Adam Belmonte

Response Paper: Dr. Goetz

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**Changes in the Tropics and Arctic: Vulnerabilities and Opportunities**

**Research Topic Overview and Techniques**

In response to the effects of climate change on global carbon dioxide emissions, Dr. Goetz’s research is focused on the application of remote sensing techniques to quantifying the large-scale changes in ecosystems and the implications of these changes on future climate. More specifically, Dr. Goetz and his colleagues study the effects of global carbon cycling resulting from alterations to tropical forest and permafrost ecosystems. This research is mainly focused on how degradation of these ecosystems changes their carbon storage capacities, and in turn highlighting the importance of preserving their core characteristics for future climate change resiliency. Due to the high level of detail and depth of the data produced by Dr. Goetz and his research teams, international working groups like the Intergovernmental Panel on Climate Change (IPCC) have sought to incorporate it into their assessment reports. In addition to the date output from current research, Dr. Goetz is involved with the development and roll-out of advanced space-borne remote sensing platforms tasked with providing highly accurate datasets over a majority of the earth’s surface.

As discussed in his presentation and publications, a primary focus of Dr. Goetz’s research is on the quantification of aboveground biomass (AGB) in the tropical forest regions of the globe. Measuring the AGB is an integral step in understanding the total amount of terrestrial carbon available from the biosphere and in turn how much carbon could be emitted from widespread deforestation of these regions. Existing under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC) the reduced emissions from deforestation and degradation (REDD+) program is the driving force behind Dr. Goetz’s research into terrestrial carbon stock quantification. The REDD+ program seeks to measure, report, and verify the changes in forest extent and health in all the countries containing such an ecosystem, and also maintain a running tab for where forest is changing while also enforcing compensation programs where necessary. To accomplish this substantial task, Dr. Goetz and his colleagues use a combination of remote sensing, aerial survey, and ground truthing techniques to create highly detailed change detection maps that measure the geographical extent of forest change as well as the changes in aboveground carbon stock resulting from such changes. Field plot data of forest structure and composition, which is directly related to its health and integrity, is used as a ground truthing method to provide direct measurements of the total available carbon stock across a region. Extensive aerial LiDAR surveys are also conducted to gather forest structure and composition information that in conjunction with plot data is used as scaling information for satellite data. Once the satellite data models are trained with the highly accurate aerial and plot level data, extensive high resolution satellite classification datasets can be produced at 30 meter resolution. Due to the frequency and predictability of satellite data returns, this process can be repeated over time to highlight areas of interest where there are trends in both deforestation and afforestation as well as the amount of biomass (in Mg C per hectare) associated with those trends. This high-resolution reproducibility is at the core of the REDD+ program because it allows for an accounting of forest systems at a sub-national scale, translating to the ability to hold people accountable for contributing to one portion of climate change.

The other aspect related to large-scale changes to terrestrial carbon stores that was presented by Dr. Goetz is his involvement in the ongoing research projects studying the effects of climate change on Boreal Forest ecosystems. The organizing body for the many different research projects comprising this annex of scientific inquiry is a NASA program called ABoVE (Arctic-Boreal Vulnerability Experiment). ABoVE seeks to quantify and explain the effects of climate change felt in arctic ecosystems, and provide a comprehensive overview of how any such change will alter the ecosystem and socio-demographic characteristics of the region. The arctic region of the planet is slated to bear the brunt of early climate change effects, and also potentially contribute significant amounts of methane and carbon dioxide to the atmosphere as the region warms. ABoVE is a collection of scientific field studies using an array of different techniques to investigate the effects of climate change on fire, vegetation, hydrology, ecology, and wildlife systems spanning the region. Dr. Goetz’s involvement with ABoVE is reflected in a number of projects researching the spatial changes of boreal vegetation ecosystems and the amount of carbon (e.g. AGB) resulting from climatic changes. This research is primarily a function of satellite and aerial survey remote sensing data, and different modelling techniques to extrapolate across the region.

**Research Questions**

-How is climate change affecting the integrity and functioning of arctic-boreal ecosystems; specifically how will continued changes to the climate alter the potential amount of carbon and methane released from these ecosystems.

-How are changes to global forest extents best quantified, and how can this information provide accurate estimates of carbon stock in tropical forests on a global scale.

-What remote sensing techniques can most accurately quantify three-dimensional properties associated with vegetative ecosystems?

**Research Connections**

My research is centered on regional estimates of atmospheric moisture measurement derived from UAV and satellite remote sensing data, and the connection to Dr. Goetz’s research is the most strong of all new faculty presentations thus far. As a cornerstone of his research, Dr. Goetz uses the Landsat family of satellites to derive remote sensing data which is also the same platform that my research will use to provide the high resolution estimates of ET across a landscape. While it seems that the estimates of AGB are rooted in actual physical model input parameters, I plan to review the extensive research of Dr. Goetz and his colleagues for indications of model structure and parameters. More specifically, I am interested in their process for scaling up plot-level and aerial survey based data to the Landsat scale and what parameters must be used to ensure an accurate outcome at high resolution.

Another aspect that Dr. Goetz briefly touched on during his presentation (not yet in his research) is the use of UAV remote sensing data as scaling data for satellite based measurements. The application of LiDAR data from a UAV platform to assess and quantify AGB in extremely high resolution is something that he mentioned could complement the upcoming space borne LiDAR mission aboard the International Space Station. The GEDI (Global Ecosystems Dynamics Investigation LiDAR) program is a major source of research and funding for Dr. Goetz and his colleagues, and is focused on mounting a full-waveform LiDAR on the International Space Station to map the three-dimensional structure of the earth’s forest ecosystems. Gathering high resolution LiDAR data from an UAV-based platform could most efficiently provide data used in the scaling and accuracy assessment of the data arising from the GEDI project. The specifics of this are something that I plan on researching and contributing to as needed, with the aim of supporting such an amazing and relevant portion of future research.