

Outline of the lecture  
**Predictability of Weather and Climate**  
ca. 11 Doppelstunden  
V. Wirth

Introduction: Order and chaos in meteorology (powerpoint)  
*Bauer et al. 2015*

Definition of predictability, climate variance as reference, measures of predictability (from information theory, entropy), practical versus intrinsic predictability, Gaussian thinking  
*chapter 4, DelSole and Tippett 2007, Mehlhauser and Zhang 2012, Rodwell et al. 2013*

Basics of dynamical systems, phase space, Hamiltonian versus dissipative system, Liouville theorem, attractor, strange attractor  
*P. Berge, Y. Pomeau, C. Vidal (1984): Order within Chaos. Wiley.*

Sensitive dependence on initial conditions: Lorenz 1963, Lyapunov exponent, singular vectors, strange attractor  
*Lorenz 1963, chapter 3*

Multiscale systems: cascade thinking, energy goes to larger (2D) versus smaller (3D) scales, error growth across scales, small scale inherits predictability from large scale, large scale is spoiled by error growth (in scale) from smaller scales  
*Vallis Textbook*

Sensitive dependence on initial conditions in a multiscale system  
*Lorenz 1969, Tribbia and Baumhefner 2004*

Error growth, error enstrophy versus energy, error in spectral space, upscale error growth (Zhang et al. 2007, Selz and Craig 2015), practical importance of small scales (Durrant)?  
*Zhang et al. 2007, Selz and Craig 2015, Durrant*

Ensemble prediction: initial versus model error, creating initial perturbations, stochastic physics, ensemble mean, ensemble spread versus skill, what is a good ensemble, Brier skill score and continuous ranked probability score, reliability and resolution, rank (Talagrand) histogram  
*chapter 17+22, Kolczunski et al. 2011, Leutbecher and Palmer 2008, Whitaker and Lough 1998, Atger 1999, Candille et al. 2007, Hamill 2001*

EDA, Kalman filter, Ensemble Kalman filter  
*chapter 6+7*

Ensemble sensitivity analysis  
*Torn and Hakim 2009*

seamless prediction, seasonal prediction,  
*chapter 12+19, Bauer et al. 2015, Buizza et al 2015*

*„Chapters“ refer to the book of Palmer and Hagedorn (2006)*