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**EARTH & SPACE  
SCIENCES**

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**Class of 2019**

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Yetter**

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Pratt**

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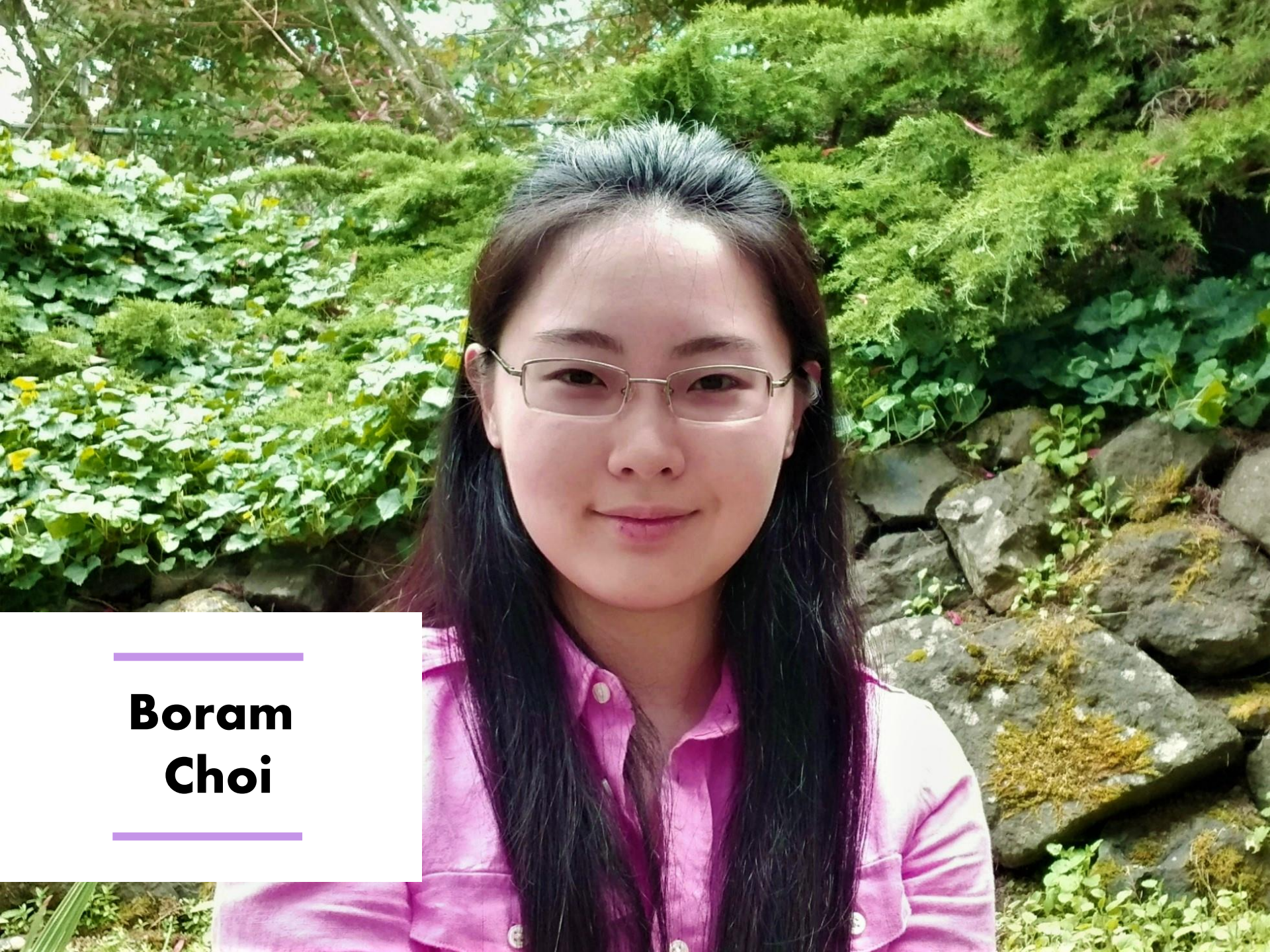
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**Bing Yu  
Lee**

