Arctic Heat Waves: Towards Quantifying the Role of Atmospheric Dynamics

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The climate of northern Alaska is influenced by synoptic-scale pressure systems centered in the North Pacific and Beaufort Sea, the Aleutian Low (AL) and Beaufort Sea Anticyclone (BSA), respectively. The NOAA/GMD Barrow Atmospheric Baseline Observatory (BRW) is strategically located for monitoring regional changes in climate in response to variations in atmospheric dynamics. In recent years, anomalously warm springtime conditions have contributed to earlier snow and ice melt in the vicinity of BRW. Arctic heat waves have occurred during both spring and winter, contributing to the record low sea ice extent observed during the 2016/2017 winter. At BRW, abnormal warmth was experienced during May 2015 (a record high) and again in 2016, when record early snowmelt occurred. January 2017 also tied the historic record for warmth at BRW.

The role of atmospheric circulation is investigated, in particular the advection of heat and moisture into the Arctic from the North Pacific. Heat waves in Alaska occur when the BSA weakens and the AL shifts westward, establishing a gradient in air pressure with a high pressure ridge to the east. The relative strengths and positions of these features determine if and when Pacific air flows into the Arctic. To quantify the potential for warm-air advection associated with the juxtaposition of the AL and BSA, an index referred to as ALBSA, is defined on the basis of the difference between east-west (E-W) and north-south (N-S) pressure gradients. Gradients between specified points are expressed in terms of differences in geopotential height at the 850 hPa pressure level using NCAR/NCEP Reanalysis fields: (https://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl). Case studies are presented to illustrate the relationship of the 2015/2016 May heat waves at BRW with positive values of ALBSA (Figure 1), and also the near-record warmth of January 2017. We find that early years of snowmelt at BRW correlate with high values of the May E-W component of ALBSA. That is, warm air advection plays a significant role in determining when the spring-to-summer transition occurs on the North Slope of Alaska. In turn, early snowmelt initiates a number of ecological responses, including an increase in the net radiation budget, greening of the tundra, permafrost thaw and enhanced methane flux.

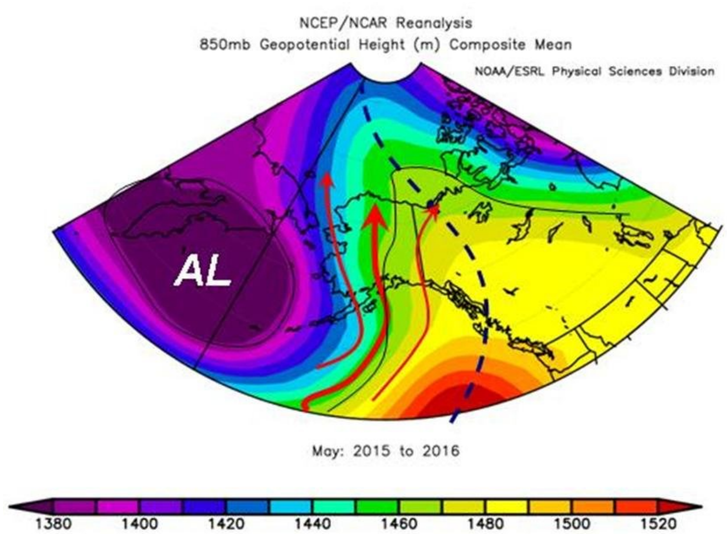

Figure 1. Mean May 850 hPa geopotential height field, averaged for 2015 and 2016 (source: NCEP/NCAR Reanalysis). Red arrows show schematically the advection of air from the north Pacific into the Arctic as a result of an east-west pressure gradient established between the Aleutian Low (AL) and high pressure ridge (dashed line) extending into the Beaufort Sea.