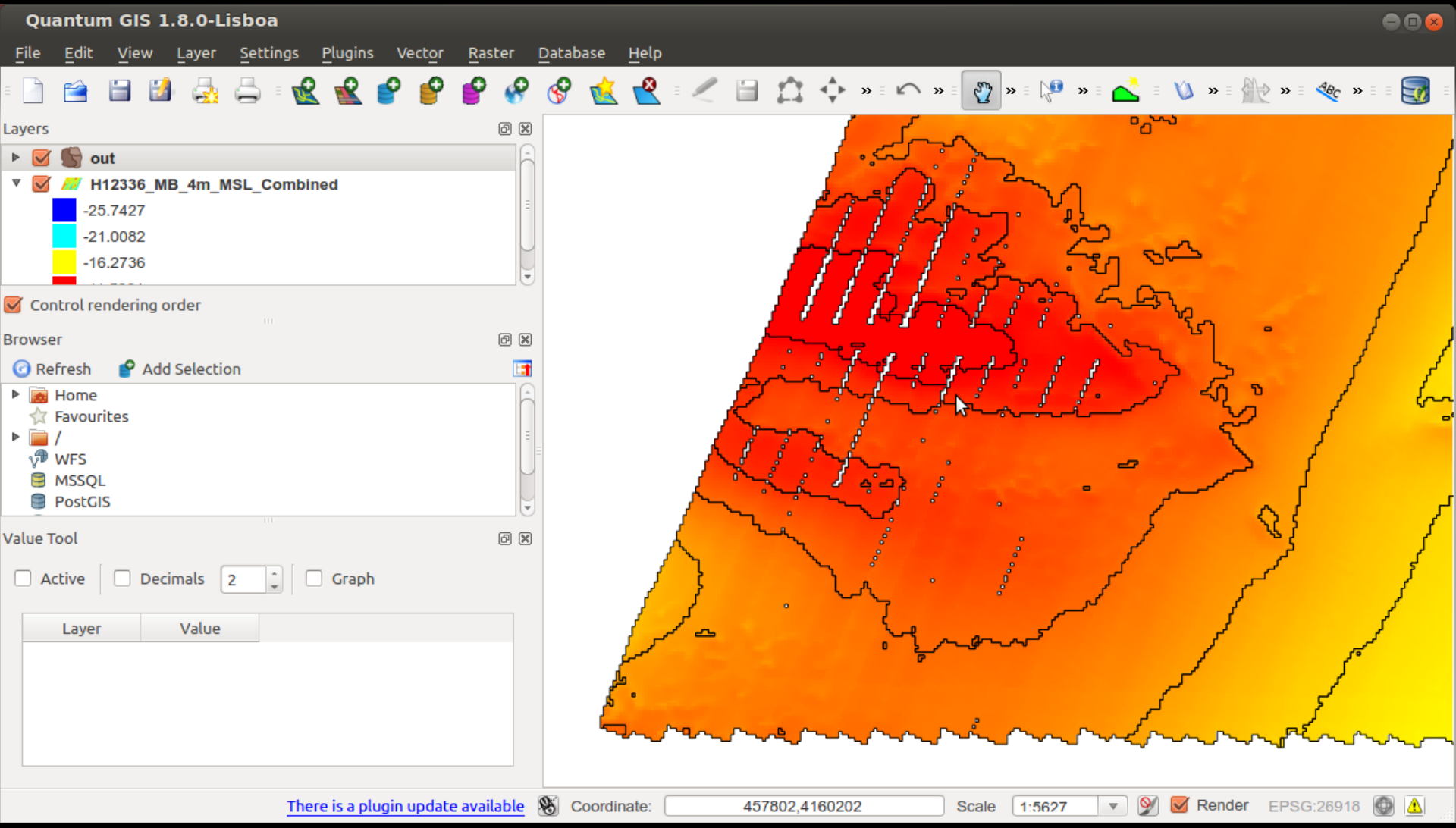
