Remote effects of tropical cyclones on heavy rainfall over the Korean peninsula

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❖ INTRODUCTION

- One of the primary hazards caused by tropical cyclones (TCs) is post-landfall heavy rainfall and attendant freshwater flooding (AMS 2007). A TC can produce tremendous rainfall in its eyewall and its surrounding rainbands. This rainfall is generally referred to as the **direct effect of TC on precipitation**, or precipitation associated with the TC vortex itself (Wang et al. 2009).
- A TC can also induce heavy rainfall at large distances from the TC vortex itself when it interacts with other midlatitude synoptic systems (Wang et al. 2009). These increases in rainfall in areas far away from the TC are generally referred to as **remote, distant or indirect effects of a TC on precipitation** (Wang et al. 2009; Schumacher et al. 2011).

This poster includes the following paper:

Byun, Kun-Young, and Tae-Young Lee, 2012a: Remote effects of tropical cyclones on heavy rainfall over the Korean peninsula - statistical and composite analysis. *Tellus A*, **64**, 14983, DOI: 10.3402/tellusa.v64i0.14983.

Byun, Kun-Young, and Tae-Young Lee, 2012b: Numerical investigation of remote effects of tropical cyclones on heavy rainfall over the Korean peninsula. *in preparation*.

Byun and Lee (2012a) - The first document about remote effects of TCs on heavy rainfall over Korea through statistical and composite analysis

❖ PURPOSES

- To examine the climatology and the typical environments associated with heavy rainfall over the Korean peninsula occurring with remote TCs

- To identify moisture source regions that contribute to heavy rainfall events through trajectory analysis

- To quantify the remote effects of tropical moisture from typhoon Bilis on heavy rainfall over the Korean peninsula using the WRF model

❖ DATA and METHODS

● **Statistical analysis**
- RSMC best track data, Observed precipitation data from about 70 manned stations of the KMA (1981-2009)
- Heavy rainfall: ≥ 40 mm $(6\ h)^{-1}$ for at least one station and ≥ 5 mm $(6\ h)^{-1}$ for the average amount of total stations
- 6-hourly typhoon position is binned into the corresponding a 2.5° lat.-long. grid box.
- Critical radius: L30(longest radius of 30kt winds)+100 km(>50-75km)+1.75° (TC moving for 6 hours)

● **Composite analysis** (Hanley et al. 2001, Galarneau et al. 2010)
- JRA-25 data - 1.25°, TC bogus
- Compositing loses potentially important characteristics of individual storms, but it retains signatures that appear repeatedly.

● **Trajectory analysis** (Stohl et al. 2008, Gustafsson et al. 2010)
- HYSPLIT trajectory model (NOAA)
- Source regions can be defined as where the trajectories got largest amount of specific humidity.
- This study used a total of 3146 release points (with 11 × 11 horizontal coordinates on 26 vertical levels) to get a good representation of the transport pathways into the target region.
- The 100 trajectories which lost the largest amount of q within the target region were selected to represent the trajectories that were likely to have contributed to significant rain inside the target region.

● **Sensitivity experiments** (Wang et al. 2009; Schumacher et al. 2011)
- WRF model (36, 12, 4km)
DRYTCI : TC radius < 3.5°, RH⇒55 %
DRYTCO : 3.5° < r < 7°, RH ⇒55 %

❖ RESULTS

Statistical analysis

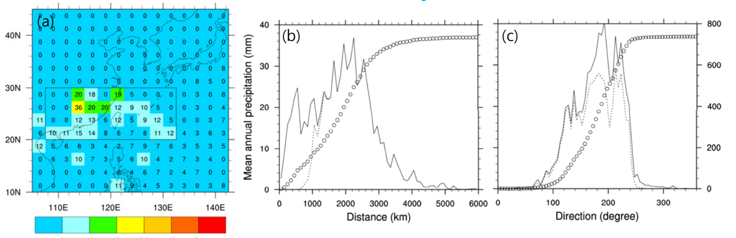

Fig. 1. (a) Geographical distributions of the rate of heavy rainfall events except for the grid box under direct effects of TCs, after TCs are located in an each grid for 1981-2009. Mean annual precipitation (black lines), mean annual precipitation except in the direct rainfall cases by TCs (dash lines), and accumulated mean annual precipitation (open circles) associated with location of the nearest TCs within varying (b) distances (every 100 km), (c) directions (every 5 degree) from the median station for surface observations of South Korea.

