

REPORT DOCUMENTATION PAGE

Form Approved OMB NO. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA, 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY) 24-08-2009		2. REPORT TYPE Final Report		3. DATES COVERED (From - To) 1-Aug-2006 - 31-Jul-2009	
4. TITLE AND SUBTITLE Final report for ARO 50472MADRI Modeling complex phenomena using multiscale time sequences			5a. CONTRACT NUMBER W911NF-06-1-0323		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER 611102		
6. AUTHORS Nicola Scafetta, Richard Moon			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAMES AND ADDRESSES Duke University Office of Research Support Duke University Durham, NC 27705 -				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211				10. SPONSOR/MONITOR'S ACRONYM(S) ARO	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) 50472-MA-DRI.2	
12. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; Distribution Unlimited					
13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.					
14. ABSTRACT The purpose of the work funded by this grant was to study and model complex phenomena by using an approach that makes use of multiscale time sequences. The underlying idea is that a complex dynamical system can be better interpreted and modeled by taking into account how its dynamics behaves at different scales and how these scales relate to each other. This can be done by combining a set of statistical fractal measures based on Hurst and Holder exponents, auto-regressive methods and Fourier and wavelet decomposition methods. The applications for this					
15. SUBJECT TERMS multiscale, dynamical systems, anomalous diffusion, fractal statistics, geophysical applications, medical applications					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Nicola Scafetta
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER 919-660-2643

Report Title

Final report for ARO 50472MADRI

Modeling complex phenomena using multiscale time sequences

ABSTRACT

The purpose of the work funded by this grant was to study and model complex phenomena by using an approach that makes use of multiscale time sequences. The underlying idea is that a complex dynamical system can be better interpreted and modeled by taking into account how its dynamics behaves at different scales and how these scales relate to each other. This can be done by combining a set of statistical fractal measures based on Hurst and Holder exponents, auto-regressive methods and Fourier and wavelet decomposition methods. The applications for this technology include mathematical algorithms to model and predict geophysical phenomena such as climate and weather patterns as well as biological/biomedical phenomena such as, for example, for the treatment of injured individuals.

List of papers submitted or published that acknowledge ARO support during this reporting period. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

- 1) N. Scafetta and B. J. West , “Phenomenological solar signature in 400 years of reconstructed Northern Hemisphere temperature record,” *Geophys. Res. Lett.*, 33, doi:10.1029/2006GL027142. (2006).
- 2) N. Scafetta, R. Moon, and B. J. West, “Physiological signals and their fractal response to stress conditions, environmental changes and neurodegenerative diseases. ” in the proceedings of The 25th Army Science Conference (ASC),Orlando, Florida, November 27-30, (2006).
- 3) N. Scafetta and B. J West, "Probability distributions in conservative energy exchange models of multiple interacting agents", *J. Phys.: Condens. Matter* 19 (2007) 065138
- 4) N. Scafetta, R. Moon, and B. J. West, “Fractal Response of Physiological Signals to Stress Conditions, Environmental Changes and Neurodegenerative Diseases,” *Complexity* 12, 12-17 (2007).
- 5) I. F. Forkner, C. A. Piantadosi, N. Scafetta, R. E. Moon, Hyperoxia-Induced Tissue Hypoxia: A Danger?, *Anesthesiology* 106, 1051-5 (2007).
- 6) N. Scafetta, and B. J. West, “Emergence of bi-fractal time series from noise via allometric filters.” *European Physical Letters* 79, 30003, (2007).
- 7) N. Scafetta, and B. J. West, “Phenomenological reconstructions of the solar signature in the NH surface temperature records since 1600.” *J. Geophys. Res.*, 112, D24S03, doi:10.1029/2007JD008437 (2007).
- 8) I. F. Forkner, C.A. Piantadosi, N. Scafetta, R. E. Moon, “Hyperoxia-Induced Tissue Hypoxia: A Danger?Reply to MS #200707041,”, *Anesthesiology*, 108 169-170 Article Number: ISSN 0003-3022 Article Number: ISSN 0003-3022 (2007-8).
- 9) N. Scafetta and Bruce J. West, “Is climate sensitive to solar variability?” *Physics Today*, 3 50-51 (2008).
- 10) N. Scafetta, "Comment on ``Heat capacity, time constant, and sensitivity of Earth's climate system' by Schwartz." *J. Geophys. Res.*, 113, D15104, doi:10.1029/2007JD009586. (2008).
- 11) K.F. Froehlich, M.R. Graham, T.G. Buchman, L.G. Girling, N. Scafetta, B.J. West, E.K-Y. Walker, B.M. McManus and W.A.C. Mutch, “Physiological Noise versus White Noise to Drive a Variable Ventilator in a Porcine Model of Lung Injury” *Canadian Journal of Anesthesia* 55(9) 572 - 576 (2008).
- 12) N. Scafetta and B. J. West, reply letter in "Variation on Sun's role in climate change," *Physics Today*, October, page 10-16 (2008).
- 13) N. Scafetta and R. C. Willson, “ACRIM-gap and Total Solar Irradiance (TSI) trend issue resolved using a surface magnetic flux TSI proxy model”, *Geophysical Research Letter* 36, L05701, doi:10.1029/2008GL036307 (2009) .
- 14) N. Scafetta, D. Marchi and B. J. West, “Understanding the complexity of human gait dynamics,” *Chaos* 19, 026108 (2009).
- 15) N. Scafetta, “Total solar irradiance satellite composites and their phenomenological effect on climate," In press on a special volume for the Geological Society of America. (2009).
- 16) N. Scafetta, “Empirical analysis of the solar contribution to global mean air surface temperature change,” *Journal of Atmospheric and Solar-Terrestrial Physics* (2009), doi:10.1016/j.jastp.2009.07.007.

