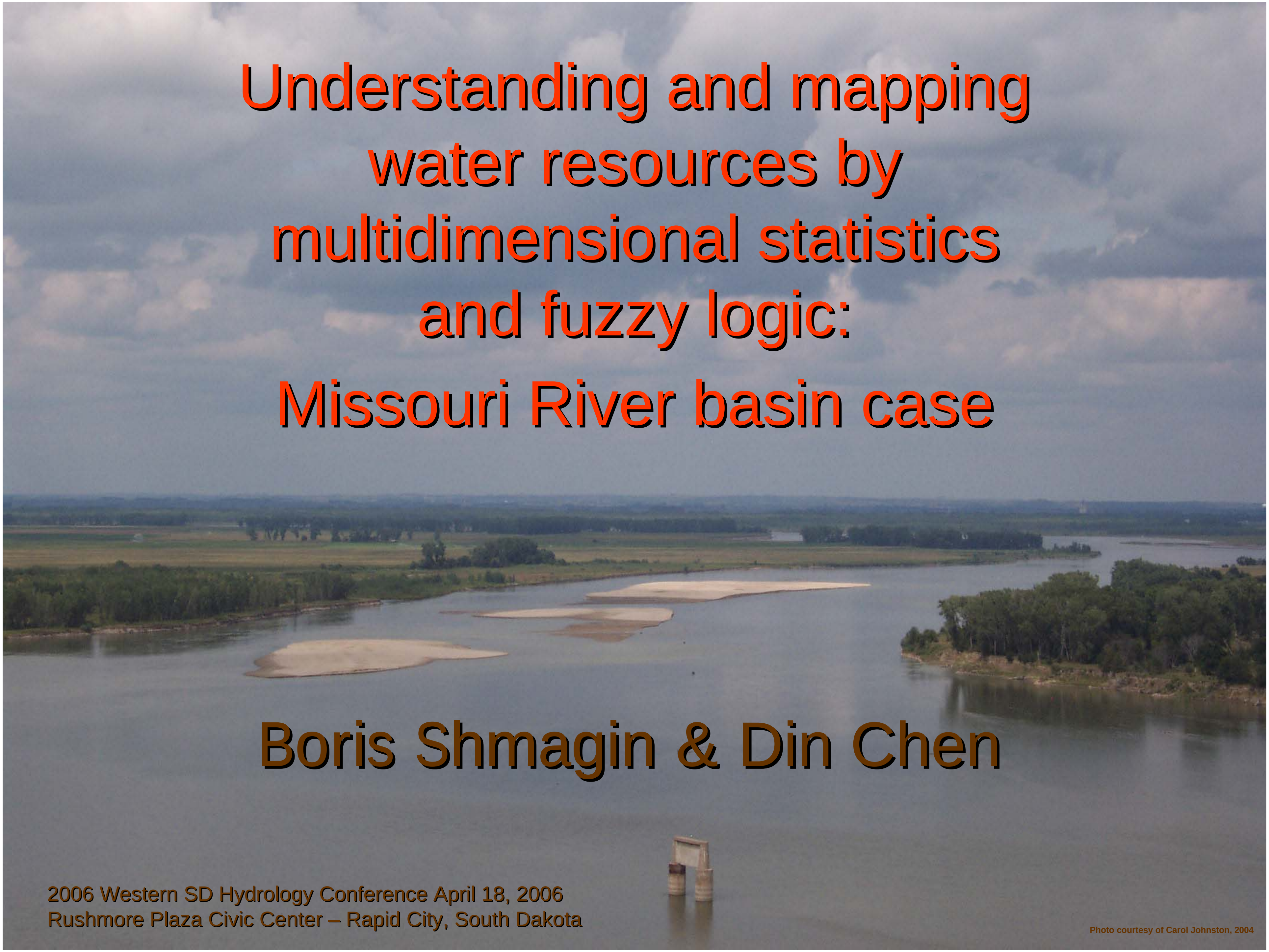
Nature Precedings : doi:10.1038/npre.2007.1071.1 : Posted 21 Sep 2007



Topics

•Spatial-temporal variations of stream runoff for Upper Missouri River watershed

* Hydrologic regime as structure

* Land cover or landscape

* Map with fuzzy boundaries

* Applications

* Decision making about water resources or Scientist vs. Lawyer

South Dakota EPSCoR
Experimental Program to Stimulate Competitive Researc

Boris Shmagin & Din Chen
SDSU Biocomplexity Studies &
Department of Mathematics and
Statistics SDSU

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant # R829643

Topic

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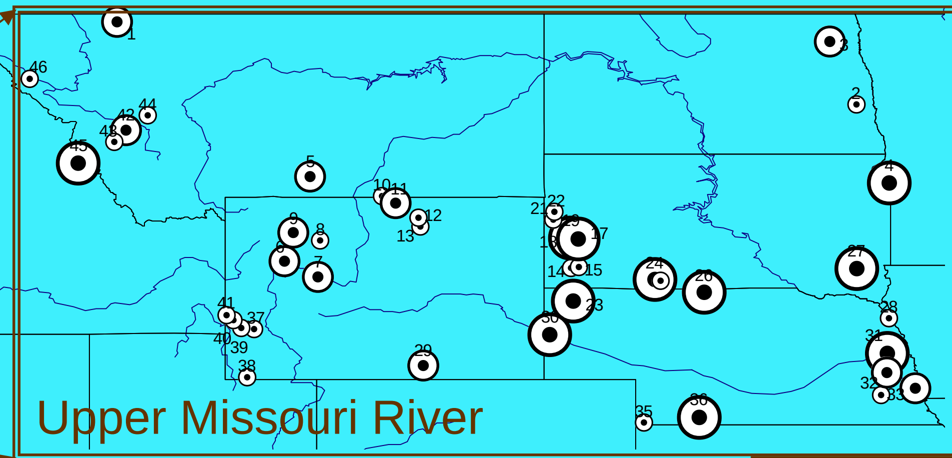
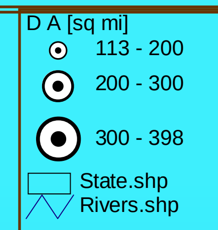
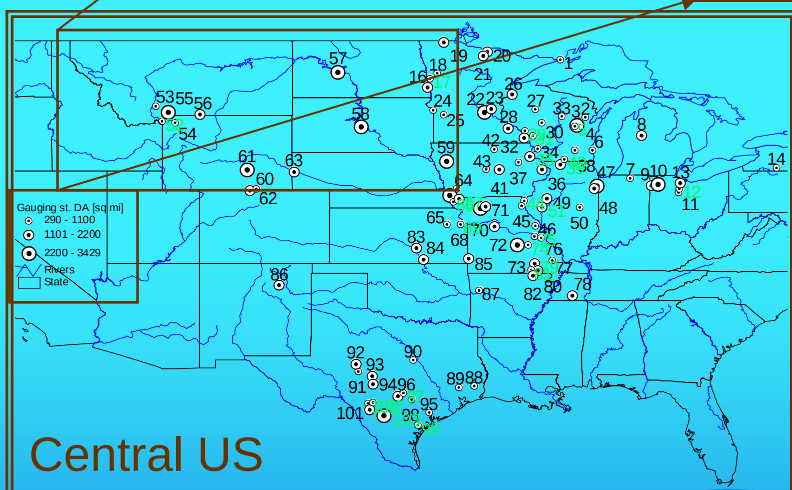
Matrixes for statistical analysis

Gauging station locations and drainage aria (DA) distribution for Central US (DA: 290-3429 sq mi) & Upper Missouri River (DA: 113-398)







Initial Matrixes:

$\{Q^{UMR}_{28*46}\}$ & $\{Q^{C\ US}_{31*101}\}$

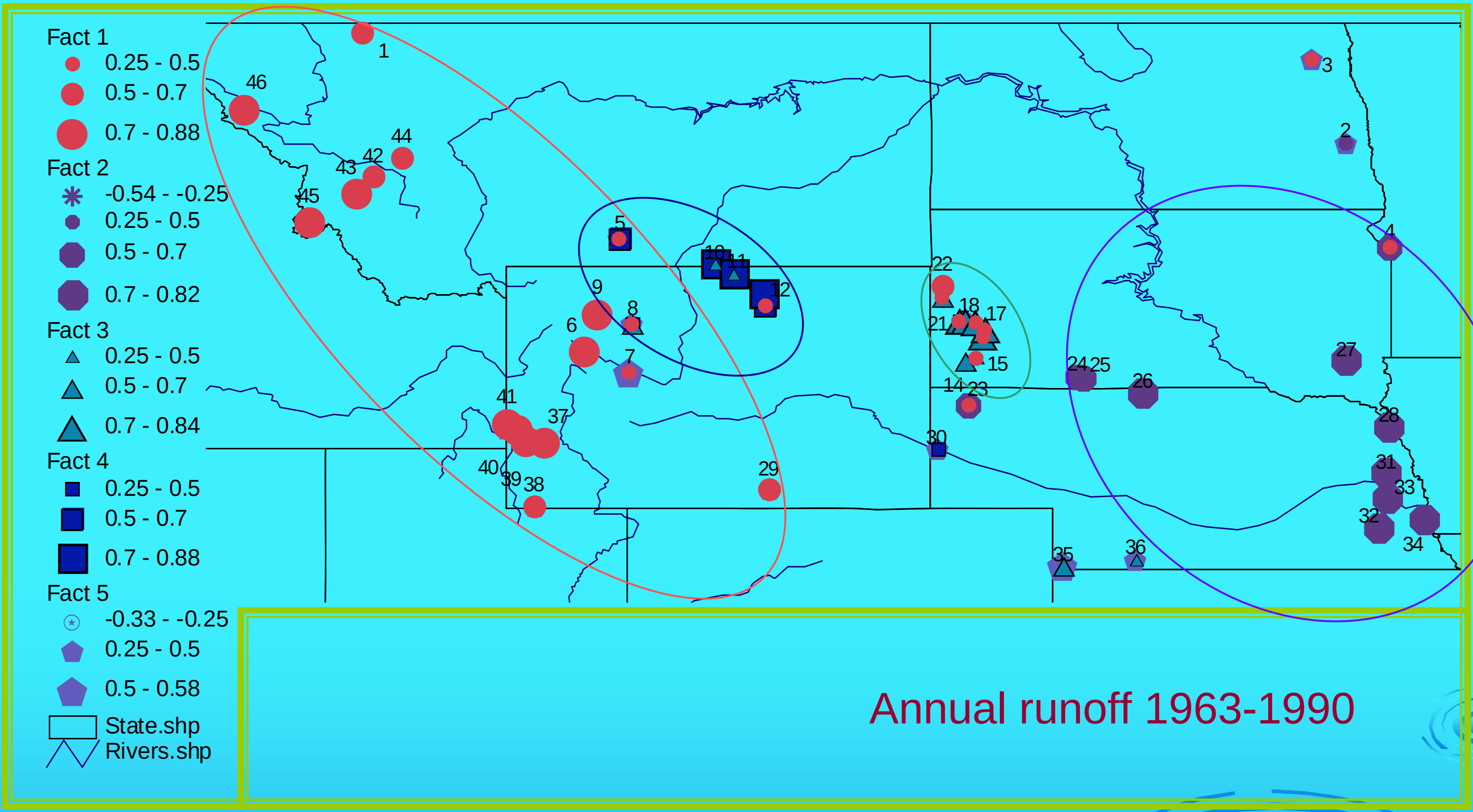
Factor analysis:

