P 22.86 DEPENDENCE OF OZONE LAMINA CHARACTERISTICS ON THE DISTANCE FROM THE POLAR VORTEX EDGE - POSSIBLE RELATION TO CLIMATE CHANGE

Peter Krizan*, Michal Kozubek
krizan@ufa.cas.cz

Institute of Atmospheric Physics, Prague, Czech Republic

*Abstract

Ozone laminae are narrow layers of enhanced (positive) or depleted (negative) ozone concentration. Large laminae are formed at the vicinity of polar vortex and they are one of the mechanism of air masses exchange between the polar vortex and its surrounding. We observed similar long-term trend pattern in the total amount of ozone in laminae per profile and in the number of laminae per profile as in the case of total ozone (Krizan and Lastovicka, JGR, 2005). The aim of this poster is to find the dependence of the ozone lamina characteristics on the value of potential vorticity at the pressure levels in the stratosphere. We expect the ozone laminae will be more frequent near the vortex edge. The number of ozone laminae will decrease with increasing distance from the vortex edge. We use data from the European middle latitudes ozonosonde stations taken from WOUDC database in Toronto. We use data from 3 stations: Hoheinpeisenberg, Edmonton and Resolute Bay. Possible changes with time of the dependence of ozone lamina characteristics on the the distance from the polar vortex edge as a consequence of long-term changes of ozone and greenhouse gas concentration in the lower stratosphere will be searched for.

1. Preface

Ozone vertical profile is not a smooth curve with maximum about 22 km, but the narrow layers of enhanced or depleted ozone concentration (laminae) are observed below ozone maximum. The example of ozone vertical profile with three laminae is showed on fig1. Ozone lamina must fulfill these three conditions:

1.The depth of lamina must be in interval 500-3500 meters. The lower limit of this interval is given by the vertical resolution of ozonesondes, which is about 150 meters The upper limit of this interval is selected with regard to the fact that ozone lamina is a comparatively thin layer of enhanced (depleted) ozone concentration, which is expressed in terms of changes of ozone partial pressure.

2. Each lamina consists of three extremes, as it shows for a schematic positive lamina in Figure 2. The positive lamina is formed by the lower minimum of ozone concentration OLmin with height Hlmin, the middle maximum Omax and the upper minimum OHmin with height Hhmin. The ozone concentration must fulfil this condition:

$$Omax - 0.5\,(OLmin + OHmin) > sl \qquad (1.1)$$

e.g. the difference between the ozone concentration in maximum and average ozone concentration from both minima must be greater than size of lamina

As a standard value for routine evaluation of laminae we use sl = 40 nbar

3. Let us define the third condition for positive laminae

$$Omax-OHmin > sl/2 \qquad (1.3)$$

$$Omax-OLmin > sl/2 \qquad (1.4)$$

This condition says that we consider only well pronounced ozone laminae.

Also the lamina minima must be strong enough for their taking into account (Reid and Vaughan, 1991) state ozone laminae occur near the vicinity of polar vortex.

In this poster we search for dependence of the number of laminae per profile and ozone in laminae per profile on the distance from the edge of the polar vortex. We use the data from WOUDC database in Toronto from these stations: Hoheinpeissenberg- the one of the best European middle latitude ozonosonde

* Corresponding author address : Peter Krizan, Institute of Atmospheric Physics, Bocni II, 141 31, Prague 4, Czech Republic, e-mail : krizan@ufa.cas.cz

station, Edmonton- the Canadian middle latitude station and Resolute Bay – the Canadian Artic station. The number of ozone profile taking into account is given in table 1. We see the number of profiles is the highest at Hoheinpeissenberg We use data from period 1970-1999, because in 2000 the vertical resolution of ozone profiles was changed at the Canadian stations. We had some problems with the computing of equivalent latitude so in this paper we do not use equivalent latitude, but the absolute values of potential vorticity (PV) from ECMWF ERA -40 reanalysis at the following pressure levels : 250, 200, 150, 100, 50, 70,50,30, 20 and 10 hPa. The best way how to define the distance from the polar vortex edge is using of difference of equivalent latitude value at the vortex edge and the equivalent latitude value at the ozonosonde station not using absolute value of potential vorticity. As a first approximation we can say for middle latitude station the higher is the value of potential vorticity the nearer to the vortex edge. This is not valid for artic station because in this case the high value of potential vorticity can mean we are inside of polar vortex not at the edge. The ozone laminae were divided into two groups according to their size: small laminae –from 10 to 20 nbar and large laminae greater than 40 nbar.

