Hydro Predict'2012

International Interdisciplinary Conference on

Prediction for Hydrology, Ecology, and Water Resources Management

PROBABILISTIC DROUGHT FORECASTING for a BASIN-SCALE WATER RESOURCES OPERATION

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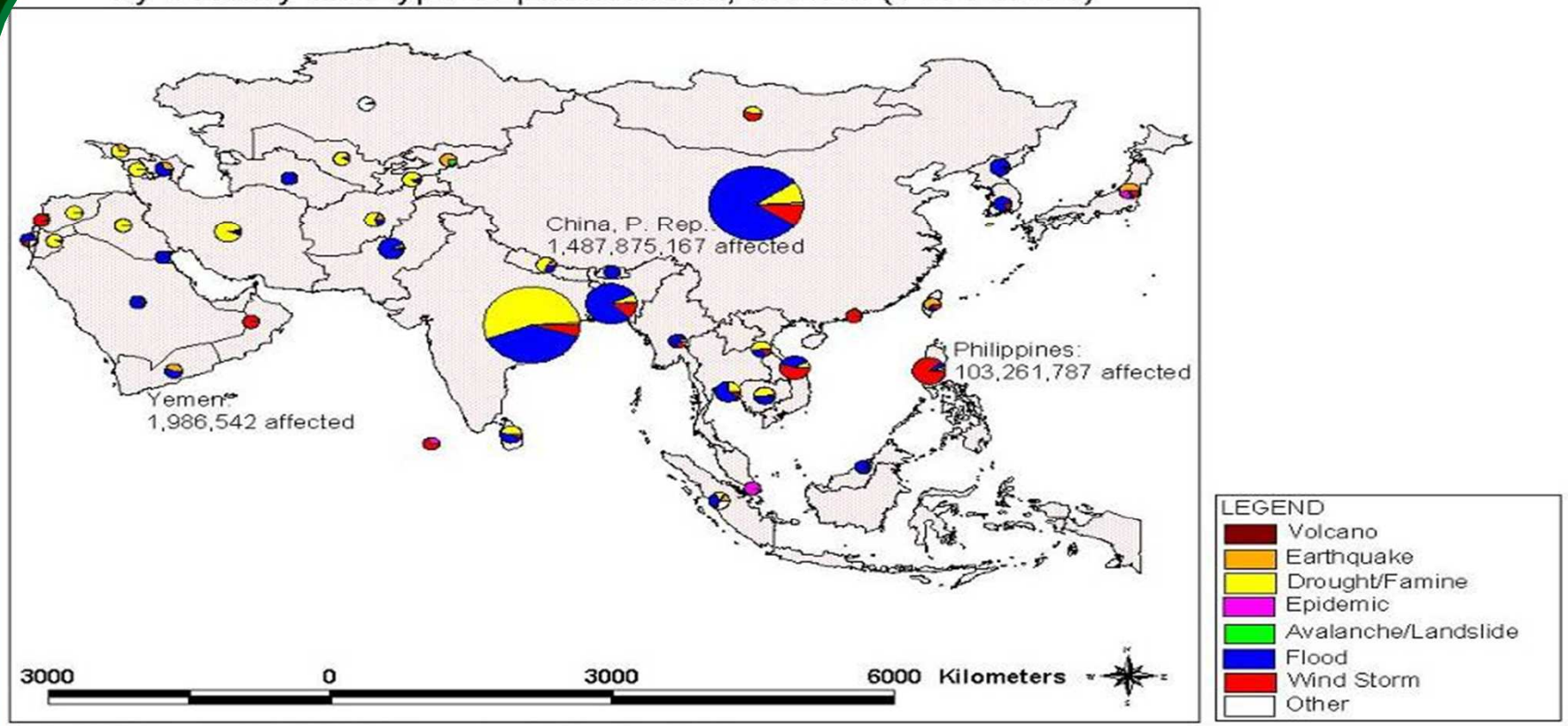
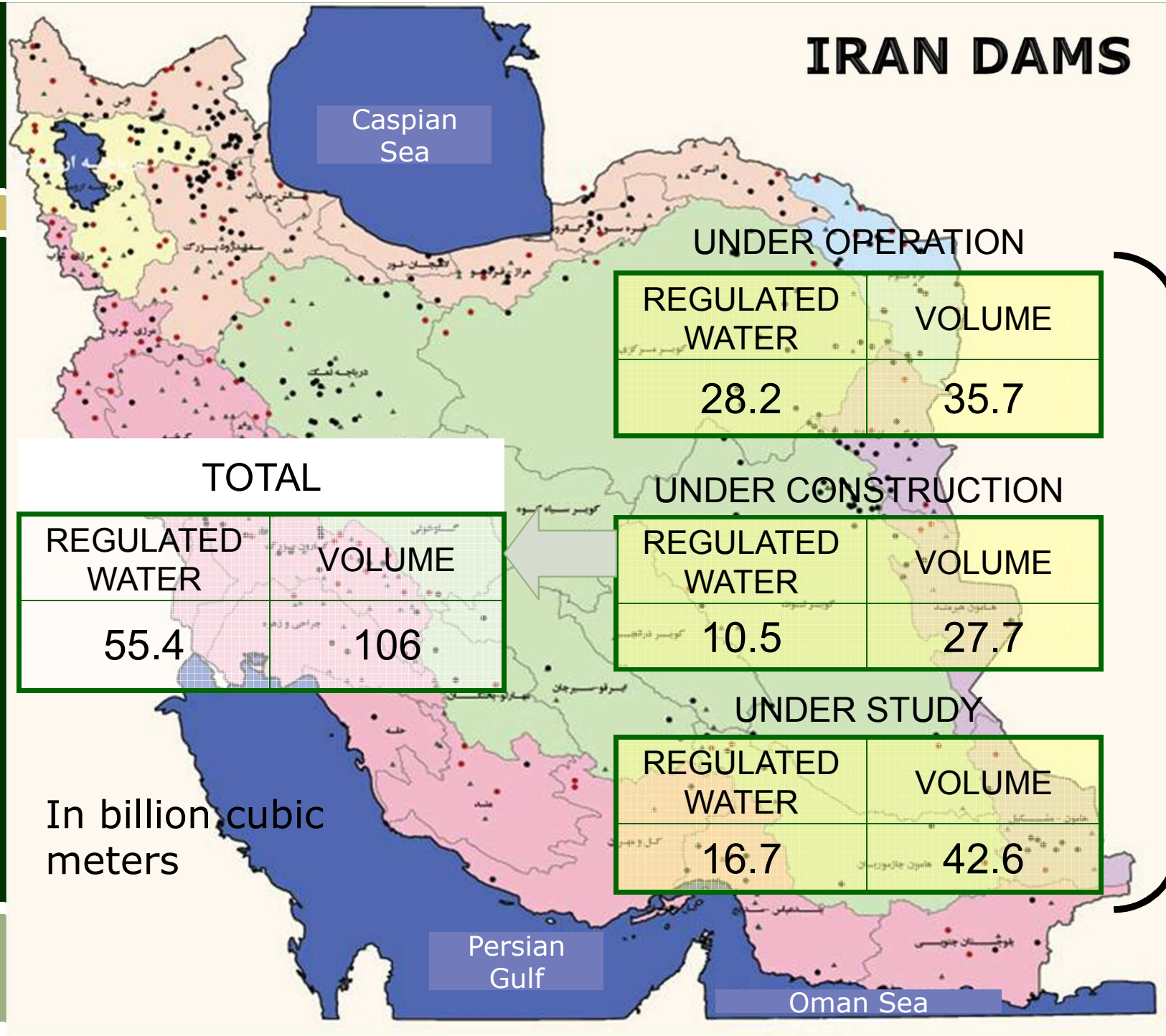
Drought is known as the deficiency of water in one or several components of the hydrological cycle. It occurs when the available water of a system is not sufficient to supply at least one of the ecological, environmental, agricultural, industrial and urban demands.



