MONITORING SELECTED ICEBERG CALVING EVENTS IN EASTERN ANTARCTICA USING OPTICAL REMOTE SENSING

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ABSTRACT

Antarctica, which holds the largest ice sheet on the Earth, is one of the most sensitive components of Earth in the realm of climate change. Calving of ice shelves and glaciers contributes to major ice loss along the coast of Antarctica. In the present study the ice dynamics along the Eastern coast of Antarctica using iceberg calving as an indicator has been studied. Using moderate resolution satellite data of LANDSAT 4-5, 7 & 8, we monitored calving events that occurred in the past and icebergs likely to be calved in future, and identified potential zones where major calving could take place along the eastern Antarctica region. The present study focuses on 3 such events from Princess Astrid Coast. In this region, as on 4-12-1989 there was a crevasse of 45.15 km which had grown up to 77.84 km by 19-11-2001. Also, as on 16-03-2016, an iceberg of an area 29.88 sq.km which is about to calve can be observed. Here the rifts can be seen which are orthogonal in orientation relative to the calving front. In the third case, there is presence of 12 widening rifts and around 48 physical structures, as observed on 16-03-2016. The total length of the 12 rifts is around 215.68 km with minimum 1.24 km and maximum 40.55 km in length. This study shows that temporal monitoring of iceberg calving is necessary for deciphering climate change signals.

1. INTRODUCTION

Remote sensing techniques have always helped in monitoring the area of interest using temporal data. When it comes to temporal data, the launch of Landsat-1 in 1972 heralded a new era of high resolution RS, and changed the perception by researchers and lay people alike of the possible ways in which to view the Earth (Lauer et al., 1997; Lowman, 1999). The Landsat programme has generated a continuous supply of high resolution imagery for the entire globe, from the first Multispectral Scanner (MSS) aboard Landsat-1 to the Enhanced Thematic Mapper plus (ETM +) aboard Landsat-7 (Mika, 1997) to Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) sensors aboard Landsat-8. After its launch in 1970s, a big dataset is available for studying the temporal changes or monitor a specific phenomenon over the globe with an unprecedented spatial resolution of 79 m for Landsat-1, -2, -3, 30 m for Landsat-4, -5, and 15/30/100 m for panchromatic/multispectral/thermal aboard Landsat-8. A study has been carried out between Indian Antarctic Research station Bharati and Amery ice shelf using RISAT-1 Synthetic Aperture Radar (SAR) data in order to understand quantification of spatial and temporal changes by monitoring the ice margins (Jayaprasad et al., 2014). In order to understand propagation of ice shelves rifts, monitoring of 78 rifts in 13 ice shelves of Antarctica using satellite data of the Moderate Resolution Imaging Spectroradiometer and Multiangle Imaging Spectroradiometer between 2002 and 2012 has been carried out (Walker et al., 2013). NISAR and SAR have also been used to study iceberg calving (Jawak and Luis, 2014; Jawak and Luis, 2015a; Jawak and Luis, 2015b). Mass loss caused by the calving of icebergs in from the Antarctica ice shelves between the year 2005 and 2011 into the ocean was studied using co-registered pairs of consecutive Envisat ASAR image mosaics (Liu et al., 2015). Wesche et al. (2013) carried out classification of the calving fronts of the Antarctica region in terms of surface structure patterns close to the calving front using mosaic of the Radarsat-1 Antarctica Mapping Project (RAMP) Antarctic Mapping Mission 1 (AMM). Optical Remote Sensing (RS) data has also been widely used for monitoring of iceberg calving (Jawak and Luis, 2017a; Jawak and Luis, 2017b; Sandeep et al., 2017). Thus from the above studies it was noted the importance of remote sensing observations in the study of calving of icebergs in the Antarctica region. This has helped many researchers in understanding the ice dynamics occurring along the Antarctic coastline. Calving of the icebergs is a natural process. The snow accumulation and ablation are year round processes maintaining the total mass balance of the ice sheet or glaciers. Thus, whenever the accumulation exceeds the limit, it is balanced by calving out the ice in the form of an iceberg. But natural processes aren't simple or linear. Any variation in any of the factor causing the process has an intense impact on it. It has been observed that in last few decades, incidents of calving of icebergs have increased. This isn't a natural process though, thus it becomes important to monitor these events, keep their record, study and understand the cause(s) behind the process.

