Mathematical modeling of the atmosphere
Wintersemester 2022

Course Syllabus

Instructor:
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Büro: 01A66

Class Times and Locations:
Vorlesung: Dienstag 900--1200, 01A74 bis 1000; 01A73 1000-1200.
Praktikum: Mittwoch 1400--1700, PC-Lab 01C07.
Ilias module number: 98880

Location: Campus Juelich, Labor Technomathematik 1.

Prerequisites: Enrollment in Master's program, plus familiarity with elementary statistics and partial differential equations.

Grading: The grade will be based on an individual oral exam near the end of the Wintersemester (i.e., first week in Feb).

Required Reading Material:

Online lecture notes: Owen, A., 2013: Monte Carlo theory, methods and examples. Chapters 8, 9, and 10.3. http://statweb.stanford.edu/~owen/mc/.

Optional Reading Material: Some of the following books are available on the top shelf of the quiet reading room in the Bibliothek.

Cotton, W. R., and R. A. Anthes, 1989: Storm and Cloud Dynamics. Academic Press.

Pope, S. B., 2000: Turbulent Flows. Cambridge University Press, 771 pp.

Stull, R. B., 1988: An Introduction to Boundary Layer Meteorology, Springer.

Press, W. H., S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, 2007: Numerical Recipes: The art of scientific computing. 3rd edition, Cambridge University Press, 1235 pp.

Gentle, J. E., 2003: Random number generation and Monte Carlo methods, 2nd Ed. Springer.

Kalos, M. H. and P. A. Whitlock, 2008: Monte Carlo Methods. 2nd edition, Wiley-Blackwell, 203 pp.

Johnson, M. E., 1987: Multivariate statistical simulation. Wiley.

Ross, S. M., 2012: Simulation. 5th edition, Academic Press, 328 pp. Available online.

Lemieux, C., 2009: Monte Carlo and quasi-Monte Carlo sampling. Springer Science & Business Media, 373 pp.

Germano, M., 1992: Turbulence: The filtering approach. *J. Fluid Mech.*, 238, 325–336.

Gibson, M. M. and B. E. Launder, 1978: Ground effects on pressure fluctuations in the atmospheric boundary layer. *J. Fluid Mech.*, 86, 491–511.

Leonard, A., 1974: Energy cascade in large-eddy simulations of turbulent fluid flows. *Adv. Geophys.*, 18A, 237–248.

2020: “CLUBB-SILHS: A parameterization of subgrid variability in the atmosphere.” V. E. Larson. https://arxiv.org/pdf/1711.03675v4.pdf.

2005: “Supplying Local Microphysics Parameterizations with Information about Subgrid Variability: Latin Hypercube Sampling." V. E. Larson, J.-C. Golaz, H. Jiang, and W. R. Cotton. *J. Atmos. Sci.*, 62, 4010–4026.

2013: “Analytic upscaling of local microphysics parameterizations, Part I: Theory." V. E. Larson and B. M. Griffin, Quart. J. Royal Met. Soc., 139, 46–57.

2013: “The Subgrid Importance Latin Hypercube Sampler (SILHS): A new subcolumn generator for large-scale models." V. E. Larson and D. P. Schanen, *Geosci. Model Dev.*, 6, 1813–1829.

Topics to be covered:

1. Equations of motion for a fluid.
2. Filtering the equations of motion.
3. Approximation: filtered higher-order equations.
4. The assumed PDF method of closure.
5. Monte Carlo integration.