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Forest fire detection and monitoring in South Korea using geostationary meteorological satellite data

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Forest fires damage forest ecosystems and result in air pollution by releasing greenhouse gases and aerosols into the atmosphere. Areas damaged by forest fires typically take a long time to recover. Most forest fires in South Korea are caused by anthropogenic factors and thus unpredictable. In addition, as forested areas in South Korea have very rugged topography, which makes it difficult to access them. Thus, satellite-based monitoring of forest fires is a good alternative to in situ observations. Various satellite data and algorithms has been used to detect forest fires, including moderate-resolution imaging spectroradiometer (MODIS) and Visible infrared imaging radiometer suite (VIIRS), which provide wildfire products (i.e. fire mask). The existing algorithms and products do not detect small forest fires (<1-2 ha) and result in a lot of false alarms in South Korea. Since small scale forest fires dominantly occur in South Korea, there is a strong need to develop an suitable algorithm to detect and monitor such small forest fires. From a monitoring perspective, it is not practical to use polar-orbiting satellite data for detecting and monitoring forest fires. Geostationary satellite data with very high temporal resolution may be a good solution for such purposes even though spatial resolution is not as good as polar-orbiting satellite data.
The purpose of this study was to detect and monitor forest fires in South Korea using Himawari-8 satellite data. Himawari-8 is the geostationary satellite sensor operated by the Japan Meteorological Agency (JMA), and it provides data every 10 minutes with 16 bands at 500 m – 2 km resolution covering from China to Australia. In-situ forest fire reference data were obtained from Korean Forest Service. The proposed model consists of two steps: thresholding and machine learning. First, we developed a threshold algorithm optimized for Himawari-8 data based on the existing algorithms. Then, random forest (RF) machine learning was applied to improve the performance of forest fire detection. RF was very useful to effectively reduce false alarms. Through the proposed model, contributing parameters to detect forest fires among input variables (i.e. each band reflectance radiance, brightness temperature (BT), band ratios, BT differences, and BT ratios) were identified. The proposed model detected forest fires better than the existing algorithms and the false alarm rate also significantly decreased. Since Himawari-8 provides data every 10 minutes, forest fires were monitored using the proposed model. Forest fire-related characteristics such as early detection, fire expansion, damaged areas and fire duration were also investigated. The proposed model was also applied to East Asia to evaluate the generalization of the approach.