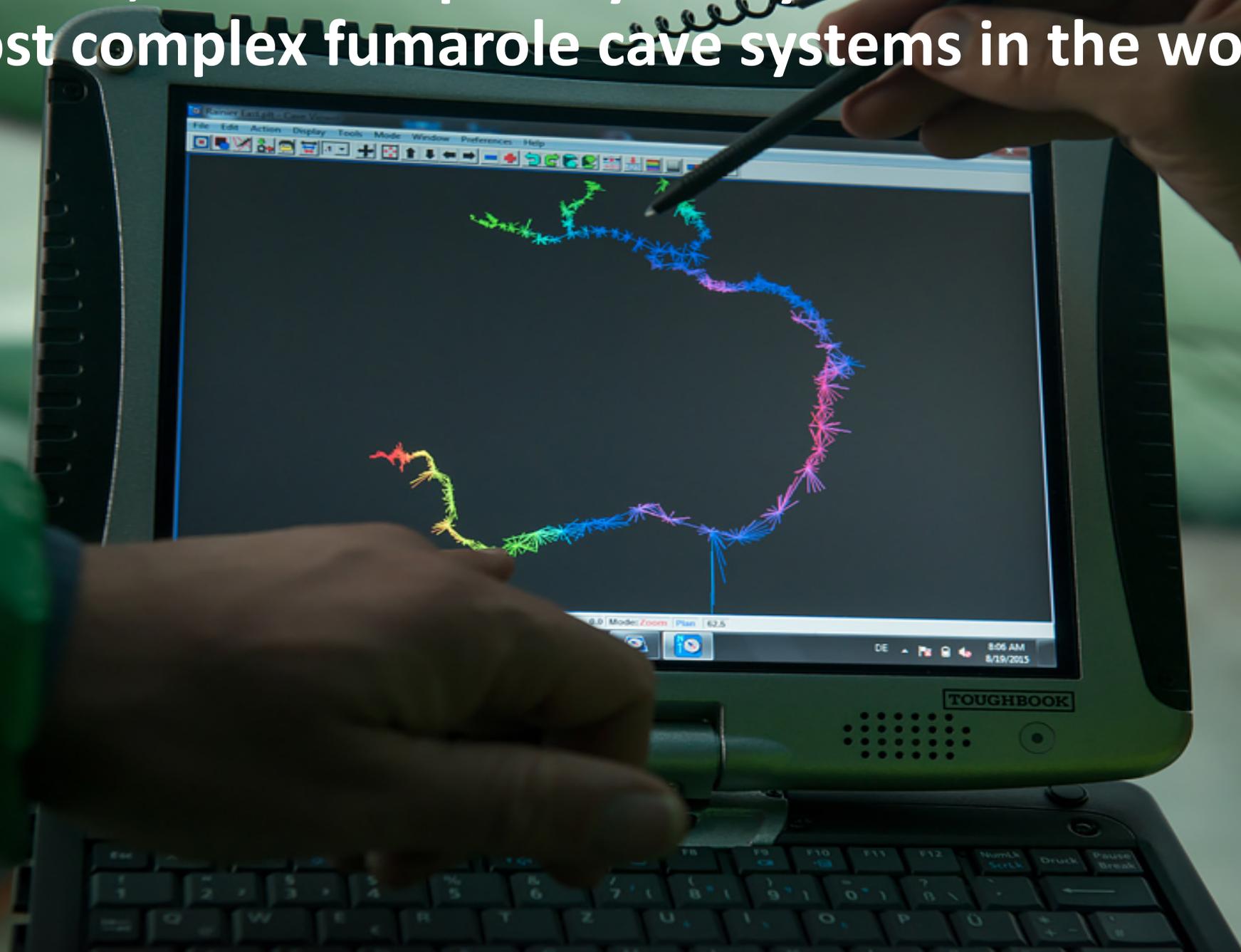


Monitoring a glacial melt lake deep in a fumarole ice cave in the summit crater of Mount Rainier, Washington State, U.S.A.

