Breaking of Larsen C from Antarctica

A huge portion of the Larsen C ice shelf (~50,000 km^2) in Antarctic Peninsula calved away to an iceberg of area ~6,200 km^2 between 10 and 12 July 2017. Larsen C is the fourth largest ice shelf in Antarctica, after Filchner-Ronne, Ross and Amery ice shelves. Unusual rift propagation at Larsen C ice shelf has excited the scientific community during the last six months. The calved area is ~1.6 times the area of Goa and ~4 times the area of Delhi. The event will not raise the sea level immediately, but the instability of the shelf and increased ice flow from ice sheet to ocean may contribute to the sea level rise in future. At the Space Applications Centre, Ahmedabad, a team of scientists in AMHTDG (Advanced Microwave and Hyperspectral Technique Development Group) has been closely monitoring the advances of Larsen C rift using space borne images since the last four months. This correspondence shows through satellite images the rift propagation clearly during the last few months till the calving events.

A rift is a large through fracture that propagates transverse to ice flow direction and acts as a precursor to ice calving. The rift propagation and calving (the disintegration of ice into a floating iceberg) are natural phenomena in the Antarctic ice margins. Constant monitoring of such a large area is required and is only possible through satellite remote sensing. Sentinel-1, a C-band (5.405 GHz) Synthetic Aperture Radar (SAR) sensor from the European Space Agency (ESA), capable of all weather, day and night imaging at a 12-day temporal resolution, provides continuous data sets of the study area. The fast pace of rift propagation is attributed to global warming in the Antarctic Peninsula (AP) and melt percolation. In summer, as atmospheric temperature increases, ice melts and percolates through the crevasses/rift and reaches the ocean. This process speed up the rift propagation and finally at a point of time, the ice collapses into the ocean as icebergs. Another process of ice calving is due to basal melting where hot water carried by ocean currents causes the bottom of the shelf to melt. The inverse propagation of crevasse from the bottom of the ice-shelf, forms a rift in the shelf and at a certain point of time, it starts calving. This results in increased proportion of sea ice formation in the ocean. Over the past three decades, more than 28,000 km^2 ice shelves have disintegrated along the AP due to catastrophic break-up of Larsen A in 1995 and Larsen B in 2002 (ref. 1). An earlier study on the stability of ice in the AP found that the melt in the northern half of the ice shelf has been accelerating since the year 2000, speeding up by 15% between 2000 and 2006 alone[2]. The study concluded that although Larsen C was not facing imminent collapse, it was undergoing significant change in the form of flow acceleration that is spatially related to thinning and fracture. Instability of the Larsen C shelf has attributed to the basal crevasses and associated surface crevassing[3,4]. Larsen ice-shelf system broadly consists of four major ice-shelves namely Larsen A/B/C/D. Larsen A receded and then collapsed in January 1995, with a loss of 1600 km^2 of ice shelf. Larsen B partially collapsed in February–March 2002, with a loss of 3250 km^2 of ice shelf. However, the hypothesis was proved wrong by the disintegration of Larsen C during this winter and subsequent calving between 10 and 12 July 2017. It is reported that the drifting of icebergs may cause major problems for ship routing in the area and hence

