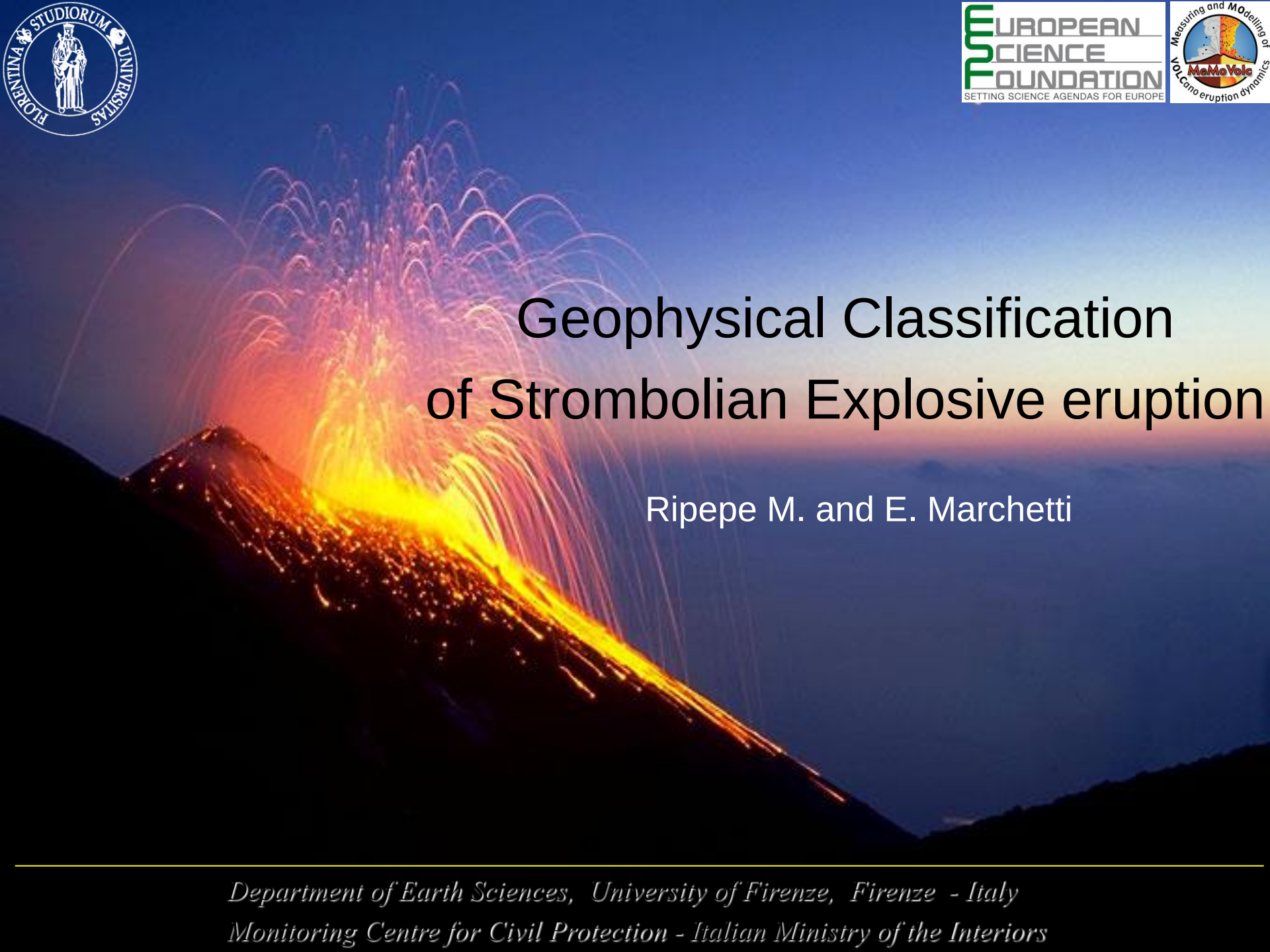


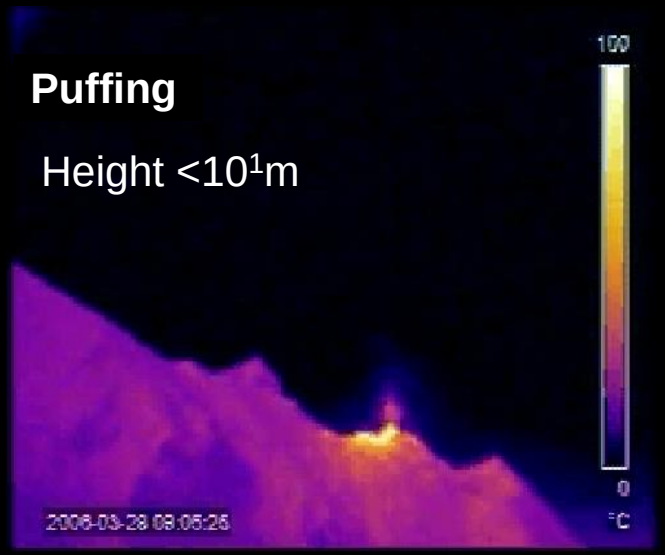
Geophysical Classification of Strombolian Explosive eruption

Ripepe M. and E. Marchetti

Department of Earth Sciences, University of Firenze, Firenze - Italy

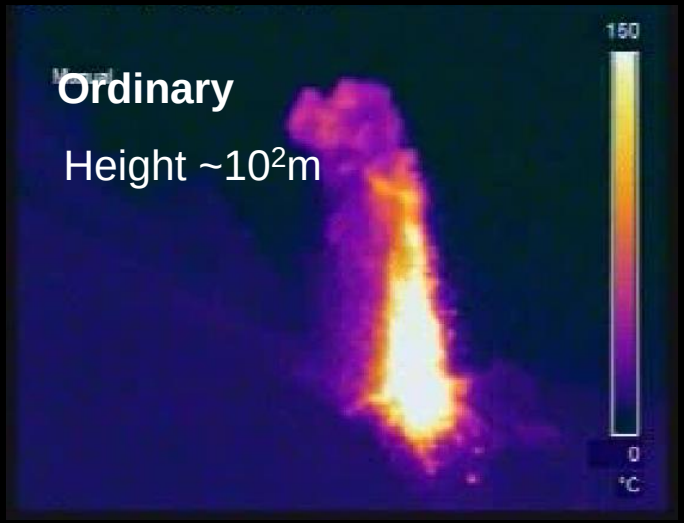
Monitoring Centre for Civil Protection - Italian Ministry of the Interiors

Explosive Activity of Stromboli



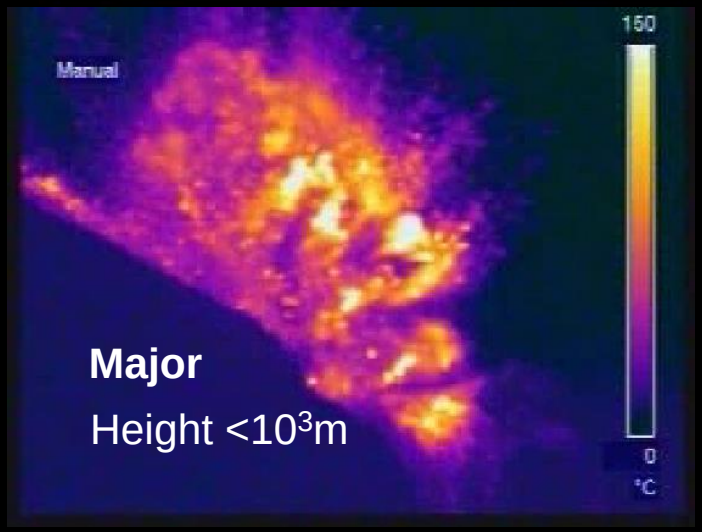
Puffing

Height <10^1m



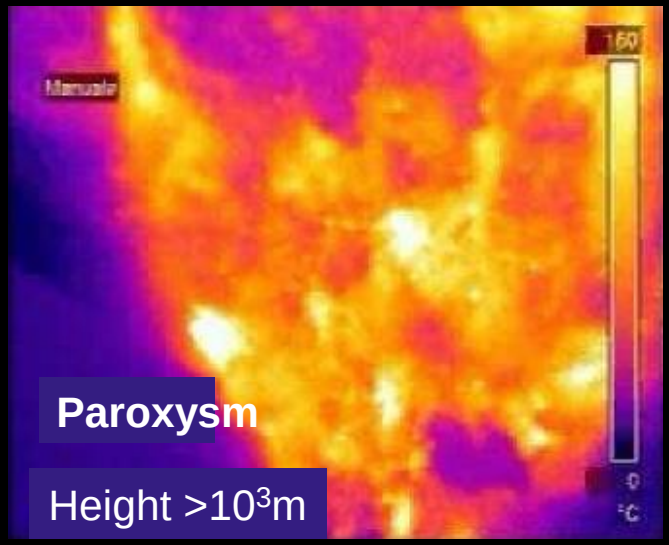
Ordinary

Height ~10^2m



Major

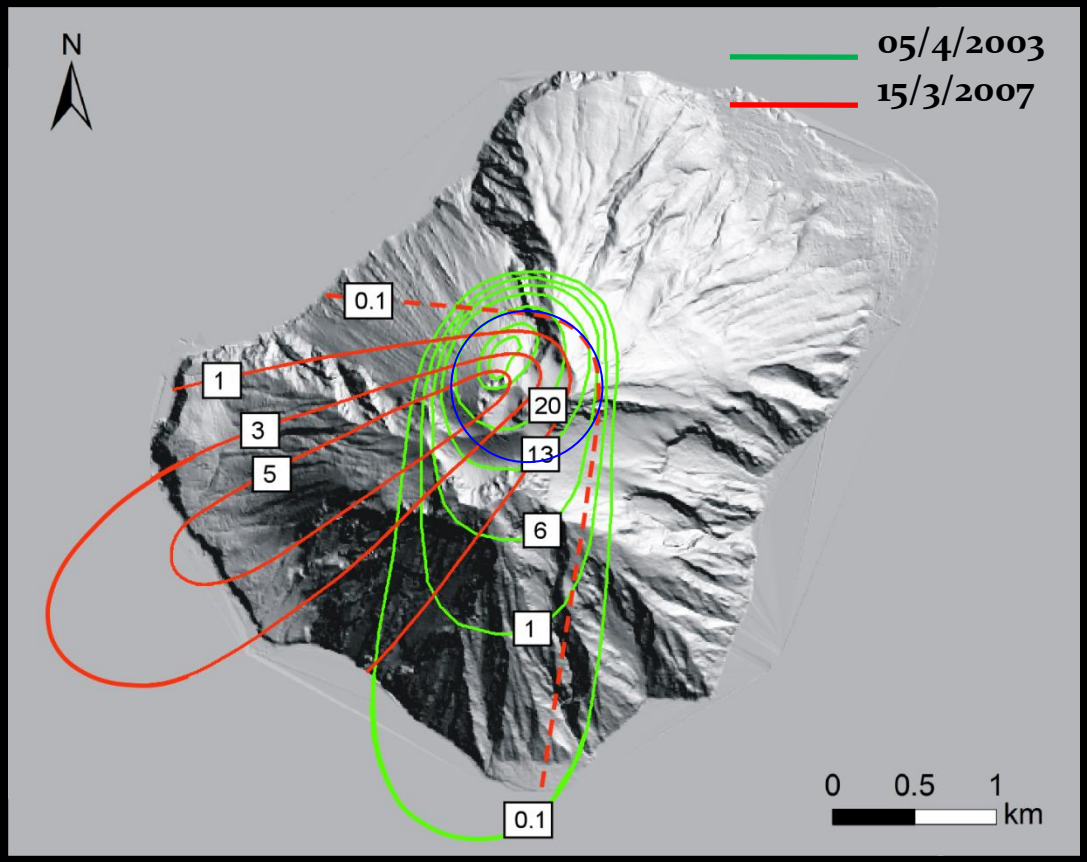
Height <10^3m



Paroxysm

Height >10^3m

Fallout dispersal, Mass and Volume



Mass

05/04/2003 = ~10^8 kg
15/03/2007 = ~10^7 kg
(Rosi et al., 2008)
(Pistolesi et al., 2011)

