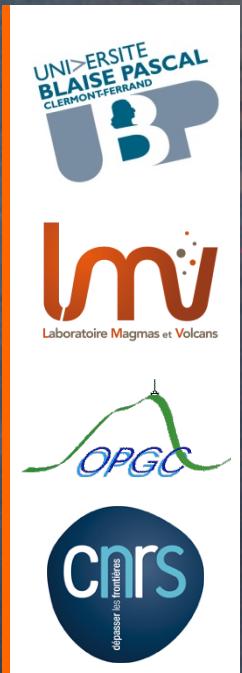
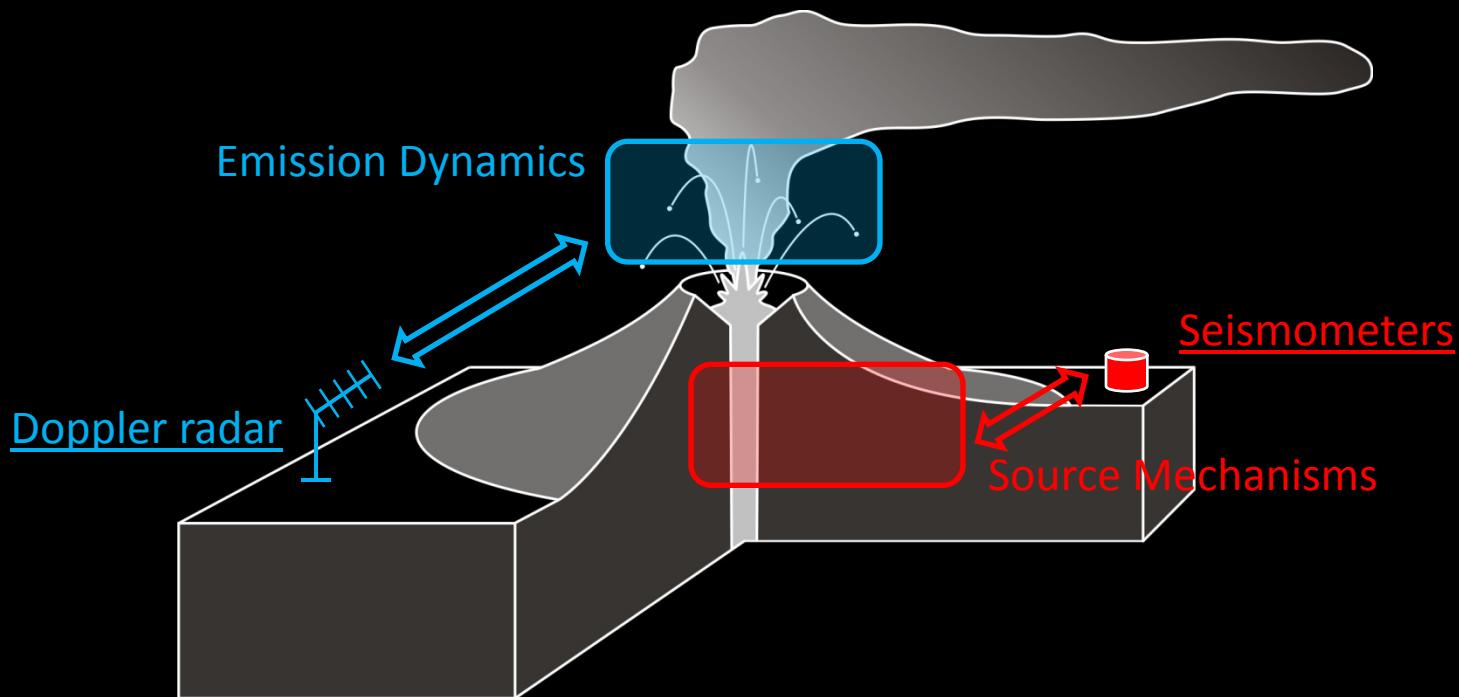


From conduit processes to surface emissions: *constraints from seismic and Doppler radar data*

Sébastien Valade, F. Donnadieu, P. Lesage, A. Harris



⇒ *gain insights into the dynamics of explosive eruptions*



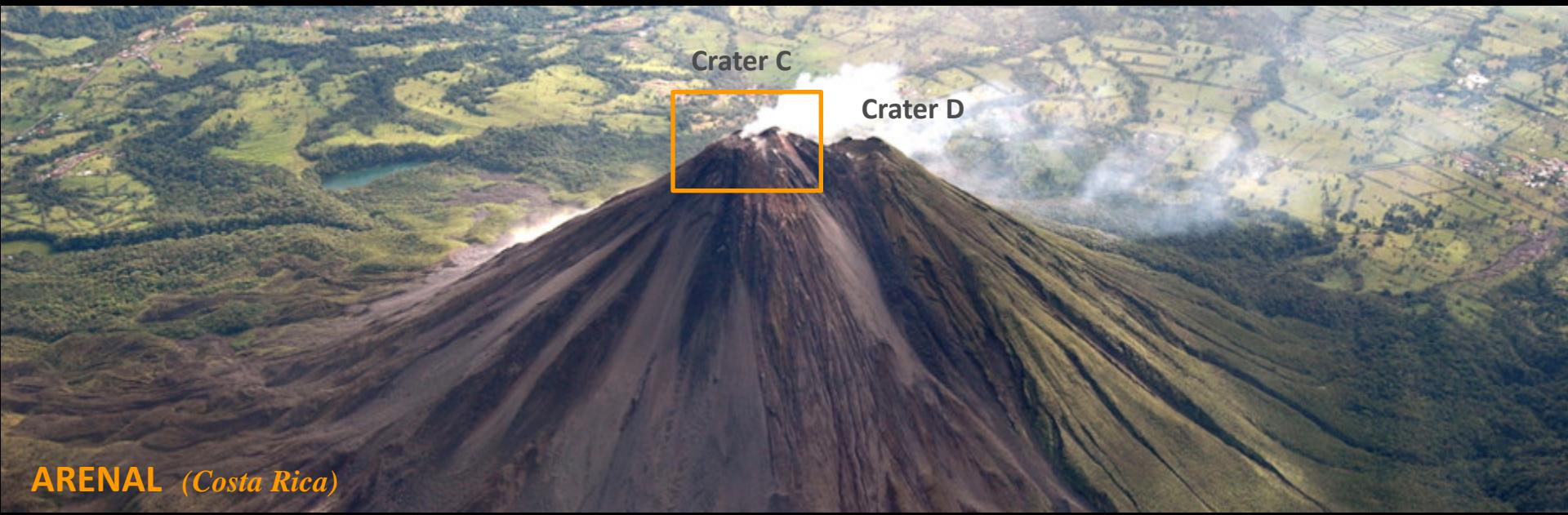
ARENAL volcano

1100 m height

Strombolian-Vulcanian
persistent activity

(amongst the 16 most active
volcanoes worldwide)

ARENAL (*Costa Rica*)



ARENAL (*Costa Rica*)

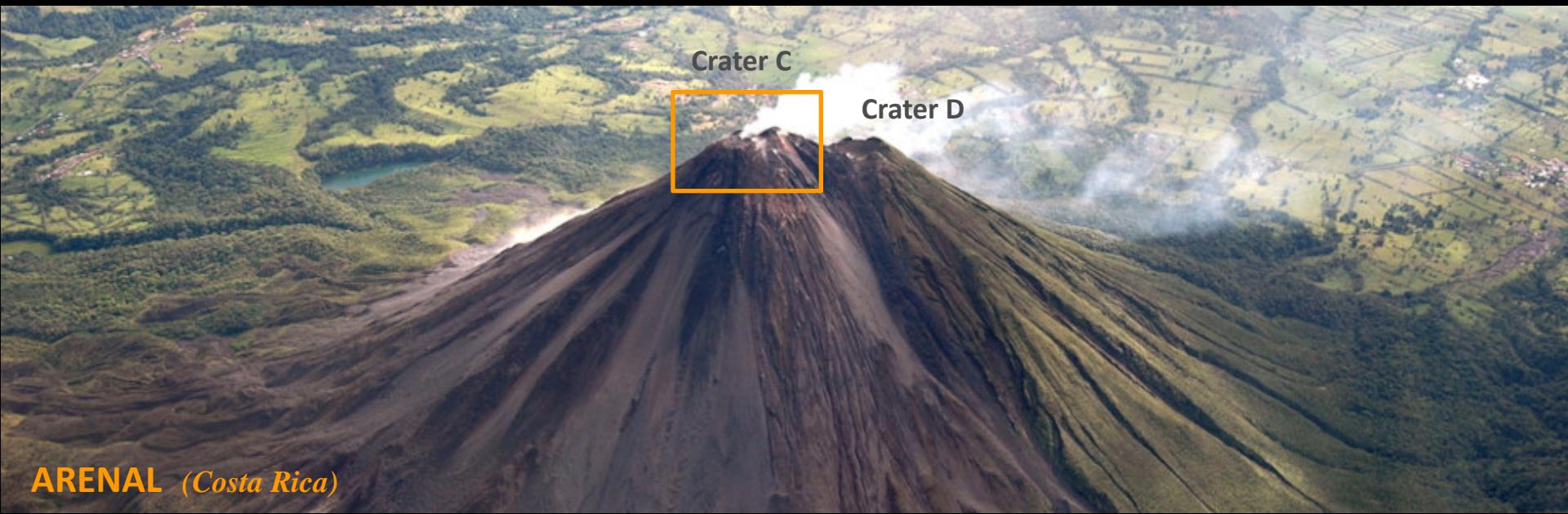
Dome-like surface



Persistent eruptive activity



lava flows

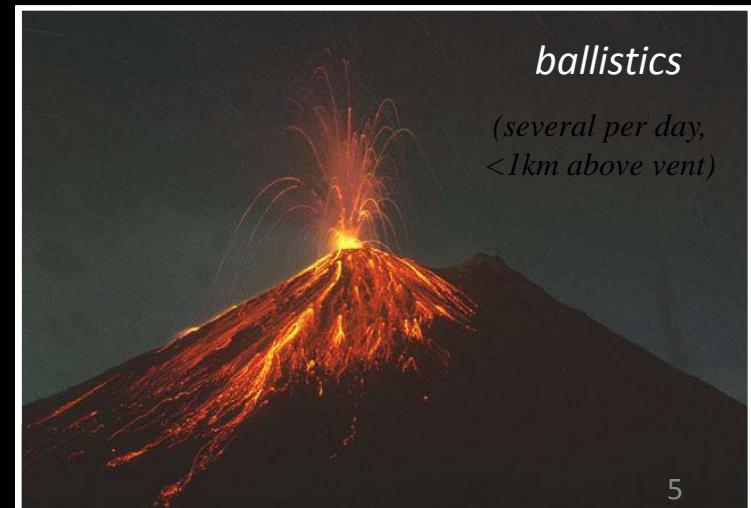


ARENAL (*Costa Rica*)