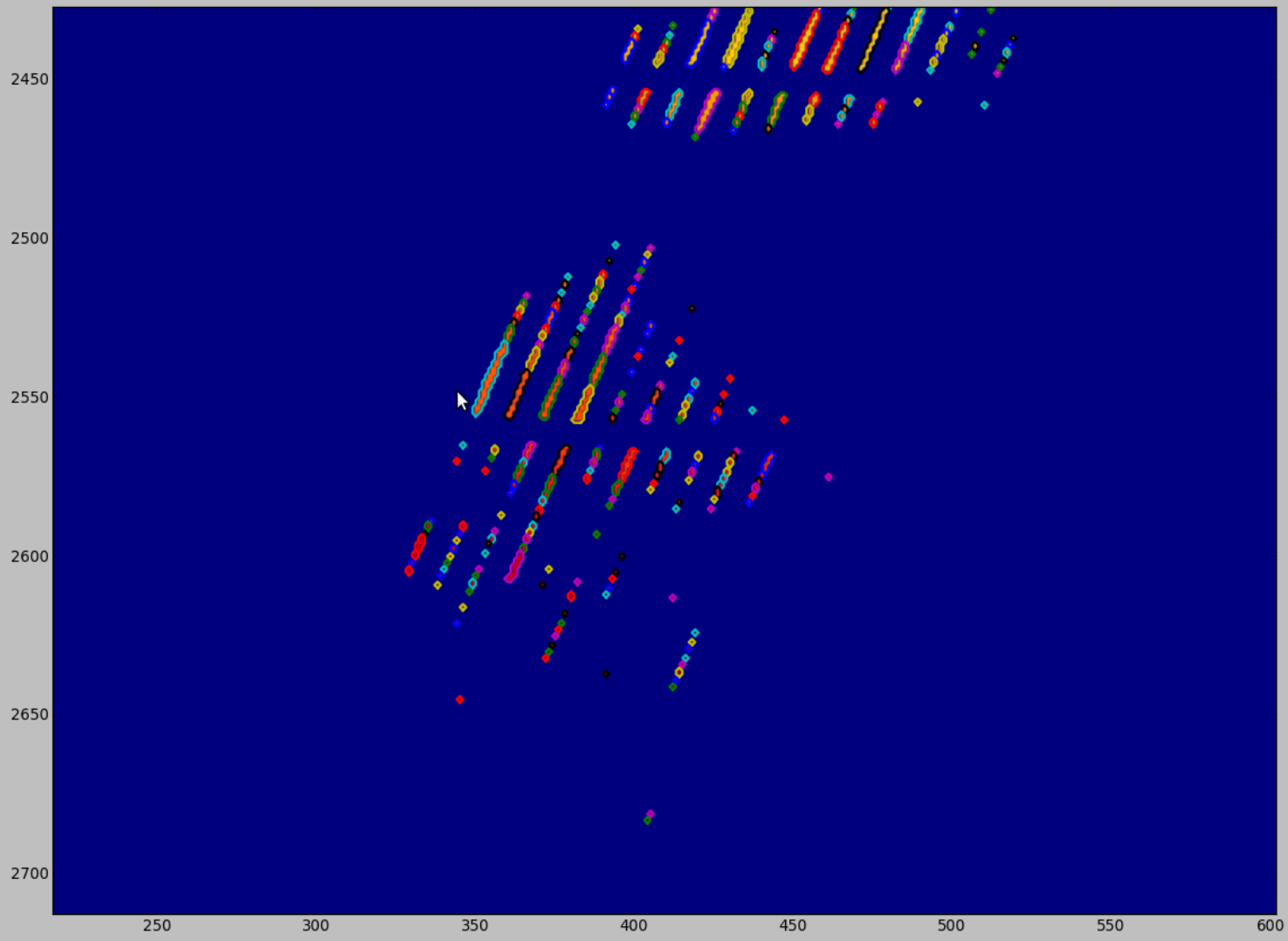

