Ocurrence and mechanisms of extreme winter air temperatures in the Arctic and surrounding continents

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EGU 2020, 4-8 May 2020

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Motivation

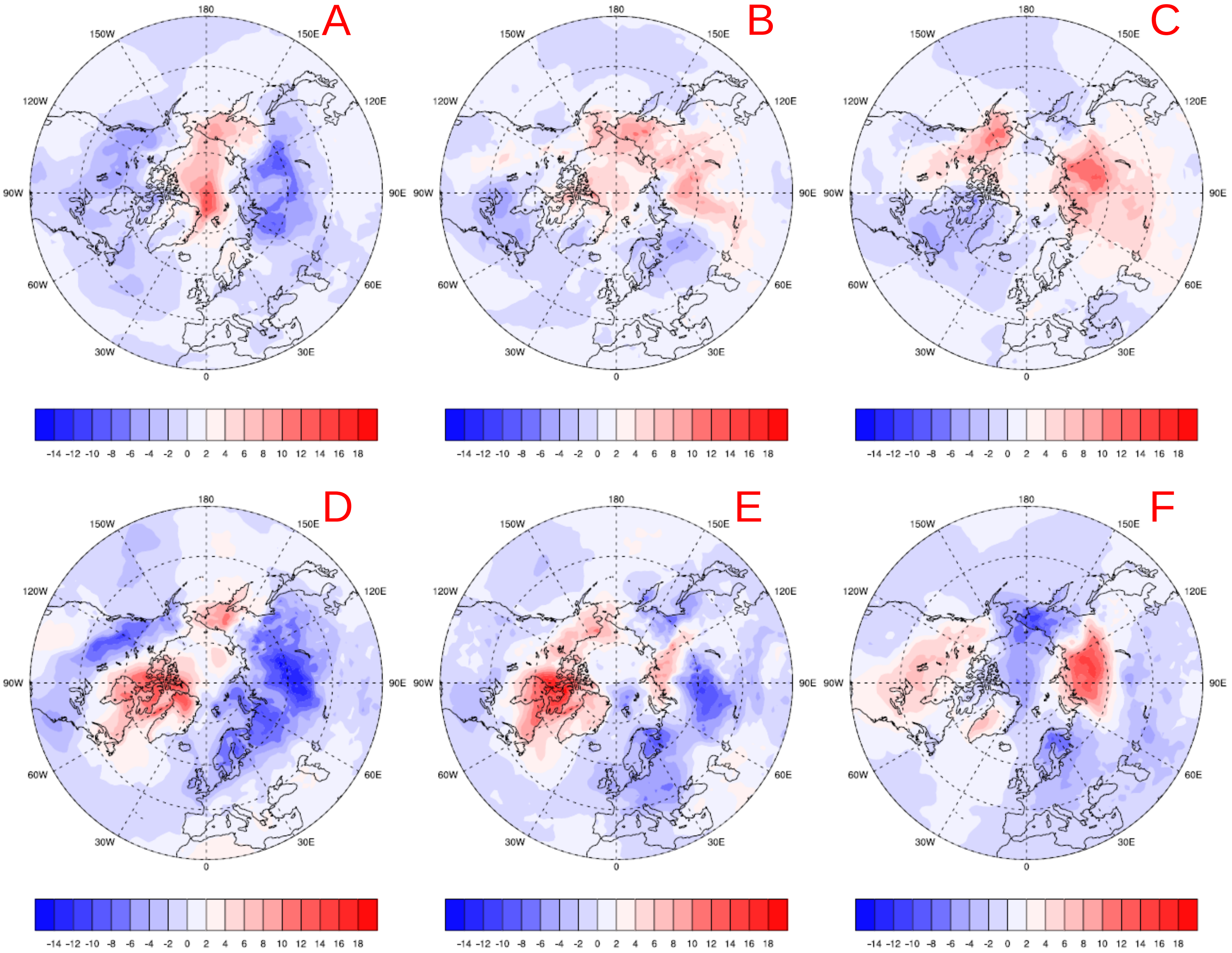
Individual cases of wintertime cold extremes in mid-latitudes and warm extremes in the Arctic have recently received a lot of attention.
Less studies have addresses larger populations of extremes in a hemispherical scale

