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Variation of humidity in the atmosphere over Poland from Humicap sensor

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Introduction

Water vapour distribution in the atmosphere has a direct impact on the Earth's radiation budget. Radiosoundings, as part of the daily worldwide routine measurements are reliable data source on relative humidity (RH). In Poland, RH has been measured by Vaisala Humicap since 1993. In 1999 the radiosonde type has been changed from RS-80A to RS-90 one. The change made data series inhomogeneous, because of different RS-80A's behaviour at low temperatures, in comparison to RS-90, which is much more sensitive.

For correction of RS-80A's humidity series, the method elaborated in Lindenberg have been used. Applying this method for Polish stations, a quasi homogeneous series of humidity since 1993 from the ground up to 200 hPa, has been received.

Homogeneous temperature and relative humidity data series 1993 - 2004 from three Polish stations (Leba, Legionowo, Wroclaw), on main geopotential surfaces from the ground up to 200 hPa have been analysed. The linear regression trends for monthly and long-term monthly means for temperature and relative humidity have been discussed. In the lower troposphere positive temperature trends and negative humidity trends have been observed. In the higher troposphere negative temperature trends and strong positive humidity trends have been found. This illustrates the accumulation of water vapour below the tropopause.

Humidity correction method for RS-80A radiosonde

The Vaisala Radiosounding System is the most spread system in the world. Change of humidity sensor has caused inhomogeneity of data series. For correction RS-80A's humidity series following correction equations have been applied:

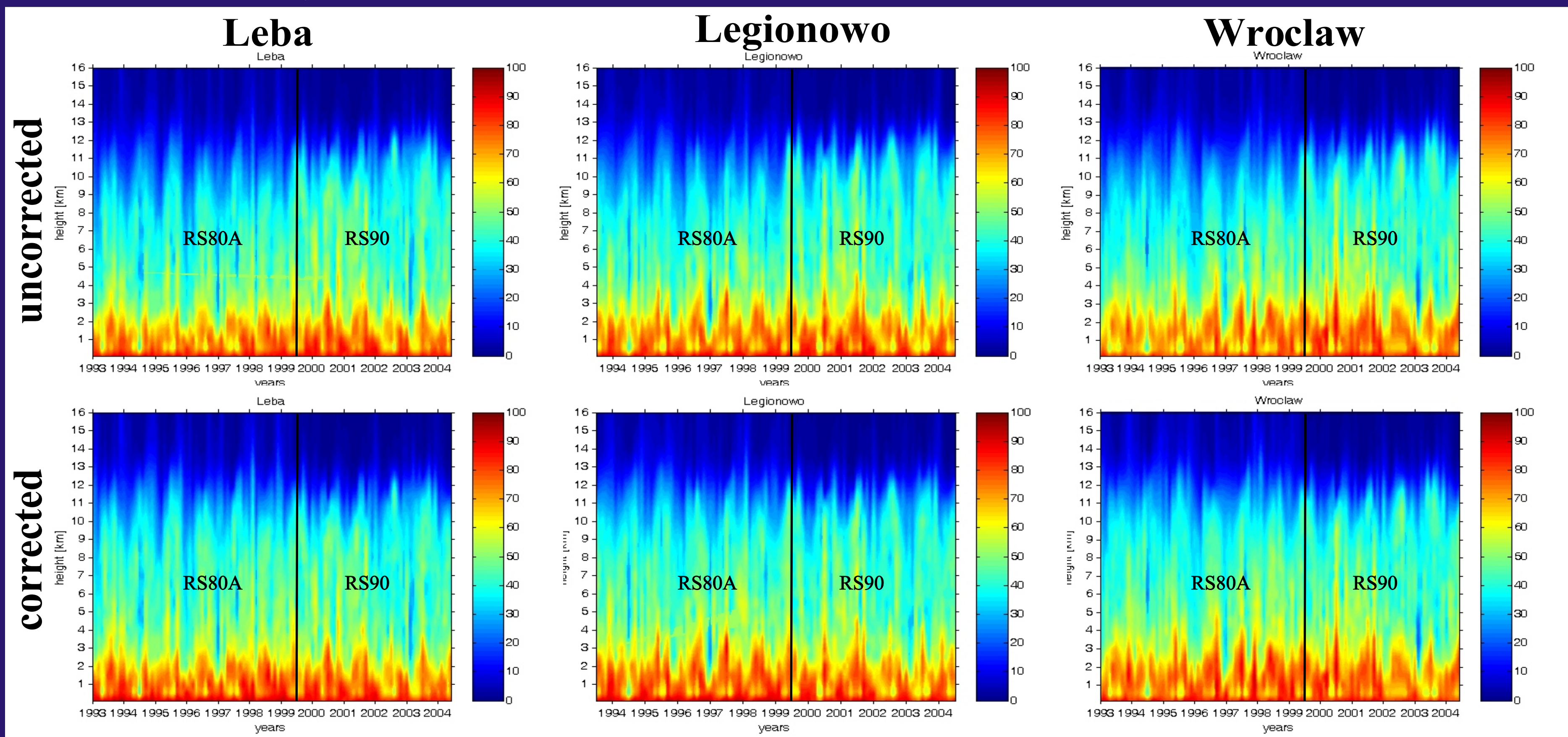
$$H_{corr} = H \left[5.6\% \cdot \frac{H}{100\%} \right] \left[0.005 \cdot t^2 + 0.112 \cdot t + 0.404 \right] \cdot \frac{H}{H_w(t, 100\% \text{ ice})} \cdot \frac{e_s(T)}{e_w(T)} \cdot 100\%$$
$$H_w(t, 100\% \text{ ice}) = \frac{H}{(0.005 \cdot t^2 + 0.112 \cdot t + 0.404)}$$

