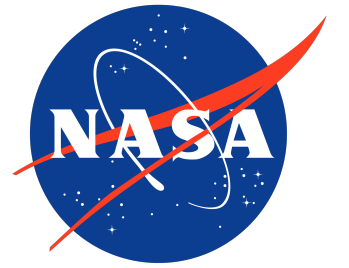




**UC DAVIS**  
UNIVERSITY OF CALIFORNIA



# ***Hydrology Research Articles are Becoming More Interdisciplinary***

**Mashrekur Rahman<sup>1</sup>, Jonathan M. Frame<sup>2,3</sup>, Jimmy Lin<sup>4</sup>, Grey S. Nearing<sup>1,5</sup>**

<sup>1</sup>Department of Land, Air and Water Resources, University of California, Davis

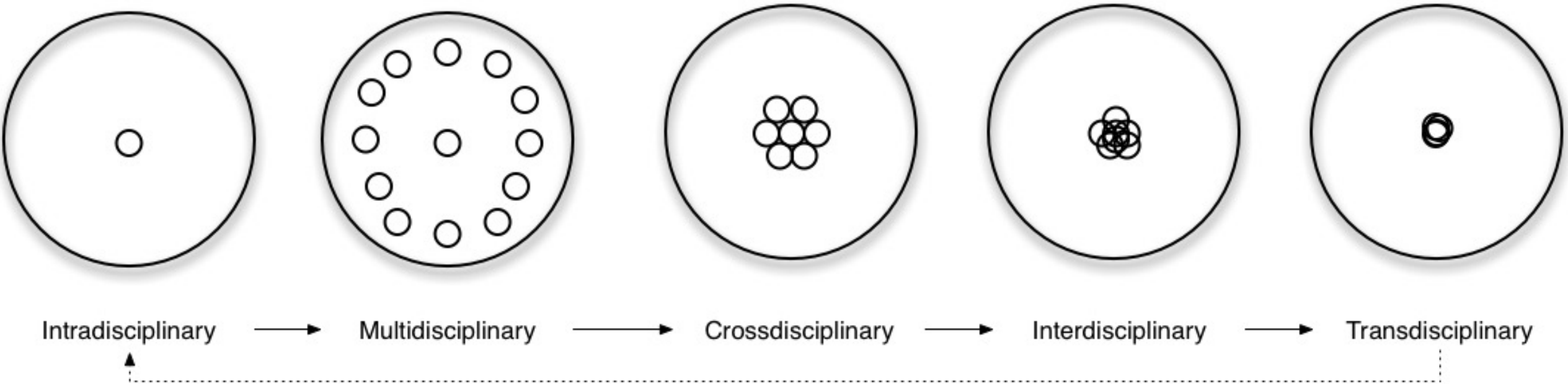
<sup>2</sup>Department of Geological Sciences, University of Alabama

<sup>3</sup>National Oceanic and Atmospheric Administration

<sup>4</sup>David R. Cheriton School of Computer Science, University of Waterloo

<sup>5</sup>Google Research

# ***What is Interdisciplinarity?***



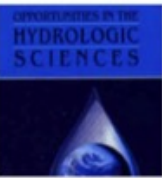
- **Intradisciplinary:** working within a single discipline.
- **Cross disciplinary:** viewing one discipline from the perspective of another.
- **Multidisciplinary:** people from different disciplines working together, each drawing on their disciplinary knowledge.
- **Interdisciplinary:** integrating knowledge and methods from different disciplines, using a real synthesis of approaches.
- **Transdisciplinary:** creating a unity of intellectual frameworks beyond the disciplinary perspectives.

# The Push for Interdisciplinarity in Hydrology

## EDUCATIONAL PROGRESS IN WATER RESOURCES PRESENT AND FUTURE

By J. W. Harshbarger and D. D. Evans

Knowledge required for understanding and solving complex water problems may be considered as a continuum extending from the basic physical and biological sciences, through the applied natural sciences, and a thrust into the behavioral sciences. The breadth of knowledge encompassed is greater than in any other field of study. A complete educational program in hydrology and water resources needs to provide the opportunity for students to specialize in any segment of the continuum as well as the opportunity for others to obtain a general education



## Opportunities in the Hydrologic Sciences

Committee on Opportunities in the Hydrologic Sciences,  
Water Science and Technology Board, National  
Research Council

ISBN: 0-309-53740-1, 368 pages, 6 x 9, (1991)

Original Article

## “Panta Rhei—Everything Flows”: Change in hydrology and society—The IAHS Scientific Decade 2013–2022

## “Panta Rhei—Tout s’écoule”: Changement hydrologique et sociétal—La Décennie Scientifique 2013–2022 de l’AISH

A. Montanari, G. Young, H.H.G. Savenije, D. Hughes, T. Wagener, L.L. Ren, ...  
Pages 1250–1275 | Received 18 Mar 2013, Accepted 21 May 2013, Accepted author version posted online 30 May 2013, Published online 05 Jul 2013

## Water Resources Research

Introduction to a Special Collection | [Free Access](#) |

## Fifty years of *Water Resources Research*: Legacy and perspectives for the science of hydrology

Alberto Montanari, Jean Bahr, Günter Blöschl, Ximing Cai, D. Scott Mackay, Anna M. Michalak, Hanhhar Rajaram, Graham Sander

First published: 24 August 2015 | <https://doi.org/10.1002/2015WR017998> | Citations: 14

WATER RESOURCES RESEARCH, VOL. 26, NO. 9, PAGES 1865–1867, SEPTEMBER 1990

## Water Resources Research and Interdisciplinary Hydrology

R. ALLAN FREEZE

Department of Geological Sciences, University of British Columbia, Vancouver, Canada



