SWAT application for water resources management in Khulm watershed, Afghanistan

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Background

- As Afghanistan is located in arid and semi-arid climate regions, agricultural productions heavily rely on irrigation.

Irrigation water amount (in the Water Law of Afghanistan)

- Cultivation area, crop type, water rights, local practices, etc.

- Ministry officials will provide necessary advice and technical guidance to increase water efficiency etc.

Irrigation water amount (in practice)

- Water masters (community-based service providers) controlled irrigation water amount in their traditional manners basically

To increase knowledge of water situation in Afghanistan

Methodology

To increase knowledge of water situation in Afghanistan (to improve current water allocation methods and to understand future water condition), two methods have been used.

1. Study on local water allocation efficiency in an irrigation command area (evaluation of current local methods)

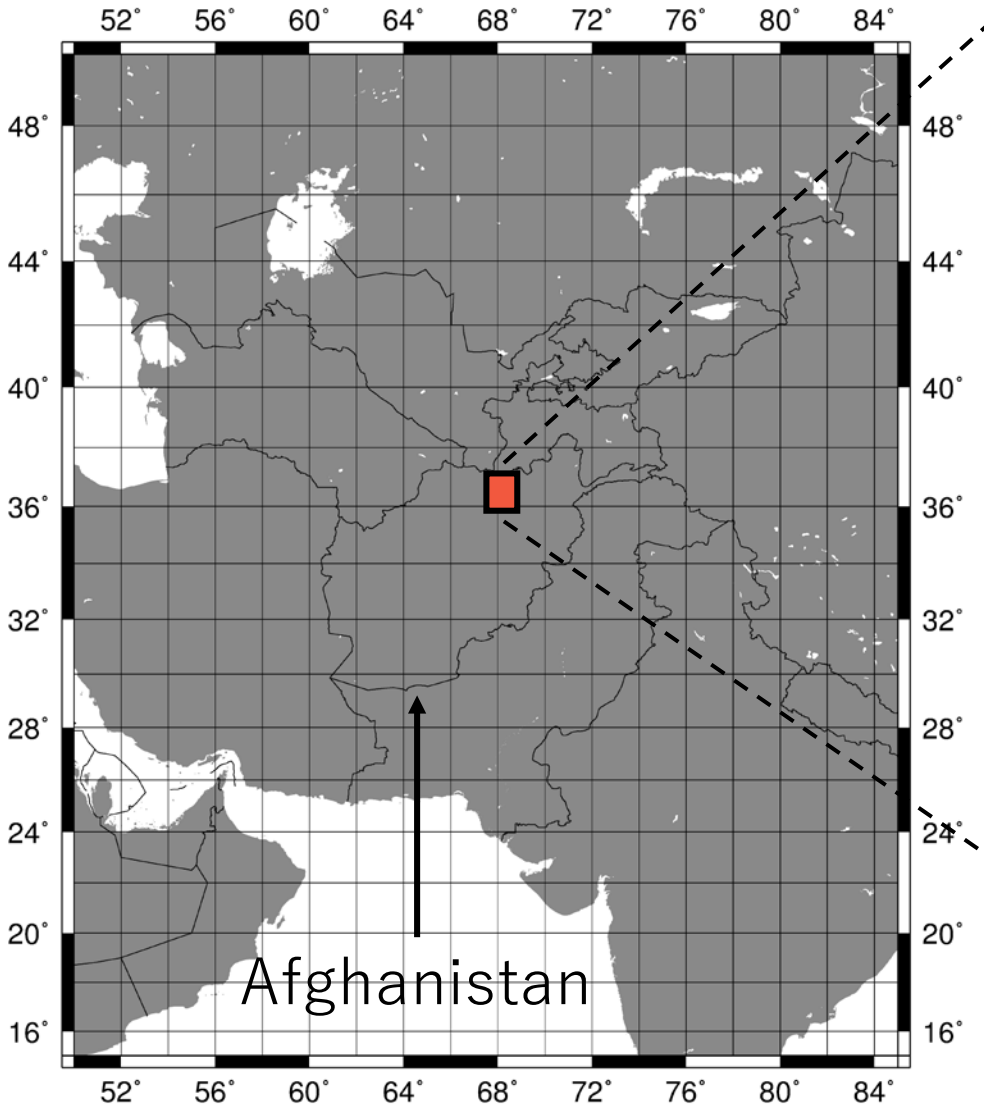
2. Study on future water situation in a watershed scale to develop suitable adaptation methods (by using SWAT)

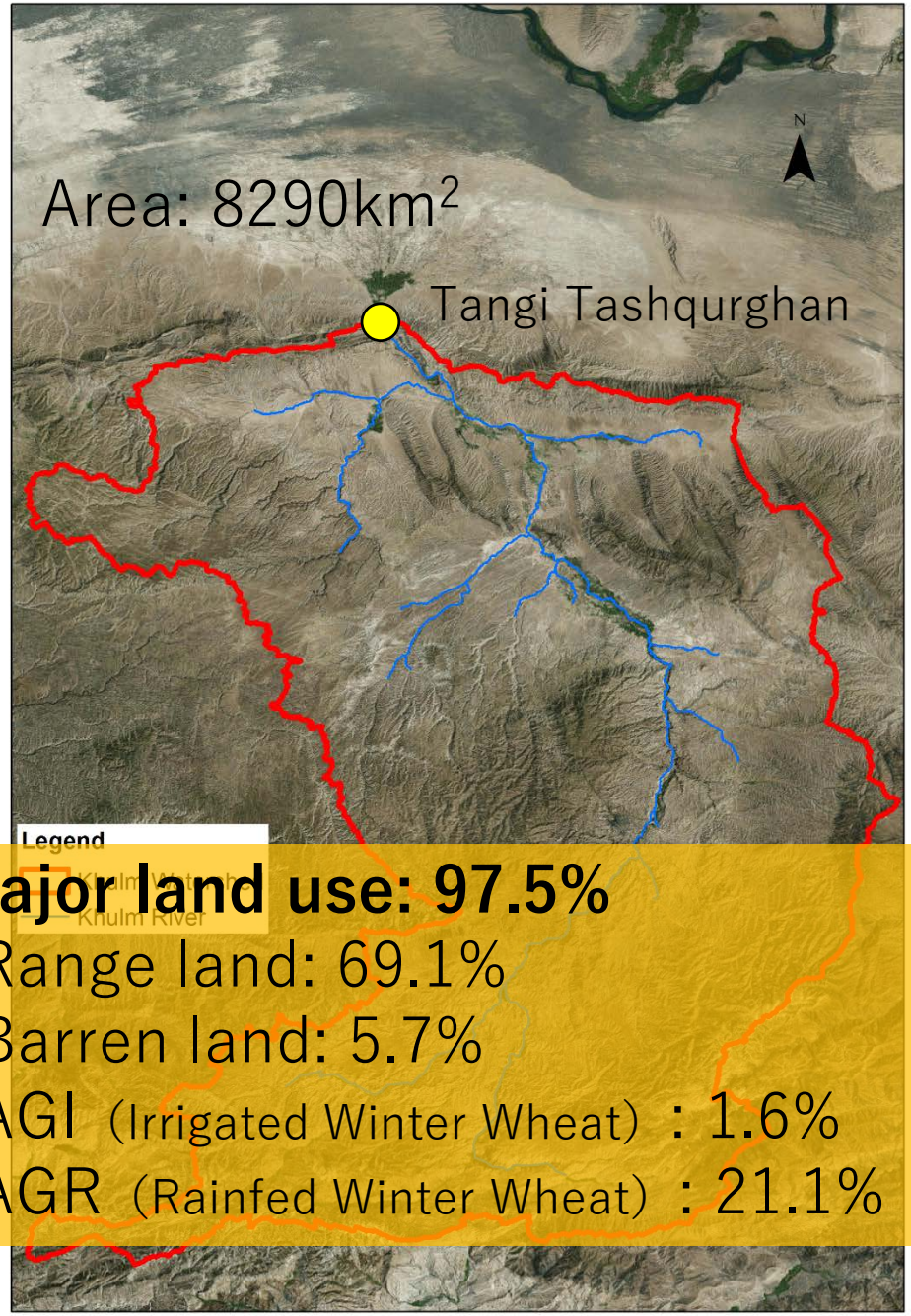
Today's contents

Challenging parts of this study

1. The Japanese government doesn't allow us to visit Afghanistan
2. It is difficult to collect long period of historic information because of the past conflicts
3. There are observed data quality problems
4. There is uncertainty in climate change projections

Study Area





Major land use: 97.5%

Range land: 69.1%

Barren land: 5.7%

AGI (Irrigated Winter Wheat) : 1.6%

AGR (Rainfed Winter Wheat) : 21.1%

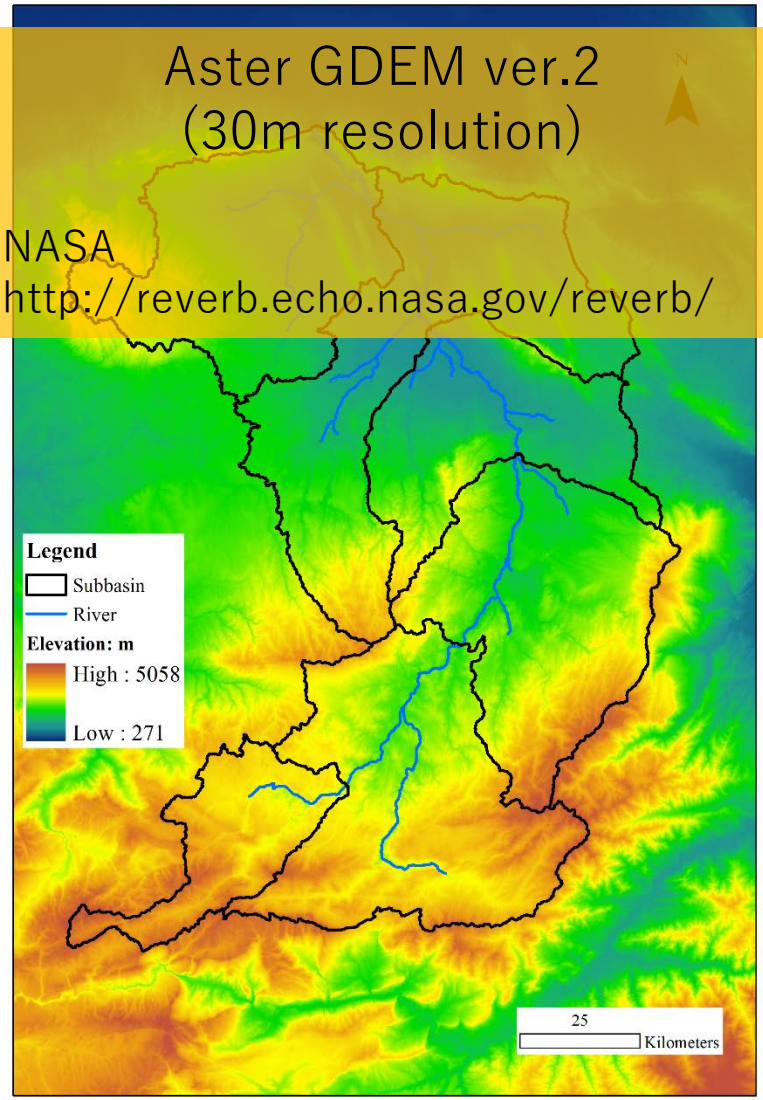
Sceneries of the target area (August 2014)

Sceneries of the target area (Spring 2017)

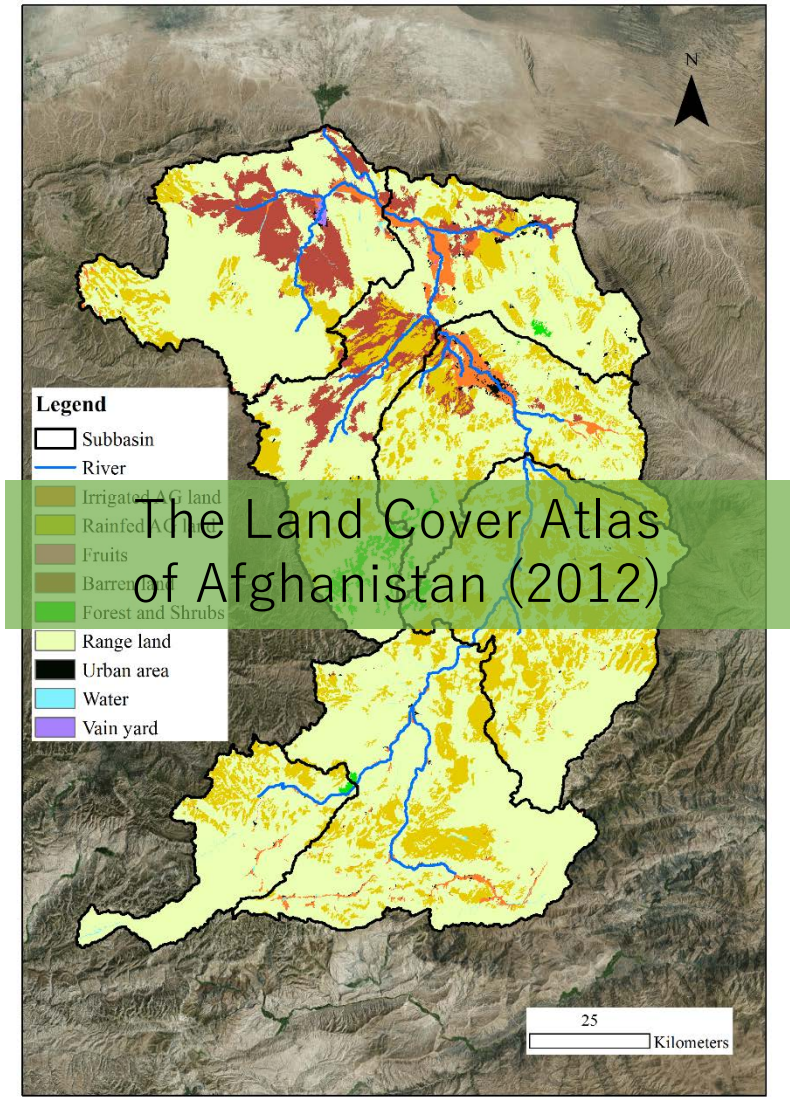
Data availability-GIS Information

Aster GDEM ver.2
(30m resolution)

