Lava Flow Hazard Assessment for the Idaho National Laboratory and Eastern Snake River Plain of Idaho, U.S.A.

Elisabeth Gallant

<u>Committee Members</u>

Charles Connor – *Major Professor*
Paul Wetmore
Sylvain Charbonnier

School of Geosciences
Master of Science
Thesis Defense
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Outline

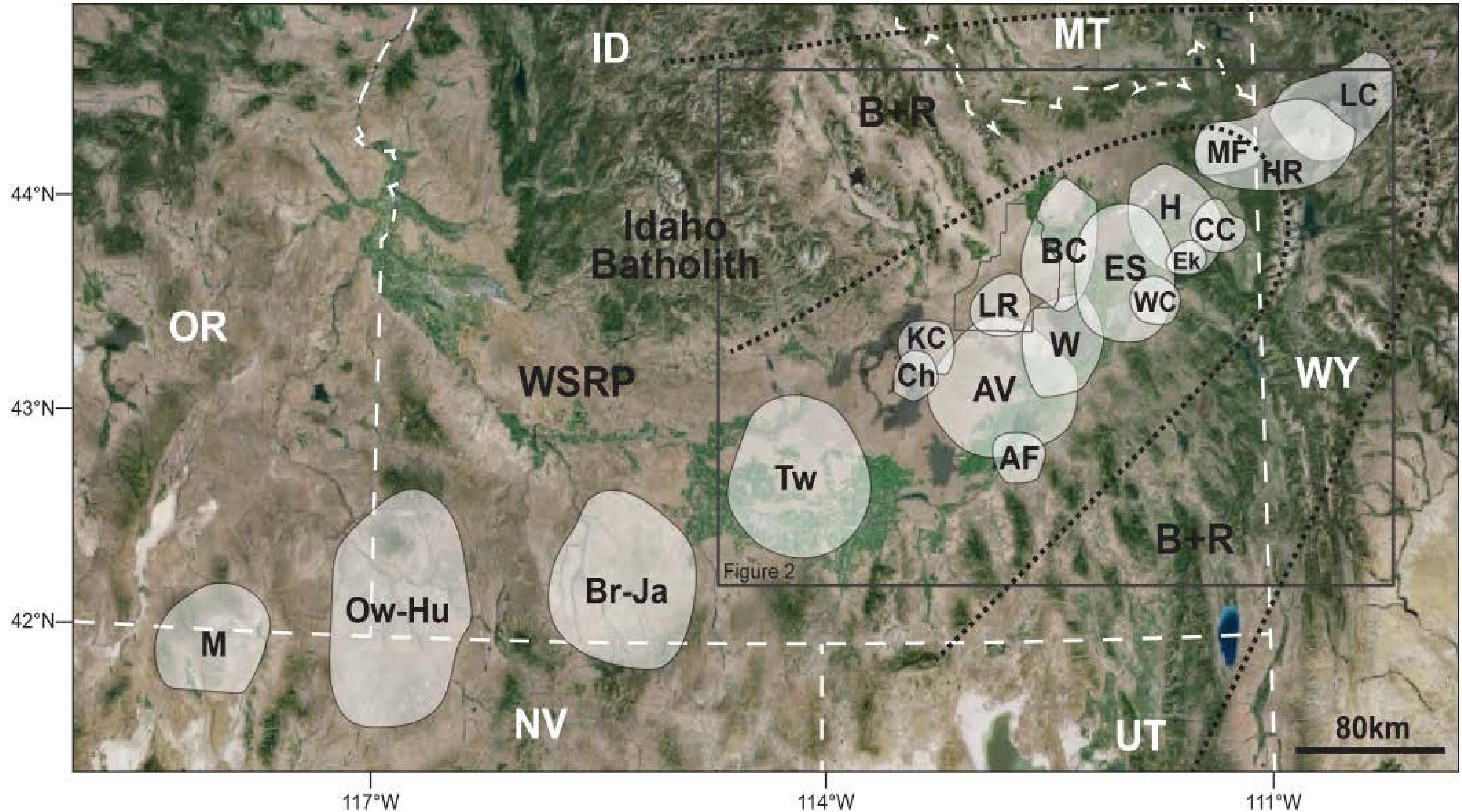
- Research motivation
- Geologic background of the ESRP
- Methodology and Results
- Conclusions
- Recommendations
- Questions

Research Motivation

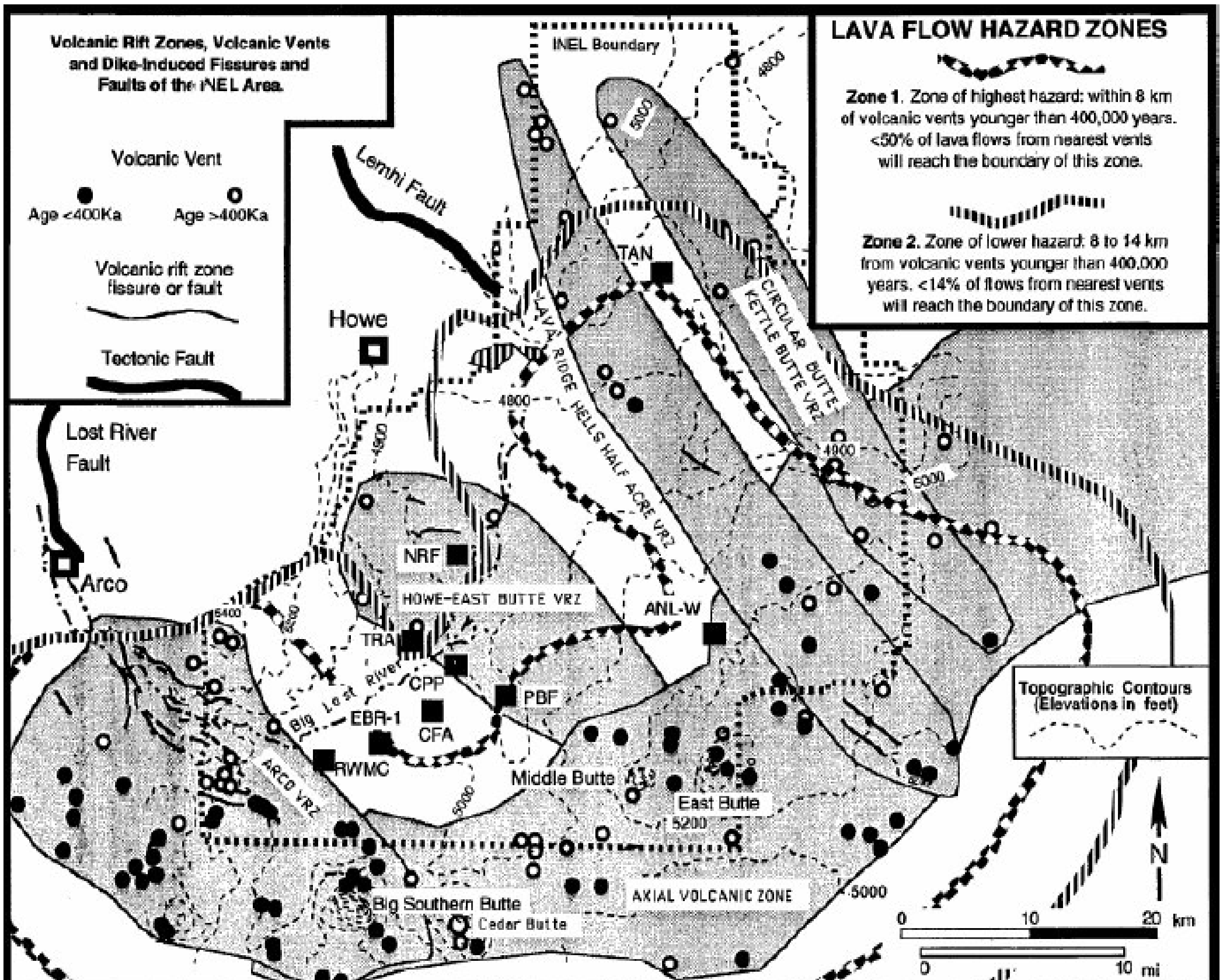
- What impact does the way we classify eruptive events have on the modeling and assessment process?
- What is the likelihood that a new lava flow will effect INL?

Research Motivation

Geologic Background



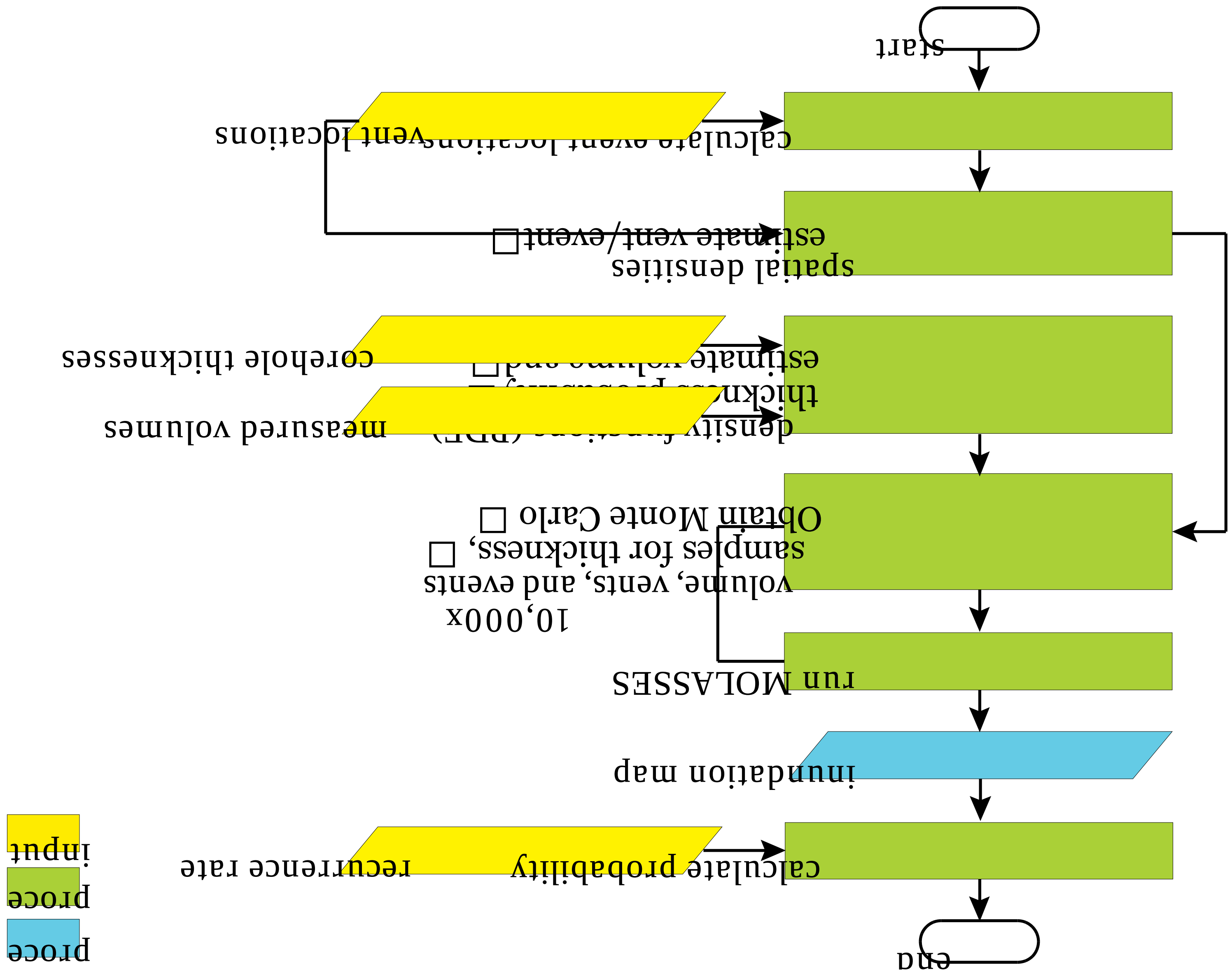
Previous Hazard Assessments



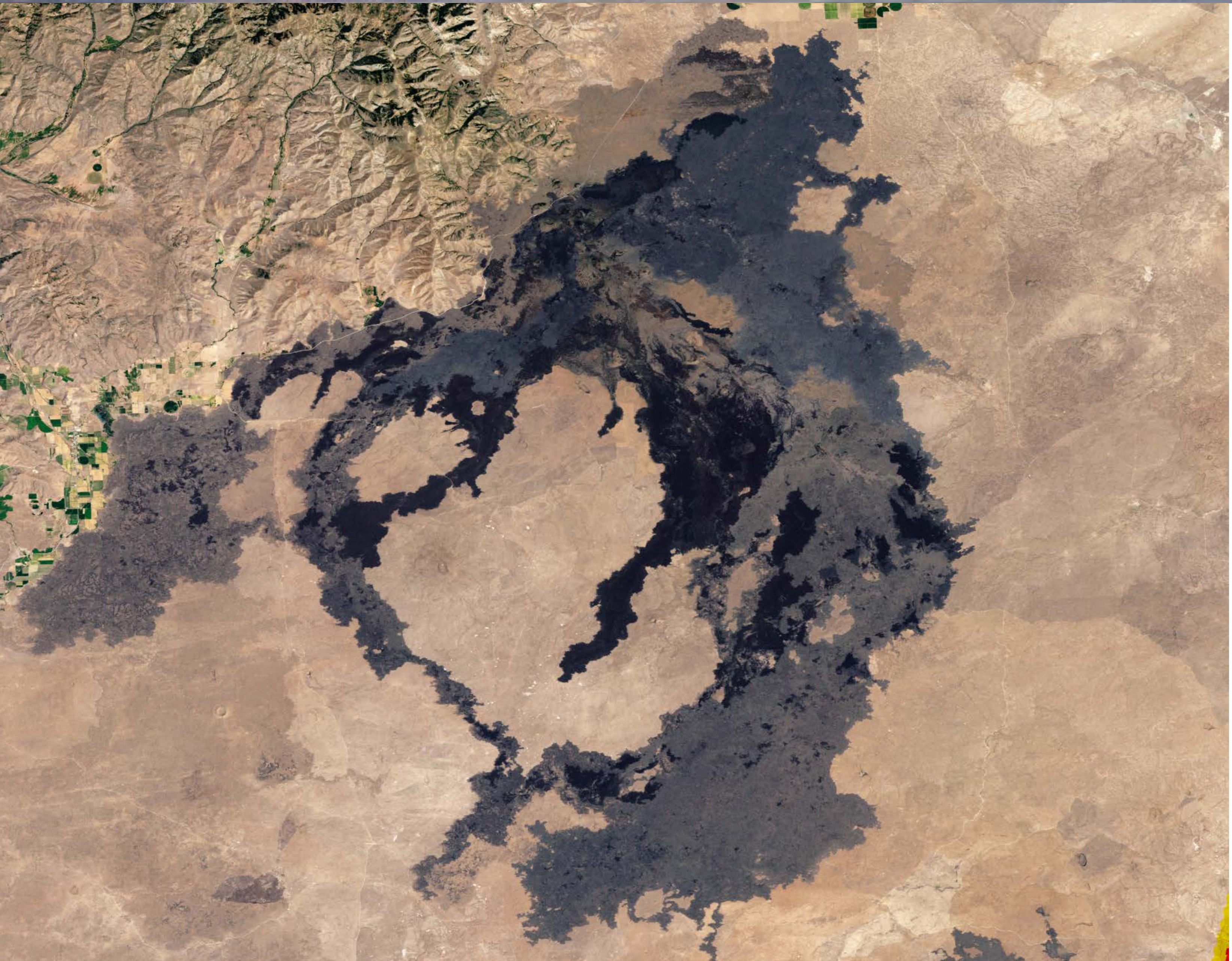
Hackett and Smith, 1994

- 1978: Kuntz
- 1979: Kuntz and Dalrymple,
- 1990: Volcanism Working Grp.
- 1994: Hackett and Smith
- 2002: Hackett et al.
- 2009: Wetmore et al.
- 2010: Eagle Rock Enrichment

