

Geophysical constraints of volcanic processes: Observations of mass flux at volcanic systems



*Results presented here
would not have been
possible without*

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Gerhard Peters
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Ralf Seyfried
Malte Vöge
several students who
helped with field work

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DFG
BMBF
NSF Antarctic Progr.
Univ. Firenze, Italy
MeTeK

Video by Benedikt Weiss

Why bother?



Photo by A. Gerst

Learn something about:

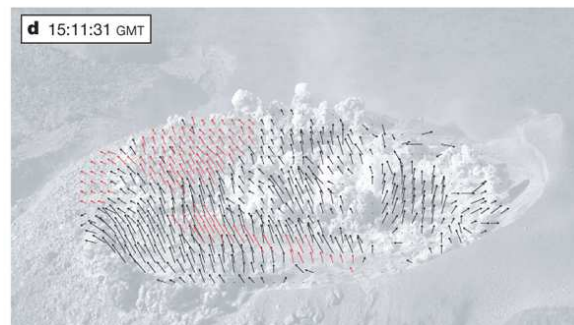
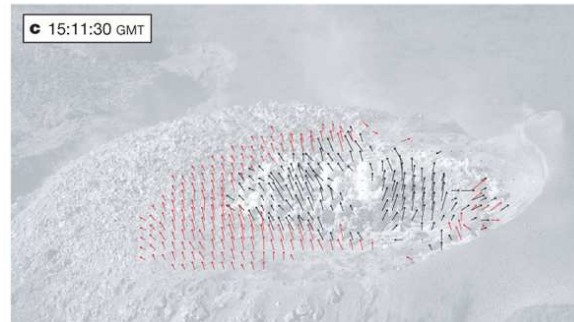
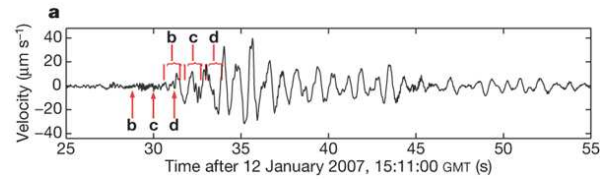
Eruption dynamics

- Conduit processes
- Pressures
- Transport velocities

Mass flux at the vent

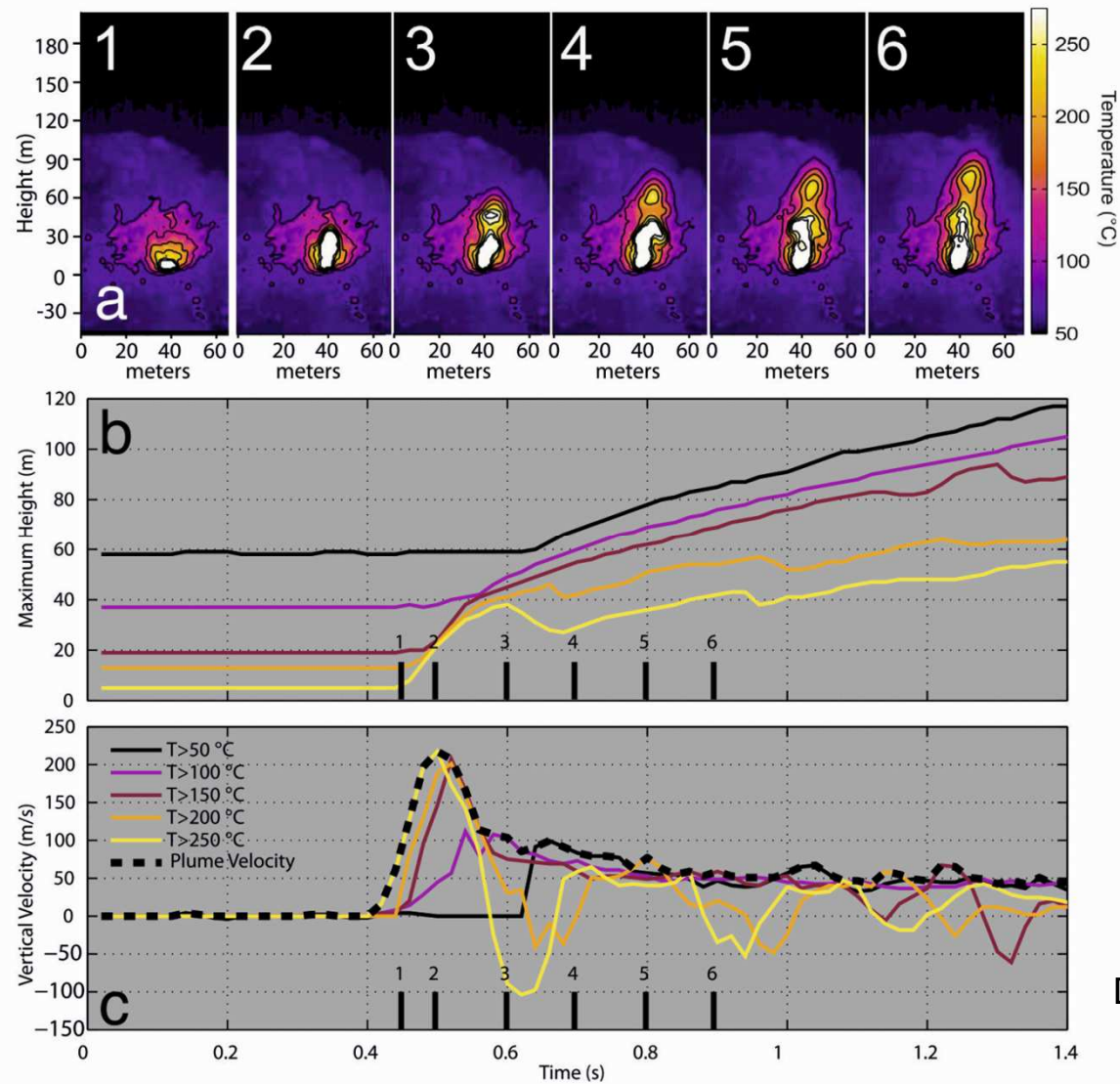
- Dispersion of ash
- Aviation
- Global climate

Visual observations



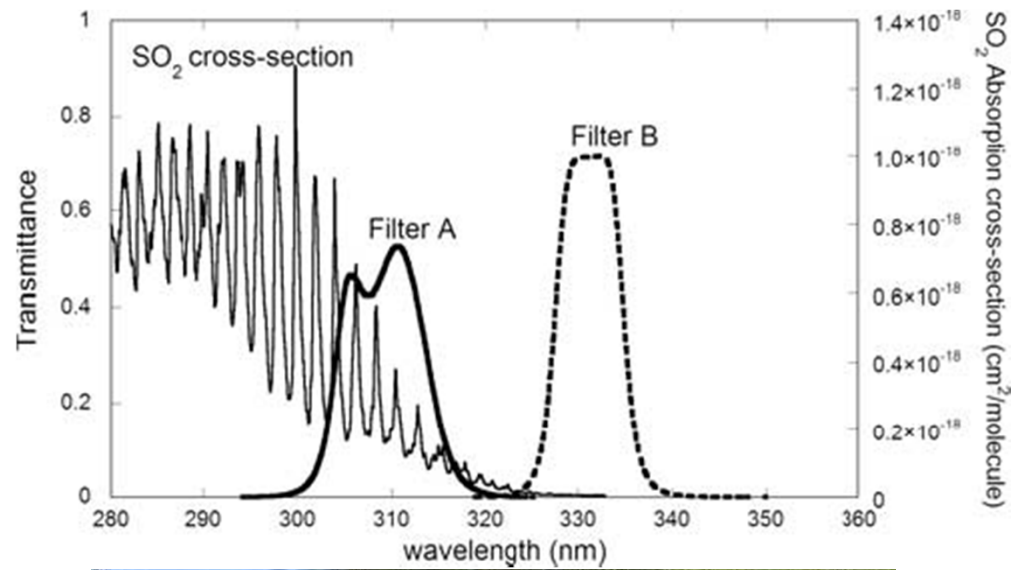
Johnson *et al.* (2008)

IR observations



Donne and Ripepe (2012)

UV measurements



Mori and Burton (2006)

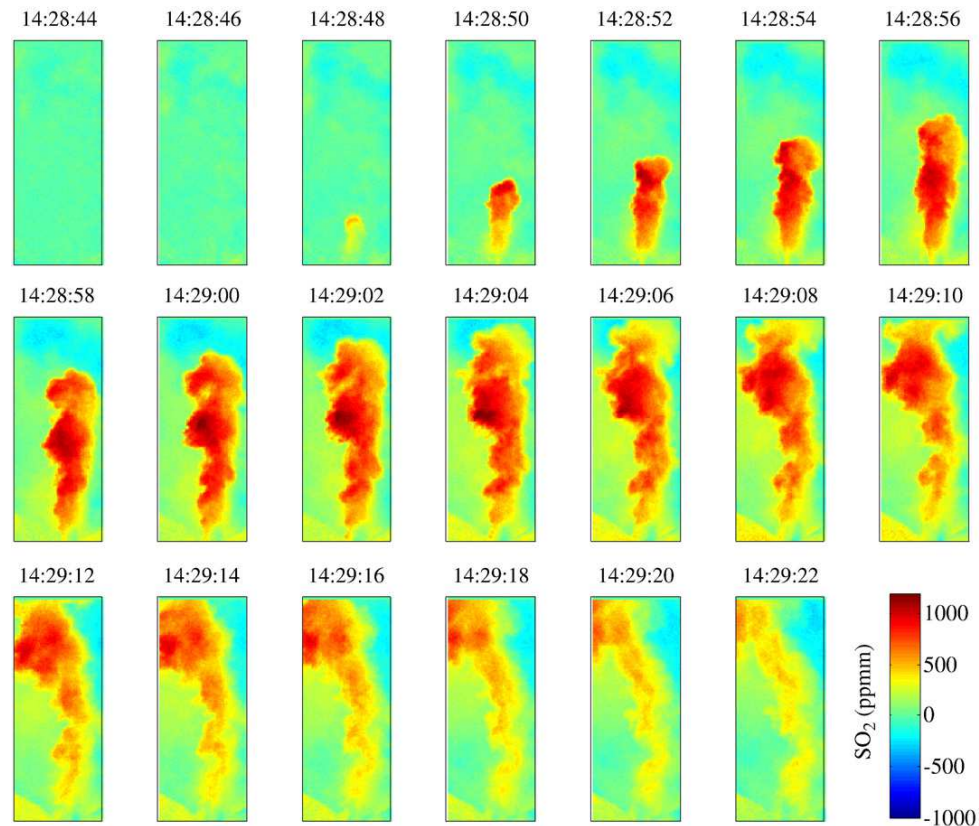


Bluth et al. (2007)



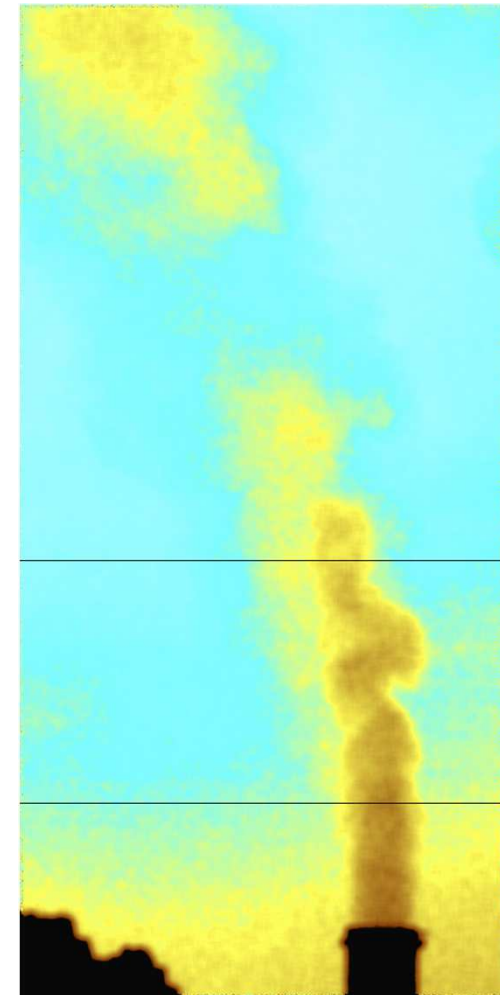
Mori and coworkers

SO₂ measurements



Time-sequence of SO₂ column amount images of a single hornito eruption that occurred at 14:28:48. Images were collected every 2 s starting at 14:28:44. Each pixel has an equivalent size at the distance to the explosive plume (~650 m) of 0.5 m×0.5 m. The images are 75 m×190 m at the plume.

