ESS 469/569
Final Project Outline: Remote Sensing

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Meet the team!

Ashley Howard:
- Background/Expertise: Minimal AI/ML experience, but I have Python and MATLAB experience. Scientific background in applied physics and physical oceanography.

Cameron Boyd:
- Background/Expertise: Minimal AI/ML experience
  - Lots of Applied Math, Python, and MatLab coursework & research

Olivia Murdock:
- Background/Expertise: No experience using AI/ML. Took STAT 311 and has experience using R

Sofia Suhinin:
- Background/Expertise: Minimal AI/ML experience
  - Worked on a research project over the summer that used PyCaret and PyTorch.

Potential Topic 1: Ice Sheet Analysis

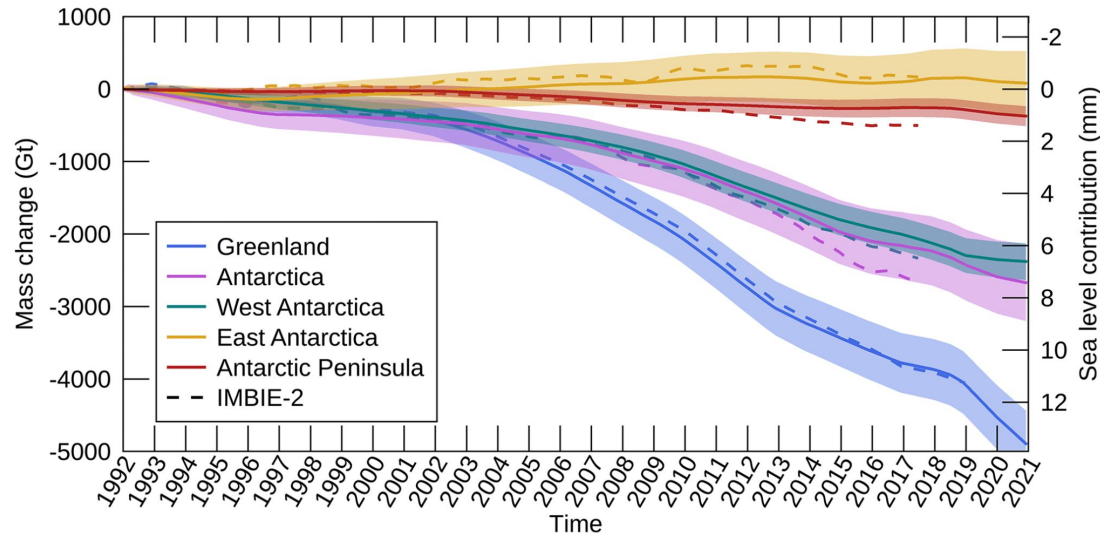**<u>Potential Topics/Questions:</u>**
- How can we use satellite imagery to measure global ice balance (surface mass balance) to look at distribution and change over time?
  - Could apply to either Greenland Ice Sheet, Antarctic Ice Sheet, or even globally
  - Can we use ML and/or AI to create a model to predict these values based on things like altimetry?
- How can we use satellite imagery to observe (and model) glacier terminus positions and velocity?
  - Can we use ML and/or AI to predict these values?

Potential Topic 1: Ice Sheet Analysis

Relevance:

Glacier and ice sheet melting has <u>HUGE</u> implications for our Earth

- Sea level rise potential:
  - Greenland: 7 m
  - Antarctica: 58 m
- Affects coastal communities globally
- Affects global ocean circulation patterns (AMOC)
- Important for regions that rely on glacial water storage

Cumulative ice sheet mass change (Gt). *Figure from Otosaka et al. 2023*

Potential Topic 2: Earth's Magnetic Field

<u>Potential Topics/Questions:</u>
- Can we use satellite measurements of the Earth's magnetic field to observe ocean circulation and currents below sea ice in the Arctic?
- Can we use AI and/or ML to detect changes in ocean heat transport in the Arctic?
  - Can this be used to predict changes in sea ice coverage or stability?
- How can we use AI and ML to constrain ocean conductivity beneath the sea ice using satellite magnetic measurements?
  - Could this be incorporated into current/future ocean models?

Potential Topic 2: Earth's Magnetic Field

<u>Relevance:</u>

- Heat in the Arctic Ocean affects how sea ice melts
  - Warm water thins ice
- Sea ice affects:
  - Arctic shipping routes
  - Animals
  - Ocean circulation patterns
  - Global climate
- Magnetic field measurements are continuous, have global coverage, and are not confined to surface measurements (product integrates all sources of magnetic field including the oceans)

Polar shipping routes. *Figure from The Geography of Transport Systems*

Potential Topic 3: Subglacial Lakes

Potential Topics/Questions:
- What can surface elevation data tell us about how subglacial lakes evolve over time?
    - Already observed in Antarctica
    - Can ML and/or AI recognize patterns in subglacial lake evolution?
- Are there geographic or surface features that signal regions where subglacial lakes more likely to occur?
    - Can ML and/or AI predict where subglacial lakes occur based on current altimetry data?

