Atmospheric Environment 77 (2013) 117–127

Contents lists available at SciVerse ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Long-term frequency and characteristics of dust storm events in Northeast Iceland (1949–2011)

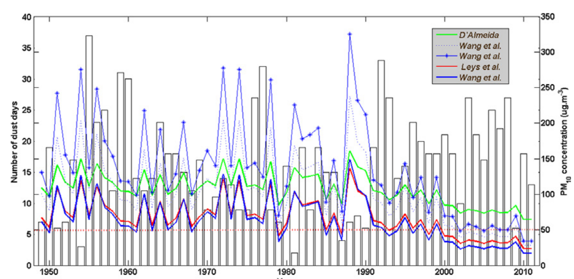
Pavla Dagsson-Waldhauserova [a,b,*], Olafur Arnalds [a], Haraldur Olafsson [b,c,d]

[a] Agricultural University of Iceland, Hvanneyri, Borgarnes IS 311, Iceland
[b] University of Iceland, Department of Physics, Reykjavík, Iceland
[c] Icelandic Meteorological Office, Bústaðavegi 9, Reykjavík IS 150, Iceland
[d] Bergen School of Meteorology, Geophysical Institute, University of Bergen, 5007, Norway

HIGHLIGHTS

- Present weather and visibility observations in Northeast Iceland.
- There were 1033 dust days in 1949–2011 with the annual mean of 16.4 dust days.
- Dust event frequency is comparable to major desert areas in the world.
- Dust production occurred during summer months, mostly June and September.
- Median concentrations were calculated as 106 μg m^{-3}.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 24 October 2012
Received in revised form
26 April 2013
Accepted 30 April 2013

Keywords:
Climatology
Visibility
Aerosol dust concentration
Dust event classification
Wind erosion

ABSTRACT

Long-term records of meteorological dust observations from Northeast Iceland were analysed and frequency of dust events from Icelandic deserts calculated. A total of 1033 dust days were reported during the period 1949–2011 with an annual mean of 16.4 dust days $year^{-1}$, placing the area among the dustiest areas in the world. The most active decades were the 2000s, 1990s and 1950s. Monthly dust event frequency is bimodal with primary and secondary maxima in June and September. A total of 14 severe dust storms (visibility < 500 m) occurred during the period. Median dust event concentration was calculated as 106 μg m^{-3} from the visibility observations. The frequency and severity of dust events depend on Sea Level Pressure (SLP) oscillation which controls the southerly winds in NE Iceland. The availability of fine sediments susceptible to dust production in outwash plains controlled by the flow rate of glacial river is also important. Volcanic ash from eruptions in 2010 and 2011 barely affected the dust event frequency in NE Iceland. Icelandic dust may be substantial source for large scale air pollution in the Arctic.

1. Introduction

Natural dust is emitted from many desert areas on Earth. The global dust belt, where most of the dust sources are located, extends from Africa, through the Middle East, into Central Asia (Formenti et al., 2011). Globally, fine dust particles may be transported at altitudes of up to 10 km and can be carried distances of >10,000 km (Husar, 2004). Grousset et al. (2003) suggested that dust particles can travel over a 20,000 km in two weeks. Dust is considered to contribute to the Arctic haze phenomena (Raatz, 1984; Quinn et al., 2002).

Although dust is most often associated with dry and warm desert areas, dust is also frequently emitted in cold climate regions and at high latitudes, foremost from glacially-derived sediments of riverbeds or ice-proximal areas (Arnalds, 2010; Crusius et al., 2011;

* Corresponding author. Agricultural University of Iceland, Keldnaholt, 112 Reykjavík, Iceland. Tel.: +354 4335267; fax: +354 4335201.
E-mail addresses: pavla@lbhi.is, paw2@hi.is (P. Dagsson-Waldhauserova), oa@lbhi.is (O. Arnalds), haraldur@vedur.is (H. Olafsson).

1352-2310/$ – see front matter
http://dx.doi.org/10.1016/j.atmosenv.2013.04.075

Prospero et al., 2012; Bullard, 2013). Glaciers produce sediments during the grinding and abrasion by ice over bedrock and meltwater transports fine particles to floodplains from which they are deflated by strong glacier-driven or katabatic winds. Eldridge (1980) considered the Arctic and Antarctic coastal zones as the windiest regions on Earth which may increase the severity of regional dust events. Furthermore, threshold wind velocities for a given particle size are lower in cold conditions than in warmer areas (Bullard, 2013). Dust emission intensity and deposition rates in glacial areas sometimes exceed those at lower latitudes (Bullard, 2013). Canada (Hugenholtz and Wolfe, 2010), Iceland (Arnalds, 2010), USA, China, and New Zealand (McGowan et al., 1996) are among areas with the highest deposition rates (Bullard, 2013). Blechschmidt et al. (2012) suggested that Icelandic deserts should be considered as major dust sources in global and regional climate models.

Iceland is an example of glaciogenic dust source area at high latitudes. In addition, Iceland is an important source of volcanic sediments that are subjected to intense aeolian processes and dust production (Arnalds et al., 2001, 2012, 2013; Arnalds, 2010; Prospero et al., 2012; Thorarinsdottir and Arnalds, 2012). Many of the major source areas for the dust have been identified (Arnalds, 2010) and the sandy deserts have been mapped (Arnalds et al., 2001). The Northeast is one of the most active aeolian areas of Iceland, with frequent dust plumes rising up from the Dyngjusandur source area and other sandy areas in the region, with dust plumes extending several hundred km from the sources (Arnalds, 2010). The Dyngjusandur active aeolian sandsheet covers an area of 270 km^2 with up to 10 m thick sediments (Mountney and Russell, 2004). Desert areas near Dyngjujokull are a result of glaciofluvial flooding, often associated with volcanic eruptions under the Vatnajokull glacier, enhanced by widespread volcanic deposition (Arnalds et al., 2001).