Dome-like surface

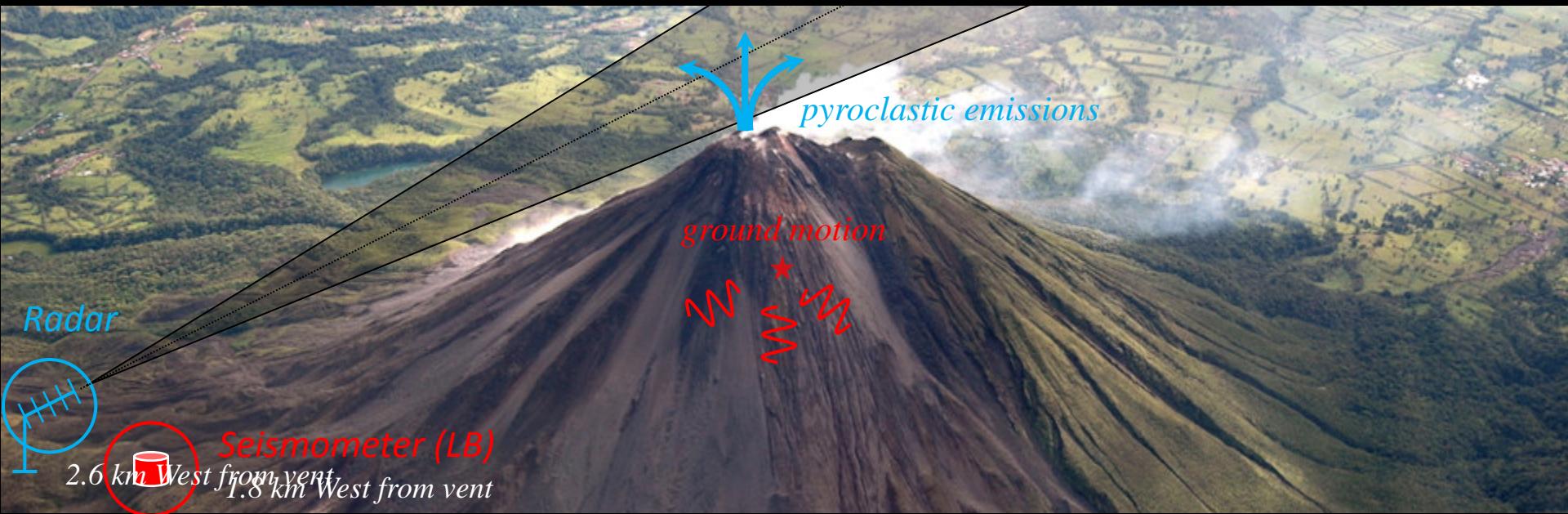


Frequent small-scale emissions

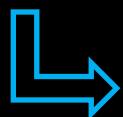


ballistics

*(several per day,
<1km above vent)*

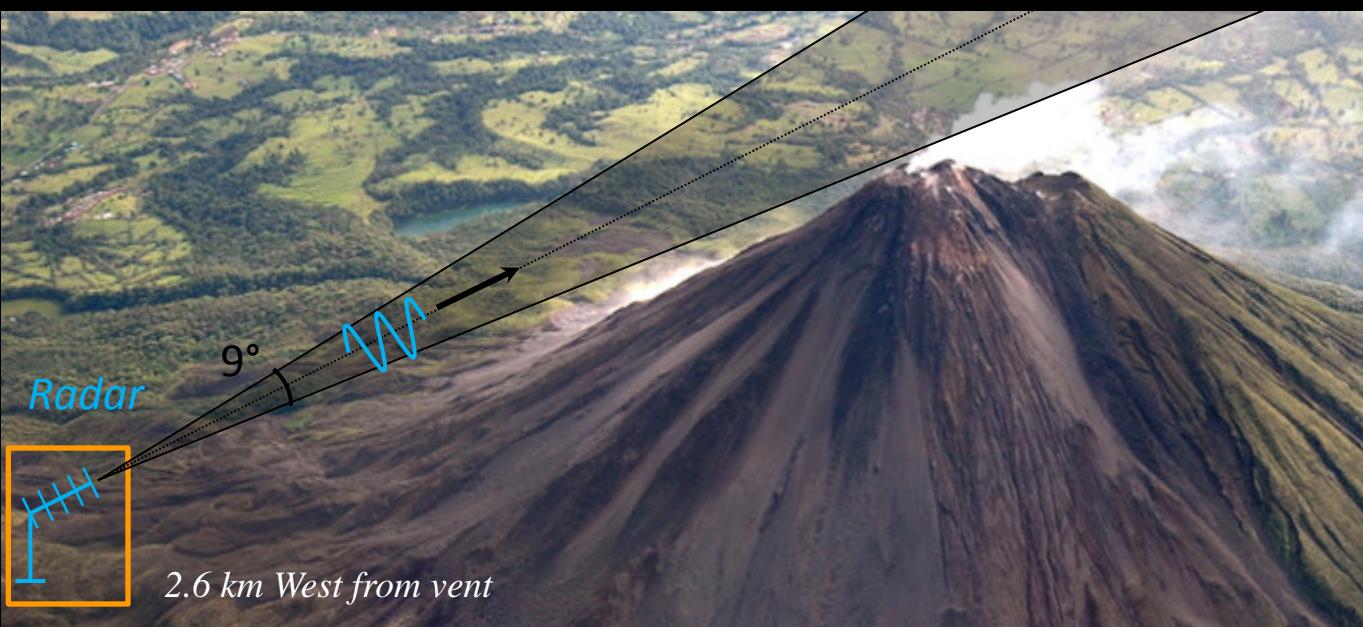


SURFACE activity \Rightarrow Doppler radar

 *radar signature* \Leftrightarrow emission dynamics

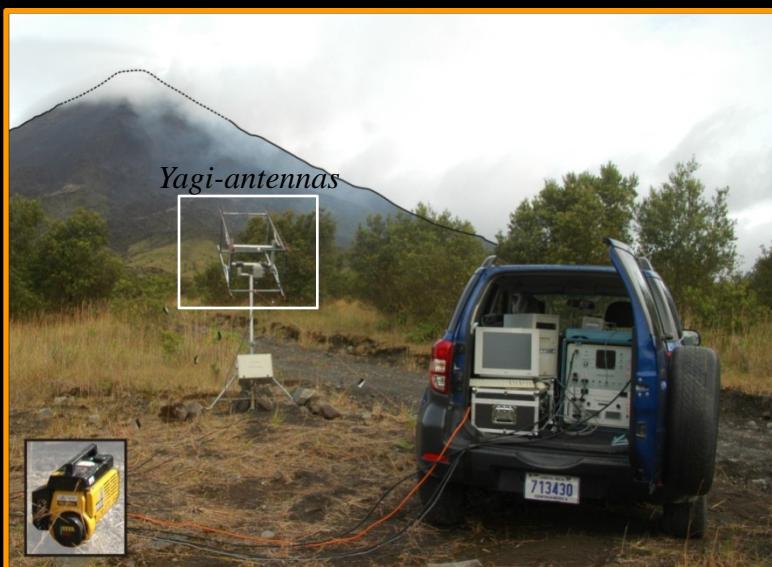
SUBSURFACE activity \Rightarrow seismometers

 *seismic signature* \Leftrightarrow conduit processes



VOLDORAD

- VOLcano DOppler RADar

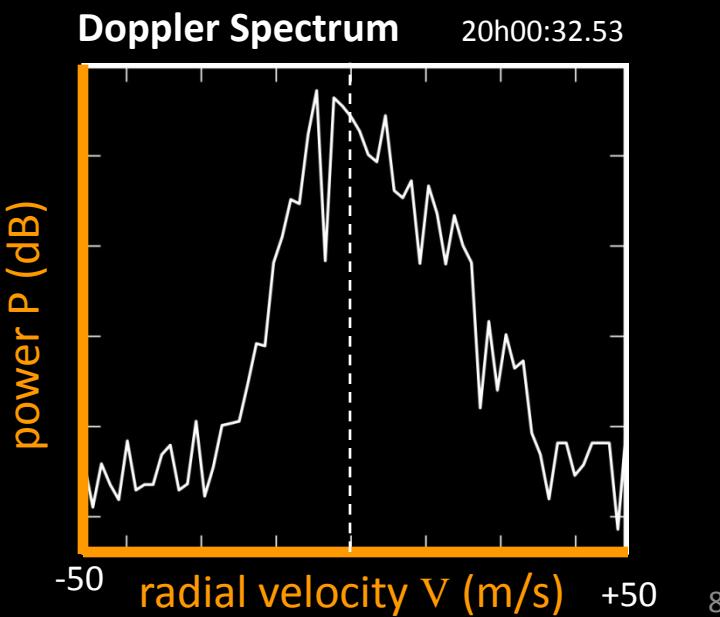




VOLDORAD

- VOLcane DOpple RADar
- Pulsed radar ($t_r = 100 \mu\text{s}$)
- Doppler radar

- backscattered **POWER** (P)
 ⇒ number / size of particles
- frequency shift ⇔ radial **VELOCITY** (V) (Doppler Effect)
 (projection of velocity vector on radar beam)

