Review on the paper **hgss-2022-9** by de Vos et al. on the drift of Shackleton's Endurence

General comment.

The 20th century reanalyses by ECMWF (ERA-20C) and NOAA (20CR) provide detailed data on the structure of the atmosphere also for time periods, where global data are sparse, e.g at the end of the 19th century and the beginning of the 20th century. With these datastets it is now possible to analyse historical meteorological events, as has been done e.g. by Brönnimann et al. (2012, DOI:10.1127/0941-2948/2012/0337) for several storms since 1871. The present paper uses ERA-20C data for the reconstruction of trajectories of ice drift during the finale days of the famous Endurance expedition. Hence the paper fits quite nicely into the application of reanalysis data to historical events. Bevor publication (which is recommended), some modifications should be made according to the comments provided below.

The authors would like to thank the reviewer for this positive and constructive input. Amendments made in response have both strengthened the manuscript directly and prompted us to enhance other aspects of the work. As the corresponding author I would also like to apologise for the delayed response. The timing of the review coincided with an Antarctic voyage, as well as other end-of-year academic commitments, thereby delaying the submission of these responses.

Specific comments

Sec. 2.3:

1.According to Poli et al (2016), the horizontal resolution for ERA-20C is about 125 km. The area for the calculation of trajectories as shown in Fig. 1 is about 40x40 km. Hence the wind data are taken only from the grid point including the target area. Is this the case?

Yes, this is the case. However, when downloading products, ECMWF makes information available at a range of regular grid resolutions via its Meteorological Interpolation and Regridding (MIR) package. Whilst no additional dynamical information is available simply by downloading data at higher interpolated resolution, the 0.125° (approx. 13.9 km) product was selected in case it facilitated somewhat smoother drift stepping. Figure 1 below shows the forcing data and search area, giving some idea of the resolution (one wind arrows for each grid cell, with cells also visible in the shading) Notwithstanding, comparing results using the 0.5° and 0.125° resolution revealed negligible differences.

In response to a call for the resolution of the data to be provided, the following text has been added to Section 2.3:

"ERA-20C has a spatial resolution of approximately 125 km on its native triangular grid (Poli et al., 2016b). However, interpolated data were downloaded on a regular grid with a resolution of 0.125. This interpolated product is produced by ECMWF's Meteorological Interpolation and Regridding (MIR) package and is available via ECMWF's download portal at: https://apps.ecmwf.int/datasets/data/era20c-daily/levtype=sfc/type=an/."

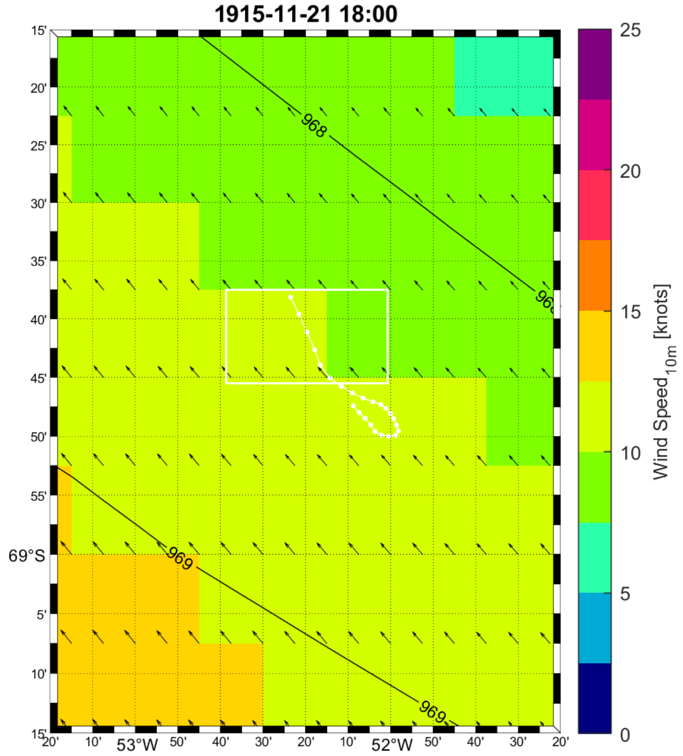

Figure 1. A snapshot of wind speed (shading & arrow length) and direction (arrow orientation) and mean sea level pressure (isobars) from ERA-20C. The search area is shown in red. There is one wind arrow per grid cell, giving an indication of the spatial resolution of the forcing product. Note that this is an interpolation onto a 0.125° regular grid from the native grid output from ERA-20. It is made available for download at this resolution via ECMWF's website.

