WATSON: A WIRELINE ULTRAVIOLET RAMAN AND FLUORESCENCE SPECTROMETER FOR SUBSURFACE ORGANIC DETECTION IN NORTHERN ICE SHEETS

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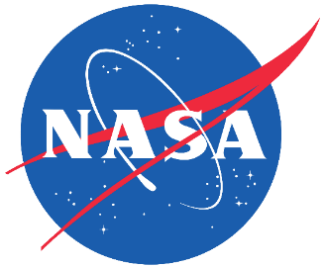

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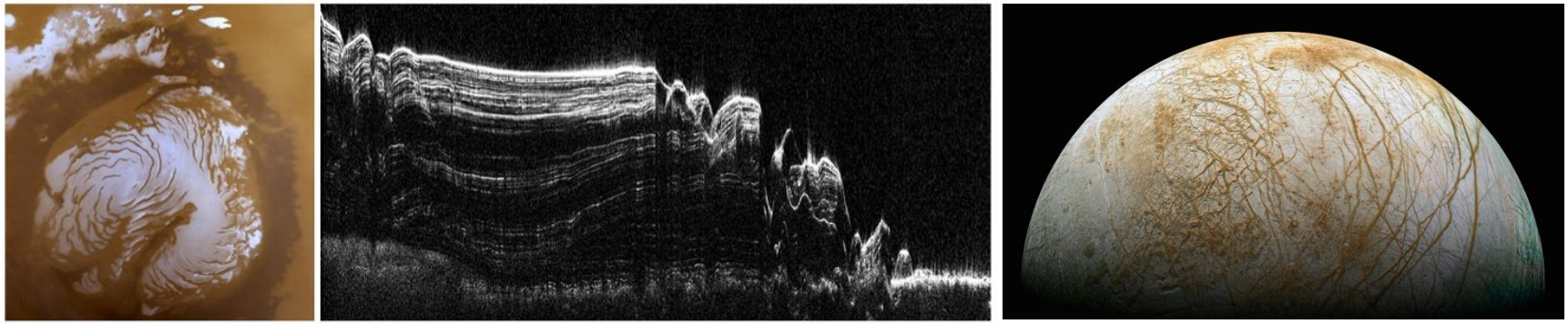
Searching for organics on icy/ocean worlds



Left: visible image of north polar cap on Mars. Middle: SHARAD sounding radar image of north polar ice cap cross section. Right: Image of Europa taken by Galileo

- Ice deposits provide an environment where chemical and biological signatures can be preserved over geological timescales
- Greenland and Antarctica have been found to preserve organic material including active microbial communities and serve as analogs for the Mars polar caps and Europan subsurface [2,3]
- In-situ organic and life-detection instruments that can investigate the chemical environment while preserving the spatial context of deposition are needed to enable future missions to these environments

The WATSON project

2017 Kangerlussuaq deployment site

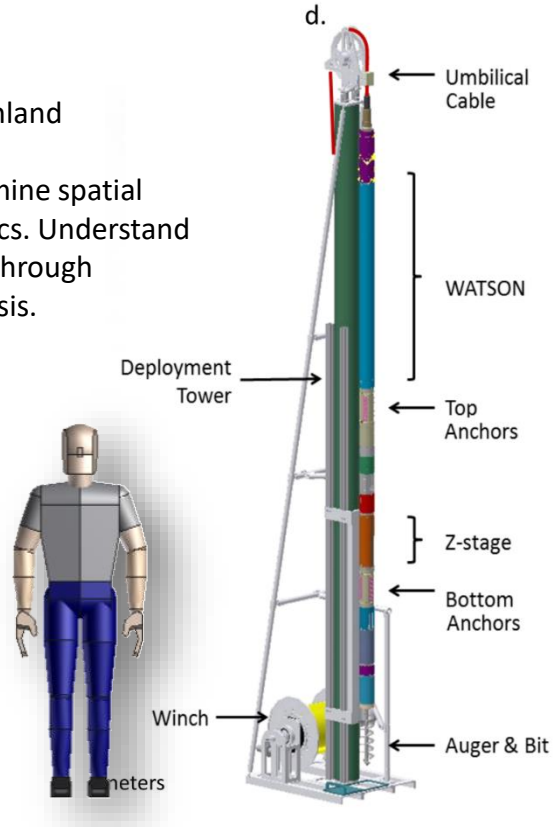
WATSON is a an instrument under development intended for ice borehole mapping and organic detection. WATSON is based on SHERLOC, the deep UV Raman and fluorescence spectrometer selected for Mars 2020 [1].

