

Remote characterization of Antarctic microbial mat communities

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McMurdo Dry Valleys (MDV)

- During the austral summers, glacial melt forms streams that flow for up to 10 weeks a year
- These streams and the soils around them are home to diverse microbial communities
- While there are estimates of *aquatic* productivity in the MDV, there are currently no systematic estimates of *terrestrial* productivity



Microbial Mat Communities



- Form mats on soil and rock adjacent to glacial meltwater streams, ponds, and lakes
- Cyanobacterial mat communities are the main drivers of primary productivity in the MDV
- Their cryptic nature and patchy distribution make assessments of productivity challenging



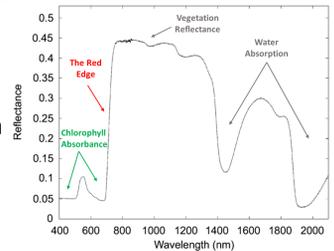
- Black microbial mats, dominated by *Nostoc* spp., are terrestrial mats found in wetted areas not inundated by water
- Mats are stratified with most chlorophyll in lower layers, protected from solar radiation by sheath pigments in the upper layers

- Scytonemin is a *microbial sunscreen* pigment found in *Nostoc* spp., giving them a black appearance

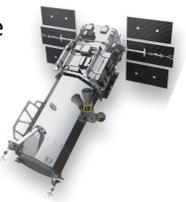
Remote Sensing in the MDV

- Remote sensing and image analysis can provide long-term, spatially-extensive estimates of biomass and productivity

- Normalized Difference Vegetation Index (NDVI) evaluates the relationship between reflectance at 680 nm and 800 nm where photosynthetic materials exhibit a diagnostic signal caused by chlorophyll-a



- Terrestrial microbial mats in the MDV exhibit strong spectral signatures of chlorophyll using imagery taken from WorldView-2 satellite

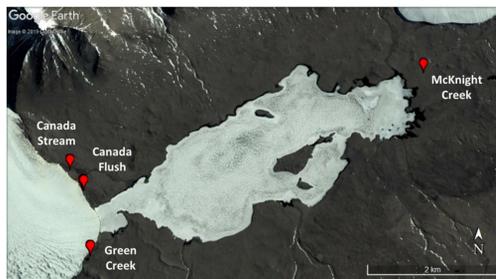


Objectives

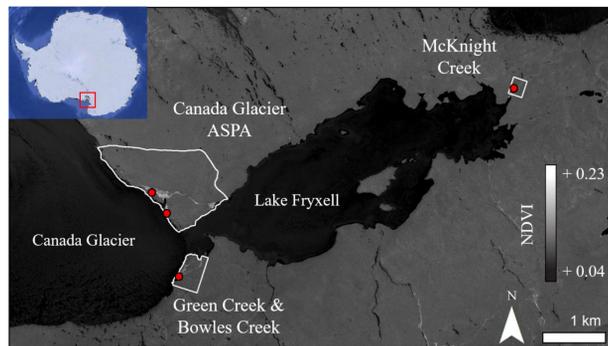
- Confirm the utility of WorldView-2 satellite in detecting photosynthetic microbial mats in the MDV
- Couple satellite imagery with *in situ* surveying and sampling to systematically estimate microbial mat biomass by:
 - 1) Conducting field surveys (*i.e.*, ground cover, ash-free dry mass (AFDM), and pigment content)
 - 2) Examining correlations of spectral NDVI data with field survey data

Field Surveys and Sampling

- Seven 100 m² plots created at Canada Stream, Green Creek, and McKnight Creek in the Lake Fryxell Basin



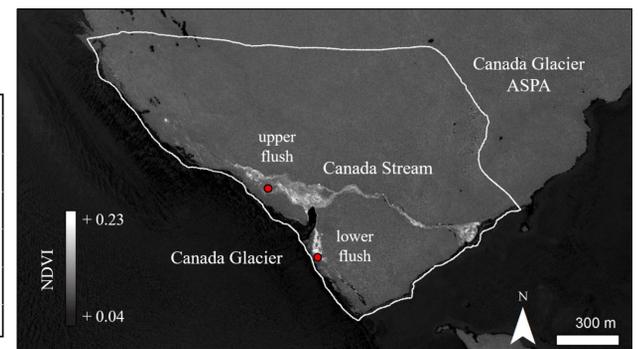
Satellite Imagery Analysis & NDVI Products



