AGU PUBLICATIONS

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Tropical Cyclone Forecasts in the DIMOSIC Project

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Contents of this file

Introduction

This supporting information file includes:

1) Analyses of TC track errors of GFDL SHiELD in the North Atlantic basin (NATL) (Text S1 and Figures S1-S3)

2) Analyses of along-track (AT) and cross-track (CT) errors for all 8 models in the 4 major sub-regions (Text S2 and Figures S4-S7)

Text S1.

During the DIMOSIC period, SHiELD is one of the top performance models which show low tropical cyclone (TC) track forecast errors in most sub-regions but not in the North Atlantic basin (NATL). We therefore further investigate the large track error of SHiELD in the NATL to supplement the results of track error analysis, and to provide references for the SHiELD development team at GFDL.

Figure S1a shows the mean TC track forecast errors for all of the 8 DIMISIC models in the NATL, with the differences of TC track errors of the 7 models comparing to IFS (Fig. S1b). It can be found that SHiELD shows a much larger track error than most other models during the 72-120 lead times.

We investigated the track forecasts of the 16 TCs in the NATL during the target year individually and found that the basin-wide mean track errors are actually dominated by 2 TCs, Hurricanes Florence (2018) and Leslie (2018). Comparing to other leading models, SHiELD shows difficulty to forecast the storm movements of these two hurricanes. Figure S2 shows the forecasted tracks of Florence from IFS-47R3, SHiELD, ICON, and UM initialized at 00Z Sep. 1st (Fig. S2a) and 00Z Sep. 13th (Fig. S2b) comparing to the best track. It can be found that SHiELD shows slow moving biases on Florence's translation in both early and late stage of its lifetime, while IFS-47R3, ICON and UM do not show similar forecast biases. Different from Florence which had a steady westward movement crossing the Atlantic Ocean, Leslie had an irregular track with many loops in the middle of Atlantic Ocean before heading northeasterly to Portugal. From Fig. S3, we can see that SHiELD didn't well capture some of the sharp turns which are critical in the track forecast of this storm. In contrast, IFS-47R3, ICON, and UM can perform much better "v" shape turns in their forecasts initialized from 00Z 1stOct. and from 00Z 7th Oct.

To summarize, the large TC track error of SHiELD in the NATL results from the slow moving bias shown in the forecasts of Hurricane Florence and the bias of direction of motion shown in the forecasts of Hurricane Leslie.

