
بسم الله الرحمن الرحیم
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Numerical Analysis and Flood Information Software

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UN 2023 WATER CONFERENCE

UNDRR
UN Office for Disaster Risk Reduction

At least

1.4 billion people have been affected ***by droughts***

1.6 billion people have been affected ***by floods***

Between **2000 and 2019**

World Bank, 2021


Strong early warning systems create benefits worth at least ten times their implementation costs, saving lives and assets.
UNDRR
UN Office for Disaster Risk Reduction


Just 24 hours warning of a coming storm or heat wave can cut the ensuing damage by 30%.
FINLAND
SWEDEN
ESTONIA
LATVIA
LITHUANIA
BELARUS
UNITED KINGDOM
IRELAND
GERMANY
POLAND
CZECHIA
SLOVAKIA
UKRAINE
AUSTRIA
HUNGARY
FRANCE
ROMANIA
CROATIA
SERBIA
ITALY
BULGARIA
PORTUGAL
SPAIN
GREECE
TUNISIA
MOROCCO
UNDRR
UN Office for Disaster Risk Reduction


UNDRR
UN Office for Disaster Risk Reduction
Enable to reduce disaster risk
Early warning systems
Preparedness plans
Social protection
Resilient infrastructure
Good governance
Inclusion

Types of Floods in Iran:

- Flash floods/Debris Floods

Small to mid size basin, Steep slope, Very high & Sensitive to erosion, High sediment transport, Very high destruction potential

- Mainstream flooding:

Small, mid size & large Basin, Moderate to low slope, High to low erosion potential, High flood level & velocity, high destruction potential

- Snow melt flooding :
- Mid to Large Basin, High to Moderate Slope, Snowpack, Heat wave with high temperature lapse rate, (Hirmand)
- Malfunction of spillway gates and other control works of dams: (Pishin, Golestan and Dez dams)