## Water Resources Research

### RESEARCH ARTICLE

10.1002/2016WR019835

Key Points:

• Hydrology is becoming increasingly

### Hyphenated hydrology: Interdisciplinary evolution of water resource science

Kathryn L. McCutley and James W. Jewitt

Hydrologic Sciences

## Grand Challenges for Hydrology Education in the 21st Century

Benjamin L. Ruddell, MASCE<sup>1</sup>, and Thorsten Wagener, MASCE<sup>2</sup>

Committee on Challenges and Opportunities in the Hydrologic Sciences  
Water Science and Technology Board  
Division on Earth and Life Studies



## Water Resources Research

### RESEARCH ARTICLE

10.1002/2016WR019835

### Special Sections

The 100th Anniversary of Water Resources Research

Key Points:

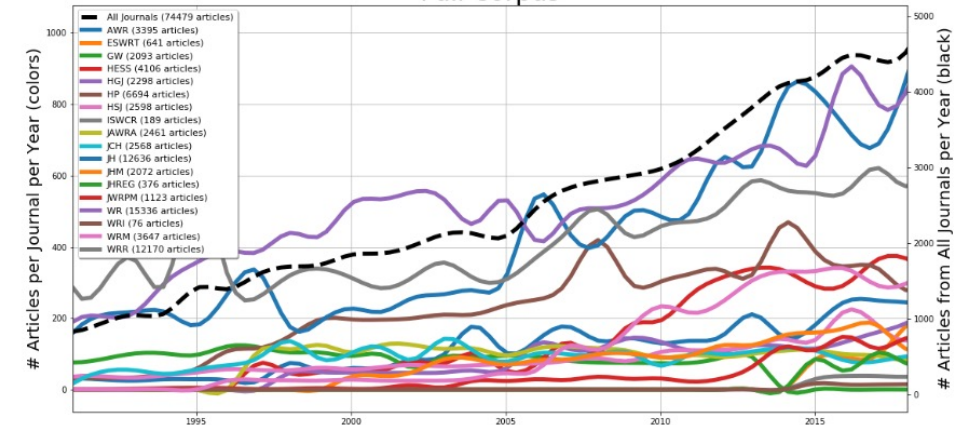
• Human activity is increasingly a part of the natural hydrologic system

### Hydrology: The interdisciplinary science of water

Richard M. Vogel<sup>1</sup>, Upmanu Lalit, Ximing Cai, Sukal Rajagopalan, Peter K. Weiskopf, Richard P. Hooper<sup>2</sup>, and Nicholas C. Wiestner<sup>3</sup>

