

Satellite Insights for Sustainable Governance: Harnessing the HAWC Mission's Potential

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Issue

The Canadian-led High-altitude Aerosols, Water vapour and Clouds mission, also known as the HAWC mission, offers a momentous opportunity for Global Affairs Canada (GAC) to integrate science, technology and the Sustainable Development Goals (SDGs), necessitating the development of comprehensive multi-stakeholder and multi-scalar governance frameworks to leverage and manage the insights from future big data of the Earth's atmosphere.

Background

The HAWC mission, under the aegis of National Aeronautics and Space Administration's (NASA's) Atmosphere Observing System (AOS) and Earth System Observatory program, is poised for launch in 2031. This mission aims to remedy significant gaps in scientific knowledge by enabling increasingly precise quantification of aerosols and clouds from polar-orbital and sub-orbital measurements. This atmospheric big data will support the prediction of severe weather events, the modelling of climate patterns and the surveillance of disease, disasters and storm dynamics. Accordingly, the HAWC mission has the potential to advance several SDGs, particularly SDG 3: Good Health and Well-being and SDG 13: Climate Action.

However, the mere collection of data is insufficient for leveraging the full eco-ethical potential of the HAWC mission. The successful mobilization of future satellite data towards a sustainable and data-driven policy will

be contingent on the implementation of effective multi-stakeholder, multi-scalar and data governance frameworks — all of which must be firmly embedded in sustainability principles. With only seven years until the HAWC mission reaches orbit, this pre-launch period represents a pivotal opportunity for GAC to develop policy frameworks for data, health and climate governance by merging technological development with principles of sustainability. Integrating the SDGs, especially SDG 3 and 13, into the foundational objectives of the HAWC mission prior to launch would promote Canadian values and interests both domestically and abroad.

The HAWC Mission and SDG 3: Good Health and Well-being

In an era characterized by global warming and escalating climate volatility, big data play a crucial role in enhancing health outcomes. As poor air quality is the single greatest environmental health risk worldwide (deSouza et al. 2020), efforts to measure and mitigate the health impacts of air pollution are needed more than ever to support smarter and increasingly integrated health services. To this end, satellite Earth observation has emerged as critical infrastructure to calculate and map the evolving nature of air pollution, disease vectors from warmer temperatures and flooding, and other environmental disasters that pose risks to human health (Kalegasi et al. 2022). The data produced by the HAWC mission will advance the objectives of SDG 3 by providing critical geospatial insights into aerosols and clouds in relation to key health indicators (CSA 2022a; deSouza et al. 2020).

The HAWC mission seeks to address critical gaps in global environmental data, especially regarding the impact of aerosols on air quality, where there is a significant lack of monitoring even for common pollutants. With approximately 90 percent of the global population breathing heavily polluted air and 141 countries lacking regular monitoring — most of which are low and middle-income countries — there is an urgent need for new and improved data collection systems (Holloway et al. 2021). Notably, as climate change continues to alter the atmospheric composition, chemistry and precipitation processes, air quality is expected to deteriorate in several densely populated areas around the world. The disproportionate impact of air pollution on developing countries makes it both a public health concern and a social justice issue. Therefore, the precise quantification of aerosol properties is progressively pertinent to global public health services to not only promote human health, protect ecosystems and manage the feedback loops that interlink them (Orru et al. 2017), but also to enhance global equity. Moreover, alongside improving global coverage of aerosol monitoring, the HAWC mission will also augment the limited geographic range of ground-based monitors, which are both sparsely located and insufficient in terms of spatial coverage (Anenberg et al. 2020; Holloway et al. 2021).

The HAWC satellite data will be crucial for informing policy making, enhancing public outreach, and ultimately improving global health outcomes (de Sherbinin et al. 2014). Additionally, by addressing gaps in current monitoring systems and providing data for tracking air quality, weather events and climate trends, the HAWC mission will enhance emergency response mechanisms to environmental disasters, forecast disease vectors and mitigate respiratory health risks — thereby strengthening societal resilience against climate change (Sayyed et al., 2024). In this manner, the HAWC mission can advance global public health and environmental justice in tandem.

The HAWC Mission and SDG 13: Climate Action

Improving the accuracy of global climate models is imperative for predicting future climate scenarios and assessing the potential impacts of policy measures. Data produced by the HAWC mission can support SDG 13 in response to climate extremes, including wildfires, floods and drought. In addition, given that aerosol and cloud properties constitute key sources of uncertainty in predicting future climate and ecosystem health (Boucher et al. 2024), the HAWC mission would address critical questions about how aerosols and clouds affect precipitation

patterns, the global energy balance and the thickness of the ozone layer. Enabling accurate measurements of aerosols and clouds would support the development of models and mitigation strategies to lessen the impact of climate change on communities worldwide. Moreover, the collected data would provide invaluable insight into the effectiveness of human interventions in the climate system through geoengineering and solar radiation management (ibid), as well as activities leading to the emission of heat-trapping aerosols.

