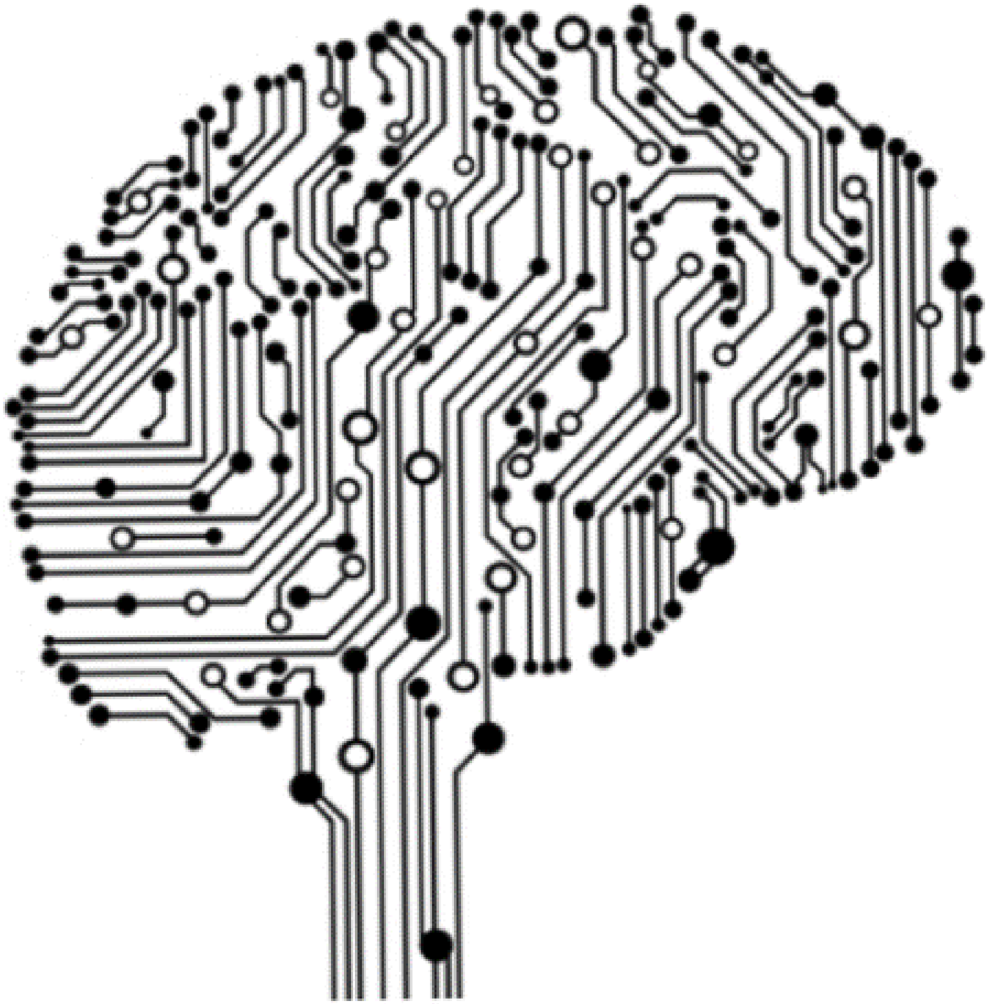


Machine Learning for Bathymetric Processing

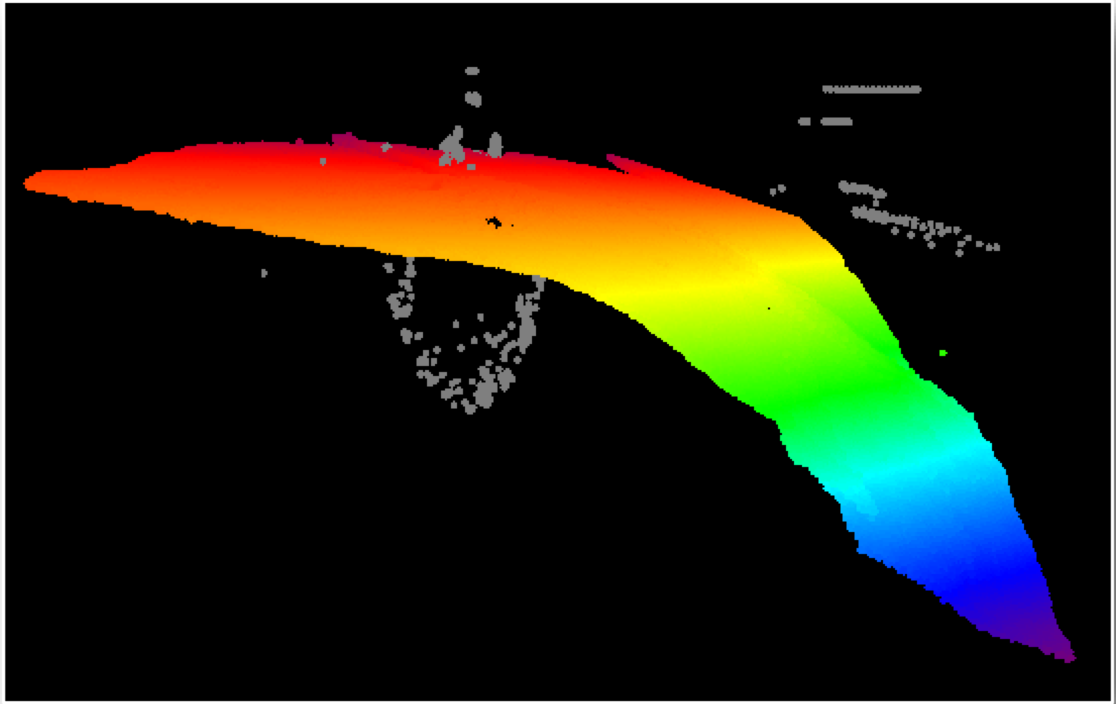
By Andy Hoggarth

TELEDYNE CARIS
Everywhereyoulook™

Sonar Noise

Types of noise:

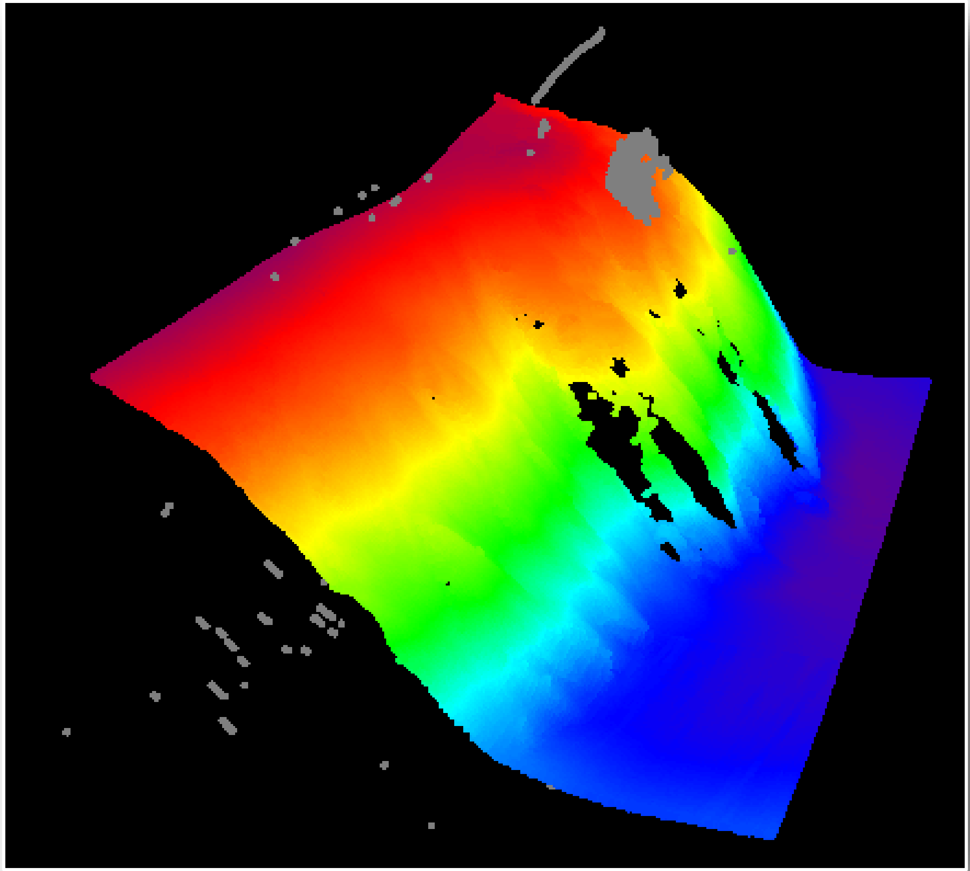
- Cavitation/bubble sweep
- Loss of bottom on outer beams
- Loss of bottom lock
- False returns from the water column



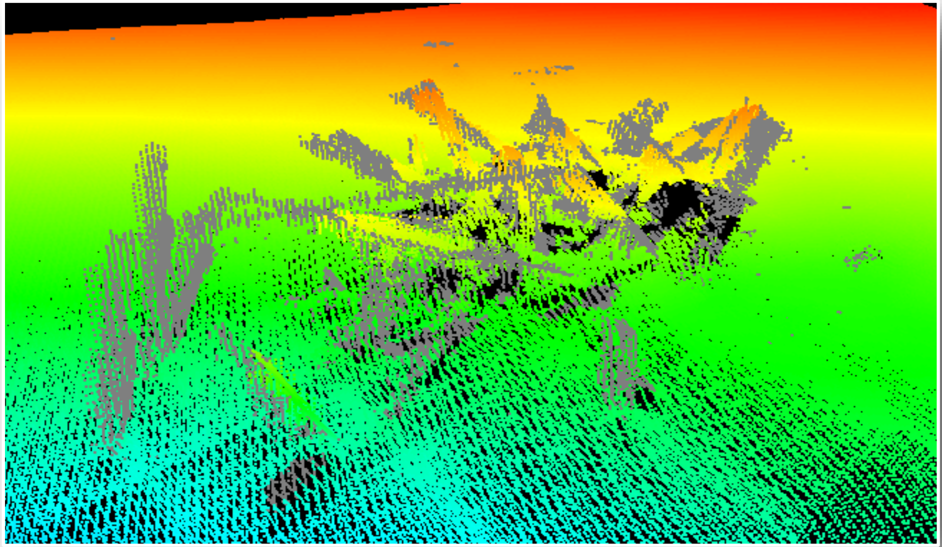
Data Cleaning

Time Consuming and labour-intensive

- Current methods:
  - Manual (dot-killing)
  - Simple filters
  - Statistical filters
  - Terrain model binning and filtering



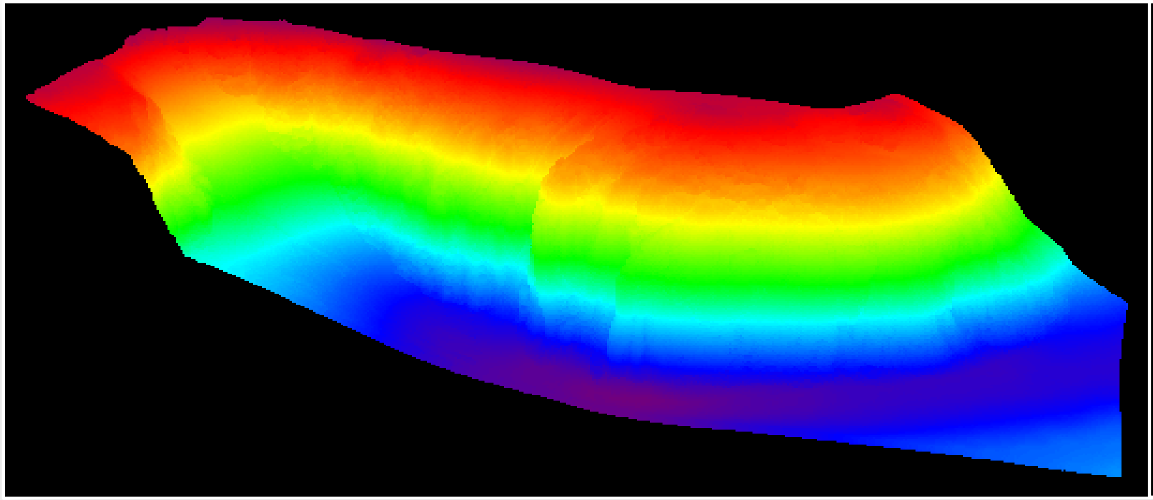
Processing Challenges

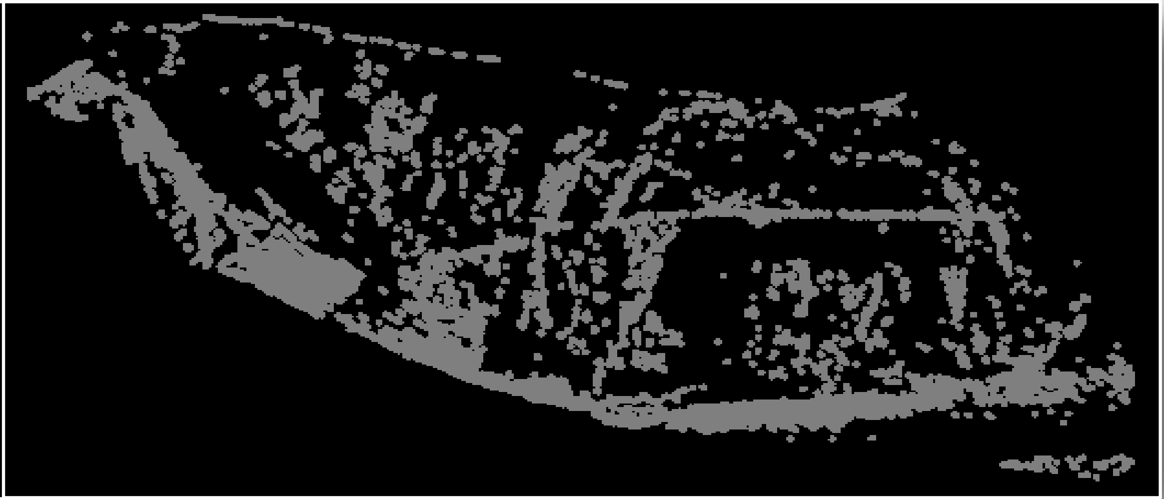


Regardless of method or filter type

- Complex features
- And steep slopes

are problematic….





