Prediction of low flow in mid-sized natural basin using GRACE derived daily Total Water Storage Anomaly

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Outline

INTRODUCTION

BACKGROUND STUDY

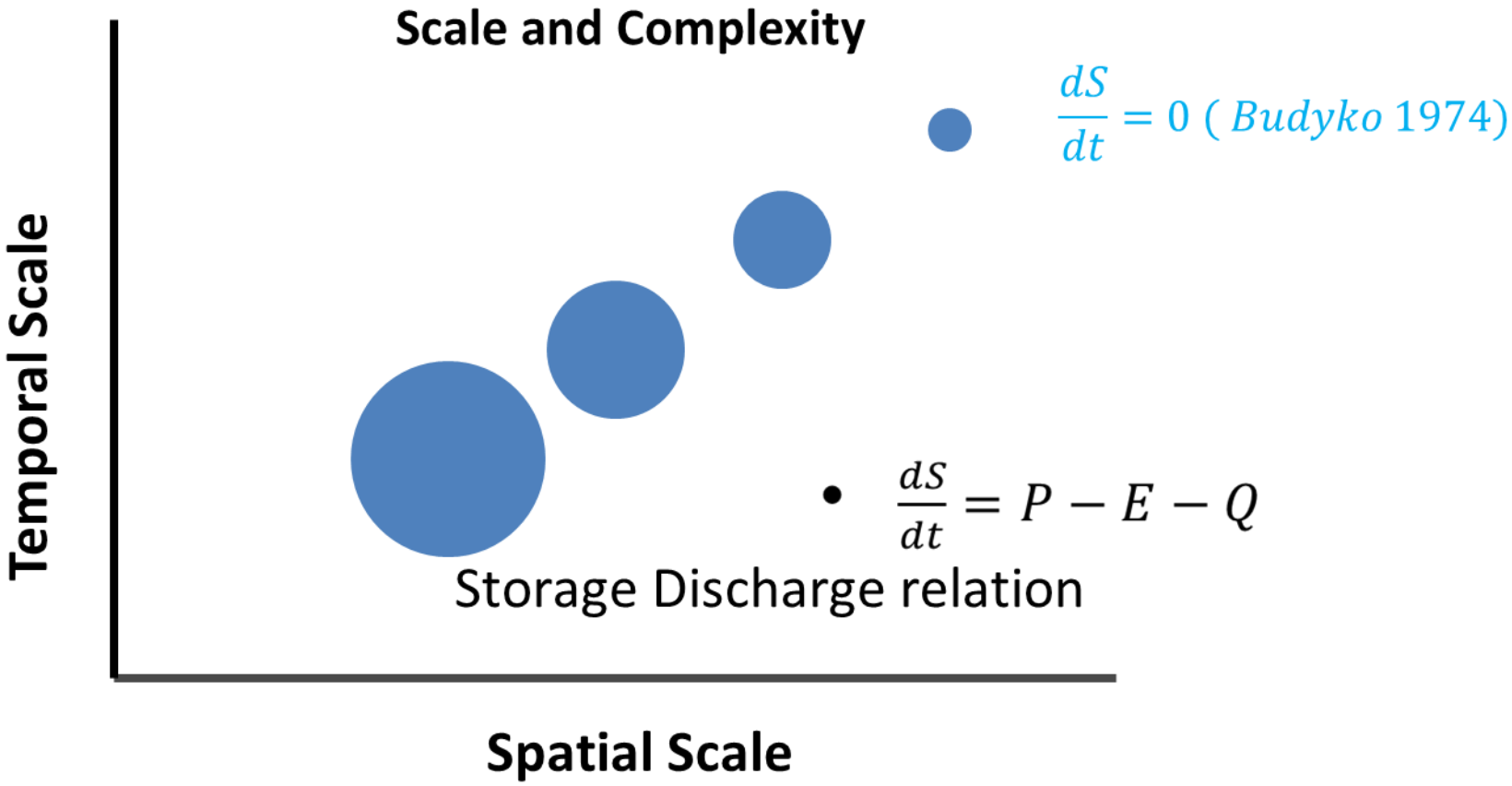
DATA AND DATA ANALYSIS

METHODLOGY

ANALYSIS

CONCLUSION

Introduction



Satellite storage measurement

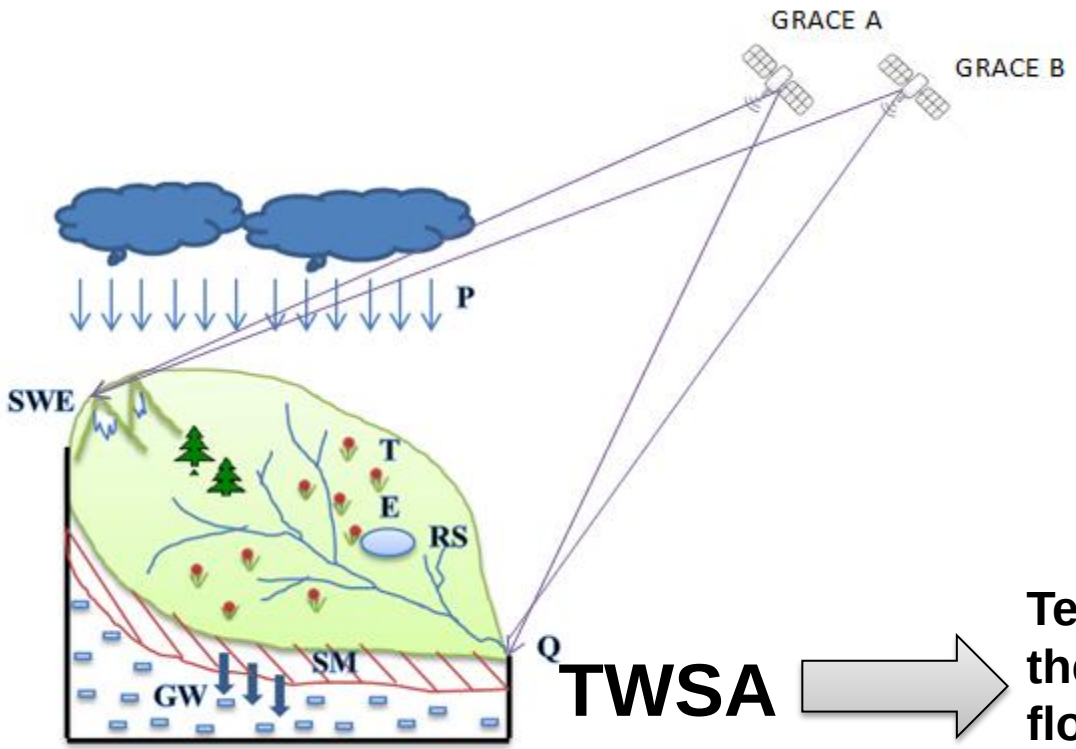
Monitoring and management of freshwater resources has long depended upon on-the-ground measurements.

