

Analysis of Tragic Summer Antarctic Storms between 14 November – 2 December 2022

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I. INTRODUCTION

On 15 November 2022, the cruise ship *Quark World Explorer* was underway on an Antarctic tourist expedition near Elephant Island (61°11' S, 55°03' W). As part of the expedition, the cruise ship sends zodiacs (small boats for transporting personnel between shore and vessels) out to shore as part of the Antarctic excursion. On this day, two fatalities occurred when a zodiac flipped in shallow waters of the Elephant Island coast. On 29 November 2022 another cruise ship, the *Viking Polaris*, was on a separate tourist expedition when a rogue wave hit their vessel causing one fatality. This fatality occurred in the Drake Passage between the Antarctic Peninsula and South America (56° 31' S, 66° 08' W). On 1 December 2022, the ship *Oceanwide Plancius* while operating near South Georgia (55°32' S, 36°46' W) had one person suffer fatal injuries, no further information about the incident was reported.

II. METHODS

A synoptic overview using the European Centre for Medium – Range Weather Forecasts Reanalysis 5 (ERA5) (Hersbach et al. 2020, 2022) output was conducted during these events as well as establishing climatological averages for comparison. The results of the climatology are summarized in Figures 1 and 2 and show the mean sea-level pressure (MSLP) was anomalously low. The assessment of the accuracy of other models to determine an accurate lead time for forecasting the events will be performed. ERA5, GFS, and AMPS models will be analyzed using observational data from stations near the incident sites.

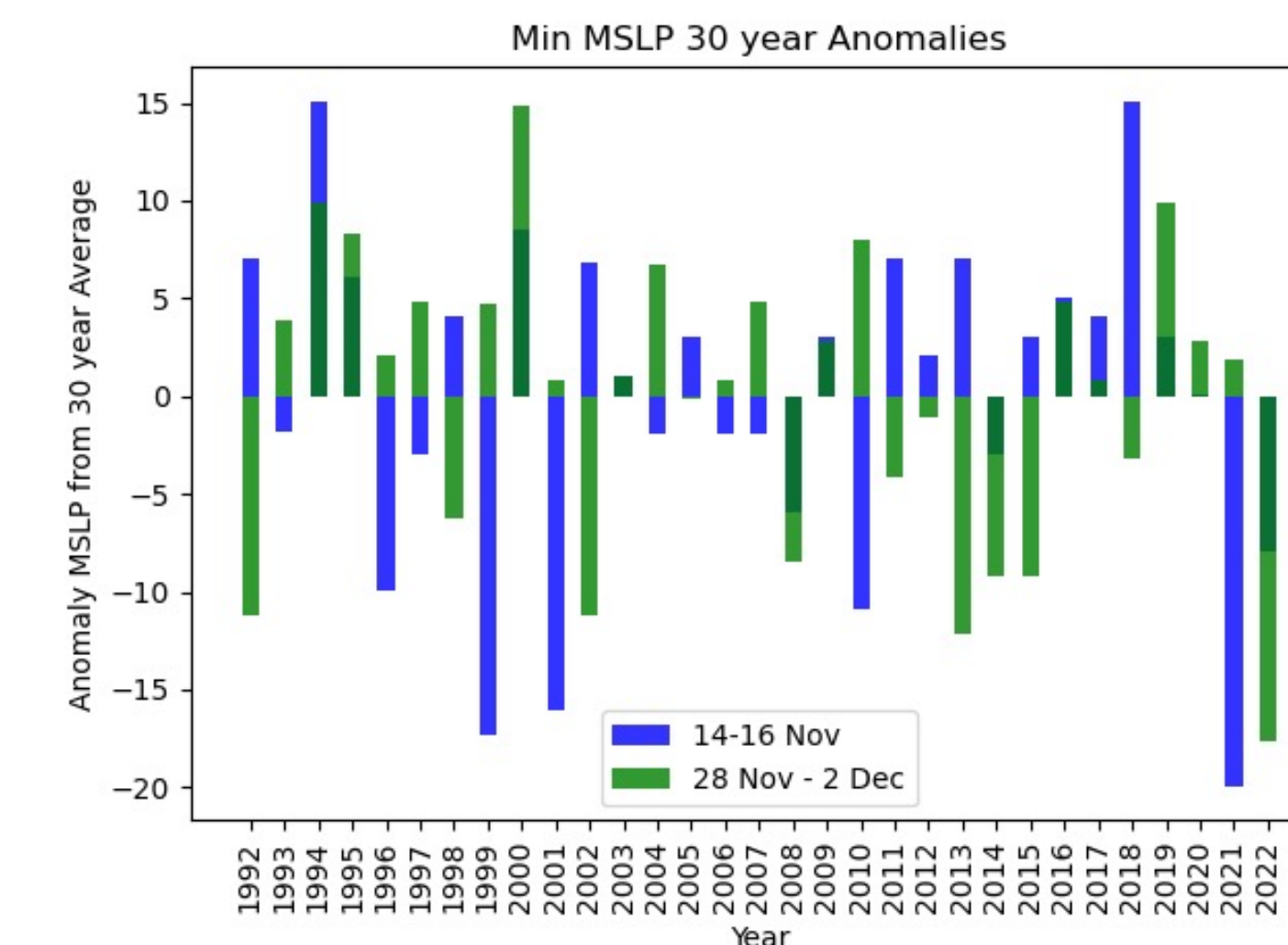


Figure 1: Yearly minimum MSLP anomalies from 1992-2022 for the two periods, 14 - 16 November and 28 November - 2 December. The values are the difference between the time average (14-16 Nov = 942.9 hPa, 28 Nov-2 Dec = 943.1 hPa) and the minimum value identified for each year. Negative values show deeper average lows and positive values show weaker lows as compared to the average.