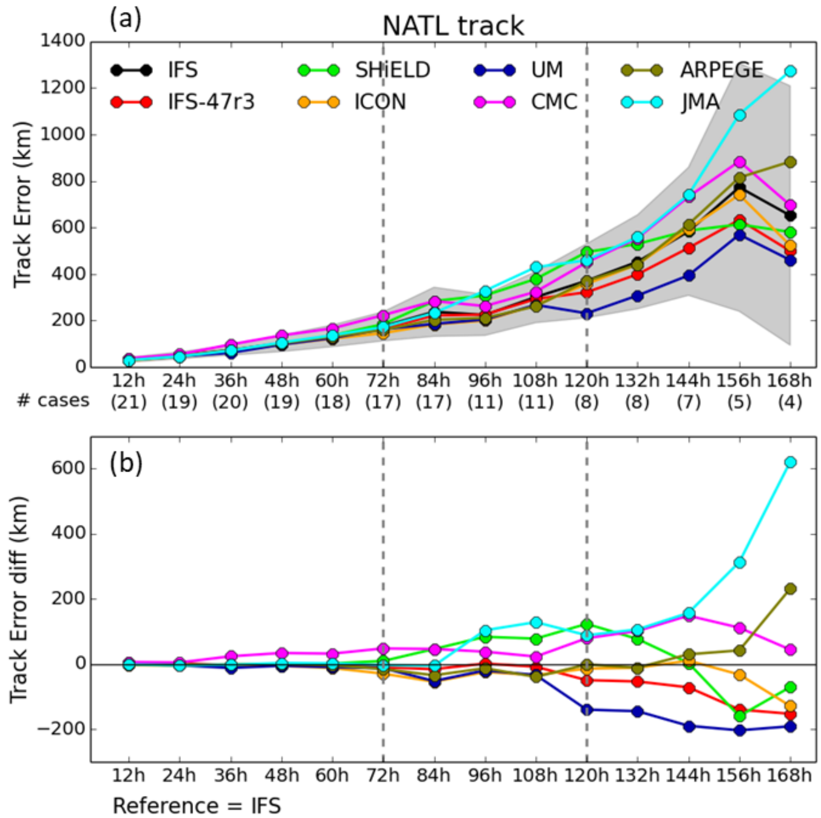

Figure S1. (a) Mean TC track forecast errors (km) along with the model forecast lead time for IFS (black), IFS-47r3 (red), SHiELD (green), ICON (yellow), UM (blue), CMC (magenta), APREGE (grass green), and JMA (light blue) in the North Atlantic basic (NATL). The 95% confidence levels for IFS are indicated by the gray color shading. Numbers of homogeneous cases for individual lead times are listed in the brackets at the bottom of each abscissa. Vertical gray dotted lines are indicated 72 and 120 h. (b) Mean TC track forecast error differences of IFS-47r3 (red), SHiELD (green), ICON (yellow), UM (blue), CMC (magenta), APREGE (grass green), and JMA (light blue) in the NATL comparing to IFS.

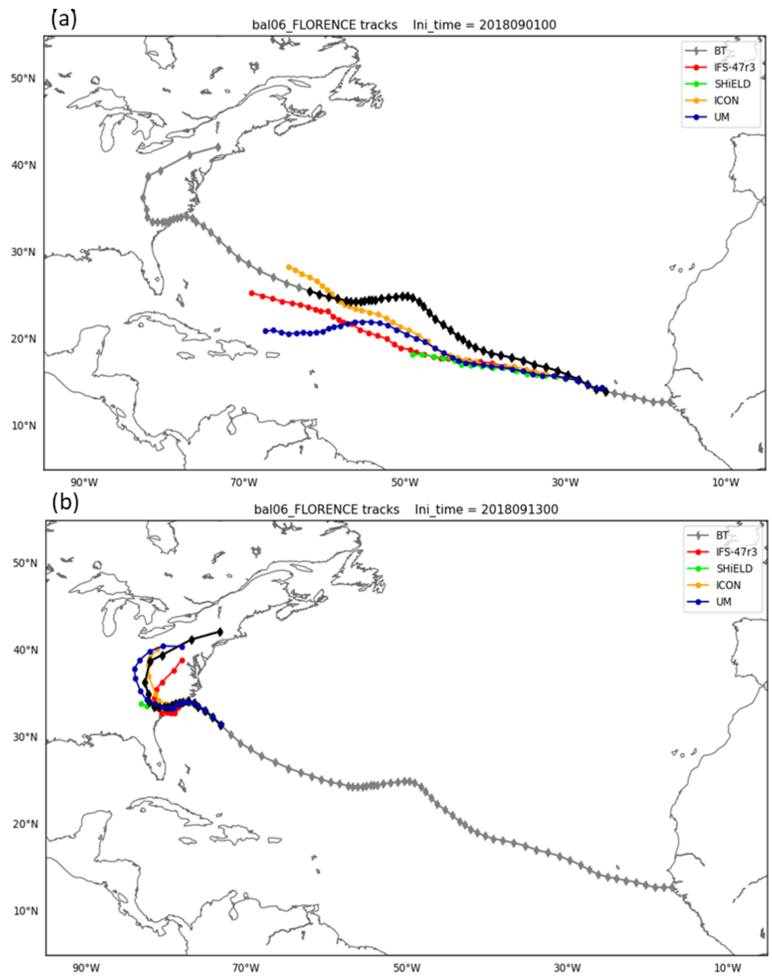

Figure S2. (a) Model forecasted tracks from IFS-47r3 (red), SHiELD (green), ICON (yellow), and UM (blue) initialized at 00Z 20180901 comparing to the Automated Tropical Cyclone Forecast (ATCF) best track for Hurricane Florence. Dots for model forecasts and typhoon symbols for the best track are at 6-hour interval. The best track of Hurricane Florence during the 10-day forecast period is plotted in black, and the rest part of the best track is plotted in grey. (b) As in (a), but for model forecasts initialized at 00Z 20180913.

