ABoVE Hyperwall Notes 2021 NOLA

*We would like to begin by acknowledging that the circumpolar Arctic is the home to many different Indigenous Peoples. We are reminded of their deep connection to this region, and our role as researchers to work towards reconciliation with our Indigenous partners. [Wherever you may be participating in the 2021 AGU Fall Meeting], please join me in honoring the place-based knowledge of Indigenous Peoples and recognizing their ancestral and contemporary stewardship of their homelands.*

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ABoVE is a large-scale study of environmental change in the Arctic and boreal regions of western North America and the implications for ecological systems and society. And of course we’re doing this as only NASA can, with a strategy that spans spatial scales from leaf to orbit.

During the course of this 10 year field campaign, we are making observations at plot, tower, airborne, and orbital scales and feeding this data into an integrated modeling framework.

Overarching Science Question:

 How vulnerable or resilient are ecosystems and society to environmental change in the Arctic and boreal region of western North America?

Overarching Science Objective:

 To investigate the underlying processes and their interactions that control vulnerability and resilience in Arctic and Boreal ecosystems of western North America to environmental change, and to assess how people within and beyond this region may respond to changes in these processes and interactions.

Vulnerability-Resilience Framework

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The Arctic is warming first and fastest.

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**Warmer temperatures are driving Vegetation Greening & Browning Trends in Canada and Alaska: 1984-2012:** High-latitude regions have been warming rapidly since the last century, at a rate higher than the global average. At continental scales, satellite data since 1984 indicate increased vegetation growth (shown here as greening), and decreased vegetation growth (shown here as browning) for certain areas of boreal forest of Canada and Alaska. These remote sensing results have been verified by on the ground observations. What do we see when we look on the ground?

White rectangles mark sites with repeat overflights of L-Band Synthetic Aperture Radar (SAR) during 2017, 2018, and 2019.

https://svs.gsfc.nasa.gov/4452

Slide 5

One of the things that’s happening across this region is an increase in fire frequency and severity. I took this photo out the window of a Twin Otter on the way from Yellowknife to Daring Lake in 2014, when a total of 2.9 million hectares burned in Canada’s Northwest Territories. This is an area larger than Maryland, Massachusetts+ Rhode Island put together.

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ASCENDS flights during the ABoVE airborne science campaign in the summer of 2017

**Key Points**

* NASA Goddard CO2 Sounder Lidar can accurately measure CO2 enhancements from wildfires through dense smoke plumes
* This is the first use of lidar to remotely sense CO2 enhancements from large wildfires
* These types of lidar measurements can be used to validate estimates of CO2 emissions from wildfires and improve estimates of carbon fluxes

(a) the cloud-free XCO2 retrievals from the CO2 Sounder lidar for the flight on August 8, 2017. Significant XCO2 enhancements were seen in the flight segment crossing Vancouver Island. The British Columbia wildfires are marked to the north of these enhancements. (b) image of the smoke plumes from the wildfires in Canadian Rockies as seen from DC-8 over Vancouver Island. (c) true color image from Aqua/MODIS showing the smoke and fires on the same day.

Slide 7

Spruce bark beetle damage in Alaska as seen from Bruce Cook’s G-LiHT airborne campaign. Shrub expansion onto alpine tundra (greening) & spruce tree death (browning)

Slide 8

Change in Tundra Greenness

Summer warming explains widespread but not uniform greening in the Arctic tundra biome. Nature Communications (2020) Berner et al. recently found that tundra greenness significantly increased across about 20% of the Arctic from 2000 to 2016, whereas tundra greenness decreased across about 6% of this region. Summer warming was the primary factor causing tundra ecosystems to become greener and more productive in recent decades, highlighting large-scale impacts of climate change on Earth’s northernmost ecosystems.

Pixel walking with Dr. Roman Dial

During summer 2021, Dial’s research team pixel-walked over 800 miles from east to west through the Brooks Range, collecting data on vegetation composition for about 100,000 Landsat pixels. Over the coming year, Dial’s team will work with Berner, Burns, and Professor Scott Goetz (ABoVE Science Team Lead) at NAU to link these extensive field data with several decades of Landsat satellite observations provided by NASA. This collaboration will help unravel the mysteries of Arctic greening and browning by shedding light on where, how, and why plant communities changed in recent decades.

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Forest aboveground biomass maps provide important constraints on climate and carbon cycle models, and enable the long term monitoring of changes to carbon stocks over time. Boreal forests are warming more rapidly than any other forests on the planet, and experience carbon losses from drought, pests, fires and deforestation while also potentially increasing growth rates in a warming world. Thus quantifying and monitoring boreal forest biomass is critical to understanding these ecosystems in the context of the global carbon cycle.