This study

- winters 2006/07 – 2015/16 at 30-90°N
- 100 coldest and 100 warmest daily 2-m air temperature anomalies detected on the basis of ERA-Interim reanalysis
- Self-Organized Maps applied to cluster the air temperature anomalies and related variables
- air mass trajectory analyses: ensembles of 5 day backward trajectories using Hysplit

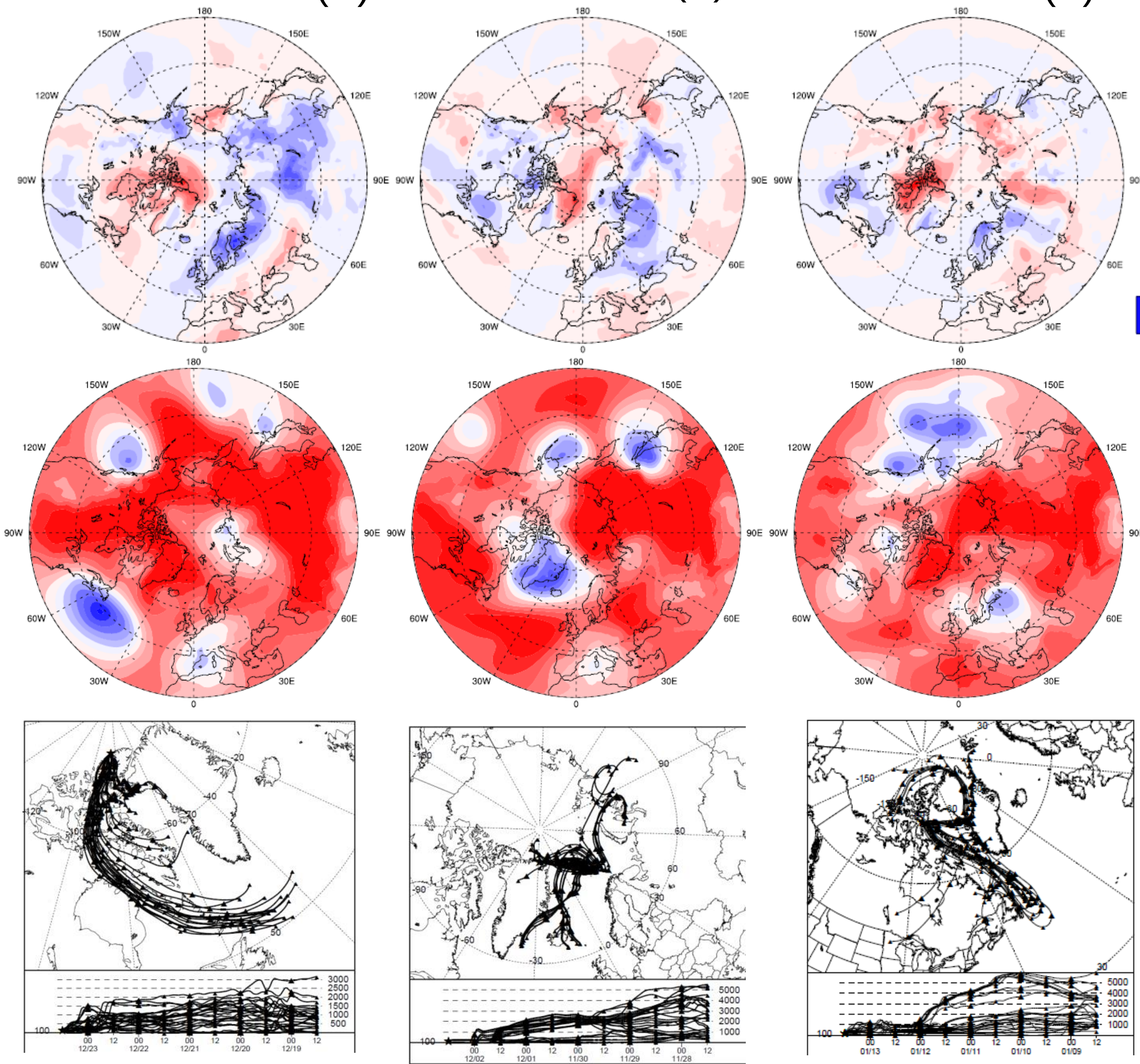
100 warmest T2m anomalies clustered in six groups (A-F)

Most common patterns A and F, together covering half of the 100-day population.

