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Look-up tables with empirical climatologies for infrasound detection, location, and characterization of long range volcanic eruptions

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T1.1-P21

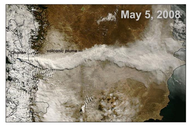
Motivation

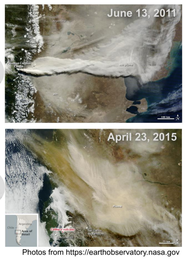
Three big eruptions in the last 11 years in southern hemisphere (Chile-Argentina).

May 2, 2008
Chaiten
VEI 4

June 4, 2011
Puyehue-Cordón Caulle
VEI 4

April 22, 2015
Calbuco
VEI 4

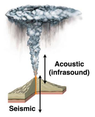




Photos from https://earthobservatory.nasa.gov

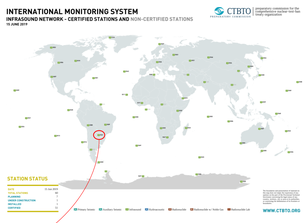
*VEI: Volcanic Explosivity Index. It ranges from 1 to 7. It is a relative measure of the explosivity of the eruption. For example, Mt. St. Helens (1985) was a VEI 4, while Pinatubo (1991) was a VEI 5.

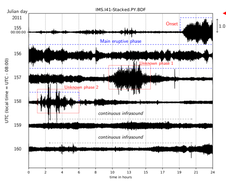
Infrasound and IMS



Volcanic acoustic signals are proficiently generated in the infrasound range (below 20 Hz), and can propagate thousands of kilometers.

The IMS network of infrasound stations can be used to detect, locate, and characterize those signals.

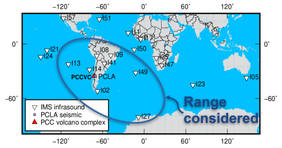




Acoustic signals Puyehue-Cordón Caulle eruption observed in I41 (Paraguay), at more than 2000 km from the source.

Data

In this work we used data from the virtual Data Explotaition Centre (vDEC).

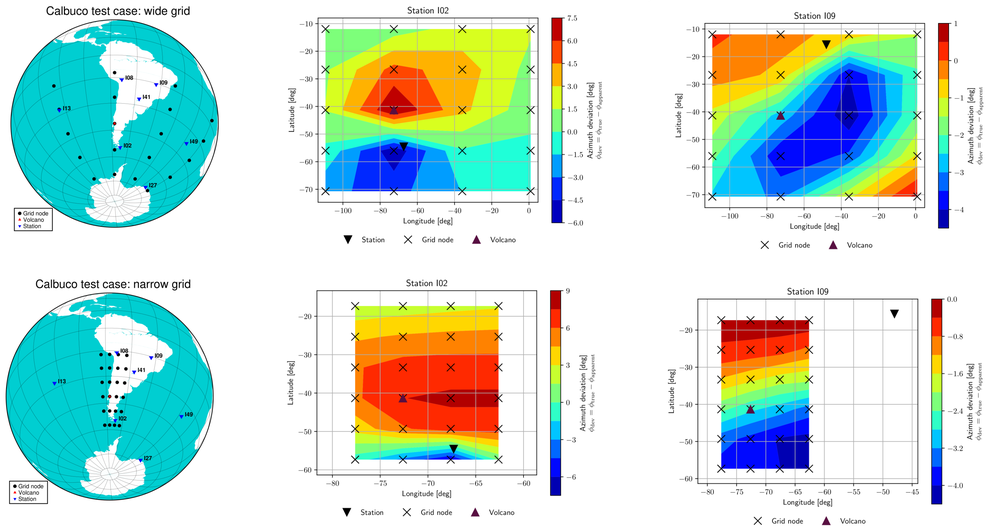


This work:
- ➔ available stations up to **~5,000 km**
- ➔ **21 days** around start of each eruption

ID	Location	Dist. (km)
I02	Bariloche, Argentina	1058
I41	Villa Florida, Paraguay	2092
I08	La Paz, Bolivia	2736
I09	Brasilia, Brazil	3623
I13	Easter Island, Chile	3712
I27	Antarctica, Germany	4846
I49	Tristan da Cunha Island, United Kingdom	5097

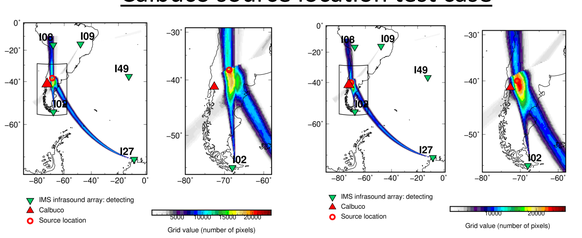
Results

From each station, predicted azimuth deviations to a regular grid of source nodes are calculated. Later, all predicted deviations are stored in a *look-up table*.



