EO-1 Observations of Volcanoes Using Hyperion and ALI

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EO-1Science Validation Team Meeting
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EO-1 Talk Outline

- Discuss rationale and objectives
- Present results of Hyperion pointing accuracy tests.
- Discuss ALI role in volcano monitoring
- Present calculated temperature results for Hyperion data of three volcanoes
- Other issues - Data re-orders

EO-1 Objectives

- Investigate the sensitivity of EO-1 instruments to high temperature volcanic thermal anomalies.
  - Active eruptions apparent at 0.9 - 2.5 μm.
  - Active basalt flows have higher reflectance.
- Create more robust algorithms for uniquely determining sub-pixel thermal anomalies.
- Determine required spectral channels.

Earth Observing -1 Volcanoes

- Many volcanoes should be acquired within the first 120 days after launch.
- These include Kilauea (3), Etna (15), Erebus (0), Erta ‘Ale (8), Mayon (7), Pacaya (0), Galeras (1), Colima (1), Lascar (3), Santiaguito(1), Popocatepetl (3), Masaya(1*4), Cotopaxi (0), Tungurahua (0).

Pointing Accuracy - Etna

Landsat 7 ETM+ Image - 10/28/99

Requested Location:

37° 44’ 2.4” N 15° 0’ 14.4” E

Hyperion Center Point:

37° 43’ 58.43” N 15° 0’ 40.86” E

Actual SE Cone Location:

37° 44’ 46.3” N 15° 0’ 7.76” E

Hyperion - Request Distance: 671 m

Pointing Accuracy - Lascar

Landsat ETM+ Image - 05/16/99

Requested Location:

23° 22’ 30” S 67° 43’ 48” W

Hyperion Center Point:

23° 22’ 31.94” S 67° 43’ 22.85” W

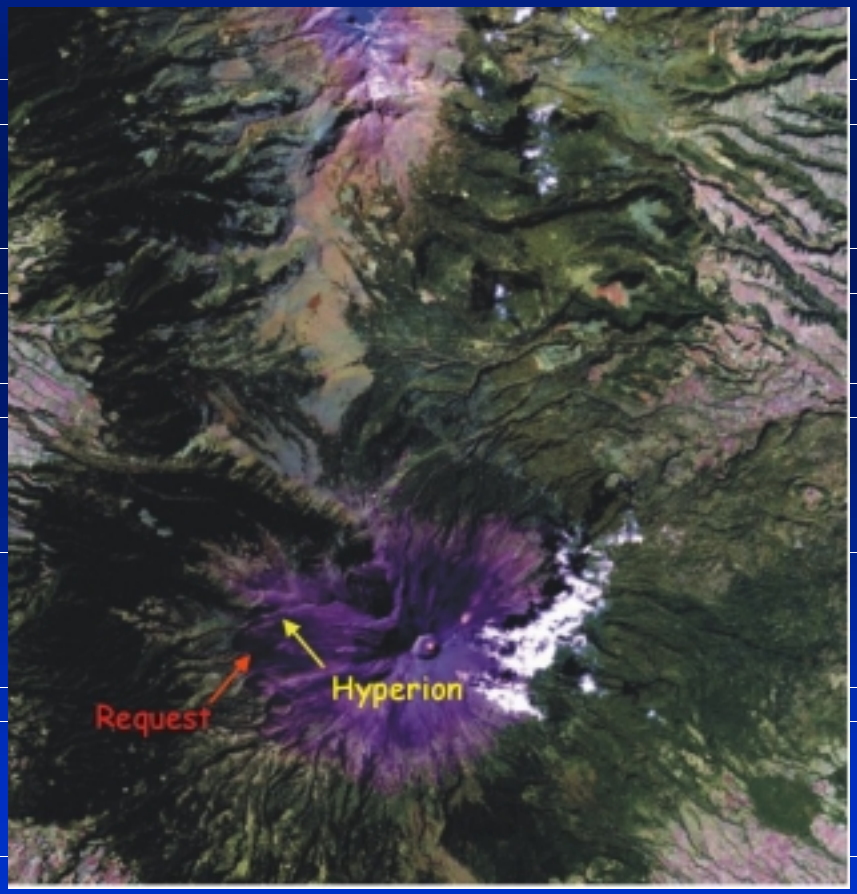
Actual Lascar Dome Location:

23° 22’ 8.72” S 67° 43’ 45.26” W

Hyperion - Request Distance: 729 m

Pointing Accuracy - Popocatepetl

Landsat ETM+ Image - 02/02/00



Requested Location:

19° 1' 22.8" N 98° 39' 43.2" W

Hyperion Center Point:

19° 1' 50.51" N 98° 39' 14.74" W

Actual Popo Dome Location:

19° 1' 20.94" N 98° 37' 9.59" W

Hyperion - Request Distance: 1,188 m

Pointing Accuracy - Santiaguito

Landsat ETM+ Image - 01/23/00

Requested Location:

14° 45’ 21.6” N 91° 33’ 3.6” W

Hyperion Center Point:

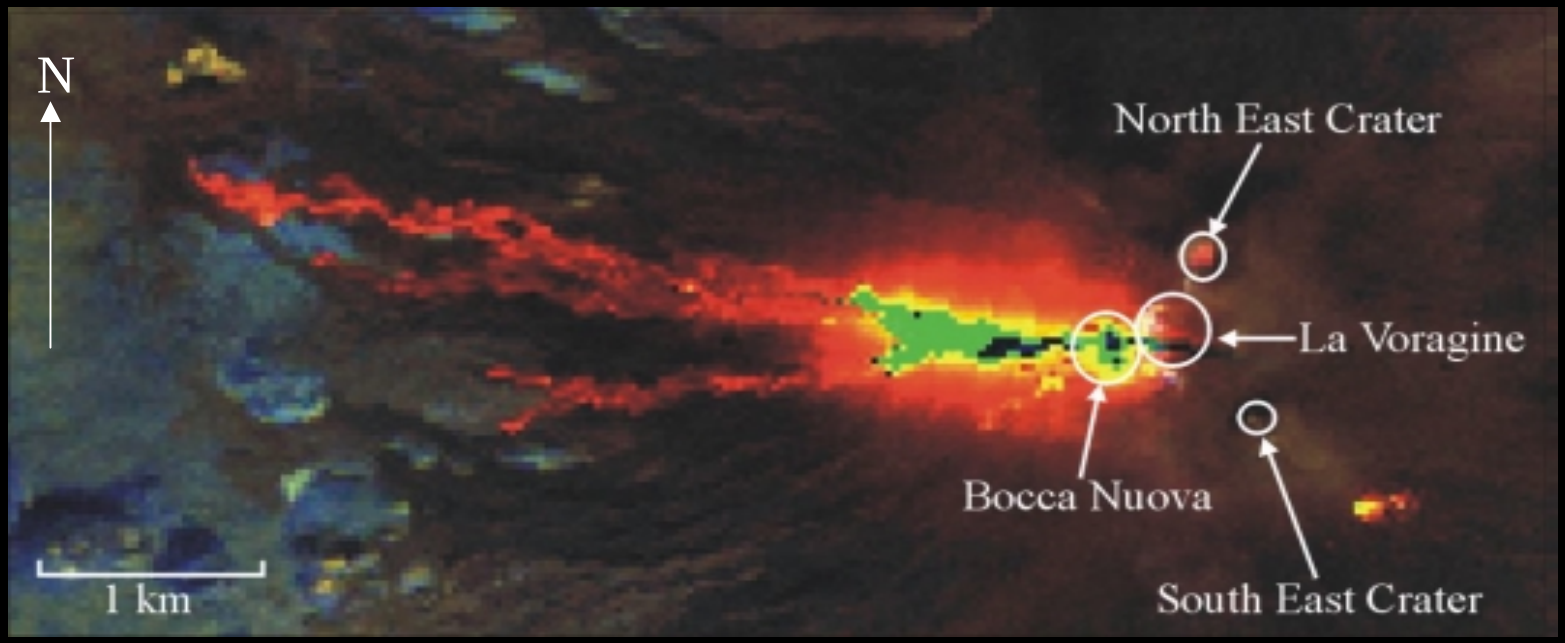
14° 46’ 3.64” N 91° 32’ 27.81” W

Actual Santiaguito Dome Location:

14° 44’ 33.54” N 91° 34’ 9.59” W

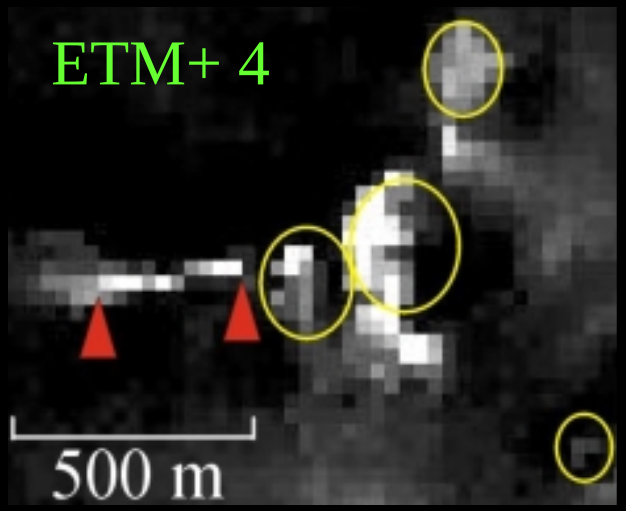
Hyperion - Request Distance: 1,570 m

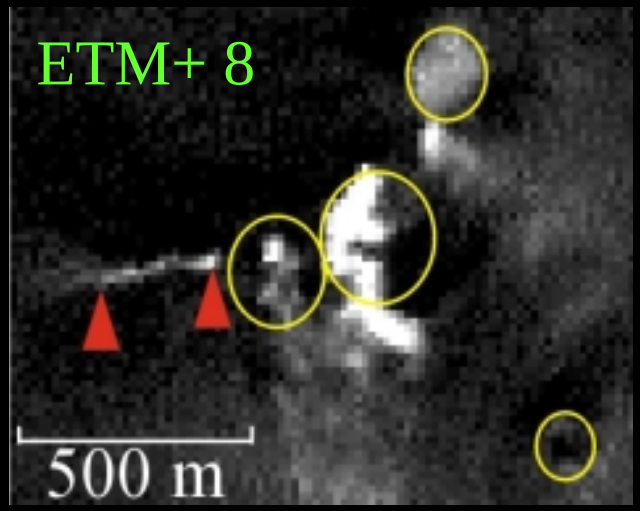
Landsat 7 ETM+ image acquired on 28 October 1999



