American Geophysical Union AMA: Hi Reddit, I'm Chris Borstad, and I'm here to talk about the peculiar nature of snow and ice related to avalanches and glaciers. Ask Me Anything!

AmGeophysicalU-AMA [1] and r/Science AMAs[1]

[1]Affiliation not available

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Absolutely fascinating area of study. What is the most common way for ice to fracture naturally? How thick is this particular ice shelf, and does movement of the ocean contribute to the shelf eventually breaking off? When it does break off where will it go? Thank you for sharing.

Ziglet_mir

Lots of good questions here!

For ice (or any other material) to fracture naturally, you need a something that causes a locally high amount of force. For glaciers and ice shelves, cracks are commonly formed in areas where the ice speeds up, such as when a glacier spills over the crest of a steep slope. Many cracks in Larsen C originate in places where the ice speeds up after flowing past the end of a peninsula (the ice scrapes along the side of the peninsula, which slows it down somewhat until it clears the end of the peninsula). Many of the details of crack formation are still unknown, however, and this is a key focus of much of my research!

Larsen C is thickest where it first comes afloat, at around 600 m (2000 ft). It gradually gets thinner as it flows out into the ocean, tapering to around 250 m (~800 ft) thick at its furthest extent from land.

It has been observed that some large cracks grow and even release icebergs following the arrival of tsunami that originate from earthquakes halfway around the planet! The following study tracked crack growth and iceberg calving associated with the arrival time of tsunami from very large earthquakes: https://scripps.ucsd.edu/biblio/structural-and-environmental-controls-antarctic-ice-shelf-rift-propagation-inferred-satellite

As for where the iceberg will go when it is released, this will depend on the ocean currents and whether the iceberg runs aground anywhere. To get an idea, my colleagues at the University of Swansea have compiled this map that tracked the paths of icebergs following the collapse of the Larsen B ice shelf in 2002: https://twitter.com/MIDASOnIce/status/831545684390211585/photo/1

What is the ~*coolest*~ thing that you've seen in your research?

spinach_nipplesalad

It's really hard to pick a single thing that is the coolest! There's nothing quite like standing on shore next to a large glacier and watching a giant iceberg break off into the ocean, causing a huge splash and a large wave that travels out into the fjord. Just as awe-inspiring (and scary!) is watching a large avalanche tumble down a mountain. During my PhD research in British Columbia, Canada, I saw some very large avalanches caused by artillery operated by the Canadian Army. There's nothing like watching a 105 mm Howitzer booming away at a mountain and causing giant avalanches that crash down across a (closed) highway!

What can be done (if anything) to prevent the Larsen C ice shelf in Antarctica from cracking and releasing the iceberg? What are the consequences of this being released?

prodigies2016

This is a very insightful question! Ice shelves actually have their own natural defense mechanism that is quite effective at "stopping" cracks like this. For an illustration of this, take a look at Figure 6 from this publication on Larsen C: https://www.researchgate.net/publication/260342546_The_structure_and_effect_of_suture_zones_in_the_Larsen_C_Ice_Shelf_Antarctica/f lo=1 It shows how, in the past, many cracks (which we call "rifts" when they penetrate through the full thickness of the ice) have been stopped for decades by what we call "suture zones" in the ice shelf. Suture zones are the boundaries between what used to be separate glaciers before they drained into the ocean and merged together as part of the floating ice shelf. For reasons that we don't entirely understand yet, these suture zones are very effective at stopping cracks. The current crack in Larsen C is stalled in the same suture zone shown in the figure, which has stabilized previous cracks for decades! Of course the current crack is much longer than any that we've seen in the past, so we expect it to break across this boundary eventually. It could be tomorrow, or it could take another year!

As for the consequences, most of the ice removed by the iceberg is "passive" and won't make a big difference to the ice shelf in the short term. Myself and colleagues have done some computer modeling of the ice shelf that indicates the remaining ice should speed up a little bit after the iceberg is released. The next big question is whether we will see similar large cracks open up in the ice, or perhaps a transition to more frequent, smaller icebergs gradually eating away at the shelf (which is what happened to the neighboring Larsen B ice shelf prior to its disintegration in 2002).

As the previous comments indicated, there will be no direct sea level rise from this iceberg, since it is already floating.

The Larson ice shelf displacement has been getting significant media coverage. Many stories draw a direct causation between this displacement and climate change. Historically, are large-scale glacier displacements somewhat commonplace or is this type of event becoming more frequent?

