Multispectral, superspectral, and hyperspectral data fusion to support ecosystem monitoring

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Introduction

- Recent and future satellite missions are poised to rapidly expand the availability of hyperspectral imagery (with hundreds of spectral bands) and "superspectral" imagery (Landsat Next[1] with 26 bands).
- It is important to understand the benefits of the improved spectral and temporal resolutions these missions will provide and to develop approaches for integrating them with existing datasets, like the Harmonized Landsat and Sentinel-2 (HLS) product[2].
- Our goals:
  1. Develop an approach for harmonizing HLS imagery with superspectral Landsat Next imagery
  2. Test how Landsat Next's enhanced spectral resolution can improve the identification of invasive annual grasses in the western US – an existing workflow[3] that utilizes HLS imagery

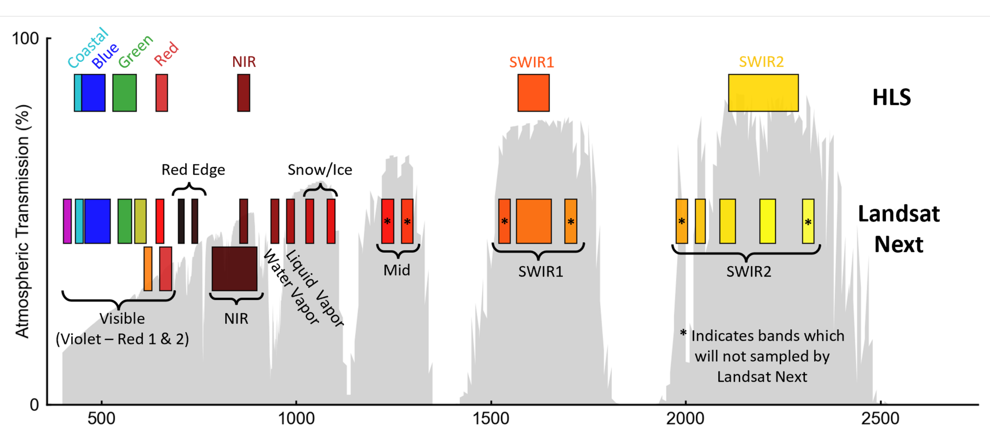

Figure 1. A comparison of the spectral resolution of HLS imagery and the Landsat Next imagery which we are creating.

Methods

- Collect training dataset of coincident cloud-free HLS and hyperspectral Earth Surface Mineral Dust Source Investigation (EMIT)[4] satellite imagery of sagebrush biome in the western US
- Create synthetic Landsat Next bands from hyperspectral EMIT images
- Train a deep-learning model to predict Landsat Next spectral bands from HLS spectral bands
- Use the derived Landsat Next imagery to identify invasive annual grasses across the western US. Does the enhanced spectral resolution improve our current workflow which uses HLS imagery?

Results and Discussion

- Our training dataset consists of >2 million points (and growing) of coincident HLS and EMIT imagery (Figure 2)
- The feed-forward deep neural network is highly accurate, with mean errors of <10% across all 26 bands (Figure 4)
- The model is robust and capable of accurate predictions across our spatial and temporal domain (as seen from a spatiotemporal cross-validation testing and visual inspection) (Figure 5)
- The modeled Landsat Next images capture the annual progression of point reflectance in much finer detail than original HLS imagery (Figure 3)
- Future work will test the serviceability of the modeled Landsat Next imagery for real-world applications by incorporating them into existing invasive species identification workflows[3]

References

[1]USGS—United States Geological Survey. Landsat Next, 2024. Available online: https://www.usgs.gov/landsat-missions/landsat-next (accessed on 28 March 2025).
[2]Claverie, M., Ju, J., Masek, J. G., Dungan, J. L., Vermote, E. F., Roger, J. C., ... & Justice, C. (2018). The Harmonized Landsat and Sentinel-2 surface reflectance data set. Remote Sensing of Environment, 219, 145-161.
[3]Dahal, D., Pastick, N. J., Boyte, S. P., Parajuli, S., Oimoen, M. J., & Megard, L. J. (2022). Multi-species inference of exotic annual and native perennial grasses in rangelands of the Western United States using harmonized Landsat and Sentinel-2 data. Remote Sensing, 14(4), 807.
[4]Green, R. O., Mahowald, N., Ung, C., Thompson, D. R., Bator, L., Bennet, M., ... & Zan, J. (2020, March). The Earth surface mineral dust source investigation: An Earth science imaging spectroscopy mission. In 2020 IEEE aerospace conference (pp. 1-15). IEEE.