Drought in ASIA

IRAN DAMS



UNDER OPERATION

REGULATED WATER	VOLUME
28.2	35.7

UNDER CONSTRUCTION

REGULATED WATER	VOLUME
10.5	27.7

UNDER STUDY

REGULATED WATER	VOLUME
16.7	42.6

TOTAL

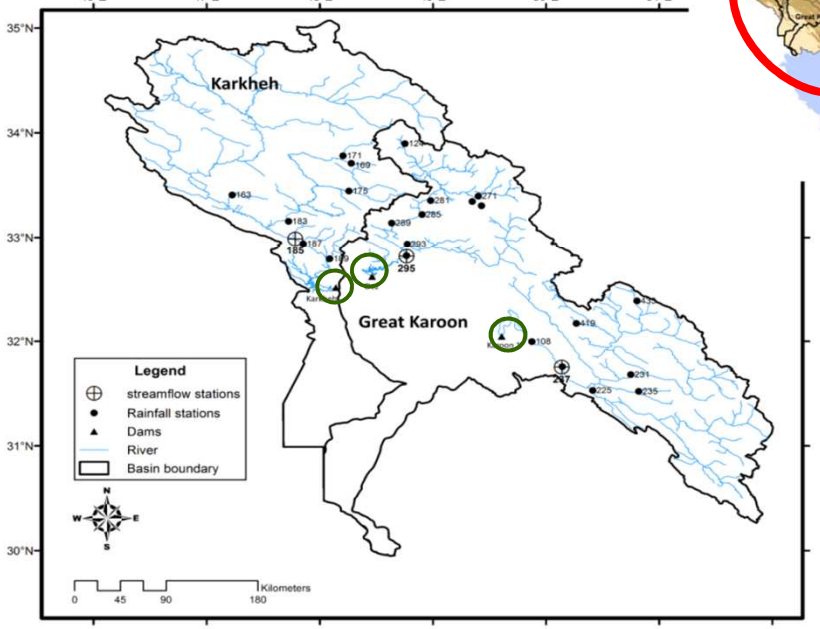
REGULATED WATER	VOLUME
55.4	106

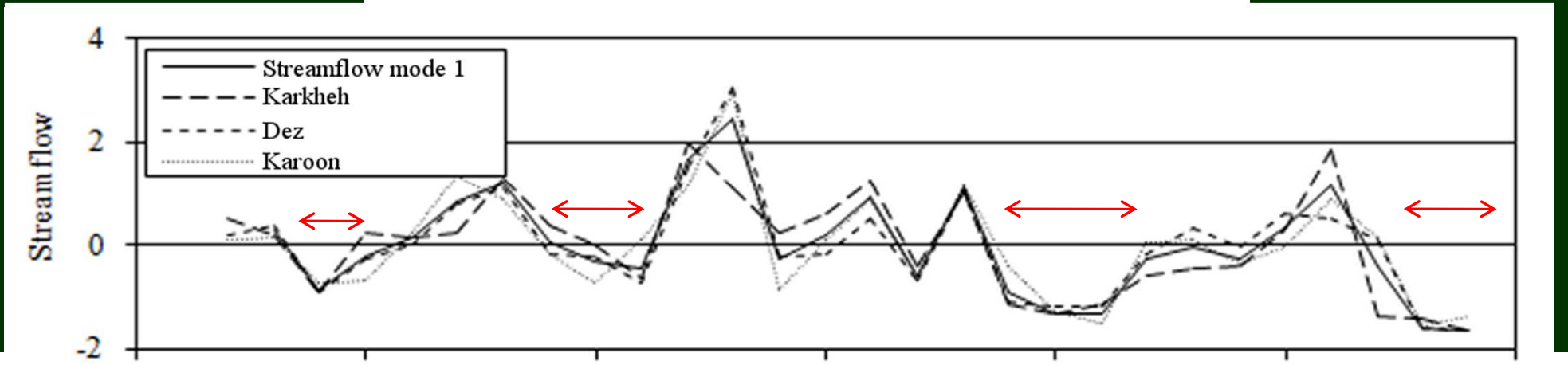
In billion cubic meters

Drought is the leading hazard in economic losses each year in Iran. A drought forecasting system is needed to help early warning of drought events to assist decision makers deciding on the mitigating activities including hedging rules, contract negotiation, hydropower generation, and agricultural water allocation.

