Fixed thermal cameras at active volcanoes

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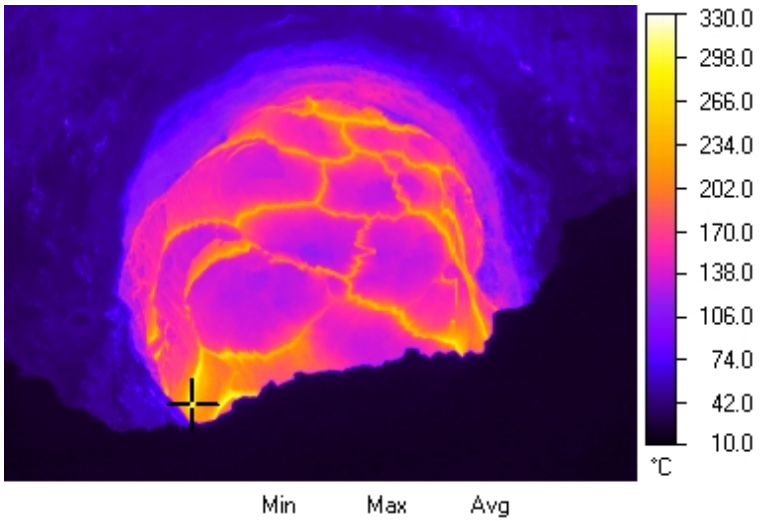
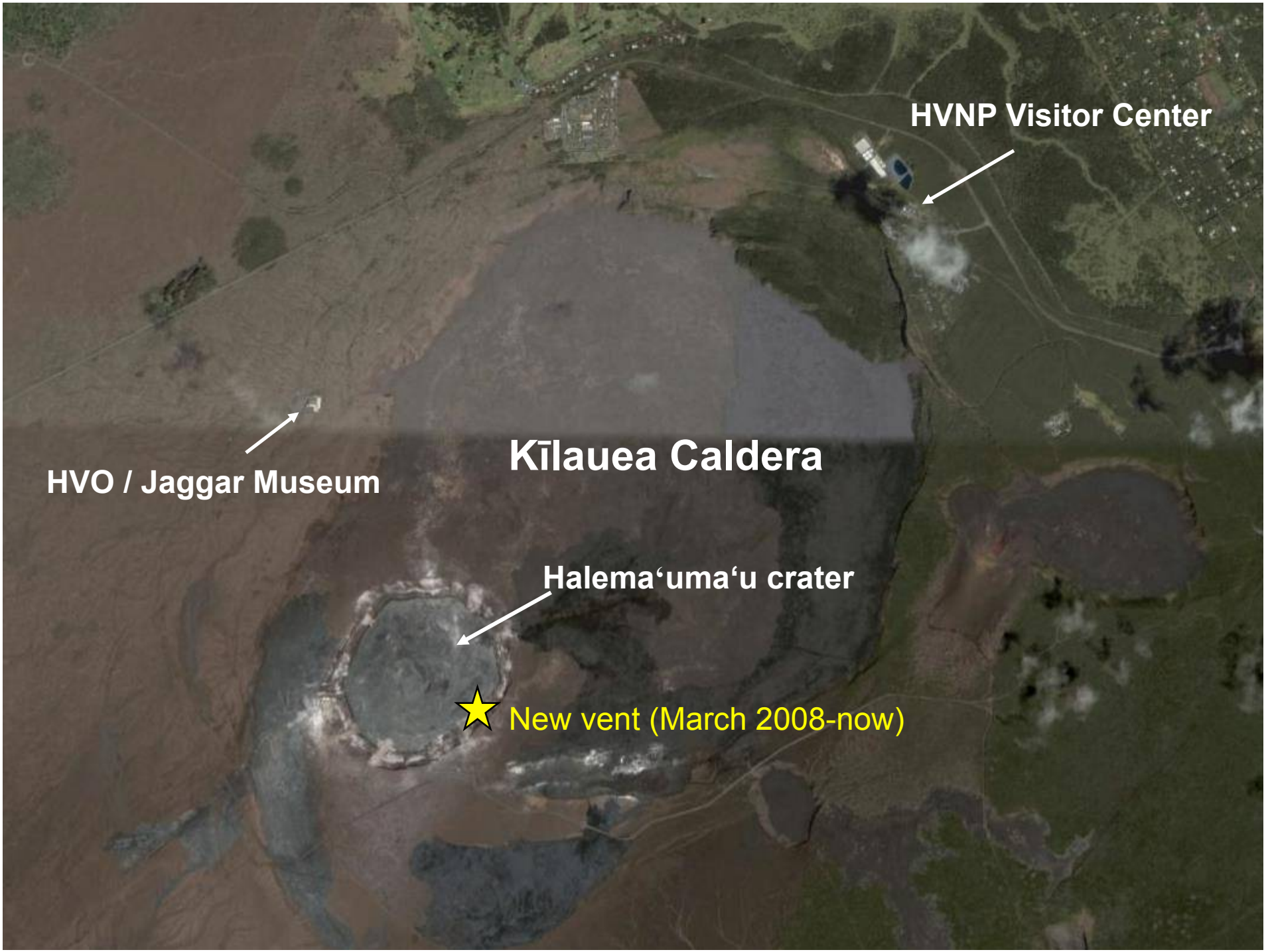
Jan 21, 2011

