Case Study: A Remote Sensing Approach to Site Selection for an Urban Deployment of Nodal Seismometers

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Introduction

Seismic data acquisition is a key step in seismic hazard mitigation, providing valuable data used in hazard assessments and tomographic imaging. Cities have the highest potential of life loss and property damage; however, urbanization makes it difficult to acquire quality data. The challenge in urban deployments lies in spacing constraints and access to suitable locations. Below, we describe a remote sensing approach often used in land cover assessments to locate features of interest (FOIs) associated with suitable deployment locations for an ambient noise seismic experiment in Las Vegas, Nevada[1][2].

Methods

Figure 1A- Sentinel-2 RGB band imagery of the Las Vegas Basin (1200 km2) at 10 meters resolution.

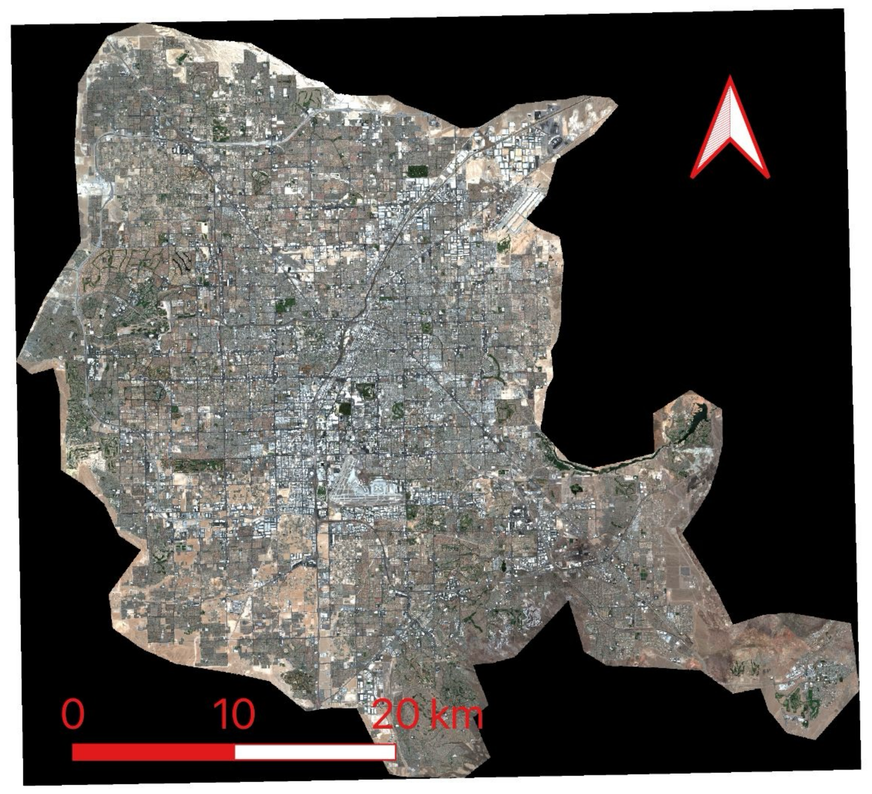


Figure 1B- Normalized Difference Vegitation Index (NDVI).
NDVI = (NIR-RED) / (NIR + RED)

