



***Missouri River Watershed:
the Object for
Hydrological Study &
Uncertainty of
Models***

**Boris Shmagin
WRI
SDSU**

The goal:

To talk on my experience of study river flow variability with use of science

The topics:

- * Introduction: Philosophy for water development
- * Knowledge & Uncertainty
- * Results as Math Models
- * Communicating the Knowledge
- * Conclusions

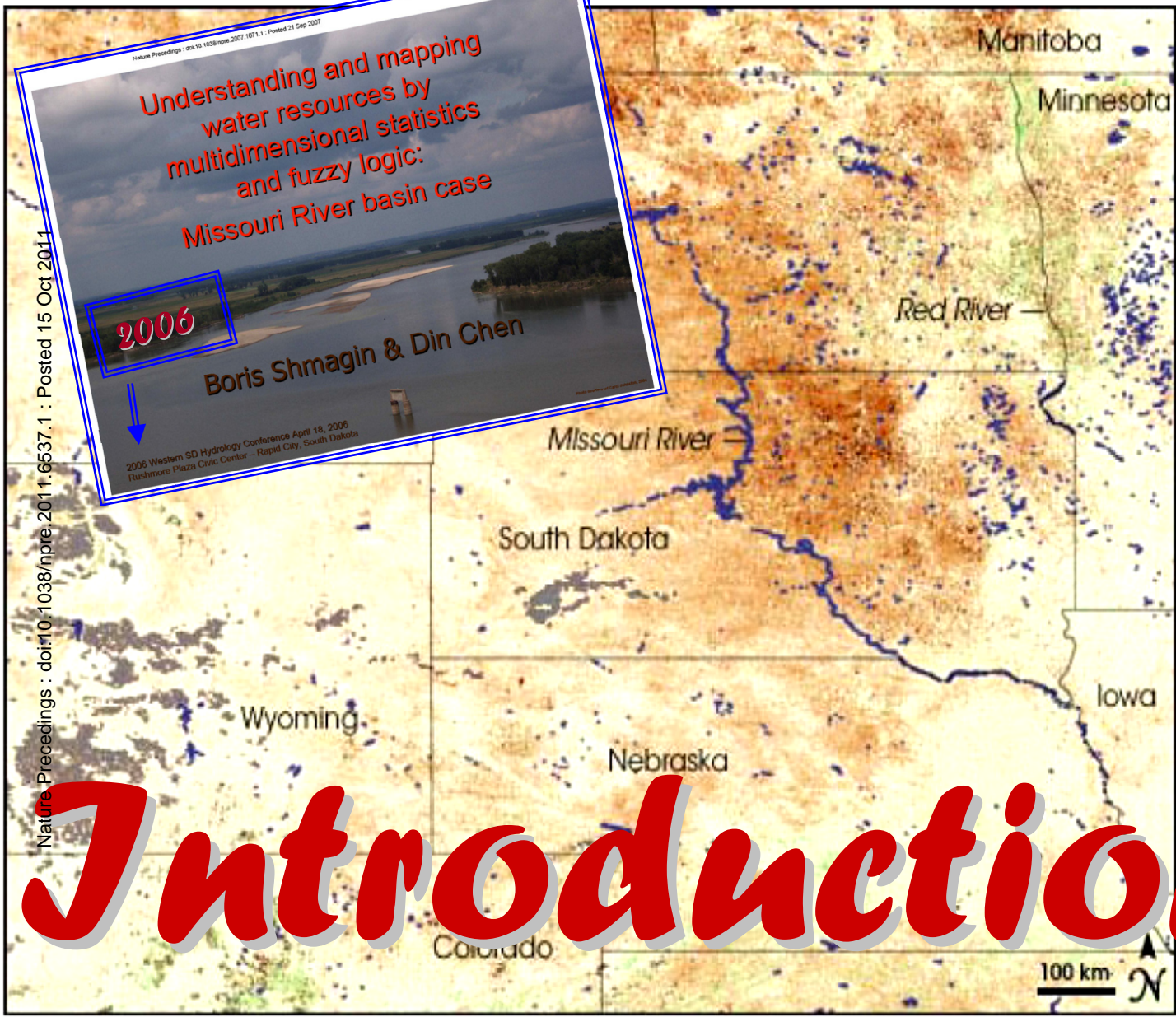
Nature Precedings : doi:10.1038/npre.2011.6537.1 : Posted 15 Oct 2011

Understanding and mapping water resources by multidimensional statistics and fuzzy logic: Missouri River basin case

2006

Boris Shmagin & Din Chen

2006 Western SD Hydrology Conference April 18, 2006
Rushmore Plaza Civic Center - Rapid City, South Dakota



Introduction

July 28 - August 12, 2006

Vegetation Anomaly (NDVI)



Variability as Math Models

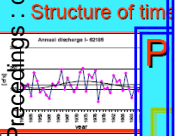
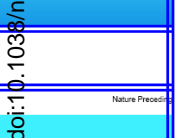
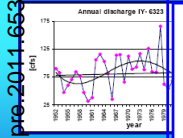
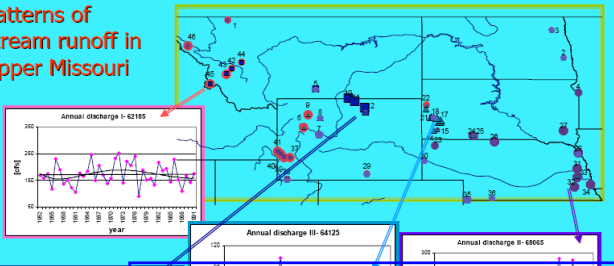
The Missouri River Basin (time-spatial variability of stream discharge)

Understanding & mapping water resources by multidimensional statistics & fuzzy logic: Missouri River basin case

Boris Shragin & Din Chen

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

Patterns of stream runoff in Upper Missouri

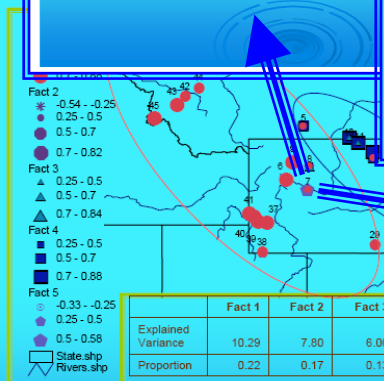


Analysis of stream runoff of with monthly teleconnections

	V F 1	V F 2	V F 3
NOV	0.91	0.90	0.75
DEC	0.91	0.90	0.75
JAN	0.94	0.94	0.94
FEB	0.96	0.96	0.96
MAR	0.77	0.26	0.20
APR	0.26	0.26	0.75
MAY	0.96	0.97	0.97
JUN	0.87	0.87	0.87
JUL	0.96	0.96	0.96
AUG	0.96	0.96	0.96
SEP	0.90	0.90	0.90

Seasonal structure of runoff for V typical watershed

Regressions and correlations analysis for annual and seasonal stream runoff characteristics of V type regime watershed (06161500) with monthly teleconnection indexes as Arctic Oscillation (AO), North Atlantic Oscillation (NAO), Antarctic Oscillation (APR) and Pacific/North American (PNA). Months from previous year indicated with -.

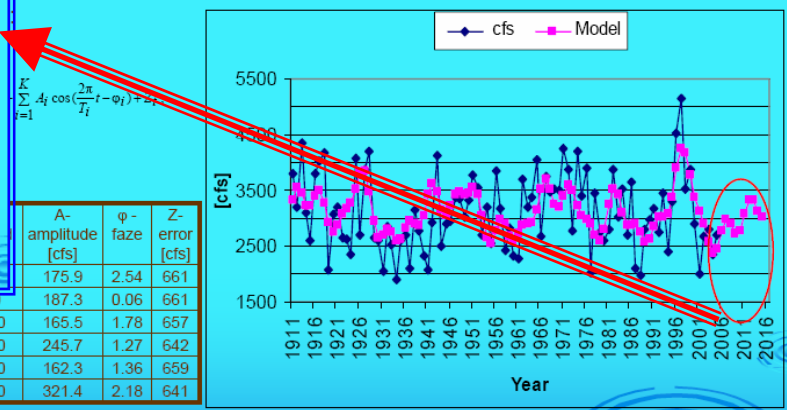


	Fact 1	Fact 2	Fact 3	Fact 4	Fact 5	Total
Explained Variance	10.29	7.80	6.00	4.52	2.70	31.31
Proportion	0.22	0.17	0.13	0.10	0.08	68%

U.S. Supreme Court declines to hear Missouri River appeal
April 2006
U.S. Water News Online

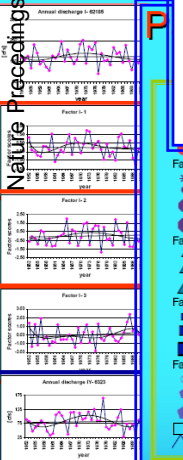
WASHINGTON -- The Supreme Court has refused to hear North Dakota's arguments that the Army Corps of Engineers has violated state water pollution laws in managing the Missouri River's water flows.

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



	A- amplitude [cfs]	φ - phase	Z- error [cfs]	
2	8.0	175.9	2.54	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

$$\sum_{i=1}^K A_i \cos\left(\frac{2\pi}{T_i} t - \theta_i\right) + Z_i$$



Nature Precedings : doi:10.1038/npre.2014.6537.1 : Posted 15 Oct 2011

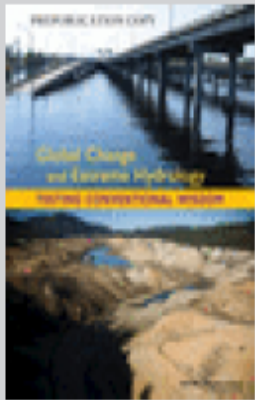
Nature Precedings : doi:10.1038/npre.2014.6537.1 : Posted 15 Oct 2011

Nature Precedings : doi:10.1038/npre.2014.6537.1 : Posted 15 Oct 2011

Annual runoff 1963-1999

From the National Research Council

Nature Precedings : doi:10.1038/npre.2011.6537.1 : Posted 15 Oct 2011



Global Change and Extreme Hydrology: Testing Conventional Wisdom

GeoJournal (2011) 76:401–415
DOI 10.1007/s10708-009-9257-x

**Democracy or expertise? objectivity as an elusive ideal
in the resolution of a Vermont land use dispute**

Thomas H.N. Young

Committee on Hydrologic Science; National Research Council

ISBN
978-0-309-21768-2

60 pages
6 x 9
PAPERBACK (2011)

... our relation to the hydrologic system requires a modicum of reverence for rivers

"The management of resources cannot be carried out successfully if it is looked upon as just another facet of economics, administration, & politics."

"The great geographer, William Morris Davis, viewed the river system as having a life of its own. Its *youthful headwaters*, he said, are steep and rugged. It rushes toward the sea, eroding bed & bank on its way. In its *central part*, it is mature, winding sedately through wide valleys adjusted to its duty of transporting water & sediment. *Near its mouth* it has reached, in its *old age*, a nearly level plain through which it wanders in a somewhat aimless course toward final extinction as it joins the ocean that had provided the sustaining waters through its whole life span."

"Man's *engineering capabilities* are nearly *limitless*. Our *economic views* are too *insensitive* to be the only criteria for judging the health of the river organism.

What is needed is a gentler basis for perceiving the effects of our engineering capabilities. This more humble view of our relation to the hydrologic system requires a modicum of reverence for rivers."

