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Investigating flow pathways and transit times for the dispersal of hydrocarbon pollution on Rabots glacier, Kebnekaise

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On March 15th 2012 a Royal Norwegian Air Force Lockheed Martin C-130J Super Hercules aircraft crashed into the western face of Kebnekaise in northern Sweden, approximately 50 m below the mountain ridge, during a military exercise. It was carrying c.14000 l of kerosene jet fuel when it left Narvik, and an estimated minimum of 8 m3 of fuel was deposited on the mountain wall. Along with a large amount of debris from the wreckage, the fuel was subsequently buried by an avalanche in a north-west facing cirque on Rabots glacier. To assess the fate of the hydrocarbon pollution, a field campaign was organised to both monitor traces of pollution in the snowpack and the proglacial river system, and to quantify the preferential pathways and transit time for pollution dispersal from the crash source zone, through the glacier, to the proglacial outlet. An intensive series of dye tracing experiments were conducted as a proxy for potential pollution flow pathways during the 2013 ablation season. Percolation pathways through the snowpack and flow rates in the basal saturated layer were investigated in the vicinity of the crash site using rhodamine dye. Flow patterns across the slush and ice surface immediately downstream of the snowline were also investigated in terms of dye dispersion and the speed with which meltwater reaches the englacial system after emerging from the snowpack.

The breakthrough of dye following injection in moulins was examined throughout the melt season, with injection sites situated along two longitudinal profiles of the glacier to investigate drainage efficiency with distance from the front. These experiments revealed a drainage axis in the glacial hydrological system, ending in two proglacial outlets of distinctly different turbidity. Furthermore, englacial dye tracing immediately downstream of the crash cirque snowpack revealed storage of dye over a long time period, followed by fast, efficient release of meltwater. This may suggest that pollution is released in pulses into the proglacial system, rather than a steady flow of pollution from the source to the river system, and is further supported by infrequent detection of pollution in river water samples. There is very little previous knowledge of the pathways for transport of hydrocarbon pollution through a full glacier system. Combined with an intensive snow and water sampling programme for detection of pollutants, this study provides an improved understanding of the long-term storage of pollutants within snow and ice and the consequent effects this may have within a pristine Arctic environment.