Xinjiang Institute of Ecology and Geography
Chinese Academy of Sciences

The fifth conference "Management of Ecosystems and Environmental Changes in Arid Lands"(MEECAL) in Urumqi, China

Drought monitor by using different indices and various sources of data

By: Nasrin Salehnia

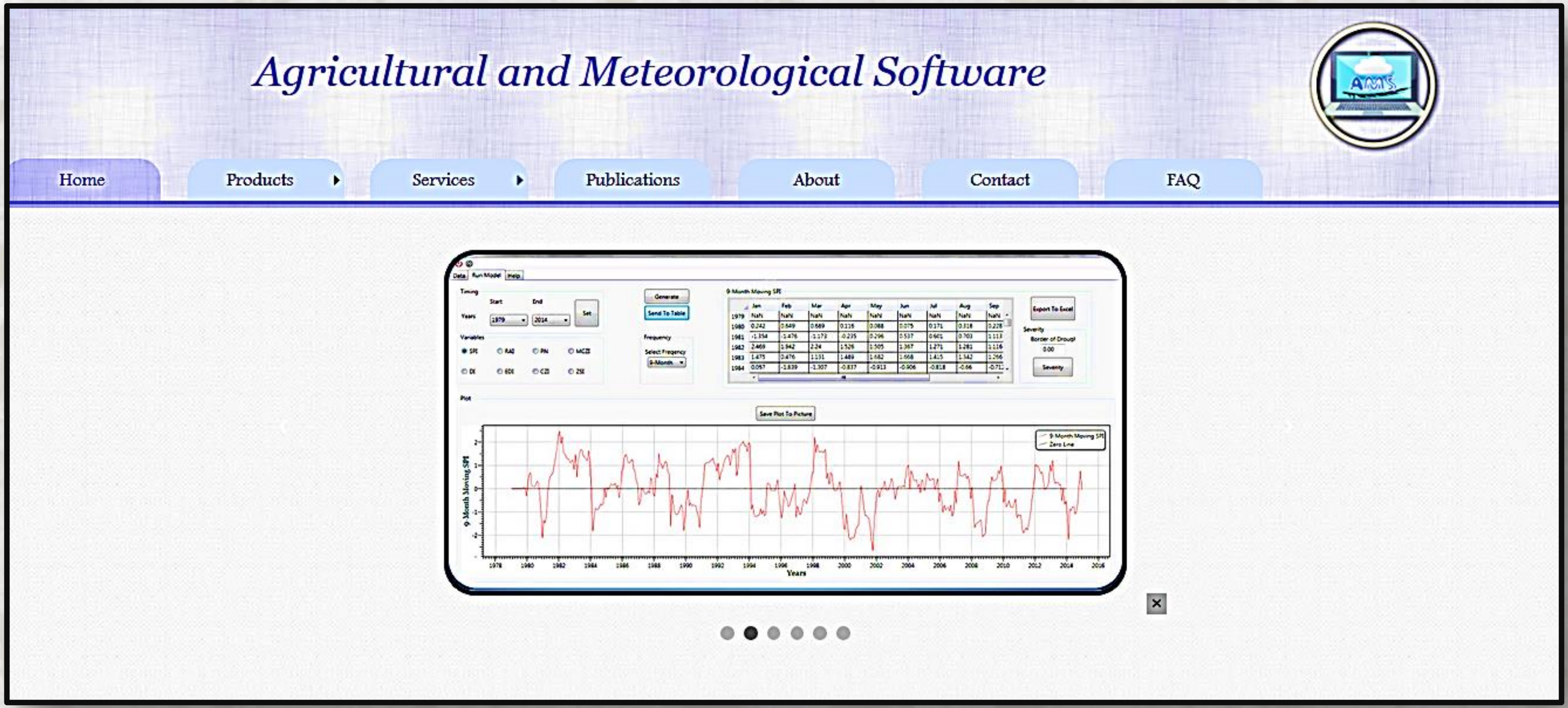
Agrimetsoft.com

Sep. 11, 2018
4:00 pm

Who am I?

- BSc. is in computer - software engineering (2002-2006).
- M.S. in Agrometeorology (2009-2011).
- Ph.D. in Agrometeorology (2013-2017).
- Visiting scholar in Florida University/USA.

Agrimetsoft Lab



Highlights

What Is Drought?

Drought Indices

Sources of Data

DDI

Drought Tools

Introduction

☼ Drought, in contrast to aridity, affects almost all climates in the world (WMO, 2006).

☼There is no universal definition of drought.

☼Drought is a deficit in normal precipitation for a region over a period of time.

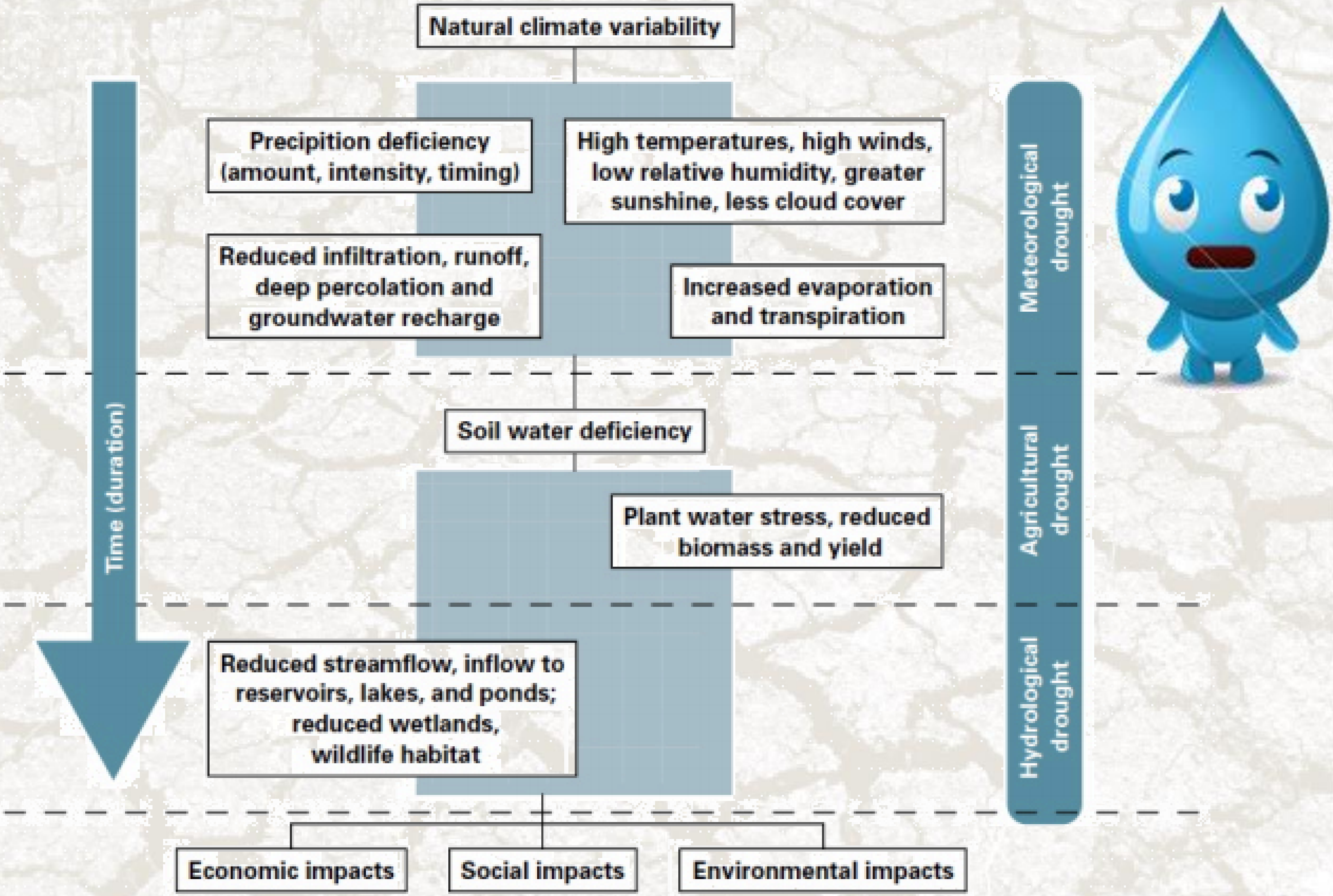
Drought effects

Droughts are expected to increase in frequency and severity → economic, social and environmental sectors of effected populations of virtually all nations (IPCC 2012).

FAO: $29 billion in losses to developing world agriculture between 2005 and 2015.

23 Mha of Asian rice producing areas experience frequent yield loss due to drought.

In Europe → €5.3 billion, In 2003, drought in Europe → €8.7 billion (European Communities, 2007).