THE AIM OF THE STUDY


Caspian Sea
IRAN
Karkheh
Great Karoon
Persian Gulf
Oman Sea


46°E
47°E
48°E
49°E
50°E
51°E
35°N
34°N
33°N
32°N
31°N
30°N
Karkheh
Great Karoon
Legend
streamflow stations
Rainfall stations
Dams
River
Basin boundary
N
S
W
E
0
45
90
180
Kilometers


Streamflow mode 1
Karkheh
Dez
Karoon
Streamflow
4
2
0
-2

CASE STUDY

1

DETERMINING APPROPRIOATE DROUGHT PREDICTORS for RAINFALL AND STREAMFLOW

- SNOW BUDGET
- PERSISTENCY OF STREAMFLOW AND RAINFALL TIME SERIES
- LARGE SCALE CLIMATE SIGNALS

2

DEVELOPING A FORECASTING MODEL

- MODEL CALIBRATION
- MODEL VALIDATION

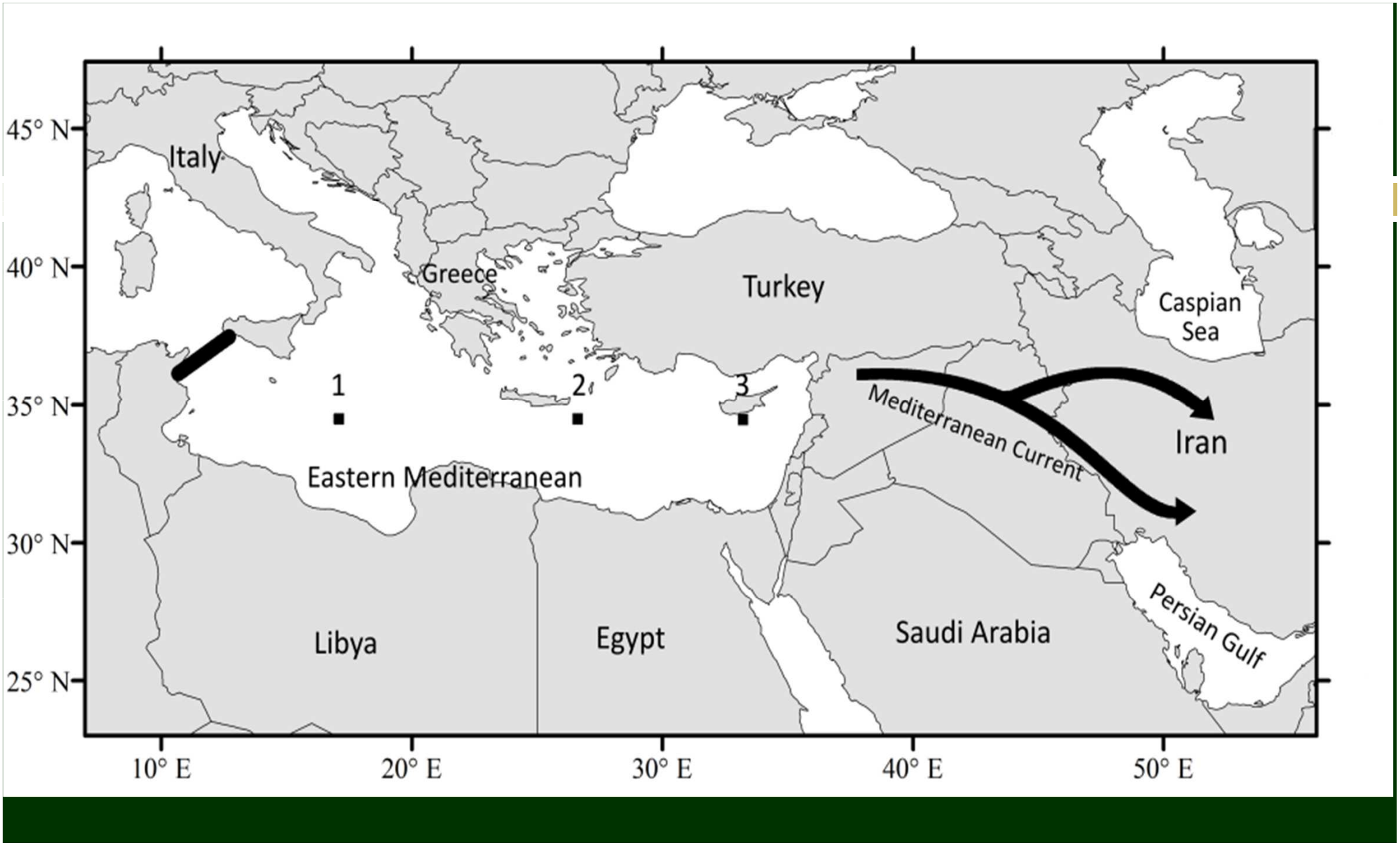
3

DEVELOPING A DECISION SUPPORT SYSTEM FOR WATER RESOURCES OPERATION

FRAMEWORK OF THE STUDY

