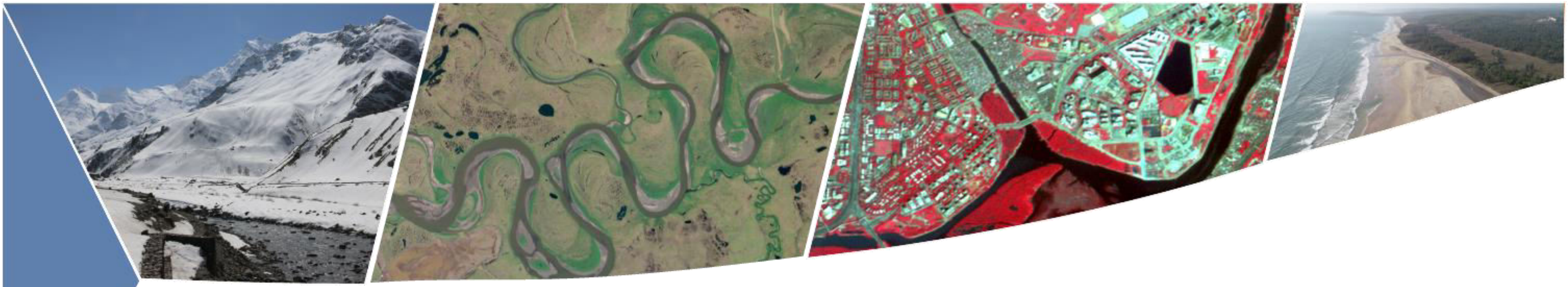

Improving the Performance of Hydrological Model Forecast using a Time-Varying Multivariate EnKF Assimilation

Visweshwaran R.[1]; Antara Dasgupta[2]; RAAJ Ramsankaran[1]; Eldho T. I.[1]

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Multivariate Data Assimilation:

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Research papers

Assimilation of soil moisture and streamflow observations to improve flood forecasting with considering runoff routing lags

Shanshan Meng[a], Xianhong Xie[a,*], Shunlin Liang[a,b]

Because assimilating either soil moisture or streamflow can achieve acceptable estimations, we hypothesize that the simultaneous assimilation of the two observation types can substantially improve flood forecasting which has been proved by several studies (Aubert et al., 2003; Barrett and Renzullo, 2009; López López

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Research papers

Simultaneous assimilation of *in situ* soil moisture and streamflow in the SWAT model using the Extended Kalman Filter

CrossMark

Leqiang Sun[a,*], Ousmane Seidou[a], Ioan Nistor[a], Kalifa Goïta[b], Ramata Magagi[b]

The combined assimilation of multiple observation variables is found to be superior to single-variable assimilation (Crow and Van Loon, 2006; Trudel et ... Moradkhani (2016) found tl

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Water Resources Research
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10.1002/2015WR018429

Dual assimilation of satellite soil moisture to improve streamflow prediction in data-scarce catchments

Camila Alvarez-Garreton[1,2,3], Dongryeol Ryu[1], Andrew W. Western[1], Wade T. Crow[4], Chun-Hsu Su[1], and David R. Robertson[5]

Sensors 2012, 12, 16291-16333; doi:10.3390/s121216291
OPEN ACCESS
sensors
ISSN 1424-8220
www.mdpi.com/journal/sensors
Review

Multivariate and Multiscale Data Assimilation in Terrestrial Systems: A Review

Carsten Montzka[1,*], Valentijn R. N. Pauwels[2], Harrie-Jan Hendricks Franssen[1], Xujun Han[1,3], and Harry Vereecken[1]

Hydrol. Earth Syst. Sci., 22, 4605–4619, 2018
https://doi.org/10.5194/hess-22-4605-2018

Hydrology and Earth System Sciences
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EGU

Joint assimilation of soil moisture retrieved from multiple passive microwave frequencies increases robustness of soil moisture state estimation

Anouk I. Gevaert[1], Luigi J. Renzullo[2], Albert I. J. M. van Dijk[2], Hans J. van der Woerd[3], Albrecht H. Weerts[4,5], and Richard A. M. de Jeu[6]

