Paris Agreement does not rule out ice-free Arctic

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Research published in this week's issue of *Nature Communications* reveals a considerable chance for an ice-free Arctic Ocean at global warming limits stipulated in the Paris Agreement. Scientists from South

Korea, Australia and the U.S. used results from climate models and a new statistical approach to calculate the likelihood for Arctic sea ice to disappear at different warming levels.

Future climate projections are usually obtained from global climate computer models. These models are based on several hundred thousand lines of computer code, developed to solve the physical equations of the atmosphere, ocean, sea-ice and other climate components. Applying future greenhouse gas concentrations, each computer model produces a version of what the future of the Earth's climate might look like. Transforming this information into practical decisions is not easy, because of the remaining uncertainties in the magnitude of future climate change on regional scales. Decision making in a warming world requires an understanding of the probabilities of certain climatic events to occur.

Up to now, it has been difficult to extract meaningful probabilities from climate models, because these models sometimes share common computer code or make similar assumptions regarding the implementation of less well understood processes, such as clouds or vegetation. To obtain more accurate probability estimates for future climate change in the Arctic region, the research team has developed a novel statistical method which translates results from a suite of climate computer model simulations to probabilities. This method ranks the models in terms of how well they agree with present-day observations and accounts also for inter-dependencies amongst the models.

"Translating model dependence into mathematical equations has been a long-standing issue in climate science. It is exciting to see that our method can provide a general framework to solve this problem," said coauthor Won Chang, assistant professor in the department of Mathematical Sciences at the University of Cincinnati, U.S..

The researchers applied the new statistical method to climate model projections of the 21st century. Using 31 different climate models, which exhibit considerable inter-dependence, the authors find that there is at least a 6% probability that summer sea ice in the Arctic Ocean will disappear at 1.5 °C warming above preindustrial levels—a lower limit recommended by the Paris Agreement of the United Nations Framework Convention on Climate Change (Figure 1). For a 2°C warming, the probability for losing the ice rises to at least 28%. Most likely we will see a sea ice-free summer Arctic Ocean for the first time at 2 to 2.5°C warming.

"Our work provides a new statistical and mathematical framework to calculate climate change and impact probabilities," commented Jason Evans, professor at the Climate Change Research Center in UNSW Australia in Sydney.

"Up to now, there was no established mathematical framework to assign probabilities on non-exclusive theories. While we only tested the new approach on climate models, we are eager to see if the technique can be applied to other fields, such as stock market predictions, plane accident investigations, or in medical research," says Roman Olson, the lead author and researcher at the Institute for Basic Science, Center for Climate Physics (ICCP) in South Korea.

More information: R. Olson, S.-I. An, Y. Fan, W. Chang, J. P. Evans. A novel method to test non-exclusive hypotheses applied to Arctic ice projections from dependent models. *Nature Communications*. DOI: 10.1038/s41467-019-10561-x

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