Impact of Wind Profile Retrievals on the Analysis of Tropical Cyclones in the JRA-25 Reanalysis

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INTRODUCTION

Leading meteorological centers in U.S.A. and Europe have performed "reanalysis" projects since early 1990's. In Japan, using the operational models of Japan Meteorological Agency (JMA), JMA and Central Research Institute of Electric Power Industry (CRIEPI) conducted a 26 year reanalysis project (JRA-25; Onogi et al., 2007). JRA-25 is the first reanalysis dataset to assimilate wind profile around tropical cyclones (TCs) reconstructed from historical best track information. Thus, we evaluated the impact of the tropical cyclone retrieval wind data (TCR data) on TC representations in our reanalysis.

TCR DATA

The retrieve scheme in JRA-25 is based on Fiorino (2002). In our approach, a retrieved wind profile is calculated as a sum of two components, an axisymmetric wind around a TC center and the storm motion (large-scale steering flow). The symmetric wind based on a radial profile of the TC is constructed from the best track maximum wind spend and wind radii that includes a constant inflow angle at 925 hPa (10 degree) and 1000 hPa (20 degree), to represent boundary-layer. The storm motion is calculated from 12-h displacement of the TC center, and is added as representative of the large-scale environment. Thus, the scheme retrieves winds at 6 standard pressure levels over the TC center, and at 2 degree away from the center in the four cardinal directions. The TCR data is treated as if they are dropwindsonde observations, and are input to the data assimilation process together with other observations. More detailed description is written in Hatsushika et al. (2006).

ANALYSIS

To check impacts of TCR data in analysis fields, a data assimilation experiment (Control experiment) is performed. The system and observation data of the Control experiment are the same, except for excluding TCR data, as in the JRA-25. ERA-40 data (Uppala et al, 2005) is also used for comparison. Analysis period of JRA-25 is between January 1979 and December 2004, ERA-40 is between January 1979 and 2nd August 2002, and Control experiment is between June 1990 to December 1992 and between January 2000 and December 2004.

TCs in these reanalyses are detected using an objective detection procedure based on relative vorticity, sea level pressure (SLP), and middle to upper tropospheric thickness within the latitudinal belt of 40N and 40S (cf. Hatsushika et al, 2006).

RESULTS

TC tracks detected in the analysis from the Control experiment, JRA-25, and ERA-40 over the Northern Hemisphere in September 1990 are shown in Fig. 1. There were 14 TCs over WN Pacific, EN Pacific and North Atlantic (ATL) basins in the period. Over the WN Pacific basin and the extratropical ATL basin, both of three