Target site

- Kangerlussuaq, Greenland
- Drill to 100 m, determine spatial distribution of organics. Understand field measurements through subsequent lab analysis.

Science objectives

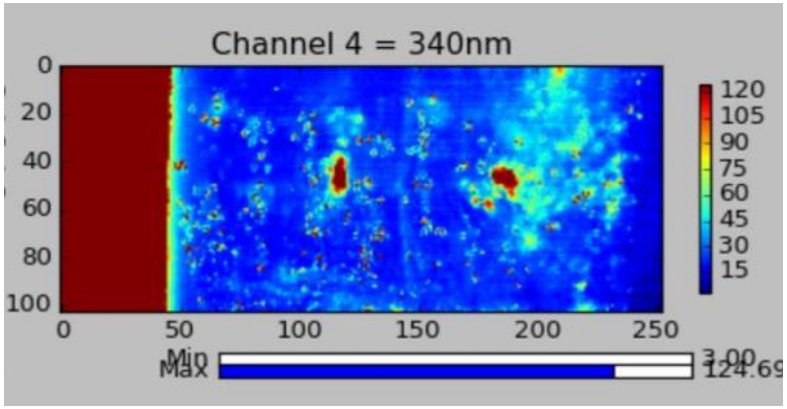
- Detect and characterize organic compounds and potential biosignatures, including microbes, in subsurface ice environments, as well as determine their spatial distribution
- Understand whether analyses of a single site can provide information regarding organic content and distribution over geological timescales
- Leverage high-TRL components to demonstrate the potential for incorporation of WATSON-like instruments into future planetary missions with astrobiological science objectives



WATSON and Honeybee drill deployment system [6]

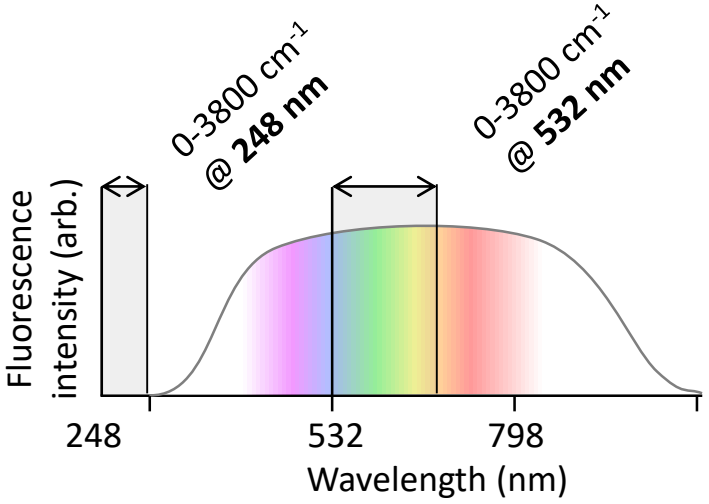
DUV Raman and fluorescence for organic detection

- Fluorescence, Raman scattering from laser interaction with vibrational and electronic states can indicate the presence of organic material
- Detect C=C, C=O, and other CHONPS bonds as well as fluorescence characteristic of aromatic organics and microbes
- Fine-scale mapping is non-destructive and preserves spatial context of organic distribution

