SIMULATED HYSPIRI DATA FOR MEASURING VOLCANIC THERMAL FEATURES

R. Greg Vaughan

USGS, Astrogeology Science Center, Flagstaff, AZ

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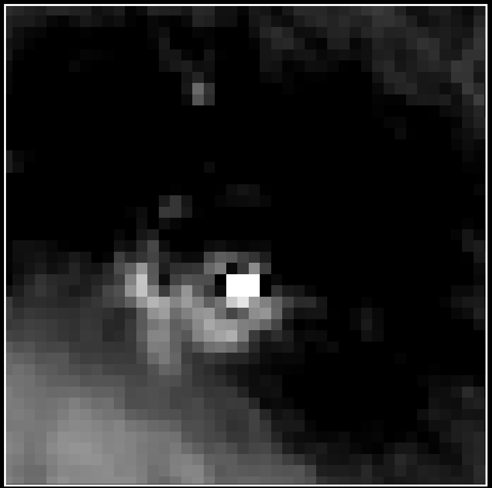

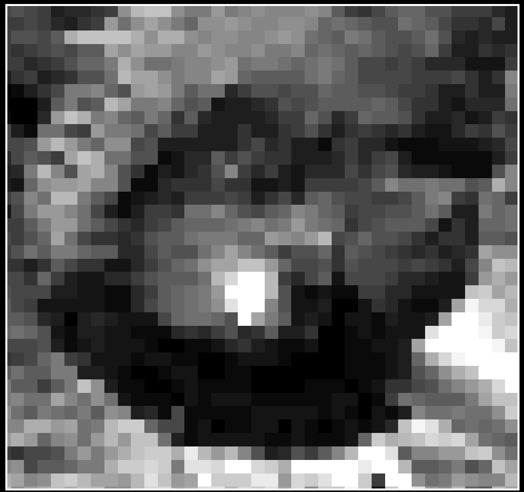

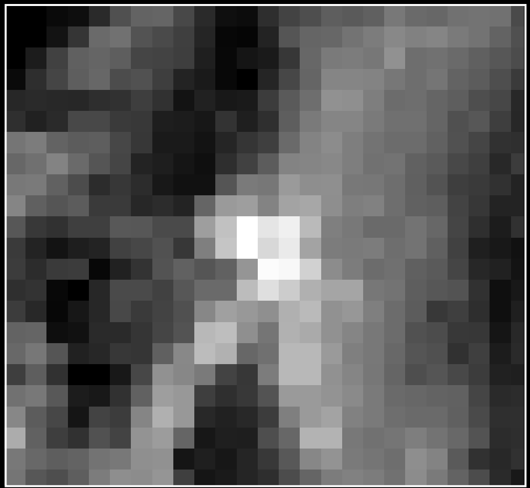

ACKNOWLEDGEMENTS

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2) USGS
3) National Park Service
4) NASA / Jet Propulsion Laboratory

HyspIRI Science Questions

1) How can we help predict and mitigate volcanic hazards through detection of transient thermal phenomena? (TQ1)

2) How do volcanoes signal impending eruptions through changes in surface temperature and thermal flux? (CQ3)

Outline

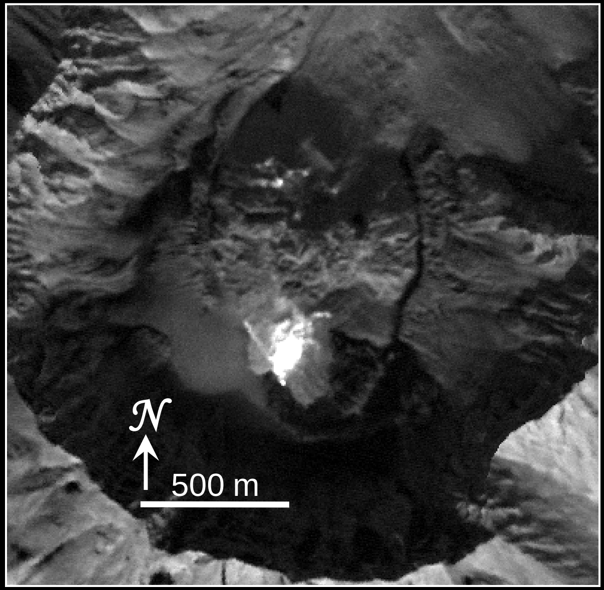
1) Simulated HyspIRI data over two different thermal targets with differing temperatures:
   - i) the 2004 Mount St. Helens dome, and
   - ii) hot springs in the Yellowstone geothermal area.

2) Analysis of the dynamic range of HyspIRI TIR (MIR and LWIR) channels.

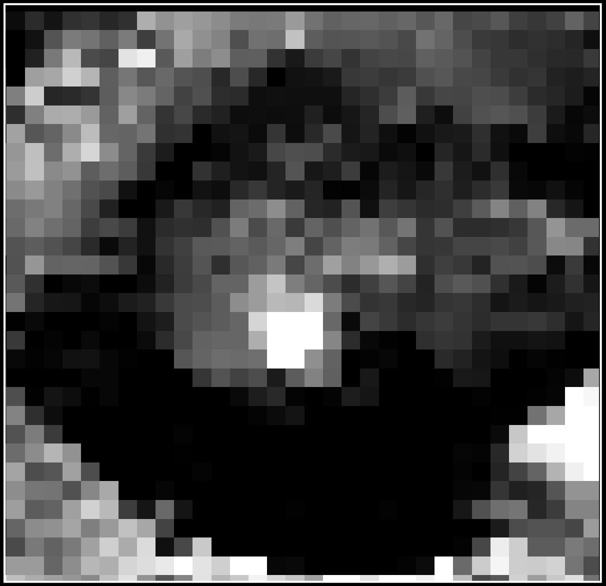
Mount St. Helens dome eruption – Oct. 2004