$$\ln e_s(T) = (-6024.5282) \cdot T^{-1} + 24.7219 + (1.0613868 \cdot 10^3) \cdot T + (-1.3198825 \cdot 10^5) \cdot T^2 + (-0.49382577) \cdot \ln T$$
$$\ln e_w(T) = (-6096.9385) \cdot T^{-1} + 16.635794 + (-2.711193 \cdot 10^3) \cdot T + (1.673952 \cdot 10^5) \cdot T^2 + 2.433502 \cdot \ln T$$

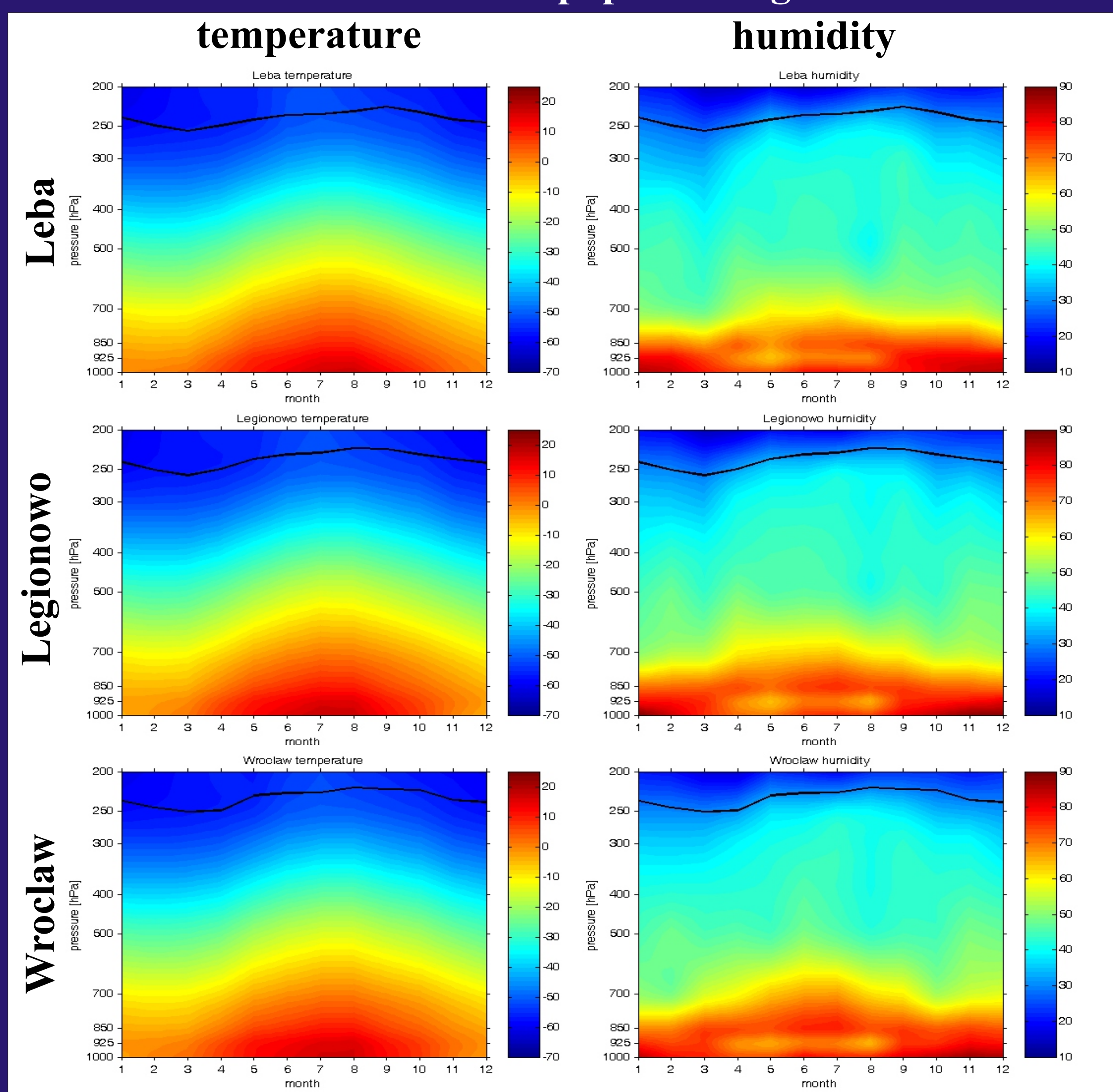
The figures present humidity series for Leba and Wroclaw (January 1993 - June 2004) and Legionowo (June 1993 - July 2004) at 00 UT for uncorrected (upper figures) and corrected (down figures) series using correction method elaborated in Lindenberg.