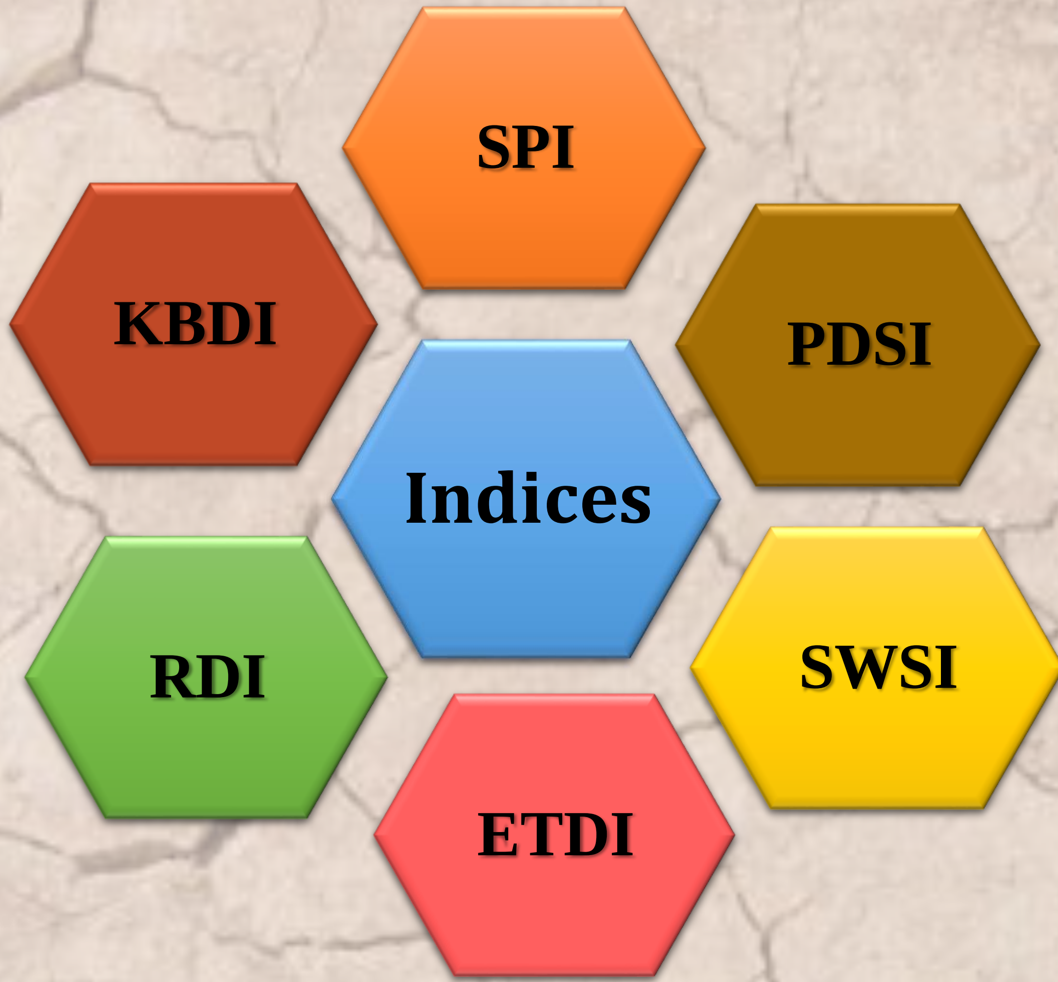
(Source: National Drought Mitigation Center, University of Nebraska-Lincoln, U.S.A.)

Monitoring Drought

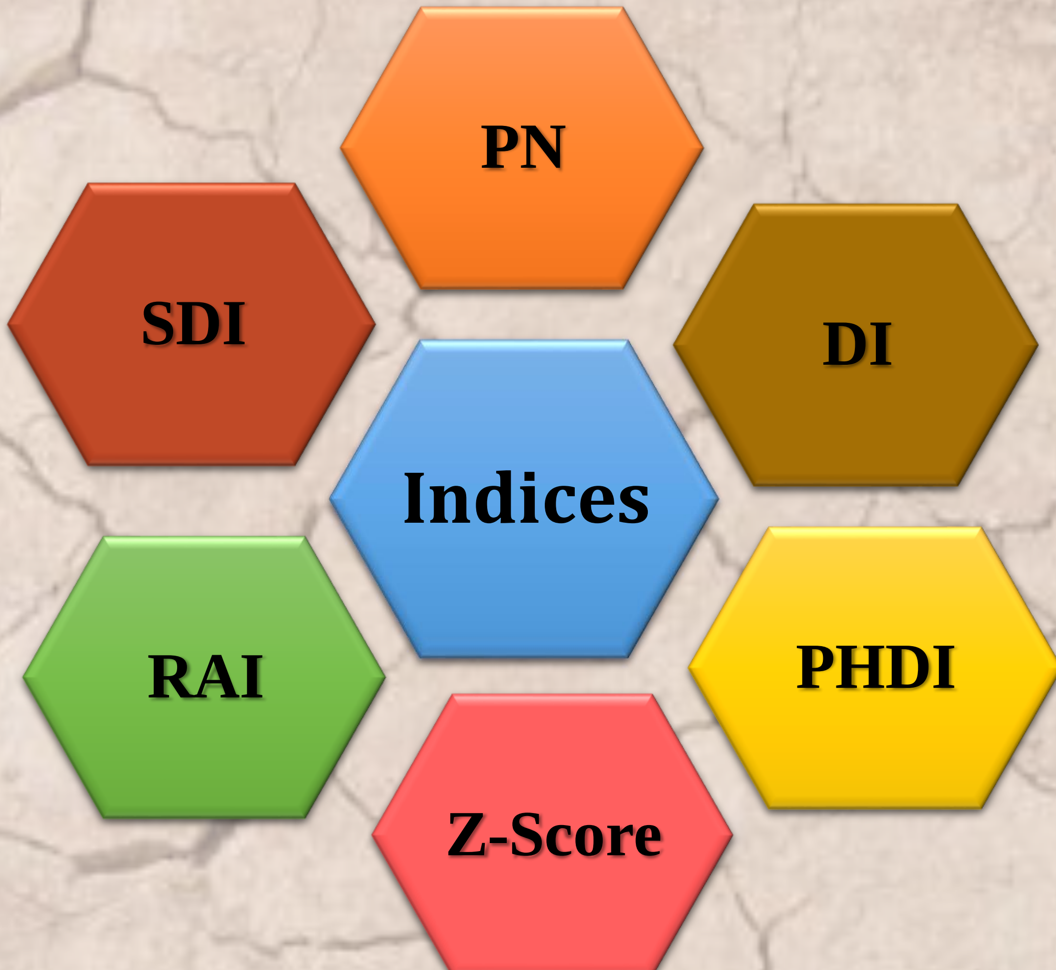
☼ Monitoring meteorological drought is a vital and important part of drought risk mitigation (Li et al., 2017) on a global scale (WMO, 2013; Li et al., 2014).

☼ For drought monitoring, various drought indices have been developed to describe the intensity of a drought.

Different Drought Indices



Different Drought Indices



By: Nasrin Salehnia

Sources of Data

In-Situ (1)

- ✓ Synoptic station
- ✓ Climatology Station
- ✓ Hydrometric Station
- ✓ Agricultural Station

Gridded Data (2)

- ✓ AgMERRA
- ✓ CRU
- ✓ TRMM
- ✓ ERA

Satellite Data & Products (3)

- ✓ MODIS
- ✓ MERRA
- ✓ AVHRR
- ✓ ….

GCM Data (4)

- ✓ CMIP3
- ✓ CMIP5
- ✓ CMIP6

J Arid Land (2017) 9(6): 797–809
https://doi.org/10.1007/s40333-017-0070-y
Science Press Springer-Verlag

Estimation of meteorological drought indices based on AgMERRA precipitation data and station-observed precipitation data

Nasrin Salehnia[1], Amin Alizadeh[1*], Hossein Sanaeinejad[1], Mohammad Bannayan[1], Azar Zarrin[2], Gerrit Hoogenboom[3]

[1] Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad 9177948944, Iran;
[2] Department of Geography, Ferdowsi University of Mashhad, Mashhad 9177948974, Iran;
[3] Institute for Sustainable Food System, University of Florida, Gainesville 110570, USA

Case Study

Table 1 Characteristics of the three weather stations

Station	Latitude	Longitude	Elevation (m)	Average T_{max} (°C)	Average T_{min} (°C)	Precipitation (mm)	Climate
Mashhad	36°16′N	59°38′E	999	21.6	8.3	256	Semi-arid
Ghoochan	37°04′N	58°30′E	1287	19.4	6.1	308	Semi-arid
Golmakan	36°29′N	59°17′E	1176	20.4	6.7	208	Arid

Note: T_{max}, maximum temperature; T_{min}, minimum temperature.