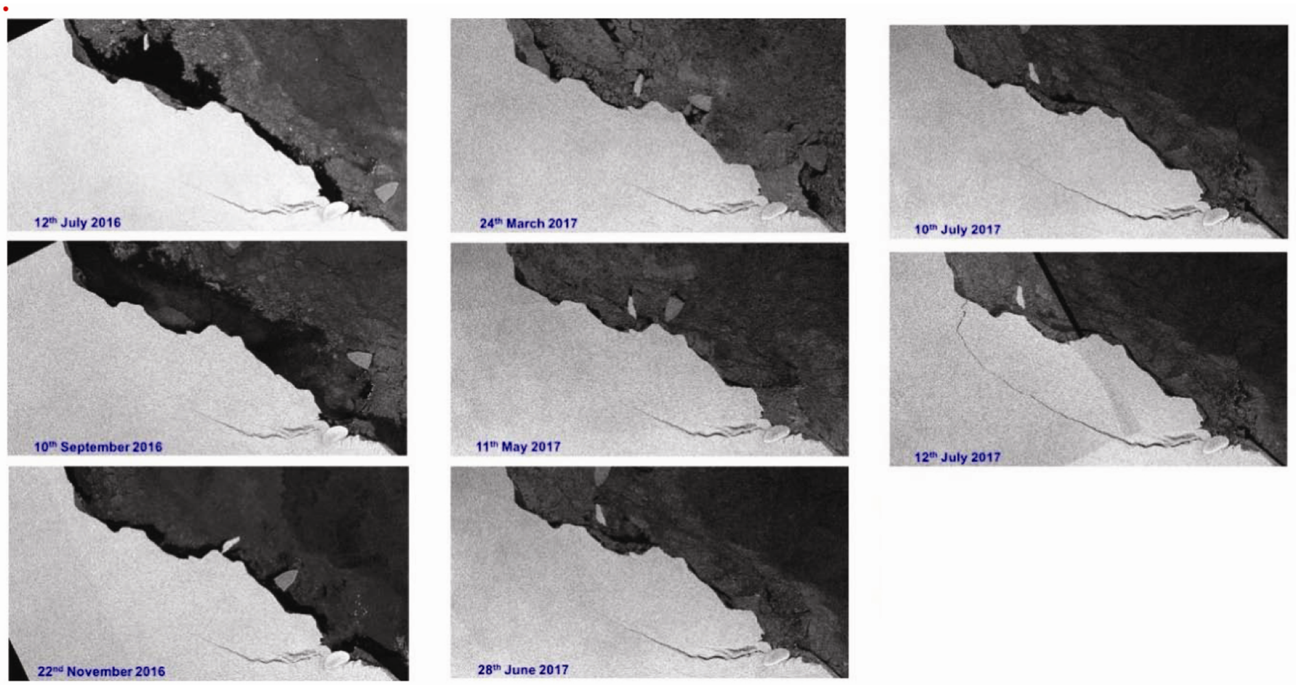

Figure 1. Sentinel-1 SAR time series analysis showing the rift propagation and calving event over the last one year.

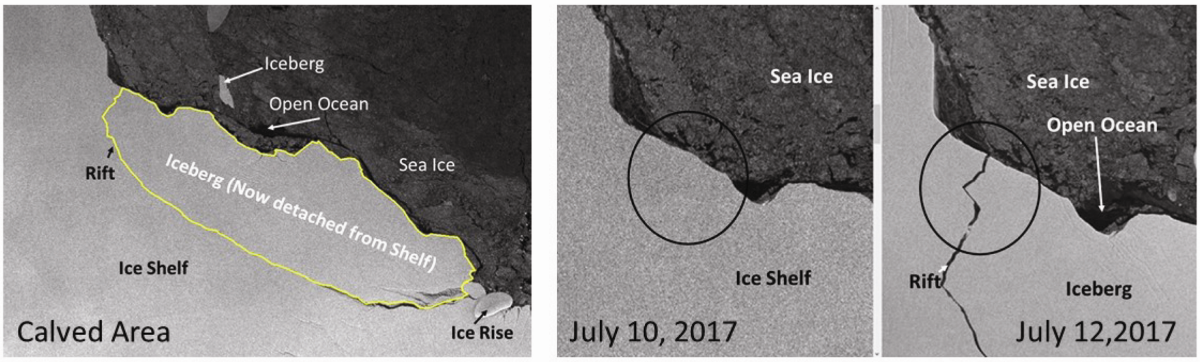

Figure 2. Calved area of Larsen C ice shelf as observed in Sentinel-1 SAR images (left image). Other two images capture the pre- and post-calving event.

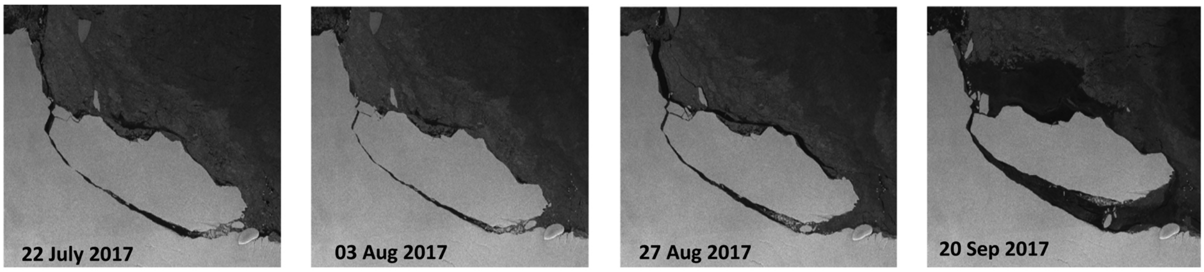

Figure 3. Calving and deformation of iceberg A68 after 12 July 2017.

constant vigil is needed through satellite images.

The Sentinel 1A/1B, with 40 m spatial resolution, Ground Range Detected (GRD), Extra Wide (EW), HH polarization data sets over Larsen C were taken from the Copernicus site (https://scihub.copernicus.eu/dhus/data) from October 2014 onwards. Systematic monitoring of the Larsen C ice shelf during high blizzard conditions with heavy cloud in the Antarctic region, particularly in the coastal region, was not possible through optical imaging. Thus SAR data played a crucial role in our studies. Blizzard is a severe snow storm with wind speed greater than 56 km/h and sustaining over a longer period, typically more than three hours to a few days. Time series of the data was analysed, for a detailed study of the rift propagation. Monitoring of the rift propagation in Larsen C in winter–summer–winter transition periods is shown for the last one year. Figure 1 shows the rift propagation and calving from July 2016 to September 2017. Figure 2 shows the pre- and post-ice calving event, and area of the calved iceberg. Figure 3 shows the iceberg deformation after the ice calving event. The summer of 2016–17 witnessed accelerated rift propagation. The images of December 2016 and January 2017 clearly show the extent of rift propagation as compared to other images. As winter begins, snow covers the rift area, which obstructs the demarcation of the exact extent.

Rift propagation and ice calving event of the giant Larsen C ice shelf was studied. Calving of ice took place between 10 and 12 July 2017, as is evident from Figure 2. Team AMHTDG at EPSA/SAC/ISRO closely monitored and analysed the event from all available satellite data sets. Ice disintegration was of the order of ~6,200 km^2 out of ~50,000 km^2. Further, the deformation of the iceberg started and movement has slowly begun. The event may not raise the sea level at present, but the instability of the shelf and increased ice flow from the ice sheet may altogether raise the sea level in future. This event may have significant bearing on the global climate in the near future.

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