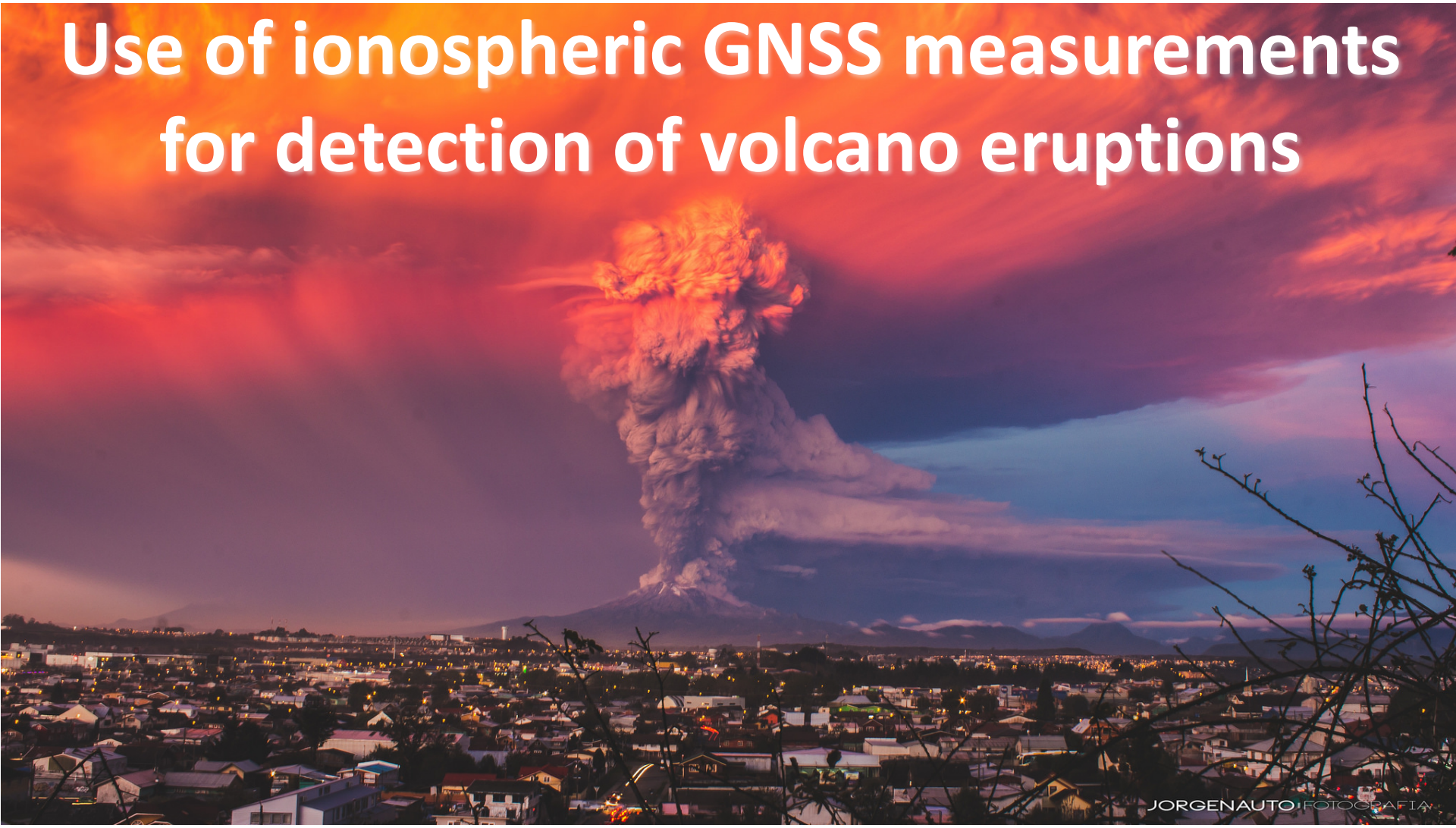
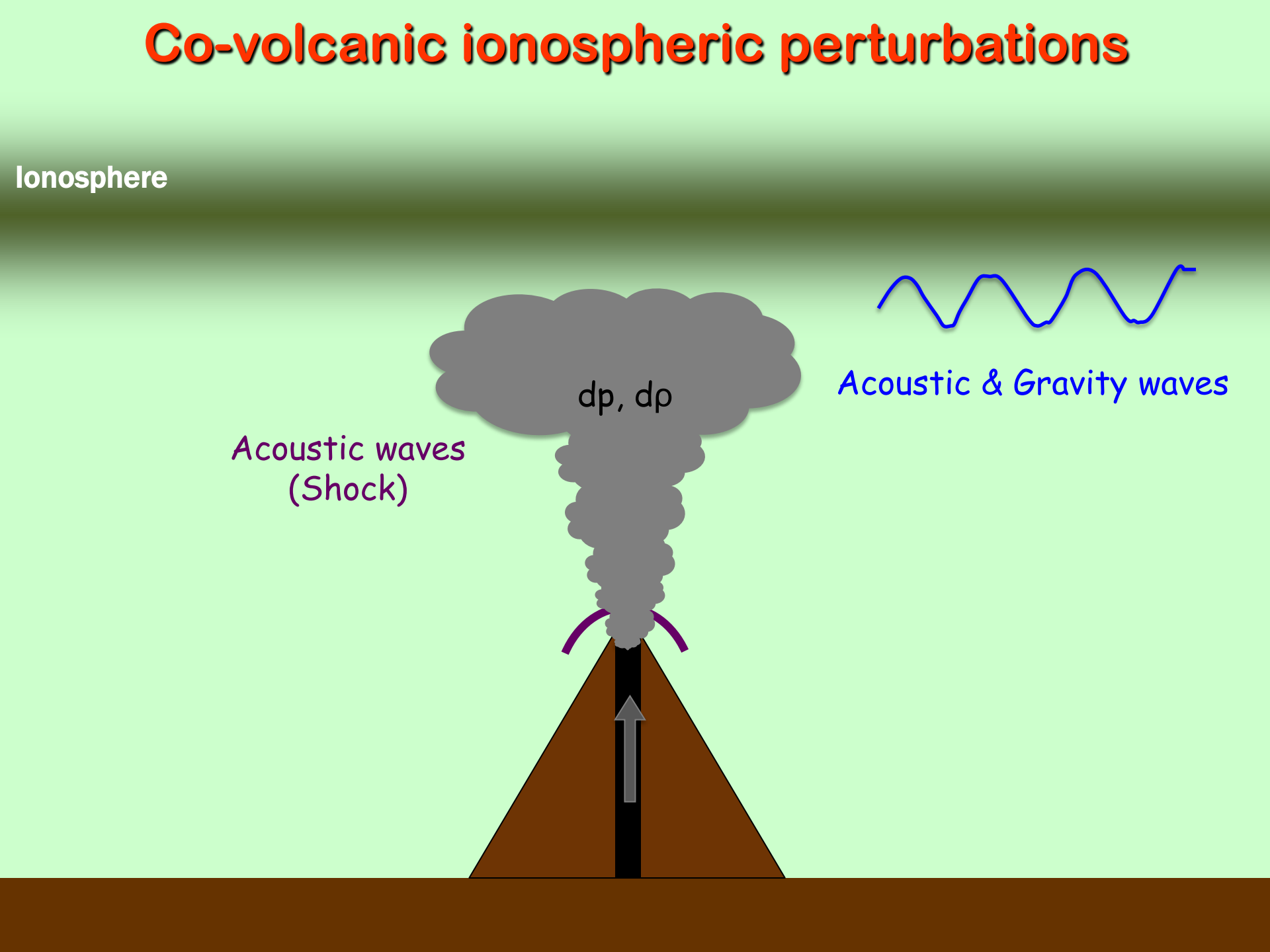
Use of ionospheric GNSS measurements for detection of volcano eruptions