1. Results

Our paper consists of two parts. At the first part we are interested in the correlation between the number of laminae and ozone content in laminae and yearly average of PV at the selected pressure levels in the stratosphere. At the second part of this paper we deal with time correlation of yearly average of PV at the pressure levels. We worked with period from November to March because in these months the polar vortex is occurred. We took into averaging only days which ozone profile was measured in. On fig3 the height dependence of correlation coefficient between the average number of laminae and average PV is shown. The vertical lines represent the values of correlation coefficient above and below which the correlations are statistically significant. In the upper panel we see the results for large laminae and in the lower panel for small laminae. We see the best correlations between the number of laminae and PV are at the station Hoheinpeissenberg. These correlations are positive and statistical significant or nearly statistical significant in the lower stratosphere up to 50 hPa. At the station Edmonton these correlations are negative and statistical insignificant. At the station Resolute Bay these correlations are positive but statistical insignificant. In the case of small laminae there are no statistical significant correlations between number of laminae and PV values in the stratosphere. Similar picture but with worse correlations is seen in the case of correlations between ozone content in laminae and PV values. On fig.4 -7 we see the trend of yearly average of PV at our ozonosonde stations at 250,100, 50 and 10 hPa. We see the values of PV are the highest at Resolute Bay at the smallest at the station Hoheinpeissenberg . On fig.8 we see the correlations between the yearly average of PV and time are mostly negative and statistical insignificant and they are the highest in the lowermost stratosphere.

2. Discussion

The correlations between the number of ozone laminae and the values of PV are statistical significant at the station Hoheinpeissenberg in the lower stratosphere. This can be caused by the fact the number of ozone profiles is the highest at this station, the vertical resolution of ozonesondes are the same during the whole period. This significant correlation is positive which means if the PV increasing, the number of laminae increasing, because the distance from the polar vortex edge decreasing.The correlations at the other stations are statistical insignificant. When we compare these correlations in the case of large and small laminae we see the correlations are more reasonable in the case of large laminae than in the case of small ones especially in the case of Hoheinpeissenberg. This fact can be explained by the separating of large laminae from the edge of polar vortex, while the small laminae can be caused also by the other mechanism e.g. gravitation waves. The values of PV are systematically higher at the station Resolute Bay compare to the Edmonton and Hoheipeissenberg, because the station Resolute is in the polar latitudes, where the PV are high.The trend of PV is negative statistical insignificant at the majority of levels in the stratosphere, except the lowermost stratosphere at the Hoheinpeissenberg, where this negative trend is statistical significant In (Krizan and Lastovicka, JGR, 2005) the trend of the number of ozone laminae per profile is negative in the period 1970-1995, which can be explained by increasing distance from the polar vortex edge of middle latitude stations. As a measure of distance from the polar vortex edge we use the absolute value of PV at selected stratospheric levels. It is better to use equivalent latitude not absolute values of PV.

3. Conclusion

1. The correlations between the ozone lamina characteristics and the PV values are positive and statistical

significant at the station Hoheinpeissenberg in the lower stratosphere. At the other stations these correlations are statistical insignificant.

2. These correlations are better in the case of the number of laminae per profile and large laminae compare to the ozone content in laminae per profile and small laminae.

3. The trends of PV values at the selected stratospheric levels are negative and statistical insignificant except the lowermost stratosphere in the case of Hoheinpeissenberg. These trends can explain the negative trend of the number of ozone laminae per profile in the period 1971-1995 at the middle latitudes ozonosonde stations.