2. STUDY AREA AND DATA

The study area consists of Princess Astrid Coast, which is a part of Queen Maud Land present on the eastern Antarctic coast. Temporal datasets from Landsat 4,5,7,8 have been used to monitor the events using their optical band combinations. Figure.1 shows the location of selected calving events on Antarctica.

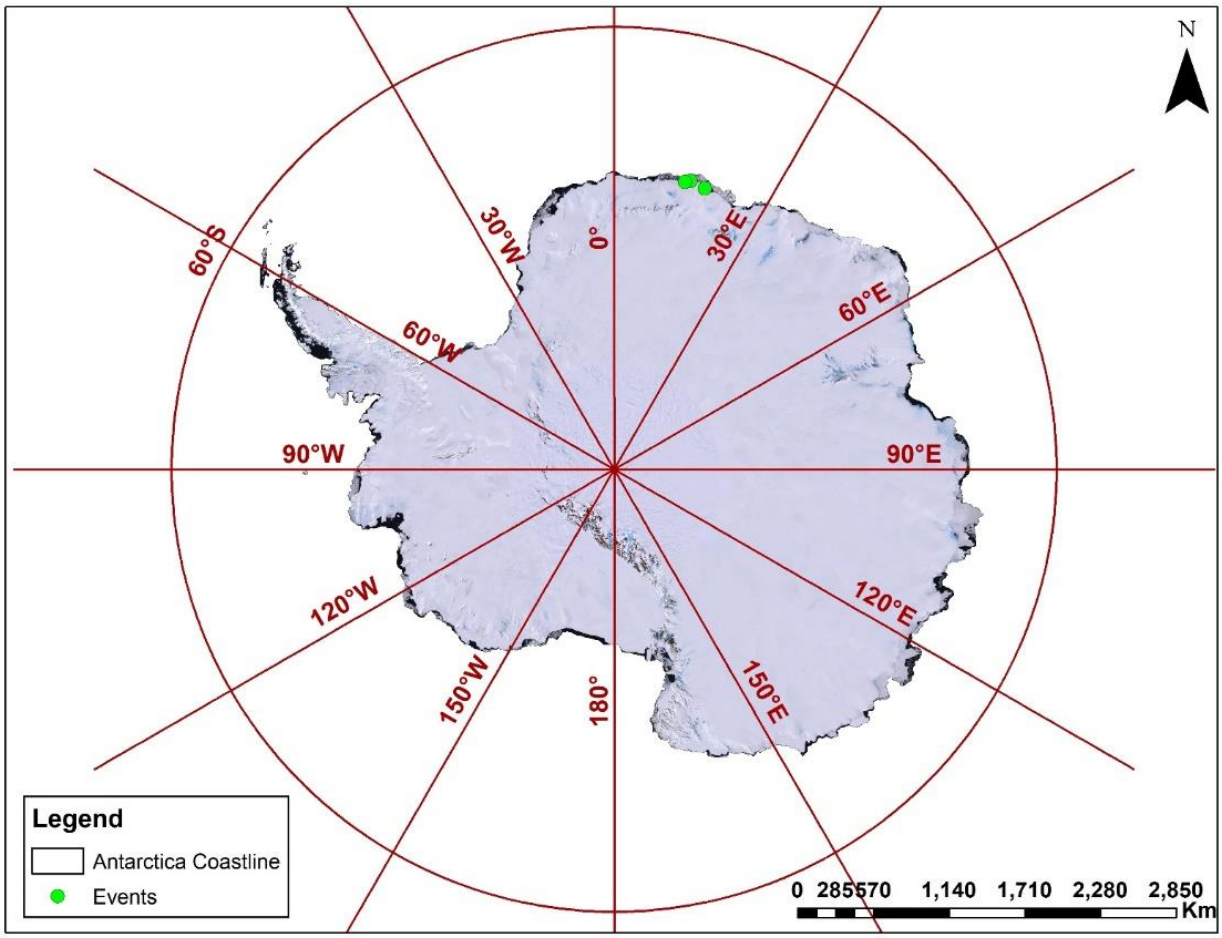

Figure 1: Location of the calving events (in green).

