FRACTAL ANALYSES OF SEDIMENTARY DEEP-SEA RECORD SHOW
EVIDENCE FOR NON-LINEAR BEHAVIOR OF THE EARTH'S CLIMATE
SYSTEM (LEG 104 SITE 643, NORWEGIAN SEA)

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A continuous undisturbed Pleistocene sedimentary record of oxygen
isotope data, calcium carbonate data and coarse fraction data from ODP Leg
104, Site 643 was investigated in the frequency domain to obtain information
about possible fractal distribution of the sedimentary record.

The results of the spectral analyses demonstrate the presence of the orbital
frequencies in the Milankovitch band, with mean periods at 100, 41, and 21 kyr.
The fractal dimension D was determined by a power spectral method. All
parameters show clear evidence for an underlying fractal Brownian process on
a 95% confidence level, i.e., 1 < D < 2. The CaCO3 signal shows a persistent
behavior (D = 1.37 ± 0.10), whereas the δ18O signal seems to be antipersistent
(D = 1.63 ± 0.09). The fractal dimension of the terrigenous component (D = 1.51
± 0.09) is ambiguous in terms of possible underlying persistence.

In addition, we compared the δ18O record of the Norwegian Sea with δ18O
records from the eastern equatorial Pacific (cores RC 13-110 and V 19-27; MIX
et al., 1991). The fractal dimensions of these records have been estimated to be
D = 1.63 ± 0.08 and D = 1.45 ± 0.10 on a 95% confidence level.

Climatic variability in the late Pleistocene can be regarded as response to
periodically changing solar insolation, due to orbital forcing at distinct
frequencies in the Milankovitch band. If the coupling between solar insolation
and the Earth's climate system were strictly linear, then one would expect only
these driving frequencies to occur in the geological record. In addition,
resonance frequencies of the climate system would appear. Such a record
would not be scale invariant and, hence, the record would not be fractal.

A possible explanation for the observed scale invariance is a non-linear
coupling between incoming solar energy and the climate system. Then, the
response of the climate system can include harmonic and subharmonic
components of the driving frequencies. Beside these harmonic components,
combination tones can be produced.

We suppose that the creation of these additional frequencies is responsible
for the observed scale invariance of the proxy records in the frequency range
between 1/125 and 1/6 kyr⁻¹. Hence, the fractal property of the sedimentary
record might be an expression of the non-linear response of the climate system
to driving solar insolation at distinct frequencies.

Mix, A.C., Pisias, N.G., Zahn, R., Rugh, W., Lopez, C., and Nelson, K., 1991,
Carbon 13 in the Pacific Deep and intermediate Waters, 0-370 Ka: Implications

HIGH RESOLUTION ANALYSIS OF THE CARBONATE-RICH SEDIMENT
CORE 74P FROM THE ONTONG-JAVA PLATEAU (WESTERN EQUATORIAL
PACIFIC)

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The concentrations of 230Th 10Be, Mn and Fe of sediment core 74P
(Ontong-Java Plateau, 2500 m water depth, 540 cm length) were measured at
high resolution (5 cm/sample). δ18O-stratigraphy of the planktonic foraminifer