Majors = ~10^6 kg
(Andronico & Pistolesi, 2008)

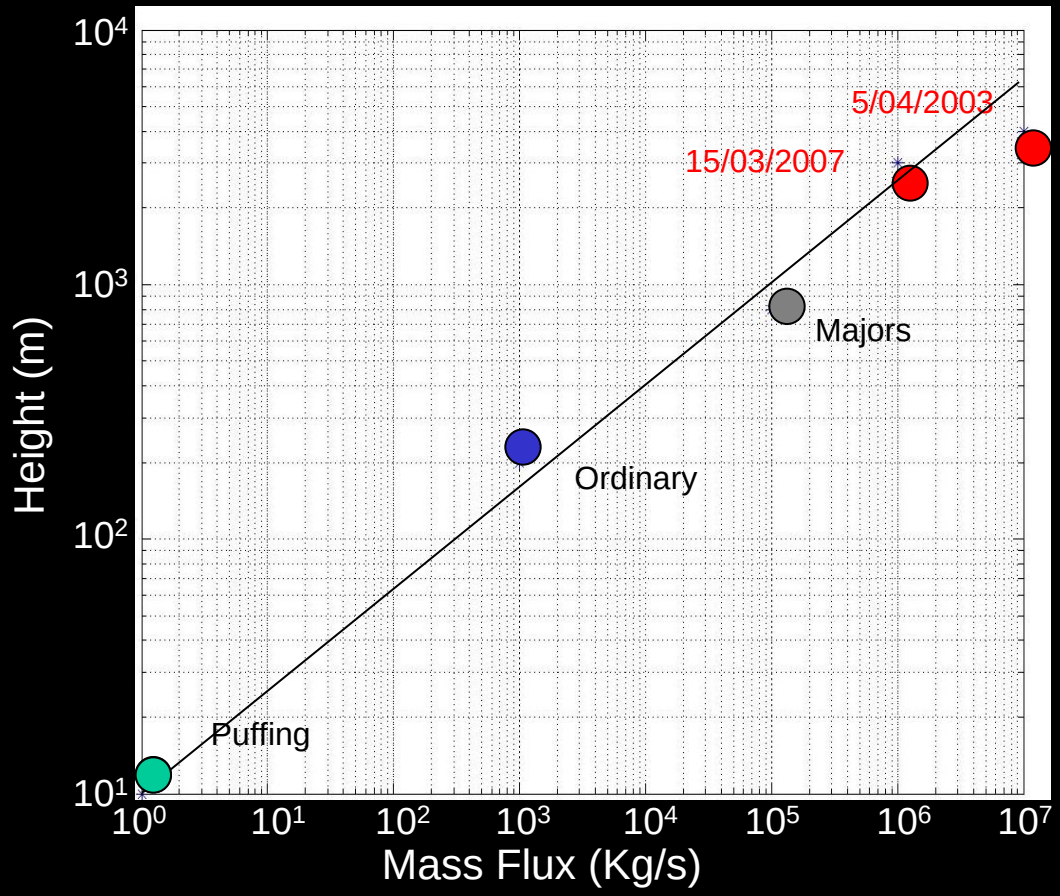
Ordinary = ~10^3 kg
(Ripepe et al., 1993)
(Harris et al., 2013)

Volume

05/04/2003 = ~10^5 m^3
15/03/2007 = ~10^4 m^3
Majors = <10^3 m^3
Ordinary = ~10^0 m^3

Mass and Volume Ejected can span Five orders of magnitude

Mass Discharge Rate of Strombolian Activity



Mass Discharge Rate

5 April	= ~10^7 kg/s	
15 March	= ~10^6 kg/s	
Majors	= ~10^5 kg/s	
Ordinary	= ~10^3 kg/s	
Puffing	= ~10^0 kg/s	

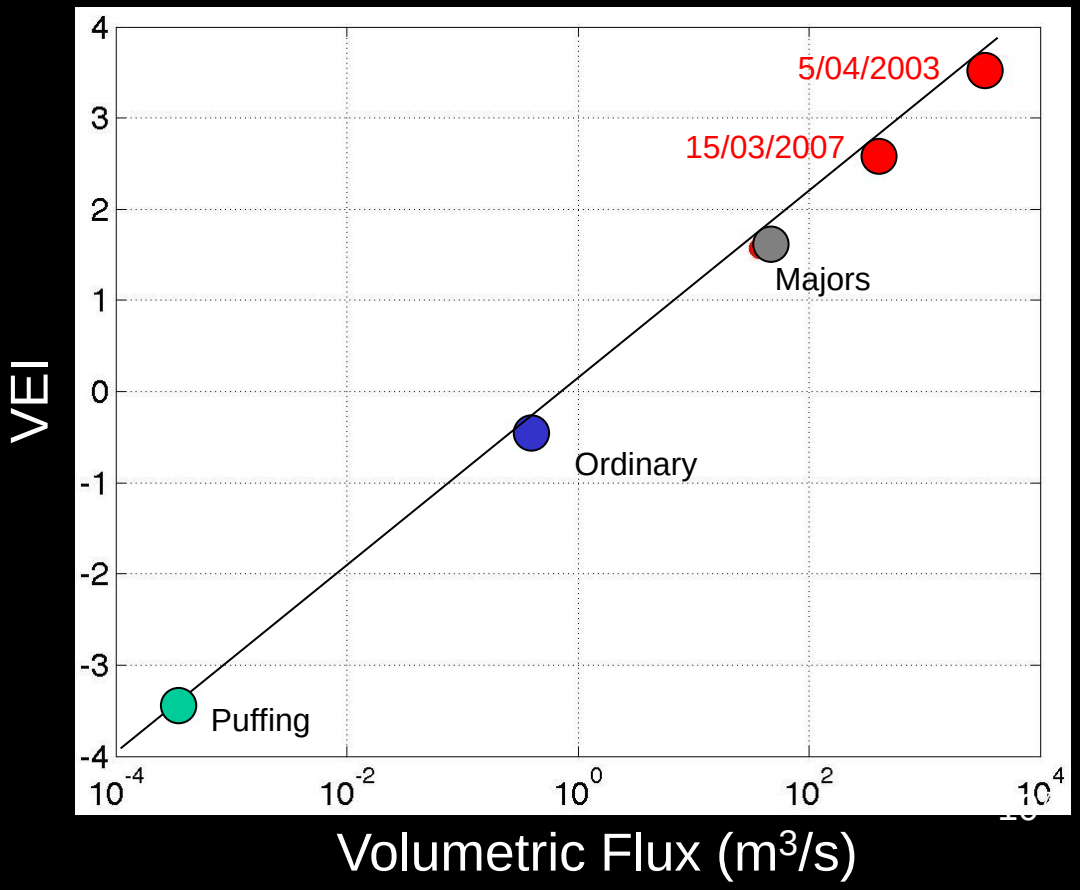
$$H = 0.25 \times Q^{0.38}$$

$$H = 2 \times Q^{0.241}$$

Mastin et al., 2009

Mass Discharge Rate scales with the “plume” height and ranges SEVEN order of magnitude

VEI of Strombolian Activity



Volumetric Discharge Rate

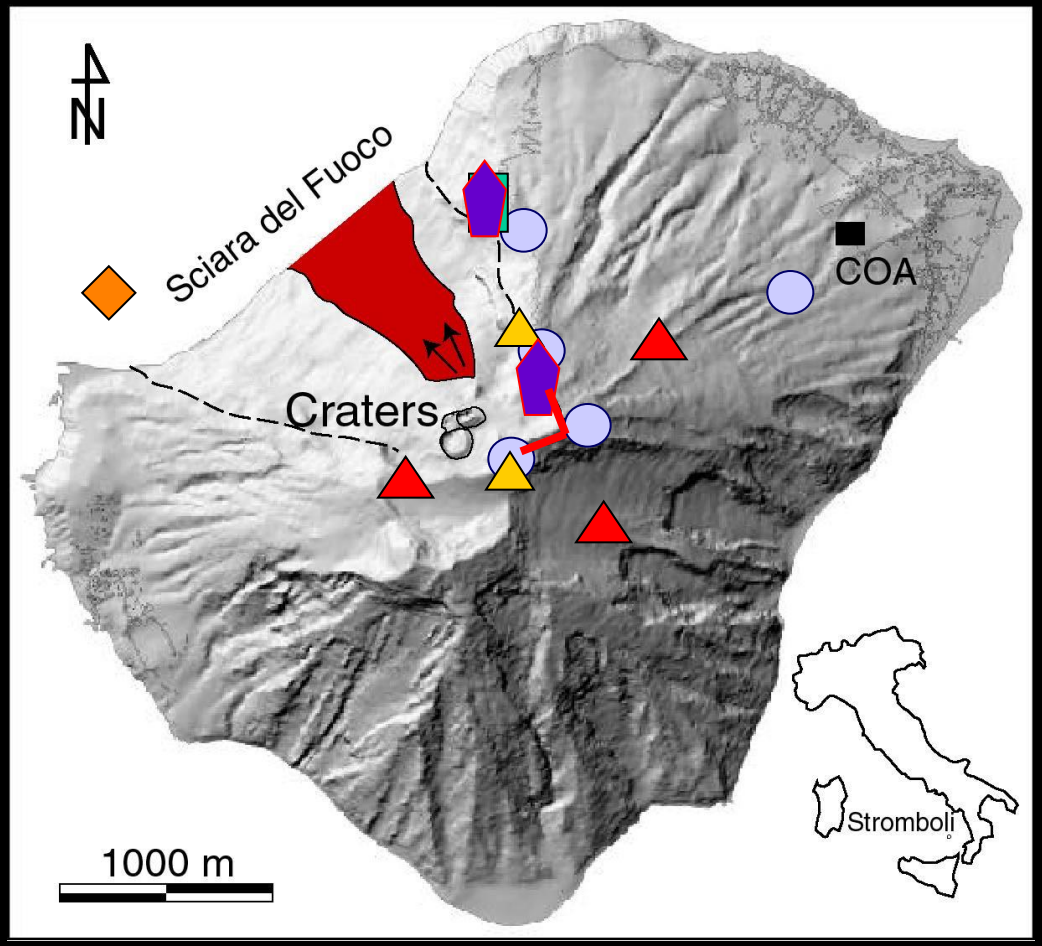
5 April = ~10^3 m^3/s
15 March = ~10^2 m^3/s
Majors = ~10^1 m^3/s
Ordinary = ~10^0 m^3/s
Puffing = ~10^{-3} m^3/s

