Space as a Tool to Foster Global Climate Change Mitigation and Adaptation

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Abstract. Global problems require global solutions, and global solutions require global data. New Space companies focused on Earth observation are already generating massive amounts of actionable information, but are typically restricted to focus on their own market niche. By collaborating with intergovernmental organizations and other public institutions, these private space entities can collectively create a comprehensive data lake of global Earth observation datasets. Through online education platforms and existing STEM outreach programs, this data lake can serve as the focal point for a diverse and inclusive community of young climate-minded technologists.

1 Introduction

Modern advances in hardware miniaturization, computational power, and communication infrastructure have led to significant growth for space-based remote sensing. Combined with cheaper access to low Earth orbit due to reusable rockets, more frequent launches from multiple providers, and split-cost rideshare programs [1], these technological and economic factors have greatly enhanced humanity's ability to observe its home planet, Earth.

In addition to larger data volumes from individual spacecrafts, efforts towards modularity and standardization [2] have resulted in the blossoming of large-scale CubeSat constellations - or fleets of small satellites - which utilize a variety of Earth observation (EO) techniques and can collectively generate petabytes of data every year [3]. One of

the major advantages of these physically dispersed orbital systems is their ability to generate truly unbiased global datasets, rather than targeted measurements over specific regions for purely commercial or political reasons.

Such datasets are monumentally valuable for our adaptation to changing global climates. However, the cost of entry for novel space endeavors is still relatively high compared to other industries, requiring most New Space startups to limit their scope and initially specialize in one type of observation data. Therefore, it is critical that intergovernmental organizations and other public institutions provide incentives for private company data pooling, as well as inclusive educational services to enable rapid adoption and tangible results.

One precedent for this is the Luxembourg Space Agency's (LSA) space analytics data lake, which is populated with data from private entities and "accessible free of charge to all start-ups, research institutes, and public agencies in Luxembourg" [4]. However, more work is needed to expand the scope and impact of such initiatives on a global scale.

2 Proposal

During his confirmation hearing for the role of NASA Administrator on 21 April 2021, Senator Bill Nelson stated that "you can't mitigate climate change unless you can measure it" and "understanding our planet gives us the means to better protect it." [5] He also acknowledged the importance of enhancing NASA's education programs and increasing diversity in the workforce. Taken separately, these statements represent positive initiatives from a leading space organization. Taken together, they imply a wider solution.

New Space companies are already producing unprecedented quantities of EO data. At the same time, global citizens are eager to take direct climate action. This is evident from the record-breaking attendance at 2019 climate protests around the world [6], before COVID-19 prohibited large gatherings of people. In the words of the Sunrise Movement, a youth-led organization campaigning to create training programs and jobs for a more sustainable economy: "There are millions of us looking for good work, and so much good work that needs to be done." [7]

Although there are unique challenges posed by working with large EO datasets, it is also true that "Big Data projects are being rapidly embraced by organizations working in the social good sector" [8]. The issues of participation, empowerment, and data literacy are actively being addressed by online education platforms such as Coursera, edX, and Khan Academy.

One example of an organization focusing specifically on diversity and inclusivity in STEM is Black Girls CODE. "By reaching out to the community through workshops and after school programs, Black Girls CODE introduces computer coding lessons to young girls from underrepresented communities" [9]. Since minority groups and indigineous peoples "are among the worst affected" by climate-related disasters [10], educational outreach is essential for empowering younger generations to make a difference in their communities. STEM literacy opens the door to creative data-driven decisions, and enables youth to directly participate in global conversations regarding climate adaptation strategies.

Considering the above, here is a threefold approach to encouraging novel climate change solutions with space-based data:

1. Provide incentives for New Space companies to pool their EO datasets together in public-facing data lakes.
2. Leverage global STEM education programs and the open-source software community to create interactive tutorials, video courses, data fusion products, and developer tools that enhance data literacy and make it easier to work with the EO datasets - regardless of prior exposure to Big Data.
3. Offer awards to young developers and data scientists who utilize the data lake in promising projects. Provide scholarships, grants, internship and employment opportunities, or even connections to venture capital funding for climate-focused technology startups.

3 Example Datasets and Applications

Satellite imagery data can be used for a variety of climate-related applications such as monitoring hurricanes or drought-afflicted regions [11]. Planet Labs is a major producer of such

data, and already provides some of it for free to help disaster response efforts [12].

Other startups focus on radiofrequency (RF) payloads like synthetic-aperture radar (SAR), which can make observations at night and through cloud cover. ICEYE is developing a SAR constellation to address "the melting ice caps, agricultural issues," and flood monitoring [13].

Another startup specializing in RF payloads is Spire Global. Tracking the world's aircrafts and ships while producing global weather forecasts, Spire's data can help reduce the carbon footprint of the transportation industry by minimizing airplane contrails [14] and maritime emissions [15] through route optimization. Spire also captures GNSS signals that have reflected off of the Earth's surface, allowing them to measure not only sea ice but also soil moisture content, which can help determine wildfire risks [16]. Additionally, Spire participates in the LSA data lake and even provided free atmospheric data to major meteorological organizations when COVID-19 caused a reduction of aircraft-observed weather measurements [17].

Relative newcomers include Bluefield Technologies, who are tackling the problem of greenhouse gas emissions by monitoring methane directly [18]. There are many other companies that could be listed here, and many more that have yet to form.

4 Conclusion

Public-private partnerships are necessary to develop the climate-related solutions that future generations depend on. Many New Space companies are already aligned with the goals of climate action, and this should be leveraged to the fullest extent. With contributions from industry, academia, and governments, we can drastically accelerate humanity's collective innovations and improve life for all on our "pale blue dot...suspended in a sunbeam." [19]

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