Publ. Astron. Obs. Belgrade No. 91 (2012), 347 - 351 *Poster*

THE INFLUENCE OF THE ACTIVE SUN ON THE CLIMATIC PERTURBATIONS

J.-C. PECKER

Collège de France, Paris

Abstract. The particles of the solar wind and those emerging from solar active regions do not carry enough energy to influence the global climate of the Earth; but they may influence, through their geomagnetic effects, the perturbations of the climate w.r. to its global behaviour, as demonstrated by using the relations between solar activity and precipitation rates. That remark leads naturally to ask a more general question: is the changing geomagnetic field influencing the climatic perturbations?

1. SECOND ORDER INFLUENCE OF THE SOLAR ACTIVITY

For years, the solar activity has been considered as responsible for the short-term evolution of many terrestrial phenomena, namely aurorae, geomagnetism, jet-stream, etc…

Truly enough the illuminance of the terrestrial ground by the Sun is closely linked with the solar undecennal cycle of activity (see the contribution by Claus Fröhlich to the Bern Workshop on the energy flows in Earth's atmosphere). This is due to the redistribution of brightness on the solar disc, dark spots and bright faculae being numerous during the active period, and scarce during the quiet Sun periods.

But the photons, which affect the global (average) climate of the Earth, are not the only vehicle for solar influence. The active regions, around the spots, emit charged particles of various energies, protons and electrons mostly, at velocities ranging from a few km s^{-1} to one third of the velocity of light. These charged particles eventually meet the magnetic field of the Earth, and, according to their velocity behave in different ways. It is admitted that they vehicle a negligible fraction of the solar energy output. But why shouldn't they affect the terrestrial climate, in changing the equilibrium conditions here and there, by their triggering action?

Indeed, one purpose of the climatic models is to explain or even predict the average, or "global", temperature of the Earth. It is indeed the *first moment* of the temperature distribution. Denoting the latter by T(x,y,z,t), the "global" temperature is $\mathcal{T}(t) = < T(x,y,z,t) >$.

Such a distribution has a *second moment*, which we shall denote by $\Delta\mathcal{T} = < T(t) - \mathcal{T}(t) >$. The flow of active particles does not influence $\mathcal{T}$, but it does influence $\Delta\mathcal{T}$, i.e. the *perturbations* of the local climates over the Earth w.r. to the global climate, - for example the polar climate, or the European climate, etc... which are undoubtedly perceived by the public much more strongly than the global climate.

But is it indeed the case? Is the solar activity influencing the local climates on Earth?

2. RELATIONS BETWEEN PRECIPITATION RATES AND SOLAR ACTIVITY

Several examples of solar-terrestrial relations have been collected in the past, notably in clarifying the link between active solar regions and global geomagnetism (for example Pecker & Roberts, 1954 a,b,c,d), Pecker, Pecker & Schatzman 1959) or between solar activity and meteorological quantities (Pecker 1974, Pecker & Runcorn, 1990); in the present paper, we shall limit ourselves to one of the studies we have contributed to, i.e. the *relation between solar activity and precipitations.*

In 1973, J. Xanthakis (Xanthakis 1973) has studied the relation between an index of solar activity and the rate of precipitations in several observatories of the northern hemisphere, at polar or high latitudes (figure 2). In 1982, following Xanthakis, we (Pecker & Lefèvre, 1982) have completed that study by that of equatorial sites. The available data cover more than a century, and allow a rather safe statistical analysis.

The first result is the evidence of a strong signature of the undecennal solar cycle on the power analysis of the temperature*, at very high and moderately high latitudes*; but there is nothing similar at moderate and equatorial latitudes (figure 1, from Pecker & Lefèvre).

The second result (figure 2, from Xanthakis) is the *correlation* between precipitations at very high latitudes and solar activity, contrasting with the *anticorrelation* found at moderately high latitudes.

