A Study of a Heavy Rainfall Event in the Central Part of Korea in a Situation of a Synoptic Scale Ridge over the Korean Peninsula

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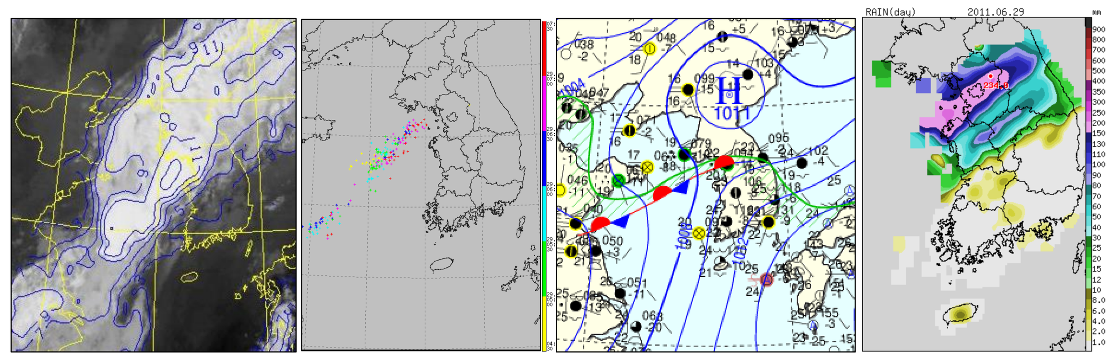
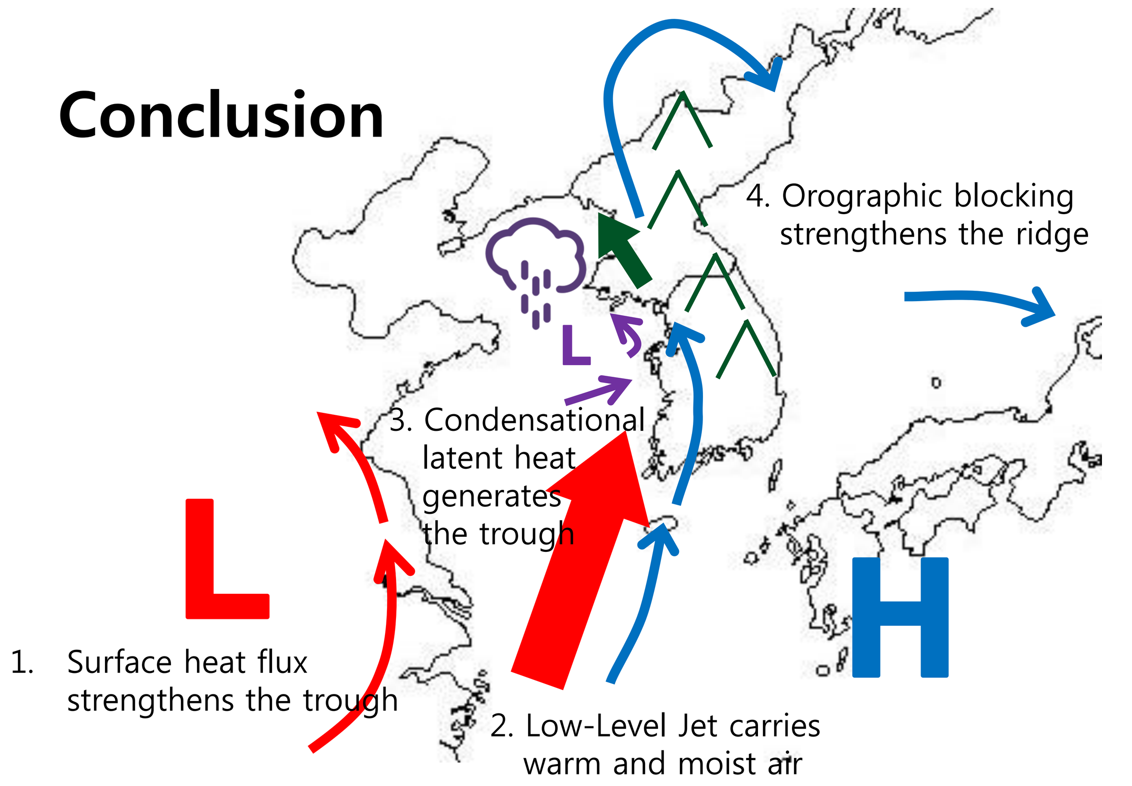
Introduction



