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From archaea to the atmosphere: Scaling methane emissions across a thawing permafrost landscape

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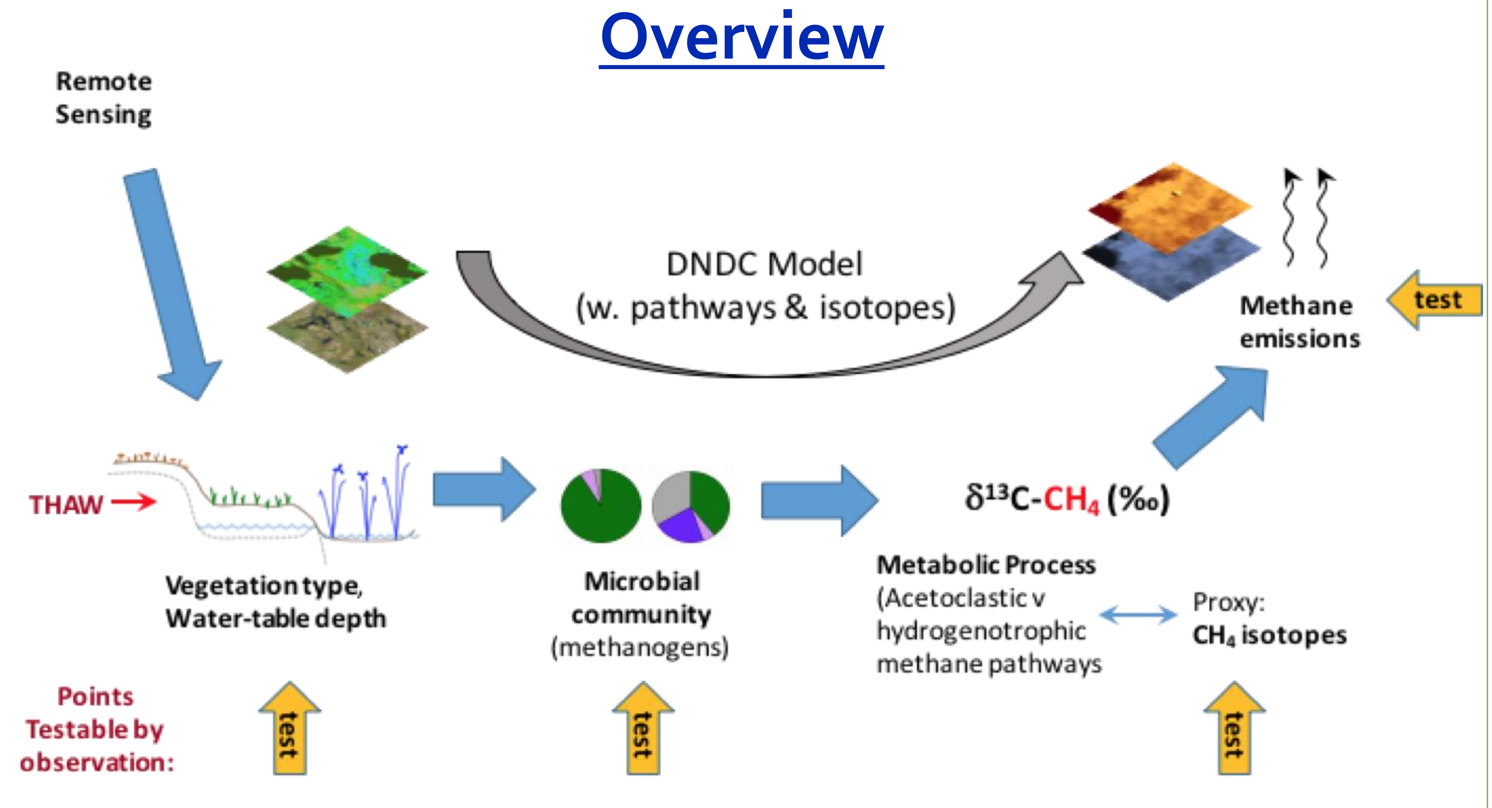
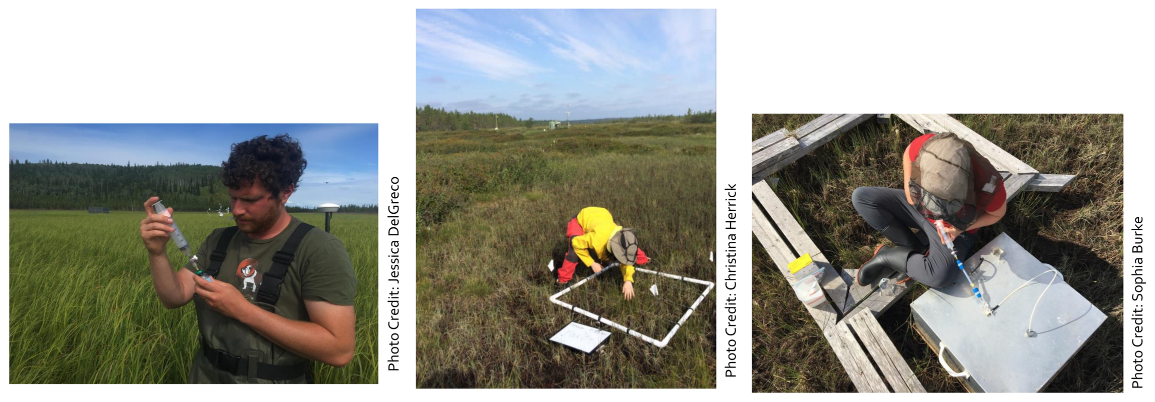
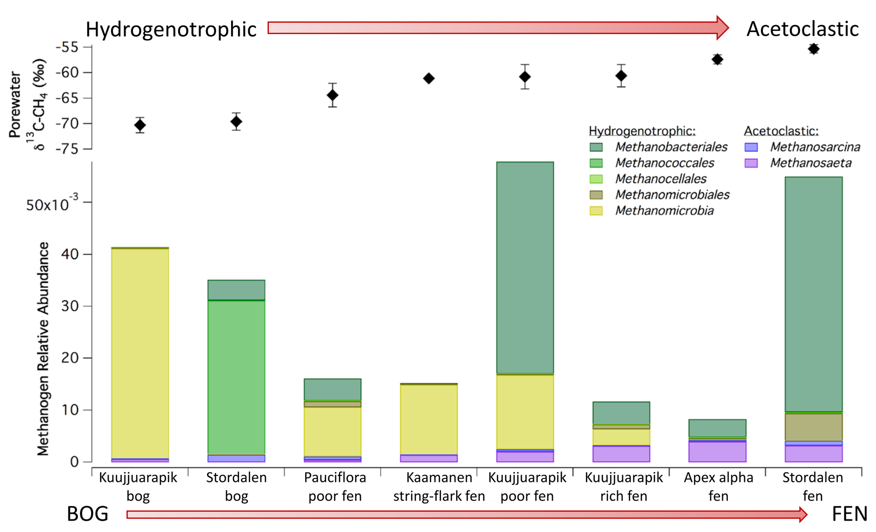
Overview

