A Global Volcano Product for Thermal Emission and Effusion Rate: Hyperion and HysplRI

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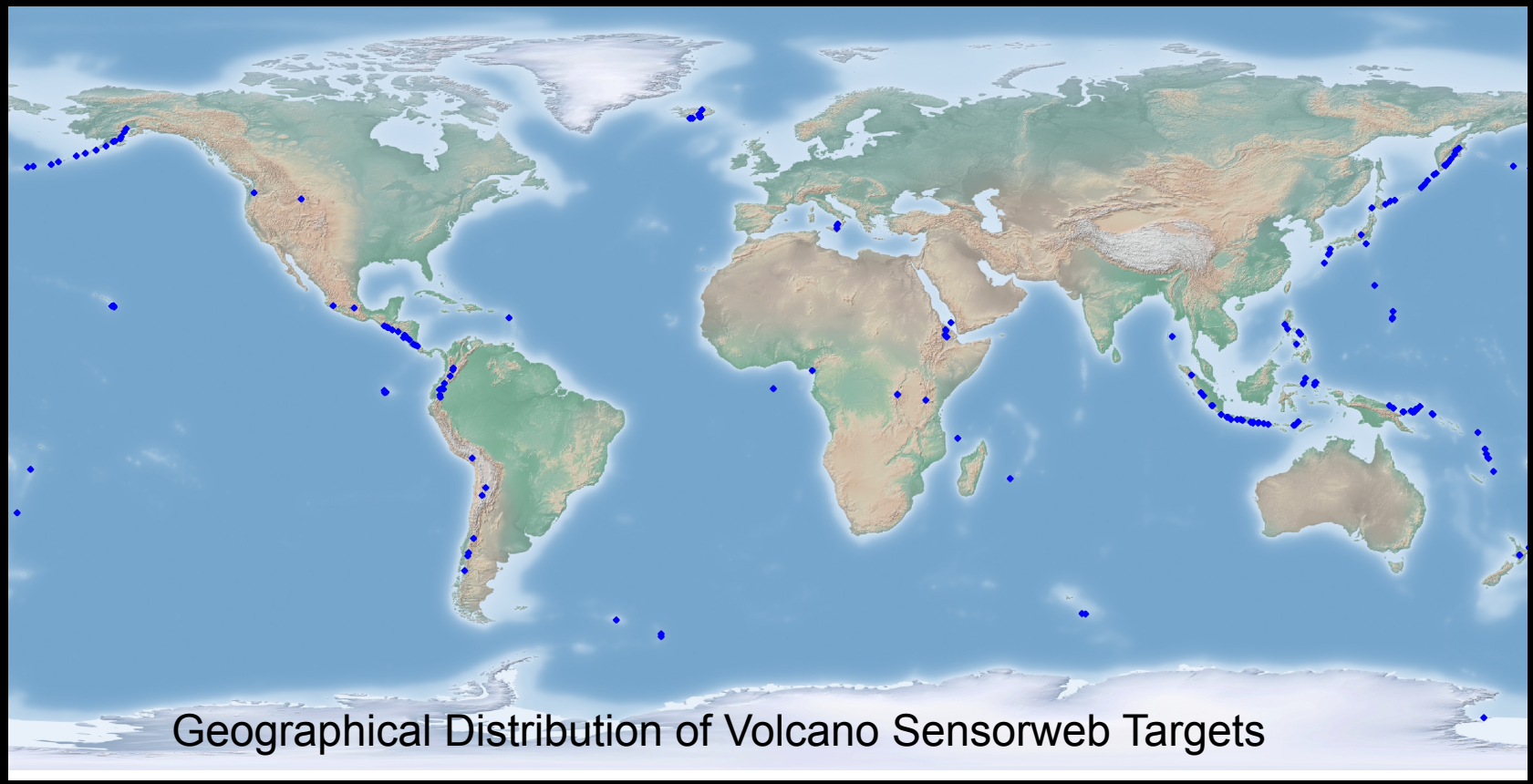
Overview

- EO-1 Volcano Sensorweb
  - Uses in-situ, other satellite, and hybrid sources to task EO-1 to acquire imagery of active volcanoes
  - Automated processing workflows to derive *science products*
  - Applicability to HyspIRI?

