BIOGRAPHICAL SKETCH

José Antonio Rial jar@email.unc.edu
Born in Tenerife, Spain. American citizen.

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Professor of Geophysics and Climatology
Fellow, American Association for Advancement of Science
Director, Environmental Visualization Laboratory, Institute for the Environment

EDUCATION

IISEE, Tokyo, Japan	MSc	8/1972	Seismology
University of Michigan	MSc	9/1975	Geology
California Institute of Technology	PhD	8/1979	Geophysics

APPOINTMENTS

Full Professor	1996- date	University of North Carolina at Chapel Hill
Associate Professor	1990-1996	University of North Carolina at Chapel Hill
Assistant Professor	1986-1990	University of North Carolina at Chapel Hill
Adjunct Professor	1982-1985	University of California, Santa Cruz
Project Seismologist	1981-1982	Woodward-Clyde Consultants, CA
Post Doctoral	1981-1982	California Institute of Technology

PUBLICATIONS ON CLIMATE CHANGE (1995-DATE)

JOURNALS

Rial, J.A. (1995): On the origin of the long period saw tooth shape of the late Pleistocene paleoclimate records: the first derivative of the earth's orbital eccentricity; *Geophy.Res Lett*. **22**, 1997-2000.

Rial, J.A. (1999): Pacemaking the Ice Ages by Frequency Modulation of Earth's Orbital Eccentricity, *Science*, **285**, pp. 564-568.

Rial, J.A. and C.A. Anaclerio (2000): Understanding Nonlinear Responses of the Climate System to Orbital Forcing, *Quaternary Science Reviews*, Vol 19, 1709-1722.

El-Kibbi, M. and **J.A. Rial** (2001): An outsider's review of the astronomical theory of the climate: is the eccentricity-driven insolation the main driver of the ice ages?. *Earth Science Reviews*, **56** 161-177.

Rial, J.A. (2004): Abrupt Climate Change: Chaos and order at orbital and millennial scales, *Global & Planet. Change*, **4**, pp 95-109.

Rial, J.A. (2004): Evidence for control of the Pleistocene ice ages by changes in earth's orbital eccentricity: The concealed pacemaker. *Global & Planet. Change,* **4**, pp 81-93.

Rial, J.A., R. Pielke, M. Beniston, M. Claussen, J. Canadell, P. Cox, H. Held, N. deNoblet-Ducoudre, R. Prinn, J. Reynolds, J. Salas (2004): Nonlinearities, Feedbacks and Critical Thresholds within the Earth's Climate system, *Climatic Change*, **65** (1-2), 11-38.

Clark, P.U., D. Archer, D. Pollard, J. Blum, **J.A. Rial**, V. Brovkin, A. Mix, N.G. Pisias, and M. Roy (2006): The Middle Pleistocene Transition: Characteristics, Mechanisms, and Implications for Long-term Changes in Atmospheric pCO_2, *Quaternary Science Reviews*, Special Issue in honor of Nick Shackleton ; **25**, pp. 3150-3184.

Rial, J.A. and M. Yang (2007): Is Abrupt Climate Change Paced by the Orbital Insolation? In AGU Monograph 173, *Ocean Circulation, Mechanisms and Impacts*, S. Hamming et al. (Eds.), pp. 167-174.

Rial, J.A. (2007): Polar Earthquakes are nothing new, and don't foretell catastrophe, *The Guardian*, London, September 13, 2007.

Rial, J.A., Tang, C. and K. Steffen (2008): Greenland's Glacial Rumblings: Indicators of Rapid Ice Sheet Response? *Journal of Glaciology* Vol. **55**, N0 191, pp1-11.

Rial, J.A. and R. Saha (2008): Stochastic Resonance, Frequency modulation and the Mechanisms of Abrupt Climate Change in the Arctic, *First International Symposium on Arctic Research*, Drastic Change Under Global Warming (ext. abs.) Vol. **1**, pp. 94-97.

Rial, J.A. and R. Saha (2011): Modeling abrupt climate change as the interaction between sea ice extent and mean ocean temperature under orbital insolation forcing, in AGU Monograph on Abrupt Climate Change 193 (H. Rashid, E. Mosley-Thompson, editors), in press.

Rial, J.A. (2011): Synchronization of polar climate variability: In search of simple rules at the heart of climate's complexity, *American Journal of Science* (in review).

PUBLICATIONS ON SEISMOLOGY (1995-DATE)

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JOURNALS

Lou, M. and **J.A. Rial** (1995): Locating an active fault zone in Coso geothermal field by analyzing seismic guided waves from micro earthquake data, Geothermal Reservoir Engineering, Proc. 20th Workshop. Pp. 115-121.

