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# The Impact of Changing Cloud Cover on the High Arctic's Primary Cooling-to-space Windows

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Abstract:
In the Arctic, most of the infrared energy emitted by the surface escapes to space in two atmospheric windows at 10 and 20 $\mu$m. As the Arctic warms, the 20 $\mu$m cooling-to-space window becomes increasingly opaque (or "closed"), trapping more surface infrared radiation in the atmosphere, with implications for the Arctic's radiative energy balance. Since 2006, the Canadian Network for the Detection of Atmospheric Change (CANDAC) has measured downwelling infrared radiance with an Atmospheric Emitted Radiance Interferometer (AERI) at the Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Canada, providing the first long-term measurements of the 10 and 20 $\mu$m windows in the high Arctic. In this work, measurements of the distribution of downwelling 10 and 20 $\mu$m brightness temperatures at Eureka are separated based on cloud cover, providing a comparison to an existing climatology from the Southern Great Plains (SGP). Measurements of the downwelling radiance at both 10 and 20 $\mu$m exhibit strong seasonal variability as a result of changes in temperature and water vapour, in addition to variability with cloud cover. When separated by season, brightness temperatures in the 20 $\mu$m window are found to be independent of cloud thickness in the summertime, indicating that this window is closed in the summer. Radiance trends in three-month averages are positive and are significantly larger (factor > 5) than the trends detected at the SGP, indicating that changes in the downwelling radiance are accelerated in the high Arctic compared to lower latitudes. This statistically significant increase (> 5% / yr) in radiance at 10 $\mu$m occurs only when the 20 $\mu$m window is mostly transparent, or "open" (i.e. in all seasons except summer), and may have long-term consequences, particularly as warmer temperatures and increased water vapour "close" the dirty window for a prolonged period. These surface-based measurements of radiative forcing can be used to quantify changes in the high-Arctic energy budget and evaluate general circulation model simulations.