Volcano Sensorweb - Hyperion

- Large archive of volcano scenes (100's/year 1000's total)
  - 589 volcanic scenes in FY2010 (10/2009-09/2010) alone
  - 249 of these have non-zero thermal signatures



Geographical Distribution of Volcano Sensorweb Targets

Volcano Sensorweb - Impact

Table 1: Volcano Science Alerts for October – November 2010 by Alert Source	
Alert Source	Number of Alerts
MODVOLC	517
AFWA	459
Iceland VEDUR	9
VAAC	2

Table 2: Volcano Science Alerts or October – November 2010 by Volcano Target	
Number of Alerts	Volcanoes with this number of alerts
50+	Batu Tara, Dukono, Kliuchevskoi, Merapi, Shiveluch
10-49	Ambrym, Bagana, Barren Island, Erebus, Erte Ale 2, Halemaumau HI, Karymsky, Kilauea 2, Manam, Piton de la Fournaise, Popocateptl, Semeru, Tinakula, Tungurahua, Villarrica
1-9	Chaiten, Eyjafjallajokull, Fuego, Grimsvotn, Ibu, Krakatau, Lolobau, Nevado del Huila, Oldoinyo Lengai, Planchon Peteroa, Reventador, Sakura Jima, Sangay, Santa Maria, Soufriere Hills, Stromboli, Sulu Range, Ubinas, Yasur.

HysplRI

- Will have much better global coverage
  - 600 km TIR swath
  - 150 km VSWIR swath
- Analysis using MODVOLC, VAAC, AFWA alerts from [10/2004-7/2010] and CBE HysplRI ephemeris [Jones 2010]

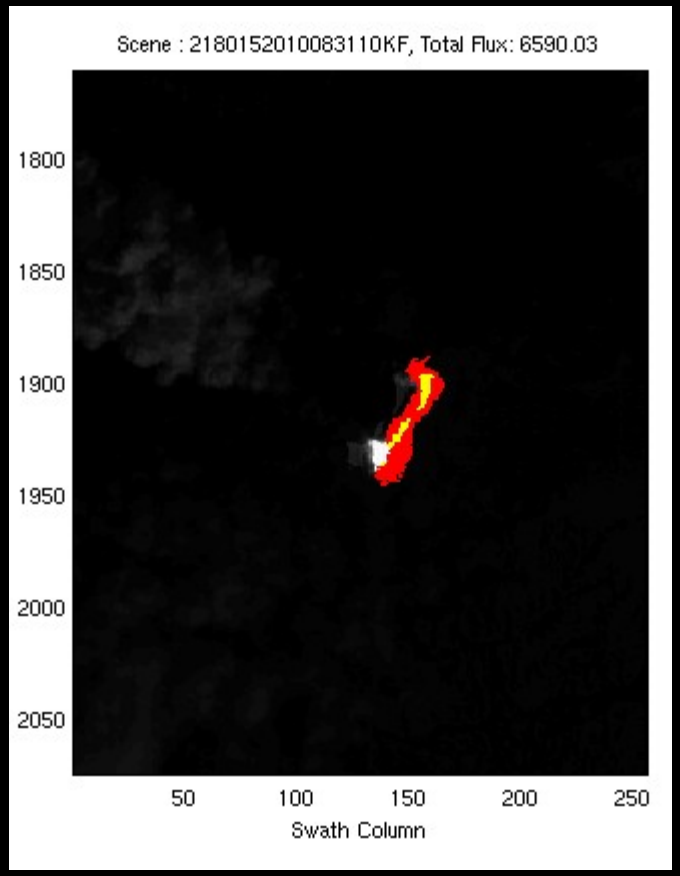
Over 5.83 years	HysplRI TIR	HysplRI VSWIR
Events per year (merge adjacent)	320	193
Overflights for events per year	2184	512

Wait…HyspIRI is Nadir!

- Alert system still useful:
  - IPM product generation @ higher priority
  - Atypical collects
    - Nighttime VSWIR
    - Plume collects (VSWIR over deep ocean)

