Groundwater from space for the Mashreq region

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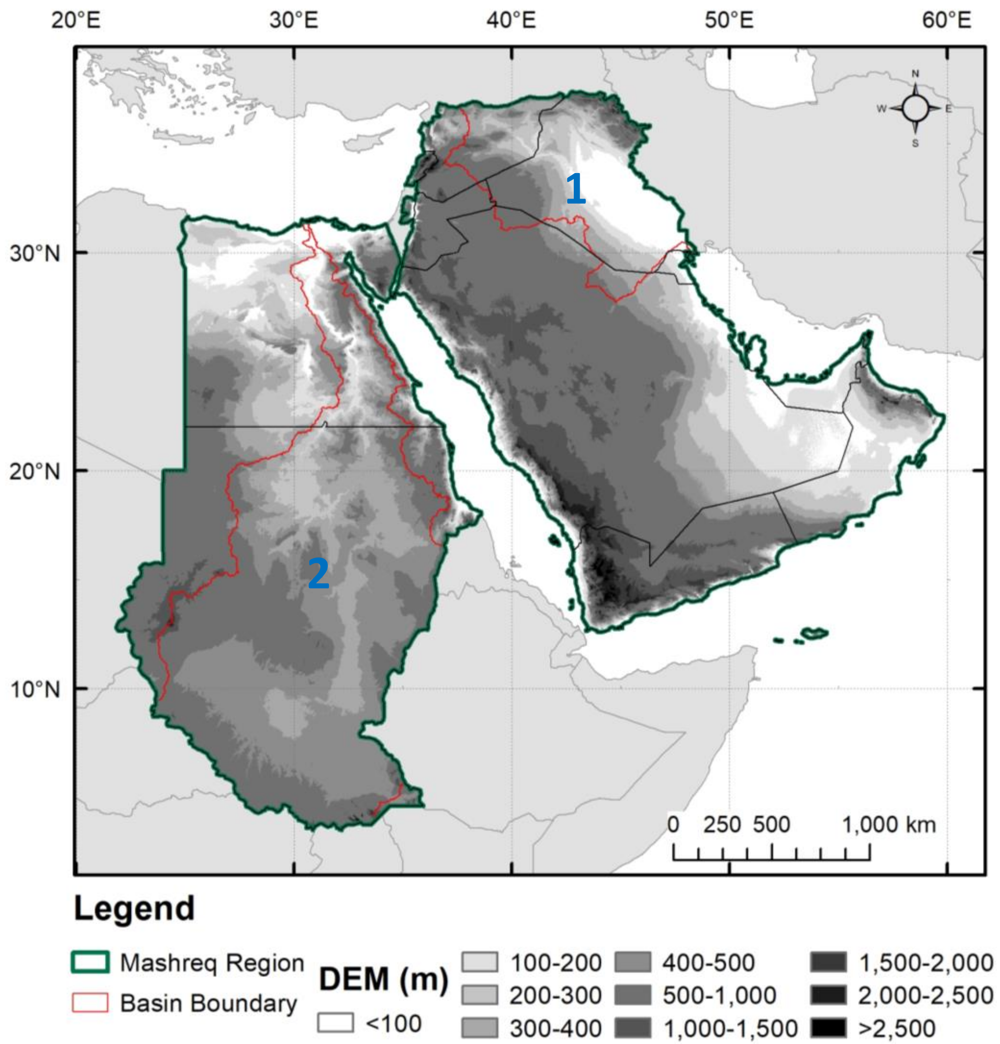
Contents

Motivation

- Study of hydrology is important for science and society
- Traditional hydrological studies using models and ground observations are limited in space and time
- Satellite sensors can cover large areas and over long periods of time
- This is specifically true for groundwater that has limited in-situ monitoring

Study Area – Mashreq region

Countries
1 Bahrain
2 Egypt
3 Iraq
4 Jordan
5 Kuwait
6 Lebanon
7 Oman
8 Palestine
9 Qatar
10 Saudi Arabia
11 Sudan
12 Syria
13 UAE
14 Yemen



Large River Basins
1 Tigris–Euphrates
2 Nile

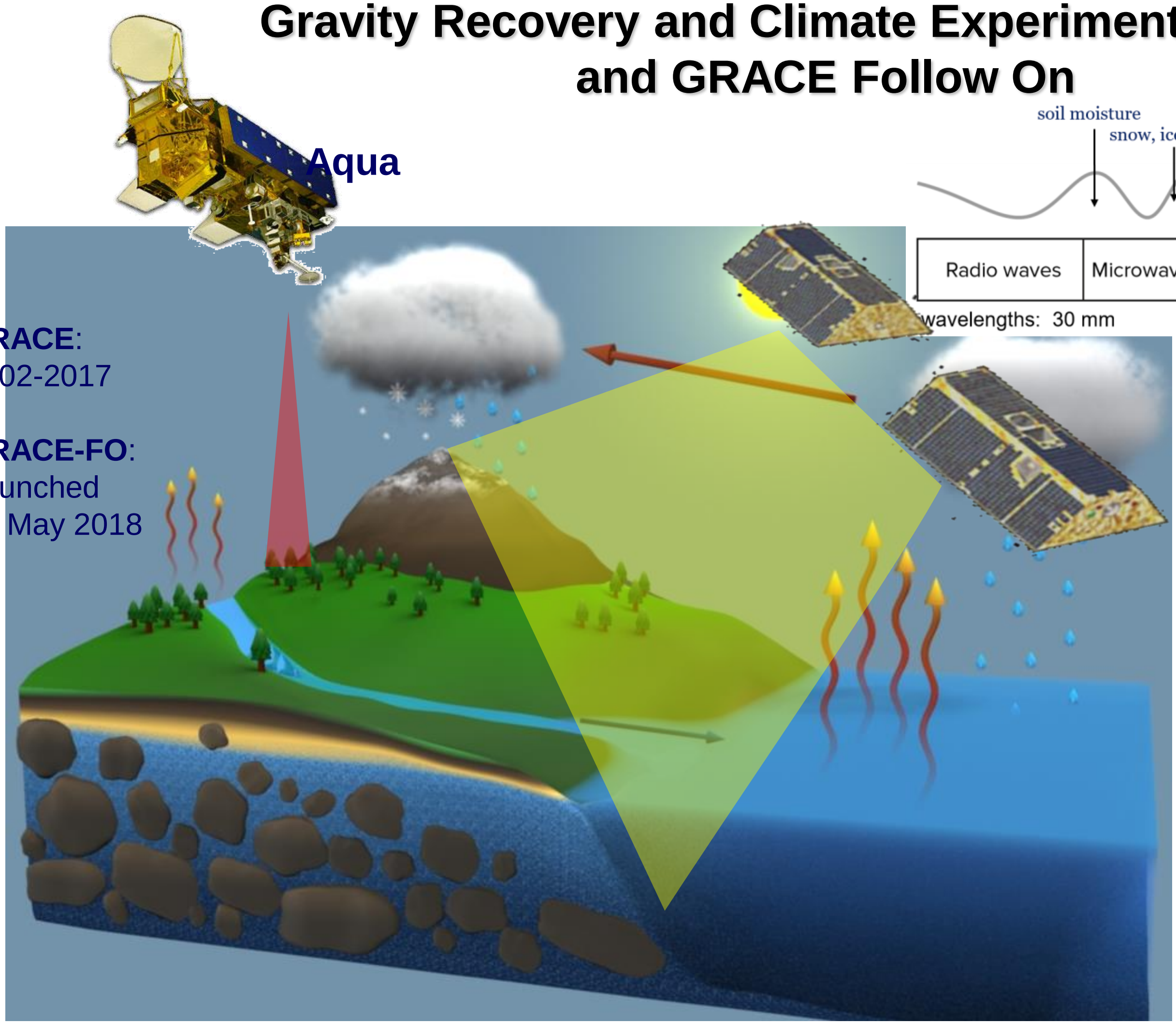
Mashreq region includes 14 countries with roughly 7 million km^2

