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Probabilistic Projection of Carbon Emissions

How can probabilistic projection methods for climate change improve upon existing methods?
The UN has concluded that human-caused temperature increases are mostly driven by carbon emissions. The Intergovernmental Panel on Climate Change (IPCC) is responsible for developing forecasts of future emissions to help estimate how much change in global temperatures can be expected by 2100.

In the past, IPCC has developed its estimates based on 4 scenarios, ranging from best case scenarios (lower levels of greenhouse gas levels over time) to worst case scenarios (high and increasing levels of emissions). A major limitation of this approach is that the scenarios are based on expert opinion rather than data and clearly stated hypotheses.

Raftery and colleagues improve upon this approach using probabilistic models to project future trends in factors that drive carbon emissions: population, GDP per capita, and carbon intensity. They develop these models based on trends observed over the past 50 years. Then, they apply them through 2100 for all countries.

What is the method for projecting the world population in 2100?
Raftery's approach relies on the demographic balancing equation for each country (the future population equals the current population plus births and immigration, minus deaths and emigration). Therefore, they must develop projections of each of these components. Using total fertility rates as an example, Raftery and his team use a Bayesian hierarchical model to develop separate estimates of changes in fertility rates for each country. The result is a sample of many possible future trajectories of TFR between now and 2100. A similar approach is applied to the other components.

What is the projected world population in 2100 based on probabilistic projections and how do they compare to prior estimates?
The current world population is 7.4 billion. The projection for 2100 using Bayesian methods is 11.2 (ranging from 10.1 to 12.4 billion with an 80% credible interval). Prior

conventional wisdom assumed the world population would peak around 2050 and then decline. However, by better accounting for the fact that fertility declines are likely to slow down, the new projections suggest the world population is unlikely to stabilize this century.

How does the probabilistic projection methods alter our understanding of projected changed in GDP and carbon intensity?

Through probabilistic projection, modeling of GDP growth can better account for the fact that GDP growth slows as a country reaches the upper reaches of global GDP levels. Through this method GDP is projected to rise approximately 1.8%.

In most countries carbon intensity has reached a peak and is now declining. There is no correlation between population and carbon intensity, although there is a correlation between GDP and carbon intensity. Of note, countries with higher GDP per capita than expected have lower carbon intensity than expected. Carbon intensity is projected to decline 1.9% annually.

Given these projections, what is the projected impact on climate change in 2100?

The median projected temperature increase is 3.2 degrees Celsius, with a 90 percent confidence interval of 2 to 4.9 degrees. The chance of staying below 2 degrees, an important threshold for catastrophic climate change, is roughly 5%.

To what degree are carbon emissions projected to be influenced by changes in population, GDP, and carbon intensity?

GDP is the largest factor, contributing to 50 percent of projected change, followed by carbon intensity at 48 percent. Population changes are only projected to contribute 2 percent of predictive variance in future carbon emissions.

What is the best focal point for policy interventions?

Given the small role of population, and the fact that efforts to reduce GDPs are not politically feasible, efforts to reduce carbon emissions should focus on reducing carbon intensity.