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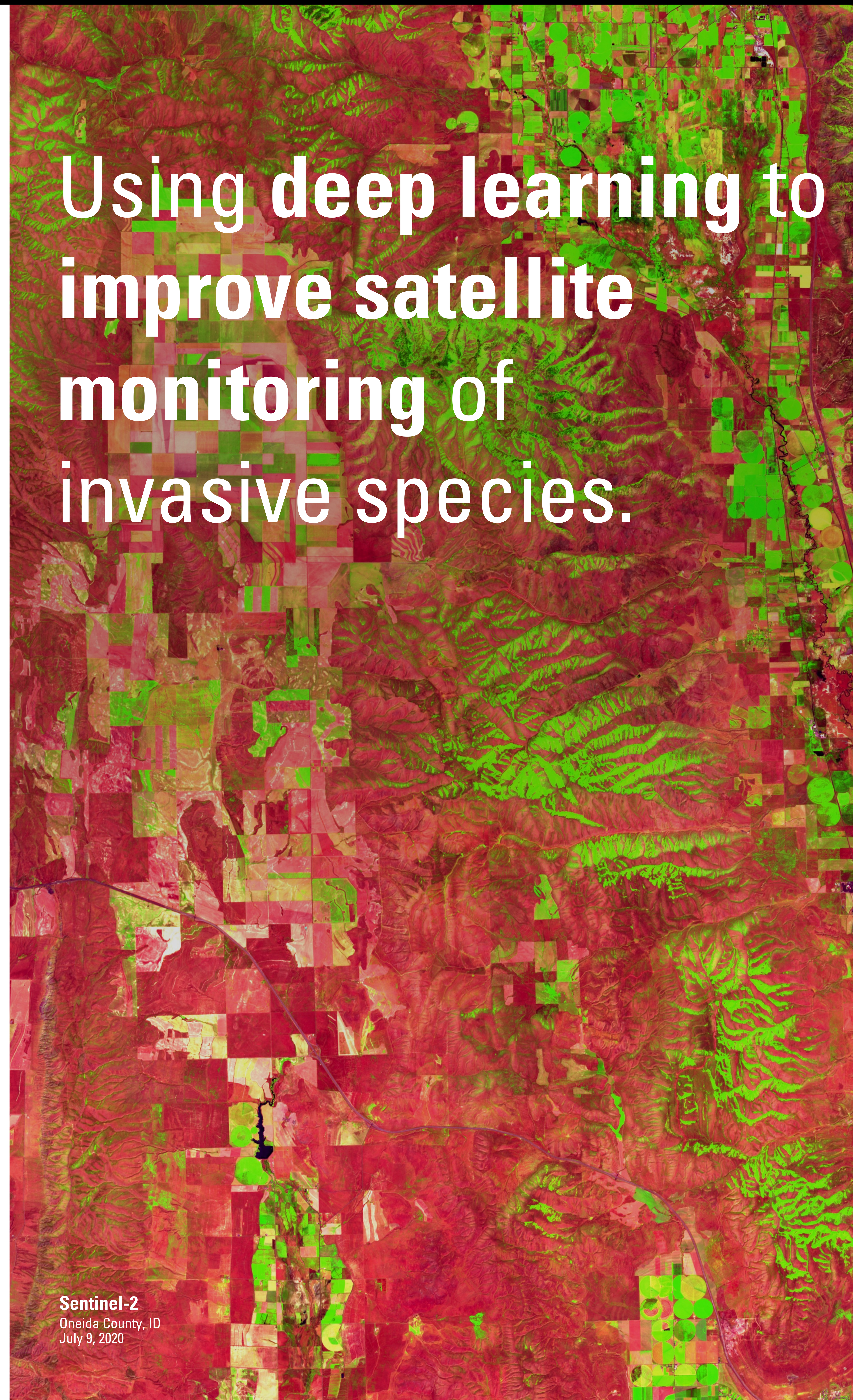