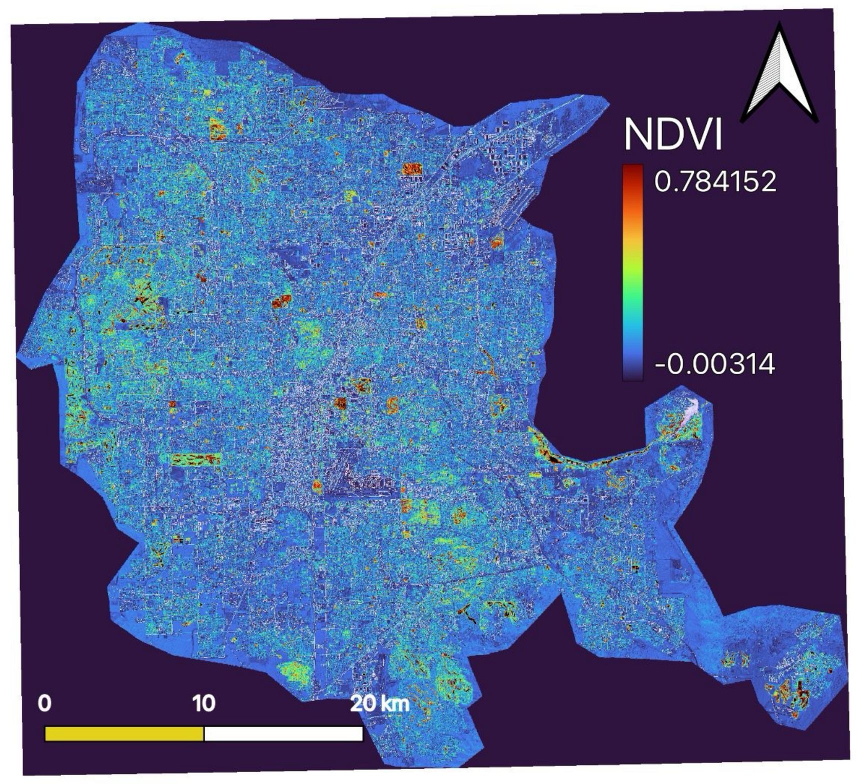


Figure 1C- Band classification of the NDVI raster layer employing a band clustering algorithm. Some of the original ten classes were combined, reducing observations to five.

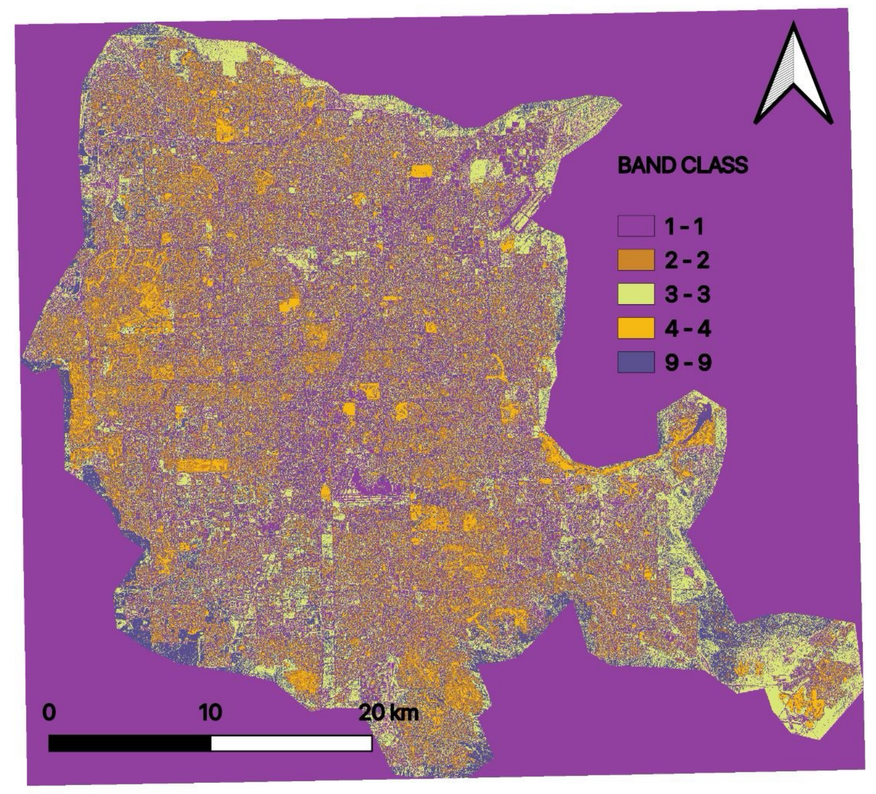


Figure 1D- Spectral signatures and NDVI indexes for the resulting band class layer. Notably, Class 2 and Class 4 have distinct spectral signatures. Their average NDVI indexes lie in the range associated with our FOIs[3].