Considering:

$$VEI = \log(Q)$$

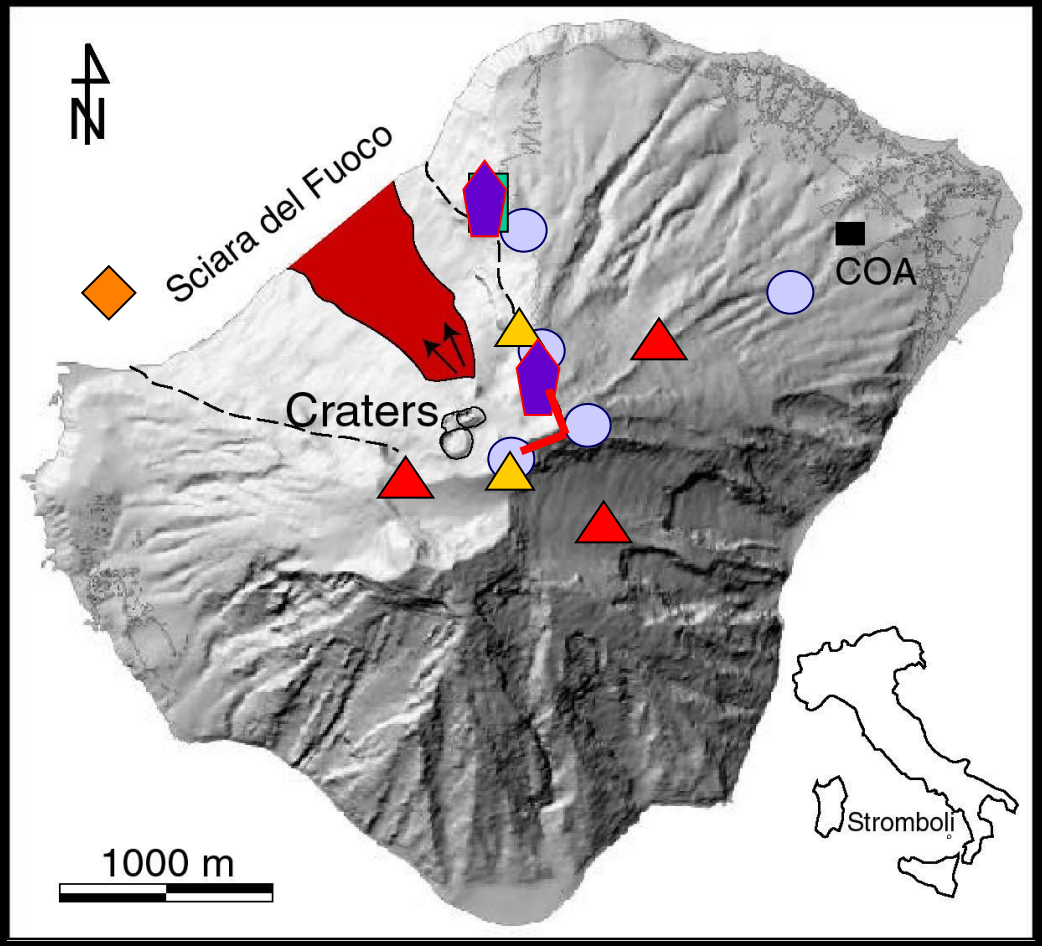
Assuming a DRE volumetric flux Strombolian activity ranges between VEI =0 and 3

Integrated Geophysical Network



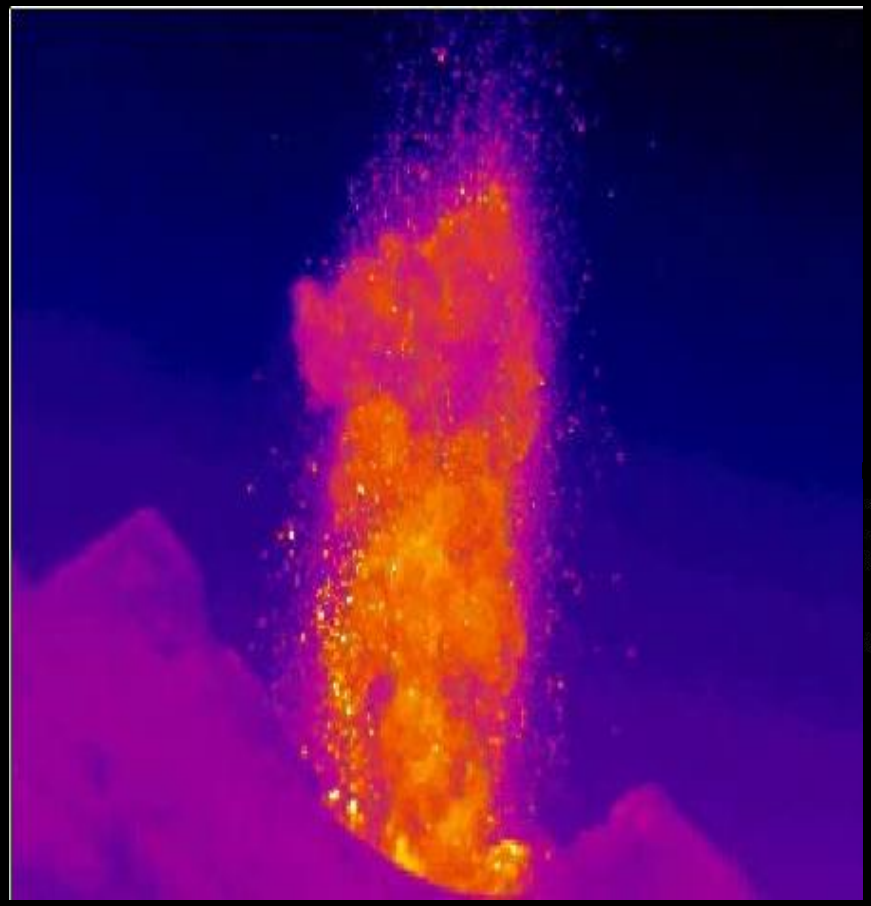
- 5 Seismic broad-band (30s) Guralp CMG40T + 5 infrasonic microphones (0.8-20 Hz)
- 2 Thermal Radiometers (9-14μ) OMEGA OS
- 3 Tiltmeters Pinnacle 5000T res. 1 nrad at 1sps
- 2 Thermal Cameras FLIR A10
- 1 Infrasonic Array
- 1 Buoy - Tide Gauge and Hydro-acoustic

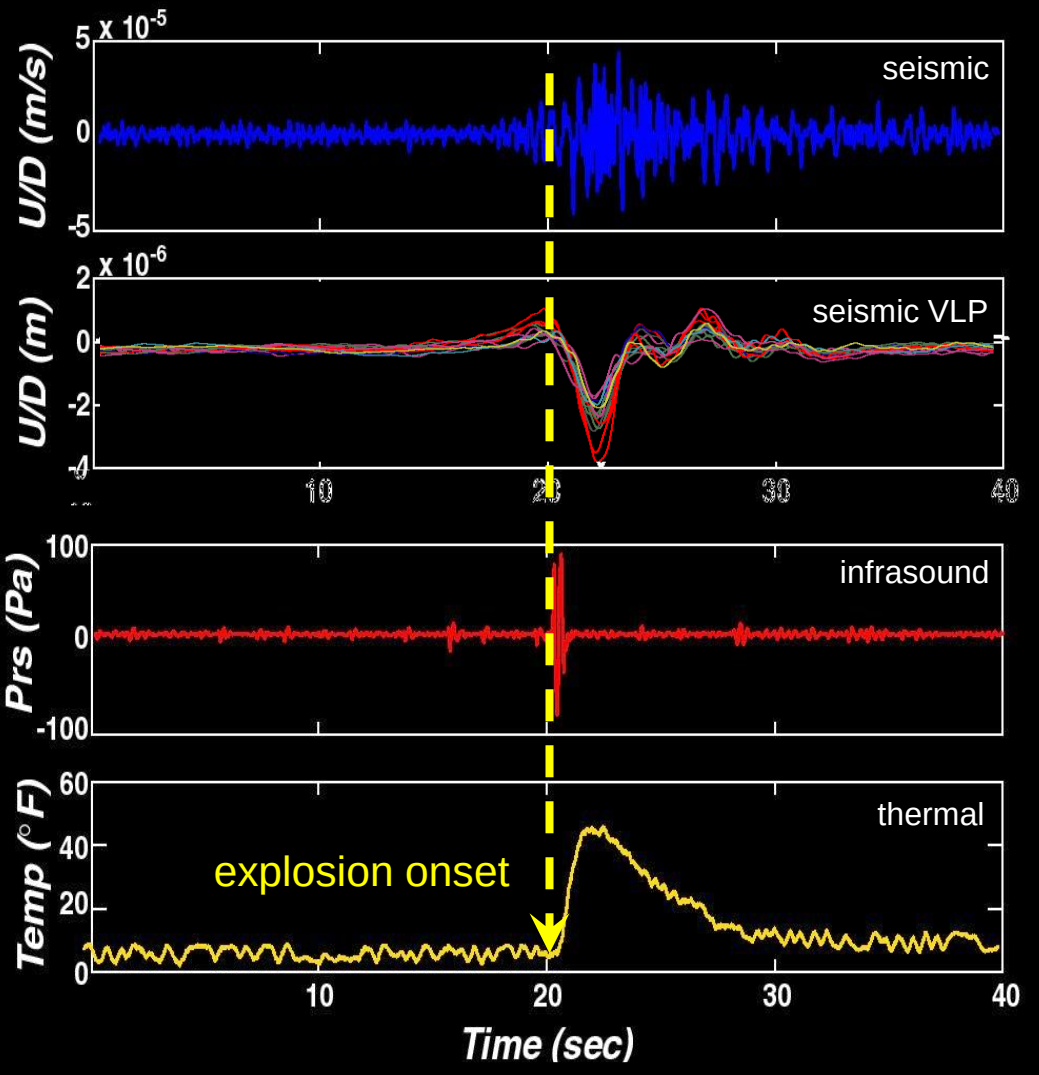
Integrated Geophysical Network



- 5 Seismic broad-band (30s) Guralp CMG40T + 5 infrasonic microphones (0.8-20 Hz)
- 2 Thermal Radiometers (9-14μ) OMEGA OS
- 3 Tiltmeters Pinnacle 5000T res. 1 nrad at 1sps
- 2 Thermal Cameras FLIR A10
- 1 Infrasonic Array
- 1 Buoy - Tide Gauge and Hydro-acoustic