Mori and Burton (2009)



F. Prata (2010, from his Webpage)

Radar observations

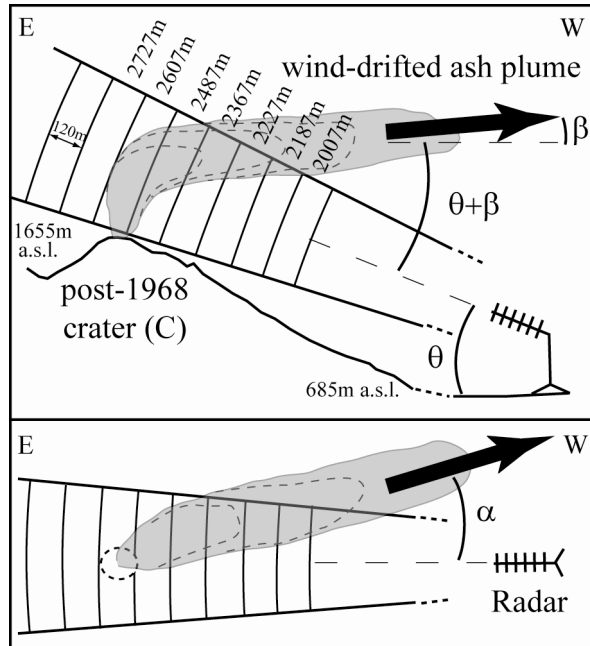


Pulsed system
High power consumption
Large opening angle
Far reach

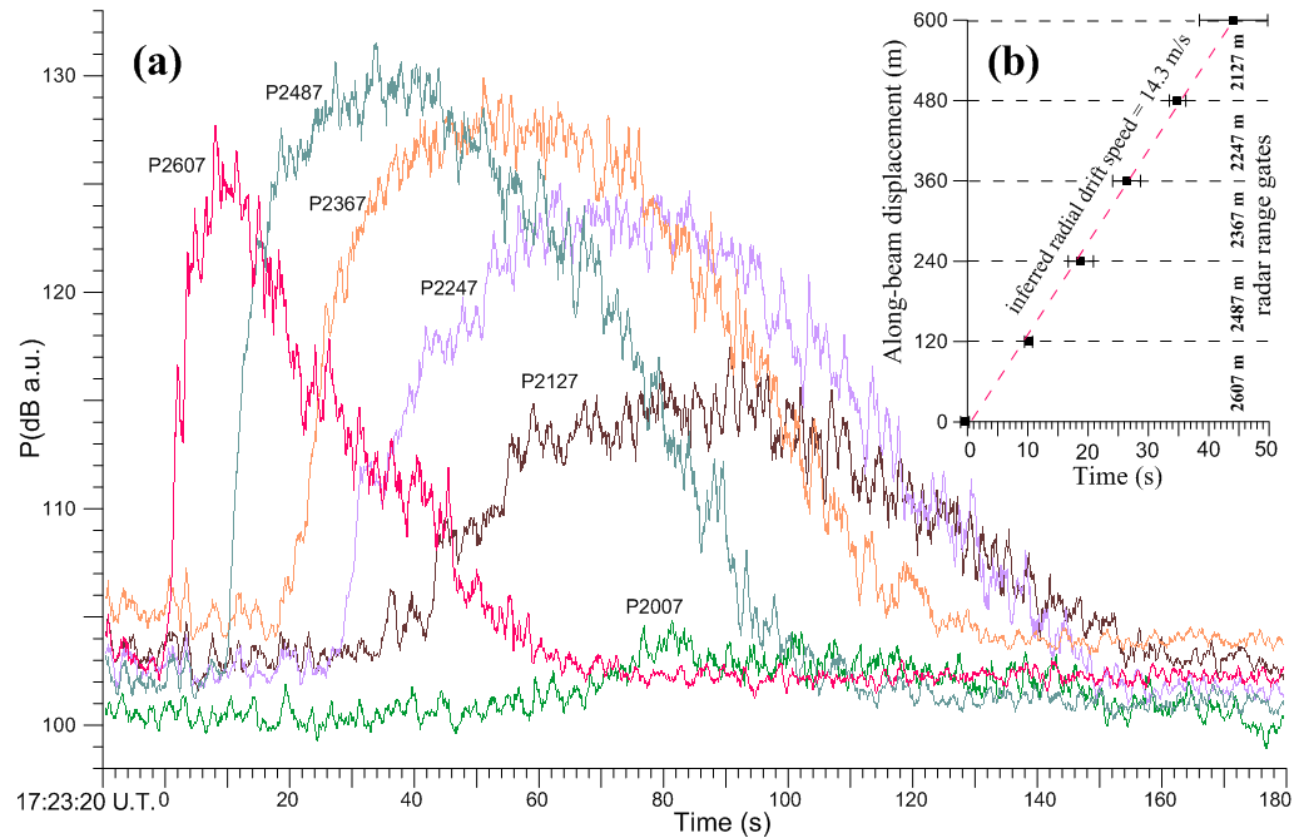


FMCW system
Low power consumption
small opening angle
Up to 6km reach

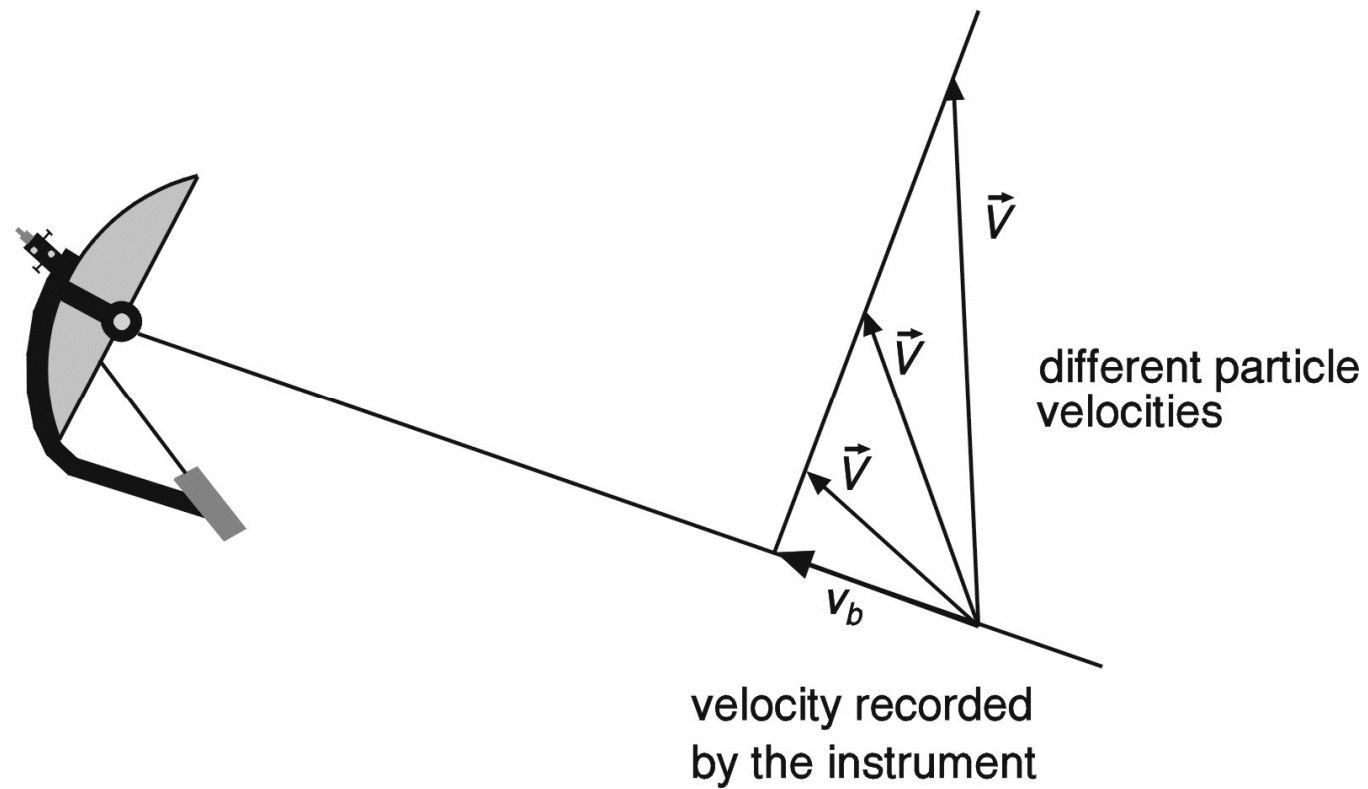
Pulsed radar observations



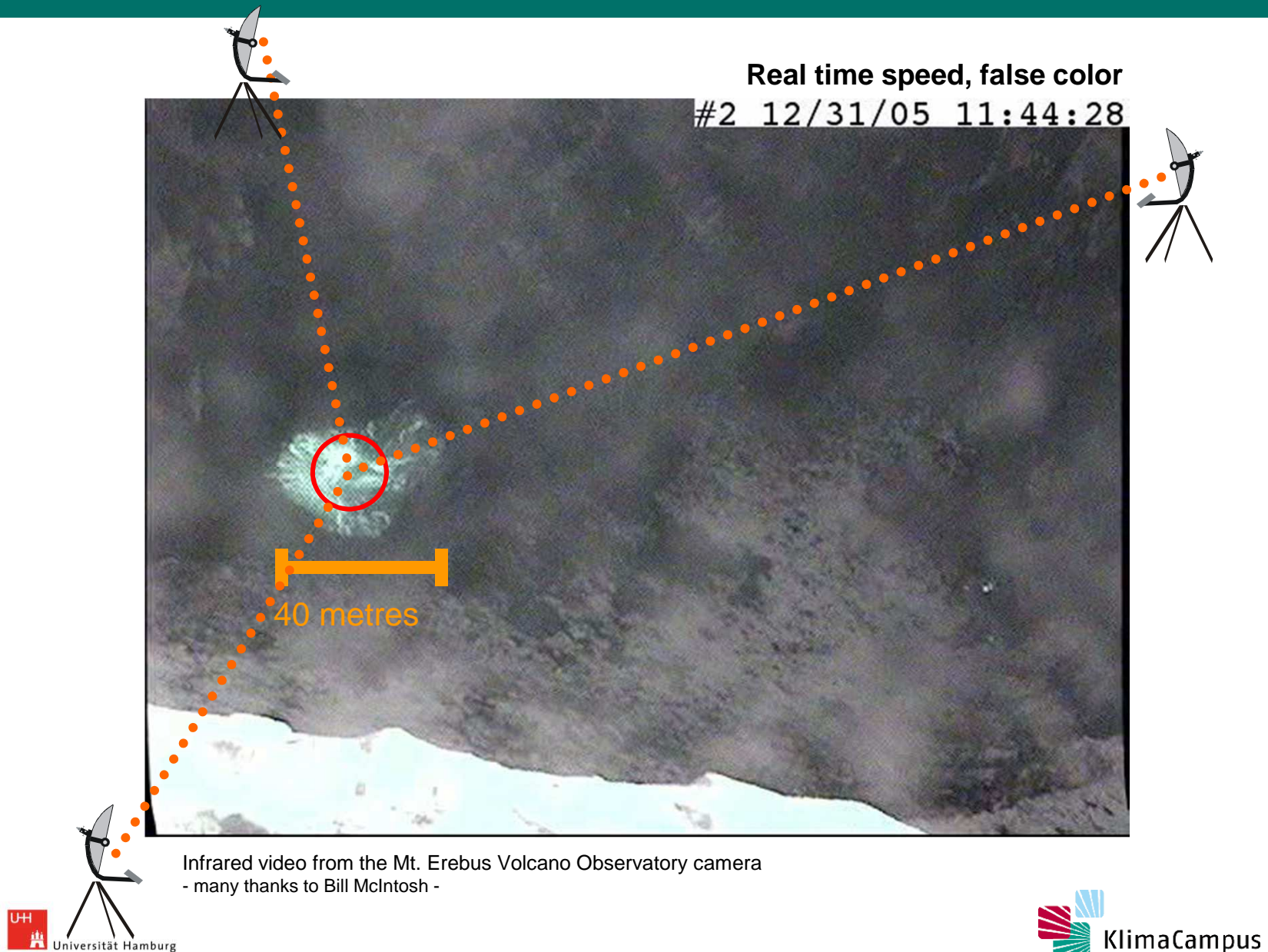
Donnadieu et al. (2011)



