# Water isotope variability between two sides of a deformed and stratigraphically complex ice core from the Allan Hills, Antarctica

COLDEX Center for Oldest Ice Exploration

Δ*IsoLab

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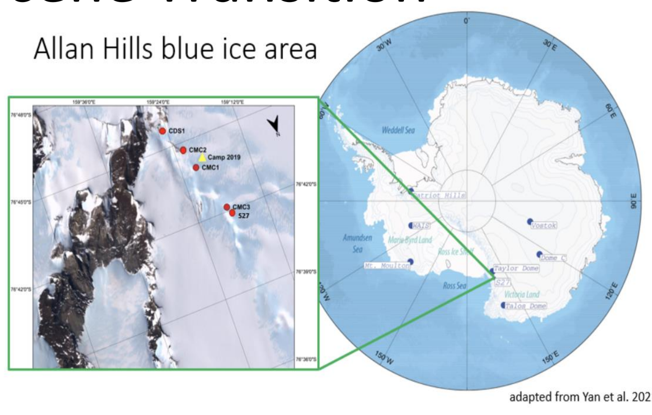
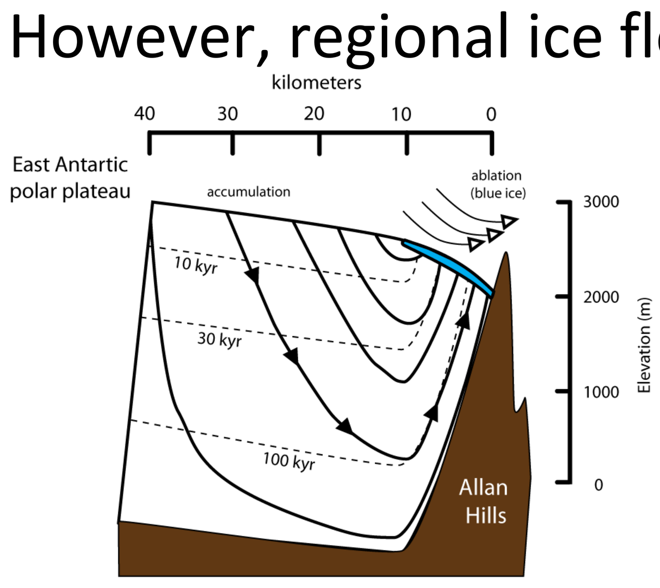
## Motivation & Methods

### Ice from the Allan Hills might address climate questions about the mid-Pleistocene Transition

COLDEX teams have retrieved >1Ma ice from the Allan Hills blue ice area

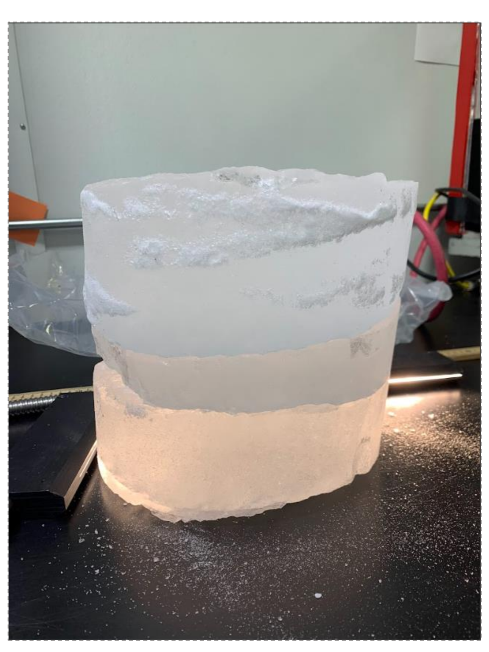



### However, regional ice flow is complex




modified from Whillans and Cassidy (1983) by John Higgins

- Stratigraphy is out of order
- Many observed layers with steep dip
- Thinning and compression might be nonuniform
- Many sections were not recovered or are very fractured



Many core sections are only tens of centimeters long. We sampled along the same azimuthal orientation when adjacent sections could be aligned, but azimuthal information was not logged in the field.