$$Q_{t*p}=F_{t*k}*A_{k*p} + E_{t*p}$$

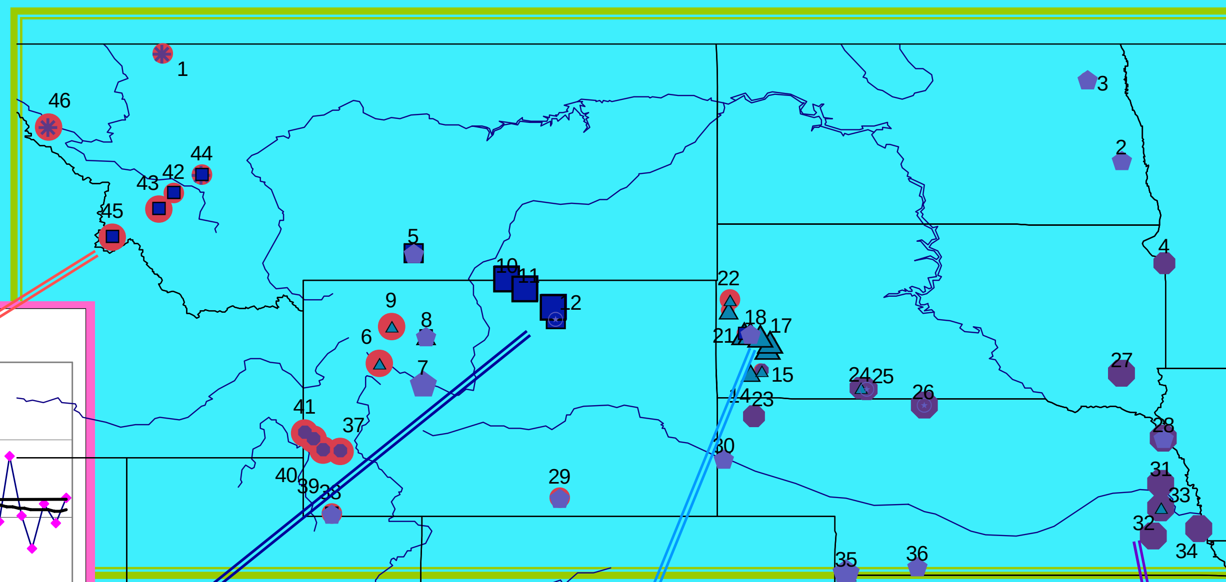
Matrixes of results:

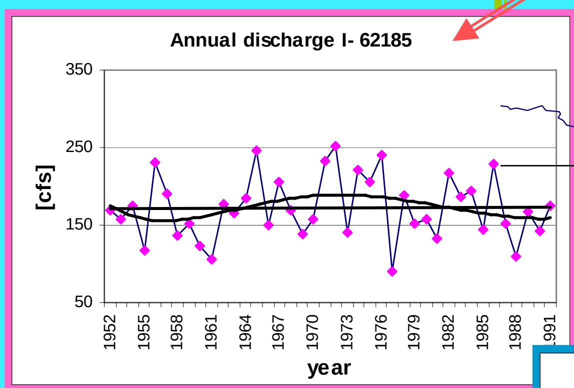
A_{k*p} – *factor loadings,*
as dimensions of process (k),
grouping by types of regime (p);
F_{t*p} – *factor scores,*
as components for types of regime

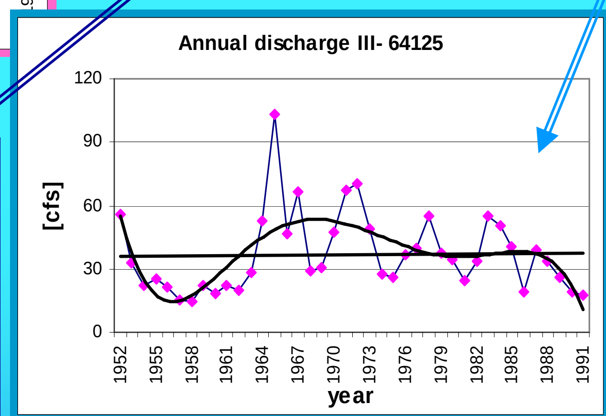
Factor Loadings of 46 gauging stations

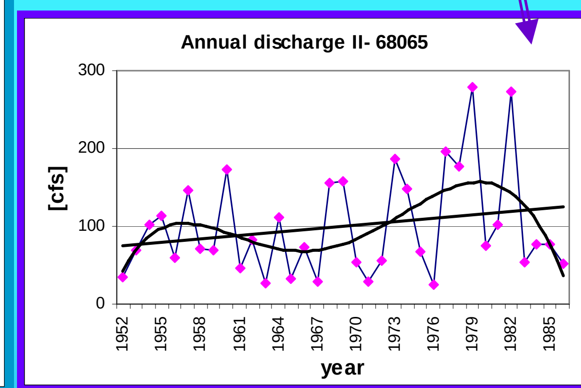


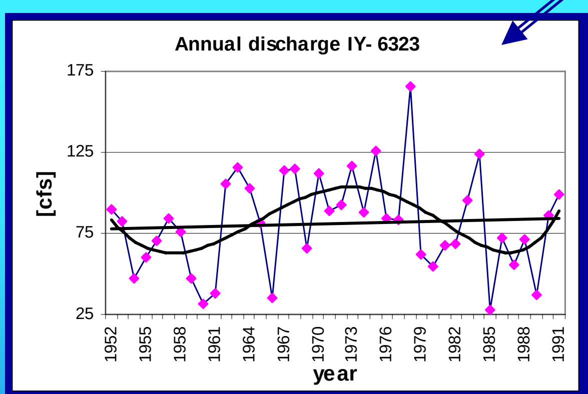
Patterns of stream runoff in Upper Missouri











Factor Loading of 46 gauging stations and graphs of annual runoff 1953 -1990 for four typical watersheds

Topic

• Spatial-temporal variations of stream runoff
for Upper Missouri River watershed

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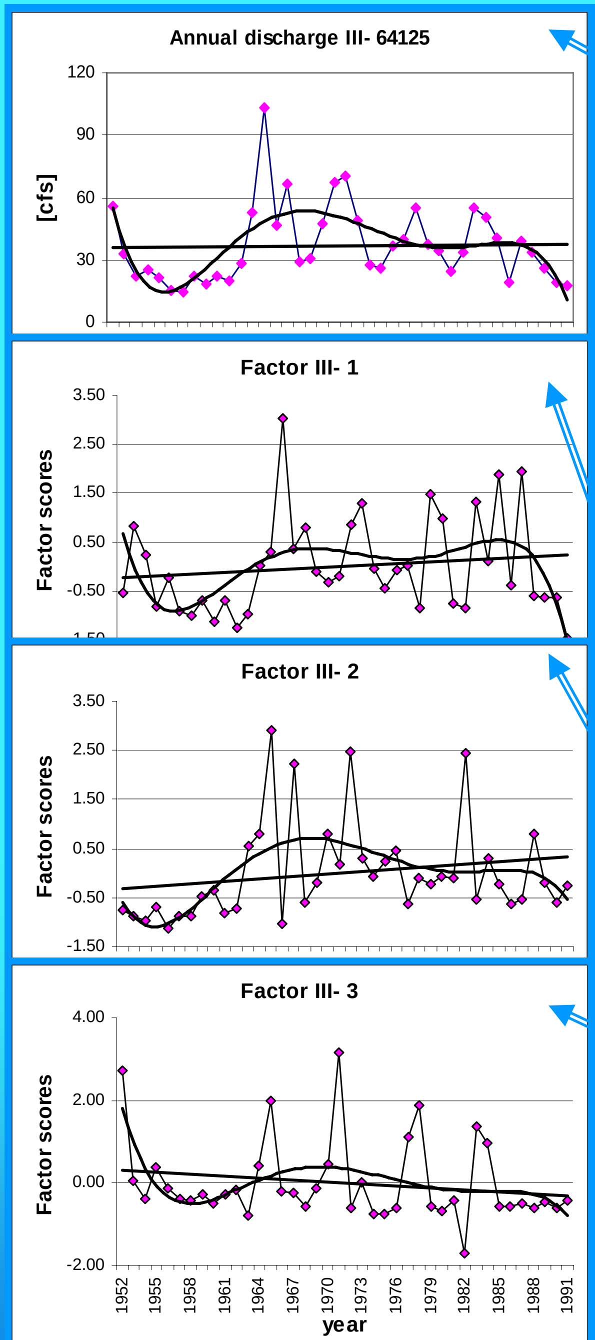
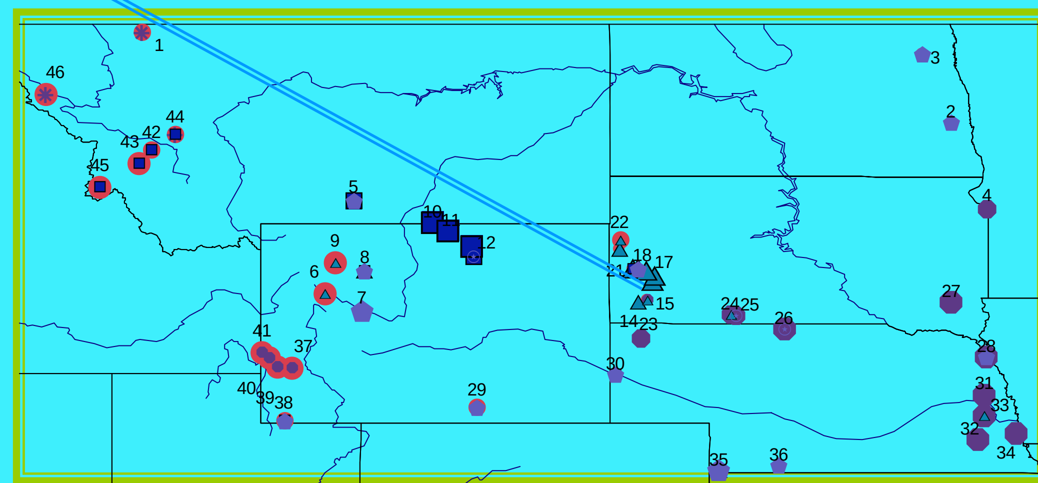
Table of seasonal runoff for four typical watersheds

