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Impact of Surface Roughness Length on Typhoon Simulations

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1.Introduction

The impact of surface roughness length and drag coefficient on typhoon simulations was investigated for real typhoons using a nonhydrostatic atmosphere model (NHMJMA) coupled with the third generation ocean wave model (MRI-III) and a multilayer ocean model. This study addresses

1) **impacts on typhoon track and intensity,** and
2) **impacts on the relation of surface wind speed to surface roughness length and drag coefficient and on their horizontal distributions**.

2.Model and data

Initial atmospheric conditions were obtained from the JMA global analysis data with a horizontal grid spacing of 20 km.

Initial oceanic conditions were obtained from the oceanic reanalysis data calculated by the MOVE system with a horizontal grid spacing of 0.1° .

Atmosphere, NHMJMA: (40 levels: Top height is nearly 23 km)

*No cumulus parameterization

*Deardorff(1980) - Blackadar(1962) atmospheric boundary layer scheme.

*Louis et al (1982) – Kondo (1975) surface boundary layer scheme.

Wave, MRI-III:

The wave spectrum consists of 900 components, 25 in frequency and 36 in direction. The wave spectrum is divided logarithmically from 0.0375Hz to 0.3000Hz.

Ocean, Multilayer ocean model: (Three layers and four levels)

Mixed-layer scheme: Deardorff (1983)

3.Roughness length schemes

The following five schemes were used, respectively:

[CH1] Charnock(1955) $$\frac{g z_0}{u_*^2} = \alpha$$

[KO1] Kondo(1975) $$z_0 = \exp\{\ln z_{10} - \kappa [C_D(10m)]^{-1/2}\}$$

[SM1] Smith et al. (1992) $$\frac{g z_0}{u_*^2} = 0.48\left(\frac{u_*}{c_p}\right)$$

[JA1] Janssen(1991) $$\frac{g z_0}{u_*^2} = 0.010\left(1-\frac{\tau_w}{\tau}\right)^{-\frac{1}{2}}$$

[TY1] Taylor and Yelland (2001) $$\frac{g z_0}{u_*^2} = 1200\left(\frac{H_w}{L_w}\right)^{4.5}$$

4. Results: Track and intensity

Choi-wan (2009) [Decaying phase]

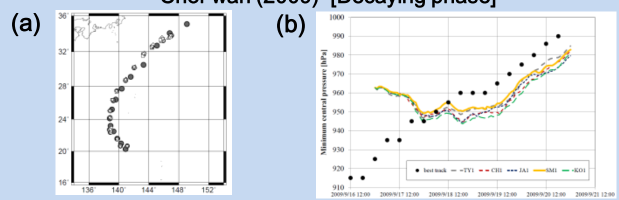

Fig.1 (a) RSMC-Tokyo best track (dark gray circles) and simulated tracks for Typhoon Choi-wan (2009) from 0000 UTC on 17 September to 1200 UTC on 20 September, and (b) time series of best-track and simulated central pressures.

Fanapi (2010) [Intensification phase]

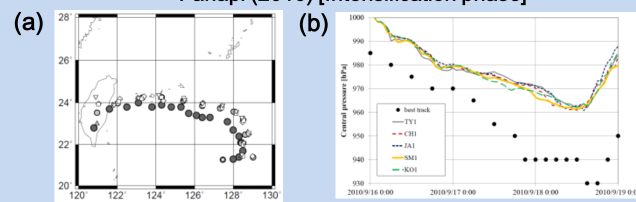

Fig.2 Same as Fig. 1 except for Typhoon Fanapi (2010). From 0000 UTC on 16 to 0000 UTC 19 September Note that light small circles indicate the results in TY1, open diamonds CH1, light gray triangles JA1, open squares SM1 and open inverse triangles KO1.