Lou, M. and **J.A. Rial** (1995): Modeling Elastic Wave Propagation in Inhomogeneous Anisotropic Media by the Pseudospectral Method, Geophys. Jour. Int; (120), 60-72.

Lou, M. and **J.A. Rial** (1995): Application of the wavelet transform in detecting multievents in micro earthquake data; Geophys. Res. Lett (22) No. 16, pp. 2199-2202.

Malin, P.E., M. Lou, and **J.A. Rial** (1996): FR waves: A second fault-guided mode with implications for fault property studies, Geophys. Res. Lett. 23, 3547-3550.

Rial, J.A. (1996): The Anomalous Seismic Response of the Ground at the Tarzana Hill site During the Northridge 1994 Southern California Earthquake: A resonant Sliding Block?, Bull. Seism. Soc. Am., 86, 1714-1723.

Lou, M., **J.A.Rial** and P.Malin (1997): Modeling fault-zone guided waves of micro earthquakes in a geothermal reservoir, Geophysics, v 62 (4), p 1278-1284.

Lou, M. and **J.A. Rial** (1997): Characterization of geothermal reservoir crack patterns using shear-wave splitting, Geophysics, v 62, (2), p487-495.

Rial, J.A. (1997): A note on the relationship between a sedimentary basin's basin topography and the damage pattern of earthquakes: Chaos and Order. Seism Res. Lett. 68,3, p451-459.

Rial, J.A. and M.H. Ritzwoller (1998): Propagation Efficiency of long-period Lg waves in the South American continent, Geophys. Jour. Int., 131,2,p401-408.

Vdovin, O., **J.A. Rial**, A.L. Levshin and M.H. Ritzwoller (1999): Surface Wave Tomography of the South America and Surrounding Oceans ,Geophys. Jour. Int., 136,324-340.

Vlahovic, G., Elkibbi, M., and **J. A. Rial** (2002). Temporal Variations of Fracture Directions and Fracture Densities in the Coso Geothermal Field from Analyses of Shear-wave Splitting, *Geothermal Reservoir En gineering* Vol **27**. SGP-TR-171.

Vlahovic, G., Elkibbi, M., and **J. A. Rial** (2002). Shear Wave Splitting and Reservoir Crack Characteriza tion: Coso Geothermal Field, Journal *of Volcanology and Geothermal Research* **120**, p123-140.

ElKibbi, M., and **Rial, J.A.** (2003). Shear-wave Splitting: an Efficient Tool to Detect and Simulate 3D Frac ture Patterns at The Geysers, CA. *Geothermal Reservoir Engineering*, Vol **28**, p 27-29.

Yang, M., ElKibbi, M., and **Rial, J.A**. (2003). Modeling of 3D Crack Attributes and Crack Densities in Geothermal Reservoirs, *Geothermal Reservoir Engineering, Vol **27**,* p 329-331.

Elkibbi, M. M. Yang and **Rial, J.A.** (2004), Imaging Crack Systems in The Geysers with Shear-wave Splitting, GRC, *Geothermal Res. Council*. **28**, pp 789-800.

Yang, M., M. Elkibbi and **J.A. Rial** (2005), An inversion scheme to model subsurface fracture systems using shear wave splitting polarization and delay time observations simultaneously, *Geophys. Jour. Int.*, Vol. **160**, pp 939-947.

ElKibbi, M. and **Rial, J. A.** (2005). The Geysers geothermal field: results from shear-wave splitting analysis in a fractured. *Geophys. Jour. Int.* doi: 10.1111/j.1365- 246X.2005.02698.x

ElKibbi, M., Yang, M. and **Rial, J.A.** (2005). Crack-induced anisotropy in The Geysers Geothermal Field. *Geophys. Jour. Int.* **162**, p1036-1048. doi: 10.1111/j.1365-246X. 2005. 02697.x

Rial, J.A., M. Elkibbi and M. Yang (2005). Shear-wave splitting as a tool for the characterization of geothermal fractured reservoirs: Lessons learned. *Geothermics,* **34** (2005) 365–385.

Tang, C., **J. A. Rial** and J. M. Lees (2005) Shear-wave Splitting: A Diagnostic Tool to Monitor Fluid Pressure in Geothermal Fields, *Geophys. Res. Letters*, Vol. **32**, L21317,
doi: 10.1029/2005GL023551.

Tang, C., **J. A. Rial** and J. M. Lees (2008): Seismic Imaging of the Geothermal Field at Krafla, Iceland Using Shear-wave Splitting. *Jour. Vol. Geotherm. Res*, **176** (2), 315-324. doi: 10.1016 / j.jvolgeores. 2008.04.017.

