

North American Extreme Winter Weather and the Polar Vortex

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INTRODUCTION

Major winter weather events in central and northeastern North America are associated with northerly-wind cold air outbreaks (CAOs). Severe CAOs cause socioeconomic impacts including economic losses, travel disruption, and fatalities (Dixon et al. 2005, Field et al. 2012).

Polar vortex/CAO events often occur contemporaneously. Anomalous behavior of the Arctic stratospheric polar vortex provides an important source of subseasonal-to-seasonal (S2S) predictability of Northern Hemisphere cold air outbreaks.

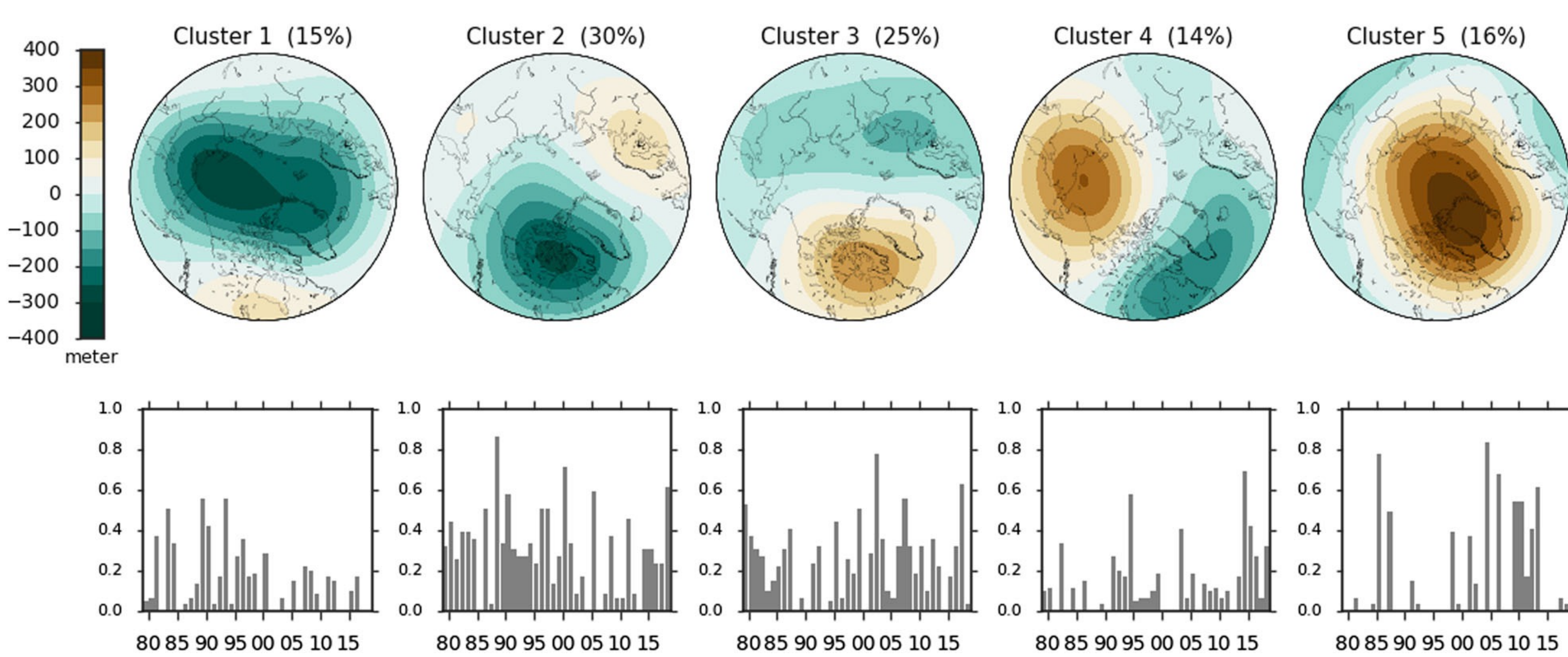


Fig. 1 Cluster representatives. Composites of geopotential height anomalies at 100 hPa in winter (JF) from 1979 to 2018 for days assigned to the same cluster. The number in brackets gives the total occurrence (in percent) over all winter days. The bar plots below the clusters shows the seasonal-mean occurrence frequency for each winter. (Kretschmer, et al., 2018.)

