Servicio Meteorológico Nacional Argentina

Volcanic ash classification from satellite data: Ubinas eruption case study

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Introduction

Volcanic ash detection is crucial for Volcanic Ash Advisory Centers's surveillance.

Previous work

Split window (Prata 1989a, 1989b)
Ash RGB (Meteorological Satellite Center (MSC) of JMA , EUMETrain, UCAR/COMET, NASA/SPoRT)
SO2 detection (Realmuto et al., 1994, 1997; Teggi et al., 1999; Watson et al., 2004; Pugnaghi et al., 2006,Prata et al., 2003, Corradini et al., 2009).
Ash pixel classification (Simpson et al., 2000, Prata et al., 2001, Yu et al., 2002, Watkin, 2003, Watson et al., 2004, Pergola et al., 2004, Pavolonis et al., 2013, , Osores et al., 2015, Guehenneux et al., 2015 , Rodriguez et al., 2018, Marchesse et al., 2021).

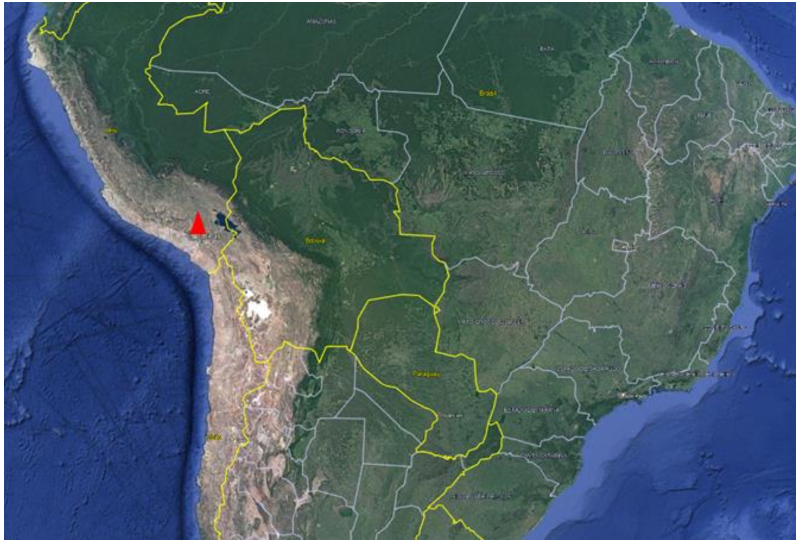
Objective

Define a pixel classification method to improve VAAC Buenos Aires ash detection capabilities and ash dispersion forecasts verification.

Based on the previous works we study different methodologies to classify scenes with volcanic ash, using IR bands brightness temperature differences applied to the new satellite generation.

Case of Study: Volcán Ubinas (2019)

Ubinas volcano (16.34°S; 70.89°W; 5672 m.s.n.m.) is an andesitic stratovolcano that is part of the Central Andes Volcanic Zone and is one of the most active volcanoes in Perú (Del Carpio and Hernando Tavera, 2019).



On 19 July 2019 the first eruption was detected at 07:30 Z GOES-16 satellite imagery.
During the following hours the VOLCAT system (https://volcano.ssec.wisc.edu/) estimated plume heights reaching up to 18- 20 km.

Data and Methodology: VIIRS Sensor

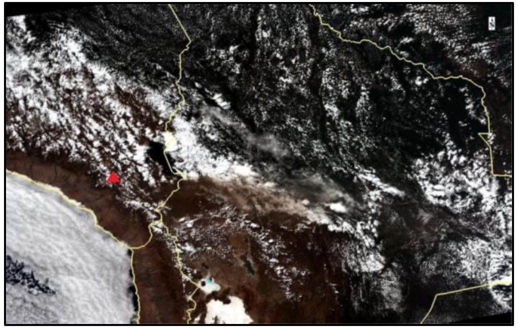
VIIRS Classification

Data: NOAA-20 VIIRS for 19 July 2019 at 17:56 UTC.