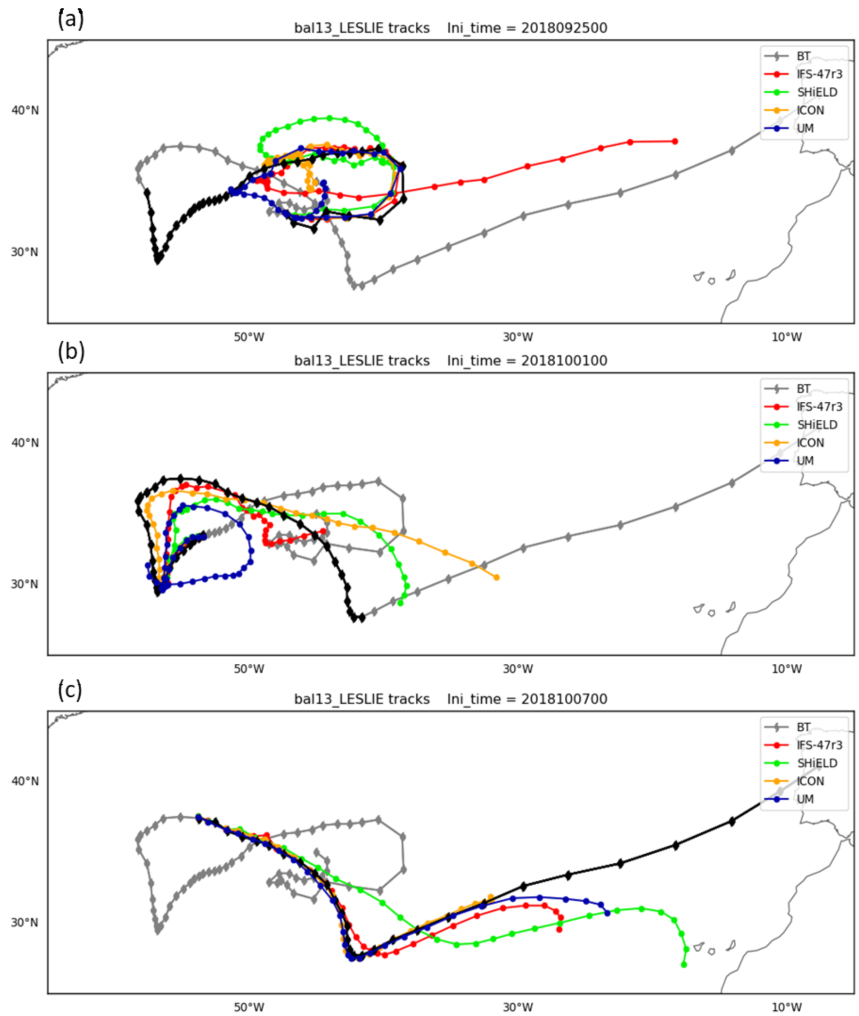

Figure S3. As in Figure S2, but for the model forecasts initialized at (a) 00Z 20180925, (b) 00Z 20181001, and (c) 00Z 20181007 for Hurricane Leslie comparing to the best track.

Text S2.

Analyses of along-track (AT) and cross-track (CT) errors for all eight models in the four major sub-regions are shown in Figs. S4-S7. We note that the models behave differently in different sub-regions. In the NATL (Fig. S4), the AT and CT errors during the first 5 days evenly contribute to the total track errors in the two IFSs. UM AT/CT skill is similar to that of the IFSs but with a larger AT error component on Day 3 to 4 (Fig. S4f). In contrast, ICON and CMC have a much larger AT error component than the CT error (Figs. S4c,e), which indicates that their total track errors in the NATL are mostly due to slow moving biases. The source of track error of SHiELD in the NATL is a combination of AT error during 96 to 132-hour lead time and CT error at Days 6 to 7 (Fig. S4d), which is consistent with the single case analyses (Text S1 and Figs. S1-S3).