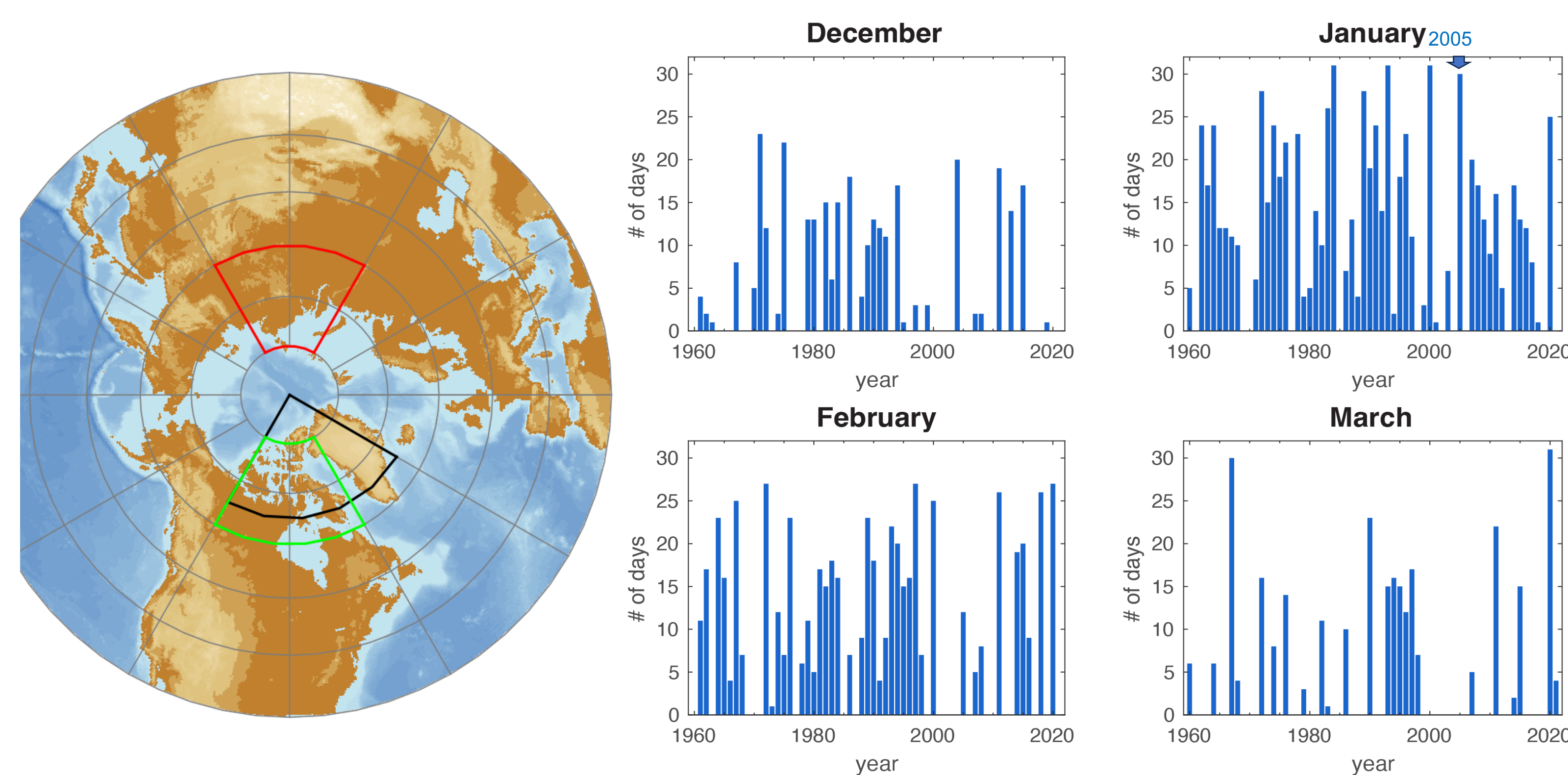


Fig. 2 Monthly accumulated number of days when Polar Vortex center shifted to the North American region (outlined by the green box in the left panel) for each individual month from 1960-2021.