Flash & Debris Floods

Tehran, Golabdareh Basin - 1987

Gilan, Masouleh Basin, 1999

Flash & Debris Floods

Golestan, Gorganroud - 2001

Mazandaran, Chalous- 2015

Mainstream Floods

Qom - 2009

Lorestan - 2019

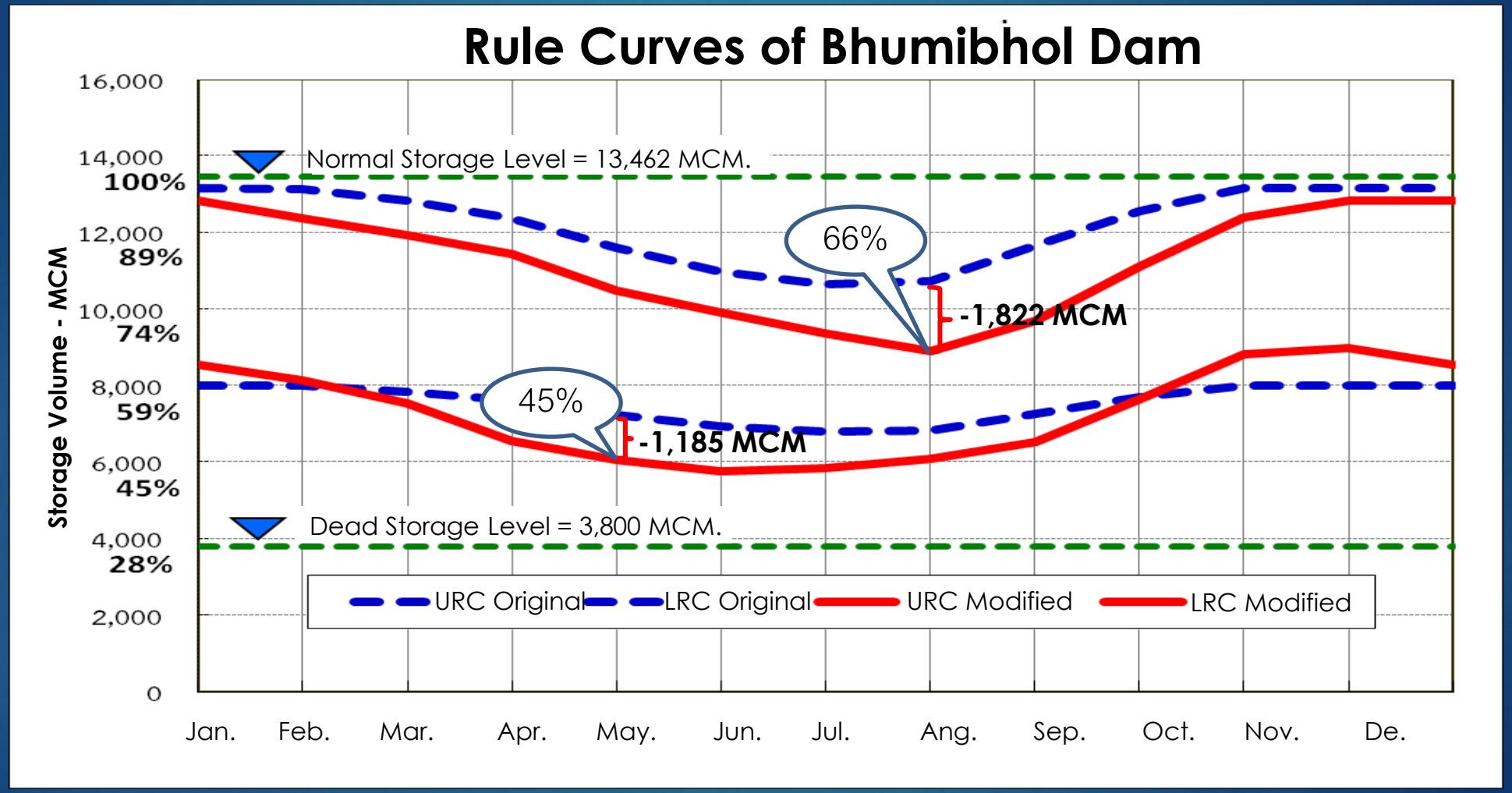
Lorestan - 2019

Mainstream Floods

A Day before flooding

Qom Flood March 2009

Malfunction of spillway gates of dams



Flood damages reduction methods

Flood Discharge reduction	*Flood Level Reduction*	*Flood Damage Reduction*	*Flood Management*
Reservoir Dam	River training	Relocation	*Flood Warning*
Flood diversion	River structure	Elevation	Flood Insurance
Watershed management	River Engineering	Flood Wall & Levee	Change Land Use
		Flood Proofing	Change construction type
			Prevent construction

Forecast specifications

1. Forecast frequency
2. Forecast horizon (maximum time range)
3. Lead time (Time between notification and occurrence of the phenomenon)

Valuable Forecast → Lead time is sufficiently longer than Action time

Flood forecasting

In general, flood forecasting is done by four methods as follows:

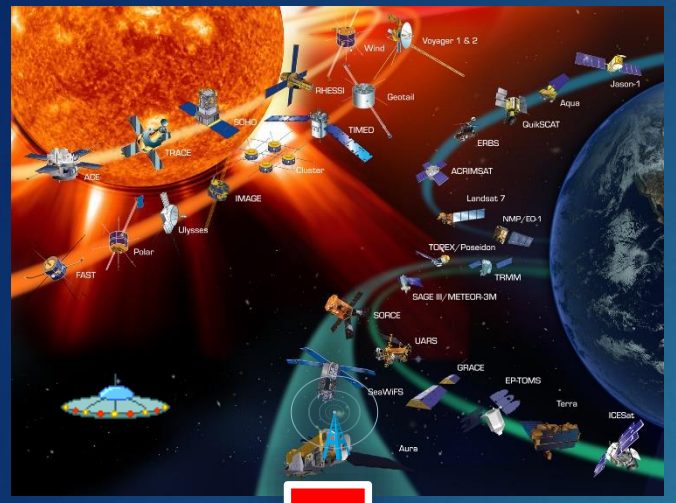
1. Forecast after precipitation => Downstream flood *forecasted* based on real time *observed* upstream flood information such as water level or flow discharge (1st generation)
2. Forecast during precipitation => For every basin, Flood *forecasted* based on (near) real time *observed* precipitation and temperature (2nd generation)
3. Forecast before precipitation => *Flood occurrence probability or possibility* estimated based on real time Synoptic weather station analysis (3rd generation)
4. Forecast before precipitation => For every basin, Flood *forecasted* based on numerical weather forecast (NWF) => Hydrograph, volume, peak discharge and time of flood (4th generation)

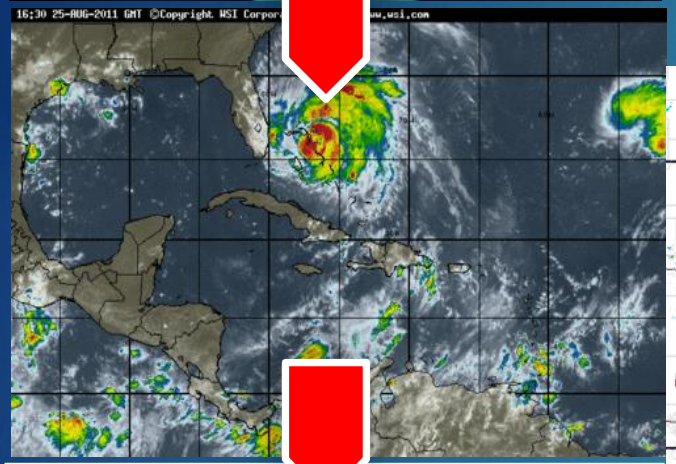
Differences in Lead time, accuracy and forecasting parameters