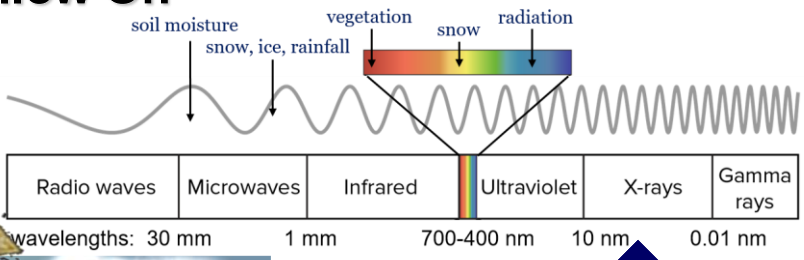
sources: https://www.hydrosheds.org/

GRACE (Gravity and Climate Experiment)

- Launched in March of 2002 - characterize variations in Earth's gravity.
- GRACE applications in water resources
  - Changes on runoff and groundwater on land masses.
  - Exchanges between ice sheets or glaciers and the ocean.
- Products
  - GRACE: 2002-2017
  - GRACE follow-on: 2018 - present

Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow On





GRACE-FO

GRACE:
2002-2017

GRACE-FO:
Launched
22 May 2018

d
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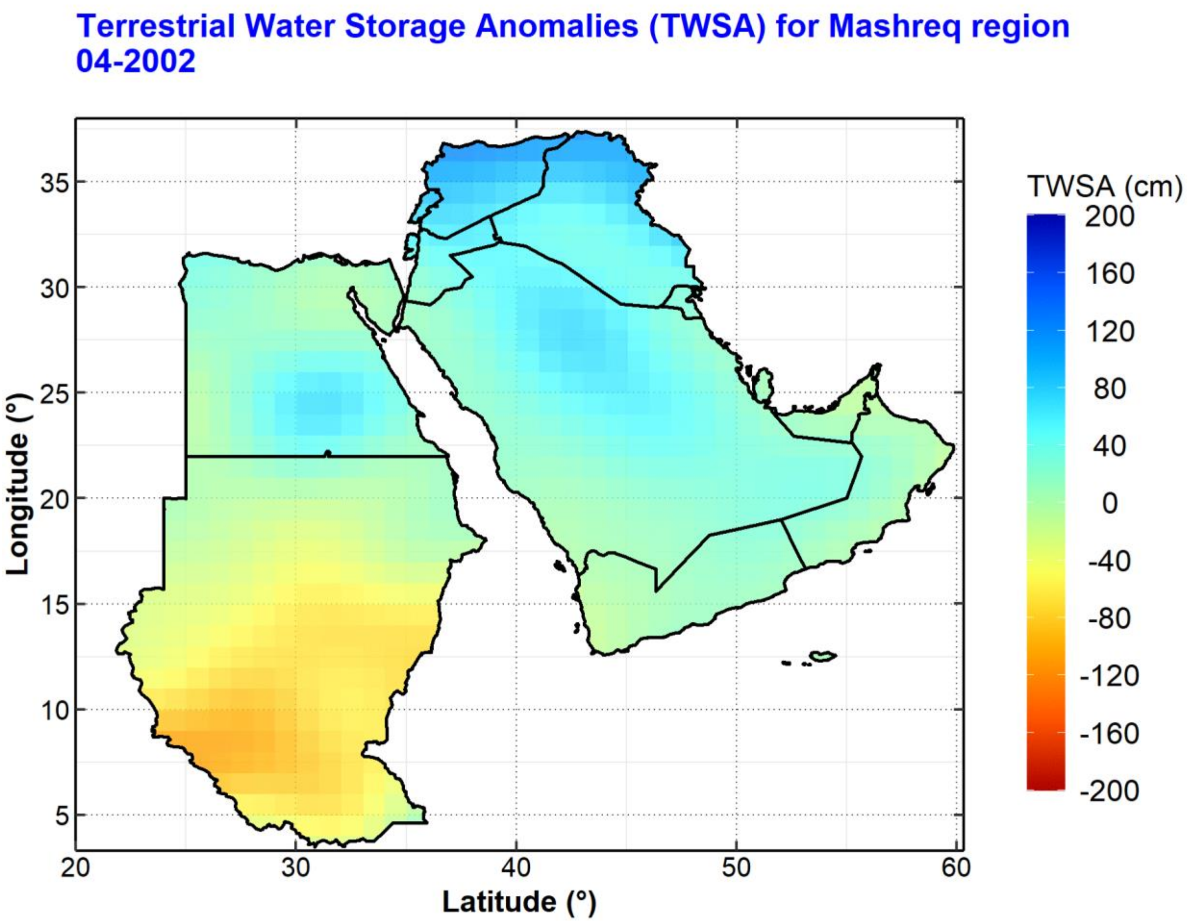
GRACE and GRACE Follow On are unique i their ability to monitor water a all levels, down the deepest aquifer

