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Sustaining Arctic Observing Networks (SAON) Canada, in partnership with the Canadian Polar Commission, is collaborating with the Association of Polar Early Career Scientists (APECS) to present results of monitoring efforts in the Canadian North, including the Yukon, Northwest Territories, Nunavut, Nunavik and Nunatsiavut.

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EXPANSION OF MUSKOX LUNGWORM ONTO VICTORIA ISLAND: IMPLICATIONS FOR POPULATION SUSTAINABILITY

Summary

- *Climate-driven range expansion of the muskox lungworm onto Victoria Island in recent years has significant implications for the sustainability of muskox populations. Muskoxen are a key Arctic species as their grazing promotes plant species diversity and they are a social, economic, and food resource for Northerners.*
- *Since 2008, researchers from the University of Calgary, Government of Nunavut, US National Parasite Collection, and Princeton University have studied parasites in muskoxen on Victoria Island under the Nunavut General Monitoring Program.*
- *Muskox lungworm was first detected on Victoria Island in 2008. Research indicates the recent establishment of muskox lungworm on southwestern Victoria Island and its rapid expansion eastward across the island.*
- *The northward expansion of muskox lungworm may negatively affect the health of affected muskoxen and has implications for population sustainability on Victoria Island and further range expansion onto other Arctic islands. This research can inform sustainable muskox harvesting practices and help scientists to better understand host-parasite transmission and parasite establishment under warming conditions.*

CONTEXT:

Muskox lungworm can cause lung disease and respiratory stress in affected muskoxen, making individuals more susceptible to other diseases and predators.

Victoria Island in the western Arctic Archipelago is home to a high proportion of the world's muskoxen population.[1] Muskox lungworm is common on the Arctic mainland but was first detected on Victoria Island in 2008.[1] Longer and warmer summers,[2] especially since the late 1990s have facilitated the northward expansion of this parasite.[3] As an important economic, social, and cultural species for Northerners, the health and sustainability of Victoria Island muskoxen is a concern.[1,4]

Since the detection of muskox lungworm on Victoria Island, researchers from the University of Calgary, Government of Nunavut, the US National Parasite Collection, and Princeton University, with the support of the Nunavut General Monitoring Program, Natural Sciences and Engineering Research Council of Canada, the Nunavut Harvesters Association, local Hunter and Trappers Organization, a commercial sport hunting outfitter, and Kitikmeot Foods, have been tracking the prevalence and range of muskox lungworm across

Victoria Island, Nunavut, in order to better understand the factors behind the range expansion and impacts on muskox health.[1,4] Lung and fecal samples have been collected from harvested muskoxen since 2008 and analysed for the presence of lungworm cysts and larvae.[1]

RESULTS & IMPLICATIONS:

Researchers have found evidence that indicates a recent establishment and rapid range expansion of muskox lungworm on Victoria Island.[1,4]

- In southwestern Victoria Island, larval stages of the muskox lungworm were detected in all collected fecal samples.[1] The number of lung cysts in muskoxen increased from 2008 to 2010, reaching an infection rate of 100% in all samples by 2010.[1]
- The presence of muskox lungworm in southeastern Victoria Island from 2009 to 2012 increased from 0% to 4% in lung samples and from 0% to 31% in fecal samples, demonstrating the rapid expansion of the parasite across the island.[1]

The expansion of muskox lungworm from the mainland to southwestern Victoria Island may be due to difficult-to-predict muskox movement between the mainland and the island.[1] Muskox lungworm may have been introduced to Victoria Island sporadically in the past, however, a warming climate has facilitated the establishment of the parasite in an environment where temperatures were once prohibitive.[1,3,5] Another factor contributing to the range expansion is the shift in the muskox lungworm life cycle from two years to one year as a result of longer and warmer summers that allow the parasite to reproduce more rapidly and be transmitted in the same summer rather than having to overwinter in the environment.[3]

POLICY LINKAGES:

- The sustainability of muskoxen as a food source and socio-economic resource is threatened by the increased health stress caused by the establishment of muskox lungworm on Victoria Island. Infected muskoxen are at risk of developing life-threatening complications in conjunction with other stressors such as disturbances to the ecosystem, predators, heat stress, and disease. These results and continued monitoring of the spread and impacts of muskox lungworm can assist the Nunavut Wildlife Management Board and the Kitikmeot Regional Wildlife Board to ensure sustainable muskoxen harvesting practices.
- The rapid spread of the muskox lungworm and the compression of its lifecycle under favourable climate conditions may be mirrored in other climate-sensitive Arctic parasites, including those less easily tracked, such as viruses and bacteria.[1] These results can assist researchers in better understanding parasite invasions, establishment and transmission under warming conditions.