A very schematic (and even doubtful!) attempt to explain this behaviour may imply the structure of the auroral zone, which in a way defines the region between what we call the "very high" and the "moderately high" latitudes. The auroral zone acts as a zone where spiralling electric currents of solar-borne charged particles build a sort of quasi-circular wall around the geomagnetic pole, a wall which contributes in its turn to create an additional local magnetic field, in addition to the component of the magnetic field due only to the Earth dynamo. In that field, charged clouds may be pushed from outside to inside the auroral zone. At times of strong solar activity, the intensity of the electric currents is increased, and precipitations may increase inside, decrease outside; there is a compensation between the two regions, as there is virtually no supply of energy, so there is no influence upon the global climate on Earth. A quantitative solution of the MHD problem so defined would no doubt bring very interesting results, and seems at this stage quite necessary.

3. WHAT ARE THE EFFECTS OF THE EVOLUTION OF THE GEOMAGNETIC BIPOLAR FIELD?

The existing relation between the geomagnetic field and the precipitations, as described above, leads immediately to another question, a broader one: are the variations of the geomagnetic field of some effect upon the climate on Earth?

It is well known that, independently from the effects of solar particles, the Earth's magnetic field is neither simple, nor constant, the terrestrial dynamo being a very complicated machine.

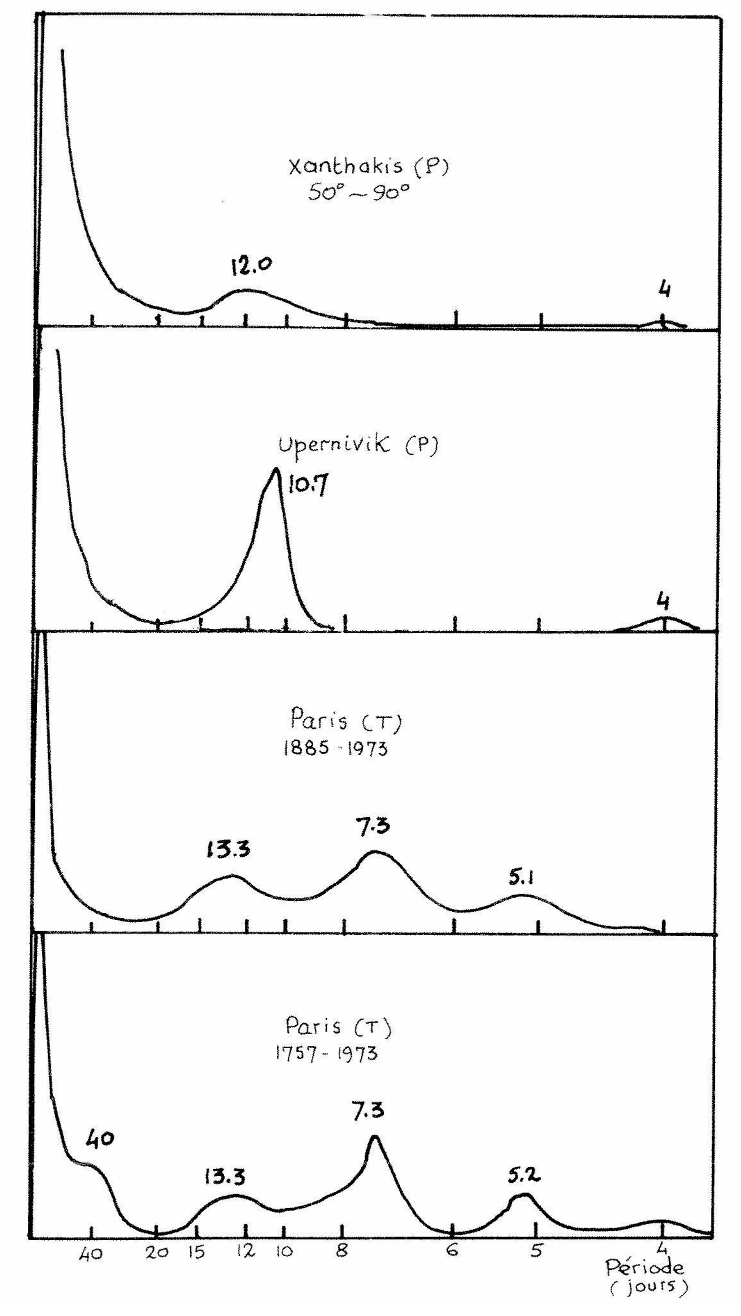

Figure 1: (from Pecker & Lefèvre) Power analysis of data at high latitude stations. From top to bottom: (a), precipitations at stations selected by Xanthakis (between 50°N and 90°N); (b) precipitations at the Greenland station of Uppernivik; (c) temperatures, at Paris, period 1885-1975 (d) temperatures, at Paris, 1757-1975.