SergePower

We don't know yet whether the current crack in Larsen C was related to climate change. Icebergs are regularly released from ice shelves, even in a stable climate. Floating ice can only spread out and thin so much before it becomes susceptible to cracking. It is possible, however, that warmer ocean currents may have been melting the bottom of the ice shelf, which may have made it easier for this crack to begin growing in the first place. This would be a plausible connection to climate change, but we have to do more research to know for sure. It is very hard to figure out what is happening in the ocean beneath hundreds of meters of ice!

Hi Chris, I am currently a Geophys Undergrad who hopes to pursue research in the Arctic Physics field. As you live on Svalbard, I assume a reasonable fraction of your work is fieldwork based. What sort of percentage of your research is in the field compared to theoretical and lab work?

duvetcover6

The ratio of field work versus theoretical/lab/numerical work varies a lot from one Arctic scientist to another. For me it varies for the snow versus glacier research I do. Most of the avalanche research I do here in Svalbard is field-based. Of course I have to spend time analyzing data and working out theory in my office here (though I have a terrific view from my office). For my glacier research, the work I do here on Svalbard glaciers is mostly field based. However, my work studying Larsen C and other ice shelves in Antarctica is mostly modeling and remote sensing. So, depending in your interests and skills, you can find a way to carve out a balance that works just right for you.

Utah native here. Lots of my friends go hiking in the backcountry with complete confidence that avalanches don't happen in that mountain rage where they hike. I know this isn't true, as I've witnessed them once or twice. They only believe in tree wells.

What is the best way to teach someone avalanche safety for mountaineering and/or backcountry skiing?

Cessna71

Some great suggestions in the comments already. I particularly like the "Know Before You Go" video and resources: http://kbyg.org/

I would recommend searching out a local Avalanche Awareness event. These are usually very fun and very educational at the same time. They typically have a combination of videos, presentations, and often a lot of free swag to give away! They can also be a good venue for meeting new friends to head out into the backcountry with.

What's your favorite place to ski?

jesuiskara

Growing up in Colorado, I skied all over the place. One of my favorite resorts was (and still is) Arapahoe Basin. When I lived in Vancouver, I really enjoyed skiing Whistler-Blackcomb. These days, I hardly ever ride a chairlift. I prefer to ski in the backcountry, seeking out fresh powder and great scenery with friends, away from the crowds. I have many favorite backcountry stashes in the Columbia Mountains of British Columbia. It's also quite special to ski here in Svalbard. Last winter I skied under the northern lights for the first time, which was a very memorable experience.

I'd like to ask a few questions related to this, if possible:

What are the long term implication factors of an iceberg the size of Delaware breaking off?

Does it automatically raise sea level any substantial amount?

Does the saltiness of the berg affect ocean chemistry in any significant way?

What are the risks for a Tsunami resulting from such a large displacement, if any?

flyingfisch

Since ice shelves themselves are already floating in the ocean, there is no change in sea level when icebergs break off. For the same reason, they do not cause tsunami when they break off.

Since ice shelves are extensions of the Antarctic ice sheet, they are mostly glacier ice that formed from years and years and years of snowfall in the interior of Antarctica. Thus there isn't really any "saltiness" in an iceberg to speak of. When icebergs melt, however, they do cause a local freshening of the surrounding ocean, which does have implications for marine biology and chemistry.

The most complicated and important question is the first: what are the long term implications? For this one iceberg, the consequences are likely to be relatively minor. A model I have developed for Larsen C indicates that the remaining ice will likely speed up a little bit after the iceberg detaches. The biggest potential long term implication is if Larsen C continues to weaken and eventually collapses entirely. Ice shelves are kind of like glacier traffic jams: they form when neighboring glaciers flow into the ocean, merge together and attempt to spread out in the water. The ice on land is at the back of this traffic jam, and has to slow down before it can reach the ocean. When an ice shelf disintegrates, this traffic jam clears and the ice on land starts to flow much faster into the ocean, and this results in an increase in sea level. So ice shelves indirectly influence sea level because they are slowing down the rate at which ice on the continent reaches the ocean.

My colleagues at the University of Swansea have been providing great updates on the situation for Larsen C on their MIDAS project blog, including this handy FAQ that answers many of these questions: http://www.projectmidas.org/blog/rift-faq/

I am currently teaching abroad and the university I work for does a "lecture series" where foreign teachers prepare one 40 minute lecture on any topic of their choice. I chose to do a talk on glaciers because, well, they are really freakin cool. I don't know too much about them and I'm about to start researching and preparing a presentation. My main goal is to spark their interest and bring attention to why glaciers are so important (we are in a climate change hotspot for flooding from glacier melt). Do you have any suggestions for me?

