Interpreting time series of radiance from volcanic eruptions

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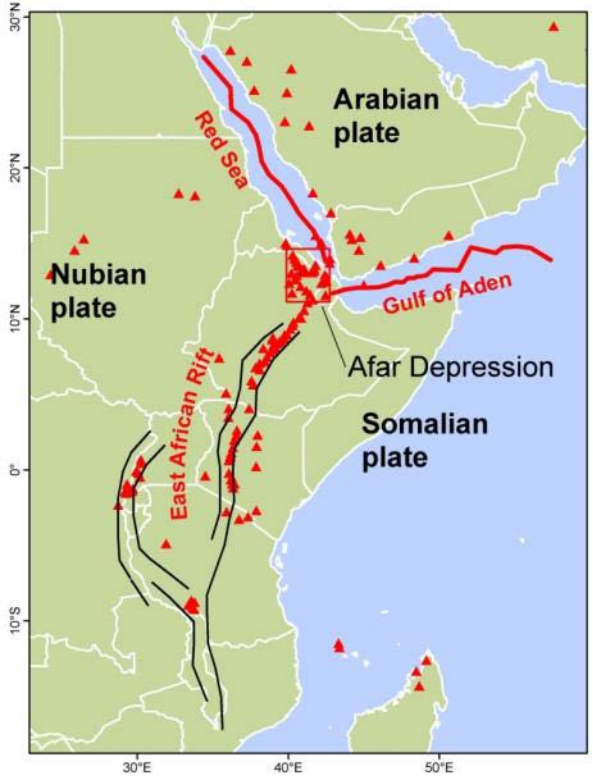
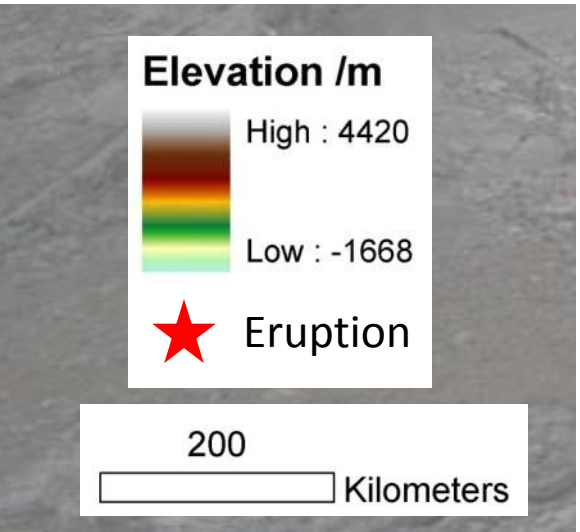
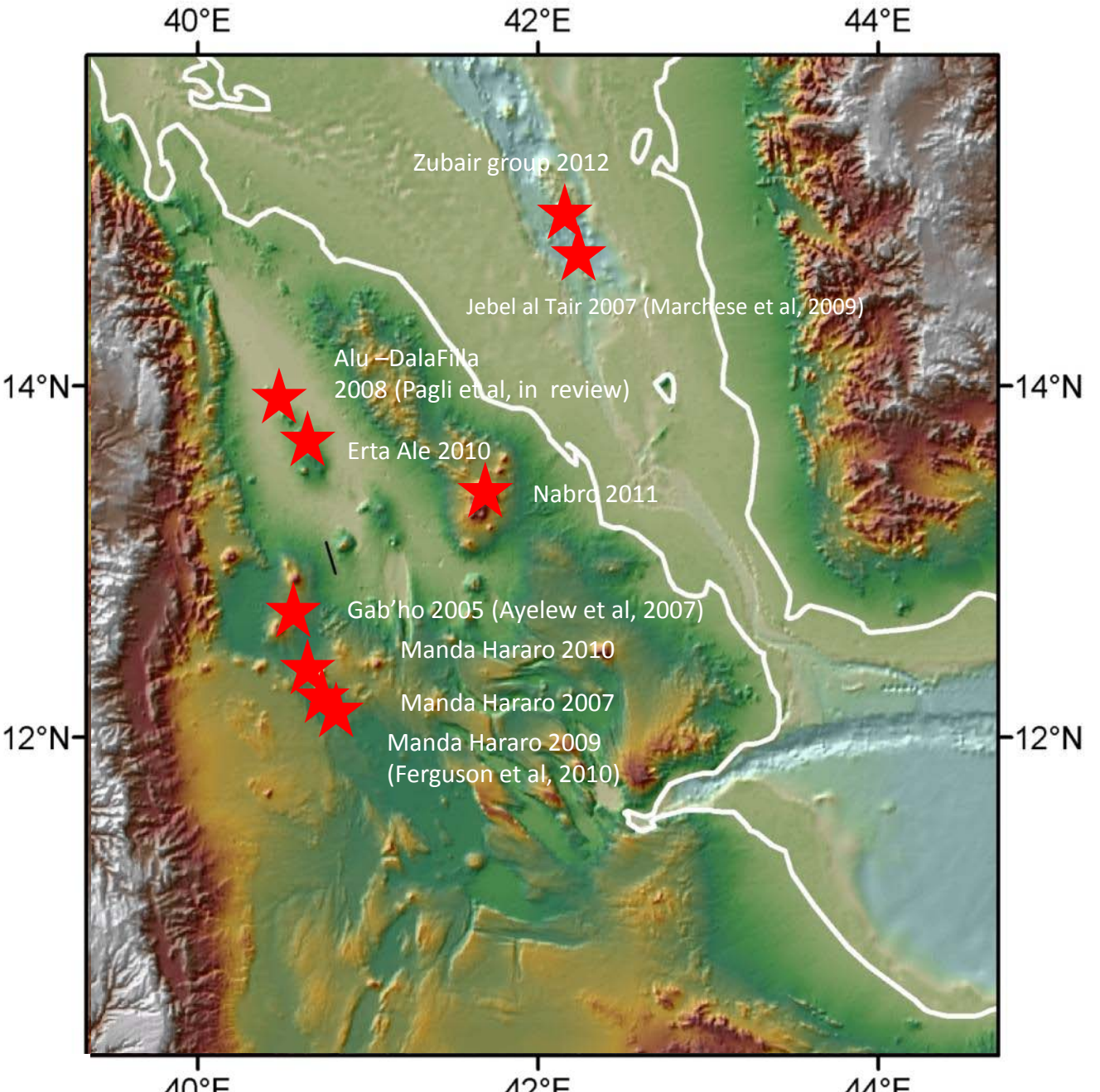
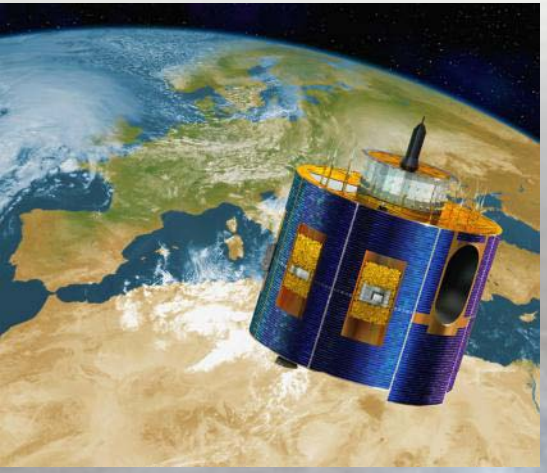
1. Location

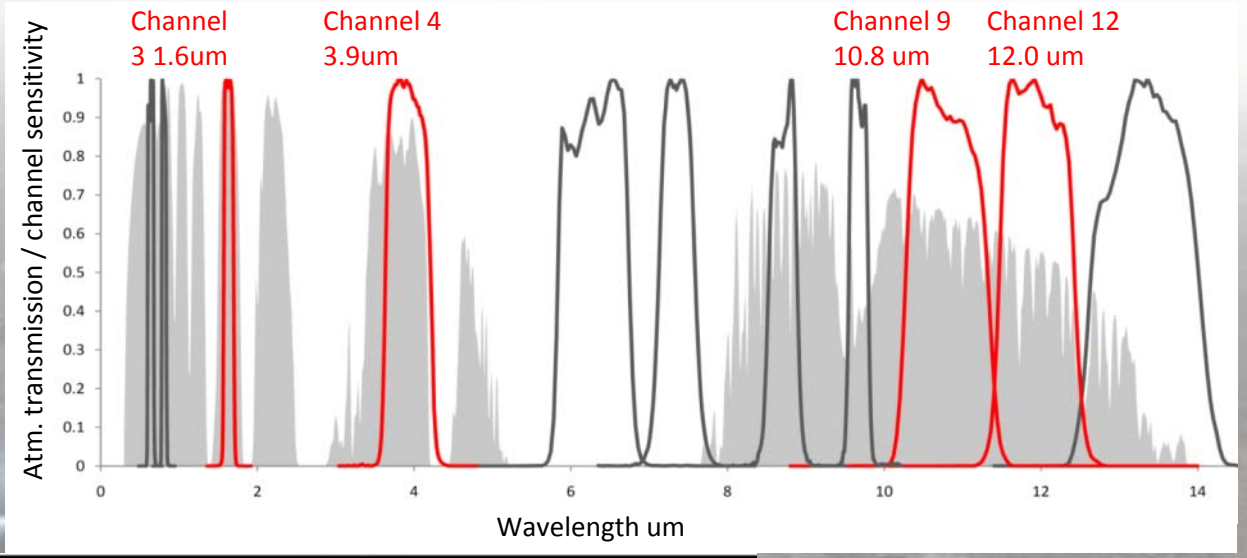

Arabian plate
Red Sea
Nubian plate
Gulf of Aden
Afar Depression
East African Rift
Somalian plate
30°E
40°E
50°E


Elevation /m
High : 4420
Low : -1668
Eruption
200
Kilometers


40°E
42°E
44°E
14°N
12°N
Zubair group 2012
Jebel al Tair 2007 (Marchese et al, 2009)
Alu –DalaFilla
2008 (Pagli et al, in review)
Erta Ale 2010
Nabro 2011
Gab'ho 2005 (Ayelew et al, 2007)
Manda Hararo 2010
Manda Hararo 2007
Manda Hararo 2009
(Ferguson et al, 2010)

