Thermal remote sensing of active volcanoes in an operational environment: approaches of Alaska (AVO) and Hawaii (HVO)

The AVO-UAF/GI remote sensing group

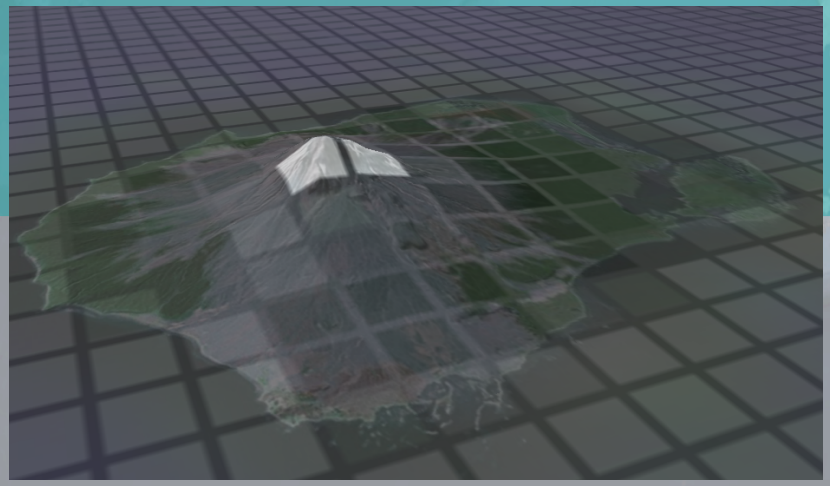
Satellite data's strengths kick in with the eruption.

THERMAL ANOMALIES:

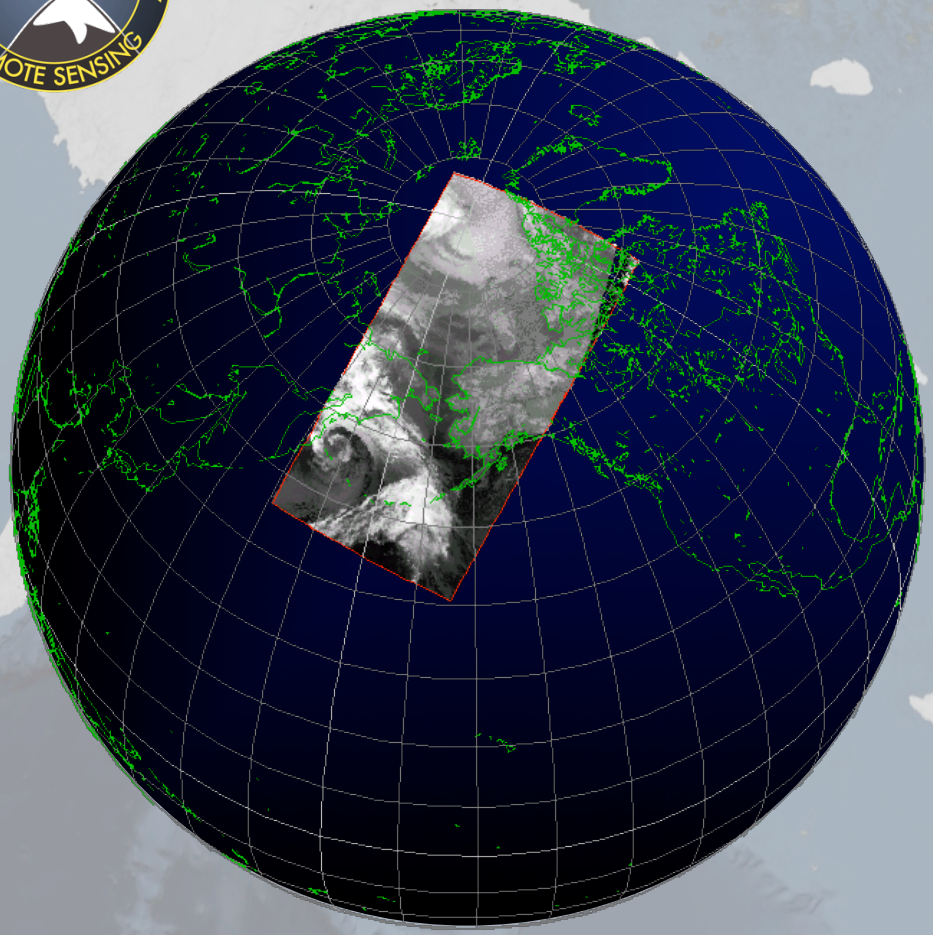
"Hotspots" where a volcano heats up before and during eruption.

VOLCANIC ASH PLUMES:

Tracking the position of volcanic ash clouds.



Satellite Monitoring of Volcanoes

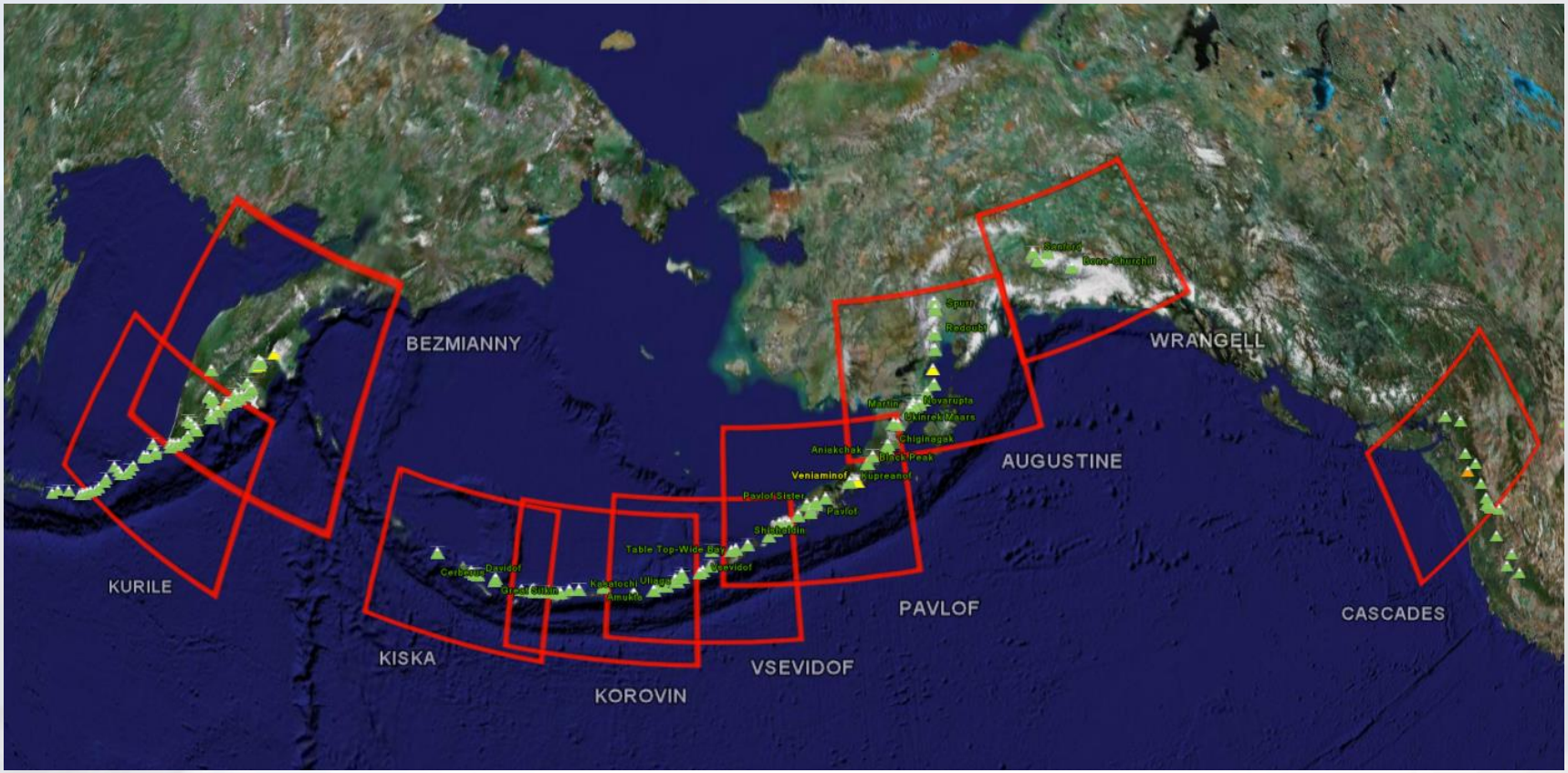


AVO is the first VO to use near real-time satellite remote sensing in its day to day operations

Data Sources:

1. Receiving stations at UAF/GI
2. Gilmore Creek NOAA
3. Navy Research Labs at Monterey, CA

Sectors and Data for Volcano Monitoring



Passes are divided in 6 s

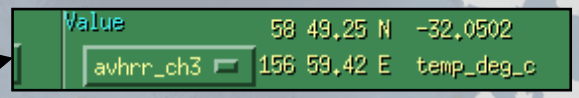
sing

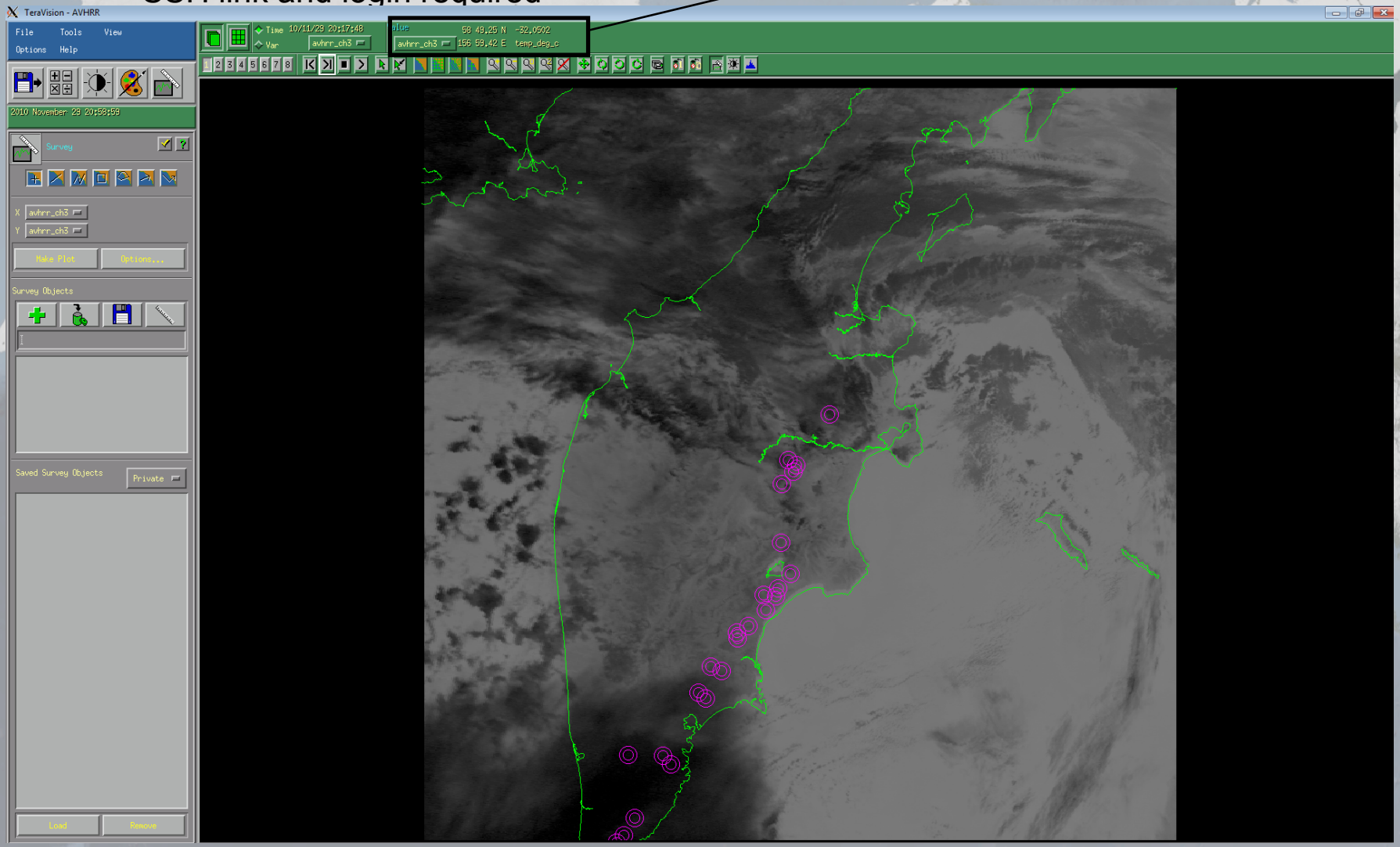
Near real-time data

- Why provide access?
  - Operational monitoring of North Pacific volcanoes
  - Need to respond 24 hours a day if an eruption
  - Need to provide quick, accurate response
- What data do we show?
  - AVHRR, MODIS, GOES and MTSAT data
  - Puff Volcanic Ash Tracking and Dispersion model
- Options to view?
  - Web / iPhone / iPad / Google Earth / ArcGIS Explorer
- Operational benefits
  - Speed of availability
  - Access anywhere

Pre web based access?