Event began ~ 17:00, 27 October 1999
Final length ~ 4.9 km
Final volume ~ 5 x 10^6 m^3

The properties of the active channel





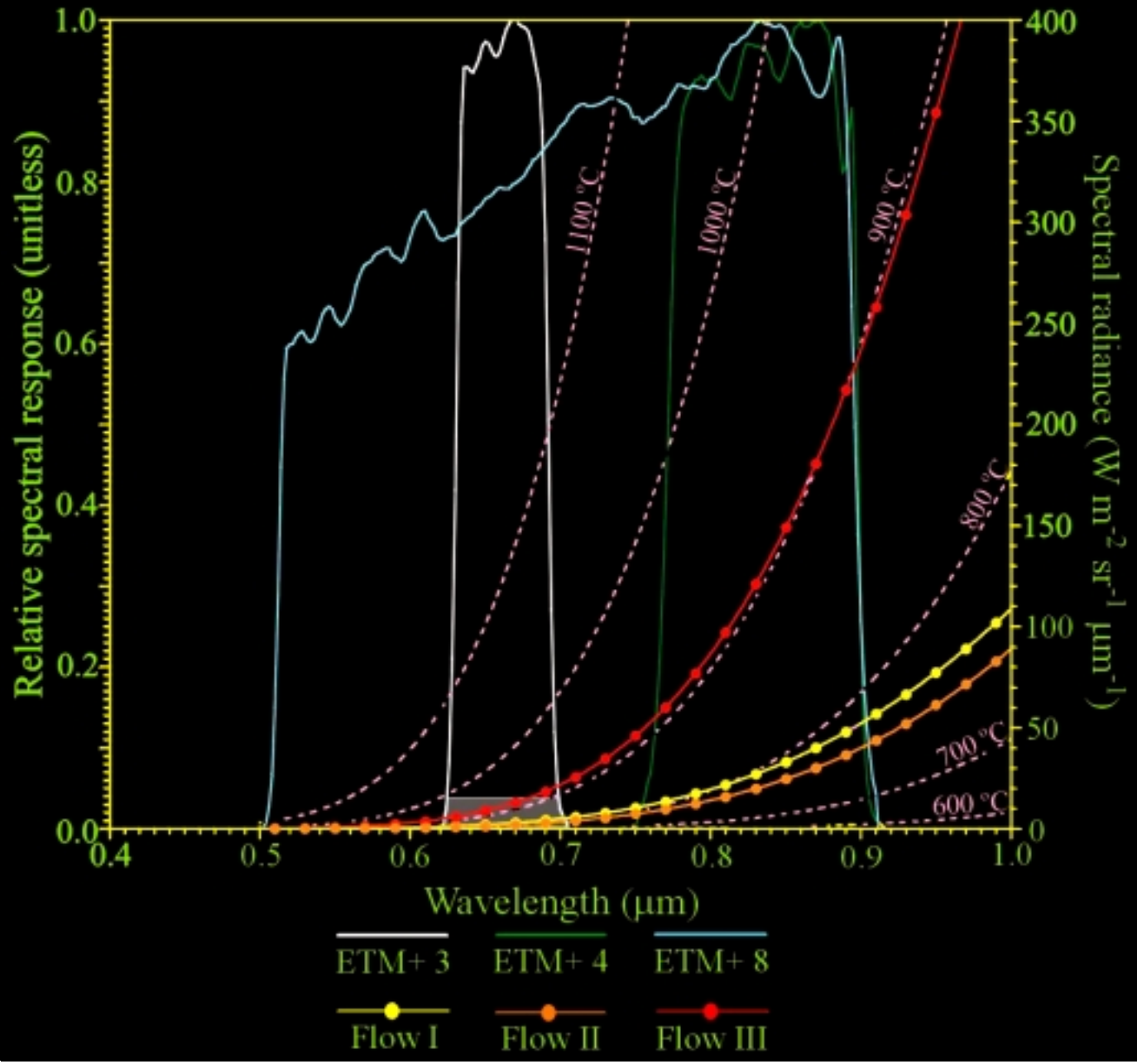
$$P_{core} = \frac{R_{4thermal} - L(\lambda_4, T_{crust})}{L(\lambda_4, T_{core}) - L(\lambda_4, T_{crust})}$$

