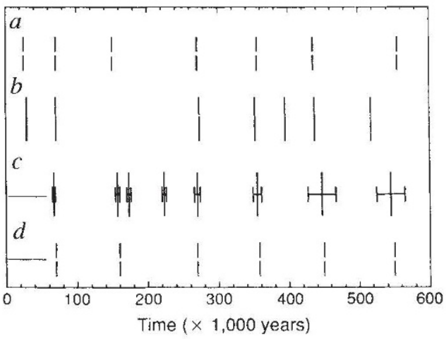
No verification for Milankovitch

SIR — We were puzzled by the table in the Scientific Correspondence[1] by Emilani. He rejects the conventionally used terminations (glacial–interglacial transitions) as time markers and focuses on bathythermals (the coldest portions of glacial cycles), which he deems to be sharper and therefore more precise time markers. He claims that bathythermals in the Devils Hole $\delta^{18}O$ chronology[2] occur at times when the orbital parameters of obliquity and eccentricity are both "low", as determined from Berger's[3] figures, thereby supporting the Milankovitch mechanism[1].

Unfortunately, Emiliani does not specifically define what he means by the critical terms "low" or "when they approach coincidence", but we assume he takes "low" to mean the times when both obliquity and eccentricity were at a minimum, or obliquity was at a minimum and eccentricity was less than at least the long-term (0–600,000-year) average value. We show in the figure the seven astronomical "low" events that Emiliani gives in the third column in his table, as well as the seven (but not identical) events that satisfy the specific definition of astronomical low conditions using data in ref. 4. We were puzzled as to why Emiliani omitted the two-well defined "low" events at 395,000 and 517,000 years and note that they do not correspond to bathythermals in either the Devils Hole[2] or the marine[5] $\delta^{18}O$ chronologies. Indeed, the 395,000-year "low" event occurs during a peak interglacial time. We also note that Emiliani's designation of a "low" event at 555,000 and 150,000 years does not fit the earlier stated definition.



Comparison of all times satisfying the definition of an astronomical low event (see text) and times when Devils Hole $\delta^{18}O$ minima occurred, with the respective values from columns 3 and 2 of the table in ref. 1. Note that the Devils Hole chronology does not cover the period 60,000 to 0 years indicated by the horizontal lines. *a*, Emiliani's astronomical low events; *b*, times when obliquity is minimal and eccentricity is either minimal or below average, *c*, Devils Hole $\delta^{18}O$ minima ($\pm 2\sigma$); *d*, Emiliani's Devils Hole ice ages.

Also show in the figure are the eight major $\delta^{18}O$ minima, denoting times of full glacial climate, found in the Devils Hole chronology, and the subset of six events that Emiliani gives in the second column in his table. He did not mention the two Devils Hole isotope minima at 223,000 and 173,000 years, which do not correspond to any astronomical "low" event.

In comparing the astronomical "low" events predicted by the specific definition with the minimal isotope events found in the Devils Hole chronology, one sees that although there are four 'matches', there are six 'non-matches', twice when a bathythermal would be predicted but did not happen, and four times when one did occur but not during an astronomical "low" event. Thus the astronomical condition that Emiliani specifies is neither sufficient nor necessary for the occurrence of bathythermals.

Jurate Maciunas Landwehr
Isaac J. Winograd
Tyler B. Coplen
US Geological Survey, National Center, Reston, Virginia 22092, USA

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Skin cancer and ultraviolet

SIR — Madronich and de Gruijl[1] provide up-to-date estimates of total column ozone depletion by latitude for the 14-year period 1979 to 1992, and estimates of corresponding increases in ground-level ultraviolet radiation with reference to the action spectra for erythema induction, DNA damage and non-melanocytic skin cancer. These are informative and useful estimates.

They also estimate increases in incidence of basal and squamous cell carcinomas of the skin that may result from the increases in ultraviolet radiation. But there is an inevitable delay following ultraviolet exposure before consequent non-melanocytic skin cancer develops in humans. Although the duration of this delay is not known, it is probably not less than about 20 years at its minimum. This minimum can be inferred from the fact that the incidence of these cancers is very low before 20 years of age[2] although exposure to solar ultraviolet begins, for most people, soon after birth. Further, it will probably be necessary for the generation experiencing the increase in ambient ultraviolet in childhood to have reached old age before new 'steady state' incidence rates of skin cancer, such as those estimated by Madronich and de Gruijl, are reached. This is suggested by evidence that about 80% of skin cancers in Australia can be attributed to exposure to the sun in the first 10 years of life[3].

Ozone-layer depletion will almost certainly increase skin cancer incidence by proportions of the order estimated by Madronich and de Gruijl. These increases, however, may not yet have begun and would not be expected to reach their maxima, even if there is little further increase in ambient ultraviolet for another 70 or 80 years.

Anne Kricker, Bruce K. Armstrong.
International Agency for Research on Cancer, 69372 Lyon Cedex 08, France
Anthony J. McMichael
Department of Community Medicine, University of Adelaide, South Australia 5005, Australia

MADRONICH AND DE GRUIJL REPLY — Extrapolating trends and effects of ultraviolet into the future is very hypothetical due to uncertainties that arise from atmospheric chemistry, epidemiology, and related disciplines. The values that we calculated[1] are one plausible measure of the magnitude of the ozone–ultraviolet effects. They represent the steady state increase in non-melanoma skin-cancer rates resulting from a permanent decrease in ozone as large as that observed in 1979–92. The timescales for atmospheric change and skin-cancer development are still far from certain: ozone reductions are expected to continue well into next century[4], and the time between ultraviolet exposure and development of skin cancer is essentially unknown, as already recognized by Kricker *et al.* Clearly, there will not be an instantaneous transition to a new steady state, but the assumptions necessary to predict the temporal evolution cannot be justified by present knowledge and would be more hypothetical.

The indication that early-life exposure does more damage is thought-provoking: although lessening the concerns for many, it also suggests that younger and future generations may be at a quantitatively higher risk in relation to atmospheric ozone trends. One should be aware, however, that most people (especially indoor workers) receive much of their lifetime ultraviolet exposure during childhood.

S. Madronich
National Center for Atmospheric Research, Boulder, Colorado 80307, USA
F. de Gruijl
University of Utrecht, Utrecht 3508 GA, The Netherlands

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