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Above the poles: ozone research and polar vortex

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Ellie Farahani, SPARC IPO, WCRP, UN

One of the more compelling issues of the 20th century arose with the discovery that the Antarctic 'ozone hole' is caused by emissions of chlorofluorocarbons (CFCs) resulting from human activities. Thanks to actions taken as the result of the Montreal Protocol from 1987, the ozone hole has stabilized and is expected to slowly recover during the 21st century. Stratospheric ozone has also been depleted in the Arctic, although to a much lesser extent.

"Perhaps the single most successful international agreement to date has been the Montreal Protocol" said Kofi Annan, former Secretary-General of the United Nations in his Millennium Report. However, the latest WMO/UNEP Ozone Assessment, which to a large extent builds on the research coordinated by the World Climate Research Programme's project on Stratospheric Processes and their Role in Climate (SPARC), made clear that there are 'factors other than ozone-depleting substances that also influence ozone and UV radiation. These factors include natural dynamical variability, volcanic eruptions, solar variations, aerosols and climate change'.

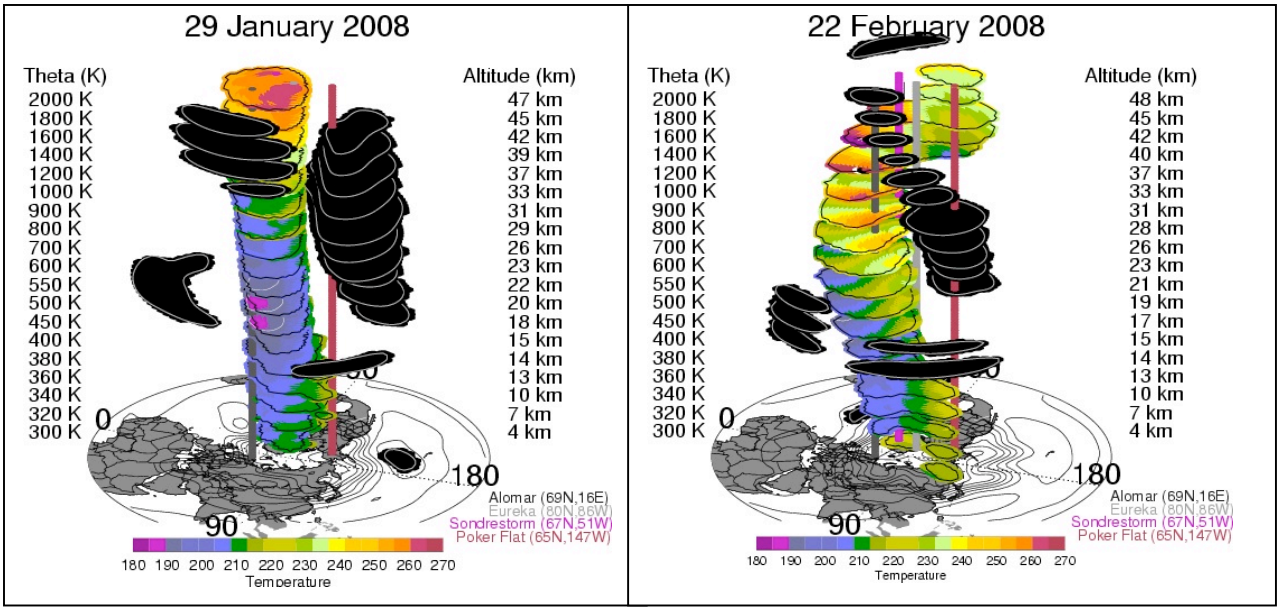
The polar vortex is a persistent, large-scale cyclone located near the Earth's poles, in the middle troposphere and upper stratosphere, say, between 6 and 10 km altitude. Large-scale cyclonic circulations are almost always centered on areas of low atmospheric pressure. Find more on ozone-polar vortex research at http://research.iarc.uaf.edu/IPY-CTSM/overview.php.

