An orbital cycle \(<I>\)

Logic: “Contrariwise, if it was so it might be; and if it were so, it would be; but as it isn’t, it ain’t,” explains Tweedledee in *Through the Looking Glass*.

In 1997, Maureen E. Raymo wrote: “the excess ice characteristic of late Quaternary ‘100-kyr’ [100,000 year] climate cycles typically accumulates when July insolation at 65°N has been unusually low for more than a full precessional cycle, or >21 kyr, and once established does not last beyond the next increase in summer insolation. Thus, the timing of the growth and decay of large 100-kyr ice sheets, as depicted in the deepsea δ¹⁸O record, is strongly (and semi-predictably) influenced by eccentricity through its modulation of the orbital precession component of northern hemisphere summer insolation.”

But a causality problem exists with the Milankovitch eccentricity explanation of the 100,000 year climatic cycle during the last 1 million years. The sudden terminations of the glacial cycles have been found to precede increases in insolation in the last 1 million years when the most extensive glaciations have occurred. Logic decrees that the 100,000 year cyclic insolation variation is irrelevant to their explanation. During earlier times, 1-3 million years ago, the dominant cycles of the ice ages centered on periods of 41,000 and 23,000 years, as Milankovitch predicted.

Richard A. Muller proposed that a 100,000 year orbital inclination cycle, \(I\), could be the true factor as this leads the climatic variation by 33,000 years (Figure b34.1). However arguments that rely too strongly on the frequency analysis could be misleading as Raymo finds that ice ages do not end with a 100,000 years metronome beat. Instead, endings are 85,000 years apart or 125,000 years apart. Even so, a cyclic variation in accretion of meteoroids or dust by Earth can be expected.

Upon looking for actual cosmic dust in marine sediments, Franco Marcontonio and Kenneth (Ken) A. Farley in 1995, reported insignificant change of its arrival flux during past climatic cycles. However, in 1997, Farley reported that the \(^{3}\text{He}\) in marine sediments does fluctuate up and down by a factor of 3 to 5 over a 100,000-year-long cycle. Also, the amount of \(^{3}\text{He}\) has been at today’s accumulation levels (40,000 tons annually) for 1 million years and had climbed steeply to this high level beginning 2 million years ago. Farley suggests that upper-atmosphere dustiness has overwhelmed other insolation factors and accounts for the 10 glacials in the last 1 million years having been significantly larger and longer than the lesser ones before.

**Figure b34.1** Comparison of delta oxygen-18 climate data (gray-warm, black-cold) and orbital inclination, \(I\).