E. Astafyeva[1], K. Shults[1], S. Adourian[2]

1 - Institut de Physique du Globe de Paris, France; 2 – Ecole Normale Supérieure , France

Co-volcanic ionospheric perturbations



Calbuco volcano - Chile

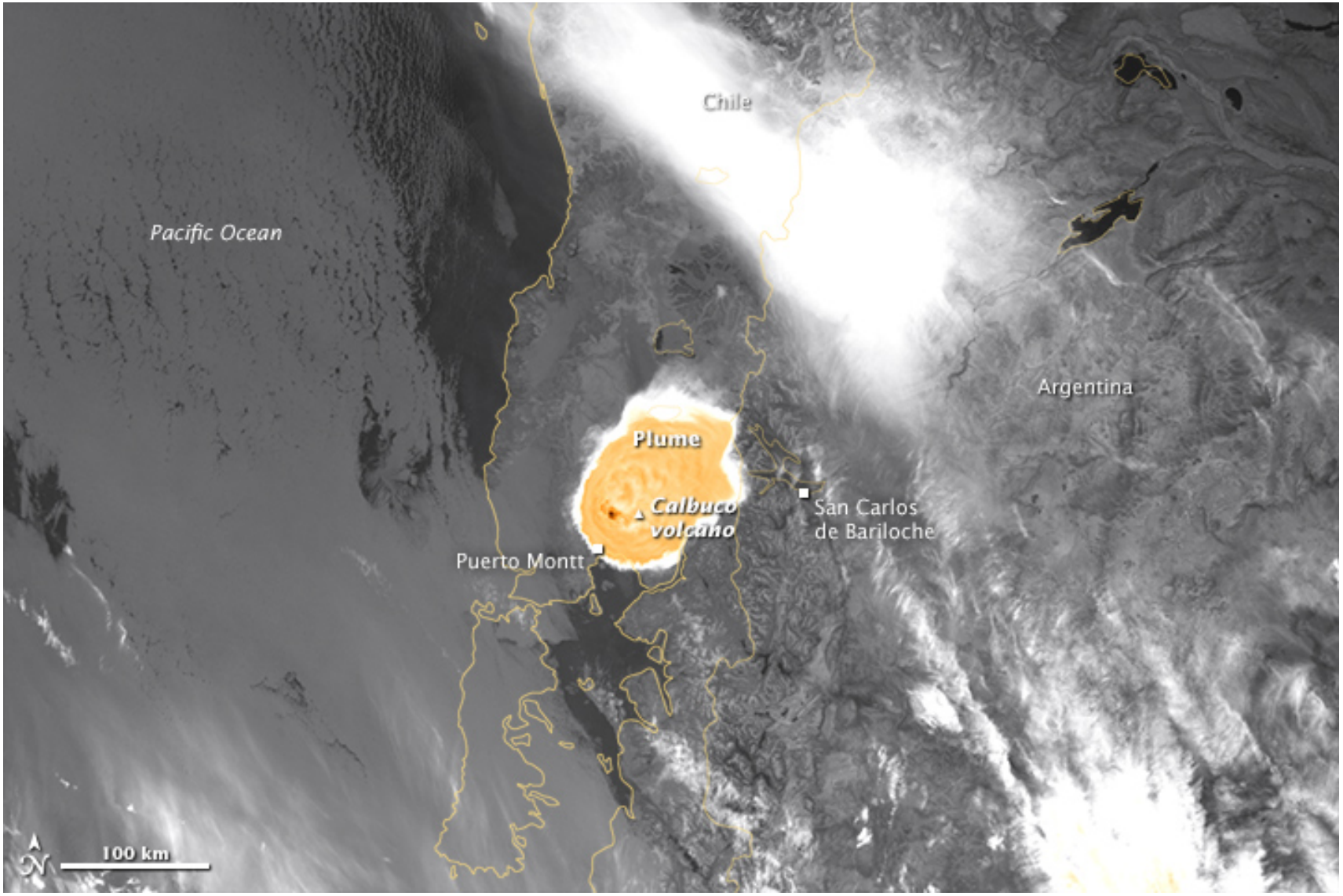
Calbuco volcano eruptions April 2015

1st eruption:
22 April 2015
21:04UT (18:04LT)

2nd eruption:
23 April 2015
04:00UT (01:00LT)