MASTER
5 m pixels

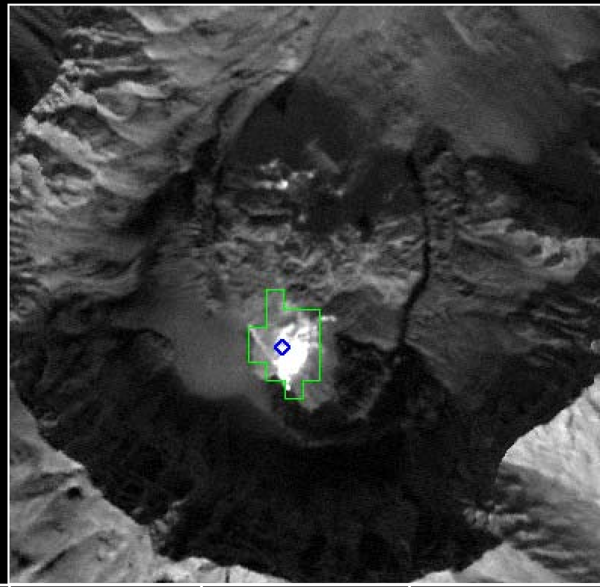
9.1 um data



HyspIRI-sim
60 m pixels

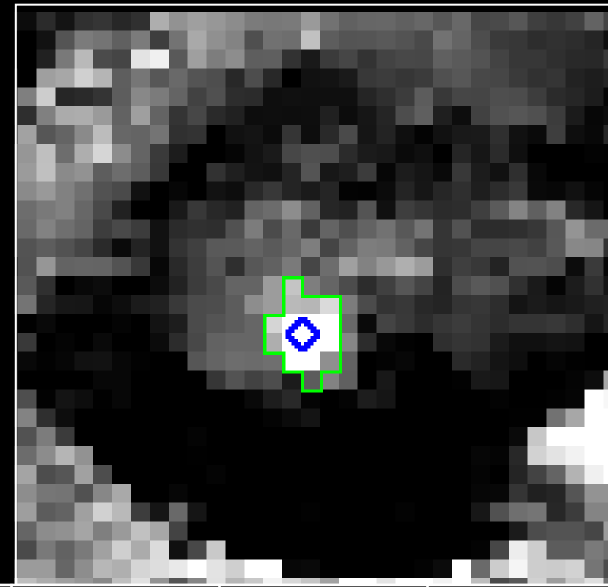


MASTER
5 m pixels



HyspIRI-sim
60 m pixels

ROI area: 57,600 m^2

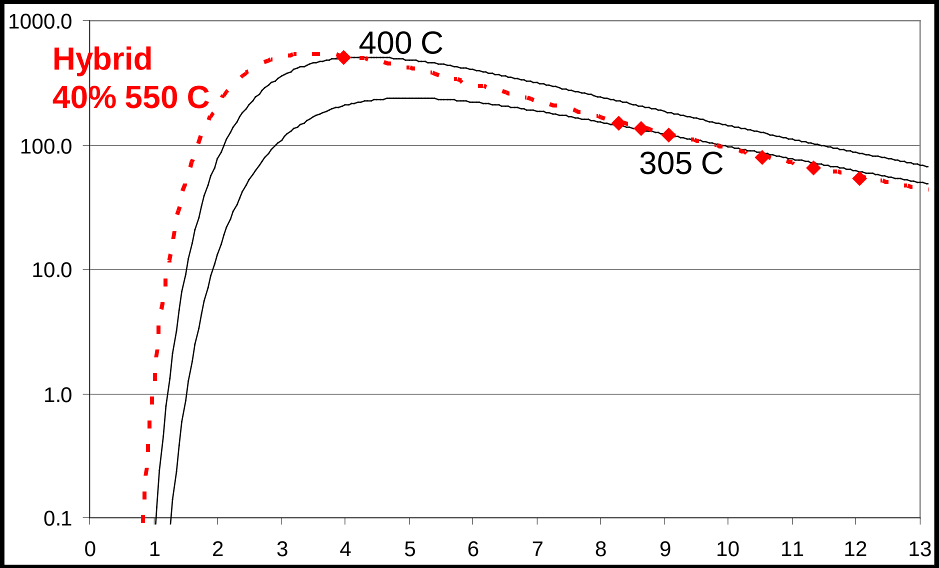


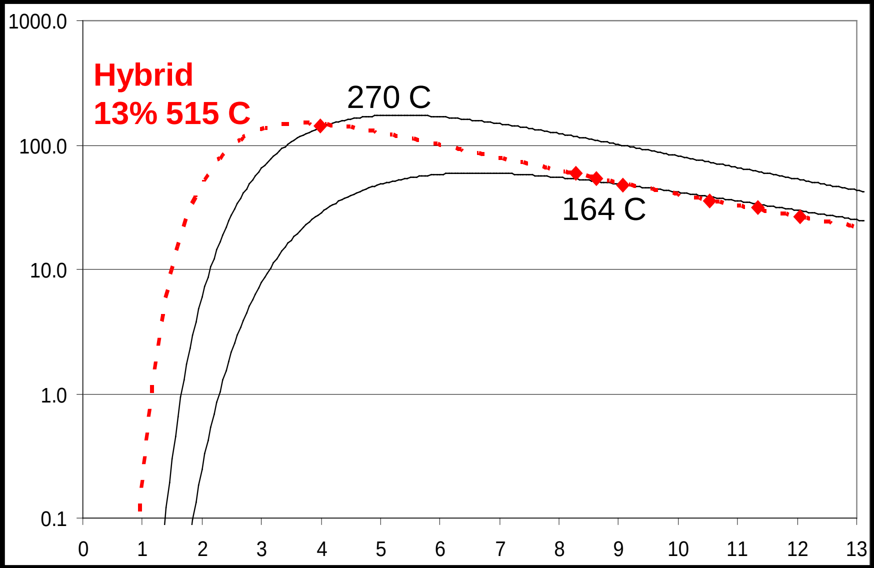
9.1 um	Min	Max	Mean		Min	Max	Mean
Radiance ($W/m^2/um/sr$)	7	119	12.5		8	47	14
Temp (C) ε = 0.9	10	305	47		20	164	55
Thermal Flux (MW)			SUM 31				SUM 34
4.0 um	Min	Max	Mean		Min	Max	Mean
Radiance ($W/m^2/um/sr$)	0.3	504	8.8		0.9	142	14
Temp (C) ε = 0.9	4	400	108		33	270	129
Thermal Flux (MW)			SUM 62				SUM 77

MASTER
5 m pixels

HyspIRI-sim
60 m pixels

ROI area: 57,600 m^2





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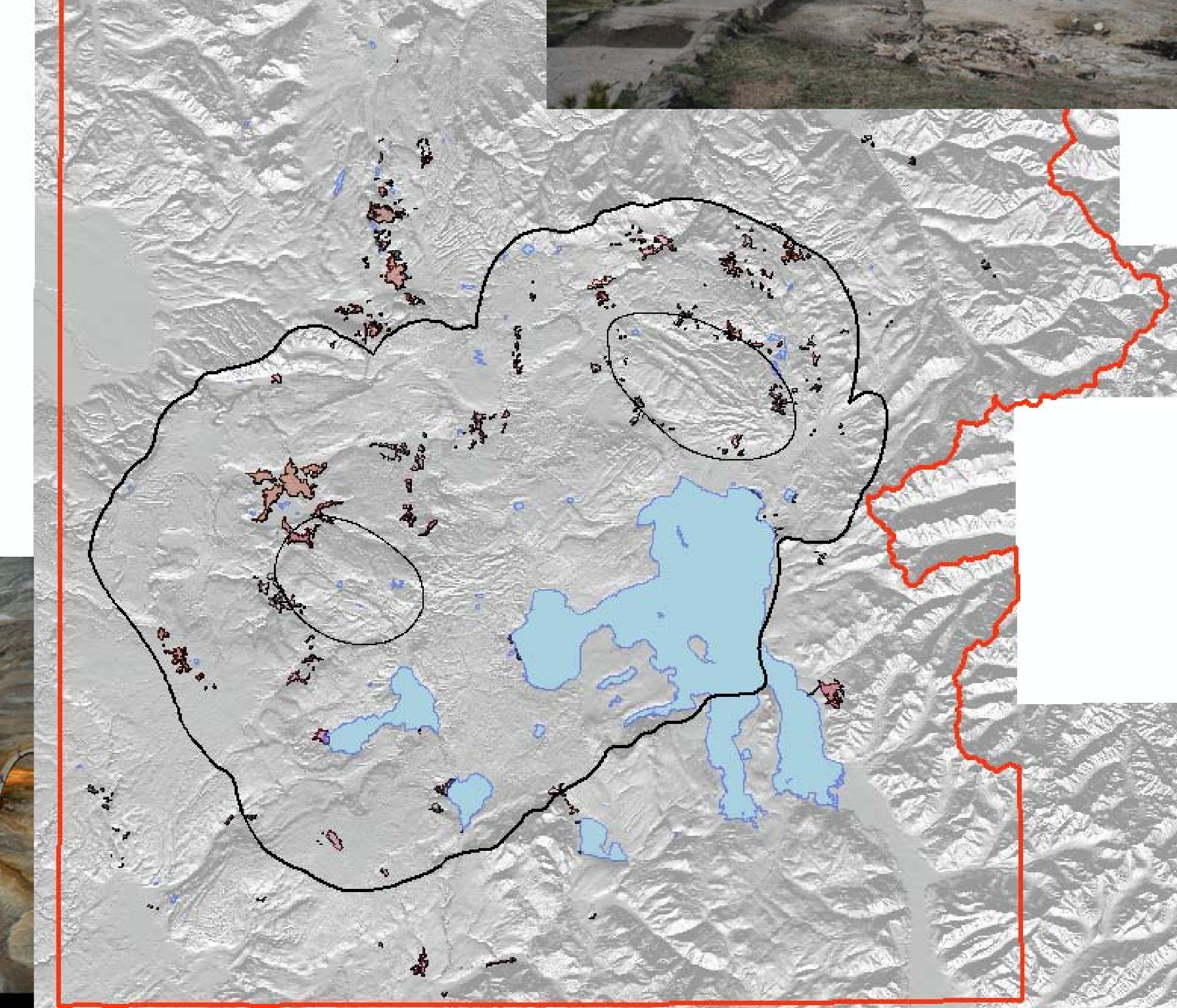
Yellowstone Geothermal Area

The Challenge of Thermal Monitoring

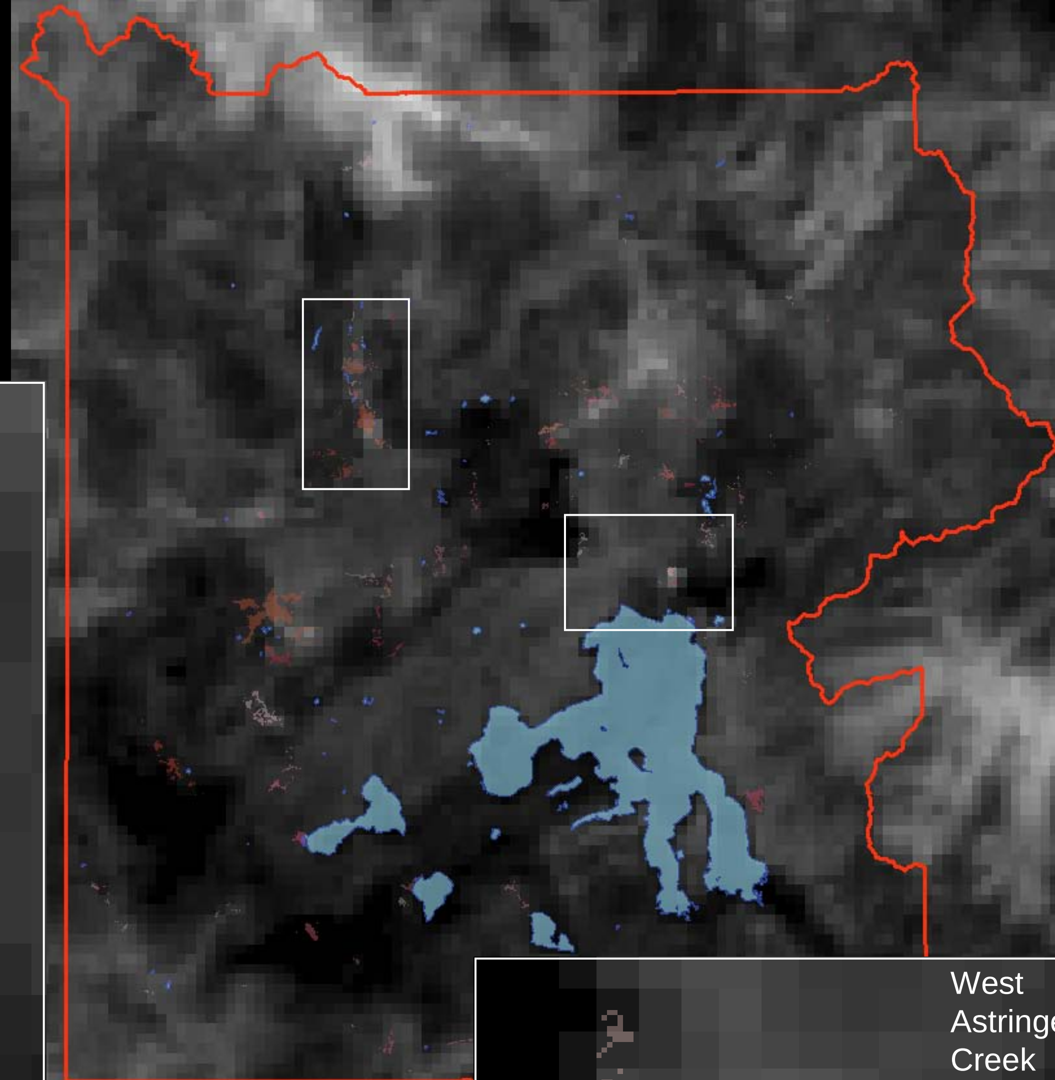
Over 10,000 individual thermal features, including fumaroles, mud pots, and the famous hot spring pools and geysers.

