DEPARTAMENTO DE GEOLOGIA
ESCUELA DE POSGRADO
UNIVERSIDAD NACIONAL DEL SUR

ENTROPY THEORY IN WATER SCIENCE AND SEDIMENTOLOGY

Professor Vijay P. Singh,
Caroline and William N. Lehrer Distinguished Chair in Water Engineering
President, FARA
President, G.B.S. Board
Editor-in-Chief, Water Science and Technology Library Bookseries
Editor-in-Chief, Journal of Ground Water Research
Editor-in-Chief, Open Agriculture

Department of Biological and Agricultural Engineering & Zachry Department of Civil Engineering
Texas A and M University

Clases en Idioma Inglés.
Fecha: 11 al 15 de abril de 9 a 12 hs
Lugar: Sala de Conferencias del Departamento de Geología, Universidad Nacional del Sur, San Juan 670, 8000 Bahía Blanca, Argentina.
Costo: $Ar 300
Contactos: Dr Gerardo M. E. Perillo gmeperillo@criba.edu.ar
Dr Claudio A. Delrieux cad@uns.edu.ar

Course Syllabus: Entropy Theory in Water Science and Sedimentology. Introduction to entropy theory, probability distributions, parameter estimation, flow distributions, sediment concentration, rainfall-runoff, sediment transport, debris flow, and sediment grainsize distribution.

Course Objectives: Water and environmental engineering systems are inherently spatial and complex, and our understanding of these systems is less than complete. Many of the systems are either fully stochastic or part-stochastic and part-deterministic. Fundamental to the planning, design, development, operation, and management of these stochastic systems is the data that are observed either in field or experimentally and the information they convey. If this information can be determined, it can serve as a basis for the design and evaluation of systems, derivation of probability distributions, parameter estimation, development of models, choosing between models, testing the goodness of a model, and so on. Entropy attempts to quantify this information. Thus, the objective of this course is to present the entropy theory and discuss its applications to a set of problems in water and environmental engineering. Indeed entropy theory transcends disciplinary boundaries and can serve as a tool to unify seemingly disparate fields.

Lectures: 3 hours a day for five days. Assignments for participants to work on.

Examination: Participants will work on assignments independently that will replace examinations. Or these will be analogous to open-book examinations. Each day will have one assignment.

Detailed Course Outline and Relevant References:

1. Introduction to Entropy Theory

1.2 Entropy Concept
1.3 Entropy Theory
1.4 Types of Entropy
1.5 Application of Entropy Theory to Engineering Problems
1.6 Hypothesis on Cumulative Distribution Function
1.7 Methodology for Application of Entropy Theory

References

Cui, H. and Singh, V.P. (2012). On the cumulative distribution function for entropy-based hydrologic modeling. Transactions of the ASABE, Vol. 55, No. 2, pp. 429-438.

Jaynes, E.T., 1957a. Information theory and statistical mechanics, I. Physical Reviews, Vol. 106, pp. 620-630.

Jaynes, E.T., 1957b. Information theory and statistical mechanics, II. Physical Reviews, Vol. 108, pp. 171-190.

Jaynes, E.T. (2003). Probability Theory. Cambridge University Press, Cambridge, 727 pp.

Shannon, C.E. (1948). The mathematical theory of communications, I and II. Bell System Technical Journal, Vol. 27, pp. 379-423.
Shannon, C.E. and Weaver, W. (1949). The Mathematical Theory of Communication. University of Illinois Press, Urbana, Illinois.

Singh, V.P. (1997). The use of entropy in hydrology and water resources. Hydrological processes, Vol. 11, pp. 587-626.

Singh, V.P. (2011). Hydrologic synthesis using entropy theory: Review. Journal of Hydrologic Engineering, Vol. 16, No. 5, pp. 421-433.

Singh, V.P. (2013). Entropy Theory and its Application in Environmental and Water Engineering. John Wiley, Chichester, England.

Tribus, M. (1969). Rational Descriptions, Decisions and Designs. Pergamon Press, New York.

2. Flow Velocity Distributions

References

Barbé, D. E, Cruise, J. F., and Singh, V. P. (1991). Solution of three-constraint entropy-based velocity distribution. Journal of Hydraulic Engineering, ASCE, Vol. 117, No. 10, pp. 1389-1396.

Chiu, C.L. (1987). Entropy and probability concepts in hydraulics. Journal of Hydraulic Engineering, ASCE, Vol. 113, No. 5, pp. 583-600.

Chiu, C.L. (1988). Entropy and 2-D velocity distribution in open channels. Journal of Hydraulic Engineering, ASCE, Vol. 114, No. 7, pp. 738-756.

Greco, M. (1999). Entropy velocity distribution in a river. Proc. of the IAHR. Symposium on River, Coastal and Estuarine Morphodynamics, Genova, Vol. II, 121-130.

Moramarco, T. and Singh, V.P. (2001). Simple method for relating local stage and remote discharge. Journal of Hydrologic Engineering, ASCE, Vol. 6, No. 1, pp. 78-81.