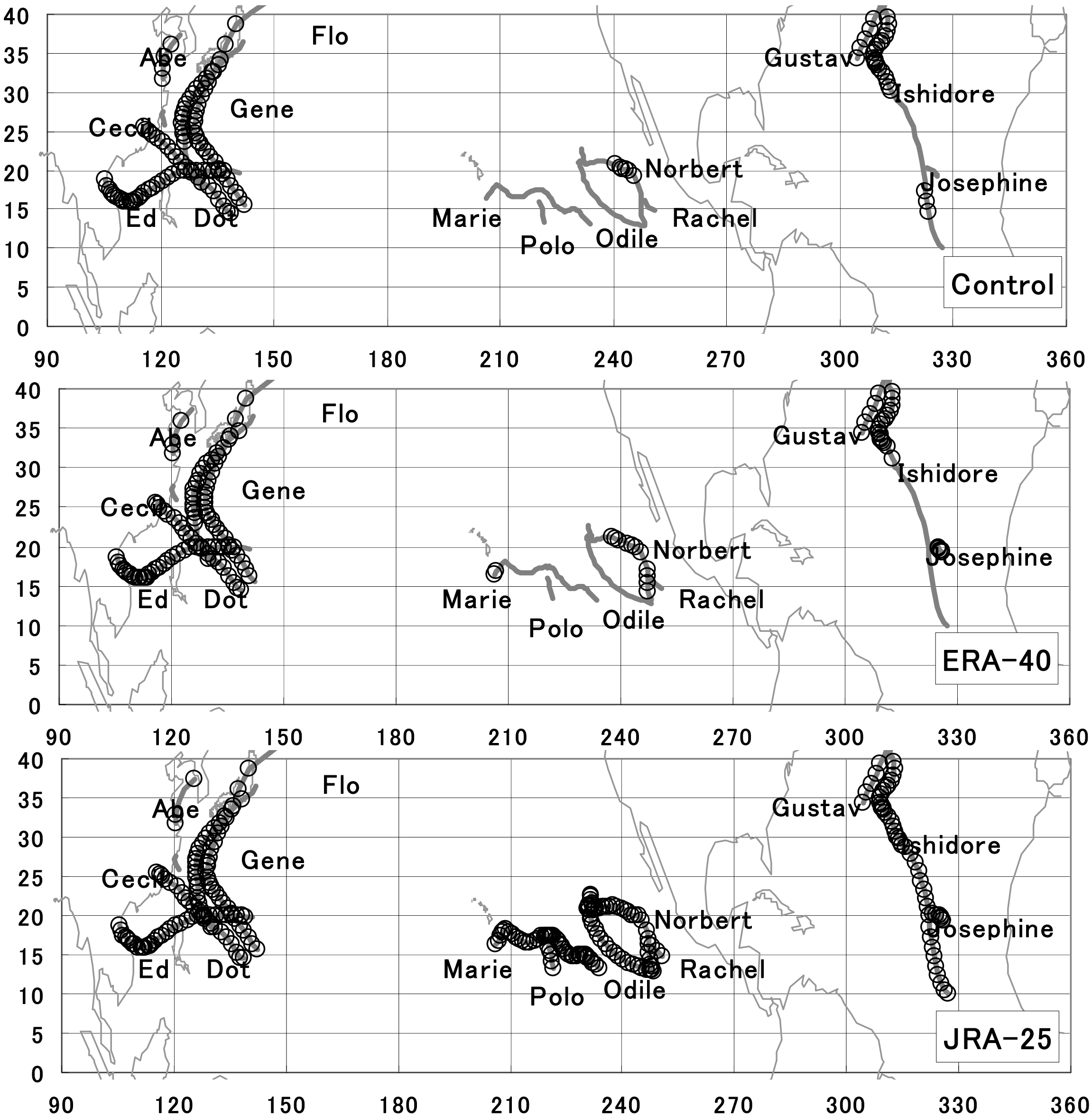

Figure 1 Observed TC tracks in September 1990 and detected TC centers in the reanalysis data. TC tracks, derived from the best track data, are drawn in lines and detected TC centers are drawn in open circles. Top: the Control experiment, middle: ERA-40, and bottom: JRA-25, respectively.

reanalyses represent TCs realistically. However, over the tropical EN Pacific and the ATL, even strong HRs like Marie (maximum wind speed is 120 kt) and Odile (125 kt) were not detected in Control experiment and in ERA-40 while relatively weak TCs like Cecile (45 kt) and Dot (75 kt) in the WN Pacific were detected. The low detection in the Control experiment and in the ERA-40 is due to the lack of non-TCR observations in the EN Pacific and in the tropical ATL.