Number of Papers published in peer-reviewed journals: 16.00

(b) Papers published in non-peer-reviewed journals or in conference proceedings (N/A for none)

Number of Papers published in non peer-reviewed journals: 0.00

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts): 0

Peer-Reviewed Conference Proceeding publications (other than abstracts):

N. Scafetta, R. Moon, and B. J. West, "Physiological signals and their fractal response to stress conditions, environmental changes and neurodegenerative diseases." in the proceedings of The 25th Army Science Conference (ASC), Orlando, Florida, November 27-30, (2006).

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts): 1

(d) Manuscripts

17) N. Scafetta, "Understanding human mobility with a three-scale diffusion model" submitted (2009)

18) N. Scafetta and B. J. West, "'Solar trends and global warming," a reply" submitted (2009)

19) N. Scafetta, "Are some multidecadal climate oscillations resonating with the orbits of the planets?" submitted (2009)

20) N. Scafetta and Richard Willson, "ACRIM composite TSI trend validated using new solar surface magnetic field TSI proxy model" submitted (2009)

Number of Manuscripts: 4.00

Number of Inventions:

Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Post Doctorates

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

- The number of undergraduates funded by this agreement who graduated during this period: 0.00
- The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00
- The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00
- Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00
- Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00
- The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00
- The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

<u>NAME</u>
Total Number:

Names of personnel receiving PHDs

<u>NAME</u>
Total Number:

Names of other research staff

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Final report for ARO 50472MADRI

Modeling complex phenomena using multiscale time sequences

Aug/01/2006 to Jul/31/2009

PI: Nicola Scafetta, Ph.D.

Co-Pi: Richard Moon, M.D.

The purpose of the work funded by this grant was to study and model complex phenomena by using an approach that makes use of multiscale time sequences. The underlying idea is that a complex dynamical system can be better interpreted and modeled by taking into account how its dynamics behaves at different scales and how these scales relate to each other. This can be done by combining a set statistical fractal measures based on Hurst and Holder exponents, auto-regressive methods and Fourier and wavelet decomposition methods. The applications for this technology include mathematical algorithms to model and predict geophysical phenomena such as climate and weather patterns as well as biological/biomedical phenomena such as, for example, for the treatment of injured individuals.

This work has produced a book that will be in press before the end of the year to be published by World Scientific. There are 16 published papers in prestigious physical, geophysical and medical journals, plus 4 papers submitted that are currently under review, and a number of additional working papers. This research has also been publicized in several international conferences pertaining to the American Geophysical Society, the Geological Society of America, The American Society of Anesthesiologists. The geophysical research related to climate change has also received a diffused international media attention.

The papers we have published describe the implementation of complex modeling to efficiently analyze and predict several geophysical and biological/biomedical phenomena.