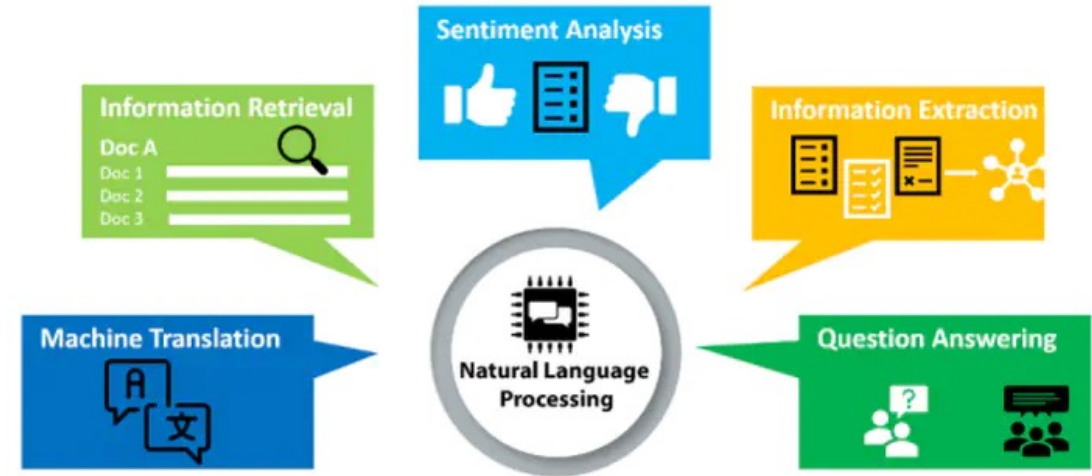
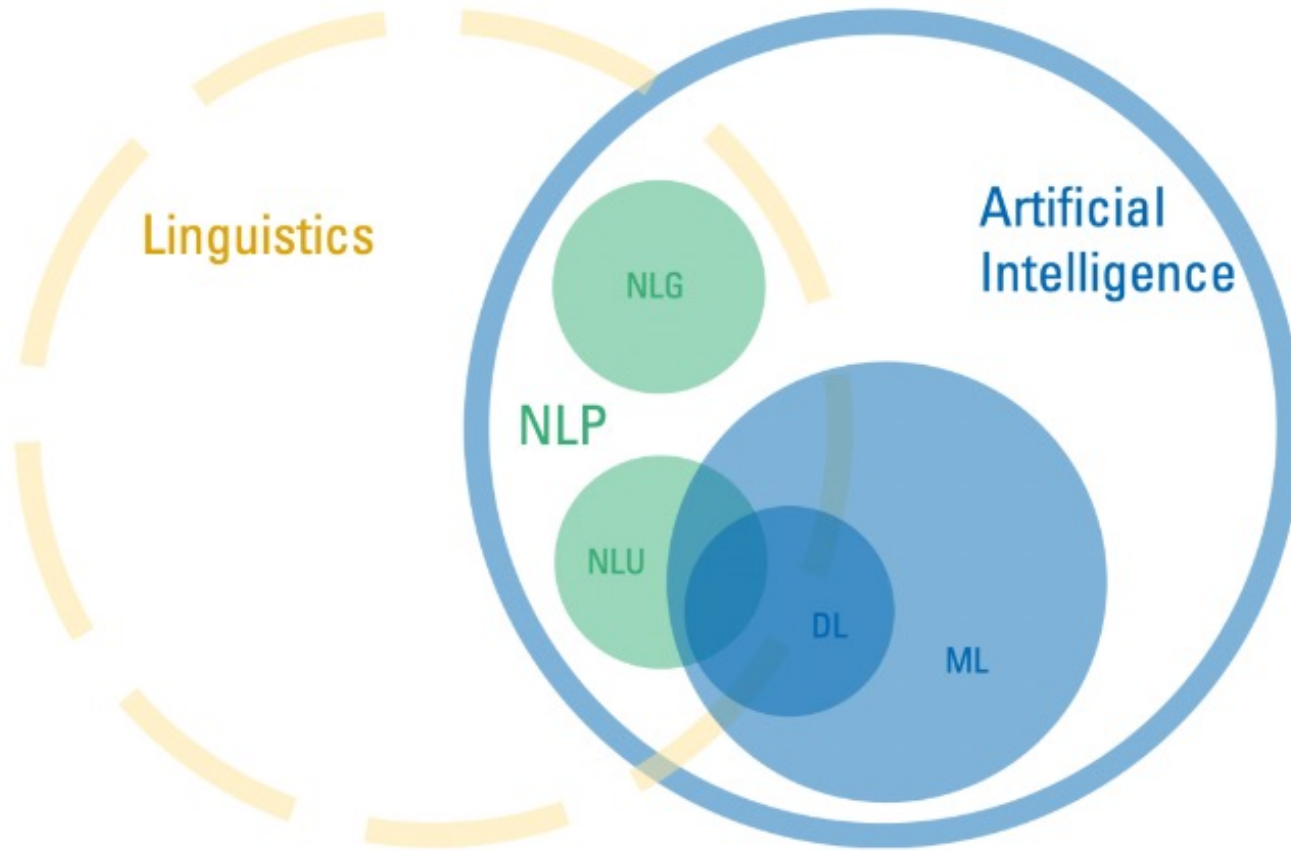
<sup>1</sup>Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA, <sup>2</sup>U.S. Geological Survey, Reston, Virginia, USA, <sup>3</sup>Department of Civil and Environmental Engineering, Columbia University, New York, New York, USA, <sup>4</sup>Department of Civil and Environmental Engineering, University of California, Berkeley, California, USA, <sup>5</sup>Department of Civil and Environmental Engineering, University of Colorado, Boulder, Colorado, USA, <sup>6</sup>Department of Civil and Environmental Engineering, University of Virginia, Charlottesville, Virginia, USA

Full Corpus



“We describe a **modern interdisciplinary science of hydrology** needed to develop an in-depth understanding of the dynamics of the connectedness between human and natural systems and to determine effective solutions to resolve the complex water problems that the world faces today. **Nearly, every theoretical hydrologic model introduced previously is in need of revision to accommodate how climate, land, vegetation, and socioeconomic factors interact, change, and evolve over time.**”

# ***Natural Language Processing – An Introduction***





# Seeking Life's Bare (Genetic) Necessities

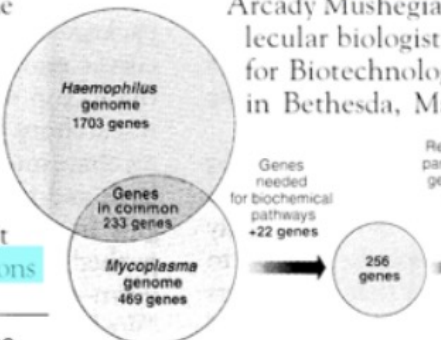
COLD SPRING HARBOR, NEW YORK—How many **genes** does an **organism** need to **survive**? Last week at the genome meeting here,\* two genome researchers with radically different approaches presented complementary views of the basic genes needed for **life**. One research team, using **computer** analyses to compare known **genomes**, concluded that today's **organisms** can be sustained with just 250 genes, and that the earliest life forms required a mere 128 **genes**. The other researcher mapped genes in a simple parasite and estimated that for this organism, 800 genes are plenty to do the job—but that anything short of 100 wouldn't be enough.

Although the numbers don't match precisely, those **predictions**

\* Genome Mapping and Sequencing, Cold Spring Harbor, New York, May 8 to 12.

"are not all that far apart," especially in comparison to the 75,000 **genes** in the human genome, notes Siv Andersson of Uppsala University in Sweden, who arrived at the 800 number. But coming up with a consensus answer may be more than just a **genetic numbers game**, particularly as more and more **genomes** are completely mapped and sequenced. "It may be a way of organizing any newly **sequenced genome**," explains