NASA
http://reverb.echo.nasa.gov/reverb/

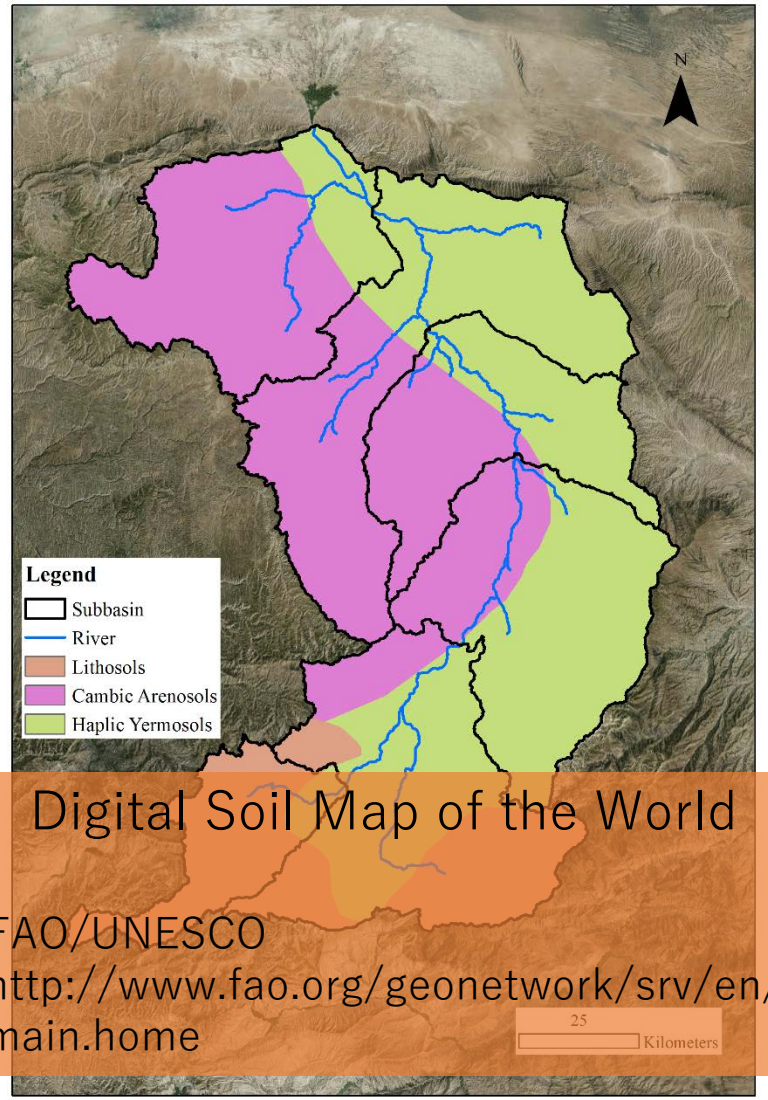


The Land Cover Atlas
of Afghanistan (2012)

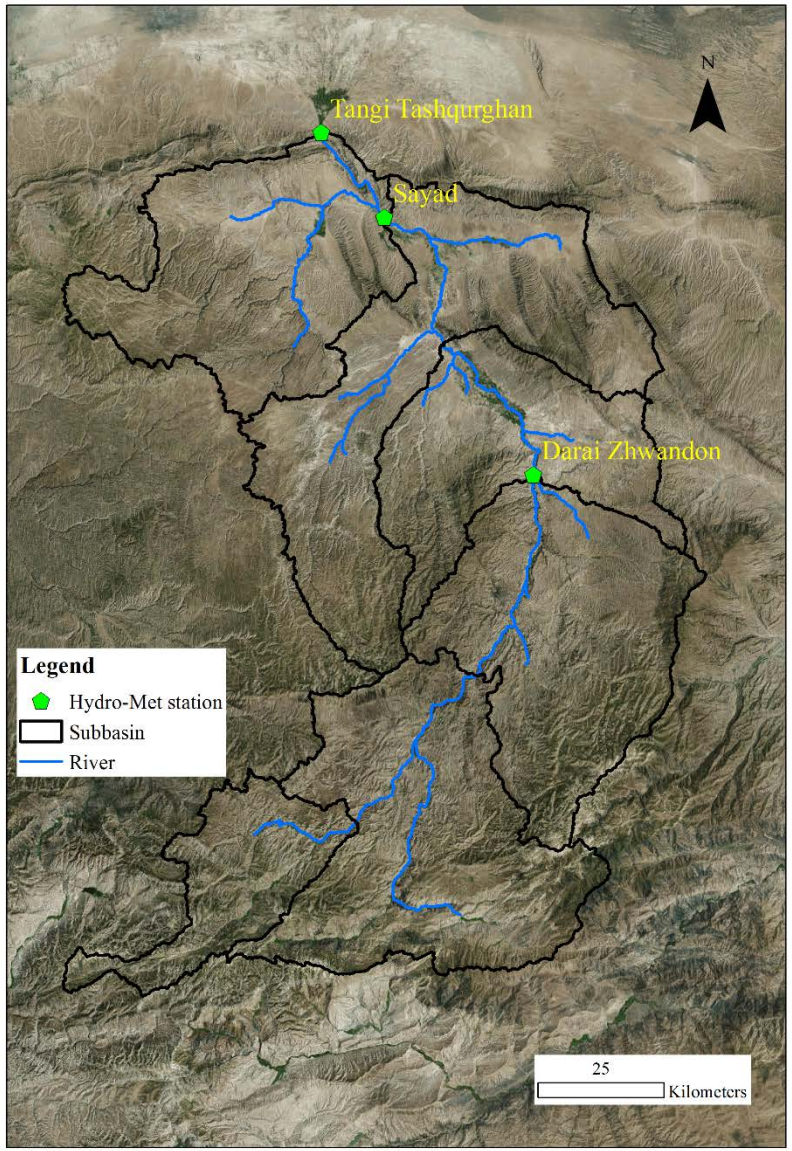


Digital Soil Map of the World

FAO/UNESCO
http://www.fao.org/geonetwork/srv/en/main.home



Data availability-River discharge



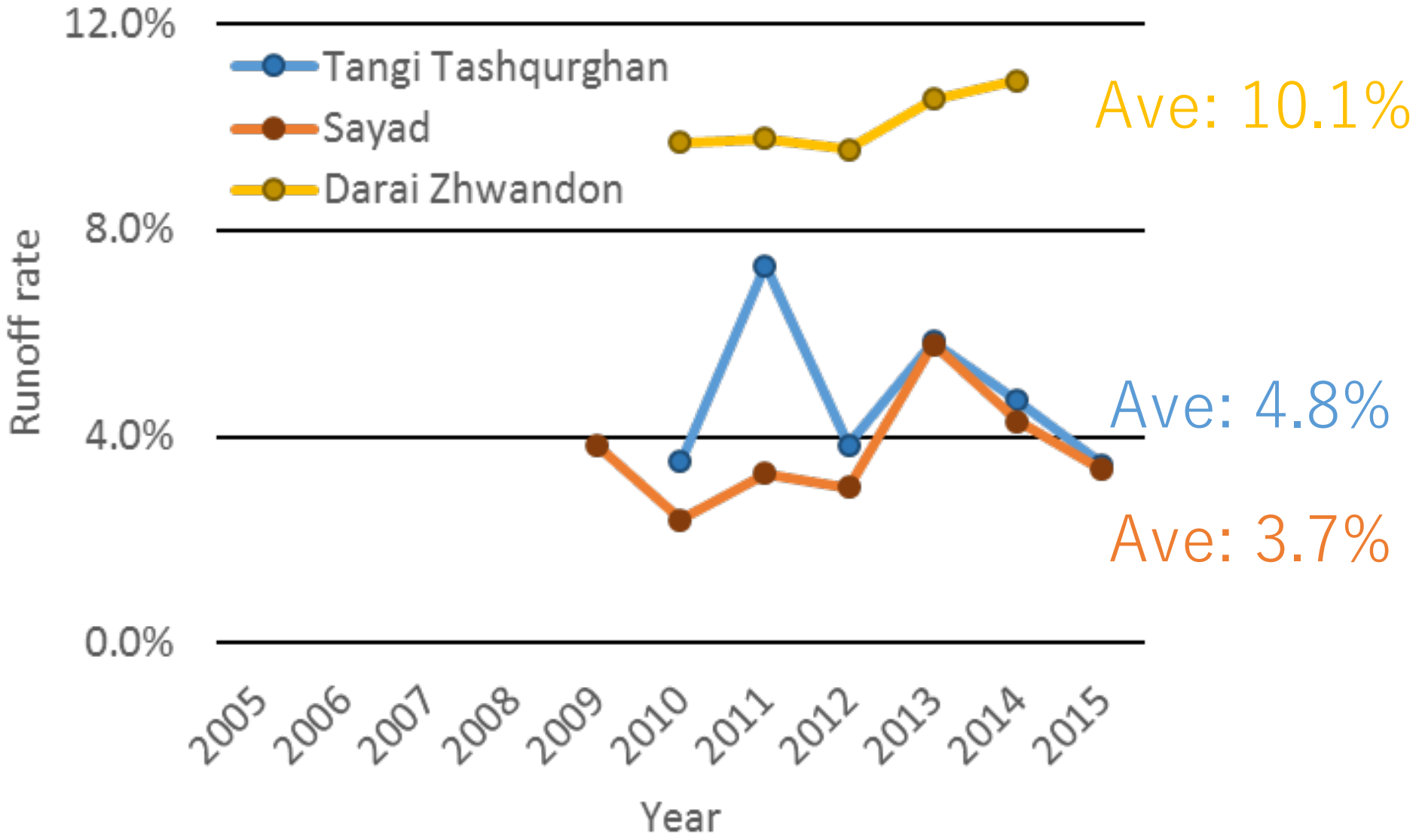
3 observatories

Tangi Tashgurghan (since 2005.4)

Sayad (since 2007.10)

Dara Zhowandon (since 2009.10)

A feature of river discharge –Runoff rate–

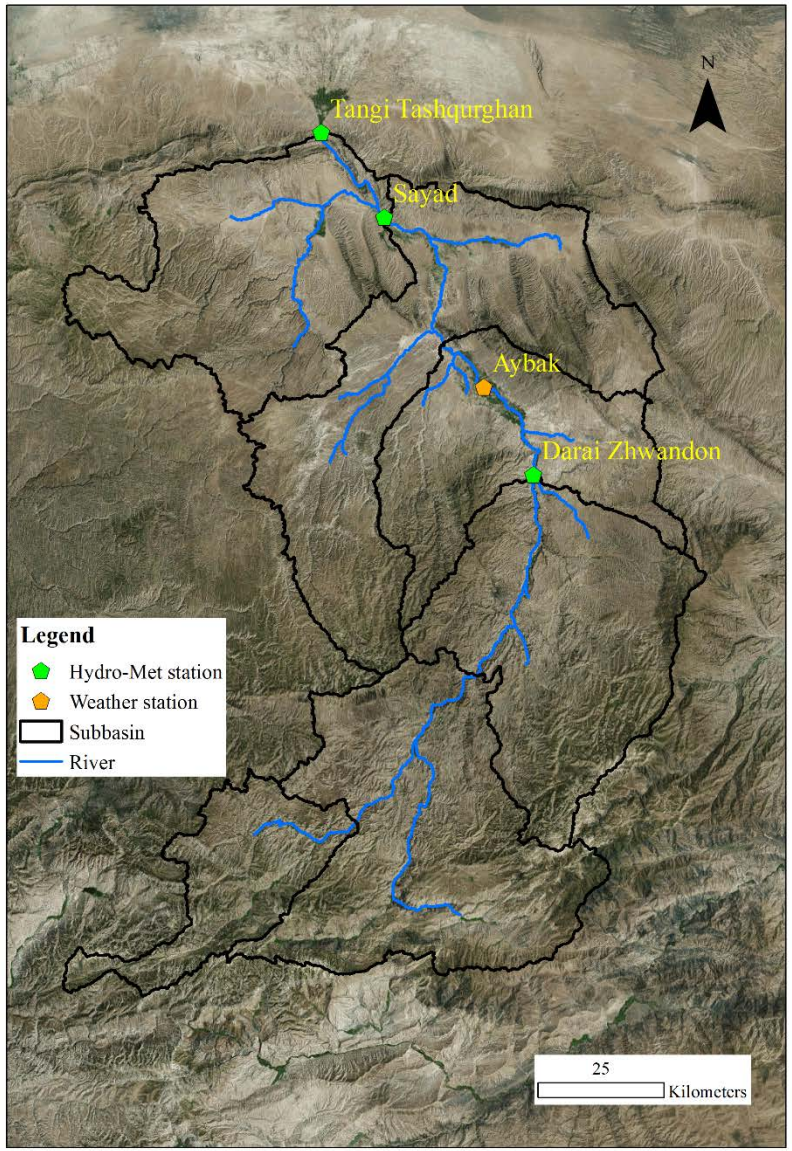


A feature of river discharge –River Regime Coefficient –

	Sayad	Darai Zhwandon
	10.1	
	4.8	13.4
	125.0	11.9
	21.2	15.5
	25.6	5.9
	14000.0	106.7
	141.7	38.1