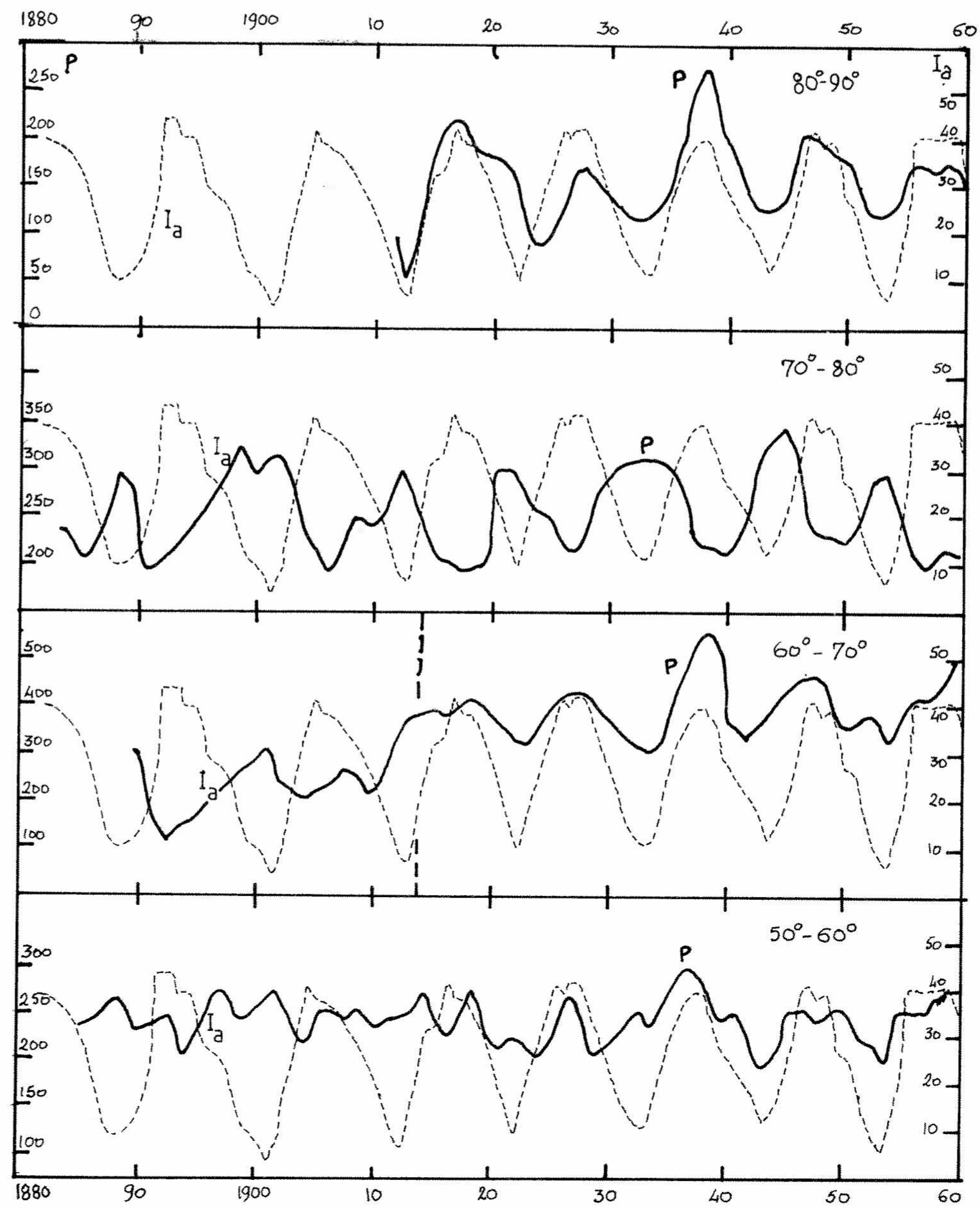

Figure 2: (from Xanthakis) In each of the four diagrams, in dotted lines, the index I_a of solar activity, in full lines, the precipitation index P. Both indices are defined by Xanthakis. From top to bottom: (a) stations of latitude $80° - 90°$; (b) stations of latitude $70° - 80°$; (c) stations of latitude $60° - 70°$; (d) stations of latitude $50° - 60°$. Note that the study by Pecker and Lefèvre, concerning Paris and 8 equatorial stations, confirm the Xanthakis conclusions; it displays periodicities obviously not linked with the solar cycle, but rather with geographic peculiarities.

The schematic magnetic dipole is not centred at the centre of the Earth: it is not even a real dipole, the quadrupolar component being important; the two magnetic "poles" are not antipodic. The two poles migrate on the surface of the Earth in a very clear way, from year to year, at an almost regular pace. During the last 50 years, the North pole has shifted by about 7° in latitude towards (roughly) the north-north-west, and in the same period, the South pole has shifted by about 4° of latitude towards the north-north-west.

The reversal of the magnetic poles has been detected several times from archeo-geology of ices, back to 5 millions years ago. It occurs at intervals of variable duration from one to the other, of 100 000 years to 1 million years. It has not occurred for the last 700 000 years. We may expect "rather soon" (1000 y? 10 000 y? 100 000 y? from now) a reversal after a period of weakened geomagnetic field.

Where are we in this inversion process, in the migration of the poles? It is difficult to predict precisely these behaviours, but the extrapolation of the present situation may suggest it is a prelude to a period of magnetic crisis.