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**Boram  
Choi**

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**Carson  
Goldsmith-Albright**

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**Christopher  
Sayles**

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**Elizabeth  
Horton**

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Jeddy**

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# Hannah Graham

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**Joel P.  
Jacobsen**

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**Jordan  
Wang**

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**Kalpana  
Prasad**

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**Max  
Podhaisky**

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# Monica Hill

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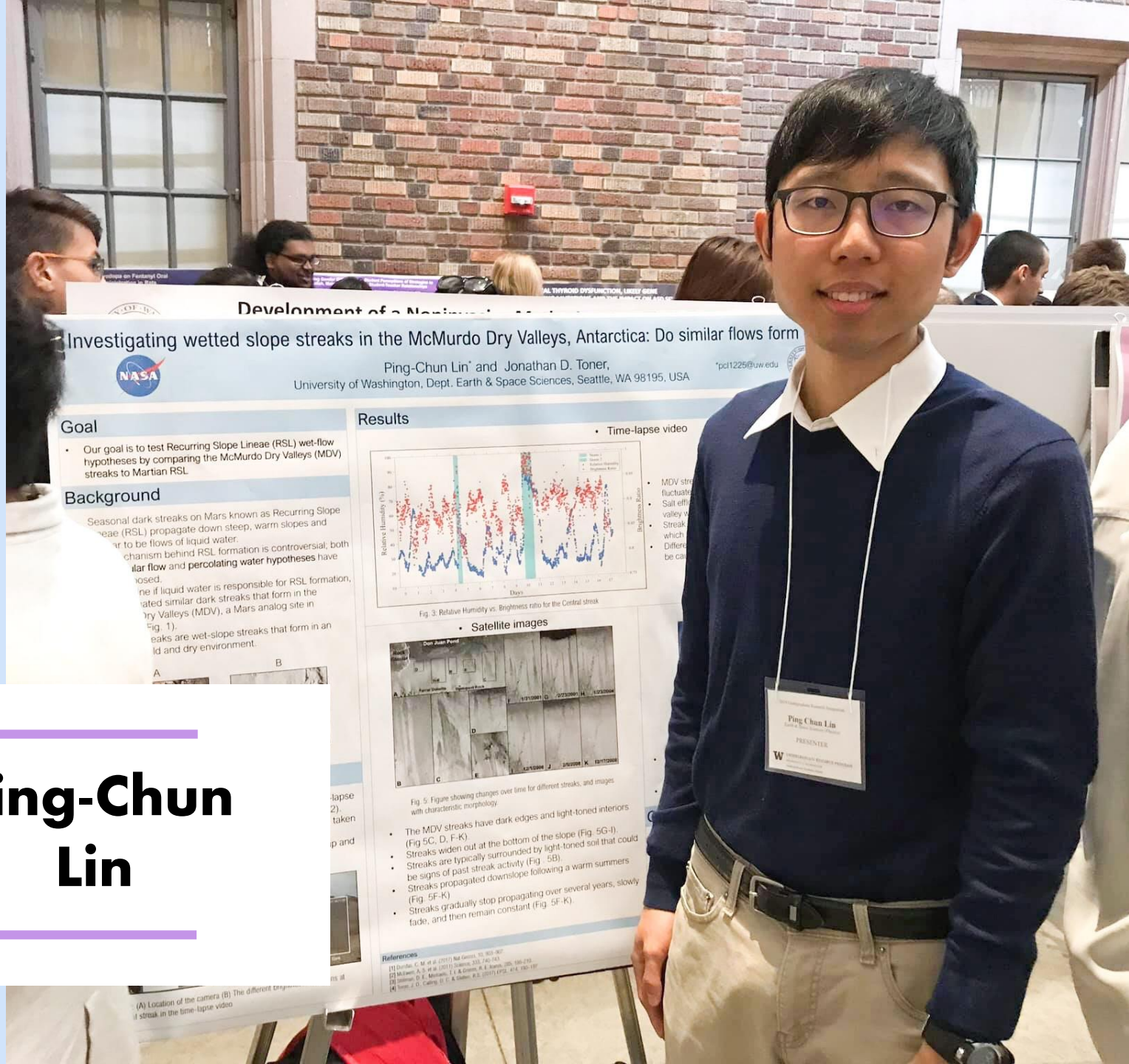
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**Natalie  
Wisdom**