TELEDYNE CARIS
Everywhereyoulook™

Machine Learning for Bathy

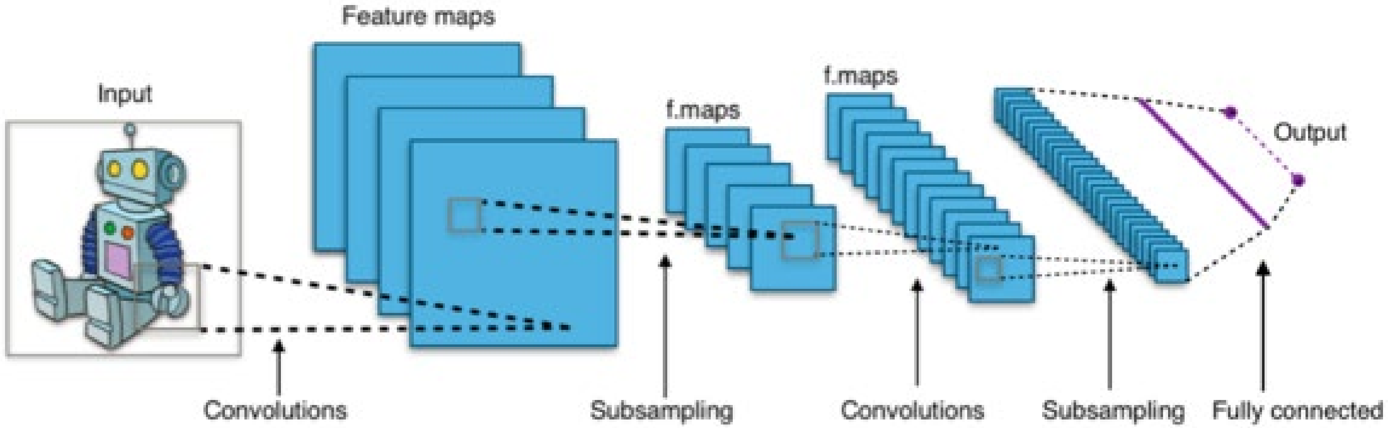
- Machine Learning is Good at:
  - Pattern recognition
  - Prediction

- *NVIDIA Titan RTX GPU for training the algorithm*
- *AWS cloud GPU service for day-to-day processing*

- Requires an extensive library of training data (feature maps)
  - Different data examples
  - Training the algorithm is intensive and requires heavy duty hardware
    - Using the algorithm is not as intensive
    - Cloud based GPU processing is efficient
    - Local PC or Server processing is possible if GPU requirements can be met

Convolutional Neural Networks (CNN)

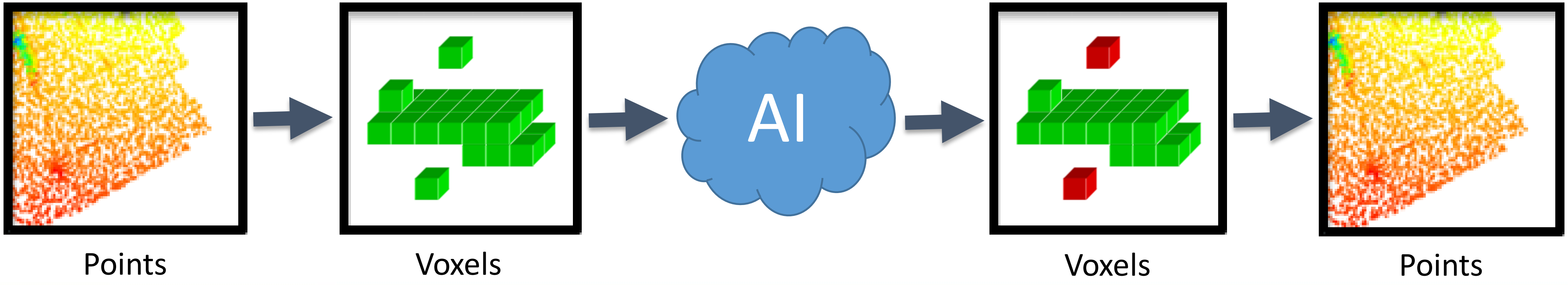
- CNN is very popular and many libraries are available



- Little published work on 3D point clouds
  - Teledyne CARIS is pioneering a **3DCNN** for classifying Sonar Noise and more…
  - Could it help MAP THE GAPS?

Sonar Noise Classification Workflow in HIPS

1. Divide dataset into tiles
2. Create a voxel grid for each tile
3. Classify the voxel grid
4. Map the result back to the points

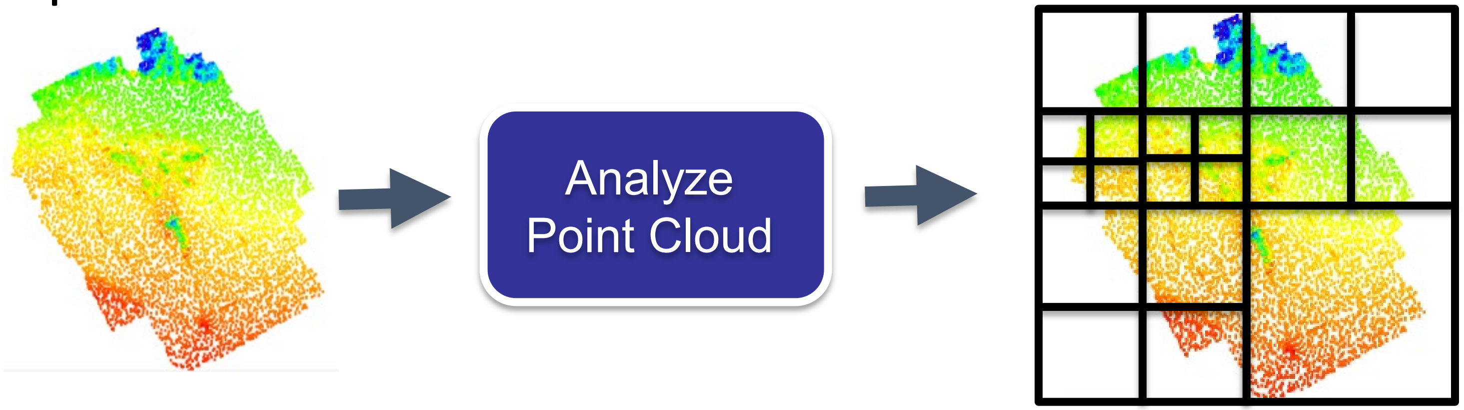


Step 1.

Data is analyzed and divided into tiles

- Based on number of points
  - Low density = big tiles

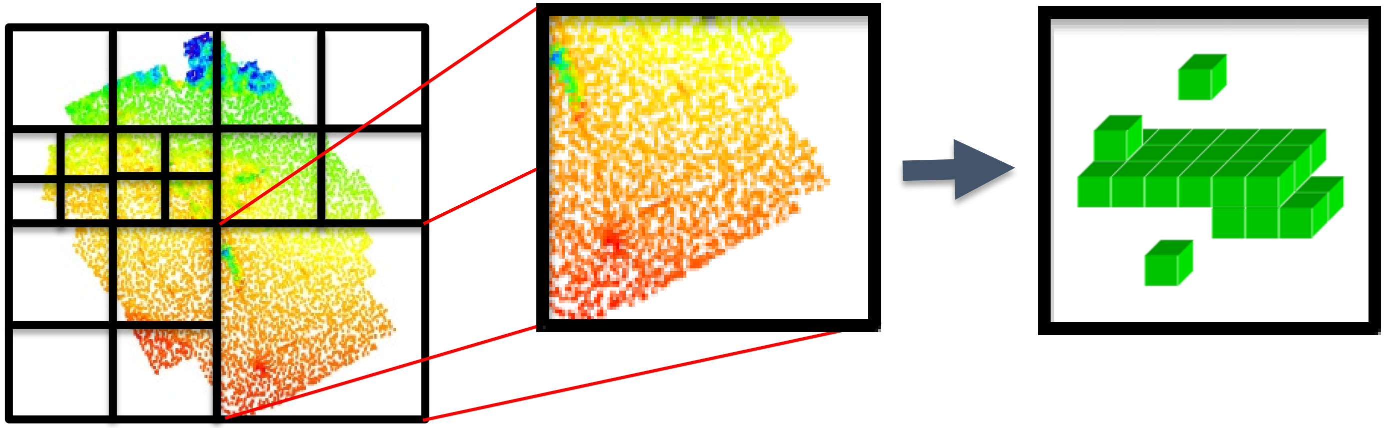
- and an optional finest vertical resolution



Step 2

A voxel grid is created of all points in each tile

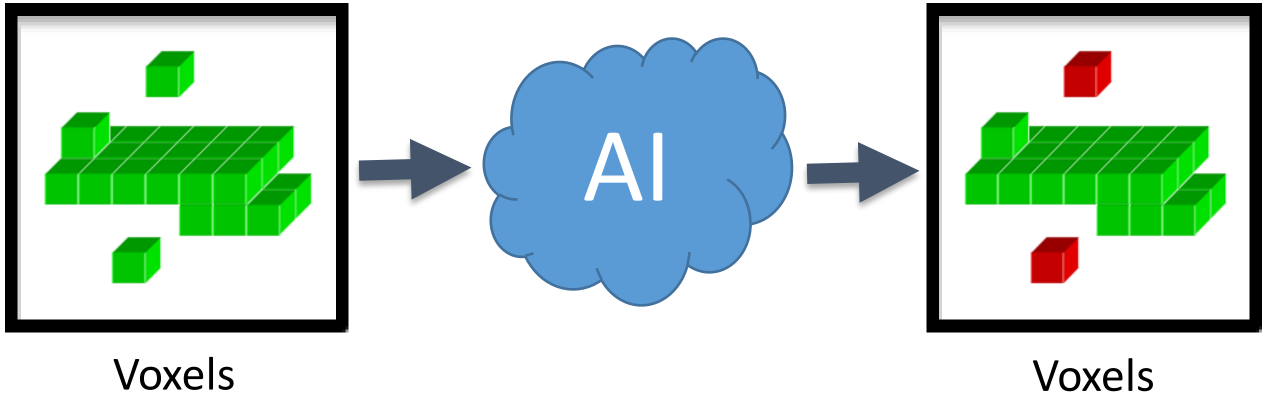
- Get the tile points
- Create voxel grid



Step 3.

Classify the voxel grid

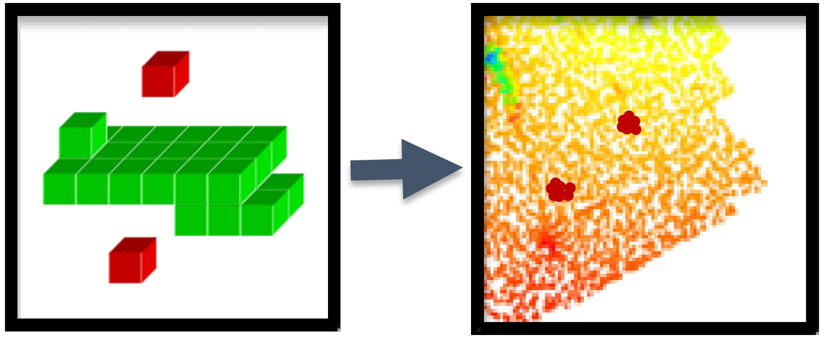
- Send voxels to AI (cloud or local)
  - 100 times smaller than full density point cloud
- Receive classification from AI



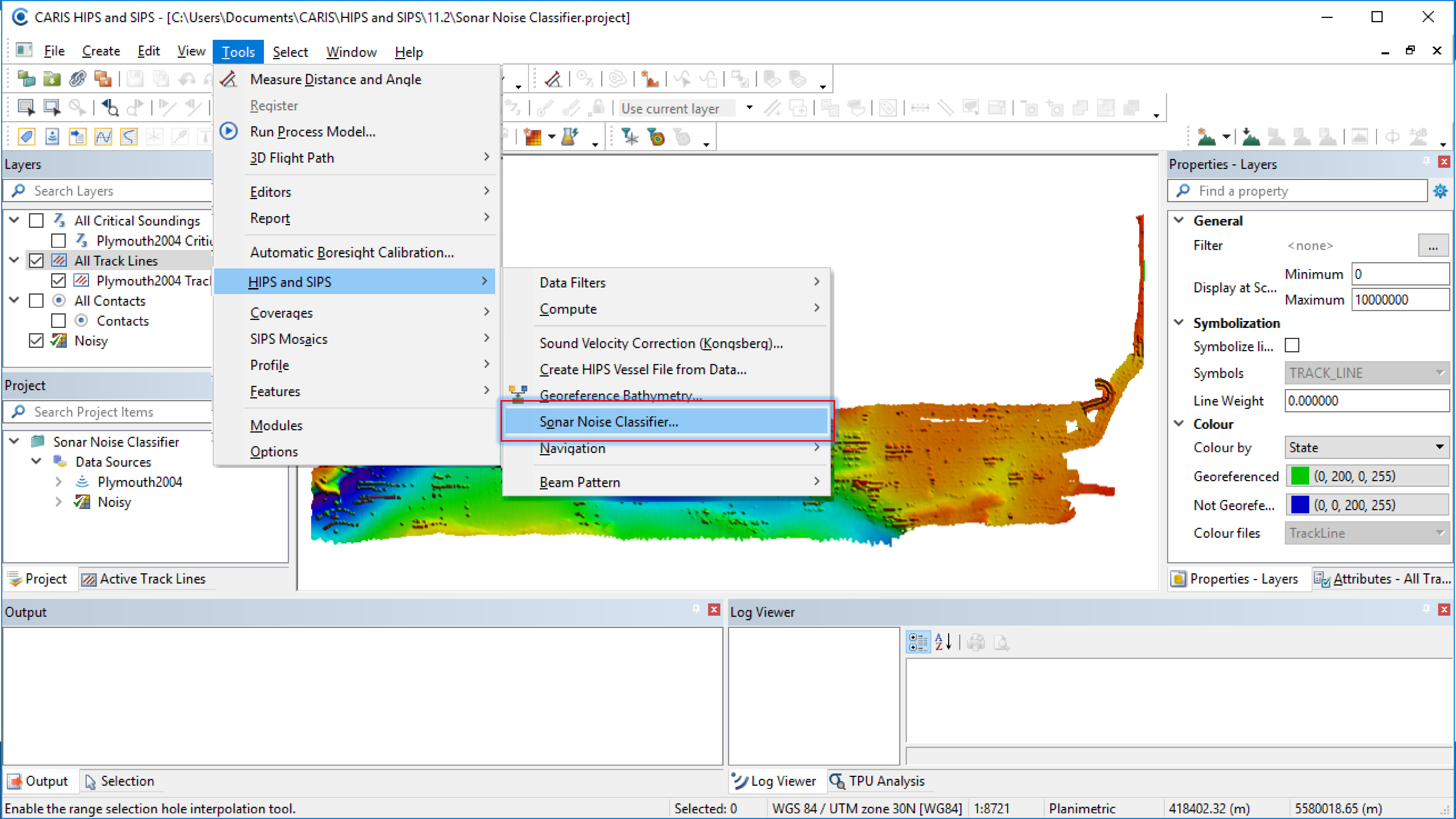
Step 4.

