CANADIAN MOUNTAIN NETWORK

Mineral Dust Dynamics and Climate Change at High Latitude Mountainous Regions

Atmospheric aerosols are a complex mixture of inorganic and organic components and can range in size from a few nanometers to several micrometers. An important fraction of the total global aerosol budget is mineral dust (MD) aerosols, which augment the atmospheric radiation budget by directly reflecting or absorbing solar radiation and indirectly, by acting as cloud condensation or ice nuclei; altering cloud properties such as albedo, lifetime and the quantity of precipitation. Once deposited, MD can behave like a black body, disproportionately enhancing the melting of snow surfaces, as well as providing essential nutrients to ecosystems. No data on Canada's total annual emissions is currently available despite a global estimate of 80-100 Tg per year of MD aerosols from high latitude sources.

Many polar landscapes contain sporadic or extensive discontinuous permafrost, and are subject to limited annual precipitation, which limit the connectivity and therefore the transfer of nutrients through the landscape, enhancing the importance of atmospheric deposition of soluble nutrients in polar landscapes. Mountainous regions are prone to meteorological conditions that produce daily winds that can erode and transport MD aerosols if the surface soil is susceptible. As average temperatures rise and snowfall cover duration decreases, more areas will be prone to wind erosion given increasing areas of bare unfrozen soil for longer periods each year.

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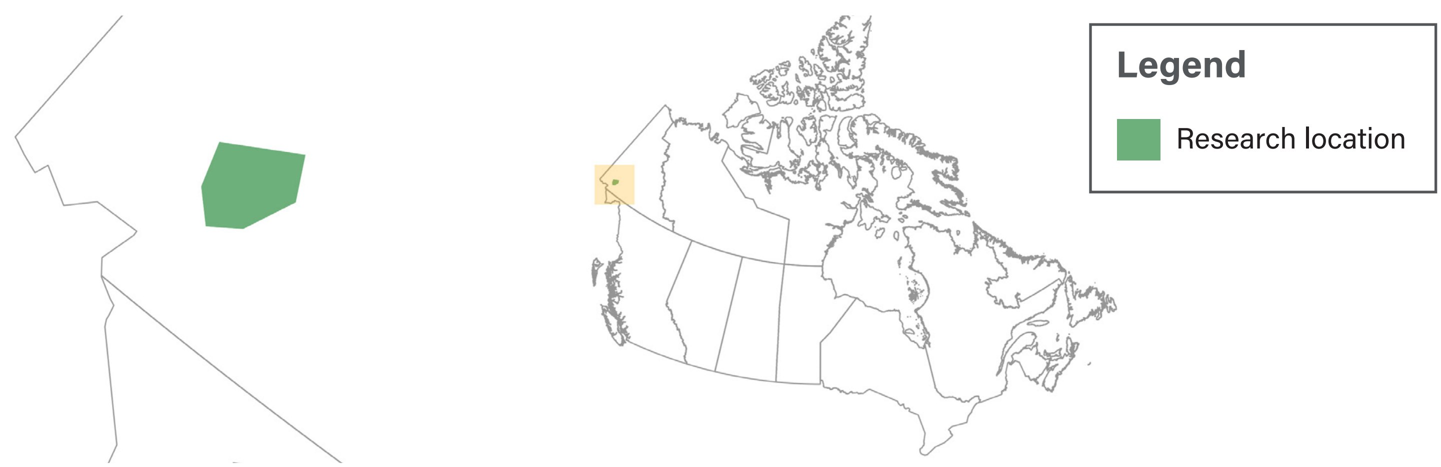

Project Partners

Yukon University, University of Toronto, University of Sheffield, University of Illinois, University of British Columbia, Université de Sherbrooke, Université de Montréal, Université de Laval, Sorbonne Université, Parks Canada, Kluane Lake Research Station (University of Calgary), Kluane First Nation, Kiel University, IIT Roorkee, Environment and Climate Change Canada, Catholic University Eichstätt-Ingolstadt