Humidity series look better with than without any correction, especially in the UTLS region, where underestimated values of humidity from RS-80A have increased after correction, making the series more homogeneous.

Humidity uncorrected (up) and corrected (down) series 00 UT 1993-2004



Long-term temperature (left) and humidity (right) monthly means with mean tropopause height



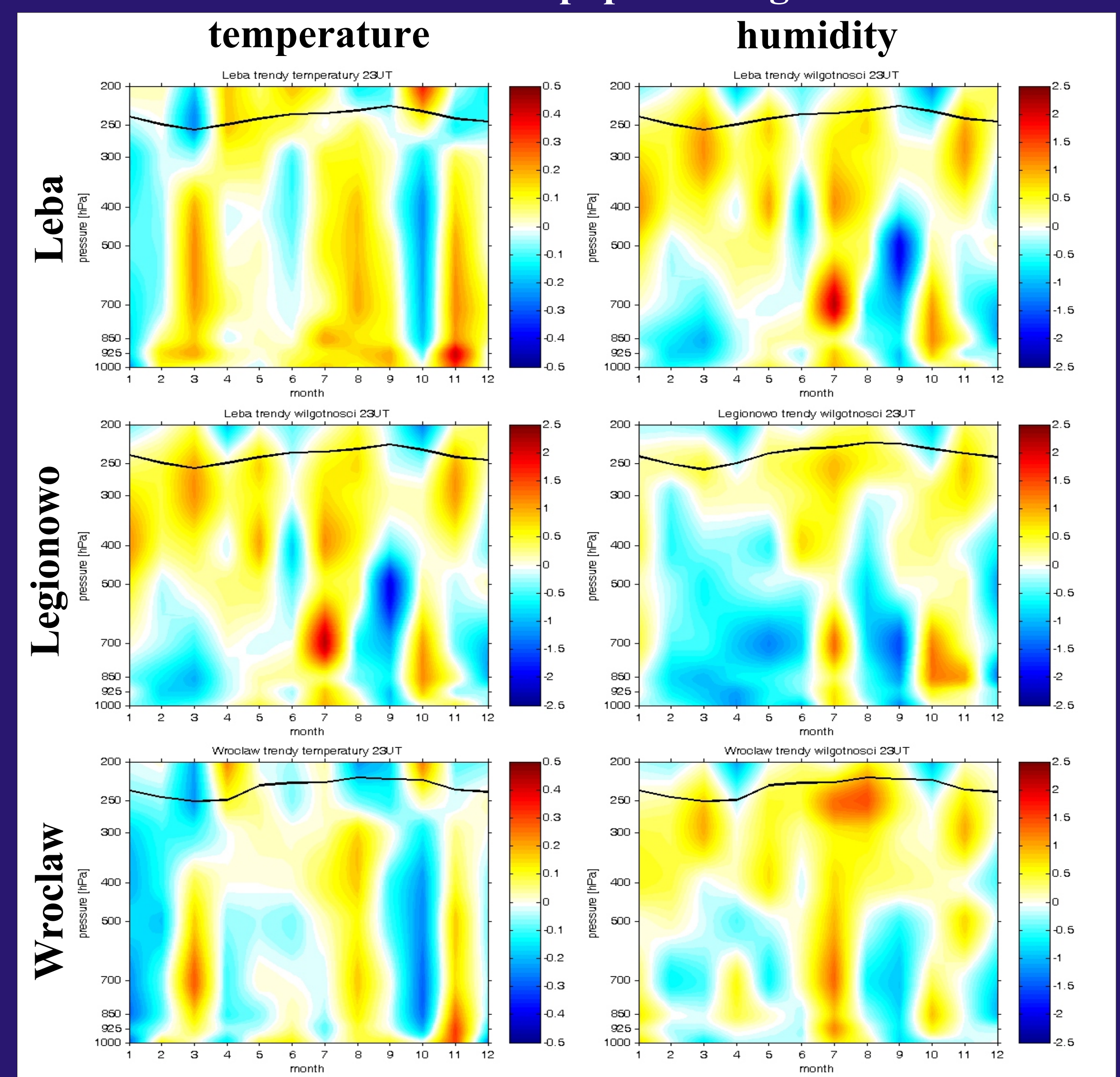
The figures present long-term temperature (left column) and humidity (right column) monthly means for Leba and Wroclaw (January 1993 - June 2004) and Legionowo (June 1993 - July 2004) at 00 UT, the mean tropopause heights (black lines) are marked.

