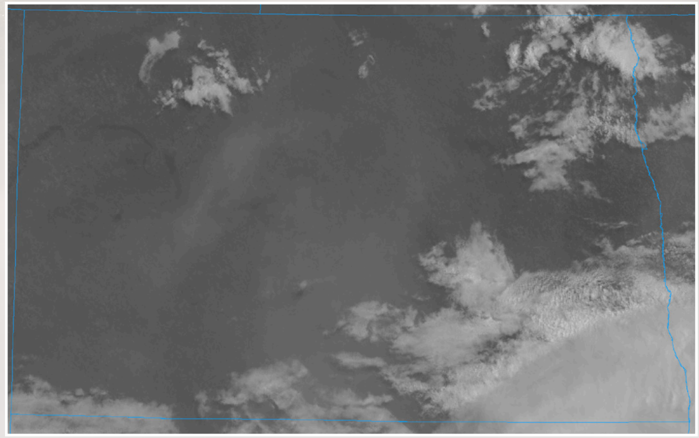

Visible satellite image of North Dakota showing widespread smoke. Courtesy of College of DuPage

SMOKE & PRECIPITATION

By Mark D. Schneider

This has been an exceptional year for wildfires in the western U.S. Widespread drought conditions dried out grass and vegetation, serving as fuel for wildfires. Many North Dakotans are curious whether smoke from wildfires has an effect on precipitation. The simple answer is yes, but the details can be very complicated depending on the situation.

To investigate this further, one must consider whether the precipitation process is a warm-rain or an ice-phase process. Within the warm-rain process called Collision-Coalescence, microscopic water droplets bump into each other and join together. Eventually the droplets that grow large enough will fall from a cloud as rain. The process is more efficient when there are different sizes of water droplets available in the atmosphere because this creates different fall speeds and increases the chances for collision. When smoke particles are introduced into the atmosphere in high enough concentrations, the air contains many small droplets that are less likely to collide and grow into large droplets, reducing precipitation.

The thunderstorms that produce beneficial rainfall during North Dakota's growing season utilize an ice-phase process where freezing occurs within clouds. This process, called the Bergeron-Findeisen-Wegener process is characterized by ice crystals growing at the expense of water droplets. In this scenario, smoke particles can serve as ice nuclei on which water droplets can freeze. An unstable atmosphere with updrafts can enhance the ice process and those ice particles melt as they fall through warmer air below. Research shows this can lead to less rainfall overall, but more intense localized storms that may include hail. In drought years such as this, there typically isn't enough moisture in the atmosphere for thunderstorms either to initially develop or to produce as much precipitation because more of it evaporates before ever reaching the ground.

Recent improvements in numerical modeling allow for remarkable three-dimensional mapping and prediction of smoke. Both researchers and weather forecasters are now better able to determine where smoke will travel, it's concentration, and how it might affect precipitation. In 2018, a five-year NASA research project called ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) set out to study aerosol interactions over the Atlantic Ocean. Because the southern part of Africa produces nearly one-third of the "man-made" aerosol particles in the world by burning fields for agriculture and grazing animals, it’s an ideal region to observe and study. Early indications from this and other studies point to reduced precipitation (warm rain process) from high concentrations of smoke. In fact, the presence of smoke actually coincided with large decreases in the amount of cloud cover in certain instances.

As you can see, our atmosphere needs particles of the right size and concentration in order to produce precipitation and even to provide us with cloud cover. By continuing our investigation of smoke and other particles in the atmosphere, we will better understand clouds and precipitation and even be able to change some of our practices to align with natural processes.

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