Contribution of surface precipitation evaporation to landfalling tropical cyclone rainfall: A modeling study of Typhoon Utor (2013)

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Introduction

Previous studies (e.g. Tuleya and Kurihara 1978; Tuleya et al. 1984; Tuleya et al. 1994) indicated that land surface evaporation, which is determined by land surface conditions, is one of the important factors affecting precipitation and intensity change of a TC after landfall. However, it is unknown so far how important the evaporation of surface precipitation is to the rainfall in TCs after landfall.

Model and experimental design

Here, Typhoon Utor (2013) remained inland over Southern China for about 4 days and brought record-breaking heavy rainfall over Guangdong Province. It is our interest to examine contribution of precipitation recycling to the rainfall amount in this extreme event.

To reduce the effect of internal variability on the physical sensitivity, 7 ensemble runs were conducted using WRF model.

CTL (7 members)	No_EVAP (7 members)
water vapor mixing ratio	water vapor mixing ratio
+3‰	+3‰
+2‰	+2‰
+1‰	+1‰
0‰	0‰
-1‰	-1‰
-2‰	-2‰
-3‰	-3‰

Table Ensemble simulation designs.

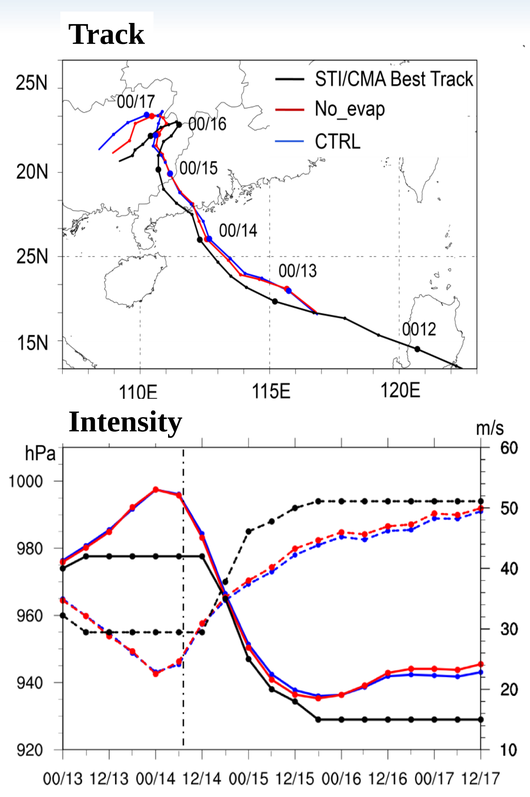

Figure Black line - CMA best track data;
Blue line - CTRL;
Red line - No_evap.

Verification of the control simulation

When the storm moved further inland, the effect of surface precipitation evaporation became gradually visible. The precipitation simulated in CTRL was smaller than that in No_evap in the border area of Guangdong Province (see the area in the black). However, the accumulated precipitation in CTRL was larger than that in No_evap in the area shown in the red.

