Does a Sudden Stratospheric Warming trigger Ozone Destruction?

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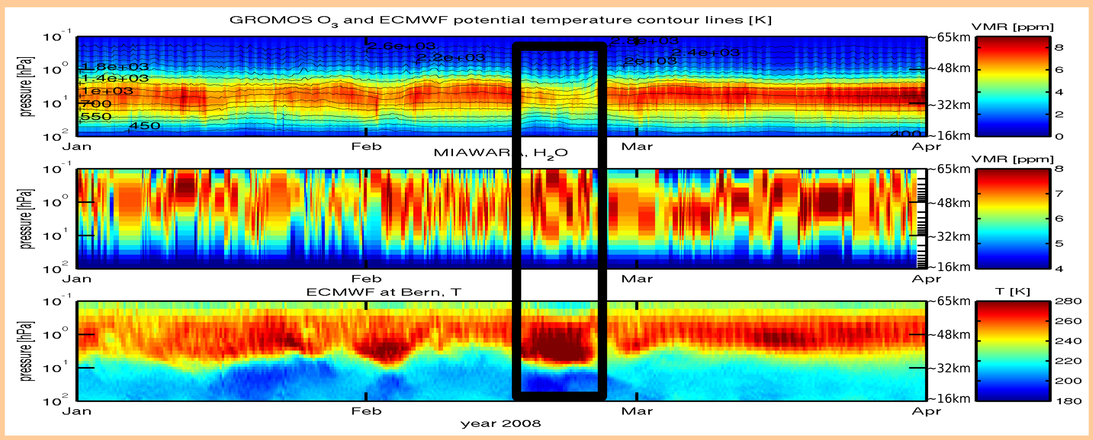
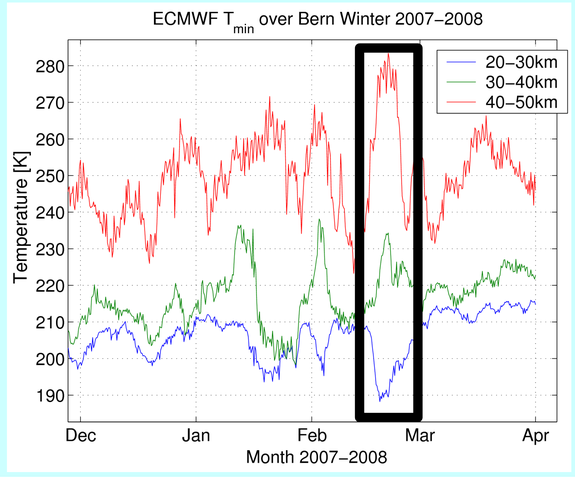
1. Introduction

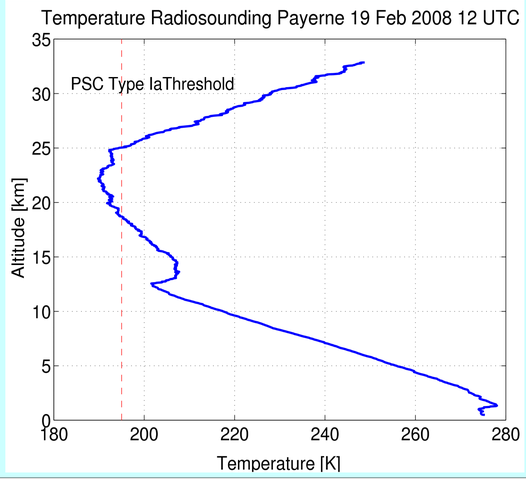
In February 2008 a sudden stratospheric warming occurred over Bern in Switzerland. Temperatures increased by more than 60 K in the upper stratosphere in a few days whereas temperatures fell to a minimum of 188 K in the lower stratosphere.
At the same time at Bern the institutes ground-based ozone radiometer GROMOS measured a O_3 depletion between 20 and 40 km and the ground- based water vapor radiometer MIAWARA measured an increase of H_2O at z > 25km.