2233UTC 28 June Cloud top height | 2230UTC 28 June Hourly lightening rates | 1800UTC 28 June Surface chart | 29 June 2011 Accumulated daily precipitation

- Over 80% of the property and 70% of the human loss from the natural disaster is caused by the heavy rainfall events in Korea.
- Maximum of 234mm rainfall was recorded on June 29 2011.
- The heavy rainfall event occurred as the synoptic-scale ridge extended from Western Pacific Subtropical High (WPSH) was maintained over East Asia.
- Strong LLJ extended from the East China Sea to the Yellow Sea plays an essential role for the occurrence of heavy rainfall.
  - There are 88.2% chances that the LLJ (max wind>12.5m/s) exist during Changma period (Hwang and Lee 1993).
- In this study, observational and numerical study is done to understand the formation and evolution of this heavy rainfall system.

Conclusion



1. Surface heat flux strengthens the trough & LLJ
2. LLJ carries warm and moist air to the center of KP.
3. Condensational latent heat generates pressure trough
4. Orographic blocking strengthens the ridge
5. Significant convergence causes to develop the precipitation system

Reference

- S.-O. Hwang and D.-K. Lee, 1993: A Study on the Relationship between Heavy Rainfalls and Associated Low-Level Jets in the Korean Peninsula. *Asia-Pacific J. Atmos. Sci.* **29**(2), 133-146

Observational study

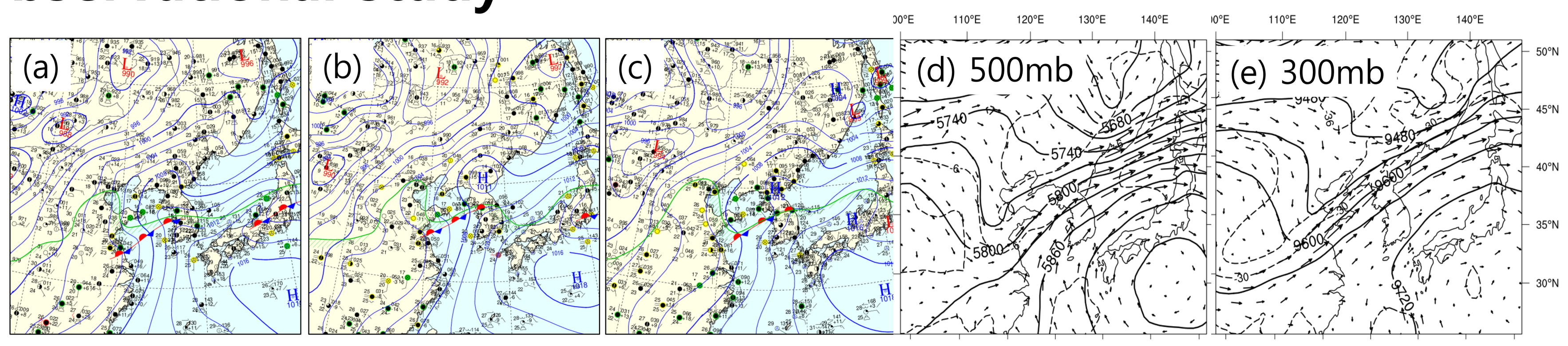


Fig. 1. Sea level pressure weather charts for (a) 12 UTC and (b) 18 UTC 28 June, (c) 00 UTC 29 June 2011, and constant pressure charts for 12 UTC 28 June 2011 (d and e).