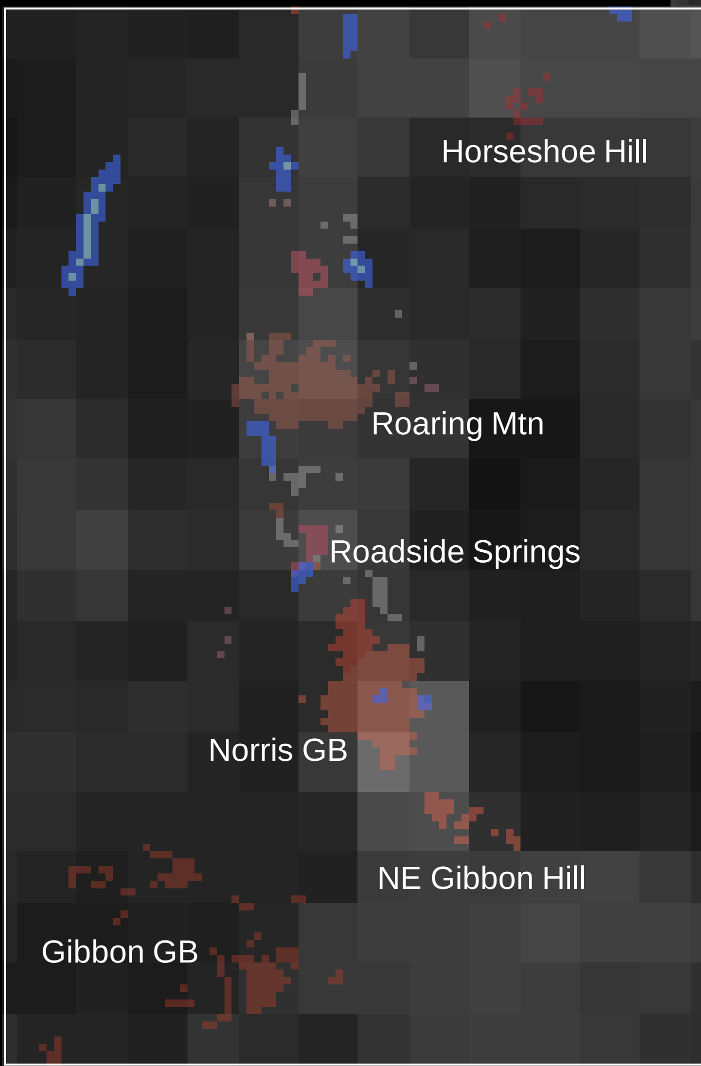
Most of these are clustered into about 80 unique thermal areas (thermal barrens).