PASI workshop

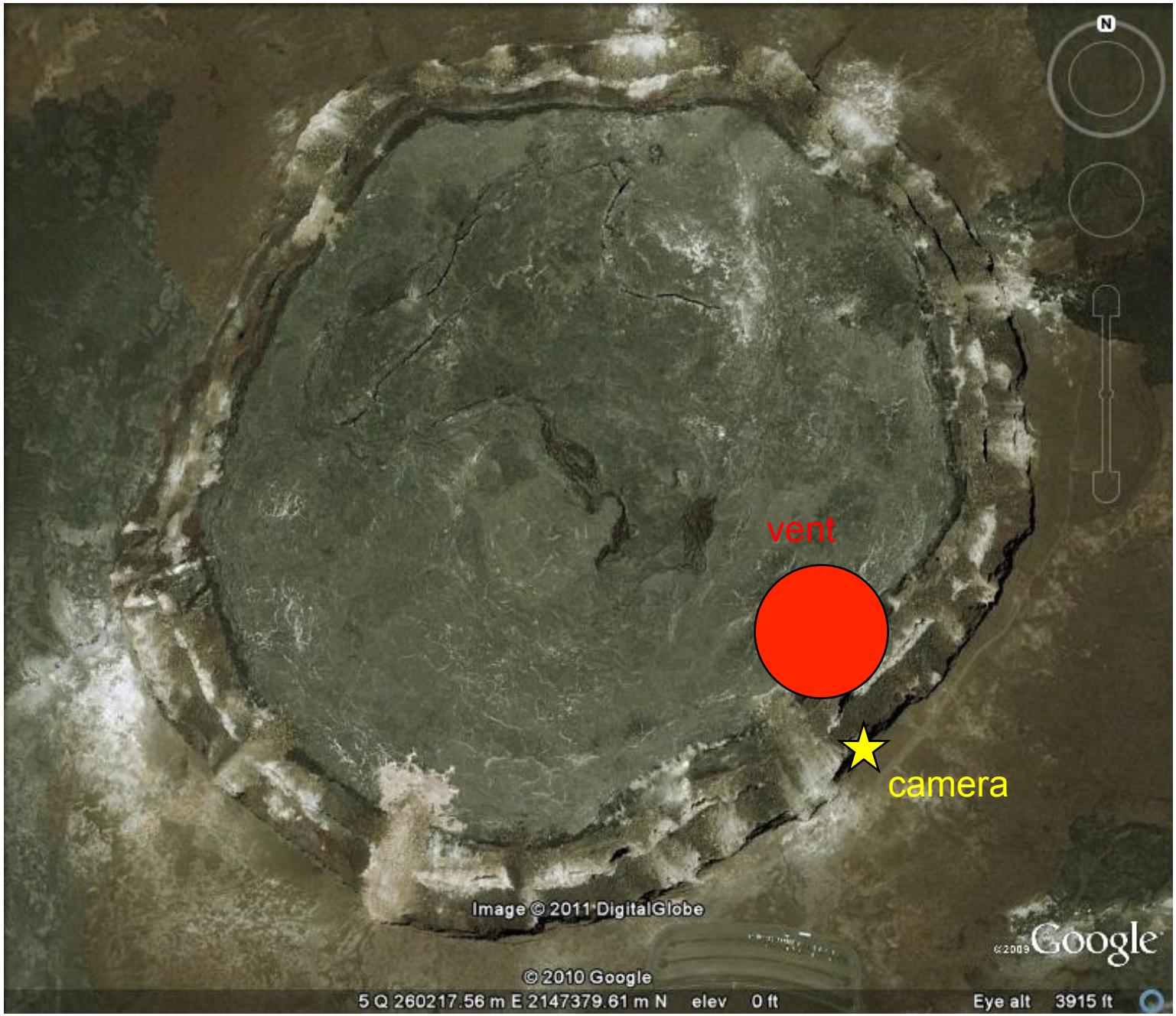


Two models commonly used

	FLIR Systems A320	Mikron Infrared M7500
		
Image size:	320 x 240 pixels	320 x 240 pixels
IR range:	8-14 micron	8-14 micron
Ethernet hookup:	yes	yes
Size:	6 inches long	12 inches long
Power usage:	5 Watts	12 Watts
Cost (root lens):	$13,000	$15,000


HVNP Visitor Center
Kīlauea Caldera
HVO / Jaggar Museum
Halemaʻumaʻu crater
New vent (March 2008-now)

Halema`uma`u crater



New power and radio hub established (for 2 cameras)