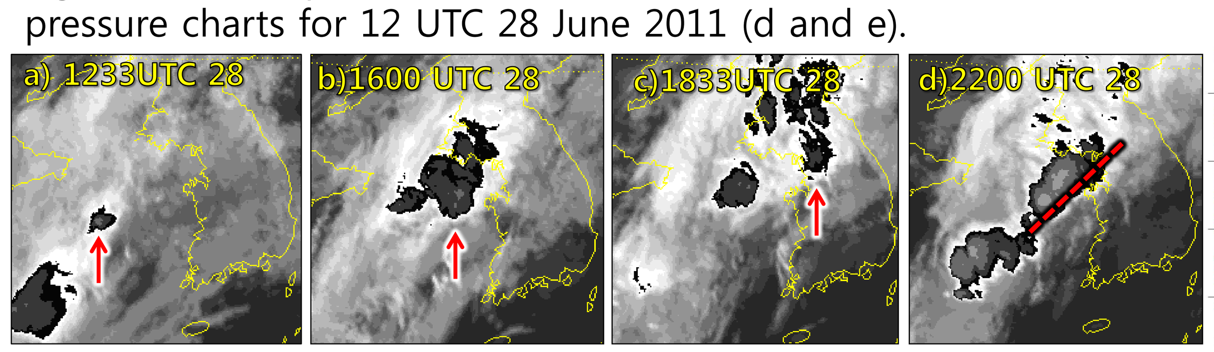


Fig. 2. MTSAT enhanced IR satellite imageries.

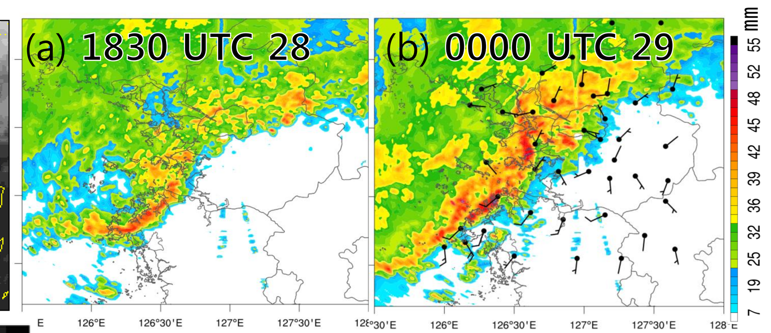


Fig. 3. Composite PPI radar imageries.

- Strong pressure gradient (PGF) induced by WPSH and low-level trough over the coast line of East China strengthens LLJ which contains moist and warm air that provides enough moisture to the rainfall area.
- Upper-level jet (ULJ) is found at the northern side of the Korean Peninsula (KP, Fig. 1e).
- The heavy rainfall formed over the Yellow Sea and transformed into a squall line, traveling northeastward.
- Organization of convective systems into MCSs can be found over the area of mesoscale trough and convergence zone in the northern end of the low-level jet (LLJ) after 2100 UTC 28 June 2011.

Cause of the formation and development of the rainfall

1 Thermodynamic cause

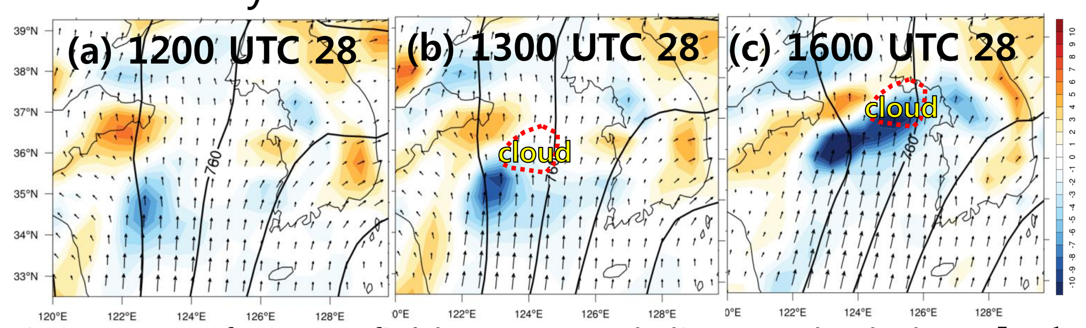


Fig. 3. CFSR forecast field: Φ_{925mb} and div_{925mb}(shaded, 10^{-5} s^{-1})

- Convective cloud appears at the northern edge of the LLJ.
- Condensational latent heating depresses the pressure field below 700 hPa.
- Pressure trough develops convective cloud.

