This study examines the processes and mechanisms relating to diurnal frost movements of material in periglacial environments. Field work will be carried out on the sub-Antarctic island Marion Island (46°S) and at Tiffendell (30°S) both in South Africa as well as in Uppsala (59°N) and Abisko (69°N) in Sweden. These locations have active diurnal frost processes, however, at different frequencies.

The aim of the investigation is to develop a new scientifically rigorous sediment transport model for material moved by diurnal frost action, mainly needle ice, and to describe mechanisms involved in such transport. Needle ice growth has been observed in most parts of the world (Lawler 1988) and has been studied since the early 1800s (Herschel 1833). Current literature does not sufficiently describe mechanisms involved in needle ice transport, therefore, there is a need to develop this understanding.

(Above) Logger station being set up based on the above schematic at Katedraalkrans on Marion Island. The station will monitor needle ice growth and decay in relation to environmental factors such as temperature, soil moisture and wind speeds. Visual documentation of growth and decay is collected by three repeat photography cameras. Environmental data is measured every 10 min while pictures are taken of the site every 5 min.

(Above) The mechanisms for sediment transport by needle ice decay as they were presented in Lawler’s 1993 paper. This paper proposes four types of transport which depend on the physical nature of needle ice decay. These are 1) direct particle fall 2) sediment-laden rivulets 3) needle ice sliding failure and 4) needle ice toppling failure. The mechanisms presented by Lawler (1993) were very generalised and relied on a very limited data set, hence the aim to further develop the understanding of these mechanisms based on ample empiric evidence.

PhD Thesis
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(Above) Data over 12 days from the 2014 April-May take-over to Marion Island. Preliminary results show two possible events of needle ice growth during this period. However, due to camera malfunction this could not be verified visually.

(Above) Generally strong winds with calms only 13% of the time. On average wind speeds were 5.7 m/s, with the study period’s strongest gust reaching 28.7 m/s.

The conditions for needle ice growth are sufficient soil moisture, modest cooling rate and suitable soil texture. Growth occurs once all three conditions are met. Enough moisture need to be present for continued moisture supply to the freezing front, cooling rate has to be slow enough that in situ freezing does not takes place and finally soil texture must be coarse enough to supply moisture to the freezing front for a sufficient vertical distance while fine enough to maintain capillary suction.