References

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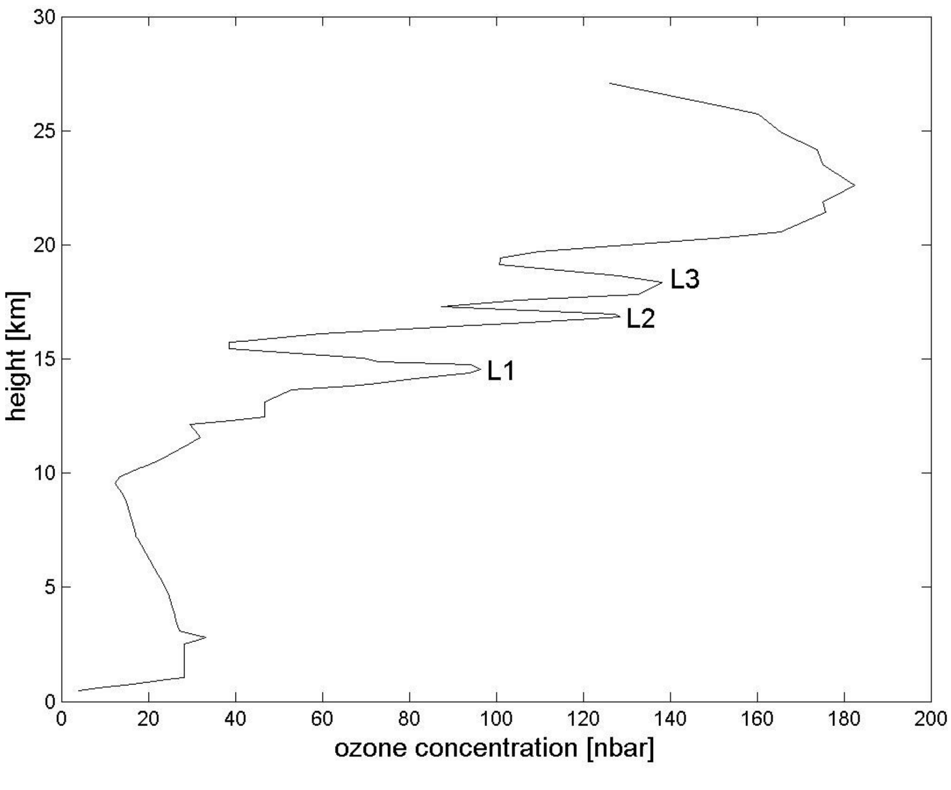

Fig.1 Example of the ozone profile with three positive laminae (L1,L2 a L3) measured at Payerne on January 7 1970