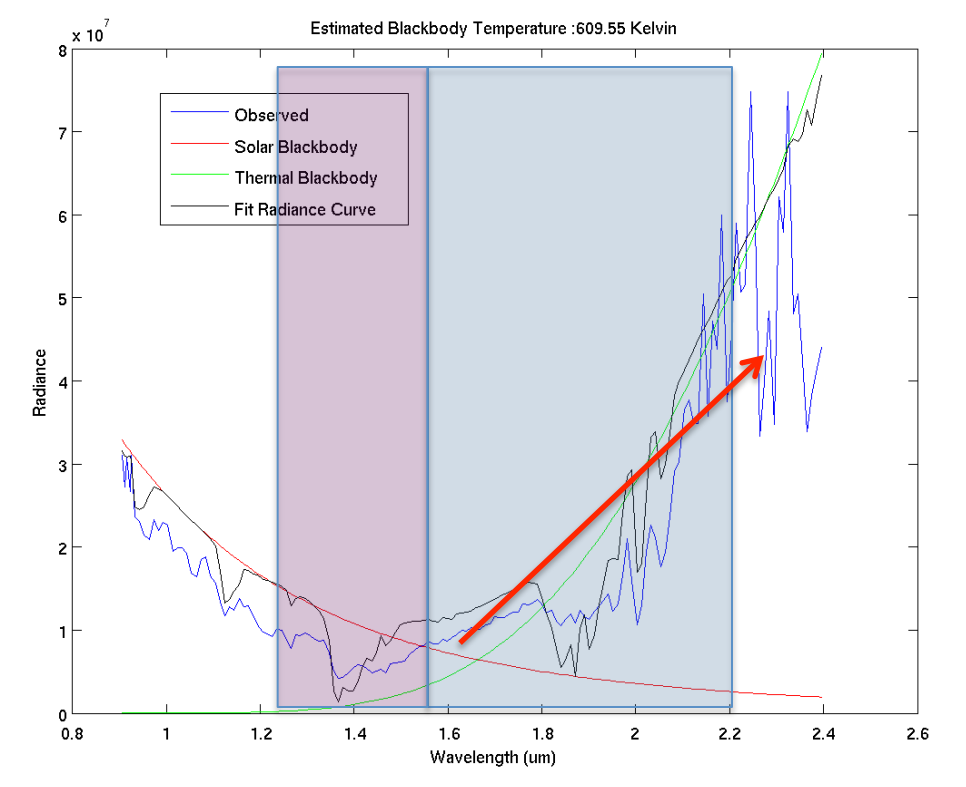
Hyperion Thermal Product: Basic

- Hyperion processing chain
  - Raw Instrument Data
  - Process to L0
  - Process to L1
  - Top of Atmosphere (TOA) radiance correction
    - Extract parameters for solar reflectance component



Hyperion Thermal Product: Basic

- Extract hot pixels
  - Use decision tree based on absolute spectral values and slope



Description	Measure
H1: Hot radiance minimum and pixel not noisy	0.625 < 1.65 μm, 2.25 μm, & 2.28 μm < 750
H2: Min. slope for trigger?	Slope G > 0.13558 G=1.4 for DNs
H3/E3: No 2.28μm spike	(2.28μm+1.65μm)/2< 2.25μm*1.2
E1: Extreme radiance min.?	0.625 < 1.25 μm, 1.65 μm, & 2.28 μm < 750
E2: Spectrum shape	2.28 μm > 1.65 μm/2

Hyperion Thermal Product: Thermal pt 2

- Per pixel
  - Delete bad bands from band table
  - Spectral set of data points
    - spectral curve trying to match
  - Use Metropolis Hastings Markov Chain Monte Carlo (MCMC) sampling to conjecture area, temp
  - Assume three parts
    - Reflected sunlight (from above)
    - Hot lava (area, temperature)
    - Ambient remainder (area, temperature)
  - Terminate based on MCMC non-improvement