REFERENCES:

1. Kutz, S.J., Checkley, S., Verocai, G.G., et al. (2013). Invasion, establishment, and range expansion of two parasitic nematodes in the Canadian Arctic. *Global Change Biology*, 19, 3254–3262. doi: 10.1111/gcb.12315.
2. Intergovernmental Panel on Climate Change. (2007). *Summary for Policymakers. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
3. Kutz, S.J., Hoberg, E.P., Polley, L., & Jenkins, E.J. (2005). Global warming is changing the dynamics of arctic host-parasite systems. *Proceedings of the Royal Society Biological Sciences Series B*, 272, 2571–2576.
4. Wu, J., Checkley, S., Dumond, M., & Kutz, S.J. (2011). 2010 Muskox health survey: Victoria Island. A report prepared for Kikimeot Food Ltd. Unpublished report, University of Calgary and Government of Nunavut.
5. Kutz, S.J., Hoberg, E.P., Molnár, P.K., Dobson, A., & Verocai, G.G. (2014). A walk on the tundra: Host-parasite interactions in an extreme environment. *International Journal for Parasitology: Parasites and Wildlife*, 3, 198-208. http://dx.doi.org/10.1016/j.ijppaw.2014.01.002

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EFFECTS OF GREENHOUSE GASES AND AEROSOLS ON RISING ARCTIC TEMPERATURES: MEASUREMENTS IMPROVE ARCTIC CLIMATE CHANGE MODELS

Summary

- *Greenhouse gas (GHG) emissions and aerosols are key factors in the rapid Arctic warming that is occurring, which has implications for snow and sea ice cover.*
- *The Canadian Sea Ice and Snow Evolution (CanSISE) Network brings together university and government researchers to better quantify and predict snow and sea ice cover in Canada, including the Arctic. Researchers within this network are working to understand the distinct effect that GHGs and other human-induced and natural factors have on Arctic warming.*
- *Results have demonstrated that approximately 60% of the warming caused by GHGs in the Arctic has been offset by aerosols, which can prevent energy from the Sun from reaching the Earth's surface. Without this offset effect, the Arctic warming of 1.2°C over the last century would have been even greater.*
- *These results can help to increase the accuracy of Arctic climate models, which can improve seasonal forecasts of snow cover and sea ice. They also highlight the need for Canada and other parties to the United Nations Framework Convention on Climate Change to implement and enforce more stringent targets to reduce GHG emissions.*

CONTEXT:

Global climate variability is driven by energy from the Sun, which is absorbed by the Earth and re-emitted back into space in the form of heat.[1] The balance of this energy exchange is influenced by external factors called forcing agents. Examples of these forcing agents are greenhouse gases (GHGs), which can trap heat within the Earth's atmosphere, and aerosols, which can reflect incoming energy back into space.

Examples of natural forcing agents include volcanic eruptions that release reflective aerosols, changes in the energy output of the Sun, and fluctuations in the Earth's orbit.[1]

Observed climate trends in the Arctic have demonstrated that the mean surface temperature has warmed substantially more than the global average in recent decades.[2] Impacts of Arctic warming are already occurring such as retreating glaciers, reduced sea ice coverage, and thawing permafrost.[3] Researchers have been exploring the extent to which rapid Arctic warming can be attributed to GHGs, other human-induced forcing agents, or natural forcing agents.

The Canadian Sea Ice and Snow Evolution (CanSISE) Network was created in 2013 to bring together university and government researchers with climate modelling and observational expertise.[4] A key research topic of focus is on how GHG emissions and other human drivers have influenced snow, sea ice, and temperature in Canada, including the Arctic.

RESULTS & IMPLICATIONS:

With support from the CanSISE Network, researchers with the Pacific Climate Impacts Consortium and the Canadian Centre for Climate Modelling and Analysis at Environment Canada are working to quantify the distinct contributions to observed Arctic land temperature change from GHGs, other anthropogenic forcing agents, and natural forcing agents.[5] Observed near-surface temperature data from 1913-2012 were compared to climate models that include the effects of historical variations in forcing agents. Results demonstrated that:

- For the first time, the impact that aerosols and other non-GHG human-sourced forcing agents have on multi-decadal temperature variations in the Arctic have been detected and quantified separately from that of GHGs; [5] and,
- Although observed warming in recent history has been driven by GHG concentrations, in the Arctic, approximately 60% of this warming has been offset by non-GHG forcing agents, which are dominated by aerosols. Without this aerosol-induced cooling, temperature increases in the Arctic would have been greater by 1.3 to 2.2°C over the last century.[5]

Due to legislation to reduce aerosol emissions in recent years, these emissions are projected to decrease while GHGs increase,[6] which will likely cause the rate of Arctic warming to increase. This is consistent with the high increases in future Arctic temperatures that are projected to occur unless GHG emissions are substantially reduced.

