Reviewer #1 (Remarks to the Authors):

Review of "A Reanalysis-Based Global Tropical Cyclone Tracks Dataset for the Twentieth Century (RGTrack-20C)" for Earth System Science Data (ESSD)

Recommendation: Accept after major revisions

Review "signed" by Chris Landsea

This paper is an innovative look at tropical cyclone activity via the model reanalysis products. This does have the potential for improving our understanding of tropical cyclone variability and trends over time. A very interesting aspect of the study is the ability of the reanalysis to fill in the gaps from historic storms to provide realistic-looking central pressure information, where little to none had existed before. There are a number of issues – a few of significant concern – that must be addressed before this reviewer can recommend publication. However, these issues should be not insurmountable and the paper should help advance the field once published.

Authors' response: Thank you very much for your valuable comments and constructive suggestions on our research work. According to your suggestions, we have made substantial revisions to the manuscript. Particularly, we have discussed the changes in the assimilation of observational data into 20CRv3, as well as the starting years for providing intensity information in each ocean basin in IBTrACS, and conducted detailed comparisons between long-term tropical cyclone trends in RGTracks-20C and observational datasets. We hope we have addressed all your concerns. Below is a point-by-point response to your comments.

Significant issues:

Point 1. Trends in the number of sea level pressure observations available to the model reanalysis: While the model reanalysis provides an objective homogeneous platform to compare tropical cyclones now versus the past, the observations going into it change over time. More sea level pressure measurement will allow for better detection of tropical cyclones as well as more complete representations of the intensity (maximum wind/minimum pressure). Please discuss/show how the number of pressure measurements from ships, stations, and buoys going into the reanalysis changes over time.

Authors' response: Thank you for the suggestion. We agree with you that the number of available observations assimilated into the reanalysis changes over time, and it does consequently impact the number of tropical cyclones (TCs) detected from the reanalysis. According to your comment, we have added discussions about the variability of the number of available observations and its impacts on our dataset to the revised manuscript: Lines 587–590 and 636–654, Supplementary Text S4, and Figs. S9–10. More details are given below.

The Twentieth Century Reanalysis Version 3 (20CRv3) Reanalysis (Slivinski et al., 2019) assimilated surface pressure data from the International Surface Pressure Databank version 4.7 (ISPD v4.7) (Compo et al., 2019), including station and marine observations as well as TC best track pressure reports. These data are available at https://downloads.psl.noaa.gov/pub/Datasets.other/ISPD/. We downloaded and employed these data in the following discussion.

As shown in Fig. R1 (same as Fig. S10 in the revised manuscript (Lines 657–660)), the annual number of available observations and assimilated observations increases over time, with both showing accelerated growth, especially after 1950. This increasing number of available observation data could improve the quality of the reanalysis (Slivinski et al., 2019, 2021). It is noted that a small portion of the assimilated surface pressure observations in Fig. R1 comes from the historical TC dataset (i.e., the International Best Track Archive for Climate Stewardship, IBTrACS) (Knapp et al., 2010; Slivinski et al., 2019). Although the number of these observations is relatively small, they are crucial for reproducing TCs in the reanalysis (Slivinski et al., 2019).