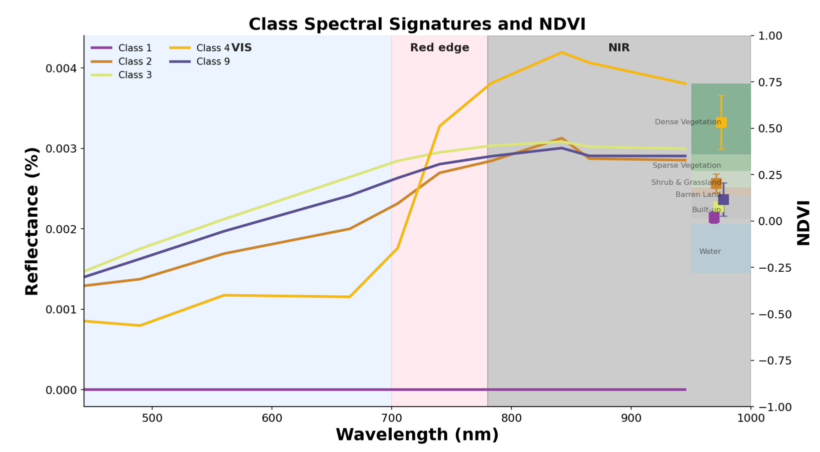


Figure 1E- Quality control and verification procedure for the classification raster layer. Here we manually compare our classified raster to RGB imagery FOIs to verify the band class pixels and rename the classes according to each class common features.