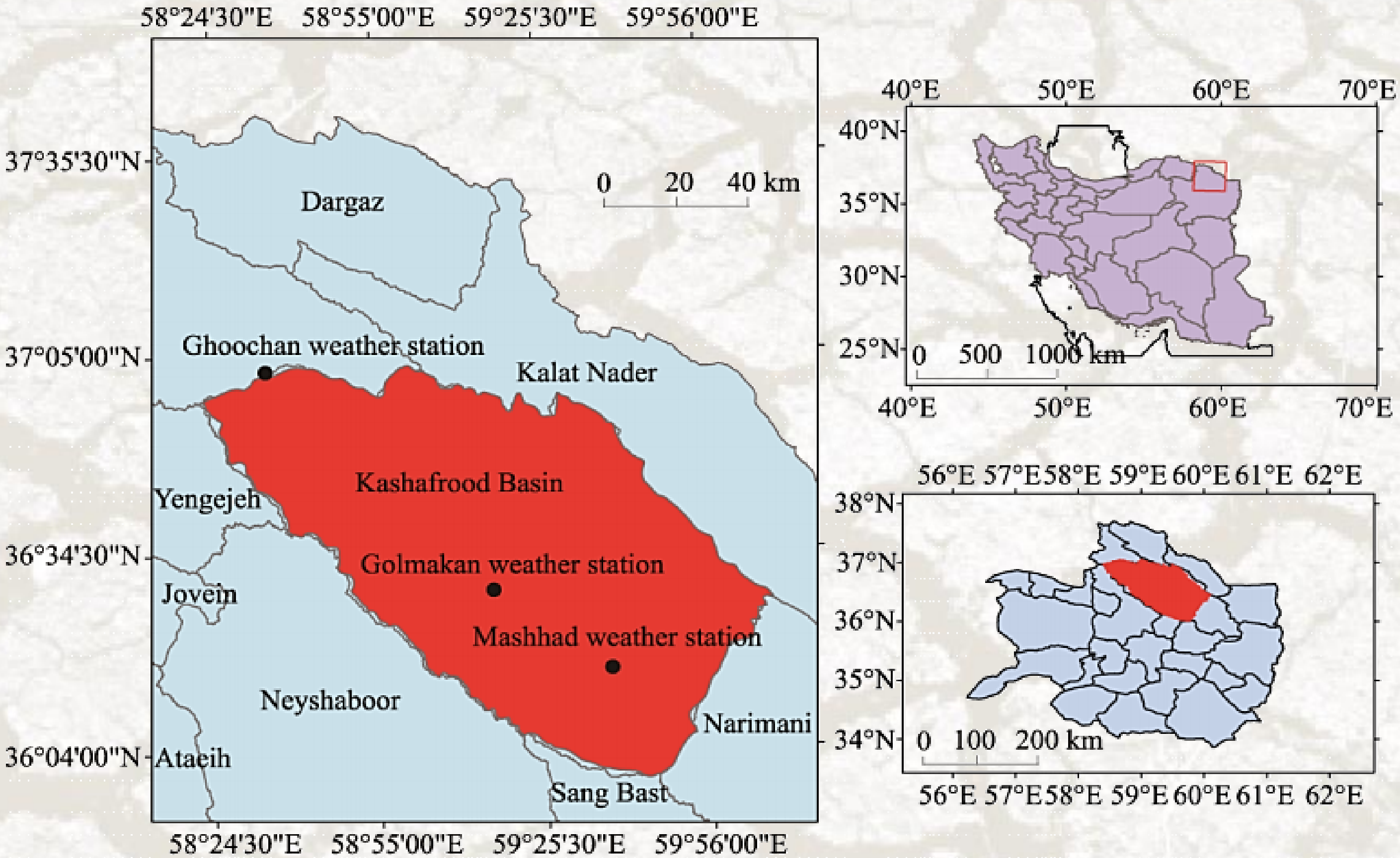
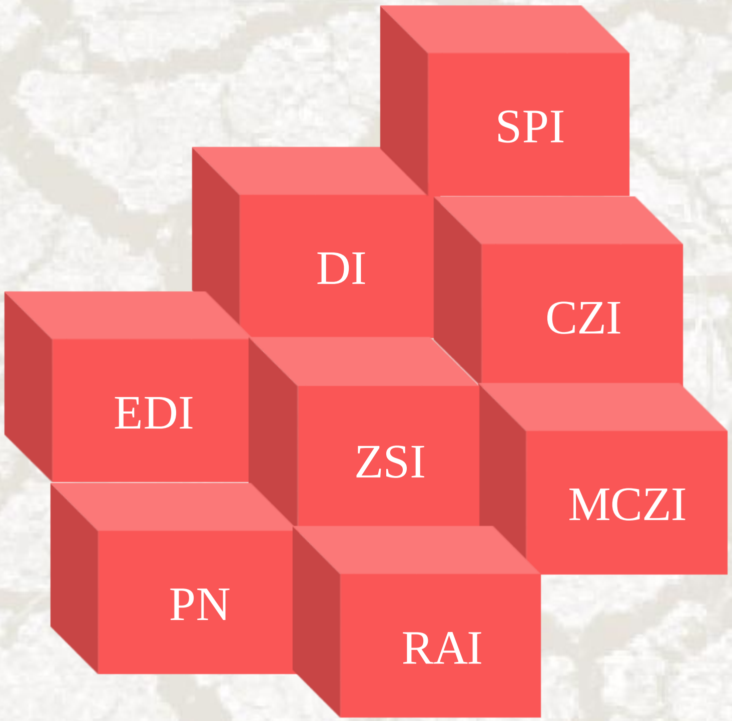


Fig. 1 Location of Kashafrood Basin (left map) in the Khorasan Province (lower-right map) of Iran (upper-right map)

☼ Rain-based Drought Indices



$$g(x)=\frac{1}{\beta^{\alpha}\Gamma(\alpha)}x^{\alpha-1}e^{\frac{-x}{\beta}}$$

$$CZI_{ij}=\frac{6}{C_{si}}\times\left(\frac{C_{si}}{2}\times\varphi_{ij}+1\right)^{1/3}-\frac{6}{C_{si}}+\frac{C_{si}}{6}$$

$$PNI={}^{P_i}\!/_{P}\times 100$$

$$EP_i=\sum_{n=1}^{i}\left(\frac{\left(\sum_{m=1}^{n}P_m\right)}{n}\right),\quad ZSI=\frac{P_i-\overline{P}}{SD},$$

$$RAI=3\times\left[\frac{(p-\overline{p})}{(\overline{m}-\overline{p})}\right],$$

DDI (Degree of Dryness)

$$DDI_y^{st} = \sum_{int=1}^{N_{int}} a_{int} \times N_{int,y},$$

$$DDI_y = \frac{\left[\sum_{st=1}^{N_{st}} DDI_y^{st}\right]}{N_{st}},$$

- a_{int} is the intensity of drought, with 1 for moderate drought, 2 for severe drought, and 3 for extreme drought;
- $N_{int,y}$ is the number of dry months for each drought category in each year;

