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DIGITAL TWINS, PLANES, AND DRONES: BRIDGING THE GAP IN ARCTIC POLAR ALTIMETRY DATA

Abstract

Security in the Arctic is a subject of rising concern as a result of the considerable risks and opportunities that climate change presents. With rising temperatures, thawing of permafrost, changes in land use and vegetation, and an increased risk of extreme events, Arctic states are faced with significant challenges to their regional infrastructure and economies. At the same time, melting sea ice creates opportunities for new maritime shipping routes, tourism, and the exploitation of marine resources, resulting in an overall increase in Arctic activity further contributing to sea ice melt. To monitor these activities and changes, Arctic states have leveraged satellite observations to support the development of effective climate change mitigation strategies but the European Commission and European Space Agency (ESA) have warned of an impending polar orbit satellite gap that could leave us unaware of changes in the Arctic and Antarctic. Although there are several polar orbiting satellites, only CryoSat-2 and IceSat-2 missions take measurements of changes in sea ice and glaciers using radar altimeters. However, both are expected to decommission before ESA can launch its Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL) satellite in late 2027 to replace Cryosat-2, leaving a considerable gap in polar satellite altimeter data. Recently, digital twins and real-time simulation models have been proposed as an effective tool for simulating essential environments and structures, from urban planning and traffic movement to greenhouse gas emissions to ensuring the integrity of vessels. Digital twins can simulate climate emergencies such as rising sea level, allowing stakeholders to develop mitigation strategies. This paper investigates the use of digital twins and satellite data, drones, planes (i.e., Operation IceBridge), and other emerging technologies to ensure the continuity of long-term environmental monitoring of Arctic activities. This paper also assesses potential areas of cooperation between European Arctic states and relevant space agencies for the creation of an Arctic Space Coalition with extensions to the United States and Canada. This coalition is designed to share in the development of digital twins, polar satellite missions, climate data sharing, and mitigation strategies, allowing policymakers and stakeholders to understand climate change consequences on regional ecosystems, communities, and economies.