2. Temperature

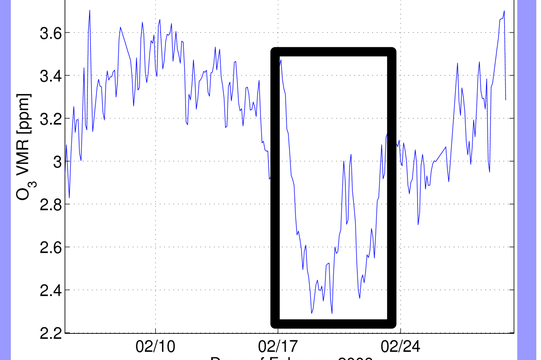
We observe a cooling between 20 and 25 km where temperatures fell below the PSC (Polar Stratospheric Cloud) threshold of 195 K and were lowest at 188 K on February 19.
At the same time warming happens in the upper stratosphere where T increased by up to 60 K and a maximum of 300 K is found at 40 km.

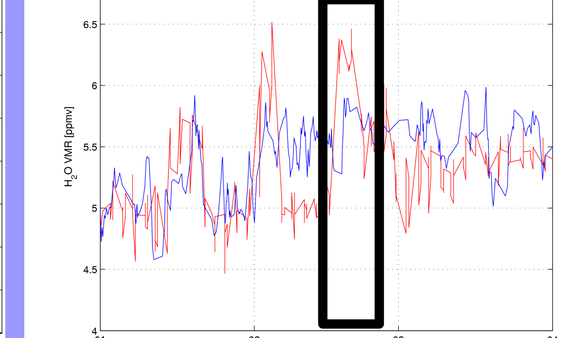




3. O_3 and H_2O

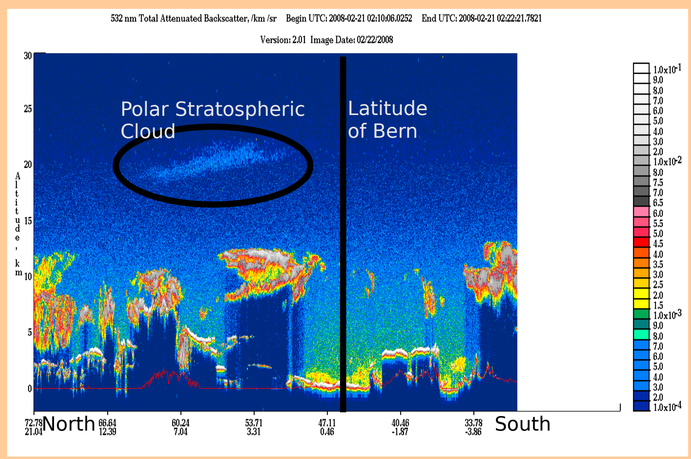
GROMOS detected a strong O_3 depletion between 20 and 40 km whilst MIAWARA and Aura/MLS measured an enhancement in H_2O between 25 and 60 km. Both phenomena can partly be explained by transport -> section 5. GROMOS and MIAWARA measure continuously O_3 and H_2O at Bern in the frame of NDACC.

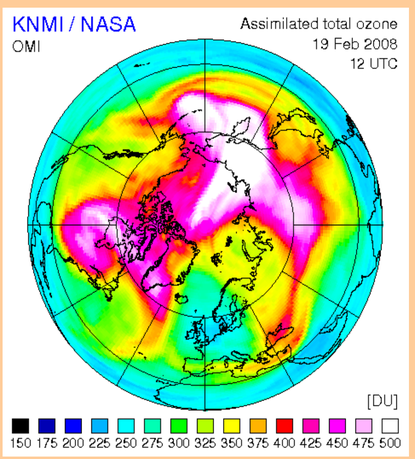




4. PSC over Europe

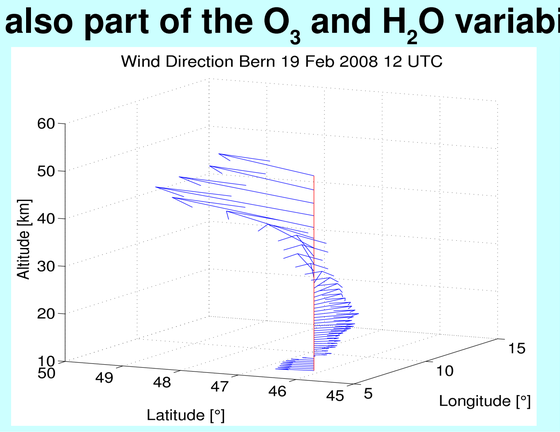
Temperatures over Bern and Europe between 20 and 25 km were cold enough for PSC. A CALIPSO backscatter image shows the occurrence of a PSC between 50 N and 66 N over central Europe.
A OMI ozone map shows a large area of ozone depletion over Europe.
The depletion of O_3 at these altitudes is caused by O_3-poor air from the vortex which is further depleted by a PSC over Europe.