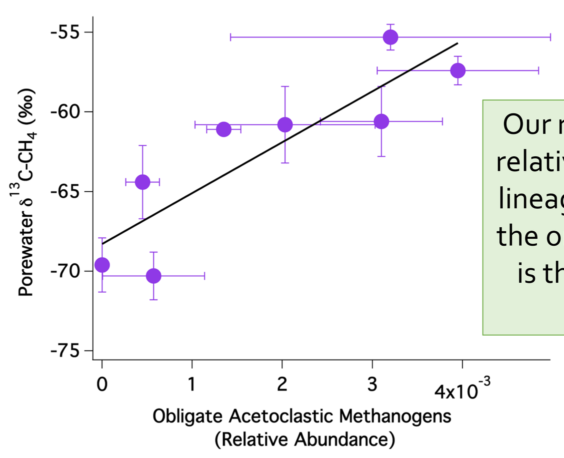


Field Isotope and Microbial Measurements

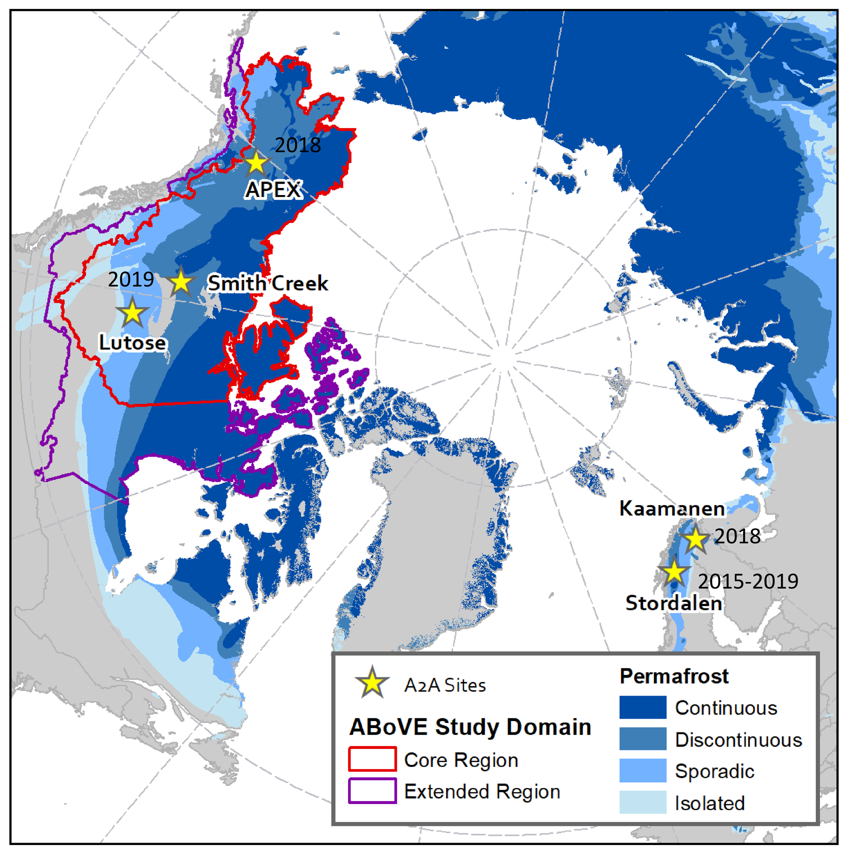
One goal of this work is to test methanogen relative abundance and isotopic ($^{13}CH_4$) relationships across several sites in the Arctic region.







