**INTRO/TITLE SLIDE**

Today we are going to be talking about using hyperspectral imaging to track algal biomass underneath sea ice. So the paper I chose is not exactly remote sensing related just yet. It focuses more on an experimental design, that could eventually become a remote sensing technology.

**SLIDE 1**

To give a quick overview of the purpose of this research and its goal and general steps. The paper states two main reasons on why we care about sea-ice algae, first when ice algae die or get released from melting ice they sink to deeper waters, transporting carbon from the surface to deeper depths, impacting the rate of carbon export within the ocean. Secondly, algae are a key food source for pelagic herbivores like phytoplankton, making them an import cog in the polar-marine ecosystem.

Now comes the question why we even need to explore hyperspectral imaging as an avenue to map algal-biomass. Compared to current methods such as ice core drilling and diver-operated fluorometers, hyperspectral imaging is less invasive, less labor intensive and allows us to map spectral signatures across larger areas and a different spectral resolutions. The relation between hyperspectral imaging and algae comes via chlorophyl A, which is the primary photosynthetic pigment in algae. Chl-a causes algae to absorb more light at the blue and red wavelengths then sea ice and water, meaning that if we measure transmitted light through those three substances, algae should produce a unique spectral signature.

The goal of this research was to assess the viability of using hyperspectral imaging to map algal-biomass at the ice/water interface of an ice sheet, and they did this by creating an inverted sea-ice tank to simulate a real world ice sheet and introduced different algal cultures into cylinders within the take. They then proceeded to take 3 hyperspectral images at 3 different spectral resolutions. To determine if the hyperspectral imaging worked, they performed Principal Component analysis or PCA to track variable features in the spectral dimension.

**SLIDE 2**

There are three main components to the experimental setup they used. First we have the tank configuration which was illustrated in figure 1. The inverted tank system was comprised of an 0.85meter by 0.85 meter block of ice that was 70 millimeters thick. Added on top of the ice was 20-30 mm of sea water, which was prechilled to prevent melting. The glass protecting the LED light was optically clear meaning it allowed more than 90% of light to be transmitted through and had little effect on properties of the transmitted light.

The algal cultures used were collected from three distinct species of algae in Antarctic sea ice. The cultures were preserved and cultivated and then samples were taken from each of them at varying concentrations and placed into 8 80 millimeter cylinders that were placed in the ice and water column. The two types of cylinders that were use were 4 PVC cylinders that contained the first control, very low, medium high and very high sample concentrations. And then the 4 acrylic cylinders contained the second control, low, medium and high concentrations.

Finally, the experiment used a SPECIM AISA KESTRAL 10 pushbroom camera, meaning it scanned a image one line at a time, that they mounted to a motorized sliding track. The camera was place 1 meter above the ice/water interface. The paper states on at least three separate occasions that the spatial resolution of the camera is 0.9 millimeters but if you do the math given the rail speed and frequency of images, the spatial resolution actually is approximately 1.6 millimeters, for the lower bound. The camera had a 40 degree filed of view and took 2048 pixels and reduced it to 1020 pixels in order to improve signal to noise ratio. We collected images at spectral resolutions of 1.7, 3.4 and 6.8 nm.

**SLIDE 3**

In order to confirm what we are seeing in the images, we need to know what the actual chl-a concentration in the cylinders was. To do this we took 5 random samples from 1centimeter squared areas per cylinder, gathering a total of 50 milli liters per cylinder, which gave us an estimated algal concentration per cylinder. The hyperspectral data came 3 days after algae had been introduced to the tank, and one image was taken per spectral resolution. Finally, the raw digital numbers from the hyperspectral images were converted to radiance values, where we then applied region of interest filtering to remove an imaged areas that were not the ice/water interface, and finally applied a Savitzy-Golay filter to reduce high frequency noise.

**SLIDE 4**

Now we get to the results. Using PCA the authors found that for a spectral resolution of 1.7 nanometers, 99.8% of the spectral variability is accounted for in principal component 1. We can attribute this large portion of variability to the spatial variations in the led light source. This is shown in figure 3b, where we see a bright yellow hot spot within our tank. The second principal component only account for 0.09 percent of spectral variability, however from figure 3c we see that it had peak intensities at approximately 450 and 680 nanometer wavelengths, which fall into the blue and red bands. This suggests that at least part of PC2 is related to algal biomass.

Figure 4 showed the results for each spectral resolution. It is pretty clear both on the hyperspectral image and intensity maps, that for 1.7 and 3.4 nanometers, PC2 has peaks at the expected bands meanwhile for 6.8 nanometers the intensity is scattered over all wavelengths, and the image does not distinguish between low and high concentration of algae.

**SLIDE 5- if time**

A very important part of this research was to determine if the experimental set up was similar enough to in-situ characteristics, if not, then the results could essentially mean nothing for in-field collection. Figure 5 shows us that the intensity of the light at different wavelengths was matched between the tank and previously collected in-situ measurements.

When light passed through the tank ice it performed similarly to light passing through sea-ice because they share similar characteristics. Specifically, both ice types contain lamellar crystals and brine and air pockets. The PCA results suggested an indifference between spatial variability of light intensity and algal biomass identification, suggesting that factors that impact light intensity at the ice/water interface, such as snow or variable ice thickness might not inhibit this method, but further research has to be done.

Finally they compare in-tank to in-situ algae. Within the tank the algal cultures were only found at the ice/water interface, but within sea ice the concentrations can also vary vertically through the ice, which could obscure the spectral signatures of algae at the interface. Finally, when the algae were placed into the tank they were at the optimal growth rate, and had no signs of death and decay, which is not guaranteed for in-situ algae.

**SLIDE 6**

To summarize the paper wanted to assess the viability of using hyperspectral imaging to map algal-biomass at the ice/water interface of an ice sheet. To do so, they created an inverted ice tank, with algal concentrations confined in cylinders, and passed over a hyperspectral camera, which captured distinct spectral signatures algae absorption wavelengths demonstrating the potential for biomass mapping. PCA demonstrated that at spectral resolutions less than 6 nanometers, we could effectively detect biomass distribution. The paper ended by discussing the future work needed which focused around developing the technique further for field deployment. This included determining an underwater transport apparatus for the camera, specific cold water protection and also determining what if any varying ice conditions and water effects could impact in-situ use of this method.

**DISCUSSION**

Before we start the discussion I want to give you guys a chance to ask an questions you came across in the paper that I can hopefully provide clarification on.

\*answer and questions\*

Awesome, now to start the discussion I am wondering if after reading the paper there was anything you believe the paper did particularly well, or was there something you think the paper could have done better?

\*flow with the conversation and such\*