$T_{core} = 1000\ °C$, $T_{crust} < 500\ °C$

$0.04 < P_{core} < 0.11$

$\overline{\chi} = 0.7$

Properties of the channel the lava channel



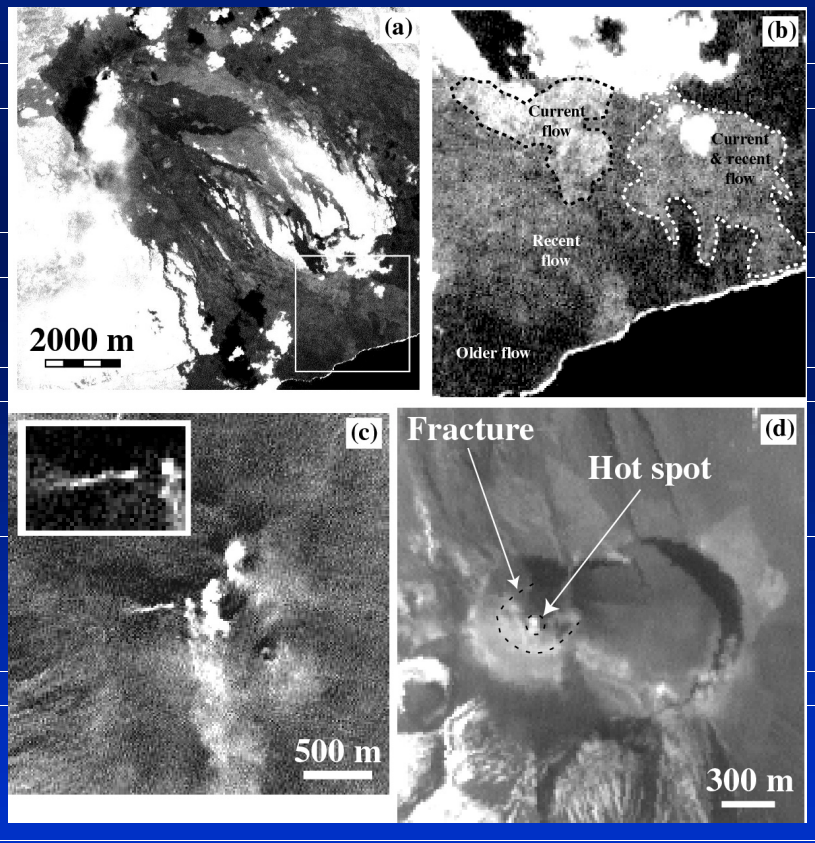
Landsat 7 ETM+

Band	Wavelength (μm)	Pixel Size (m)	Min. temp. (°C)	Max. temp. (°C)
1	0.450 – 0.515	30 x 30	1051 (1075)	1483 (1526)
2	0.525 – 0.605	30 x 30	900 (922)	1301 (1340)
3	0.630 – 0.690	30 x 30	755 (775)	1119 (1156)
4	0.750 – 0.900	30 x 30	595 (613)	926 (961)
5	1.55 – 1.75	30 x 30	206 (217)	417 (440)
6	10.40 – 12.50	60 x 60	-33(-134)	51 (77)
7	2.09 – 2.35	30 x 30	92 (101)	258 (276)
8	0.520 – 0.900	15 x 15	702 (721)	1056 (1092)

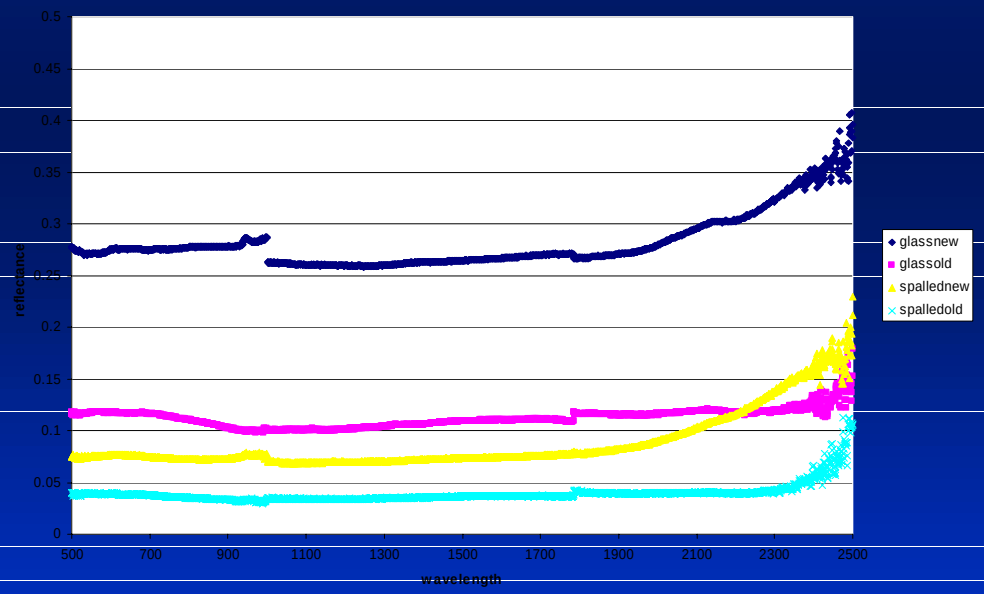
ALI Spectral Bands

Band	Wavelength (µm)	Pixel Size (m)	Landsat 7 Wavelength
Pan	0.480 - 0.690	10 x 10	0.520 - 0.900 (15m x 15m)
1’	0.433 - 0.453	30 x 30	
1	0.450 – 0.515	30 x 30	0.450 - 0.515
2	0.525 – 0.605	30 x 30	0.525 - 0.605
3	0.630 – 0.690	30 x 30	0.630 - 0.690
4	0.775 – 0.805	30 x 30	0.750 - 0.900
4’	0.845 – 0.890	30 x 30	
5’	1.200 – 1.300	30 x 30	
5	1.55 – 1.75	30 x 30	1.55 - 1.75
6	10.40 – 12.50	60 x 60	Not Available on ALI
7	2.08 – 2.35	30 x 30	2.09 - 2.35

Reflectance of fresh lava flows



Reflectance of s-type lava



Eruption of Mt. Etna, Sicily

A’a Flow Channels

Etna lava flows typically form flow channels especially during high effusive periods. A’a flow channels have rafted crust over molten lava. Sometimes, the channels overflow their banks.

