Potential Links between Precipitation and Anthrax Outbreak at North-West Siberia

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Abstract

West Siberia is a region subject to fast warming and unstable precipitation regime. In 2016, the most devastating anthrax outbreak in seventy years occurred in the northern part of the region. A working hypothesis suggests that permafrost thawing led to an exposure of old infected carcasses. We performed a thorough analysis of climatic factors in the region. Our analysis of soil temperature observations from the last 20 years indeed reveals rapid permafrost thawing near outbreak localization starting from 2010. We further analyzed meteorological observations to estimate the effect of warming and precipitation on permafrost. We showed that permafrost thawing was significantly accelerated during two consequent years with anomalously thick snow cover. Furthermore, spread of the disease was possibly intensified by an extremely dry summer. Precipitation in June-July 2016 did not exceed 10% of the climatological normals in the region. We conclude that epidemiological situation concerning anthrax remains highly unstable in the region due to the drastic decrease in summer precipitation and potential winter precipitation extremes.

Keywords: anthrax, permafrost, snow, precipitation, CALM

1. Introduction

Anthrax outbreak of 2016 on Yamal Peninsula in North-West Siberia (Popova *et al.*, 2016) got a lot of media attention. It was a major epizootic in the region since 1940s with more than 2500 reindeer incinerated. There were 36 human infection cases and 1 human died. Media emphasized the link between anthrax outbreak and permafrost thawing largely associated with climate change.

Anthrax is a natural focal disease, sensitive to climatic factors. It is caused by *Bac. Anthracis*. Bacteria are resistant to harsh conditions and therefore can survive for a long time in permafrost. Anthrax outbreak of 2016 is currently considered to be triggered by an unusually warm summer in 2016, causing permafrost thawing and leading to the exposure of old livestock carcasses infected by *Bac. Anthracis*. While exposed carcass version itself sounds plausible, one-year time framework does not. Permafrost thawing is a highly inertial process, especially in soils characterized by high water content (peatlands, e.g. Smith and Riseborough, 2002) and one warm year is not likely to cause an abrupt permafrost thaw. A thorough consideration of various climatic factors during longer time period is vital for our understanding on permafrost dynamics in the region. Not only temperature dynamics should be taken into account, but also snow long-term variability. Snow is an effective insulator, which prevents soil from deep freezing in winter. Stieglitz *et al.* (2003) have demonstrated that thick snow may have an effect on permafrost thawing comparable to that of recent warming temperatures. Sherstyukov (2008) has demonstrated the importance of snow for annual soil temperature dynamics in Siberia.

Another important factor influencing anthrax is summer precipitation. Dry summer weather can be dangerous bringing spores from the soil depth to the surface with soil moisture. Importantly, dry weather favors a high activity of blood-sucking insects such as tabanids, putting high stress on the livestock and playing an important role for the spread of infection (Gainer, 2016).

In this study, we focused on climatic parameters associated with anthrax to reveal the major processes that could have led to the outbreak. We conducted a comprehensive analysis of meteorological parameters in the region during the last 15 years, quantified the effect of temperature and snow cover on permafrost dynamics and compared it with available observations. In addition, we studied current trends in summer precipitation.

2. Materials and Methods

2.1. Data sets

The data sets include an active layer thickness (ALT) and meteorological observations. The active layer thickness is the maximal depth of thawed upper layer during the year. We took that ALT measurements from Circumpolar Active Layer Monitoring site (CALM), which is an international network providing free access to the data. The sites we chose for the analysis are Nadym, Vorkuta and Vaskiny Dachi. The sites are located within 200 km from the region of outbreak to the north, south and west. The data sets are quality checked by the principal investigators of the data.

Meteorological data include temperature, snow thickness, and precipitation. The data were measured at nine official WMO stations around the region of outbreak in 2005-2018. Data are freely accessible at www.rp5.ru. The data sets were quality checked and outliers were removed.

2.*2. Methods*

To study permafrost thawing and explain an observed ALT dynamics, we calculated the mean annual air temperature (MAAT) and mean snow thickness for all nine stations. Based on the mean snow thickness and mean annual air temperature, we estimated n-factors at three representative sites following Smith and Riseborough (2002). n-factors are bulk coefficients characterizing heat transfer through the surface. Using n-factors and air day-degree sums, we calculated temperature at the top of permafrost (TTOP). TTOP is a parameter characterizing permafrost thawing and related to ALT. Furthermore, we analysed summer precipitation and compared it to the climatological normals as it is one of the major factors influencing spread of the disease.

3. Results

We observed an ALT increase at Nadym and Vaskiny Dachi starting from 2010 and peaking in 2016. The increase was ca. 40% in the region of discontinuous permafrost (Nadym), as compared to the mean ALT in 1997-2010, and ca. 25% in the region of continuous permafrost. The temporal dynamics of TTOP calculated using meteorological data is in agreement with ALT dynamics. We found that the factors leading to positive TTOP dynamics include warmer winters and summers as well as a thick snow cover during some years. We observed a thick snow cover in 2014-2015 at several meteorological stations near the outbreak region, which could prevent the soil from freezing during cold winters.

We also observed a drastic decrease in summer precipitation in 2014-2018 as compared to the latest climatological normal (1981-2010). The monthly mean precipitation halved in June and August and decreased by a factor of four in July. In particular, summer of 2016 was extremely dry with some 2 mm instead of 30 mm of precipitation in July.

In summary, we have shown that the rapid increase in ALT, triggering anthrax outbreak in Russia in 2010, is likely due to the combined effect of snow during cold winters and warmer freezing/thawing seasons. Furthermore, extremely dry summer weather could have boosted spread of disease.

Finally, our results indicate unstable climatic situation in the region and raise concerns about epidemiological situation in the North-West Siberia. Therefore, vaccination of reindeer is highly important.

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