J. S. Famiglietti et. al 2015

Work with GRACE

Paper		Resolution
Characteristic mega-basin water storage behavior using GRACE (Reager, J. T., & Famiglietti, J. S. (2013)		Spatial Resolution large Temporal Resolution – 1 month
Analysis of terrestrial water storage changes from GRACE and GLDAS Syed, T. H., Famiglietti, J. S., Rodell, M., Chen, J., & Wilson, C. R. (2008).		Spatial Resolution large Temporal Resolution – 1 month
GRACE storage-runoff hystereses reveal the dynamics of regional watersheds. Sproles, E. A., Leibowitz, S. G., Reager, J. T., Wigington, P. J., Famiglietti, J. S., & Patil, S. D. (2015).		Spatial Resolution large Temporal Resolution – 1 month
Daily GRACE gravity field solutions track major flood events in the Ganges-Brahmaputra DeltaGouweleeuw, B. T., Kvas, A., Grüber, C., Gain, A. K., Mayer-Gürr, T., Flechtner, F., & Güntner, A. (2017).		Spatial Resolution large Temporal Resolution – 1 day
Prediction of low flow using GRACE derived daily Total Water Storage Anomaly (Our Analysis)		**Spatial Resolution - mid size river basin** **Temporal Resolution – 1 day**

Storage-Discharge Relationship from GRACE



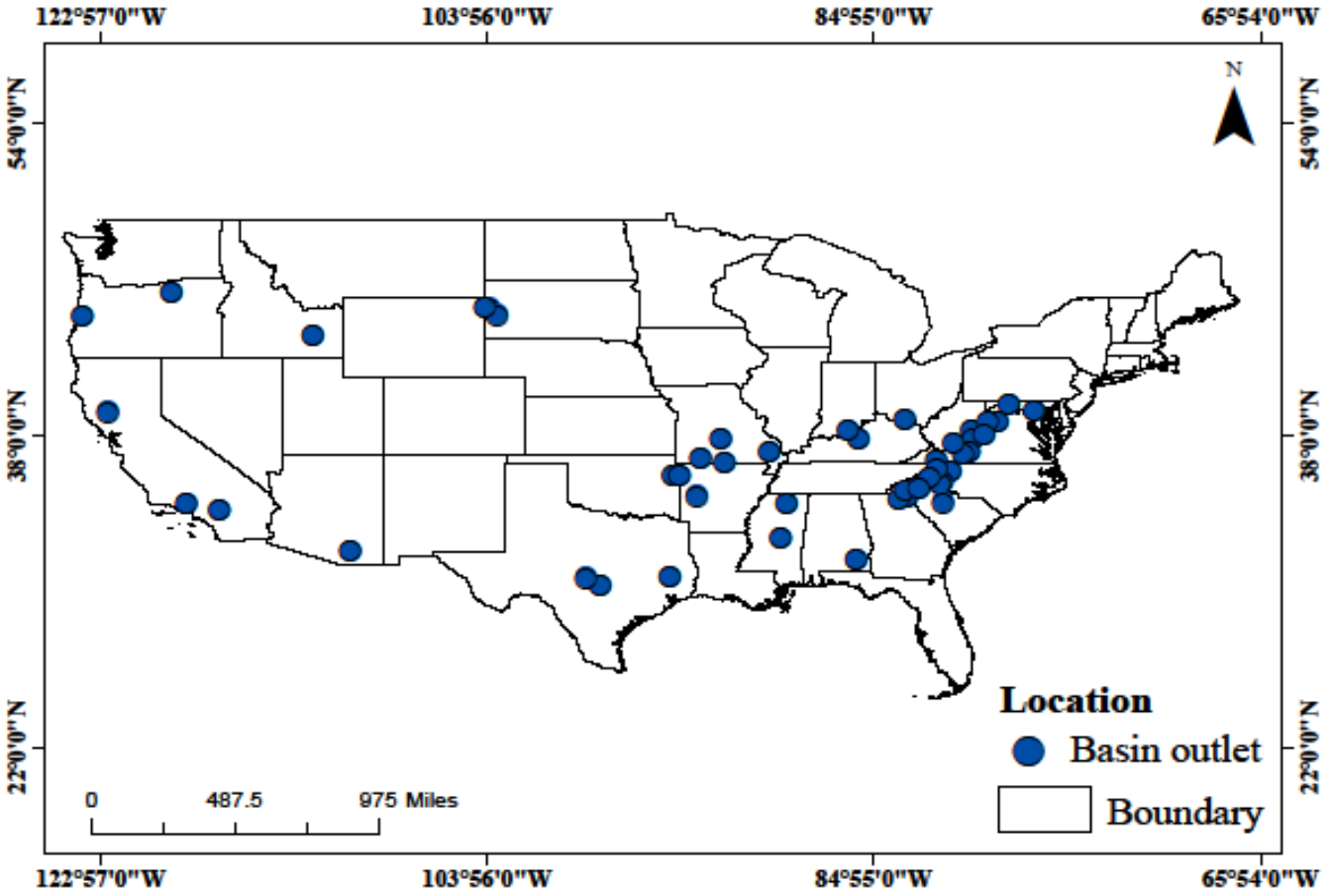
TWSA

Terrestrial water storage is the key entity that determines flows in river channels