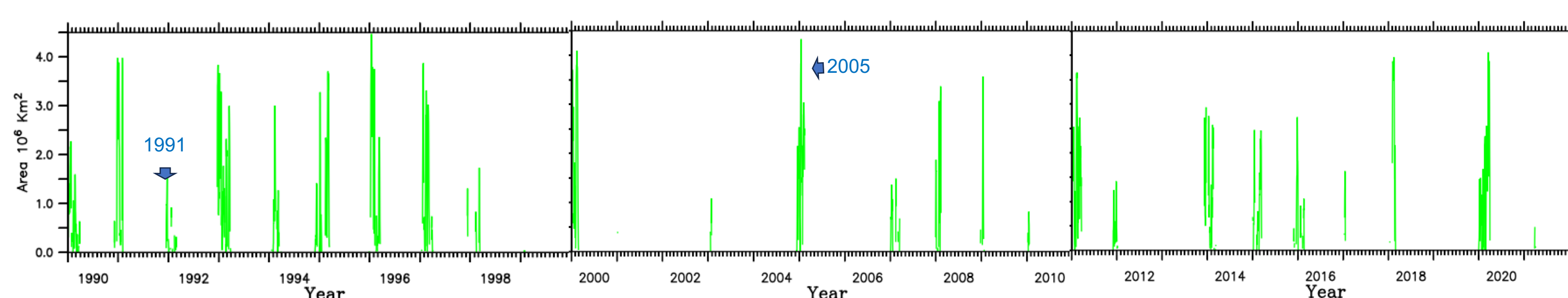
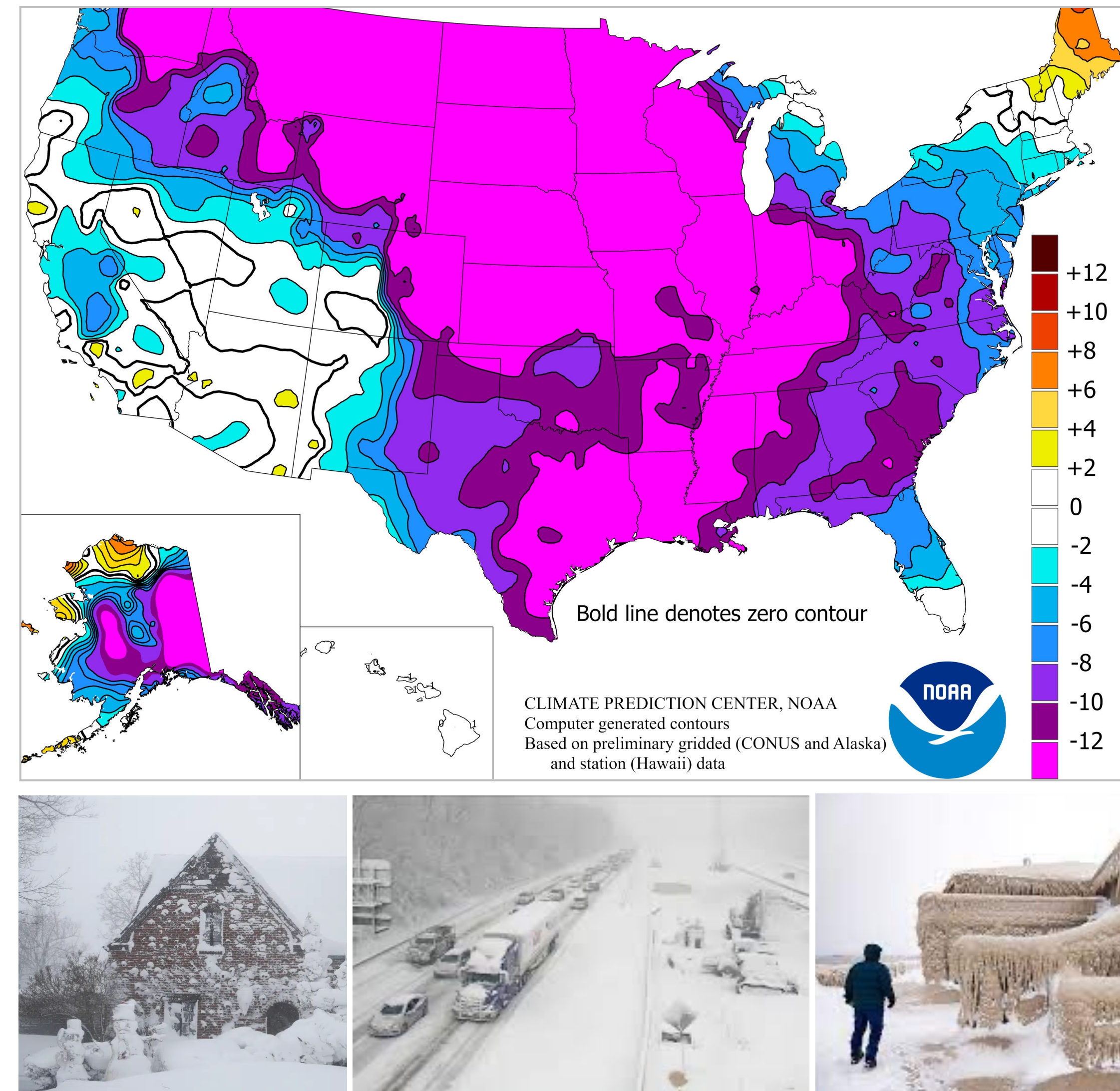