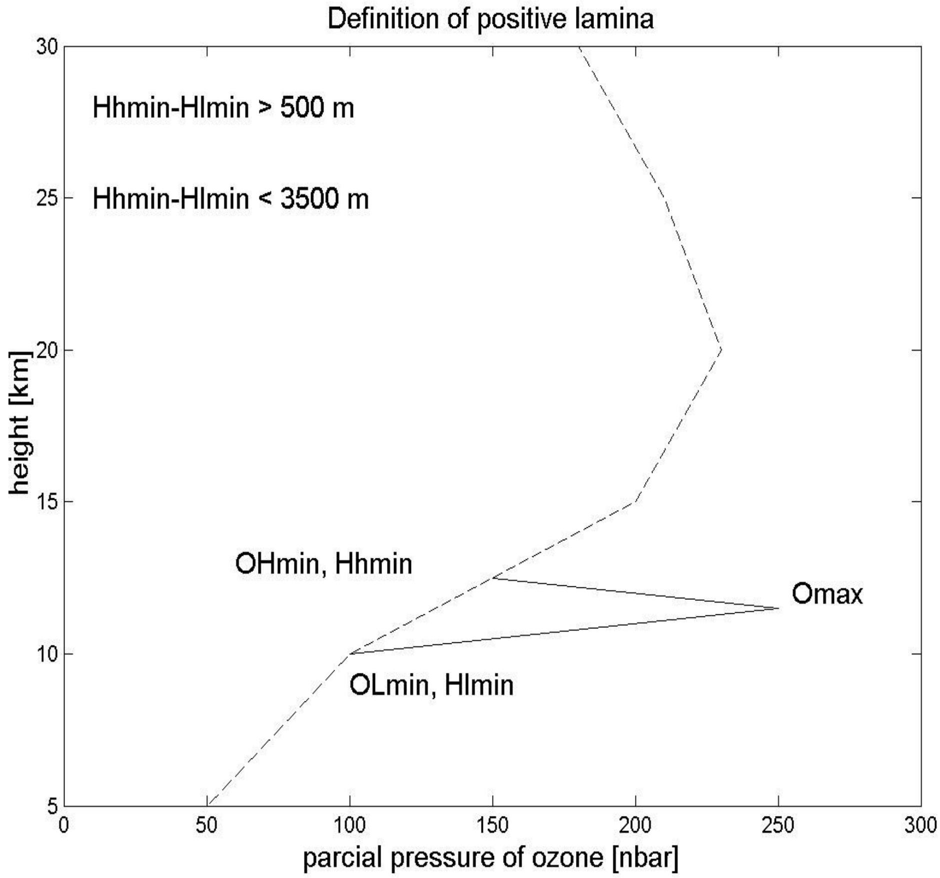

Fig. 2 Definition of positive lamina

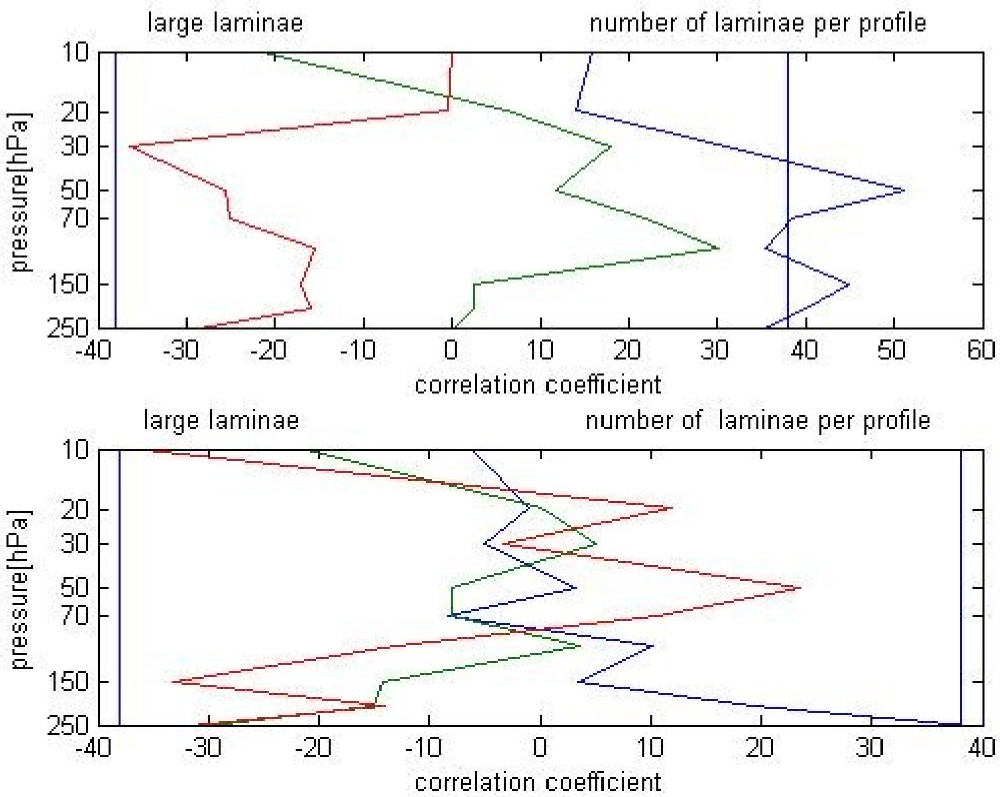

Fig.3 Vertical dependence of correlation coefficient between the average number of laminae and average absolute values of PV in the case of large (upper panel) and small(lower panel) laminae at the station Hoheinpeissenberg (blue), Edmonton(red) and Resolute Bay (green)

