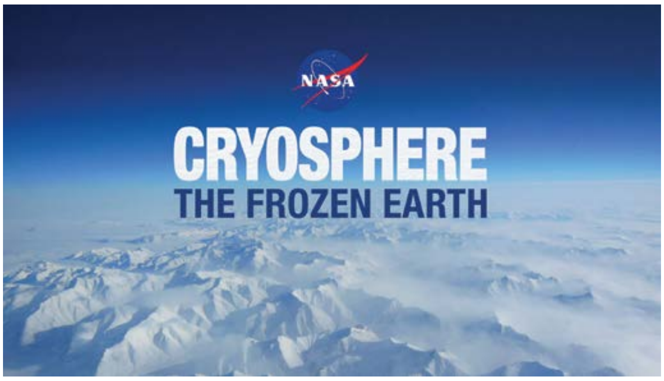
Monitoring ice from space

The Antarctic and Greenland ice sheets are losing ice six times faster than in the 1990s, having caused a rise in sea level of at least 17.8 mm in the intervening period. This was reported in March 2020 by the team who conducted the Ice Sheet Mass Balance Intercomparison Exercise (IMBIE), involving 89 polar scientists from 50 international organisations. The IMBIE team used data from 11 different satellite missions, including measurements of the ice sheets' changing volume, flow and gravity.

The findings, published in two separate papers in *Nature*, show that Greenland and Antarctica lost 6.4 trillion tonnes of ice between 1992 and 2017. Some 60% of the resulting sea level rise was due to ice losses in Greenland and 40% to Antarctica. Almost all of the ice lost from Antarctica, and half of that lost from Greenland, has been triggered by oceans melting their outlet glaciers. The remainder of Greenland's ice losses are due to rising air temperature, which has melted the ice sheet at its surface.

The study was supported by the European Space Agency's (ESA) Climate Change Initiative and the National Aeronautics and Space Administration's (NASA) Cryosphere Programme.



NASA

The cryosphere is the collective term used for all the frozen parts of our planet, including ice sheets, glaciers, sea ice, lake and river ice, snow cover, permafrost and seasonally frozen ground.

Sea ice is frozen ocean water, whereas an ice sheet is a mass of glacial land ice larger than 50 000 km^2.

Satellites in sync

NASA's ICESat and ESA's CryoSat-2 were among the 11 satellite missions used for the IMBIE study. While many other satellites can measure changes in the spatial extent of ice, these two measure ice height, which can be used to work out changes in thickness and volume of ice. They do this in different ways though – ICESat uses laser altimetry, while CryoSat-2 uses radar altimetry.

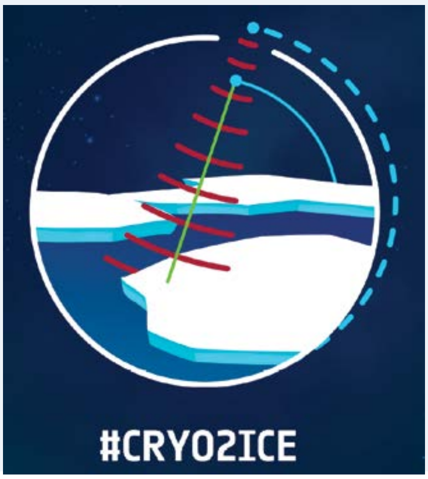
The original ICESat (an acronym for Ice, Cloud and land Elevation Satellite) provided data from 2003 to 2009, before being decommissioned in 2010. ICESat-2 was launched in September 2018, and has a better instrument, called the Advanced Topographic Laser Altimeter System, or ATLAS. Like the previous altimeter, it times how long it takes photons in pulses of light sent down to Earth to return to the satellite in order to measure surface elevation, but the ATLAS laser is split into six beams and has an extremely high pulse rate of 10 000 pulses per second. This means that ATLAS can take measurements every 0.7 m along the satellite's ground path and with such precision that scientists can determine the year-to-year change in ice thickness to within a couple of centimetres.

CryoSat-2 was launched in April 2010, five years after the first one was destroyed during its launch in Russia because of a rocket malfunction. The satellite's primary payload is the Synthetic Aperture Radar (SAR) Interferometric Radar Altimeter – called SIRAL. It works by sending radar pulses towards the Earth's surface and studying the returning echoes.

In the last two weeks of July 2020, ESA performed a series of thruster burns to change the orbit of CryoSat-2 so that it overlaps with that of ICESat-2 every 30 hours or so for a 3 000 km stretch over the Arctic Ocean, allowing for almost simultaneous measurements of sea ice.

This is particularly useful because the laser light from ICESat-2 reflects off the surface of the snow layer on top of the sea ice, whereas the radar waves from CryoSat-2 penetrate the snow and are reflected off the sea ice itself. Sea ice thickness is typically estimated by first measuring how much of the floating ice protrudes above sea level, but overlying snow can weigh the ice down, so that the ice sits lower in the water. Having both measurements will allow scientists to measure the snow layer thickness and produce substantially improved estimates of sea ice thickness.

In the future, it's possible that the orbit will be realigned again, so that the overlap is over the Antarctic.



ESA

The CRYO2ICE campaign aligned the orbits of ESA's CryoSat-2 and NASA's ICESat-2 satellites.

2020

Quest Volume 16 Number 3 2020

Academy of Science of South Africa (ASSAf)

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