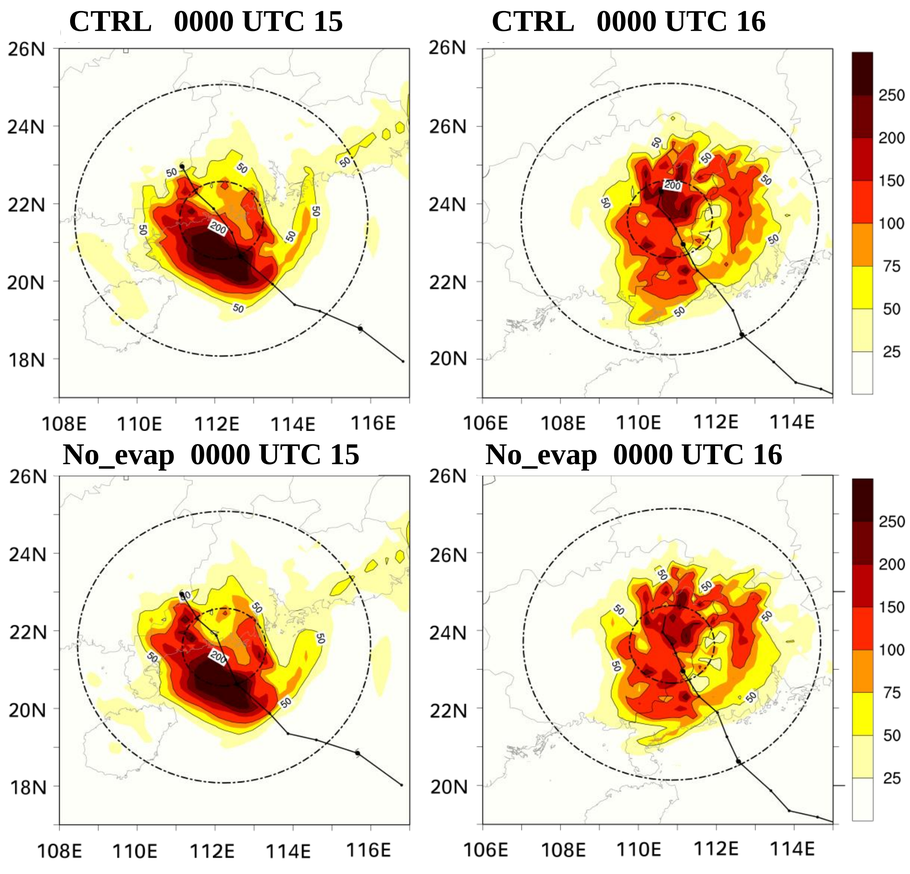

Figure 24 h –accumulated precipitation

Conclusion

Results show that the evaporation of surface precipitation contributed about 15% - 20% to the total rainfall in the inner core within a radius of 100 km after landfall while contributed only about 5% within a radius of 350 km of the TC center.

The primary reasons for this is that cutoff of surface precipitation evaporation reduced soil moisture, the latent heat flux and the strong low-level inflow in storm, thus reduced the water mixing ratio in the inner core of storm, causing significant decrease in rainfall in TC.

Contribution of surface precipitation evaporation

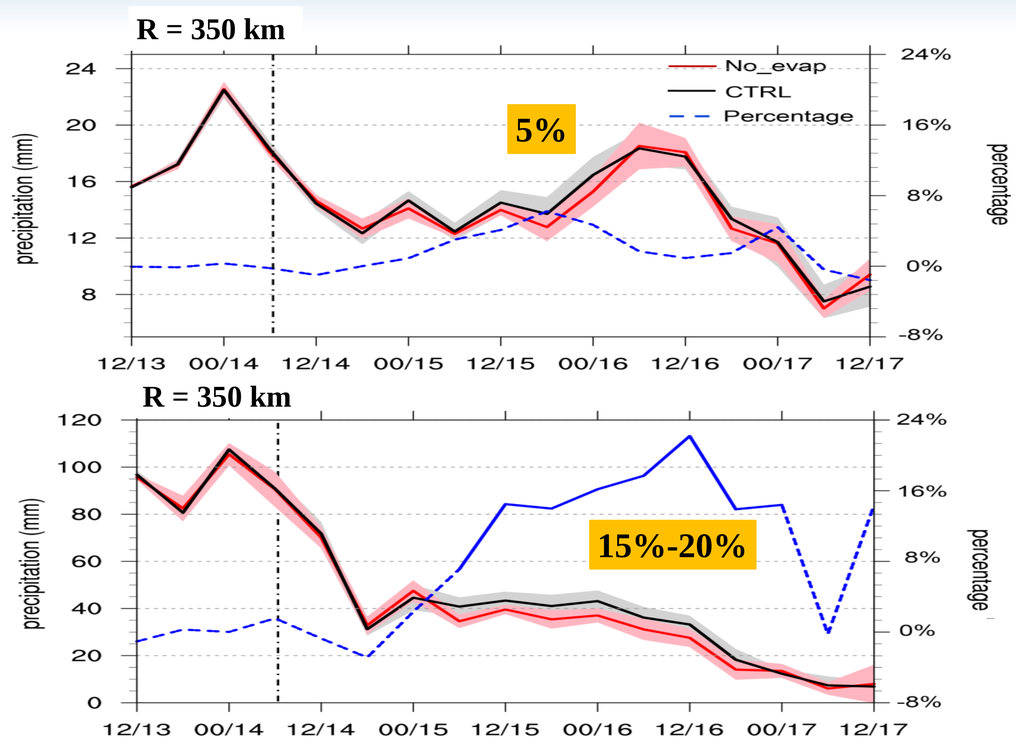

Figure Time series of the 6-h accumulated area-averaged ensemble mean rainfall amount (mm, solid) in CTRL (black), No_evap (red), and the percentage of their difference ((CTRL−No_evap)/No_evap, dashed, blue).

