Dynamic Downscaling GPM Precipitation and SMAP Soil Moisture using WRF-*pt*RIBS-VEGGIE Model - A Preliminary Test

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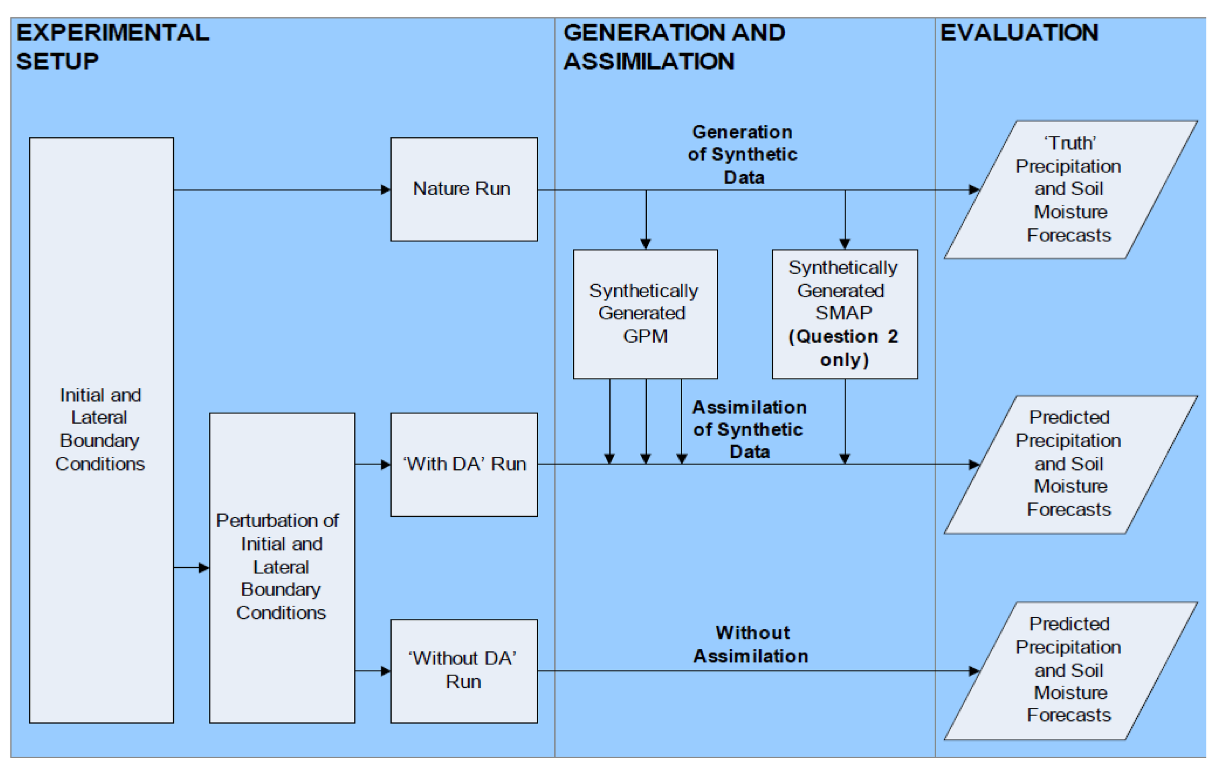
Summary

This paper reports the first step of dynamic downscaling GPM precipitation and SMAP soil moisture data through data assimilation using the WRF-*pt*RIBS-VEGGIE modeling system. A test of the coupled eco-hydro-atmospheric model shows that it is capable of predicting high resolution space-time distributions of precipitation, soil moisture, vegetation and other hydro-meteorological processes. The sensitivity analysis has provided important information about the effects of uncertainties in model input on model predicted precipitation and soil moisture that will guide the on-going work on dynamic downscaling using 4DVAR and Kalman filter data assimilation methods.

1. Objective

Developing a modeling and data assimilation framework for downscaling of Global Precipitation Mission (GPM) and Soil Moisture Active and Passive (SMAP) observations to produce precipitation and soil moisture predictions at fine scales for hydro-meteorological applications. It is hypothesized that a high resolution regional climate model coupled to a physically-based representation of sub-grid land-atmosphere feedbacks with data assimilation may be an optimal approach for downscaling of coarse-scale remote sensing data of precipitation and soil moisture.