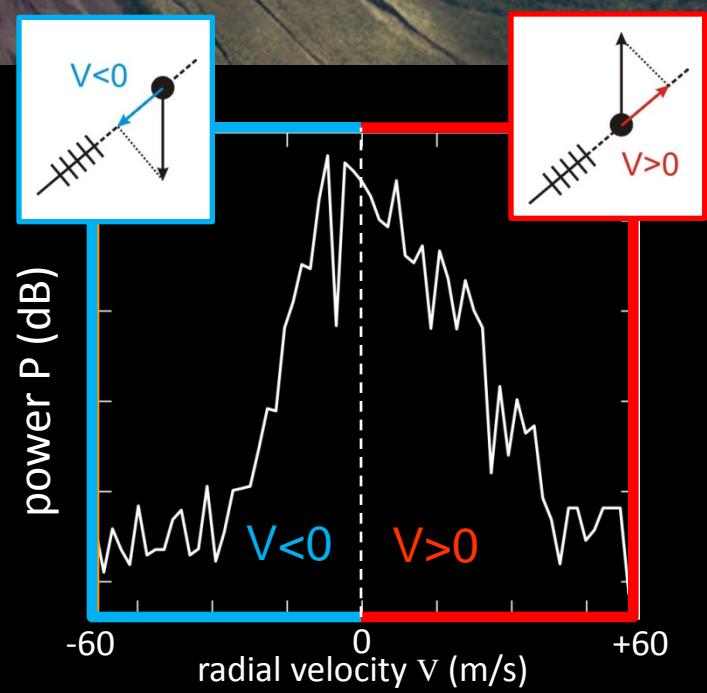




VOLDORAD

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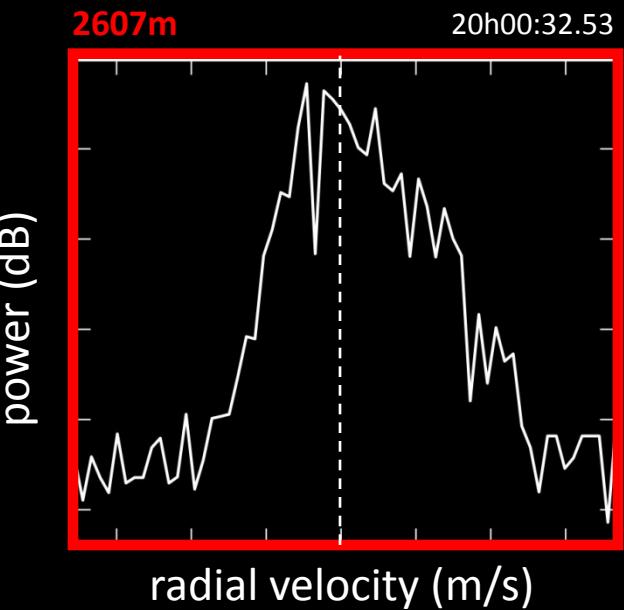
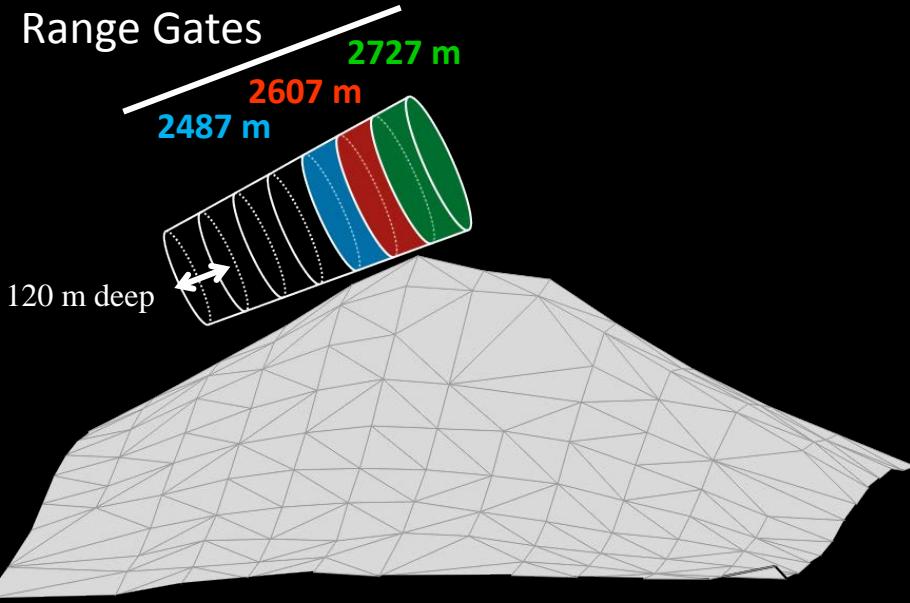


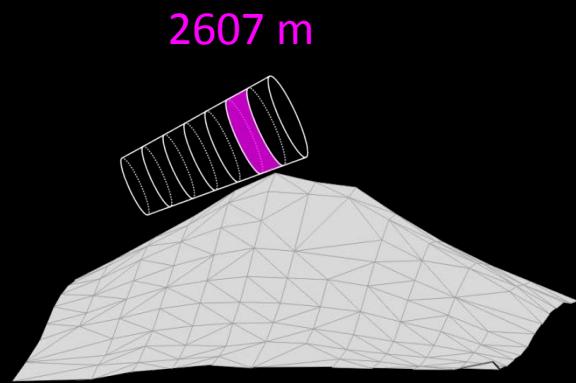
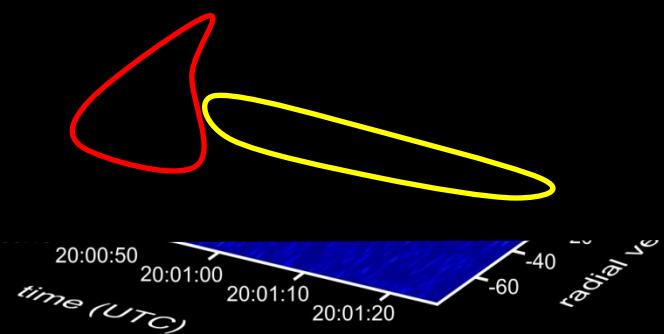
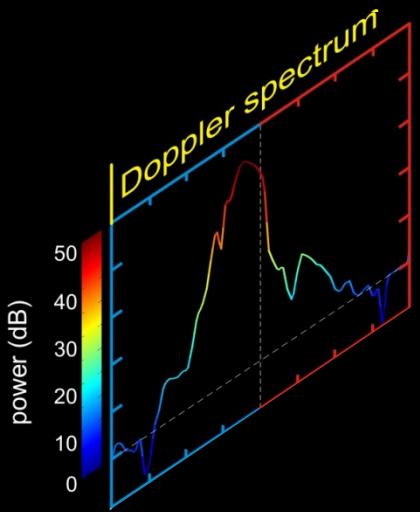
RANGE GATES



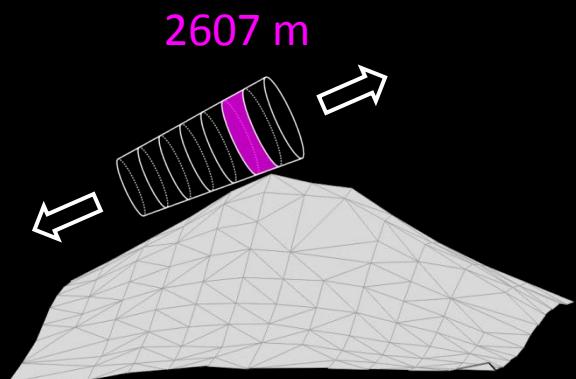
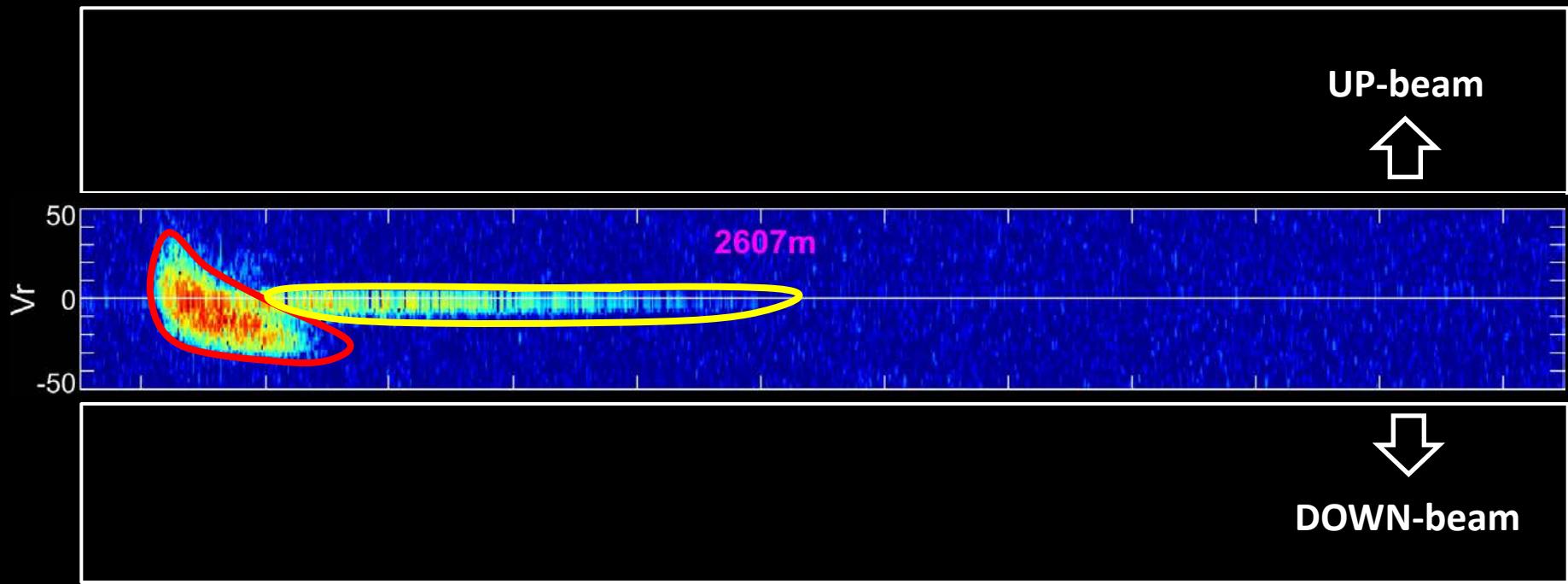
VOLDORAD