Moreover, the HAWC mission would support international efforts to institute standards for the global dissemination of, and open access to, satellite Earth observation data, which are required to track progress toward climate goals (Kalegasi et al. 2022). Standardizing the dissemination of satellite data ensures that data from diverse sources are compatible and can be integrated seamlessly, thereby enhancing the global scientific community's ability to monitor and address climate change. Open data policies are essential for fostering transparency and collaboration among researchers, policy makers and the public, as well as enabling individuals and institutions in both developing and developed countries alike to access, analyze and utilize data to inform evidence-based decisions and achieve sustainable development (Kavvada et al. 2020). The integration of standardized statistical systems, spatial data infrastructures and statistical and geospatial agencies that are subject to open data policies is thus crucial for leveraging data in support of the SDGs (Andries et al. 2022). Finally, the HAWC mission can support the assessment of progress toward international climate treaties such as the Paris Agreement (IPCC 2022).

A Global Gift Focusing on Key Governance Areas

The HAWC mission has the potential to advance several SDGs, especially SDG 3: Good Health and Well-being and SDG 13: Climate Action. However, this potential is not guaranteed. To ensure that the data gathered from the HAWC mission are applied responsibly and effectively in future health and climate policy development, it is recommended that Canada, through a collaboration between GAC and the CSA on the HAWC mission, presents a gift that benefits the world from both a scientific and developmental standpoint. This gift exceeds GAC's purview but should be advocated by GAC on the global stage. By working with the CSA, GAC should establish a global platform to provide worldwide access to the data collected through the HAWC mission — the Space

Agency Data Index (SADI). To be fully effective, the SADI should prioritize the implementation of data governance, multi-stakeholder governance and multi-level governance frameworks. This three-pronged approach, based on evidence from prior satellite Earth observation strategies, would facilitate the promotion of global and domestic best practices aligned with the SDGs.

Data Governance

The HAWC mission and subsequent gifted SADI will necessitate meticulous attention to data governance practices throughout its data collection, analysis, processing and dissemination phases (Cooper 2018). Effective, participatory data governance mechanisms maintain the integrity and reliability of the information gathered, which will ultimately support more accurate and timely weather predictions. Data from the HAWC mission should be made fully accessible to all through the SADI, encouraging effective and comprehensive study across various scientific and policy-making communities. Providing open access to the SADI should encourage collaboration among researchers and ensure that policy makers have access to the latest and most accurate information for informed decision-making (Reichmann and Wieser 2022). It should also promote inclusivity and support more effective data applications, preventing marginalization (Barbero and Richards 2022).

By prioritizing the implementation of proper data governance mechanisms, the HAWC mission can significantly enhance the ability to predict and respond to extreme weather events. Accurate weather predictions are vital for mitigating the adverse effects of these events, protecting lives and property, and enabling the efficient allocation of resources during emergencies. Moreover, reliable data supports long-term climate research, helping to shape effective environmental policies and strategies that address the causes of climate change.

Multi-stakeholder Governance

GAC's gift should adopt a multi-stakeholder framework to ensure that the HAWC mission's data is used to create an environment conducive to Earth observation data applications, directly supporting SDG 3 and SDG 13. This approach bridges the gap between sectors — including industry, academia, governments and Indigenous communities — to promote participatory knowledge production, encourage whole-of-society collaboration and reinforce Canada's comprehensive engagement strategy in satellite Earth observation (Anenberg et al. 2020; CSA

2022b). For example, capacity-building initiatives, such as providing training and resources to stakeholders, have been proven to optimize the application of Earth observation data for health and climate initiatives — particularly within developing countries (Kavvada et al. 2020). Public engagement is vital: fostering awareness and participation from the public can encourage citizen science projects, in-situ networks and community-based monitoring efforts (ibid). Equitable access to satellite data is also imperative, particularly for underrepresented groups such as Indigenous communities, ensuring they can both benefit from and contribute to these advancements (Barbero and Richards 2022). By integrating a multi-stakeholder governance model into the SADI, GAC and the CSA can create a cohesive and inclusive framework that maximizes the benefits of the HAWC mission, ensuring that it effectively supports SDG 3 and SDG 13 both within Canada and abroad.