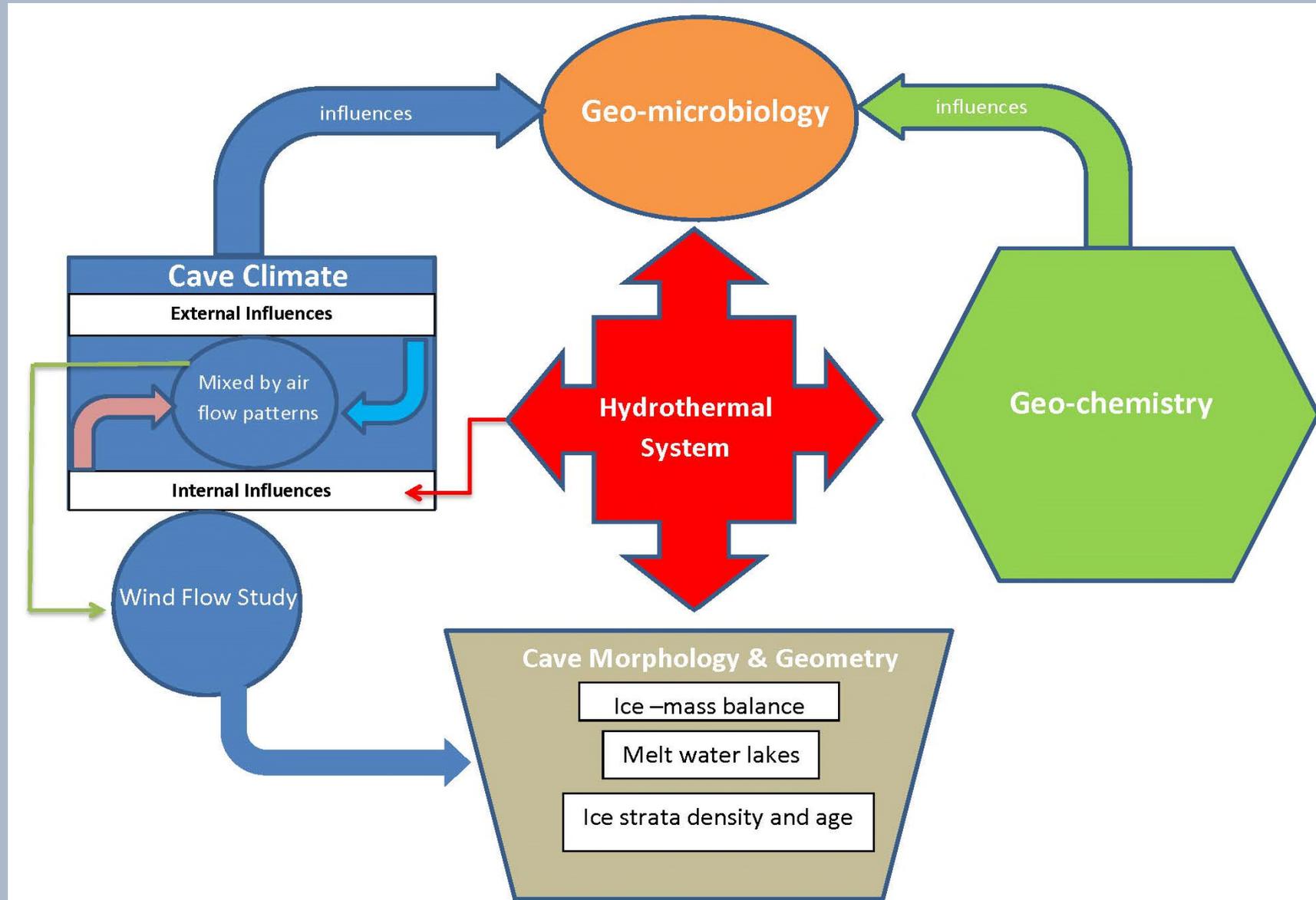
Lee J. Florea – Indiana University
Eduardo Cartaya – Glacier Cave Explorers
Andreas Pflitsch – Ruhr-Universität Bochum

An integrated, multidisciplinary study of one of the largest and most complex fumarole cave systems in the world!



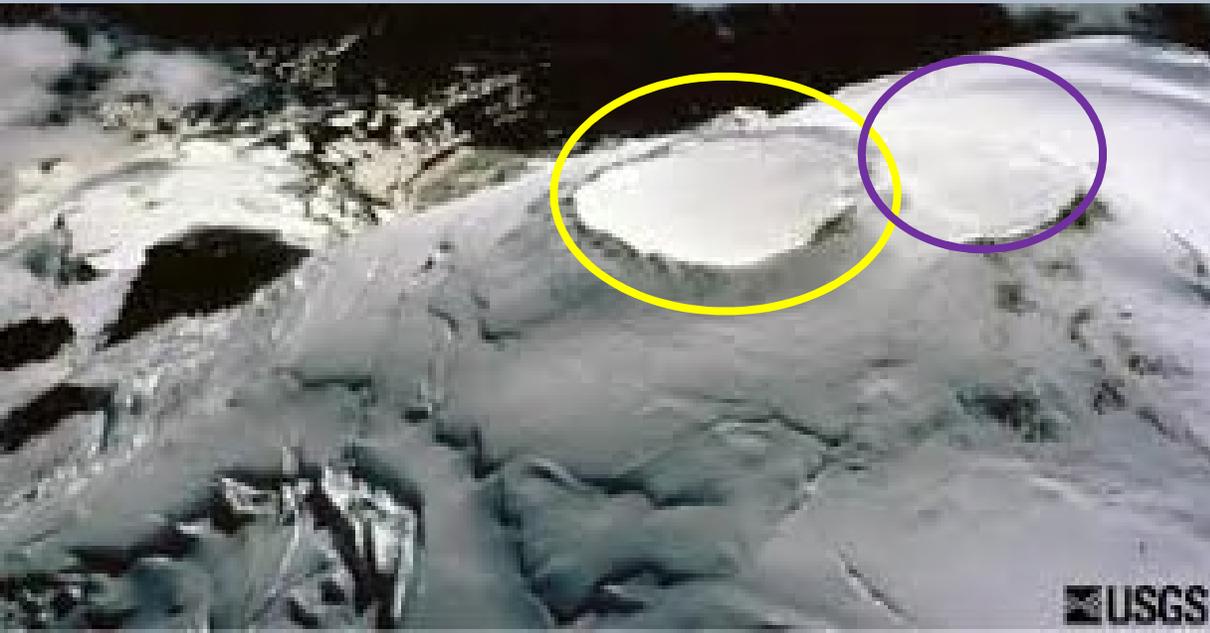
Why the Project?

- Characterize the nature of the fumarole cave systems
 - Detailed map
 - Scientific monitoring
 - Rescue planning
 - Resource inventory
- Relate volumetric changes in the caves and sub-glacial lakes to the hydrothermal system.
- Terrestrial analogy to potential extremophile conditions on other ice bodies in solar system.
- Outreach and education.