2 Secondary circulation by ULJ

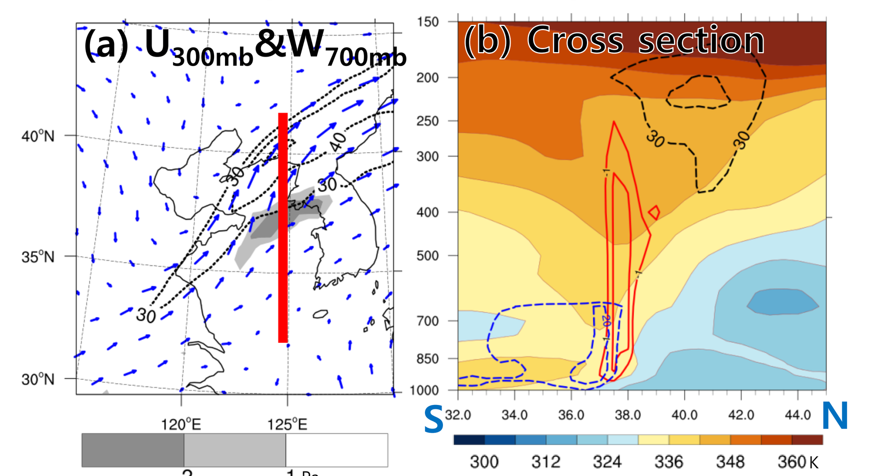


Fig. 4. (a) 300 hPa wind (vector), wind speed (dashed line, >30 m/s), and updraft (shaded, Pa) and (b) cross section (long: 125˚E) of LLJ (blue dashed line), ULJ (black dashed line), updraft (red line), and equivalent potential temperature (shaded, K) at 1800 UTC 28 June 2011.

- Upward motion is found at the entrance of the ULJ and the exit of the LLJ.
- Updraft may be induced by the ageostrophic circulation.

3 Orographic blocking

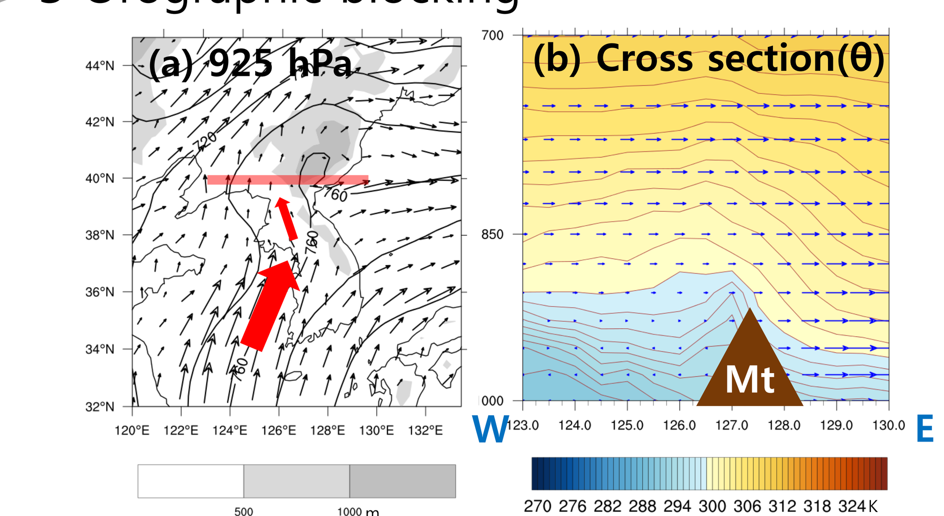


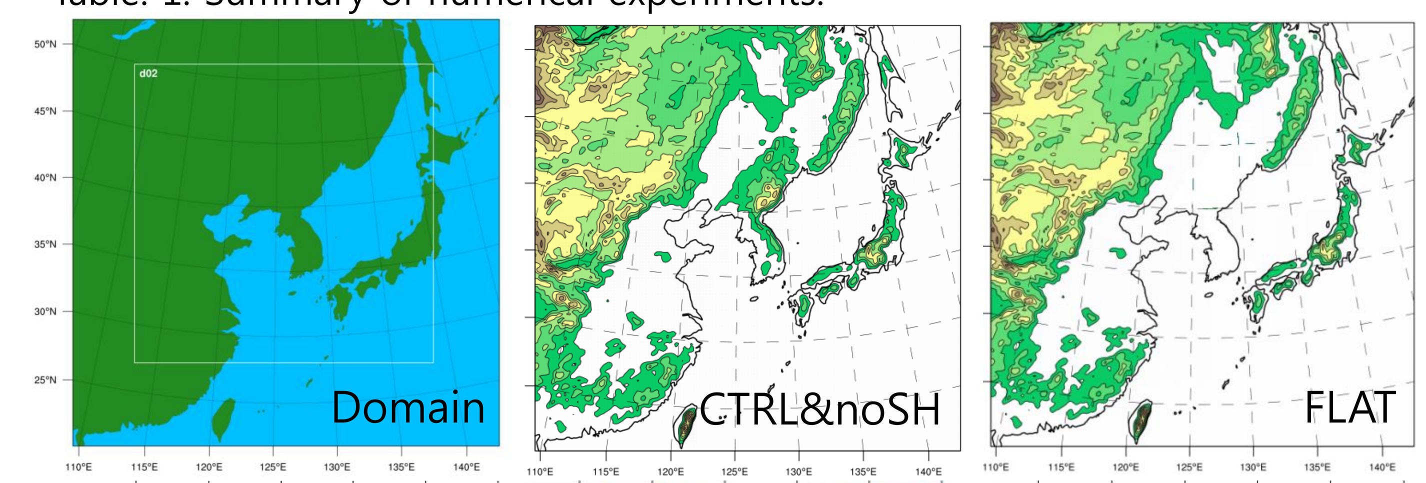
Fig. 5. (a) 925 hPa chart and (b) cross section (lat: 40˚N) of potential temperature (shaded, K) at 1800 UTC 28 June 2011.

