Coal Mine Reclamation Performance Assessment using Time-Series Landsat Data

Introduction

The Alberta Energy Regulator/Alberta Geological Survey is investigating the potential of Earth Observation (EO) data to enhance the auditing process by identifying sites-at-risk for ground assessment and tracking reclamation progression over time. The criteria for evaluating sites-at-risk include vegetation type and vegetation health considering the surrounding land cover type as well as the undisturbed land conditions prior to coal mining. Vegetation health is considered as a key site-at-risk indicator as it reflects if the soil is capable of sustaining life. Landsat time-series datasets were tested to assess the coal mine reclamation with the extraction of progression of coal mine disturbances and vegetation recovery from 1972 to 2016. The study area includes Gregg River, Luscar, and Cheviot coal mines located south of Hinton, Alberta (Figure 1).

Method

Chronology of coal mine disturbances and vegetation recoveries were extracted based on multi-temporal changes in the Normalized Difference Vegetation Index (NDVI) using Landsat data from 1972 to 2016 collected in summer (Figure 2). A land use/land cover classification was produced using 2016 Landsat-8 data with Maximum Likelihood classifier, where training datasets were selected from the unchanged areas of 2000’s Alberta Ground Cover Classification (AGCC) data. Types of vegetation recovery and coal mining related land disturbances at current state and pre-disturbance state were addressed on the classification maps. Accuracy assessment of change detection results were conducted using land change data from the Natural Resources Canada/Pacific Forestry Centre (PFC). In addition, AGCC data was used for accuracy assessment of classification results.

Results

Vegetation recovery was observed on 59%, 27%, and 8% areas of the Gregg River, Luscar, and Cheviot coal mines, respectively (Figures 3-5). For the Gregg River coal mine, the highest disturbance occurred in 1995 - 2000 (37%) and the highest recovery occurred in 2000 - 2005 (41%). For the Luscar coal mine, the highest disturbance occurred in 1995 - 2000 (26%) and the highest recovery occurred in 1985 - 1990 (23%). For the Cheviot coal mine, the highest disturbance occurred in 2010 - 2015 (34%) and the highest recovery occurred in 2010 - 2015 (78%). For all three coal mines, 90% vegetation recovery includes grass/shrub/short vegetation and the remaining includes trees/continuous forest. Coal mine disturbance prior to 1972 was visually assessed using an aerial photo from 1955 (Figures 4 a, b, c, and d). An average accuracy of 64% was observed for land change detection and land use/land cover classification (Tables 1 and 2).

Conclusions

This study demonstrates an application of Historical Landsat data for coal mine reclamation assessment to quantify the chronological sequence of disturbance and recovery with current state assessment of land use and land cover. This helps improving the auditing process for numerous industry submissions including validation of industry submitted information to obtain the reclamation certificate as well as to implement an efficient and transparent land-use plan to support sustainable development.

Reference

Jiaolian Zhao, Xue C., Tie Li, C., and Michael R. Widner (2017) Vegetation of Landsat data to quantify land use and land cover changes related to coal and gas activities in West Central Alberta from 2005 to 2013, Geoscience & Remote Sensing, DOI 10.1109/GRS.2017.2719942

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