A reverence for rivers

Luna B. Leopold

Keynote address to the Governor's Conference on the California Drought

Los Angeles, California, March 7, 1972

Lula Leopold

Nature Precedings doi:10.1028/npre.2011.6537v1 | Posted 15 Oct 2011

The Concept of Entropy in Landscape Evolution

by LUNA B. LEOPOLD *and* WALTER
THEORETICAL PAPERS IN
GEOMORPHIC SCIENCES

PHILOSOPHY FOR WATER DEVELOPMENT

GEOLOGICAL SURVEY PROFESSIONAL P



DEPARTMENT OF THE INTERIOR

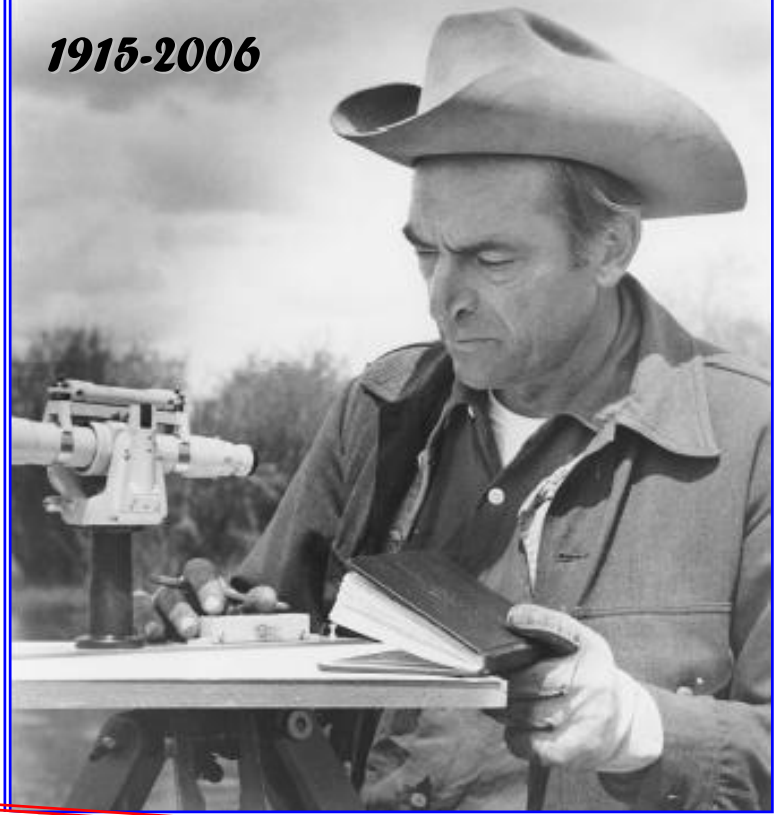
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For Release to PM's, MARCH 28, 1961

ADDRESS BY LUNA B. LEOPOLD AND E. L. HENDRICKS, GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR, AT THE NATIONAL WATER RESEARCH SYMPOSIUM, WASHINGTON, D. C., MARCH 28, 1961

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1

1915-2006



Chief Hydraulic Engineer
Room 2227 GS Bldg.
Geological Survey

DO
DEPARTMENT OF THE INTERIOR

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1

PHILOSOPHY FOR WATER DEVELOPMENT

The Knowledge & the Uncertainty



The Uncertainty & Information

Toward a generalized theory of uncertainty (GTU)—an outline

Lotfi A. Zadeh

Berkeley initiative in Soft Computing (BISC), and the Electronics Research Laboratory, Department of Computer Science, University of California, 615 Soda Hall, Berkeley, CA 94720

Received 21 December 2004; accepted 15 October 2011

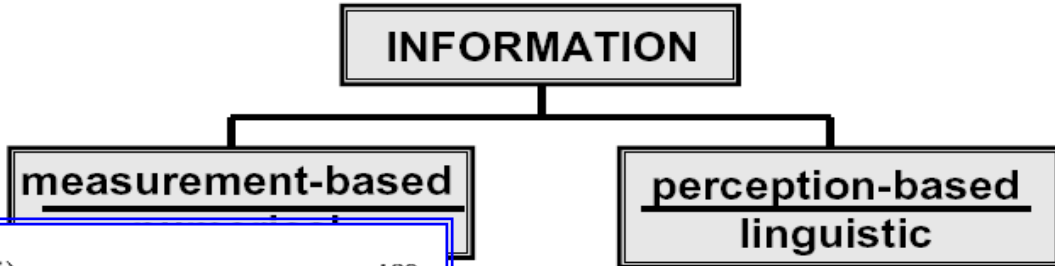
Dedicated to Didier Dubois, Henri Prade and to Richard Bellman and Herbert A. Simon

L. A. Zadeh / Information Sciences 172 (2005) 1–40

15 Oct 2011

Abstract

It is a deep-seated tradition in science to view uncertainty as a lack of information. The generalized theory of uncertainty (GTU)



INFORMATION SCIENCES 8, 199–249 (1975)

199

The Concept of a Linguistic Variable and its Application to Approximate Reasoning—I

A. ZADEH

Computer Sciences Division, Department of Electrical Engineering and Computer Sciences, and the Electronics Research Laboratory, University of California, Berkeley, California 94720

ABSTRACT

By a *linguistic variable* we mean a variable whose values are words or sentences in a natural or artificial language. For example, *Age* is a linguistic variable if its values are linguistic rather than numerical, i.e., *young, not young, very young, quite young, old, not very old and not very young*, etc., rather than 20, 21, 22, 23, In more specific terms,

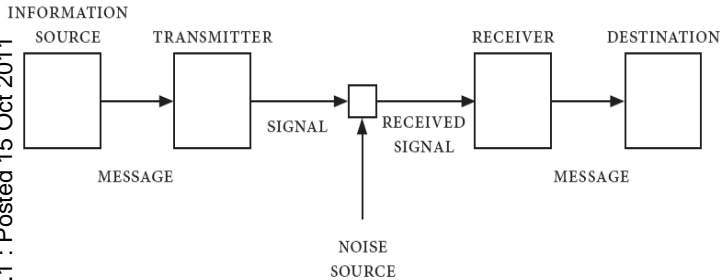
- It is very warm
- Most Swedes are tall
- probability is high
- it is cloudy
- traffic is heavy
- it is hard to find parking near the campus

Information may be viewed as a special case of

Measurement-based information is intrinsically imprecise

Measurement-based vs. perception-based information.

Information in the Language

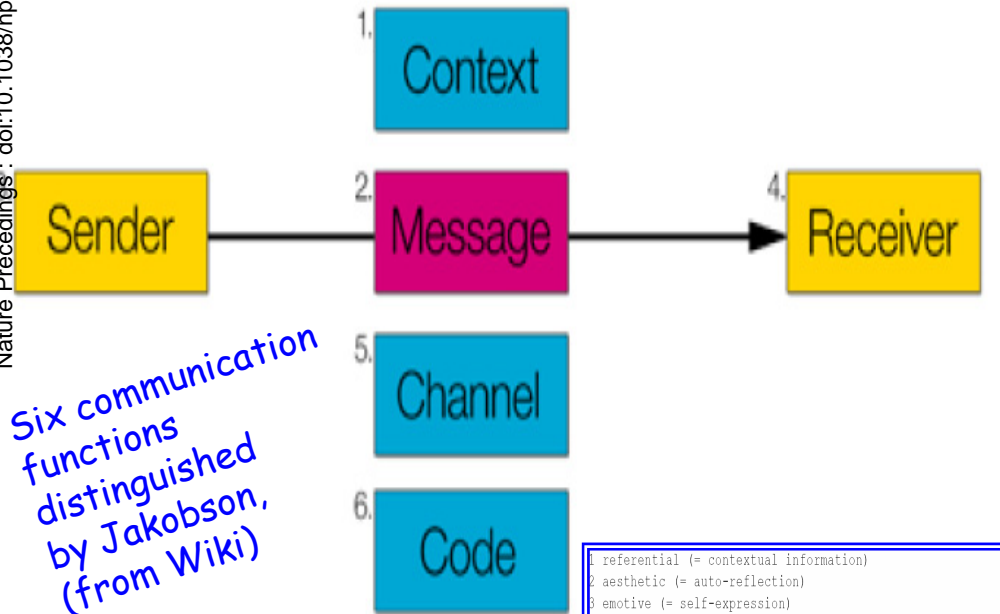


6537.1 : Posted 15 Oct 2011

Figure 1. Shannon's communication channel

Roman Jakobson, cybernetics and information theory
A critical assessment¹

Nature Precedings : doi:10.1038/npre.2011



Six communication functions distinguished by Jakobson, (from Wiki)

- 1 referential (= contextual information)
- 2 aesthetic (= auto-reflection)
- 3 emotive (= self-expression)
- 4 conative (= vocative or imperative addressing of receiver)
- 5 phatic (= checking channel working)
- 6 metalingual (= checking code working)^[2]

Walle

Folia Linguistica Historica 29/1-2 (2008), 1-37.

"In cognitive linguistics as in cognitive science, the human mind is considered to be an information-processing device (Stillings 1995), & language is viewed as a vehicle for communicating information."

From: J. Van de Walle, 2008

The Science & the Language

Precedings : doi:10.1038/npre.2011.6537.1 : Posted 15 Oct 2011

John R. Searle

Page 1

6 November, 2006

What is Language for Landau FNL Savas

What is Language: Some Preliminary Remarks¹

By John R. Searle

Copyright John R. Searle

Naturalizing Language

I believe that the greatest achievements in philosophy over the past hundred or the hundred and twenty five years have been in the philosophy of language. Beginning with Frege, who invented the subject, and continuing through Russell, Wittgenstein, Quine, Austin and their successors, right to the present day, there is no branch of philosophy with so much high quality work as the philosophy of language. In my view, the only achievement comparable to those of the great philosophers of language is Rawls's reinvention of the subject of political philosophy (and therefore implicitly the subject of ethics). But with this one possible exception, I think that work in the philosophy of language is at the top of our achievements.

"Chomsky argues that no science has a mechanical procedure for discovering the truth anyway"

"the proper object of study was the speaker's underlying knowledge of the language, his "linguistic competence" that enables him to produce & understand sentences he has never heard before"

From: "*Chomsky's Revolution in Linguistics*" by John R. Searle
The New York Review of Books, June 29, 1972

Statistics & Uncertainty

The Statistician (2000)
49, Part 3, pp. 293–337

The philosophy of statistics

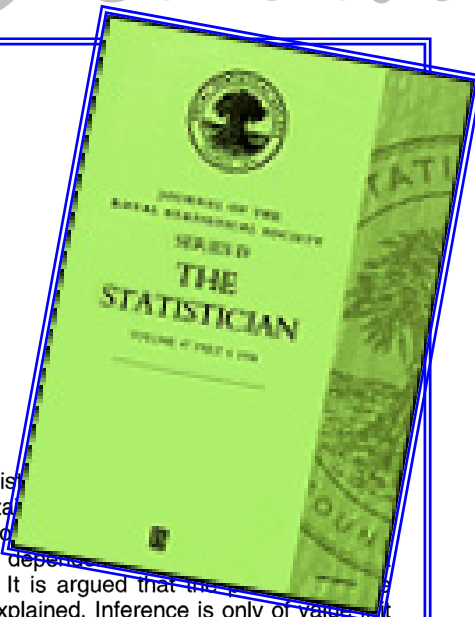
Dennis V. Lindley

Minehead, UK

[Received June 1999]

Summary. This paper puts forward an overall view of statistical study of uncertainty. The many demonstrations that underpin the rules of the probability calculus are summarized. The calculus is firmly based on probability alone. Progress is therefore dependent on probability model; methods for doing this are considered. It is argued that the model is personal. The roles of likelihood and exchangeability are explained. Inference is only of value if it can be used, so the extension to decision analysis, incorporating utility, is related to risk and to the use of statistics in science and law. The paper has been written in the hope that it will be intelligible to all who are interested in statistics.

Keywords: Conglomerability; Data analysis; Decision analysis; Exchangeability; Law; Likelihood; Models; Personal probability; Risk; Scientific method; Utility



The statistician's task is to articulate the scientist's uncertainties in the language of probability...

A model is merely your reflection of reality &, like probability, it describes neither you nor the world, but only a relationship between you & that world." (p. 303)

Nature Preprints : doi:10.1038/npre.2011.6537.1 : Posted 15 Oct 2011

... data analysis assists in the formulation of a model & is an activity that precedes the formal probability calculations that are needed for inference." (p. 305)

"Statisticians are not masters in their own house.

