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EFFECTS OF CORPUSCULAR RADIATION ON WEATHER AND CLIMATE

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INTRODUCTION

HARRY VAN LOON and JEFFERY C. ROGERS (1978) have investigated the wellknown tendency for winter temperatures to be low over northern Europe when they are high over Greenland and the Canadian Arctic, and conversely (Fig. 1).Well-defined pressure anomalies over most of the Northern Hemisphere are associated with this regional seesaw in temperature, and these pressure anomalies are so distributed that the pressure in the region of the Icelandic low is negatively correlated with the pressure over the North Pacific Ocean and over the area south of 50°N in the North Atlantic Ocean, Mediterranean and Middle East, but positively correlated with the pressure over the Rocky Mountains. Since 1840 the seesaw, as defined by temperatures in Scandinavia and Greenland, occurred in more than 40% of the winter months and the occurrences are seemingly not randomly distributed in time as one anomaly pattern would be more frequent than the other for several decades. For this reason the circulation anomalies in the seesaw come to play an important part in deciding the level of regional mean temperatures in winter and thus in deciding the long-term temperature trends. These regional temperature trends are then closely associated with changes in frequency of atmospheric circulation types, and it is therefore unikely (VAN LOON, ROGERS, 1978) that the trends are caused directly by changes in insolation or in atmospheric constituents and aerosols.

RESULTS

Changes in winter temperature (Nov. Dec. Jan. Feb.) in Oslo have a similar character as in Prague. Fig. 2 shows a comparison of changes in geomagnetic activity (C indices) with winter temperatures at several sites, Prague and Oslo which are positively correlated, and Jakobshavn and Walla-Walla which are negatively correlated. Very expressive is the positive correlation between the geomagnetic activity and temperature in Prague (c.c.0.63). This seems to be in favour with the fact that the increased corpuscular (geomagnetic) activity is connected with the prevailing zonal type of atmospheric circulation (r.h.s. of Fig. 2 bottom) leading to the warming in Prague and Oslo. On the other hand at the time of low corpuscular activity the meridional type prevails (r.h.s. of Fig. 2 top) and causes the cooling in Prague and Oslo due to the prevailing flow from the North during low geomagnetic activity at these sites, while Jakobshavn and Walla - Walla are at the same time under the influence of warm air from the south along the western side of mighty high pressure areas.

This relation can be seen also in Fig. 3 showing that below normal temperatures in Prague (10 cases) occurred at the time of low geomagnetic activity and above normal temperatures (10 cases) correspond to high geomagnetic activity.

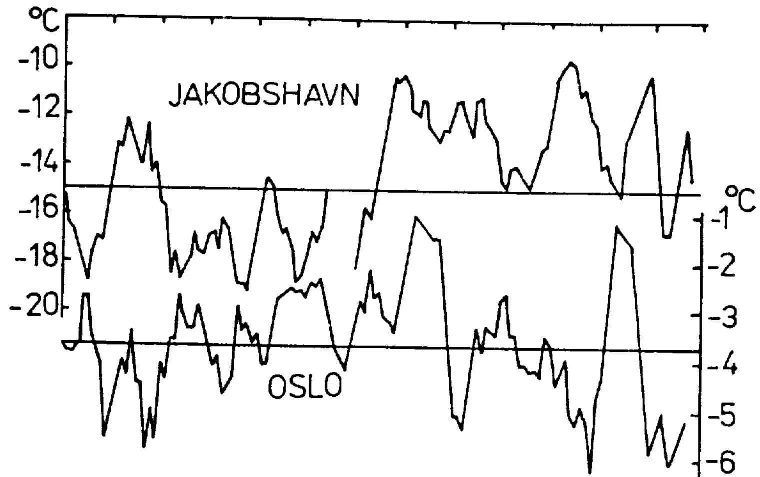

Fig. 1. Five-year running means of winter temperature at Jakobshavn and Oslo (°C) (H.VAN LOON and J.C.ROGERS,1978).