	October	November	December	January	February	March	April	May	June	July	August	September	Annual	Expl. Var.
Factor I- 1						0.31			0.90	0.86	0.94	0.83	0.93	4.25
Factor I- 2	0.80	0.80	0.87	0.83	0.78	*0.50*								3.63
Factor I- 3						0.33	0.83	0.78						1.58
Factor II- 1	0.84	0.91	0.93	0.83	0.43	0.27	0.41	0.40					0.43	3.91
Factor II- 2					*0.62*		*0.57*	*0.62*	0.88				0.69	2.47
Factor II- 3	0.37				-0.25			0.43			0.88	0.44	0.29	1.55
Factor II- 4						*0.60*	0.44			0.76		*0.56*	0.46	1.72
Factor III- 1	0.79	0.81	0.93	0.85	0.85	0.79	0.45						0.37	4.75
Factor III- 2									0.72	0.90	0.90	0.88	*0.64*	3.42
Factor III- 3							0.70	0.90	0.49				*0.64*	2.12
Factor IY- 1	0.84	0.90	084	0.77	0.70	0.52	0.56						0.81	3.98
Factor IY- 2									0.84	0.88	0.31		0.46	2.43
Factor IY- 3						0.67					*0.62*	0.86		1.79
Factor IY- 4				0.38			0.38	0.88	0.30					1.68

Different number of seasons, composition and influence on annual

Annual and seasonal stream runoff of third regime type in Upper Missouri





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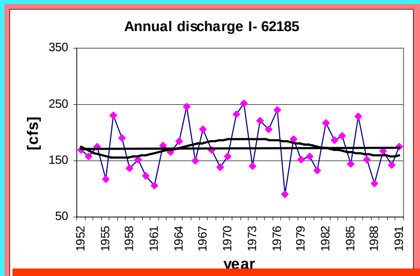
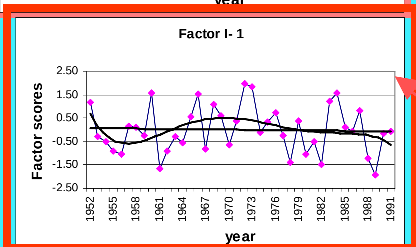
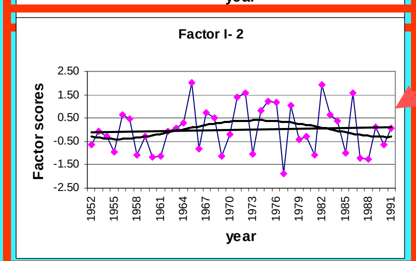
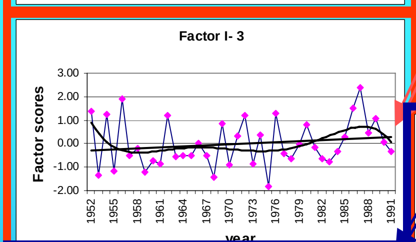
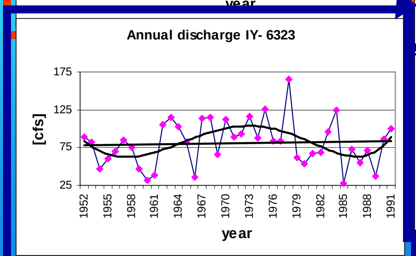
Structure of time spatial variability of stream runoff for Upper Missouri

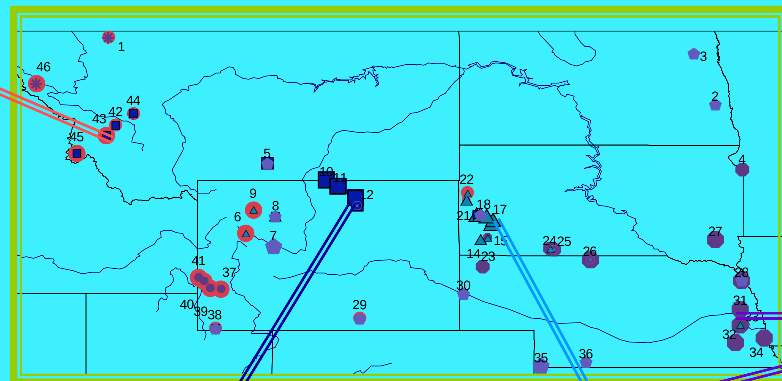


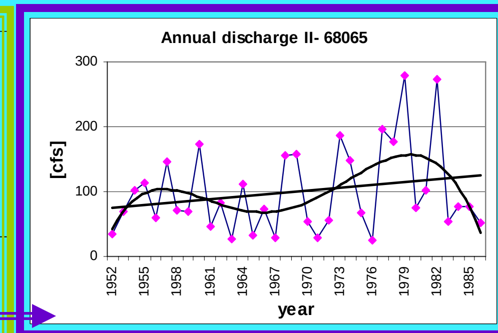












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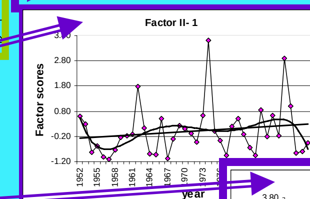
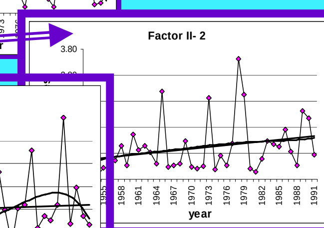
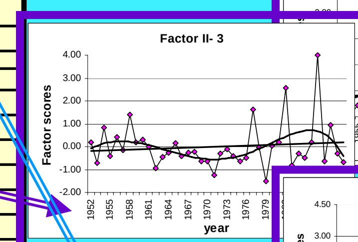
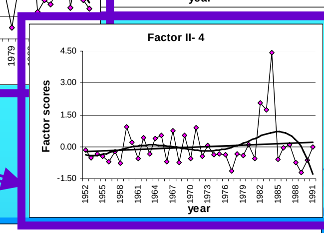
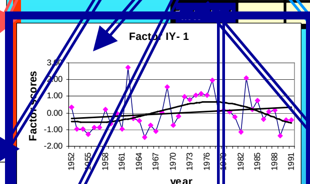
[illegible]				0.38			0.38	0.88	0.30					