Their task is to help the client to handle the uncertainty that they encounter. The 'you' of the analysis is the client, not the statistician." (p. 318)

From Data Analysis to Statistical Learning

Philosophy of Science 50 (1988) pp. 283-295

THE PHILOSOPHY OF EXPLORATORY DATA ANALYSIS*

I. J. GOOD†

Statistics Department
Virginia Polytechnic Institute

J. R. Statist. Soc. A (1995)
158, Part 3, pp. 419-466

Model Uncertainty, Data Mining and Statistical Inference

By CHRIS CHATFIELD†

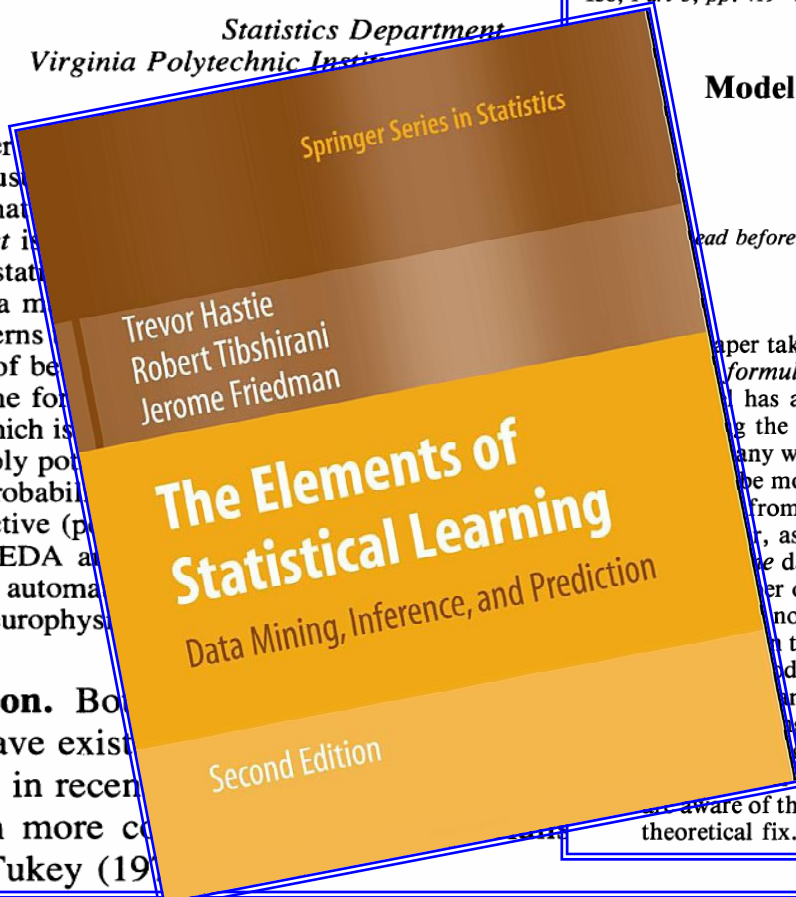
University of Bath, UK

Read before The Royal Statistical Society on Wednesday, January 18th, 1995, the President, Professor D. J. Bartholomew, in the Chair]

This paper is more precisely than usual and somewhat

A *data set* is descriptive statistics presented in a manner finding patterns probability of being a pattern is one for "cativity", which is to be probably possible theory of probability (used), subjective (philosophy of EDA as science; the automated hypotheses; neurophys

Introduction. Both CDA (CDA) have existed for a century, but in recent years much more emphasis has been placed on the influence of Tukey (19



SUMMARY

This paper takes a broad, pragmatic view of statistical inference to include all aspects of *formulation*. The estimation of model parameters traditionally assumes that the model has a *prespecified known form* and takes no account of possible uncertainty in the model structure. This implicitly assumes the existence of a 'true' model, which many would regard as a fiction. In practice *model uncertainty* is a fact of life and can be more serious than other sources of uncertainty which have received far more attention from statisticians. This is true whether the model is specified on subject-matter knowledge, as is increasingly the case, when a model is formulated, fitted and checked against the data set in an iterative, interactive way. Modern computing power allows a large number of models to be considered and data-dependent specification searches have become the norm in many areas of statistics. The term *data mining* may be used in this context when the analyst goes to great lengths to obtain a good fit. This paper reviews the effects of model uncertainty, such as too narrow prediction intervals, and the non-trivial effects of parameter estimates which can follow data-based modelling. Ways of assessing the effects of model uncertainty are discussed, including the use of simulation methods, a Bayesian model averaging approach and collecting additional data where possible. Perhaps the main aim of the paper is to ensure that statisticians are aware of the problems and start addressing the issues even if there is no simple, general theoretical fix.

ADDRESSING THE COMPLEXITY OF THE EARTH SYSTEM

BY CARLOS NOBRE, GUY P. BRASSEUR, MELVYN A. SHAPIRO, MYANNA LAHSEN, GILBERT BRUNET, ANTONIO J. BUSALACCHI, KATHY HIBBARD, SYBIL SEITZINGER, KEVIN NOONE, AND JEAN P. OMETTO

Nature Precedings : doi:10.1038/npre.2011.6597.1 : Posted 15 Oct 2011

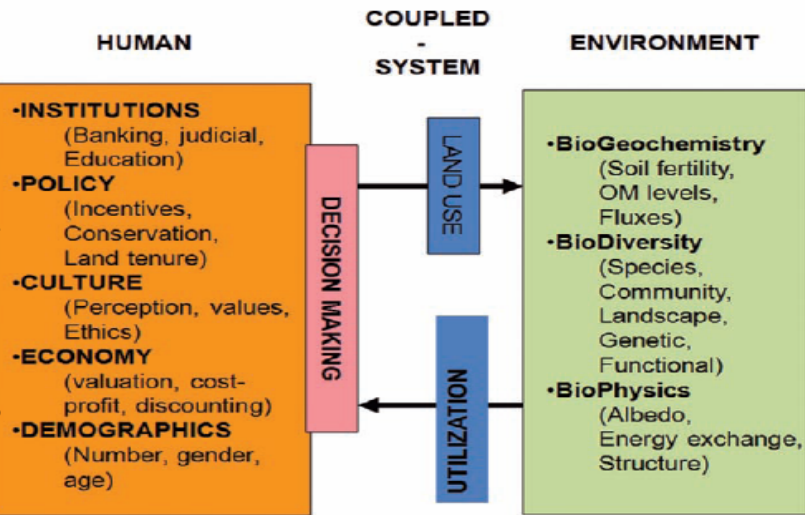


FIG. 4. An example of a model of a coupled human-environmental system that accounts for the influences of one subset of human actions (land use) on the natural systems and for the role of environmental goods and services for human welfare (utilization). [While “culture” is listed as a separate factor in this list, it is worth emphasizing that culture is a pervasive factor that also shapes institutions, economy, science, etc. (Proctor 1998).]

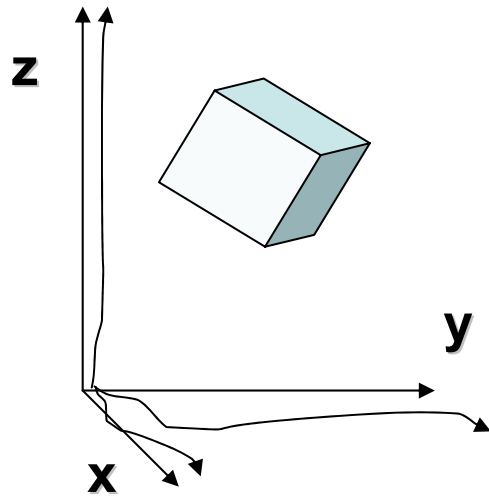
al, and societal processes would accelerate
 th system prediction.

OCTOBER 2010 BAMS

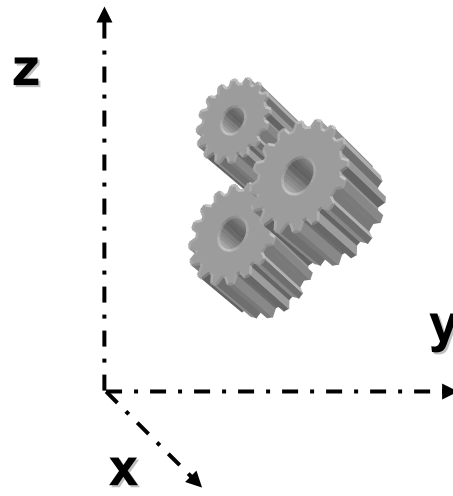
*& of the
 Watershed*

The Uncertainty & Different Systems of Coordinates

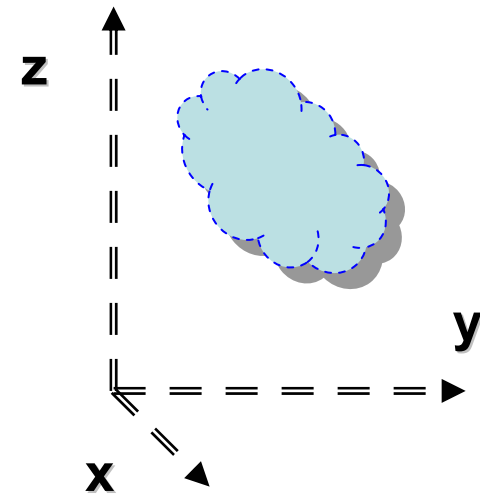
Nature Precedings : doi:10.1038/npre.2011.6537.1 : Posted 15 Oct 2011



Mathematical & physical objects are abstractions & "have" the principle of uncertainty



Technological objects have the errors of measurement



Natural objects have fuzzy boundaries in their own coordinates of multi-dimensional process & nonstationary axes

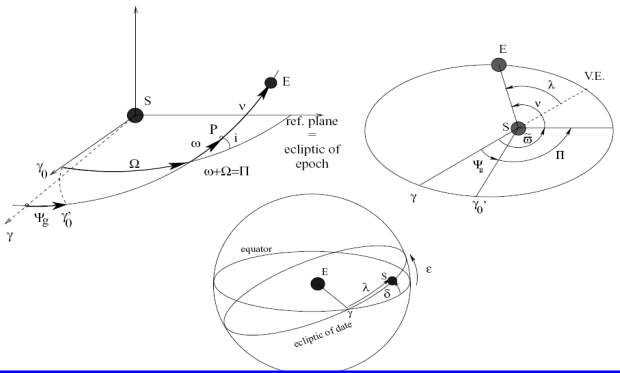
THE CLIMATE RESPONSE TO THE ASTRONOMICAL FORCING

M. CRUCIFIX*, M. F. LOUTRE and A. BERGER

Institut d'Astronomie et de Géophysique G. Lemaître, Louvain-la-Neuve, Belgium

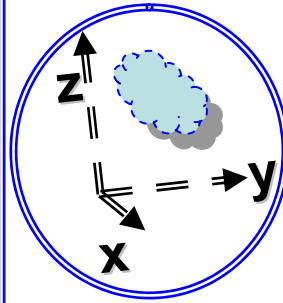
(* Author for correspondence: E-mail: michel.crucifix@uclouvain.be)

(Received 30 August 2005; Accepted in final form 22 February 2006)



years. Two
theory of
in marine
essential
(2) to infer
the impact
important

Coordinates for the Earth



Nature Precedings : doi:10.1038/npre.2011.6557.1. Posted 15 Oct 2011

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Press Release 11-016

First Large-Scale, Physics-Based Space Weather Model Transitions Into Operation

Provides forecasters with one-to-four-day advance warning of 'solar storms'

A coronal mass ejection (CME) in a model; the CME is the gray cloud toward the lower right.
[Credit and Larger Version](#)

This Center for Integrated Space Weather Modeling display will be used to predict space weather.
[Credit and Larger Version](#)

A large coronal mass ejection observed by the SOHO spacecraft in December, 2003.
[Credit and Larger Version](#)

Earth's Magnetosphere Posted April 23, 2011

acquired February 7, 2011

download large image (620 KB, PNG)

Next Image

Share this image
You've seen the pattern in science class when you laid bits of iron around a bar magnet. The invisible force field around the magnet becomes suddenly visible when the iron filings fall into line.

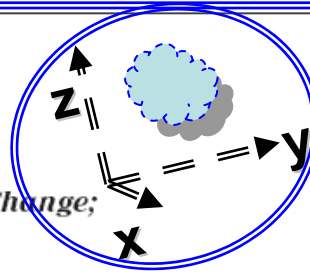
The iron-cored Earth is also a great magnet, and scientists have spent a century