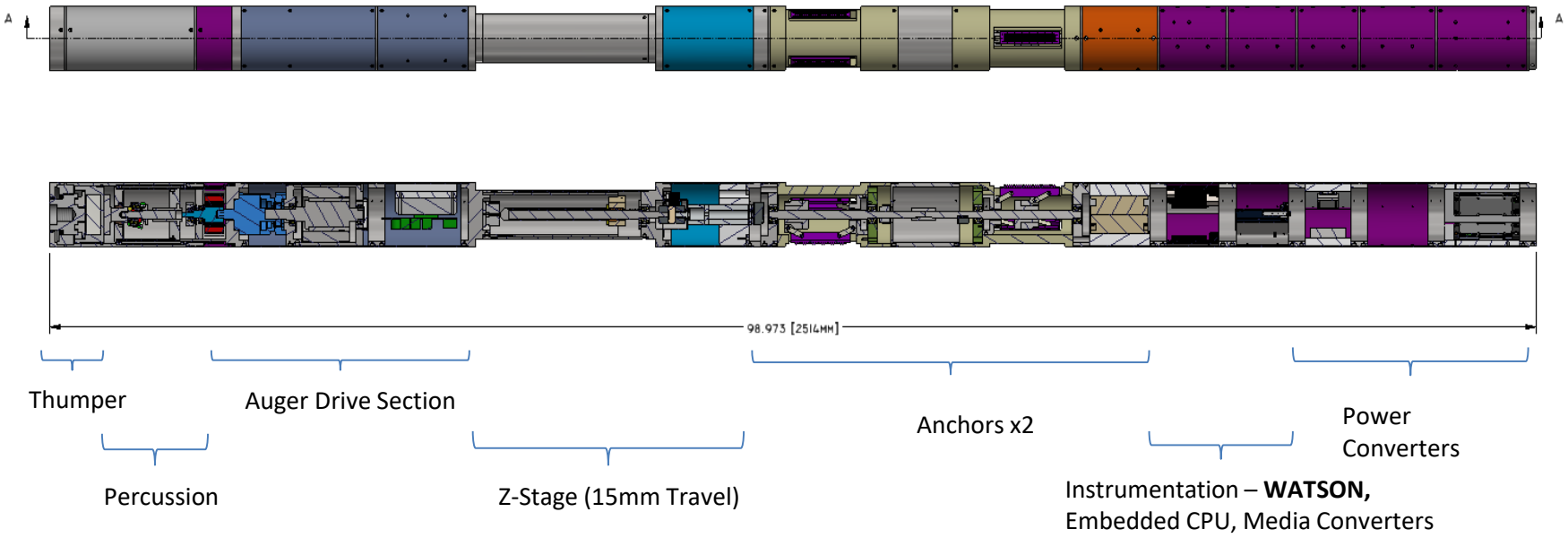


Benefits of DUV excitation

- Pre-resonance or resonance enhancement in some organics
- Raman window below 270 nm, out of the fluorescence region [4,5]



Honeybee drill system



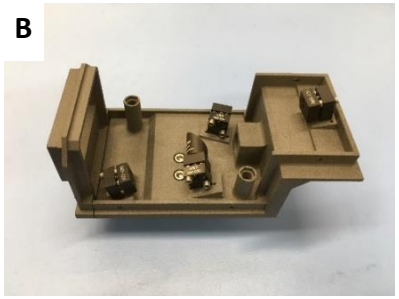
Drilling mechanism

- Dry drilling prevents borehole contamination from oils or other fluids
- Anchors hold the drill in place during drilling and scanning with the instrument
- Z-stage allows drill to inchworm down until auger is full
- Auger returned to surface when full to remove ice shavings (saved for analysis)