3. METHODOLOGY

The methodology used for the present study work can be divided into the following stages: (a) identification of calving events, (b) confirmation of calving events, (c) correction of scanline error in LANDSAT-7 imageries, and, (c) extraction of features. Figure 2 depicts the methodology employed in this study.

3.1 Identification of Calving Events

The historical feature of Google Earth enables the user to observe a region with the temporal images of it at a glance just by sliding the time scale bar. This tool was used for the identification of iceberg calving events along the east Antarctic coastline.

3.2 Confirmation of calving events

The data of the identified events was then confirmed from the USGS website by observing the thumbnails of the respective events. This was important to differentiate between the actual calved iceberg and fast ice. After the confirmation, the temporal data of the event was downloaded.

3.3 Correction of Scanline error in LANDSAT-7 Imageries

The layers were stacked using the optical band combination. LANDSAT-7 imageries consisted of scanline errors because of which there were gaps in the images where the data was absent. This gap was filled using the Focal Analysis tool.

3.4 Extraction of Features

The features like calved iceberg, physical structures, widening rifts were identified and then extracted using digitisation. The statistical analysis of the extracted features consisting of surface area of the iceberg, length of the physical structures and rifts, their total number, etc., was carried out.

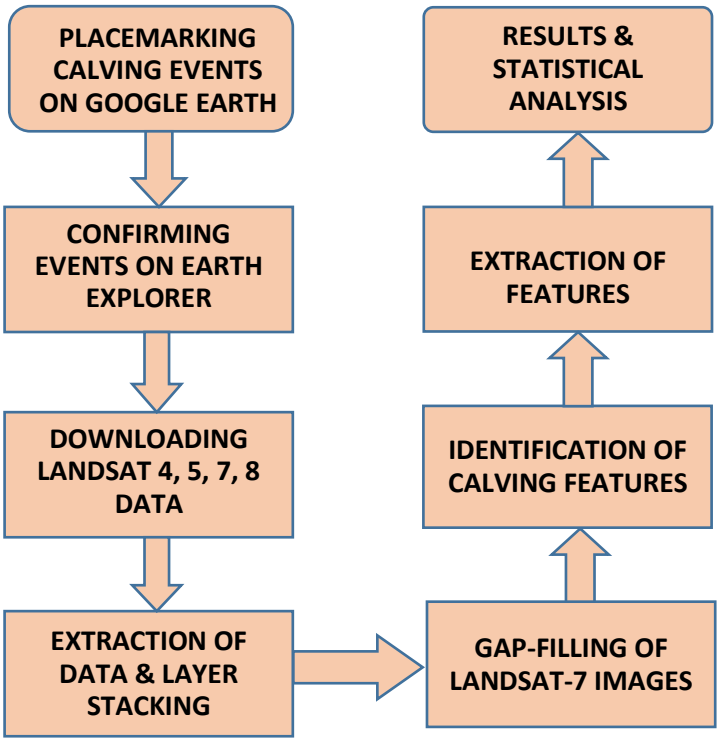

Figure 2: Methodology Flowchart

4. RESULTS AND DISCUSSION

In the first event, calving took place between 19-11-2017 and 22-11-2001, the image for which wasn't available. Earlier on 04-12-1989 the ice shelf had crevasse of 45.15 km. The crevasse grew up to 77.84 km by 19-11-2001, after which the iceberg was calved. The second event consists of about-to-calve iceberg of an area 29.88 sq.km. Here the rifts were seen orthogonal in orientation. Five rifts are observed having total length of 13.01 km consisting 0.81 km as minimum and 5 km as maximum length. In future these rifts may continue to grow which can lead to the calving of icebergs. In case of third event, Figure 3 shows the region which consists of 12 widening rifts and around 48 physical structures. The total length of the 12 rifts is around 215.68 km with minimum 1.24 km and maximum 40.55 km in length. The total length of the physical structures is 682.88 km, with minimum of 0.477 km and maximum of 39.75 km. Table 1 summarizes the statistics of the rifts and their physical structures.