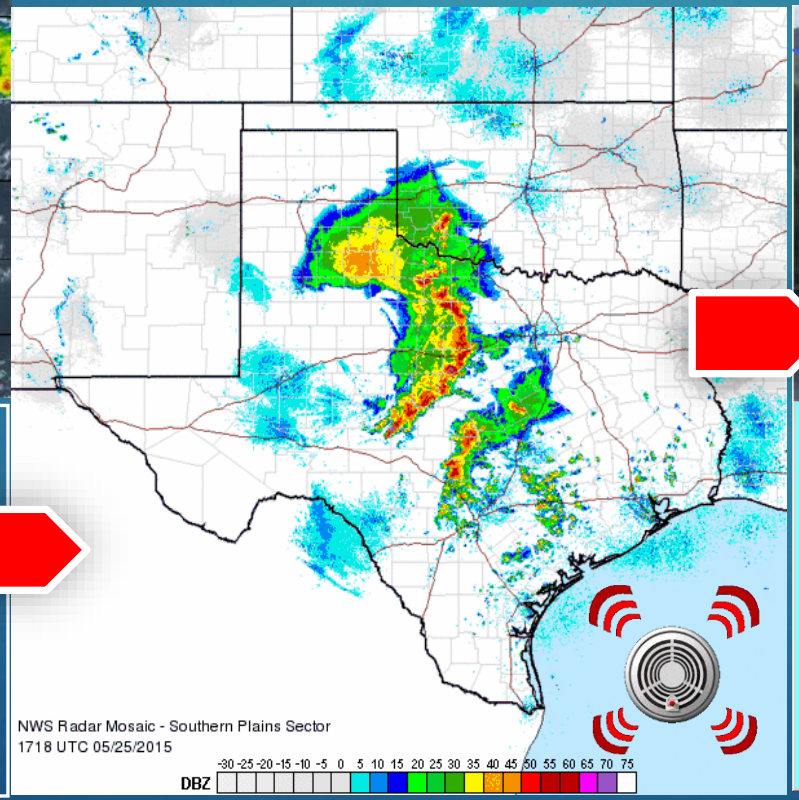
4th Generation Flood forecasting Software

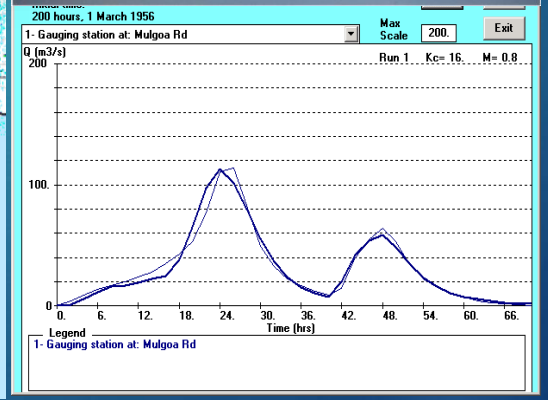
Based on Coupling of Different numerical weather forecast (NWF), Radar Data, RS, Weather Station with Hydrological Simulation Models

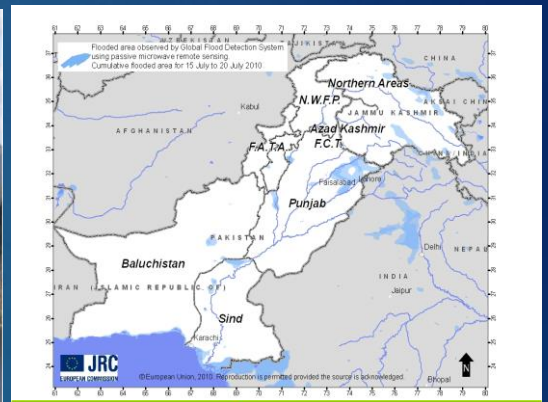
Flood Forecasting Lead time increase up to 5 days