The Coordinates on the Earth

Taking the "Boulder" Step From Static to Dynamic Geoid

2009 Workshop on Monitoring North American Geoid Change;
Boulder, Colorado, 21-23 October 2009

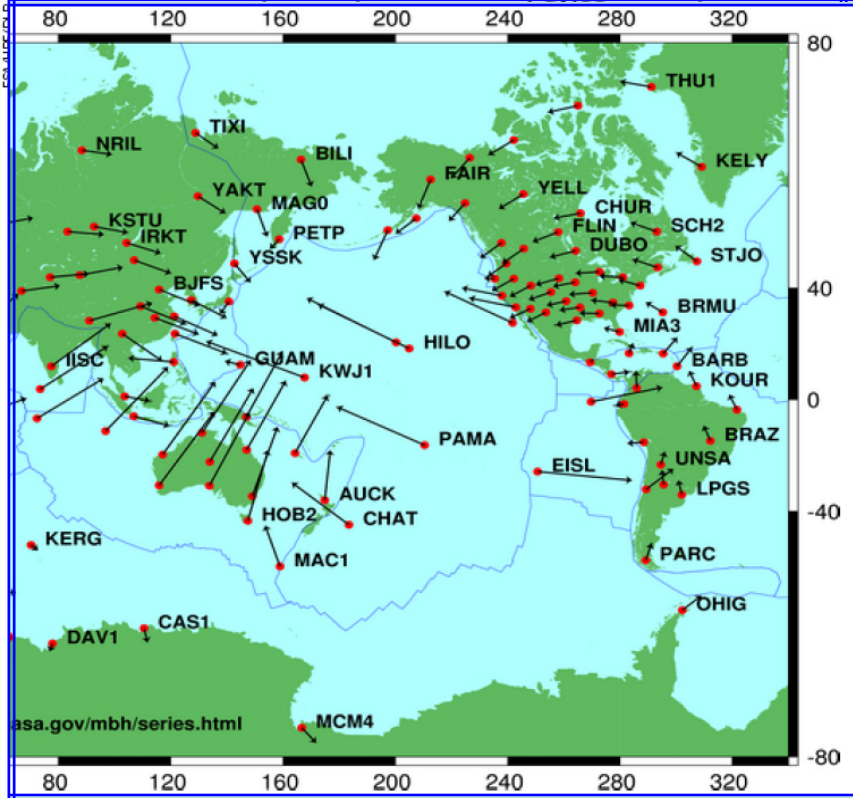
PAGE 46



the Earth

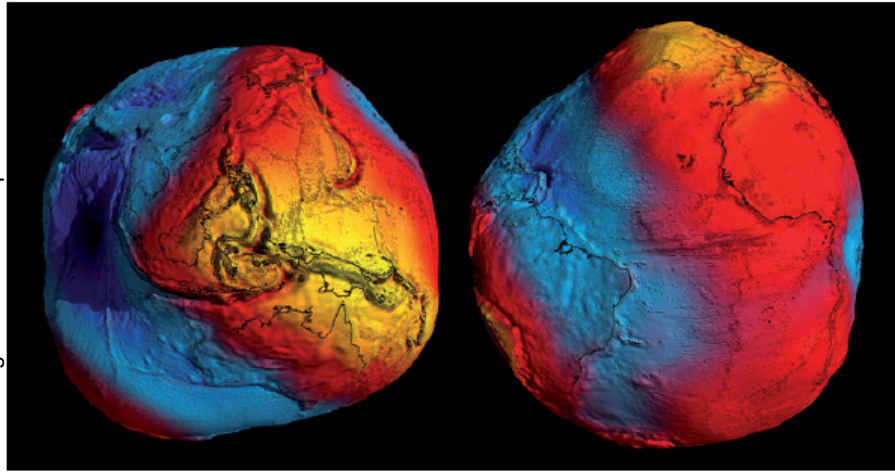
...tion would average out over the
...-low span of ...
...a primary ...
...dynamic geoid, taking into
account deep tectonic mass changes
(such as the continental uplift seen in the
region of Hudson Bay and southern Canada)
while separating out the small-scale or
episodic geophysical (e.g., water table
or magma) changes and weather phenomena.
The means by which absolute and rela-

and Mexico) and Europe specializing in satellite and terrestrial geodesy as well as in Colorado.



avimetric noise Columbus

Nature Precedings : doi:10.1038/npre.2011.6537.1 : Posted 15 Oct 2011

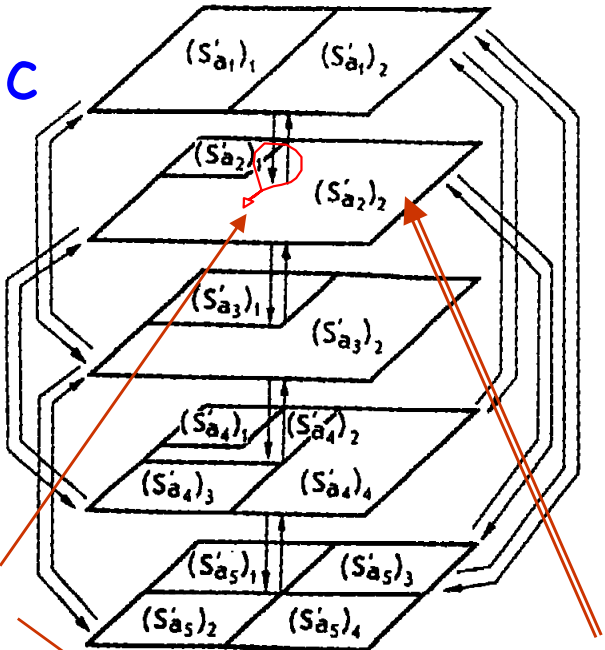
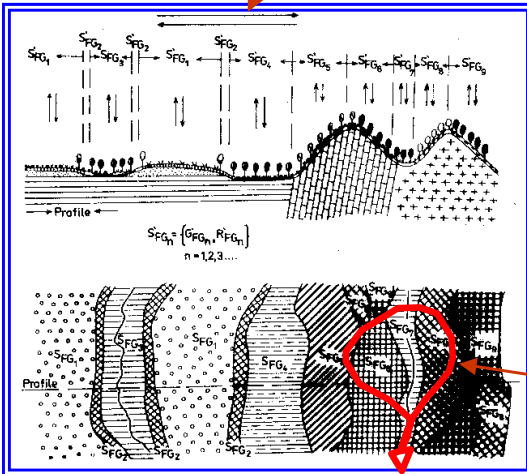
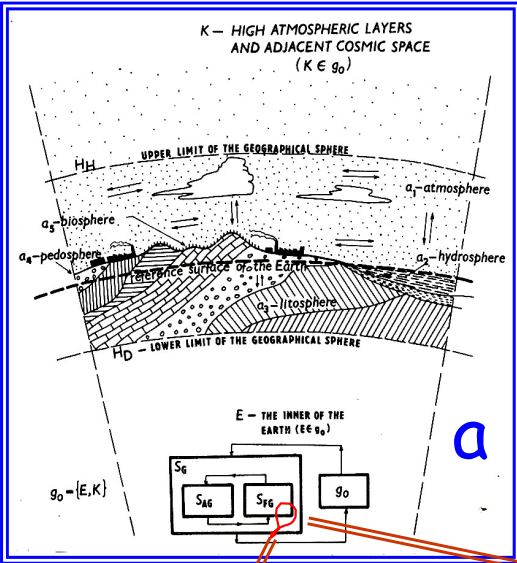


The pull of the planet

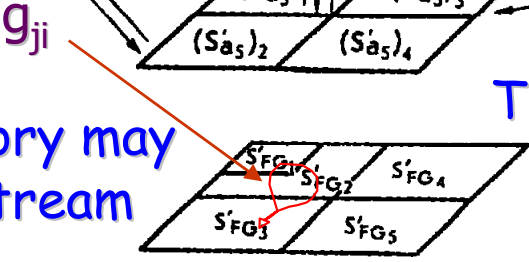
The most detailed map of Earth's gravity ever made was unveiled last week in Munich, Germany, when researchers presented eight months' worth of data from the European Space Agency's Gravity Field and Steady-State Ocean Circulation Explorer (GOCE), a satellite launched in 2009. GOCE maps subtle variations in Earth's gravitational field that arise

from the planet's uneven distribution of mass. The result is a 'geoid' (pictured — variations exaggerated 10,000 times), showing the world if it were covered by an ocean whose height was influenced only by gravity. This reference allows geoscientists to precisely measure the heights of shifting oceans and continents. GOCE will continue mapping until the end of 2012.

Cybernetic Model (a) for Watershed in Landscape, with Map of Conditions (b) & Multilayer Map (c)



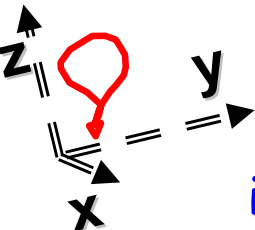
System of Physical Geography Sphere (S_{FG}) with five independent elements:
 a_1 - atmosphere,
 a_2 - hydrosphere,
 a_3 - lithosphere,
 a_4 - pedosphere,
 a_5 - biosphere
 (after Krcho, 1978)



The g_2 - stream runoff system as a part of a_2 - hydrosphere may be presented as:

Any watershed g_{ji} for territory may be considered as a part of stream runoff system Sg_2 .

Each of these components may be characterized by matrix of input $\{W_i\}$, matrix of output $\{Q_i\}$, & matrix of states $\{H_i\}$.



$Sg_2 = \{ g_{ji}, R_{ji} \}$,
 where g_{ji} - watershed in specific coordinates

Math Models for the Analysis

The Duration Curves

Journal of Hydrology 408 (2011) 67–77

Contents lists available at SciVerse ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Posted 15 Oct 2011

Nature Precedings doi:10.1038/npre.2011.6537.1

44°00'N

Fig. 1. valid station



Spatially smooth regional estimation of the flood frequency curve (with uncertainty)
 Laio ^{a,*}, D. Ganora ^a, P. Claps ^a, G. Galeati ^b

Hydrol. Earth Syst. Sci., 15, 2805–2819, 2011
 www.hydrol-earth-syst-sci.net/15/2805/2011/
 doi:10.5194/hess-15-2805-2011
 © Author(s) 2011. CC Attribution 3.0 License.



Towards reconstruction of the flow duration curve: development of a conceptual framework with a physical basis

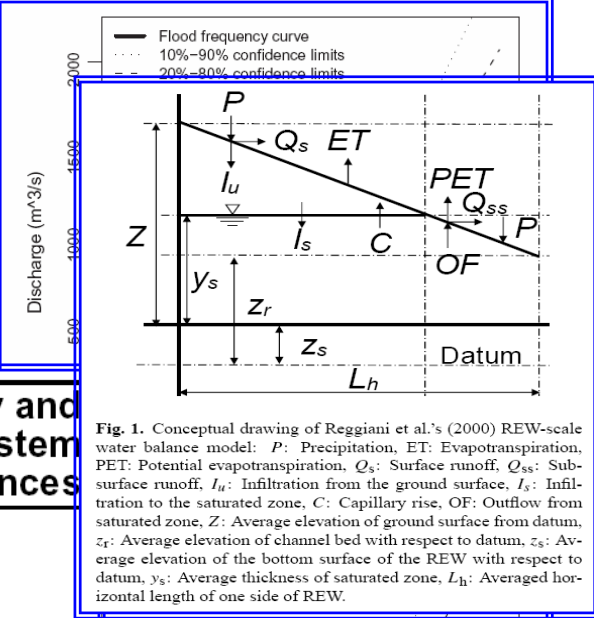
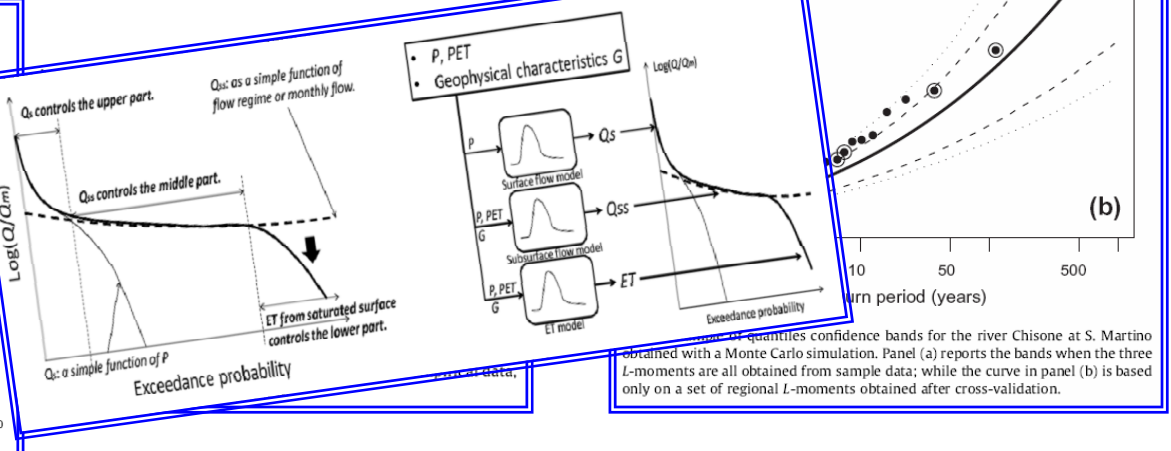
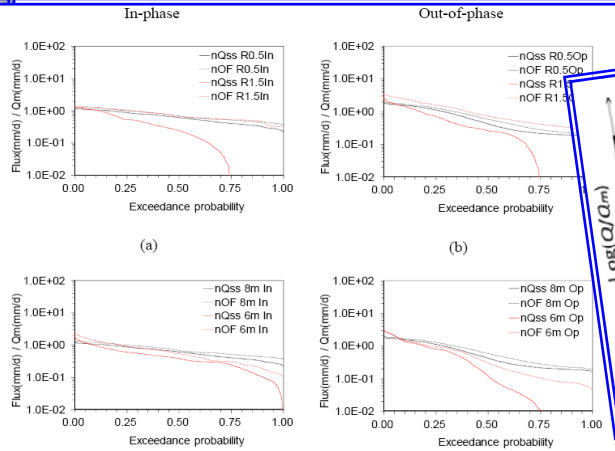
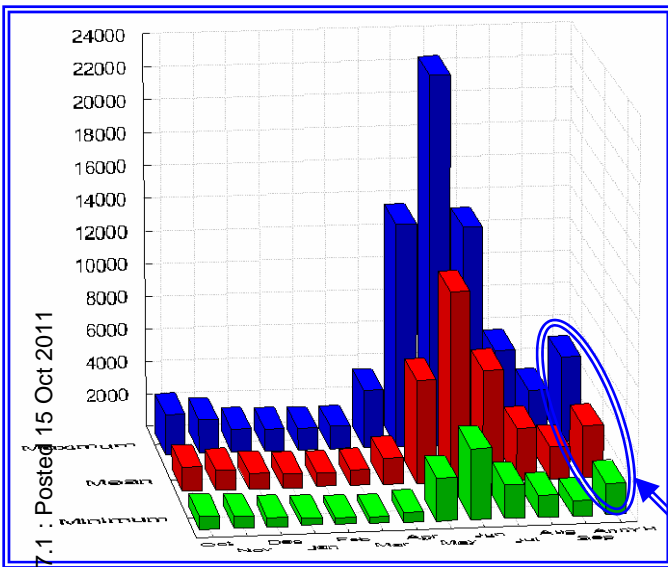


Fig. 1. Conceptual drawing of Reggiani et al.'s (2000) REW-scale water balance model: *P*: Precipitation, *ET*: Evapotranspiration, *PET*: Potential evapotranspiration, *Q_s*: Surface runoff, *Q_{ss}*: Sub-surface runoff, *I_u*: Infiltration from the ground surface, *I_s*: Infiltration to the saturated zone, *C*: Capillary rise, *OF*: Outflow from saturated zone, *Z*: Average elevation of ground surface from datum, *Z_r*: Average elevation of channel bed with respect to datum, *z_s*: Average elevation of the bottom surface of the REW with respect to datum, *y_s*: Average thickness of saturated zone, *L_h*: Averaged horizontal length of one side of REW.