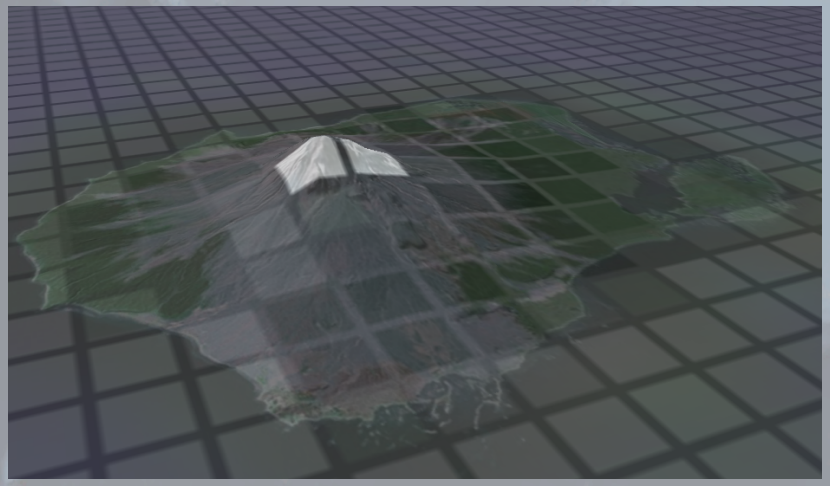
- TerraScan Software
  - Requires access to server for data
  - SSH link and login required





Analysis of Volcanic Activity

- Thermal anomalies
  - 3.6 µm channel
  - “Hotspots” where a volcano heats up before and during eruption
- Volcanic Ash Clouds
  - 11 and 12 µm channels
  - Tracking the position of volcanic ash clouds.
- Automated alarm system and daily monitoring
  - Text and email alerts
  - Daily AM and PM reports and database entry



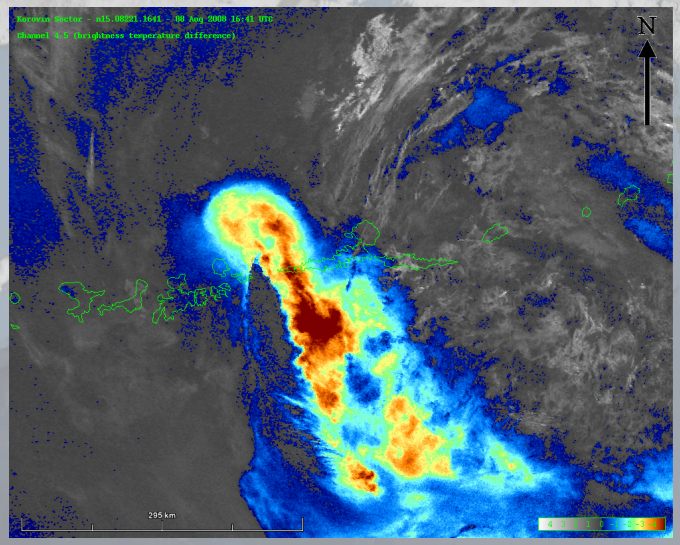
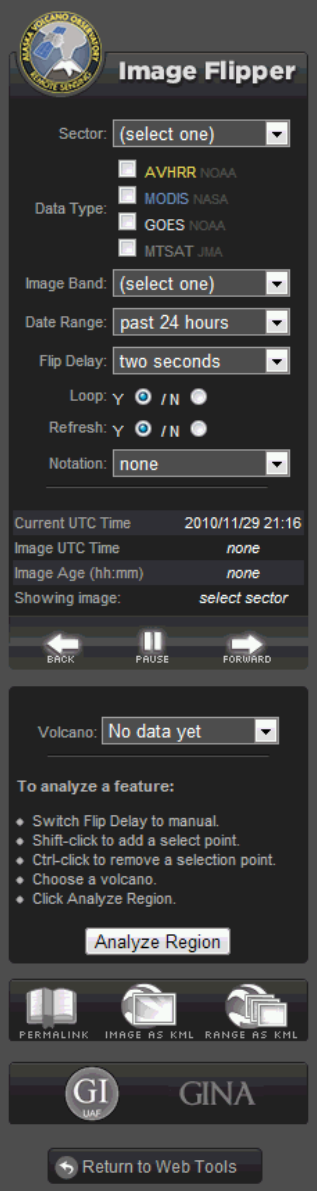


Image Flipper http://avo.images.alaska.edu/tools/ftp_browser.php



GEOPHYSICAL INSTITUTE

ALASKA VOLCANO OBSERVATORY

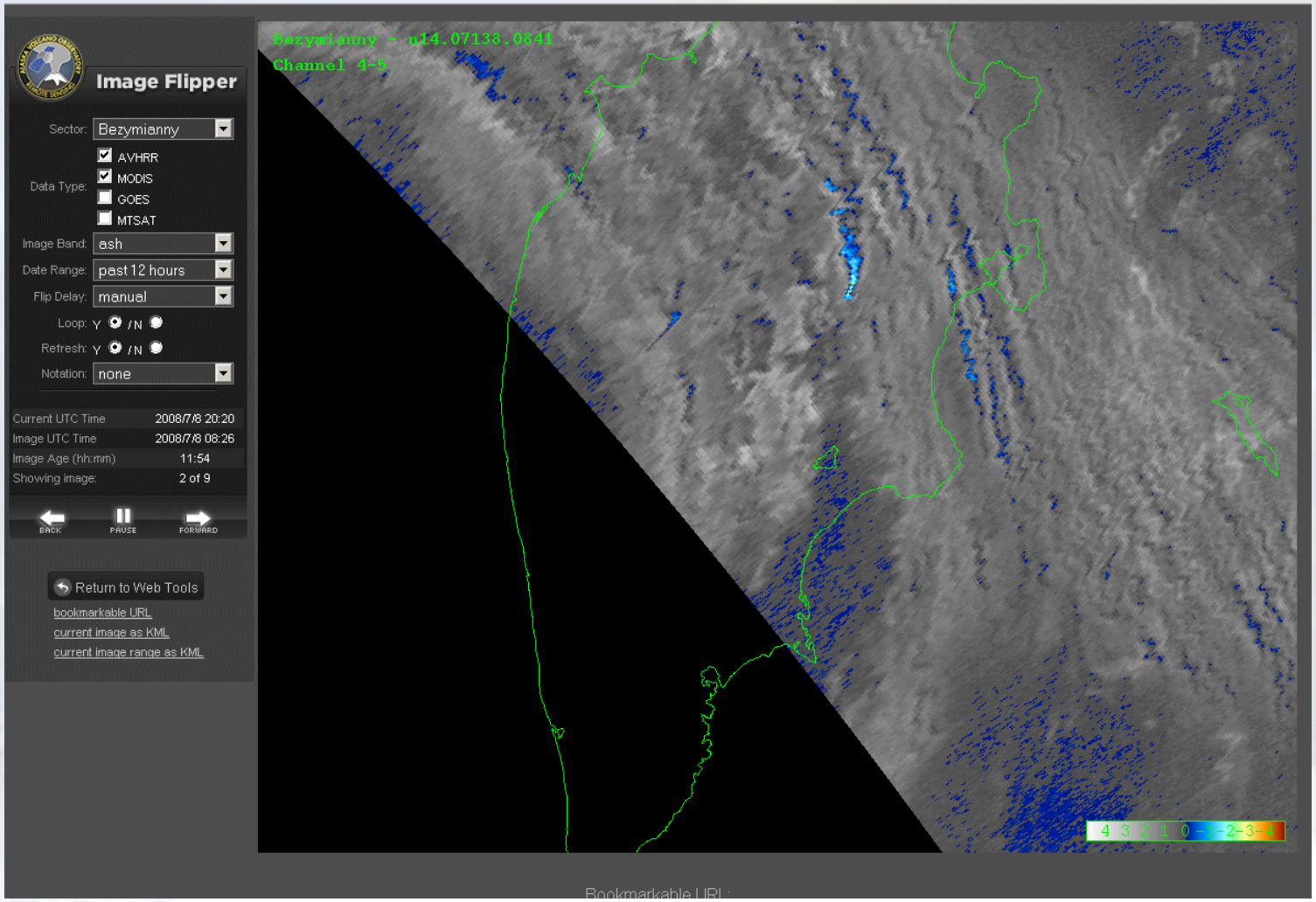
REMOTE SENSING

UNIVERSITY OF ALASKA FAIRBANKS

IMAGE SOURCE

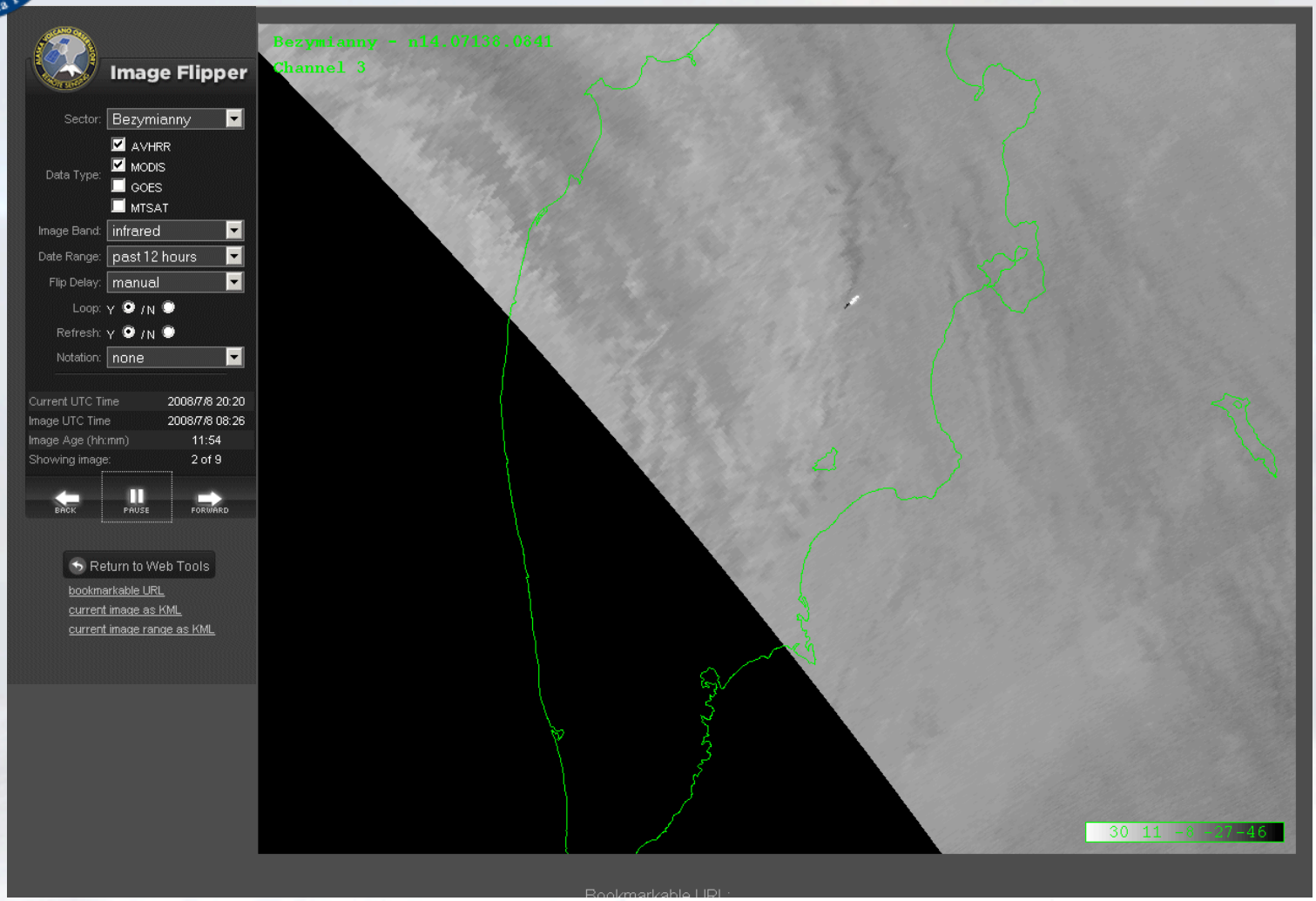
ftp://avo-ftp.images.alaska.edu/Volcano_Images

Image flipper :: Volcanic Ash



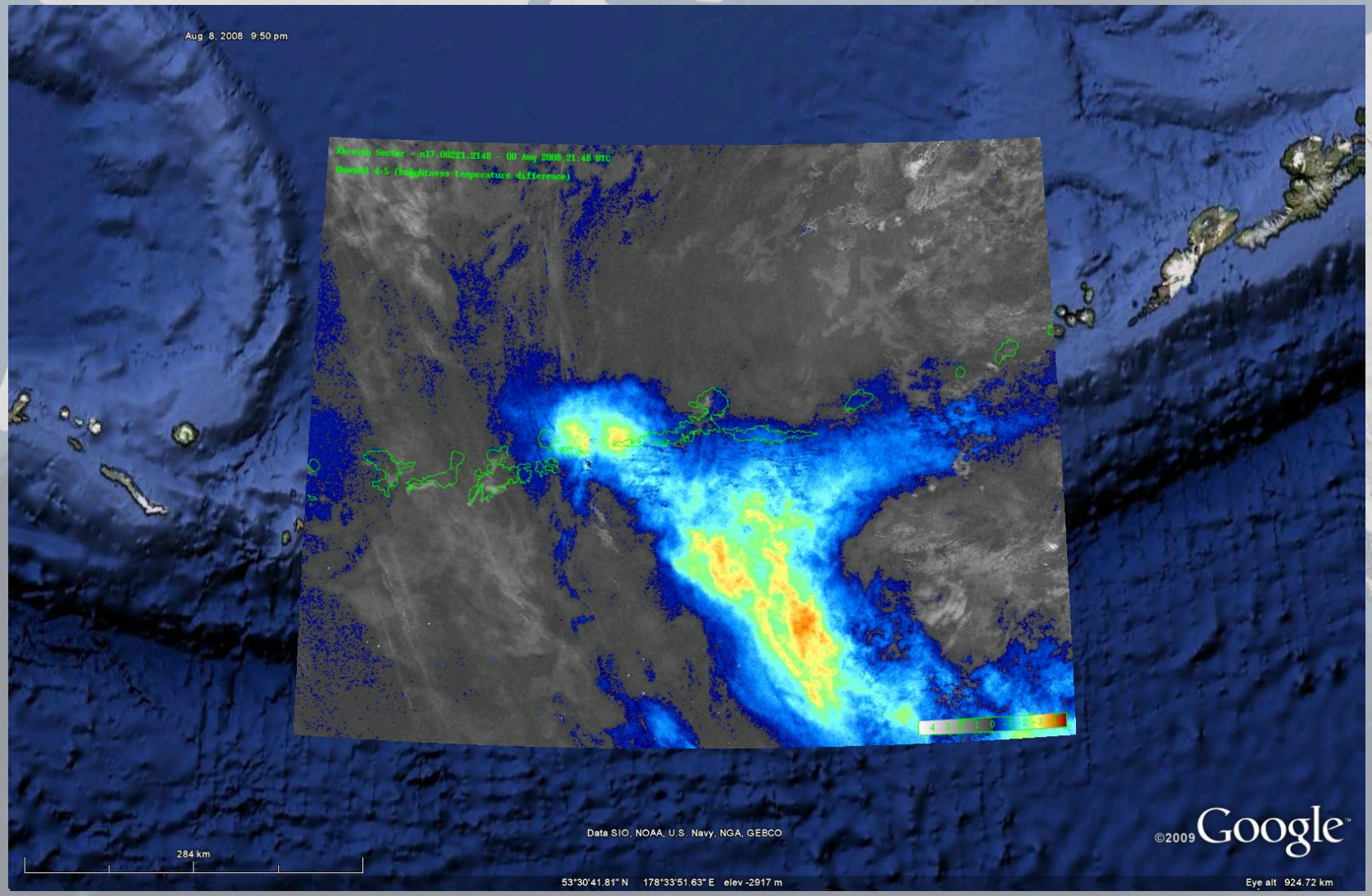
http://avo.images.alaska.edu/tools/ftp_browser.php