Objective of our study

To use GRACE derived daily Total Water Storage Anomaly for predicting low flow in mid-sized natural basin

Data and Study Area



Daily Discharge data from USGS waterwatch
ITSG-GRACE 2016 DATA

Methodology

$S = (GW + SM + SWE + T + E + RS)$

$$\frac{dS}{dt} = P - Q$$

$$Q = f(S)$$

$$\frac{dQ}{dt} = \frac{dS}{dt}$$

twsa (total water storage) = S

Methodology contd…

$TWSA\_m = TWSA - \min(TWSA)+1$

1. Daily discharge data
2. Daily twsa data
3. Find recession events and corresponding *twsa*
4. Determine *k* at α = 2
5. Using this k, explore relationship between *k* and *twsa*

$$\frac{dQ}{dt} = -kQ^{\alpha}$$ Brutsaert and Nieber

$$k = k_N^{'} Q_N^{-\lambda_N}$$ Biswal and Marani 2010

$$\boldsymbol{k = k_N^{''} twsa_{pN}^{-\lambda_{N'}}}$$

Methodology contd…

Integrating equation $\frac{dQ}{dt} = kQ^{\alpha}$

Between (t=0, Q_0) and (t=t_t, Q_t) and by taking $\alpha = 2$ and k as

$$k = k_N^{''} twsa_{pN}^{-\lambda_{N'}}$$

We have

$$\boldsymbol{Q_t = \frac{Q_0}{(1 + k_N^{"} twsa_{pN}^{-\lambda n} t_t Q_0)}}$$

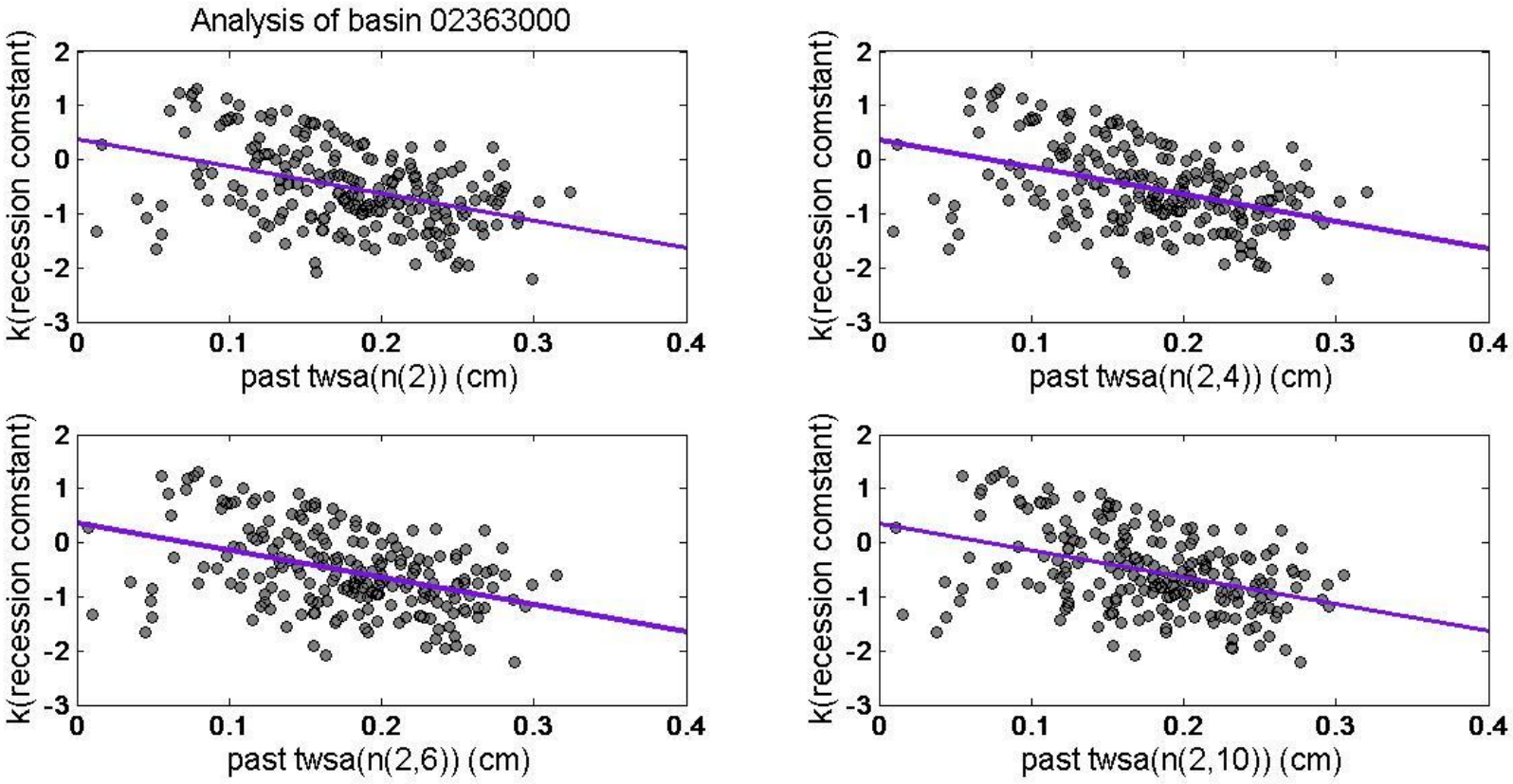
Our Approach

When only discharge is decreasing

When both discharge and TWSA are decreasing

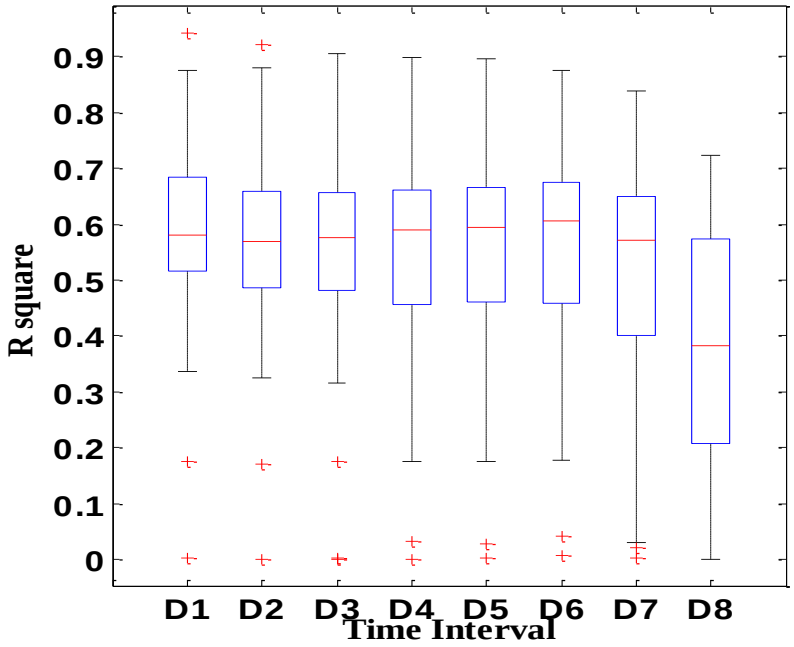
Results:

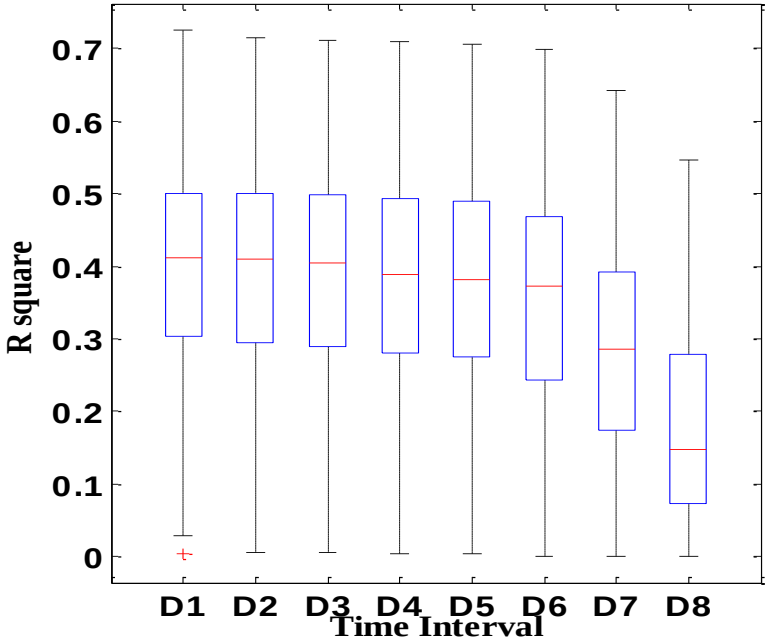
Generating scatter plots for past twsa and k.



Results contd. . .

