The Aral Sea has made Central Asia significantly dustier, according to study

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The dust from the Aralkum Desert is considered much more dangerous because it also contains residues of fertilisers and pesticides from former agriculture. Credit: Dietrich Althausen, TROPOS

The drying up of the Aral Sea has made Central Asia 7% dustier in the last 30 years. Between 1984 and 2015, dust emissions from the growing

desert almost doubled from 14 to 27 million tons. This is the result of a study by the Leibniz Institute for Tropospheric Research (TROPOS) and the Free University of Berlin.

The amounts of dust have probably been underestimated so far because two-thirds of it is swirled up under cloudy skies and therefore may go unnoticed by traditional satellite observations, report the researchers at the Second Central Asian DUst Conference (CADUC-2), which is taking place from 15–22 April 2024 in Nukus, Uzbekistan, near the former Aral Sea.

The dust not only endangers the inhabitants in the region, but also affects the air quality in the capitals of Tajikistan and Turkmenistan. In addition, it may accelerate the melting of glaciers and thus exacerbate the water crisis in the region.

Until the early 1960s, the Aral Sea in Central Asia was the fourth largest lake in the world with an area of 68,000 square kilometers—fed by the Amu Darya and Syr Darya rivers from the Pamir and Tian Shan mountain ranges. Due to the excessive use of the rivers for agricultural irrigation, less and less water reached the lake. As a result, huge areas dried up, the lake shrank to a fraction of its size and most of it became a desert.

The Aralkum Desert is now considered one of the most significant man-made sources of dust on earth. At 60,000 square kilometers, this new desert is much smaller than the neighboring natural deserts of Karakum (350,000 square kilometers) to the south in Turkmenistan and Kyzylkum (300,000 square kilometers) to the southeast in Uzbekistan and Kazakhstan. But the dust from the Aralkum Desert is considered much more dangerous because it contains residues of fertilizers and pesticides from former agriculture.

The Aral Sea is not the only lake in Central Asia and the Middle East that has shrunk dramatically in recent decades. Lake Urmia in north-western Iran and Lake Hamoun in the Iran-Afghanistan border region have also become local heavy sources of dust. This desertification therefore has a major impact on the climate and living conditions of the people in the region. The interest of international science in better understanding these processes is correspondingly great, in order to be able to better assess future trends up to the global climate.

At around 60,000 square kilometres, the Aralkum Desert is now considered one of the most significant man-made dust sources on Earth. Credit: Dietrich Althausen, TROPOS

To estimate the effects of dust from the Aralkum Desert, the TROPOS and FU Berlin team used the COSMO-MUSCAT atmospheric dust model, which simulates emissions, atmospheric concentrations and radiation effects of dust particles. One challenge was the limited data on the soil and surface properties in the Aralkum Desert. The other challenge was the different wind directions in different years.

Winds from westerly directions can dominate the dust storm activity, but north, east and south also play a role depending on the season. With the warming of the Arctic, westerly wind currents could become even more frequent in winter, with consequences for the people east of the desert: on an annual average, up to half of the dust currently may already go eastwards.

Especially the agricultural areas along the Syr Darya are negatively affected by the dust, but even in the big cities of Central Asia like Ashgabat (capital of Turkmenistan) and Dushanbe (capital of Tajikistan) the dust is still felt, even if they are more than 800 kilometers away.

Based on the modeling study for Central Asian dust presented in the *Journal of Geophysical Research: Atmospheres* in 2022, the team led by Jamie Banks from FU Berlin and TROPOS then investigated the impact of Aralkum dust on radiative effects over Central Asia in order to better understand the influence of increasing dust storms on the climate.

COSMO-MUSCAT model simulations were used to quantify the direct radiative effects (DREs) of Aralkum dust and the associated impacts on the atmosphere. The second study is currently in the discussion and review process as a preprint in the open access journal *Atmospheric Chemistry and Physics*.

On the ground, dust has a cooling effect during the day because it dims the sunlight, and a warming effect at night because it reflects the long-

wave heat radiation. The net radiative effect of dust can therefore be cooling or warming, depending on the height of the dust in the atmosphere, the time of day, the season, the surface albedo and the exact mineralogical and optical properties of the dust.

"Looking at the changes between the past and the present, the near doubling of dust emissions over the Aral Sea/Aralkum region has led to an increase in both radiative cooling and radiative heating at the surface and in the atmosphere," reports Dr. Jamie Banks.

"However, these 'new' dust events do not occur throughout the year, but in episodes in June, September, November, December and March. On an annual average, the Aralkum dust probably cools both at the surface and in the atmosphere, but only minimally at -0.05 ±0.51 watts per square meter."

In addition to the radiation effects, the researchers have also found indications that the dust could change the large-scale weather patterns: Aralkum dust increases the air pressure at ground level in the Aral region by up to +0.76 Pascal on the monthly time scale, which means a strengthening of the Siberian high in winter and a weakening of the Central Asian heat low in summer.

As many questions about the climate effects of the dust are still unanswered, the researchers recommend investigating the optical properties of this dust in more detail. Their knowledge improves the satellite-based and thus large-scale remote sensing of mineral dust. The Leibniz junior research group OLALA (Optical Lab for Lidar Applications), which was founded at TROPOS in Leipzig in 2023, will be addressing this challenge in the coming years.

The studies underline that increasing desertification due to the desiccation of lakes is not only a local problem, but affects large regions.

Deserts are spreading particularly rapidly in the Middle East and Central Asia. The retreat of glaciers in the high mountains also contributes to this. The new data on the Aral Sea dust source help to better assess the influence of desert dust on the climate.

More information: Jamie R. Banks et al, Radiative cooling and atmospheric perturbation effects of dust aerosol from the Aralkum Desert in Central Asia, *Atmospheric Chemistry and Physics* (2023). DOI: 10.5194/egusphere-2023-2772

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