

GEOL 170
Lab 11
12 April 2013

The Antarctica Climate Skeptic

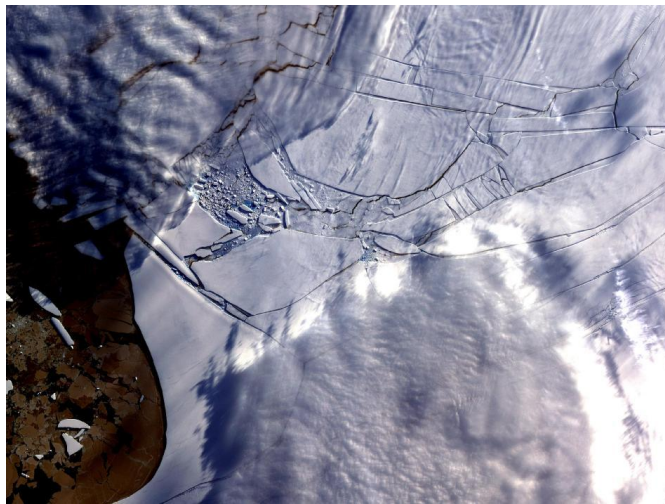
In the following conversation, we will attempt to model the debate surrounding localized cooling versus global warming trends. Specifically, we will address the climate skeptic argument that sees evidence of cooling in East Antarctica as capable of undermining climate scientists' claims that climate change is occurring primarily due to anthropogenic causes. We will situate this debate in the context of a non-academic conversation between two friends on campus, because we are all familiar with situations in which we have to take a defensive position in discussing anthropogenic causes of climate change with friends and family of different mindsets, beliefs, and backgrounds.

Climate believer (CB): Wow, it is such a warm day and it's only April. Global warming is already upon us.¹

Climate skeptic (CS): It might be hotter here, but Antarctica is cooling. The East Antarctic ice sheet is actually growing. Global warming should mean that the Antarctic ice shelf is shrinking. But that is not what is actually happening. So I'm skeptical about the global warming hypothesis.

CB: Really? I've never heard of that argument before. Where did you read that?

CS: This is from an article in news.com.au by Greg Roberts. It said that ice core drilling of East Antarctica's ice sheet showed 2008's ice sheet being above average in maximum thickness. In fact, 2008 was densest over the whole of the past decade with an ice sheet maximum thickness



of 1.89m. The average thickness since the 1950s has been just 1.67m. Also, a Scientific Committee on Antarctic Research report noted that the South Pole has significantly cooled in the recent decades.

CB: Interesting. That may be true for East Antarctica, but it's clear that West Antarctica, on the other hand, is experiencing warming. Have you heard of the Wilkins ice shelf? In 2008 it "experienced multiple disintegration events" according to NASA. Check out this image of the ice shelf. It's obvious that it has undergone massive melting in the 21st

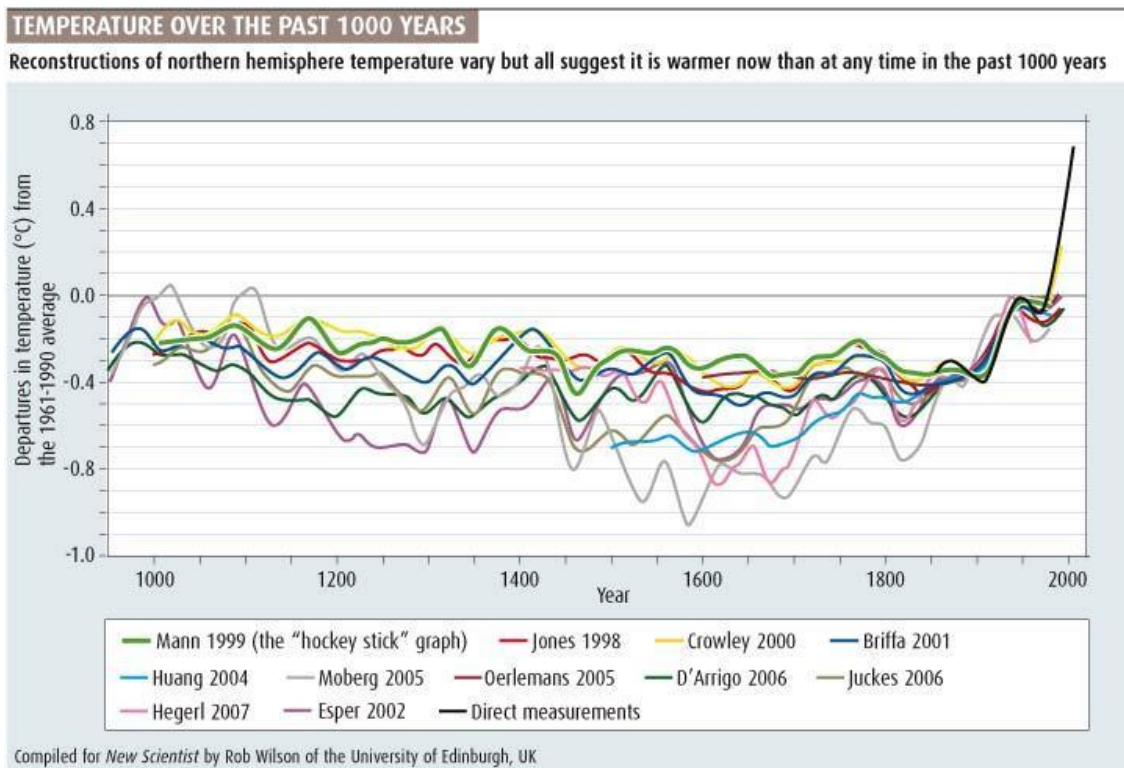
century, as it no longer remains in tact.

