Development of a New Graduate Class: Spatial Hydrology

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Abstract

This proposal seeks funds to support the development of a graduate level course that integrates remote sensing, GIS and spatially explicit modeling in hydrologic research. Tentatively titled "**Spatial Hydrology**", this course will be developed in the Summer and Fall of 2009 and taught for the first time in Spring 2010 out of the Department of Renewable Resources. This class addresses several teaching gaps at the University of Wyoming and will provide graduate students with highly relevant and current knowledge that will bolster research at UW and better prepare them for post-University careers. Spatially explicit process-based understanding of hydrology has been a desired goal of the research community for the past several decades. The incorporation of remote sensing and GIS strategies has been absolutely critical to this field. While UW offers several courses in GIS and remote sensing, our graduate students in earth-based science are under-served from a teaching perspective and there is a significant lack of classes taught (a) specifically at the graduate school level and (b) in the critically important fields of hydrology and water resources. The proposed course addresses key goals of NASA and the UW Space Grant, as well as fits within the Areas of Distinction and depth identified at UW, specifically improved Graduate School education and Water. This course will be designed to serve students from a multidisciplinary perspective and could prove beneficial to students interested in hydrology, rangeland processes, reclamation and restoration, SENR, energy development, geology, geography, and engineering.

Introduction

Water resources are at the core of both research and educational needs at the University of Wyoming, and there is a clear and demonstrable need to enhance graduate-level education in this area. Spatial hydrology is an emergent field that links hydrological processes with spatially explicit landscape-scale modeling using remote sensing (primarily NASA platforms) and GIS. This field relies upon technology and is where an abundant of interesting and challenging topics can be addressed in the classroom. The University *currently does not offer a class in this field*, which is a detriment to graduate students interested in pursuing water resources, watershed hydrology, environmental and civil engineering, and geography (among other fields). Funds are requested for summer salary (2009) that will be used to develop and establish a course in the Department of Renewable Resources titled "**Spatial Hydrology**" that will serve the larger University community and provide substantive feedback to research initiatives in water and water resources.

The scope of this class will be aimed at the use of established and emergent spatially explicit techniques for hydrologic investigations. It is anticipated that this class will be lecture/lab arrangement with the labs and lectures highly linked in scope and content. Critical processes that drive the water cycle will be

examined, including evapotranspiration, runoff, soil moisture, snowpack/glacial processes, and rainfall. Remote sensing technologies aimed at identifying and interpreting these elements will be presented and taught in labs, along with GIS-based tools used by researchers such as spatially explicit hydrologic models.

During the preparation of this class I will examine both established and nascent practices and ensure that the class is up-to-date with respect to the literature. I will also examine strategies for effective technology teaching; I have been teaching in this sector for 10+ years but recognize that a periodic review is very important for both professional development and effective teaching. A review of similar classes taught at other Universities will be undertaken, and I will reach out to other educators in this area to identify successful methods and content.

Project Narrative

Over the course of Summer and Fall 2009 I will develop a 3- or 4-unit lab/lecture course titled "**Spatial Hydrology**", to be taught at the Graduate Level in the Department of Renewable Resources. I intend to devote significant time during the summer (2009) to developing the class lecture and lab materials, finalizing the classroom preparation during the Fall, with the course first taught in Spring 2010. Thus I am requesting slightly less than one month's summer salary ($10,000 with salary and benefits) to cover my time investment. In preparation for the course I intend to have the following core activities: (1) review of research and education in Spatial Hydrology; (2) literature review and personal interviews with other educators in effective strategies for teaching technology; (3) formulation of a course syllabus; (4) development of lecture and lab materials to fill the curriculum. Throughout the project I will meet with other faculty with research and education interests in the fields of remote sensing, GIS, and hydrology to ensure that the course scope and sequence complements ongoing efforts and will give maximum benefit to the students who enroll in the course.

I have longstanding research and teaching experience in the fields of hydrology and the use of technology in hydrology, watershed science, geomorphology, and landscape ecology. I have taught several classes that use GIS and remote sensing to better examine spatial processes, and teach Wildland Hydrology. My title is "Spatial Processes Hydrologist", and I actively pursue lines of inquiry that necessitate high technology, modeling, and the use of spatial analysis. I do not consider myself a true remote sensing expert, but have abundant experience in its use in research and teaching and feel fully capable of teaching the proposed scope of subject matter (and am frankly very enthusiastic about diving into this arena more thoroughly).

1. *Review of research and education in Spatial Hydrology*. In this phase of the project I will more thoroughly look through other Universities' Bulletins and contact colleagues in the field to identify potential models of instruction. For example, the Universities of Arizona, Santa Barbara, Texas and Oregon State cover this field to some degree or another in their course catalog, and effectively incorporate the use of remote sensing and GIS into their graduate degree programs in water resources.
2. *Literature review and personal interviews.* A review of new and effective strategies for incorporating technology into teaching is warranted. I have been teaching in this field for many years and see this as an opportunity to better align myself with teaching methods that have become proven and/or use strategies with which I am unfamiliar. The University Consortium for

Geographic Information Science (http://www.ucgis.org/), for example, offers a venue for linking with other educators and researchers. The Journal of Spatial Hydrology (http://www.spatialhydrology.com/journal) offers excellent information and links to this subject matter.

