APS March Meeting 2015
San Antonio, Texas
http://www.aps.org/meetings/march/index.cfm
A Test for Periodic and Quasi-Periodic Fluctuations in Past Climate Change Data

JAMES OTTO, JAMES ROBERTS, University of North Texas — In this work the temperature fluctuations for a number of proxy data sets were analyzed to test for periodic and quasi-periodic fluctuations in climate changes in the past. The data sets analyzed indicate temperature functions which could be modeled using amplitude and frequency modulated sinusoidal waves. Data for the past 2000 years were tested and they show select periods of 11 years, 100 years, 300 years and 600 years. Longer term data (million years) indicate periods of 21000 and 41000 years as predicted by Milankovitch.

11:27AM  B33.00002 Nonlinear/Non-Gaussian Data Assimilation

JUAN RESTREPO, Department of Mathematics, Oregon State University — Data and models, with their inherent uncertainties and errors, are blended within a Bayesian framework with the aim of improving estimates of dynamic processes. This process, called data assimilation, is said to be responsible for significantly better weather/climate forecasts. Nonlinear/non-Gaussian processes, however, pose special conceptual and computational challenges. In the context of generic transport problems of importance in climate and weather a strategy which I have been investigating involves adding physically based constraints, leading to smaller but higher quality ensembles with which to produce estimates. I will describe some of the tradeoffs and their implications on filtering and forecasting.

1Supported by NSF and BP/GoMRI

11:39AM B33.00003 The Role of Radiation in Organizing Tropical Convection

SHARON SESSIONS, STIPO SENTIC, MICHAEL HERMAN, DAVID RAYMOND, New Mexico Institute of Mining and Technology — Convective organization regulates the radiation emitted to space, and therefore is important for the global heat budget. Organized convection—regions of intense convection surrounded by large cloud-free regions—permit more longwave radiation to escape and therefore may constitute a net cooling effect, while more scattered convection promotes greenhouse warming. Models which simulate the spontaneous organization of deep tropical convection—self-aggregation—suggest that radiative cooling in response to water vapor content is essential for convection to spontaneously organize. Multiple equilibria—steady states which maintain persistent precipitating convection or are completely dry—in small domains with weak temperature gradients (WTG) are analogous to dry and moist regions in larger scale simulations of convective self aggregation. We explore the role of radiative cooling in multiple equilibria. Interactive radiative cooling suppresses convection in the dry state and it permits multiple equilibria over a larger parameter range. However, multiple equilibria still exist with fixed radiative cooling. This suggests that while interactive radiation is conducive for organizing convection, it is not essential. This study elucidates radiation’s role in convective organization.

1Work supported by the NSF

11:51AM B33.00004 Thermodynamics of Hurricanes

KERRY EMANUEL, MIT — No abstract available.

12:27PM  B33.00005 Stratified shear flow instability: Application to oceanic overflows

ROBERT ECKE, Los Alamos National Laboratory, PHILIPPE ODIER, Ecole Normale Superieure Lyon — The Earth’s thermohaline circulation provides major oceanic transport of heat and salinity and is an important determining factor in the climate of nearby land areas. We address the stability of overflow currents of heavier water moving into a region of less heavy quiescent fluid using experimental measurement of wall bounded stratified boundary currents under controlled laboratory conditions. In these currents, the stratification acts to stabilize the flow whereas the shear associated with the moving current produces turbulent kinetic energy and has the potential for destabilizing the flow. Our experimental measurements using particle-image velocimetry and laser-induced fluorescence allow the simultaneous acquisition of velocity and density fields, respectively. Rather than using traditional time-averaged statistics, we consider the stability of unperturbed sections of the interface and use a measure of the overturning or mixing called the Thorpe length. We present evidence for universal behavior in the normalized Thorpe length probability distribution and the general properties of the system under increasingly stable conditions. We relate these properties to realistic circumstances in the ocean.

12:39PM B33.00006 Eliminating Major Tornadoes in Tornado Alley

R. TAO, Temple Univ — In my recent paper, I propose that major tornadoes in Tornado Alley can be eliminated by building east-west ranged walls, 300 meter high and 50 meter wide. The work has received much attention, but some meteorologists are against the idea, claiming that the major tornadoes in Tornado Alley are not related to the collisions between northbound warm air flow and southbound cold air flow because supercells are not at the collision front. In this talk, we will show that wind tunnel experiments and airplane wing tip vortices clearly demonstrate that vortices produced by air mass collisions are usually not at the collision front because of the extremely volatile condition over there; they are either near the ends or at side of the collision fronts. When the warm and moist wind collides with the cold wind violently in Tornado Alley, similarly, the supercell storms cannot be right at the collision fronts, but are near the ends or at sides of the collision fronts. While only a small portion of vortices in the warm air side may have a chance to develop into tornadoes, the major tornadoes in Tornado Alley indeed start from the air mass clashes. If we can weaken such violent air mass collisions, we will eliminate the major tornadoes in Tornado Alley.