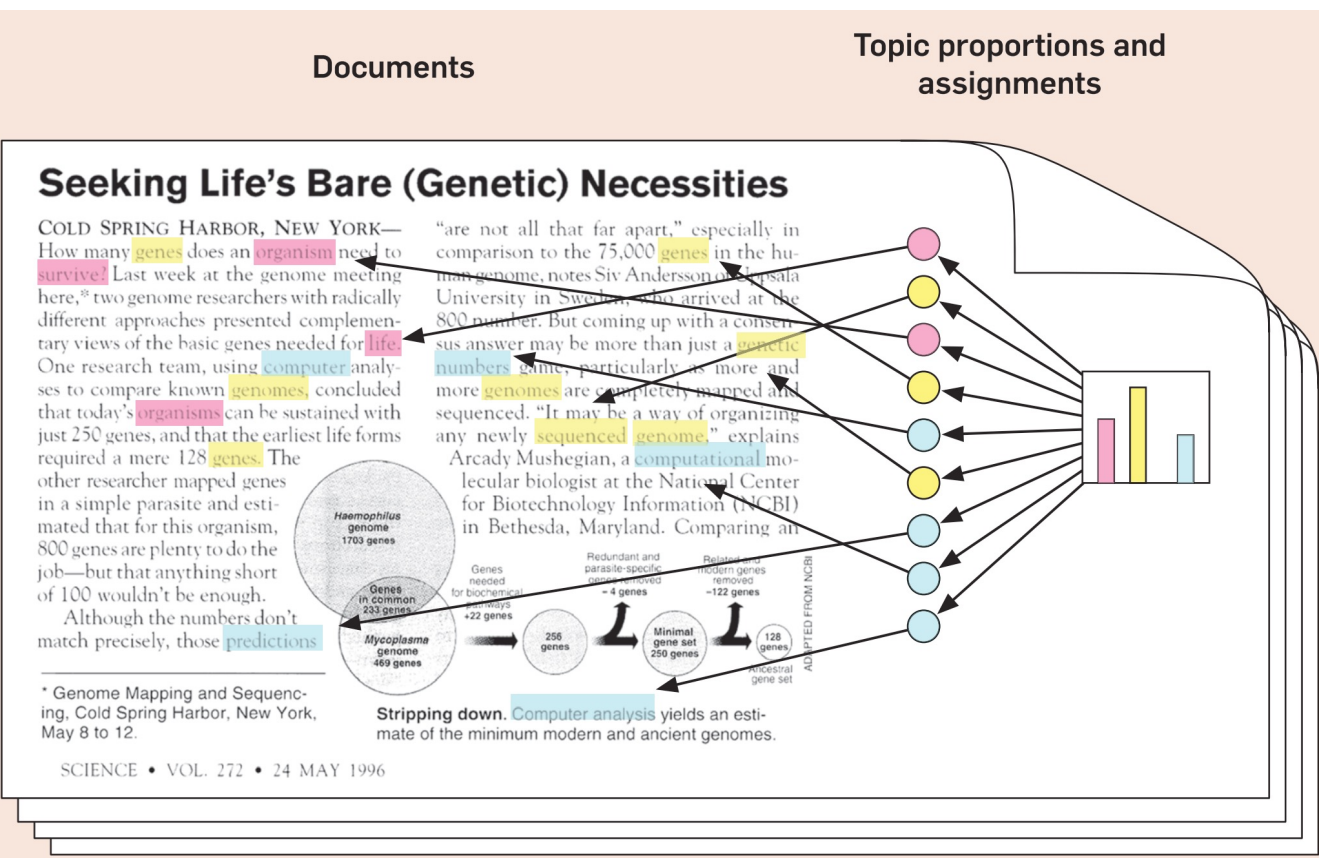
Arcady Mushegian, a molecular biologist at the National Center for Biotechnology Information in Bethesda, Md.



Stripping down. Computer analysis yields an estimate of the minimum modern and ancient genomes.

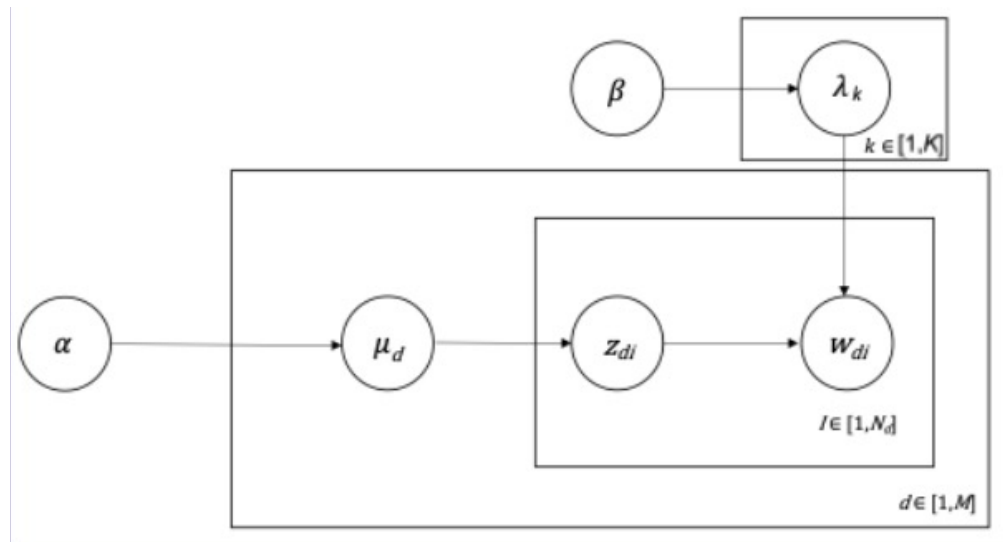
Topics	
gene	0.04
dna	0.02
genetic	0.01
...	
life	0.02
evolve	0.01
organism	0.01
...	
brain	0.04
neuron	0.02
nerve	0.01
...	
data	0.02
number	0.02
computer	0.01
...	