Chalupanana

Glaciers are really freakin' cool!!!

I think a fantastic and accessible resource is the website http://www.antarcticglaciers.org/ which is maintained by fellow glaciologist Bethan Davies. It has a lot of great information to get you started in thinking about putting together a basic lecture. Good luck!

I've found that most cellphones these days can't function very well in even near freezing temperatures, which makes me wonder: What cellphone (or satellite phone) do you use in the extreme cold? Do you need a specific case? What's the craziest cold related technology fuck up you've experienced out there? Wicked cool job man!!!

becauseIthinktoomuch

Yes, this is definitely an issue here. Some phones seem to do better than others in the cold. I generally try to keep my phone in an internal pocket so that it stays warm from my body heat (although well separated from my avalanche beacon! cell phones can interfere with beacon transmission). Then I'm generally okay if I need to pull the phone out briefly for something like taking a picture. However, as a rule I try not to rely on my cell phone when I'm out in the cold. If it's really cold, usually my biology fails before most of my technology ;)

Living in a place that remote do you get used to seeing Northern Lights?

Talltrackie92

I still haven't grown tired of seeing the Northern Lights :)

I kind of agree with the previous comment, if the activity is faint I may not get too excited or go out of my way to watch. However, when the activity is high and the aurora is really dancing around overhead, my jaw still drops!

Is it possible to rejoin icebergs to mainland, atleast in theory?

TheVikO_o

Well, in theory, if you clamp two ice cubes together in your freezer, they will eventually re-join as one. However, in practice it is hard to imagine the logistics of putting a Delaware-sized iceberg "back in place" against an ice shelf, especially because the ice shelf is continuing to deform and flow out into the ocean. That would make for quite an episode of Mega Machines ;)

Colorado splitboarder here... As you probably know, Colorado sees some of the most dangerous avalanche conditions in North America, year in and year out. There's been a lot of improvement in gear over the last decade, but fatalities and accidents continue, especially as more people head into the backcountry. CAIC here does a fantastic job here, and education is key, so I'm wondering if there is any new information on the science of avalanches that will/should be added to the AIARE courses?

Specifically, anything you've added to your education from personal experience, which could provide other seasoned enthusiasts a heads up when skiing or touring? I know it's a deep and complex subject, but I'm always looking for better advancement of the education from others. Thanks in advance.

EliteAsFuk

I grew up in Colorado, so I know firsthand how scary the snowpack can be with respect to avalanches there! As for the evolution of science and avalanche curricula, the avalanche community is quite unique in that there are regular exchanges between avalanche researchers and practitioners (guides, avalanche forecasters, ski area operators, etc.). Every two years there is an International Snow Science Workshop (http://www.issw.net/), the most recent of which was in October 2016 in Breckenridge, CO. My colleague and friend Ethan Greene, who is the director of the Colorado Avalanche Information Center, was one of the Conference Chairs of ISSW 2016, so I can assure you that he is aware of the latest research presented at the conference. I'm not fully up to date on the latest developments in the AIARE curriculum, but I do know that this does evolve as the science evolves.

What are the hypothesized "runaway"-type effects of something like the release of a giant iceberg? That is, can it lead to other abnormal events that might affect the climate? Do you have models that try to describe these?

BBBBBernIsTheWord

The biggest potential runaway effect following the release of the iceberg would be further iceberg calving until eventually the ice shelf disintegrates, as its neighbor Larsen B did in 2002 (http://earthobservatory.nasa.gov/Features/WorldOfChange/larsenb.php). For Larsen B, this was like “popping the cork” which allowed the glaciers feeding the ice shelf to begin flowing faster and faster into the ocean. They are continuing to flow faster than they used to, which has increased the sea level contribution from these nearby glaciers. The concern is that Larsen C may have the same fate in the not-to-distant future. We do have models that attempt to predict how/when this may happen, and some results suggest that Larsen C may be quite vulnerable to any further iceberg calving after this current large iceberg detaches.

Do tectonic forces play much part in the behaviour of ice shelves or is it predominantly the action of the elements which is responsible?

halborn

For the most part, ice shelves spread out simply under the action of gravity as they float in the ocean (like pancake batter spreading out in a skillet). However, tectonic forces indirectly influence ice shelves when earthquakes cause tsunami, which can cause cracks to grow and icebergs to release.

how about the job market? do you have stable contracts? in germany researchers usually only get contracts for 1/2 or 1 year

winniekawaii

It's a good time to be a glaciologist! Our work relates to the effects of climate change and predicting sea level rise, which are important (and relatively well funded) research subjects globally. The length of contracts varies a lot, depending on whether you are funded by individual research grants or hired directly by a university or research institute.