...quantities confidence bands for the river Chisone at S. Martino obtained with a Monte Carlo simulation. Panel (a) reports the bands when the three L-moments are all obtained from sample data; while the curve in panel (b) is based only on a set of regional L-moments obtained after cross-validation.

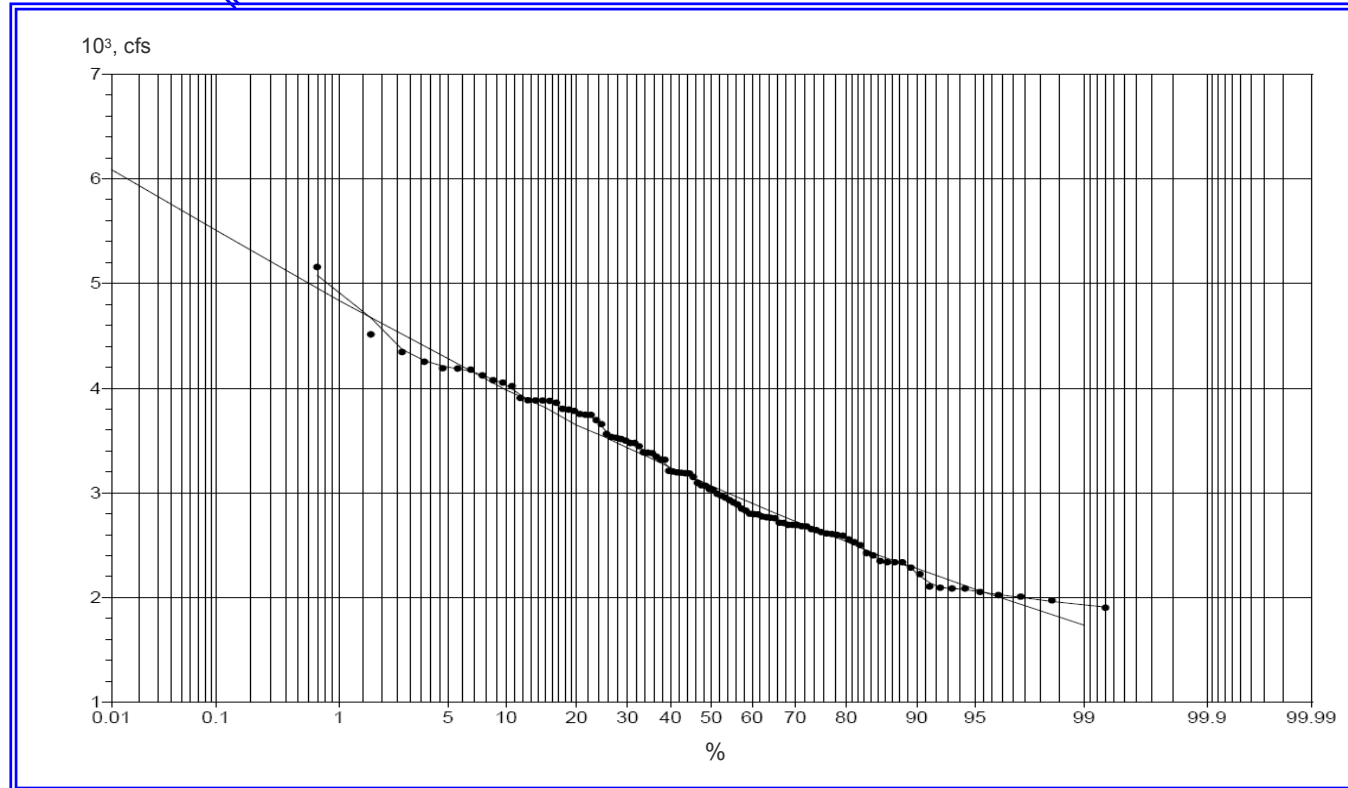
The Duration Curve



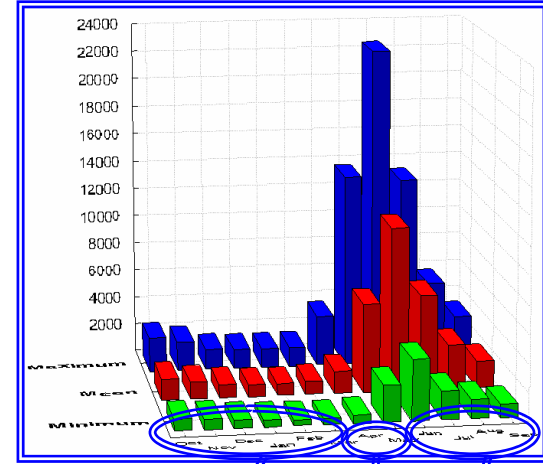
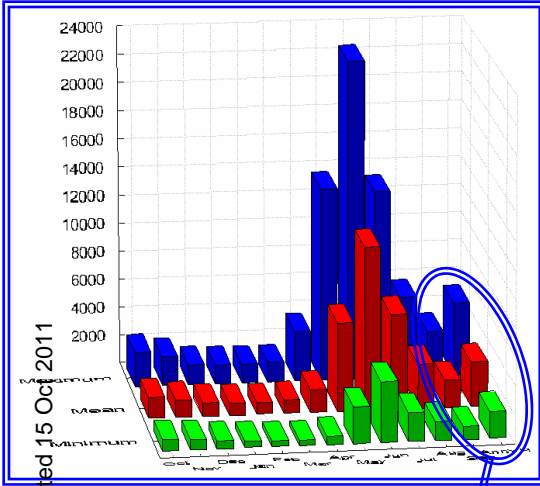
The hydrograph of hydrological year for USGS 06191500 1911-2010

Nature Precedings : doi:10.1038/npre.2011.6537.1

Empirical
durations curve
1911-2010 for
USGS 06191500
Yellowstone
River at Corwin
Springs, MT

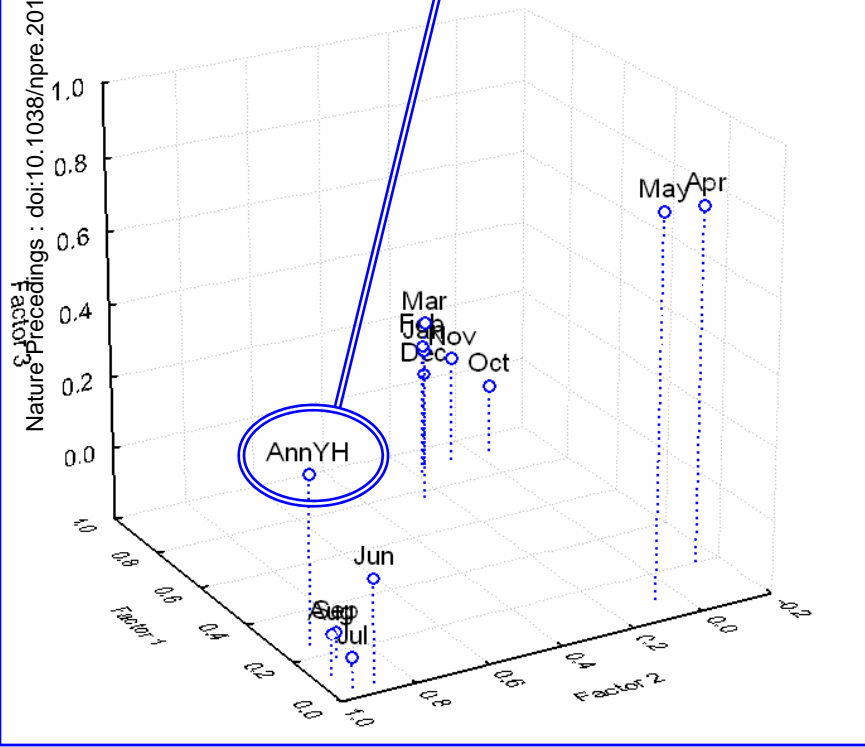


Annual distribution



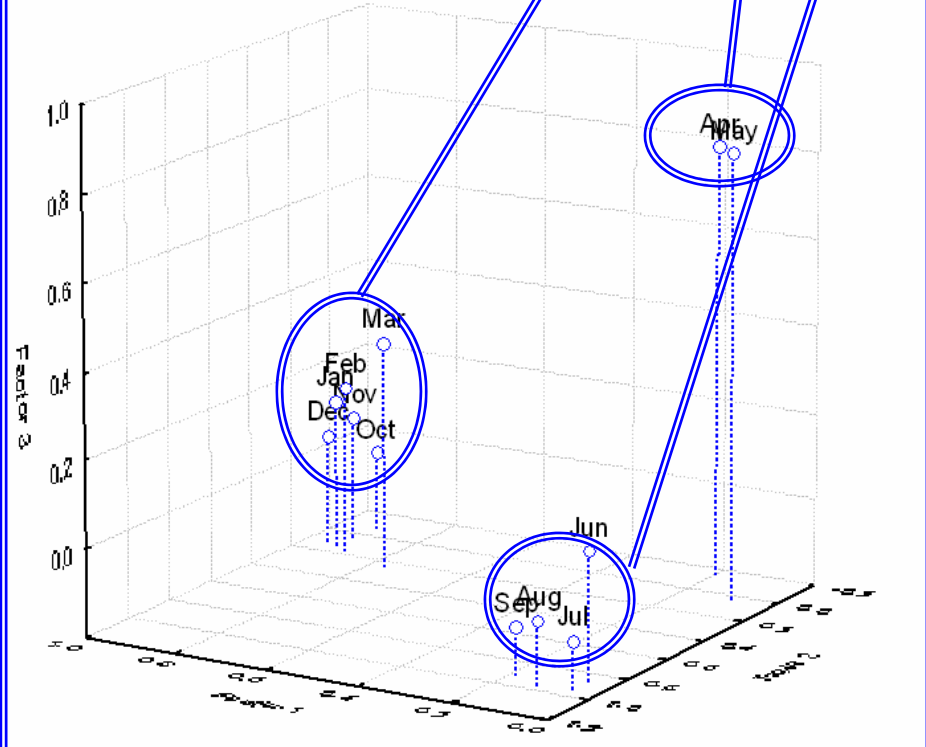
Factor Loadings, Factor 1 vs. Factor 2 vs. Factor 3

