Explaining Unsupervised Detections of Natural Hazards from Multispectral Satellite Image Time-Series

Data acquired by satellites with low revisit periods are crucial for detecting and tracking changes in land cover due to natural hazards globally and accelerating decision-making for disaster mitigation. The multispectral aspect of such datasets allows capturing rich information unique to a given type of change and can be viewed as a signature of the change, enabling its use for detecting and distinguishing changes. However, the large volume of such datasets and the variations in change types and their signatures necessitates the use of unsupervised approaches without prior knowledge of these signatures. Moreover, for assisting domain scientists and transparently informing hazard mitigation strategies, explaining these detections are also vital.

To this end, this work explores unsupervised change detection approaches to detect natural hazards and examines model-agnostic methods to explain change decisions. Multispectral land surface reflectance observations from the Moderate Resolution Imaging Spectroradiometer are used in this study. Change detection and its explanations are obtained with a two-step approach. The change detection step learns a pixel-based, pre-change multispectral model of a region characterizing the spectral signature before a change and monitors incoming observations for deviations caused by changes using reconstruction-based techniques such as the autoencoder and variational autoencoder. As this assumes no prior knowledge of the type of deviation caused by a change, it is extendible to different change types. The reconstruction error then is viewed as an explanation of change using Shapley values of each band or feature. The bands most relevant for explaining a change type are observed to match with bands commonly used in forming change-specific band ratios and reconstruction errors naturally extract this information without supervision. As a baseline, the reconstruction error magnitude is also used to explain change decisions.