SPATIO-TEMPORAL STUDY OF SELECTED ICEBERG CALVING EVENTS IN ANTARCTICA USING LANDSAT DATA

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ABSTRACT

Calving is the breaking of large chunks of icebergs from glaciers or ice shelves. The alarming rate at which the process is taking place needs a special attention. In this study there were quite a few events that have already taken place and at the same time many that are yet to happen. This paper discusses 3 such calving events in Antarctica using Google Earth imageries and Landsat imageries. The first event is observed in the vicinity of Caird Coast in West Antarctica where a rift is growing wide and long within a very short span of time. Based on Google Earth imageries, the rift has grown from a 22 km stretch in 1984 to 55 km in 2017. The second event is reported in West Antarctica along the Luitpold Coast that shows a rift formed in the year 2013 and has since then showed a steady increase both in terms of length and width. The width has been increasing at the rate of half a km per year. Another rift runs somewhat parallel to the former rift and is around 8 km from away. The third event is reported close to Princess Astrid Coast in East Antarctica that took place in the year 2016 which was the result of an ongoing process that started in 2009. The calved portion covers an area of around 1 km^2. This study highlights the effective usage of Google Earth imageries and Landsat satellite imageries for monitoring iceberg calving events in Antarctica.

1. INTRODUCTION

Iceberg calving is a natural phenomenon occurring usually in areas like Antarctica and Greenland. It is a form of ice ablation/ disruption which causes normally due to glacier expanding. This leads to the sudden release and breaking away of ice from a glacier, iceberg, and ice shelf or ice front. Post the breakage, entry of ice into the waters causes large and dangerous waves. Sometimes the waves produced are so large that boats cannot approach closer than 3 km. Among the various reasons that cause calving; the prominent three are as follows:(1) Longitudinal stretching- controls the formation of crevasses; (2) Melting at the waterline- undercuts the subaerial ice, leading to collapse and (3) Tidal, Seismic, Buoyant forces and melt water wedging. The effect of calving events on the ocean system is also important. This helps in the study of ice shelf mass budgets, drift patterns and ocean currents as well as life history of bergs (Elliott et al., 2014). Among the many calving vents that have occurred in the past; some of the major reported calving events are as follows: (1) Filchner-Ross ice shelf (2) Amery ice shelf (3) Larsen Ice shelf. In this study, we have marked 2 such events where a growing rift is seen to be growing at a considerable pace o the years and that have the capability to remove a large chunk of the ice shelf from to coast of Antarctica in the coming future. Remote sensing plays a vital role in the study of iceberg calving as it provides a synoptic coverage, which helps study the entire area without having to go to the field to carry out the study. Synthetic Aperture Radar (SAR) techniques have been carried out in the past to monitor and study calving events (Jawak and Luis, 2014; Jawak and Luis, 2015a; Jawak and Luis, 2015b). The present study utilizes optical Remote Sensing (RS) data (to analyze iceberg calving events in Antarctica (Jawak and Luis, 2017a; Jawak and Luis, 2017b)

2. STUDY AREA AND DATA

The two events studied belong to Caird coast and Luitpold coast along the coastline of Western Antarctica. Data used for this project consist of multi-temporal LANDSAT images. Images have been downloaded from USGS'S Earth Explorer portal and they have been taken from Landsat 8 Operational Land Imager-Thermal Infrared Sensor Collection 1 Level-1, Landsat 7 Enhanced Thematic Mapper Plus Collection 1 Level-1 and Landsat-4 and 5 Thematic Mapper Collection 1 sensors as shown in the Table 1.

