Using Integrated Earth Observation-Informed Modeling to Inform Sustainable Development Decision-Making

Ph.D. Thesis Proposal Abstract and Committee Members

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Dear Professor Machover and the MAS Committee,

This is to inform you that Jack Reid intends to develop a thesis on the subject matter described in the below abstract and under the supervision of the listed committee, whose short biographies are available following the abstract.

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Abstract

Over the past two decades satellite-based remote observation has blossomed. We have seen a rapid increase in the number of Earth Observation Systems (EOSs) in orbit, significant improvements in their capabilities, and much greater availability of the data that they produce. This trend has occurred as part of a greater trend of increasing data availability, computational power, and modeling ability. Unfortunately, up until now, this earth observation (EO) data has been largely used only by governments and academics for scientific purposes, typically to understand and predict environmental phenomena. Large corporations and non-governmental organizations (NGOs) have recently been conducting their own analyses, but these have required significant expertise and resources, and the results have sadly been mostly unavailable to the broader public.

There is a real need for (a) making remote observation data not just available but accessible to a broader audience by developing data products that are relevant to everyday individuals, particularly those involved in local, rather than national or global decision-making; (b) linking the EO-supported environmental modeling with the societal impact of a changing environment; and (c) putting policy and sensor design decision-making in the hands of a broader population.

This work aims to demonstrate the viability of a particular methodology for achieving (a) and (b), while laying the groundwork for a more detailed consideration of (c). To that end, this work centers on exploring the efficacy and difficulties of ***collaboratively developing*** a ***systems-architecture-informed***, multidisciplinary ***geospatial information system (GIS) decision support system (DSS)*** for ***sustainable development*** applications that makes significant use of ***remote observation data***.

This is done through the development and evaluation of DSSs for two primary applications: (1) mangrove forest management and conservation in the state of Rio de Janeiro, Brazil; and (2) coronavirus response in six metropolitan areas across Angola, Brazil, Chile, Indonesia, Mexico, and the United States. In both cases, the methodology involves the application the system architecture framework, an approach that has been previously adapted from the aerospace engineering discipline by Prof. Wood for use in sociotechnical systems. This includes using stakeholder mapping and network analysis to inform the design of the DSS in question. Other components of the methodology taken in this work are developing the DSS through an iterative and collaborative process with specific stakeholders; pursuing targeted, related analyses, such as on the value of certain ecosystem services, the value of remote sensing information, and human responses to various policies; and evaluating the usefulness of both the DSS and the development process through interviews, workshops, and other feedback mechanisms.

All of this takes place under the umbrella of the Environment, Vulnerability, Decision-Making, Technology (EVDT) Modeling Framework for combining EO and other types of data to inform decision-making in complex socio-environmental systems, particularly those pertaining to sustainable development. As the name suggests, EVDT integrates four models into one tool: the Environment (data including Landsat, Sentinel, VIIRs, Planet Lab's PlanetScope, etc.; Human Vulnerability and Societal Impact (data including census and survey-based demographic data, NASA's Socioeconomic Data and Applications Center, etc.); Human Behavior and Decision-Making (data including policy histories, mobility data, and urban nightlight data); and Technology Design for earth observation systems including satellites, airborne platforms and in-situ sensors (data including design parameter vectors for such systems). The data from each of these domains is used by established models in each domain, which are adapted to work in concert to address the needs identified during the stakeholder analysis. This framework is currently being used by several researchers in the Space Enabled Research Group and elsewhere. The capabilities provided by this framework will improve the management of earth observation and socioeconomic data in a format usable by non-experts, while harnessing cloud computing, machine learning, economic analysis, complex systems modeling, and model-based systems engineering.

Thesis Committee Biographies

Prof. Danielle Wood

Danielle Wood is an Assistant Professor in the Program in Media Arts & Sciences and holds a joint appointment in the Department of Aeronautics & Astronautics at Massachusetts Institute of Technology (MIT). Within the Media Lab, Prof. Wood leads the Space Enabled Research Group which seeks to advance justice in Earth's complex systems using designs enabled by space. Prof. Wood is a scholar of societal development with a background that includes satellite design, earth science applications, systems engineering, and technology policy. In her research, Prof. Wood applies these skills to design innovative systems that harness space technology to address development challenges around the world. Prior to serving as faculty at MIT, Professor Wood held positions at National Aeronautics and Space Administration (NASA) Headquarters, NASA Goddard Space Flight Center, Aerospace Corporation, Johns Hopkins University, and the United Nations Office of Outer Space Affairs. Prof. Wood studied at MIT, where she earned a Ph.D. in engineering systems, S.M. in aeronautics and astronautics, S.M. in technology policy, and S.B. in aerospace engineering.

Prof. David Lagomasino

David Lagomasino is an Assistant Professor in the Department of Coastal Studies at East Carolina University. He previously studied at Florida International University, where he received a B.S. and a Ph.D. in Geological Sciences, in between which he received a M.S. in Geology at East Carolina University. Lagomasino uses satellite, airborne, drone, and ground measurements to identify areas of coastal resilience and vulnerability. His research links remotely sensed spatial data directly with stakeholders in order to address exposure and sensitivity issues for coastal/wetland management and ecosystem valuation. He has been involved in a number of coastal blue carbon projects with funding from NASA's Carbon Monitoring Systems Program, NASA's Biodiversity and Forecasting Program, USDA's National Forest Inventory Assessment Program, NASA's New Investigator Program, and the Center for International Forestry. His goal is to provide meaningful information that will better inform coastal management practices while also inspiring students and the community to become environmental stewards in order to help sustain our coastal resources. Prior to his current post, he conducted research at NASA's Goddard Space Flight Center just outside Washington, D.C., in partnership with the University of Maryland, to develop models that measure the where when, and why shorelines are the world are changing.

Prof. Sarah Williams

Sarah Williams is an Associate Professor of Technology and Urban Planning at MIT where she is also Director of the Civic Data Design Lab and the Leventhal Center for Advanced Urbanism. Williams' combines her training in computation and design to create communication strategies that expose urban policy issues to broad audiences and create civic change. She calls the process Data Action, which is also the name of her recent book published by MIT Press. Williams is co-founder and developer of Envelope.city, a web-based software product that visualizes and allows users to modify zoning in New York City. Before coming to MIT, Williams was Co-Director of the Spatial Information Design Lab at Columbia University's Graduate School of Architecture Planning and Preservation (GSAPP). Her design work has been widely exhibited including work in the Guggenheim, the Museum of Modern Art (MoMA), Venice Biennale, and the Cooper Hewitt Museum. Williams has won numerous awards including being named one of the top 25 technology planners and Game Changer by Metropolis Magazine.