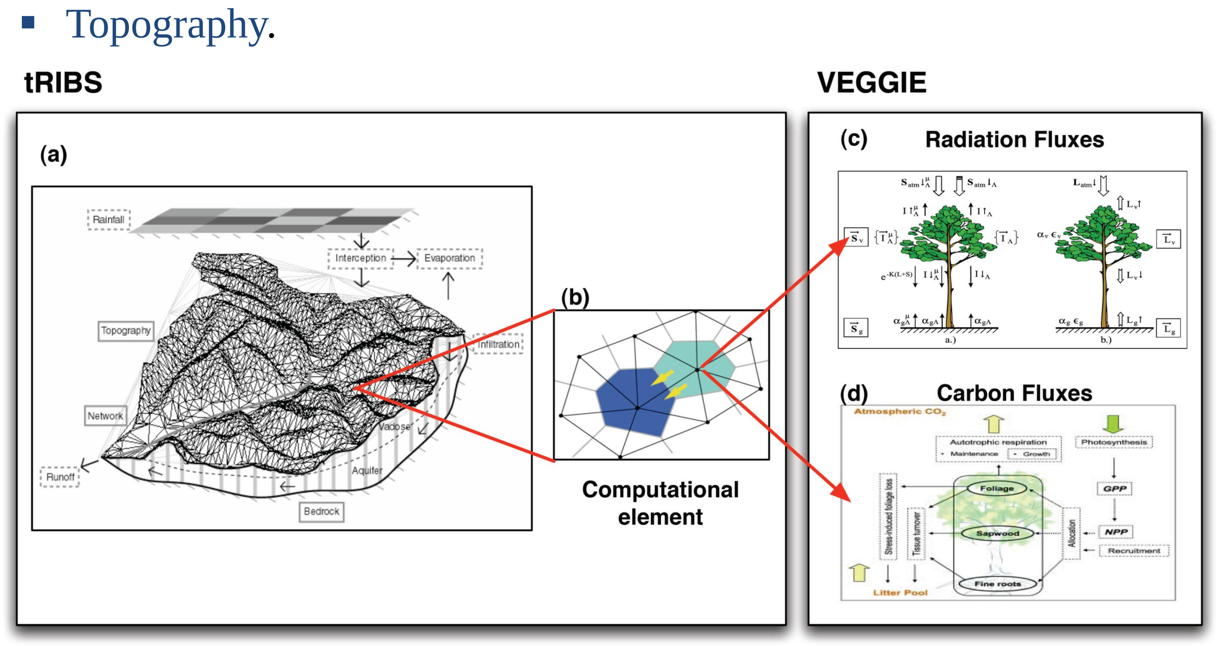
2. WRF-*pt*RIBS-VEGGIE Model

The modeling system includes:

- *Weather Research Forecasting* (WRF) model, a regional atmospheric model,
- *Parallel Triangulated Irregular Network (TIN)-based Real-time Integrated Basin Simulator* (*pt*RIBS), a distributed land surface hydrologic model,
- *VEGetation Generator for Interactive Evolution* (VEGGIE), a dynamic vegetation model (*Bisht et al*., 2008; 2010)