1The work is supported in part by Naval Research Lab.
2Dept. of Physics, Temple University, Philadelphia, PA 19122

12:51PM B33.00007 Random Focusing of Tsunami Waves

HENRI-PHILIPPE DEGUELdre, JAKOB J. METZGER, RAGNAR FLEISCHMANN, THEO GEISEL, Max Planck Institute for Dynamics and Self-Organization, Goettingen — When waves propagate through a weakly scattering, correlated random medium, the consecutive effects of small focusing events give rise to the phenomenon called branched flow, producing patterns of high intensity fluctuations. As tsunamis are deflected by underwater structures in the depth profile of the ocean floor, we investigate how it affects tsunami propagation and derive the typical length scale on which the highest waves are to be expected. We show that as a consequence of this effect the inaccuracies in the current knowledge of the ocean floor topography can prevent reliable tsunami forecasts on medium to large length scales.
In the previous study, we used integrated kinetic energy as a measure of beam intensity. We compare these results with a method using energy flux. We also study radiative forcing by WMGHGs, confirming theoretical predictions of the atmospheric greenhouse effect.

Of the time-series of WMGHG surface radiative forcing directly attributable to recent increases in WMGHGs, in this case between 2000-2010. The time-series and water vapor, spectra from the DOE ARM Program's Atmospheric Emitted Radiance Interferometers (AERI) yield the first direct observational evidence of the surface energy balance has not been experimentally confirmed in the field. Using infrared WMGHG absorption bands and controlling for atmospheric temperature and Rossby waves, convective lofting and detrainment of either high or low ozone amounts from the boundary layer, and intrusions of air masses with high ozone concentrations from the stratosphere. Here, we examine the range of observed laminae characteristics and describe methods for tracing the origins of tropospheric ozone laminae.

1:03PM B33.00008 Energy Dissipation when Internal Wave Beams Reflect from a Slope. BRUCE RODENBORN, Centre College, DANIEL KIEFER, Center for Nonlinear Dynamics, University of Texas at Austin, HEPENG ZHANG, Jiao Tong University, HARRY L. SWINNEY, Center for Nonlinear Dynamics, University of Texas at Austin — Internal wave reflection from a uniform sloping boundary is often analyzed using linear or a weakly nonlinear inviscid theory. Under these assumptions for a linearly stratified fluid, Thorpe and Tabaei et al. derived predictions for the boundary angle where second harmonic generation should be most intense. We previously conducted experiments and simulations that found the angle that maximizes second harmonic generation is given instead by an empirical geometric relationship between the wave beam and boundary angles. In the previous study, we used integrated kinetic energy as a measure of beam intensity. We compare these results with a method using energy flux. We also study the energy flux into and out of a surface above the reflection region $E_{\text{out}}/E_{\text{in}}$ and find high rates of energy dissipation $O(90\%)$. The rates remain high even for weakly nonlinear wave beams and with the viscosity reduced by an order of magnitude.


1:15PM B33.00009 Lamination in Atmospheric Ozone: A Diagnostic for Tracer Transport Mechanisms. KENNETH MINSCHWANER, Department of Physics, New Mexico Institute of Mining and Technology, GLORIA MANNEY, NorthWest Research Associates, LUIS TORRES, Department of Physics, New Mexico Institute of Mining and Technology — An understanding of ozone variability in the upper troposphere (from $\sim$5 km altitude up to the tropopause level) is critical to assessing the radiative forcing of climate by ozone, and for evaluating the impact of transport on regional air quality. Part of this variability arises in fine-layered (~0.2 to $\sim$2 km) structures seen in vertical profile measurements of ozone. These laminae are also generally limited on horizontal scales (10’s to 100’s of km), leading to spatial ozone variability observed on quasi-horizontal coordinate surfaces. Given the relatively long photochemical time constants for ozone in the upper troposphere, most of the observed variability arises from transport rather than photochemistry. There are a wide range of dynamical processes that can generate ozone laminae in the upper troposphere, such as gravity and Rossby waves, convective lofting and detrainment of either high or low ozone amounts from the boundary layer, and intrusions of air masses with high ozone concentrations from the stratosphere. Here, we examine the range of observed laminae characteristics and describe methods for tracing the origins of tropospheric ozone laminae.