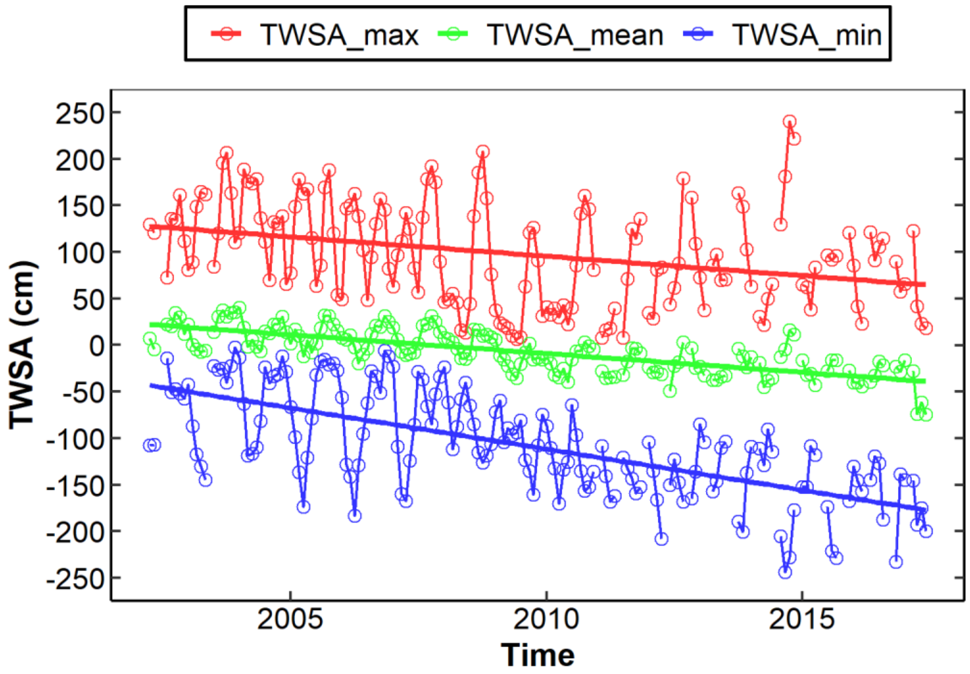
Source: Matt Rodell, NASA

Changes in Terrestrial Water Storage Anomalies for Mashreq region



Changes in TWSA for for the time period between April 2002 and June 2017

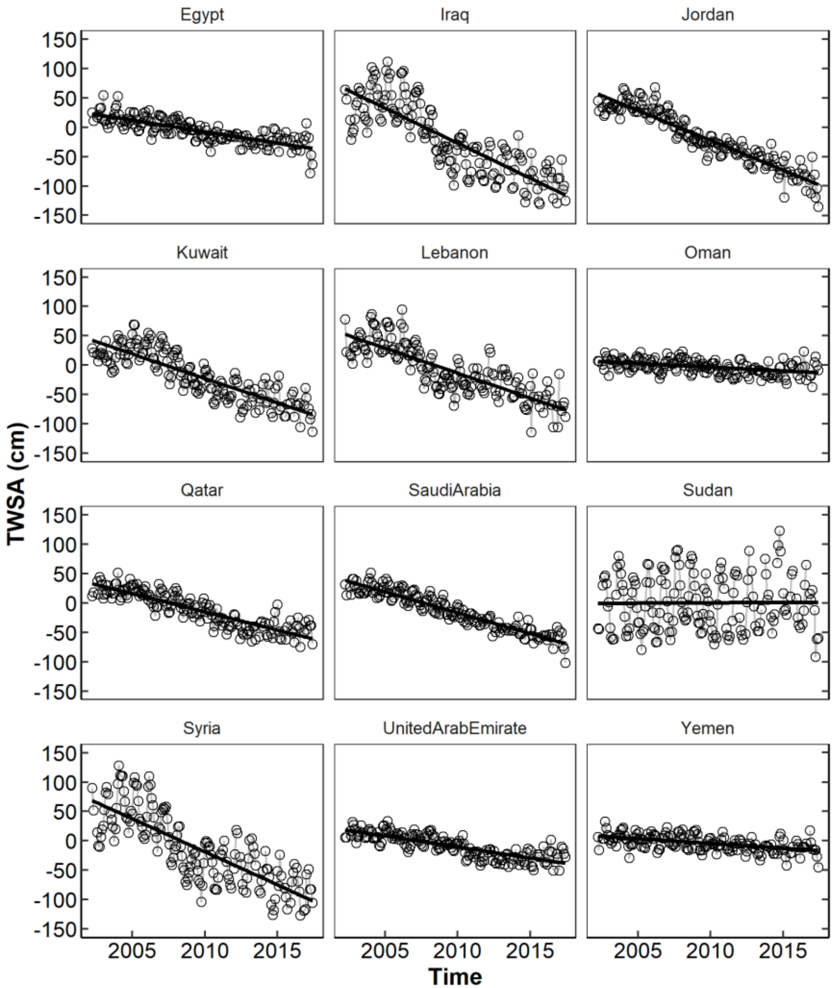
Terrestrial Water Storage Anomalies trends for entire Mashreq region

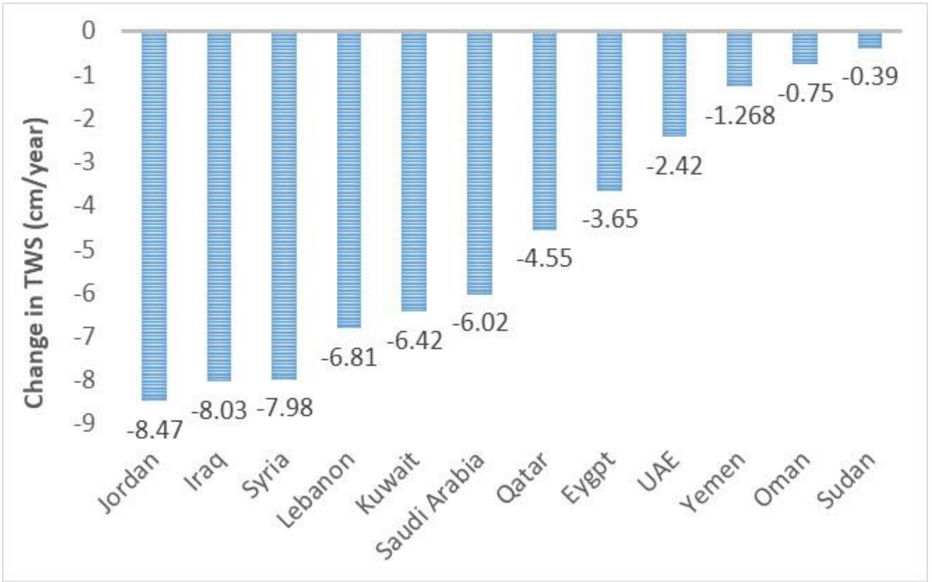


Estimate change: -3.18 cm/ year

Terrestrial Water Storage Anomalies seems to increase (become more negative) over Mashreq region (decreasing water storages)