MODIS TIR radiance
1 km pixels

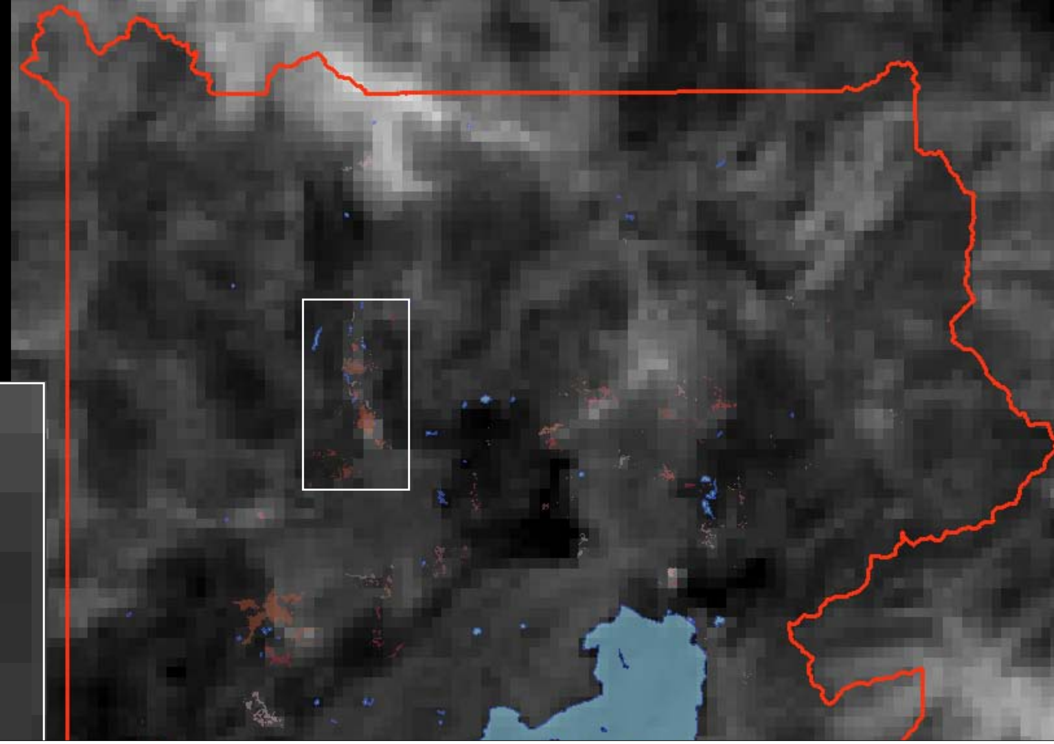
March 3, 2000 – Night
Nadir
Cloud-free

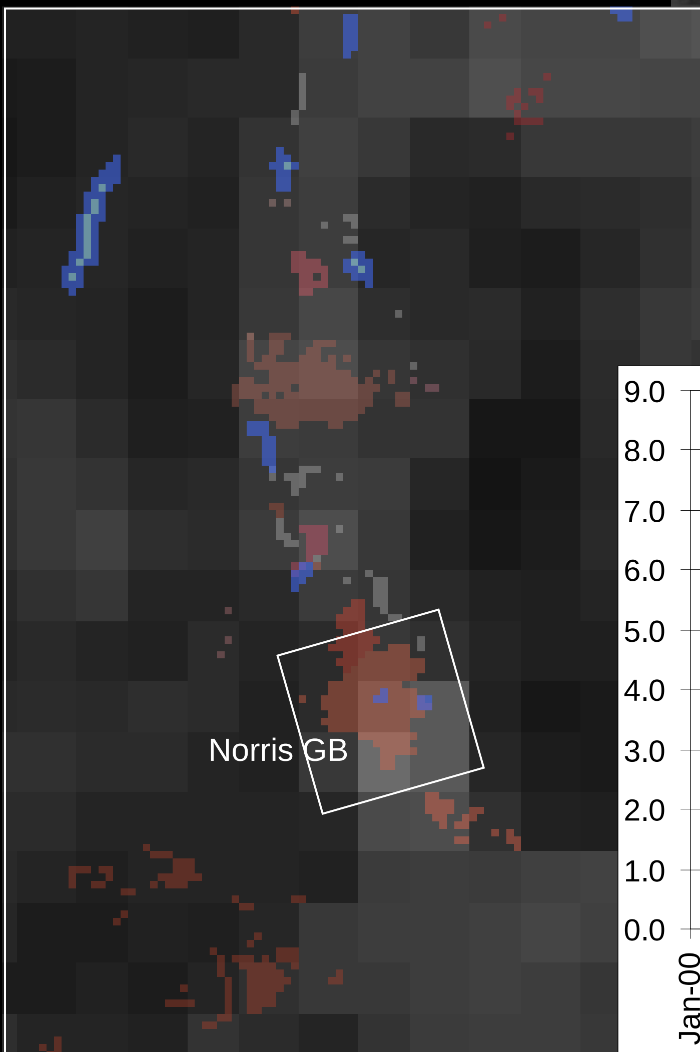


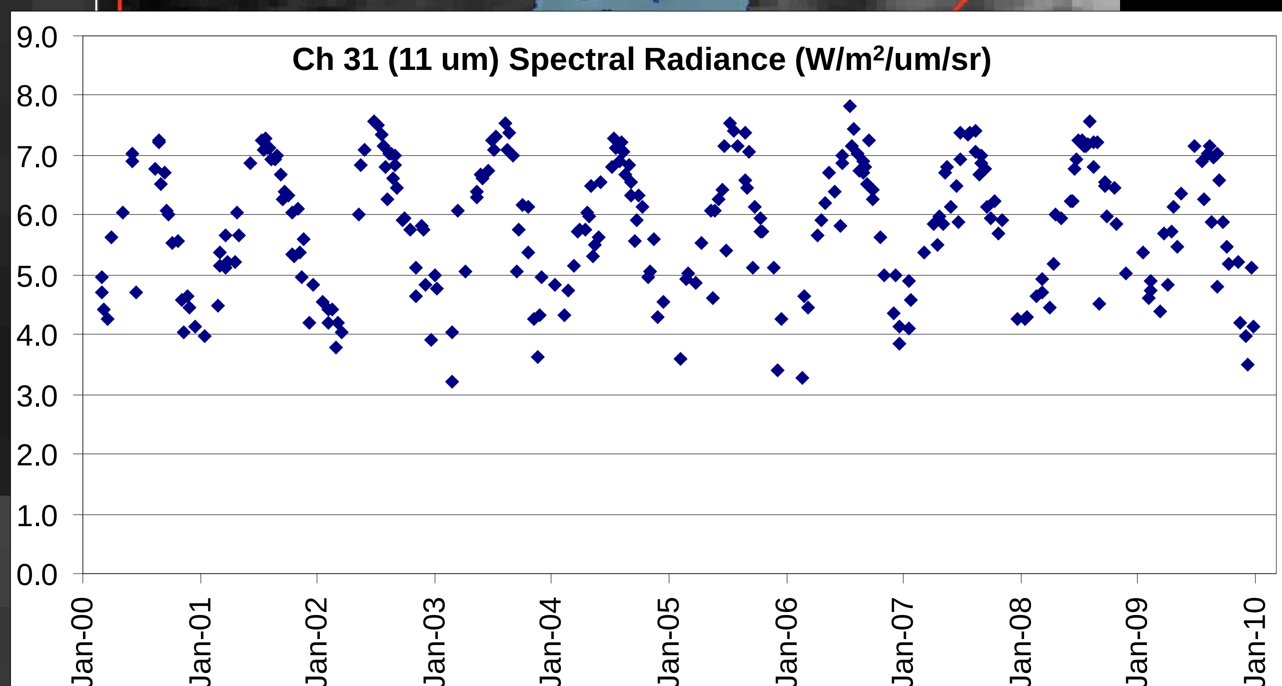


MODIS TIR radiance
1 km pixels

March 3, 2000 – Night
Nadir
Cloud-free

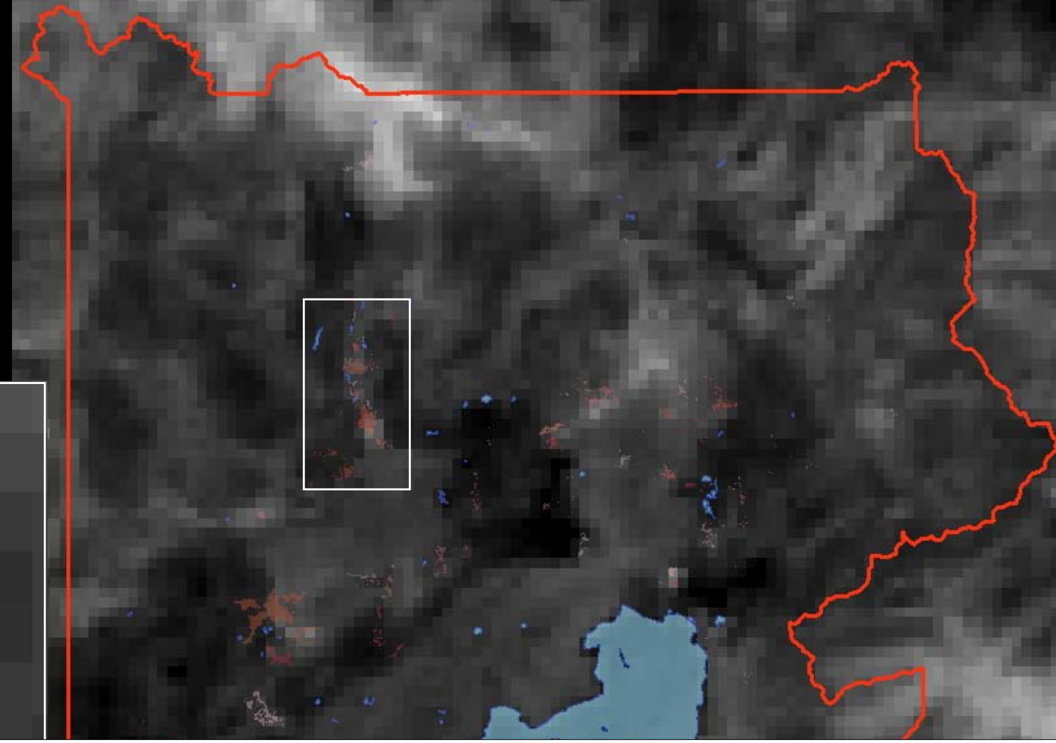


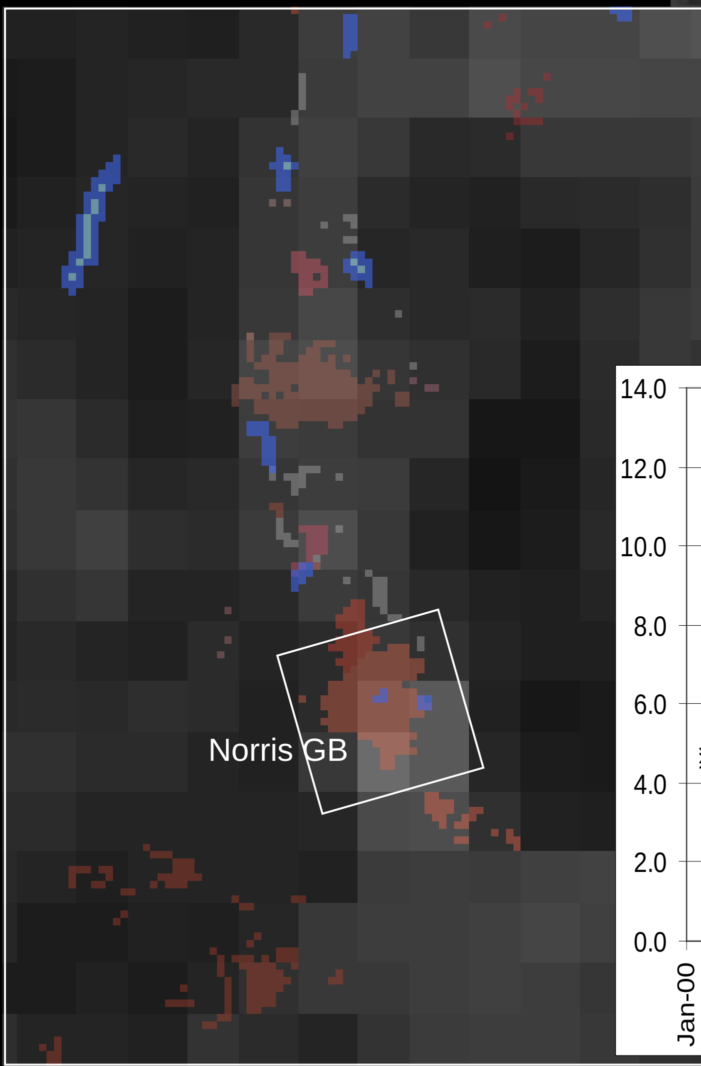


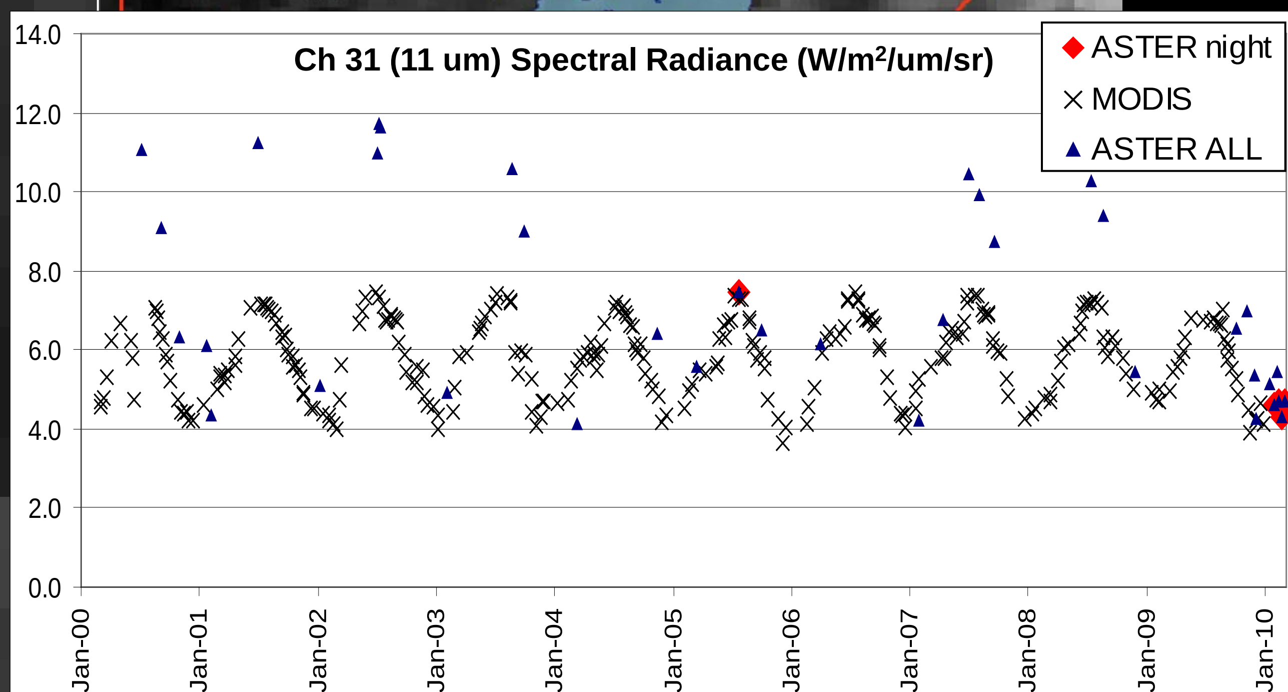


MODIS TIR radiance
1 km pixels