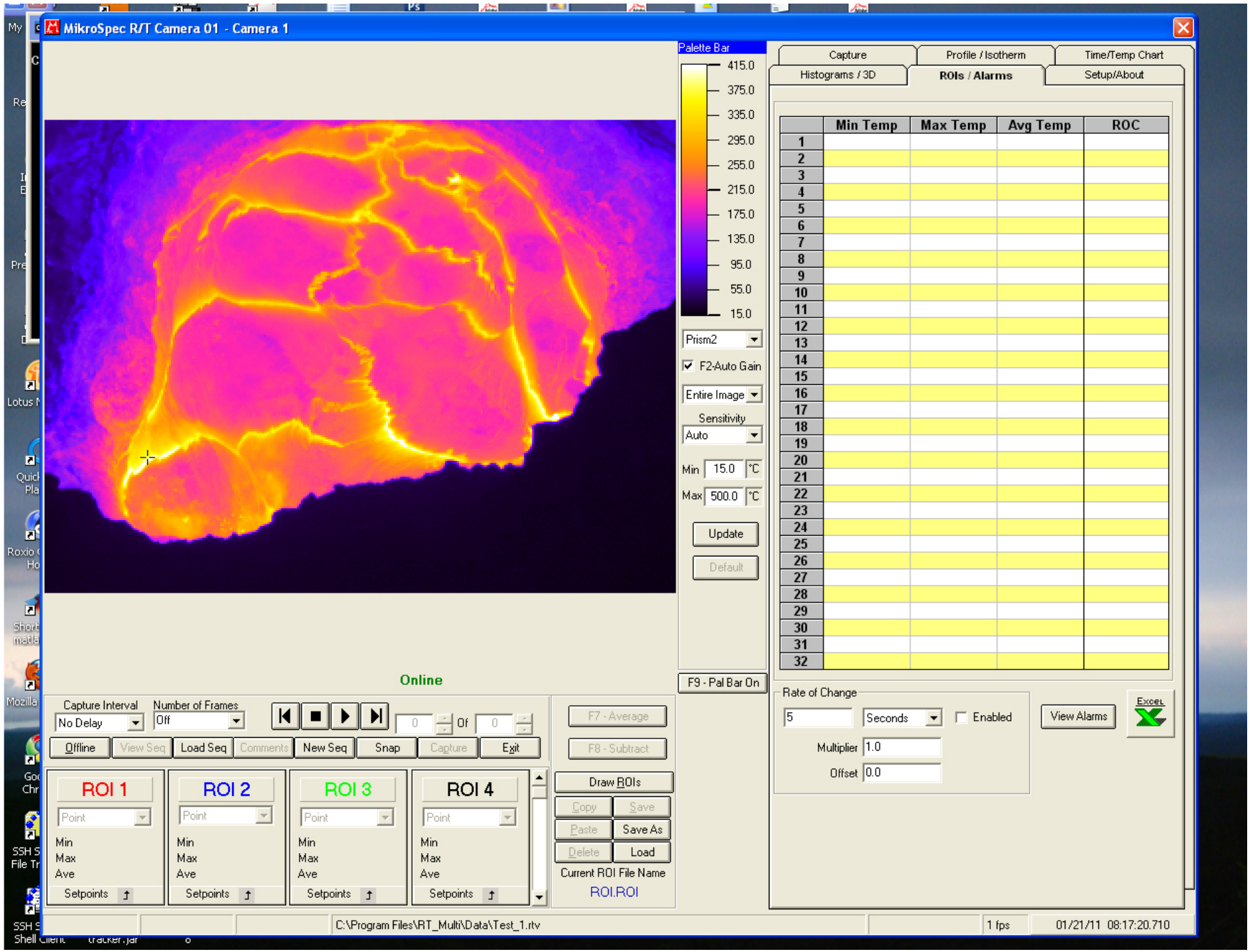
Camera in Pelican case, attached to aluminum baseplate

Germanium window

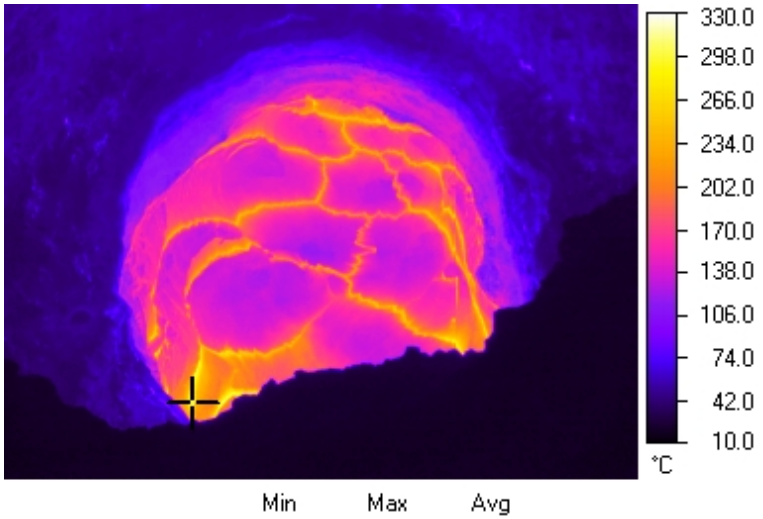
- 3 inch diameter
- 8mm thickness
- diamond-like coating
- in PVC window frame