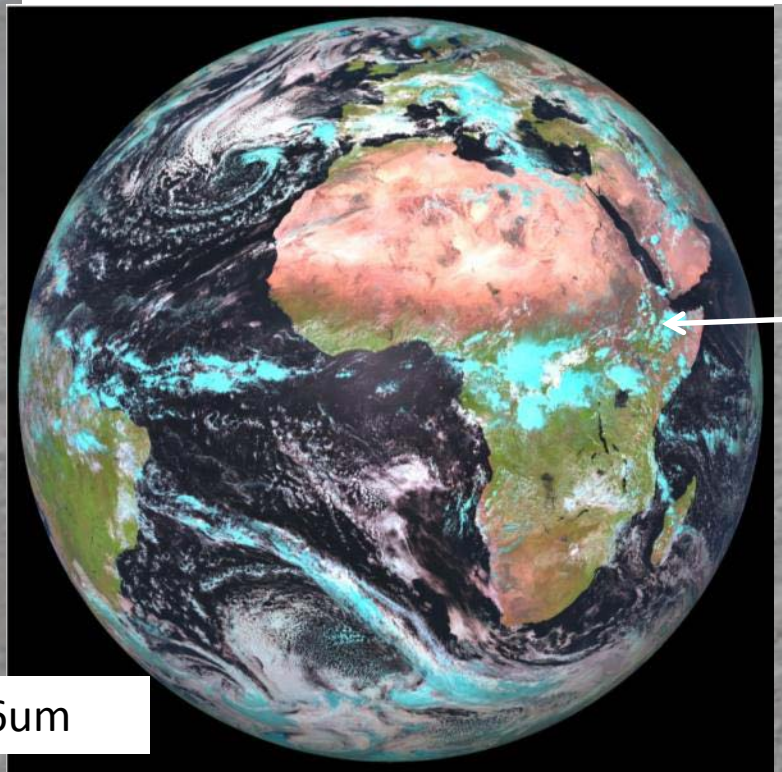
2. SEVIRI instrument





In geostationary orbit- each pixel images the same area with the same look angle in successive images

Images acquired in 12 bands every 15 minutes, with ~3km pixel spacing at nadir

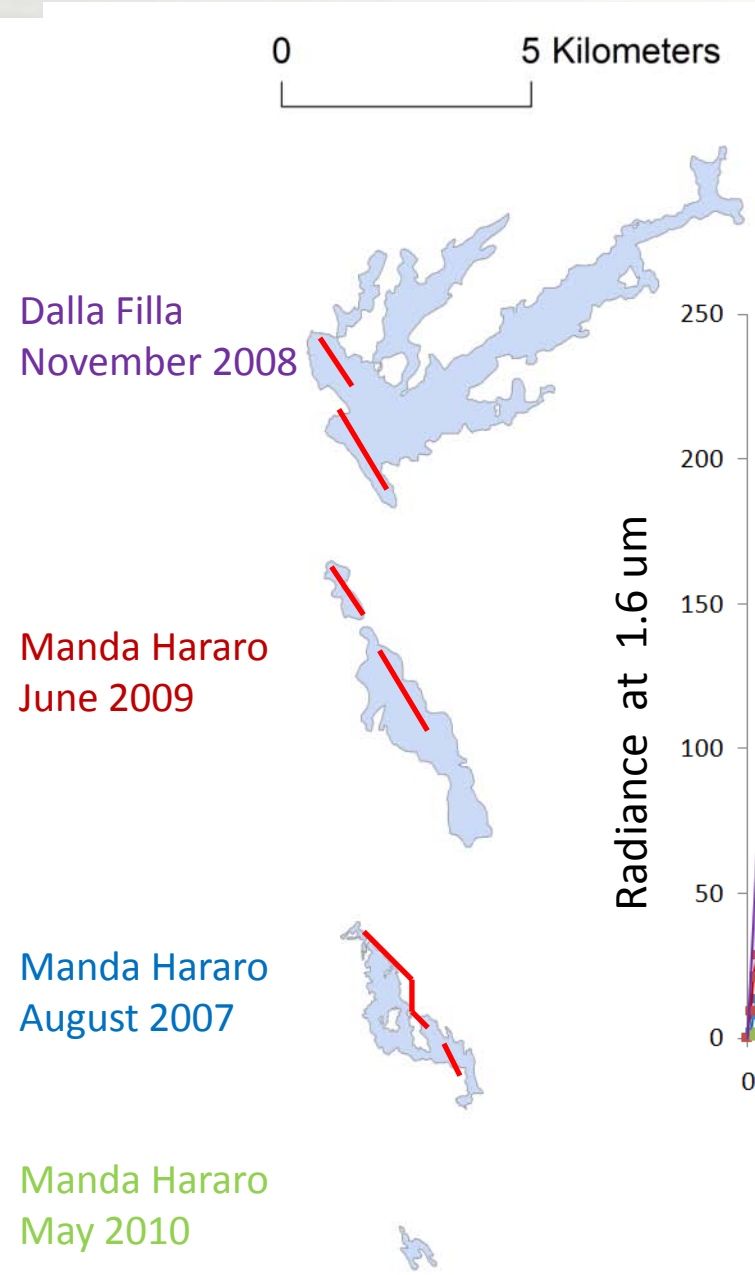


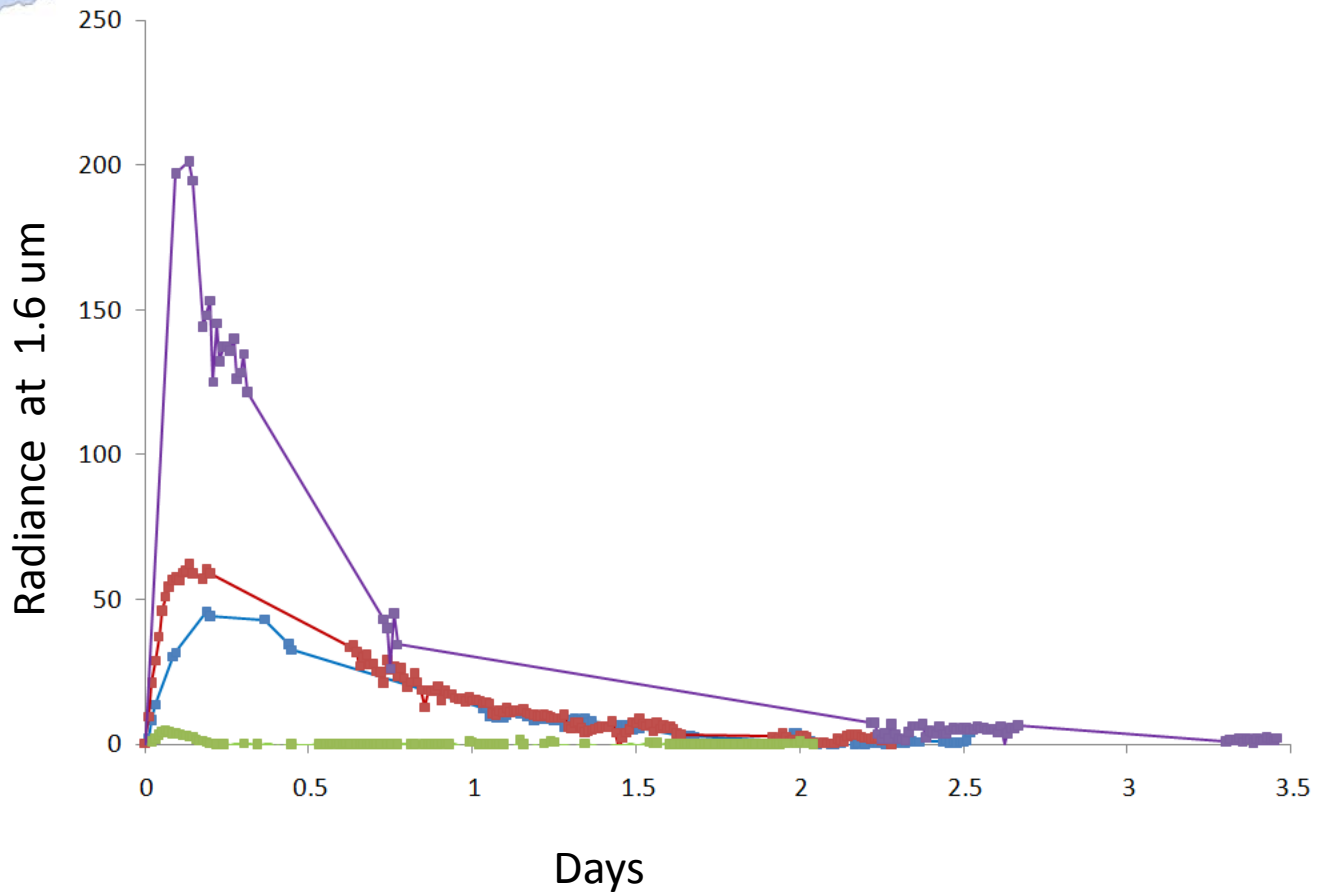
Afar / Red sea region

R:1.6 um, G:0.8 um, B:0.6um

Aminou 2007, Aminou et al, 1997,1999

3. The large fissure eruptions





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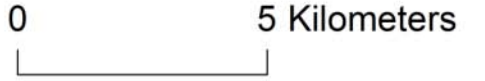
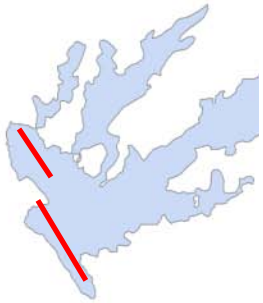


