# Tracking Volcano Eruption Dynamics using Remote Sensing: State of the Art

## Thermal Monitoring Systems to Track Eruptive Activity at Stromboli & The Role of LMV

# Stromboli

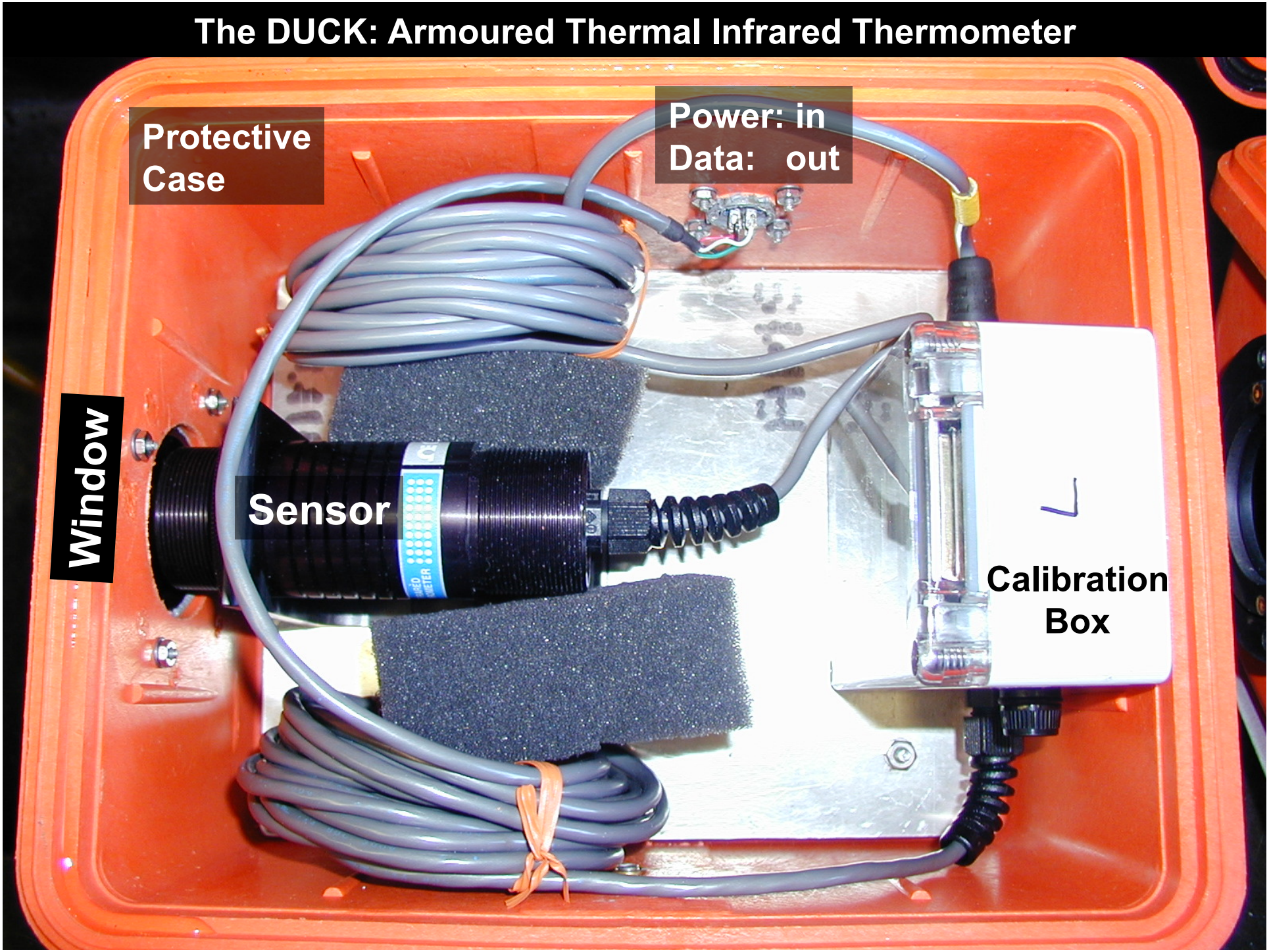
# Tracking System Dynamics at Stromboli

1. Thermal instrumentation
   - Radiometers (+ infrasound & seismic)
   - FLIR (Thermal Video)
   - Typical activity at Stromboli

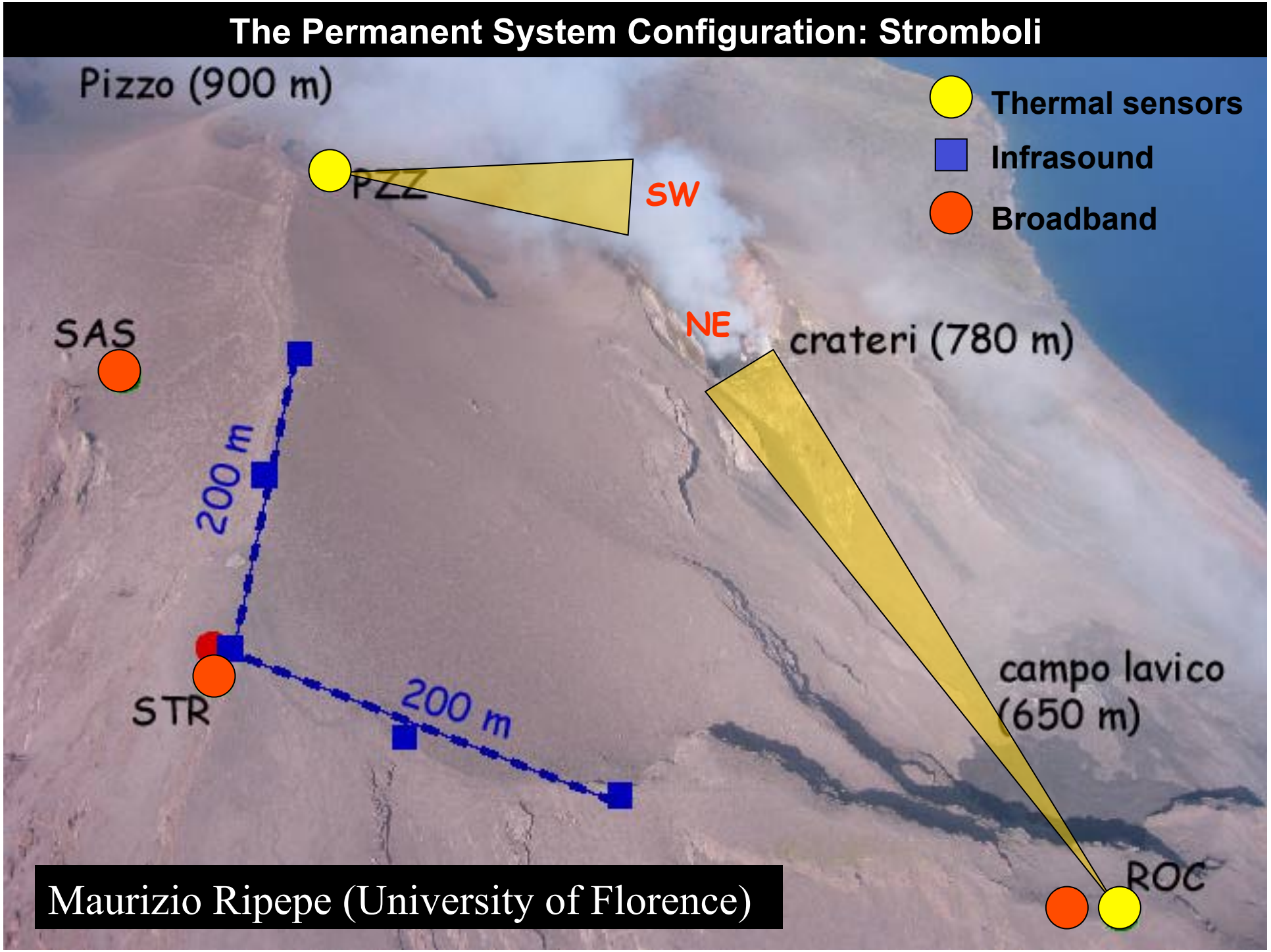
2. The 2002-03 Effusive Event:
   - Tracking the effusive phase
   - Recovery of the system
   - The April 5 paroxysm

3. Prospects and Conclusions:
   - Laboratoire Magmas Volcans: directions

# The DUCK: Armoured Thermal Infrared Thermometer



# The Permanent System Configuration: Stromboli




Maurizio Ripepe (University of Florence)

# The Forward Looking Infrared Camera (FLIR)


**FLIR S40**

**240 x 320 pixel image**
**Gain 1: -40 – 120 C**
**Gain 2: 30 – 500 C**
**Gain 3: 25 – 1500 C**
**Sample Rate: 30 Hz**

# Temporary FLIR Deployment at Stromboli

## Typical Strombolian Activity at Stromboli

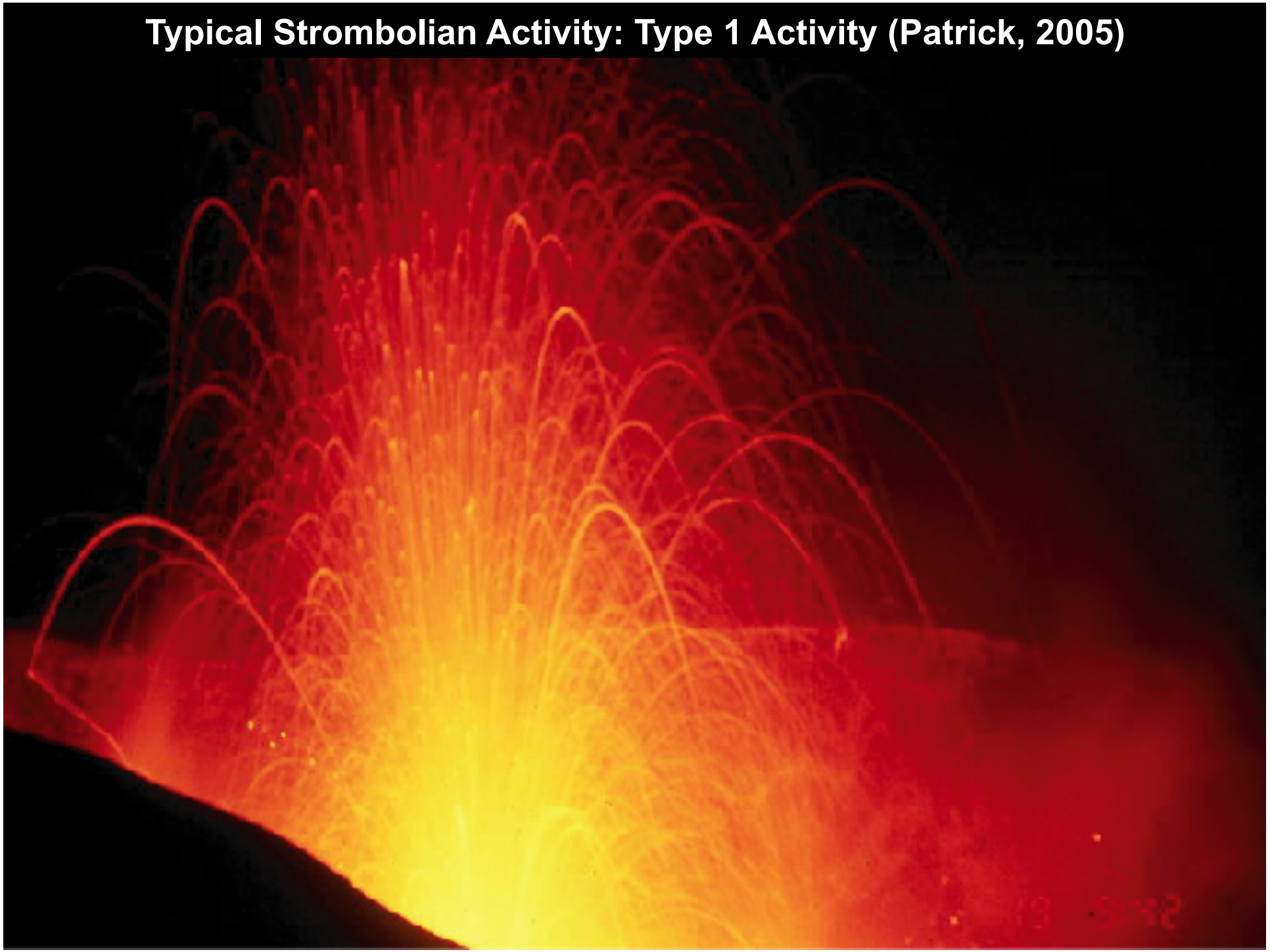
Persistently active since between 3rd & 7th Century A.D.
(Rosi et al., 2000)

Typically ~13 Strombolian eruptions per hour
(1999 –2004)

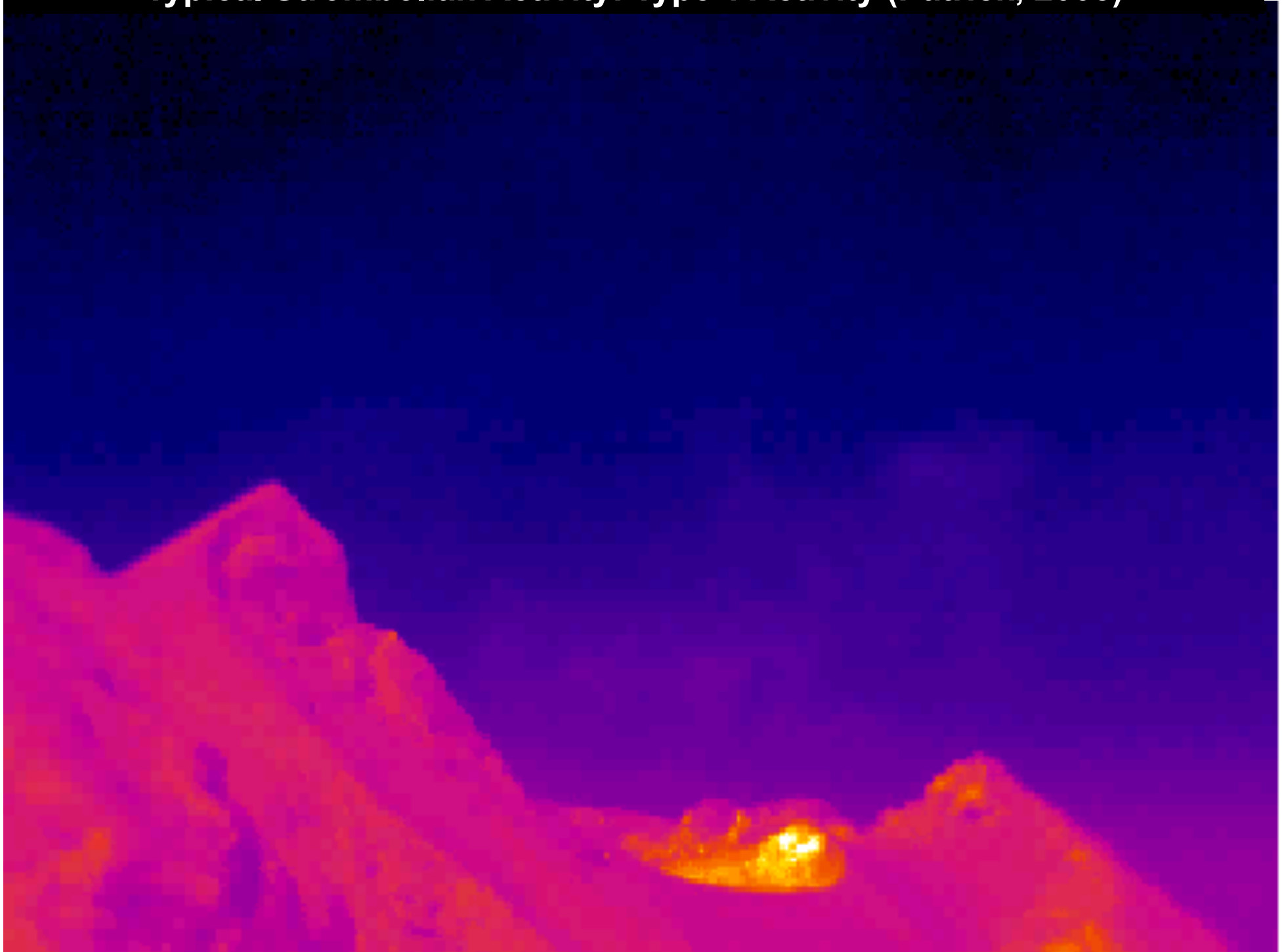
Persistent degassing at a rate of ~765 tons of $SO_2$ per day
65 t/d from explosions
- 700 t/d from persistent degassing + gas puffing