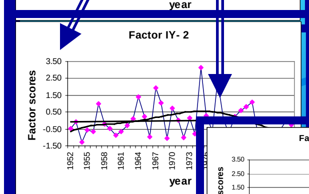


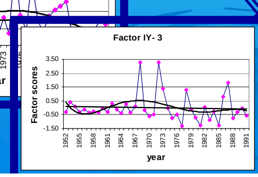


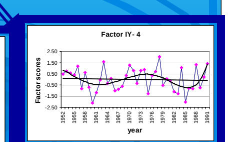


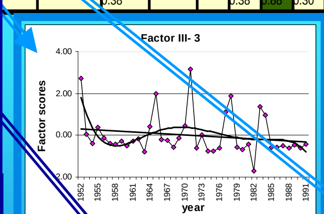


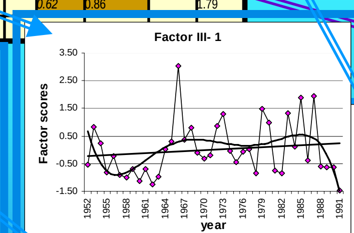


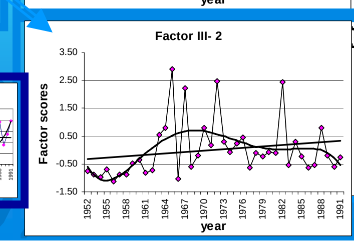


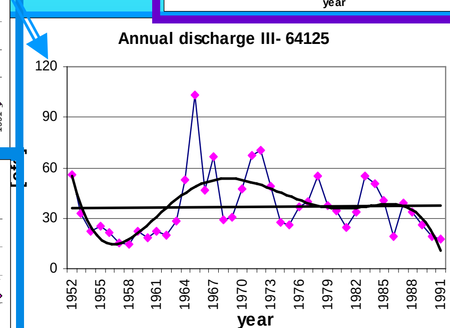




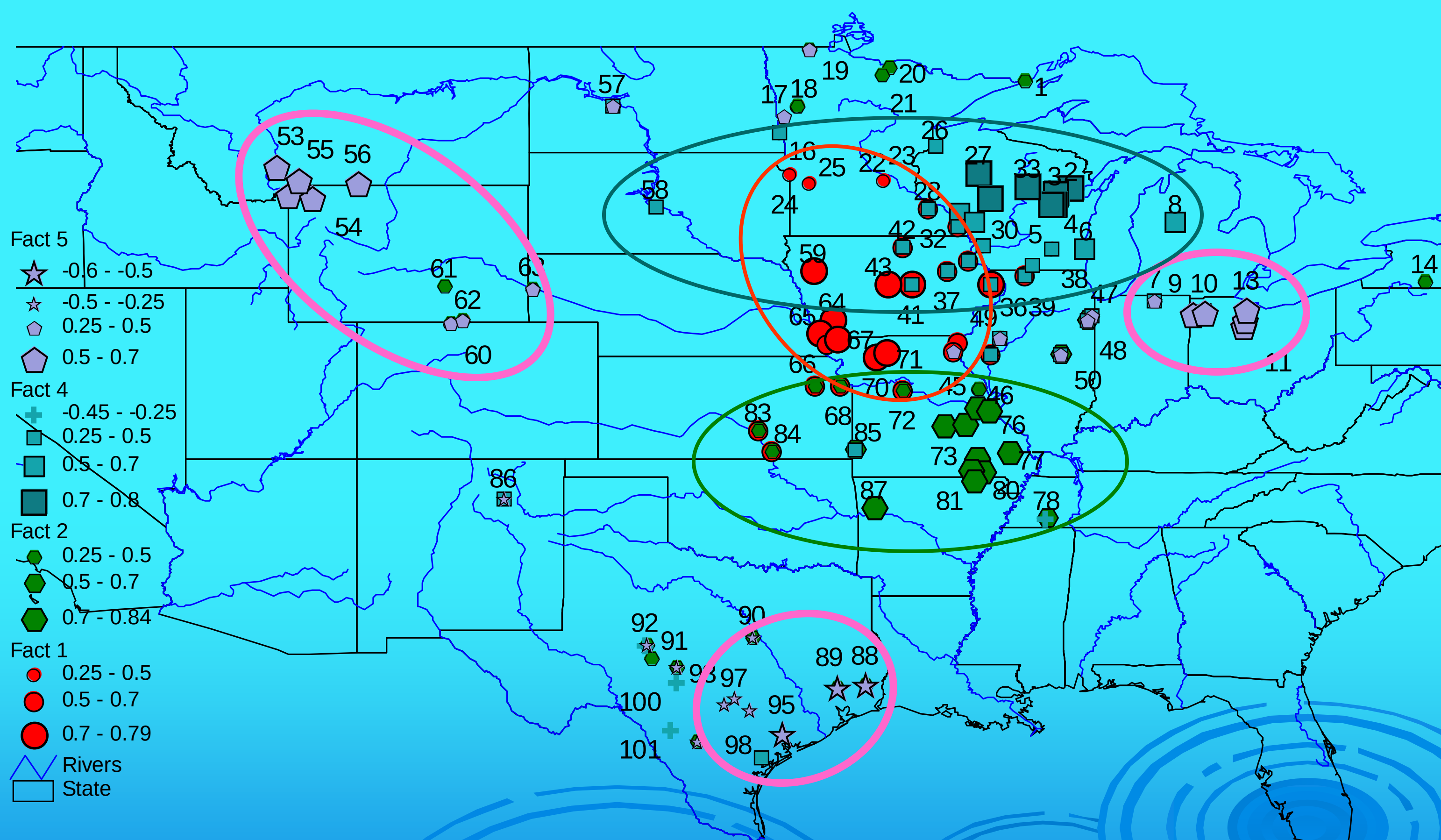




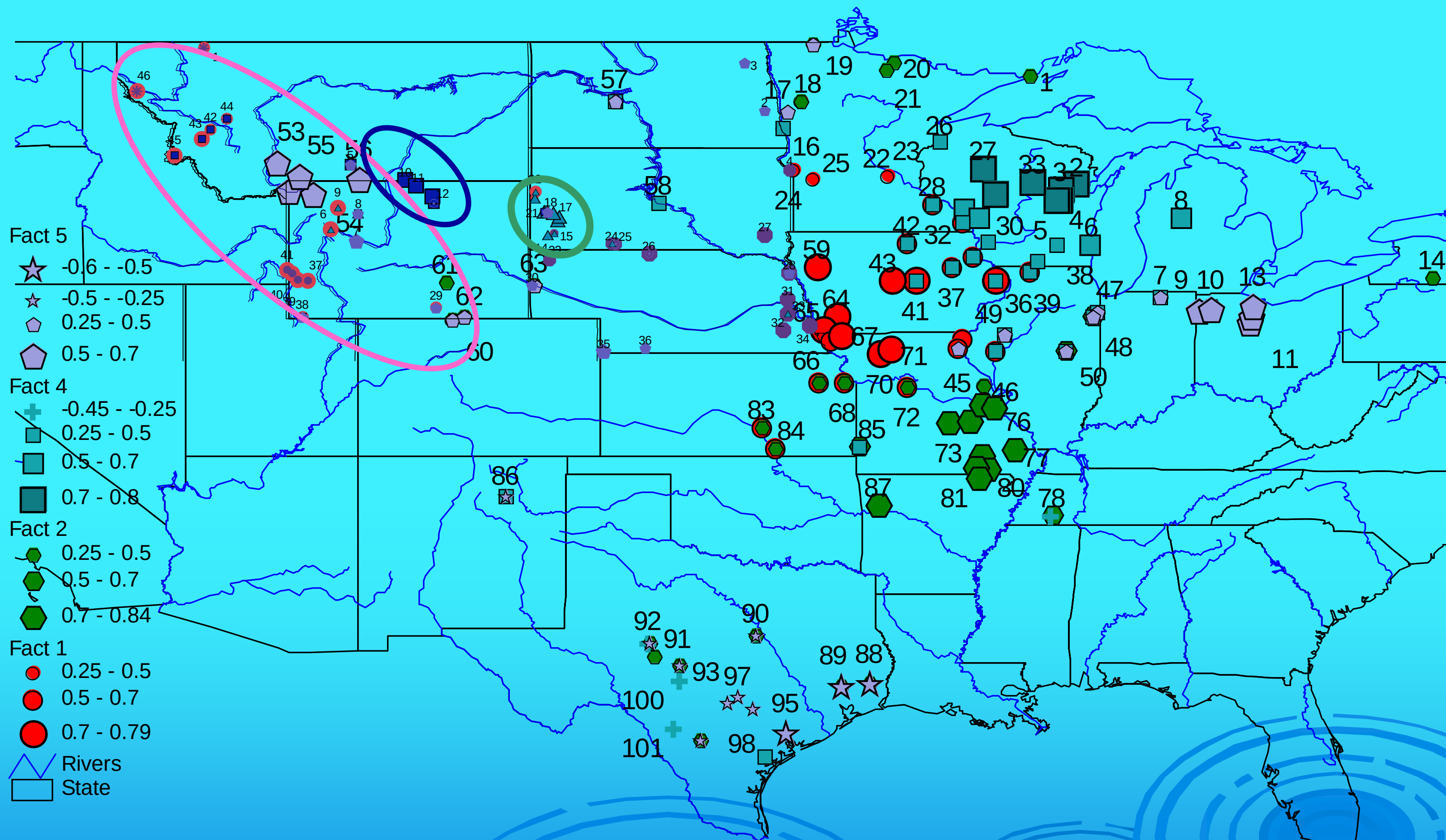




Factor Loadings of 101 gauging stations



Patterns of stream runoff in Central US and Upper Missouri



Topic

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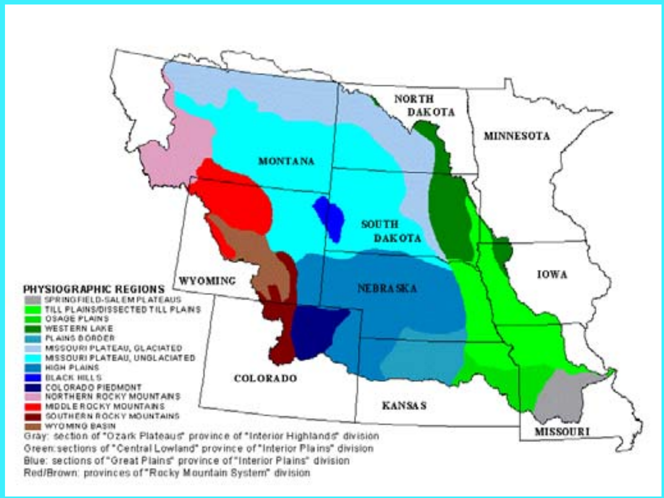
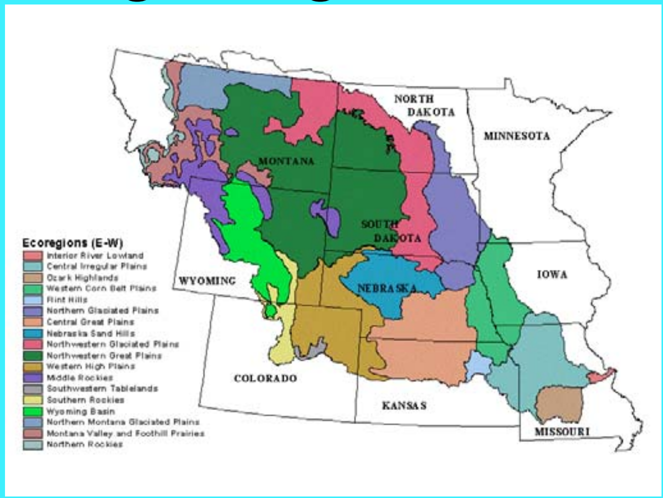
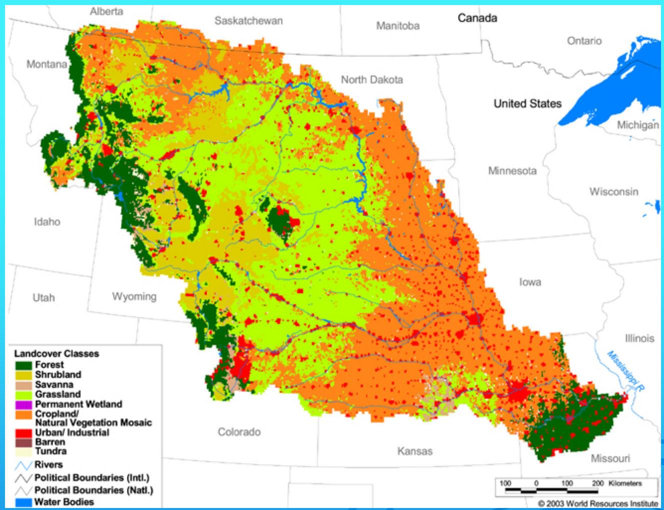
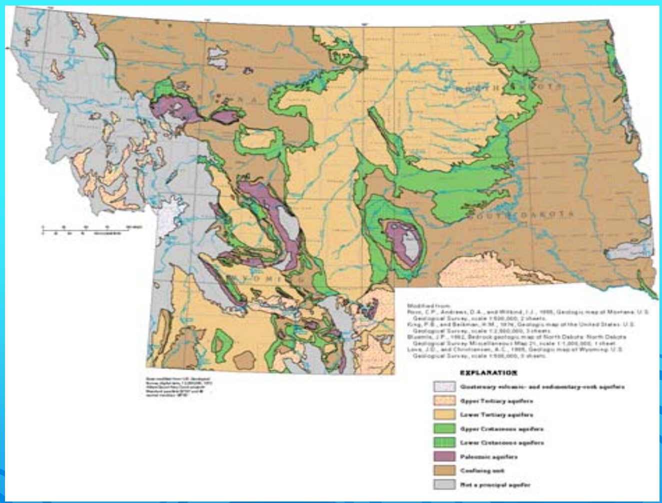
Maps: physiographic, ecoregions, landcovers and hydrogeological