On surveyors tripod overlooking ledge

Looking into the Halema`uma`u vent

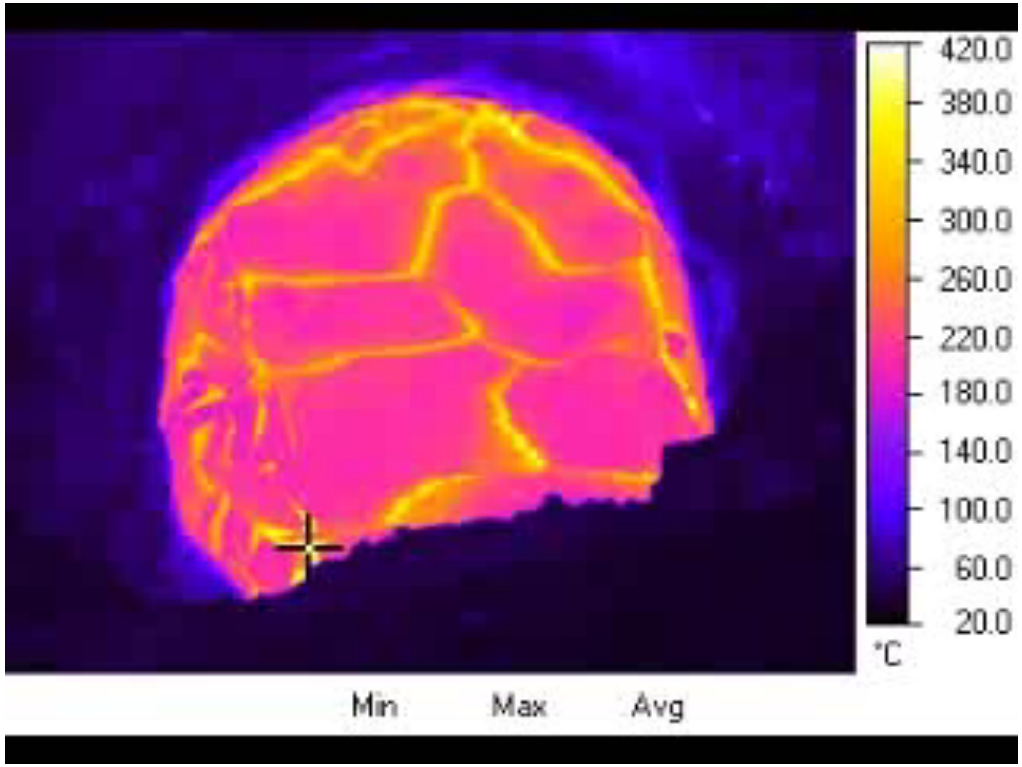

MikroSpec R/T Camera 01 - Camera 1
Palette Bar
415.0
375.0
335.0
295.0
255.0
215.0
175.0
135.0
95.0
55.0
15.0
Prism2
F2-Auto Gain
Entire Image
Sensitivity
Auto
Min 15.0 °C
Max 500.0 °C
Update
Default
F9 - Pal Bar On
Capture
Profile / Isotherm
Time/Temp Chart
Histograms / 3D
ROIs / Alarms
Setup/About
Min Temp
Max Temp
Avg Temp
ROC
Online
Capture Interval
No Delay
Number of Frames
Off
Of
Offline
View Seq
Load Seq
Comments
New Seq
Snap
Capture
Exit
F7 - Average
F8 - Subtract
ROI 1
ROI 2
ROI 3
ROI 4
Point
Min
Max
Ave
Setpoints
Draw ROIs
Copy
Save
Paste
Save As
Delete
Load
Current ROI File Name
ROI.ROI
Rate of Change
5
Seconds
Enabled
Multiplier 1.0
Offset 0.0
View Alarms
Excel
C:\Program Files\RT_Multi\Data\Test_1.rtv
1 fps
01/21/11 08:17:20.710

