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Environmental controls, sediment sources and spatiotemporal variability of suspended sediment yields in partly glacierized catchment systems in western Norway

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This work focuses on environmental controls, sediment sources and the spatiotemporal variability of suspended sediment yields in the neighboring, partly glacierized and steep Erdalen (79.5 km2) and Bødalen (60.1 km2) catchment systems in the fjord landscape of the inner Nordfjord in western Norway. Field work, including extended samplings and measurements, was carried out since 2004 in Erdalen and since 2008 in Bødalen. Fluvial suspended sediment transport in the inner Nordfjord is altogether supply-limited and larger thermally and/or pluvially generated runoff events occurring mostly during the period April-November are needed to mobilize and transport significant amounts of suspended sediments. The distinct intra- and inter-annual temporal variability of suspended sediment transport found is mostly controlled by meteorological events, with most suspended sediment transport occurring during pluvial events in autumn (September-November), followed by mostly thermally determined glacier melt in summer (July-August), and by mostly thermally determined snowmelt in spring (April-June). Extreme rainfall events (>70 mm/d) in autumn can trigger relevant debris-flow activity that can cause significant transfers of suspended sediments from ice-free surface areas with sedimentary covers into main stream channels and is particularly important for fluvial suspended sediment transport. In years with occurring relevant debris-flow activity the total annual drainage-basin wide suspended sediment yields are strongly determined by these single extreme events. The share of glacier coverage, followed by steepness of slopes, and degree of vegetation cover in ice-free surface areas with sedimentary covers are the main controls of the detected spatial variability of suspended sediment yields. The contemporary sediment delivery from glacierized surface areas through different outlet glaciers shows a high spatial variability which is mostly explained by a spatially variable availability of sediments in the lithologically homogenous areas. The fact that the mean annual suspended sediment yield of Bødalen is almost twice as high as the mean annual suspended sediment yield of Erdalen is to a large extent explained by the higher share of glacier coverage in Bødalen (38% of the catchment surface area) as compared to Erdalen (18% of the catchment surface area) and by an altogether significantly higher suspended sediment yield from the glacierized area of the Bødalen catchment compared to the glacierized surface area in Erdalen. When looking at the total annual mass of suspended sediments being fluvially exported from the entire Erdalen and Bødalen catchment systems, the total amount of suspended sediments coming from the ice-free catchment surface areas altogether dominates over the total amount of suspended sediments coming from the glacierized surface area of both catchments. Mean annual drainage-basin wide contemporary suspended sediment yields range from 16.4 t km-2yr-1 for Erdalen to 31.3 t km-2yr-1 in Bødalen and are - due to the high resistance of the predominant gneisses towards glacial erosion and weathering, the altogether only small amounts of sediments being available within the entire catchment systems, the stable and nearly closed vegetation cover in ice-free surface areas with sedimentary covers and the given efficiency of proglacial lakes in trapping sediments supplied by defined outlet glaciers - altogether rather low when compared with mean annual suspended sediment yields of other partly glacierized catchment systems in Norway and in other cold climate environments worldwide. Contemporary suspended sediment transport accounts for almost two-thirds of the total fluvial transport and, accordingly, plays an important role within the sedimentary budgets of the entire Erdalen and Bødalen catchment systems. The long-term (post 8150 cal yr BP) average suspended sediment yield as reconstructed from lake-floor stratigraphy has the same order of magnitude as the monitored contemporary rates, which indicates that the suspended sediment supply has been generally low and that the sedimentary system has been supply limited since at least 8150 cal yr BP.