Methodology



Methodology: Vents-to-Events



Craters of the Moon

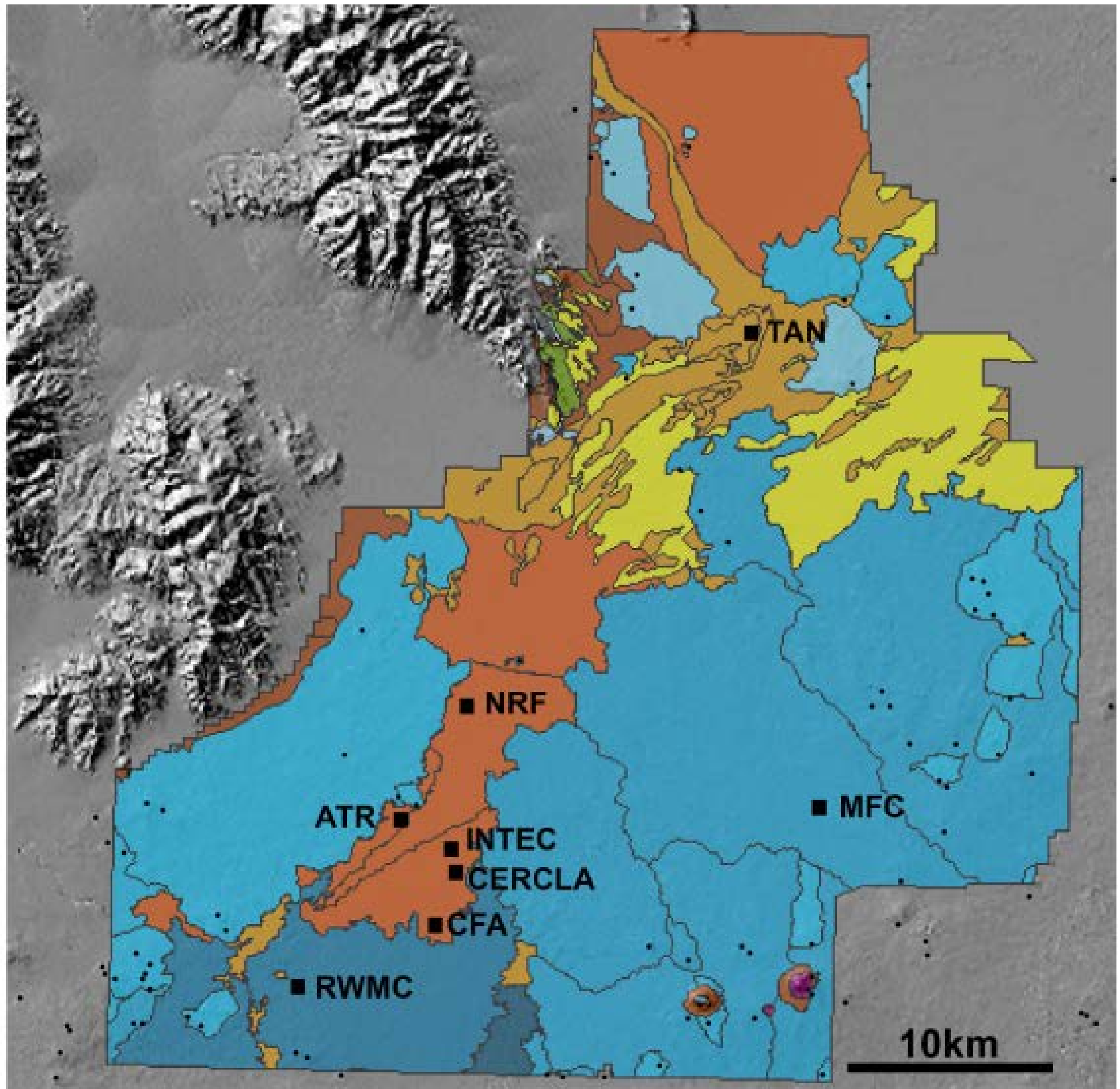
- Active 15k – 2.1k
- Area: 1,600 km^2
- Volume: 30 km^3
- 60+ flows
- 25 tephra cones
- 8 fissures

Methodology: Vents-to-Events

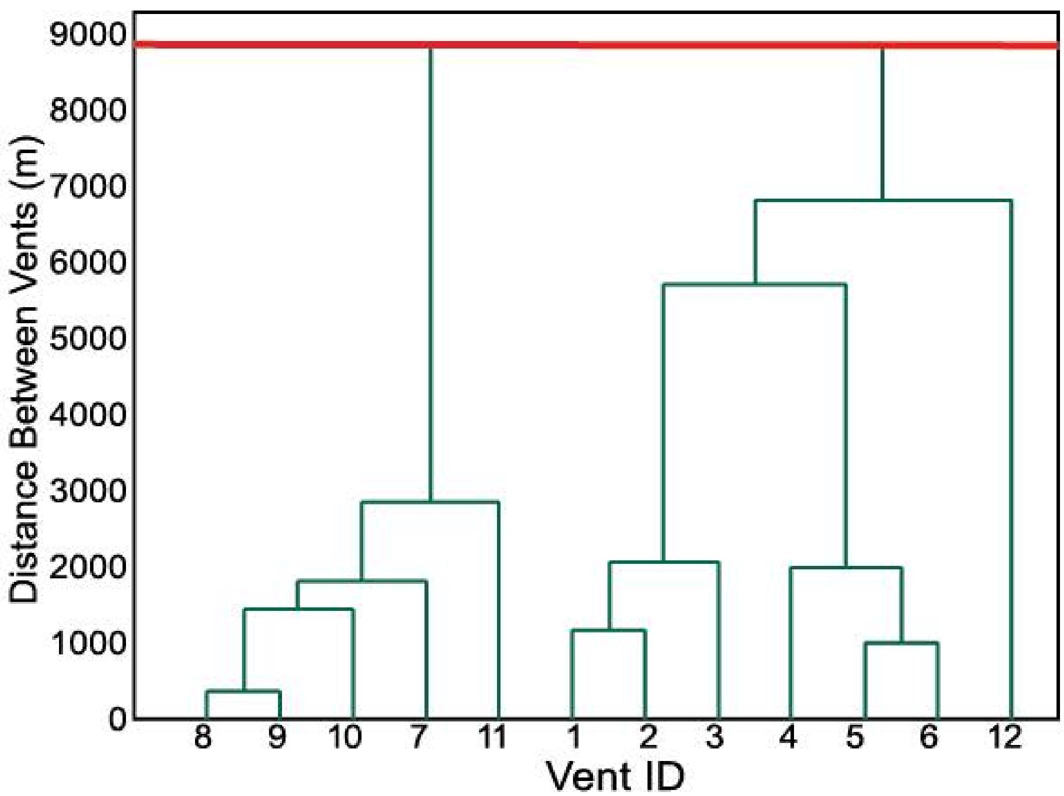
Mafic Material
- <15ka basalt
- 15 - 200ka basalt
- 200 - 400ka basalt
- 400 - 730ka basalt
- >730ka basalt

Felsic Material
- rhyolite dome
- hotspot tuff

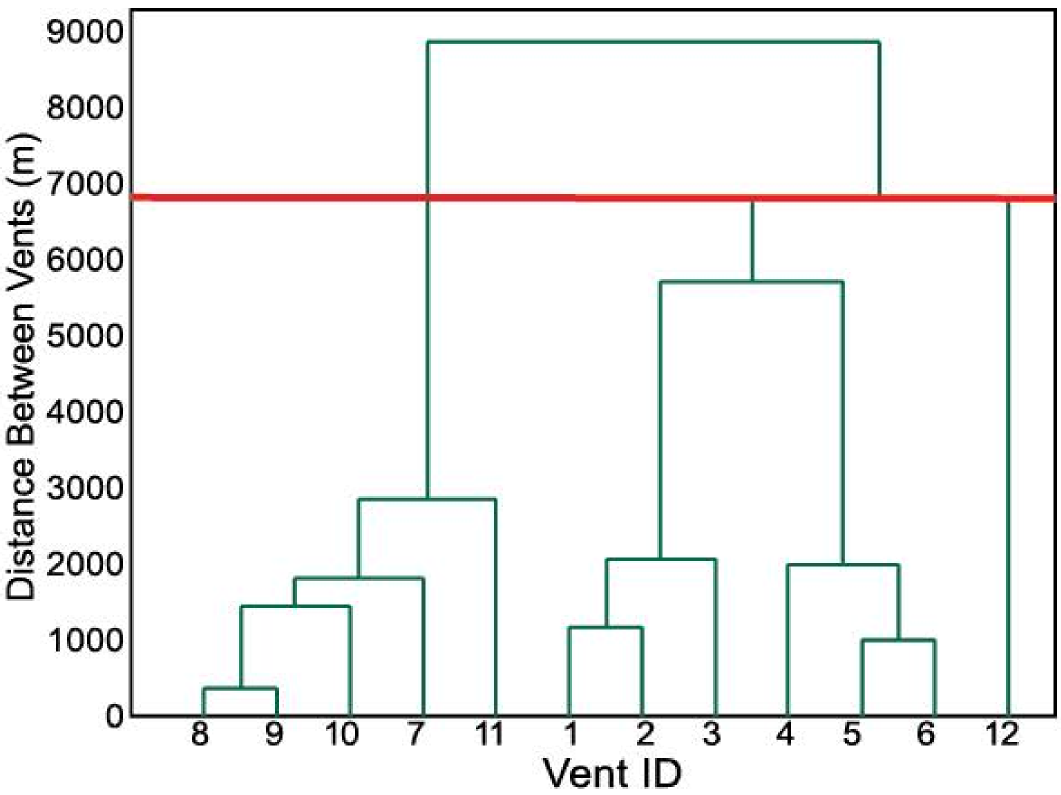
Sedimentary Deposits
- alluvial fan
- fluvial
- lacustrine
- eolian