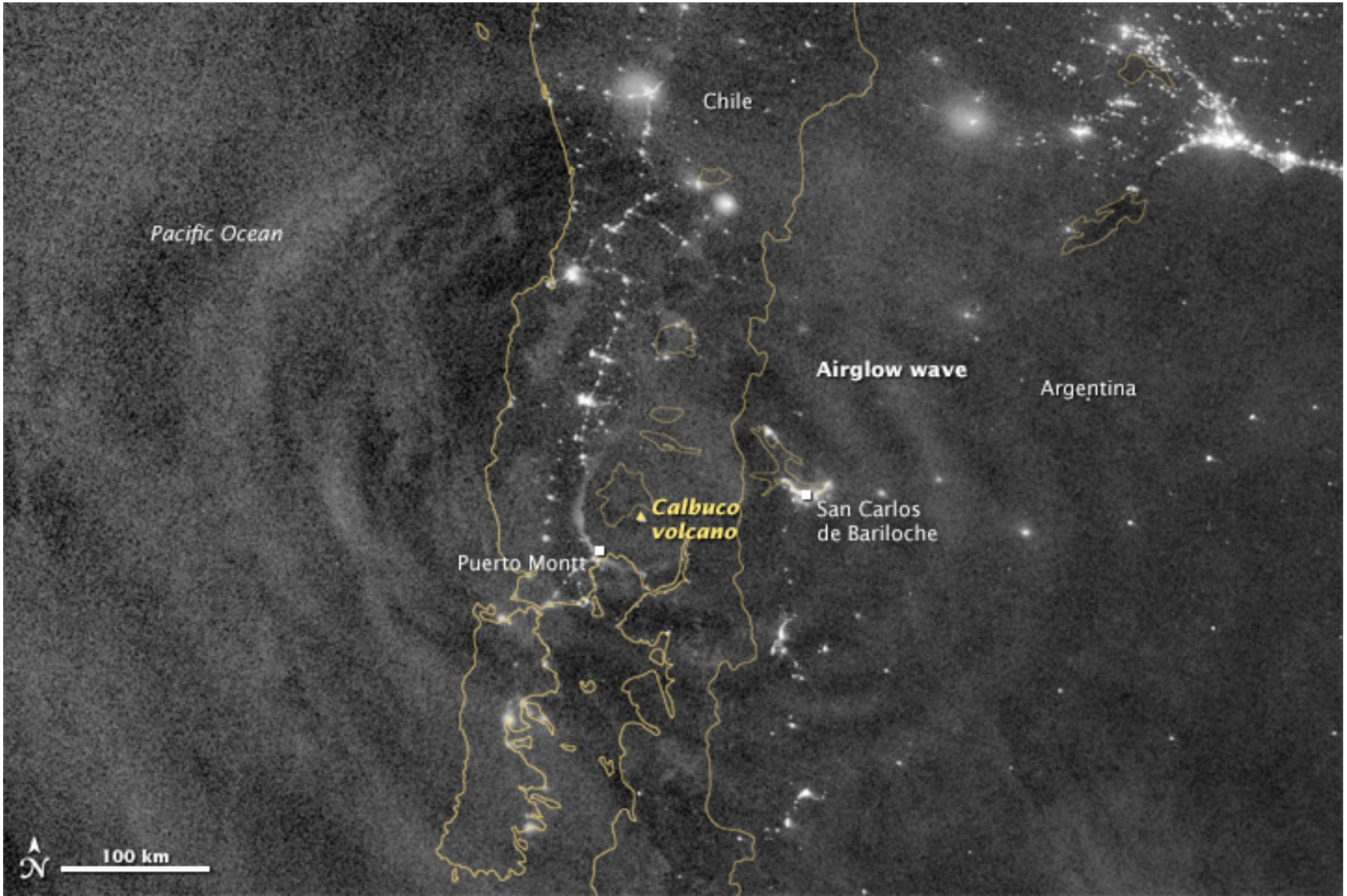
VEI: 4 (Sub-Plinian) Plume of ~15km alt.

Volcanic plume from space



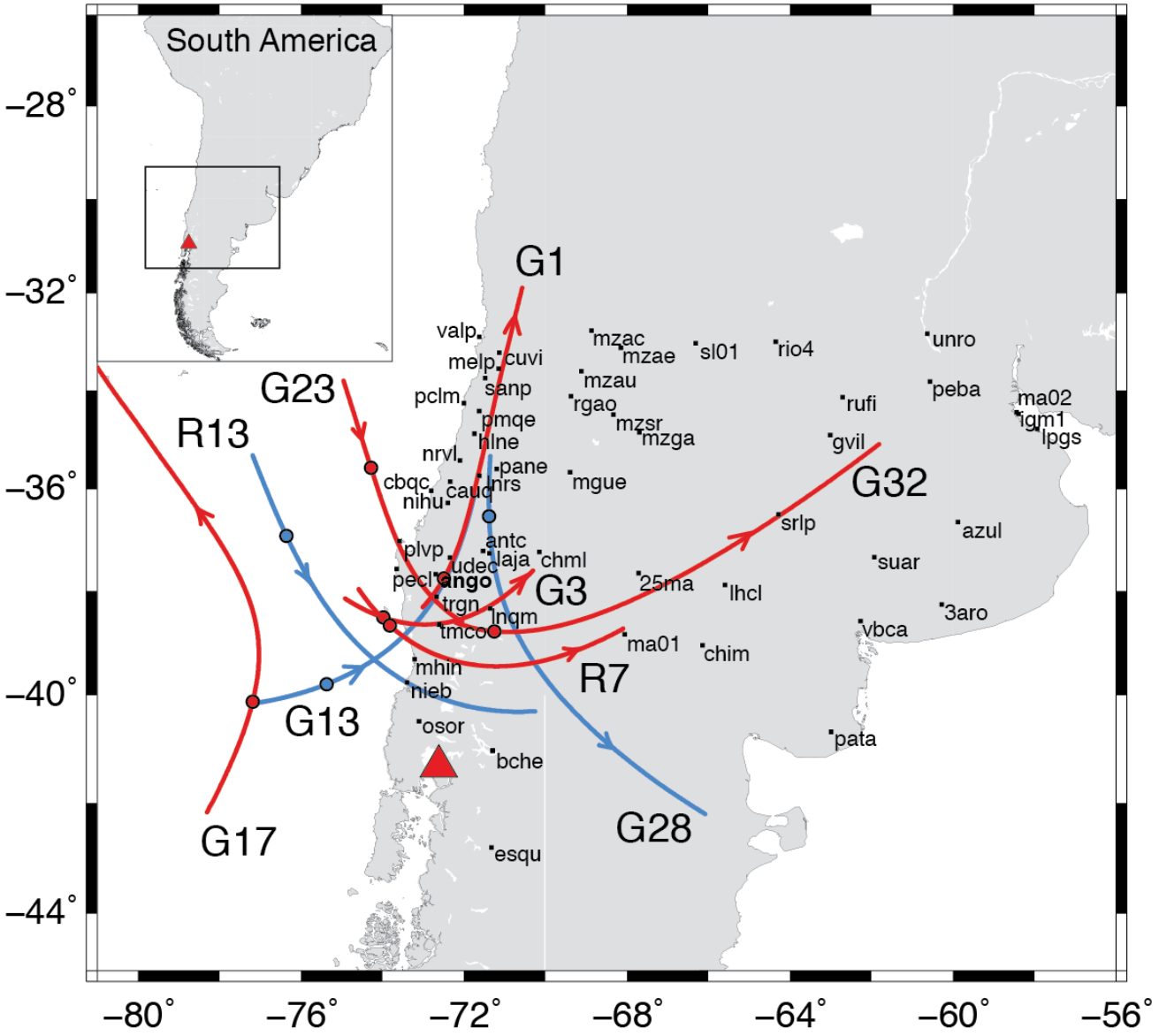
Visible Infrared Imaging Radiometer Suite (VIIRS)