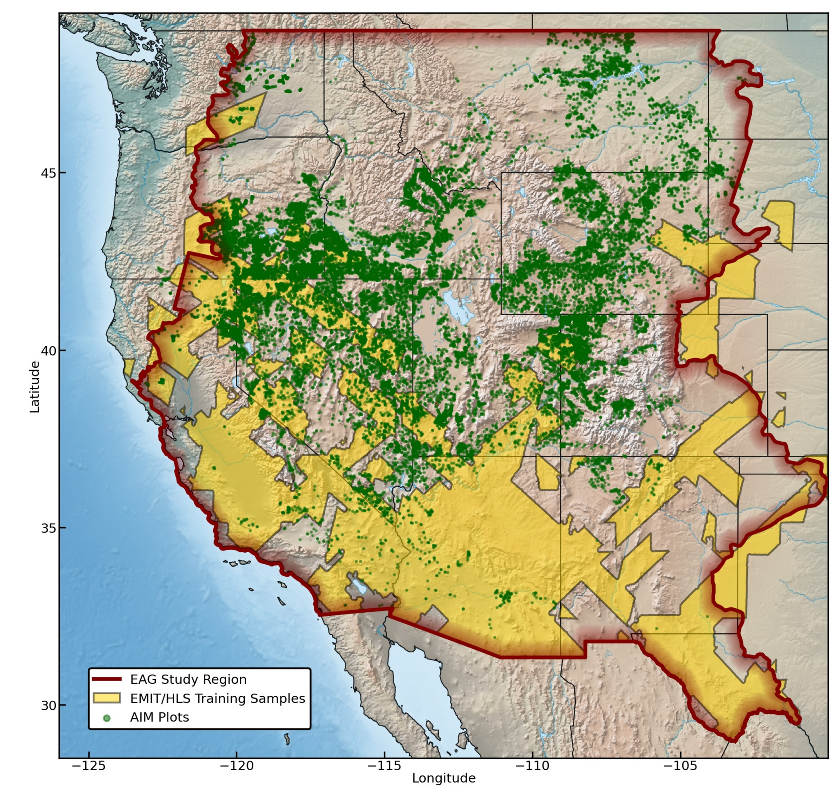

Figure 2. The study area (red), with locations of coincident HLS/EMIT training points (yellow) and in-situ exotic annual grass observations (green).

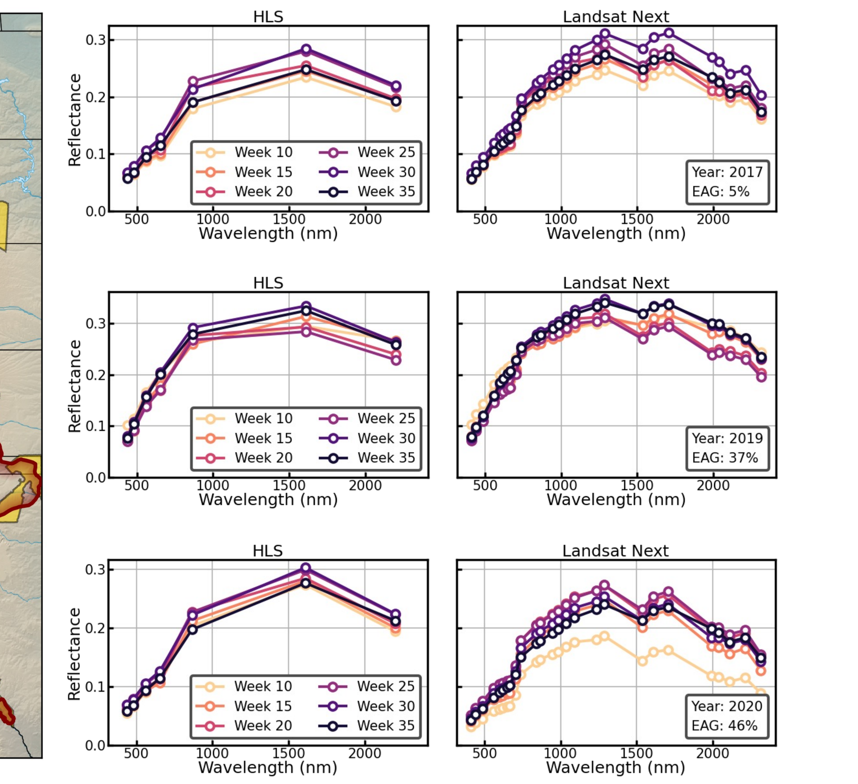

Figure 3. Examples of the annual progression of reflectance curves at three points for HLS (left) and modeled Landsat Next (right), highlighting the details revealed by the higher spectral resolution Landsat Next observations.

