The Data Analysis & the Knowledge of Climate & Water Resources in SD

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Introduction

The goal:
The general look on science & knowledge about climate & water resources for South Dakota

- Introduction
- Results as Math Models
- Forecast & Uncertainty
- Data analysis & Natural Structures
- Art, Science & Community
  - Epilogue
  - Questions
Obtained results for seven years did not make to the community.

Several questions were asked, which were:

- 2004 - 2005
- 2006 - 2007
- 2008 - 2009

Introduction
Introduction

"Art is a lie that makes us realize truth."

Pablo Picasso
(1881-1973)

"Science is not a heartless pursuit of objective information; it is a creative human activity"

Stephen Jay Gould
(1941-2002)

was the Alexander Agassiz Professor of Zoology & Professor of Geology at Harvard University. He published over twenty books, received the National Book & National Book Critics Circle Awards, & a MacArthur Fellowship.
The knowledge could be useful at the time.
Results

Aberdeen, SD, 2007
8 inches for 28 hours - record rain

Math Models

Results could provoke more substance study
From textbook:

Simple linear model

For description of two variables Y & X relations lets use the simple regression model like:

\[ Y = a + b \cdot x + e \]

- \( a \) - is the constant (or intercept),
- \( b \) - is the slope (also designated as the coefficient for X),
- \( e \) - denoted the error term or residual.

The \( Y = a + b \cdot x + e = E + e; \) & \( E \) - mathematical expectation.
The components of variance with use of simple linear model are:

a- full: $Y - \bar{Y}$

b- by regression: $E - \bar{Y}$

c- residual: $Y - E$

The coefficient of determination by regression is equal to the variance of regression divided on full variance:

$$R^2_{x,y} = \frac{S(E - \bar{Y})^2}{S(Y - \bar{Y})^2}$$

The values of this coefficient are from 0 to 1. Square root of $R^2$ is coefficient of paired correlation.

From textbook: Variance of the dependent variable & the coefficient of paired correlation

The approach with linear model is to reflect & present connection obtained from empirical data.
Model for simplified Fourier analysis:

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

Where are:

- \(X_t\) - observation,
- \(X_0\) - mean for the interval of observations,
- \(A_i\) - amplitude,
- \(T_i\) - period,
- \(\varphi_i\) - phase of \(i\)-cosinusoid,
- \(Z_t\) - difference between observation & model.

May be used for time-series analysis.

Model presented as a synthetic time series \(X_s\) that is sum of two

\[(X_s = X_1 + X_2)\]

with characteristics:

\[A_1 = 2,\]
\[T_1 = 3,\]
\[A_2 = 1,\]
\[T_3 = 12.\]

The different model may be considered.
Empirical observations may be presented as synthetic time series $X_s$ as sum of two ($X_s = X_1 + X_2$) with characteristics:

- $A_1 = 2$, $T_1 = 3$
- $A_2 = 1$, $T_2 = 12$

The equation quotients are calculated separately for each selected period & for all periods together under the condition of minimization of the random part, that is the same as in case of regression.
Forecast on this time scale is good.

Cascading model uncertainty from medium range weather forecasts (10 days) through a rainfall-runoff model to flood inundation predictions within the European Flood Forecasting System (EFFS)

F. Pappenberger¹, K.J. Beven¹, N.M. Hunter², P.D. Bates², B.T. Gouweleeuw³, J. Thielen³, and A.P.J. de Roo³

¹Lancaster University, Institute of Environmental Science, Bailrigg, Lancaster, LA1 4YQ, UK
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Fig. 1. Sketch of the uncertainty cascade
A UNIFIED MODELING APPROACH TO CLIMATE SYSTEM PREDICTION

by James Hurrell, Gerald A. Meehl, David Karoly, Thomas L. Delworth, Bin Rayyan, and Bruce Weirich

Uncertainty

The unified approach for modeling...

Fig. 1. Schematic illustrating interactions between various time and space scales in the climate system. (left) Space scales and (right) possible forecasts are indicated. Though “synoptic” is the smallest time scale, these interactions could continue to infinitely short time scales and small space scales.

Fig. 3. Space-time spectrum of the 15°–15°N symmetric component of precipitation, divided by the background spectrum. (top) Observational estimates from an atmospheric reanalysis product and (bottom) results from a coupled climate model simulation.

