Investigating the impact of improved rainfall model error characterization on the assimilation of synthetic soil moisture fields in a land data assimilation system

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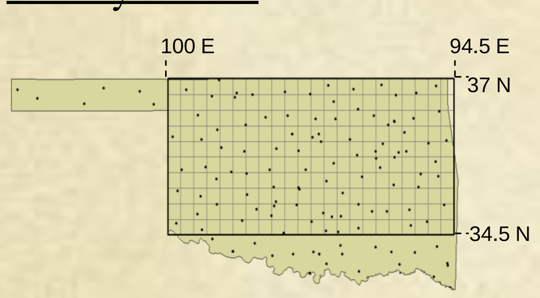
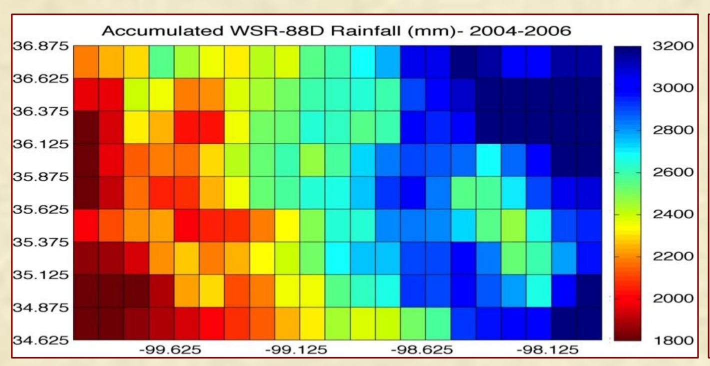
Introduction

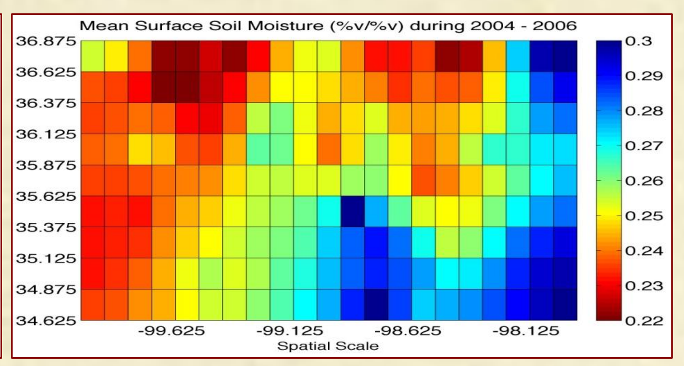
Objective: to assess the impact of satellite-rainfall error structure on the efficiency of assimilating soil moisture in a land data assimilation system.

Specifically, the study contrasts a multi-dimensional satellite rainfall error model (SREM2D, *Hossain and Anagnostou*, 2006) to the standard rainfall error model used to generate rainfall ensembles as part of the Land Data Assimilation System developed at the NASA Global Modeling and Assimilation Office (NASA-LDAS).

Study Area:







