"In June 2017, a giant iceberg the size of Delaware broke off the Larsen C Ice Shelf in West Antarctica, creating an 80-mile long crack in the ice. How do relatively small shifts, rifts and changes lead to a long lasting effect on our planet's climate?"

In itself, the partial collapse of the Larsen C Ice Shelf, resulting in the loss of approximately 12% of the shelf's area, was a vital step in a "vicious cycle", which is predicted to result in further destabilisation of the ice shelf and a potential for extensive collapse[1]. However, drastic events such as this have many repercussions, not only for the immediate environment, but for the planet's climate in its entirety.

A key component of the planet's climate are ocean currents, controlling climate and extreme weather events. One important oceanic event, specifically in the Southern Hemisphere, are El Niño years and the accompanying effects on the climate of nearby continents. In normal years, upwelling of cold water brought by the Atlantic Drift brings a high-pressure system to the west coast of the Americas, which results characteristic dry seasons. South-easterly trade winds assist the movement and gradual warming of the current across the Pacific, where it brings the monsoon season to Australia and South-East Asia. In El Niño years, the south-easterly winds are weaker or reversed, pushing warm currents of water from Pacific land masses to the west coasts of the Americas. This causes irregular weather patterns to form on both sides of the Pacific, resulting in flooding on the Americas' coastal plains and bringing drought to Australian and South-East Asian coastlines. Whilst this is a natural phenomenon, the severity of the warm, reversed current and its effects have grown more pronounced in recent decades; 1997-8 saw some of the worst impacts of El Niño thus far, with forest fires breaking out in South-East Asia, intense drought in Australia and heavy flooding in Peru[2]. This is mostly due to the impact of the enhanced greenhouse effect on the planet's climate. More heat trapped in the atmosphere by gases such as CO_2 and methane results in more of this same heat being absorbed by the oceans. This exacerbates the warm current flowing southwest in El Niño years, and worsens the effects surrounding the localised change in climate. It is believed that El Niño also takes its toll on Arctic sea ice, as although sea ice undergoes natural fluctuations in size over the year, drastic reductions in sea ice area often correspond with El Niño season, due to the warmer sea surface temperatures it causes which can spread as far as the Arctic ice sheets[3]. This is just one example of how a small change in a naturally occurring phenomenon can have devastating consequences.

However, whilst changing currents can influence the melting and collapse of sea ice, the reverse is also true. Sheets of sea ice are vast stores of freshwater, which, when melted, enters the ocean. This freshwater dilutes the natural salinity of the surrounding sea water, which can have a variety of consequences. Whereas saline water is dense, and has a tendency to sink, the lighter and more diluted water will rise and expand as it absorbs heat. This is predicted to have a significant impact on rising sea levels, however it is also believed to impact global climate as a result of its influence over ocean currents. Less saline water lies near the surface due to its reduced density, meaning it stores more heat and is also more easily shifted by air currents than the denser water below, which forms the underlying currents less easily affected by changes in wind direction.[4] However, as more ice sheets melt and overall water density decreases, this is predicted to cause more unpredictable

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[1] https://www.theguardian.com/world/2017/aug/02/what-happened-next-to-the-giant-larsen-c-iceberg - *What happened next to the giant Larsen C iceberg?*- Davis- 02/08/17

[2] http://climatetracker.org/climate-change-el-nino-sri-lanka/
Explaining Climate Change and El Niño- Pathmeswaran- 21/04/17

[3] https://climate.nasa.gov/news/2341/arctic-sea-ice-minimum-extent-reached-el-nino-link-unclear/ -*Arctic sea ice minimum extent reached, El Niño link unclear*- Viñas- 15/09/15

[4] https://science.nasa.gov/earth-science/oceanography/physical-ocean/salinity -*Salinity*

climates and weather, as the surface currents and the accompanying weather systems grow more mobile. This once again demonstrates the impacts small shifts might have on the planet's climate.