## Topic Modeling - Intuition



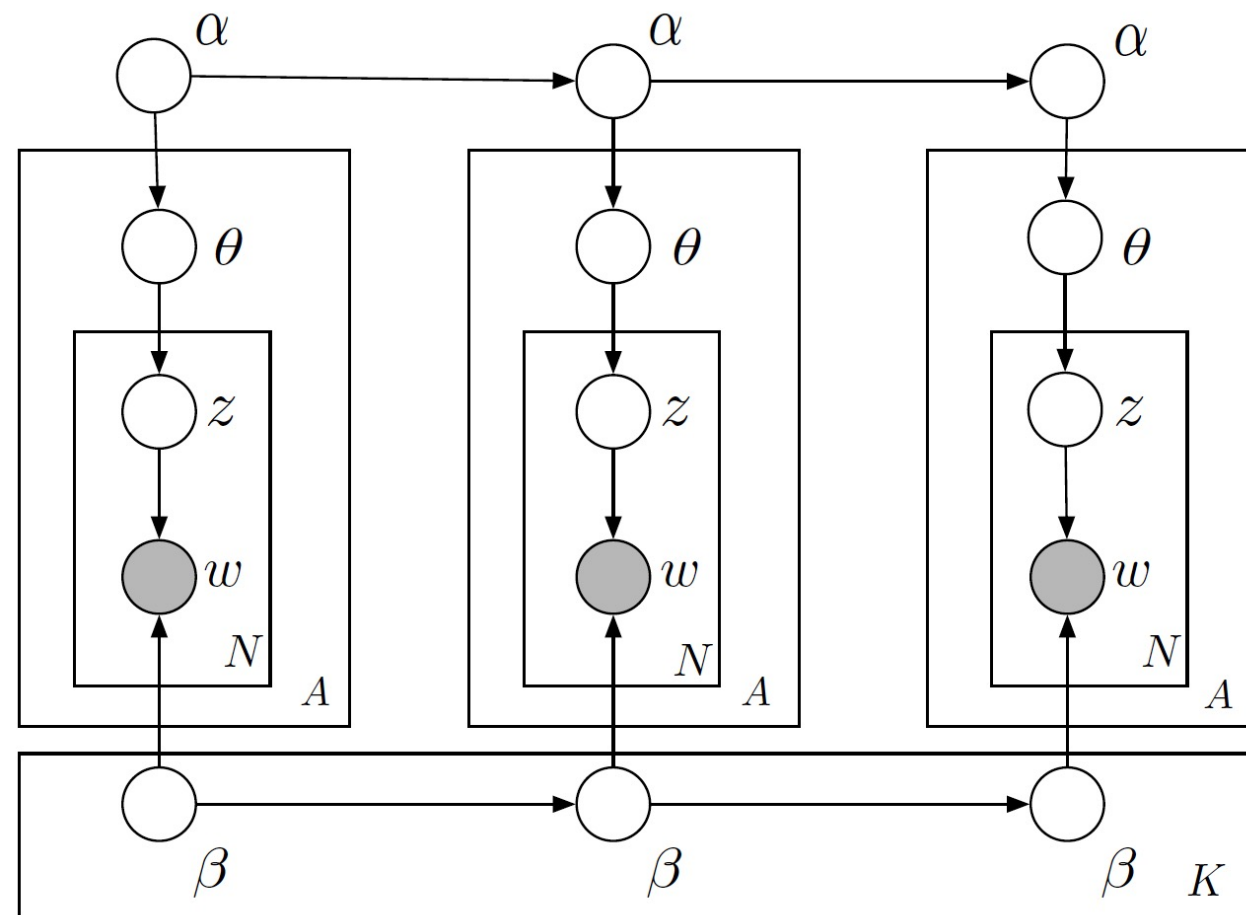
# Latent Dirichlet Allocation (LDA)

