Application of steering weight concept to Typhoon Saomai (2000)

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Tropical cyclone (TC) motion is one of the most important forecasting issues both in the numerical weather prediction (NWP) and operational forecasting. Even with the state-of-the-art NWP models significant disagreements can be sometimes observed in TC track forecast among them although it has been believed that TC movement is primarily determined by the large-scale flow field and therefore should be well predicted with such models.

In an attempt to diagnose the mechanism by which a typhoon moves through vertically sheared environmental flows with keeping its vertical coherency, a series of idealized numerical simulations of typhoon are carried out and eventually a new approach termed "steering weight concept" is proposed based on the numerical results (Ueno 2003). The steering weight is a set of weighting factors numerically derived from the surface pressure tendency equation and can be a measure of the relative contribution of the steering flow at each vertical level to the storm motion. The weight varies significantly depending on the simulated storm structure, and is somewhat inherent to the convection scheme used, while it is found to be robust against the change of environment specified. The overall movements of simulated typhoons are well explained by taking into consideration not only so called "steering flow" but also the steering weight, suggesting that the diversity of simulated tracks is partly attributable to that of the weight.

In this paper the new approach is applied to one of the real typhoon cases, that is, the case of Typhoon Saomai in 2000, to confirm the validity of the concept in real situations. The forecast experiments are performed using a 20km version of the Meteorological Research Institute / Numerical Prediction Division unified nonhydrostatic model with an Arakawa-Schubert cumulus parameterization scheme (AS) or an explicit moisture scheme only (EX). The model uses so-called z* coordinate in the vertical and therefore the model variables are defined on constant height surface over the sea. It is found from the experiment that the simulated motion of Saomai is sensitive to and systematically changed with the tuning parameters included in the convection scheme such as entrainment rate and relaxation time, in a consistent manner with the foregoing idealized simulations. When the new approach is applied to the model results, all the simulated tracks are well reproduced by the combination of the respective steering weight and steering flow.

Unlike the foregoing study in which the model variables are defined on sigma surface, the steering weight in the present study is calculated in a straightforward manner. Figure 1 shows the vertical profile of the steering weight averaged over the integration period of 39 hours for two extreme track cases (AScntl and EX) obtained from the forecast experiment. The profiles seem reasonable in that the weight is very small at the very high levels near the tropopause, which is consistent with previous observational studies. Once the steering weight is obtained, the steering motion component is easily computed using the steering flow which is defined as an areal-mean asymmetric flow near the storm center. Figure 2 compares the track reproduced from the steering motion component (SW) with "actual" one which is obtained as successive

MSLP center locations. To see the impact of steering weight on the reproduced track, the track obtained from the conventional deep-layer-mean-flow approach (DLMF) is shown in the figure, in which the steering motion component is defined as the pressure-weighted 850-300 hPa depth-averaged mean flow. The close proximity of DLMF track to SW one in the EX experiment is due primarily to a highly barotropic structure of the simulated steering flow.

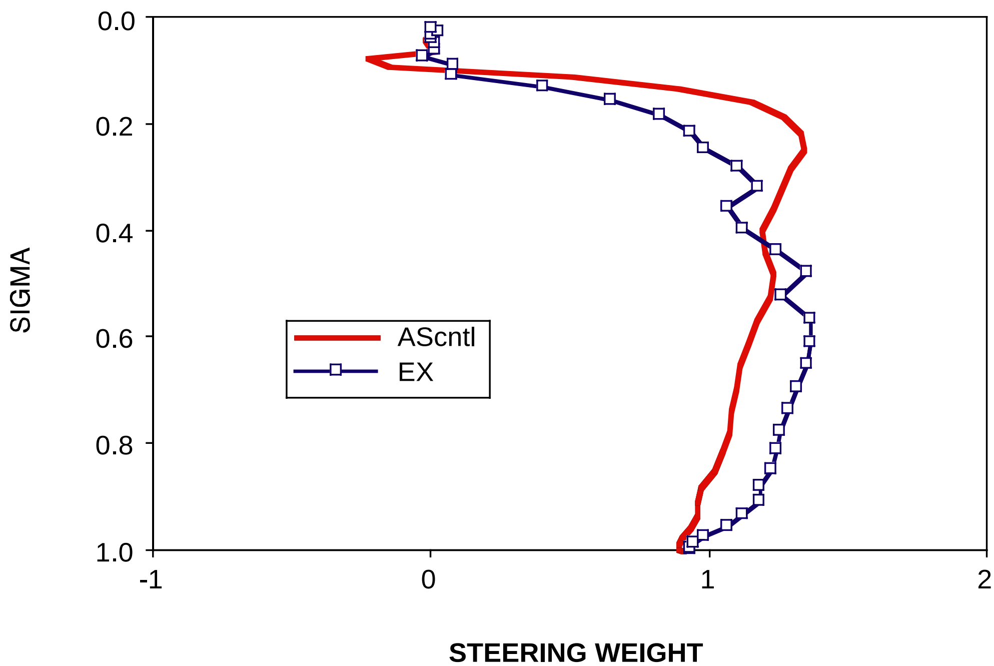

Figure 1: Vertical profile of steering weight.

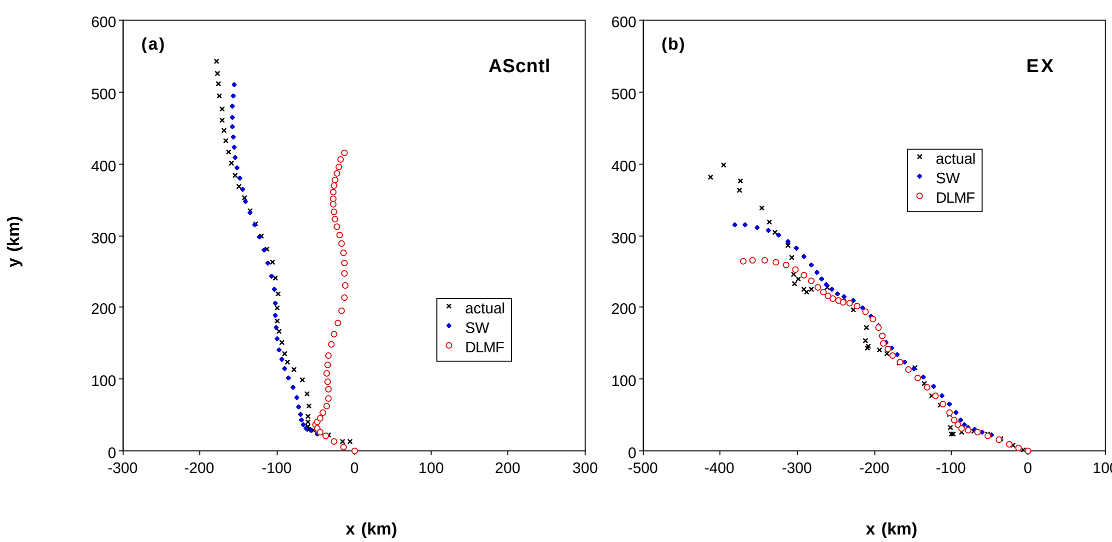

Figure 2: Vortex tracks reproduced from velocity components for (a) AScntl and (b) EX. The vortex is placed at (0,0) initially and symbols indicate hourly positions.

Reference

Ueno, M., 2003: Steering weight concept and its application to tropical cyclones simulated in a vertical shear experiment. *J. Meteor. Soc. Japan*, **81**, 1137-1161.