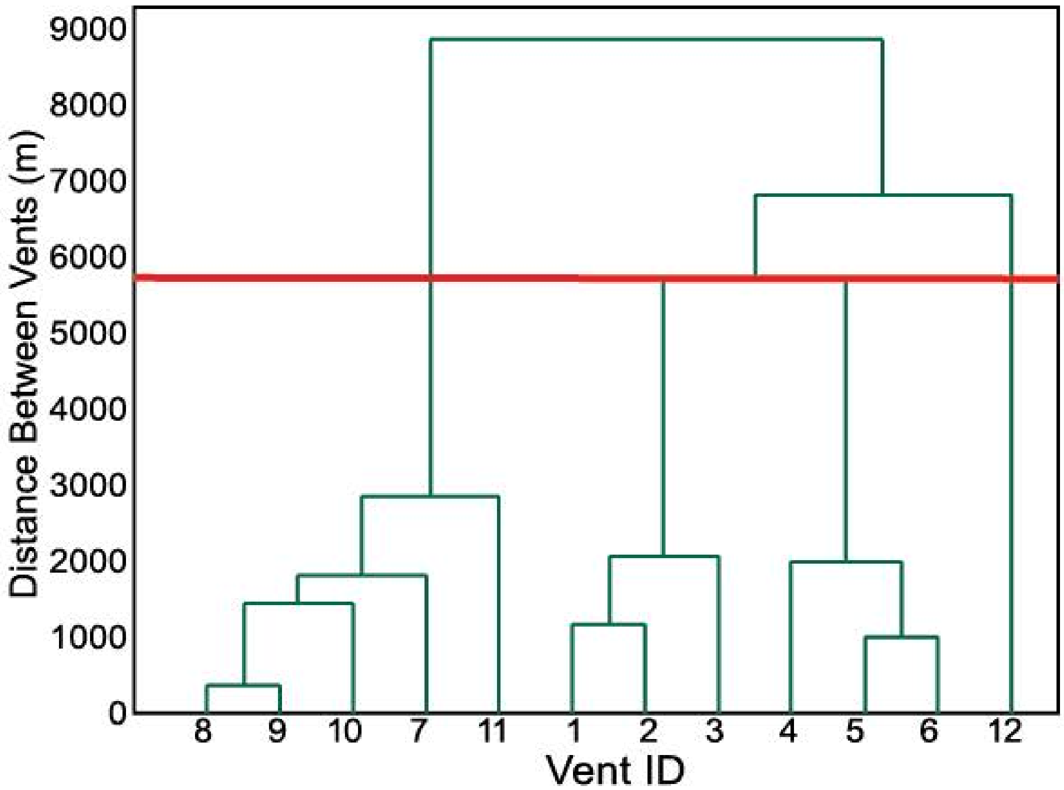
Methodology: Vents-to-Events

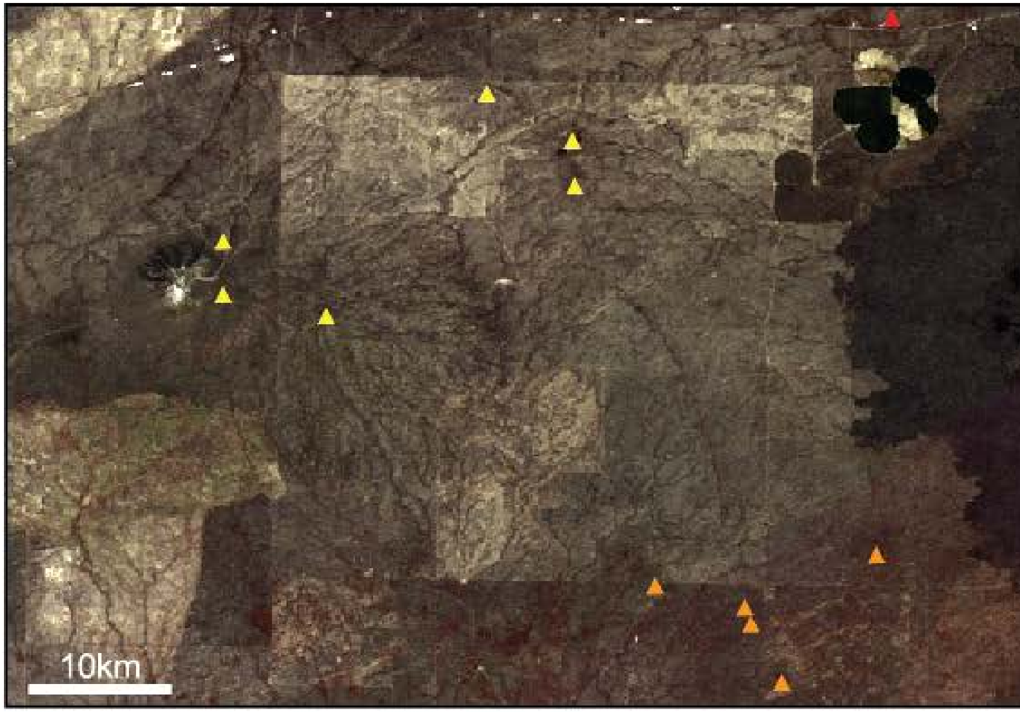


Methodology: Vents-to-Events

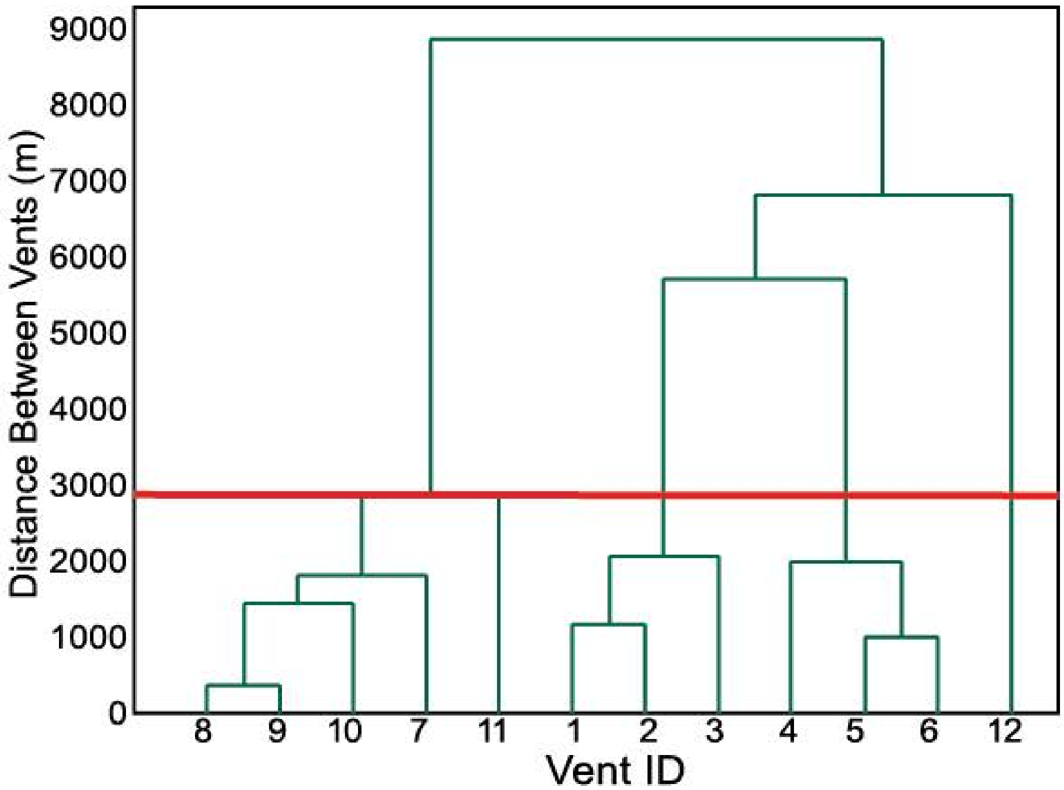


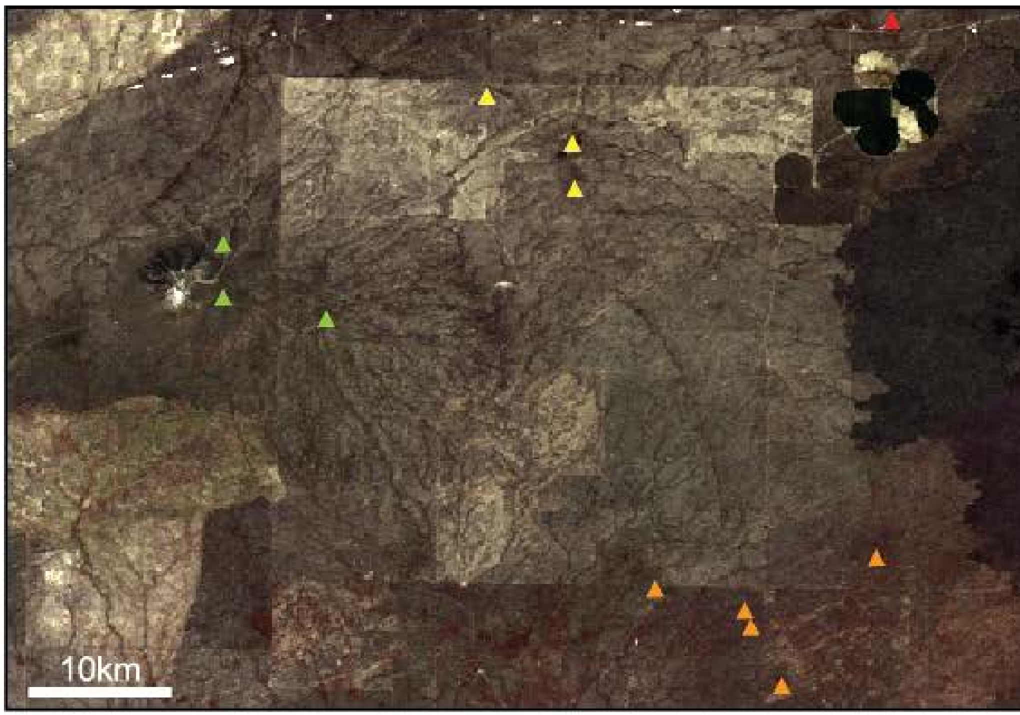
Methodology: Vents-to-Events



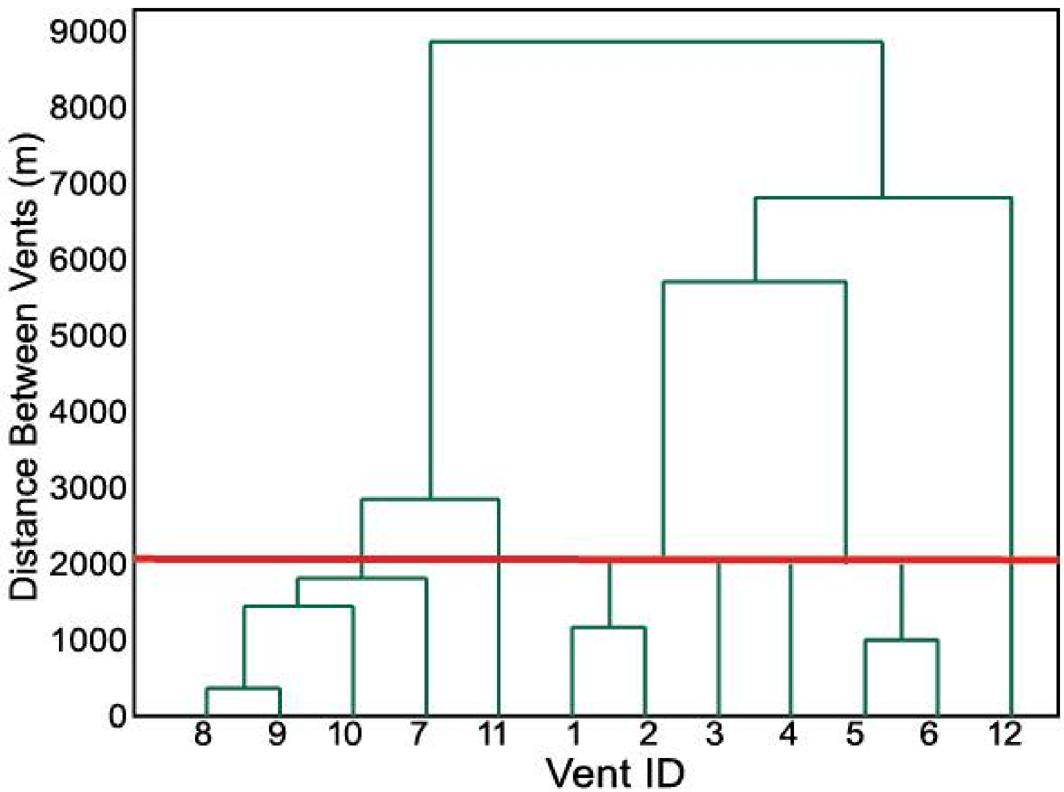


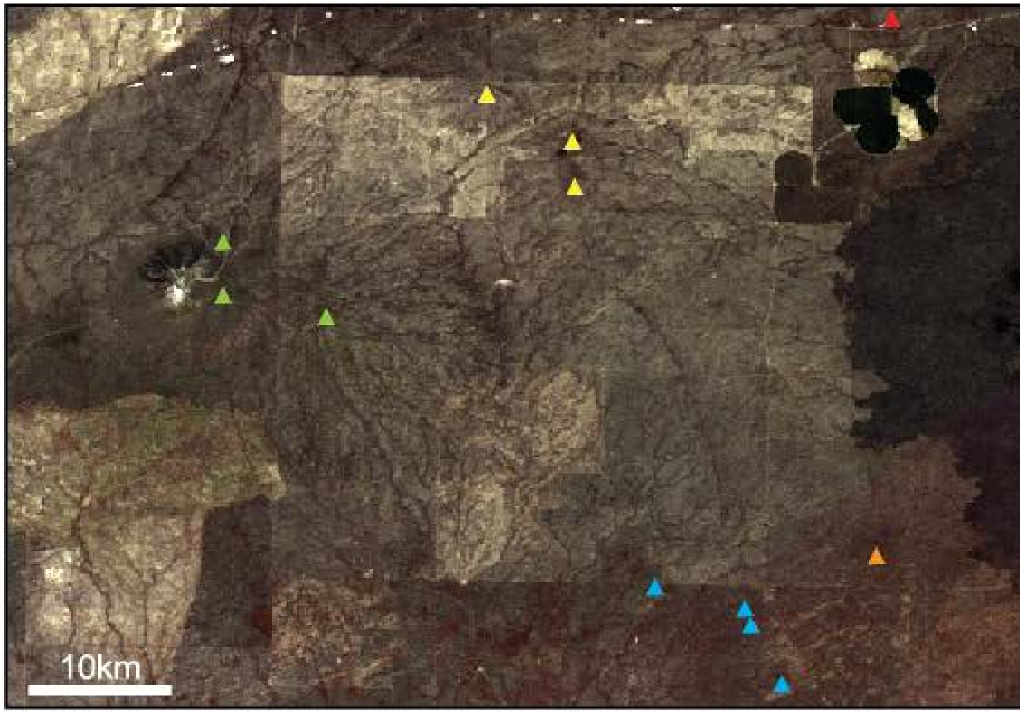
Methodology: Vents-to-Events



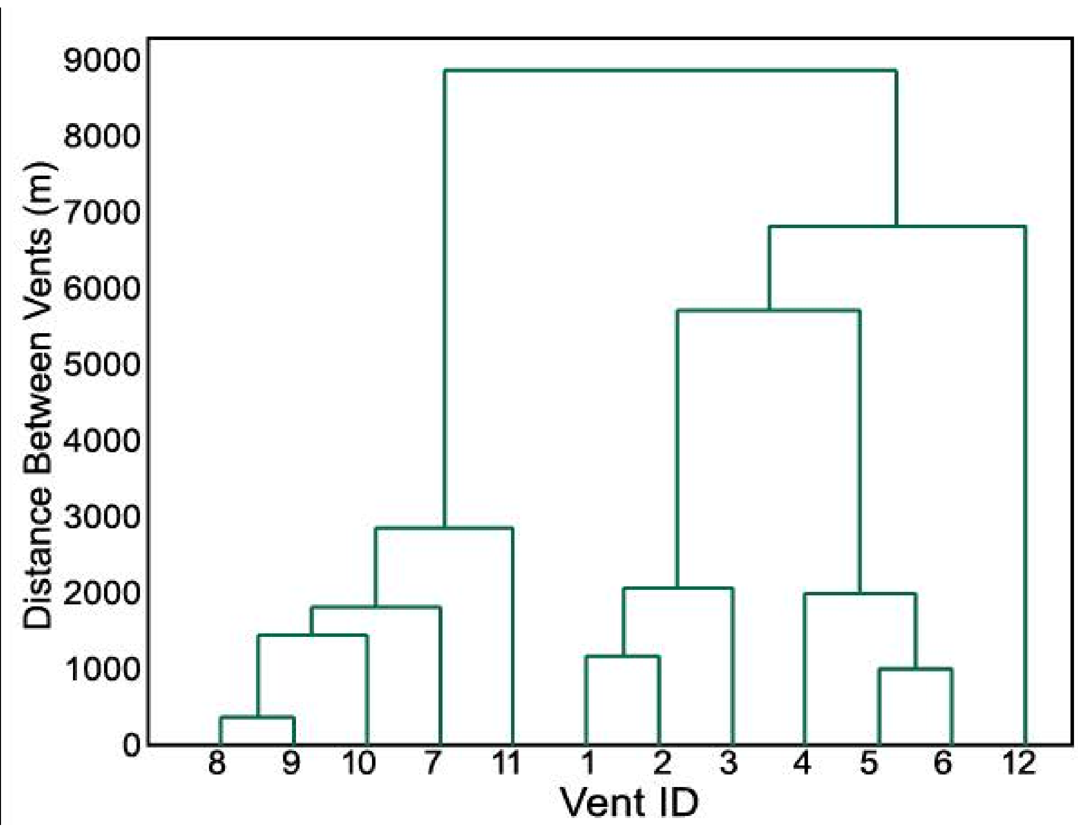


Methodology: Vents-to-Events

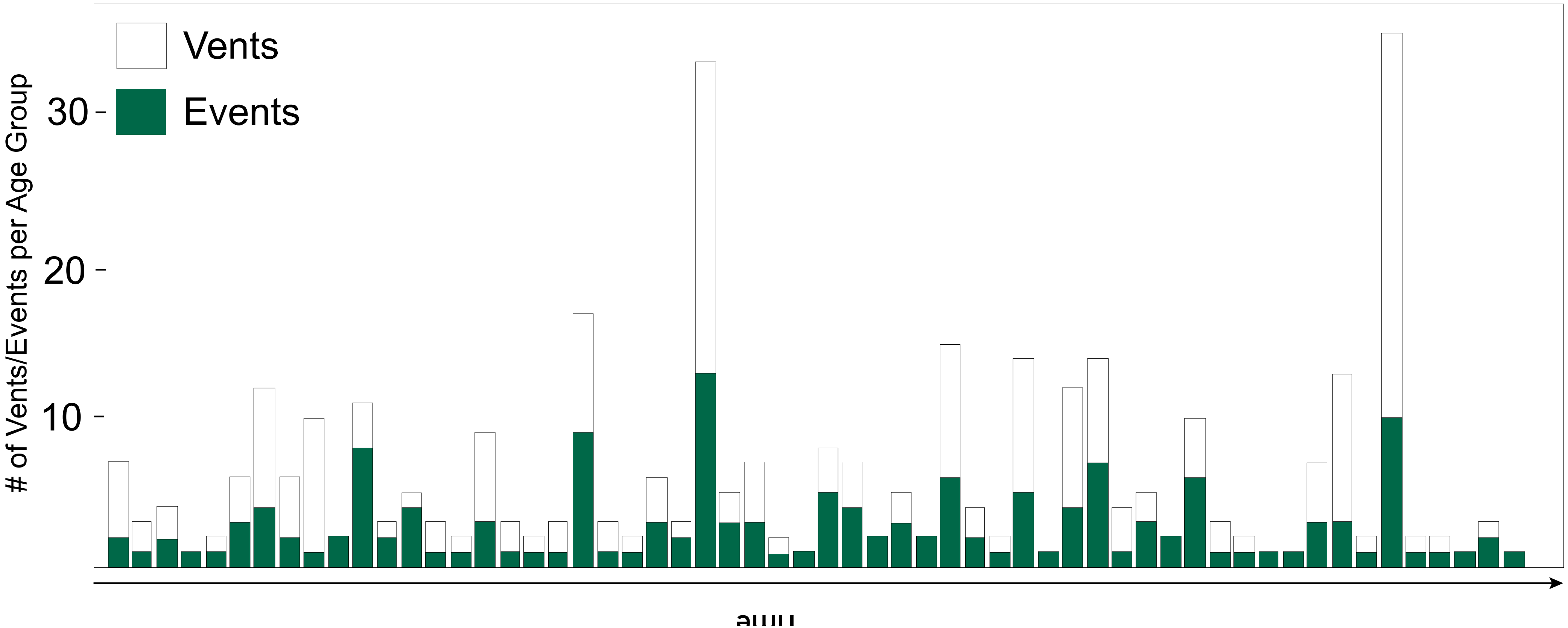




Methodology: Vents-to-Events



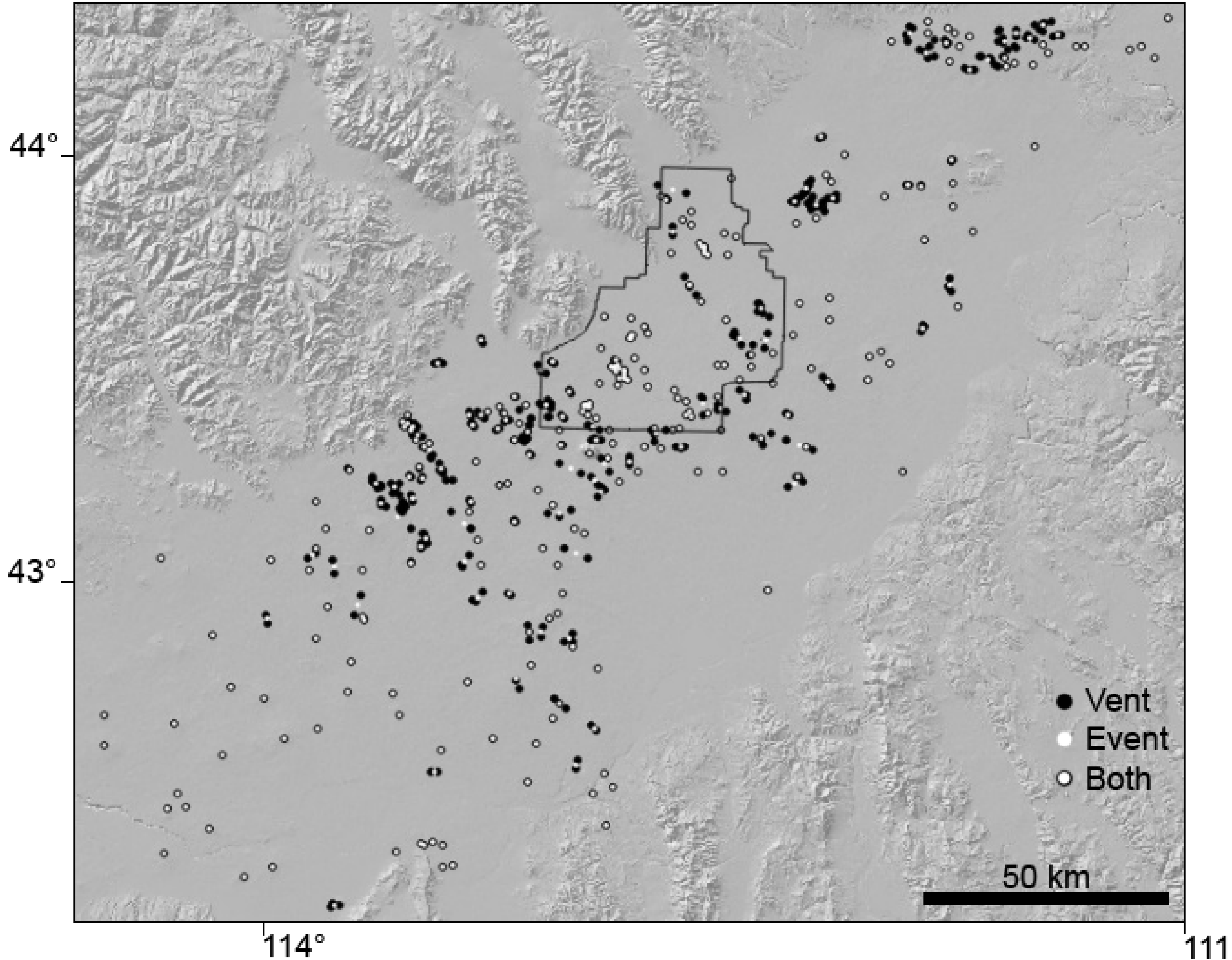