In distinct behavior from the NATL, seven of the eight models show positive AT error biases in the EPAC during the first five days (Fig. S5). This indicates that the model-predicted TCs are usually moving too fast in this basin. In contrast, JAM suffers a slow-moving bias as shown by a dominant negative AT error bias (Fig. S5h). Also, the large track error of UM during the first five days in this region (Fig. 3) is mostly from a fast-moving bias, but a southward-moving bias also contributes. In the WPAC, all models consistently show negative AT error biases and positive CT error biases after Day 5 (Fig. S6). It is clear that a slow-moving bias is the main source of the total track errors in the two IFSs in this region (Figs. S6a,b). UM and JMA show large contributions of AT errors during Days 4-5, but northward-moving biases also contribute to the total error substantially (Figs. S6f,h). ICON, SHiELD, and CMC show even greater contributions of AT and CT errors to their total track errors than other models (Figs. S6c-e). In the SHEM (Fig. S7), except for SHiELD showing a relatively even contribution of AT and CT errors with small biases, other models generally exhibit much larger components of AT errors than CT errors. However, there are no consistently slow- or fast-moving biases among models in this basin. IFSs and CMC show consistently slow-moving biases after three days, while UM shows fast-moving biases in the later lead times. ICON, APREGE, and JMA show mixed slow- or fast-moving biases in the seven days of lead time.