Extreme, Severe, or Moderate

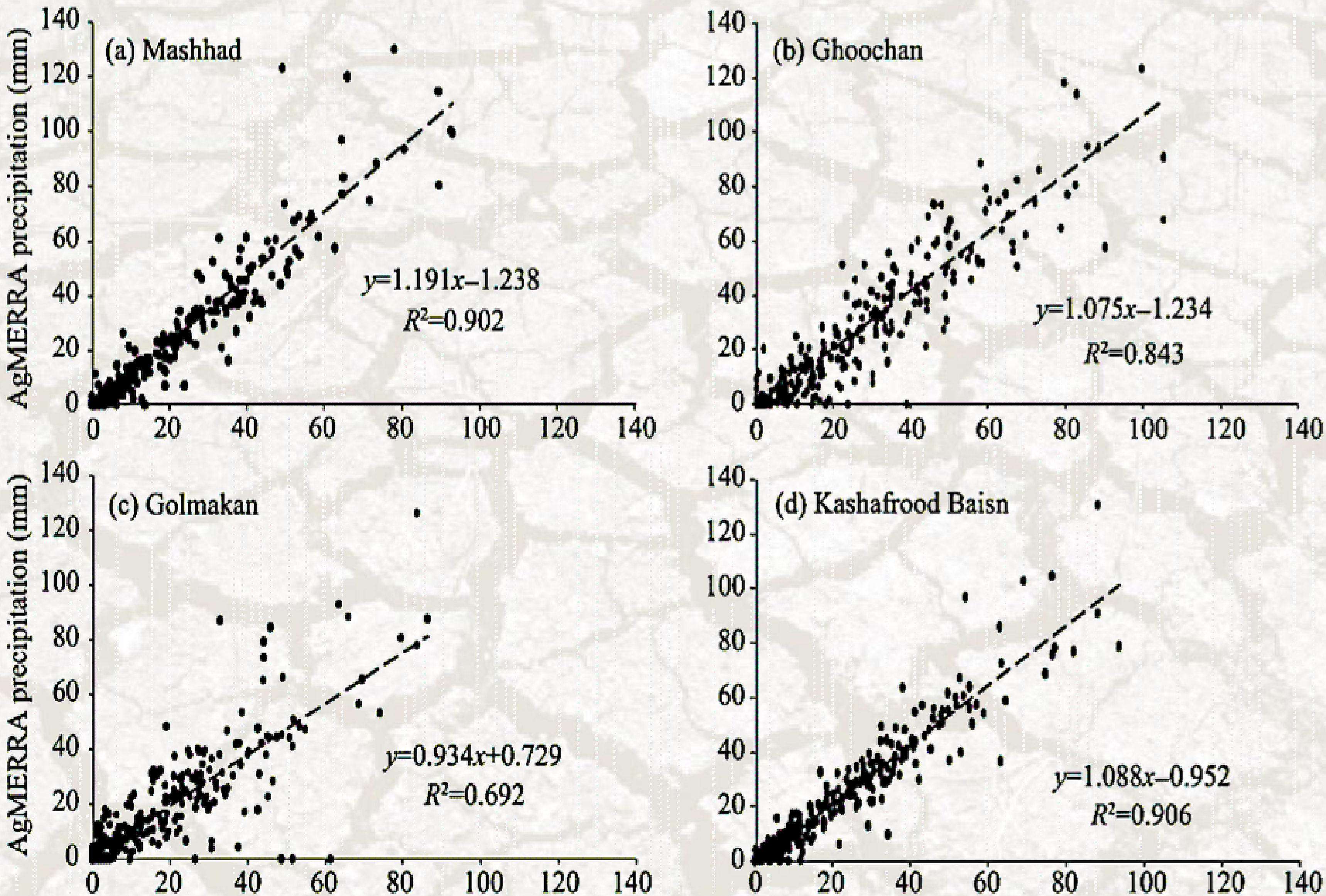
- DDI_y is the average value of degree of dryness index in each year for all stations; and N_{st} is the number of stations

DDI=(1×3)+(0×2)+(2×1)=5

By: Nasrin Salehnia

Results

Comparison of AgMERRA vs. Station Data



By: Nasrin Salehnia

Agrimetsoft.com

Comparison of AgMERRA vs. Station Data

Table 2 Statistical indices between the AgMERRA precipitation data and the station-observed precipitation data for Mashhad, Ghoochan, Golmakan stations and for the Kashafrood Basin

Region	ABIAS (%)	MAE (mm)	ME (mm)	r
Ghoochan	28.4	7.17	−0.67	0.92
Golmakan	37.5	6.45	0.39	0.85
Mashhad	25.2	4.50	−2.20	0.96
Kashafrood Basin	21.0	4.20	−0.83	0.95

Note: *ABIAS*, relative absolute bias; *MAE*, mean absolute error; *ME*, mean errors; *r*, Pearson's correlation coefficient.

☼ The AgMERRA precipitation data are quite consistent with the station-observed precipitation data

Comparison of Drought Indices

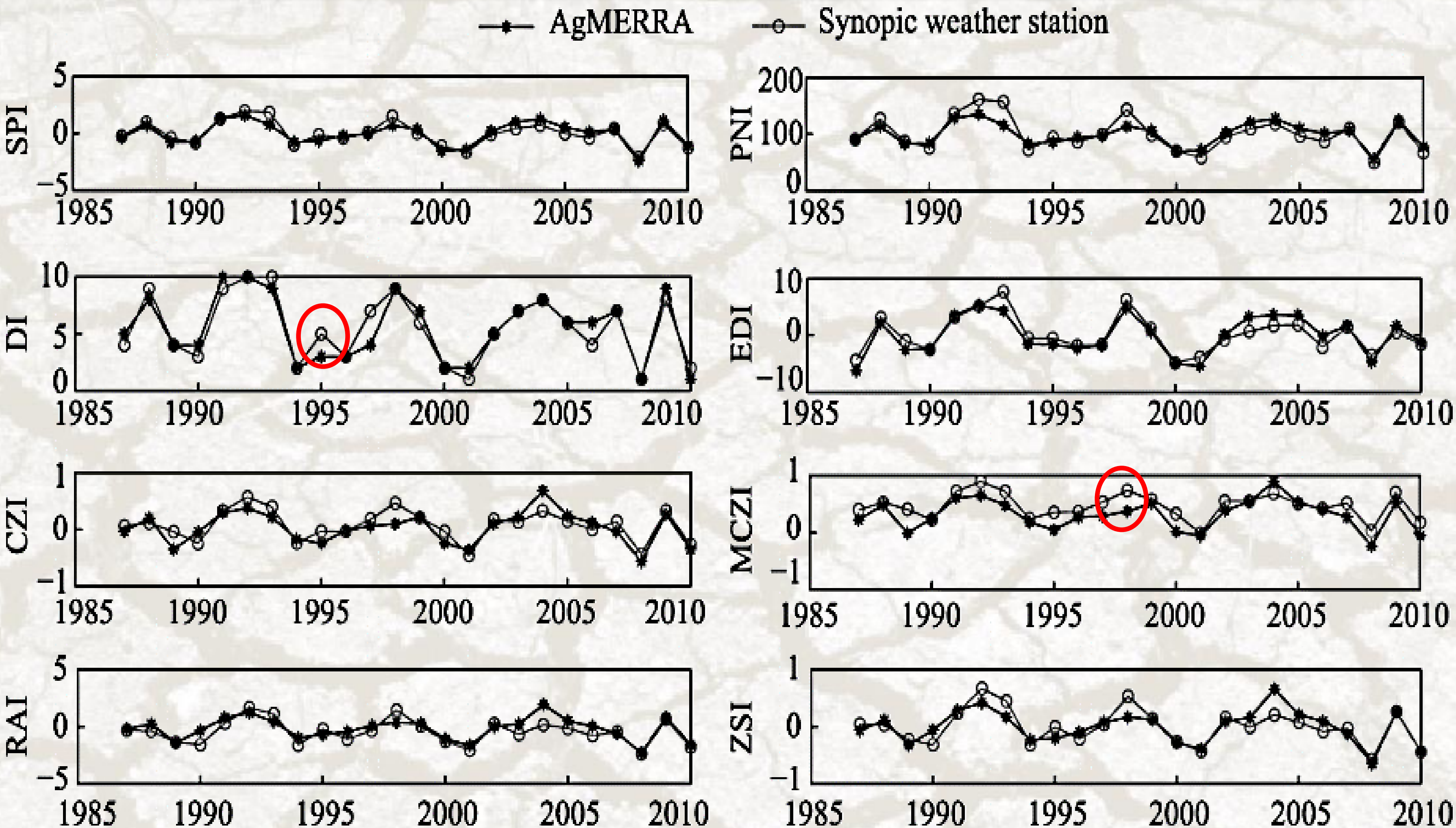


Fig. 3 Comparison of eight drought indices derived from the AgMERRA precipitation data and from the station-observed precipitation data at an annual time scale for Mashhad station. SPI, Standardized Precipitation Index; PNI, Percent of Normal Index; DI, Deciles index; EDI, Effective Drought Index; CZI, China-Z Index; MCZI, Modified CZI; RAI, Rainfall Anomaly Index; ZSI, Z-score Index.