Glacier formed by snow & ice accumulation in high altitude crater

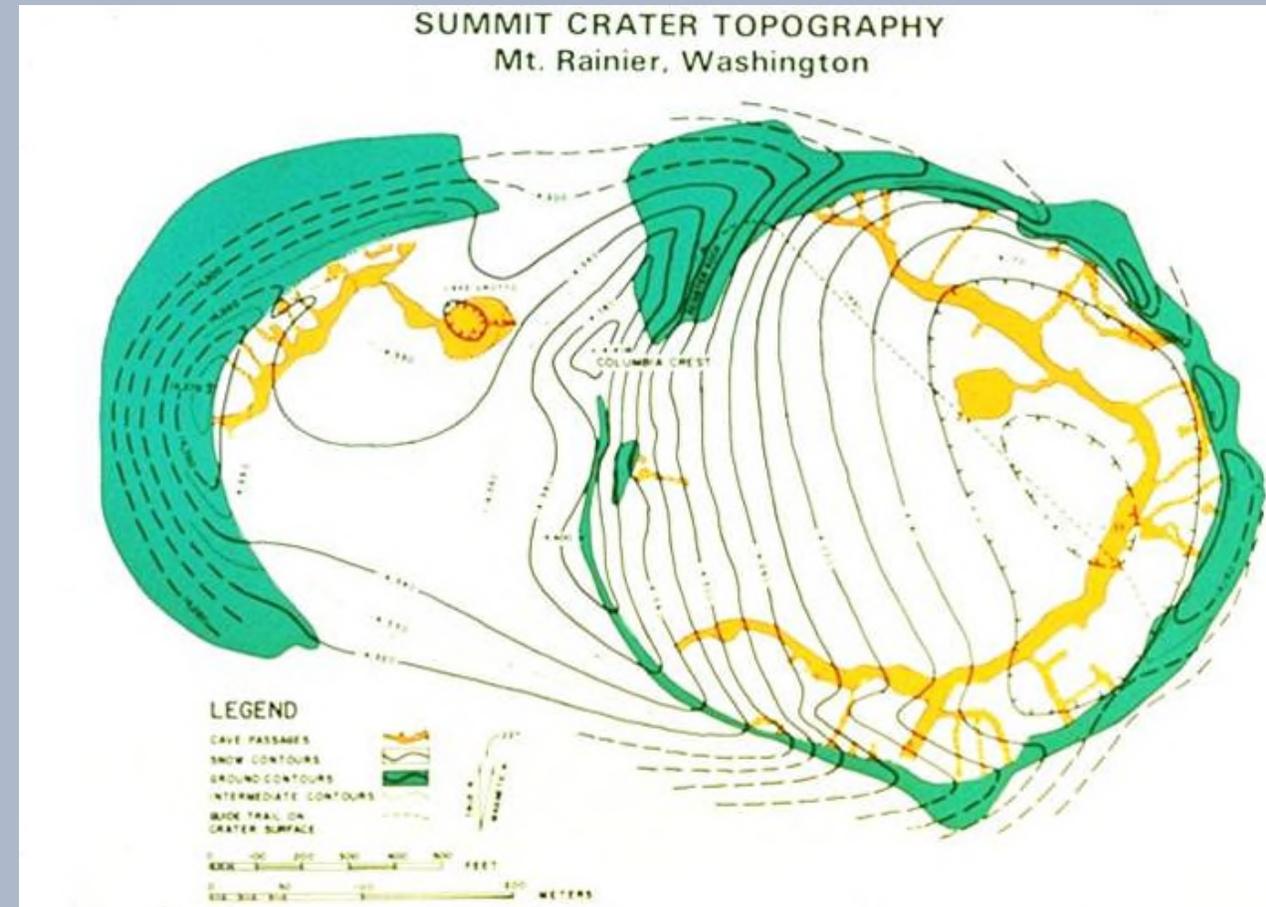
- **East Crater:**
- Uncertain depth... Estimates between 150 to 200 meters.
- Bucket: Contains a trapped crater glacier.
- Ice accumulation roughly balanced by bottom melting.
- Ice flows downward with horizontal & rotational components.
- **West Crater:**
- Unknown depth
- Ladle: Breach in south rim feeds flank glaciers



The Fumarole Caves

- These summit craters contain the world's largest fumarole glacier cave system
- Low volume, variable fumaroles permit formation of complex passages up to 120 m below crater rim.
- Caves visited by climbers & researchers since the late 1800's, including the 1st authenticated summit climb in 1870.
- Each crater houses its own cave system
- Caves do not connect; they are separated by the overlapping rims of the Columbia Crest.

Cave systems as mapped in 1970. Bill Lokey



The Climb



The Climb

ING CEMENTO



The Climb



The Climb



The Climb



The Camp



The Camp



The Camp



The Cave



The Cave



The Map



CAVE SURVEY

- Conduct 3-D survey
- Annual volumetric survey at reference points
- Systematic representation of resource