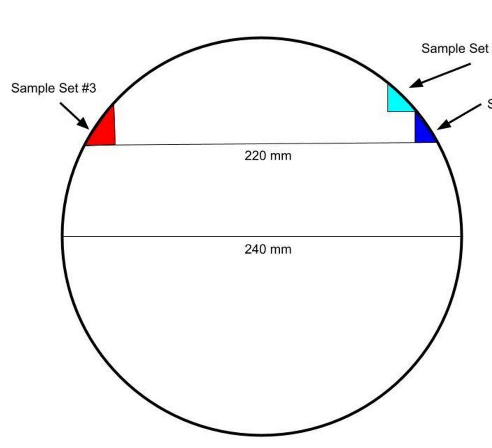
Visible ash layer with 45° dip in the ALHIC1901 core

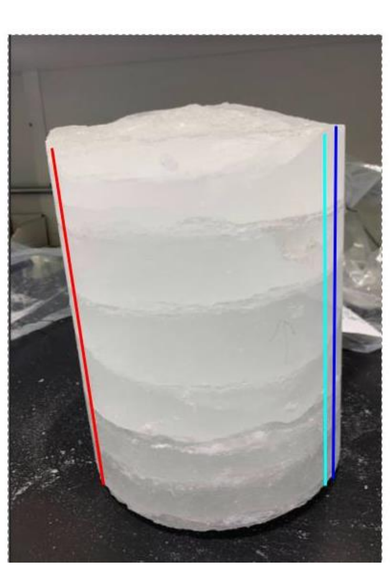
*Is the water isotope signal the same on both sides of the core?*

*If not, how can we ensure future measurements account for horizontal heterogeneity?*

### We measured duplicate sets of 70 samples with 1-cm resolution

- Sample pairs were separated by 22 cm in the xy-plane of the core, as shown on the cut diagram below. A few samples were measured in triplicate from a third section.

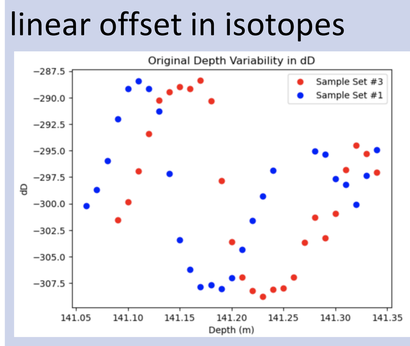
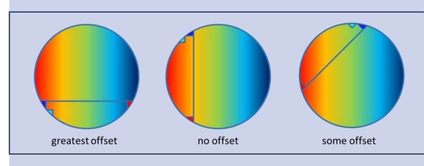
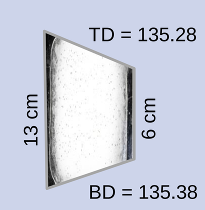
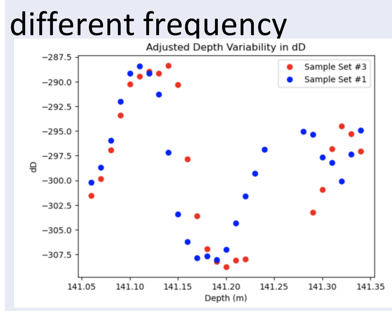


- All samples were measured by laser spectroscopy (Picarro L-2140*i* and L-2130*i*).
- We measured duplicates in continuous ice sections with identifiable isotopic patterns (shown below) and then evaluated vertical offsets and other discrepancies.