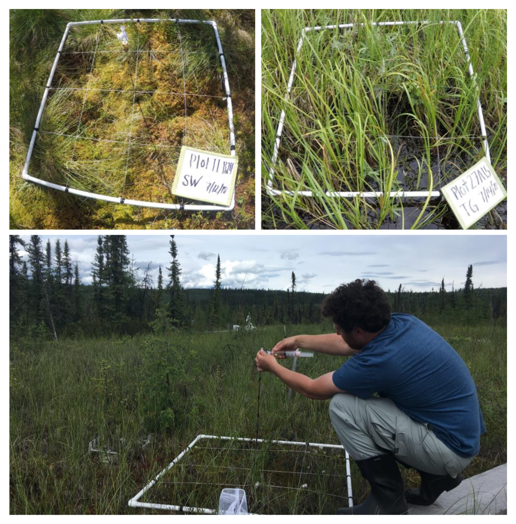
Our results to date indicate that the relative abundance of methanogenic lineages in the genus *Methanosaeta*, the only known obligate acetoclasts, is the best predictor of porewater methane isotopes



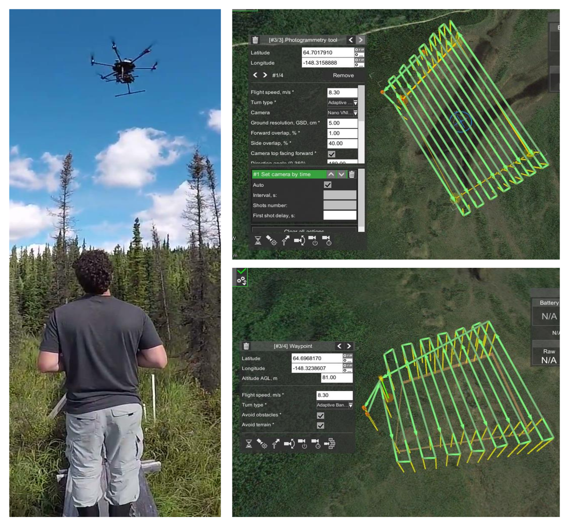
Check out other posters from the A2A group Here:

Remote Sensing

Classification begins at the site level and is analyzed according to vegetation function. Remote sensing products will be used to scale over the global Arctic.