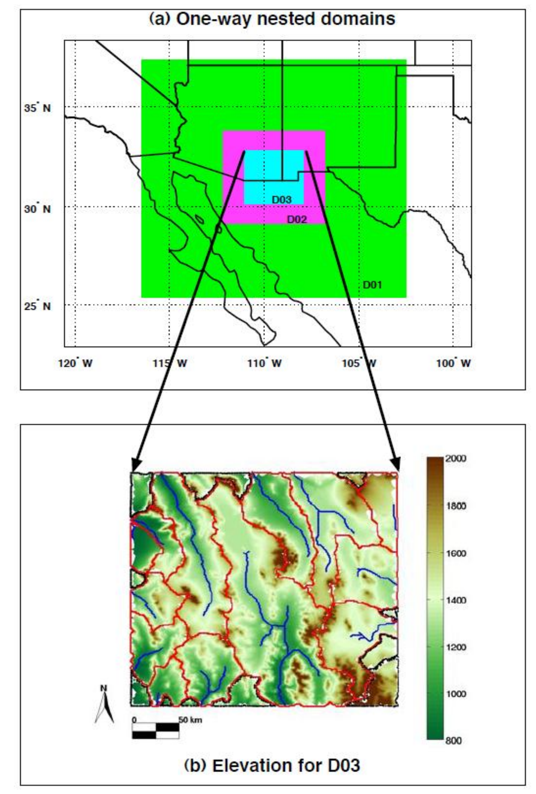
The WRF-*pt*RIBS-VEGGIE system for dynamic downscaling of GPM and SMAP data through high resolution representation of:

- Water and energy balance,
- Vegetation dynamics,
- Topography.