3. *Formulation of a course syllabus.* This is, of course, a foundation of any course, but it is all too frequent an occurrence that a new course is thrown together without enough regard to sequencing. I have a general idea about the scope and sequence of the course that focuses on covering each element of the water balance in both theory and modeling while teaching remote sensing and/or GIS techniques for spatially modeling those elements. At present I intend to thoroughly cover these elements so that students build an effective toolbox that will allow them to spatially model and interpret hydrological response after they complete the classes. The class must touch on aspects of uncertainty, error, modeling, and data analysis within this general context. However, the most successful way in which these elements can be threaded together, or taught in a lecture or lab, needs thorough vetting. At present I have not identified an effective textbook but will seek to identify reading materials in the primary literature or from other books that will support the syllabus.
4. *Development of lecture and lab materials to fill the curriculum.* A self-evident aspect of this project, developing the lecture and labs will constitute a significant portion of the project, and I expect the timeline to stretch into the Fall. My goal is to have each lab tested by myself and students in my GIS lab (www.uwyo.edu/sawls) multiple times prior to the Spring semester so that things go as smoothly as possible. My strategy is to very closely link the lecture and lab materials so that they complement and compound the effectiveness of each other.

   During this phase of the project I will conduct a thorough review of accepted and emerging strategies and models for spatial analysis of hydrological processes. There have been excellent advances in the integration of remote sensing, GIS and modeling watershed processes and I have familiarity with a wide variety of these techniques but am not naïve enough to think that *at this point* (a) I am fully conversant or (b) am able to incorporate them into my teaching. That, however, is a primary reason for this grant; to afford the time to better investigate and test these advances. I have access to outstanding LiDAR, RADAR, and other remote sensing and GIS products from my research and will use these data products in the lab and lecture materials, but have not intention to restrict my teaching to that which I already know. For example, there have been great strides made in the interpretation of soil moisture, which has great practical application for precision agriculture but also for hydrological processes and the water balance; I intend to pursue such lines of investigation and capture them for classroom instruction and lab activities.

A critical component of this project is that I will reach out to educators, researchers and students at UW as I build the course syllabus. To date I have met with a variety of faculty members, including many who self-identify as water resources faculty and have developed this proposal based on my own interests and feedback from these meetings. I am a founding member of the WRESE program (www.uwyo.edu/wrese) and have had several discussions regarding the University Bulletin and course offerings in the general area of Hydrology with other members of the WRESE program (notably Dr. Fred Ogden who is leading the effort). The strong consensus is that this course will be an ideal fit in the water program at UW and will fill a critical need. Over the past few years I have had many discussions with faculty members on how we can effectively train our students in the appropriate use of models and GIS in hydrology. There is

a very significant National need to educate the workforce in this discipline; there are many horror stories in the inappropriate use of technology in research and management (Klemes, 1986; Miller et al., 2007; SpatialHydrology, 2009), and I have been interested in this subject for quite some time from a practical perspective (Miller and Guertin, 1999). Other faculty members are able to offer excellent insight into strategies for building outstanding representatives of the University and I intend to make use of my peer group in the development of this course.

Relevance and Justification

Links to NASA and Space Grant Goals

The proposed course is directly in line with the stated NASA earth science goals to monitor Earth's changing environments and interconnections with humans and their relative effects on the environment. The goal of NASA's Earth Science Enterprise is to understand the changing Earth and the responses to and consequences of this change. In this class we will investigate how hydrologic connections respond to soil and vegetative characteristics which have direct and profound linkages among human-induced change, perturbations in landscape ecology and downstream effects on hydrological systems.

With respect to Space Grant goals, this class directly addresses multiple goals by promoting science, math, engineering and technology education at the University level and by encouraging interdisciplinary education and research in remote sensing and engineering. This project is intended to raise the profile of space-based remote sensing platforms and foster their use in research at UW.

Links to University of Wyoming Goals

The University of Wyoming has several initiatives aimed at areas that are addressed by this proposal:

1. The quality of graduate education. At present most graduate-level classes are taught with a split 4000/5000 designation, which reduces their efficacy at the MS and PhD level. In our department, graduate student consistently request higher-level courses that will promote and advance their skills.
2. Enhancement of research and education in water and water resources. This is one of the key areas of distinction in the University Plan.
3. Use of technology in classroom and research. This class will develop and rely on skills in remote sensing and GIS. These are skills highly in demand by students at UW and resonate with both education, research, and applied institutions.
4. Support for the newly formed PhD program in Water Resources/Environmental Science and Engineering (WRESE; http://www.uwyo.edu/WRESE/). This interdisciplinary PhD program has identified gaps in the teaching portfolio in water resources and engineering, and this class will directly fill several identified needs (graduate-level course; remote sensing and GIS; and process-based hydrology).
5. Interdisciplinary application and support. Students involved in restoration and reclamation, engineering, geomorphology, and geology have been identified as likely students, and it noteworthy that faculty and students that need a course such as Spatial Hydrology are distributed throughout the campus.