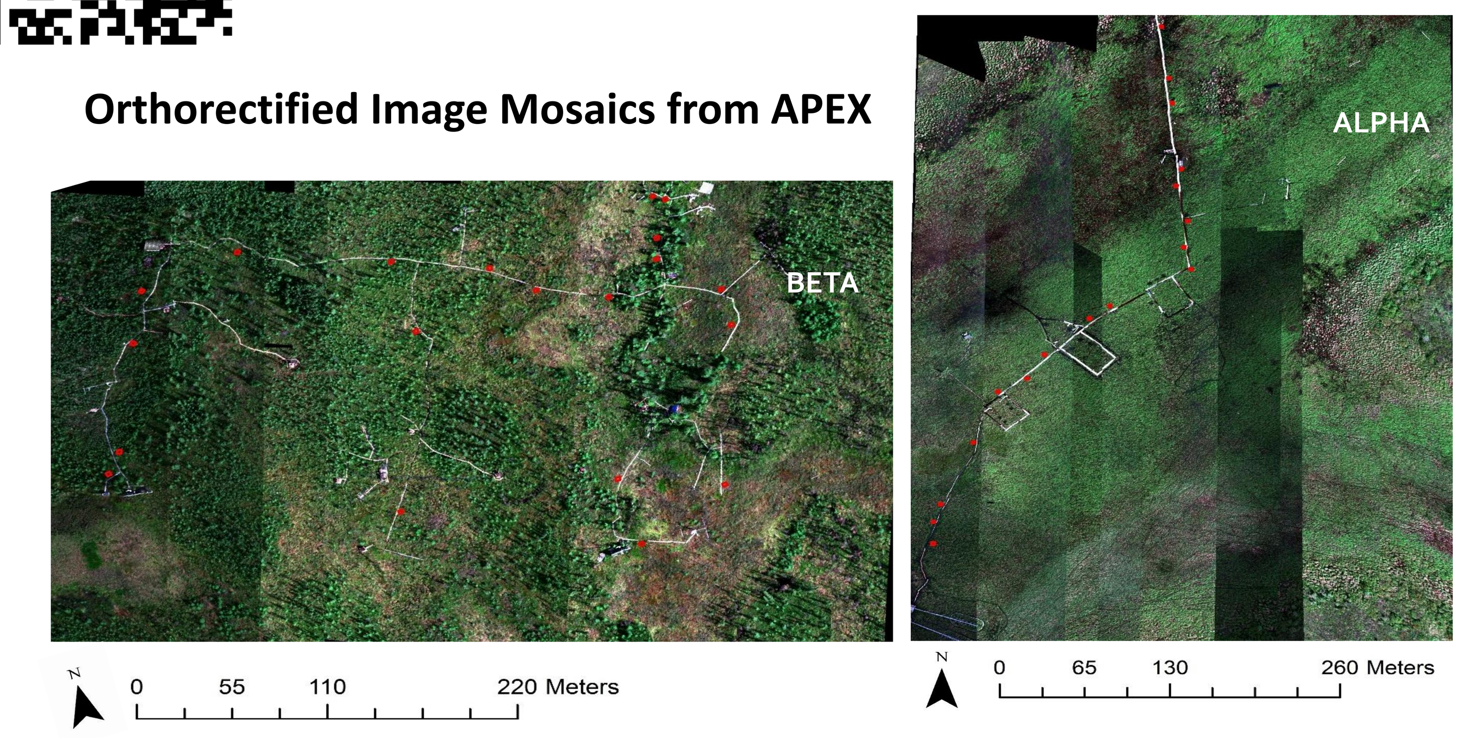
In summer 2019, we sampled at the APEX site in AK. Working with collaborators, we identified 20 plots in both the Alpha and Beta sites. Plots were characterized by cover type, and species composition was estimated. Peat cores and porewater samples were also collected for microbial and isotopic analyses.



Prior to disturbing plots for peat core sampling, we conducted drone flights at each of the two subsites using a DJI Matrice 600 Pro with a Nano-Hyperspec mounted on a 3-axis gimbal. Flights were conducted on mostly clear, but not cloud free, days near solar noon. As best as possible, flights were conducted between passing clouds.

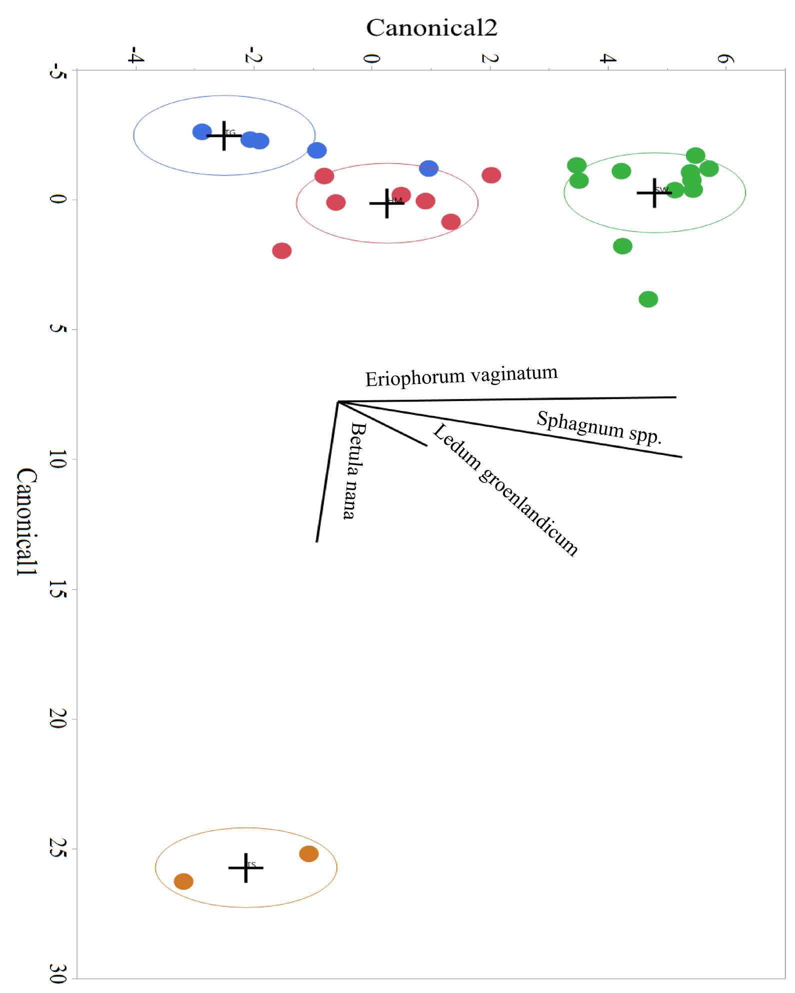
Hyperspectral data cubes were post-processed using Headwall Photonics, Inc. software, SpectralView. Flight lines were orthorectified using 1/3 arcsecond digital terrain models from the National Elevation Dataset and the on-board GPS/IMU data collected during the flight. Image analysis was performed in ArcMap and JMP.