Rotation: Varimax normalized
Extraction: Principal components



Factor Loadings, Factor 1 vs. Factor 2 vs. Factor 3

Rotation: Varimax normalized
Extraction: Principal components

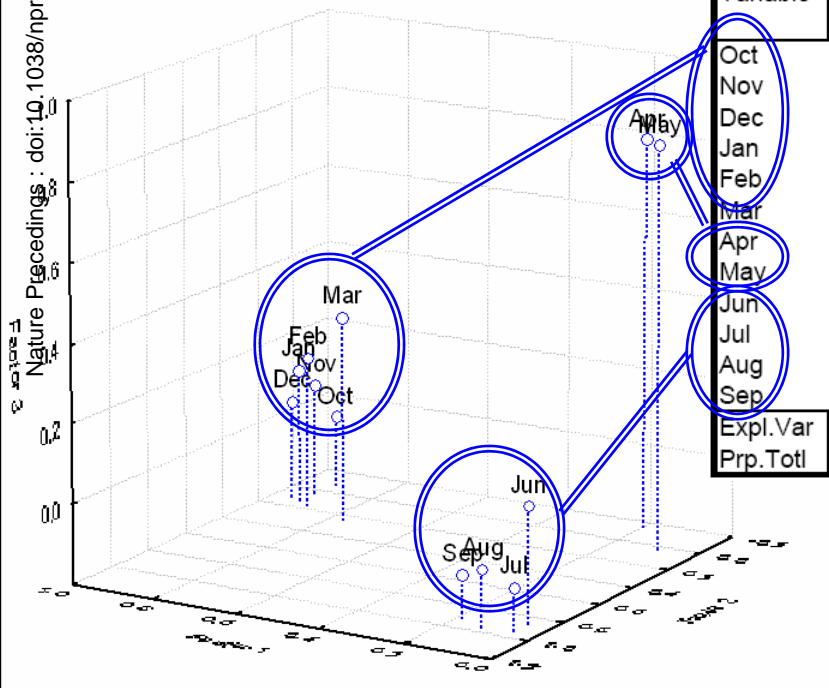


Structure of the seasonal variability

Nature Precedings : doi:10.1038/npre.2011.6537.1 : Posted 15 Oct 2011

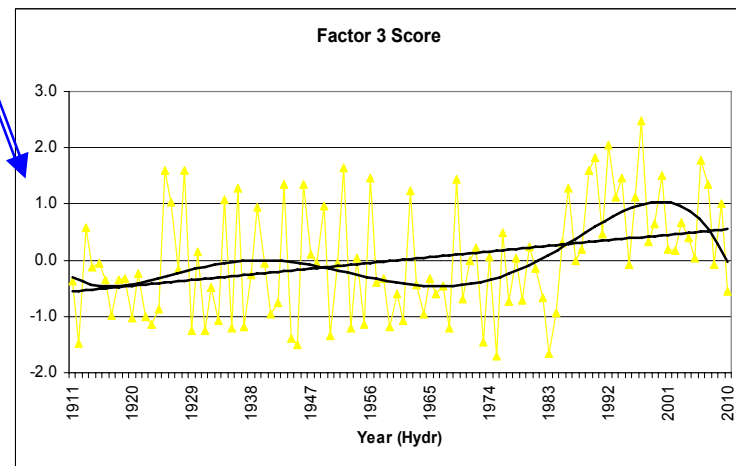
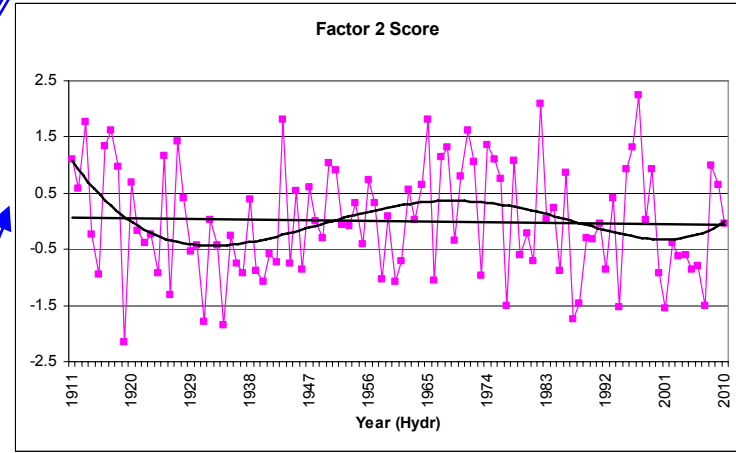
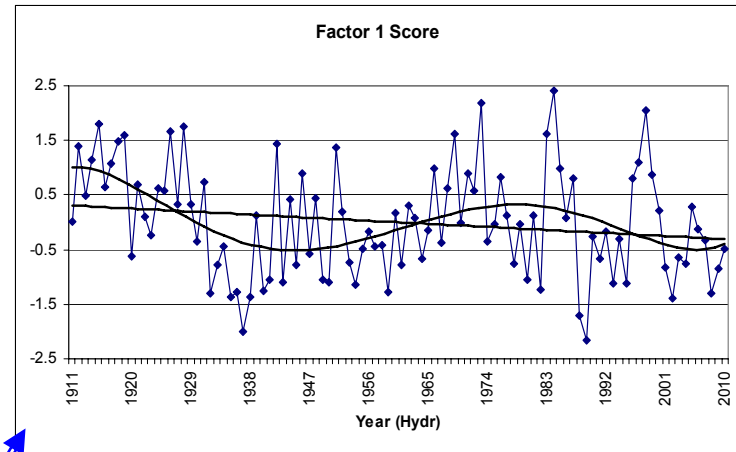
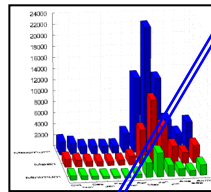
Factor Loadings, Factor 1 vs. Factor 2 vs. Factor 3

Rotation: Varimax normalized
Extraction: Principal components



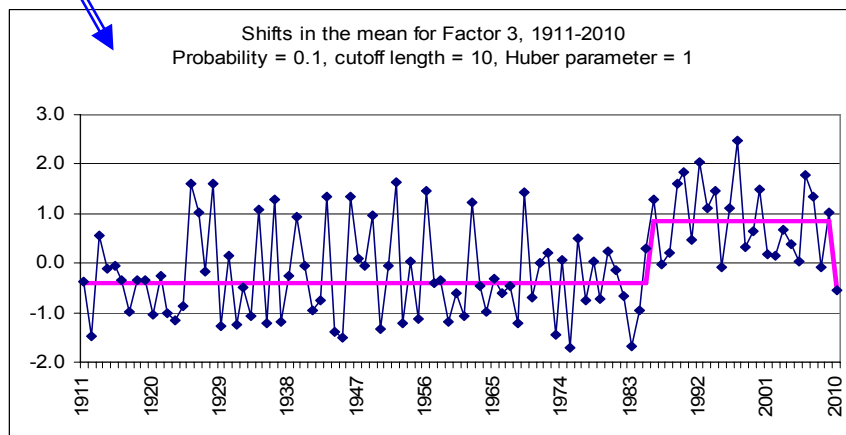
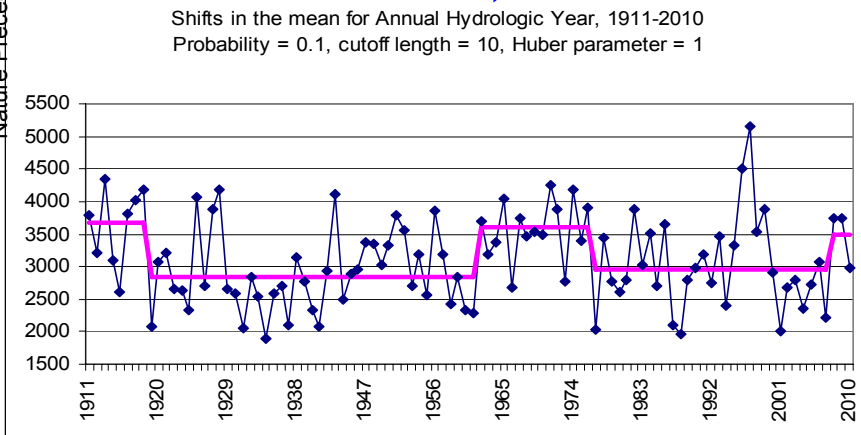
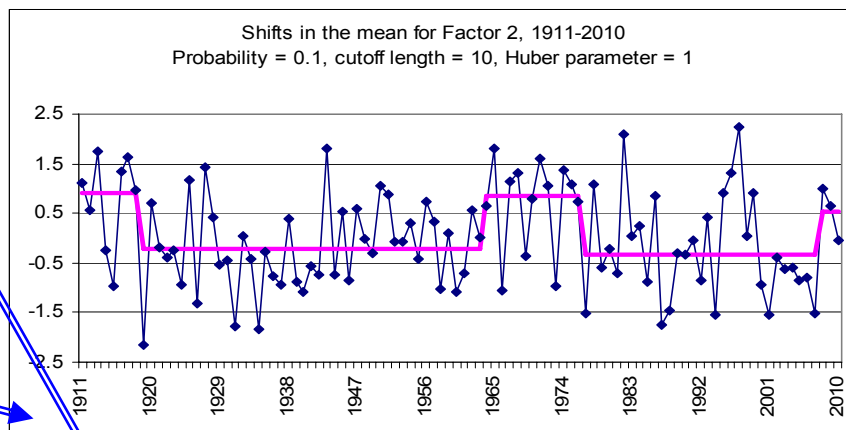
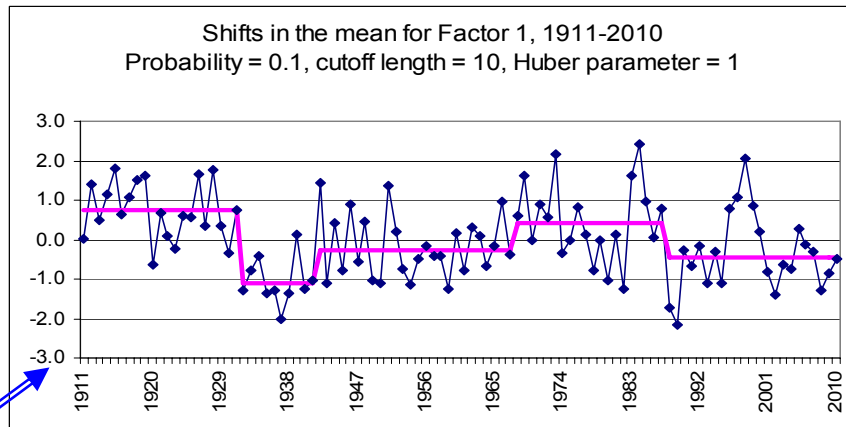
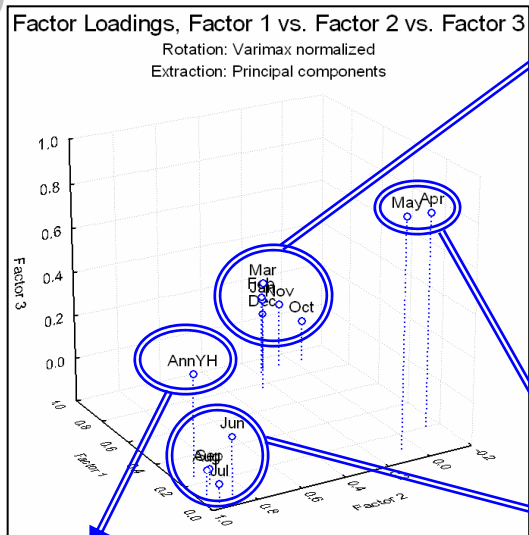
Variable	Factor Loadings		
	Fact 1	Fact 2	Fact 3
Oct	0.92		
Nov	0.92		
Dec	0.95		
Jan	0.92		
Feb	0.89		
Mar	0.77	0.25	0.32
Apr			0.79
May			0.82
Jun		0.87	
Jul		0.94	
Aug		0.96	
Sep		0.97	
Expl.Var	4.93	3.54	1.50
Prp.Totl	0.41	0.30	0.12