Image flipper :: Hotspot



http://avo.images.alaska.edu/tools/ftp_browser.php

Remote Sensing data in Google Earth™



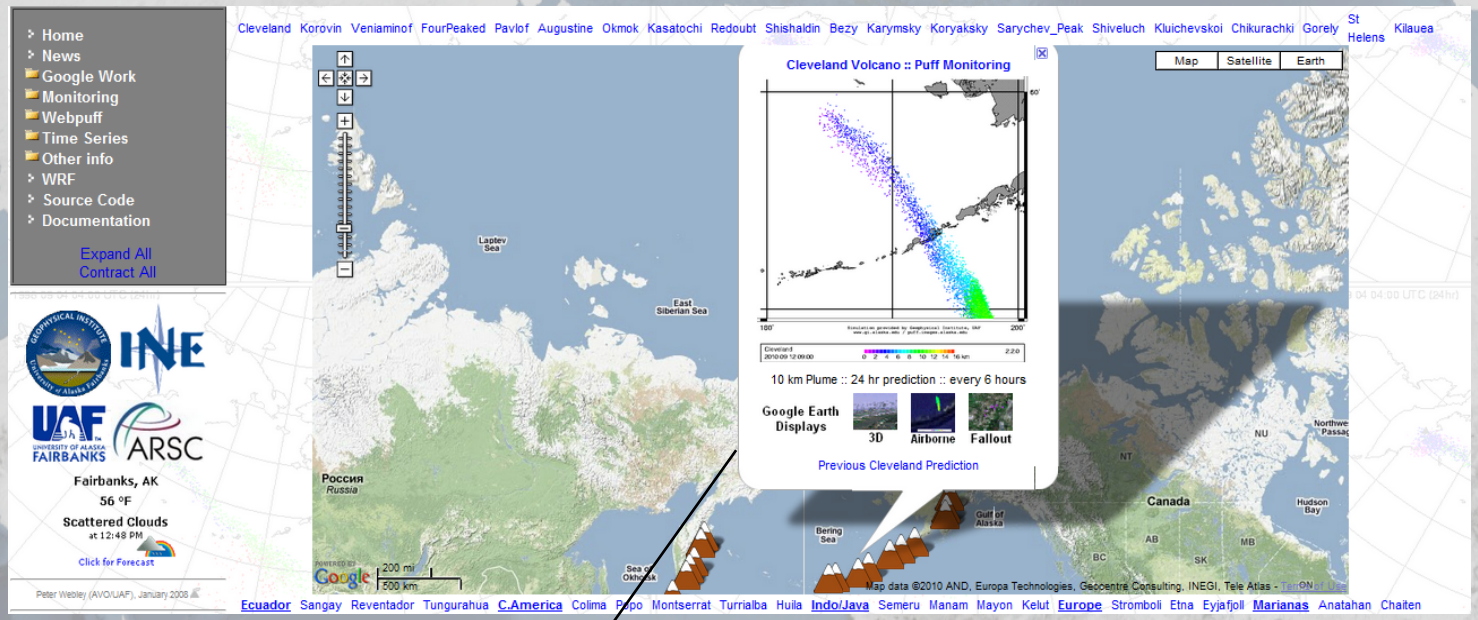
What is the Puff model?

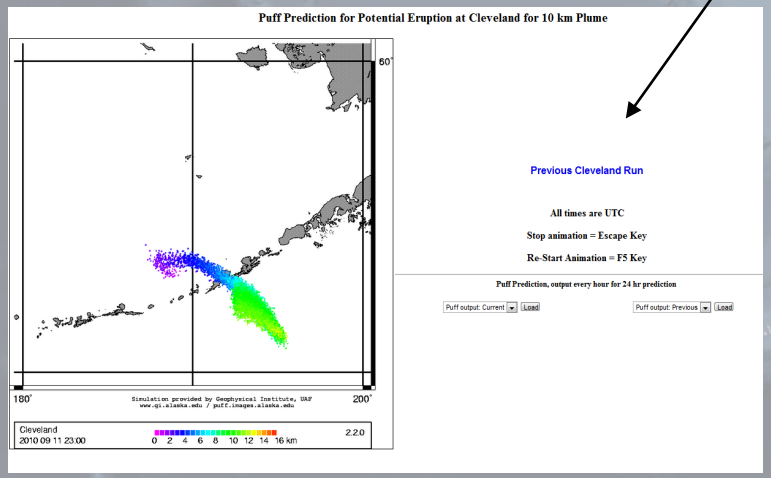
- Specifically tailored for volcanic ash and 3D tracking of volcanic ash particles
- Ash particles released over volcano and tracked over time
- Uses meteorological wind fields (GFS, NAM216, Reanalysis, WRF)
- Initialization parameters include
  - Volcano name and location
  - Number of particles
  - Mean Particle size and spread
  - Plume dimensions (height, width and shape)
  - Length of model prediction and length of eruption
  - Output time step
  - Horizontal and Vertical Diffusion (constant or varying)
  - Wind field model

(http://puff.images.alaska.edu)

Puff – Volcanic Ash Tracking and Dispersion model

http://puff.images.alaska.edu

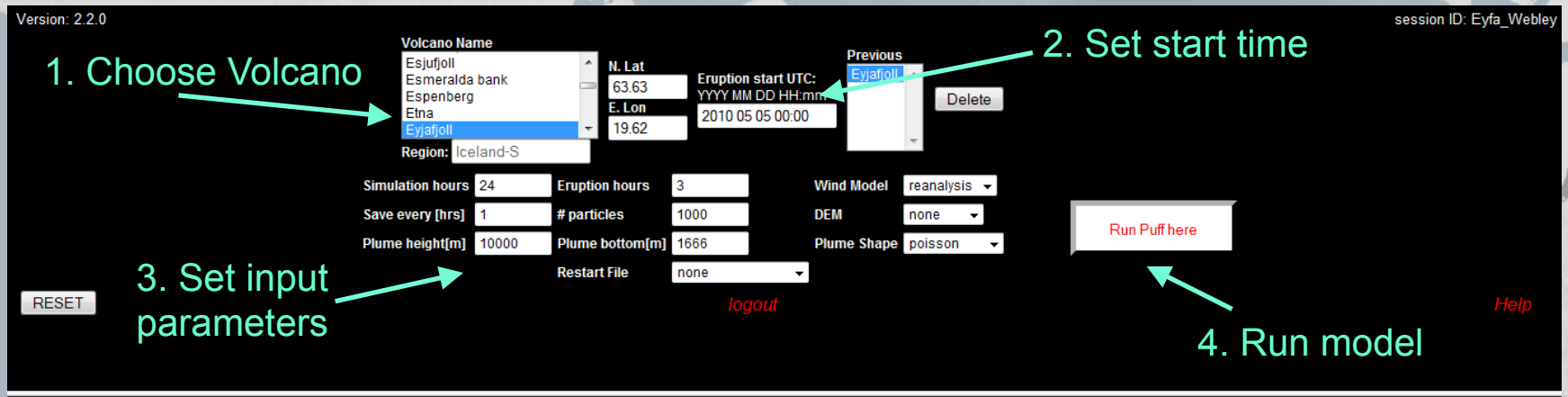


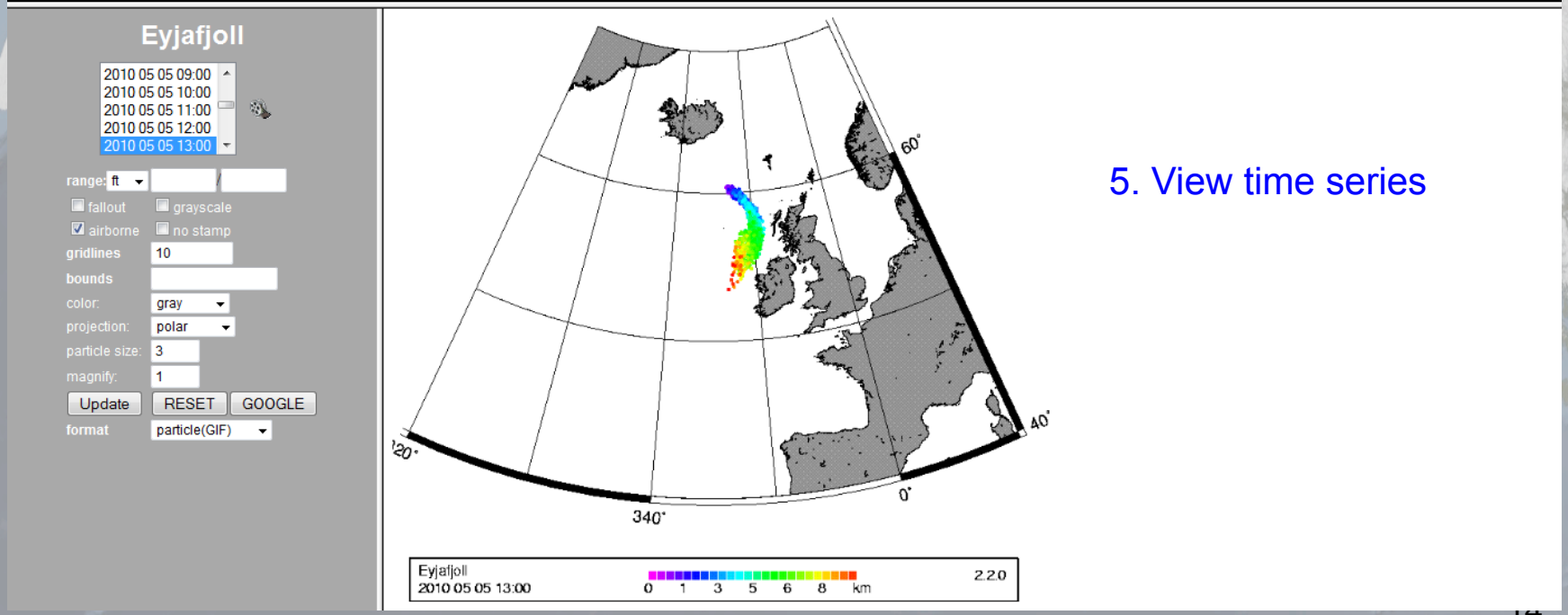


- Automated forecasts for 37 volcanoes worldwide
- Forecasts for initial plumes from 4 – 16 km ASL
- 24 hour forecasts, updated every 3 – 6 hours
- Standardized displays to reduce hazard assessment time
- Two-dimensional and Three-dimensional visualizations
- NWP vertical profiles to assist plume height determination

Online WebPuff

http://puff.images.alaska.edu/cgi-bin/login_agu.pl

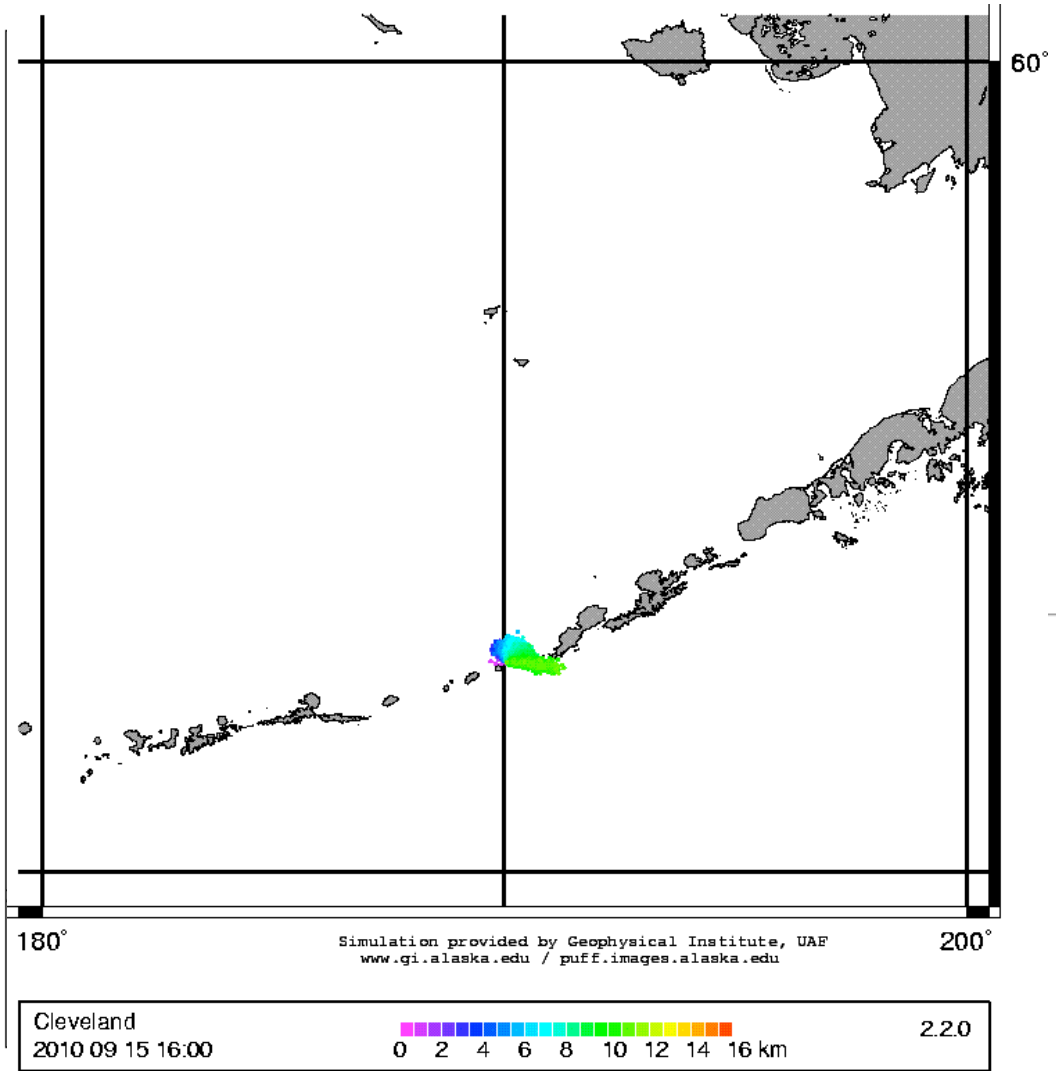




Run for any volcano worldwide in real time or retrospectively from 1970 – present