Tang, C., Zhao, Y., **Rial, J. A**., and Lees, J. M. (2011). Automatic, Real-time Detection of Subsurface Cracks in Geothermal Fields Using Shear-wave Splitting. *Geophys. J. Int.* (accepted).

RESEARCH, TEACHING AND OUTREACH ACTIVITIES

I am an active researcher in the areas of climate change and nonlinear dynamics applied to understanding abrupt climate change. In an attempt to understand the mechanics of collapsing glaciers and ice sheets I have spent so far six field seasons in western Greenland recording ice quakes and the seasonal evolution of moulins.

SPONSORED RESEARCH PROJECTS

1. Abrupt climate change and global warming Sponsored by NSF and McDonnell Foundation**.** The history of the earth's climate, as recorded in the ice caps of Greenland and Antarctica contain the most puzzling episodes of global warming and abrupt climate change that we know of. The earth's climate has changed abruptly and dramatically (~12 degrees Celsius jumps in the Arctic) many times in the past 100,000 years, and no one knows why. Thus, no one knows whether the episode of global warming we are currently experiencing is of the same type of those in the past, nor whether CO_2 emissions may in fact trigger one gigantic flicker of the climate, leading to scenarios not too different from some predicted in fictional accounts of global climate change. Several lines of evidence support my hypothesis that during the last ice age, and likely in earlier times, millennial-scale temperature changes around the north and south poles were coupled and synchronized. As a working hypothesis polar synchrony brings new insights into the dynamic processes that link Greenland's Dansgaard-Oeschger (DO) temperature fluctuations to Antarctic temperature variability.

2. Seismic Monitoring of Greenland's Ice Sheet Sponsored by NSF, NASA, National Geographic. As part of my NOAA/CIRES fellowship I designed and developed SMOGIS, a collaborative field project with CU and NASA glaciologists that consists in the deployment of arrays of portable, 3-component short period seismic stations on the ice sheet to detect local microseismic activity within the ice sheet, between the ice sheet and the bedrock and around moulins. The increasing mechanical instability of the ice sheet due to global warming needs to be quantified, and this project, which I expect to last several more years, will contribute to that goal.

3. Detecting subsurface fracture systems in Indonesia Sponsored by Supreme Energy, Jakarta. This is a project to develop the geothermal potential in the volcanic island of Sumatra. Our first area of study is at Maura-Laboh, a volcanic edifice over which an array of portable and down-hole seismic instruments has been installed for the purpose of detecting seismic shear wave splitting parameters that are inverted to obtain the geometry of the subsurface cracks. The entire span of the volcanic region will be subject f this research, so this project is expected to last several years.

4. NARNEA Sponsored originally by UNC's Johnston Center for Excellence in Undergraduate Teaching, The North American Renewable Neutral Energy Alliance (NARNEA) is a project that proposes a network of exclusively renewable energy plants (enhanced geothermal, concentrated solar thermal, wind, tidal, biofuels) throughout North America that will allow the continent to phase out over 80% of all coal burning, substantially reducing atmospheric greenhouse gas concentrations, health hazards, pollution and environmental degradation. The biofuel component of NARNEA will reduce US dependence on foreign oil. As currently conceived NARNEA will create millions of jobs and cost a mere trillion dollars over ten years. At this point the project is aimed to promote the idea among the general public that there are solutions to the energy and climate crises, and one of them is NARNEA. This is undergraduate research, involving Sophomores to Seniors, half of them from enthusiastic under-represented minorities.

ACTIVE RESEARCH GRANTS

McDonnell Foundation 21st Century Science Initiative on Complex Systems: *Synchronization of polar climate variability over the last ice age: In search of simple rules at the heart of climate's complexity*, 09/11-09/15, $400,340 (sole PI).

National Science Foundation, *Synchronization of Climatic Change Between the Polar Regions and the Origin of the Bipolar Seesaw*, 09/11/-09/14 $290,000 (sole PI).

National Science Foundation, *Understanding the origins of abrupt climate change*, 03/07-03/12, $426,000 (sole PI).

National Geographic Committee for Research & Exploration, *Seismic monitoring of large displacements in Greenland's Ice Sheet*, $19,000, 2/09- 2/12 (sole PI).

Supreme Energy, Jakarta, Indonesia, *Shear wave splitting in selected geothermal fields of Indonesia*, $210,000 12/10-12/12 (sole PI).