Map the result back to the points

- Adjust confidence threshold if required
- Apply as filter to dataset
- Points falling inside Rejected voxels are Rejected (like CUBE)



Voxels Points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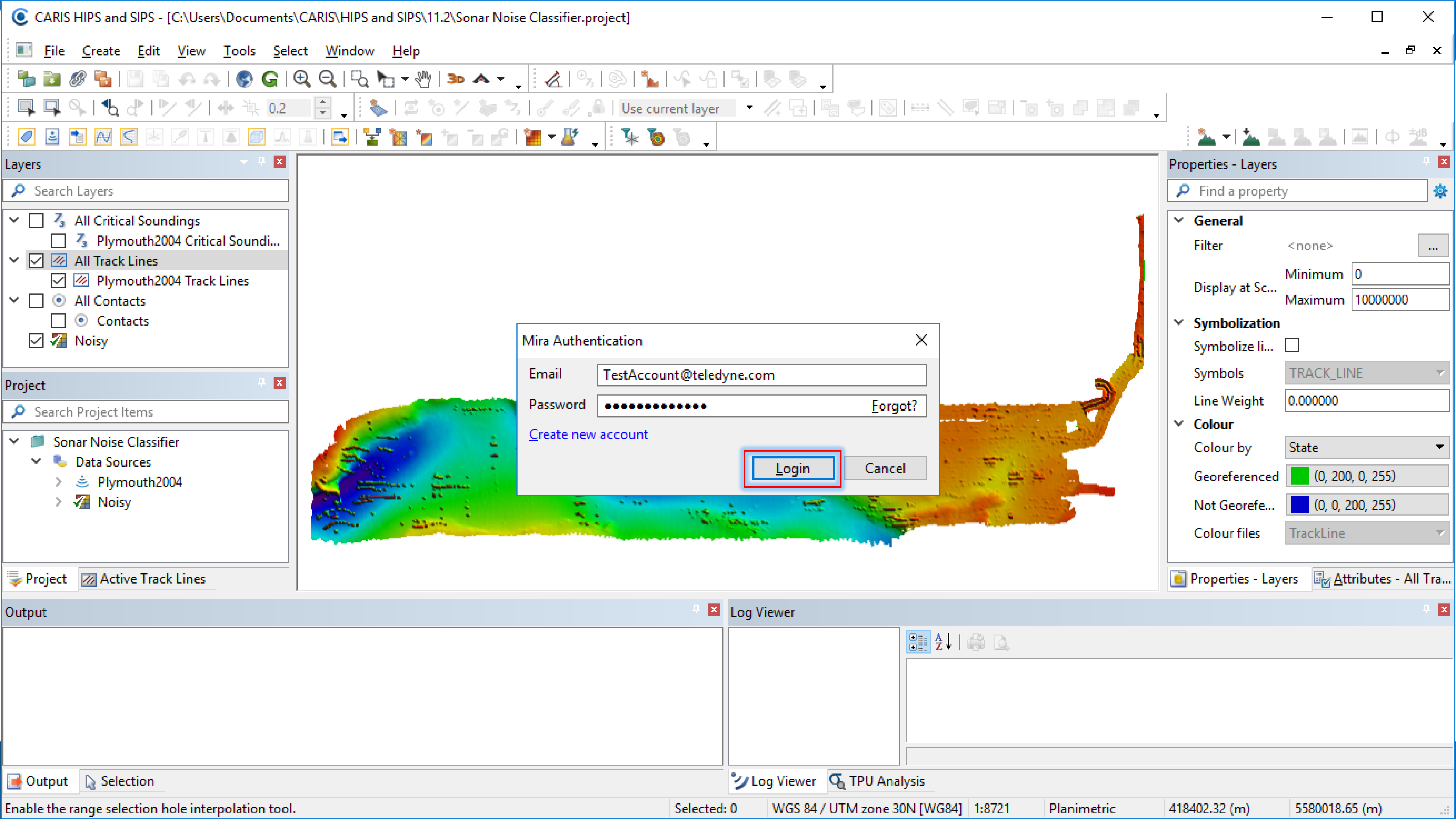
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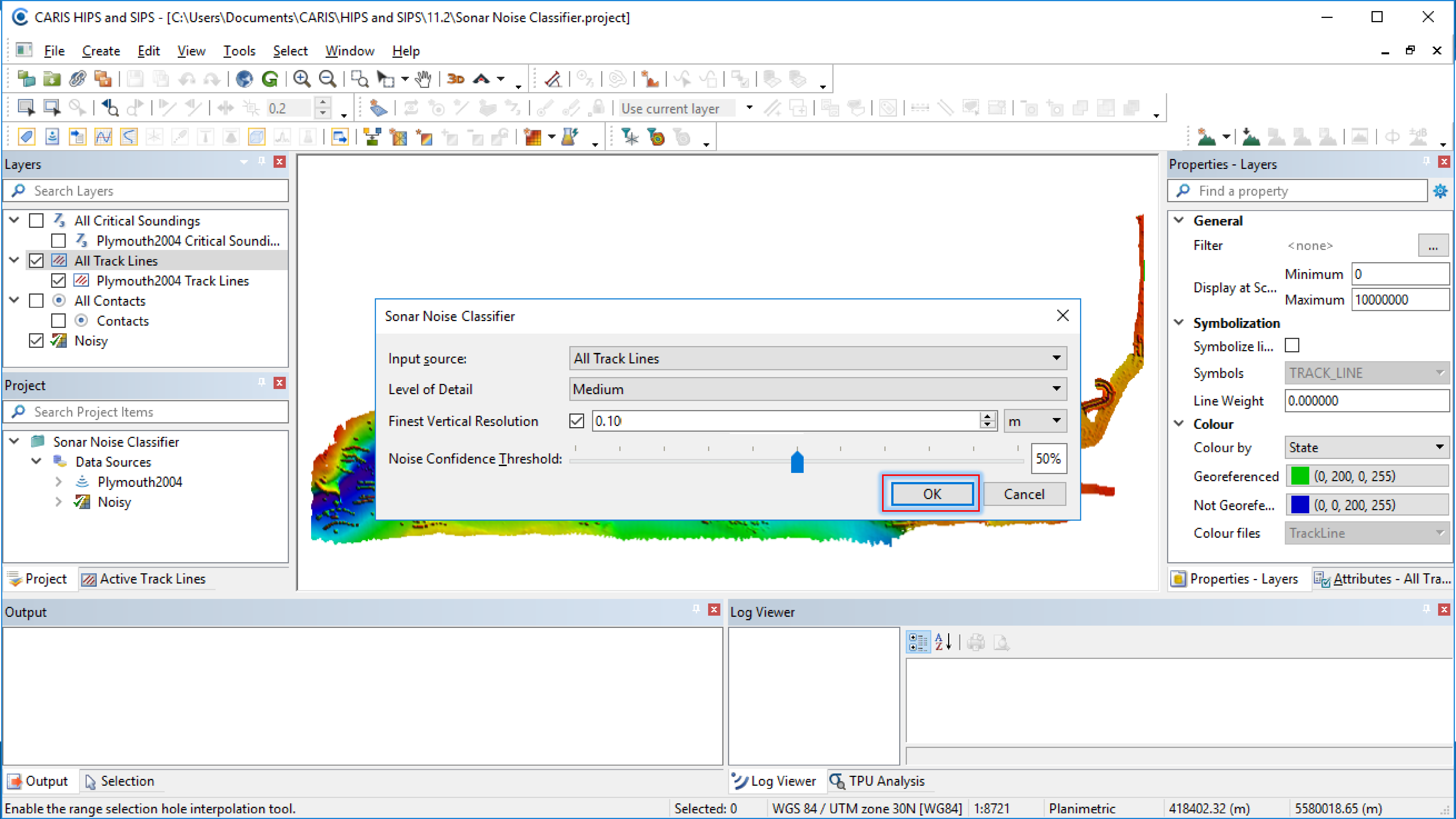
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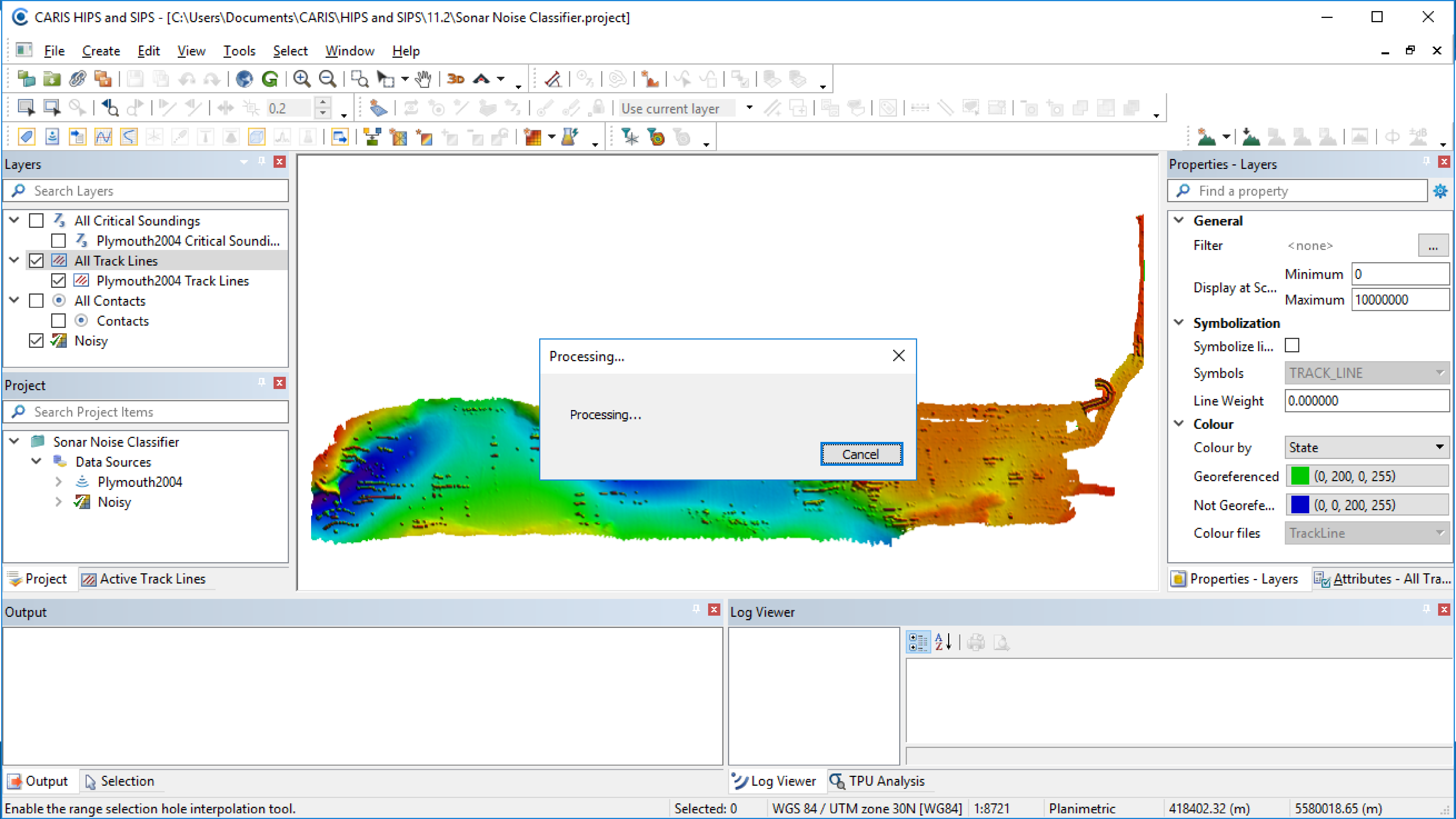
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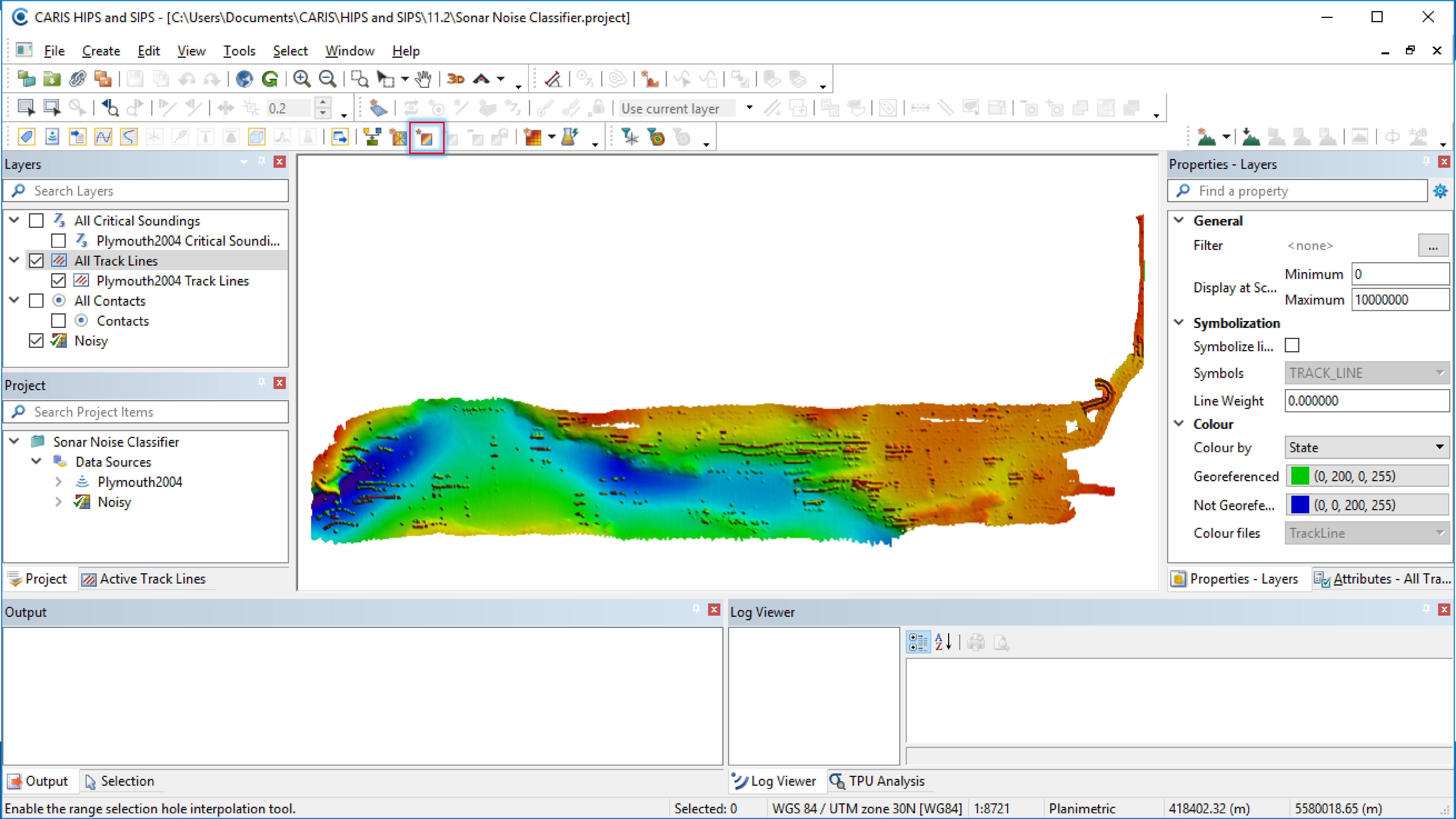
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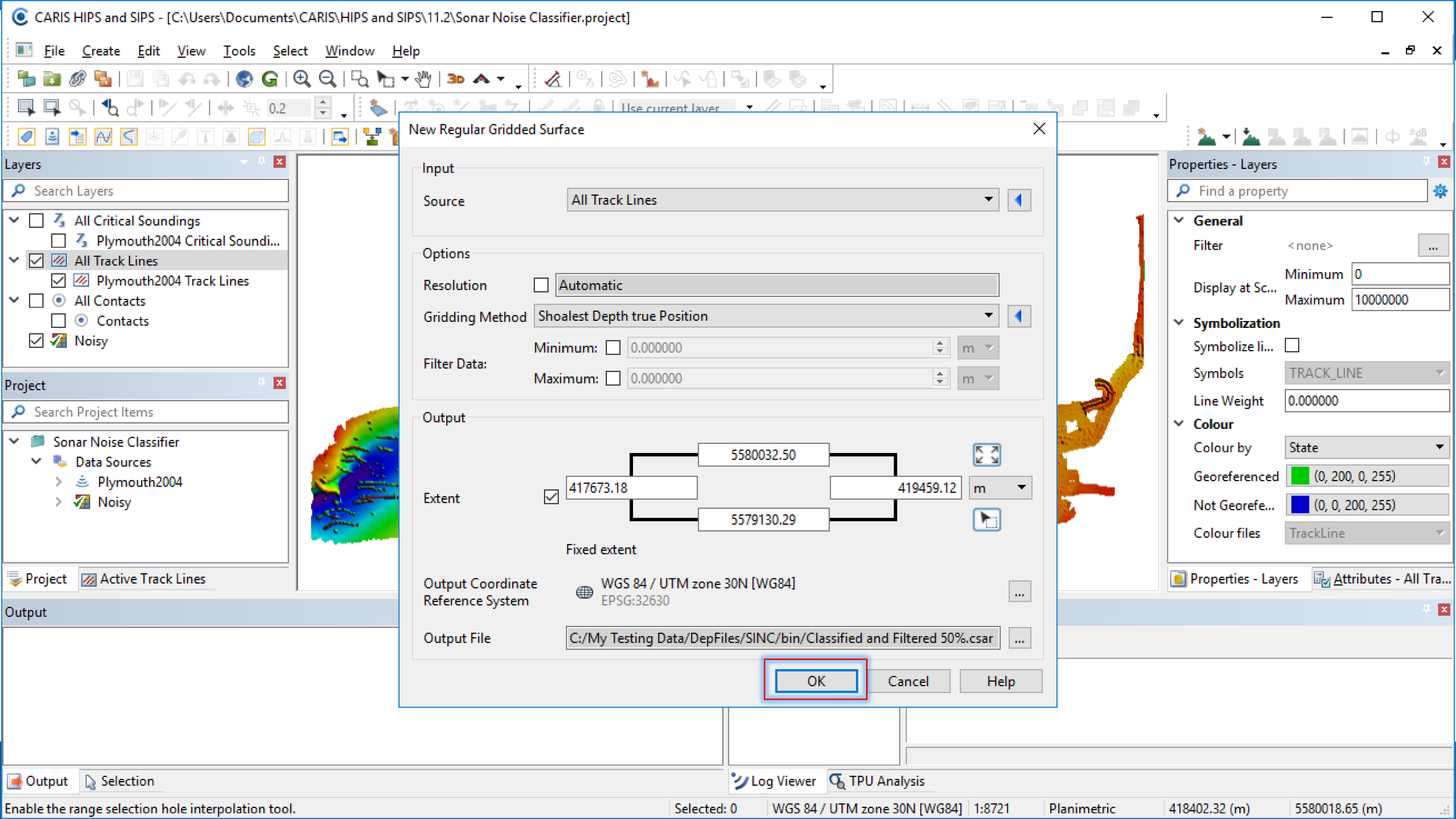