7th International Polar Day on 4 December 2008: http://www.ipy.org/index.php?/ipy/detail/abovethepoles

Ted Shepherd, Co-Chair of the SPARC Scientific Steering Committee, analysed the key issues arising from the 2006 Ozone Assessment report for the SPARC research agenda and noted that predictions of the evolution of ozone concentration in the atmosphere above the poles are "highly uncertain", in particular for Arctic ozone, because of "large uncertainties in the future dynamical state of the Arctic polar vortex". SPARC research focuses on improving model simulation of ozone to become more robust and provide better estimates of the uncertainty associated with natural variability as well as the effects of climate change.

A SPARC activity conducted during the International Polar Year 2007-2008 studies this interplay between polar vortex and ozone in polar regions with a particular emphasis on the stratospheric layer which extents above 8 km altitude. The main goal of the project (SPARC-IPY activity No. 217) is to document the dynamics, chemistry and microphysical processes within the polar atmosphere.

One of the most active components of this SPARC-IPY activity is the Pan-Arctic Study of the Stratospheric and Mesospheric Circulation. This comprehensive observational and modelling study of the Arctic aims to extend our understanding of upper atmospheric circulation and features and its interaction with the lower atmosphere. A description of the structure and evolution of Arctic vortex and anti-cyclones is only one of the features analysed. For this, satellite measurements and data from radiosondes and lidars, laser technology measuring the properties of scattered light, are used. The resulting high-resolution 'state-of-the-Arctic middle atmosphere' data set is then assimilated in numerical models to yield an improved understanding of the circulation of the Arctic middle atmosphere. High-resolution temperature and wind data form the basis of a detailed analysis of polar vortex evolution (**figure**). Ultimately, the reproduction of processes in this atmospheric region will help to generate predictions of responses of the Arctic middle atmosphere to changes in the circulation. The Pan-Arctic observational network consists of five lidars (= light detecting and ranging technology) in Norway (69°N, 16°E), Canada (80°N, 86°W), Alaska, USA (65°N, 147°W), Greenland (67°N, 51°W), and Germany (54°N, 12°E).



Comparison of the polar cyclone (coloured circles) and anticyclones (black circles) on 29 January 2008, a quiet day, and 22 February 2008, a day with disturbances in the middle and upper atmosphere. Between 17 February and 23 February 2008 a major stratospheric warming resulted in a very mobile and split vortex. The travelling anticyclone over Russia and the Aleutian High over the North Pacific merge on 21 February. The resulting anticyclone weakens and distorts the shape of the vortex. On February 22nd and 23rd, the anticyclone is over the pole and the vortex is "wrapped" around it in midlatitudes. The vortex in the upper stratosphere is split into three distinct lobes. As a result, none of the four lidars provide continuous sampling inside the vortex. Image source: http://research.iarc.uaf.edu/IPY-CTSM/.

Today, on 4 December 2008, the International Polar Year 2007-2008 (IPY) launches its seventh International Polar Day focusing on research above the polar regions, including atmospheric sciences, meteorology, astronomy, and the view of the polar regions from space. This event coincides with the start of the International Year of Astronomy (IYA) in 2009 and the lead-up to IPY Celebrations in February 2009.
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Links & references

Annan, K. A. (2000) We the peoples. The Role of the United Nations in the 21st century. http://www.un.org/millennium/sg/report/full.htm

Shepherd, T. and W. J. Randel (2007) Key issues arising from the 2006 WMO/UNEP Ozone Assessment. SPARC newsletter No. 29, July 2007. http://browser.grik.net/www.atmosp.physics.utoronto.ca/SPARC/Newsletter29/newsletter29.pdf

SPARC project http://www.atmosp.physics.utoronto.ca/SPARC/

SPARC-IPY mission http://www.atmosp.physics.utoronto.ca/SPARC-IPY/IPYmain.html

SPARC-IPY activity No. 217 http://research.iarc.uaf.edu/IPY-CTSM/overview.php.