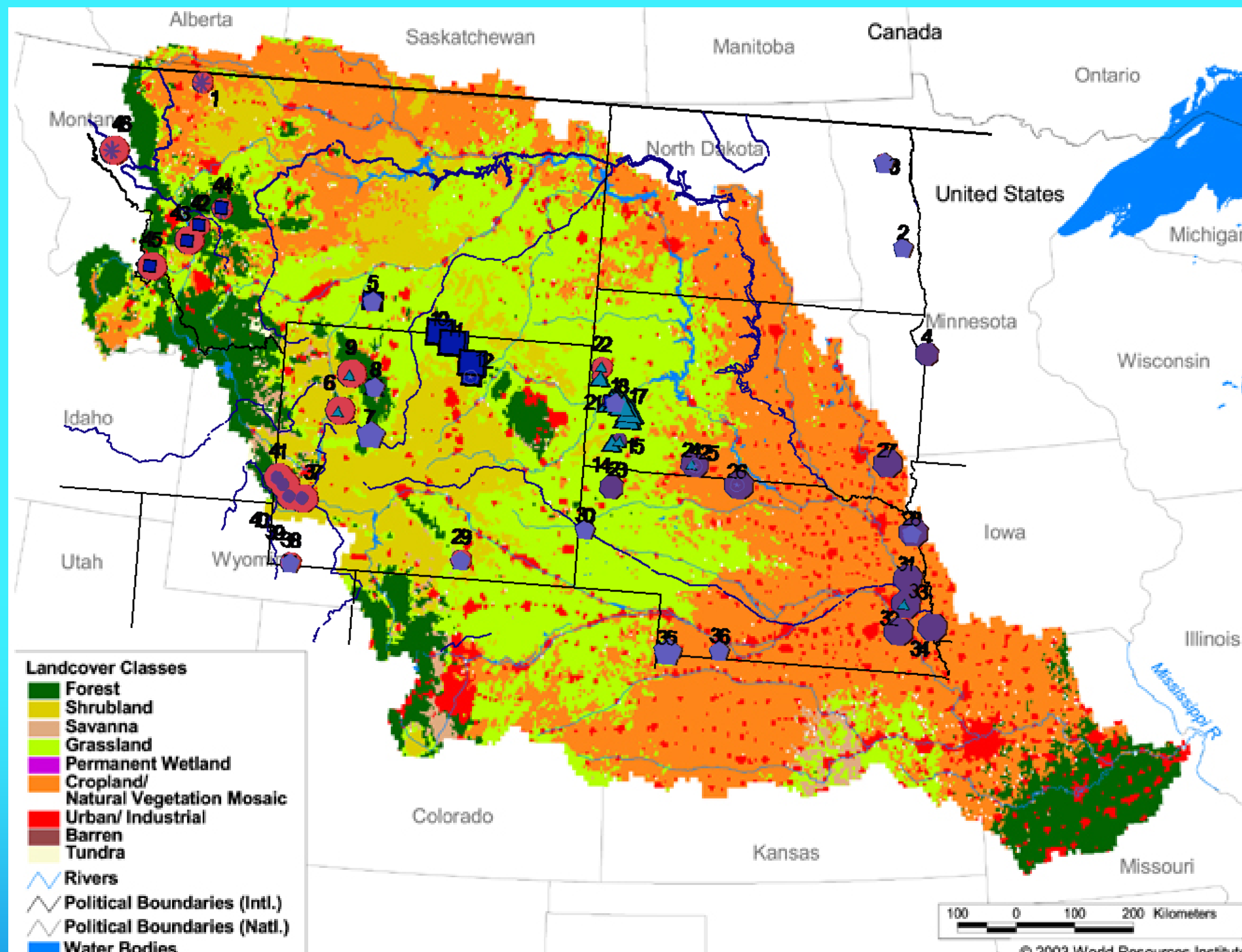




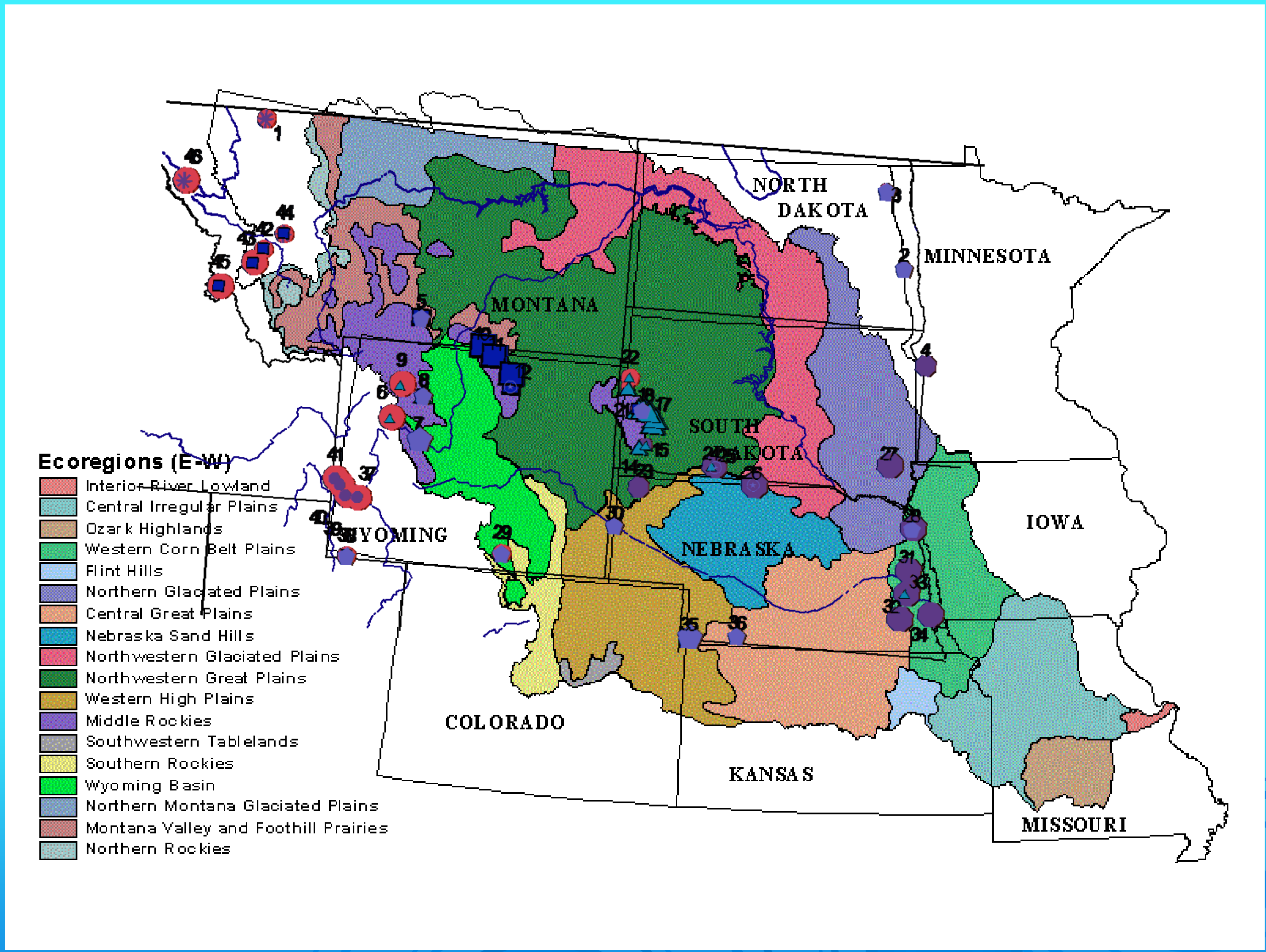




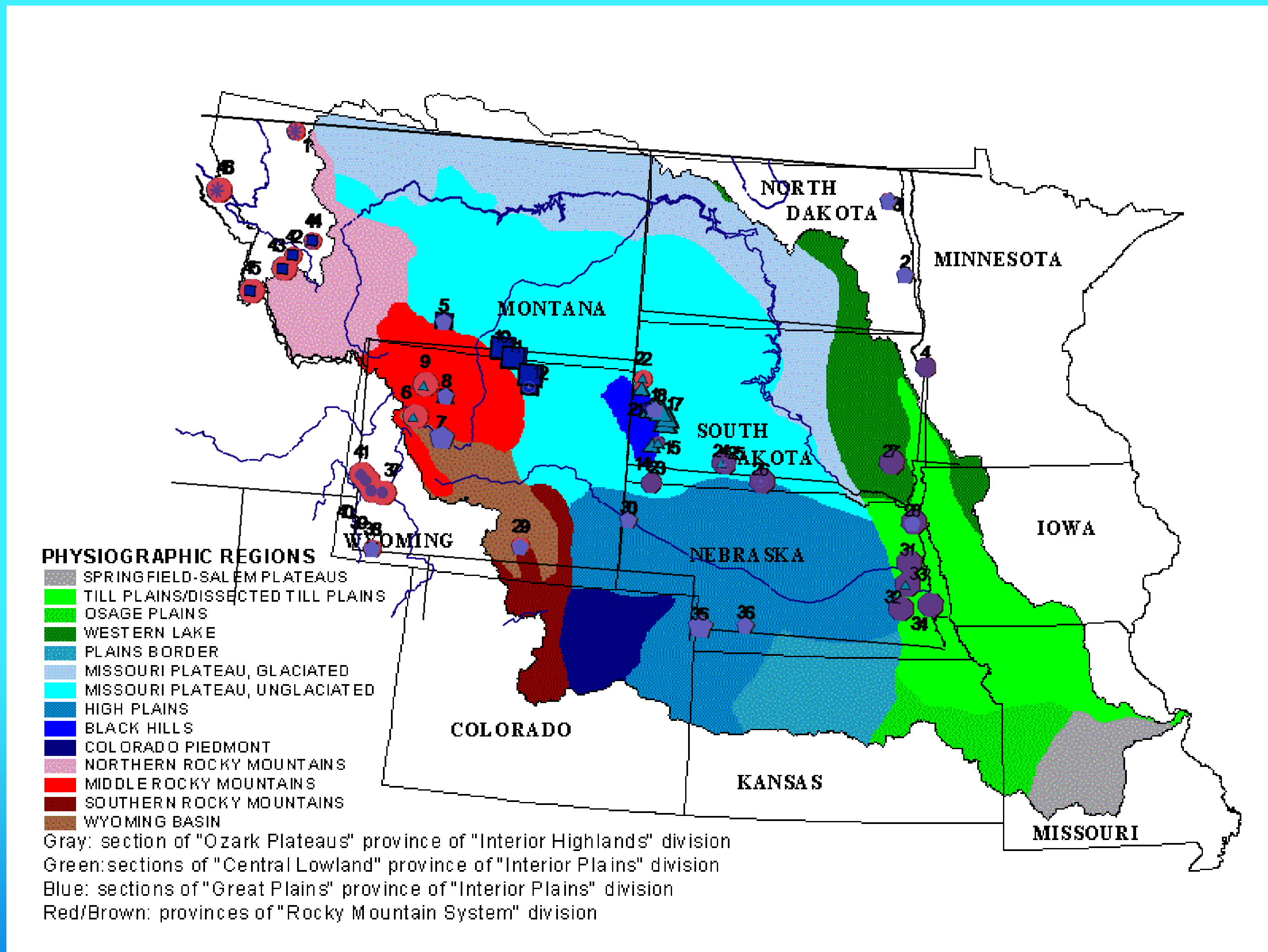
Map: landcovers



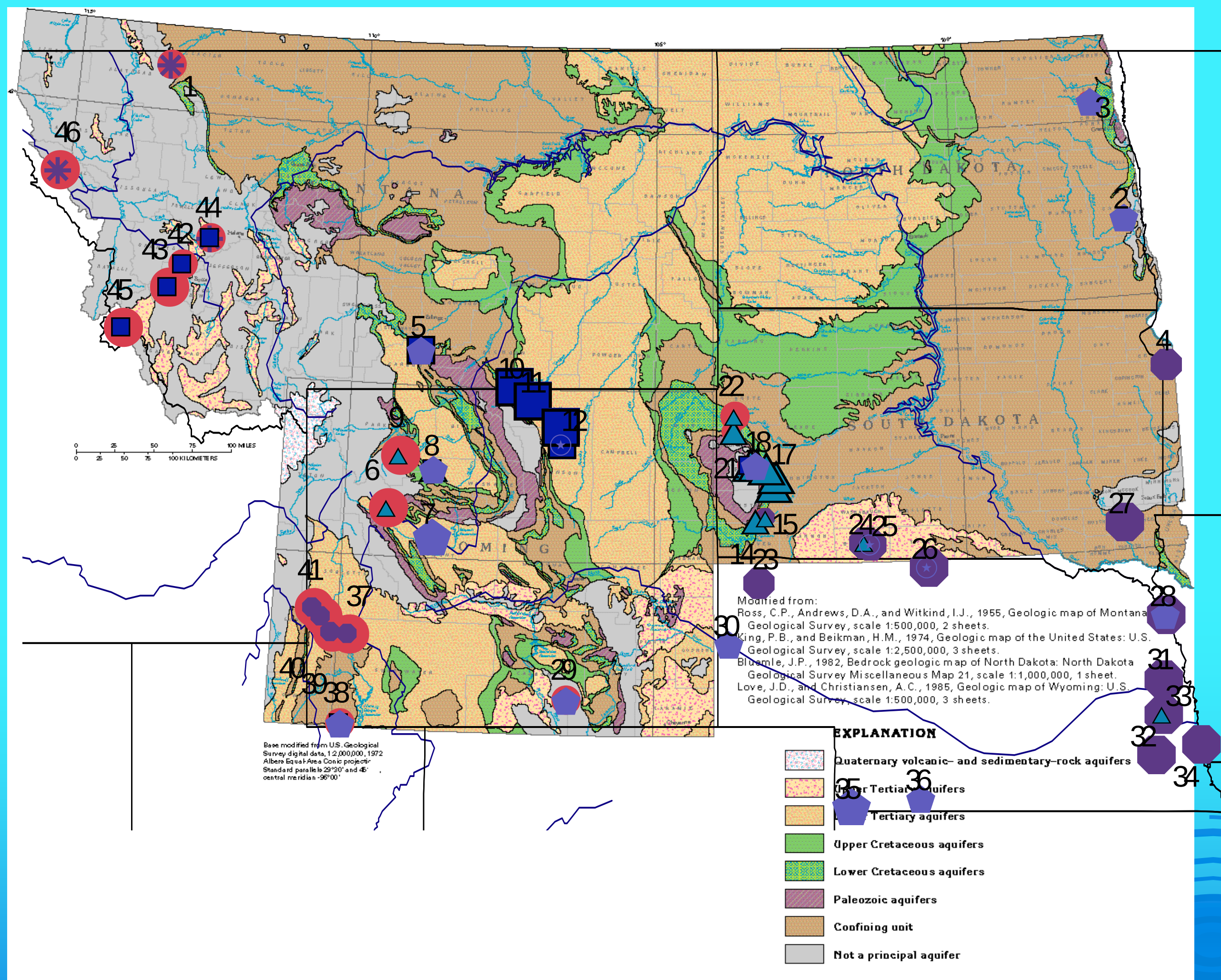
Map: ecoregions



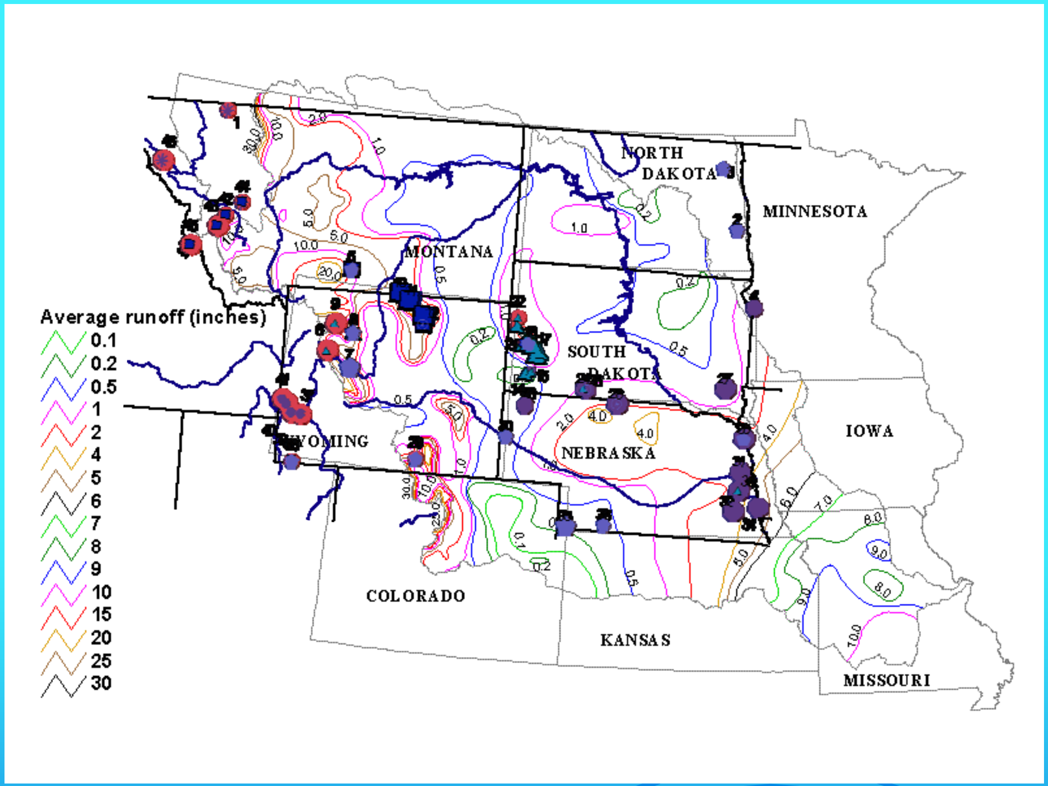
Map: physiographic



Map: hydrogeological



Control of patterns of stream runoff in Central US and Upper Missouri



* Topography
* Landscape property like hydrogeology

Topic

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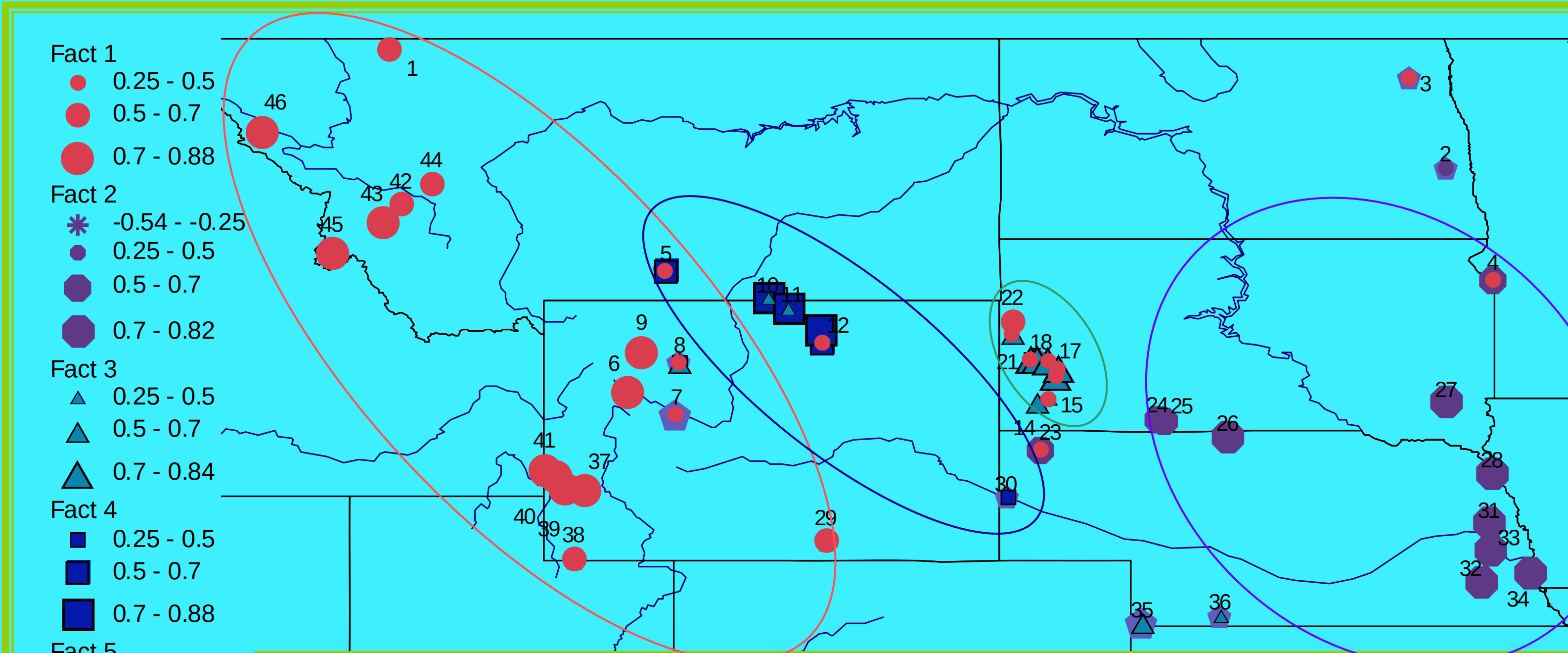
R829643

Patterns of stream runoff in Upper Missouri



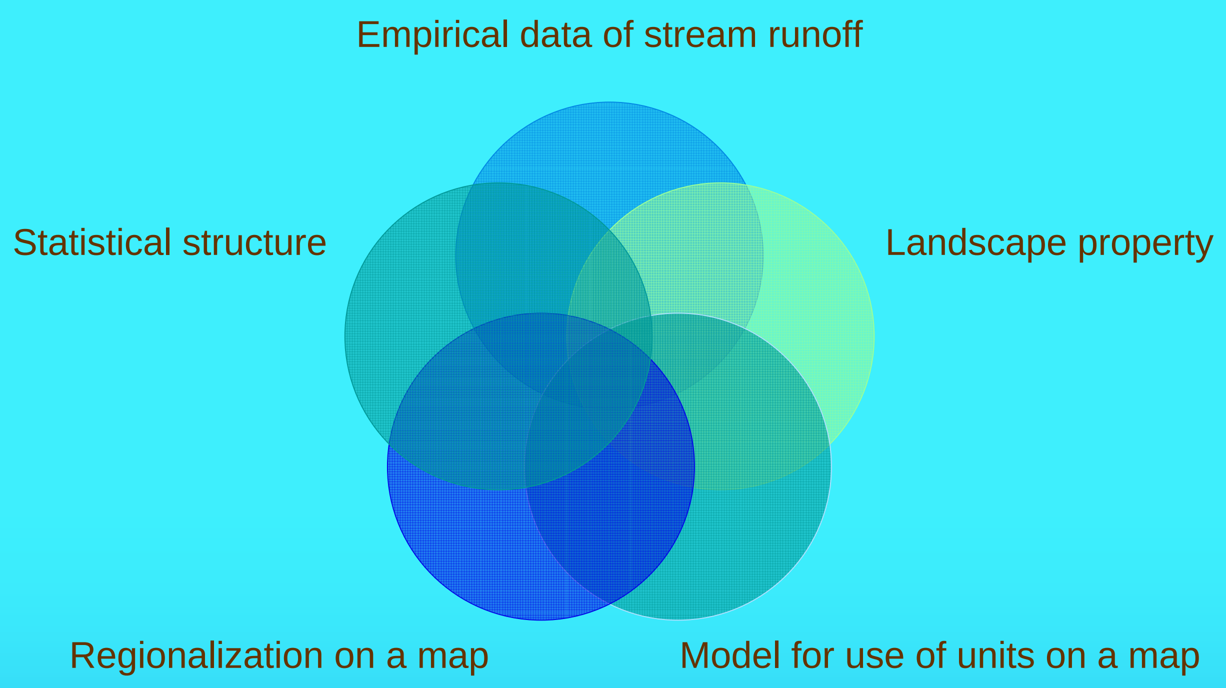
	Fact 1	Fact 2	Fact 3	Fact 4	Fact 5	Total
Explained Variance	10.29	7.80	6.00	4.52	2.70	31.31
Proportion	0.22	0.17	0.13	0.10	0.06	68%

Annual runoff 1963-1990

Fuzzy Logic rules for mapping the statistical structure

