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TESTING THE PERFORMANCE OF DYNMICAL INITIALIZATION FOR THE RAPID INTENSIFICATION IN THE WSTERN NORTH PACIFIC

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1. INTRODUCTION

The improvement of tropical cyclone (TC) intensity forecast tends to be much slower than track forecast. One of the causes of large intensity errors may be associated with the failure of prediction of the rapid intensification (RI). RI is generally defined for TCs with the sea level pressure decreased by over 42 hPa or the maximum surface wind speed increased by over 30 kt within 24 h (Holliday and Thompson 1979; Kaplan and DeMaria 2003). To tackle TC forecast improvement using numerical models, lots of special technique like an implementation of bogus vortex, 3D/4D variational assimilation, ensemble Kalman Filter, and dynamical initialization (DI) have been developed (Kurihara et al. 1993; Zou and Xiao 2000; Kwon and Cheong 2010; Wu et al. 2010; Zhang et al. 2012; Cha and Wang 2013). Nevertheless, the prediction of RI event still remains difficult.

In this study, we have developed the digital initialization (DI) method combined with the high-order filter equations (Cheong et al. 2004; 2015), which can decompose the synthesis field into large-scale and vortex-scale fields. 11 RI cases, which simultaneously satisfy both aforementioned RI conditions, are selected from 2013 to 2016 in the western North Pacific. The selected cases are as follows: Usagi (2013, 19th), Lekima (2013, 28th), Haiyan (2013, 30th), Vongfong (2014, 19th), Nuri (2014, 20th), Hagupit (2014, 22nd), Soudelor (2015, 13th), Nepartak (2016, 1st), Meranti (2016, 14th), Chaba (2016, 18th), and Nock-ten (2016, 26th), respectively.

2. MODEL AND DATA

In the present study, the Advanced Research Weather Research and Forecasting (WRF-ARW) version 3.8.1 (Skamarock et al. 2008) is employed, and the lateral and initial conditions are provided by ERA-Interim data from European Centre for Medium-Range Weather Forecast. As the nested configuration, the three domains have 12/4/1.33 km horizontal grid spacing with 40 uneven vertical eta levels. For the better best track information, it has been integrated from three different operational agencies, i.e., Joint Typhoon Warning Center (JTWC), Korea Meteorological Administration (KMA), and Japan Meteorological Agency (JMA), respectively.

3. DESIGN OF DI METHOD

Figure 1 illustrates the flowchart of the current DI method. At an incipient stage of DI method, the vortex in reanalysis data is relocated into best track location. And then, it moves on the cycle-run process if the vortex needs some improvements with respect to intensity. During the cycle-run process, the vortex scale is only updated using high-order filter equations from integrated model output. After that, if the vortex intensity has comparable intensity with best track data, DI process goes to final stage of the current DI method. At the final stage, the free forecasting with initialized vortex is carried out for 72 h.

4. RESULTS

Super Typhoon Haiyan (2013) has been initialized with 12 h intervals from the genesis to dissipation based on the current DI method. Figure 2 shows the results for the Haiyan case. Overall, the initialized vortices tend to well predict track and intensification compared to best track, even though most earlier initialize vortex shows time-lagged intensification. This time-lag phenomenon tends to be gradually overcome as TC intensifies. However, after RI event, the initialization for intense tropical cyclones tends to be failed due to the coarse grid-spacing (used only single domain). To solve this problem, we have two ways to initialize vortex:

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1. Get initial condition from the previous model output as shown in Fig. 3; 2. Set nested domain (second domain will have 4 km resolution) to give more sufficient grid-spacing to simulate detailed structure and intensity. This result will be presented in the conference with other detailed analysis for RI cases.

5. CONCLUDING REMARKS

In this study, we have examined the performance of the current DI method for RI cases. In early stage of TCs, it tends to be limited to predict RI event. However, the likelihood of RI prediction has increased as TC intensity approached the category-1 Hurricane wind intensity. It may imply that, as TCs travel favorable largescale environments, the likelihood of RI event can be increased. In addition, we think that the better initial conditions in the numerical models, the more accurate predictions are possible in the future. In the conference, we will elaborate more detailed and common features on RI event through the numerical simulation.