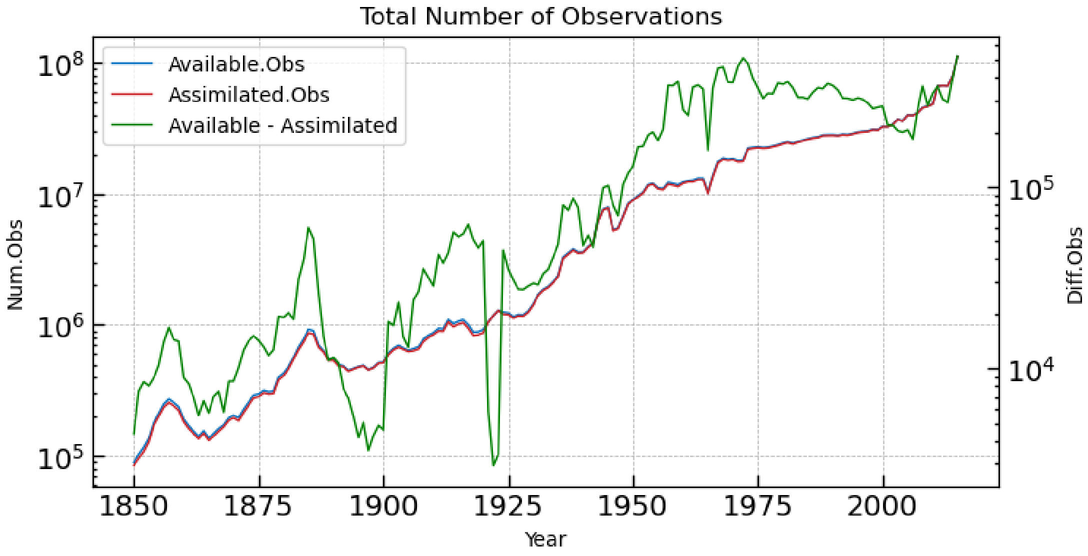

Figure R1 (Fig. S10 in the revised manuscript): Time series of the total number of available and assimilable observations per year from 1850 to 2015. The blue line represents the available observations, the red line represents the assimilated observations, and the green line is the difference between the two.

As illustrated in Fig. R2 (same as Fig. S11 in the revised manuscript (Lines 587–590 and 657–660)), prior to 1945, the global annual number of recorded TCs was generally fewer than 20, mainly due to the limited observational capabilities of ships and coastal stations. After 1945, with the introduction of aircraft observations, the number of TCs recorded in IBTrACS increased, particularly between 1945 and 1979, reflecting an overall rise in global observational coverage. After 1980, the development of satellite observation technology led to stabilization in the annual number of recorded TCs, typically ranging between 80 and 100. Table R1 provides further details on the starting years of TC surface pressure observations for various basins, which shows that such observations are available only since the period of 1945–1979, especially in the western North Pacific (WNP), North Atlantic (NATL), and Southern Hemisphere. This aligns with the observed increase in TC records shown in Fig. R2. Thus, during this period, the number of assimilated observations in reanalysis increased significantly, indicating that the number of TC observations assimilated into the 20CRv3 also increased accordingly.

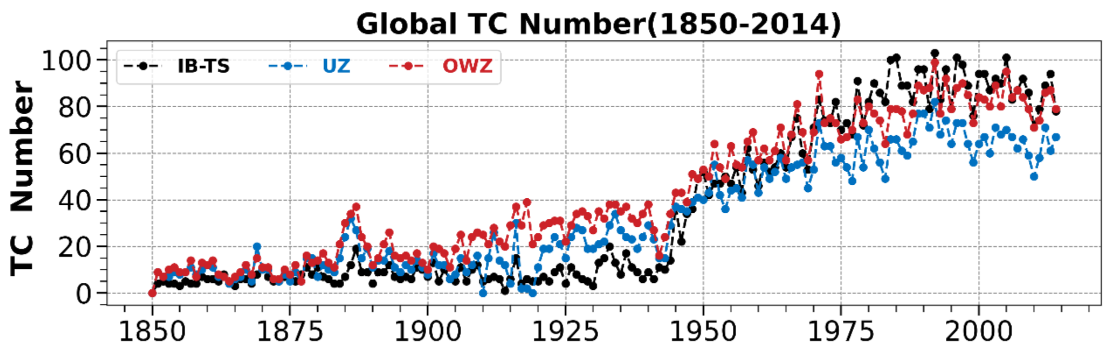

Figure R2 (Fig. S11 in the revised manuscript): Time series of annual TC numbers from 1850 to 2015. (Black line: storms lasting >2 days and storms peak intensity >16 $m \cdot s^{-1}$, blue line: UZ tracker, red line: OWZ tracker)