Typical Doppler radar signals



Strombolian eruptions: Single bubble bursts

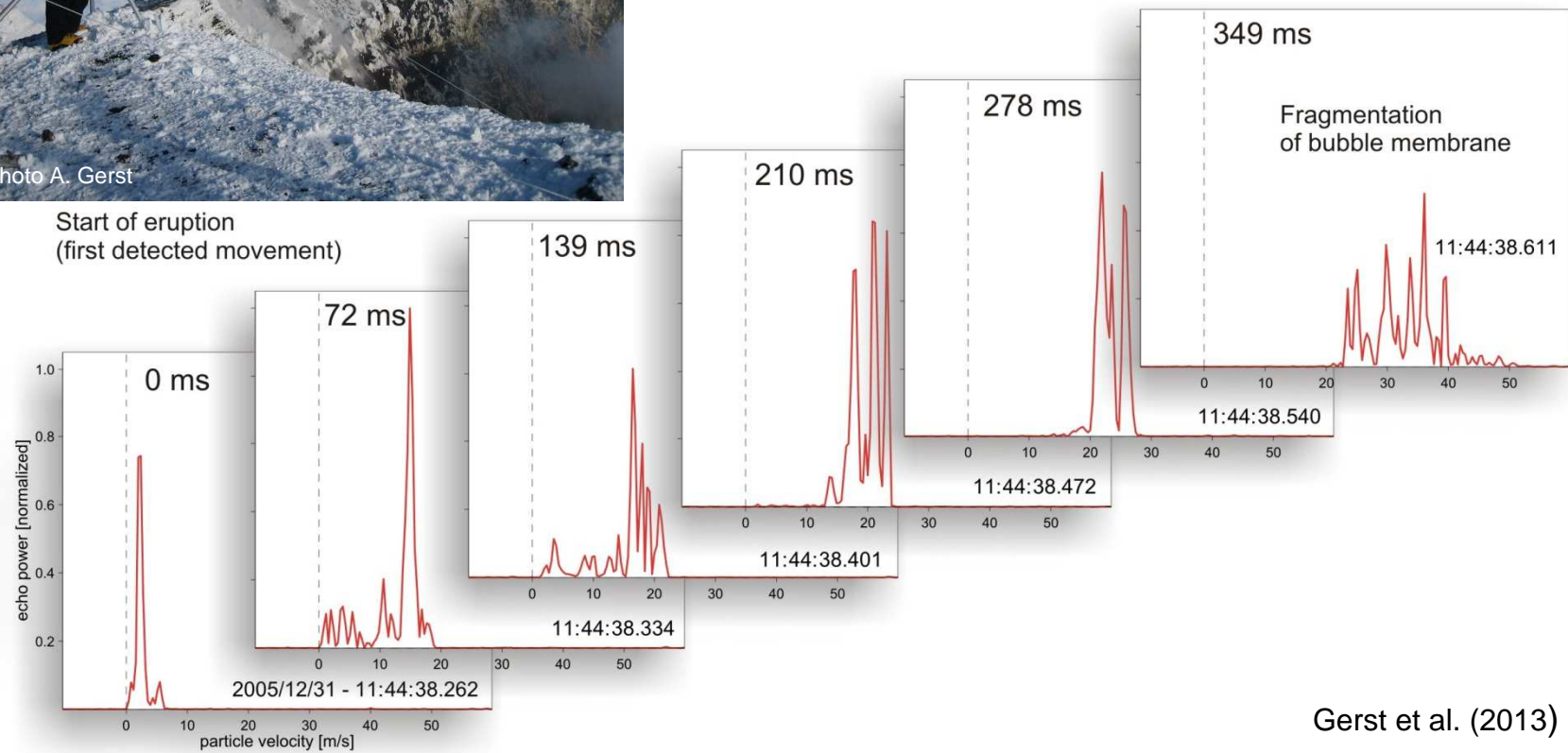


Onset of an eruption: Mt. Erebus, Antarctica



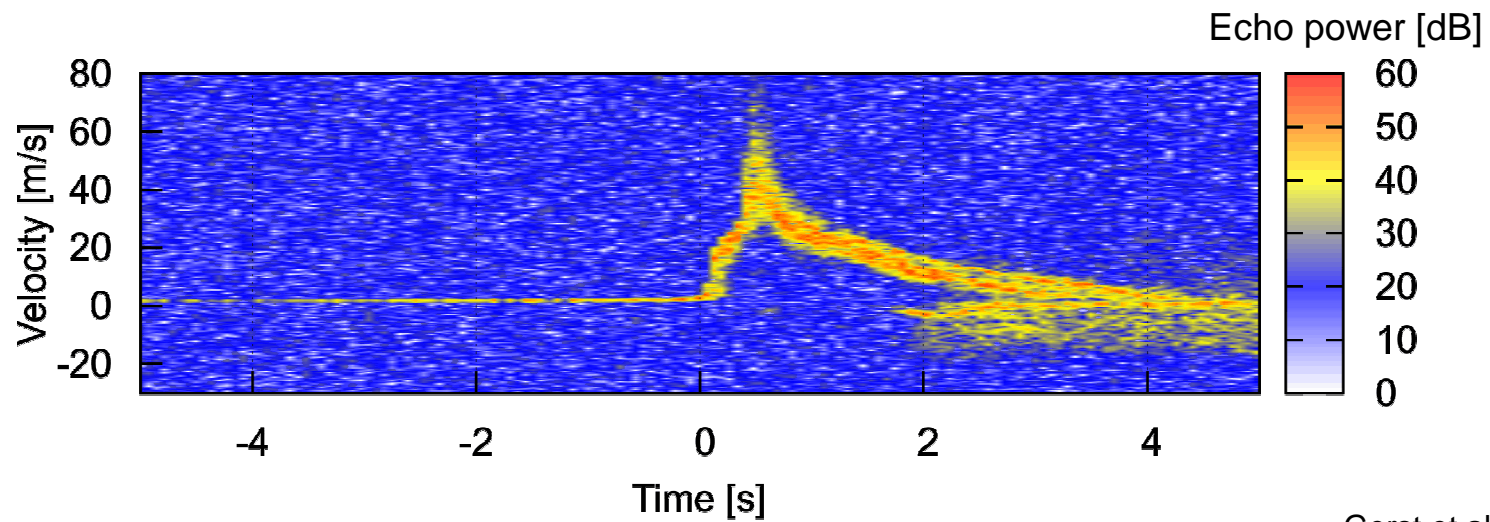
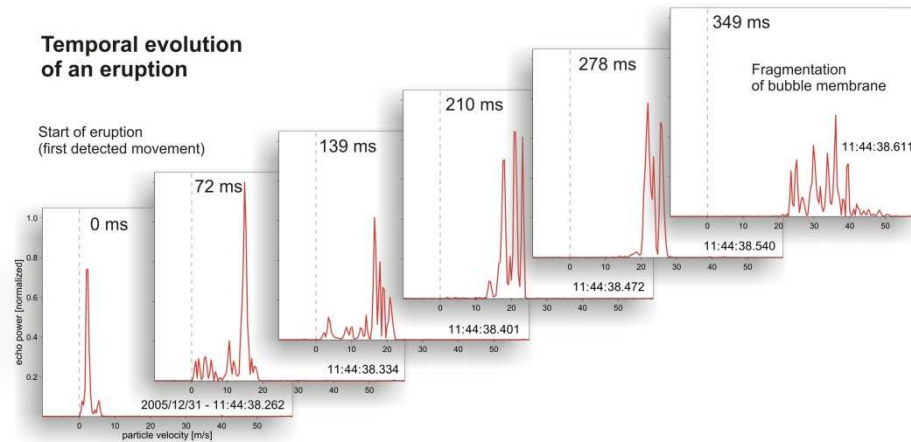
Photo A. Gerst

Start of eruption
(first detected movement)



Gerst et al. (2013)

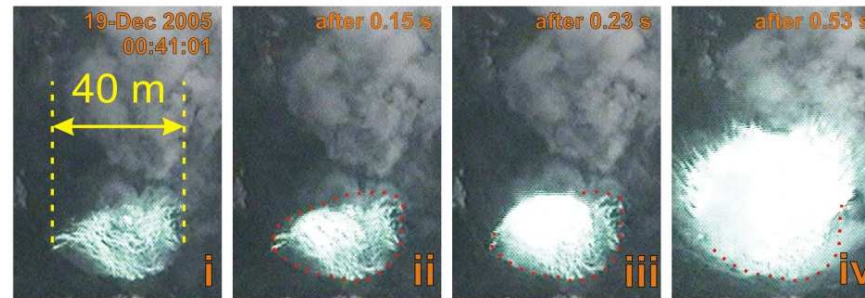
Temporal evolution of a bubble burst as seen by the Radar



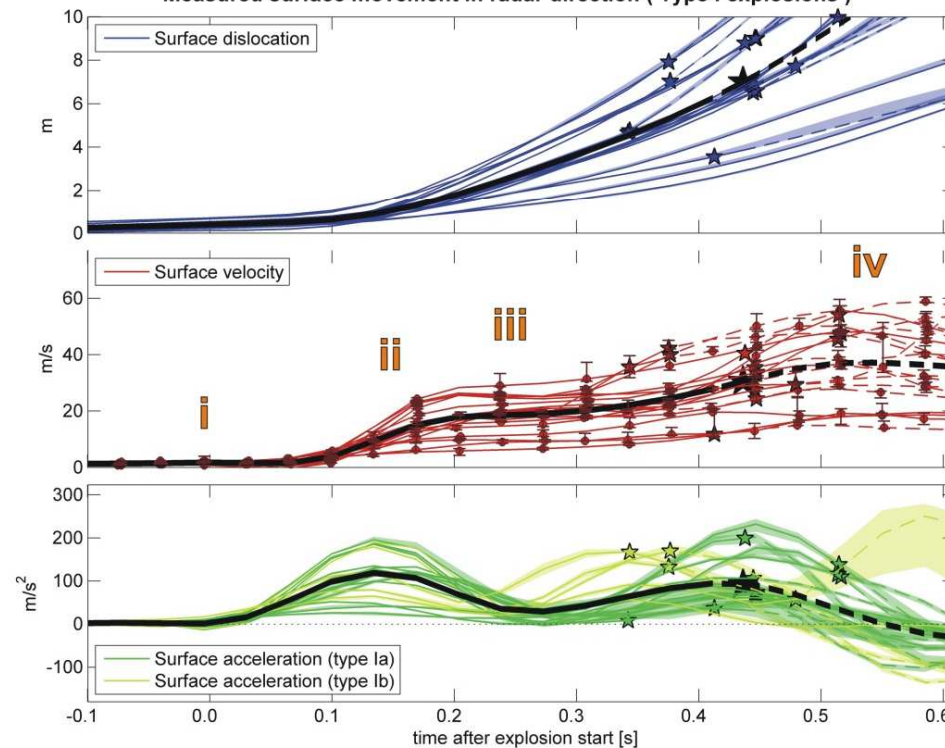
Gerst et al. (2013)

Detailed analysis of eruption with regard to pressures and energies

Type I explosions

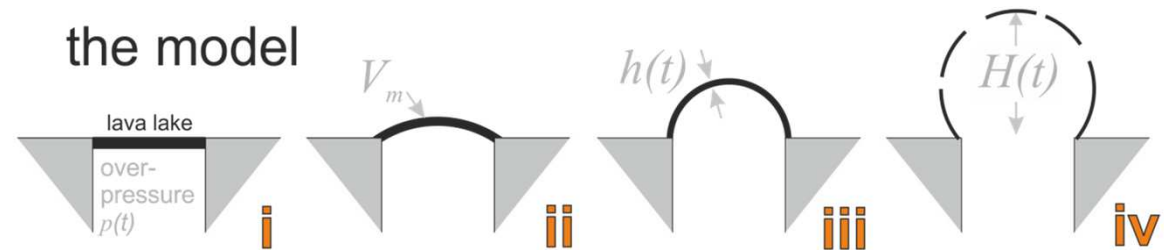
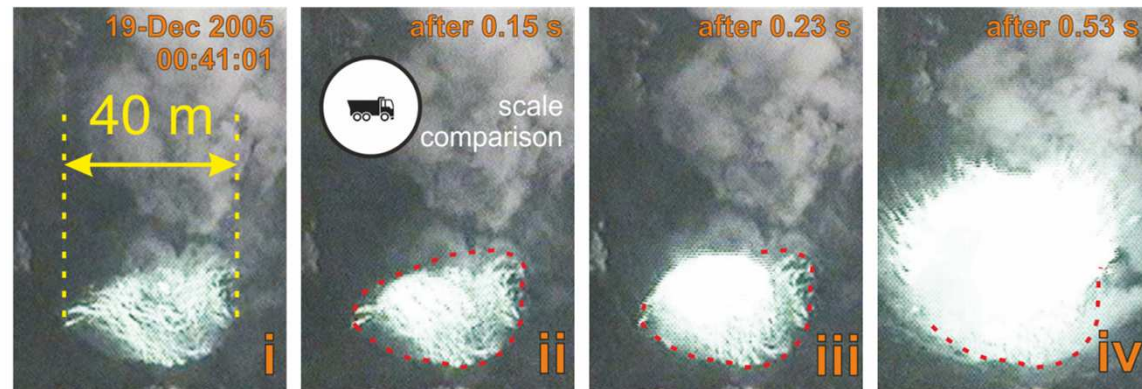


Measured surface movement in radar direction (Type I explosions)



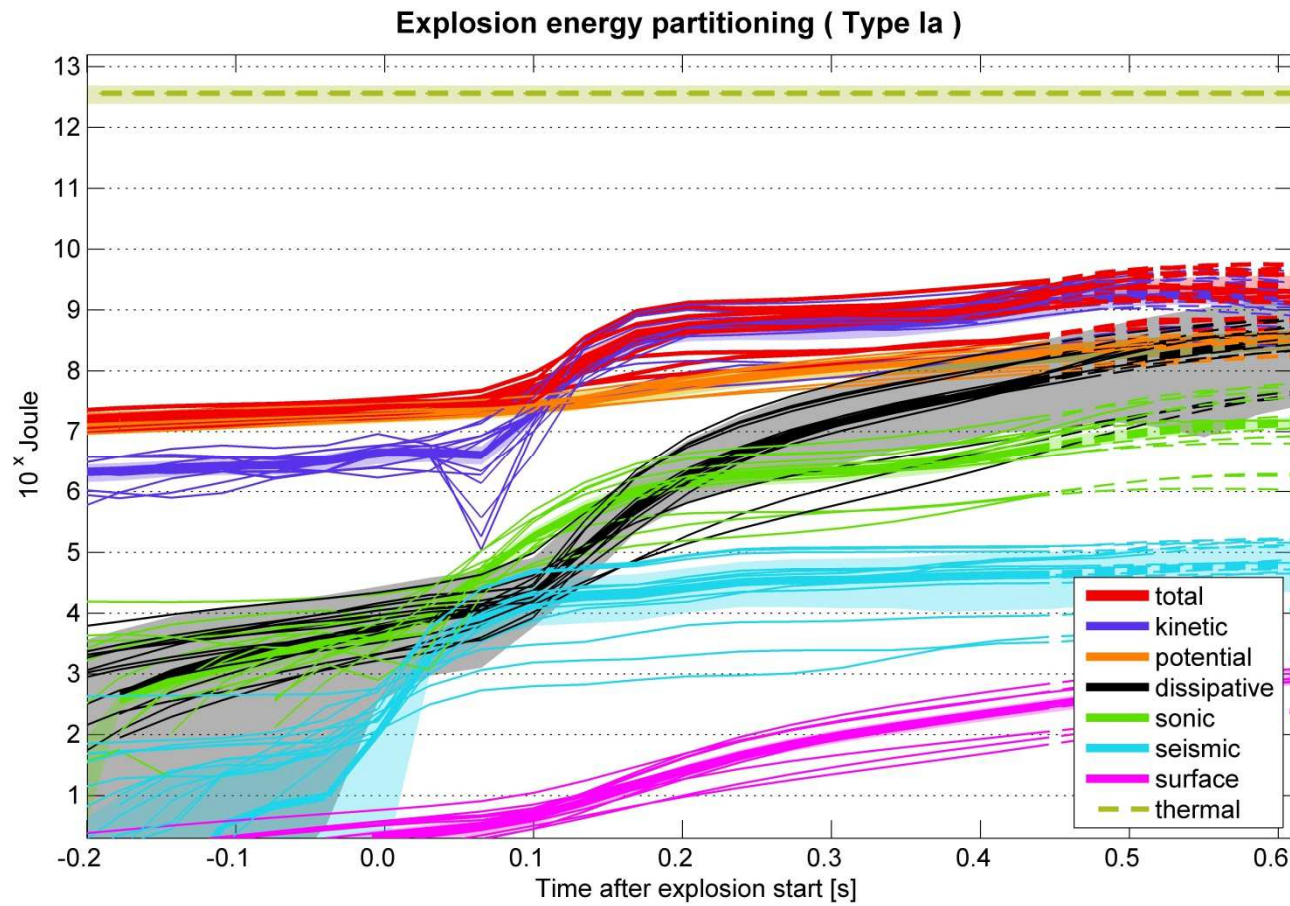
Gerst et al. (2013)