Only discharge is decreasing

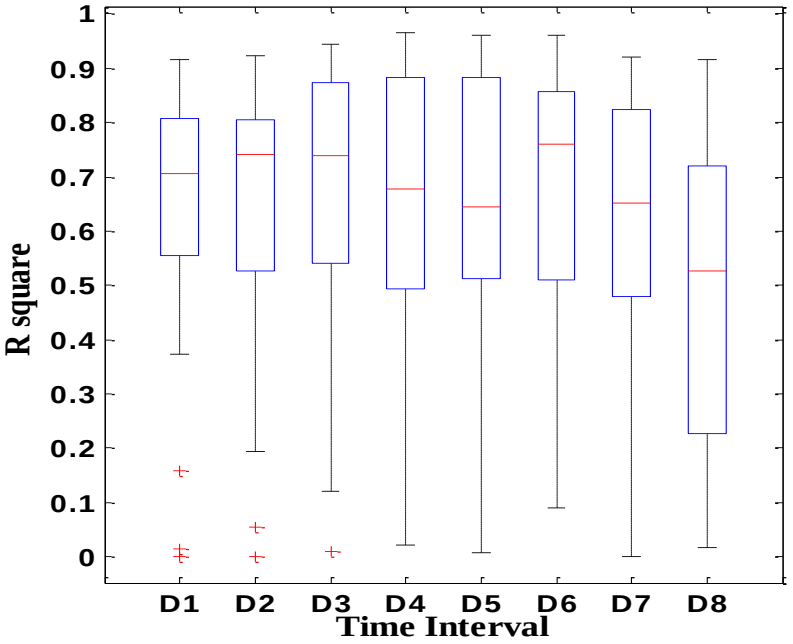


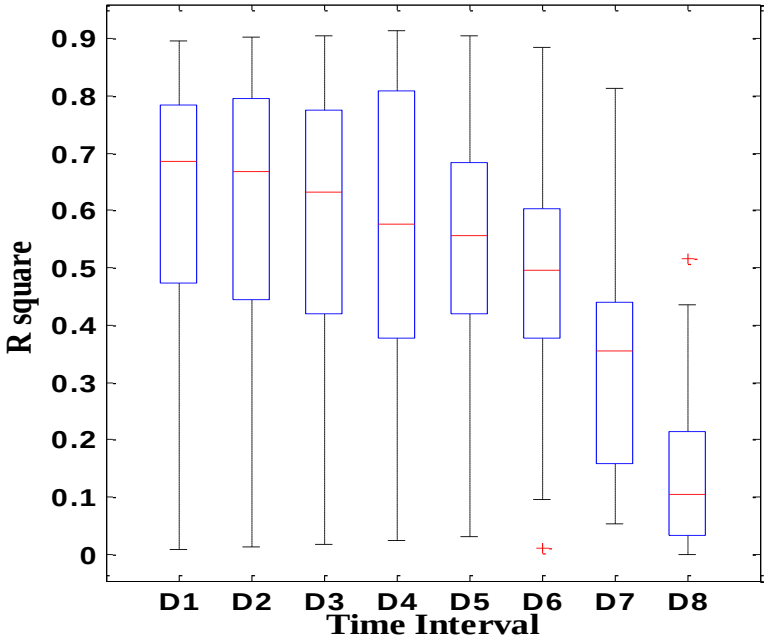


Strong relationship between power-law recession coefficient and initial storage (TWSA at the beginning of recession event).

Results contd. . .

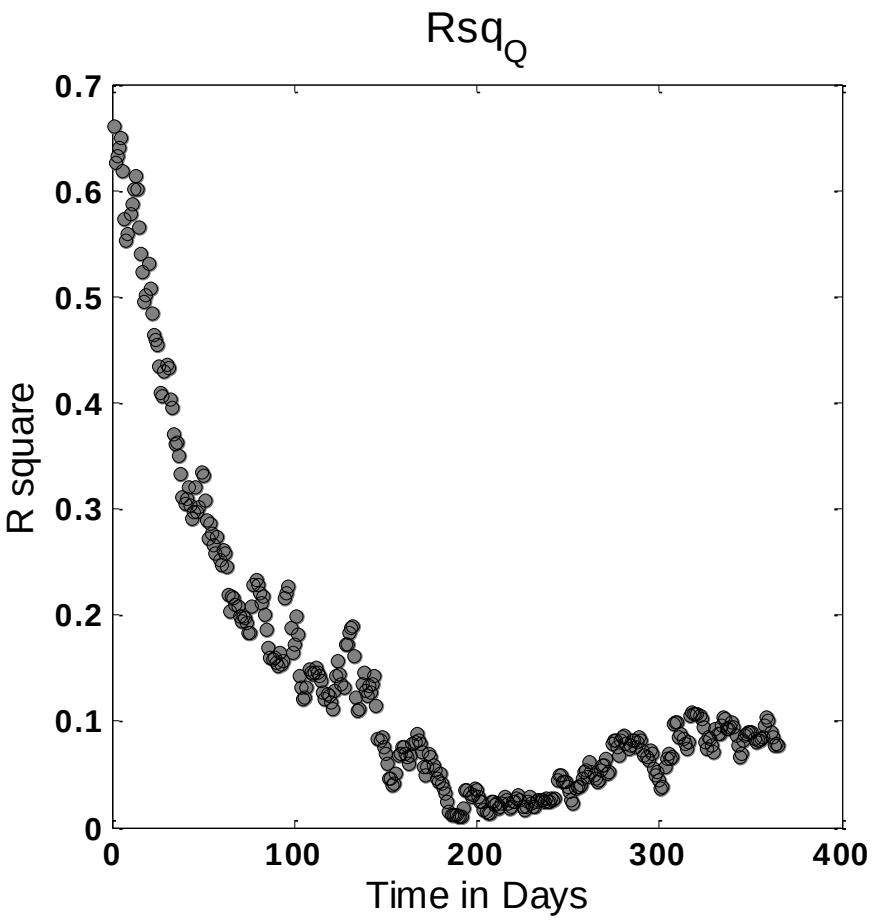
When both discharge and twsa are decreasing

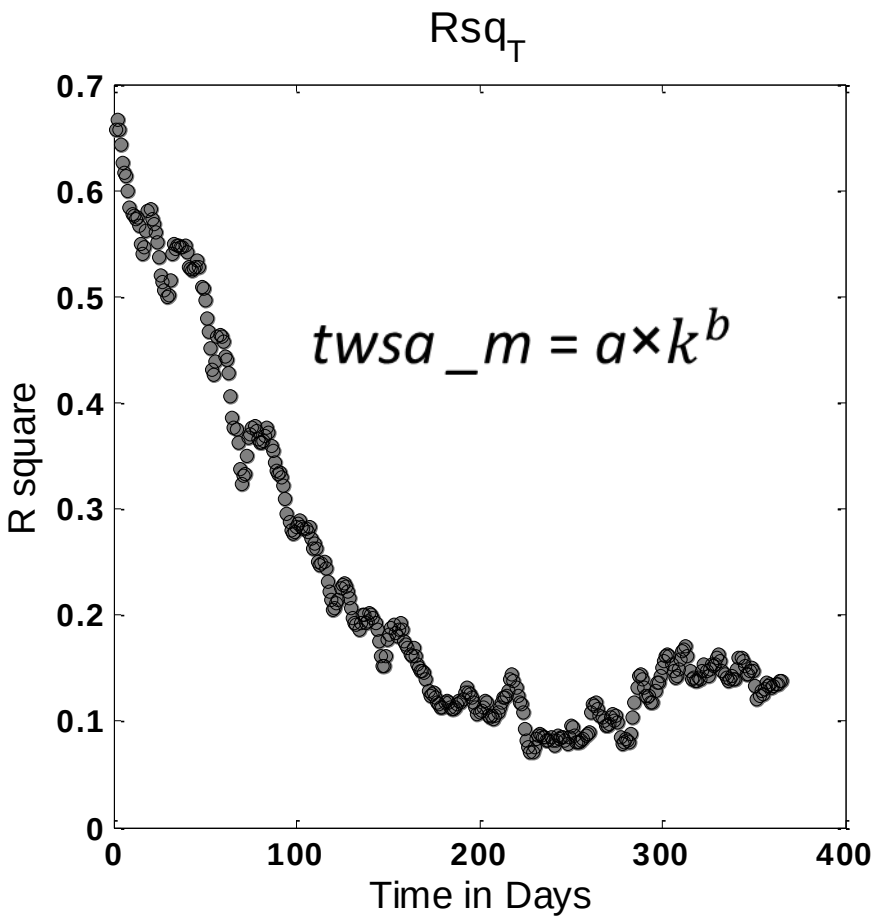




Relationship increases significantly, when we consider decrease in both discharge and *twsa.*