(Image from NASA: http://www.nasa.gov/multimedia/imagegallery/image_feature_1341.html).

¹ Global warming need not imply that a particular day in April will become hotter.

CS: But there is nothing unusual about the West Antarctic ice shelf losses. Icebergs episodically calve off from ice sheets every 10 or 20 or 50 years. It is normal for even large icebergs 100-200km long to break off. Moreover, East Antarctica is four times the size of West Antarctica. An Australian Antarctic Division glaciology program found that sea ice losses in Antarctica over the past 30 years have been more than offset by increases in Ross Sea region, just one area of East Antarctica. I know that sea ice melting won't increase sea levels, but the sea ice increases in East Antarctica provide some evidence that Antarctica is cooling on average.

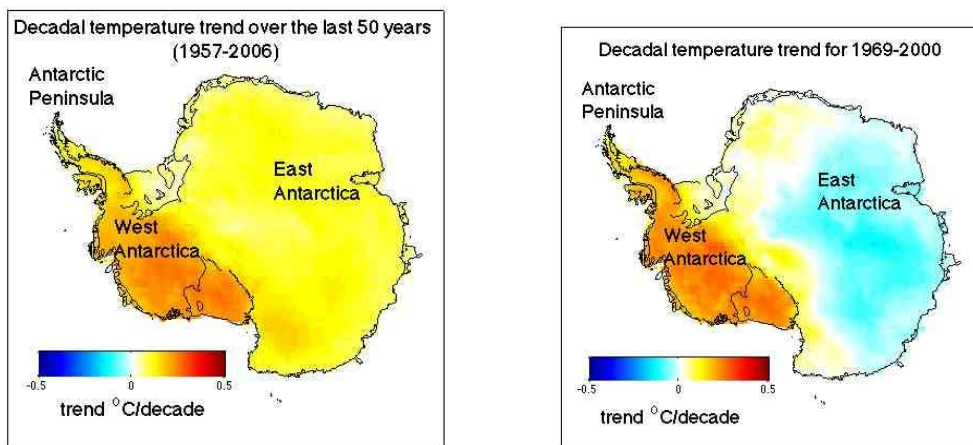
CB: I guess I'll take your word for it, but you should understand that it is very clear that the climate is showing a general warming trend. *New Scientist* claims that "even if Antarctica was getting cooler, it would not mean the world as a whole isn't warming. Climate models do not predict an even warming of the whole planet" (McKenna 2007). Although East Antarctica might be cooling, the globe as a whole is obviously warming on average. Check out the graph below. It shows a huge variety of scientific reports, all of which agree that "it is warmer now than at any other time in the past 1000 years." (Image from *New Scientist*: http://www.newscientist.com/data/images/ns/cms/dn11648/dn11648-2_726.jpg).