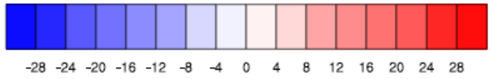


Three warmest anomalies in the Arctic (75-90N)

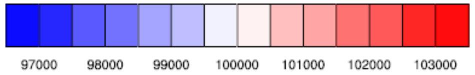
23 Dec 2010 (D) 2 Dec 2014 (A) 13 Jan 2016 (B)



T2m



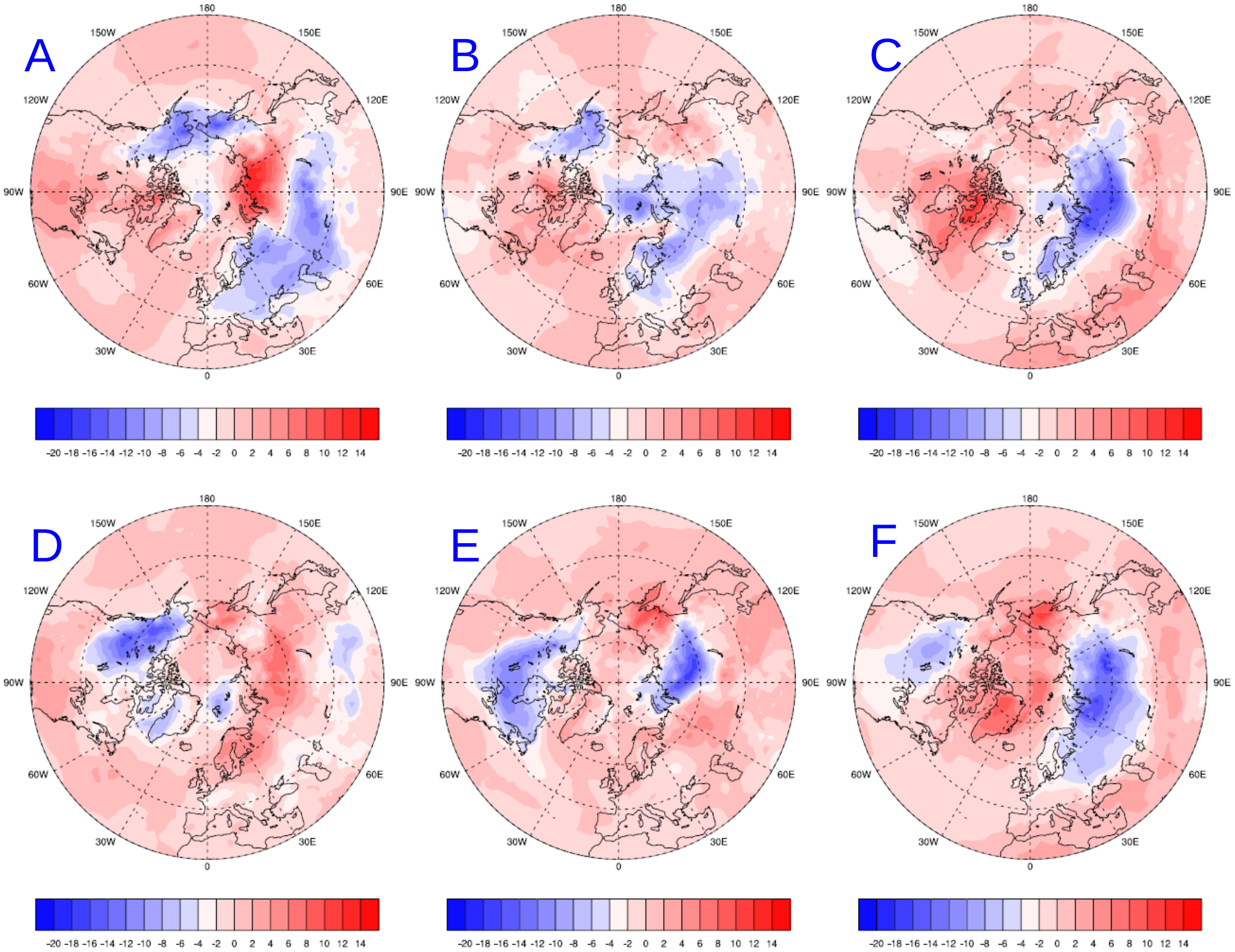
mslp



Warm anomalies up to 28 K occur under mslp as high as 1020-1030 hPa. Why?