Terrestrial Water Storage Anomalies trends for countries in Mashreq region

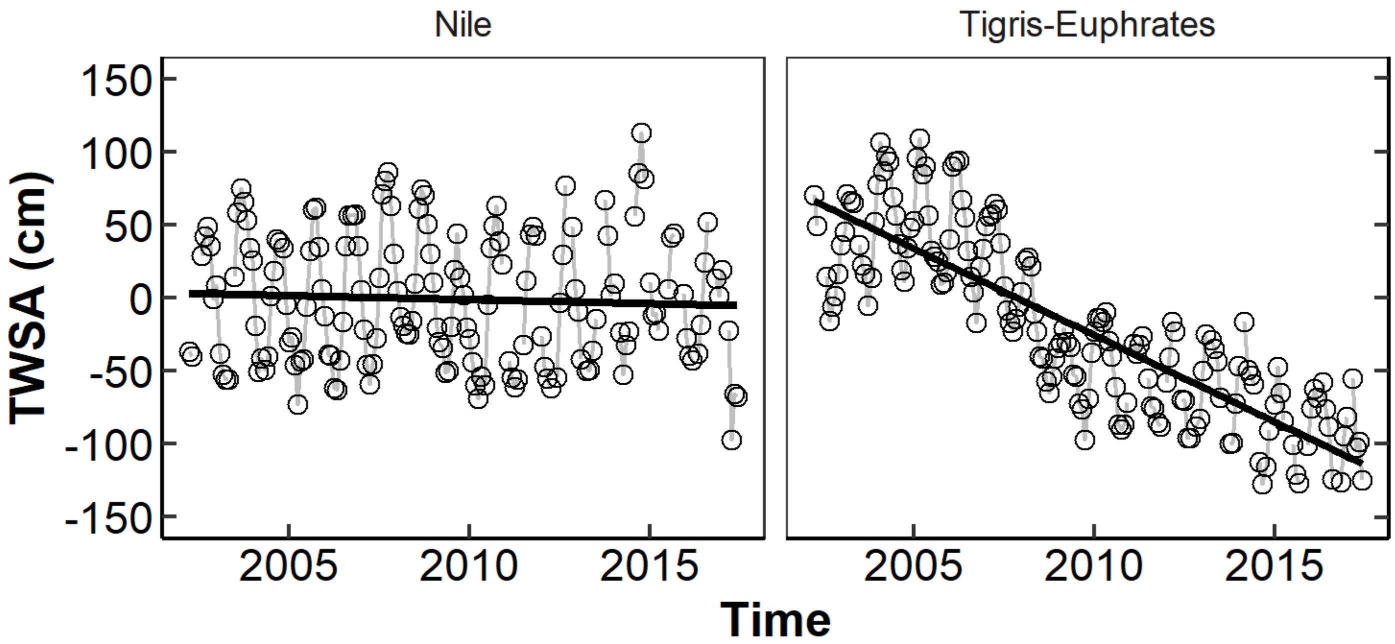




Northeastern Mashreq region (Jordan, Iraq, Syria, and Lebanon) experienced very high rate of negative changes in TWS

Kuwait, Saudi Arabia, and Qatar also have high rate of negative TWS

Terrestrial Water Storage Anomalies trends for basins in Mashreq region

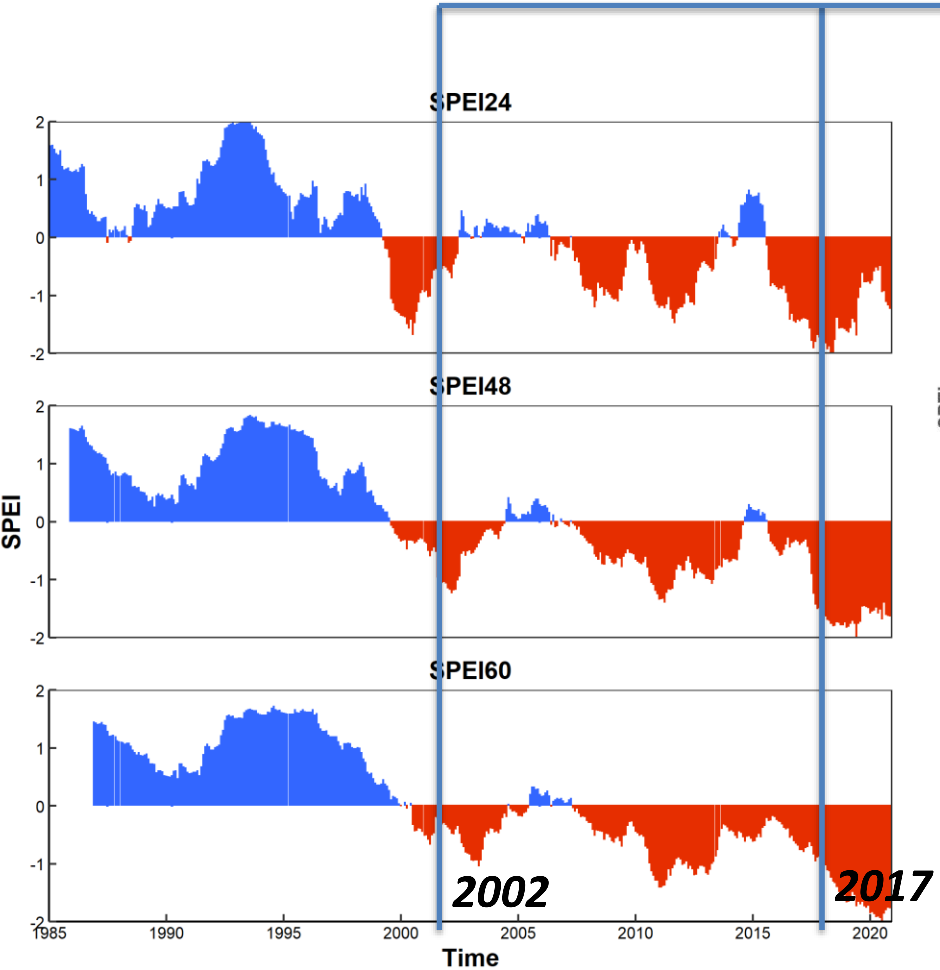


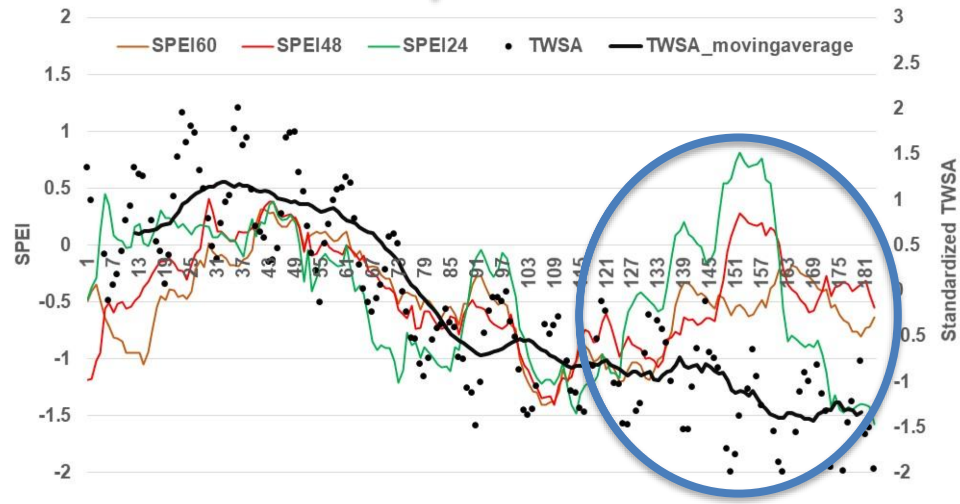
Compared with TWSA of Nile (-1.02 cm/year), TWSA of Tigris-Euphrates River basin is significant reduction with a rate of -8.22 cm/year.