Atmospheric dust can reduce visibility and cause health risks. The World Health Organization considers that annual $PM_{2.5}$ concentration of 10 μg m^{-3} and estimated visibility 67 km indicates health risk, or daily standard of 35 μg m^{-3} and visibility range 31 km (WHO, 2005). In comparison, visual range can be over 300 km in dry climates and 100 km in humid climates on clear days (Hyslop, 2009). Observations of visibility during dust events are a key indicator of the severity of dust events where no aerosol measurements are conducted.

Many factors affect dust activity, such as sediment availability and climate factors. It is important to monitor changes in dust activity in time, especially in relation to climate and environmental changes. Atmospheric dust and visibility observations are available at weather stations in Iceland for more than 60 years (Arason et al., 2010). These data are ideal for studying long term variability in dust production and severity of historical dust events.

The main objectives of the study presented here were: (i) to explore the long term (63 years) variability in dust activity in NE Iceland (ii), to determine climatological characteristics of episodic dust events in a subarctic region, (iii) to place Icelandic dust production into international perspective.

2. Methods

2.1. Meteorological data

A network of eight weather stations in NE Iceland was chosen for the study. Fig. 1 depicts the location of the stations at Akureyri

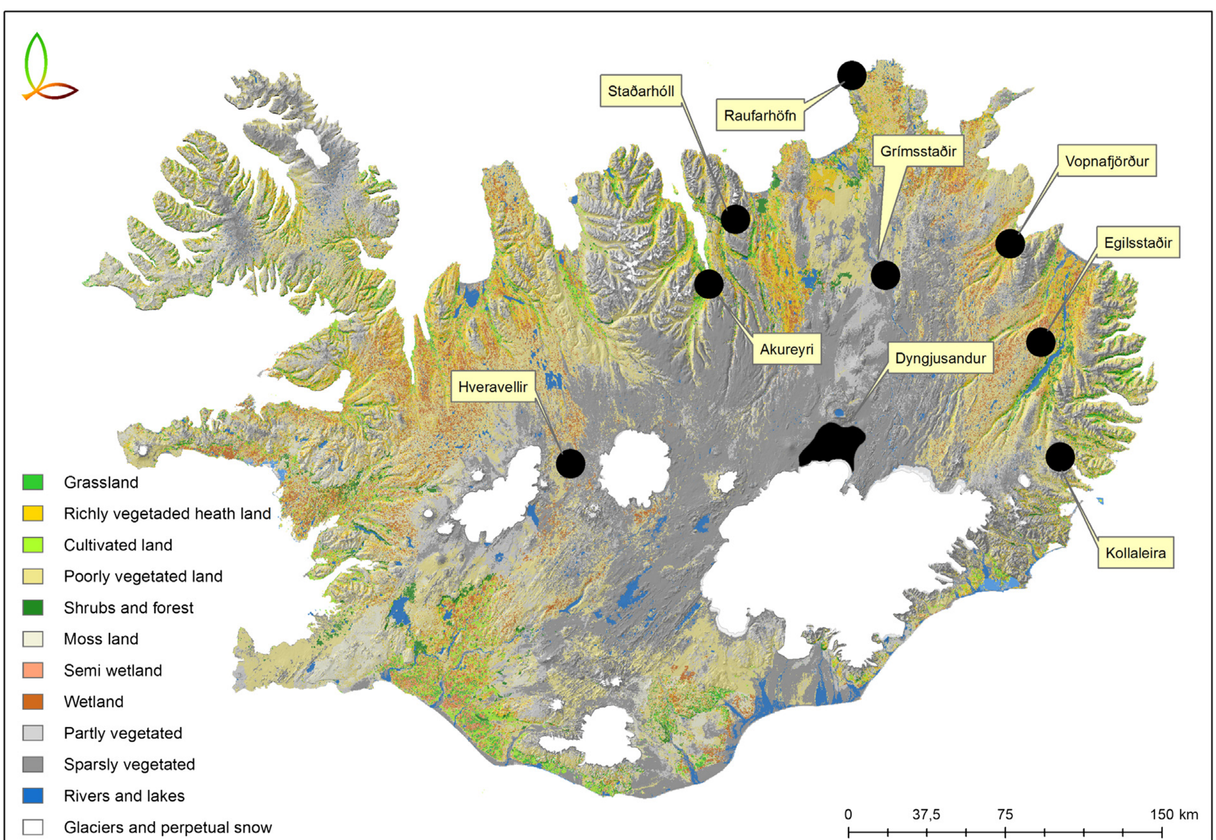


Fig. 1. A map showing the locations of weather stations in Northeast Iceland [Akureyri (AK), Egilsstadir (EG), Grimsstadir (GS), Raufarhofn (RH), Stadarholl (SH), Vopnafjordur (VO), Kollaleira (KL)] and a station in central Iceland [Hveravellir (HV)]. Base map from the Agricultural University of Iceland land use database (Nytjaland).