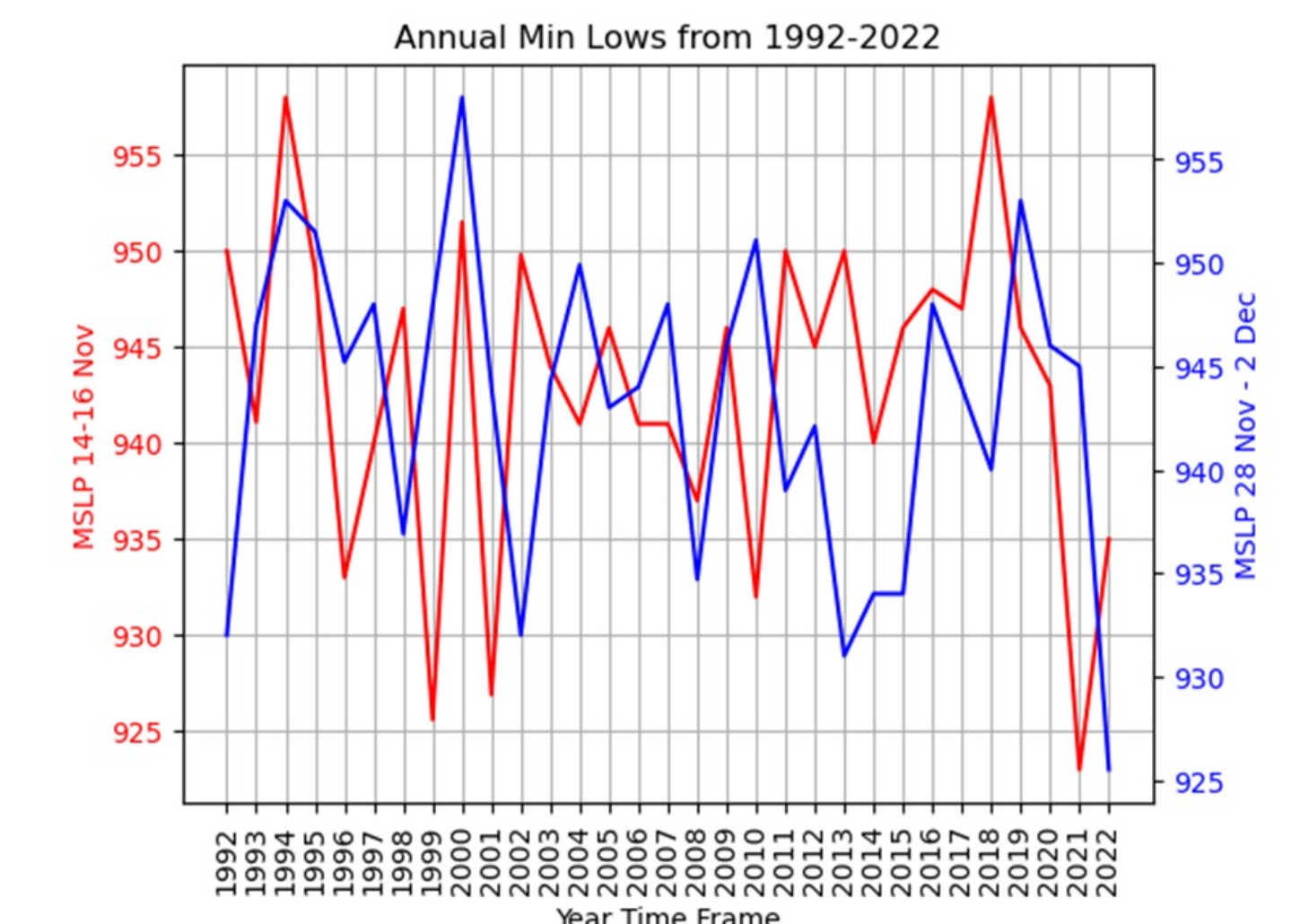


Figure 2: Minimum MSLP values for each interval plotted by year for 1992-2022. The graph shows trends between minimum pressures and the numerical values associated with the anomalies in Figure 1. The year 2022 is the lowest ERA5 pressure in Drake Passage between 28 November – 2 December.

III. Synoptic Analysis

The first event series from 14 -16 November 2022 reanalysis shows a cyclone event in the Peninsula region (Figures 3 and 4). The low-pressure center developed west of the Peninsula in the Amundsen Sea on 14 November 2022, which is a typical formation point for cyclones in the Antarctic during summer (Wenta and Cassano 2020) and remained in the region for 72 hours when the intensity of this system fluctuated over time with an initial increase in pressure before decreasing due to an upper-level trough by 15 November 12Z. A coupled system with high- and low-pressure centers is located east and west of the Peninsula, respectively, which provided a mechanism for potentially degraded surface conditions; however, wind and surface pressure charts indicate that conditions in the Elephant Island region were benign. Wave swell model output does not suggest the sea conditions to be degraded; charts estimate waves as high as 3 meters (Figure 5). From this, we can conclude that local weather is not a significant factor between 14 – 16 November 2022 for any incidents within the Drake Passage, namely the zodiac accident associated with the *Quark World Explorer*. The weather appears calm when compared to average conditions and would not pose any major concerns from an operational stance.

On 29 November 2022, a rogue wave event impacted the *Viking Polaris*. Surface pressure reanalysis chart on 29 November (Figure 6) show a deepening low and the associated wind chart (Figure 7) shows intensified winds flowing through the Drake Passage up to 14 m/s that impacted the *Viking Polaris*. The 500 hPa chart indicates a trough to the west of and supporting the deepening of that surface low. This means that the atmosphere has physical mechanisms to allow for the intensification of the surface storm. This low system can be clearly seen on the 28 November surface reanalysis charts and continued for the next four days as it circulated around the coast. ERA5 sea swell chart estimated increasing waves up to 6m in height on 29 November (Figure 8) and were sustained around 10 m until 2 December 12Z in the Drake Passage. Sea surface conditions were degraded and continued to worsen based on the ERA5 reanalysis which negatively affected the *Viking Polaris*.

On 1 December 22 at 00Z the surface low reached a minimum of 925.5 hPa (Figure 9) which is the lowest during the period of the three events of interest. Surface winds reached a peak of about 25 m/s according to the ERA5 estimation (Figure 10) and the 500 hPa level model chart shows a deep Low on the Eastern base of the Peninsula. The low is vertically stacked which implies maximum intensity of the surface low and a jet streak above the trough axis increased potential vorticity advection and in turn baroclinic instability within the atmosphere. *Oceanwide Plancius* was reported to have one casualty off the coast of South Georgia which, based on the ERA5 reanalysis, was just outside the cyclone boundary where most severe weather took place and Figure 11 shows low sea wave swells on the date of the incident. It appears that the *Oceanwide Plancius* was not affected by adverse weather.