Moramarco, T., Saltalippi, C. and Singh, V.P. (2004), Estimating the Cross-Sectional Mean Velocity in Natural Channels Using Chiu's Velocity Distribution. Journal of Hydrologic Engineering, ASCE, Vol. 9, No. 1, pp. 42-50.

Prandtl, L. (1925). Bericht uber unter suchugen zur ausgebildeten turbulenz. Zeitschrift fur Angewanate Mathematik und Mechanik, Berlin, Germany, Vol. 5, No. 2, pp. 136.

Singh, V.P. (1996). Kinematic Wave Modeling in Water Resources: Surface Water Hydrology. John Wiley, New York, N.Y.

Von Karman, T. (1935). Some aspects of the turbulent problem. Mechanical Engineering, Vol. 57, No. 7, pp. 407-412.

Xia, R. (1997). Relation between mean and maximum velocities in a natural river. Journal of Hydraulic Engineering, Vol. 123, No. 8, pp. 720-723.

Xia, R. and Yen, S. (1994). Significance of averaging coefficients in open channel flow equations. Journal of Hydraulic Engineering, Vol. 120, N. 2, pp. 169-180.

3. Sediment Concentration

3.1 Preliminaries
3.2 Sediment Concentration
3.3 Entropy-Based Derivation of Sediment Concentration Distribution

References

Bagnold, R.A. (1954). Experiments on gravity-free dispersion of large solid spheres in a Newtonian fluid under shear. Proceedings, Royal Society, London, Series A, Vol. 225, pp. 49-63.

Cheng, N.-S. (1997). Simplifies settling velocity formula for sediment particle. Journal of Hydraulic Engineering, ASCE, Vol. 132, N. 2, pp. 149-152.

Chiu, C.L., Jin, W. and Chen, Y.C. (2000). Mathematical models of distribution of sediment concentration. Journal of Hydraulic Engineering, Vol. 126, No. 1, pp. 16-23.

Einstein, H.A and Chien, N. (1955). Effects of heavy sediment concentration near the bed on velocity and sediment distribution. Report No. 8, M.R.D., Sediment Series, U.S. Army Corps of Engineers, Omaha, Nebraska, August.

Garcia, M.H., editor (2008). Sedimentation Engineering. ASCE Manuals and reports on Engineering Practice No. 110, ASCE Press, Reston, Virginia.

Vanoni, V.A. (1975). Sedimentation Engineering. ASCE Press, New York.

van Rijn, L.C. (1984). Sediment transport, part II: suspended load. Journal of Hydraulic Engineering, Vol. 110, No. 11, pp. 1813-1641.

Zanke, U. (1978). Berechnung der sinkgeschwindigkeiten von sedimenten. Mitteilungen des Franzius-Institures, Vol. 46, pp. 231-245.

4. Sediment Transport

4.1 Preliminaries
4.2 Suspended Sediment Discharge
4.3 Entropy-Based Derivation of Sediment Discharge

References

Bagnold, R.A. (1954). Experiments on gravity-free dispersion of large solid spheres in a Newtonian fluid under shear. Proceedings, Royal Society, London, Series A, Vol. 225, pp. 49-63.

Chiu, C.L., Jin, W. and Chen, Y.C. (2000). Mathematical models of distribution of sediment concentration. Journal of Hydraulic Engineering, Vol. 126, No. 1, pp. 16-23.

Choo, T.H. (2000). An efficient method of the suspended sediment-discharge measurement using entropy. Water Engineering Research, Vol. 1, No. 2, pp. 95-105.

Coleman, N.L. (1986). Effects of suspended sediment on open channel velocity distribution. Water Resources Research, Vol. 22, No.10, pp. 1377-1384.

Einstein, H.A. (1950). The bed load function for bed load transportation in open channel flows. Technical Bulletin No. 1026, USDA Soil Conservation Service, pp. 1-71, Washington, D.C.

Einstein, H.A and Chien, N. (1955). Effects of heavy sediment concentration near the bed on velocity and sediment distribution. Report No. 8, M.R.D., Sediment Series, U.S. Army Corps of Engineers, Omaha, Nebraska, August.

Garcia, M.H., editor (2008). Sedimentation Engineering. ASCE Manuals and reports on Engineering Practice No. 110, ASCE Press, Reston, Virginia.

Vanoni, V.A. (1975). Sedimentation Engineering. ASCE Press, New York.

van Rijn, L.C. (1984). Sediment transport, part II: suspended load. Journal of Hydraulic Engineering, Vol. 110, No. 11, pp. 1813-1641.

5. Debris Flow

5.1 Notation and Definition
5.2 Entropy Theory
5.3 Sediment Concentration Distribution
5.4 Equilibrium Sediment Concentration

References

Bagnold, R.A. (1954). Experiments on gravity-free dispersion of large solid spheres in a Newtonian fluid under shear. Proceedings, Royal Society, London, Series A, Vol. 225, pp. 49-63.