Uncertainty

Forecast &

Fig. 6. Rainfall variability simulated by several AGCMs forced with observed sea surface temperatures. Each model simulation includes an ensemble of nine initial conditions, the differences in which are designed to mimic potential observational errors. The first column shows the rainfall variance of the ensemble mean of each model. This is the signal variance. The second column shows the variance about the ensemble mean or the variance resulting from atmospheric internal dynamics. The last column is the ratio of the ensemble mean variance divided by the internal dynamics variance, i.e., a signal-to-noise ratio. (Results are from WCRP/CLIVAR/WGESP SMIP project and the figure is courtesy of In Seok Kang Seoul National University.)
Forecast & Uncertainty

The Pacific Northwest should brace for a colder and wetter than average winter, while most of the South and Southwest will be warmer and drier than average through February 2011, according to the annual Winter Outlook released today by NOAA’s Climate Prediction Center. A moderate to strong La Niña will be the dominant climate factor influencing weather across most of the U.S. this winter.

... provides nice pictures ...
... but the numbers are not so good; the summer had record precipitations & the fall is not cool so far.
We know about past events much better...
On the Cause of the 1930s Dust Bowl

Siegfried D. Schubert, Max J. Suarez, Randal D. Koster, Julio T. Bacmeister

During the 1930s, the United States experienced one of the most devastating droughts of the past century. The drought affected large parts of the country and parts of Mexico and Canada and was accompanied by numerous dust storms that occurred in the southern plains. In this study, we present model results that indicate that the 1930s drought was driven by anomalous tropical sea surface temperatures and interactions between the atmosphere and the land surface. We also contrast the 1930s drought with other severe droughts of the 20th century.

... & try to use models of explanations for forecast
The balance of probabilities

IPC members last week considered the best way to quantify uncertainty. They are not alone in
wishing to do so — the media must also take a firm line when it comes to scientific reporting.

The purpose of this report is to imagine the unthinkable — to push the boundaries of current
research on climate change so we may better understand the potential implications on United
States national security.

We have interviewed leading climate change scientists, reviewed several iterations of the scenario with these experts,
but caution that the scenario depicted is extreme, they suggest the occurrences we outline would most likely
occur regionally, than on globally. Second, they say the magnitude of the

We have created a climate change scenario that although not the most likely, is plausible, and
would challenge United States national security in ways that should be considered
immediately.
Toward a generalized theory of uncertainty (GTU)—an outline

Lotfi A. Zadeh *

Berkeley initiative in Soft Computing and the Electronics Research Laboratory 615 Soda Hall
Received 21 December 2004

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

The new horizon in the direction to deal with the uncertainty in life

The new horizon in the direction to deal with the uncertainty in life

It is very warm
Most Swedes are tall
• probability is high
• it is cloudy
• it is hard to find parks on the campus

measurement-based numerical
perception-based linguistic

It is 35 C°
Over 70% of Swedes are taller than 175 cm
• probability is 0.8
•

measurement-based information
perception-based information

perception-based information is intrinsically imprecise

Fig. 2. Measurement-based vs. perception-based information.

Lotfi A. Zadeh

(born Feb 4, 1921)
Professor in the Graduate School, Computer Science Division Department of Electrical Engineering & Computer Sciences
Director, Berkeley Initiative in Soft Computing University of California Berkeley, CA 94720 -1776

“Uncertainty is a personal matter; it is not the uncertainty but your uncertainty.”

Dennis Victor Lindley

born 25 July 1923)
Professor Emeritus of Statistics, & past Head of Department, at University College London (UK).

He is a British statistician, decision theorist & leading advocate of Bayesian statistics.

Economists need their own uncertainty principle

The economists are trying to find right approach in their field

Forecast & Uncertainty
There is an approach to data analysis that is more systemic than usual, and to produce the beginings of a philosophy of data analysis.}

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

*I. J. GOOD*

**Statistics Department.**

Virginia Polytechnic Institute and State University, 1984.

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A Bayesian approach to data analysis and statistics is proposed. It is shown how the personal probabilities can be used to test hypotheses and predict events. The approach is illustrated with examples from many fields, including economics, psychology, and biology. In particular, the method is applied to the analysis of the data from a clinical trial of a new drug.