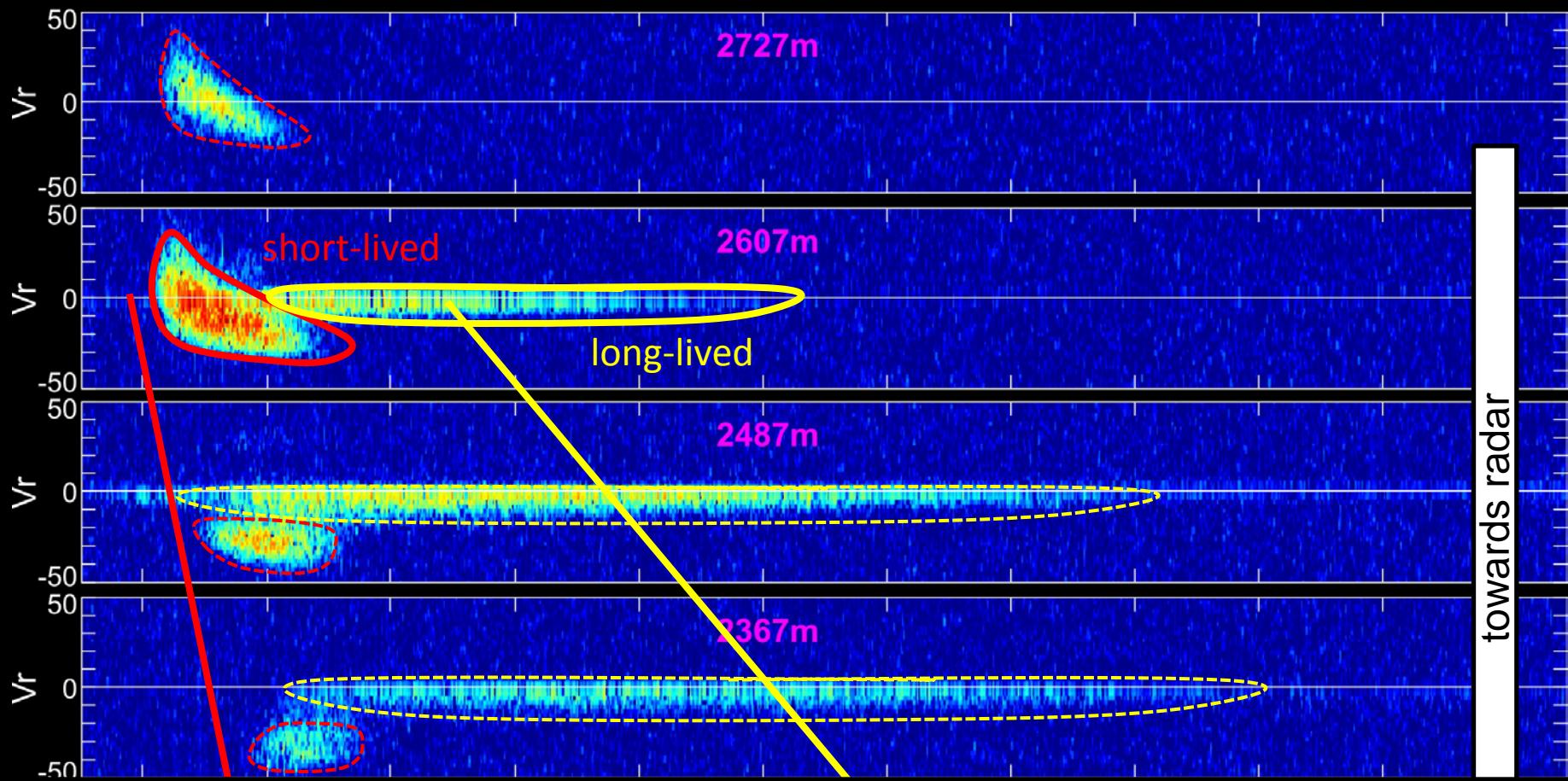
- VOLcano DOppler RADar
- Pulsed radar ($t_r = 100 \mu\text{s}$)
- Doppler radar
- 11 recorded ranges gates