Cleveland, Alaska

Puff Prediction for Potential Eruption at Cleveland for 10 km Plume



Previous Cleveland Run

All times are UTC

Stop animation = Escape Key

Re-Start Animation = F5 Key

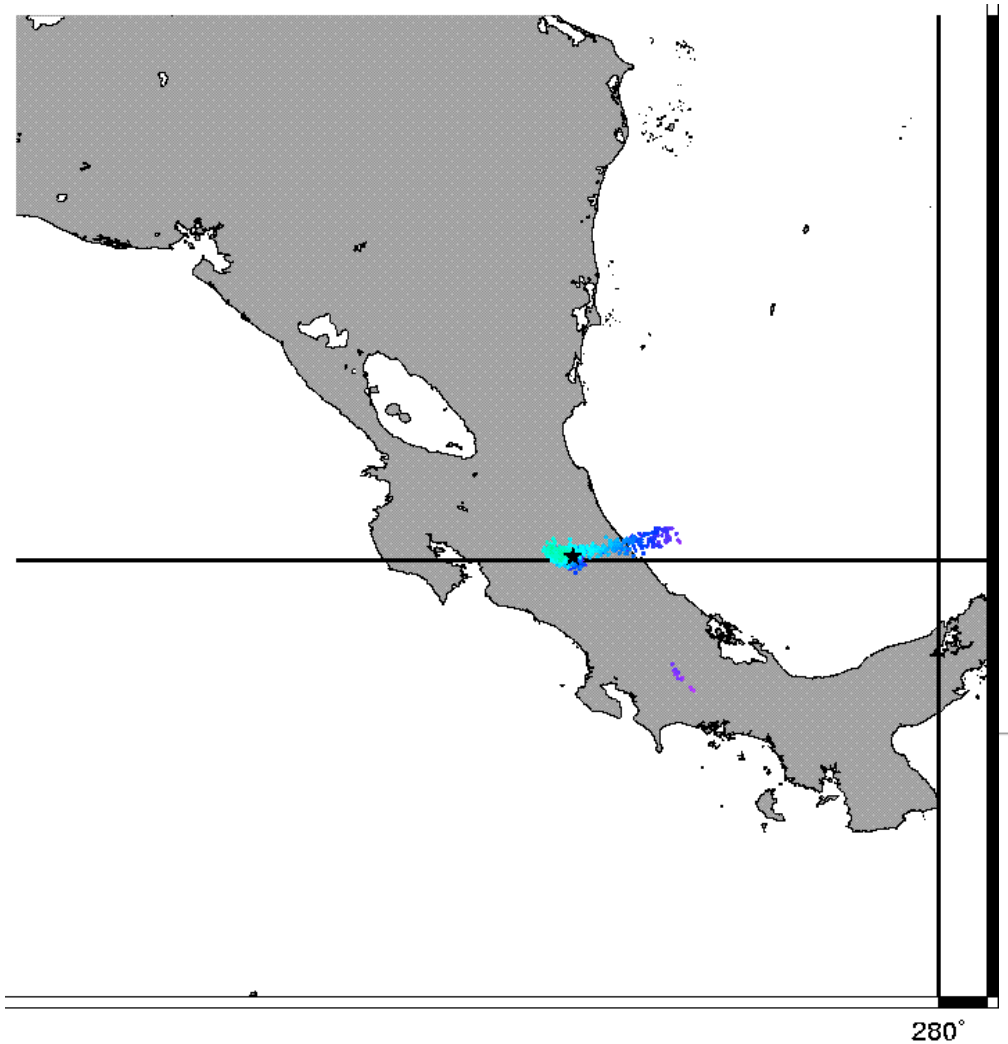
Puff Prediction, output every hour for 24 hr prediction

Puff output: Current Load

Puff output: Previous Load

Turrialba, Costa Rica

Puff Prediction for Potential Eruption at Turrialba for 10 km Plume



Simulation provided by Geophysical Institute, UAF
www.gi.alaska.edu / puff.images.alaska.edu

