A Global Anomaly in Earth's Atmosphere in 1940–1942

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An unprecedented climatic anomaly occurred in the tropics and in the Northern Hemisphere in 1940-1942. During a strong and prolonged El Niño [Bigg & Inoué, *QJRMS* 118 (1992), 125], extremely cold winters were observed in Europe, accompanied by very warm temperatures in Alaska and large parts of the Arctic and a cold North Pacific. The anomalies were strong (comprising the two coldest European winters of the 20th century) and extraordinarily persistent. In addition, exceptionally high values of total ozone are reported [Langlo, *Geofys. Publ.* 18/6 (1952)], pointing to an anomalous stratospheric circulation. Events of this magnitude have a strong economical and environmental impact; the 1940s anomaly even affected World War II. Studying this anomaly in detail contributes to (1) document the extent of 20th century climate variability, (2) understand large-scale coupling processes between the tropics and the extratropics and between the troposphere and the stratosphere and (3) develop tools to analyse past upper-level climate variability prior to 1948, *i.e.*, the reanalysis period.

For this study we have compiled, digitised, controlled, corrected, and validated several tens of thousands of temperature and pressure profiles from aircraft and radiosonde ascents up to 50 hPa [Brönnimann, *Int. J. Clim.* 23 (2003), 769]. The upper-air data were supplemented with data from the Earth's surface and used to statistically reconstruct monthly upper-level fields for the extratropical Northern Hemisphere up to 100 hPa [Brönnimann & Luterbacher, *Clim. Dyn.*, submitted]. Although the quality of these data in the stratosphere is not comparable to more recent data, it is sufficient to allow a broad characterisation of the circulation at 100 hPa during the early 1940s. In addition to meteorological data, several total ozone series from these years were re-evaluated [Brönnimann *et al.*, *QJRMS* 129 (2003), 2819], providing additional information on the stratosphere. In this paper we present an analysis of these novel data sets and compare the results to an analysis of climate model data.

It is demonstrated that the climate anomaly at the ground was accompanied in the lower stratosphere by a weak polar vortex and warm temperatures over the polar region, Eurasia, and the North Pacific. The total ozone data show a peak in 1940–1942 in all available records, at sites as far apart as China, North America, central Europe, and the Arctic. The co-occurrence of warm tropical SSTs (related to El Niño), a weak polar vortex and warm lower stratosphere over polar regions, and a total ozone increase are in agreement with findings by van Loon and Labitzke [*Mon. Wea. Rev.* 115 (1987), 357]. Using the 290-yr control run of the Community Climate System Model CCSM-2.0 provided by UCAR we show that such large-scale coupling events on interannual to decadal scale are related to an exceptionally large difference between tropical and northern-extratropical SSTs in context with strong, persistent El Niño events. The coupling most likely proceeds through a change in planetary wave activity in the northern extratropics that manifests itself in a strong Aleutian low and a weak Icelandic low and in a disturbance of the polar vortex in the stratosphere.

The global climate anomaly in 1940-1942 is not particularly well kown among climate scientists. However, the anomaly is unprecedented in strength, yet exemplary in character, providing a unique opportunity to study large-scale climate coupling processes.