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**SUMMARY**

This paper takes a broad, pragmatic view of statistical inference to include all aspects of model formulation. The explicit form of model parameters is taken as a given, and the problem is to estimate the values of these parameters. The methods employed are Bayesian, empirical Bayes, and maximum likelihood. The focus is on the use of personal probabilities in statistical inference.

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**Model Uncertainty, Data Mining and Statistical Inference.**

BY CHRIS CHATFIELD

University of Bath, UK.

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There is an approach to data analysis that is more systemic than usual, and to produce the beginings of a philosophy of data analysis.
Factor analysis is a method for extraction that are regarded as the basic variables that account for the interrelations observed in the data.

A factor is a portion of a quantity, usually an integer or polynomial that, when multiplied by other factors, gives the entire quantity.

The main applications of factor analytic techniques are:

- (1) to reduce the number of variables and
- (2) to detect structure in the relationships between variables, that is to classify variables.

(From: Wolfram MathWorld)

The variables selected after factor analysis are considered as typical & may be used for time-series analysis.
Pacific and Atlantic Ocean influences on multidecadal drought frequency in the United States

Gregory J. McCabe*, Michael A. Palecki*, and Julio L. Betancourt*

*U.S. Geological Survey, Denver Federal Center, MS 412, Denver, CO 80225; *Midwestern Regional Climate Center, Illinois State Water Survey, 3900 S. Fourth Drive, Champaign, IL 61820; and *U.S. Geological Survey, Desert Laboratory, 1675 West Anklam Road, Tucson, AZ 85745

Edited by Inez Y. Fung, University of California, Berkeley, CA, and approved January 12, 2004 (received for review October 17, 2003)

Fig. 2. (A–C) Loadings for the first three components of a rotated principal components analysis of monthly anomalies of standardized climate index departures over the conterminous United States compared to standardized 20-year moving averages of the annual PDO, AMO, and NH temperature (NH Temp). The NH Temp values are multiplied by −1 for easy comparison with PC3 scores. All values are plotted at the centers of the window periods.


Forced and unforced variability of twentieth century North American droughts and pluvials

Benjamin I. Cook · Edward R. Cook · Kevin J. Anchukaitis · Richard Seager · Jon L. Miller

Fig. 1 Conceptual workflow for the PDSI modeling using prescribed and modeled PCs from principal component analysis. PCs 1, 2, and 3 are referred to as prescribed or modeled via phase randomization. The remaining PCs and residual PDSI are modeled.

Fig. 2 PDSI from the NADA v2a, for the four persistent twenty century hydroclimatic events over North America. The four events were the 1905–1917 pluvial, the 1932–1939 “Dust Bowl” drought, the 1948–1957 drought, and the 1998–2002 drought.
Data analysis

The structures of hydrosphere underlay the forecasts

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


Patterns of stream runoff in Upper Missouri

Structure of time spatial variability of stream runoff for U
Data analysis & Natural Structures

Scale of research is different for state

Table 3. Factor Loadings (> 0.25) for monthly precipitation. Data are from Aberdeen, SD.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor Loadings</th>
</tr>
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<tbody>
<tr>
<td>Jan</td>
<td>0.84</td>
</tr>
<tr>
<td>Feb</td>
<td>0.78</td>
</tr>
<tr>
<td>Mar</td>
<td>0.65</td>
</tr>
<tr>
<td>Apr</td>
<td>0.53</td>
</tr>
<tr>
<td>May</td>
<td>0.42</td>
</tr>
<tr>
<td>Jun</td>
<td>0.31</td>
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<tr>
<td>Jul</td>
<td>0.22</td>
</tr>
<tr>
<td>Aug</td>
<td>0.11</td>
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<tr>
<td>Sep</td>
<td>0.08</td>
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<tr>
<td>Oct</td>
<td>0.05</td>
</tr>
<tr>
<td>Nov</td>
<td>0.03</td>
</tr>
<tr>
<td>Dec</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Fig. 1. Time series of precipitation anomalies averaged over the U.S. Great Plains region (30°N to 50°N; 95°W to 105°W; see box in inset). A filter (28) is applied to remove time scales shorter than about 6 years. The thin black curves are the results from the 14 ensemble members from the C20C era. The green solid curve is the ensemble mean. The red curve shows the observations. The maps show the simulated (left) and observed (right) precipitation anomalies averaged over the Dust Bowl period (1932 to 1938). Units, mm/day.

