Project acronym: CARBFLUX

Project title: Chemical Weathering and the Inorganic Carbon Flux of a High Arctic River

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Discipline: Earth Sciences & Environment

Station(s): Zackenberg Research Station (Greenland)

The Zackenberg river system and respective hydrological catchment are examples of pristine high-Arctic environments where the impacts of a rapidly changing climate system can be examined. Climate warming-induced changes in high latitude polar regions, and high altitude third pole regions, have the potential to significantly influence the future of Earth's biogeochemical cycles and landscape evolution through permafrost thawing, glacial retreat and cryogenic weathering processes. The weathering (chemical and physical breakdown) of rocks at the Earth's surface is a fundamental process in the long-term inorganic carbon cycle, and plays a key role in climate stability. Weathering of silicate rocks removes carbon dioxide (CO2) from the atmosphere by the generation of alkalinity (HCO3-). However, the interaction between sulfuric acid (produced by the chemical weathering of sulfide minerals) with carbonate minerals potentially releases more atmospheric CO2 than silicate weathering is removing, especially in regions of high physical erosion e.g., mountains. Constraining the links between silicate, carbonate and sulfuric acid weathering and CO2 release or drawdown is critical. However, understanding the role of chemical, physical and cryogenic weathering in glaciated and permafrost dominated high-Arctic regions in relation to CO2 cycling remains poorly understood. As the Arctic climate warms, melt seasons are lengthening, winter freezing starts later in the year, the ratio of wet (rain) to dry (snow) precipitation is increasing and permafrost active layers are thawing to greater depths. Such processes significantly alter surface and subsurface water flow-paths impacting freshwater fluxes and substantially changing mineral, elemental, nutrient and carbon fluxes (dissolved and particulate) into the ocean and atmosphere. Here we propose that the continuous freeze-thawing and cryogenic weathering in permafrost regions, in addition to the enhanced physical erosion in glaciated terrains (particularly associated with seasonal high-discharge glacial lake outflow (GLOF) events), may increase sulfide mineral oxidation and hence sulfuric acid weathering, (analogous to the high physical erosion environments in mountainous terrains). This is turn may counteract CO2 consumption by silicate weathering, such that Arctic rivers may in fact act as a source for CO2. In turn, our research aims to quantify how silicate, carbonate and sulfuric acid weathering processes impact atmospheric CO2 and, ultimately, the climate system in high Arctic environments. To be able to trace silicate, carbonate and sulfide weathering processes we utilize a mix of elemental and isotopic techniques, that Dr Murphy and myself use regularly in out postdoctoral work. Such methods are analytically intensive, yet the results have a very high impact. Using the method of Torres et al., (2016, EPSL 450, 381–391) we propose to determine if the Zackenberg river catchment is a source or sink for inorganic carbon over short term and geological time scales. Elemental, isotopic and insitu hydrochemical measurements will allow us to determine the chemical reactions that turn bedrock into dissolved elements, and in the process sequester or release CO2. Such calculations will in turn allow us to determine the proportion of sulfide oxidation to carbonate, and silicate rock dissolution in the dissolved loads of the Zackenberg river waters (Fig 1), and thus if this pristine high arctic river is a source or sing of CO2.