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# Ping-Chun Lin



## Investigating wetted slope streaks in the McMurdo Dry Valleys, Antarctica: Do similar flows form



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### Goal

- Our goal is to test Recurring Slope Lineae (RSL) wet-flow hypotheses by comparing the McMurdo Dry Valleys (MDV) streaks to Martian RSL

### Background

Seasonal dark streaks on Mars known as Recurring Slope Lineae (RSL) propagate down steep, warm slopes and are thought to be flows of liquid water. The mechanism behind RSL formation is controversial; both surface runoff and percolating water hypotheses have been proposed. If liquid water is responsible for RSL formation, we expect to find similar dark streaks that form in the McMurdo Dry Valleys (MDV), a Mars analog site in Antarctica (Fig. 1). MDV streaks are wet-slope streaks that form in an arid and dry environment.



### Results

#### Time-lapse video

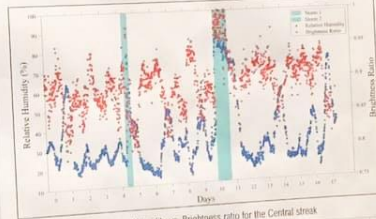


Fig. 3. Relative Humidity vs. Brightness ratio for the Central streak

- MDV streaks fluctuate in brightness
- Salt efflorescence in valley walls
- Streaks are typically surrounded by light-toned soil that could be signs of past streak activity
- Differences in streak morphology

#### Satellite images



Fig. 5. Figure showing changes over time for different streaks, and images with characteristic morphology

- The MDV streaks have dark edges and light-toned interiors (Fig. 5C, D, F-K)
- Streaks widen out at the bottom of the slope (Fig. 5G-I)
- Streaks are typically surrounded by light-toned soil that could be signs of past streak activity (Fig. 5B)
- Streaks propagated downslope following a warm summer (Fig. 5F-K)
- Streaks gradually stop propagating over several years, slowly fade, and then remain constant (Fig. 5F-K)

#### References

- [1] Drobner, C. M. et al. (2017) Nat. Geosci. 10, 803-807
- [2] McEwen, A. S. et al. (2011) Science 333, 740-743
- [3] Toner, J. D., S. M. McLennan, J. E. Crayston, R. A. Brown, 2005, 986-990
- [4] Toner, J. D., Crayston, J. E., & S. M. McLennan, R. A. Brown, 2007, EPSL, 254, 480-497

(A) Location of the camera (B) The different orientations of the streak in the time-lapse video



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**Simon  
Anderson**

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**Stokke  
Xu**

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**Vanessa  
HaeBin  
Echols**

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**“The Cat”**

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**Carson  
Goldsmith-  
Albright**

