Detecting Volcanic Ash Clouds Making Use of Satellite Images and Machine Learning Algorithms

Camilo Naranjo Ariza[1], Guillermo Toyos[2], and Gustavo Villarosa[3]

[1]IPATEC-CONICET
[2]National Commission of Space Activities of Argentina (CONAE)
[3]Grupo de Estudios Ambientales, IPATEC-CONICET

November 22, 2022

Abstract

Volcanic ash detection is important for effective emergency management. Ash emitted by volcanoes is injected at high altitudes into the atmosphere, dispersed and driven by wind and extended for kilometres away from volcanoes. It can affect communities in different ways including health, agriculture, the environment and air traffic. Thus, detecting and tracking the volcanic ash clouds using satellite images can help civil protection authorities and volcanic ash advisory centres respond rapidly to a volcanic event. Satellite based detection of volcanic ash has traditionally entailed the implementation of radiances, reflectances, brightness temperatures (BT), brightness temperature differences (BTD), beta ratios and cloud objects tracking tools. The aim of this study is to test machine learning algorithms on satellite data in order to identify volcanic ash in the atmosphere as an attempt to enhance the space-borne ash detection capabilities especially in ambiguous cases, where image classification is hard, such as when ash, clear land and cirrus clouds coexist within a scene. We used a set of 10 satellite images acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the satellites Terra and Aqua just after the 4 June 2011 eruption of the Puyehue Cordon Caulle Volcanic Complex to train and test two supervised classification algorithms: K-Nearest Neighbours and Support Vector Machine, for volcanic ash detection in the atmosphere. We first built a database that consists of 217,859 pixels identified and labelled, on the basis of visual interpretation of color composites, according to seven classes: volcanic ash above the emission centre, land and sea, meteorological clouds above land and sea, and clear sky above land and sea. For each of the seven classes, sample pixel values were retrieved for six features, which are given by the BT at 11?m and the BTDs between 11 and 12 ?m, 11 and 3.9 ?m, 11 and 6.7 ?m, 11 and 8.5 ?m and a BTD that combines the BTs measured at 11, 12 and 8.5 ?m. We show preliminary results on statistical analysis of the training datasets and performance of both algorithms for volcanic ash detection above land and sea including verification tests with MODIS datasets that cover the April 2015 eruption of Volcan Calbuco (Chile).

Detecting Volcanic Ash Clouds Making Use of Satellite Images and Machine Learning Algorithms

Camilo Naranjo[1,2], Guillermo Toyos[1,3], Gustavo Villarosa[1,2]

[1]CONICET (National Research and Technical Council), Argentina Republic

[2]Grupo de Estudios Ambientales, IPATEC, UNCo

[3]CONAE (Comisión Nacional de Actividades Espaciales)

Volcanic ash detection is important for effective emergency management. Ash emitted by volcanoes is injected at high altitudes into the atmosphere, dispersed and driven by wind and extended for kilometres away from volcanoes. It can affect communities in different ways including health, agriculture, the environment and air traffic. Thus, detecting and tracking the volcanic ash clouds using satellite images can help civil protection authorities and volcanic ash advisory centres respond rapidly to a volcanic event. Satellite based detection of

volcanic ash has traditionally entailed the implementation of radiances, reflectances, brightness temperatures (BT), brightness temperature differences (BTD), beta ratios and cloud objects tracking tools. The aim of this study is to test machine learning algorithms on satellite data in order to identify volcanic ash in the atmosphere as an attempt to enhance the space-borne ash detection capabilities especially in ambiguous cases, where image classification is hard, such as when ash, clear land and cirrus clouds coexist within a scene. We used a set of 10 satellite images acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the satellites Terra and Aqua just after the 4 June 2011 eruption of the Puyehue Cordon Caulle Volcanic Complex to train and test two supervised classification algorithms: K-Nearest Neighbours and Support Vector Machine, for volcanic ash detection in the atmosphere. We first built a database that consists of 217,859 pixels identified and labelled, on the basis of visual interpretation of color composites, according to seven classes: volcanic ash above the emission centre, land and sea, meteorological clouds above land and sea, and clear sky above land and sea. For each of the seven classes, sample pixel values were retrieved for six features, which are given by the BT at 11?m and the BTDs between 11 and 12 ?m, 11 and 3.9 ?m, 11 and 6.7 ?m, 11 and 8.5 ?m and a BTD that combines the BTs measured at 11, 12 and 8.5 ?m. We show preliminary results on statistical analysis of the training datasets and performance of both algorithms for volcanic ash detection above land and sea including verification tests with MODIS datasets that cover the April 2015 eruption of Volcan Calbuco (Chile).

Detecting Volcanic Ash Clouds Making Use of Satellite Images and Machine Learning Algorithms

Camilo Naranjo[1,2], Guillermo Toyos[1,3], Gustavo Villarosa[1,2]

[1] CONICET (National Research and Technical Council), Argentina Republic
[2] Grupo de Estudios Ambientales, IPATEC, UNCo
[3] CONAE (Comisión Nacional de Actividades Espaciales)

Volcanic ash detection is important for effective emergency management. Ash emitted by volcanoes is injected at high altitudes into the atmosphere, dispersed and driven by wind and extended for kilometres away from volcanoes. It can affect communities in different ways including health, agriculture, the environment and air traffic. Thus, detecting and tracking the volcanic ash clouds using satellite images can help civil protection authorities and volcanic ash advisory centres respond rapidly to a volcanic event. Satellite based detection of volcanic ash has traditionally entailed the implementation of radiances, reflectances, brightness temperatures (BT), brightness temperature differences (BTD), beta ratios and cloud objects tracking tools. The aim of this study is to test machine learning algorithms on satellite data in order to identify volcanic ash in the atmosphere as an attempt to enhance the space-borne ash detection capabilities especially in ambiguous cases, where image classification is hard, such as when ash, clear land and cirrus clouds coexist within a scene. We used a set of 10 satellite images acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the satellites Terra and Aqua just after the 4 June 2011 eruption of the Puyehue Cordon Caulle Volcanic Complex to train and test two supervised classification algorithms: K-Nearest Neighbours and Support Vector Machine, for volcanic ash detection in the atmosphere. We first built a database that consists of 217,859 pixels identified and labelled, on the basis of visual interpretation of color composites, according to seven classes: volcanic ash above the emission centre, land and sea, meteorological clouds above land and sea, and clear sky above land and sea. For each of the seven classes, sample pixel values were retrieved for six features, which are given by the BT at 11μm and the BTDs between 11 and 12 μm, 11 and 3.9 μm, 11 and 6.7 μm, 11 and 8.5 μm and a BTD that combines the BTs measured at 11, 12 and 8.5 μm. We show preliminary results on statistical analysis of the training datasets and performance of both algorithms for volcanic ash detection above land and sea including verification tests with MODIS datasets that cover the April 2015 eruption of Volcan Calbuco (Chile).