Advancing Antarctic Research with Canadian Space Science and Technology

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**Information Paper submitted by Canada**

***Summary***

The Canadian space program supports scientific research on Antarctica through the development of key technologies, knowledge and expertise. This Information Paper describes important contributions of the Canadian space program that have enabled Antarctic research across a variety of priority science research areas. The paper discusses how open and accessible Canadian satellite data contributes to international collaboration and coordination on Antarctic research, including environmental monitoring and climate change. It also outlines additional activities being conducted by the Canadian space program that may have a potential impact on future Antarctic studies and research.

***Introduction***

Since the creation of the Canadian Space Agency (CSA) in 1989, Canadian atmospheric and Earth observation satellites[[1]](#endnote-1) have played an important role in monitoring the Polar Regions. Satellite Earth observation (SEO) data has, for decades, offered the only continuous source of scientific observations of the challenging and changing Antarctic environment. Canadian satellites have provided the international scientific community with a rich source of atmospheric and geophysical information, expertise and knowledge that has documented environmental changes, enabled space science, and advanced the understanding of Antarctic research.

***Canadian Space Programs and Capabilities supporting Antarctic Research***

Data collected from Canada’s RADARSAT satellites has contributed to consistent monitoring and mapping of Antarctica and support Antarctic science and research for over 28 years. The CSA has collected a large archive of images over the Polar Regions, providing imaging of the Arctic Ocean, Greenland ice sheet and Antarctic ice sheet, which has provided unique comparative datasets for assessing climatic conditions around both poles.

Launched in 1995, RADARSAT-1 (R-1) [[2]](#endnote-2) was Canada’s first Earth observation satellite equipped with a powerful C-band synthetic aperture radar (SAR) that captured high quality images of the Earth during the day and night and in all-weather conditions, including through clouds, smoke and haze. As part of the Antarctic Mapping Mission (AMM), a collaboration between the CSA and the National Aeronautics and Space Administration (NASA), R-1 images were acquired between September and October 1997. The SAR images that were collected were instrumental in developing the first complete mosaic of Antarctica and supported the scientific community’s understanding of the geological and glaciological features of the continent. SAR images collected by R-1 were also critical to monitoring glaciers, ice sheets, sea ice cover, seasonal changes, ice shelves, and coastline during a period of increased Antarctic ice. In April 2019, Canada made over 710,000 historical R-1 SAR images of the Earth openly and freely available to researchers, industry and the global public to use in support of international climate change research.

In December 2007, Canada launched RADARSAT-2 (R-2).[[3]](#endnote-3) Similar to its predecessor, R-2’s orbital inclination, field-of-view, and advanced SAR instrument have allowed consistent coverage of Antarctica. In 2008, the CSA collected more than 3,150 images of the continent comprising a single pole-to-coast map covering all of Antarctica.[[4]](#endnote-4) The full dataset is available free of charge for science and research purposes and has contributed to the significant scientific discoveries that require continuous coverage of the continent, including the landmark discovery of unique features revealing direction and velocity of ice in Antarctica during the International Polar Year 2007-2008.

The RADARSAT Constellation Mission (RCM), launched in 2019, is Canada’s newest generation of Earth observation satellites. The trio of satellites are equipped with advanced SAR and Automatic Identification System (AIS) payloads.[[5]](#endnote-5) Designed to allow daily access of approximately 90% of the Earth’s surface, the system offers Antarctic coverage up to four times daily. The RCM continues to provide satellite Earth observation coverage over Antarctica for sea ice and glacier monitoring, serving as a key data source for international science activities involving Antarctica.

Canadian satellites monitoring the atmosphere of Polar Regions include Canada’s SCISAT[[6]](#endnote-6) satellite and the Canadian OSIRIS[[7]](#endnote-7) optical instrument on-board the Swedish Odin satellite. These missions monitor ozone and ozone depleting substances (ODSs), all major greenhouse gases (GHGs), including Hydrofluorocarbons (HFCs), more atmospheric trace gases than any other satellite worldwide, and complement the air quality observations of Canada’s MOPITT[[8]](#endnote-8) instrument on NASA’s Terra satellite. SCISAT and OSIRIS have been instrumental in detecting ozone depletion (or the “ozone hole”) above Antarctica. With over 20 years of datasets that are free and openly available, Canada’s atmospheric missions contribute to accurate global monitoring efforts, improved climate and air quality models, ozone recovery, and Antarctic studies from researchers around the world.[[9]](#endnote-9)

Lastly, through the CSA's Geospace Observatory (GO) Canada program and its predecessors, scientists have taken advantage of Canada’s northern location to deploy more than 120 sophisticated space weather instruments. These instruments gather data on one of the most active regions of near-Earth space and have enabled a significant increase in Canadian knowledge and expertise to better predict and respond to potential threats and impacts from solar disturbances that can affect the Earth. Due to a unique magnetic connection between Canada (in particular the Northern part of the province of Quebec) and Antarctica, instruments deployed in Canada’s High Arctic and in eastern Canada experience the same space weather as Antarctica, making Canadian instruments and expertise highly relevant to Antarctic space weather research.