Table 1. Sensor Details

Sensor	Bands	Wavelength range(µm)
Landsat 4-5 TM	Band 1-Blue	0.45-0.52
	Band2-Green	0.52-0.60
	Band 3-Red	0.63-0.69
	Band 4- NIR	0.76-0.90
Landsat7ETM+	Band 1-Blue	0.45-0.52
	Band 2 Green	0.52-0.60
	Band 3-Red	0.63-0.69
	Band 4 NIR	0.77-0.90
Landsat8 OLI/TIRS	Band 2-Blue	0.45-0.51
	Band 3-Green	0.53-0.59
	Band 4-Red	0.64-0.67
	Band 5- NIR	0.85-0.88

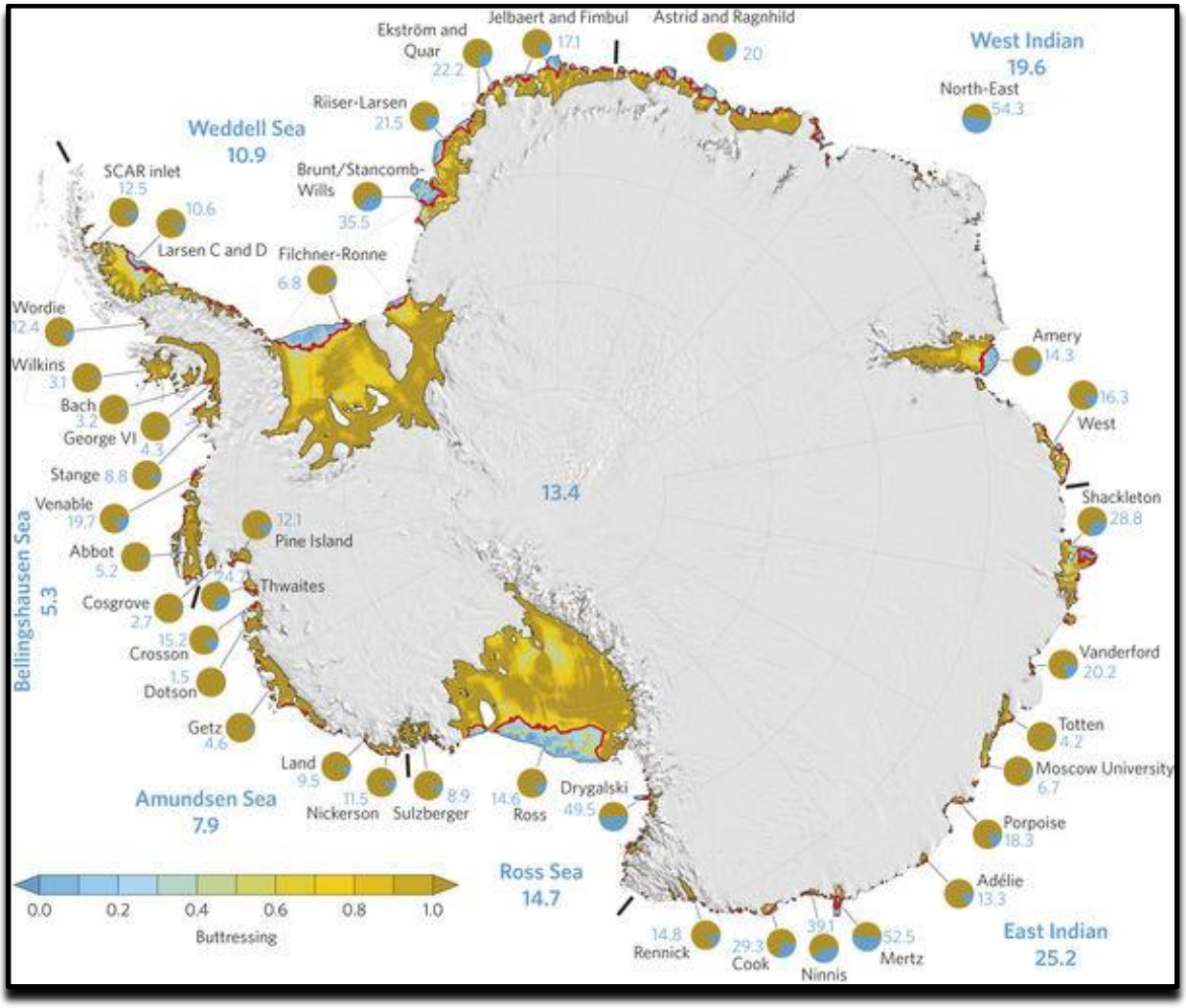

Figure 1. Geographic location of study area

3. METHODOLOGY

The processing begins with the detection events in Google Earth. The selected events are then confirmed with the help of Landsat images from