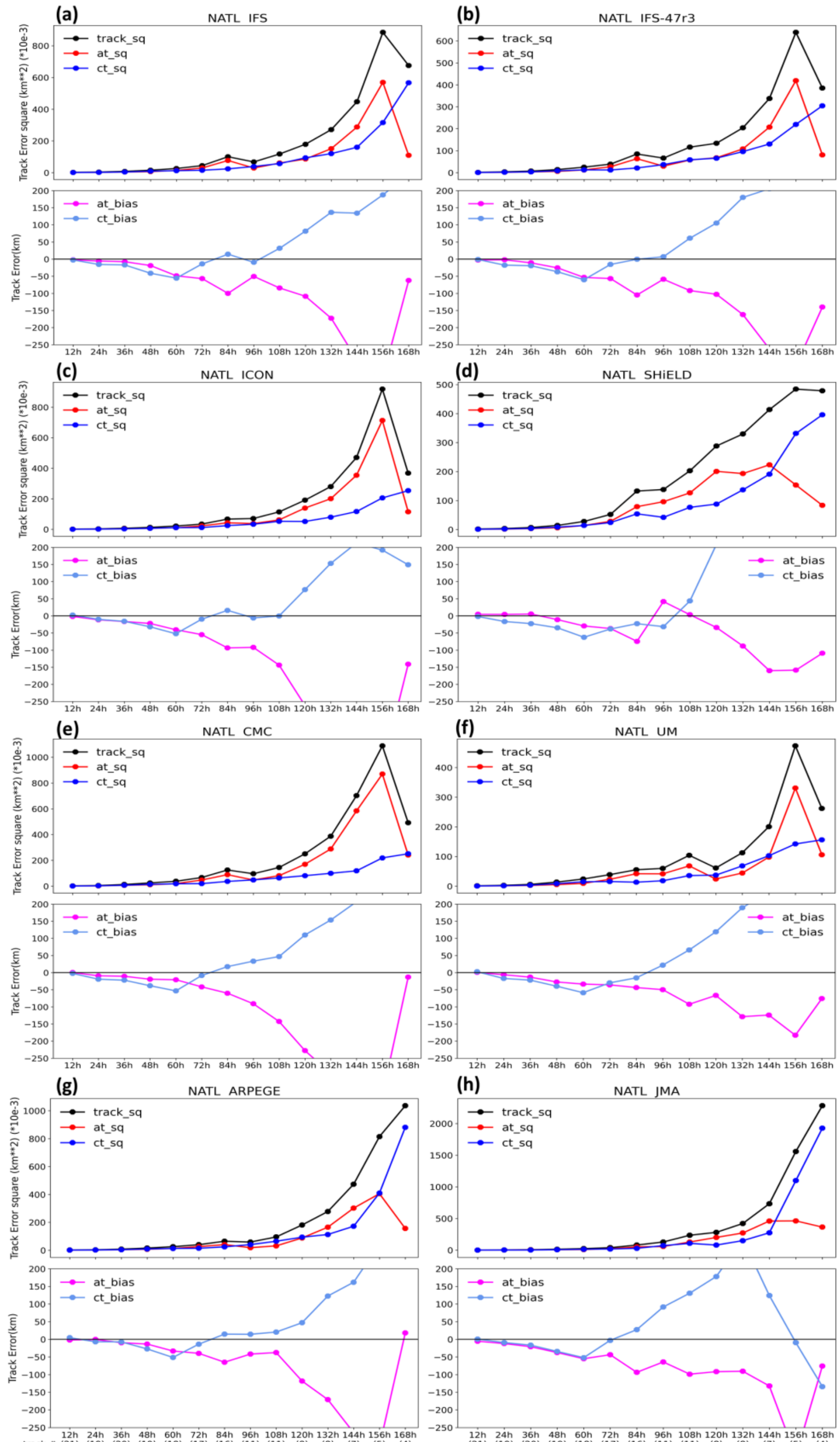

Figure S4. Analyses of along-track (AT) error and cross-track (CT) error for (a) IFS, (b) IFS-47R3, (c) ICON, (d) SHiELD, (e) CMC, (f) UM, (g) ARPEGE, and (h) JMA in the North Atlantic basin (NATL). The squares of total track errors (black), along-track errors (red), and cross-track errors (blue) are in the upper panels for each model. The biases of along-track (magenta) and cross-track (light blue) errors are in the lower panels. Numbers of homogeneous cases for each lead time are listed at the bottom of lower panels.

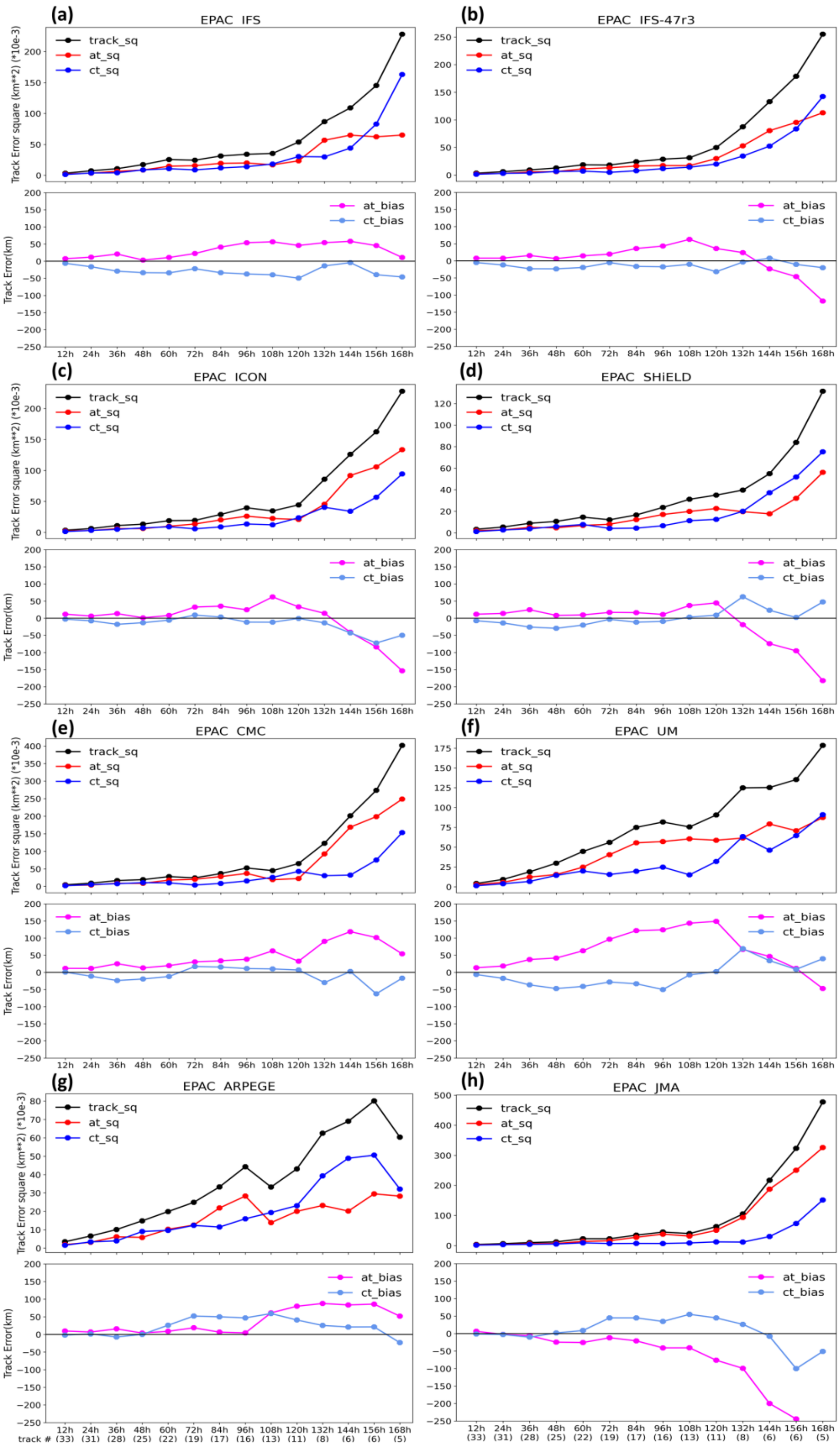

Figure S5. As in Figure S4, but for the analyses in the northeast Pacific basin (EPAC).