Regarding geophysical research, our study focused on addressing the solar influence on climate change. The sun-climate link is clearly a multiscale phenomenon given the fact that sun can affect climate through different channels and each time scale must be identified and modeled. We have adopted several methods and have refined the multiscale method [1, 7, 9, 10, 12, 16, 18, 19, 20]. My last publication [16] proposes that the solar signature on climate can be obtained with a bi-scale model. This is due to the finding that the climate system is indeed characterized by two scales [10]. Once the climate sensitivity to solar variations at the two scales is determined the solar signature can be predicted over centuries. To efficiently apply the technique we have also addressed a important controversy regarding total solar irradiance satellite composite [13, 15] that can be addressed with the same multi-scale philosophy. Three other studies related to this topic are currently submitted to journals [see submitted papers]. Both solar and climate findings have importance for the current global climate change debate. Specifically, I have demonstrated that solar dynamics are extremely important for interpreting climate change.

Our research also focused on biological/biomedical applications, for which mathematical statistical algorithms were developed based on fractal and multifractal exponents. The application of this methodology includes characterization of physiological signals such as respiration, heart rate and blood pressure with the aim of developing strategies to monitor critically ill patients. We have studied

physiological signals and their fractal response to stress conditions, environmental changes and neurodegenerative diseases [2, 4, 14], contributed to a medical project dedicated to the development of a biological ventilator [11] and constructed a model to evaluate the hypothesis of hyperoxia-induced tissue hypoxia [5, 8]. A large project designed to develop monitoring facilities for post-operative patients by using breathing fractal and multifractal patterns is ongoing [see the works in progress, 21, 23, 23].

Finally, there are other three studies:

- 1) Probability distributions in conservative energy exchange models of multiple interacting agents. This has been implemented by using several alternative models for energy exchange [3]. This study shows that the property of an energy distribution of a given population of interacting agents or particles does depend on the specific properties of how the energy is exchanged among the agents. We show that different distributions emerge: some have a finite variance while others have a Levy/Pareto behavior. The study is important for interpreting several complex phenomena which are made of an interacting population that exchanges some form of energy or information. Applications might include better understanding a network population formation and grow as well as interpretation of some anomalous chemical reaction.
- 2) Emergence of bi-fractal time series from noise via allometric filters [6]. This study shows why it is so common to find bi-fractal time sequences in nature.
- 3) Description of human mobility using a three-scale diffusion model [see submitted works, 17]. Understanding the basic law governing human motion is fundamental for urban planning, traffic forecasting and, especially, for understanding the spread of biological and mobile viruses. This study has shown that human mobility can be described using a multiscale model.

The following pages contain brief descriptions and abstracts of papers related to this project.

Part of this research has been summarized in a book “Disrupted Networks: from Physics to Climate Change.” (in press).

Book:

Scafetta N. and B.J. West, *Disrupted Networks: from Physics to Climate Change*.

This is a 300-page book on complex systems that is will be published in a few months by World Scientific.

Published works or works in Press:

- 1) N. Scafetta and B. J. West , “Phenomenological solar signature in 400 years of reconstructed Northern Hemisphere temperature record,” *Geophys. Res. Lett.*, 33, doi:10.1029/2006GL027142. (2006).
- 2) N. Scafetta, R. Moon, and B. J. West, “Physiological signals and their fractal response to stress conditions, environmental changes and neurodegenerative diseases. ” in the proceedings of The 25th Army Science Conference (ASC),Orlando, Florida, November 27-30, (2006).
- 3) N. Scafetta and B. J West, "Probability distributions in conservative energy exchange models of multiple interacting agents", *J. Phys.: Condens. Matter* 19 (2007) 065138
- 4) N. Scafetta, R. Moon, and B. J. West, “Fractal Response of Physiological Signals to Stress Conditions, Environmental Changes and Neurodegenerative Diseases,” *Complexity* 12, 12-17 (2007).
- 5) I. F. Forkner, C. A. Piantadosi, N. Scafetta, R. E. Moon, *Hyperoxia-Induced Tissue Hypoxia: A Danger?*, *Anesthesiology* 106, 1051-5 (2007).
- 6) N. Scafetta, and B. J. West, “Emergence of bi-fractal time series from noise via allometric filters.” *European Physical Letters* 79, 30003, (2007).
- 7) N. Scafetta, and B. J. West, “Phenomenological reconstructions of the solar signature in the NH surface temperature records since 1600.” *J. Geophys. Res.*, 112, D24S03, doi:10.1029/2007JD008437 (2007).
- 8) I. F. Forkner, C.A. Piantadosi, N. Scafetta, R. E. Moon, “Hyperoxia-Induced Tissue Hypoxia: A Danger?Reply to MS #200707041,” *Anesthesiology*, 108 169-170 Article Number: ISSN 0003-3022 Article Number: ISSN 0003-3022 (2007-8).
- 9) N. Scafetta and Bruce J. West, “Is climate sensitive to solar variability?” *Physics Today*, 3 50-51 (2008).
- 10) N. Scafetta, "Comment on ``Heat capacity, time constant, and sensitivity of Earth's climate system' by Schwartz." *J. Geophys. Res.*, 113, D15104, doi:10.1029/2007JD009586. (2008).
- 11) K.F. Froehlich, M.R. Graham, T.G. Buchman, L.G. Girling, N. Scafetta, B.J. West, E.K-Y. Walker, B.M. McManus and W.A.C. Mutch, “Physiological Noise versus White Noise to Drive a Variable Ventilator in a Porcine Model of Lung Injury” *Canadian Journal of Anesthesia* 55(9) 572 - 576 (2008).
- 12) N. Scafetta and B. J. West, reply letter in "Variation on Sun's role in climate change," *Physics*

Today, October, page 10-16 (2008).

13) N. Scafetta and R. C. Willson, "ACRIM-gap and Total Solar Irradiance (TSI) trend issue resolved using a surface magnetic flux TSI proxy model", *Geophysical Research Letter* 36, L05701, doi: 10.1029/2008GL036307 (2009) .

14) N. Scafetta, D. Marchi and B. J. West, "Understanding the complexity of human gait dynamics," *Chaos* 19, 026108 (2009).

15) N. Scafetta, "Total solar irradiance satellite composites and their phenomenological effect on climate," In press on a special volume for the Geological Society of America. (2009).

16) N. Scafetta, "Empirical analysis of the solar contribution to global mean air surface temperature change," *Journal of Atmospheric and Solar-Terrestrial Physics* (2009), doi:10.1016/j.jastp.2009.07.007.

Submitted works:

17) N. Scafetta, "Understanding human mobility with a three-scale diffusion model" submitted (2009)

18) N. Scafetta and B. J. West, "'Solar trends and global warming,' a reply" submitted (2009)

19) N. Scafetta, "Are some multidecadal climate oscillations resonating with the orbits of the planets?" submitted (2009)

20) N. Scafetta and Richard Willson, "ACRIM composite TSI trend validated using new solar surface magnetic field TSI proxy model" submitted (2009)

Works in progress:

21) Moon RE, Scafetta N, Mielke L, Klein F. "Fractal analysis of breathing pattern in patients after surgery." (To be submitted to *Anesthesiology*).

22) Moon RE, Scafetta N, Keifer J, Krystal AD. "Polysomnography and fractal analysis of respiratory pattern in patients receiving opioids after major surgery." (to be submitted to *Anesthesiology*).

23) Pollock NW, Scafetta N, Cherry AD, Forkner IF, Frederick HJ, Freiburger JJ, Stolp BW, Rhodes MA, Moon RE. "End-tidal and arterial PCO₂ differences in divers at 122 fsw." (To be submitted to *Undersea & Hyperbaric Medicine*).

SUMMARY:

(starting with the latest)

Works in progress:

(these are works at an advanced stage).

Moon RE, Scafetta N, Mielke L, Klein F. "Fractal analysis of breathing pattern in patients after surgery." (To be submitted to Anesthesiology).

Moon RE, Scafetta N, Keifer J, Krystal AD. "Polysomnography and fractal analysis of respiratory pattern in patients receiving opioids after major surgery." (to be submitted to Anesthesiology).

Pollock NW, Scafetta N, Cherry AD, Forkner IF, Frederick HJ, Freiburger JJ, Stolp BW, Rhodes MA, Moon RE. "End-tidal and arterial PCO2 differences in divers at 122 fsw." (To be submitted to Undersea & Hyperbaric Medicine).