Bubble burst model



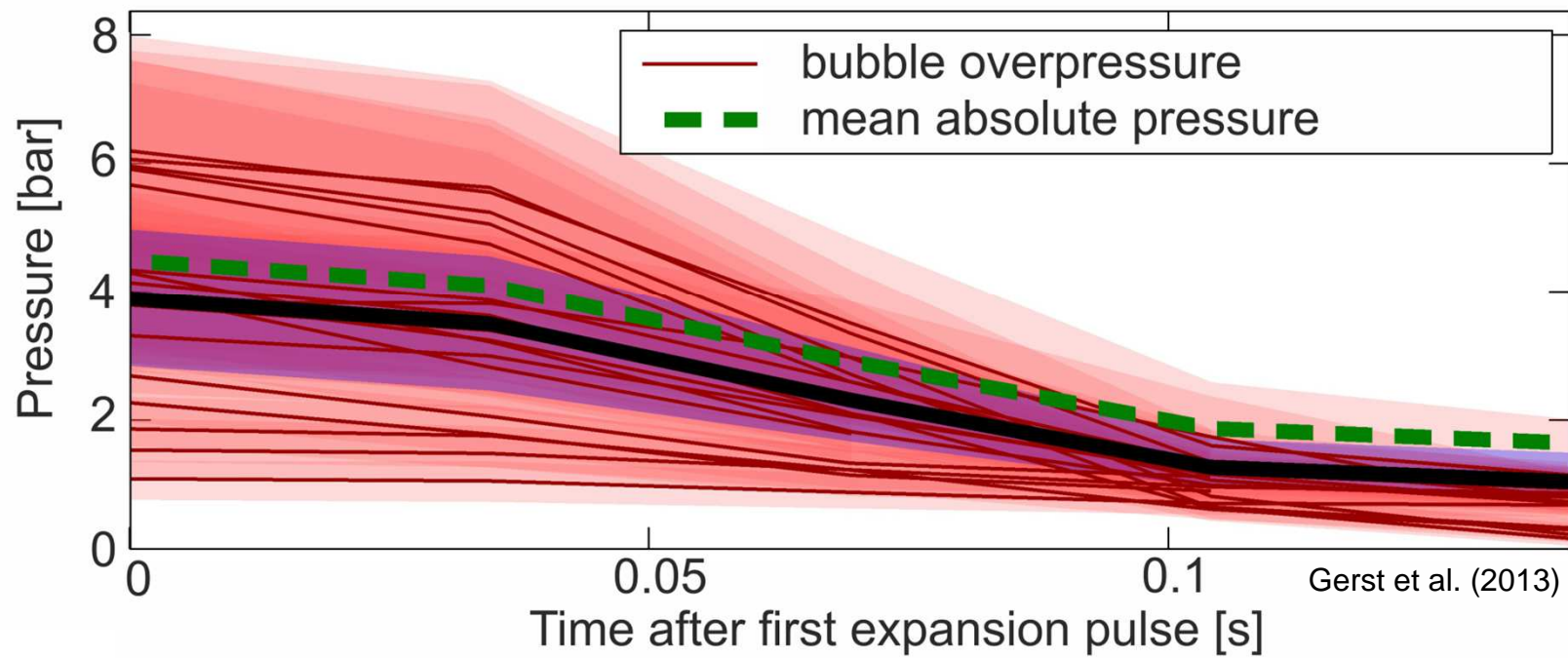
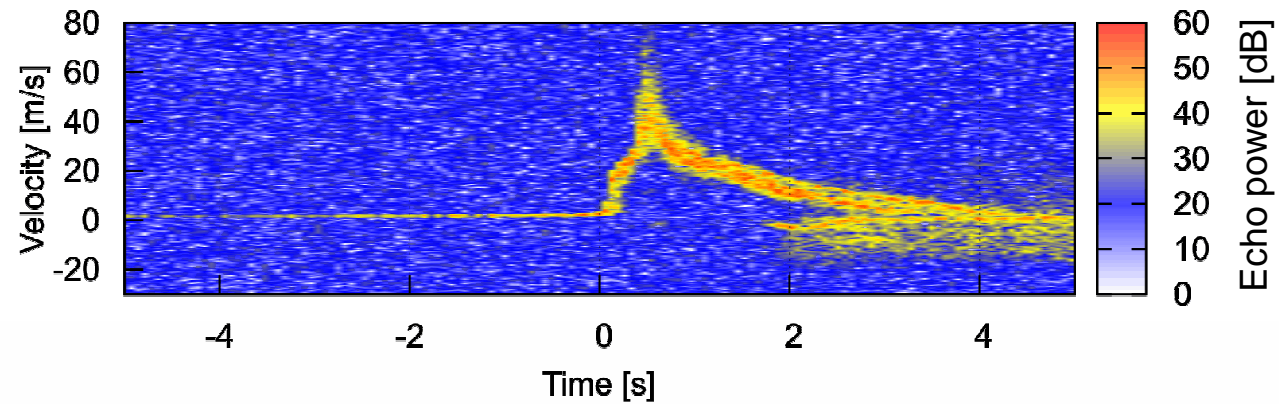
Gerst et al. (2013)

Complete Energy balance

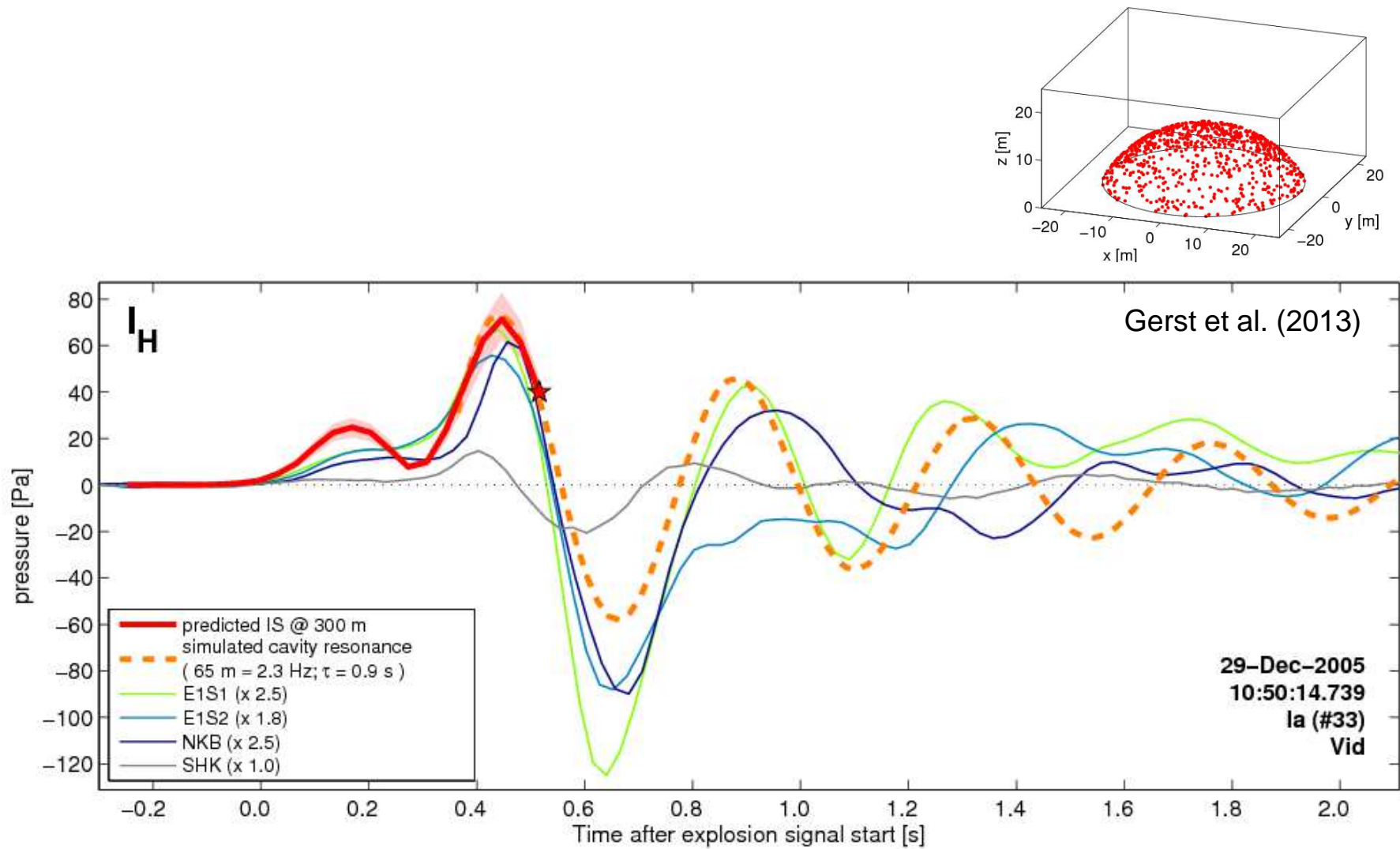


Gerst et al. (2013)

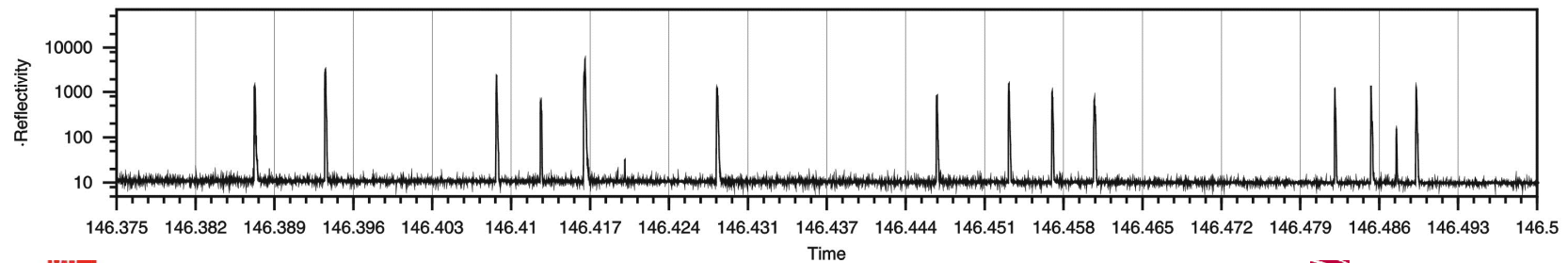
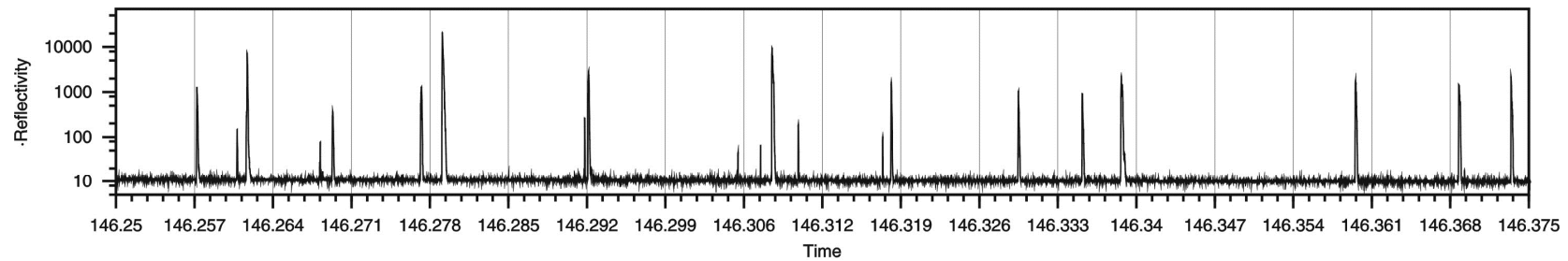
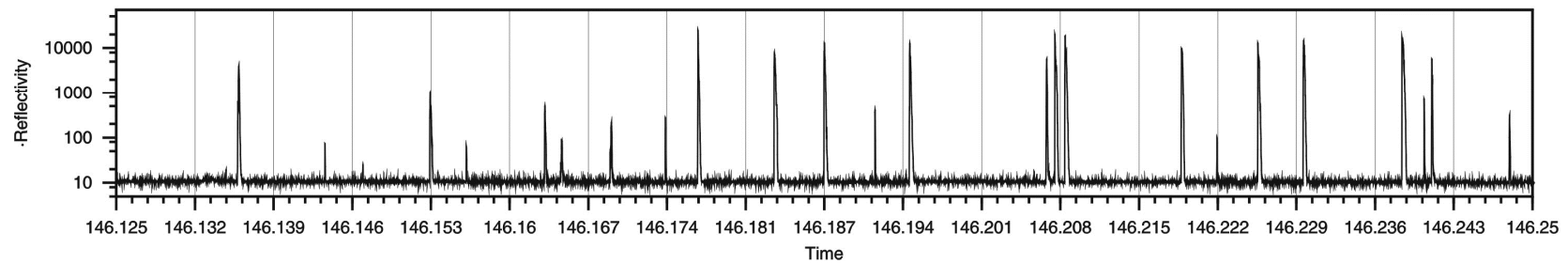
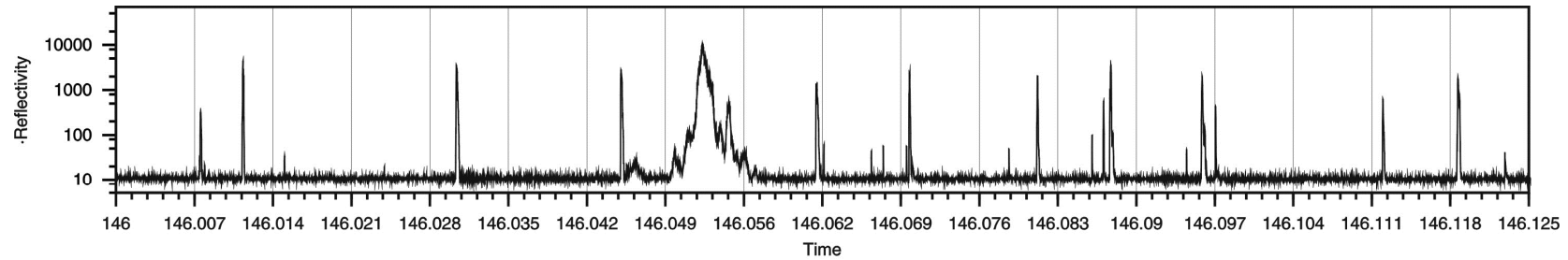
Bubble overpressures