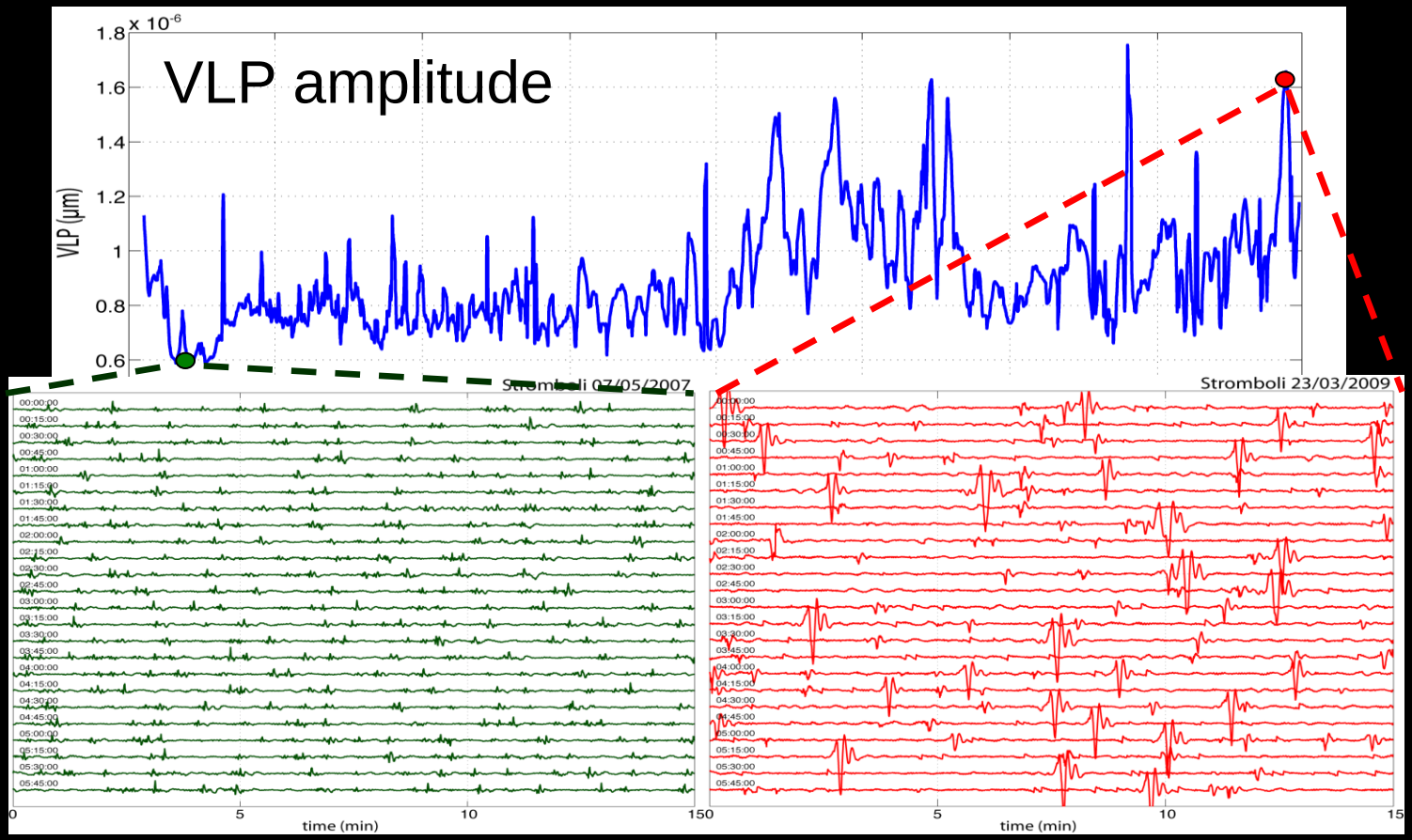
Geophysical parameters monitored





Infrasound and Thermal Camera can help to constraint seismic source

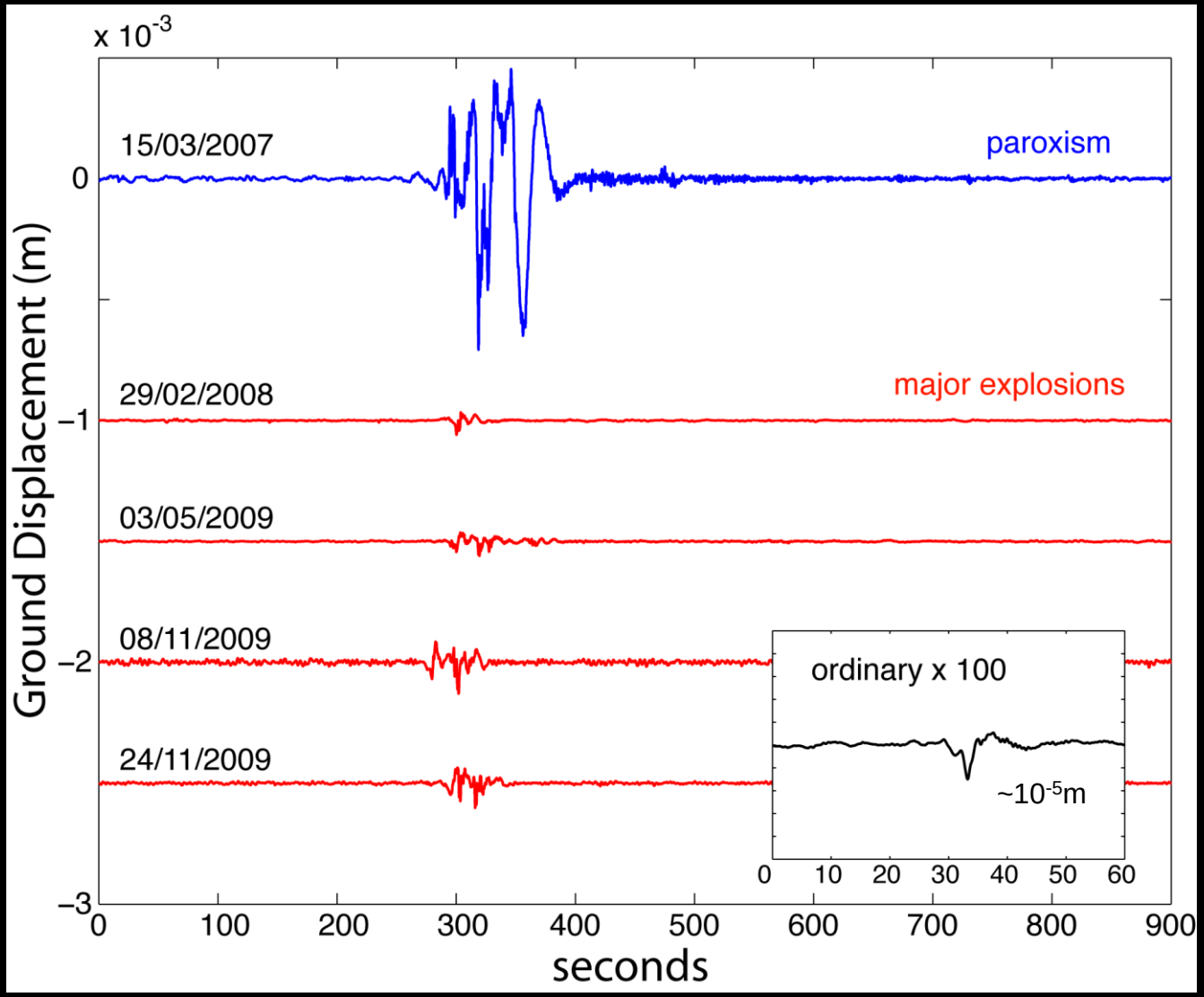
Amplitude Variability of seismic VLP



Low amplitude VLP

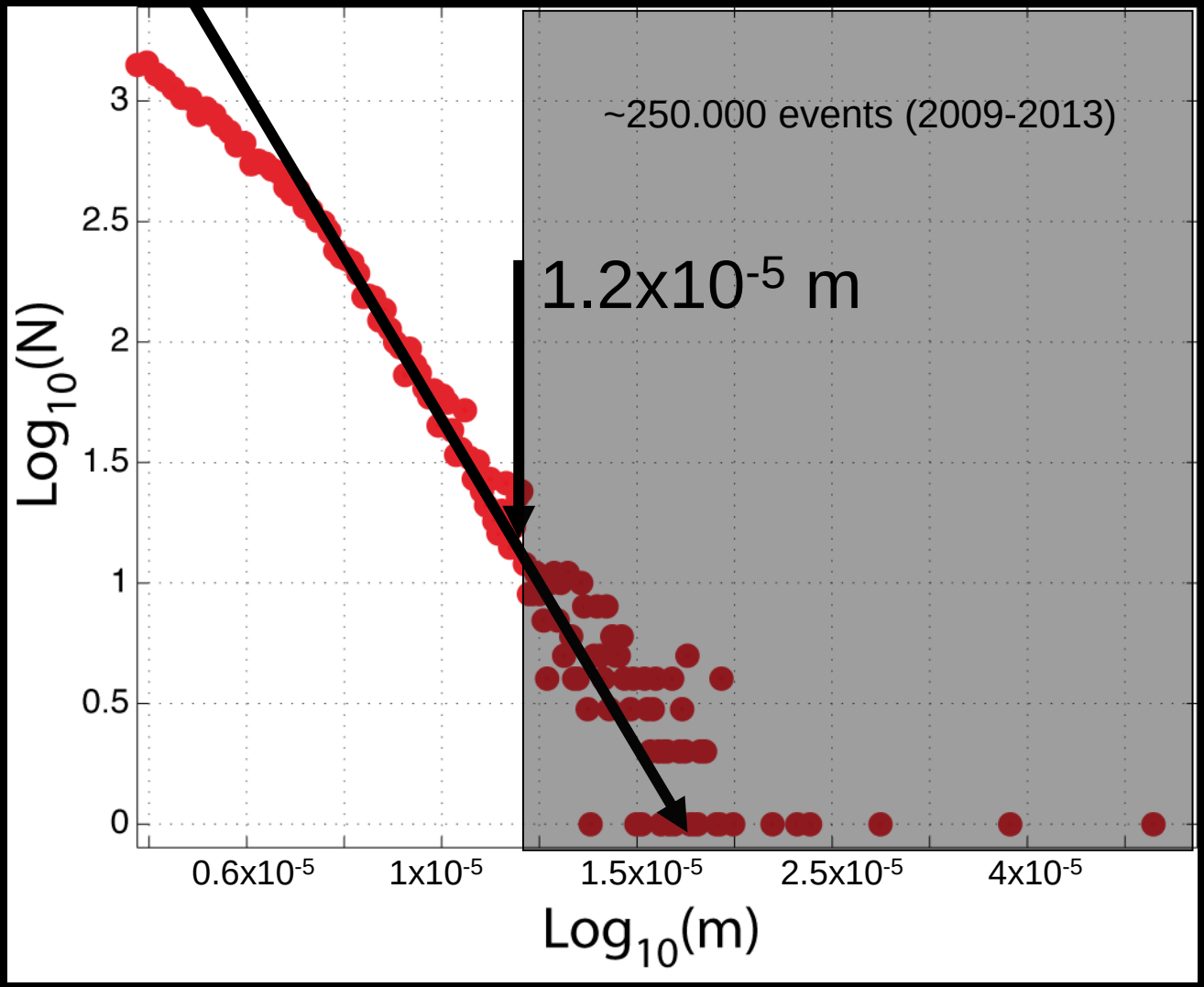
High amplitude VLP

Amplitude Variability of seismic VLP