March 3, 2000 – Night
Nadir
Cloud-free

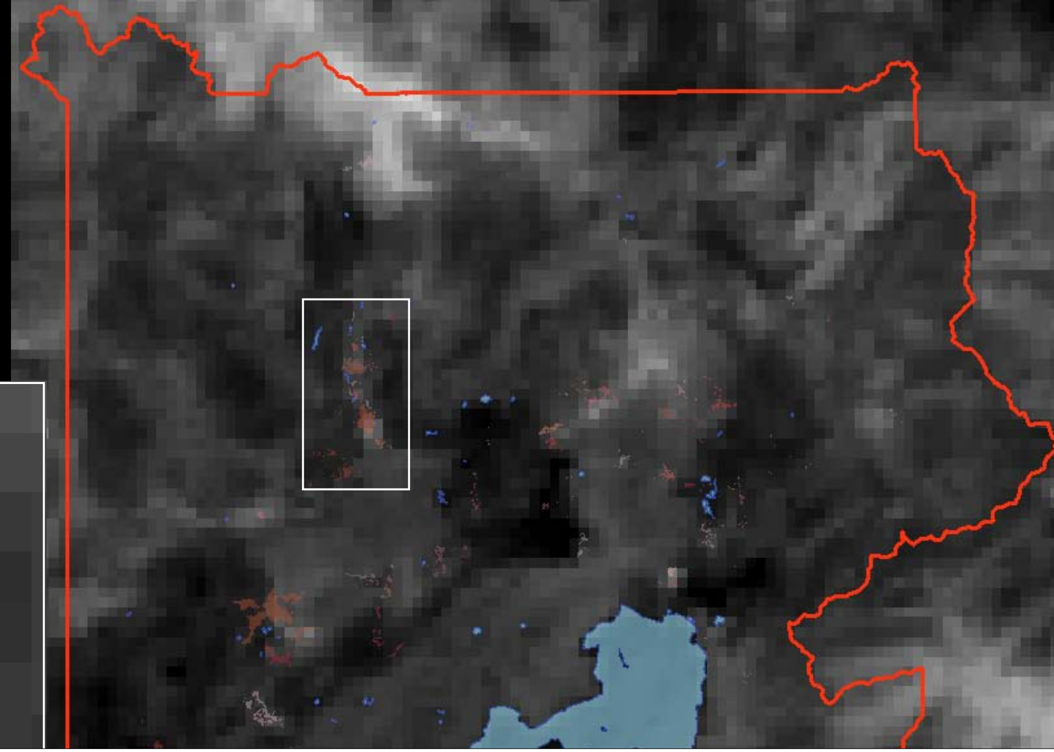


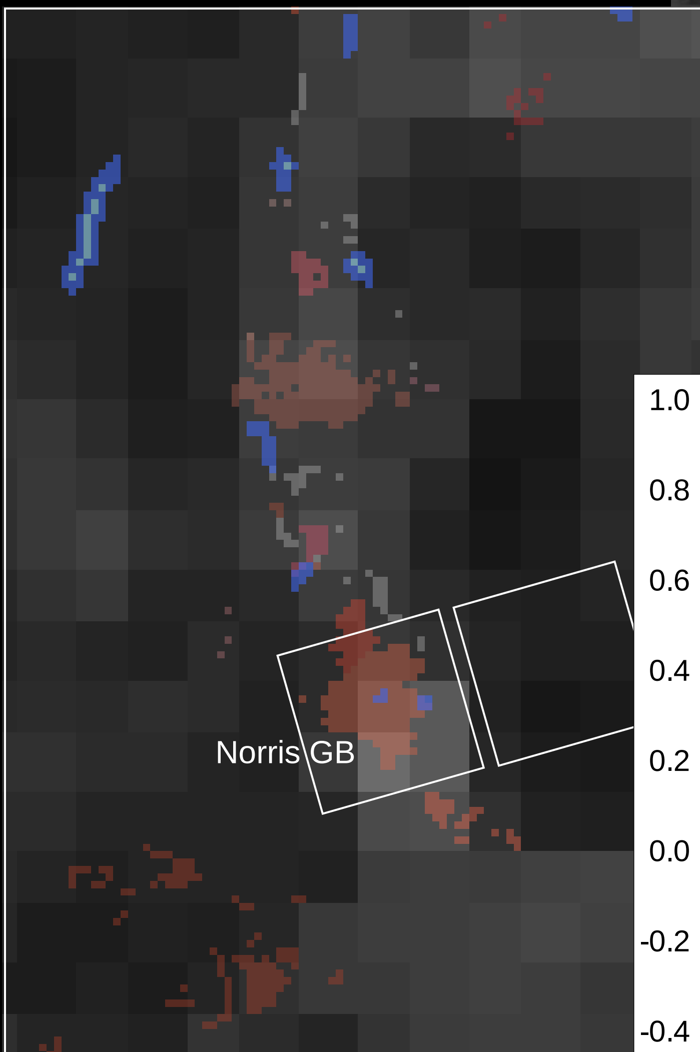


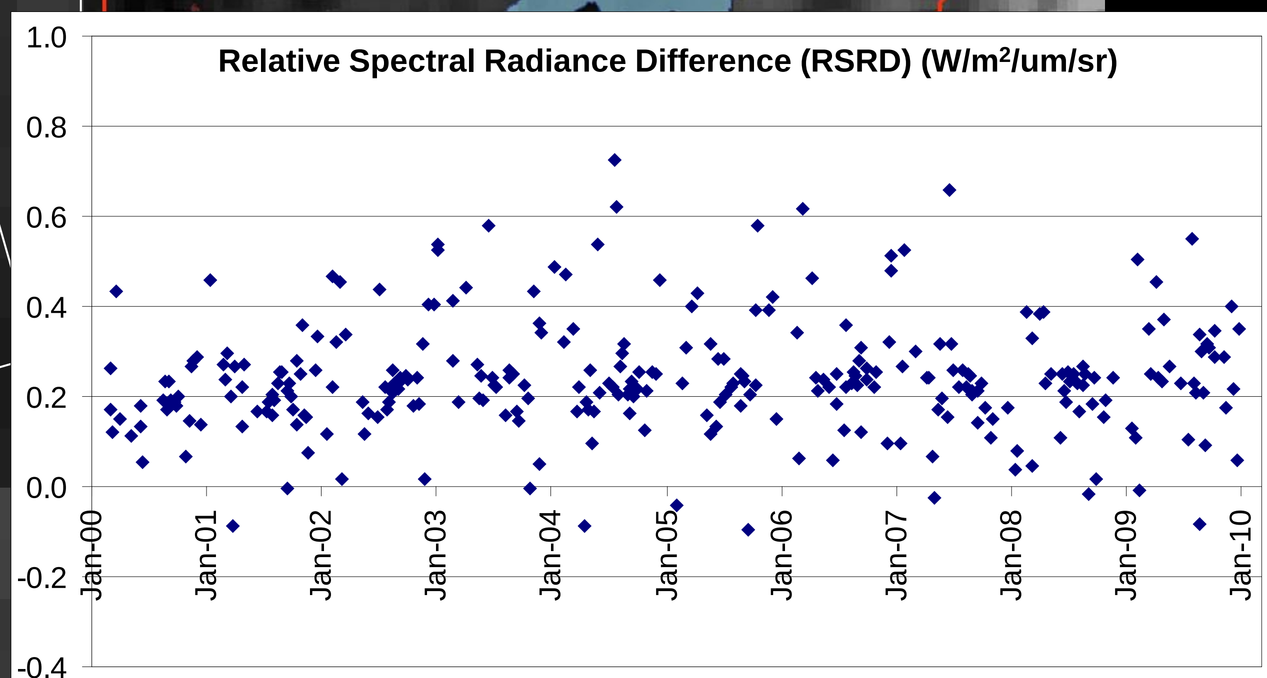


MODIS TIR radiance
1 km pixels

March 3, 2000 – Night
Nadir
Cloud-free





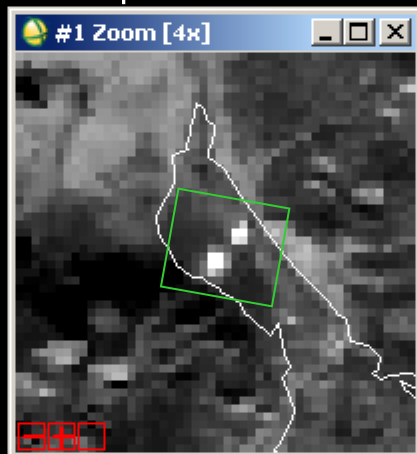


Yellowstone Geothermal Area

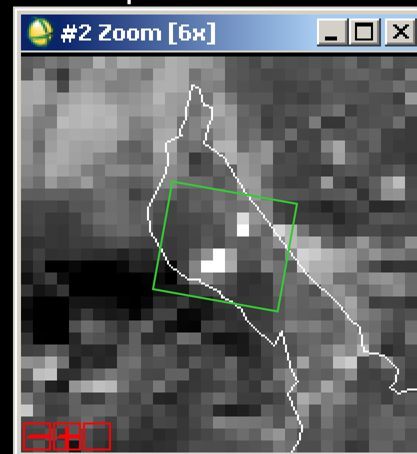
Midway Geyser Basin
Grand Prismatic
Spring & Excelsior
Geyser Crater