River Regime Coefficient: Calculated from maximum and minimum discharge in a year, and larger value shows large fluctuation

Data availability-Climatic information



5 observatories

Precipitation, Temp., and RH

- Tangi Tashgurghan
- Sayad
- Aybak (MEW and MAIL)
- Dara Zhowandon

Wind Speed

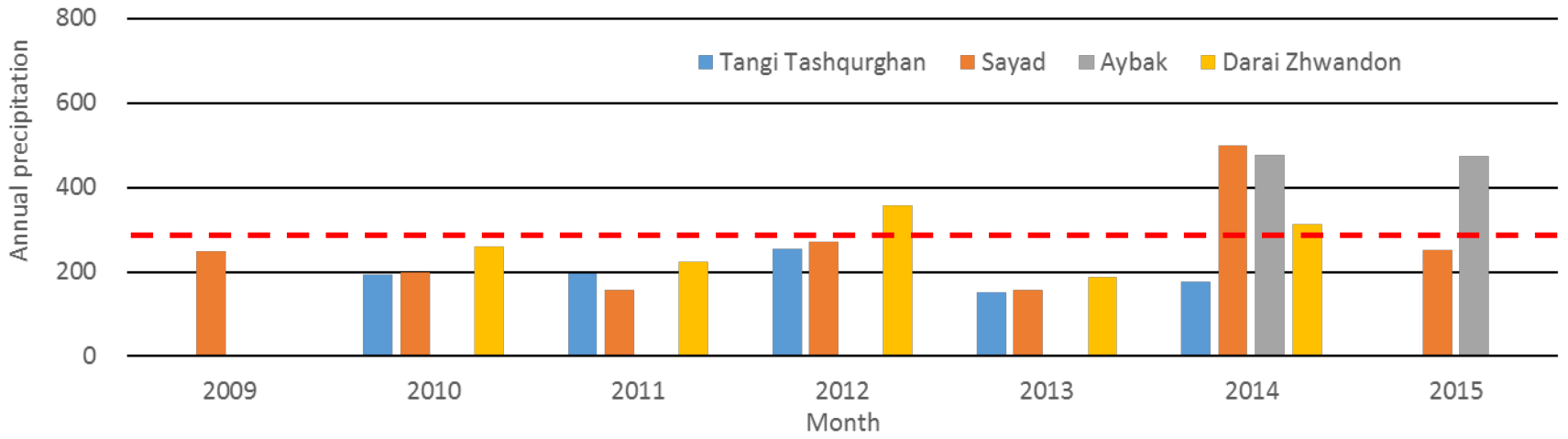
- Aibak (MEW)

Solar Radiation (Sunshine Duration)

- Aibak (MEW and MAIL)

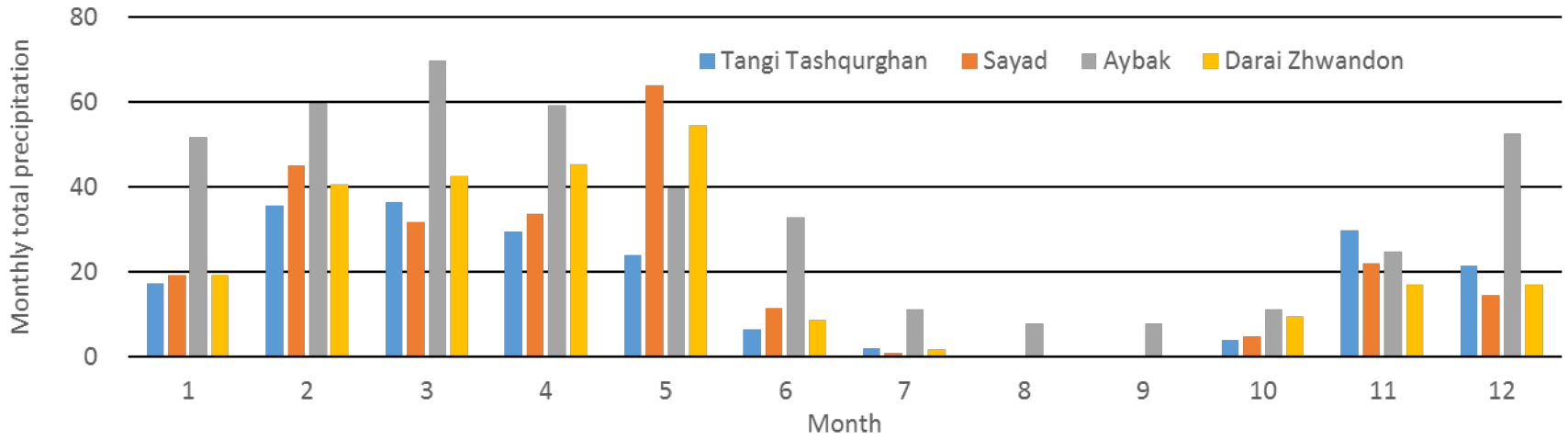
Feature of climate information -precipitation-

