**Ice Thickness Change at Cook Ice Shelf.** J. J. Shum1 and F. S. McCormack2, 1Monash University ([jshu0010@student.monash.edu](mailto:jshu0010@student.monash.edu)), 2Monash University ([Felicity.McCormack@monash.edu](mailto:Felicity.McCormack@monash.edu)).

**Introduction:** Anthropogenic climate change has resulted in global climatic changes which both directly and indirectly impact ice sheets and glaciers around the world. Since pre-industrial times, mean land and ocean surface temperatures have increased by 1.59°C and 0.88°C respectively [1]. Similarly, global sea levels have risen at a rate of 1.5 - 2 mm/yr throughout the last century [2], suggesting increased retreat/melting of ice sheets and glaciers.

The region of interest for this abstract relates to the Cook Ice Shelf. Located in East Antarctica, this ice shelf is buttressed against the Cook Glacier and has an area of ~ 3,500 km2 [3]. The Cook Ice Shelf is of particular interest, as the Cook Glacier receives ice discharge from the Wilkes Subglacial Basin (WSB) (the largest East Antarctic basin) [3]. This abstract aims to assess the changes in ice thickness of the Cook Ice Shelf, and to assess the potential causes of this change.

**Methods:** In response to the overall aim, code was scripted in Python to create geometry profiles of a transect running through the Cook Ice Shelf, as well as a timeseries comparison of thickness and basal melt rate (BMR) anomalies. All the input data used in this project originated from NSIDC’s Making Earth System Data Records for Use in Research Environments (MEaSUREs) project [4-6]. The NetCDF files from these databases were imported into QGIS, where raw GeoTIFF files outlining the Cook Ice Shelf were exported, and directly used in Python.

For the profile transects, the GeoTIFF file from MEaSUREs BedMachine Antarctica V3 [4] had to be reprojected using the *Rasterio* package, from the polar stereographic EPSG:3031 to EPSG:4326, to convert the northing and easting coordinates into latitude and longitude. From these GeoTIFF files, a digital elevation model (DEM) was plotted. Next, a transect profile line of the surface geometry was scripted using an interpolation function. The transect was drawn originating from a higher latitude (~ -68.1°) to a lower latitude (~ 68.9°). This was repeated for the bed geometry of the ice shelf. Additionally, the thickness of the transect could be plotted separately by subtracting the bed elevation from the surface elevation and illustrating the results as a cross section running along the transect.

Data from the MEaSUREs ITS\_LIVE database [6] were used to calculate mean and median ice thickness and BMR anomalies using the *Rasterio* package. The *polyfit* function was also used to plot a linear regression for each time series.

**Results:** The DEMs in Figure 1a and c illustrate the distinct change in elevation at the edge of the Cook Ice Shelf compared to the Cook Glacier. The Cook Ice Shelf has a surface elevation close to 0 m, and a basal depth of ~ -620 m. As visualised in Figure 1b and d, the surface elevation gradually increases to 100 m by 0.7° (~77 km) along the transect line, whereas the bed depth fluctuates but reaches ~ -640 m by 0.7° (~77 km) along the transect line. This approximate distance indicates the transition from the ice *shelf* to the ice *sheet* (Cook Glacier), where changes in the geometry of the profile change the most. The surface elevation peaks at ~ 450 m at the end of the transect line, and the bed depth reaches a local trough of -760 m at 0.8° (~88 km) along the transect line. The similarity between these two variables is depicted in Figure 1e: there is a change in elevation for both surface and bed profiles as the ice shelf connects to the ice sheet, just in opposing directions. The overall ice thickness along the transect is shown to increase as you move inland, from ~ 550 m thick at the start of the transect (at the edge of the ice shelf) to 1,200 m at the end of the transect (on the ice sheet known as Cook Glacier). Although Figure 1 illustrates how ice thickness can change throughout segments of the Cook Ice Shelf, it does not analyse how thickness of the entire ice shelf changes over time. This is why the timeseries of thickness and BSM was created.

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*Figure 1: Transect Thickness. A: Surface DEM of Cook Ice Shelf. B: Transect Surface Elevation Profile. C: Bed DEM of Cook Ice Shelf. D: Transect Bed Elevation Profile. E: Transect Thickness Profile.*

Figure 2 shows the trend in anomalies of thickness and BSM between 1992 and 2017. Subplot a indicates a clear increase in thickness anomaly over time, from ~ -11 m in 1992 to ~ 1 m in 2017. The mean against which these anomalies were calculated against was 487 m. So, for example, the thickness anomaly in 2015 of 3 m means that the mean thickness for that quarterly period was 450 m. The r-squared value of 0.84 means that there is a strong correlation (84%) between an increase in year resulting in an increase in thickness anomaly value. The median anomaly values are approximately evenly spaced above the mean value for the first half of the period (pre-2005) and below for the second half (post-2005), suggesting that this data is normally distributed. A linear regression analysis resulted in a gradient of 0.56.

Figure 2b indicates no trend. The scattered data has an r-squared value of 0.08, indicating that there is an extremely insignificant relationship between changes in time and changes in the BMR anomaly. A linear regression analysis is not necessarily suitable for this subplot, however it was constructed to illustrate the stark difference between time and BMR anomaly, as well as the unrelated trends between changes in thickness anomalies compared to BMR anomalies.

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*Figure 2: Anomaly Timeseries. A: Time series of shelf-averaged 3-monthly thickness anomalies (relative to mean) for the Cook Ice Shelf over 1992-2017. B: Time series of shelf-averaged 3-monthly BMR anomalies (relative to mean) for the Cook Ice Shelf over 1992-2017.*

**Discussion:** Analysis of the transect line through the Cook Ice Shelf reflects an increase in ice thickness as you move closer to the ice sheet/glacier. This may be due to glacial erosion of the ice shelf, which deepens towards the Cook Glacier/ice sheet [7]. Another increasing trend is the linear regression gradient of 0.56, which is associated with the thickness anomaly timeseries. This suggests an annual ice shelf thickening of 0.56 metres, however, the tail-end data from 2015 onwards appears to saturate and level out. Greater temporal data is required to critically analyse the reasoning behind this trend.

Estimating that 1,000 km3 of ice melt is equivalent to a global sea level rise of 2.5 mm [8], the thickening of the Cook Ice Shelf from 1992 to 2017 is equivalent to a global sea level fall of 0.12 mm, however factors such as hydrostatic equilibrium are not accounted for in this calculation (see bottom of *Code Availability* file for calculations). There are various potential reasons for this increase in ice thickness, despite climate change. However, an increase in BSM is not one of them. This is articulated by the r-squared value of 0.08, as this indicates that there is no relationship between a change in time, and a change in BSM anomaly which aligns with the increasing trend of the ice thickness anomalies.

Other factors which might relate to the increased ice thickness include an increase in snowfall accumulation, decreases in ice velocity, and changes in the ice-ocean interactions. However, the most likely factor behind this trend is the interconnection between the Cook Ice Shelf and the WSB. The WSB itself is ~ 400,00 km2 in area [9], and encompasses many glacial and shelf outputs, such as the Cook Ice Shelf. Consequently, this ice shelf experiences a discharge of 40.6 Gt annually into the ocean [9]. These high inflows and outflows may have caused the Cook Ice Shelf to increase in ice thickness over the period 1992 - 2017.

**Data and Code Availability:** Supporting data and code is available at DOI:[10.5281/zenodo.15067368](https://doi.org/10.5281/zenodo.15067368), with the corresponding GitHUB Repository linked [here](https://github.com/jeremaiahMON/Ice-Thickness-Change-at-Cook-Ice-Shelf).

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