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Objectives

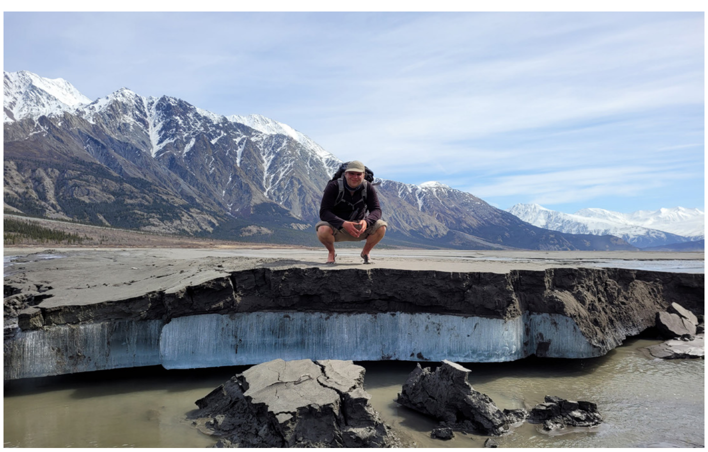
This researcher-led, partnership-assisted, and indigenous community-supported project's goal is to identify and quantify the climatic variables that control dust emissions from mountainous regions, integrate them into a new dust production model to inform Environment Canada's current global climate model for its emission and transport of MD aerosols, and evaluate the current and historical impacts of the deposited MD aerosols on surrounding polar landscapes. A combination of intensive field measurements, remote sensing analyses, climate model development, and paleoclimate reanalysis will provide the basis to meet the goals of the proposed research. A goal parallel to the science goals was to develop partnerships with indigenous community groups and with Parks Canada and the Yukon Government.

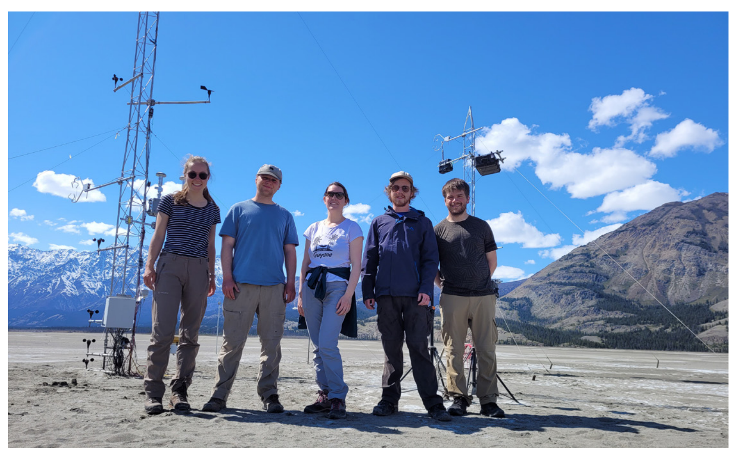
Main findings or outcomes

The project's key findings emphasize the impact of dust emissions and subsequent deposition on the environment, along with the influence of local mountainous topography on wind patterns, challenging current climate models. Regarding deposition, trace metals like arsenic, carried by wind erosion, are detected in significant quantities up to 15 km away from the emission source, enriching surface plants and soils. Dust emission sources are seasonally variable, with summer precipitation predominantly limiting their magnitude and frequency. Valley winds inducing dust emissions are primarily steered by synoptic scale winds from the Pacific Ocean, less influenced by local katabatic flows than by up-valley flow from the Alsek/Kaskawalsh Valley. In summary, collaborating with a First Nation on this Western science project proves challenging, as the community has minimal input on research questions or outcomes, providing little to no benefit for them.

Key Outcomes & Impact

Key impacts involve dust emissions' influence on the environment and the anticipated changes resulting from this interaction, notably an elevated release of trace metals into the air and surroundings, such as arsenic, with recognized health effects. Continuous variations in valley hydrology, tied to meteorology and dust emission activity, suggest significant year-to-year weather fluctuations, posing challenges in assessing overall environmental impacts. Notably, areas capable of emitting dust have substantially increased during the study, reshaping the approach for assessing aerosol significance in high-latitude environments. Traditional methods reliant on 'seeing' aerosols in transport via remote sensing face considerable challenges in this region with limited access and frequent cloud cover. Our studies propose that identifying landscape changes offers a more efficient means to estimate potential shifts in mineral aerosol contributions to radiative and nutrient budgets, given these challenges.





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