References

American Spatial Hydrology Union , 2009. Journal of Spatial Hydrology. We site accessed may 2009: http://www.spatialhydrology.com/journal/copyright.html.

Klemes, V., 1986, Dilettantism in hydrology: transition or destiny?, Water Resour. Res., 22(9), 177s-188

Miller, S.N., and D.P. Guertin, 1999. Teaching Spatial Analysis for Hydrology and Watershed Management. Proceedings of the 19th Annual ESRI User Conference, San Diego, July 26-30, 1999.

Miller, S.N., D.P. Guertin, and D.C. Goodrich, 2007. Hydrologic modeling uncertainty resulting from land cover misclassification. Journal of the American Water Resources Association 43(4):1065-1075. DOI: 10.1111/j.1752-1688.2007.00088.x

SAWLS Group, 2009. Spatial Analysis of Watershed and Landscape Systems Group. Web site accessed May 2009: www.uwyo.edu/sawls

SpatialHydrology, 2009. Web site accessed May 2009. http://www.spatialhydrology.com/

Budget

Support for the proposed activities is to cover close to one month of summer salary (approximately 28 days) and benefits.

- 28 days of summer salary = $7,813.00
- Benefits (28%) = $2,187
- Total = $10,000.00

Description of Previous Space Grant Funding

In 2005 I was the recipient of a faculty research grant titled “Spatial Analysis of Watershed in a Rapidly Developing Changing Landscape: Inside and Outside the Fence at Kruger National Park, South Africa”.

In this project I led a small team that investigated the temporal and spatial impacts of land cover change in the Luvuvhu River and surrounding areas to the West of Kruger National Park, South Africa (KNP). Remote sensing data were collected and classified to map change within the study area over the past several decades. A database of relevant Geographic Information Systems (GIS) data related to soils, topography, and climate was developed in coordination with institutional partners in KNP.

These data were used to model the hydrology of the study area and identify whether dams or land cover change were more relevant to the observed changes in river hydrology and riparian damage. Institutional partnerships with regional universities and the Park were built, and I continue to work and communicate with a scientist at KNP.

This project led to the successful completion of an MS student (Hannah Griscom) and publication of several manuscripts and presentations:

- Griscom, H.R., and S.N. Miller, 200x. Modelling the impacts of dams and land cover change on low flows in the Luvuvhu river, South Africa. Submitted to Water SA. Status: re-submitted after revisions.
- Griscom, H.R., S.N. Miller, T. Gyedu-Ababio, and R. Sivanpillai, 2009. Mapping Land Cover Change for Hydrological Modelling of the Luvuvhu Catchment, South Africa. Accepted for Publication in Geojournal; in Pre-Press.
- Miller, S.N., and H.R. Griscom, 2006. Watershed and River Management in Africa: Njoro Watershed, Kenya and the Luvuvhu River, South Africa. Invited speaker to Geography 4080: Management of Major River Basins, Univ. of Wyoming, Laramie, WY, March 28, 2006.
- H.R. Griscom, S.N. Miller, and T. Gyedu-Ababio, 2006. Drying of the Luvuvhu River, South Africa: examining the roles of land cover change and water extraction with GIS-based hydrologic modeling and remote sensing. Abstract and poster presentation at AWRA Conference on Geographic Information Systems (GIS) and Water Resources IV, Houston, Texas, May 8-10, 2006.
- H. Griscom, S.N. Miller, and T. Gyedu-Ababio, 2006. Kruger National Park, South Africa: Using GIS-based Hydrologic Modeling & Remote Sensing to Assess Human Impacts on the Luvuvhu River. Abstract and oral presentation to University of Wyoming Graduate Student Symposium, Laramie, WY, April 3, 2006.
- Miller, S.N., H.R. Griscom, T. Gyedu-Ababio, N.M. Korfanta, and W.A. Shivoga, 2005. A Multidisciplinary Research and Outreach Framework For The Sustainable Management Of Watersheds. Abstract and oral presentation at The 3rd KNP Science Networking Meeting. Skukuza, Mpumalanga, South Africa, April 4-8, 2005.
- Korfanta, N.M., S.N. Miller, and H. Bergman, 2005. Beyond the fence: linking on- and off-park land uses with biodiversity conservation in Kruger National Park. Abstract and oral presentation at The 3rd KNP Science Networking Meeting. Skukuza, Mpumalanga, South Africa, April 4-8, 2005.
- Griscom, H.R., T. Gyedu-Ababio, and S.N. Miller, 2005. Designing land use and hydrologic assessments for the Upper Luvuvhu and Shingwedzi Rivers: A step towards Integrated Catchment Management. Abstract and oral presentation at The 3rd KNP Science Networking Meeting. Skukuza, Mpumalanga, South Africa, April 4-8, 2005.
- Hannah R. Griscom, MS student, Department of Renewable Resources, University of Wyoming. Thesis topic: Land cover and hydrologic assessments of the upper Luvuvhu and Shingwedzi watersheds, South Africa: steps towards integrated catchment management. Completion date: May, 2007