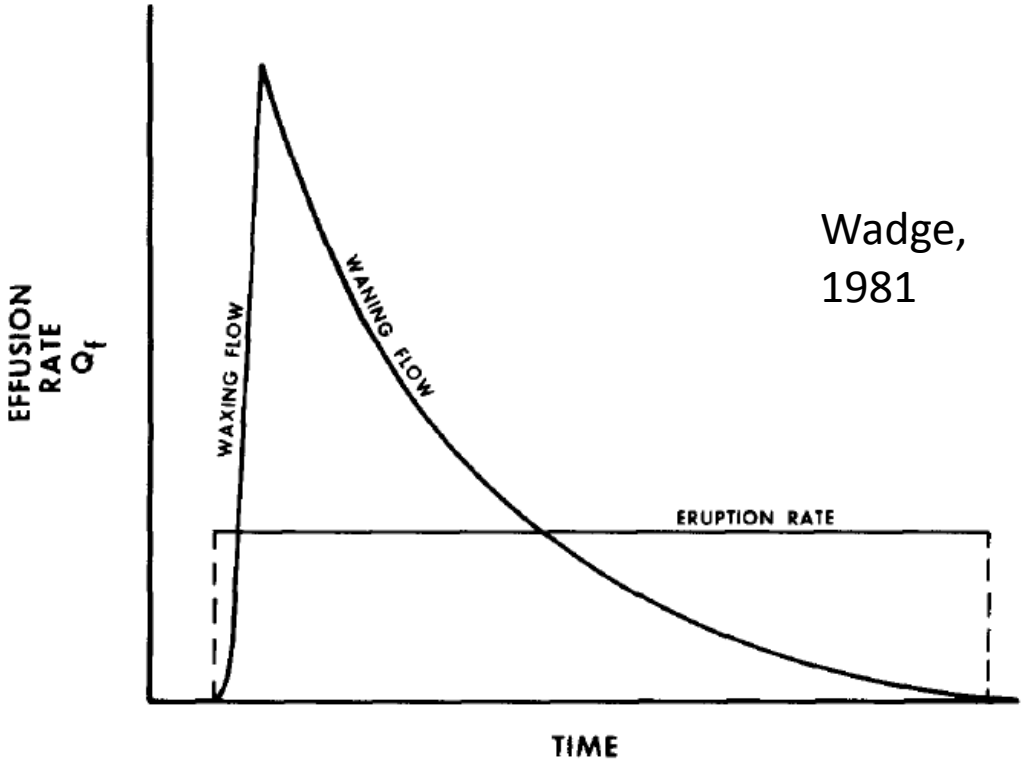
Dalla Filla
November 2008



Manda Hararo
June 2009

Manda Hararo
August 2007

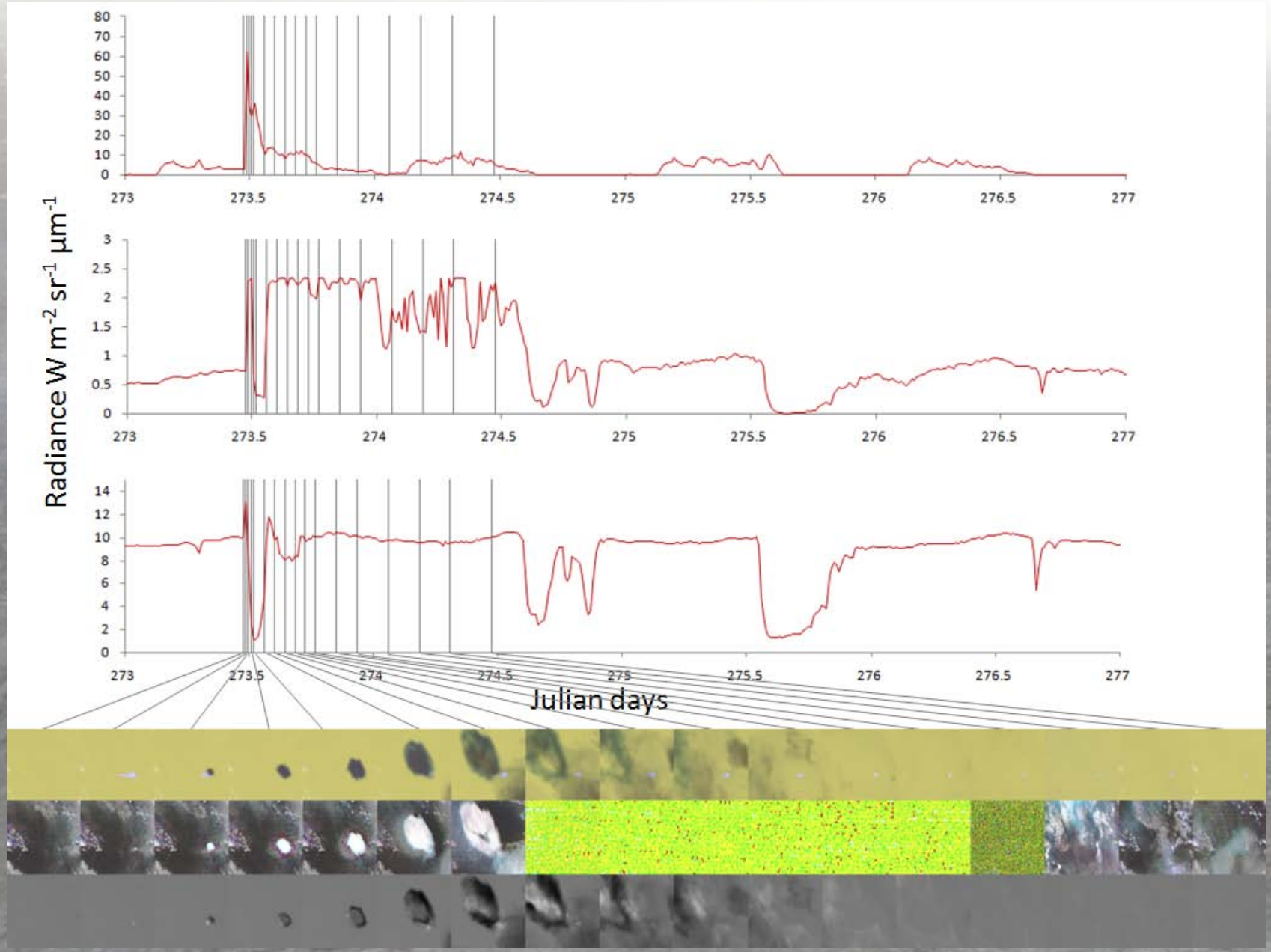
Manda Hararo
May 2010



Wadge, 1981

Fig. 1. Variation of effusion rate with time for a hypothetical basaltic eruption. The eruption rate, calculated by dividing the total volume of material by the duration of the eruption, is also shown.

4. Jebel al Tair



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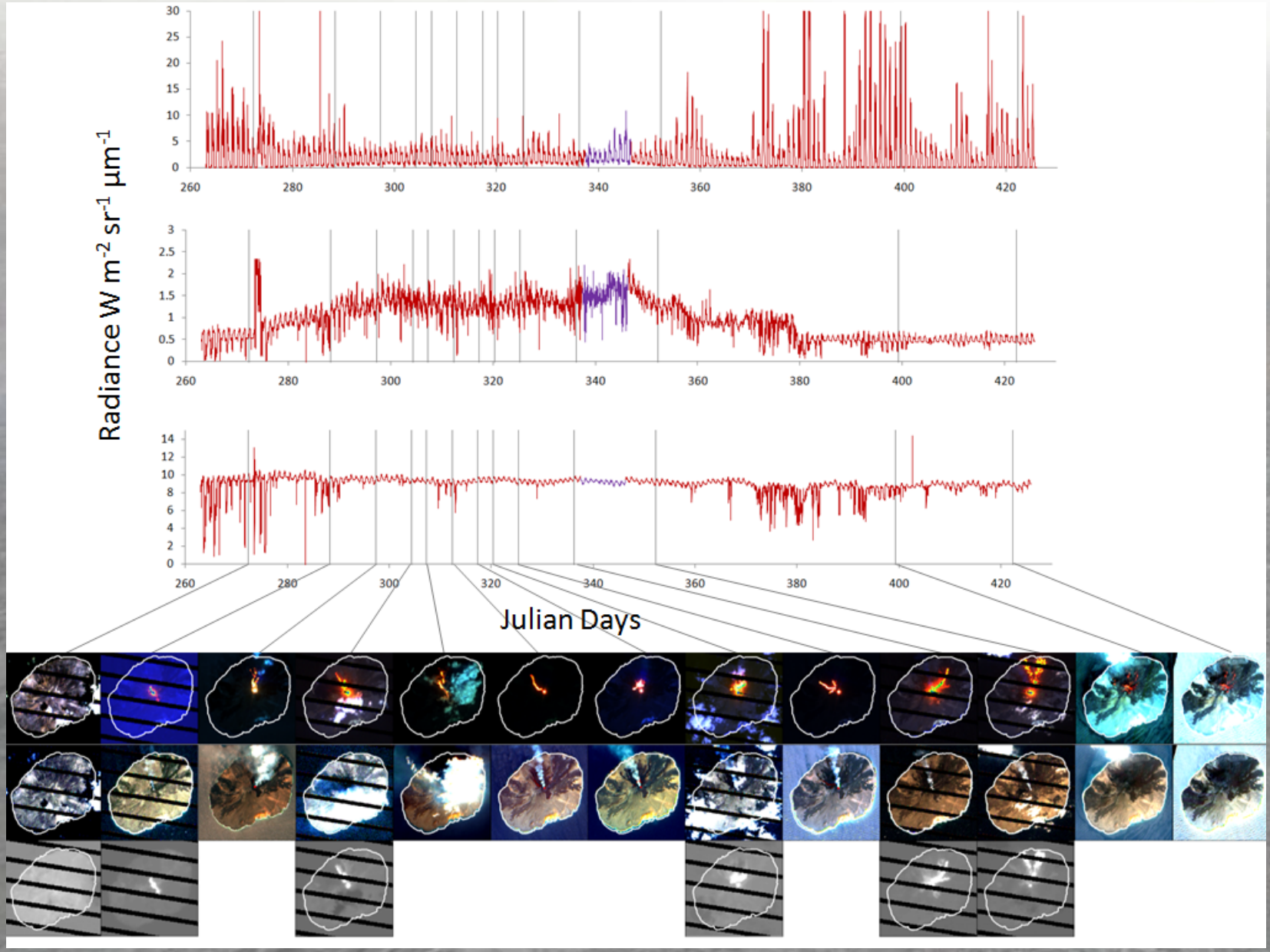
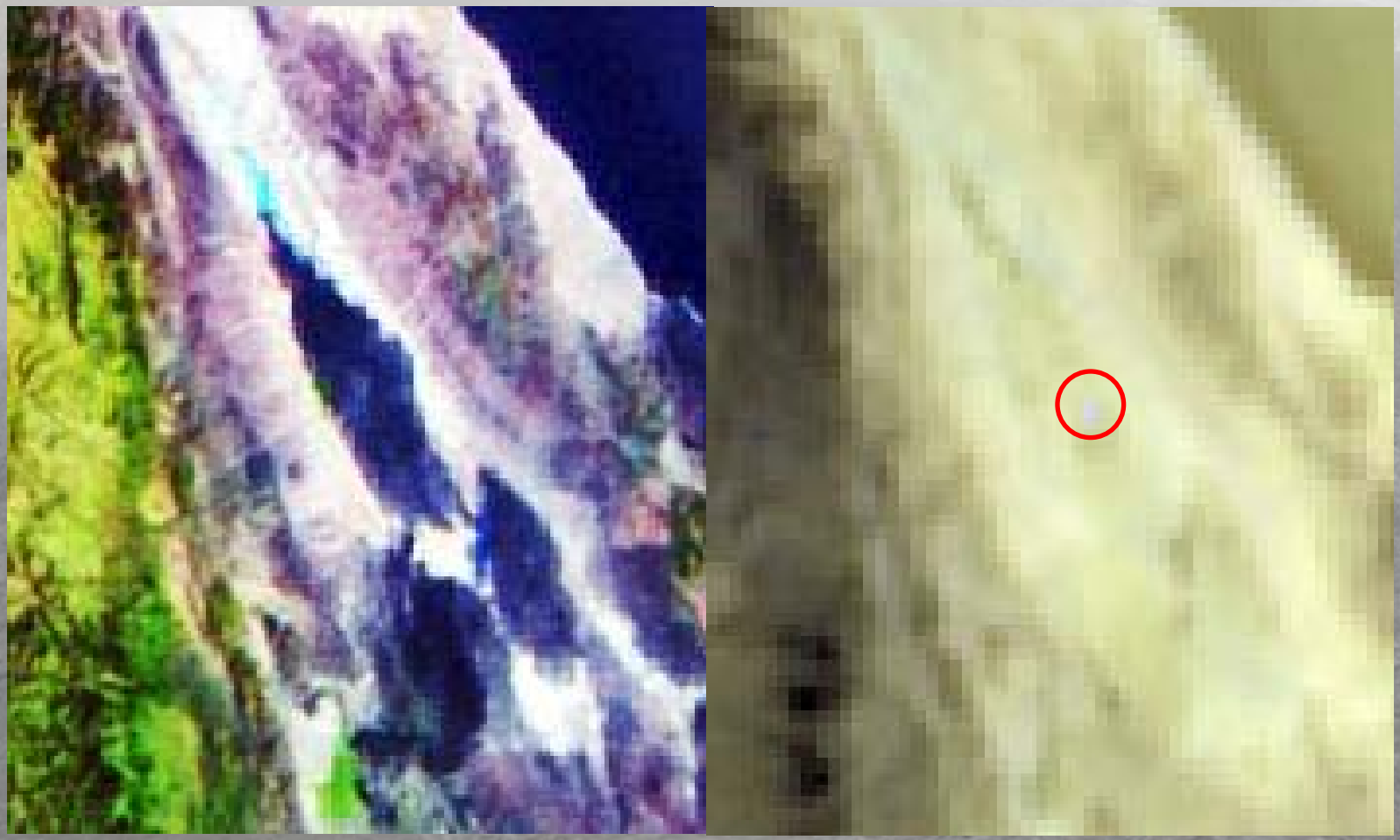


