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## Global Warming: Impact of Melting Snow

There is a pureness that originates from skiing. The people, places, and the environment are connected by a love of winter and the mountains. This pureness has the possibility of being nothing but a distant memory that we one day we might get to tell future generations. This imminent doom can be pointed at one thing, climate change and the effects of global warming. There's a common misconception about climate change and global warming. Global warming refers only to the earth rising temperature and climate change including aspects of warming and the symptoms of warming. Such symptoms include melting glaciers, rising temperatures, extreme weather situations, and the one I fear most, the adverse effect on ski season and winter itself. These effects can point to one thing, and that's us, yes you too.

Climate change is dominantly driven by human activity and the misuse towards our planet. The longtime debate about climate change is over. Climate change is happening now, and it's affecting this world we call home. Home is defined as "the place where one lives permanently" ("Home"). We only get one planet, one home. All of my life I have lived in Colorado and I'm proud to call this is my home. When I'm on the slopes, there isn't a worry in the world. I'm not thinking about upcoming deadlines in school or the responsibilities that I have. It's just me and the mountain. I don't want to worry that something I love to do is in jeopardy due to climate change. The only thing I want to worry about is the about finding powder and the next run. The mountain of evidence of climate change is daunting.

Climate change is an issue that needs to be addressed to preserve the pureness of winter and skiing. Record-breaking heat, prolonged drought, wildfires, extreme weather, flooding, sea level rise, even ocean dead zones all of these trends were predicted by climate scientists' decades ago and now they are a reality. "According to the International Union of Geological Sciences (IUGS), the professional organization in charge of defining Earth's time scale, we are officially in the Holocene ("entirely recent") epoch, which began 11,700 years ago after the last major ice age" (Stromberg). Have we left enough of a mark on the world that it makes sense to bid the Holocene epoch goodbye? Reflecting on the impact on the globe caused by humans, some geoscientists and biologist have advanced the concept that we are living in a new geological period, the Anthropocene.

Anthropocene is a new geological epoch in which human activity is the primary driver of changes on Earth, including the greatest change of all, climate change. "It will be another strong reminder to the general public that we are now having undeniable impacts on the environment at the scale of the planet as a whole, so much that a new geological epoch has begun" (Stromberg). Climate change in itself is dynamic. Given the fact that we humans are

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dependent on ecosystem services for air, food, and water. There is always a need for water, its an essential part of living. In the western part of the United States, many states depend upon the Colorado River for a dominant source of water. No snow equals no skiing, which in turns equals a limited source of water for many states. Warmer winters as opposed to cool one, suggest that evaporation or snowmelt, changes from snow to rain in warmer winters. "It is expected that as warming continues, the negative effects of temperature on water year UCRB (upper Colorado River basin) streamflow will become more evident and problematic" (McCabe et al. 1-14).

There has been low snowfall over the last couple years, the amount of snow runoff is limited. Snow runoff provides the significant amount of water for the Colorado River, with warming temperatures, drought and the lack of snow is diminishing this highly used water source. Less snow and ice cover mean more heat. Ice and snow cover acts as an air conditioner for the northern hemisphere. "A long-term retreat in snow and ice cover in the Northern Hemisphere is weakening the ability of these seasonal cloaks of white to reflect sunlight back into space and cool global climate" ("Global Warming: Impact of Receding Snow and Ice Surprises Scientists"). The decrease in snowfall and the increase of snow and ice melt messes with the earths albedo effect. Albedo is a measure of a surfaces ability to reflect light. If the snow and ice cover reflecting the sun disappears, it's like flipping a switch. Instead of reflecting the sun you are absorbing it, increasing global warming. Sea level is on the rise. Global sea levels are rising by 3.4 millimeters per year. In 80 years the ocean has the potential to be 1.3 meters (4.3 feet) higher than today. This sea level rise is accelerated mainly to the melting of ice in Greenland and Antarctic. This rise in sea level is hard to fathom, especially living in Colorado where we are a mile above sea level, in the Rocky Mountains, and a thousand miles from the nearest ocean. But places that are low lying like Miami, New Orleans, or Amsterdam where the effects of sea-level rise are already apparent. In just a few decades the problem will be unavoidable. Half of the world's population lives within 60 kilometers (37 miles) of a coast. So why is the sea level rising?