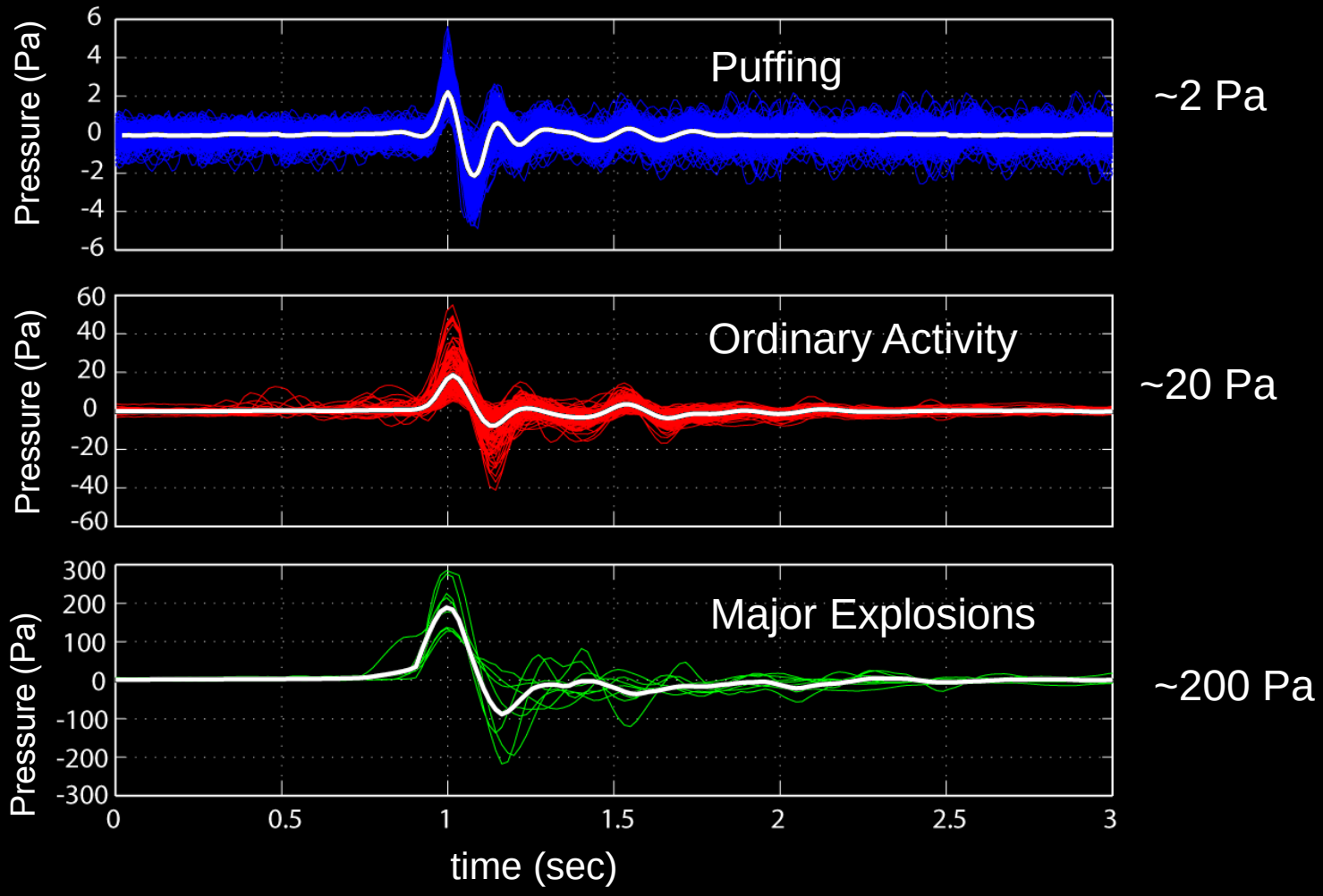
VLP amplitude shows a three order of magnitude variation

Distribution of Seismic VLP Amplitude



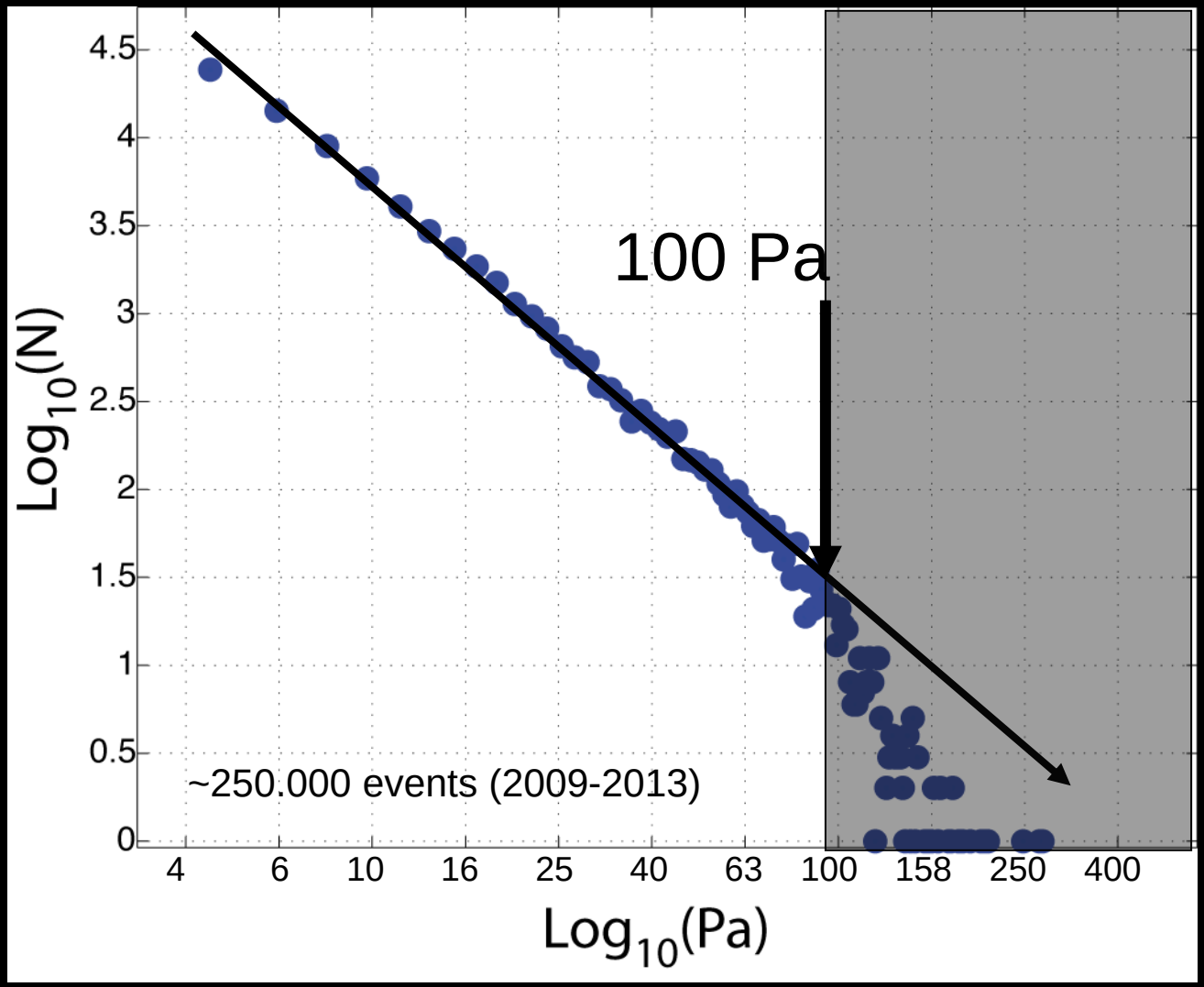
Seismic VLP amplitude shows a threshold at 1.2×10^{-5} m

Variability of Infrasonic Pressure



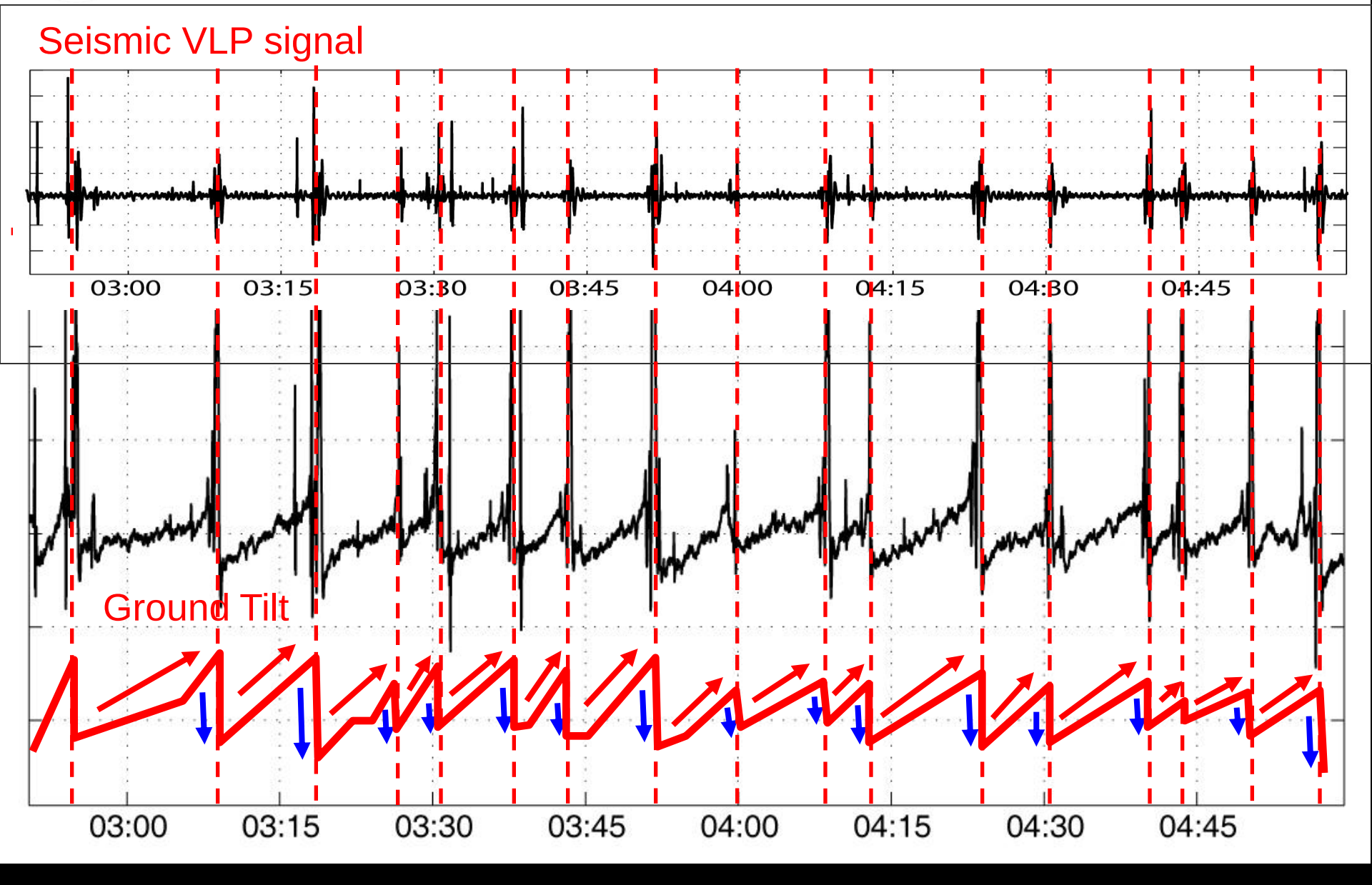
Infrasonic Waveform is Stable but Amplitude ranges two orders