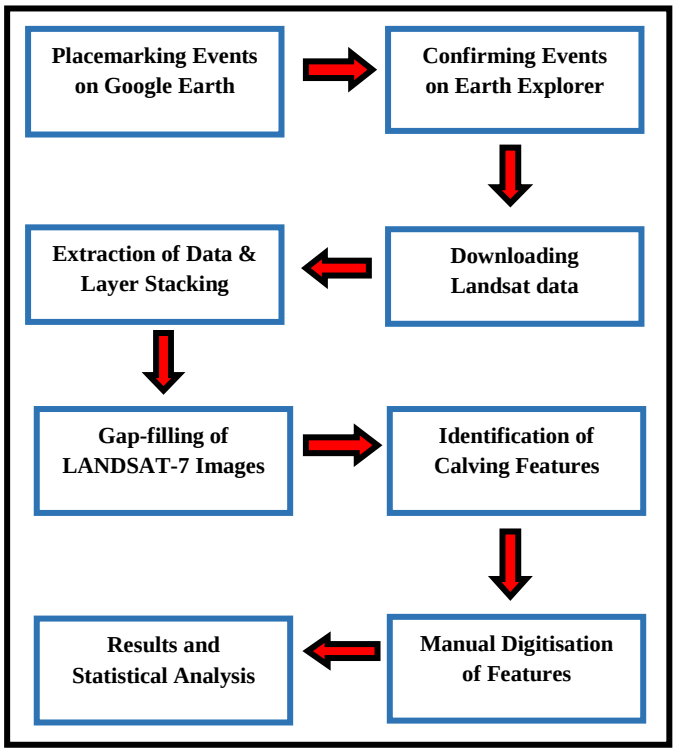

Figure 2. Methodology protocol.

USGS' Earth explorer. The downloaded images contain various bands which are stacked together with the help of Layer stacking tool in ERDAS Imagine. Certain images come along with scan line errors that are caused by the techinal anomalies in the satellites itself. These are corrected with the help of Focal Analysis tool in Erdas Imagine. The final image is then processed and digitised in ArcMap manually. Figure 2 illustrates the methodology protocol adopted for carrying out the present study.

4. RESULTS AND DISCUSSION

Located in the western part of Antarctica, the first event appeared as a rift is seen growing ever since its inception. The rift was observed to have formed in the early 1980s and has showed a steady increase both in terms of length and width over the years todate. The co-ordinates of the location is 72°57'42"S, 19°6'8"W. The location of the event is on the western part of Antarctica at ~380 km away from the coast of Caird (Fig. 3). This is an about-to-calve event where a large chunk of ice shelf will get calved if the rift continues to grow with the same pace over the coming years. The events were studied from the year 2002 to 2017 and the results were quite interesting. Back in 2002, the width of the rift was calculated to be 3.42 km and the length stretched up to 41.88 km. The same rift stretched further to a whopping 50 km and it widened to 3.75 km by the year 2011. In the year 2017, the length of the rift went up further to 55.13 km and width increased to 4 km. It is just a matter of time before the actual calving of the entire ice shelf could take place provided there is a continuous increase in the size of the ever growing rift.
Located in the western part of Antarctica is yet another about-to-calve event, which showed considerable increase in the size with each passing year. Data were taken from three different time periods: 2013, 2014 and 2015 where the most prominent changes were observed as far as the rift is concerned. The location of the event is on the western part of Antarctica around 350 km away from the Luitpold coast at 77°43'51"S, 48°38'46"W. In the year 2013, the area of the rift was measured to 14.28 km^2 which later on increased by 4 km^2 by the year 2014 whereas the length of the rift was found to be 18 km. In 2015, the rift expanded and the area increased further to 22km^2, indicating that the size of the rift constantly increased every year.