Hi!

I'm not sure if you've read about it but four people, including an instructor, recently died in an avalanche in Tignes, France (link here).

I was just wondering if you could weigh in? I know it's not quite the same level of discussion as the Larsen C ice shelf, but these people were under supervision of a trained professional and had already ski-ed the route that day. What kind of factors might be involved in a slide like this?

Ed_is_on_Reddit

I don't intimately know the details of this avalanche. From the media reports, it sounds like the avalanche was triggered by someone above them. It looks like the avalanche then flowed down on top of the victims and buried them, presumably through no fault of their own (disclaimer: I am purely speculating here based on limited information).

If this is true, it is a very unfortunate circumstance of being in the wrong place at the wrong time. This is usually not the case in most avalanche accidents involving humans, however (of course the tragic avalanche accident in central Italy earlier this winter, in which a hotel was buried, is a notable exception). The majority of people killed in avalanches either triggered the avalanche themselves, or had it triggered by someone in their group. So usually avalanche accidents are the result of human error.

Thank you so much for speaking with us today.

Have you had any close calls while doing field work?

Is there any way to slow ice shelf loss at this point or are we now in mitigation mode?

What has been the most surprising data to come out of your research?

Thank you again! Your time is appreciated.

FillsYourNiche

It will be hard to slow the thinning and loss of ice shelves in many parts of Antarctica. Warming in the atmosphere and ocean are eating away at ice shelves from above and below. This is especially the case in West Antarctica, where warm ocean currents are rapidly melting ice shelves from below. Most of the West Antarctic Ice Sheet sits on bedrock below sea level, which leaves this sector of Antarctica very vulnerable to irreversible retreat. In fact, many of my colleagues believe that the collapse of the West Antarctic Ice Sheet may already be underway, and there is nothing that we can do to stop it.

http://www.antarcticglaciers.org/2014/05/west-antarctic-ice-sheet-collapsing/

What originally ignited your passion for ice and snow? :)

Darling_Jess

I grew up in Colorado, and always enjoyed winter sports, especially skiing. As I was finishing up my undergraduate degree at Colorado State University, I took my first recreational avalanche course. I was immediately fascinated with how complicated avalanches were! Snow is one of the most complicated materials around! I was probably the annoying student in class that kept asking question after question after question. Eventually I discovered that there were graduate programs in avalanche science, so I followed my curiosity to Vancouver, British Columbia for a Master's degree and then PhD studying avalanches. Following my PhD, I thought it would be interesting to start looking at solid ice, and I managed to land a Postdoctoral fellowship with NASA to bring my expertise in fracturing of snow to look at fracturing of ice shelves.

How have computer simulations helped you better understand the composition of snow and ice? What kind of data on glaciers and avalanches do you want, but typically have trouble accumulating?

Scarbane

The data that we typically want the most is from places we can't reach: the bottom of a glacier, or the ocean cavity beneath an ice shelf. When we see meltwater flowing into a glacier, we would really like to know where it goes, and how it travels through or under a glaicer. For some of this, we do use computer simulations to help us infer what is happening in places we can't see by calibrating our models to behave according to what we can measure from the surface (how fast the ice is moving and how thick the ice is, for example).

Do you know of any papers on numerical models of glaciers and the erosion that they do?

Marthinwurer

This is a great question for a glacial geologist! Which isn't me...

Glaciers do modify the landscape as the evolve through the long stages of glaciation and deglaciation. Some great introductory reading, with links to some specific papers, can be found here: http://www.antarcticglaciers.org/glacial-geology/glacial-landforms/

Is there a way to actively and effectively prevent avalanches? I've heard in some areas they use old artillery to trigger avalanches preemptively. Is this true?

Last_Paladin

Explosives are indeed used in many places to cause avalanches in a controlled manner while people are out of the way. There isn't really a practical way to prevent avalanches.

I know this might sound stupid, but is there anything we could potentially do to refreeze portions of ice on/around glaciers?

For example, I recently saw a video on how as glaciers freeze over seawater, the water molecules freeze and but the salty brine does not and will leak out from beneath the ice. As it falls due to what I assume is density differences, the supercooled substance is so cold that it instantly freezes the water around it, forming a brinicle. What I'm wondering is if we could potentially reproduce this effect on a larger scale to yield anything positive for the ice caps.

Thank you for your time, I look forward to hearing from you.

EDIT: Link to video in question.