Effects of warm-air advection and subsidence heating dominate over the high pressure, which would favour low T2m in winter.

100 coldest T2m anomalies at 30-90N during last ten winters clustered in six groups



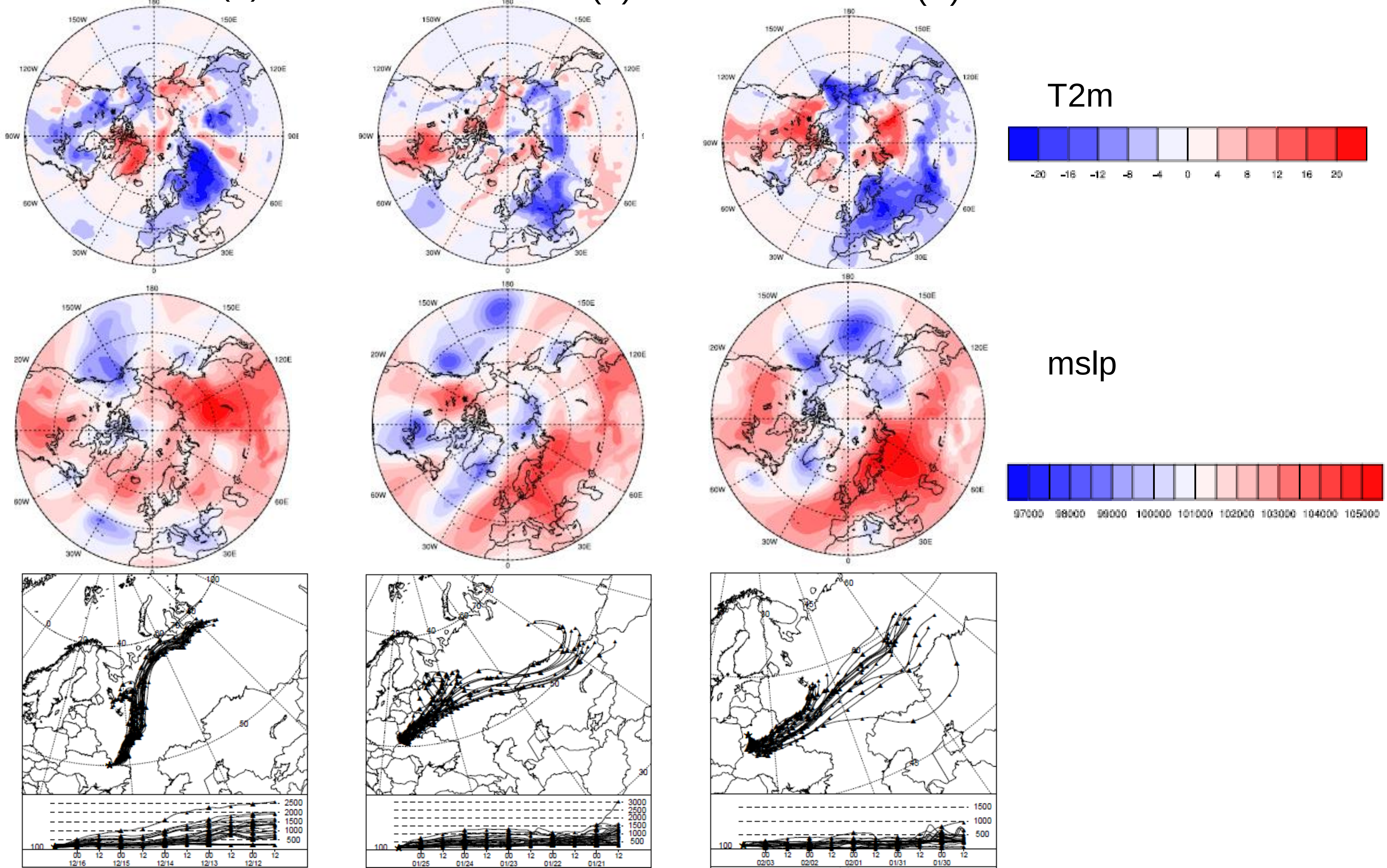
Highest occurrence of cold anomalies in climatologically cold areas.

Cold-air advection
-> cold anomalies at mid-latitudes.