Rising sea level is one of the most noticeable effects of man-made climate change. If it wasn't for the surplus of CO<sub>2</sub> and other greenhouse gas levels in the atmosphere sea level rise should have only risen about an inch or two in the previous century. Since we have the highest CO<sub>2</sub> levels at any point in human history, sea level rose by 14 centimeters (5.5 inches) between 1900 and 2000. This was the fastest sea level rise in 27 centuries, and its only speeding up. About 99% of all freshwater in the world resides in two ice sheets, one in Antarctica and the other in Greenland. Both of these ice sheets are expected to melt if CO<sub>2</sub> levels don't decrease rapidly. "Sea levels have naturally risen and receded for billions of years, but they've never risen this quickly in modern history – and they've never had so much human help." (McLendon).

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Global warming can result in more snow. This seems like a foolish statement, obviously if it gets warmer there is no snow. Snowfall is entirely dependent on temperature. “A warmer atmosphere holds more moisture. If the air is too cold, it cannot hold enough moisture for a heavy snowfall. If the air is too warm (greater than 32-degree Fahrenheit or 0 degree Celsius), precipitation falls as rain instead of snow” (Hagenstad, Burakowski, & Hill). In the past couple years, the United States in some areas have seen record snow fall and record low temperatures. The world is facing irreversible changes, unless we limit the amount of heat, trapping CO2 and other greenhouse gases within the atmosphere. According to NASA (National Aeronautics and Space Administration), the ten warmest years on record have been since 1997. This past decade has been the warmest. 2016 was the hottest year recorded and in 2017 we topped that.

The National Atmospheric and Oceanographic Administration (NOAA) report that recent decades have been the warmest since around 1000AD. You can't predict climate by focusing on a particular cold day, or season, or even year. It's about long-term trends. While larger snowfall events are probable in a warming climate, the impact of warmer temperatures is a loss in snowfall as more precipitation falls as rain instead of snow. Winter is warming, snowfall is depleting, and that trend hits Colorado communities in the wallet. The ski industry is an integral part of Colorado, serving as a significant economic contributor and driver of state visitation. In mountain towns across Colorado rely on winter tourism, snow is their currency. In Colorado alone winter sports generates \$3.4 billion annually. “The winter sports tourism industry generates \$12.2 billion and 23 million Americans participate in winter sports annually. Changes in the winter season driven by climate change were costing the downhill ski resort industry approximately \$1.07 billion in aggregated revenue over high and low snow years over the last decade” (Hagenstad, Burakowski, & Hill).

The snow sports industry in 2016 supported 191,000 jobs, \$6.9 billion in wages nationally. Warming temperatures put season start on halt for many resorts. It is too warm to make snow. Ski area openings get delayed, ski town jobs on low reserves, and the number of visitors down. For many ski resorts opening before the holiday season is crucial to remaining profitable and staying in business. To rush opening day's ski resorts, make their snow. To maintain the goal of opening before the holidays its estimated that there needs to be a minimum of 450 hours of snowmaking. By 2050 many lower elevation resorts will fail to reach the 450 hours of snowmaking plateau, by 2090 some resorts will fail to reach that mark at all. “At Aspen Skiing Company, operators say temperatures have gone up so much that their snowmaking machines are operating at the limit — another degree or two warmer and they'd be unable to produce it at all ...

We often make snow within one degree, or one and a half degrees, of being able to. If we can't make snow, we have a problem.” (Motavalli). Eighty-nine percent of ski resorts use

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snowmaking, and a small number of resorts have resorted to snow harvesting to extend their seasons, to improve snow quality. Breckenridge for this past season had to bulldoze and move snow from the parking lots up onto the mountain due to a lack of snow cover. Many resorts are planning for a business model with year-round revenue. Unchecked warming poses a threat beyond the winter snow sports industry to adapt. Relationships exist between snow quality and skier visits. Any change in snow quality could induce economic loss to Colorado. Each Colorado resort and the surrounding community will have to adapt to climate change because there is a range of outcomes, the effects are very spatial. Lack of snowfall during the winter jump starts fire season in Colorado.