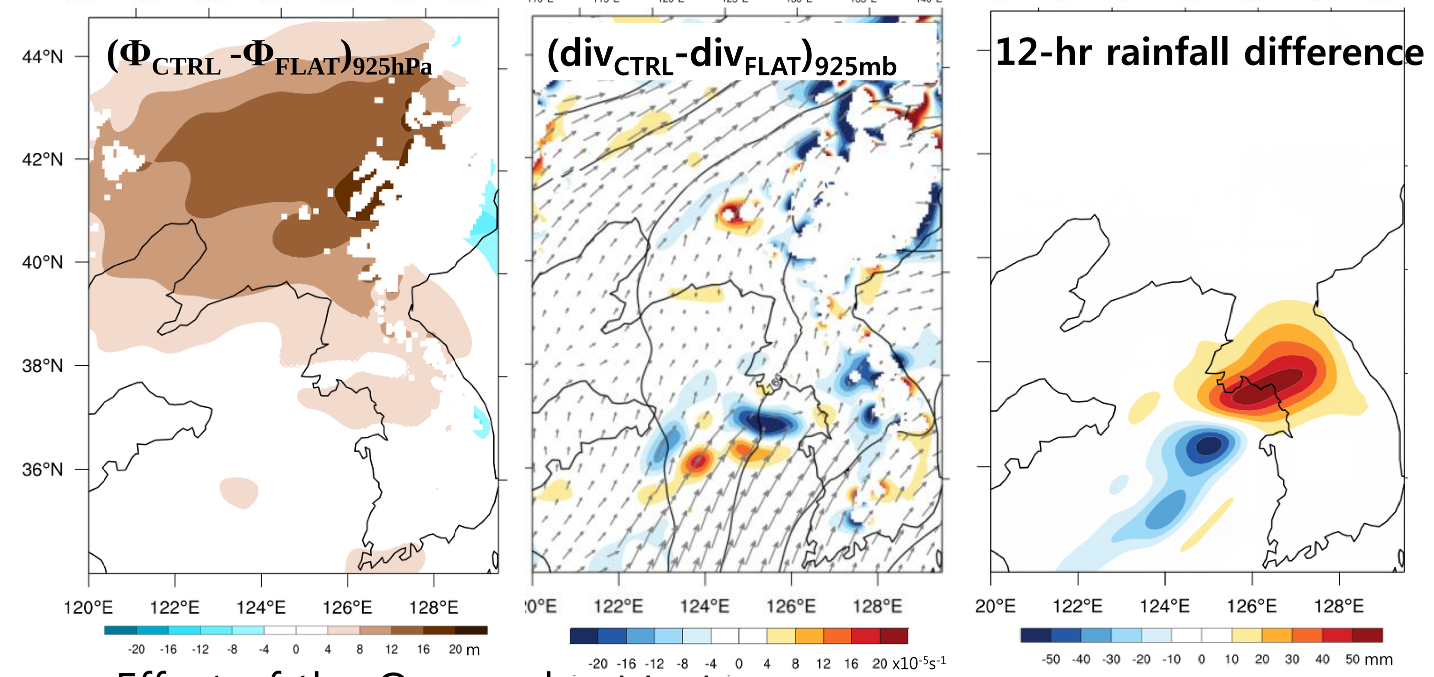
- Wind speed decreases and cold dense air pile up at the windward side of the mountain.
  → pressure increases
- Orographic blocking changes wind speed and direction on the windward side of the mountain.
  → affects horizontal wind shift line at the rainfall area

