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The planetary- and synoptic-scale controls on lake mixing in the western Arctic

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The biological productivity of Arctic lakes that are deep enough to stratify during the ice-free summer season is dependent on the distribution of dissolved gases and nutrients by vertical mixing. Stratification occurs as the lake surface is heated over the summer, while mixing is initiated by individual weather events - primarily cold fronts that drive strong wind stresses and heat fluxes. Summertime Arctic warming might be expected to stabilize these lakes, but the control of individual weather events on a season's mixing characteristics complicates the ability to predict trends in stability and mixing. Toolik Lake is a Long Term Ecological Research site located on the northern slope of the Brooks Range in Alaska with high resolution multi-depth lake and surface meteorology data dating back to 1998. This work aims to characterize weather systems that are conducive to mixing at Toolik as a means to elucidate the climatic drivers of productivity in western Arctic lakes. High resolution lake and meteorological data from the research site were used to identify mixing while atmospheric reanalysis data (Modern Era-Retrospective Analysis for Research and Applications - MERRA) were used to describe the weather systems. An automated algorithm was developed to detect weather-driven mixing events that are separated by at least the synoptic timescale so that any given weather system should cause at most one mixing event. The 10-day running mean of the daily-averaged 500 hPa geopotential height field from MERRA (1979-2013) in the western Arctic and corresponding subpolar region centred on Toolik (120°E to 60°W, 35°N to 90°N) was clustered using the K-Means method. The mixing events were then classified according to the event date's cluster type. Two weather regimes were found to be primarily associated with mixing: one with a strong cold front, as was expected from previous analyses, and the other characterized by warm, windy weather at Toolik without a strong temperature change. These distinct regimes reinforce the idea that a simple warming trend may not directly reduce mixing frequency in the western Arctic. Instead, the connection to the planetary-scale 500 hPa variability in the current and future climate should be analysed.