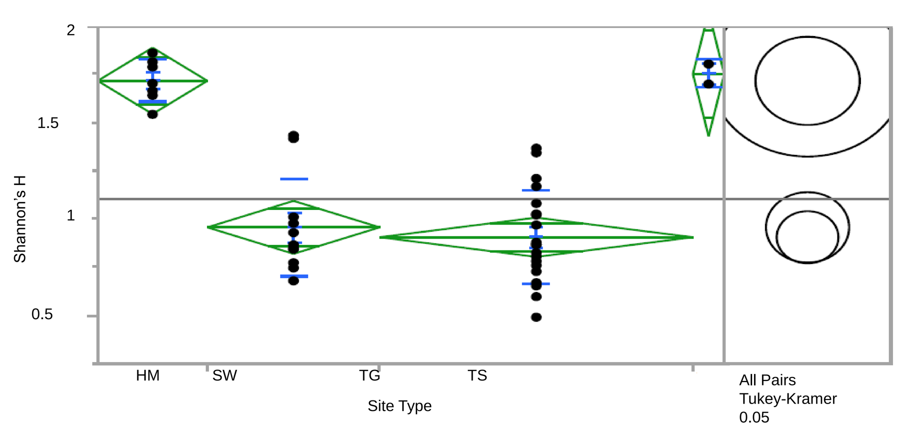
Orthorectified Image Mosaics from APEX

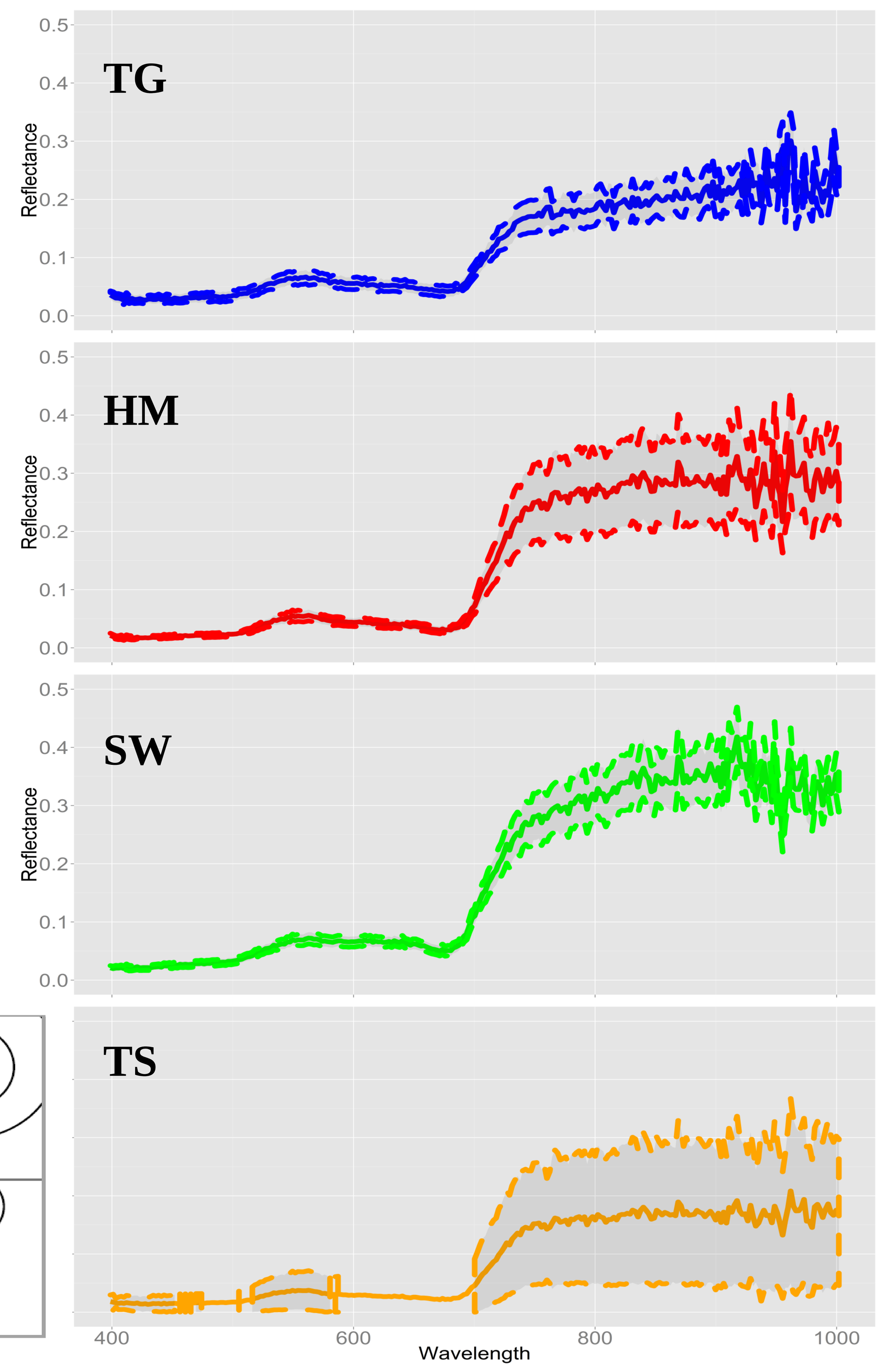


RGB display orthomosaics created in Headwall Photonics Inc.'s SpectralView software for the APEX Beta (left) and Alpha (right) sites. These orthomosaics contain hyperspectral data for 273 bands from approximately 400 nm to 1000 nm. Images were acquired on July 12, 2018 for Alpha and July 13, 2018 for Beta under mostly sunny conditions. Each flight line was orthorectified separately, hyperspectral cubes were mosaiced, and mosaiced images were georectified using high accuracy GPS locations along boardwalks and at boardwalk junctions. The spatial resolution of the final orthomosaics is approximately 8 cm. Locations of field plots are marked in red, and were collocated with the boardwalk to avoid disturbance of sensitive peat and permafrost areas and to avoid other research equipment.

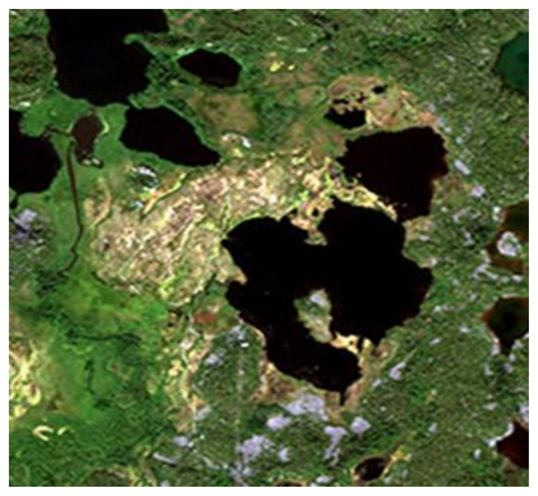
Scaling and Modeling CH_4 and $^{13}CH_4$ emissions