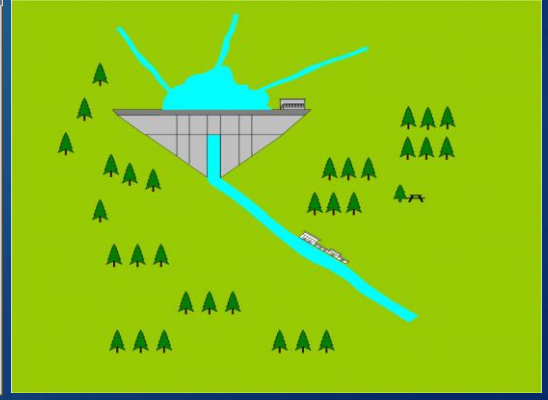




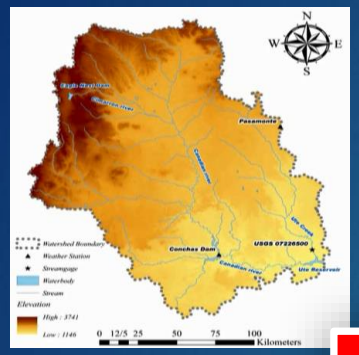


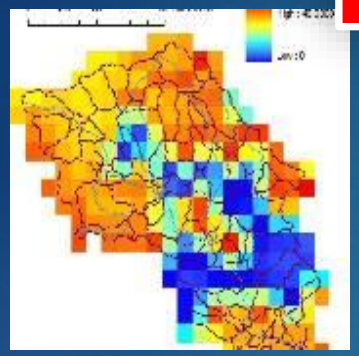






Forecast Progress

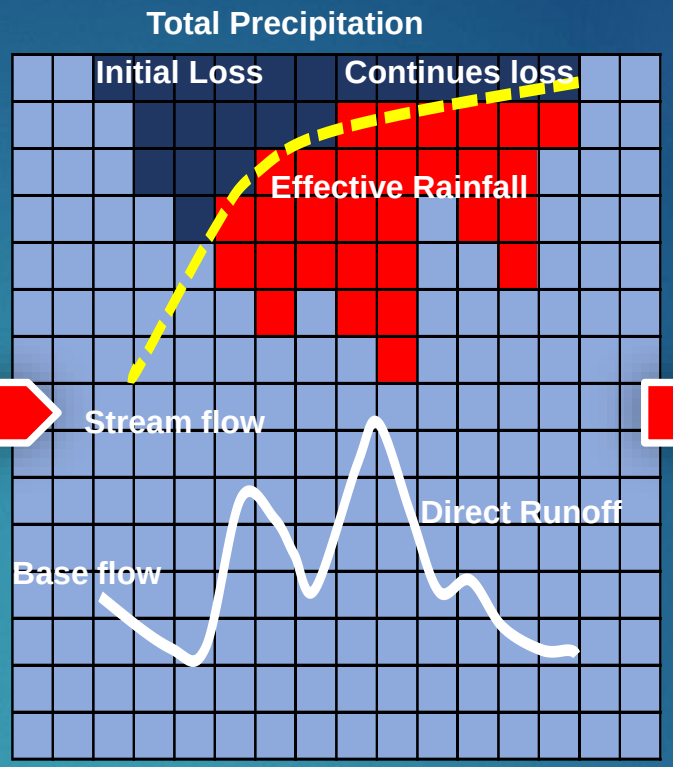




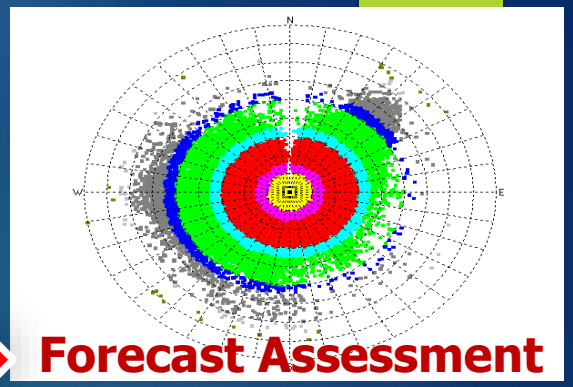
Calibration Data Base

Running Scenario

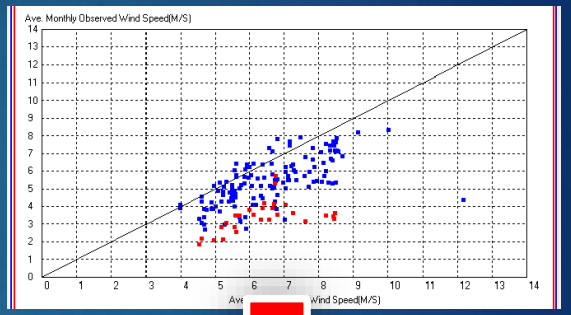
Hydrological Simulation

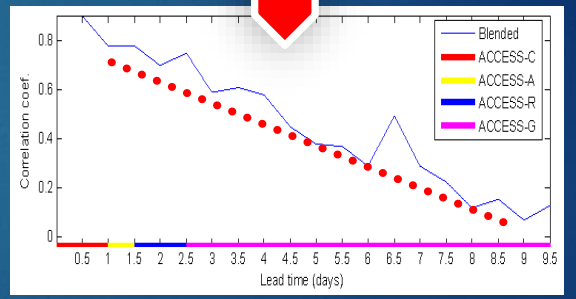


Forecasted Hydrograph



Forecast Assessment





1. **Forecast frequency (Daily, Can be increase up to 4 times per day)**
2. **Forecast horizon (Next 120 Hours)**
3. **Warning Lead time (Up to 5 days)**
4. **Forecast Accuracy (Up to 95 %, Increase during lead time)**

Valuable Forecast ➔ Lead time is sufficiently longer than Action time

Hydrological Simulation Main Components

- Sub basin, Base flow, Rainfall, Snowfall, Snowmelt, Snowpack, Runoff
- River reach flow routing
- Reservoir flow routing
- Flow diversion and reach return flow
- Junction points

Input Data:

The software can work with a series of different Input Weather data type:

- Deterministic NWF Data (Generated daily by WRF or other NWF software's such as GFS, ICON, ECMWF, … in text format)
- Ensemble NWF (Generated daily by WRF - 7 members)
- Probabilistic NWF (Generated Based on WRF Ensemble Data by NAFIS)
- Real time Radar Data
- Observed weather station data