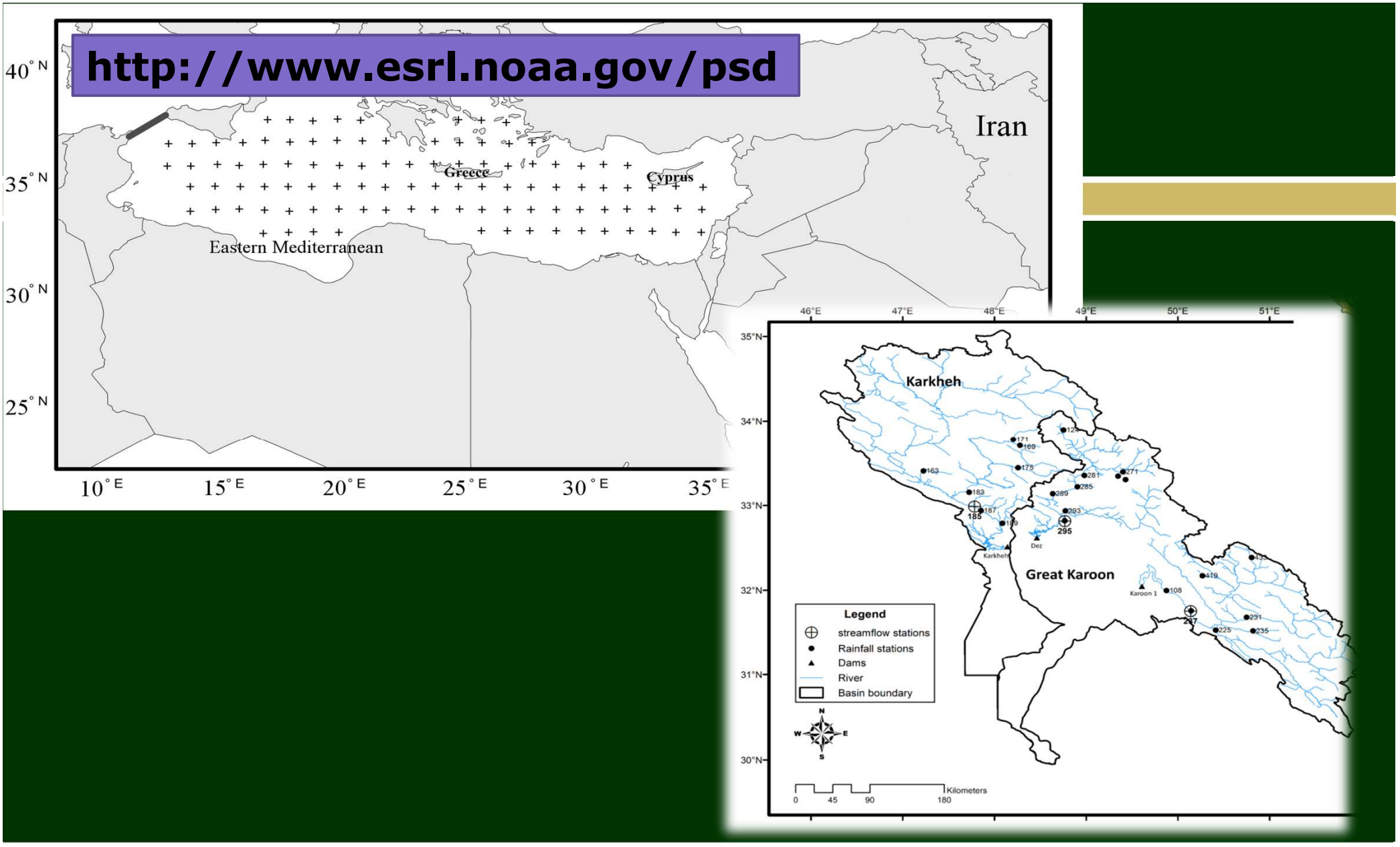
7/20

CLIMATE PREDICTORS:
SST OF MEDITERRANIAN SEA



8/20

The MEDITERRANIAN CURRENT


http://www.esrl.noaa.gov/psd
40° N
35° N
30° N
25° N
10° E
15° E
20° E
25° E
30° E
35° E
Iran
Greece
Cyprus
Eastern Mediterranean
46°E
47°E
48°E
49°E
50°E
51°E
35°N
34°N
33°N
32°N
31°N
30°N
Karkheh
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streamflow stations
Rainfall stations
Dams
River
Basin boundary
N
W
E
S
Kilometers
0
45
90
180

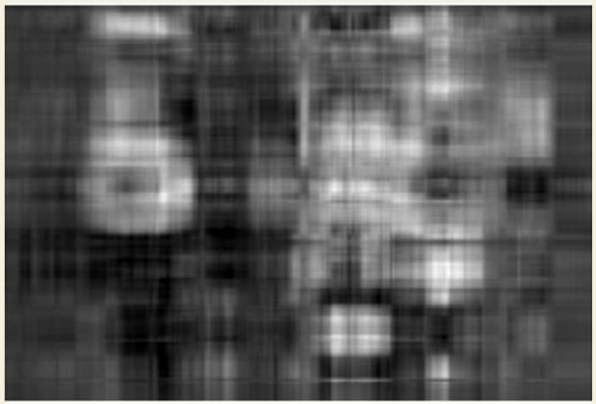
$$\mathbf{A}_{mn} = \mathbf{U}_{mm}\mathbf{S}_{mn}\mathbf{V}^{T}_{nn}$$

$$SVD(A_{gs}) = (U_{gg}, \begin{bmatrix} s_{1,1} & \cdots & 0 \\ & \ddots & \vdots \\ 0 & & s_{gs} \end{bmatrix}, V_{ss})$$