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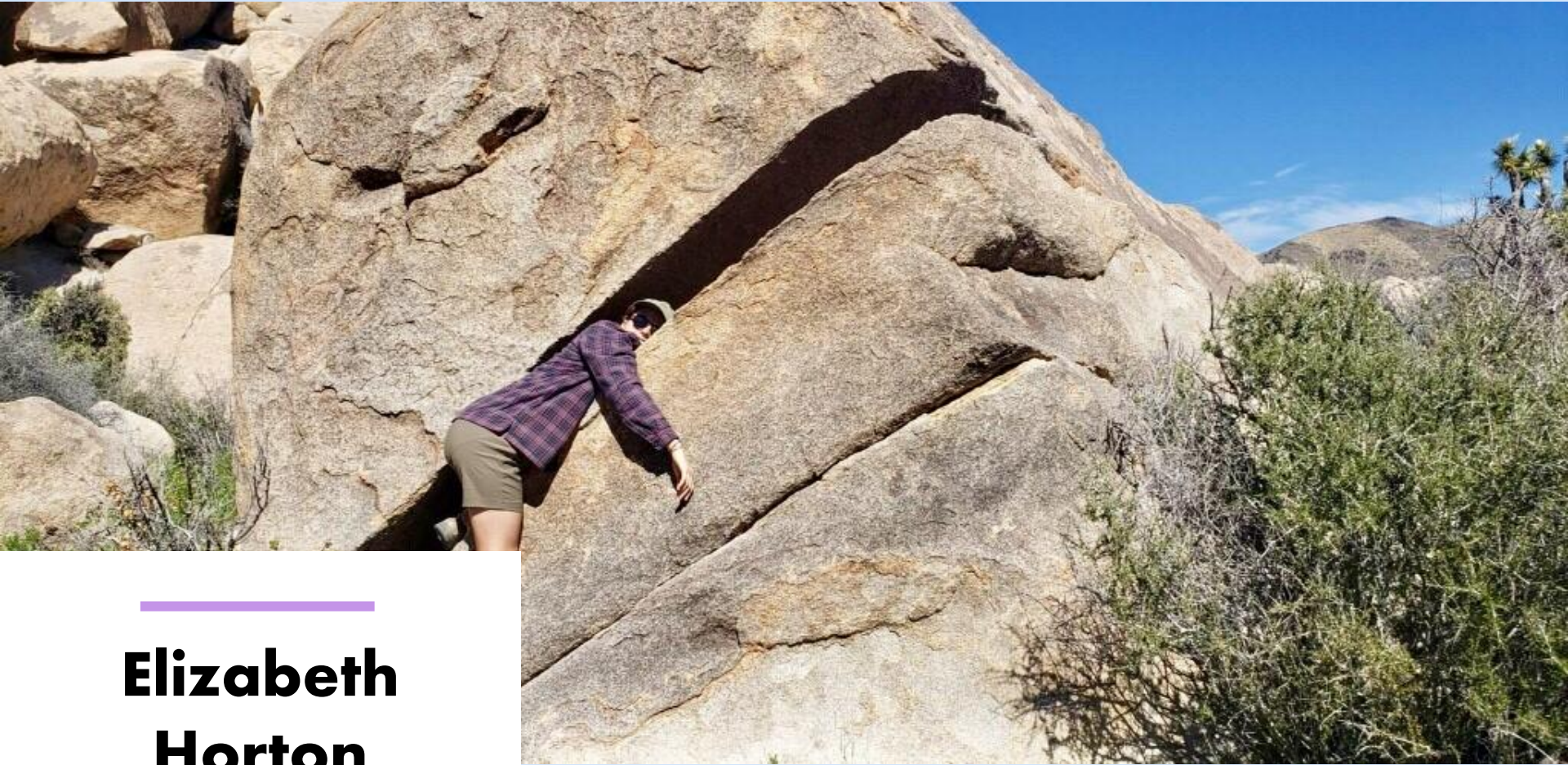


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**Jordan  
Wang**

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**Elizabeth  
Horton**

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**Emily  
Wilbur**

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**Max  
Podhaisky**

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# Anthropogenic Influence on Reactive Chlorine in the Troposphere

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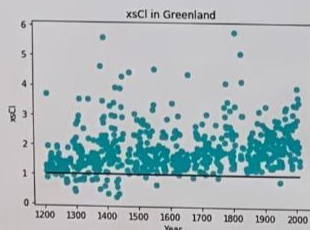
## 1. Introduction

Reactive halogens are important for atmospheric chemistry because they act as a sink for organic pollutants and greenhouse gases such as methane, as well as contribute to the formation of particulate matter. One form of reactive Cl, the Cl radical, is a small sink for methane (CH<sub>4</sub>) that results in a large isotopic fractionation. The main source of reactive halogens is from acid-catalyzed reactions between ozone and sea-salt aerosol and the ocean surface. Based on modeling studies, it is thought that anthropogenic activity has increased the atmospheric abundance of reactive halogen concentrations due to anthropogenic increases in ozone and atmospheric acidity (Sherwen et al., 2016). Here, we use a Greenland ice-core record of chloride (Cl) to investigate if these observations are consistent with this hypothesis.