5. Erta Ale overflow

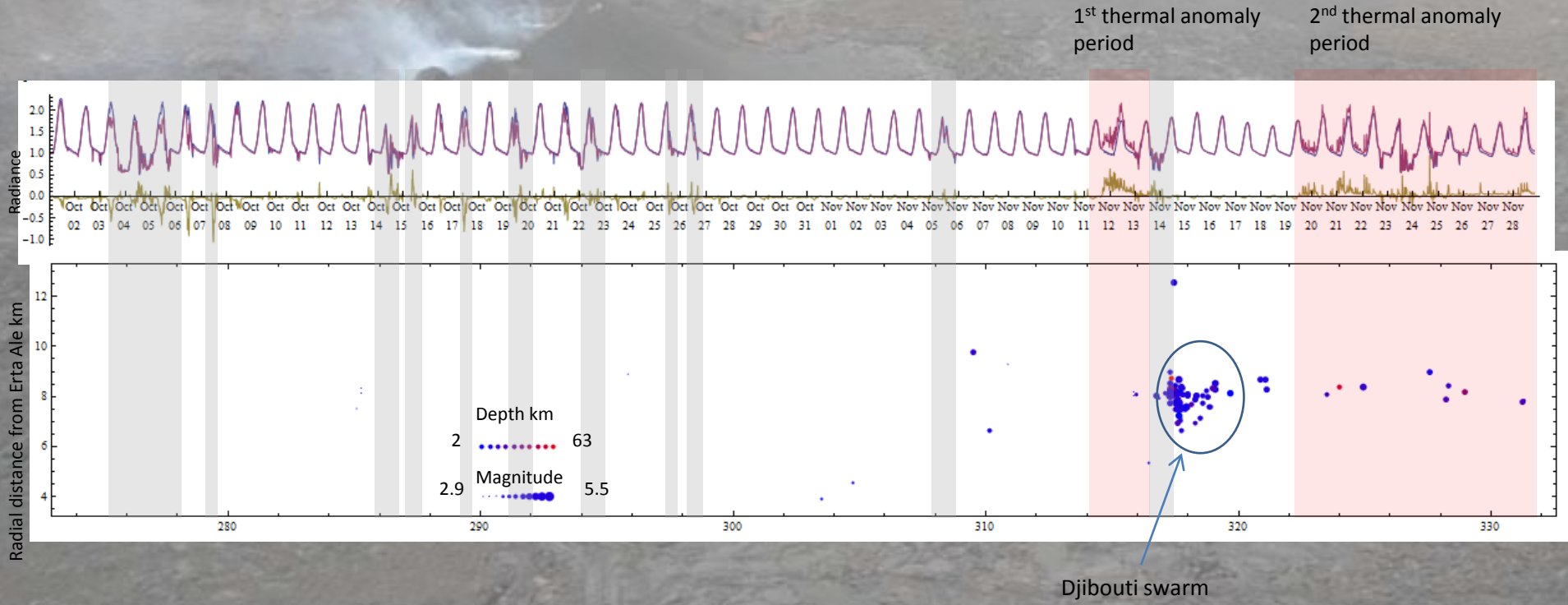


R:1.6 um, G:0.8 um, B:0.6um

5. Erta Ale overflow

Top graph:
Red curve: radiance from Erta Ale pixel
Blue curve: radiance from background pixel
Yellow curve: difference (excess thermal radiation from Erta Ale)
Grey tint shows cloud contamination (ignore these parts)
Red tint shows presence of thermal anomaly

Bottom graph:
Earthquakes in region from EMSC plotted as radial distance from Erta Ale against time, color indicates depth, size indicates magnitude.