East Crater Cave

Length: 2.2 miles

Vertical Extent: 463 feet

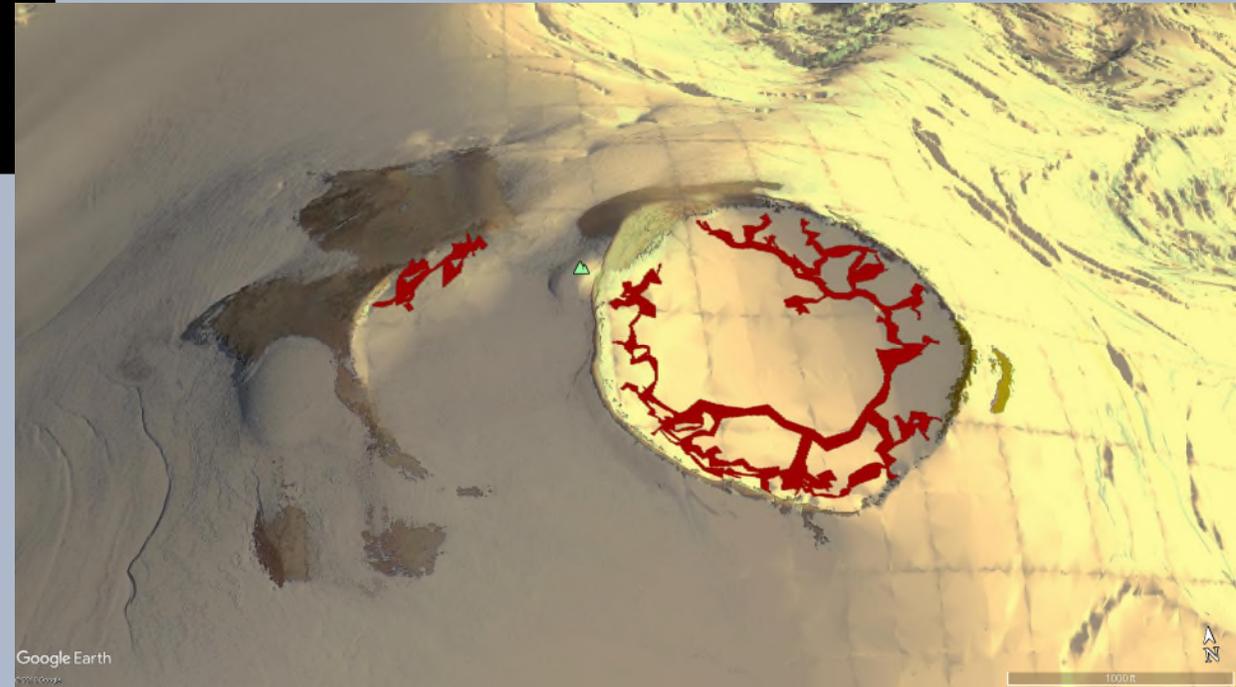
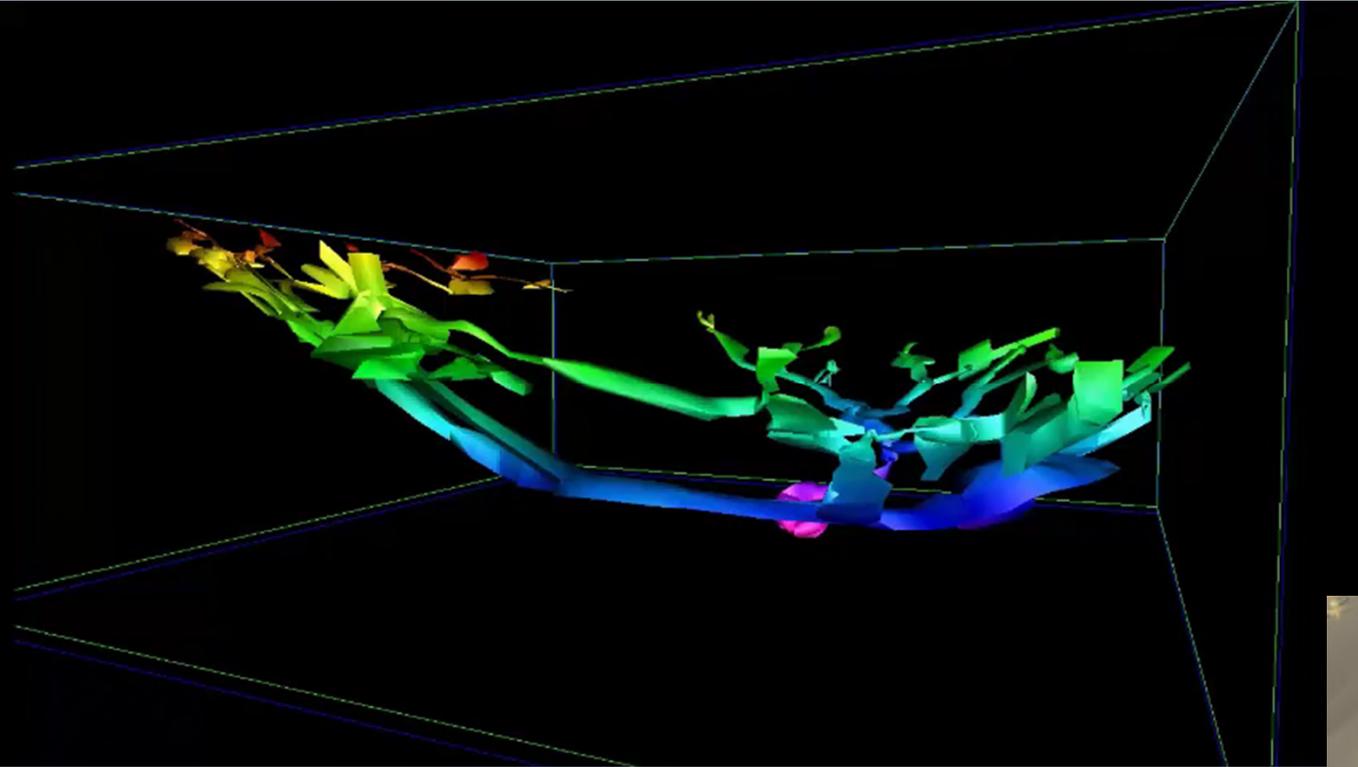
West Crater Cave