Surface and groundwater

- Lower precipitation initiates a requirement to withdraw water from aquifers
- This results in an aquifer loss that is much greater than recharge and this accumulates
- The surface water deficit is quantified by drought indices – dependent on precipitation
- Increase in population and agricultural activities increase withdrawal during drought periods

Relationship between natural climate variability and TWSA – Case study of Tigris-Euphrates





Significant reduction in TWSA is associated with natural drought. However, human activities may accelerate this process after 2015 (wetness increases but TWSA still low)

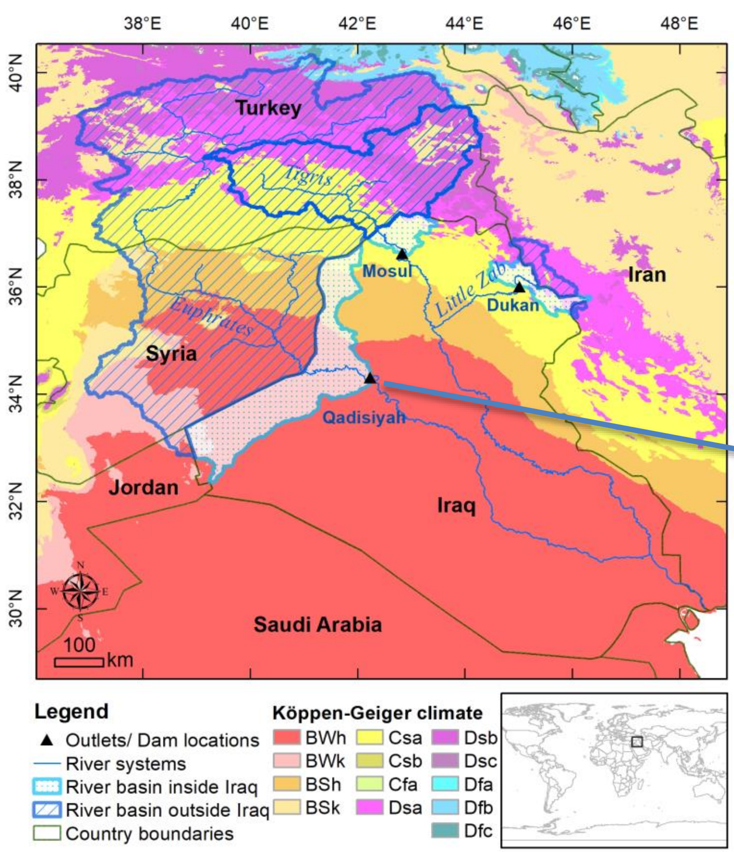
Meteorological drought (SPEI Standardized Precipitation Evapotranspiration Index)) over Tigris-Euphrates from 1985-2020 at three scales (SPEI24, SPEI48, and SPEI60).

Note 1: The drought datasets are derived from the Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System (FLDAS)

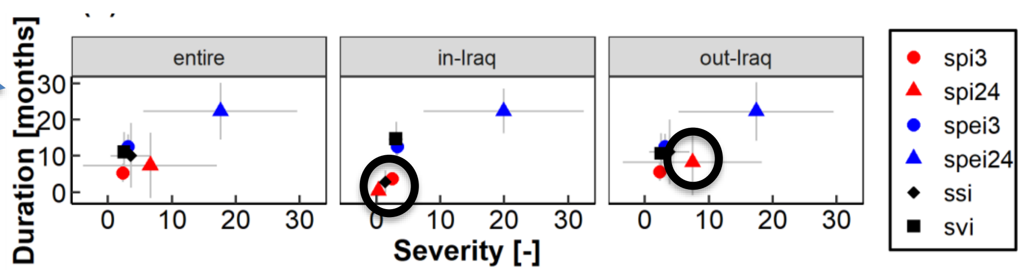
Note 2: for a comparison between TWSA and drought index, TWSA is standardized

Relationship between natural climate variability and TWSA – Case study of Tigris-Euphrates

Since Tigris-Euphrates is a transboundary river, changes in water resources may caused by upstream countries.

