Climate downscaling for Arizona using WRF: Dependence of precipitation on model resolution and convective parameterization

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Introduction

➢ Climate in Arizona is generally dry with intermittent seasonal rainfall in summer and winter that is spatially heterogeneous.

➢ Winter is chosen for simulating precipitation because the model generally simulates the climatology of the cold season more accurately than the warm season.

➢ Using the WRF 3.1 model, this study will perform a series of seasonal simulations with multiple nesting centered in Arizona to clarify the dependence of the simulated rainfall on the model resolution and the switching on/off of cumulus parameterization scheme.

Model Setup

➢ Six hourly NCEP Global Analysis data on 1 x 1 degree grid (FNL) are used to construct the initial and boundary conditions.

➢ Liquid-form precipitation (RAINC and RAINNC) is analyzed.

➢ Analysis of the time series of local rainfall on a sub-domain in southern Arizona (see the square box in Fig. 1a, defined as 111.78° W-113.61° W and 31.90° N-33.69° N) over which almost all precipitation is in the form of rain.

Results

➢ At 6 km, we find that when cumulus parameterization is turned off, grid-scale convective rainfall increases to compensate for the absence of subgrid-scale rainfall.

➢ At relatively coarse 12 km grid resolution, the rainfall produced by the subgrid-scale cumulus parameterization becomes more prominent, while grid-scale rainfall becomes weaker compared to the 6 km runs. The total rainfall is also weak compared to 6 km runs.

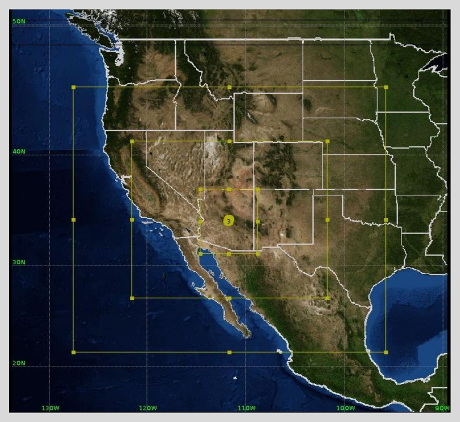
➢ While RAINC is smaller than RAINNC in most areas for 6 km and 12 km runs, a few exceptions such as the wet spot in northern Mexico occur due to the increasing importance of small-scale convection as one moves toward warmer and more humid latitudes.

➢ The 3 km run has a slight increase in the maximum rainfall over the mountains in central Arizona and emergence of more fine-scale structures in the rainfall pattern that reflects the influence of topography.

➢ Time series of hourly rainfall averaged over the square box in southern Arizona show that RAINC and RAINNC generally has a similar pattern in their temporal evolution; A rainfall event with a large RAINNC usually has a large RAINC.

Domain	Outermost domain	Intermediate domain	Innermost domain
2 layer nesting	36 km	-	12 km
3 layer nesting	54 km	18 km	6 km
3 layer nesting	48 km	12 km	3 km

Runs	Cumulus convective Kain-Fritsch scheme
12 km	✓
6 km: Case 1	✓
6 km: Case 2	☒
3 km	☒



