Assay of satellite methodology for volcanic ash classification. Calbuco volcano case

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ABSTRACT

The dispersion of volcanic ash in the atmosphere, as a result of volcanic eruptions or the subsequent re-suspension of volcanic ash deposits, causes environmental impacts and disruptions in human activities at different scales. It is possible to monitor volcanic ash clouds through remote sensors mounted on satellites.

This work presents a satellite methodology test, based on the use of MODIS sensor on board the TERRA and AQUA satellites, for the classification of pixels with volcanic ash. The eruption of Calbuco Volcano in April 2015 in Chile was selected as a case study. These results could be used as an analysis tool at Volcanic Ash Advisory Centers (VAAC).

INTRODUCTION

Various products made through the combinations of thermal and reflective bands corresponding to the MODIS sensor are currently used to determine the presence of volcanic ash in suspension or on the surface (Prata, 1989; Pavolonis et al., 2013).

In this line Osores et al. (2015) presented a volcanic ash classification methodology based on the use of Brightness Temperature Differences (BTD) between the bands of 10.8µm and 12µm for their detection (Prata 1989 a, b) and Land surface temperature (LST) (Wan et al., 2015). Based on the previous work, here we study different thresholds for ash detection during the eruption of Calbuco Volcano in April 2015.

METHODOLOGY

BTD images were processed and LST images were used to perform the classification tests. To support the methodology based on previous analyzes (Bolzi et al., 2012), true color RGB MODIS images were used (Figure 1), using the bands of 0.64µm (b1), 0.55µm (b4) and 0.46µm (b3) respectively and of the 0.85µm (b2) band of the MODIS sensor. The True Color RGB shows the volcanic ash cloud in a lighter and brighter ocher color, where the optical thickness is greater as well as the reflectance values.

In contrast, in places where the ash cloud is translucent, the reflectivity decreases and the optical thickness is smaller.

The BTD, B2 and LST images corresponding to different scenes were inspected and transects were performed, to then determine the threshold values of BTD and LST that were used in each of the classification test. Then a classification of suspended ash, no-ash and uncertain pixels was performed.

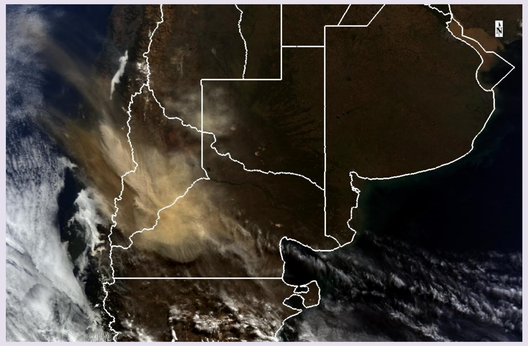

Figure 1: True Color (1, 4, 3)
TERRA-MODIS 23/04/2015, 14:20 UTC

CLASSIFFICATION TEST

For this test, the BTD and LST images (**Figure 3)** corresponding to April 23, 2015 at 14: 20 UTC were used to get classification thresholds.

The presence of volcanic ash is shown with negative values in BTD **(Figure 2**, black color in the image), while the LST shows different values that correspond to the surface temperature of the ground (gray tones) and the presence of clouds is represented in black.

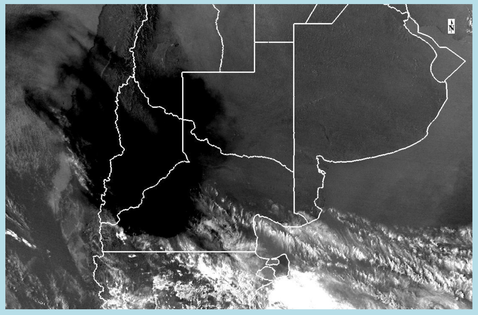

Figure 2: BTD, 23/04/2015 14: 20 UTC. TEST 1
TERRA-MODIS 23/04/2015, 14:20UTC

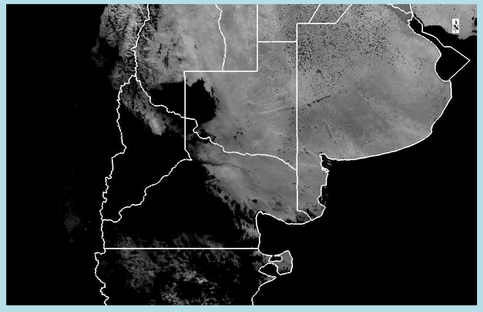

Figure 3: LST, 23/04/2015 14: 20 UTC. TEST 1
TERRA-MODIS 23/04/2015, 14:20UTC

TRANSECT 1 is shown over a RGB color composition image (BTD, LST, B2) (Figures 4 and 5).