Submitted works

N. Scafetta, "Understanding human mobility with a three-scale diffusion model" submitted (2009)

Here I have shown that the distribution of human displacements can be described by three consecutive inverse power law distributions with simple integer exponents equal to 1, 2 and 3 corresponding to three displacement length zones, respectively. These zones correspond to short, medium and long displacement ranges which are at about $\Delta r < 10$ km, $10 \text{ km} < \Delta r < 300$ km and $\Delta r > 300$ km, respectively. These three zones can be geographically and physically determined. The incremental values of these exponents can be explained with a three-scale diffusion cost model for human displacements. The three displacement zones are characterized by the fact that the number of cost mechanisms involved in a given displacement increases with the displacement length.

Nicola Scafetta and Bruce J. West, "Solar trends and global warming," a reply" submitted (2009)

This is a reply to Benestad and Schmidt [2009] (BS09), who asserted that several empirical climate studies that attempt to measure the solar signature on climate are non-robust." We demonstrated that in BS09 there are a number of fundamental mathematical errors in the application of wavelet analysis to time series leading to erroneous physical interpretations of their analyses. Moreover, we demonstrated that the GISS ModelE used by them is not sufficiently statistically robust to be used to test the empirical studies. The GISS climate model is shown: 1) to underestimate the 11-year solar signature by

a factor of 3 for the surface measurements up to a factor of 8 for the lower stratosphere measurements; 2) to significantly overestimate the volcano signal both in amplitude and duration; 3) do not reproduce the Little Ice Age. We established that through a combination of mathematical errors, misinterpretations and using basically flawed climate models that BS09 misleads the debate on the solar contribution to climate change.

N. Scafetta, "Are some multidecadal climate oscillations resonating with the orbits of the planets?" submitted (2009)

We investigated whether some climate oscillations are extraterrestrially induced and linked to planetary motion. We found that several global surface temperature records since 1850 and the speed of the sun relative to the center of mass of the solar system present a common set of frequencies: at least 10 cycles with periods between 5 and 100 years closely correspond in the two records. In particular, large climate oscillations with peak-to-trough amplitude of about 0.1°C and 0.25°C and periods of about 20 and 60 years, respectively, are in phase with equivalent oscillations found in the above solar index. These natural oscillations can be used to model temperature changes since 1850 and make partial forecasts for the 21st century. These projections indicate that climate may stabilize or cool until 2030. At least 60% of the global warming observed from 1970 to 2000 has been induced by the combined effect of the above natural multidecadal climate oscillations.

N. Scafetta and Richard Willson, "ACRIM composite TSI trend validated using new solar surface magnetic field TSI proxy model" submitted (2009)

Here we resolved the ACRIM-gap continuity dilemma for satellite total solar irradiance observations by comparing the NIMBUS7/ERB satellite observations [Hoyt et al., 1992] against a recent TSI proxy model based on variations of the surface distribution of the solar magnetic field [Wenzler et al., 2006]. We found that the TSI observed by NIMBUS7/ERB and predicted by the proxy model agree during the 'ACRIM gap' (1990 to 1992.5). This agreement is a validation of the ACRIM composite TSI approach and its 0.037%/decade trend during solar cycles 21 – 23 [Willson and Mordvinov, 2003]. Conversely, the trend-less PMOD composite TSI [Frohlich and Lean, 1998, Frohlich, 2006] is incompatible with this finding which refutes their claim that NIMBUS7/ERB results suffered from an anomalous upward sensor drift during the ACRIM gap.

Published works or works in Press

1) Scafetta N. and B.J. West, Disrupted Networks: from physics to climate change. This is a 300-page book on complex systems that will be published in a few months by World Scientific.

N. Scafetta, "Empirical analysis of the solar contribution to global mean air surface temperature change," Journal of Atmospheric and Solar-Terrestrial Physics (2009), doi:10.1016/j.jastp.2009.07.007.