Results: Vents-to-Events



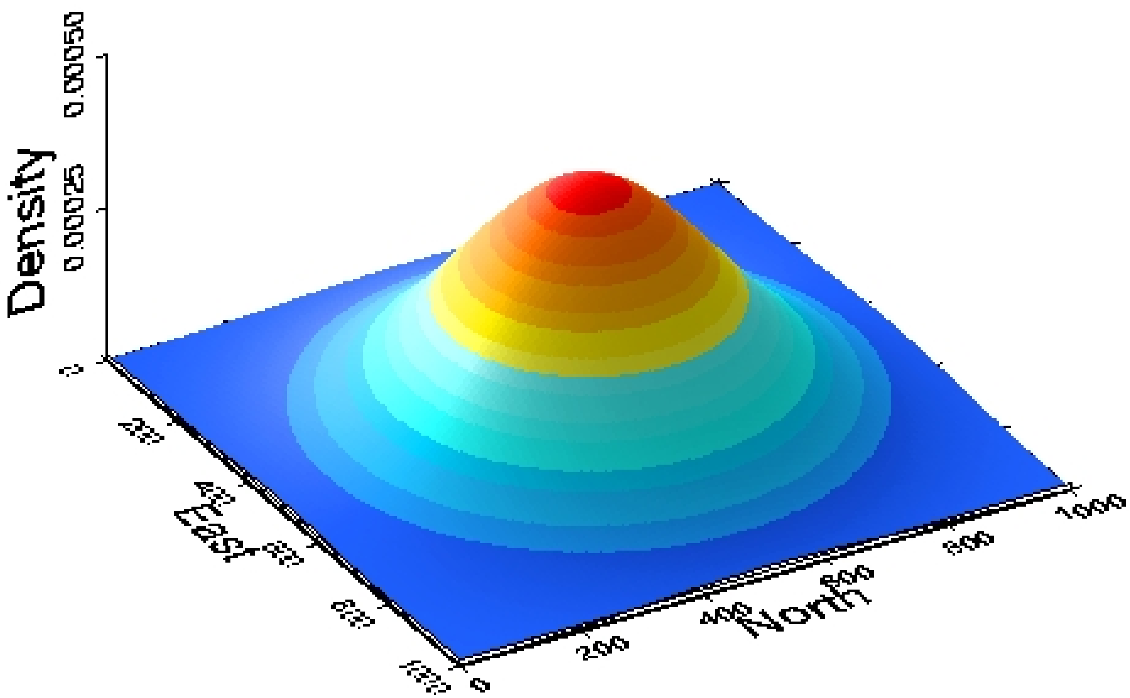
- Average: 1.54 vents / event
- Maximum: 3.60 vents / event
- Minimum: 1.00 vent / event

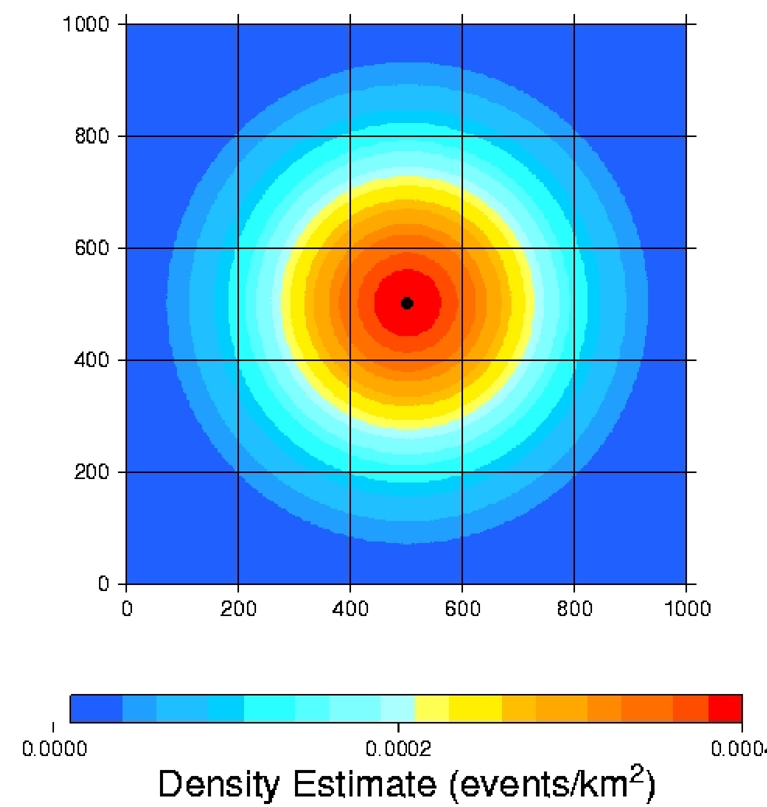
- Reduction of spikes in the time series illustrates removal of potential preservation bias

Results: Vents-to-Events



Methods: Spatial Density

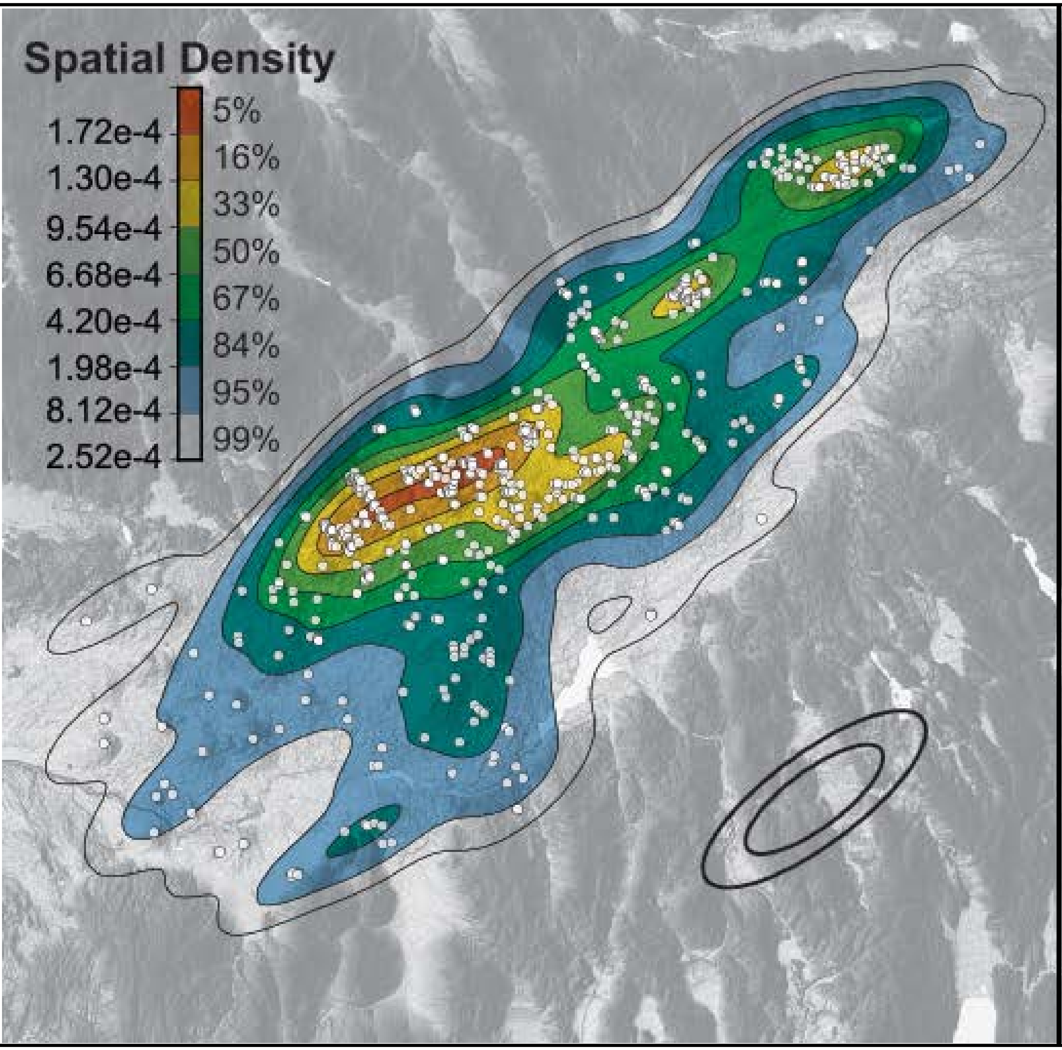




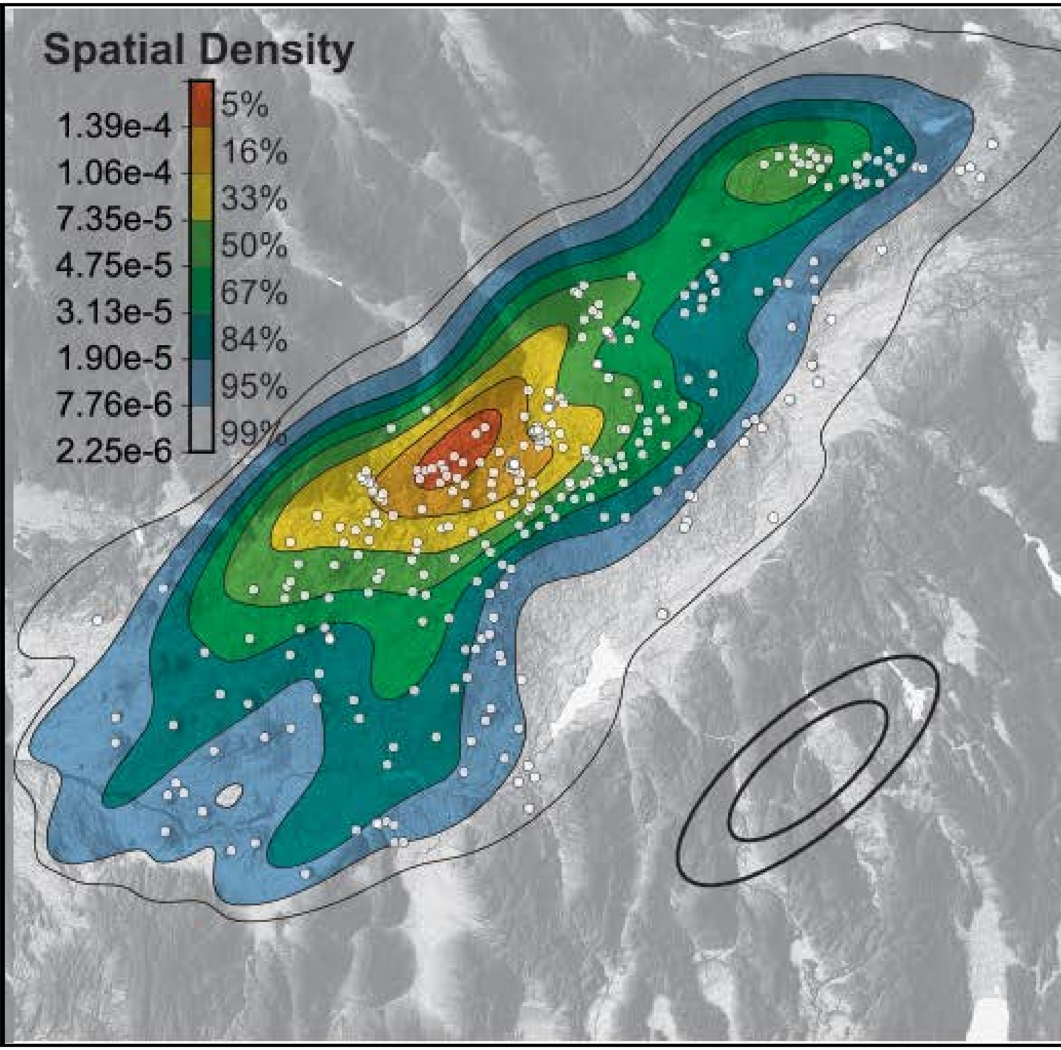
$$\hat{\lambda}(s) = \frac{1}{2\pi\,|H|}\sum_{i=1}^{N} exp[-\frac{1}{2}\mathbf{b}^T\mathbf{b}]$$