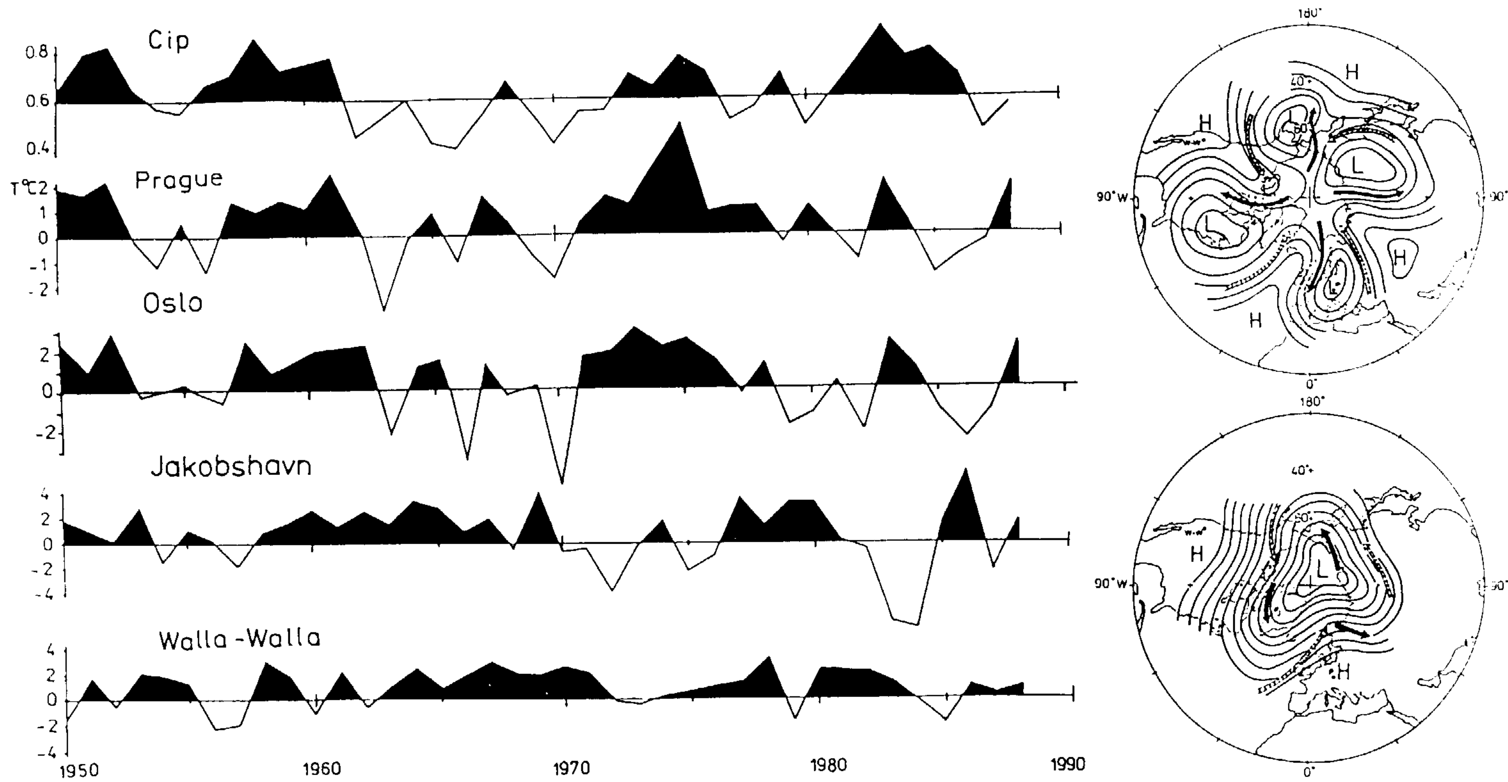

Fig. 2. Changes in geomagnetic activity (C indices - averages for months November, December, January, February) and in temperature for Prague and Oslo showing positive correlation and for Jakobshavn (Greenland) and Walla-Walla (Washington) showing negative correlation with geomagnetic activity. Meridional type of circulation - r.h.s., top, zonal type - r.h.s. bottom.