Length: 999 feet

Vertical Extent: 91 feet



Summit Caves



The Science



The Science
1 N 6 2 C I 6 N C 6



The Science

ING SCIENCE



The Science



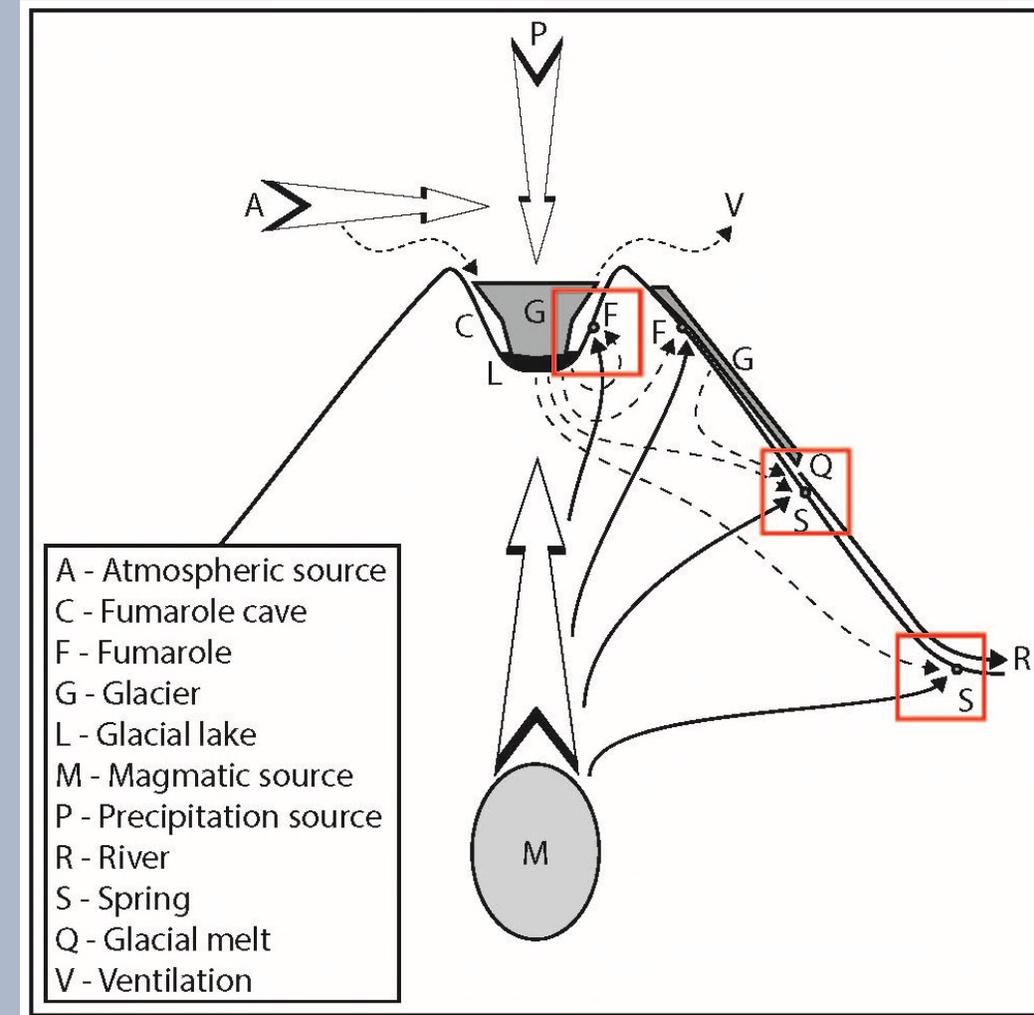
The Science

ING SCIENCE

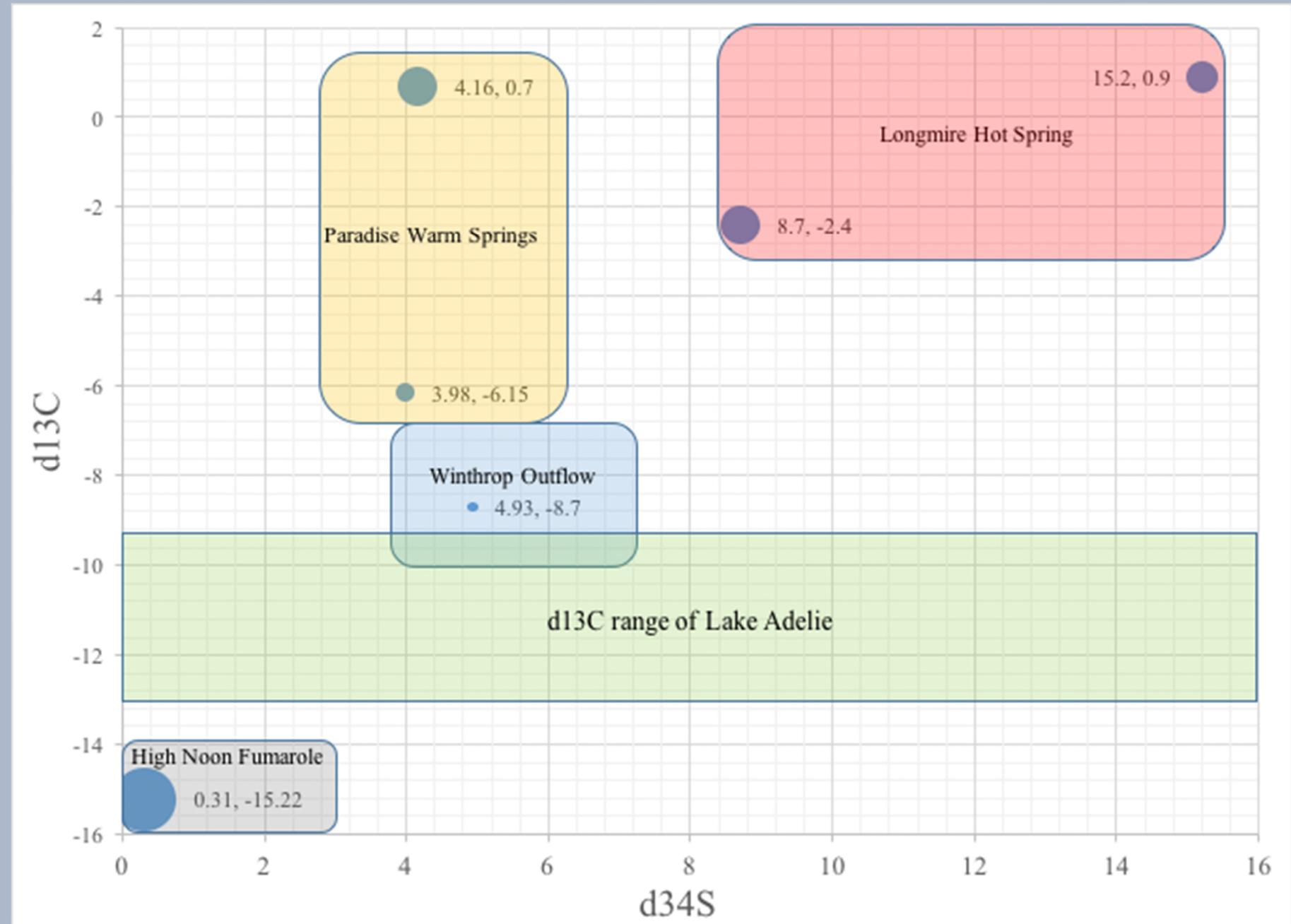


Hydrology & Geochemistry

