Evaluation of multi-physics on the simulation of extreme hot summer in 2003 over CORDEX-EA-II Region

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Abstract

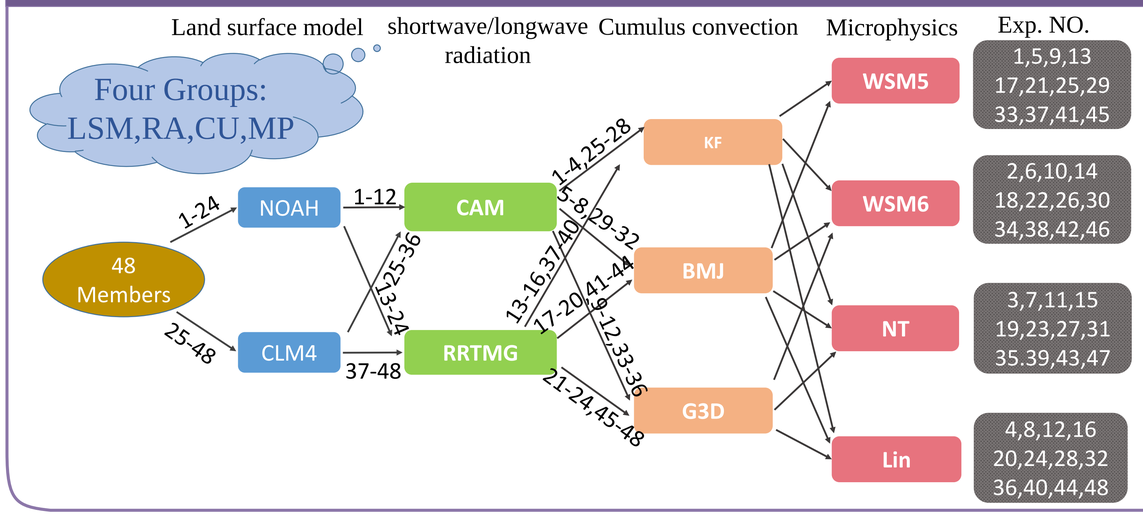
In this paper, we use the WRF model to build a multi-physics ensemble. The extreme precipitation and temperature in 2003 summer are simulated with this ensemble system over CORDEX-EA-II domain, with the ERA-interim reanalysis as external forcing. The performance of 48-member ensemble for JJA precipitation indicates certain dependence on the climate regimes, and it is also evident that Land Surface Models and radiation schemes play a crucial role for surface temperature over all studied regions. Meanwhile cumulus and microphysical schemes have a direct effect on precipitation. Specifically, the influence of radiation schemes on precipitation is outstanding in Tibetan Plateau. The interaction between soil and atmosphere is essential for extreme temperature simulation over CORDEX East Asia region, as the surface extreme climate produced by ensemble members with Noah LSM is more close to observation than those with CLM4. However, the overestimation of JJA precipitation is evident shown as continuous large rainfall instead of the periodic precipitation process.

The diurnal cycle of precipitation features noon rainfall over Tibetan Plateau. In all ensemble members, the ones with CLM4 show larger spread and aggressive overestimation of precipitation compared to Noah when simulating diurnal cycles, indicating that Noah LSM would be more suitable option for WRF to capture the diurnal variation for extremes over Tibetan Plateau. Analysis shows that the simulated JJA meridional wind at 850hPa is sensitive to LSMs, which reveals the indirect effect of land-air interaction on extreme precipitation through large-scale circulation. This effect is obvious in high altitude/dry sub-regions such as northeast China, northern China, northwest China and Tibetan Plateau. The meridional hydrologic transport can be modulated by model's land surface process, either limiting or boosting the accuracy of model simulation of extreme precipitation. Our analysis also shows that the combination of Noah Land Surface Model(LSM), Lin microphysical, G3D Cumulus and CAM radiation schemes provides the most reliable reproduction of climate extremes for both precipitation and temperature over China.