Results: Spatial Density

Vents

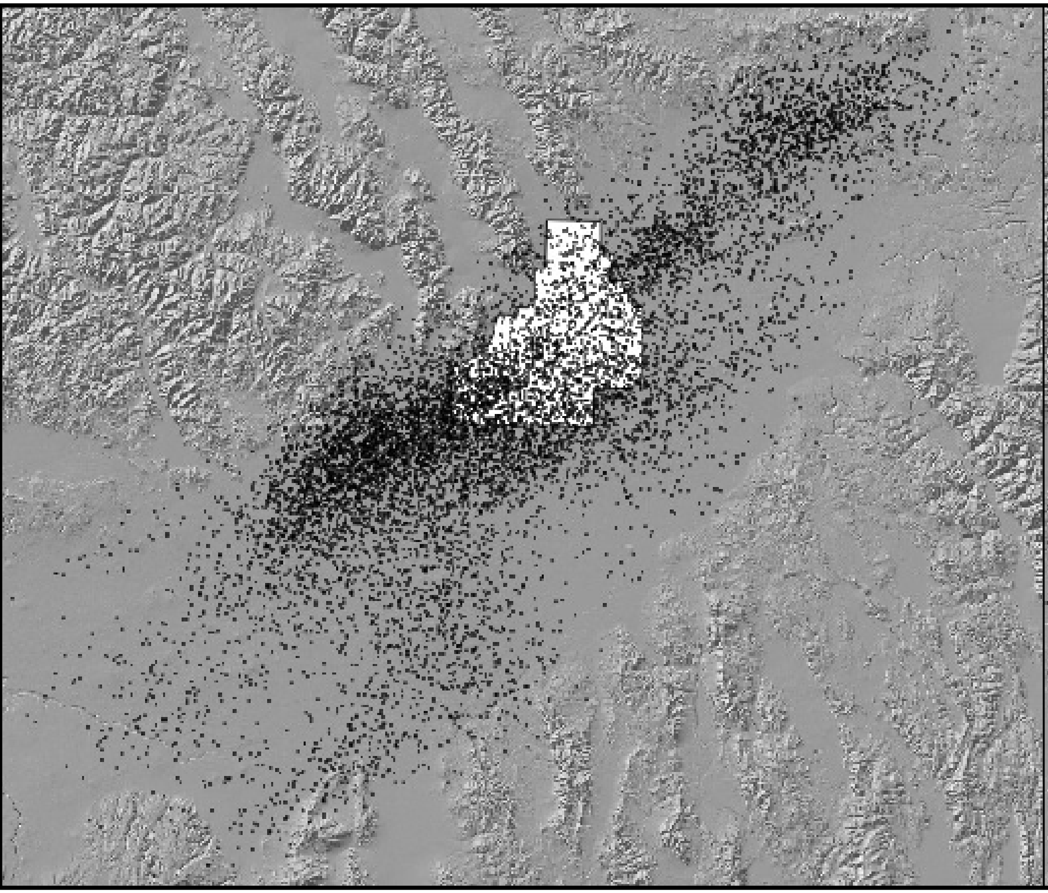


Events

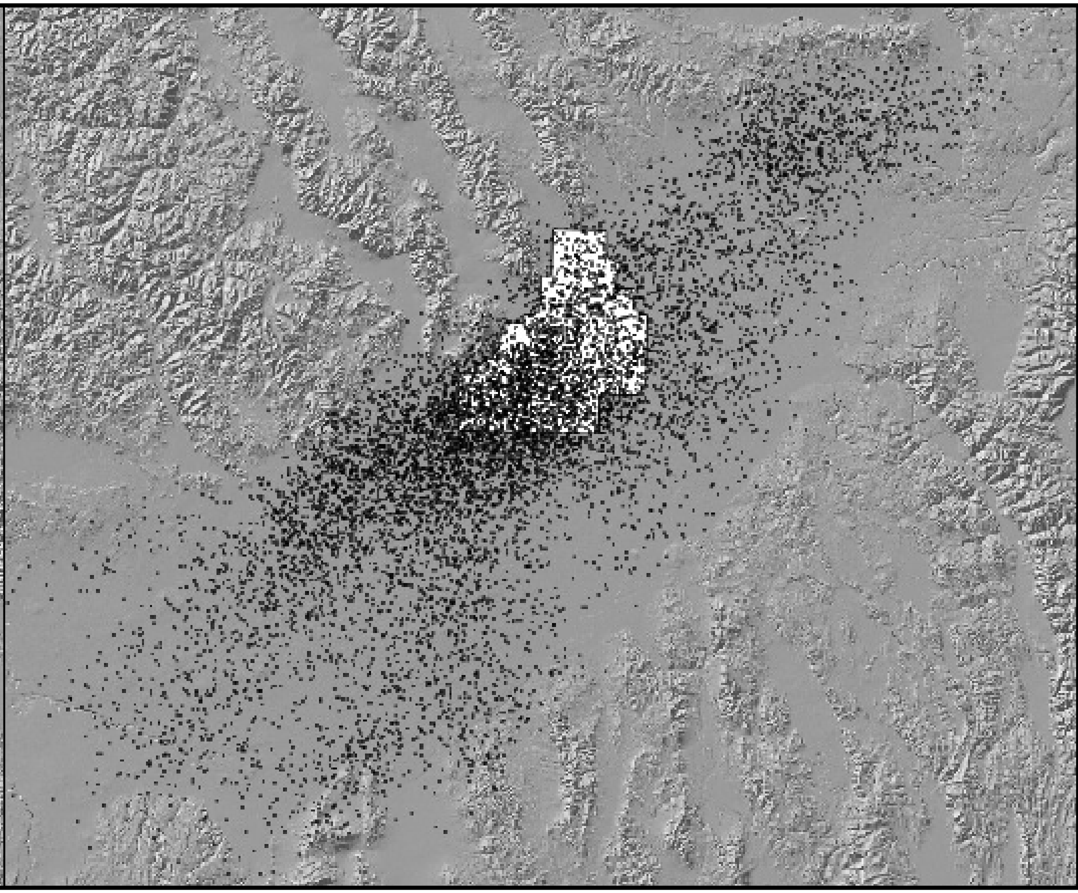


Results: Spatial Density

Vents



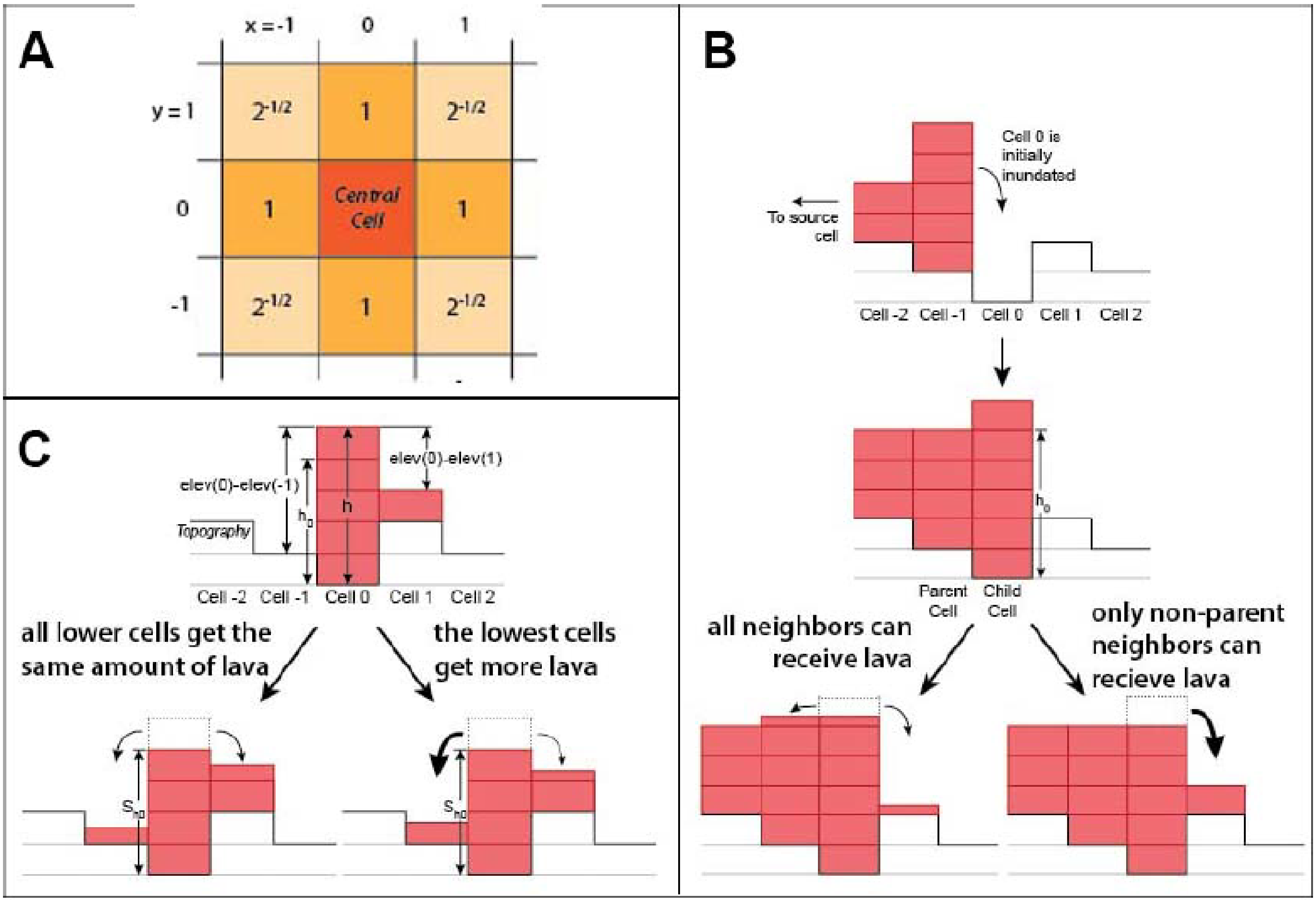
Events



- P [Vent within INL | given eruption] = 1.872×10^{-1}
- P [Event within INL | given eruption] = 2.583×10^{-1}