Recent awards, honors

Director, Environmental Modeling Laboratory (Institute for the Environment), 2007-date
Co-chair, Environmental Sciences Curriculum, Carolina Environmental Program, 2007-2009
Visiting Fellow, NOAA/CIRES (University of Colorado), 2005.
Distinguished Visiting Scientist, CSIRO, Earth Observation Center, Australia, 2005
Fellow, American Association for the Advancement of Science (AAAS), 2001

TEACHING TEACHING LOAD: THREE COURSES/YEAR

NEW COURSES

***Burch Seminar to Alaska and Iceland. July-August 2010.**
Global Climate Change and Energy Resource Depletion: The Crises, the Challenges and the Solutions
HONOR Courses:

HNRS 351/GEOL 555 - Global Climate Change: The Science and the History (4 credits)
HNRS 351/GEOL 556 - Energy Resources: the Science and the Policy (4 credits)

***Our Energy and Climate Crises**, INST108/GEOL460. Taught for the first time in Fall 2010. Instructors: G. Cecil (Physics), J. Bane (Marine Sc), D. MacNelis (IE), G. Gangi (IE), C. Jones (Math), J. Rial (GEOL)

SAMPLE OF COURSES TAUGHT (2003-2011)

Undergraduate courses

****Energy resources for a hungry planet*** (GEOL0076). First Year Seminar Freshman course. Introduction to the main energy resources of the earth. Energy supply and demand. The fossil fuels. The renewable energies. US hesitant energy policy. Future of global energy. Uses debates through the semester and as final exam.

****Global warming and the fate of the planet*** (GEOL0073). First Year Seminar Freshmen course. Discussions are centered on the problem of global change and specifically, global warming and the effects of anthropogenic gases on the atmosphere, oceans and life, now and in the future. Use debates as active learning.

****Introduction to Geophysics***. Advanced undergraduate, graduate course. The earth systems. Heat

from the earth interior, earthquakes. Principles of climatology. (Once a year).

Cross-listed courses (Interdisciplinary)
****Earth's Dynamic Systems*** (Geol213/ENST213). Semi-quantitative approach to global geophysics. Earth as a heat engine: heat from the interior, heat from the sun. From the inner core to top of the atmosphere, from convection in the mantle to global warming.

Graduate courses
****Physics of the Earth's Interior*** (Geology/Phys) Graduate course. The earth's layered structure, core, mantle and crust. Theories of earth evolution and acretionary history. The origin of the molten core. Seismic wave radiation and propagation. The earth's magnetic field.
Modeling of earth and marine systems (GEOL106/ENST106). Principles of mathematical methods in modeling of earth and marine systems. From population growth to climate change.
****Principles of Climate Modeling*** (ENST530/GEOL861). This course includes the history of global change over the last 4 billion years with modeling examples, from EBMs to GCMs. Hands-on experience on everything related to global climate change from a modeler's point of view. Time series analyses of ice and sediment core proxies.
****Advanced seismology*** **(to be taught Spring 2012)** The seismic source, integral representations. Moment tensor. Seismic wave propagation. Integral methods of solving the elastodynamic equation. Synthetic seismograms and global seismology. Elastic and inelastic wave propagation.
* Courses I developed.

OUTREACH

To contribute to increase climate change awareness among general and technical audiences, I organize the now six-year-old annual Carolina Climate Change Seminars (CCCS), which brings to UNC top climate scientists (Sherwood Rowland, Wally Broecker, Ellen Mosley-Thompson, Michael Mann among others have been CCCS guest speakers in recent years) for two days of conversations on climate science research with students, faculty and the general public. Every year selected groups of local high school students, especially from under-represented groups, are invited to attend the CCCS, which thus serves as a recruiting tool for earth science students. Typically attendance to the public talks is 250-300 people. The 2011 speaker is Dr. Benjamin Santer, from Lawrence Livermore National Laboratory.
My research in Greenland attracted quite a bit of press and a number of articles (domestic and foreign), radio interviews (domestic and foreign) and web sites have featured my SMOGIS (Seismic Monitoring of Greenland's Ice Sheet) project. Because it is related to global warming SMOGIS also attracted the attention of a number of politicians, including a delegation from the US Congress, with Speaker of the House Nancy Pelosi (D-CA) and Senator Ed Markey (D-MA). From the other side of the aisle, my work attracted the attention of Senator J. Inhofe (R-OK) who cited it in his speech to Congress attacking global warming alarmists. Unfortunately the senator did not read the article in its entirety. In addition, topical articles have appeared in *Los Angeles Times* (copied over on multiple outlets), *Daily Grist*, SigmaXi's *Science in the News*, interviews for Australian and German Public Radio, and locally in Radio en Vivo, and in articles in *Endeavors Magazine*, and UNC *Alumni Review*.

I am experienced in talking to the media and the general public. News and interviews featuring my research have appeared in The Guardian of London, Los Angeles Times, NY Times, SigmaXi's Science in the News, US and foreign Radio, YouTube, and NC media outlets.

Polar Exploration: Captivating Tales of Polar Explorers. FedEx Global Education Center, Family-friendly talks about Arctic and Antarctic expeditions by UNC polar explorers.