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The Arctic is melting – so what?

Featured scientists: James Screen from University of Exeter, Clara Deser from National Center for Atmospheric Research, and Lantao Sun from University of Colorado at Boulder.
Co-produced with Science Journal for Kids. Written by Erin Conlisk.

Research Background:

A view of sea ice in the Artic Ocean.

Think of the North Pole as one big ice cube – a vast sheet of ice, only a few meters thick, floating over the Arctic Ocean. Historically, the amount of Arctic sea ice would be at a maximum in March. The cold temperatures over the long winter cause the ocean water to freeze and ice to accumulate. By September, the warm summer temperatures cause about 60% of the sea ice to melt every year. With global warming, more sea ice is melting than ever before. If more ice melts in the summer than is formed in the winter, the Arctic Ocean will become ice-free, and would change the Earth as we know it.

This loss of sea ice can have huge impacts on Arctic species and can also affect climate around the globe. For example, polar bears stand on the sea ice when they hunt. Without this platform they can't catch their prey, leading to increased starvation. Beyond the Arctic, loss of sea ice can change the climate around the globe through the **albedo effect** (or the amount of incoming solar radiation that is reflected by a surface). Because ice is so white, it has high albedo and reflects a lot of the sunlight that hits it and keeps the earth cooler. Ice's high albedo is why it seems so bright when the sun reflects off snow. When the ice melts and is replaced by water, which has a much lower albedo, more sunlight is absorbed by the earth's surface and temperatures go up.

Scientists wanted to know whether the loss of sea ice and decreased albedo could affect extreme weather in the northern hemisphere. **Extreme weather** events are short-term atmospheric conditions that have been historically uncommon, like a very cold winter or a summer with a lot of rain. Extreme weather has important impacts on humans and nature. For example, for humans, extreme cold requires greater energy use to heat our homes and clear our roads, often increasing the use of fossil fuels. For

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wildlife, extreme cold could require changes in behavior, like needing to find more food, build better shelters, or move to warmer locations.

To make predictions about how the climate might change in the coming decades to centuries, scientists use **climate models**. Models are representations, often simplifications, of a structure or system used to make predictions. Climate models are incredibly complex. For example, climate models must describe, through mathematical equations, how water that evaporates in one region is transferred through the atmosphere to another region, potentially hundreds of miles away, and falls to the ground as precipitation.

Releasing a weather balloon to collect data for climate models.

James is a climate scientist who, along with his colleagues, wondered how the loss of arctic sea ice would affect climates around the globe. He used two well-established climate models – (1) the UK's Hadley Centre model and (2) the US's National Center for Atmospheric Research model. These models have been used previously to predict how much sea ice to expect in 2100. The climate models are not described in detail here because it would take thousands of pages!

Scientific Question: Based on these climate models, how will the projected decrease in Arctic sea ice levels affect climate around the world?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Scientific Data:

Climate models function like an experimental system, predicting future extreme weather under two "treatments": the current sea ice levels (control) versus the reduced sea ice coverage predicted for 2100 (treatment). James and his collaborators ran the two models varying only the starting conditions of how much sea ice was present. For both the current and reduced sea ice coverage, the computer calculated an answer to a complex series of equations that describes the climate in future years. The results of the calculations are shown in the figure.

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Taking a sea ice core to determine its thickness.

The scientists expected that changing the amount of sea ice in the Arctic would impact weather around the globe, with different changes in different parts of the world. They expected that, compared to the control, the treatment models with reduced sea ice would have more extreme weather.

To figure out if weather is considered extreme you need to look to the past. To define extremely warm and cold days, take all the observed temperature values for a particular day of year and rank them from warmest to coldest. The 10th percentile reflects the temperature value where 10% of all the temperature values fall below that value. Because only a few observations are colder than the 10th percentile (specifically, only 1 in 10 days), we define it to be a "cold" day. Similarly, the 90th percentile reflects the temperature value where 90% of all the temperature values fall below that value. A day that was historically hotter than 90% of all other days is thus defined as a "warm" day.

From both the control and treatment climate models, scientists collected four pieces of data:

1. Warm days: Percent (%) of days when the maximum temperature is greater than the 90th percentile of historic temperatures
2. Cold days: Percent (%) of days when the maximum temperature is less than the 10th percentile of historic temperatures
3. Wet days: Number of days per years when daily precipitation is greater than 1 cm
4. Dry days: Number of days per years when there is no precipitation

They then took this data and compared the results of the control and treatment models, looking for differences between the two. The scientists separated the data out into different parts of the globe because they expected that the effect of sea ice on extreme weather would vary by location.