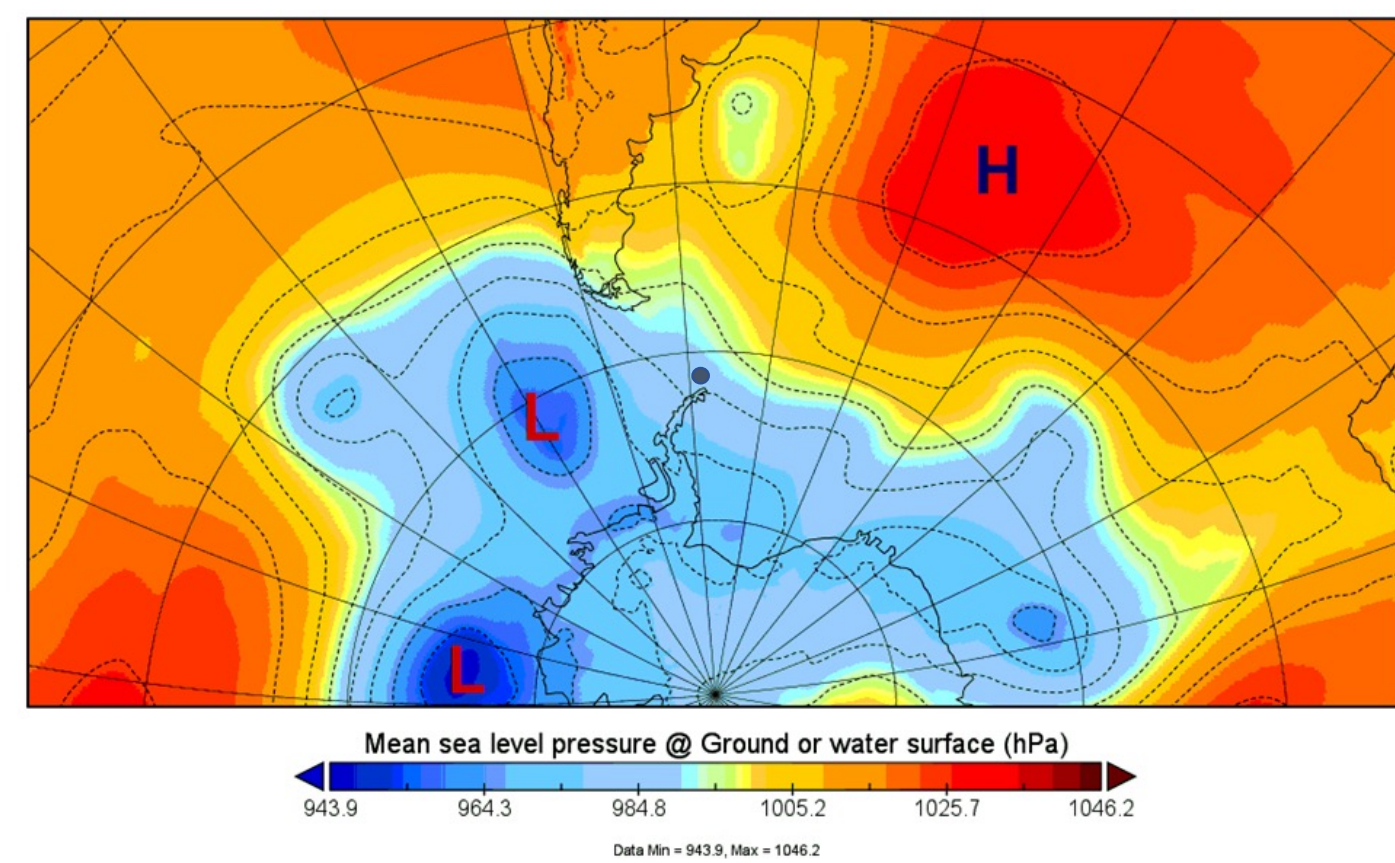


Figure 3: Mean sea level pressure (hPa) reanalysis chart with high- and low-pressure centers indicated for 15 Nov 22 at 12Z. Black dot locates Elephant Island.