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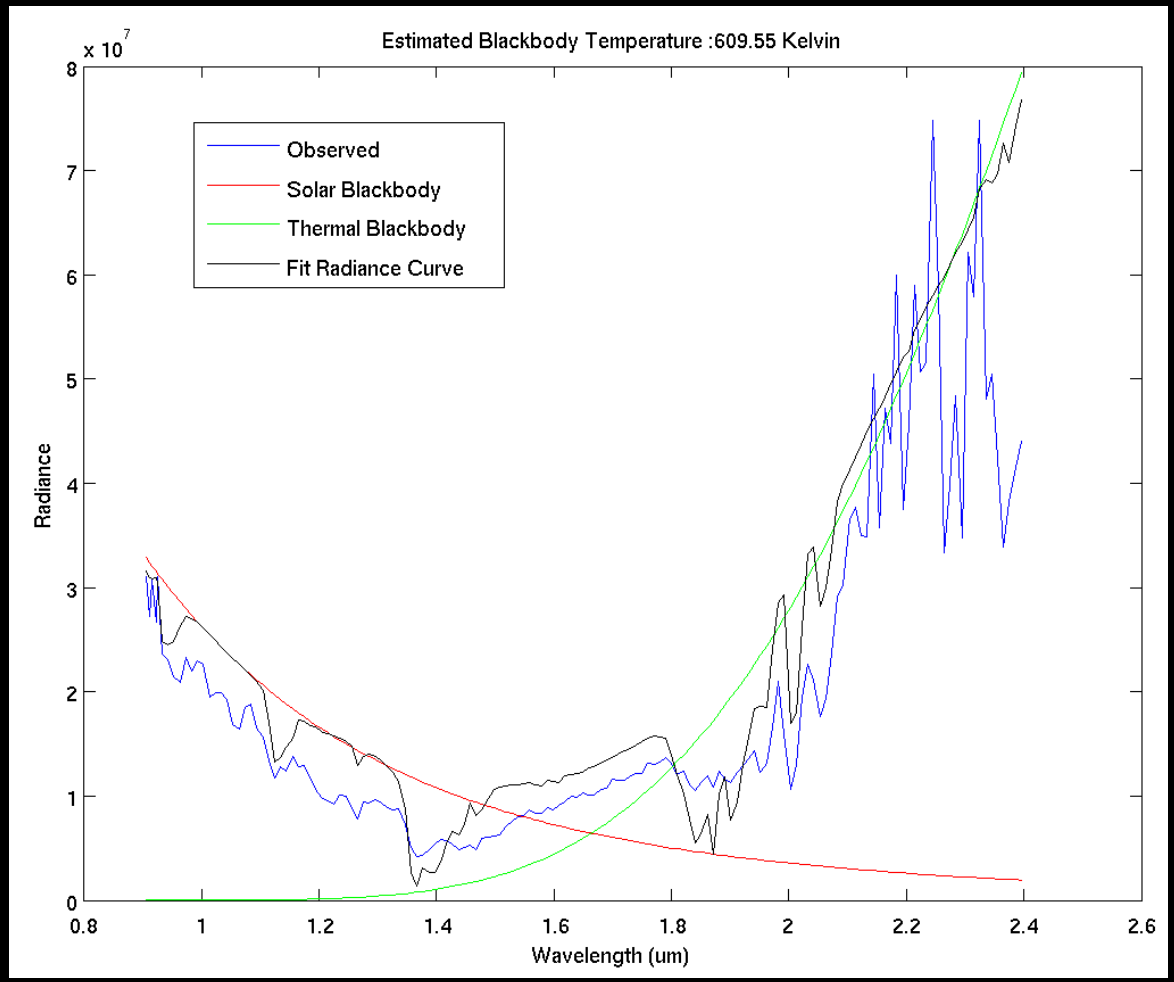
Current work:
model multiple lava areas, temperatures