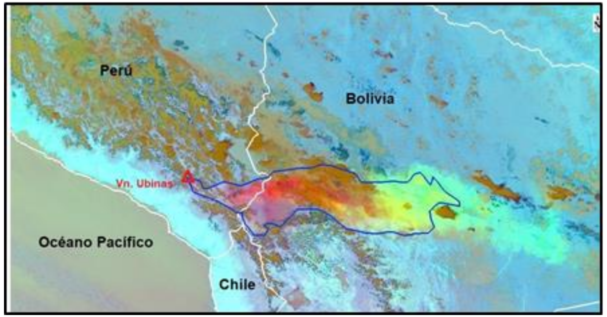
B1: M14 (8.55 µm) - M15 (10.76µm)
B2: M15 (10.76 µm) - M16 (12.013 µm)

Classification	Condition
Ash	B1 ≤ -0.6K and B2 ≥ -9K
Ash	-0.6K < B1 ≤ 0.1K and B2 ≥ -1.2K
No Ash	B1 > 0.1K and B2 < -9K

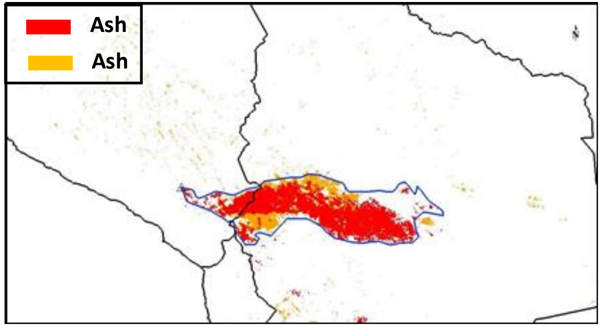
RGB True color [R:M4,G:M5,B:M6]



RGB Ash [(R:M16-M15), G:(M15-M14), B: M15]



Method M3B2



Classification of ash and no ash pixels based on a 3 IR band differences (using 8.55µm, 10.763µm and 12.013 µm) method proposed by Guehenneux et al. (2015) that was adapted for VIIRS Sensor by Rodriguez et al.,(2022).

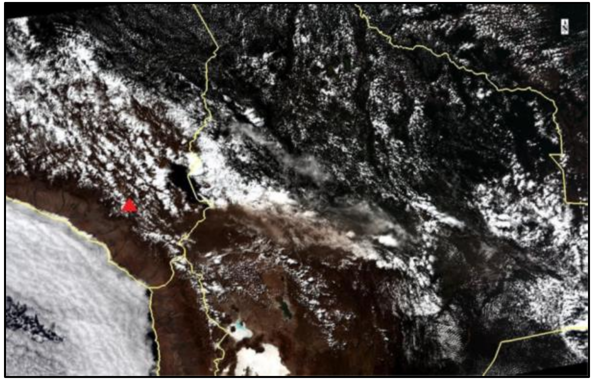
Data and Methodology: ABI Sensor (GOES-16)

B1: C13 (10.3μm) - C15 (12.3μm)
B2: C11 (8.4μm) - C13 (10.3μm)
B3: C10 (7.3μm) - C09 (6.9μm)

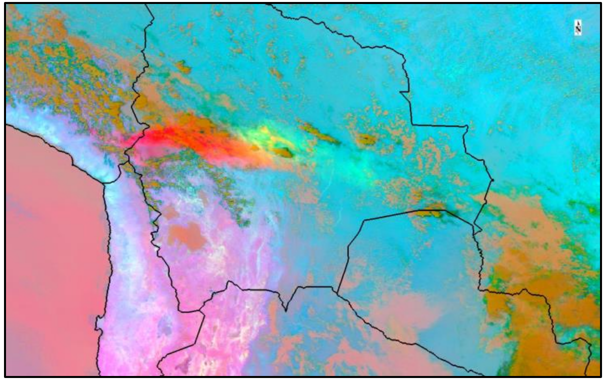
Method	Classification		Definition/Condition
M2B ("Split Window")	Ash	-	B1 ≤ 0K
	No Ash	-	B1 > 0K
M3B	Ash	1	(B1 ≤ -0.7K) and (B2 ≥ -1.2K)
		2	(-0.7K < B1 ≤ 1K) and (B2 ≥ -0.1K)
	No Ash		Anything that does not match the 3 conditions above
M5B	Ash	1	(B1 ≤ -0.7K) and (B2 ≥ -1.2K)
		2	(-0.7K < B1 ≤ 1.0K) and (B2 ≥ -0.1K)
		3	(B1 ≤ 1K) and (B3 < 0K)
	No Ash		Anything that does not match the 3 conditions above

