A novel European windstorm dataset based on ERA5 reanalysis from 1940 to present

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Response to Reviewer #1

Thank you for your work in developing the European windstorm dataset based on ERA5 reanalysis.

This work lacks a good motivation for their study as providing windstorm track data from already existing ERA5 reanalysis data for insurance and risk management industry is not an innovation. Not sure why authors did not come up with strong objectives that should result in a journal paper. The authors mentioned, “The objective of this innovation is to promote a knowledge-based assessment of the nature ...,” which clearly is vague. The overall paper is written inadequately and hard to follow the style.

We would like to thank Reviewer #1 (hereafter Rev1) for the comments provided. These suggestions were valuable in guiding the revision and reorientation of the manuscript.

Integrating the comments received from the two Reviewers, we propose a revised version of the manuscript, focusing exclusively on the analysis of extratropical cyclone (ETC) diagnostics derived from the ETC track datasets. Other components of the windstorm service included in the original version will be succinctly introduced but not examined to sharpen the scientific focus and make the manuscript more concise.

The core of the revised manuscript will be represented by a set of twelve ETC diagnostics (Table R2.1), characterizing dynamical and impact-relevant features of ETCs like wind gusts and precipitation (Corner et al., 2025). Here, we will examine the modulation introduced by considering ETCs detected by two tracking algorithms leveraging two different variables to identify cyclone centers (850hPa relative vorticity and mean sea level pressure (mslp) for TRACK and TempestExtremes (TE) respectively).

Analysis based on ETC diagnostics enables the following: (i) to perform a thorough examination of the structural differences of the ETC detected by the two tracking algorithms used in the windstorm service, and (ii) to explore whether ERA5 can be reliably used for trend detection of ETC diagnostics and its applicability in climate impact studies. In this regard, following suggested studies (Bloomfield et al., 2018; Cusack, 2023; Wohland et al., 2019) and (Scoccimarro et al., 2024) we examine how the selected time period may influence the sign and robustness of possibly detected trends considering the evolving nature of ERA5's data assimilation system over decades. Within the set of ETC diagnostics, special attention will be paid to precipitation-based ETC diagnostics, where ERA5 trends will be compared against other observational reference datasets such as MSWEP (Beck et al., 2019) and whether changes in precipitation extremes associated with ETCs are consistent with expectations from the Clausius–Clapeyron relationship (Pall et al., 2007; Scoccimarro et al., 2024).

The revised version will be built on a more defined methodological framework, incorporating the main comments raised by the Reviewers and articulating as follows:

(i) the characterization of the mean features of the ETCs detected by the TRACK and TE algorithms;

(ii) ETC diagnostics trends across different periods;

(iii) a comparison of ETC precipitation diagnostics with reference datasets and physical scaling expectations;

(iv) a discussion on the implications of the analyzed periods on ETC diagnostic trends detection.