## 2. Does a Greenland ice-core record reactive Cl?

$$xsCl = \frac{conc\ Cl}{conc\ Na \times 1.8}$$

Equation 1. Calculates xsCl ratio by using the measured concentration of Cl divided by the measured concentration of Na multiplied by the standard mass<sup>2</sup> ratio of Cl / Na of seawater (= 1.8)



## 3. Has reactive Cl increased in the Industrial Era?

The formation of reactive chlorine from sea salt aerosol will increase the atmospheric lifetime of chlorine, allowing it to be transported farther from it's source, leading to an excess of Cl relative to Na.

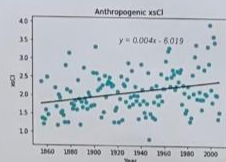
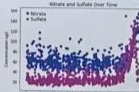


Fig. 2 Plot of xsCl vs. time over the anthropogenic era (1850 – present). The small increase in xsCl over the 157 year period is smaller than the interannual variability, suggesting an insignificant influence of anthropogenic activity.

## 4. Is there a relationship between xsCl and acidity?



$$Acidity = 2 \times Sulfate + Nitrate$$

Equation 2. Acidity is defined as the sum of 2 times sulfate and nitrate in mol/l

Fig. 1 xsCl, Nitrate, and Sulfate plotted together over the entirety of the Greenland Ice Core record, with volcanic years (Cole-Dai et al. 2013) ± 2 removed.

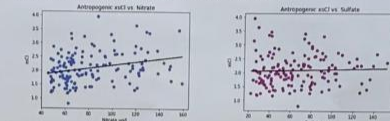


Fig. 4 Plots of nitrate and sulfate vs xsCl. The slope of the linear regression for nitrate vs xsCl is 0.0057 and the slope of the linear regression for sulfate vs xsCl is 0.0008.

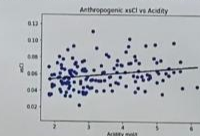


Fig. 5 Plot of xsCl vs. Acidity with a linear regression slope of 0.0037. This plot also demonstrates an insignificant increase in xsCl's impact on acidity.

## 5. Conclusions

- xsCl > 1 is recorded throughout the entirety of the Greenland Ice Core record (1200 – 2006 C.E.)
- The observations of ice-core xsCl suggest an insignificant increase in reactive Cl during the anthropogenic era.
- Although the formation of reactive Cl is acid-catalyzed, the observations do not show a significant relationship between xsCl and acidity, suggesting other factors are limiting it's formation in the atmosphere.
- The xsCl observations suggest that although reactive Cl is highly variable over time, there are no significant trends in the anthropogenic era. This suggests that any observed trends in the CH<sub>4</sub> growth rate or CH<sub>4</sub> isotopes are not influenced by changes in reactive Cl.

## References

Brody, A. L., Savarino, J., Thieme, M. H. and McConnell, J. R. (2013) Two likely stratospheric volcanic eruptions in the 1450s C.E. found in a bipolar, subannually dated 800 year old ice core. *Geophysical Research: Atmospheres* 118: 7429–7446.  
U.S. Geological Survey (n.d.). Retrieved from <https://web.stanford.edu/group/Urchin/mineral.html>  
"Halogen chemistry reduces tropospheric O<sub>3</sub> radiative forcing." *Atmos. Chem. Phys.* 17: 1557-1569.

**Joel P. Jacobsen**







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**Jordan  
Wang**

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**Kalpana  
Prasad**

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**Max  
Podhaisky**

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# Monica Hill

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**Claudiu  
Nistor**

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**Max  
Podhaisky**



Luke Russell  
JK

D-ROCK  
Tanni

Sustin Johnson  
JK

UW

Bing Yulee  
JK

Claudia  
Nistor  
JK

ESS 463 '19

Qui Quia Quia

Monica Hill

Natalie  
Wisdom

Max Pod :)

Matt  
mehr

Elizabeth  
Horton  
JK

Returning from last  
year's season of  
Survivor:

Nolan Conway  
JK

Katie Richtbre

Sam Shekht  
Esten King  
Ian Spendlove

Katana Prasad  
JK

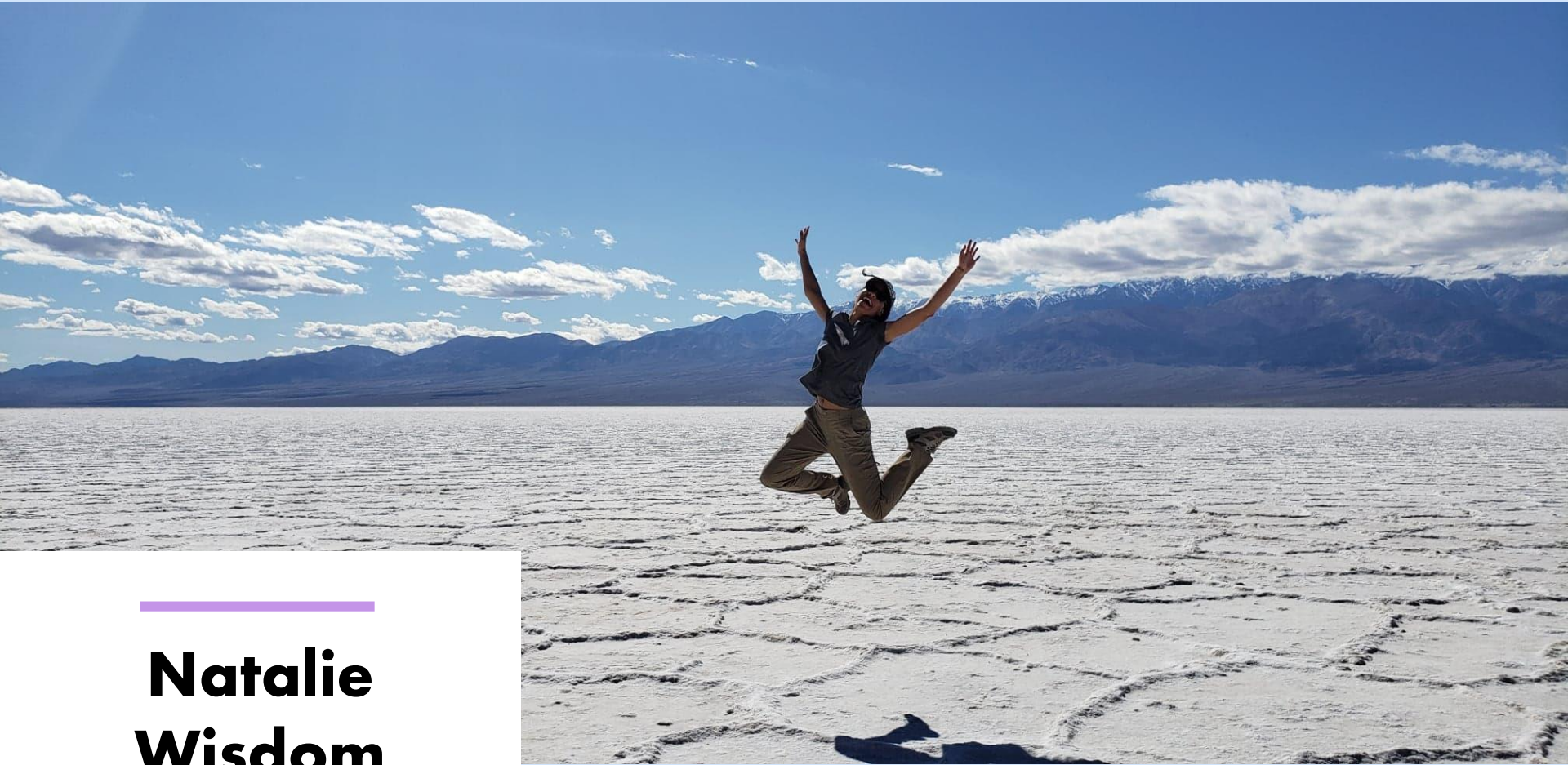
MARY Alice  
Benson

Cody Chawsee

Kathy  
Toast

Chris  
Bourgeois  
JK





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**Natalie  
Wisdom**

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**Max  
Podhaisky**

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**Vanessa  
HaeBin  
Echols**