Annual cycle of temperature is typical for middle and high latitude continental humidity regime in the Northern Hemisphere. For the all stations the maximum of temperature is observed in the summer months (July, August) and the minimum in the winter months (January, December).

In the lower troposphere at 925 hPa small humidity values are observed from April to August, the smallest in May and August. This can be explained by small frequency of Stratus clouds in summer time.

A decrease of the tropopause height connected with humidity decrease below the tropopause have been shown off in March. This phenomenon is the strongest for Leba and the weakest for Wroclaw. It is related to an intrusion of stratospheric air to the troposphere.

Long-term temperature (left) and humidity (right) trends with mean tropopause height



The figures present long-term temperature (left column) and humidity (right column) trends for Leba and Wroclaw (January 1993 - June 2004) and Legionowo (June 1993 - July 2004) at 00 UT, the mean tropopause heights (black lines) are marked.

For the all stations the strongest positive temperature trends in the troposphere have been observed in March and in November (the most intense for Legionowo) and the strongest negative temperature trends have been observed in January and in October (particularly for Wroclaw).

In the lower stratosphere (250 - 200 hPa) the positive temperature trends have been observed in April and in October and the negative ones in March, August and September.

In the lower troposphere for the all stations strong negative humidity trends have been observed in September (expressly for Leba). For Legionowo, additionally negative humidity trends are observed in winter - spring time with minimum in May at 700 hPa. Strong positive humidity trends have been observed in July at all surfaces. For all months the humidity trends are positive above 400 hPa, what illustrates the accumulation of water vapour below the tropopause.

CONCLUSIONS

For homogenisation of the RS-80A and RS90 humidity series the method elaborated in Lindenberg have been used. Applying this method for Polish stations, a quasi-homogeneous series of humidity up to 200 hPa since 1993, has been obtained.

In the lower troposphere low humidity values from April to August have been observed, what can be explained by small frequency of Stratus clouds.

A decrease of the tropopause height connected with humidity decrease below the tropopause have been shown off in March. This illustrates an intrusion of the stratospheric air to the troposphere.

Generally, the positive temperature trends are correlated with the negative humidity trends and conversely correlation of negative temperature trends to positive humidity trends is observed.

The observed positive humidity trends above 400 hPa indicate the accumulation of water vapour below the tropopause.

References

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- [3] Brzoska, B., et al.: "Homogenisation of water vapour data from RS-80A and RS-90"; Interior report, 2004.
- [4] Litynska, Z., et al.: "Variation of temperature and humidity in troposphere in the year 1971 - 1990"; Interior report, 1994.