Monday, March 2, 2015 2:30PM - 3:54PM — Session D33 GPC DFD: Focus Session: The Physics of Climate II 208 - Juan Restrepo, Oregon State University

2:30PM D33.00001 Scattering and Absorption of E&M radiation by small particles-applications to study impact of biomass aerosols on climate. SOLEMON BILLILIGN, North Carolina A&T State University, Department of Physics, SUJEETA SINGH, MARC FIDDLER, DAMON SMITH, North Carolina A&T State University — The phenomena of scattering, absorption, and emission of light and other electromagnetic radiation by small particles are central to many science and engineering disciplines. Absorption of solar radiation by black carbon aerosols has a significant impact on the atmospheric energy distribution and hydrologic processes. By intercepting incoming solar radiation before it reaches the surface, aerosols heat the atmosphere and, in turn, cool the surface. The magnitude of the atmospheric forcing induced by anthropogenic absorbing aerosols, mainly black carbon (BC) emitted from biomass burning and combustion processes has been suggested to be comparable to the atmospheric forcing by all greenhouse gases (GHGs). Despite the global abundance of biomass burning for cooking, forests clearing for agriculture and wild fires, the optical properties of these aerosols have not been characterized at wide range of wavelengths. Our laboratory uses a combination of Cavity ring down spectroscopy and integrating nephelometry to measure optical properties of (extinction, absorption and scattering coefficients) of biomass aerosols. Preliminary results will be presented.

1Supported by the Department of Defense under grant #W911NF-11-1-0188.

2:42PM D33.00002 Observations Determination of Surface Radiative Forcing by CO2 and CH4. WILLIAM COLLINS, Lawrence Berkeley Natl Lab and UC Berkeley, DANIEL FELDMAN, Lawrence Berkeley Natl Lab, JONATHAN GERO, University of Wisconsin-Madison, Space Science and Engineering Center, MARGARET TORN, Lawrence Berkeley Natl Lab and UC Berkeley, ELI MLAWER, Atmospheric and Environmental Research, Inc., TIMOTHY SHIPPERT, Pacific Northwest National Laboratory, Fundamental and Computational Sciences — Earth’s background atmospheric CO2 and CH4 concentrations have been steadily rising due to anthropogenic emissions, and these increases since 1750 have implications for the radiative balance of the Earth’s atmosphere. The physics governing how atmospheric CO2 and CH4, both well-mixed greenhouse gases (WMGHGs), influence atmospheric infrared energy balance, and thus climate, are well established, but the impact of recent atmospheric WMGHG trends on the surface energy balance has not been experimentally confirmed in the field. Using infrared WMGHG absorption bands and controlling for atmospheric temperature and water vapor, spectra from the DOE ARM Program’s Atmospheric Emitted Radiance Interferometers (AERI) yield the first direct observational evidence of the time-series of WMGHG surface radiative forcing directly attributable to recent increases in WMGHGs, in this case between 2000-2010. The time-series shows a secular trend of in the radiative forcing from both CO2 and CH4. This data record provides the first comprehensive observational evidence of surface radiative forcing by WMGHGs, confirming theoretical predictions of the atmospheric greenhouse effect.

Office of Biological and Environmental Research, Department of Energy

2:54PM D33.00003 Interaction between carbon dioxide and coal: atomic-scale characteristics and electronic structures. YINGDI LIU, SANYU WANG, Department of Physics and Engineering Physics, The University of Tulsa — Geologic sequestration of CO2 in unmineable coal seams has been suggested to mitigate the effect of the increasing of the atmospheric CO2 concentration on global warming. Extensive experimental studies have been performed for the injection of CO2 into coalbeds. However, the atomic-level mechanism for the interaction between CO2 and coal has not been fully explored. We report first-principles density-functional calculations and ab initio molecular dynamics simulations for the interaction between CO2 and the coal network. In particular, we report results about atomic-scale and electronic properties of the interaction. We also report a comparison with the interaction between CH4 and coal.