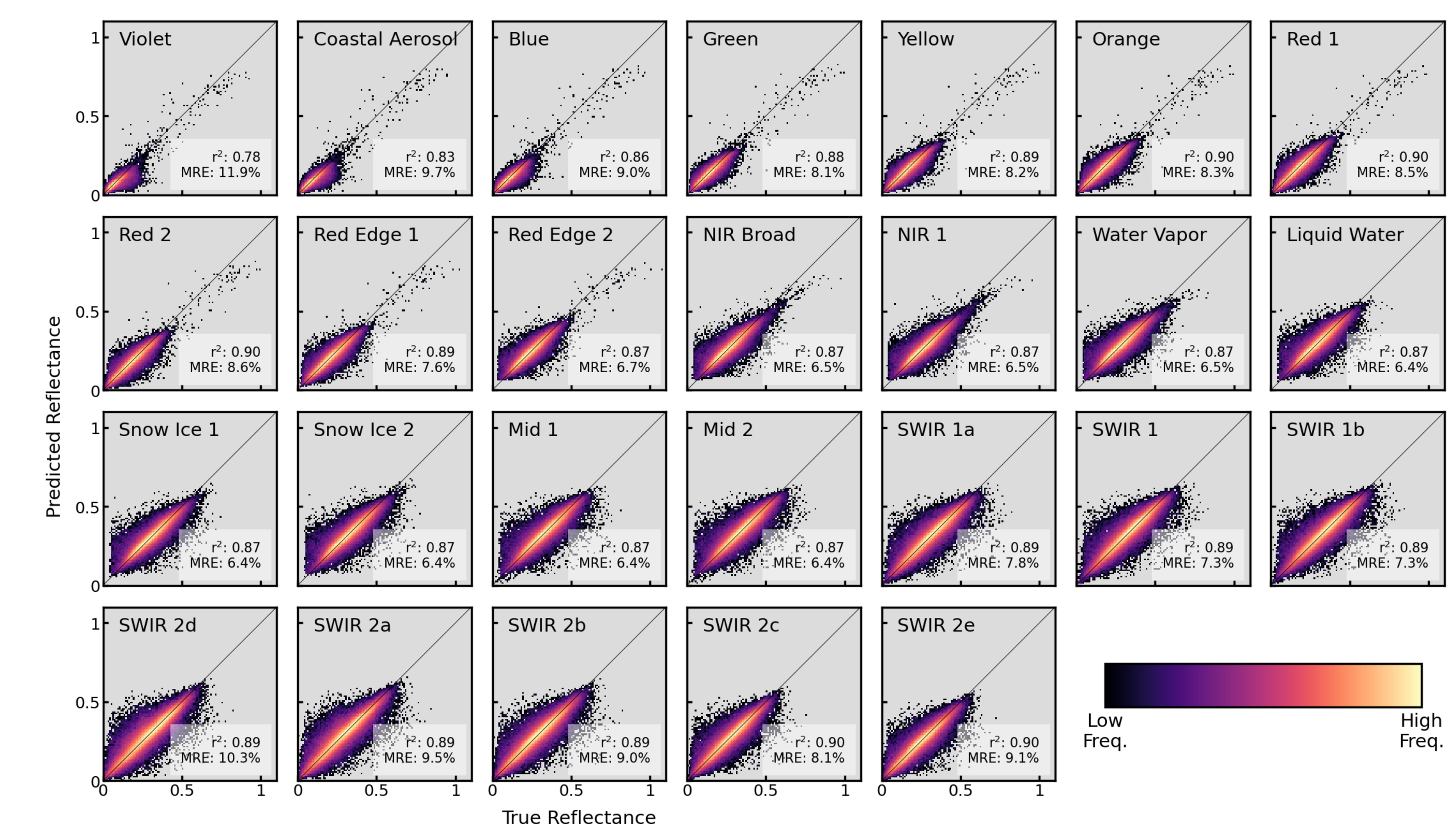

Figure 4. Heatmaps highlighting the accuracy of the HLS-to-Landsat Next model across each of the 26 spectral bands.