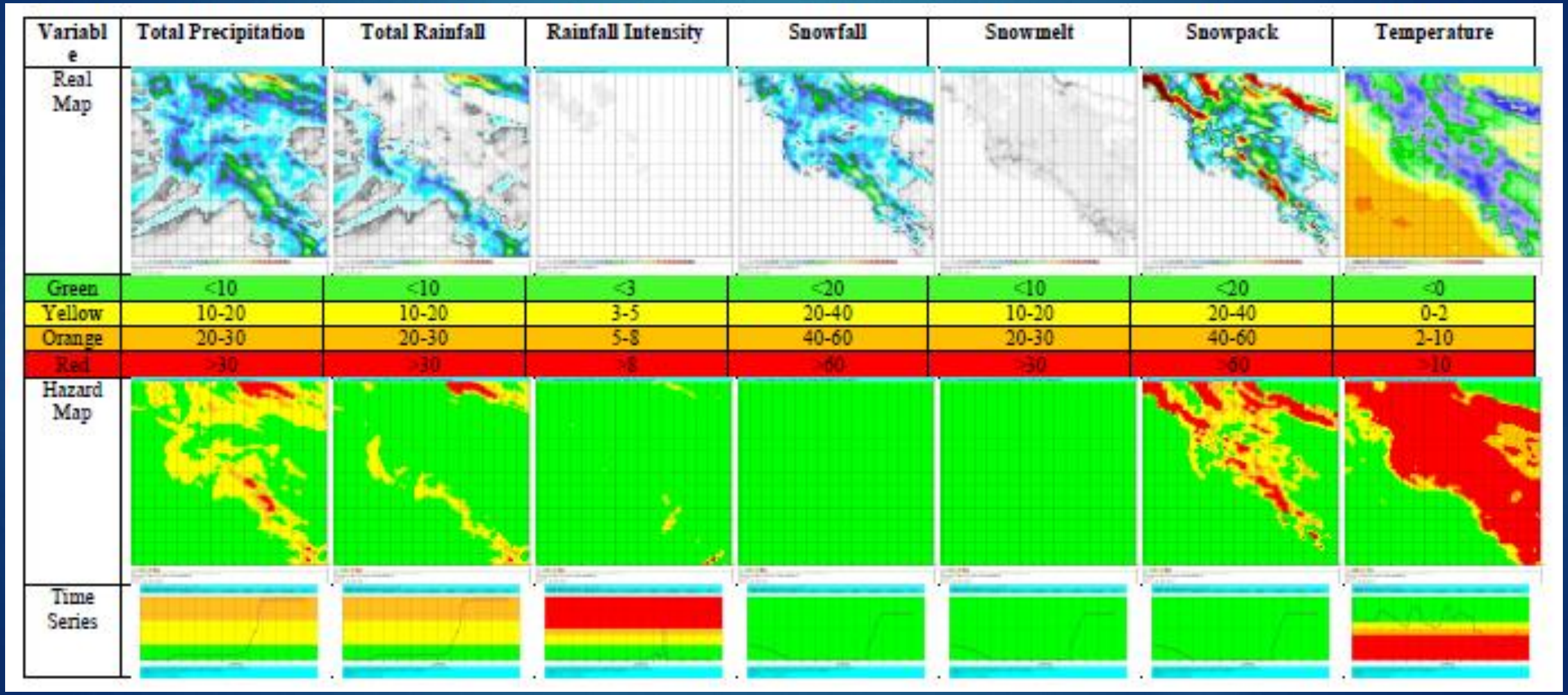
NAFIS Products:

The software produces a series of hydrological products after running hydrological model of each basin. These products are:

- Weather maps (Precipitation, Rainfall, Rain intensity, Snowfall, Snowmelt, Snowpack and Temperature)
- Trigger hazard maps (For every of weather maps, most of them is Rain intensity hazard map (PIN) for thresholds of 5, 8 and 10 mm/hr that shows probable points which have direct runoff and flood potential)
- Basin weather maps (Precipitation, Rainfall, Rain intensity, Snowfall, Snowmelt, Snowpack and Temperature)
- Basin and sub basins weather time series (Precipitation, Rainfall, Rain intensity, Snowfall, Snowmelt, Snowpack, Temperature and lapse rate)
- Generating RR simulation of sub basins, river and reservoir flow routing, flow diversion and accumulation and creating hydrograph for all control points.
- Those procedure done for all of input data (D1,E1..E7,P10..P90,RD,OB,SA=>20 Run simulation for each basin)

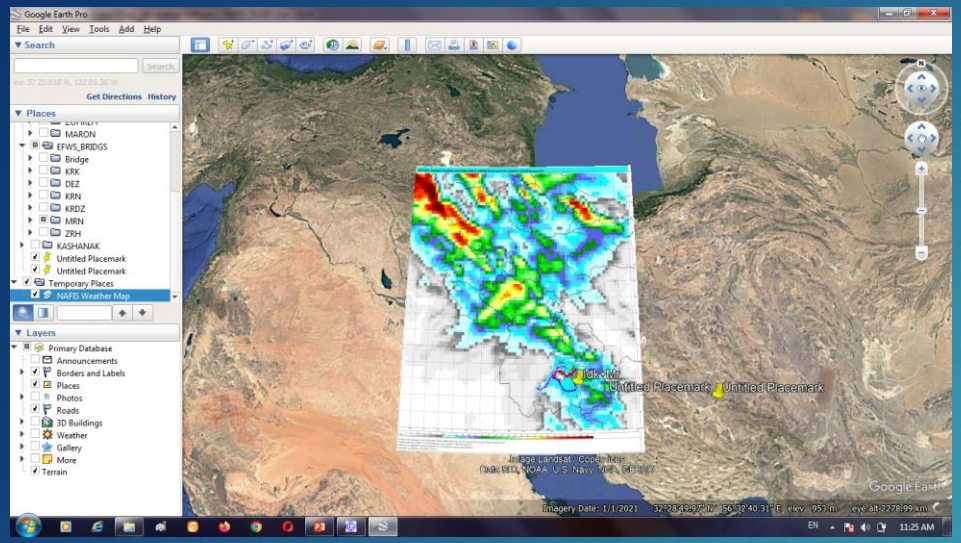
Weather Product Samples:

- General Weather Maps
- Trigger Hazard maps (Weather Watch Hazard Maps)
- Time Series