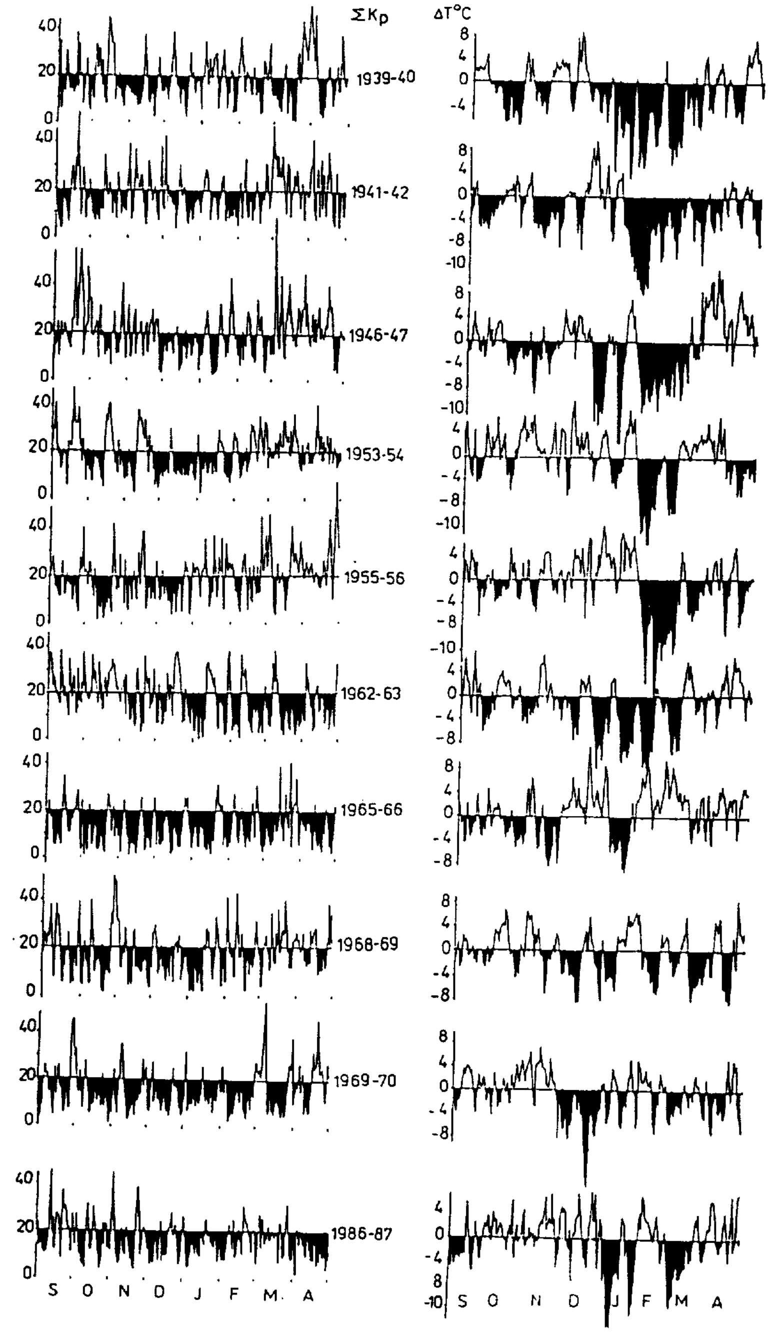

Fig. 3 a Changes of the diurnal values of geomagnetic activity (ΣKp indices l.h.s.) and of temperature (deviations from the normal) in Prague - r.h.s. for the period September-April. Severe winters correspond to very low values of geomagnetic activity - Fig. 3.a, mild winters occurred at the time of enhanced geomagnetic activity - Fig. 3.b