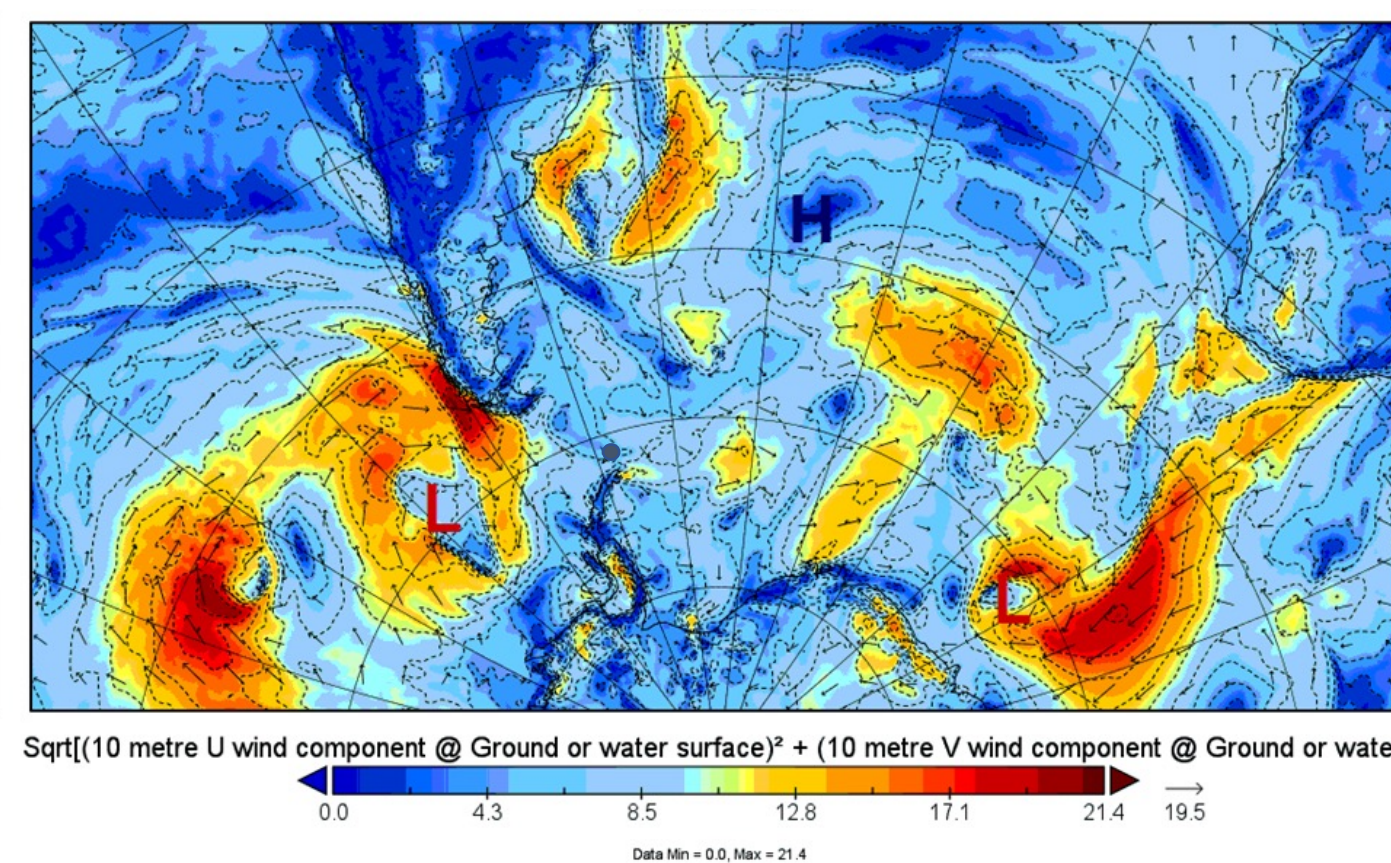


Figure 4: Mean sea level surface wind (m/s) reanalysis chart with high- and low-pressure centers indicated for 15 Nov 22 at 12Z. Black dot locates Elephant Island.

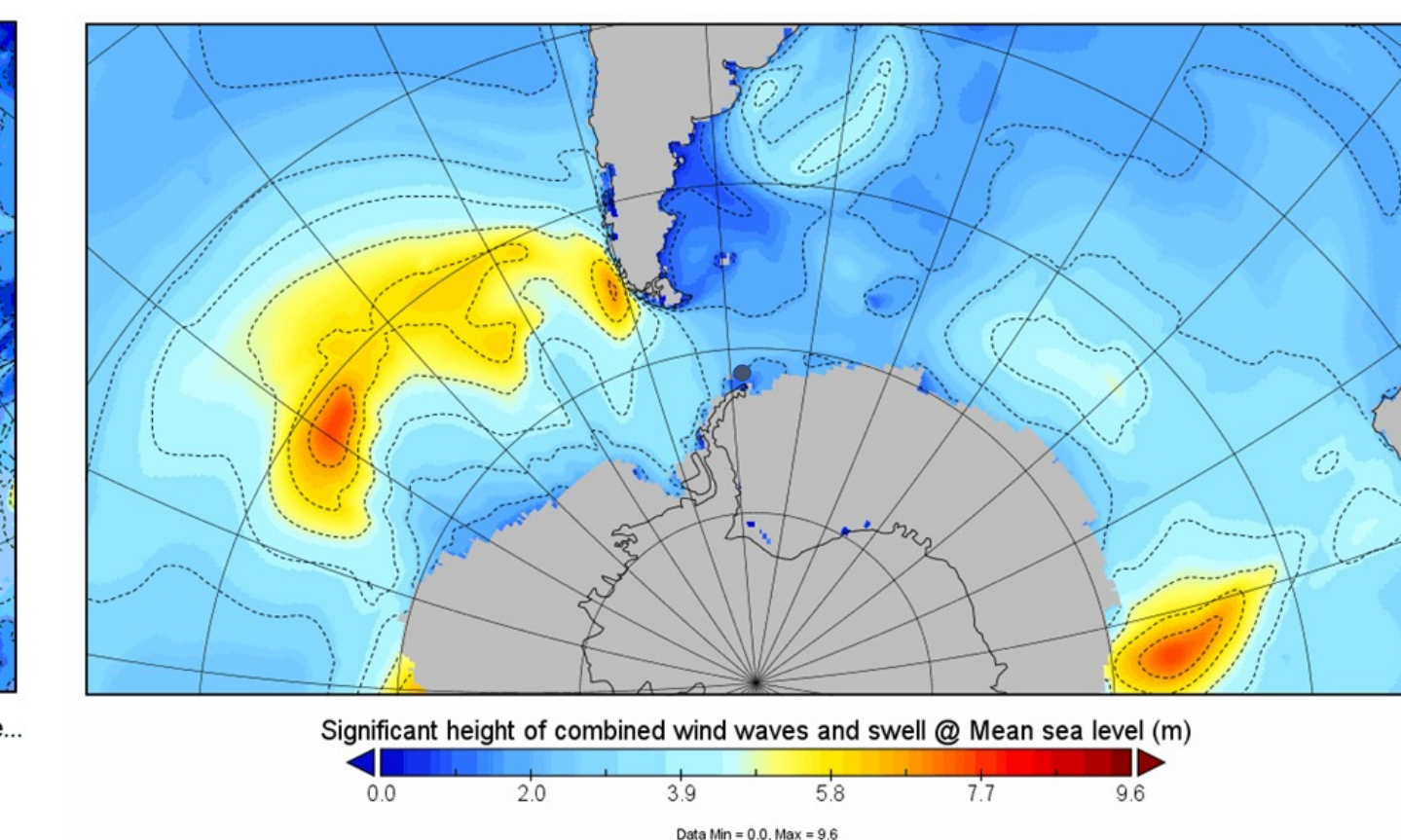


Figure 5: Heights of significant combined wind waves and swell (m) reanalysis on 15 Nov 22 at 12Z. Black dot locates Elephant Island.