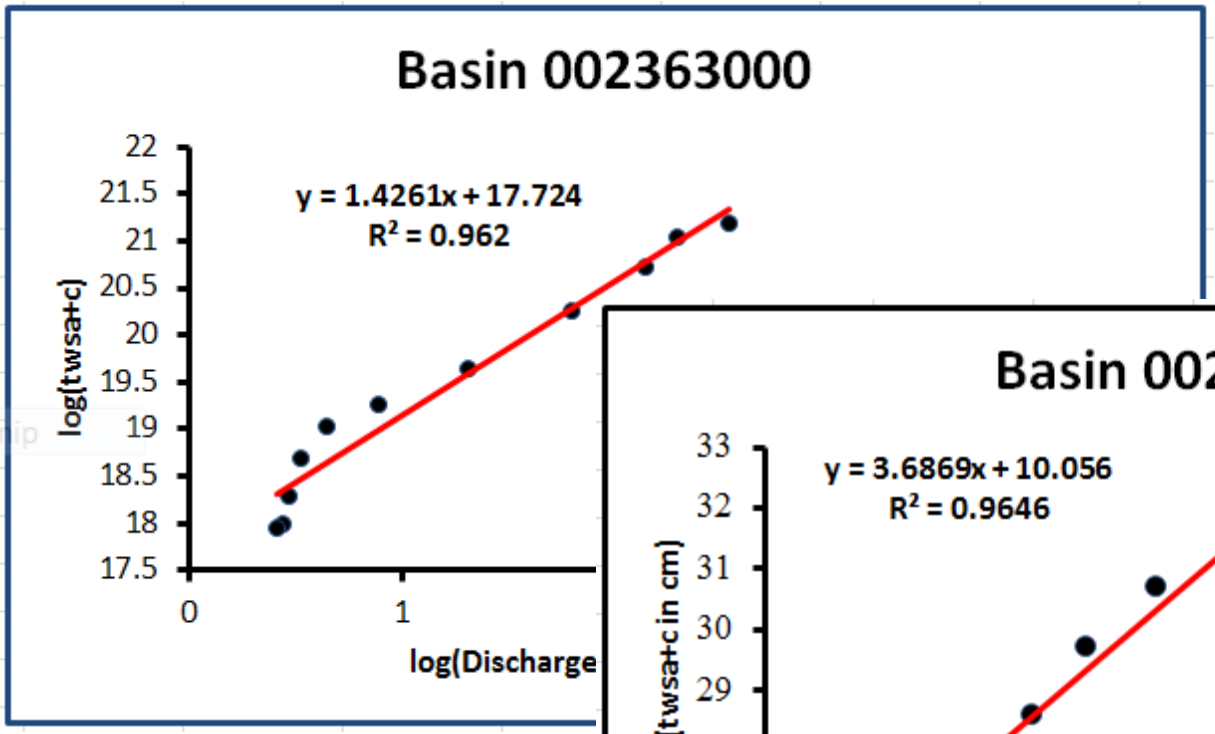
Results contd . . .