CS: OK, let's move from the empirics to the dynamics. If global temperatures are warming on average, can you explain why Antarctica is not warming so? What do you predict will happen to Antarctica's climate in future? I predict that Antarctica is going to become cooler and perhaps even counter-balance the warming global average temperature. As the East Antarctic ice sheet is growing, its rising surface albedo will reflect more sunlight, cool down air temperatures, and

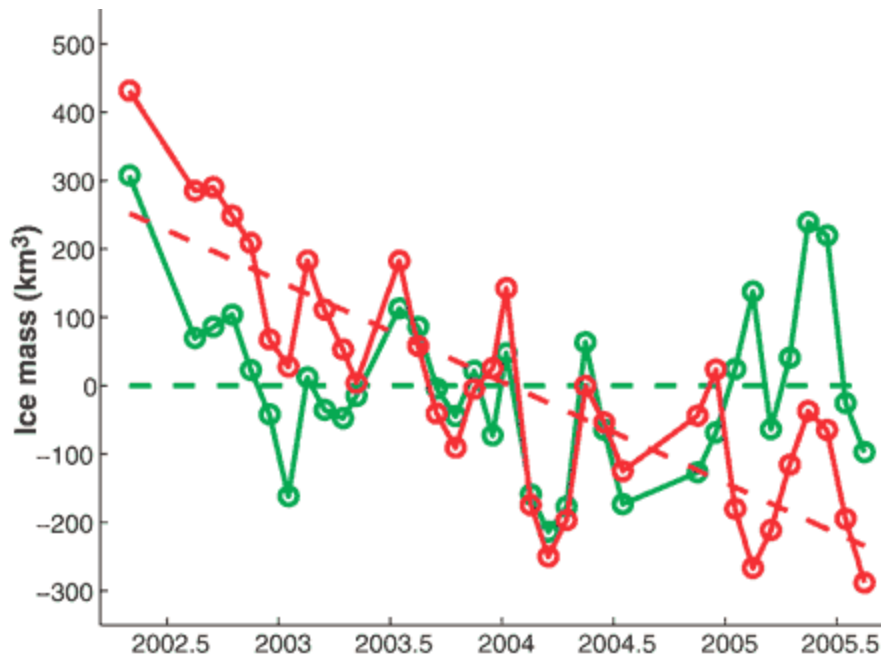
cause the ice sheet to grow even larger. This is a good positive feedback loop for us! Are you ready for the next ice age?!

CB: Wait, we aren't done with the empirics yet! A paper by Steig et al. (2009) in *Nature* concluded that Antarctica (both East and West) has been warming over the past 50 years, backed up by quality data from automatic weather stations and borehole thermometry. And significant warming has occurred in West Antarctica. See the graphics. Even East Antarctica has warmed a bit. While East Antarctica has definitely cooled since 1969, its magnitude is way smaller. Steig et al. mention that this cooling isn't at a statistically significant rate. Any ice albedo feedback because of East Antarctica is likely to be dwarfed by the West Antarctic warming. I suggest that you forget about your ice age dreams for now.



(Image from RealClimate <http://www.realclimate.org/index.php/archives/2009/01/state-of-antarctica-red-or-blue/>).

This is not all. The next graphic on ice mass change from gravity variation measurements by the GRACE satellite shows that from 2002 to 2005, East Antarctica was in approximate mass balance, whereas West Antarctica is losing ice. In fact, Skeptical Science notes that Antarctica's land ice mass is not only decreasing, but is decreasing at an accelerating rate of 26 Gigatonnes/yr².



(Image from Skeptical Science: <http://www.skepticalscience.com/Is-Antarctic-ice-melting-or-growing.html>)

CS: OK, I agree that East Antarctica hasn't been cooling as much thus far. But we should both bear in mind that there has been uncertainty over exactly how Antarctica's climate is changing. There aren't many weather stations and most of them are located towards the periphery, rather than the interior. Moreover, the instrumental record goes back over only a few decades. So let's move on to the dynamics. How would you explain why East Antarctica has "anomalously" been cooling and what is your prediction for the future?

CB: Of course. Have you heard about the hole in the ozone layer over Antarctica?

CS: Yes, the ozone layer has been thinning over the Antarctic continent since the late 1970s. Less ozone in the Antarctic stratosphere would mean less absorption of UV rays from the sun. As ozone is one of the principal reasons for the increase in stratospheric temperatures with altitude, the ozone hole might cause stratospheric temperatures to fall. How does this relate to the East Antarctic cooling?

CB: Well, Thompson and Solomon (2002) argue that that hole situated above Antarctica has increased the strength of the circumpolar westerly winds around Antarctica. These winds ended up cooling parts of the Antarctic continent by preventing warmer air from the north from reaching the interior of the Antarctic continent. This seems to make sense when you see the ozone hole building only since the late 1970s. This has also been the time around which any significant cooling began in East Antarctica.