Distribution of Acoustic Pressure



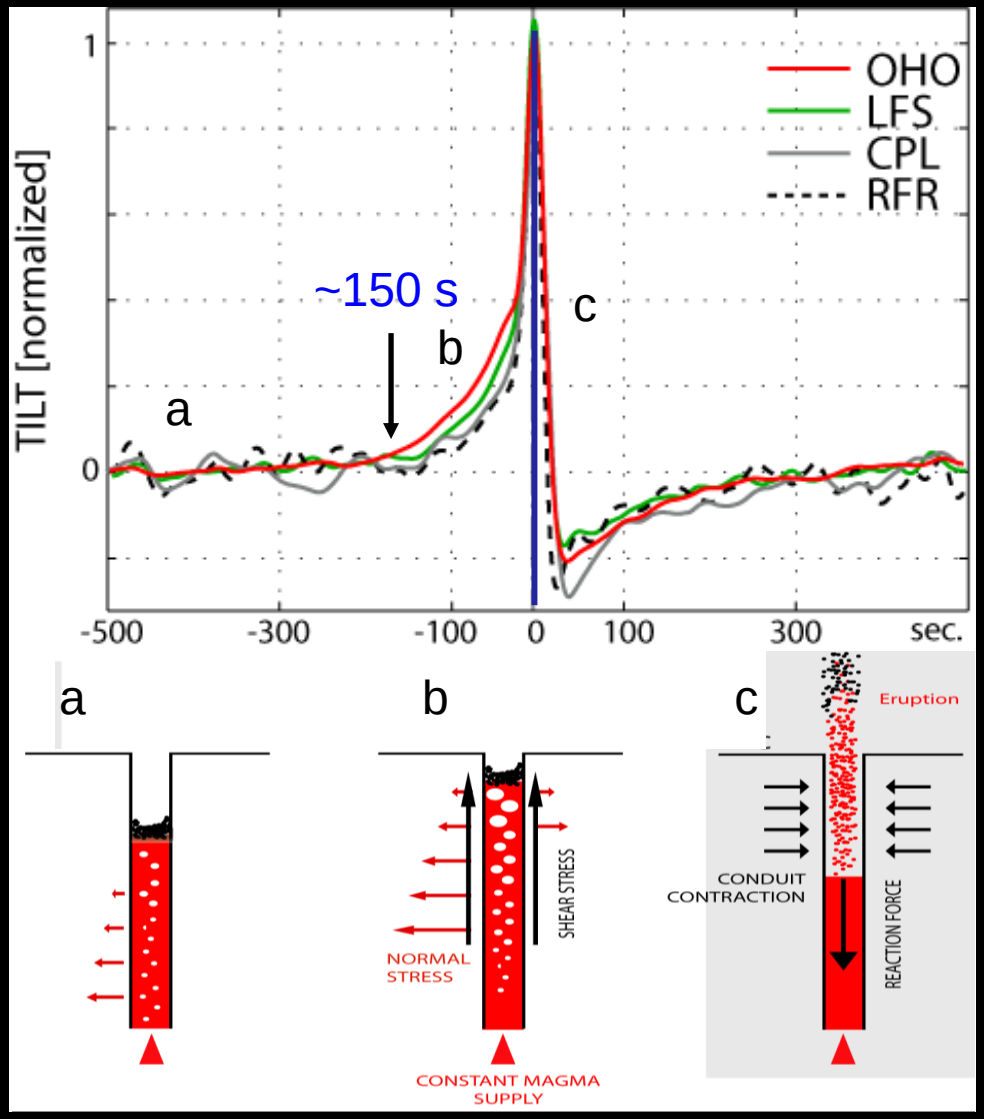
Infrasonic Pressure shows a threshold at ~100 Pa

Ground deformation



Ground Deformation Induced by Explosive Dynamics

Stacked Inflation/Deflation ~ 1000 Events



(Genco & Ripepe, 2010)

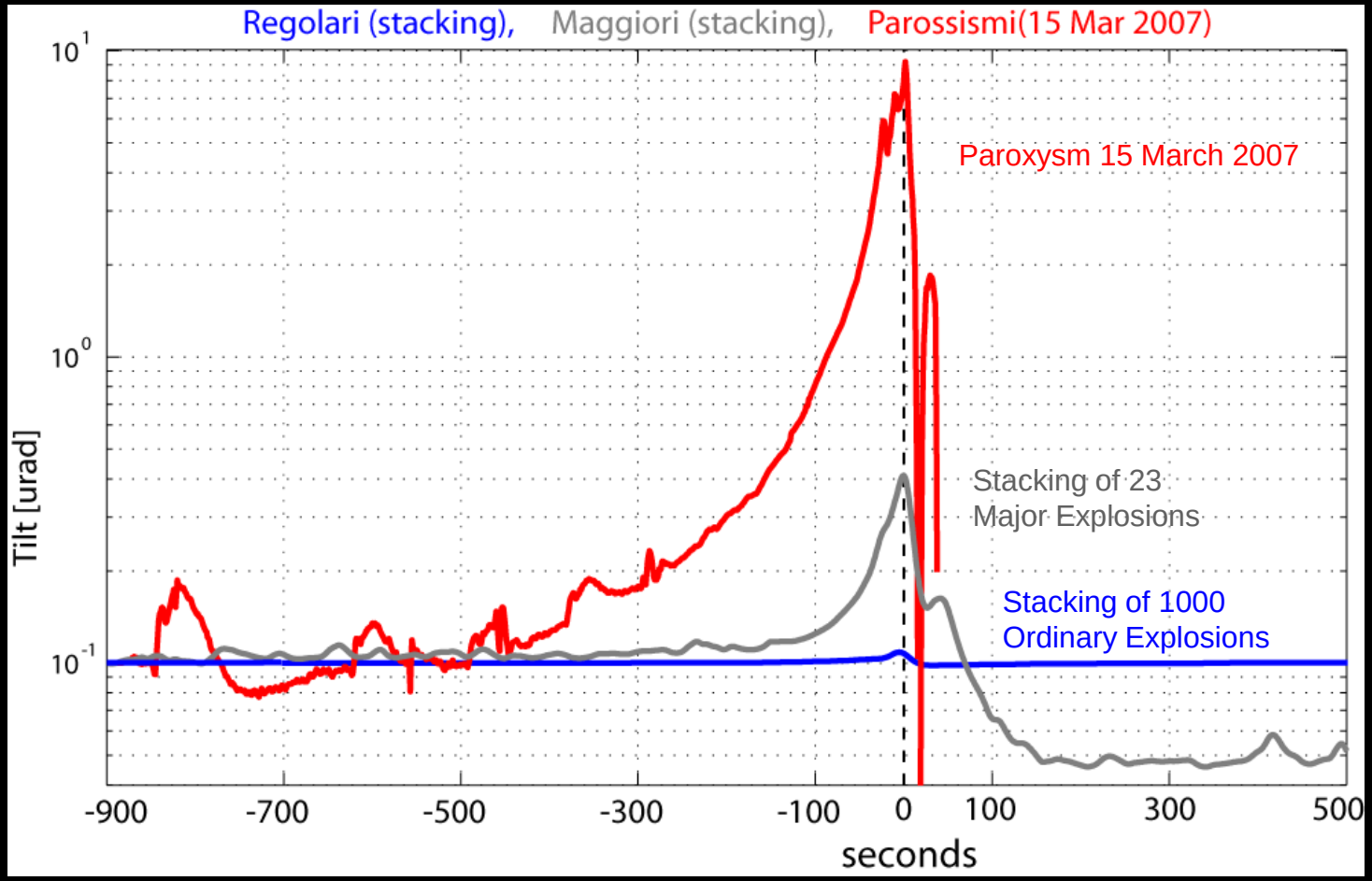
a,b) Ground inflation controlled by magma rise and diffusive bubble growth.

$t \mu t^{1.5}$ *(Nishimura, JVGR, 2009)*

c) Ground deflation following explosion acted by conduit contraction and reaction force.

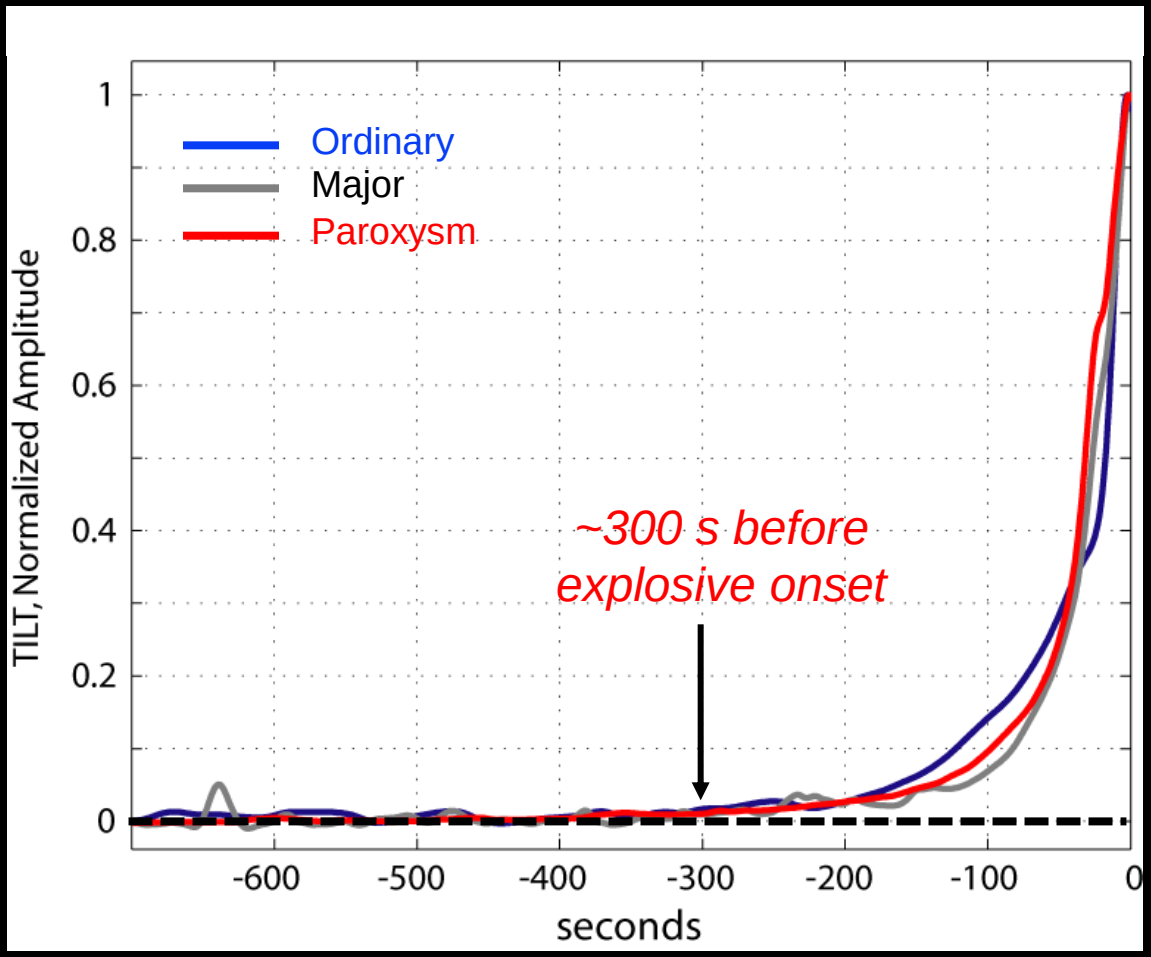
Inflation Starts ~150 s before Explosions