Mesospheric gravity waves
23 April 2015, at 05:09UTC



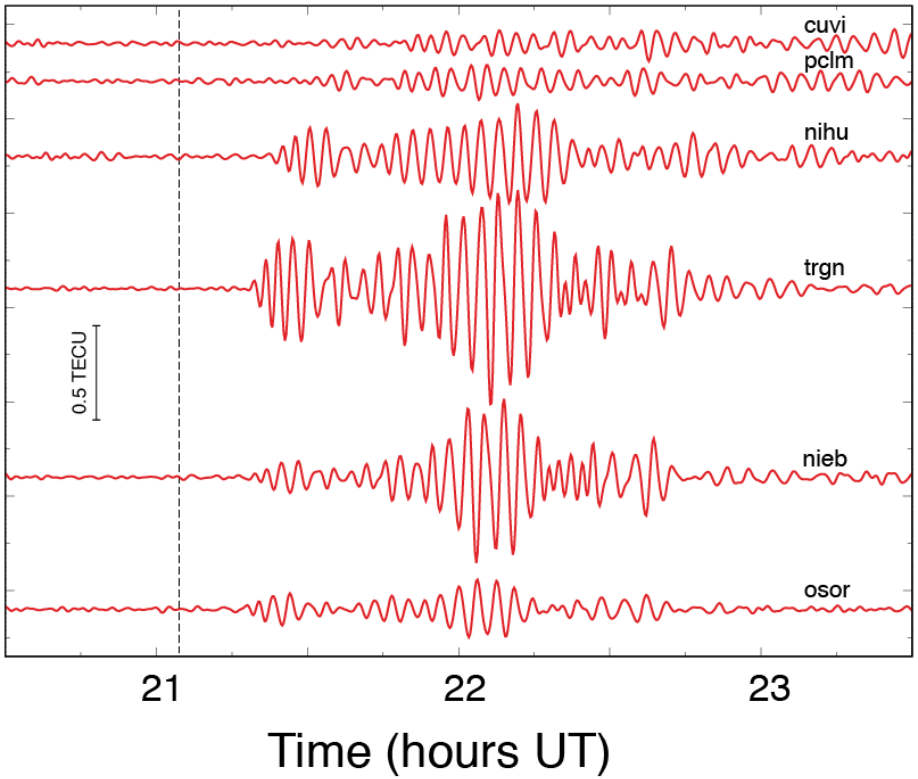
SUOMI Satelllite (NOAA) - Airglow

Ionospheric response to Calbuco eruptions

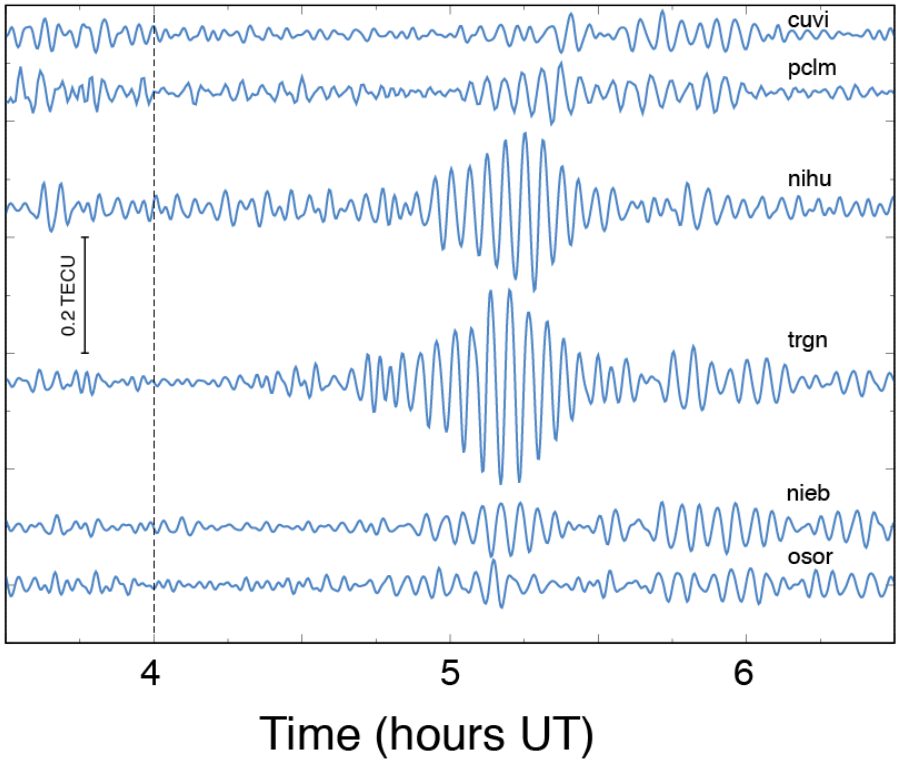


TEC response to the eruptions

1st eruption:
22 April 2015
21:04UT (18:04LT)



2nd eruption:
23 April 2015
04:00UT (01:00LT)



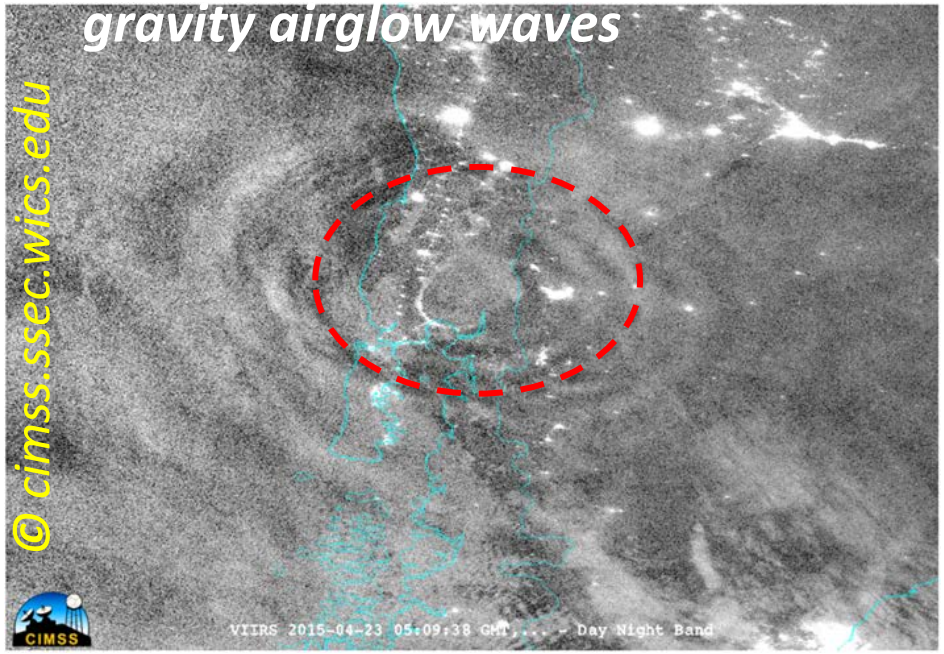
Calbuco: 2nd eruption: 23/04/2015 - 04:00UT

