A Refined Model for Sediment Transport by Diurnal Frost Processes in Periglacial Environments

PhD Thesis
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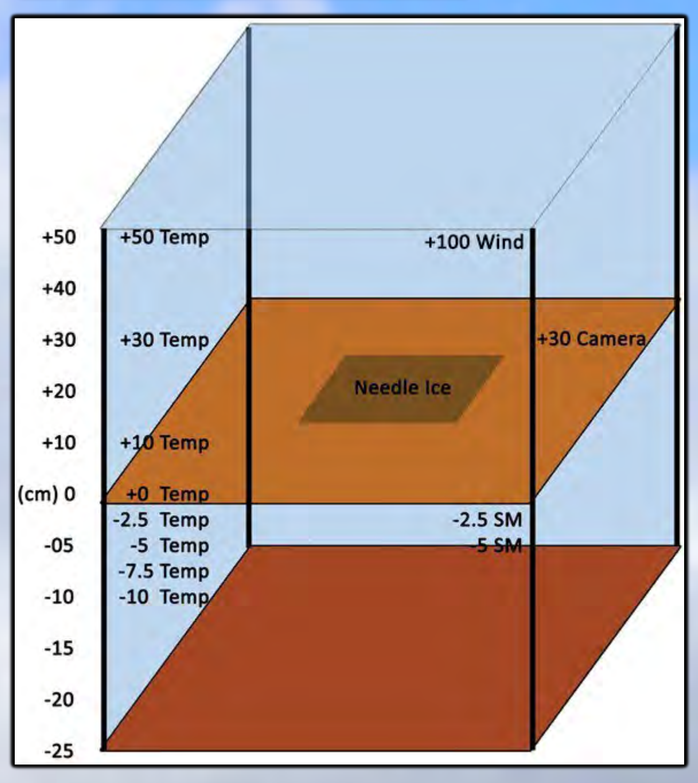
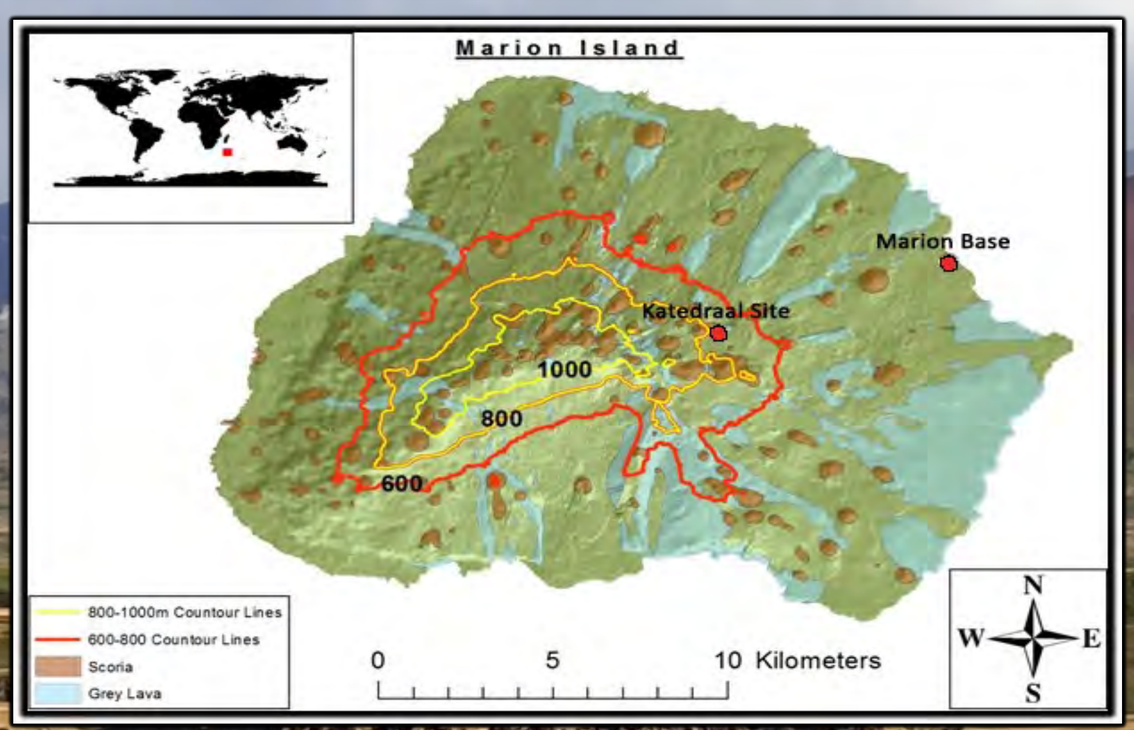
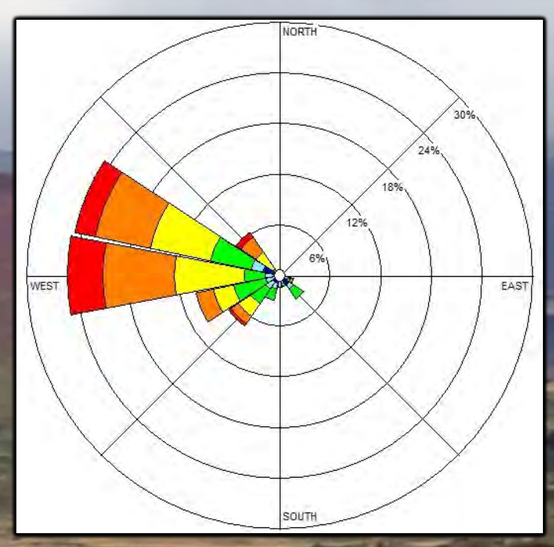


This study examines the processes and mechanisms relating to diurnal frost movements of material in periglacial environments. Field work will be carried out on the sub-Antarctic island **Marion Island** (46°S) and at **Tiffendell** (30°S) both in South Africa as well as in **Uppsala** (59°N) and **Abisko** (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 (Herchel 1833). Current literature does **not sufficiently describe** mechanisms involved in needle ice transport, therefore, there is a need to develop this understanding.