This research used the supercomputer resources at NERSC, of XSEDE, at TACC, and at the Tandy Supercomputing Center.
3:06PM D33.00004 Polar Oceanography, Arctic Sea Ice and Climate, MARY-LOUISE TIMMERMANS, Yale University — Intensive sampling from oceanographic moorings, shipboard measurements, and drifting autonomous buoy systems has brought new understanding to Arctic freshwater dynamics, ocean heat and mixing processes, circulation and eddies, and atmosphere-ice-ocean interactions. Observations indicate apparently rapid changes in the basin-scale freshwater distribution that have marked effects on Arctic stratification. Recent measurements support the idea that a strengthened stratification limits the vertical flux of deep-ocean heat. All ocean layers exhibit a rich mesoscale eddy field; eddies, with scales comparable to the Rossby Deformation Radius [O(10km)], transport water and heat over long distances and enhance ocean mixing. Measurements further reveal an active submesoscale flow field in the ocean surface layer. These upper-ocean features, having length scales of a few kilometers or less, are dynamically important in that they can impede surface-layer deepening and modify heat, salt, and momentum fluxes between the surface ocean and adjacent sea-ice cover. This talk will review highlights of recent Arctic Ocean observational studies across a range of temporal and spatial scales, and outline advances in our understanding of ocean drivers of sea ice and climate change.

3:42PM D33.00005 Study of Aerosol Chemical Composition Based on Aerosol Optical Properties, AUSTIN BERRY, RUDRA ARYAL, Eckerd College — We investigated the variation of aerosol absorption optical properties obtained from the CIMEL Sun-Photometer measurements over three years (2012-2014) at three AERONET sites GSFC, MD Science Center and Tudor Hill, Bermuda. These sites were chosen based on the availability of data and locations that can receive different types of aerosols from land and ocean. These absorption properties, mainly the aerosol absorption angstrom exponent, were analyzed to examine the corresponding aerosol chemical composition. We observed that the retrieved absorption angstrom exponents over the two sites, GSFC and MD Science Center, are near 1 (the theoretical value for black carbon) and with low single scattering albedo values during summer seasons indicating presence of black carbon. Strong variability of aerosol absorption properties were observed over Tudor Hill and will be analyzed based on the air mass embedded from ocean side and land side. We will also present the seasonal variability of these properties based on long-range air mass sources at these three sites.

Ballroom B - John Wettlaufer, Yale University

11:15AM G20.00001 Big science with little data: separating random waves from vortices in atmosphere and ocean fluid dynamics, OLIVER BUHLER, Courant Institute of Mathematical Sciences, New York University — How to extract physical and conceptual meaning from limited data sets has been a perennial problem in atmosphere ocean science. This is especially pressing in the current era of large-scale numerical models that seek, for the first time, to simulate directly all the most energetic scales in these systems. This effort requires observational guidance at unprecedented small spatial scales. Progress in extracting physical meaning from data is therefore inseparable from progress in climate simulation and forecasting overall. For example, the successful planning of costly satellite missions depends crucially on the physical nature of the expected motions that are to be observed. In many cases, data are obtained along one-dimensional ship or flight tracks, in which case there are both kinematic and dynamic aliasing effects that obscure the physical meaning of the data. Here kinematic refers to well-known aliasing effects that arise when three-dimensional flow fields are observed only along a line. Dynamics aliasing refers to the more subtle situation when physically different processes project into the same data stream. Indeed, it is well known in atmosphere ocean science that random waves and vortices overlap and intermingle in a complex wave-turbulence jigsaw puzzle, which we need to solve! This talk describes recent progress on this problem, which led to a new method to decompose one-dimensional data into its wave and vortex constituents. The new method works by combining a new Helmholtz decomposition method for one-dimensional velocity spectra with a theoretical framework to separate random waves and vortices in one-dimensional data set. This talk describes the current era of large-scale numerical models that seek, for the first time, to simulate directly all the most energetic scales in these systems. This effort requires observational guidance at unprecedented small spatial scales. Progress in extracting physical meaning from data is therefore inseparable from progress in climate simulation and forecasting overall. For example, the successful planning of costly satellite missions depends crucially on the physical nature of the expected motions that are to be observed. In many cases, data are obtained along one-dimensional ship or flight tracks, in which case there are both kinematic and dynamic aliasing effects that obscure the physical meaning of the data. Here kinematic refers to well-known aliasing effects that arise when three-dimensional flow fields are observed only along a line. Dynamics aliasing refers to the more subtle situation when physically different processes project into the same data stream. Indeed, it is well known in atmosphere ocean science that random waves and vortices overlap and intermingle in a complex wave-turbulence jigsaw puzzle, which we need to solve! This talk describes recent progress on this problem, which led to a new method to decompose one-dimensional data into its wave and vortex constituents. The new method works by combining a new Helmholtz decomposition method for one-dimensional velocity spectra with a theoretical framework to separate random waves and vortices in one-dimensional data. Applications of the new method to oceanic data sets and to the famous Gage–Nastrom spectrum in the atmosphere are presented, with surprising results.

