Winter of extremes in the North Atlantic region

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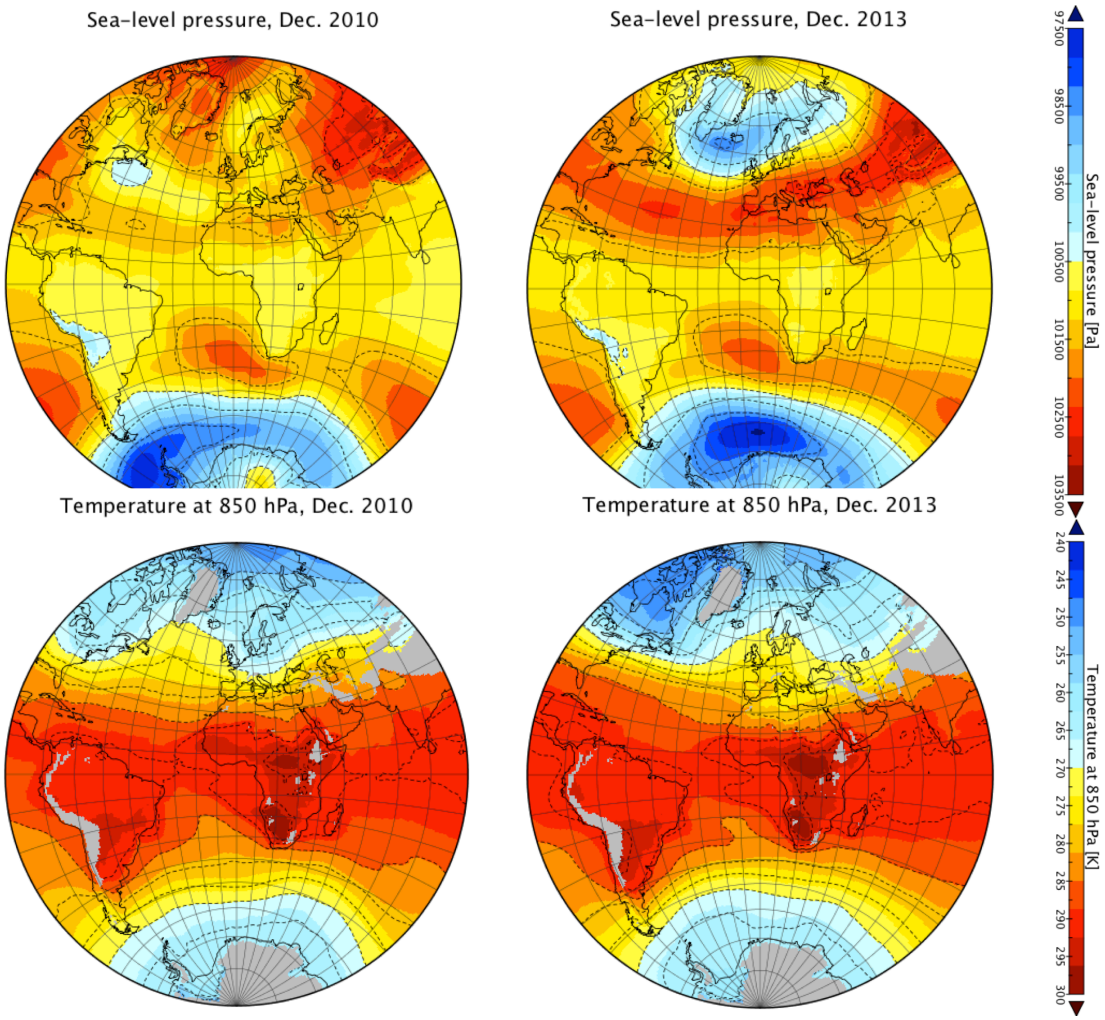
This winter blizzards and extremely low temperatures affected Eastern Canada and the United States, while temperatures were relatively high on the other side of the Atlantic Ocean. The coasts of Western Europe, from Portugal to Scotland, were repeatedly battered by huge waves, whipped up by hurricane force winds. These winds were associated with exceptionally deep and large cyclonic depressions. Sea-level pressures below 940 hPa were no exception. The genesis area of these depressions, as is usual, coincided with the warm Gulf Stream, close to the east coast of the United States, where horizontal temperature gradients exceed the threshold for the occurrence of an instability, called "baroclinic instability", which is the seed for the growth of a cyclone. However, this winter the horizontal temperature gradients in this area were very large, not only due to the persistent and extremely low temperatures over Eastern Canada, but also due to the simultaneous presence of relatively warm air over the southern part of the United States (e.g. Florida). This led to repeated "explosive" cyclogenesis over the Western Atlantic Ocean.

Very mild and moist air was transported to Europe by the westerly winds associated with these storms. In Vlissingen, on the south west coast of the Netherlands, the temperature at standard observation height (1.5 m above the earth's surface) did not drop blow freezing during both December 2013 and January 2014, which is very exceptional. The average temperature in De Bilt (The Netherlands) in the months of December and January was about 2.5 K above normal. At the same time, on the west side of the Atlantic Ocean, very cold air was transported from the Arctic into Eastern Canada and parts of the United States. Due to this, the strong baroclinic instability was promoted over the Western Atlantic, leading to the formation of new intense cyclones, which moved slowly towards Europe.

The repeated presence over the central Atlantic Ocean of huge cyclones with diameters of many thousands of kilometers, simultaneously influencing the weather in countries as far away as Portugal and Scotland, sets this winter apart from other winters, even those that were also characterized by strong cyclonic activity over the Atlantic ocean. These winters are always characterized by positive North Atlantic Oscillation (NAO) index. This index reflects the sea level pressure difference between Iceland and the Azores. A positive NAO-index indicates above normal pressure over the Azores and simultaneously below normal pressure over Iceland (see http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml).

The panels on the right in the figure below show the average sea level pressure and the average temperature at 850 hPa in December 2013, according to the "MERRA" reanalysis (http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset.pl). For comparison, the panels on the left show the average of the same variables for the month of December 2010, which was characterized by a negative NAO-index. In the negative NAO-index month sea level pressure is high in high latitudes and low in lower latitudes. In other words, in December 2010 more atmospheric mass was shifted towards pole while in December 2013 more atmospheric mass was shifted towards sub-tropics, thus strengthening the subtropical highs at the surface. The processes that determine these meridional mass shifts are the subject of intense research, also at IMAU.



Average sea level pressure and average temperature at 850 hPa in december 2010 (left panel) and in December 2013 (right panel). Contour interval is 10 hPa and 5 K. The first winter is characterized by high sea level pressure at high latitudes and weak horizontal temperature contrasts in the Western Atlantic, while the second (present) winter is characterized by low sea level pressure over the Arctic, in particular over the North Atlantic Ocean, high sea level pressure in the subtropics and intense horizontal temperature contrasts in the Western Atlantic. Source of the data: http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset.pl.