The solar contribution to global mean air surface temperature change has been analyzed by using an empirical bi-scale climate model characterized by both fast and slow characteristic time responses to solar forcing: $t_1 = 0.4 \pm 0.1$ yr, and $t_2 = 8 \pm 2$ yr or $t_2 = 12 \pm 3$ yr. Since 1980 the solar contribution to climate change has been uncertain because of the severe uncertainty of the total solar irradiance satellite composites. The sun may have caused either a slight cooling, if PMOD TSI composite is used, or a significant warming (up to 65% of the total observed warming) if ACRIM, or other TSI composites are used. The model is calibrated only on the empirical 11-year solar cycle signature on the instrumental global surface temperature since 1980. The model reconstructs the major temperature patterns covering 400 years of solar induced temperature changes, as shown in recent paleoclimatic global temperature records.

N. Scafetta, "Total solar irradiance satellite composites and their phenomenological effect on climate," In press on a special volume for the Geological Society of America. (2009).

Here I discussed and proposed updated satellite composites of the total solar irradiance covering the period 1978-2008. The composites were compiled from measurements made with the three ACRIM experiments and measurements from the NIMBUS7/ERB and the ERBS/ERBE satellite experiments are used to evaluate the gap from June 1989 to October 1991 between ACRIM1 and ACRIM2 experiments. The climate implications of the alternative satellite composites are discussed by using a phenomenological climate model for reconstructing the total solar irradiance signature on climate during the last four centuries.

N. Scafetta, D. Marchi and B. J. West, "Understanding the complexity of human gait dynamics," Chaos 19, 026108 (2009).

Time series of human gait stride intervals exhibit fractal and multifractal properties under several conditions. Records from subjects walking at normal, slow, and fast pace speed were analyzed to determine changes in the fractal scalings as a function of the stress condition of the system. Records from subjects with ages ranging from childhood to the elderly, and including patients suffering from

neurodegenerative disease were analyzed to determine changes in the fractal scalings as a function of the physical maturation or degeneration of the system. A supercentral pattern generator model was presented to simulate the above two properties that are typically found in dynamical network performance: that is, how a dynamical network responds to stress and to evolution.

Nicola Scafetta and Richard Willson, "ACRIM-gap and Total Solar Irradiance (TSI) trend issue resolved using a surface magnetic flux TSI proxy model", Geophysical Research Letter 36, L05701, doi:10.1029/2008GL036307 (2009) .PDF Supporting material.

This paper resolves the ACRIM-gap (1989.5–1991.75) continuity dilemma for satellite TSI observations by bridging the satellite TSI monitoring gap between ACRIM1 and ACRIM2 results with TSI derived from Krivova et al.'s (2007) proxy model based on variations of the surface distribution of solar magnetic flux. 'Mixed' versions of ACRIM and PMOD TSI composites are constructed with their composites' original values except for the ACRIM gap, where Krivova modeled TSI is used to connect ACRIM1 and ACRIM2 results. Both 'mixed' composites demonstrate a significant TSI increase of 0.033%/decade between the solar activity minima of 1986 and 1996, comparable to the 0.037% found in the ACRIM composite. The finding supports the contention of Willson (1997) that the ERBS/ERBE results are flawed by uncorrected degradation during the ACRIM gap and refutes the Nimbus7/ERB ACRIM gap adjustment Frohlich and Lean (1998) employed in constructing the PMOD.

Nicola Scafetta and Bruce J. West, reply letter in "Variation on Sun's role in climate change," Physics Today, October, page 10-16 (2008).

K.F. Froehlich, M.R. Graham, T.G. Buchman, L.G. Girling, N. Scafetta, B.J. West, E.K-Y. Walker, B.M. McManus and W.A.C. Mutch, "Physiological Noise versus White Noise to Drive a Variable Ventilator in a Porcine Model of Lung Injury" Canadian Journal of Anesthesia 55(9) 572 - 576 (2008).

Purpose: Variable ventilation is superior to control mode ventilation in a number of circumstances. The nature of the breathing file used to deliver the variable rate and tidal volume has not been formally examined.

Methods: We compared two different noise files in a randomized prospective trial of variable ventilation. Pigs were anesthetized, intubated, and mechanically ventilated. Oleic acid was infused to introduce lung injury. The animals were ventilated at a tidal volume of 7 mL·kg⁻¹, in variable mode, with either physiologically- derived noise (variability file – 1,587 breath intervals– obtained from a spontaneously breathing volunteer; n = 10) or a variability file of identical length derived from computergenerated white noise (n = 10).

