Motivation:

Rivers are a strategic component of our daily lives, providing us with services ranging from food supply and energy generation to waste management. Also, rivers are a part of nutrient and carbon (Organic Matter) cycles and play a role in nutrient distribution across ecosystems and atmospheric carbon budget. However, the mechanisms and controls of OM cycle in rivers is understudied. This leads to wide variations when it comes to estimating contributions with environmentally relevant products like CO_2 and CH_4 from rivers to the atmosphere.

Some questions that still require more effort include: 'Where does most of OM cycling occur; channel or sediment?', 'What is the distribution of so called 'hot spots' in rivers and how do these active biogeochemical regions contribute to OM cycling in rivers ', 'What is the impact of physical controls like temperature and river stage on OM cycle?', 'How is OM distributed in river sediment (OM pools) and what are the controls and mechanisms that impact the degradation of those pools?', 'How would coupling of river domains (stream and channel) as well as accounts for river-atmosphere interactions impact estimates of OM cycle contributions from rivers?', ' What are the effects of physical controls and OM pool distribution on microbial communities in rivers?'. These are just a few major questions that still are a focal point of many laboratory and field studies. Understanding how the dynamic coupling of physical chemical and biological controls affect OM cycle in the entire river corridor will help us better prepare for future environmental scenarios.

Past and Present Contributions:

Numerous laboratory, field, and modeling studies that aim at helping answer questions about the role of rivers in OM cycle have been conducted over several decades. Yet, because of the complex nature and the interplay of processes that occur in rivers, many knowledge gaps remain. For example: batch experiments or 1-D column experiments brought us closer to understanding processes in separate sections of the river corridor. Field experiments provided us with valuable observational data but often, under highly variable environmental conditions. The use of de-coupled models and model validations through highly variable field data, result in important insight but inaccurate predictions of effects of controls on river corridors and ecosystems.

During my Ph.D. I was focused on studying the OM cycling in the entire, coupled stream and sediment domains using flume environment. Unlike field studies, a flume allows for control of variables like OM input and stream flow velocity. And, unlike 1-D column experiments, a flume provides a 2-D domain suited not only for temporal, but also for spatial studies of river processes. Specifically, my dissertation work was tailored to help narrow the gap in understanding of coupled river domains (river corridor). During my dissertation I employed the use of well-developed and novel laboratory techniques and instruments available at the Jackson School of Geosciences and through collaborations. Through my dissertation work I became an expert user of various traditional hydrology field equipment; general bench-chemistry equipment; specialized laboratory instruments like bulk carbon and nitrogen analyzer, ion-chromatograph; and novel optical oxygen measuring instruments.

Using these instruments, I was able to shed light on how particular OM influences oxygen consumption in river corridor. Oxygen is important for OM degradation and improvement of water quality, and for sustenance of many aquatic species. Prior to my study, OM consumption in rivers were compartmentalized and de-coupled. Through my study, I was able to show that channel and sediment have different response times and magnitudes to OM perturbations; the importance of OM as an additional 'hot spot' for biogeochemical reactions; and the importance of temperature on OM cycling in river corridor.

Additionally, I employed novel high-resolution molecular carbon analysis, available through collaborations, to answer the question of OM-pools distribution and consumption rates throughout river corridor. The nature of OM-pools variation comes from molecular differences in OM composition and degradation rates associated with these differences. Molecularly complex structures of OM are degraded at slower rate compared to simple-structured OM molecules. In other words, the reactivity of OM is variable. The results from this study will help develop better predictive models that incorporate changing OM reactivity and better quantify OM cycling in river corridor.

New Research Directions:

Using the past knowledge about the river corridor, future directions for my research group would involve implementations of OM reactivity into recently developed models where stream and sediment river domains are coupled. Also, the existent models are poorly accounting for microbial diversity in sediment domain of river corridors. Expanding the project into investigation of microbial community interactions under varying OM molecular complexity would be another rout for my research group. Additionally, expanding our understanding of river corridor interactions with the riparian zone would help develop more accurately linked predictive models on watershed scales. These areas of research are a 'hot topic' supported by the Department of Energy with available PI and student grants, and access to unique laboratory instruments through collaborations with national laboratories.

Collaborations:

In addition to my existent collaborations with the scientists from Northwest Pacific National Laboratory and Pennsylvania State University, when at Prestigious University (PU), I would welcome collaborations with Professor Jane Doe from the Department of Environmental and Geological Sciences, and her research group that focuses on plant - atmosphere interactions. Additionally, I would welcome collaborations with Associate Professor John Smith from the Department of Environmental and Geological Sciences and his research group. Along with my understanding of river corridor processes Dr. Smith's expertise on flow and transport through porous media and Dr. Doe's expertise in ecohydrology would be an invaluable resource for any graduate student. I would gladly serve on the committee of any graduate student advised by either Dr. Doe or Dr. Smith and share my knowledge. Moreover, because of our common interests and overlaps, which leads to commonly used techniques to answer different questions, we will be strong candidates for grants aimed towards expanding the array of instruments and/or commercial software (if open source software with comparable capabilities does not exist) available through the department. Also, these collaborations will open doors to multiple undergraduate opportunities spanning from laboratory assistance work, field assistance, and employment of simple modeling tools.

Student benefits:

While at PU, I will offer a biogeochemistry class that will incorporate hydrology and modeling tools components. Recent developments of open source modeling packages that allow to investigate complex, coupled environments will be a great tool for undergraduate and graduate students. I have the expertise with open source modeling tools like PHREEQC – a geochemistry modeling tool developed by USGS, KBase – platform supported by the Department of Energy that contains vast biochemical data sets with ability of performing biogeochemical modeling, OpenFOAM – an open source flow and reactive transport modeling tool, also supported by the Department of Energy, and other commercial software.

In addition to the classroom teaching, I would introduce a hydrology class with emphasis on field experience. Such class would be a major benefit, in particular to the undergraduate and Masters degree students. Current job market and entry level job positions at many environmental companies and government entities are calling for field hydrologists. Equipping students with skills in the field would help students stand out as employees and promote the professionalism and skills of all graduates from the department of Environmental and Geological Sciences at PU.

References:

(to be continued)