Matlab scripts to automate processing of thermal images

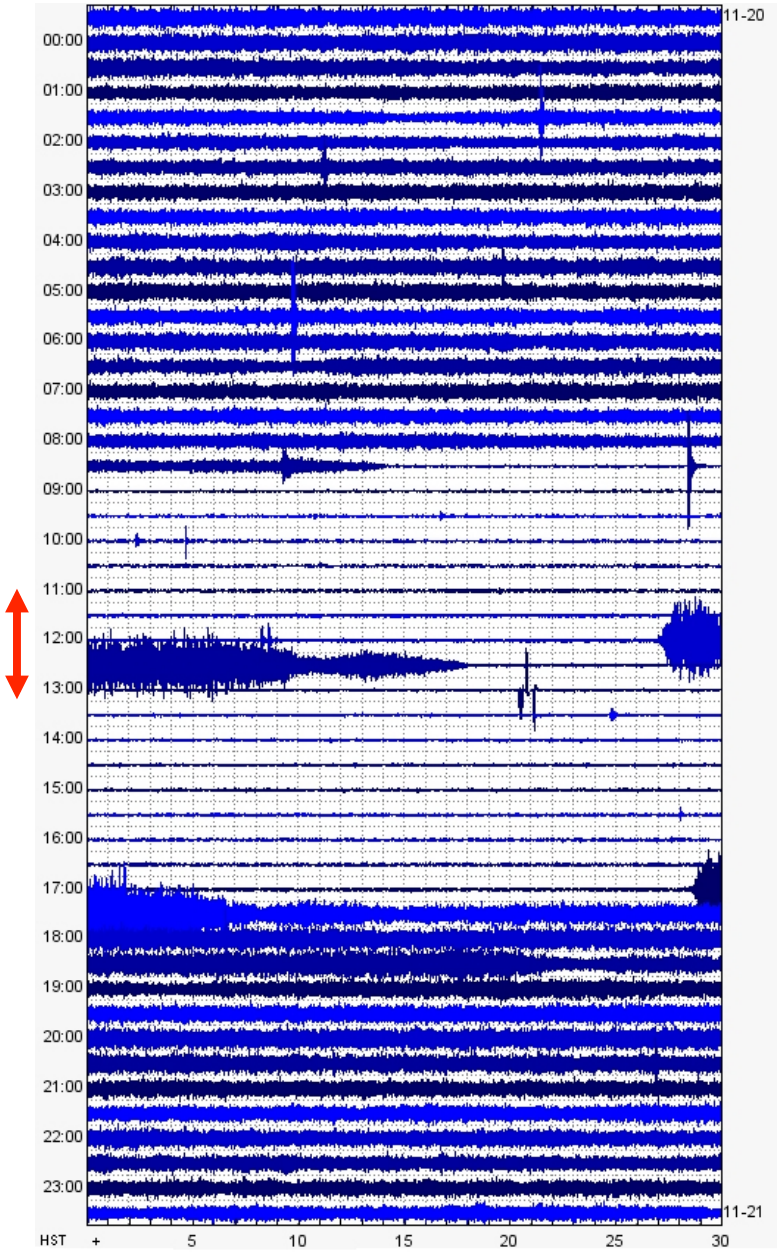


1) Lava level measurement: script measures pixel location of top of lava lake, converts to absolute depth using estimated geometry of vent cavity
2) Crust velocity measurement: script measures velocity of crust at center of lava lake, using small window and 2D cross correlation between successive images
3) Data management: images are transferred to date folders (year, month, day, hour) each hour
5) Datastream continuity: every five minutes script checks that images are still incoming. If not, Mikron acquisition program restarted
7) Data distribution: each morning at 6am, summary plot of last day/week distributed via email

