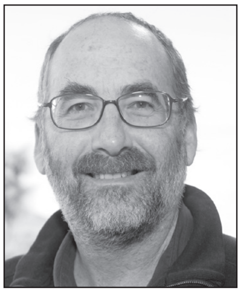
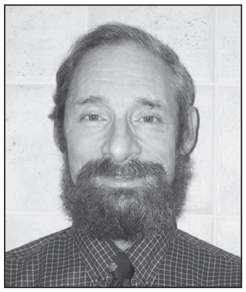
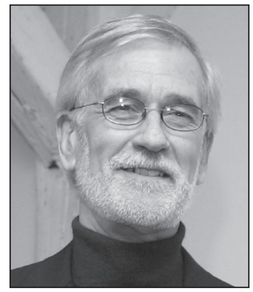


David A. Siegel
For accelerating our understanding of the biogeochemistry and the biological carbon pump of the ocean using novel optical measurements, analyses, and models.



Matthew Sturm
For exceptional leadership in snow and ice research in the Arctic and Antarctic.

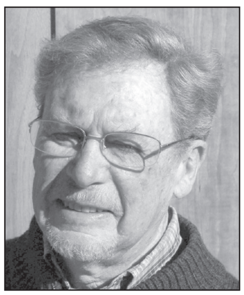
Richard E. Thomson
For the depth, breadth, quality, and abundance of his scientific contributions to understanding physical, chemical, and biological interactions within the oceans of our solar system.



Compton J. Tucker
For pioneering satellite-based monitoring of terrestrial photosynthesis, and elucidating the seasonal, interannual, and longer-term dynamics of terrestrial ecosystems on continental to global scales.

Albert J. Valocchi
For seminal contributions to fundamental understanding and mathematical modeling of reactive transport and nonequilibrium processes in the subsurface.

Robert A. Vincent
For his distinguished career using observations to constrain atmospheric wave theory.



Roland von Huene
For the impact of his studies at subduction zones addressing crustal recycling, seismicity, and subducting relief.

Richard J. Walker
For developing the Re-Os isotope system into a useful tool, and applying it to achieve fundamental discoveries in a wide range of topics in the Earth and planetary sciences.

Richard H. Wanninkhof
For his groundbreaking research and scientific leadership on air-sea gas exchange and the global carbon cycle.

Donald J. Wuebbles
For his pioneering studies of stratospheric ozone depletion, atmospheric chemistry, and climate change.

MEETING

Evolving Views on a Dynamic Greenhouse Earth

Climatic and Biotic Events of the Paleogene (CBEP 2009) Conference; Wellington, New Zealand, 12–15 January 2009

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The Paleogene (65–24 million years ago) was a dynamic period in Earth's history in which major mammal groups became established and diversified, rapid and repeated extreme global warming events occurred, and climate began its stuttering progression from a greenhouse to an icehouse climate state. With atmospheric carbon dioxide concentrations in the range projected to occur over the next several centuries (>1000 parts per million), the Paleogene is also a window into our future (see J. C. Zachos et al., *Nature, 451,* 279–283, 2008).

Long-standing interest in understanding the causes and consequences of global change in the Paleogene and the current timeliness of greenhouse climate research explain why conferences are periodically devoted to the climatic and biotic events of the Paleogene. The 2009 conference, held in New Zealand, attracted 130 participants from 20 countries. Presentations demonstrated substantial progress in new climate proxy development, new multiproxy approaches, and closer integration of paleoclimate records with climate models, consolidating around three main issues.

First, several speakers presented research showing how new temperature estimates based on reappraised traditional and exciting new proxies (e.g., marine crenarchaeol tetraether lipids (TEX_{86}), the alkenone undersaturation index, and "snake paleothermometry") from polar to tropical locations indicate that parts of the Paleogene were much warmer than previously reconstructed (J. J. Head et al., *Nature, 457,* 715–717, 2009; C. J. Hollis et al., *Geology, 37,* 99–102, 2009; Z. Liu et al., *Science, 323,* 1187–1190, 2009). High tropical temperatures are consistent with high greenhouse gas concentrations, but the cause of extreme high-latitude warmth during hyperthermals remains poorly understood.

Second, new high-resolution records show that Paleogene climate was highly variable. Large-scale floral and faunal shifts during the Paleocene-Eocene thermal maximum (~55 million years ago), associated with poleward migration of subtropical species, contrast with middle Eocene open-ocean salinity perturbations and the first Arctic occurrence of sea ice diatoms. Debate at the conference focused on the drivers of this variability, including whether the major warmings were in or out of phase with orbital forcing and whether all warmings were associated with negative carbon isotope excursions, and vice versa.

Finally, simultaneously explaining early Paleogene warmth and variability is challenging. The most plausible cause of early Paleogene global warmth is high greenhouse gas concentration. However, the relationship between radiative forcing and greenhouse gas concentration is considered to be logarithmic, so much more greenhouse gas must be added to the atmosphere to cause warming from a higher baseline. As described in several conference presentations, models have difficulty reproducing the range of climate variability reported from Paleogene without invoking unreasonably large forcing. Climate models seem to lack key components or feedbacks that may enhance climatic sensitivity to radiative forcing at high greenhouse gas concentrations.

Ongoing coordinated efforts of this community will better constrain the rates, magnitudes, and variation in greenhouse gas–induced climate change of the past, with implications for the future. For further details, see http://www.gns.cri.nz/cbep2009/.