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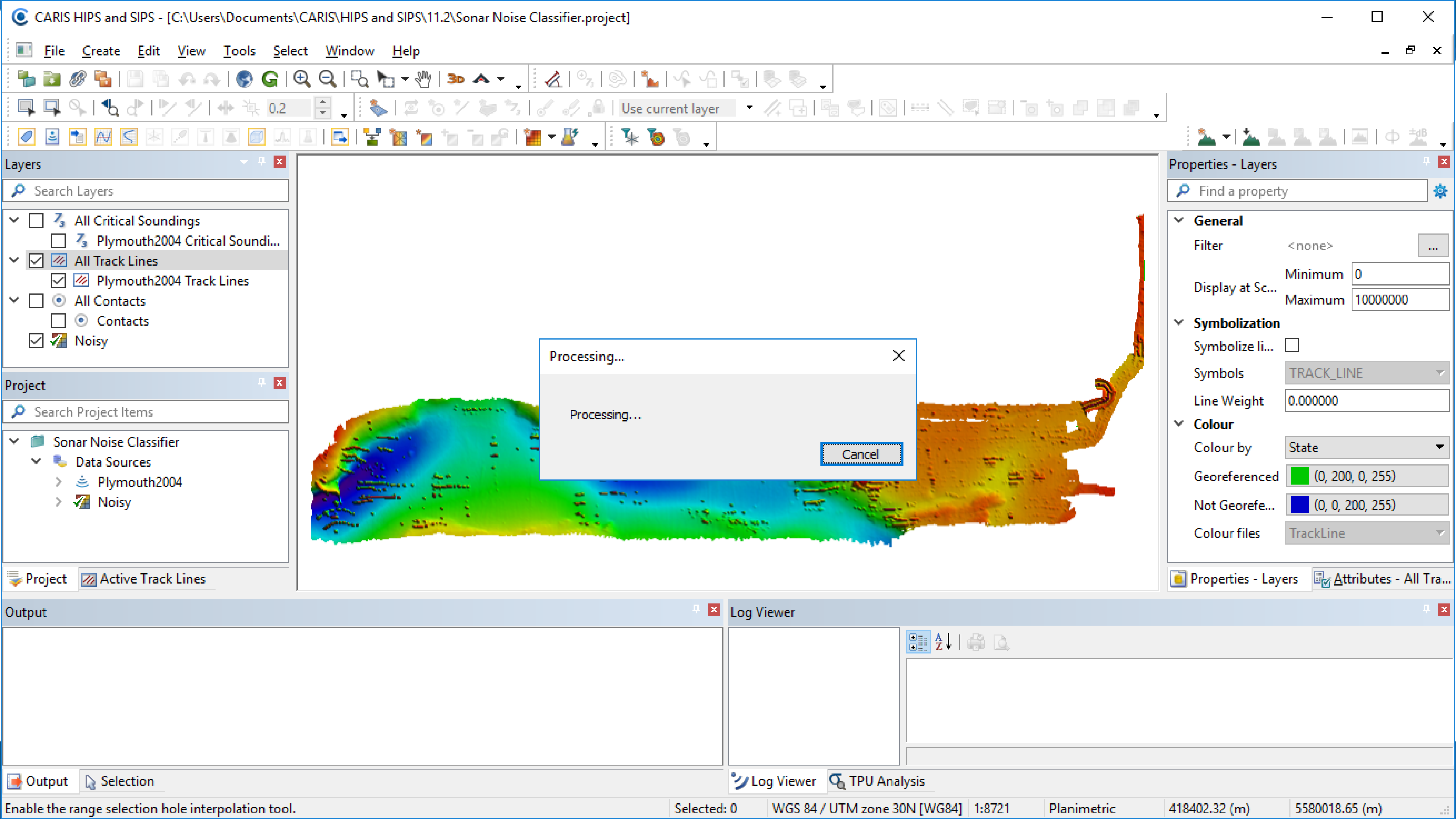
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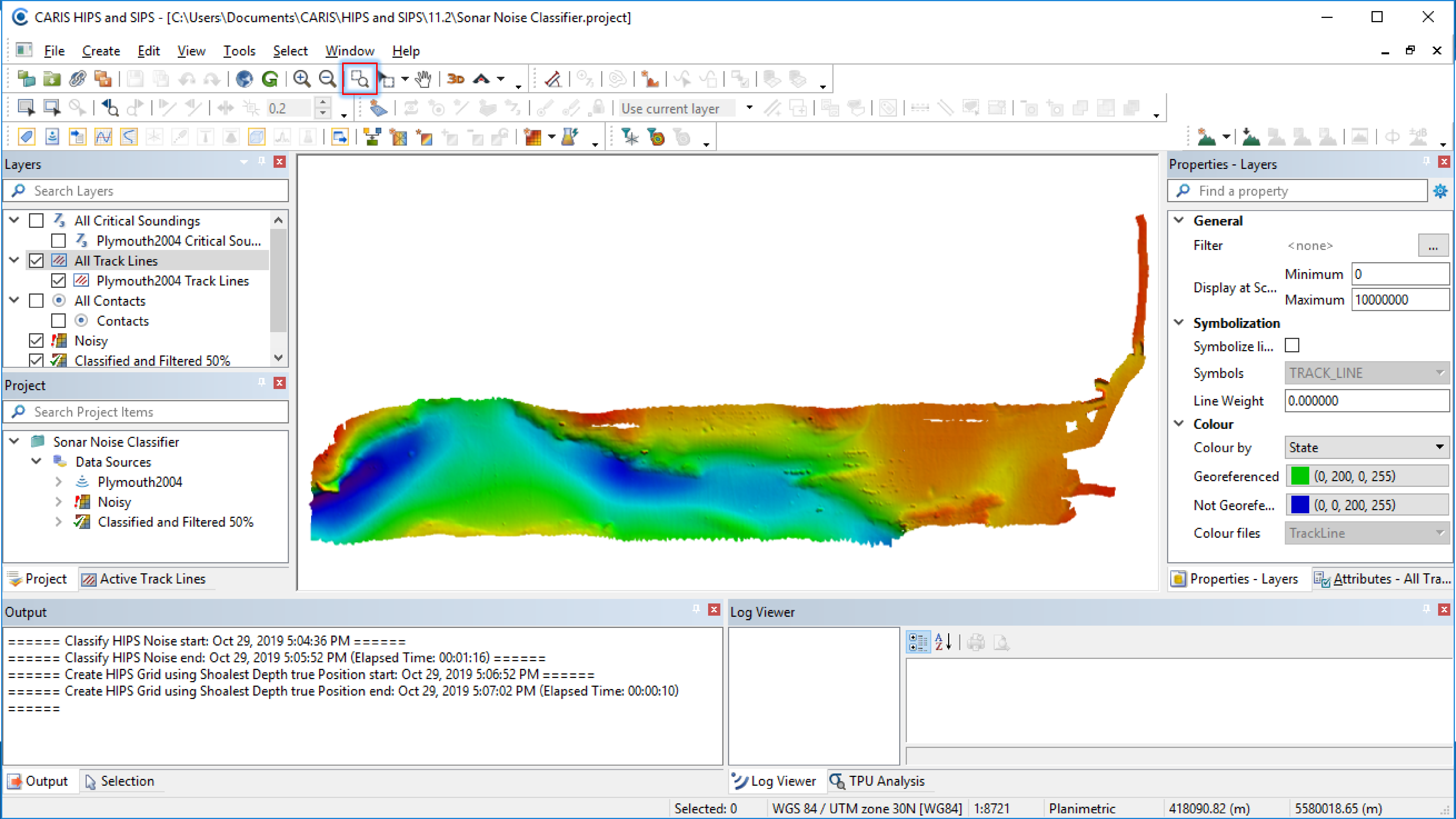
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====== Classify HIPS Noise end: Oct 29, 2019 5:05:52 PM (Elapsed Time: 00:01:16) ======
====== Create HIPS Grid using Shoalest Depth true Position start: Oct 29, 2019 5:06:52 PM ======
====== Create HIPS Grid using Shoalest Depth true Position end: Oct 29, 2019 5:07:02 PM (Elapsed Time: 00:00:10)
