INTRODUCTION

The majority of mass lost from the Antarctic ice sheet takes place at the fringing ice shelves via iceberg calving. Iceberg calving is controlled by the initiation and propagation of large scale rifts (fractures that penetrate through the entire ice shelf thickness), which precede large tabular iceberg detachment and can lead to ice shelf break-up.

Our study area is the Amery Ice Shelf (AIS), East Antarctica (Fig. 1), where we have observed an active rift system using a network of GPS stations. The Loose Tooth rift system is located at the NE end and west side of the AIS, at about 750 km inland, where the rift has likely calved and produces a relatively large iceberg in the future. It consists of two longitudinal-to-flow rifts (denoted L1 and L2) and two transverse-to-flow rifts (denoted T1 and T2) (Fig. 2).

A GPS network of 11 sites, situated around the tip of the T2 rift, was observed over three weeks during the 2004/05 Antarctic summer period (18 Dec – 9 Jan). The GPS data were processed in daily (24-hr) sessions with the Leica Geo Office version 5.0 software, using IGS precise ephemerides and full antenna phase centre variation models. The Saastamoinen model was applied to account for the dispersive delay, while an ionospheric model was computed from the reference station data of each baseline.

CUMULATIVE SUM ANALYSIS

Several baseline pairs of the 2004/05 Loose Tooth GPS network are analyzed using the CUSUM technique. A known jump in baseline length across the rift tip on day 9, inferred from seismic data collected at the sites [2], can be reliably detected as a peak on day 8 in all (but one) pairs containing a across-rift tip baseline (Fig. 6). These results show that the CUSUM technique is an effective method to detect small baseline length changes. Further peaks are visible, possibly attributable to fractional movements in longitudinal flow lines and across rift jumps, but at this stage no conclusive statement can be made due to the limited sequence of baselines available. In order for a jump to be reliably determined, it needs to be present in multiple baseline pairs.

STRAIN ANALYSIS

Since the distances between sites is on the order of 1.5 km and relative measurements between points are used, a quasi-stationary ice shelf can be assumed where differential tidal motion and atmospheric variations between sites are assumed negligible. A common systematic effect removed. With the underlying uniform motion of the ice shelf across the network, remaining relative movements between network points can then be interpreted as strain. The strain rates are determined according to the procedure outlined by [1].

Maximum principal strain rates are of the order of f-6 to f-7 per year across the network, with two extremes of 87 and 97 [x 10^-6] per year in the two ‘sliver’ triangles, which are anchored on both sides of the rift tip and include the short across-rift tip baseline T2S5-T2N1. Minimum principal strain rates are about 1-17 [x 10^-6] per year. The orientation axes and magnitudes of the principal strain rate within the network are illustrated in Fig. 3.

In order to investigate possible changes in rift tip strain rate characteristics between field seasons, the curvilinear 2002/03 summer season results are combined with those from 2003/04 (Fig. 4), however, obviously referring to different parts of the ice shelf.

In the 2002/03 summer season, a sparsely 6-station network with baselines < 5 km was deployed for 46 days (8 Dec – 23 Jan). Principal strain rates were of the order of 2-21 [x 10^-6] per year across the network, generally smaller than in 2003/04. Transverse-to-flow strain rates exceeded longitudinal-to-flow strain rates, with the exception of a balanced situation in the rift tip. Maximum principal strain rates were generally smaller at the rift tip, compared to the situation on either side of the rift.

CONCLUSIONS

This study is one of a few field projects investigating an active ice shelf rift system and contributing to a better understanding of ice shelf rift processes. Here, the strain rate distribution in close proximity to the tip of a propagating rift system on the Amery Ice Shelf had previously been determined using in situ GPS observations. Transverse-to-flow strain rates gradually exceed longitudinal-to-flow strain rates, with some notable exceptions in triangles anchored on both sides of the rift. Evident changes in the strain distribution can mostly be attributed to the GPS sites straddling existing longitudinal-to-flow fractures and the episodic movement of the tip rift. Results also confirm the trend that the rift propagation is currently slowing down, the rift having only propagated by ~1 km in two years, between the Antarctic summer seasons of 2002/03 and 2004/05.

Analysis of the GPS network using a cumulative sum (CUSUM) approach, obtained by differencing a pair of residual baseline time series separated approximately normal and parallel to the rift, is found to be an effective method to detect small baseline length changes. Simulation shows that using first differences (between successive epochs) as input, rather than the original baseline lengths proposed by [4], any sudden change in slope of the CUSUM (here between days 13 & 14) appears as a clear peak or jump (Fig. 5b). However, potential difficulties in distinguishing a jump from a peak are also evident.

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