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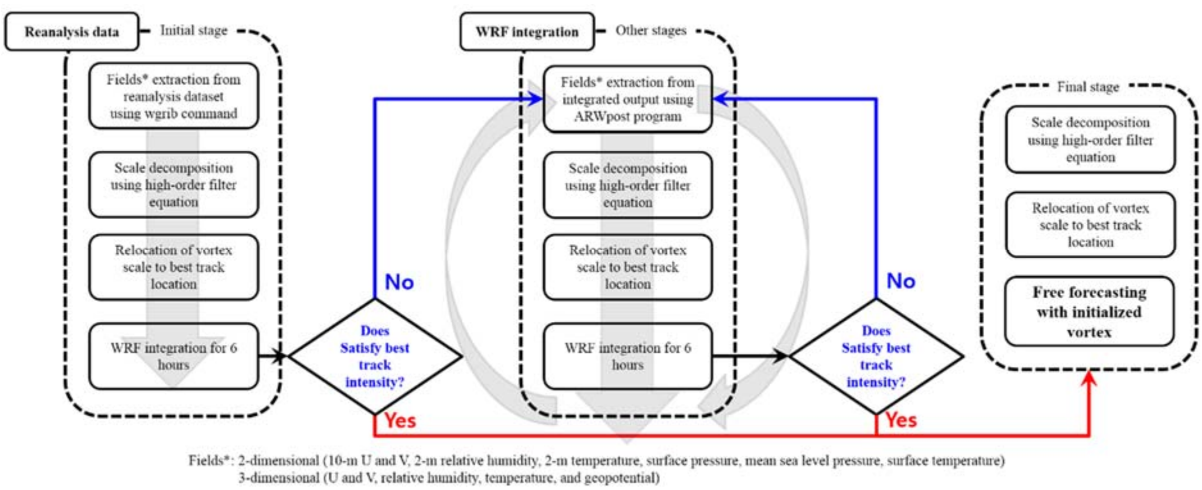

Fig. 1. The whole procedure of current DI method. The 12 variables denoted as "Fields" are improved through the cycle-run step.

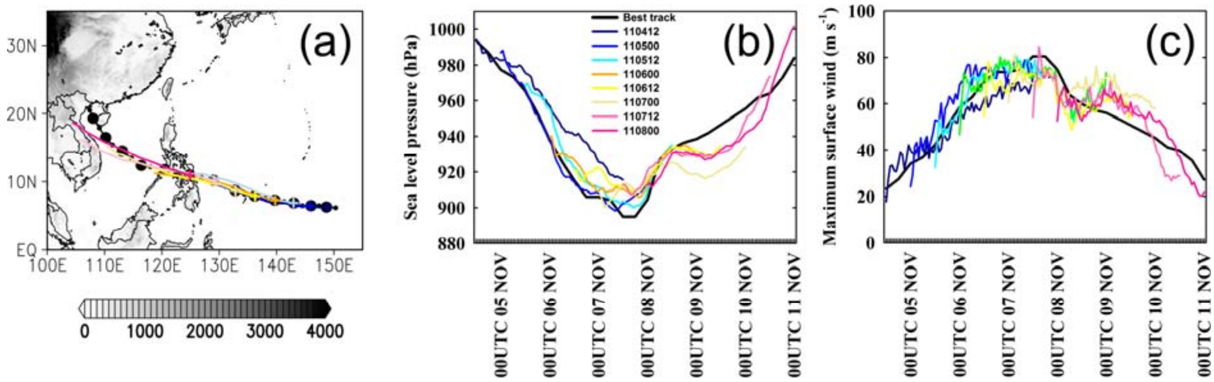

Fig. 2. The preliminary results of Haiyan (2013) in terms of (a) track, (b) sea level pressure, and (c) 1-minute maximum surface wind, respectively. The thick black solid line indicates the integrated best track from three different operational agencies (JTWC+KMA+JMA).

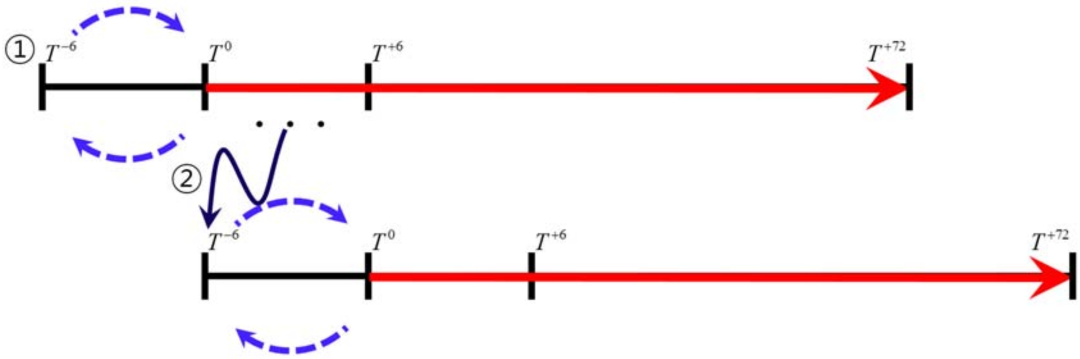

Fig. 3. The detailed approach for the DI method. In the first stage of DI, the vortex is initialized using global reanalysis data as shown in ①. After the first stage, the vortex is recycled using previous model output having 0 h to 6 h time domain. If the vortex needs some improvements, the cycle-run step denoted as in blue is executed. The red line indicates free forecasting with initialized vortex.