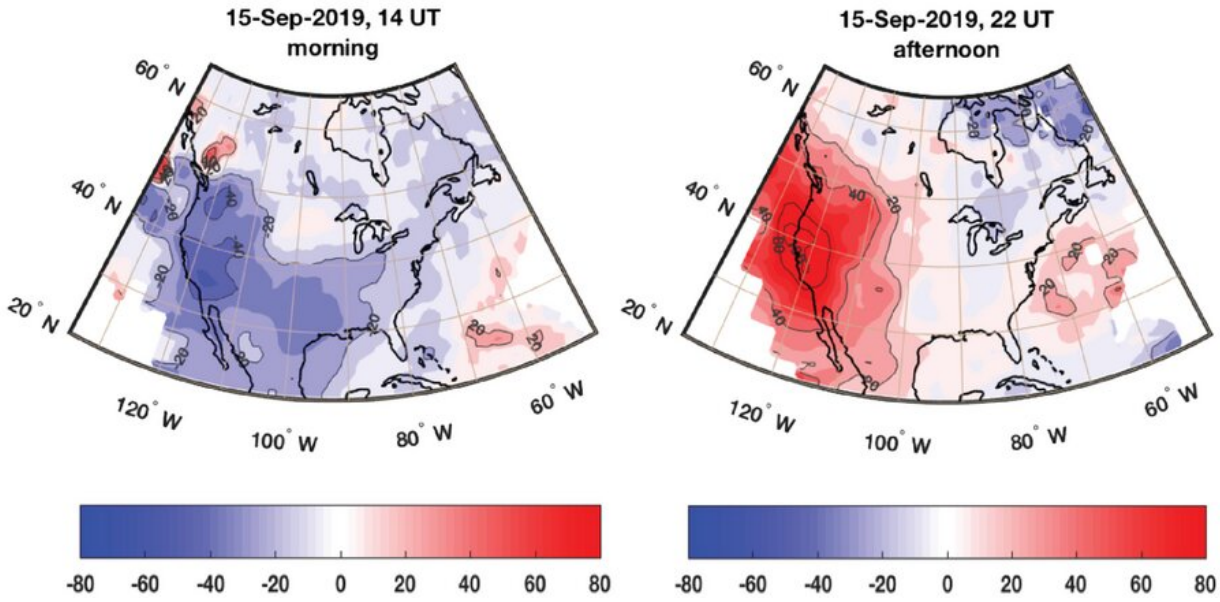
How a sudden stratospheric warming affected the Northern Hemisphere

July 23 2021, by Nancy Wolfe Kotary



Ionospheric anomalies observed on Sept. 15, 2019 over North America. Anomalies are shown for TEC (total electron content) and expressed as percentage compared to the average values for this season. A 50-80 percent increase in TEC observed over western United States is linked to the Antarctic sudden stratospheric warming. The colored areas show where the TEC levels are shifted over North America and Europe in the afternoon; red indicates an increase of up to 80 percent versus the baseline regular levels, and blue indicates a decrease of up to –40 percent versus regular levels. Credit: Goncharenko et al.

Weather is a tricky science—even more so at very high altitudes, with a

mix of plasma and neutral particles.

In sudden stratospheric warmings (SSWs)—large meteorological disturbances related to the polar vortex in which the polar stratosphere temperature increases as it is affected by the winds around the pole—the polar vortex is weakened. SSWs also have profound atmospheric effects at great distances, causing changes in the hemisphere opposite from the location of the original SSW—changes that extend all the way to the upper thermosphere and ionosphere.

A study published on July 16 in *Geophysical Research Letters* by MIT Haystack Observatory's Larisa Goncharenko and colleagues examines the effects of a recent major Antarctic SSW on the Northern Hemisphere by studying changes observed in the upper atmosphere over North America and Europe.

In an SSW-caused anomaly, changes over the pole cause changes in the opposite hemisphere. This important interhemispheric linkage was identified as drastic shifts at altitudes greater than 100 km—for example, in total electron content (TEC) measurements as well as variations in the thermospheric O/N_2 ratio.

SSWs are more frequent over the Arctic; these cause TEC and other related anomalies in the Southern Hemisphere, and thus more observations have been made on this linkage. Since the Antarctic SSWs are less common, there are fewer opportunities to study their effects on the Northern Hemisphere. However, the greater density of TEC observation locations in the Northern Hemisphere allows for precise measurement of these upper atmospheric anomalies when they do occur.

In September 2019, an extreme, record-breaking SSW event occurred over Antarctica. Goncharenko and colleagues found significant resulting changes in the upper atmosphere in mid-latitudes over the Northern

Hemisphere following this event; more observations are available for this region than in the Southern Hemisphere. The changes were notable not only in severity, but also because they are limited to a narrow (20–40 degrees) longitude range, differ between North America and Europe, and persist for a long time.

In the figure above, red areas show where TEC levels are shifted over North America and Europe in the afternoon; red indicates an increase of up to 80 percent versus the baseline regular levels, and blue indicates a decrease of up to –40 percent versus regular levels. This TEC shift persisted throughout September 2019 over the western United States, but was short-lived over Europe, indicating different mechanisms at play.

The authors suggest that a change in the thermospheric zonal (east–west) winds are one reason for the variance between regions. Another factor is differences in magnetic declination angles; in areas with greater declination, the zonal winds can more efficiently transport plasma to higher or lower altitudes, leading to the build-up or depletion of plasma density.

More study is needed to determine the precise extent to which these factors affect the linkage between polar stratospheric events and near-Earth space in the opposite hemisphere. These studies remain a challenge, given the relative rarity of Antarctic SSWs and sparse availability of ionospheric data in the Southern Hemisphere.

More information: Larisa P. Goncharenko et al, Impact of September 2019 Antarctic Sudden Stratospheric Warming on Mid-Latitude Ionosphere and Thermosphere over North America and Europe, *Geophysical Research Letters* (2021). DOI: 10.1029/2021GL094517

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