POLICY LINKAGES:

- This research provides important contextual information to improve climate models that predict snow cover and sea ice changes. This can help to improve Environment Canada's ability to provide accurate forecasts of seasonal snow cover and sea ice for the general public as well as the water resource, transportation, and energy resource sectors.[7]
- To keep global temperature rise under 2°C, Canada and other parties to the United Nations Framework Convention on Climate Change are working towards long-term post-2020 GHG emissions reduction targets that will be covered under a 2015 legally binding agreement. Given that GHG emissions cause high rates of Arctic warming, these results highlight the need for more stringent GHG emissions reduction targets under this agreement and associated enforcement and climate change policies and action plans at the provincial, territorial, national, and international levels to reach these targets.

REFERENCES:

1. Zwiers, F. W., Hegerl, G. C., Zhang, X., & Wen, Q. (2014). Quantifying the Human and Natural Contributions to Observed Climate Change. *Statistics in Action: A Canadian Outlook*, p. 321-340.
2. Walsh, J. E. (2014). Intensified warming of the Arctic: Causes and impacts on middle latitudes. *Global and Planetary Change*, Volume 117, p. 52-63.
3. Arctic Climate Impact Assessment (ACIA). *(*2005*). Arctic Climate Impact Assessment, 1042 pp., Cambridge University Press,* Cambridge, U. K.
4. Canadian Sea Ice and Snow Evolution Network (CanSISE). (2013). Canadian Sea Ice and Snow Evolution Network. CanSISE: Our Research. Retrieved from http://www.cansise.ca/our-research/
5. Najafi, M. R., Zwiers, F. W., & Gillett, N. P. (2015). Attribution of Arctic temperature change to greenhouse-gas and aerosol influences. *Nature Climate Change*. Retrieved from: http://www.nature.com/nclimate/journal/v5/n3/full/nclimate2524.html
6. Gillett, N. P. & Von Salzen, K. (2013). The role of reduced aerosol precursor emissions in driving near-term warming. *Environmental Research Letters*, *8*(3), 6 pp.
7. Kushner, P. et al. (2013). The CanSISE Network: Annual Progress Report, December 2013. Retrieved from: http://www.cansise.ca/reports-publications/

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BASELINE EXPOSURE OF LABRADOR INUIT TO MERCURY PRIOR TO FLOODING FROM A HYDROELECTRIC DAM

Summary

- *Once commissioned, the planned hydroelectric dam in Labrador in 2017 will result in flooding of parts of the lower Churchill River. There is concern, however, that this could cause downstream mercury dynamics in Lake Melville to change, potentially causing more methylmercury (a toxic metal) to enter the food chain and to bioaccumulate in top predators, including humans.*

- *Researchers from Harvard University are working with the Nunatsiavut Government to assess baseline Inuit exposure to methylmercury from food harvested from Lake Melville, a large estuary downstream from the lower Churchill River in Labrador.*

- *Hair samples and dietary surveys from Labrador Inuit were collected in 2013 and 2014 to better understand the current level of risk to human health from mercury in fish and seal harvested from Lake Melville. These samples, along with water and sediment samples collected in Lake Melville in 2012 and 2013 are helping to build an understanding of how mercury moves throughout the estuarine ecosystem and is converted to the neurotoxin methylmercury. Researchers are also investigating how biogeochemical factors influence the amount of methylmercury in Lake Melville and in turn, humans.*

- *Results provide important data for modeling potential future mercury exposure scenarios and developing appropriate human health risk mitigation options prior to flooding of the reservoir. Potential future methylmercury exposure resulting from the hydroelectric development can also be measured relative to these baseline data, and used for post-flooding human health risk mitigation.*

CONTEXT:

Mercury dynamics in Lake Melville, a large saltwater estuary in Labrador fed by the Churchill River, could be affected when the lower Churchill River is flooded in 2017 as a result of a hydroelectric dam. Approximately two-thirds of Lake Melville is part of the treaty-negotiated hunting and fishing territory for Labrador Inuit. Although the impacts on mercury levels from past flooding of the upper Churchill River in the 1970s for hydroelectricity are uncertain, elevated methylmercury in fish from Lake Melville has been observed[1]. Future flooding events could increase the amount of methylmercury in the food chain, and result in increased risk to human health from the

Methylmercury (MeHg) is a potent neurotoxin and is the only form of mercury that biomagnifies in aquatic food webs. Individuals who eat seal and other country foods from the top of the food chain can have increased exposure to methylmercury, which may cause adverse effects on neurodevelopment and cardiovascular health.[2,3]

consumption of country foods like seal and fish.