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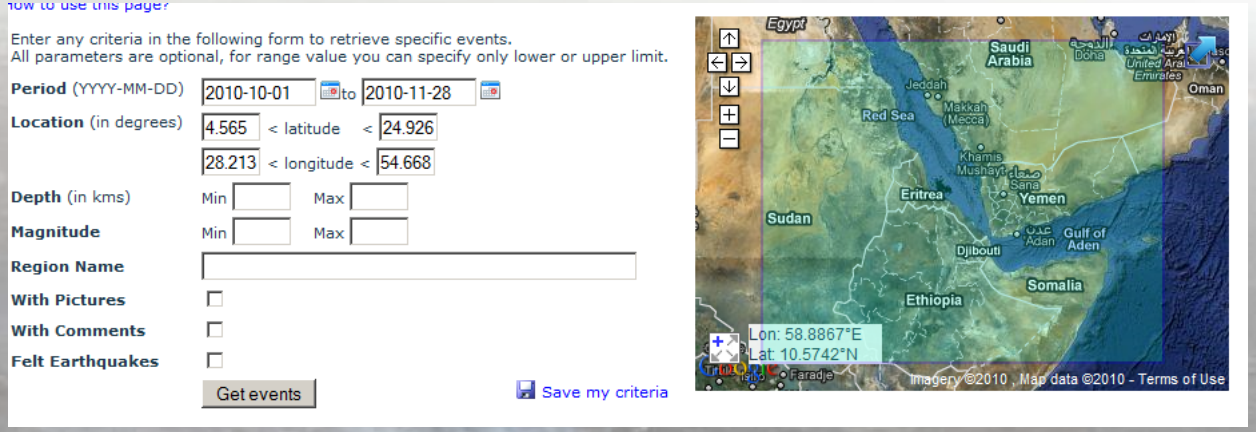
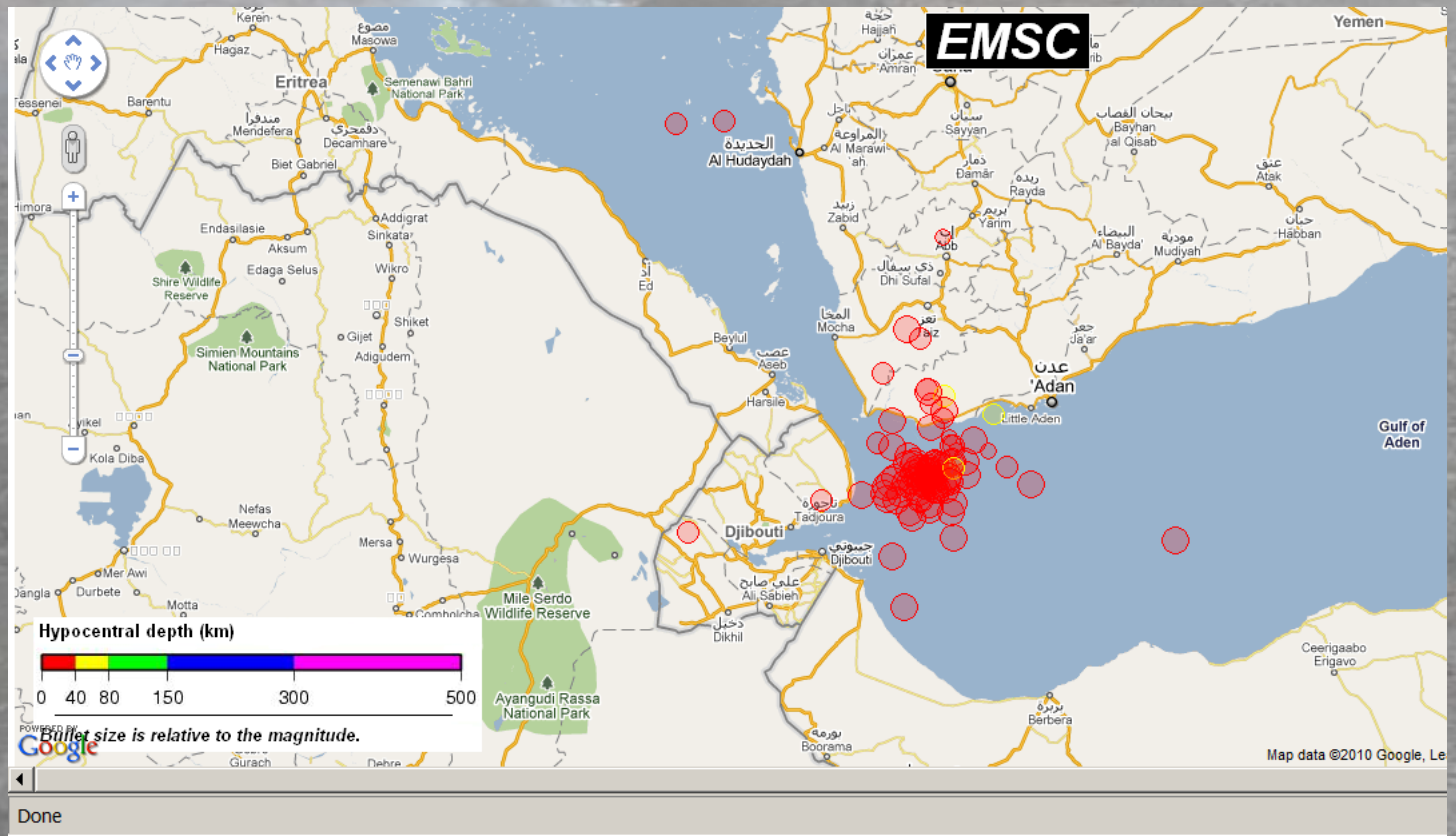
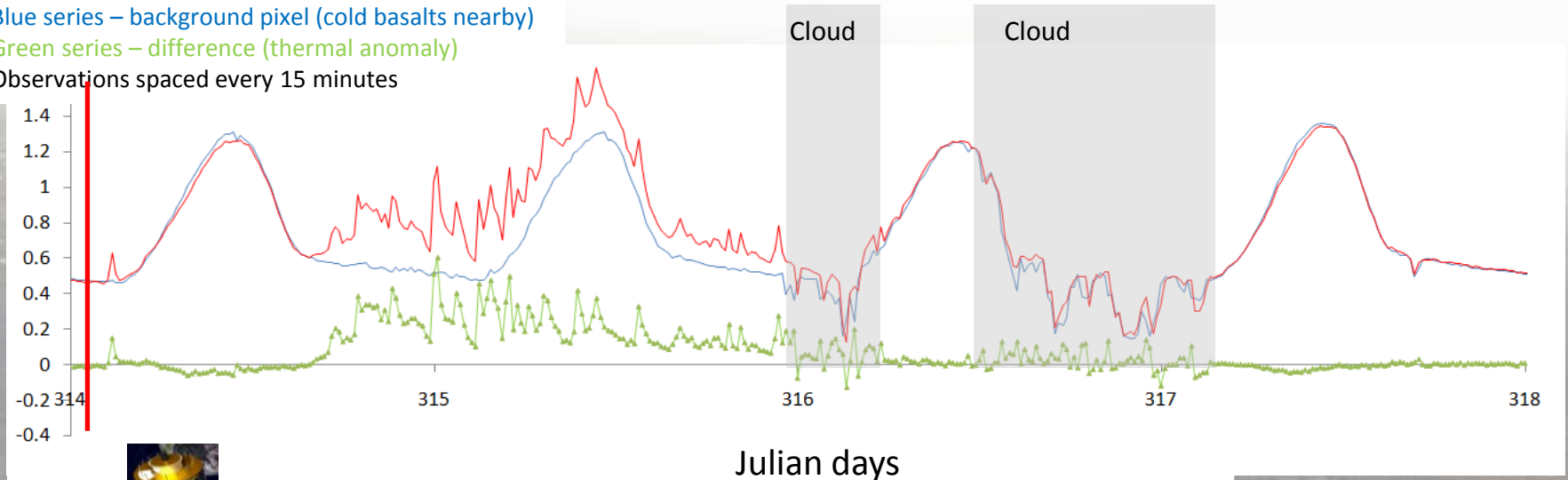
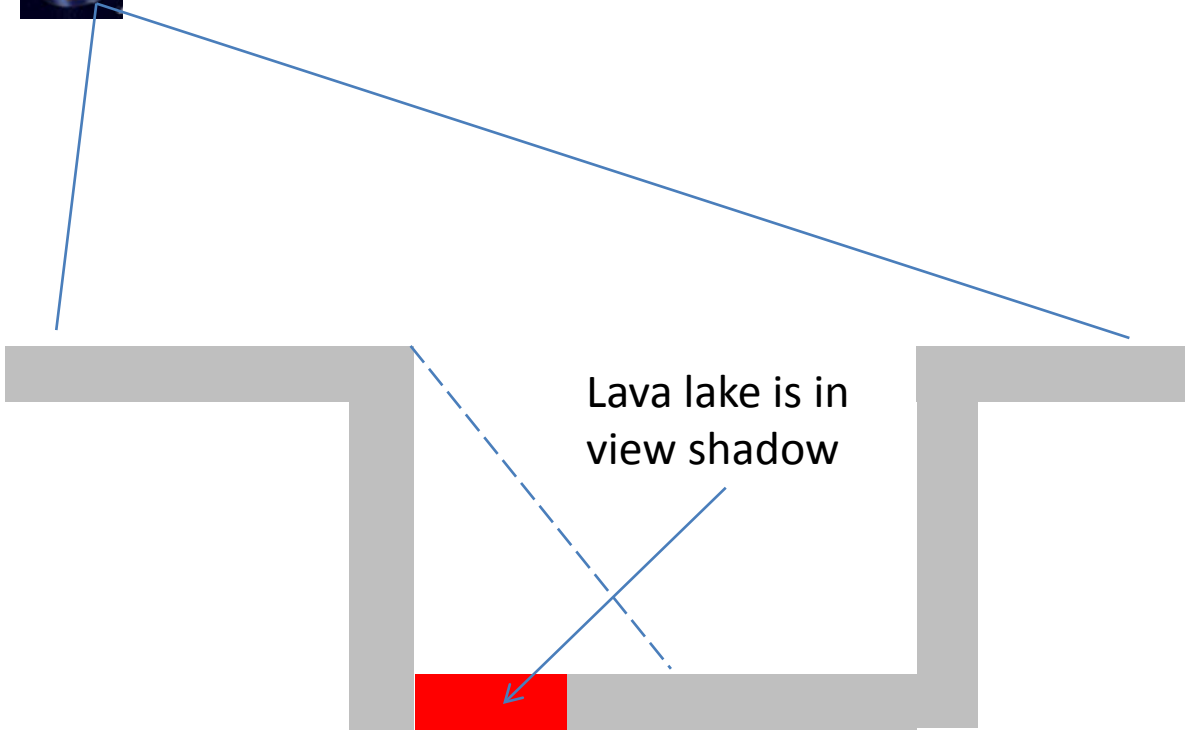




Red series – Erta Ale pixel
Blue series – background pixel (cold basalts nearby)
Green series – difference (thermal anomaly)
Observations spaced every 15 minutes





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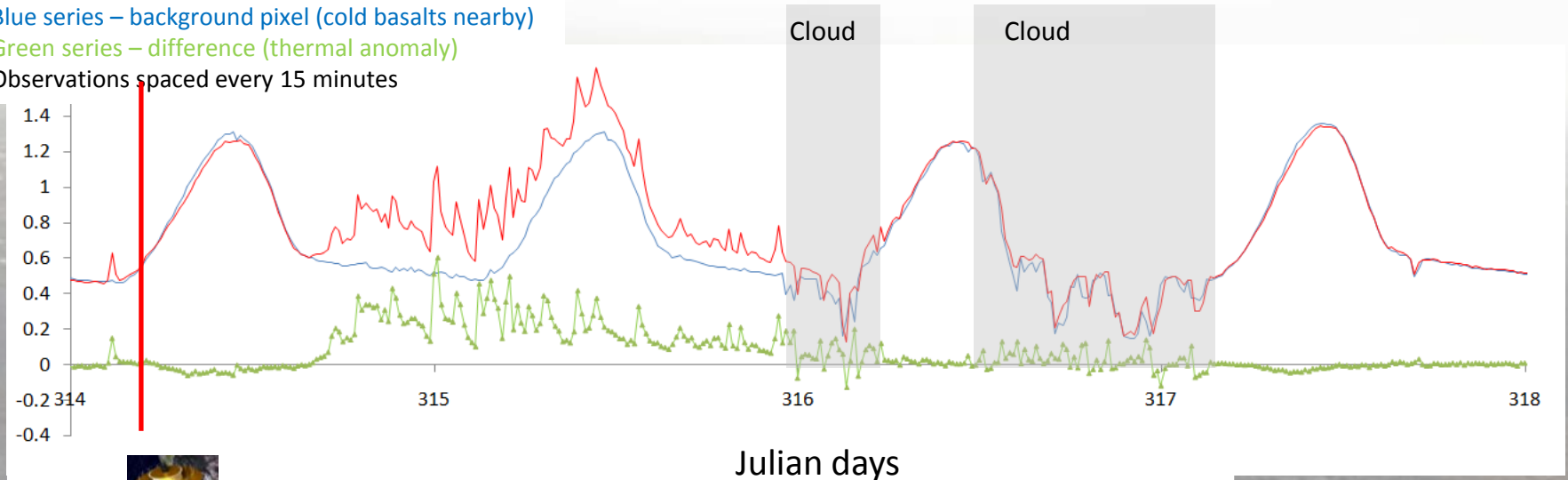

