Record high pressure over the North Pole in March 2013 extends the winter in Europe

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Large parts of Europe experienced extreme weather conditions in March 2013. Northern Europe was relatively dry and very cold, while many parts of Southern Europe were very wet. Halfway March, a region over Central Europe extending from England over Northern France and further eastward was covered by a heavy blanket of snow.

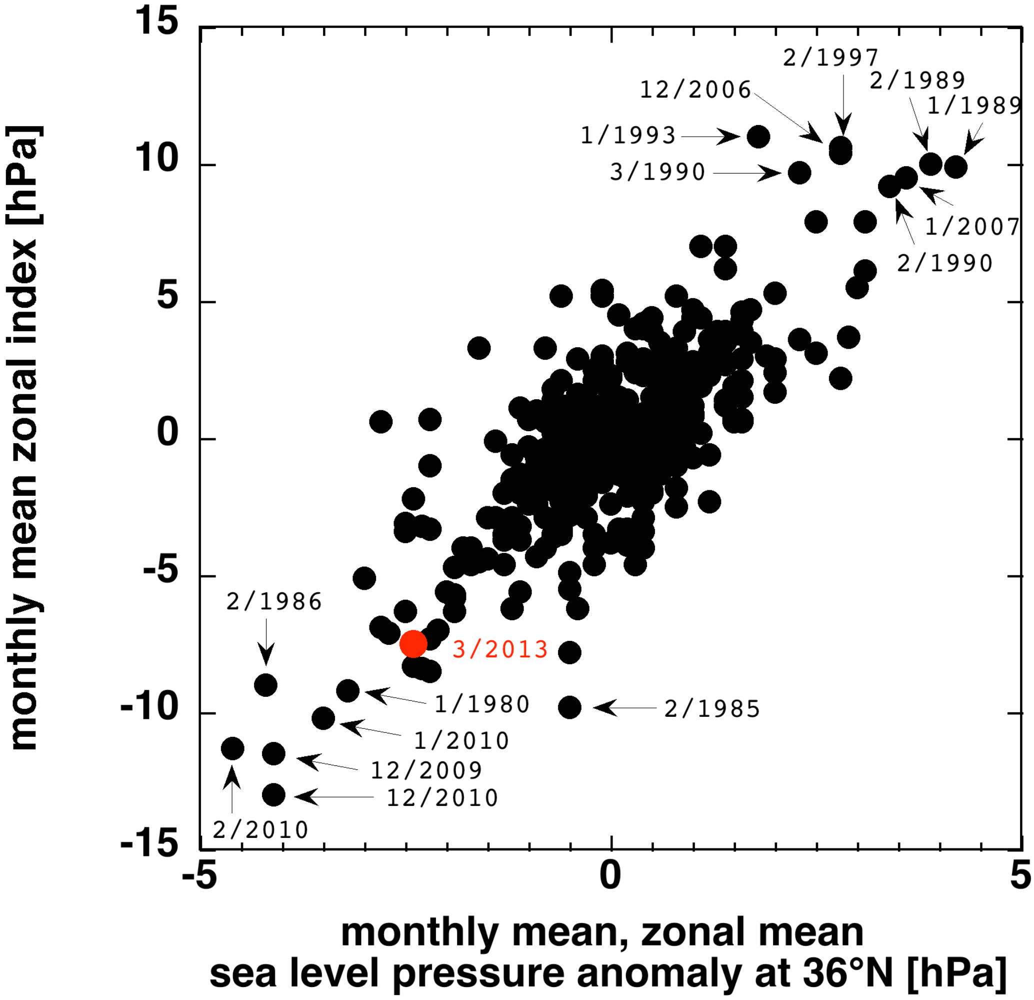
Reasons for these weather extremes can be traced back to anomalously high sea level pressure over the Arctic. Monthly mean sea-level pressure at the North Pole in March 2013 was 1035.8 hPa, which is by far the highest value recorded since the beginning of trustworthy reanalyses in January 1979. The previous record (1033.7 hPa) was set in februari 2010. Simultaneously, sea level pressure was lower than normal at middle latitudes. This very persistent sea level pressure pattern led to strong easterly winds, bringing very cold air from Russia to Northern Europe. The storm track was shifted southward towards Southern France and Italy.

The occurrence of anomalously high sea level pressure over the Arctic and, at the same time, anomalously low sea level pressure at middle latitudes is the consequence of systematic shifts of masses of air from the middle latitudes towards the Polar cap. This phenomenon, which is frequently described as "blocking", is most typical of the winter period between December and March.

Traditionally, the intensity of "blocking" is measured by an index, called the "zonal index". Following Li and Wang (http://ljp.lasg.ac.cn/dct/page/65569) the "zonal index" is defined here as the anomaly, with respect to the long term average, of the zonal mean (mean with respect to the longitude) sea level pressure difference between 36°N and 66°N. The monthly mean values of this quantity are plotted in the figure below, as a function of the zonal mean sea level pressure anomaly at 36°N. Apparently, the two quantities are linearly correlated. This clearly reflects the seesaw in mass between the middle latitudes and the polar cap. Periods with excessive mass over the Arctic are followed by periods with excessive mass over the middle latitudes. In the former case high pressure areas are formed at high latitudes, while in the latter case subtropical high pressure areas, such as the Azores high, are stronger than average.

Swings between positive zonal index (anomalously low sea level pressure in the Arctic) and negative zonal index (anomalously high sea level pressure in the Arctic) are largest in the winter. There is an interesting and ill understood clustering in time of months possessing extreme values of the zonal index, such as in the winter of 2009-2010 and in the winters of 1988-1989, 1989-1990 and 2006-2007. This suggests that the zonal index is governed by anomalous physical processes that can be sustained for at least a month or, perhaps, even for a year.

Zonal mean equatorward mass transfer in winter occurs in bursts of several days at low levels in polar air outbreaks, while sustained zonal mean net poleward mass transfer occurs principally in the extratropical upper troposphere and lower stratosphere, the "Ex-UTLS".



Scatterplot showing the monthly mean, zonal mean sea-level pressure anomaly at 36 °N (horizontal axis) and the difference of this quantity with the monthly mean, zonal mean sea-level pressure anomaly at 66°N, i.e. the zonal index (vertical axis). Every black dot in the graph corresponds to one of the 408 months in the years 1979 to 2012. Anomalies are computed with respect to the monthly mean climate over the period 1979-2012. The red dot corresponds to March 2013. The months with largest anomalies are indicated explicitly. Data for the period 1979-2012 is based on the ERA-Interim reanalysis.

Insight into the interaction between dynamics and radiation in the Ex-UTLS as well as knowledge of what governs the latitude of the storm track, and therefore the latitude of cold air outbreaks, probably represent keys to understanding the variability of the zonal index. These topics are the object of research at IMAU (see van Delden and Hinssen, 2012). Hopefully, this research will also lay bare the reasons for the recent sustained high values of the zonal index.

Reference

A.J. van Delden and Y.B.L. Hinssen, 2012: PV-theta view of the zonal mean state of the atmosphere. **Tellus A** 2012, 64, 18710, http://dx.doi.org/10.3402/tellusa.v64i0.18710.