Shults et al., JGR, 2016

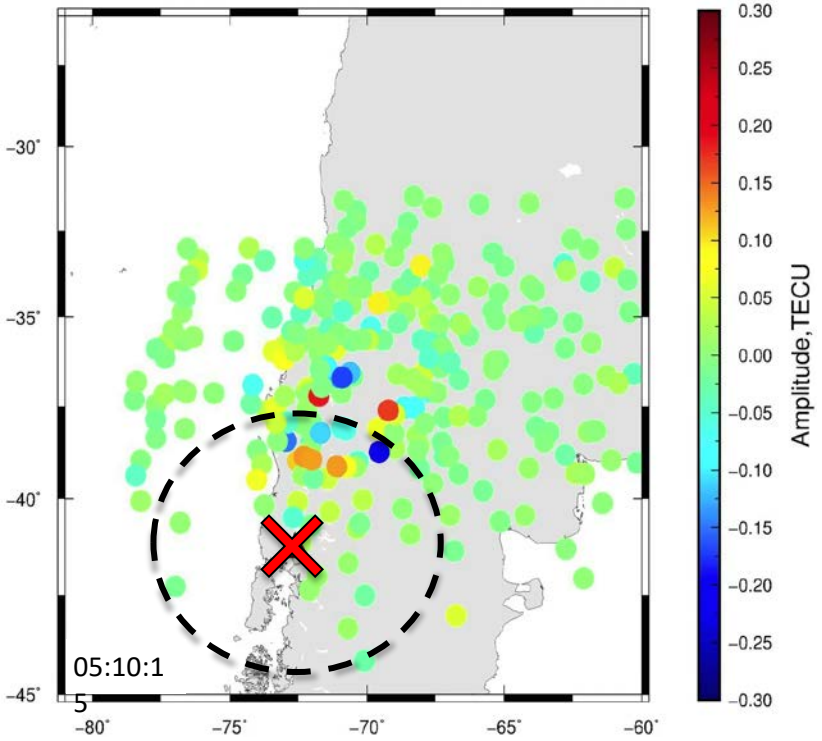
Calbuco: 2nd eruption: 23/04/2015 - 4:00UT

MESOSPHERE (50-80km):