Ordinary Activity, Major Explosion and Paroxysm



Deformation Spans Two Orders of Magnitude

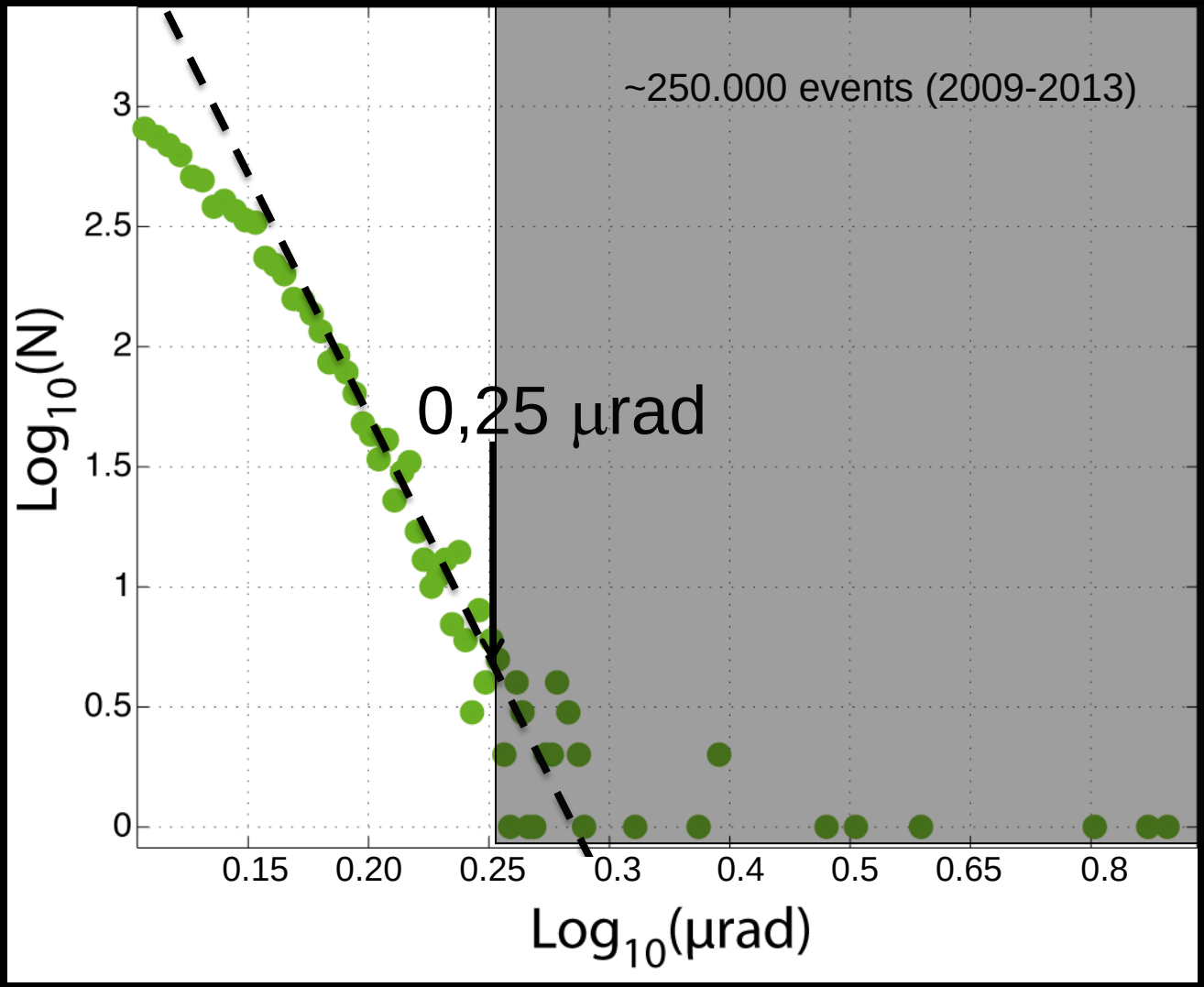
Inflation rate for ordinary, majors and paroxysm



Same Inflation Rate: Sharing the same Dynamics !

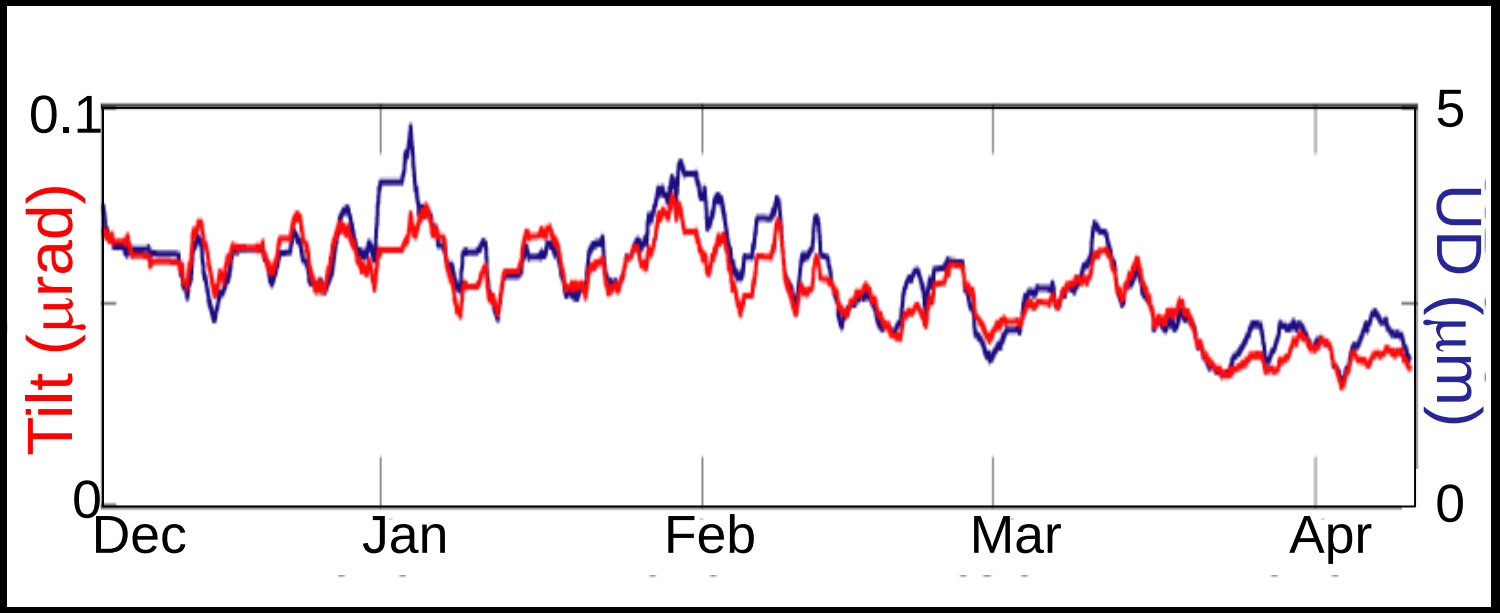
Implications for Early Warning System

Distribution of ground tilt



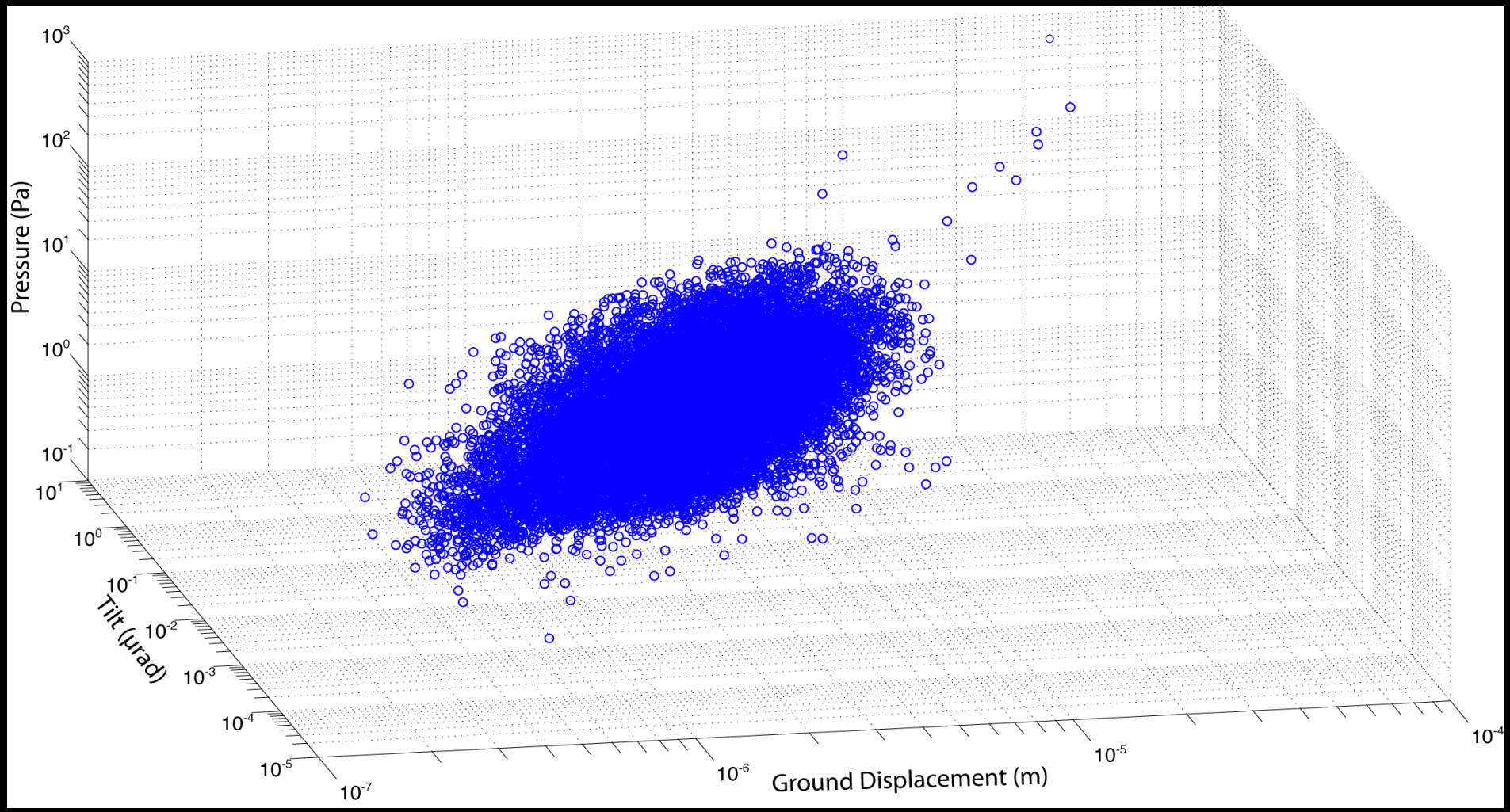
Ground Tilt shows a threshold at ~0.25 μrad