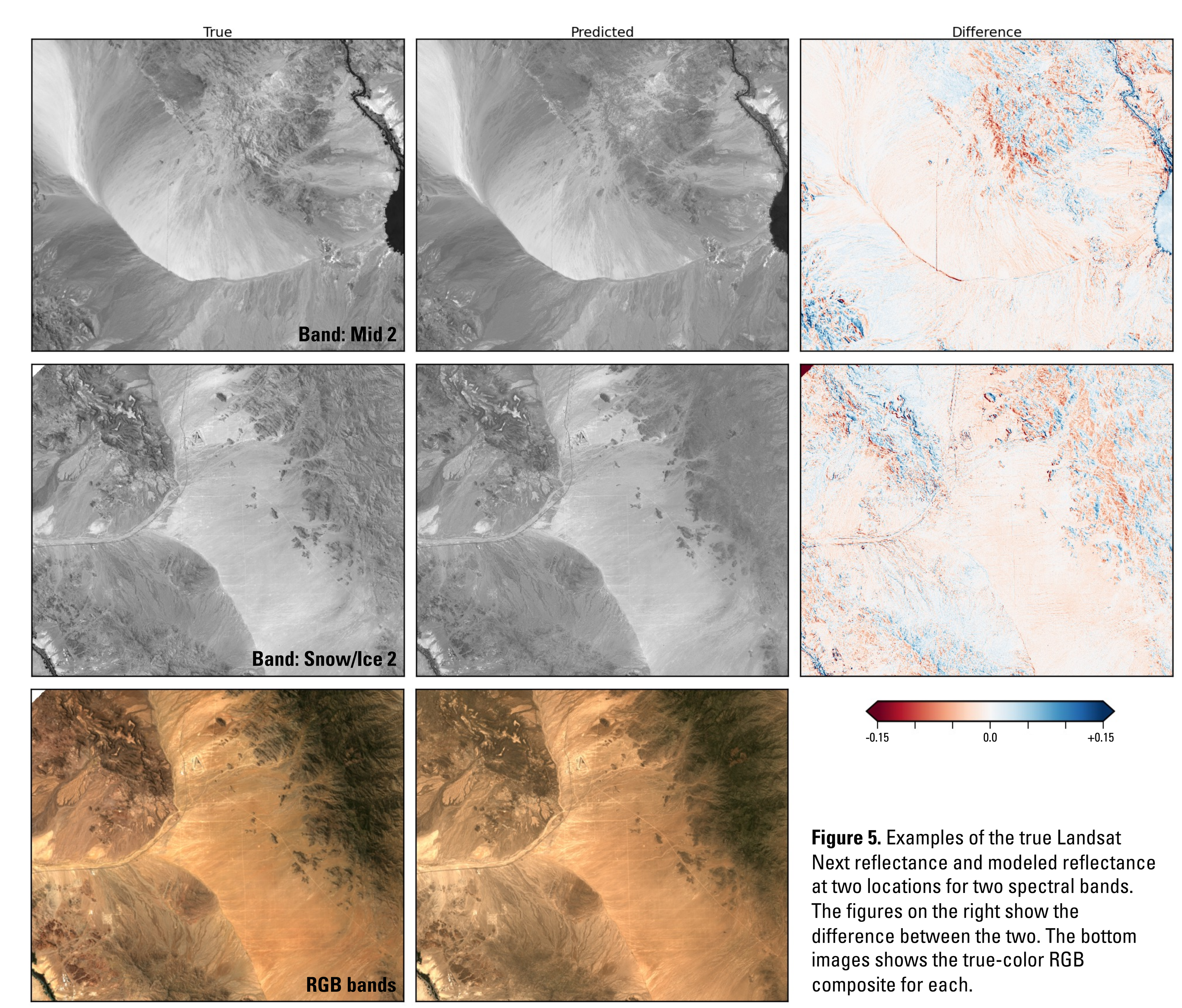

Figure 5. Examples of the true Landsat Next reflectance and modeled reflectance at two locations for two spectral bands. The figures on the right show the difference between the two. The bottom images shows the true-color RGB composite for each.

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