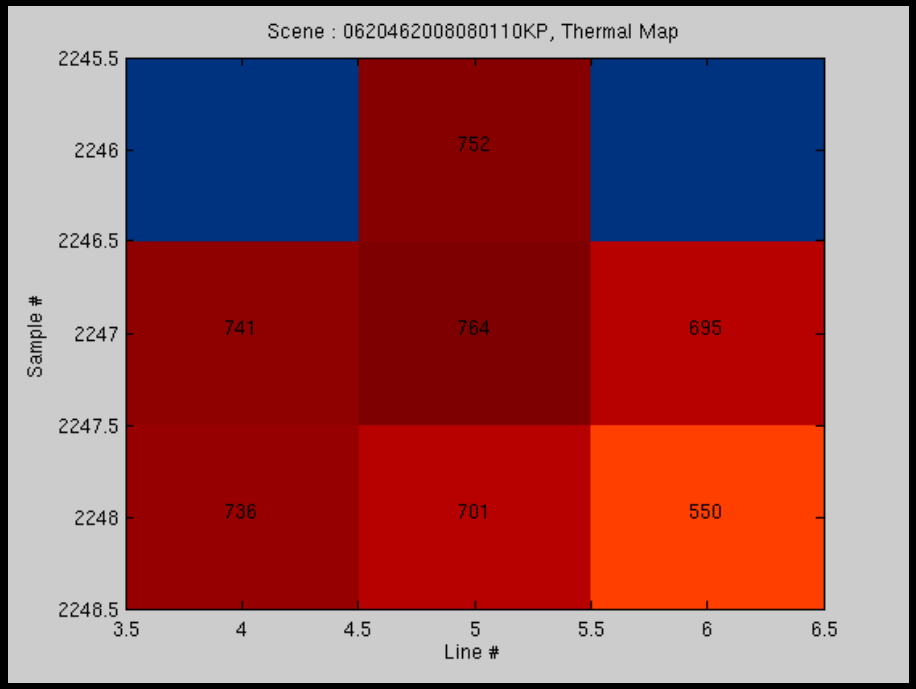
Hyperion Thermal Product: Thermal pt 2

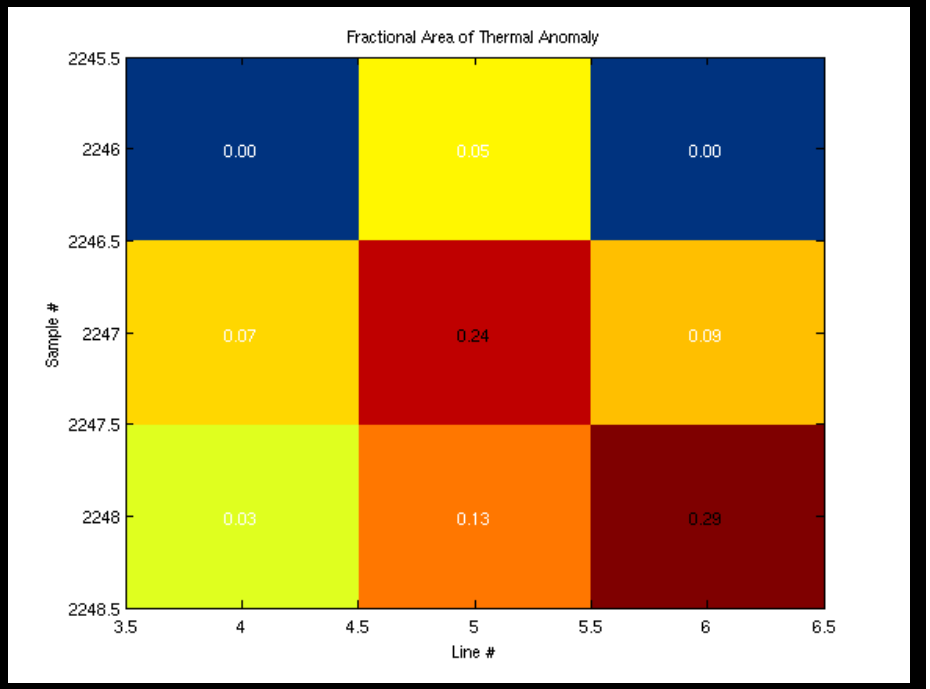
- Per pixel



Hyperion Thermal Product: Thermal pt 2

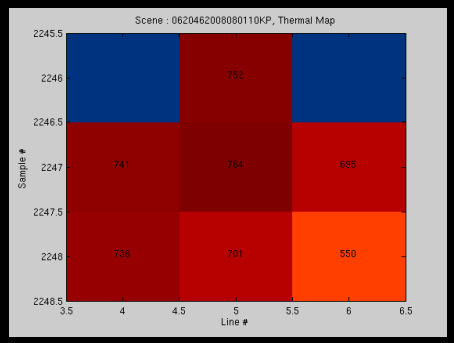
- Preliminary set of areas and temperatures

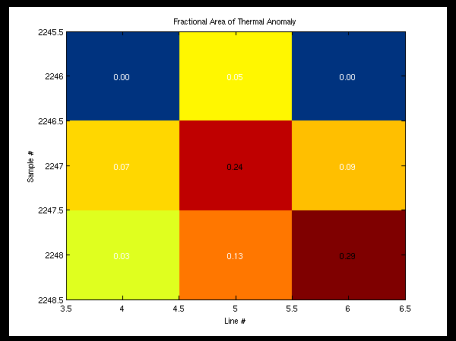




Hyperion Thermal Product: Thermal pt 2

- Correct for viewing geometry (look angle)
- Correct for distance to target
  - orbital altitude & geometry
- Produces refined set of areas and temperatures → energy loss → effusion rate