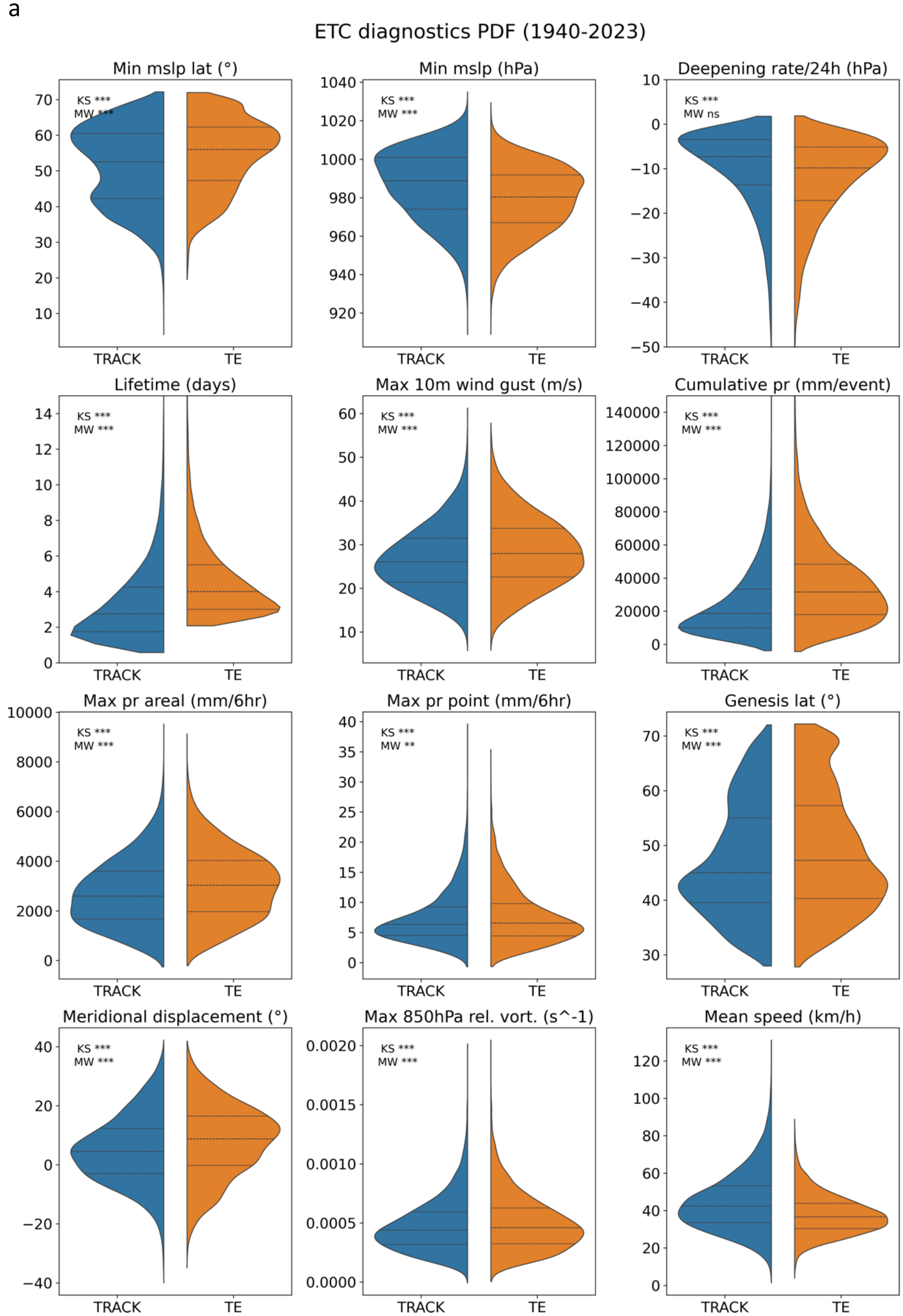
After having outlined the main pillars of the revised manuscript, we then provide a point-by-point response to Rev1 comments (in blue), highlighting the parts that we believe should be included in the revised manuscript.

In line 55, authors used words, such as “innovation” which I would rather avoid using such words or phrasing without claiming any notable innovation. We agree that the use of the term “innovation” may have overstated the contribution in its current form. In the revised manuscript, we will remove or rephrase such terms to more accurately reflect the scope of the work and its contribution, focusing instead on the added value of the service in terms of long-term consistency, methodological transparency, and user relevance.

The conclusion section is more geared towards “summary and conclusions.” Please take care of it. The conclusion section will be written accordingly to highlight the main take-home messages of the windstorm service and the scientific results of the paper.