Methods: MOLASSES

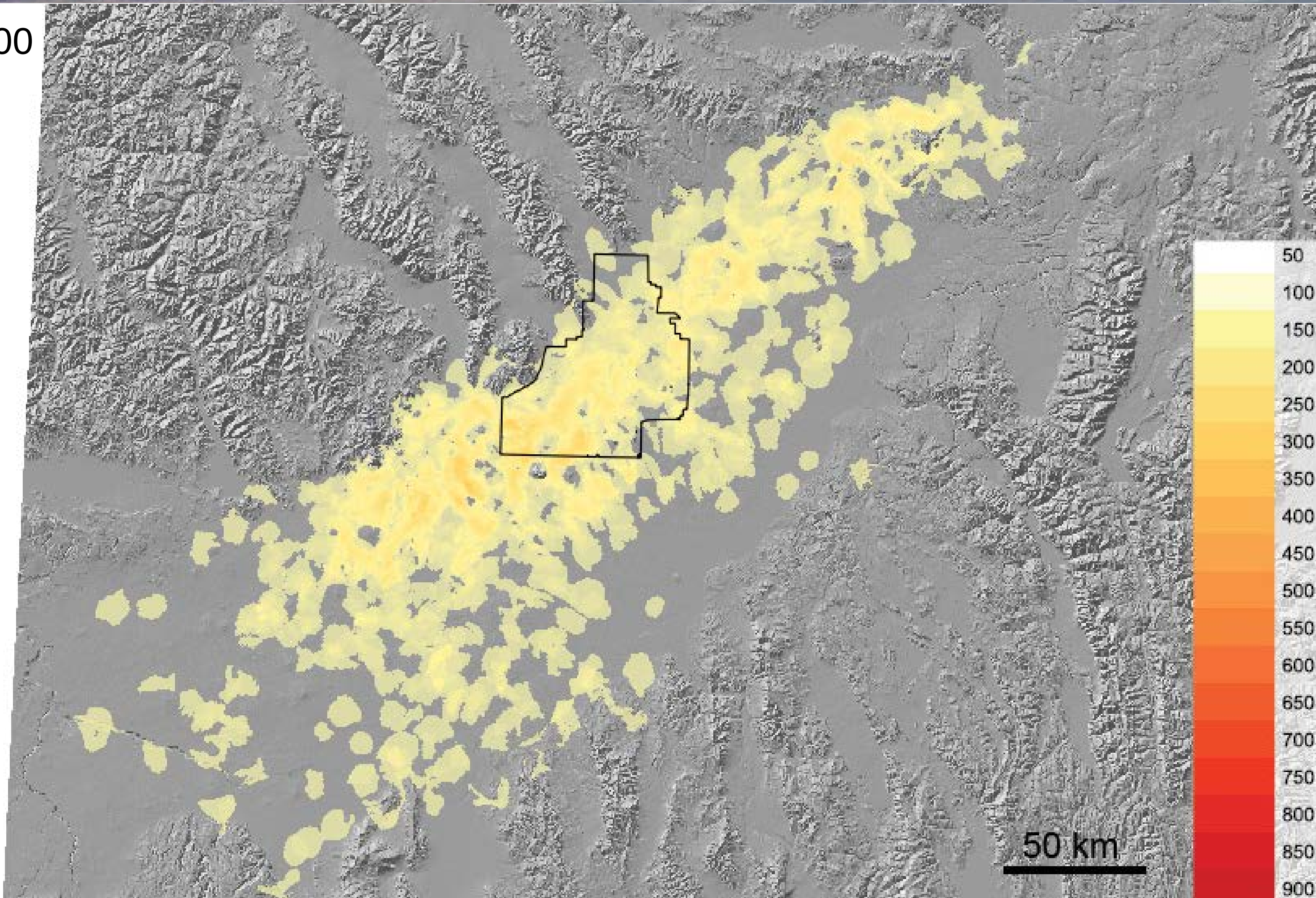
Methods: MOLASSES



Results: MOLASSES

N = 10,000

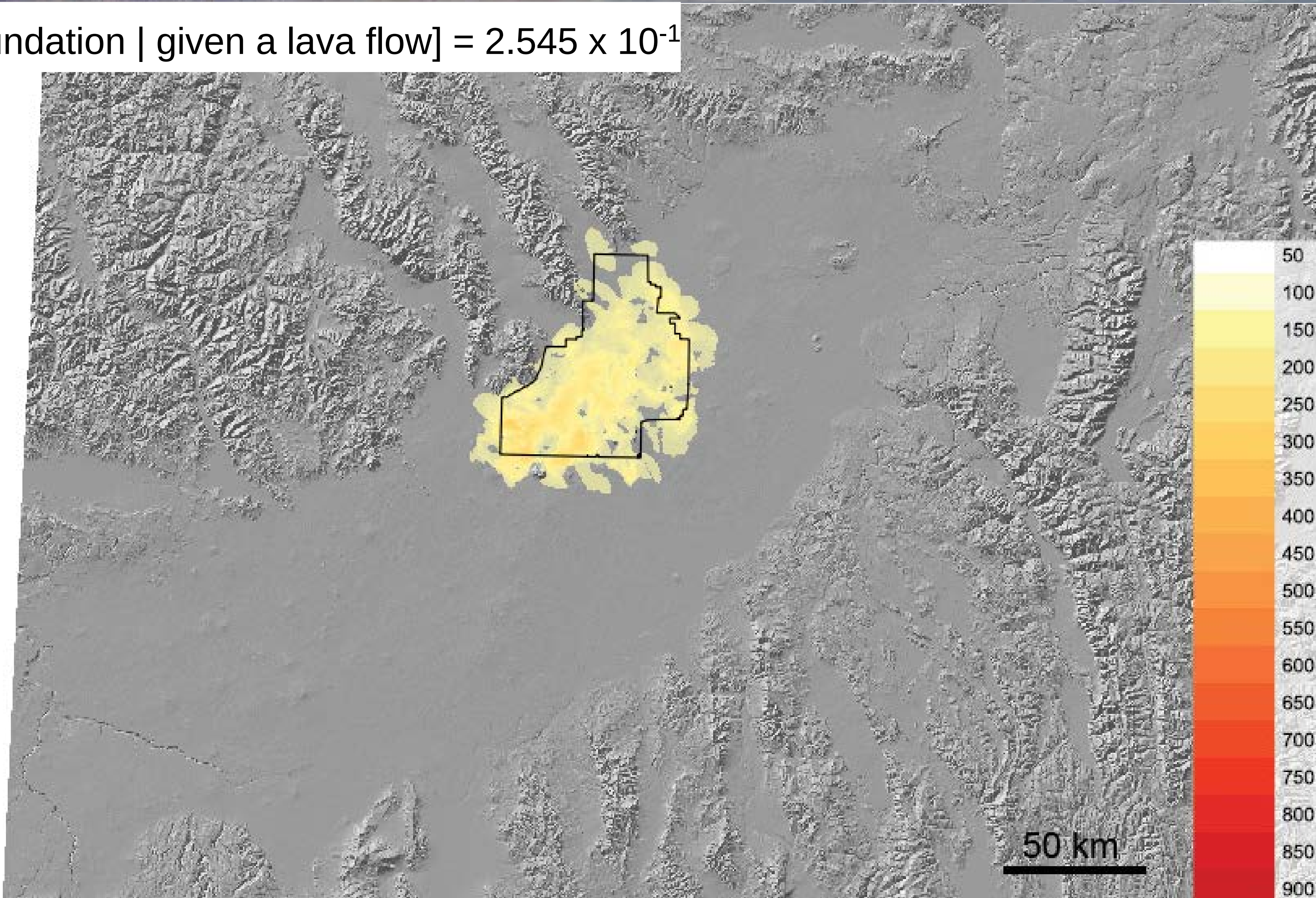
All vent simulations



Results: MOLASSES

P[site inundation | given a lava flow] = 2.545×10^{-1}

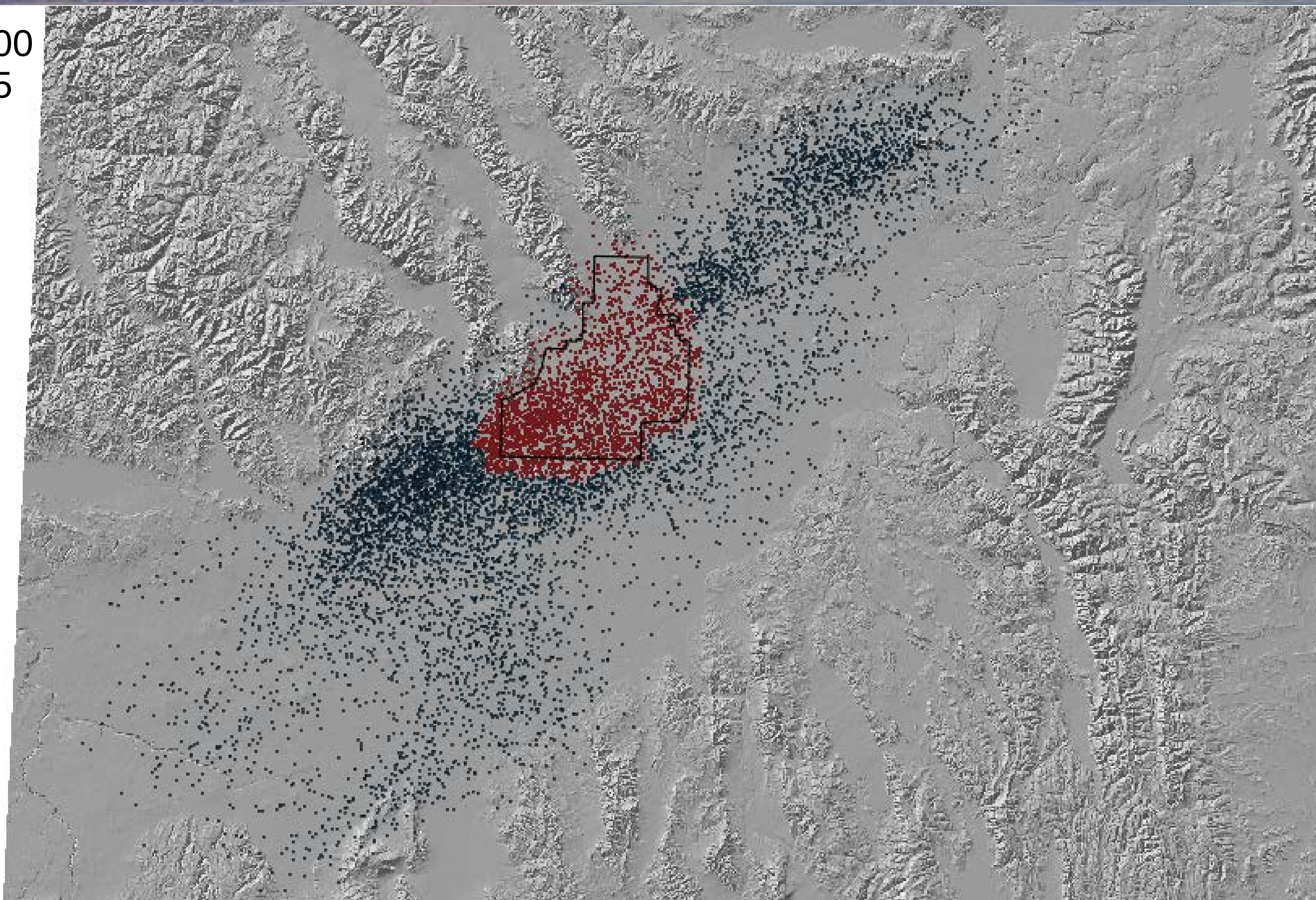
All vent inundations



Results: MOLASSES

N = 10,000
H = 2,545

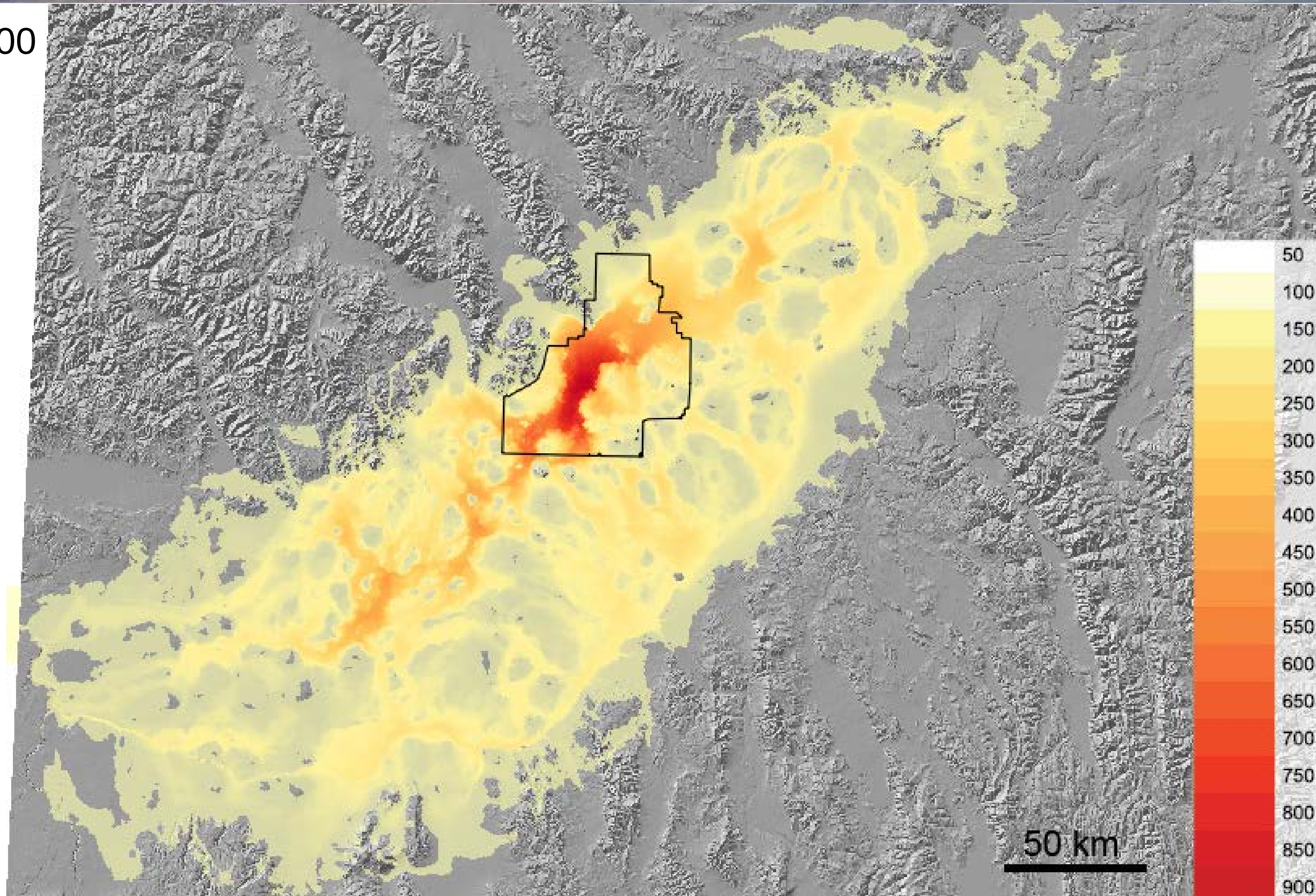
All vent eruption sites



Results: MOLASSES

N = 10,000

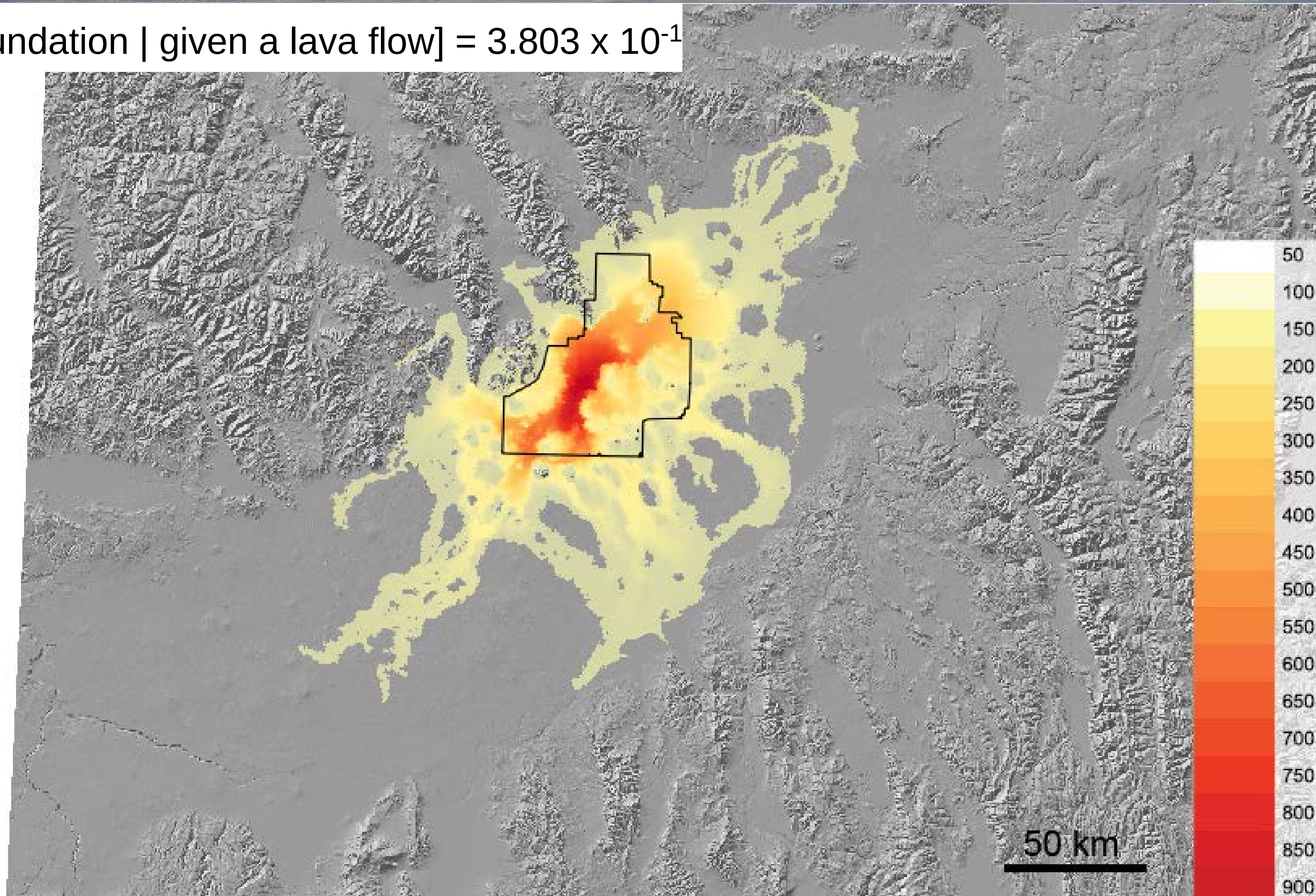
All event simulations



Results: MOLASSES

P[site inundation | given a lava flow] = 3.803×10^{-1}

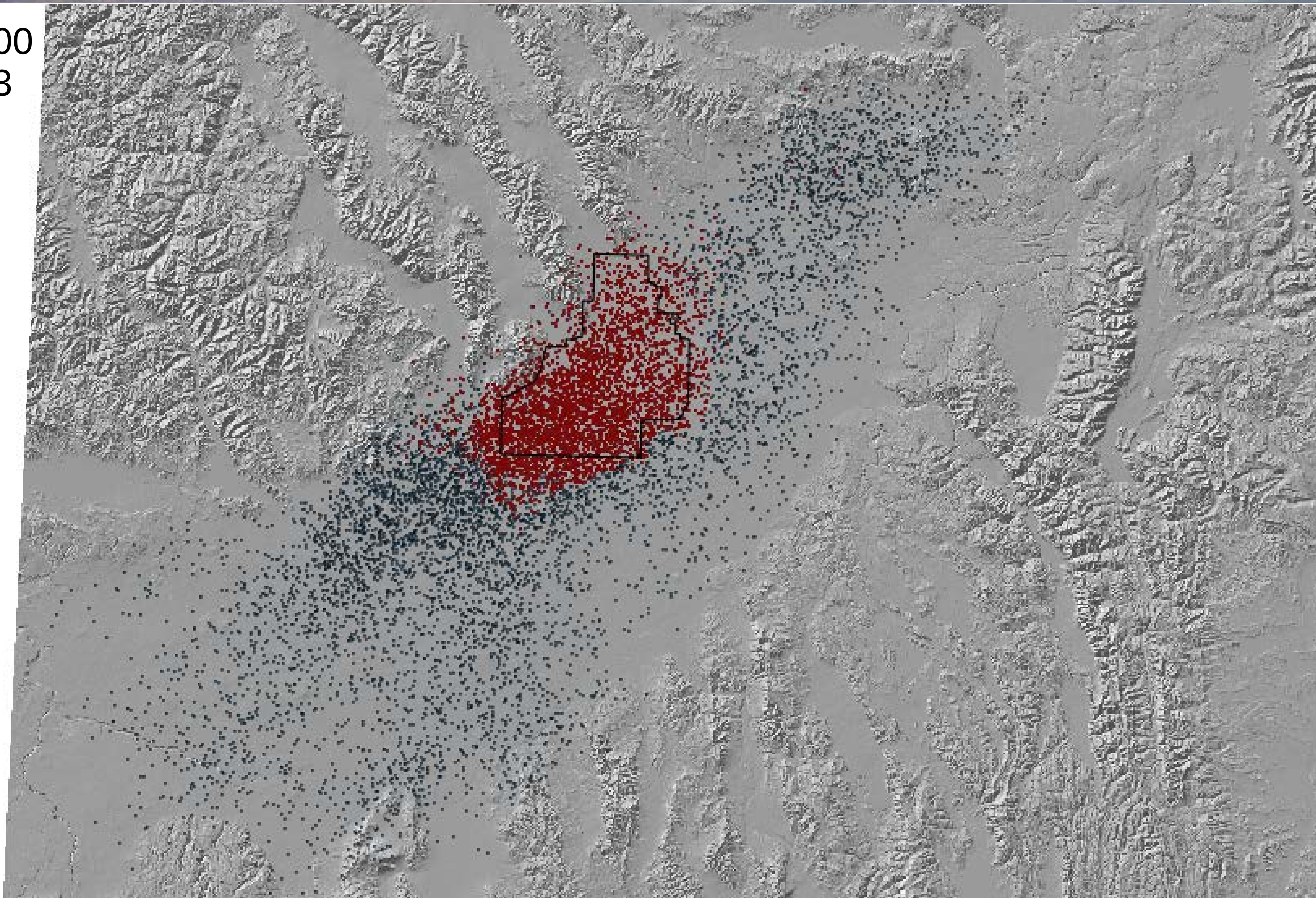
All event inundations



Results: MOLASSES

N = 10,000
H = 3,803

All event eruption sites



Methodology: Recurrence Interval

$$\hat{\lambda} = \frac{N - 1}{T_0 - T_M}$$

where N is the total number of events (N = 506 for vents and N = 308 for events), T_0 is the age of the oldest datum (1.2 Ma), and T_M is the age of the youngest datum (2,076 ya)

Results: Recurrence Interval

Vents: 2,403 years

$$\lambda = \frac{506 - 1}{1.2\ Ma - 2.1\ ka}$$

- Yearly vent opening: 4.161×10^{-4}
- INL inundation: 2.545×10^{-1}
- Yearly INL inundation: 1.059×10^{-4}
- Vent opening in INL: 1.827×10^{-1}
- Yearly INL vent opening: 7.602×10^{-5}
- Max. hit intensity: 2.40×10^{-2}
- Yearly max. hit intensity: 9.99×10^{-6}

Events: 3,941 years

$$\lambda = \frac{308 - 1}{1.2\ Ma - 2.1\ ka}$$

- Yearly vent opening: 2.537×10^{-4}
- INL inundation: 3.803×10^{-1}
- Yearly INL inundation: 9.648×10^{-5}