Annual precipitation



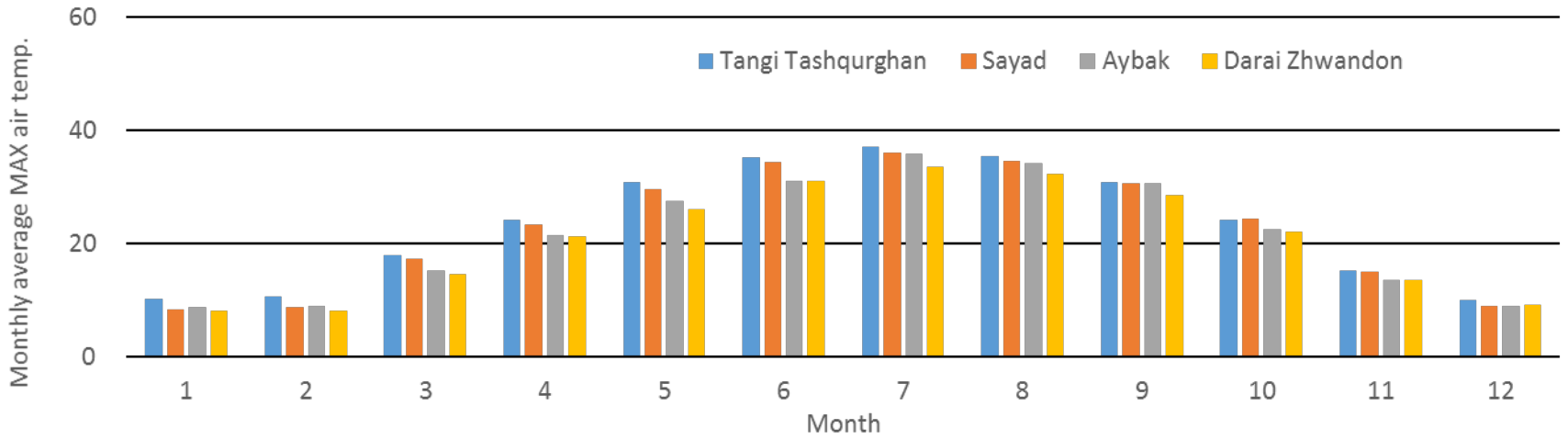
266mm

Monthly precipitation

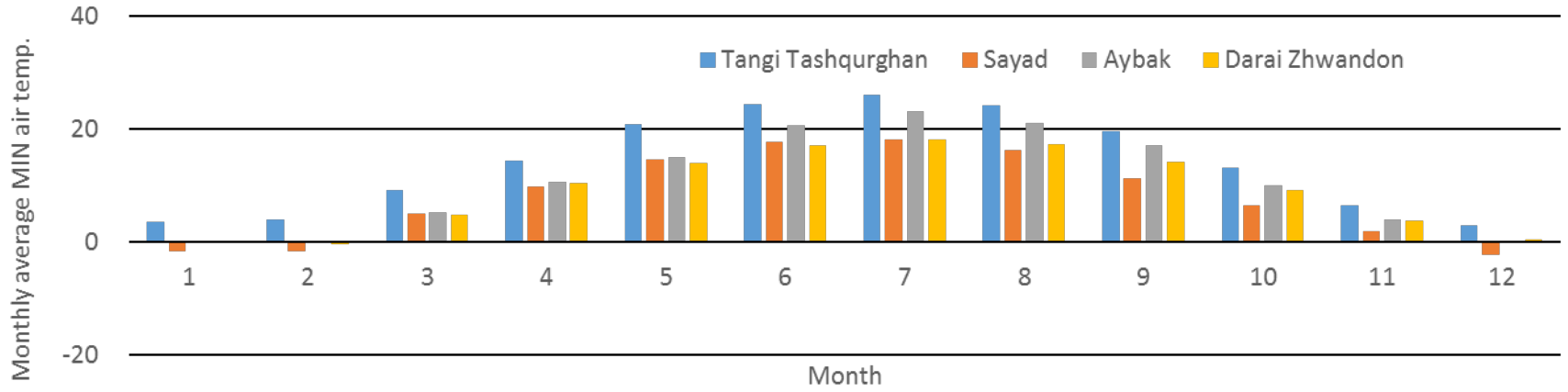


Feature of climate information -temperature-

Maximum

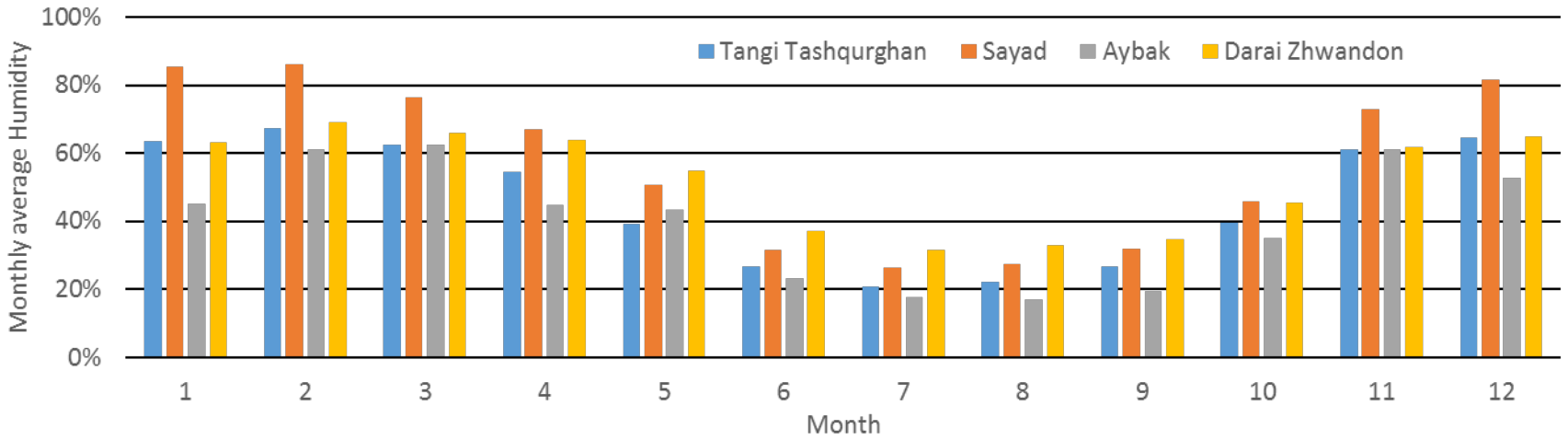


Minimum

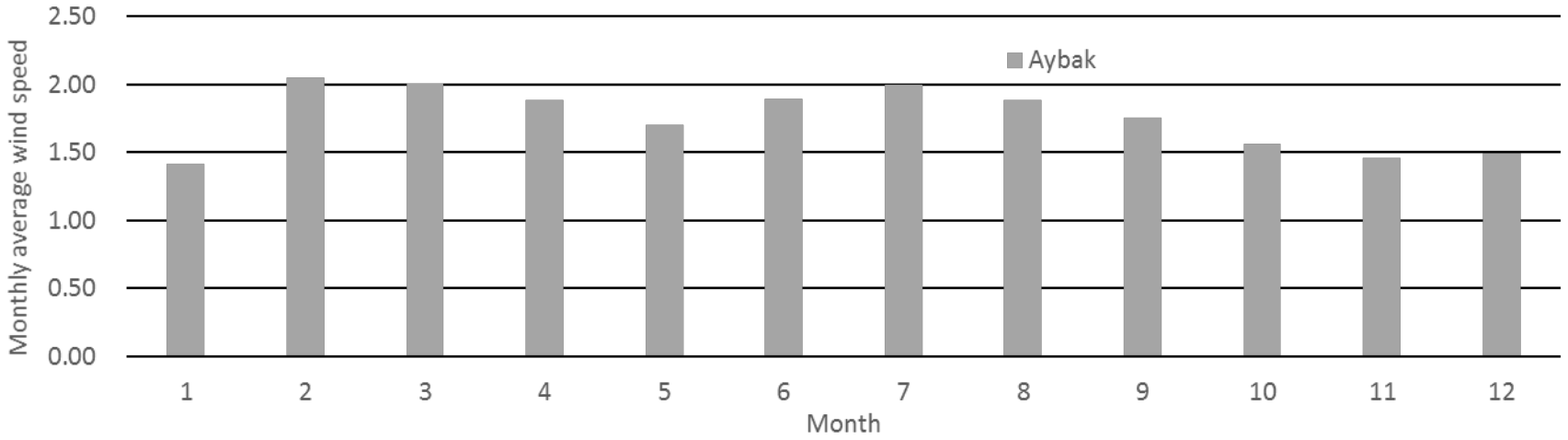


Feature of climate information –RH&WS-

Relative Humidity

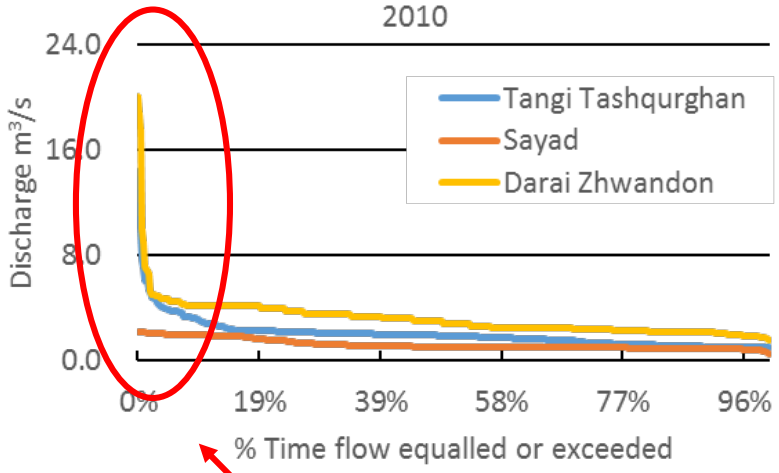


Wind Speed

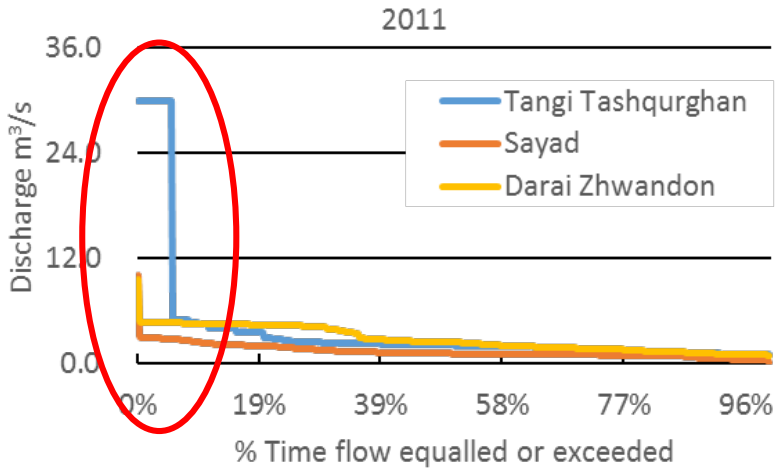


Data quality –Discharge Information-

Quality check of river discharge (as examples from 2010 to 2012)

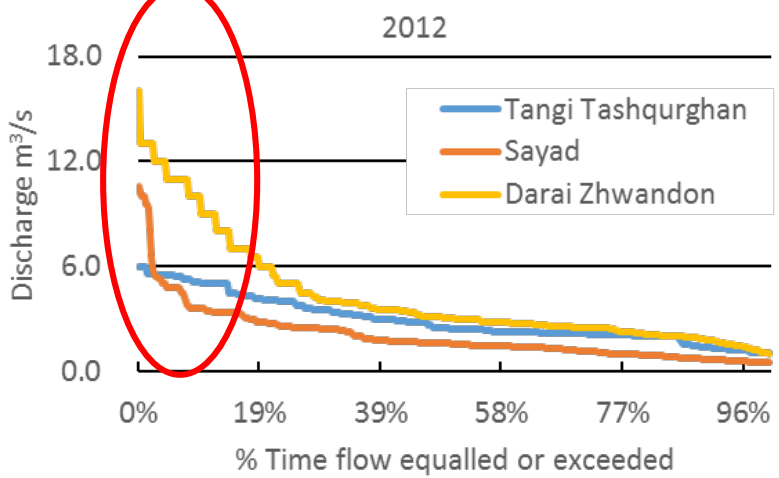


No peak only at Sayad

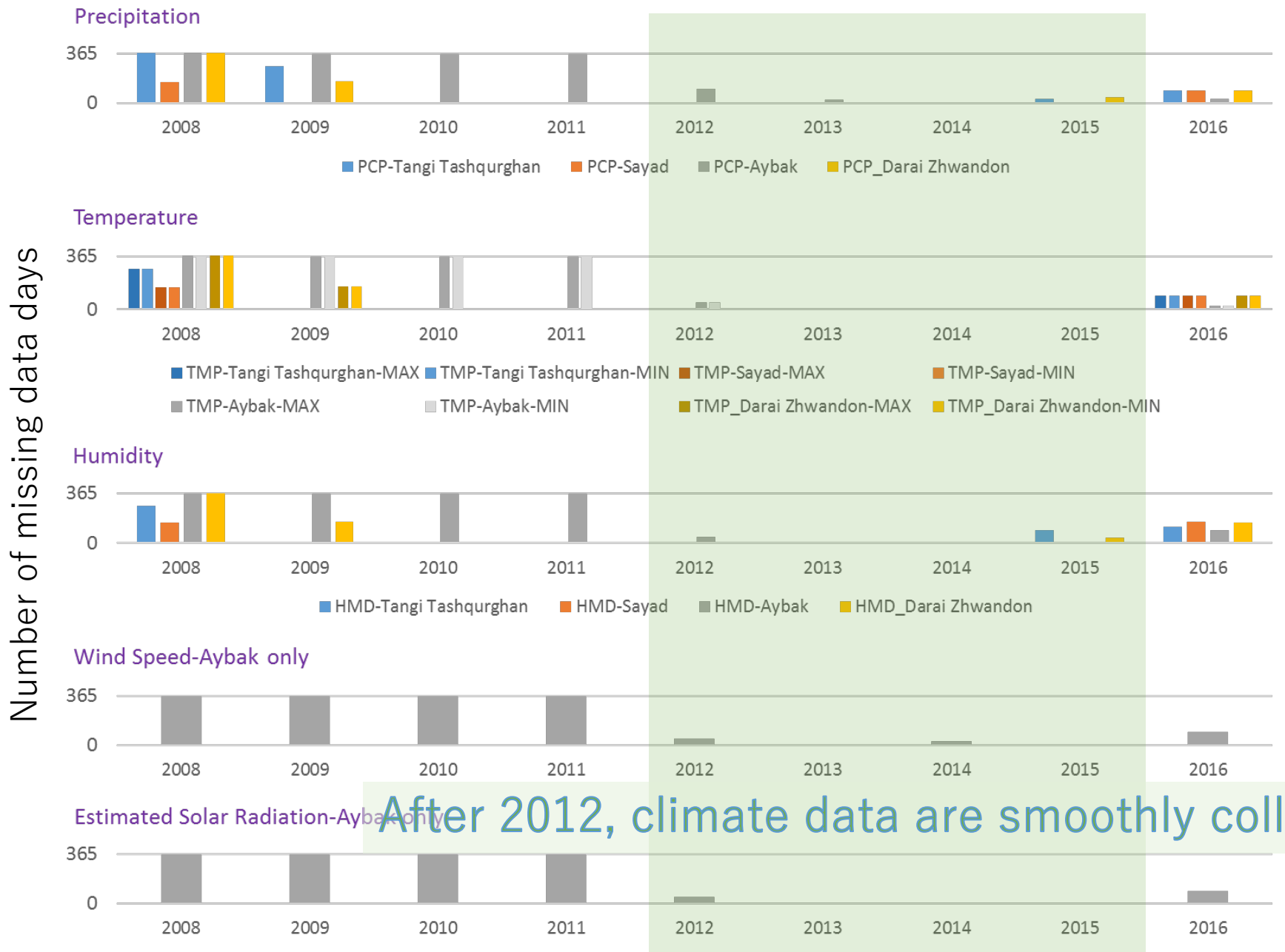


Unnatural behavior

Unnatural behavior
(a staircase pattern)

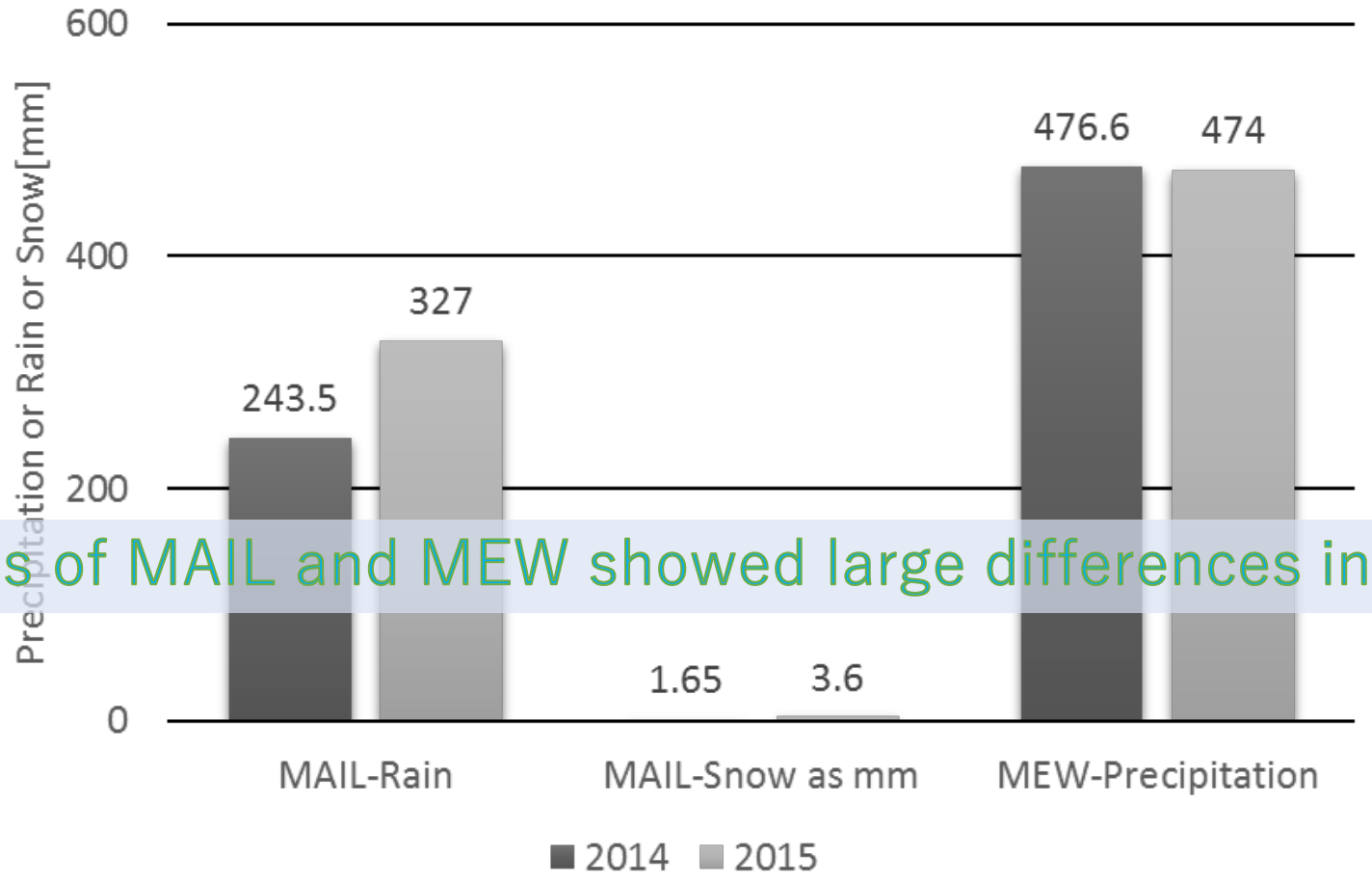


Data quality-Missing Weather Information



Data quality -precipitation data-

Quality check of weather information (as an example at Aybak observatories)