* The set of sampled gauging stations (watersheds) with results of factor analysis of stream runoff may be regarded as a fuzzy set
* Factor Loadings provide the values for grouping by fuzzy membership functions (i.e. degree of fuzziness)
* Groups with fuzzy membership of watersheds with different stream runoff regime create regional units for map

Components of analysis uncertainty of stream runoff for a region



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Analysis of stream runoff of type V watershed with monthly teleconnection indexes

	V F 1	V F 2	V F 3
ANN		**0.93**	*0.26*
OCT	**0.91**		
NOV	**0.91**		
DEC	**0.94**		
JAN	**0.94**		
FEB	**0.90**		
MAR	**0.77**	*0.28*	*0.25*
APR	*0.29*		**0.75**
MAY			**0.87**
JUN		**0.87**	
JUL		**0.94**	
AUG		**0.96**	
SEP		**0.90**	

Seasonal structure of runoff for V typical watershed

Predictor	BETA	St. Err. of BETA	B	St. Err. of B	t(35)	p-level
V F		**R= .8492 R^2= .7212 Adjusted R^2= .6762**				
JAN^p	-0.58	0.10	-234.92	39.36	-5.97	0.00
NOV$^p_1$	-0.28	0.10	-166.92	60.07	-2.78	0.01
NOV$^n_1$	-0.47	0.10	-295.50	63.13	-4.68	0.00
AUG^n	0.33	0.10	389.19	120.26	3.24	0.00
SEP$_1$	0.29	0.10	331.76	120.21	2.76	0.01
V F 1		**R= .6016 R^2= .3619 Adjusted R^2= .3039**				
AUG$^n_1$	0.40	0.14	0.71	0.24	2.90	0.01
MAR^p	0.35	0.14	0.27	0.11	2.53	0.02
JUL$^p_1$	0.29	0.14	0.66	0.32	2.09	0.04
V F 2		**R= .8108 R^2= .6574 Adjusted R^2= .5889**				
JAN^p	-0.53	0.11	-0.33	0.07	-4.69	0.00
JUL$_1$	0.27	0.11	0.58	0.24	2.46	0.02
AUG^n	0.38	0.11	0.70	0.21	3.39	0.00
SEP$^n_1$	0.29	0.11	0.44	0.17	2.60	0.01
MAR	0.29	0.11	0.21	0.08	2.69	0.01
NOV$^n_1$	-0.32	0.11	-0.31	0.11	-2.83	0.01
V F 3		**R= .7130 R^2= .5084 Adjusted R^2= .4469**				
DEC$^p_1$	-0.35	0.13	-0.24	0.09	-2.82	0.01
APR^n	0.48	0.13	0.63	0.17	3.70	0.00
NOV$^n_1$	-0.45	0.13	-0.44	0.12	-3.53	0.00
JUN^p	-0.30	0.13	-0.51	0.22	-2.27	0.03