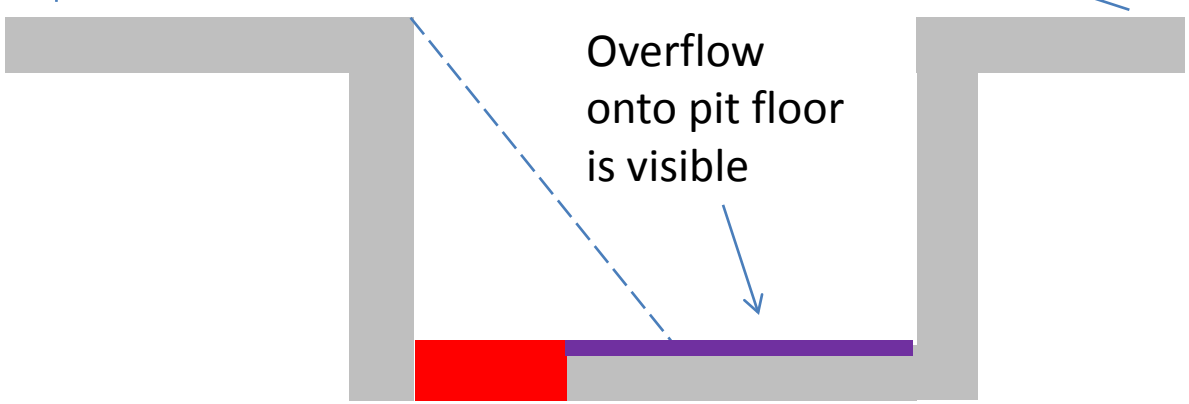

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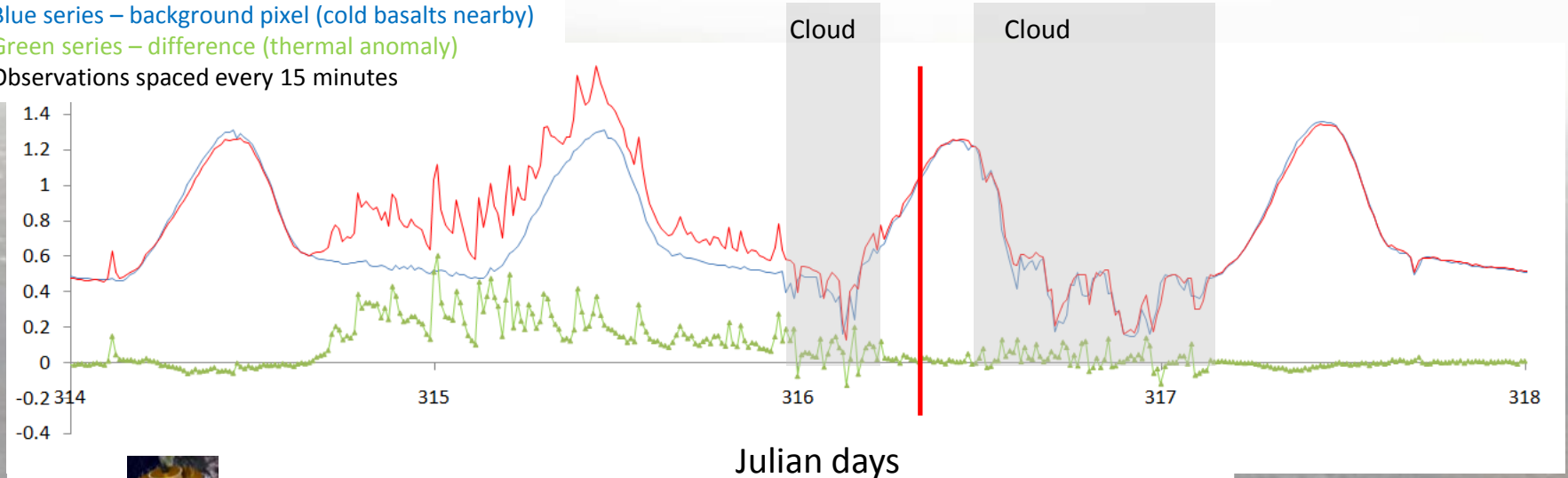
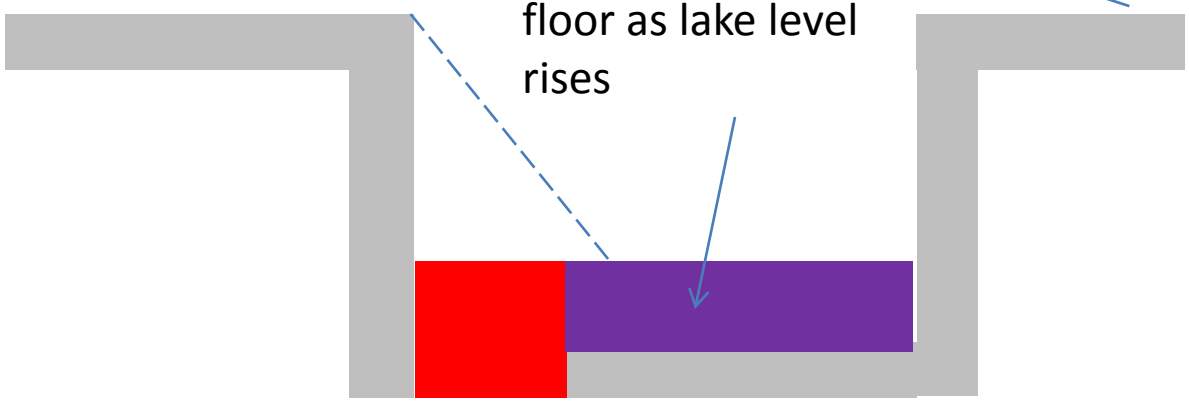
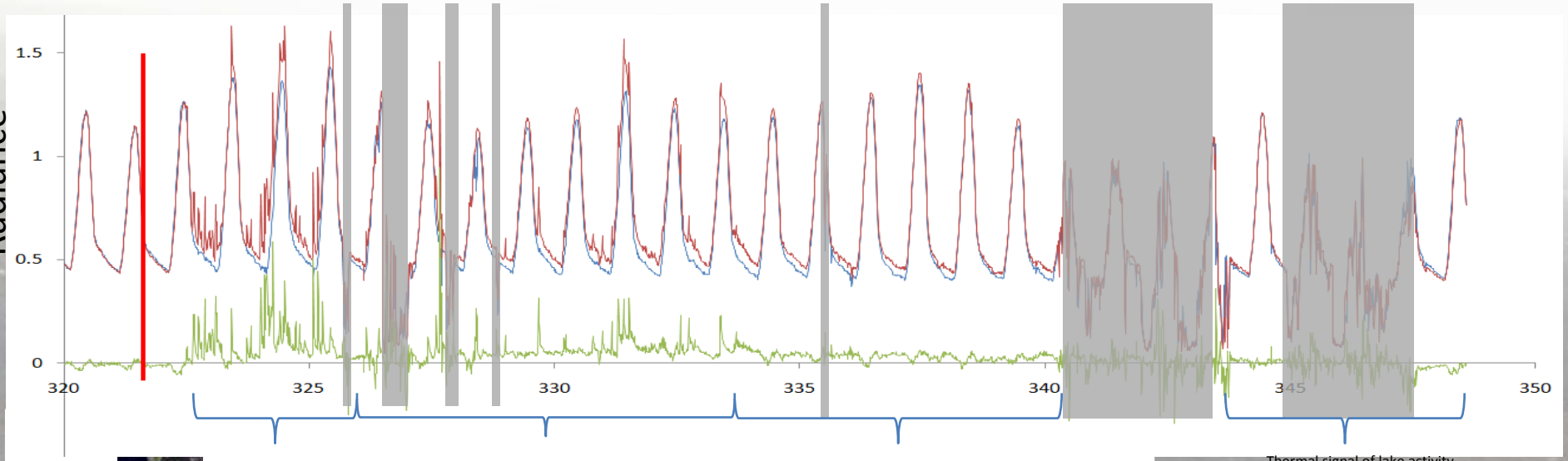