September 2006 – Day – 10.7 um

MASTER
45 m pixels

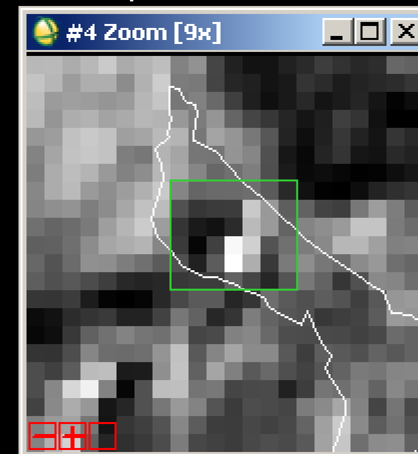


HyspIRI-sim
60 m pixels



September 2007 – Day – 10.7 um

ASTER
90 m pixels



10.7 um	Max Temp (C)	Mean Temp (C)	Thermal Flux (MW)
MASTER 45-m	57	22	143
MASTER 60-m	56	21	142
ASTER 90-m	35	22	142

ROI area:
340,000 m^2

ASTER TIR radiance
90 m pixels

Mostly cloud-free
Night time Mosaic
Thermal areas in blue

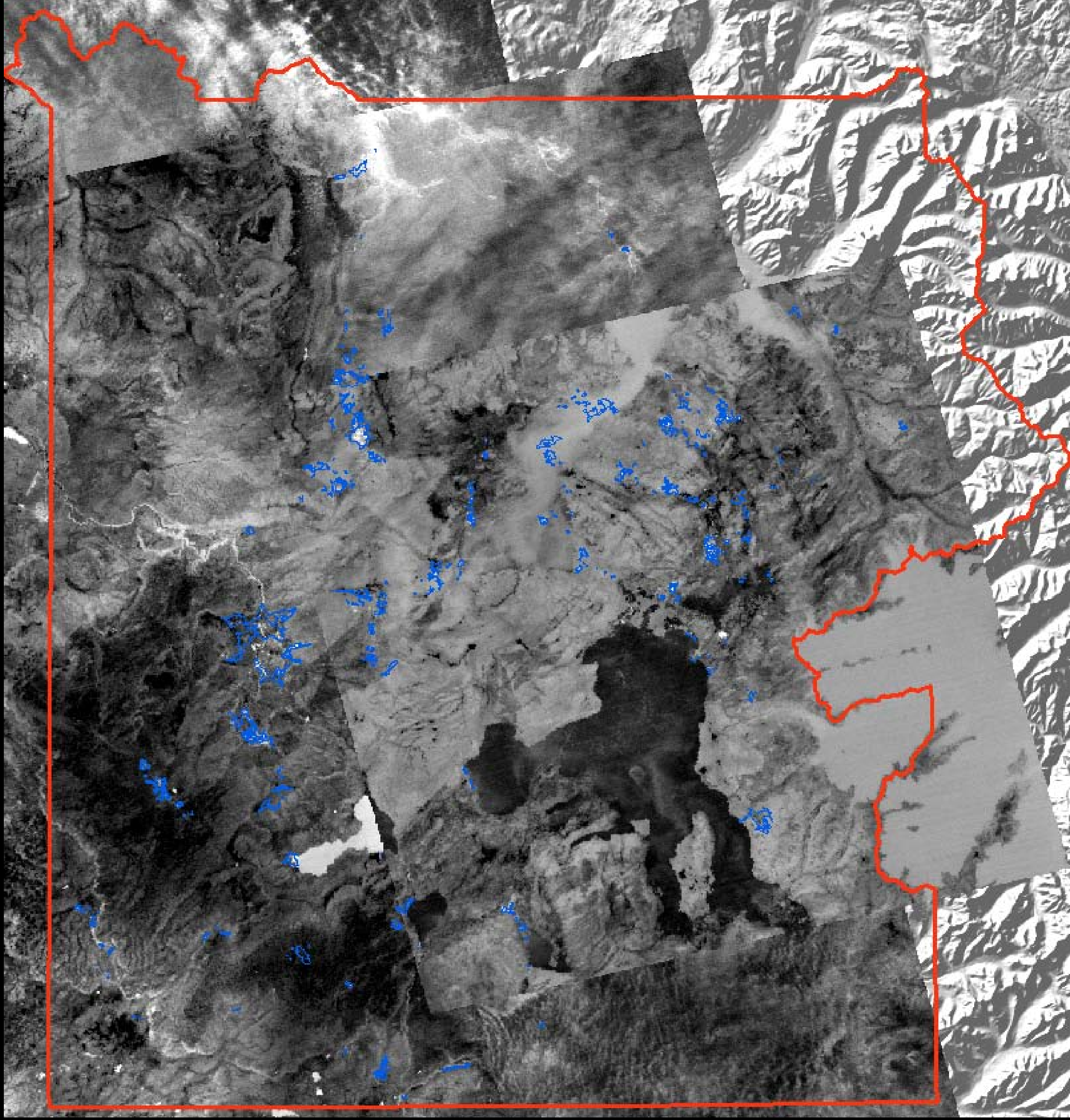
Total Geothermal Heat Flux

From Cl^- flux measurements:
4.5 to 6.0 GW

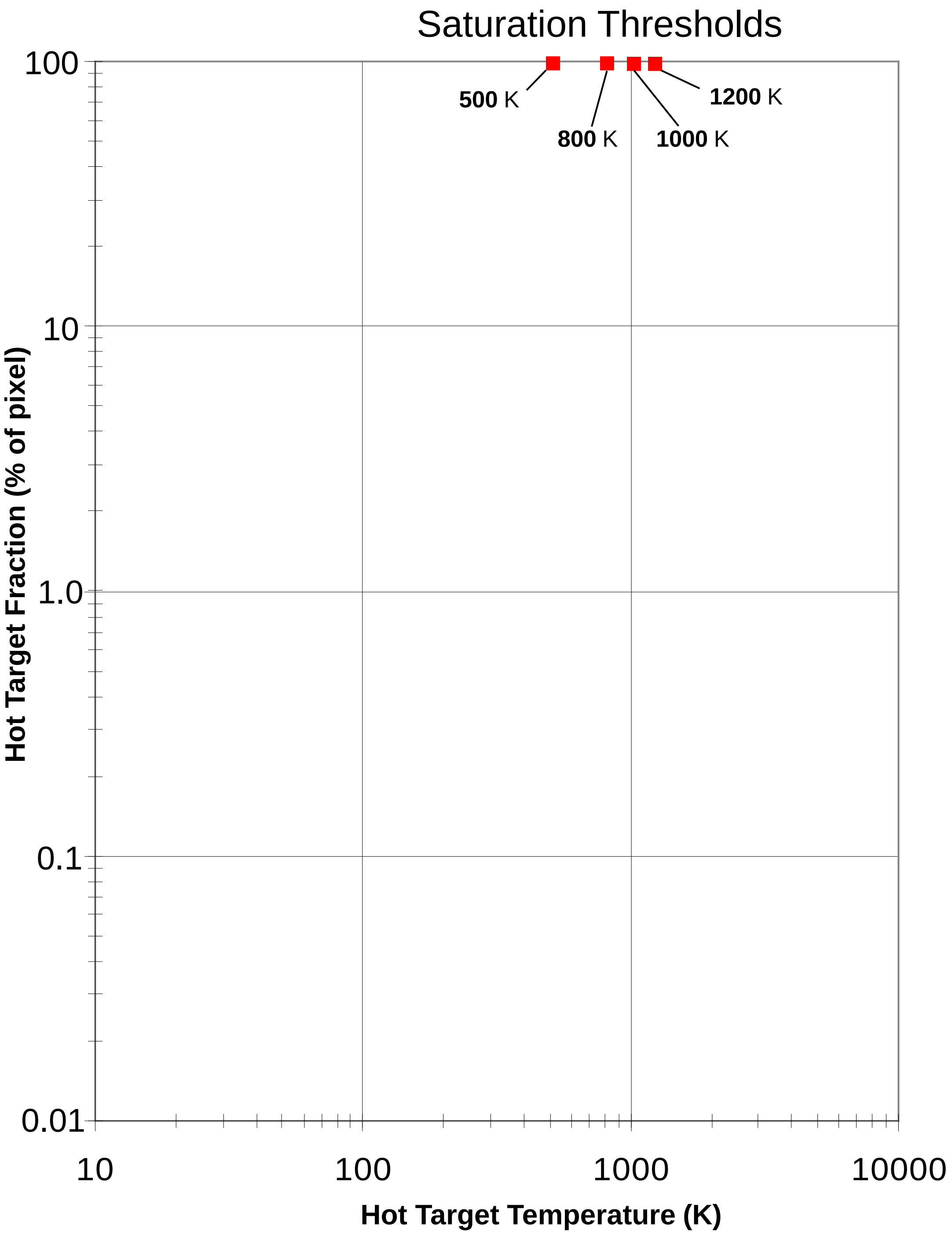
From MODIS night time data:
1.7 to 2.2 GW