Nearby stations of MAIL and MEW showed large differences in precipitation

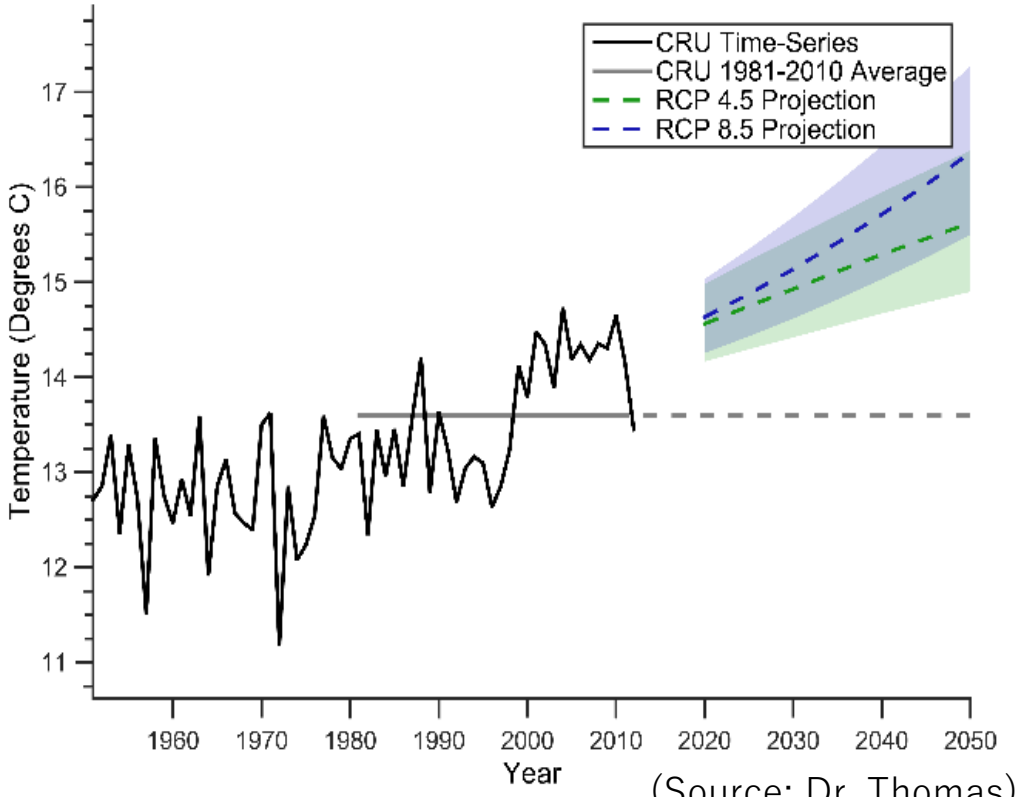
Future projections of precipitation and temperature for sensitivity analysis

Climate models: 11 models
Scenarios: RCP4.5 and RCP8.5

Representative **C**oncentration **P**athways (**RCPs**)

11 models:
BCC CMS1.1, CanESM2, CCSM4, CNRM CM5, GFDL ESM2M, HadGEM3 CC, IPSL CM5A-LR, MICOC ESM, MIROC ESM-CHEM, and NorESM1-M

Average annual climate change for Afghanistan

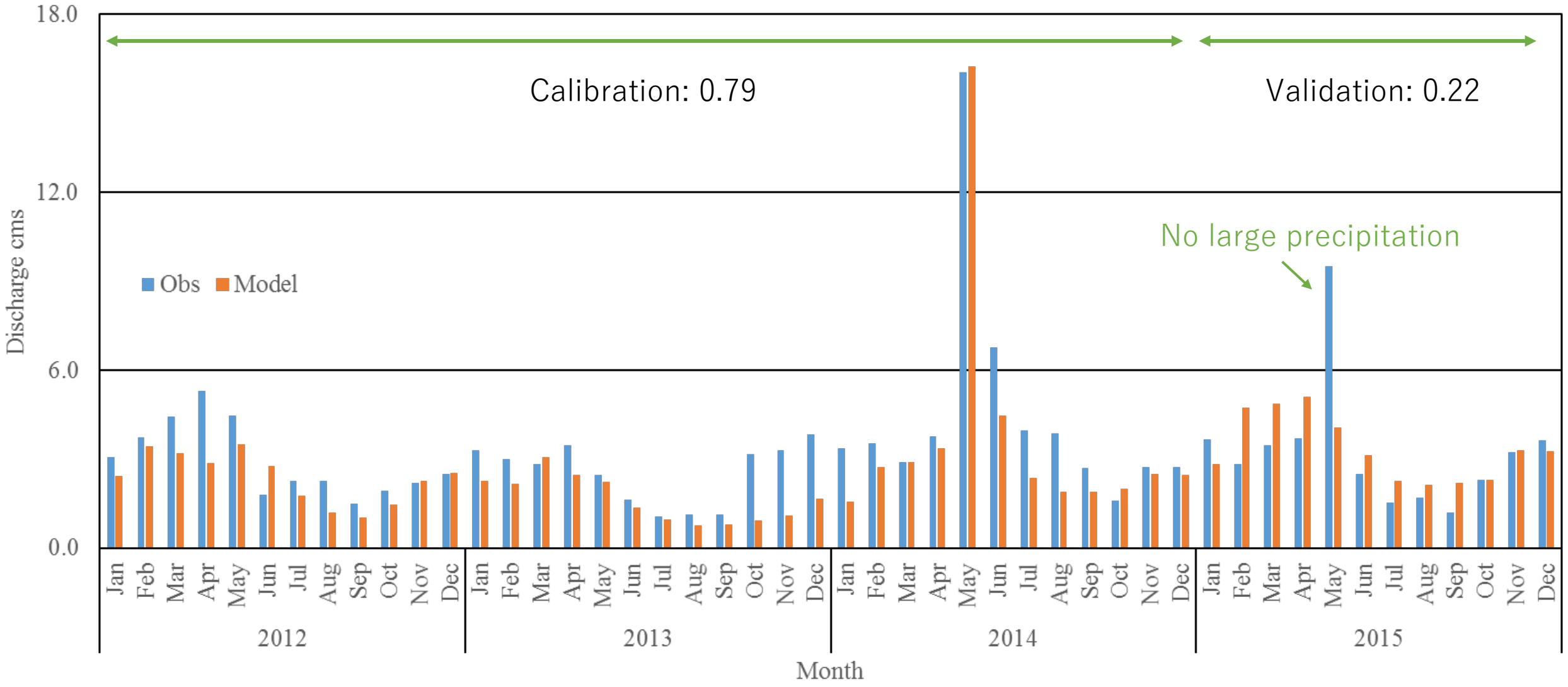


(Source: Dr. Thomas)

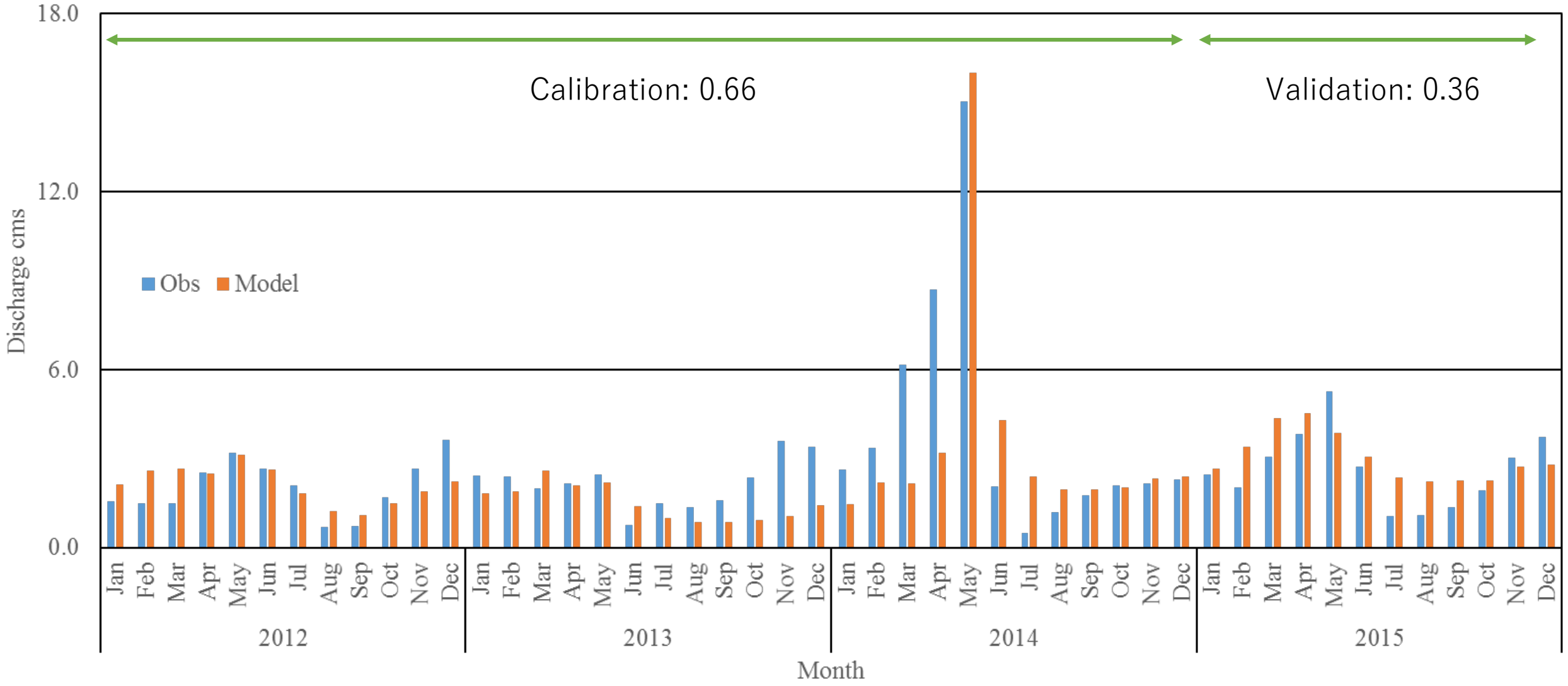
Acknowledgment

The information was prepared by Dr. Thomas M. Mosier (Oregon State University)

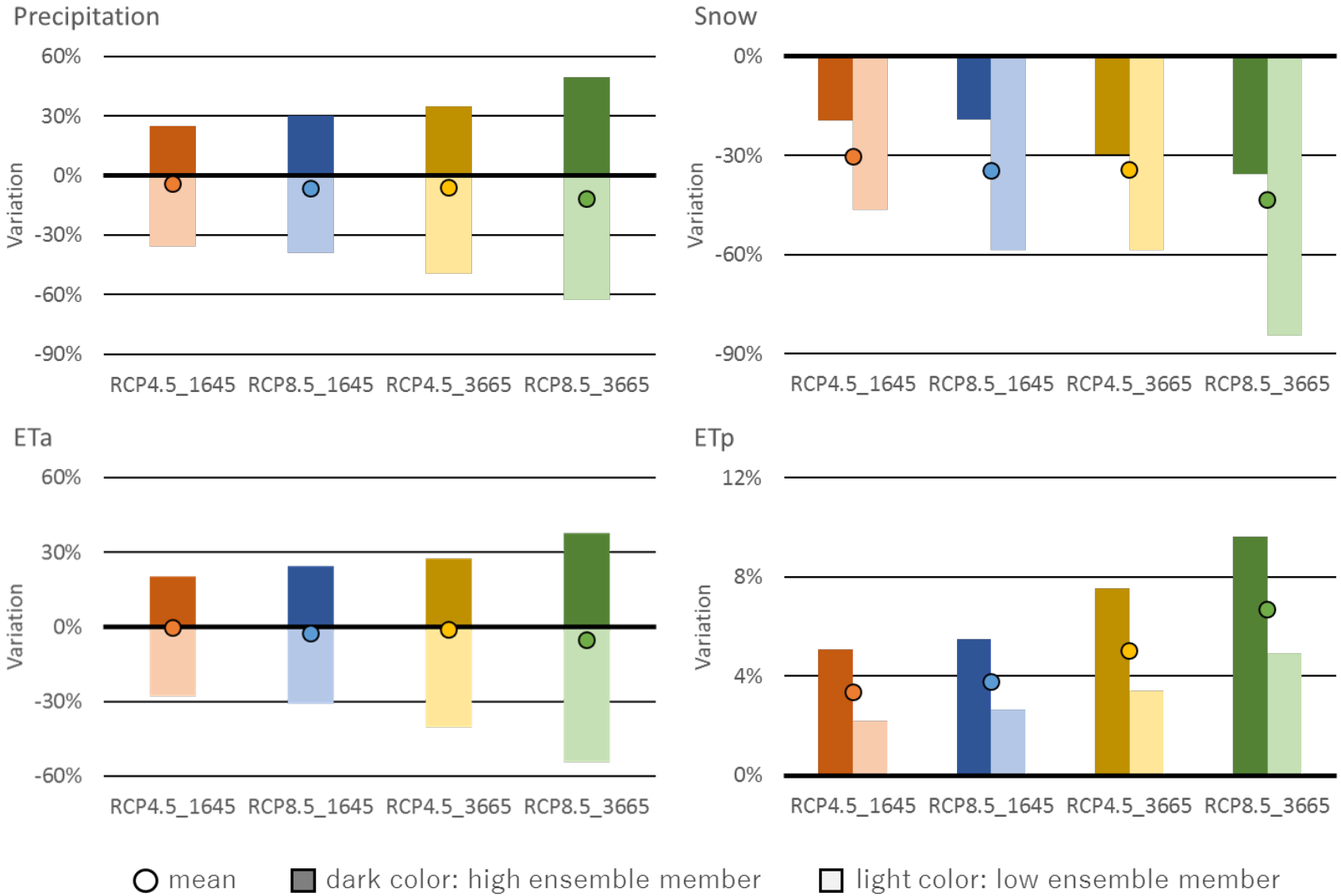
Reproducibility of flow - Tangi Tashqurghan