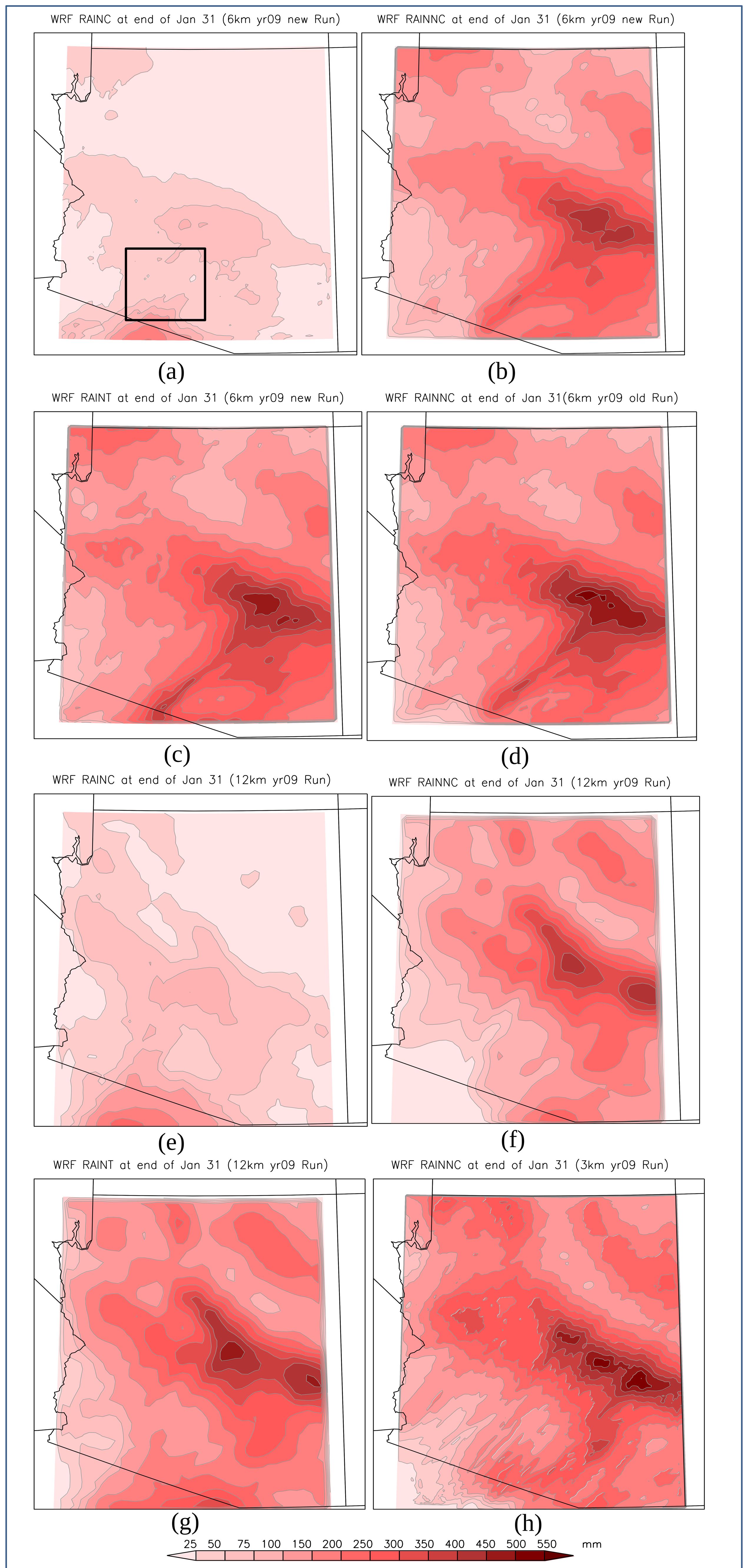


Fig. 1. Seasonal cumulative rainfall for Nov'09-Jan'10. The box in (a) shows the area chosen for time-series of rainfall in Fig. 2.