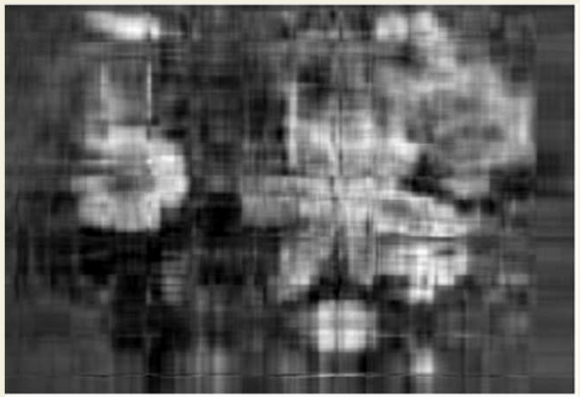
A_{hd}

Singular Value Decomposition

362*500



5



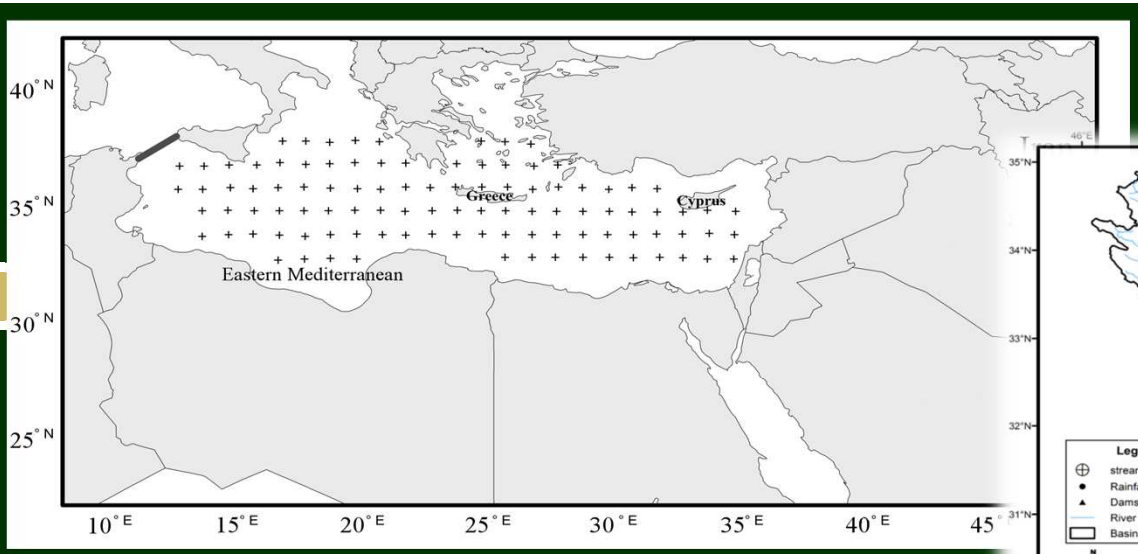
10

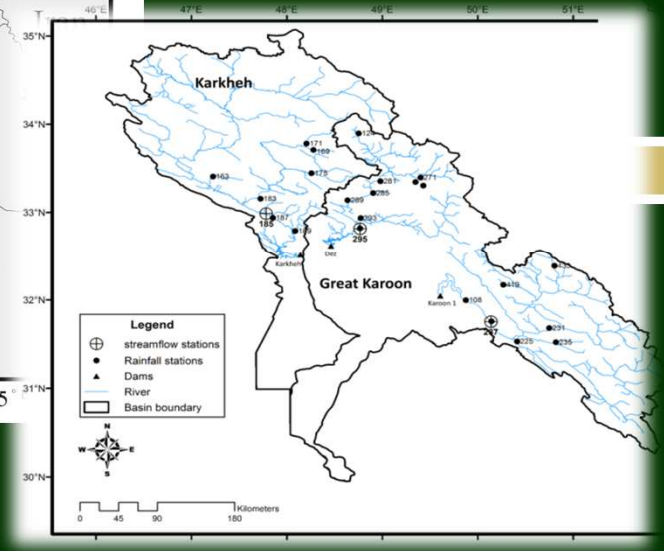
20

50

100

150





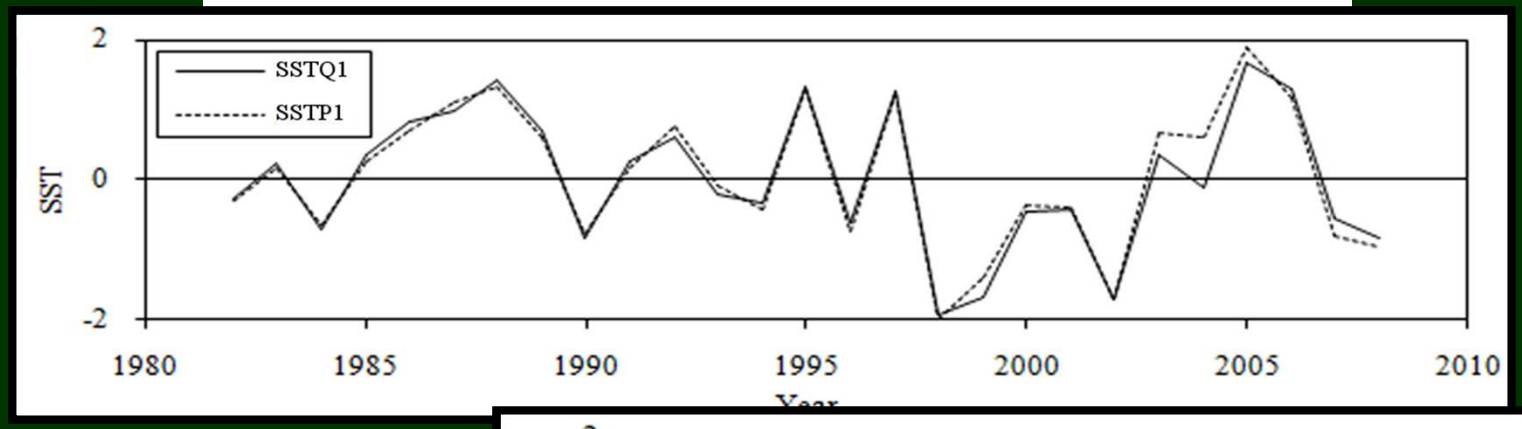
y=number of year of recorded data
g=number of grids of recording SST
s=number of precipitation stations