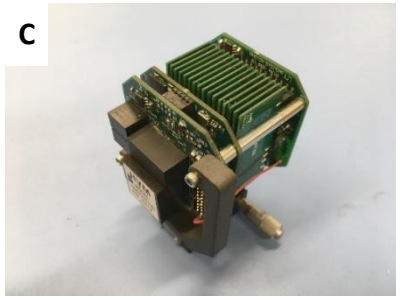
WATSON instrument

A

B



C



WATSON

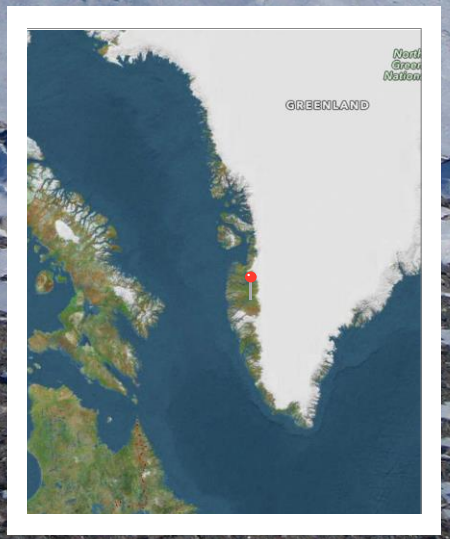
Exploring Microbial Life in Subsurface Ice

- Borehole wall is 1/8” from instrument
- High f/# optics allow interrogation into the ice (depths of mm), not just observing the ice surface
- Incorporates lessons learned from DEBI-T (marine UV fluorescence)

A. 248.6 nm SHERLOC heritage laser
B. Miniaturized fluorescence spectrometer
C. 32 channel PMT array (detector)

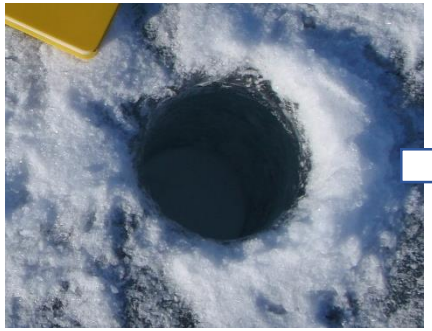
2017 Kangerlussuaq deployment

Russell Glacier, Kangerlussuaq. Right: (top) map of Greenland, (bottom) path to site.