Quantum GIS 1.8.0-Lisboa
File Edit View Layer Settings Plugins Vector Raster Database Help
Layers
out
H12336_MB_4m_MSL_Combined
-25.7427
-21.0082
-16.2736
Control rendering order
Browser
Refresh
Add Selection
Home
Favourites
/
WFS
MSSQL
PostGIS
Value Tool
Active
Decimals
2
Graph
Layer
Value
There is a plugin update available
Coordinate:
457802,4160202
Scale
1:5627
Render
EPSG:26918

Figure 1



pan/zoom, x=344.308 y=2548.13

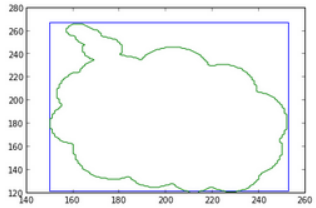
IPython Notebook - Google Chrome

opencv-contour | learning-countours | IPython Notebook

127.0.0.1:8888/2d387df8-6e23-4e1a-a030-a840f966608f/print

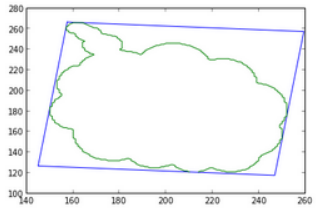
In [73]:
```
r_x, r_y, r_w, r_h = cv2.boundingRect(cnt)
r_x, r_y, r_w, r_h  # (150, 121, 103, 146)
plot((r_x, r_x, r_x+r_w, r_x+r_w, r_x), (r_y, r_y+r_h, r_y+r_h, r_y, r_y))
plot(x,y)
```

Out[73]:
```
[<matplotlib.lines.Line2D at 0x6eab610>]
```



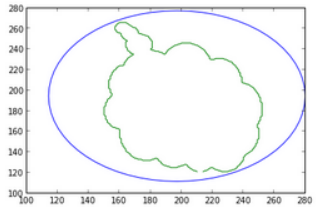
In [88]:
```
rect = cv2.minAreaRect(cnt)
rect # ((202.134521484375, 192.14178466796875), (102.39618682861328, 140.3079376220703), -5.128190994262695)
box = cv2.cv.BoxPoints(rect)
box # ((157.41201782226562, 266.59124755859375), (144.87069702148438, 126.84494018554688), (246.85702514648438, 117.69232177734375), (259.3983459472656,
# plot( [p[0] for p in box] + [box[0][0]], [p[1] for p in box] + [box[0][1]] )
box_list = list(box)
box_list.append(box[0])
ba = np.array(box_list) # Box array
plot(ba[:,0], ba[:,1])
plot(x,y)
```

Out[88]:
```
[<matplotlib.lines.Line2D at 0x7746a10>]
```



In [97]:
```
(c_x, c_y), radius = cv2.minEnclosingCircle(cnt)
c_x, c_y, radius # (197.0, 194.5, 82.92139434814453)
center = shapely.geometry.Point(c_x, c_y)
circle = np.array(center.buffer(radius).boundary.coords)
len(circle) # 66 points
plot(circle[:,0], circle[:,1])
plot(x,y)
```

Out[97]:
```
[<matplotlib.lines.Line2D at 0x7ba81d0>]
```



In [100]:
```
ellipse = cv2.fitEllipse(cnt)
ellipse # ((199.31251525878906, 185.9192352294922), (93.7149658203125, 138.58531188964844), 202.948486328125)
# TODO: what is a convenient way to get the coords for an ellipse?
```

Out[100]:
```
((199.31251525878906, 185.9192352294922),
 (93.7149658203125, 138.58531188964844),
 202.948486328125)
```

In [ ]:

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Layers

H11076_50cm_MSL_8of13

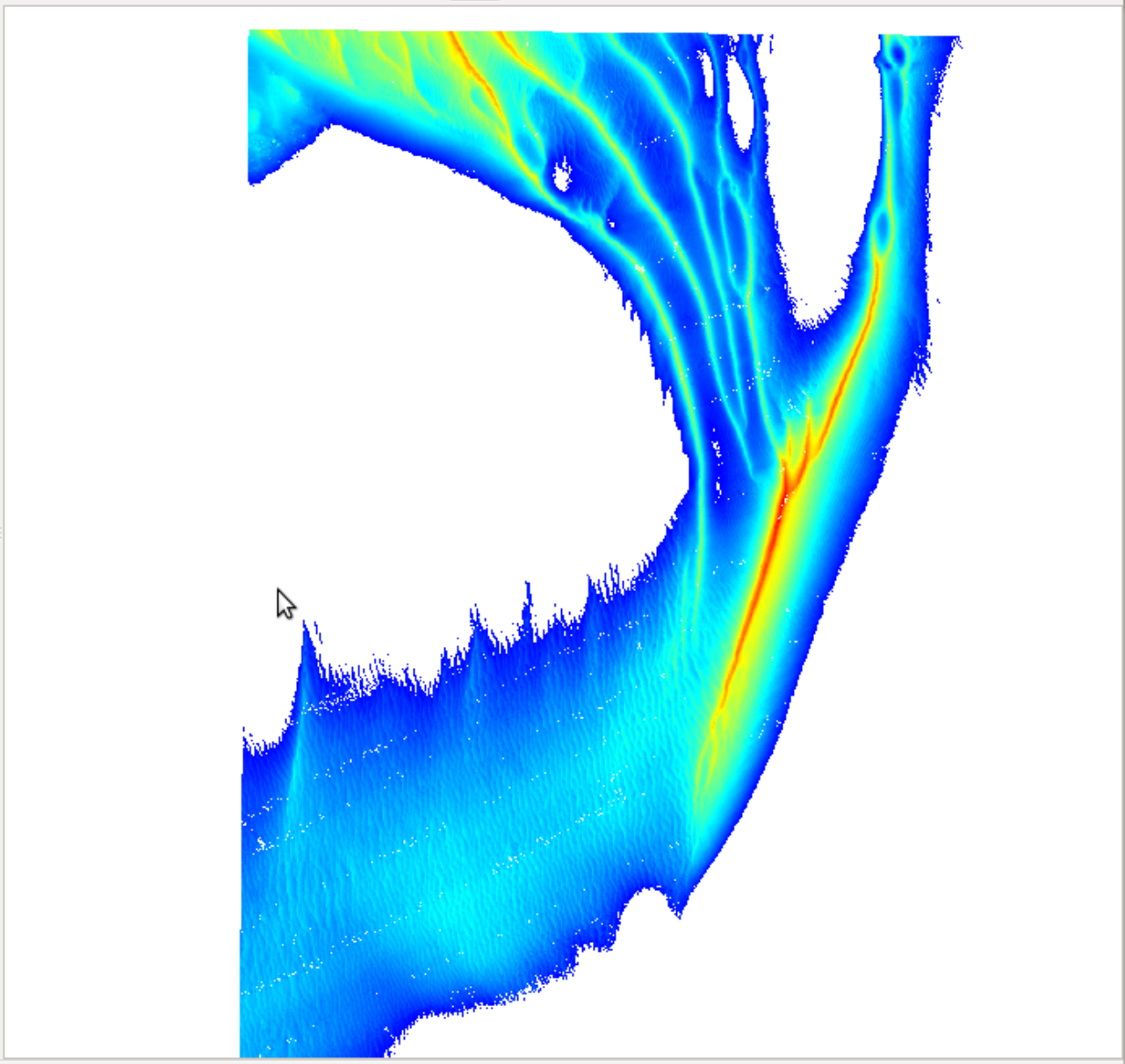
H11076_50cm_MSL_8of13-filled