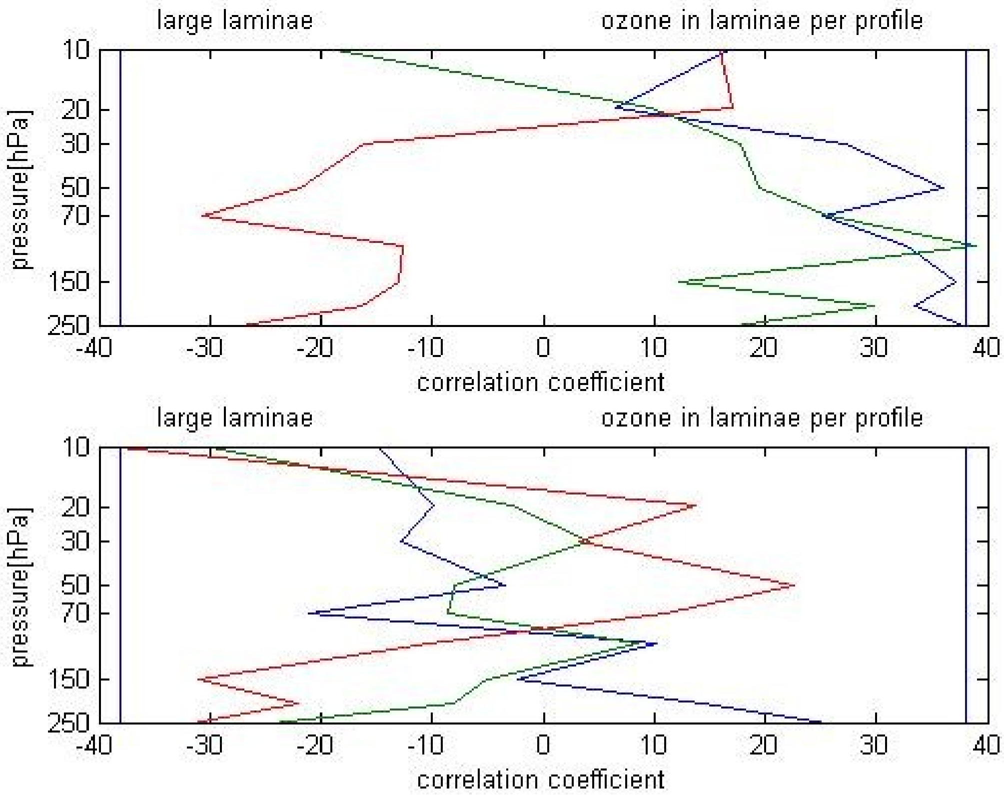

Fig. 4: The same as fig.3 but for average ozone content in laminae per profile

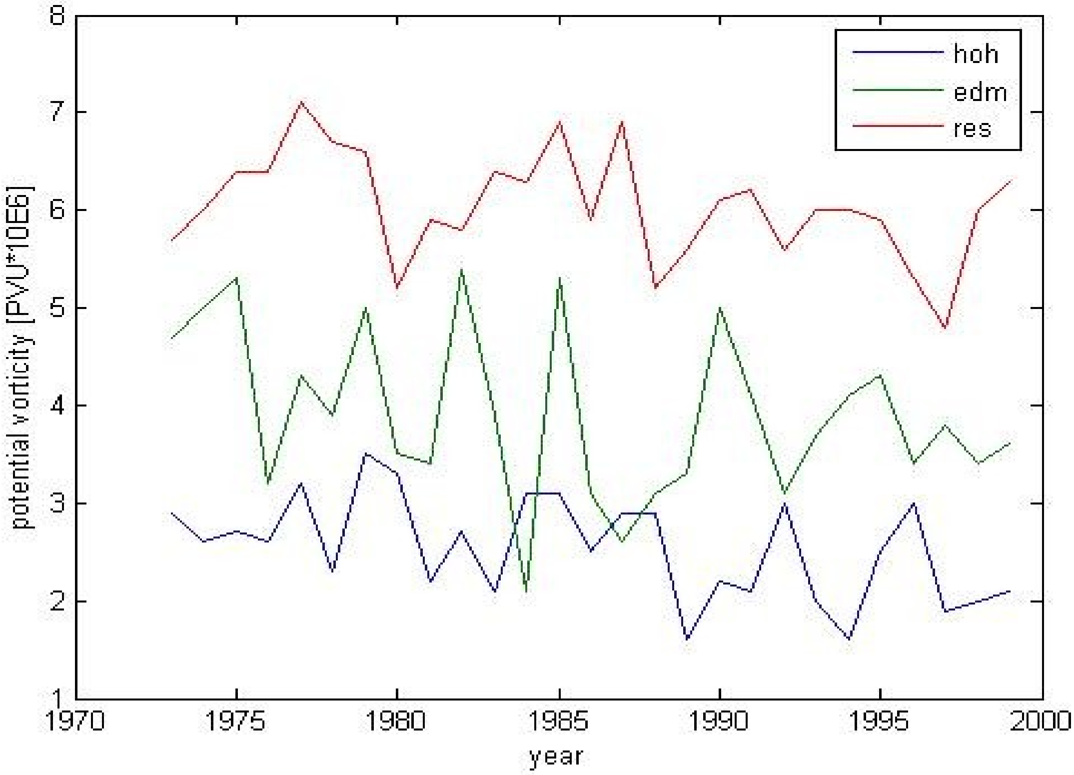

Fig.5 Trend of average PV values at the level 250 hPa at the station Hoheinpeissenberg-Hoh, Edmonton - Edm and Resolute Bay – Res