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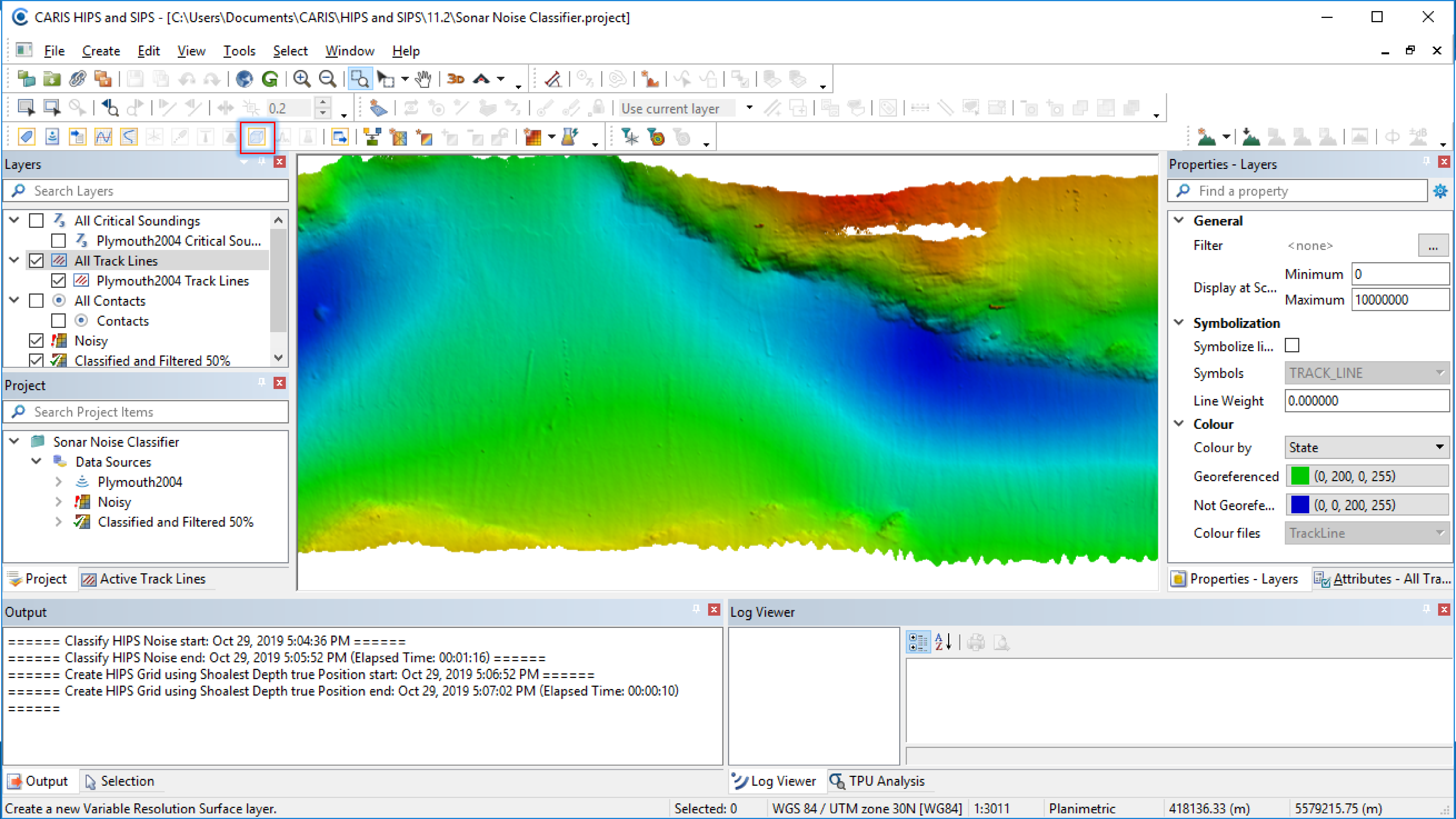
5580018.65 (m)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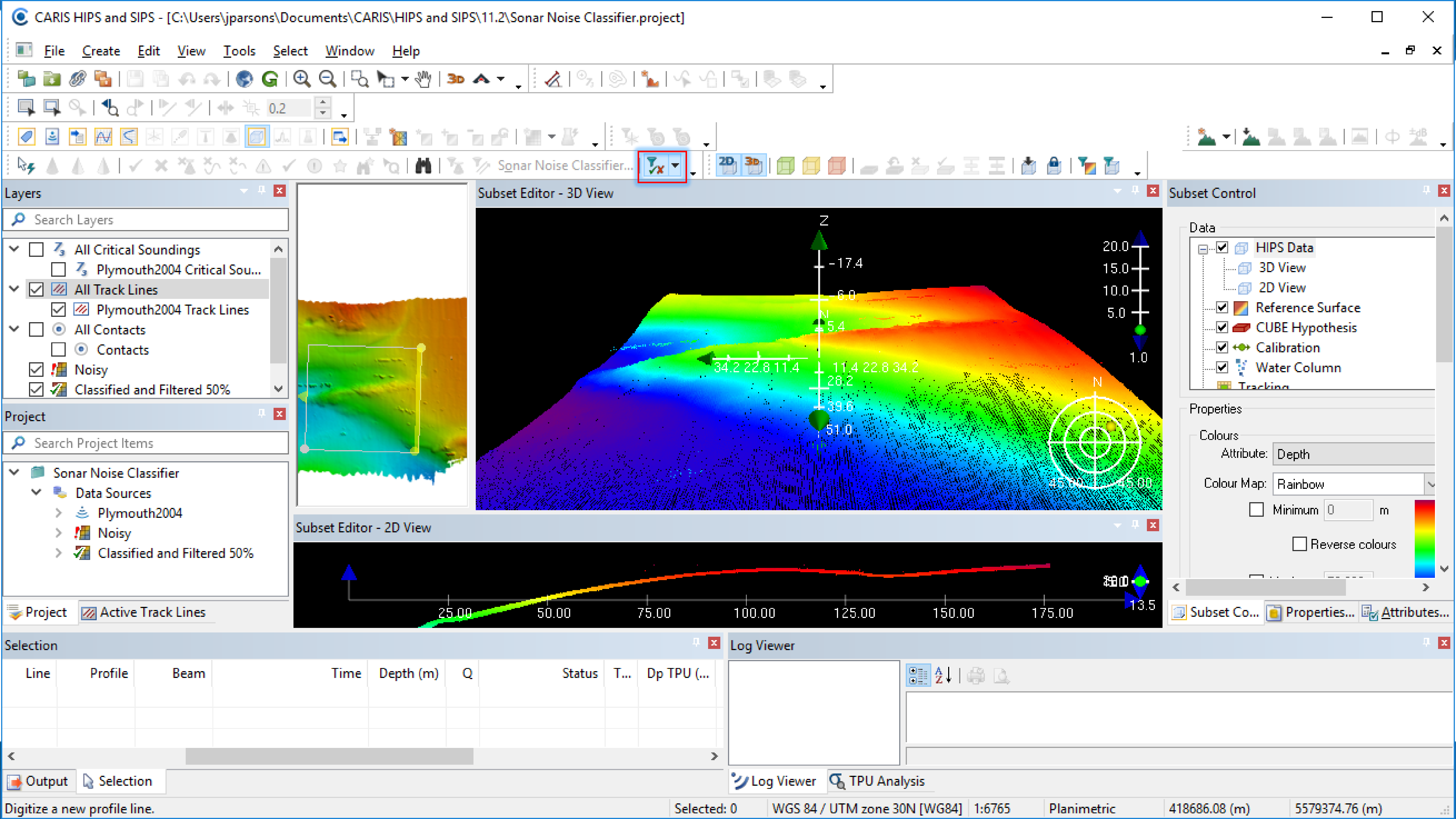
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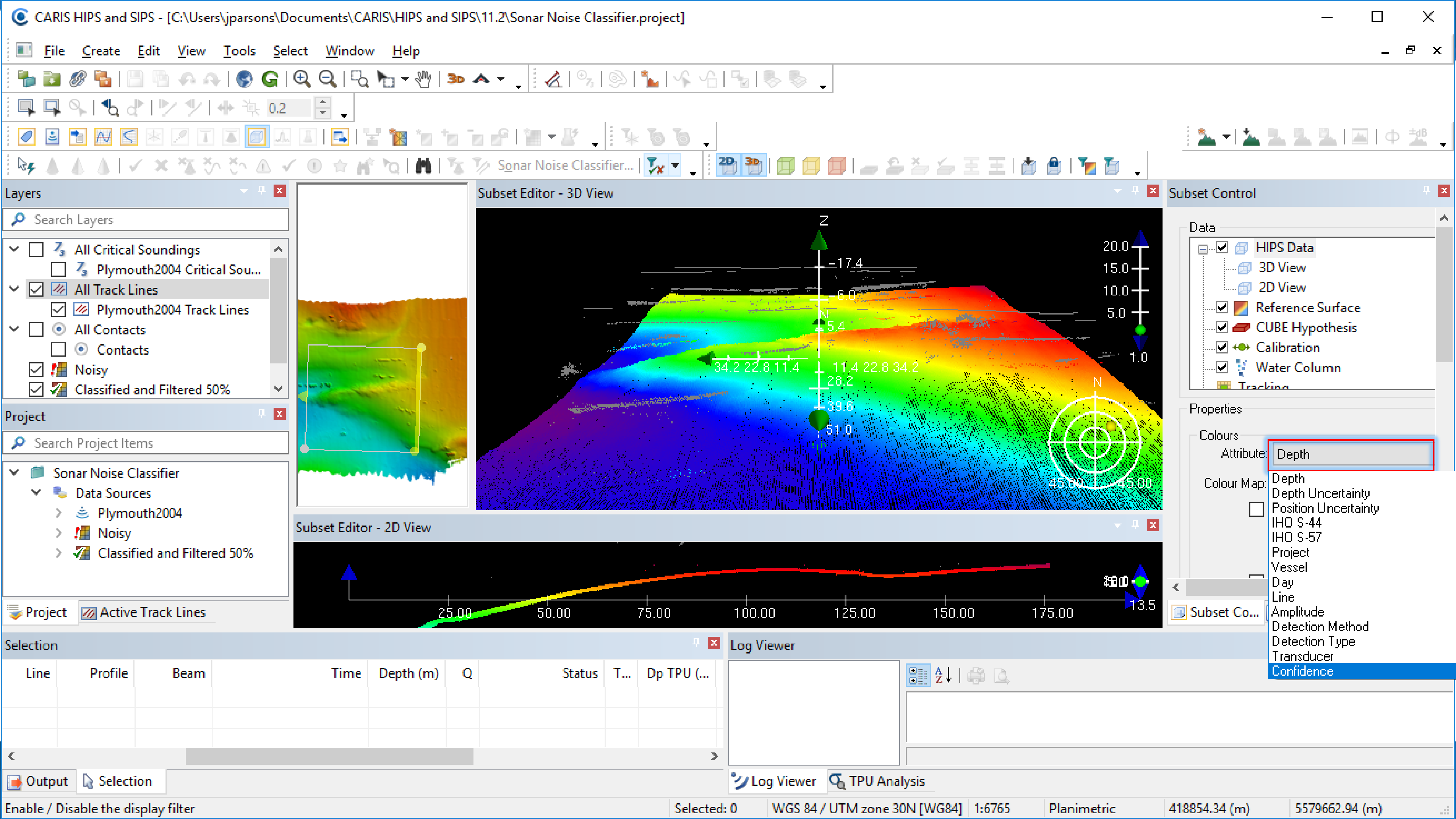
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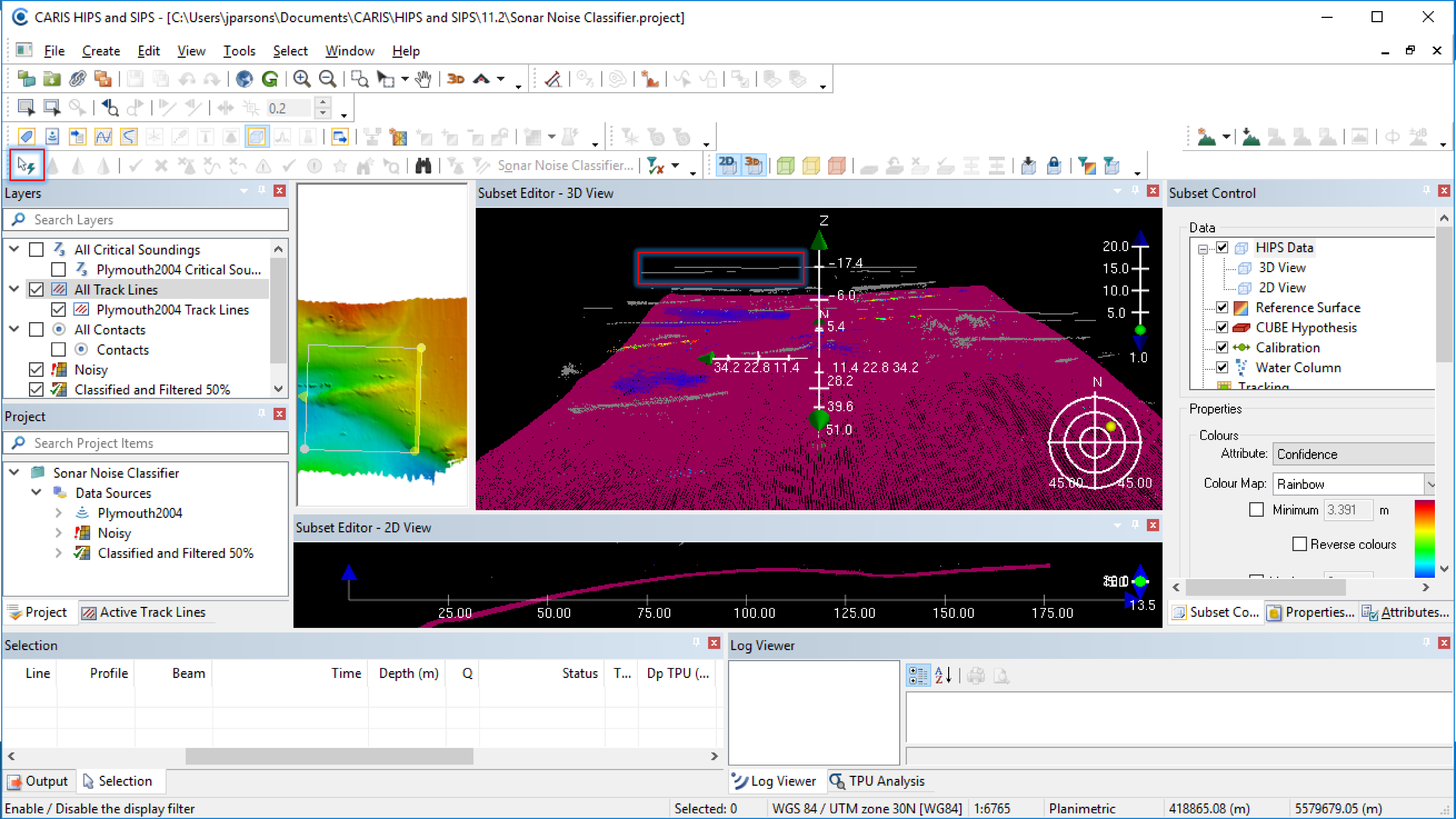
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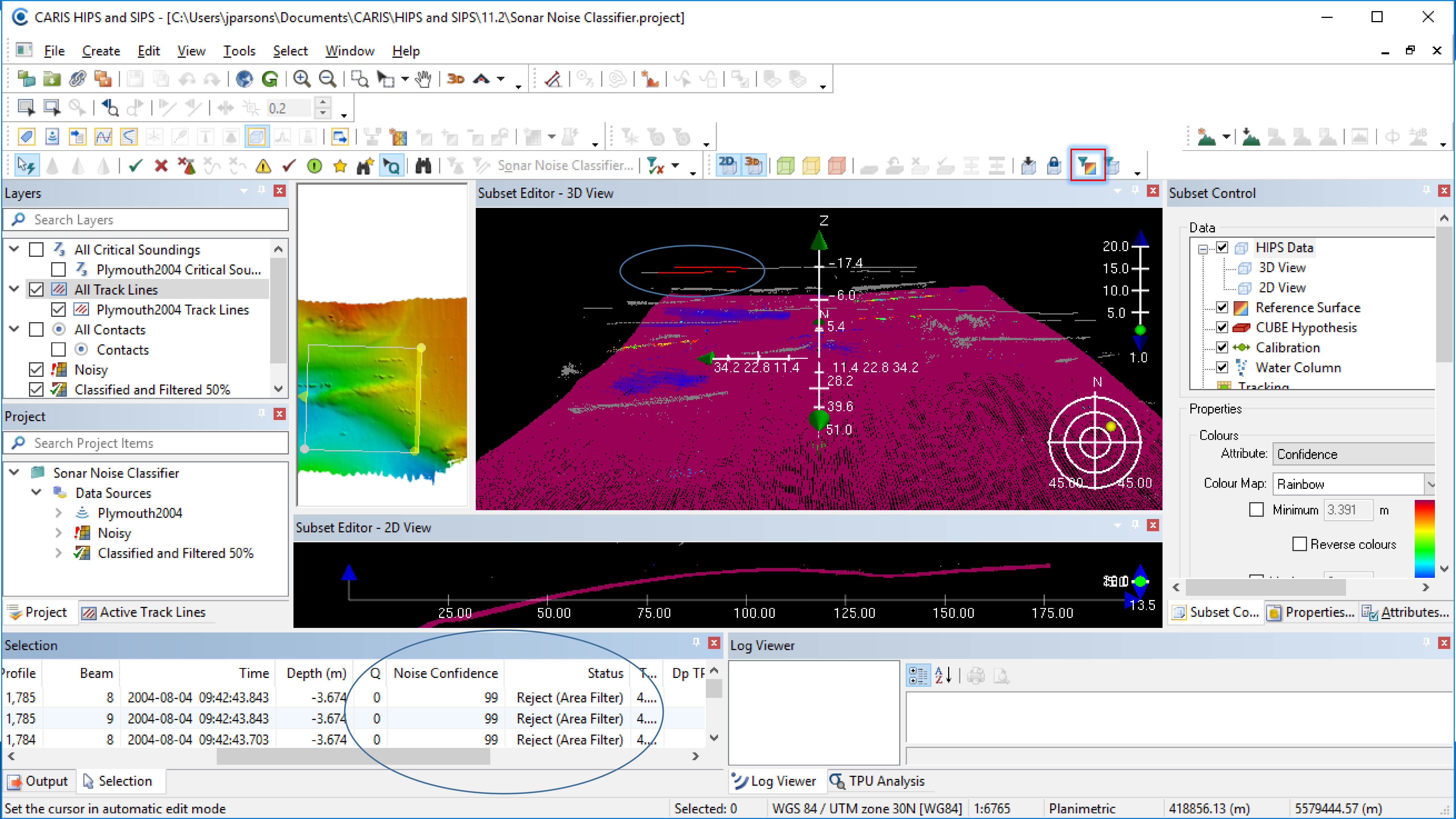
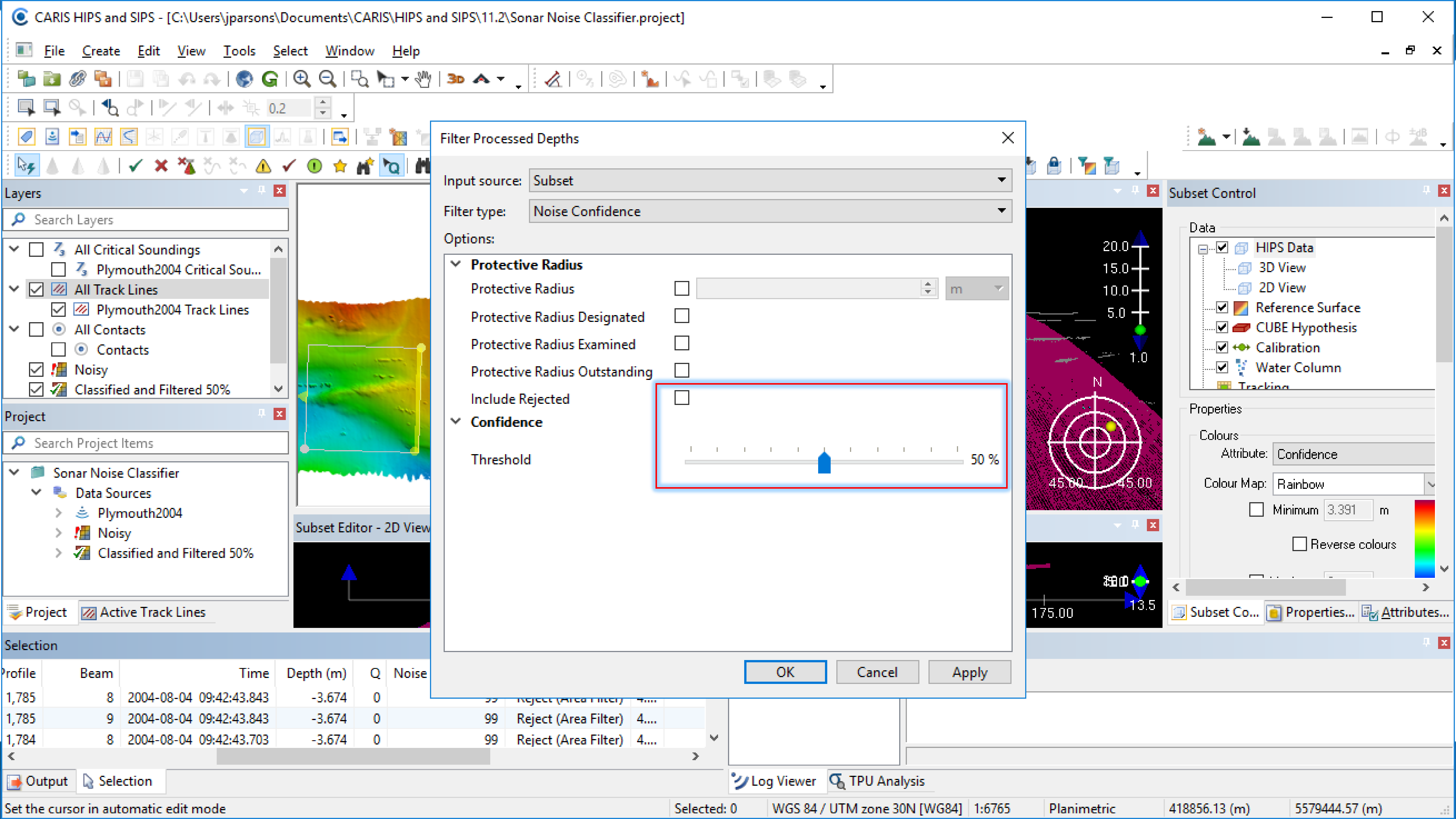
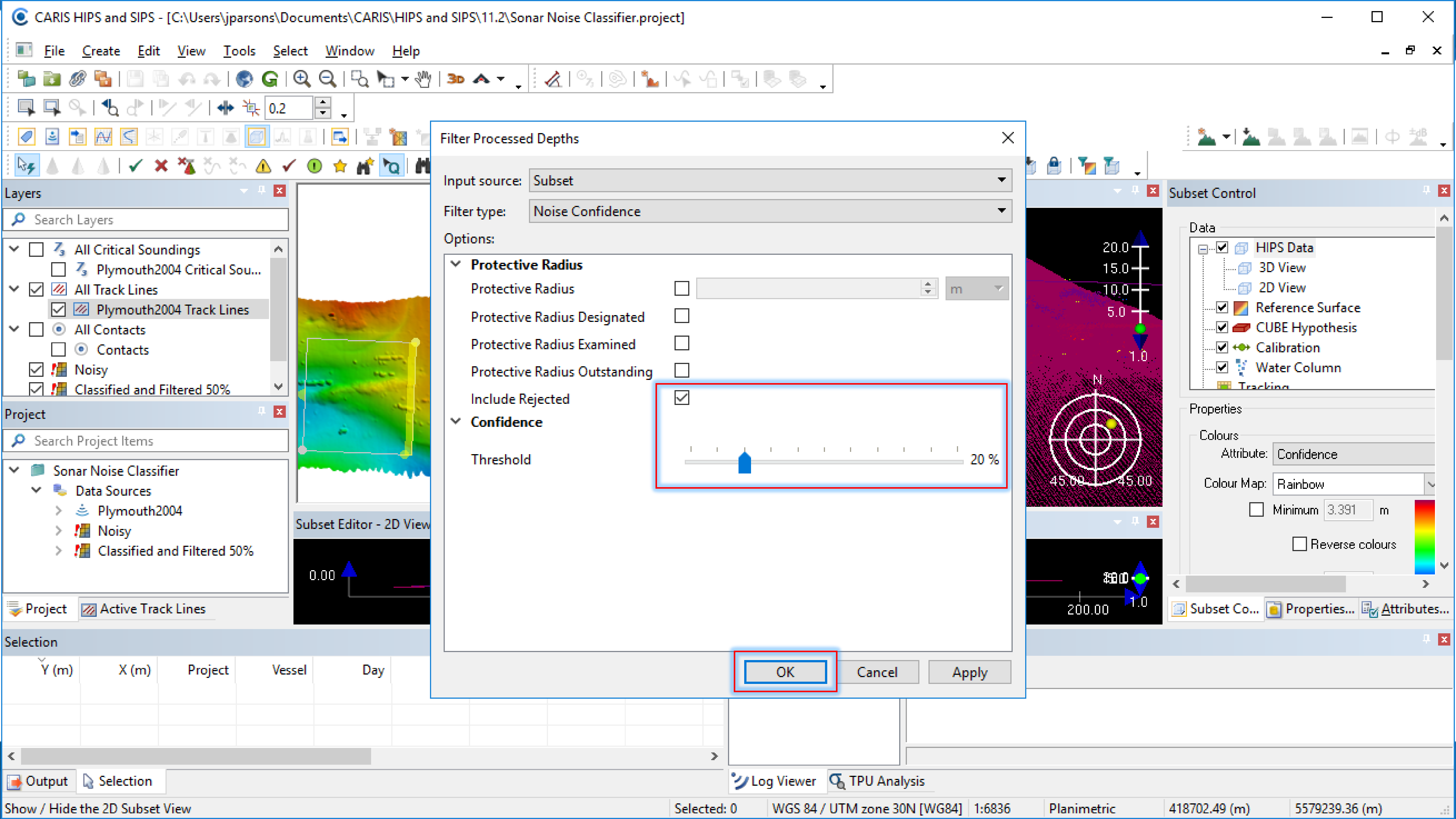
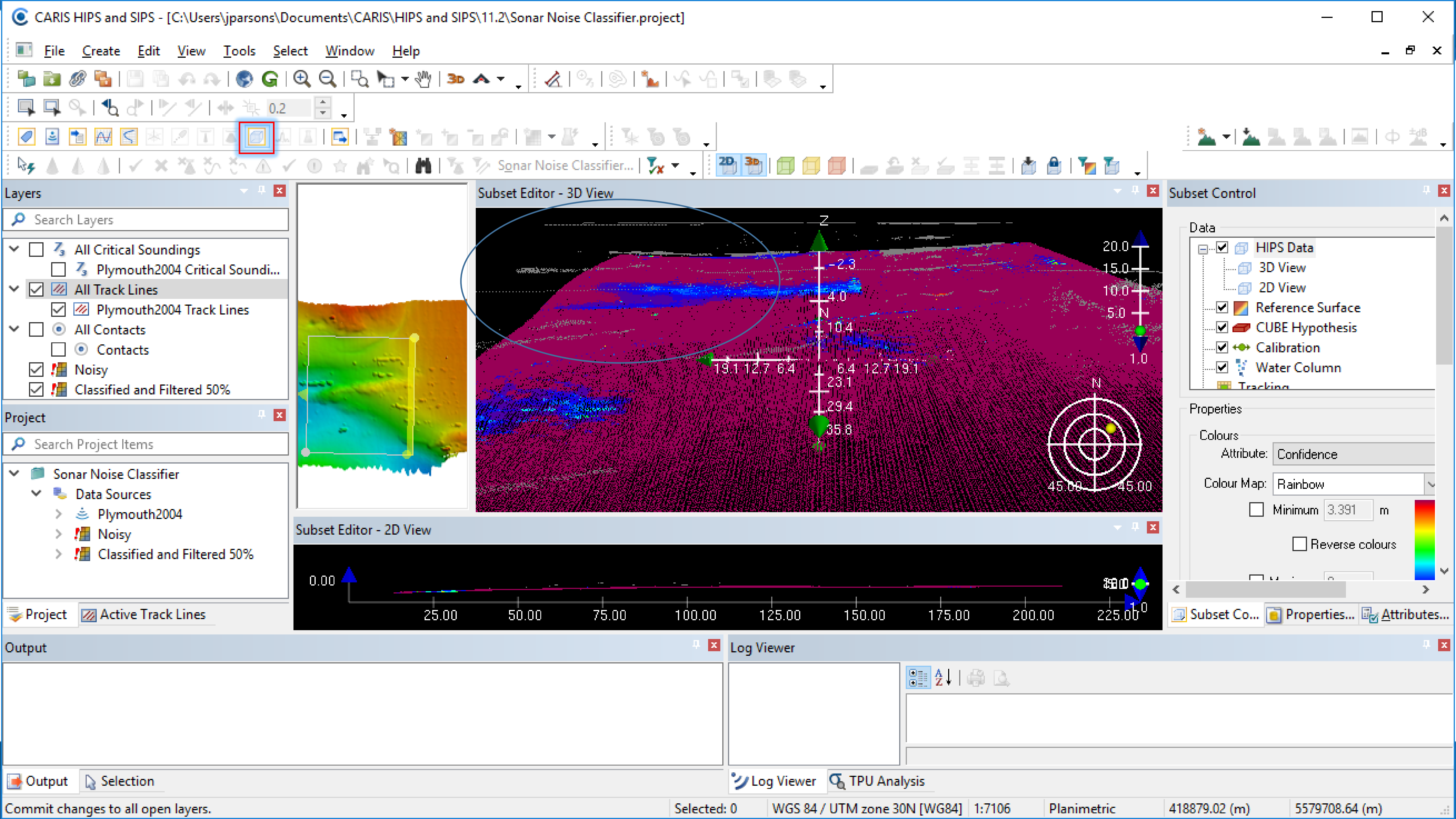
34.2 22.8 11.4
11.4 22.8 34.2
28.2
39.6
51.0
20.0
15.0
10.0
5.0
1.0
N
45.00
45.00
Subset Editor - 2D View
25.00
50.00
75.00
100.00
125.00
150.00
175.00
13.5
Subset Control
Data
HIPS Data
3D View
2D View
Reference Surface
CUBE Hypothesis
Calibration
Water Column
Tracking
Properties
Colours
Attribute:
Confidence
Colour Map:
Rainbow
Minimum
3.391
m
Reverse colours
Subset Co...
Properties...
Attributes...
Selection
Line
Profile
Beam
Time
Depth (m)
Q
Status
T...
Dp TPU (...
Output
Selection
Log Viewer
Log Viewer
TPU Analysis
Enable / Disable the display filter
Selected: 0
WGS 84 / UTM zone 30N [WG84]
1:6765
Planimetric
418865.08 (m)
5579679.05 (m)