Control rendering order

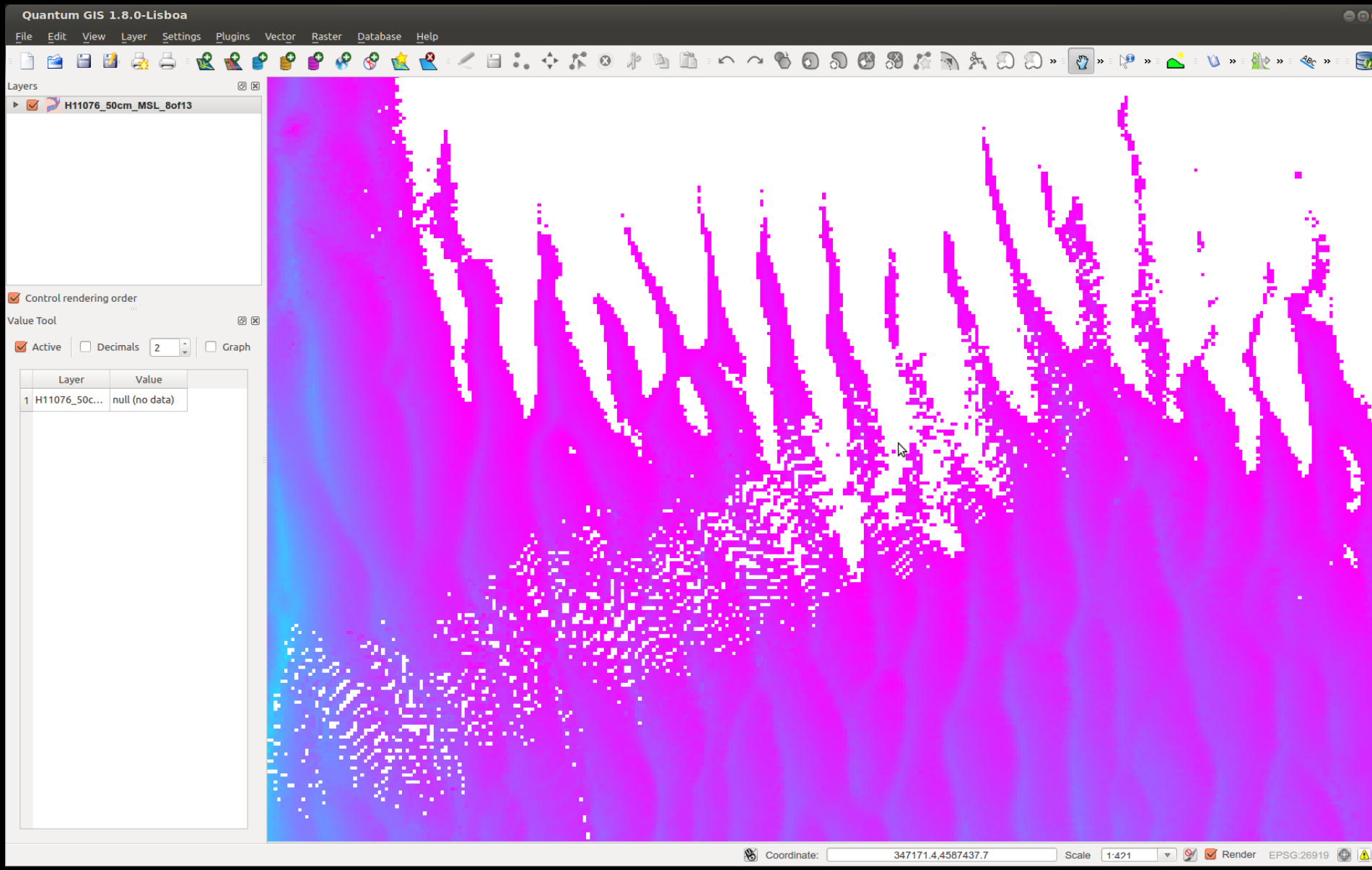
Value Tool

Active Decimals 2 Graph

	Layer	Value
1	H11076_50cm_MSL_8o...	null (no data)



