High-resolution regional climate simulations of precipitation patterns over the western U.S. using WRF

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Summary and motivation

This study shows the overall performance of different Regional Climate Model (RCM) configurations using the WRF 3.1.1 model for climate variability and change projections and impact studies.

Test sensitivity to 3 nested domains with 36, 12 and 4 km horizontal grid resolutions.

Test sensitivity to selection of relevant physical parameterizations.

Test performance of RCM during two cold seasons (Oct-July) with observed seasonal precipitation extremes (2002-03 as DRY and 2004-05 as WET years).

No previous studies have systematically diagnosed the sensitivity of a RCM at 4km over the intermountain west .

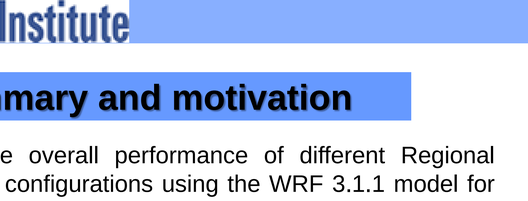
Mountain-Valley systems over eastern Nevada, Nov 1, 2010. Typical arid and semi-arid landscape in the intermountain west.

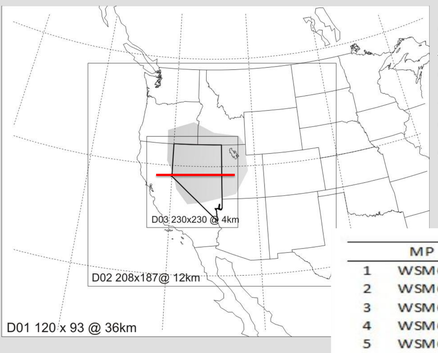
27 Jan, Seattle, WA. Presented at the 2011 AMS-annual meeting,

Methodology

Model: Weather Research & Forecasting model (WRF V3.1.1) in climate mode.
Forcing data: NCEP/NCAR reanalysis products (NNRP).
Bottom BCs updates: SST + deep soil temperature.
No Nudging
2-years spin-up period for slow varying quantities + 2 nine-month periods Oct-June:

Dry year 2002-2003
Wet year 2004-2005



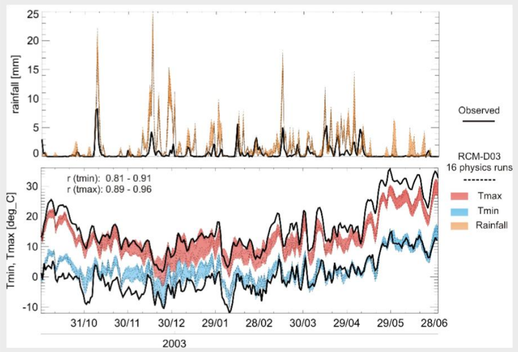


Nested domains over SW North America (at 36 km grid size), the Great Basin (at 12km grid size) & Tri-State, and Nevada (at 4km grid size). Gray shadings represent approximate location of the Great Basin region.

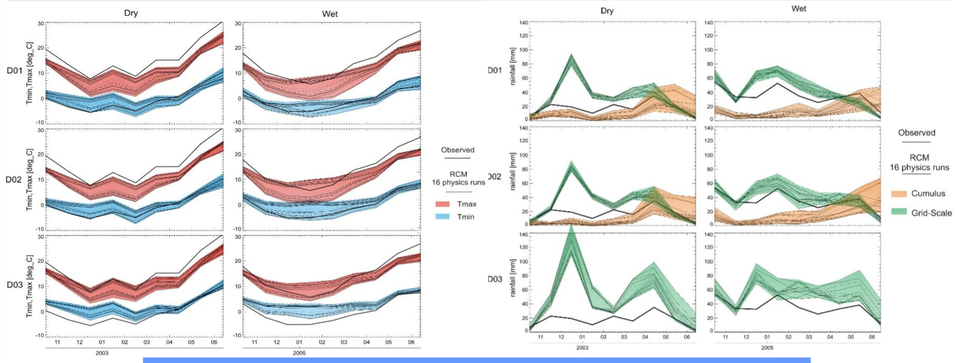
	MP	Rad	LSM	PBL	Cu
1	WSM6	RRTMg	Noah-4	YSU	KF
2	WSM6	RRTMg	Noah-4	MYJ-TKE	KF
3	WSM6	RRTMg	Thermal-5	YSU	KF
4	WSM6	RRTMg	Thermal-5	MYJ-TKE	KF
5	WSM6	CAM	Noah-4	YSU	KF
6	WSM6	CAM	Noah-4	MYJ-TKE	KF
7	WSM6	CAM	Thermal-5	YSU	KF
8	WSM6	CAM	Thermal-5	MYJ-TKE	KF
9	Thompson	RRTMg	Noah-4	YSU	KF
10	Thompson	RRTMg	Noah-4	MYJ-TKE	KF
11	Thompson	RRTMg	Thermal-5	YSU	KF
12	Thompson	RRTMg	Thermal-5	MYJ-TKE	KF
13	Thompson	CAM	Noah-4	YSU	KF
14	Thompson	CAM	Noah-4	MYJ-TKE	KF
15	Thompson	CAM	Thermal-5	YSU	KF
16	Thompson	CAM	Thermal-5	MYJ-TKE	KF