## Static LDA

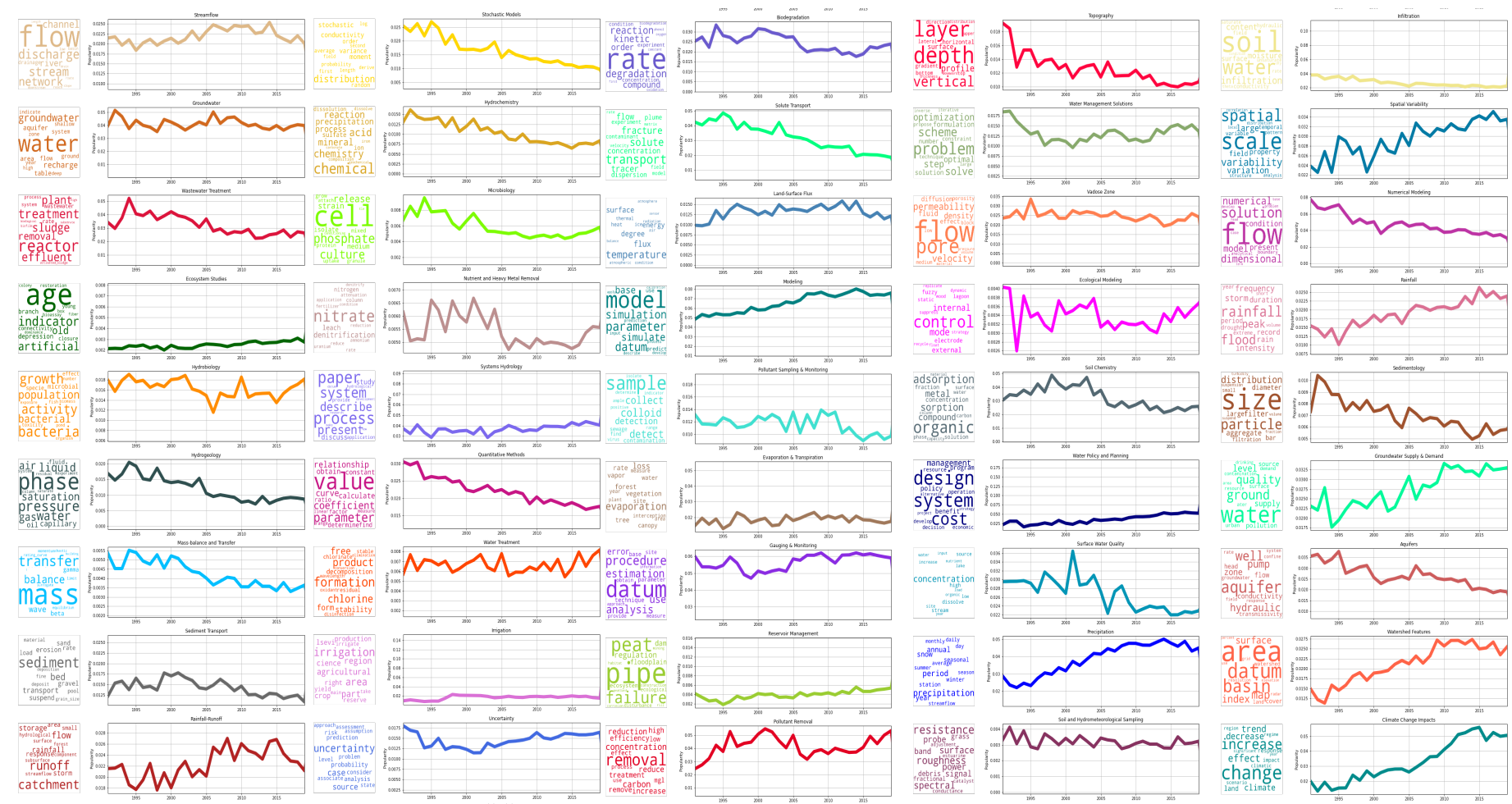


- $\mu_d$  – Per-document topic distribution
- $\lambda_k$  – Per-topic word distribution
- $\alpha$  - Dirichlet prior on the per-document topic distribution
- $\beta$  - Dirichlet prior on the per-topic word distribution
- $z_{di}$  – Topic assignment for each word
- $w_{di}$  - Generated word
- $K$  – Number of topics
- $k$  – Topic
- $M$  – Corpus

## Sequential LDA



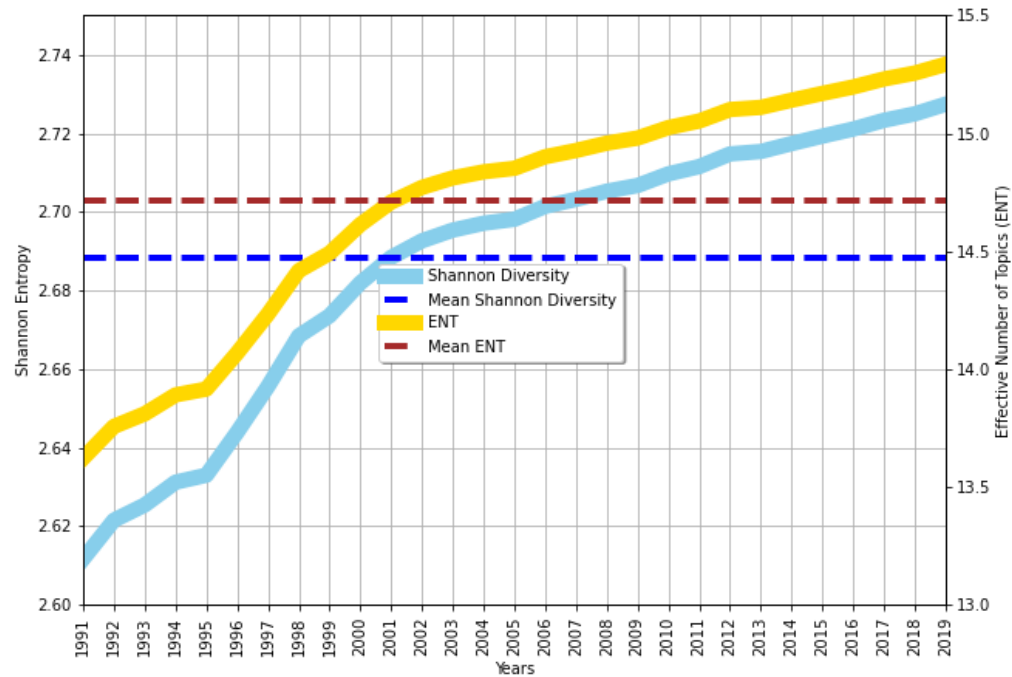
# Topics & Trends



Rising Trends		
Topic	p-val	BF10
Rainfall-Runoff	1.24E-04	253.82
Water Policy and Planning	2.42E-04	139.38
Precipitation	1.92E-04	171.40
Spatial Variability	8.20E-05	367.25
Rainfall	1.30E-04	242.14
Groundwater Supply & Demand	5.12E-09	2.50E+06
Watershed Features	5.61E-13	1.13E+10
Climate Change Impacts	1.06E-14	4.47E+11
Ecosystem Studies	4.46E-03	10.74
Falling Trends		
Topic	p-val	BF10
Wastewater Treatment	4.86E-07	3.85E+04
Hydrogeology	1.41E-10	6.86E+07
Mass-balance and Transfer	1.94E-10	5.11E+07
Stochastic Models	1.34E-14	3.58E+11
Hydrochemistry	2.21E-11	3.79E+08
Microbiology	1.52E-07	1.11E+05
Quantitative Methods	5.38E-16	7.05E+12
Surface Water Quality	2.35E-06	9.13E+03
Numerical Modeling	3.54E-10	2.93E+07
Sedimentology	5.51E-08	2.83E+05
Aquifers	6.43E-10	1.69E+07