Composite analysis

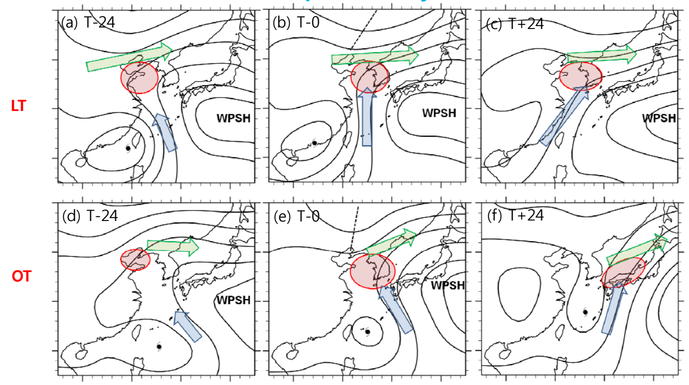

Fig. 2. Conceptual models of synoptic-scale environment associated with HR over the Korean peninsula occurring with remote TCs for LT (left panels) and OT (right panels) at: (a, d) T-24; (b, e) T-0; and (c, f) T+24. The symbols indicate smoothed 850 hPa geopotential height (black line), LLJ (blue arrow), ULJ (green arrow), low-level convergence and high-CIMFC (red area), and synoptic-scale trough (dashed line).

Trajectory analysis

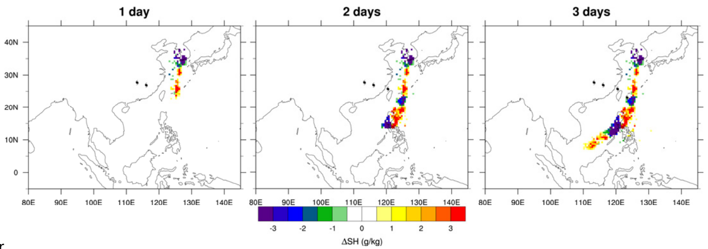

Fig. 3. Maps of accumulated change of q [Values of $(E-P)_c^{1,i}$, $(E-P)_c^{2,i}$, $(E-P)_c^{3,i}$], diagnosed from 5-day back trajectories of the target particles arriving in the target region.

Sensitivity experiments

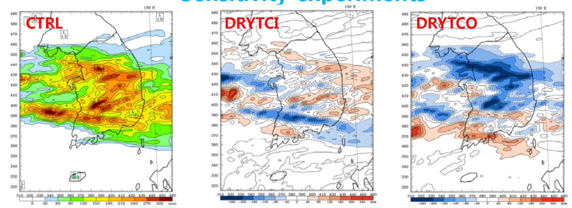

Fig. 4. Accumulated simulated precipitation (mm) from the CTRL simulation and the differences with CTRL in the 48-h accumulated rainfall amount (mm) for DRYTCI and DRYTCO simulations for 48 hours. Model results are based on the 4-km experiments.

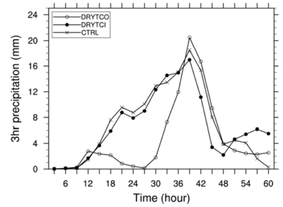

Fig. 5. Time series of 3-hourly area-averaged rainfall amount (mm), calculated over the Korean peninsula.

	CTRL	DRYTCI	DRYTCO
6 h max. rainfall	114.2	105.3	82.9
6h area-averaged accumul.	11.5	9.6 (-16.5%)	4.5 (-60.9%)
48h max. rainfall	398.5	443.8	322.2
48h area-averaged accumul.	137.4	132.5 (-3.6%)	87.7 (-36.2%)

Table 1. Comparison of the simulated rainfall amounts (mm) from DO3 of CTRL and sensitivity experiments for 6-hourly and 48-hourly precipitation.

❖ SUMMARY and CONCLUSIONS

- The probability of heavy rainfall over the peninsula is higher with TCs that make landfall on southern and eastern China compared to other regions.

-The composite analysis shows that remote TCs can influence heavy rainfall over the peninsula by helping establish a convectively unstable environment and a large-scale convergence of air.

- In trajectory analysis, the air parcel's origin is associated with remote TC's circulation. This represents that some moisture which induces heavy rainfall over the peninsula is related to the remote TC's outer circulation.

- Numerical simulation confirms the environment related to heavy rainfall over the Korean peninsula occurring with remote TCs. The CTRL reproduced the extreme rainfall amounts, although the simulated rainfall was displaced from where it was observed.

- There was an approximately 19% reduction in the maximum precipitation amount and a 36% reduction in the total precipitation from the control simulation to the DRYTCO run. The moisture of the TC's outer circulation is more dominant for enhancing remote rainfall than the moisture of the TC's inner core.

ACKNOWLEDGMENTS

This research was supported by Leading Foreign Research Institute Recruitment Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (MEST) (2010-00715).

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