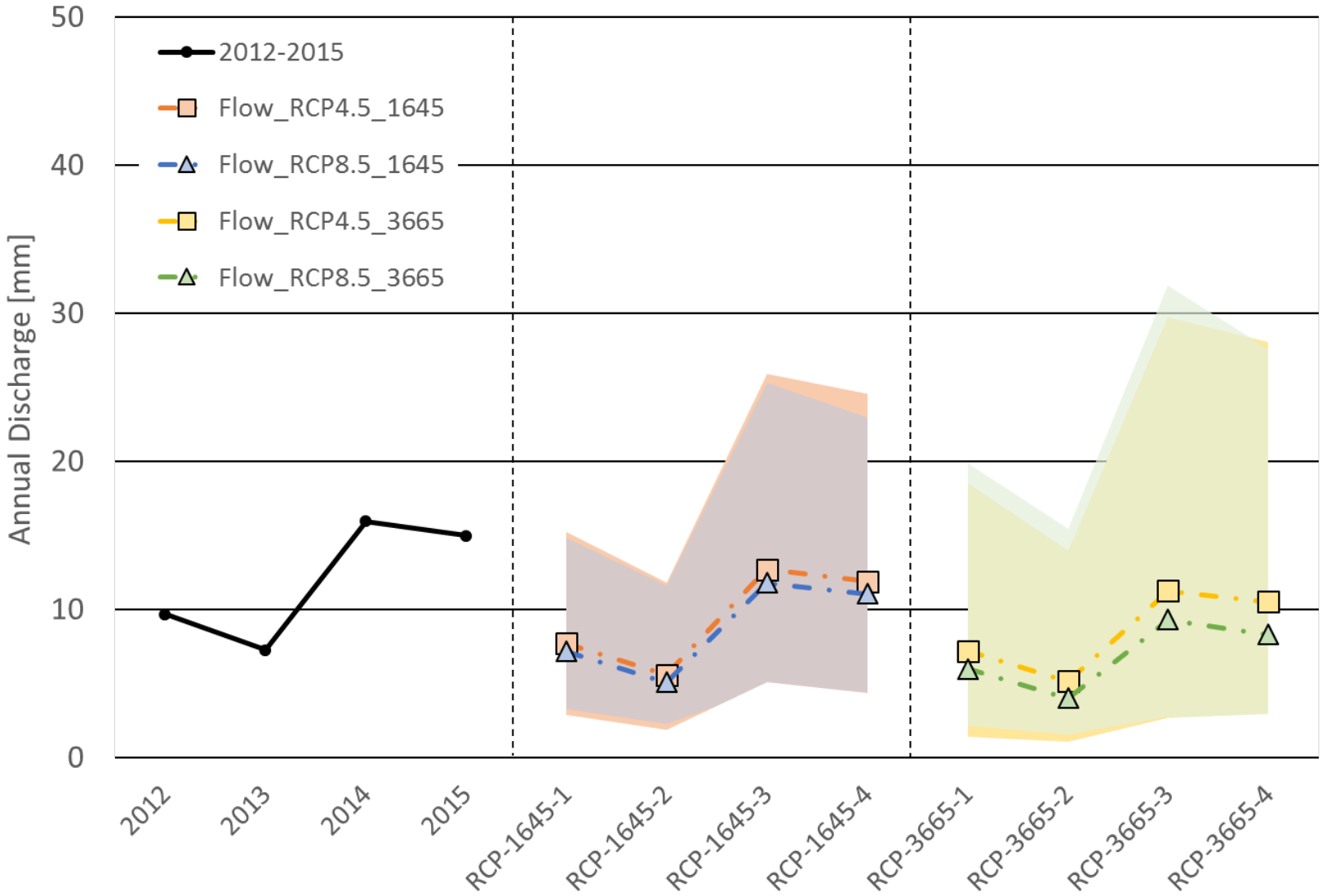
Reproducibility of flow - Sayad



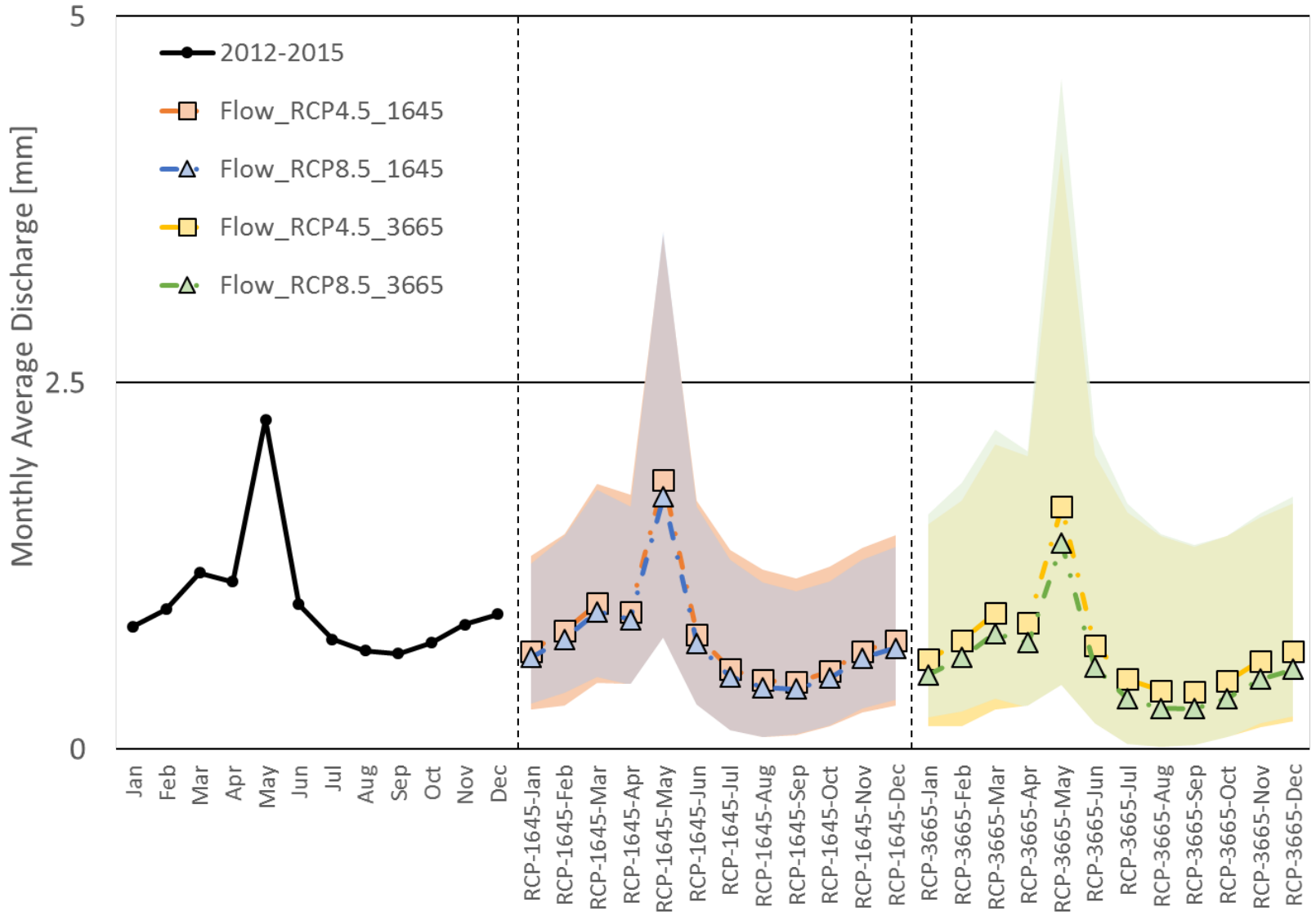
Sensitivity analyses under climate change scenarios - Variation of climate elements -



Sensitivity analyses under climate change scenarios - Annual discharge variation at Tangi Tashqurghan-



Sensitivity analyses under climate change scenarios
- Monthly discharge variation at Tangi Tashqurghan-



Sensitivity analyses under climate change scenarios

- Monthly variation of river discharge from Tangi Tashqurghan to Downstream-

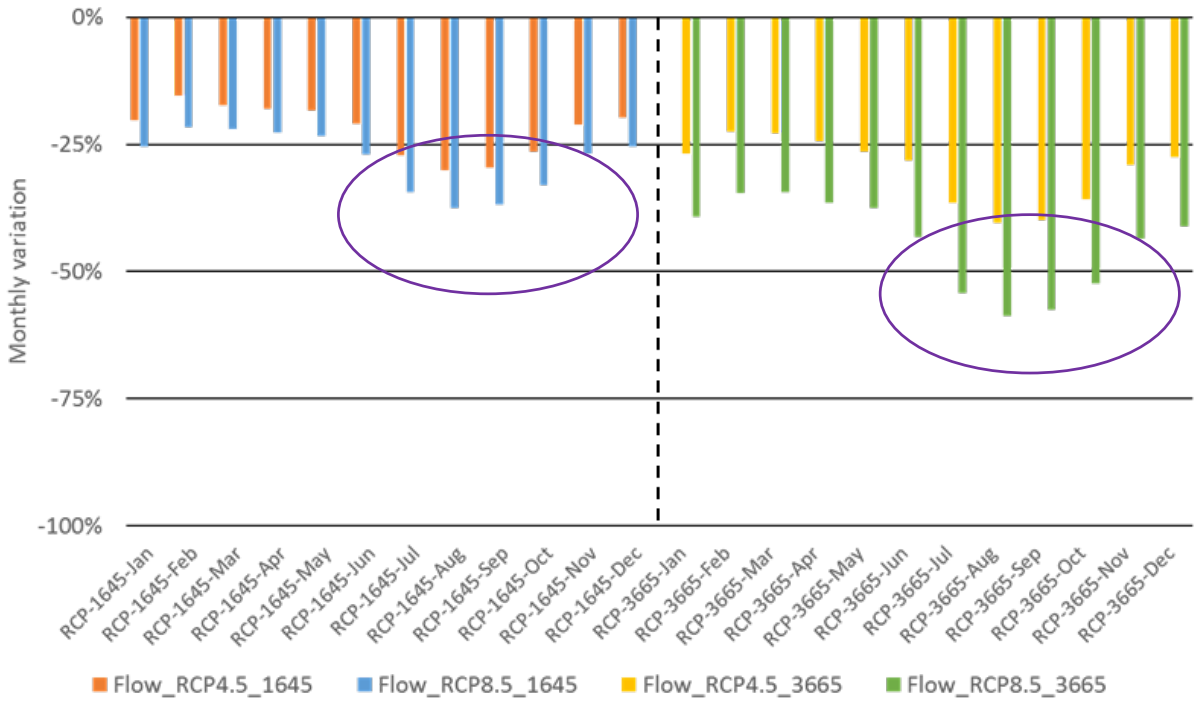
In annual basis, river discharge at Tangi Tashqurghan will be decreased (in the mean).