2.The wind observations by Hussey have been interpolated to hourly values (Sec. 2.2). Was the same interpolation also performed for the 3 hourly ERA data?

We thank the reviewer for picking this up. Both sets of trajectories (ERA and Hussey) were computed at both 1 and 3-hourly resolution, producing negligible differences. However, it's true that the temporal resolution of the manuscript results should be consistent. We have thus changed the Hussey trajectories to 3-hourly to match the ERA ones.

Sec. 2.4:

1.The drift trajectories are calculated from the wind data. But which method is used for the calculation, e.g. a simple Euler forward time step or a more advanced integration/ interpolation method?

Two methods were tested. At each time step, the new position is computed from the start position by supplying the drift direction and distance to:

1. The Vincenty formula (Vincenty, 1975) via the *m_fdist.m* function for MATLAB by Pawlowicz (2020)
2. A simple trigonometric approach via the *ptlatlon.m* function for MATLAB by (Marty, 2018). Specifically:

$$lat_{end} = \operatorname{asin}\left(\sin(lat_{start})\cos\left(\frac{drift\_dist}{R_{earth}}\right) + \cos(lat_{start})\sin\left(\frac{drift\_dist}{R_{earth}}\right)\cos\left(drift\_bearing\right)\right.$$

$$lon_{end} = \mathrm{lon_{start}} + atan2\left(\sin\left(drift_{bearing}\right)\sin\left(\frac{drift\_dist}{R_{earth}}\right)\cos(lat_{start})\cos\left(\frac{drift\_dist}{R_{earth}}\right) - \sin(lat_{start})\sin\left(lat_{end}\right)\right.$$

Both methods produce nearly identical trajectories

2.Which time step is used for integration?

1-hourly and 3-hourly were tested. For the ERA, the 1-hourly represents an interpolated step, as the native resolution is 3-hourly. For the Hussey trajectories, both the 1 and 3-hourly are interpolated steps, as they are daily (mostly noon) observations. Since the trajectories were insensitive to the choice of time step, all trajectories presented in the manuscript utilised a 3-hourly time step.

Sec. 3.2: Positions of the Endurance were predicted for the entire period. Please provide the beginning and end of this period.

The period for which the drift simulation error was assessed was 18th January 1915 until 21st November, 1915. This is the period from when Endurance became beset until the time of the sinking. The text shall be amended to include this information.

Sec. 3.3:

1.In this section the winds obtained by ERA-20C and Hussey are compared indirectly by comparing trajectories which are an integrated form of winds. But the reader has no idea about the original wind data. Hence it is suggested, that the authors provide figures showing time series of wind speed and wind direction from both datasets , which is much more instructive for the comparison.

We thank the reviewer for this valuable suggestion. Timeseries graphs of wind speed and direction have been prepared and shall be included in the revised manuscript. This will also help to elucidate the differences between the ERA-20C and Hussey trajectories.

2.When comparing wind data from different sources one has to make sure, that these are taken at the same height above ground or have been interpolated to the same height. At which heights are the winds from Hussey and ERA-20C taken?

This is a valuable comment. In the initial set of results, the 10 m winds from ERA-20C were used without correction (as were the Hussey observations). We have now interpolated both the ERA-20C winds and Hussey's observed winds to the 2 m level by means of a logarithmic wind profile correction (Manwell et al., 2009), prior to use in the drift calculations. The choice of 2 m is a best guess to try and capture the winds which the floes of variable thickness (and irregular ridges) might have been forced by.

A note:
Data from NOAA-20CR reanalysis have been used by Etling (2017, DOI: 10.1127/metz/2017/0853) for investigating the atmosperic conditions of another famous polar expedition, the balloon flight of Andre and his crew in order to reach the North Pole in 1897 (which failed)

References

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Pawlowicz, R.: M_Map: A mapping package for MATLAB, https://www.eoas.ubc.ca/~rich/map.html, 2020.

Marty, R.: ptlatlon, https://nl.mathworks.com/matlabcentral/fileexchange/67254-ptlatlon, 2018.

Vincenty, T.: Direct and Inverse Solutions of Geodesics on the Ellipsoid with Application of Nested Equations, 88–93 pp., 1975.