Turrialba
2010 09 14 17:00

0 2 4 6 8 10 12 14 16 km

2.2.0

Previous Turrialba Run

This page will refresh in 4:56 mins

To manually refresh, use the F5

All times are UTC

Stop animation = Escape Key

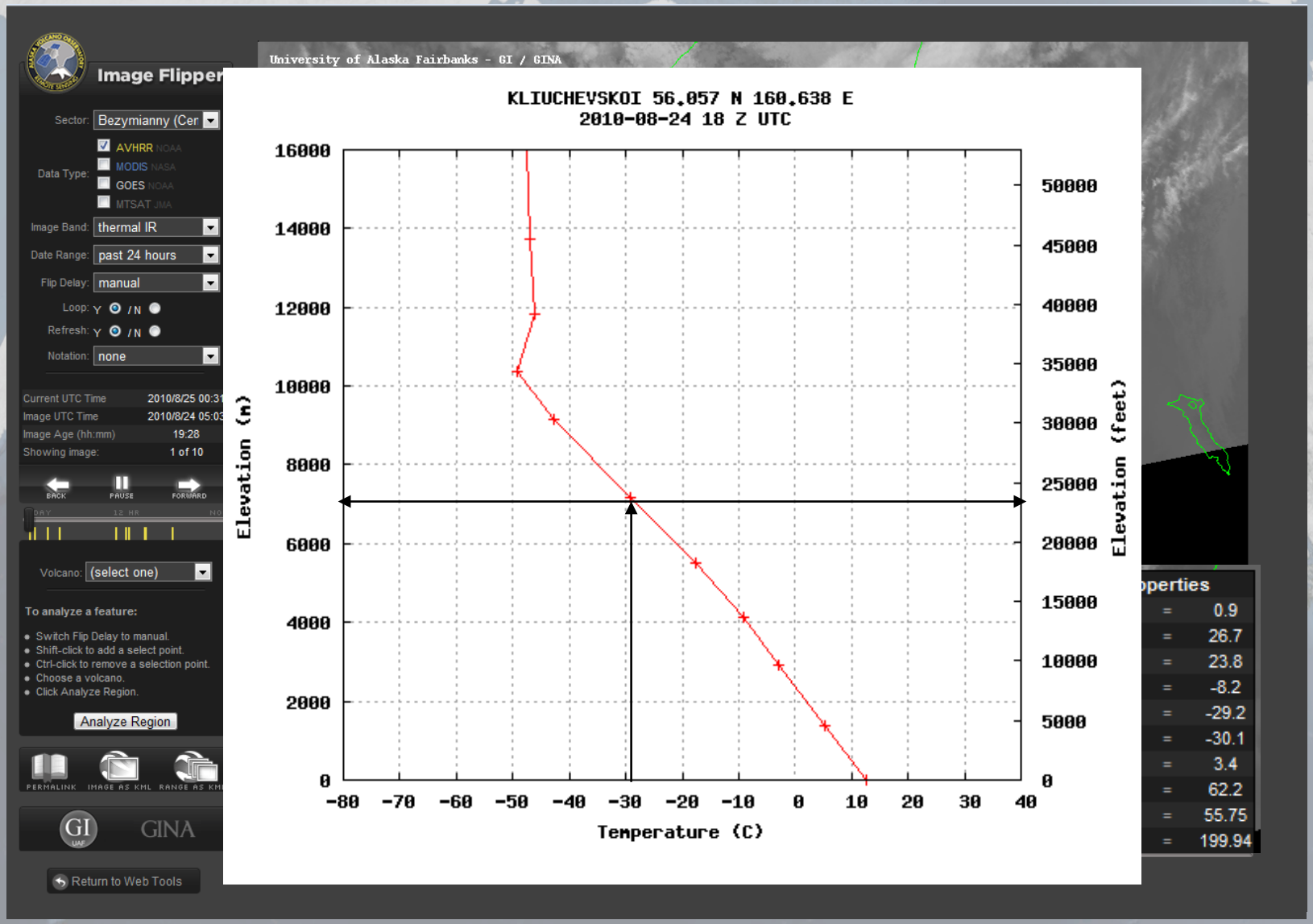
Re-Start Animation = F5 Key

Puff Prediction, output every hour for 24 hr prediction

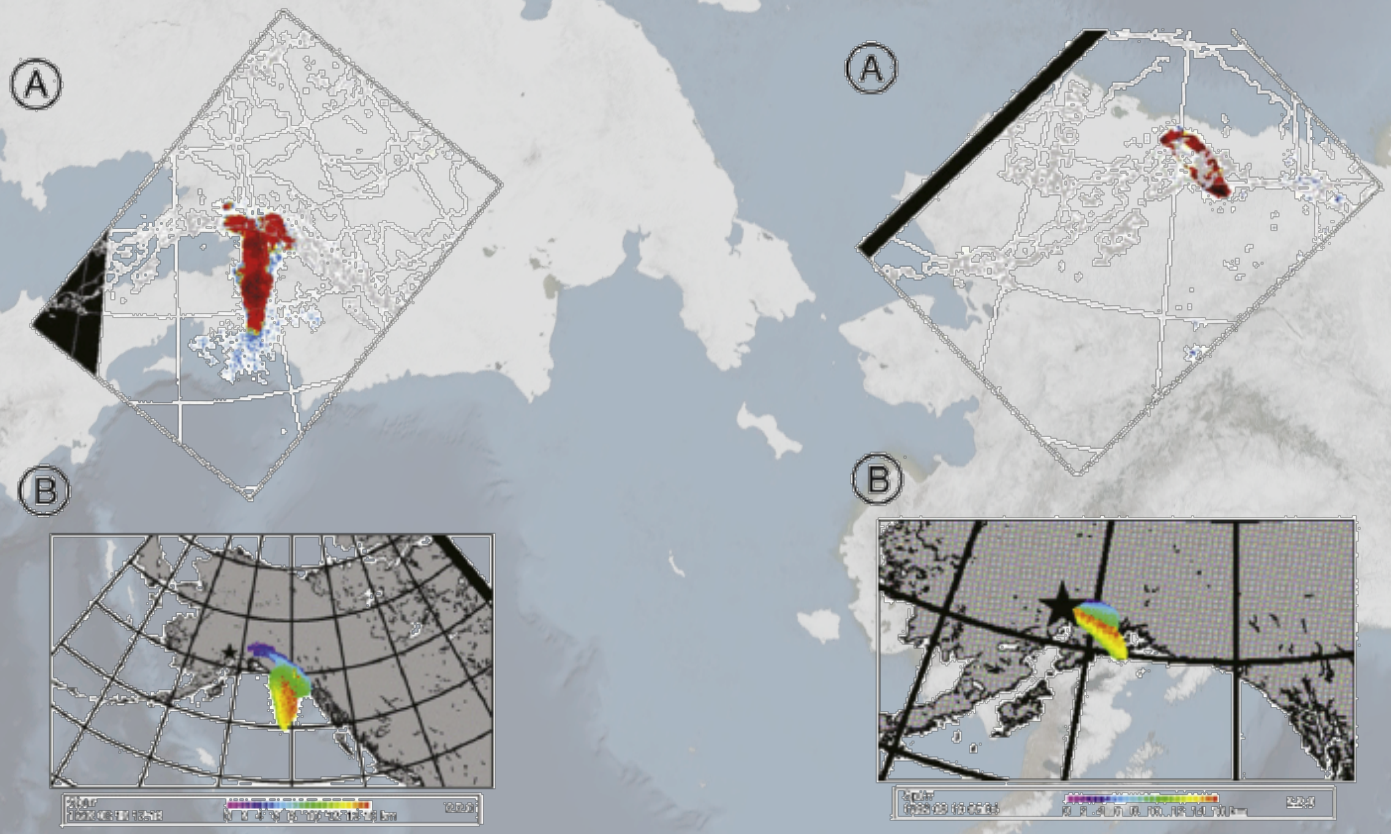
Puff output: Current Load

Puff output: Previous Load

Determination of Plume Heights



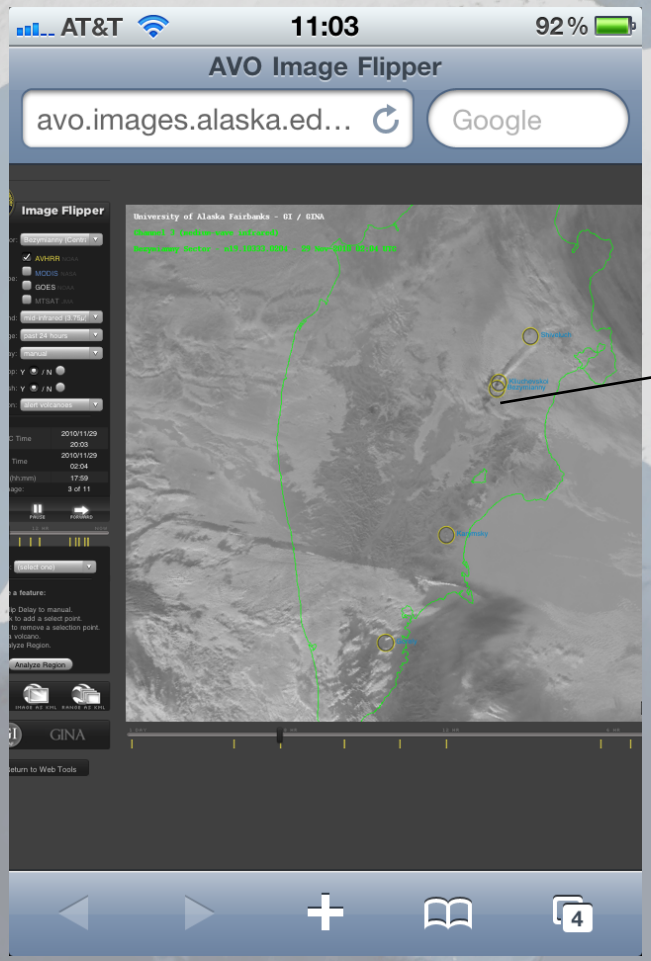
Puff to Satellite comparison

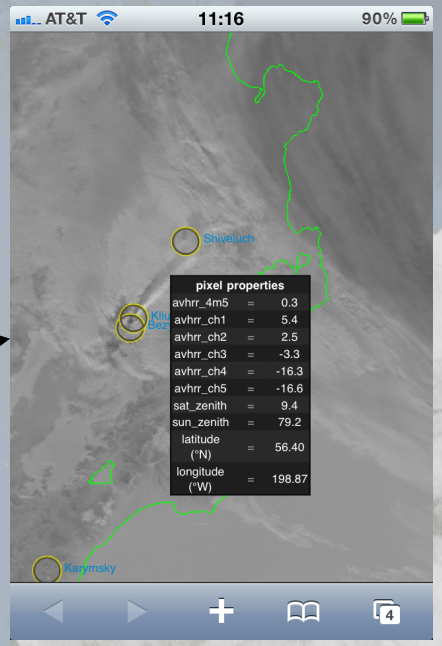


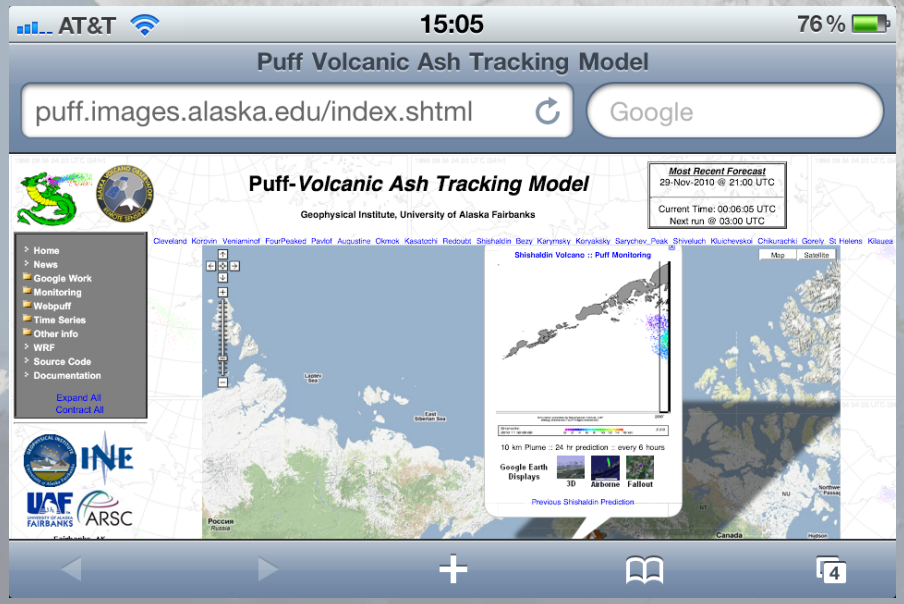
Threat Score from how much over- and under- estimated by model?

Webley, P. W., Stunder, B.J.B., and K.G. Dean (2009). Significant eruption source parameter(s) for operational ash cloud transport and dispersion models. *Journal of Volcanology and Geothermal Research: Special Issue on Volcanic Ash Clouds, eds. Larry Mastin and Peter Webley,* **186** (1 – 2), 108 - 119.