## Results

### Isotope variability arises from natural heterogeneity and sample handling

| Isotope observation | Natural cause | Handling cause |
|---|---|---|
| linear offset in isotopes   | dipping isochrons (i.e. heterogenous same-depth samples) <br> *Correlation: -0.13  | error in depth assignments caused by irregular "wedge" shapes  |
| different frequency  | nonuniform thinning across the core | small changes in bandsaw setting (<5%) |



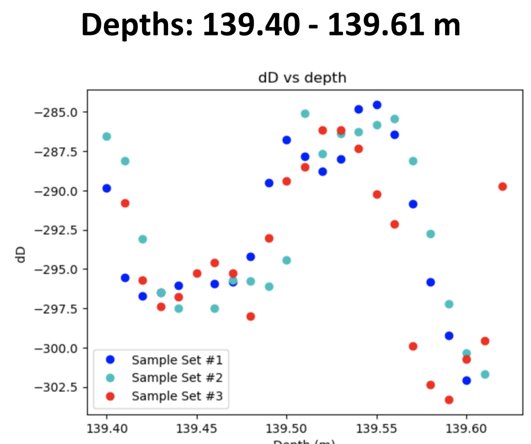
*Correlation: 0.68

### We adjusted the depth assignments to maximize cross-correlation

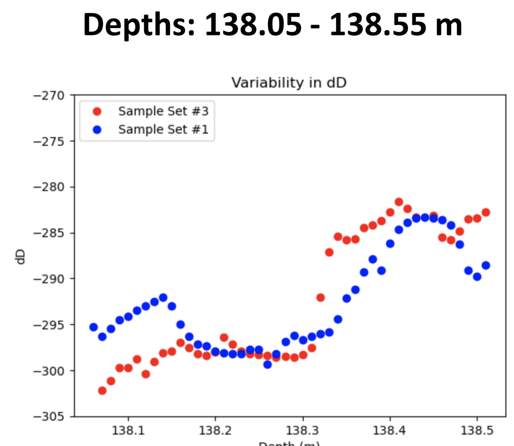
**Depths: 141.05 - 141.35 m (shown above)**

- Original depth assignments were interpolated from the field-logged depths and actual dimensions of our ice in the lab, and result in an offset for this section of 3cm (~3000 – 80,000 years)
- We adjusted this offset by shifting sample set #3 to line up with sample set #1, but the signal was still less compressed in #3 than #1.
- We tested how *squeezing or stretching* the depths changed the correlation coefficient between each data set.
- These sections differ by about 15%, which is greater than the error possible by bandsaw discrepancies. This means there are likely compressional differences within the ice layers across these 22cm.

**Depths: 139.40 - 139.61 m**

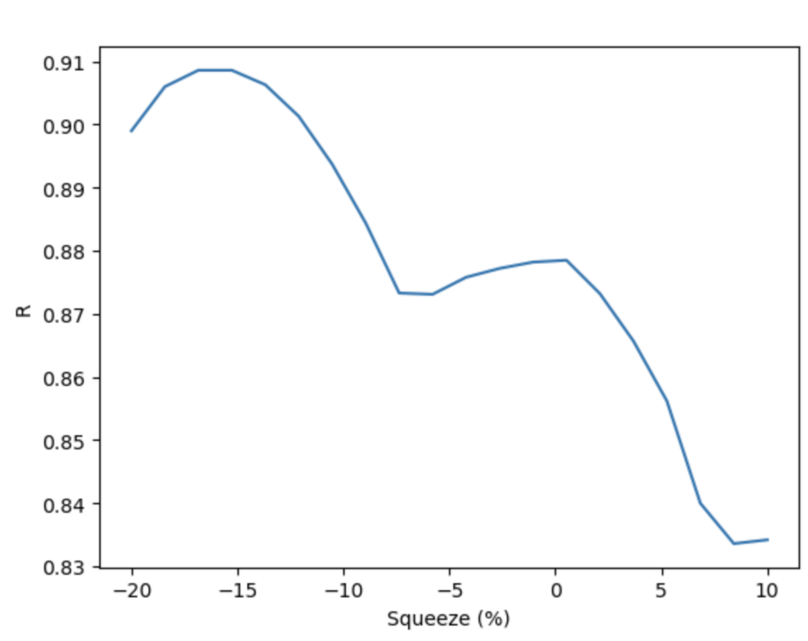



**Depths: 138.05 - 138.55 m**




- Each section has unique lag values and stretching factors, which could be due to differences in ice properties or handling procedures. Knowing the azimuthal orientation would eliminate a large source of this uncertainty.