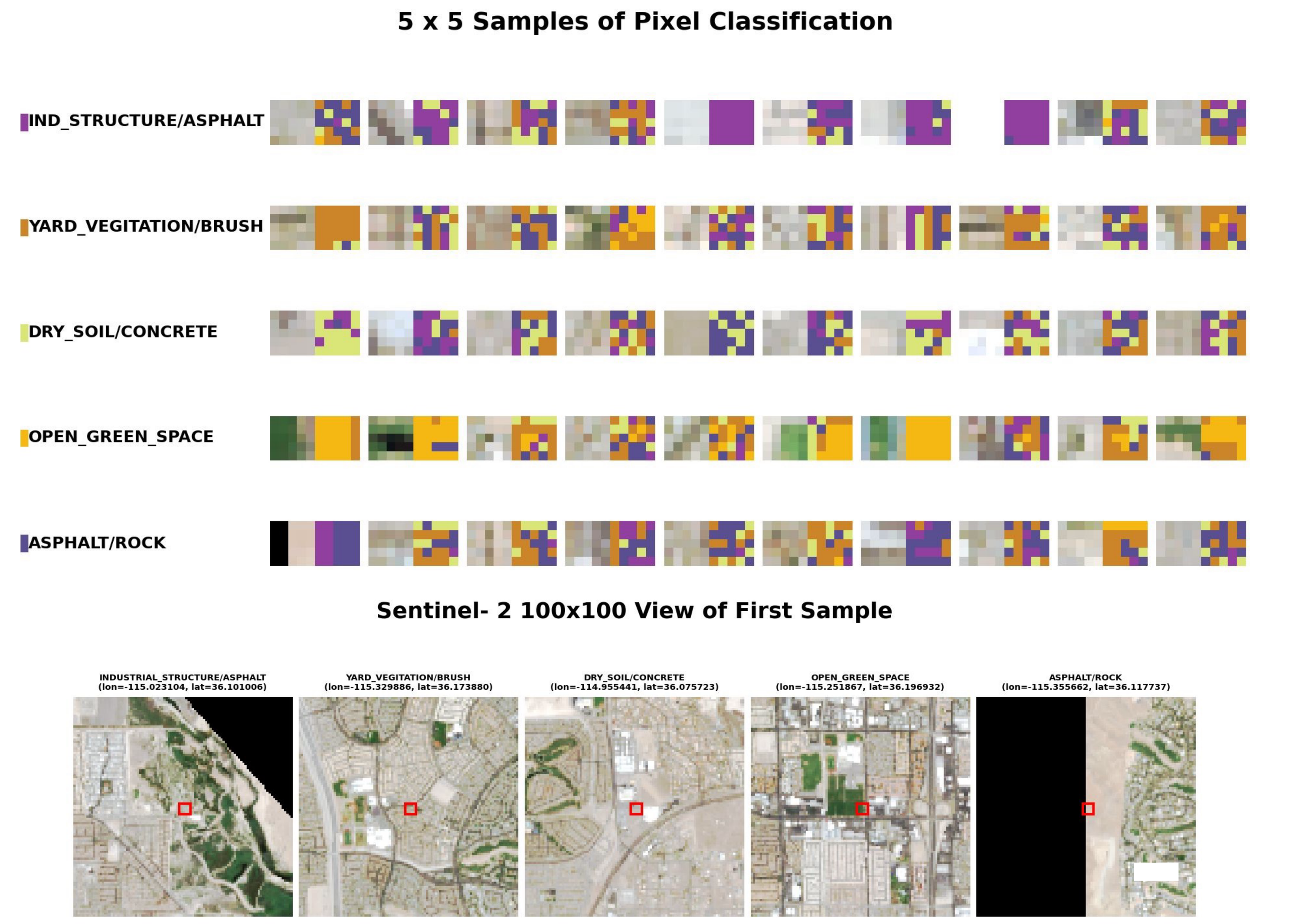


Figure 2A- After geolocating the pixels of class 2 and 4, we use a blue noise poisson disk sampling method to achieve a uniform distribution of 120 potential stations while maintaining a ~5 km2 spacing.

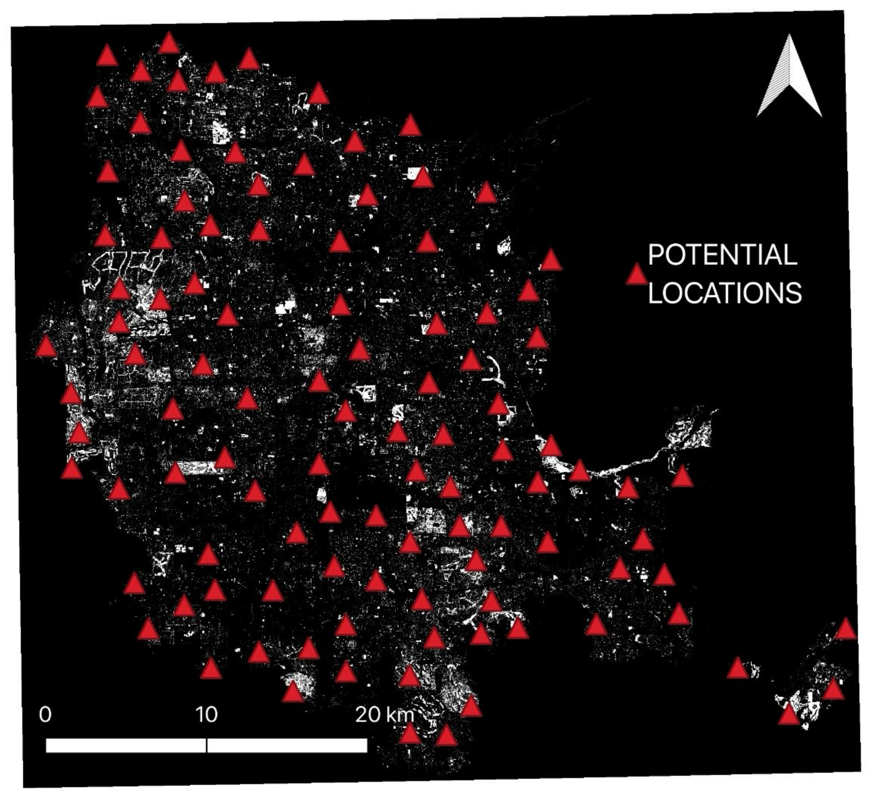


Figure 2B - Early June 2025, We deployed 91 of 106 available seismometers. They were retrieved ~30 days later [2](Poster #020).

