Classifying rooftop materials using globally available satellite imagery and convolutional neural networks

Maxwell C. Cook1,2\*†, Cibele Amaral2,3†, Joseph McGlinchy2, Johannes H. Uhl5,6, Stefan Leyk1,5, Erick Verley2,3, Jennifer K. Balch1,3

**Affiliations:**

1 Department of Geography, University of Colorado Boulder, Boulder, CO, USA

2 Earth Lab, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder, Boulder, CO, USA

3 Environmental Data Science Innovation and Inclusion Lab (ESIIL), University of Colorado Boulder, Boulder, CO, USA

5 University of Colorado Boulder, Institute of Behavioral Science (IBS), Boulder, CO, USA

6 European Commission, Joint Research Centre (JRC), Ispra,VA, Italy

\*Corresponding author. Email: [maxwell.cook@colorado.edu](mailto:maxwell.cook@colorado.edu)

†These authors contributed equally to this work.

**Abstract**: Building materials and their spatial distribution play a significant role in determining the outcomes of human-caused and natural disasters in the built environment, particularly for urban and peri-urban centers. Rooftops represent one important component of building materials that can notably be viewed from space, presenting a unique opportunity for widespread mapping using available remote sensing data. Here, we investigate the application of a Convolutional Neural Network (CNN) model alongside globally consistent high-resolution multispectral imagery from PlanetLabs to classify ten rooftop materials in Washington, District of Columbia and Denver, Colorado, United States. To overcome challenges associated with consistent training data, we integrate geospatial vector data of individual building roofprints with real estate industry-derived building-level characteristics, including rooftop materials, to create labeled image data from globally available high-resolution multispectral imagery. To demonstrate the capability of this approach, we compare the CNN classifier to a less computationally expensive pixel-based machine learning algorithm. Our results suggest that our CNN-based pipeline is a viable tool for mapping rooftop materials in built environments with distinct urbanization patterns. With F1-scores ranging from 0.56 and 0.95 for the most common roof material classes, the CNN model outperformed the pixel-based ML classifier by 15% and 17% in Washington, D.C. and Denver, Colorado respectively based on weighted F1-scores across all classes. Our effort advances the mapping of urban materials and provides a scalable open-source pipeline, useful for risk and exposure mapping, emergency management, and community preparedness in the U.S. and beyond.

**Keywords:** Built Environment, Rooftop Materials, Convolutional Neural Networks, XGBoost, Planet SuperDove, Scalable Computing, Data Integration

**Highlights:**

* A CNN-based pipeline for classifying roof materials across urban landscapes is described.
* Training data was produced by integrating building footprint and property data.
* High classification accuracy was achieved in Washington, D.C. and Denver, Colorado.
* ResNet-18 outperformed XGBoost overall and for individual roof material classes.
* Open code for scalable computing allows creating roof-type maps across other cities and regions.

1. **Introduction**