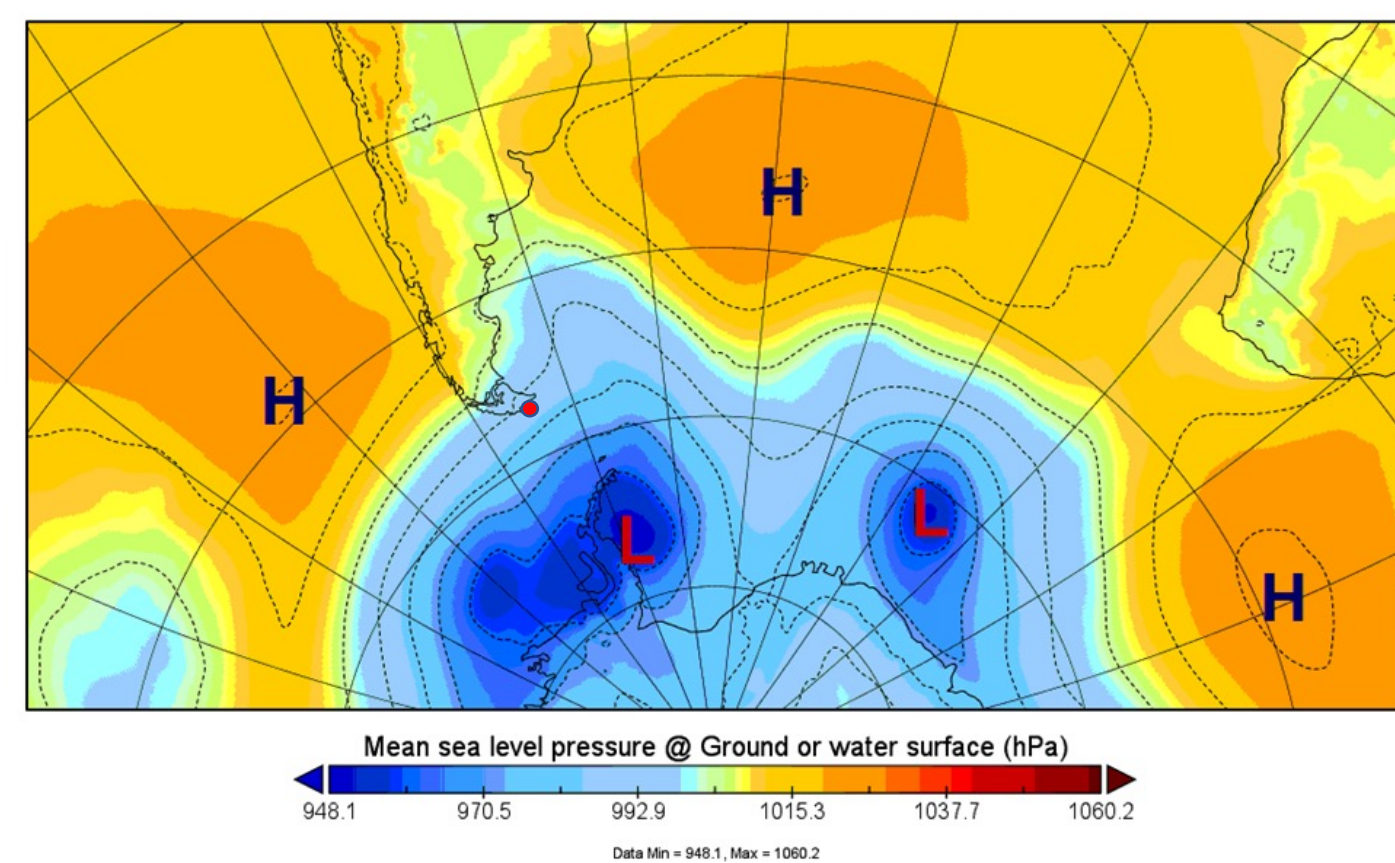


Figure 6: Mean sea level pressure (hPa) reanalysis chart with high- and low-pressure centers indicated for 29 Nov 22 at 12Z. Red dot locates *Viking Polaris*.