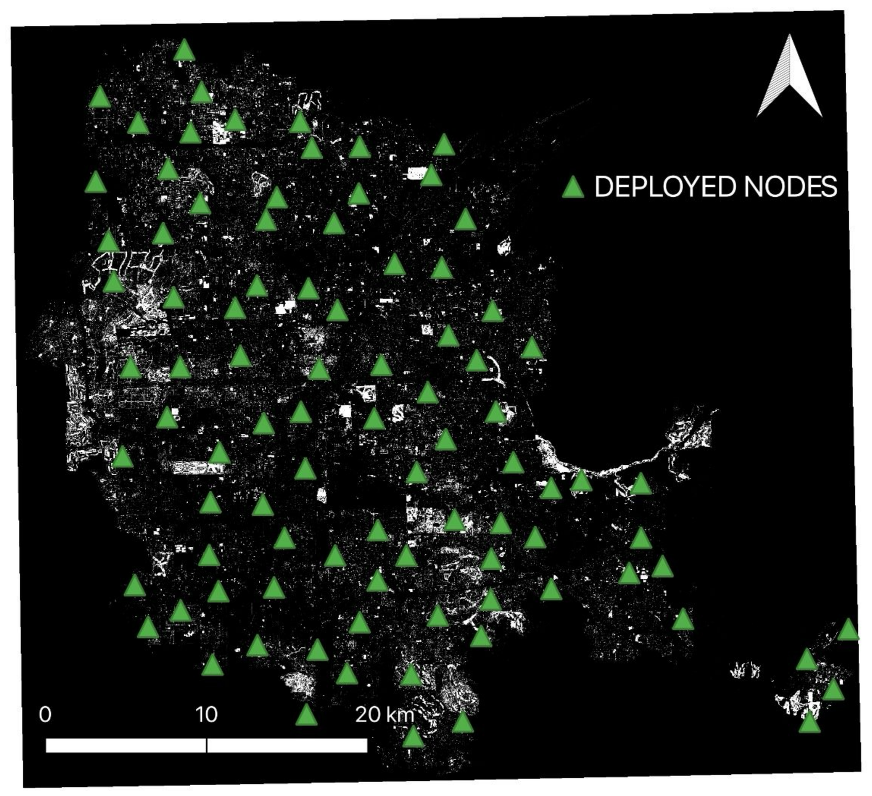
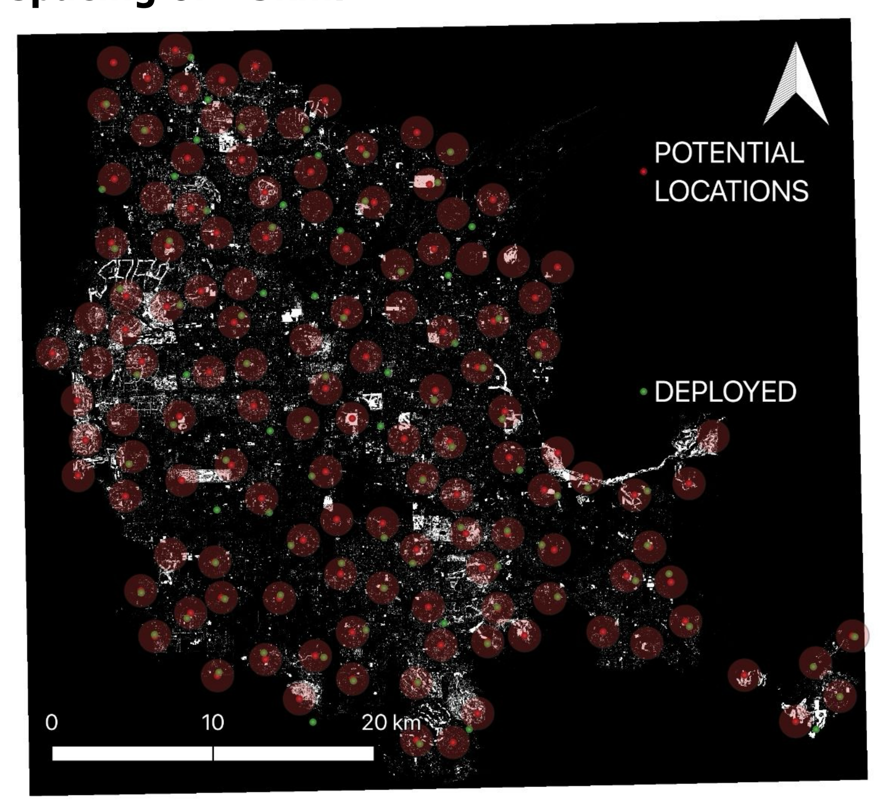


Figure 2C- Researchers aimed to deploy stations to nearest potential location, within a 5km2 radius buffer. The buffer helps increase acquisition opportunities, while keeping the instrument within proximity of the desired spacing of ~5km.