***International Scientific Cooperation and Contributions***

Openly available long-term datasets from Canadian satellite data collected over Antarctic ice sheets continue to enable international collaboration and coordination through the Polar Space Task Group, established under the auspices of the World Meteorological Organization (WMO). Ice sheets are acknowledged by the WMO and the United Nations Framework Convention on Climate Change (UNFCCC) as an Essential Climate Variable (ECV), and significant progress has been made in the generation of global climate products and derived information using Canada’s RADARSAT satellites and heritage space assets.

The long duration and consistent quality of Canadian atmospheric measurements and resulting datasets have historical value and play an important role in international efforts, as well as in the development of ECV data products for ozone and all major GHGs. The measurements inform and support monitoring for multilateral environmental agreements, legally binding international treaties, and international assessment reports.[[10]](#endnote-10)

***Supplemental Activities with Benefits to Antarctic Research***

Canadian innovations in the Arctic have brought about support for technological development in remote regions that have had an impact on life sciences, health sciences and the human and social sciences. The CSA’s Naurvik project, “the growing place” in Inuktitut, is a community-led hydroponic food production system located in Gjoa Haven, Nunavut. The project provides expertise in hydroponics, controlled environment food production and environmental control systems powered almost entirely by renewable energy sources. The technologies developed through the Naurvik project will assist in developing high-quality and fresh produce in an extreme, frigid climate that will benefit many remote communities, as well as astronauts on long-duration space missions.

In 2021, the CSA created the Health Beyond initiative to identify and develop innovative, relevant and sustainable solutions to healthcare challenges experienced by astronauts in deep-space missions. The initiative aims to address existing healthcare challenges that are shared between remote and medically isolated populations, including polar communities on Earth, and future astronauts in outer space.

Lastly, Canada is exploring options to develop new sources of SEO data and expertise that may further advance Antarctic science. For example, the CSA is exploring a potential satellite mission that would provide new observations with unprecedented frequency and density for weather, GHGs, air quality and space weather over northern latitudes using two satellites in a highly elliptical orbit, with datasets and scientific knowledge that could be employed for comparative Antarctic studies. The CSA is also exploring a potential satellite mission that would measure snow cover in the Arctic, including permafrost warming and thawing under a changing climate, as a key component of the water cycle, which could be leveraged for Antarctic observations during the Arctic summer.

***Supporting Antarctic Science and Research from Outer Space***

Canada’s advancements in space science and technology significantly contribute to Antarctic research, benefitting researchers, industry and the global community. Through Canadian observations and space assets, Canada will continue to support international collaboration and coordination to monitor, and enhance the understanding of Antarctica’s unique and challenging environment.

**End Notes**

1. Earth observation satellites (or ‘satellite Earth observations’), including atmospheric satellites, is the use of satellites in space to gather information about Earth’s oceans, land, climate, and populated areas. Source: Resourceful, Resilient, Ready: Canada’s Strategy for Satellite Earth Observation, 2022. <https://asc-csa.gc.ca/eng/publications/canada-strategy-for-satellite-earth-observation/default.asp> [↑](#endnote-ref-1)
2. What is RADARSAT-1: <https://www.asc-csa.gc.ca/eng/satellites/radarsat1/what-is-radarsat1.asp> [↑](#endnote-ref-2)
3. See also <https://www.asc-csa.gc.ca/eng/satellites/radarsat2/> [↑](#endnote-ref-3)
4. Rignot E, Mouginot J, Scheuchl B. Ice Flow of the Antarctic Ice Sheet. *Science*. 2011;333(6048):1427-1430. [↑](#endnote-ref-4)
5. As with R1 and R2, RCM is able to capture high quality images of the Earth during the day and night and in all-weather conditions, including through clouds, smoke and haze. See also <https://www.asc-csa.gc.ca/eng/satellites/radarsat/> [↑](#endnote-ref-5)
6. SCISAT stands for Science Satellite. Launched in 2003, SCISAT observations are helping scientists better understand the effects of atmospheric chemistry, specifically ozone recovery and ozone depleting substances, greenhouse gas levels, clouds and small particles (e.g. aerosols) on Earth's climate. See also <https://www.asc-csa.gc.ca/eng/satellites/scisat/> [↑](#endnote-ref-6)
7. OSIRIS stands for Canada’s Optical Spectrograph and InfraRed Imaging System. Launched in 2001, it is measuring and mapping ozone and detecting aerosols and nitrogen dioxide in the atmosphere, monitoring signs of climate change and improving our understanding of human activities and volcanic emissions affect the atmospheric environment. See also <https://www.asc-csa.gc.ca/eng/satellites/odin.asp> [↑](#endnote-ref-7)
8. MOPITT stands for Measurements of Pollution in The Troposphere. Launch in 1999, it makes long-term measurements of carbon monoxide (CO) concentrations. It is the longest-running pollution monitor in space today and the longest continuously operating space mission in Canadian history. See also <https://www.asc-csa.gc.ca/eng/satellites/mopitt.asp> [↑](#endnote-ref-8)
9. Studies also include those found in notable scientific journals, including Nature (2023), Journal of Geophysical Research: Atmospheres (2021, 2020), Atmosphere Chemistry Physics (2021), and Atmospheric Remote Sensing (2019). [↑](#endnote-ref-9)
10. Examples include: The Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer, the Kigali Amendment to the Montreal Protocol, the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement, United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution, the World Meteorological Organization (WMO) Scientific Assessment of Ozone Depletion reports, and the Intergovernmental Panel on Climate Change (IPCC) assessment reports. [↑](#endnote-ref-10)