Three factors affect how a fire will behave: Topography, weather, and fuels. The winter snowpack affects fuel sources, the vegetation the fire burns. Early spring is the time of year where attention is directed to snowpack, a fuel source that should be under snow and now isn't. The pine beetle has killed many trees in Colorado's forests. The pine beetle's ability to survive and thrive is dependent upon temperature and precipitation. Warmer winters have allowed these beetles to flourish in Colorado. As a result, one in fourteen trees are dead in Colorado. Colorado's mountains pine beetle infestation has killed trees across 3.4 million acres. Over 800 million dead trees offer the potential fuel source waiting for the next wildfire. "The Arapahoe and Roosevelt National Forest use both tree removal and spraying to respond to the issue in high-value recreation areas." ("Bark Beetle: About the Epidemic). Spraying and removing trees can only do so much, what the forest and the mountains need are colder climates and a constant rate of snowfall and lower temperatures. Smoky the Bear said it best "Only you can prevent forest fires." But what can prevent forest fires now is a good cold freezing winter.

With all of these problems, what can be done to help prevent a drastic change? Addressing climate change needs to be a top priority, not only at a local level but on a global scale. The town of Breckenridge recently launched to commit the city to 100 percent renewable energy by 2025. "Breckenridge is a part of the High-Country Conservation Center, an organization focused on waste reduction, energy efficiency and clean energy, water conservation, and sustainable food production. The town has put \$4 million into their transit system to reduce carbon dioxide emissions from personal vehicles and their transit fleet." (Hagenstad, Burakowski, & Hill). More than 75% of ski resorts nationwide have announced these types of changes in the past. The National Ski Areas Association (NSAA) has led the way advocating for environmental sustainability at ski areas. We can no longer presume that individual actions by citizens or business are enough to turn the tide of this global generational crises. "Snow sports participants need to reexamine the source of their power and vote with their dollars and their voices, holding businesses to the high standard of activism. Wielding this economic power forms, the foundation of a social movement that enables electoral victories that will influence legislative action." (Hagenstad, Burakowski, & Hill).

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Not only do people who enjoy the benefits of winter, but the entire population needs to speak up and stand for change. To have a chance of regulating temperature increases below 2 degrees Celsius, which is the long-term goal of most countries, it would help stabilize atmospheric concentrations at 450 parts per million. This can be achieved by cutting global emissions by 80 percent. Snow isn't only crucial to skiing, but its nature's way of storing water. It's vital how resorts watch their water usage, not only as an economic benefit but as an environmental benefit. Vail Resorts owns and operates 5 of the most popular ski resorts in Colorado: Vail, Beaver Creek, Breckenridge, and Keystone. At each of these resorts, Vail Resorts have installed water-less and low flow appliances and fixtures, and this saves about 200,000 gallons of water each year. Alone replacing sinks in public areas, it has led to a 27% reduction in annual water use. More companies and organizations need to follow in Vail Resorts steps.

In 2015, 200 world leaders and representatives from various countries assembled to create a plan for climate change, this is known as the Paris Accord. The goal of the accord to keep global temperatures below 2 degrees Celsius. Limit greenhouse gases emitted by human activity. Review and upscale each countries contribution to cutting emissions every five years, and for developed rich countries to help out poorer nations by providing Climate Finance, adapting with climate change and to switch to renewable energy options. The Paris accord won't by itself stop temperatures from rising, the point of the Paris agreement is to provide incentives for countries to commit to reduce rising temperature voluntarily. This is the right step for humanity in fighting climate change. President Trump decided to pull the United States out of this agreement. "This agreement is less about climate and more about other countries gaining a financial advantage over the United States..."

So, we're getting out. But we will start to negotiate, and we will see if we can make a deal that's fair, and if we can, that's great. And if we can't, that's fine" (Trump). Having a president that doesn't see the bigger picture when it comes to climate change is frightening. He talks about a deal that's fair, fair to Americans, but what about what's appropriate to the world? What's fair to every single person that calls this planet home? Climate change affects us all. Climate change is happening, and if as the human race we sit back and do nothing, the consequences are definite. Surface temperature is rising due to an increase of CO2 emissions and the melting of ice and snow cover. Sea level is increasing possibly putting millions of lives at stake. Ski season is shortening, the economic loss is vast, especially in Colorado. Some people are fighting for and causing change, but our President isn't one of them. We need to start reducing our CO2 emissions, lower our carbon footprint and save winter and thus save skiing. Right now, we have the advantage of agonizing over how climate change may affect the world. At this moment, we get the opportunity to help manage the results, as opposed to a response to an inevitable end. On the off chance that we sit around and do nothing for the following years, we won't be stressed over powder days, which run to take next or having fun. We'll be stressed over the solidness of our environment, our jobs, and our economy. Climate

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change is already affecting winter

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