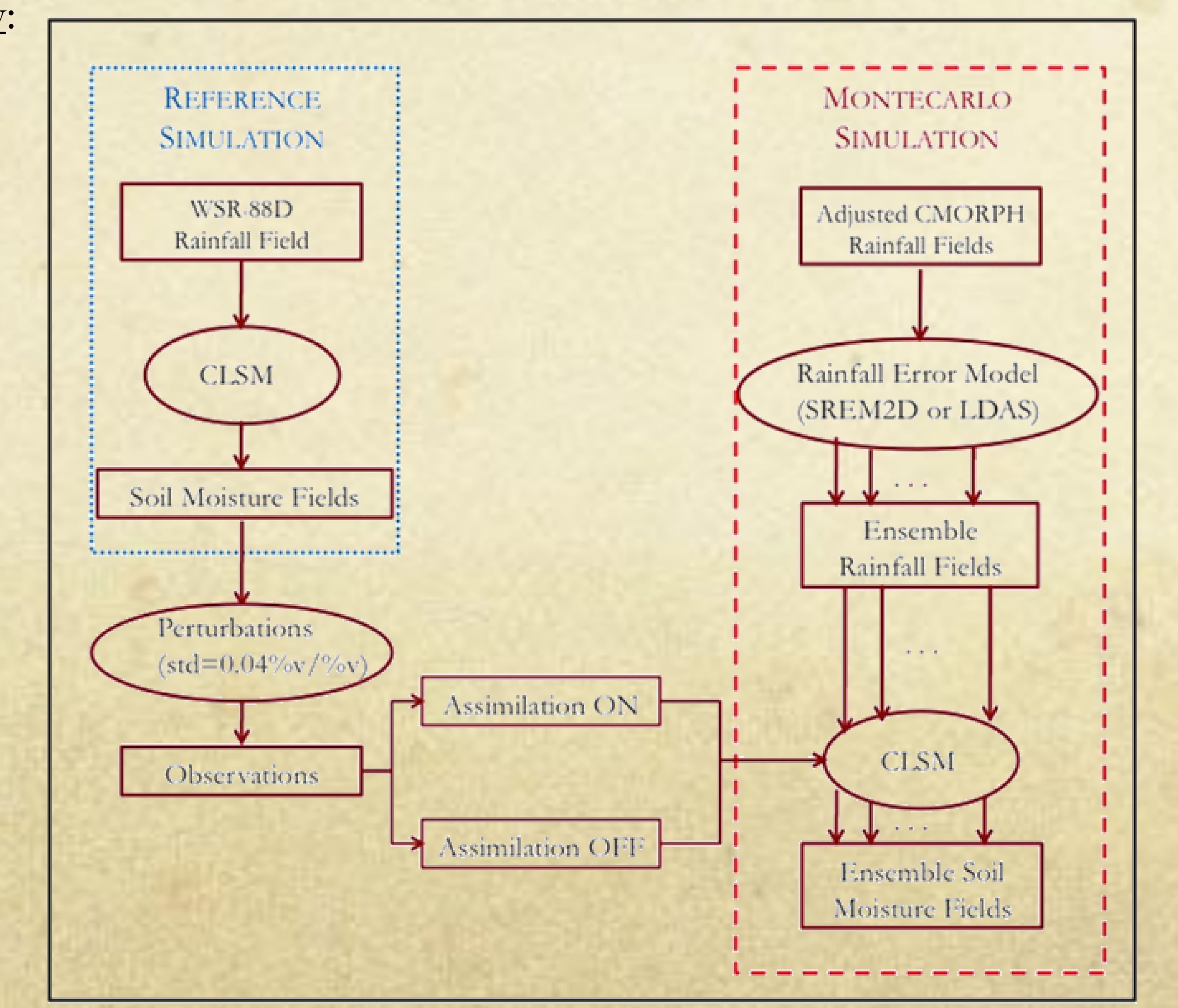
Dataset: (a) high-resolution satellite rainfall fields derived from the NOAA CMORPH global satellite product; and (b) rain gauge-calibrated radar rainfall fields (WSR-88D, considered as reference rainfall).

Resolution: 3 hourly, 25km. The time series is 3-year long (2004-2006).

LSM: the NASA Catchment Land Surface Model (CLSM; *Koster et al.*, 2000)

Data Assimilation Framework: the system used at the NASA GMAO (*Reichle et al.*, 2007) that utilizes the ensemble Kalman filter (EnKF).

Methodology:



Results

Four experiments have been run (2 for each rainfall error model), turning off/on the assimilation of soil moisture fields. Statistics have been calculated for the 25km grid for both surface soil moisture and root zone soil moisture.

