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Efficiency of HEO versus LEO Satellite Constellation for Observing Polar Regions

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Recent reports on Arctic environment have increased an interest in the development of a new observing system for this region, specifically a satellite system making use of a highly elliptical orbit (HEO), such as the Polar Communications and Weather (PCW) system. This paper attempts to quantify the advantages of such a system relative to a traditional constellation of Lower Earth Orbit (LEO) polar satellites. The two-satellite HEO system was compared with two-, four- and seven-satellite LEO currently operational constellation in terms of spatio-temporal coverage and capability to provide the sequence of single, dual and triplet images at required temporal resolution. This is important to properly monitor dynamic events, such as atmospheric motion winds, volcanic ash transport, frontal systems, or smoke from wild fires. It is demonstrated that a two-satellite HEO system is 5 to 10 times more efficient for monitoring dynamic events from image pairs above 70degN than a standard four-satellite morning-afternoon sun synchronous LEO constellation. The capability of the LEO system to produce 15 min sequences is nearly nonexistent for latitudes below 70deg. Calculations show that the LEO constellation with orbital characteristics similar to upcoming Joint Polar Satellite System (JPSS) should include as many as 23(35) spacecrafts to achieve coverage with 15(10) min refresh rate at 60degN, i.e. the capability of a two-satellite HEO system. In addition, the data collection issues and the need for complex image compositing for a LEO system affect product latency and further reduce its efficiency in comparison to HEO system.