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Effects of dust storms on ancient and modern climates in proglacial valleys

Aerosols currently contribute the largest uncertainty of radiative forcing in global climate change models (Boucher et al, 2013) and for mineral aerosols or dust, this uncertainty is largely in part to the unknown contribution of high latitude dust emission sources (Bullard, 2013). A recent increase in investigations in high latitudes (greater than 60 degrees) has been sparked by confirmation of the more important role aerosols have at high latitudes (Oman et al., 2006). The focus of high latitude dust studies have been centred in Greenland (Bullard and Austin, 2011), Argentina (Johnson et al. 2011), and more recently Iceland (Arnalds, 2010) and Alaska (Crusius et al., 2011). These high latitude regions are no stranger to dust and in fact, the majority of soils in Northwest Canada and Alaska contain large amounts of loess from previous changes in climatic periods since the late Pleistocene (Sanborn, 2009). The processes associated with the climatic conditions that resulted in loess creation are still widely uncertain for many regions, while at high latitudes they are found on the side of foothills and river floodplains (Hugenholtz and Wolfe, 2010) in addition to blanketing regions near proglacial valleys (Muhs et al., 2013). Loess-based soils support the theory that Beringia meadows in the southwest Yukon region sustained megafauna up to the late Pleistocene before their extinction by a combination of climate change and hunting by early humans (Haile et al 2009). Vegetation that would be needed to support the grazing of megafauna could only have been supported by high nutrient renewal like that of regularly deposited loess surfaces (Laxton et al., 1996). For high latitude regions, the timing of dust fluxes to support loess meadows has never been estimated because the variables that control the process of dust emissions from proglacial valleys is unknown. No research to date has attempted to model the rate of processes that could result in the quantity of loess found in these regions.

The main objective of the proposed research project is to quantify the connection between climatic factors contributing to proglacial valley dust emissions, and loess-based soil vegetation productivity, within ancient and modern climates. This objective will be accomplished by achieving the following three tasks within the Slims proglacial valley on Kluane Lake in southwestern Yukon:

1. *Develop an algorithm for mapping erodibility factors in a proglacial valley.* It is proposed that high resolution repeat multispectral remote sensing imagery can identify the spatial and temporal variation of wind erodibility factors within a proglacial valley. Correlations between erodibility factors and dust emissions will be formulated based on reanalysis wind fields, high temporal resolution multispectral imagery, and an in situ automated camera system to identify local dust emissions.
2. *Test the hypothesis that dust emissions in proglacial systems provide nutritional input to surrounding soils.* This hypothesis will be tested by collecting and analyzing sediment transported at the emission source and deposited regions for chemical composition. Additionally, climate variables and fluxes of dust at their source and sink locations will be measured to test the algorithm developed in Task 1. If the analysis supports this hypothesis, it would provide previously unknown estimates of the control the dust emission process has on the terrestrial productivity in proglacial valleys.
3. *Develop a model for dust emission and deposition for a proglacial valley in the present climate from the results of Task 1 and 2, and use the model to derive the processes in past and future climates.* Proglacial and high latitude specific erodibility and emissivity factors will formulate a new dust production model that can corroborate estimates of soil development from previous climates. Once tested, dust production and deposition in forecasted climates will be generated to predict the impact climate change will have on the terrestrial ecosystem.

The proposed developments would quantify the important role of dust emissions in high latitude ecosystems. This can be a critical component to an earth systems approach for forecasting the impact of climate change in addition to providing insight to the ecosystems of the past in this region.