Projections for climate change in Vermont

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Working with the RACC project — Research on Adaptation to Climate Change — engineering grad student Justin Guilbert, and statistics expert Brian Beckage were keenly aware that nine of the ten warmest years in the Vermont climate record occurred between 1990 and 2012. Their new study forecasts that this is just the beginning. Credit: Joshua Brown

Here's your northern Vermont forecast for the rest of this century: Annual precipitation will increase by between a third and half an inch per decade, while average temperatures will rise some five degrees Fahrenheit by midcentury. By late in the century, average temperatures will have spiked more than eight degrees. In July, by 2100, the City of Burlington will have at least ten additional days above ninety degrees. The growing season picks up 43 more days. Looking at ski conditions, expect annual snowfall at six major ski resorts to decline about fifty

percent by century's end.

And these are just a few of the estimates by a team of University of Vermont and other scientists in a new research study, "Impacts of Projected Climate Change over the Lake Champlain Basin in Vermont," published in the current issue of the *Journal of Applied Meteorology and Climatology*.

Scaled-down

A tidal wave of historical data, current observations, and computer models makes it clear that the earth's climate is getting hotter, and dangerously so. But one of the fundamental challenges of climate change forecasting is how to bridge the gap between global-scale models and local impacts.

"Our new study helps close this gap," says Justin Guilbert, the lead author on the new study and a doctoral student in UVM's College of Engineering and Mathematical Sciences. In one of the first such studies of its kind, he and his colleagues took four climate projections—that had been downscaled from global-scale "general circulation models," or GCMs—to look at likely climate change in northern Vermont and southern Quebec in greater detail.

This new study "gives us regionally downscaled climate change information that was not previous available," notes Gillian Galford, a University of Vermont climate scientist not involved in the new study and who leads the Vermont Climate Assessment project. "It is an advancement in climate modeling that has been needed by the state to build resilience economically, socially and environmentally in the face of climate change."

Using two scenarios of possible greenhouse-gas concentrations in the

future—a "high" and a "moderate" trajectory of C02 levels (called "RCP 4.5" and "RCP 8.5" to climate change wonks)—the team of scientists calculated a range of probable outcomes for the Lake Champlain Basin over the next 85 years. They then combined these projections with historical data on temperature and precipitation from weather stations over the period from 1961 to 2000 to assess Vermont's future climate.

"The strength of our study is that we used a much finer resolution grid—approximately 13 kilometers on side—instead of hundreds of kilometers, as you see in the GCMs, where all of Vermont fits in one or two boxes," notes UVM professor Brian Beckage who helped lead the new study. "This finer scale will capture more of the heterogeneity in the climate and landscape—and yields a more accurate local forecast," he says.

For example, the new study suggests that the number of days suitable for making maple syrup will decrease, and coarser global models might lead one to think that this would be a uniform problem across the state—or even that sugar maples themselves may be pushed out. "But if you look with this much finer resolution, you will see that there will be areas where the temperature will remain well within the range for sugar maple, at higher elevations and in these coves. It's more likely that its distribution will change. With a finer-scale model, we'll have a less dramatic headline, and a more accurate forecast," Beckage says.

"We wanted planners, the general public, and others to get a feeling for changes that they are likely to care about," Guilbert says. These include a rising heat index—"values in July for late in the century will make the average day feel approximately 13° Fahrenheit warmer," the scientists write. They also forecast more extreme temperature and precipitation events, increased chances for flooding, but also rising aridity during the growing season and increased number of short droughts.

Vermont Climate Assessment

The new study follows in the wake of the release of the National Climate Assessment at the White House in May, and the Vermont Climate Assessment, released by UVM's Gund Institute, in June.

The new study is the "type of work that is useful and meaningful to planners, policy makers and citizens," UVM's Gillian Galford notes, "These findings are consistent with the trends outlined by the Vermont Climate Assessment and go further—the authors provide quantitative details, such as a precipitation increase" of a third to a half an inch per decade. "These specifics were not previously available from existing tools and represent significant progress in understanding the local outcomes from global climate change."

Northern Vermont and the Lake Champlain Basin experience very different climates than Vermont's southern and northeastern region, Galford said, and "the state could use comprehensive analysis of climate change patterns across the state as these researchers continue to refine and expand their models."

Known unknowns

The conditions in the Lake Champlain region are forecast to—probably—get wetter and "this increased flow could overwhelm current infrastructure including bridges and culverts as well as increase nutrient loading to Lake Champlain through overland flow and stream bank erosion," the team writes. But there is enough uncertainty in the precipitation modeling, that, in fact, conditions could be drier by the end of the century, or patterns of rain and drought could be different than today.

"Things are obviously changing, but the climate system is complex. We'll never know exactly how it's going to respond," notes Beckage, an expert on ecological modeling and statistics. But getting closer, reducing error bars, clarifying what is and isn't "well-bounded," as the scientists say, is one of the great and urgent science challenges of the age.

"We're more confident about temperature," Beckage says, "precipitation is much harder to get right." And for policymakers, as well as scientists, knowing what is unknown—and levels of uncertainty—may prove as important as what is known.

Even the specifics of temperature are fuzzy. "It's going to get warmer, but it might get a lot warmer or it might just get a little bit warmer," Beckage says. He points at a graph in the new study labeled "temperature delta" where monthly temperature changes range from about a two-degree Fahrenheit rise to an alarming eleven-degree rise that might be in store over the next century. "That's huge uncertainty," he says.

But what makes the "known unknowns," in the inimitable words of Donald Rumsfeld, even more complicated is that scientific knowledge always, inescapably, lives in a social context. And no social context around science is more complex and fraught than the one around climate change.

Uncertainty, unfortunately, often leads to public confusion and feeds the fires of the climate-change skeptic community. A growing body of social science research makes clear that among people who are already skeptical about climate change, greater scientific information and literacy makes them more skeptical of the reality of climate change.

"The climate change skeptics like to focus on uncertainty and say, 'we should do nothing because it's so uncertain.' The other side is really worried, and wants to save the world, so they discount the uncertainty,"

Beckage says. "The most interesting and complex part of climate change science has become the social dynamic."

"Whether climate is changing and how much it will change is not like an electoral process that is determined by people's beliefs. Nature is going to behave the way nature is going to behave." Beckage says. "But the climate is a coupled human and natural system and we have a hand in what will happen next."

More information: "Impacts of Projected Climate Change over the Lake Champlain Basin in Vermont." Justin Guilbert, Brian Beckage, Jonathan M. Winter, Radley M. Horton, Timothy Perkins, and Arne Bomblies, 2014: Impacts of Projected Climate Change over the Lake Champlain Basin in Vermont. *J. Appl. Meteor. Climatol.*, 53, 1861–1875. dx.doi.org/10.1175/JAMC-D-13-0338.1

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