The Nunatsiavut Government and the Nain Research Centre in Labrador, in partnership with university researchers, have developed a research and monitoring program investigating Inuit health, community wellbeing, and ecosystem integrity around Lake Melville prior to the development of the dam in 2017. This program is supported by funding from ArcticNet, the Northern Contaminants Program, and the Oak Arctic Marine Fund of Tides Canada Foundation. Under this ongoing program, a team of researchers from Harvard University have collected baseline data since 2012 on mercury levels and dynamics in Lake Melville, as well as baseline data in 2013 and 2014 on human exposure to mercury[4].

RESULTS & IMPLICATIONS:

- In 2012 and 2013, sediment and water samples were collected from Lake Melville to measure mercury levels and investigate biogeochemical factors that influence the movement of mercury throughout the aquatic ecosystem and food web.[1] These samples suggest that rivers are a major source of mercury and methylmercury in the Lake Melville ecosystem[4,5].
- In 2013 and 2014, fish and seal were sampled from Lake Melville to measure mercury levels. Labrador Inuit were also invited to voluntarily share hair samples and complete a dietary survey to better understand their current individual level of mercury exposure. Results from the hair samples and dietary surveys are confidential as they are currently being shared with the volunteers who provided the samples.
- Mercury exposure based on Inuit hair samples and dietary surveys, and mercury levels in Lake Melville water and sediments are informing the development of an ecosystem model that describes how mercury currently moves in and out of Lake Melville through various pathways (e.g., inputs from rivers and the atmosphere, outputs through burial in lake sediments). This model will also provide simulations of how Inuit exposure to methylmercury is likely to change with future flooding of the river.

POLICY LINKAGES:

- Results can inform discussions between the Nunatsiavut Government, the Government of Newfoundland and Labrador, the Government of Canada, and Nalcor Energy regarding the potential impacts from hydroelectric development such as changes in mercury exposure for Labrador Inuit, and options for mitigating health risks, both pre-flooding, and post-flooding.
- The model of mercury movement in this ecosystem could be adapted for use in other northern regions that are working to develop hydroelectricity, to assist in investigating potential human health impacts from mercury.

REFERENCES:

1. Nain Research Centre. (2015). Lake Melville – Avativut, Kanuittailinivut. Accessed March 2015. Retrieved from: http://nainresearchcentre.com/research-projects/lake-melville-avativut-kanuittailinnivut/
2. Stowe, J., E. Krümmel, T. Leech, & S. Donaldson. (2011). What is the impact of mercury contamination on human health in the Arctic? Chapter 8, in *AMAP Assessment 2011: Mercury in the Arctic*. Oslo, Norway: Arctic Monitoring and Assessment Program. Retrieved from: http://www.amap.no/documents/doc/amap-assessment-2011-mercury-in-the-arctic/90
3. Health Canada. (2004). Mercury – Your Health and the Environment. Accessed March 2015. Retrieved from: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/mercury/mercur-eng.pdf
4. Sunderland, E.M., A. Schartup, R. Calder, R. Mason, & P. Balcom. (2014). Impacts of climate and industry on methylmercury exposures for Inuit in Labrador. Platform # 281. P*roceedings from Society for Environmental Toxicology And Chemistry (SETAC) North America 35th Annual Meeting*. Vancouver, BC. Page 78: http://vancouver.setac.org/wp-content/uploads/2014/10/SETAC-Vancouver-Abstracts.pdf
5. Sunderland, E.M. (2014). Biogeochemistry of Global Contaminants Research Group. Harvard School of Engineering and Applied Sciences, and Harvard School of Public Health. Research Projects Website. Accessed 10 March 2015. Retrieved from http://bgc.seas.harvard.edu/projects.html

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GLACIER MASS LOSS IN THE ST. ELIAS MOUNTAINS, YUKON: IMPLICATIONS FOR SEA LEVEL RISE AND THE KLUANE NATIONAL PARK

