What is space weather? What contributes to it? In this fourth episode of Space Weather FX, we look at some causes of space weather effects that come from our own stratosphere.

Space Weather FX 04: Sudden Stratospheric Warming
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Opening graphic: Sun, moves down to Earth, opening title sequence.

VOICE-OVER: Space weather is something we experience because we live near a star — the Sun. But solar activity may not be the only cause of disturbances in our upper atmosphere.

High-altitude view of MIT Haystack Observatory

VOICE-OVER: Out in the countryside near Boston Massachusetts, scientists at MIT’s Haystack Observatory are looking at other actions in our lower atmosphere that might also be stirring up a little space weather.

Title sequence and music, crossfade to Phil on camera, and animation of solar outburst in background; then crossfade to quiescent Sun from SOHO and graphic: 2007-2009: Solar Minimum Conditions

PHIL: In previous episodes of Space Weather FX, I’ve talked about what happens during solar outbursts, when material from our Sun impacts our upper atmosphere. But, the Sun isn’t always sending big blasts of charged particles our way. For the past couple of years, it’s been extremely quiet. We’ve seen very little in the way of big space weather.

This period, which we call “solar minimum”, is an excellent time to look at other events in our atmosphere that drive space weather activity in the ionosphere.
My colleague, Dr. Larisa Goncharenko, here at Haystack Observatory, has been studying what are called “stratospheric sudden warming events.” She and her colleagues have found a kind of space weather that seems to go not from the top of our atmosphere down, but from the bottom up. I recently spoke to Larisa about the characteristics of a stratospheric sudden warming event.

Larisa, what is a stratospheric warming event?

Larisa: Stratospheric warming is a large-scale dramatic change in wintertime polar stratosphere, at altitudes between maybe 20-50 kilometers above the ground.

Phil: So these events are in the layers of the atmosphere that are closer to the ground and closer to the types of weather that meteorologists would study.

Larisa: Yes, this is correct. And this type of event involves real profound changes. For example, temperatures can rise up to several tens of degrees, and winds changes from a winter-type pattern to a summer-type pattern. These events were discovered in the 1950s and so then they attracted a lot of attention from atmospheric researchers from different fields.
PHIL: So Larisa, can you tell us how changes in the stratosphere affect weather in the upper atmosphere.

LARISA: In 1980s, scientists discovered that warming in the stratosphere is accompanied by cooling in the mesosphere, which is altitudes between maybe 70 to 90 kilometers. Up to now, it wasn't known if any changes occurred at higher altitudes. January 2008, our Haystack Observatory group, together with colleagues from other research organizations, carried out a major experiment to see if any changes occur at altitudes above one hundred kilometers. What we saw exceeded our highest expectations.

We saw that when stratospheric warming occurs at polar latitudes — accompanied by mesospheric cooling, which we knew before — but we saw another layer of warming at altitudes above about 120 kilometers, and large cooling all the way up to several hundred kilometers.

PHIL: So the changes you're seeing were larger than expected before these experiments were conducted?

LARISA: This is the first time it was seen.

PHIL: You also found changes that occur not only as a function of altitude, but also
globally from the pole to the equator.

_Cut to Larisa against Earth backdrop._

**LARISA:** Yes, in fact we found that this is really a global event.

_Cut to Phil asking question._

**PHIL:** This work also shows that the strength of the connection between the lower and the upper atmosphere is much stronger than previously expected.

_Cut to Larisa._

**LARISA:** This is a great mystery which we’re trying to solve right now.

_Cut to Phil._

**PHIL:** So, Larisa, how do these changes connect to what we would normally think of as space weather?

_Cut to Larisa and graphic of data._

**LARISA:** This work actually shows that space weather can happen for different reasons, and the upper atmosphere can vary a lot even when the Sun is really, really quiet.

_Cut to Larisa against quiescent Sun from SOHO and backdrop of Earth and atmosphere._

In fact, making such observations during variable solar activity really helps us to understand what exactly drives the variations in the upper atmosphere.
Scientists suspected long time ago that the upper atmosphere is linked to the lower atmosphere, but it was difficult to study because the sun is a major driver of the space weather. With sunspots and solar activity out of our way during the deep solar minimum, we can take a close look how exactly upper atmosphere links to the lower atmosphere.

So, now that things are quiet on the solar front, this is a good time to study all the layers of our atmosphere — to understand how they are coupled together. What we are finding out is just how complex our atmosphere and that it responds not only to the Sun, but to events from much closer to Earth’s surface.

People suspected a long time ago that the lower atmosphere can affect the state of the upper atmosphere, but it was very difficult to study because the Sun is such a major driver of space weather. And now, during solar minimum, when the sunspots and solar activities are out of our way, this is a perfect time to organize this type of study and see what exactly drives the coupling between the lower and higher altitudes.

Cut to Phil in closing comments.

PHIL: So these studies have uncovered a new type of space weather that was really there all along, but was very difficult to detect until recently.

Closing title sequence.