-21.2% under RCP4.5_1645
-27.0% under RCP8.5_1645

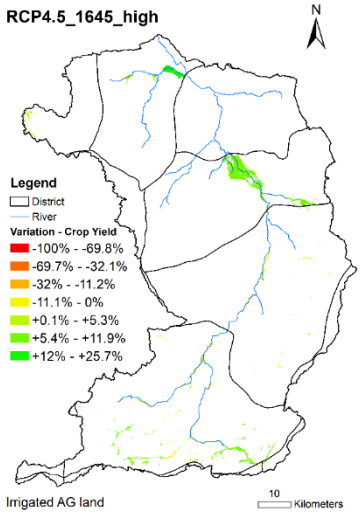
-28.5% under RCP4.5_3665
-42.4% under RCP8.5_3665

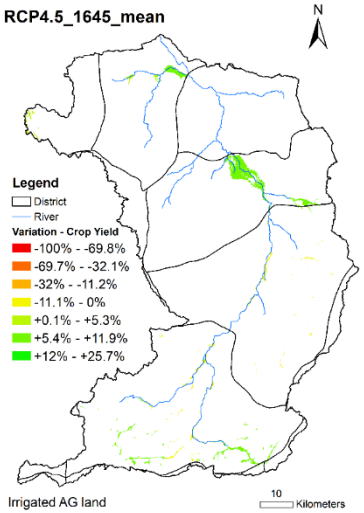
Khulm district will be influenced by future climate conditions

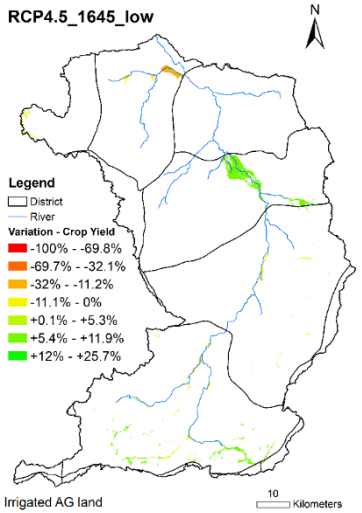
In monthly basis, larger decrease from July through October

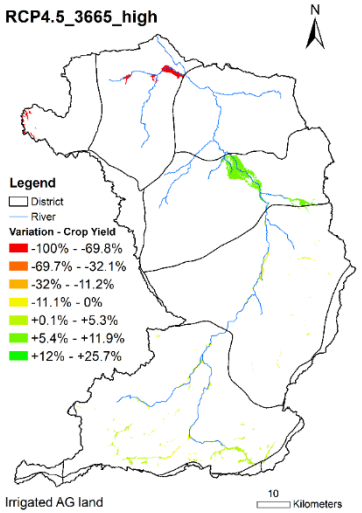


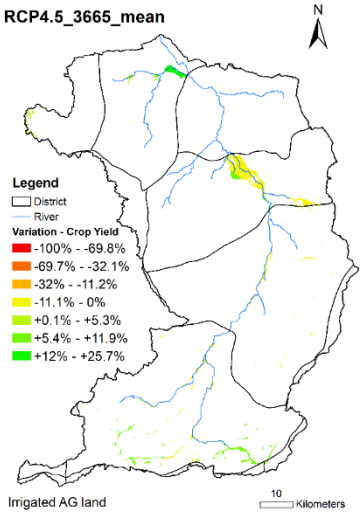
Sensitivity analyses under climate change scenarios - Crop yield (Wheat) variation : Irrigated AG land-

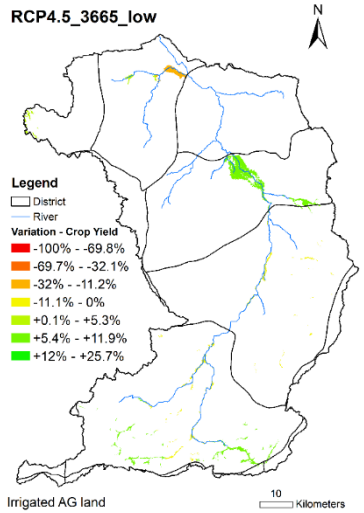


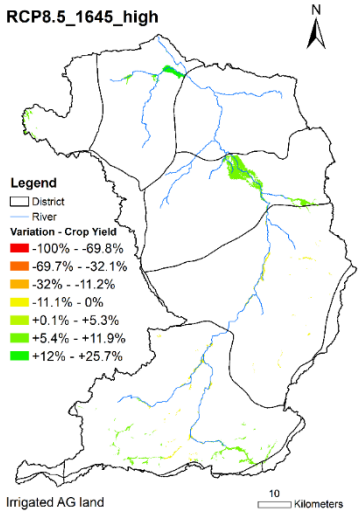


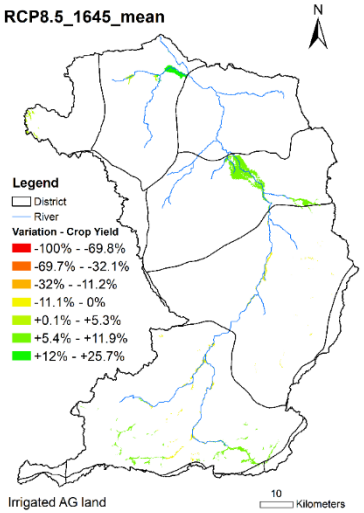


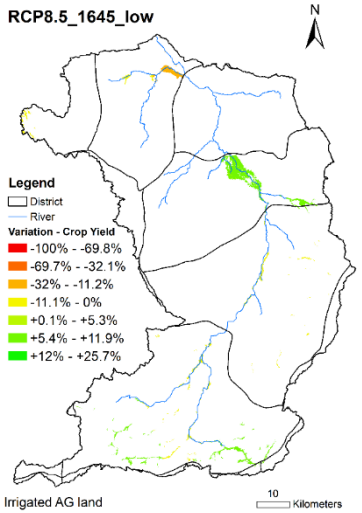


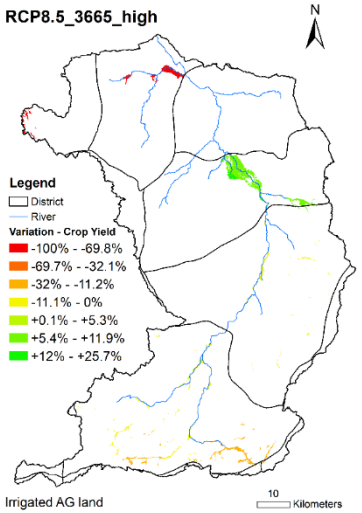


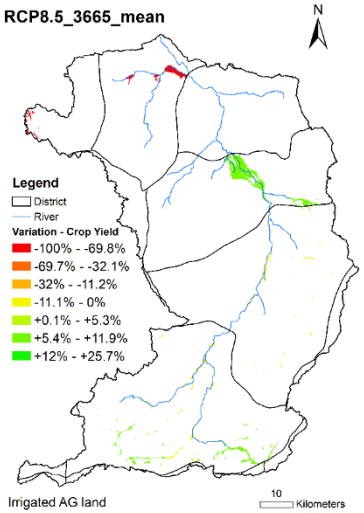


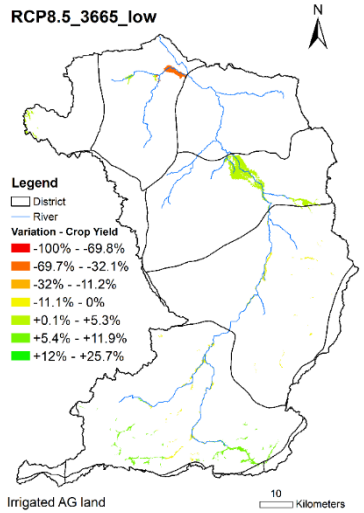




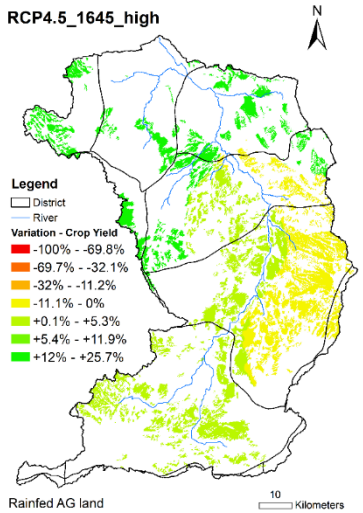


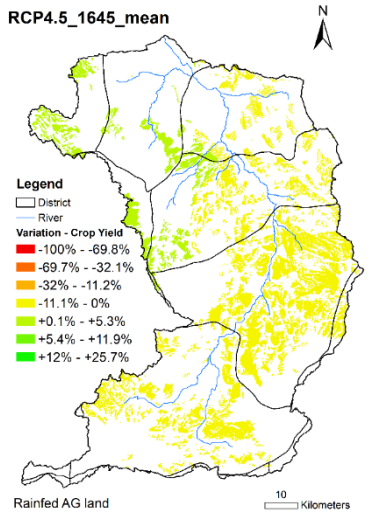


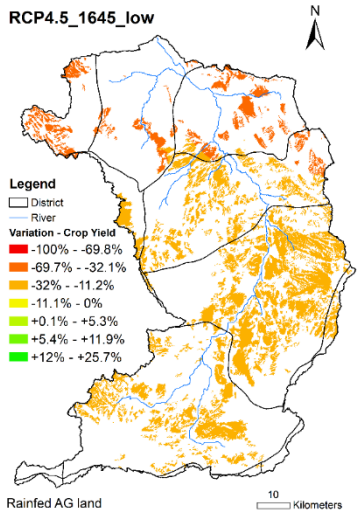


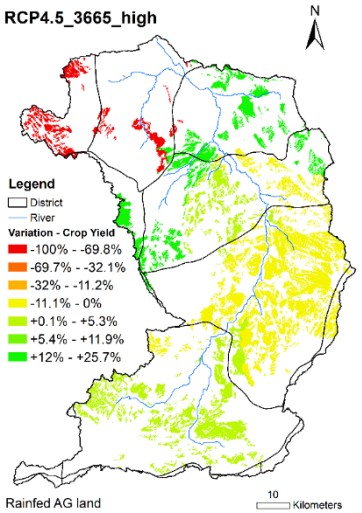


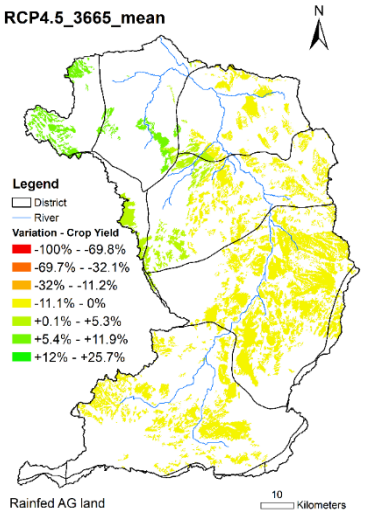
Sensitivity analyses under climate change scenarios - Crop yield (Wheat) variation : Rainfed AG land-

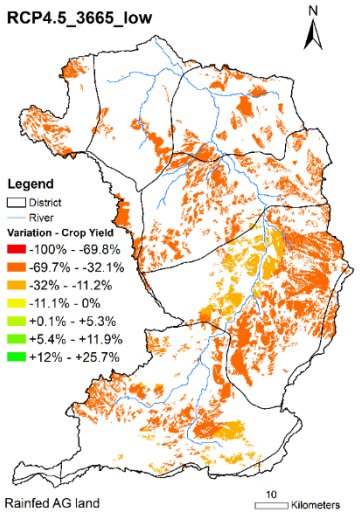


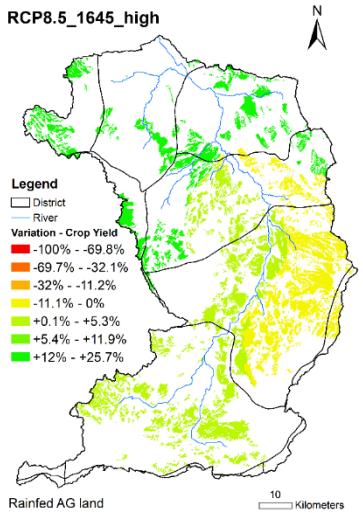


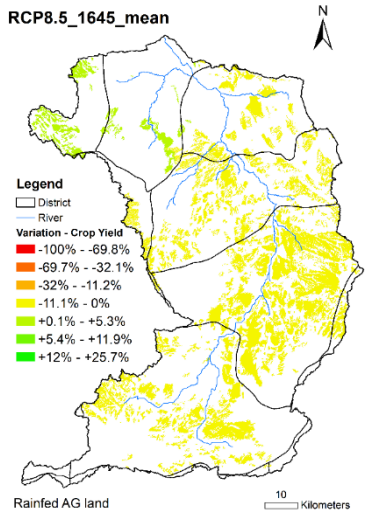


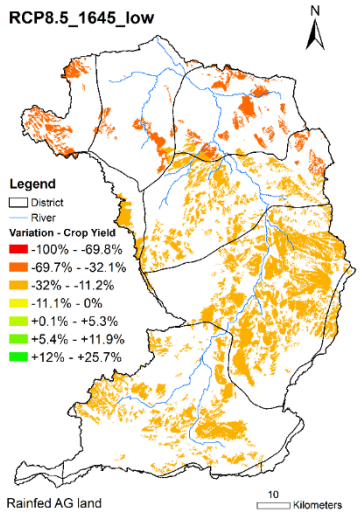


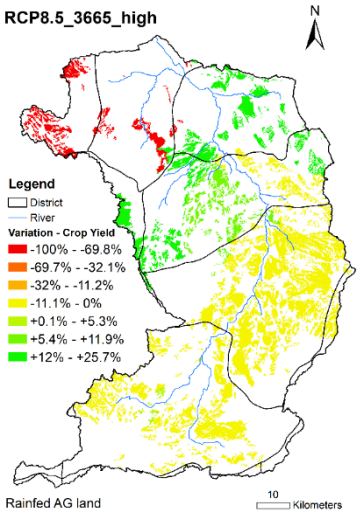


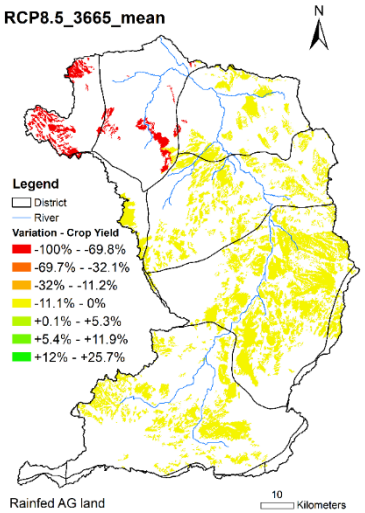


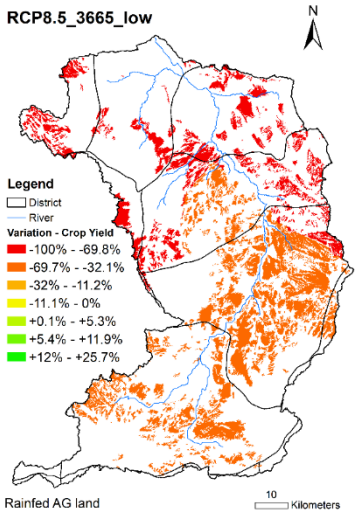












Conclusions

- SWAT was successfully applied to the target watershed (not yet obtained satisfactory result)
- Quality control of observed information need to be carried out for improving model outputs
- From projections of future climate, it was understood that precipitation will decrease in average, but variation of the projections is large. Thus, it is difficult to conclude water availability of the future at this moment
- Crop yield also increased or decreased depending on future projections. Thus, continuing study should be conducted for understanding future conditions of crop productivity