Point 2. IBTRACS' central pressures into reanalysis: The IBTRACS' central pressure values for tropical cyclones are included as an "observation" for the reanalysis to assimilate. This means that the reanalysis and IBTRACS are not independent and that the reanalysis should replicate much of the characteristics of IBTRACS. Please make sure that this point is clearly stated. Moreover, please indicate in the paper what year by basin that the central pressures were routinely included into IBTRACS. For example, the Northeast/North Central Pacific only began including pressures into IBTRACS starting in 1988. This has a profound effect on the ability of the reanalysis to detect the tropical cyclone activity. Again, focusing upon the NE/NC Pacific, the low hit/high miss rate in in Figure 3, the very low numbers of TCs in Figure 7a before 1988, the very low duration of TCs in Figure 7b before 1988, and the low correlations in Table 3 are likely a consequence of these missing pressures before 1988. Please address these issues and also point out where other basins may have similar issues before central pressures were routinely included into IBTRACS.

Authors' response: Thank you for your comments and the valuable information provided.

1) We agree with you that the IBTRACS' central pressure data are included as an "observation" in the 20CRv3 production. In the 20CRv3, surface pressure reports from ISPD 4.7 (Compo et al., 2019) are assimilated, which include station observations, marine observations, and TC data from the IBTrACS(Knapp et al., 2010; Slivinski et al., 2021). Therefore, 20CRv3 and IBTrACS are not independent, and this has been explicitly stated in the revised manuscript (Lines 120–130 and Supplementary Text S4).

2) As mentioned by the reviewer, the year in which central pressure data were incorporated into IBTrACS varies with basins. And, this may impact the results of detecting TCs from the 20CRv3. For instance, as the reviewer highlighted, in the Northeast/North Central Pacific, the inclusion of pressure data in IBTrACS only began in 1988. Specifically, the low hit rate and high miss (Fig. 3), the very low number of TCs before 1988 (Fig. 8a), the shorter TC durations (Fig. 8b), and the low correlations (Supplementary Figs. S4a–d and Table S2) may be consequences of the missing pressure data before 1988 (Table R1).

According to the reviewer's suggestion, we have requested information regarding the year of inclusion of pressure data in IBTrACS from the 20CRv3 production team. Table R1 lists the information provided by Dr. Jennifer Gahtan from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information. We found that in addition to the Northeastern Pacific (ENP), the Northern Indian Ocean (NI) also began incorporating central pressure data into IBTrACS primarily after 1990, which likely contributes to the lower correlation between RGTracks-20C and IBTrACS in these regions (Fig. 8 and Supplementary Figs. S5e–h and Table S2). In summary, the onset year of reliable TC information in IBTrACS affects both the TC results derived from 20CRv3 and the assessment results in this study.

These discussions have been included in Supplementary Texts S2.2 and S2.4. We have also added remarks noting the limitation of the RGTracks-20C in reproducing realistic TC variability in early years (Lines 157–159, 627–640 and 657–665 in the Usage Notes section).

Table R1 (Table. S3 in the revised manuscript): Years of the beginning of the recording of the *SLP_{min}* for TCs by different agencies in the most important ocean basins. (The information in the table was provided by Dr. Jennifer Gahtan from NOAA's National Center for Environmental Information.)

Basin	Agencies							
North Atlantic	HURDAT2	M Chenoweth	DS824	TD9636				
	1979*1	1851	1851	1899				
East Pacific	HURDAT2		DS824					
	1988		1949					
Central Pacific	HURDAT2							
	2001							
West Pacific	China	Japan	HKO	JTWC	DS824	TD9636		
	1949	1951	1961	2001	1945	1945		
North Indian Ocean	India	JTWC	DS824					
	1990*2	2001	Mid-1970's					
Southern Hemisphere	La Reunion	Australia	New Zealand	Nadi	JTWC	DS824	Neumann	TD9636
	1977	1907	1968	1992	2001	1877	1960s	1956

Note:

*1. North Atlantic: 1979 (with prior data given if there was a specific observation) HURDAT2

*2. North Indian Ocean: 1990 (soon to be 1982) India

3. Multiple Basins 1945 TD9635

Minor Points:

Point 1. Does duration include non-tropical cyclone stages (extratropical, pre-genesis low, remnant low)? It should not.

