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Review article

The Icelandic volcanic aeolian environment: Processes and impacts — A review

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ABSTRACT

Iceland has the largest area of volcaniclastic sandy desert on Earth or 22,000 km^2. The sand has been mostly produced by glacio-fluvial processes, leaving behind fine-grained unstable sediments which are later re-distributed by repeated aeolian events. Volcanic eruptions add to this pool of unstable sediments, often from subglacial eruptions. Icelandic desert surfaces are divided into sand fields, sandy lavas and sandy lag gravel, each with separate aeolian surface characteristics such as threshold velocities. Storms are frequent due to Iceland's location on the North Atlantic Storm track. Dry winds occur on the leeward sides of mountains and glaciers, in spite of the high moisture content of the Atlantic cyclones. Surface winds often move hundreds to more than 1000 kg m^{-1} per annum, and more than 10,000 kg m^{-1} have been measured in a single storm. Desertification occurs when aeolian processes push sand fronts and have thus destroyed many previously fully vegetated ecosystems since the time of the settlement of Iceland in the late ninth century. There are about 135 dust events per annum, ranging from minor storms to >300,000 t of dust emitted in single storms. Dust production is on the order of 30–40 million tons annually, some traveling over 1000 km and deposited on land and sea. Dust deposited on deserts tends to be re-suspended during subsequent storms. High PM_{10} concentrations occur during major dust storms. They are more frequent in the wake of volcanic eruptions, such as after the Eyjafjallajökull 2010 eruption. Airborne dust affects human health, with negative effects enhanced by the tubular morphology of the grains, and the basaltic composition with its high metal content. Dust deposition on snow and glaciers intensifies melting. Moreover, the dust production probably also influences atmospheric conditions and parameters that affect climate change.

Contents

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1. Introduction

Iceland is one of the most active aeolian areas on Earth, despite the fact that it does not lie in an arid region. Unstable sandy surfaces are widespread and subject to frequent high-velocity winds, resulting in numerous wind erosion events and dust production. Airborne redistribution of surface materials has a dominant influence on Icelandic soils and ecosystems. It also affects such factors as human health, climate, snowmelt, Icelandic soils, and possibly ocean fertility. Icelandic desert areas comprise the largest volcaniclastic desert area in the world (Edgett and Lancaster, 1993; Arnalds et al., 2001a), which distinguishes them from other areas of intense aeolian activity. Icelandic sand-fields have served as analogs for planetary desert landscapes and processes, such as on Mars (e.g., Baratoux et al., 2011; Mangold et al., 2011).

Volcanic eruptions in Iceland occur every 3–5 years, fed by the mantle plume or hotspot under the island (Thordarson and Höskuldsson, 2008). About 11% of the country is covered by glaciers (Björnsson and Palsson, 2008) with many active volcanoes located under the ice. This enhances production of volcanic ash during "wet explosive eruptions". The glaciers also produce glacio-fluvial plains covered with sediments that might be termed "volcano-fluvial" deposits. These materials are primarily basaltic in composition, while andesite and rhyolite also occur in smaller amounts. The influence of the dust deposits on ecosystems is amplified by the volcanic nature, basaltic composition and rapid weathering of the materials.

Knowledge of aeolian activity in Iceland is of crucial importance for understanding aeolian processes in general and their impact on ecosystems and atmospheric processes. Furthermore, aeolian processes in Iceland can shed light on global loess production, large scale wind erosion and the impact of dust on both the natural environment and society. Understanding of aeolian processes in Iceland has improved substantially in recent years. The purpose of this paper is therefore to review and summarize our current knowledge of aeolian processes in Iceland.

2. Background

Iceland is a volcanic island with an area of 103,000 km^2 located just south of the Arctic Circle, lying between 63° and 66.6° north latitudes and 13–24° west longitudes (Fig. 1). The climate is relatively mild in spite of its northern position as it is influenced by the

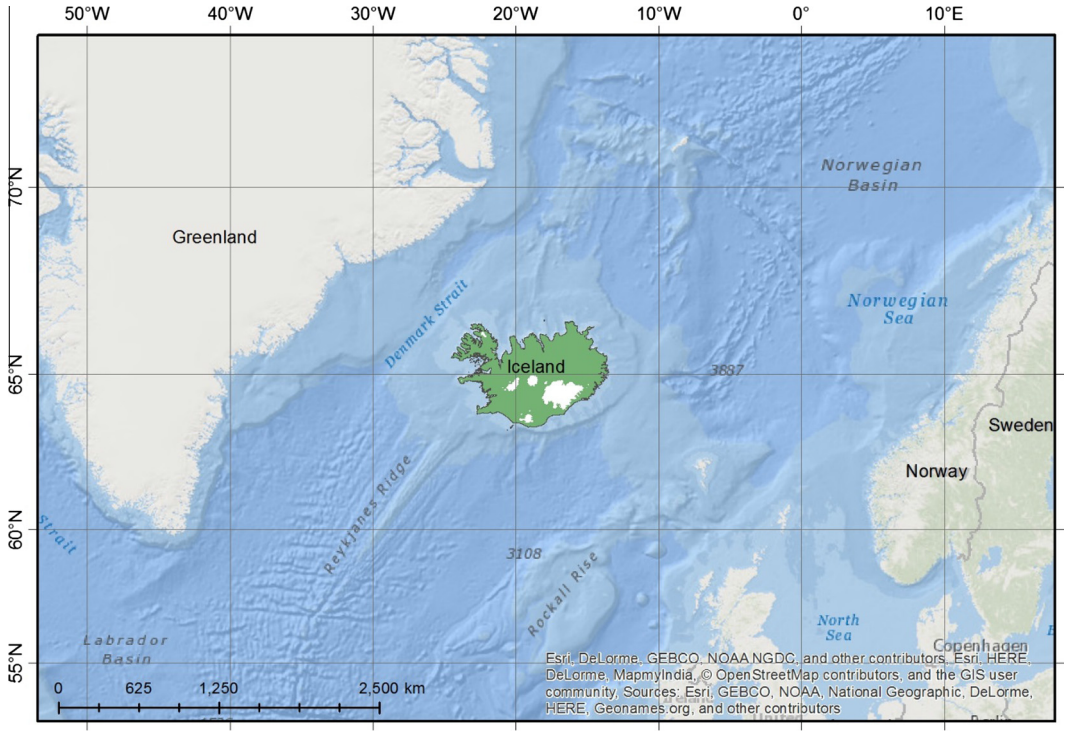

Fig. 1. Location of Iceland in the North-Atlantic Ocean.