

## RESEARCH LETTER

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## Key Points:

- Arctic winter warming events are a normal part of the Arctic winter climate. Observations of these events date back to the Fram expedition
- North Pole region typically experiences 10 distinct warming events per winter, compared with 5 in the Pacific Central Arctic
- Positive trends in the number and duration of Arctic winter warming events (1980–2016), with strongest trends for North Pole domain

## Supporting Information:

- Supporting Information S1

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## Increasing frequency and duration of Arctic winter warming events

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**Abstract** Near-surface air temperatures close to 0°C were observed in situ over sea ice in the central Arctic during the last three winter seasons. Here we use in situ winter (December–March) temperature observations, such as those from Soviet North Pole drifting stations and ocean buoys, to determine how common Arctic winter warming events are. Observations of winter warming events exist over most of the Arctic Basin. Temperatures exceeding –5°C were observed during >30% of winters from 1954 to 2010 by North Pole drifting stations or ocean buoys. Using the ERA-Interim record (1979–2016), we show that the North Pole (NP) region typically experiences 10 warming events (T2m > –10°C) per winter, compared with only five in the Pacific Central Arctic (PCA). There is a positive trend in the overall duration of winter warming events for both the NP region (4.25 days/decade) and PCA (1.16 days/decade), due to an increased number of events of longer duration.

**Plain Language Summary** During the last three winter seasons, extreme warming events were observed over sea ice in the central Arctic Ocean. Each of these warming events were associated with temperatures close to or above 0°C, which lasted for between 1 and 3 days. Typically temperatures in the Arctic at this time of year are below –30°C. Here we study past temperature observations in the Arctic to investigate how common winter warming events are. We use time temperature observations from expeditions such as Fram (1893–1896) and manned Soviet North Pole drifting ice stations from 1937 to 1991. These historic temperature records show that winter warming events have been observed over most of the Arctic Ocean. Despite a thin network of observation sites, winter time temperatures above –5°C were directly observed approximately once every 3 years in the central Arctic Ocean between 1954 and 2010. Winter warming events are associated with storm systems originating in either the Atlantic or Pacific Oceans. Twice as many warming events originate from the Atlantic Ocean compared with the Pacific. These storms often penetrate across the North Pole. While observations of winter warming events date back to 1896, we find an increasing number of winter warming events in recent years.

### 1. Introduction

Temperatures in the Arctic are increasing twice as fast as the global average [Serreze and Francis, 2006; Graversen et al., 2008; Serreze and Barry, 2011]. The most rapid Arctic warming has been recorded during the winter months [Graversen et al., 2008; Bekryaev et al., 2010; Boisvert and Stroeve, 2015], and 2015–2016 was the warmest winter since records began in 1950 [Cullather et al., 2016b; Overland and Wang, 2016]. Winter 2015–2016 featured an Arctic wide (north of 66°N) winter temperature anomaly of approximately 5°C, which was 2°C warmer than the previous record [Overland and Wang, 2016]. The winter maximum sea ice extent in March 2017 was the lowest in the 38 year satellite record (<http://nsidc.org/arcticseaicenews/>). March 2016 and March 2015 were the joint lowest, prior to 2017 [Perovich et al., 2016].

In late December 2015, there was widespread media attention following observations that near-surface air temperatures close the North Pole increased to approximately 0°C during midwinter [Boisvert et al., 2016; Moore, 2016]. These extreme temperatures were observed in situ by several Snow Buoys [Grosfeld et al., 2016]. Data from these buoys were transmitted in near real time via the Global Telecommunication System (GTS), for assimilation into weather forecast models, and the anomalous temperatures were rapidly reported by the press. During this event, temperatures exceeded –10°C for between 1 and 2 days (Figure 1a). This type