Author's Response: Thank you for the suggestions. We do agree that non-tropical cyclone stages should be removed in the TC duration analyses. However, in our manuscript, we did not explicitly remove these non-tropical cyclone stages for two reasons:

(1) In normal practices, distinguishing between tropical and non-tropical stages relies on wind field characteristics and thermal structure. However, current reanalysis products, including 20CRv3, have significant uncertainties in wind field representation, particularly for TCs. Classifying TC and non-tropical cyclone stages based solely on these wind fields would be unreliable and could introduce biases and uncertainties into our duration estimates.

(2) The current goal of this paper is to develop a historical TC dataset spanning the 20th century. Detecting the duration of TCs from 20CRv3 using tracking algorithms may vary depending on the algorithm employed. For instance, the OWZ algorithm, designed based on the genesis conditions of TCs, can capture tropical depression phases (Tory et al., 2013), whereas the UZ algorithm cannot(Bourdin et al., 2022). Consequently, the OWZ algorithm demonstrates good agreement with observed TC durations, while the UZ algorithm yields notably shorter durations compared to observations. Although both algorithms require a minimum two-day duration threshold (Lines 211–213 and 236–237 in the revised manuscript), it remains challenging to entirely distinguish tropical non-tropical phases, and previous studies have lacked consistent standards for such differentiation.

We agree with you that including non-tropical cyclone stages may introduce biases in the TC duration analyses, but this may not be technically practical for the current version of RGTracks-20C which is produced based on simple UZ and OWZ algorithms. We will introduce more advanced TC tracking algorithms which are able to distinguish TCs at different stages (Han and Ullrich, 2025) (as also suggested by another reviewer) in the future versions of RGTracks-20C. Meanwhile, in this manuscript, we have added discussion acknowledging the above issues in the TC duration assessment (Lines 441–445 and 623–626, Supplementary Sect. S2.3).

Point 2. Figure A: It is noted that the reanalysis completely missed the Category 3 hurricane stage of Hurricane Andrew while it was over the Gulf of Mexico. This could be related to the very small size of system.

Author's Response: Thank you for the comment. We completely agree that Hurricane Andrew's relatively small size over the Gulf of Mexico contributed to the differences in TC positions between RGTracks-20C and IBTrACS. The coarse horizontal resolution of 20CRv3 (1° × 1°) hinders its ability to accurately and completely simulate Hurricane Andrew, leading to errors in its detection. This is evident in Fig. R3, which presents the sea level pressure and 10-meter wind field from August 24 to August 25, 1992. Results show that, starting from 12:00 on August 24, 1992, the position tracked by the OWZ tracker began to deviate from that recorded by IBTrACS, where the 20CRv3 exhibited a weakening in the pressure field and a diminishing structure of closed isobars. As time progressed, the closed isobar structure completely disappeared, suggesting significant errors in the 20CRv3 simulation of this hurricane phase.

We have added a discussion in the revised manuscript (Lines 548–550, Fig. S5).