CS: OK, I agree that the circumpolar westerlies were contributing to the cooling of East Antarctica. But I'm skeptical that it was just the ozone hole that was responsible for this. You can't just infer causality because the ozone hole and East Antarctic cooling were occurring around the same time! Perhaps this was due to some natural variability that might return again periodically in the future and keep the East Antarctic ice sheets from shrinking too much.

CB: Actually, a paper by Gillet et al. concluded in 2008 that observed changes in Antarctic temperatures are not consistent with natural variability alone and are attributable to human influence. The hole in the ozone layer is also a product of humans messing up the environment. Our emissions of chlorofluorocarbons (CFCs) led to an atmospheric breakdown of ozone, and although the Montreal Protocol in 1987 began to ban CFCs, they persist in the atmosphere today.

However, as the CFCs diminish from the atmosphere, the ozone layer is going to continue to recover. As the ozone hole recovers, the circumpolar westerlies will weaken and allow warmer winds from the north to cause rapid warming throughout Antarctica. This means that the East Antarctic cooling is only a temporary phenomenon and might reverse itself in future. This isolated Antarctic anomaly doesn't disprove the global warming hypothesis by any means.

CS: OK, it might be true that global temperatures are warming and that Antarctica might warm in future. But would this really mean any danger to us in terms of sea level rise? Antarctica has 90 percent of the Earth's ice and 80 percent of Earth's fresh water. Only extensive melting of the Antarctic ice sheets would result in any significant sea level rise. Such an extensive melting isn't happening right now. Why should we bother so much about global warming?

CB: If the Wilkins ice shelf that I mentioned earlier is any indicator, Antarctica can show abrupt signs of being affected by global warming trends. The fact that the vast majority of Earth's ice and fresh water are concentrated in one place, especially at the south pole, worries me. In fact, the Antarctic ice sheets "hold enough water to raise sea level by a catastrophic 61 metres, should it all melt" (McKenna 2007). Global warming is also expected to impact the poles more than mid-latitudes due to something called polar amplification (which arises from the ice-albedo feedback).

CS: Even though you might have convinced me that the Antarctic cooling doesn't disprove global warming, I disagree that global warming will cause the Antarctic land ice to melt away rapidly. In fact, the IPCC third assessment report mentions that global warming will lead to an increase in precipitation over the Antarctic and thicken the ice sheets over the coming years. This is a great negative feedback loop at work! This will mitigate both global warming and sea level rise through the ice-albedo effect. We're saved!

CB: Wait, you've got to look at the scale of the negative feedback loop! While it is true that we can expect some increase in the land ice because of increased precipitation, IPCC mentions that the increase will be very slight and do little more than maintain the ice mass balance intact. And remember, global warming on average and Antarctic cooling aren't contradictory. The IPCC also notes that warming temperatures will primarily cause ice mass shrinkage in both West

Antarctica and Greenland. This is bad news for low-lying regions across the world. I hope you are convinced at least now that global warming is happening and that nature won't automatically stabilize it.

CS: No, I'm not going to accept the global warming and sea level rise threats! Global warming might be happening now, but it won't go on forever. Let's wait and see. I bet you'll soon hear good news about Antarctica's land ice growing thicker and thicker from all the extra precipitation! OK, right now, I'm going to buy myself an extra pair of sweaters to get ready for the great cooling up ahead!

Informal Bibliography:

From IPCC:

http://www.grida.no/publications/other/ipcc%5Ftar/?src=/climate/ipcc_tar/wg2/600.htm.

From Gillet et al. (2008)

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<http://www.skepticalscience.com/antarctica-gaining-ice-basic.htm>.

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<http://www.sciencemag.org/content/296/5569/895.abstract>.

Reflection:

We initially thought that a skeptic trying to challenge climate change based on just the Antarctic cooling will be unable to come up with a strong argument, given all the evidence that even East Antarctica is heating up slowly and that ice losses will increase as ozone levels recover. However, given that so many feedbacks that either stabilize or amplify climate change are possible, we learned how easy it can be for a skeptic to over-emphasize one small feedback and arrive at a misguided conclusion. Also, it is interesting that skeptics strategically choose Antarctica to debunk global warming because a growth in Antarctic ice will have an amplified cooling effect due to the ice-albedo feedback. Skeptics can also exploit the fact that good past climate records from Antarctica's interior are unavailable, making trends harder to discern. Overall, we were happy that we couldn't just push aside the skeptic's argument as just another regional cooling case. The skeptic's questions about the dynamic causes of Antarctica's cooling (whether it has to do with the ozone hole or not) and about its continuation in future remain fruitful areas of inquiry and debate.