### Signal variability persists even with optimal cross-correlation values

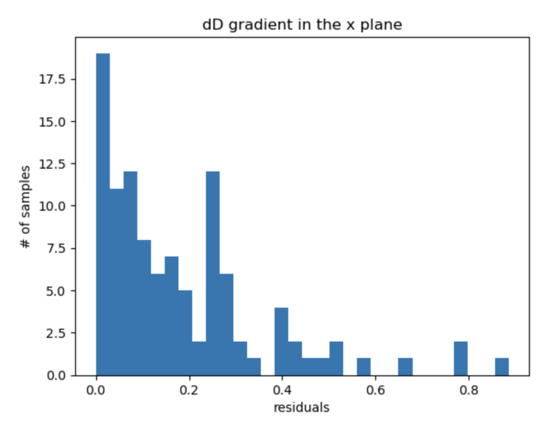


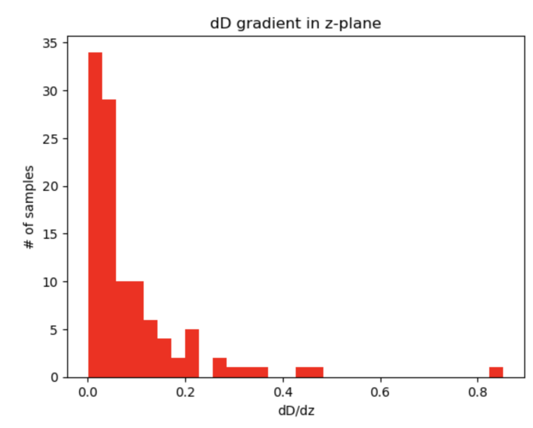

- Optimal correlation around 0.91 which is still not a perfect match.
- Other sections also don't look too similar with potentially poorer correlation coefficients.
- Tells us there is something else happening here such as heterogeneous isotope diffusion.

