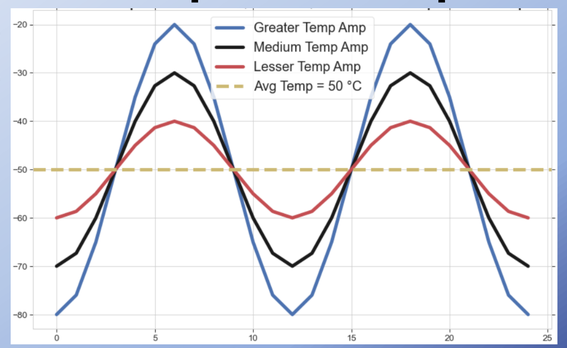
Temperature Amplitude and Isotope Diffusion in Firn

Cody Cruz, T.J. Fudge

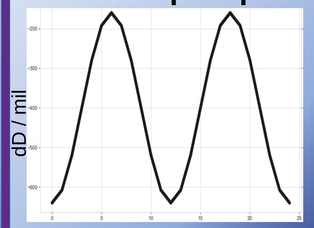
NASA SURP – UW ESS OGIVE 8/12/2022

How do **warm** summers and **cold** winters **affect** the top layer of **glaciers?**

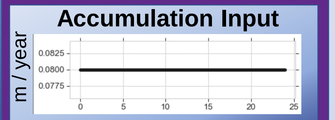
Temperature Input

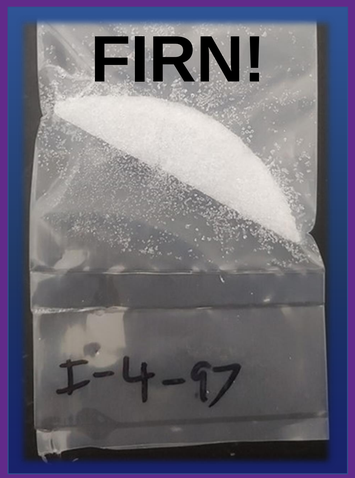


dD Isotope Input



Accumulation Input





South Pole Model Forcings

The Community Firn Model evolved the firn column for 1500 years to track isotope diffusion with depth

Atmospheric Temperature: Three separate input runs with amplitudes of the seasonal cycle: 10, 20, and 30 °C from mean -50°C