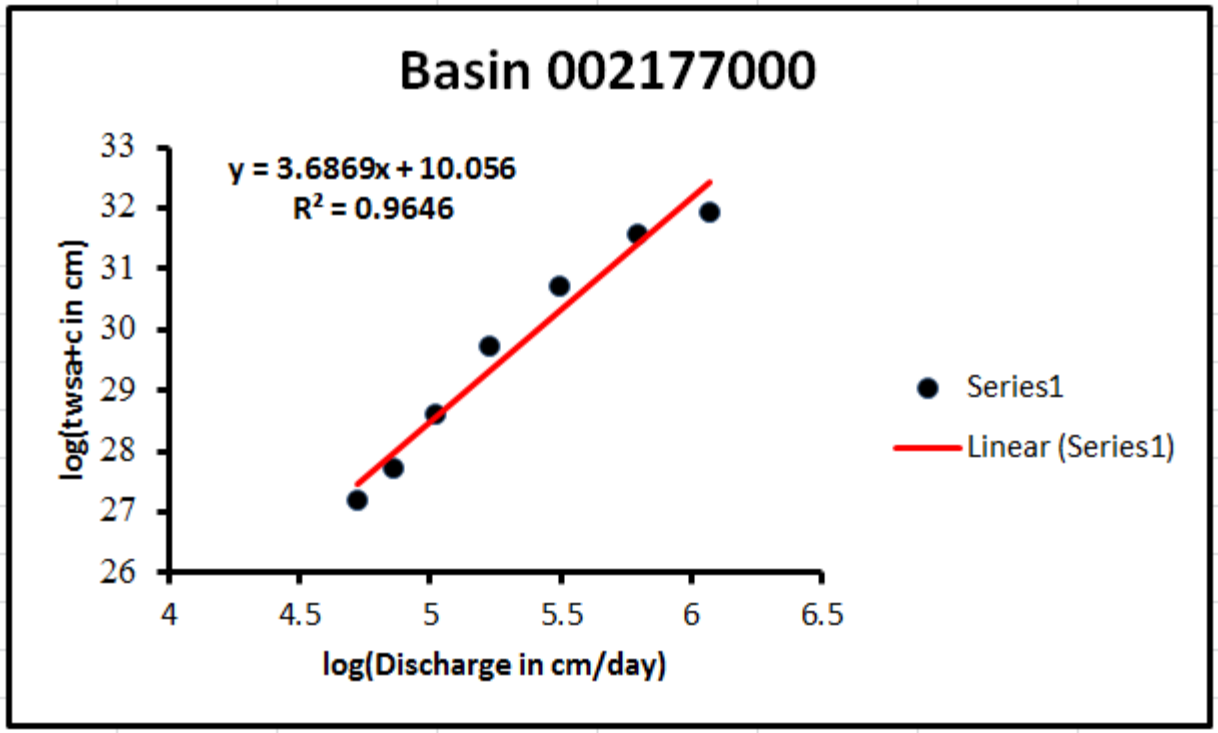


Appreciable relationships are observed between k and past TWSA values implying that storage takes time to deplete completely.

Results contd . . .



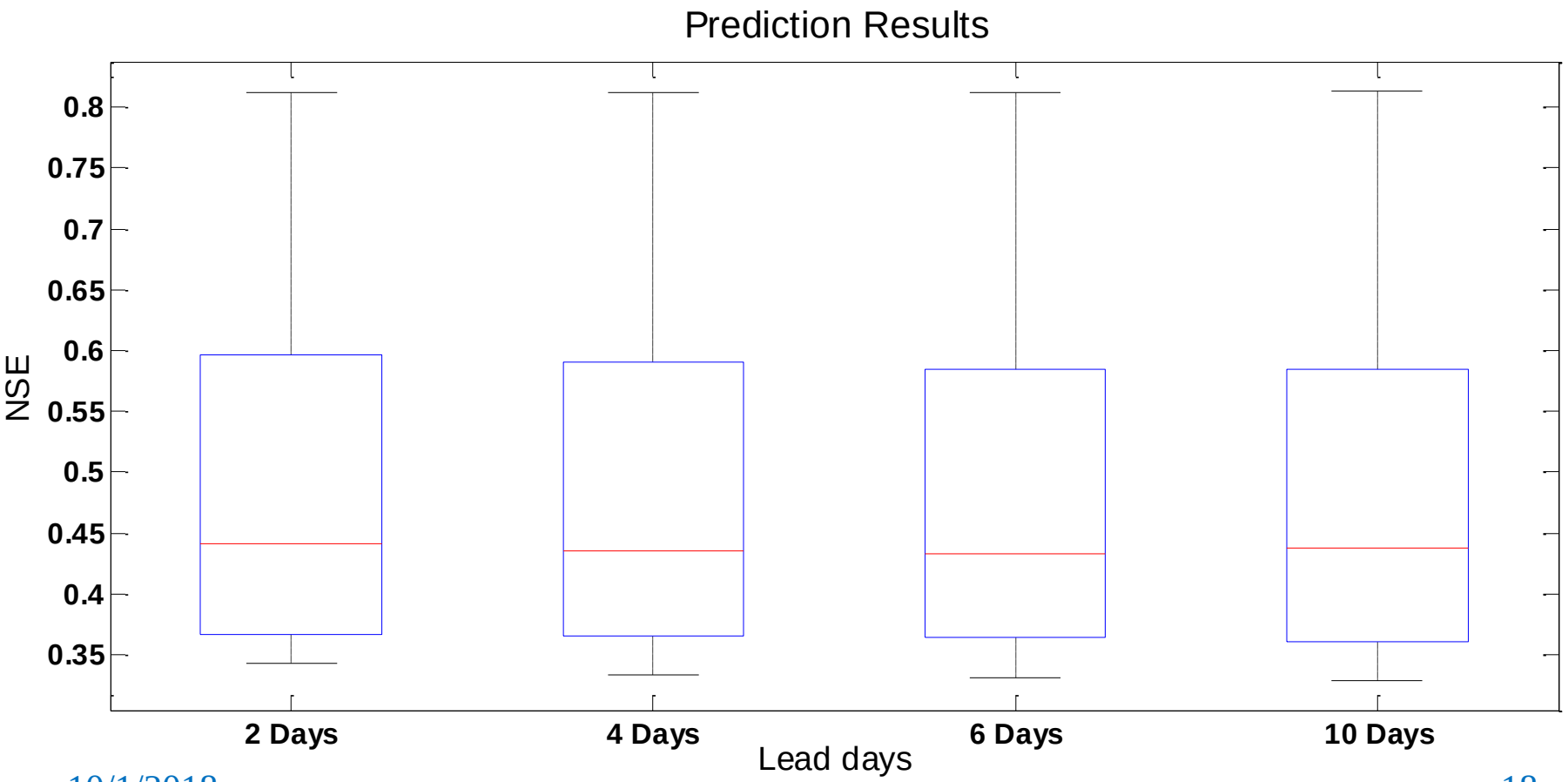
Scatter plots of individual recession events