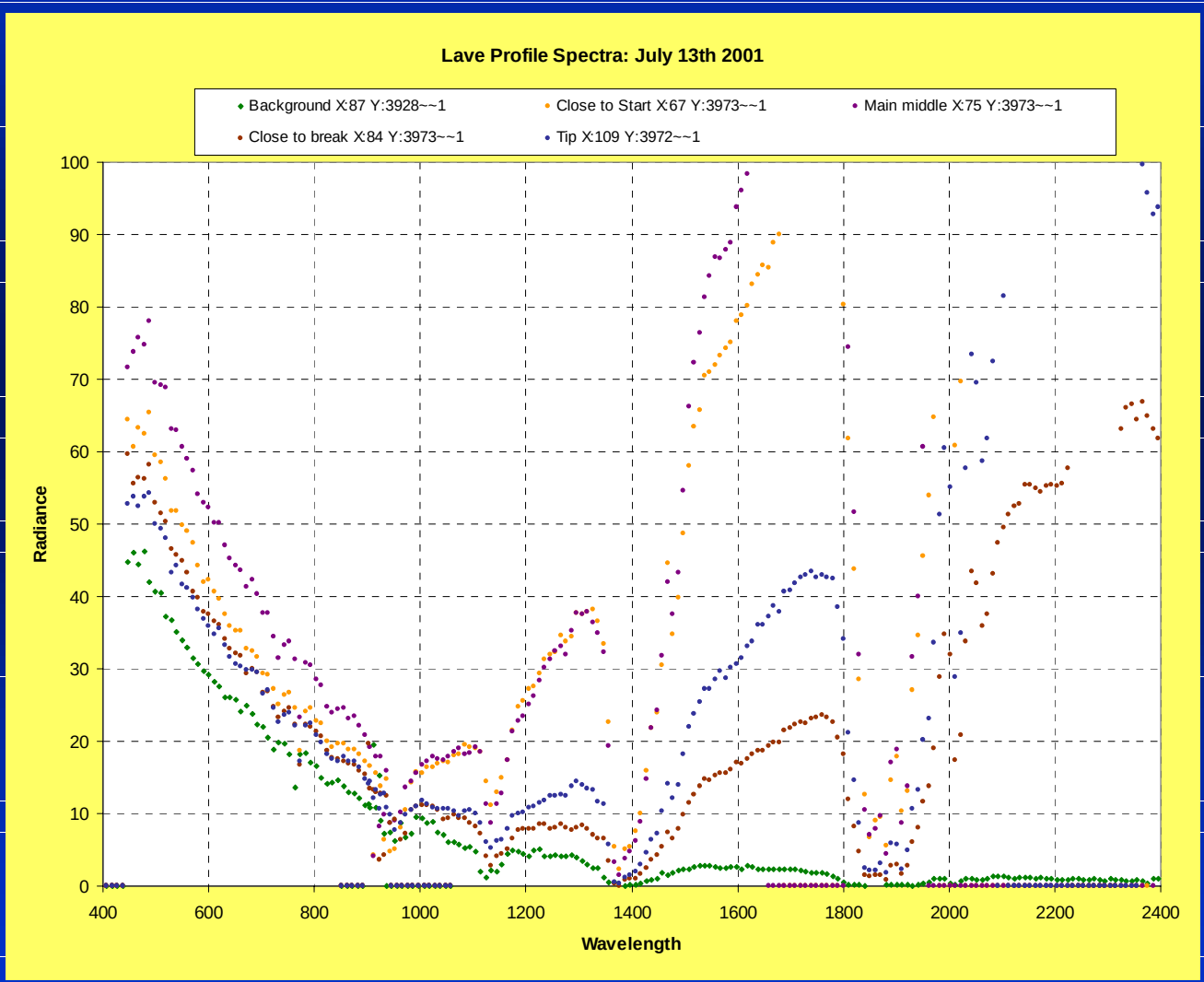
Hyperion Observes Etna - July 13

Hyperion bands 213, 152, and 32 were used to create this RGB image.

Lava flow activity from the base of the South East cone before larger eruptive episode on July 17, 2001.

Hyperion data are limited to a 7.5 km swath width because the sensor is 512 element array which effectively collects 30 m spatial resolution pixels.