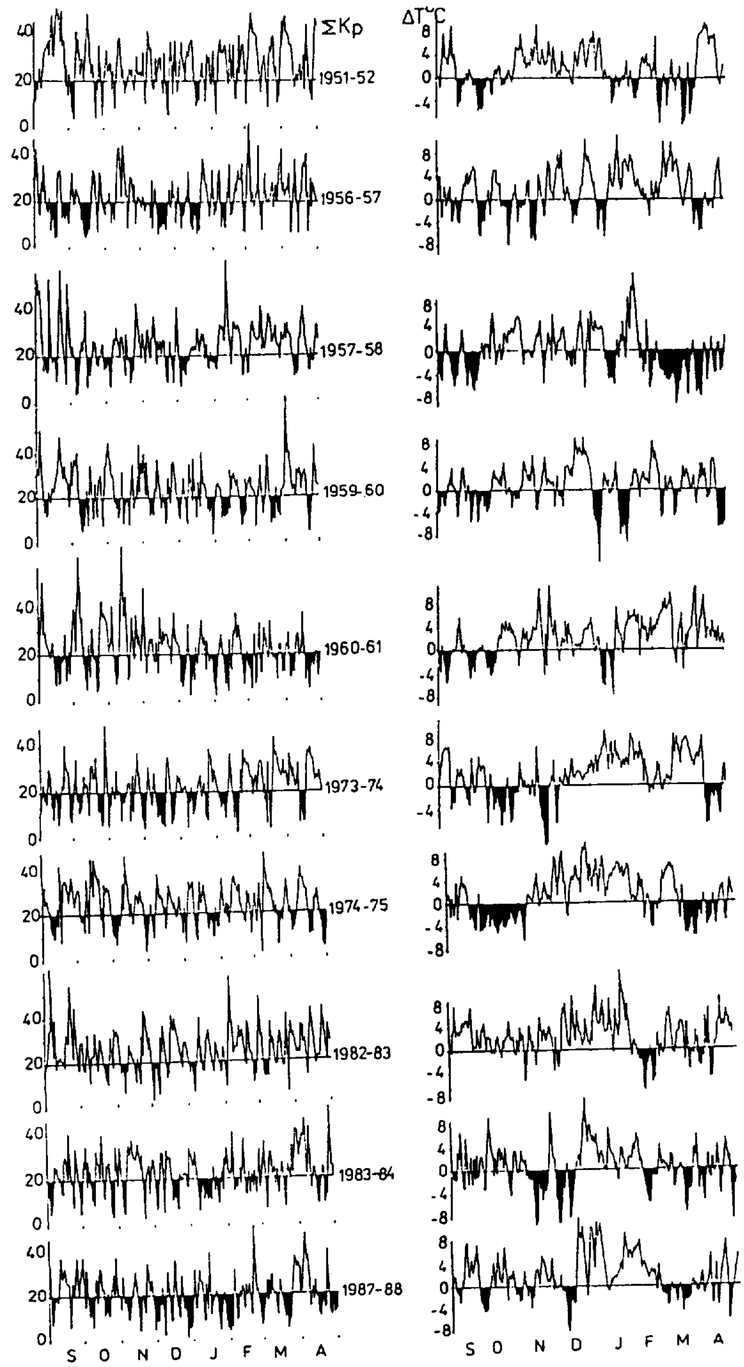
ΣKp
ΔT°C
1951-52
1956-57
1957-58
1959-60
1960-61
1973-74
1974-75
1982-83
1983-84
1987-88
S O N D J F M A
S O N D J F M A

Fig. 3 b

Somebody can object why at the time of extremely low geomagnetic activity (1965-66) the winter in Prague was not so severe. This seems to be connected with a different type of atmospheric circulation as described earlier (BUCHA, 1988).