Summary

- *Glaciers in the St. Elias Mountains, Yukon are experiencing significant mass loss. Glacier mass loss in this and other regions has been identified as an important contributor to global sea level rise.*
- *Since 2006, researchers at Simon Fraser University, the University of Ottawa, and the University of British Columbia have been studying the glaciers of the St. Elias Mountains, focusing on changes to glacier size and flow speeds.*
- *Results have demonstrated rapid loss of ice from these glaciers and variability of glacier dynamics, including between neighbouring glaciers.*
- *This information is important at several scales. Globally, ongoing monitoring and modelling of future glacier dynamics is key to forecasting their contribution to rising sea level in global climate models. Regionally, the glaciers of the St. Elias Mountains drain into important rivers in the Kluane National Park and Reserve, and can impact summer water levels and sediment concentrations. Monitoring changes in meltwater runoff can inform park management plans for these bodies of water.*

CONTEXT:

The St. Elias Mountains and southwestern Yukon Territory are expected to experience 3-4ºC in warming by 2100 compared to the 2-3 ºC rise predicted globally for the same period.[6]

Some of the largest icefields outside of the High Arctic are found in the St. Elias Mountains in southwestern Yukon.[1,2] These glaciers, including the well-studied Kaskawulsh glacier, have experienced significant mass loss in recent decades as a result of climate change, with an average mass loss measured at approximately 0.52m per year between the 1950s and 1990s[3]. This accounts for about 9% of the measured sea level rise during that period[3]. These glaciers are located in the Kluane National Park and Reserve (KNPR), which rated their ecological integrity as 'fair' in the 2008 State of the Park Report[2] due to ongoing melt.

Researchers at Simon Fraser University, the University of Ottawa and the University of British Columbia have been carrying out ongoing monitoring of the Kaskawulsh glacier and other smaller alpine glaciers in the St. Elias Mountains since 2006. Their work has focused on quantifying changes to the glaciers, and understanding the impacts of climate on glaciers and the factors influencing glacier sliding.

RESULTS & IMPLICATIONS:

Ongoing monitoring of glaciers of the St. Elias Mountains by researchers at Simon Fraser University, the University of Ottawa and the University of British Columbia since 2006 has demonstrated some of the following results:

- Between 1977 and 2007, the Kaskawulsh glacier lost 1.53% of its area, the equivalent of 3.27-5.94km^3 of water in volume, about one-quarter to one-half the volume of Lake Erie, and the end of the glacier receded 655m between 1956 and 2007. Most of this loss from Kaskawulsh was from the height of the glacier, rather than the extent.[4]
- Smaller glaciers in the region have also been losing ice since 2006 at rates of decimetres of water equivalent per year.[1]
- Ongoing study of two similarly sized neighbouring glaciers in the St. Elias Mountains indicated different dynamics and velocities.[5]

POLICY LINKAGES:

- Given that glacier mass loss is an important contributor to sea level rise, monitoring and modeling of glacial velocity and mass loss is key to predicting contributions to global sea level rise in global climate models. However, the variability of glacier dynamics between two neighbouring glaciers highlights the difficulty of this task and need for further research and monitoring.
- At the regional level, meltwater runoff from glacier mass loss could affect summer water levels and sediment concentrations in nearby rivers and lakes that are fed by these glaciers[2]. Monitoring results can inform Kluane National Park and Reserve management plans pertaining to water resources.

REFERENCES:

1. Flowers, G., Copland, L., Schoof, C.G. (2014). Contemporary Glacier Processes and Global Change: Recent Observations from Kaskawulsh Glacier and the Donjek Range, St. Elias Mountains. *Arctic*, v. 67, suppl. 1, 2014, p. 22-34.
2. Parks Canada. (2010). Kluane National Park and Reserve of Canada: Management Plan. Yukon Territory: Parks Canada. Retrieved from: http://www.pc.gc.ca/eng/pn-np/yt/kluane/plan.aspx
3. Arendt, A.A., Echelmeyer, K.A., Harrison, W.D., Lingle, C.S., Valentine, V.B. (2002) Rapid wastage of Alaska glaciers and their contribution to rising sea level. *Science*. 297(5580)382-386
4. Foy, N., Copland, L., Zdanowicz, C., Demuth, M., Hopkinson, C. (2011). Recent volume and area changes of Kaskawulsh Glacier, Yukon, Canada. *Journal of Glaciology* 57(203) 515-525.
5. Wilson, N.J., Flowers, G.E., Mingo, L. (2013). Comparison of thermal structure and evolution between neighbouring subarctic glaciers. *Journal of Geophysical Research: Earth Science*. 118: 1443-1459, doi:10.1002/jgrf.20096, 2013.
6. Christensen, J.H. et al. (2007). Regional climate projections. In: Solomon, S., Qin, D., et al. eds. Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press. 847 – 940.

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