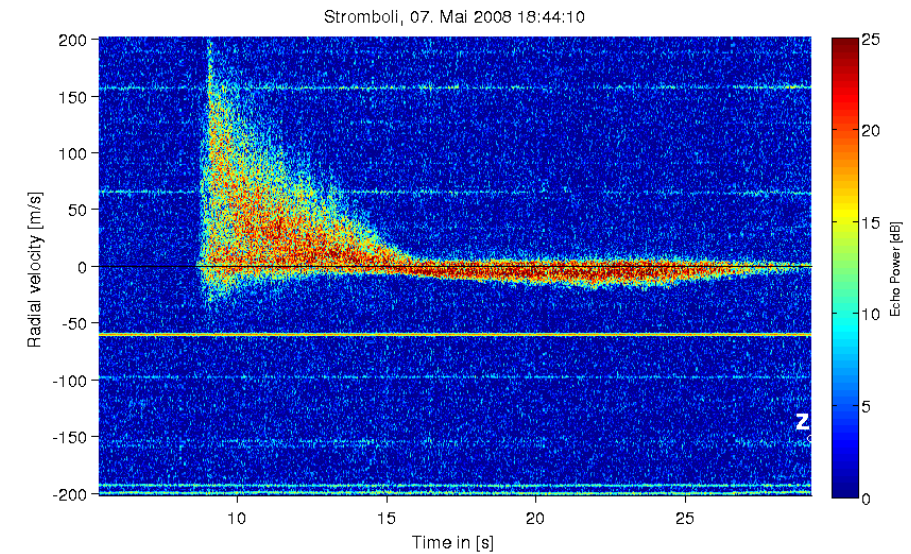
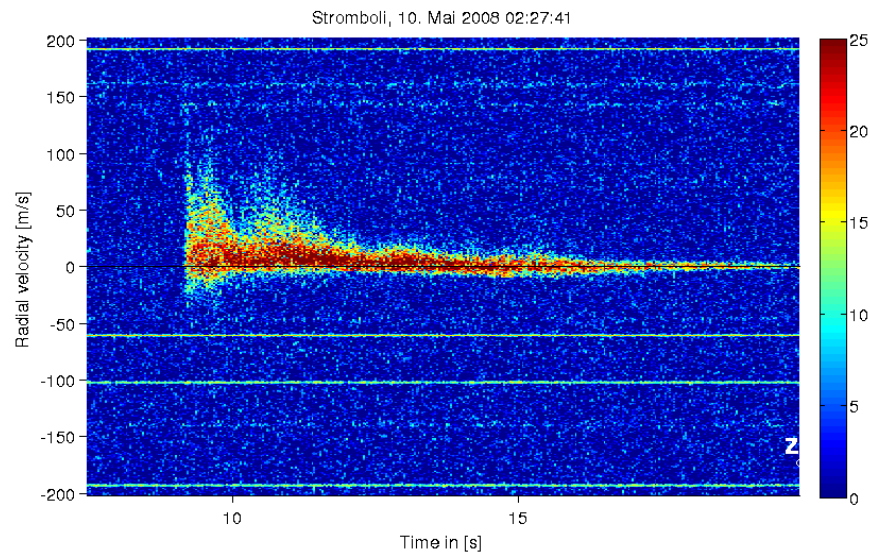
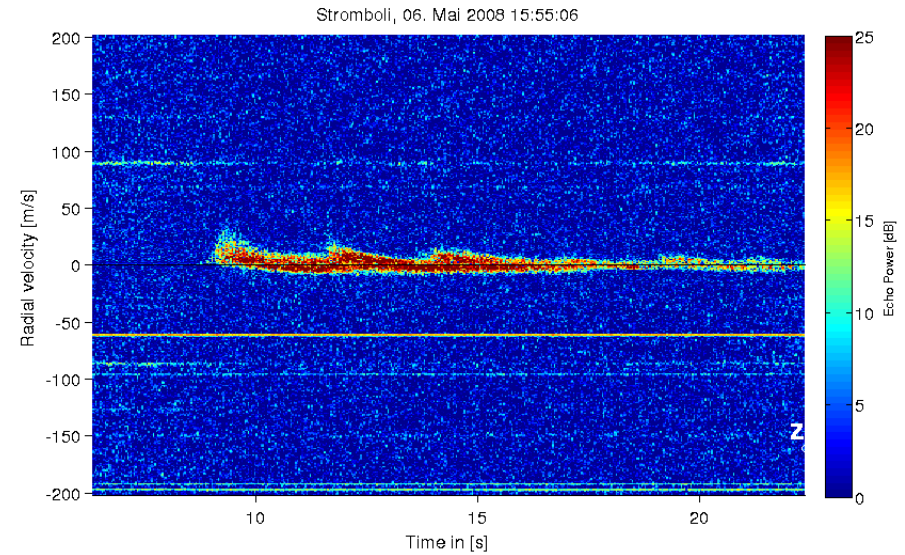
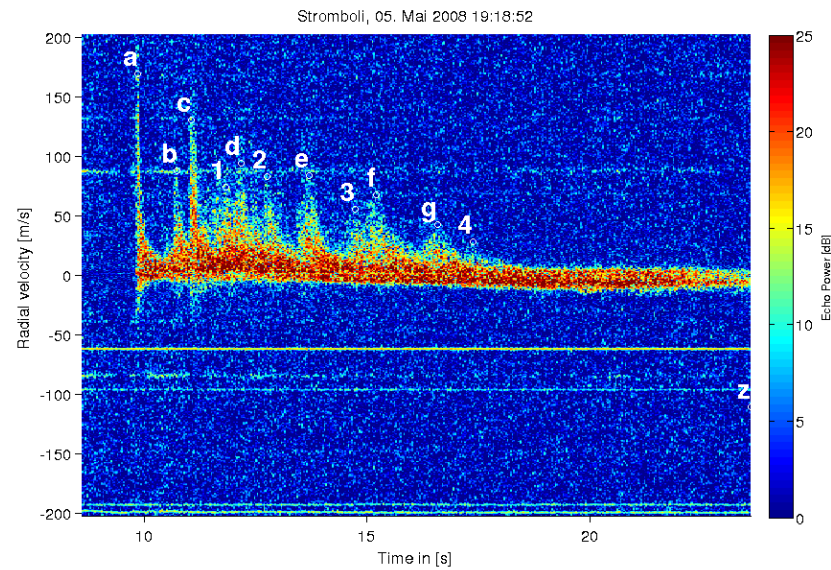
Modelling infrasound



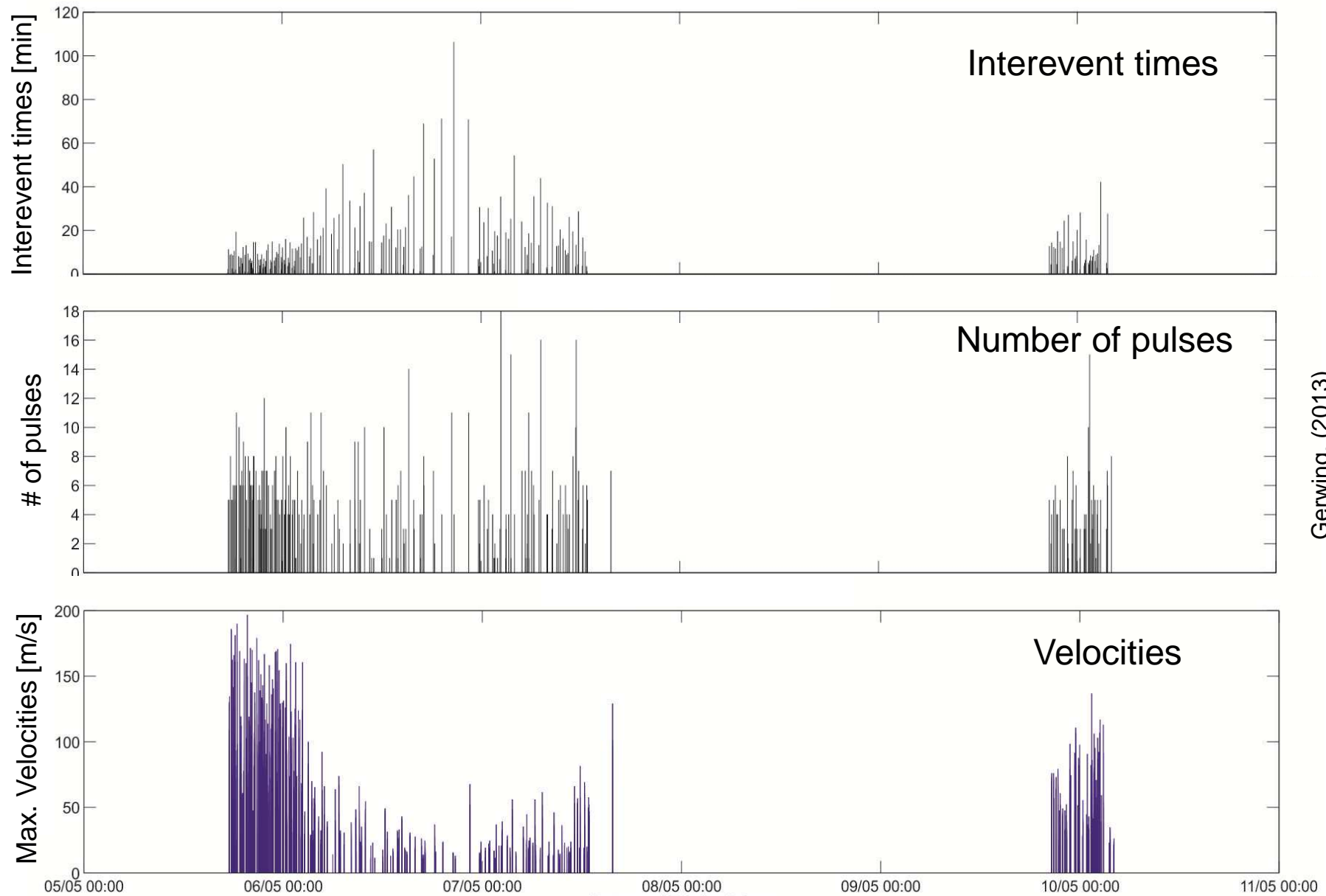
Continuous strombolian activity: SWC Stromboli