dD Isotope: Single amplitude of 240 dD/mil from mean -400 dD/mil

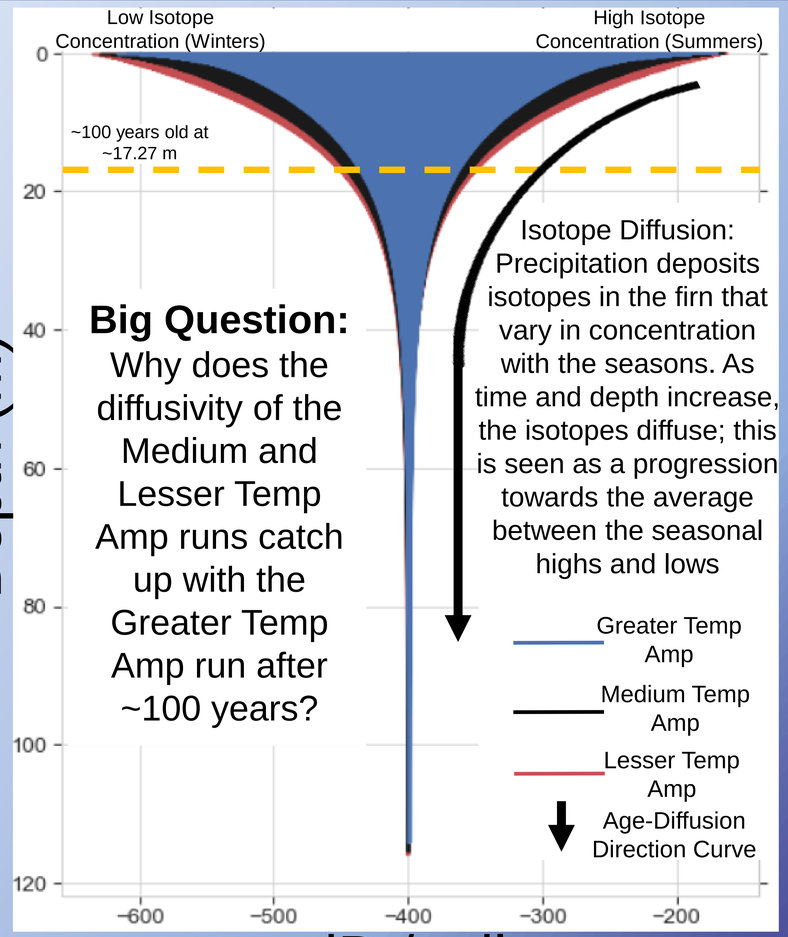
Accumulation: Constant 0.08 m/yr

Next Steps: The above **firn sample** is one of ~350 I am currently measuring in the IsoLab for isotope concentrations. As spectrometry is almost finished, **future work** will use the firn modeling to **interpret** the South Pole firn **samples**

- **Firn**: Snow compacting into ice at the surface of a glacier, records characteristics of years of snowfall
- **Deuterium** (dD): Hydrogen that is heavier due to an additional neutron
- **Warmer** atmospheres can hold heavier particles aloft

➡ dD can be used as a proxy for temperature

Deuterium Diffusion Variance



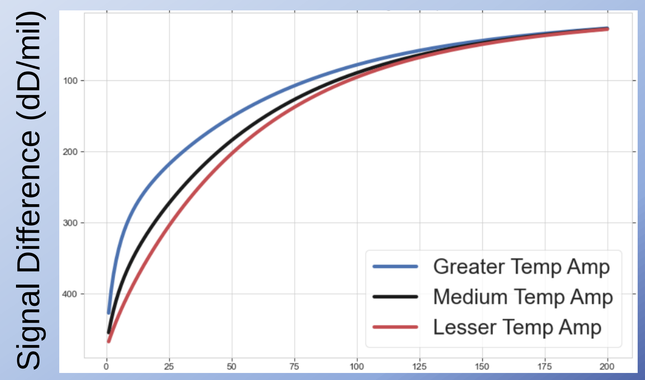
Firn Diffusivity Equation:

$$\Omega_f = \frac{m \cdot \rho \cdot \Omega_q}{R \cdot T \cdot \alpha \cdot \tau} \cdot \left(\frac{1}{p} - \frac{1}{p_{ice}}\right)$$

Ω_f = Firn Diffusivity, m = Molar Weight of Water, ρ = Saturation Vapor Pressure, Ω_q = Air Diffusivity, R = Gas Constant, T = Firn Temperature, α = Fractionation Factor, τ = Tortuosity, p = Density

Air Interaction and the Community Firn Model: Because firn is porous and interacts with the atmosphere, tortuosity and density are important factors in the diffusion of isotopes as the firn ages.

Seasonal Diffusion Difference



In the top ~100 years of firn, the greater the seasonal temperature amplitude, the more diffusion

Acknowledgements: Ben Hills, Sarothi Ghosh, OGIVE NASA UW Space Grant Consortium and SURP Max Stevens (CFM), Andrew Schauer and UW IsoLab, UW Glaciology Group, UW ESS

Firn Diffusivity Equation: Johnsen, S.J., Clausen, H, B., Cuffey, K,M., Hoffmann, G., Schwander, J., Creyts, T. (2000). Diffusion of stable isotopes in polar firn and ice: the isotope effect in firn diffusion. *Physics of Ice Core Records. https://doi.org/10.7916/D8KW5D4X*

CFM: Stevens, M.C., Verjans, V., Lundin, J,M,D., Kahle, E,C., Horlings, A,N., Horlings, B,I,. Waddington, E.D., (2020). The Community Firn Model (CFM) v1.0. https://doi.org/10.5194/gmd-13-4355-2020