- Effusive events once every ~10 years
  (1975, 1985-86, 2002-03 … … but then another in 2007)
- More energetic explosions: 1-3 times/year
- Major paroxysms every ~100 years
  (1930, 2003 … … but then another in2007)

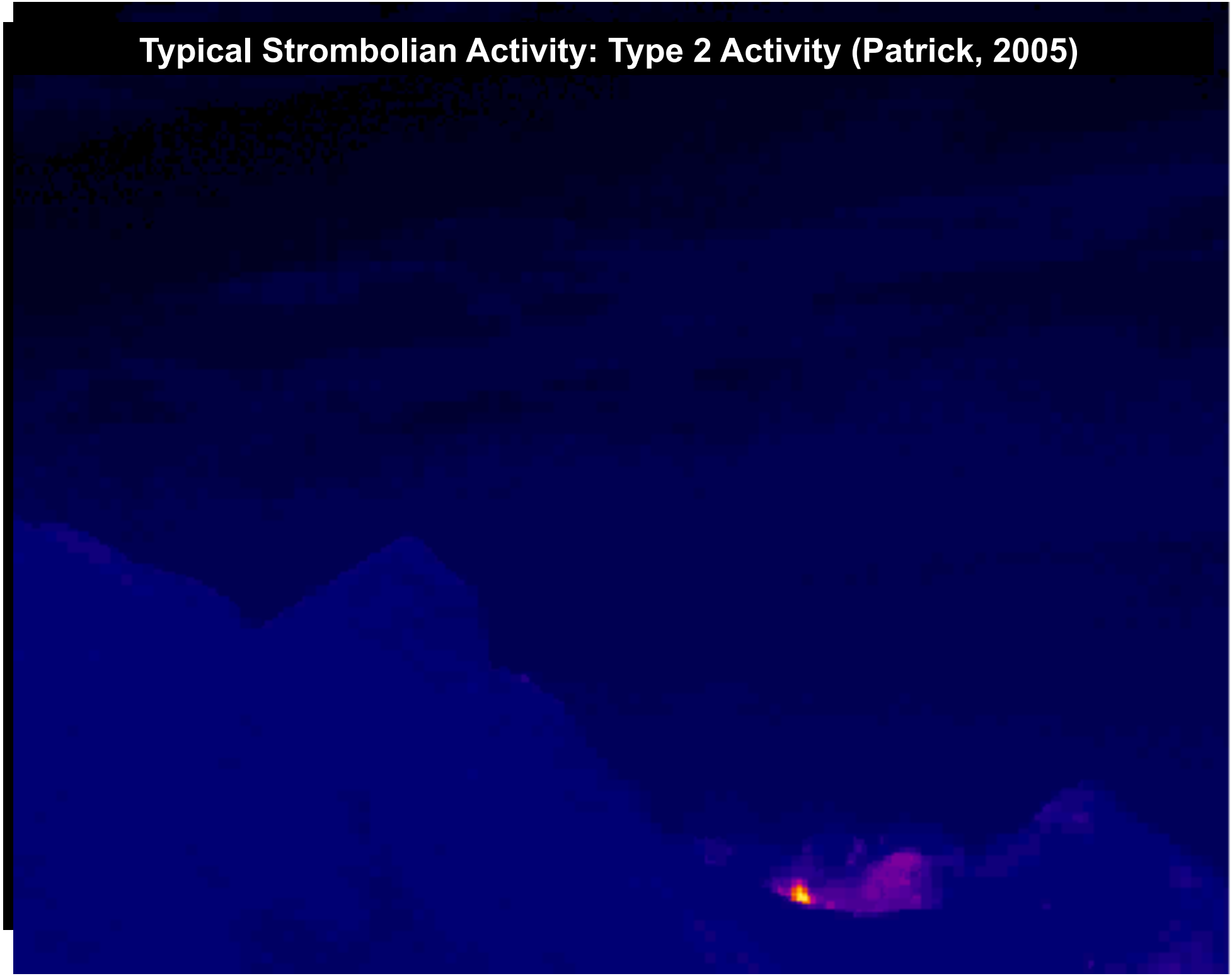
# Typical Strombolian Activity: Type 1 Activity (Patrick, 2005)



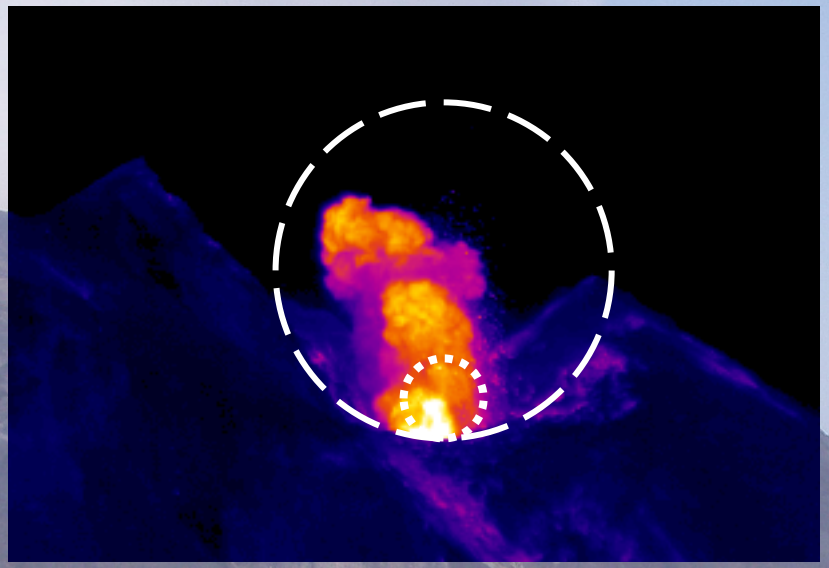
# Typical Strombolian Activity: Type 1 Activity (Patrick, 2005)



# Typical Strombolian Activity: Type 2 Activity (Patrick, 2005)

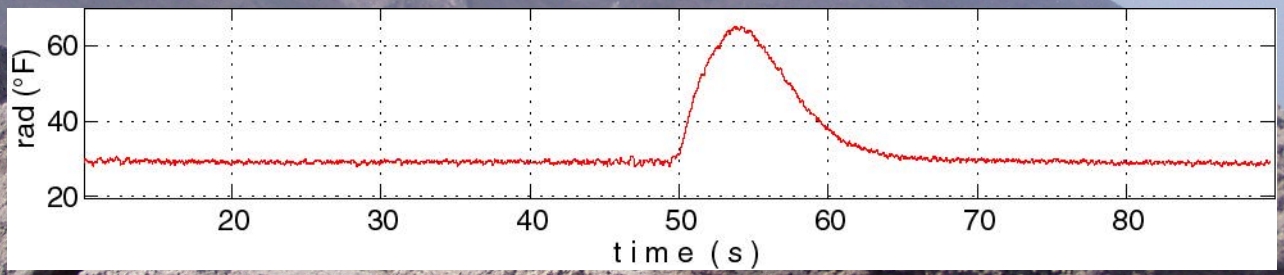

Typical Strombolian Activity: Type 2 Activity (Patrick, 2005)
50
0

# Associated Thermal Signal

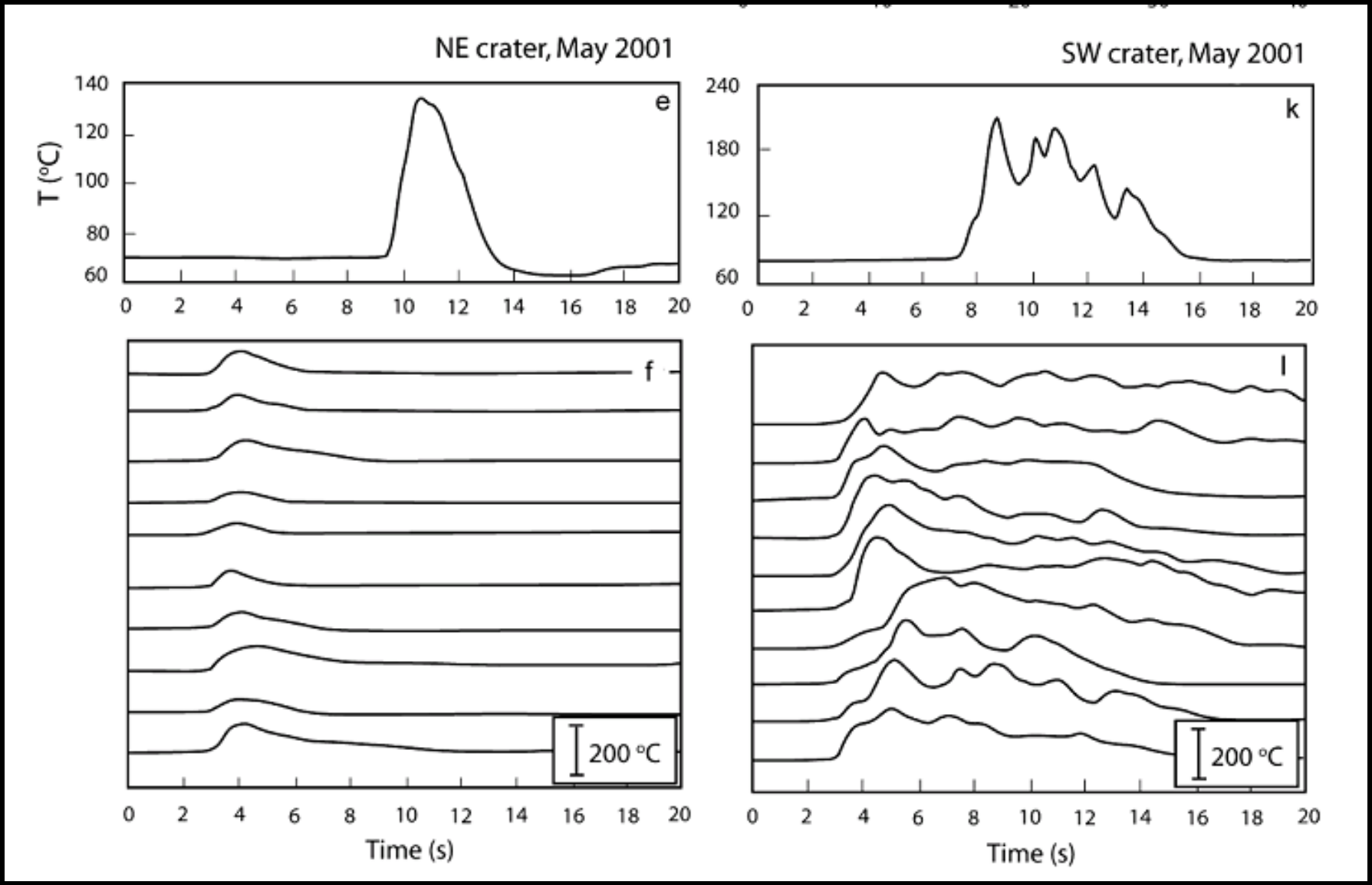


15 degree FOV
Diameter = 120 m

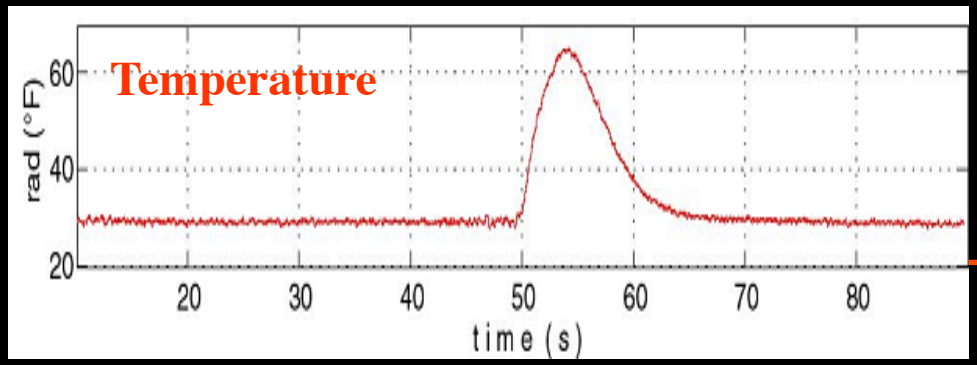
1 degree FOV
Diameter = 8 m

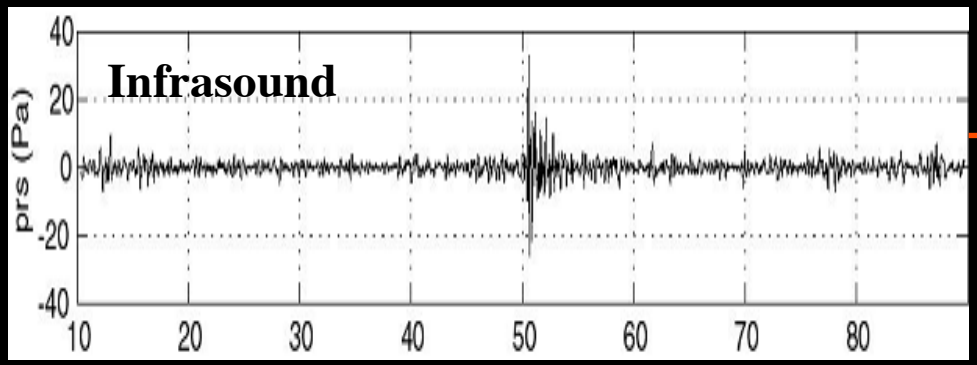


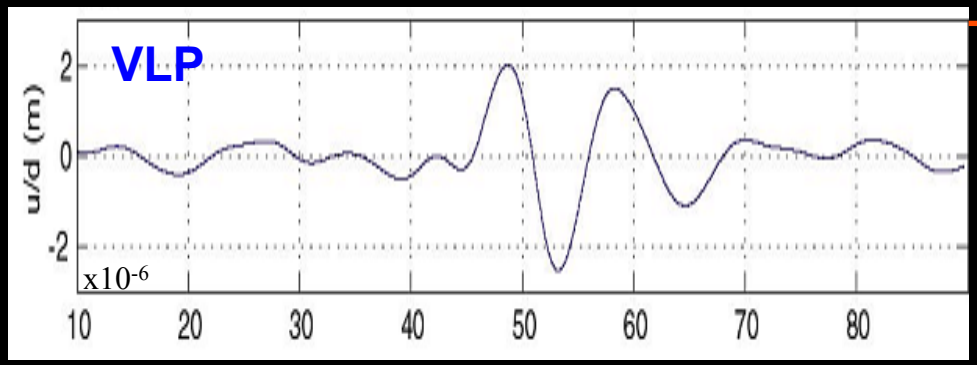
# Thermal Waveform Character (NE versus SW Crater)