- Vent opening in INL: 2.585×10^{-1}
- Yearly INL vent opening: 6.558×10^{-5}
- Max. hit intensity: 8.45×10^{-2}
- Yearly max. hit intensity: 2.14×10^{-5}

Conclusions

- 25.45% of vents and 38.03% of events inundated INL
- INL faces yearly inundation probabilities of 1.059 x 10^{-4} for vents and 9.648 x 10^{-5} for events
- 18.27% of vents and 25.83% of events erupted within INL
- Yearly probabilities of eruptions initiating within INL are 7.602 x 10^{-5} for vents and 6.558 x 10^{-5} for events
- These probability estimates for volcanic eruptions impacting the INL sites are approximately 100 x to 1000 x higher than thresholds suggested by the international community (International Atomic Energy Agency)

Recommendations

- **Explore different uses for the vent-to-event process**

  - Use the linkage elements of this process to highlight units that require age dating

- **Continue to date basaltic strata on the ESRP**

  - Understanding the timing of activity is critical for calculating accurate recurrence intervals, which drive impact probabilities

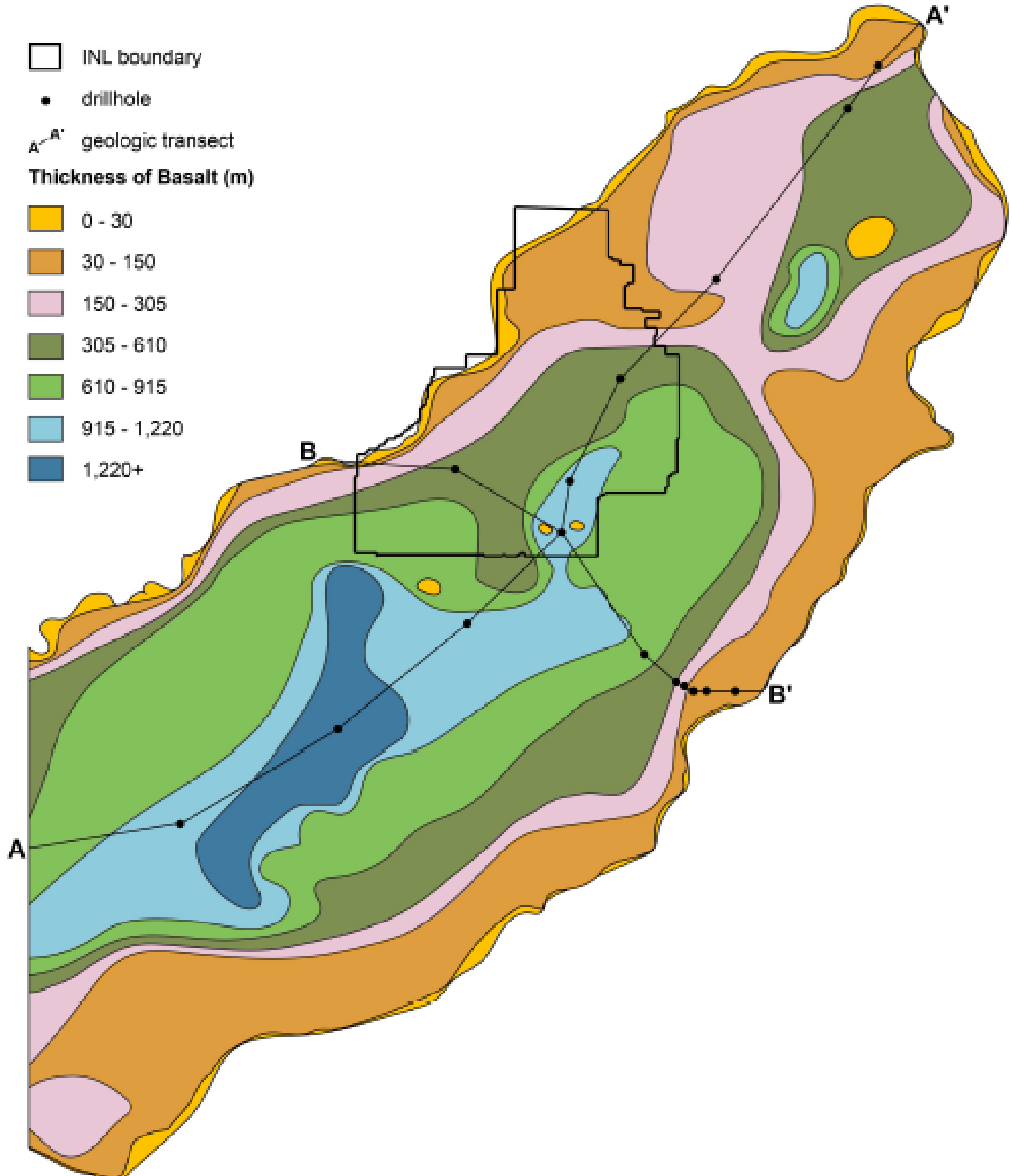
- **Increase the number of flow volume estimates**

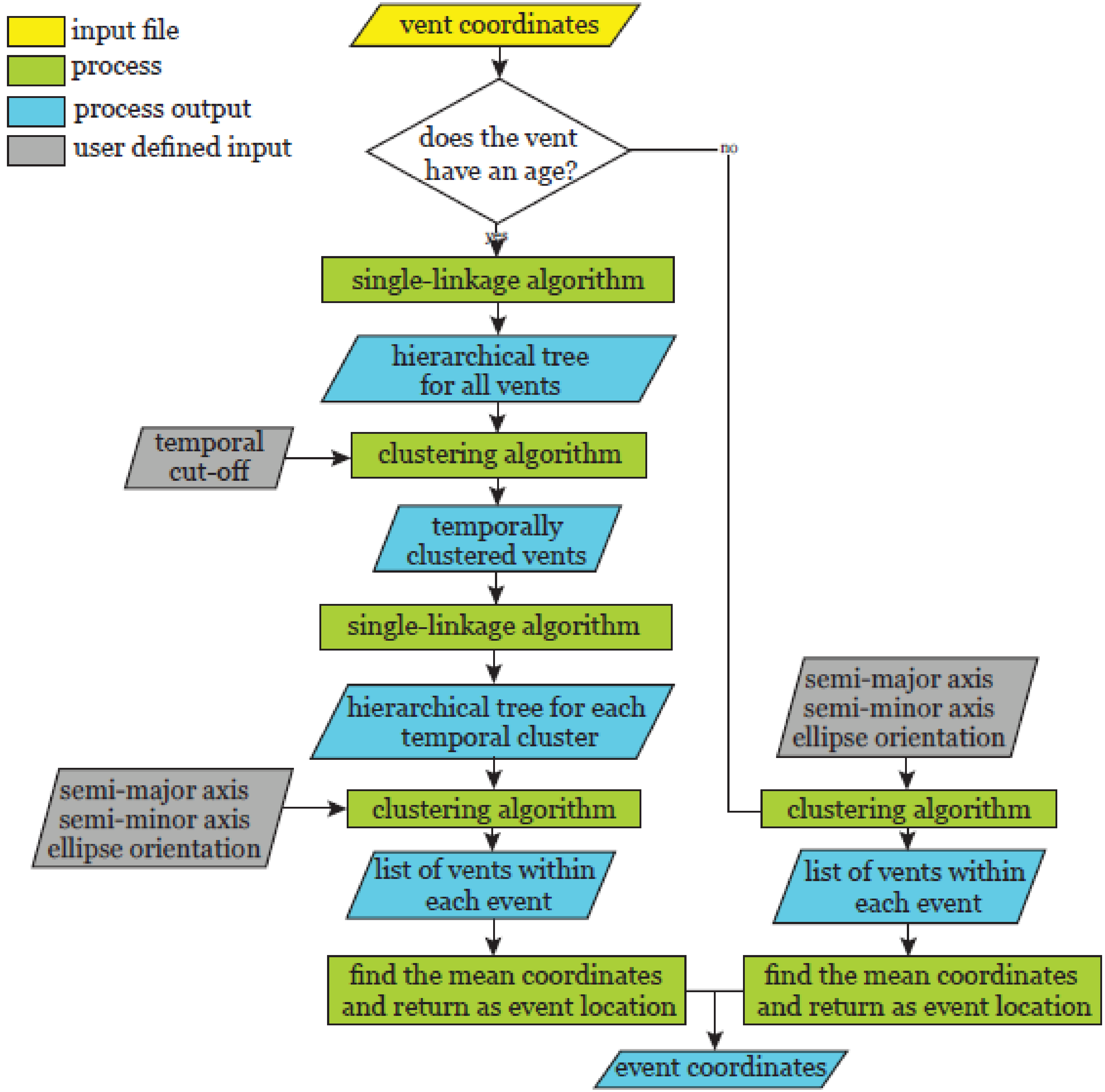
  - The dearth of eruptive volume estimates should be rectified in order to more accurately model eruptions

- **Examine future results as they relate to infrastructure within INL**

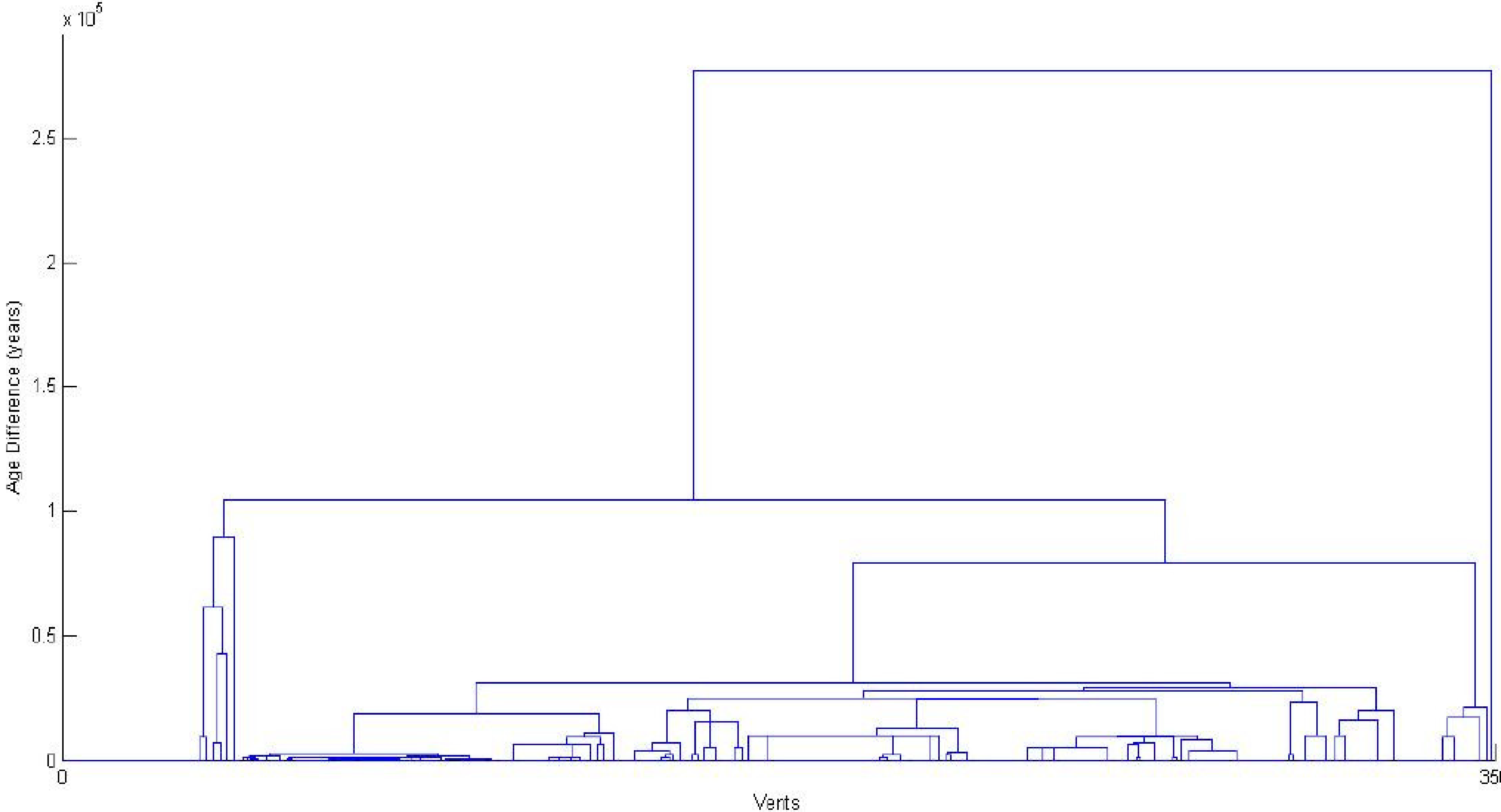
  - Inundation of the boundary may not necessarily disrupt operations at individual facilities


Questions?