Fig. 3 Area of Polar Vortex occupied in the North American region based on daily 100hPa geopotential height -

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NWS: Dec 23-24, 2022 Winter Storm and Arctic Blast
An Arctic cold front swept through the region on the late afternoon and evening of December 23rd, with temperatures dropping over 30 degrees in 18 hours (highs in the mid-30s to lows in the single-digits below zero). [https://www.weather.gov/iwx/20221223_WinterStorm]

APPROACH

Persistent anomalies in the stratosphere polar vortex strength and location are associated with a robust regional surface weather response. (Huang et al. 2021). Our goal is to learn more about how the polar vortex provides useful information for understanding of CAO type events and increase the lead-forecast time of CAO events based on polar vortex. Mitchell et al. (2013) noted that split polar vortex events relate to colder temperatures across Eurasia, while displaced polar vortex events lead to CAOs across North America. Thus, Clusters 2 from Kretschmer et al. (2018) is of particular interest for North America. We use Z100 to identify the strength and duration of polar vortex for the period, and its association with the CAO events in eastern North America.

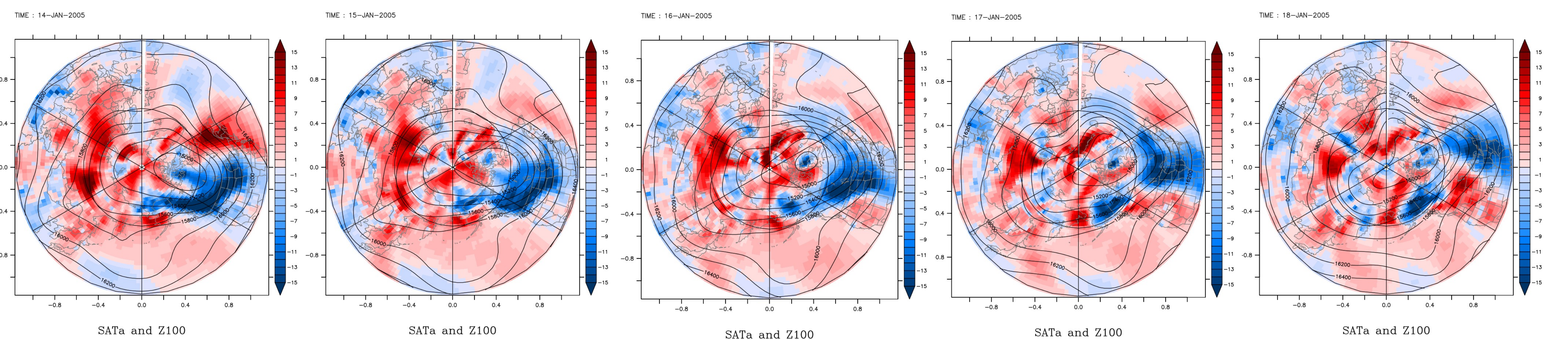
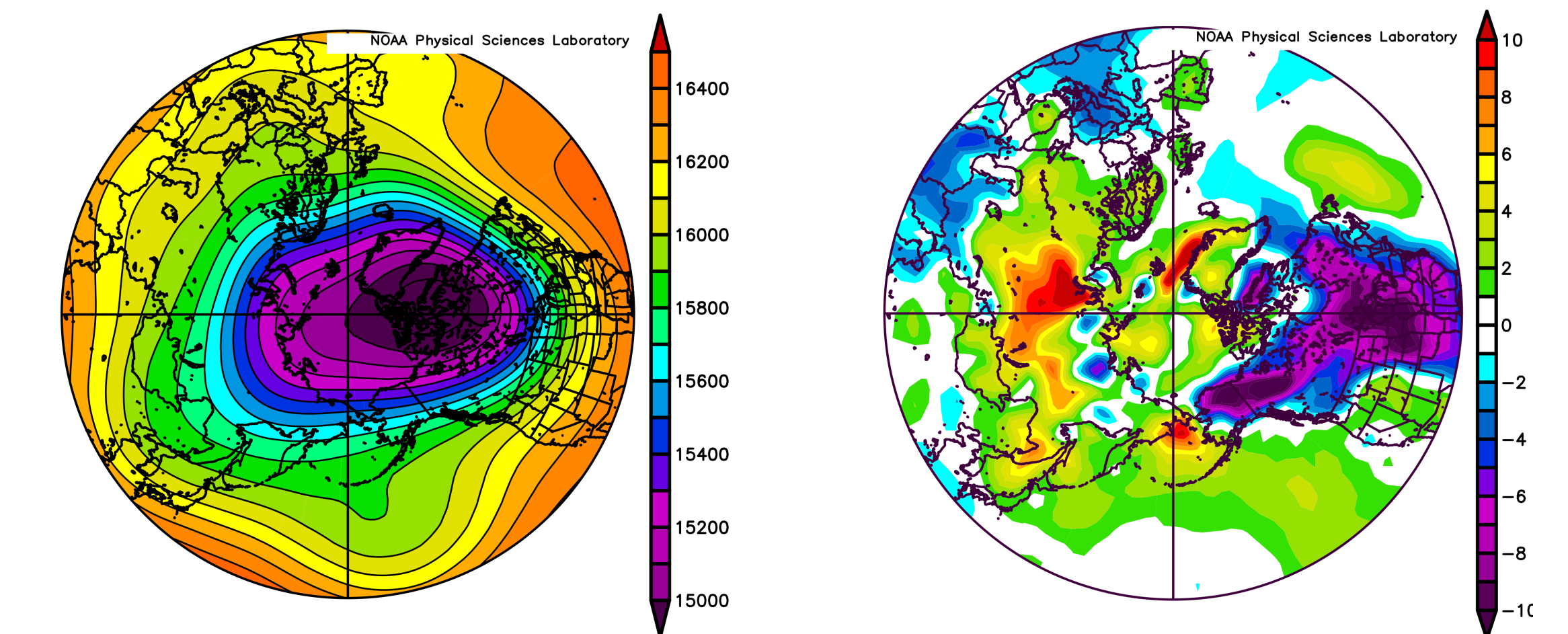


Fig. 4 Composite of 100hPa (Z100) geopotential height and surface air temperature anomaly (top panels) for January 14-17, 2005. The bottom panels show the evolution of flow pattern (Z100, contour) and the surface temperature anomaly (shading) during the CAO event.