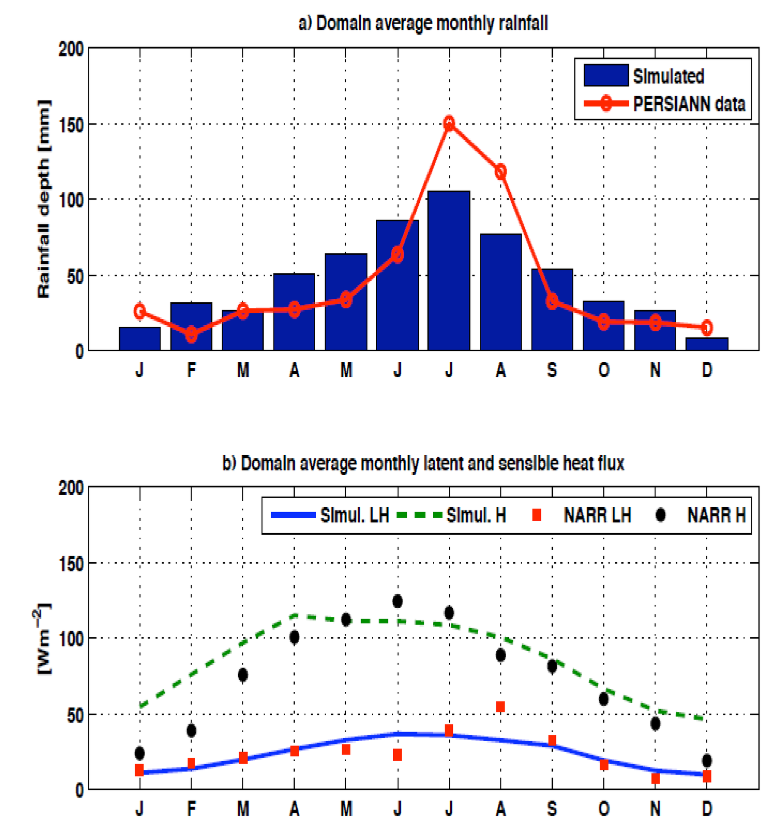


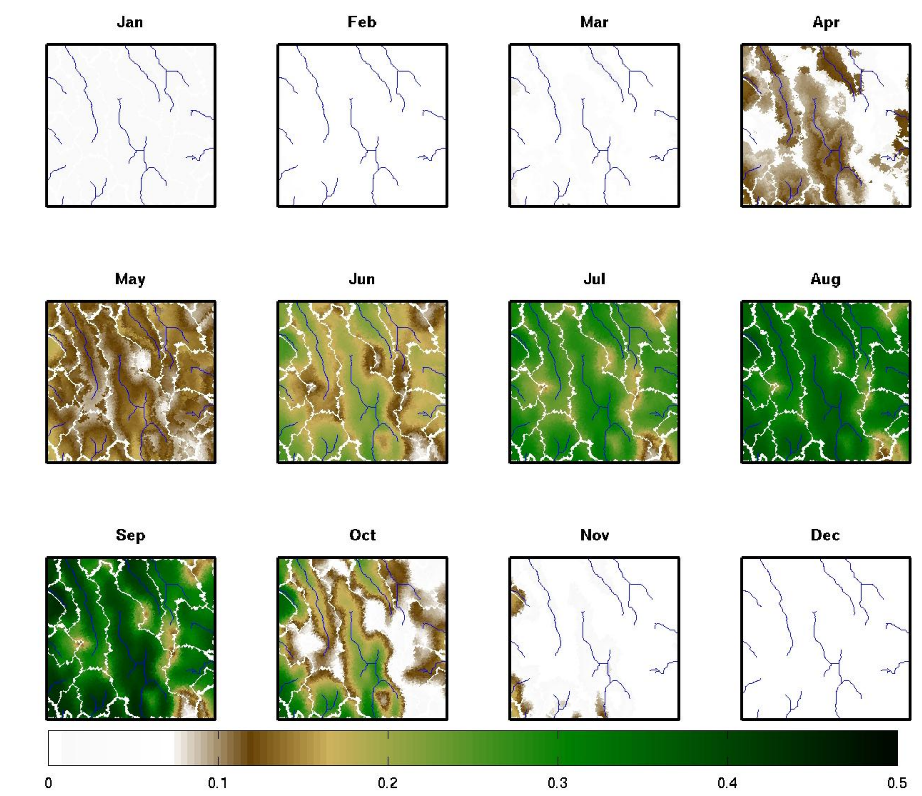
3. Coupled Model Simulations

Initial and boundary condition	NARR data
Microphysics	Lin et al.
Cumulus	Kain-Fritsch
PBL	YSU (Yunsei U.)
Land surface	NOAH and tRIBS-VEGGIE
D01 (96x96)	27 km
D02 (57x57)	9 km
D03 (67x67)	4.5 km
Time step	20 sec
Vertical layers	30



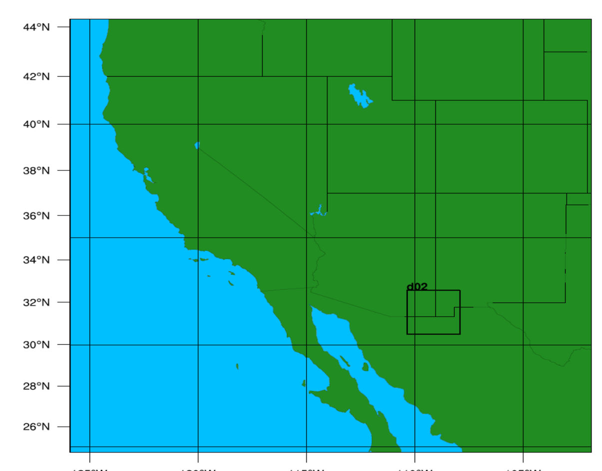
- WRF coupled with *pt*RIBS-VEGGIE predicts domain averaged monthly precipitation (**top-left**) consistent with the PERSIAN data product,
- *pt*RIBS-VEGGIE coupled with WRF predicts domain averaged monthly surface fluxes (**bottom-left**) consistent with the NARR data products,
- VEGGIE coupled with WRF and *pt*RIBS predicts domain averaged monthly leaf area index (LAI) (**right**) consistent with the MODIS LAI data (not shown here) capturing the seasonality of vegetation (e.g. peaking in August-September).





