Simulated diurnal cycle of summer precipitation over the Tibetan Plateau at gray-zone grid spacing

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A high-resolution regional dynamical downscaling is required.
Spatial scale and CU related to precipitation simulation

- **LES**: Large-eddy simulation
- **CU**: Cumulus scheme
- **IFS**: Integrated Forecasting System

(Prein et al. 2015)

**Gray-zone**

<table>
<thead>
<tr>
<th>CU</th>
<th>CU/No CU?</th>
<th>CPM (No CU)</th>
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</table>

- Length scale of the energetic eddies
- Scale of the spatial smoothing filter

(Wyngaard 2004)

**Horizontal wavenumber magnitude**

- $\Delta >> /$
- $\Delta << /$

- $\sim 10 \text{ km}$
- $\sim 4 \text{ km}$
- $\sim 1 \text{ km}$
- $\sim 250 \text{ m}$
Question:
Is it necessary to use CU to realistically simulate diurnal cycle of precipitation at the gray-zone grid spacing (9 km) over the TP.

Aim:
To investigate the impact of CUs on the simulations of summer rainfall diurnal cycle over the TP at the gray-zone grid spacing (9 km).
Model set up

WRF 3.7.1 – ERA5
9km, 60 level up to 10hp
Spectral nudging (3 hr)
X ~1900km, Y ~2200km
U/V, T, Φ, No Q
Nudging coefficient: 0.0003
No nudging in the PBL
No nudging below level 5
Limit nudging from above level 5

PBL: Yonsei University (YSU)

Land surface: Unified Noah Land Surface Model

Microphysics: Double Moment 6-class Cus:
Without CU (no CU)
Multiscale Kain-Fritsch Scheme (MSKF)
Grell 3D Ensemble Scheme (Grell)
New Simplified Arakawa–Schubert Scheme (NSAS)
Simulated monthly mean precipitation

(a) Taylor diagram

(b) Monthly mean precipitation

- Gauge
- Mean Sat (GPM, CMORPH)
- GPM - CMORPH
- ERA5
- WRF(No CU)
- WRF(MSKF)
- WRF(Grell)
- WRF(NSAS)
Diurnal peak time of precipitation amount (LST)

(a) Mean Sat (GPM, CMORPH)
(b) Gauge
(c) GPM - CMORPH
(d) ERA5 - Mean Sat
(e) WRF (No CU) - Mean Sat
(f) WRF (MSKF) - Mean Sat
(g) WRF (Grell) - Mean Sat
(h) WRF (NSAS) - Mean Sat

-0.8 -0.4 0 0.4 0.8
A mplitude

RMSE values:
-ERA5: 5.09
-WRF(Grell): 5.45
-WRF(No CU): 5.67
-WRF(MSKF): 5.02
-WRF(NSAS): 5.67
-WRF(Mean (GPM, CMORPH)): 6.36
Diurnal peak time of precipitation frequency (LST) (hourly precipitation ≥ 0.1 mm h⁻¹)
Diurnal peak time of precipitation intensity (LST)
Diurnal distribution of the frequency of the start hour of precipitation events

(a) 1-3 hours duration precipitation
(b) 4-6 hours duration precipitation
(c) Longer than 6 hours duration precipitation
Conclusions

• Simulations with CUs, especially the Grell and NSAS, tend to overestimate summer precipitation with an early peak of hourly precipitation frequency compared to observation;

• Both no-CU experiment and experiment with a scale aware CU, namely the MSKF, have their advantage in simulating the diurnal cycle of summer precipitation over the TP, with the no-CU experiment more realistically captured the diurnal cycle of precipitation frequency and the MSKF experiments better reproduced the diurnal cycle of precipitation intensity;

• No-CU works fine at 9km resolution.