Hydrol. Earth Syst. Sci., 20, 4341–4357, 2016
www.hydrol-earth-syst-sci.net/20/4341/2016/
doi:10.5194/hess-20-4341-2016

Hydrology and Earth System Sciences
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Multivariate hydrological data assimilation of soil moisture and groundwater head

Donghua Zhang[1], Henrik Madsen[2], Marc E. Ridler[2], Jacob Kidmose[3], Karsten H. Jensen[1], and Jens C. Refsgaard[3]

Time-Varying MVDA:

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Advances in Water Resources 28 (2005) 135–147
Advances in Water Resources
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Dual state–parameter estimation of hydrological models using ensemble Kalman filter

Hamid Moradkhani [a,*], Soroosh Sorooshian [a], Hoshin V. Gupta [b], Paul R. Houser [c]

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Abstract

Hydrologic models are twofold: models for understanding physical processes and models for prediction. This study addresses the latter, which modelers use to predict, for example, streamflow at some future time given knowledge of the current state of the system and model parameters. In this respect, good estimates of the parameters and state variables are needed to enable the model to generate accurate forecasts. In this paper, a dual state–parameter estimation approach is presented based on the Ensemble Kalman Filter (EnKF) for sequential estimation of both parameters and state variables of a hydrologic model. A systematic approach for identification of the perturbation factors used for ensemble generation and for selection of ensemble size is discussed. The dual EnKF methodology introduces a number of novel features: (1) both model states and parameters can be estimated simultaneously; (2) the algorithm is recursive and therefore does not require storage of all past information, as is the case in the batch calibration procedures; and (3) the various sources of uncertainties can be properly addressed, including input, output, and parameter uncertainties. The applicability and usefulness of the dual EnKF approach for ensemble streamflow forecasting is demonstrated using a conceptual rainfall-runoff model.

Keywords: Streamflow forecasting; Stochastic processes; Data assimilation; Ensemble Kalman filter; Dual estimation; Kernel smoothing

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Research papers

Identifying time-varying hydrological model parameters to improve simulation efficiency by the ensemble Kalman filter: A joint assimilation of streamflow and actual evapotranspiration

Mengsi Xiong[a,b], Pan Liu[a,b,*], Lei Cheng[a,b], Chao Deng[c,d], Ziling Gui[a,b], Xiaojing Zhang[a,b], Yanghe Liu[a,b]

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[c] State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Hohai University, Nanjing 210098, China
[d] College of Water Resources and Hydrology, Hohai University, Nanjing 210098, China

1. Introduction

Hydrological model parameters play a critical role in model simulation. It is generally assumed that model parameters calibrated by limited data will be applicable in the future. In other words, the parameters of hydrological models are treated as constants while model inputs are vary over time. However, this assumption may lead to large errors in simulated streamflow owing to climatic temporal variations and human activities. There is an increasing awareness of the need to consider model parameters as continuously time-varying (Brigode et al., 2013; Thirel et al., 2015; Patil and Stieglitz, 2015). On one hand, model parameters may potentially vary with climatic temporal variations because calibrated parameters are supposed to compensate for model structure and observation data problems (Wagener et al., 2003; Merz et al., 2011). On the other hand, human activities, such as the construction of water conservancy projects and urbanization, could result in underlying surface changes, which also may change model parameters because some parameters represent transient catchment characteristics (Legesse et al., 2003; Brown et al., 2005). Hence, it is of paramount importance to study the time-variability of hydrological model parameters.

Is DA Efficient?