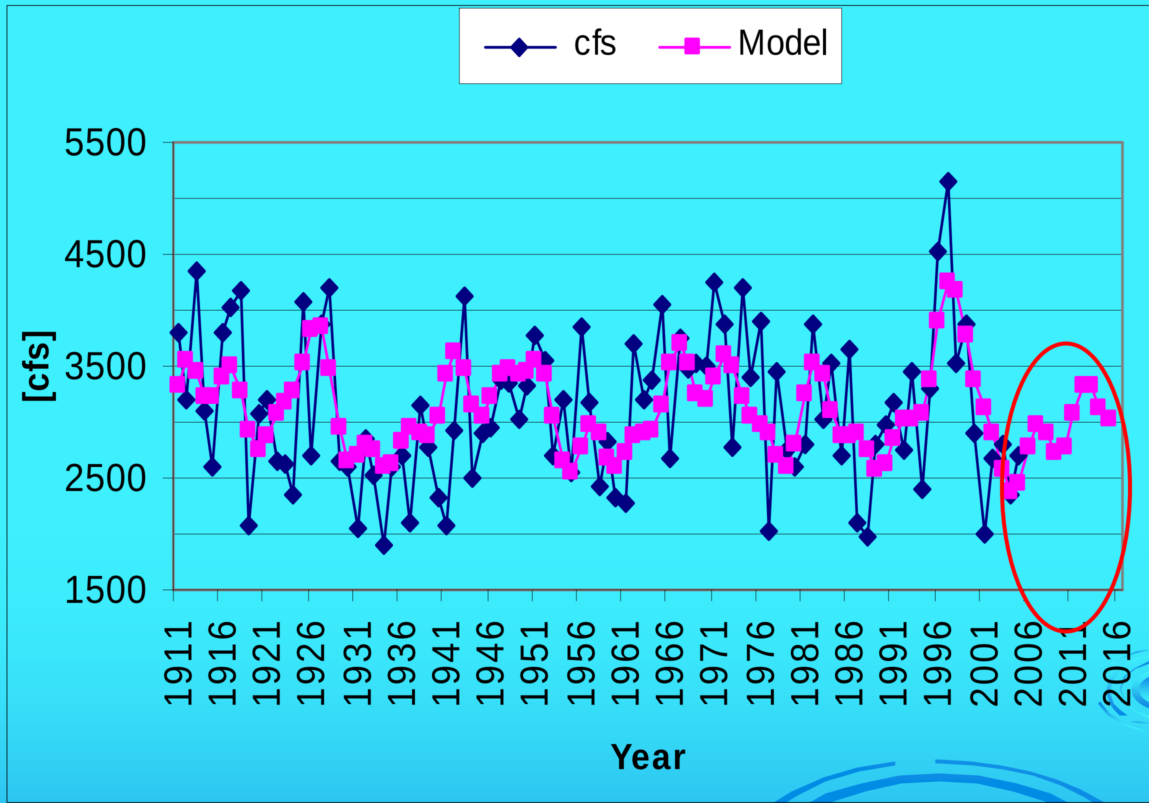
Regressions and correlations analysis for annual and seasonal stream runoff characteristics of V type regime watershed (06191500)
with monthly teleconnection indexes as Arctic Oscillation, North Atlantic Oscillation (^{n}), Antarctic Oscillation (APR^a) and Pacific/ North American (^{p}).
Months from previous year indicated with - $_1$.

Chart of annual observed stream runoff for 1911-2005 and as a harmonic model

Model:

$$X_t = X_0 + \sum_{i=1}^{K} A_i \cos\left(\frac{2\pi}{T_i} t - \varphi_i\right) + Z_t ,$$

No	T-period [year]	A-amplitude [cfs]	φ - faze	Z-error [cfs]
1	5.0	175.9	2.54	661
2	8.0	187.3	0.06	661
3	12.0	165.5	1.78	657
4	14.0	245.7	1.27	642
5	17.0	162.3	1.36	659
6	25.0	321.4	2.18	641



Topic

* Spatial-temporal variations of stream runoff for Upper Missouri River watershed

* Hydrologic regime as structure

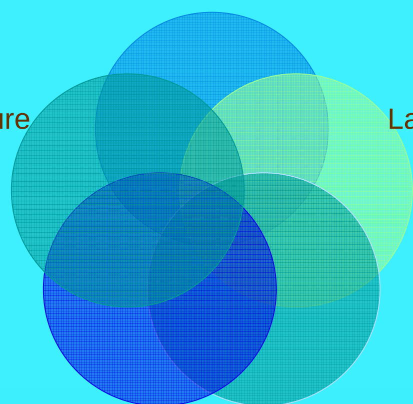
* Land cover or landscape

* Map with fuzzy boundaries

* Applications

* Decision making about water resources
or
Scientist vs. Lawyer

Decision making about water resources make sense only with use of "Model for utilization of units on a map"



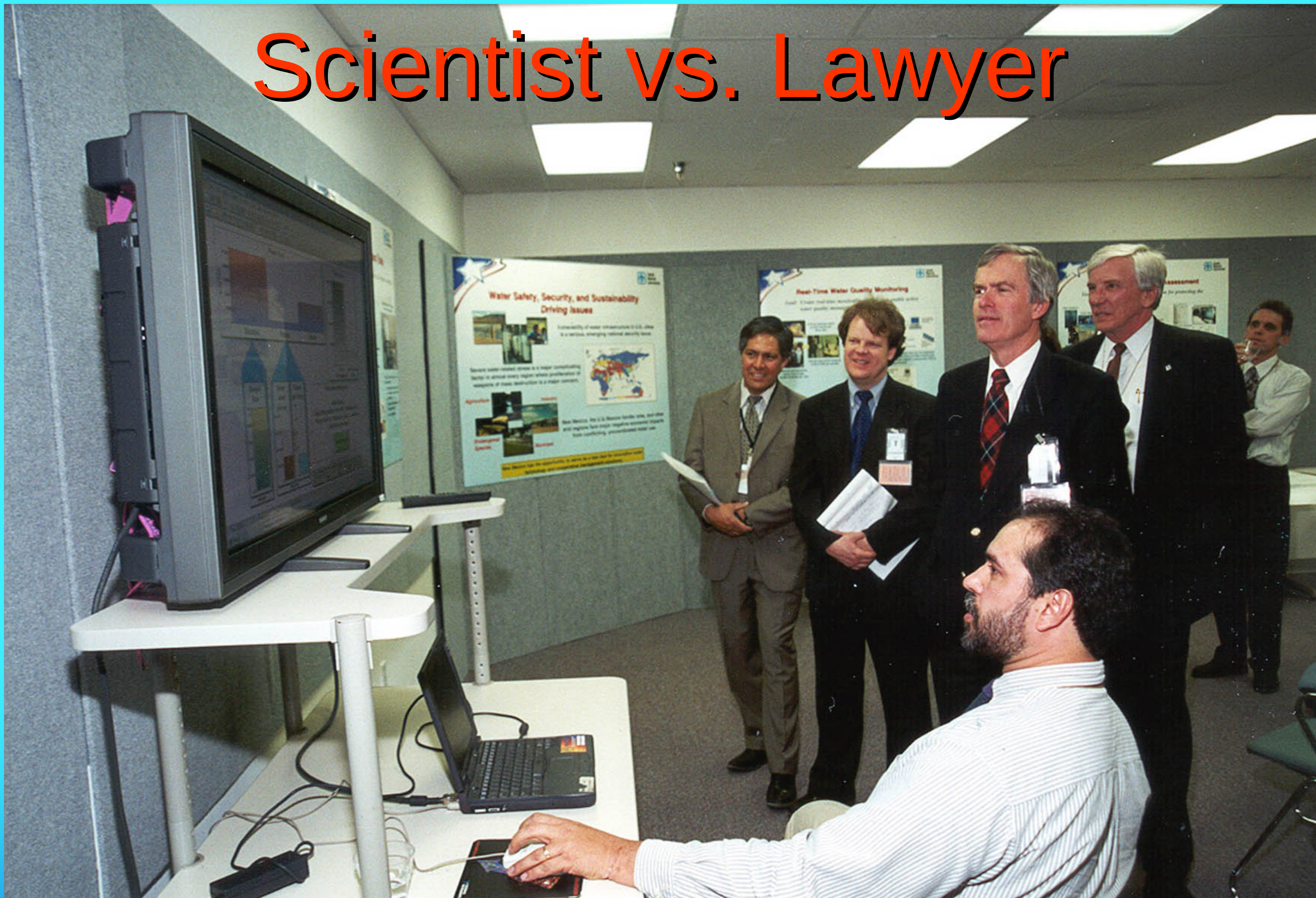
U.S. Supreme Court declines to hear Missouri River appeal

April 2006

U.S. Water News Online

WASHINGTON -- The Supreme Court has refused to hear North Dakota's arguments that the Army Corps of Engineers has violated state water pollution laws in managing the Missouri River's water flows.

Scientist vs. Lawyer



Sandia NL scientist Dr. Steve Conrad demonstrates the Middle Rio Grande Water Budget Model to Sen. Jeff Bingaman (D, NM)

"The total benefits of U.S. National Weather Service (NWS) forecasts are estimated to be $166 million. The additional benefits potentially Obtainable from a perfect temperature forecast are $75 million per year. It is estimated that an incremental 1% improvement in the forecast quality (from the current NWS forecast) would be worth an additional $1.4 million per year.

These numbers do not include other possible benefits of forecasts to the electricity industry, such as those from the improved scheduling of plant maintenance."

THE ECONOMIC VALUE OF TEMPERATURE FORECASTS IN ELECTRICITY GENERATION

BY THOMAS J. TEISBERG, RODNEY F. WEIHER, AND ALIREZA KHOTANZAD

United States electricity generators save $166 million annually using 24-h temperature fore-casts to improve the mix of generating units that are available to meet electricity demand.

Good theory with efficient tools is a best practical thing to use

South Dakota EPSCoR
Experimental Program to Stimulate Competitive Research

Boris Shmagin & Din Chen
SDSU Biocomplexity Studies &
Department of Mathematics
and Statistics SDSU

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
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