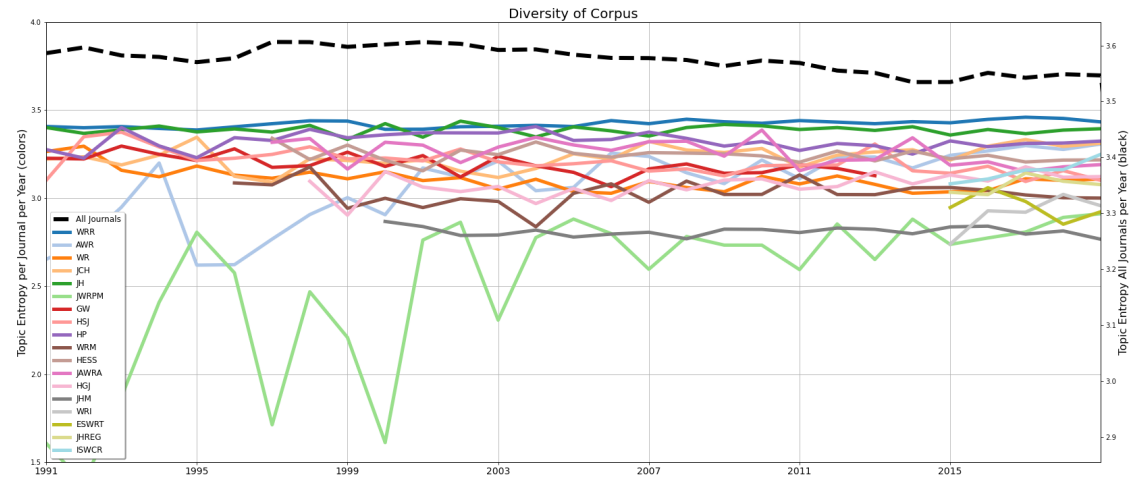
# Interdisciplinarity in Hydrology Literature

## Per-article Diversity



- ENT per article steadily rose from 13.62 in 1991 to 15.29 in 2019
- 4.44% rise in mean per article topic diversity translates to 12.26% rise in the number of equally-common topics per article

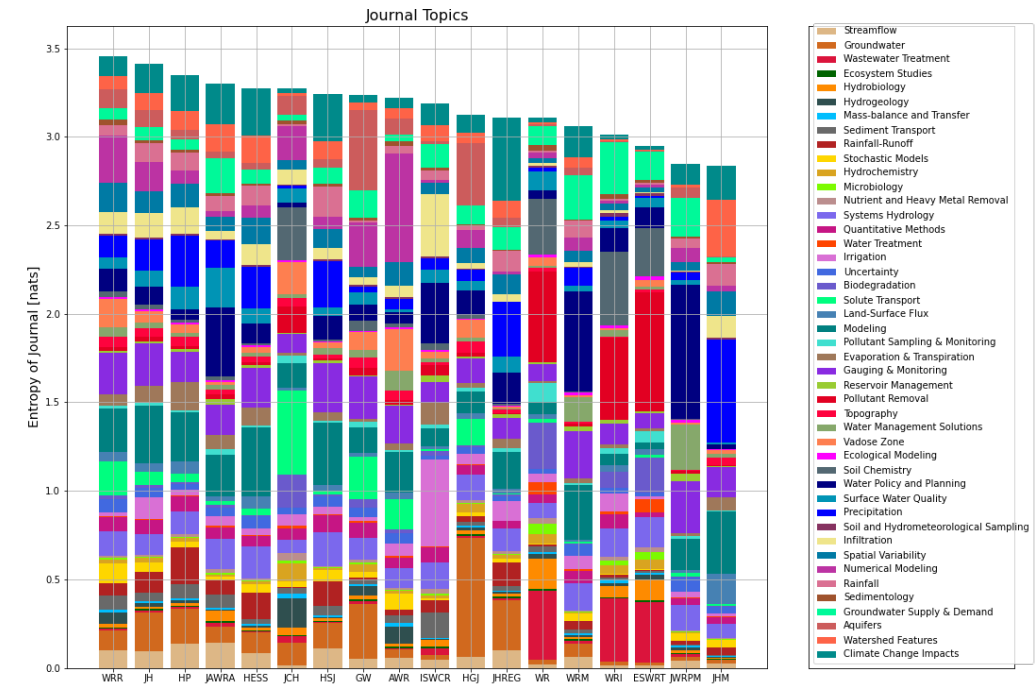
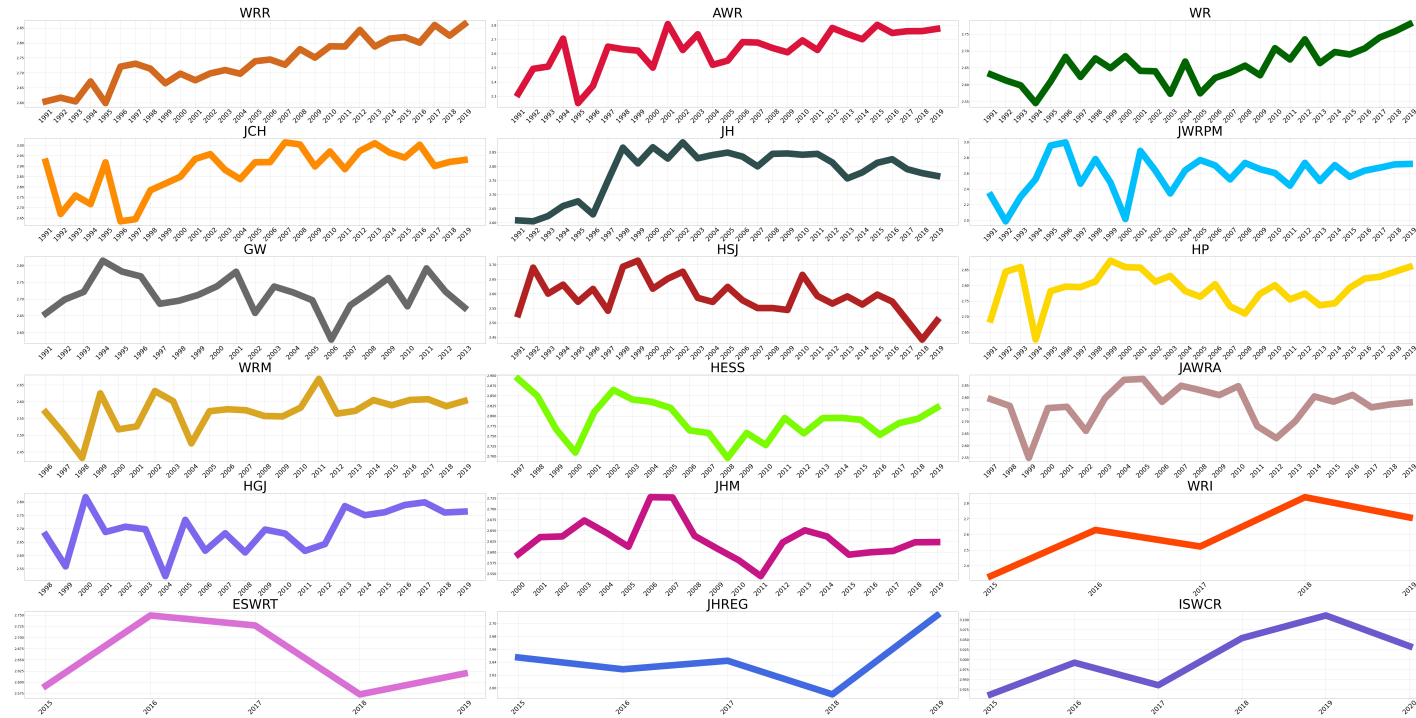
## Corpus Diversity