Surface roughness length (z_0) and drag coefficient (C_D)

Choi-wan (2009)

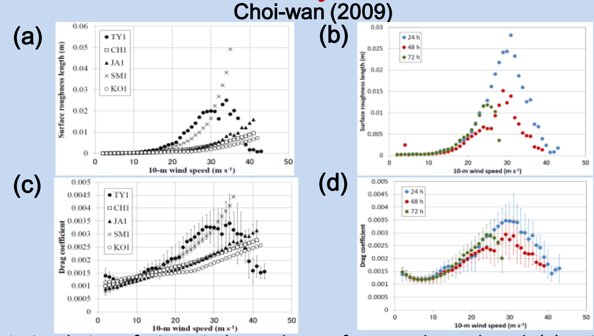

Fig.3 Relation of 10m wind speed to surface roughness length (a) at 24 h and (b) that in TY1 at 24 h, 48 h and 72 h and that to drag coefficient (c) at 24 h and (d) that in TY1 at 24 h, 48 h and 72 h for Typhoon Choi-wan in 2009.

Fanapi (2010)

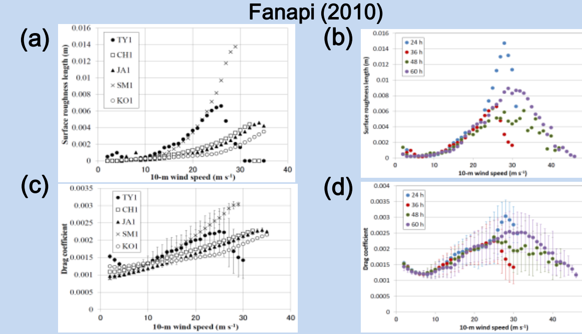

Fig.4 Relation of 10m wind speed to surface roughness length (a) at 36 h and (b) that in TY1 at 24 h, 36 h, 48 h and 60 h and that to drag coefficient (c) at 36 h and (d) that in TY1 at 24 h, 36 h, 48 h and 60 h for Typhoon Fanapi in 2010.

Horizontal distribution of wind speed, significant wave height, z_0 and C_D

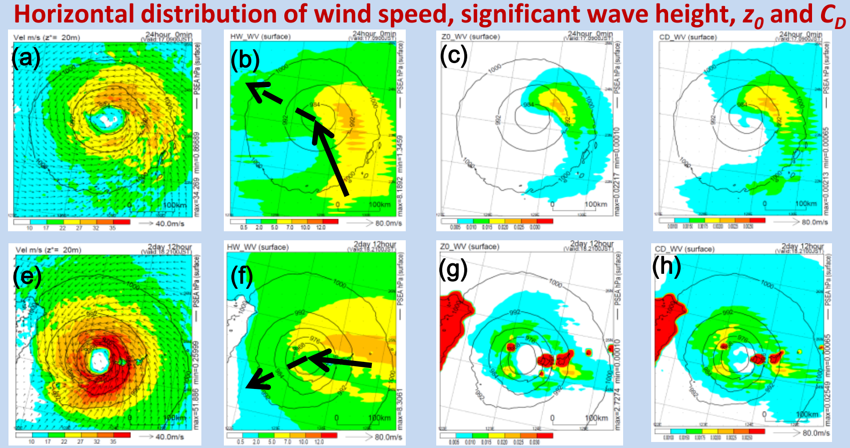

Fig.5 Horizontal distribution of (a,e) wind speed at 20-m height, (b,f) significant wave height, (c,g) surface roughness length, and (d,h) drag coefficients (a-d) at 24 h and (e-fh at 60 h in TY1 for **Typhoon Fanapi** in 2010.

5. Summary

- The impact of a difference of surface-roughness-length schemes on typhoon track is small. But the impact on simulated central pressures is not negligible.
- Surface roughness length and drag coefficient level off when 10-m wind speed exceeds 20 m s^{-1} in TY1 and much higher in JA1. The relation and horizontal distributions of z_0 and C_D differs depending on the developing phase of typhoon.