—CHRIS HOLLIS, GNS Science, Lower Hutt, New Zealand; E-mail: c.hollis@gns.cri.nz; and MATTHEW HUBER, Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, Indiana

BOOK REVIEW

Hilbert-Huang Transform Analysis of Hydrological and Environmental Time Series

A. Ramachandra Rao and En-Ching Hsu
Water Science and Technology Library, Volume 60
Springer; 2008; xii + 244 pp.; ISBN 978-1-4020-6453-1; $139.

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Climatic and hydrologic time series often display periodicities, and thus Fourier spectral analysis sometimes is appropriate. However, time series that are nonstationary, and also perhaps nonlinear, are not well handled by standard Fourier spectral analysis.

Methods to handle nonstationarity, such as moving-time-window Fourier spectral analysis, assume linearity and have known limitations regarding the combined frequency and time resolution. For example, if the time series is stationary, then it is well known that better frequency resolution can be achieved by observing a longer time series (more time points). However, if the time series is nonstationary, then shorter time windows are required to estimate the "local in time" spectrum, analogous to using short-memory moving averages that use only the recent past few values to forecast the next value (P. Bloomfield, *Fourier Analysis of Time Series: An Introduction*, 2nd ed., John Wiley, 2000) because the mean value is changing over time. Therefore, in nonstationary time series analysis, there is a tension between the competing goals of time and frequency resolution. This tension is the reason that N. Huang et al. (*Proc. R. Soc. A, 454*, 903–995, 1998) introduced the Hilbert-Huang Transform (HHT) as an alternative to moving-time-window Fourier spectral analysis (Bloomfield, 2000).

Prior to my writing this review of *Hilbert-Huang Transform Analysis of Hydrological and Environmental Time Series*, I had not heard of the HHT, but I was aware of limitations of moving-time-window Fourier spectral analysis (T. Burr et al., *Radio Sci.*, *40*(6), RS6016, doi:10.1029/2005RS003246, 2005). After reading a Wikipedia description of the HHT (see http://en.wikipedia.org/wiki/Hilbert-Huang_Transform), however, I wanted to read this book. The description claimed promising empirical results without a fully corresponding theory.

The two key components of the HHT are the empirical mode decomposition (EMD) and the Hilbert transform. The EMD is required to transform the time series x into intrinsic mode functions (IMF) to which Hilbert spectral analysis can be applied. An IMF is a function that satisfies two requirements: In the whole data set, the number of extrema and the number of zero-crossings must either be equal or differ at most by 1; and, at any point, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima must be zero.

An IMF can have variable amplitude and frequency along the time axis. Extracting an IMF is called sifting and consists of three steps: (1) identifying all of the local extrema in the test data, (2) connecting all of the local maxima by a cubic spline (a smooth fit) as the upper envelope, and (3) repeating the procedure for the local minima to produce the lower envelope.

Results reported to date for the HHT are mostly empirical, without corresponding theory to fully support each stage of analysis. For example (chap. 2, p. 25), one unresolved technical issue is that the connection of local maxima using a cubic spline is reasonable but ad hoc. Certainly, splines are a well-established method to fit a smooth curve to data, but their role in the broader context of the HHT is currently purely empirical. Therefore, the HHT essentially is a recipe that does not yet have formal justification to estimate the instantaneous spectral frequency. However, reasonable empirical justification is provided throughout the text and in the growing HHT literature. I anticipate that the HHT literature will continue to grow, partly because the open-source statistical programming language R (http://www.r-project.org/) now has a package named EMD containing functions for the empirical mode decomposition and Hilbert spectral analysis (the HHT transform).

The book has eight chapters. Chapter 1 is an introduction, discussing published HHT applications and describing the research presented in later chapters to apply the HHT to univariate climatic and hydrologic time series, such as rainfall, runoff, and temperature. Chapter 2 describes the HHT and includes brief descriptions of standard and tapered Fourier analysis for nonstationary data. Tapered Fourier analysis is a common way to minimize spectral leakage, which refers to power at a given frequency having undesired impacts on the power spectrum estimate at other frequencies.

Chapter 3 illustrates how to simulate some nonlinear and nonstationary time series that resemble real time series of interest. The chapter also applies the HHT and tapered Fourier analysis to the simulated time series. Chapters 4–8 provide detailed case studies (research by the authors prepared while writing this text) in applying the HHT and tapered Fourier analysis to specific hydrologic and climatic data sets.

I believe *Hilbert-Huang Transform Analysis of Hydrological and Environmental Time Series* will satisfy researchers in any discipline who analyze nonstationary and/or nonlinear time series. The book does not claim to be a final word on the merits of the HHT, but it does extend empirical claims regarding the potential effectiveness of the HHT. There are no exercises, although the book could be used in a teaching setting.

I have some relatively minor suggestions for improvement. First, the section in chapter 2 on windowed and tapered Fourier analysis could be lengthened and improved, perhaps at the level of the introductory text by Bloomfield (2000) on spectral analysis. As written, the section assumes the reader is familiar with windowed and tapered Fourier analysis, so it does not explicitly define all terms such as "spectrogram" and "window leakage." Second, the authors have clearly conveyed the key concepts of the HHT, but there are many grammatical errors that would be simple, although time-consuming, to remove. And third, some of the plots use very small fonts that should be larger for visibility.

Overall, I was glad to read the book and believe the HHT is well worth continued study as a potentially effective tool in the challenging area of nonstationary and nonlinear time series analysis.

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