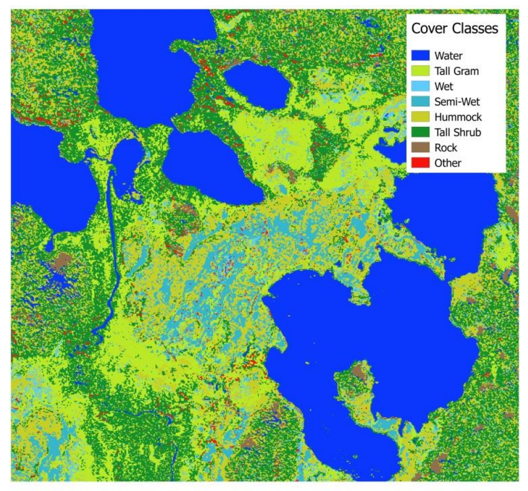




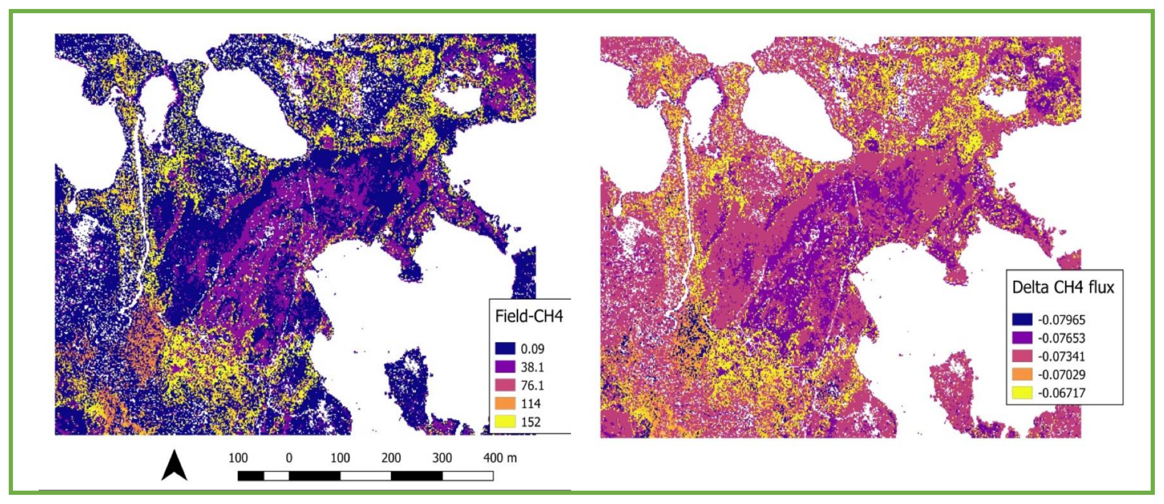
At the APEX sites, species were identified that are important for discriminating four key cover types that we can model CH_4 and $^{13}CH_4$ emissions for: (top left), hummock (red), tall graminoid (blue), tall shrub (orange), and semi-wet (green), including *Betula nana*, *Ledum groenlandicum*, *Sphagnum* spp., and *Eriophorum vaginatum*. Hummock and tall shrub cover types are also distinct from tall graminoid and semi-wet in terms of diversity (bottom right). We expect these species to be useful for determining important spectra for species and cover type classification. Cover type mean spectra with confidence intervals were extracted from hyperspectral imagery and plotted in R (right).



Georectified WV2 image of Stordalen Mire, Abisko Sweden (M. Palace)



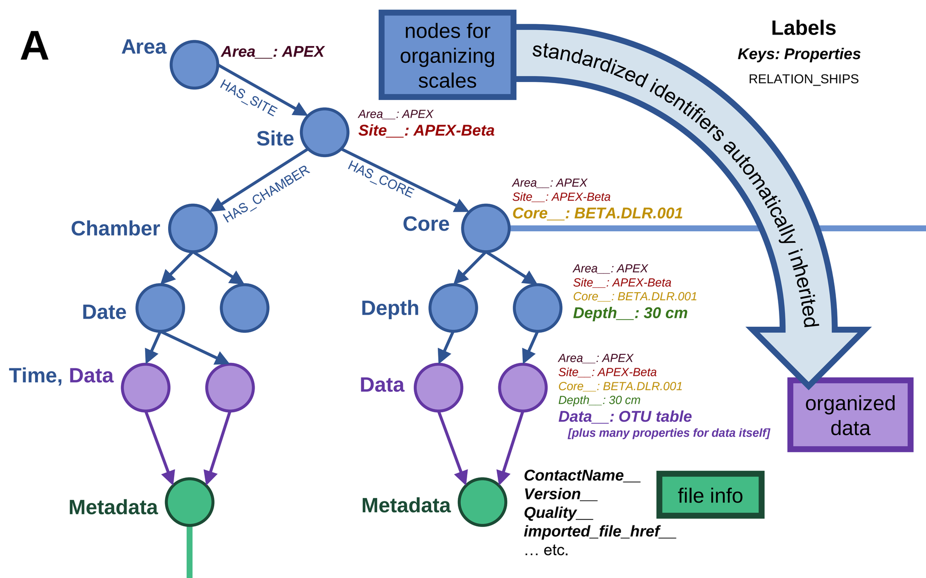
Using a fixed wing UAS to scale vegetation communities as input to DNDC (M. Palace)