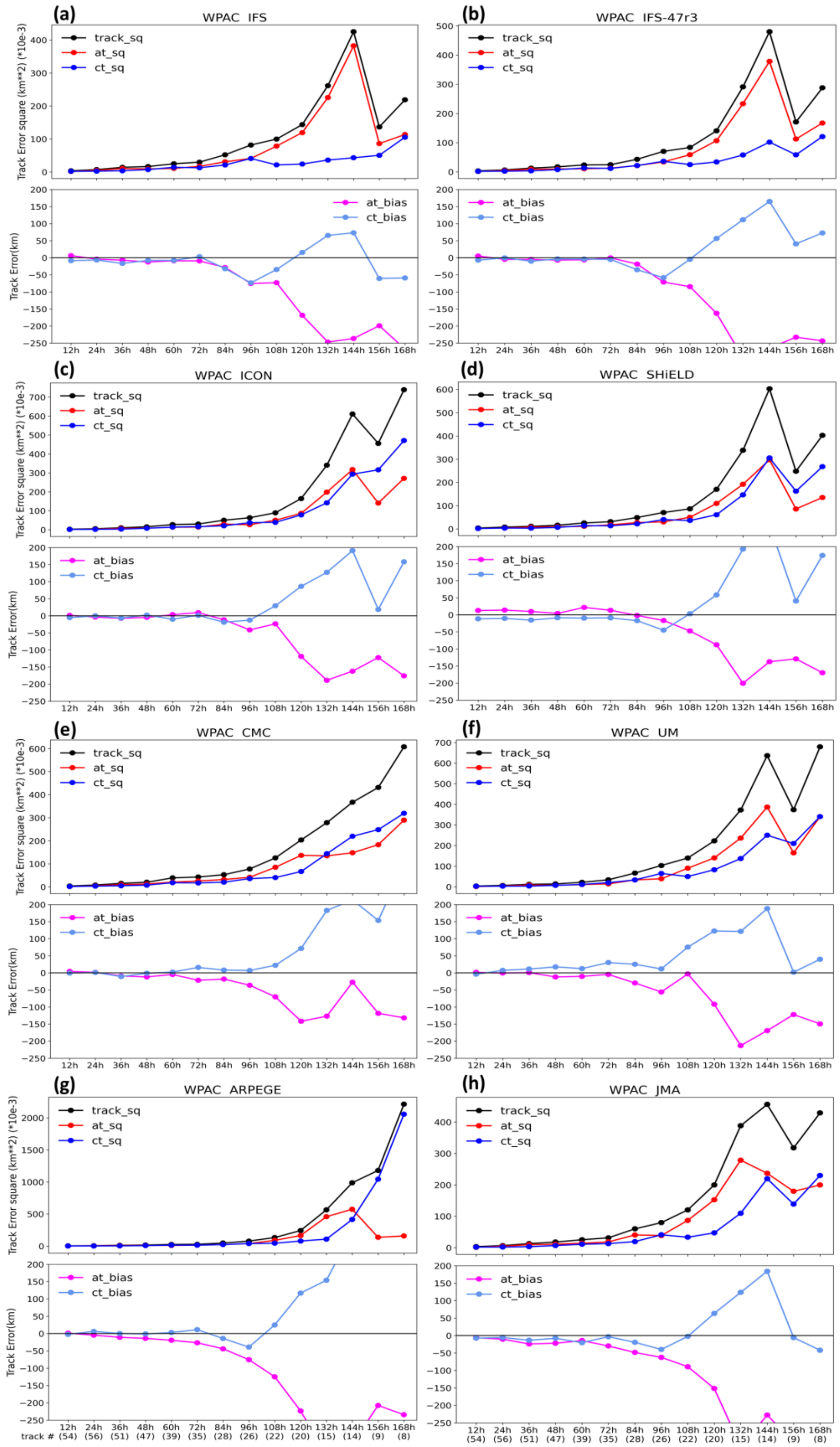

Figure S6. As in Figure S4, but for the analyses in the northwest Pacific basin (WPAC).