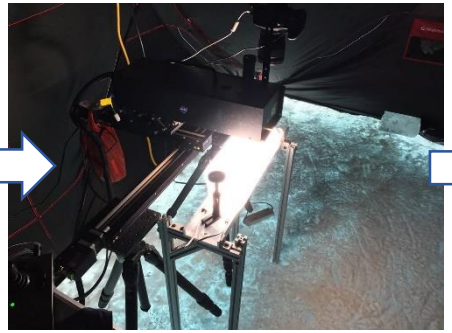
Analysis pipeline

A core is obtained from the field site



The core is cut and cataloged

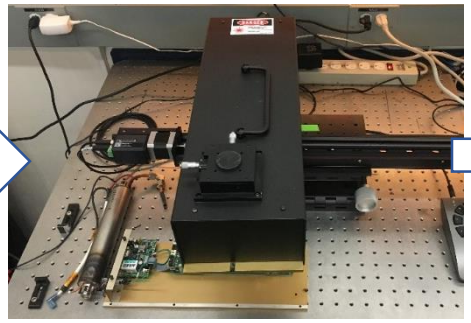
The core is scanned with MOSAIC



WATSON interrogates the borehole

Cores are packaged and returned to the lab

Cores are re-scanned with MOSAIC

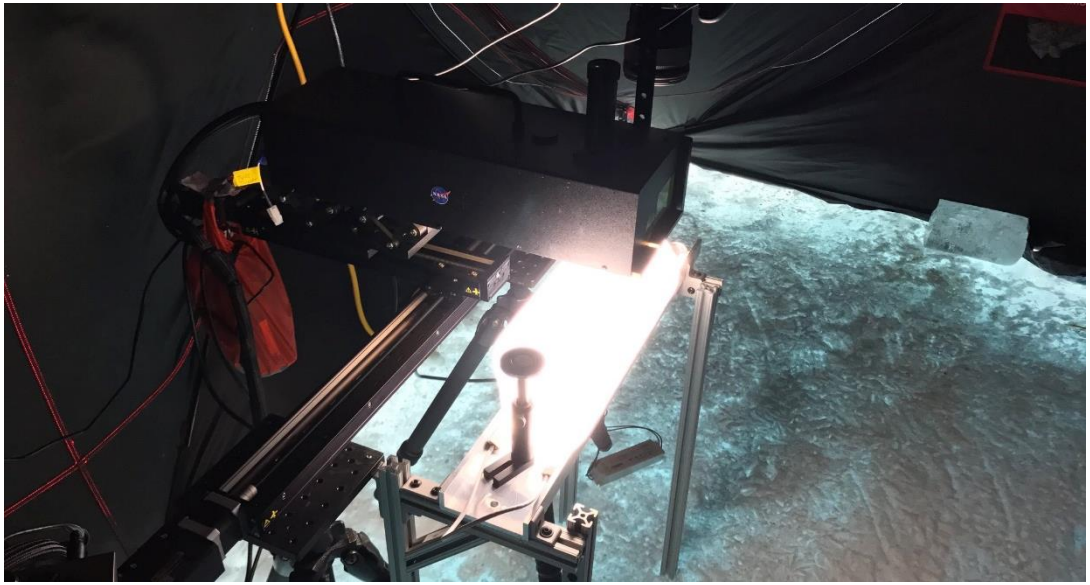


Additional analytic techniques are applied to understand field data (e.g. high-resolution UV Raman/fluorescence spectroscopy)

Upcoming deployments will incorporate the drilling system with a target depth of 100 m

2017 Kangerlussuaq deployment

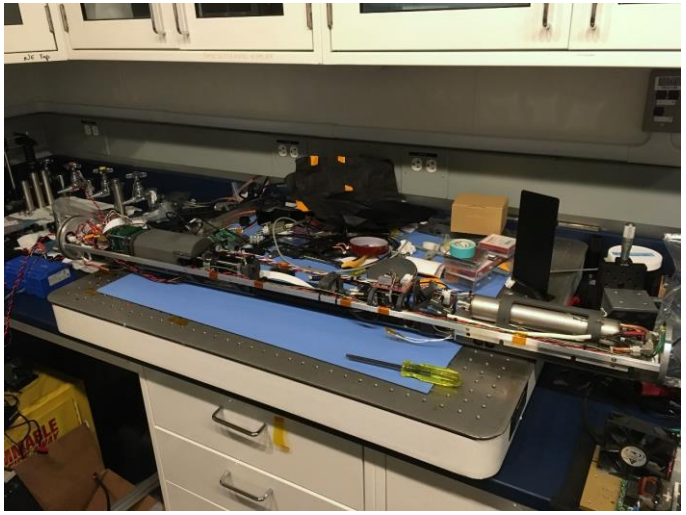
Objectives: test instrument prototype, identify potential drilling sites, obtain ice cores