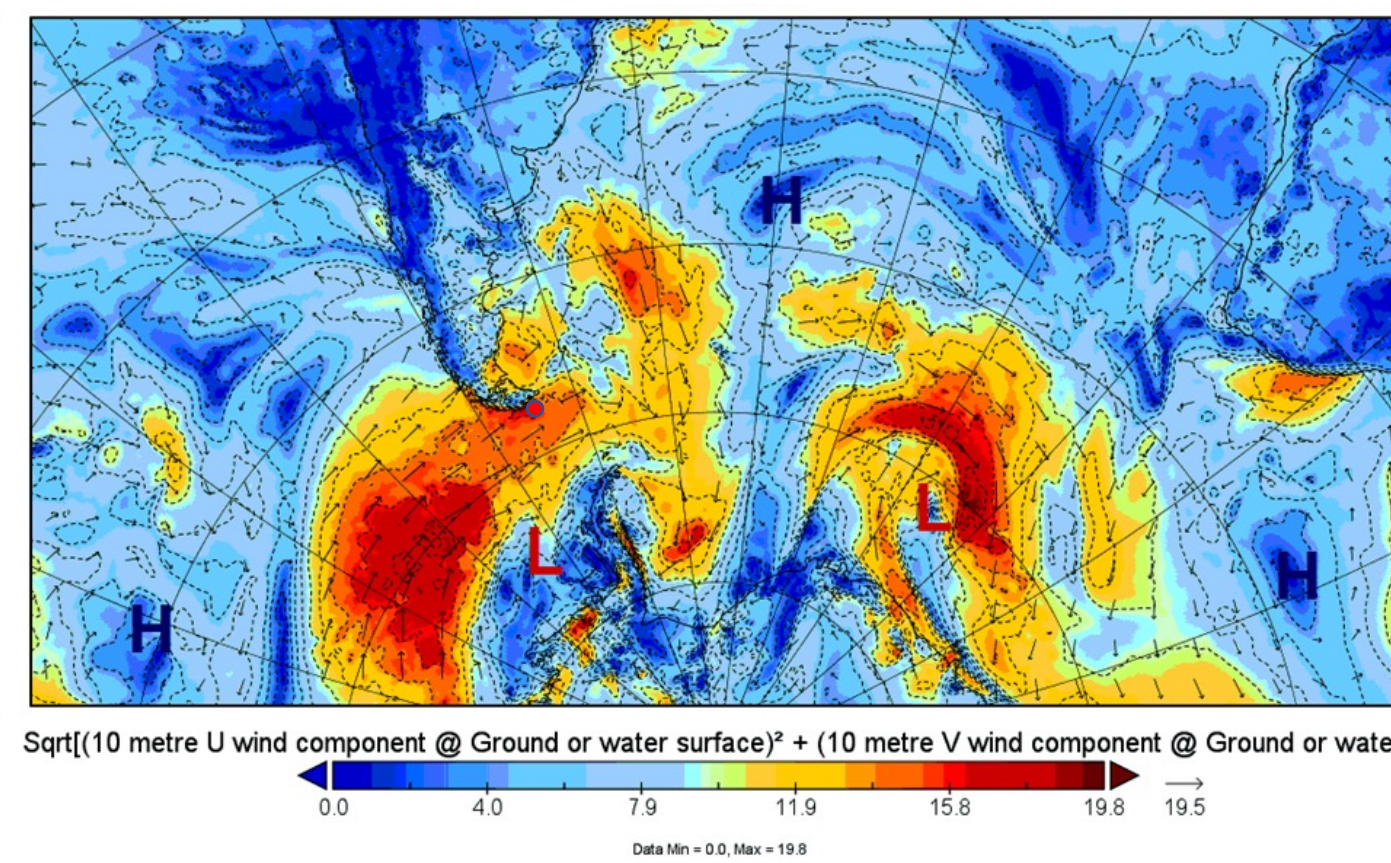


Figure 7: Mean sea level surface wind (m/s) reanalysis chart with high- and low-pressure centers indicated for 29 Nov 22 at 12Z. Red dot locates *Viking Polaris*.

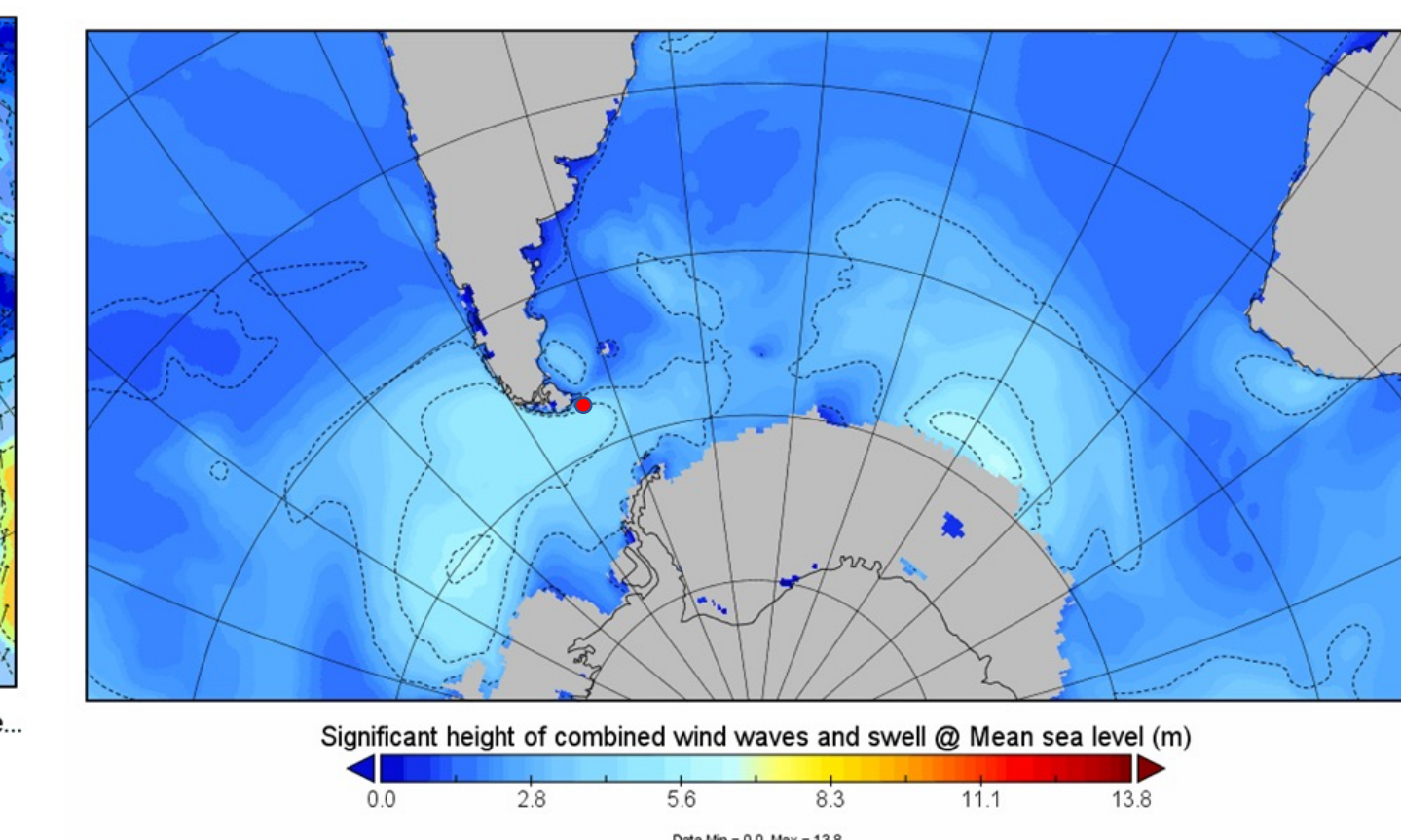


Figure 8: Heights of significant combined wind waves and swell (m) reanalysis on 29 Nov 22 at 12Z. Red dot locates *Viking Polaris*.

IV. Conclusion

Research of these three events revealed that on 29 November 2022 a low-pressure system as indicated on ERA5 reanalysis is an indication of severe weather impacting the *Viking Polaris* in the Drake Passage. This weather presented a hazard to sea operations and posed increased risk to personnel that may have been exposed to the conditions. The two incidents involving the *Quark World Explorer* and *Oceanwide Plancius* appear to not have any negative effects due to weather conditions. Further investigation into the validation of forecast models will show if the system between 29 November – 2 December 2022 was accurately forecast. In addition, we will identify the lead time for which models were most able to predict the Antarctic severe weather.

