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Neural-Network approach to hyperspectral data analysis for volcanic monitoring of sulphur dioxide

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This study is about an Artificial Neural Network (ANN) algorithm that recognizes volcanic SO_2 in the atmosphere using hyperspectral remotely sensed data from the Infrared Atmospheric Sounding Interferometer Instrument (IASI) instrument aboard the METOP-A satellite. The remote sensing of volcanic sulphur dioxide (SO_2) is important because it is used as a proxy for volcanic ash which is dangerous to aviation and is generally more difficult to discriminate. The importance of this approach lies in its speed and its application to near real-time volcanic monitoring. In this paper an ANN algorithm is demonstrated on date of the eruption of the Eyjafjallajökull volcano (Iceland) during the months of April and May 2010, and on the Grímsvötn eruption occurring during May 2011.
The algorithm consists of a two output neural network classifier trained with a time series consisting of some hyperspectral eruption images collected during Eyjafjallajökul 2010 and eruption and Grímsvötn 2011 eruption. The inputs were all channels (441) in the IASI $\nu 3$ band and the target outputs (truth) were the corresponding Oxford retrievals of SO_2 amount.
The classifier was validated on four independent IASI orbits, two that included observations of the Eyjafjallajökull eruption and two that included observations of the Grímsvötn volcanic eruption that occurred in May 2011.
The validation results for the Eyjafjallajökull independent data-sets had an overall accuracy of 100%. The validation of the neural network classifier on images from the Grímsvötn eruption shown lower overall accuracies due to the presence of omission errors. Statistical analysis revealed that those false negatives lie near the detection threshold for discriminating pixels affected by SO_2. This demonstrated that the accuracy in classification is strictly related to the sensitivity of the model.
Nevertheless results obtained underlined that no commission errors were present at the validation stage (pixels erroneously labelled as affected by SO_2) and the method has shown the same accuracy when applied to IASI images with different illumination conditions (morning and afternoon orbits) and in cloudy sky conditions.