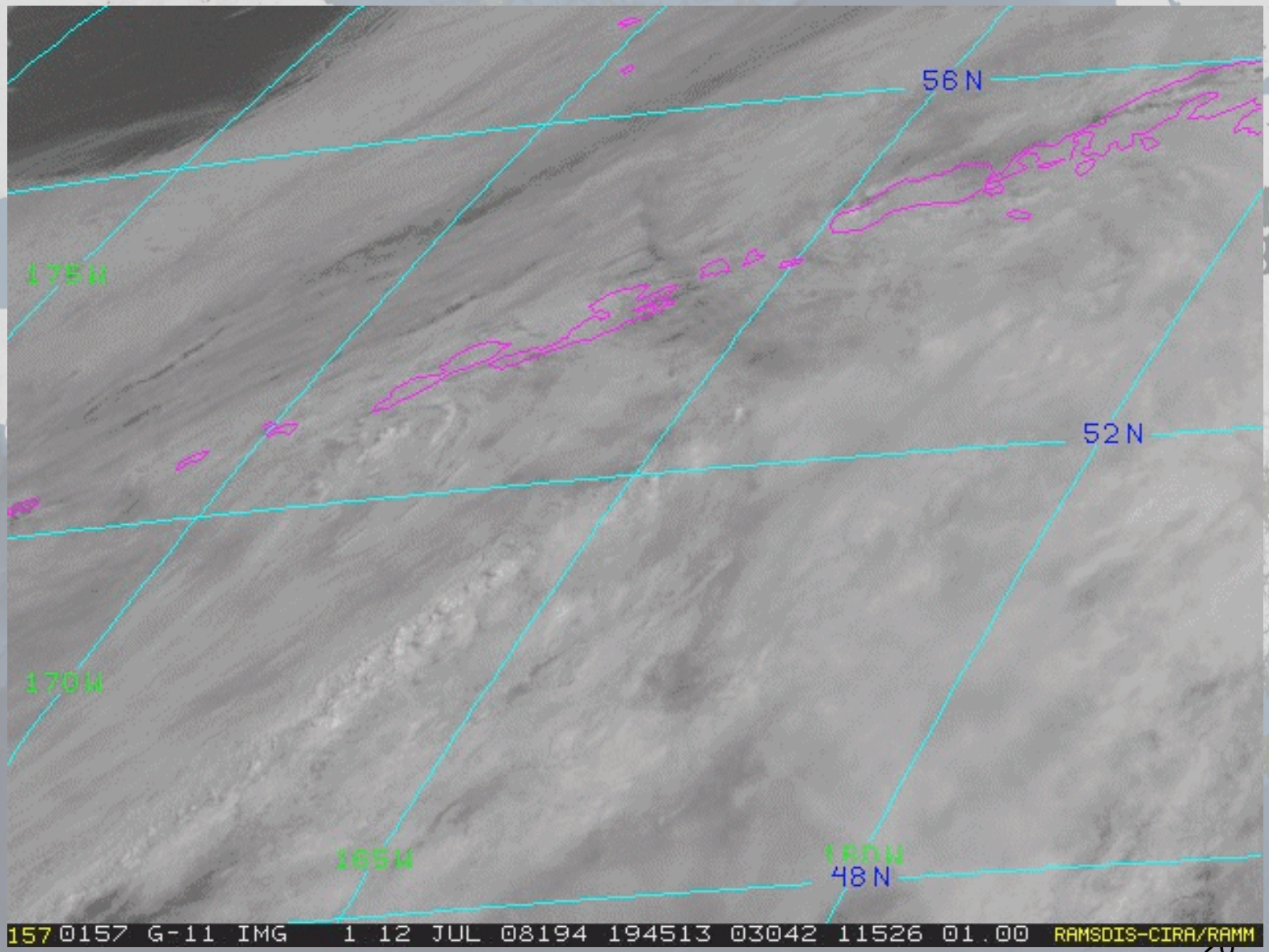
iPhone access to data



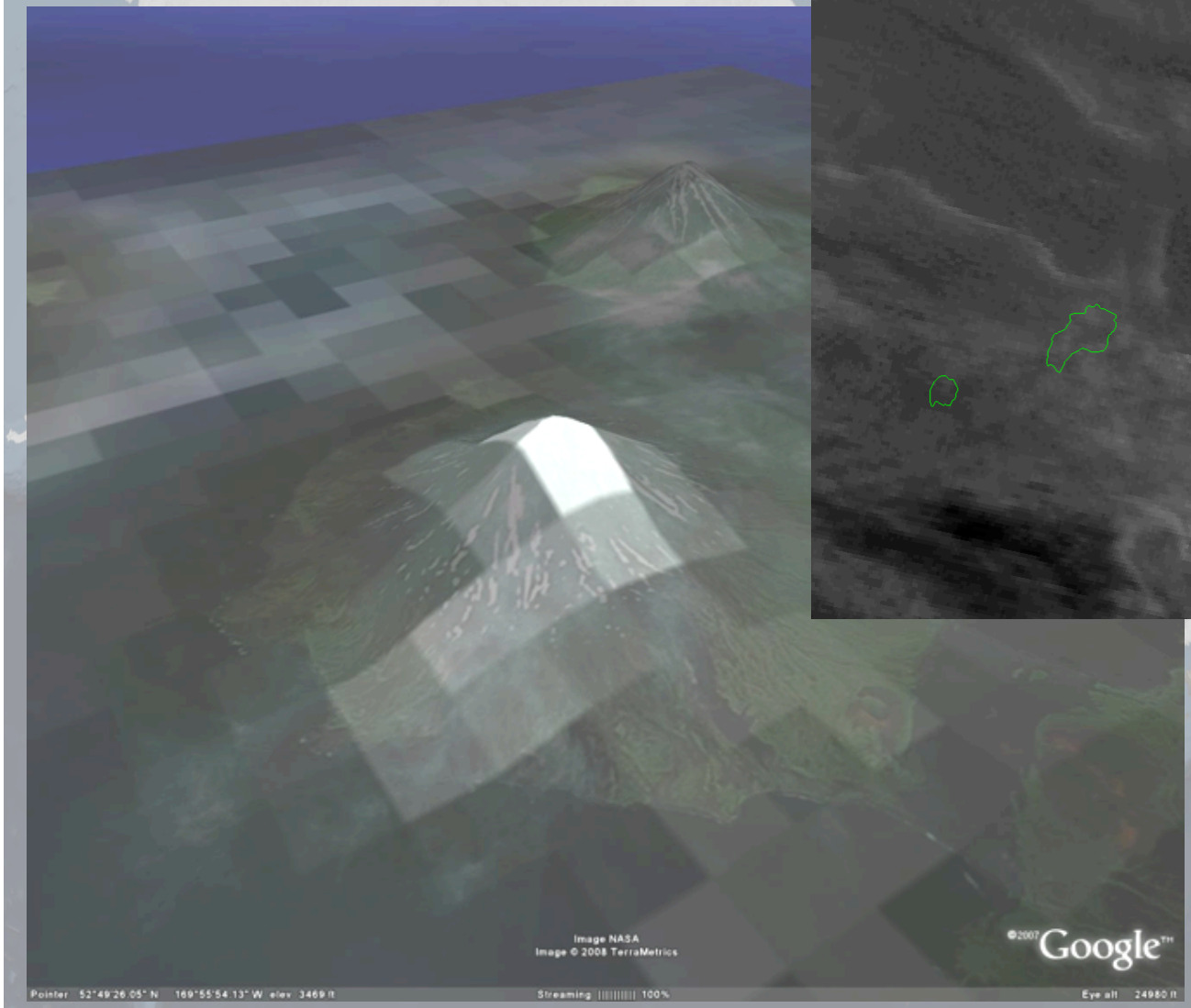


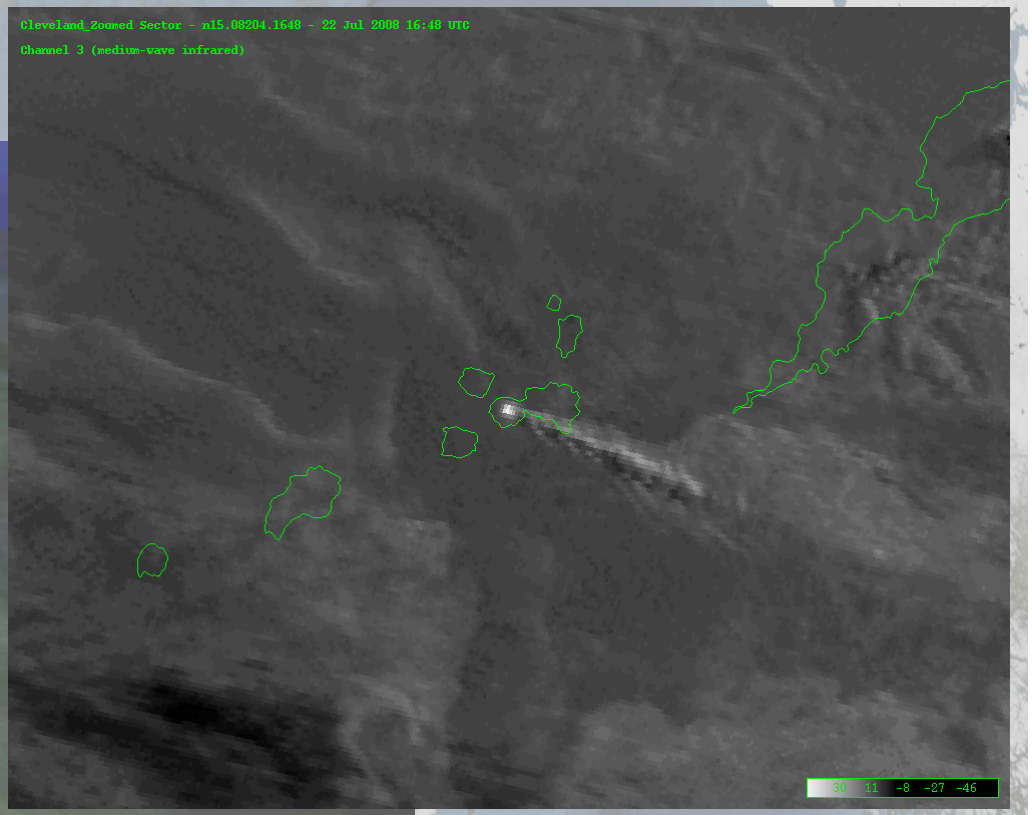


Okmok Volcano, Alaska - 2008

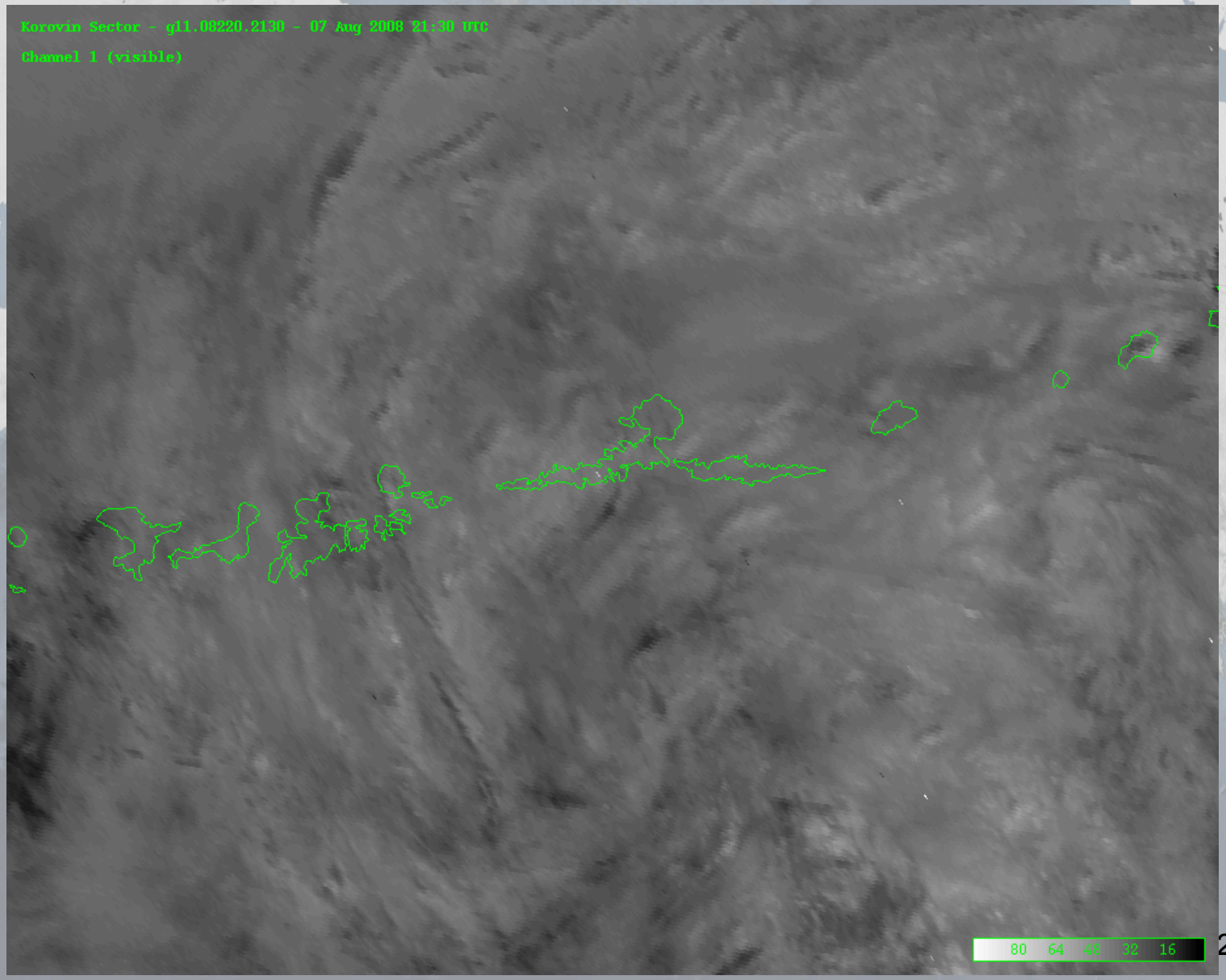


Cleveland Volcano, Alaska - 2008

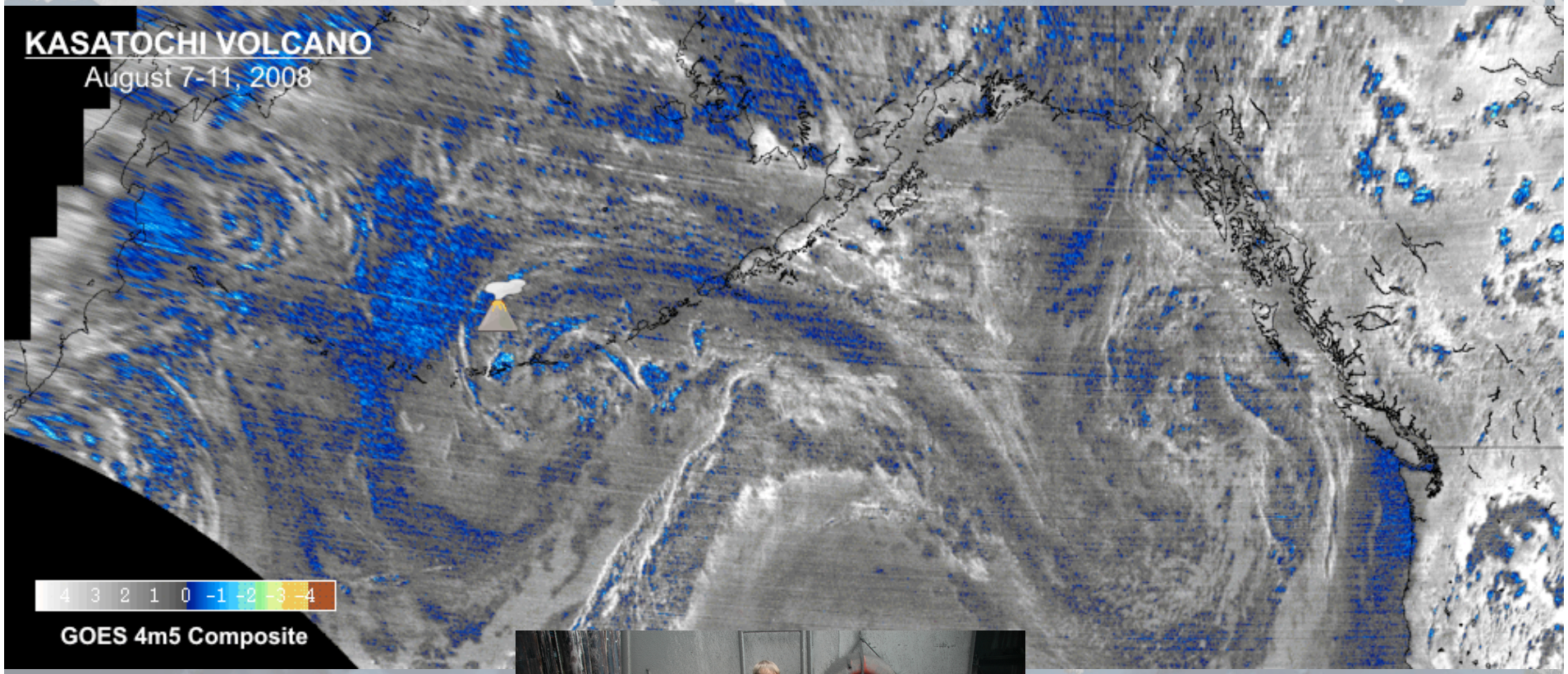




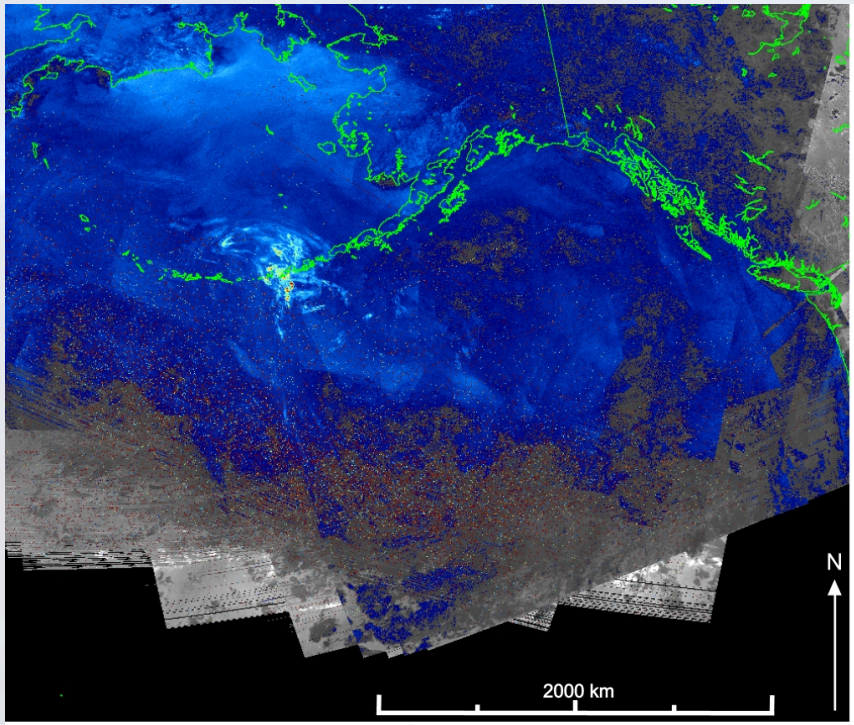
Kasatochi Volcano, Alaska - 2008



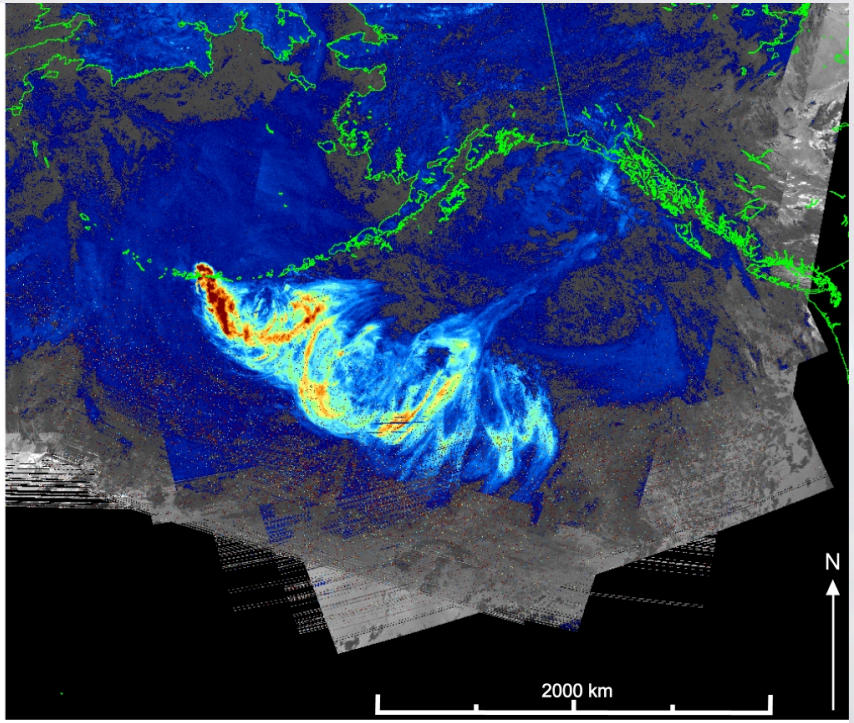
Kasatochi Volcano, Alaska



Okmok versus Kasatochi Volcanic Clouds



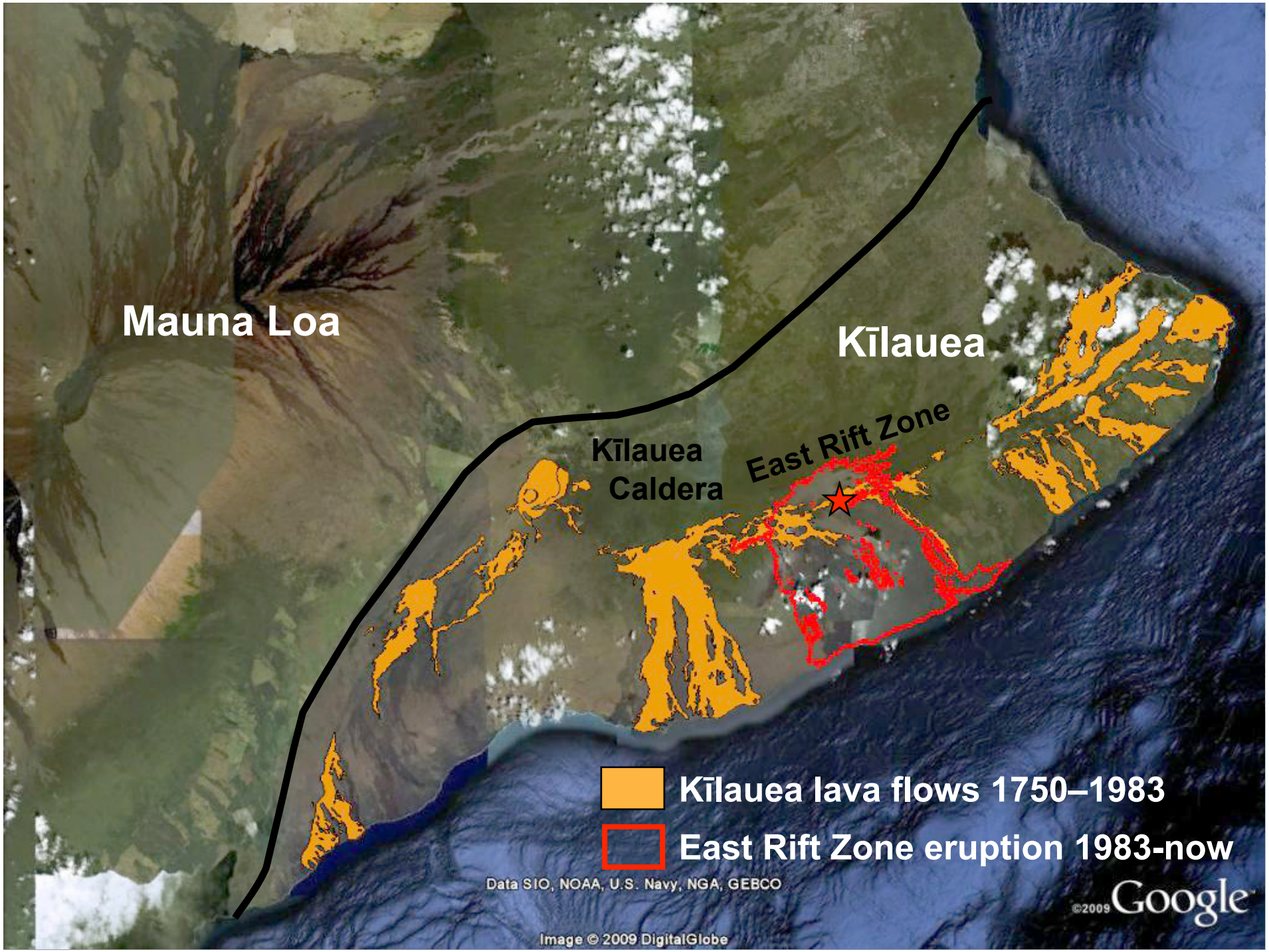
Okmok



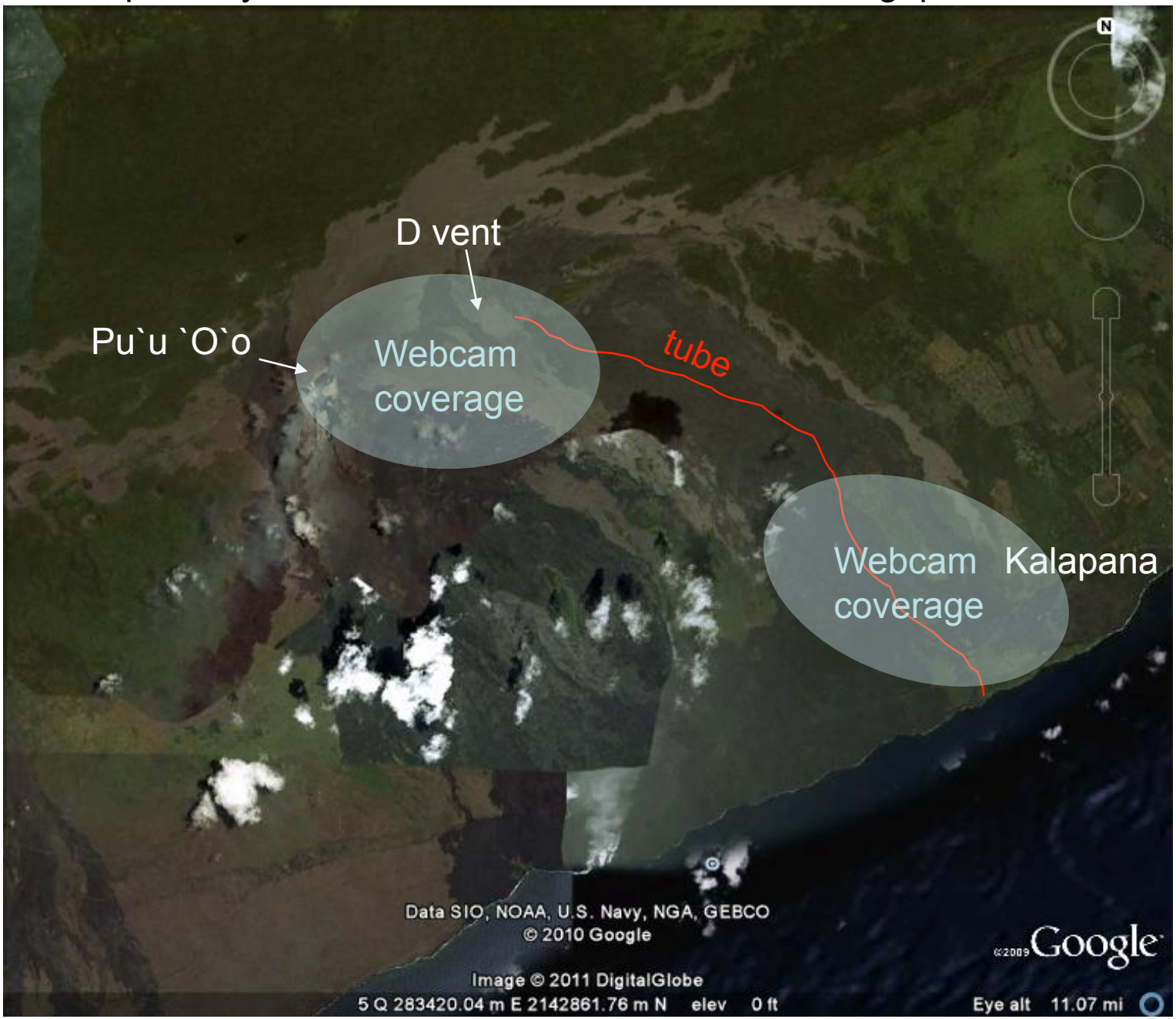
Kasatochi

http://avo.images.alaska.edu/tools