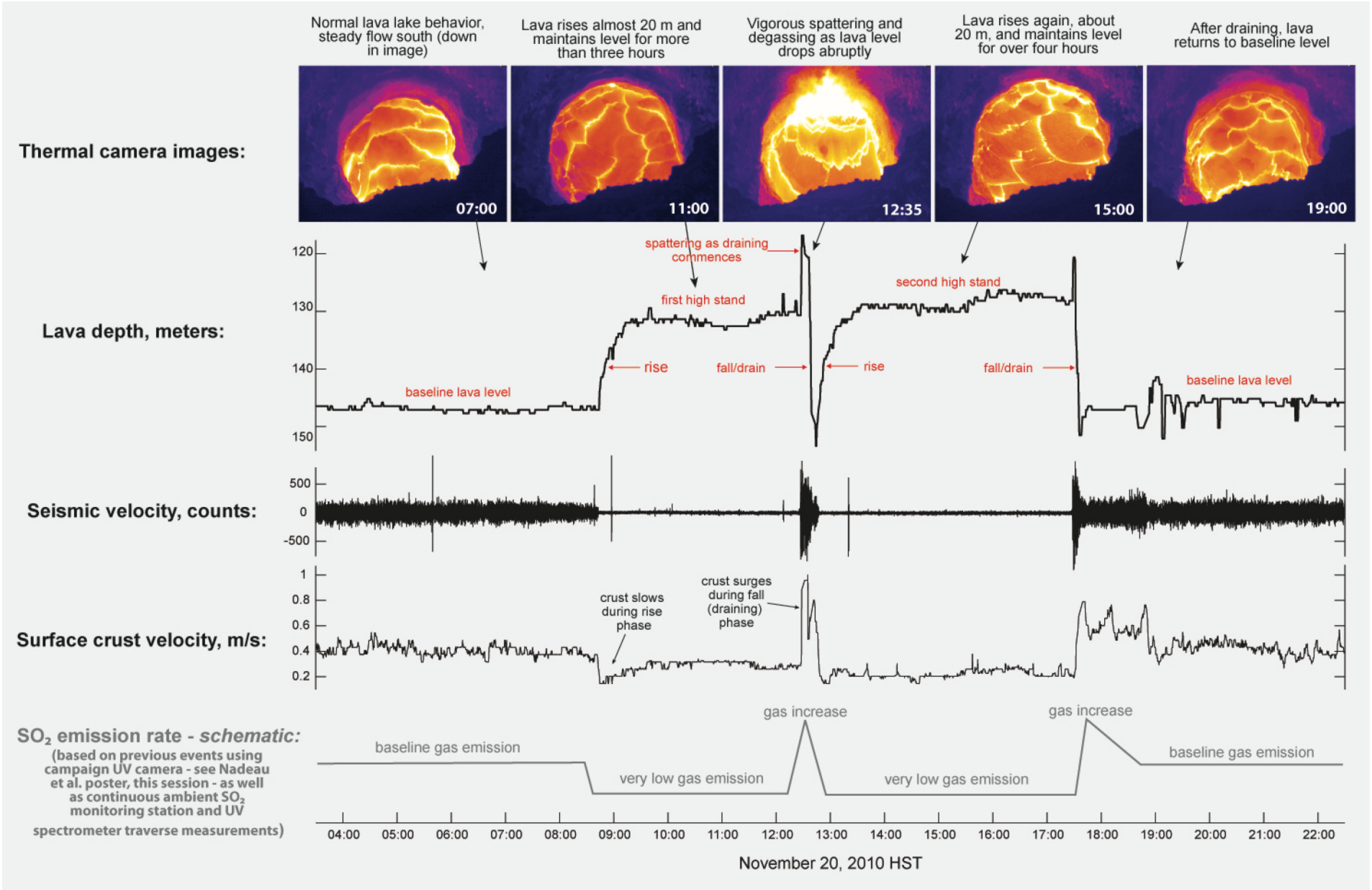
Nov 20, 2010 thermal camera sequence



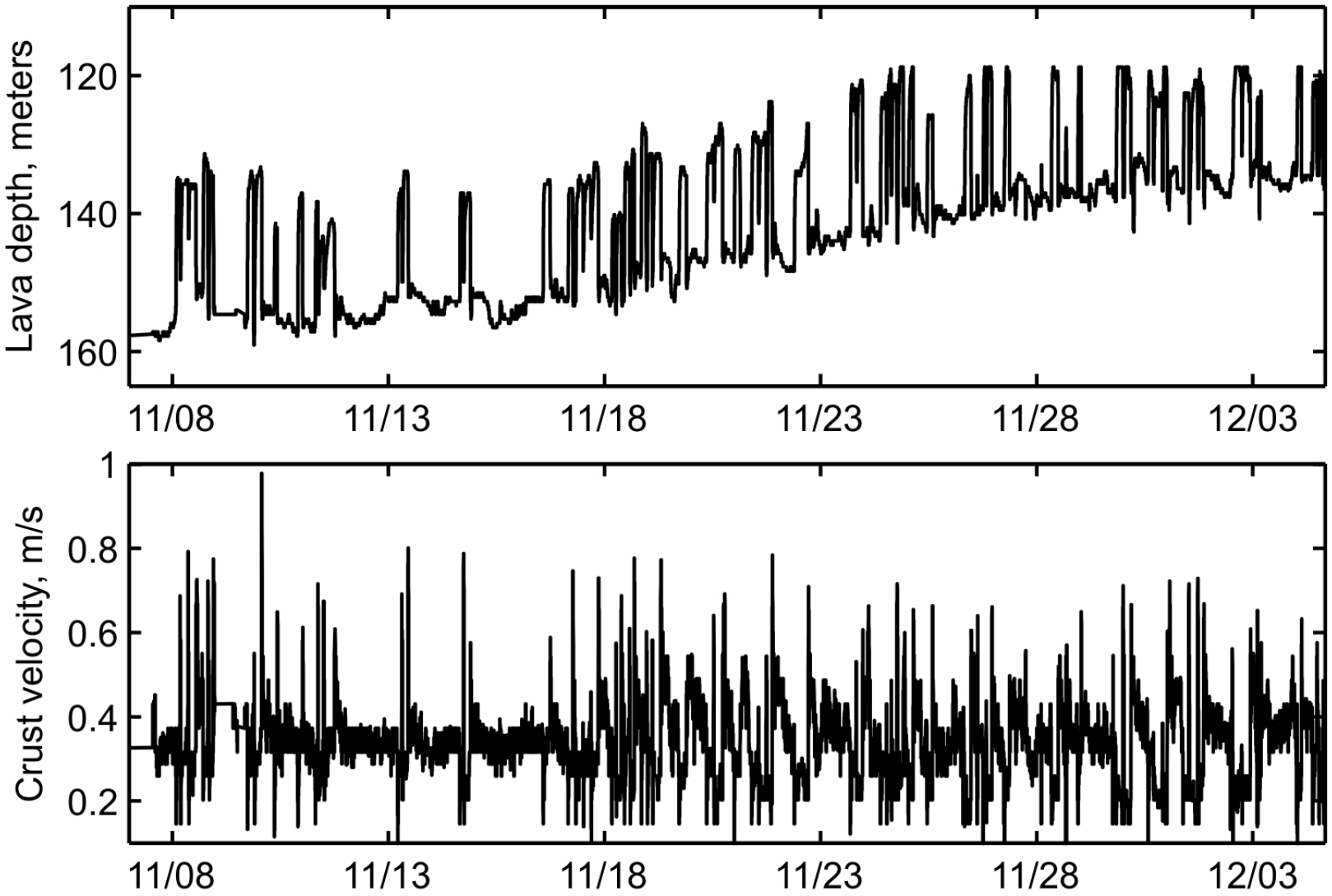
Nov 20, 2010 seismicity



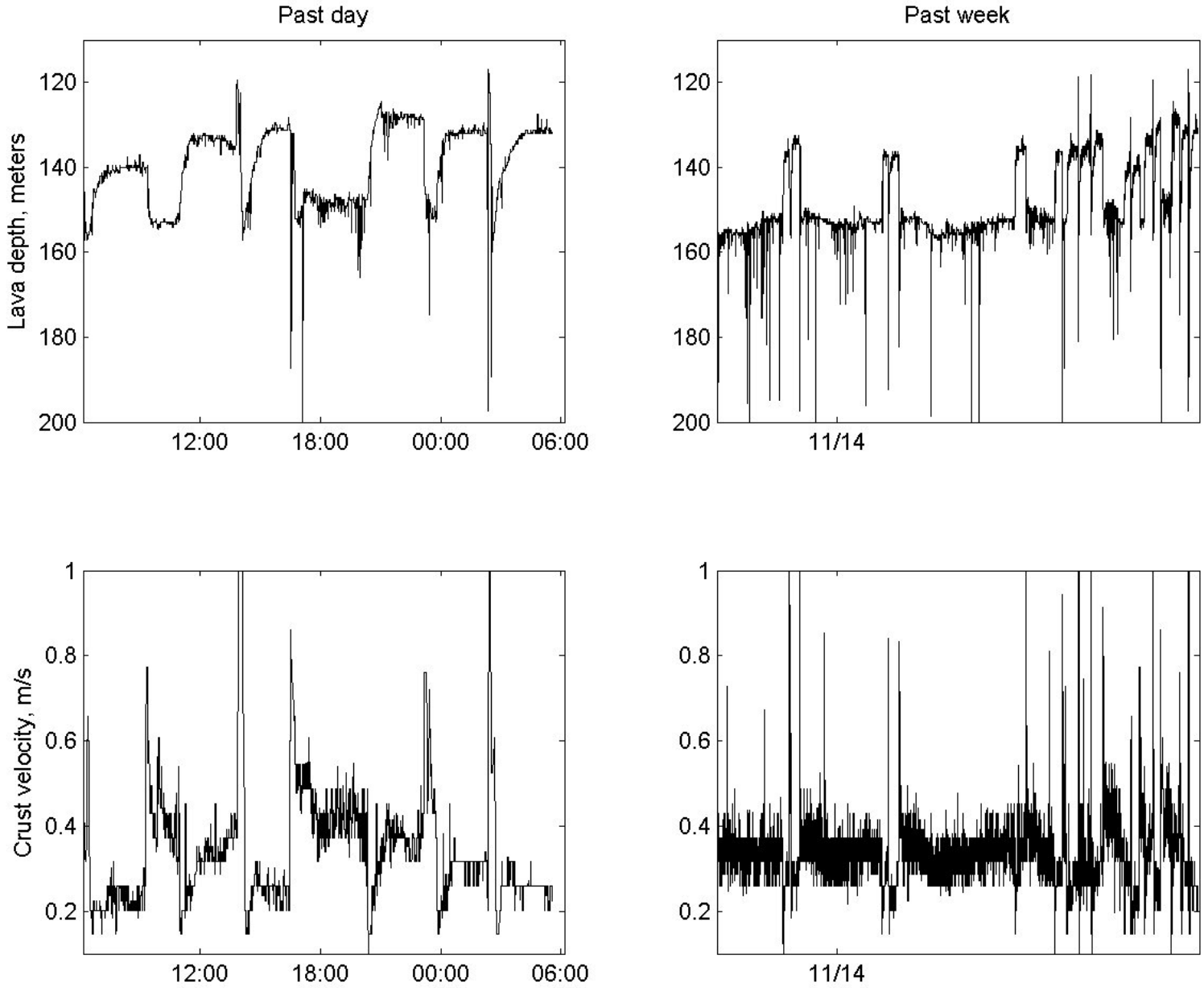
Multidisciplinary analysis of lava rise-fall cycles: favors shallow gas accumulation model



Long-term tracking of Halema`uma`u lava lake level



Automated update on lava lake level and crust velocity



“Poor man’s” thermal camera: surveillance webcam in “IR” mode

Pros:

- Inexpensive (~$1000 or less)
- Higher spatial resolution than thermal IR
- Very sensitive to hot surfaces (show lava very well)
- Can see through some fume

Cons:

- fume penetration is limited
- no radiometric information
- doesn’t pick up warm surfaces well
- often shows little during the day