Multi-level Governance

Actionable policy changes that result from the collaboration between the CSA and GAC on the HAWC mission will depend on reconciling the varying roles of the municipal, provincial and federal governments in Canada as well as the interactions of the Canadian government on the international level. Climate reduction strategies in Canada depend on city leadership, as 80 percent of Canadians live in urban populations containing most of the infrastructure (Johnston 2022). However, Canadian municipalities rely on the governing standards decided at the provincial and federal levels. For example, acting on flooding issues engages the municipal level to implement road, housing, land use and emergency management policies, but the provincial level is responsible for public health and the natural resources ministries (Cappell 2022). Municipalities require local exposure data and funding capacities from the provincial and federal governments (ibid). The gifted global data repository would help to facilitate multi-level cooperation.

Beyond Canadian intergovernmental collaboration, the transboundary nature of the satellite mission emphasizes the need for GAC to leverage Canada's position as a member of the World Meteorological Organization (WMO) to ensure that globally, SDG 3 and 13 can be met from the data retrieved from the HAWC mission. In the case of hydrometry, intergovernmental cooperation and innovative collaboration between members of the WMO have enabled more comprehensive and actionable global approaches to managing water resources and water-related disasters (Dixon et al. 2022). Furthermore, the Global Framework for Climate Services (GFCS) led by the WMO

was created to address the SDGs' challenges and to transfer climate data into informed decision making and policy development (Giuliani et al. 2017).

Recommendations

GAC's contribution to the global data repository, or the SADI, should include three actionable steps to ensure adherence to effective data governance, multi-stakeholder governance and multi-level governance frameworks:

Create a National Earth Observation Data Training Program: GAC can promote a multi-stakeholder approach to leveraging future big data of the Earth's atmosphere by implementing a nationwide capacity-building initiative about the proposed SADI that educates and empowers local stakeholders. The technical expertise required for satellite Earth observation for health and climate often creates a gap between data production and use, requiring collaborative approaches for actionable environmental and public health knowledge (Anenberg et al. 2020). Building upon the intrinsically collaborative nature of the HAWC mission, GAC and the CSA should implement a National Earth Observation Data Training Program comprised of online and in-person training modules on satellite Earth observation data, its applications and analysis tools, with specialized content that focuses on the SADI and the SDGs. Partnering with universities, technical agencies and local communities, the program would deliver training sessions and offer certifications. Community workshops in various regions, especially those with limited access, would be organized with local experts to tailor content to specific needs. Furthermore, as an accessible online platform, the SADI website would provide training resources, tutorials and forums for continuous learning, available in multiple languages. Funding and resources, such as software licenses and technical support, would be allocated to local initiatives that demonstrate innovative data uses in support of the SDGs. The SADI and its associated training program would enhance local capacity, increase stakeholder collaboration and empower communities to make data-driven decisions, ultimately serving to strengthen Canada's position as a global leader in sustainable development.

Establish a Global Data Governance Committee: To optimize the utility of data derived from the HAWC mission and ensure their accessibility on a global scale, robust data governance mechanisms surrounding the SADI are indispensable. It is recommended that GAC establish a dedicated committee to enforce data governance mechanisms as regards the SADI and forge partnerships with international organizations boasting open-data

repositories and data sharing networks, such as the WMO, Group on Earth Observations and the United Nations's Systematic Observations Financing Facility. This committee should also use the Canadian Open Government Registry/Portal to facilitate further data exploration and accessibility for researchers and policy makers.

The committee's mandate would be to uphold data governance principles by ensuring high-quality data, transparency in data sharing and responsible data stewardship. This includes the timely updating of data, adherence to ethical and quality standards, elimination of data withholding practices and mitigation of dissemination biases concerning the HAWC and AOS data. By facilitating broader access to this data, scientists, policy makers and researchers worldwide would be empowered to conduct comprehensive analyses and drive innovation, thereby enhancing weather forecasting capabilities and disaster preparedness. Establishing such a committee under the auspices of GAC aligns with the objectives outlined in Canada's Strategy for Satellite Earth Observation (CSA 2022b), providing a reliable framework for effective stewardship in extreme weather prediction.

Promote Intergovernmental Cooperation:

Intergovernmental collaboration, both nationally and internationally, is required to translate data from the HAWC mission and the SADI into viable climate policies, considering the varying capacities of different levels of government. Nationally, Canada should nominate a table of members from the municipal, provincial and federal governments to create an action plan to downscale global climate data practices and projects such as the proposed SADI. An intergovernmental table with a clear plan can boost Canada's position as a climate leader (Johnston 2022). This action plan should ensure that municipal governments have the resources and funds to effectively implement climate strategies in response to the data collected from the HAWC mission.

Internationally, Canada must promote further intergovernmental collaboration between the WMO members and the GFCS concerning the HAWC mission to advance Canada's global position as a leader in achieving the SDGs. By cooperating with the members of the WMO and leveraging existing international climate data frameworks that prioritize the SDGs, such as the GFCS, Canada can ensure that the SADI results in actionable global policies that target the achievement of health and well-being, and climate action worldwide.

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