Mathematical Epidemiology

Thursday, August 7, 1:00 p.m. - 3:50 p.m., Hilton Portland, Plaza Level, Pavilion East

Mathematical Epidemiology has grown at an accelerated pace over the last two decades through the integration of mathematical models, available data, computational methods and fieldwork. Successful epidemiological models are validated using parameters from particular epidemics, can predict likely outcomes of an epidemic, and can be used to propose specific interventions strategies.

Modern epidemiological models involve temporal and spatial features, age structure, transmission across networks or patches, deterministic and stochastic elements, seasonality, ecological factors, and more. The inclusion of these features also calls for new mathematical analysis of the models. This session features expository presentations covering a variety of aspects of modern Mathematical Epidemiology.

Ricardo Cortez, *Tulane University*

Comparing Risk for Chikungunya and Dengue Emergence using Mathematical Models

1:00 p.m. - 1:20 p.m.

Chikungunya is a re-emerging mosquito-borne infectious disease native to Africa that is currently spreading rapidly across the Caribbean. Two common mosquito species, *Aedes aegypti* and *Aedes albopictus*, which are found all over the world, are competent vectors for chikungunya virus. We design and analyze a nonlinear coupled system of ordinary differential equations with mosquito dynamics for the spread of chikungunya. The spread of chikungunya is then compared to that of another common mosquito borne virus, dengue. We use sensitivity analysis to indicate where future research and mitigation efforts can focus for greatest effect in controlling the spread of chikungunya.

Carrie Manore, *Tulane University*

How Are Fish Population Dynamics Shaped by a Changing Environment? Insights from a Mathematical Model Driven by Temperature and Dissolved Oxygen Data from Lake Erie

1:30 p.m. - 1:50 p.m.

In this talk, I will fist introduce and discuss a spatially explicit model of fish growth and survival that captures their movement through a heterogeneous physical environment here with strong gradients in water temperature and levels of dissolved oxygen [DO]. I'll focus on the population consequences of seasonal hypoxia (low DO) by using a species-specific fish bioenergetics model and high-resolution spatiotemporal data from Lake Erie to drive this model. I'll then discuss some hypotheses about how seasonal hypoxia might affect disease dynamics in pelagic fish species, using an extension of this modeling framework that includes infectious disease transmission.

Paul Hurtado, *Mathematical Biosciences Institute*

Determining Causal Networks in Nonlinear Dynamical Systems: Ecosystem Applications

2:00 p.m. - 2:20 p.m.

Given a set of time series of environmental variables, such as species populations, disease incidence, or climate, we would like to be able to deduce the relationships between them strictly from data analysis. In particular, we would like to know if one variable partially causes another, if there is mutual feedback, or if two variables are unrelated. There are many techniques that attempt to do this, and I will discuss one technique that is appropriate for analyzing deterministic nonlinear systems that are weakly coupled and that exist on an attractor. By this I mean that the variables are not completely synchronized - they maintain some independent dynamics - and they have an invariant character over time, but may be unpredictable due to the existence of a chaotic attractor. This work is in collaboration with Tomas Gedeon, Kelly Spendlove.

Bree Cummins, *Montana State University*

Epidemic Forecasting and Monitoring using Modern Data Assimilation Methods

2:30 p.m. - 2:50 p.m.

When was the last time you checked a weather report to see if you need to bring a coat or an umbrella with you to work? Imagine being able to check a report on the likelihood of contracting influenza to determine if you should wear a facemask or be extra vigilant about hand sanitizing. In this talk we will detail how the combination of three research areas in mathematics can be brought together to create such a report. As methods of modeling disease spread have grown more accurate, and new data sources for monitoring disease spread have become available, predicting the future course of seasonal disease outbreaks accurately has become more feasible.

Kyle Hickmann, *Los Alamos and Tulane University*

Qualitative Inverse Problems using Bifurcation Analysis in the Recurrent Neural Network Model

3:00 p.m. - 3:20 p.m.

We develop a framework for determining when there is bistability and multistability in the expression states of systems described by this network model. Our results show that, although bistability can be generated with autoregulation, it is also the case that both autorepression or no autoregulation can yield bistability as long as a sigmoidal behavior is present. Additionally, our results suggest that allowing only a single connection when inferring a network may be a reason why parameter values in the inferred gene networks in the literature are not be realistic.

Stephen Wirkus, *Arizona State University*

Mathematics of Planet Earth 2013+: Management of Natural Resources

3:30 p.m. - 3:50 p.m.

The workshop on management of natural resources at Howard University in DC from June 4-6, 2015 will be investigating challenges for the mathematical sciences using models that describe processes affecting water, forests and food supplies. In this talk, we will use water contaminants and associated waterborne diseases to introduce some of the mathematical challenges.

Abdul-Aziz Yakubu, *Howard University*