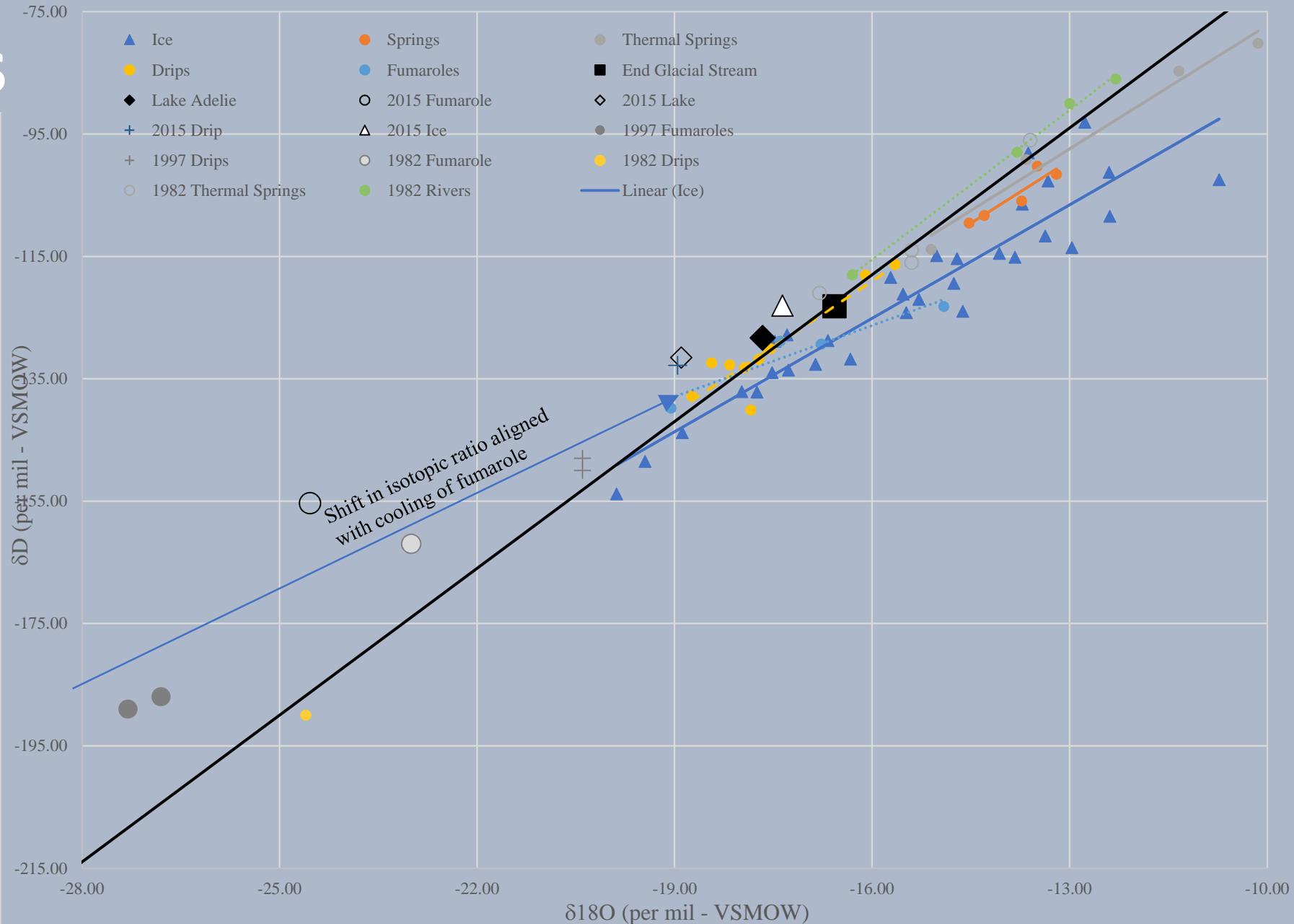
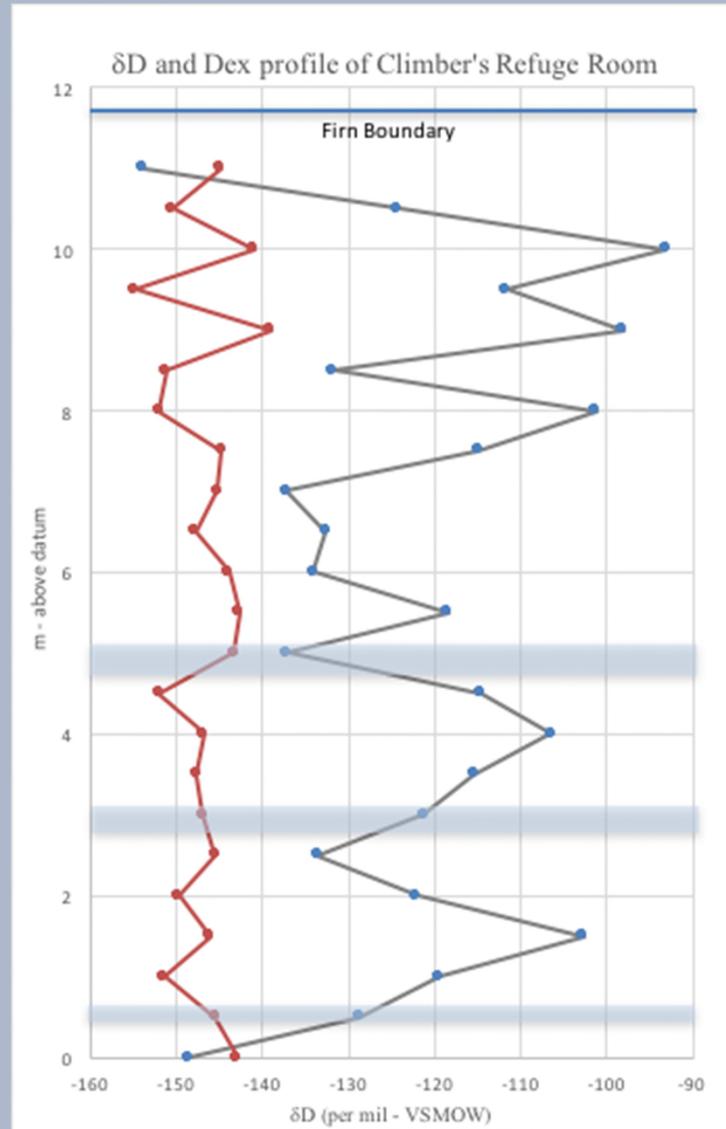
- Lake Adelie is comprised largely of glacial melt
 - Temperature is close to freezing point, conductivity was very low $<2 \mu\text{S}/\text{cm}$, and pH was slightly acidic.
 - Low inorganic carbon in the lake water with $\delta^{13}\text{C}$ values (-9‰ to -13‰) suggesting a mixture of atmospheric CO_2 and fumarole gas.
 - Values of $\delta^2\text{H}/\delta^{18}\text{O}$ in the lake are a mixture of fumarole condensate (-155‰/-24.5‰) and glacial melt (-132‰/-19‰).