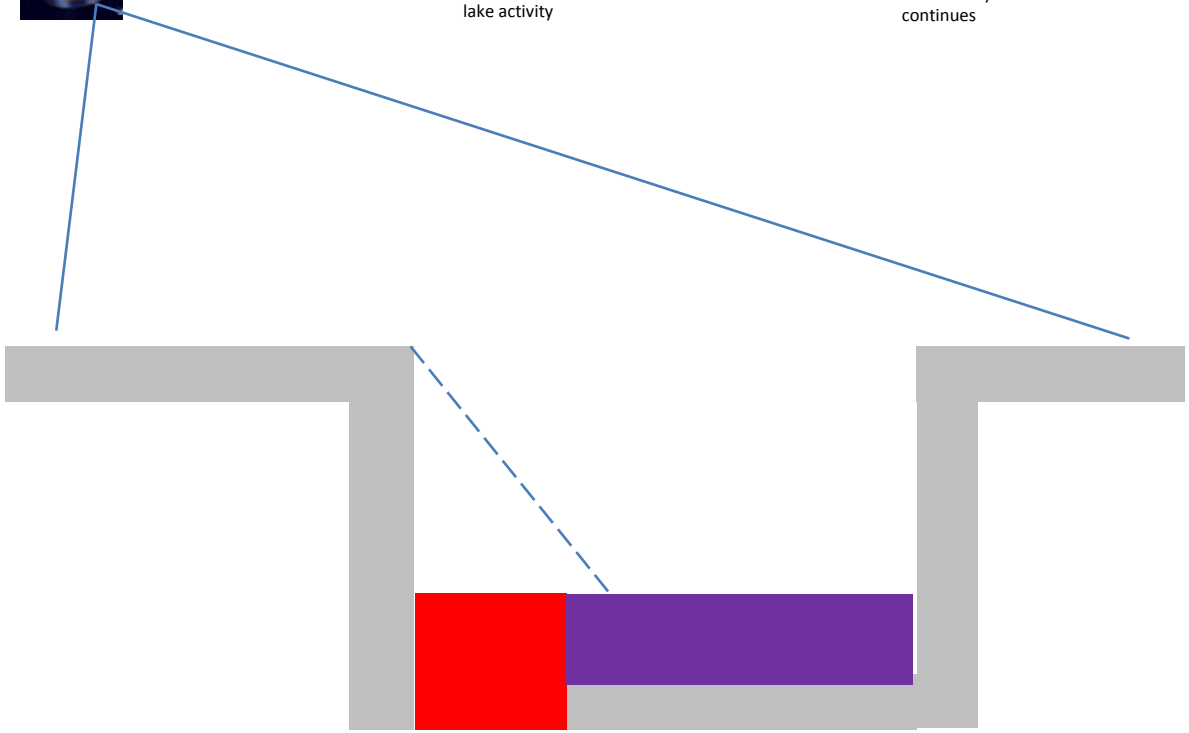


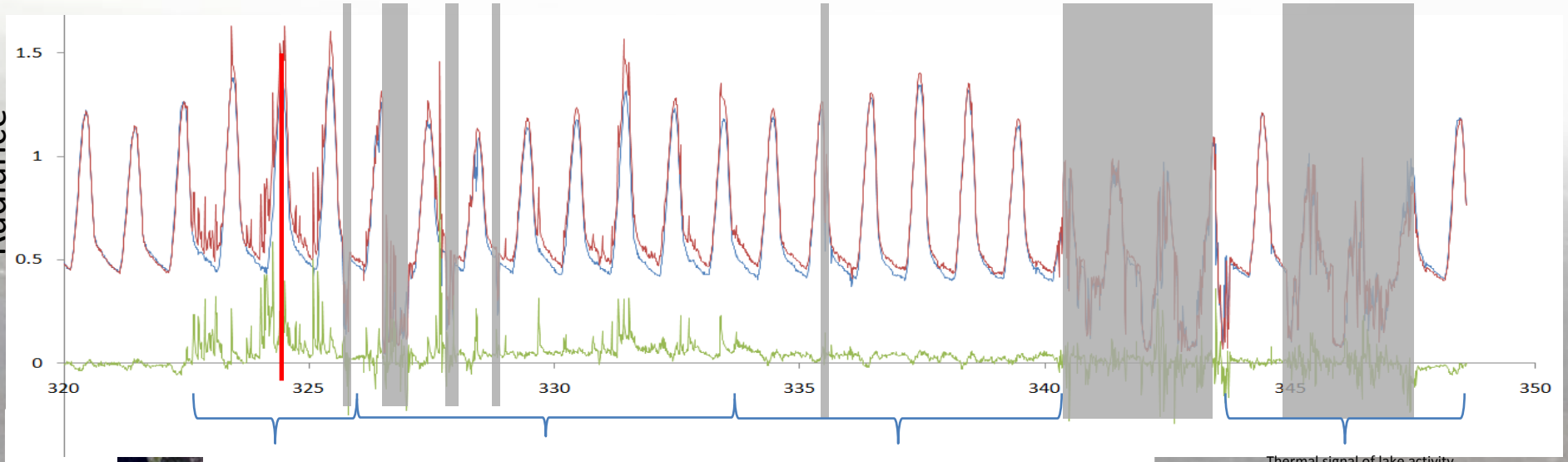
Lots of overflows

Some overflows, superimposed on background lava lake activity

No overflows, but background lava lake activity continues

Thermal signal of lake activity fades away. Looks like lake level has sunk below SEVIRI line of sight, as MODIS, which gets a better view angle, is still registering thermal anomalies





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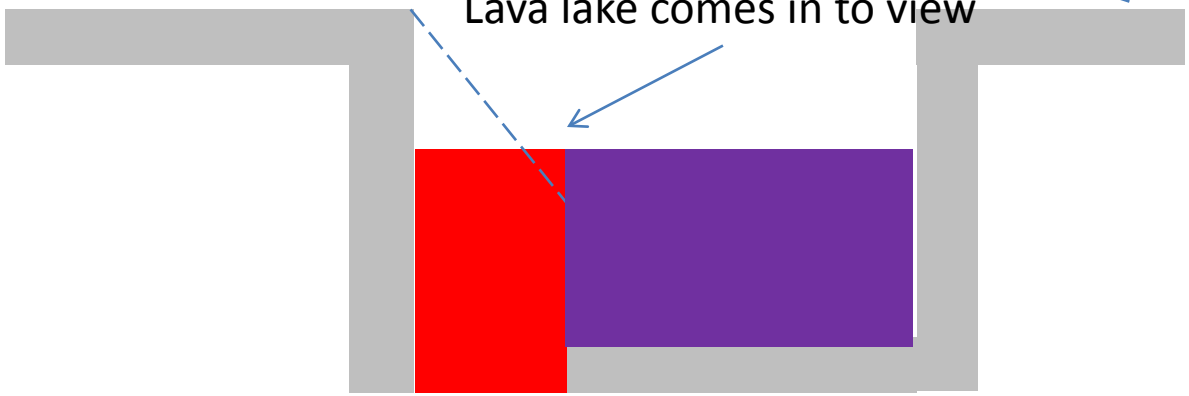

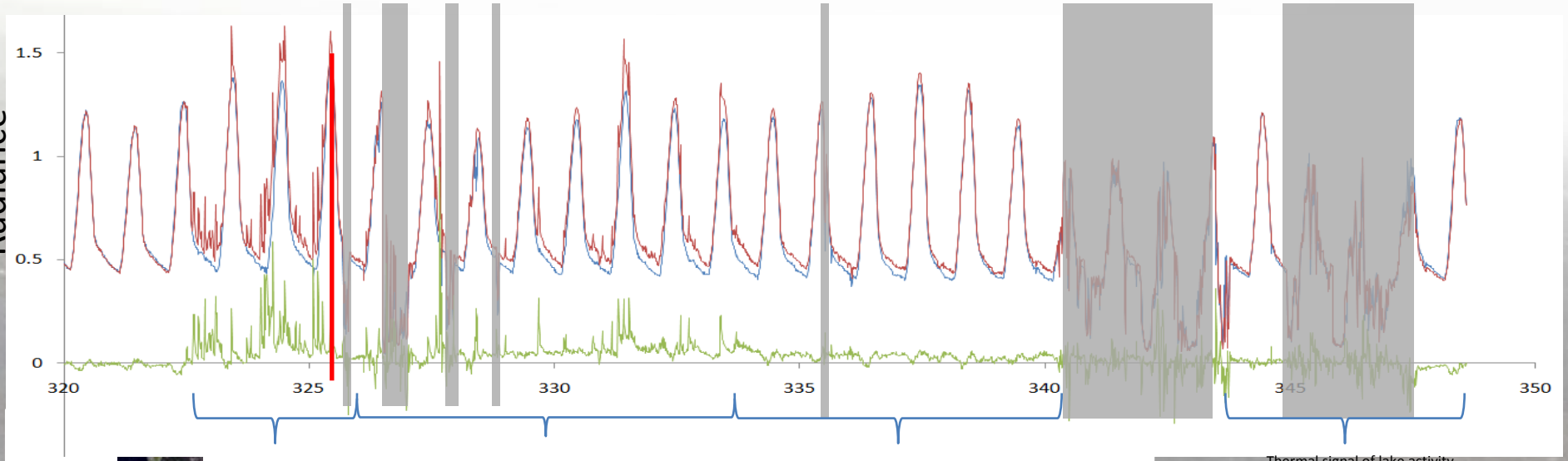

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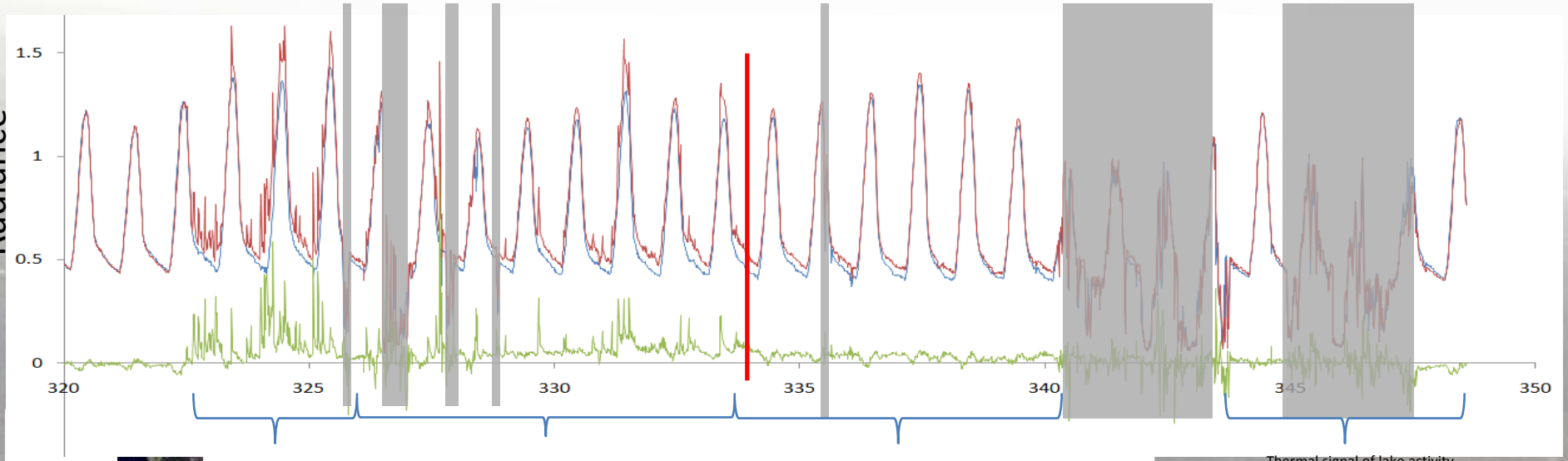