Numerical study

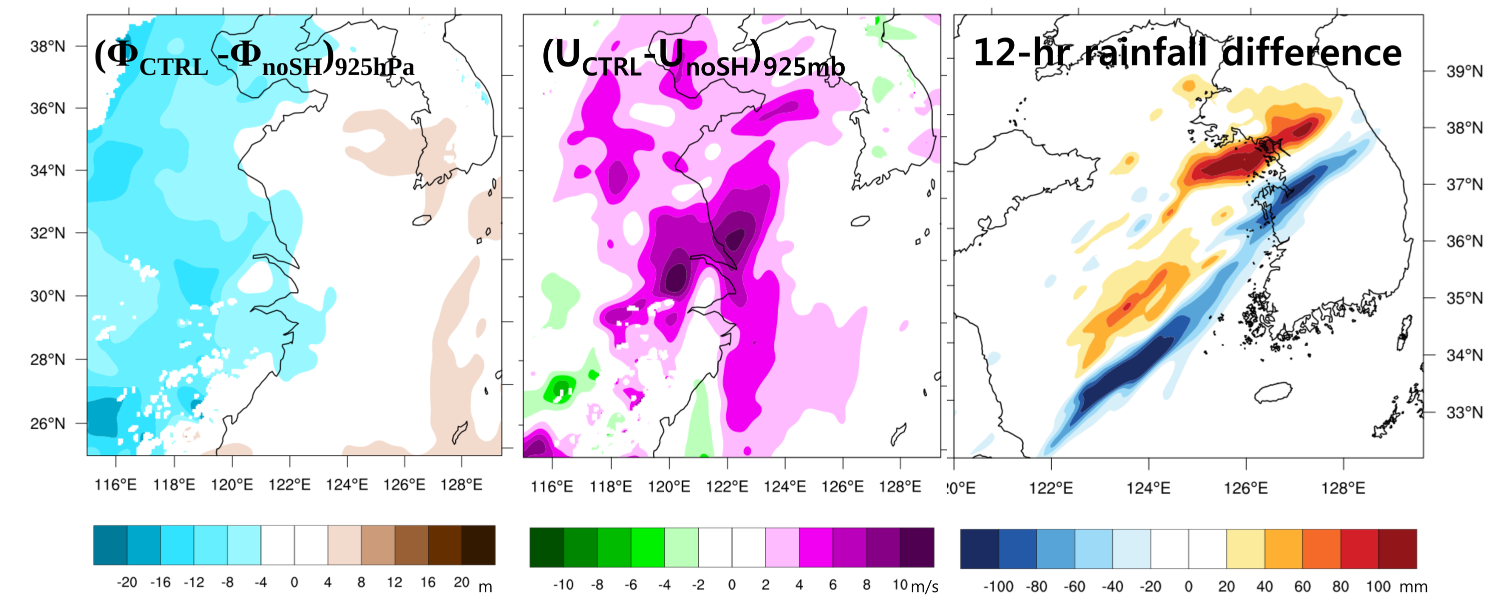
Date	CTRL	FLAT	noSH
Model/Initial data	WRF-ARW V.3.6.1/NCEP CFSR		
Run time	from 18 UTC 27 to 18 UTC 29 June 2011 (48hr)		
Domain/time step	Horizontal: D01—18 km (200x200)/45s, D02—6km (420x420)/15s Vertical : ~50hPa (38 layers)		
Topography		KP topo. = 0 m	
Physics	MP: Thompson PBL: YSU PBL CP : Kain-Fritsch (only on D01)		solar radiation = 10 Wm^{-2}

Table. 1. Summary of numerical experiments.





- Effect of the Orographic blocking
  - Higher pressure is simulated on the windward side of the Mt.
  - Stronger convergence at the rainfall area
  - Increase in rainfall amount (maximum of 27%)



- Effect of the solar heating (coastline of the East China)
  - $T_{land\_925hPa} > T_{ocean\_925hPa}$, $Z_{land\_925hPa} < Z_{ocean\_925hPa}$ (daytime).
  - Stronger PGF at the coastline.
  - Stronger LLJ brings warm and moist air to the north.

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