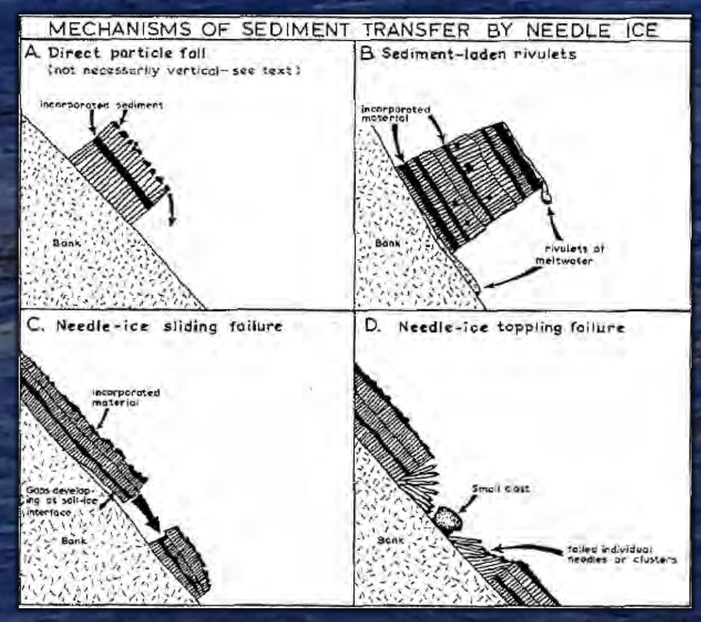
(Above) Logger station being set up based on the above schematic at Katedraalkrans on Marion Island. The station will monitor needle ice growth and decay in relation to environmental factors such as **temperature, soil moisture and wind speeds**. Visual documentation of growth and decay is collected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



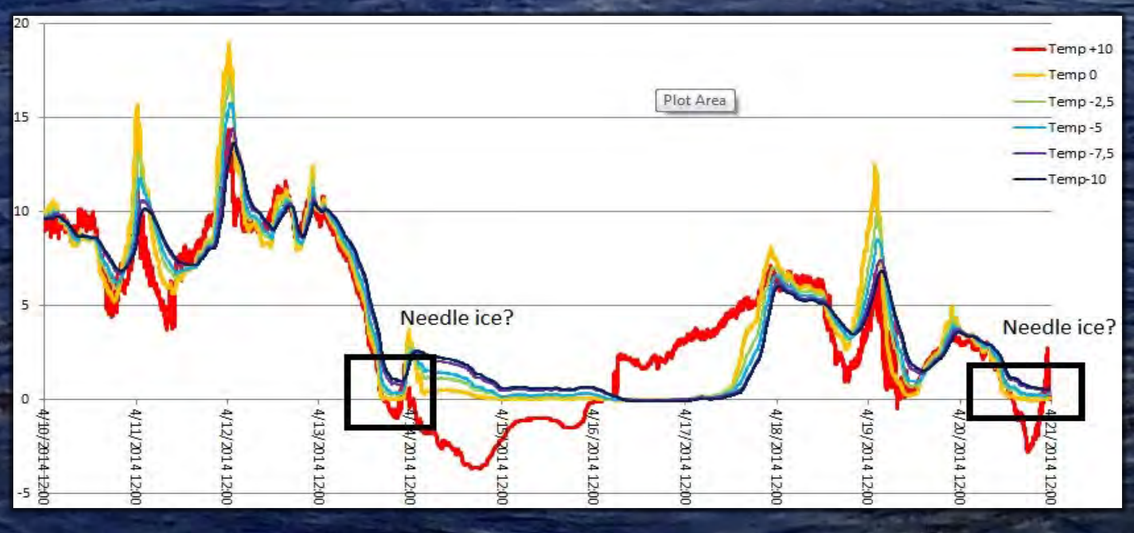


(Left) Data over 12 days from the 2014 April-May take-over to Marion Island. Preliminary results show **two possible events of needle ice** growth during this period. However, due to camera malfunction this could not be verified visually.

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



(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.



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 course enough to supply moisture to the freezing front for a sufficient vertical distance while fine enough to maintain capillary suction.

Herschel, J.F.W., 1833. Notice of a remarkable deposition of ice round the decaying stems of vegetables during frost. Lond. Edinb. Philos. Mag. J. Sci. 2, 110–111. doi:10.1080/14786443308647983

Lawler, D.M., 1993. Needle ice processes and sediment mobilization on river banks: the River Ilston, West Glamorgan, UK. J. Hydrol. 150, 81–114.