Comparison of Drought Indices

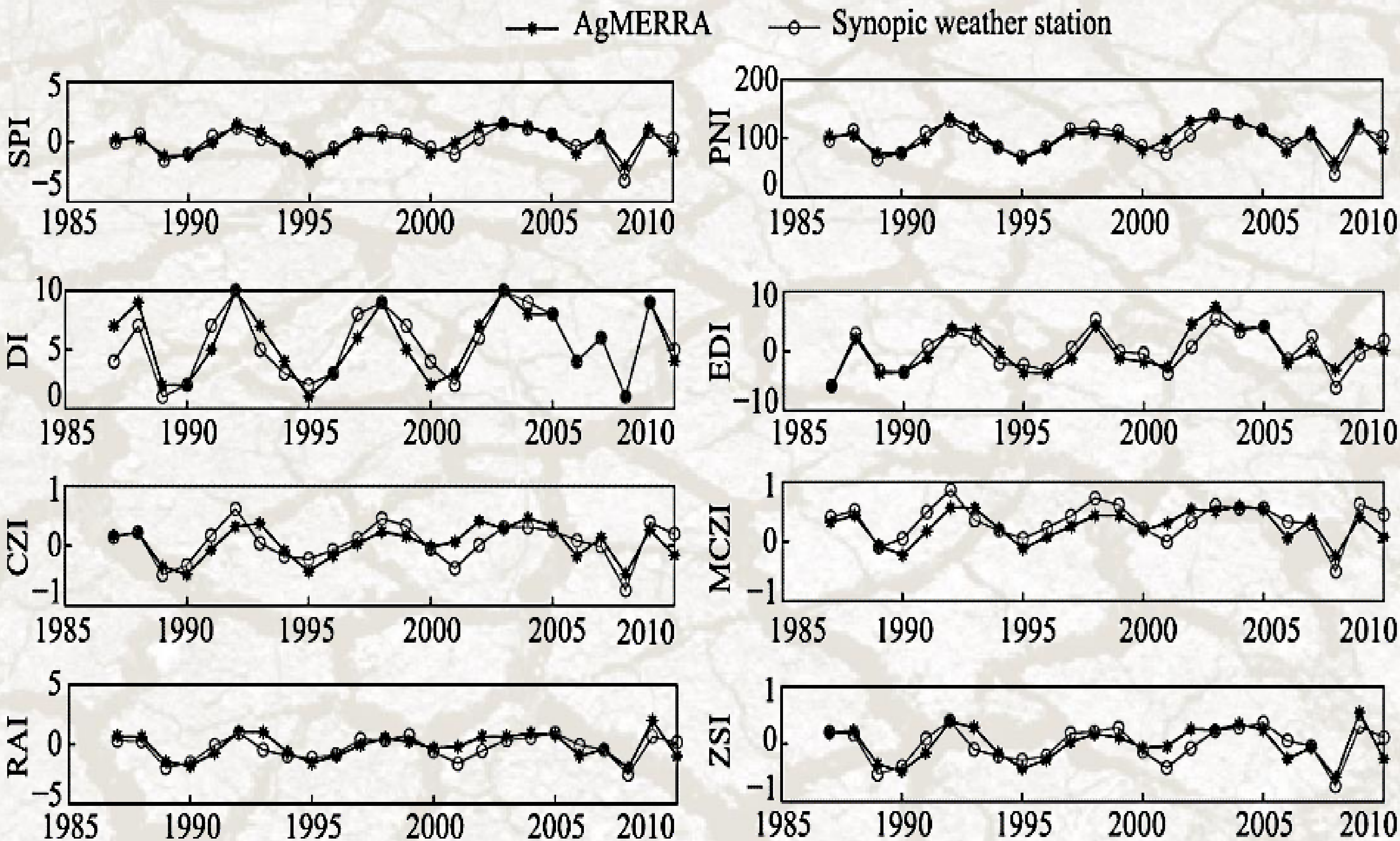


Fig. 4 Comparison of eight drought indices derived from the AgMERRA precipitation data and from the station-observed precipitation data at an annual time scale for Ghoochan station

Comparison of Drought Indices

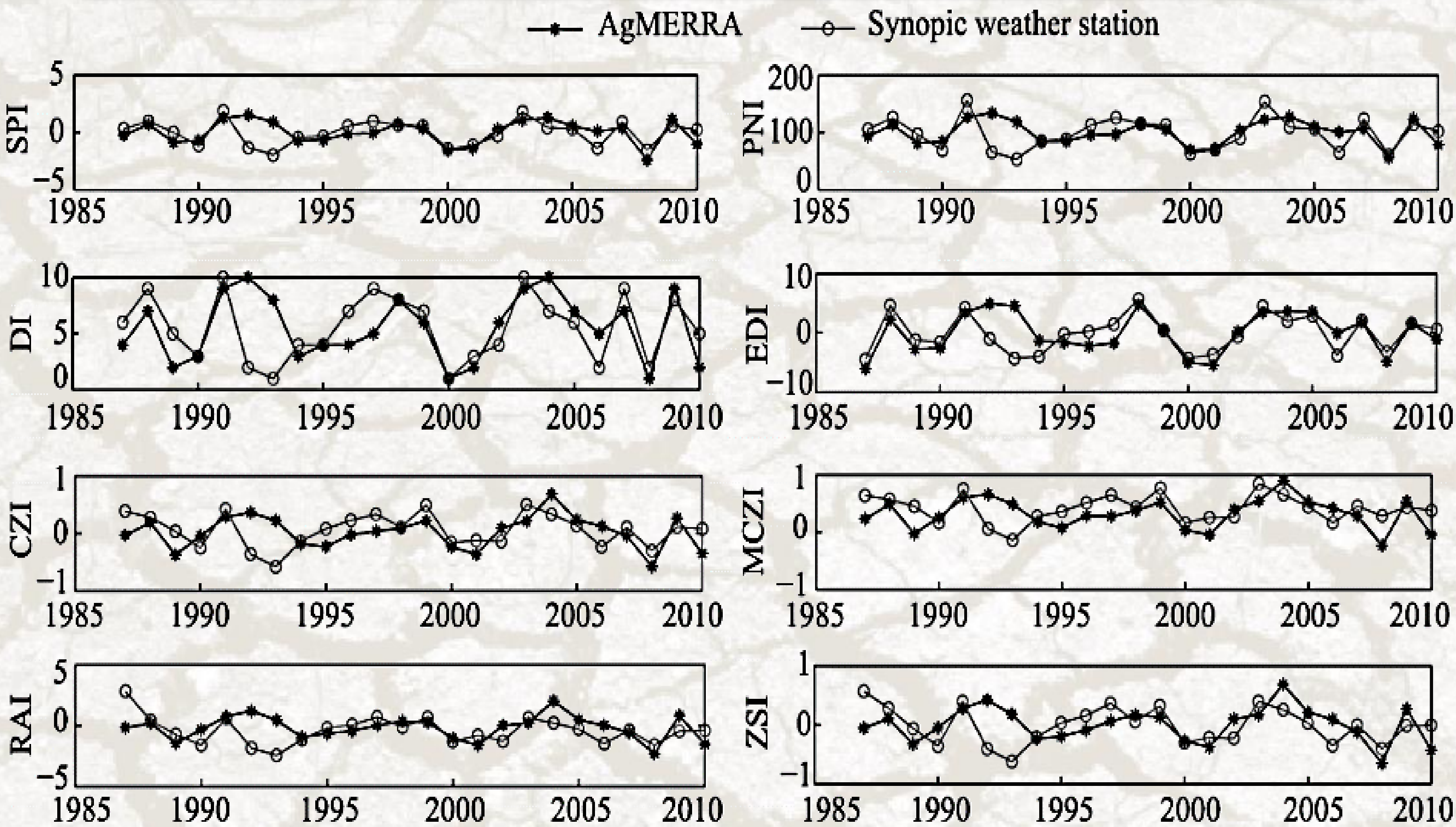


Fig. 5 Comparison of eight drought indices derived from the AgMERRA precipitation data and from the station-observed precipitation data at an annual time scale for Golmakan station

Comparison of Drought Indices

Table 4 Pearson's correlation coefficients between drought indices derived from the AgMERRA precipitation data on an average annual basis

	SPI	PNI	DI	EDI	CZI	MCZI	RAI	ZSI
SPI	1.00	0.99	0.99	0.84	0.94	0.95	0.94	0.95
PNI	0.99	1.00	0.99	0.85	0.94	0.95	0.94	0.95
DI	0.99	0.99	1.00	0.85	0.94	0.95	0.94	0.95
EDI	0.84	0.85	0.85	1.00	0.78	0.81	0.74	0.76
CZI	0.94	0.94	0.94	0.78	1.00	0.99	0.98	0.98
MCZI	0.95	0.95	0.95	0.81	0.99	1.00	0.96	0.97
RAI	0.94	0.94	0.94	0.74	0.98	0.96	1.00	0.99
ZSI	0.95	0.95	0.95	0.76	0.98	0.97	0.99	1.00

Table 5 Pearson's correlation coefficients between drought indices derived from the station-observed precipitation data on an average annual basis

	SPI	PNI	DI	EDI	CZI	MCZI	RAI	ZSI
SPI	1.00	0.99	0.99	0.84	0.94	0.96	0.87	0.92
PNI	0.99	1.00	0.99	0.86	0.92	0.95	0.85	0.90
DI	0.99	0.99	1.00	0.86	0.92	0.95	0.85	0.90
EDI	0.84	0.86	0.86	1.00	0.73	0.76	0.60	0.68
CZI	0.94	0.92	0.92	0.73	1.00	0.99	0.96	0.98
MCZI	0.96	0.95	0.95	0.76	0.99	1.00	0.93	0.97
RAI	0.87	0.85	0.85	0.60	0.96	0.93	1.00	0.99
ZSI	0.92	0.90	0.90	0.68	0.98	0.97	0.99	1.00

Select the last Indices

- The Pearson's correlation coefficients for SPI, PNI and DI were more or less identical (0.91, 0.89, and 0.89, respectively).