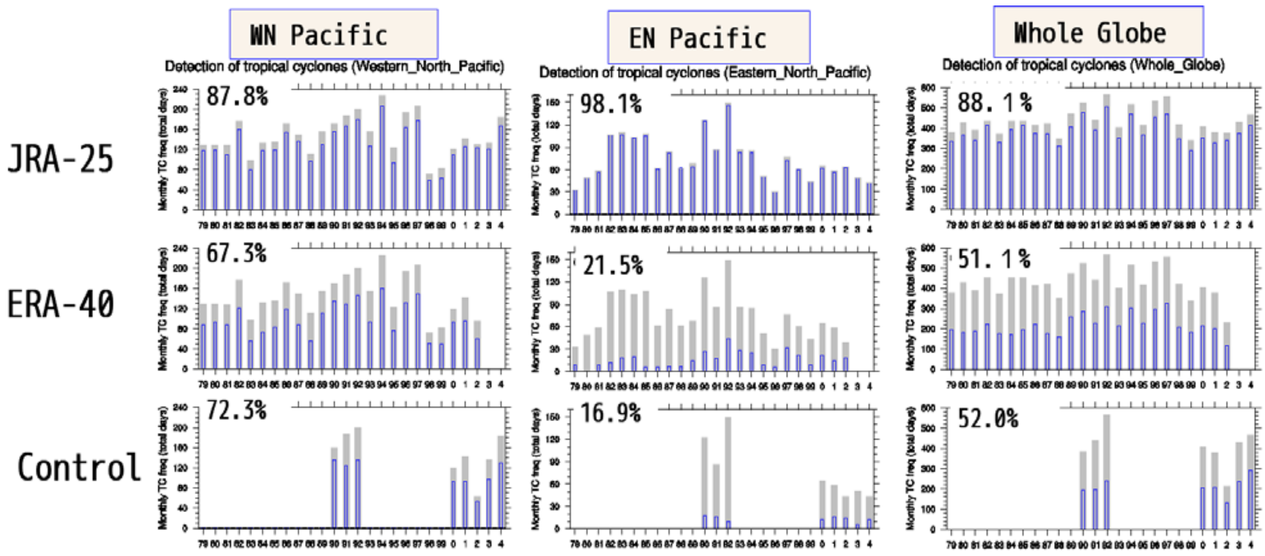

Figure 2 Observed and detected TC frequencies in a year for WN Pacific, EN Pacific and whole globe. Left: WN Pacific, center: EN Pacific and right: whole globe, and top: JRA-25, middle: ERA-40 and bottom: control experiment, respectively. Representation rates are drawn in the top left of each panel.

Figure 2 shows monthly frequencies in terms of total TC days per month in the WN Pacific, EN Pacific, and in the whole globe. In this analysis, TCs are classified not by their genesis location but by their location at each analysis time. Frequencies in JRA-25 are in good agreement with observations. The detected rate is about 88% over WN Pacific basin, about 98% over EN Pacific basin, and about 88% of the global frequency in the JRA-25. On the other hand, the Control experiment and the ERA-40 data grossly failed to produce sufficient TCs in the EN Pacific and ATL basins. The rates are about 67%, 22%, and 51% in the ERA-40, and 72%, 17%, and 52% in the Control experiment, respectively. Interannual variability of the detection rate is small in JRA-25 compared to the ERA-40 data. Thus, the quality of the JRA-25 reanalyses around TCs is higher, and more consistent in time.

We also measured the quality of the reanalyses in some case studies of TC track forecasts in the WNP. Track forecast skills for TY Flo in September 1990 in the JRA-25 forecast were better than in the Control forecast, while difference in track skills for TY Ed in the same month was less obvious. We assume the track forecast skill for recurving TCs is sensitive to dynamical TC motion processes, and surrounding large-scale atmosphere. Thus, improvements in the track forecasts in the JRA-25 forecasts suggest that the initial TC structure, and surrounding atmosphere provided from the JRA-25 reanalysis data are realistic. Appropriate TC intensities, and locations in the initial conditions, may be essential for some TC track forecasts. However, more forecasting studies for recurving TCs are needed to determine the skill improvement using TCR data.

CONCLUSION

TCR data was especially effective in regions of sparse upper conventional observation, such as the ENP basin, and the data are consistent with other observations in data dense regions. The overall result of this study suggests that the JRA-25 reanalysis has potential to substantially improve our understanding of the climatological aspects of TCs. In addition, this reanalysis data is useful not only for climate variability study but also for boundary conditions of regional model and for surface flux forcing in ocean circulation models.