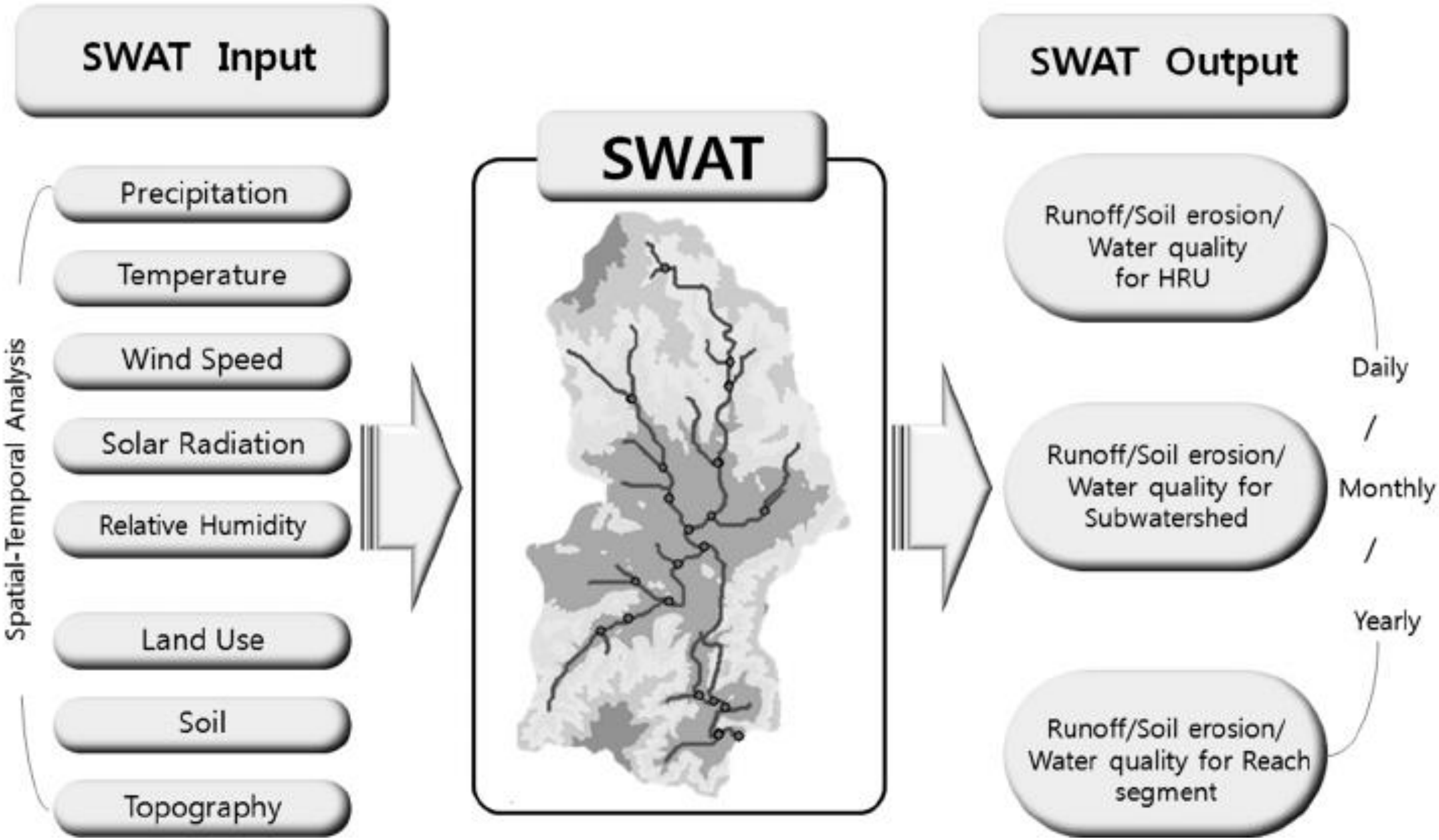


SPI Standardized precipitation index
SVI Standardized vegetation index
SSI Standardized streamflow index
SPEI Standardized Precipitation Evapotranspiration Index



Comparison between drought duration and drought severity for Qadisiyah River basin during 2015-18. The drought conditions inside Iraq and outside Iraq (upstream countries) are significantly different (SPI). In Iraq, there is a wet period but not for upstream basin.

Hydrological Simulation using Soil Water Assessment Tool



Parameters for the Soil Water Assessment Tool model

Inputs Discharge from in-situ sites from Ministry of water resources

Rainfall Ministry of Water Resources of Iraq

Other meteorological inputs are model derived by the SWAT community

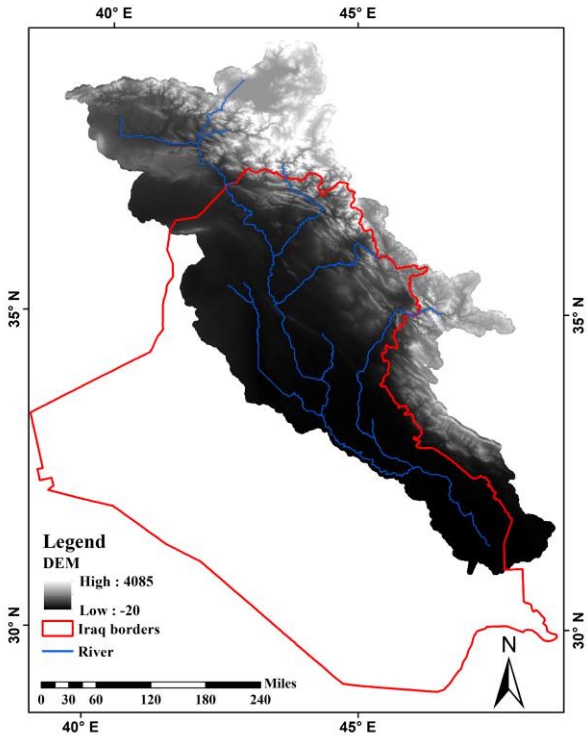
The period 1934-1979 was chosen as the period before dam construction in the region

Table 1 Calibration parameters

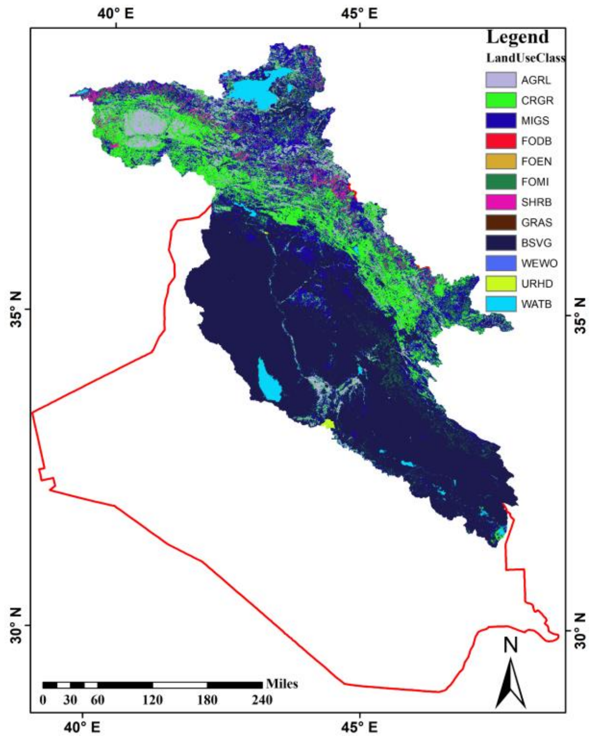
Parameter name	SWAT default value	Final Value	Definition
r__CN2.mgt	(-)0.4-0.4	-0.05	SCS runoff curve number factor
r__SOL_AWC(..).sol	(-)0.3-0.3	0.1	Available water capacity of the soil layer
r__ESCO.hru	0.1- 0.95	0.3	Soil evaporation compensation factor
r__RCHRG_DP.gw	0-0.9	0.1	Deep aquifer percolation fraction
r__ALPHA_BF.gw	0.05- 0.5	0.2	Baseflow alpha factor (days)
r__SURLAG.bsn	0-10	0.2	Surface runoff lag time
v__GWQMN.gw	0-2500	940	Treshold depth of water in the shallow aquifer required for return flow to occur (mm)
v__GW_REVAP.gw	0.05-0.5	0.1	Groundwater "revap" coefficient
v__GW_DELAY.gw	25-350	125.7	Groundwater delay (days).
r__SOL_K(..).sol	(-)0.2-0.2	-0.1	Saturated hydraulic conductivity.
v__SMTMP.bsn	(-)2-2	-0.01	Snow melt base temperature.
v__CH_K2.rte	0-100	24	Effective hydraulic conductivity in main channel alluvium.
v__CH_K1.sub	10-150	103.7	Effective hydraulic conductivity in tributary channel alluvium
v__CH_N1.sub	0-0.3	0.01	Manning's "n" value for the tributary channels.
v__SFTMP.bsn	(-)5-5	0.7	Snowfall temperature (˚C)
v__SMTMP.bsn	(-)5-5	4.5	Snow melt base temperature.
v__SMFMX.bsn	0-10	4.0	Maximum melt rate for snow during year (occurs on summer solstice)
v__SMFMN.bsn	0-10	0.1	Minimum melt rate for snow during the year (occurs on winter solstice)
v__TIMP.bsn	0-1	0.8	Snow pack temperature lag factor.
v__SNOCOVMX.bsn	0-500	50.0	Minimum snow water content that corresponds to 100% snow cover
v__SNO50COV.bsn	0-1	0.1	Snow water equivalent that corresponds to 50% snow cover