More than one dimension



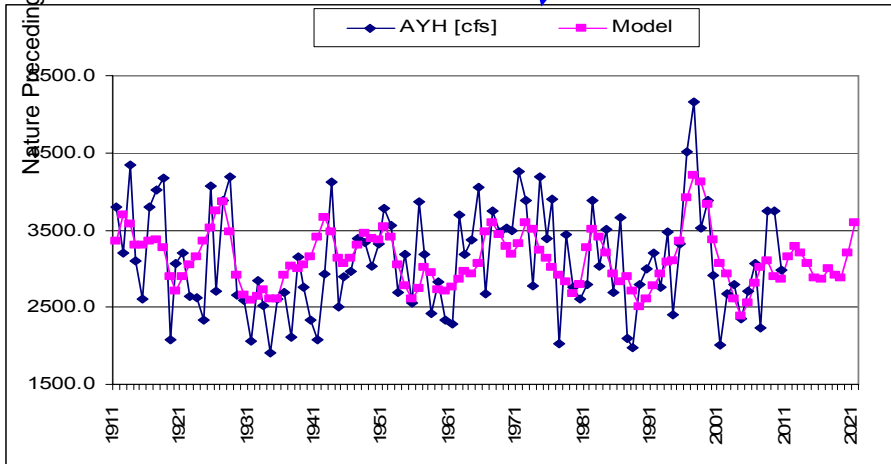
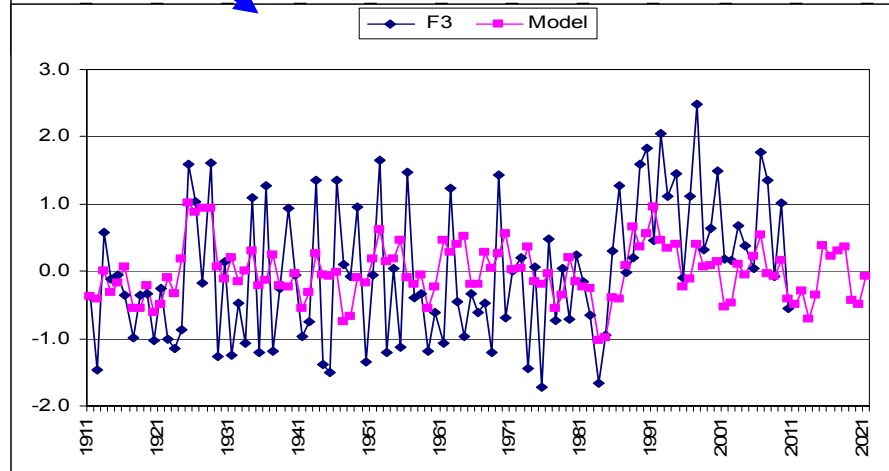
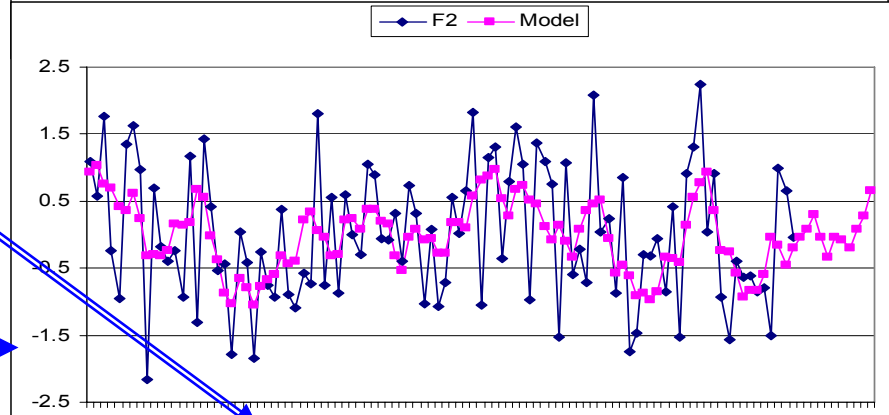
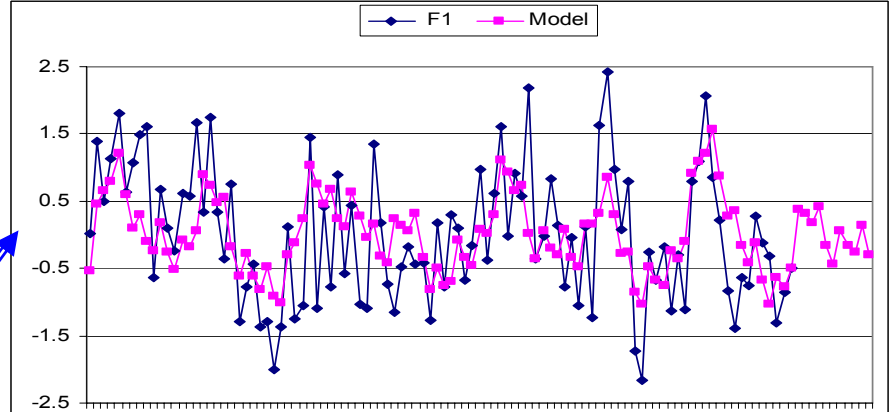
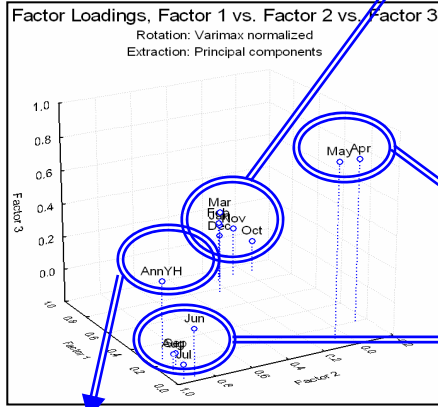
Interannual seasonal regime: shifts

Nature Precedings : doi:10.1038/npre.2011.63371 : Posted 15 Oct 2011



Modeling the Regimes 1911-2010 (2021)

doi:10.1038/npre.2011.6537.1; Posted 15 Oct 2011



The Wavelets

Global and Planetary Change 78 (2011) 1–13



Nature Precedings : doi:10.1038/npre.2011.6337.1 : Posted 15 Oct 2011

A synthesis of the time-scale v
continuous wavelet transform

Rossi *, N. Massei, B. Laignel



A wavelet-support vector machine conjunction model for monthly
streamflow forecasting

Ozgur Kisi ^{a,*}, Mesut Cimen ^b

^a Erciyes University, Engineering Faculty, Civil Eng. Dept., Hydraulics Division, 38039 Kayseri, Turkey

^b Suleyman Demirel University, Engineering-Architecture Faculty, Civil Eng. Dept., Isparta, Turkey



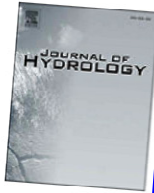
journal home

Journal of Hydrology 376 (2009) 295–306

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A coupled approach of surface hydrological modelling and Wavelet Analysis
for understanding the baseflow components of river discharge in karst
environments

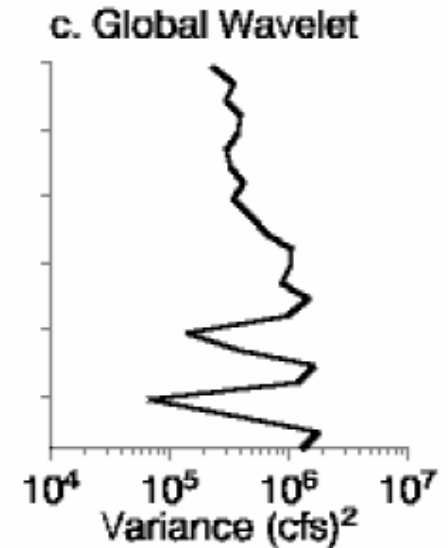
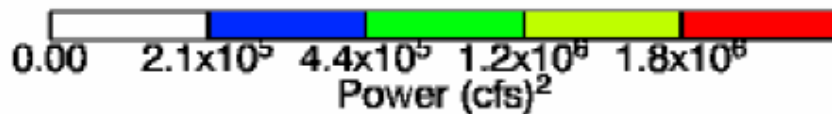
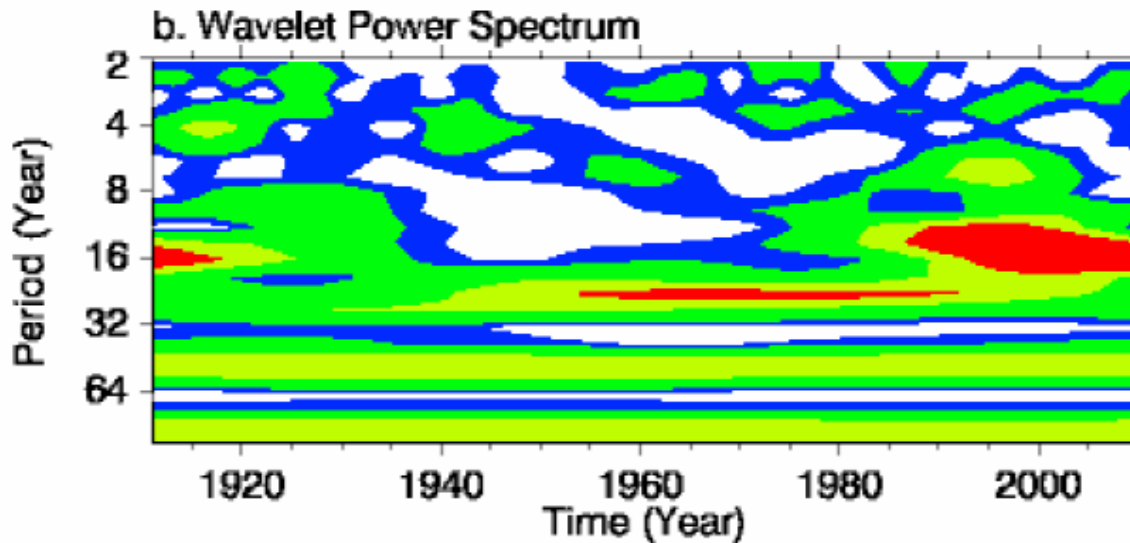
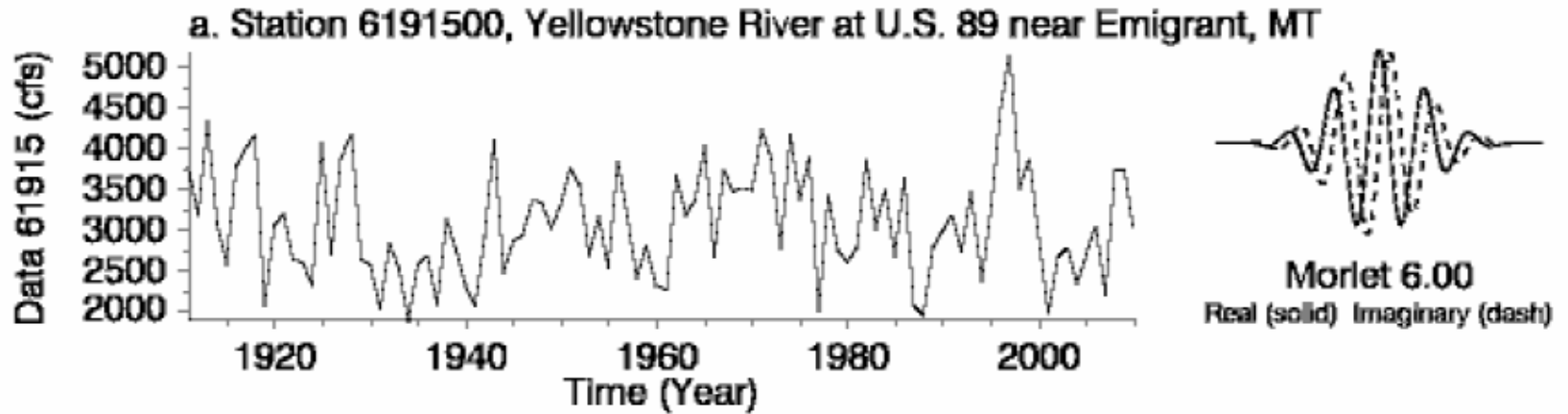
F. Salerno *, G. Tartari

Water Research Institute, National Research Council (IRSA-CNR), Località Occhiate, 20047, Brugherio, Milan, Italy

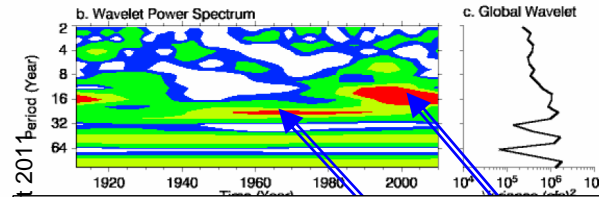
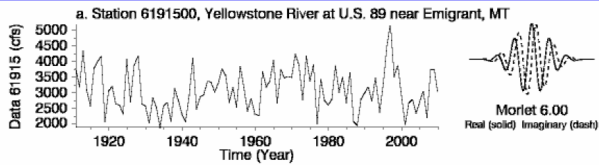
Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