Hyperion Observes Etna - July 13



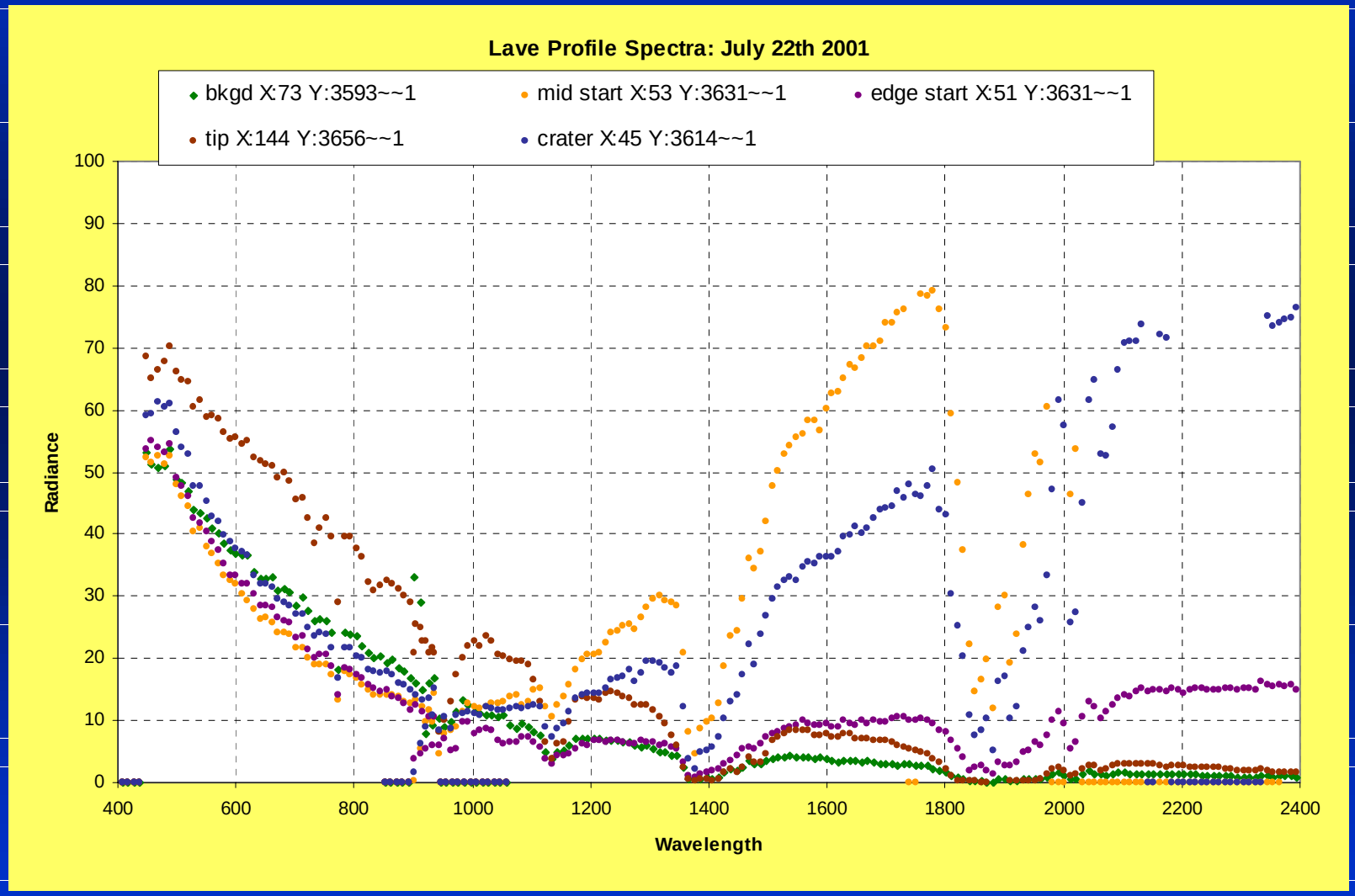
Hyperion Observes Etna - July 22

Part of a Hyperion image on left showing more extensive eruption.

Saturation of detectors over hot channels cause a radiance echo in Hyperion data.

We are working to reconstruct the original analog signal from the saturated pixels and the radiant echo.

Hyperion Spectra - July 22, 2001



Hyperion Temperatures for Etna

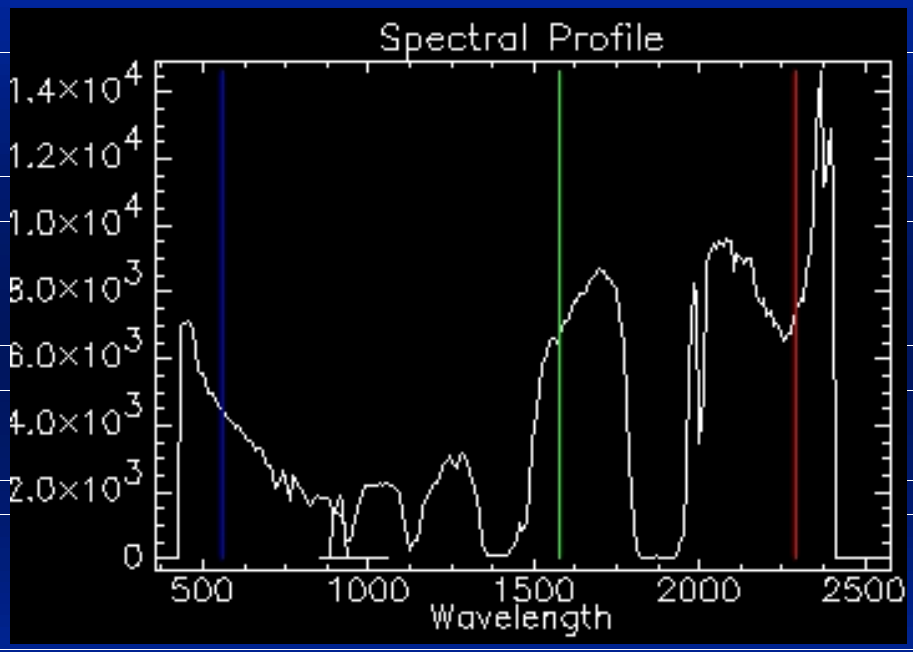
Spectrum	Crust Temp	Hot Temp	Area Hot
J 13 - CTB	346 C	994 C	0.0025
J 13 - MM	874 C	876 C	0.45
J 13 - CTS	976 C	978 C	0.47
J 13 - TipX	210 C	900 C	0.00034
J 22 - MS	726 C	1075 C	0.090
J 22 - CX	487 C	1075 C	0.022
J 22 - RS*	1054 C	1058 C	0.690

Erta Ale Lava Lake, Ethiopia

Erta Ale lava lake in the Danakil Depression of Ethiopia has been almost continuously active since before 1973. Observations of the lake are few and far between because of the adverse environmental and political climate.