M2B "Split Window": 19/07/2019 18:00 UTC

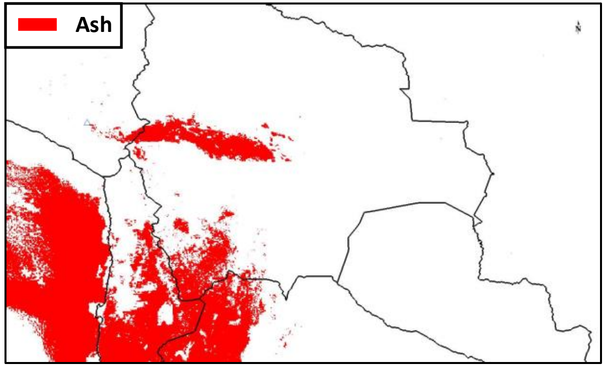
RGB True color from VIIRS



Ash RGB [(R: C15-C13) ; (G: C13.C11) ; (B: C13)]

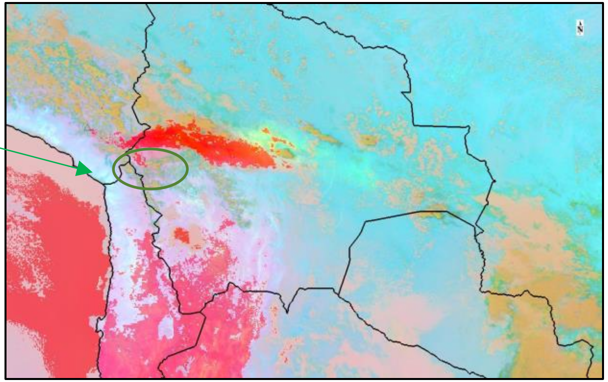


2-band classification method (M2B).



No ash detected

Ash RGB versus M2B



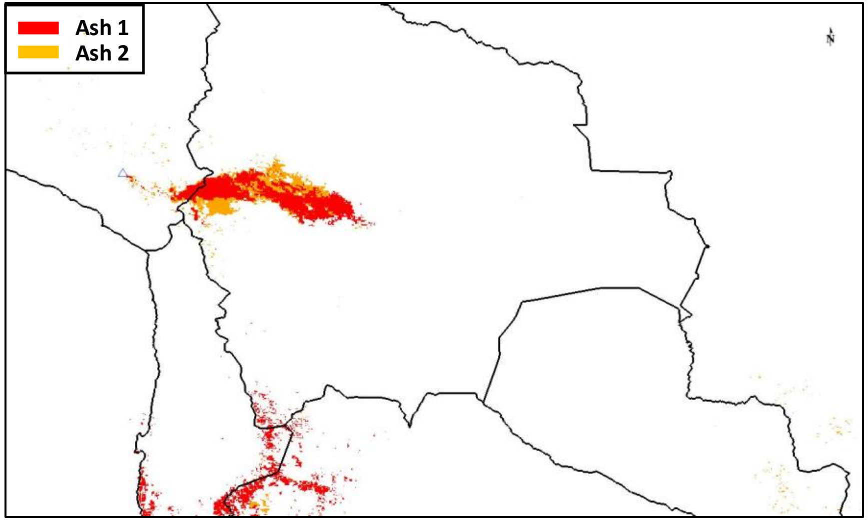
Thresholds for volcanic ash classification corresponding to the M2B method.