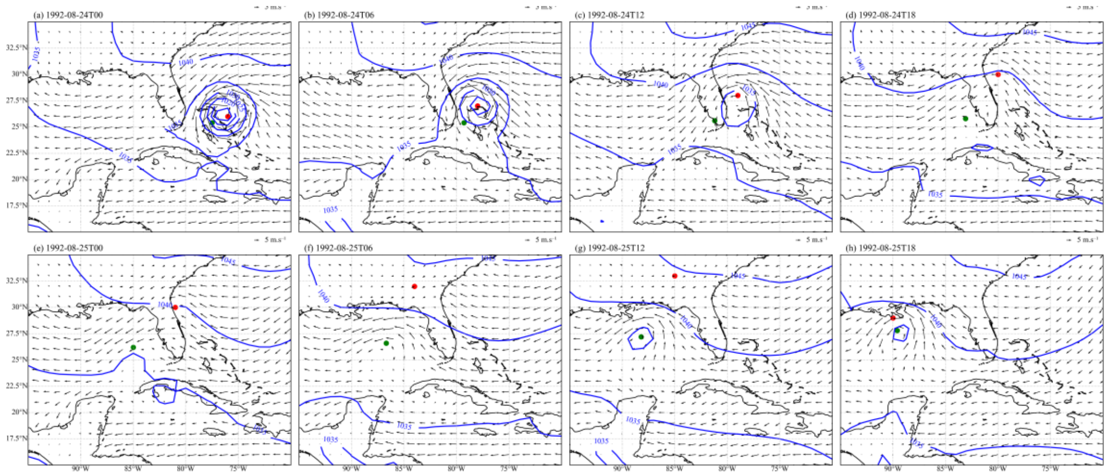

Figure R3 (Fig. S5 in the revised manuscript): Hurricane Andrew's August 24-25, 1992, sea level pressure and wind speed at 10 m obtained from 20CRv3.

Point 3. Figure 4 and S4: Are the red and green curves right on top of each other on C) and D) (A to D in S4)? If so, please mention this explicitly.

Author's Response: Thank you for the question. By zooming in Fig. 4c (Fig. 5c in the revised manuscript), in the previous version (shown in Fig. R4), we find that the red and green lines do not completely overlap. Furthermore, analysis of Figs. 7c–d indicates that, despite bias corrections applied to RGTracks-20C, discrepancies between RGTracks-20C and IBTrACS still persist. According to your comment, we have clarified the differences between two red and green curves (Lines 466–468, Fig. 5 in the revised manuscript).

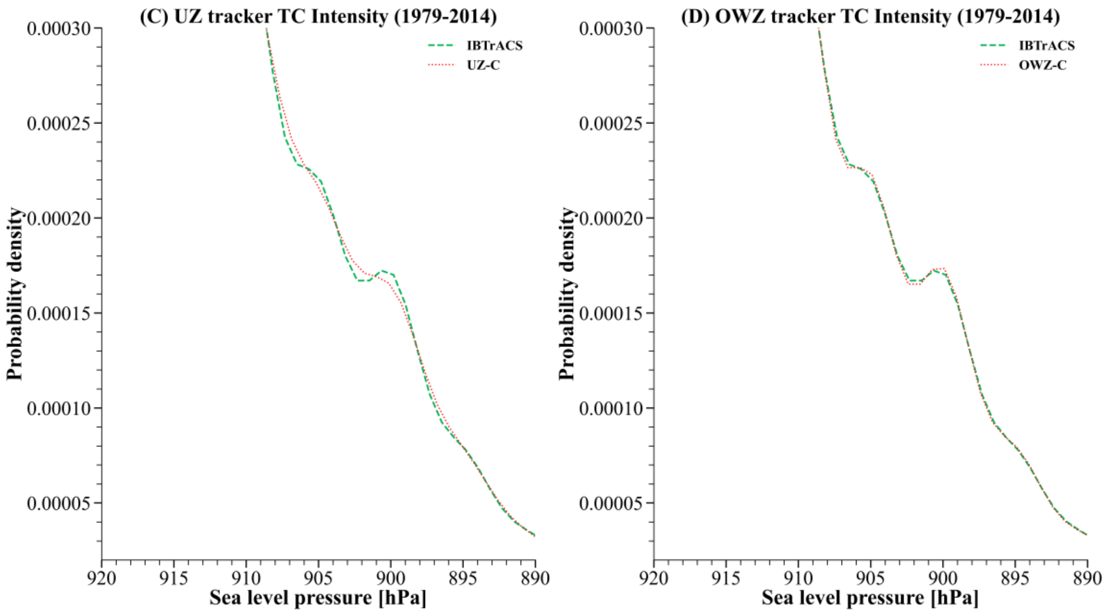

Figure R4 (Figs. 4c–d subplot in the revised manuscript): As in Fig. 4c–d, but as a cutoff and enlargement from Fig. 4c–d.