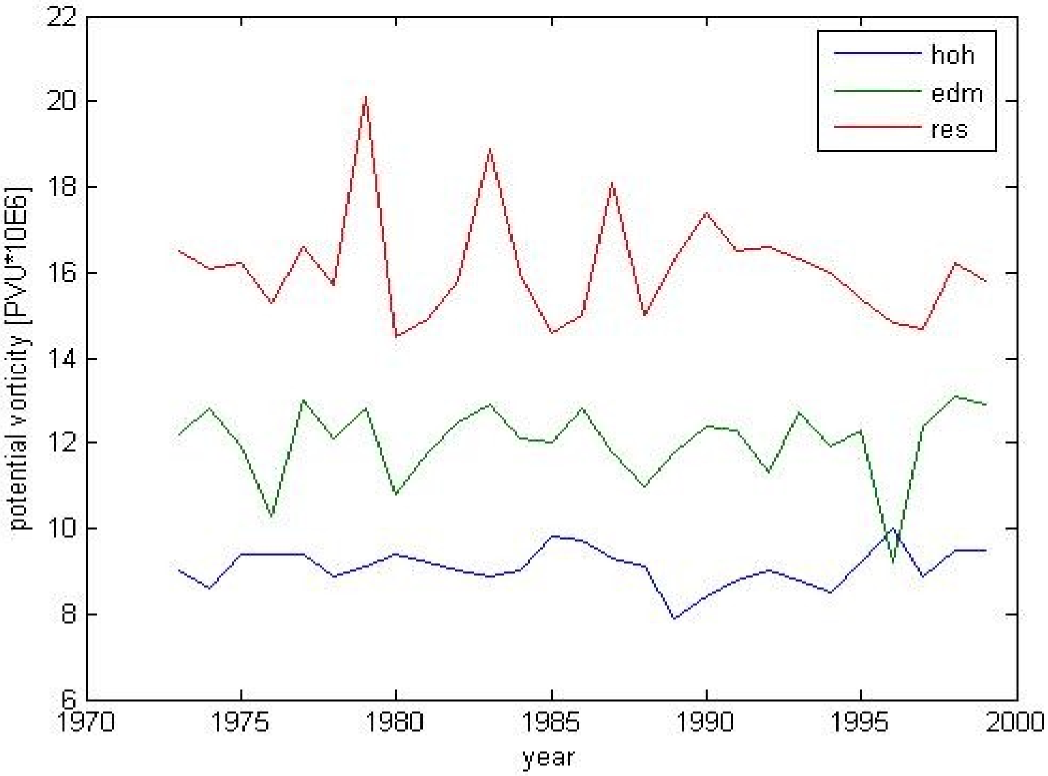

Fig.6 The same as fig.5, but for 50 hPa

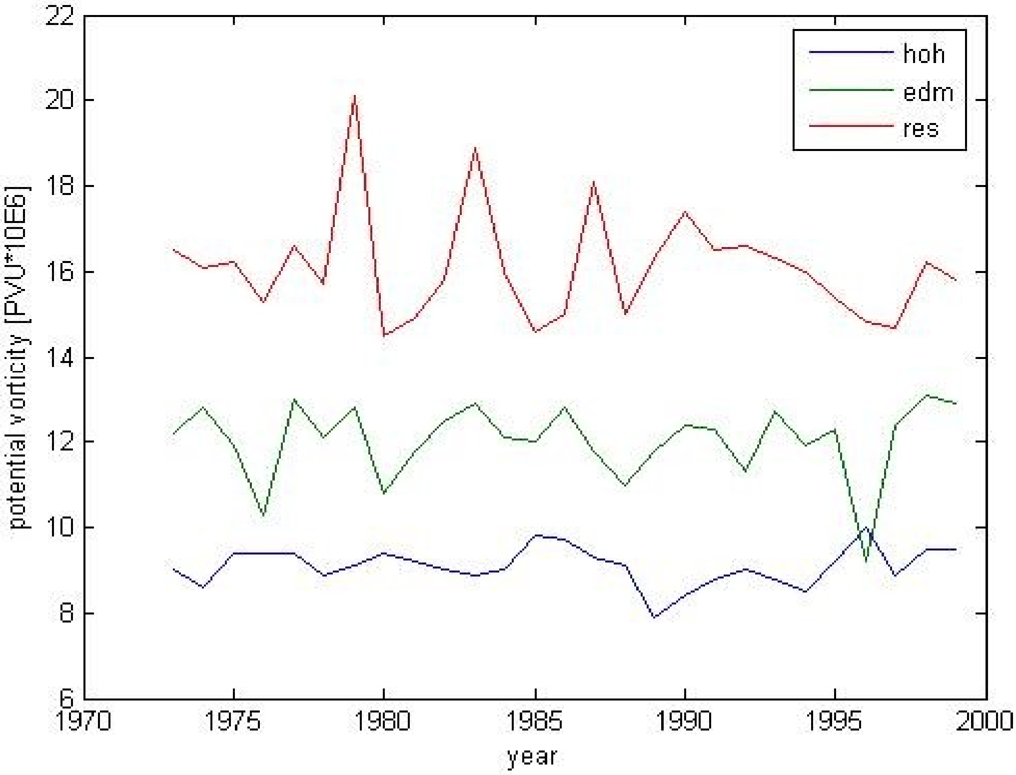

Fig.7 The same as fig.5 but for 10 hPa

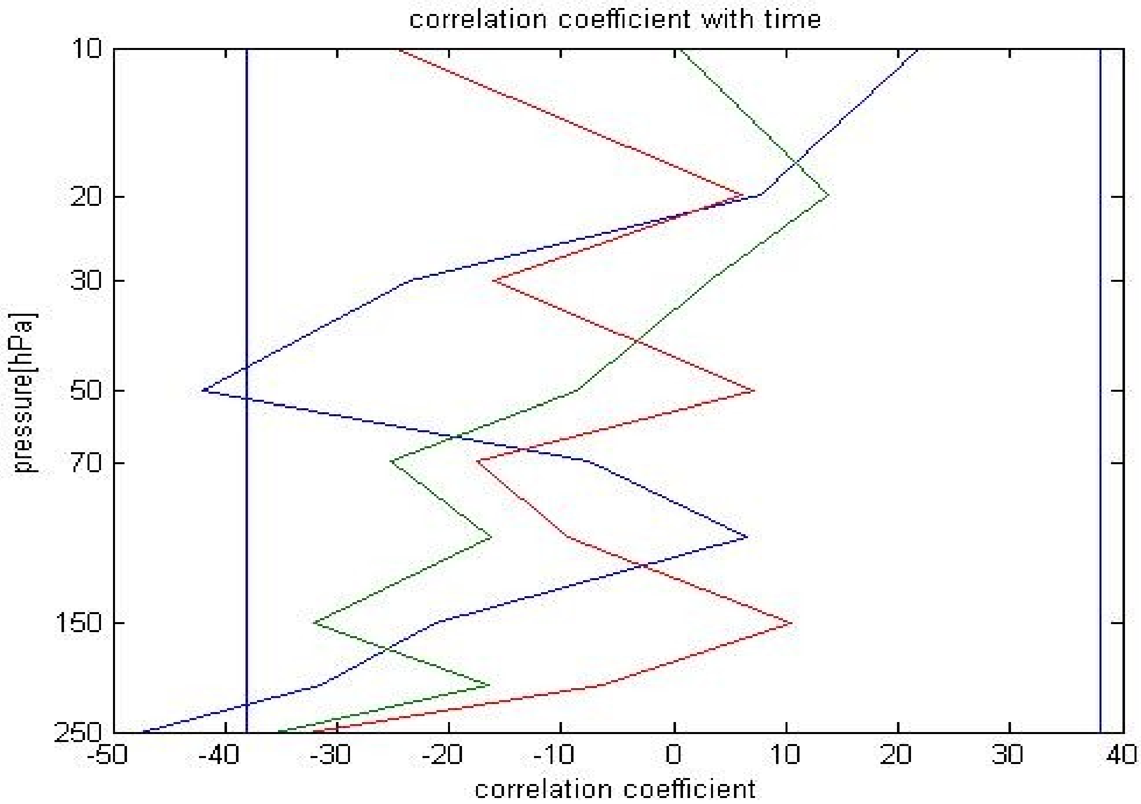

Fig.8 Vertical dependence of correlation coefficient between the time and average absolute values of PV at Hoheinpeissenberg (blue), Edmonton(red) and Resolute Bay (green)

Hoheinpeissenberg	1592
Edmonton	498
Resolute Bay	528

Tab. 1 Number of observations at the selected ozonosonde stations