V. References

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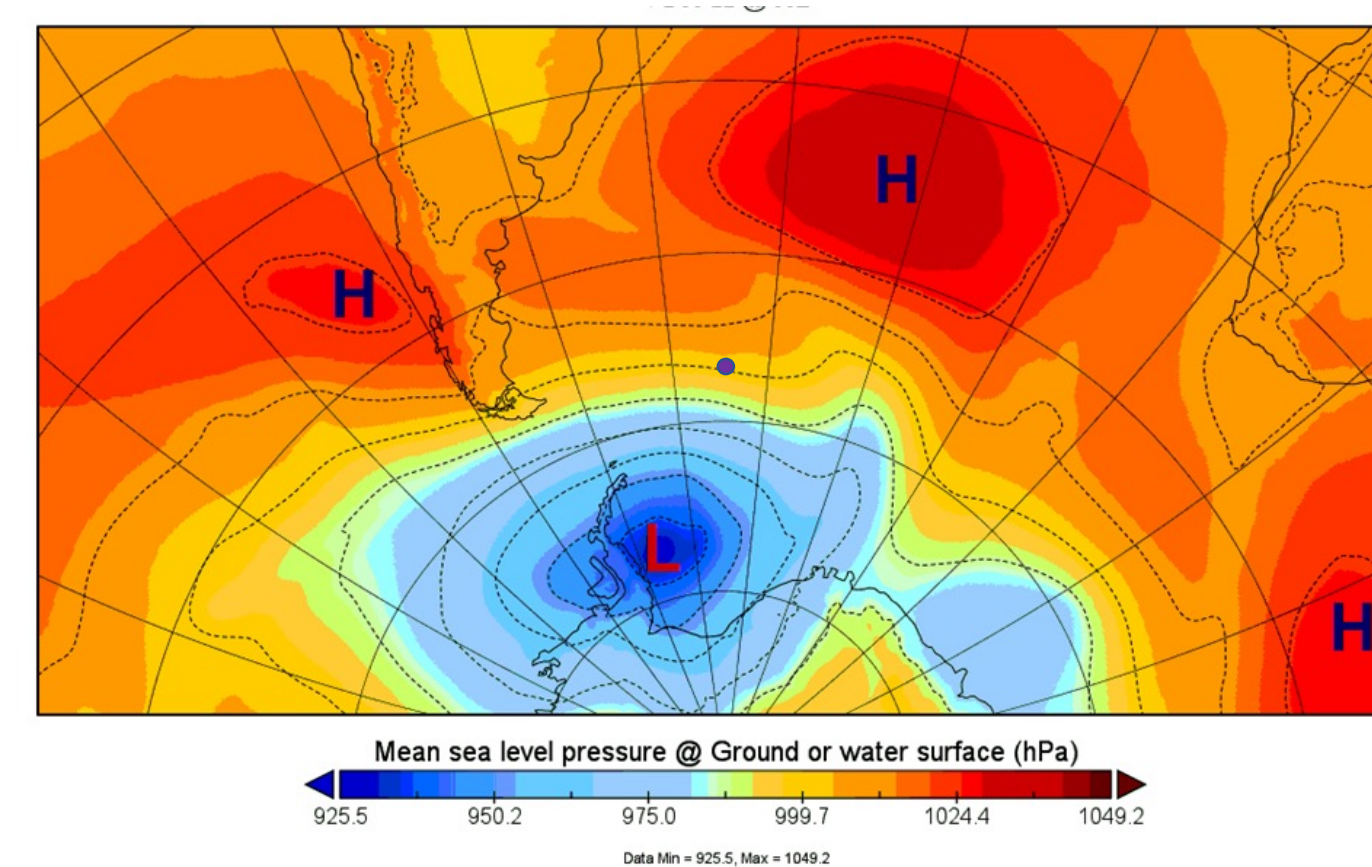


Figure 9: Mean sea level pressure (hPa) reanalysis chart with high- and low-pressure centers indicated for 1 Dec 22 at 00Z. Purple dot locates South Georgia.