Hawaiian Volcano Observatory (HVO): just starting to use thermal satellite data

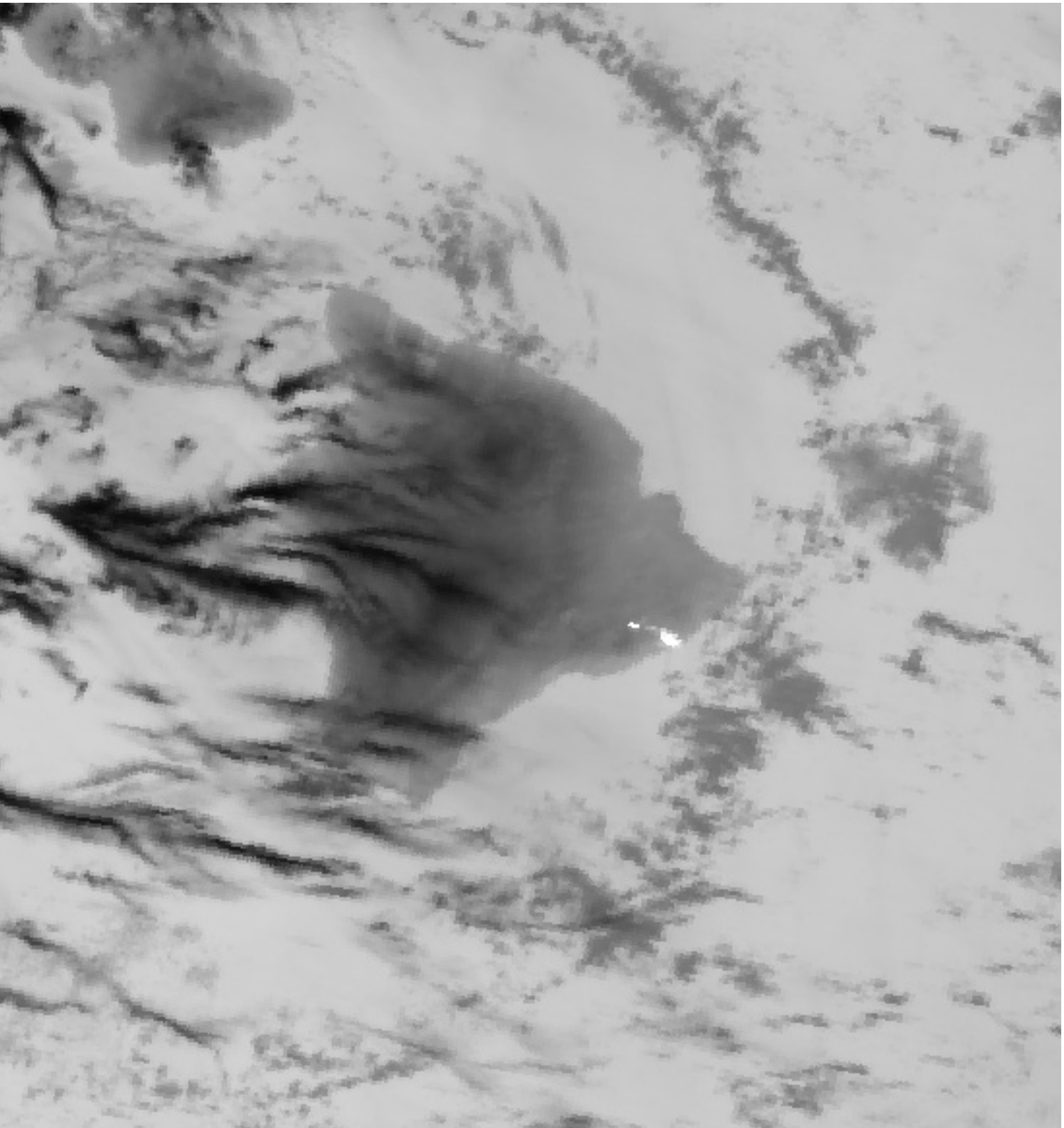

Mauna Loa
Kīlauea
Kīlauea Caldera
East Rift Zone
Kīlauea lava flows 1750–1983
East Rift Zone eruption 1983-now
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
©2009 Google
Image © 2009 DigitalGlobe

Kilauea: exceptionally well-monitored, but still observational gaps



In Hawaii, primary hazard is lava flows – destruction of property/infrastructure

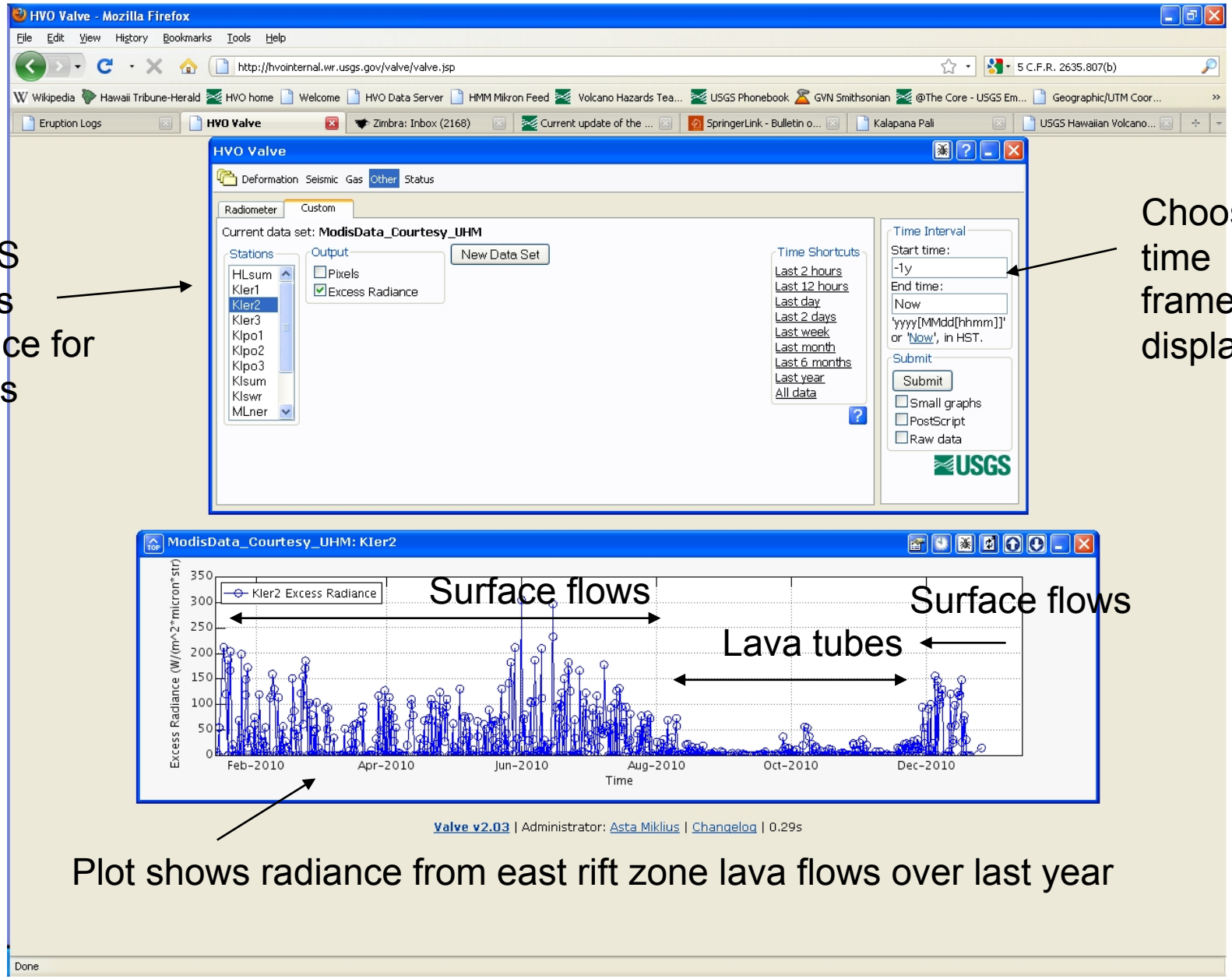
Photos by Bruce Omori



MODIS data are incoming to HVO thanks to UH Manoa (thanks Rob!)