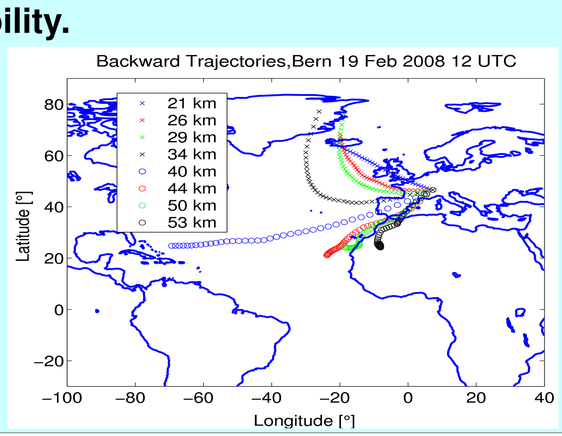




5. Trajectories during the SSW

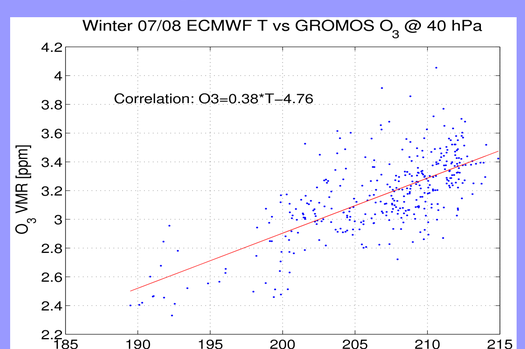
A strong wind shear is found at 35 km. "Tom's Trajectory Model (TomToM)" calculation based on ECMWF winds reveals that air below z = 35 km is of polar origin whilst water vapor rich air came from the subtropics above z = 35 km and underwent descent motion and adiabatic heating.
The different origins and descent motion from the subtropics explain the extreme vertical temperature gradient at z = 35 km and also part of the O_3 and H_2O variability.

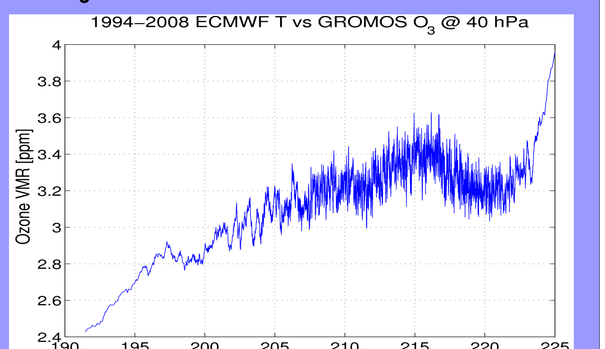




6. Discussion

The SSW leads to meridional transport of air: Below z = 35 km polar air flows to mid latitudes and beyond air comes from the subtropics in downward motion.
The warming happens at z > 35 km due to transport and adiabatic heating whilst the lower stratosphere is cooled (displacement of polar vortex) leading to a PSC and O_3 destruction.
A scatter plot of ECMWF temperatures and O_3 at 40 hPa (~22km) shows a dependence: low T -> low O_3 vmr (caused by PSC).





7. Conclusions

It seems that the question of the poster title can be answered twice with "YES" (at least for this specific SSW in Feb 2008). We distinguish 2 layers:
1) z > 35 km: Yes, the SSW induces a descent of the air -> adiabatic heating -> accelerated O_3 destruction.

2) z < 35 km: Yes, the SSW shifts the cold polar vortex towards Europe, where a PSC is formed in the sunlit sector -> extended and fast ozone depletion.

Further results: H_2O enhancement, wind shear

Acknowledgments: We thank for the data from MeteoSwiss, ECMWF and the NASA satellite experiments Aura/MLS, Aura/OMI, CALIPSO.