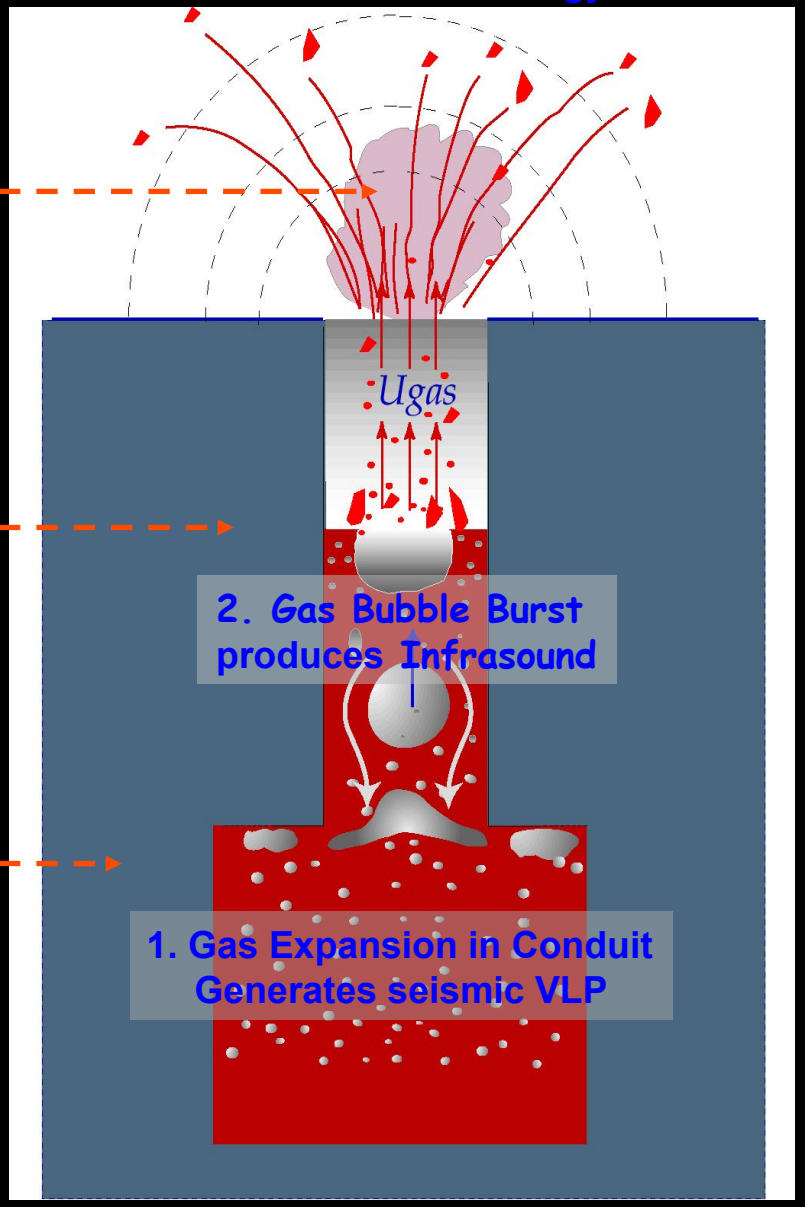
# Seismic, Acoustic, Thermal Signal during Explosion

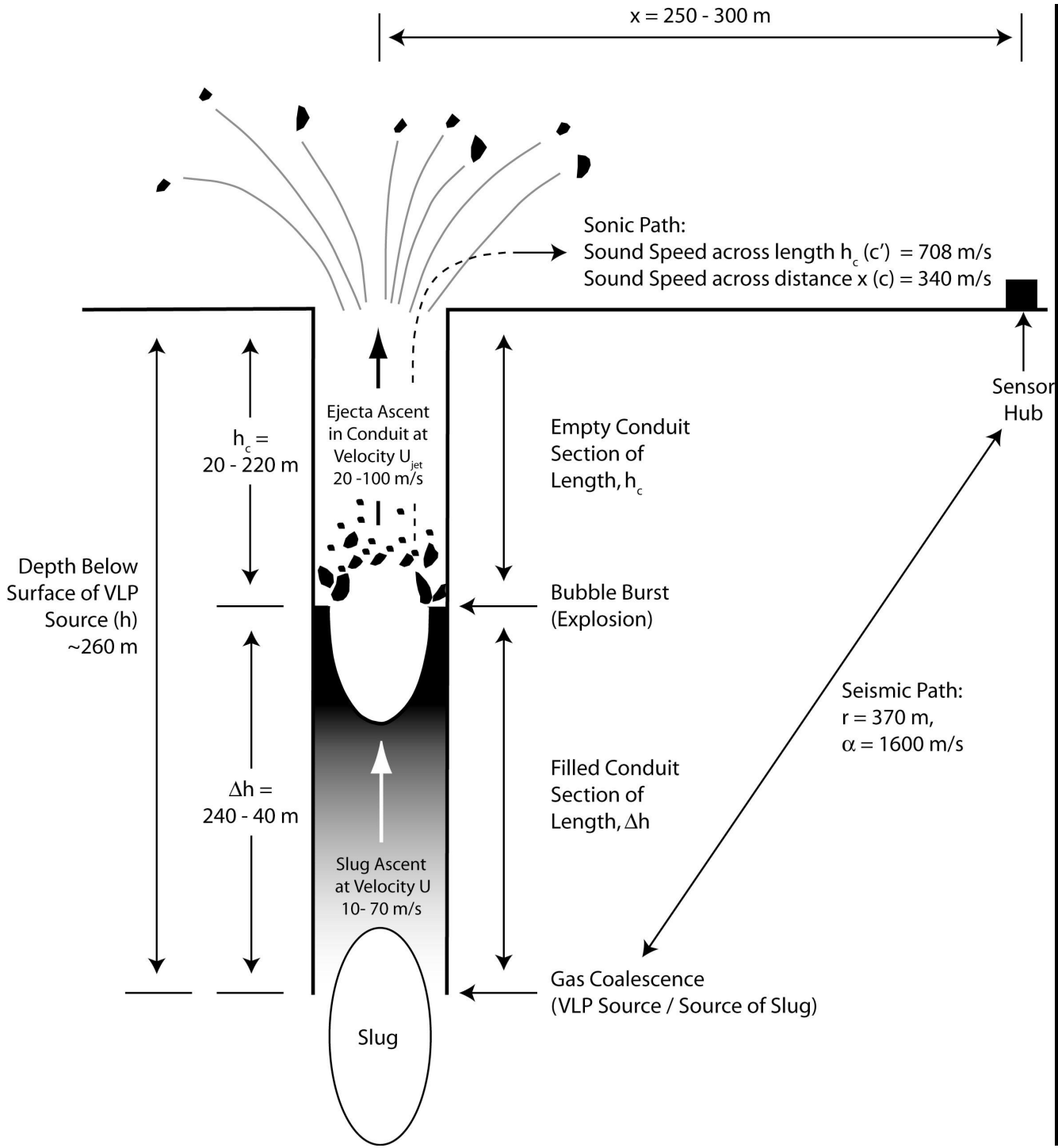


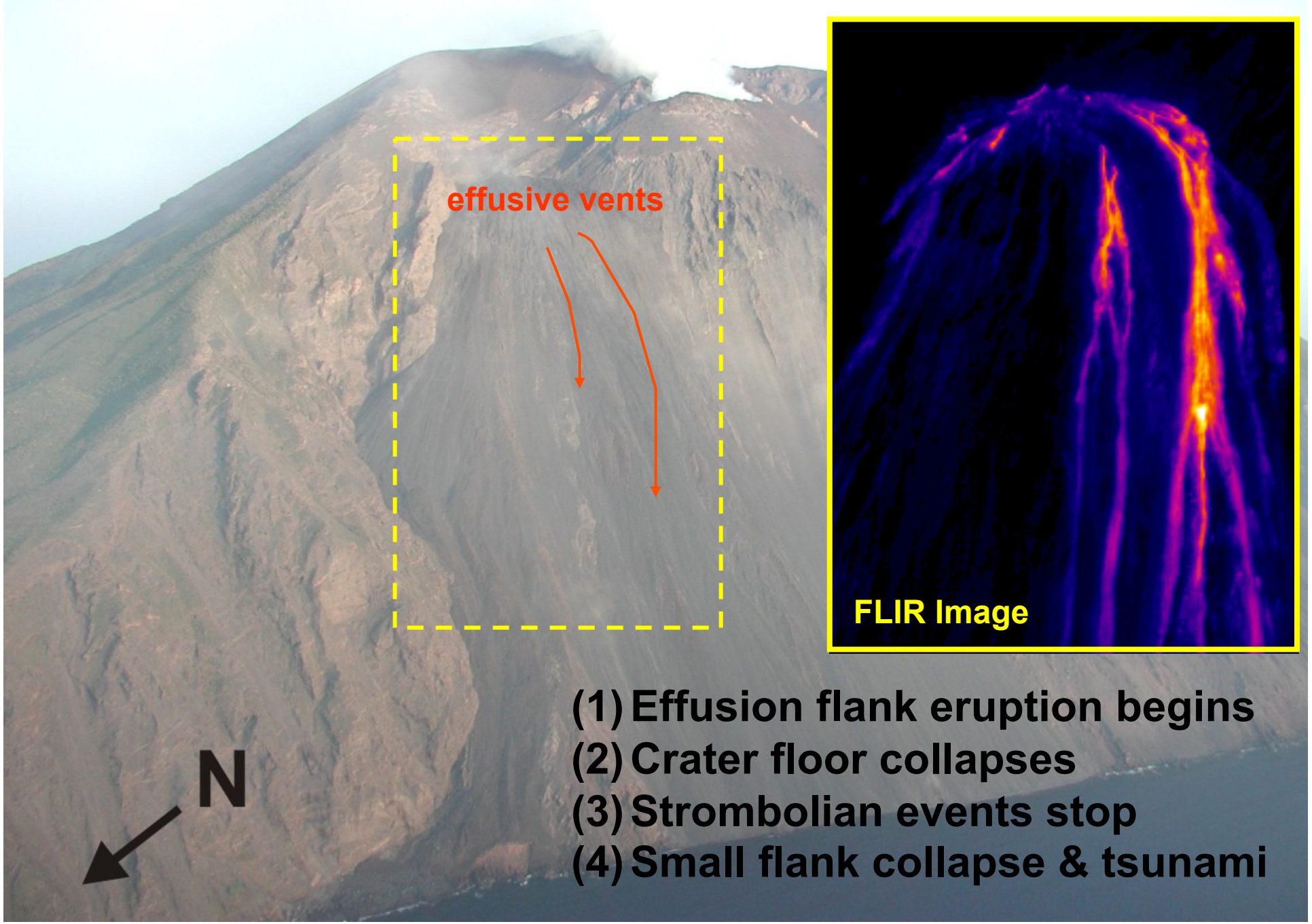

3. Gas and hot fragments
Irradiate Thermal energy





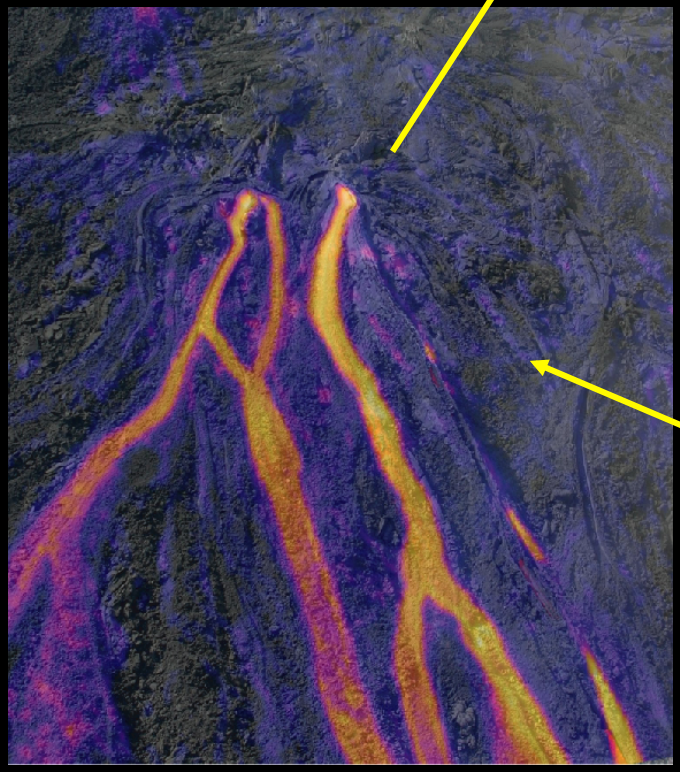

# Shallow System Geometry: 1999-2005

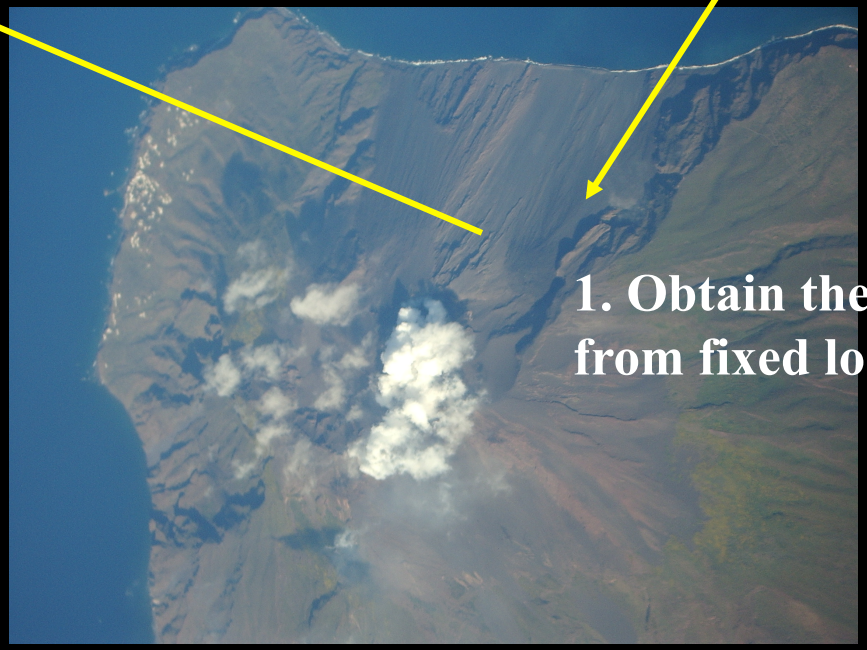
# Stromboli: 28 December 2002 – 22 July 2003