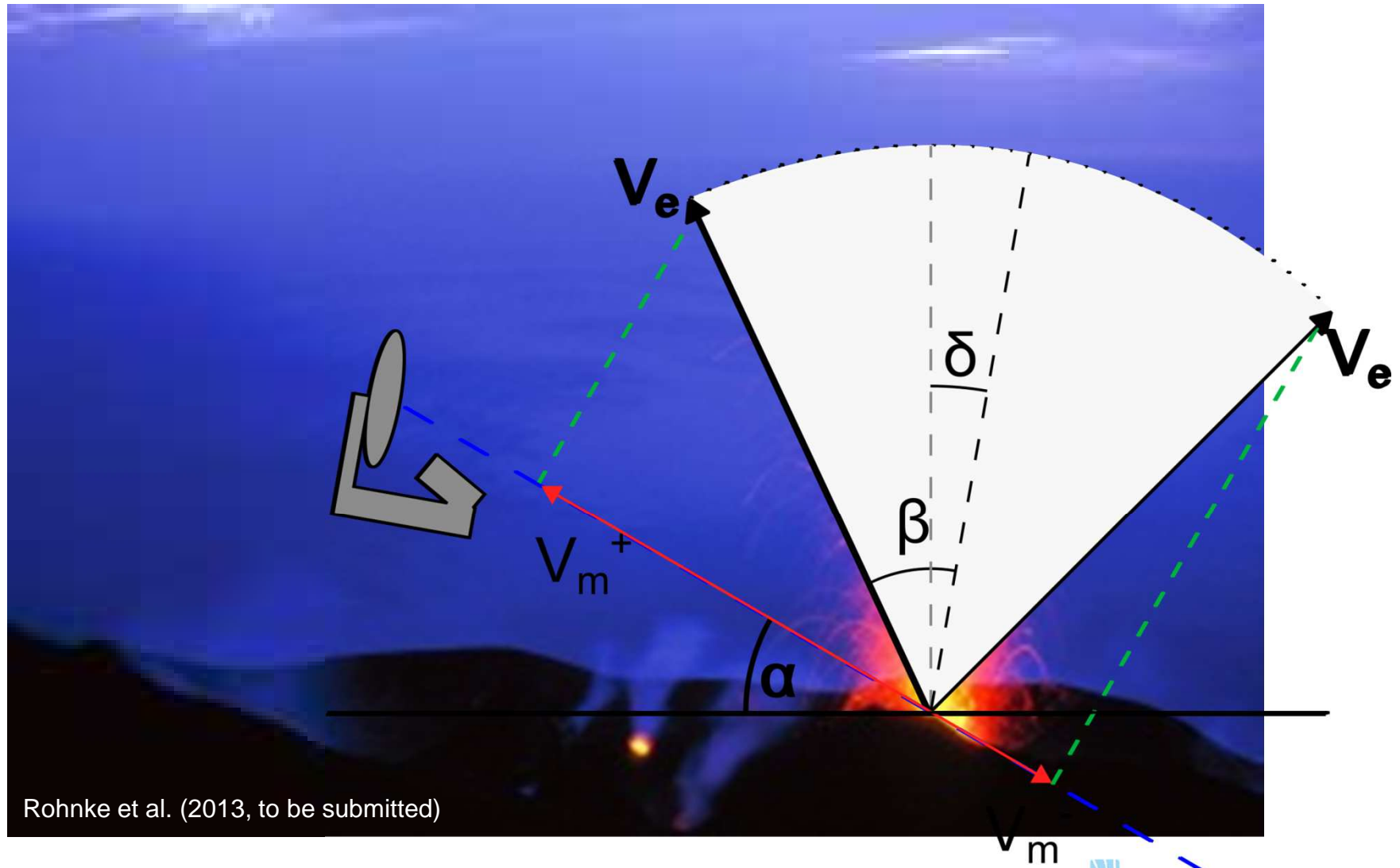
Pulsations of the eruption column



Pulsations of the eruption column

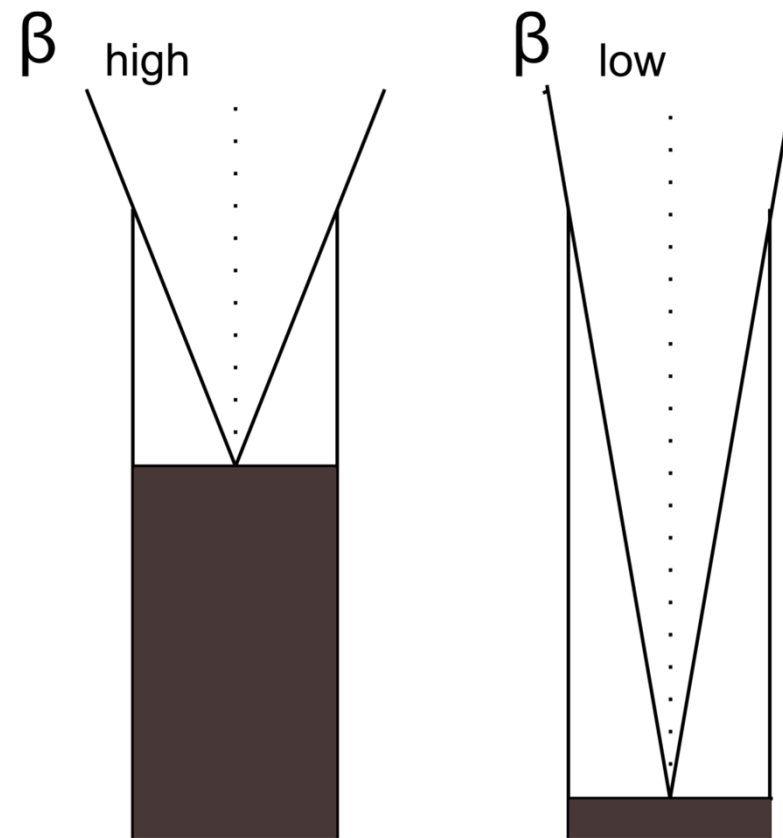


Simplified geometry of a strombolian eruption



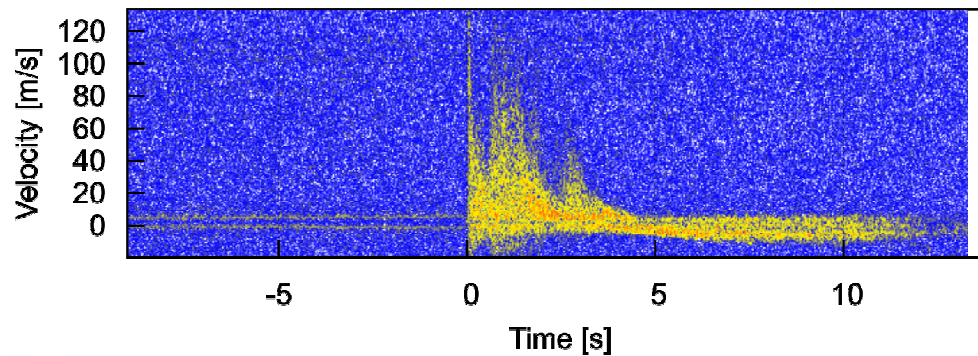
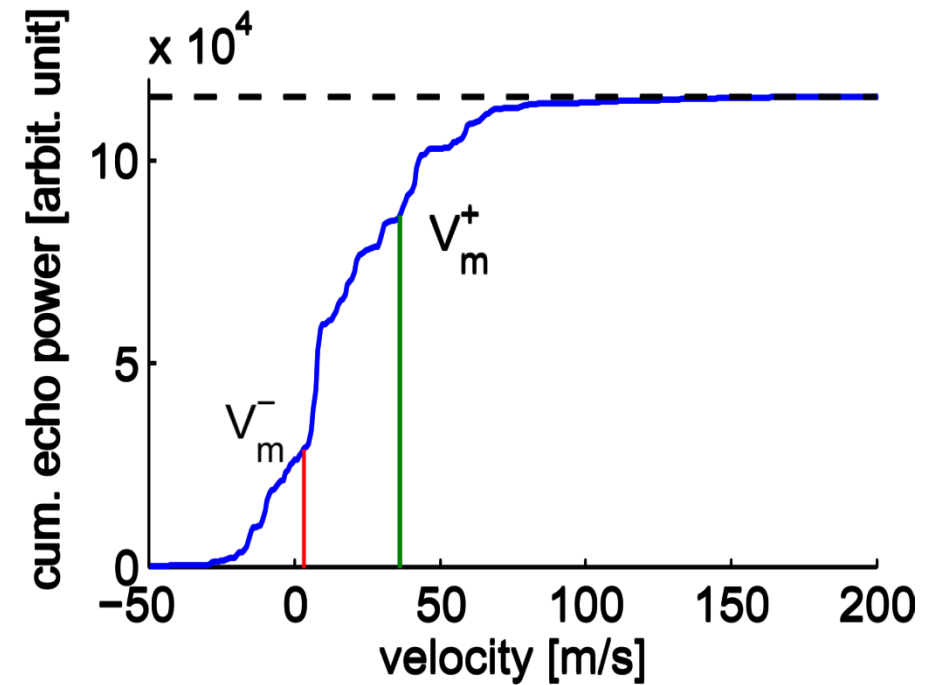
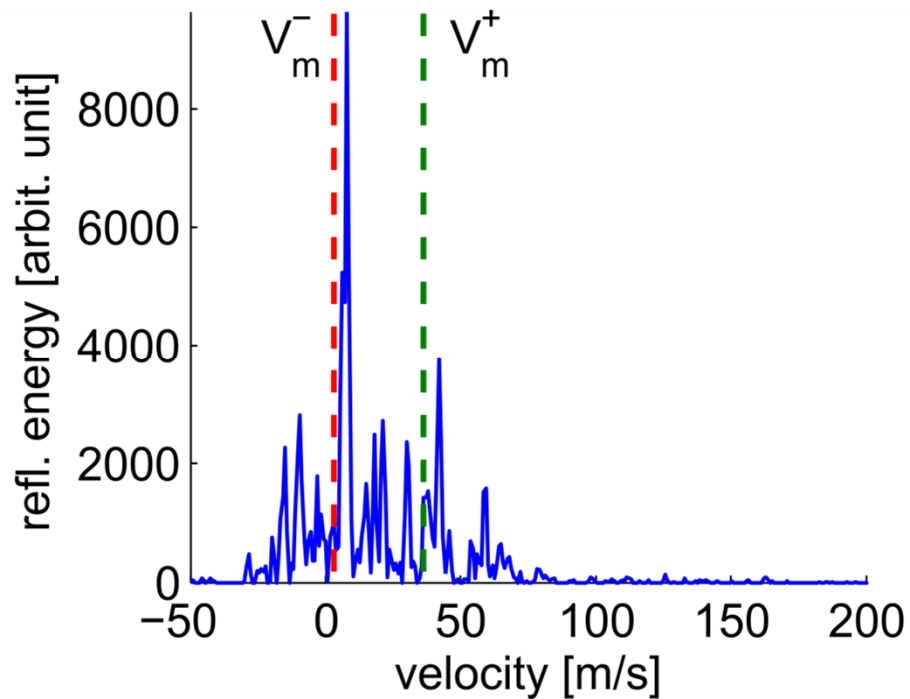
Rohnke et al. (2013, to be submitted)

Where is the magma?



Rohnke et al. (2013, to be submitted)

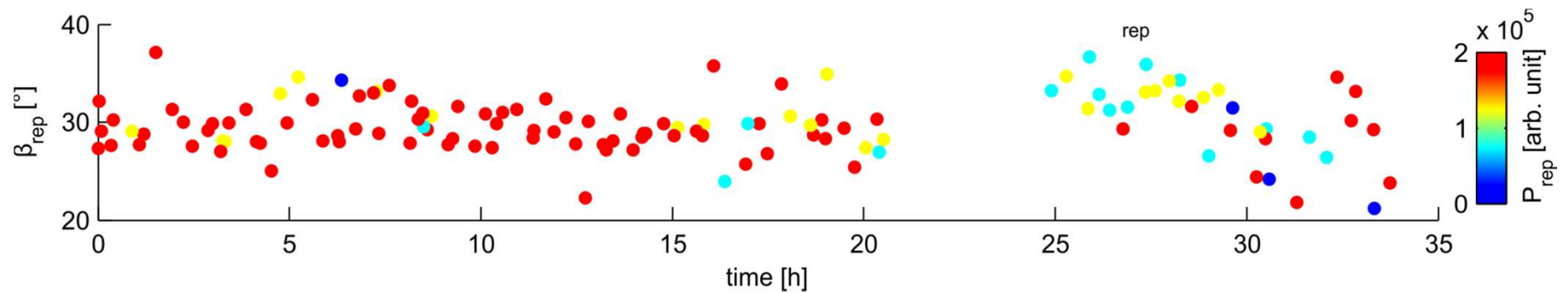
Snapshot of Velocity distribution during an eruption



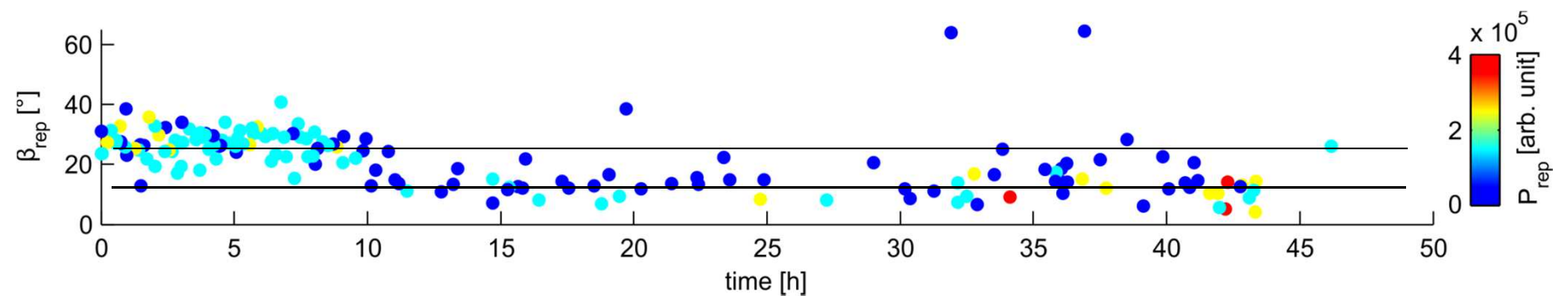
Rohnke et al. (2013, to be submitted)