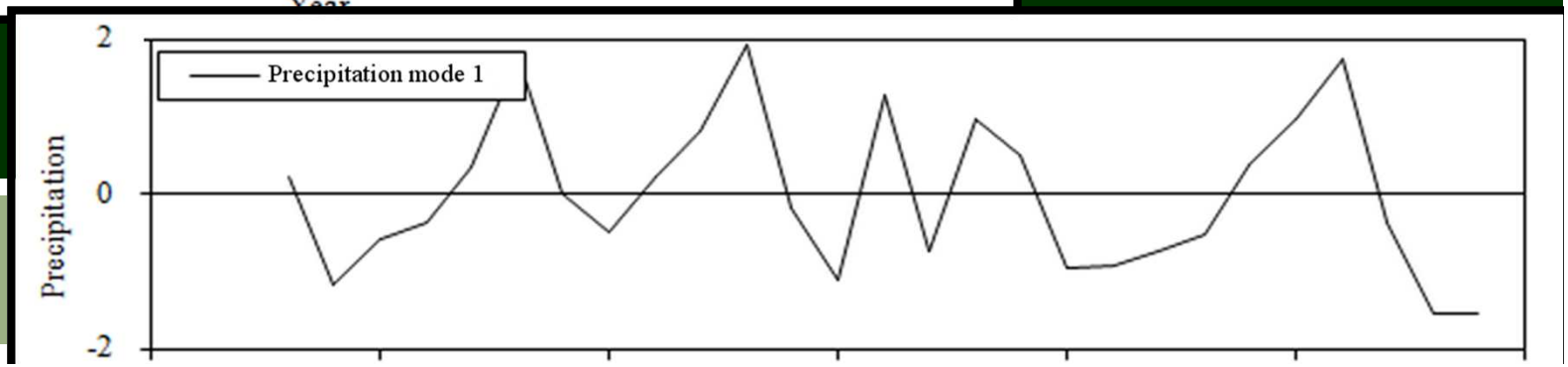
$$Cov = \frac{1}{y} \times \begin{bmatrix} sst_{1,1} & \cdots & sst_{1,y} \\ \vdots & \ddots & \vdots \\ sst_{g,1} & \cdots & sst_{g,y} \end{bmatrix} \times \begin{bmatrix} p_{1,1} & \cdots & p_{1,s} \\ \vdots & \ddots & \vdots \\ p_{y,1} & \cdots & p_{y,s} \end{bmatrix}$$

Singular Value Decomposition

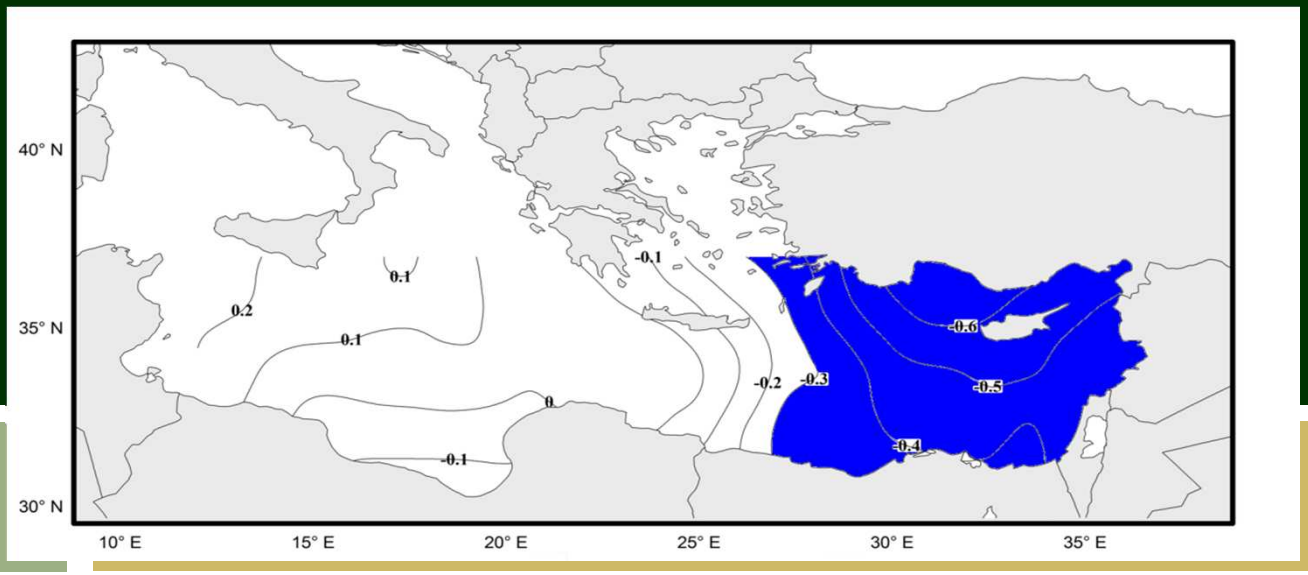
$$SVD\,(COVAR\,) = (U_{gg}, \begin{bmatrix} s_{1,1} & \cdots & 0 \\ & \ddots & \vdots \\ 0 & & s_{gs} \end{bmatrix}, V_{ss})$$

$$SSTP\,(i) = \begin{bmatrix} sst_{1,1} & \cdots & sst_{1,g} \\ \vdots & \ddots & \cdots \\ sst_{y,1} & \cdots & sst_{y,g} \end{bmatrix} U\,(:, i)$$