Local thermodynamic processes and small heat capacity of a very stable boundary-layer
-> even stronger cold anomalies in the Arctic, although advection does not play as large a role.

Three coldest anomalies in Central Europe (5-30E, 45-55N)

16 Dec 2009 (**F**) 25 Jan 2010 (**F**) 3 Feb 2012 (**A**)



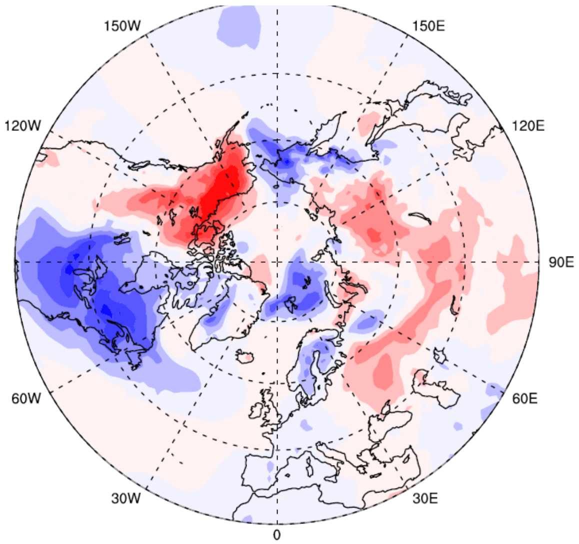
Coldest anomalies in Europe occur under high pressure.

Strongest cold anomalies related to easterly / northeasterly air-mass origin

Three coldest anomalies in eastern North America (70-90W, 30-45N)