Ash: B1 < 0

Day time

M3B: 19/07/2019 18:00 UTC

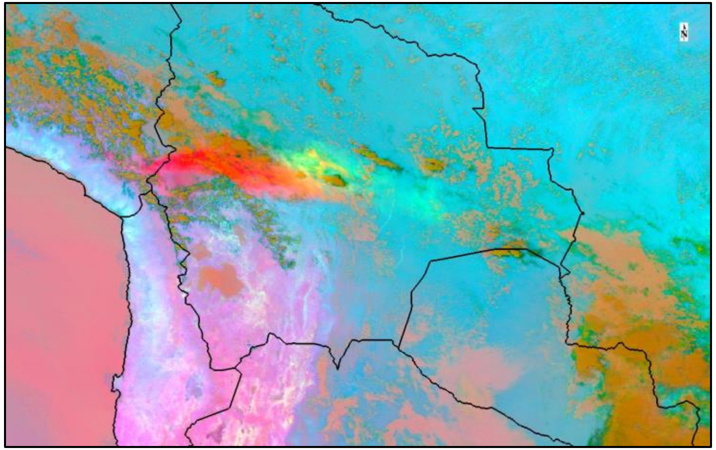
M3B method



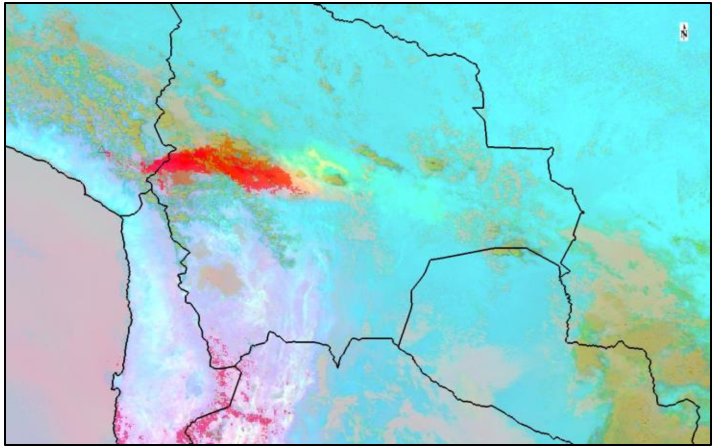
Thresholds for volcanic ash classification corresponding to the M3B method.

Ash 1: (B1 ≤ -0.7) and (B2 ≥ -1.2)
Ash 2: (-0.7 < B1 ≤ 1) and (B2 ≥ -0.1)

Ash RGB [(R: C15-C13) ; (G: C13.C11) ; (B: C13)]