Variation of opening angle with time

Stromboli SW crater

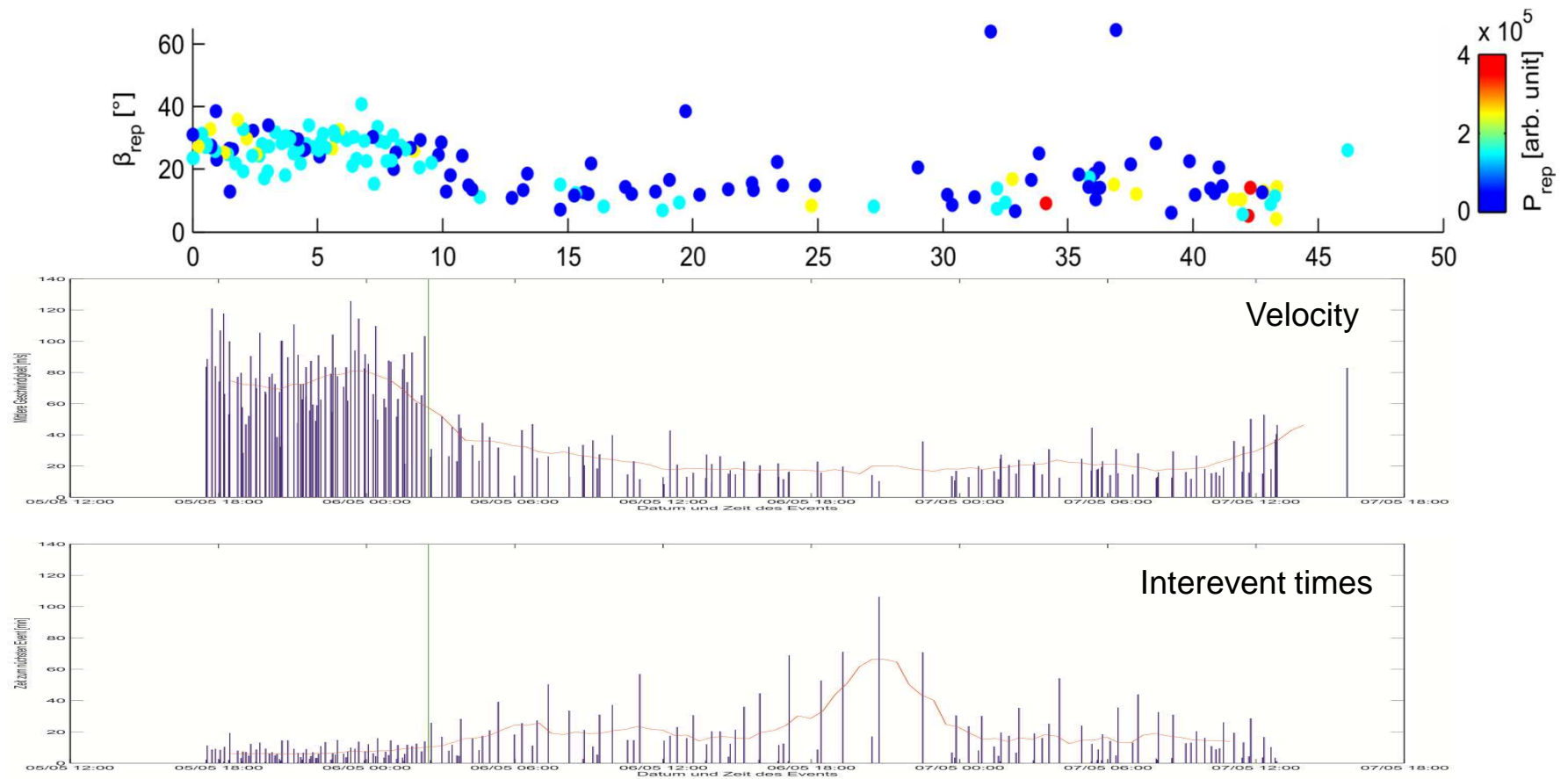


Stromboli NE crater



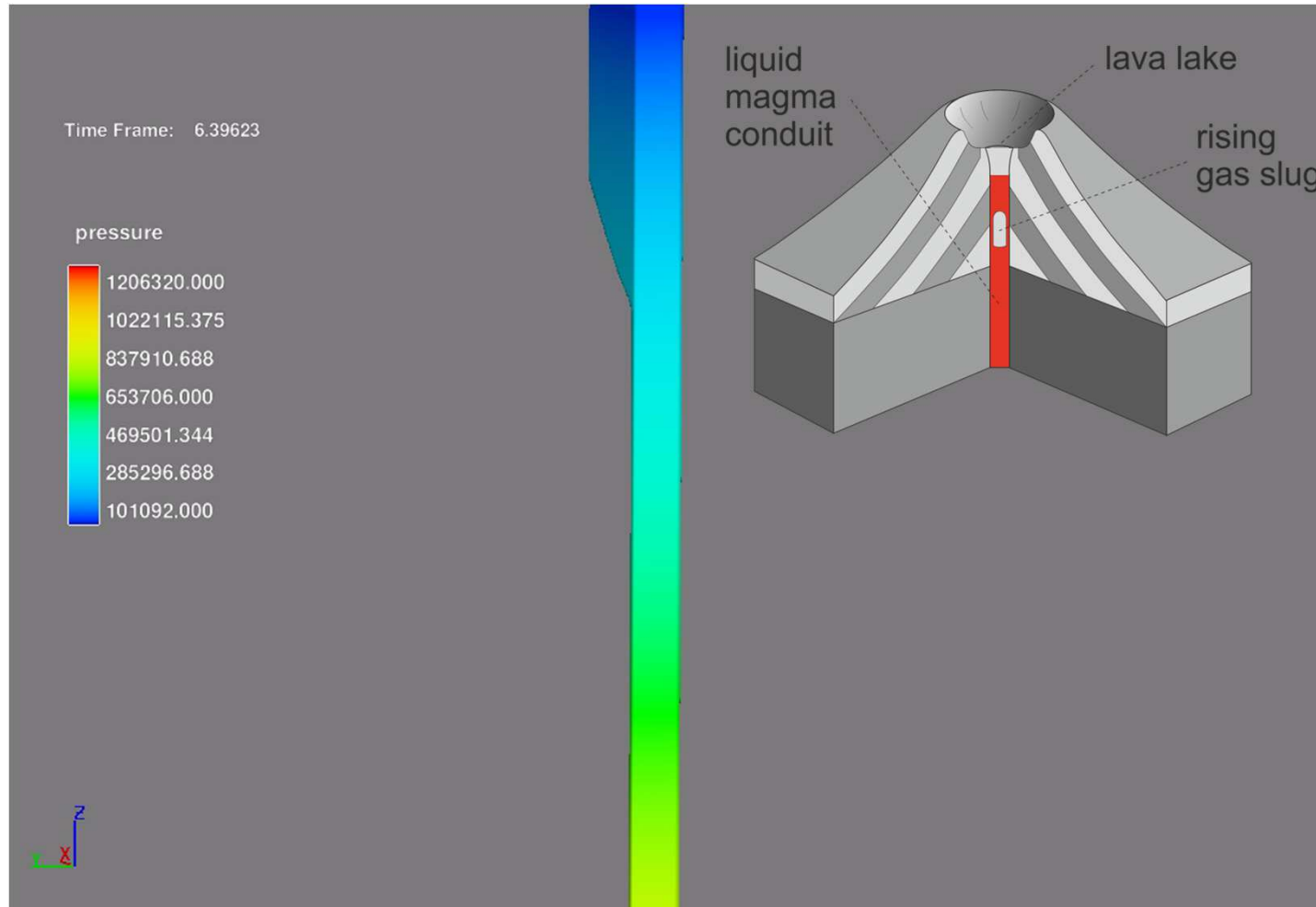
Rohnke et al, 2013 (to be submitted)

Variation of opening angle with time



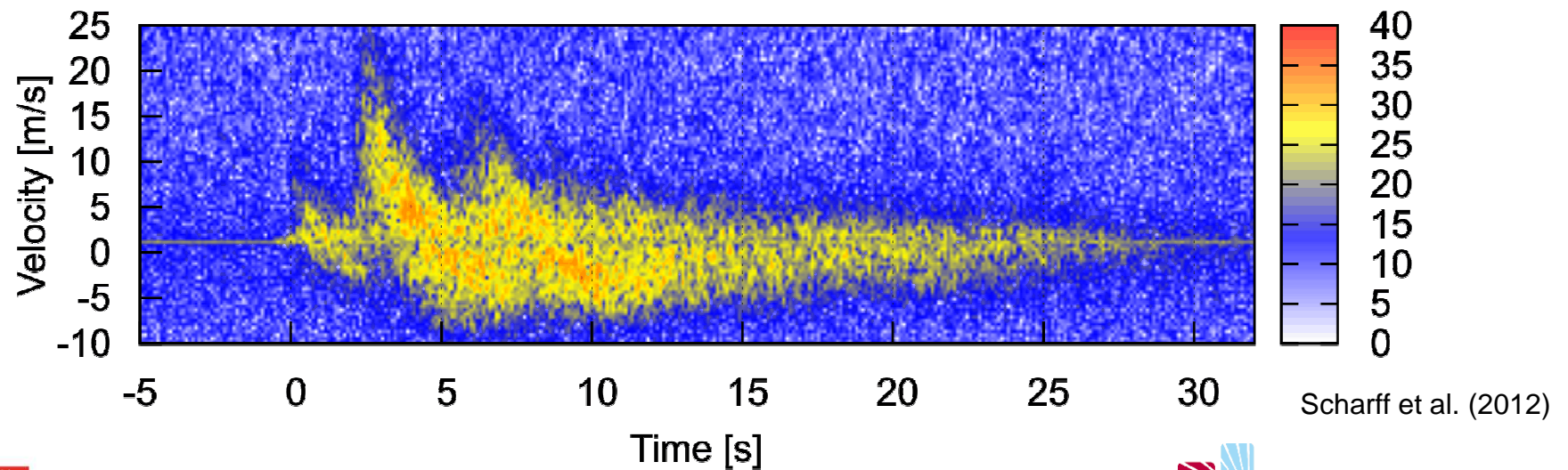
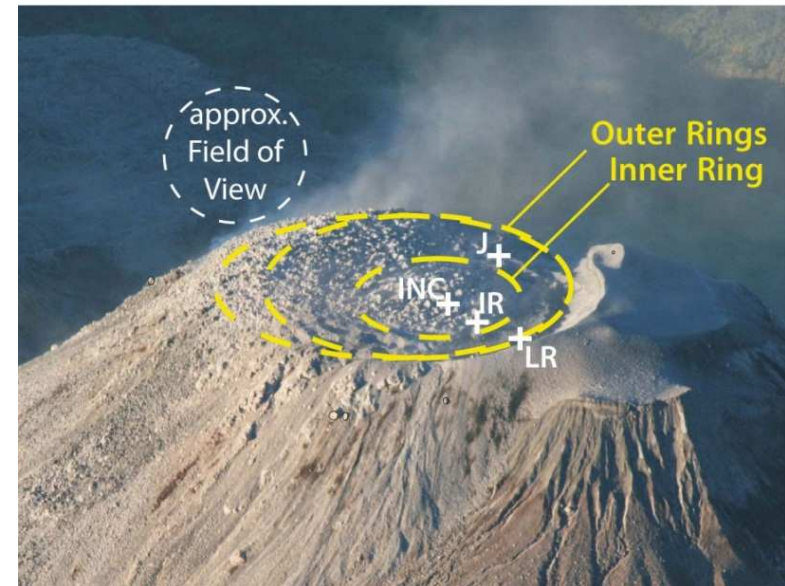
Gerwing, (2013)