There is a plugin update available Coordinate: 347044,4587577 Scale 1:8899 Render EPSG:26919


Quantum GIS 1.8.0-Lisboa
File Edit View Layer Settings Plugins Vector Raster Database Help
Layers
H11076_50cm_MSL_8of13
Control rendering order
Value Tool
Active Decimals 2 Graph
Layer Value
1 H11076_50c... null (no data)
Coordinate: 347171.4,4587437.7 Scale 1:421 Render EPSG:26919

Quantum GIS 1.8.0-Lisboa

File Edit View Layer Settings Plugins Vector Raster Database Help

Layers

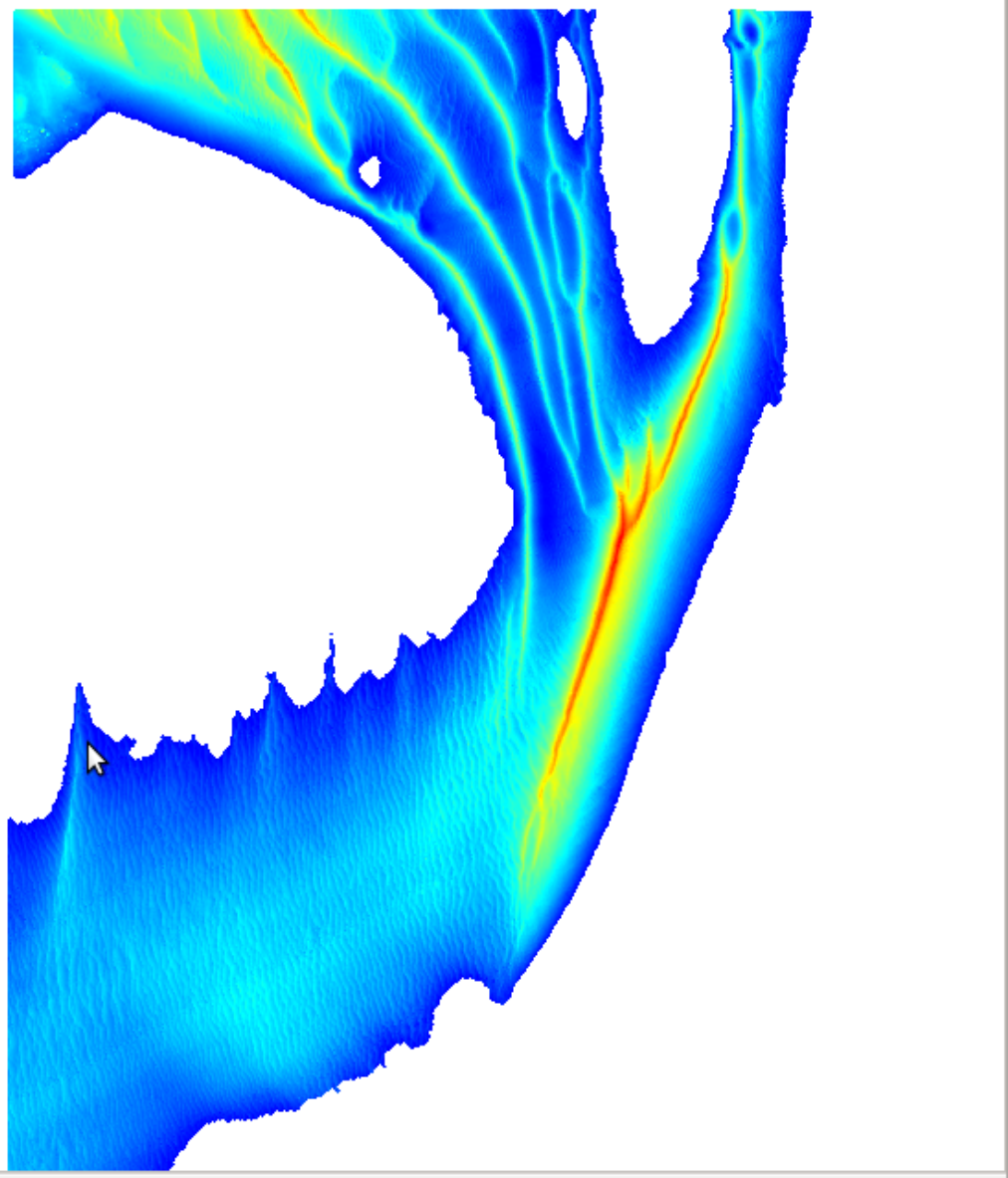
- H11076_50cm_MSL_8of13
- H11076_50cm_MSL_8of13-filled