Taking into account the observations described here above in §2, we can conclude that *it is not unlikely that the evolution of the geomagnetic field could strongly influence the* *distribution* *of climatic conditions on the Earth, perhaps more than do the solar forcing or the anthropic forcing.* This warning may be considered as our conclusion.

References

Fröhlich, C.: 2011, Bern ISSI Workshop, in press.

Pecker, J.-C.: 1974, Météorologie et activité solaire, *L'astronomie*, p. 277.

Pecker, J.-C. & Lefèvre, C.: 1982, Caractères météorologiques du climat et activité solaire, in *Compendium in Astronomy*, Reidel publ., pp 151-160.

Pecker, J.-C., & Roberts, W. O.: 1954a, La prédiction des perturbations géomagnétiques, *C.R.Acad.Sc.*, Paris, **239**, 635.

Pecker, J.-C., & Roberts, W. O.: 1954b, The possibility of an avoidance region for the solar M-regions, *Astr. J.*, **59**, 330.

Pecker, J.-C., & Roberts, W. O.: 1954c, The possibility of an avoidance region for the solar M-regions, *Academy of Colorado- Wyoming*, 10th March 1954.

Pecker, J.-C. & Roberts, W. O.: 1954d, Solar corpuscles responsible for geomagnetic disturbances, *J. Geophys. Res.*, **60**, 33.

Pecker, J.-C.,& Runcorn, K.: 1990, The Earth's climate and variability of the Sun over recent millennia, *The Royal Society publ.* (in this volume, the two co-editors have written together a "preface", p. *v*, and an "introduction", pp 1-5; each of them is the author of "closing remarks", J.-C. Pecker from the astronomical point of view, pp 285-286).

Pecker, J.-C., & Schatzman, E.: 1959, *Astrophysique Générale*, pp 690-695, Masson éd., Paris.

Xanthakis, J.: 1973, *Solar activity and related terrestrial phenomena*, Springer publ., Heidelberg.