Tellus
Tellus (2008), 60A, 964–978

TELLUS

Computation of observation sensitivity and observation impact in incremental variational data assimilation

By YANNICK TRÉMOLET*, Global Modeling and Assimilation Office, Code 610.1, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

1. Introduction

As the number of observations being assimilated to produce meteorological forecasts has grown almost exponentially over the years, the data assimilation process has become more and more complex and expensive. It is important to evaluate the impact of all these observations, to assess the cost effectiveness of collecting and assimilating them, and to assess the ability of the data assimilation system to use these observations effectively. One technique to evaluate the value of observations is by way of observing system experiments (OSE), but they tend to be very expensive because they can be performed for only one subset of observations at a time. Ensemble techniques have also been applied to assess the potential impact of future observing system, for example by Tan et al. (2007). This technique also has the disadvantage of cost since an ensemble of data assimilation systems is required. Both techniques have the disadvantage that modifying the observation system can change the value of remaining observations. For these reasons, these techniques cannot be used routinely in operational systems.

Model sensitivity

Water Resources Research
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RESEARCH ARTICLE
10.1029/2021WR031092

Sensitivity-Based Soil Moisture Assimilation for Improved Streamflow Forecast Using a Novel Forward Sensitivity Method (FSM) Approach

R. Visweshwaran[1], RAAJ. Ramsankaran[1], T. I. Eldho[1], and S. Lakshmivarahan[1,2]
[1]Department of Civil Engineering, Indian Institute of Technology, Bombay, Mumbai, India, [2]School of Computer Sciences, University of Oklahoma, Norman, OK, USA
S. Lakshmivarahan is a visiting Professor at Indian Institute of Technology, Bombay, Mumbai, India.

Key Points:

- The potential of assimilating only

With new satellite missions being launched, the amount of data is expected to increase by orders of magnitude. In such a scenario, the FSM based strategy would play a vital role in the optimal selection of appropriate observations during the assimilation process and the researchers can gain insight on when and what to assimilate with the reduced computational burden. Although the current work identified and effectively assimilated sensitive observations in the time domain, further research is needed to extend this work by including spatial heterogeneity using distributed hydrological models to identify spatially sensitive locations. Once identified, the observations from only these sensitive locations can be leveraged to enhance assimilation efficiency, especially in regions where data availability remains a challenge.

Solution: First-order derivative

$$\frac{\partial M(t)}{\partial X(t)} \text{ i.e. } \frac{\partial Q(t)}{\partial SM(t)}$$

Methodology:

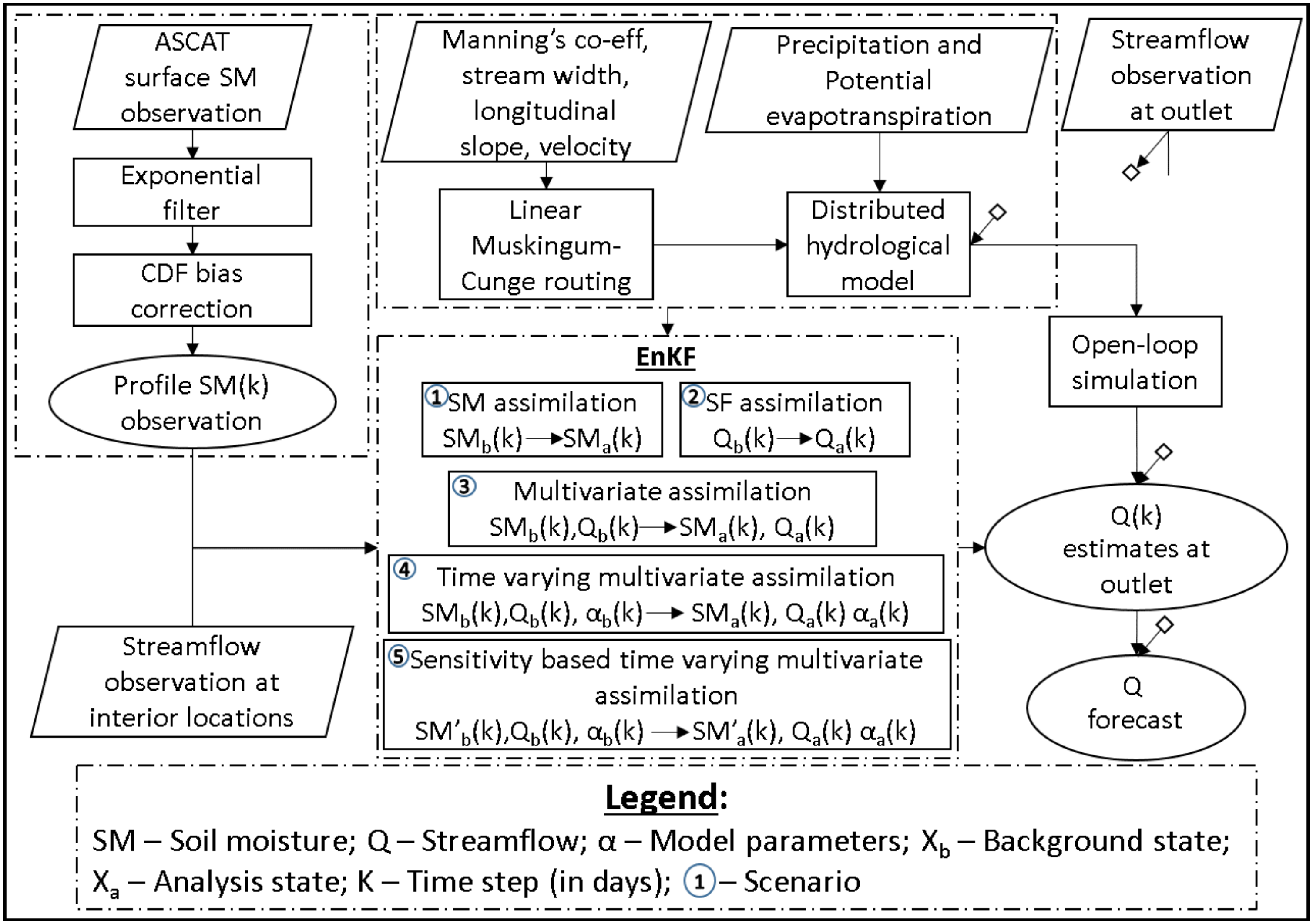

Figure 1: The flowchart of the study framework.

Study Area:

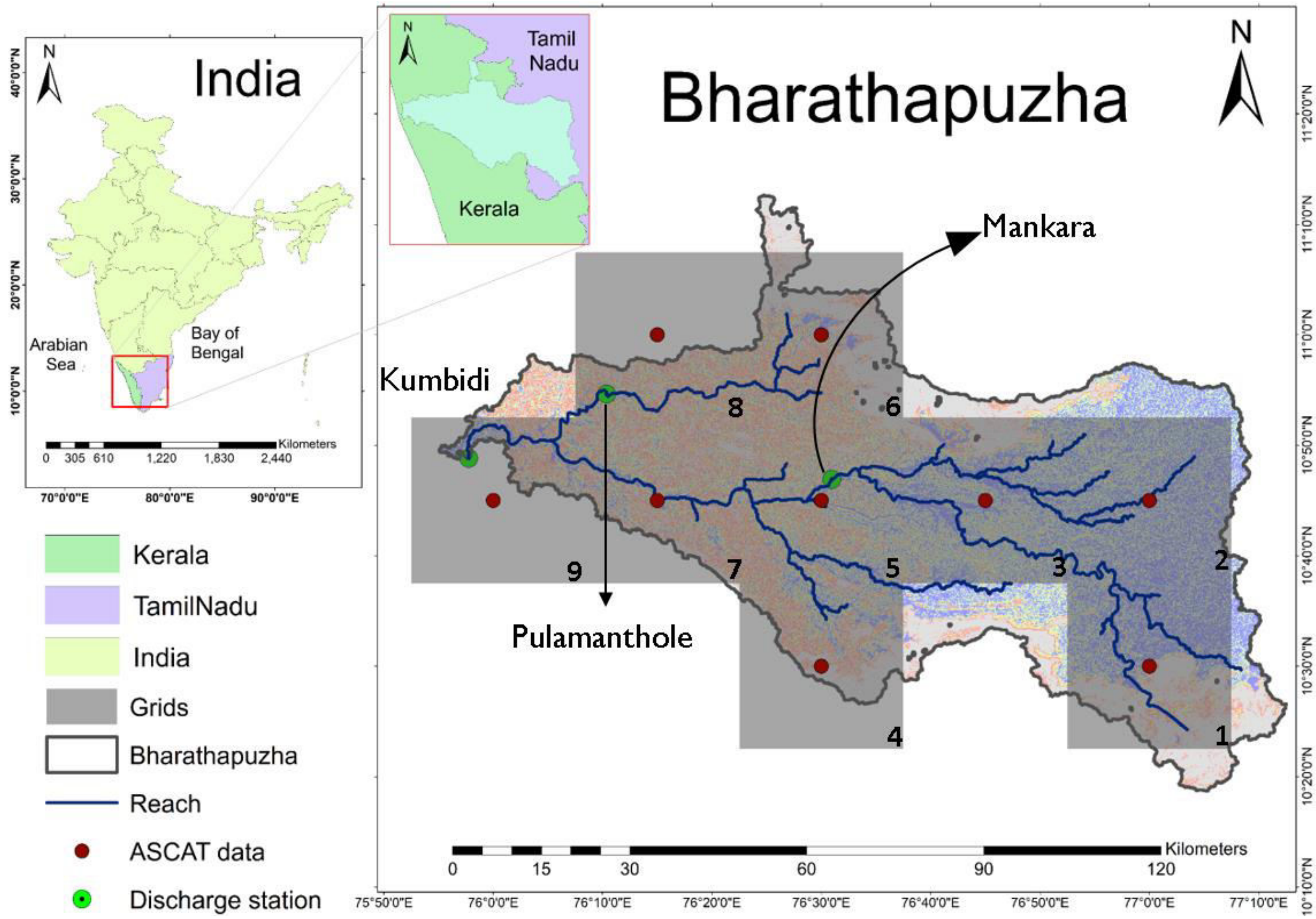

Figure 2: Geographical location map of the Bharathapuzha river basin (BRB) along with the depiction of stream networks, ASCAT observation grids, and streamflow gauging stations.

Univariate SM and Q Assimilation (SC 1 and 2):

Table 1: Performance statistics of the soil moisture, and streamflow estimation during the open-loop, SMDA, and QDA scenarios.

Type of assimilation	Scenario	RMSE (mm)	PBIAS (%)	KGE (-)	R^2 (-)	RMSE (Cumecs)	PBIAS (%)	KGE (-)	R^2 (-)	EFF (-)
		Average Soil Moisture				Streamflow at Outlet				
Open-loop	OL	30.4	60.3	0.29	0.45	158.6	-28.89	0.68	0.76	0
SMDA	SC 1	19.2	-6.56	0.77	0.61	156.6	10.72	0.72	0.78	0.16
Grid 5 QDA	SC 2a	31.6	31.16	0.5	0.54	147.7	-44.6	0.76	0.79	0.18
Grid 8 QDA	SC 2b	29.5	12.8	0.56	0.53	157.5	-45.52	0.72	0.82	0.18
Both QDA	SC 2c	29.1	31.9	0.5	0.53	145.9	-27.97	0.75	0.84	0.2

Both SMDA and QDA improved the model performance.

However, MVDA (SC 3) improved the model much better than any of the UVDA.

Table 2: Performance statistics of the soil moisture, and streamflow estimation during the MVDA, TV-MVDA, and Sens-TVMDA scenarios.