This new boreal-wide forest aboveground biomass map using data from NASA’s ICESat-2, topographic information from the Copernicus, and spectral data from Landsat 8. This 30-m product is representative of 2019-2021 conditions, and enables the estimation of both boreal-wide and local to regional forest aboveground biomass. This provisional product is an input to a global forest biomass harmonization activity and will continue to be refined based on the results from global validation activities. This provisional product can be explored here: <https://earthdata.nasa.gov/maap-biomass/products/icesat2_boreal>

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A world of lakes, seen here from the NASA Gulfstream V jet somewhere over Canada's Northwest Territories

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Methane ebullition in the summer

Slide 12

Methane ebullition in the winter: when I say this is methane, do you believe this is methane?

Slide 13

a thermokarst lake with methane ebullition. It shows the various sizes of the methane ebullition bubbles, there is a white and red-striped meter stick on the ice.

Slide 14

One of the ABoVE projects, led by PI Franz Meyer, established that L-band SAR backscatter from early winter lake ice is correlated with field-measured methane ebullition fluxes. White ebullition bubbles are frozen in the ice, causing slower ice growth beneath the bubble columns resulting in a reflective rough water surface for SAR microwaves. This study used ALOS-1 data from the ASF DAAC, and the principles will be expanded to the upcoming L-band NISAR satellite mission.

Engram, M., Walter Anthony, K.M., Sachs, T., Kohnert, K., Serafimovich, A., Grosse, G., & Meyer, F.J. (2020). Remote sensing northern lake methane ebullition. Nature Climate Change, 10, (6) 511-517, 10.1038/s41558-020-0762-8

**Science Question**

Lakes are significant sources of atmospheric methane (CH4), a potent greenhouse gas, yet large uncertainties exist in quantifying lake-source CH4, especially discrepancies between higher bottom-up and lower top-down estimates.

**Analysis**

Used L-band SAR imagery of early winter lake ice (PALSAR from the Alaska Satellite Facility).

Inverted empirical regression model correlating SAR to field measurements on 48 lakes to estimate CH4 flux from 5000+ lakes in five regions in Alaska.

**Results**

Our regional SAR-based lake-source CH4 fluxes, based for the first time on satellite remote sensing analyses, lowered emissions compared to previous estimates based on upscaling from individual lakes and compared favorably with independent airborne CH4 observations.

High permafrost carbon combined with high limnicity yielded large emissions from northern Seward Peninsula thermokarst lakes.

**Significance**

This new approach to estimate lake-source CH4 from ebullition offers a unique opportunity to improve knowledge about CH4 fluxes for seasonally ice-covered lakes globally.

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Seasonal Respiration: Jenny Watts et al.

The animation shows the seasonal cycle of soil CO2 emissions. These are monthly averages in units of gC m2 d.  Soil CO2 emissions are relatively minimal (but persistent) over the cold winter months. They begin to ramp up in spring (April/May), peak mid-to-late summer (July/August), and then ramp down in autumn as soils begin to freeze.  Note: Emissions were computed at a 300m resolution; we did not calculate soil flux for non-permafrost landscapes.

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These are based on results from our Watts et al. 2021 ERL paper ([https://iopscience.iop.org/article/10.1088/1748-9326/ac1222/meta](https://gcc02.safelinks.protection.outlook.com/?url=https%3A%2F%2Fiopscience.iop.org%2Farticle%2F10.1088%2F1748-9326%2Fac1222%2Fmeta&data=04%7C01%7Cpeter.c.griffith%40nasa.gov%7Cb3f69ac1f7ad4b2047e608d9a398c4fc%7C7005d45845be48ae8140d43da96dd17b%7C0%7C0%7C637720698809827874%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=LZzjLrMxWlyJP0L8ZAssWTzN1tWaEAGn55%2B7fgEH%2FrU%3D&reserved=0));

Watts used statistical methods and remote sensing inputs to upscale soil respiration fluxes for the ABoVE domain. Here we define soil respiration as all belowground components (ra + rh). The map shows how annual soil CO2 emissions are offsetting annual carbon uptake by plants within the ABoVE domain. We see very large offsets occurring in tundra (e.g., North Slope), and in areas of recent disturbance (e.g. burn scars in AK boreal zone). Note: this assessment was for the 2016/2017 period and we expect that % offsets may have increased in more recent years due to very warm temperatures and increasing depth/duration of soil thaw.

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Eight Mile Lake respiration chambers