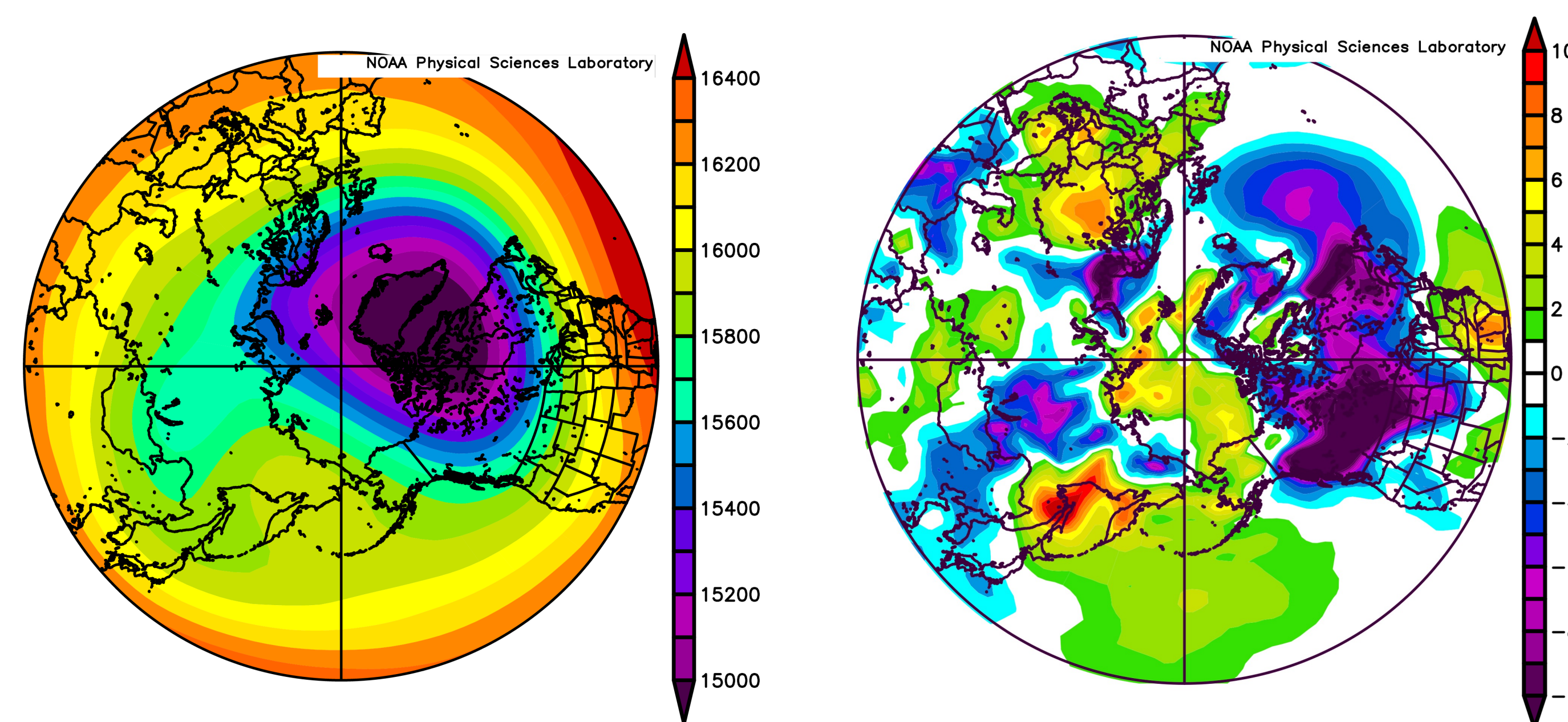


Fig. 5 Composite of Z100 (left) and surface air temperature anomaly (right) for January 5-9, 1991.

SUMMARY

Cases are shown when Polar Vortex and CAO events occur contemporaneously in January 15-18, 2005, and January 5-9, 1991. Comparison of the events showed that orientation of polar vortex axis also plays a role. Although there are many days of polar vortex center can show up in the NA region, the extent of polar vortex (i.e. the area of its center) may actually determine whether such signal will propagate down to the surface.

REFERENCES

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