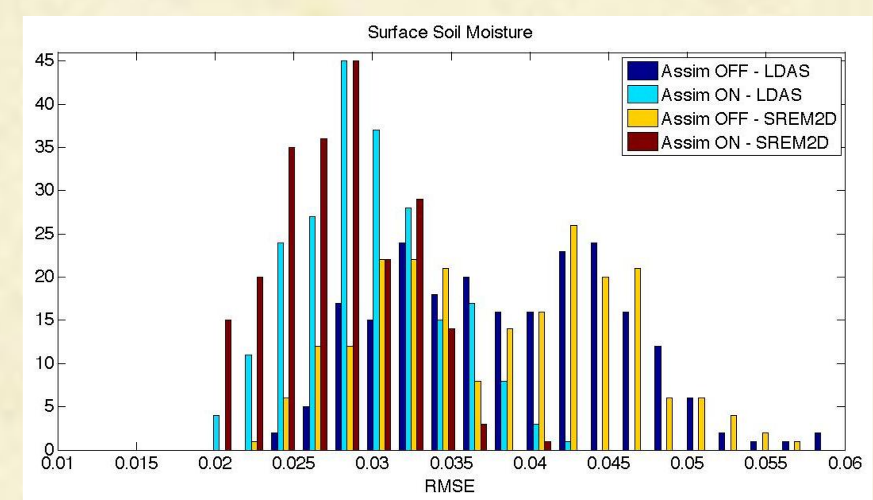
RMSE

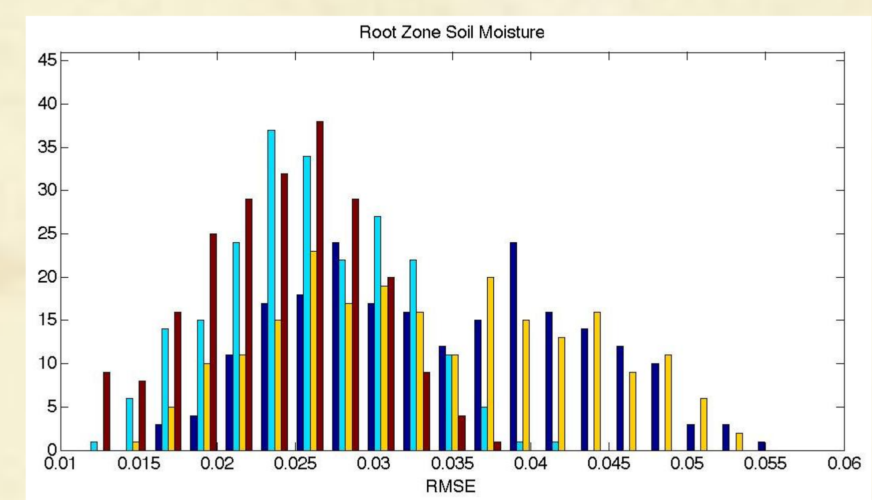
LDAS / *SREM2D*	Assim. Off	Assim. On	Relative Difference
SSM	0.0395 / *0.0388*	0.0301 / *0.0280*	-0.24 / *-0.28*
RZSM	0.0355 / *0.0348*	0.0265 / *0.0245*	-0.25 / *-0.30*

Anomaly Correlation Coefficient

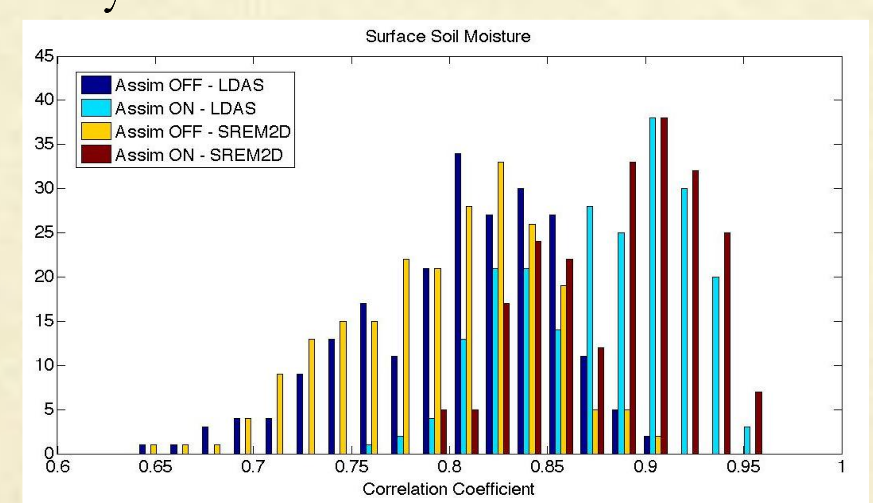
LDAS / *SREM2D*	Assim. Off	Assim. On	Relative Difference
SSM	0.81 / *0.80*	0.88 / *0.89*	0.09 / *0.11*
RZSM	0.79 / *0.79*	0.89 / *0.90*	0.13 / *0.14*