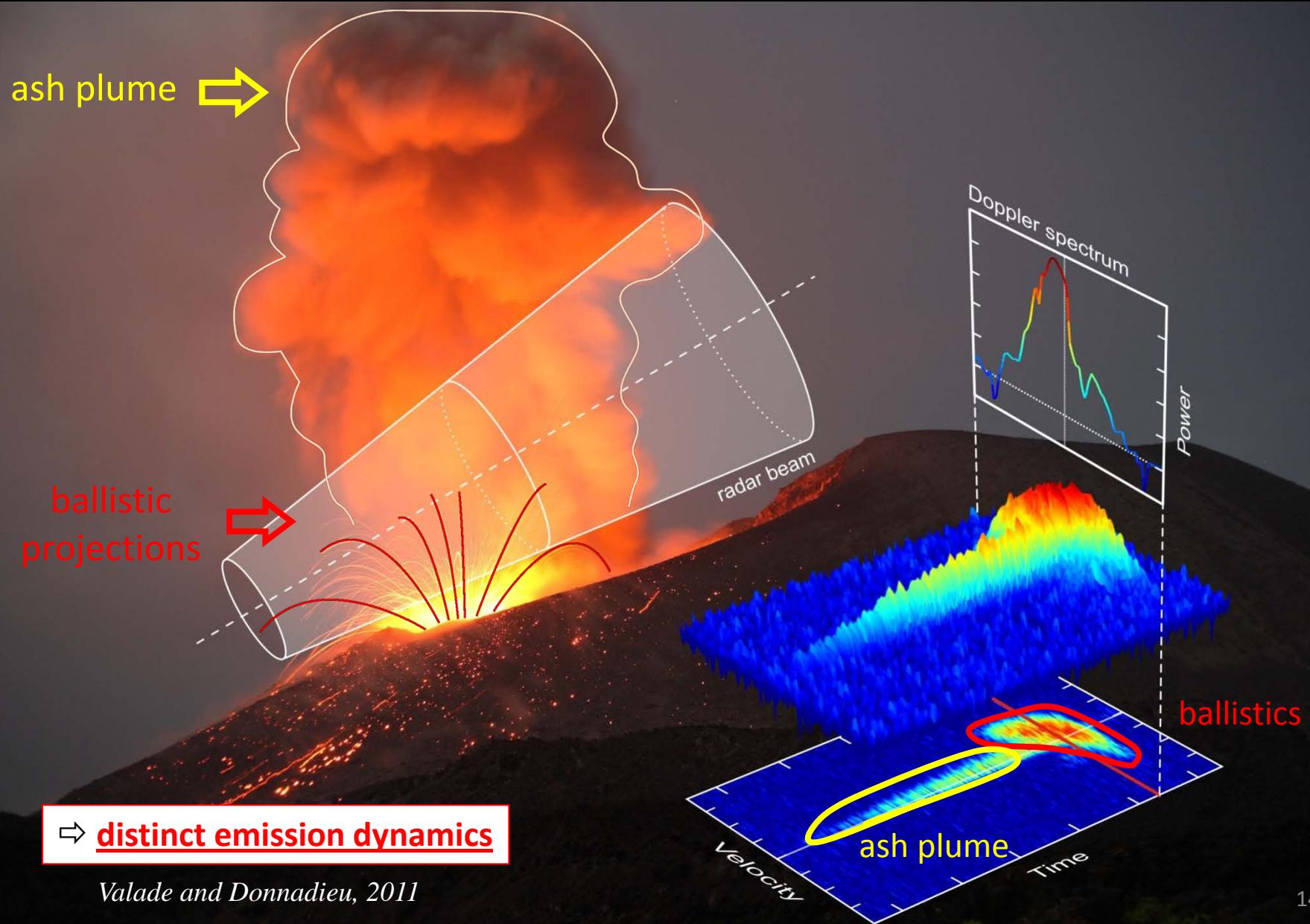


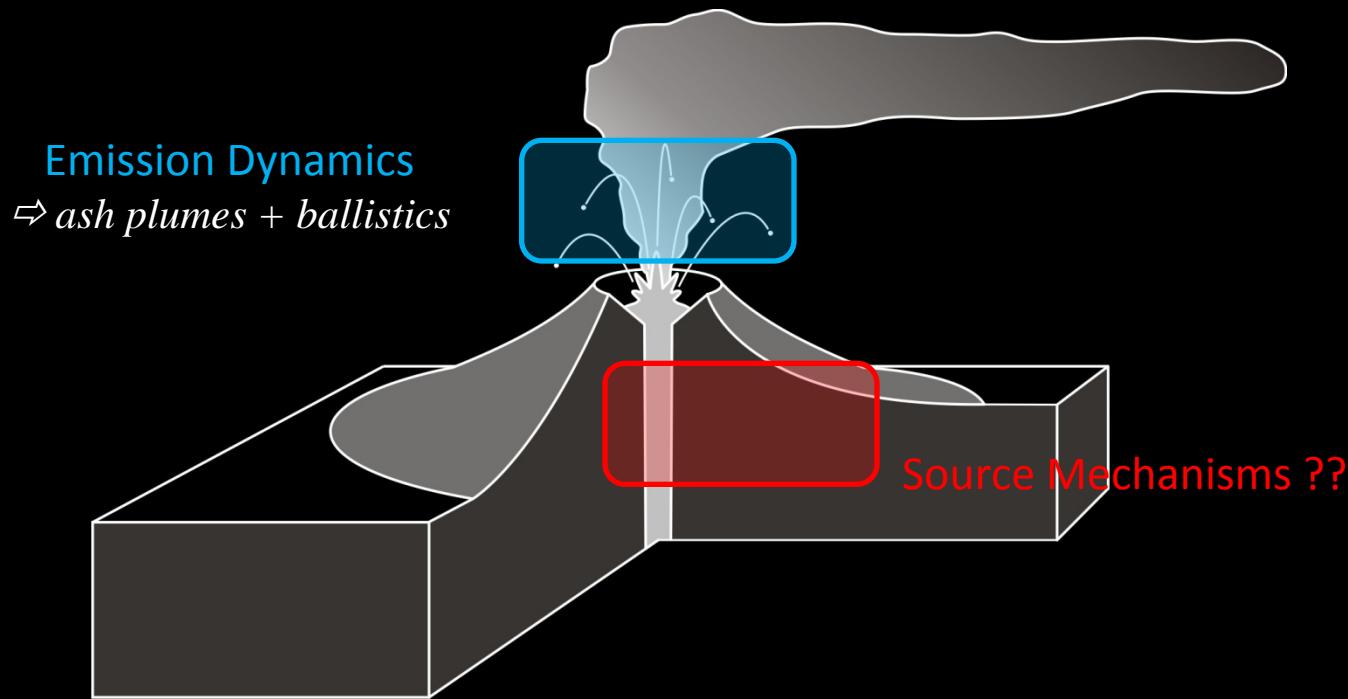
Doppler radargram = time – velocity distribution of power

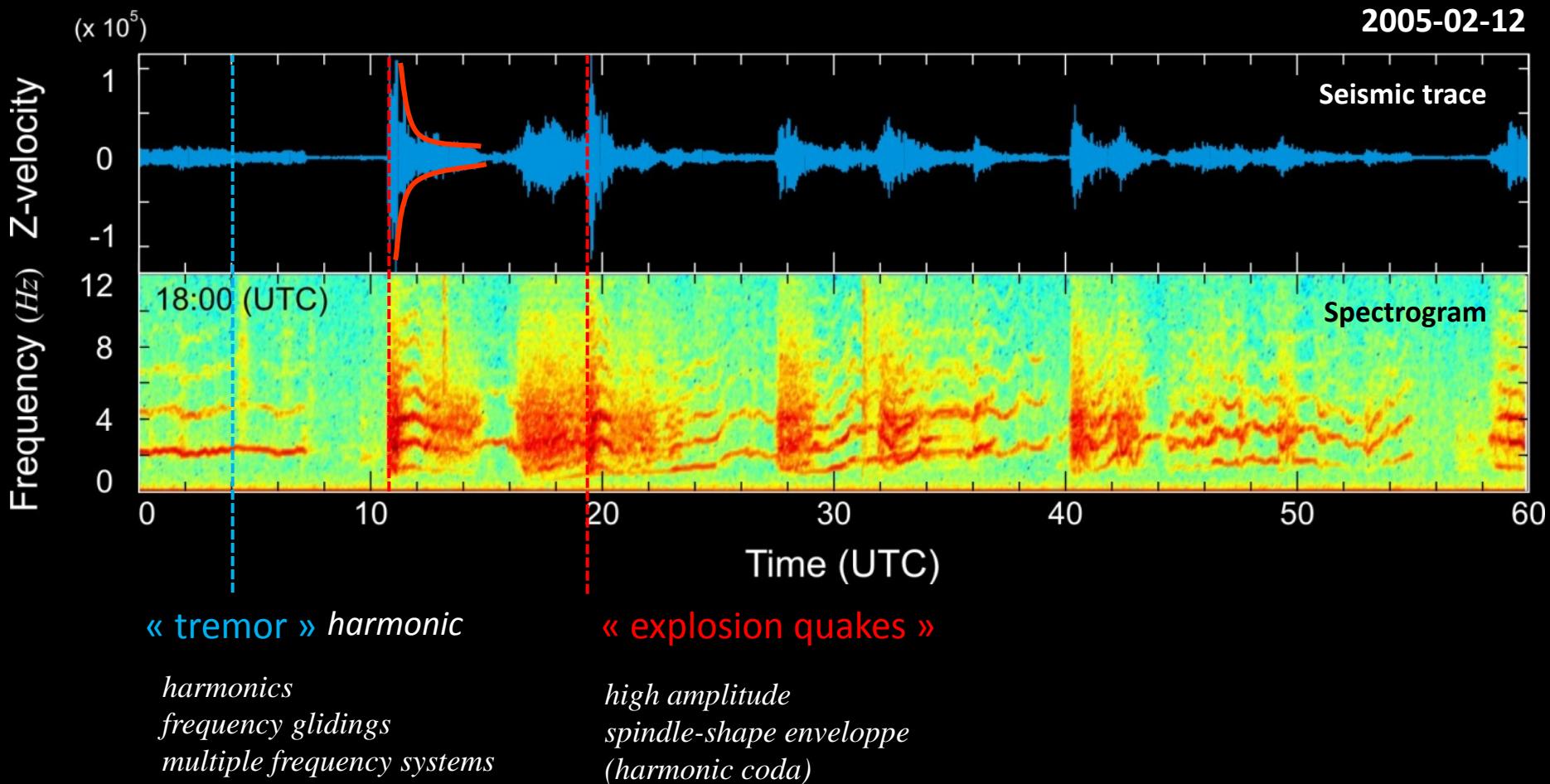


Arenal 2004-02-19

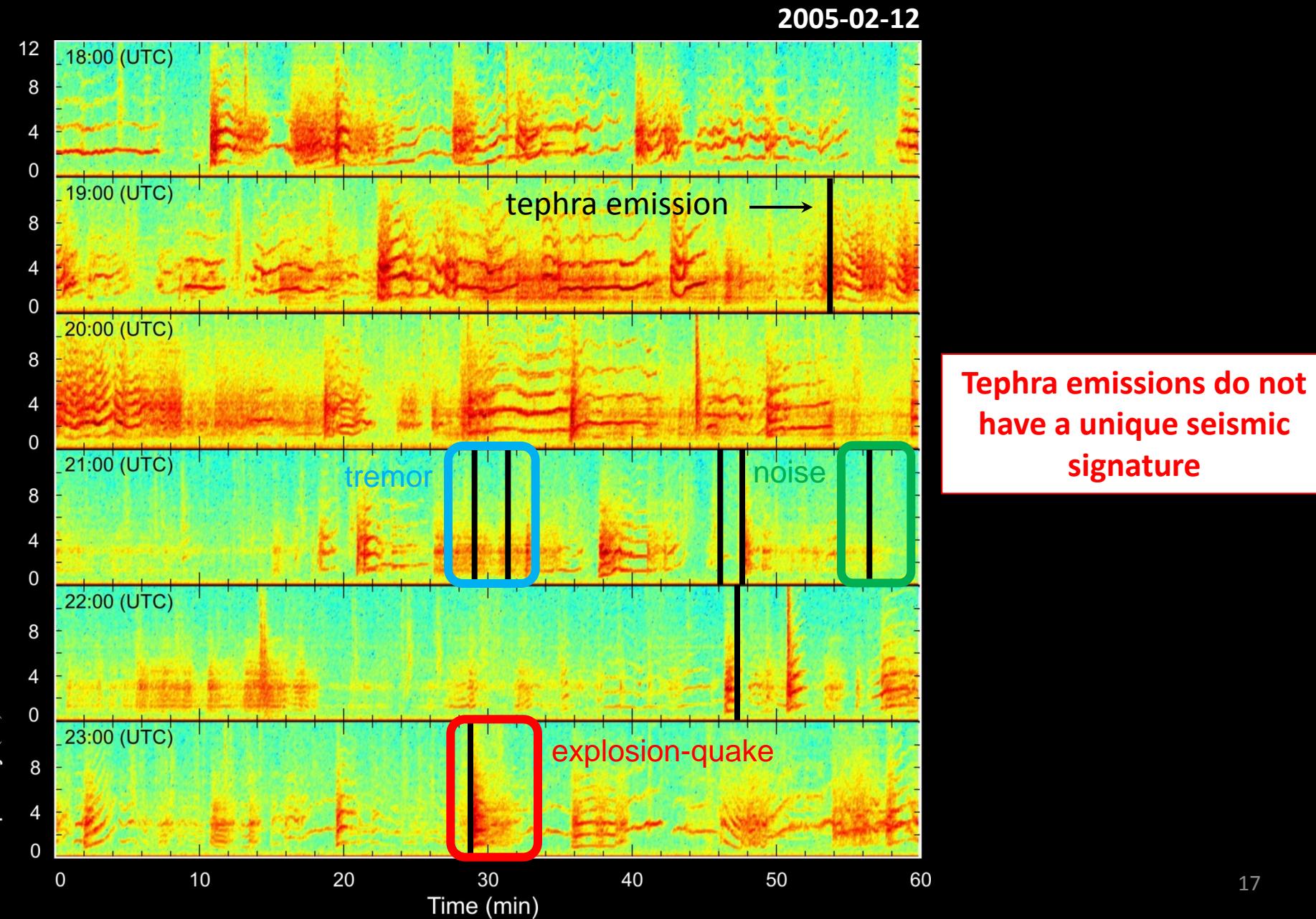
Numerical modeling of pyroclastic emissions
⇒ construction of synthetic Doppler radargrams