# Volume Fluxes (Effusion Rates)

3. Convert to Effusion Rate



1. Obtain thermal image from fixed location

2. Isolate flow area, extract surface temperatures & calculate total heat loss

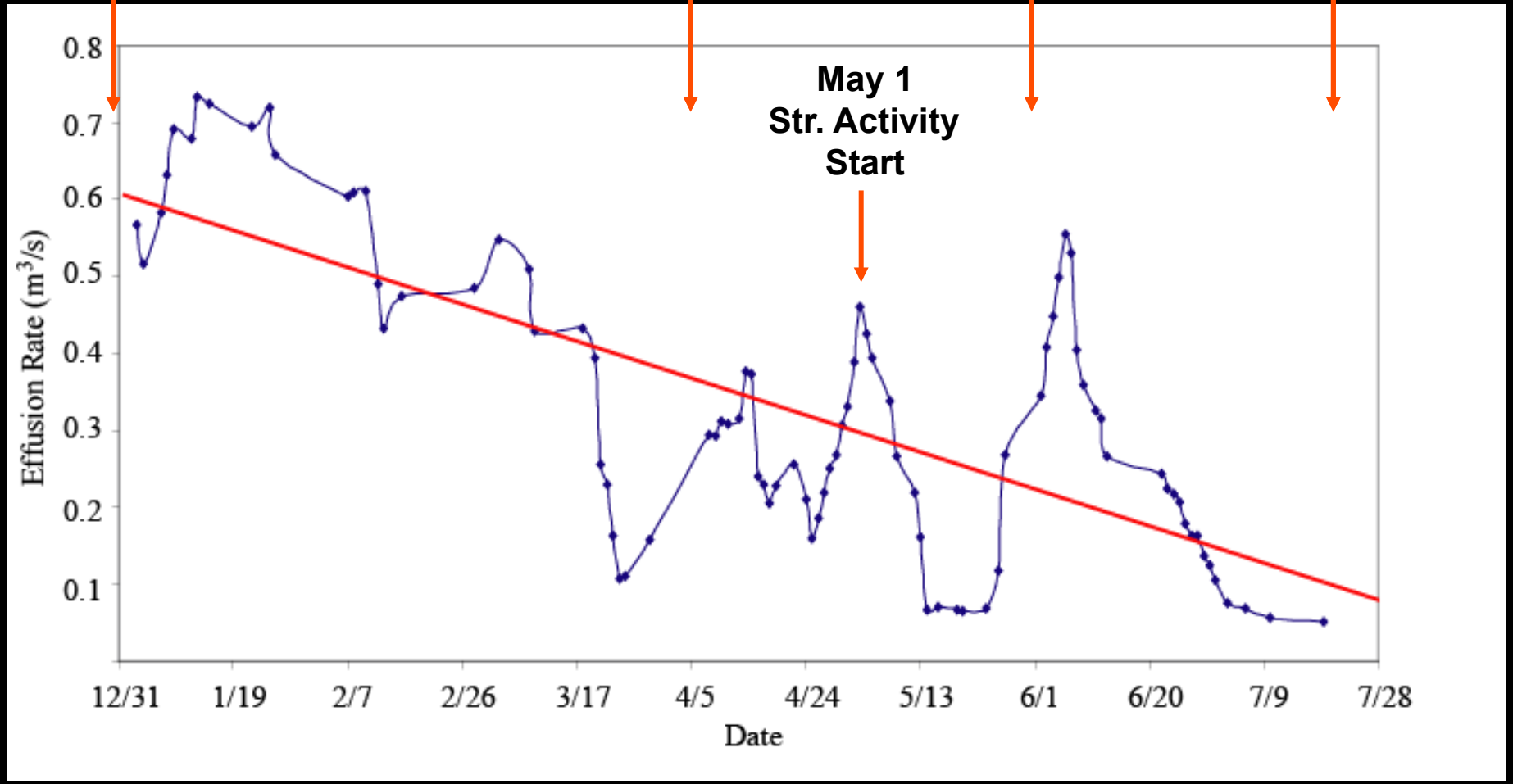
# Stromboli, Effusion Rates 2002-2003

December 28
Effusive Phase
Start

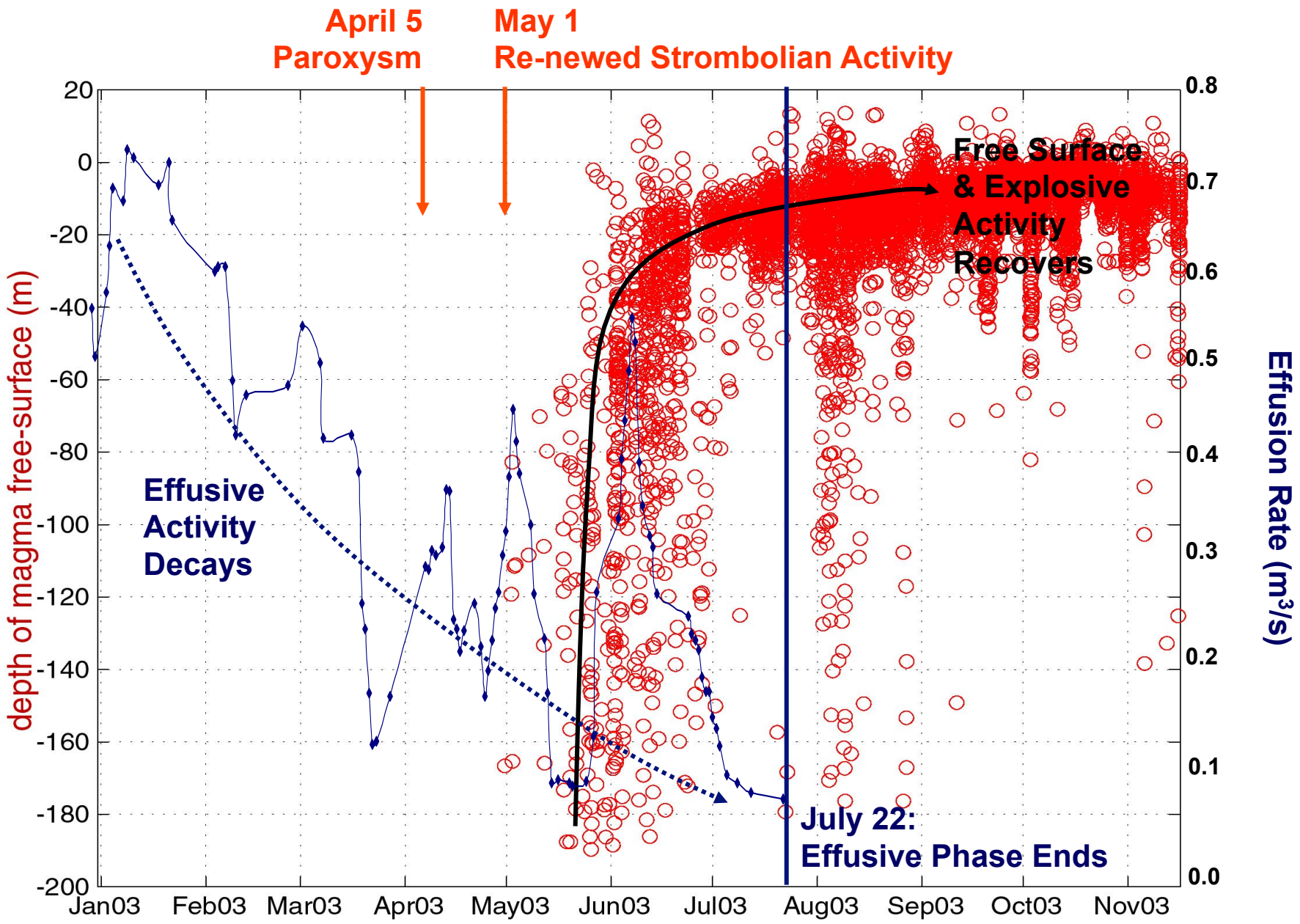
April 5
Paroxysm

May 31 – June 3
Intense Strombolian
Activity

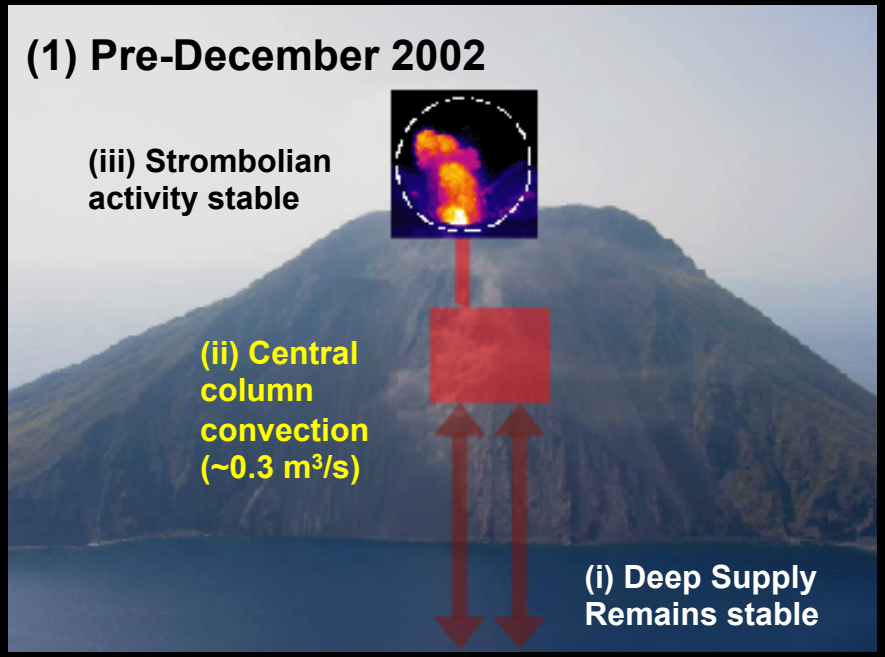
July 22
Effusive Phase
End

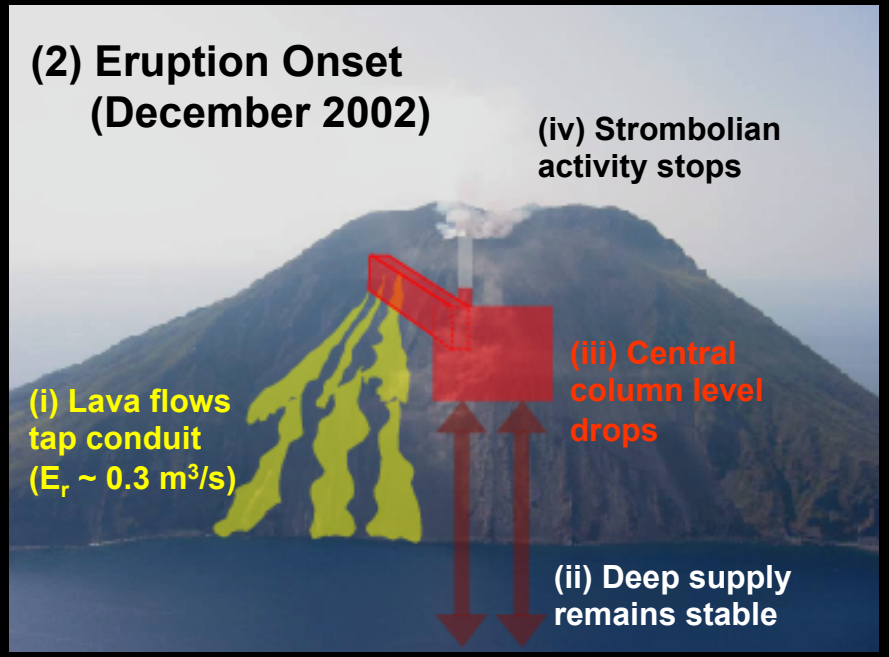


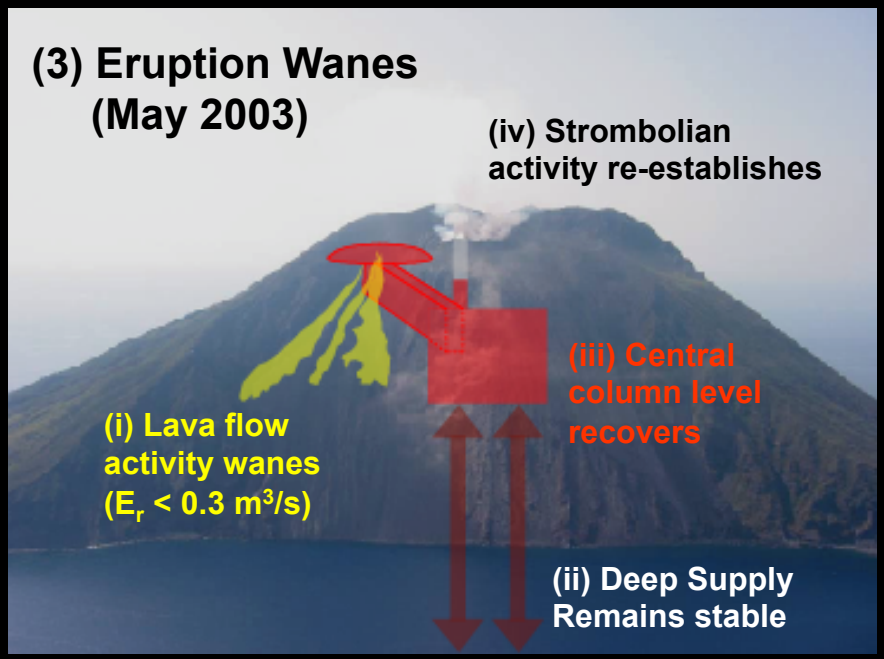
# Stromboli: Effusion Rate & Recovery of Free Surface