- In Mashhad, the trends of MCZI were somewhat different from those of CZI.

- In contrast to Mashhad and Ghoochan stations, the correlations (>0.31) between the AgMERRA-derived drought indices and the station-derived drought indices for Golmakan station (r<0.65; Table 3; Fig. 5) were not robust at all.

- This discrepancy was likely caused by the 300-m elevation difference between the Golmakan station and the nearest pixel of AgMERRA.

Comparison of DDI

Table 6 Average yearly Degree of Dryness Index (DDI) for five drought indices derived from the AgMERRA precipitation data and from the station-observed precipitation data across the Kashafrood Basin

Year	SPI		CZI		ZSI		EDI		RAI	
	WS	AgM	WS	AgM	WS	AgM	WS	AgM	WS	AgM
1987	2	5	2	4	1	3	29	29	11	13
1988	2	1	1	1	0	1	0	0	12	7
1989	3	6	2	5	1	3	23	24	19	19
1990	2	4	3	2	1	2	29	34	17	15
1991	1	1	1	0	1	0	6	8	12	11
1992	2	2	1	2	1	1	8	0	15	12
1993	3	2	3	2	2	2	12	0	17	10
1994	0	0	1	0	0	0	26	21	17	14
1995	3	4	2	4	1	3	13	25	14	18
1996	1	3	1	2	1	2	20	33	12	13
1997	1	3	1	3	0	2	10	20	12	11
1998	2	3	1	2	1	2	0	0	11	14
1999	1	0	0	1	0	0	4	6	7	10
2000	4	6	3	5	2	4	24	29	15	14
2001	4	3	4	3	2	2	36	35	20	16
2002	1	1	1	0	1	0	10	8	14	12
2003	0	1	0	0	0	0	0	0	11	9
2004	1	1	1	0	0	0	0	0	11	7
2005	2	1	1	1	1	1	0	0	14	9
2006	2	2	2	2	1	1	24	10	14	11
2007	3	2	2	1	1	1	3	3	14	12
2008	5	3	5	4	3	3	30	29	18	18
2009	2	2	1	2	0	1	7	9	9	8
2010	4	3	2	3	1	2	8	17	14	13

Conclusion

Conclusion

- We compared eight drought indices to track the drought history.
- Our comparison shows that all indices agree that the most severe droughts for the study period occurred in 2001 and 2008.
- A high cross-correlation coefficients (R2>0.90) were obtained among ZSI, CZI, and SPI, and among SPI, DI and PNI, and between CZI and MCZI in both data sources.
- The DDI values from EDI and RAI seem to be more sensitive to the observed droughts than the DDI values from other drought indices.

Conclusion

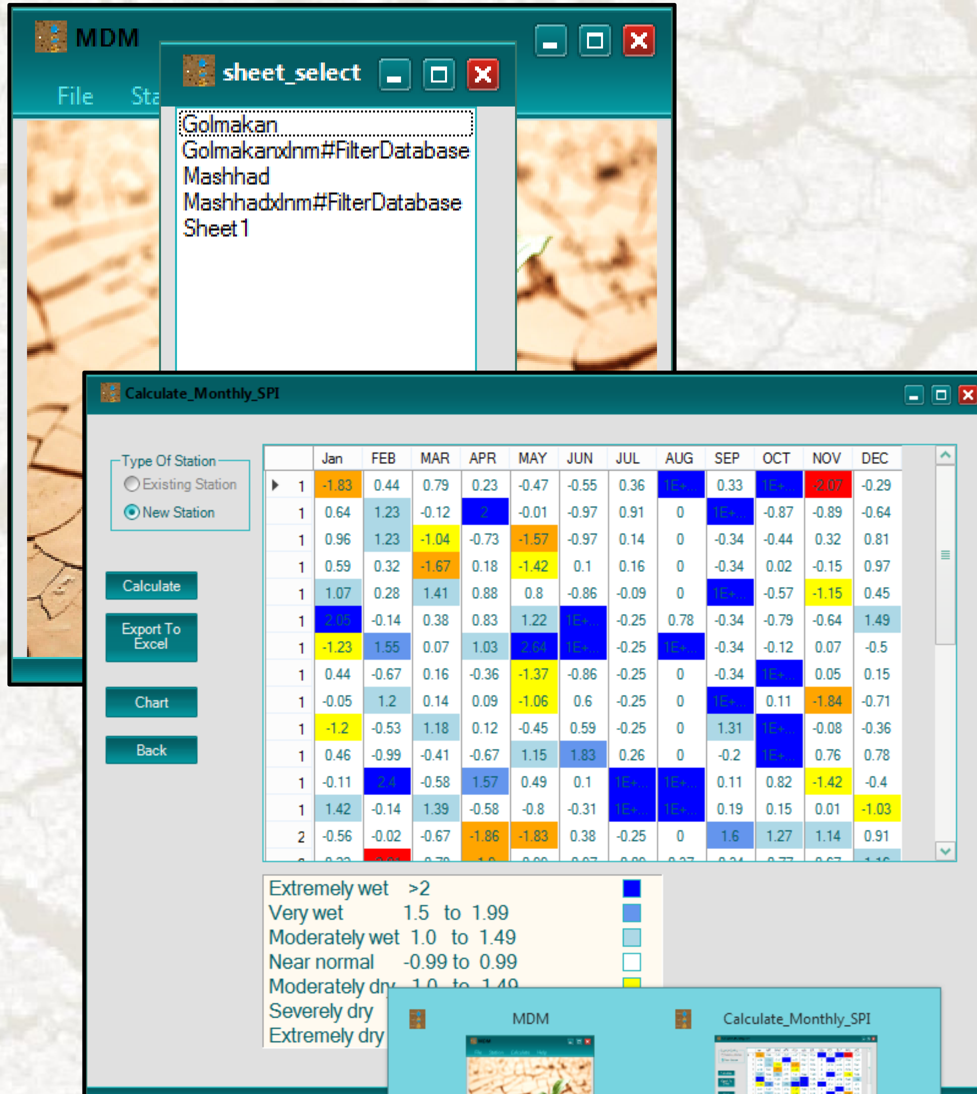
- The AgMERRA precipitation data can be used for filling the gaps existed in the station-observed precipitation data.
- In addition, if tested by station-observed precipitation data, the AgMERRA precipitation data may be used for the data-lacking areas.

Applicable and Useful Software Tools

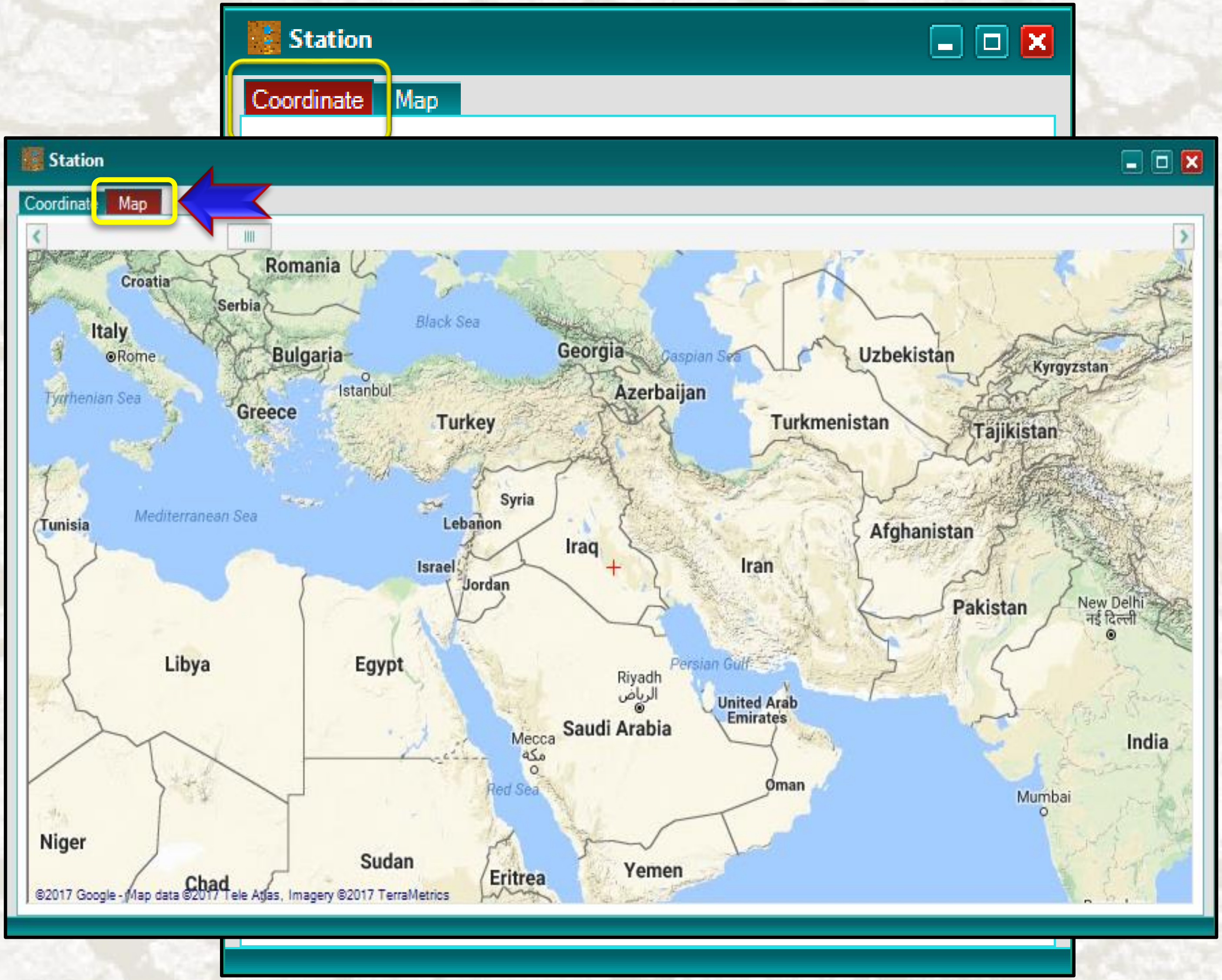
- **MDM** (Meteorological Drought Monitor)
- **DMAP** (Drought Monitor and Prediction)