Type of assimilation	Scenario	RMSE (mm)	PBIAS (%)	KGE (-)	R^2 (-)	RMSE (Cumecs)	PBIAS (%)	KGE (-)	R^2 (-)	EFF (-)
		Average Soil Moisture				Streamflow at Outlet				
MVDA	SC 3	24	32.5	0.53	0.58	121.3	-8.66	0.86	0.83	0.41
TV-MVDA	SC 4	22.4	21.2	0.64	0.61	119.4	-8.28	0.87	0.84	0.42
Sens-TV-MVDA	SC 5	25	31.4	0.52	0.53	129.1	-18.3	0.86	0.83	0.4

Streamflow Estimates and Forecast during MVDA (SC 3 and 4):

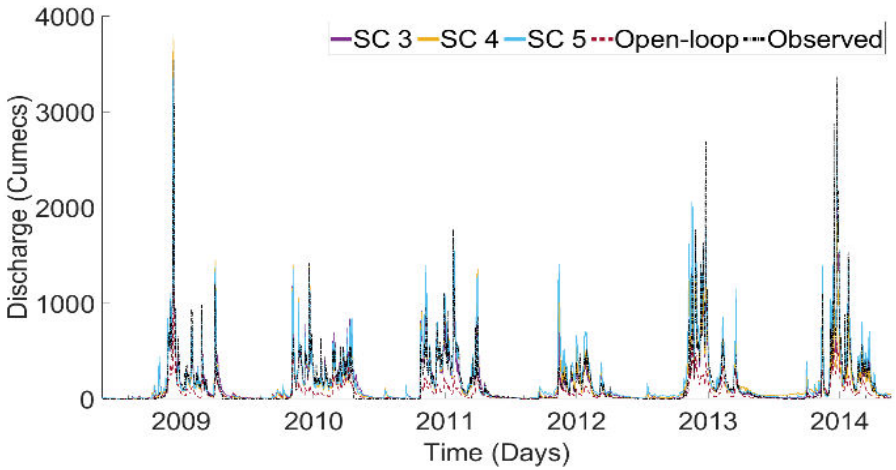

Figure 3: Time series plot showing the streamflow at the BRB outlet (Kumbidi) during open-loop, MVDA, TV-MVDA, and Sens-TV-MVDA scenarios

Effect of making the parameters dynamic (SC 4) did not improve the model performance as compared to SC 3

However, it constrained the model well during low flows during non-monsoon period

TV-MVDA (SC 4) showed the best result suggesting that the updating the model parameters periodically captured the transient nature of the catchment.

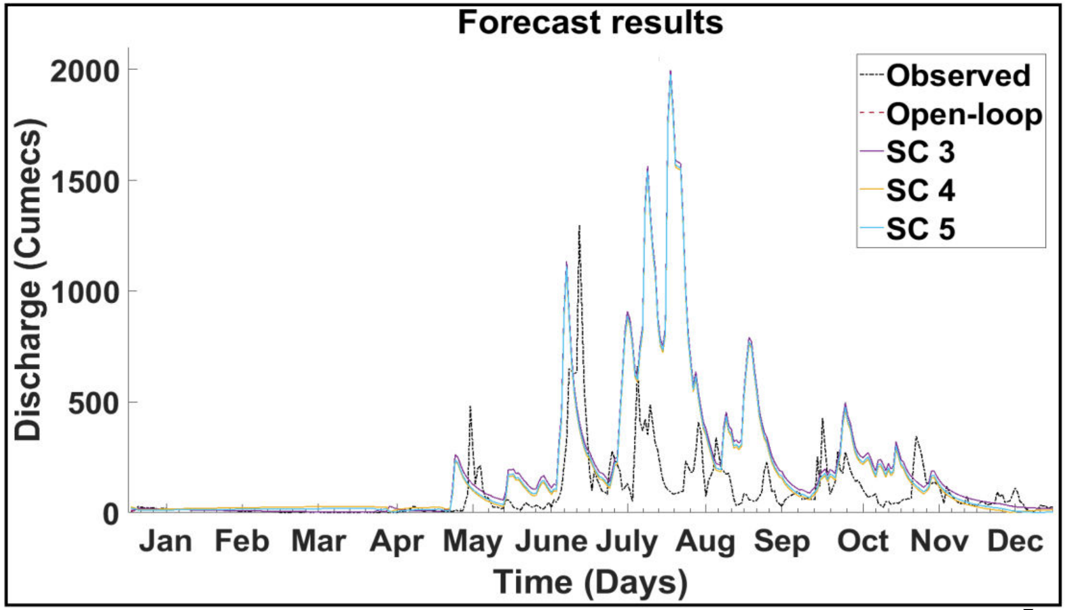

Figure 4: Time series plot showing the streamflow forecast during open-loop, MVDA, TV-MVDA, and Sens-TV-MVDA scenarios.

