

RESEARCH, TEACHING, AND SERVICE ACTIVITIES: ELIZABETH A. WENTZ

Research Activities

My research focuses on the design, implementation, and evaluation of geographic technologies with particular emphasis on applying these tools to study and understand the urban environment. Geographic technologies, which include Geographic Information Systems (GIS), remote sensing, and spatial analysis, provide quantitative methods to measure and analyze human activities and physical processes and the interaction between them. My contributions to understanding these dynamics fall into three main categories: analytic geographic tool development, urban remote sensing, and analysis of the urban environment. My work in these areas demonstrates that quantifying spatial interactions improves understanding of the spatiotemporal dynamics of urban systems. To accomplish this, I have collaborated with researchers across a network of social, physical, and computational disciplines.

Geographic tool development

My work in geographic tool development has centered on geographic shape and pattern analysis. Shape analysis refers to assigning a quantitative description to a geometric space that is homogenous relative to some chosen attribute. Pattern analysis deals with mathematically characterizing the organization of these shapes within a geographic region. Both shape and pattern analyses provide insights into understanding an important class of spatiotemporal processes such as how and why cities grow or how species interact with their habitat. The research challenge is translating human cognition and insight of shape and pattern into a unique and quantifiable representation, which is critical when addressing complex integrated systems such as cities. This challenge has been instrumental in moving me toward the development of a mathematically based theoretical framework to analyze geographic patterns. I have published two papers in this area, one that quantifies pattern similarity based on spatial attributes of type, orientation, shape, and size and a second that develops a shape grammar for rapid rendering of complex point visualizations. My sabbatical plans for 2011–12 include developing and testing a pattern similarity metric and writing a theoretical paper that will extend mathematical pattern theory to an explicit geographic context. I have been invited to be a visiting scholar at the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland for part of my sabbatical.

Geographic shapes and patterns are dynamic over time resulting in space-time dependencies in human and physical systems that need to be understood. Vast amounts of space-time data are now available, but may not exist at the necessary level of spatial and/or temporal detail. Spatial data interpolation tools provide estimated values of attributes at geographic locations where no data were collected. The estimates are based upon the spatial dependencies within the observed data. These methods can be applied separately to individual time slices to create a temporal series of spatial data, but this approach ignores the strong temporal dependencies that exist in addition to the spatial ones. This limitation led me to the development of an operational space-time interpolation framework and tool. This approach permits joint spatial-temporal

interpolation by using data collected at specific geographic locations and at frequent time intervals to be used to estimate values at spatial locations where no data were collected. The technique effectively makes use of both the spatial and temporal dependencies in the data. A case study shows that Phoenix land use change patterns can be visualized and understood with increased spatial and temporal resolution. My future research will develop tools to analyze patterns jointly in space and time.

Analysis of the Urban Environment

Many of the case studies associated with my tool development work are linked to my research interests in the analysis of the urban environment. A key issue here is how to restructure cities so they can deal effectively with global climate change. I have focused on the water-use adaptation potential of residents living in both single and multi-family housing, which may arise due to drought in the US Southwest. This interest emerged through my involvement as a core senior scientist and executive committee member of the Decision Center for a Desert City (DCDC), a National Science Foundation funded project on decision-making under climatic uncertainty. My initial paper quantified the factors influencing single-family water demand in Phoenix and, as anticipated, increased water use was associated with larger lots, presence of a pool, irrigated landscaping, and larger households. While these factors are intuitive, we also found that the amount each factor contributed to water use varied significantly by geographic location. This strongly suggests that for maximum effectiveness, policies must be geographically adaptive (Wentz and Gober 2007).

My subsequent research on water demand continues to incorporate both spatial effects as well as temporal changes. I adapted the statistical tool Bayesian Maximum Entropy (BME) to analyze and map spatial (Lee and Wentz 2008) and temporal (Lee et al. 2010) estimates of urban water use. These papers demonstrated that increased mapping accuracy is obtained when soft data (theoretically-derived) are used with hard data (empirically observed). My modeling efforts are reflected in a DCDC-developed decision-tool called WaterSim, designed for use by local water managers. WaterSim calculates the relationship between water supply, as estimated by standard climate models, water demand using population growth scenarios and parameters from the Wentz and Gober model, and several water management policies. A co-authored paper assessing WaterSim demonstrates how the decision-tool can accurately forecast past patterns of water supply and demand and therefore can effectively assist planners in the comparison of alternative policy choice scenarios (Gober et al 2011).

My published research in urban environmental analysis extends beyond water to include studies of land cover dynamics, spatial patterns of birds, and human health. My current interests in this area lie in investigations of the tradeoffs between residential water and energy use. Observations show that outdoor water use induces a reduction in the urban heat island. In theory, this should reduce residential energy usage required for cooling. Nevertheless, preliminary findings show that neighborhoods with high water use and high vegetation coverage are also associated with higher energy use. The additional complexity here is the energy consumption embedded in the treatment and

delivery of water and in the water consumption associated with the production of energy. The relationship between these factors is the focus of current investigation.