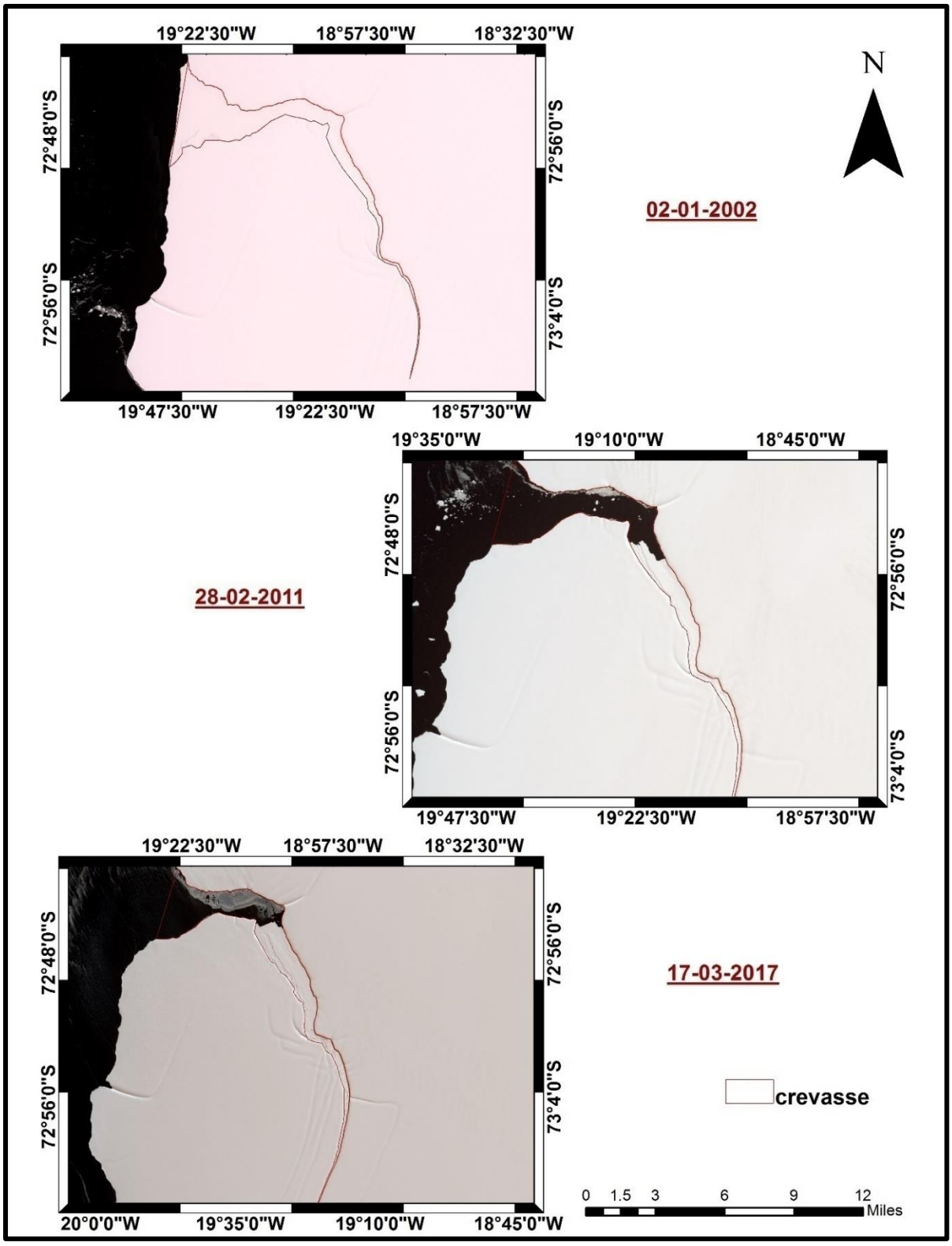

Figure 3. Layout of the event

5. CONCLUSION

The subject of calving events are grouped in three main categories namely, to be calved, calved icebergs and the potential locations that are about to be calved. Studying these events using remote sensing was a much effective and easier work as it provides a large area coverage allowing us to look into the specific areas without even having to go to the field. Though here only the calved instances have been studied there are far too many hotspots where

calving could be seen in the years to come which have the potential to wash out a considerable amount from the coastline which could lead to a drastic increase in the sea level.

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