SHORT COURSE – Stochastic processes theory and applications

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We present a concise introduction of stochastic processes, including its consequences in terms of parameter estimation from empirical data and model comparison, from basic notions on mathematics. Basic notions of probability theory are introduced, following the application to dynamic stochastic processes, from discrete maps via the Perron-Frobenius type equations to time continuous state discrete systems and approximations via the Fokker-Planck equations derived via Kramers-Moyal expansion. Maximum likelihood and Bayesian methods of parameter estimation in stochastic processes will be demonstrated, and model comparison in Bayesian frameworks discussed. If time permits, spatially extended stochastic processes will be described, leading in mean field approximation to partial differential equations, including ordinary diffusion and in the framework of fractional calculus also superdiffusive processes. All material will be complemented with examples from population biology and especially epidemiology, now in the wider public attention due to the COVID-19 pandemic experienced in recent years. The examples allow a hands on approach to current research questions in stochastic processes, well beyond the demonstated examples of the course.