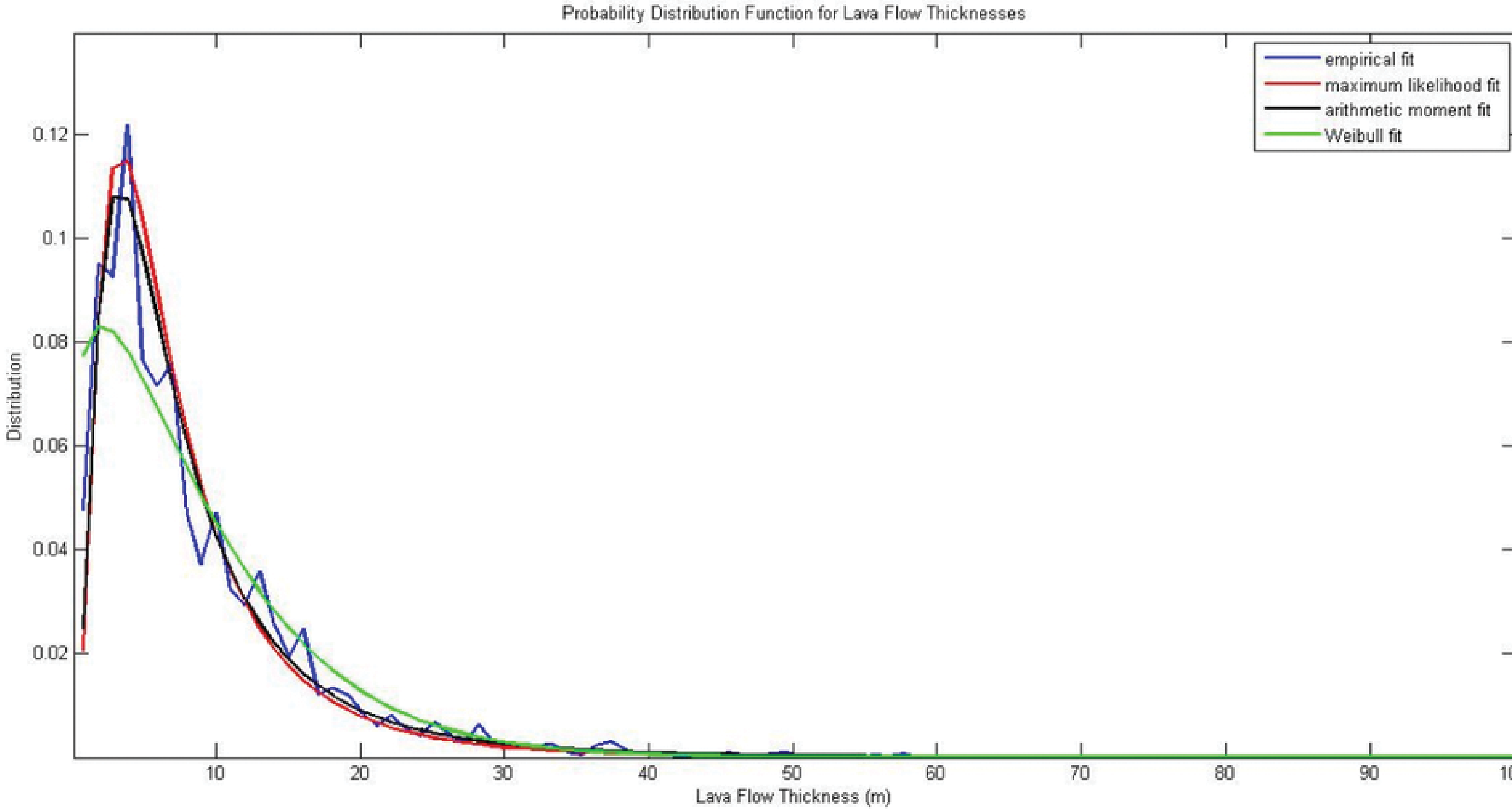

INL boundary
drillhole
A A' geologic transect
Thickness of Basalt (m)
0 - 30
30 - 150
150 - 305
305 - 610
610 - 915
915 - 1,220
1,220+
A'
B
B'
A

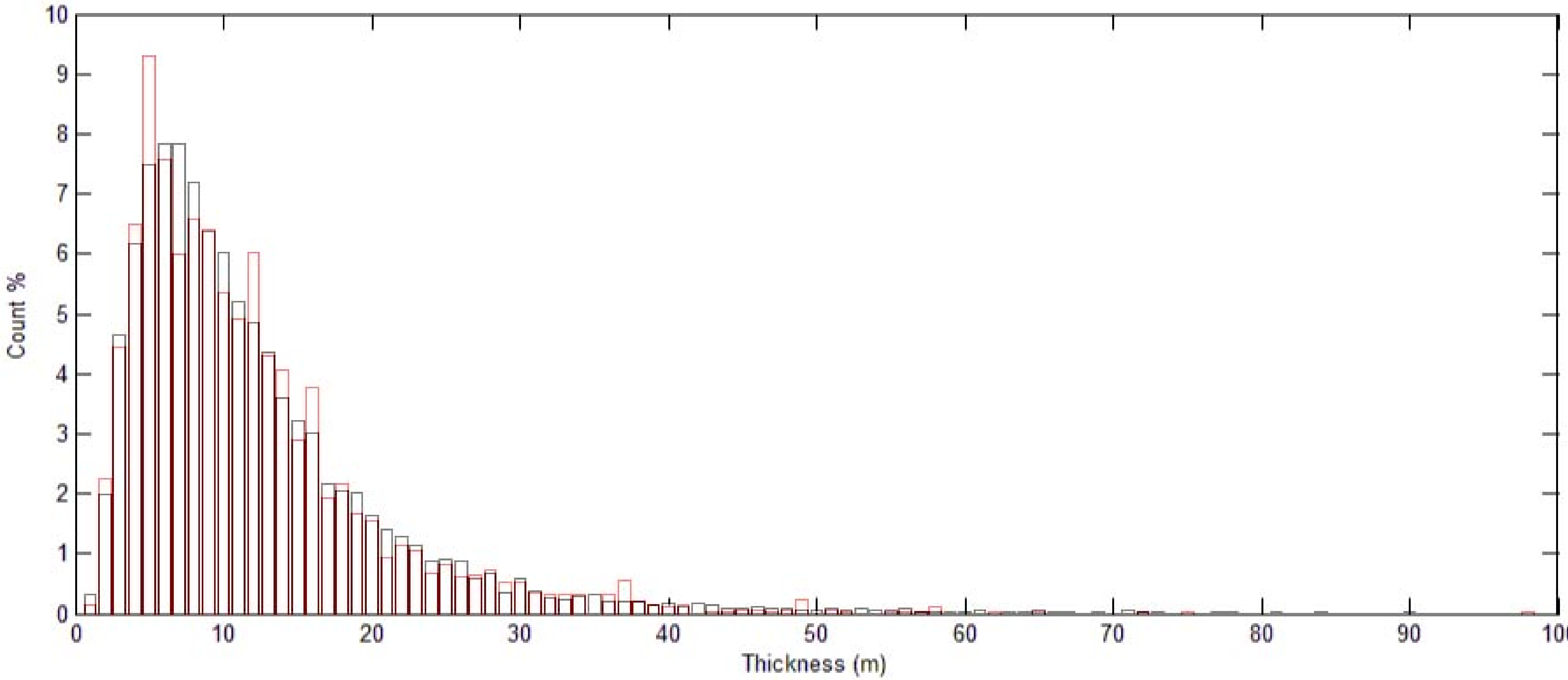


input file
process
process output
user defined input
vent coordinates
does the vent have an age?
no
yes
single-linkage algorithm
hierarchical tree for all vents
temporal cut-off
clustering algorithm
temporally clustered vents
single-linkage algorithm
hierarchical tree for each temporal cluster
semi-major axis
semi-minor axis
ellipse orientation
clustering algorithm
list of vents within each event
semi-major axis
semi-minor axis
ellipse orientation
clustering algorithm
list of vents within each event
find the mean coordinates and return as event location
find the mean coordinates and return as event location
event coordinates

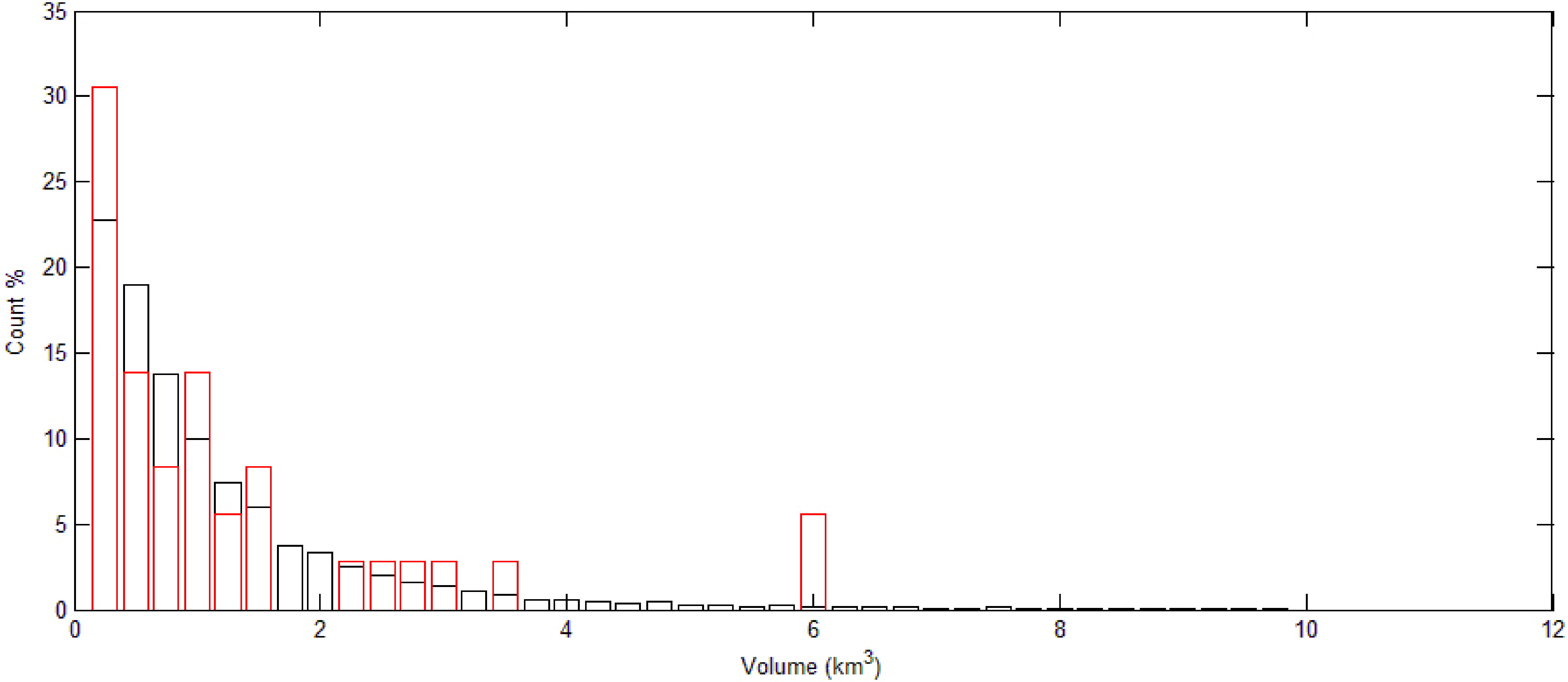


x 10^5
2.5
2
1.5
1
0.5
0
Age Difference (years)
0
356
Vents


Probability Distribution Function for Lava Flow Thicknesses
empirical fit
maximum likelihood fit
arithmetic moment fit
Weibull fit
Distribution
0.12
0.1
0.08
0.06
0.04
0.02
10
20
30
40
50
60
70
80
90
100
Lava Flow Thickness (m)

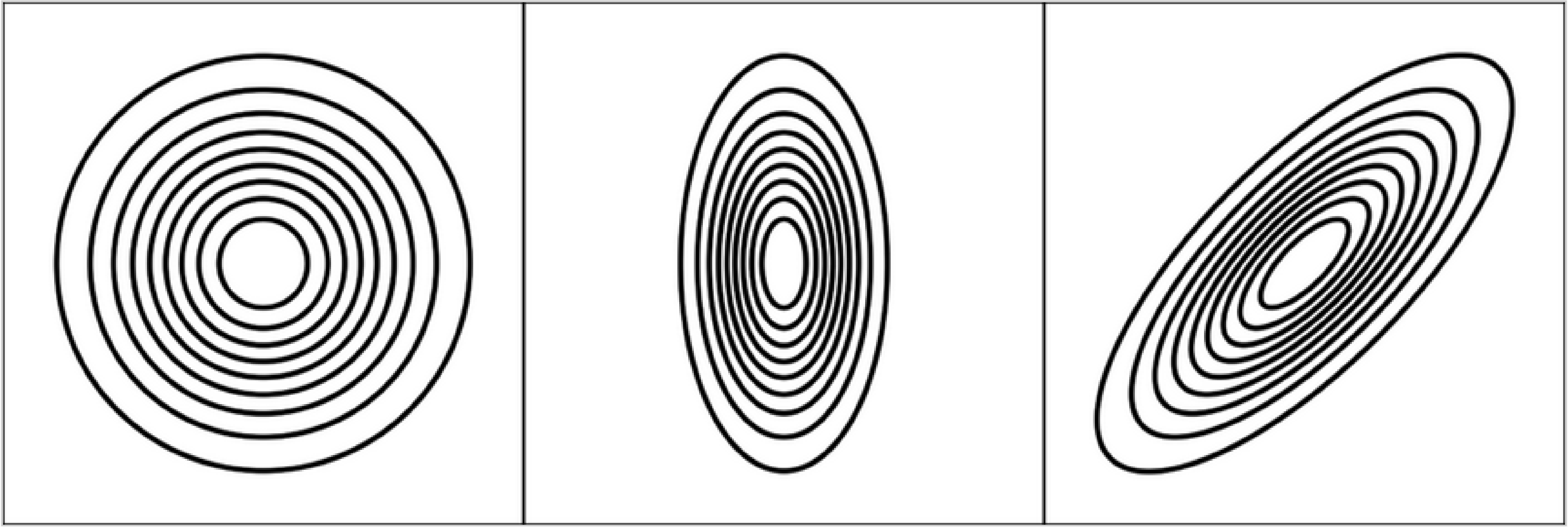


Count %
Thickness (m)
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
90
100



35
30
25
20
15
10
5
0
Count %
0
2
4
6
8
10
12
Volume (km^3)

Spatial Density Estimation



Comparison of the three main bandwidth matrix parametrisation classes. Left. *S* positive scalar times the identity matrix. Centre. *D* diagonal matrix with positive entries on the main diagonal. Right. *F* symmetric positive definite matrix.