Results and Future Work

Figure 3A- Using the deployed station locations, we computed the optimal potential coverage for an ambient noise tomographic study that aims to image between 10-20 km[4]. We searched for pairs ≥resolvable wavelength, ~14.64 km (~3*avg. spacing). Using a generic Rayleigh wave dispersion reference curve, we identified an optimal period band with sufficient pairs between 6.65s and 12.15s.

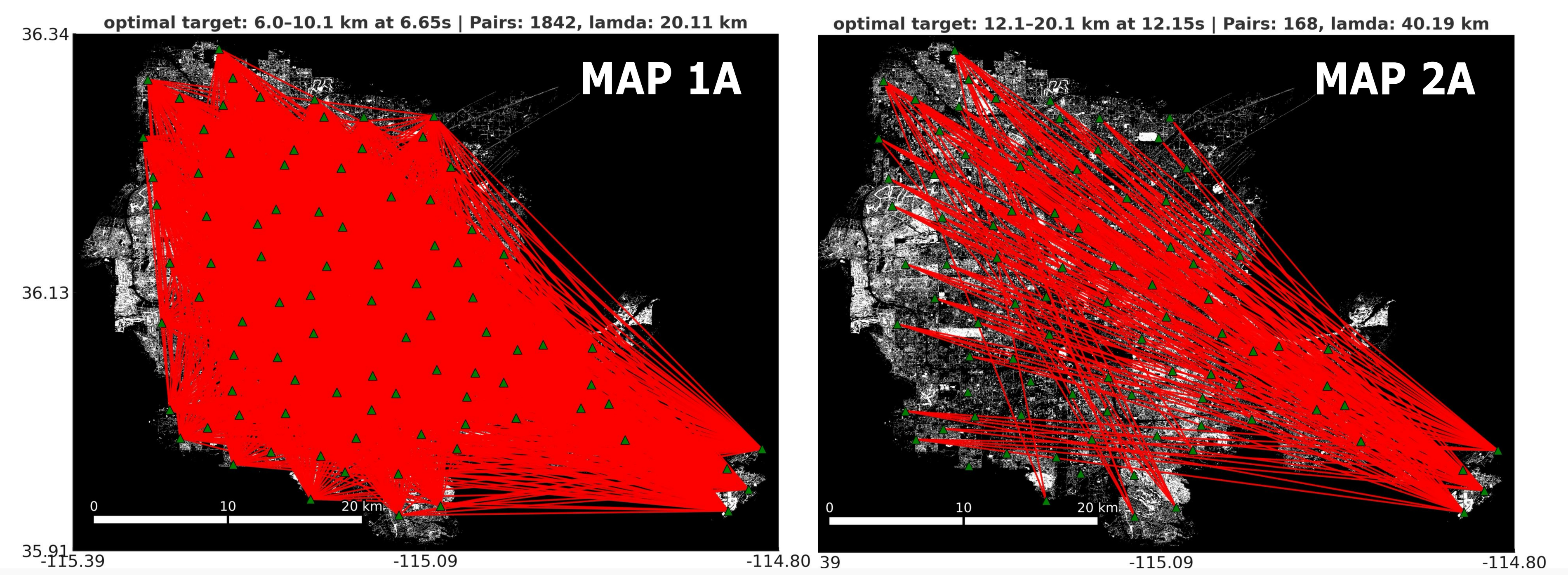


Table 1B- Deployment metrics.

Measurement	Value
NN4 Spacing (km)	4.88
min lamda (km)	14.64
Pmin (s)	5.05
Pmax (s)	16.70
Deployed–Potential Dist avg (m)	931.00
Deployed–Potential Dist std (m)	737.00
Deployed–Potential Dist min (m)	29.70
Deployed–Potential Dist max (m)	2915.50
Deployed–Class Dist avg (m)	7.21
Deployed–Class Dist std (m)	15.07
Deployed–Class Dist min (m)	0.00
Deployed–Class Dist max (m)	133.42
Deployed within 5km2 buffer	66 / 91