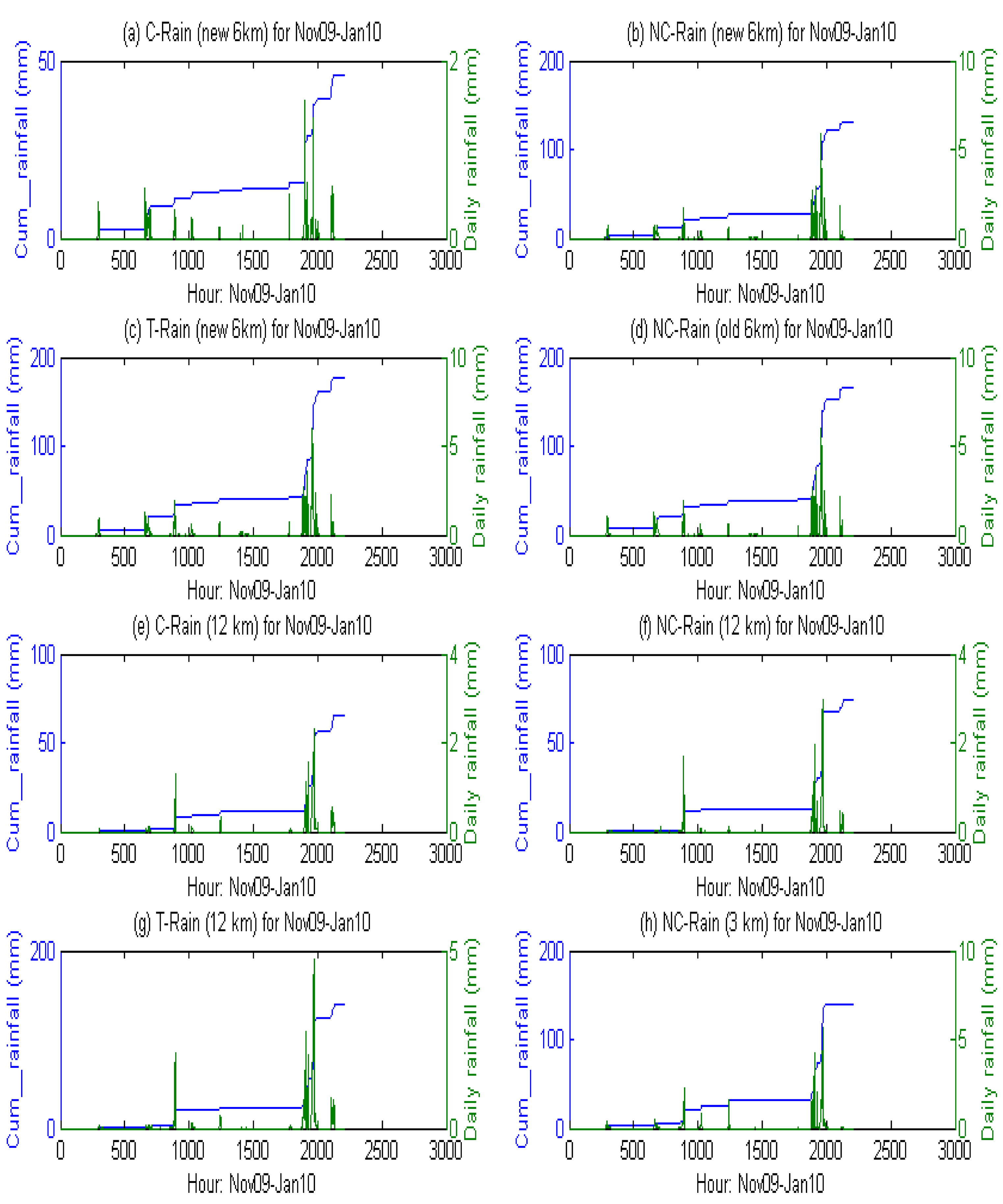


Fig. 2. Time-series of hourly rainfall averaged over the box in Fig. 1a for 1 Nov'09-31 Jan'10 for set of runs that correspond to the 8 panels in Fig. 1.

Conclusion

➢ From the series of simulations of wintertime rainfall over Arizona, we find a significant increase in the total rainfall when model resolution is refined from 12 to 6 km, and relatively mild increase in rainfall when the grid size is further refined to 3 km.

➢ At the 6 km resolution, turning the cumulus parameterization off resulted in about the same amount of total rainfall, due to the compensation by an increase in the grid-scale rainfall.

➢ This indicates that for climate downscaling for Arizona it may be appropriate to switch off cumulus convective scheme when the grid size of the regional model is refined to 6 km or smaller.

Acknowledgments:
Sharma is supported in part by NSF AGS-0543256. Huang acknowledges support by NSF AGS-0543256, NSF AGS-0934592, and NOAA CPPA Program.

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