Simple explanation for pulsed behaviour in low viscosity systems

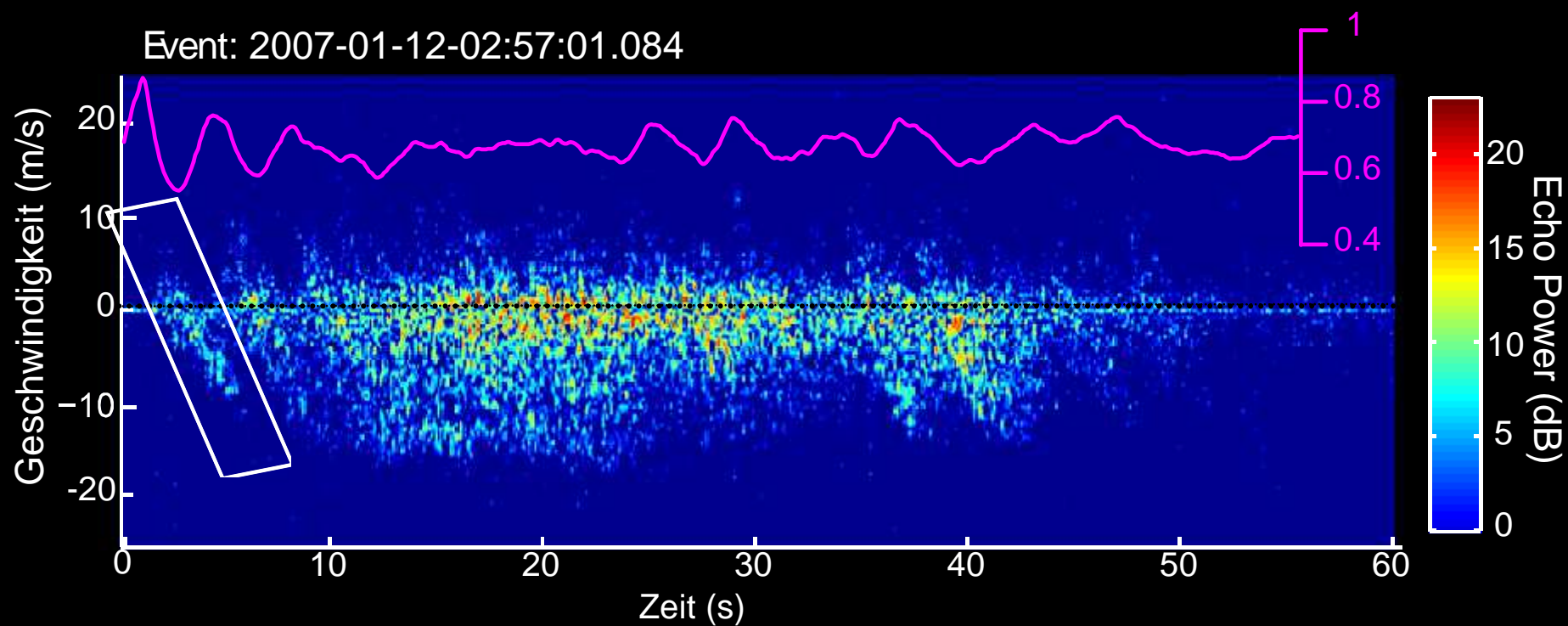


Model calculations performed by F. Petersen, Uni. Hamburg

Dome building volcanoes: Santiaguito volcano, Guatemala

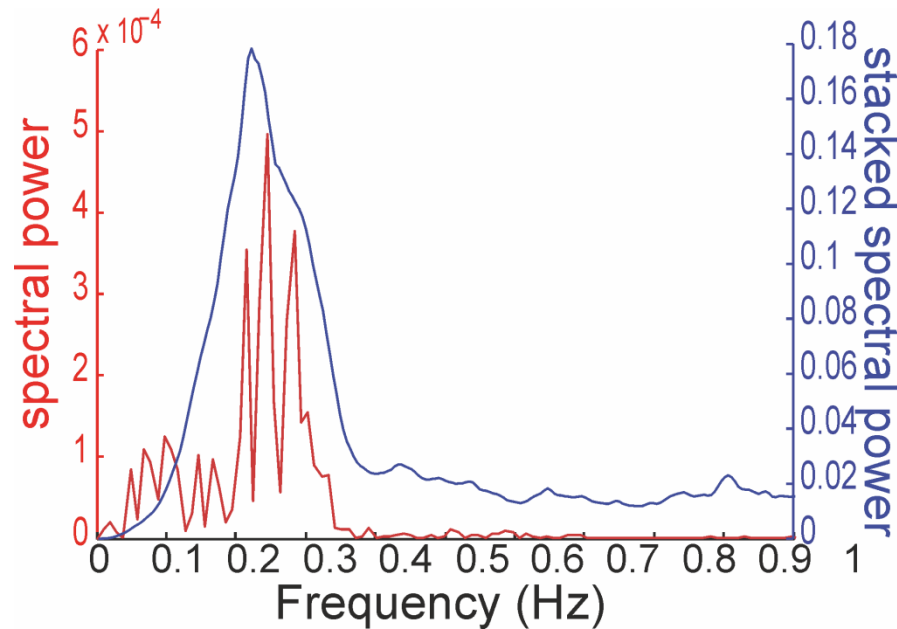


Searching pulses



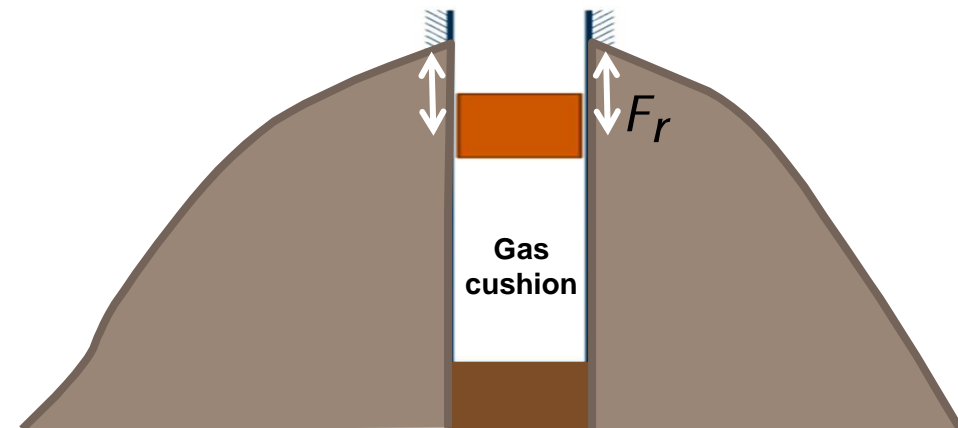
Scharff et al. (2014, in revision)

Model for pulsed gas release



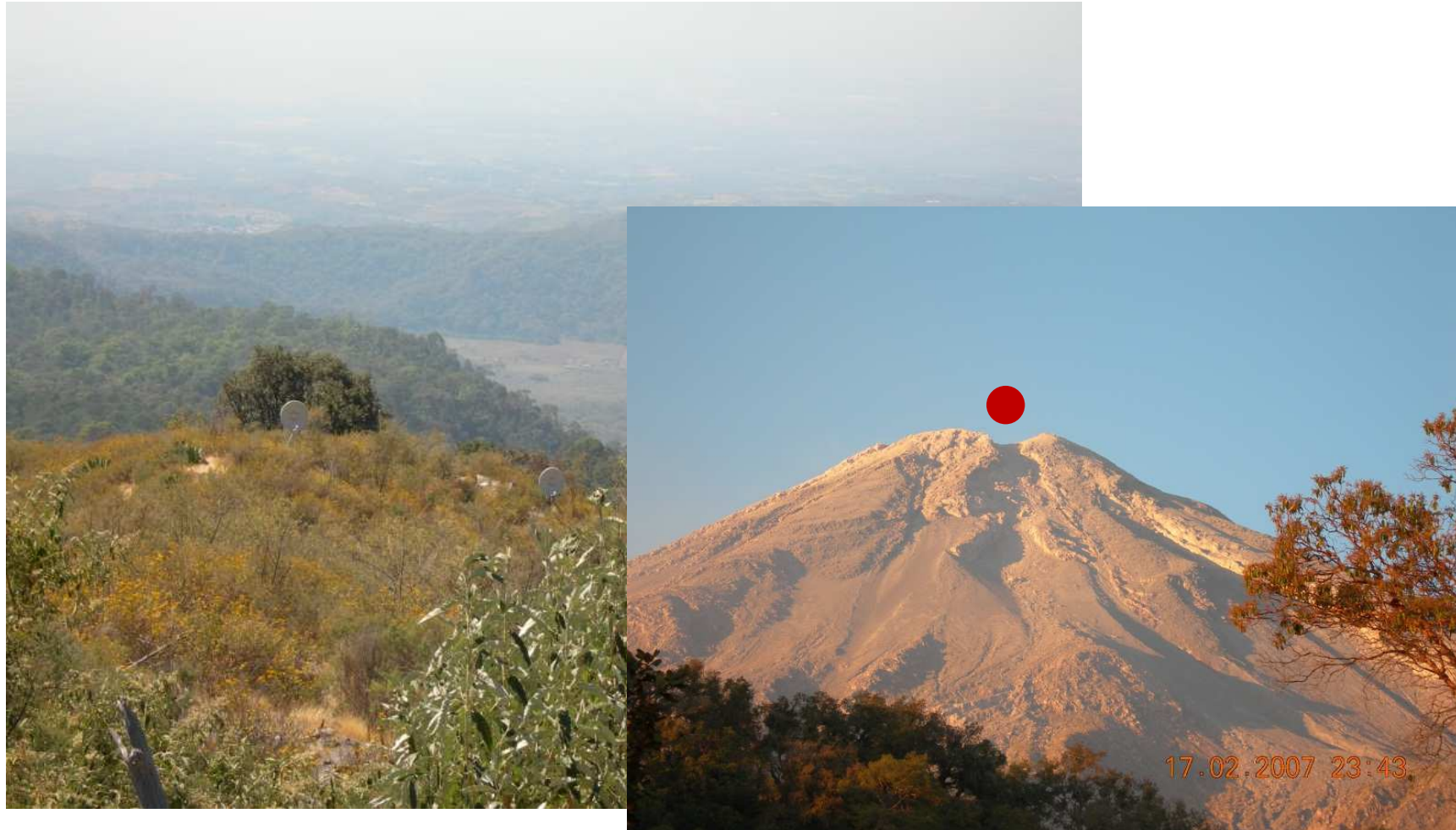
Model includes:

- Damping due to viscous friction
- Release of gas using Darcy flow and var. permeability

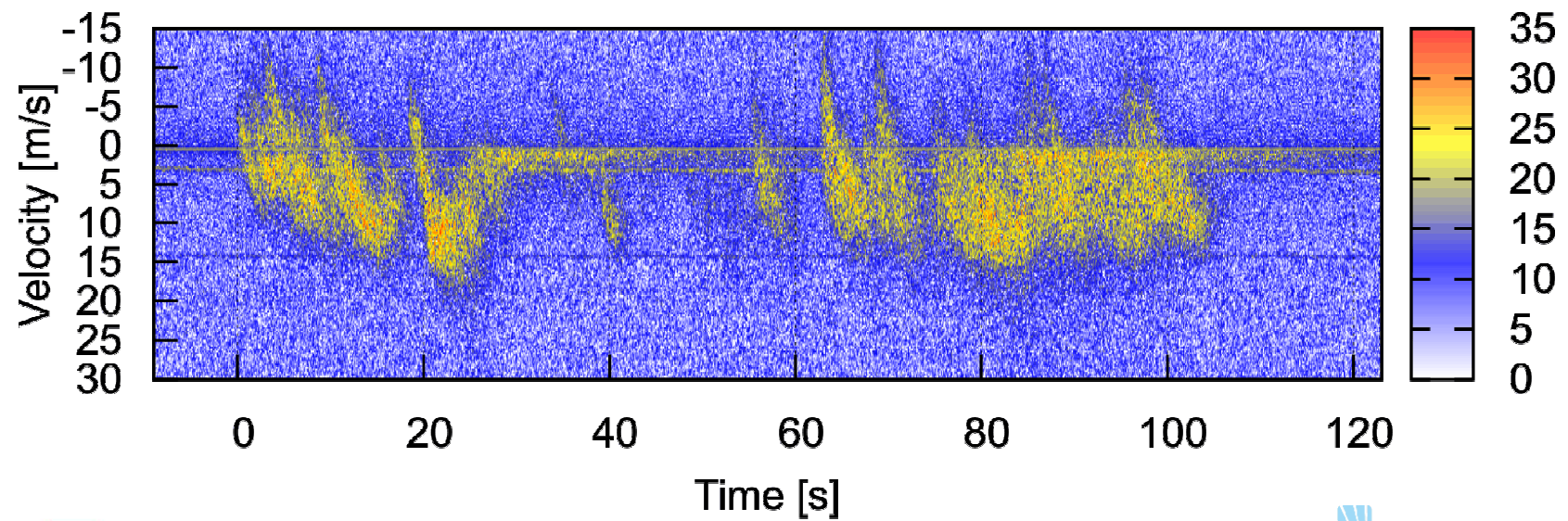
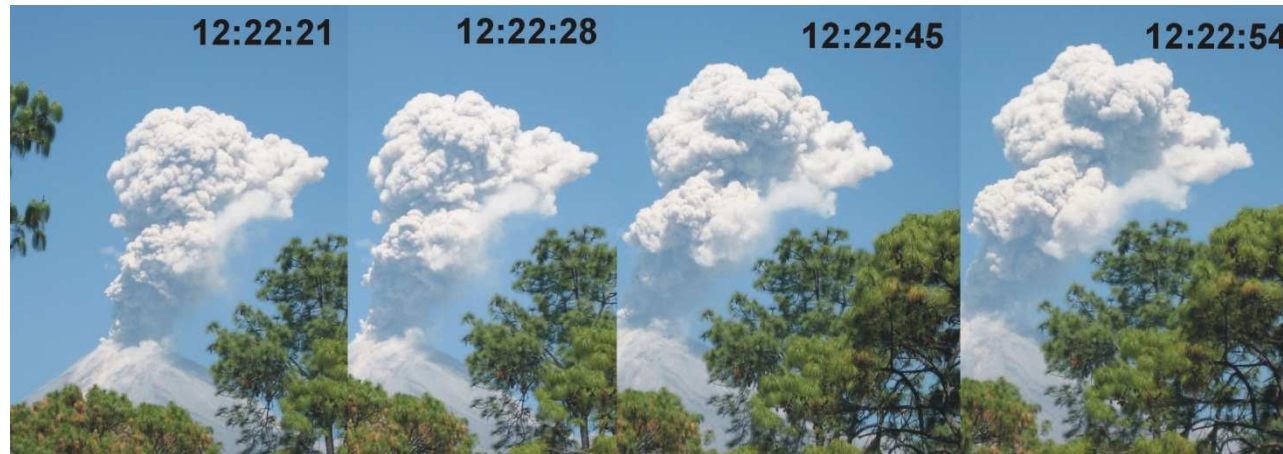


Scharff et al. (2014, in revision)

What about other dome building volcanoes: Colima volcano, Mexico

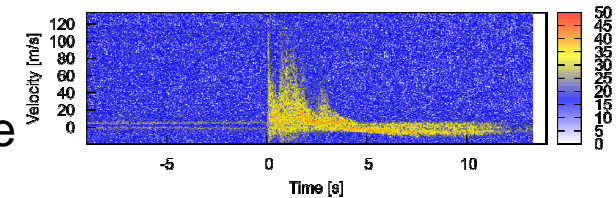


Pulsed eruption at Colima volcano

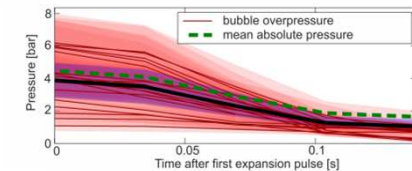


Take home points

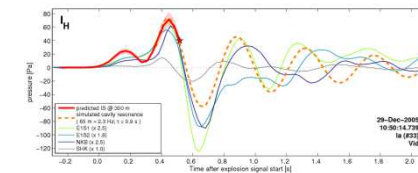
Mass flux at the vent is probably often non continuous
Eruption dynamics are probably controlled by near surface conduit geometry



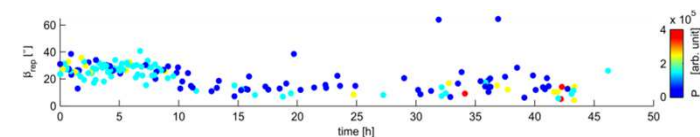
Bubble overpressures are on the order of bicycle tire pressures



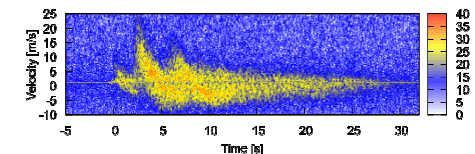
Acoustic signals are generated at the magma air interface



Magma levels in the conduit are likely to change



Dome building systems appear to oscillate giving rise to pulsed gas release



Thank you for your attention