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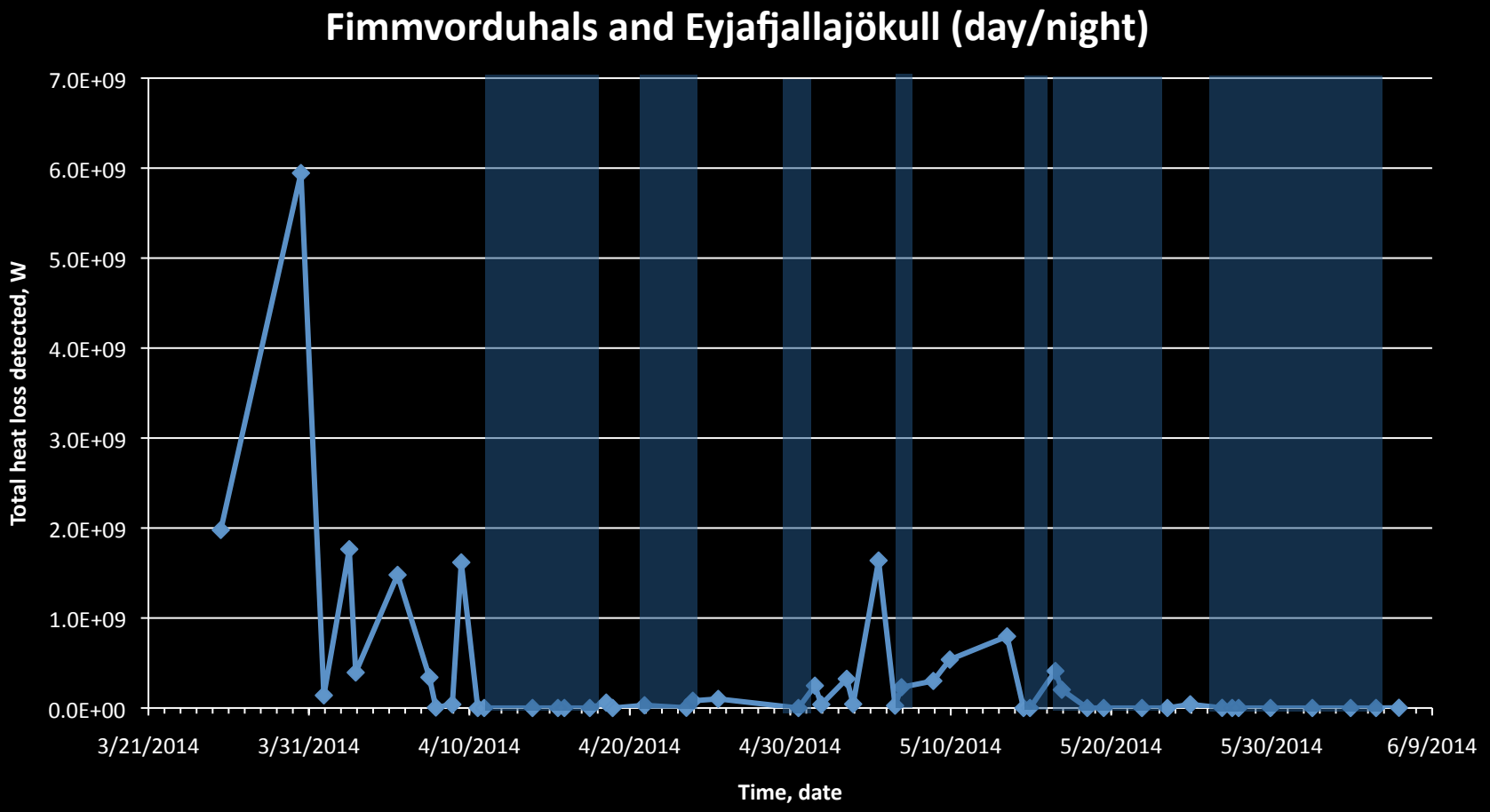
Parameters:

Mass Effusion rate: 6590.03 kg/s
Volumetric Effusion rate: 2.64 m^3/s
Total Power loss: 1.98e+09 W
Radiative Power loss: 1.61e+09 W
Convective Power loss: 3.66e+08 W
Total effective area : 7.98e+04 m^2
Effective temperature: 7.73e+02 K
Look Angle: 12.63 deg.
Range to Ground: 705.85 km

Convective, radiative power loss using ambient temperature

Effusion Timeseries



Thermal emission estimate is minimum value:

- estimates from short wavelength data
- thermal detections heavily impacted by cloud and/or plume…
  (~ 25 / 50% of 50 images taken in this timespan)

… and we would like to know by how much!

Ideally

- Data would be automatically assimilated with other sources
  - MODIS (VIIRS in HyspIRI era)
  - ASTER
  - In-situ (e.g. Iceland, aerial FLIR, ground FLIR)

Conclusions

- Volcano sensorweb alerts can be used to estimate coverage and volume of volcano products
- Automation can enable rapid tasking, automated analysis, and data delivery
- End goal is integrated sensing, modeling, and product generation/delivery
- All of the above concepts are mature and directly applicable to HyspIRI mission