5. CONCLUSION

In this study, monitoring iceberg calving in the eastern part of Antarctica using optical bands of LANDSAT series was carried out. The study reveals three different stages of calving, which consists of the first event where the calving has already taken place. The second one includes an about-to-calve iceberg and the last one identifies the potential zone for future calving events. Thus in the current study the calving of the icebergs along the coastline of Antarctica has been done with the help of remotely sensed data which proves very useful for the study of a region, where human access is difficult due to hostile weather conditions and expensive logistics.

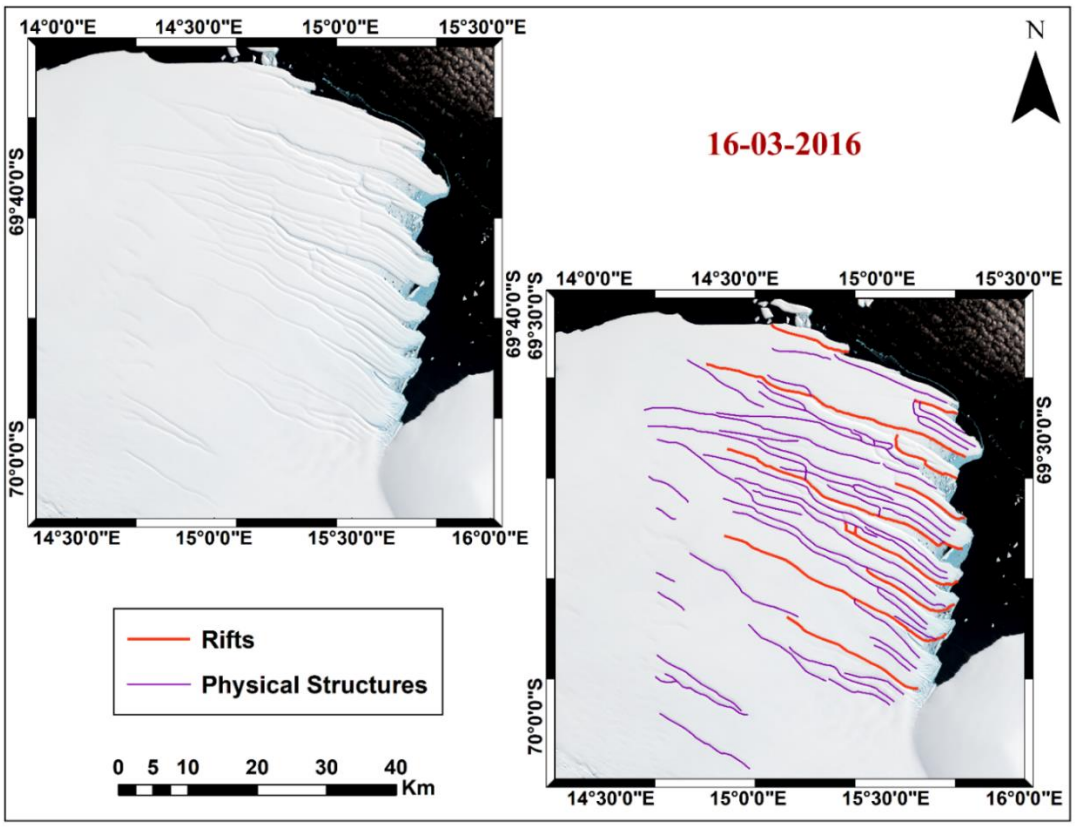

Figure 3: Event-03 Physical Structures and Rifts

Table 1: Event-3 Statistics

	Total number	Total length (km)	Minimum length (km)	Maximum length (km)
Rifts	12	215.68	1.24	40.55
Physical structures	48	682.88	0.477	39.75

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