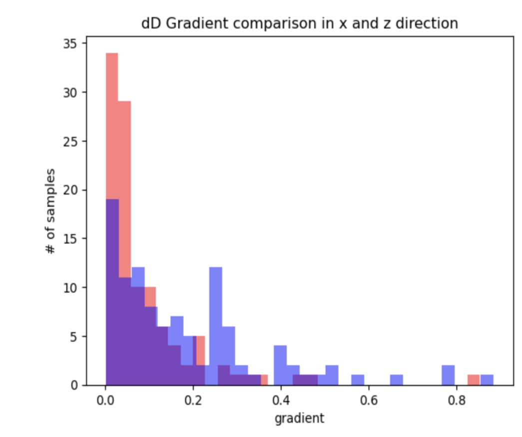
## Discussion

### We evaluated 22-cm differences in the horizontal and vertical planes

**ALHIC1901 Core**



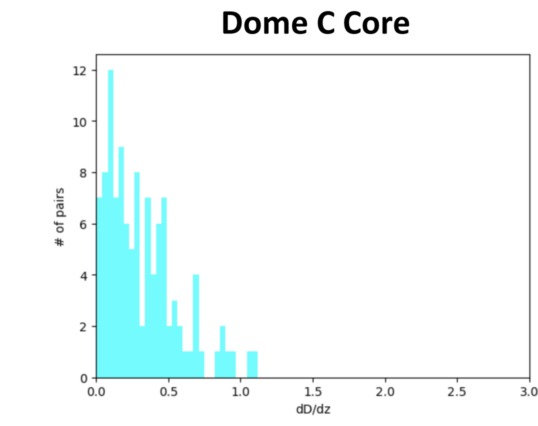



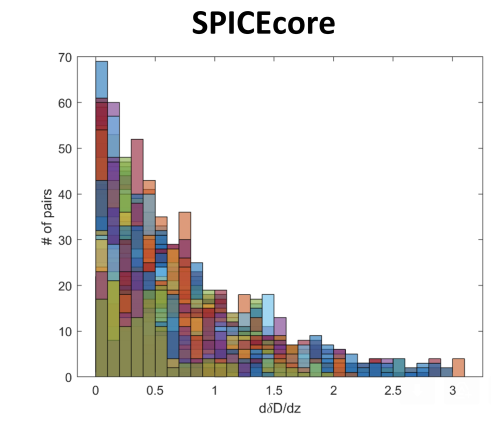

- In these depths of this core, the x-gradient is more nonzero than the z-gradient.

**Typical ice cores**

**Dome C Core**



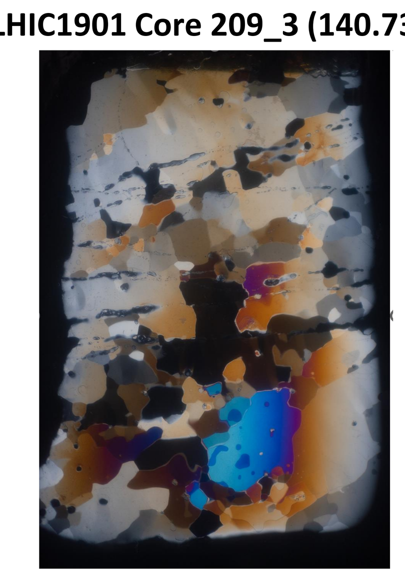

**SPICEcore**

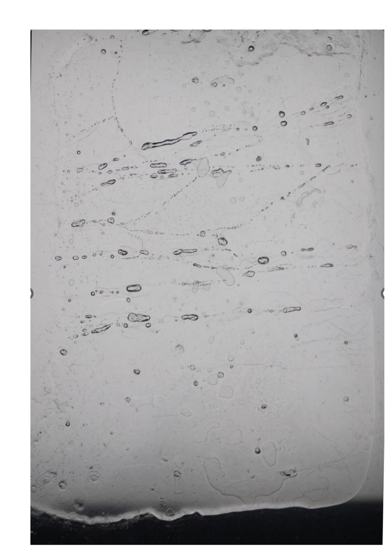



- In these cores, it is assumed that there is no x-gradient.

### Thin Section of Ice

**ALHIC1901 Core 209_3 (140.73-140.82m)**

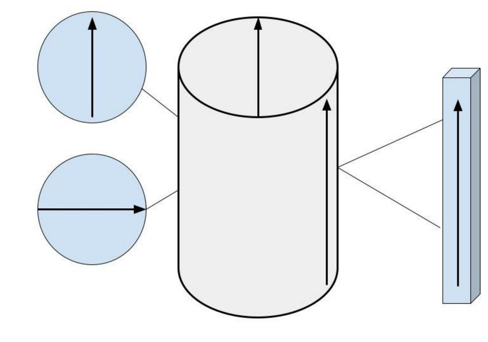




### Implications for future Allan Hills measurements

**Field logging practices are important for preserving detail in stratigraphically complex ice**

- Logging the vertical and azimuthal orientation information in the field will eliminate uncertainty between discontinuous sections
- Logging the shape of each piece and minimum/maximum top and bottom depths might help to reduce depth offsets from CFA or high-resolution discrete cuts



**Future work**

- Analyze all sections in this depth range for sample set #3 to find the full range of 22-cm x-gradients
- Analyze sample set #2 (or others?) for sections with large differences between #1 and #3