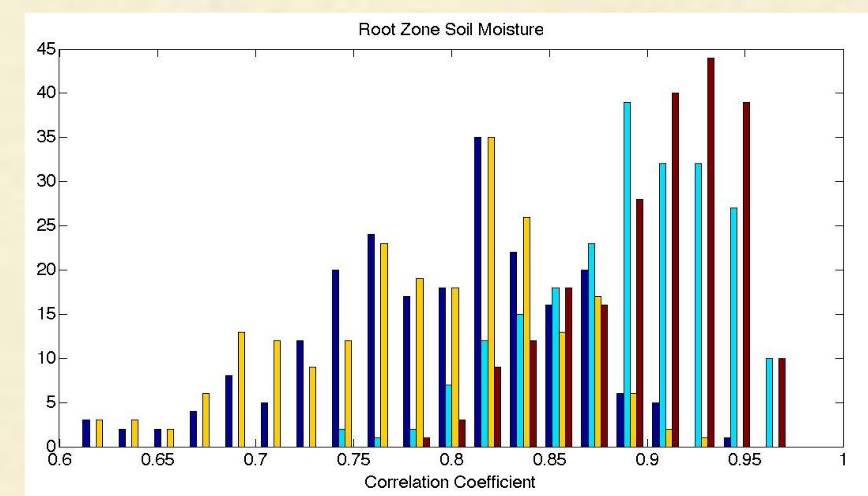
RMSE





Anomaly Correlation Coefficient

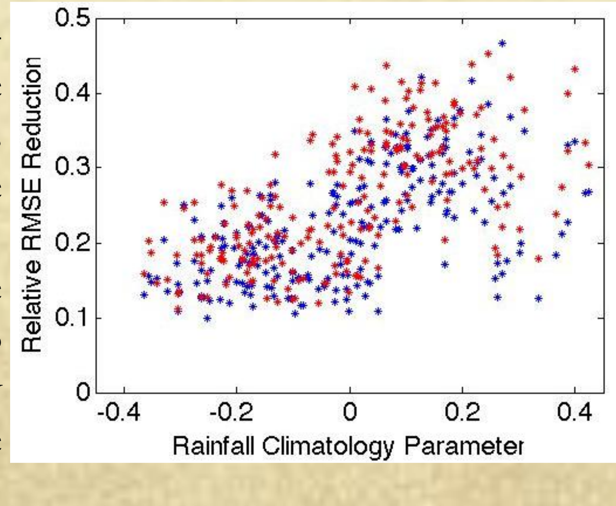




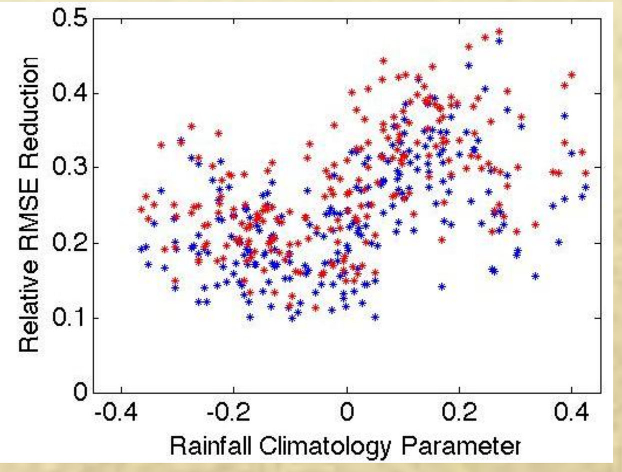
Relative RMSE Reduction

Relative RMSE reduction is defined as the difference between the RMSE of the assimilation off-simulation and the RMSE of the assimilation-on simulation, normalized by the RMSE of the simulation without assimilation. The figures show the RMSE reduction with respect to the rainfall climatology parameter defined as $\frac{R_i - R_{mean}}{R_{mean}}$ where R_i is the radar rainfall for the *i-th* grid cell averaged over the 3-year period and R_{mean} is the mean value for the entire 10x22 grid area and the 3-year period. This parameter can be interpreted as a climatological wetness indicator of the area covered by the respective grid cell; positive (negative) values would indicate areas that are generally moist (dry) with respect to the climatology of the entire study region, defined as the 3-year average rainfall value.

Surface Soil Moisture



Root Zone Soil Moisture



Conclusions

Comparisons of assimilation experiments against simulations of soil moisture generated by the land surface model show an improvement in the error statistics, with:

- higher anomaly correlation coefficients;
- lower root mean squared errors.

This was observed for both surface and root zone soil water content at the 25km spatial scale.

The two rainfall error models of different complexity generate comparable soil moisture estimates in both simulations (with or without assimilation). However, slight improvements are observed in the case of the more complex error model SREM2D when assimilation is turned on (as highlighted by the relative differences in the tables).

The relative reduction of the error due to soil moisture assimilation is higher in wetter conditions, as shown by the scatter plots, for both surface and root zone soil moisture cases.

Further studies may include:

- longer time series of data;
- the assimilation of remotely sensed data from actual satellite retrievals in the LDAS.

References

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