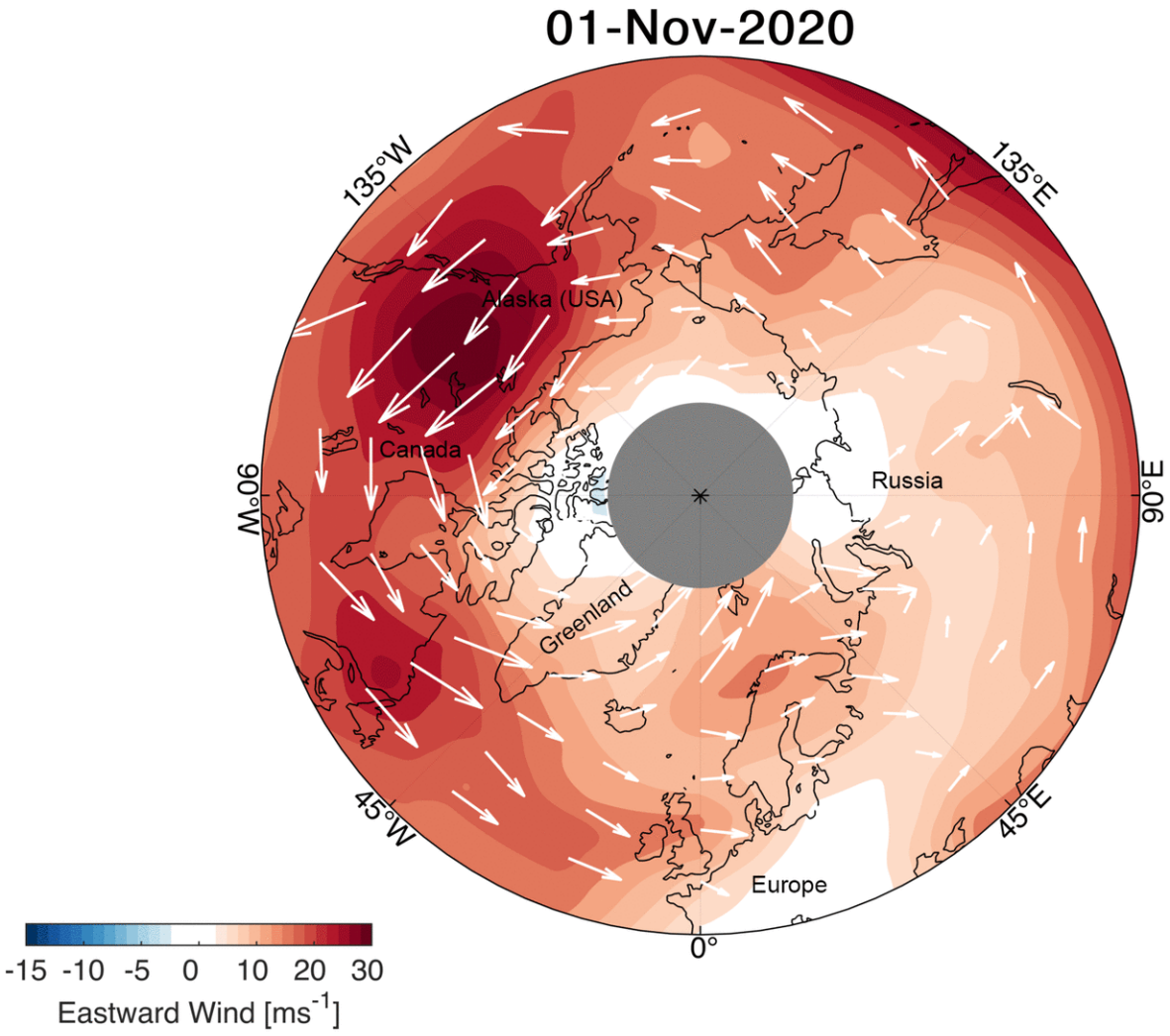
Aeolus shines a light on polar vortex

February 4 2021



The animation uses data from ESA's Aeolus wind satellite and shows how the polar vortex in the lower stratosphere changed between 1 December 2020 and 1 February 2021. The first few plots at the beginning of December show the vortex in a comparatively normal state, but in mid-December patches of blue

wind appear, and the wind is going backwards relative to normal conditions. Scientists are using wind information from Aeolus to shed more light on this complex phenomenon that can disrupt the weather at lower latitudes. Credit: University of Bath/C. Wright