Discussion & Conclusion

This remote sensing approach offers a supervised, fairly automated process that provides a random distribution of potentially ideal deployment locations in urban settings based on FOIs. The FOI's purpose is to offer a distribution of potential locations that intersect with an advantage towards the deployment of the instrument. A FOI can be practical or scientific, or some combination of both. For this study, we determined an FOI to be sparse vegetation because of its strong association with neighborhood yards in Las Vegas, NV. This approach is subject to inaccuracies introduced by poor raster resolution and misclassification of FOIs, which further emphasizes the role of the observer. In most use cases, specifically seismology, we may have geologic interest where station density may be weak due to the random distribution. We can control distribution manually using polygons in a specific area during the array design or adjust them in the field. In the field, we consult the class layer for direction using electronic field mapping software like ArcGis FieldMaps or CalTopo[3](Poster #020). The resulting array will be used to compute ambient noise tomography (Fig. 2A). Overall, this method offers the potential to help mitigate the challenge of siting for an urban deployment.

References

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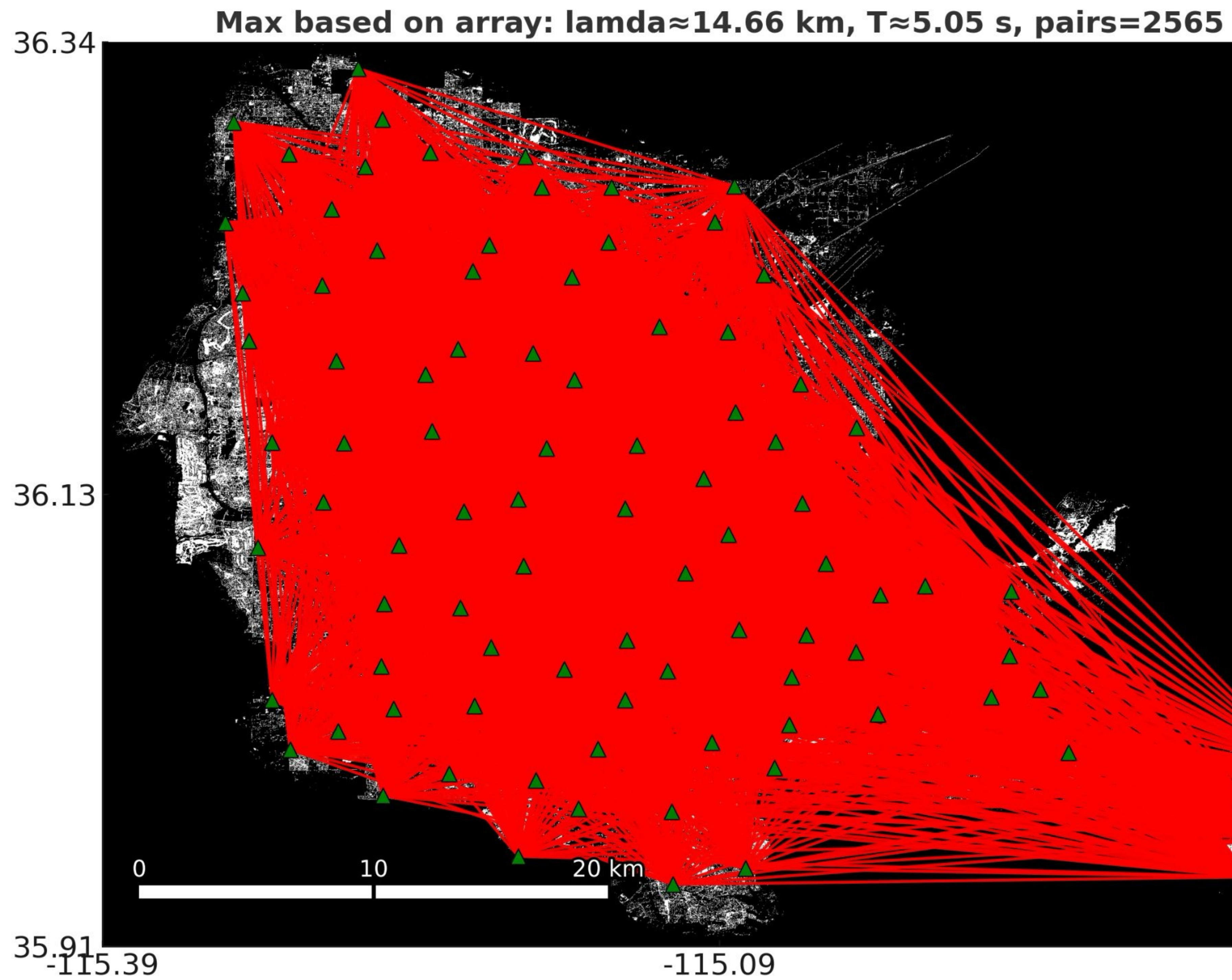

