Volcanic ash retrieval from IR multispectral measurements by means of Neural Networks

Picchiani M., Chini M., Corradini S., Merucci L., Sellitto L., Del Frate F., Stramondo S.

The lesson learned from the recent Icelandic Eyjafjallajokull volcanic eruption is the need to obtain accurate near real time retrievals in order to sample the phenomenon evolution. In particular, because of the harming effects of fine volcanic ash particles on aircrafts, the real time tracking of volcanic clouds is a key issue for aviation safety.
The current mostly utilized procedure for the ash retrievals is based on the Brightness Temperature Difference (BTD) algorithm, using the 11 and 12 μm channels measurements and radiative transfer model computation. This latter requires many input parameters and is time consuming, preventing the utilization during the crisis phases.
In this work a fast and accurate Neural Network (NN) approach has been developed to detect and retrieve volcanic ash cloud properties using multispectral IR measurements. The exploited data come from the Moderate Resolution Imaging Spectroradiometer (MODIS) acquired over Mt. Etna volcano during the 2001, 2002 and 2006 eruptive events.
The procedure consists in two separate steps that uses the three MODIS channels 28, 31 and 32: the detection and the ash retrievals.
The detection is reduced to a classification problem. In this context several classes can be individuated, such as free sea surface, meteorological clouds, and ash plume. To maintain the solution of the problem as easy as possible we have simplified the scenario identifying only two classes on the MODIS images: 'ash' and 'no ash' pixels. This approach is coherent with the philosophy of this work in which the time passed to obtain the result is a stringent factor.
For the ash mass retrieval, the trained network replicates the model. In fact, in order to have a network able to learn a behavior and to represent it through a functional approximation, it is necessary to provide appropriate information by an ensemble of examples. These latter can be obtained from a model if a direct measure is not available. In this work the results obtained with the BTD procedure have been considered.
The results obtained from the entire procedure are encouraging, indeed the confusion matrix for the test set has an accuracy greater than 90%. Moreover the ash mass retrieval shows a good agreement with that achieved by BTD procedure.