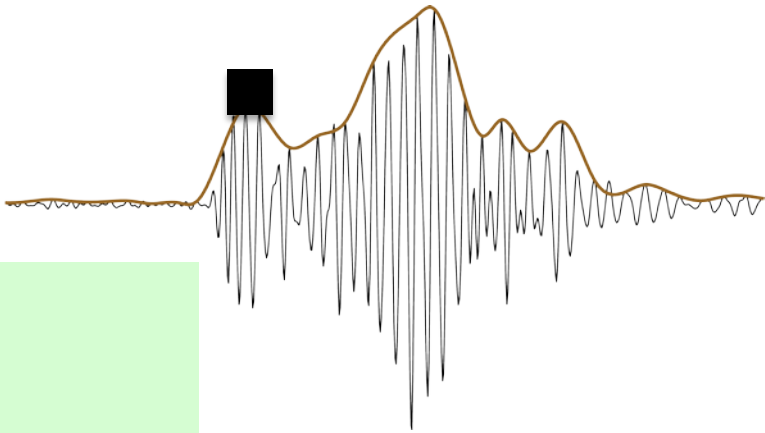
gravity airglow waves

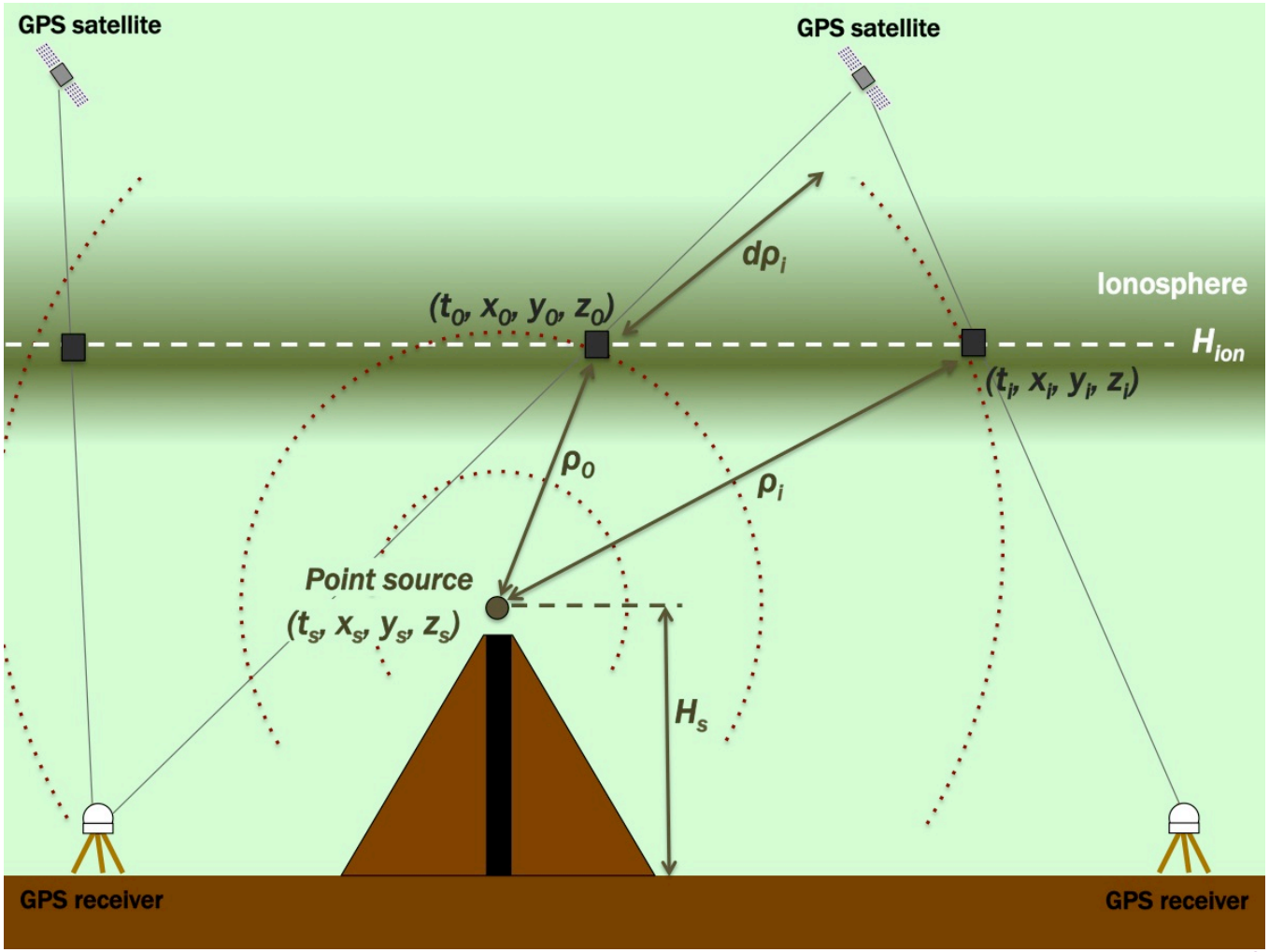


IONOSPHERE (250-400km):



Localization of eruption from the ionosphere





- Spherical wave
- Point source
- Constant speed

Shults et al. (JGR-Space Physics, 2016)

«Ionospheric Volcanology» : first results

Calbuco: -41.32; -72.61

1st eruption: 22 April 2015, 21:04UT

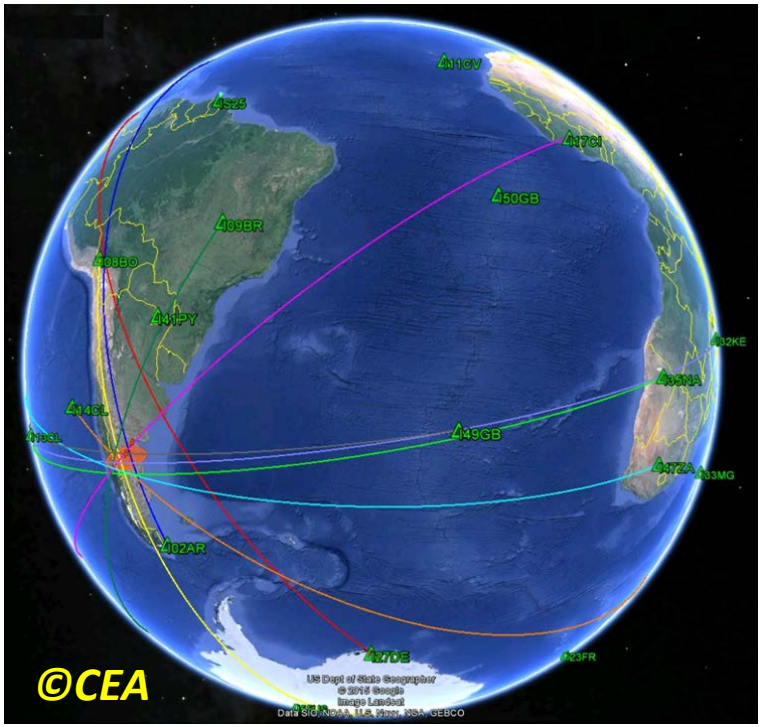
Sat. used	Lat	Lon	UT (hrs)	Hs (km)	Vr (m/s)
ango-G03,chml-G03,plvl-G03	-43.4	-72.7	21.1773	140	500
ango-G03,tmco-G03,chml-G03	-40.6	-73.2	21.3952	140	850
25ma-G17, chml-G03, laja-G03, pecl-G03	-41.2	-72.4	21.2658	140	420
25ma-G17,lnrs-G03,cbqc-G03	-41.8	-73.1	21.2441	140	460

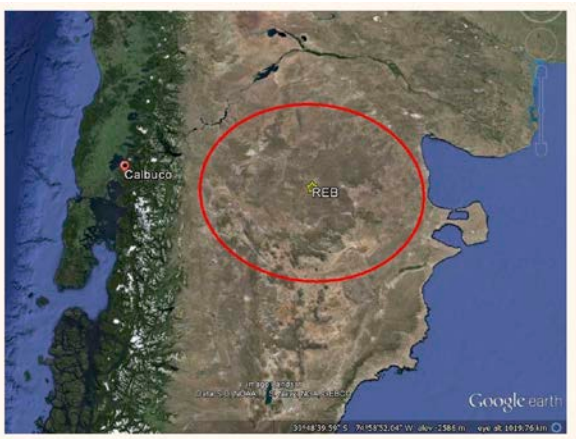
2nd eruption: 23 April 2015, 04:00UT

Sat. used	Lat	Lon	UT (hrs)	Hs (km)	Vr (m/s)
ango-G13,chml-G13,plvl-G13	-43.5	-70.2	4.94337	300	400
ango-G13, chml-G13, laja-G13, pecl-G13	-39.1	-71.5	5.12943	300	720
25ma-R13, pane-G13, nrvl-G13	-39.1	-71.6	5.05413	300	400
ma01-R13, laja-G13, chml-G13	-42.2	-72.5	5.04021	300	890

Localisation of eruptions:

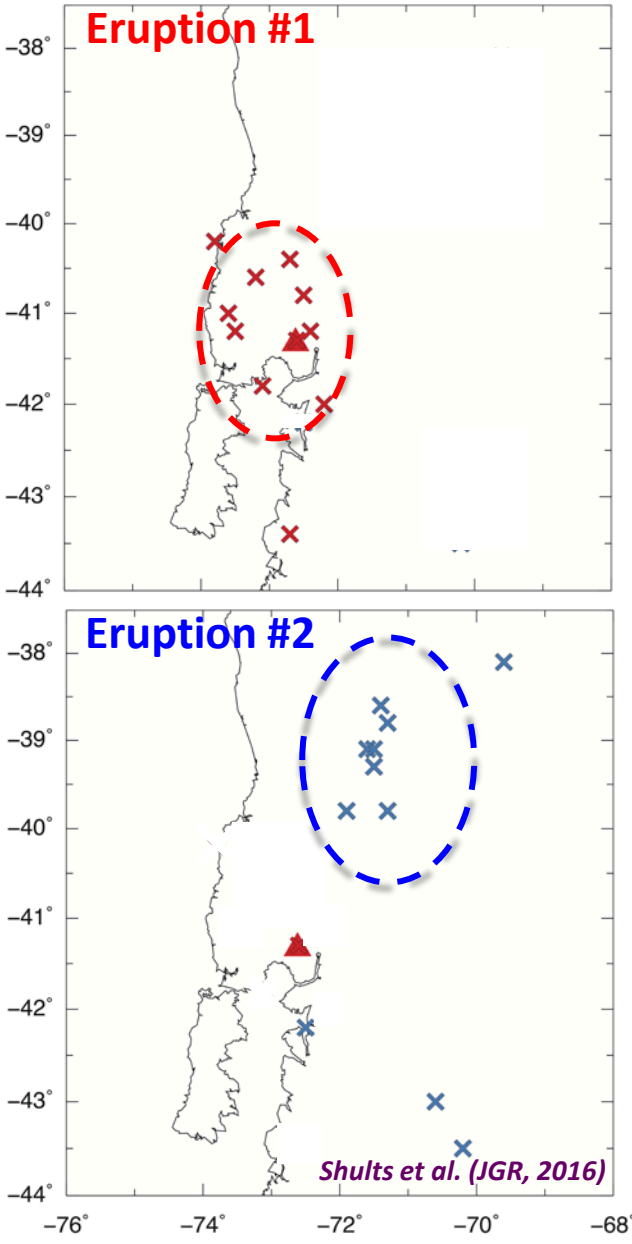
… from infrasound observations





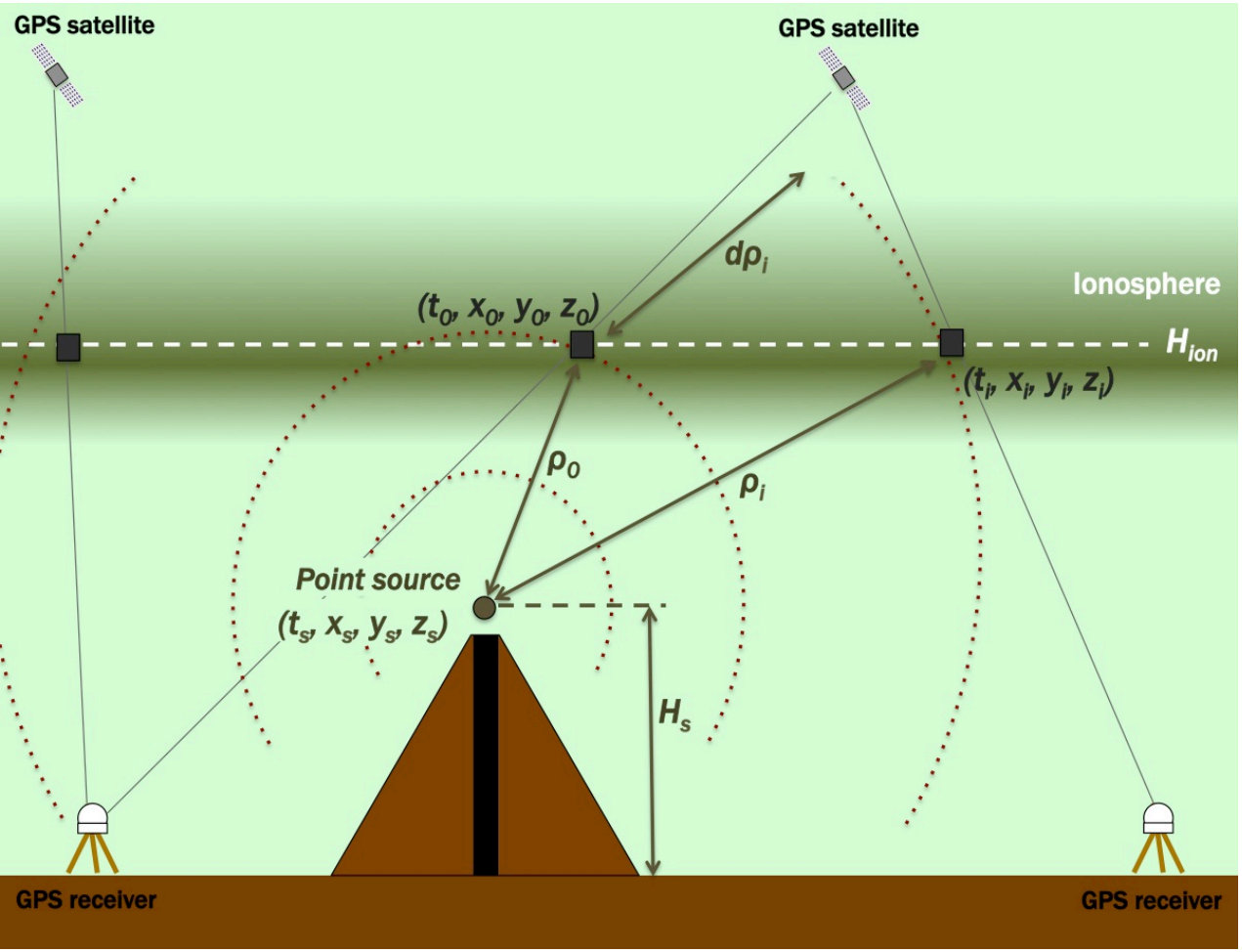
P. Bittner et al. (ctbto.org)
2ème éruption – 400 km away

… from the ionosphere



Eruption time

$$t_s = t_0 - \frac{\sqrt{(x_0 - x_s)^2 + (y_0 - y_s)^2 + (z_0 - z_s)^2}}{V}$$



First eruption:

Ts_seis = 21.07UT

Ts_infra = 21.17UT(±5min)

Ts_iono = 21.18 to 21.39UT

Second eruption:

Ts_seis = 04.00UT

Ts_infra = 04.00UT

Ts_iono = 4.78 to 4.98UT

SUMMARY

- ☑ **By using data from ground-based GNSS receivers we analyzed the ionospheric TEC response to two eruptions of the Calbuco volcano of 22-23 April 2015;**

- ☑ **Ionospheric GNSS measurements can be used for the detection of eruptive volcanoes. Higher resolution data & other models might/should give better results... ☺**

