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.

METHODLOGY
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 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.

CLASSIFICATION 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.

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 of 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.

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).

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.

REFERENCES
Bolzi, S., Rodríguez, D., Velasco, I. y Morin, M., 2012: Detección y análisis espectroscópico de partículas en la atmósfera utilizando sensores remotos. III Congreso Argentino de Meteorología - CONGAREMET

Table 1: Classification and class thresholds