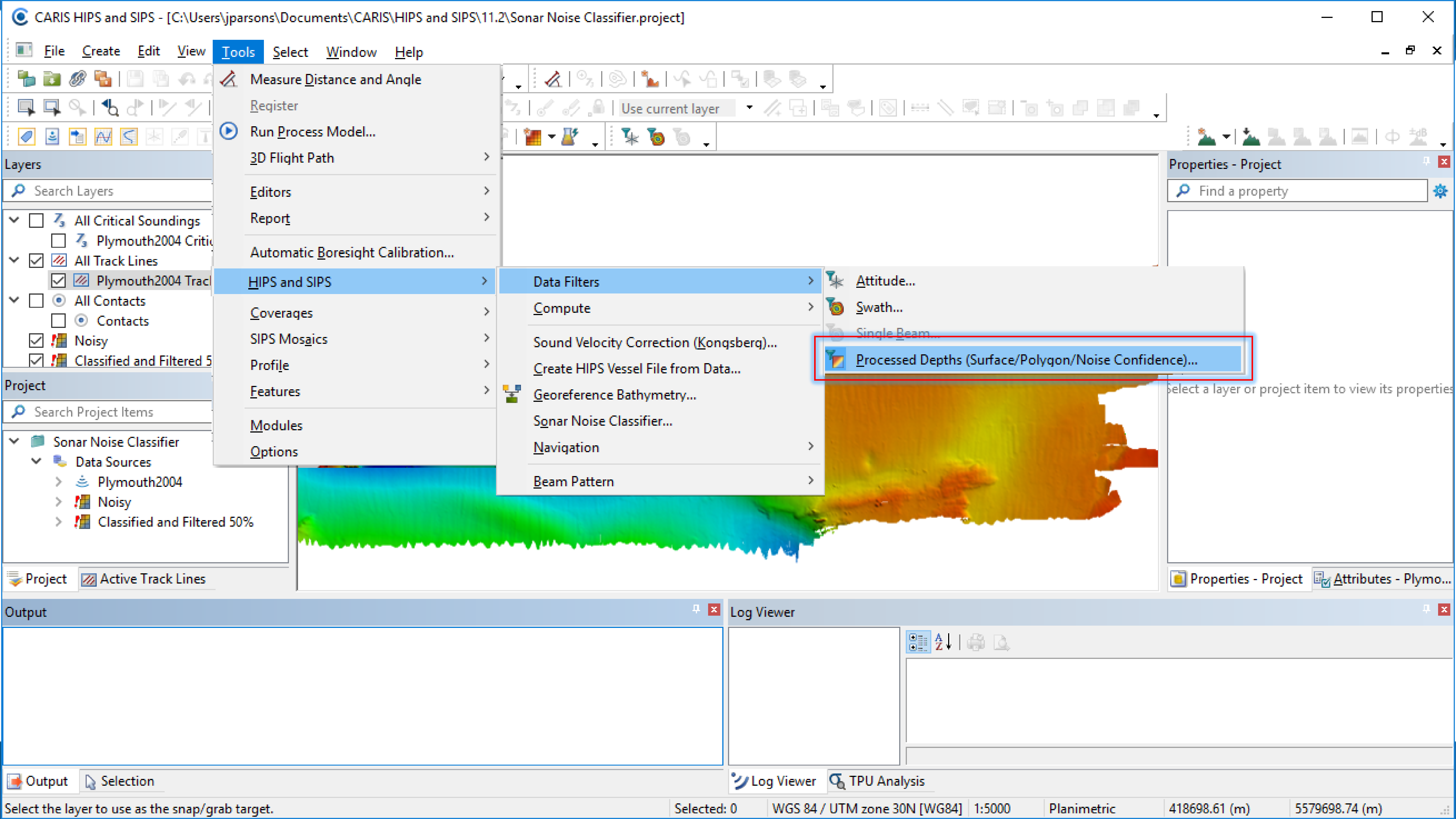

CARIS HIPS and SIPS - [C:\Users\jparsons\Documents\CARIS\HIPS and SIPS\11.2\Sonar Noise Classifier.project]
File Create Edit View Tools Select Window Help
Sonar Noise Classifier...
Layers
Search Layers
All Critical Soundings
Plymouth2004 Critical Sou...
All Track Lines
Plymouth2004 Track Lines
All Contacts
Contacts
Noisy
Classified and Filtered 50%
Project
Search Project Items
Sonar Noise Classifier
Data Sources
Plymouth2004
Noisy
Classified and Filtered 50%
Project
Active Track Lines
Subset Editor - 3D View
Subset Editor - 2D View
Subset Control
Data
HIPS Data
3D View
2D View
Reference Surface
CUBE Hypothesis
Calibration
Water Column
Properties
Colours
Attribute: Confidence
Colour Map: Rainbow
Minimum 3.391 m
Reverse colours
Subset Co...
Properties...
Attributes...
Selection
Profile | Beam | Time | Depth (m) | Q | Noise Confidence | Status
1,785 | 8 | 2004-08-04 09:42:43.843 | -3.674 | 0 | 99 | Reject (Area Filter)
1,785 | 9 | 2004-08-04 09:42:43.843 | -3.674 | 0 | 99 | Reject (Area Filter)
1,784 | 8 | 2004-08-04 09:42:43.703 | -3.674 | 0 | 99 | Reject (Area Filter)
Output
Selection
Log Viewer
TPU Analysis
Set the cursor in automatic edit mode
Selected: 0
WGS 84 / UTM zone 30N [WG84]
1:6765
Planimetric
418856.13 (m)
5579444.57 (m)

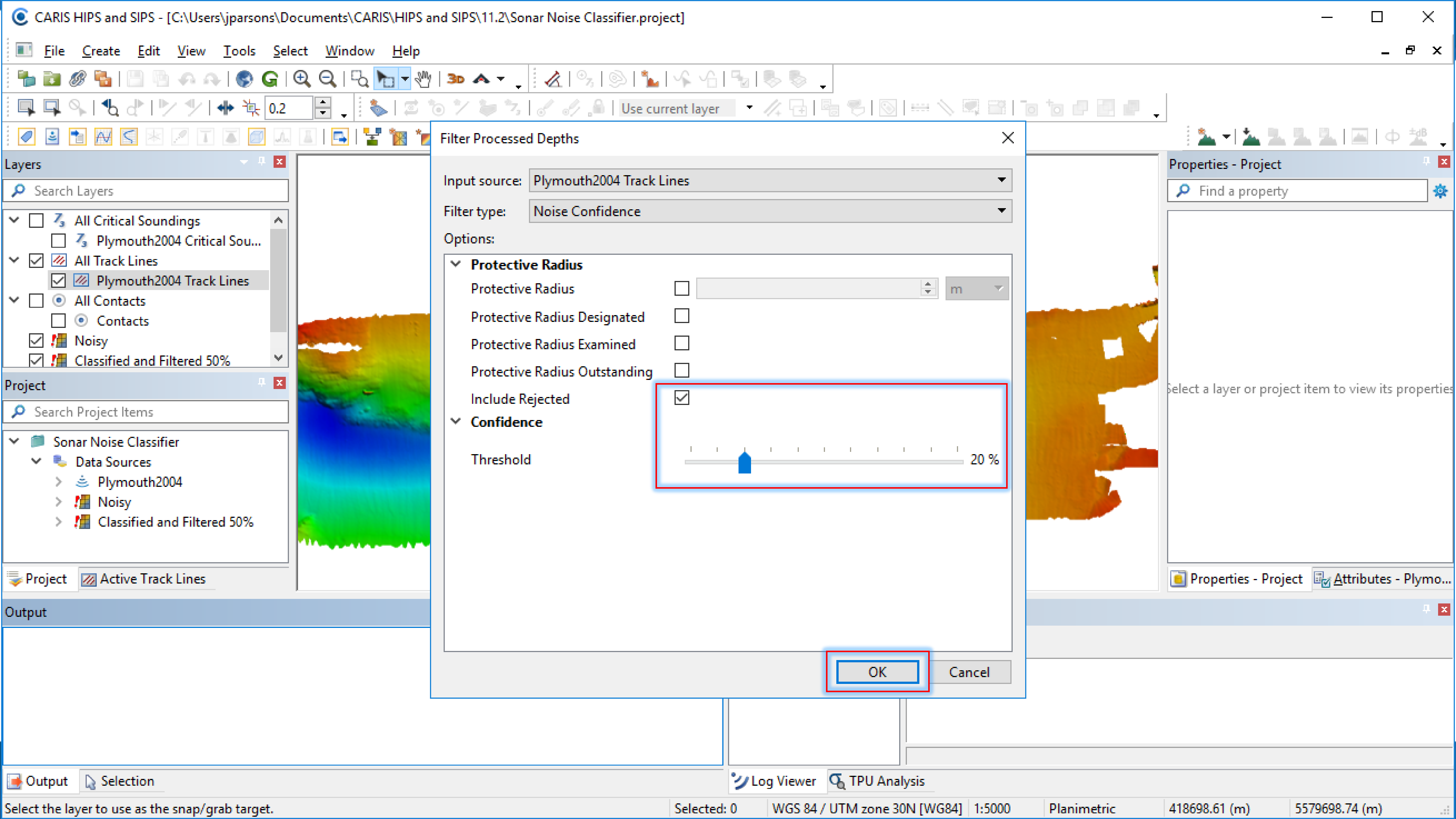

CARIS HIPS and SIPS - [C:\Users\jparsons\Documents\CARIS\HIPS and SIPS\11.2\Sonar Noise Classifier.project]
File
Create
Edit
View
Tools
Select
Window
Help
Filter Processed Depths
Input source: Subset
Filter type: Noise Confidence
Options:
Protective Radius
Protective Radius
m
Protective Radius Designated
Protective Radius Examined
Protective Radius Outstanding
Include Rejected
Confidence
Threshold
50 %
OK
Cancel
Apply
Layers
Search Layers
All Critical Soundings
Plymouth2004 Critical Sou...
All Track Lines
Plymouth2004 Track Lines
All Contacts
Contacts
Noisy
Classified and Filtered 50%
Project
Search Project Items
Sonar Noise Classifier
Data Sources
Plymouth2004
Noisy
Classified and Filtered 50%
Project
Active Track Lines
Subset Editor - 2D View
Subset Control
Data
HIPS Data
3D View
2D View
Reference Surface
CUBE Hypothesis
Calibration
Water Column
Tracking
Properties
Colours
Attribute: Confidence
Colour Map: Rainbow
Minimum 3.391 m
Reverse colours
Subset Co...
Properties...
Attributes...
Selection
Profile
Beam
Time
Depth (m)
Q
Noise
1,785 8 2004-08-04 09:42:43.843 -3.674 0
1,785 9 2004-08-04 09:42:43.843 -3.674 0 99 Reject (Area Filter) 4....
1,784 8 2004-08-04 09:42:43.703 -3.674 0 99 Reject (Area Filter) 4....
Output
Selection
Log Viewer
TPU Analysis
Set the cursor in automatic edit mode
Selected: 0
WGS 84 / UTM zone 30N [WG84]
1:6765
Planimetric
418856.13 (m)
5579444.57 (m)



CARIS HIPS and SIPS - [C:\Users\jparsons\Documents\CARIS\HIPS and SIPS\11.2\Sonar Noise Classifier.project]
File Create Edit View Tools Select Window Help
Layers
Search Layers
All Critical Soundings
Plymouth2004 Critical Sou...
All Track Lines
Plymouth2004 Track Lines
All Contacts
Contacts
Noisy
Classified and Filtered 50%
Project
Search Project Items
Sonar Noise Classifier
Data Sources
Plymouth2004
Noisy
Classified and Filtered 50%
Project
Active Track Lines
Subset Editor - 2D View
Filter Processed Depths
Input source: Subset
Filter type: Noise Confidence
Options:
Protective Radius
Protective Radius
Protective Radius Designated
Protective Radius Examined
Protective Radius Outstanding
Include Rejected
Confidence
Threshold
20 %
OK
Cancel
Apply
Subset Control
Data
HIPS Data
3D View
2D View
Reference Surface
CUBE Hypothesis
Calibration
Water Column
Tracking
Properties
Colours
Attribute: Confidence
Colour Map: Rainbow
Minimum 3.391 m
Reverse colours
Subset Co...
Properties...
Attributes...
Selection
Y (m)
X (m)
Project
Vessel
Day
Output
Selection
Log Viewer
TPU Analysis
Show / Hide the 2D Subset View
Selected: 0
WGS 84 / UTM zone 30N [WG84]
1:6836
Planimetric
418702.49 (m)
5579239.36 (m)

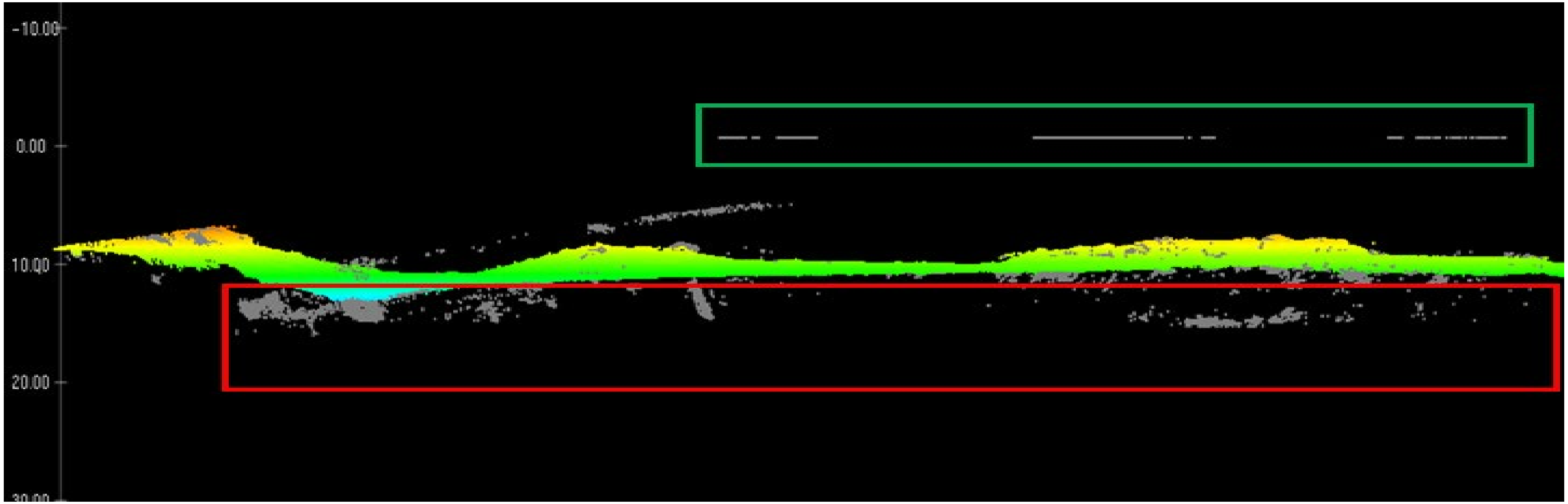

CARIS HIPS and SIPS - [C:\Users\jparsons\Documents\CARIS\HIPS and SIPS\11.2\Sonar Noise Classifier.project]
File Create Edit View Tools Select Window Help
Sonar Noise Classifier...
Layers
Search Layers
All Critical Soundings
Plymouth2004 Critical Soundi...
All Track Lines
Plymouth2004 Track Lines
All Contacts
Contacts
Noisy
Classified and Filtered 50%
Project
Search Project Items
Sonar Noise Classifier
Data Sources
Plymouth2004
Noisy
Classified and Filtered 50%
Project
Active Track Lines
Subset Editor - 3D View
Subset Editor - 2D View
Subset Control
Data
HIPS Data
3D View
2D View
Reference Surface
CUBE Hypothesis
Calibration
Water Column
Properties
Colours
Attribute: Confidence
Colour Map: Rainbow
Minimum 3.391 m
Reverse colours
Subset Co...
Properties...
Attributes...
Output
Log Viewer
Output
Selection
Log Viewer
TPU Analysis
Commit changes to all open layers.
Selected: 0
WGS 84 / UTM zone 30N [WG84]
1:7106
Planimetric
418879.02 (m)
5579708.64 (m)