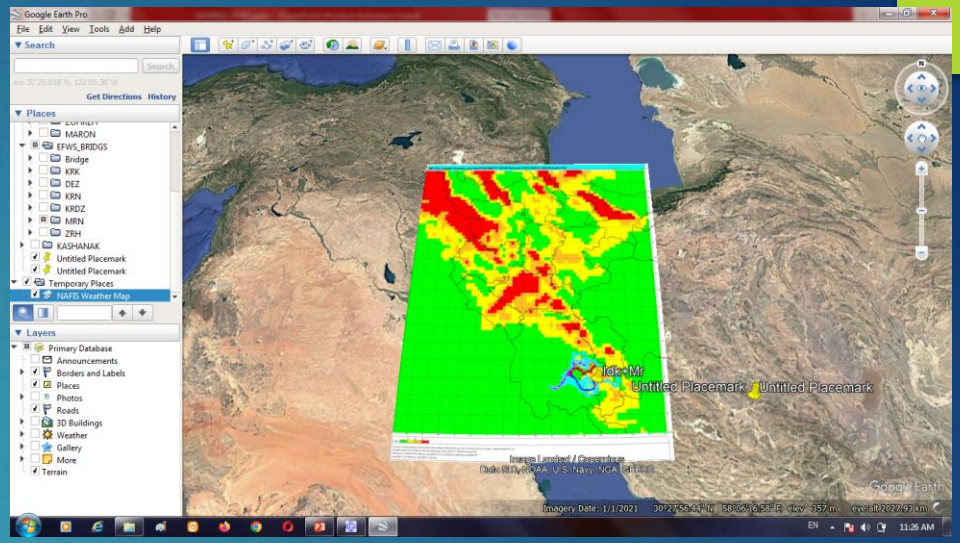


Variable	Total Precipitation	Total Rainfall	Rainfall Intensity	Snowfall	Snowmelt	Snowpack	Temperature
Real Map							
Green	<10	<10	<3	<20	<10	<20	<0
Yellow	10-20	10-20	3-5	20-40	10-20	20-40	0-2
Orange	20-30	20-30	5-8	40-60	20-30	40-60	2-10
Red	>30	>30	>8	>60	>30	>60	>10
Hazard Map							
Time Series							