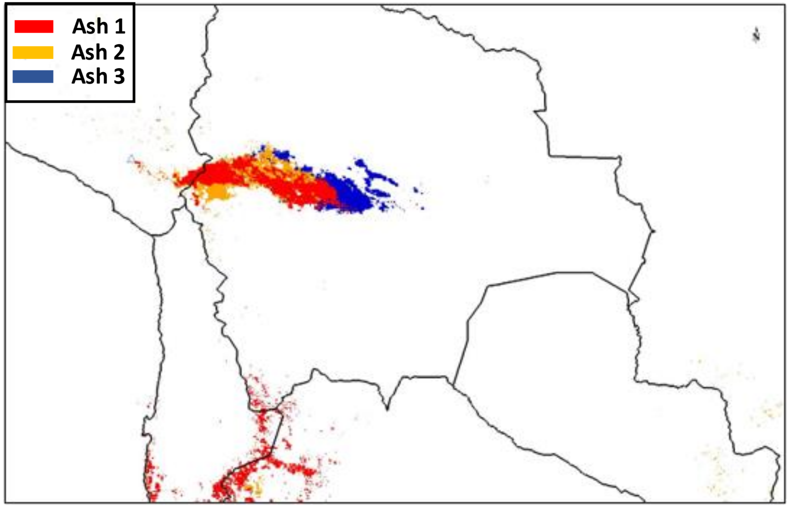
Ash RGB versus M3B



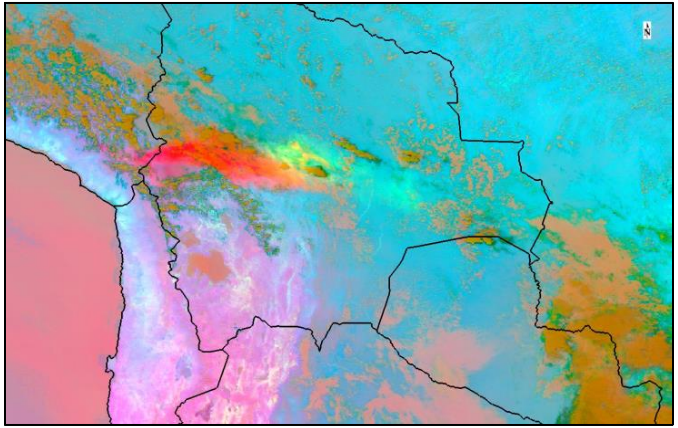
Day time

M5B: 19/07/2019 18:00 UTC

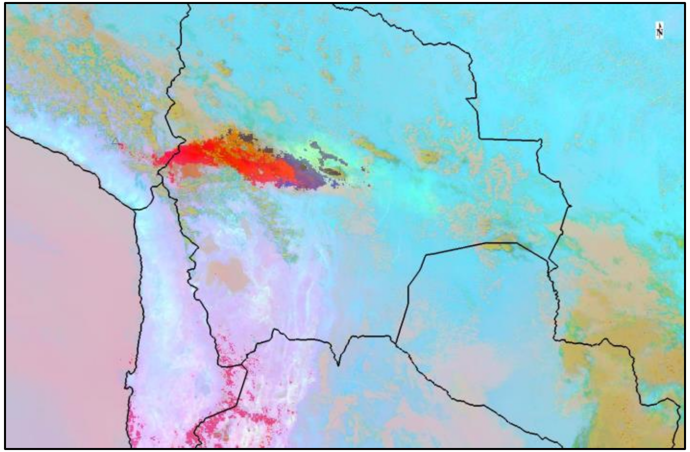
M5B method



Ash RGB [(R: C15-C13) ; (G: C13.C11) ; (B: C13)]



Ash RGB versus M5B



Thresholds for volcanic ash classification corresponding to the M5B method.

Ash 1: (B1 ≤ -0.7) and (B2 ≥ -1.2)
