Unlikely high temperatures in December 2015

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https://www.uu.nl/en/news/unlikely-high-temperatures-in-december-2015

With summer approaching, one may already have forgotten the past winter. This is understandable, because this winter was rather uneventful, apart from the highly exceptional mildness of December. The monthly average temperature in the Netherlands, measured in December 2015 (9.6°C in De Bilt), would have been normal for the Mediterranean coast of Spain or Italy, and is higher than the normal temperature in April in the Netherlands. In fact, the average temperature in the second half of April 2016 was 3.4°C lower than the average temperature in the second half of December 2015, despite the fact that daily incoming solar radiation is more than 3 times higher in the second half of April (**figure 1**).

Alpine ski slopes received their first significant batch of snow at the end of November 2015, but this snow quickly melted during the first half of December. Christmas holidays in the Alps were thus spent hiking and enjoying picnics in the sun, instead of skiing (**figure 2**).

In the middle and west of continental Europe, positive temperature anomalies of 6°C were widespread. The positive monthly temperature anomaly in December 2015 in De Bilt by far exceeded any previous such anomaly in any month since 1900 (**figure 3**). What physical processes were responsible for the occurrence of this positive outlier?

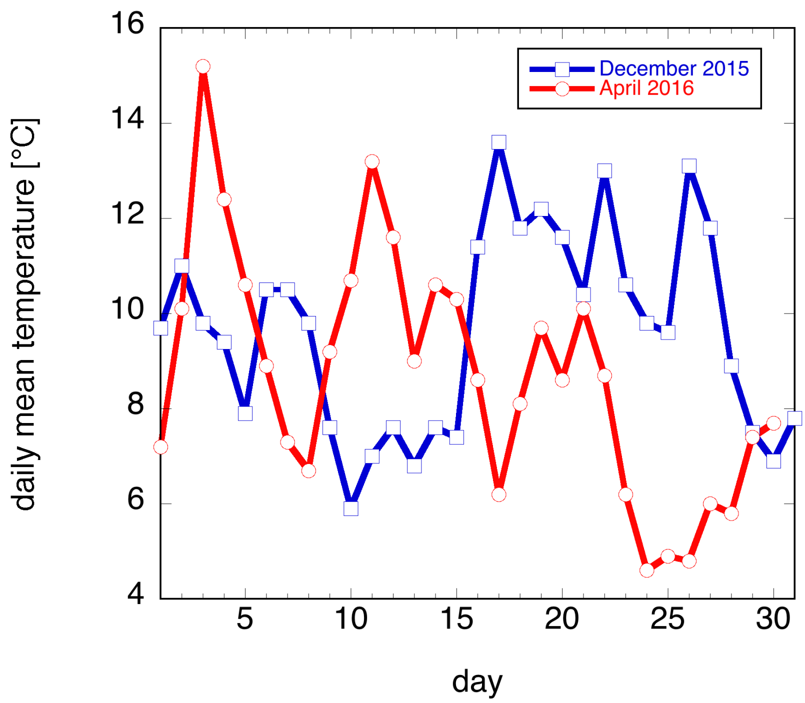

Figure 1. Daily average temperatures in De Bilt in December 2015 (blue) and in April 2016 (red). Source of the data: http://www.knmi.nl/nederland-nu/klimatologie-metingen-en-waarnemingen.

Figure 2. Having lunch outside at 1800 metres above sea level near Meribel in the French Alps on December 30, 2015.