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**Joel P.  
Jacobsen**

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**Jordan  
Wang**

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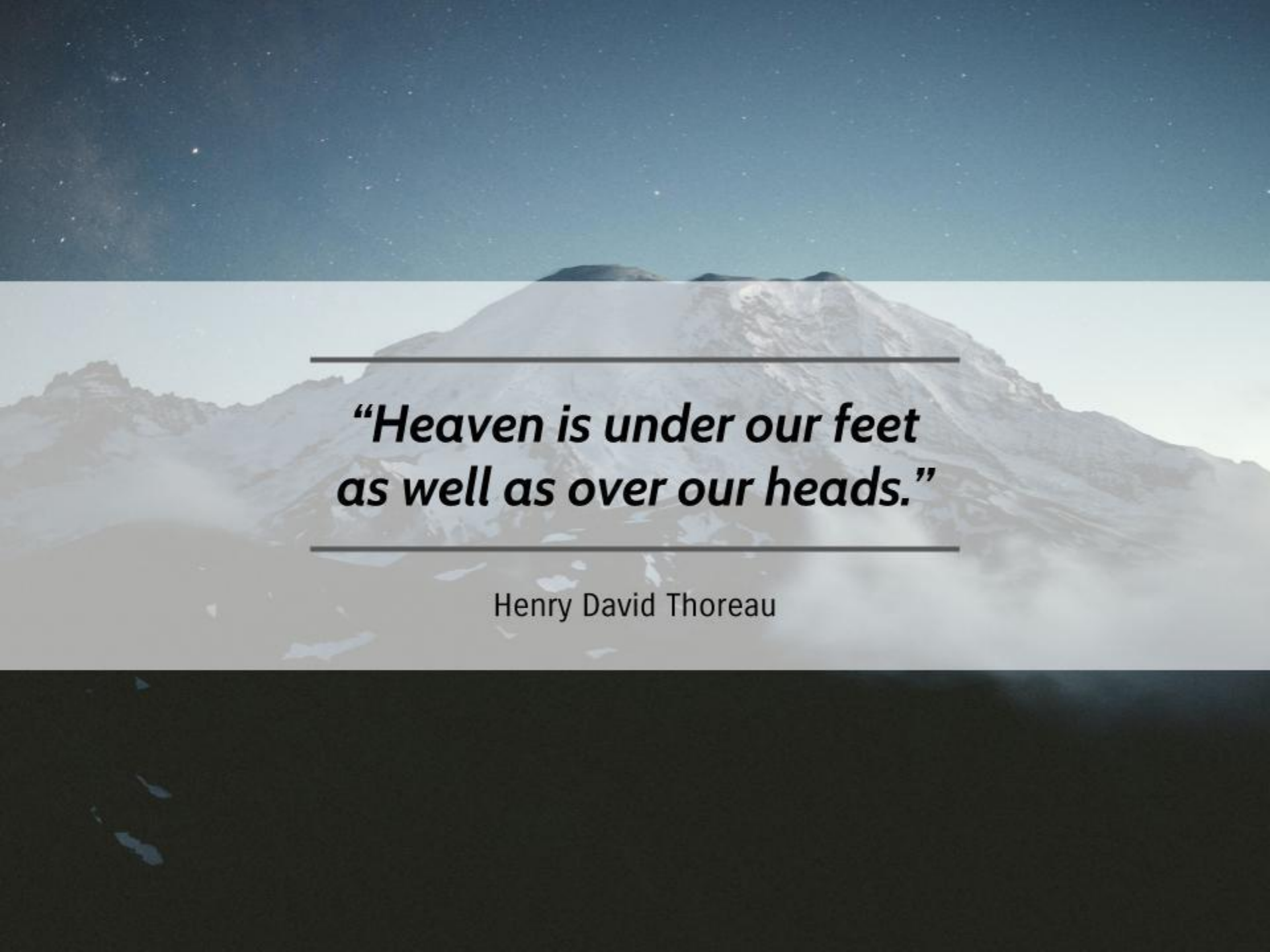
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**Max  
Podhaisky**

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***“Heaven is under our feet  
as well as over our heads.”***

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Henry David Thoreau