Responding to data challenges: urban remote sensing

One of the challenges in geographic tool development and urban environmental analysis is the need for accurate mapping of surface features over time, such as vegetation cover to quantify water use. Remotely sensed images, often collected from satellites with spatial resolutions down to 1 meter, are a powerful source of these data. The challenge of using these data arises from the need to extract desired features with a reasonable level of accuracy. This led me to explore the development of new approaches for classifying imagery. This represented a significant shift from my prior emphasis on Geographic Information Systems (GIS) and resulted in a one-year gap (2005) in my refereed publications. However, my publications in 2005 include a co-edited volume (proceedings from an international conference on urban remote sensing) and two non-refereed publications in remote sensing. Subsequently, in 2006, I published a refereed paper on remote sensing in *Computers, Environment and Urban Systems*.

A later paper, published in the *International Journal of Remote Sensing*, reflects my initial attempt to develop approaches to classify imagery for urban areas (Wentz et al 2008). It evaluates how well an expert system designed for one geographic area can be applied to a different study region. Expert systems use rules to assign pixels to specific classes. For example, a pixel will be assigned to the class 'low density residential' based on spectral information, texture, and zoning. The reason for classifying imagery with expert systems is that resulting images can have a higher number of classes with greater classification accuracy. However, the challenge is the assignment rules are determined on a case-by-case basis, unlike other approaches where a simple formula is applied. My research demonstrated that some the rules could be successfully transferred from a prior study (Phoenix) to imagery from another (New Delhi). However, user knowledge of the local area was critical to success.

My work in urban remote sensing recently culminated in funding from the NSF to support an international workshop to examine how remotely sensed data acquisition and analysis can be used to support urban challenges (http://urbangrowth.ugecproject.org/index.php?title=Main_Page). The URS workshop was held in April 2011 in conjunction with a Urbanization and Global Environmental Change (UGEC) organized and NASA funded workshop on forecasting urban land use change (FORE), organized by Karen Seto and Michail Fragkakis. Each academic participant was asked to invite a collaborator/colleague from the public sector to attend the workshop, resulting in a total of 18 URS participants. Engagement with FORE workshop participants provided core linkages to the climate change community and policy-based research. Key outcomes included the need for increased communication between users and data providers, the opportunity to develop more case studies embedded in a comprehensive framework, and the difficulty of data access and management. I am working with URS and FORE participants to prepare manuscripts for publication in several outlets describing the outcomes and steps forward.

Teaching

My teaching focuses largely on education in geographic technologies and research design and proposal writing at the graduate level. My philosophy for education at this level is that my role as an instructor is to facilitate learning through directed activities and research projects. That is, I do not prepare exercises for students to step-through with detailed point-and-click instructions. Instead, I attempt to invoke critical thinking and problem solving through open-ended and self-directed graduate student projects. Through these projects, several students have developed master's theses and PhD dissertation topics. Furthermore, these activities have resulted in several refereed journal papers where I have been a co-author with graduate students. For example, one paper was co-authored with an ecology PhD student and her advisor and used geographically weighted regression to analyze the spatial characteristics of stream denitrification (Harms et al. 2009).

One of the difficulties in GIS education is that many of the US programs focus on software training over in-depth attention to geographic and computational concepts. Recognition of this led me to an opportunity to participate in the development of a model GIS curriculum. The result was a collaborative effort toward the creation of a body of knowledge, curricula, and pathways through the curricula. The first published step toward this effort is a catalog of the body of knowledge, which was published and distributed by the Association of American Geographers (AAG). A summary of the effort resulted in a refereed publication (DiBiase et al 2007).

Leadership and Service Activities

My service activities emerge in several leadership positions. I received a one-year fellowship to work in ASU's Office of the Provost. My activities were to observe acting administrators and participate in selected upper university administration activities. The skills I acquired have positively impacted my current position as Associate Director for the School of Geographical Sciences and Urban Planning. In this role I participate in the day-to-day decision-making and operation of the unit, including budgetary planning, graduate student policy making, and personnel matters. The other administrative positions I hold within the unit are director of the GIS graduate certificate program and interim director for the Master of Advanced Study in Geographic Information Systems (MAS GIS).

In addition to my university service, I am a leader in several disciplinary organizations. For the Association of American Geographers (AAG), I have served as a member of the nomination committee, as the chair of the Geographic Information Systems and Science (GISS) specialty group, chair of the Marble-Boyle undergraduate award committee, and as a member of the organizing committee for the 2011 Space-Time Symposium. In addition to the AAG, I also served as a Board Member for the Cartography and Geographic Information Society (CaGIS) and as a Regional Director for the Southwest Region of the American Society for Photogrammetric and Remote Sensing (ASPRS). I intend to continue to be involved with and assume leadership positions in both university and disciplinary leadership activities throughout the remainder of my professional career.