CARIS HIPS and SIPS - [C:\Users\jparsons\Documents\CARIS\HIPS and SIPS\11.2\Sonar Noise Classifier.project]
File
Create
Edit
View
Tools
Select
Window
Help
Measure Distance and Angle
Register
Run Process Model...
3D Flight Path
Editors
Report
Automatic Boresight Calibration...
HIPS and SIPS
Coverages
SIPS Mosaics
Profile
Features
Modules
Options
Data Filters
Compute
Sound Velocity Correction (Kongsberg)...
Create HIPS Vessel File from Data...
Georeference Bathymetry...
Sonar Noise Classifier...
Navigation
Beam Pattern
Attitude...
Swath...
Single Beam...
Processed Depths (Surface/Polygon/Noise Confidence)...
Use current layer
Layers
Search Layers
All Critical Soundings
Plymouth2004 Critic
All Track Lines
Plymouth2004 Tracl
All Contacts
Contacts
Noisy
Classified and Filtered 5
Project
Search Project Items
Sonar Noise Classifier
Data Sources
Plymouth2004
Noisy
Classified and Filtered 50%
Project
Active Track Lines
Properties - Project
Find a property
Select a layer or project item to view its properties
Properties - Project
Attributes - Plymo...
Output
Log Viewer
Output
Selection
Log Viewer
TPU Analysis
Select the layer to use as the snap/grab target.
Selected: 0
WGS 84 / UTM zone 30N [WG84]
1:5000
Planimetric
418698.61 (m)
5579698.74 (m)


CARIS HIPS and SIPS - [C:\Users\jparsons\Documents\CARIS\HIPS and SIPS\11.2\Sonar Noise Classifier.project]
File
Create
Edit
View
Tools
Select
Window
Help
Use current layer
Layers
Search Layers
All Critical Soundings
Plymouth2004 Critical Sou...
All Track Lines
Plymouth2004 Track Lines
All Contacts
Contacts
Noisy
Classified and Filtered 50%
Project
Search Project Items
Sonar Noise Classifier
Data Sources
Plymouth2004
Noisy
Classified and Filtered 50%
Project
Active Track Lines
Output
Output
Selection
Filter Processed Depths
Input source:
Plymouth2004 Track Lines
Filter type:
Noise Confidence
Options:
Protective Radius
Protective Radius
m
Protective Radius Designated
Protective Radius Examined
Protective Radius Outstanding
Include Rejected
Confidence
Threshold
20 %
OK
Cancel
Properties - Project
Find a property
Select a layer or project item to view its properties
Properties - Project
Attributes - Plymo...
Log Viewer
TPU Analysis
Select the layer to use as the snap/grab target.
Selected: 0
WGS 84 / UTM zone 30N [WG84]
1:5000
Planimetric
418698.61 (m)
5579698.74 (m)

Performance / Accuracy

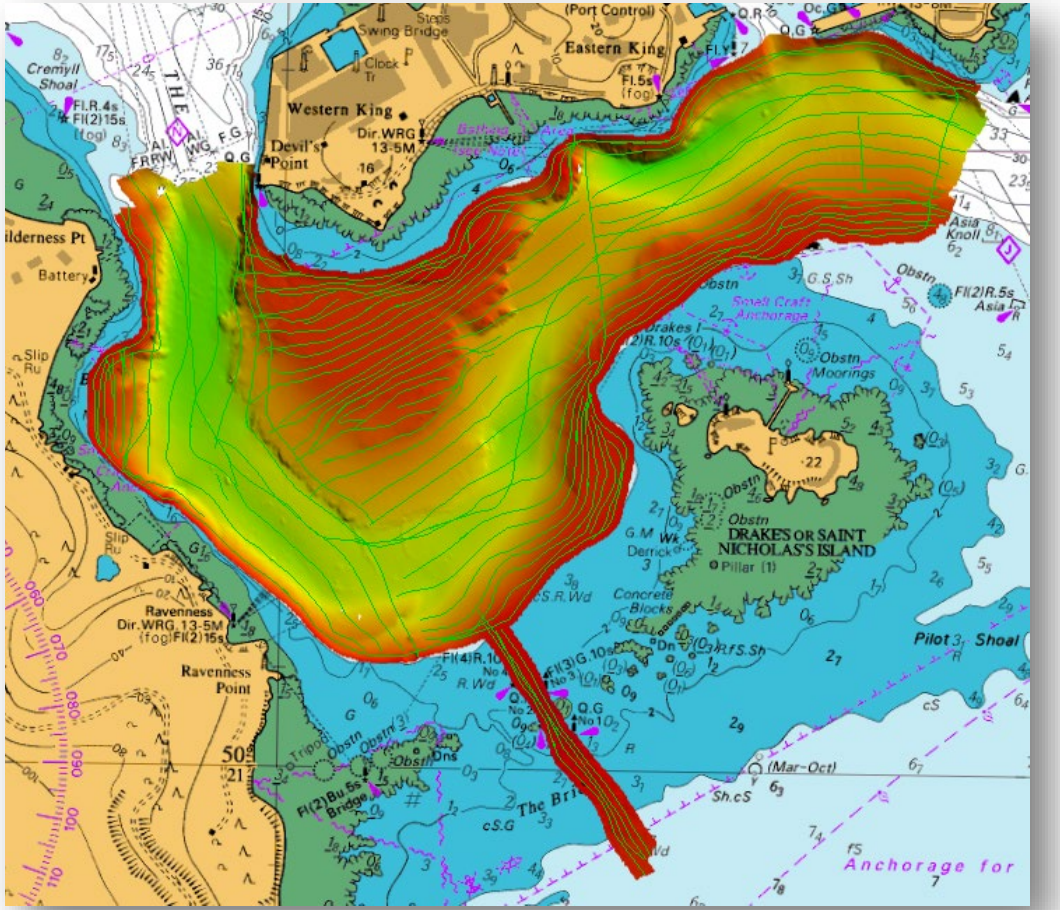
- > 97% “real” points retained
- ~95% noisy points classified



Reducing Processing Times

Shallow Survey 2015 Demo Dataset

- *Collected using Teledyne Seabat T20P*
- *Approx 175M soundings*
- *44 line km of survey*
- *Roughly 9 ½ hours online survey time*



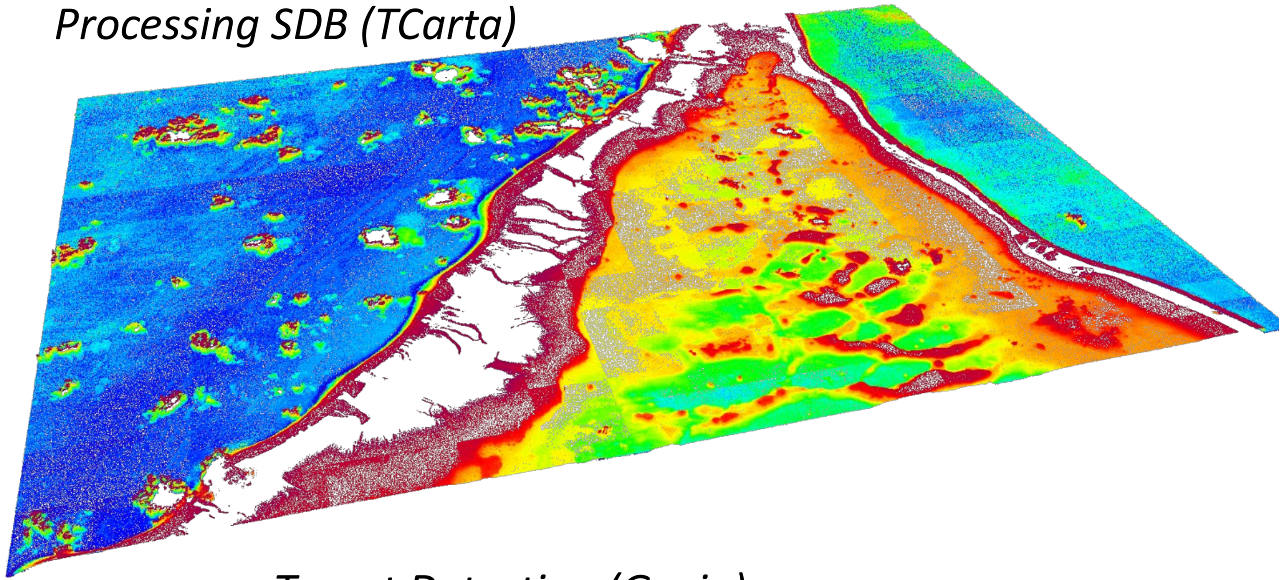
Time Trials

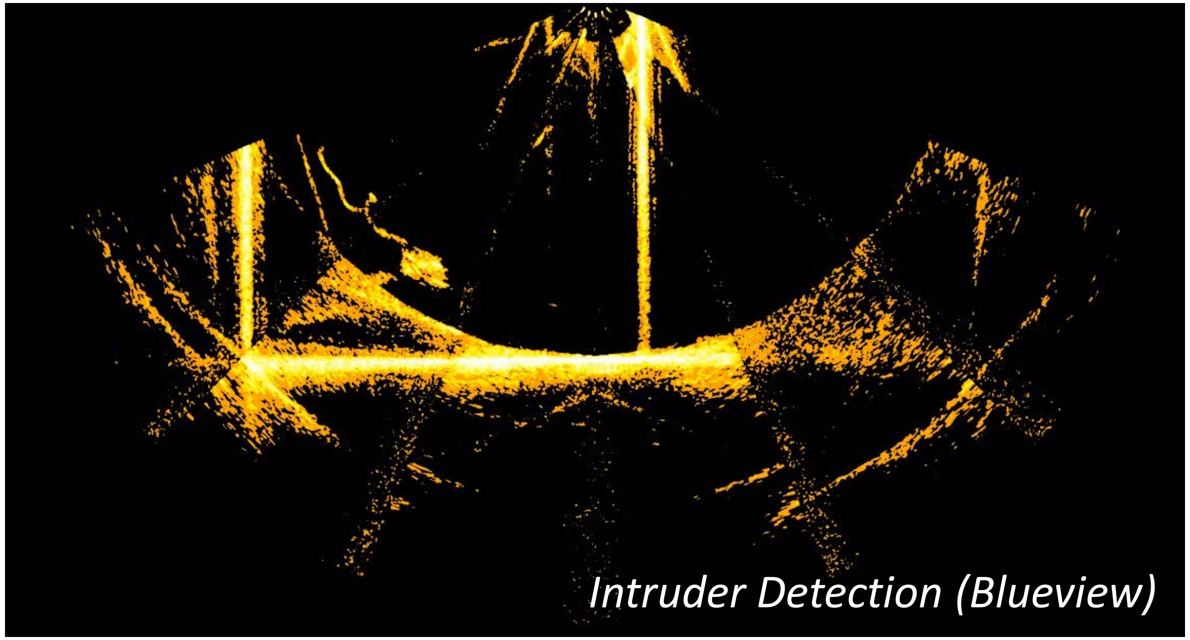
- Time trials (N=1, HH:MM)

Workflow	Automatic	Manual	Total	Acquisition/Processing
Manual	00:00	05:52	05:52	**1h/36m**
Terrain Model Filtering	00:29	02:30	02:59	**1h/20m**
AI Noise Classifier	00:20	00:35	00:55	**1h/6m**

Other CARIS AI Initiatives

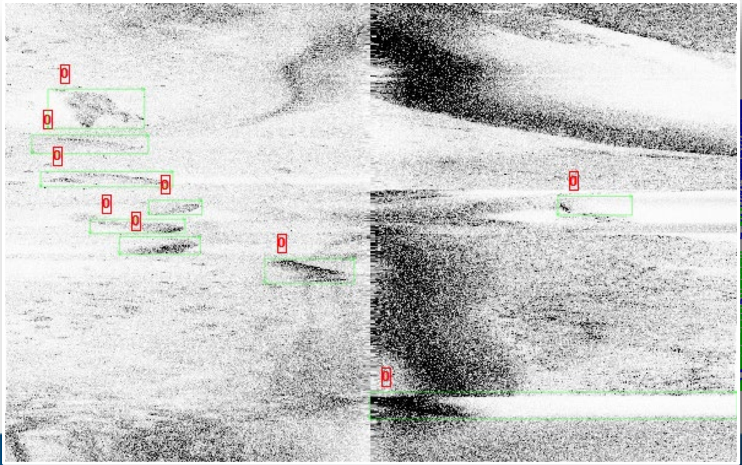
Processing SDB (TCarta)



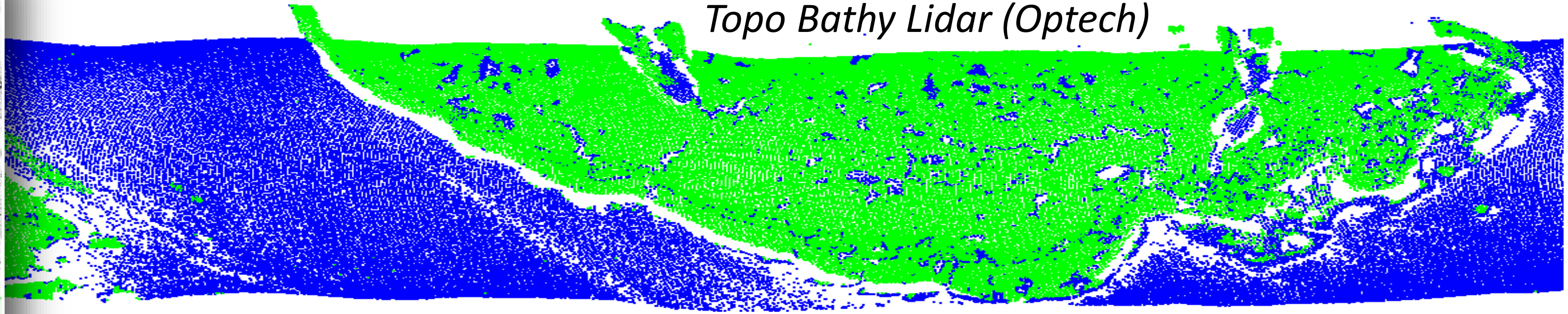


Intruder Detection (Blueview)

Target Detection (Gavia)



Topo Bathy Lidar (Optech)



Mapping the Gaps

- Option to apply AI when contributing bathy data (e.g. DCDB website)
- Run data through Cloud based AI algorithm for noise removal
  - Providing data processing consistency
- Streamline data integration into regional and / or GEBCO grid
- Potential to use AI to make legacy data consistent
- Develop a “community” to further train the AI algorithm
  - Incentivize

Thank You
Questions?

@hydrohogg