Greenhouse gases versus solar heating: New research shows complexity of global warming

30 January 2013

This shows clouds over the Pacific. Credit: Shang-Ping Xie

Global warming from greenhouse gases affects rainfall patterns in the world differently than that from solar heating, according to a study by an international team of scientists in the January 31 issue of *Nature*. Using computer model simulations, the scientists, led by Jian Liu (Chinese Academy of Sciences) and Bin Wang (International Pacific Research Center, University of Hawaii at Manoa), showed that global rainfall has increased less over the present-day warming period than during the Medieval Warm Period, even though temperatures are higher today than they were then.

The team examined global precipitation changes over the last millennium and future projection to the end of 21st century, comparing natural changes from solar heating and volcanism with changes from man-made greenhouse gas emissions. Using an atmosphere-ocean coupled climate model that simulates realistically both past and present-day climate conditions, the scientists found that for every degree rise in global temperature, the global rainfall rate since the Industrial Revolution has increased less by about 40% than during past warming phases of the earth.

Why does warming from solar heating and from greenhouse gases have such different effects on global precipitation?

"Our climate model simulations show that this difference results from different sea surface temperature patterns. When warming is due to increased greenhouse gases, the gradient of sea surface temperature (SST) across the tropical Pacific weakens, but when it is due to increased solar radiation, the gradient increases. For the same average global surface temperature increase, the weaker SST gradient produces less rainfall, especially over tropical land," says co-author Bin Wang, professor of meteorology.

But why does warming from greenhouse gases and from solar heating affect the tropical Pacific SST gradient differently?

"Adding long-wave absorbers, that is heat-trapping greenhouse gases, to the atmosphere decreases

the usual temperature difference between the surface and the top of the atmosphere, making the atmosphere more stable," explains lead-author Jian Liu. "The increased atmospheric stability weakens the trade winds, resulting in stronger warming in the eastern than the western Pacific, thus reducing the usual SST gradient—a situation similar to El Niño."

Solar radiation, on the other hand, heats the earth's surface, increasing the usual temperature difference between the surface and the top of the atmosphere without weakening the trade winds. The result is that heating warms the western Pacific, while the eastern Pacific remains cool from the usual ocean upwelling.

"While during past global warming from solar heating the steeper tropical east-west SST pattern has won out, we suggest that with future warming from greenhouse gases, the weaker gradient and smaller increase in yearly rainfall rate will win out," concludes Wang.

More information: Jian Liu, Bin Wang, Mark A. Cane, So-Young Yim, and June-Yi Lee: Divergent global precipitation changes induced by natural versus anthropogenic forcing. Nature, 493 (7434), 656-659; DOI: 10.1038/nature11784