Note: v_ means the existing parameter value is to be replaced by a given value, and r_ means an existing parameter value is multiplied by (1 + a given value). (..)means for different soil layers or months

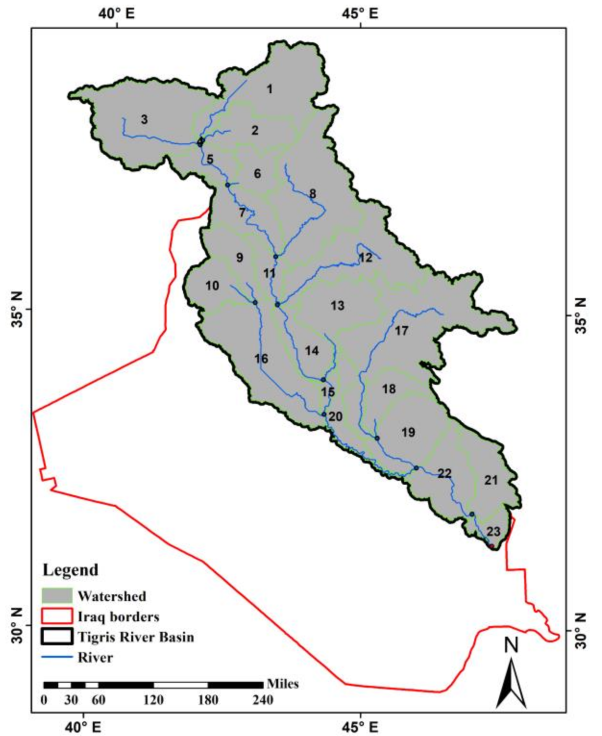
Modeling of the Tigris River Basin using Soil Water Assessment Tool