Egashira, S., Itoh, T. and Takeuchi, H. (2001). Transition mechanism of debris flow over rigid bed to over erodible bed. Physics and Chemistry of Earth, Vol. 26, No. 2, pp. 169-174.

Lien, H.P. and Tsai, F.W. (2000). Debris flow control by using slit dams. International Journal of Sediment Research, Vol. 15, No. 4, pp. 391-409.

Lien, H.P. and Tsai, F.W. (2003). Sediment concentration distribution of debris flow. Journal of Hydraulic Engineering, Vol. 129, No. 12, pp. 995-1000.

Major, J.J. and Pierson, T., 1992. Debris flow rheology: experimental analysis of fine-grained slurries. Water Resources Research, Vol. 28, No. 5, pp. 841-857.

Ou, G. and Mizuyama, T. (1994). Predicting the average sediment concentration of debris flow. Journal of Japanese Erosion Control Engineering Society, Vol. 47, No. 4, pp. 9-13 (Japanese).

Shields, A. (1936). Anwendung der ahnlichkeitsmechanik und der turbulenzforschung auf die geschiebebewegung, Mitt. Der Preuss. Versuchanstait der Wasserbau und Schiffbau, Berlin, 26, 98-109 (in German).

Takahashi, T. (1979). Mechanical characteristics of debris flow. Journal of Hydraulics Division, ASCE, Vol. 104, No. 8, pp. 1153-1169.

6. Sediment Grain Size Distribution

6.1 Grain Size Distribution
6.2 Characterizing Grain Size Distribution
6.3 Derivation of Grain Size Distributions
6.4 Soil Characteristics Using Grading Entropy

References

Baker, H.A. (1920). On the investigation of the mechanical constitution of loose arenaceous sediments by the method of elutriation, with special reference to the Thanet beds of the southern side of the London basin. Geological Magazine, Vol. 57, pp. 363-370.

Blatt, H., Middleton, G. and Murray, E. (1980). Origin of Sedimentary Rocks. Prentice-Hall, Englewood Cliffs, New Jersey.

Folk, R.L. (1966). A review of grain size parameters. Sedimentology, Vol. 6, pp. 3537-3548.

Folk, R. L. and Ward, W.C. (1957). Brazos River bar-a study in the significance of grain size parameters. Journal of Sediment Petrology, Vol. 27, pp. 3-26.
Forrest, J. and Clark, N.R. (1989). Characterizing grain size distributions: evaluation of a new approach using a multivariate extension of entropy analysis. Sedimentology, Vol. 36, pp. 711-722.

Friedman, G.M. (1962). On sorting, sorting coefficients and the log-normality of grain size distribution of sand stones. Geology Journal, Vol. 70, pp. 737-753.

Friedman, G.M. (1967). Dynamic processes and statistical parameters compared for size frequency distributions of beach and river sands. Journal of Sedimentary Petrology, Vol. 37, pp. 327-354.

Full, W.E., Ehrlich, R. and Kennedy, S.K. (1983). Optimal definition of class intervals for frequency tables. Particulate Science and Technology, Vol. 1, pp. 281-293.

Einav, I. (2007). Breakage mechanics-Part I: Theory. Journal of the Mechanics and Physics of Solids, Vol. 55, No. 6, pp. 1274-1297.

Krumbein, W.C. and Pettijohn, F.J. (1938). Manual of Sedimentary Petrology. 549 p., D. Appleton-Century Company, Inc., New York.

Mazzulo, J. and Ehrlich, R. (1980). A vertical pattern of variation in the St. Peter sandstone-Fourier grain shape analysis. Journal of Sediment Petrology, Vol. 50, pp. 63-70.

Niggli, P. (1935). Die charakterisierung der klastischen sediments nach der kornzusamensetzung. Schweizer, Mineralogy und Petrology Mitt., Vol. 15, pp. 31-38.

Semple, R.K., Youngman, C.E. and Zeller, R.E. (1972). Economic regionalization and information theory: An Ohio example. Discussion paper 28, Department of Geography, Ohio State University, Columbus, Ohio.

Sharp, W.E. (1973). Entropy as a parity check. Earth Research, Vol. 1, pp. 27-30.

Sharp, W.E. and Fan, P. (1963). A sorting index. Geology Journal, Vol. 71, pp. 76-84.

Swan, D., Clague, J.J. and Leternauer, J.L. (1979). Grain size statistics I: Evaluation of the Folk and Ward graphic measures. Journal of Sedimentary Petrology, Vol. 48, pp. 863-878.

Swan, D., Clague, J.J. and Leternauer, J.L. (1979). Grain size statistics II: Evaluation of groped moment measures. Journal of Sedimentary Petrology, Vol. 49, pp. 487-500.

Udden, J.A. (1914). Mechanical composition of clastic sediments. Geological Society of America Bulletin, Vol. 25, p. 655-744.