Point 4. Figure 7 and 8: The authors should note and comment about where there are discrepancies in the slope of the long-term trend between the reanalysis and IBTRACS, such as Figure 6C for central pressure.

Author's Response: Thank you for this valuable suggestion.

On a global scale, IBTrACS and the RGTracks-20C (20CRv3-derived TCs) show rather good consistency in the long-term trend of TCs (Table R2). For TC intensity, the directions of the trends are consistent in both datasets, with the trends in the OWZ being similar to those of IBTrACS, though with smaller magnitudes. However, the long-term trends in TC number and TC days are not statistically significant in either dataset.

Regionally, the long-term trend of TC activity in RGTracks-20C is consistent with IBTrACS in the WNP, NATL, NI, South Indian Ocean (SI) and South Pacific (SP) basins (as indicated by the grey background in Table R2). In the WNP, NATL, and SP, the directions of the TC trends are the same in both datasets, with most results passing the 90% confidence level. In the SI, the trends in TC number and days are not statistically significant for either dataset. However, the trends in TC intensity are consistent, and the trends in TC activity from the OWZ tracker closely match the observed trends. In the NI, the trends in TC activity from both datasets are not statistically significant. Notably, there are significant discrepancies in the long-term TC activity trends between RGTracks-20C and IBTrACS in the ENP.

In the revised manuscript, we have discussed TC activity trends in IBTrACS and RGTracks-20C in Supplementary Text S2.4 and added a discussion in the revised manuscript (Lines 482–465, 512–516, 530–534 and 627–640).

Table R2 (Table S4 in the revised manuscript): Linear trends in TC activity globally and across six basins, as recorded in IBTrACS and RGTracks-20C. Grey background indicates that the trends between IBTrACS and RGTracks-20C are consistent sign and statistical significance. Asterisks indicate the confidence levels, 1 asterisk (*) = 90%, 2 asterisks (**) = 95%, and 3 asterisks (***) = 99%. UZ-C and OWZ-C represent results after intensity bias correction.

		Global	WNP	ENP	NATL	NI	SI	SP
Number ($year^{-1}$)	IBTrACS	**-0.06**	**-0.12***	-0.08	**0.24*****	**0.01**	**-0.04**	**-0.10***
	UZ	**-0.01**	**-0.14***	0.16***	**0.07**	**0.02**	**-0.01**	**-0.12****
	OWZ	0.19	**-0.12***	0.20***	**0.14****	-0.04	0.04	**-0.08**
TC days ($day \cdot year^{-1}$)	IBTrACS	**-2.70**	**-3.64*****	-0.03	**1.93*****	**0.16**	**-0.15**	**-1.02***
	UZ	**-0.29**	**-0.95**	0.97**	**0.59**	**0.11**	**-0.40**	**-0.72***
	OWZ	1.82	**-1.32**	1.86***	**1.38****	-0.14	0.63	**-0.79***
Intensity ($hPa \cdot year^{-1}$)	IBTrACS	**0.17*****	**0.03**	0.24**	**-0.06**	-0.09	**0.27*****	**0.08**
	UZ	**0.03**	**0.01**	-0.09	**-0.06**	0.03	**0.05**	-0.06
	OWZ	**0.05*****	**0.03**	-0.05	**-0.05**	0.03	**0.08*****	**0.03**
	UZ-C	**0.04**	**0.02**	-0.12	**-0.10**	0.01	**0.07**	-0.10
	OWZ-C	**0.09*****	**0.04**	-0.07	**-0.08**	0.02	**0.13*****	**0.05**

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With kind regards,
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