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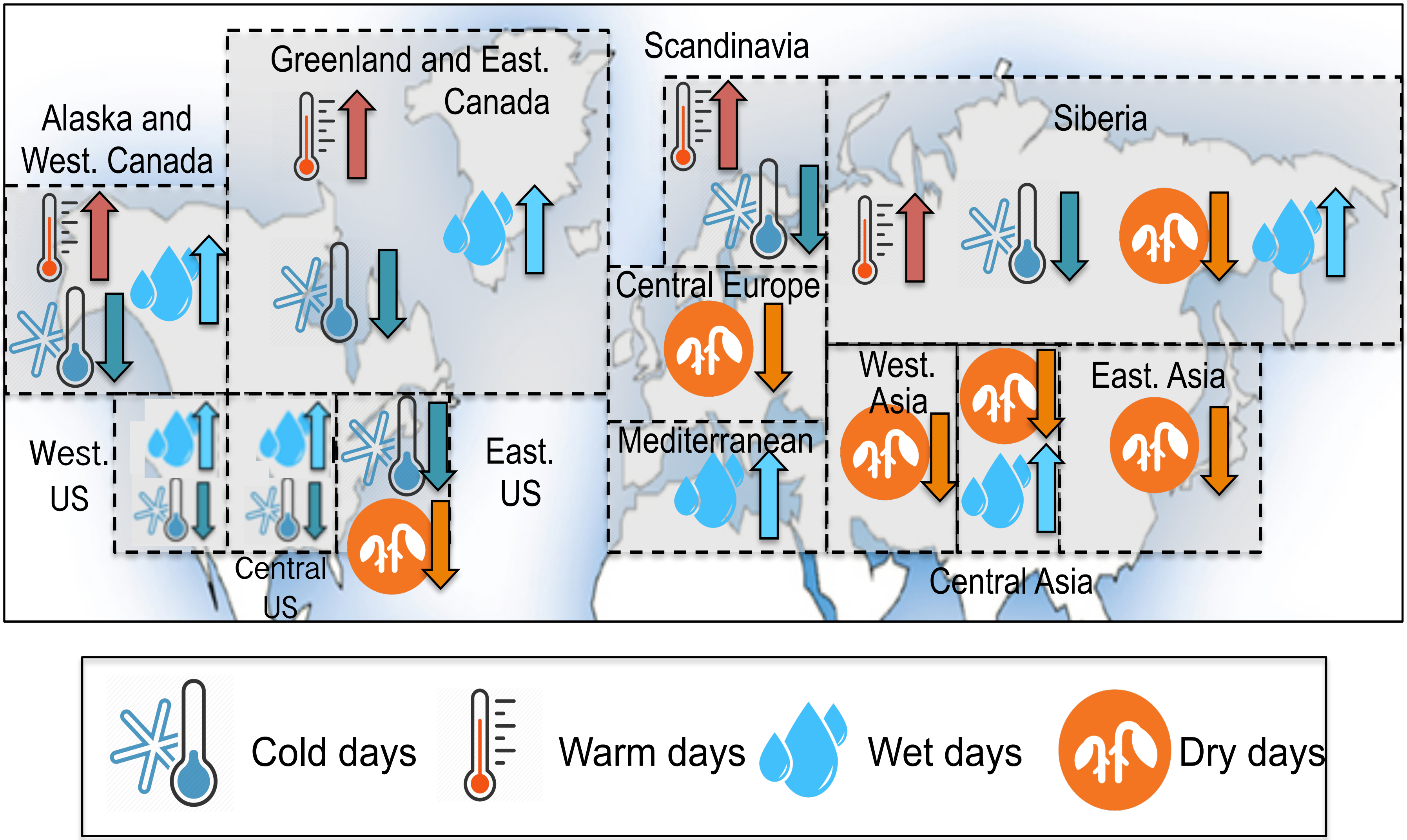
Use the model results below to answer the scientific question:



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What data will you use to answer the question?

Independent variable: ____

Dependent variables: ____

Interpret the model results:

What is the effect of decreased Arctic sea ice on different regions of the globe? Complete the table below with your extreme weather observations.

Extreme Weather		Observations
	**Cold days**	
	**Warm days**	
	**Wet days**	
	**Dry days**	

Make a claim that answers the scientific question.

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What evidence was used to write your claim? Reference specific changes in climate at different locations on the model.

Explain your reasoning and why the evidence from the model supports your claim. Connect the data back to what you learned about how models can be used to predict outcomes based on varying amounts of sea ice.

Did the data support James' hypothesis? Use evidence to explain why or why not. If you feel the data are inconclusive, explain why.

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Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on James' research? How do your questions build on the research that has already been done?