11:51AM G20.00002 Convection, Stability, and Turbulence, CHARLES R. DOERING, University of Michigan — Many natural flows are driven by buoyancy forces, perhaps the most familiar being those resulting from density variations due to temperature or compositional differences in the presence of a gravitational field. Buoyancy-driven flows of this sort play a major role in geophysical fluid mechanical processes and their transport properties and are central to climate dynamics. The simplest setting to study this phenomena is so-called Rayleigh-Bénard convection, the buoyancy driven flow in a horizontal layer of fluid heated from below and cooled from above. This seminal problem has received tremendous attention over the last century but many riddles remain, especially regarding strongly nonlinear turbulent convection. In this presentation, following an introduction to the phenomena and its applications along with a review of the current state of theory and experiments on high Rayleigh number convection, I will describe some recent results that mathematical analysis has contributed to our understanding of turbulent heat transport.

12:27PM G20.00003 A look at two disparate limits of the climate system: oceanic submesoscales and global energy balance, BALU NADIGA, LANL — A common theme underlying this journey across scales is that of energy balance. The first topic considers scales from a few tens of meters to a few tens of kilometers and grapples with a fundamental question that concerns energetics of ocean circulation: how does ocean circulation equilibrate in the presence of continuous large-scale forcing and a tendency of geostrophic turbulence to confine energy to large and intermediate scales. In particular, interior instabilities are shown to provide an energy pathway between the largely-balanced, energetic oceanic mesoscales and smaller unbalanced scales (J. Fluid Mech. (2014), vol. 756, pp. 965-1006; doi:10.1017/jfm.2014.464). The second topic zooms out to the global scale and considers global warming from an energy balance perspective. With the global ocean sequestering in excess of 90% of the recent warming due to energy imbalance at the top of the atmosphere, sensitivity of warming and depth of penetration of warming are characterized in a probabilistic fashion.

Supported in part by the LDRD program at LANL (project number 20110150ER)
1:03PM G20.00004 Stochastic models for tropical convection and extreme rainfall events\textsuperscript{1}. SAMUEL STECHMANN, University of Wisconsin-Madison — In the Tropics, storms and convection occur intermittently and have a major impact on weather and climate. In recent years, tropical rainfall statistics have been shown to conform to paradigms of critical phenomena and statistical physics. To gain further insight into these statistics and extreme events, this talk presents simple stochastic models for the statistics of precipitation events and water vapor dynamics (local in space, and evolving in time). Through exact solutions and simple numerics, a suite of observed rainfall statistics is reproduced by the model, including power-law distributions and long-range correlations. The key ingredients of the model are the dynamics of column water vapor, governed by a combination of Gaussian stochastic forcing and nonlinearity provided via a threshold and/or stochastic trigger. Finally, these statistics are being explored in climate model simulations with collaborators.

\textsuperscript{1}The research of S.N.S. is partially supported by Office of Naval Research grants ONR N000141210744 and ONR N000141210912.

1:39PM G20.00005 Climate Variability and Nonequilibrium Steady-States\textsuperscript{1}. JEFFREY WEISS, University of Colorado, Boulder — The climate system is forced by incoming solar radiation and damped by outgoing long-wave radiation. As a result, the climate system is not in thermodynamic equilibrium but is better conceptualized as residing in a nonequilibrium statistically steady-state. Nonequilibrium steady-states have internal fluctuations which appear as natural variability of the climate system. Additionally, the phase space has nonzero probability current loops which are manifested as preferred patterns of natural climate variability. Nonequilibrium steady-states are often modeled by stochastic Langevin dynamics, and many aspects of the physics of these models are well understood. Simple stochastic models have been applied to a variety of climate phenomena including El-Niño, the North Atlantic Gulf Stream, surface temperature patterns, ocean heat content, and atmospheric Storm Tracks. In their simplest form, these models describe a stable steady-state with linear nonconservative damping perturbed by additive Gaussian white noise and thus fall into the class of models capturing nonequilibrium steady-states where previous results from Langevin models apply while the climate context motivates additional new questions.

\textsuperscript{1}This work supported by the National Science Foundation under Grant No. OCE-1245944.

Tuesday, March 3, 2015 5:45PM - 6:45PM —
Session K33 GPC: GPC Business Meeting 208 -