Discussion

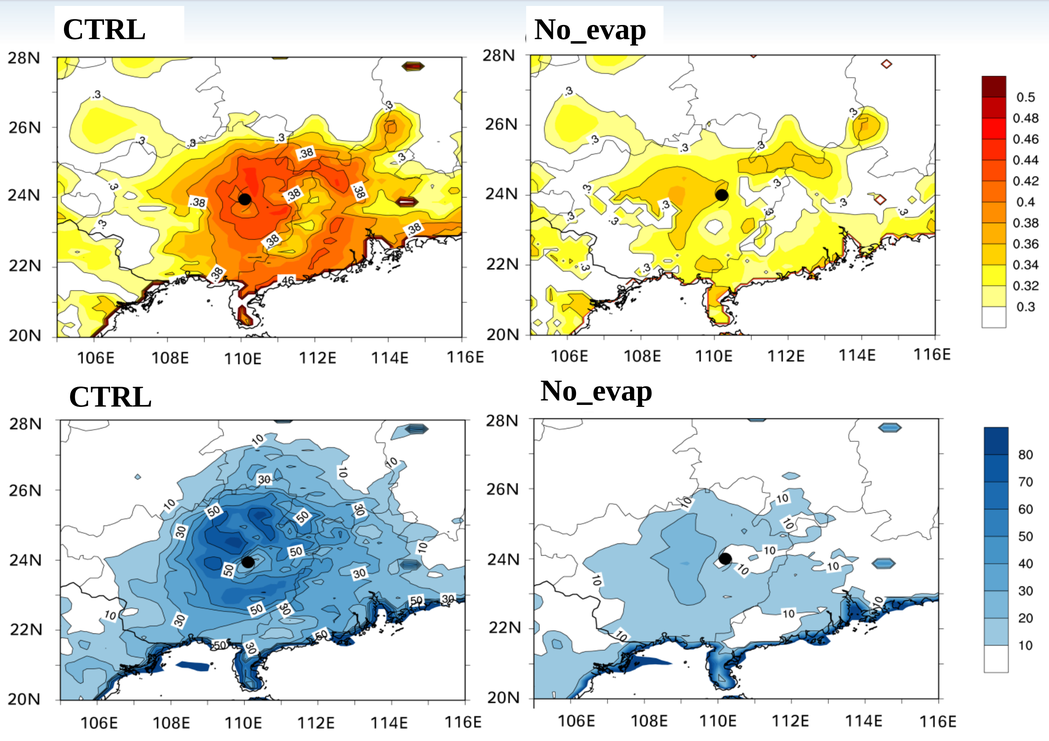

Figure Distribution of soil humidity ($m^3\ m^{-3}$) in the shallow layer (a, b) and latent heat ($W\ m^{-2}$) flux at the surface (c, d)

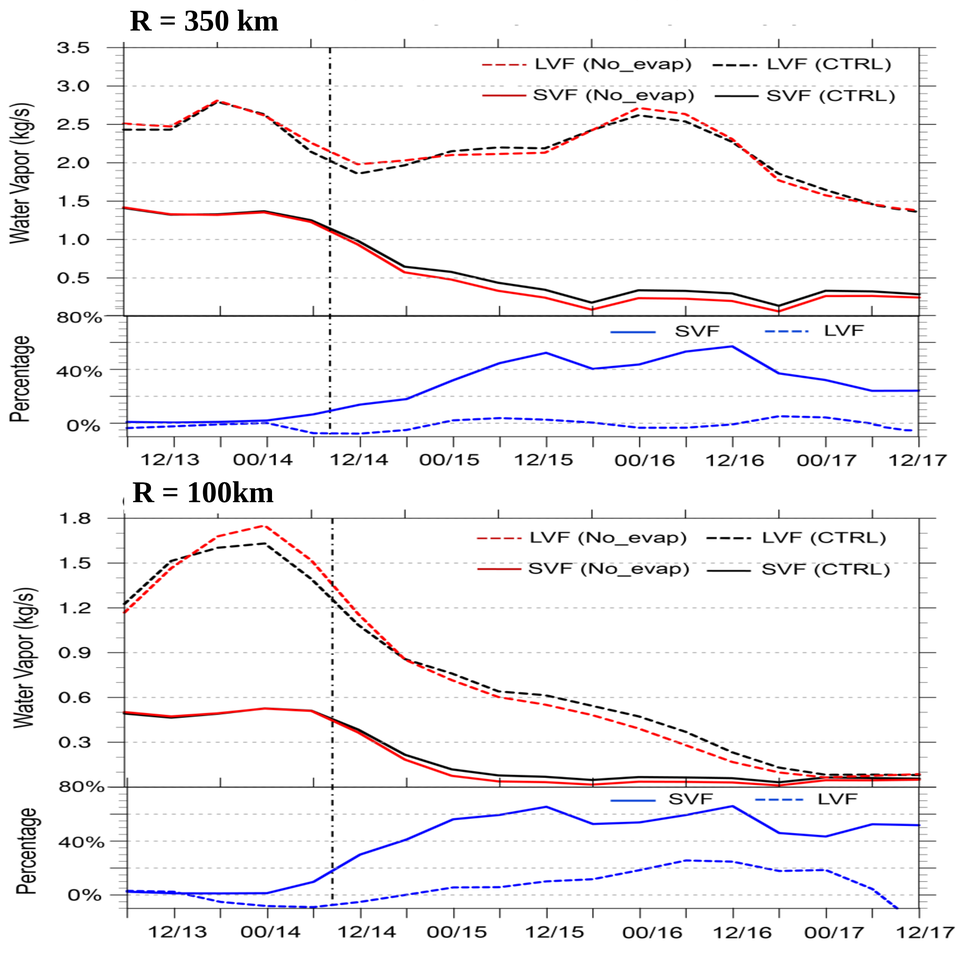

Figure Time series of the area-averaged surface vapor flux (SVF, 108 kg s^{-1}, solid), lateral vapor flux (LVF, 108kg s^{-1}, dashed), and the their difference (blue) and the percentage of in the large-core region.

Cutoff of surface precipitation evaporation reduced soil moisture and thus surface evaporation during and after the landfall of the storm, which also reduced the latent heat flux to the storm and thus led to a slightly weaker storm in No_evap than in CTRL.