…but images are generally 1 day old

VALVE: web-based display of monitoring data (seismic, GPS, gas, etc.)

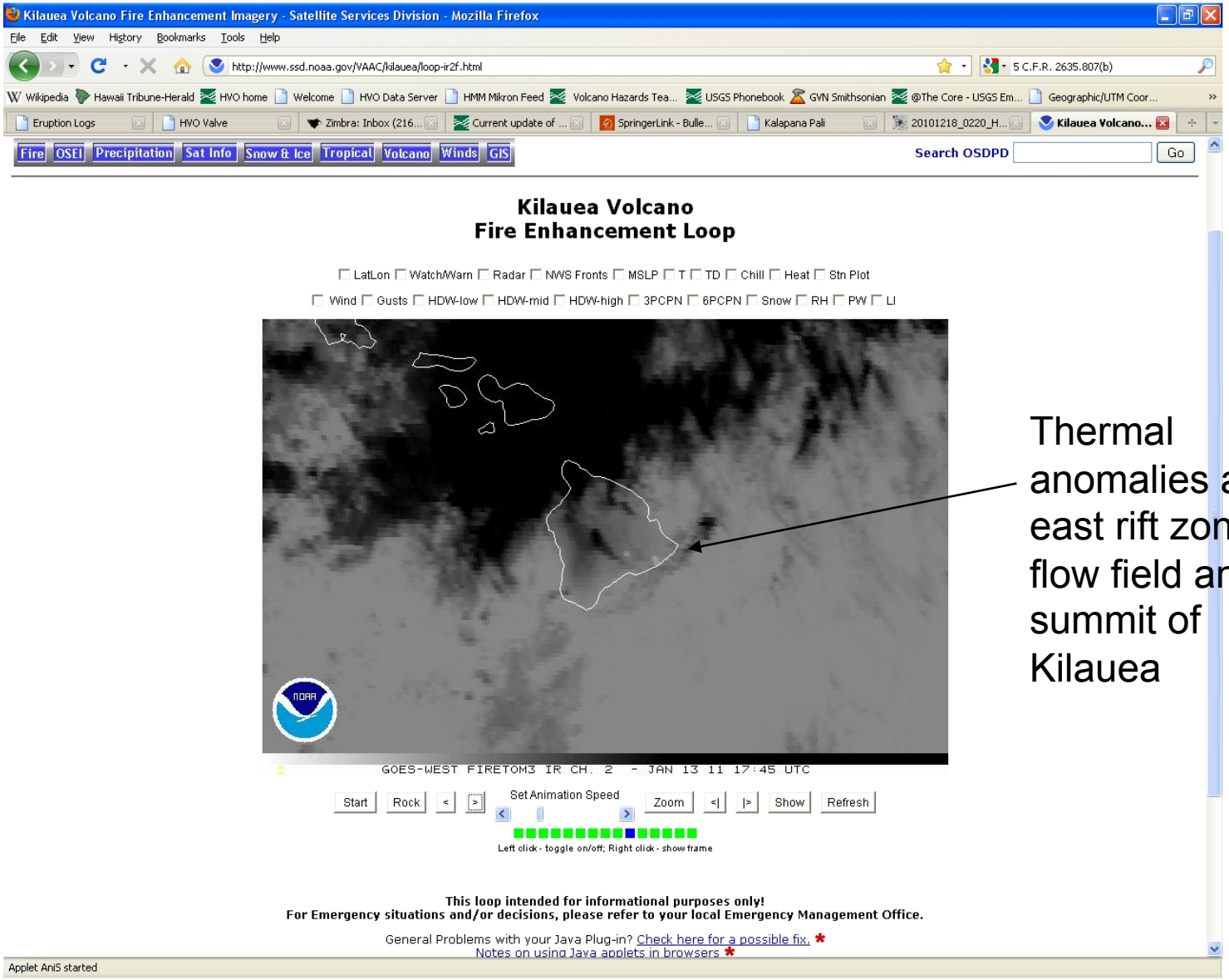


MODIS excess radiance for various ROIs

Choose time frame for display

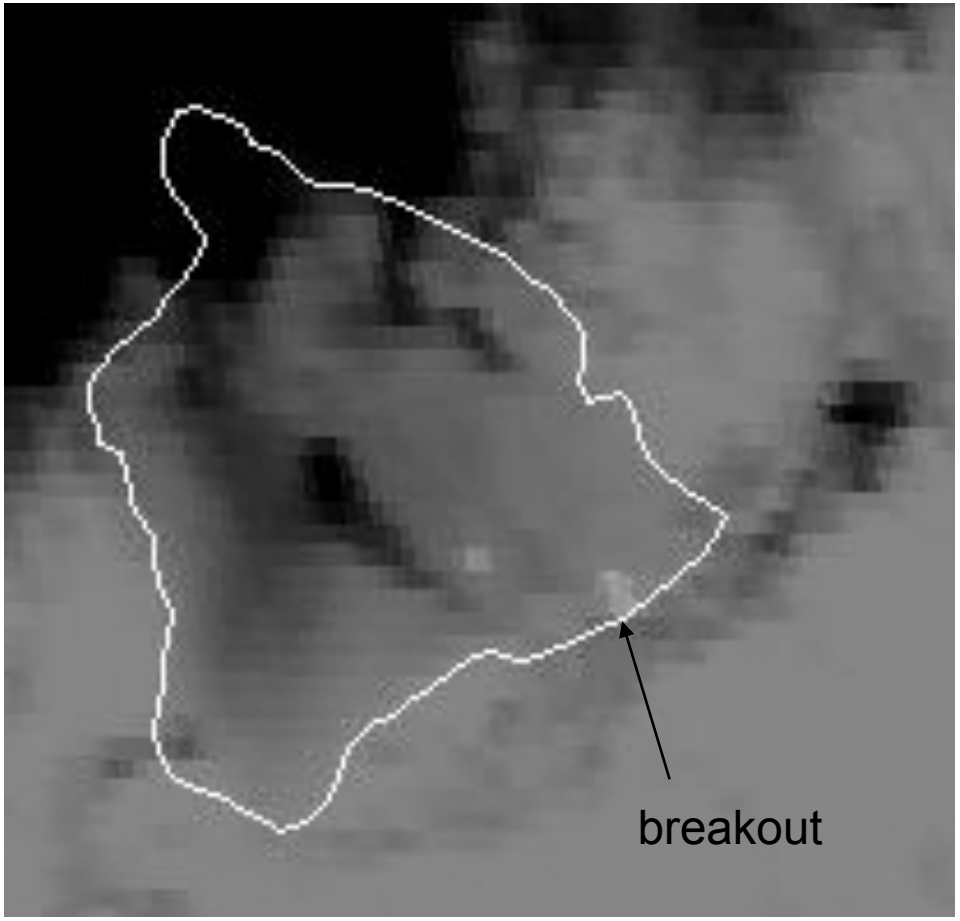
Plot shows radiance from east rift zone lava flows over last year

NOAA GOES website: image every 30 minutes, shown within an hour of acquisition



Thermal anomalies at east rift zone flow field and summit of Kilauea

GOES: excellent temporal resolution (30 minutes), poor spatial resolution (4 km)

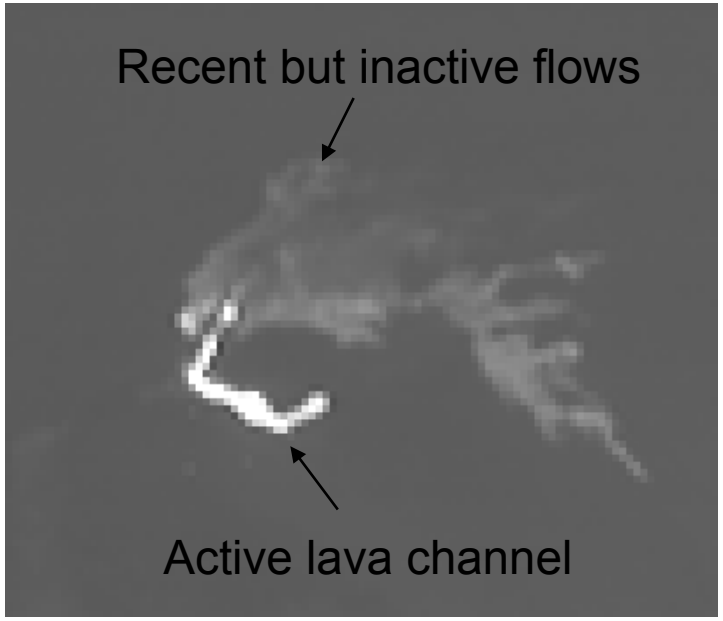


BUT: on east rift zone, it can tell us if there are new breakouts or not

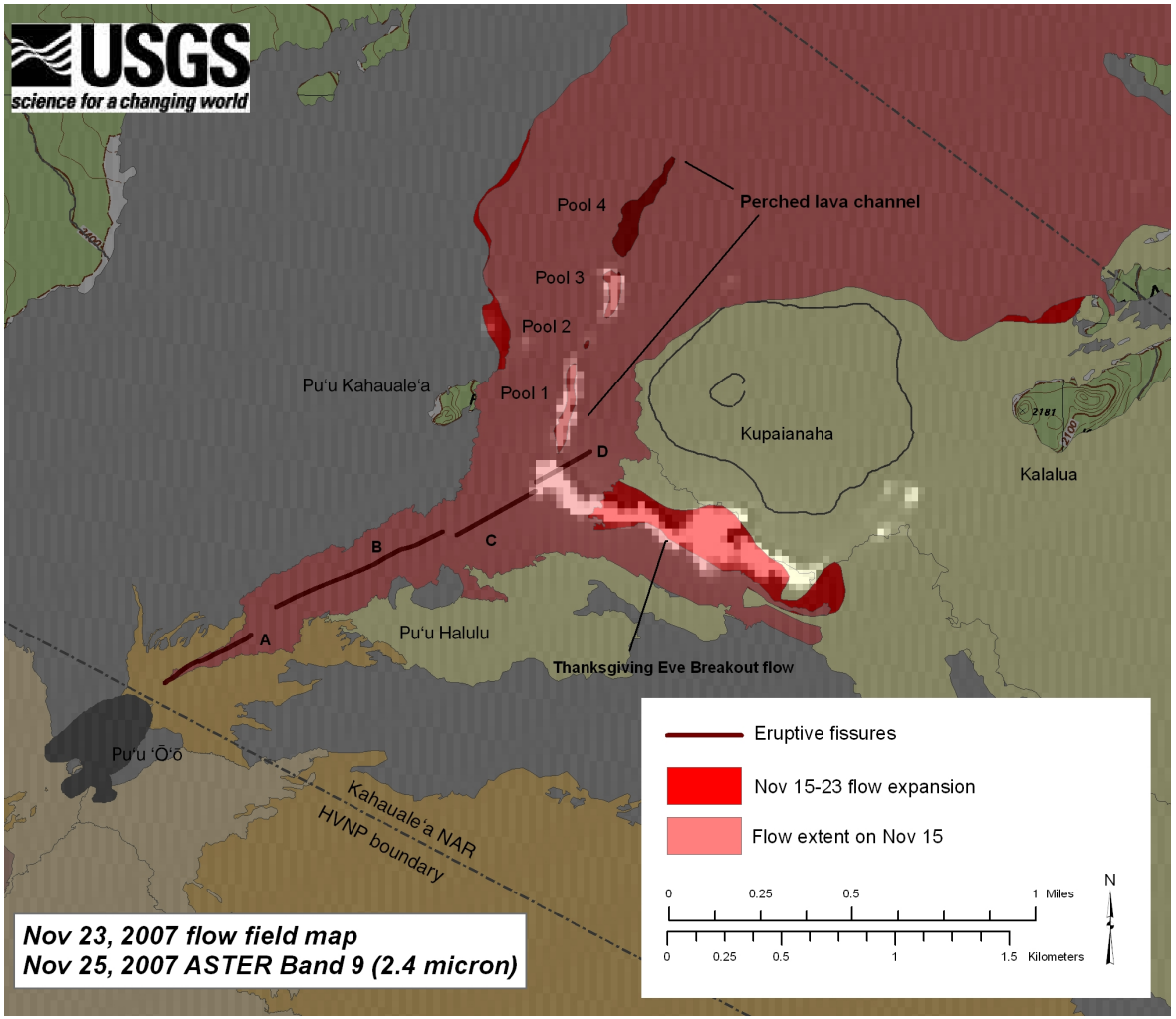
No thermal anomaly: all lava flowing through tubes

Thermal anomaly: lava breaking out from tube system, creating surface flows

ASTER thermal data (90 m pixel size) useful for locating surface flows, but currently too slow to arrive – a day or more late



Comparison of ASTER and flow field map



Can you help us with this, Mike?

Differences between AVO and HVO

- AVO main hazard is ash plumes, HVO is lava flows
- AVO needs images in minutes, HVO would be fine with hours
- HVO needs to know location of lava flows within tens to hundreds of meters – so high-resolution imagery (10-90 m) is necessary
- AVO does not need high resolution imagery
- HVO doesn't have receiving station

	AVO: ash plumes	**HVO: lava flows**
Threat speed:	fast (km/hr)	slow (<km/day)
Temporal resolution needed:	minutes	hours
Threat size:	big (kms)	small (10s meters)
Spatial resolution needed:	km	10s meters

Similarities between AVO and HVO

- Require imagery within minutes to hours – currently easiest solution to this problem is to have a receiving station (expensive - AVO has one, HVO doesn't)
- Require automated pre-processing of images – cannot waste time on routine processing
- Web-based analysis/viewing tools extremely useful (and portable)
    - AVO: image flipper/web-tools
    - HVO: VALVE, GOES website
- Low spatial resolution data can still be very useful for both
    - at HVO, low resolution data can say if there's a breakout or not (triggers overflight or visit on foot)

Temporal resolution is irrelevant if access time is long

Take home point: need short access time