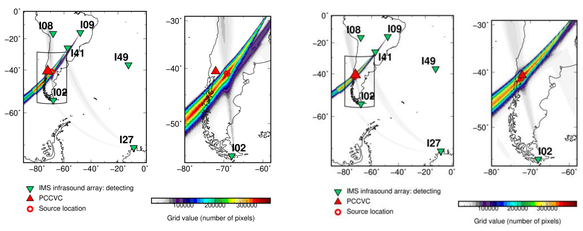
With the predicted azimuth deviations for the "narrow grid", we corrected the effect of crosswinds to better locate the infrasonic source for Puyehue-Cordón Caulle volcanic complex (PCCVC) and Calbuco volcano eruptions.

Calbuco source location test case



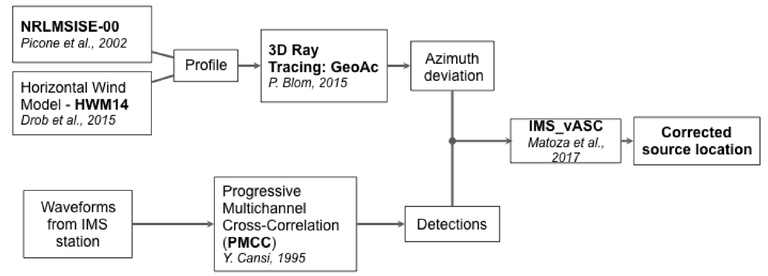
Left: without correction at 498 km from true.
Right: with correction at 183 km from true.

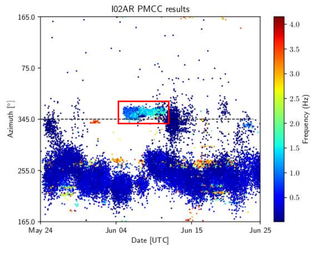
PCCVC source location test case



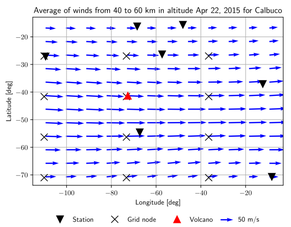
Left: without correction at 226 km from true.
Right: with correction at 75 km from true.

Methods

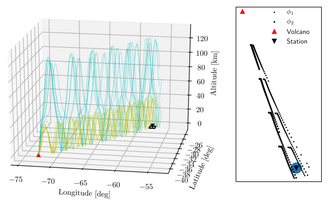




PMCC *family* detections from I02 around PCCVC eruption (red box).
Azimuth of associated detections is positively deviated from true as expected.

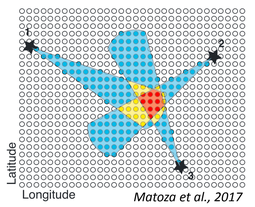


Zonal (E-W) and Meridonial (N-S) winds are predicted with empirical climatologies (NRMLSISE and HWM).



Considering the estimated climatologic conditions, 3D ray tracing (GeoAc) is used to estimate a minimum (ϕ_1) and maximum (ϕ_2) launch azimuth, for which ground intercepts are obtained inside a threshold area around the station.

An expected azimuth deviation for arrivals in the station is calculated and stored in the look-up table.



Azimuths of PMCC family detections are corrected, and then IMS_vASC (Matoza *et al.*, 2017) is used to locate the source.

Conclusions

For Calbuco case, the improvement in source location is about 63%; while for PCCVC case, it is about 67%. The increase of available stations (I41) in the area considerably reduces the misfit in source location, therefore it is expected a significant source accuracy gain for the region as soon as I01 (Bariloche, Argentina) is operative.
Source location results using realistic atmospheric modelling for Calbuco eruption (Matoza *et al.*, 2018) are comparable with ours. Using a combined empirical and physical modelling like AVO-G2S (Schwaiger *et al.*, 2019) will likely reduce the source location misfit obtained from look-up tables for IMS stations.