Potential Topic 3: Subglacial Lakes

Relevance:

Glaciology:

- Subglacial hydrological networks
  - Locating hidden subglacial lakes can show drainage and filling patterns
- Isolation from atmosphere
  - Ecosystems within glaciers have been kept from sunlight and atmospheric conditions which mimic other planetary environments
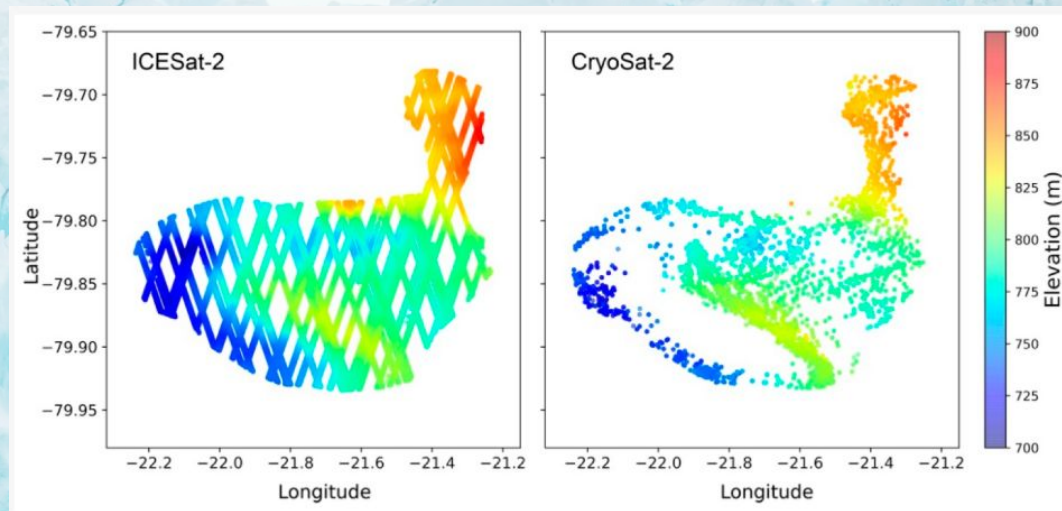
Astrobiology:

- Europa is one of the big interests in the search for extraterrestrial life
  - Jupiter's Icy Moon

- Europa Clipper will include tools to measure the moon's surface elevation
  - Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON)

Potential Data Sources & Metadata

Altimetry Data Sources:
1. CryoSat-2 (ESA):
   - ~1 km Gridded Resolution
   - Open Access, Lots of Documentation
   - NetCDF Format
2. ICESat-2 (NASA):
   - Jupyter Notebook Tutorials
   - Accessible through API
   - Resolution up to ~11 m