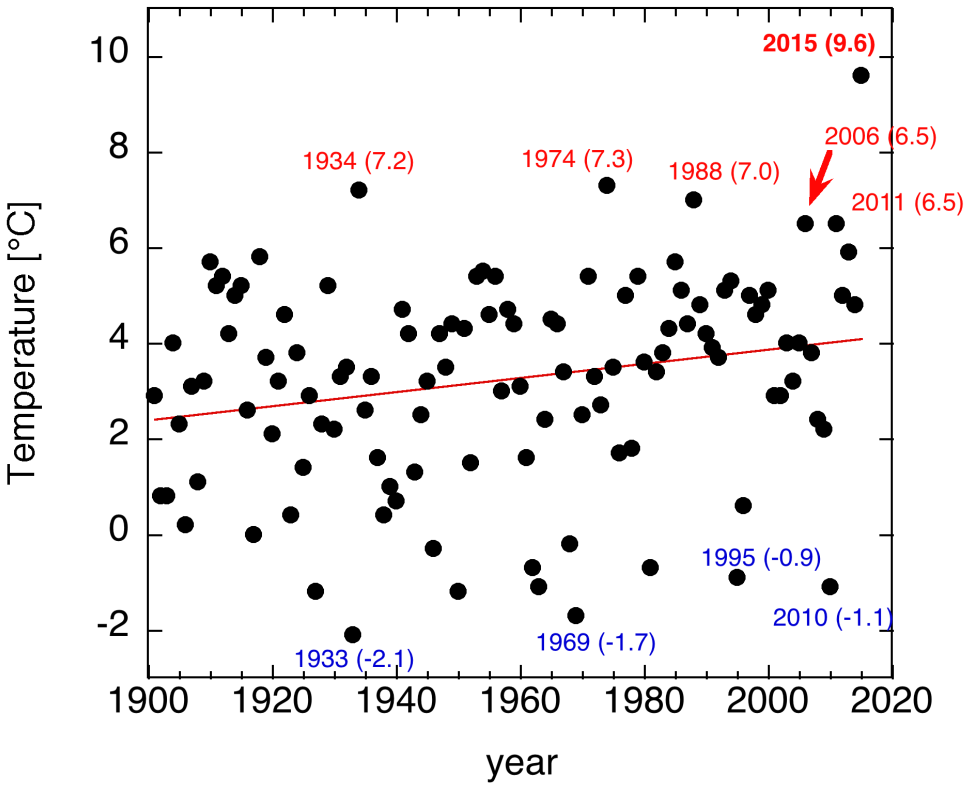

Figure 3. Average temperature in December, in De Bilt, between 1900 and 2015. The previous record of 1974 was beaten by more than one standard deviation in December 2015. The linear trend of +1.5 °C per century, indicated by the straight red line, is a reflection of "global warming" due to increasing greenhouse gas concentrations. The outlier of 2015 might be a reflection of feedback mechanisms induced by "global warming".

Most of continental Europe was extremely dry. Athens and Palma de Mallorca did not receive a drop of rain in December 2015. Total precipitation for this month in Madrid, Gibraltar, Marseille, Munich, Rome, Prague, Budapest, Bucharest and Istanbul was less than 10 mm. On the other hand, rainfall in Northern England and Southern Scotland was truly phenomenal. At Eskdalemuir (longitude: 3°W), in Southern Scotland, precipitation in December 2015 totaled
569 mm, more than 3 times the long term December average (185 mm).

Feedback mechanisms usually serve as an explanation for the occurrence of extremes in temperature. The *albedo-feedback*, whereby snow and ice reflect solar radiation, easily explains the extreme negative temperature anomalies in winter, such as the all-time record temperature anomaly of February 1956 (-9.4°C in De Bilt), and probably also every *negative* outlier in **figure 3.** Strong *positive* outliers in winter are more difficult to explain, as opposed to positive temperature anomalies in summer, which are frequently attributed to the feedback between the water cycle and net radiation. This feedback can, for example, explain the abnormally high temperatures in the dry months of April 2007, April 2011 and July 2006 (with temperature anomalies between +4 and +5°C in De Bilt), whereby, due to the soil-dryness, solar heating is *not* used to evaporate water, but almost exclusively to heat the lower atmosphere, which leads to reduced cloud cover and reduced precipitation, thus amplifying both the drought and the heat. Although this feedback does not work if net radiation is dominantly negative, as in December at the latitude of De Bilt (52°N), it is likely that the drought in southern Europe raised low- level temperatures there. This might also have contributed to positive temperature anomalies farther north, since the dominant wind direction was southerly throughout the month. Nevertheless, the extreme warmth of December 2015 can probably not be attributed to one specific feedback mechanism.