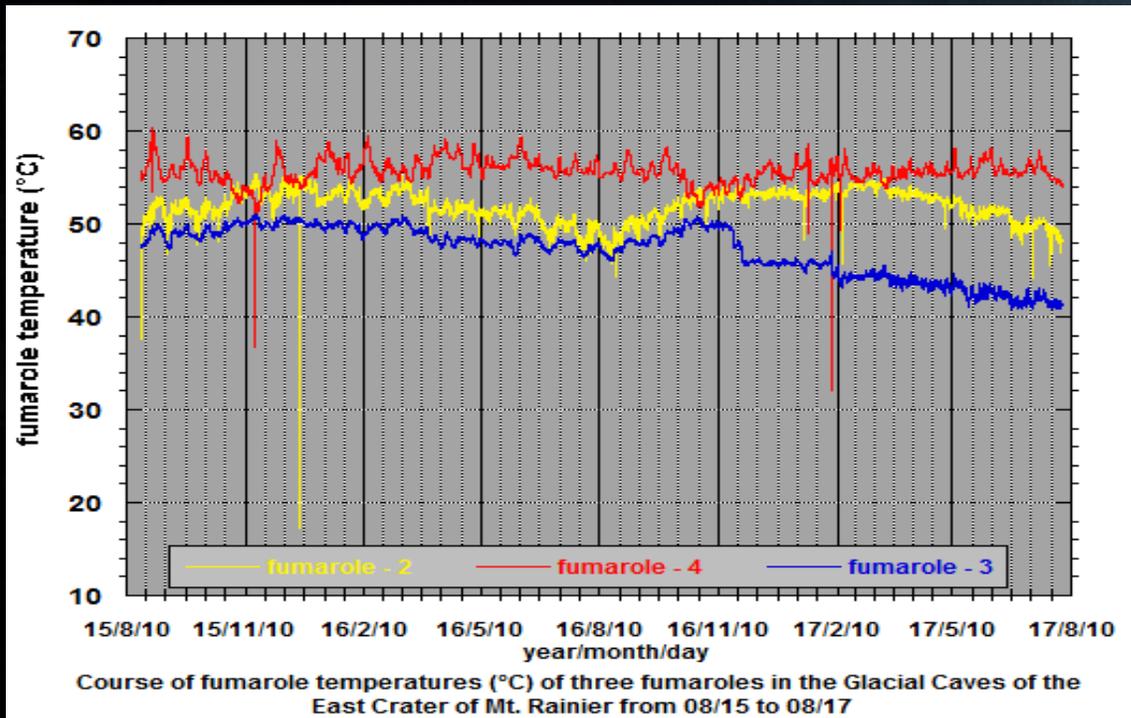
Carbon and Sulfur isotopes



Water isotopes

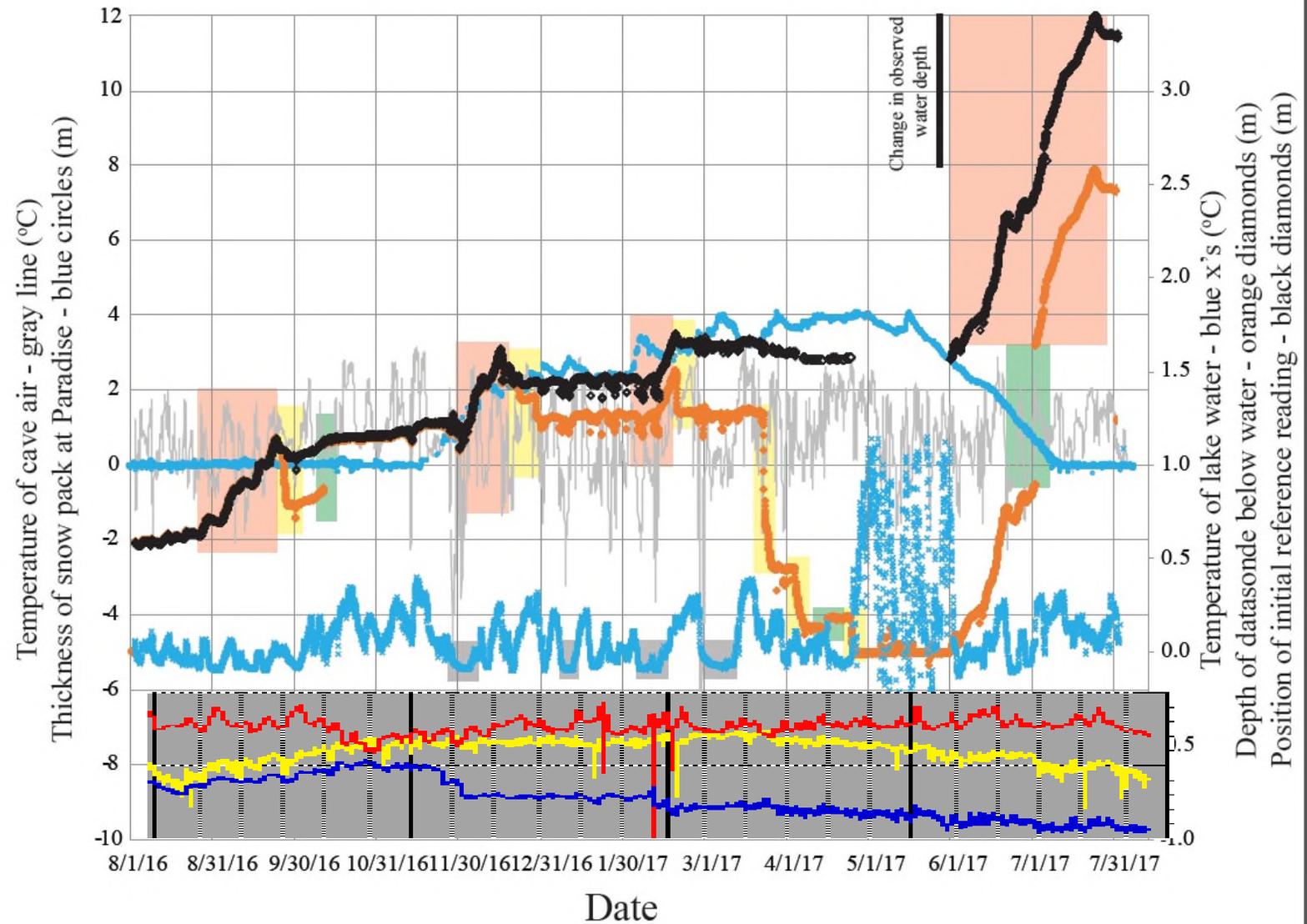


Climatology / Micro-meteorology



Continuous monitoring data

Oh what a story...



Red - Increase in water depth from accelerated melting. Observed visible water level change (0.7 m).
Yellow - Decrease in probe depth resulting, in part, from translational motion of anchor boulder (2.0 m).
Green - Increase in probe depth resulting, in part, from subsidence of anchor boulder (0.8 m).
Gray - Period of significant lake ice.

What's next/Future work

1. More substantial airflow and ablation studies (helicopter support!)
2. Annual trips to download logger data.
3. Annual laser scanning for detailed analyzing of volumetric changes
4. Monitoring of fumarole activity (temperature& volume)
5. Amassing more data on flanking springs and end-glacial streams

THANK YOU FOR YOUR TIME!

QUESTIONS?