CLASSIFICATION TEST

Figure 6 shows how TRANSECT 1 takes BTD values close to -1.5K and reflectance around 10.5% in places where the volcanic ash cloud becomes translucent, instead at the end of TRANSECT, where the ash cloud is more opaque, the BTD has values of -2.5 K and the reflectance is around 12%. The shaded area of the graph represents a region free of meteorological clouds.

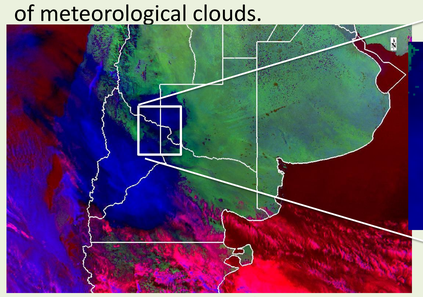

Figure 4: RGB (BTD/LST/B2) Area for **TRANSECT1**. TERRA-MODIS 23/04/2015, 14:20UTC

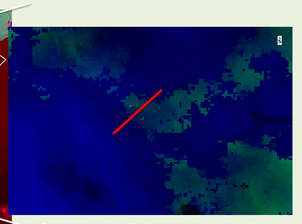

Figure 5: ZOOM **TRANSECT 1**

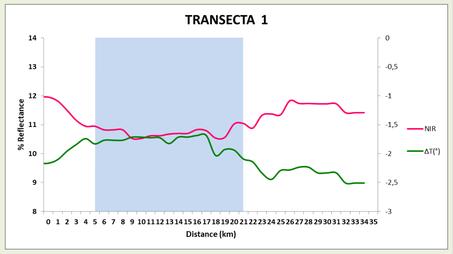

Figura 6: Reflectance (%) y Brightness Temperature (K) as a function of the distance (m) for transects 1

According to the inspection of TRANSECT 1, where the volcanic ash cloud is translucent it corresponds to a value of LST = 290 K. Based on these results we performed a pixels classification of ash, no-ash and two types of uncertain, using BTD, LST and B2 thresholds values (Table 1).

CLASSIFICATION	BRIGHTNESS TEMPERATURE DIFFERENCE (BTD)	SURFACE TEMPERATURE (LST)	CLASS
ASH	BTD ≤ -0.3	LST ≤ 290	1
NO ASH	BTD > -0.3	LST > 0	2
UNCERTAIN 1	BTD > -0.3	LST = 0	3
UNCERTAIN 2	BTD ≤ -0.3	LST > 290	4

Table 1: Classification and class thresholds

RESULTS

The classification image **(Figure 7a)** shows the pixels with ash, without ash and uncertain. The values used as thresholds of this scene were 290 K and -0.3 K for the LST and BTD respectively.

These new values allowed to identify as pixels with ash some of those that were taken as uncertain with the original classification method used by Osores et al., (2015). These results show good agreement with Volcanic Ash Observation polygon array from VAAC Buenos Aires at 13:38 UTC **(Figure 7 b)**.

Figure 7: (a) MODIS Classification filtering uncertain pixels (04-23-2015 14:20 UTC). **(b)** Volcanic Ash Observation polygon array from VAAC Buenos Aires at 13:38 UTC (uncertain pixels are filtered). In both images the presence of ash is indicated in red, the absence in blue and uncertain pixels are translucid.

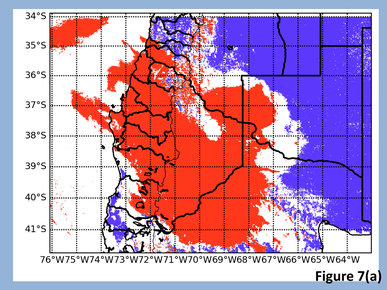

Figure 7(a)

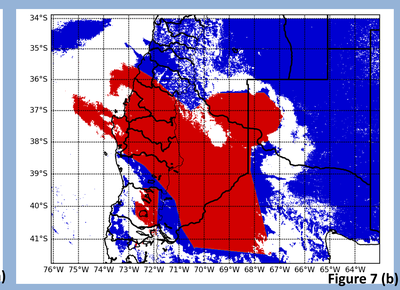

Figure 7 (b)

CONCLUSION

BTD image shows clearly the presence of volcanic ash inside volcanic plumes. The combination of LST and BTD, allows to determine the certainty of the pixels with and without volcanic particles and also classify those that are uncertain .

Threshold values might vary from scene to scene, therefore further studies are needed to improve the classifications thresholds proposed.

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