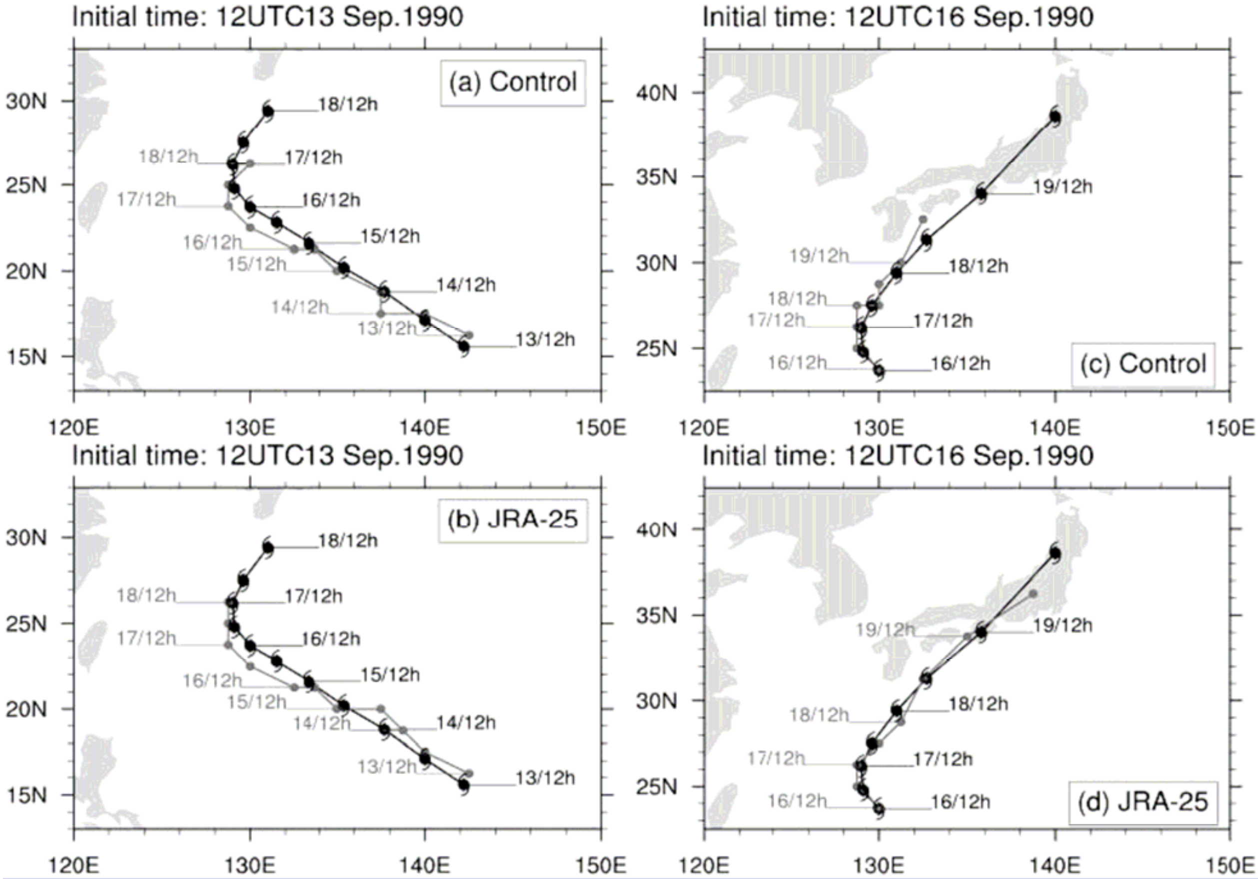

Figure 3 TC tracks of Flo in the forecasting experiments. Gray line with five-point stars denotes track and TC center locations for each forecasting experiment, and black line with weather symbols denotes best track. Data are thin down to 12 hourly intervals. (a) Five days forecast using initial condition at 1200 UTC 13 September 1990 in the Control experiment. (b) Same as (a), but for the JRA-25 data (JRA-25). (c) Same as (a), but the initial time is 1200 UTC 16 September 1990. (d) Same as (c), but for JRA-25.

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