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Lasers, Penguins, and Polar Bears: Novel Outreach and Education Approaches for NASA'S ICESAT-2 Mission**Valerie A. Casasanto^{a*}, Brian Campbell^b, Adriana Manrique^c, Kate Ramsayer^d, Thorsten Markus^e, Thomas Neumann^e**^a *Joint Center for Earth Systems Technology (JCET) University of Maryland, Baltimore County (UMBC)/NASA Goddard Space Flight Center (GSFC), 8800 Greenbelt Rd., Code 610.6, Greenbelt, MD 20771, vcas@umbc.edu*^b *Global Science & Technology, Inc./NASA Wallops Flight Facility (WFF), Wallops Island, VA, USA*^c *USRA/NASA Goddard Space Flight Center (GSFC), 8800 Greenbelt Rd., Greenbelt, MD 20771USA*^d *Telophase Corp./NASA Goddard Space Flight Center (GSFC), 8800 Greenbelt Rd., Greenbelt, MD 20771USA*^e *NASA Goddard Space Flight Center (GSFC), 8800 Greenbelt Rd., Code 615, Greenbelt, MD 20771USA*

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Abstract

NASA's Ice, Cloud, and land Elevation Satellite (ICESat-2), to be launched in 2018, will measure the height of Earth from space using lasers, collecting the most precise and detailed account yet of our planet's elevation. The mission will allow scientists to investigate how global warming is changing the planet's icy polar regions and to take stock of Earth's vegetation. ICESat-2's emphasis on polar ice, as well as its unique measurement approach, will provide an intriguing and accessible focus for the mission's education and outreach programs. Sea ice and land ice are areas that have experienced significant change in recent years. It is key to communicate why we are measuring these areas and their importance. ICESat-2 science data will provide much-needed answers to climate change questions such as, "Is the ice really melting in the polar regions?" and "What does studying Earth's frozen regions tell us about our changing climate?" In this paper, lessons-learned and novel techniques for engaging and educating all audiences in the mission will be discussed, such as including results of a unique collaboration with art design school the Savannah College of Art Design (SCAD) to create fun and exciting products such as animated characters and interactive stories. Future collaborations with wildlife researchers, a new citizen science program in collaboration with GLOBE, and evidence from other STEAM (Science, Technology, Engineering, Arts, Math) education approaches will also be detailed in this paper.

Keywords: STEAM, Earth Science, polar regions, lasers, ICESat-2**1. Introduction**

NASA's Ice, Cloud, and land Elevation Satellite (ICESat-2) mission [1] will let scientists and others view the globe in 3-dimensions – adding measurements of elevation to images of our planet. To provide these measurements, however, requires the incredibly precise engineering of the ICESat-2 satellite and its laser altimeter instrument. Time is measured in picoseconds, light is measured in individual photons, and ice is measured in centimeters. Elevation is determined by the time it takes for a laser pulse to be emitted from the satellite, bounce off Earth's surface, and then return to the satellite. Because the speed of light is very well known, this time can be converted into elevation.

To introduce the importance and excitement of such a complex mission to the general public, the ICESat-2 outreach and communications team at NASA is employing several different strategies and approaches. The team has developed hands-on exhibits to explain

concepts including laser altimetry and sea-ice melt. We have created the ICESat-2/Savannah College of Art Design (SCAD) Collaborative Student Program to bring fresh, visually creative ideas to outreach efforts, including animated mascots. We continue to work with NASA's social media team to keep up with the latest ways of reaching new and changing audiences.

As the mission nears its launch date, and as the satellite starts collecting data, we will continue to evolve new methods of engaging the public to share ICESat-2's novel engineering that allows us to gather data to answer essential science questions.

1.1 Polar Regions Matter

The warming temperatures of a changing climate are already impacting the Arctic – sea ice cover is decreasing and glaciers in Greenland and elsewhere are retreating. But for many people the polar regions are "out of sight, out of mind." They don't understand that changes in Earth's icy regions can impact the rest of the planet, with impacts including sea level rise, changing

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