MDM (Meteorological Drought Monitor)

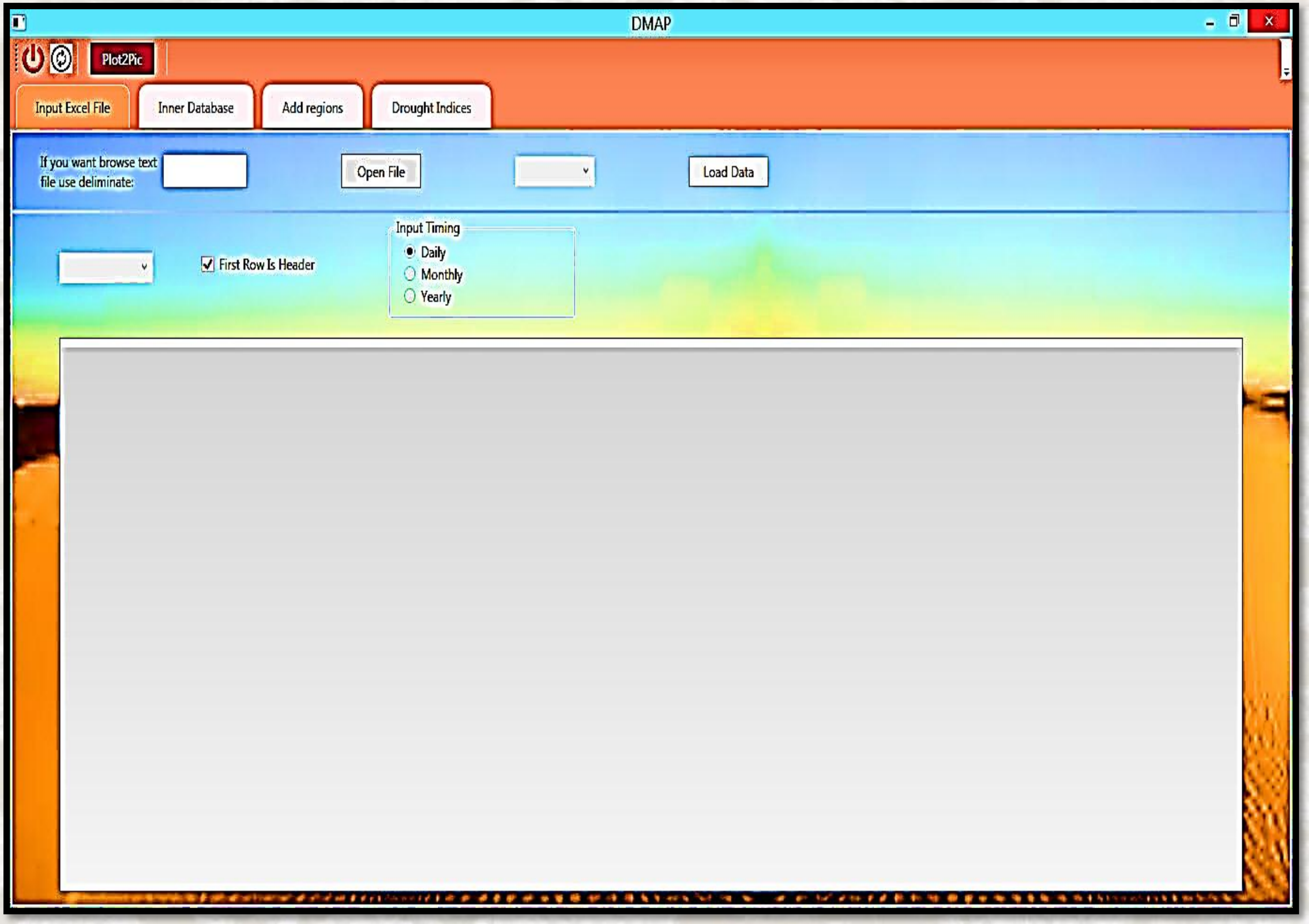
MDM (Meteorological Drought Monitor)



MDM (Meteorological Drought Monitor)

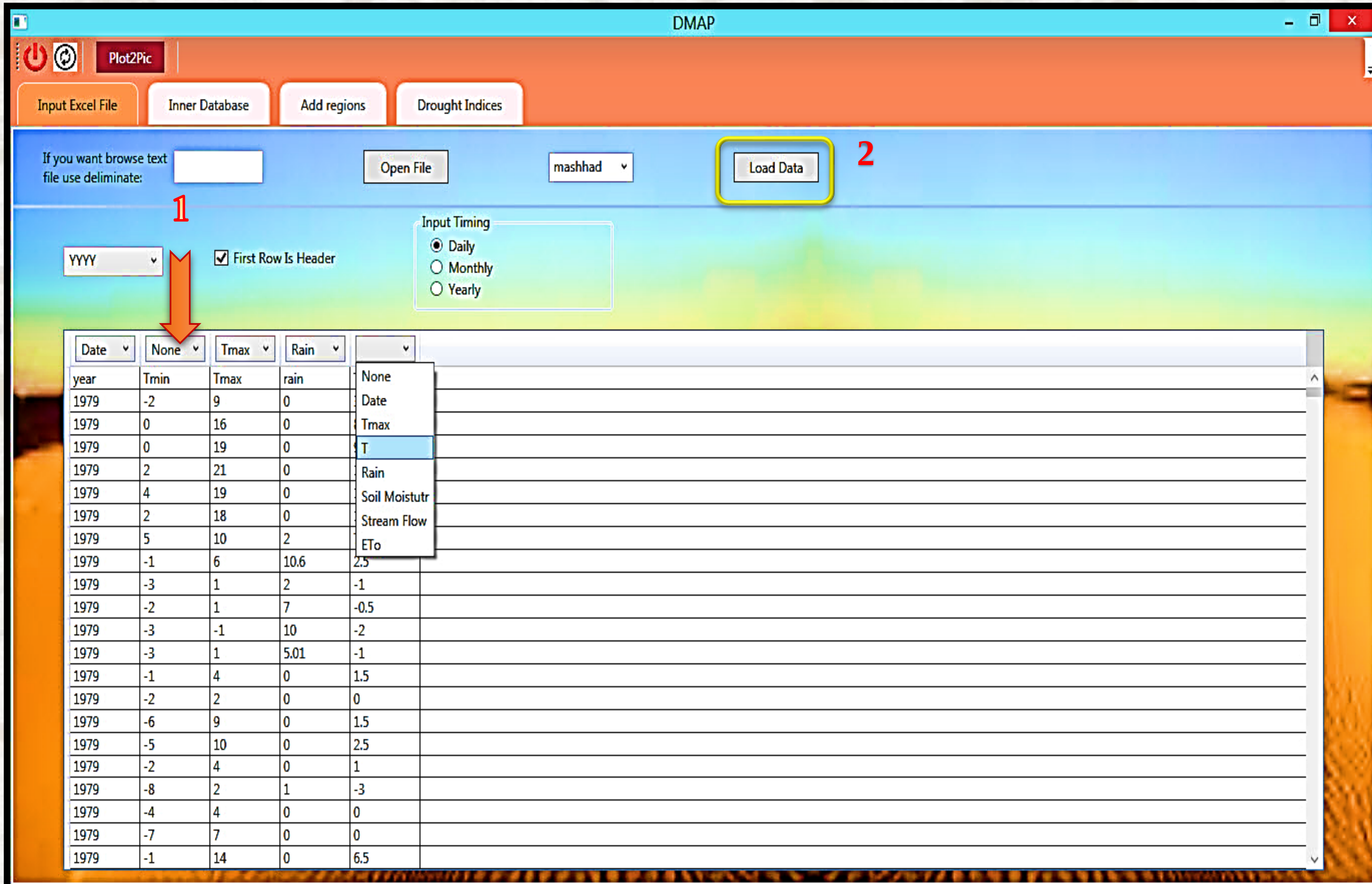


DMAP (Drought Monitor and Prediction)