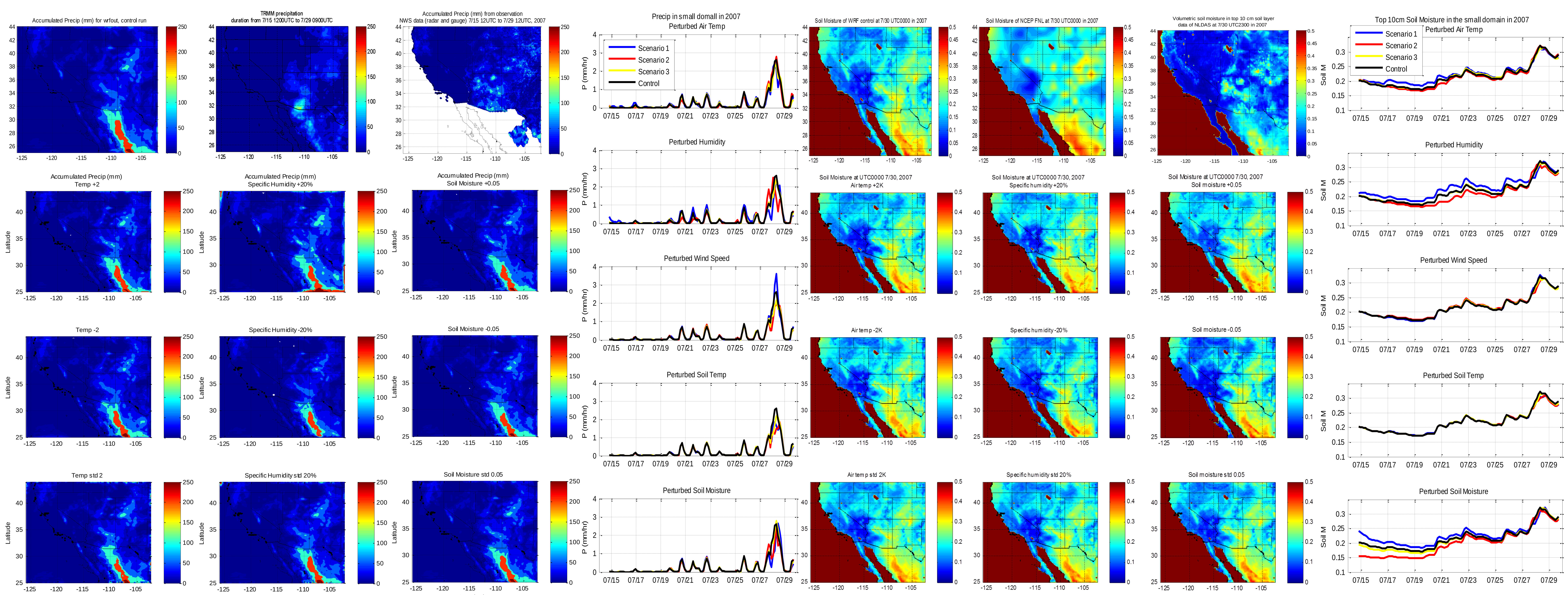
4. Sensitivity Analysis of WRF Simulations

Initial and boundary condition	FNL data
Microphysics	WSM 3-class.
Cumulus	Kain-Fritsch
PBL	YSU
Land surface	NOAH
D01 (99x99)	27 km
Time step	60 sec
Vertical layers	27



Perturbed Variables	Scenario 1	Scenario 2	Scenario 3
Air Temperature	+2 K	-2K	std of 2K
Air Specific Humidity	+20%	-20%	std of 20%
Air Wind Speed	+20%	-20%	std of 20%
Top 10 cm Soil Temperature	+2 K	-2K	std of 2K
Top 10 cm Soil Moisture	+0.05	-0.05	std 0.05

- The simulated cumulative precipitation (**col 1-3 from left**) is consistent with TRMM, WSR-88D NEXRAD and NWS rain-gauge data. Precipitation is most sensitive to the transport of water vapor and least sensitive to wind speed and top-layer soil temperature (**col 4 from left**).
- The simulated soil moisture at the end of the period (**col 5-7 from left**) is closely correlated with the simulated precipitation and consistent with FNL data. It is most sensitive to initial soil moisture and the transport of water vapor, presumably through precipitation. The time-scale of the influence of perturbed initial conditions is about nine days (**col 8 from left**).
- The results highlight the crucial role of the coupled WRF-*pt*RIBS-VEGGIE model in downscaling of coarse-resolution GPM and SMAP data to capture fine-scale distributions of precipitation and soil moisture.



5. On-Going Work

1) Test of a radiation transfer model (RTM) coupled to WRF-*pt*RIBS-VEGGIE model for simulating GPM and SMAP satellite signals,
2) Test of Kalman filter data assimilation module in *pt*RIBS-VEGGIE model for downscaling of soil moisture,
3) 4DVAR data assimilation runs of WRF-*pt*RIBS-VEGGIE model for downscaling of precipitation.

References

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