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Analysing variability in climate models: memory, entropy, extremes

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Analysis of climate variability is based on dynamical and statistical measures suitable for model comparison. While traditional analyses concentrate on first and second moments other approaches may be applied. Three examples are presented characterizing long-term aspects like memory, entropy and extremes.

(i) Long-term memory is a measure of the low-frequency variability and defined by scaling properties (power-law) of power-spectra, f^{-b} with b depending on region and time scale: Up to a century, observations and some AO-GCMs show near surface temperature scaling, which is white ($b = 0$) over inner continents, flicker-noise ($b = 1$) over the N-Atlantic and parts of the circumpolar current. Trends in scenarios do not affect this variability. Up to millennia, a low-resolution AO-GCM (CSIRO) at present day conditions shows SST-scaling in the N-Atlantic comparable to δ^{18}O records of the Holocene ($b = 0.8$). Scaling of ocean and atmospheric dynamics (Meridional Overturning Circulation and convective available potential energy) are also discussed.

(ii) Entropy production at its maximum (the statistically most probable state) may serve climate simulations in model building and performance evaluation: Maximum entropy production (MEP) of an atmospheric global circulation (A-GCM) and its core are analysed testing MEP sensitivity by varying boundary layer (dissipation) properties. A-GCM coupling to a mixed layer ocean is tested to provide a concept for paleo-simulations, if ocean heat transfer follows MEP.

(iii) Extreme events evaluated by standardized distributions are suitable for model-observation or control-scenario comparison: The standardized precipitation index (SPI) commonly employed for monitoring dry- and wetness (on various time scales to distinguish meteorological from hydrological droughts) serves as an example. Changing climate conditions can be expressed in terms of standardized values applying a

suitable transformation to future precipitation in a standardized form.