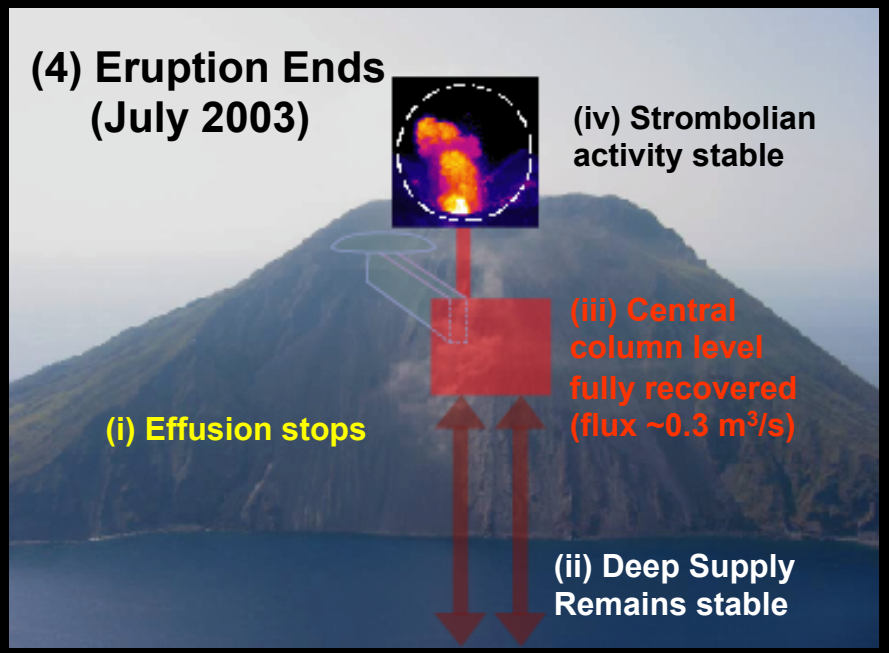


# Stromboli: System Model



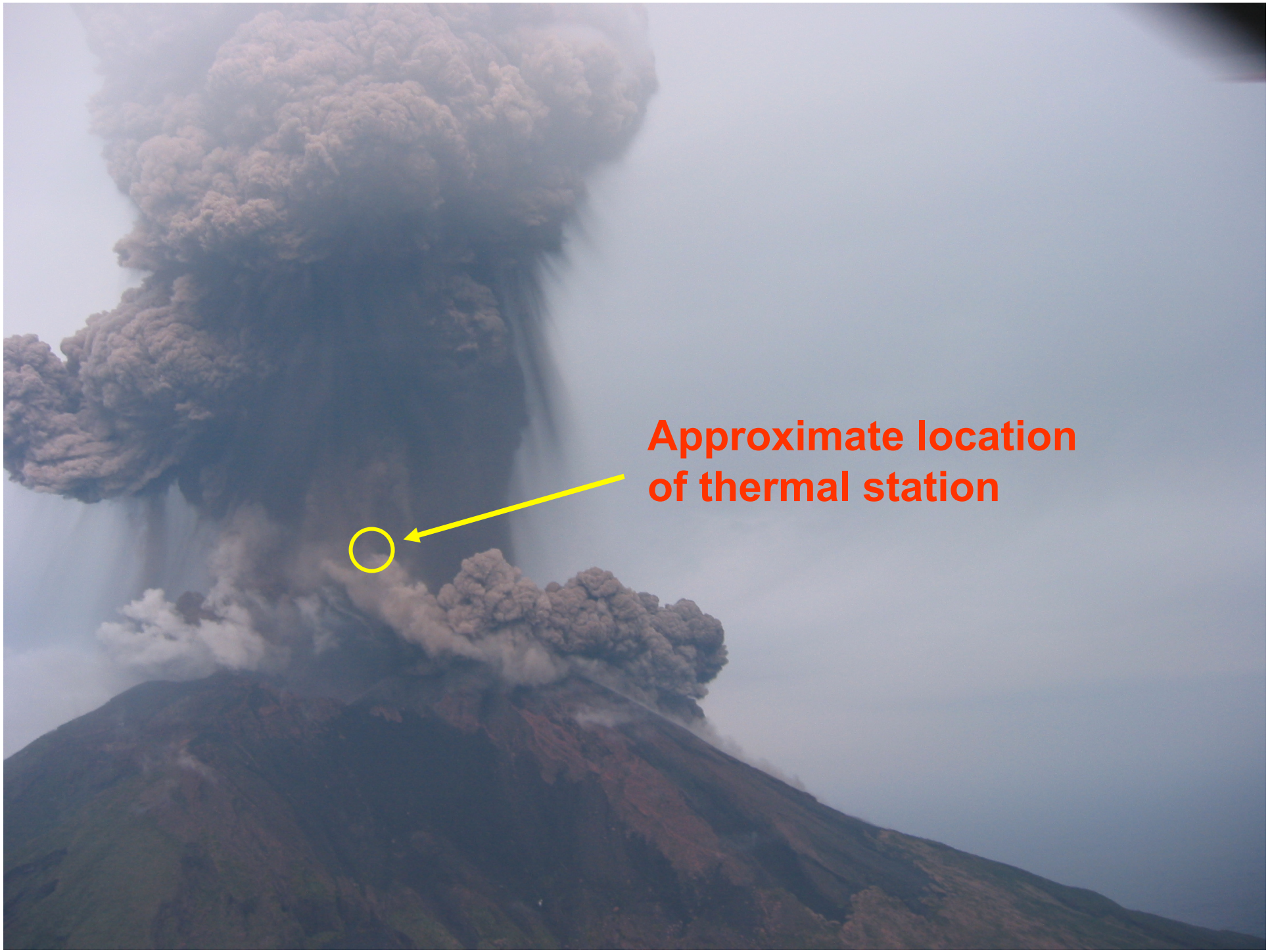



# Stromboli: April 5, 2003 Paroxysm

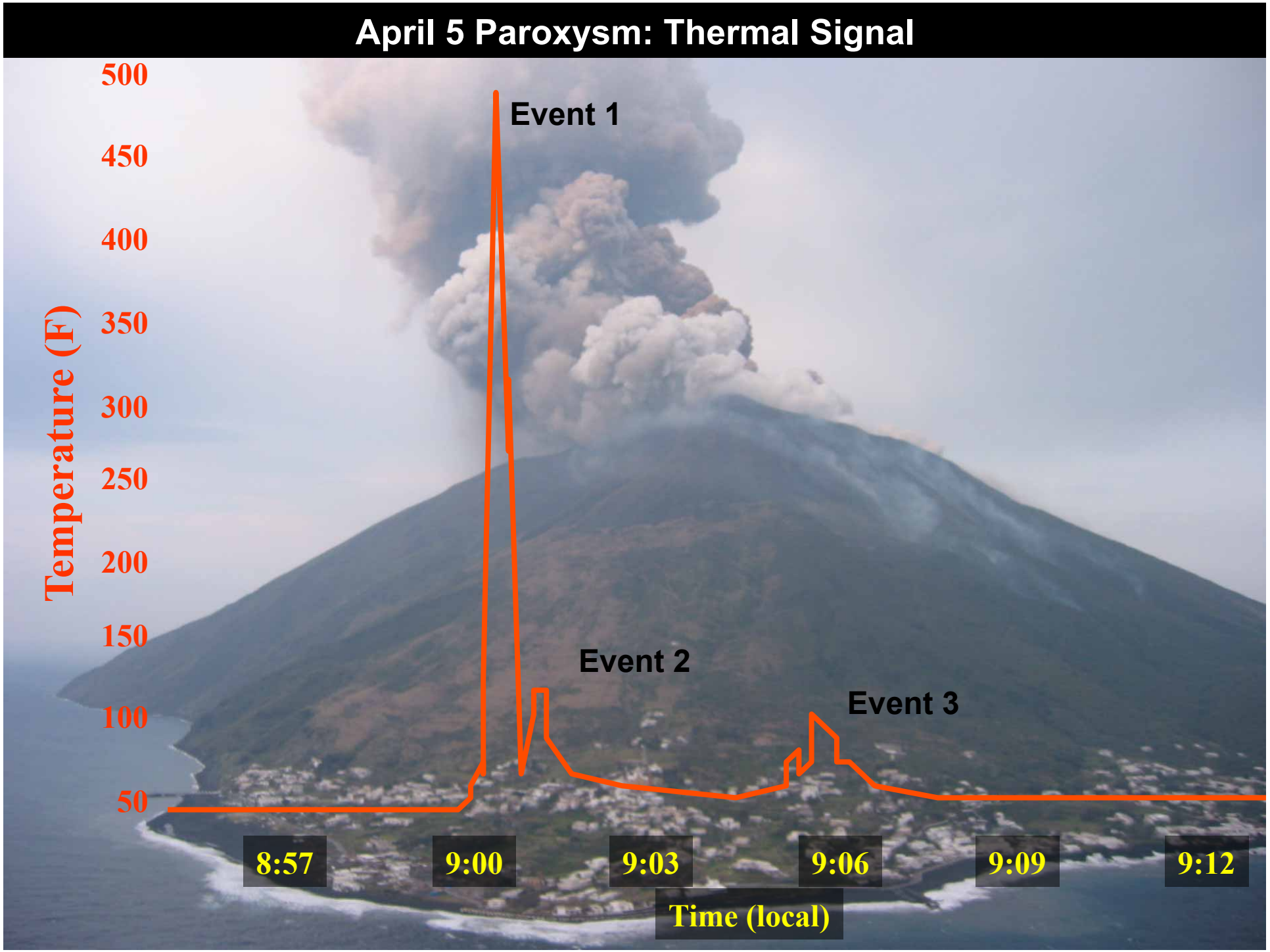
Stromboli: April 5, 2003 Paroxysm
Photo sequence from Sonia Calvari (INGV-Catania)


Approximate location
of thermal station

# Instrument Bunker Before April 5 Paroxysm

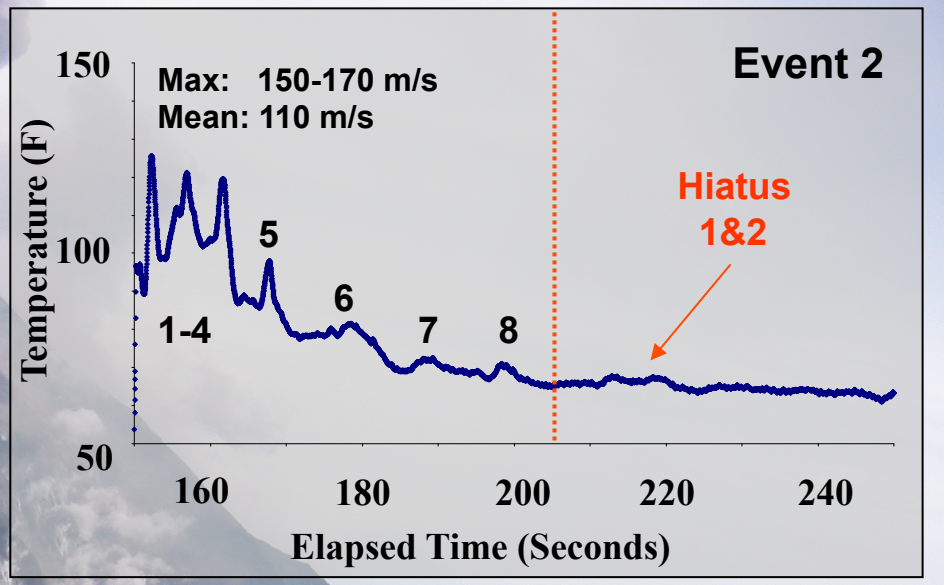
# Instrument Bunker After April 5 Paroxysm