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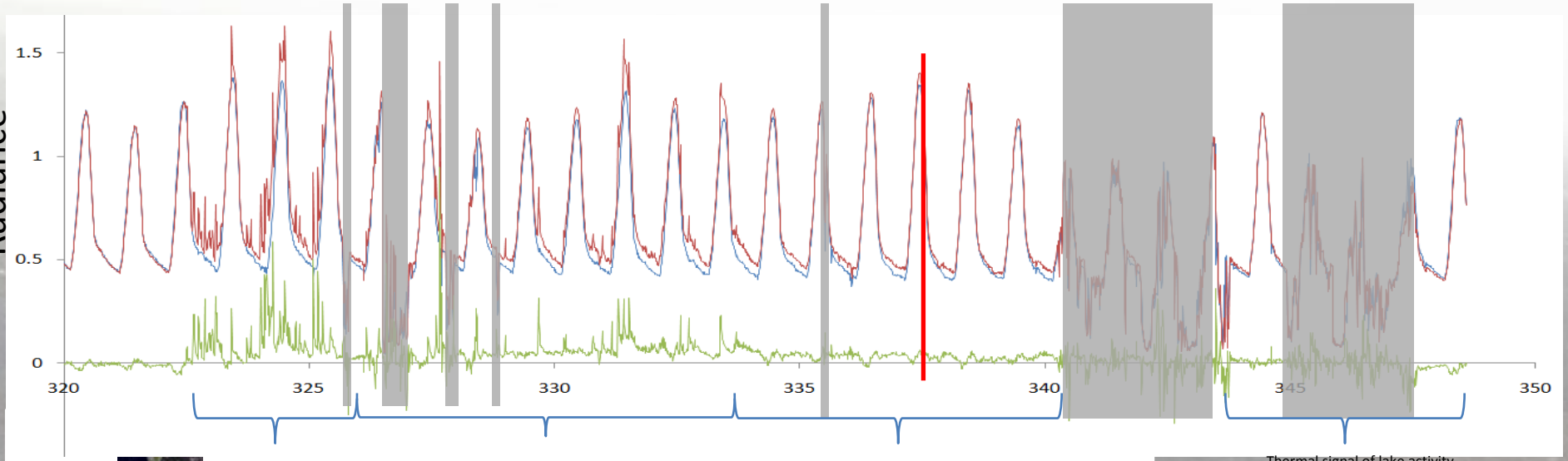

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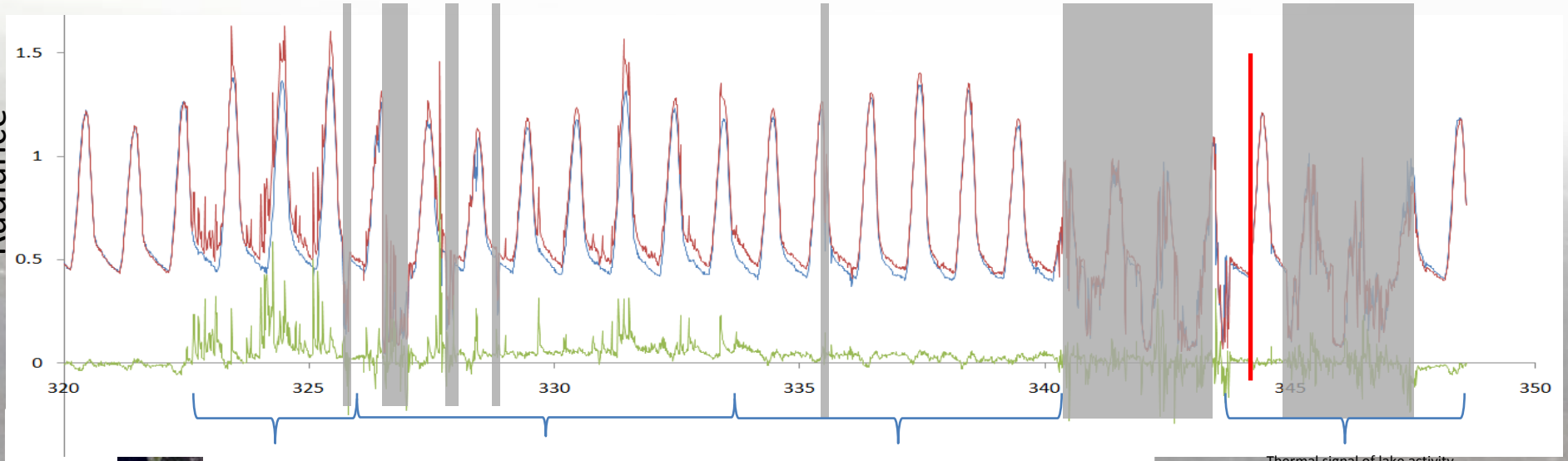

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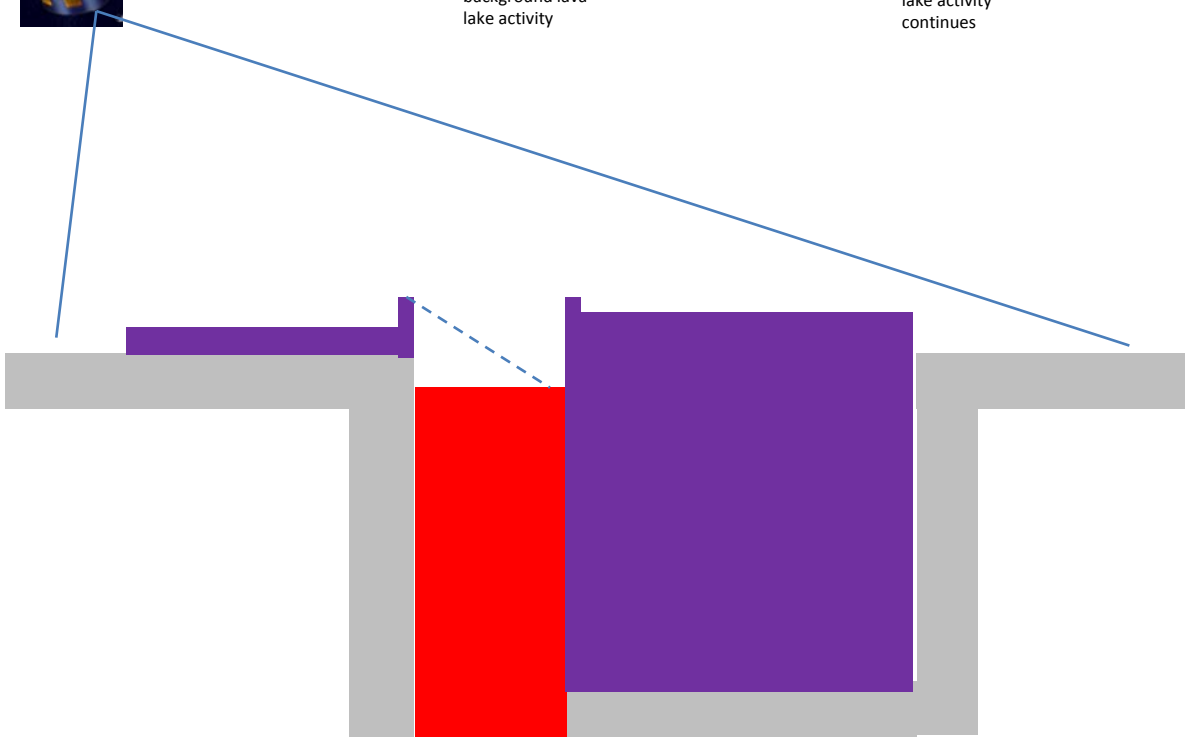
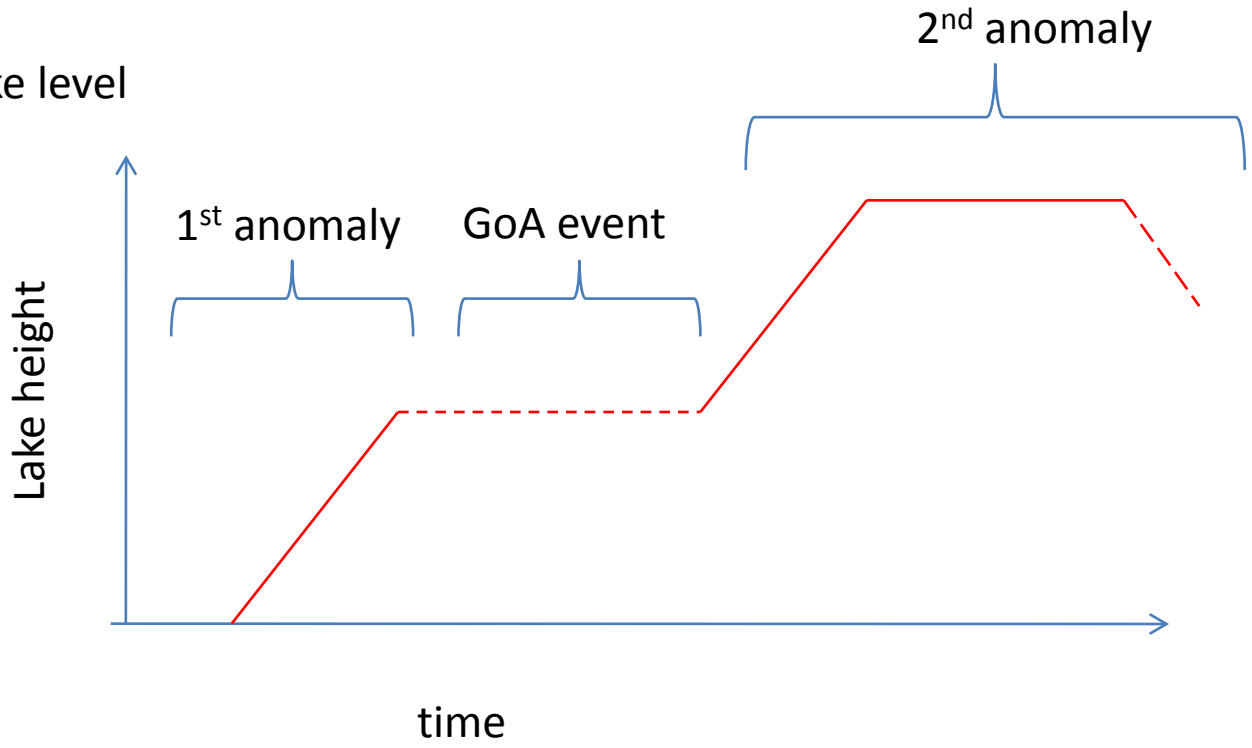


5. Erta Ale overflow

Sequence of events appears to be as follows:

1) A period of lake level rise
2) Hiatus in lake rise or lake fall, preceeding;
3) Seismic swarm in Gulf of Aden
4) Second period of lake level rise
5) Period of stable high lake level
6) Fall in lake level



6. Conclusions and future work

Bands at 1.6 , 3.9 and 10.8/12.0 um facilitate detection of eruptive activity at a range of different scales, from ~30m diameter lava lake to km long basaltic fissures – one band will be free from saturation

High repeat rate captures short term variations in radiance from the waxing and waning of large fissure eruptions to individual hour long lava lake overflows, and allows them to be correlated with seismic events and terrestrial observations

Acknowledgments:

Ethiopian Geophysical Observatory
Addis Ababa University
Ethiopian air force