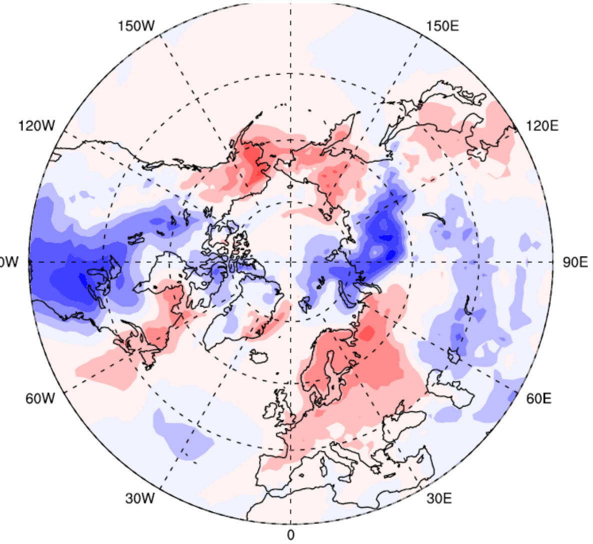
16 Jan 2009

T2m



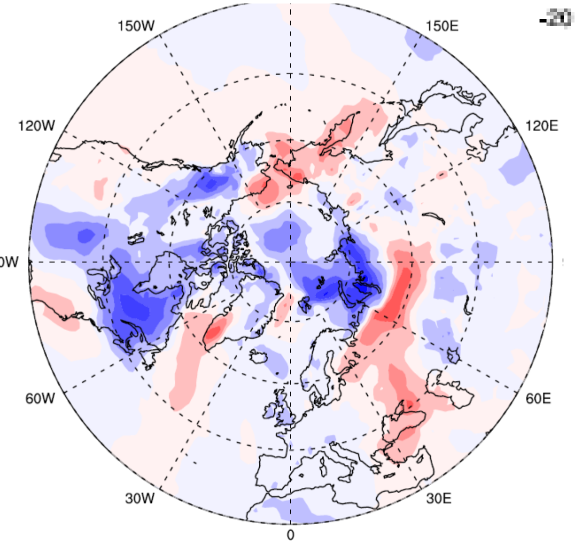
7 Jan 2014

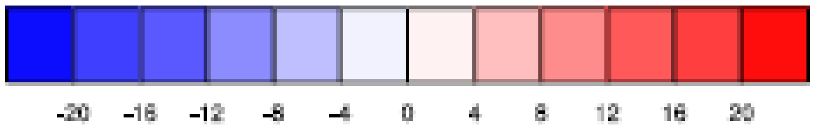
T2m

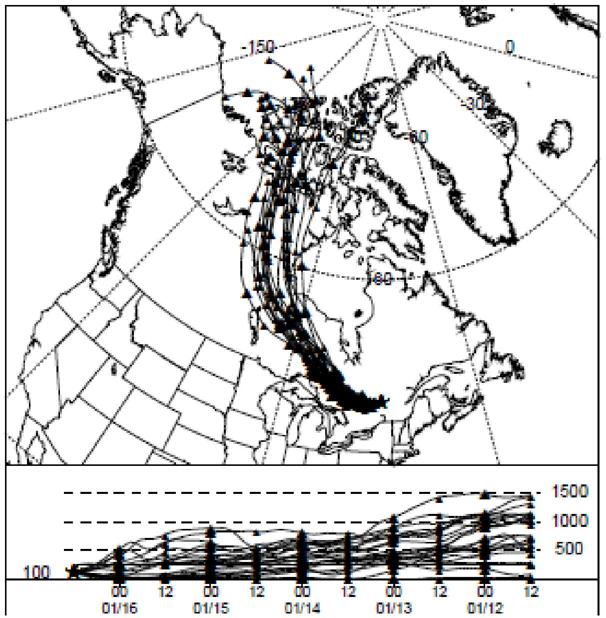


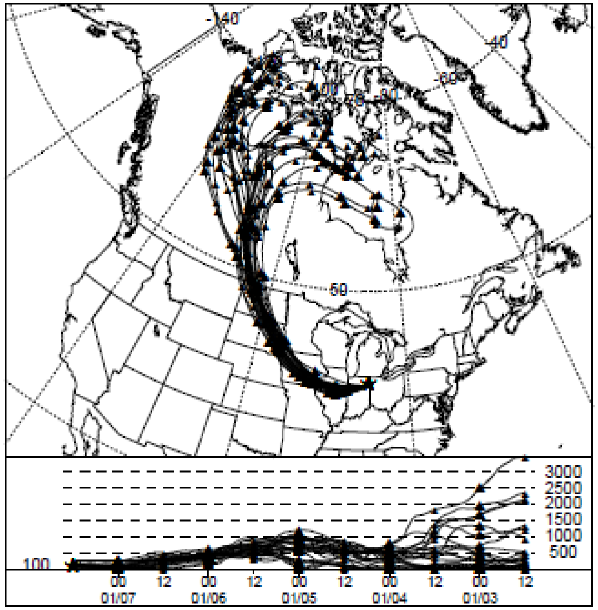
2 Feb 2015

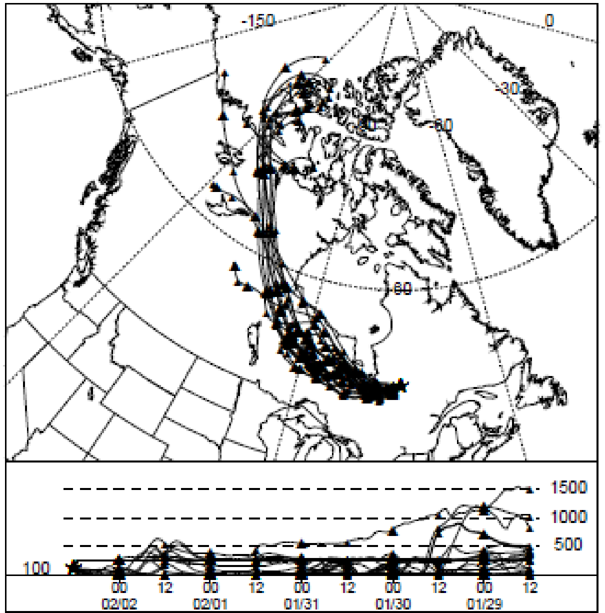
T2m







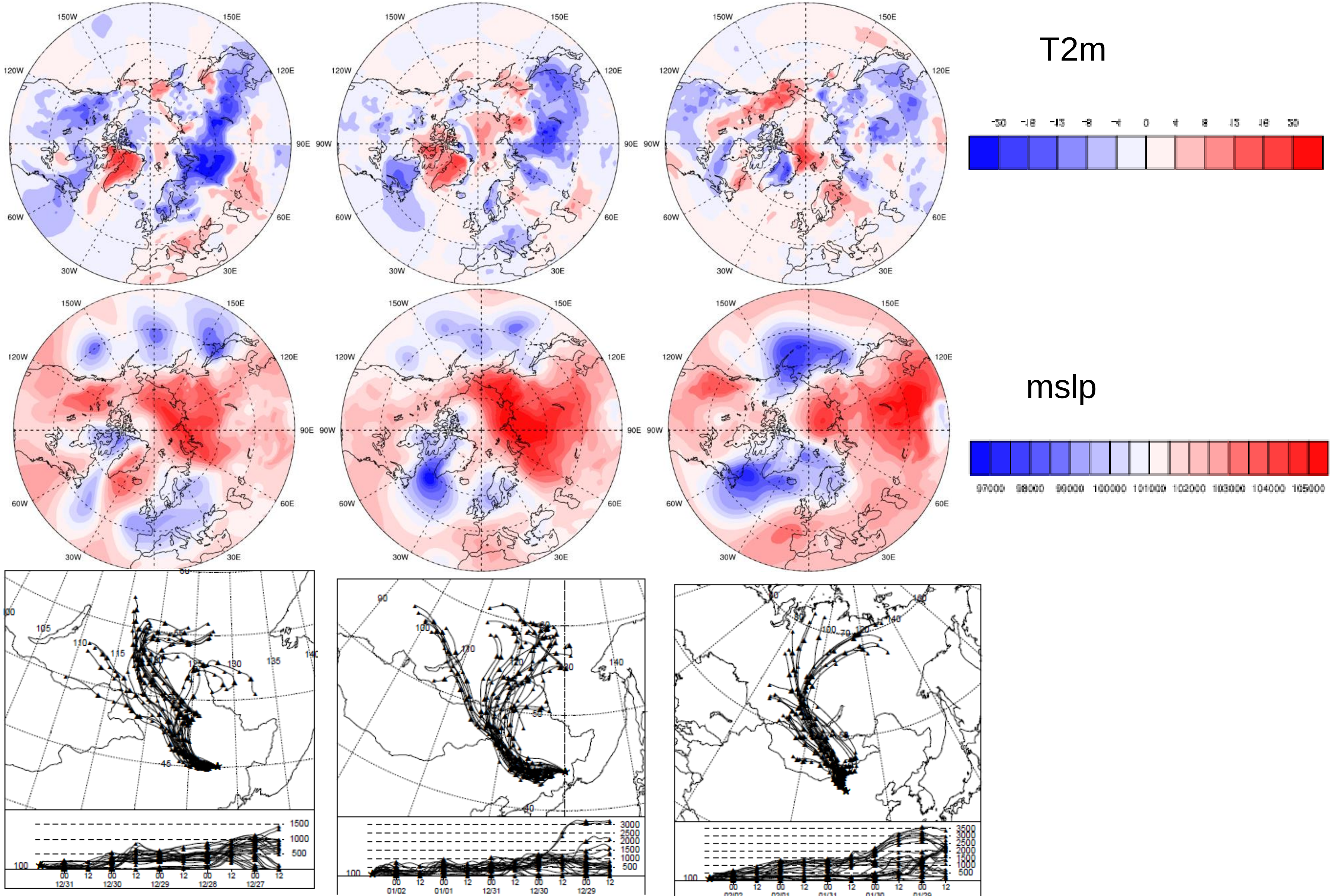




Three very similar cases of strong cold-air outbreaks from the Arctic

Three coldest anomalies in East Asia (110-145E, 30-45N)

31 Dec 2009 2 Jan 2013 2 Feb 2010



Coldest anomalies occur under high pressure and weak winds (short trajectories)

Role of cold-air advection much weaker than in the North American cases.

Conclusions

- Strong warm and cold anomalies in winter are most common in climatologically cold regions

- Three warmest anomalies in the central Arctic were driven by warm-air advection from mid-latitudes and subsidence heating. These together dominated over the effect of a high pressure pattern, which is typically associated with cold winter weather in the Arctic

- Three coldest anomalies in Central Europe were due to a local high pressure pattern and cold air advection from Eurasian continent

- Three coldest anomalies in North-American East Coast were due to strong cold air advection from the Arctic

- Three coldest anomalies in East Asia were due to a local high pressure pattern, weak winds, and moderate cold air advection from Siberia

- Better understanding on the generation of strong temperature anomalies requires attention to both large-scale circulation and local surface energy balance / boundary-layer processes