I. Background

- The performance of RCM relies on the model thermo-dynamical core, and the parameterizations of sub-grid processes (Gomez-Navarro et al., 2012; Deque et al., 2007; Stensrud, 2007). The combination of different options of physical schemes can lead to divergent downscaling results and large uncertainty.
- The suitable combination of physical parameterizations can vary with the study regions (Mercader et al., 2010; Evans et al., 2011).
- In 2009, CORDEX, the Coordinated Regional Climate Downscaling Experiment, was coordinated by the World Climate Research Program (WCRP) to provide the high-resolution regional climate change projections for all terrestrial regions in the world (Giorgi et al., 2009; Jones et al., 2011).
- The summer in 2003 received both social and academic attentions for its occurrence of both wet and hot extremes, as the Huaihe River basin suffered from heavy rainfall and floods during June to late July, while the hotwave extreme and drought occurred in south China and Jiangnan.

II. Experiment design



III. Results

1.Spatial distributions of JJA precipitation over Tibet Plateau (75-105°E, 28-40°N)

- **JJA precipitation is more sensitive to physics than Temperature.**
  Using Taylor diagram, it is clear that the simulated JJA precipitation is more sensitive to the combinations of physical schemes than temperature over CORDEX-EA-II domain, which shows high correlations above 0.9 with little inter-group difference (not shown here).
- **Tibet Plateau is the key region when studying the effect of physical parameters.**
  The sensitivity of precipitation on physical options depends on regions. With large spread of all four groups, Tibet Plateau is one of the most sensitive sub-regions to physical parameterizations in China.
- **The impact of Cu schemes is outstanding.**
  Over Tibet Plateau, the cumulus (Cu) schemes can cause larger spread for simulated JJA precipitation pattern than the rest of physical processes do.

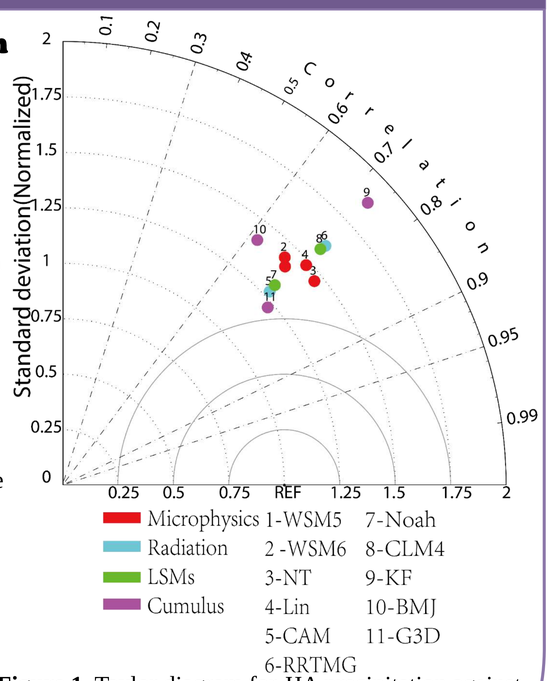


Figure 1. Taylor diagram for JJA precipitation against CN05.1 over Tibet Plateau

2. Temporal variance of surface climate over Tibet Plateau

- **Model's precipitation extreme is more sensitive to radiation and land surface models over Tibet Plateau.**
  The sensitivity of temporal evolution for daily precipitation represents different characteristics over Tibet Plateau from those over other sub-regions, where convective and microphysical processes might be the key element in providing accurate JJA precipitation. The simulation of temporal variation of rainfall depends more on the options of radiation and LSMs than Cu and MP over Tibet Plateau.
- **Land surface models play a crucial role for surface temperature over Tibet Plateau.**
  The experiments with NOAH LSM (Exp.NO. 1-24) have better simulations for temperature extremes than CLM4 which shows large overestimation in JJA 2003.
- **With CAM radiation scheme and NOAH LSM applied, the reproduction for daily rainfall and maximum temperature can be improved.**