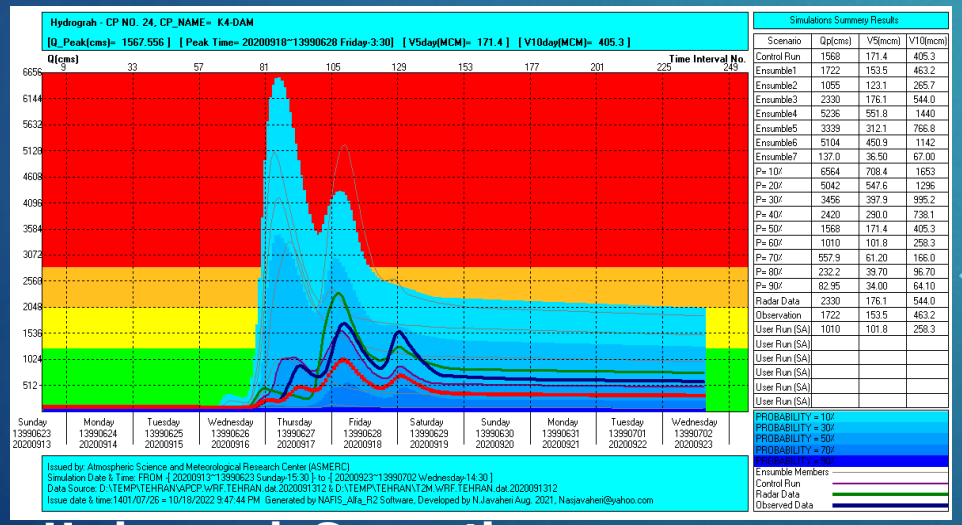
GIS Based Weather Forecast Products



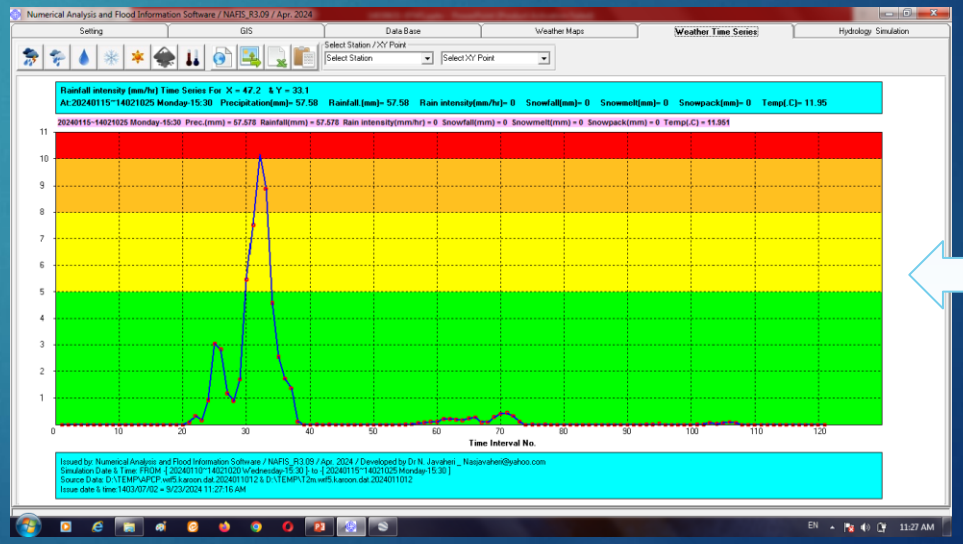
GIS Base Precipitation Map



GIS Base Precipitation Hazard Map

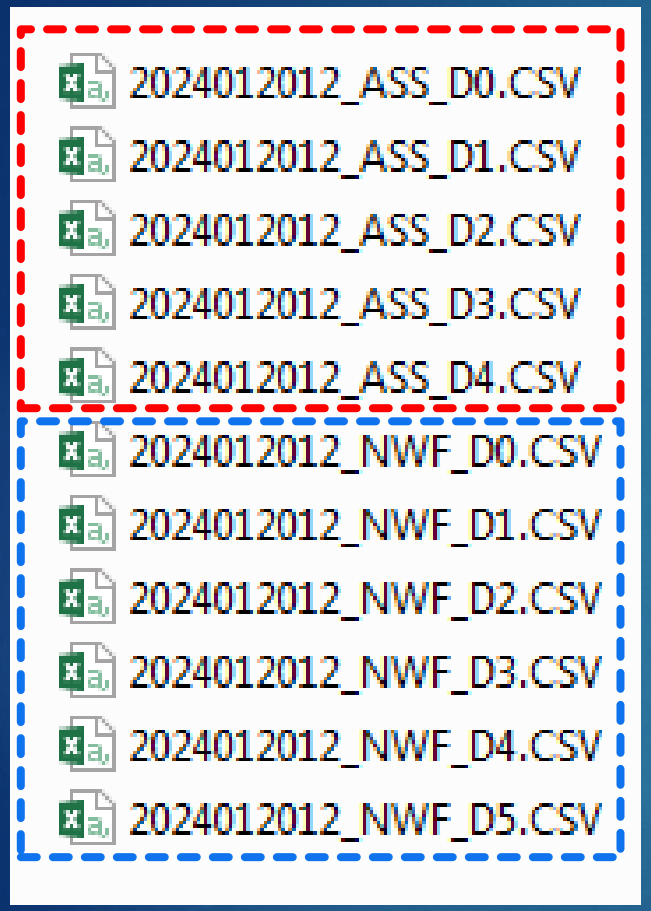


Hydrograph Generation
Ensemble, Probability, Deterministic, Radar, RS and observed



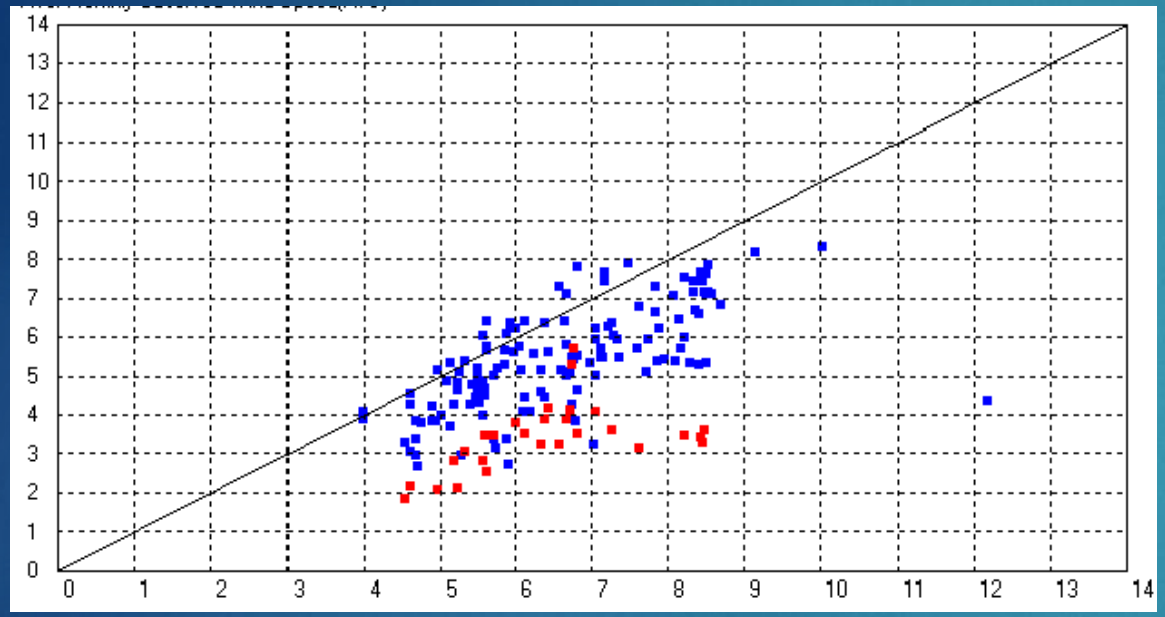
Exported Heavy Precipitation Time series in selected high risk point