The cross-correlation of daily changes K_p and T in Prague showed the time lag of 27 days between the increase resp. decrease in geomagnetic activity and increase resp. decrease of temperature in Prague to be the most frequent in the period 1932 - 1985 (BUCHA, HEJDA, 1988). In this way these connections as given in Figs. 1,2,3 seem to confirm the effect of corpuscular radiation on the intensification of processes in the auroral oval and on the increase of temperature leading to the occurrence of zonal type of circulation.

One possibility how to explain the peculiar behaviour of the atmospheric circulation is the intensification of processes which take place along the auroral oval at the time of enhanced corpuscular (geomagnetic) activity characterized by the penetration of energetic particles and bremsstrahlung as far as the lower stratosphere (BUCHA,1986) resulting in the sudden formation of cirrus clouds, in direct increases of temperature and pressure even in the troposphere, and causing the zonalization of atmospheric flow to increase (BUCHA 1984,1988). According to other mechanisms (HINES, 1974) stratospheric and mesospheric winds play a dominant role in determining the "refractive index" for planetary waves (e.g., see CHARNEY and DRAZIN, 1961; MATSUNO 1970; and SCHOEBERL and GELLER, 1976) which will, in turn, determine the transmission-reflection properties of these waves. Thus, changes in the middle atmosphere flow due to corpuscular radiation might lead to changes in the tropospheric amplitudes and phases of planetary waves that propagate to this level. The energetics of these changes are such that relatively small amounts of energy may give rise to significant effects in the upper atmosphere where the density is low, and these upper atmosphere effects merely act to modulate the effect of fixed energy sources in the troposphere. According to BATES (1977) the amplitude and phase of the tropospheric planetary waves as well as the resulting meridional heat flux were found to vary significantly when the tropospheric forcing remained fixed but the stratospheric wind and/or static stability fields were altered.

The three main dissipation mechanisms operative in the stratosphere and mesosphere are radiative damping acting through carbon dioxide and ozone, mechanical dissipation which is presumed to act through the turbulent mixing that results from the "breaking" of waves and tides, and the possible absorption of wave momentum at critical levels.

GELLER and ALPERT´s modeling study indicated (1980) that if solar disturbance effects lead to changes in the mean zonal middle stratospheric flow of 20 %, then changes in the strengths of the high-latitude quasi-stationary troughs and ridges amounting to 20% of the observed range of variability may occur. They believe that they have demonstrated the viability of the HINES (1974) mechanisms for solar effects on the troposphere and have given an idea of the magnitudes of the effects to be anticipated if the stratospheric mean zonal winds vary with solar cycle below an altitude of 35 km.

Furthermore, GELLER and ALPERT´s results indicate (1980) that the tropospheric planetary wave response to solar-induced changes in the zonal mean state of the stratosphere occur regionally, that is to say, they may be much more evident at some longitudes and latitudes than at other locations where they may be absent altogether.

It is known that the zonal flow steadily prevails in the southern hemisphere, while periods with zonal or meridional flow alternativaly occur in the northern hemisphere as a result of the corpuscular radiation effect (BUCHA,1988) . The orographic effect due to continents and oceans seems to influence the flow to such degree that we should consider the meridional flow with atmospheric blocking (Fig. 2, r.h.s. top) to be basic in the middle latitudes of the northern hemisphere and not the zonal flow as was presented till now. During several winter periods, when the geomagnetic activity was low, e.g. 1962-65, 1976-80,the meridional circulation together with expresive blocking high pressure areas prevailed in the northern hemisphere with cold winters in Europe and North America. On the other hand, at the time of high geomagnetic activity, e.g. 1959, 1960, 1974, 1975, 1982,1983 the zonal flow with a high index cycle persisted practically during the whole winter period. This again seems to confirm our conclusions that the processes in the auroral oval due to the corpuscular radiation lead to the zonalization of atmospheric circulation (BUCHA, 1983) .