- No trend is observed for the entire corpus

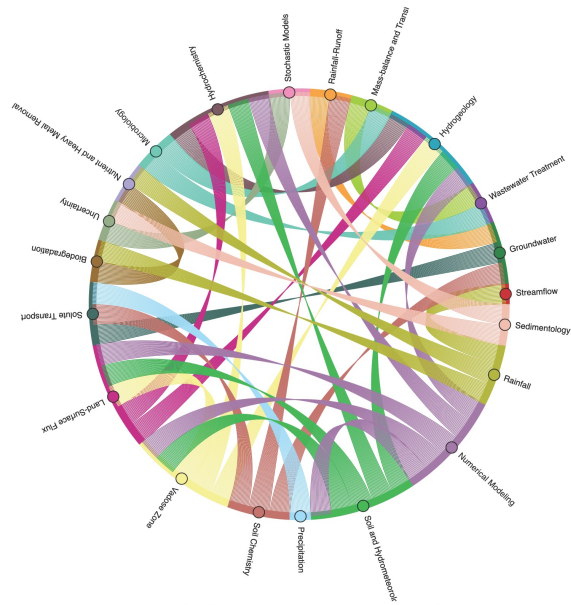


# Interdisciplinarity Trend in Journals

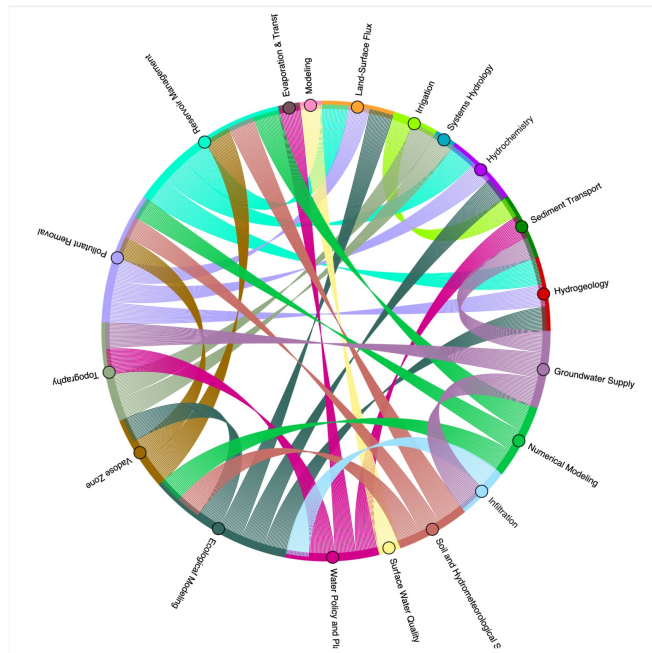




## Detecting Isolated Topics



## Positive Correlations



## Negative Correlations

