International Max Planck Research School on Earth System Modelling

Can convective precipitation variability be deduced from the variability in CAPE and CIN? An analysis of global CAPE and CIN variability in present and future climates

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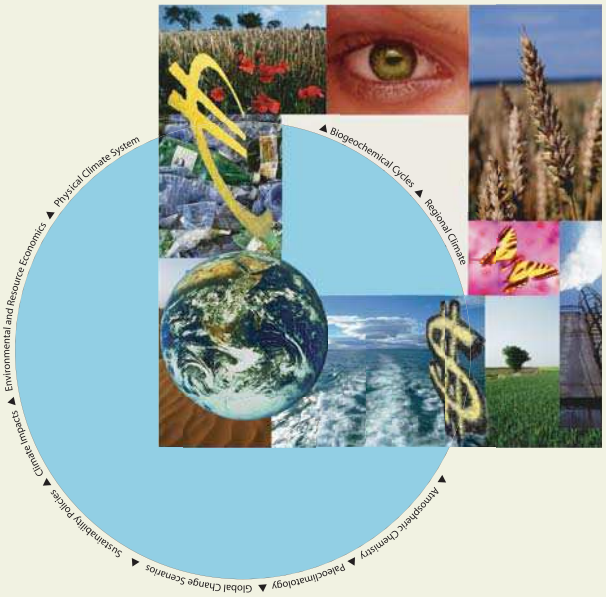

Abstract

The variability of convective precipitation is relevant for its prediction on short and long time scales. On short time scales severe weather events are vital for weather forecasting, on long time scales convection anomalies affect wetness and droughts. Since convective precipitation requires parameterisation in numerical models, CAPE (convective available potential energy) and CIN (convective inhibition) are applied to estimate trends and long-term memory. Their variability is determined in present-day climate (ECMWF reanalysis: 6 hourly during 1979-2001 in T106 truncation; ECHAM5/MPI-OM, 20C simulation: 6 hourly during 1902-2001 in T63 truncation) and a possible warmer future scenario (ECHAM5/MPI-OM, A1B scenario: 6 hourly during 2002-2101 in T63 truncation).

Future changes in CAPE and CIN reveal similar changes for small, mean and large values. A global pattern is found of increasing values in CAPE and CIN over most regions of the continents and northern hemispheric ocean basins, while decreasing values are found over the Southern Ocean. This pattern changes towards mostly positive trends if CAPE is analysed for large CIN occurring simultaneously. In contrast, the original pattern remains similar if CAPE is investigated for small CIN.

Temperature and humidity, which form the basis of CAPE and CIN, show almost entirely higher values in the future. Decreasing values in CAPE and CIN correlate with large scale patterns like the North Atlantic Oscillation (NAO), El Niño/Southern Oscillation (ENSO) and the Southern Annular Mode (SAM). Furthermore, a southward shift of the descending branch of the southern hemisphere Hadley Cell in a warmer climate decreases CAPE further.

The correlations of CAPE with the above named teleconnections influence the distribution of global memory on long time scales. The influence of ENSO on the memory in CAPE and CIN intensifies in a warmer climate with regards to spread and frequency. Furthermore, the impact of the NAO on CAPE also spreads in terms of location, while the frequency remains similar in a warmer climate. In contrast, the regions where SAM influences CAPE decrease due to declining values of the SAM index. Additional analyses with an ECHAM5 simulation and climatological sea surface temperature reveal that the variability of the ocean has a stronger influence on CAPE than on CIN.