Changes in carbon dioxide concentration are believed to be one of the main factors which influenced and influence the temperature fluctuations on the globe; high concentration of CO_2 was at the time of interglacials and low CO_2 during glacials. But it is of course also possible that the solar activity influenced global temperature which could cause changes in the CO_2 concentration.

CONCLUSION

There is no doubt that the antropogenic effect, especially during the past 40 years, plays an important role. Our task,however, is to distinguish between antropogenic effect in the atmosphere due to human activities and natural climatic fluctuations influencing biological systems. As can be seen in Fig. 4, the increase in global temperature during the past 100 years is in relatively good coincidence with the increase in geomagnetic (corpuscular) activity. That´s why we can conclude that it could have been the increase in temperature on the northern hemisphere, due to the processes occurring in the auroral oval under enhanced corpuscular radiation (BUCHA, 1988) which led to an increased atmospheric concentration of CO_2 in the past. Both processes, i.e. antropogenic and solar activity effects, should be therefore intensively studied due to their important role for elucidating the past and present global change mainly in temperature, climate and biological systems.

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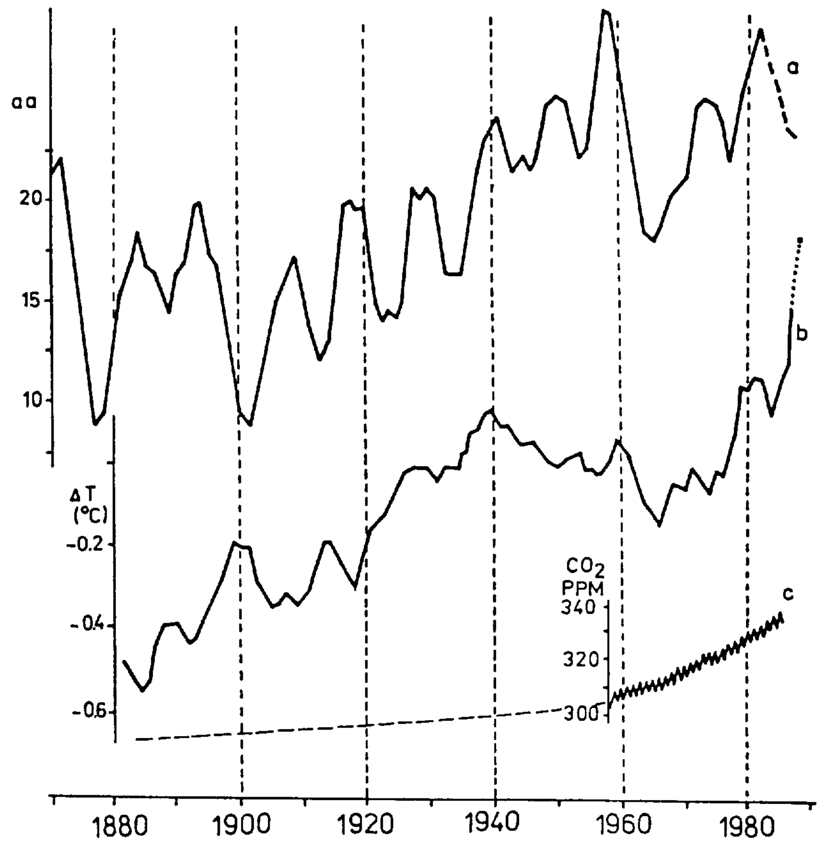

Fig. 4

a/ Changes in geomagnetic activity (aa indices) - five years gliding averages.

b/ Global surface air temperature change (five year running mean) for the past century, with zero point defined as the 1951-1980 mean. The 1988 point compares the January-May 1988 temperature to the mean for the same 5 months in 1951-1980(HANSEN).

c/ Changes in the atmospheric CO_2 concentration,observed increase in atmospheric carbon dioxide,resulting in part from human activities.

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