Jennifer Francis, at Rutger University (USA), has pointed to a statistical connection between the dramatic reduction of Arctic sea ice in this century and the increased meridional amplitude of stationary waves in the circumpolar circulation of the northern hemisphere, leading to either persistent poleward (warm) winds or persistent equatorward (cold) winds at specific longitudes, depending on the phase (position) of the wave.

While the average wind direction at 500 hPa over Europe is northerly in a normal December, the opposite was true for December 2015. Indeed, very strong and sustained southerly winds were observed at all levels in the troposphere over most of Western Europe, especially over the British Isles. The complete absence of polar air outbreaks over Western Europe was remarkable. Apparently (**figure 4**), the southerly flow was connected to a highly abnormal and persistent position and amplitude of the planetary waves over the Atlantic sector between 60°W and 60°E.

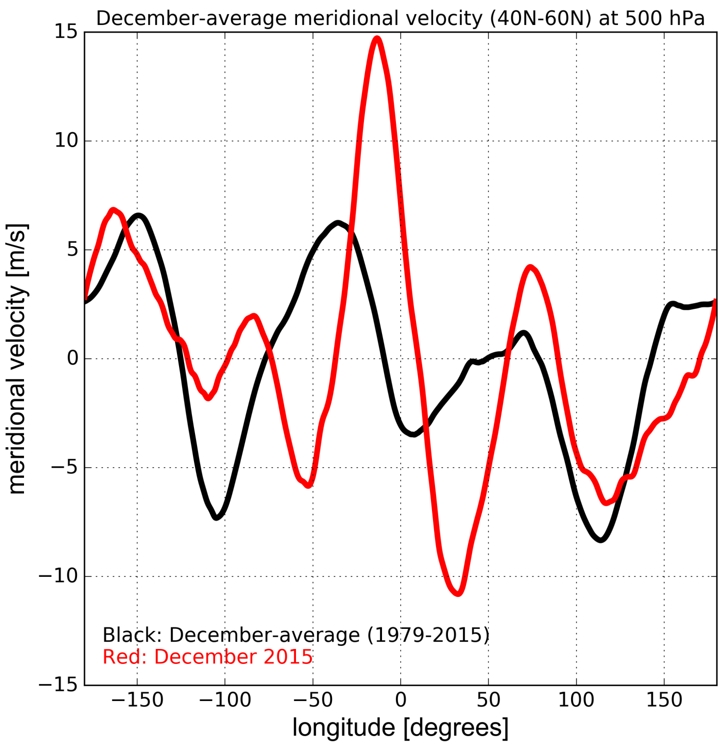

Figure 4. Monthly average meridional (south-north) component of the wind at 500 hPa (about 5 km above sea level (positive is northward), averaged over the latitude band between 40°N and 60°N, as a function of longitude in December 2015 (**red curve**) compared to the December-average between 1979 and 2015 (**black curve**). Source of the data: ERA-Interim-reanalysis: http://apps.ecmwf.int/datasets/data/interim-full-moda/levtype=pl/).

Unfortunately, statistics do not provide much physical insight. Many fundamental questions, relating to physics, remain unanswered. For instance: how does reduced Arctic sea ice cover influence the amplitude of planetary waves in the jet stream? Did the strong "El Niño", which was at its height at the end of 2015, have an influence on the position, amplitude and number of atmospheric troughs and ridges in the Atlantic sector? These questions can be answered only if we have a more detailed understanding of how planetary waves are affected by mountains, land-sea contrasts and changes in atmospheric and sea-surface temperature distributions.

References

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