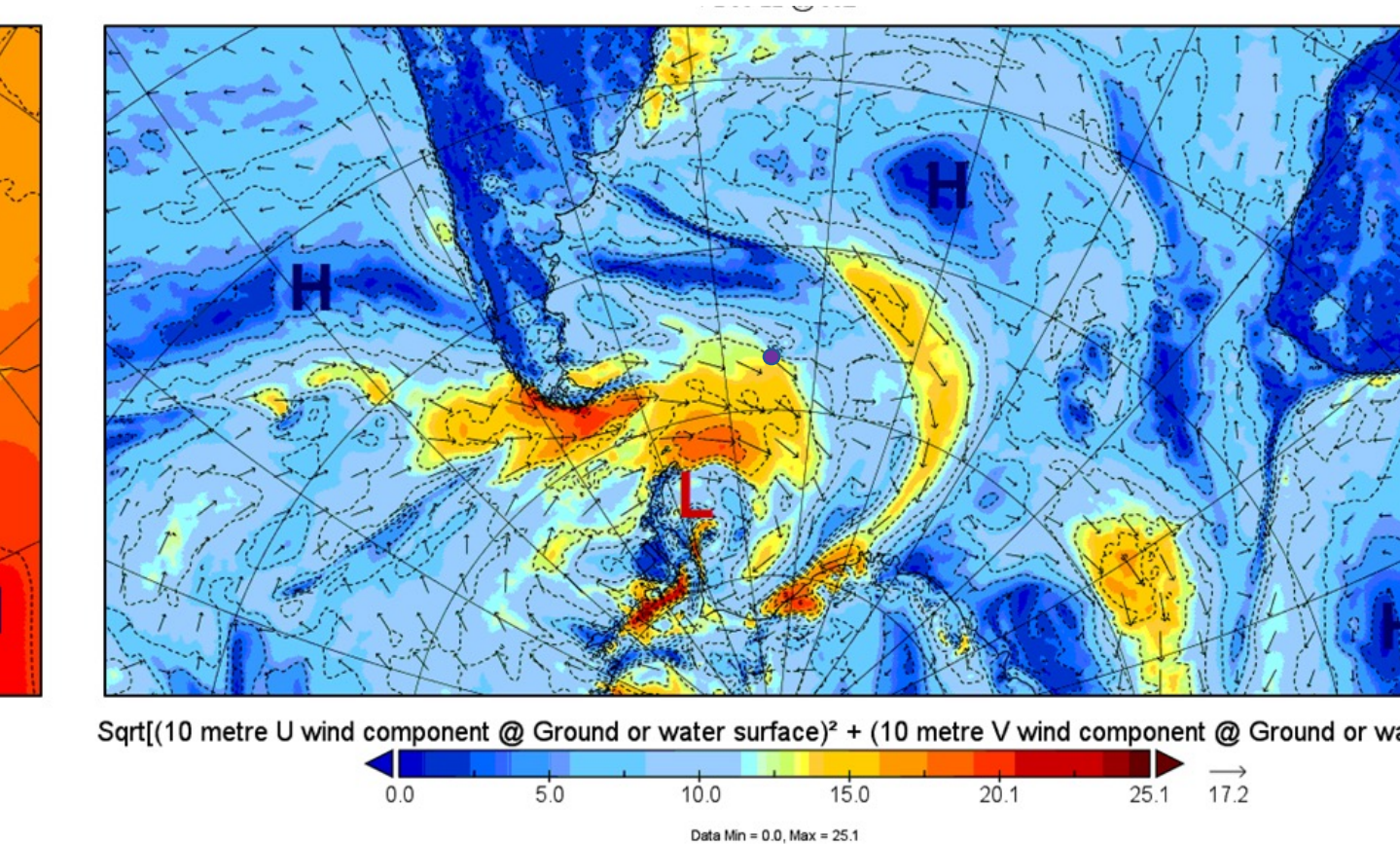


Figure 10: Mean sea level surface wind (m/s) reanalysis chart with high- and low-pressure centers indicated for 1 Dec 22 at 00Z. Purple dot locates South Georgia.

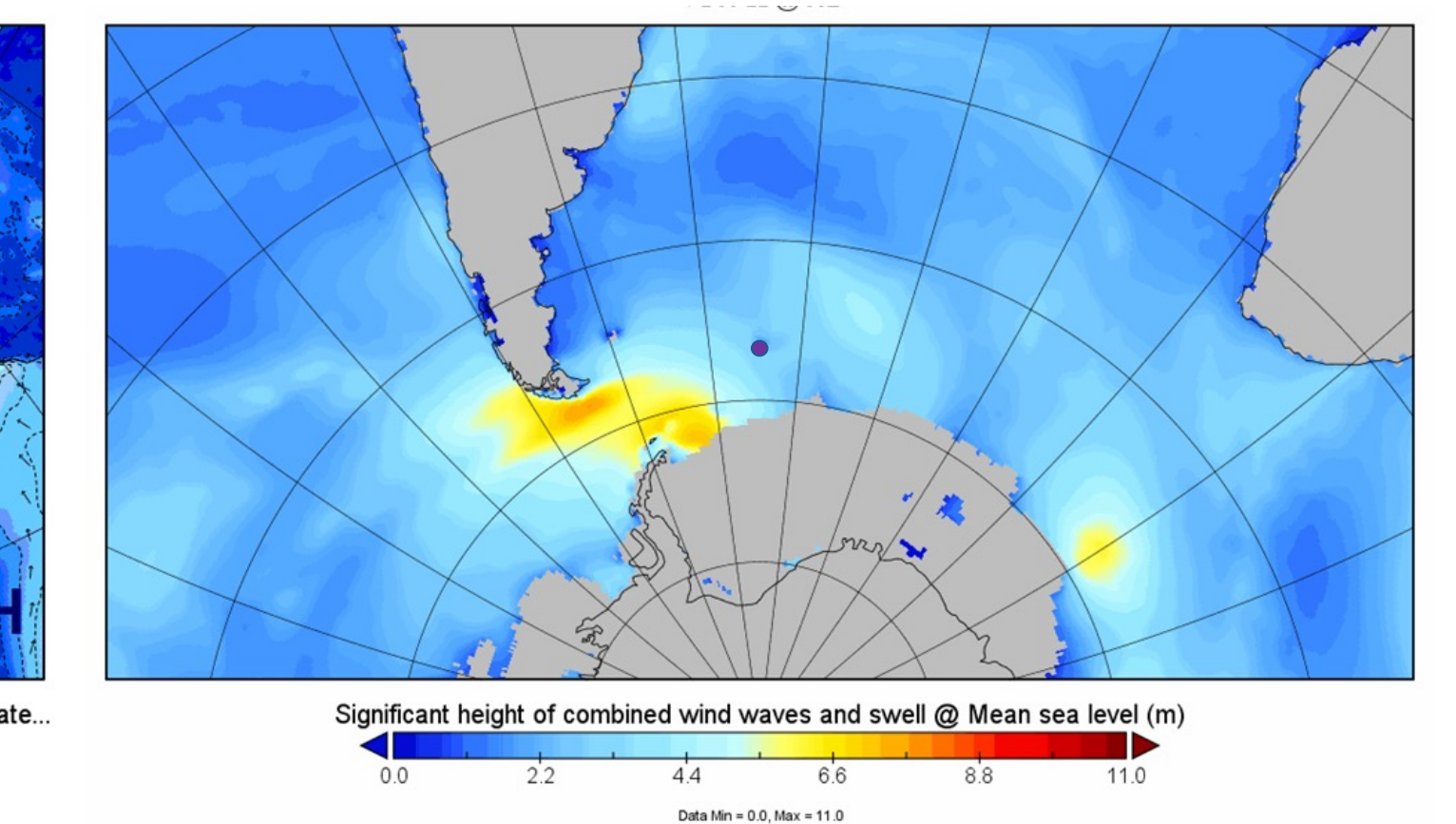


Figure 11: Heights of significant combined wind waves and swell (m) reanalysis on 1 Dec 22 at 00Z. Purple dot locates South Georgia.



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