Results: The physiologically-derived noise had a power law γ - exponent of -0.27 and a Hölder exponent of -0.38, indicative of auto-correlated noise. The computer-generated noise had an exponent of -0.52 and a Hölder exponent of -0.49, indicative of white noise. Both files showed multifractal characteristics. There were no differences between groups, at any time period, or PaO₂, PaCO₂, and static or dynamic respiratory system compliance. No differences were observed between groups for wet:dry lung weight ratios or for interleukin-8 in bronchoalveolar lavage fluid.

Nicola Scafetta, "Comment on ``Heat capacity, time constant, and sensitivity of Earth's climate system' by Schwartz." J. Geophys. Res., 113, D15104, doi:10.1029/2007JD009586. (2008).

Nicola Scafetta and Bruce J. West, "Is climate sensitive to solar variability?" Physics Today, 3 50-51 (2008).

The causes of global warming—the increase of approximately 0.8 ± 0.1 °C in the average global temperature near Earth's surface since 1900—are not as apparent as some recent scientific publications and the popular media indicate. We contend that the changes in Earth's average surface temperature are directly linked to two distinctly different aspects of the Sun's dynamics: the short-term statistical fluctuations in the Sun's irradiance and the longer-term solar cycles. This argument for directly linking the Sun's dynamics to the response of Earth's climate is based on our research and augments the interpretation of the causes of global warming presented in the United Nations 2007 Intergovernmental Panel on Climate Change (IPCC) report.

Ivy F. Forkner, Claude A. Piantadosi, Nicola Scafetta, Richard E. Moon, "Hyperoxia-Induced Tissue Hypoxia: A Danger?Reply to MS #200707041," Anesthesiology, 108 169-170 Article Number: ISSN 0003-3022 Article Number: ISSN 0003-3022 (2007-8).

Nicola Scafetta, and Bruce J. West, "Phenomenological reconstructions of the solar signature in the NH surface temperature records since 1600." J. Geophys. Res., 112, D24S03, doi:10.1029/2007JD008437 (2007).

Abstract:

Herein, a phenomenological climate model is adopted to estimate the relative contribution of the (solar-induced) natural versus anthropogenic-added climate forcing during the industrial era (roughly since 1900) under different pre-industrial temperature and solar data reconstructions since 1610. We argue that the thermodynamical inertia of the ocean suggests that climate experienced a large pre-industrial secular variability such as the paleoclimate temperature reconstruction suggested by Moberg et al.

[2005] and that the total solar irradiance experienced a lower variability such as the reconstruction by Wang et al. [2005]. Under this data scenario the Sun might have contributed 44% (or more) of the observed global warming since 1900.

Nicola Scafetta, and Bruce J. West, "Emergence of bi-fractal time series from noise via allometric filters." *European Physical Letters* 79, 30003, (2007).

Abstract:

We show how fractal time series can naturally emerge from an input signal, which might be also random noise, when processed by some allometric mechanisms. In particular, we introduce and study the properties of allometric low and high-pass filters. We also argue that in nature pure monofractal signals could be unphysical, while bi-scaling signals might be extremely common, a fact that might be due to allometric geometrical constraint. Finally, we suggest how allometric physical mechanisms could give an approximate interpretation of the fractional calculus.

Ivy F. Forkner, Claude A. Piantadosi, Nicola Scafetta, Richard E. Moon, *Hyperoxia-Induced Tissue Hypoxia: A Danger?*, *Anesthesiology* 106, 1051-5 (2007).

Abstract:

OXYGEN supplementation has traditionally been believed to increase blood and tissue oxygenation. However, hyperoxia induces bradycardia and a reduction in cardiac output, which partly offsets the otherwise increased oxygen delivery. Recently, an additional mechanism that could further reduce tissue oxygen delivery has been propounded. Experiments in animals and normal humans have suggested that breathing very high concentrations of oxygen can cause an increase in ventilation. [1–4] Proposed mechanisms for this include increased production of reactive oxygen species directly stimulating brain stem carbon dioxide chemoreceptors, [5] oxygen disinhibition of an inhibitory input present during normoxia, [6] and increased brainstem partial pressure of carbon dioxide (PCO_2) secondary to the Haldane effect. As a result of the observed ventilatory effects of oxygen, it has been speculated that hypocapnia ensuing from hyperoxia-induced hyperventilation can reduce organ blood flow sufficiently to cause hypoxia. [7] This notion is now being used by some clinicians for clinical decision making and has been published in the clinical literature. [8] During hyperoxia, the solubility of carbon dioxide in blood is reduced. This is known as the Haldane effect and is a result of the displacement of carbon dioxide from hemoglobin by oxygen. As a result, it has been argued that this decrease in carbon dioxide solubility causes PCO_2 in both venous blood and tissue to increase. Hyperventilation should ensue due to increased PCO_2 .

