Scaling climate impacts on forest growth: linking long-term monitoring and remote-sensing data

Overview

Forests help to mitigate climate change by taking carbon dioxide (CO2) from the atmosphere and sequestering it in long-lived woody tissues, and future trajectories of forest productivity will influence both Earth's climate system and the future state of forests. Remote sensing of forest canopies is an essential tool for scaling forest growth responses to local processes that drive forest growth to the regional, sub-continental, and global scales at which models assess and predict forest productivity and climate change feedbacks. There exists a growing wealth of remotely sensed data on forest structure and function across scales. Co-located with many of these are databases of individual tree growth that also span spatial and temporal scales. However, there have been few efforts to link these. The Smithsonian has three forest plots where both remote sensing and tree growth data exist across extensive spatial and temporal scales, offering a unique opportunity to advance understanding of forest productivity through remote sensing and offering new ways of understanding the processes that drive forest response to climate change. These datasets are also positioned for publication and curation for public use, vegetation model development, and broader incorporation in future remote sensing missions.

Importance

Tree growth in intact forests is a critical carbon sink in Earth's terrestrial system. Climate change is affecting forest growth, threatening the role forests might play in limiting peak global warming to under 2º C. A grand challenge in advancing our understanding of tree growth is connecting the mechanisms that drive growth at the individual and community scale to the remote sensing platforms that can extrapolate those mechanisms to the globe. This endeavor marks the cutting edge of forest demographic modeling, remote sensing, and statistical scaling of environmental data.

The remote sensing data linked to tree growth has primarily been pursued through observational campaigns. Lidar missions estimate forest structure using laser returns, which identify where vegetation is at one time and where it is (or is not) at another. Hyperspectral data, images that capture how light reflects off tree canopy surfaces, can indicate the chemical and physical status of trees, including insights into photosynthetic activity and health. Both of these tools are currently collected using drone, airborne and space-borne instruments. Remote sensing programs, however, have only recently begun to link remote sensing data to groundbased monitoring of tree response to climate and to how biodiversity mediates these connections.

The Smithsonian has invested in programs that monitor individual tree growth across hundreds of species in temperate and tropical forests. These initiatives include information about how trees grow over decades, but also how individual trees allocate carbon to stem growth at the scale of days, weeks, years, and decades. Integration with remote sensing data is needed to extend our understanding of the resilience and vulnerabilities of species to climate change impacts such as drought and extreme temperatures.

Potential Research Themes

There is an opportunity to link tree growth to remote sensing data using detailed data on tree growth that has been collected in research forests at SERC, NZCBI, and STRI and co-located remote sensing campaigns through partnerships with NEON, NASA, and university research teams. The Smithsonian is also a key leader of the GEOTREES program, an international consortium of forest monitoring networks that explicitly looks to scale forest dynamics to the globe using remote sensing. Potential research themes in this domain include, but are not limited to:

- How whole forest productivity is represented by satellite and International Space Station instruments.
- How intra-annual carbon allocation to tree growth responds to water deficits and hyperspectral traits of canopy crowns.
- The importance of species diversity in resilience of forest carbon acquisition to climate change.
- Advancing statistical models of scaling that can be incorporated in global vegetation models.

PROGRAMS AND ASSETS

The Smithsonian is ideally positioned to address the challenge of scaling patterns and mechanisms of tree growth response to climate change globally due to both the extensive detailed data on tree growth that has been collected in research forests at SERC, NZCBI, and STRI, as well as being a host to a variety of remote sensing campaigns through partnerships with NEON, NASA, and university research teams. Many other data streams are also available, relating to hydrology, carbon fluxes, micro-climate, and others.

The community for the Fellow would be focused around SERC, NZCBI, STRI, and NMNH, but also include a larger collection of researchers including collaborators at regional universities, NASA, and the DOE.

ADVISORS

The following Smithsonian staff scientists commit to advise fellows, provide datasets and guidance to link their research to broader conservation and restoration goals: Sean McMahon, SERC, Kristina Anderson-Teixeira, NZCBI, Helene Muller-Landau, STRI, Stuart Davies, ForestGEO, STRI.