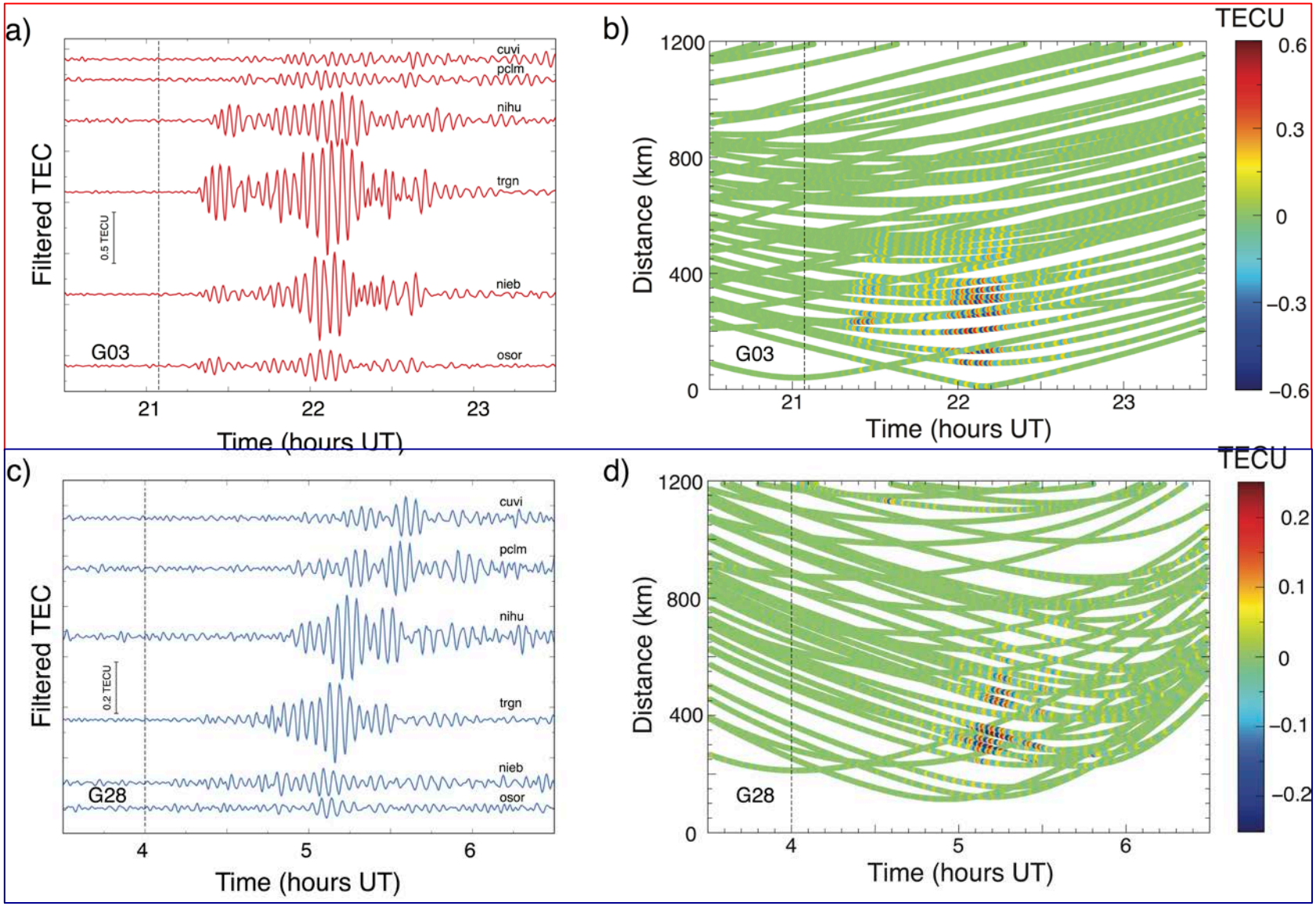
Thank you!

IPGP
INSTITUT DE PHYSIQUE DU GLOBE DE PARIS

astafyeva@ipgp.fr

Travel-time diagrams

Vh ~900-1200 m/s

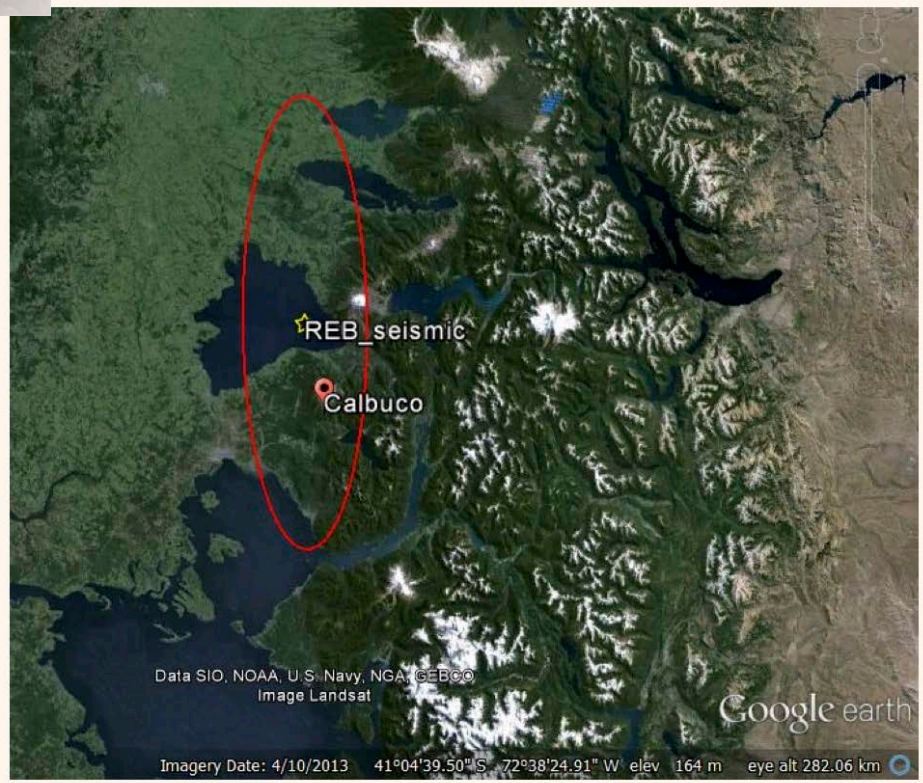


Shults et al. (JGR-Space Physics, 2016)

Calbuco: 1st eruption: 22/04/2015 - 21:04UT

Shults et al., JGR, 2016

Location of seismic event related to Calbuco activity



http://argentina-travel-blog.sayhueque.com/calbuco-volcano/