An example of dataset visualization from Fan et. al (2022)[1] This paper tackled using time evolved elevation data to track subglacial lakes in Antarctica filling and emptying.
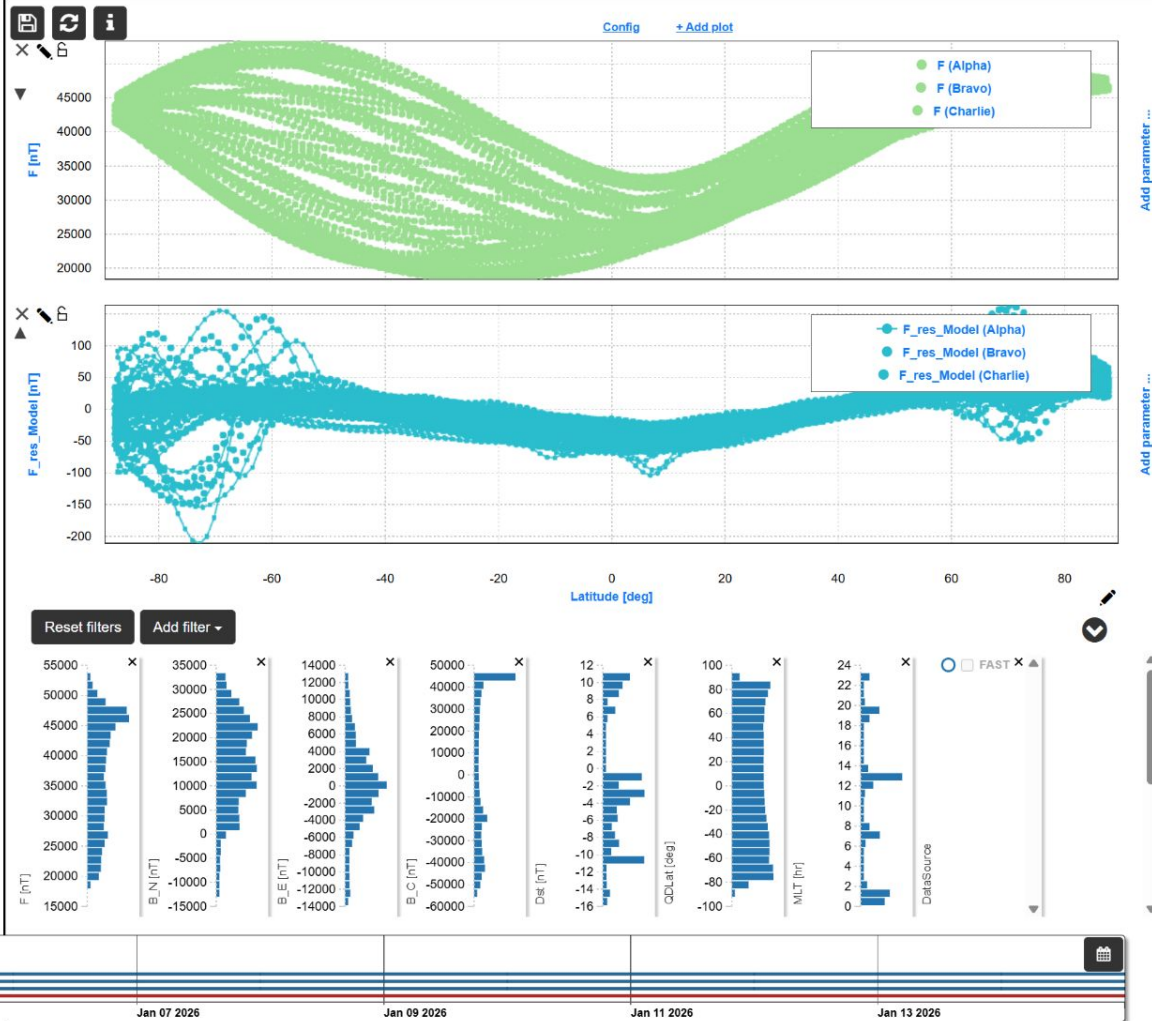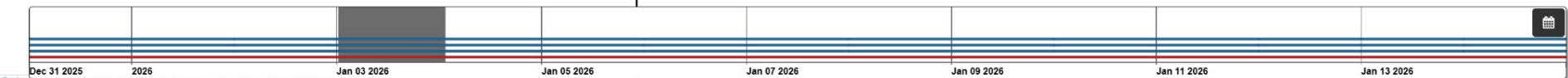
1. https://www.mdpi.com/2072-4292/14/4/898#

Potential Data Sources & Metadata

Magnetic Field Data Sources:
1. Swarm (ESA)
   - 3 satellites (A, B, and C)
     - Orbital altitude of 450 km
     - Global coverage
   - Sampling Rate:
     - Vector Field Magnetometer (VFM): 50 Hz
     - Absolute Scalar Magnetometer (ASM): 1 Hz
   - ViRES (Virtual environments for Earth Scientists) for Swarm available
     - Accessible online and via API
     - Python environment containing thematic libraries
     - Also provides access to the CHAOS-8 Core magnetic field model generated from the data

References:

Potential Topic 1: Ice sheet analysis
https://essd.copernicus.org/articles/15/1597/2023/
https://www.antarcticglaciers.org/glaciers-and-climate/what-is-the-global-volume-of-land-ice-and-how-is-it-changing/

Potential Topic 3: Subglacial Lakes:
https://science.nasa.gov/mission/europa-clipper/spacecraft-instruments/

Cryo-Sat Metadata:
https://cs2eo.org/
https://earth.esa.int/eogateway/missions/cryosat/data
https://earth.esa.int/eogateway/documents/20142/37627/CryoSat-netCDF-L1b-Product-Format-Specification.pdf

ICE-Sat Metadata:
https://icesat-2.hackweek.io/
https://icesat-2.gsfc.nasa.gov/science/specs
https://icesat-2.gsfc.nasa.gov/science/data-products
https://nsidc.org/data/icesat-2
https://icesat-2.gsfc.nasa.gov/icesat-2-data

Swarm Metadata:
https://earth.esa.int/eogateway/tools/vires-for-swarm
https://www.frontiersin.org/journals/astronomy-and-space-sciences/articles/10.3389/fspas.2022.1002697/full