From ASTER night time data:
3.1 to 5.2 GW

From HyspIRI nighttime data:
I can't wait …



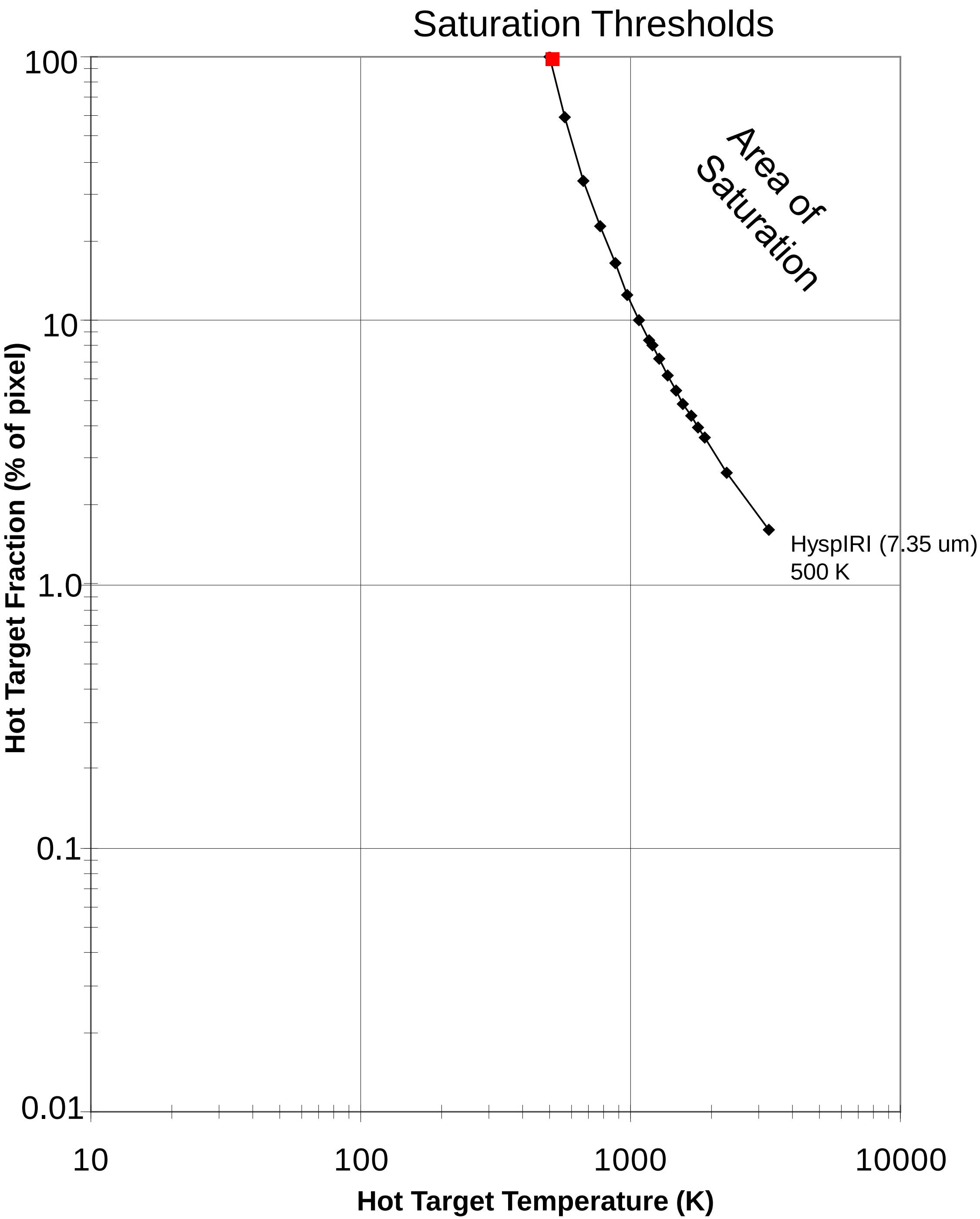
HyspIRI Dynamic Range



<u>Thermally Homogenous</u>
100% of pixel is a hot target. Obviously, in this case the saturation temperature will be the predefined maximum temperature.

If we set the max temperature of a certain TIR channel to a certain temperature, say 500 K, then if the total pixel integrated radiance corresponds to a temperature that exceeds this, you will have a saturated pixel.

HyspIRI Dynamic Range



<u>Thermally Mixed</u>

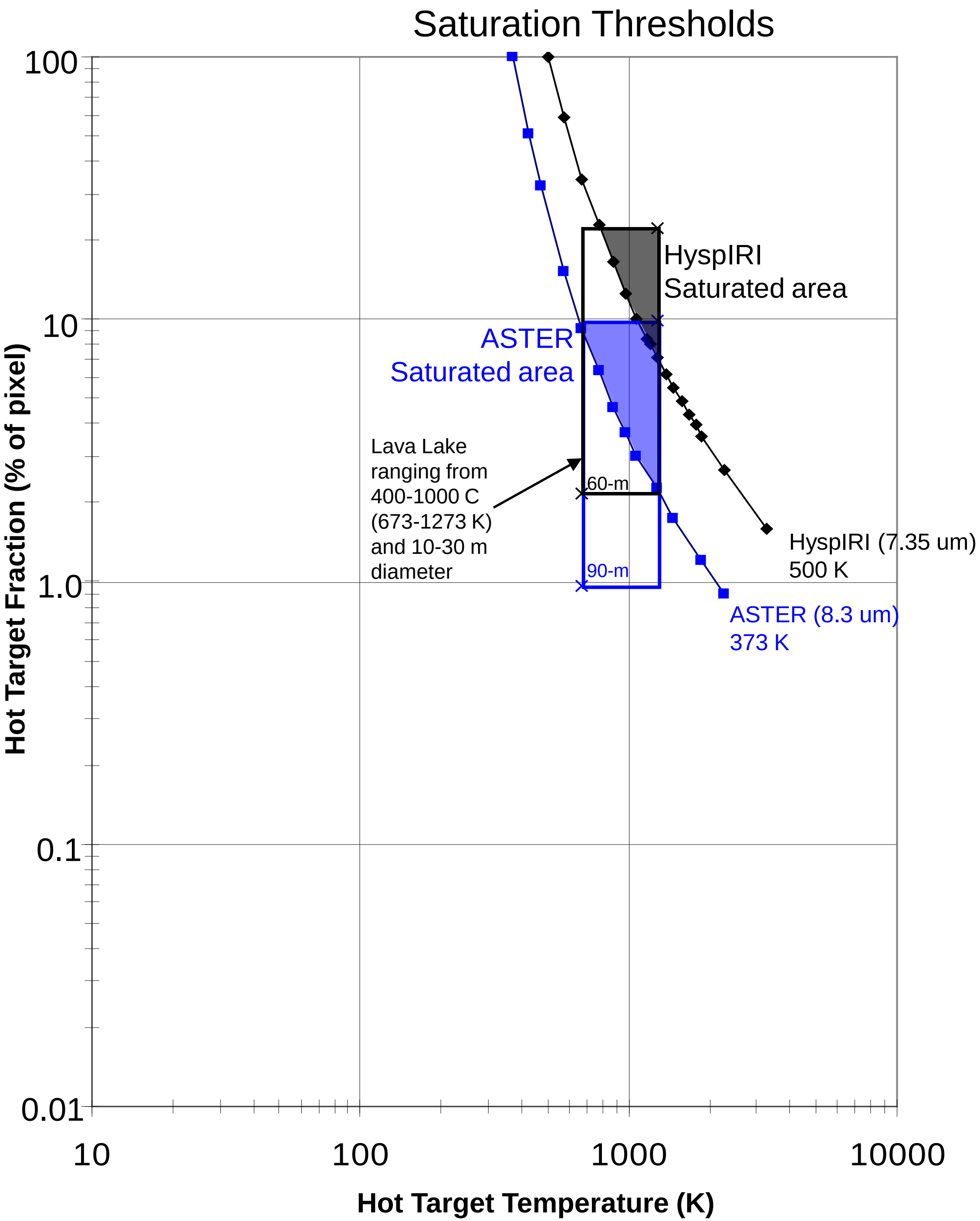
if only a fraction of the pixel is hot target, and the rest is cooler background, then the saturation threshold will change.

<u>Saturation Thresholds</u>

For a range of hot target temps (with $T_{background}$=273 K) and target fractional areas, radiance values were calculated (ε=0.96) for each wavelength channel of interest.

For each Delta T ($T_{targ} – T_{bg}$), the % target area that resulted in a spectral radiance value corresponding to the saturation temperature for that channel defines the threshold curve.