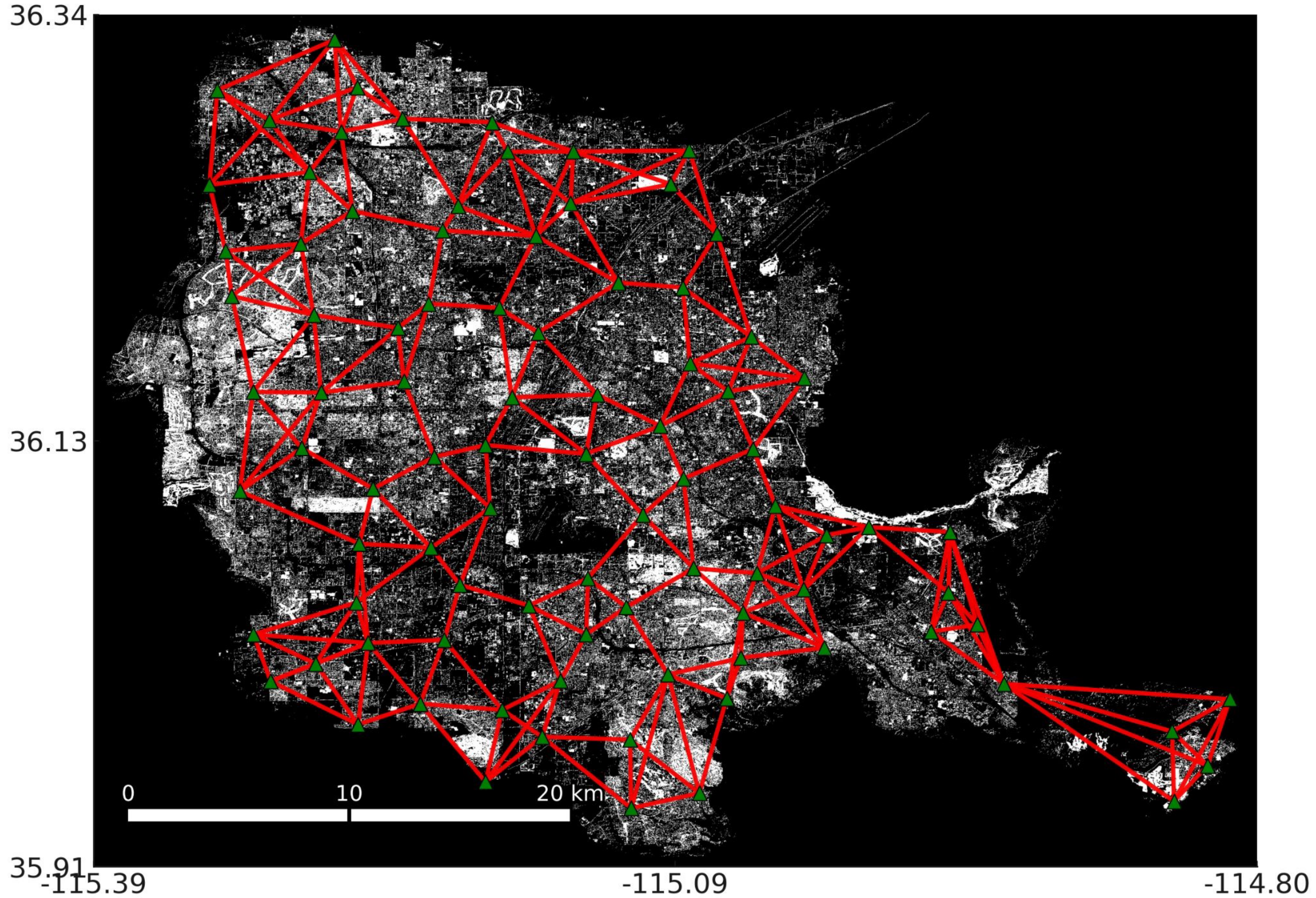

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