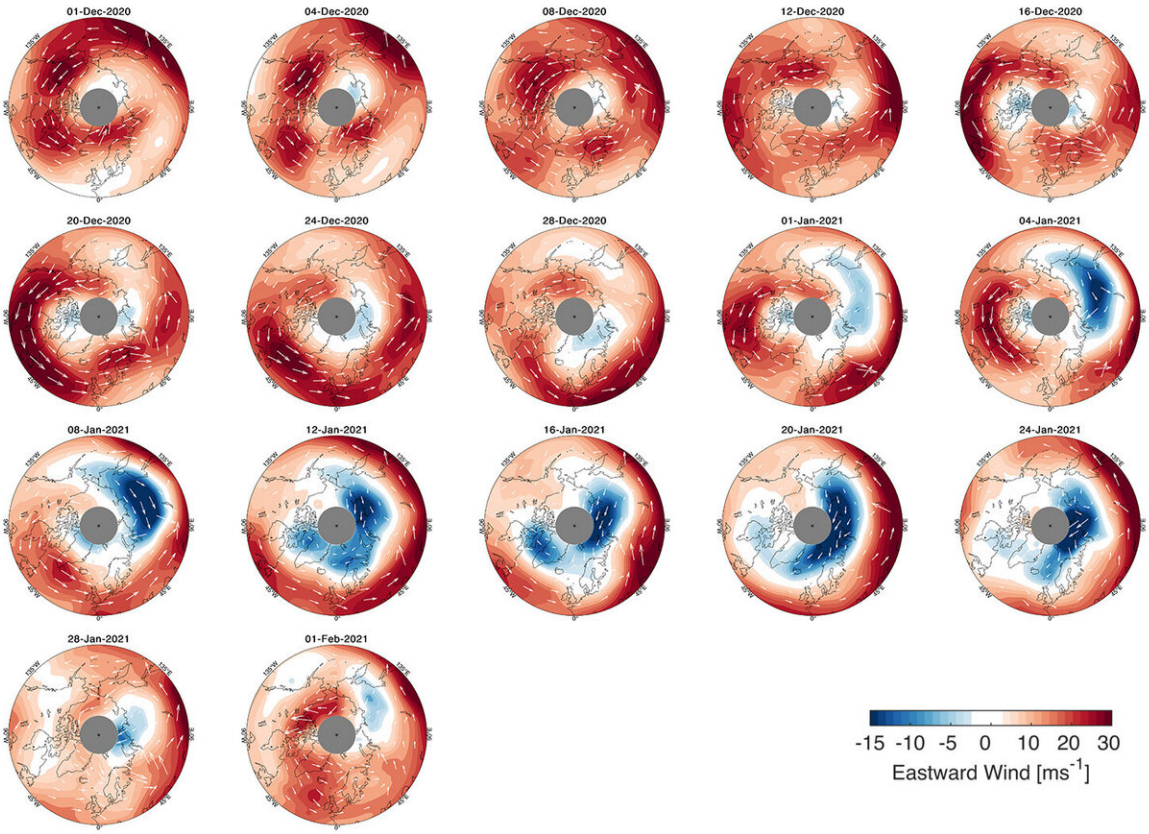
As this winter's polar vortex currently sends extreme icy blasts of Arctic weather to some parts of the northern hemisphere such as the northeast of the US, scientists are using wind information from ESA's Aeolus satellite to shed more light on this complex phenomenon.