Sensitivity-based MV Assimilation (SC 5):

Grids that are spatially closer to catchment outlet are more sensitive in nature.

Sensitivity-based TV-MVDA (SC 5) showed a similar result as compared to TV-MVDA (SC 4). However, it used less than 30% of SM observations across the basin to achieve these results.

Major Contribution:

Reduced the computational burden by more than 60%.

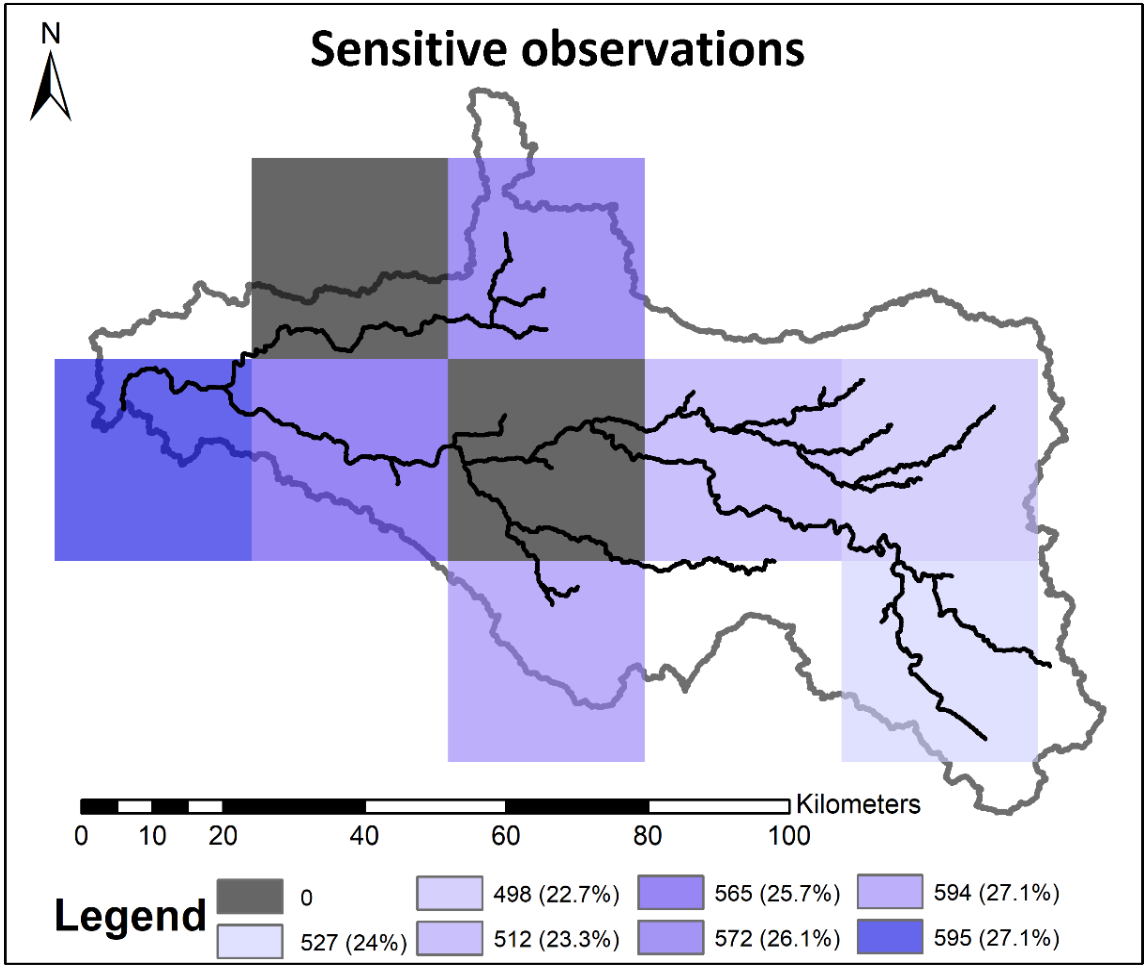

Figure 5: Spatial plot showing the % of SM observations used for the assimilation purpose during the Sens-TV-MVDA scenario

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Effect of Perturbing the Input Forcings:

1) δ_P has more impact on the model error covariance than δ_{PET}

2) At higher perturbation values, TPM started behaving randomly showing poor model results.

