Sensitivity of a simulated landfalling typhoon to soil moisture initialization

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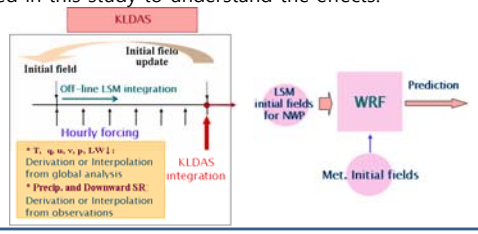
❖ INTRODUCTION

- The decay of tropical cyclone (TC) intensity occurs due to surface evaporation reduction and increased friction as a TC approaches the land. In spite of decreased intensity, landfalling typhoons or hurricanes result in tremendous damage along with heavy rainfall and strong winds.
- TC intensity is affected by surface feedback mechanisms both over land and water (Shen et al. 2002). Land surface conditions, which can control surface fluxes, play an important role on the simulation of landfalling typhoons.

- Previous studies

Dastoor and Krishnamurti (1991) - Surface moisture parameterizations improved the structure and motion of a landfalling TC.
Tuleya (1994) - Surface roughness and reduced relative wetness enhance the decay of landfalling hurricanes.
Shen et al. (2002) – They investigated the effects of land surface water on landfalling hurricanes, including surface temperature changes and their influence on changes in surface heat, hurricane structure and intensity.
Emanuel et al. (2008) - Warm-core cyclones can indeed intensify when the underlying soil is sufficiently warm and wet. (Simulations are performed with a simple TC model coupled to a one-dimensional soil model.)
Kimball (2008) - The impact of different land surface characteristics on hurricane rainfall distribution before, during, and after landfall was investigated.

- However, many details of land-atmosphere interaction for lanfalling TCs are still not well understood. Simulations of real landfalling TCs using high resolution models are needed in order to understand those. Moreover, we have developed the improved initial soil fields over East Asia from KLDAS (Korea Land Data Assimilation System; Lim et al. 2006), and the improved data were used in this study to understand the effects.



❖ OBJECTIVES

- To understand the effects of soil moisture initialization on a landfalling typhoon using real numerical simulations (WRF)
- To evaluate the effects of KLDAS on a landfalling typhoon over the Korean Peninsula

❖ EXPERIMENTAL DESIGN

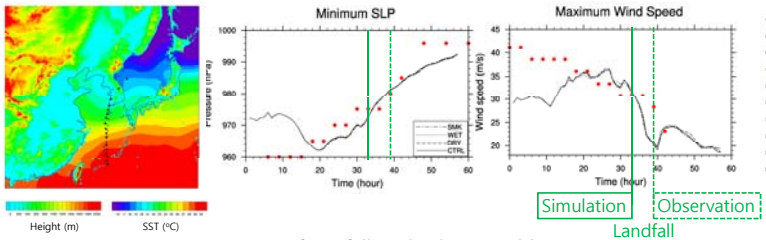
Case	Ewiniar (July 2006)
Model	ARW WRF (ver. 3.1)
Grid size	10 km (350 x 330)
Time step	30 sec.
I.C. & B.C.	NCEP FNL (1°x1°) Analysis
Vertical layers	31 layers (Top : 50 hPa)
Parameterization	KF, WSM5, YSU PBL, Noah LSM

Exp.	Description
CTRL	NCEP FNL
DRY	CTRL soil moisture - σ (0.086)*
WET	CTRL soil moisture + σ (0.086)
SMK	soil moisture from KLDAS
KLDAS	soil moisture, soil and skin temperature from KLDAS

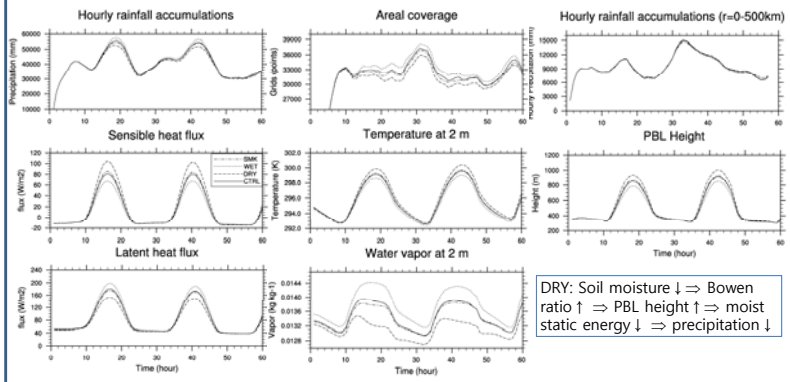
* the standard deviation of total moisture contents in this experimental domain