Map of Digital elevation model (DEM) for the Tigris River Basin

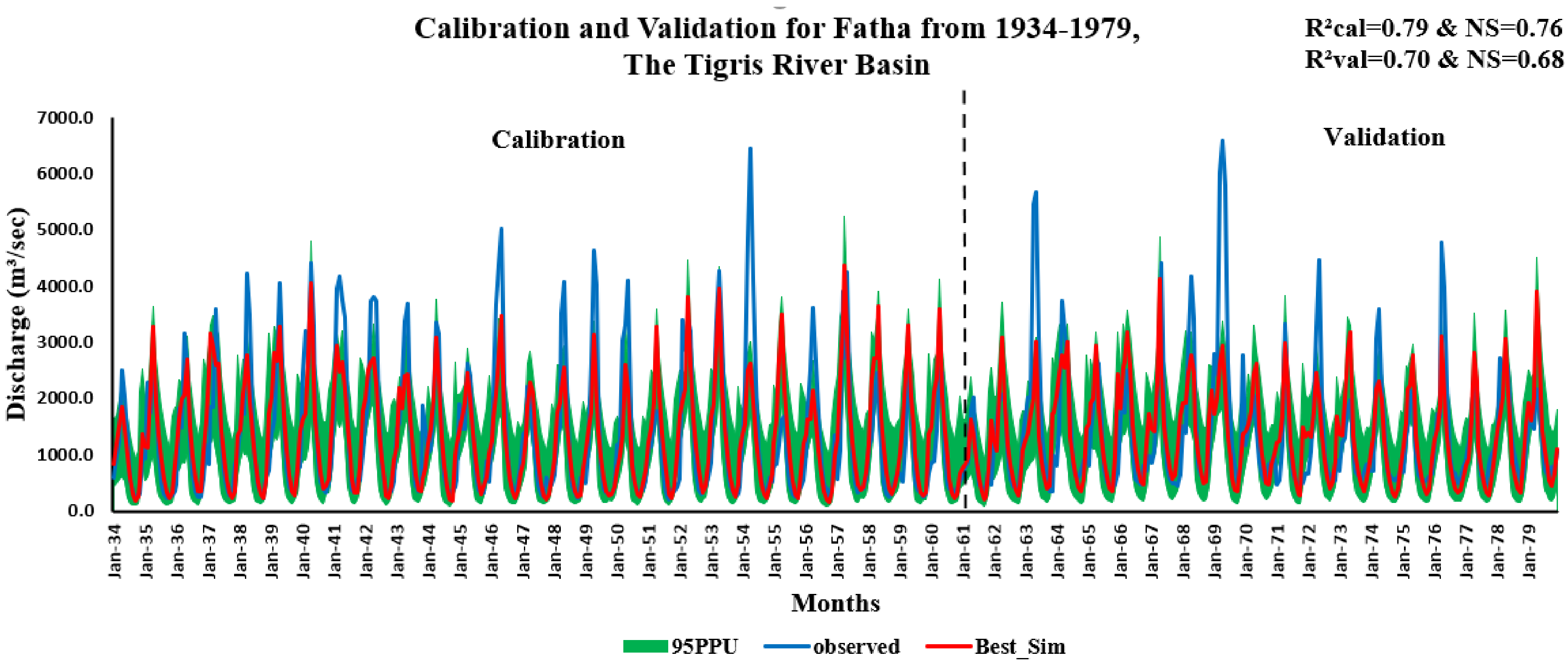


Land cover/use of the Tigris River Basin

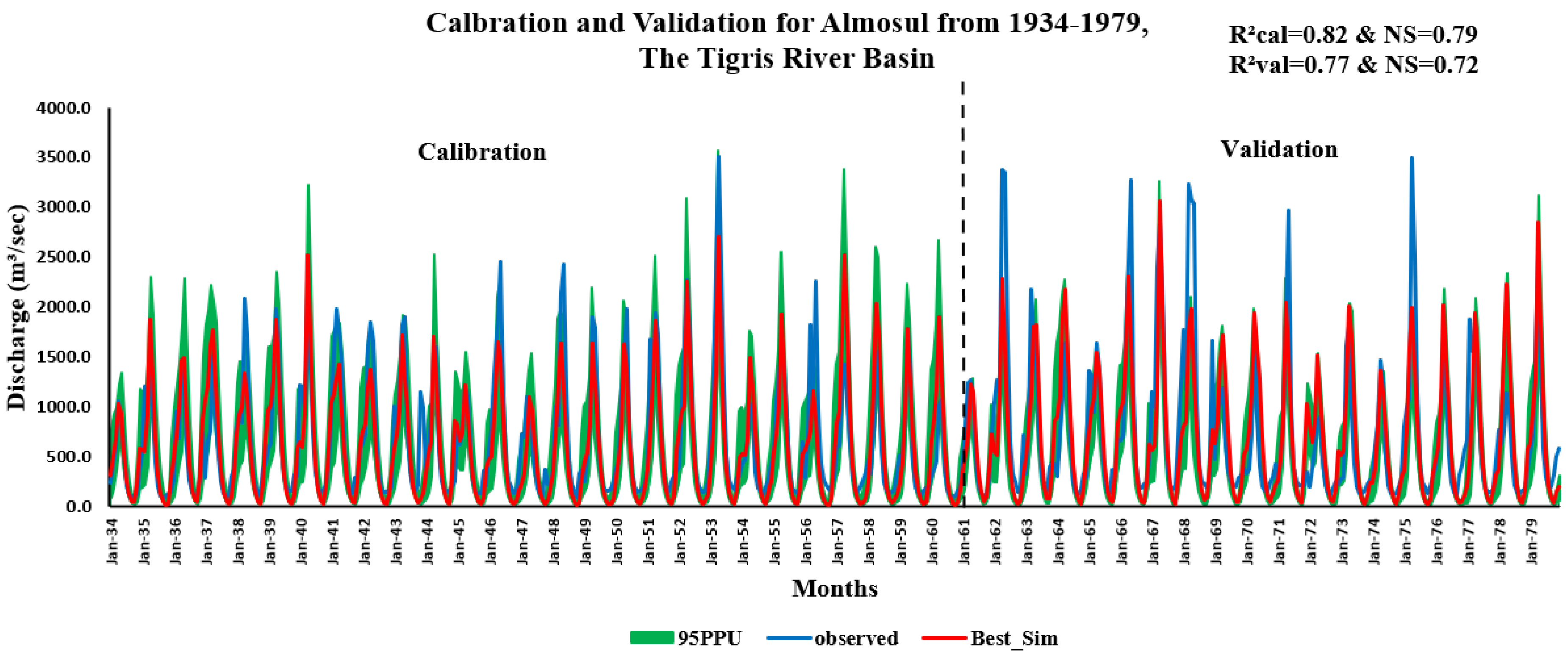


SWAT-DEM delineated subbasins of the Tigris River Basin

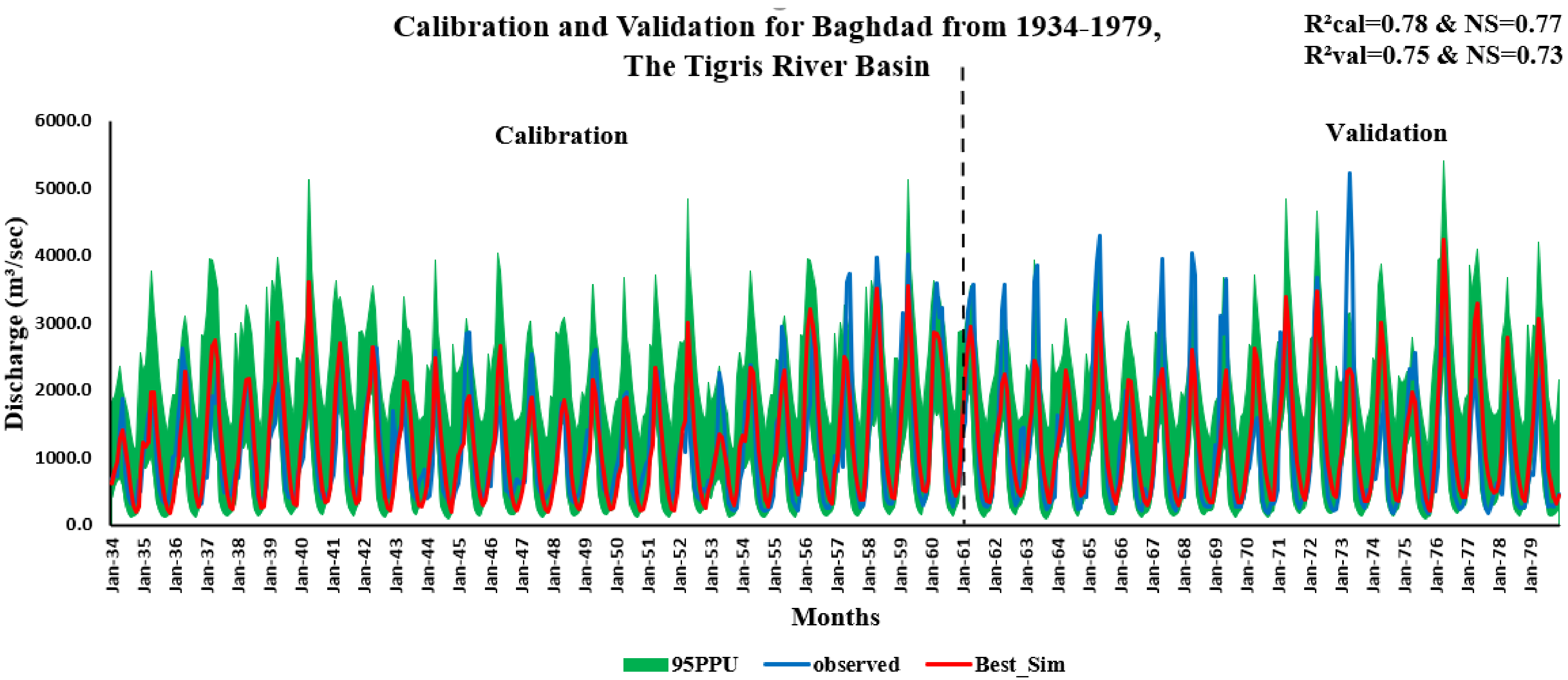
Modeling of the Tigris River Basin using Soil Water Assessment Tool



Modeling of the Tigris River Basin using Soil Water Assessment Tool



Modeling of the Tigris River Basin using Soil Water Assessment Tool



Conclusions

- Satellite-based datasets could provide unique opportunities to assess changes in groundwater resources at large scale.
- Mashreq region is an excellent example for applications of satellite-related products and models as in-situ data is scarce.

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Thank you