Stardot webcam on IR mode: Jan 13, 2011, rockfall triggers draining event

Fixed thermal cameras are becoming more common

Italy: Etna, Stromboli, Campi Flegrei

Montserrat

Iceland

Costa Rica: Turrialba, Poas (soon)

Japan: Sakurajima, Usu (and probably several others)

Stromboli: three fixed thermal cameras operated by INGV, plus one operated by Univ. Firenze (Maurizio Ripepe)

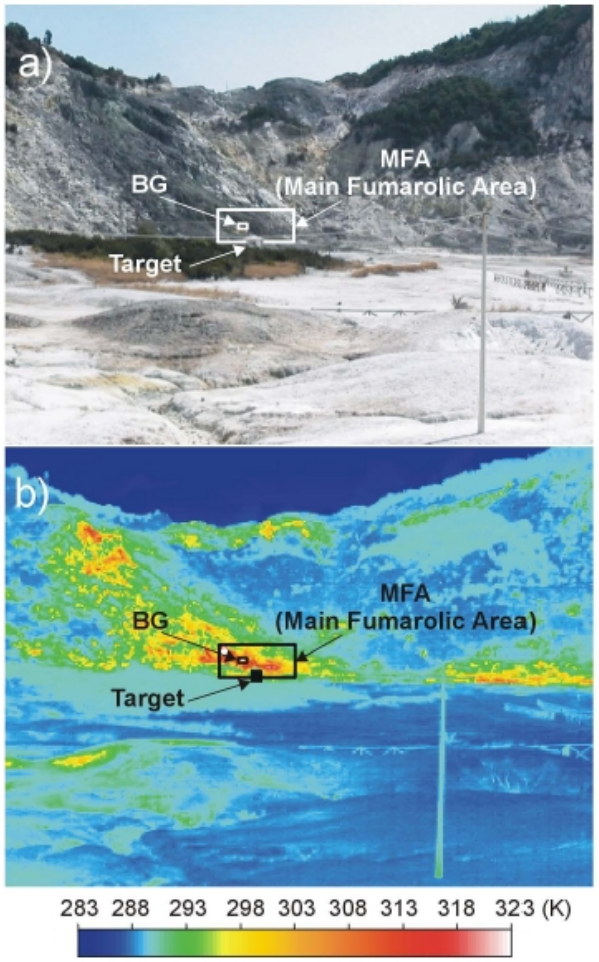
INGV thermal camera at Stromboli summit

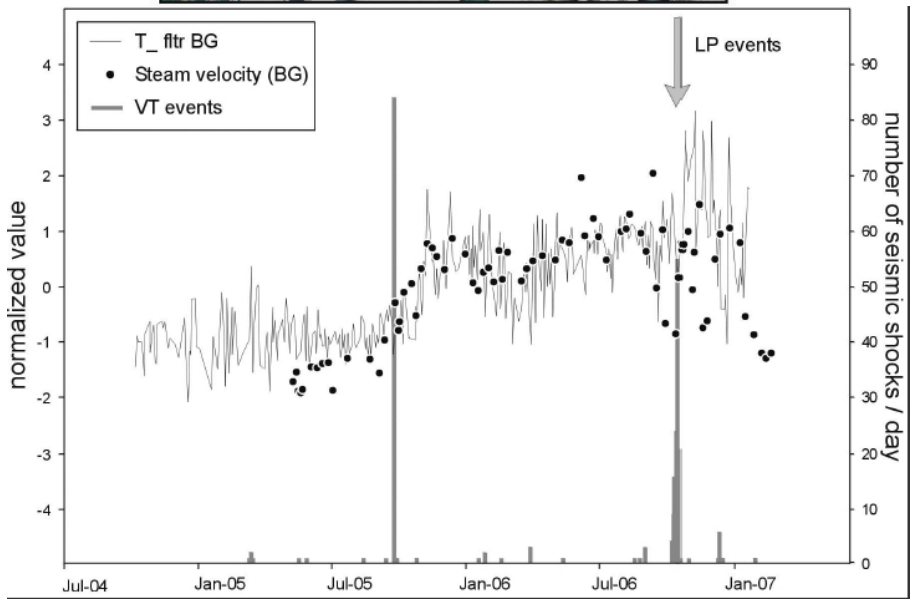
90 dg lens shows whole crater terrace

Thermal images allow counting of explosive events, and views through partially cloudy weather

Chiodini et al. (2007): tracking thermal activity at Campi Flegrei

Jumps in temperature, appearance of new fumaroles, following earthquake swarms





Fixed thermal cameras provide several benefits to visual cameras

- Can see through significant amounts of fume and cloud
- Thermal contrast of volcanic events often greater than visible contrast – better capabilities for qualitative identification/analysis of events
- Temperature values, even if significantly attenuated by fume, provide automated alarming potential not possible with visible images

Cautionary notes:

- Data should be treated as “apparent temperature” and not over-analyzed – due to ubiquitous gas and the mixed-pixel problem common at large distances
- In operational environment, temperature values better analyzed in relative sense, or used as minimum values