Ash 2: (-0.7 < B1 ≤ 1) and (B2 ≥ -0.1)
Ash 3: (B1 ≤ 1) and (B3 < 0)

Day time

19/07/2019 15:30 UTC

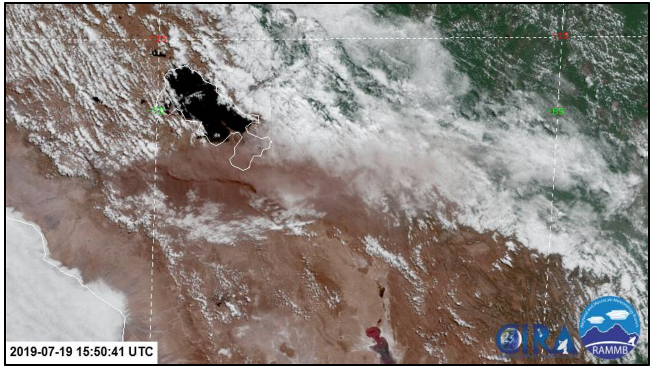


Image corresponding to the GEOCOLOR at 15:50 UTC.

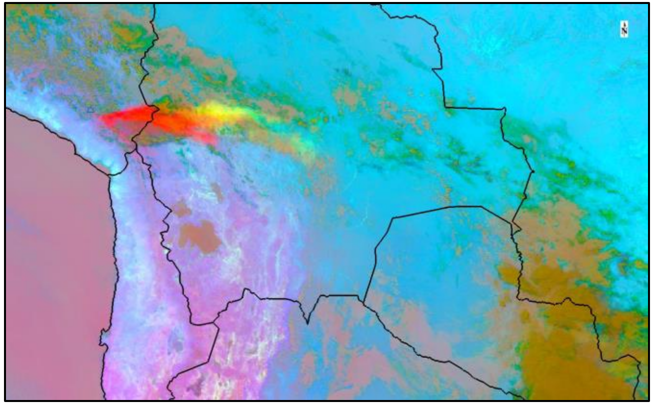
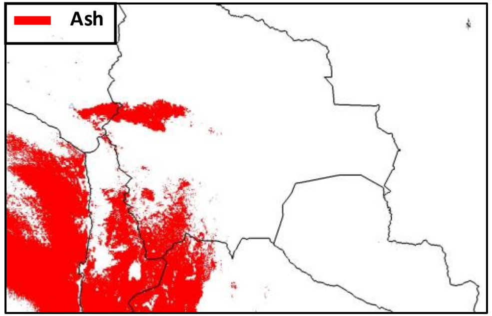
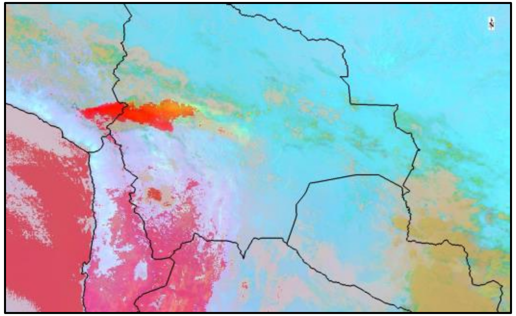
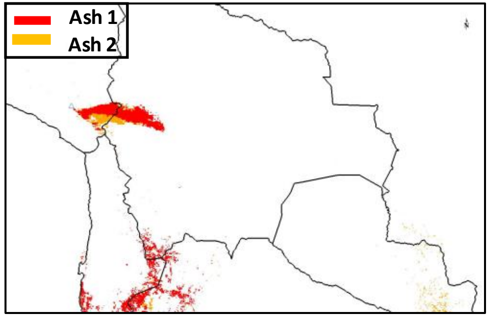