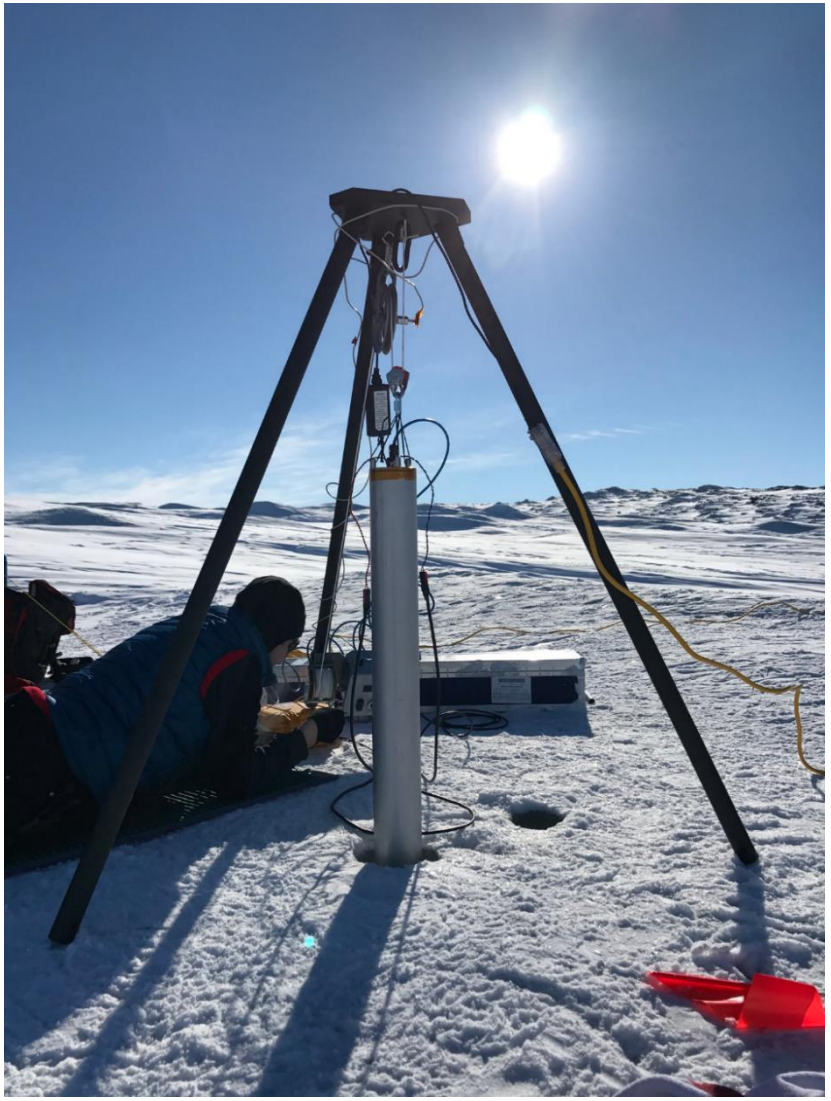
- Ice was cored (top)
- Cores were measured and recorded (right top)
- Fluorescence maps were obtained of cores (right bottom), to be correlated with WATSON and lab analysis

2017 Kangerlussuaq deployment

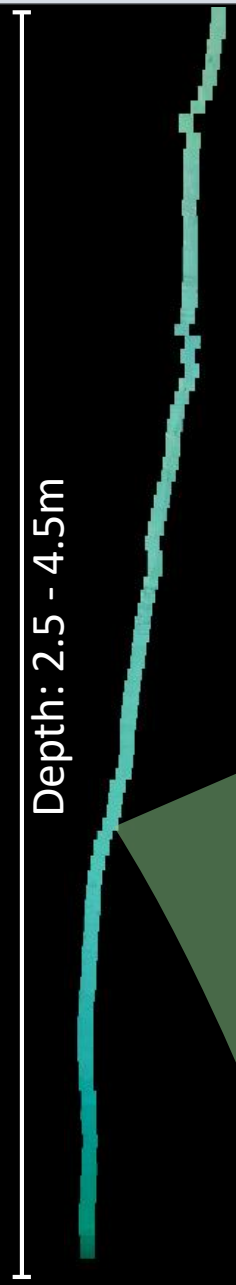
WATSON prototype prior to deployment



WATSON deployed in the field



Sample data products obtained from Greenland



Outwards-facing camera in WATSON provides context imagery, used to identify features observed in spectral maps.

Images can be stitched to generate a mosaic of the borehole.