HyspIRI Dynamic Range



<u>Saturation Thresholds</u>

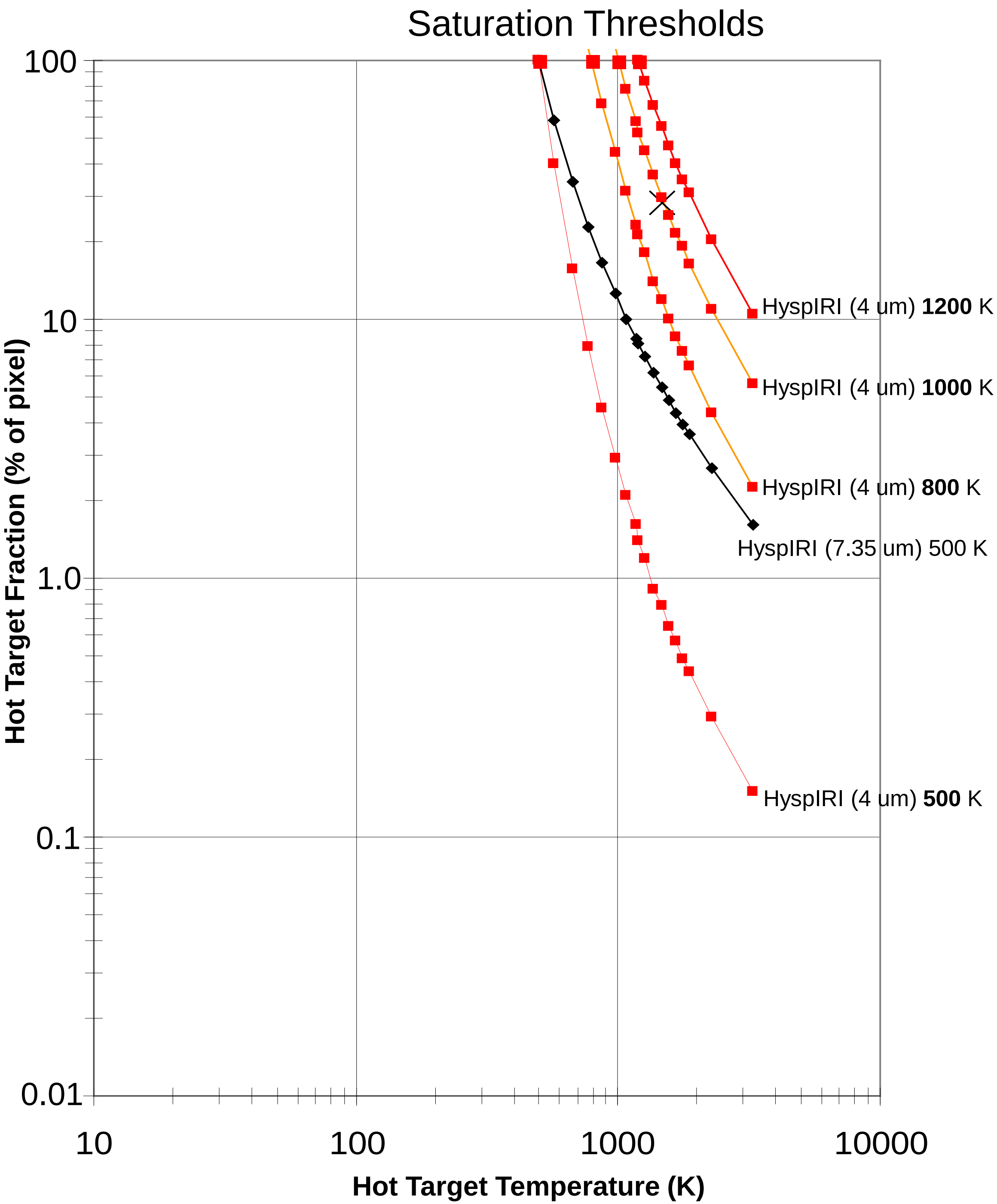
HyspIRI compared to ASTER

Trade-off between smaller pixels and higher saturation temperature

Overall improvement for HyspIRI

Less likely for HyspIRI to saturate over the same hot target than ASTER

HyspIRI Dynamic Range



<u>Saturation Thresholds</u>

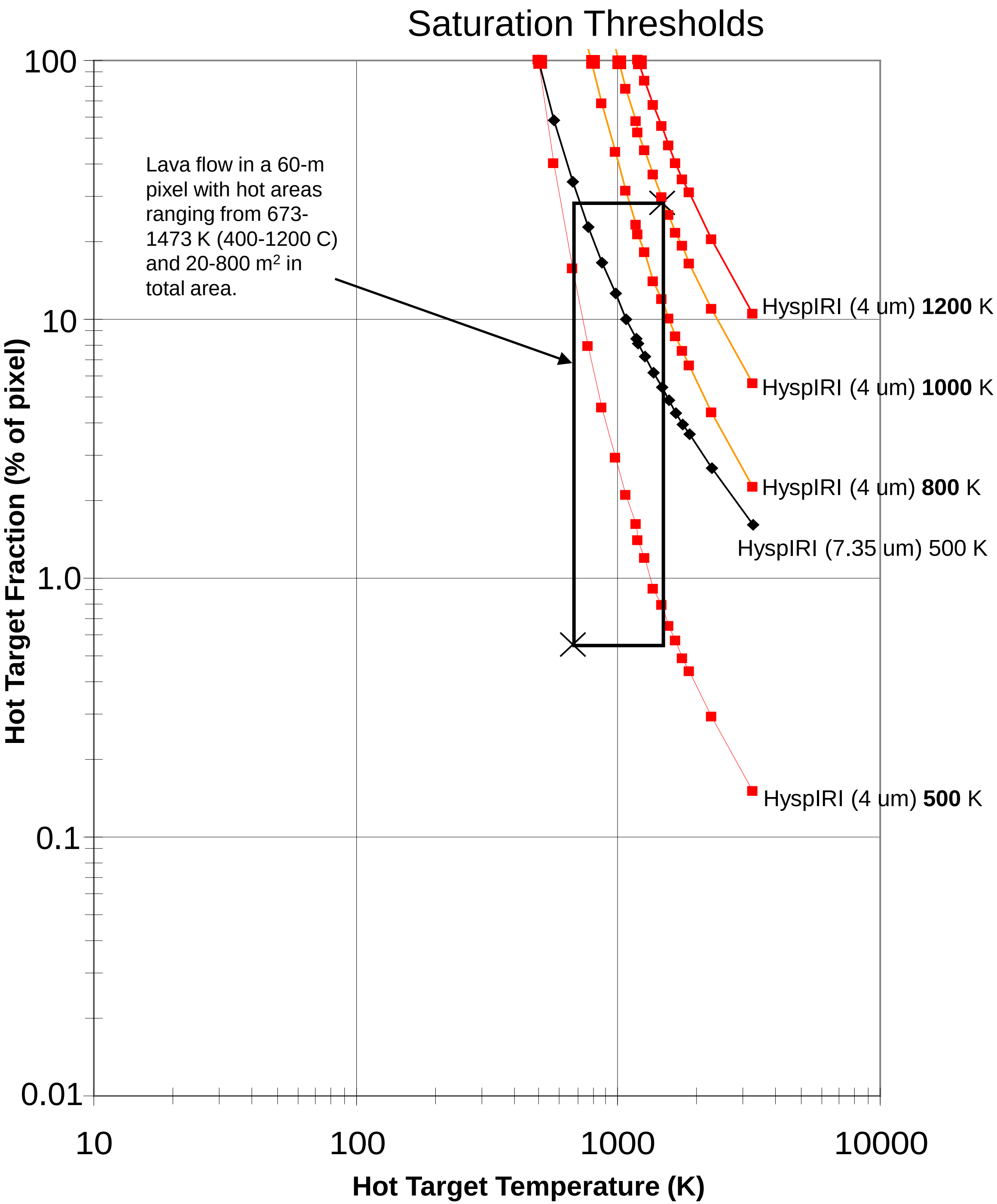
The MIR 4- um channel

At what temperature should the saturation be set?

If it's too high (higher than any possible or expected temp / area conditions), then dynamic range is being wasted.

If it's too low, then we will get saturated pixels over some very hot volcanic or fire targets, and the purpose of the 4-um channel is to characterize very hot targets, so saturation is to be avoided.

HyspIRI Dynamic Range



<u>Saturation Thresholds</u>

The MIR 4- um channel

At what temperature should the saturation be set?

Is a 1000-K saturation temperature good enough to cover the hottest likely volcanic features?

Some Concluding Thoughts

Pixel Size

The larger the pixels the less spatial information and the more sub-pixel thermal mixing. HyspIRI TIR data are comparable to ASTER TIR data, slightly better, but regardless of pixel size, you can model high temperature sub-pixel components very well with the wide wavelength separation of channels at the same spatial resolution.

Observation Frequency

Time series HyspIRI TIR data for continuous monitoring will be more like MODIS than ASTER, but with the sensitivity of ASTER – an important improvement.

Saturation

Compared to ASTER, HyspIRI TIR should be less likely to saturate over any given hot target. Having the 4-um channel with a saturation temperature of at least 1000 K to 1100K, a critical advantage.

Some Concluding Thoughts

1) How can we help predict and mitigate volcanic hazards through detection of transient thermal phenomena? (TQ1)

>> By the accurate characterization of transient thermal phenomenon (including spatial, temporal and thermal characteristics), which leads to hazard forecasting.

2) How do volcanoes signal impending eruptions through changes in surface temperature and thermal flux? (CQ3)

>> By exhibiting changes in surface temperature and thermal flux. And if we can measure these changes accurately in space, time, and magnitude, then we can use this information to help forecast volcanic hazards.

EXTRAS

HyspIRI Spectral Response