❖ RESULTS

Track & Intensity

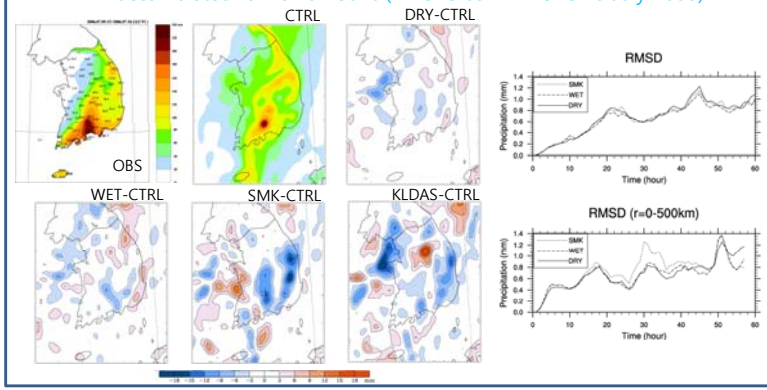


Time series of rainfall and other variables

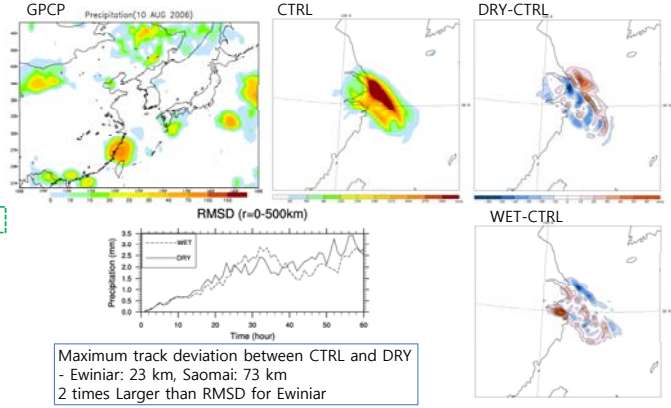


DRY: Soil moisture ↓ ⇒ Bowen ratio ↑ ⇒ PBL height ↑ ⇒ moist static energy ↓ ⇒ precipitation ↓

24h accumulated rainfall amount (12 UTC 09 – 12 UTC 10 July 2006)

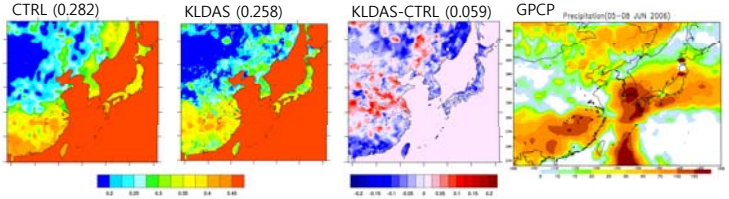


Preliminary results for a landfalling typhoon (Saomai) over China



Maximum track deviation between CTRL and DRY
- Ewiniar: 23 km, Saomai: 73 km
2 times Larger than RMSD for Ewiniar

Total soil moisture contents for 12 UTC 08 July 2006



❖ SUMMARY

In order to investigate the sensitivity of simulated landfalling typhoons to soil moisture initialization, numerical simulations with the WRF model were conducted.
- No significant difference is seen in the track and intensity of a landfalling typhoon (Ewiniar) compared to the control experiment.
- The difference of rainfall amount around TC center in SMK and KLDAS is more sensitive than that in DRY and WET experiment. Therefore, the distribution of soil moisture is more important than the absolute deviation. This means the usefulness of high-resolution initial soil fields on predicting the rainfall related to landfalling TCs.
- KLDAS initialization does not present a significant improvement of surface variable and precipitation in Ewiniar case (not shown).
- The preliminary results for Saomai show the possibility of improving TC landfall predictability using KLDAS.

FUTURE WORKS

More experiments for other cases
Simulations of Saomai's landfall using initial data from KLDAS
Sensitivity tests of landfalling TCs to other surface variables

ACKNOWLEDGMENTS

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