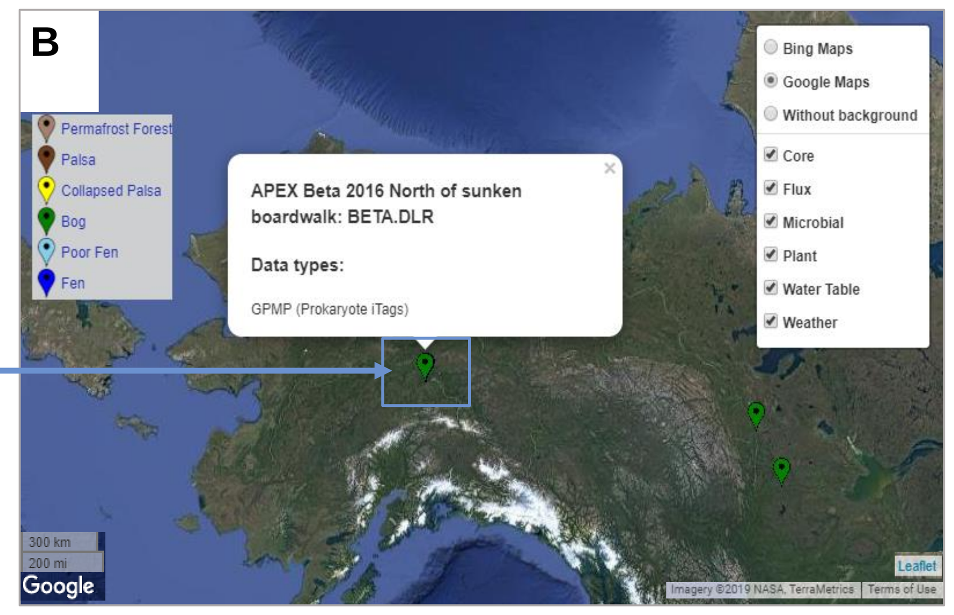


Modeled emissions (mg CH_4 m^{-2} d^{-1}) and isotopic signature (‰) of emitted CH_4 at Stordalen Mire in 2014 using DNDC (Deng et al., 2017). **Future work: applying modeling at other pan-Arctic locations.**

Database

(A) The basic database framework follows a graph format, which enables efficient, detailed querying for relationships among different datasets. The database is publicly accessible via a web portal, which includes (B) a *Map Interface* with points corresponding to georeferenced entities in the graph DB (example shown for a core), and (C) a *Data Downloads* page providing access to source datasets, which map to Metadata nodes in the graph DB. **A2A-DB website:** https://a2a-db.asc.ohio-state.edu/





C APEX

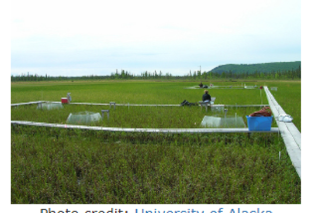


Photo credit: University of Alaska Fairbanks, Spatial Ecology Lab

Site(s)	Data Types	Dataset README	Files	Current version	Contributor/Contact	Publication/Citation
APEX-Alpha	Meteorology from 2007-2011	metadata HTML, metadata EML, site schematic	original files	0.0.0	Evan Kane, Merritt Turetsky, J. M. Waddington	Bonanza Creek LTER (doi: 10.6073/pasta/67fc1e8a0d27bce751c307d15d3e4ec2), Turetsky et al. (2008)
APEX-Beta & Gamma	CH_4 & CO_2 fluxes & $\delta^{13}C$ (CH_4 only) from chambers in 2012-2013	README, metadata XML	original Excel (truncated dates), corrected Excel	0.0.0	Mark Waldrop	UAF SNAP data portal

Check out the A2A- database HERE:

References:
Deng, J., C.K. McCalley, S. Frolking, J. Chanton, P. Crill, R.K. Varner, G. Tyson, V. Rich, M. Hines, S. Saleska, C. Li (2017) Adding stable carbon isotopes improves model representation of the role of microbial communities in peatland methane cycling, J. Adv. Model. Earth Syst., 9, 1412–1430, doi:10.1002/2016MS000817; McCalley, C. K., et al. (2014), Methane dynamics regulated by microbial community response to permafrost thaw, Nature, 514(7523), 478–481.Deng, J., C.K. McCalley, S. Frolking, J. Chanton, P. Crill, R.K. Varner, G. Tyson, V. Rich, M. Hines, S. Saleska, C. Li (2017) Adding stable carbon isotopes improves model representation of the role of microbial communities in peatland methane cycling, J. Adv. Model. Earth Syst., 9, 1412–1430, doi:10.1002/2016MS000817 .; Palace, M, C. Herrick, J. DelGreco, R. Varner, D. Finnell, AJ. Garnello, (2019), "Unmanned Aerial Imagery over Stordalen Mire, Northern Sweden, 2014", https://doi.org/10.7910/DVN/SJKV4T, Harvard Dataverse, V1; Palace M, C. Herrick, J. DelGreco, D. Finnell, A.J. Garnello , C. McCalley, K. McArthur, F. Sullivan, R.K. Varner. (2018). Determining Subarctic Peatland Vegetation Using an Unmanned Aerial System (UAS). Remote Sensing; 10(9):1498. doi: 10.3390/rs10091498

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