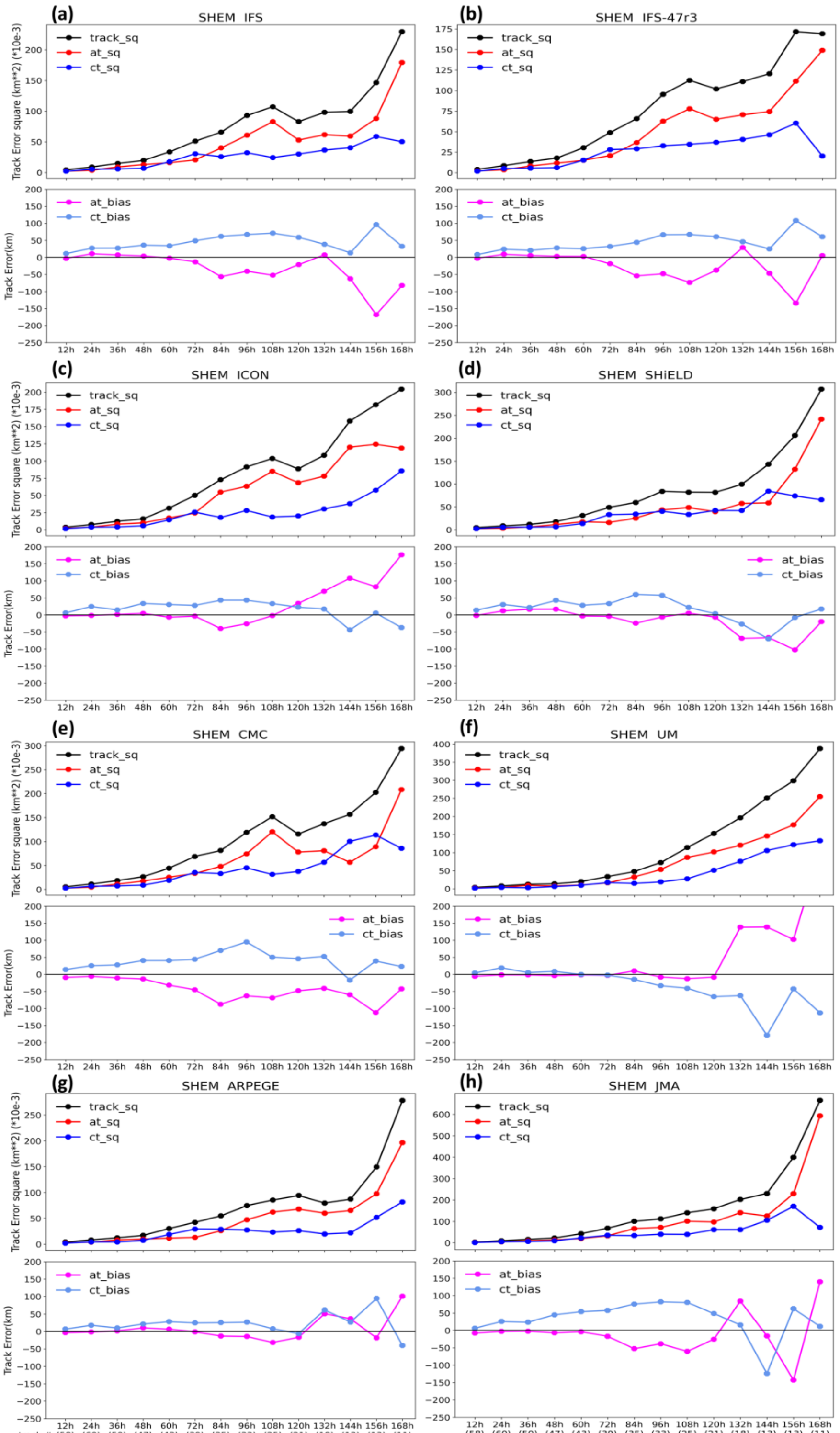

Figure S7. As in Figure S4, but for the analyses in the Southern Hemisphere (SHEM).