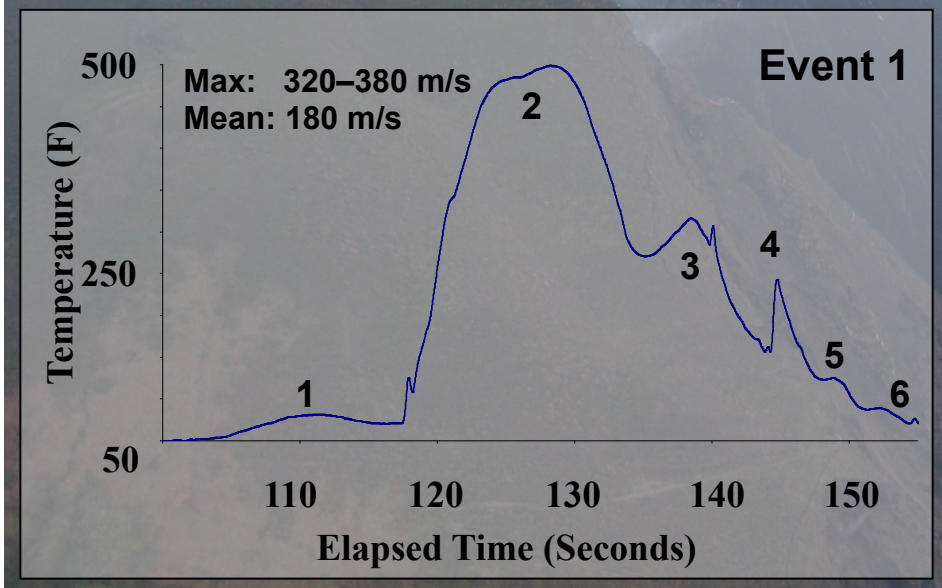
# April 5 Paroxysm: Thermal Signal



# April 5 Paroxysm: Dynamics

Thermal-Infrasound Time Delay (~3 s): Explosion at 10's meters



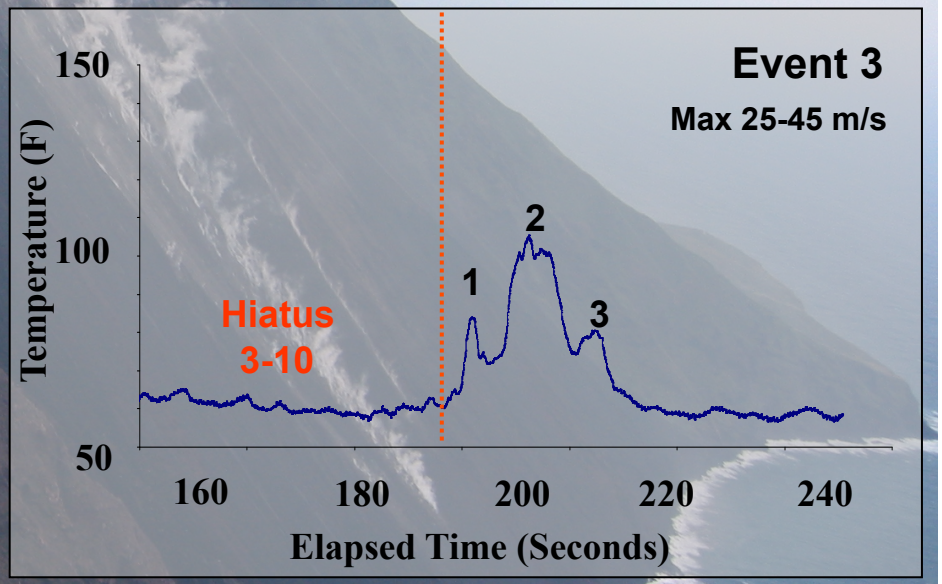
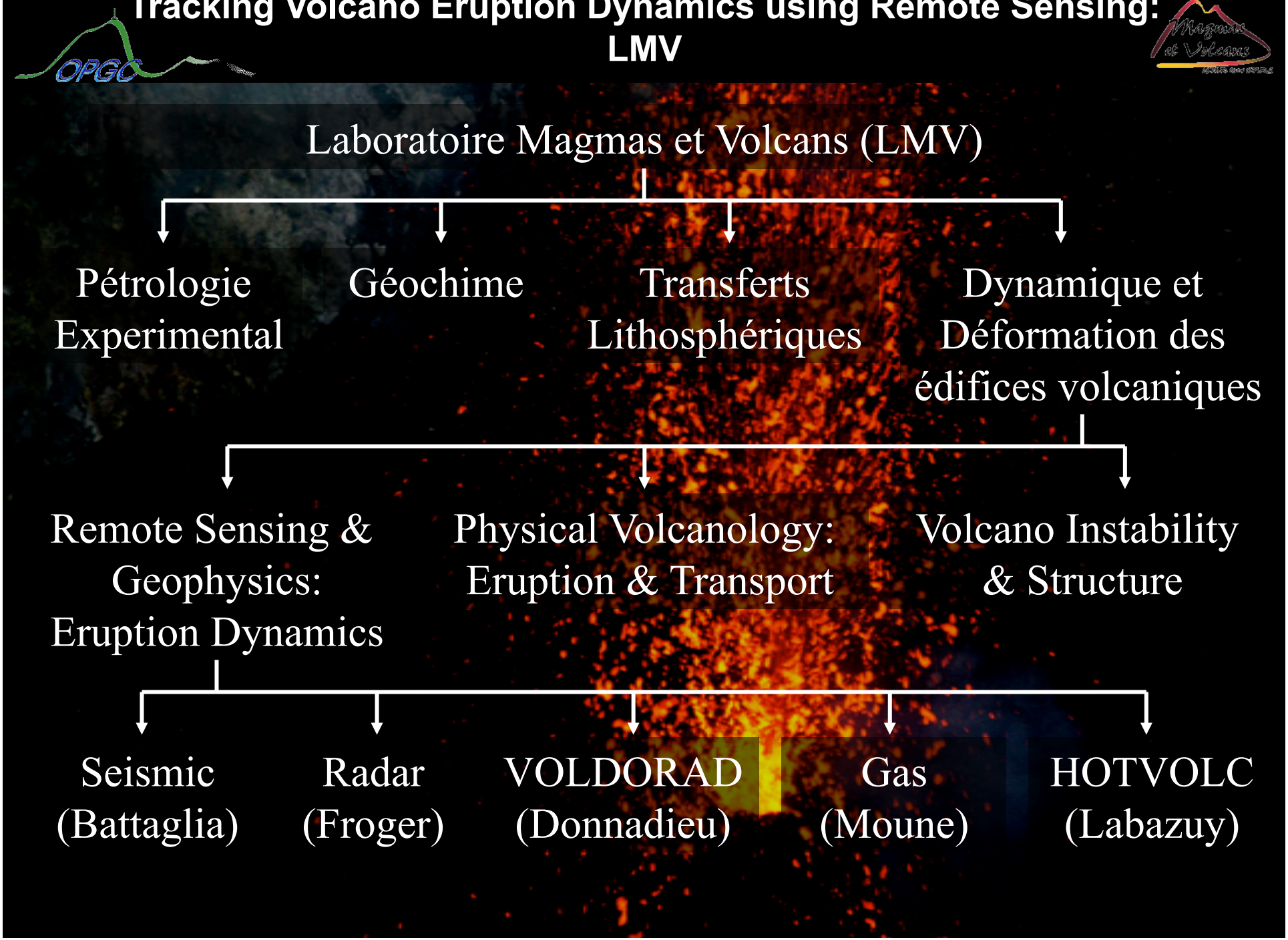
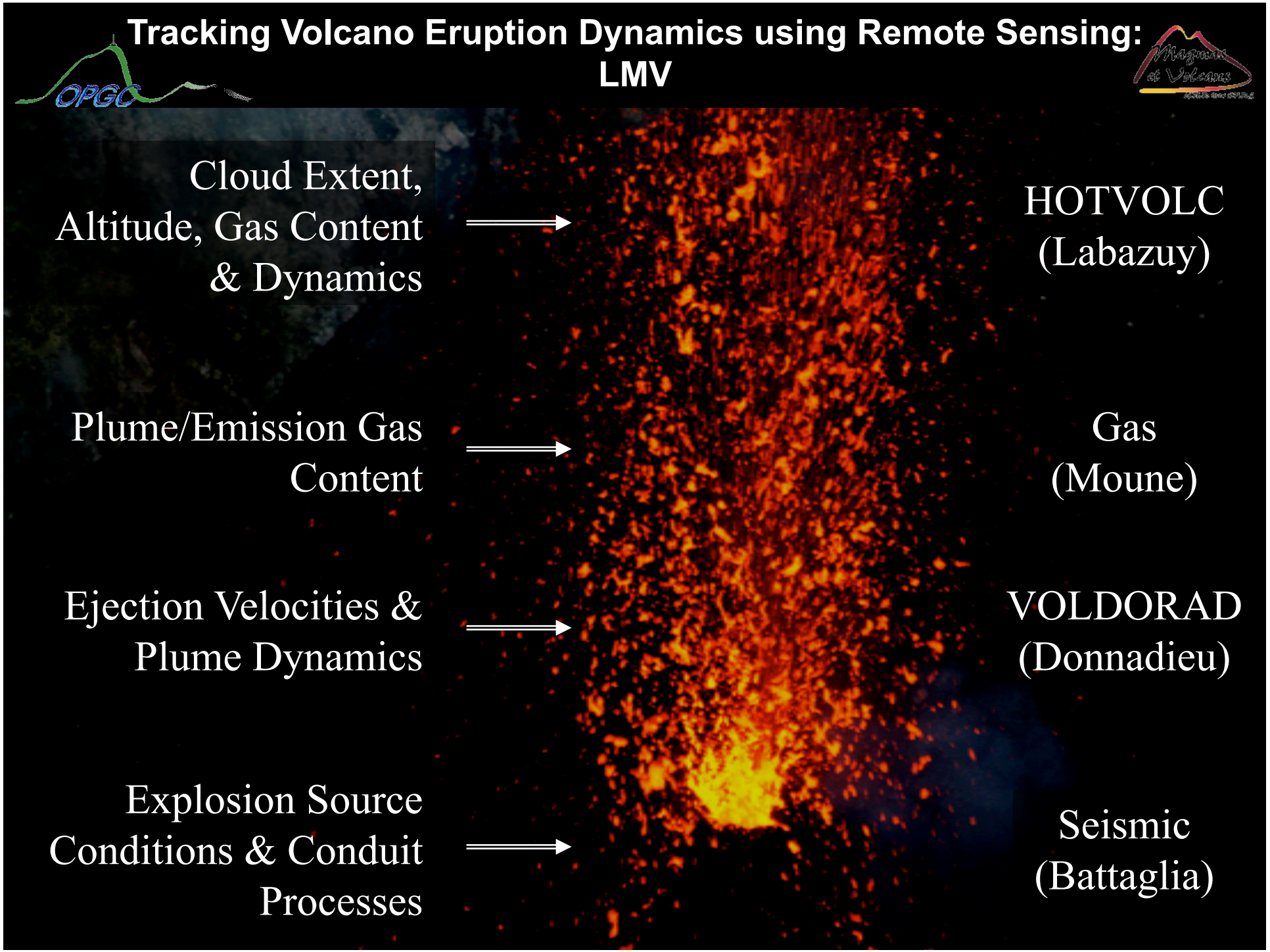




Photo: Sonia Calvari (INGV-Catania)

# Tracking Volcano Eruption Dynamics using Remote Sensing: LMV



# Tracking Volcano Eruption Dynamics using Remote Sensing: LMV



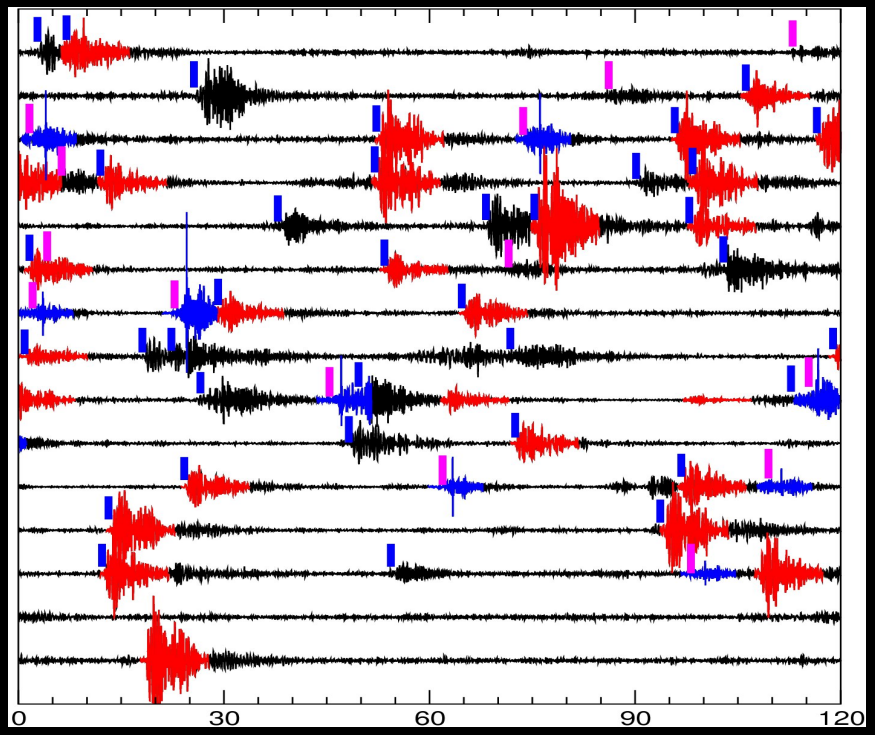
# Seismics: Jean Battaglia

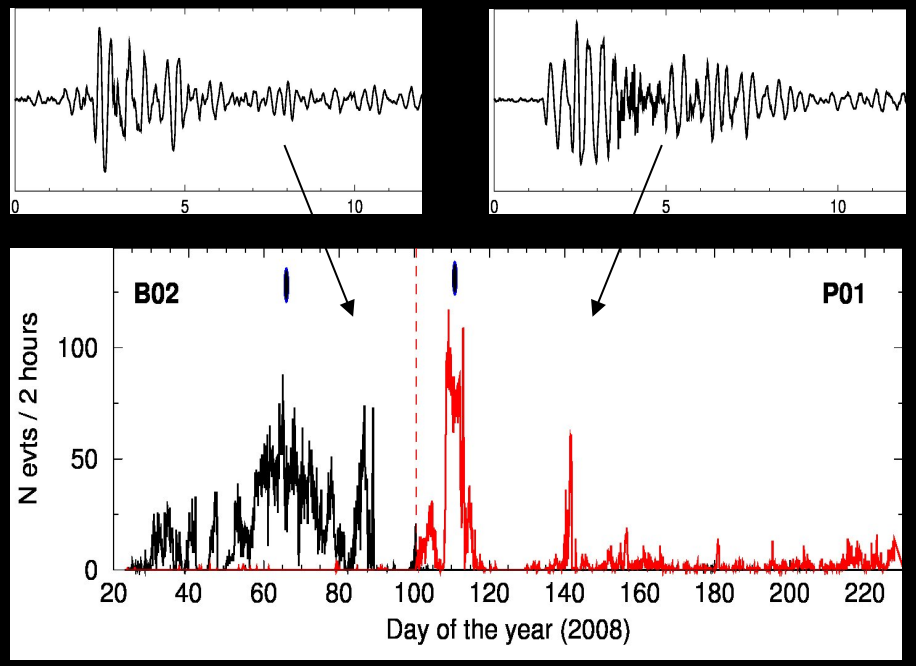
Strombolian activity at Yasur Volcano (Tanna Island)

Installation of temporary seismic network: Jan. 2008 – Feb. 2009 including:

- 12 antenas composed of 7 short period sensors
- 10 broadband sensors

# Seismics: Jean Battaglia



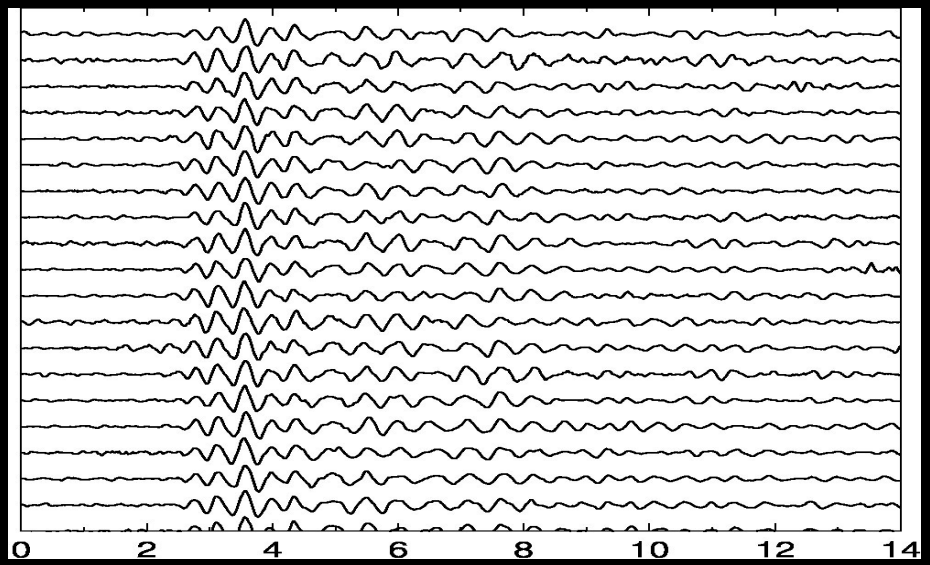




**Intense seismic activity with mostly explosion quakes**

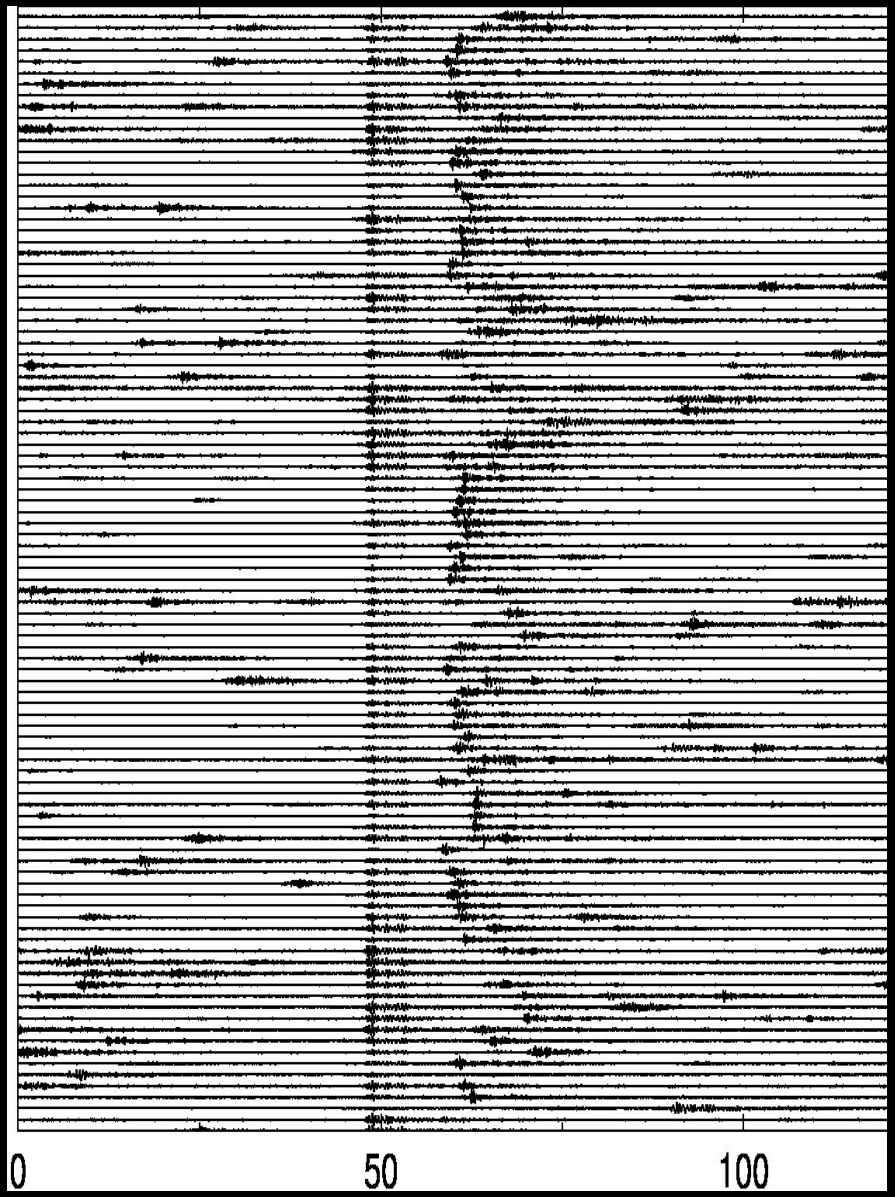
**Including families with similar waveforms corresponding to modes of escillation of the volcanic conduits**

**Characteristic waveforms can be tied to individual vents and periods**

# Seismics: Jean Battaglia

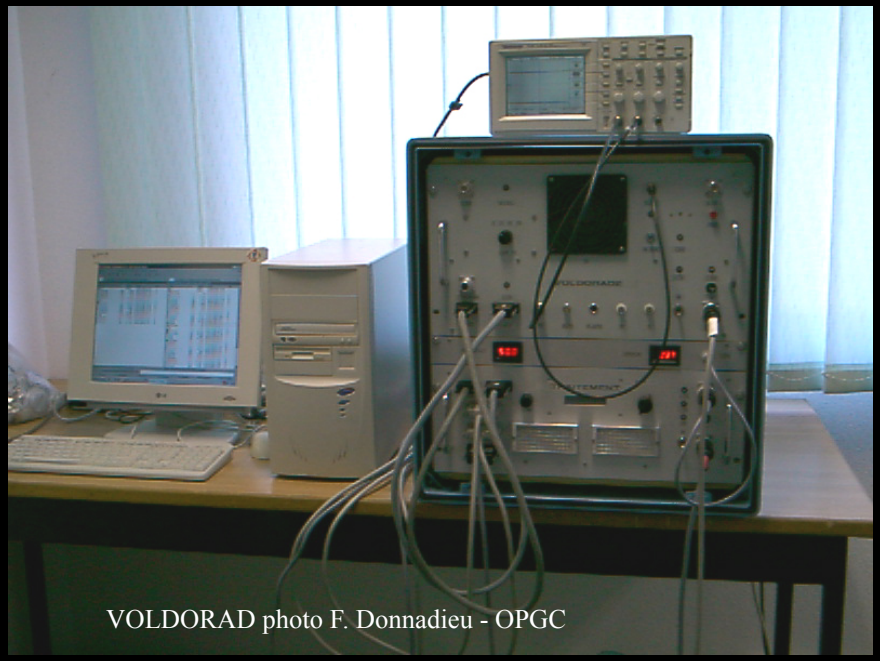



**LP events not directly associated with surface explosions and related to deeper processes: short term precursors of strombolian explosions**



# VOLDORAD (Volcano Doppler Radar): Franck Donnadieu

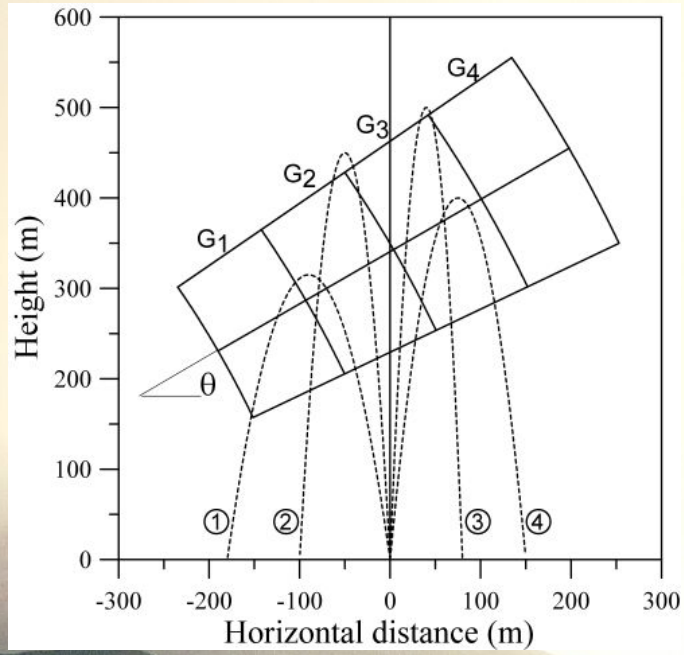
Portable system, 50 kg,
60*60*60 cm unit
PC-controlled




Frequency: 1.274 GHz **λ=23.5 cm**
Pulse repetition freq.: 100 µs
Pulse duration: 0.4 - 1.5 µs
Transmitted power: 60 W
Power consumption: 200 W (av.)


9° beamwidth,
Gain ~ 23 dB

# VOLDORAD: Franck Donnadieu



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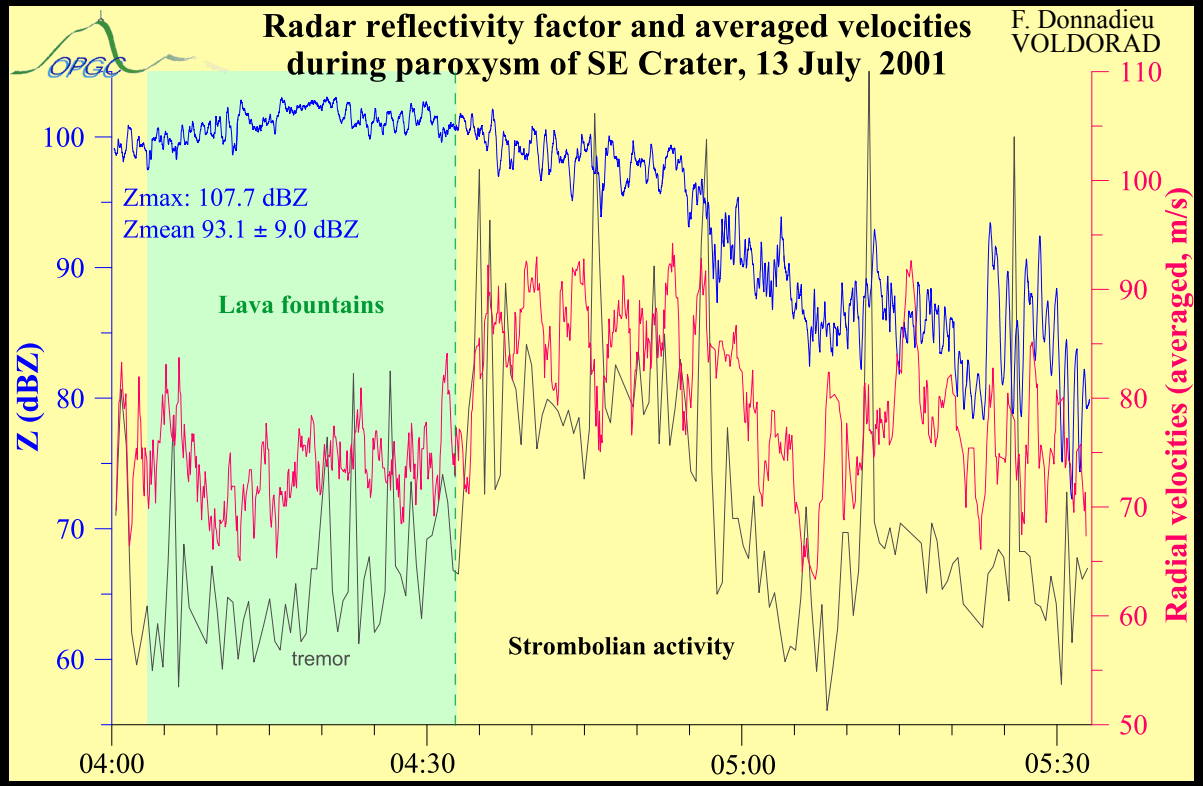


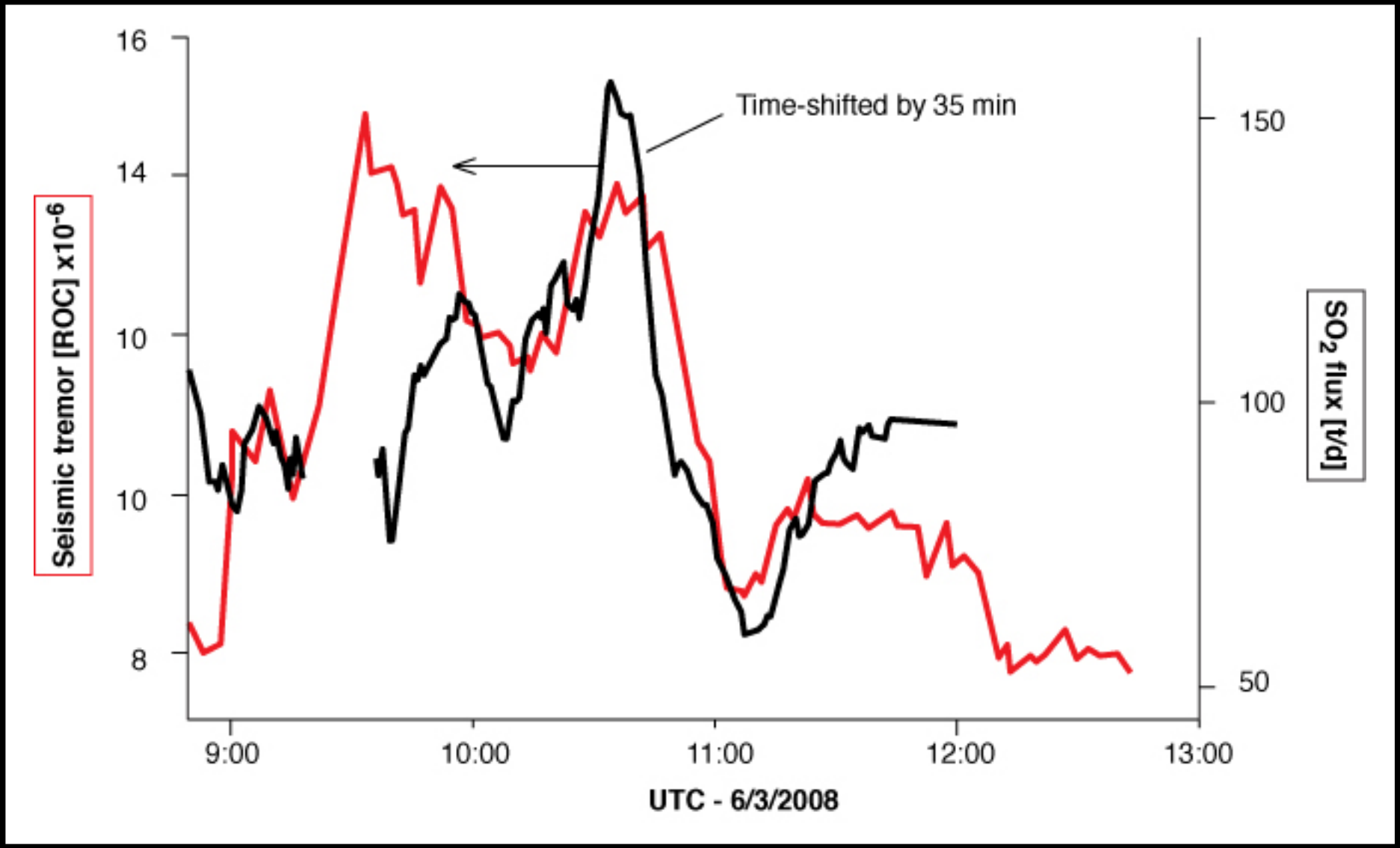

- Correlation between tremor intensity + eruptive velocities
- Main control on the volcanic tremor at Etna & Stromboli is the dynamics of gas bubbles ascending the conduit
- Maximum reflectivity during lava fountains
- More discontinuous, less dense, higher velocity jets during Strombolian activity
- More gas and fragmentation?

## Gas: Severine Moune

Mini-DOAS Gas Spectrometer at Stromboli

## Gas: Severine Moune

The relation between tremor and gas flux at Stromboli




Loyc Vanderkluysen

# HOTVOLC: Philippe Labazuy

Http://wwwobs.univ-bpclermont.fr/SO/televolc/hotvolc/index.php

# HOTVOLC: Philippe Labazuy

THE Sun

Friday, April 16, 2010 20p thesun.co.uk



FIRST ELECTION TV DEBATE

# WE'RE ALL PARALYSED BY HOT AIR

Big offer . . . Rooney

## Madrid to grab Wayne 'n Fab

EXCLUSIVE by NEIL CUSTIS and ROB BEASLEY

ENGLAND soccer ace Wayne Rooney and boss Fabio Capello are the target of an amazing double swoop by Real Madrid.