- In Jan. 2018, WorldView-2 satellite acquired eight-band multispectral imagery with 1.84 m resolution
- Imagery processed using NDVI

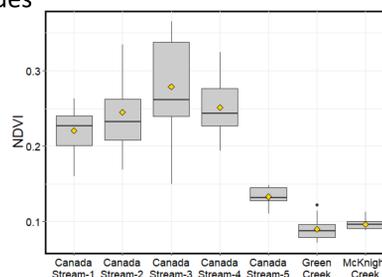
$$NDVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red}}$$

- Spectral analyses revealed the strong absorption of visible light (~0.4–0.7 μm) and strong reflectance of near-infrared light (>0.7 μm), consistent with photosynthetic signals

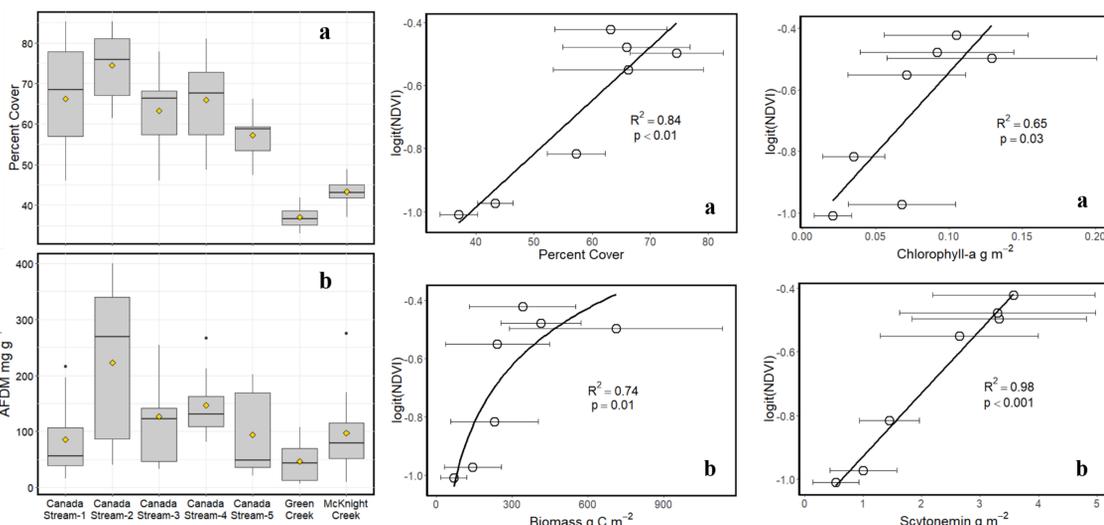


- Each plot corresponds to ~14-17 pixels (5.95 m² each) with unique NDVI values

- NDVI values of each selected pixel were exported and averaged by plot to compare to survey and chemistry data



NDVI Relationships with Field Survey Data

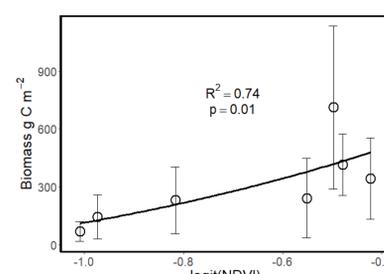


- Variation in percent cover and AFDM among plots

- NDVI increases significantly with increasing percent cover and biomass of microbial mats

- NDVI significantly correlated to chlorophyll-a, but... seems to be more driven by percent cover, biomass, and scytonemin

Upscaling Biomass



- Using the NDVI – biomass exponential relationship, we estimate carbon (C) stocks of 21,715 kg (139 g C m⁻²) in the Canada Glacier Antarctic Specially Protected Area (ASPA)

Significance

- Satellite imagery can detect microbial mats
- We extrapolated significant carbon stocks in stream margins, wetland areas, and even in drier soils
- First satellite-derived estimate of microbial mat biomass for the Canada Glacier ASPA
- Our work suggests low productivity environments, due to their large spatial extents, may have more C overall than the highly productive areas in the Canada ASPA
- Future work: develop a tool for systematic estimation of microbial mat *productivity*
- Changing climate may enhance productivity. We aim to monitor and forecast how this ecosystem may respond.

Acknowledgements

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