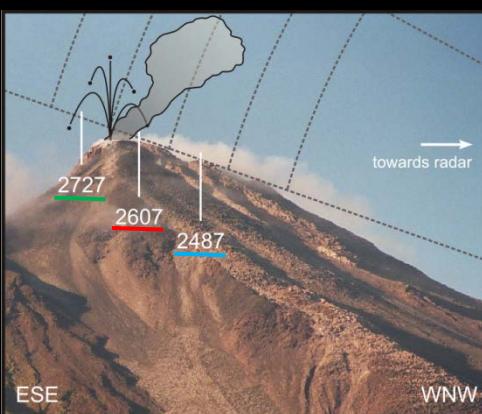
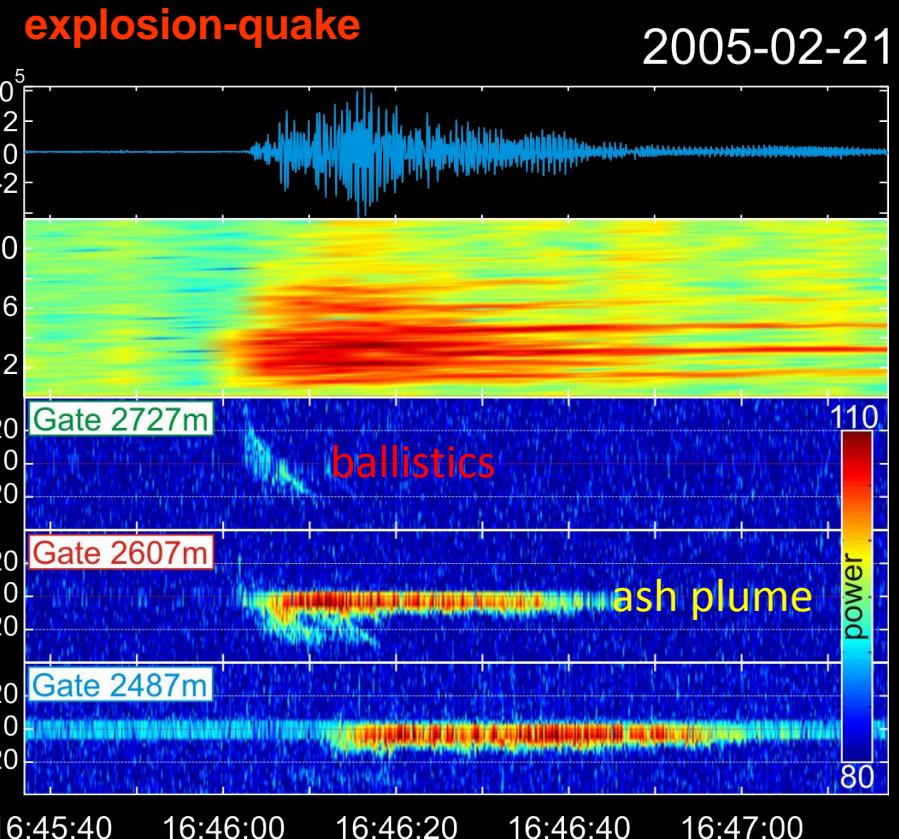
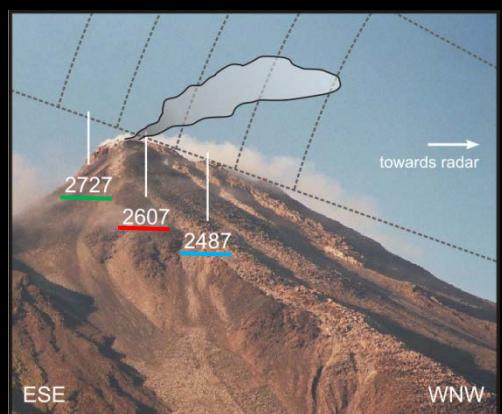
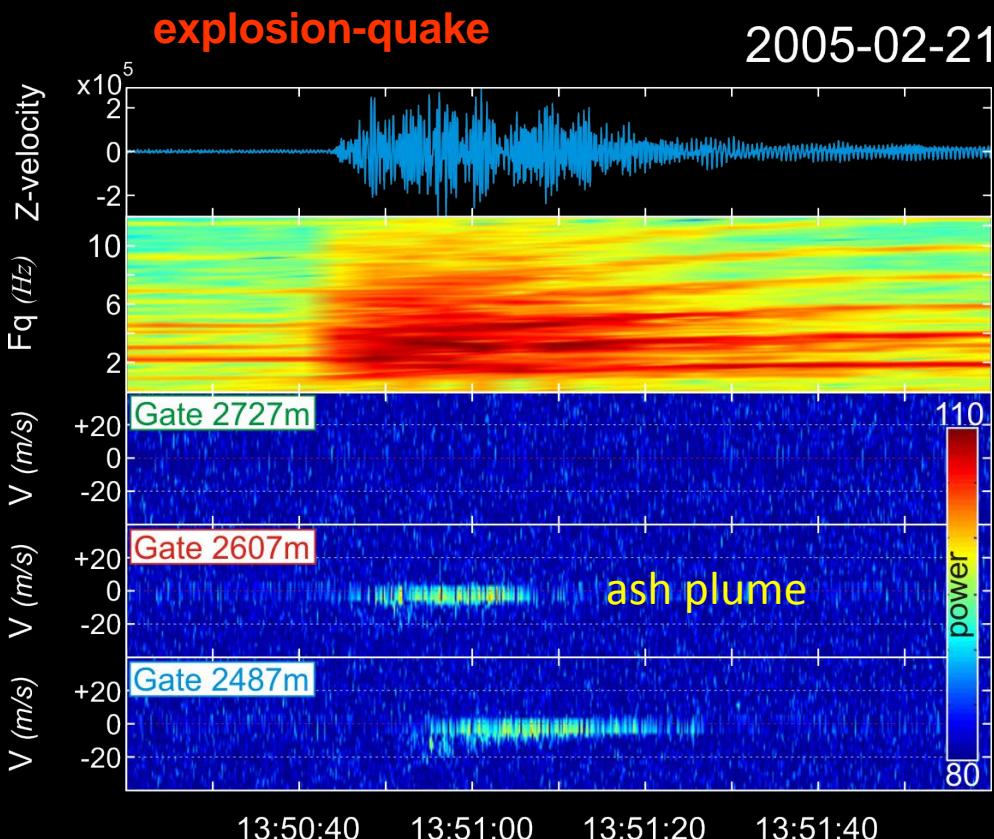


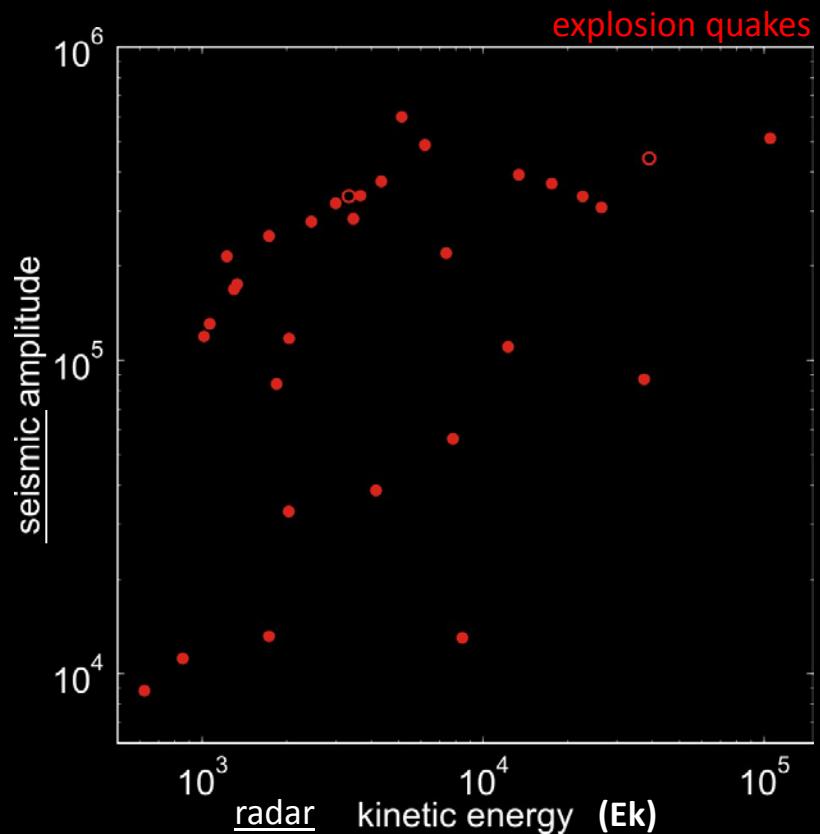




How are tephra emissions related to the seismic activity ?