16 combinations of physics parameterization combinations. Microphysics (MP); short- and long-wave radiation (Rad); Land Surface Model (LSM); Planetary Boundary Layer (PBL); Cumulus physics (Cu) only for 12 and 4 km domains.

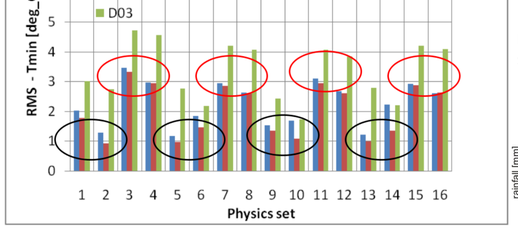
Day-to-day Variability and Monthly Means



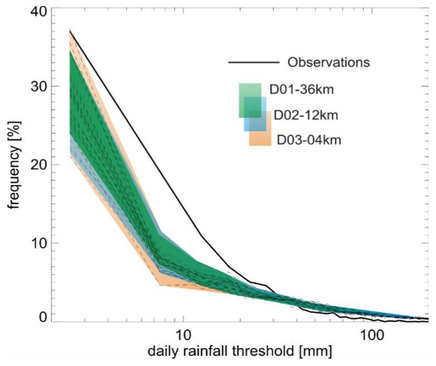
Model evaluation was performed using 94 Active (2002-2005) NOAA/NWS and Cooperative Observer Network Stations (NCDC),FAA, Agro-Met. QA/QC: missing observations, "day- time-shifting" and other observer-related errors.
(**Left**) NV statewide synoptic time-scale variability is well captured by the model. However, precipitation is overestimation during weather events. (**Bottom-L**) NV statewide monthly means show systematic biases (drifting) regardless of the physics package. Model underestimates the amplitude of diurnal cycle of temperature. (**Bottom-R**) Too much grid-scale precipitation. However, rainfall partition and seasonal evolution vary accordingly



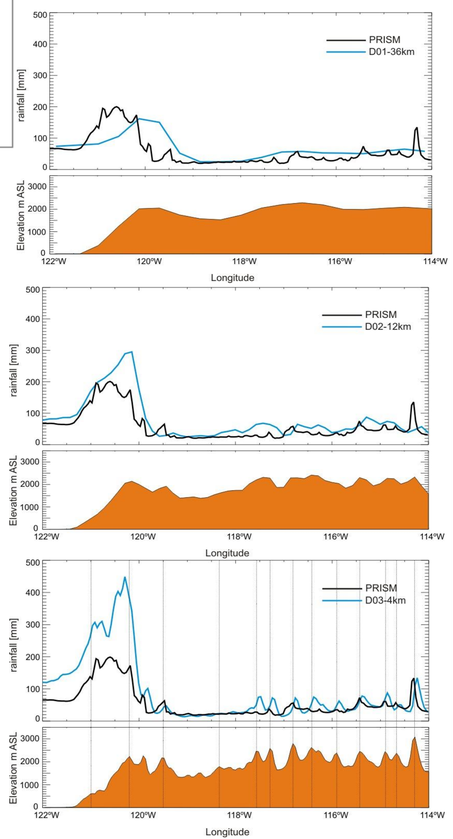
Do Physics and Grid Size Matter?