Nicola Scafetta, Richard Moon, and Bruce J. West, "Fractal Response of Physiological Signals to Stress Conditions, Environmental Changes and Neurodegenerative Diseases," *Complexity* 12, 12-17 (2007).

In the past two decades the biomedical community has witnessed several applications of nonlinear system theory to the analysis of biomedical time series and the development of nonlinear dynamic models. The development of this area of medicine can best be described as nonlinear and fractal physiology. These studies have been intended to develop more reliable methodologies for understanding how biological systems respond to peculiar altered conditions induced by internal stress, environment stress, and/or disease. Herein, we summarize the theory and some of our results showing the fractal dependency on different conditions of physiological signals such as inter-breath intervals, heart inter-beat intervals, and human stride intervals.

Nicola Scafetta and Bruce J West, "Probability distributions in conservative energy exchange models of multiple interacting agents", J. Phys.: Condens. Matter 19 (2007) 065138

Abstract:

Herein we study energy exchange models of multiple interacting agents that conserve energy in each interaction. The models differ regarding the rules that regulate the energy exchange and boundary effects. We find a variety of stochastic behaviours that manifest energy equilibrium probability distributions of different types and interaction rules that yield not only the exponential distributions such as the familiar Maxwell–Boltzmann–Gibbs distribution of an elastically colliding ideal particle gas, but also uniform distributions, truncated exponential distributions, Gaussian distributions, Gamma distributions, inverse power law distributions, mixed exponential and inverse power law distributions, and evolving distributions. This wide variety of distributions should be of value in determining the underlying mechanisms generating the statistical properties of complex phenomena including those to be found in complex chemical reactions.

Nicola Scafetta, Richard Moon, and Bruce J. West, “Physiological signals and their fractal response to stress conditions, environmental changes and neurodegenerative diseases. ” in the proceedings of The 25th Army Science Conference (ASC),Orlando, Florida, November 27-30, (2006).

Abstract:

During the last decades nonlinear system theory has been widely applied to the analysis of biomedical time series and given rise to what is known as nonlinear and fractal physiology. Some of these studies have been intended to develop more reliable methodologies for understanding how biological systems respond to peculiar altered conditions induced by internal stress, environment stress and/or disease. Herein, we show some of our results regarding the fractal dependency on different conditions of physiological signals such as inter-breath intervals, heart inter-beat intervals and human stride intervals.

Nicola Scafetta and Bruce J. West , “Phenomenological solar signature in 400 years of reconstructed Northern Hemisphere temperature record,” *Geophys. Res. Lett.*, 33, doi:10.1029/2006GL027142. (2006).

We study the solar impact on 400 years of a global surface temperature record since 1600. This period includes the pre-industrial era (roughly 1600–1800 or 1600–1900), when negligible amount of anthropogenic-added climate forcing was present and the sun realistically was the only climate force affecting climate on a secular scale, and the industrial era (roughly since 1800–1900), when anthropogenic-added climate forcing has been present in some degree. We use a recent secular Northern Hemisphere temperature reconstruction (Moberg et al., 2005), three alternative total solar irradiance (TSI) proxy reconstructions (Lean et al., 1995; Lean, 2000; Wang et al., 2005) and a scale-by-scale transfer climate sensitivity model to solar changes (Scafetta and West, 2005, 2006). The phenomenological approach we propose is an alternative to the more traditional computer-based climate model approach, and yields results proven to be almost independent on the secular TSI proxy reconstruction used. We find good correspondence between global temperature and solar induced temperature curves during the pre-industrial period such as the cooling periods occurring during the Maunder Minimum (1645–1715) and the Dalton Minimum (1795– 1825). The sun might have contributed approximately 50% of the observed global warming since 1900 (Scafetta and West, 2006). We briefly discuss the global cooling that occurred from the medieval maximum (1000–1100 AD) to the 17th century minimum.