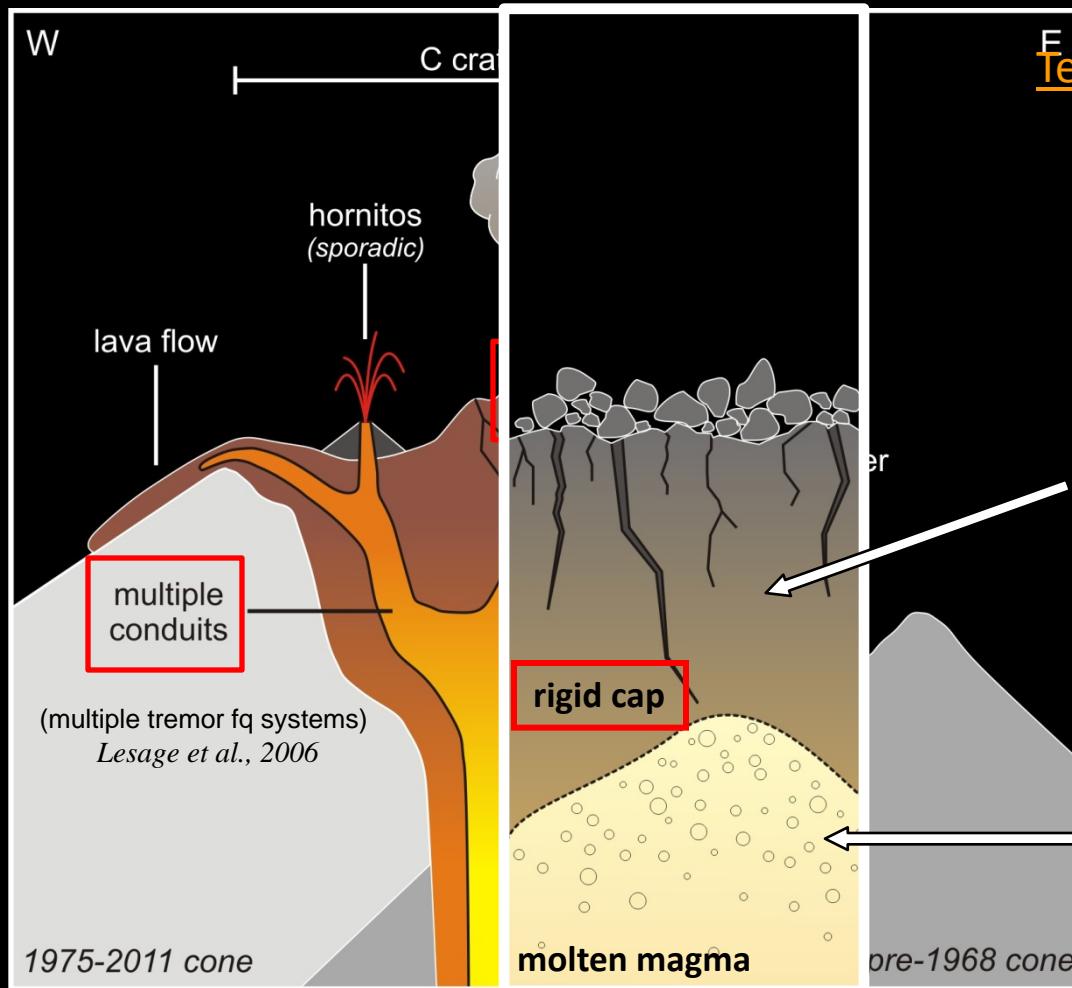




⇒ wide scattering of data set

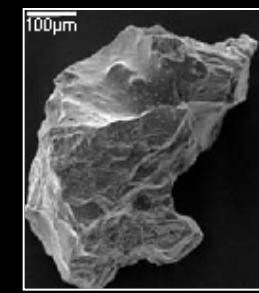
Variable energy partitioning

Conceptual model accounting for geophysical signals
and their complex interplay ?



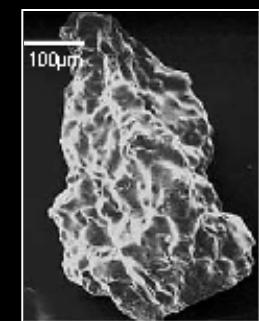
F Tephra morphology

Cole et al., 2005

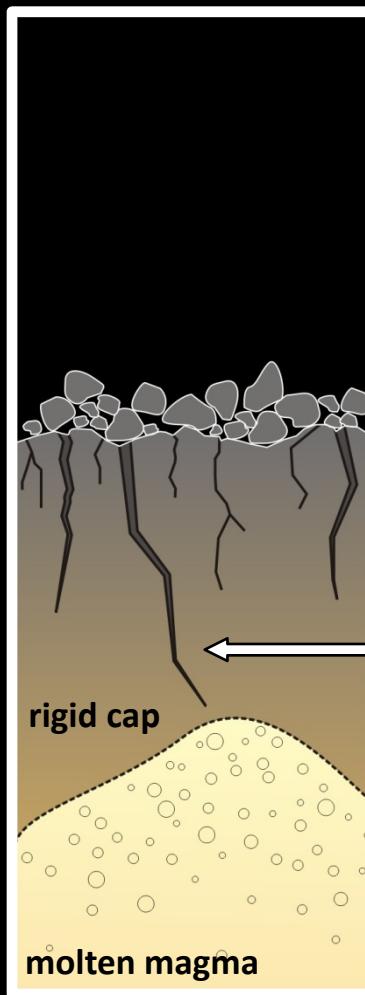
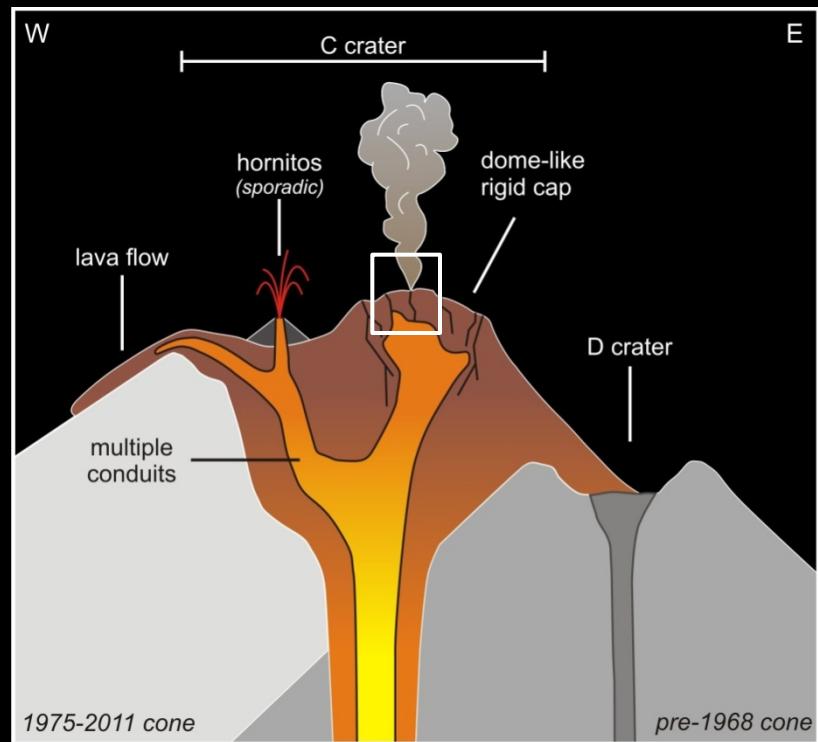