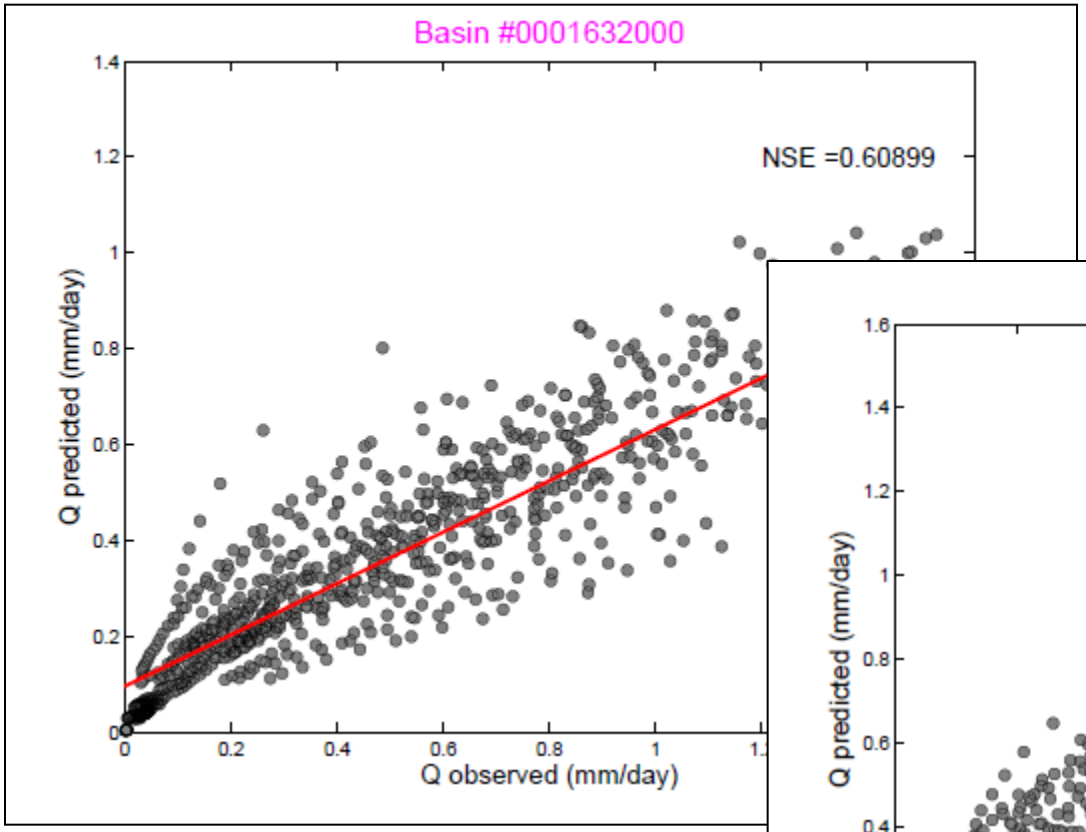
Exponential relationship

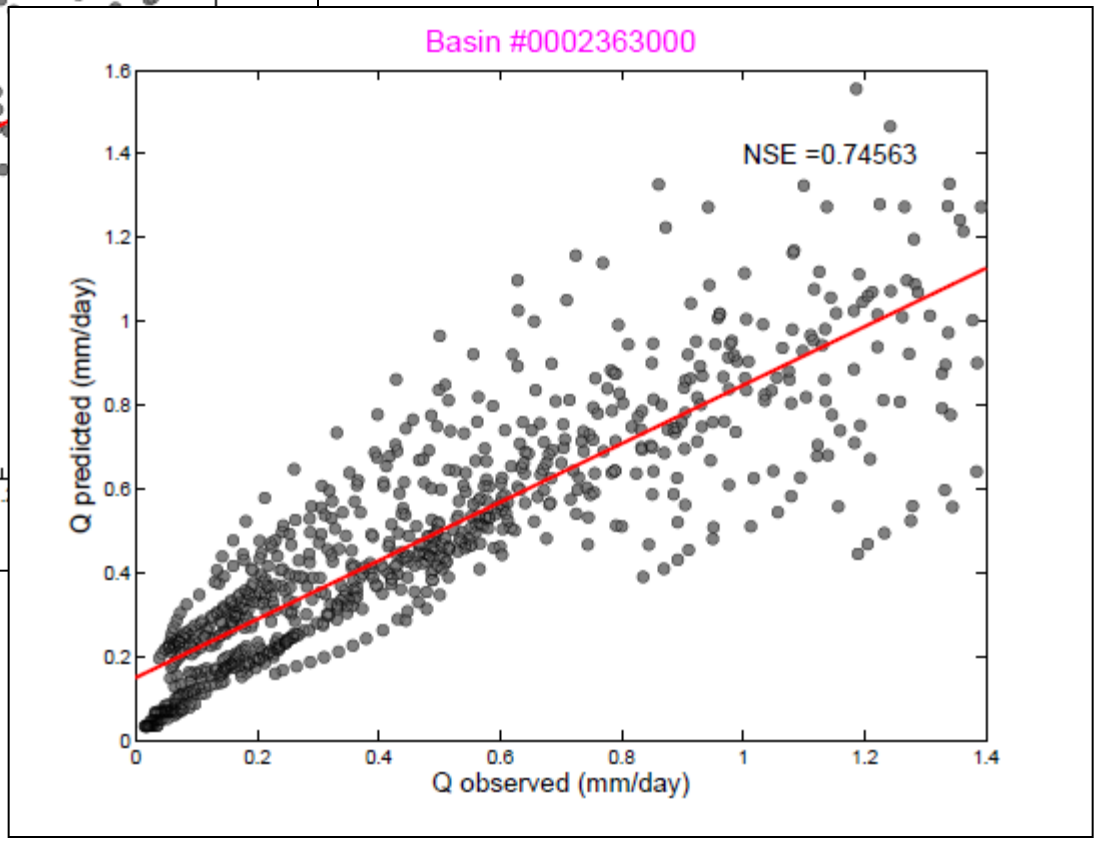
Results contd . . .

$$Q_t = \frac{Q_0}{(1 + \ddot{k_N} twsa_{pN}^{-\lambda n} tQ_0)}$$



Results contd . . .





Conclusions

Daily storage-discharge relationship is highly dynamic, which generates large amount of scatter in storage-discharge plots.

There is a strong relationship between power-law recession coefficient and initial storage (TWSA).

Furthermore, appreciable relationships are observed between recession coefficient and past TWSA values implying that storage takes time to deplete completely.

With such a coarse data we got median Nash–Sutcliffe efficiency of 0.45.

Result will increase significantly by using finer resolution data

Thank you