Recent observers note that the lake is usually covered by a solid crust. Overturning events occur randomly.

Erta Ale Spectrum



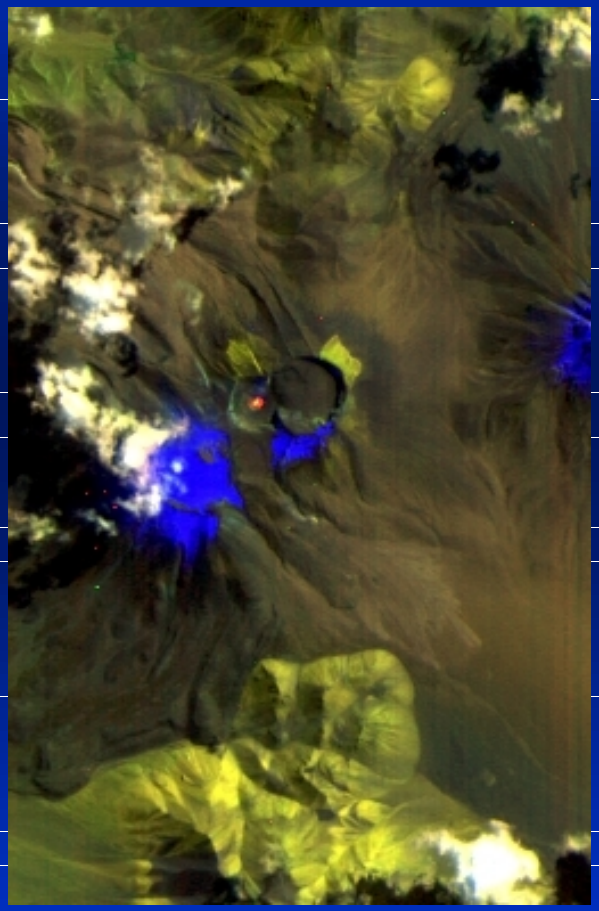
This Hyperion spectrum was acquired from the active lava lake.

Data from 2.1 - 2.5 µm could not be used because of saturation.

Best fit: $T_c = 952^oC$, $T_h = 955^oC$,

$A_h = 0.135$

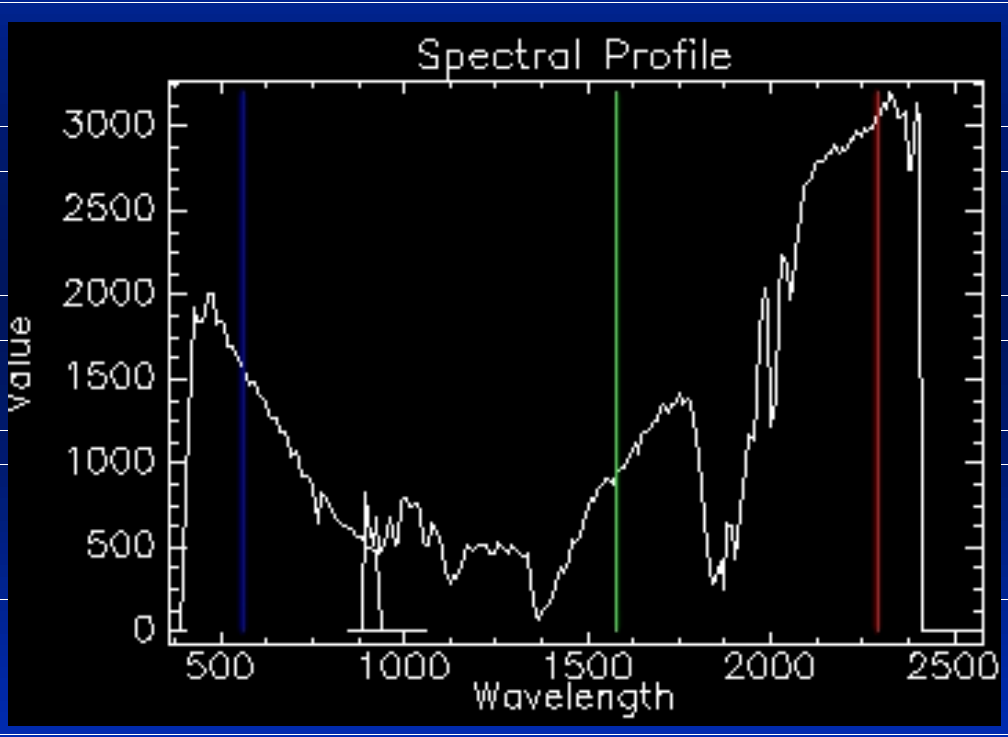
Lascar Lava Dome, Chile



Volcanic activity at Lascar volcano, Chile is marked by development and collapse of lava domes. The dome itself can be covered with cooled lava blocks that are piled 10's of meters over molten, viscous lava.

