Cloudy feedback on global warming

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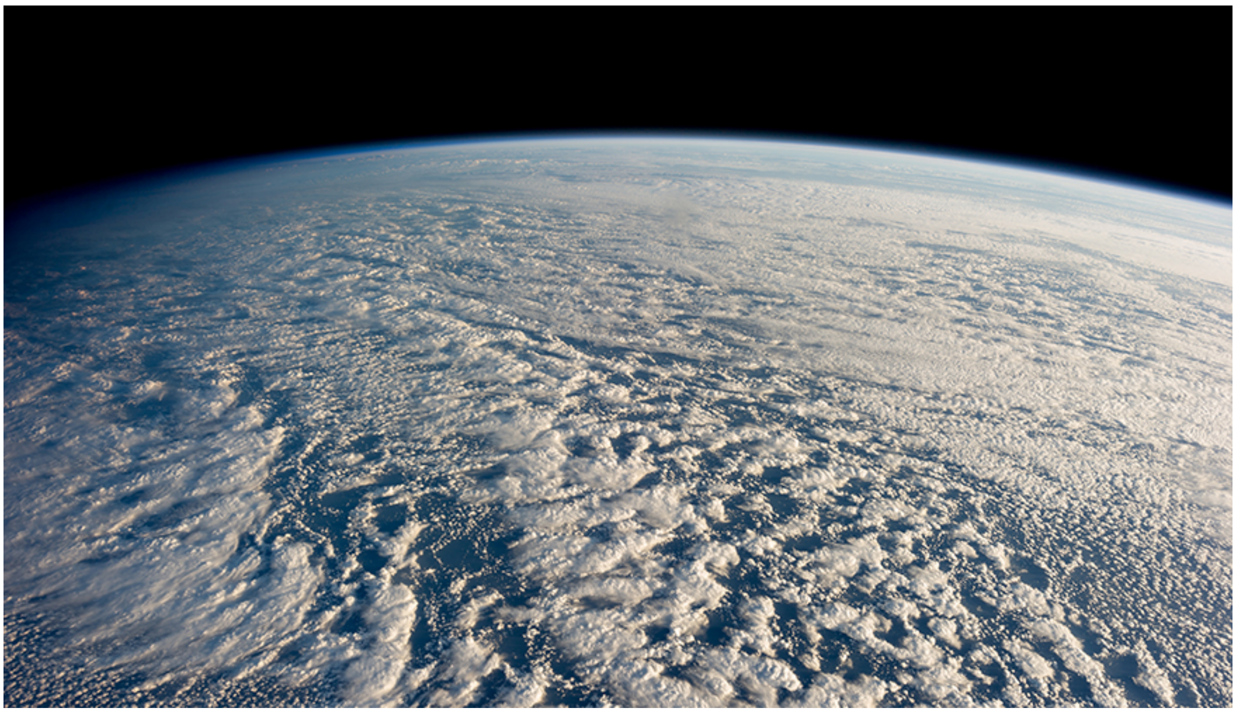

Lawrence Livermore scientists studied low-level stratocumulus clouds to identify their effects on global warming. Credit: Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory researchers have identified a mechanism that causes low clouds - and their influence on Earth's energy balance - to respond differently to global warming depending on their spatial pattern.

The results imply that studies relying solely on recent observed trends are likely to underestimate how much Earth will warm due to increased carbon dioxide. The research appears in the Oct. 31 edition of the journal, *Nature Geosciences*.

The research focused on clouds, which influence Earth's climate by reflecting incoming solar radiation and reducing outgoing thermal radiation. As the Earth's surface warms, the net radiative effect of clouds also changes, contributing a feedback to the climate system. If these cloud changes enhance the radiative cooling of the Earth, they act as a negative, dampening feedback on warming. Otherwise, they act as a positive, amplifying feedback on warming. The amount of global warming due to increased carbon dioxide is critically dependent on the sign and magnitude of the cloud feedback, making it an area of intense research.

The researchers showed that the strength of the cloud feedback simulated by a climate model exhibits large fluctuations depending on the time period. Despite having a positive cloud feedback in response to long-term projected global warming, the model exhibits a strong negative cloud feedback over the last 30 years. At the heart of this difference are low-level clouds in the tropics, which strongly cool the planet by reflecting solar radiation to space.

"With a combination of climate model simulations and satellite observations, we found that the trend of low-level cloud cover over the last three decades differs substantially from that under long-term global warming" said Chen Zhou, lead author of the paper.

"The key difference is the spatial pattern of global warming", said Mark Zelinka, LLNL climate scientists and co-author of the study. "Not every degree of global warming is created equal, in terms of its effect on low clouds."

In response to increased carbon dioxide, climate models predict a nearly uniform warming of the planet that favors reductions in highly reflective low clouds and a positive feedback. In contrast, over the last 30 years, tropical surface temperatures have increased in regions where air ascends and decreased where air descends. "This particular pattern of warming is nearly optimal for enhancing low cloud coverage because it increases low-level atmospheric stability that keeps the lower atmosphere moist and cloudy", said Stephen Klein, the third co-author.

"Most satellite data starts around 1980, so linear trends over the last three decades are often used to make inferences about long-term global warming and to estimate climate sensitivity," said LLNL's Chen Zhou, lead author of the study. "Our results indicate that cloud feedback and climate sensitivity calculated from recently observed trends may be underestimated, since the warming pattern during this period is so unique."

Global temperature has gradually increased over the instrumental record due to increased greenhouse gas concentrations. But superimposed on this warming are large temperature fluctuations due to natural internal variability of the climate system, as well as influences from volcanic eruptions, aerosol pollution and solar variability. Whereas warming due to CO_2 tends to be relatively spatially uniform, surface temperature trends due to internal climate variability and aerosol pollution are highly non-uniform, with trends on one side of an ocean basin often opposing those on the other. Trends computed over short time periods are often strongly influenced by factors other than CO_2 and can be highly misleading indicators of what to expect under CO_2-forced global warming.

The team emphasized that clouds are particularly sensitive to subtle differences in surface warming patterns, and researchers must carefully account for such pattern effects when making inferences about cloud feedback and climate sensitivity from observations over short time periods.

More information: Chen Zhou et al, Impact of decadal cloud variations on the Earth's energy budget, *Nature Geoscience* (2016). DOI: 10.1038/ngeo2828

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