Image corresponding to the ASH RGB composition product.

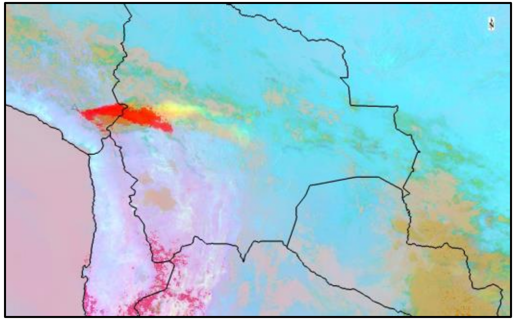


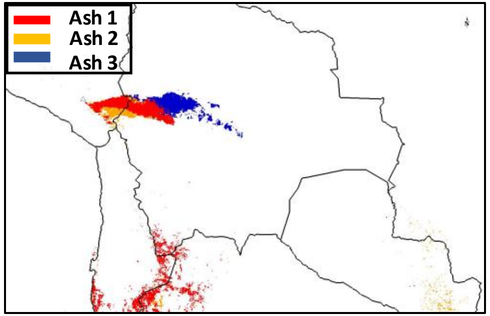
M2B



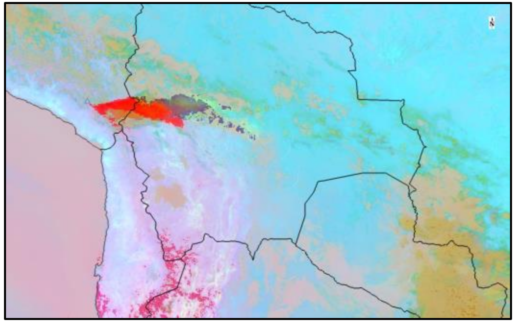


M3B





M5B



Day time

19/07/2019 03:10 UTC

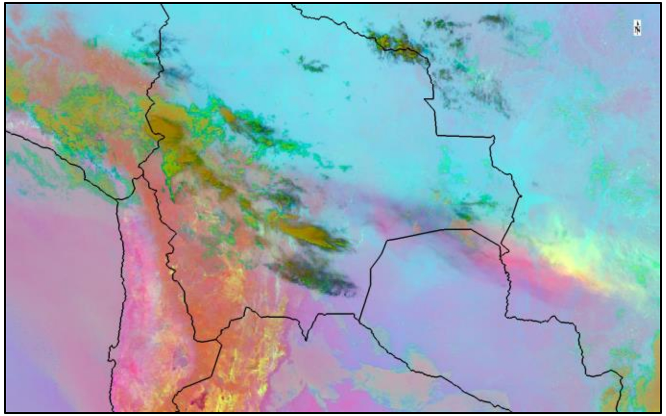
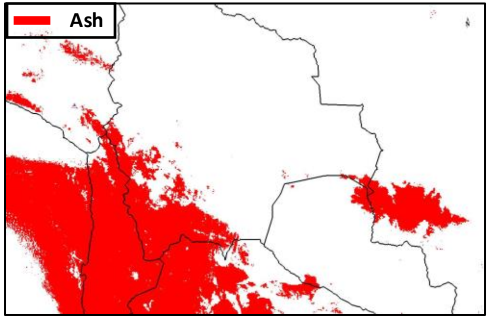
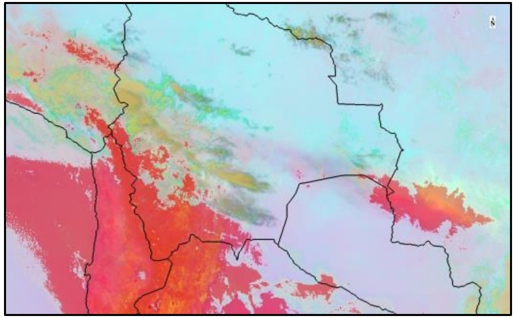
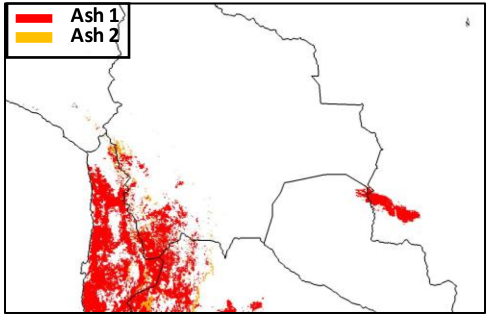


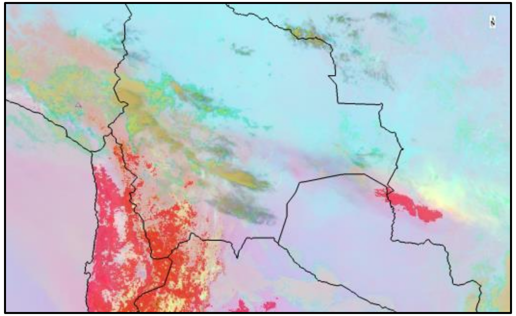
Image corresponding to the ASH RGB composition product.



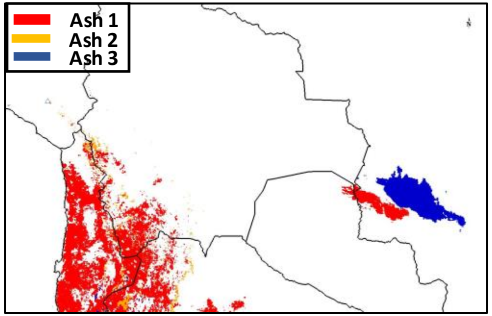


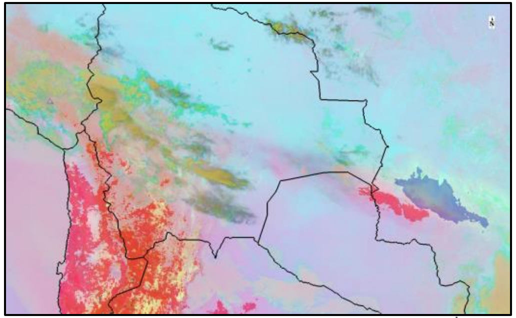
M2B





M3B





M5B

Nigth time

Conclusions

- Different classifications are analyzed using up to 5 IR bands for the detection of ash and mixed pixels (SO_2+ash) using the case study of the Ubinas volcano.
- Using the classical split window methodology, many false alarms are observed over the ocean with low-level clouds and arid soils.
- By adding the BTD (8.4-10.3 microns) condition (M3B) and allowing some positive values of split window, false alarms are reduced, and the number of ash pixels increases, resulting in an improvement in the classification compared to what is observed in the Ash RGB.
- The use of the 5 bands (M5B) allow a better classification of mixed pixels.
- Although there is an improvement in the classification of the ash area, some false positives are still present associated with arid soil and cloudiness.

Future work

- Test the classification with more scenes (such as scenes with different types of soil).
- Include a cloud cover layer to filter those pixels that contain meteorological clouds, where ash could could be embedded or bellow it.
- Test the classification method to verify the QVA.

Thanks for your attention

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