Authors said, “The choice of the tracking algorithm is shown to be an important factor in the decision-making process, as it results in non-negligible uncertainties in main windstorm statistics,” I would suggest that adding a quantifiable result that can really show if it is an important factor or not. As previously mentioned, to improve the comparison between the two tracking algorithms, we introduce a set of ETC diagnostics aimed at capturing the main structural and dynamic features of the identified thunderstorms. Beyond simply counting storms and paths, this approach allows us to identify systematic differences in how intensity and dynamic characteristics compare in the events detected by the two tracking algorithms, and to assess their implications for downstream applications, such as wind footprint estimation. Diagnostics results for the two tracking algorithms, spatially averaged over the whole domain considered and for two different periods are shown in Figure R1.1. Related trends are shown in Figure R2.2.

a



ETC diagnostics PDF (1940-2023)
Min mslp lat (°)
Min mslp (hPa)
Deepening rate/24h (hPa)
Lifetime (days)
Max 10m wind gust (m/s)
Cumulative pr (mm/event)
Max pr areal (mm/6hr)
Max pr point (mm/6hr)
Genesis lat (°)
Meridional displacement (°)
Max 850hPa rel. vort. (s^-1)
Mean speed (km/h)
KS ***
MW ***
MW ns
MW **
TRACK
TE