Commander_Prime

Brinicle formation is quite a fascinating phenomenon! This kind of behaviour in sea ice doesn't really offer us a solution for ice on land, unfortunately.

Glaciers and ice caps are MUCH thicker ice (hundreds to thousands of meters thick, compared to just a few meters for typical sea ice). There isn't really a practical way to "cool" ice on land, aside from the natural and slow action of climate.

Can you give a list of things to watch out for before going in deep pow? (BTW I live in switzerland if it changes anything)

BLACK_CROWS

Read the avalanche forecast so you know what to look out for in the snowpack, keep an eye out for signs of avalanche activity (shooting cracks in the snow, whumpfing sounds, other avalanches nearby), choose terrain that is appropriate for the level of avalanche danger, poke your head into the snow yourself to confirm whether the regional avalanche forecast is valid for the particular slopes you're thinking about skiing. Be equipped with the necessary safety gear and know how to use it!

What micro-scale studies are being done on the ice shelf? I'm really interested in how ice is deforming at the microscopic level, and if studying that can help shed light on the bigger picture of what's happening at Larsen C.

earth2m

There are groups working on the microscopic details of ice deformation, and how we can use this knowledge to help us better understand and model ice at large scales. Here is one example:

http://microdice.eu/

Hi Chris - does the Larsen C ice shelf provide a significant buttressing effect for the glaciers that flow into it, and if so, do you anticipate an acceleration of flow in those glaciers in response to such a major chunk of ice being released? Are there any predictions of how large this effect could be, and how it could affect the timeline for disintegration of the ice shelf?

PardusPardus

Larsen C, as with most ice shelves, does provide buttressing for the tributary glaciers that flow into it. The iceberg that is about to be released comes from the front of the ice shelf that does not provide much buttressing, however. Thus we say that most of the ice removed is already "passive". I did some modeling work in a 2013 paper to quantify how much buttressing Larsen C provides. You can look at Figure 5 in this paper:

http://www.the-cryosphere.net/7/1931/2013/tc-7-1931-2013.pdf

There isn't much color in the front part of the ice shelf where the iceberg will be detached. Other colleagues of mine have made similar model predictions. However, if more is is lost, then you start to eat away at the "buttressing" ice!

Hey Chris, thanks for doing this AMA.

I live in Montana and, even with our amazing avalanche prediction methods (Flathead Avalanche Center is on point), it still seems like slides are an act of god, relatively unpredictavle for the person on the ground, skiing.

Where do you see the future of avalanche prediction going? Tied to danger levels (as it is now), or will there be more precise measurement tactics that can predict specific slopes?

earlierson

There will always be an element of risk that cannot be eliminated in avalanche forecasting, even with better knowledge of avalanche physics. We can't really "measure" our way out of the problem of spatial variability!

What is the minimum slope required for a potentially fatal avalanche to occur?

racing-to-the-bottom

Most avalanches are triggered on slope angles between about 30 and 45 degrees. If the snow is exceptionally unstable, avalanches can be triggered even from a flat slope in the valley bottom!

https://www.mtavalanche.com/sites/default/files/MSA_Slope_Angle_Final.pdf

When the ice and snow begin to slide in an avalanche, does it create enough friction against the static surface to melt? What about glaciers?

zyzzogeton

For many avalanches, when the flowing snow comes to rest it sets up nearly as hard as concrete! This can be in part due to friction within the flowing snow that might be sufficient to cause some melting, which then refreezes when the flow comes to rest.

In thick glaciers, simply the weight of hundreds of meters of ice can be sufficient to cause melting at the bottom of the glacier. This is process known as pressure melting, and is a peculiar feature of ice.

To what extent do you utilize seismic surveys (active and/or passive) in predicting potential fractures and how effective are they? Thanks for the AMA.

drunkstormtrooper

Passive seismic surveys are being used more and more to study glacier dynamics! Some colleagues of mine in Oslo have been looking at the distinct seismic signature of iceberg calving events from tidewater glaciers:

http://www.mn.uio.no/geo/english/research/projects/calvingseis/

I don't have a question. Just wanted to say great work! As a life long resident of Colorado learning to read snow conditions is vital. Thanks for what you do.

Ealthina

Thanks a lot! This has been a lot of fun, I wish I had more time to answer questions, and to give more thorough explanations!

So, in cartoons, and movies, and such, can avalanches be caused by sound, or does there have to be a larger interruption for the snow to slide Down hill?

wickedfandude

There isn't enough energy in a sound wave to create an avalanche, so this is a bit of a fictional idea...