Extreme weather in remote places: Snowfall in the Sahara

Despite being the one of the world's hottest deserts, the Sahara experiences different types of extreme weather. Temperatures of over 50°C have been recorded within the desert itself, and these are important for breaking down rocks by thermal weathering and contributing to the generation of loose sand. Temperatures as low as -14°C have also been recorded in the mountains of the Algerian Sahara, and these too can contribute to rock breakdown by frost shattering processes. By contrast, rainfall can also be highly variable – central parts of the Sahara are hyperarid, receiving less than 100 mm of rainfall per year. Areas such as the Gilf Kebir of SW Egypt have an annual average rainfall of less than 5 mm and experience no rain for years, possibly decades. But then sudden and extreme rainstorms can bring tens of millimetres of rain over a few hours, triggering flash floods and rapid land surface change within reactivated wadi channels.

Although uncommon, snowfall in the Sahara can also take place, most recently in January 2022. Snow requires both low atmospheric temperatures and moist air and thus reflects an unusual combination of weather conditions. Moist air comes into the Sahara from low pressure cells (cyclones) developed over the surrounding water bodies of the Atlantic Ocean (to the west) and the Mediterranean Sea (to the north). The proximity of these water-source areas means that the margins of the Sahara (in particular the north) are wetter than more inland areas. A key factor triggering rainfall (or snowfall, if air temperatures are low enough) is the presence of mountains near to the coast. This is because, as air rises over higher ground, it can cool, condense and form clouds from which rainfall can take place, giving rise to flooding in lowland areas adjacent to these mountains. If the air temperature is low enough, snowfall can take place over the mountains and in areas immediately inland. The most common snowfall events, and the greatest snow depths when such events occur, are found in the Anti Atlas range of southern Morocco, and Saharan Atlas range of NW Algeria. In the Anti Atlas are found the region's few ski resorts (supplemented by machine-made snow), and in the Saharan Atlas near the town of Aïn Séfra, blizzards have been recorded several times in recent decades, resulting in roads being closed and communities cut off. The snowfall in this region in January 2022 was not a one-off event but part of a repeated winter pattern taking place when the air and

land surface are both cold, allowing snow to fall and then to settle (for at least a few days). Remote sensing technologies can give greater insight into the timing and spatial patterns of snowfall across the Sahara, and this may help identify the effects of climate change or weather patterns on snowfall climatology. Satellite radar technology can be used to accurately map rainfall patterns, and hyperspectral satellite imagery to map soil moisture and land surface temperatures. These are significant advancements in understanding weather and climate in the Sahara and similar remote areas.

The role of climate change

The Sahara Desert is commonly viewed as being hot and dry all the time, and thus an unlikely place to examine the effects of climate change. However, the Saharan climate is actually quite variable and can include both periods and locations where cold temperatures, high event-scale rainfall and even snow are recorded. In part, this variability is because the Sahara is a very big place, covering over 9 million km^2 and with environments extending across a latitudinal range of some 15 degrees (equivalent to the range between Durban and Lusaka). It also reflects the different directions from which weather systems are derived – west, from the Atlantic Ocean; north, from the Mediterranean Sea; and east from the Red Sea. Monsoon rainfall patterns and seasonal harmattan winds also affect some parts of the Sahara. Climate change influences the large-scale patterns of atmospheric circulation that bring seasonal rainfall into the wetter margins of the Sahara, and as such may influence the position of the intertropical convergence zone and the timing and strength of the West African monsoon. In theory, such weather patterns can be used to identify the fingerprint of climate change in the Sahara; but in reality there is a lack of long-term instrumental weather records in the region to track any climate changes, so such a link cannot yet be made.

Despite this, it is interesting to look at extreme weather events (e.g. heatwaves, cold snaps, rainfall leading to flash floods) because climate models show that these events will increase in frequency and magnitude under global climate change. Snowfall across the Sahara can be considered as an extreme event because it takes place relatively uncommonly and reflects both cold atmospheric temperatures and moist air being present. Snow has been recorded several times in the Sahara Desert over recent decades, most recently in January 2022, and can settle for several days when the land surface is also cold. The NW Algerian town of Aïn Séfra is particularly affected by snow events, receiving snow in the winters of 1979, 2016, 2017, 2018, 2021 and 2022. This latter event was just a light dusting, whereas in 2018 up to 30 cm of snow fell over higher ground. Several times, historically, snowfall has closed roads in this region. It is unclear from climate models or from historical records whether snowfall events are changing in their timing, frequency or distribution in the Sahara – there is just not enough data. But extreme weather events as hazards in the Sahara should not be underestimated. Heatwaves and floods can also be made worse by human activity including urban growth, agriculture, and over-exploitation of groundwater resources. Climate change is already drying out the wetter margins of the Sahara, and the desert itself is getting bigger. In turn, this will make weather extremes more widespread. We do not yet have a full understanding of the range of weather extremes present in the Sahara, or their impacts, but this is needed if impacts of extremes like snowfall on local communities are to be successfully mitigated.

Written by Jasper Knight
Professor of Physical Geography
University of the Witwatersrand, Johannesburg, South Africa