Lascar last erupted in July, 2000.

Lascar Dome Spectrum



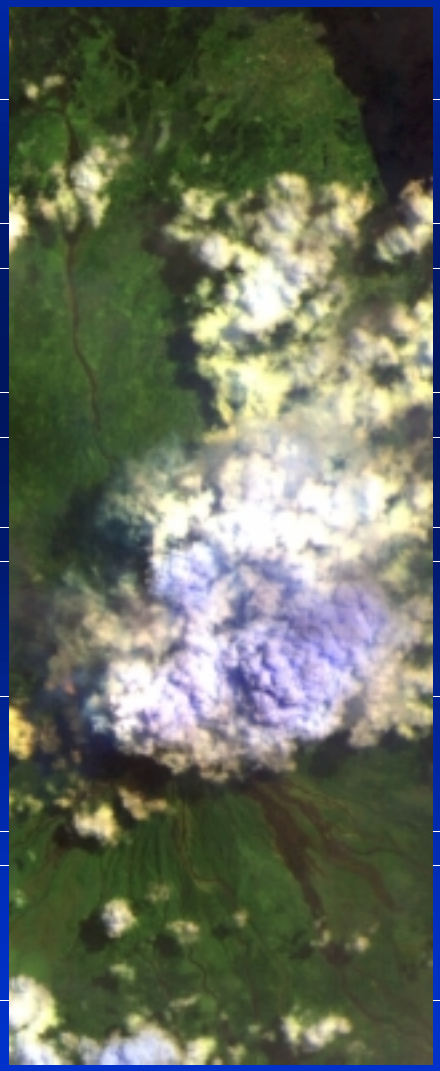
This spectrum was acquired from Lascar volcano lava dome.

Best Fit: $T_c = 505^oC$,

$T_h = 1100^oC$, $A_h = 0.0081$

Corresponds to 7.3 m^2 of molten lava within pixel.

EO-1 Observes Mayon Eruption



EO-1 data swath of the Mayon eruption in the Philippines. The image was collected on July 7, 2001. Bands displayed are 214, 143, and 21 corresponding to wavelengths at 2.295, 1.578, and 0.560 microns.

No hot spot identified in this image.

Summary of Data Acquisitions

- Hyperion pointing very accurate for small targets.
- Re-schedule acquisitions for Popocatepetl, Mexico; Kilauea, Hawaii; Pacaya, Guatemala; and Masaya. Some of these may already have been taken.
- Check reprocessing of “bad” striped data files.

Global Record of Hot Spots

MODIS Thermal Alert web site provides global coverage of the world's hot spots. Data include the lat/lon of the hot spot and its thermal IR radiance.

Web site:
http://hotspot.higp.hawaii.edu/modis

UNIX_Time	Year	Mo	Dy	Hr	Mn	Longitude	Latitude	B21	B22	B29	B31	B32	SatZen	SatAzi	SunZen	Line	Samp	Ratio
1002771300	2001	10	10	17	35	64.641052	38.794113	1.551	1.856	5.827	6.725	6.526	20.479	78.610	139.687	1716	904	-0.557
1002771300	2001	10	10	17	35	64.653824	38.796238	2.140	4.347	5.968	6.858	6.732	20.367	78.610	139.687	1716	903	-0.215
1002771300	2001	10	10	17	35	64.796318	38.932163	1.110	1.155	5.531	6.544	6.401	19.136	79.297	139.687	1728	889	-0.694
1002771300	2001	10	10	17	35	65.778328	31.655418	1.047	1.095	7.366	7.833	7.512	28.648	79.068	144.901	926	992	-0.746
1002771300	2001	10	10	17	35	71.343300	35.445694	1.226	1.638	6.797	7.413	7.029	22.269	-97.575	145.589	1250	431	-0.622
1002771300	2001	10	10	17	35	71.349426	35.442635	3.819	4.347	7.729	7.969	7.549	22.269	-99.752	145.589	1249	431	-0.269
1002771300	2001	10	10	17	35	71.354286	35.446976	2.458	4.347	7.091	7.605	7.292	22.381	-97.575	145.589	1250	430	-0.253
1002771300	2001	10	10	17	35	71.361343	35.444050	1.516	1.302	6.732	7.394	7.143	22.381	-99.752	145.589	1249	430	-0.692
1002771000	2001	10	10	17	30	72.341019	18.705587	1.374	1.445	8.124	8.459	7.700	2.854	80.214	156.417	1453	709	-0.697
1002765000	2001	10	10	15	50	100.845001	4.471719	1.337	1.404	7.518	8.069	7.449	3.609	-94.481	161.746	292	637	-0.683
1002765000	2001	10	10	15	50	102.316833	8.033021	1.094	1.082	8.209	8.722	7.962	24.060	-98.434	163.579	657	412	-0.761

Work in Progress

- Assess Etna lava channel radiance using ALI MS 5’ band.
- Assess ALI pan band for mapping fresh lava flows.
- Complete Hyperion survey of different types of volcanic targets.