b

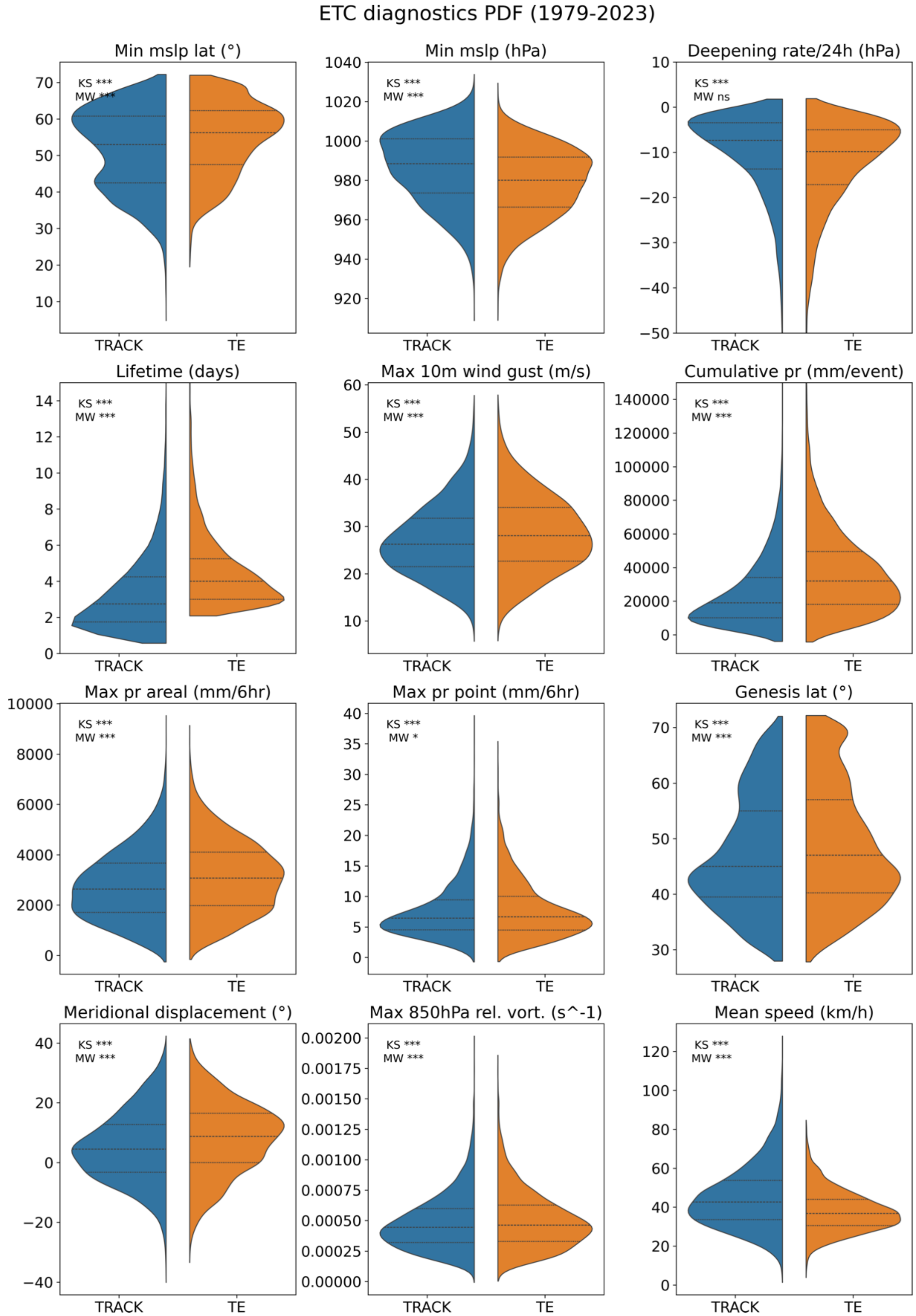


Figure R1.1. Vertically oriented PDFs built on spatially averaged ETC diagnostics considering tracks produced by TRACK and TE algorithms. Two periods are considered: 1940-2023 (a) and 1979-2023 (b). KS and MW identify the presence and level of statistical significance of the Kolmogorov-Smirnov (KS) and Mann-Whitney U (MW) tests, respectively. Inside each violin plot, the horizontal solid line represents the PDF median, whereas dashed lines the 25th and 75th percentiles.

Figure R1.1 presents the probability density functions (PDFs) of a set of spatially averaged cyclone diagnostics (as defined in Table R2.1), calculated from the tracks identified by the two tracking algorithms (indicated along the x-axis) over two time periods: 1940–2023 (panel a) and 1979–2023 (panel b). Statistical differences between the distributions were assessed using two non-parametric tests: the Kolmogorov–Smirnov (KS) test, which is sensitive to differences in the full shape of the distributions, and the Mann–Whitney U (MW) test, which emphasises differences in central tendency (i.e., the medians). Significance levels are indicated as follows: *** $p < 0.001$, ** $0.001 < p < 0.01$, * $0.01 < p < 0.05$.

Results indicate that the two tracking algorithms detect ETCs with significantly different features. TE algorithm tends to detect fewer (see also event density in Figure R2.5) but more intense ETC. TE-tracked storms are generally characterised by lower minimum sea-level pressure, faster-deepening rates, longer lifetimes, and greater cumulative precipitation. Spatially, TE events exhibit a larger meridional displacement, tend to originate further north and show lower mean translation speeds, pointing to greater persistence, as confirmed by their significantly longer duration. Importantly, these diagnostic distributions are consistent across the two periods considered, with no significant differences observed between the 1940–2023 and 1979–2023 PDFs. This temporal robustness stands in contrast to the trend analyses of the same diagnostics (see Figure R2.2), where substantial differences emerged across periods.

Possible explanations for differences, e.g. the propagation speed difference, lay on the fact that TE relies on pressure minima means and it possibly won't identify systems in strong background flows as the systems won't necessarily have a closed circulation. These systems will be travelling very fast, so TE probably only identifies them after they have undergone development and slowed down, whereas using vorticity allows these fast-moving early stages to be identified (Sinclair, 1997; Sinclair Mark R., 1994). The larger number of systems identified by TE at high latitudes is possibly due to the converging meridians when using a lat-long projection and might also explain why there are deeper systems due to the lower background pressures at higher latitudes. The other issue is that spectral filtering is used by TRACK to focus on synoptic scale cyclones whereas TC does not filter.

The font sizes of axes, ticks, titles, captions, etc. are non-uniform in most of the figures. The same goes for the colorbar as well. Please be sure to make them uniform. The figure resolution needs to be enhanced for better readability as they appear to be of low resolution in the current version of the manuscript. In addition, some of the figure captions are inadequately written without adequate sub- plot numbers, such as a, b, c, etc. for the reader. Make sure to provide numbering to all sub-plots and be consistent with the results and discussions provided. All the Figures of the manuscript have been modified and/or redone with higher resolution (300 DPI).

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