blocky 50-71 %

>>



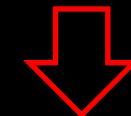
fluidal 6 %



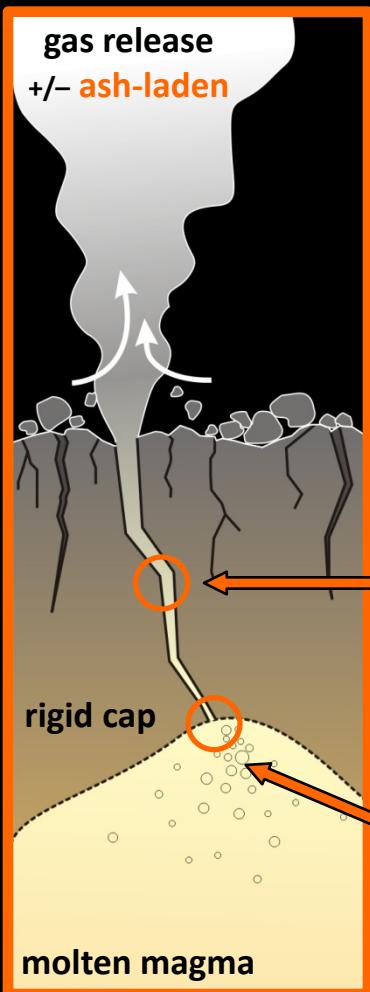
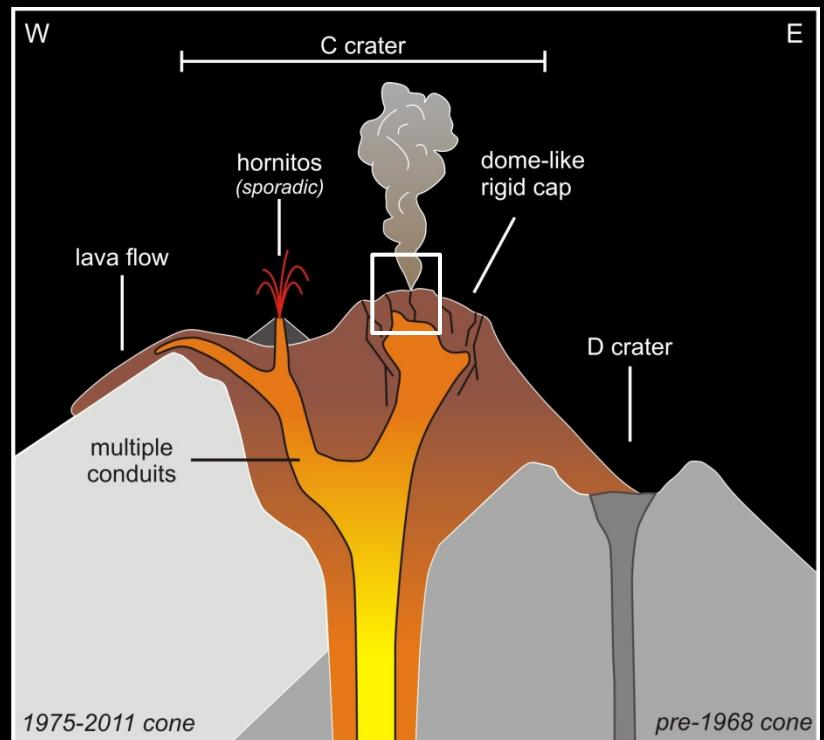
**pyroclast loading controls
the RADAR signal**



fractures control degassing



**degassing regime controls
the SEISMIC signal**



Vigorous degassing

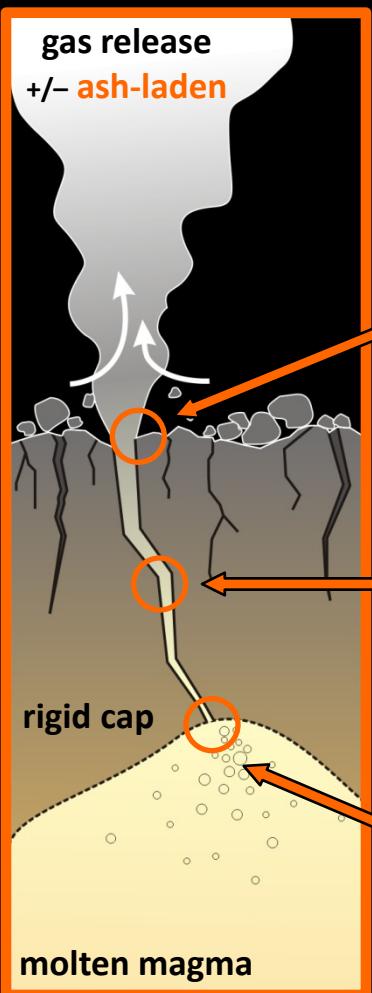
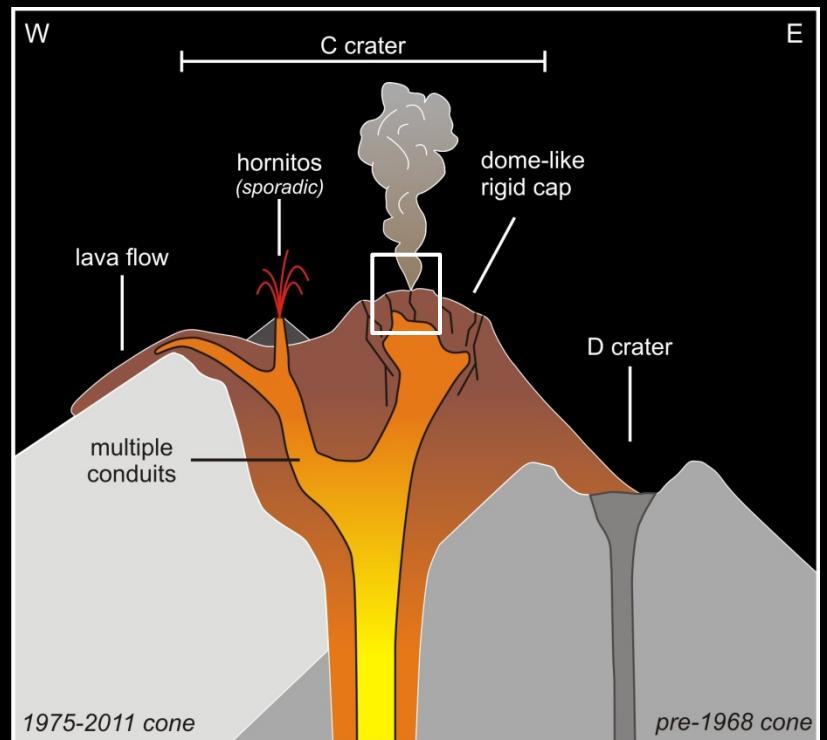
⇒ explosion-quake (Valade et al., 2012)
⇒ fragmentation

plug-breaching
(brittle fragmentation)



bubble rupture
(fluid fragmentation)





Intermittent degassing

⇒ *tremor* (Lesage et al., 2006)
⇒ remobilization

debris picked-up
(within fractures & atop)

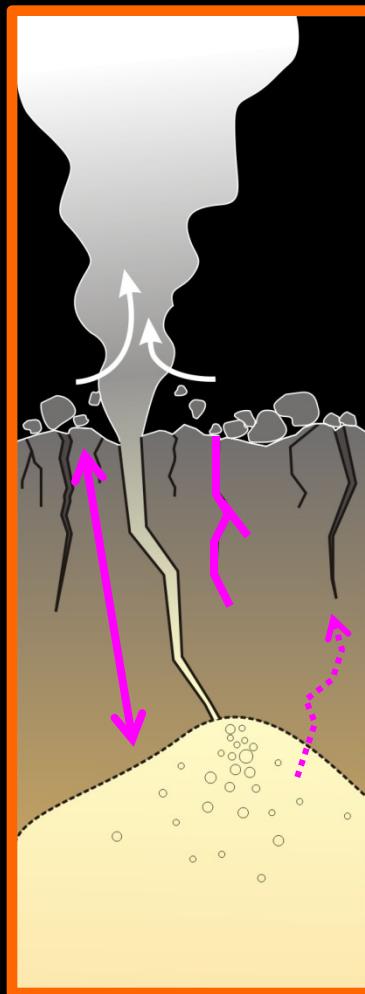
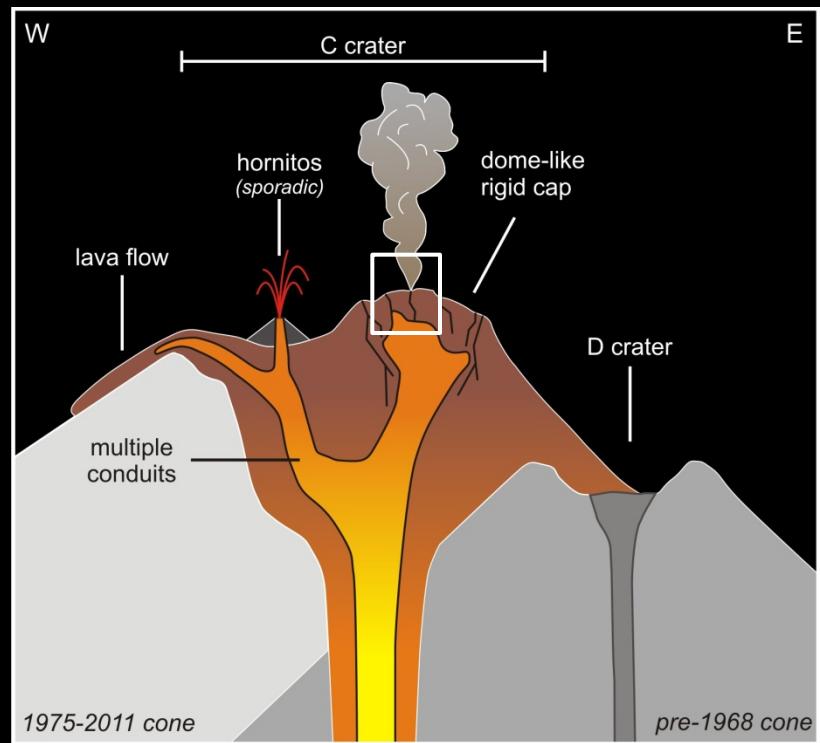


plug-breaching
(brittle fragmentation)



bubble rupture
(fluid fragmentation)





Persistent activity

⇒ highly variable shallow conditions
(*plug rheology, fracturing, gas-permeability, ...*)

⇒ variability in gas/ash emission & resulting geophysical signals

- Doppler radar can probe the internal dynamics of pyroclastic emissions
⇒ ballistic projections and ash plumes discriminated (distinctive Doppler signatures)
Valade & Donnadieu, 2011
- Seismic data can inform on shallow conduit processes
Lesage et al., 2006
- Cross correlation of radar & seismic data at Arenal
⇒ conceptual model to account for complex interplay, whereby fractures through a rigid cap control system's degassing & associated geophysical signals
Valade et al., 2012



Merci

2005-02-20