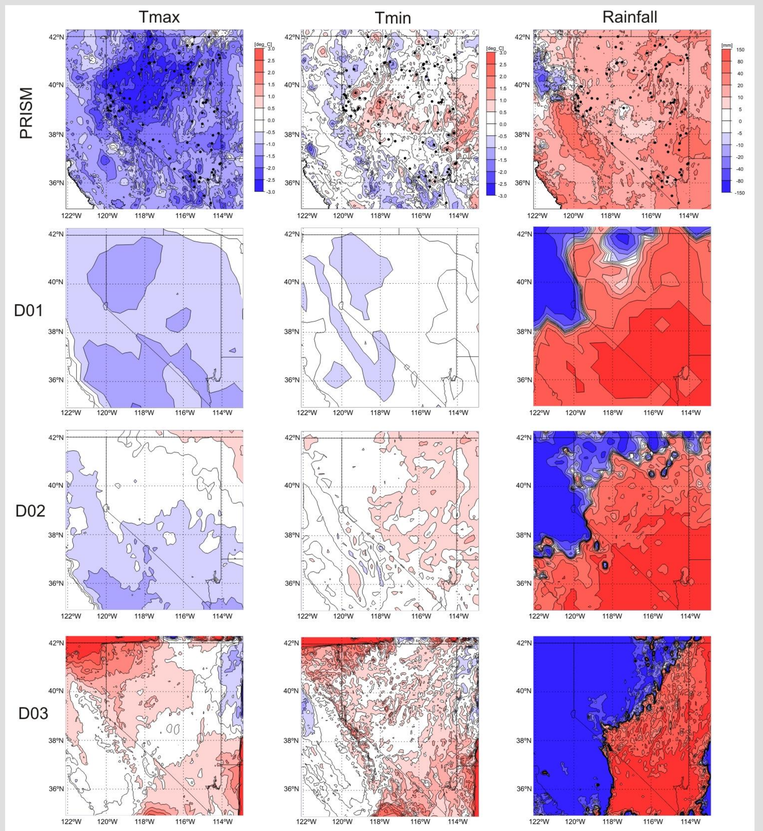
(**Top**) Error statistics systematically show that D01 and D02 perform better than D03, while highlighting some potential for optimization of physics selection (e.g. T*min* performs better using Noah-4 LSM scheme than Thernal-5). (**Bottom**) Not apparent difference in grid-size and physics selection stand out when looking at rainfall extreme events. The models systematically underestimate frequency of light rainfall events while overestimate heavy rainfall events.



(**Bottom**) Precipitation gradients do improve with increasing grid size (when comparing against PRISM Climate Group, Oregon State University, http://www.prismclimate.org). Amplitude of features associated with orographic rainfall are larger for D03. Phase problems still persist even for D03.. Still need a high-quality ground truth products (remote sensing?).



Response to Climate Patterns



An important challenge for RCMs is whether they are capable of transferring the correct climate signal upon a known large-scale climate patterns (i.e. transferability of information from global seasonal forecast, climate change scenarios, to regional-local scales). Despite the systematic biases previously shown by the different model configurations, the amplitude (**WET minus DRY**) of the overall climate patterns over NV and the Sierra Madre appears to be well-reproduced by D01 and D02 when comparing against PRIMS (Observed – 4 km products) difference fields. D03 does not show comparable difference fields.

Concluding Remarks

RCM shows grid size and regime dependence. However, finer-resolution does not translate into overall better simulations.
- 36 and 12 km runs do provide better error statistics,
- while 4 km runs improve spatial distribution. (non-linear interactions, dynamics)

Physics schemes reveal some potential for regional optimization. (Combination #1) WSM6 + RRTM + Noah-LSM + MYJ (commonly accepted and is now implemented in our long term runs)

The RCM reproduce wet and dry anomalies accordingly, with limitations.

The RCM overestimates daily rainfall amounts with large scale dependency.

The RCM underestimates frequency of small events and overestimates frequency of large event.

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