**Mahmoud Shehata | Research Statement**

**Research Motivation and Interests**

The ever-increasing world population is exerting an increasing pressure on global water resources to satisfy the resulting increase in demand. Many factors exacerbated this issue such as the major water reallocation around the globe resulting from the changing climate, and the misalignment between the water-availability and population distributions. The combined influence of all these factors resulted in tremendous stress on the regions that have limited water resources and raised many concerns regarding water security and water quality degradation in these regions. Therefore, it is essential to improve the water management systems to enhance the water use efficiency in the different human-activities to reduce their water and pollution footprints. Agriculture is by far the largest consumer of freshwater. Water needs in agricultural activities are also expected to increase in the future due to the large-scale switch from rainfed to irrigated agricultural practices in many regions in response to the changes in temperatures and precipitation rates caused by climate change. The majority of farmers still, however, rely on intuition and/or on rules-of-thumb while deciding on the amount and rates of irrigation water. Even the most advanced farms rely on a small number of sensors that measure soil moisture at single locations across the field. These limited measurements typically do not reflect the actual water needs across the field and lead to waste irrigation water. Also, excessive irrigation can cause excessive volumes of Nitrogen and Phosphorus compounds to reach and contaminate groundwater and nearby surface water systems. Therefore, there is a real need for efficient irrigation systems to help to face the current and future challenges in water availability and quality.

These wide-spread inefficient irrigation practices are caused primarily by the lack of more-informative, but still practical, techniques to monitor the variability in soil moisture. The current techniques either have limited coverage area (e.g. single-location sensors) or have insufficient resolution to map the soil moisture variability at the field scale (e.g. satellite data). Therefore, developing reliable and accurate monitoring techniques to measure key soil properties over a wide range of spatial scales is essential to optimize current agriculture practices. My research focuses mainly on utilizing and combining modern sensors and technologies such as the Fiber-optic Distributed Temperature Sensing (FO-DTS), aerial mapping, and remote sensing to develop new techniques to monitor irrigation water use efficiency. These new techniques will act, once optimized, as a foundation to improve our irrigation systems and to reduce the water footprint of agricultural systems.

**Current Research Projects**

I was involved in several research projects while I was conducting my Ph.D. under the supervision of Dr. Chadi Sayde. In one of my Ph.D. projects, I developed a novel technique that used the FO-DTS technology to extend the spatial coverage of the Dual-probe Heat-Pulse approach to measure soil thermal properties and moisture content over a wide range of spatial scales (0.1m to 10,000 m). The novel technique is capable of acquiring measurements with 0.125 m spatial, and sub-hour temporal resolutions. I tested the performance of the novel DTS technique in a laboratory soil-column experiment and it was capable of measuring soil moisture with an accuracy of ~3%. The results of my laboratory study have been submitted for the Journal of *Water Resources Research* and are currently under review. I am currently testing how my novel technique will perform under field conditions. This technique can provide us with unprecedented high-resolution datasets over spatial-scales not yet covered by other traditional soil moisture measuring techniques.

In another Ph.D. project, I investigated the applicability of the FO-DTS technology to act as a spatially distributed weather station capable of measuring several environmental parameters under field conditions. This three-year field experiment was performed in the Southern Great Plains site, one of the leading atmospheric observatory in the world. Both aerial and underground fiber-optic cables were installed over a total distance of 1200 m to monitor the atmospheric turbulence structure and the soil moisture content, respectively. The ground FO-DTS measurements were used to test how different active and passive FO-DTS soil moisture measuring techniques can be coupled to overcome their key limitations. The high-resolution data obtained from this experiment was also used to study the different factors that governed the precipitation water partitioning to the different hydrological components in that field. Two publications are currently being developed to summarize the finding of the field study. The results from all my research projects were presented in several conferences targeting different scientific communities that can benefit from them such as the American Society of Agricultural and Biological Engineers and The American Geophysical Union.

**Future Research and Vision**

In the future, I plan to continue to investigate how to optimize the physical system design and data interpretation techniques of the FO-DTS soil moisture systems and how to couple them with irrigation systems to achieve real-time control of irrigation water application. I want also to investigate the potential and benefits of combining the optimized FO-DTS soil moisture systems with other technologies such as Unmanned Aircraft Systems imagery and remote sensing to support better management of the hydrological systems. For example, data from FO-DTS systems have the potential to calibrate land surface temperature data obtained by remote sensing to produce high-resolution soil moisture maps. These high-resolution datasets can be used to validate the accuracy of the theories and assumptions typically included in current hydrological analyses. In addition, they have many practical applications such as supporting advanced flooding and fire warning systems. Finally, I want to use the expertise I gained in hydraulic and hydrological modeling through my master's degrees to investigate how these novel high-resolution datasets can be used to validate different models and test the adequacy of their parametrizations.

Collaborative work is essential for these multidisciplinary projects to be successful. I plan to actively seek out collaborations with other faculty members in the department, researchers from other departments and universities, and agricultural experts throughout my career. Also, I aim to disseminate the findings of my research in top-rank journals to reach a wider audience both nationally and internationally, which can lead to new collaborations. The targeted journals include the *Journal of Hydrology*, the journal of *Water Resources Research,* and the journal of *Hydrological Processes.* I also encourage the participation of undergraduate students in my research activities to provide them with early exposure to graduate school.

In summary, my goal throughout my career will be to make long-lasting collaborations aimed toward advancing our understanding of the different hydrological processes and optimizing the current management systems to achieve better water use efficiency.