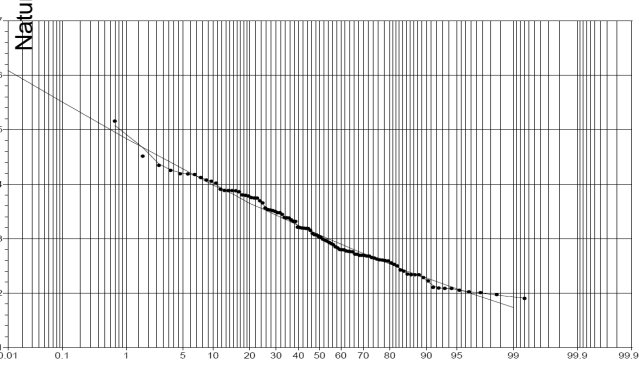
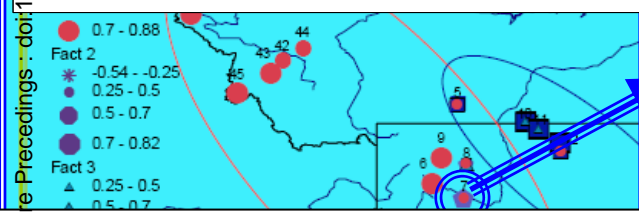
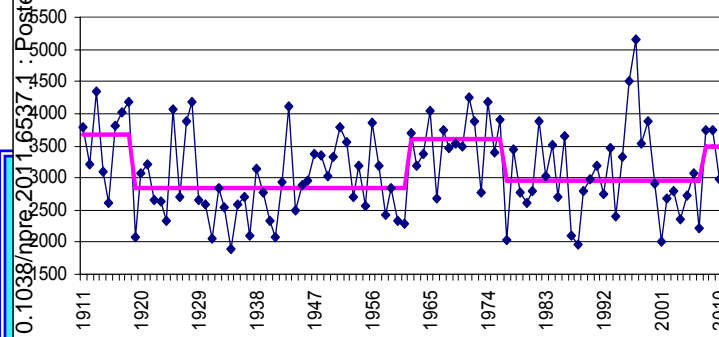
The Wavelets



Math Models &



Shifts in the mean for Annual Hydrologic Year, 1911-2010
Probability = 0.1, cutoff length = 10, Huber parameter = 1



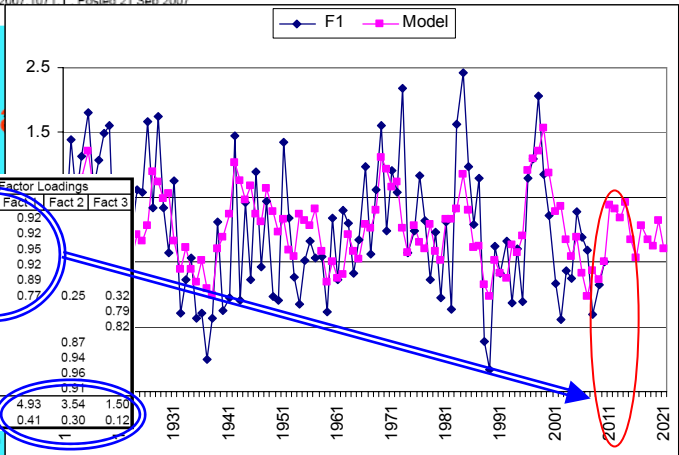
Nature Precedings : doi:10.1038/npre.2007.1071.1 - Posted 21 Sep 2007

Chart of annual 1911-2005

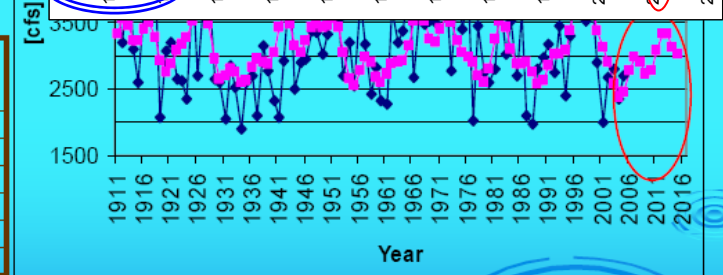
Model:

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

Variable	Factor Loadings	Factor 1	Factor 2	Factor 3
Oct		0.92		
Nov		0.92		
Dec		0.95		
Jan		0.92		
Feb		0.89		
Mar		0.77	0.25	0.32
Apr				0.79
May				0.82
Jun			0.87	
Jul			0.94	
Aug			0.96	
Sep			0.91	
Expl.Var		4.93	3.54	1.50
Prp.Tot		0.41	0.30	0.12



N	T-period [year]	A-amplitude [cfs]	φ-phase [cfs]	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	162.0	1.36	659
6	25.0	321.4	2.18	641



	Fact 5	Total
4		
2	2.70	31.31
0	0.06	68%

Annual runoff
1963-1990

Time Variability

The Knowledge of Variability for Watershed

- * The Knowledge about watershed comes only from the analysis of the empirical data (instrumental observations)
- * Variability has to be defined as annual & seasonal structure in coordinates of the hydrologic time & space for particular watershed (coordinates have nonstationary axes, the factor's axes for multidimensional process are considered as the basis for coordinate system)
- * The math model does not have criteria to verify itself (Gödel's incompleteness theorems) & multi models & scales studies with use of empirical data have to be completed

Communicating the Knowledge

The Uncertainty in Hydrology: the Usual Approach

Climatic Change (2011) 105:387–408
DOI 10.1007/s10584-010-9896-4

The role of uncertainties in the design of international water treaties: an historical perspective

Jelena Drieschova · Itay Fischhendler · Mark Giordano

Nature Precedings doi:10.1038/npre.2011.6537.1 · Posted 15 Oct 2011

Table 1 Uncertainty language in transboundary water agreements, 1900–2007

Nature of uncertainty	% of sample which mentioned
Exogenous resource uncertainty	
<u>Flow variability</u>	<u>49%</u>
General environmental	13%
Scientific	4%
Explicit climate change uncertainty	0.69%
Exogenous background	
International relations	
Demand uncertainty	
Induced endogenous uncertainty	
Treaty implementation	
Data	
Treaty finance	
Treaty effectiveness	
Treaty created infrastructure	

Table 2 Changes in types of uncertainty mentioned in transboundary water agreements, 1900–2007

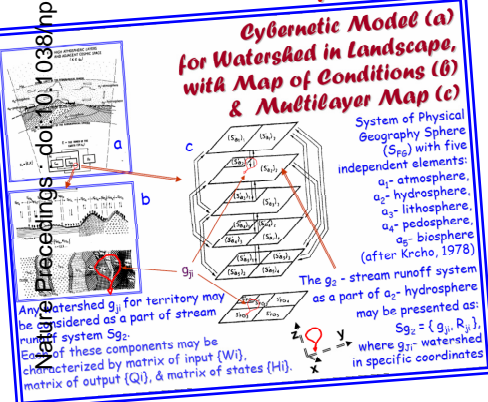
	1900–1949	1950–1969	1970–1989	1990–2007
Exogenous resource uncertainties				
<u>Flow variability</u>	<u>44%</u>	<u>56%</u>	<u>41%</u>	<u>51%</u>
General environmental uncertainty	2%	6%	19%	24%
Scientific uncertainty	4%	1%	6%	6%
Explicit climate change uncertainty	0%	0%	0%	3%
Exogenous background uncertainties				
International relations	17%	4%	7%	4%
Induced endogenous uncertainties				
Implementation uncertainty	6%	7%	6%	7%
Data uncertainty	2%	0%	0%	1%
Financial uncertainty	6%	6%	7%	4%
Effectiveness uncertainty	4%	1%	7%	4%
Infrastructural uncertainty	10%	13%	15%	28%

The Uncertainty & The Knowledge through Modeling: Object, Data, Analysis & Results

Posted 15 Oct 2011



The knowledge (K) = 0, about a new object for the consideration the uncertainty (U) = 1



$K_p = 1$ & we have the direction for the research, the task, $U = 0$, but the Knowledge is previous (K_p)

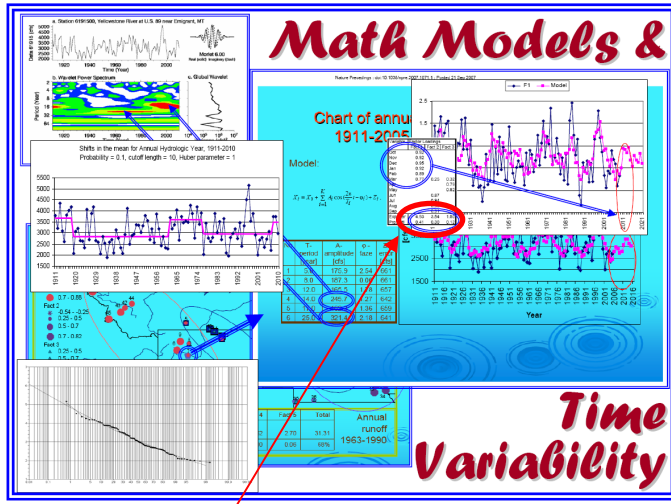
From Data Analysis to Statistical Learning

THE PHILOSOPHY OF EXPLORATORY DATA ANALYSIS*
 I. J. GOOD†
 Statistics Department, Virginia Polytechnic Institute

Model Uncertainty, Data Mining and Statistical Inference
 By CHRIS CHATFIELD
 University of Bath, UK

The Elements of Statistical Learning
 Trevor Hastie, Robert Tibshirani, Jerome Friedman
 Data Mining, Inference, and Prediction
 Second Edition

Philosophy of Science, 50 (1983) pp. 283-295



The conceptual model (Cybernetic Model) is the way to use previously obtained Knowledge

The Uncertainty from Analysis obtained for every model. For Factor Analysis $U=1$ - explained variability

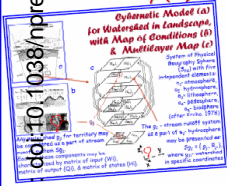
Communicating the Knowledge for the Watershed

Nature Previews | doi:10.1038/npre.2011.6537.1 | Posted 15 Oct 2011

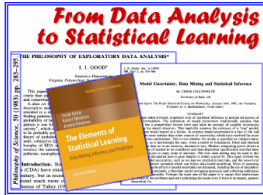
The Uncertainty & The Knowledge through Modeling: Object, Data, Analysis & Results



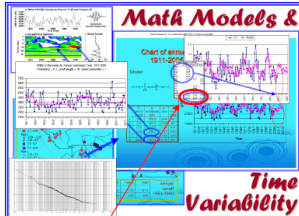
The knowledge (K) = 0, about a new object for consideration
uncertainty (U) = 1



K = 1 & we have the information for the research, the task, K = 0, but the knowledge is previous (K_p)



The Statistical Learning is the way to obtain ("extract") the structure of a natural object



After Statistical Learning
K > U

The conceptual model (Cybernetic Model) is the way to use previously obtained Knowledge

The Uncertainty from Analysis obtained for every model.
For Factor Analysis
U=1- explained variability

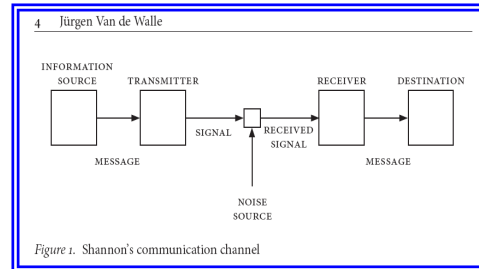
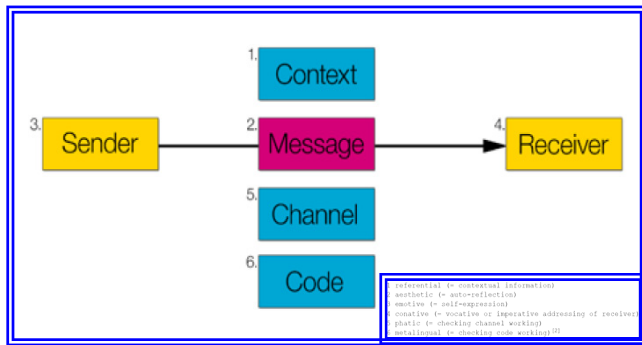
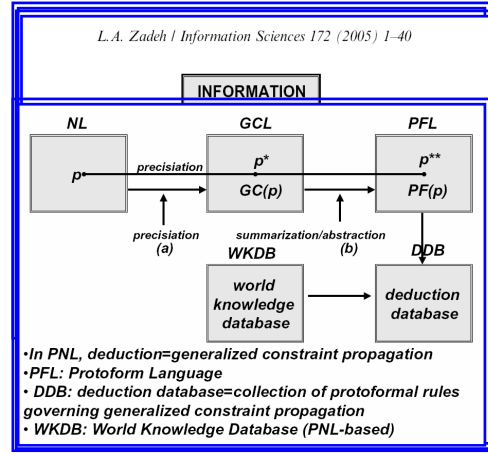


Figure 1. Shannon's communication channel



- In PNL, deduction = generalized constraint propagation
- PFL: Protoform Language
- DDB: deduction database = collection of protoformal rules governing generalized constraint propagation
- WKDB: World Knowledge Database (PNL-based)

Scientist working in Hydrology have to handle the Uncertainty & communicate the Knowledge about time-spatial variability of the Watershed characteristics

Conclusions

- * The Knowledge & the Uncertainty obtained with math models help to determine:
 - the scope of practical applications to be developed (like water balance estimations for conservation &/or management of water resources in different scales),
 - the tasks to educate the public/communities about water resources & environmental issues.
- * Communication of the knowledge of hydrologic objects & processes is successful with colleagues with equal experience.
- * Education has be based on research.