Run assessment Model

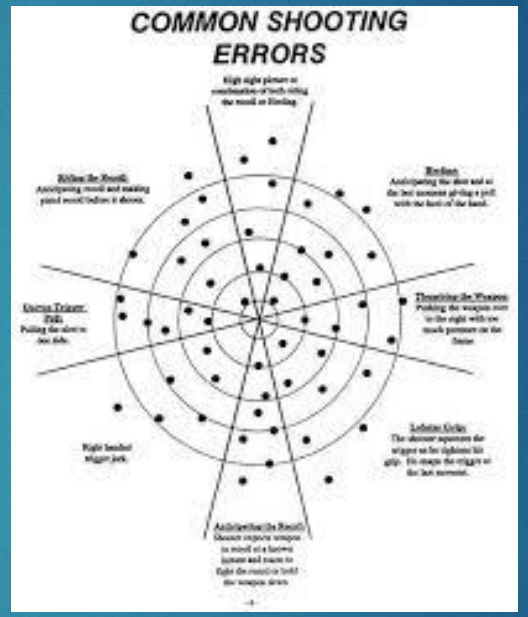


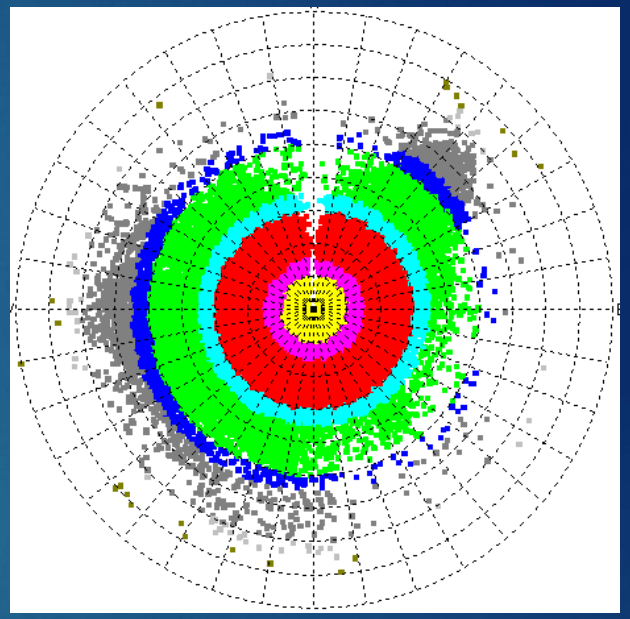
A	B	C	D	E	F	G	H	I	J	K
ion_id	Name	lon	lat	ground_elevation	NWF_tmax	Obs_tmax	NWF_tmin	Obs_tmin	NWF_rrr	Obs_rrr
99373	Karaj (Agricultu	50.9378	35.7803	1261.1	9.601	14.6	4.831	-0.7	0	0
99396	Hashtgerd	50.74694444	36.00666667	1612.9	6.522	10.5	2.056	1.1	0	0
40752	Karaj	50.95388889	35.80694444	1292.9	6.22	13.2	2.769	0.6	0	0
99321	Taleghan	50.76666667	36.16666667	1857	0.739	9.3	-3.533	-2.5	0	0
99202	Bilehsowar	48.31916667	39.365	101.4	7.294	1.7	0.748	-0.4	0	18.9
40708	Ardebil	48.32861111	38.21805556	1314.3	7.294	6.9	0.748	2.6	0	0
99263	Firuzabad (Ard	48.23555556	37.58888889	1175.7	9.336	10.5	1.925	0	0	0
40714	Germi	48.05722222	39.05	749	9.085	2	1.654	-2.4	0	8.4
99233	Nir	48.02555556	38.0375	1593	8.231	2.8	0.771	0.9	0	0.2
40705	Meshkinshahr	47.67777778	38.375	1560.6	12.178	-1.6	2.157	-2	0	3.4
99232	Namin	48.49111111	38.42027778	1480.2	3.176	3	-1.194	-1.7	0	0
99231	Sareyn	48.08055556	38.14694444	1658.3	9.085	1.6	1.654	-0.6	0	0.6
40704	Ahar	47.06666667	38.43333333	1391	6.727	0	-0.852	-2.5	0	8
99239	Bonab	46.05166667	37.37027778	1281	6.221	5.6	0.587	3.2	0	0.5
99283	Charoymaq	46.9667	37.1331	1302	7.715	3.8	-3.80E-02	1.1	0	0.01
99227	Shabestar	45.68333333	38.18333333	1350	7.918	2.9	4.303	1.8	0	0.4
99234	Tabriz (Sharq)	46.3331	38.0494	1495	0.976	4.7	-3.289	1.5	0.074	1.1
99228	Heris	47.13333333	38.23333333	1950	6.727	0.3	-0.852	0	0	0
99236	Ajabshir	45.85	37.5	1311	7.879	5.2	0.797	2.2	0	1.6
40702	Jolfa	45.6	38.9333	736.2	7.638	-0.2	4.842	-1	0	0.4
40711	Kalibar	47.01666667	38.86666667	1180	5.932	-1.5	-1.036	-4.2	0	7.3
99284	Malekan	46.08333333	37.15	1302	10.454	6.4	0.397	3	0	0
99220	Marand	45.76666667	38.41666667	1550	9.333	-3.8	1.68	-5	0	10.2

Run assessment and Calibration



Correlation Chart





Gun Target Chart with normalized variables

NAFIS Implementation

Right now, NAFIS is installed at IRIMO as of flood forecasting system in some of large basins of Iran and generate daily hydrograph for about 550 control points.

1. Karun & Dez
2. Golestan
3. Karkheh
4. Sirvan
5. Zohreh
6. Kelas
7. Gilan
8. Qomroud
9. North Khorasan
10. Tehran
11. Shamil & Nian
12. Lorestan

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Thank you for your attention