The polar vortex is a huge mass of frigid air high above the North Pole in the polar stratosphere. It is surrounded by a strong jet of air swirling counter-clockwise along the vortex's boundary. The vortex tends to be much stronger in the winter, keeping bitter cold air locked in around the Arctic.

However, sometimes the vortex can weaken, become distorted or even split into two and meander further south, affecting the weather and jetstream further down in the troposphere, potentially bringing unusually cold weather and snow to lower latitudes.

One meteorological event that can disturb the polar vortex is known as a 'sudden stratospheric warming," which is what has been happening over the last couple of months. Sudden stratospheric warmings happen to some extent every year, but the current event has been categorized as major, and is less common.

Such dramatic events cause the strong wind around the edge of the polar vortex to weaken or reverse, leading the temperature of the polar stratosphere to rise rapidly by tens of degrees Celsius.



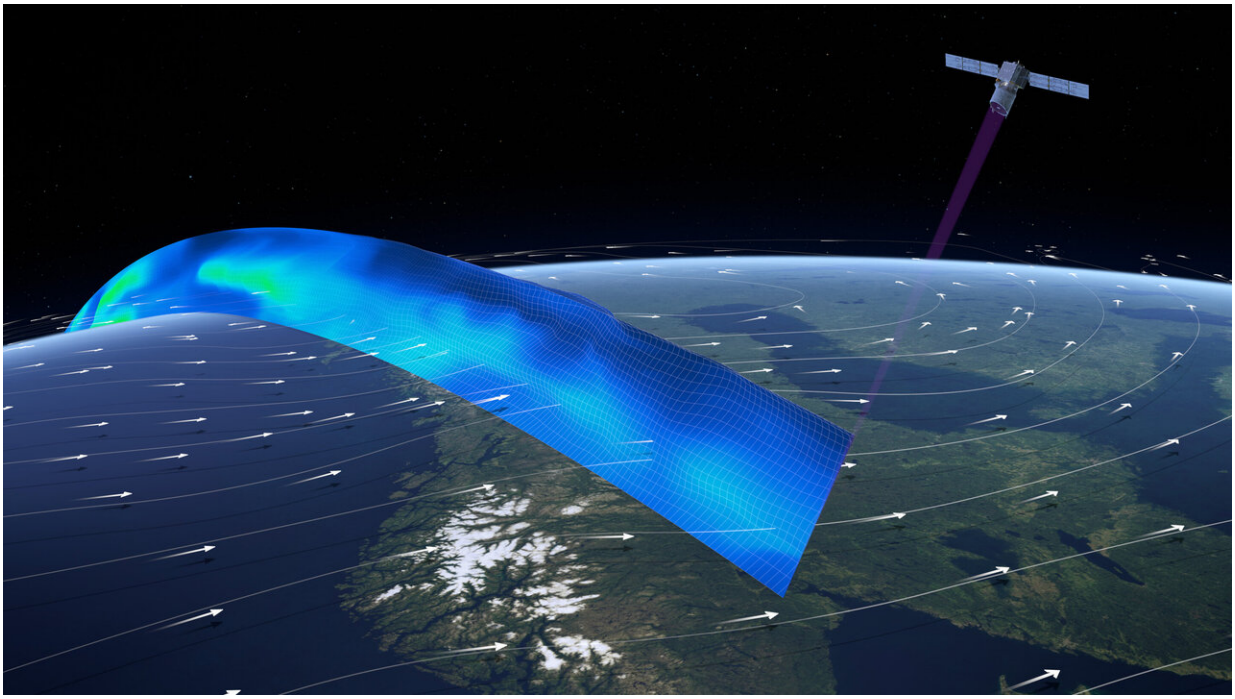
Based on data from ESA's Aeolus wind mission, the image shows how the polar vortex in the lower stratosphere changed between 1 December 2020 and 1 February 2021. The first few plots at the beginning of December show the vortex in a comparatively normal state, but in mid-December patches of blue wind appear, and the wind is going backwards relative to normal conditions. Credit: University of Bath/C. Wright

Since these events can trigger extreme weather in Europe and North America, they are of scientific and practical interest. However, the processes involved are not fully understood, and until recently there have been major technical challenges in measuring wind from space, which is needed to measure and monitor such a large-scale event.