Shifts in climate have continued to have more extreme effects in recent years. The California wildfires of December last year, which destroyed around 1.2 million acres, and are unlikely to be fully contained until late January, were some of the worst in California's history, and are predicted to see a repeat in the winter of 2018[5]. Wildfires themselves are not uncommon in California's naturally warm and dry climate, but the scale and severity of these have increased exponentially in recent decades, due to a variety of circumstances. A key factor in most blazes is an extended drought- usually spanning several months- with the months July-December inclusive leading up to the fires averaging 0.7 inches below normal precipitation levels[6]. This, and the longer-term droughts in the years 2011-2015, are believed to have been caused in part by the melting of Arctic sea ice. This is due to the oceanic temperature changes induced by melting sea ice, altering normal convection currents and creating an area of high atmospheric pressure known as the North Pacific Ridge, which is believed to "push" lower-pressure weather systems away from California and associated areas[7]. This then prevents the rainfall that the systems would usually bring to these areas in winter months, causing droughts which can result in wildfires. Another factor that is believed to have impacted the Californian wildfires is El Niño's counterpart, La Niña. La Niña years are characteristically similar to "normal" years, but bring in extreme weather systems; thus, the typical high pressure along the coasts of the Americas is intensified, resulting in lower precipitation levels and a higher risk of drought and wildfires.

In and of themselves, wildfires can have a devastating impact on climate and environment. Locally, the effects on climate can be severe, as loss of vegetation results in less evapotranspiration by plants, leading to a drier local atmosphere and increasing the risk of future wildfires. The loss of plant roots stabilising the soil also means that the area is more susceptible to erosion, reducing the quality of agricultural land, and additionally increases the risk of flash floods, as the soil is less stable and thus less able to absorb large volumes of water in the event of a storm. However, the loss of vegetation as a result of widespread fires, such as those in California, can also have a wider impact. It costs the planet's atmosphere a "carbon sink"- organisms which absorb CO_2 from the atmosphere- meaning that there is more CO_2 to contribute to the greenhouse effect. This, in addition to the CO_2 produced by the burning of vegetation, leads to large volumes of CO_2 being emitted into the atmosphere, or not being removed via photosynthesis. This once again demonstrates the impact a localised climatic event can have on the planet's climate.

Yet despite all these relatively short-term consequences of shifts in climate, by far the most destructive long-term effect will be the vicious cycle that many of these events are a part of. The impacts of the collapsing ice sheets are manifold and devastating. It is predicted that by 2050, new shipping routes linking the Atlantic and Pacific Oceans will open up as a result of the collapsing Arctic ice sheet[8], and will also make deep-sea oil reserves available for extraction and consumption. The

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[5] https://www.washingtonpost.com/graphics/2017/national/california-wildfires-comparison/?utm_term=.1d435042b890 - *The grim scope of 2017's California wildfire season is now clear. The danger's not over.* – Tierny- 04/01/18

[6] http://www.laalmanac.com/weather/we13a.php -*2017-2018 Seasonal Rainfall to Date (Precipitation) Downtown Los Angeles*

[7] https://www.nature.com/articles/s41467-017-01907-4 -*Future loss of Arctic sea-ice cover could drive a substantial decrease in California's rainfall*- Cvijanovic, Santer, Bonfils, Lucas, Chiang, Zimmerman- 05/12/17

[8] http://www.pnas.org/content/110/13/E1191.abstract - *New Trans-Arctic shipping routes navigable by mid-century*- Smith, Stephenson- 25/01/13

implications of this will have a long-lasting and widespread impact on the planet's climate, as exploitation and use of oil reserves will result in more "greenhouse gases" being released, and increased shipping through newly-available routes will likewise result in increased emissions, adding to the enhanced greenhouse effect. This in turn will cause the atmosphere to trap more heat, causing global temperatures to rise, and further aiding the melting of sea ice, implementing a vicious cycle that will have widespread consequences for the global climate. Changes to sea temperatures will result in changes to ocean currents and the seasonal weathers they bring- for example, monsoon seasons in India and South-East Asia will likely be diminished, and eventually disappear entirely, as ENSO (El Niño and Southern Oscillation) events become more frequent due to increased sea surface temperatures, resulting in the reversal of the "normal" current. This in turn will alter these regions' yearly cycle, and thereby permanently alter the climate. This is just one demonstration of the long-lasting effects of small shifts on the planet's climate- and, in the coming decades, many, more devastating consequences, are likely to make themselves apparent.