Correlation between Seismic and Tilt



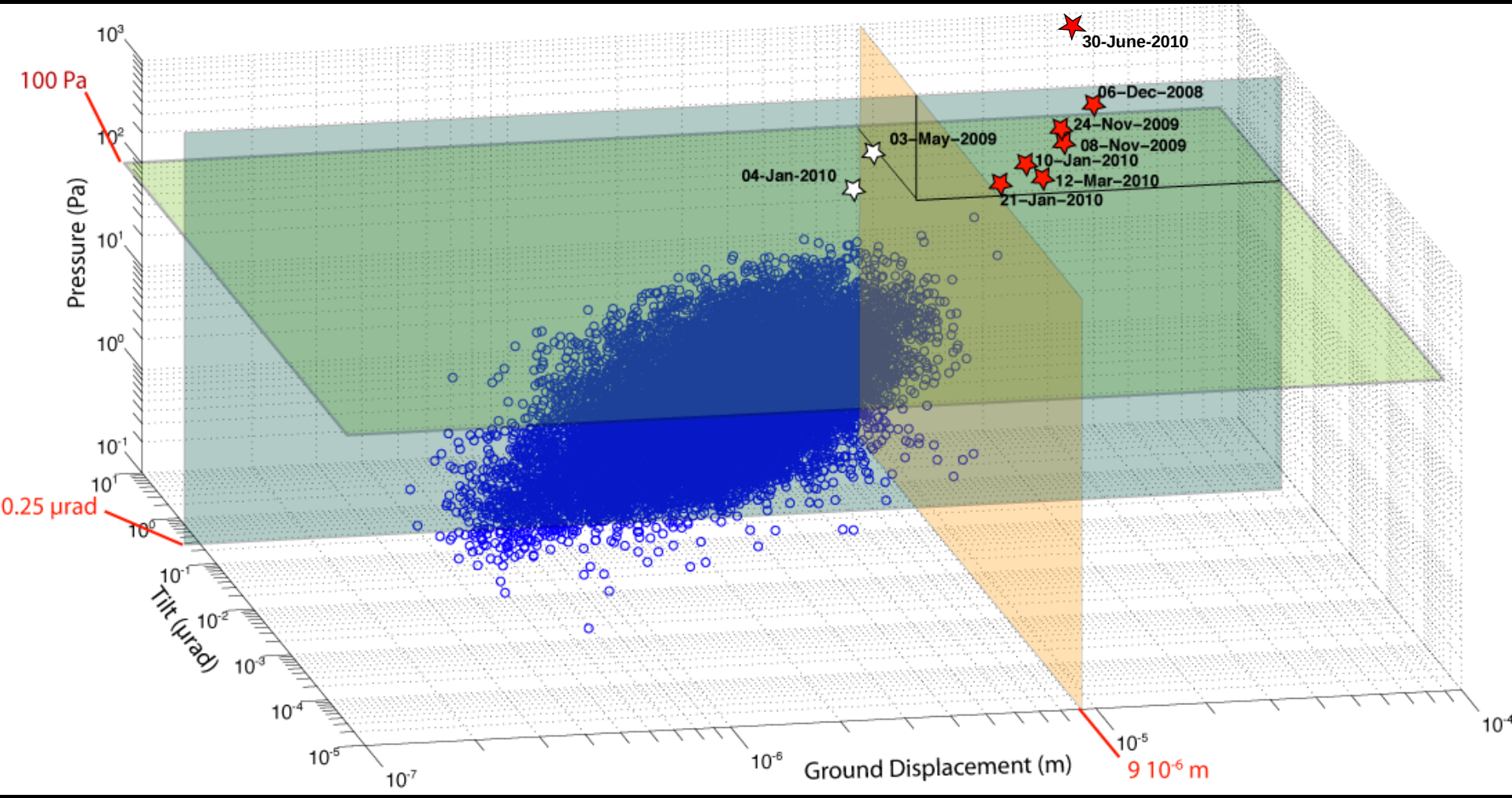
Ground Tilt is well correlated to Seismic VLP Amplitude

Log Distribution of Seismic, Pressure and Tilt



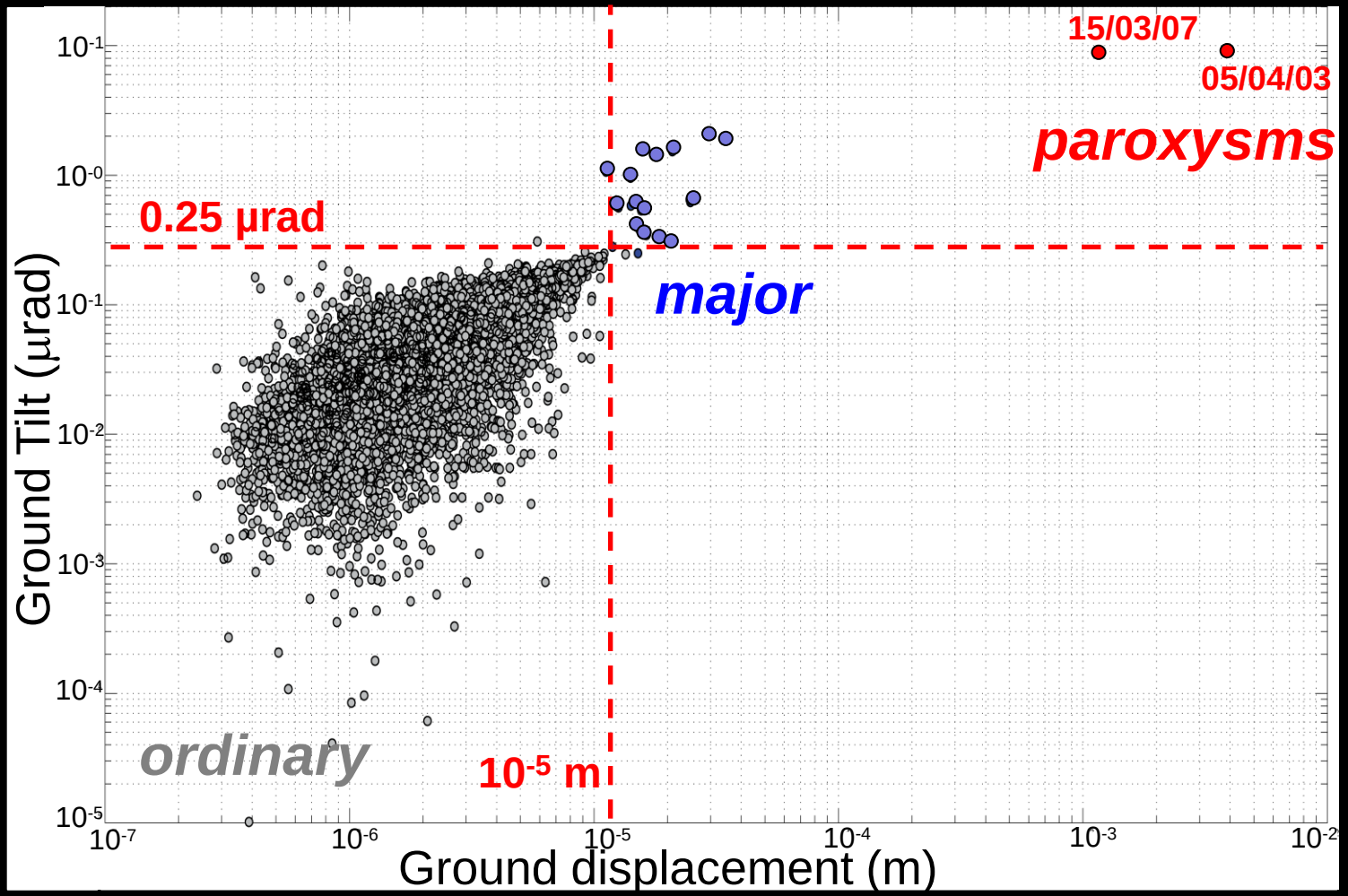
Ordinary activity & major explosions since Dec. 2008

Log Distribution of Seismic, Pressure and Tilt

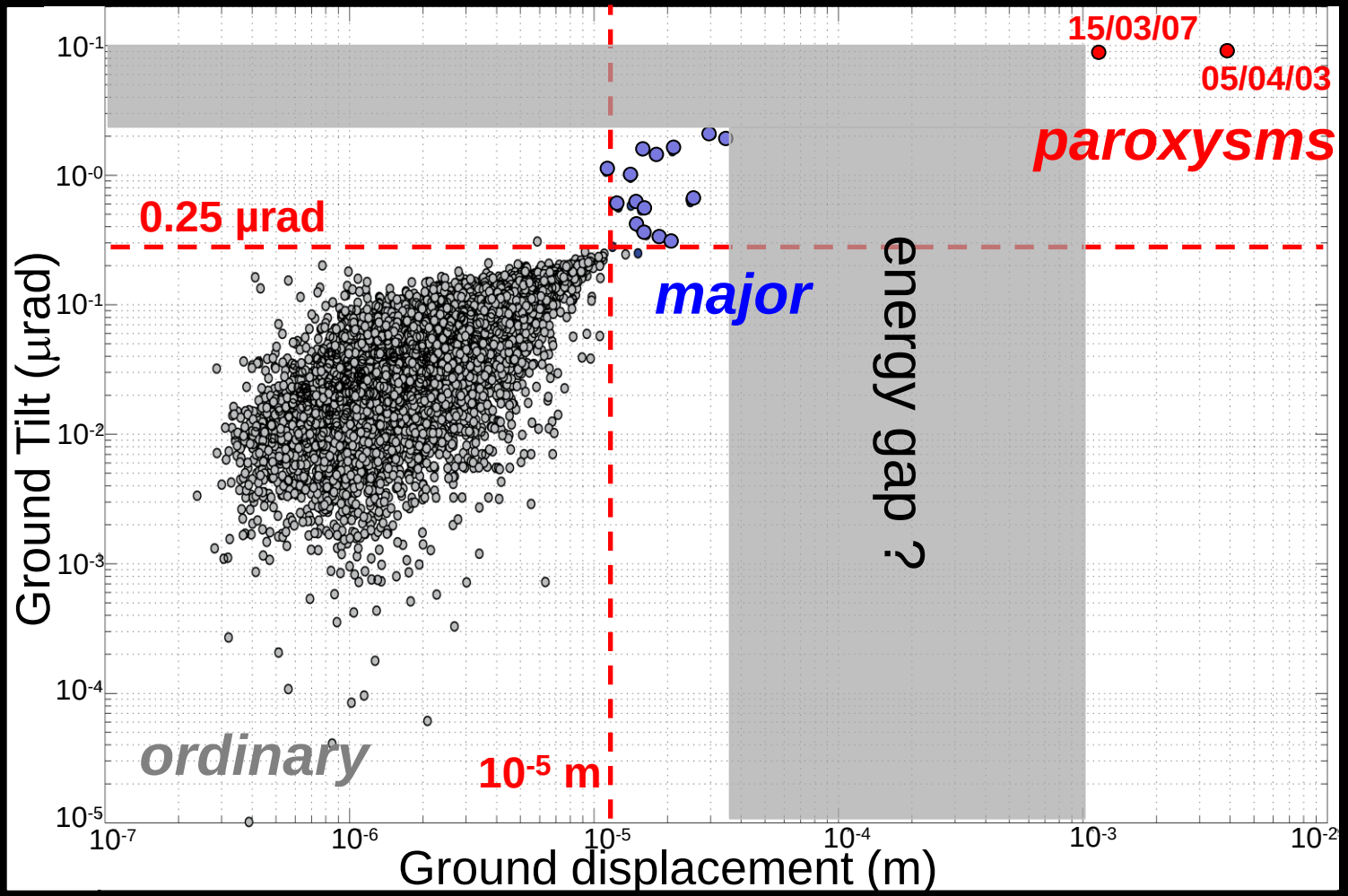


Major explosions are clearly above the Ordinary activity threshold

VLP seismic amplitude and Ground Tilt



VLP seismic amplitude and Ground Tilt



Is this GAP reflecting a different dynamics ?
or it is only matter of time !!

Conclusive Remarks

- Strombolian activity spans 7 order of magnitude in terms of mass ejected and mass discharge rate

- Major Explosions can be defined on the base of seismic, ground deformation and acoustic pressure.

- Ground Tilt indicates that Strombolian Activity is characterized by a persistent Inflation/Deflation Cycle

- Inflation Rate is Compatible with a deformation controlled by magma rise and diffusive bubble growth.

- Ground Inflation starts ~350 s before the Explosive Onset and could be used as Early Warning Parameter

- Geophysical Parameters evidence a Gap in the Intensity between Major Explosions and Paroxysms.