Fortunately, scientists now have ESA's Aeolus satellite at hand to help understand more about why and how the polar vortex is pushed off balance.

Aeolus is the first satellite in orbit to profile directly Earth's winds from space.

It works by emitting short, powerful pulses of ultraviolet light from a laser and measures the Doppler shift from the very small amount of light that is scattered back to the instrument from molecules and particles to deliver profiles of the horizontal speed of the world's winds mostly in the east-west direction in the lowermost 26 km of the atmosphere.



The Aeolus mission was not only built to advance our understanding of atmospheric dynamics, but also to provide much-needed information to improve weather forecasts. The satellite carries the first wind lidar in space, which can probe the lowermost 30 km of the atmosphere to provide profiles of wind,

aerosols and clouds along the satellite's orbital path. The laser system emits short powerful pulses of ultraviolet light down into the atmosphere. The telescope collects the light that is backscattered from air molecules, particles of dust and droplets of water. The receiver analyses the Doppler shift of the backscattered signal to determine the speed and direction of the wind at various altitudes below the satellite. These near-realtime observations will improve the accuracy of numerical weather and climate prediction and advance our understanding of atmospheric dynamics and processes relevant to climate variability. Credit: ESA/ATG medialab

Although Aeolus only measures wind in the lower part of the atmosphere, the lower part of the current stratospheric polar vortex jet leaves a signature in the satellite's data.

Corwin Wright, Royal Society research fellow at the University of Bath in the UK, said, "Changes in the wind structure in a sudden stratospheric warming event have never been observed directly at a global scale before. So far, our understanding of these changes has been developed using point measurements, measurements along localized aircraft flight tracks, through the use of temperature observations, and, primarily, computer models and assimilative analyzes.

"However, we can now exploit novel measurements from Aeolus, the first satellite capable of observing winds directly in the upper troposphere and lower stratosphere, to study this process observationally during this current major event."

Anne Grete Straume, ESA's Aeolus mission scientist, commented, "We are currently observing a polar vortex event where we see it split into two, with one spinning mass of air over the North Atlantic and one over the North Pacific.

This image of snow in the Great Lakes region in the US was captured by the Copernicus Sentinel-3 mission's ocean and land colour instrument on 3 February 2021. While there are reports of record-low ice cover on the lakes this year, there has, nevertheless, been heavy snowfall across the Midwest and Great Lakes over the last few days. Snow has also hit the northeast US. It is thought that this winter's polar vortex is currently sending extreme icy blasts of Arctic weather to some parts of the northern hemisphere. Scientists are using wind information

from ESA's Aeolus satellite to shed more light on the complex polar vortex phenomenon. Credit: contains modified Copernicus Sentinel data (2021), processed by ESA, CC BY-SA 3.0 IGO

"The split leads to changes in the tropospheric circulation allowing cold air masses from the poles to more easily escape down to lower latitudes. At the moment, parts of North America seem to be experiencing colder weather than Europe, although we have seen events of cold air reaching quite far south in Europe over the past few weeks causing, for example, heavy snowfall in Spain.

"What scientists would also like to understand is whether sudden stratospheric warming events might become more frequent owing to climate change. Also for this, Aeolus wind data will be very important to better understand the mechanisms triggering these weather events.

"It is early days yet to draw any scientific conclusions from our Aeolus data, but work is certainly underway to shed new light on why this seasonal phenomenon can sometimes be extreme—watch this space."

Provided by European Space Agency