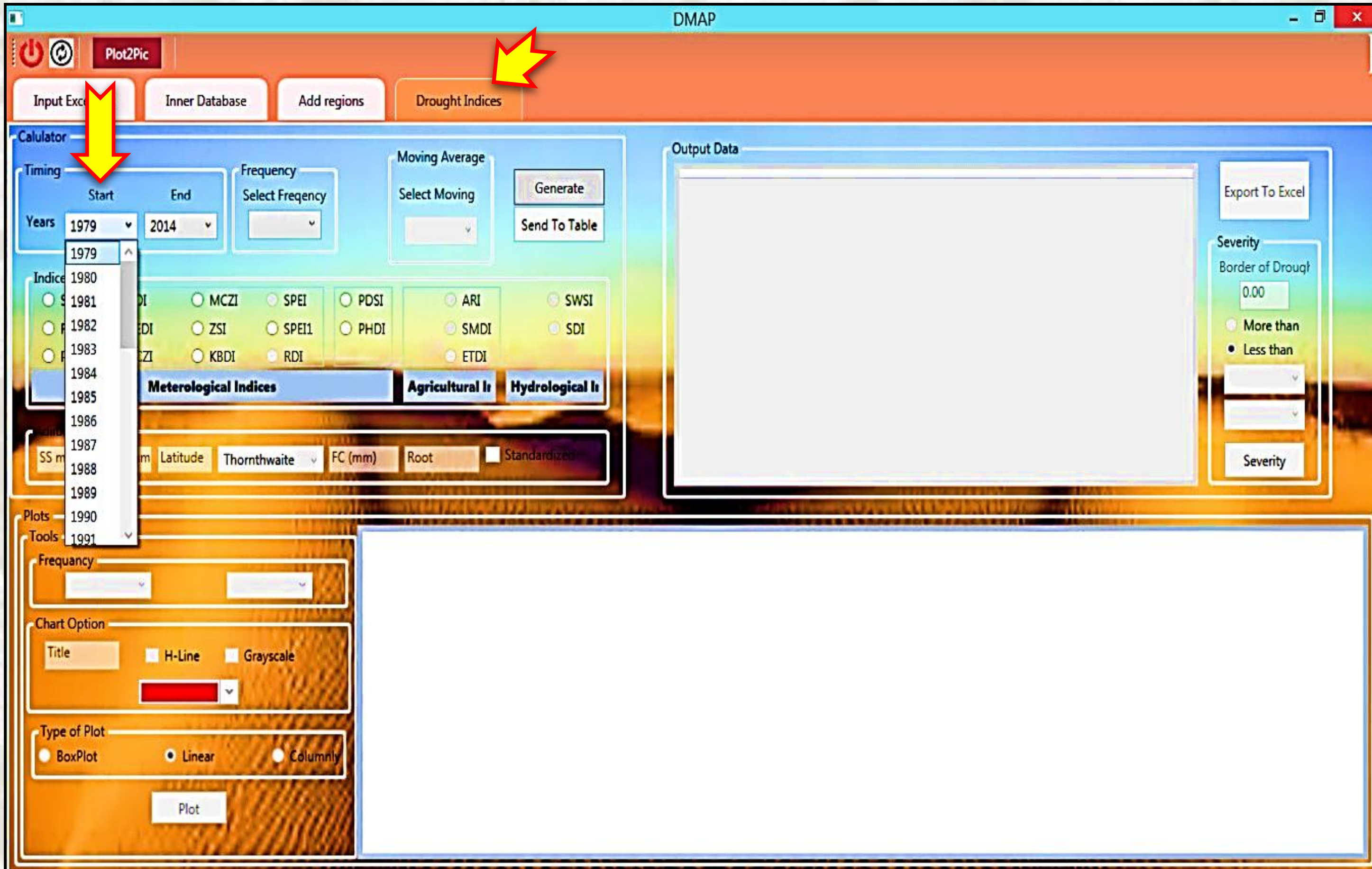
The main screen of DMAP tool with the main tabs.

DMAP (Drought Monitor and Prediction)



Assign all the variables, without any specific order.

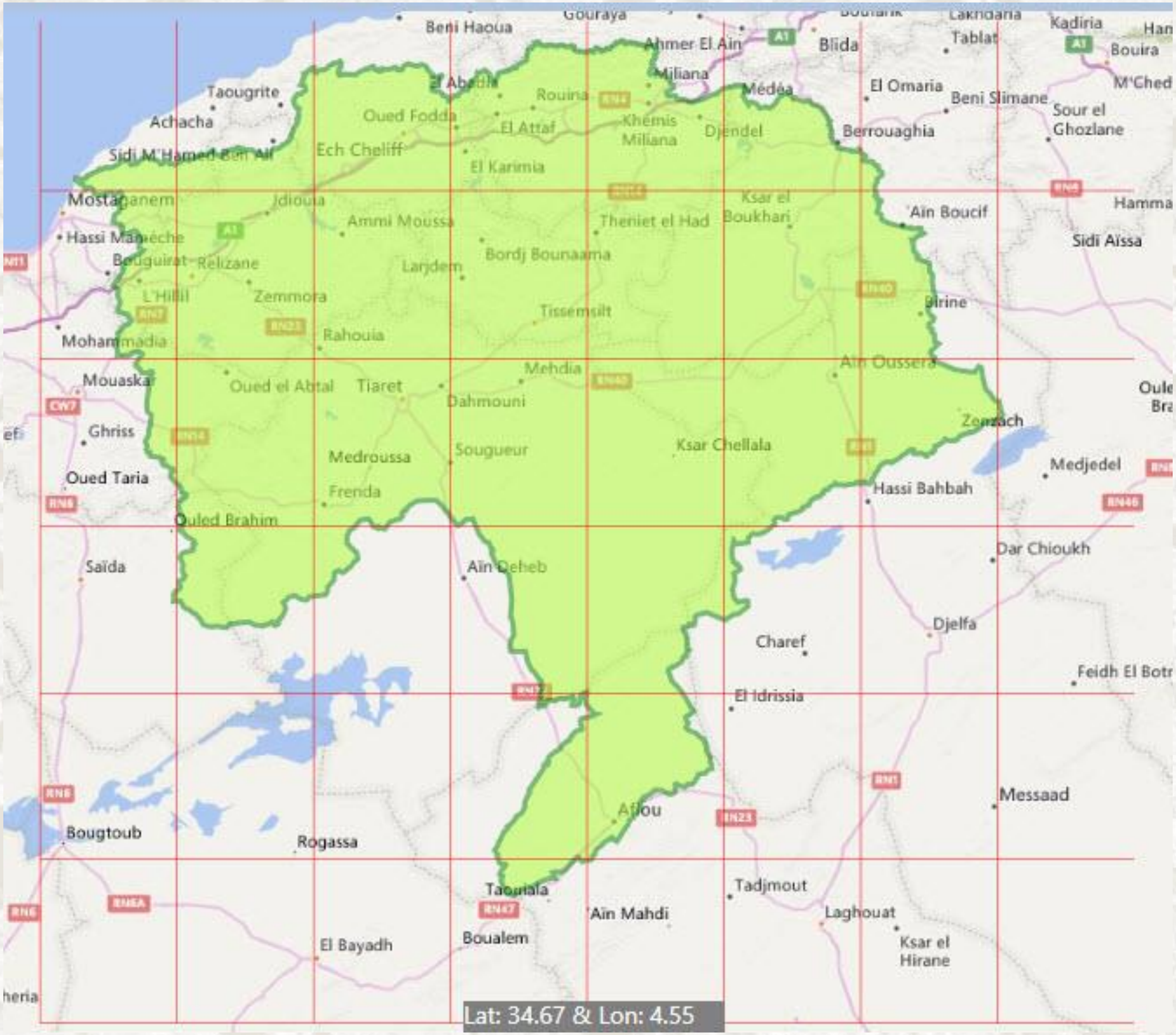
DMAP (Drought Monitor and Prediction)



Select the start year in the “Timing” panel.

DMAP (Drought Monitor and Prediction)

DMAP (Drought Monitor and Prediction)



Sincere Thanks For Your Attention

Who you are tomorrow begins with what you do today.

Nasrin Salehnia
Salehnia61@gmail.com
www.agrimetsoft.com