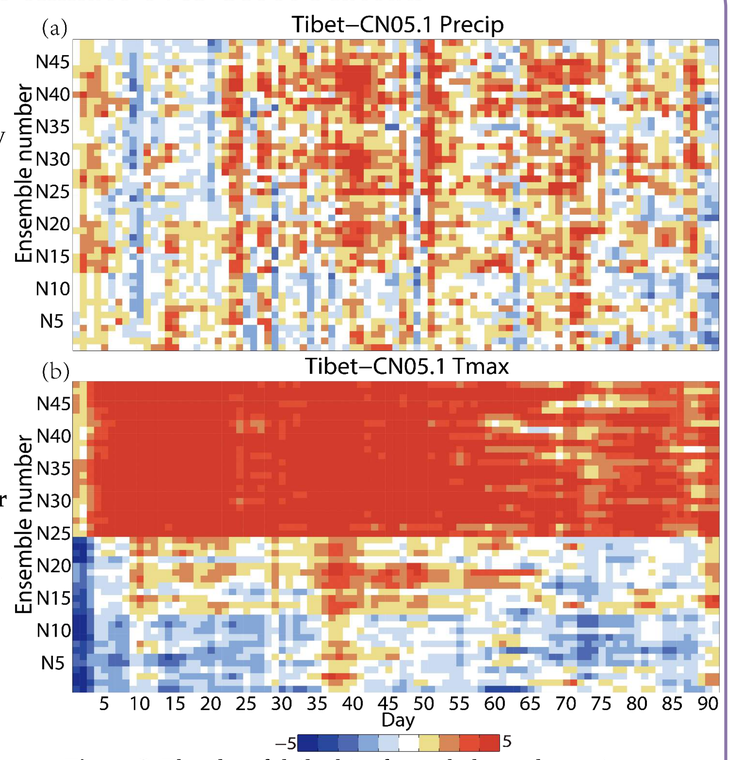


Figure 2. The plot of daily bias for each day and experiments over Tibet Plateau. (a) for precipitation(unit: mm) and (b)for daily maximum temperature(unit:°C)

3. The diurnal cycle of precipitation over Tibet Plateau

- **Noah LSM would be more suitable option for WRF to capture the diurnal variation for extremes over Tibetan Plateau.**
  The diurnal cycle of precipitation features noon rain over Tibetan Plateau. In all ensemble members, the ones with CLM4 show larger spread and aggressive overestimation of precipitation compared to NOAH when simulating diurnal cycles. Also, Exp. No.12 performs closer than any other experiment indicating the better performance of NOAH.

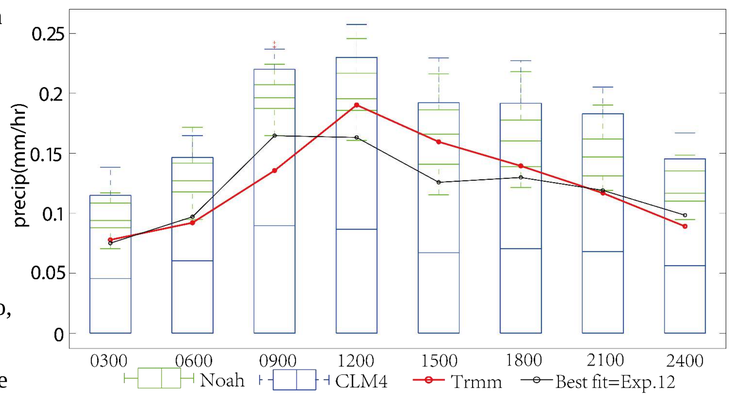


Figure 3. Diurnal cycle of 2003 JJA precipitation averaged over Tibet Plateau.

IV. Conclusion

- **The performances for the combinations of physical schemes in WRF for JJA precipitation in 2003 depend observably on the regions.**
- **Radiation and land surface models have an outstanding influence on the simulation of temporal evolution for precipitation, while the effect from cumulus convective processes is distinct for spatial pattern of rainfall in summer over Tibetan Plateau.**
- **Land surface models play the crucial role for surface temperature extremes and NOAH is more reliable LSM choice for JJA 2003 climate over Tibetan Plateau.**
- **The essential contribution of land-atmosphere interaction to the large-scale circulation can have a significant influence on WRF's ability to simulate the extremes. The meridional hydrologic transport can be modulated by model's land surface process, either limiting or boosting the accuracy of model simulation of extreme precipitation.**