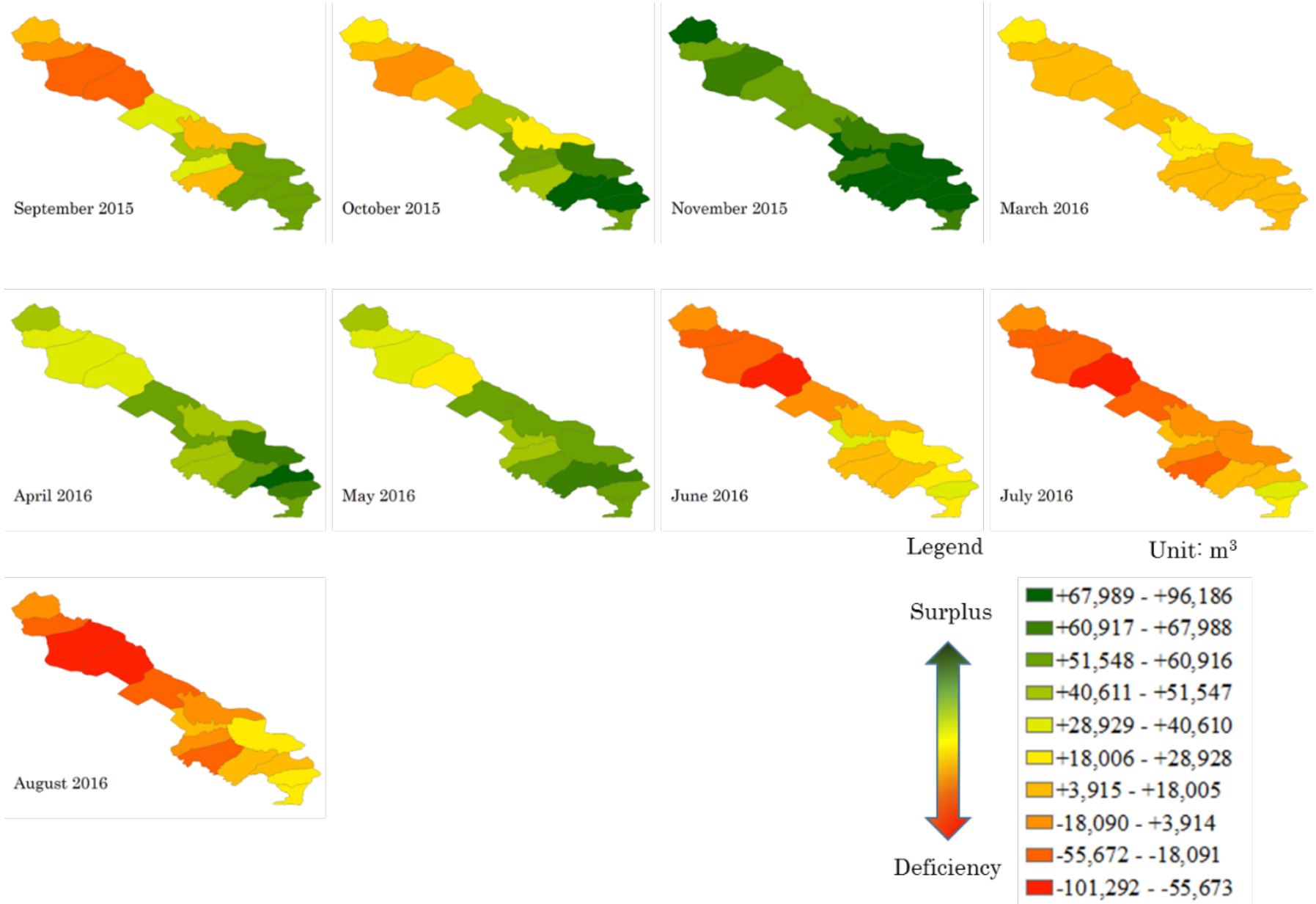
Acknowledgment

This study is in cooperation with:

- Dr. Toru Konishi, Ms. Akiko Nakagawa, and Dr. Thomas Mosier in World Bank
- Officials in Afghanistan Ministry of MEW and MAIL

Spatial distribution of water balance (supply vs. demand) to each block in the Zohrabi canal command area

For Irrigated AG land



Estimation of Solar Radiation (R_s)

➢Available Information

1. Solar radiation at Samangan (Aybak) from 2 Dec. 2015 to 8 Dec. 2016
   Source: MAIL
2. Sunshine Duration at Aybak from 1 Dec. 2015 to 31 Oct.2016
   Source: MEW

➢Parameter adjustment: Minimization of average relative error

MAIL info vs. Angstrom formula with MEW info

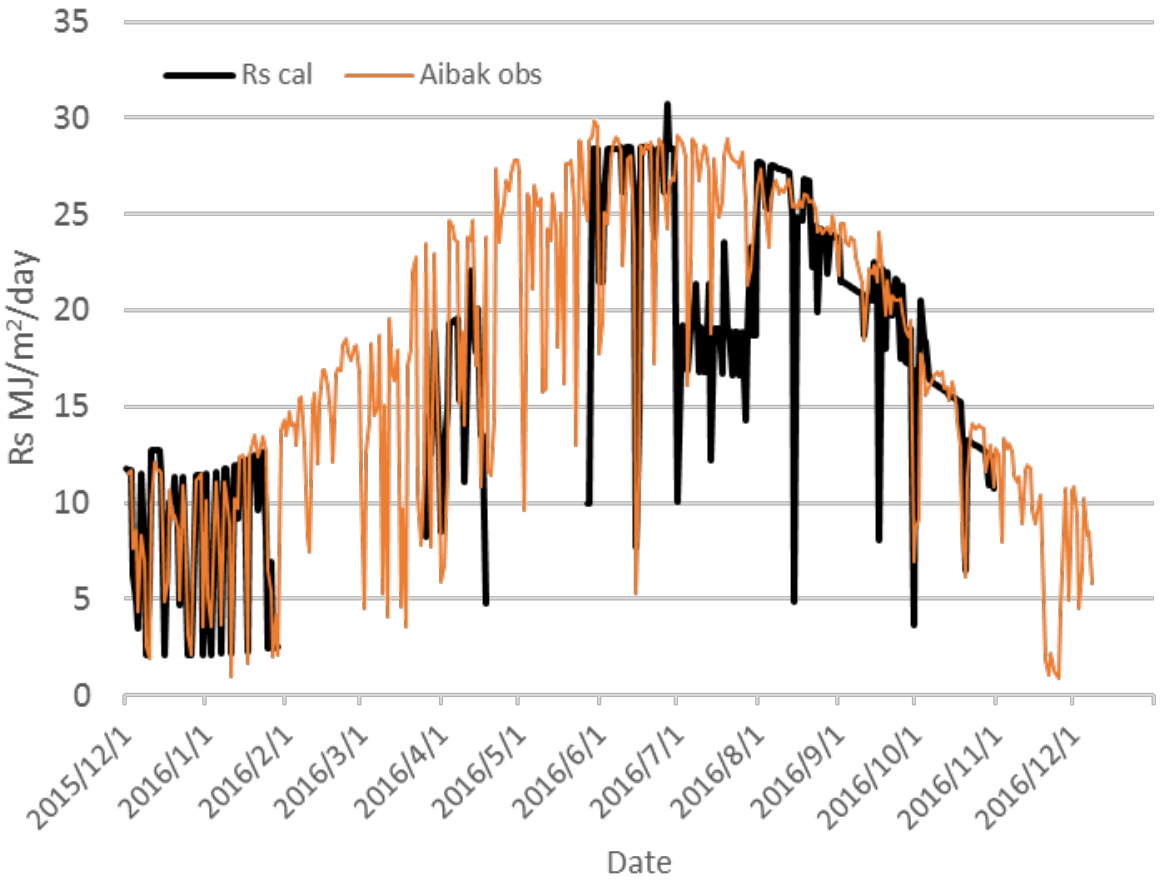
$$R_s = \left(a_s + b_s \frac{n}{N}\right) R_a$$

R_s: Solar Radiation[MJ/m^2/day], R_a: extraterrestrial radiation[MJ/m^2/day], n: Actual duration of sunshine[hour], N: Maximum possible of sunshine or daylight hours[hour], a_s: regression constant expressing the fraction of extraterrestrial radiation reaching the earth on overcast days (n=0), a_s+b_s: fraction of extraterrestrial radiation reaching the earth on clear days (n=N)

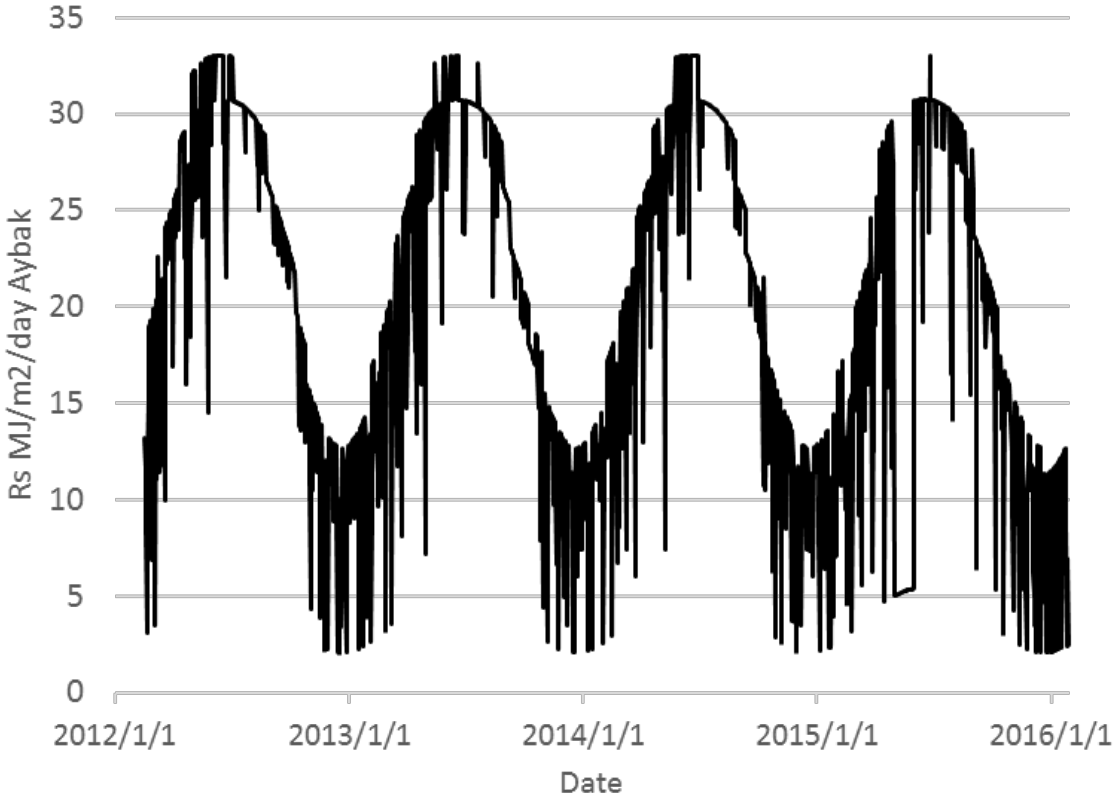
➢Estimation of Solar Radiation

Solar Radiation at Aybak (Lat. 36.279 Lon. 67.982) from 17 Feb 2012 to 29 Jan 2016

Estimation of Solar Radiation (R_s)



Calibration of a_s and b_s



Estimated Aybak Solar Radiation
from 17 Feb 2012 to 29 Jan 2016