Control rendering order

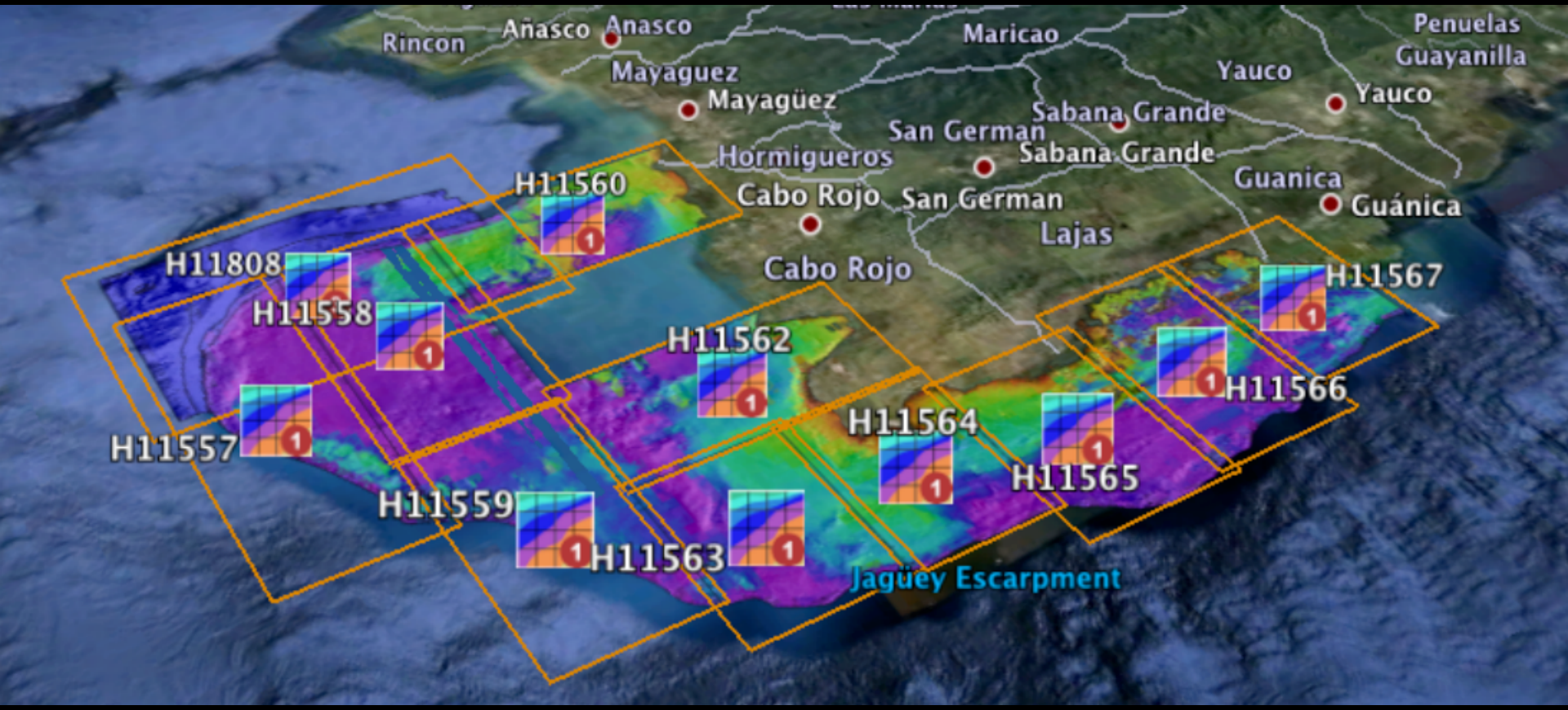
Value Tool

Active Decimals 2 Graph

	Layer	Value
1	H11076_50cm_MSL_8o...	-16.9547



There is a plugin update available Coordinate: 347096,4587445 Scale 1:8899 Render EPSG:26919


Rincon
Añasco
Anasco
Mayaguez
Mayagüez
Maricao
Yauco
Yauco
Penuelas
Guayanilla
Sabana Grande
San German
Hormigueros
Sabana Grande
Cabo Rojo
San German
Guanica
Guánica
Lajas
Cabo Rojo
H11560
H11808
H11558
H11562
H11567
H11566
H11557
H11564
H11565
H11559
H11563
Jagüey Escarpment

Classifications

What is a hole?

- Data gap
- Island
- Algorithmic error
- Data in another file

What is the boundary?

- Survey area
- Cut for grid size
- Shallow w/out land
- Shallow with land

Source & relationship

- VB, MB, Lidar etc
- Low & High res
- Singleton or many pieces

What artifacts?

- Tidal Zones
- Sonar errors
- Processing errors
- Sound speed drift

Open Source Software

proj
gdal
qgis
grass
gmt
mbsystem
...

python
ipython notebook
lxml
numpy
scipy measurements
shapely
opencv
...

A call for open data formats and more release data with open formats

Bathymetry
Lidar
...

GSHHS & other shorelines
Raw tide records
...

SAIC's Generic Sensor Format (GSF) library is NOT currently licensed as open source software!

http://meridian.aag.org/callforpapers/program/AbstractDetail.cfm?AbstractID=55122

Abstract Title: ***Classification of Bathymetry Grids Using Open Source Tools***

is part of the Paper Session:Advances and Challenges in Digital Elevation Models I (Overview)

Author(s): Kurt Schwehr, PhD* - Google, Jamie Adams - Google, Jenifer Austin Foulkes - Google

Abstract:

Creating global synthesis views of the Earth's bathymetry is a challenge complicated the process of merging data products from diverse sensor platforms with a wide range of data artifact classes. Processing large numbers of gridded bathymetry DEMs requires being able to automatically classify the input DEMs based on the surveying and gridding techniques used and the resulting artifacts. The platform type and details of techniques used are not detailed in a machine readable form within the ISO XML metadata contained in Bathymetry Attributed Grids (BAGs). We demonstrate the results of processed NOAA NGDC's archive of BAGs using Open Source tools to identify the quantity and morphology of data gaps using the Python SciPy library's image processing routines. Once grids have been classified and referenced to the same vertical datum using the Geospatial Data Abstraction Library (GDAL), the grids can be hole filled and merged based on project specific requirements. We will discuss the general classes of artifacts that can be found and propose how each class might be handled to produce a more continuous surface. We show how to use IPython Notebooks and QGIS to assist with quality checking BAGs insure the archived grids represent the quality of the sensor platform and acquisition strategy. We will conclude with suggested strategies for data acquisition and gridding that are more likely to produce DEMs that blend well with large global scale projects such as Google Ocean.

Keywords:

dem,terrain,open source,gdal,python,scipy