Figure 5. Annual precipitation (in inches) and Factor Scores for seasons. Precipitation (solid line) with correlations of months presented as Factor Loadings in Table 3. Factor Loadings above 0.25 are highlighted. Seasonal precipitation with linear trend line and 5th power polynomial curve; b – f - Factor Scores with linear trend line and 5th power polynomial curve.

Art, Science & Community

There & now
Art, Science & Community

The School of Athens

& there were people in SD who saw the connections


Raphael (1509-1510) Fresco (500*770 cm) Vatican City, Apostolic Palace
Richard P. Feynman (1918 – 1988) was an American physicist. He held the Richard Chace Tolman professorship in theoretical physics at the California Institute of Technology. For his contributions to the development of quantum electrodynamics, he received the Nobel Prize in 1965. He assisted in the development of the atomic bomb & has been credited with pioneering the field of quantum computing, & introducing the concept of nanotechnology.

In ... Caltech ... in 1976, the late Richard Feynman & I spoke about a theoretical paper he published 20 years earlier in quantum optics that opened the field to experiments, offering a way to visualize the interaction of laser light & matter. With a smile he told me that at the time he only wanted to answer a fundamental question: if a spin moment can precess in a magnetic field, would an optical transition moment do the same?“

From: Ahmed Zewail.

“We do much less well with the earth than we do with the conditions of matter in the stars. The mathematics involved seems a little too difficult, so far, but perhaps it will not be too long before someone realized that it is a important problem and really work it out. “

The Feynman Lectures of Physic, 1962)
Science in the digital age

As it is always science & research need to communicate with the community.
Art has strait & very powerful appeal to the community.

Soviet Premier Nikita Khrushchev gives Van Cliburn a congratulatory embrace (1958)
"Science is like sex: sometimes something useful comes out, but that's not the reason we are doing it."

Richard P. Feynman

"Art is a lie that makes us realize truth, at least the truth that is given us to understand. The artist must know the manner whereby to convince others of the truthfulness of his lies."

(The Arts, Picasso Speaks, 1923)
EDITORIAL

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Practice and Teaching of American Water Management in a Changing World

by Donna J. Charlevoix

Improving Teaching and Learning through Classroom Research

by Robert Maynard Hutchins (1923)

Art, Science & Community
"In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual."

Galileo Galilei
(Born: Feb 15, 1564 - Pisa, Italy
Died: Jan 8, 1642 - Arcetri, Italy)
IST AUSTRIA IS LOOKING FOR

Professors and Assistant Professors

IST Austria (Institute of Science and Technology Austria) is a new Institute located on the outskirts of Vienna, dedicated to cutting-edge basic research. The Institute invites applications and nominations for Professors and Assistant Professors in all fields of the natural sciences and related disciplines. Outstanding scientists in the Physical Sciences, Neurosciences, and Mathematics are especially encouraged to apply.

The Institute, established by the Austrian Government, opened its campus allowing for over 500 employees and graduate students by 2010. IST Austria includes an English language Graduate School. It aims to achieve an academic excellence and potential, by recruiting leading researchers from around the world.

Professors and Assistant Professors have fixed-term contracts for an initial period of five years plus automatic renewal for two additional years. Before the end of this period, an indefinite appointment as a Professor at IST Austria, the decision being for a “Tenure-Track Assistant Professor” at US universities.

The selected candidates will receive a competitive salary and substantial operating expenses and the cost of PhD students, postdoctoral fellows, and starting a new laboratory, including instruments and infrastructure, will be expected to apply for internal research grants.

The market is searching for the personalities in science.

Up to 56% of professors are predicted to be non-Swiss by 2018.

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Conclusions

Science is one of many components of our life & scientist is the only holder of the “truth” & creator of the knowledge about the nature.

The climate change & water resources for the territory of state have to be studied in the state.

The universities are the intellectual centers to follow the frontier in science & provide the knowledge to the community.

To support independent & informed communities the state has to support the research in the universities.

The only active working in science faculty is capable of bringing the knowledge to the classroom.
Questions