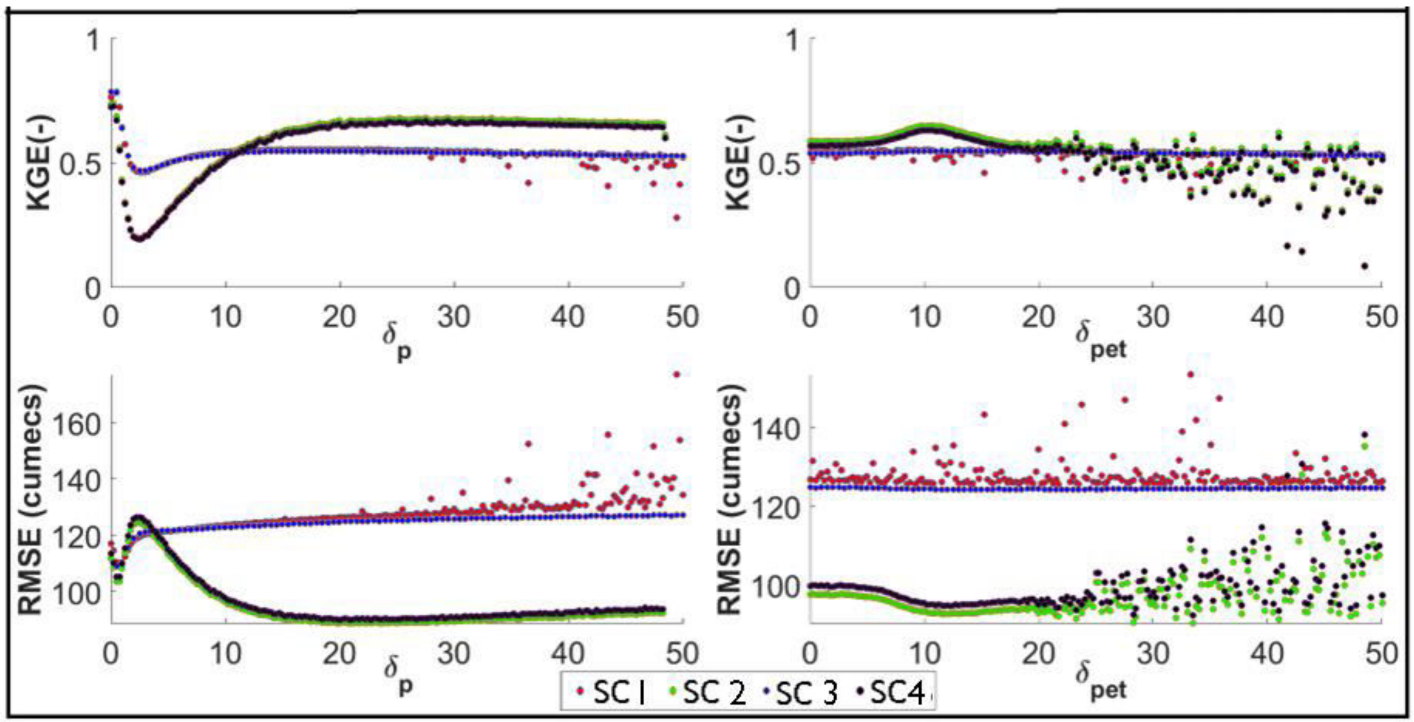

Figure 6: Scatter plot showing the variations in the model performance for different perturbations applied to the precipitation (δP) and potential evapotranspiration data (δPET) .