Basin	SSTP1		SOI		NAO		PDO		AMO	
	Wet	Drought	Wet	Drought	Wet	Drought	Wet	Drought	Wet	Drought
Dez	-0.36	-0.34	-0.24	-0.12	-0.03	-0.09	0.14	0.14	0.06	-0.13
Karoon	-0.58	-0.45	-0.50	-0.38	0.22	0.03	-0.16	0.19	0.26	-0.46
Karkheh	-0.41	-0.35	-0.49	-0.31	0.30	-0.31	-0.04	0.29	0.12	-0.09
Average	**-0.46**	**-0.39**	**-0.42**	**-0.27**	**0.17**	**-0.11**	**-0.03**	**0.20**	**0.15**	**-0.24**



DETERMINING APPROPRIOATE DROUGHT PREDICTORS for RAINFALL AND STREAMFLOW

LARGE SCALE CLIMATE SIGNALS

PERSISTENCY OF STREAMFLOW AND RAINFALL TIME SERIES

SNOW BUDGET

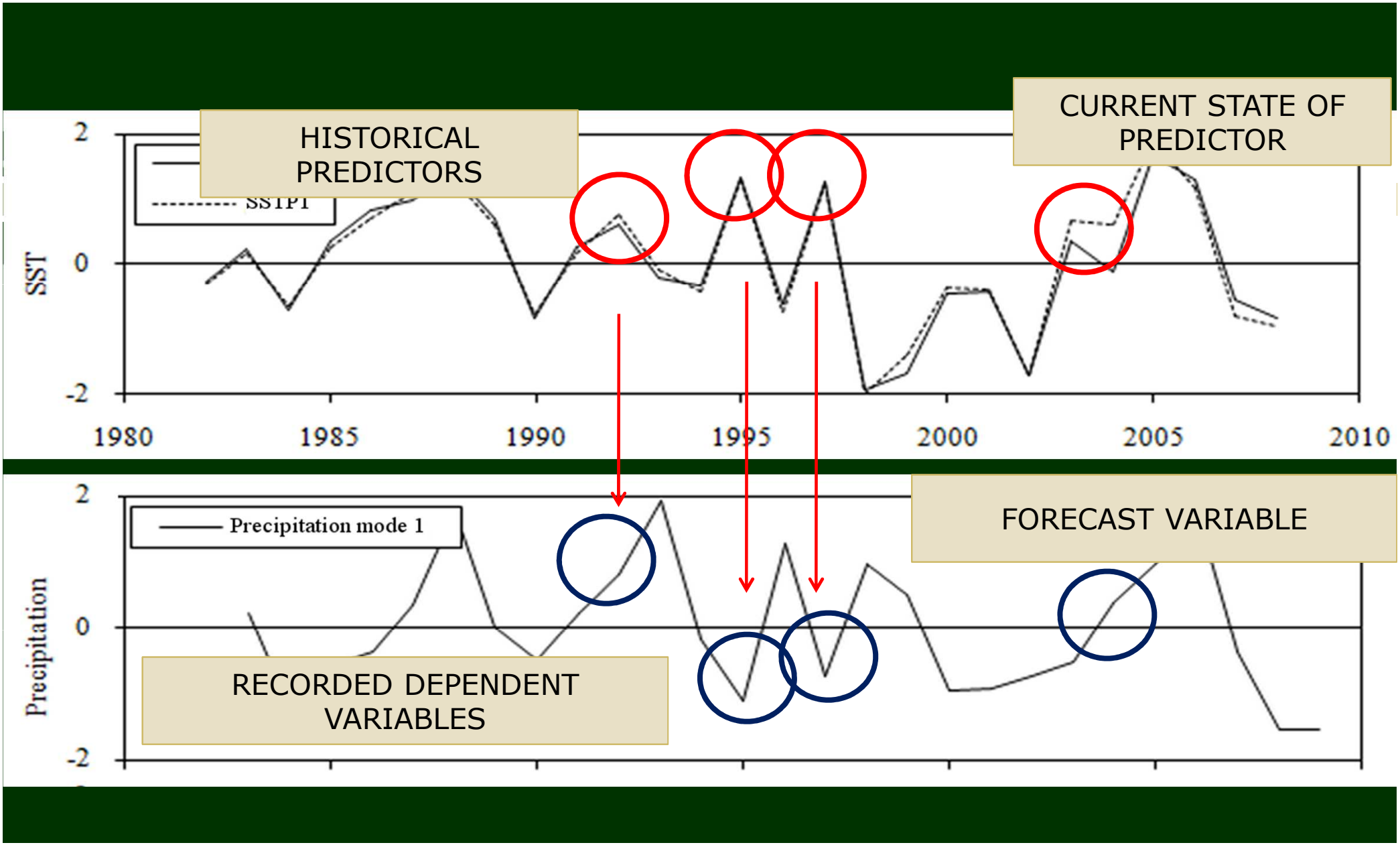
DEVELOPING A PROBABILISTIC FORECASTING MODEL

MODEL CALIBRATION

MODEL VALIDATION

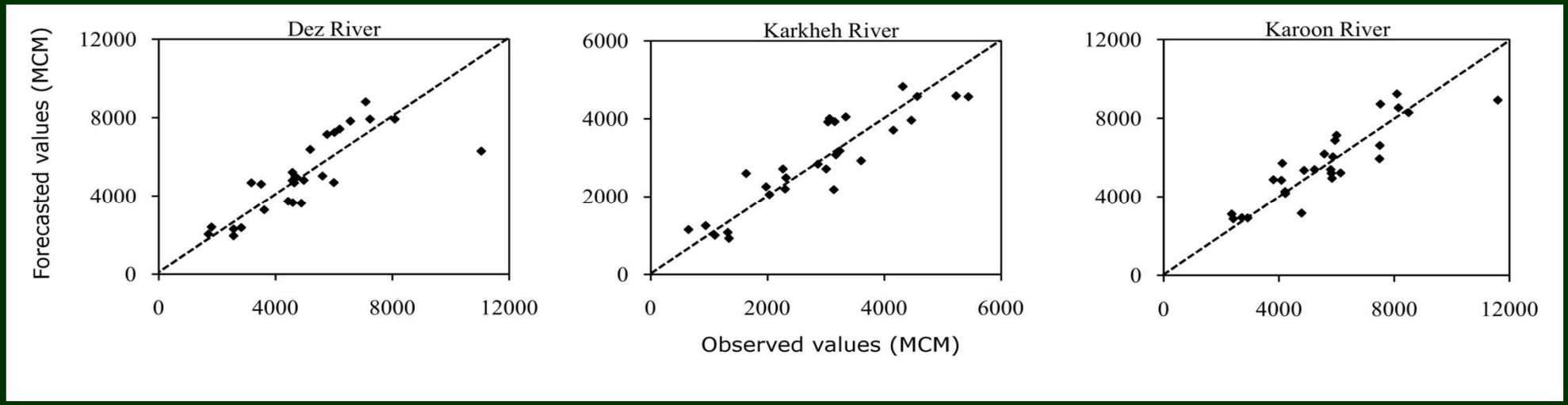
DEVELOPING A DECISION SUPPORT SYSTEM FOR WATER RESOURCES OPERATION

FRAMEWORK OF THE STUDY

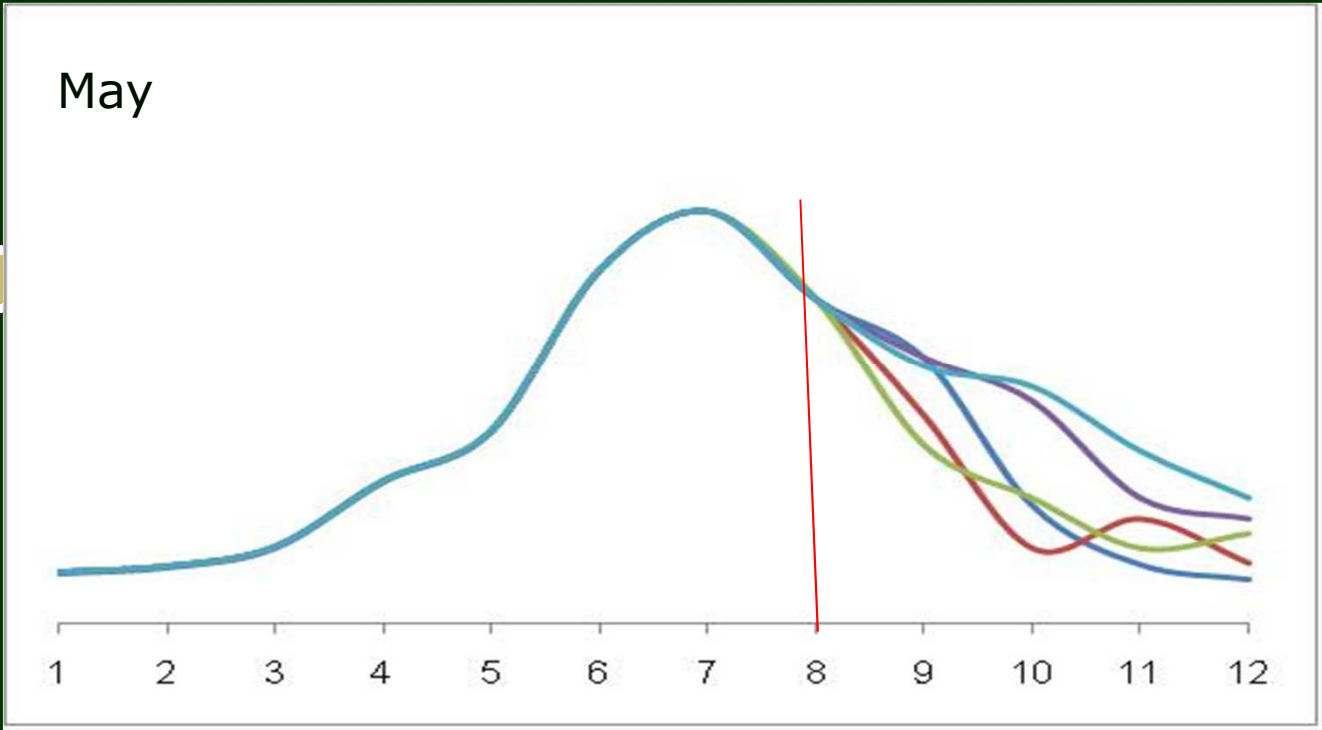


FORECASTING MODEL:
K-NEAREST NEIGHBOUR (K-NN)

$$Y_r = \sum_{k=1}^{K} f_k(\Delta_{rk}) Y_k - \sum_{k=1}^{K} f_k(\Delta_{rk}) E_k$$



FORECASTING MODEL: KNN



PREDICTORS	DEPENDANTS	AVERAGE FORECASTING ERR.
SUMMER SST+SOI+PDO	OCT. to JAN. Streamflow	18-25
Autumn SST+SOI+PDO+PREVIOUS STR./RAI.	FEB. to MAY. Streamflow	14-23
SNOW BUDGET + PREVIOUS STR./RAI.	Jun. to Sep.	6-8

FINAL RESULTS

❖SST of Mediterranean Sea Could be a Predictor for Climate Variation of Western Basins of Iran

We Need Information from Physical and Dynamic Meteorology to Confirm the above Result

❖The Probabilistic Non-Linear Regression of K-NN is useful for Long-Lead Forecasting

The approach of Multi-Model data Fusion Could Improved the Results

❖Developing a Decision Support System Could Significantly Improve the Efficiency of the Developed Models

CONCLUSION

The Best Way to Predict the Future Is to Invent It

Alan Kay

THANK YOU

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