The Spanish giants plan to make a £150mil-

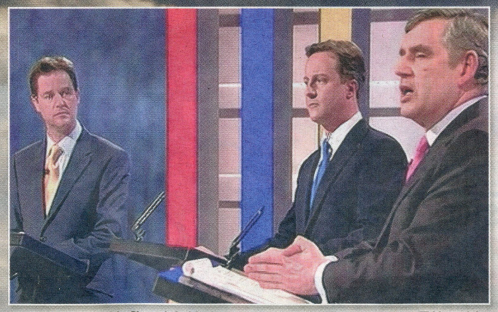
Target . . . Capello

lion raid for Wayne, 24. They will offer Manchester United £90million for their star striker and the player £250,000 a week for five years.

And they are also determined to net Capello, 63, after the World Cup.

*Full Story — SunSport*





Up for debate . . . Mr Clegg, left, Mr Cameron and PM Mr Brown appear on TV last night

By TOM NEWTON DUNN
Political Editor

**BRITAIN was awash with hot air last night — after a huge plume of volcanic ash was followed by a clash between our top three politicians.**

Gordon Brown, David Cameron and Nick Clegg took part in the first-ever live General Election TV debate.

They rattled off poll pledges to an audience in Manchester for ITV.

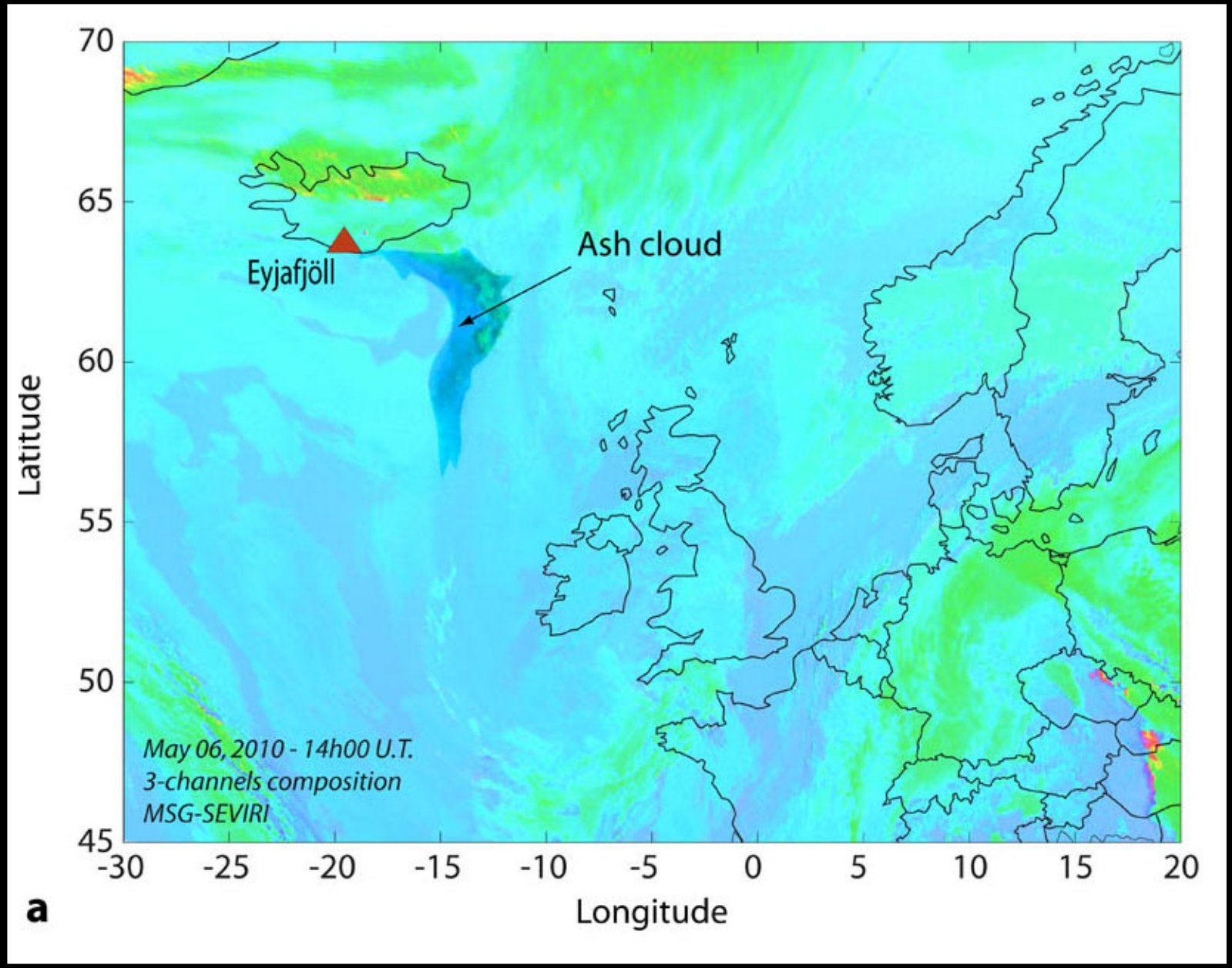
In a Sun poll, Tory boss Mr Cameron emerged as favourite to be next PM — while Lib Dem leader Mr Clegg was judged to have won the debate.

Meanwhile the cloud spewing from Iceland looked set to paralyse flights for a second day.

## Leaders clash as jets grounded by ash

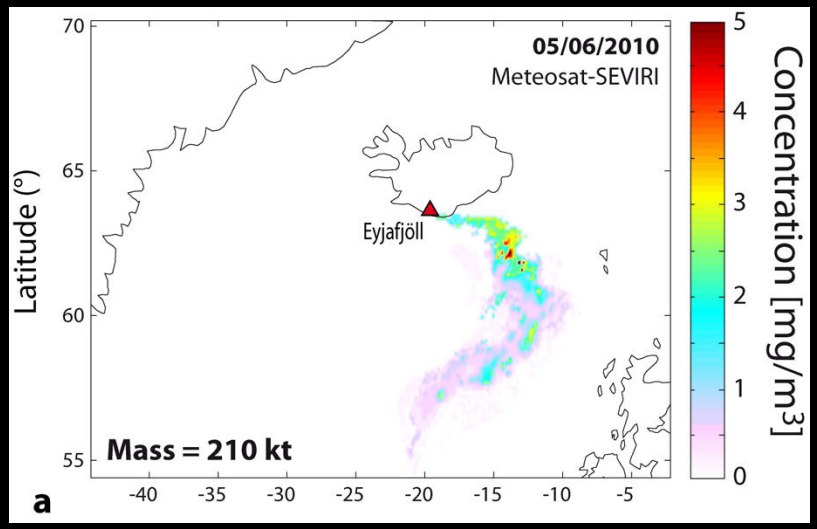
PAGES 4, 5, 6, 7, 8 & 9

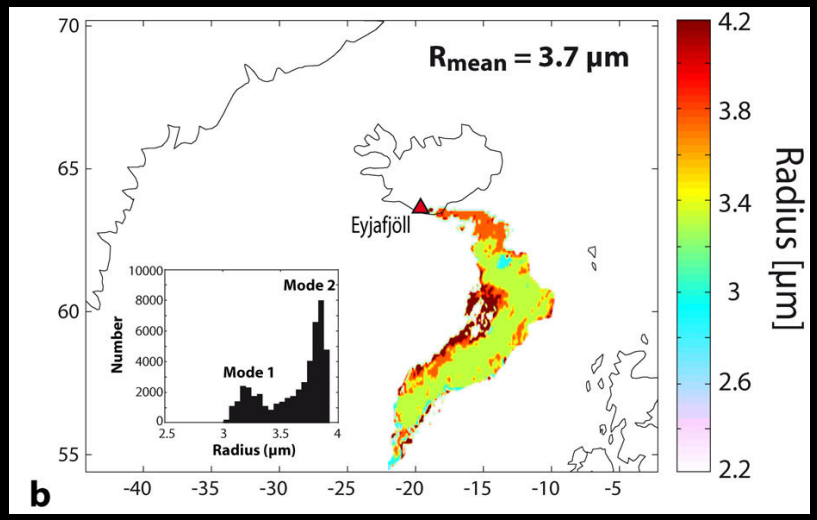
# HOTVOLC: Philippe Labazuy

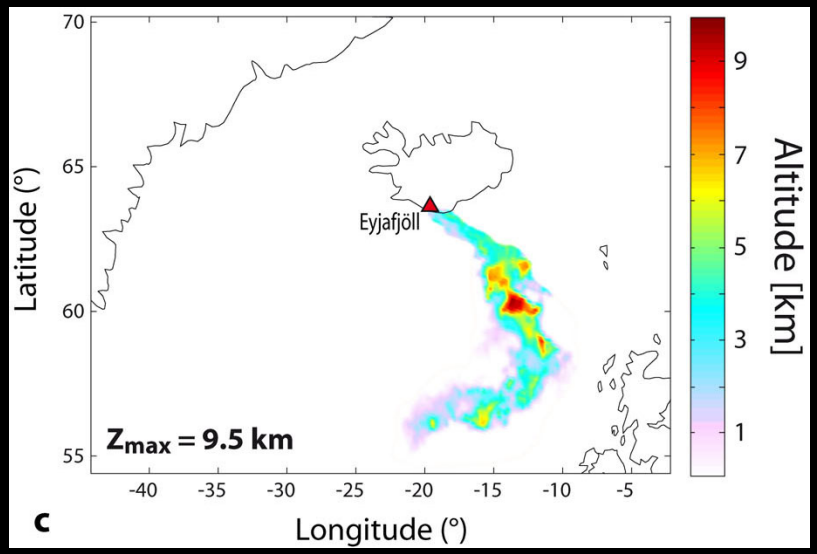


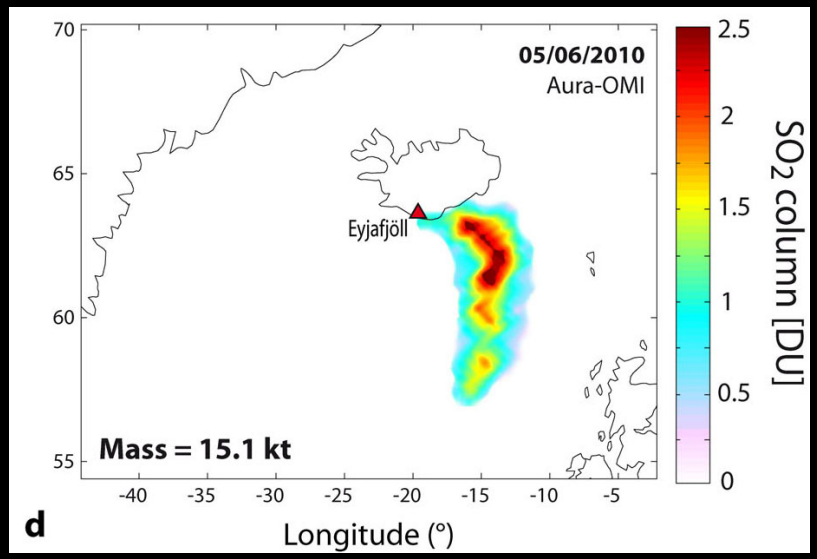

Mathieu Gouhier

# HOTVOLC: Philippe Labazuy




Mathieu Gouhier

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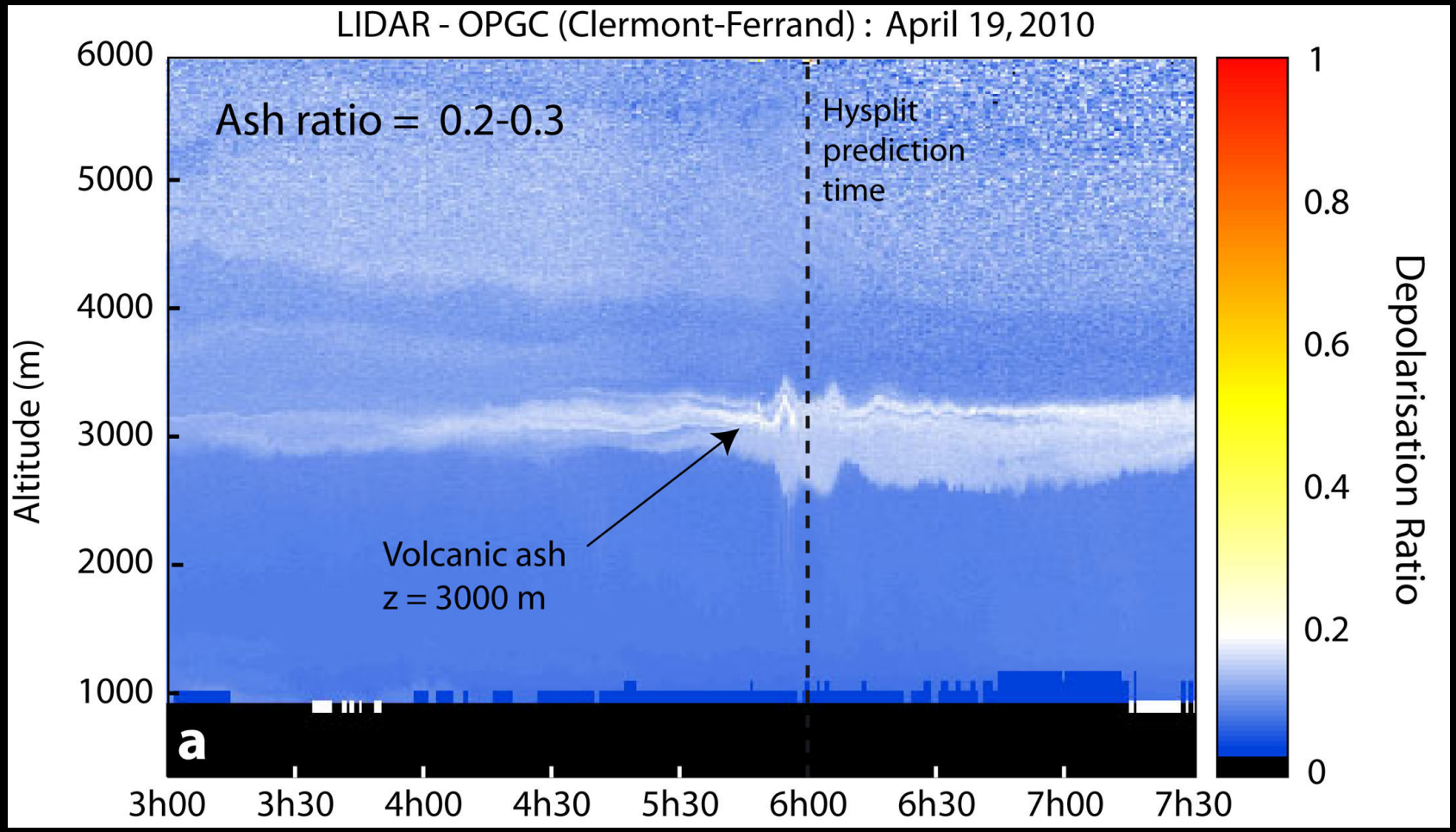


Mathieu Gouhier

# The Chain de Puys

Les cônes de la Vache et Lassolas