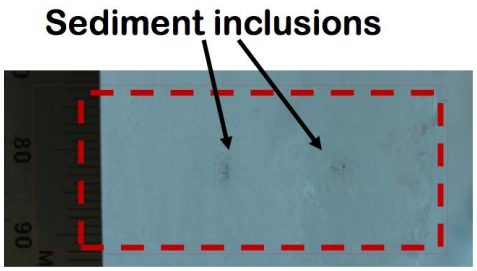
Left, right: sample borehole images. Ambient light persisted to the maximum core depth (4.5 m)

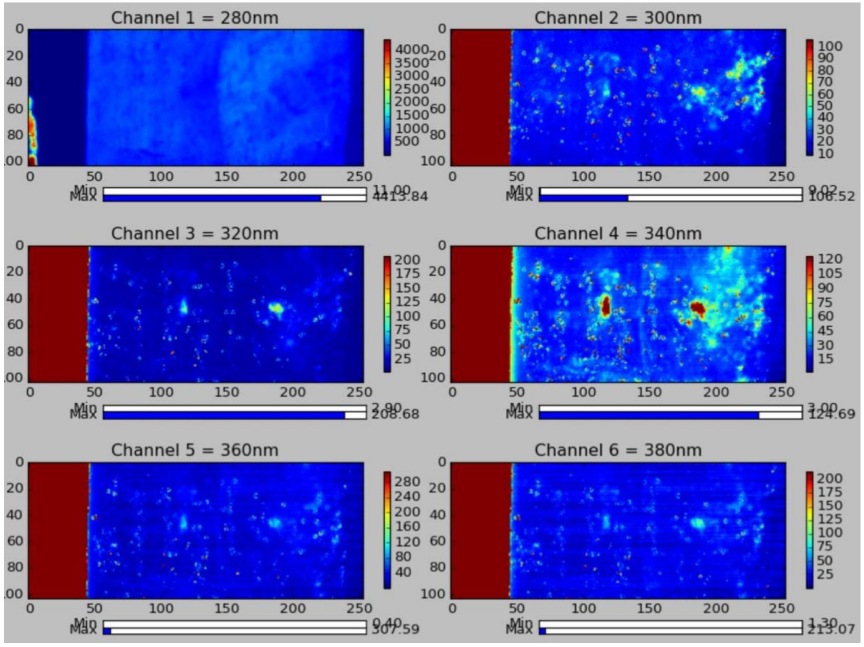
Ice borehole without WATSON (top), and with WATSON (bottom)

Sample data products obtained from Greenland

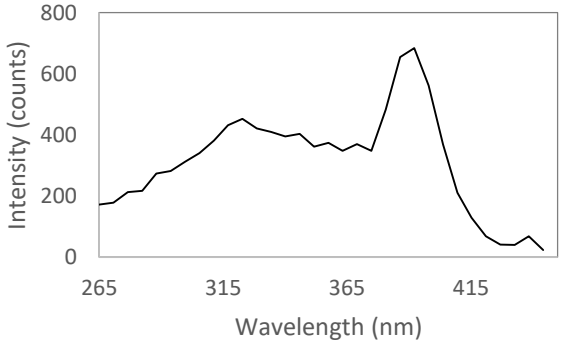
All data presented is preliminary

MOSAIC (lab instrument)

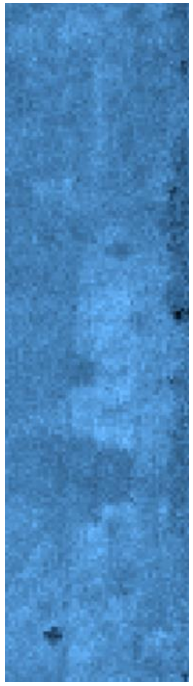




WATSON (borehole analysis)



- Data is preliminary
- Next steps are to correlate MOSAIC and WATSON data, as well as follow-on analysis of returned ice cores



40x8 mm

Questions

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Acknowledgements

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